UNIVERSITY OF TECHNOLOGY SYDNEY

UTS CENTRAL PROJECT

Acoustic Report for State Significant Development Application

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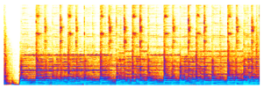

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Table of Contents

Executive Summary

The University of Technology Sydney (UTS) is currently proposing to redevelop Buildings CB02 and extend the podium of CB01 within its Broadway Precinct of the UTS City Campus.

This acoustic report includes a noise and vibration assessment that has been undertaken to establish the potential impacts of operational noise, including mechanical services impacts, and construction noise and vibration of the proposed UTS Central project.

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 including:

- NSW Industrial Noise Policy 2000
- Interim Construction Noise Guideline 2009
- Assessing Vibration: A Technical Guideline 2006
- Relevant documentation from the City of Sydney Council incuding - City of Sydney Construction Hours / Noise within the Central Business District – Code of Practice (CoS-CP)

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

- Operational Noise

  Mechanical Plant

  At this stage, final 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 based on the most restrictive criteria. Based on this preliminary assessment, noise emissions from rooftop plant shall be limited to 75 dBA at 1 metre from the plant room boundaries.

  Noise controls will be incorporated within the design of the rooftop plant room and any other plant located outdoors or on other levels of the proposed building 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 plant and/or acoustic noise control measures such as enclosures, barriers, acoustic louvres, sound absorptive panels, etc.

Traffic Noise Generation

Additional traffic noise generation is considered negligible as there a no significant changes to traffic flow expected once the UTS Central Project is completed.

Rooftop Terraces

Based on the predictions in Section 6.3, we expect that there will be no adverse noise impact as a result of the use of the rooftop terraces, and noise emissions are expected to comply with the relevant criteria.

- Construction Noise

  Continuous construction noise associated with demolition, refurbishment and new-build works is expected to comply with stated criteria for nearest residential and educational receivers when these activities occur indoors.

  However, there will be times / situations when demolition and new-build works are likely to exceed stated criteria, particularly when works occur in the areas closer to sensitive receivers.

  If, during construction works, an item of equipment exceeds the stated airborne noise criteria at any sensitive location, the additional noise control measures presented in Section 8.4.4, together with construction best practices presented in Section 8.4.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Construction Vibration

  At this stage, we anticipate that construction works will result in no adverse vibration impacts at surrounding receivers.

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

1 Introduction

This acoustic report supports a State Significant Development Application (SSDA) submitted to the Department of Planning and Environment pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The SSD Application relates to the Concept Plan Approval for the University of Technology Sydney (UTS) City Campus Broadway Precinct, which was approved in December 2009 (MP08_0116).

The proposed works relate specifically to the UTS Central Project, more specifically the extension of Building 1 (podium) and redevelopment of Building 2 at the City Campus, Broadway Precinct.

As the development has a capital investment value of more than $30 million as an educational establishment, it is identified as State Significant Development under the *State Environmental Planning Policy (State and Regional Development) 2011*, with the Minister for Planning the consent authority for the project.

This report has been prepared having regard to the Secretary's Environmental Assessment Requirements issued for the project.

This acoustic assessment report has been prepared in support of the EIS for the proposed UTS Central Project.

Noise and vibration generated by the development is addressed in this report according to the following guidelines:

- NSW Industrial Noise Policy 2000
- Interim Construction Noise Guideline 2009
- Assessing Vibration: A Technical Guideline 2006
- Relevant documentation from the City of Sydney Council including - City of Sydney Construction Hours / Noise within the Central Business District – Code of Practice (CoS-CP)

The acoustic report assesses noise impacts at nearby noise sensitive receivers due to operation of the UTS Central Project once it is completed.

Furthermore, a quantitative construction noise and vibration assessment has been conducted for the proposed construction stage of the UTS Central Project.

This report presents the findings of both the operational and construction noise and vibration assessments. It includes measured environmental noise survey data and environmental noise limits based on the measured noise levels in the area. Compliance with these limits will ensure that any noise from the overall development will not impact negatively on the nearest existing residences. The report also provides recommendations for appropriate vibration level criteria during construction.

2 Description of Proposal

2.1 Project background

UTS recognised the need to upgrade the City Campus in 2000, and undertook a number of visioning and master planning projects culminating in the *City Campus Masterplan 2020* (BVN, 2008) which provides a framework for refurbishments and new building works across the campus (comprising the Broadway Precinct and other sites in the Sydney CBD) in order to provide improved facilities and to accommodate future expected student and staff growth.

The long term strategic vision for UTS is 'to be one of the world's leading Universities of Technology'.

On 23 December 2009 a critical step in realising UTS's vision and identity for the Broadway Precinct was realised, with approval of the UTS City Campus Broadway Precinct Concept Plan (BPCP) – approved under the former Part 3A of the EP&A Act (MP 08_0116). The approved Concept Plan supports the significant redevelopment of the Broadway Precinct providing for new buildings, alternations and additions to existing buildings, along with associated landscaping and public domain works.

Since approval of the Concept Plan in 2009 UTS has secured the necessary detailed planning approvals and delivered a number of state of the art and iconic learning, research and social facilities across the Broadway Precinct, including:

- Faculty of Engineering and IT Building, designed by Denton Corker Marshall Architects.
- Multi-Purpose Sports Hall.
- Alumni Green, designed by ASPECT Studios Landscape Architects.
- Faculty of Science and Graduate School of Health Building, designed by Durbach Block Jaggers in association with BVN Architecture.
- Library Retrieval System.
- Great Hall and Balcony Room Upgrade, Designed by DRAW Architects in association with Kann Finch Architects.

As part of the staged delivery of the Concept Plan and as expected in its natural evolution, there have been a number of modifications to the Concept Plan. Of note, Modification No 5 to the Concept Plan provides for the complete redevelopment of Building 2, including additional floors above a new podium building.

2.2 Overview of Proposed Development

This SSD Application seeks approval for the following components of the development:

- Site preparation works, including demolition and clearance of existing Building 2 down to approximately ground level and associated tree removal;
- Retention and re-use of existing basement Level 1 and Level 2;
- Construction and use of a new podium building fronting Broadway (Building 1 extension and new Building 2);
- Construction and use of new floors above new Building 2 podium;
- Public domain improvements surrounding the site;
- Landscaping works to roof levels;
- Retention of existing vehicle access and parking arrangements;
- Provision of new at-grade loading space off Jones Street; and
- Extension and augmentation of physical infrastructure / utilities as required.

The new floor space will accommodate a range of educational and ancillary educational uses, such as:

- Library
- Research
- Teaching Space
- Informal Learning Space
- Student Centre
- Student Union Spaces
- Food and Beverage Outlets
- Academic (including Faculty space)

A more detailed and comprehensive description of the proposal is contained in the Environmental Impact Statement (EIS) prepared by JBA.

2.3 The Site

The Broadway Precinct of the UTS City Campus is located on the southern edge of the Sydney Central Business District with frontages to Broadway, Thomas, Wattle and Harris Streets (see Figure 1). Central station is located less than 500m to the east.

More specifically the UTS Central project site relates to Building 1 (excluding the Building 1 tower) and Building 2 of the Broadway Precinct.

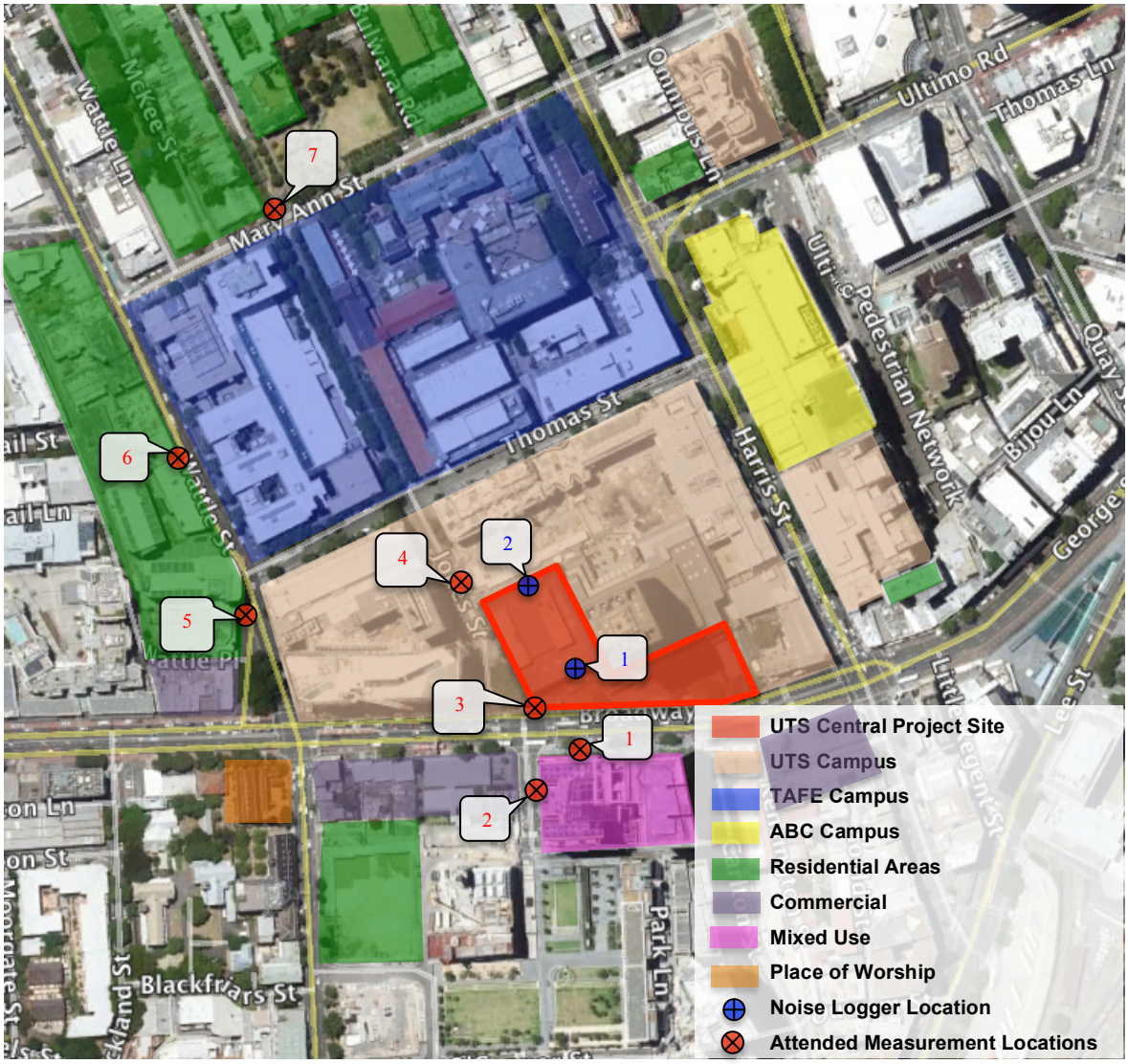


Figure 1: Project site and surrounds

2.4 Sensitive receivers

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

- A **mixed-use** development that includes the nearest off-campus **residential** property (at approximately 45m) is Central Park, across Broadway to the south. This is a high-rise tower and a mid rise tower (Number One Central Park) that overlooks the existing Building 2 and includes **commercial** facilities on the lower levels.
- Other off-campus **residential** includes residential apartments along Wattle Street, which will have a line of site to the upper levels of completed Building 2.
- At a greater distance there are also off-campus residential apartments along Mary Ann St to the north.
- There is also an **ABC campus** located at a further distance to the north east across Harris Street from the UTS Campus.
- **Commercial** premises are located across Broadway to the south and further down Broadway to the west.
- **St Benedicts Catholic Church** is also located at the corner of Abercrombie St and Broadway.

The educational receivers surrounding the site are as follows:

- Existing **UTS campus** buildings to the west north and east including:.
    - Building 10 and 11 to the west.
    - Building 7 to the north.
    - Building 3 to 6 to the east.
- The **TAFE campus** across Thomas St to the north.

For the purpose of this noise and vibration assessment, it is noted that if impacts associated with the UTS Central project are controlled at the nearest residential properties (i.e. residences across Broadway to the south of the site) and also at the nearest educational premises (i.e. adjacent UTS buildings) that will imply compliance with the recommended criteria and limits at all sensitive receivers listed above.

2.5 Operating hours

Once the UTS Central project is completed, the premises is to be operative during the following hours:

- Monday to Thursday – 8am to 10pm
- Friday – 8am to 9pm
- Saturday and Sunday – 10am to 6pm.

It is expected that some plant will operate 24 hours a day.

Any plant associated with the building operations will be provided with noise controls as required to meet the environmental noise limits set in this report.

3 The Key Acoustic Issues

The following acoustic issues are to be addressed as part of the Noise Impact Assessment for the UTS Central project:

External Noise Emissions - Noise emissions from the proposed development will need to be managed to limit environmental noise impacts on nearby buildings resulting from the operation of the proposed development. In particular this applies to:

- Building services and plant - The impact of mechanical noise generated by mechanical plant to be installed at basement and roof level of Building 2. The mechanical plant noise levels are to be assessed against the NSW Industrial Noise Policy (INP) 2000.
- Traffic noise generation - The impact of traffic noise on surrounding receivers from changes in traffic flow as a result of the new development.

External Noise Intrusion - The new building envelope must limit external noise intrusion levels so that appropriate internal noise levels are achieved within the sensitive spaces. In particular, this applies to traffic noise intrusion from Broadway and the impact on accommodation in the new building.

Construction Noise and Vibration - The impact of noise and vibration generated during the construction stage of the project on surrounding noise sensitive premises (including other UTS buildings within the campus).

The development will contribute noise and vibration to the surrounding environment during the construction stage of the UTS Central 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 construction noise impacts have been anticipated from standard construction procedures.

The construction noise and vibration limits and expected impacts 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 UTS Central site was conducted with two unattended noise monitors used to continuously record the noise levels on the site. Long term noise monitoring was carried out from Tuesday 17th November to Tuesday 24th November 2015 to establish the typical range of ambient noise levels of the proposed site and surrounds.

Long term noise monitoring was carried out with the following noise loggers:

- Logger 1: Acoustic Research Labs - Ngara 878066.
- Logger 2: Acoustic Research Labs - Ngara 8780D6.

The loggers 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 loggers was checked before and after use and no variation was noted.

Operator attended short-term monitoring was also carried out on Monday 23rd , Tuesday 24th and Friday 27th November 2015 in order to confirm the validity of the long-term data across the site and to sample background and ambient noise levels at key surrounding receivers at various times of the day and night.

Short-term measurements were made with Brüel & Kjær Hand-held Analysers Type 2250 (Serial Numbers 2446899 and 2832406). The calibration of the analysers was checked before and after the survey and no variation in level occurred.

A windshield was used to protect the microphones of both the loggers and the analysers. Weather conditions were calm and dry during the noise surveys.

Anthony Cano and Saiham Siraj of Acoustic Studio Pty Ltd carried out the surveys.

The long and short-term noise monitoring locations are shown in Figure 1 in Section 2.

4.2 Long-term monitoring results

The loggers were located at the northern and southern ends on the rooftop of the existing Building CB02. These positions were chosen as they represent a secure place to leave the noise loggers unattended whilst obtaining typical representative background and ambient noise levels at the nearest noise sensitive receivers. The long-term noise monitoring locations are shown in Figure 1 in Section 2.

The detailed results of the long term noise monitoring at both logger locations 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 representative of the area. The recorded background noise levels have been used to establish a limiting criteria for noise emitted from the operation of the new buildings.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{90}. The ambient noise level impacting on the buildings is referred to as the equivalent continuous sound level (L_{eq}). 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	Background Noise Levels (RBL), dB(A)			Leq Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
L1 – Building CB02 (Rooftop – Southern End)	58	57	53	68	67	62
L2 – Building CB02 (Rooftop – Northern End)	56	56	53	58	57	55

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

From observations during our site visits, it is noted that both ambient and background noise levels around the UTS Central project site were generally dominated by mechanical plant from the UTS buildings and its surrounds plus traffic noise along Broadway.

4.3 Short-term monitoring results

Seven (7) short-term noise-monitoring locations were chosen as representative of the site and surrounds as follows:

- **Location 1** on the footpath in front of Central Park apartments and shopping centre directly across Building CB02.

  Location 1 is representative of current background and ambient noise (primarily traffic) levels currently at the nearest off-campus residential and commercial receivers.

- **Location 2** on the footpath of Chippendale Way to the side of Central Park apartments / shopping centre.

  Location 2 is representative of background and ambient noise levels of the Central park western façade which has less exposure to noise from Broadway but still has some line of site to the UTS Central project site.

- **Location 3** on the footpath in front of the current Building CB02.

  Location 3 is representative of traffic noise levels incident on the Building CB02 at the worst affected (closest distance to Broadway).

- **Location 4** on the Jones Street footpath in the open area between UTS buildings CB02 and CB07.

  Location 4 is representative of current background and ambient noise levels at the UTS campus buildings nearest to the project site.

- **Location 5** on the Wattle Street footpath at the residential apartment block across from UTS Building CB10.

- **Location 6** on the Wattle Street footpath at the residential accommodation (Urban Nest) across from the TAFE campus at a further distance from traffic along Broadway.

- **Location 7** on Mary Ann Street footpath at the nearest residential dwelling across from the TAFE campus, with a line of site to the UTS Central project site.

The existing ambient noise levels at the measurement locations were generally dominated by traffic noise (locations nearby to Broadway and Wattle Street) and / or mechanical plant noise from UTS buildings (including general urban hum).

A summary of the measured values of the short-term background and ambient noise monitoring around the existing site is shown in Table 2.

Location	Time of Measurements	$L_{eq,15min}$ Ambient Noise, dB(A)	$L_{90,15min}$ Background Noise, dB(A)	Notes
1 Broadway (Central Park)	23-24/11/15 (11pm to 1am)	67	58	Dominated by traffic noise
	27/11/15 (1pm to 3pm)	75	66	
2 Chippendale Way	23-24/11/15 (11pm to 1am)	61	54	Dominated by traffic noise
3 Broadway (CB02)	27/11/15 (1pm to 3pm)	72	61	Dominated by traffic noise
4 Jones Street	23-24/11/15 (11pm to 1am)	55	53	Plant noise from UTS Buildings
5 Wattle St	23-24/11/15 (11pm to 1am)	69	52	Dominated by traffic noise + Plant noise from UTS Buildings
6 Wattle St	23-24/11/15 (11pm to 1am)	70	49	Dominated by traffic noise + Plant noise from UTS Buildings
	27/11/15 (1pm to 3pm)	72	57	Dominated by traffic noise + Plant noise from UTS Buildings
7 Mary Ann St	23-24/11/15 (11pm to 1am)	49	44	Faint plant noise from nearby TAFE
	27/11/15 (1pm to 3pm)	62	53	Distant Traffic Noise from Wattle Street

Table 2 : Summary of short-term background and ambient noise levels measured around the UTS Central site

When considering the relevant distances from each receiver to the project site, the difference in attended measurement results at each receiver position confirms that if impacts associated with the UTS Central project are controlled at the nearest residential properties (i.e. residences across Broadway to the south of the site) and also at the nearest educational premises (i.e. adjacent UTS buildings) this will ensure compliance with the recommended criteria and limits at all sensitive receivers listed above at all times.

5 Acoustic Design Criteria

5.1 External Noise Emissions

5.1.1 Protection of the Environment Operations Act (POEO) 1997

The Protection of the Environment Operations (POEO) Act 1997 defines "Offensive Noise" as follows:

"...

(a) that, by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances:

(i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or

(ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or

(b) that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations. ..."

Further advice on the assessment of "Offensive Noise" is provided in the Noise Guide for Local Government (NGLG), 2010, which provides a checklist (shown in Table 3 below), of items that may be considered.

Offensive noise test: Checklist of considerations

Q1: Is the noise loud in an absolute sense? Is it loud relative to other noise in the area?

This establishes that the noise is likely to be heard by neighbours. Its volume alone may be annoying. An example would be music being played at a very high volume in a residence so it can be heard over very noisy activity outside, such as construction work. The noise may also be loud relative to the background noise. An example would be loud fireworks set off late at night. Noise measurements using a sound level meter would help to determine how loud the noise is relative to the background noise level in the area.

Q2: Does the noise include characteristics that make it particularly irritating?

The presence of tones, impulses or fluctuations in volume can make people more likely to react to the noise. These can be judged subjectively but noise measurements will help to quantify the extent of these characteristics. Examples might be screeching sounds from poorly maintained equipment or a 'beeper' alarm that uses a pulsed sound made up of one or two alternating frequency tones, usually higher pitched, that are louder than the background noise in the area.

Q3: Does the noise occur at times when people expect to enjoy peace and quiet?

People usually expect their surroundings to be quieter during the evening and at night. Talk to the complainants about how the noise affects them to see if it is interfering unreasonably with their comfort at home. Is it regularly disturbing their sleep, making it difficult to have a conversation, study, read or hear the TV? Noise that regularly disturbs sleep is likely to be considered offensive by complainants and this should be taken into account in your assessment.

Q4: Is the noise atypical for the area?

Where noise from an activity that is causing nuisance is new or unusual for an area, people are more likely to react. Look at the typical uses of the area and determine whether the activity is consistent with the local environmental plan. An example might be a rock drill used on a residential construction site.

Q5: Does the noise occur often?

Noise can be more annoying when it occurs frequently. Examples might be a leaf blower used every morning or a band that practises frequently without regard to the impact on neighbours.

Q6: Are a number of people affected by the noise?

Only one person needs to be affected by the noise for it to be deemed offensive. However, talking to other neighbours likely to be exposed to the same noise about how it affects them may assist in deciding what action to take. Some councils have a policy of requiring a minimum number of complaints from different individuals before taking formal action.

Table 3: NGLG Offensive Noise Checklist

5.1.2 NSW Industrial Noise Policy (INP)

The NSW Industrial Noise Policy 2000 of the NSW Department of Environmental and Heritage 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) 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 a detailed NSW INP analysis and the derivation of the environmental noise break-out limits shown in Table 4.

Receiver Type	Period	INP Criteria			
		Acceptable Noise Level	Amenity $L_{eq\ (period)}$, dBA	Intrusiveness $L_{eq\ (15\text{-}minute)}$, dBA	INP Project Specific[1]
Residential	Day (7am-6pm)	60	58	63	58
	Evening (6pm-10pm)	50	57	62	57
	Night (10pm to 6am)	45	52	58	52
Commercial premises	When in use	65	65	-	65
Educational (TAFE)	Noisiest 1-hour period When In Use	45[2]	46	-	46

Table 4: NSW INP Project specific noise levels for the site

5.1.3 City of Sydney Standard Conditions of Development Consent (COS-SCDC)

General

The COS SCDC states the following general requirements for noise control.

"...

NOISE - GENERAL

a) The emission of noise associated with the use of the premises including the operation of any mechanical plant and equipment shall comply with the following:

i) The $L_{Aeq,\ 15minute}$ noise level emitted from the use must not exceed the project specific noise level for that receiver as determined in accordance with the NSW EPA Industrial Noise Policy. Noise must be measured in accordance with the Industrial Noise Policy and relevant requirements of Australian Standard AS 1055-1997 Acoustics – Description and measurement of environmental noise.

[1] Project Specific Criteria are based on the more stringent of the Amenity and Intrusiveness Criteria.

[2] The NSW INP specifies an internal ANL of 35. The NSW INP also states that where internal noise levels are specified, external noise 10 dB above internal noise levels can be applied which should achieve an internal noise level where a window is adequately opened to provide natural ventilation.

ii) *Project specific noise levels shall be determined by establishing the existing environmental noise levels, in complete accordance with the assessment $L_{A90,\ 15minute}$ / rating $L_{A90,\ 15minute}$ process to be in accordance with the requirements for noise monitoring listed in the NSW EPA Industrial Noise Policy and relevant requirements of Australian Standard AS1055-1997 Acoustics – Description and measurement of environmental noise.*

iii) *Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable.*

b) *An $L_{Aeq,\ 15\ minute}$ noise level emitted from the use must not exceed the $L_{A90,\ 15\ minute}$ noise level by more than 3 dB in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) when assessed inside any habitable room of any affected residence or commercial premises provided that;*

i) *Where the $L_{A90,\ 15\ minute}$ noise level is below the threshold of hearing, Tf at any Octave Band Centre Frequency shall be used instead.*

ii) *The $L_{Aeq,\ 15\ minute}$ noise level and the $L_{A90,\ 15\ minute}$ noise level shall both be measured with all external doors and windows in the affected residence closed;*

iii) *The relevant background noise level ($L_{A90,\ 15\ minute}$) is taken to mean the day evening or night rating background noise level determined in complete accordance with the methodology outlined in the NSW EPA Industrial Noise Policy and Australian Standard AS1055-1997 Acoustics – Description and measurement of environmental noise.*

iv) *Background noise shall be established in the absence of all noise emitted from the use but with the ventilation equipment normally servicing the affected residence operating. Background noise measurements are to be representative of the environmental noise levels at the affected location.*

i) *Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable. Internal noise measurements are not to be corrected for duration.*

The requirements of Item a) for external noise emissions at **external boundaries** are consistent with the relevant criteria established in Table 4.

With respect to Item (b) The NSW INP states that where an internal noise criterion is specified and the potentially affected room has a window open sufficiently to provide adequate ventilation then an external noise level 10 dB above the internal noise criteria shall apply. This methodology assumes that the external background noise level directly influences the internal background noise level, with the level difference between the two being equal to the sound insulation provided by the separating element (such as a window). Therefore, as a worst-case assessment it is assumed that achieving $L_{A90,\ 15\ minute}$ + 3 dB (condition b) externally will also result in achieving $L_{A90,\ 15\ minute}$ + 3 internally.

Based on this the following criteria for noise emissions measured **internally at residential and commercial receivers** are:

Location	Time	Descriptor		Measured sound level, dB re 20 µPa									
				Overall dB(A)	Octave band centre frequency[1], Hz								
					31.5	63	125	250	500	1k	2k	4k	8k
Residential/ Commercial	Day (7am-6pm)	Lowest Measured Background Noise Level	L_{90}	58	62	63	59	57	55	53	49	41	31
		Corresponding Project Criteria (COS)[2]	**$L_{EQ} \leq L_{90}$ + 3dB**	**61**	**65**	**66**	**62**	**60**	**58**	**56**	**52**	**44**	**34**
	Evening (6pm-10pm)	Lowest Measured Background Noise Level	L_{90}	57	61	62	58	56	54	52	48	40	30
		Corresponding Project Criteria (COS)[2]	**$L_{EQ} \leq L_{90}$ + 3dB**	**60**	**64**	**65**	**61**	**59**	**57**	**55**	**51**	**43**	**33**
	Night (10pm to 7am)	Lowest Measured Background Noise Level	L_{90}	53	57	58	54	52	50	48	44	36	26
		Corresponding Project Criteria (COS)[2]	**$L_{EQ} \leq L_{90}$ + 3dB**	**56**	**60**	**61**	**57**	**55**	**53**	**51**	**47**	**39**	**29**

Note: 1. Octave band data is based on attended measurements at attended measurement Position 1 adjusted to reflect the overall levels for each assessment period established using measured Logger 1 data.

2. The internal assessment criteria is based on an external background noise level with the assumption that compliance externally will also indicate compliance internally.

Table 4: COS SCDC external general noise criteria

In addition to the NSW INP, the COS SCDC provides specific noise criteria to control noise emissions from a premise related to mechanical plant and equipment and is defined as follows:

"... NOISE - MECHANICAL PLANT AND EQUIPMENT

Noise associated with the use of mechanical plant and equipment must not give rise to any one or more of the following:

(a) Transmission of "offensive noise" as defined in the Protection of the Environment Operations Act 1997 to any affected receiver.

(b) A sound pressure level at the boundary of any affected receiver that exceeds the background (LA90, 15minutes) noise level by more than 5dB. The background noise level must be measured in the absence of noise emitted from the use in accordance with Australian Standard AS1055. ..."

We note that the COS SCDC requirement for noise emissions from mechanical plant is consistent with the NSW INP "Intrusiveness Criteria". Therefore, achieving compliance with the INP project specific criteria outlined in Table 5 will also achieve compliance with the COS SCDC requirements for residential receivers. However, the SCDC requirement is applicable to "any affected receiver" (not limited to residential), therefore the following criteria for receivers other than residential is provided below. This should be considered in conjunction with Table 5.

Receiver Type	Period	Background Noise Level L_{90} dBA	Criteria $L_{eq} = L_{90} + 5$ dBA
Any Receiver	Day (7am-6pm)	58	63
	Evening (6pm-10pm)	57	62
	Night (10pm to 7am)	53	58

Table 5: COS SCDC external mechanical plant noise criteria

5.1.4 Summary of External Noise Emission Criteria

The following table provides a summary of the adopted worst-case criteria, which considers both the NSW INP and COS SCDC that are detailed in the previous sections.

Location	Time	Criteria	Descriptor	Measured sound level, dB re 20 µPa									
				Overall dB(A)	Octave band centre frequency[1], Hz								
					31.5	63	125	250	500	1k	2k	4k	8k
Residential/ Commercial	Day (7am-6pm)	CoS	L_{EQ}	**61**	**65**	**66**	**62**	**60**	**58**	**56**	**52**	**44**	**34**
	Evening (6pm-10pm)			**60**	**64**	**65**	**61**	**59**	**57**	**55**	**51**	**43**	**33**
	Night (10pm to 7am)			**56**	**60**	**61**	**57**	**55**	**53**	**51**	**47**	**39**	**29**
Educational (non UTS)	When In Use	INP		46	-	-	-	-	-	-	-	-	-

Note: 1. Octave band data is based on attended measurements at attended measurement Position 1 adjusted to reflect the overall levels for each assessment period established using measured Logger 1 data.

2. The internal assessment criteria is based on an external background noise level with the assumption that compliance externally will also indicate compliance internally.

Table 6: Project specific adopted worst case criteria

5.1.5 Noise impacts on the existing UTS Campus

Whilst redevelopment of an existing site must consider surrounding neighbouring receivers, noise impacts on the existing UTS Campus will also be considered. In particular, this includes the need to control plant noise emissions affecting the existing UTS Tower CB01.

Once plant room locations and openings to the environment (louvre locations, etc) are finalised, in addition to the requirements to control noise emissions to surrounding neighbouring receivers, noise controls will be implemented to ensure that existing UTS campus accommodation is also not adversely affected.

This will be considered during the detailed design stage with input from Acoustic Studio.

5.1.6 Traffic Noise Emission Criteria

NSW Road Noise Policy

The NSW Road Noise Policy (RNP) provides criteria for traffic noise from new roads or additional traffic generated on roads from land use development.

When considering land use redevelopment and the impact on sensitive land uses (residential / schools / hospitals / recreational) the guideline states that *" In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB"...* (in relation to existing noise levels).. *"represents a minor impact that is considered barely perceptible to the average person".*

5.1.7 Sleep Disturbance

Some short-duration noises that occur at night may comply with the criteria described in in the previous sections above, and yet be undesirable because of the sleep arousal effect, particularly between the hours of 10 pm and 7 am.

Sleep arousal is a function of both the noise level and the duration of the noise. Not all people are affected to the same degree by noise, and at different times, a person will be more or less affected by the same noise. Even though a person is not actually awoken by a noise, one's rest may be significantly disturbed by noise that occurs while one is asleep. Therefore reference is made to the NSW Industrial Noise Policy Application Notes (Sleep Disturbance

The NSW INP application notes states the following in relation to sleep disturbance:

"…OEH reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.

From the research, OEH recognised that current sleep disturbance criterion of an LA1, (1, minute) not exceeding the LA90, (15 minute) by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, OEH will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover the maximum noise level or LA1, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:

- *how often high noise events will occur*
- *time of day (normally between 10pm and 7am)*
- *whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*

The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under 'fast' time response. OEH will accept analysis based on either LA1, (1 minute) or LA, (Max)…"

Based on the measured noise levels detailed in Section 4 and the sleep disturbance assessment methodology outlined above, Table 7 details the corresponding project specific sleep disturbance criteria. Note that the criteria have been determined using the lowest Background (L_{90}) value at attended measurement position for residential receivers corresponding to the proposed operating times during the night period.

Recever Type	Time	Background Noise Level L_{90} dBA	Sleep Distrubance Criteria L_1 or L_{max} = L_{90} + 15 dBA
Residential (Central Park)	Night (10pm to 7am[1])	53	68

Table 7: INP project specific sleep disturbance criteria for external noise emissions from proposed site

5.2 External Noise Intrusion

5.2.1 TRAFFIC NOISE

SEPP 2007

Clause 102 of SEPP 2007 outlines requirements related to the assessment of noise impact from non-road developments that are adjacent to road corridors with traffic volumes of more than 40,000 vehicles.

Objective criteria for internal noise levels that must be achieved are provided for residential development only.

In the absence of objective criteria for the educational facilities, reference is made to NSW Department of Planning (DoP), Development Near Busy Roads and Rail Corridors – Interim Guideline and Australian Standard AS2107, which recommends internal design noise levels within, occupied spaces and is detailed below.

NSW DoP, Development Near Busy Roads and Rail Corridors

For airborne noise from road traffic and the rail corridor, the NSW DoP Interim Guideline sets an internal noise of 40 dB(A)[3] for educational institutions.

AS 2107:2000

AS 2107 recommends internal noise level design criteria within occupied spaces of a large range of buildings and applies to steady and quasi steady state (e.g air-conditioning – steady state, and continuous traffic noise – quasi steady state).

The following table provides recommended satisfactory and maximum internal design sound levels (based on AS2107) corresponding to the key spaces within the proposed development.

Room Type	Recommended Design Sound Level, L_{eq},dB(A)	
	Satisfactory	Maximum
Lecture theatres		
Without speech reinforcement	30	35
With speech reinforcement	35	40
Teaching Spaces	35	45
Office Areas	40	45

[3] Airborne noise is from traffic is calculated as $L_{eq\ 15\ hr}$ Day and $L_{eq\ 9\ hr}$ night.

Room Type	Recommended Design Sound Level, L_{eq},dB(A)	
	Satisfactory	Maximum
Libraries		
General	40	50
Reading Areas	40	45

Table 8: Recommended Internal Design Noise Levels

AS2107 provides recommended design noise levels as a range from satisfactory to maximum.

The satisfactory design sound level is defined in 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." Therefore, it is also considered as acceptable, but there is a greater perception of intrusion of this noise level into 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.

6 Operational Noise Impact Assessment (External Noise Emissions)

6.1 Mechanical Plant

Plant associated with the operation of the proposed buildings should be controlled to ensure external noise emissions are not intrusive and do not impact on the amenity of neighbouring receivers with the relevant criteria in Section 5.1 of this report.

Major plant is proposed to be located in the basement and at roof level.

At this stage, final 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 major plant locations including external roof plant in particular, as shown in Figure 2.

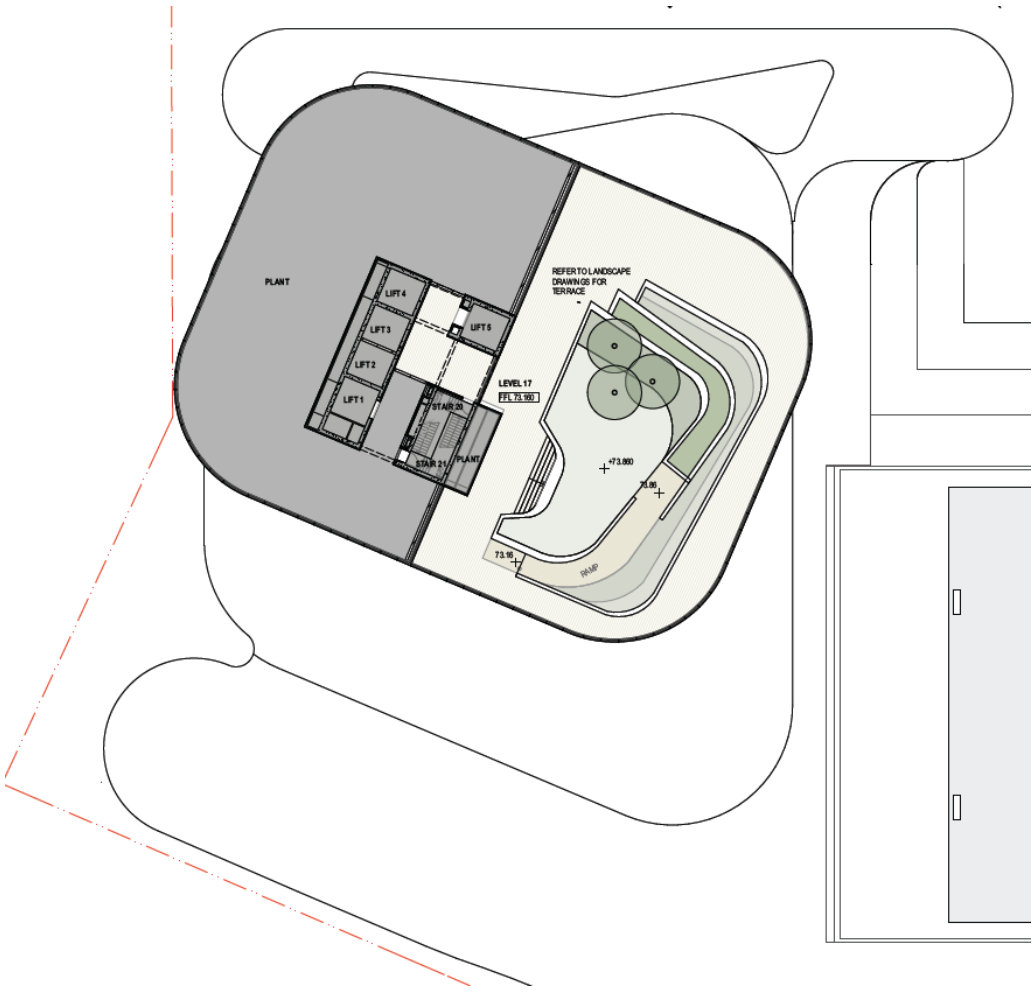


Figure 2: Roof Level Plan – Plant Room and Terrace

The assessment has considered the cumulative impact of noise from the current proposals for roof plant. We make the following comments:

- For plant room openings on the northern and western facade, the most restrictive criteria is the criteria for educational facilities detailed in Table 6.
- For plant openings on the southern façade, the most restrictive criteria is the night-time criteria as detailed in Table 6 for residential / commercial noise receivers.
- Ensuring that noise from plant is no more than 75 dB(A) at 1m from a plant room opening will ensure that the most stringent criteria can be achieved.

Noise controls will be incorporated with the design of the plant rooms and any other plant located outdoors on other levels of the proposed building 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 typically include, but are not limited to:

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

6.2 Traffic Noise Generation

Acoustic Studio has considered noise associated with additional traffic generation on streets surrounding the UTS campus.

Following a review of the Traffic Impact Assessment prepared by GTA Consultants (ref: *University of Technology Sydney Broadway Precinct – UTS Central Traffic Impact Assessment*, Issue A-Dr) we make the following comments:

- We understand that there is no parking provision for the development proposal and therefore traffic generation from the proposed development is likely to remain similar to existing conditions.
- In addition, the limited availability of parking off site further discourages the use of travel by car, with nearby on-street parking imposed with time restrictions and parking fees.
- The increase in floor area associated with the UTS Central Project will generate additional trip generation associated with public transport. We understand there is available capacity with current bus services passing the Broadway site for additional bus patronage to accommodate this additional trip generation.

Based on the above comments, the additional traffic noise generation is considered negligible as there a no significant changes to traffic flow expected once the UTS Central Project is completed.

6.3 Operational Noise from Rooftop Terrace

A rooftop terrace will be used as part of the new UTS Central development as shown in Figure 2.

There will be a limited number of people in these external areas at any given time and activities are not expected to give rise to excessive noise levels.

Use of the rooftop terraces should be managed to ensure that adverse noise impacts are avoided at all times of the day and night.

It is assumed that the vocal effort of people communicating in these external areas will generally be “normal” speech. The assessment has generally assumed the following:

- Male persons talking “normally” voices to provide a worst-case scenario.
- Full terrace occupancy accommodating 60 people. For every two persons only one person will be speaking at any given time with a “normal” voice (i.e. 30 people speaking with a “normal” voice).

The L_{eq} noise source (at 1 m) of a person talking normally is shown in Table 9.

Description	Sound pressure level, dB re 20µPa								
	Overall dB(A)	Octave band centre frequency, Hz							
		31.5	63	125	250	500	1k	2k	4k	8k
Person "normally" at 1m	62	-	-	54	60	60	58	51	45	35

Table 9: Sound levels likely to be generated by a single person speaking "normally"

It is also possible that occasionally people on the rooftop terrace might shout to each other or they may be laughter for a short period, generating L_{Amax} levels that might potentially cause sleep arousal (whilst not necessarily affecting the L_{eq} levels used in the CoS assessment).

The L_{Amax} of a male shouting is approximately 85dB(A) at 1m. For a conservative assessment the L_{Amax} of two males shouting is used in the assessment corresponding to 88dB(A) at 1m.

The assessment has considered the most sensitive worst-case noise receiver with a direct line of sight to the rooftop terrace. These are the Central Park Apartments at 45m from the closest part of the rooftop terrace edge. The following table details the predicted noise levels at the nearest affected receiver with the worst-case scenario (i.e. night time period).

Calculation	Sound pressure level, dB re 20µPa								
	Octave band centre frequency, Hz								
	31.5	63	125	250	500	1k	2k	4k	8k
L_{eq} of speech from 60 people talking with "normal" voices	-	-	69	75	75	73	66	60	50
Building attenuation / shielding / reflections / directivity	+3	+3	+3	+3	+3	+3	+3	+3	+3
Distance (45m) attenuation, dB	-33	-33	-33	-33	-33	-33	-33	-33	-33
Resulting level at the nearest residential boundary - Central Park	**-**	**-**	**39**	**45**	**45**	**43**	**36**	**30**	**20**
CoS Criteria – Internal[1] (Night – 10pm to 7am)	**60**	**61**	**57**	**55**	**53**	**51**	**47**	**39**	**29**
Complies?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Table 10 : Noise assessment at residential receivers from rooftop terrace – people talking with "normal" vocal effort

Calculation	Noise Level dB(A) SPL
L_{max} of 2 people shouting at 1 m	88
Building attenuation / reflections / directivity, dB	+3
Distance (45 m) attenuation, dB	-33
L_{max} resulting level at the residential boundary	**58**
Sleep Arousal Criteria	**68**
Complies?	**Yes**

Table 11 : Sleep arousal noise assessment at residential receivers from rooftop terrace - people talking with "normal" vocal effort

Based on the predictions detailed above, we expect that there will be no adverse noise impact as a result of the use of the rooftop terraces, and noise emissions are expected to comply with the relevant criteria.

6.4 Offensive Noise

Based on the preliminary assessment and details provided in the previous sections, we make the following comments with respect to offensive noise.

- The primary noise emissions from the proposed building will be mechanical plant. This will be designed to meet the relevant criteria, which will ensure that the noise emitted is not loud in an absolute sense and not loud relative to the pre existing ambient and background noise levels that surround the site.
- Noise from mechanical pant is generally broadband, and will be controlled so that there are no characteristics that will make it particularly irritating.
- Noise from associated with the operation of the new building may operate up to 24 hours per day however the type of noise emitted is typical for the area.
- By controlling noise emissions (associated with the operation of the proposed development) in accordance with the relevant criteria, amenity of noise sensitive receivers will be maintained and noise emissions should not be intrusive, therefore it is not expected that people and noise sensitive receivers will be adversely affected by the development.

Based on the comments above, the development will satisfy the requirements of the POEO for "Offensive Noise" provided the relevant criteria outlined in Section 5 are achieved.

7 Traffic Noise Intrusion

Noise from Broadway will be the key traffic noise source affecting the building.

Based on long term unattended and short term attended noise data, a summary of traffic noise levels incident on the Broadway façade of the proposed building is provided in Table 12.

Location	Traffic Noise Levels, dB(A)			
	Period		Noisiest 1 Hour Period	
	Day $L_{eq, (15\ hr)}$	Night $L_{eq, (9\ hr)}$	Day $L_{eq, (1\ hr)}$	Night $L_{eq, (1\ hr)}$
Broadway Facade	68	62	76	71

Table 12: Day and night traffic noise levels based on attended measurements and logger data

At this stage, layouts and configurations for internal spaces on the building perimeter that fronts Broadway has not been finalised; therefore a detailed assessment has not been able to be carried out.

Acoustic Studio has carried out a high level review of traffic noise impacts and identified that the southern façade (fronting Broadway) and parts of the western façade (fronting Jones Street with line of site to Broadway) of the new building will require a design performance of approximately R_W 40 with consideration of low frequency performance for heavy vehicles such as buses.

Final details and extent of the façade that will require this glazing performance will be determined with input from Acoustic Studio at the detailed design stage.

8 Construction Noise and Vibration Assessment

The following provides a preliminary construction noise and vibration assessment based on an indicative construction program provided by Richard Crookes Construction, which is to be further developed.

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 UTS Central project:

- NSW Department of Environment and Climate Change "Interim Construction Noise Guideline", 2009
- NSW Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline", 2006
- The City of Sydney "Construction Hours / Noise within the Central Business District – Code of Practice", 1992
- Australian Standard "AS 2436 : Guide to Noise Control on Construction, Maintenance & Demolition Sites", 1981
- Australian Standard "AS 1055 : Acoustics – Description and Measurement of Environment Noise", 1997
- Australian Standard "AS 2670.2 : Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)", 1990
- British Standards Institution "BS 6472 – Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)", 1992
- German Institution for Standardisation "DIN 4150.3 : Structural vibration – Effects of vibration on structures", 1999
- Protection of the Environment Operations Act 1997

8.2 Criteria and limits

8.2.1 Airborne noise

City of Sydney Construction Hours / Noise within the Central Business District – Code of Practice (CoS-CP)

Table 13 below shows the different time frames and associated noise criteria for nominated affected residential receivers as presented in the CoS-CP as applicable to the Project.

At this stage we understand works will be carried out during standard hours and not during the night time period. Therefore, night-time noise limits / criteria and assessment are not included in this quantitative assessment.

The CoS-CP describes criteria in the form of "average Lmax" (L_{Avmax}), which is equivalent to L_{A10}.

Day	Time Period	Airborne Construction Noise Criteria, dB L_{A10}	
Monday to Friday	00:00 – 07:00	Background + 0 dB	N/A
	07:00 – 08:00	Background + 5 dB	57 + 5 = **62**
	08:00 – 19:00	Background + 5 + 5 dB	58 + 10 = **68**
	19:00 – 23:00	Background + 3 dB	N/A
	23:00 – 24:00	Background + 0 dB	N/A
Saturday	00:00 – 07:00	Background + 0 dB	N/A
	07:00 – 08:00	Background + 5 dB	55 + 5 = **60**
	08:00 – 17:00	Background + 5 + 5 dB	57 + 10 = **67**
	17:00 – 23:00	Background + 3 dB	N/A
	23:00 – 24:00	Background + 0 dB	N/A

Table 13 : CoS-CP construction airborne noise criteria for residential receivers

OEH Interim Construction Noise Guideline (OEH ICNG)

OEH's "Interim Construction Noise Guideline" suggests construction noise management levels for commercial premises surrounding construction sites. They are as follows:

- Industrial premises, offices, retail: $L_{Aeq,15min}$ 70dBA (external)
- Classrooms: $L_{Aeq,15min}$ 45dBA (internal)

These levels are applicable to the commercial / industrial premises nearby to the site - when they are in use. The criterion for "classrooms" is relevant to adjacent and nearby UTS and TAFE accommodation.

Based on observations during our visits to site, it is expected that a minimum sound reduction of 25 dBA would be provided by the existing façade. Therefore a 70dB(A) external noise criterion for classrooms would be considered appropriate and consistent with the "Industrial premises, offices, retail" criterion.

Plant and Equipment Noise Level Limits

The allowable $L_{A\ avmax}$ noise levels for construction appliances, which are equivalent to L_{A10}, as per City of Sydney CoS-CP are shown in Table 14 below.

GROUP A (see Note 2)	GROUP B 90dBA	GROUP C 85dBA	GROUP D 80dBA	GROUP E 75dBA	GROUP F 70Dba
Pile drivers Hydraulic hammers Machine mounted rock breakers Sand blasters Steam cleaners Mole borers	Earthmoving equipment of engine capacity above 200kW NEP Warning sirens* Reversing alarms+ Trucks	Impulsive tools - air, electric or hydraulic Earthmoving equipment of engine capacity between 100kW and 200kW NEP Explosive power tools Impact wrenches Refuse chutes* Scabblers Chain saws Rock drills	Concrete agitators Concrete pumps Concrete saws Cranes (fixed) Cranes (mobile) Earthmoving equipment up to and including engine capacities of 100kW NEP Concrete vibrators Portable hand tools Vibratory compacters	Air compressors above 170 L/s capacity Construction dumpers over 1m^3 capacity Public address system* Internal combustion or electrically driven equipment (unless grouped elsewhere) over 14kW NEP	Air compressors up to 170 L/s capacity Fluid pumps Internal combustion or electrically driven equipment (unless grouped elsewhere) up to 14kW NEP

* To be measured at the site boundary closest to the affected area.
\+ Reversing alarms must be controlled so that noise levels produced do not exceed the background sound level by more than 10dBA.

Table 14 : Listed appliances and allowable noise levels relevant to the Project as per CoS-CP

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 OEH / EPA 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 Construction Vibration

There are three key items that should be considered in the assessment of vibration impacts from construction works. These include vibration impacts in terms of:

- Human comfort
- Sensitive equipment and processes (where applicable)
- Structural damage

Relevant criteria for each of these are detailed in the sections that follow.

8.2.4 Human Comfort

The Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline", (2006) provides suitable criteria that can be applied to the assessment of vibration and human comfort. The guideline makes reference to the British Standard BS 6472: 1992, which shares many similarities to the Australian Standards AS 2670.2: 1990. This guideline presents preferred and maximum vibration values for use in assessing human responses to vibration plus limits for critical areas in hospital buildings, and provides recommendations for measurement and evaluation techniques.

Vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. 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 in buildings may also occur from internal sources (within a building structure), such as building services and plant. As well as being sensitive to vibration, medical equipment can also be the source of vibration within the building.

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). This type of vibration is assessed on the basis of weighted rms acceleration values.
- **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, railway trains and traffic passing by). This type of vibration is assessed on the basis of vibration dose values.

The criterion also considers the type of vibration being assessed, namely continuous, impulsive and intermittent vibration. Examples of these vibration types are provided in Table 15 below.

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

Table 15: Examples of vibration types

The relevant criteria for human exposure to continuous and impulsive vibration are detailed in Table 16. Vibration levels are assessed through the consideration of the summation of effects for vibration levels at frequencies from 1 to 80 Hz for all axes.

Human exposure to intermittent vibration is assessed using the Vibration Dose Value (VDV). The VDV accumulates the vibration energy experienced over an extended period (daytime and night-time periods) from intermittent events. Table 16 sets out the acceptable VDV values for intermittent vibration.

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration					
Critical areas	Day or night time	0.10	0.072	0.20	0.14
Residences	Day time	0.20	0.14	0.40	0.28
	Night time	0.14	0.10	0.28	0.2
Offices, schools, educational institutions and places of worship	Day or night time	0.40	0.28	0.80	0.56
Workshops	Day or night time	0.80	0.58	1.6	1.16
Impulsive vibration					
Critical areas	Day or night time	0.10	0.072	0.20	0.14
Residences	Day time	6.0	4.2	12.0	8.4
	Night time	2.0	1.4	4.0	2.8
Offices, schools, educational institutions and places of worship	Day or night time	13.0	9.2	26.0	18.4
Workshops	Day or night time	13.0	9.2	26.0	18.4

Table 16: Preferred and maximum weighted rms values for continuous and impulsive vibration velocity (mm/s) 1-80 Hz

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

Table 17: Acceptable vibration does values for intermittent vibration ($m/s^{1.75}$)

8.2.5 Sensitive Equipment

Neighbouring vibration receivers with sensitive equipment are likely to require a higher degree of vibration isolation than the values outlined in Table 16 and Table 17.

Vibration Criterion (VC) curves are used to provide the basis for the design and protection of highly vibration sensitive equipment. Table 18 details the VC curves applicable to a range of highly sensitive equipment that should be referred to and considered in conjunction with manufacturer guidelines specific to each type of equipment.

Curve	Max Value 8-80Hz	Detail Size	Equipment Types / Requirements
	Microns / sec, rms	Microns	
VC-A	50	8	Bench Microscopes < 400 x Magnification, optical and other precision balances, coordinate measuring machines and optical comparators
VC-B	25	3	Bench Microscopes > 400 x Magnification, microsurgery and neurosurgery
VC-C	12.5	1	Electron Microscopes < 30,000 x magnification, magnetic resonance imagers and microelectronics manufacturing equipment
VC-D	6	0.3	Electron Microscopes > 30,000 x magnification, mass spectrometers and cell impact equipment
VC-E	3	0.1	Un Isolated laser and optical research systems

Table 18: VC Curves for Highly Sensitive Equipment

Figure 3 shows the relationship between criteria for highly sensitive equipment and human exposure criteria shown in Table 16.

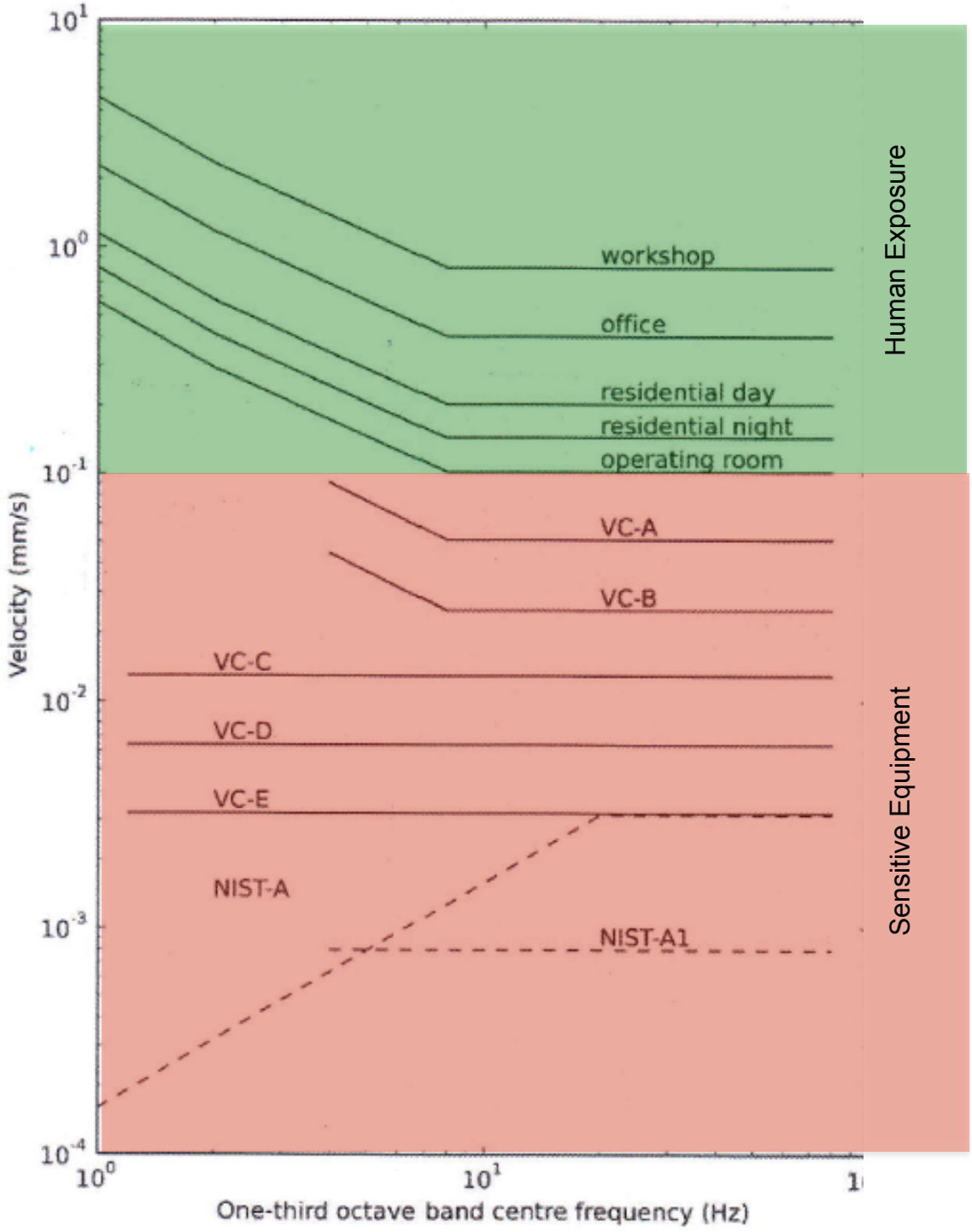


Figure 3: VC Curves - *Source: ANC Guidelines – Measurement and Assessment of Ground-borne Noise & Vibration, Association of Noise Consultants (2012)*

At this stage no structures at or surrounding the site have been identified as having particularly vibration sensitive equipment.

Recommended approach to vibration management

The criteria given in Table 16 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.

It is recommended that a precautionary approach for managing vibration-induced damage be taken for this project, whereby conservative vibration criteria are adopted in the first instance. It would be possible to relax these criteria if required, subject to review of specific buildings by a structural engineer and a regime of vibration monitoring.

The recommended precautionary criteria are:

- 3 mm/s (130 dB re 10^{-6} mm/s) for buildings surrounding the project site identified as "sensitive". At this stage no structures at or surrounding the site have been identified as particularly sensitive to vibration induced damage.
- 5 mm/s (134 dB re 10^{-6} mm/s) for residential dwellings
- 20 mm/s (146 dB re 10^{-6} mm/s) for UTS and TAFE classrooms, non precision laboratories, commercial premises

8.3 Construction noise and vibration assessment

8.3.1 Description of proposed works

The Project Manager has developed a construction program that outlines the key construction activities in each particular location. Based on this, it is anticipated that the key construction activities to occur for each area / stage are as follows:

Stage of Works (Period)	Main Tasks	Itemised Activities[4]	Typical Plant
Enabling Works (July to October 2016)	Services Disconnection and Relocations		Angle grinders / drills
	Bathroom Relocations		Angle grinders / jack hammers / hand tools / drills
	Construct new LRS fire escape		Demo saw / air compressors / jack hammers / excavators with hammers / mobile crane / rattle guns / tipper trucks
	Relocate supply and Exhaust		Demo saw / air compressors / jack hammers / excavators with hammers / angle grinder / hand tools / drills
Hazardous Material Removal (July to September 2016)	Remove hazardous material including asbestos		Hand tools
Site Establishment (September to October 2016)	Installation of Perimeter Fencing		Hiab trucks / mobile cranes / drills / hand tools / circular saws
Structural Strengthening (August 2016 to February 2017)	Temporary strengthening of existing structure to allow demolition to proceed		Excavator with hammer / bobcats / tip trucks / bin lift trucks / demo saw / forklifts / mobile cranes / hammer drills
	Permanent Structural Strengthening of Existing Structure		Excavator with hammer / bobcats / tip trucks / bin lift trucks / demo saw / forklifts / mobile cranes / hammer drills / concrete trucks / concrete vibrators
Demolition (July 2016 to November 2016)	Internal Strip out and Demolition of existing Building 2 structure	Scaffold Existing Building	Hand tools / mobile cranes
		Strip out existing building	Excavators with hammer / bobcats / tip trucks / bin lift trucks

[4] Where applicable

Stage of Works (Period)	Main Tasks	Itemised Activities[4]	Typical Plant
		Demolish concrete structure	Mobile crane / tower crane / excavator with hammer / tip truck / demo saw
		Excavate lift shafts in rock	Excavator with hammer / rock saw / rock anchor drill / demo saw
Structure (October 2016 to April 2018)	Formwork		Tower crane / hand tools / jump form hydraulic jacks
	Concrete place		Concrete trucks / concrete placing boom / concrete pump / concrete vibrator
Façade (July 2017 to April 2018)	Installation of Glazing		Drill / mobile crane / tower crane
Fitout (April 2017 to December 2018)	Services Install		Hand tools / circular saw / angle grinder
	Masonry		Cement mixer / masonry saw
	Internal Linings and Joinery		Hand tools / circular saw / angle grinder / circular saw
	Floor finishes and tiling		Cement Mixers / angle grinders
External Works (March 2018 to December 2018)	In ground services		Demo saw / excavators
	Landscaping		Demo saw / excavator / hand tools / drills / angle grinders / hammer drill / mobile crane / tower crane
Note: Items shaded in grey are works to be carried out internally within the building			

Table 19: Proposed Works

8.3.2 Construction noise and vibration sources

The key construction noise sources for the works occurring during the project and the associated equipment noise levels are listed in Table 20 below. These values are based on Acoustic Studio's database plus Australian and International Standards.

Equipment Type	Item	Typical Noise Level $L_{A10,15min}$ SWL
Heavy Vehicles	Tipper Truck	114
	Bin Lift Truck	114
	Hiab Truck	116
	Delivery trucks (semi-trailers, rigid trucks)	108
	Concrete Mixer trucks	112
Site Machinery	Tower crane	108
	Mobile Crane	111
	Bobcat	113
	Excavator (with rock breaker / rock saw)	119
	Excavator (8 Tonne w/bucket)	108
	Air Compressor	110
	Forklift	113
	Rock Anchor Drill	119
	Jump form Hydraulic Jacks	< 110
	Concrete Vibrator	104
	Concrete pump	113
Hand held tools	Angle Grinder	104
	Drill	94
	Hammer Drill	107
	Jackhammer	113
	Hand Tools (Electric)	102
	Circular saw	115
	Demo Saw	122
	Rattle Gun	116

Table 20: Anticipated airborne noise levels for construction noise equipment / plant

Potential sources of vibration and ground-borne noise during the UTS Central project works include:

- Demolition and excavation plant including rock-breakers and jack hammers.
- Installation of structure
- Grinding, cutting and drilling of existing building structures.

Vibration and ground-borne noise impacts are likely to be highest during the demolition and excavation stages of the project, when equipment such as rock breakers and jackhammers are used.

8.3.3 Sensitive receivers

Nearest sensitive receivers to the UTS Central site that will be potentially affected by noise and vibration associated with proposed construction works are surrounding residential and educational premises as presented in Section 2.4.

Table 21 outlines the most critical receivers surrounding the site for each type of impact.

Receiver	Impact	Location	Approximate Distance from construction site (closest point)
Residential	Airborne	Central Park (South)	45m
Educational	Airborne + Ground borne + Vibration (Human Comfort & Building Damage)	Adjacent UTS Tower (East)	< 10 m
	Airborne + Ground borne	UTS Building 10 and 11 across Jones St (West)	25 m
	Airborne + Ground borne	UTS Building 7 across Alumni Green (North)	38 m
	Airborne	TAFE (North)	80 m

Table 21: Noise sensitive receivers and approximate distance (closest point) to Project site

8.3.4 Methodology

A preliminary assessment of the likely noise impacts of the proposed works on the most-affected receivers surrounding the site has been carried out.

The assessment has considered the following:

- Typical construction activities considered in the noise impact assessment are as detailed in Table 19.
- Project specific criteria at each sensitive receiver location as outlined in Section 8.2 for Monday to Friday between 8am to 7pm and Saturday between 8am and 5pm. These are the time periods where the majority of works will occur.
- Noise level predictions are calculated using the noise data provided in Table 20.
- Noise level predictions consider for:
    - Distance attenuation
    - Attenuation from shielding from existing structures
    - Ground and building reflections
- $L_{A10\ and}$ noise levels are predicted for the operations at typical distances from each construction area to each sensitive residential receiver location.
- The predictions consider a range from individual task and associated equipment up to the cumulative noise contribution from all key activities and corresponding equipment with plant running simultaneously for each phase and main task.
- The predictions assume continuous operation of equipment / plant over the 15-minute assessment period.
- For the purposes of this assessment, predictions have only been undertaken for worst-case external activities to be carried out at the site. Continuous construction noise associated with demolition, refurbishment and new-build works is expected to comply with stated criteria for nearest residential and educational receivers when these activities occur indoors.

8.3.5 Noise assessment results

The following section presents the results of the preliminary noise assessment carried out for external construction works scheduled for the project.

This construction noise assessment determines the potential noise impact of activities and associated plant and equipment at the most affected receivers.

Table 22 below presents the predicted construction noise levels at the nearest affected locations, with comparison against the relevant criteria.

Location and Construction Activity	Predicted equipment noise level, in $dBL_{A10,15min}$				
	Central Park (Residential)	TAFE (Educational)	UTS CB07 (Educational)	UTS CB10 and CB11 (Educational)	UTS Tower (Educational)
Site Establishment	61 to **81**	56 to **76**	63 to **83**	66 to **86**	**74** to **94**
Demolition	**70**[5] to **88**	65 to **83**	**72** to **90**	**75** to **93**	**84** to **101**
Structure	**68**[5] to **76**	63 to **71**	70 to **78**	**73** to **81**	**81** to **89**
Façade	66 to **73**	61 to 68	68 to **75**	**71** to **79**	**79** to **87**
External Works	61 to **82**	56 to **77**	63 to **84**	66 to **87**	**74** to **95**

Table 22: Predicted equipment/plant noise levels at nearest sensitive residential and educational receiver locations – Levels predicted to exceed the Monday to Friday 8am to 7pm criteria are in **red** and Levels predicted to exceed the Saturday 8am to 5pm criteria are in **blue**[6]

[5] Marginally above the relevant criteria.

[6] Levels highlighted in red also exceed the Saturday 8am to 5pm criteria.

Based on the results of the assessment detailed in Table 22, we make the following comments:

- Noise Levels at Residential Receivers.
    - Noise levels at the nearest residential receivers are generally able to comply with the relevant criteria when considering individual tasks occurring at times that the majority of works are proposed to be carried out (i.e. Monday to Friday 8am to 7pm and Saturday 8am to 5pm).
    - For works carried out between 7am and 8am Monday to Saturday, noise levels are generally predicted to exceed the relevant criteria. Therefore scheduling and noise control measures outlined 8.4 shall be considered and implemented wherever reasonable and feasible.
    - The worst-case cumulative noise contribution from works has potential to exceed the relevant criteria by up to 21 dB at the nearest residential noise receiver.
- Noise Levels at Educational Receivers.
    - Noise levels at the nearest non-UTS educational receivers are able to comply with the relevant criteria when considering tasks carried out individually.
    - For UTS educational receivers there will be times / situations (demolition, structure and façade works) where works are likely to exceed stated criteria, particularly when works occur in the areas closer to sensitive receivers.
    - The worst-case cumulative noise contribution from works has potential to exceed the relevant criteria by up to 31 dB at the nearest educational noise receiver.
- The predictions above for noise levels exceeding the relevant criteria is not unusual given the heavy plant and equipment that must be used and the proximity of adjacent neighbours.
- The noise levels shown in the assessment indicate the likely worst case when works occur at the construction site boundary closest to the potentially affected noise receivers.
- For each of these activities and assuming that, in fact, these activities are found to exceed the noise criteria, then the noise control measures in 8.4.1 shall be considered and implemented wherever reasonable and feasible. In addition, the construction best practices presented in Section 8.4.4 shall be considered to minimise the noise impacts on the neighbourhood.

8.4 Control elements

8.4.1 Noise

As a general rule, prevention should be applied as universal work practice at any time of day, but especially for the occasional 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.
  - Keep truck drivers informed of designated routes, parking locations and delivery hours.

8.4.2 Vibration

At this stage, we anticipate that construction works will result in no adverse vibration impacts at surrounding receivers.

The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating 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.

8.4.3 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.

8.4.4 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 presented in Section 8.4.1, 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, residential receivers are likely to be more sensitive to noise before 9 am than the UTS and TAFE campus receivers.
- Consider implementing equipment-specific screening or other noise control measures recommended in Appendix E of AS2436.
- 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.

8.5 Noise and vibration monitoring

8.5.1 Noise monitoring

The Contractor should consider implementing environmental noise monitoring at the locations described below.

- Southern boundary facing nearest residential receivers on Broadway (Central Park).
- Boundary of nearest on-campus educational receivers to UTS Central site.

An allowance of 1.5 days per week, at least, should be dedicated to monitoring of noise and vibration for the first four weeks of demolition and construction. Further monitoring should be reviewed after this time or sooner should it be deemed necessary by the Acoustic Consultant and the Project Manager. This should take place mainly at the above locations although other locations and plant and equipment monitoring should take place as and when necessary. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

8.5.2 Vibration monitoring

A vibration monitoring system could be implemented. 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.

8.5.3 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.

8.6 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.

8.7 Non-compliances

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

9 Conclusion

A noise and vibration assessment report has been produced to establish the potential impacts of operational noise plus construction noise and vibration of the proposed UTS Central project.

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 established based on relevant guidelines and standards.

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

- Operational Noise

  Mechanical Plant

  At this stage, final 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 based on the most restrictive criteria. Based on this preliminary assessment, noise emissions from rooftop plant shall be limited to 75 dBA at 1 metre from the plant room boundaries.

  Noise controls will be incorporated within the design of the rooftop plant room and any other plant located outdoors or on other levels of the proposed building 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 plant and/or acoustic noise control measures such as enclosures, barriers, acoustic louvres, sound absorptive panels, etc.

  Traffic Noise Generation

  Additional traffic noise generation is considered negligible as there a no significant changes to traffic flow expected once the UTS Central Project is completed.

  Rooftop Terraces

  Based on the predictions in Section 6.3, we expect that there will be no adverse noise impact as a result of the use of the rooftop terraces, and noise emissions are expected to comply with the relevant criteria.

- Construction Noise

  Continuous construction noise associated with demolition, refurbishment and new-build works is expected to comply with stated criteria for nearest residential and educational receivers when these activities occur indoors.

  However, there will be times / situations when demolition and new-build works are likely to exceed stated criteria, particularly when works occur in the areas closer to sensitive receivers

  If, during construction works, an item of equipment exceeds the stated airborne noise criteria at any sensitive location, the additional noise control measures presented in Section 8.4.4, together with construction best practices presented in Section 8.4.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Construction Vibration

  At this stage, we anticipate that construction works will result in no adverse vibration impacts at surrounding receivers.

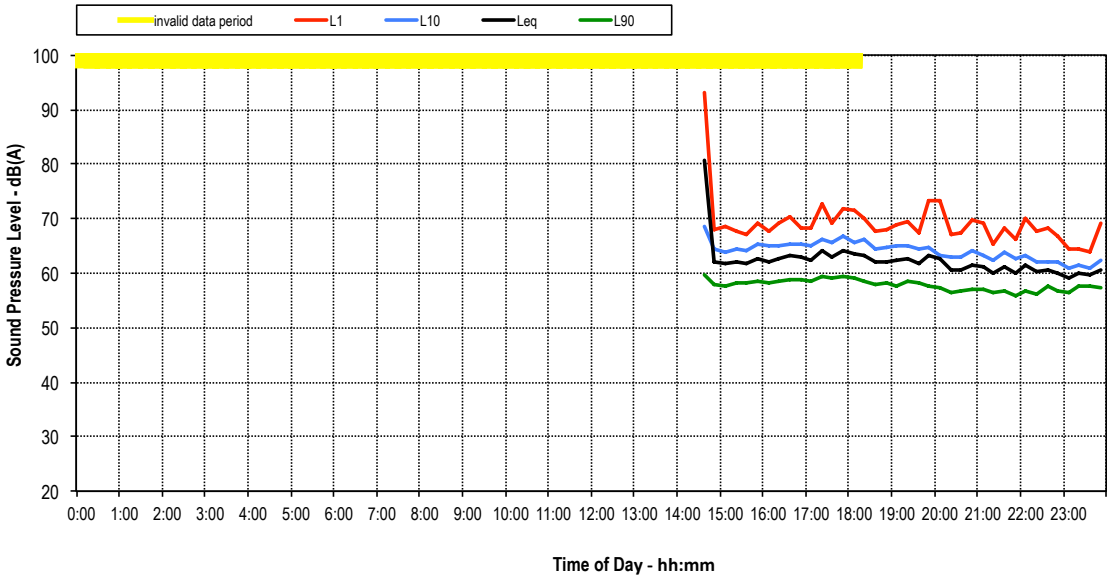
The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating activity to determine whether the existence of significant vibration levels justifies a more detailed investigation.

Appendices

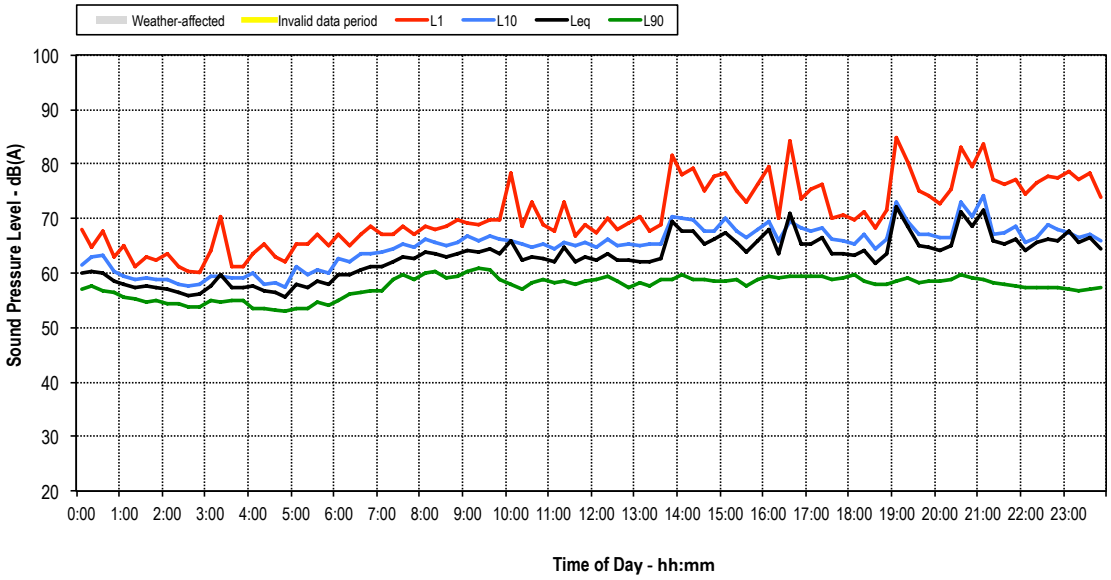
Appendix A : Long-term monitoring results

Logger Location 1

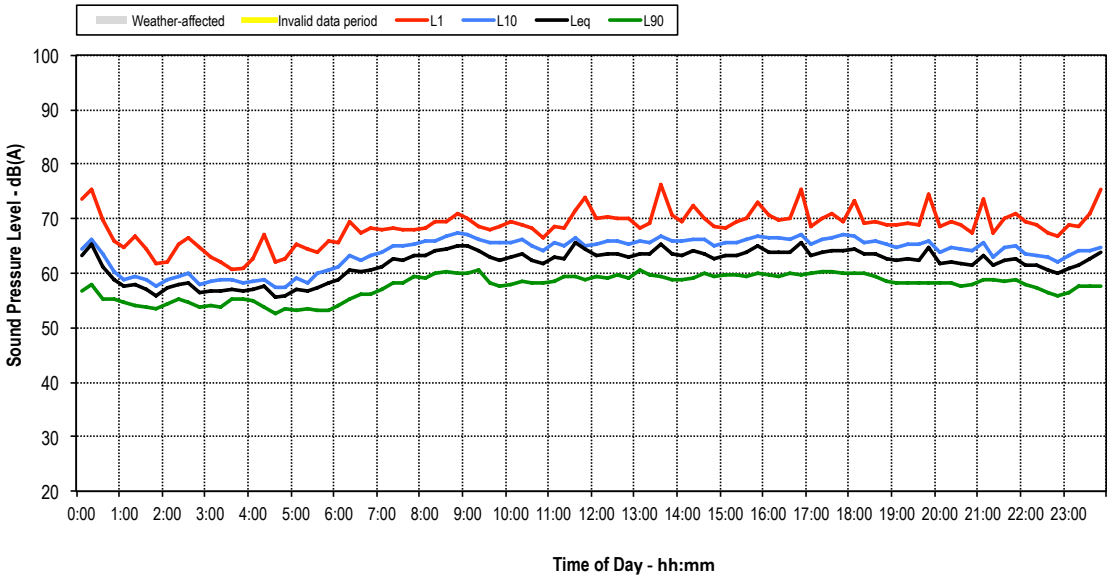
UTS - Broadway - Tuesday 17 November 2015



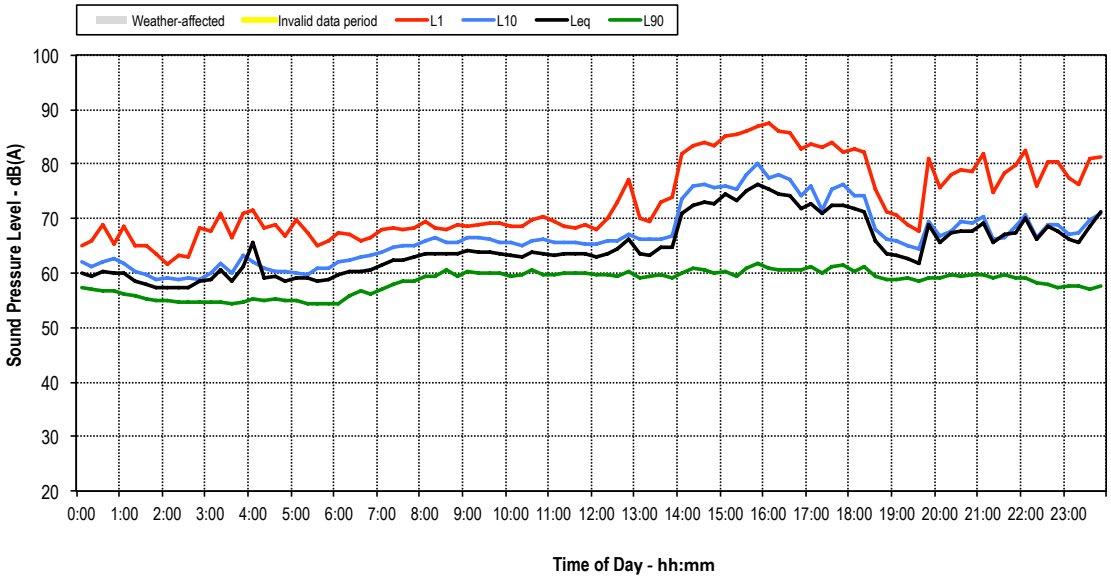
UTS - Broadway - Wednesday 18 November 2015



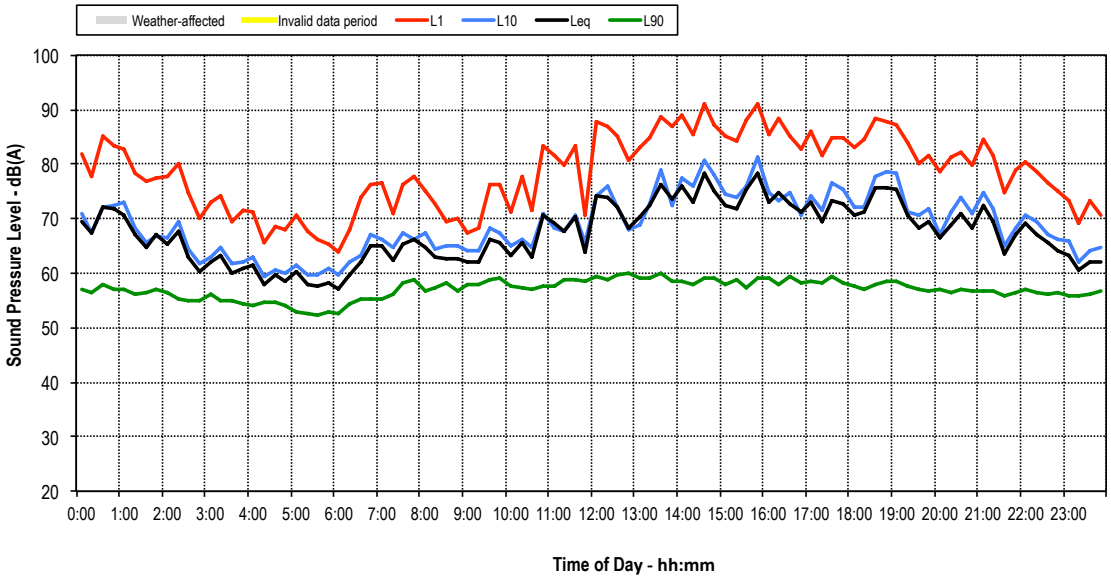
UTS - Broadway - Thursday 19 November 2015



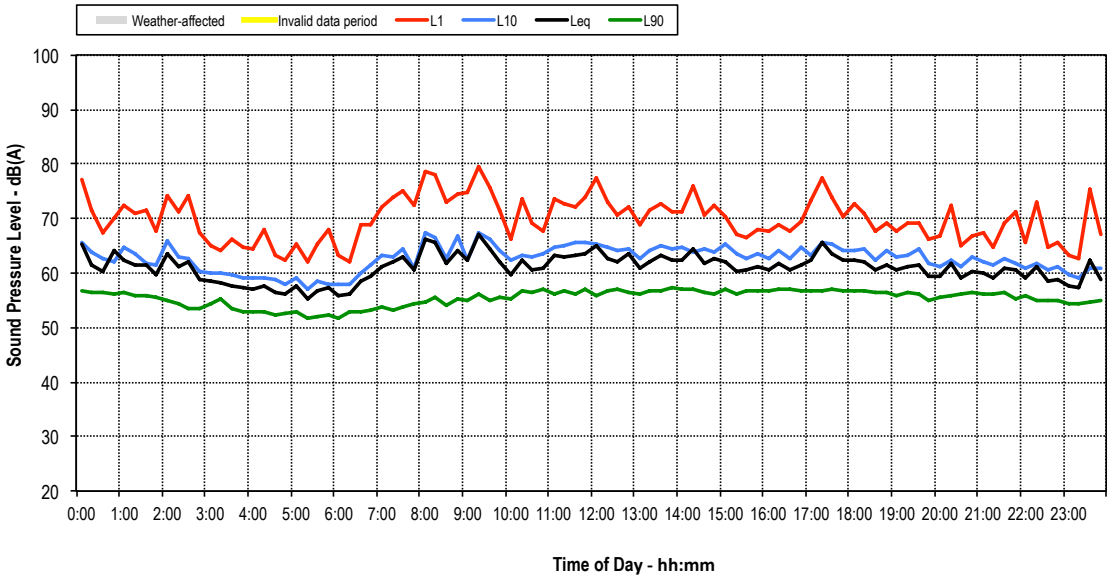
UTS - Broadway - Friday 20 November 2015



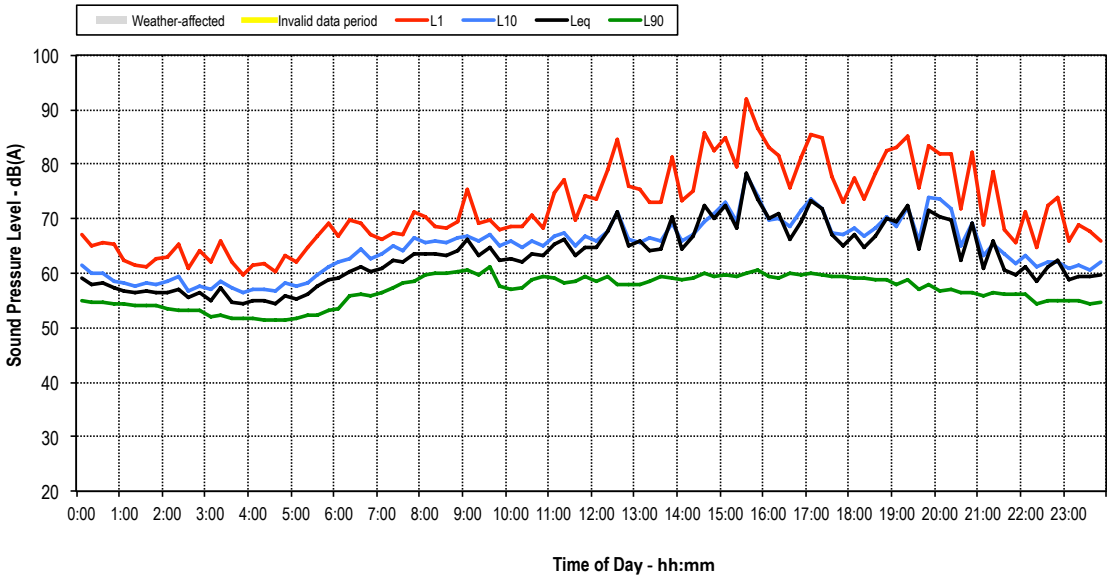
UTS - Broadway - Saturday 21 November 2015



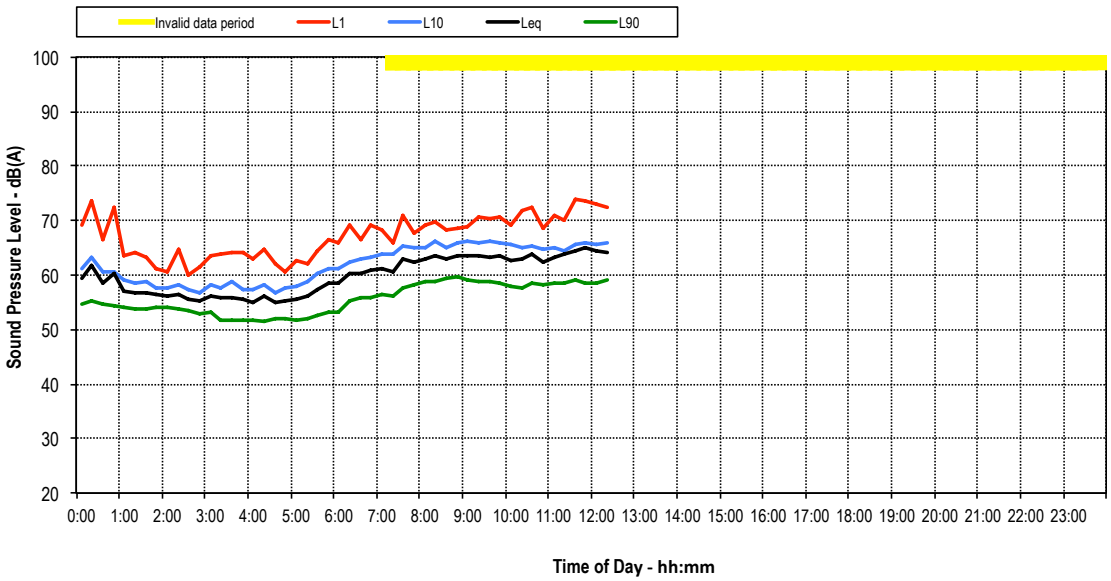
UTS - Broadway - Sunday 22 November 2015



UTS - Broadway - Monday 23 November 2015

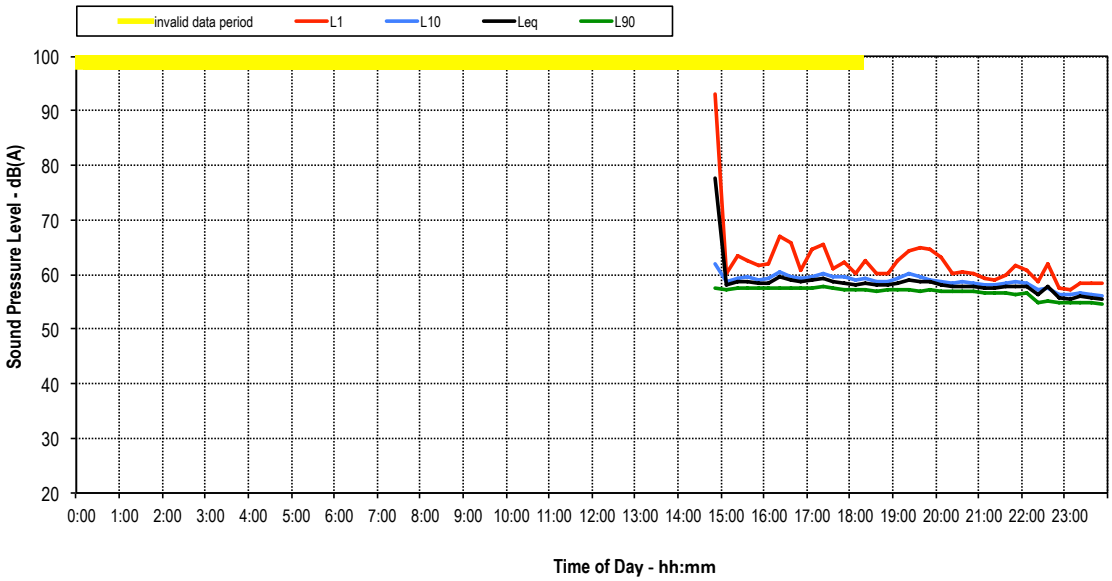


UTS - Broadway - Tuesday 24 November 2015

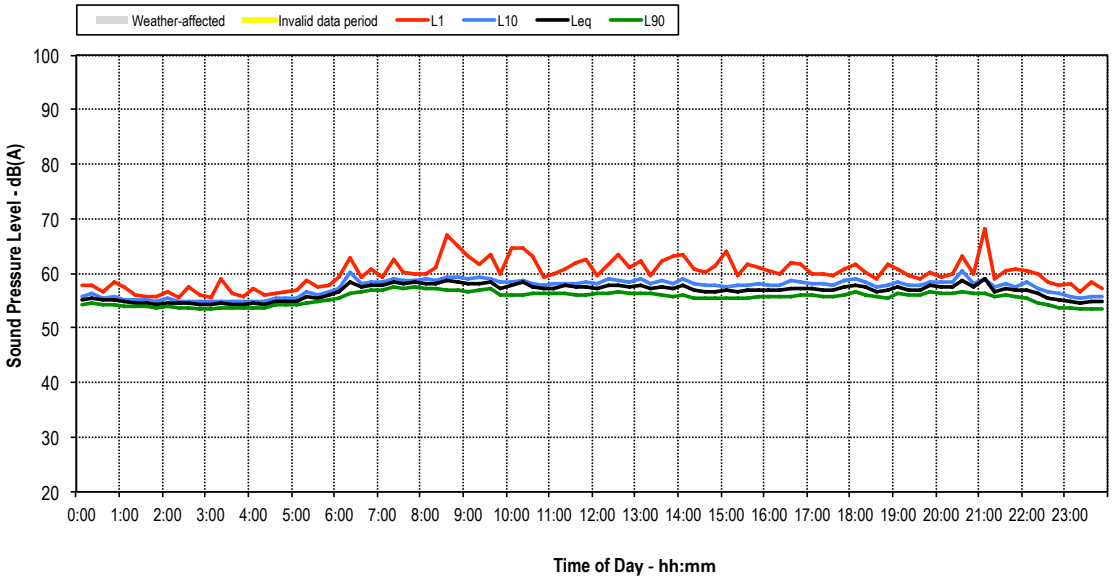


Logger Location 2

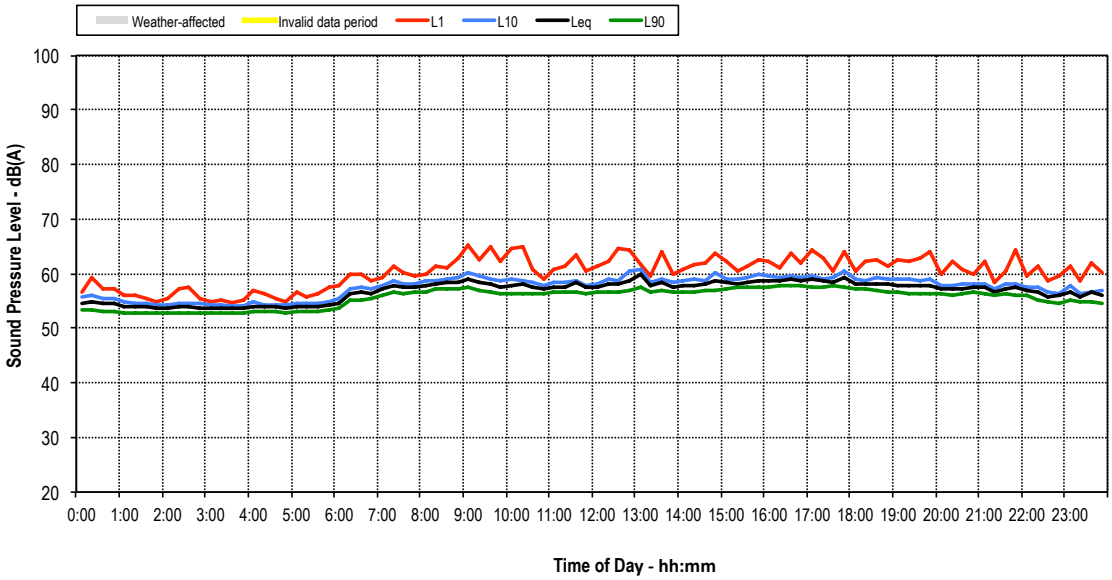
UTS - Jones St - Tuesday 17 November 2015



UTS - Jones St - Wednesday 18 November 2015



UTS - Jones St - Thursday 19 November 2015



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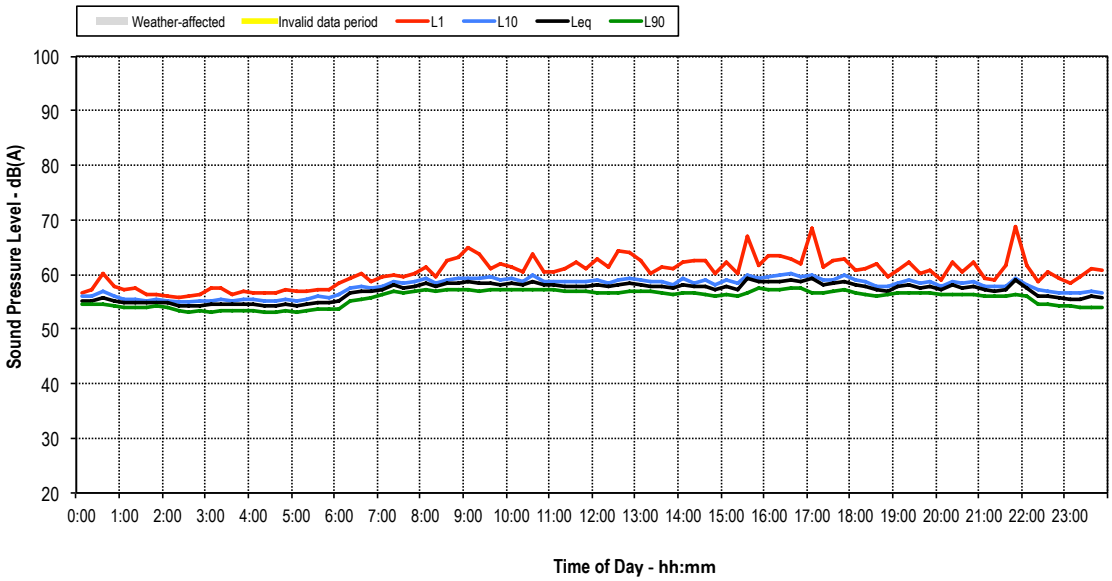

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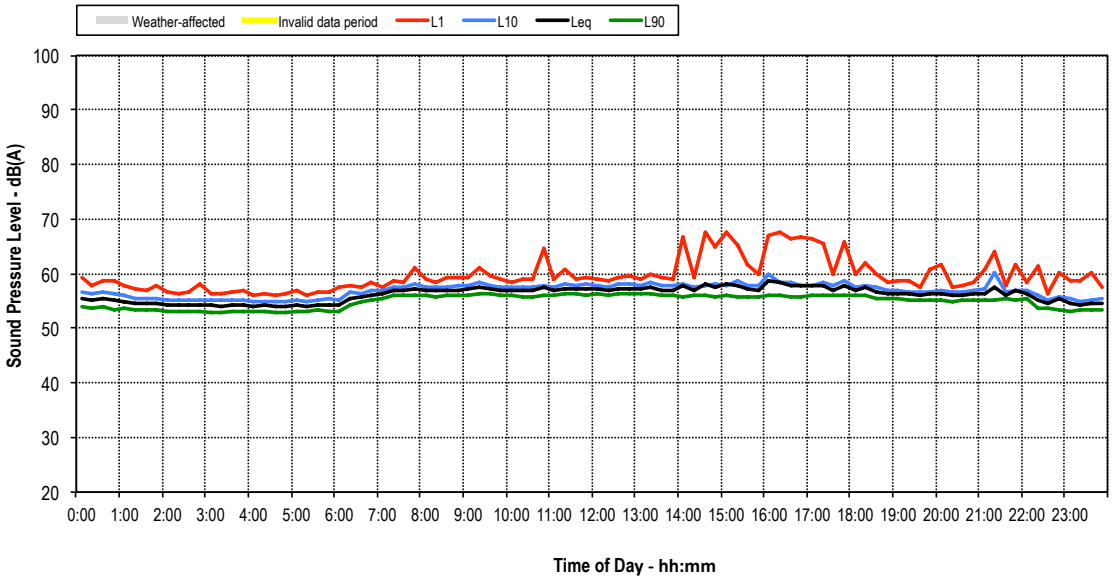
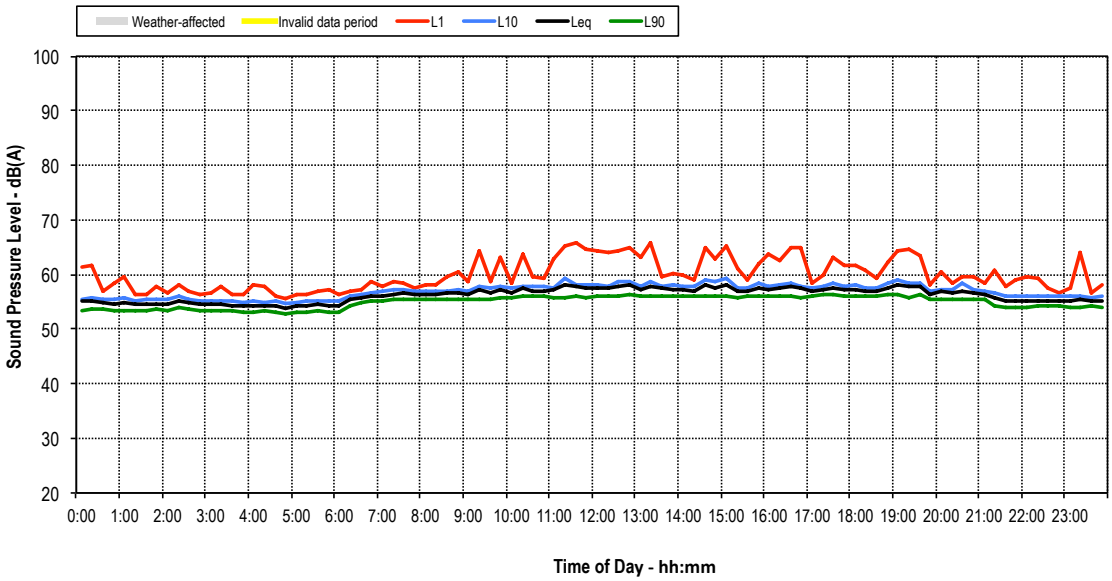
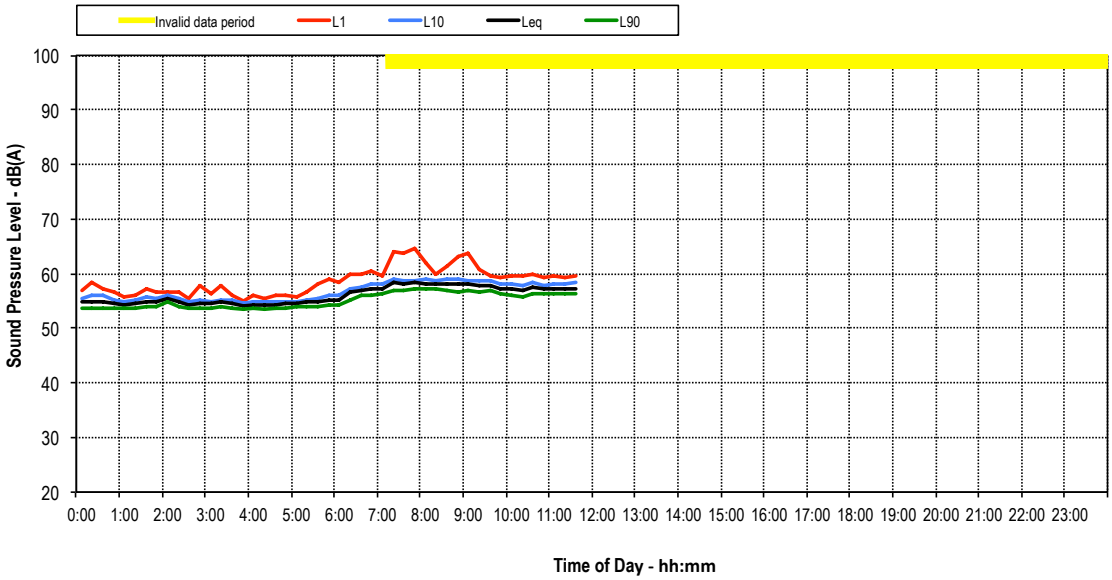


UTS - Jones St - Sunday 22 November 2015



UTS - Jones St - Monday 23 November 2015



Appendix B : Derivation of Environmental Noise Break-out Limits

One of the main sources of noise break-out from the UTS Central site to the environment will be mechanical services plant – particularly roof plant.

The environmental noise impact of the proposed roof 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 roof 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.

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} 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 – Building CB02 (Rooftop – Southern End)	58	57	53	68	67	62
L2 – Building CB02 (Rooftop – Northern End)	56	56	53	58	57	55

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

From observations during our site visit, it is noted that both ambient and background noise levels around the UTS Central site were dominated by mechanical plant noise from surrounding UTS buildings, and traffic noise along Broadway.

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 B.1 for each period and from the short-term measurements presented in Section 4.3. The intrusiveness criterion is established for residential receivers and in this instance is based on Logger location L1.

- Day Intrusiveness criterion of 58 + 5 = **63 dB(A)**
- Evening Intrusiveness criterion of 57 + 5 = **62 dB(A)**
- Night Intrusiveness criterion of 53 + 5 = **58 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.

Type of Receiver	Period	Recommended $L_{Aeq, period}$ Noise Level (ANL)	
		Acceptable	Recommended Maximum
Residential – Urban (external)	Day	60	65
	Evening	50	55
	Night	45	50
Commercial (external)	When in use	65	70
Classroom (Internal / External)	Noisiest 1-hr period when in use	35 / 45[7]	40

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

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

Existing L_{Aeq} levels

The existing L_{Aeq} levels, determined from the ambient noise level measurements, are as follows:

Type of Receiver	Period	Existing L_{Aeq} Level
Residential – Urban (external)	Day	68
	Evening	67
	Night	62
Commercial / Classroom	When In Use	56[8]

Table B3 : Existing L_{Aeq} Levels for nearest residential receiver location for project

[7] The NSW INP specifies an internal ANL of 35. The NSW INP also states that where internal noise levels are specified, external noise 10 dB above internal noise levels can be applied which should achieve an internal noise level where a window is adequately opened to provide natural ventilation.

[8] When considering both day and night

Amenity criterion

The amenity criterion is determined from the relationship of the existing L_{Aeq} noise level from industrial sources and the Acceptable Noise Levels (ANLs) for each land use type under consideration (as detailed in Table 2.1 of the NSW Industrial Noise Policy).

This process is summarised below in Table B4.

Receiver	Period	Existing L_{Aeq} Level	ANL	Adjustment to ANL	Amenity Criterion
Residential	Day	68	60	Existing L_{Aeq} minus 10	58
	Evening	67	50	Existing L_{Aeq} minus 10	57
	Night	62	45	Existing L_{Aeq} minus 10	52
Commercial	When in Use	56	65	No Adjustment	65
Educational	Noisiest 1-hour period When In Use	56	45	Existing L_{Aeq} minus 10	46

Table B4 : 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) for new roof plant associated with the site are shown in Table B5 below (PNLs shown shaded in grey).

Type of Receiver	Period	Intrusiveness Criterion	Amenity Criterion
Residential – Suburban (external)	Day	63	58
	Evening	62	57
	Night	58	52
Commercial (external)	When in use	-	65
Classroom (Internal)	Noisiest 1-hr period when in use	-	46

Table B5 : Determination of project specific noise levels for UTS CENTRAL

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, why the British Standards Institution (BSI) did not provide guidance before 1992 and why there are still no International Organisation for Standardisation (ISO) guidance limits.

There are however several standards that can be referred to.

German Standard

The relevant German standard is DIN 4150: Part 3: 19862. This standard gives guidelines for short-term and steady state structural vibration. For short-term vibration in buildings the following limits are given:

Structural type	Vibration Velocity, v_i, in mm/s			
	Foundation			Plane of floor of uppermost full storey
	less than 10Hz	10 to 50 Hz	50 to 100 Hz	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.

Swiss Standard

The relevant Swiss standard is SN 640 312:1978. 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

British Standard

The relevant standard is BS7385: Part 2: 1993[9]. 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 Hz to 15 Hz	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

[9] British Standards 7385:1993 Part 2 "*Evaluation and Measurement for vibration in Buildings. Guide to damage levels from ground-borne vibration"*

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.

Australian Standard

There is no specific Australian Standard referring to structural vibration in buildings. There is however AS 2187.2 - 1993[10], 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.

[10] AS 2187.2 - 1993 Explosives - Storage, transport and use. Part 2: Use of explosives