



University of Sydney
Engineering & Technology Precinct

SEARs Noise and Vibration Assessment

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B	23 March 2018	Updated with additional background monitoring data
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D	30 November 2018	Inclusion of loading dock assessment and gas storage area

Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Daytime	Between 7 am and 6 pm as defined in the INP.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of loudness.
dB(A)	‘A’ Weighted sound level in dB.
Evening	Between 6 pm and 10 pm as defined in the INP.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second. The human ear responds to sound in the frequency range of 20 to 20,000 Hz.
INCG	New South Wales Department of Environment & Climate Change (now Environment Protection Authority) <i>Interim Construction Noise Guideline</i> , 2009.
INP	New South Wales <i>Industrial Noise Policy</i> , 2000.
Intrusive Noise	Noise emission that when assessed at a noise-sensitive receiver (principally a residential premises boundary) is greater than 5 dB(A) above the background noise level.
L ₁₀	Noise level exceeded for 10% of the measurement time. The L ₁₀ level is commonly referred to as the average maximum noise level.
L ₉₀	Noise level exceeded for 90% of the measurement time. The L ₉₀ level is commonly referred to as the background noise level.
L _{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
L _{max}	Maximum measured sound pressure level in the time period.
mm/s	Millimetres per second—units of vibration velocity.
Night-time	Between 10 pm on one day and 7 am on the following day as defined in the INP.
Rating Background Level (RBL)	Overall single-figure A-weighted background level representing an assessment period (Day/Evening/Night). For the short-term method, the RBL is simply the measured L _{90,15min} noise level. For the long-term method, it is the median value of all measured background levels during the relevant assessment period.

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Executive summary

The University of Sydney is proposing to develop an Engineering Technology Precinct (ETP) within the existing campus in Darlington, which will provide a new contemporary, flexible and collaborative facility. The proposed building will enable the Engineering and Technology faculty to expand its research and teaching facilities.

The Department of Planning & Environment (DPE) has issued the ETP with Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEAR 7 defines the requirement for a Noise and Vibration Assessment as part of the EIS, to consider construction and operational noise and vibration from the development. This report has been prepared to address SEAR 7.

Construction phase

A preliminary construction noise and vibration assessment has been conducted against noise and vibration criteria determined from:

- existing noise monitoring data for the site
- the *Interim Construction Noise Guideline* (ICNG)
- *Assessing Vibration – a technical guideline* (the Vibration Guideline).

Based on the preliminary assessment, it is likely that construction works may have some noise impact on University student accommodation land uses at Urbanest Darlington and International House, and residential land uses to the east of the site on Shepherd Street during major external works. The University will also manage the noise and vibration impacts of works on adjoining University teaching and office uses.

The construction noise and vibration impacts are considered to be manageable through:

- the development and implementation of a Construction Noise and Vibration Management Plan
- carrying out noisier works during daytime Standard Working Hours wherever possible
- appropriate stakeholder consultation and complaint handling procedures for noise and vibration
- the implementation of all feasible and reasonable work practices to minimise noise and vibration from the site in accordance with the ICNG and Vibration Guideline.

Operational phase

Operational noise emission criteria for the development have been established in accordance with the NSW *Industrial Noise Policy* (INP). The noise emission criteria for the nearest noise-sensitive land uses are shown in Table 1.

Table 1 INP noise emission criteria for residential land uses and Colleges

Location	INP noise emission criteria, dB(A) $L_{eq,15min}$		
	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am
Residential land uses on Shepherd Street (north of Ivy Street) and Cleveland Street	53	40	40
Residential land uses on Shepherd Street (south of Ivy Street) including Calder Road	48	37	35
Urbanest Darlington and International House student accommodation	52	42	42

Noise emissions from the development will predominantly be a result of rooftop mechanical plant including a rooftop plant room, water-cooled chiller and cooling towers, and emergency generator. A preliminary rooftop plant layout and selection has been assessed and the following recommendations provided such that noise emissions can achieve the INP criteria for both normal and emergency operations:

- The Chillers should be located in an enclosed plant room on Level 10. The plant room should be constructed with a solid roof achieving no less than an R_w 35 rating and solid walls achieving no less than R_w 40.
- The CAT C13 generator should be installed in an acoustic enclosure that achieves a rating of 80 dB(A) at 1 m.
- Outlet attenuators are required for the Stair Pressurisation fans and Toilet Exhaust fans, acoustically equivalent to Fantech RS07C. Alternatively, the outlet ductwork from the fans is required be at least 3 m in length, 50 mm thick internally lined, incorporate at least one 90-degree bend, with the outlets facing north or south.

As the design progresses, noise mitigation measures should be reviewed to ensure that noise from rooftop plant in particular can comply with the INP noise emission criteria at neighbouring noise-sensitive land uses if the rooftop plant design changes.

Activities at the loading dock and gas storage areas near Shepherd Street, at the eastern end of the Engineering Link Building, have also been assessed. Deliveries, collections and refuelling activities should be restricted to the hours of 7:30 am to 6 pm Monday to Friday and trucks using these areas should have their engines switched off when in position rather than left in idle.

1 Introduction

The University of Sydney is proposing to develop an Engineering Technology Precinct (ETP) within the existing campus at Darlington, which will provide a new contemporary, flexible and collaborative facility. The proposed building will enable the Engineering and Technology faculty to expand its research and teaching facilities.

The ETP will involve the provision of a new building extension to the north of, and integration, with the 'South Tower' of the Engineering Precinct. The building will accommodate a range of uses including teaching and research laboratories, workplaces, offices, lecture theatres and other teaching spaces, administration areas and a loading dock and storage area. To facilitate the new structure and linkages, the existing north tower of the J03 Electrical Engineering Building will be demolished.

The Department of Planning & Environment (DPE) has issued the ETP with Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEAR 7 defines the requirement for a Noise and Vibration Assessment as part of the EIS:

Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation. Outline measures to minimise and mitigate the potential noise impacts on surrounding sensitive receivers.

Relevant Policies and Guidelines:

- *NSW Industrial Noise Policy (EPA)*
- *Interim Construction Noise Guideline (DECC 2009)*
- *Assessing Vibration: A Technical Guideline (DEC 2006)*

This report has been prepared to address SEAR 7 and:

- Defines noise and vibration assessment criteria for the construction and operation of the ETP.
- Identifies likely construction phase noise and vibration impacts and recommends management procedures to be implemented during construction.
- Provides a preliminary assessment of operational noise from the development.

2 Project description

2.1 Location

The ETP will be constructed on the Darlington campus. The site is bounded by the Mechanical Engineering Building and Seymour Centre to the north, the Peter Nicol Russell (PNR) Building to the south and the Engineering Link Building to the east. Figure 1 shows the proposed site location.

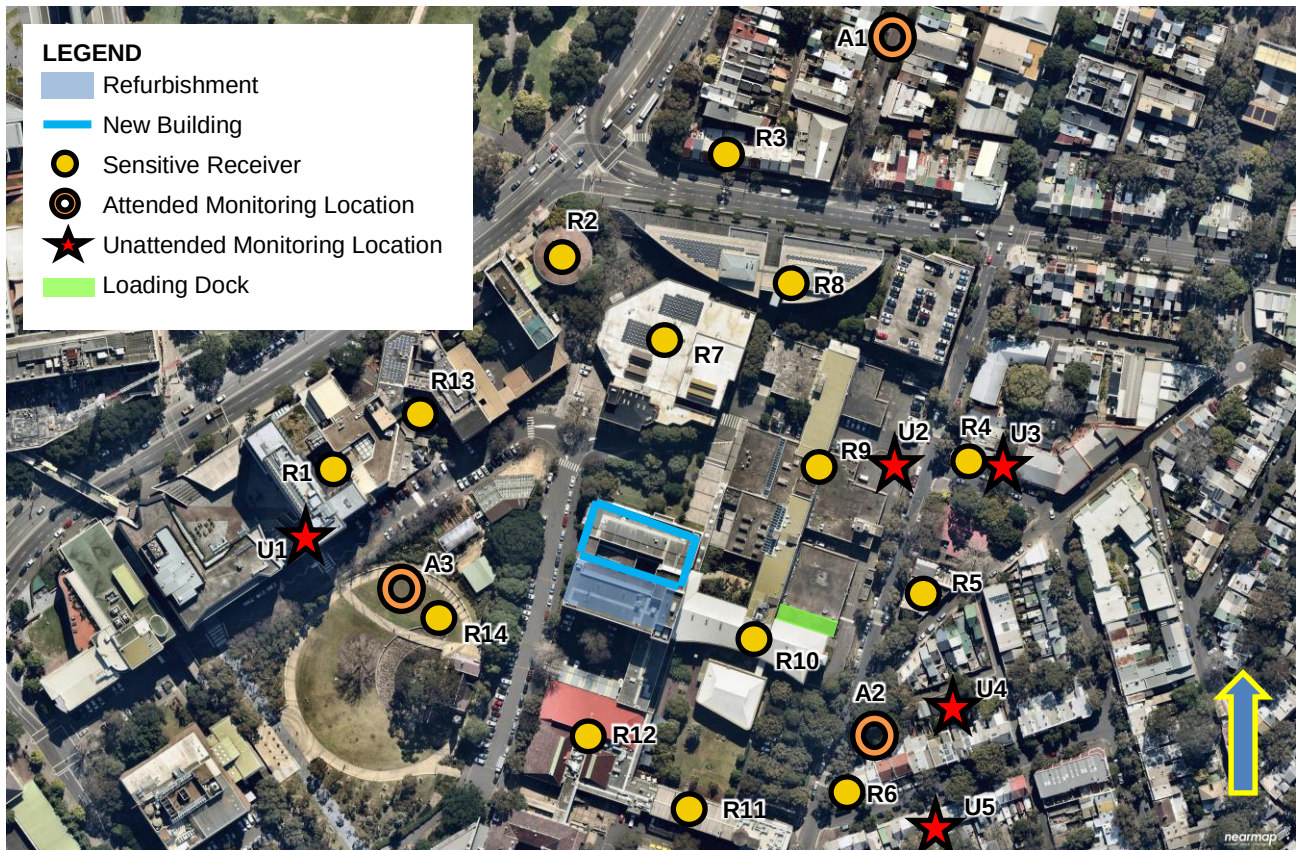


Figure 1 ETP site location

A number of noise and vibration-sensitive land uses are located in the immediate vicinity of the Stage 1 site as shown in Figure 1, with the most significant being existing University buildings. The nearest residential land uses are the Urbanest Darlington Student Accommodation to the west (represented by R1), the residences on the eastern side of Shepherd Street (represented by R4, R5 and R6) and the residences on the northern side of Cleveland Street (represented by R3).

The sensitive land uses are summarised in Table 2 alongside a description of the land use.

Table 2 Noise and vibration sensitive land uses

Reference (see Figure 1) and name	Description
Residential buildings	
R1 – Urbanest Darlington	Residential land uses 80 m away or more from new building. Cleveland Street and Shepherd Street residences shielded by intervening buildings.
R2 – International House	
R3 – Cleveland Street residences	
R4 – Shepherd Street residences north	
R5 – Shepherd Street residences south	
R6 – Calder Road residences	
University of Sydney buildings	
R7 – Seymour Centre	Performing Arts Centre within the University of Sydney, approximately 45 m north of the new building.
R8 – Warren Centre	Various University buildings associated with Engineering Faculty that surround the project site.
R9 – Mechanical Engineering	
R10 – Engineering Link Building	
R11 – Civil Engineering	
R12 – PNR Building	
R13 – Wentworth Building	Faculty of Architecture, Design and Planning
Recreational land uses	
R14 – Cadigal Green	Public recreation area. Includes heritage-listed Old School building on Maze Crescent.

2.2 ETP development

The ETP will involve the construction of a ten-level new building on the footprint shown in Figure 1. The neighbouring building will be refurbished and linkages created between the two buildings. Landscaping will also occur around the Precinct area.

2.2.1 Construction

Construction of the ETP development is scheduled to commence in the first quarter of 2018 and be completed by mid-2020. The construction staging has been broadly summarised in Table 3.

Table 3 Anticipated construction schedule

Stage	Description
Site establishment and enabling works	Services diversions, initial demolition works (Engineering Walk) and vegetation clearance. March – August 2018
Demolition	Demolition of north tower May – August 2018

Stage	Description
Retaining piles and excavation	Piling works and bulk excavation December 2018 – February 2019
Substructure	Creation of substructure. February – March 2019
Frame	Creation of building superstructure. April – August 2019
Facade works	Construction of building façade August – October 2019
Internal works and fitout	Internal works and fitout of all levels. Will commence progressively as Level superstructures completed. May 2019 – March 2020

It is planned that works would be undertaken during the hours of:

- Monday to Friday 7 am to 6 pm
- Saturday 8 am to 3:30 pm
- No work on Sundays or public holidays.

2.2.2 Operation

The ETP building will house teaching, research, office and support spaces that are not expected to have a noise and vibration impact outside of the building footprint.

The predominant operational noise consideration for the development will be the rooftop plant, which will include water-cooled chillers and cooling towers. An emergency standby generator will also be installed on the roof level.

Additionally, the following areas will contribute to noise from the site at certain times:

- Loading dock: a new loading dock would be located adjacent to the existing Engineering Link building with access provided via Blackwattle Creek Lane, and will be serviced by heavy, medium and light commercial vehicles. The location of the loading dock is shown on Figure 1.
- Gas storage areas: two new gas storage vessels would be installed at the Shepherd Street end of the Engineering Link building. While no noise is anticipated from the storage facilities themselves, the delivery of gas to these facilities will generate noise due to occasional delivery truck movements.

3 Existing environment

The existing environment in the area immediately around the site is typical of an urban University campus, with a level of steady background noise from distant traffic and mechanical plant, with short-term noise from pedestrians and occasional vehicles on and around the campus. At the nearest residential uses, noise from traffic on Shepherd Street, Cleveland Street and the Princes Highway contributes to the ambient environment.

3.1 Unattended noise monitoring

Unattended noise monitoring conducted in accordance with the NSW Industrial Noise Policy (INP) has been used to establish existing conditions at the following locations around the site:

- U1: Urbanest Darlington – nearest residential-type land uses to the west of the site. Monitoring conducted from 12 to 19 March 2018.
- U2: Blackwattle Creek Lane entry – monitoring undertaken on University of Sydney land on western side of Shepherd Street. Monitoring conducted from 12 to 19 March 2018.
- U3: Residence at 130 Shepherd Street – residence to the east of the site. Monitoring was conducted from 10 to 17 August 2018, but due to battery failure of the noise logger data was only available from 10 to 13 August.
- U4: Residence at 32 Calder Street – residence to southeast of the site. Monitoring was conducted from 10 to 17 August 2018.
- U5: Residence at 41 Calder Street – residence to southeast of the site. Monitoring was conducted from 10 to 17 August 2018.

The unattended measured noise levels are presented in Table 4. Details on the monitoring conducted by Resonate at each site are included within Appendix A.

Table 4 Unattended monitoring results

Location ¹	Rating Background Level, dB(A) L ₉₀ ²			Ambient noise level, dB(A) L _{eq}		
	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am
U1: Urbanest Darlington	54	50	46	60	58	55
U2: Blackwattle Creek Lane	51	48	43	59	57	52
U3: 130 Shepherd Street	48	45	40	59	59	53
U4: 32 Calder Street	43	42	37	56	50	45
U5: 41 Calder Street	43	42	38	51	49	45

(1) Refer to Figure 1 for the location of the monitoring.

(2) The Rating Background Level is a measure of the typical minimum steady background noise level for each time of day.

The measured noise levels show quieter noise levels at night time, particularly in the Calder Road area to the southeast of the site where background noise levels are below 40 dB(A) at night. Noise levels were higher around the Urbanest Darlington site, with background noise levels of 46 dB(A) at night due to the relatively proximity of this site to the Princes Highway / City Road.

Only three days of data were able to be obtained in August 2018 at 130 Shepherd Street due to battery failure of the noise monitoring equipment but the measurement results at that location were similar to the results of the longer monitoring period at the entry to Blackwattle Creek Lane (immediately across the road from 130 Shepherd Street) in March 2018. The background noise levels were 3 dB lower at 130 Shepherd Street for all time periods, but this was attributed to the fact that the monitoring at 130 Shepherd Street occurred across the weekend rather than during the week. However, as a conservative approach, the ambient and background noise levels measured at 130 Shepherd Street have been adopted for residences in this area.

No unattended noise monitoring was able to be conducted to the north of the site (northern side of Cleveland Street) as no permission was obtained from landowners in this area. Supplementary attended monitoring was carried out in this area, as detailed in Section 3.2, and it has been assumed that the background noise levels in this area are equivalent to those measured at 130 Shepherd Street. This is considered a conservative approach as the northern residential areas is much closer to Cleveland Street and City Road.

3.2 Attended noise monitoring

Attended monitoring was conducted at locations around the site on Wednesday, 8 November 2017 between 11:00 am and 1:00 pm. The monitoring was conducted during the study break prior to University exam period and therefore there were fewer pedestrians on campus at the time of the measurements than would be during teaching times.

The measured noise levels at each location are shown in Table 5, with the measurement locations shown on Figure 1.

Table 5 Attended monitoring results on Wednesday, 8 November 2017

Location	Measured noise level, dB(A)				Description
	L _{max}	L ₁₀	L _{eq}	L ₉₀	
Rose Street to north A1	79	56	53	50	15-minute measurement at 12:10 pm. Well-shielded from proposed development site. Road traffic noise contribution from Cleveland Street and City Road.
Rose Street to north A1	58	52	50	48	Short-term measurement at 12:30 pm with no local car movements. Controlled by steady background noise including mechanical plant noise.
Cnr of Boundary and Shepherd St A2	70	60	56	52	15-minute measurement at 11:15 am. Steady background noise from mechanical plant serving various University buildings, with short-term noise from car pass-bys.
Cadigal Green A3	67	58	55	52	15-minute measurement at 11:40 am. Steady background noise from mechanical plant serving various University buildings, with distant traffic from City Road.

The measurements indicate that there is a moderate level of existing noise in the environment during the daytime period, due largely to mechanical plant noise from the University of Sydney and local and distant traffic. Even without significant contribution from traffic noise, the measured background noise at Rose Street to the north (and further from the University) was 48 dB(A) L₉₀ and controlled by mechanical plant from University uses.

Measurements at Location 1 and Location 2 were repeated on the morning of Friday, 17 November, in order to determine the typical noise environment between 6 am and 7 am which would be the earliest time that mechanical plant on the ETP would be expected to operate. The measured noise levels at each location for this time period are shown in Table 6.

Table 6 Attended monitoring results on morning of Friday, 17 November 2017

Location	Measured noise level, dB(A)				Description
	L _{max}	L ₁₀	L _{eq}	L ₉₀	
Rose Street to north A1	75	55	52	49	15-minute measurement at 6:15 am. Well-shielded from proposed development site. Distant road traffic noise contribution from Cleveland Street and City Road.
Cnr of Boundary and Shepherd St A2	72	57	54	50	15-minute measurement at 6:40 am. Steady background noise from mechanical plant serving various University buildings, with short-term noise from car pass-bys.

The measurement results presented in Table 6 indicate that noise levels were not markedly different between the early morning and midday periods. The consistent level of background noise (L₉₀) demonstrated across both measurement periods is representative of the steady level of mechanical plant noise from various sources, including existing University of Sydney buildings.

3.3 Noise catchment areas

Based on the results of the noise monitoring conducted around the site, four noise catchment areas (NCAs) have been defined for the different residential land use areas around the University of Sydney. This includes the student accommodation uses at International House and Urbanest Darlington.

The NCAs have been defined as shown on Figure 2 and are broadly described as follows:

- NCA1: Student accommodation areas to west and northwest of site. Background noise environment established based on monitoring results from U1.
- NCA2: Residential areas to the north of the site and on the northern side of Cleveland Street. Background noise environment established based on monitoring results from U3.
- NCA3: Residential areas to the northeast of the site and on the eastern side of Shepherd Street and north of Ivy Street. Background noise environment established based on monitoring results from U3.
- NCA4: Residential areas to the east and southeast of the site, on the eastern side of Shepherd Street and south of Ivy Street. Background noise environment established based on monitoring results from U4.



Figure 2 Noise catchment areas

4 Assessment criteria

4.1 Construction noise

Construction noise in New South Wales is assessed using the Department of Environment & Climate Change (now Environment Protection Authority) *Interim Construction Noise Guideline* (ICNG).

The ICNG aims to manage noise from construction works regulated by the EPA. It is also intended to provide guidance to other interested parties in the management of construction noise, and has therefore been adopted for this construction noise assessment. The ICNG prescribes $L_{eq,15min}$ Noise Management Levels (NML) for sensitive receivers as part of a quantitative construction noise assessment. Where the predicted or measured construction noise level exceeds these management levels, then all feasible and reasonable work practices should be implemented to reduce construction noise, and community consultation regarding construction noise is required to be undertaken.

4.1.1 Standard Working Hours

The ICNG recommends standard working hours for construction as follows:

- Monday to Friday, 7 am to 6 pm
- Saturday, 8 am to 1 pm
- No work on Sundays or Public Holidays

To encourage work during the Standard Working Hours, and to reflect the lower impact of work at these times, the ICNG prescribes less stringent Standard Working Hours NMLs. Generally, the proposed working hours for the ETP align with the ICNG Standard Working Hours, with the exception of the period from 1 pm to 3:30 pm on Saturday afternoon. While this is generally a lower impact out of hours period, more stringent NMLs and noise management requirements will apply to work at this time.

It should be noted that the Standard Working Hours are only applicable to residential (or similar) land uses. At educational or commercial land uses, where evening amenity and sleeping is not a concern, the impact of construction noise is assessed based on the times that the land use operates.

4.1.2 Residential land uses

The NMLs prescribed for residential land uses by the ICNG are presented in Table 7. The levels apply at the most exposed property boundary of the noise sensitive receiver at a height of 1.5 metres above ground level. The NMLs have also been adopted for the International House and Urbanest student accommodation sites around the site.

4.1.3 Other sensitive land uses

The ICNG also prescribes NMLs for other sensitive land uses, including educational buildings and offices. The NMLs for relevant land uses are summarised in Table 8 and apply only when those land uses are in use.

For those receivers where an internal NML applies, it is common to assume an outdoor-to-indoor noise reduction of 25 dB(A). This is based on a standard commercial building facade with windows kept closed, such as that at most University Buildings. Therefore, for this assessment, an external NML of 70 dB(A) $L_{eq,15min}$ will be used for the educational sensitive land uses surrounding the development site.

It is noted that as most of the surrounding buildings are University of Sydney land uses, no specific requirements are applied by the ICNG, which is intended to manage construction noise impacts between uses not managed by the same body. As the relevant uses around the ETP site are all managed by the University of Sydney, management of construction noise impacts on adjoining uses will be undertaken by the University. However, as good practice and to provide guidance to the University, the NMLs recommended by the ICNG have been adopted for the University of Sydney uses in this assessment.

Table 7 Noise management levels for residential land uses

Time of day	NML, $L_{eq,15min}$	Application notes
Recommended Standard Working Hours	Noise affected: RBL + 10 dB(A)	May be some community reaction to noise. - Where the predicted or measured construction noise level exceeds the noise affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. - All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.
	Highly noise affected: 75 dB(A)	May be strong community reaction to noise. - Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. - Respite activities would be determined taking into account times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.
Outside recommended Standard Working Hours	Noise affected: RBL + 5 dB(A)	- A strong justification would typically be required for works outside the recommended standard hours. - The proponent should apply all feasible and reasonable work practices to meet the affected noise level. - Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the affected noise level, the proponent should negotiate with the affected community.

Table 8 ICNG noise management levels for other sensitive land uses

Land use	NML $L_{eq,15min}$ (applies when property in use)
Classrooms at schools and other educational institutions	Internal noise level of 45 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation).	External noise level of 60 dB(A)
Offices, retail outlets	External noise level of 70 dB(A)

4.1.4 Noise Management Levels

Table 9 summarises the NMLs applicable to sensitive land uses around the ETP site during the construction phase. The NMLs are based on the background noise levels from unattended monitoring.

Table 9 Noise Management Levels applicable to ETP

Land use	NML for time period, dB(A)			
	Standard Working Hours	Out of Hours Day ¹ (Saturday afternoon & Sundays)	Out of Hours Evening ²	Out of Hours Night ³
NCA1 – student accommodation uses	64 (NML) 75 (Highly noise affected)	59	55	51
NCA2	58 (NML)	53	50	45
NCA3	75 (Highly noise affected)			
NCA4	53 (NML) 75 (Highly noise affected)	48	47	42
University of Sydney uses	70	70	70	70
Cadigal Green	60	60	60	60

- (1) Any out of hours work occurring between 7 am and 6 pm.
- (2) Any out of hours work occurring between 6 pm and 10 pm.
- (3) Any out of hours work occurring between 10 pm and 7 am.

It is noted that the only works proposed outside of Standard Working Hours are from 1 pm to 3:30 pm on Saturday afternoons. However, NMLs for other periods are shown for information should this change in the future.

4.2 Construction vibration

Ground vibration generated by construction can have a range of effects on buildings and building occupants. The main effects are generally classified as:

- human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- effects on building structures – vibration which may compromise the condition of the building structure itself.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on buildings. Building occupants will normally feel vibration readily at levels well below those which may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3¹
- Human comfort: *Assessing Vibration – A Technical Guideline: DEC 2006* (the Vibration Guideline)

4.2.1 Cosmetic and structural damage

DIN 4150-3 summarises structural and cosmetic damage assessment criteria for different types of buildings, which are presented in Table 3, which are widely used for the assessment of construction vibration effects on buildings in Australia. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

Table 3 DIN 4150-3 vibration cosmetic and structural damage criteria

Structure type	Peak Particle Velocity (PPV), mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	<10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

With respect to the project site, the Old School building on Cadigal Green is heritage-listed and therefore subject to the most stringent vibration limits. It is approximately 50 m from the site.

¹ German Standard DIN 4150-3, 1999, *Structural Vibration – Part 3: Effects of vibration on structures*.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended would not necessarily result in damage. Rather, it recommends these values as maximum levels of short-term construction vibration at which experience has shown damage reducing the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as it considers a reduction in serviceability of the structure is deemed to have occurred if cracks form in plastered surfaces of walls, existing cracks in the building are enlarged or partitions become detached from loadbearing walls or floors.

4.2.2 Human comfort

The ICNG recommends that vibration from construction works be assessed under *Assessing Vibration – a technical guideline* (the Vibration Guideline), consistent with the SEARs issued by DPE. The vibration assessment criteria defined in the Vibration Guideline are for human comfort and represent goals that, where exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Vibration Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classified according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build-up to a vibration peak followed by damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).

The majority of construction activities as part of the proposed works would be expected to be continuous or intermittent in nature.

Table 10 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted RMS vibration velocity levels. The Vibration Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

Table 10 RMS velocity management levels for continuous and impulsive vibration

Land use	Continuous vibration – RMS vibration velocity, mm/s		Impulsive vibration – RMS vibration velocity, mm/s	
	Preferred	Maximum	Preferred	Maximum
Critical areas ¹	0.1	0.2	0.1	0.2
Residences and hospital wards – daytime ²	0.2	0.4	6.0	12.0
Residences and hospital wards – night time ³	0.14	0.28	2.0	4.0
Offices, schools	0.4	0.8	13.0	26.0
Workshops	0.8	1.6	13.0	26.0

- (1) Critical operating areas include hospital operating theatres and precision laboratories where sensitive operations are occurring.
- (2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.
- (3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in Table 11.

Table 11 VDV management levels for intermittent vibration

Land use	VDV – intermittent vibration, m/s ^{1.75}	
	Preferred	Maximum
Critical areas ¹	0.1	0.2
Residences and hospital wards – daytime ²	0.2	0.4
Residences and hospital wards – night time ³	0.13	0.26
Offices, schools	0.4	0.8
Workshops	0.8	1.6

- (1) Critical operating areas include precision laboratories where sensitive operations are occurring.
- (2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.
- (3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

4.3 Operational noise criteria

Noise emissions from the ETP when operational should comply with the requirements of the NSW *Industrial Noise Policy* (INP). It is noted that the INP has recently been superseded by the *Noise Policy for Industry* but, as the SEARs reference the INP, the INP has been adopted for this assessment. This is in accordance with NSW EPA recommendations where existing conditions reference the older document.

The INP sets two separate noise criteria to meet desirable environmental outcomes:

- Intrusiveness – steady-state noise from the site should be controlled to no more than 5 dB(A) above the background noise level in the area. In this case, the steady-state L_{eq} noise level should not exceed the background noise level measured for different time periods in the environment.
- Amenity – amenity criteria are set based on the land use of an area. It requires noise levels from new industrial noise sources to consider the existing industrial noise level such that the cumulative effect of multiple sources does not produce noise levels that would significantly exceed the amenity criteria.

The INP applies to noise emissions from rooftop plant and the like at the development. It sets noise emission criteria for the Day, Evening and Night periods. While the ETP will generally operate during the Day period, it is noted that building services may commence operation at 6 am and therefore assessment against the more stringent Night period criteria is required.

4.3.1 Normal operation

Table 12 presents the INP noise emission criteria for residential land uses, including the International House and Urbanest, for the Day, Evening and Night periods.

The background noise levels for the purposes of determining the Intrusive criteria have been applied as per the designation of background noise monitoring locations to NCAs detailed in Section 3.3.

The existing industrial noise levels for each area have been determined on the basis of attended monitoring as well as consideration of the unattended monitoring results for relevant locations where appropriate. For example, an existing industrial noise level of 45 dB(A) has been adopted for NCA4 (Calder Road) given the consistent night time ambient noise levels at these locations, although it is noted higher ambient noise levels were measured at this area during the early morning period from 6 am – 7 am when the ETP would be operating. This is a conservative approach for this NCA as it results in a lower project-specific noise criterion.

4.3.2 Emergency operation

A rooftop emergency generator will be installed as part of the ETP development. This will only operate in emergencies and during occasional short-duration daytime maintenance periods.

The NSW INP does not specify requirements for emergency equipment but does suggest that short-term exceedances of the approved noise levels may be required depending on the nature of the site. Based on the INP and our previous experience, it is recommended that the applicable noise criteria for the emergency generator be relaxed (increased) by 5 dB(A).

Table 12 INP noise emission criteria for residential land uses and student accommodation

Level	INP noise emission criteria, dB(A) $L_{eq,15min}$ (dB re 20 μ Pa)								
	NCA1: Urbanest Darlington, International House			NCA2 & NCA3: Cleveland St and Shepherd Street north residences			NCA4: Shepherd Street south and Calder Rd residences		
	Day 7 am– 6 pm	Evening 6 pm– 10 pm	Night 10 pm– 7 am	Day 7 am– 6 pm	Evening 6 pm– 10 pm	Night 10 pm– 7 am	Day 7 am– 6 pm	Evening 6 pm– 10 pm	Night 10 pm– 7 am
Rating Background Level (RBL)	54	50	46	48	45	40	43	42	37
Existing industrial L_{eq}^2	52	52	52	50	50	50	45	45	45
Intrusive criterion (RBL + 5 dB)	59	55	51	53	50	45	48	47	42
Amenity criterion for all sources (Suburban ¹)	55–60	45–50	40–45	55–60	45–50	40–45	55–60	45–50	40–45
Amenity criterion for new sources	52	42	42	53	40	40	55	37	35
Project specific criterion³	52	42	42	53	40	40	48	37	35

- (1) A suburban classification has been adopted for the site, described as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry.
- (2) Based on attended monitoring results at relevant locations, with consideration of unattended monitoring results where appropriate.
- (3) The project-specific criteria are the minimum of the Intrusive criterion and the Amenity criterion for new sources for period.

5 Construction assessment

5.1 Construction noise

5.1.1 Construction noise sources

Table 13 summarises the assumed sound power levels (L_w) for the major construction noise sources which we expect would be on site during each phase. The sound power levels have been based on data obtained from previous measurements conducted by Resonate and those within the UK Department for Environment, Food and Rural Affairs (DEFRA) *Update of noise database for prediction of noise on construction and open sites*. An overall sound power level for each phase has also been assumed based on the loudest typical source(s) operating for each works phase.

Table 13 Construction noise source sound power levels

Stage	Typical plant items	Assumed sound power level, dB(A)
Site establishment and enabling works	Large excavator	111
	Vibratory roller	107
	Concrete truck	109
	Concrete pump	107
	Large truck	108
	Chainsaw	114
	Typical overall sound power level	112
Demolition	Large excavator	111
	Rockbreaker	121
	Crane	106
	Pneumatic jackhammer	109
	Large truck	108
	Typical overall sound power level	118
Retaining piles and excavation	Bored piling rig	111
	Large excavator	111
	Crane	106
	Large truck	108
	Typical overall sound power level	112
Substructure	Crane	106
	Large excavator	111
	Pneumatic jackhammer	109
	Concrete truck	109
	Concrete pump	107
	Large truck	108

Stage	Typical plant items	Assumed sound power level, dB(A)
	Typical overall sound power level	114
Frame	Concrete truck	109
	Concrete pump	107
	Crane	106
	General hand tools	98
	Large truck	108
	Typical overall sound power level	111
Facade works	Crane	106
	General hand tools	98
	Large truck	108
	Typical overall sound power level	107
Internal works and fitout	General hand tools	98
	Compressor	94
	Portable generator	95
	Typical overall sound power level	84¹

(1) Includes a 15 dB(A) indoor-to-outdoor reduction in noise levels for internal works.

5.1.2 Typical construction noise levels during Standard Works Hours

Typical worst-case construction noise levels have been predicted using a three-dimensional environmental noise model of the site and surrounds, developed in SoundPlan version 7.4 environmental noise modelling software, including:

- topography
- building structures
- ground absorption (ground assumed to be 50% absorptive and 50% reflective)
- air absorption
- attenuation with distance.

Predictions have been carried out based on the environmental noise prediction algorithms documented in ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*. This provides predictions typical of conditions where the receiver is downwind of the source or where there is a moderate ground-based temperature inversion.

It is important to note that these predictions are typical worst-case predictions as they assume that:

- The construction works are occurring at the nearest point to each receiver and that the receiver is located at the most exposed position (e.g. the nearest windows of Urbanest Darlington and International House).
- The noisiest construction sources are operating continuously for the entire 15-minute period. This will not occur at all times as equipment will regularly be stood down or idled while other activities are undertaken.

Typical worst-case predicted noise levels are shown in Table 14 for each sensitive-receiver location and each phase of works. Predicted noise levels that exceed the relevant Standard Work Hours NML are highlighted in **bold** type.

Table 14 Typical worst-case external construction noise levels for Standard Working Hours

Receiver	Typical worst-case external construction noise level for phase during Standard Working Hours, dB(A) L_{eq}						
	Site establishment	Demolition	Retaining piles and excavation	Substructure	Frame	Facade works	Internal works and fitout
R1 – Urbanest Darlington	63	69	63	65	62	58	35
R2 – International House	66	72	66	68	65	61	38
R3 – Cleveland Street residences	50	56	50	52	49	45	22
R4 – Shepherd Street residences north (NCA3)	53	58	53	54	52	48	24
R5 – Shepherd Street residences south (NCA4)	55	61	55	57	54	50	27
R6 – Calder Road residences (NCA4)	50	56	51	53	49	46	22
R7 – Seymour Centre	72	78	72	74	71	67	44
R8 – Warren Centre	62	68	62	64	61	57	34
R9 – Mechanical Engineering	78	84	78	80	77	73	50
R10 – Engineering Link Building	80	86	80	82	79	75	52
R11 – Civil Engineering	61	67	61	63	60	56	33
R12 – PNR Building	69	75	69	71	68	64	41
R13 – Wentworth Building	65	71	65	67	64	60	37
R14 – Cadigal Green	66	72	66	68	65	61	38

Based on the predictions, it can be seen that construction noise from the site is predicted to exceed the relevant Standard Working Hours NMLs at:

- The nearest residences to the east on Shepherd Street (in NCA4) during major works. This would affect the residences on Shepherd Street between Calder Lane and Ivy Street during noisy construction periods. Residences to the north of Ivy Street (represented by R4) and further to the south of Calder Lane (represented by R6) are not expected to be exposed to construction works above the standard hours NML, other than during noisy demolition works.
- The University student accommodation sites during most external works (mainly International House).
- The Seymour Centre during most external works.
- Other Engineering Faculty uses during major external works, in particular areas of the Mechanical Engineering building and the Engineering Link building.

No residential land uses are predicted to be highly noise affected by construction works.

At other locations, no significant noise impacts are expected during the construction phase, particularly if work is only undertaken during standard working hours.

Recommendations for construction noise management are provided in Section 5.3.

5.1.3 Typical construction noise levels during Saturday afternoon works

Table 15 presents typical predicted construction noise levels and highlights NML exceedances for those works occurring outside of Standard Working Hours, on Saturday afternoons from 1 pm to 3:30 pm.

Table 15 Typical worst-case external construction noise levels for work outside of Standard Working Hours

Receiver	Typical worst-case external construction noise level for phase outside of Standard Working Hours, dB(A) L _{eq}						
	Site establishment	Demolition	Retaining piles and excavation	Substructure	Frame	Facade works	Internal works and fitout
R1 – Urbanest Darlington	63	69	63	65	62	58	35
R2 – International House	66	72	66	68	65	61	38
R3 – Cleveland Street residences	50	56	50	52	49	45	22
R4 – Shepherd Street residences north (NCA3)	53	58	53	54	52	48	24
R5 – Shepherd Street residences south (NCA4)	55	61	55	57	54	50	27
R6 – Calder Road residences (NCA4)	50	56	51	53	49	46	22

The predictions indicate that:

- Predicted worst-case construction noise levels exceed the NML for most work phases for Urbanest Darlington and International House.
- Predicted worst-case construction noise levels at the Cleveland Street residences are below the out of hours NML with the exception of noisy demolition works.
- Predicted worst-case construction noise levels at the northern Shepherd Street residences in NCA3 exceed the out of hours NML for the demolition and structure phases but the exceedance is 5 dB or below.
- Predicted worst-case construction noise levels at the southern Shepherd Street residences in NCA4 exceed the out of hours NML for most phases. The worst case exceedances are predicted for noisy demolition works if carried out on Saturday afternoons.
- It is expected that internal works and fitout can generally occur outside of Standard Hours without unduly impacting on residential land uses.

Recommendations for construction noise management for works outside of Standard Working Hours are provided in Section 5.3.

Note that the assessment of work outside of standard hours has not considered the commercial and educational land uses as the NMLs for these land uses remain the same regardless of the work hours. It is noted, however, that conducting works on a Saturday afternoon period from 1 pm to 3:30 pm would be expected to reduce the overall noise impact on neighbouring commercial and educational buildings as these uses are typically less sensitive (and often largely unoccupied) at these times.

5.2 Construction vibration

Table 16 summarises recommended safe working distances for key vibration-generating activities that would be expected during the construction phase, based on prior measurements conducted by Resonate. We understand that preliminary geotechnical studies have indicated that bored piling will be able to be undertaken.

Table 16 Recommended safe working distances for key vibration generating activities

Plant	Rating	Typical safe working distance for occupant comfort, m		Typical safe working distance for building damage, m	
		Preferred vibration target	Maximum vibration target	Heritage structure	Commercial building
Vibratory roller	< 7t	≥ 35	≥ 20	≥ 10	≥ 2
	7t – 12t	≥ 50	≥ 30	≥ 15	≥ 5
	≥ 13t	≥ 75	≥ 40	≥ 20	≥ 10
Small hydraulic hammer	300 kg – 5 to 12T excavator	≥ 12	≥ 7	≥ 5	≥ 2
Medium hydraulic hammer	900 kg – 12 to 18T excavator	≥ 35	≥ 23	≥ 15	≥ 7
Large hydraulic hammer	1600 kg – 18 to 34T excavator	≥ 65	≥ 45	≥ 35	≥ 22
Excavator	Large excavator digging	≥ 25	≥ 15	≥ 5	≥ 1
Bored piling	≤ 800mm	≥ 20	≥ 10	≥ 2	≥ 1
Jackhammer	Handheld	— ⁽¹⁾	— ⁽¹⁾	≥ 3	≥ 1

Based on the safe working distances above, vibration impacts on buildings are not expected, including to the heritage-listed Old School building. Impacts on occupant comfort are likely to be limited to any vibratory compaction works and rock-breaking works occurring near to existing Engineering Faculty buildings and consultation should be undertaken with the users of these areas during vibration-intensive works. Recommendations are provided in Section 5.3 for the management of construction vibration from the works.

5.3 Recommendations

To manage the potential impact of noise and vibration during construction, reasonable and feasible management measures and work practices should be implemented as detailed below.

5.3.1 Construction Noise and Vibration Management Plan

Prior to the commencement of major construction works for the ETP building being considered as part of this EIS, the contractor should develop a Construction Noise and Vibration Management Plan (CNVMP). The CNVMP should:

- identify relevant construction noise and vibration criteria as detailed in this report
- identify neighbouring sensitive land uses for noise and vibration
- summarise key noise- and vibration-generating construction activities and the associated predicted levels at neighbouring land uses
- identify reasonable and feasible work practices to be implemented during the works
- summarise stakeholder consultation and complaints handling procedures for noise and vibration.

5.3.2 Stakeholder consultation

Nearby stakeholders should be consulted prior to the works and kept regularly informed of potential noise and vibration impacts from the works. Specifically, this would involve:

- Consultation with management of International House and Urbanest Darlington during major external works.
- Consultation with residences on Cleveland Street and Shepherd Street in both NCA3 and NCA4.
- Specific reference to works occurring until 3:30 pm on a Saturday to be included in the consultation with the above land uses.

The University of Sydney will also consult with various University stakeholders at the Engineering Faculty and the Seymour Centre during the works.

A noise and vibration complaints handling procedure and register should be developed and implemented during construction.

5.3.3 Work programming

Work should be programmed such that particularly noisy works occur during Standard Working Hours wherever feasible, namely:

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

It is proposed that works will also occur during the Saturday afternoon period from 1 pm to 3:30 pm. While this will assist in reducing the noise impact on the nearer commercial and educational land uses, it does result in works occurring outside of the Standard Working Hours for residential land uses. For works conducted during this extended Saturday afternoon period, it is recommended that:

- Wherever feasible, noisier works (in particular noisy rock-breaking or demolition) are not conducted in this extended period.
- Consultation is undertaken with International House and Urbanest Darlington, as detailed above, to inform them of the extended Saturday afternoon working period and to respond to any concerns that they may have with this.

If high noise works are to occur outside of the Standard Working Hours and later than 3:30 pm on a Saturday, then the CNVMP should define an approval process for undertaking out of hours works and for identifying reasonable and feasible mitigation measures to be implemented.

5.3.4 Truck movements and site access

Truck movements during long term construction projects have the potential to cause annoyance for sensitive receivers, even where trucks may be travelling on sealed roads. The design and selection of site access routes shall consider the potential disturbance to residents. In particular:

- site access and delivery points shall be located as far away from residences as possible
- truck movements shall use arterial roads and be diverted away from residential streets where feasible
- deliveries to/from site shall not occur during the night time period where possible.

5.3.5 Site management

Site management procedures should include the following:

- processes that generate lower noise levels should be selected where feasible
- noisy plant should be located as far away from residences as is practical to allow efficient and safe completion of the task
- the potential shielding provided by site topography and intervening buildings should be taken into account in locating equipment
- site compounds should be located as far away as possible from residences
- equipment that is used intermittently should be shut down or throttled down to a minimum during periods where it is not in use
- works should be planned to minimise the reduce the noise from reversing signals
- warning horns should not be used as signalling devices
- two way radios should be set to the minimum effective volume
- noise associated with packing up plant and equipment at the end of works should be minimised.

5.3.6 Equipment management

Equipment management should include the following:

- selection of low-noise plant and equipment where possible
- equipment should be well maintained
- equipment should have quality mufflers and silencers installed where relevant
- equipment not in use on site should be shut down
- tasks should be completed using the minimum feasible power and equipment.

6 Operational assessment

6.1 Mechanical plant including emergency generator

Laing O'Rourke has advised that major rooftop plant as part of the ETP would be expected to include:

Level 10 plant within plant rooms and enclosures

- 3 x BAC CPSC-0716-07M Cooling Towers – sound power level of 99 dB(A)
- 1 x Low Load Chiller – sound pressure level of 80 dB(A) at 1 m
- 2 x High Load Chiller – sound pressure level of 85 dB(A) at 1 m

Assorted rooftop fans

- 33 x Fume Cupboard fans – sound power level of 77 dB(A)
- 2 x Stair Pressurisation fans – sound power level of 106 dB(A)
- 2 x Toilet Exhaust fans – sound power level of 109 dB(A)

Emergency equipment

- 1 x CAT C13 generator in proprietary acoustic enclosure
- 3 x smoke spill fans with sound power level of 102 dB(A).

As the equipment will be located on the rooftop there will be little or no direct line-of-sight between the rooftop plant and most neighbouring noise-sensitive land uses. The exception to this is the upper levels of Urbanest Darlington.

Based on the mechanical plant information above, noise levels have been predicted at the various noise sensitive locations around the site using a three-dimensional environmental noise model developed in SoundPlan version 7.4 environmental noise modelling software implementing the ISO 9613-2:1996 prediction algorithms. The model also takes into account:

- distance attenuation
- ground absorption (ground assumed to be 50% absorptive and 50% reflective)
- air absorption
- the topography and relative height of the noise sources and receivers
- shielding provided by buildings and intervening structures where relevant.

Operation of the plant may commence at 6 am and therefore compliance would be required with the most stringent night time noise criteria. Compliance with the night time criteria would result in compliance being achieved with the less stringent day and evening INP criteria.

Based on an assessment of the proposed rooftop plant layout, it is expected that the following measures would be required based on the current design:

- The Chillers should be located in an enclosed plant room on Level 10. The plant room should be constructed with a solid roof achieving no less than an R_w 35 rating and solid walls achieving no less than R_w 40.
- The CAT C13 generator should be installed in an acoustic enclosure that achieves a rating of 80 dB(A) at 1 m.
- Outlet attenuators are required for the Stair Pressurisation fans and Toilet Exhaust fans, acoustically equivalent to Fantech RS07C. Alternatively, the outlet ductwork from the fans is required to be at least 3 m in length, 50 mm thick internally lined, incorporate at least one 90-degree bend, with the outlets facing north or south.

With the incorporation of the above measures, predicted noise levels from the rooftop plant is predicted to achieve the INP criteria for both normal and emergency operation (with 5 dB relaxation).

6.2 Transient noise sources

6.2.1 Loading dock

The Transport and Accessibility Assessment report prepared by GTA Consultants for the ETP (dated 11 January 2018) predicts the following movements at the proposed loading dock at the eastern end of the Engineering Link building:

- 3-4 heavy vehicles (12.5 m long) per week
- 10-15 medium vehicles (8.8 m long) per week
- 10 light vehicles (cars/vans) per day.

Vehicles will need to access the loading dock by travelling in a southbound direction along Blackwattle Creek Lane before reversing into the loading dock. The length of the reverse procedure will be approximately 20 metres. Egress will occur via Shepherd Street near the School of Civil Engineering.

The nearest noise sensitive receptors are residences along Shepherd Street near the intersections with Boundary Street and Calder Lane. The nearest residence on Shepherd Street is approximately 35 m from the entrance to the loading dock area. As the trucks reverse up towards the loading dock entrance, they will be further removed from the residences and shielded from some of the nearest residences as shown in Figure 3 based on the Cox architectural drawings. In the position shown in Figure 3, the truck is approximately 50 m from the nearest residence with a direct line of sight.



Figure 3 Truck in loading dock

Noise levels from loading dock activities have been predicted based on:

- Sound power levels based on previously measured Resonate data of:
 - 97 dB(A) L_W for 12.5 m heavy truck
 - 93 dB(A) L_W for 8.8 m medium truck
 - 85 dB(A) L_W for a light van.
- A 15-minute period consisting of:
 - Vehicle reversing for approximately 20 m from Blackwattle Lane into the loading dock (30 seconds only).
 - Vehicle switched off when in the loading dock.
 - Loading dock activity with a sound power level of 80 dB(A) L_W when the truck is in the loading dock, to account for noise from trolleys and palettes. Note that this noise source is shielded by the truck and awning in the loading dock area.
 - Truck exiting in a forward direction to the south to Shepherd Street (15 seconds only).
- A penalty of 5 dB being applied to truck movements to account for tonal reversing noise (estimated to occur for 30 seconds only).

Noise levels from truck deliveries were predicted using the noise model detailed in Section 6.1. The predicted noise levels are summarised in Table 17 for the nearest noise-sensitive land uses on Shepherd Street and Boundary Street against the INP noise emission criteria. The predicted noise level is shown for the most exposed residence at 39 Boundary Street, which had the highest predicted noise level of any residence.

Table 17 Predicted loading dock noise levels versus INP noise emission criteria

Vehicle type	Predicted noise level at most exposed residence	INP noise emission criteria, dB(A) $L_{eq,15min}$		
	dB(A) $L_{eq,15min}$	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am
Heavy truck	46	48	37	35
Medium truck	42			
Light van	38			

From Table 17 it can be seen that noise from truck movements is predicted to comply with the INP noise emission criteria during the daytime periods but exceed the INP noise emission criteria at the nearest residences on Shepherd Street and Calder Lane during the evening and night time periods.

Therefore, to minimise any potential noise impact on neighbouring land uses, it is recommended that use of the loading dock for deliveries and any waste collection be restricted to between the hours of 7:30 am to 6 pm Monday to Friday. Additionally, all trucks should be switched off when in position in the loading dock.

6.2.2 Gas storage areas

Laing O'Rourke has advised that the two gas storage areas would be located at the eastern end of the Engineering Link building. The proposed locations are shown in Figure 4, with the nearest storage area approximately 30 m away from the nearest residence on Boundary Street.

The gas storage is not expected to generate audible noise at the residences but deliveries of gas to the storage will. The gas storage areas would be filled as required by trucks that will vary in size from 6.5 m (typical for a 7000 L delivery) to 13 m (largest truck that may be used).

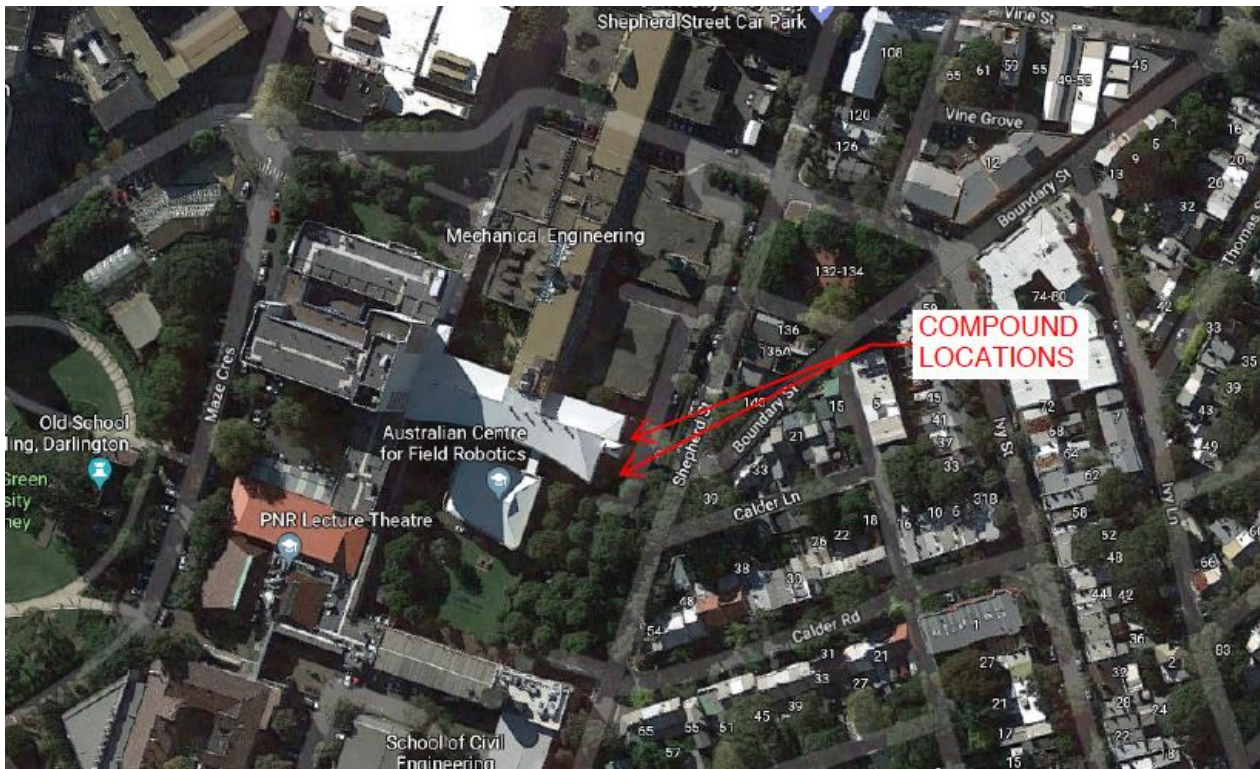


Figure 4 Gas storage areas

Noise predictions have been carried out based on a sound power level of 97 dB(A) L_w for the largest 13 m truck proposed. It has been assumed that the truck would travel in a forward direction along Blackwattle Lane and refuel the gas storage without needing to reverse, with the truck engine operating for a total of 45 seconds encompassing arrival, being switched off for refuelling, and leaving. During refilling with the engine source switched off, a pump sound power level of 85 dB(A) L_w has been assumed.

Based on the above, the predicted noise level at the nearest residential land use on Boundary Street is 47 dB(A) $L_{eq,15min}$, compliant with the INP daytime noise emission criteria but above the evening and night time criteria. Therefore, gas deliveries should be restricted to the same times as proposed for the loading dock.

6.3 Recommendations

Noise mitigation techniques will need to be reassessed and further developed as the design of the building and the rooftop progresses. Techniques that will be considered if the rooftop plant design or plant selections change will include:

- Selection of lower noise plant and equipment where plant items are changed or altered.
- Screening of external plant using solid barriers or acoustic louvres if necessary.
- Appropriate construction of a rooftop plant room to reduce noise emissions to neighbouring land uses in line with the recommendations above for the Chillers.

The noise levels from mechanical plant, and other noise sources, will be assessed as the design progresses to ensure that compliance with the INP noise emission criteria can be achieved.

To minimise any potential noise impact on neighbouring land uses, it is recommended that the following activities are undertaken only between the hours of 7:30 am to 6 pm Monday to Friday:

- Goods/gas deliveries

- waste collection
- grounds maintenance around the building.

Additionally, trucks using the loading dock and servicing the gas storage facilities near Shepherd Street should have their engines switched off once they are in position rather than left in idle.

7 Conclusion

This report presents a construction and operational noise and vibration assessment for the proposed ETP development at the University of Sydney. The proposed building will enable the Engineering and Technology faculty to expand its research and teaching facilities.

Construction noise and vibration criteria have been determined in accordance with relevant guidance such as the ICNG and Vibration Guideline. It is likely that construction works may have some noise impact on University student accommodation land uses at Urbanest Darlington and International House, and on residential land uses on Shepherd Street, particularly to the south of Ivy Street. It is anticipated that these impacts will be able to be managed through noisy works being carried out during standard working hours, with out of hours works limited to Saturday afternoons (1pm to 3:30pm), and with the implementation of reasonable and feasible work practices. The University will also manage the noise and vibration impacts of works on adjoining University teaching and office uses.

Operational noise emission criteria have been set in accordance with the NSW INP and apply predominantly to mechanical plant noise emissions from the site. A preliminary rooftop plant layout and selection has been assessed and recommendations provided such that noise emissions can achieve the INP criteria for both normal and emergency operations. As the design progresses, noise mitigation measures should be reviewed to ensure that noise from rooftop plant in particular can comply with the INP noise emission criteria at neighbouring noise-sensitive land uses if the rooftop plant design changes.

Activities at the loading dock and gas storage areas near Shepherd Street, at the eastern end of the Engineering Link Building, have also been assessed. Deliveries, collections and refuelling activities should be restricted to the hours of 7:30 am to 6 pm Monday to Friday and trucks using these areas should have their engines switched off when in position rather than left in idle.

Appendix A—Unattended noise monitoring information

Unattended noise logging

An initial unattended environmental noise survey was conducted during the period 12 to 19 March 2018. The noise logging was conducted at two locations, with positions shown on Figure 1:

- Location U1: ground level on the southwest side of Urbanest Darlington, shielded from City Road.
- Location U2: at entry to Blackwattle Creek Lane in garden on western side of Shepherd Street footpath immediately across from residence at 130 Shepherd Street.

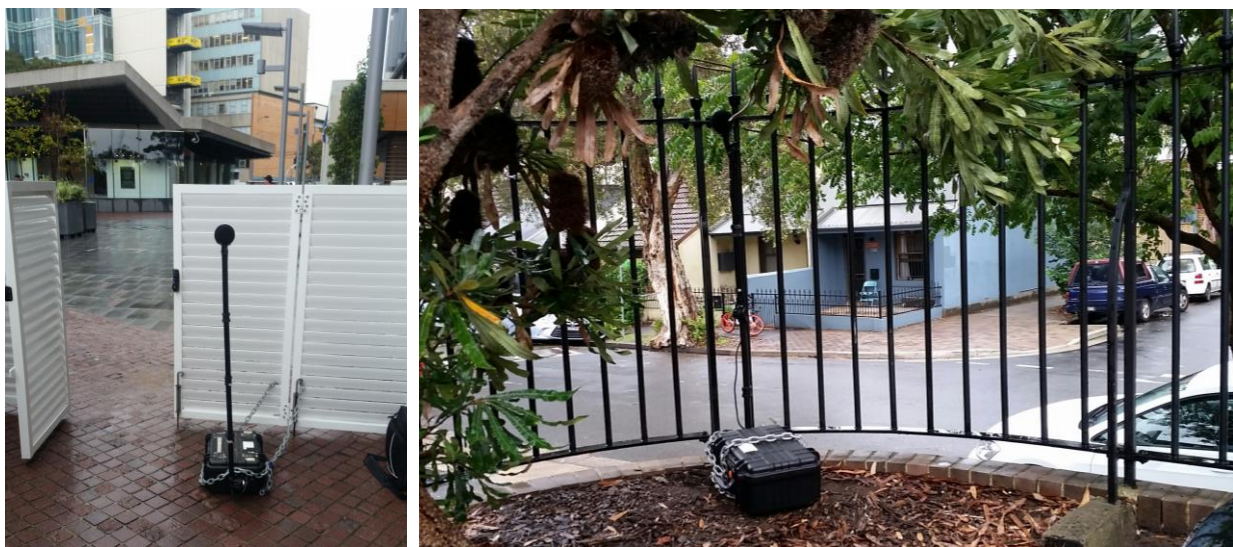


Figure A1 March 2018 noise monitor installations – Location U1 (left) and Location U2 (right)

To obtain more data in surrounding residential areas, additional unattended noise monitoring was conducted during the period 10 to 17 August 2018. This noise logging was conducted at the following three locations, with positions shown on Figure 1:

- Location U3: at western facade of residence at 130 Shepherd Street with direct line-of-sight to University.
- Location U4: backyard of 32 Calder Road residence.
- Location U5: front yard of 41 Calder Road residence.



Figure A2 August 2018 noise monitor installations – Location U3 (left), Location U4 (centre) and Location U5 (right)

Equipment

The noise loggers were configured to record all relevant noise indices, including A-weighted background noise level (L_{90}) and equivalent continuous noise levels (L_{eq}). Samples were accumulated at 15-minute intervals. The time response of the logger was set to 'fast'. The equipment used was:

- Location U1: Rion NL-42 sound level meter, serial number 946975.
- Location U2: Rion NL-42 sound level meter, serial number 946983.
- Location U3: Rion NL-42 sound level meter, serial number 946978.
- Location U4: Rion NL-42 sound level meter, serial number 946983.
- Location U5: Rion NL-42 sound level meter, serial number 946975.

Both noise monitors carry current calibration certificates from a NATA-accredited laboratory. Field calibration was conducted at the commencement and conclusion of the logging period and no significant drift was observed.

Weather conditions

In order to provide an indication that noise data was obtained during suitable meteorological conditions, half-hourly weather data was obtained from the Bureau of Meteorology (BOM) Automatic Weather Station (AWS) 066062 at Observatory Hill, Sydney.

Noise data has been excluded from the processed results if:

- Rain was observed during a measurement period, and/or
- Wind speed exceeded 5 m/s (18 km/h) at the measurement height of 1.5 m above ground. Wind data obtained from the BOM is presented as the value at 10 m above ground. These values are divided by 1.5 for the purpose of estimating wind speed at 1.5 m above ground.

Measured noise levels

For reference, a weekly chart showing the graphed noise logging results is shown in Figures A3 to A7.

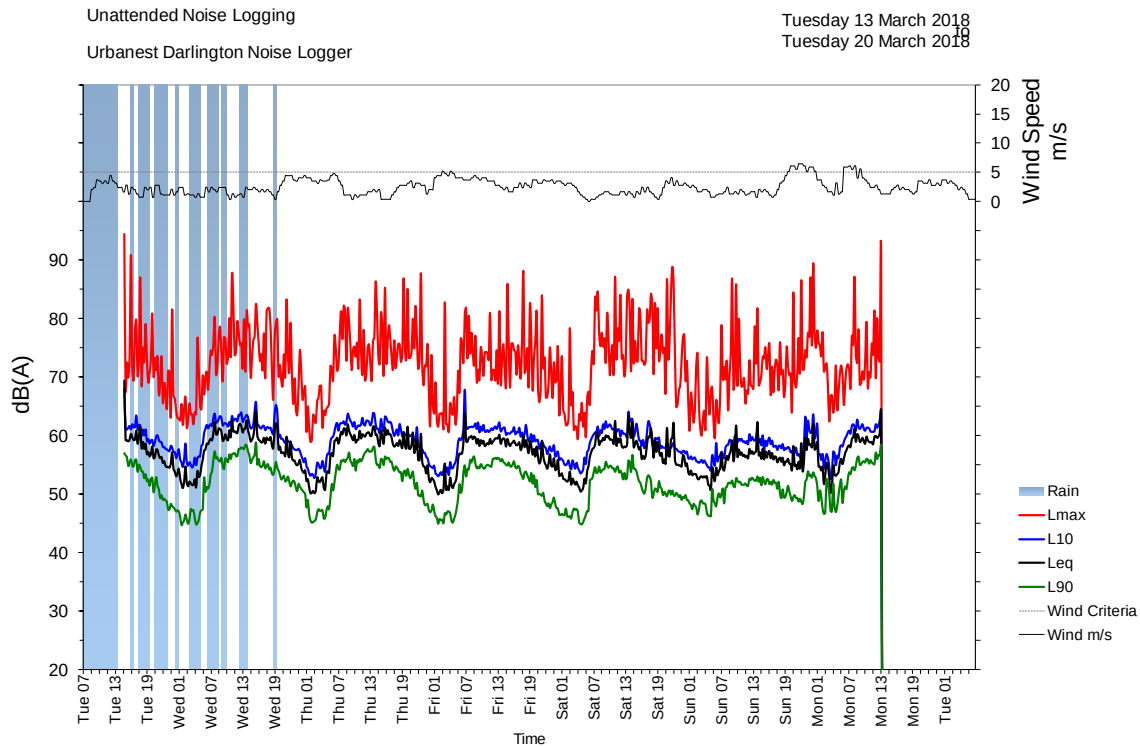


Figure A3 Noise monitoring results for Location U1 (Urbanest Darlington)

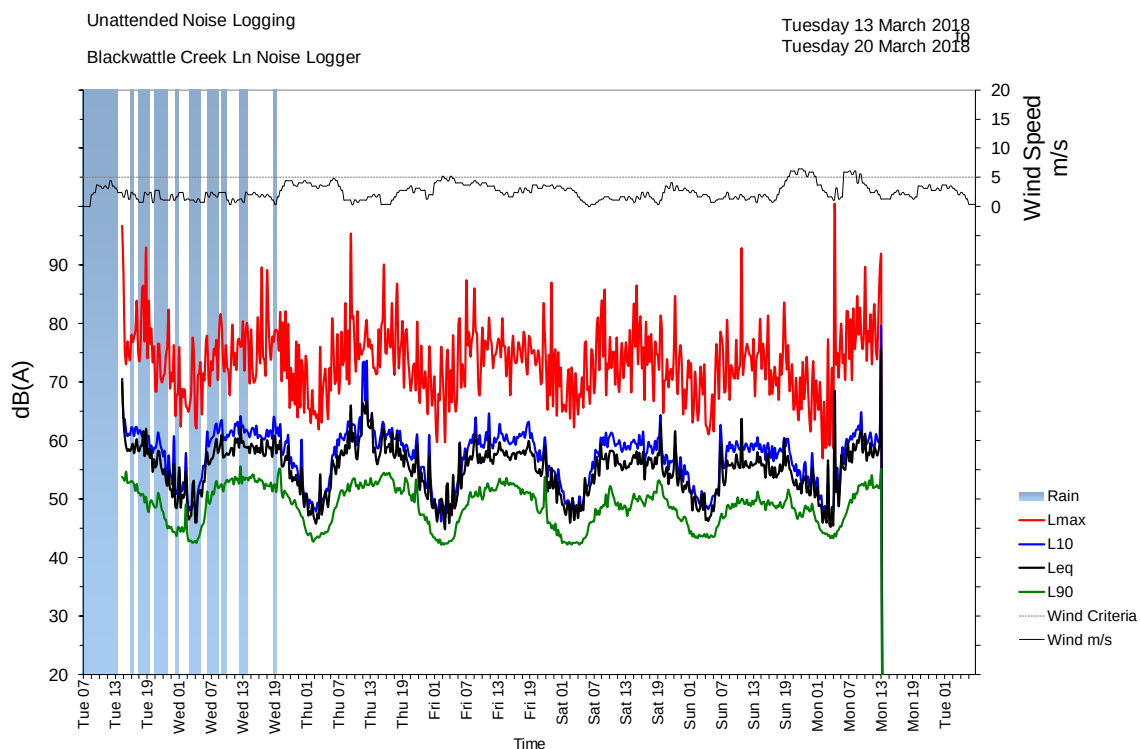


Figure A4 Noise monitoring results for Location U2 (Blackwattle Creek Lane)

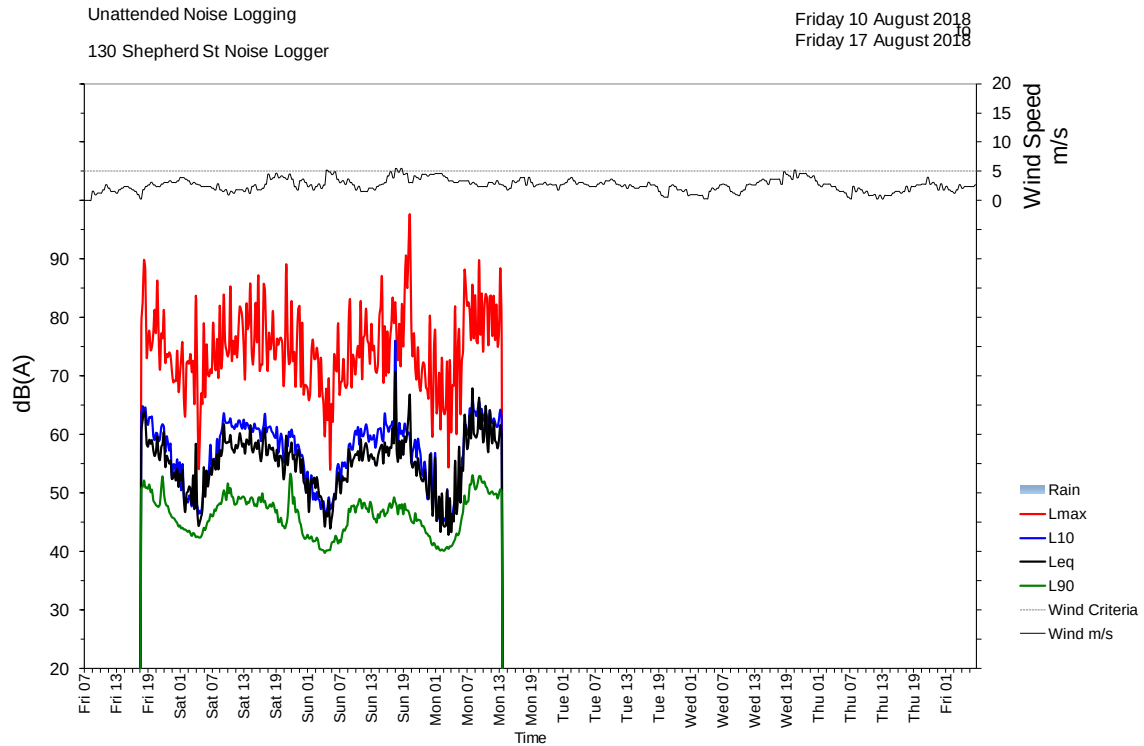


Figure A5 Noise monitoring results for Location U3 (130 Shepherd Street)

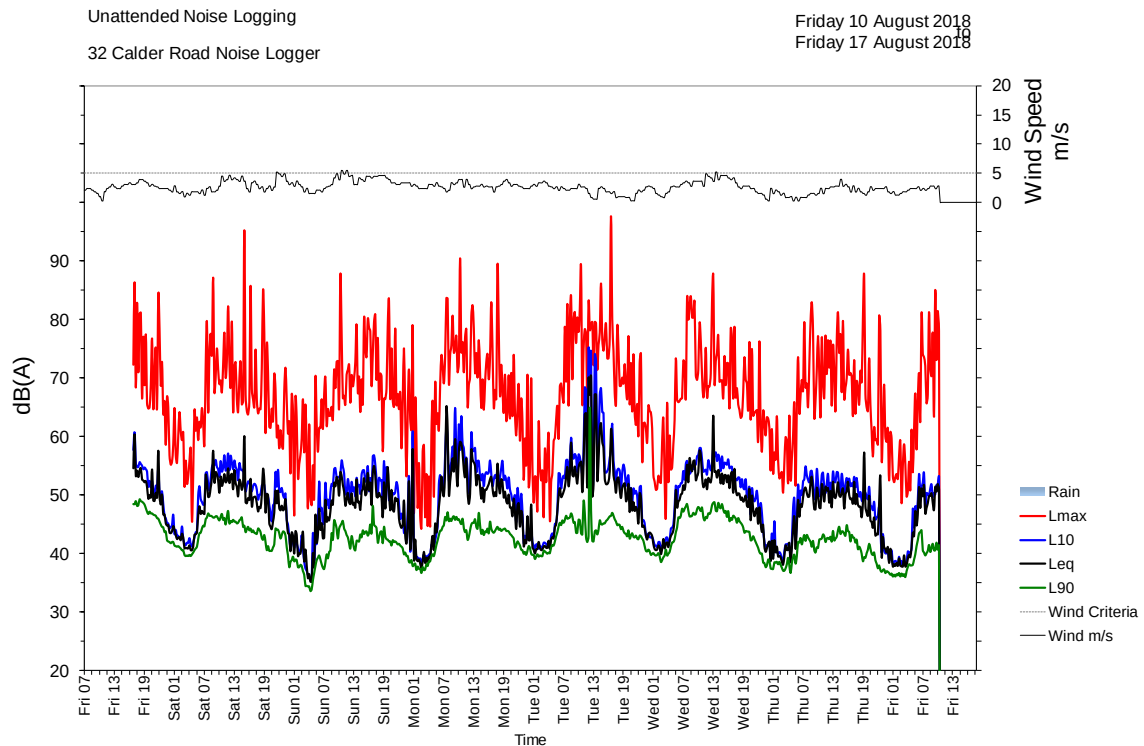


Figure A6 Noise monitoring results for Location U3 (32 Calder Road)

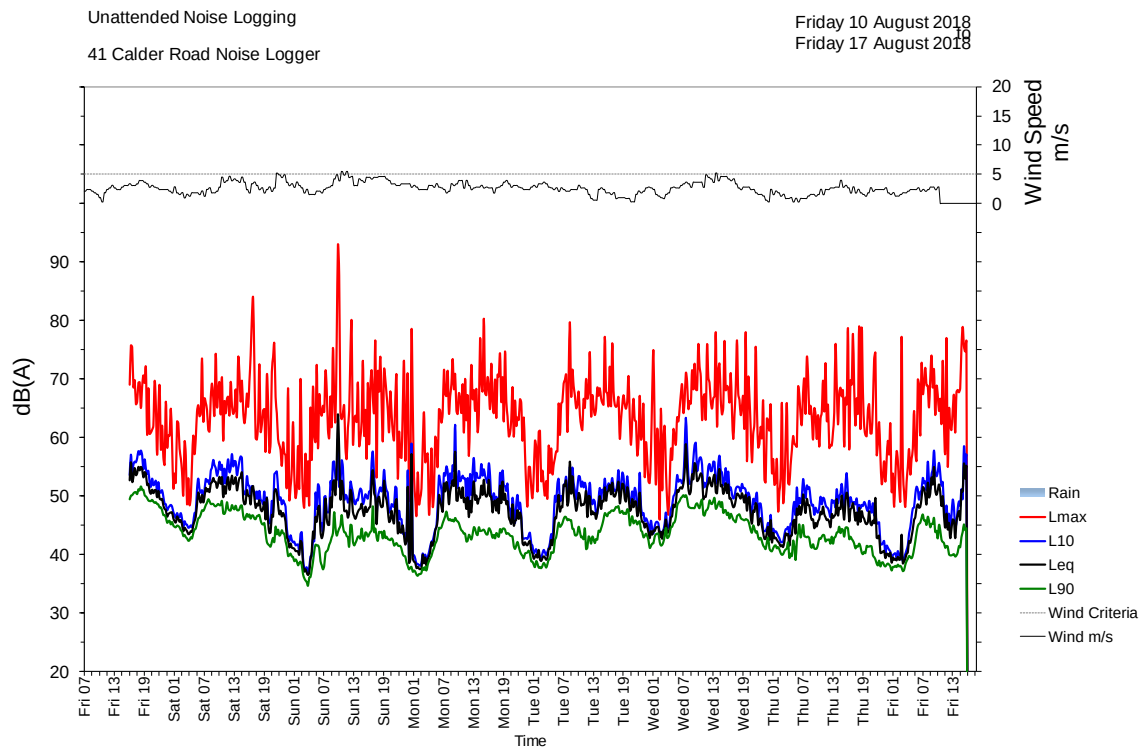


Figure A7 Noise monitoring results for Location U3 (41 Calder Road)