UNIVERSITY OF SYDNEY

F07 CARSLAW BUILDING EXTENSION (LEES1 PROJECT)

Acoustic Assessment for Development Application

Issued

16 March 2016

acoustic studio

abn 76 106 325 982
address Unit 27 43-53 Bridge Road Stanmore NSW 2048 Australia
tel (+61) 2 9557 6421
email mail@acousticstudio.com.au

Contact for this Report

Jason Cameron
jason.cameron@acousticstudio.com.au

acoustic studio

abn 76 106 325 982
address Unit 27 43-53 Bridge Road Stanmore NSW 2048 Australia
tel (+61) 2 9557 6421
email mail@acousticstudio.com.au

Proj & Code	University of Sydney – F07 Carslaw Building Extension (LEES1 Project)		UOS-3001
Doc Title	Acoustic Assessment for Development Application		
Ref	20160316 UOS3003.0002.Rep.rev2.docx		
Date	16 March 2016		Revision: 2
Author(s)	Jason Cameron & Jorge Reverter		
Circulation	**Organisation**	**Location**	**Delivered Via**
Tony Neill	Richard Crookes Construction	Sydney	e-mail
Alex Matovic	Rice Daubney	Sydney	e-mail
Attachment(s)	As listed on the Table of Contents		

acoustic studio is a member of the
Association of Australian Acoustical Consultants

Table of Contents

Executive Summary

The University of Sydney (UoS) is currently proposing to develop an extension of the F07 Carslaw Building (LEES1 Project) within its Camperdown/Darlington campus. The proposal involves the extension of Building F07 to accommodate teaching and research labs plus write up spaces.

Secretary's Environmental Assessment Requirements (SEARs) have been issued, requiring the preparation of an Environmental Impact Statement (EIS) for the proposed development. This acoustic assessment report has been prepared in support of the EIS for the proposed LEES1 project.

As per item 7 of the SEARs, noise and vibration generated by the development is addressed in this report according to the following guidelines:

- EPA/OEH NSW Industrial Noise Policy 2000 (INP)
- DECCW Interim Construction Noise Guideline 2009 (ICNG)
- DECC Assessing Vibration: A Technical Guideline 2006

In addition, this report includes an assessment of the impact of road traffic noise under the provisions of Clause 102 of State Environmental Planning Policy (Infrastructure).

The existing noise environment has been established based on long-term and short-term monitoring data. Appropriate criteria for both noise and vibration have been discussed and set according to established guidelines and standards as per the SEARs.

A summary of the outcomes and recommendations of the noise and vibration assessment are as follows:

- Mechanical services noise

  At this stage the plant selections have not been made; therefore a detailed assessment has not been able to be carried out. A preliminary review has been carried out for the plant rooms, and based on the location and the most restrictive criteria, noise emissions from the plant rooms shall be limited to 67 dB(A) SPL at 1 metre of the plant rooms boundaries.

  Noise controls will be incorporated within the design of the mechanical plants to ensure that the cumulative noise output from plant at the nearest affected receivers is within the allowable limits. General design consideration and controls implemented will typically include: strategic selection and location of

the plant and/or acoustic noise control measures such as enclosures, barriers, acoustic louvres, silencers, sound absorptive panels, etc.

- Traffic noise assessment

  The façade comprises a combination of glazed curtain walling plus solid cladding panels and aluminium cladding. A minimum Sound Reduction assessment has been undertaken. This assessment has assumed the traffic noise levels from City Road, the recommended background noise levels and reverberation times within the spaces, areas of façade for each space and distance to City Road.

  Based on the above, the minimum overall sound reduction rating for the façade system in order to achieve the design noise levels within the affected spaces, shall achieve R_w 41 dB.

- Construction noise and vibration

  Continuous construction noise and vibration associated with earthworks, excavation and new-build works shall comply with stated criteria for nearest residential and educational receivers.

  However, there will be times/situations when works are likely to exceed the stated criteria, particularly when works occur in the areas closer to sensitive receivers or with direct view between receivers and the works.

  If, during construction works, an item of equipment exceeds the stated airborne noise and/or vibration criteria at any sensitive location, the additional noise/vibration control measures presented in Section 8.3, together with construction best practices, shall be considered to minimise noise and vibration impacts on the sensitive receivers.

1 Introduction

The University of Sydney (UoS) is currently proposing to develop an extension of the F07 Carslaw Building (LEES1 Project) within its Camperdown/Darlington campus. The proposal involves the extension of Building F07 to accommodate teaching and research labs plus write up spaces.

Acoustic Studio has been engaged by the proponent to provide acoustic engineering services for the Development Application. HDR Rice Daubney is the Architect, Steensen Varming is the Mechanical Services Consultant and the University of Sydney is the Project Manager.

Secretary's Environmental Assessment Requirements (SEARs) have been issued, requiring the preparation of an Environmental Impact Statement (EIS) for the proposed development. This acoustic assessment report has been prepared in support of the EIS for the proposed LEES1 project.

As per item 7 of the SEARs, noise and vibration generated by the development is addressed in this report according to the following guidelines:

- EPA/OEH NSW Industrial Noise Policy 2000 (INP)
- DECCW Interim Construction Noise Guideline 2009 (ICNG)
- DECC Assessing Vibration: A Technical Guideline 2006

This acoustic report assesses noise impacts at nearby on-campus and off-campus sensitive receivers due to operation of the LEES1 project once it is completed, and presents the findings of a construction noise assessment. These are in accordance as per SEARs' items 4 and 7, and the objectives of this assessment are to:

- Identify noise sensitive receivers that will potentially be affected by the operation of the proposed building extension.
- Carry out noise surveys to determine existing ambient and background noise levels at the nearest noise sensitive receivers that surround the site.
- Establish the appropriate noise assessment criteria in accordance with the relevant standards and guidelines.
- Determine wether the relevant criteria can be achieved based on proposed operations. Where applicable, provide recommendations for any necessary acoustic control measures that will need to be incorporated into the development or use in order to ensure with the assessment criteria.
- Provide recommendations for Construction Noise and Vibration Planning.

In addition, this report includes an assessment of the impact of road traffic noise under the provisions of Clause 102 of State Environmental Planning Policy (Infrastructure).

2 Description of Proposal

2.1 Project Background

Located in Sydney, UoS has over 52,000 students in 2014[1]. The 72-hectare Camperdown/Darlington site is the main campus and is located near the junction of Parramatta and City Roads.

The LEES1 project involves a new building annexed to the F07 Carslaw Building. This proposed building will accommodate both teaching and research laboratories plus write up spaces. Figure 1 below shows the location of the project and the surrounding area.

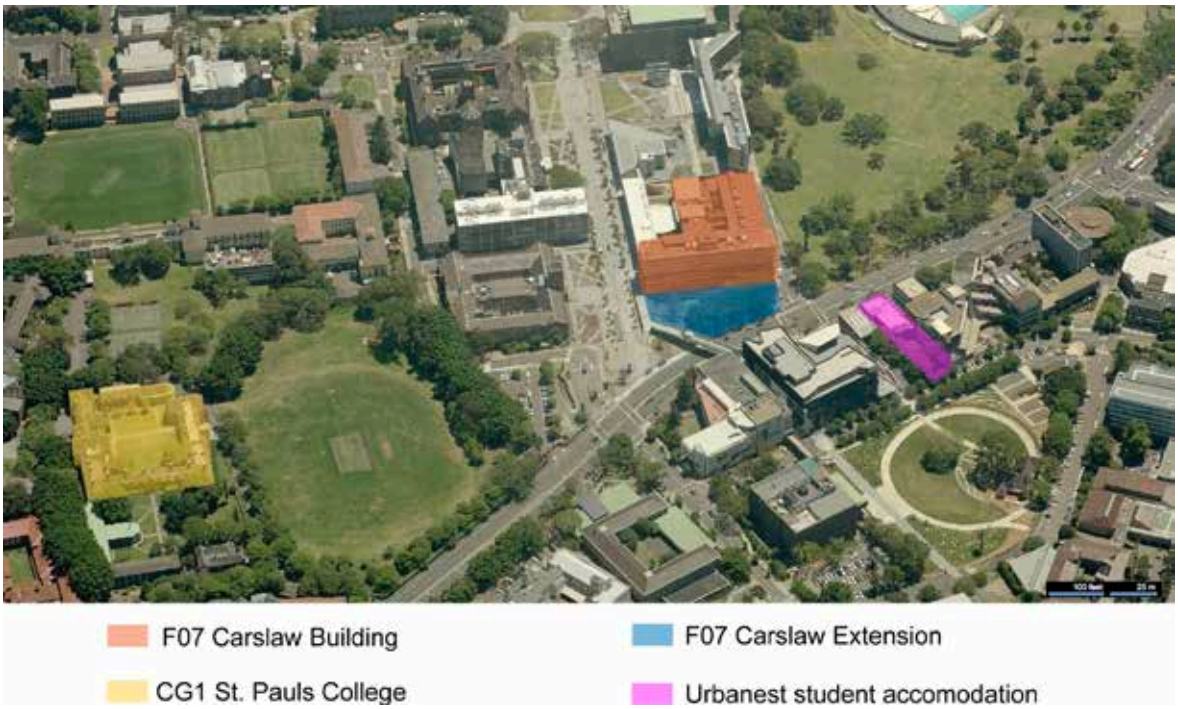


Figure 1: Project site and surrounds

2.2 The Site and Surrounding Area

The F07 Carslaw Building is located within the UoS' Camperdown/Darlington campus and is bordered by City Road, Victoria Park and Eastern Avenue.

[1] http://sydney.edu.au/staff/planning/statistics/enrol/enrol.php?ci=3&type=fac&yr=2014

The site is located within an urban environment characterised by medium to high levels of activity throughout the day and evening, and decreasing noise levels at night.

As shown in Figure 1, the noise sensitive receivers surrounding the site are as follows:

- The nearest residential properties are located to the east of the proposed project, at the Urbanest student residential building sited at 152 City Road approximately 45 metres from the site.
- The nearest on-campus residential properties are located to the west of the proposed project, at St. Pauls College approximately 260 metres from the site.

The educational receivers surrounding the site are as follows:

- The nearest on-campus teaching premises are located within Building F07 to the north of the proposed project and adjacent to the site.
- Other nearby on-campus teaching premises are located within Building F09 (Madsen Building), Building F11 (School of Chemistry) and Building G04 (Architecture).

For the purpose of this noise and vibration assessment, it is noted that if impacts associated with the LEES1 project are controlled at the nearest residential properties and at the nearest educational premises, then compliance with the recommended criteria and limits at all sensitive receivers will be achieved.

2.3 Operating Hours

The proposed development will not change the operating hours of the University. Once the LEES1 project is completed, the premises are expected to normally operate during daytime from 8 am to 6 pm on weekdays, although student/staff 24-hour access is available.

Notwithstanding the above, mechanical plant associated with the F07 Carslaw Building Extension will be operational 24/7.

3 The Key Acoustic Issues

As per the SEARs, the following acoustic issues are to be addressed as part of the EIS for the LEES1 project:

- The impact of mechanical noise generated by mechanical plant to be installed within the extension of Building F07 plantrooms.

  The mechanical plant noise levels are to be assessed against the NSW Office of Environment and Heritage (OEH, previously EPA) Industrial Noise Policy (INP) 2000.

  The mechanical plant noise impact assessment has been presented in Section 6.

- The impact of traffic noise from City Road into the spaces within the building.

  The traffic noise impact assessment has been presented in Section 7.

- The impact of noise and vibration generated during the construction stage of the project on surrounding residential premises and on other UoS buildings within the campus.

  The development will contribute noise and vibration to the surrounding environment during the construction stage of the LEES1 project. Typically, this will result from intermittent noise from construction equipment and plant commonly used on construction sites.

  Design noise and vibration limits have been set for the project and general recommendations for best noise and vibration control practices during the construction are provided.

  The construction noise and vibration limits and recommendations are reported in Section 8 of this report.

4 Existing Noise Environment

4.1 General Survey Information

A survey of the existing noise environment around the LEES1 site was conducted with an unattended noise monitor used to continuously record the noise levels on the site. Long term noise monitoring was carried out from Tuesday 28th July to Tuesday 4th August 2015 to establish the typical range of ambient noise levels of the proposed site and surrounds.

Long term noise monitoring was carried out with a RTA Technology Environmental Noise Logger Type 02 (Serial Number 38). The logger recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the 7-day measurement period. The calibration of the logger was checked before and after use and no variation was noted.

Operator attended short-term monitoring was also carried out on Wednesday 22nd July, Thursday 30th July and Tuesday 4th August 2015 in order to confirm the validity of the long-term outdoor data across the site, to sample background and ambient noise levels at key surrounding residential receivers during the early morning period and to determine traffic noise levels affecting the site.

Short-term measurements were made with a Brüel&Kjær Hand-held Analyser Type 2250 (Serial Number 2446899). The calibration of the analyser was checked before and after the surveys using a Brüel&Kjær Sound Level Calibrator Type 4231 (Serial Number 2438997) and no variation in levels occurred.

A windshield was used to protect the microphone of both the logger and the analyser. Weather conditions were calm and dry during the attended noise survey. The analyser and logger microphones were mounted 1.5 metres above ground.

Jorge Reverter of Acoustic Studio Pty Ltd carried out the surveys, in accordance with the method of measurement described in the *AS/NZS 1055:1997 'Description and measurement of environmental noise', parts 1 and 2*.

The long-term and short-term noise monitoring locations are shown in Figure 2.

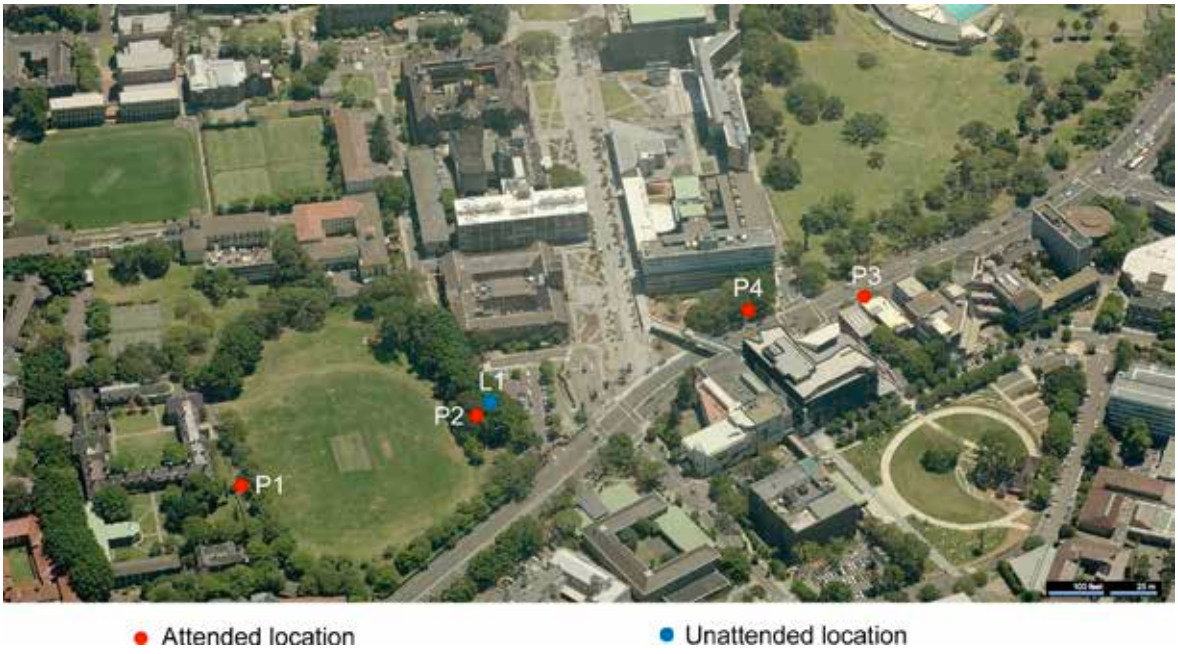


Figure 2: Noise survey locations

4.2 Long-term Monitoring Results

The logger was located to the west of the proposed LEES1 site. This position was chosen since it represented a secure place to leave the noise logger unattended whilst obtaining typical representative background and ambient noise levels at residential receivers. The long-term noise monitoring location (L1) is shown in Figure 2.

The detailed results of the long term noise monitoring at Location L1 are shown graphically in Appendix A.

Weather patterns were monitored during the survey period and were typically calm and dry during the unattended noise survey.

The logged data shows the background and ambient noise levels of the area. The recorded background noise levels have been used to establish a limiting criteria for noise emitted from the building.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{A90}. The ambient noise level impacting on the building is referred to as the equivalent continuous sound level (L_{Aeq}). This parameter is commonly used to describe a time varying noise such as traffic noise.

The background sound levels have been established in general accordance with the methodology described in the NSW INP (see Appendix B for details), i.e. the 10^{th} percentile background sound level for each period for each day of the ambient noise survey. The median of these levels is then presented as the background

sound level for each assessment period. These background noise levels are shown in Table 1 below together with the L_{Aeq} ambient noise levels measured for each period.

As stated in the INP, any data likely to be affected by rain, wind or other extraneous noises has been excluded from the calculations.

Location	*L_{A90} Background Noise Levels, dB(A)*			*L_{Aeq} Ambient Noise Levels, dB(A)*		
	Day 7am-6pm	*Evening 6pm-10pm*	*Night 10pm-7am*	*Day 7am-6pm*	*Evening 6pm-10pm*	*Night 10pm-7am*
L1 – Fisher Road	50	49	43	58	55	52

Table 1: Long-term background and ambient noise levels measured around LEES1 site

From observations during our site visits, it is noted that both ambient and background noise levels around the LEES1 site are currently dominated by traffic noise from City Road located to the south of the project site.

4.3 Short-term Monitoring Results

Four (4) short-term noise monitoring locations were chosen as representative of the site and surrounds as follows:

- **Location P1** on St. Pauls College. Location P1 is representative of current background and ambient noise levels currently impacting nearest campus residential receivers to the west of the proposal.
- **Location P2** on Fisher Road. Location P2 is representative of current background and ambient noise levels at the noise logger location.
- **Location P3** on City Road. Location P3 is representative of current background and ambient noise levels currently impacting nearest off-campus residential receivers to the east of the proposal.
- **Location P4** on City Road. Location P4 is representative of current traffic noise levels currently impacting the proposed building.

The existing ambient noise levels at these locations were dominated by continuous traffic noise from City Road.

The results of the short-term background and ambient noise monitoring around the existing site are shown in Table 2.

Location	Date and time	Parameter	Sound Pressure Level, dB re 20μPa								
			Overall dB(A)	Octave Band Centre Frequency, Hz							
				31.5	63	125	250	500	1k	2k	4k	8k
P1	22/07/2015 2:08 pm	$L_{90,15min}$	**50**	62	63	56	49	47	45	40	31	20
		$L_{eq,15min}$	**55**	65	69	62	55	53	49	45	41	32
		$L_{10,15min}$	**58**	67	72	65	59	56	52	47	41	33
	04/08/2015 12:03pm	$L_{90,15min}$	**46**	61	59	53	46	40	40	36	27	15
		$L_{eq,15min}$	**55**	65	68	64	57	51	48	44	39	32
		$L_{10,15min}$	**59**	68	71	66	59	54	51	47	41	32
P2	22/07/2015 2:25 pm	$L_{90,15min}$	**52**	64	65	59	49	49	47	42	35	22
		$L_{eq,15min}$	**58**	69	72	64	55	56	53	49	44	38
		$L_{10,15min}$	**60**	73	75	67	58	58	55	51	46	39
	04/08/2015 12:21pm	$L_{90,15min}$	**50**	63	63	55	48	48	45	40	32	20
		$L_{eq,15min}$	**57**	68	72	63	55	54	52	48	44	34
		$L_{10,15min}$	**60**	71	76	67	59	57	54	49	43	36
P3	30/07/2015 1:00 am	$L_{90,15min}$	**50**	57	55	53	49	47	46	39	29	18
		$L_{eq,15min}$	**64**	63	65	66	61	60	61	56	48	38
		$L_{10,15min}$	**68**	65	65	64	63	64	65	61	51	42
	04/08/2015 11:32am	$L_{90,15min}$	**59**	67	66	61	58	55	53	49	44	33
		$L_{eq,15min}$	**69**	74	75	73	68	66	65	60	55	46
		$L_{10,15min}$	**72**	78	77	75	71	69	68	64	57	48
P4	22/07/2015 2:45 pm	$L_{90,15min}$	**59**	68	66	63	58	56	54	50	43	34
		$L_{eq,15min}$	**70**	78	76	74	69	67	66	62	55	49
		$L_{10,15min}$	**74**	77	79	76	72	71	70	65	58	50

Table 2: Short-term background and ambient noise levels measured around the LEES1 site

5 Relevant Standards and Guidelines

5.1 Operational Noise

The following standards and guidelines are considered relevant to the project and have been referenced in developing the project noise level criteria.

- Environmental Planning and Assessment Act 1979.
- Protection of the Environmental Operations (POEO) Act 1997.
- EPA / OEH NSW Industrial Noise Policy (INP) 2000.

We note that the noise definitions and conditions provided by the POEO are generally based around a subjective assessment.

Acoustic Studio recommends determining suitable objective criteria for assessing offensive noise, for noise emissions from mechanical plant and the building operations. Compliance with the criteria described in Section 6.1 in this report, in accordance with the NSW INP will ensure that the applicable general noise conditions will be met.

5.2 Construction Noise and Vibration

This acoustic report does not examine in detail the potential impacts from construction noise and vibration on sensitive receivers. The Contractor will be required to prepare a full Construction Noise and Vibration Impact Assessment once the likely construction methods are developed.

The primary references are:

- DECCW Interim Construction Noise Guideline (ICNG) 2009.
- DECC Assessing Vibration – a technical guideline 2006.

5.3 Road Traffic Noise

The following standards and guidelines are considered relevant to the project and have been referenced in developing the project traffic noise level criteria.

- State Environmental Planning Policy (Infrastructure) 2007 – Reg 102

6 Mechanical Plant Noise Impact Assessment

6.1 Environmental Noise Limits

The NSW Industrial Noise Policy (INP) 2000 of the NSW Office of Environment and Heritage (OEH, previously EPA) is specifically aimed at assessing noise from industrial noise sources scheduled under the Protection of the Environmental Operations (POEO) Act 1997.

An assessment carried out in accordance with the requirements of the Policy must:

- Identify any beneficial or adverse noise impacts that might result in the surrounding community.
- Describe any noise mitigation measures and strategies that will be necessary to protect the acoustic amenity of the area.
- Describe the methods by which compliance with the acoustic criteria can determined after the facility is operational.

The assessment is carried out by comparing the new predicted intrusive noise level against the criterion based on the pre-existing background noise level.

Where the intrusive noise is greater than the pre-existing background noise level, the potential exists for disturbance and annoyance. However, the impact is considered marginal if the difference between the pre-existing background noise level and the intrusive noise is 5 dB(A) SPL or less. This concept has resulted in the commonly used criterion of "*background noise level + 5dB*" – applicable between 7:00 am and midnight.

Often the criterion becomes more stringent after midnight, recognising the increased sensitivity of this late night period in residential neighbourhoods. This has resulted in the commonly used criterion of "*background noise level + 0dB*" between midnight and 7:00 am.

These noise level limits are assessed at the boundary of the neighbouring residential properties.

Appendix B contains an extended NSW INP analysis and the derivation of the environmental noise break-out limits shown in Table 3.

Indicative Noise Amenity Area	*Period*	*Intrusiveness Criterion*	*Amenity Criterion*
Residential	Day	55	56
	Evening	54	45
	Night	48	42

Table 3: Determination of project specific noise levels (ANLs – light grey shadows) for the LEES1 site

6.2 Noise Sources

At this stage, final plant selections have not been made. However, we understand that the plant rooms on Level 2, and Level 8 contain mechanical plant that will operate continuously during weekdays and weekends in order to maintain the laboratories pressure regime. The proposed plant room locations are shown in Figures 3, and 4 below.

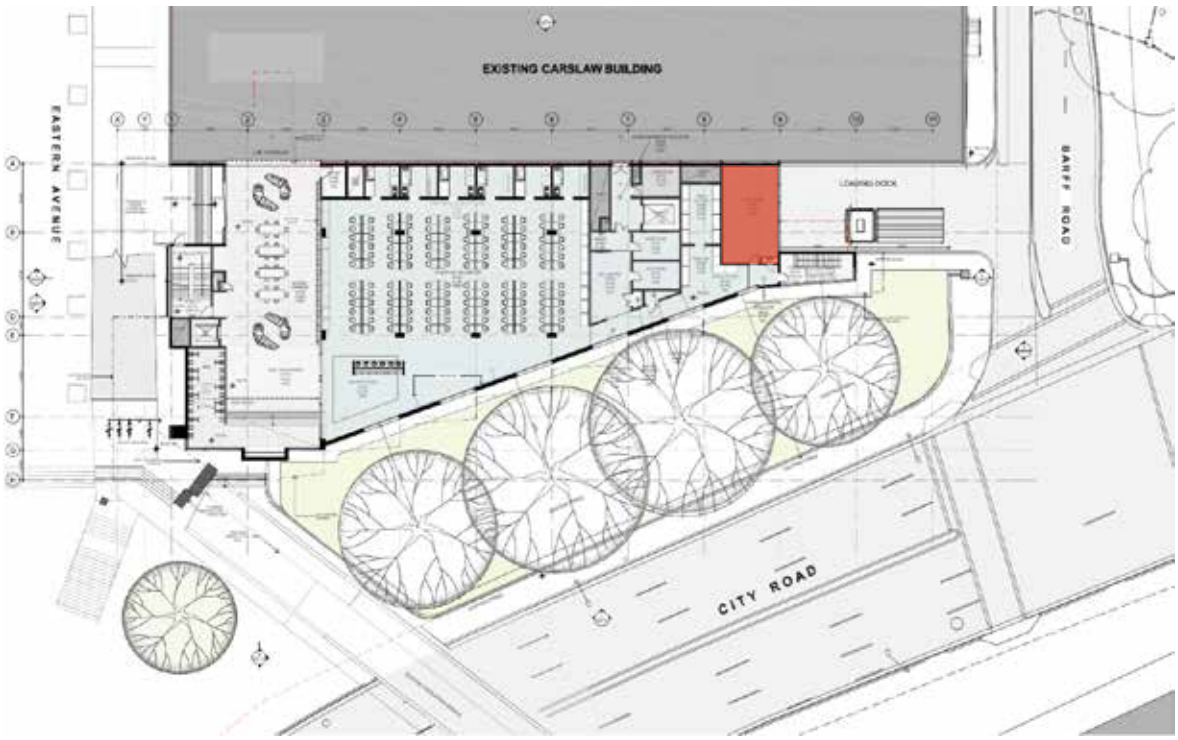


Figure 3: Level 2 plant room location (highlighted in red)

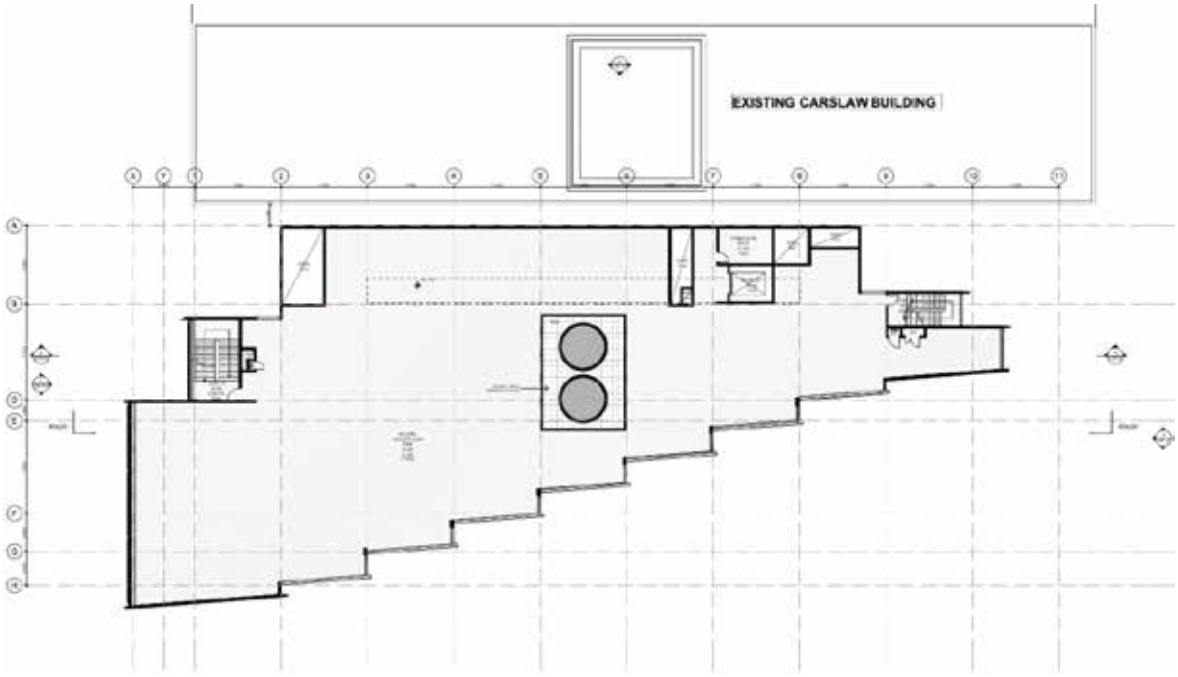


Figure 4: Level 8 plant room location (entire Level 8)

6.3 Noise Assessment and Noise Control Recommendations

Plant associated with the operation of the proposed building shall be controlled to ensure external noise emissions are not intrusive and do not impact on the amenity of neighbouring receivers. In particular, externally located plant, air intake and discharge louvres in the external walls, roof mounted and roof discharging extract and exhaust fans, and externally located chillers or condenser units shall require acoustic attenuation measures.

At this stage, final plant selections have not been made; therefore it is not possible to undertake a detailed assessment.

A preliminary review has been carried out for the plant rooms and we make the following comments:

- Based on the plant room locations, the most restrictive criteria (see Section 6.1) are 55 dBA, 45 dBA and 42 dBA at residential receivers on City Road (Urbanest student accommodation) during the day, evening and night-time periods respectively.
- Considering the distance from the plant rooms to the nearest sensitive receiver on City Road, noise emissions from the plant rooms shall be limited to L_{Aeq} 67 dBA SPL at 1 metre from each plant room boundary to comply with the most restrictive criteria.

Noise controls will need to be incorporated with the design of the plant rooms to ensure that the cumulative noise output from plant at the nearest affected receivers is within the allowable limits.

General design considerations and controls that may need to be implemented will typically include, but are not limited to:

- Strategic selection and location of plant to ensure the cumulative noise contribution at the receiver boundaries is achieved, and/or
- Acoustic noise control measures to be put in place to minimise noise impacts such as:
  - Noise enclosures as required
  - Noise barriers as required
  - Acoustic louvres as required
  - In-duct attenuation
  - In-built attenuation for noisy equipment
  - Sound absorptive panels

7 Traffic Noise Assessment

7.1 Internal Design Sound Levels and Reverberation Times

The State Environmental Planning Policy (Infrastructure) 2007 - Reg 102 requires that traffic noise impacts be assessed for educational building developments that are *"…on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 40,000 vehicles…".*

Recommendations for the internal design sound levels are made by reference to Australian Standard AS/NZS 2107:2000, '*Recommended design sound levels and reverberation times for building interiors*'. This Standard recommends design criteria for conditions affecting the acoustic environment within occupied spaces of a range of buildings.

The design sound levels are given as equivalent continuous A-weighted sound pressure levels measured in decibels, L_{Aeq} dB(A). They take into account the function of the area(s) and apply to the space unoccupied but fully fitted-out and ready for occupancy.

The Standard applies to *steady state* and/or *quasi-steady-state* sounds (e.g. air-conditioning noise – *steady state,* and continuous traffic noise – *quasi-steady-state*). The sound levels apply to the normal operating conditions of the building and represent the total sound level from all *steady-state* or *quasi-steady-state* sounds normally affecting the space.

The recommended noise level is presented as a range from *satisfactory* to *maximum*.

The *satisfactory* design sound level is defined as: *The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.*

The *maximum* design sound level is defined as: *The level of noise above which most people occupying the space start to become dissatisfied with the level of noise*. It can also be considered acceptable, but there is a greater perception of intrusion of this noise level and effect on the activities of the space. Beyond this *maximum* level there is a risk of increasing user dissatisfaction with the environment of the space in question.

The indoor noise level requirements from the UoS Mechanical Design Guideline address to the AS 2107:2000, and sets a NR curve criteria for specific areas.

Table 4 shows the recommended design sound levels and reverberation times within the various spaces as per AS 2107:2000 and UoS Mechanical Design Guideline. Light grey shadowed cells show the most-stringent criteria for each space.

Type of occupancy / activity	*AS2107:2000 Recommended design sound levels, L_{Aeq} dB(A)*		*UoS Mechanical Design Guideline Indoor Noise levels*		*AS2107:2000 Recommended design reverberation time (s)*
	Satisfactory sound level	*Maximum sound level*	*Lower Level*	*Upper Level*	
Laboratories – Teaching	35	45	NR25 (≈35)	NR30 (≈40)	0.5 to 0.7
Laboratories – Working	40	50	NR25 (≈35)	NR30 (≈40)	0.6 to 0.8
Professional and Administrative Offices	35	40	NR25 (≈35)	NR30 (≈40)	0.6 to 0.8
Office Areas	40	45	NR25 (≈35)	NR30 (≈40)	0.4 to 0.6
Corridors and Lobbies	45	50	---		0.6 to 0.8
Staff Common Areas	40	45	---		0.4 to 0.6
Toilets / Changers / Showers	45	55	---		---
Not classified in AS/NZS 2107:2000					
Plant rooms	65	75	---		---
Storage and Utility Rooms	45	50	---		---

Table 4: Design sound levels and reverberation times for internal areas

7.2 Façade Sound Reduction Assessment

Noise from City Road traffic will be the key noise source - since traffic noise levels around the site are dominated by constant traffic along City Road.

Following the analysis of the attended noise monitoring (P4 location – refer to measured data presented in Section 4.3), the L_{Aeq} noise source spectra of City Road during a busy traffic hour is used for assessment purposes.

These noise levels have been considered as continuous over a 15-minute assessment period to provide a worst-case scenario.

The façade comprises a combination of glazed curtain walling plus solid cladding panels and aluminium cladding. A minimum Sound Reduction assessment has been undertaken. This assessment has assumed the traffic noise levels noted above, the recommended background noise levels and reverberation times within the spaces, areas of façade for each space and distance to City Road.

In order to achieve the total internal noise levels proposed for each space in Table 4, the façade, other external building elements and ventilation openings will need to be designed to provide the following external-to-internal sound insulation performance:

Parameter	*R, dB ref 20μPa*							
		Octave Band Centre Frequency, Hz						
	R_w	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*
Approximate Minimum Sound Reduction	41	24	33	36	39	42	42	38

Table 5: Approximate Minimum Airborne Sound Reduction Index for the façade system – Lab test

8 Construction Noise and Vibration Management

Currently the project is at an early design stage and the detailed construction program is not yet fully defined. This section of the assessment provides general recommendations only and provides applicable criteria together with best noise and vibration control practices to be observed during the construction of the LEES1 project.

This preliminary advice in relation to construction noise and vibration management shall form the basis for the Contractor's Construction Noise Management Plan.

8.1 Relevant Codes and Standards

In preparing this construction noise and vibration assessment, the following legislation, codes and standards have been found to be relevant for the LEES1 project:

- OEH / DECCW Interim Construction Noise Guideline, 2009
- OEH / DECC Assessing Vibration: A Technical Guideline, 2006
- AS 2436:2010 Guide to noise and vibration control on construction, demolition and maintenance sites
- AS 2670.2:1990 Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)
- BS 6472.1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting
- Protection of the Environment Operations Act 1997

8.2 Construction Noise and Vibration Criteria

8.2.1 Airborne Noise

The noise criteria and operational levels presented in this section are for guidance only and do not form part of any legal obligation on the part of the project proponent. However, compliance with these criteria/limits is considered best practice.

The ICNG suggests construction noise management levels that may minimise the likelihood of annoyance being caused to noise sensitive residential receivers depending on the duration of works. The management levels for long-term duration works, such as those proposed for the LEES1 Project, are as follows:

- Within recommended standard hours.

  The $L_{Aeq,15min}$ level measured at the most exposed boundary of any affected residential receiver when the construction site is in operation must not exceed the background noise level by more than 10 dB(A) SPL. This noise level represents the point above which there may be some community reaction to noise.

  However, in the case of a highly noise affected area, the construction noise level ($L_{Aeq,15min}$) at the most exposed boundary of any affected residential receiver when the construction site is in operation should not exceed 75 dB(A) SPL. This level represents the point above which there may be strong community reaction to noise.

- Outside recommended standard hours.

  The $L_{Aeq,15min}$ level measured at the most exposed boundary of any affected residential receiver when the construction site is in operation must not exceed the background level by more than 5 dB(A) SPL.

  It is noted that a strong justification is required for works outside the recommended standard hours.

The ICNG also suggests construction noise management levels for commercial and retail premises and for recreation areas surrounding construction sites. These levels are applicable to the commercial/retail and educational premises within and around the UoS Camperdow/Darlington campus. They are as follows:

- Commercial and retail premises: $L_{Aeq,15min}$ 70 dBA (external)
- Educational institutions: $L_{Aeq,15min}$ 45 dBA (internal)

Table 6 below summarises the airborne construction noise criteria for most-affected noise sensitive receivers surrounding the LEES1 site.

Sensitive Receiver	*Airborne Construction Noise Criteria, L_{Aeq} dB(A)*	
	Within Standard Hours	*Outside Standard Hours*
Residential receivers		
Noise affected	58 + 10 = **68**	52 + 5 = **57**
Highly noise affected	75	N/A
Commercial and retail	70	
Educational premises	45 (internal)	

Table 6: ICNG construction airborne noise criteria for sensitive receivers surrounding LEES1 site

8.2.2 Ground-borne Noise

The ICNG recommends internal ground-borne noise maximum levels at residences affected by nearby construction activities. Ground-borne noise is noise generated by vibration transmitted through the ground into a structure and can be more noticeable than airborne noise for some sensitive receivers. The ground-borne noise levels presented below from the ICNG are for residential receivers during evening and night-time periods only, as the objective is to protect the amenity and sleep of people when they are at home.

- Evening: $L_{eq,15min}$ 40 dB(A) (internal)
- Night: $L_{eq,15min}$ 35 dB(A) (internal)

The internal noise levels are assessed at the centre of the most affected habitable room.

8.2.3 Vibration

Vibration Criteria for Human Comfort

The OEH / DECC *"Assessing Vibration: A Technical Guideline"* is based on the guidelines contained in BS 6472.1:2008, Guide to evaluation of human exposure to vibration in buildings - Vibration sources other than blasting.

This guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques.

Vibration in buildings can be caused by many different external sources, including construction works. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time).

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent:

- Continuous vibration continues uninterrupted for a defined period (usually throughout daytime and/or night-time).
- Impulsive vibration is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.
- Intermittent vibration can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or

continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery). This type of vibration is assessed on the basis of vibration dose values.

Vibration criteria for continuous and impulsive vibration is presented in Tables 7 and 8 below.

Location	*Assessment Period*	*RMS velocity, mm/s (dB ref 10^{-6} mm/s)*		*Peak velocity, mm/s (dB ref 10^{-6} mm/s)*	
		Preferred	*Maximum*	*Preferred*	*Maximum*
Residential	Daytime	0.20 mm/s (106 dB)	0.40 mm/s (112 dB)	0.28 mm/s (109 dB)	0.56 mm/s (115 dB)
	Night-time	0.14 mm/s (103 dB)	0.28 mm/s (109 dB)	0.20 mm/s (106 dB)	0.40 mm/s (112 dB)
UoS Laboratories	When in use	0.40 mm/s (112 dB)	0.80 mm/s (118 dB)	0.56 mm/s (115 dB)	1.1 mm/s (121 dB)
Commercial and retail	When in use	0.40 mm/s (112 dB)	0.80 mm/s (118 dB)	0.56 mm/s (115 dB)	1.1 mm/s (121 dB)

Notes: Daytime is 7.00am to 10.00pm and night-time is 10.00pm to 7.00am

Table 7: Continuous vibration criteria applicable to the LEES1 Project – Human Comfort

Location	*Assessment Period*	*RMS velocity, mm/s (dB ref 10^{-6} mm/s)*		*Peak velocity, mm/s (dB ref 10^{-6} mm/s)*	
		Preferred	*Maximum*	*Preferred*	*Maximum*
Residential	Daytime	6.0 mm/s (136 dB)	12 mm/s (142 dB)	8.6 mm/s (139 dB)	17 mm/s (145 dB)
	Night-time	2.0 mm/s (126 dB)	4.0 mm/s (132 dB)	2.8 mm/s (129 dB)	5.6 mm/s (135 dB)
UoS Laboratories	When in use	13 mm/s (142 dB)	26 mm/s (148 dB)	18 mm/s (145 dB)	36 mm/s (151 dB)
Commercial and retail	When in use	13 mm/s (142 dB)	26 mm/s (148 dB)	18 mm/s (145 dB)	36 mm/s (151 dB)

Notes: Daytime is 7.00am to 10.00pm and night-time is 10.00pm to 7.00am

Table 8: Impulsive vibration criteria applicable to the LEES1 Project – Human Comfort

When assessing intermittent vibration comprising a number of events, the vibration dose value (VDV) should be used. The VDV is given by the fourth root of the integral with respect to time of the fourth power of the acceleration after it has been weighted. This is the root-mean-quad approach. The use of the fourth power method makes VDV more sensitive to peaks in the acceleration waveform. VDV accumulates the vibration energy received over the daytime and night-time periods.

VDV_e may be calculated for each event as:

$$VDV_e = 1.4 \times a_{rms} \times t^{0.25}$$

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

The total VDV is then calculated using the following formula:

$$VDV = \left(\sum_{n=1}^{n=N} VDV_{e_n}^4 \right)$$

where VDV is the total vibration dose for the day in $m/s^{1.75}$, "VDV_e" is the vibration dose for each event ($m/s^{1.75}$) and "N" is the total number of vibration dose events.

Acceptable values of vibration dose for the LEES1 Project are presented in Table 9.

Location	*Assessment Period*	*Vibration Dose Values, $m/s^{1.75}$*	
		Preferred	*Maximum*
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
UoS Laboratories	When in use	0.40	0.80
Commercial and retail	When in use	0.40	0.80

Table 9: Intermittent vibration criteria applicable to the LEES1 Project

Vibration criteria for building damage

The criteria given in Table 6 for Human Comfort shall generally form the limiting vibration criteria for the Project.

Further criteria to prevent building damage and disruption to equipment and processes are discussed in Appendix C.

For unoccupied buildings or during periods when the buildings are unoccupied, the criteria for building damage suggested by German Standard DIN 4150.3:1993 is to be adopted as follows:

- 5 mm/s (134 dB ref 10^{-6} mm/s) for residential dwellings
- 20 mm/s (146 dB ref 10^{-6} mm/s) for UoS classrooms, laboratories and other commercial premises

8.3 Control Elements

The University of Sydney will require the Contractor to minimise the impacts of noise and vibration from the construction site upon occupants of the F07 Carslaw Building and on surrounding areas.

In order to meet the noise and vibration requirements of the site, the Contractor will be required to engage a qualified acoustic consultant to assist in the compilation of a Construction Noise and Vibration Management Plan, and undertake noise and vibration monitoring for the duration of the project.

8.3.1 Working Hours

Recommended standard hours of work in the OEH / DECCW Interim Construction Noise Guideline (ICNG) are as follows:

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

The project construction hours will be in accordance with the DA conditions.

8.3.2 Noise

As a general rule, prevention should be applied as universal work practice at any time of day, but especially for any construction works to be undertaken at critical times outside normal daytime/weekday periods.

It is noted that the reduction of noise at the source and the control of the transmission path between the construction site and the receiver(s) are the preferred options for noise minimisation. Providing treatments at the affected residences or other sensitive land uses should only be considered as a last resort.

Construction noise shall be managed by implementing the strategies listed below:

- Plant and equipment
  - Use quieter methods.
  - Use quieter equipment.
  - Operate plant in a quiet and effective manner.
  - Where appropriate, limit the operating noise of equipment.
  - Maintain equipment regularly.
  - Where appropriate, obtain acoustic test certificates for equipment.
- On site noise management
  - Strategically locate equipment and plant.
  - Avoid the use of reversing alarms or provide for alternative systems.
  - Maximise shielding in the form of existing structures or temporary barriers.
  - Schedule the construction of barriers and structures so they can be used as early as possible.
- Consultation, notification and complaints handling
  - Provide information to neighbours before and during construction.
  - Maintain good communication between the community and Project staff.
  - Have a documented complaints process and keep register of any complaints.
  - Give complaints a fair hearing and provide for a quick response.
  - Implement all feasible and reasonable measures to address the source of complaint.
- Work scheduling
  - Schedule activities to minimise noise impacts.
  - Ensure periods of respite are provided in the case of unavoidable maximum noise levels events.
  - Flexible working hours avoiding noise works during normal business hours and during University exam periods.
  - Keep truck drivers informed of designated routes, parking locations and delivery hours.

8.3.3 Vibration

The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating plant to determine whether the existence of significant vibration levels justifies a more detailed investigation.

A more detailed investigation will involve methods of constraining activities generating high vibration levels. A method of monitoring vibration levels will then need to be put in place. Vibration mitigation measures and a review of vibration criteria may then be necessary.

All practical means should be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.

The following considerations shall be taken into account:

- Modifications to construction equipment used.
- Modifications to methods of construction.
- Rescheduling of activities to less sensitive times.

If the measures given above cannot be implemented or have no effect on vibration levels or impact generated, a review of the vibration criteria should be undertaken and the vibration management strategy amended.

8.3.4 Vibration Surveys

Since the actual vibration levels experienced will be dependent upon the site characteristics and the specific equipment being used, early vibration level checks should be carried out on site at the outset of each key vibration generating activity (if vibration is considered to be an issue).

Shortly before the commencement of each activity the background vibration level could be measured and again once the activity has begun. If the survey indicates levels of vibration exceeding those expected, the vibration management strategy for that process could be re-assessed.

8.3.5 Additional Noise and Vibration Control Measures

If, during construction, an item of equipment exceeds ether the noise criteria at any location or the equipment noise level limits, the following noise control measures, together with construction best practices, shall be considered to minimise the noise impacts on the neighbourhood.

- Schedule noisy activities to occur outside of the most sensitive times of the day for each nominated receiver. For example, the residential receivers are likely to be more sensitive to noise before 9 am than the UoS campus receivers.
- Consider implementing equipment-specific screening or other noise control measures recommended in Appendix C of AS 2436:2010.
- Limit the number of trucks on site at the commencement of site activities to the minimum required by the loading facilities on site.
- When loading trucks, adopt best practice noise management strategies to avoid materials being dropped from height into dump trucks.
- Avoid unnecessary idling of trucks and equipment.
- Ensure that any miscellaneous equipment (extraction fans, hand tools, etc) not specifically identified in this plan incorporates silencing/shielding equipment as required to meet the noise criteria.

Implementation of all reasonable and feasible mitigation measures for all internal and underground works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when noise goals cannot be met due to safety or space constraints.

8.4 Noise and Vibration Monitoring

8.4.1 Noise Monitoring

The two phases of the project to be noise monitored are:

- Earthworks and Excavation phase.
- Structure and Finishes phase.

Noise monitoring will be undertaken to monitor and help to minimise construction noise in order to avoid discomfort to occupants of the surrounding areas.

An allowance of 1.5 days per week, at least, should be dedicated to monitoring of noise and vibration for the first four weeks. Further monitoring should be reviewed after this time or sooner should it be deemed necessary by the Acoustic Consultant and the Project Manager. If results indicate noise levels exceeding allowable limits appropriate action should be taken.

8.4.2 Vibration Monitoring

A vibration monitoring system shall be implemented during the earthworks and excavation phase in order to monitor human discomfort and potential structural damage in and around adjacent buildings.

This system would monitor vibration levels when there is potential for them to change. This could happen in various situations, such as, changes in equipment and activities or changes to work procedures that might affect existing vibration control measures. The monitoring procedure would be carried out with appropriate equipment so that results obtained are readily comparable with results obtained earlier. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

8.4.3 Reporting

The Contractor should prepare a noise monitoring report each month for review by the Project Manager. The reports should summarise and interpret the results of the noise and vibration monitoring carried out during the past month.

8.5 Communication and Complaints

The Contractor should establish a communications register for recording incoming complaints. The registration of a particular item will remain open until the complaint has been appropriately dealt with.

In addition the following procedures are an example of the procedures that should be specifically adopted for complaints relating to noise.

Upon receipt of a complaint The Contractor should:

- Try to ascertain from the complaint which appliance is causing the problem i.e. inside or outside the site and in what position.
- Establish from the monitoring equipment if the allowable noise levels have been complied with.
- Establish if the appliance positioning has previously been highlighted as a problem area. If not and the noise levels are above the allowable limit, then the equipment and its position shall be noted.
- Move machinery if the allowable levels have been exceeded or take other acoustic remedial action.

If the activity is occurring outside normal working hours, the activity should be immediately stopped. Where stopping the activity would create a safety issue the activity may be permitted to continue only as long as is necessary to make the area safe. The activity should then cease.

Any activity which is directed to cease due to excessive noise should not recommence until the Project Manager is satisfied that the noise and vibration

limits requirements can be met and has given permission to recommence the activity.

The Site Supervisor should ensure that a report of any incident is provided to the Project Manager.

The Project Manager should provide a report on the incident to the relevant stakeholders.

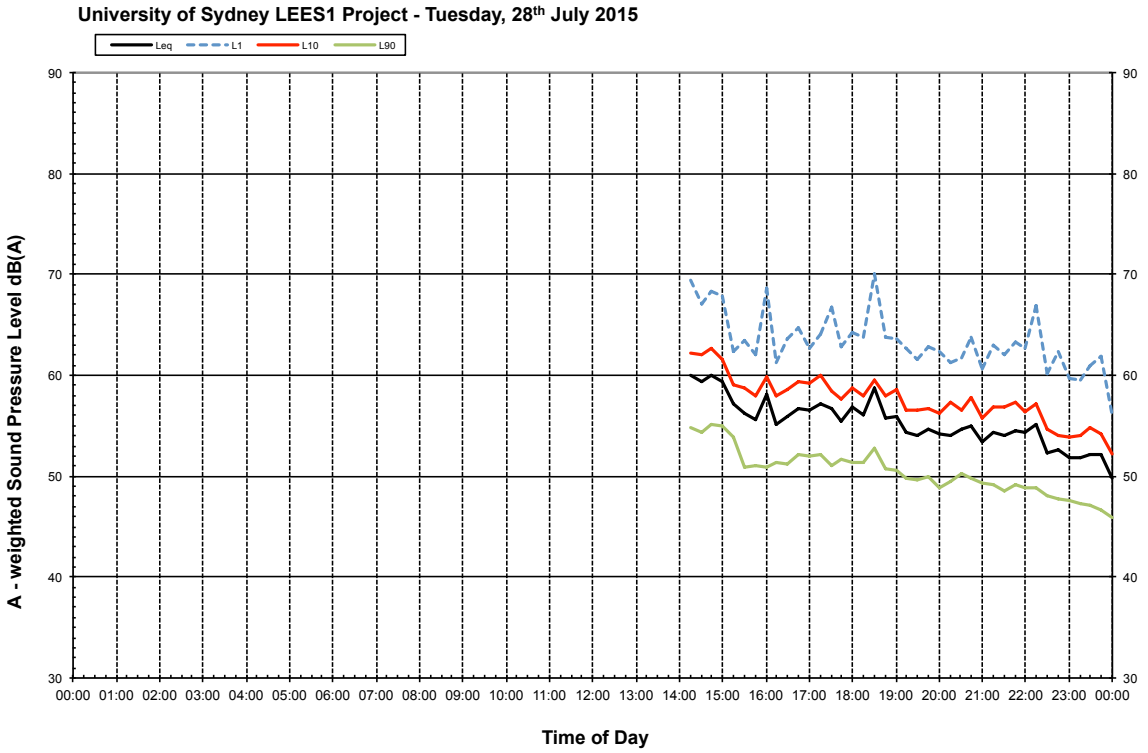
The Contractor should provide a 24 hour telephone contact number and this number should be prominently displayed on the site.

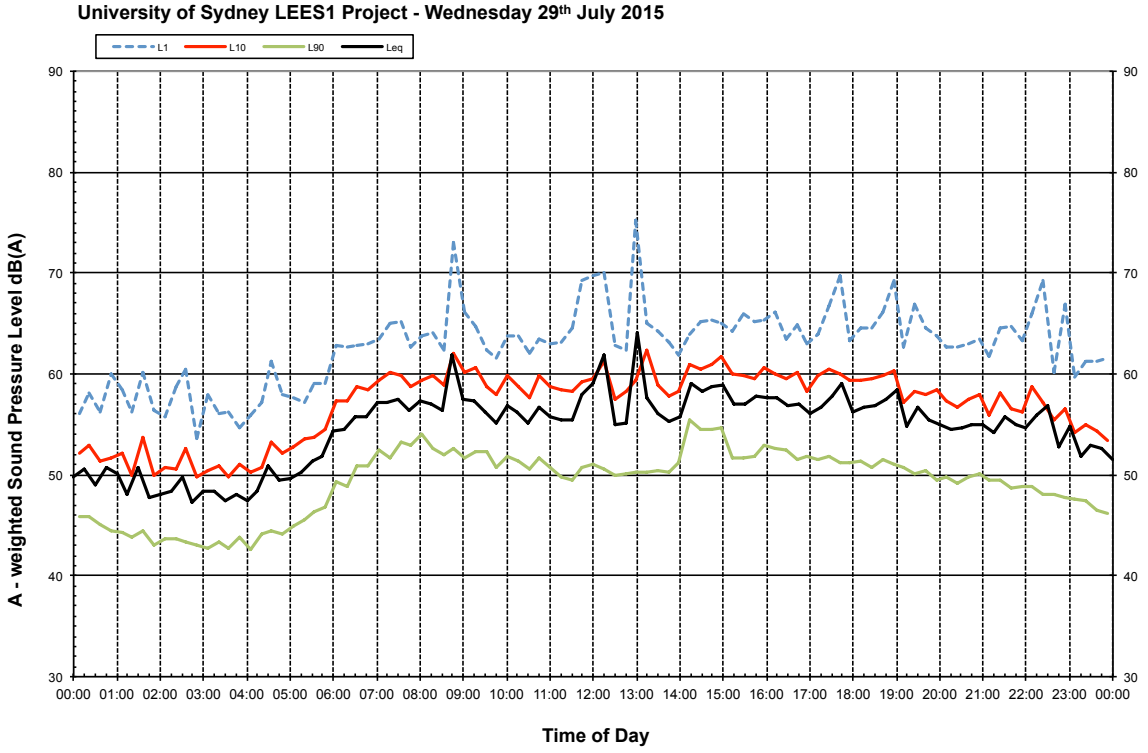
8.6 Non-compliances

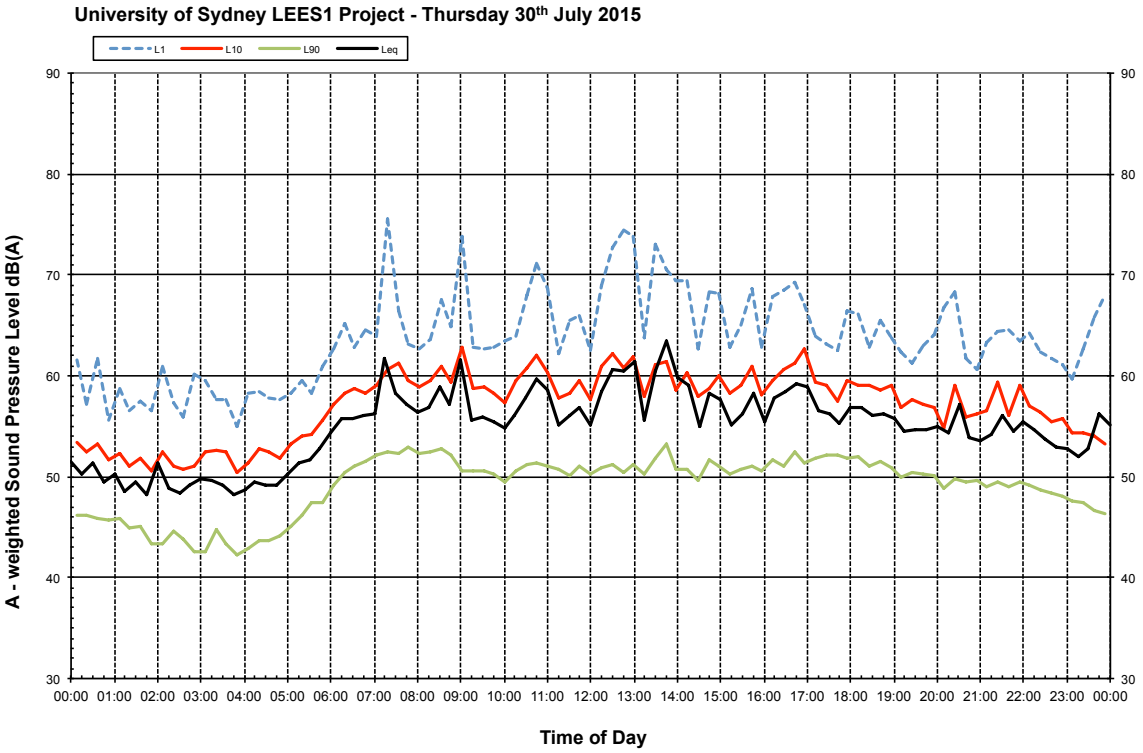
Non-compliance reports can be used as appropriate to deal with failures to meet the construction vibration management and control requirements.

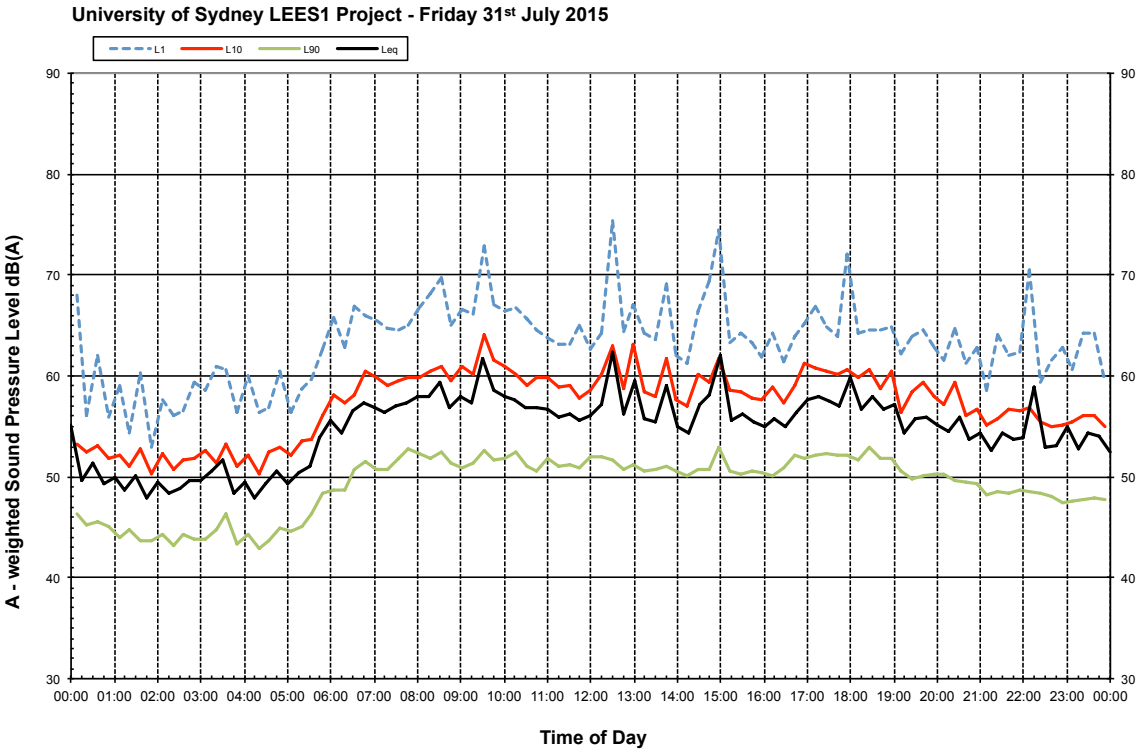
Appendices

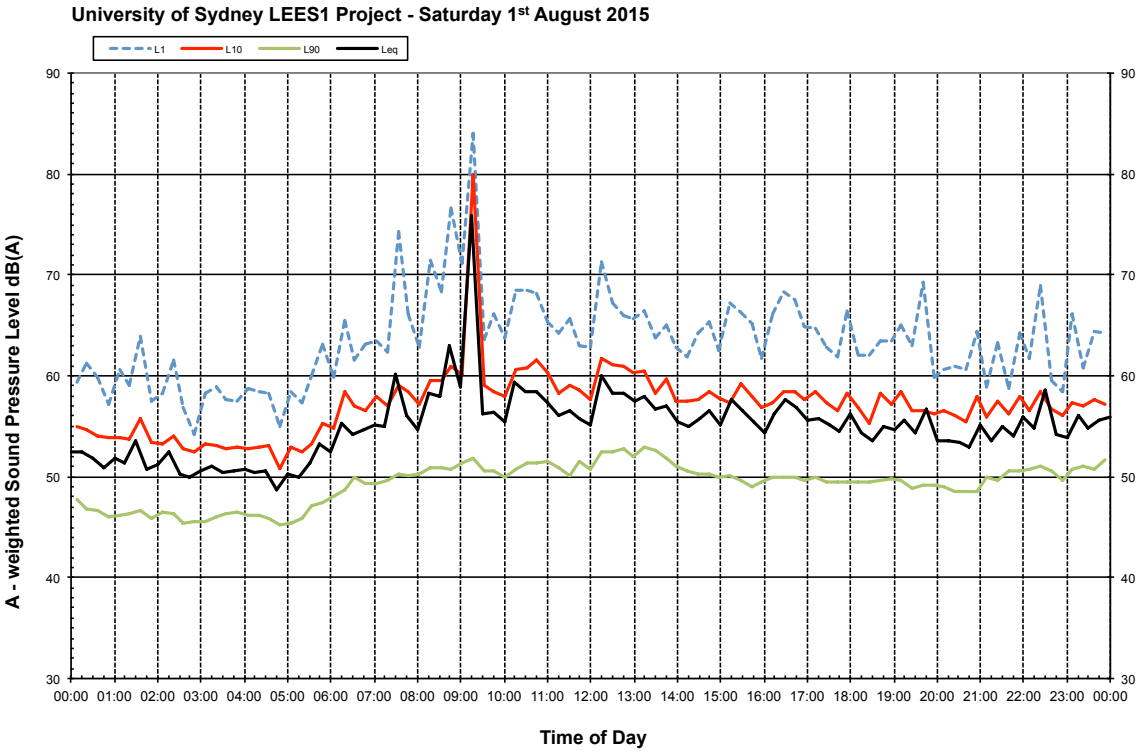
Appendix A: Long-term Monitoring Results

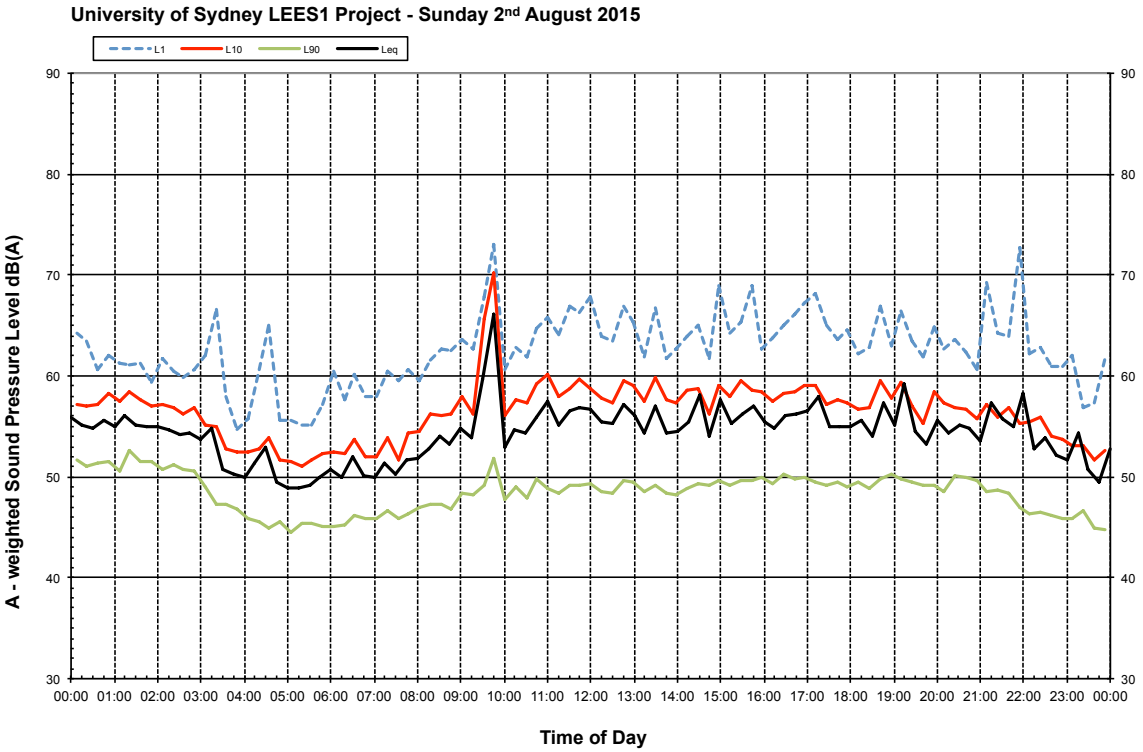


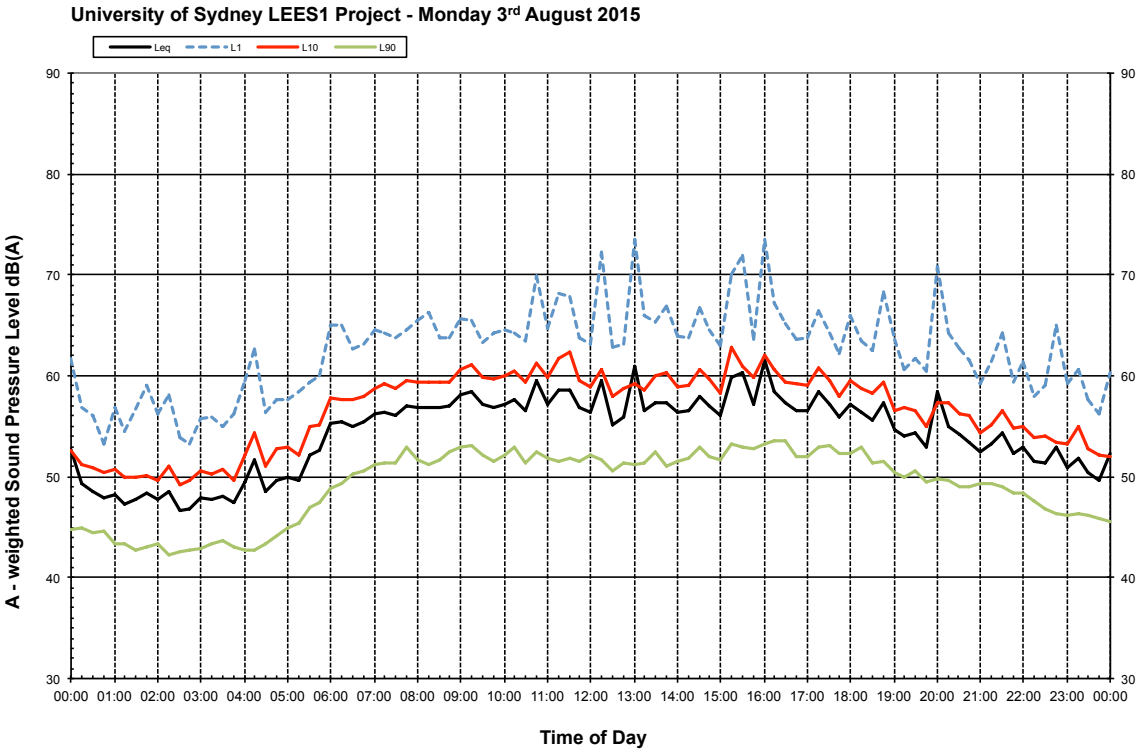


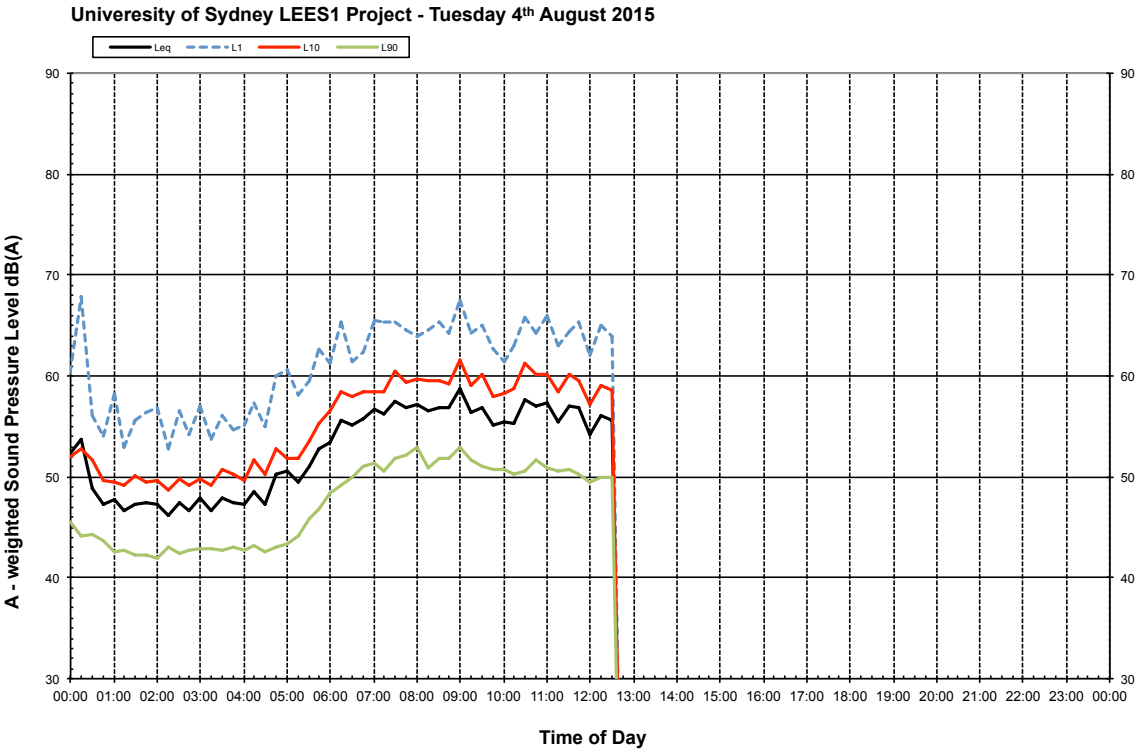

University of Sydney LEES1 Project - Thursday 30th July 2015
L1
L10
L90
Leq
A - weighted Sound Pressure Level dB(A)
90
80
70
60
50
40
30
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00
Time of Day


University of Sydney LEES1 Project - Friday 31st July 2015
L1
L10
L90
Leq
A - weighted Sound Pressure Level dB(A)
90
80
70
60
50
40
30
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00
Time of Day


University of Sydney LEES1 Project - Saturday 1st August 2015
L1
L10
L90
Leq
A - weighted Sound Pressure Level dB(A)
90
80
70
60
50
40
30
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00
Time of Day


University of Sydney LEES1 Project - Sunday 2nd August 2015
L1
L10
L90
Leq
A - weighted Sound Pressure Level dB(A)
90
80
70
60
50
40
30
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00
Time of Day


University of Sydney LEES1 Project - Monday 3rd August 2015
Leq
L1
L10
L90
A - weighted Sound Pressure Level dB(A)
90
80
70
60
50
40
30
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00
Time of Day


Univeresity of Sydney LEES1 Project - Tuesday 4th August 2015
Leq
L1
L10
L90
A - weighted Sound Pressure Level dB(A)
90
80
70
60
50
40
30
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00
Time of Day

Appendix B: Derivation of Environmental Noise Break-out Limits

The main source of noise break-out from the LEES1 site to the environment will be mechanical services plant.

The environmental noise impact of the mechanical plant will be assessed in accordance with the NSW Industrial Noise Policy 2000 (NSW INP).

The NSW INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. Both are used to derive the project specific noise level.

Assessing intrusiveness

The intrusiveness criterion essentially means that the equivalent continuous noise level of the source should not be more than 5 dB above the measured existing background noise level.

Assessing amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise, including plant. The existing noise level from industry (or plant) is measured - if it approaches the criterion value, then the noise levels from new plant need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion.

The cumulative effect of noise from all industrial or plant sources is considered in assessing impact.

Project specific noise level

For the new plant, the more stringent of the intrusive and the amenity criteria sets the project specific noise level.

The derivation of the project specific noise levels is provided below.

B.1 Existing Background and Ambient Noise Levels

The rating background level (RBL) has been determined from $L_{A90,15min}$ measured during the long-term noise survey in accordance with the methodology prescribed in NSW INP. Data affected by adverse weather conditions was removed for the analysis procedure. This data are shaded on the graphs in Appendix A

Three time periods are considered (consistent with the operating times of the plant associated with the development and the time of day classifications in the Policy):

- Day - 7 am to 6 pm
- Evening - 6 pm to 10 pm
- Night - 10 pm to 7 am

From the noise logged data presented in Appendix A, the calculated RBL's and measured ambient noise levels are shown below in Table B1.

Location	*L_{90} RBL Background Noise Levels, dB(A)*			*L_{eq} Ambient Noise Levels, dB(A)*		
	Day 7am-6pm	*Evening 6pm-10pm*	*Night 10pm-7am*	*Day 7am-6pm*	*Evening 6pm-10pm*	*Night 10pm-7am*
L1 – Fisher Road	50	49	43	58	55	52

Table B1: Long-term background and ambient noise levels measured around LEES1 site

From observations during our site visit, it is noted that both ambient and background noise levels around the LEES1 site are currently dominated by traffic noise from City Road.

B.2 Determination of intrusiveness criterion

The intrusiveness criterion is defined as:

$$L_{Aeq,15\ minute} \leq \text{rating background level plus 5}$$

The intrusiveness criterion has been determined from the RBL's presented in Table B1 for each period and from the short-term measurements presented in Section 4.3.

- Day Intrusiveness criterion of 50 + 5 = **55 dB(A)**
- Evening Intrusiveness criterion of 49 + 5 = **54 dB(A)**
- Night Intrusiveness criterion of 43 + 5 = **48 dB(A)**

B.3 Determination of amenity criterion

To limit continuing increases in noise levels, the maximum ambient noise levels within an area from industrial noise sources should not normally exceed the acceptable noise levels appropriate for the type of area (e.g. the acceptable noise level in a rural area would be less than that in an urban or industrial area).

Recommended L_{Aeq} noise levels from industrial noise sources within NSW INP

The Acceptable Noise Levels (ANLs) for each land use type under consideration (as detailed in Table 2.1 of the NSW Industrial Noise Policy) are given in Table B2 below.

The nearest residential receivers to the project are considered to be in a Noise Amenity Area characterised by the NSW Industrial Noise Policy as Urban.

Indicative Noise Amenity Area	*Period*	*Recommended $L_{Aeq,period}$ Noise Level (ANL)*	
		Acceptable	*Recommended Maximum*
Residential	Day	60	65
	Evening	50	55
	Night	45	50

Table B2 : Recommended L_{Aeq} noise levels from industrial noise sources at residential receivers

For the purpose of this assessment, “Acceptable” noise levels as presented in the table above are to be adopted.

Amenity criterion

The amenity criterion is determined from the relationship of the existing L_{Aeq} noise level and the Acceptable Noise Levels (ANL’s) for each land use type under consideration using Table 2.2 of the NSW Industrial Noise Policy. This process is summarised below in Table B3 for the closest residential receivers to the site.

Indicative Noise Amenity Area	*Period*	*Existing L_{Aeq}*	*ANL*	*Adjustment*	*Amenity Criterion*
Residential	Day	58	60	ANL minus 4	56
	Evening	55	50	Existing L_{Aeq} minus 10	45
	Night	52	45	Existing L_{Aeq} minus 10	42

Table B3 : Determination of amenity criterion for residential receivers

B.4 Project specific noise level

The Project Specific Noise Level is defined as the lower of the intrusiveness and the amenity criteria. On this basis, the Project Specific Noise Levels (PNLs) are shown in Table B4 below (PNLs shown shaded).

Indicative Noise Amenity Area	*Period*	*Intrusiveness Criterion*	*Amenity Criterion*
Residential	Day	55	56
	Evening	54	45
	Night	48	42

Table B4 : Determination of project specific noise levels for the LEES1 site

Appendix C: Building Damage Vibration Criteria

There is little reliable data on the threshold of vibration-induced damage in buildings. Although vibrations induced in buildings by ground-borne excitation are often noticeable, there is little evidence that they produce even cosmetic damage. This lack of data is one of the reasons that there is variation between international standards.

There are however several standards that can be referred to.

C.1 ISO Standard

There is an international standard ISO 4866:1990[2] which provides general procedures for the measurement and evaluation of vibration in buildings. It applies to structures built above or below ground, such structures that are used or maintained for buildings.

It classifies damage to structures, as 'cosmetic' (formation of hairline cracks or growth of existing cracks), 'minor' (formation of large cracks or loosening and falling plaster) and 'major' (damage to structural elements). It does not provide levels of permissible vibration to prevent onset of cosmetic damage. This is left to National standards bodies, but does indicate factors which increase sensitivity of a structure to vibration damage such as; category of structure (elderly/modern), foundation types (from piled to no foundation at all), soil type (from rock to fill). It indicates that limits should be approached in a probabilistic way, where minimal risk for a named effect (e.g. cosmetic damage) is usually taken as a 95% probability of no effect.

C.2 German Standard

The relevant German standard is DIN 4150.3:1999[3]. This standard gives guidelines for short-term and steady state structural vibration. For short-term vibration in buildings the following limits are given:

[2] ISO 4866:1990 *'Mechanical Vibration and Shock – Vibration of Fixed Structures – Guidelines for the Measurement of Vibrations and Evaluation of Their Effects on Structures'*

[3] DIN 4150.3:1999 *'Structural Vibration Part 3: Effects of vibration on structures'*

Structural type	*Vibration Velocity, v_i, in mm/s*			
	Foundation			*Plane of floor of uppermost full storey*
	Less than 10Hz	*10 to 50Hz*	*50 to 100Hz*	*Frequency mixture*
Commercial, industrial or similar	20	20 to 40	40 to 50	40
Dwellings or similar	5	5 to 15	15 to 20	15
Particularly Sensitive	3	3 to 8	8 to 10	8

Table C1: Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Short-term Vibration

The guidelines state that:

"…Experience to date has shown that, provided the values given in Table D2 are observed, damage due to vibration, in terms of a reduction in utility value, is unlikely to occur. If the values of table D2 are exceeded, it does not necessarily follow that damage will occur. Should these values be significantly exceeded, further investigation is necessary."

C.3 Swiss Standard

The relevant Swiss standard is SN 640312A:1992[4]. For steady state vibration, form machines, traffic and construction in buildings the following limits are given:

Structural type	*Vibration Velocity, v_i, in mm/s*	
	Foundation	
	10 to 30Hz	*30 to 60Hz*
Commercial, industrial including retaining walls	12	12 to 18
Foundation walls and floors in concrete or masonry. Retaining walls and ashlar construction	8	8 to 12
Foundations and basement floors concrete, with wooden beams on upper floors. Brick walls	5	5 to 8
Particularly Sensitive	3	3 to 5

Table C2: Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Steady State Vibration

[4] SN 640312A:1992 *'Vibrations - Vibration Effects In Buildings'*

C.4 British Standard

The relevant standard is BS 7385.2:1993[5]. This standard was developed from an extensive review of UK data, relevant national and international documents and other published data, which yielded very few cases of vibration-induced damage. This standard contains the most up-to-date research on vibration damage in structures. Part 2 of the standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk.

The Standard proposes the following limits on the foundations of the building:

Structural type	*Peak component particle velocity in frequency range of predominant pulse*	
	4 to 15Hz	*15Hz and above*
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s @ 4Hz increasing to 20mm/s @ 15Hz	20mm/s @ 15Hz increasing to 50mm/s @ 40Hz and above

Table C3: Transient Vibration Guide Values for Cosmetic Damage

The standard states in Annex A, that "… *the age and existing condition of a building are factors to consider in assessing the tolerance to vibration. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other ground-borne disturbance."*

It is recommended that buildings of importance be considered on a case-by-case basis with detailed engineering analysis being carried out if necessary.

Annex B of the Standard gives a breakdown of data that should be recorded. Included in this are details of the building structure, such as general condition of the structure, list of defects, photographs, details of all major extensions, repairs and renovations. A crack exposure report should be prepared both pre and post exposure, both internally and externally.

[5] BS 7385.2:1993 '*Evaluation and Measurement for vibration in Buildings. Guide to damage levels from ground-borne vibration*'

C.5 Australian Standard

There is no specific Australian Standard referring to structural vibration in buildings. There is however AS 2187.2:1993[6], which, in Appendix J, recommends maximum peak particle velocities, measured at the ground surface due to blasting. The lower recommended peak particle velocity is 10 mm/s. The standard states however, that structures that may be particularly susceptible to ground-borne vibration should be examined on an individual basis. It is suggested that in the absence of a particular site-specific study then a maximum peak particle velocity of 5 mm/s is used.

[6] AS2187.2:1993 *'Explosives - Storage, transport and use. Part 2: Use of explosives'*