Construction and Operation Impact Assessment

Australian Museum - Additions and Alterations

Prepared for Australian Museum
October 2018

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1 Introduction

EMM Consulting Pty Ltd (EMM) has been engaged by the Australian Museum (the Museum) to provide an acoustic assessment of construction and operational noise associated with the proposed additions and alterations (the project) to the Museum, located on William Street in Sydney NSW. This construction and operation impact assessment has been prepared to support the Development Application (DA) for the project, addressing the SEAR's (SSD 9452) requirements, specifically Item 10, shown below:

10. Noise and vibration

- A noise and vibration assessment prepared in accordance with the relevant EPA guidelines. This assessment must detail construction and operational noise impacts on nearby noise sensitive receivers (including Sydney Grammar School) and outline proposed noise mitigation and monitoring procedures.
- Confirmation of whether the museum will be served by a back-up generator.

Australian Museum advised that the proposed 'works' areas are all serviced by existing HVAC systems, and any related changes would be minor consisting of replacement of equipment in existing plantrooms. Final details are not available at this time and have not been considered further in this report. It is recommended that during the detailed design phase, any mechanical plant changes be reviewed to ensure assessment goals outlined in Chapter 4 are satisfied.

Australian Museum has confirmed that a back-up generator would not be required as part of these works.

1.1 Guidelines

This assessment has been developed in accordance to the following relevant guidelines, policies and standards:

- City of Sydney Development Control Plan 2012;
- Department of Environment and Climate Change (DECC) 2009, *Interim Construction Noise Guideline* (ICNG);
- New South Wales Environmental Protection Authority (2017), *Noise Policy for Industry*; and
- Australian Standard AS/NZS 2107-2016: *Acoustics – Recommended design sound levels and reverberation times for building interiors.*

1.2 Glossary of acoustic terms

A number of technical terms are required for the discussion of noise. These are explained in Table 1.1

Table 1.1 Glossary of acoustic terms

Term	Description
dB(A)	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
L_1	The noise level exceeded for 1% of a measurement period.

Table 1.1 Glossary of acoustic terms

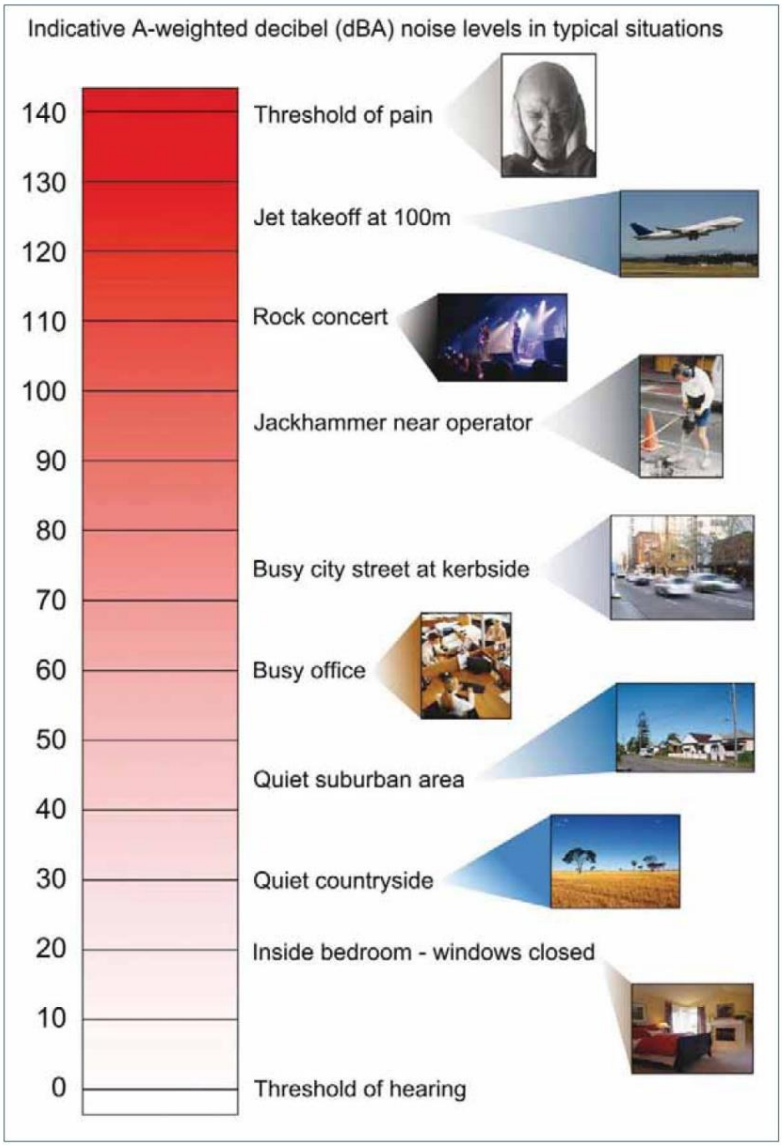
Term	Description
L_{10}	A noise level which is exceeded 10% of the time. It is approximately equivalent to the average of maximum noise levels.
L_{90}	Commonly referred to as the background noise, this is the level exceeded 90% of the time.
L_{eq}	It is the energy average noise from a source, and is the equivalent continuous sound pressure level over a given period. The $L_{eq,15min}$ descriptor refers to an L_{eq} noise level measured over a 15-minute period.
L_{max}	The maximum root mean squared sound pressure level received at the microphone during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period.
Sound power level	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.
Temperature inversion	A positive temperature gradient. A meteorological condition where atmospheric temperature increases with altitude.

It is useful to have an appreciation of decibels, the unit of noise measurement. Table 1.2 gives an indication as to what an average person perceives about changes in noise levels:

Table 1.2 Perceived change in noise

Change in sound level (dB)	Perceived change in noise
1 to 2	typically indiscernible
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud

Examples of common noise levels are provided in Figure 1.1.



Source: Road Noise Policy (Department of Environment, Climate Change and Water (DECCW) 2011).

Figure 1.1 Common noise levels

2 Project description

2.1 Overview

This assessment references architectural drawings by Neeson Murcutt Architects Pty Ltd dated August 2018 (Appendix A).

The proposed redesign seeks to expand exhibition and visitor spaces largely within the existing envelope, through a redesign of the Museum 'heart' and the William Street entrance. Key aspects of the redevelopment include:

- demolition and relocation of stairway running from the basement to level 2;
- demolition of the level 1 mezzanine;
- construction of a new escalator and elevator from the basement to ground level;
- extension of the existing 'Crystal Hall' entrance;
- construction of new entry via William Street;
- removing, realigning and replacing existing internal walls; and
- landscaping and redesign of existing exterior.

Total duration of the construction works is anticipated to be up to 60 weeks, with the internal demolition and removal of the Level 1 mezzanine floor expected to be completed in 6-8 weeks.

3 Existing environment

3.1 Site surrounds

The Museum is located on the corner of William Street and College Street Darlinghurst, on the outskirts of the Sydney Central Business District (CBD).

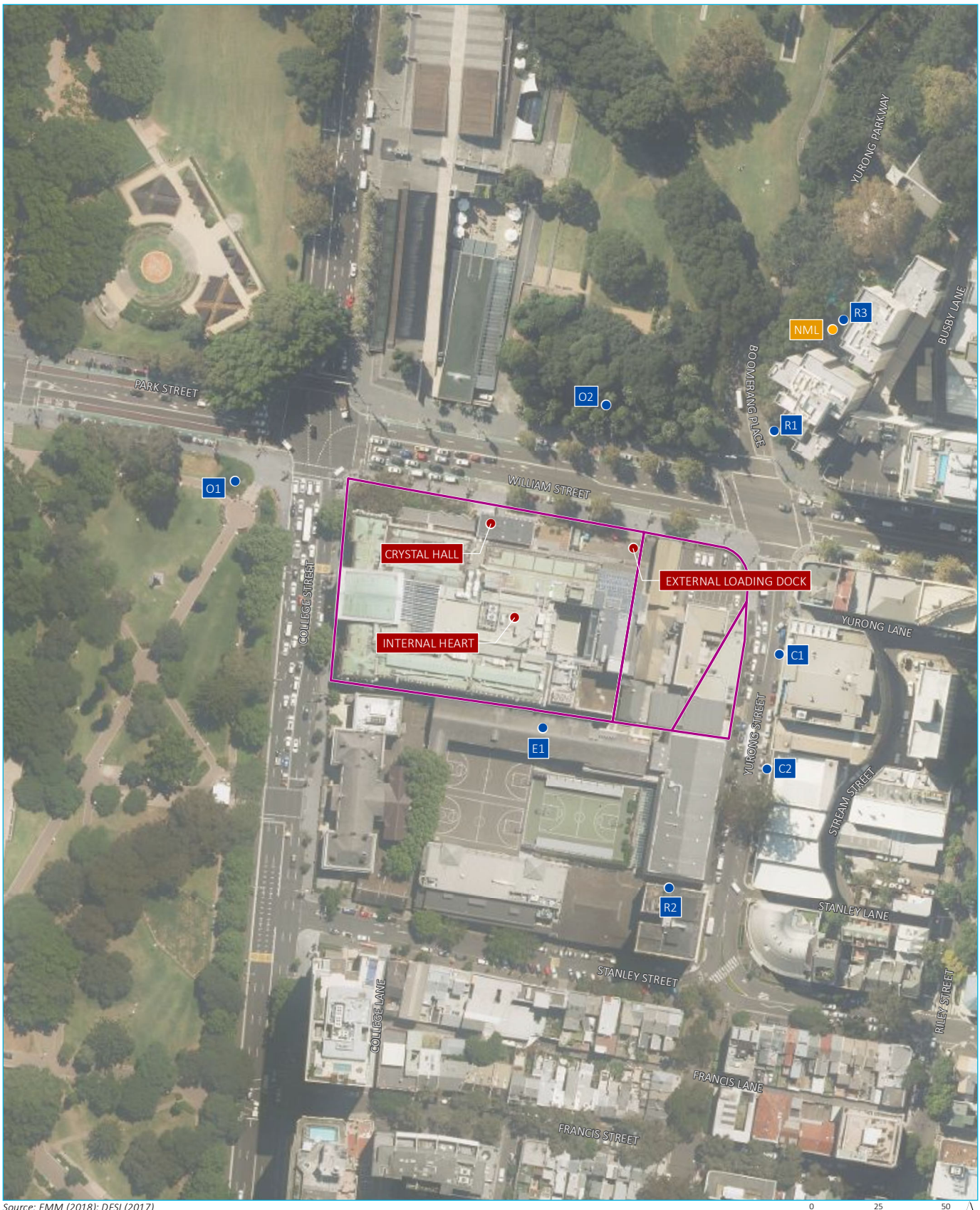
The Museum surrounds are characterised by a mix of commercial, residential, educational, special use and outdoor parks and facilities. Adjacent to the Museum to the south is Sydney Grammar School. To the north and west of the site are passive outdoor areas, Cook Phillip Park and Hyde Park respectively, including a public sporting facility, Cook Phillip Park Pool to the north.

To the east and north-east of the site is a mix of commercial and residential premises. An apartment building approximately 60 m to the north-east is the closest residential premises, situated on the corner of William Street and Boomerang Place and identified as 1 Boomerang Place, Woolloomooloo. Various commercial premises are located approximately 50 m to the east of the Museum, across Yurong Street. To the north-east on Yurong Parkway is KU Phillip Park Childrens Centre located approximately 140m from the site.

Noise and vibration impacts have been assessed to the nearest representative noise sensitive receivers as outlined above and listed in Table 3.1. The Museum location and site surrounds, as well as noise monitoring locations and sensitive receivers, are shown in Figure 3.1.

Table 3.1 Noise sensitive receivers

ID	Receiver type	Location
R1	Residential	1 Boomerang Place Woolloomooloo (south)
R2	Residential	21 Yurong Street Darlinghurst
R3	Residential	1 Boomerang Place Woolloomooloo (north)
E1	Educational facility	Sydney Grammar School, 10-12 College Street Darlinghurst
C1	Commercial	4-16 Yurong Street Darlinghurst
C2	Commercial	Hostel, 20 Yurong Street Darlinghurst
O1	Outdoor passive recreation area	Hyde Park, 120 Elizabeth Street Sydney
O2	Outdoor passive recreation area	Cook Phillip Park, 2 College Street Sydney



Source: EMM (2018); DFSI (2017)

0 25 50 m

GDA 1994 MGA Zone 56

N

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KEY

- Site boundary
- Receiver point
- Construction site
- Noise monitoring location

Site location, sensitive receivers and noise monitoring location

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Figure 3.1

EMM
creating opportunities

3.2 Existing background and ambient noise environment

EMM completed unattended noise monitoring from 29 August to 11 September 2018, at a representative location of the surrounding sensitive receivers, situated within the entrance grounds of R1 (Figure 3.1). The location was selected to represent the most sensitive residential receivers and was shielded from direct exposure to road traffic on William Street. We note that apartments within the southern portion of this building fronting William Street would be exposed to significantly higher background noise levels during the day and evening and accordingly higher NML's would be appropriate. Adoption of the noise levels at NL1 (at R3) represents a conservative approach for assessing impacts at R1.

The ambient noise environment is influenced by traffic noise from William Street, and general urban hum of the city, evident in the monitoring data charts. Other noise sources include birdlife and insects, activities and passers-by in the adjacent park and local traffic along Boomerang Place.

The results from the noise monitoring are presented in Table 3.2. Rating Background Levels (RBL) have been calculated according to the EPA's Noise Policy for Industry (NPfI) for each period. A review of the noise measurement data with and without prevailing weather effects (wind and rain) confirmed equivalent L_{A90} and L_{Aeq} noise levels presented below.

Table 3.2 Rating Background Levels

Measurement location	ID	RBL[1] (dB)			$L_{Aeq,15min}$		
		Day	Evening	Night	Day	Evening	Night
Entrance grounds of 1 Boomerang Place	NL1	50	48	44	57	55	51

Notes: 1. The RBL is an NPfI term and is used represent the background noise level. The levels adopted as the final RBL are the lowest ABL as defined in the NPfI.
2. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: 10 pm to 7 am.

4 Construction noise criteria

4.1 Interim Construction Noise Guideline (NSW EPA)

The ICNG provides guidelines for the assessment and management of noise from construction works. The ICNG quantitative approach is described below. It is more suited to longer periods of construction rather than intermittent maintenance or servicing.

4.1.1 Construction hours

The ICNG's fundamental approach to construction noise management is through the following time restrictions for activities where the noise is audible at residential premises:

- Monday to Friday 7 am to 6 pm;
- Saturday 8 am to 1 pm; and
- no construction work is to take place on Sundays or public holidays.

It is expected that construction likely to be audible at residences will occur during standard ICNG hours only.

4.1.2 Residential

Table 4.1 is an extract from the ICNG and provides noise management levels (NML) for residential receivers for standard construction hours and out of hours (OOH) periods.

Table 4.1 ICNG residential noise management levels

Time of day	Management level Leq (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 + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq,15\text{-}min}$ 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 75 dB(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; and • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Table 4.1 ICNG residential noise management levels

Time of day	Management level Leq (15 min)	How to apply
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 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7.2.2.

Source: ICNG 2009

In summary, the ICNG noise management levels (NMLs) for activities during the standard hours are 10 dB above the existing background levels. For activities outside of the above hours the noise levels should be no more than 5 dB above the existing background levels.

4.1.3 Other noise sensitive land uses

Table 4.2 is an extract from the ICNG and provides noise management levels for other land uses.

Table 4.2 ICNG noise levels at other land uses

Land use	Management level, $L_{Aeq,15\ minute}$
Industrial premises	External noise level 75 dB (when in use)
Offices, retail outlets	External noise level 70 dB (when in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB (when in use)
Hospital wards and operating theatres	Internal noise level 45 dB (when in use)
Places of worship	Internal noise level 45 dB (when in use)
Active recreation areas	External noise level 65 dB (when in use)
Passive recreation areas	External noise level 60 dB (when in use)

4.1.4 Construction noise management levels

The NMLs for residential and other relevant land uses for the proposed development are provided in Table 4.3.

Table 4.3 Site specific construction noise management levels

Receiver	Receiver type	Period	NML $L_{Aeq,15minute}$, dB			
			Day	Day OOH	Evening	Night
R1, R2, R3	Residential	Recommended standard hours	60	55	53	49
E1	Educational facility	When in use	45 (internal)	-	-	-

Table 4.3 Site specific construction noise management levels

Receiver	Receiver type	Period	NML $L_{Aeq,15minute}$, dB			
			Day	Day OOH	Evening	Night
C1, C2	Commercial	When in use	70 (external)	-	-	-
O1, O2	Outdoor Passive recreation area	When in use	60 (external)	-	-	-

4.2 Operational noise

Details of any changes or additional mechanical plant and equipment associated with the alterations and additions to the Australian Museum are unknown at this stage, any related changes would be relatively minor consisting of replacement of equipment in existing plantrooms. This section of the report has considered the guidelines contained in the NPfI in developing project noise trigger levels for consideration during the design development phase of the project.

The objectives of the NPfI noise trigger levels are to protect the community from excessive intrusive noise and preserve amenity for specific land uses. It should be noted that the audibility of a noise source does not necessarily equate to disturbance at an assessment location.

To ensure these objectives are met, the EPA provides two separate noise trigger levels: intrusiveness and amenity. The fundamental difference being intrusiveness noise levels apply over 15 minutes in any period (day, evening or night), whereas the amenity noise levels apply to the entire assessment period (day, evening or night).

4.2.1 Intrusiveness noise levels

The intrusiveness noise trigger levels require that $L_{Aeq,15\ minute}$ noise levels from the site during the relevant operational periods (ie day, evening and night) do not exceed the RBL by more than 5 dB. The NPfI recommends that the intrusive noise trigger level for evening be set at no greater than the intrusive noise level for daytime and that the intrusive noise level for night-time should be no greater than the intrusive noise level for day or evening.

Table 4.6 presents the intrusive noise level determined for the proposal based on the adopted RBLs. It is noted that intrusive noise levels are applicable at residential assessment locations only.

Table 4.6 Project intrusiveness noise levels

Assessment location	Period[1]	Adopted RBL, dB	Project intrusiveness noise level dB, $L_{Aeq,15\ minute}$
Any residential property	Day	50	55
	Evening	48	53
	Night	44	49

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: 10 pm to 7 am.

4.2.2 Amenity noise levels

The assessment of amenity is based on noise levels specific to the land use. The noise levels relate only to industrial noise and exclude road or rail noise. Where the measured existing industrial noise approaches recommended amenity noise level, it needs to be demonstrated that noise levels from new industry will not contribute to existing industrial noise such that amenity noise levels are exceeded.

To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, the project amenity noise level for new industrial developments is the recommended amenity noise level (outlined in Table 2.2 of the NPfI) minus 5 dB. However, exceptions to this approach apply 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 level for the development.

Residential assessment locations potentially affected by operation of the site have been categorised in the NPfI "urban" amenity category as per the definitions provided in the NPfI, since they were deemed to be in an area with an acoustical environment that:

- is dominated by 'urban hum' or industrial source noise, where urban hum means the aggregate sound of many unidentifiable, mostly traffic and/or industrial related sound sources;
- has through-traffic with characteristically heavy and continuous traffic flows during peak periods;
- is near commercial districts or industrial districts; and
- has any combination of the above.

The corresponding project amenity noise levels for the site are given 4.7.

Table 4.7 Project amenity noise levels

Assessment location	Indicative area	Time period[1]	Recommended amenity noise level, $L_{Aeq,period}$	Project amenity noise level dB, $L_{Aeq,period}$
Residential	Urban	Day	60	55
		Evening	50	45
		Night	45	40
Commercial	All	When in use	65	60

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: 10 pm to 7 am.

4.2.3 Project noise trigger level

The project-noise trigger level (PNTL) is the lower of the calculated intrusive or amenity noise level and is provided in Table 4.8 for all assessment locations.

To standardise the time periods for the intrusiveness and amenity noise levels, it has been assumed that the $L_{Aeq,15\ minute}$ will be taken to be equal to the $L_{Aeq,period}$ + 3 decibels (dB). This is consistent with NPfI methodology.

Table 4.8 Project noise trigger levels

Assessment location	Period[1]	Intrusive noise level dB, $L_{Aeq,15\ minute}$	Amenity noise level dB, $L_{Aeq,period/15minute}$	Project noise trigger level (PNTL), dB
Residential (all assessment locations)	Day	55	55/58	55 $L_{Aeq,15\ minute}$
	Evening	53	45/48	48 $L_{Aeq,15\ minute}$[2]
	Night	49	40/43	43 $L_{Aeq,15\ minute}$[2]
Commercial	When in use	n/a	60	63 $L_{Aeq,15\ minute}$

Note: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: 10 pm to 7 am.
2. As per NPfI
3. To standardise the time periods for the intrusiveness and amenity noise levels, it has been assumed that the $L_{Aeq,15\ minute}$ will be taken to be equal to the $L_{Aeq,period}$ + 3 decibels (dB). This is consistent with NPfI methodology.

5 Construction vibration guidelines

5.1 Human comfort

5.1.1 General discussion on human perception of vibration

Humans are sensitive to vibration and they can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2 1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in Table 5.1.

Table 5.1 Peak vibration levels and human perception of motion

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 H-80 Hz.

Source: German Standard DIN 4150 Part 2 1975.

Table 5.1 suggests that people will just be able to feel floor vibration at levels of approximately 0.15 mm/s and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

5.1.2 Assessing vibration - a technical guideline

Environmental Noise Management – Assessing Vibration: a technical guideline (DEC 2006) is based on guidelines contained in BS 6472 – 2008, Evaluation of human exposure to vibration in buildings (1-80Hz).

The guideline BS 6472 – 2008 presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration levels below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration levels are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community member(s).

The guideline BS 6472 – 2008 defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 5.2.

Table 5.2 Examples of types of vibration

Continuous vibration	Impulsive vibration	Intermittent vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, eg occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990).	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is 3 or fewer these would be assessed against impulsive vibration criteria.

i Intermittent vibration

The relevant type of vibration expected from proposed works, intermittent vibration (as defined in Section 2.1 of the guideline BS 6472 – 2008), is assessed using the vibration dose concept which relates to vibration magnitude and exposure time. This is the most relevant type of vibration for the proposed development.

Intermittent vibration is representative of activities such as impact hammering or rolling.

Section 2.4 of the guideline BS 6472 – 2008 provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted rms (root mean square) acceleration levels over the frequency range 1 Hz - 80 Hz. To calculate VDV the following formula is used (refer Section 2.4.1 of the guideline):

$$VDV = \left[\int_0^T a^4(t)dt\right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The acceptable VDV for intermittent vibration are reproduced in Table 5.3 from Table 2.4.2 of *Assessing Vibration: a technical guideline* (DEC 2006).

Table 5.3 Acceptable vibration dose values for intermittent vibration

Location	Daytime		Night-time	
	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$
Critical areas	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

There is a low probability of adverse comment or disturbance to building occupants at vibration levels below the preferred values. Adverse comment or complaints may be expected if vibration levels approach the maximum values. The guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

5.2 Structural vibration criteria

Most commonly specified "safe" structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks and are set well below the levels that have potential to cause damage to the main structure.

In terms of the most recent relevant vibration damage criteria, *Australian Standard (AS) 2187.2 - 2006 Explosives - Storage and Use - Use of Explosives* recommends the frequency dependent guideline values and assessment methods given in *BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2* be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 5.4 and graphically in Figure 5.1.

Table 5.4 Transient vibration guide values – minimal risk of cosmetic damage

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz - 15 Hz	15 Hz and Above
1	Reinforced or framed structures industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	N/A
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

AS2187 states that the guide values in Table 5.4 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration gives rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 5.4 may need to be reduced by up to 50%.

Sheet piling activities (for example) are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may, therefore, be appropriate to reduce the transient values by 50% for this activity.

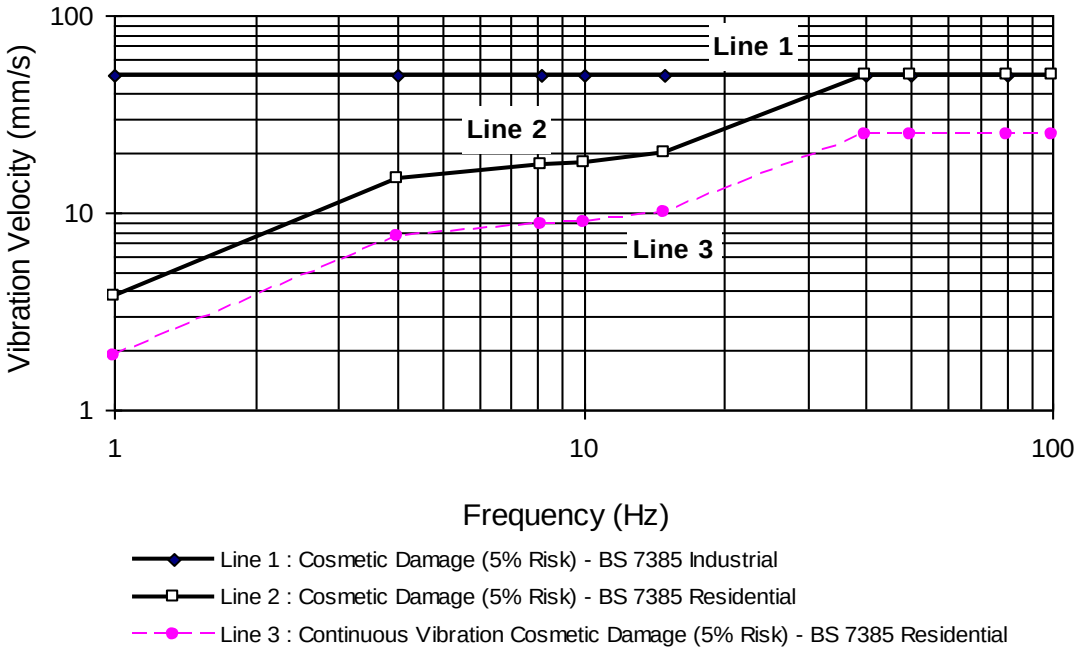


Figure 5.1 Graph of transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 5.4, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 5.4 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 5.4.

It is noteworthy that, additional to the guide values nominated in Table 5.4, the standard states that:

> Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

Also that:

> A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

6 Construction noise assessment

6.1 Construction hours

The proposed construction hours are expected to be largely consistent with the NSW EPA's Interim Construction Noise Guideline (ICNG) recommended standard construction hours:

- Monday to Friday 7 am to 6 pm;
- Saturday 8 am to 1 pm; and
- No work on Sundays or public holidays.

However due to the potentially high noise levels and impacts on visitors and staff of the Museum consideration to either closing the museum during noisy activities or conducting activities outside of standard hours would be considered.

6.2 Construction equipment

The main noise and vibration generating construction equipment expected to be used on site include, but may not be limited to:

- concrete saws, including a excavator mounted saw;
- pulveriser;
- boom lifts;
- two excavators;
- two dump trucks;
- scissor lift;
- concrete trucks for crystal hall extension; and
- general hand tools for scaffold and formwork setup.

Due to the heritage value of the building and presence of highly vibration sensitive displays and exhibits within the Museum, the use of significant vibration inducing equipment during demolition such as rock breakers and jack hammers would not be possible.

The construction noise impact assessment has adopted equipment noise emission values from the EMM noise database, as well as equipment manufacturer specifications and the Department for Environment Food and Rural Affairs (DEFRA) UK *Noise Database for Prediction of Noise on Construction and Open Sites*. Table 6.1 summarises typical equipment items, sound power level and quantities adopted in the noise modelling of works.

Table 6.1 Typical construction equipment

Equipment	Sound power level, $L_{Aeq,15minute}$ (dB)	Total scenario sound power level, $L_{Aeq,15min}$ (dB)
Internal works		
Pulveriser mounted on excavator	108	114
Excavator mounted concrete saw	110	
Scissor lift	106	
Boom lift	105	
External works – loading dock		
Excavator loading dump truck	108	111
Dump truck	108	
External works – Crystal Hall		
Excavator mounted concrete saw	110	115
Scissor lift	106	
Boom lift	105	
Excavator loading dump truck	108	
Dump truck (dumping rubble)	108	

6.3 Construction noise modelling method and results

Construction noise levels have been predicted to the nearest noise-sensitive receivers assuming attenuation due to distance, acoustic shielding and building reductions. The results are presented for only the time periods proposed activities could occur.

Construction equipment has been modelled at possible locations nearest to and furthest away from the closest residences to represent the range of noise levels that may be experienced over the relevant periods (ICNG standard construction hours). The noise predictions are provided in Table 6.2 for each phase of construction activity.

Table 6.2 Construction noise predictions

Receiver	Predicted $L_{Aeq,15\ minute}$ noise levels, dB			Construction noise management level (NML) dB $L_{Aeq,15\ minute}$				Predicted exceedance at receiver (dB $L_{Aeq,15min}$)											
								Internal works				External works – loading dock				External works – Crystal Hall			
	Internal works	External works – loading dock	External works – Crystal Hall	Day/When in use[1]	Day OOH	Evening	Night	Day	Day OOH	Evening	Night	Day	Day OOH	Evening	Night	Day	Day OOH	Evening	Night
R1	36	65	69	60	55	53	49	0	0	0	0	5	10	n/a	n/a	9	14	n/a	n/a
R2	36	40	44	60	55	53	49	0	0	0	0	0	0	0	0	0	0	0	0
R3	32	58	63	60	55	53	49	0	0	0	0	0	3	n/a	n/a	3	8	n/a	n/a
E1	40	46	50	55[2]	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-
C1	37	53	52	70	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-
C2	36	50	54	70	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-
O1	37	54	64	60	-	-	-	0	-	-	-	0	-	-	-	4	-	-	-
O2	37	67	70	60	-	-	-	0	-	-	-	7	-	-	-	10	-	-	-

Notes: 1. NMLs apply to non-residential receivers during all periods where the premises are in use.

2. The ICNG NML for educational facilities is 45dB $L_{Aeq,15min}$ internal, a building of standard construction with windows open sufficient for ventilation purposes would provide a reduction across the facade of at least 10dB, hence an NML of 55dB $L_{Aeq,15min}$ externally has been adopted for assessment purposes.

A review of the predicted noise levels confirmed that internal construction activities within the 'heart' of the museum satisfy the NML's for all assessment locations during standard ICNG and OOH periods. External works associated with rubble removal and Crystal Hall extension are predicted to satisfy the NML's for Sydney Grammar School and commercial receivers.

Construction noise levels associated with external activities for Crystal Hall extension are predicted to exceed the NMLs at assessment locations R1, R3 and passive recreation areas (O1 and O2) for standard and daytime OOH periods, with loading dock activities predicted to exceed at R1 and O2 in standard and daytime OOH periods (and during daytime OOH at R3). This is typical of construction projects and is largely a function of proximity to sensitive receivers and the fact that construction is noise intensive, particularly in early stages. The predictions presented in Table 6.2 are also conservative as they assume that all plant and equipment listed in Table 6.1 is operating concurrently for a full 15 minute assessment period. This is unlikely to happen in practice and provides the upper level of possible noise levels.

The ICNG requires that all feasible and reasonable noise mitigation is considered if noise levels above NMLs are identified. The proponent will actively manage construction noise from the site. Further advice and discussion is provided in Chapter 8 of this report.

The Australian Museum intend to conduct construction activities during the ICNG standard hours. Where this is not possible due to internal impacts, traffic or other unforeseen events, noise will be managed to minimise impacts for activities out of standard hours. Where OOH works is proposed it is recommended that as part of the preparation of a Construction Noise and Vibration Management Plan (CNVMP), a OOH Works Protocol be developed in order to minimise adverse noise impacts.

7 Construction vibration assessment

Safe working distances for typical items of vibration intensive plant are listed in Table 7.1. The safe working distances are quoted for both “Cosmetic Damage” (refer British Standard BS 7385) and “Human Comfort” (refer British Standard BS 6472-1).

Table 7.1 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Vibratory Roller	<50kN (Typically 1-2 tonnes)	5 m	15 to 20 m
	<100kN (Typically 2-4 tonnes)	6 m	20 m
	<200kN (Typically 4-6 tonnes)	12 m	40 m
	<300kN (Typically 7-13 tonnes)	15 m	100 m
	>300kN (Typically 13-18 tonnes)	20 m	100 m
	>300kN (>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

Source: From Transport Infrastructure Development Corporation Construction’s Construction Noise Strategy (Rail Projects), November 2007.

The safe working distances presented in Table 7.1 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

In relation to human comfort response, the safe working distances in Table 7.1 relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed, as discussed in BS 6472-1.

The nearest residential dwellings are located approximately 60 m from the eastern boundary and the nearest premise (Sydney Grammar School) is located approximately 30 m from areas with potential vibration inducing works.

Due to the sensitivity of the display contents of the museum buildings and the structures themselves, vibration generating plant is not proposed and construction methodology will be tailored to minimise potential vibration impacts. If the vibration impacts are managed for the sensitive contents and structures of the museum, then they would also be managed for the assessment locations offsite. For example, the structural engineer has indicated that even where the level 1 mezzanine floor is saw cut into small sections, a ‘catch’ mechanism will be used to ensure that cut portions would not fall and impact on the floor directly below.

8 Recommendations

Chapter 6 has identified that construction noise levels may exceed the relevant NML's at some assessment locations. Accordingly during the design phase of the development and when a contractor has been engaged it is recommended that a CNVMP be prepared for the site. Section 8.1 provides site-specific noise mitigation and management measures that are to be implemented at the site.

8.1 Site-specific mitigation and management

The following measures will be implemented at the site with the aim of reducing construction noise levels nearer to or below NMLs:

- external works to be restricted to ICNG standard hours and daytime OOH only;
- loading of rubble into trucks is to occur within a dedicated area at the loading dock. Consideration of localised screening or acoustic 'tent' where practical;
- consideration of loading internal rubble into 'skips' that are loaded onto trucks in lieu of utilising a loader or excavator and dumped into trucks at loading dock. Skip bin to be located within a dedicated area with perimeter acoustic screening;
- consideration of temporary acoustic barriers (eg. Echobarrier or eq.) on scaffolding for 'Crystal Hall';
- access from 'heart' and internal works to loading dock incorporate self-closing door, air lock or acrylic curtains (min. 3mm thick) to control breakout noise;
- idle plant and equipment to be switched off when not in active use;
- minimise the number of plant items operating concurrently, particularly when in close proximity to surrounding receivers;
- minimise the need for vehicle reversing by arranging for one-way site traffic routes. If this is unachievable, install reversing "quackers" rather than "beepers"; and
- noise and vibration monitoring will be adopted as a management strategy if complaints are received during the construction period.

8.2 Adoption of general noise & vibration management practices (AS 2436-2010)

AS 2436-2010 *"Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites"* sets out numerous practical recommendations to assist in mitigating construction noise emissions. Examples of strategies that could be implemented on the subject project are listed below.

8.3 Universal work practices

These include:

- regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration;
- regular identification of noisy activities and adoption of improvement techniques;

- avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents;
- developing routes for the delivery of materials and parking of vehicles to minimise noise;
- where possible, avoiding the use of equipment that generates impulsive noise;
- minimising the movement of materials and plant and unnecessary metal-on-metal contact;
- minimising truck movements; and
- scheduling respite periods for intensive works as determined through consultation with potentially affected neighbours (eg a daily respite period for a minimum of one hour at midday).

8.3.1 Plant and equipment

Additional measures for plant and equipment include:

- choosing quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks;
- using temporary noise barriers (in the form of plywood hoarding or similar) to shield intensive construction noise activities from residences;
- operating plant and equipment in the quietest and most efficient manner; and
- regularly inspecting and maintaining plant and equipment to minimise noise and vibration level increases, to ensure that all noise and vibration reduction devices are operating effectively.

8.3.2 Work scheduling

- these include: scheduling activities to minimise impacts by undertaking all possible work during hours that will least adversely affect sensitive receivers and by avoiding conflicts with other scheduled events;
- scheduling work to coincide with non-sensitive periods;
- planning deliveries and access to the site to occur quietly and efficiently and organising parking only within designated areas located away from the sensitive receivers;
- optimising the number of deliveries to the site by amalgamating loads where possible and scheduling arrivals within designated hours;
- designating, designing and maintaining access routes to the site to minimise impacts; and
- include contract conditions that include penalties for non-compliance with reasonable instructions by the principal to minimise noise or arrange suitable scheduling.

8.3.3 Operational noise

During the design phase of the project, it is recommended that all external fixed plant and equipment be reviewed and assessed to ensure that the PNTL's outlined in Chapter 4 are satisfied.

9 Conclusion

EMM has prepared a construction and operational noise and vibration impact assessment to support the development application (DA) for proposed alterations and additions to the Australian Museum in Sydney NSW.

Total duration of the construction works is anticipated to be up to 60 weeks, with the internal demolition and removal of the Level 1 mezzanine floor expected to be completed in 6 to 8 weeks.

As would be expected with typical construction works of this nature and in proximity to neighbours, predictions indicate that construction noise levels are likely to be above the noise management levels at some locations without mitigation at times during proposed construction activity. This is typical of construction projects and is largely a function of proximity to sensitive receivers and the fact that construction is noise intensive, particularly in early stages. Furthermore, the predictions presented are conservative as they assume that all plant and equipment is operating concurrently for a full 15 minute assessment period. This is unlikely to happen in practice and noisy activities such as concrete saw cutting is anticipated to be short in duration.

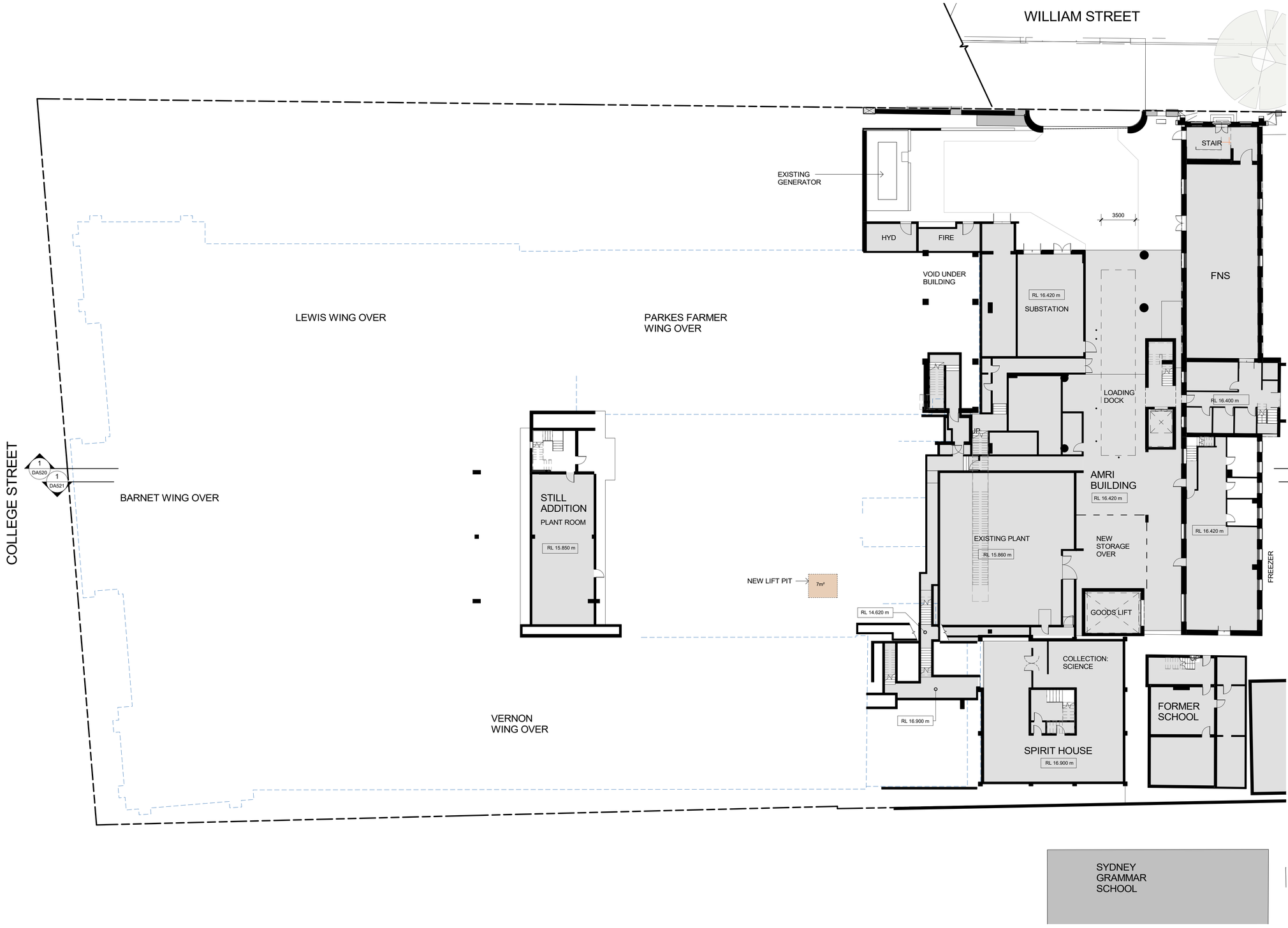
For vibration, the guide values presented in Table 5.4 should be followed. It is understood that due to the value and sensitivity of the museum's internal fittings and displays to vibration intensive activity, vibration intensive works are unlikely. Due to these limiting factors, vibration impacts are not anticipated at nearby offsite assessment locations.

To ensure that noise and vibration are addressed effectively, a CNVMP shall be prepared during the design phase of the development. Recommendations have been provided regarding work practices to be considered to minimise construction noise and vibration from the project in Chapter 8.

The assessment of potential operational noise has recommended that all external fixed plant and equipment be reviewed and assessed to ensure that the PNTL's outlined in Chapter 4.3 are satisfied.

Appendix A

Architectural drawings



Area Schedule EX LOAD		
Zone	Name	Area
	PLANT	7 m²
		7 m²
AMRI	EXISTING	1034 m²
		1034 m²
Eastern Site	EXISTING	1040 m²
		1040 m²
FNS	EXISTING	366 m²
		366 m²
Parkes Farmer	EXISTING	19 m²
		19 m²
Spirit House	EXISTING	208 m²
		208 m²
Still	EXISTING	112 m²
		112 m²
Grand total: 28		2786 m²

AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

EXISTING

PLANT

LEGEND

NEW CONSTRUCTION WORK

DP NEW DOWNPIPE
EC EXISTING COLUMN
SC NEW STEEL COLUMN

AUSTRALIAN MUSEUM | barrabuwari muru | AUSTRALIAN MUSEUM | MASTER PLAN

FLOOR PLAN - LOADING DOCK - PROPOSED
AM ADDITIONS & ALTERATIONS

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Revision: D
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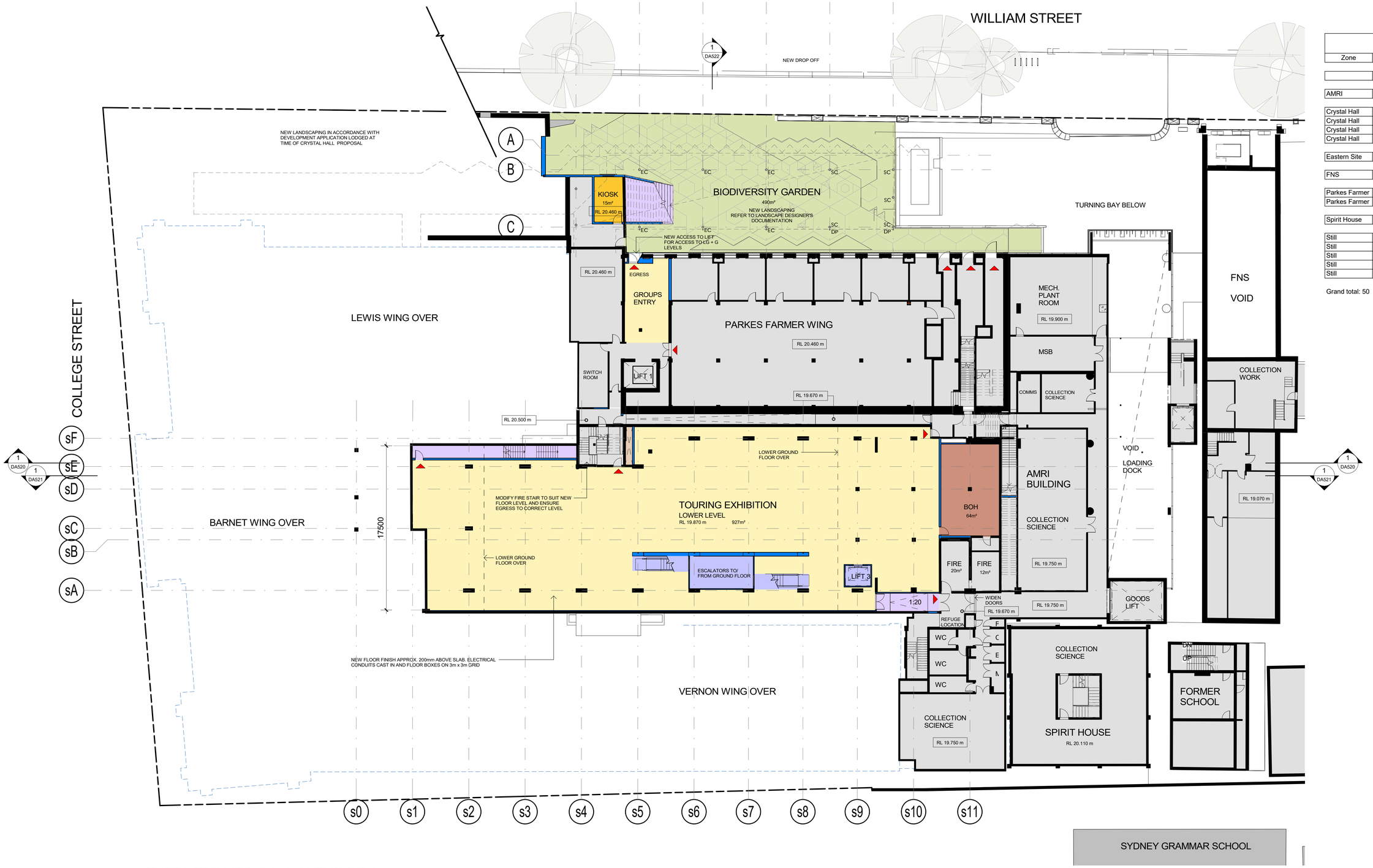

Area Schedule LG1		
Zone	Name	Area
	PLANT	5 m²
		5 m²
AMRI	EXISTING	671 m²
		671 m²
Crystal Hall	CIRCULATION - GENERAL	24 m²
Crystal Hall	EXISTING	28 m²
Crystal Hall	LANDSCAPING	490 m²
Crystal Hall	RETAIL (FOOD/ SHOP)	15 m²
		557 m²
Eastern Site	EXISTING	715 m²
		715 m²
FNS	EXISTING	227 m²
		227 m²
Parkes Farmer	EXISTING	795 m²
Parkes Farmer	PUBLIC - FOYER	42 m²
		837 m²
Spirit House	EXISTING	206 m²
		206 m²
Still	CIRCULATION - GENERAL	40 m²
Still	CIRCULATION - VERTICAL TRANSPORT	56 m²
Still	EXISTING	86 m²
Still	PUBLIC - GALLERY	927 m²
Still	STORAGE	64 m²
		1173 m²
Grand total: 50		4391 m²

AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

- CIRCULATION - GENERAL
- CIRCULATION - VERTICAL TRANSPORT
- EXISTING
- LANDSCAPING
- PLANT
- PUBLIC - FOYER
- PUBLIC - GALLERY
- RETAIL (FOOD/ SHOP)
- STORAGE

LEGEND

EC	EXISTING COLUMN
SC	NEW STEEL COLUMN
	NEW CONSTRUCTION WORK
DP	NEW DOWNPIPE
EC	EXISTING COLUMN
SC	NEW STEEL COLUMN

AUSTRALIAN MUSEUM | barrabuwari muru | AUSTRALIAN MUSEUM | MASTER PLAN

FLOOR PLAN - BASEMENT LEVEL - PROPOSED
AM ADDITIONS & ALTERATIONS

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Project Number: 51023
Drawing Number: DA221
Revision: C
Date: 10/08/18

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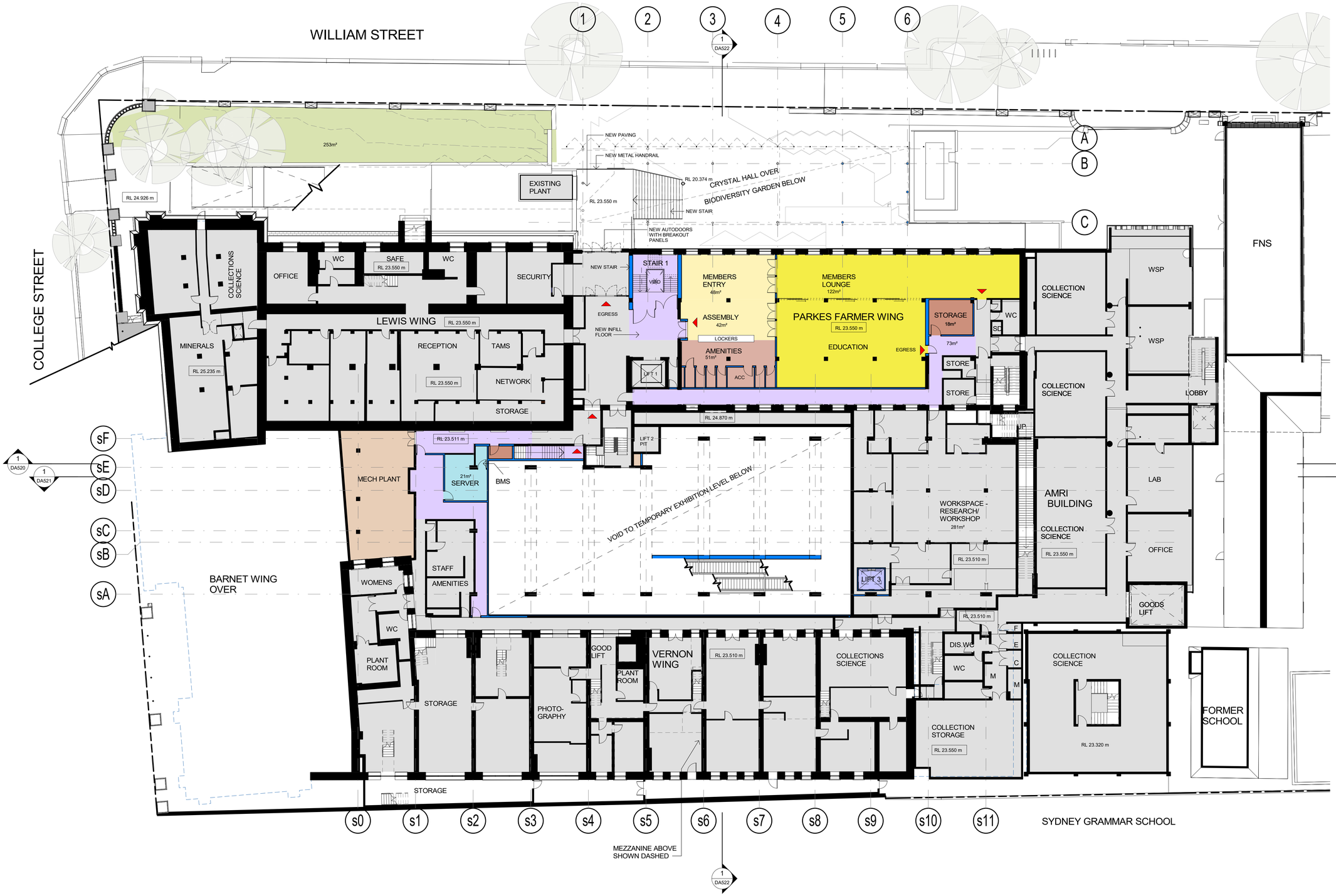

Area Schedule LG2		
Zone	Name	Area
	EXISTING	8 m²
	STORAGE	4 m²
		12 m²
AMRI	EXISTING	892 m²
		892 m²
Barnet Wing	EXISTING	211 m²
		211 m²
Crystal Hall	EXISTING	14 m²
Crystal Hall	LANDSCAPING	253 m²
		267 m²
FNS	EXISTING	172 m²
		172 m²
Lewis Wing	EXISTING	515 m²
		515 m²
Parkes Farmer	AMENITIES	51 m²
Parkes Farmer	CIRCULATION - GENERAL	122 m²
Parkes Farmer	EXISTING	364 m²
Parkes Farmer	PUBLIC - FOYER	90 m²
Parkes Farmer	PUBLIC - OTHER	122 m²
Parkes Farmer	STORAGE	18 m²
		765 m²
Spirit House	EXISTING	209 m²
		209 m²
Still	CIRCULATION - GENERAL	79 m²
Still	CIRCULATION - VERTICAL TRANSPORT	7 m²
Still	EXISTING	584 m²
Still	PLANT	96 m²
Still	WORKSPACE - OFFICE	24 m²
		790 m²
Vernon Wing	EXISTING	833 m²
		833 m²
Grand total: 105		4666 m²

AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

- AMENITIES
- CIRCULATION - GENERAL
- CIRCULATION - VERTICAL TRANSPORT
- EXISTING
- LANDSCAPING
- PLANT
- PUBLIC - FOYER
- PUBLIC - OTHER
- STORAGE
- WORKSPACE - OFFICE

LEGEND

NEW CONSTRUCTION WORK

DP	NEW DOWNPIPE
EC	EXISTING COLUMN
SC	NEW STEEL COLUMN

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FLOOR PLAN - LOWER GROUND - PROPOSED
AM ADDITIONS & ALTERATIONS

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Project Number: 51023
Drawing Number: DA222
Revision: L
Date: 10/08/18

NEESON MURCUTT ARCHITECTS PTY LTD

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Area Schedule LG@ mez		
Zone	Name	Area
AMRI	EXISTING	31 m²
		31 m²
Parkes Farmer	EXISTING	11 m²
		11 m²
Spirit House	EXISTING	213 m²
		213 m²
Vernon Wing	EXISTING	520 m²
		520 m²
Grand total: 6		775 m²

AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

EXISTING

LEGEND

NEW CONSTRUCTION WORK

DP NEW DOWNPIPE
EC EXISTING COLUMN
SC NEW STEEL COLUMN

NOTE

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FLOOR PLAN - LOWER GROUND MEZZANINE - AM ADDITIONS & ALTERATIONS

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North:

Project Number: 51023
Drawing Number: DA223
Revision: J
Date: 19/07/18

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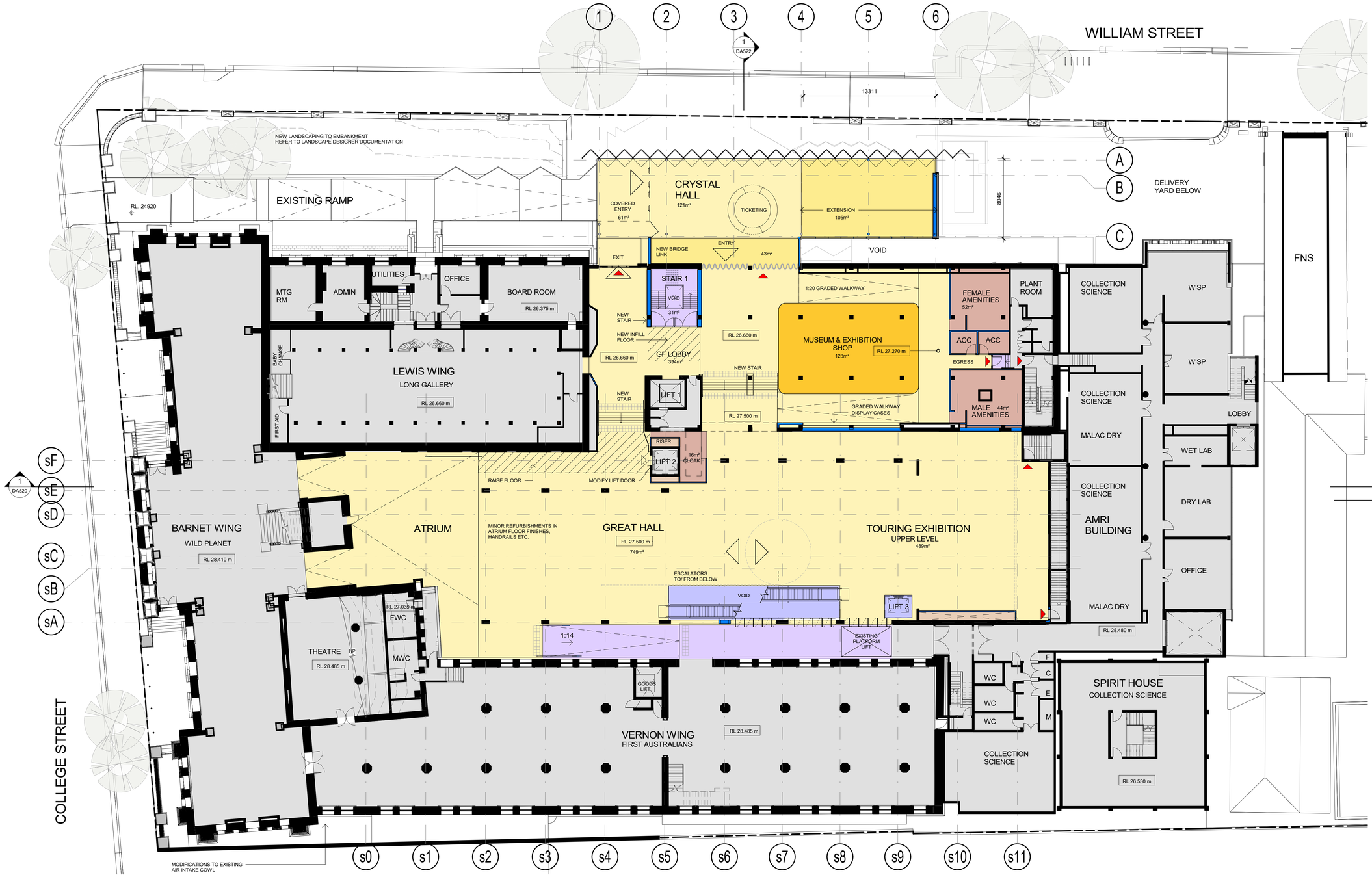

Area Schedule GF		
Zone	Name	Area
AMRI	EXISTING	924 m²
		924 m²
Barnet Wing	EXISTING	659 m²
		659 m²
Crystal Hall	PUBLIC - FOYER	182 m²
Crystal Hall	PUBLIC - FOYER - NEW BUILD	148 m²
		330 m²
Lewis Wing	EXISTING	524 m²
		524 m²
Parkes Farmer	AMENITIES	95 m²
Parkes Farmer	CIRCULATION - GENERAL	34 m²
Parkes Farmer	EXISTING	104 m²
Parkes Farmer	PLANT	9 m²
Parkes Farmer	PUBLIC - FOYER	394 m²
Parkes Farmer	RETAIL (FOOD/ SHOP)	128 m²
		764 m²
Spirit House	EXISTING	229 m²
		229 m²
Still	AMENITIES	16 m²
Still	CIRCULATION - GENERAL	120 m²
Still	CIRCULATION - VERTICAL TRANSPORT	64 m²
Still	EXISTING	18 m²
Still	PLANT	5 m²
Still	PUBLIC - FOYER	749 m²
Still	PUBLIC - GALLERY	489 m²
		1462 m²
Vernon Wing	EXISTING	986 m²
		986 m²
Grand total: 66		5879 m²

AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

- AMENITIES
- CIRCULATION - GENERAL
- CIRCULATION - VERTICAL TRANSPORT
- EXISTING
- PLANT
- PUBLIC - FOYER
- PUBLIC - FOYER - NEW BUILD
- PUBLIC - GALLERY
- RETAIL (FOOD/ SHOP)

LEGEND

- NEW CONSTRUCTION WORK
- DP NEW DOWNPIPE
- EC EXISTING COLUMN
- SC NEW STEEL COLUMN

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FLOOR PLAN - GROUND FLOOR - PROPOSED
AM ADDITIONS & ALTERATIONS

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North:

Project Number: 51023
Drawing Number: DA224
Revision: M
Date: 10/08/18

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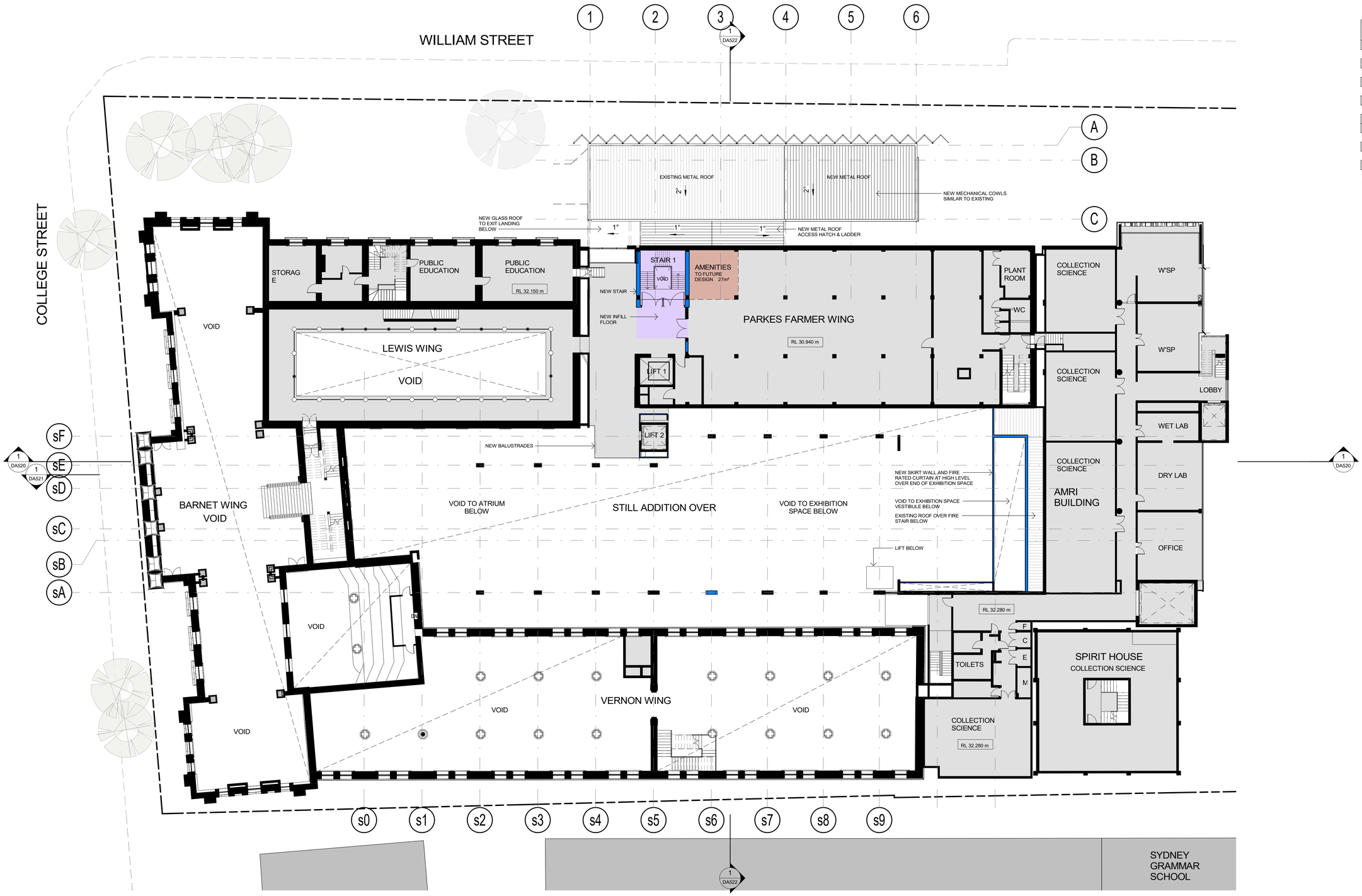

Area Schedule LV1		
Zone	Name	Area
	AMENITIES	27 m²
		27 m²
AMRI	EXISTING	902 m²
		902 m²
Lewis Wing	EXISTING	378 m²
		378 m²
Parkes Farmer	CIRCULATION - GENERAL	49 m²
Parkes Farmer	EXISTING	668 m²
		716 m²
Spirit House	EXISTING	208 m²
		208 m²
Vernon Wing	EXISTING	12 m²
		12 m²
Grand total: 35		2244 m²

AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

- AMENITIES
- CIRCULATION - GENERAL
- EXISTING

LEGEND

- NEW CONSTRUCTION WORK
- DP NEW DOWNPIPE
- EC EXISTING COLUMN
- SC NEW STEEL COLUMN

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FLOOR PLAN - LEVEL 1 - PROPOSED
AM ADDITIONS & ALTERATIONS

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North:

Project Number: 51023
Drawing Number: DA225
Revision: H
Date: 10/08/18

NEESON MURCUTT ARCHITECTS PTY LTD

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Area Schedule LV2		
Zone	Name	Area
	STORAGE	2 m²
		2 m²
AMRI	EXISTING	1009 m²
		1009 m²
Barnet Wing	EXISTING	851 m²
		851 m²
Lewis Wing	EXISTING	404 m²
		404 m²
Parkes Farmer	AMENITIES	85 m²
Parkes Farmer	CIRCULATION - GENERAL	90 m²
Parkes Farmer	EXISTING	160 m²
Parkes Farmer	PUBLIC - OTHER	404 m²
		739 m²
Spirit House	EXISTING	184 m²
		184 m²
Still	AMENITIES	42 m²
Still	CIRCULATION - GENERAL	77 m²
Still	EXISTING	79 m²
Still	PLANT	2 m²
Still	PUBLIC - OTHER	369 m²
Still	RETAIL (FOOD/ SHOP)	218 m²
		787 m²
Vernon Wing	EXISTING	816 m²
		816 m²
Grand total: 51		4792 m²

AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

- AMENITIES
- CIRCULATION - GENERAL
- EXISTING
- PLANT
- PUBLIC - OTHER
- RETAIL (FOOD/ SHOP)
- STORAGE

LEGEND

- NEW CONSTRUCTION WORK
- DP NEW DOWNPIPE
- EC EXISTING COLUMN
- SC NEW STEEL COLUMN

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FLOOR PLAN - LEVEL 2 - PROPOSED
AM ADDITIONS & ALTERATIONS

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Scale: 1:200 @ A1
0 — 16

North:

Project Number: 51023
Drawing Number: DA226
Revision: H
Date: 10/08/18

NEESON MURCUTT ARCHITECTS PTY LTD

Hames Sharley

Area Schedule LV3		
Zone	Name	Area
	AMENITIES	28 m²
		28 m²
AMRI	EXISTING	870 m²
		870 m²
Barnet Wing	EXISTING	63 m²
		63 m²
Lewis Wing	EXISTING	202 m²
		202 m²
Parkes Farmer	CIRCULATION - GENERAL	85 m²
Parkes Farmer	EXISTING	635 m²
		719 m²
Still	EXISTING	740 m²
		740 m²
Grand total: 32		2622 m²

AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

- AMENITIES
- CIRCULATION - GENERAL
- EXISTING

LEGEND

- NEW CONSTRUCTION WORK
- DP NEW DOWNPIPE
- EC EXISTING COLUMN
- SC NEW STEEL COLUMN

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FLOOR PLAN - LEVEL 3 - PROPOSED
AM ADDITIONS & ALTERATIONS

Status: PRELIMINARY
Path: C:\Users\owellings\Documents\51023_Host_R2017_owellings.rvt
Note: INDICATIVE ONLY - SUBJECT TO SURVEY & SPECIALIST CONSULTANT DESIGN INPUT. INTERNAL WALL LININGS HAVE NOT BEEN ALLOWED FOR IN AREA CALCULATIONS

Scale: 1:200 @ A1
0 16

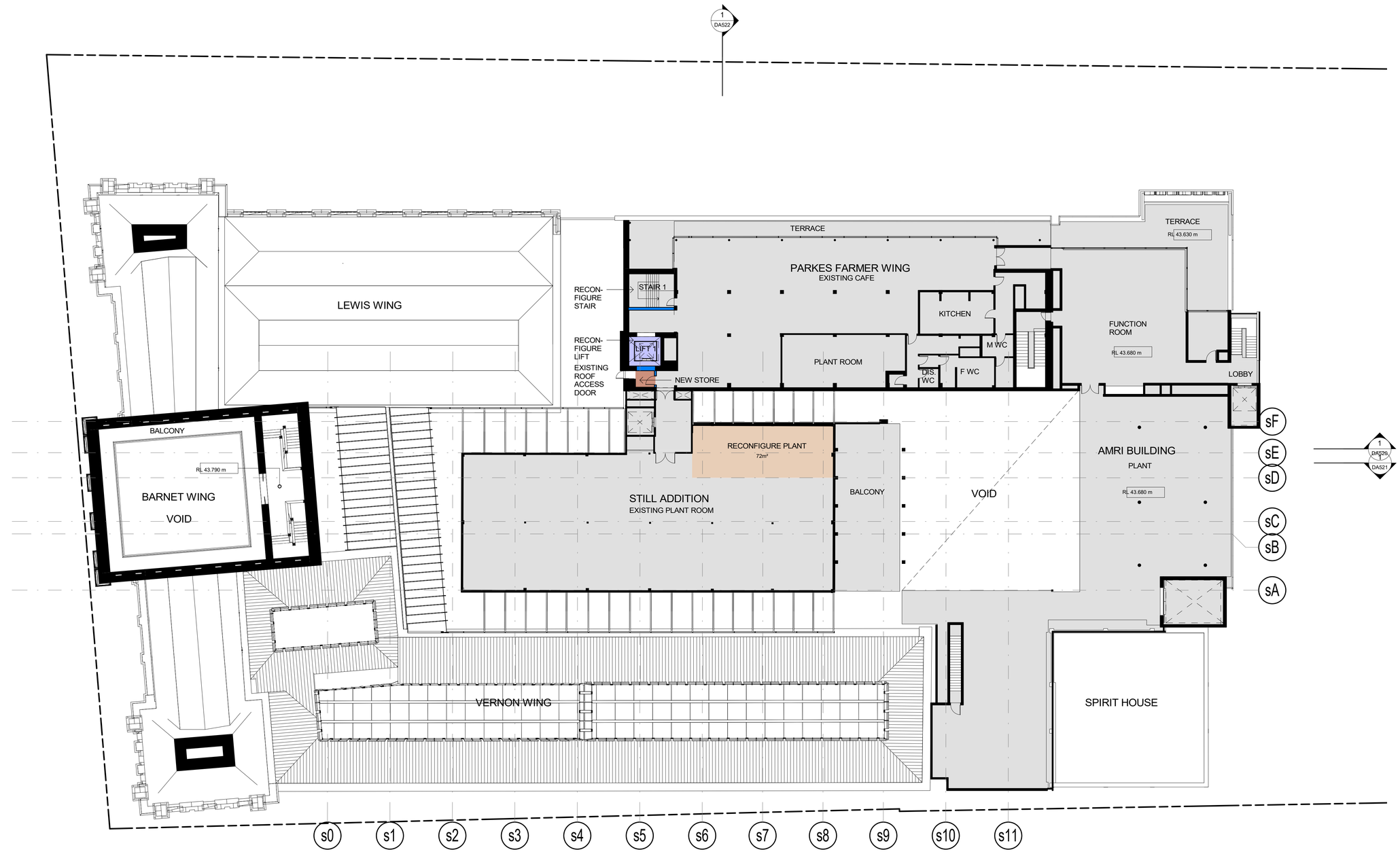
North:

Project Number: 51023
Drawing Number: DA227
Revision: F
Date: 10/08/18

NEESON MURCUTT ARCHITECTS PTY LTD

Hames Sharley

Area Schedule LV4		
Zone	Name	Area
	EXISTING	2 m²
	PLANT	72 m²
	STORAGE	3 m²
		78 m²
AMRI	EXISTING	905 m²
		905 m²
Parkes Farmer	CIRCULATION - VERTICAL TRANSPORT	9 m²
Parkes Farmer	EXISTING	637 m²
		646 m²
Still	EXISTING	579 m²
		579 m²
Grand total: 28		2208 m²



AREA LEGEND - REFURBISHMENT (NEW BUILD INDICATED SEPARATELY)

- CIRCULATION - VERTICAL TRANSPORT
- EXISTING
- PLANT
- STORAGE

LEGEND

- NEW CONSTRUCTION WORK
- DP NEW DOWNPIPE
- EC EXISTING COLUMN
- SC NEW STEEL COLUMN

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FLOOR PLAN - LEVEL 4 - PROPOSED

AM ADDITIONS & ALTERATIONS

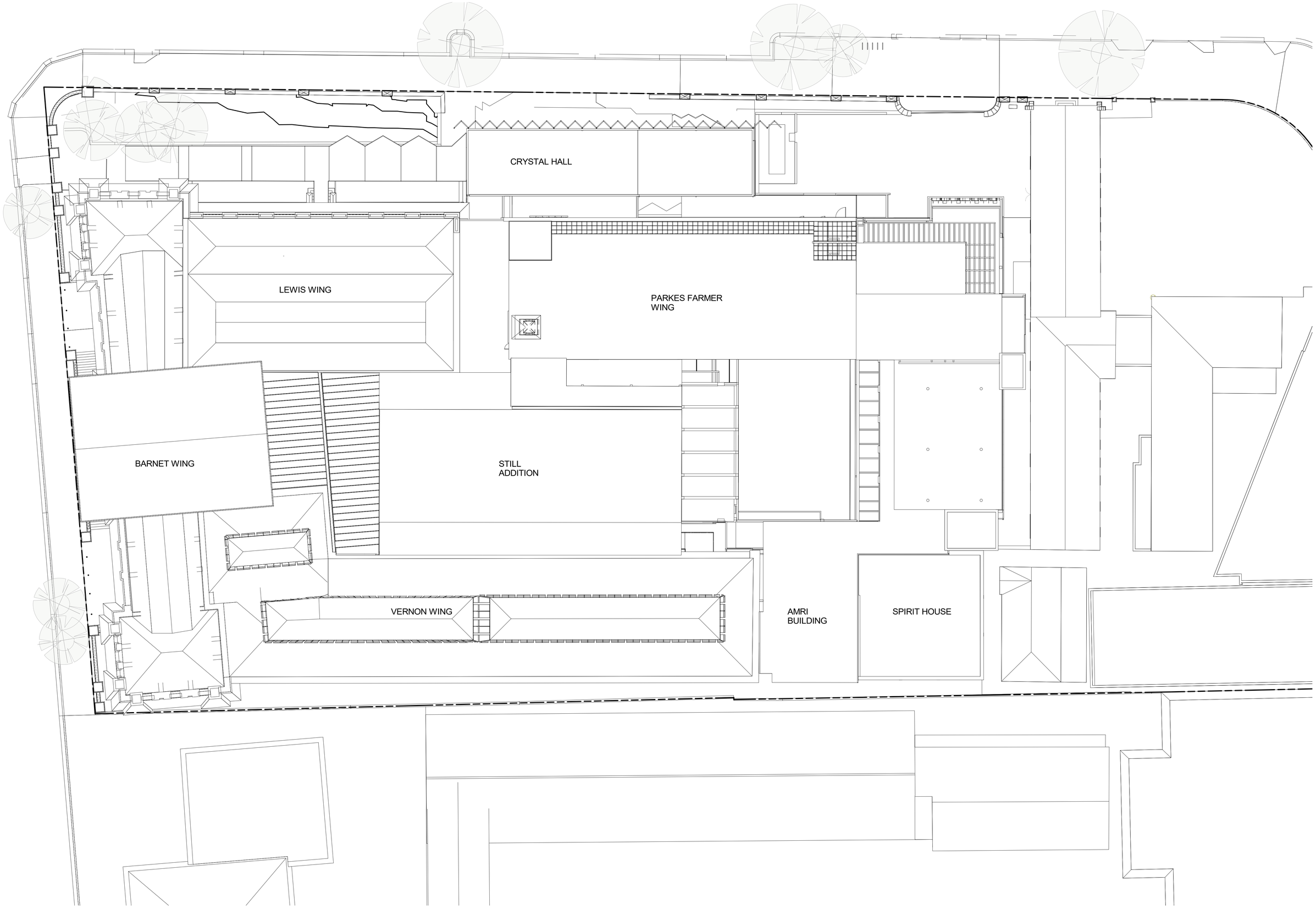
Status: PRELIMINARY
Path: C:\Users\owellings\Documents\51023_Host_R2017_owellings.rvt
Note: INDICATIVE ONLY - SUBJECT TO SURVEY & SPECIALIST CONSULTANT DESIGN INPUT. INTERNAL WALL LININGS HAVE NOT BEEN ALLOWED FOR IN AREA CALCULATIONS

Scale: 1:200 @ A1
0 16
North:

Project Number: 51023
Drawing Number: DA228
Revision: F
Date: 10/08/18

NEESON MURCUTT ARCHITECTS PTY LTD

Hames Sharley



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ROOF PLAN - PROPOSED

AM ADDITIONS & ALTERATIONS

Status: PRELIMINARY
Path: C:\Users\owellings\Documents\51023_Host_R2017_owellings.rvt
Note: INDICATIVE ONLY - SUBJECT TO SURVEY & SPECIALIST CONSULTANT DESIGN INPUT. INTERNAL WALL LININGS HAVE NOT BEEN ALLOWED FOR IN AREA CALCULATIONS

Scale: 1:200 @ A1
0 16

North:

Project Number: 51023
Drawing Number: DA229
Revision: A
Date: 27/06/2017

NEESON MURCUTT ARCHITECTS PTY LTD

Hames Sharley

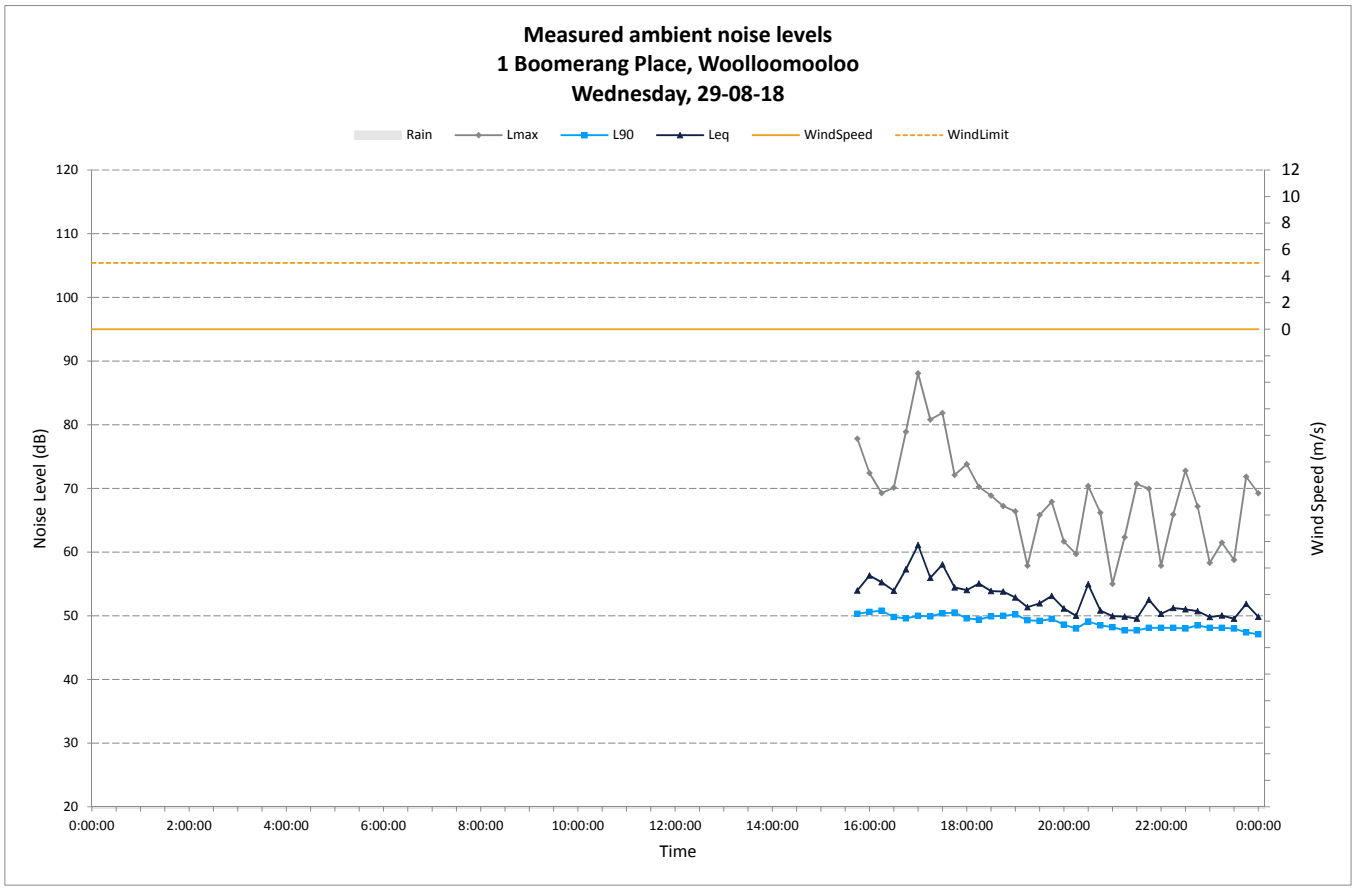
Appendix B

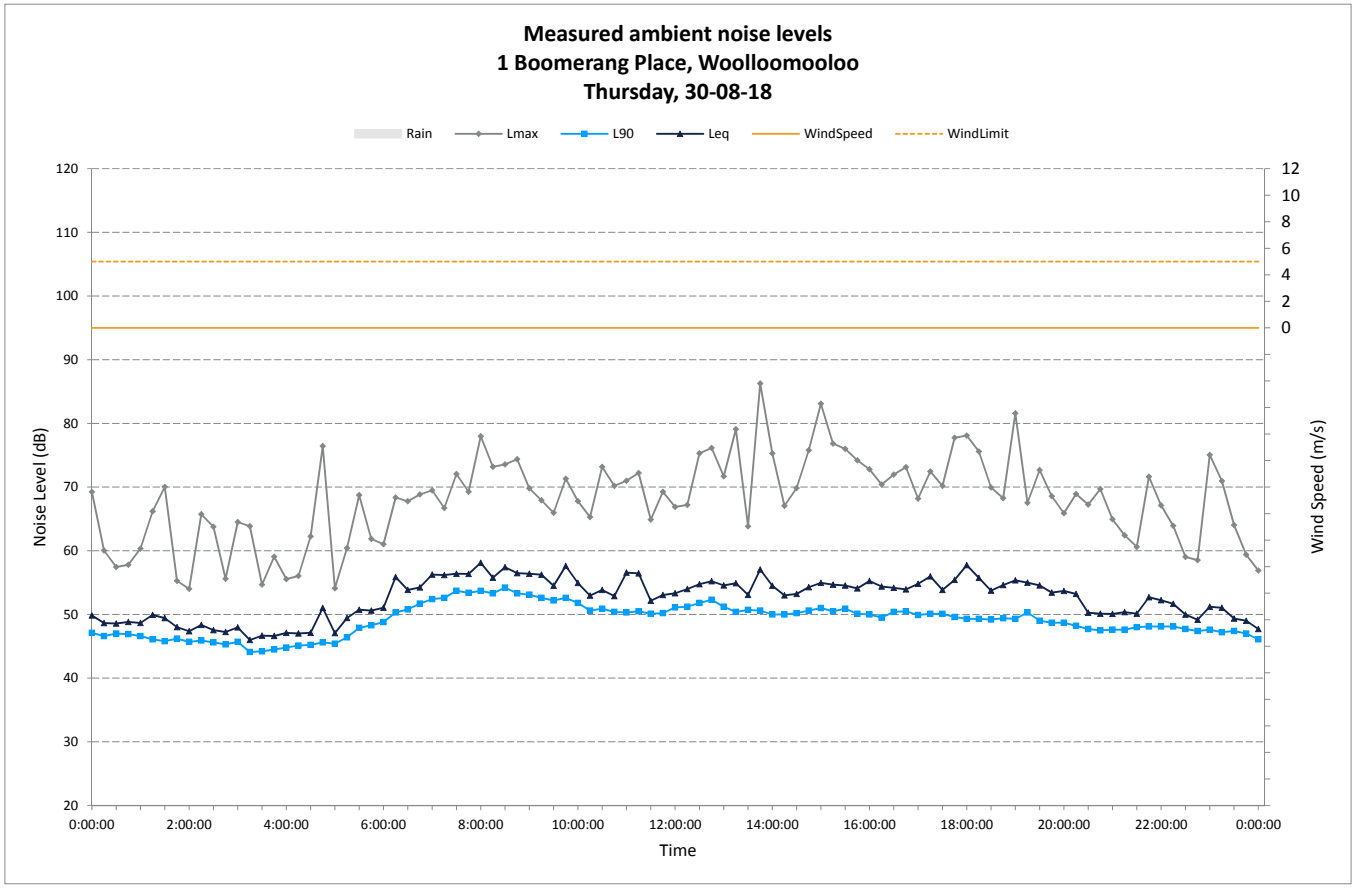
Unattended noise monitoring results

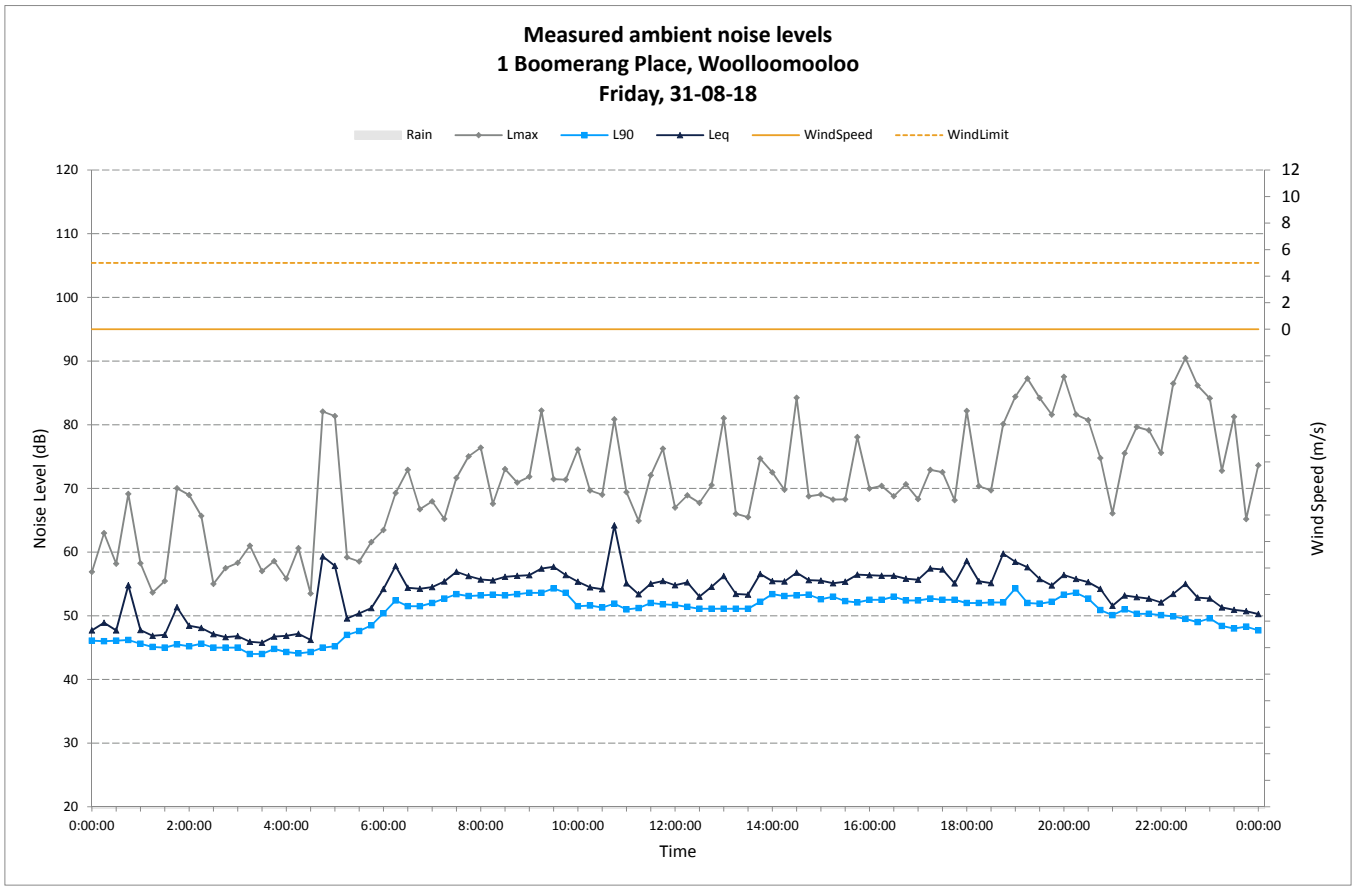
B.1 Logger results

Table B.1 Summary results

Date	ABL Day	ABL Evening	ABL Night	Leq 11hr Day	Leq 4hr Evening	Leq 9hr Night	Leq 15hr Day	Leq 24hr Day	Leq 8hr
Wednesday, 29-08-18	0	48	45	0	52	50	0	0	49
Thursday, 30-08-18	50	48	44	55	53	52	55	54	51
Friday, 31-08-18	51	50	45	56	56	52	56	55	50
Saturday, 01-09-18	50	49	44	57	52	50	56	55	50
Sunday, 02-09-18	46	46	44	54	50	49	53	52	48
Monday, 03-09-18	50	47	43	57	52	52	56	55	51
Tuesday, 04-09-18	50	47	43	57	52	50	56	55	48
Wednesday, 05-09-18	50	48	44	55	56	50	55	54	49
Thursday, 06-09-18	51	50	45	57	54	54	56	55	54
Friday, 07-09-18	51	49	45	59	63	51	60	59	50
Saturday, 08-09-18	49	49	45	56	52	50	55	54	50
Sunday, 09-09-18	48	48	45	55	52	51	54	53	49
Monday, 10-09-18	50	47	44	58	52	50	57	55	48
Tuesday, 11-09-18	52	49	0	58	57	0	58	0	0
Summary Values	**50**	**48**	**44**	**57**	**55**	**51**	**56**	**55**	**50**


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Wednesday, 29-08-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Thursday, 30-08-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Friday, 31-08-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
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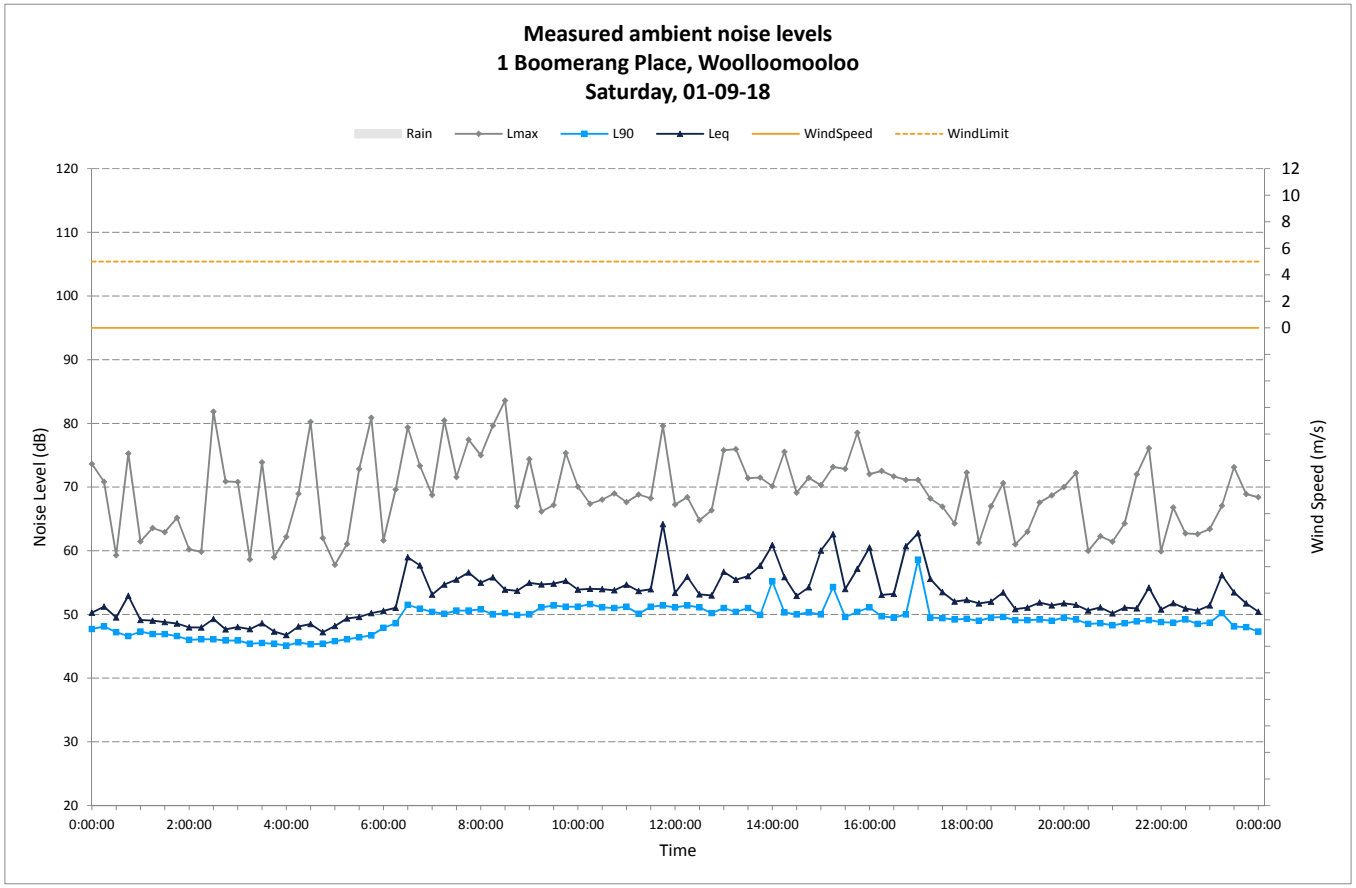
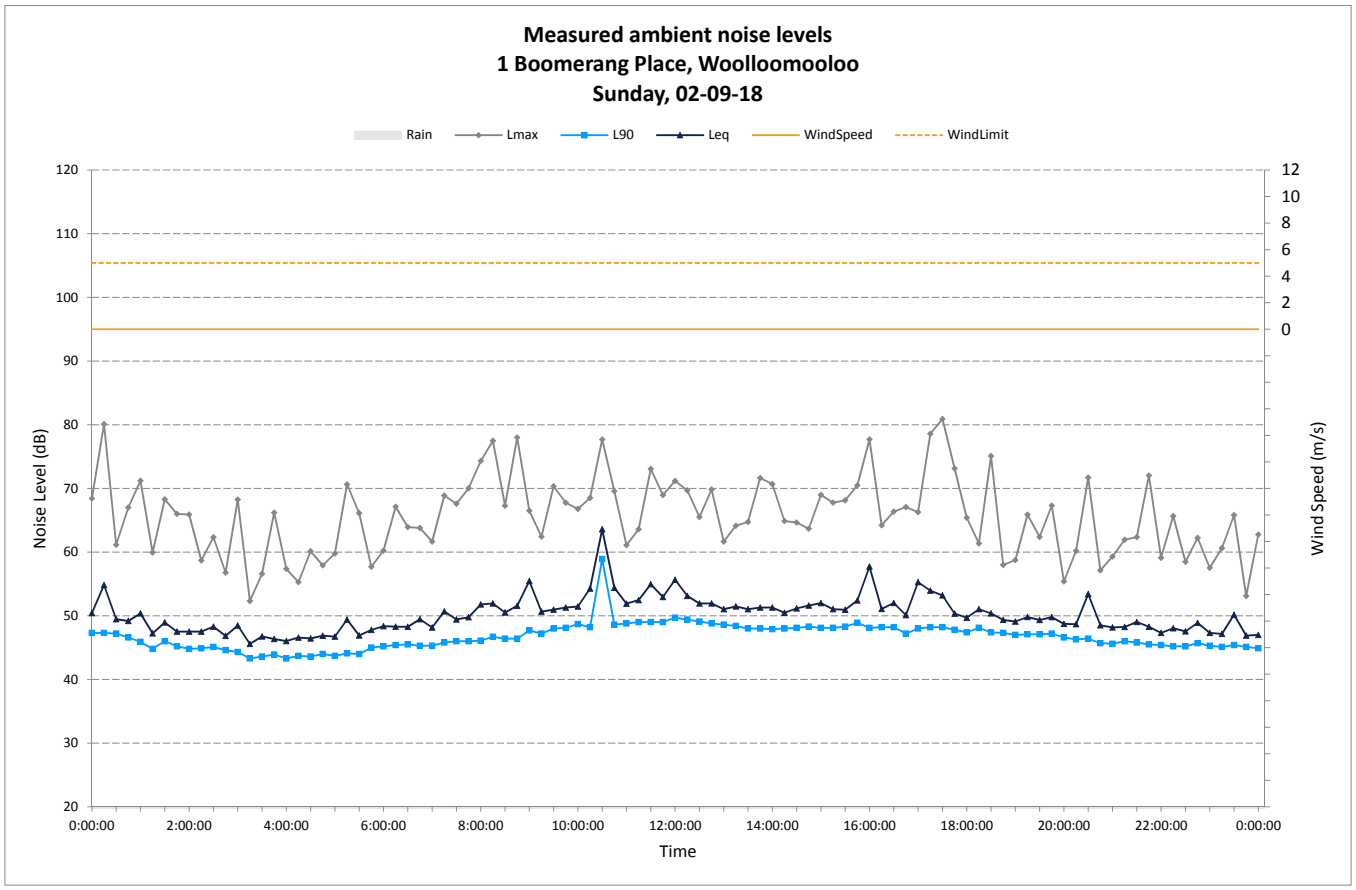
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Saturday, 01-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Sunday, 02-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
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12:00:00
14:00:00
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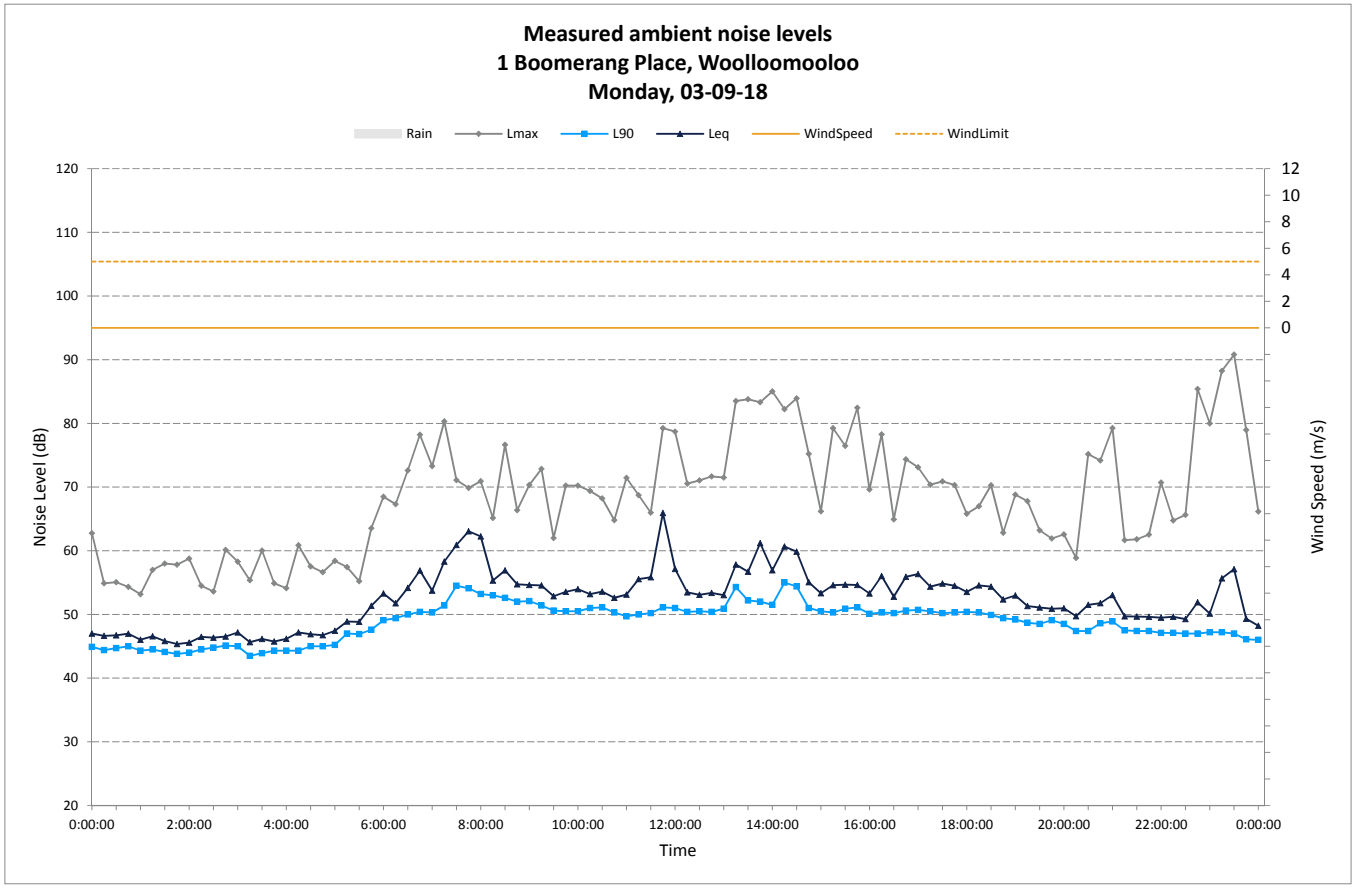
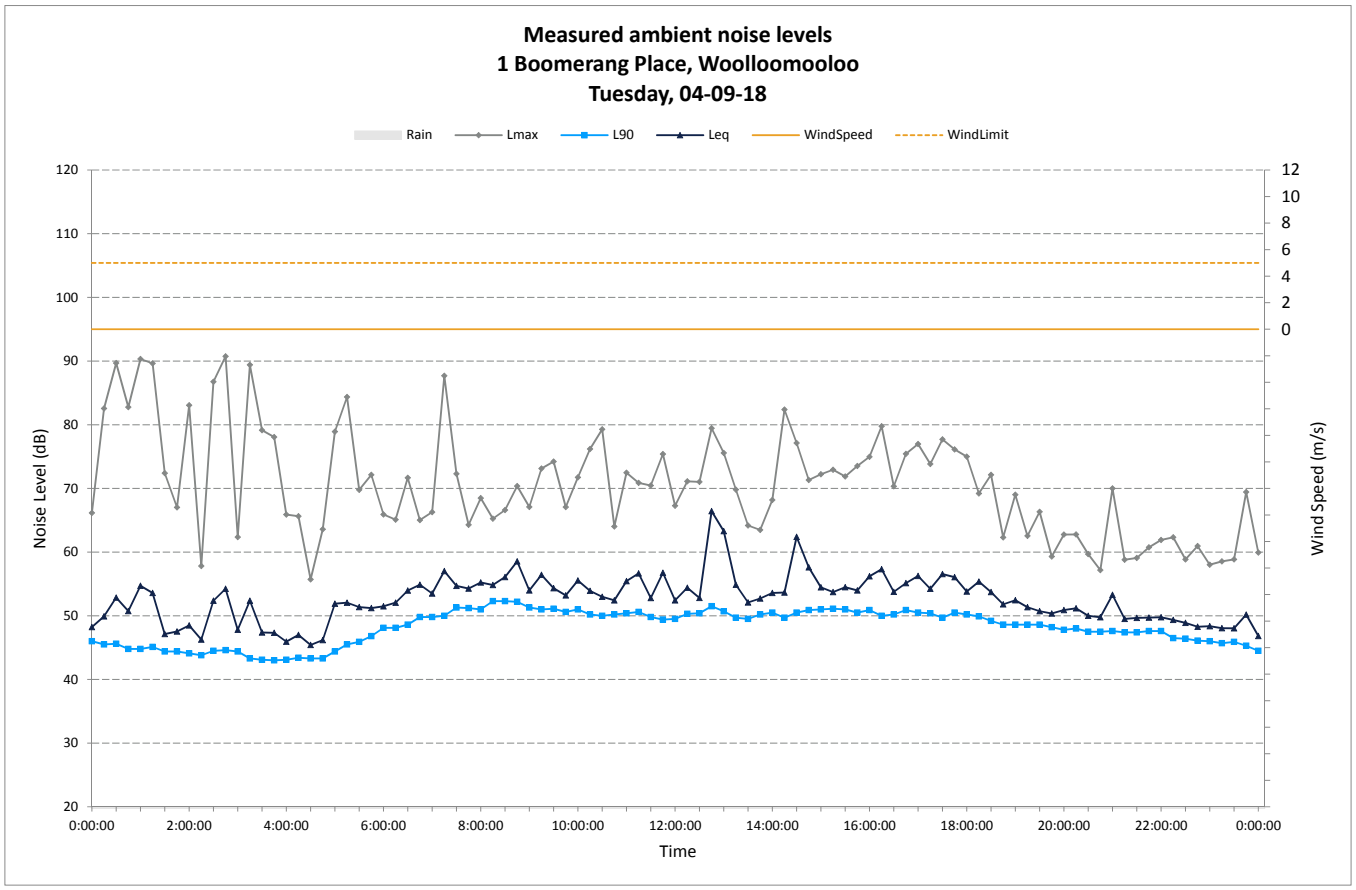
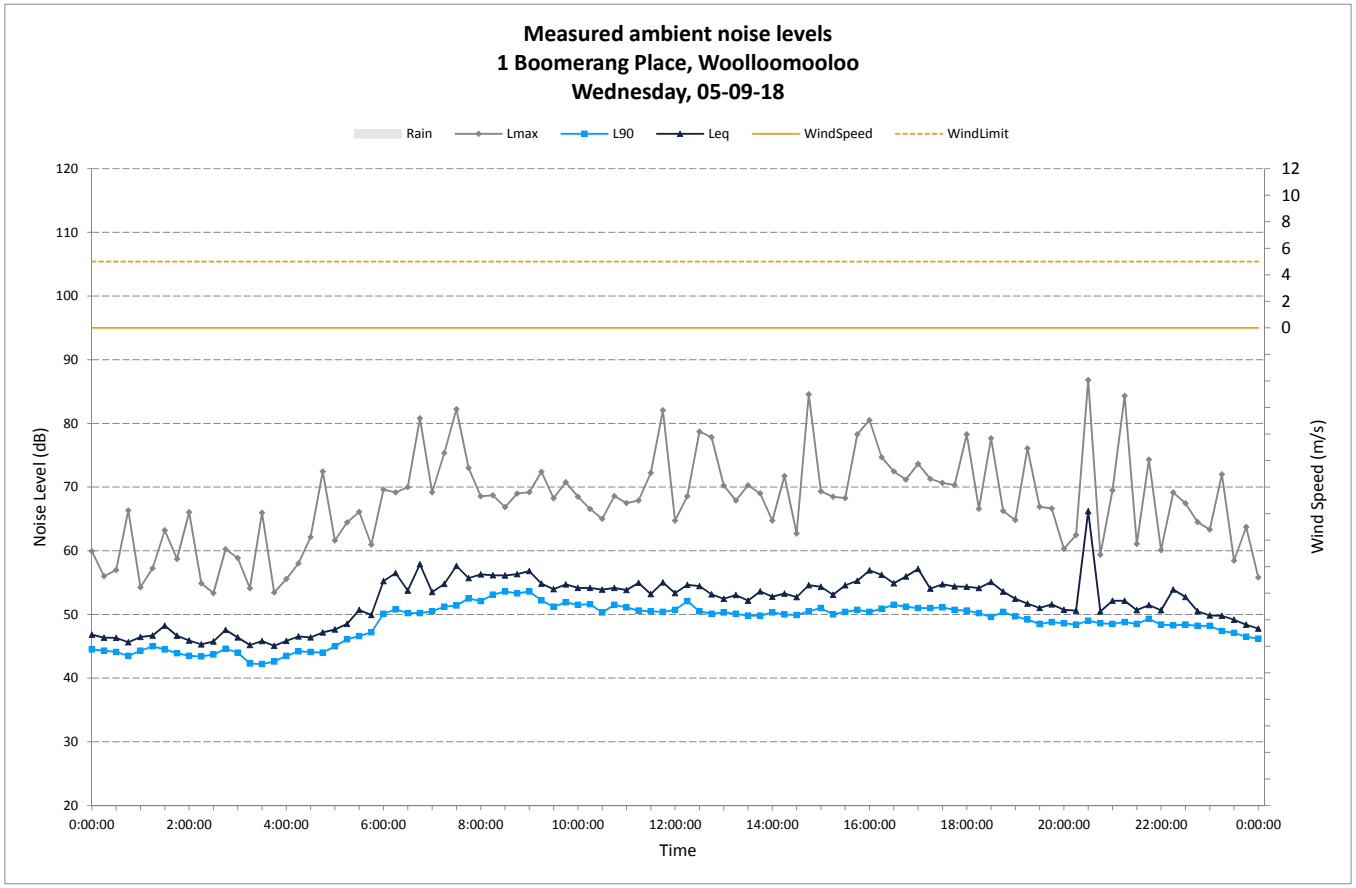
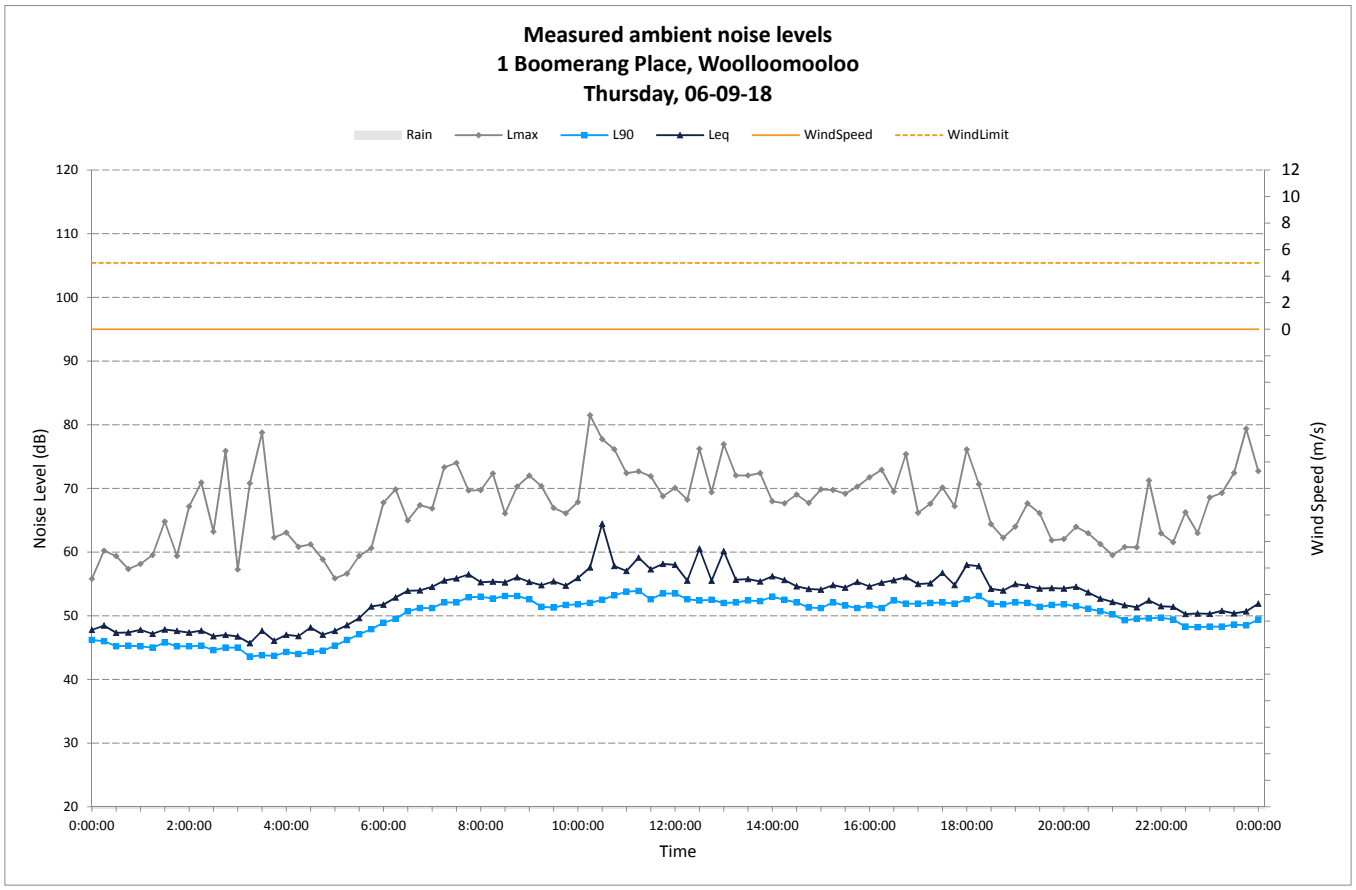
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Monday, 03-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Tuesday, 04-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Wednesday, 05-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Thursday, 06-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
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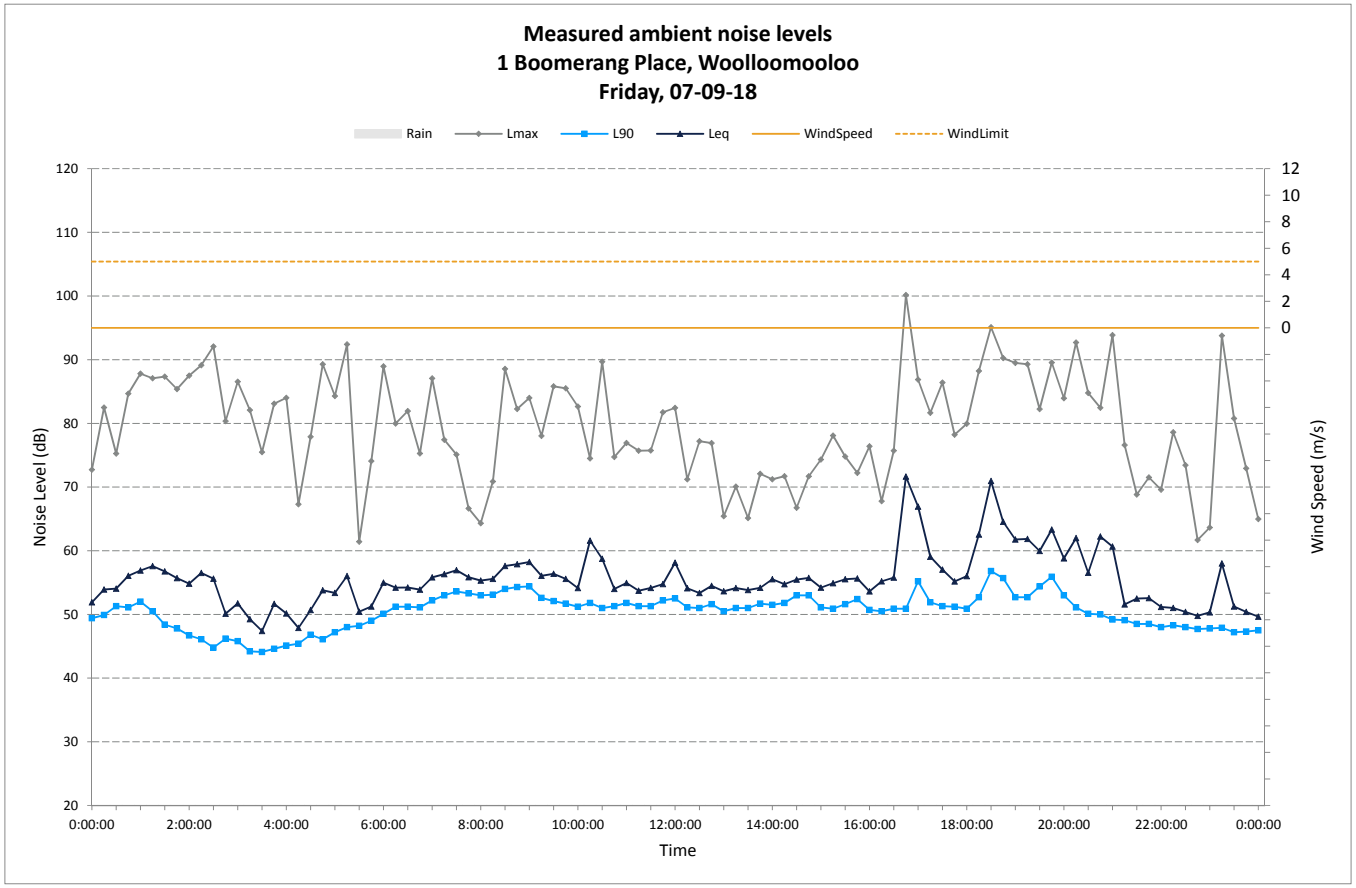
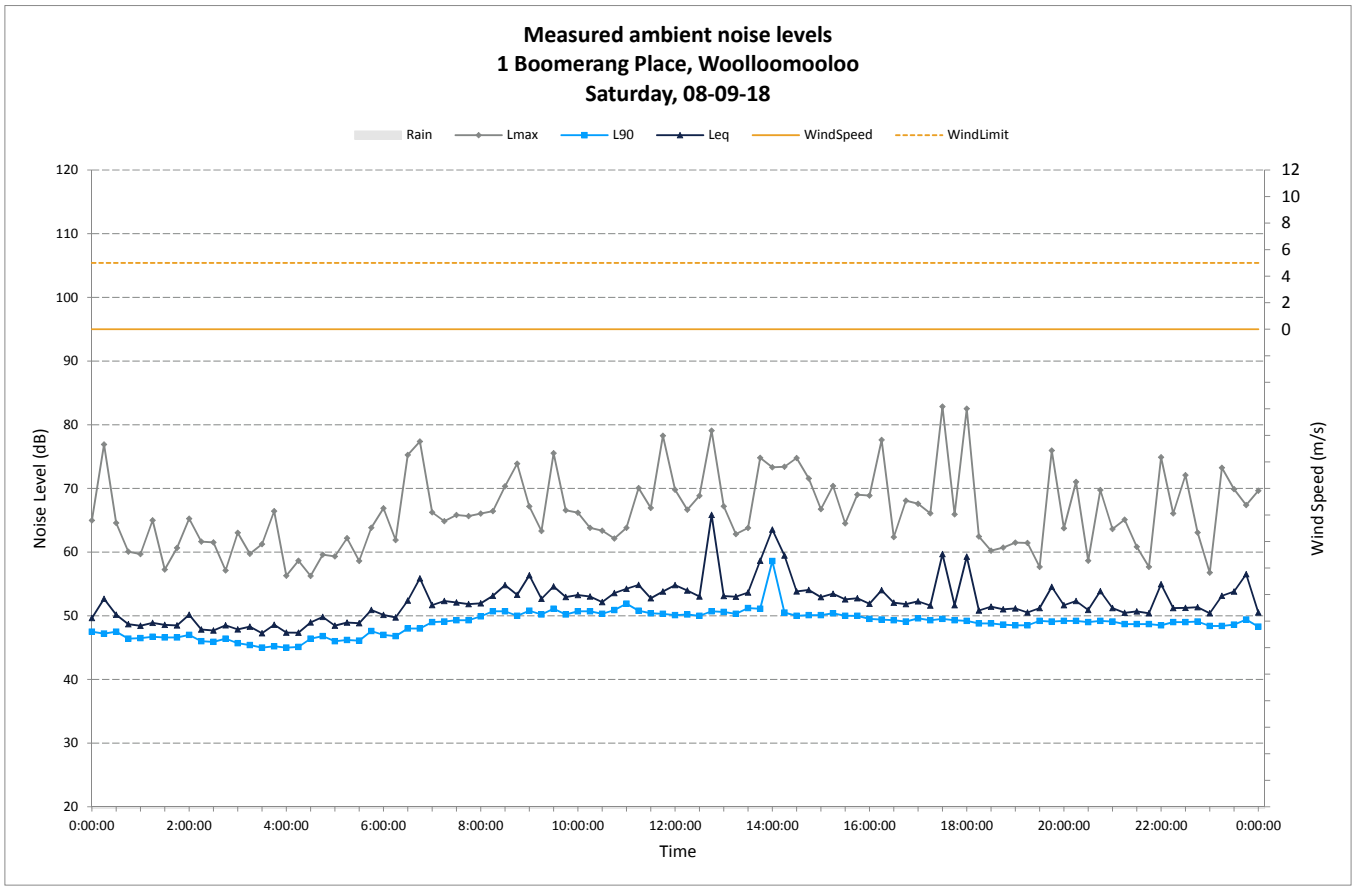
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Friday, 07-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
0:00:00


Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Saturday, 08-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
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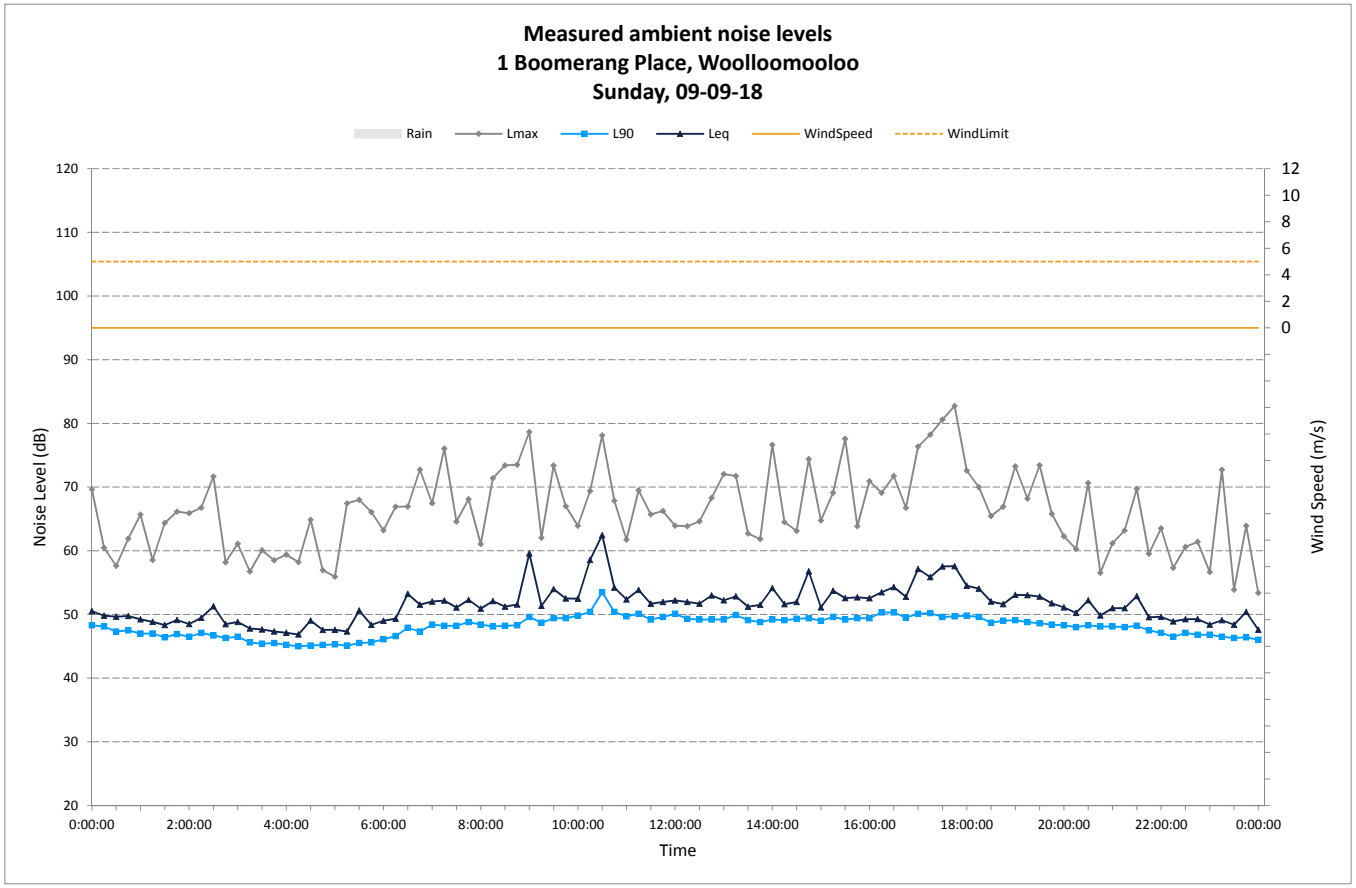
Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Sunday, 09-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
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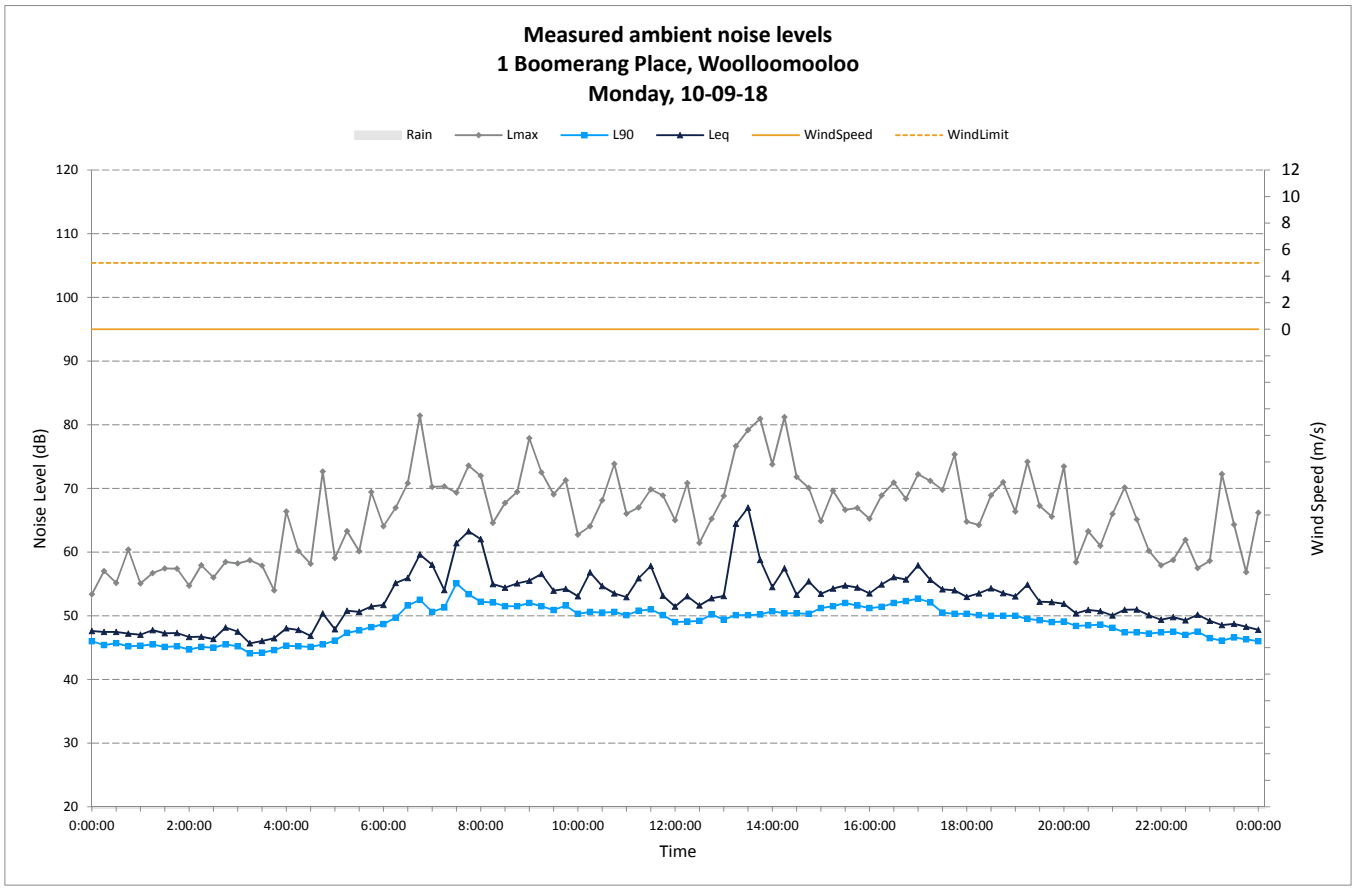
Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Monday, 10-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
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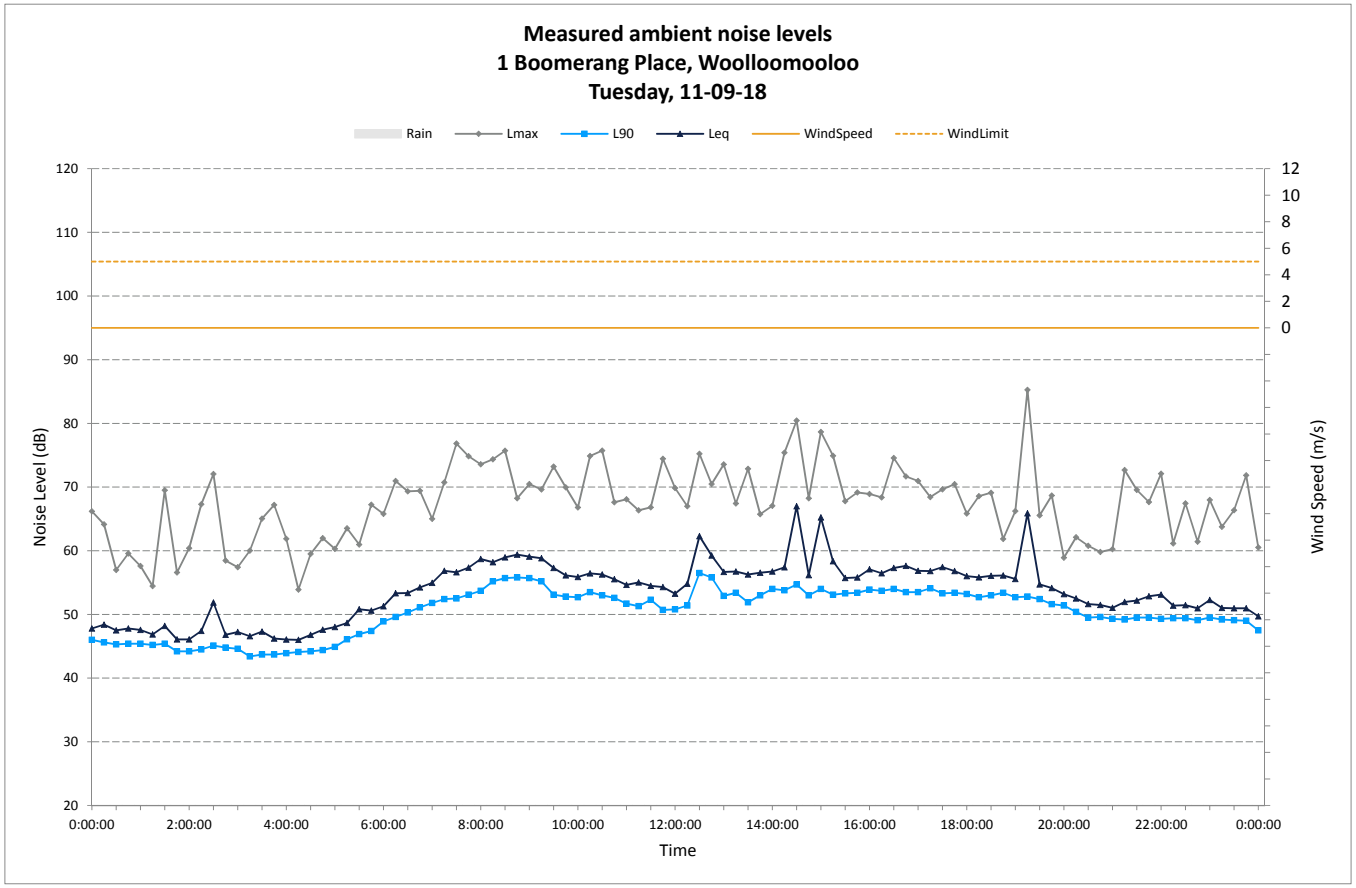
Measured ambient noise levels
1 Boomerang Place, Woolloomooloo
Tuesday, 11-09-18
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
0:00:00