

Australian Institute of Nanoscience - University of Sydney

Construction and Operation - Environmental Noise and Vibration Impact Assessment



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Construction and Operation - Environmental Noise and Vibration Impact Assessment

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1.0 Introduction

AECOM Australia Pty Ltd (AECOM) has been commissioned by Lend Lease Project Management & Construction (Australia) Pty Ltd (LLPM&C) on behalf of the University of Sydney to assess the potential noise and vibration impacts associated with the construction and operation of the proposed new Australian Institute of Nanoscience Facility (AIN Facility) at the University of Sydney, Camperdown Campus, NSW.

This Construction and Operation Noise and Vibration Impact Assessment Report forms part of the Environmental Impact Statement (EIS) submission to the Department of Planning and Infrastructure (DP&I).

1.1 Project description

The University of Sydney is proposing to construct a new research and education facility at its Camperdown Campus to house the AIN Facility on land located immediately behind and to the south of the existing School of Physics Building (building A28). The proposed AIN Facility will accommodate students, teaching staff, research staff and industry partners in a national and international resource. It will support a diverse range of research and teaching activities.

The project involves the establishment of a new research and educational facility that will incorporate highly specialised research laboratories, general laboratories, staff and postgraduate workspace and shared teaching, learning, office and social spaces within the University of Sydney Camperdown Campus, NSW.

The proposed AIN Facility comprising a single four storey building with two wings, which will be integrated with the existing School of Physics Building (existing heritage building), will deliver the following facilities:

- 'Specialist' laboratory spaces for research groups including: precision metrology laboratories, two Transmission Electron Microscope (TEM) suites, high-performance electronics and optics laboratories and a cleanroom with expansion space.
- General laboratories for research groups.
- Teaching and learning spaces comprising:
 - a 320 person lecture theatre
 - one flexible, flat-floored learning studio space for up to 90 persons
 - two flat-floored seminar spaces for up to 80 and 40 persons respectively
 - a Video Conference (VC) enabled seminar room
 - a teaching laboratory for up to 40 3rd Year Students
 - an informal student commons space for up to 105 persons.
- Workspace at the AIN Facility will augment the research and teaching facilities and will comprise single-person and shared offices with formal, enclosed and informal open, meeting settings, breakout spaces, facilities rooms, tea points and centralised storage.
- Support spaces will include landscaping and a Café to support interaction within the School of Physics.

1.2 Report objective

This report has been prepared to accompany the EIS application for a State Significant Development (reference SSD 5087-2011), for the construction and operation of a major science research and education facility, the AIN Facility.

This impact assessment addresses the Director-General's Environmental Assessment Requirements (DGRs) by considering the potential noise and vibration impacts on nearby sensitive receivers during the construction and operation phase of the AIN Facility.

This report is technical in content. A glossary of acoustic terminology is included in Appendix A.

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1.3 Director General's Requirements

The DGRs for the proposed AIN Facility were issued by DP&I on 1 February 2012.

The DGRs for this project note the following matters in relation to noise and vibration, refer to Table 1. Details of where each requirement is covered in this document are provided in Table 1.

Table 1 Director-General's Requirements and document references

Description	Document Reference
Key Issues	
The EIS must address the following specific matters:	
5. Amenity Assess the impact on the amenity of buildings in the locality and future occupants of the development with respect to solar access, acoustic impacts, visual privacy, impact on the amenity of neighbouring properties, servicing requirements (including but not limited to, waste management, loading zones, mechanical plant), view loss overshadowing and wind impacts. A high level of environmental amenity must be demonstrated.	Entire document
6. Noise and Vibration Identify the main noise generating sources and activities at all stages of construction, and any noise sources during operation. Outline measures to minimise and mitigate the potential noise impacts on occupants and residents in neighbouring buildings.	Entire document
Relevant Policies and Guidelines: - NSW Industrial Noise Policy (EPA) - Interim Construction Noise Guideline (DECC)	
5. Heritage - An heritage impact statement of the likely impacts of the proposal on surrounding/nearby heritage items, including: - Construction and operational impacts on adjoining heritage items;	Section 3.2 and 5.4
15. Operational Management The EA should address noise from plant and equipment, material hazards security, emergency and evacuation procedures, lighting and signage associated with the development.	Section 4.0 and 6.0

1.4 Relevant guidelines

1.4.1 Construction

- Director-General Requirements for Science Research and Education Facility (SSD 5087-2011).
- Interim Construction Noise guideline, Department of Environment and Climate Change, NSW (ICNG, DECC 2009).
- Assessing vibration: a technical guideline, Department of Environment and Conservation, NSW (DEC 2006).
- DIN Standard 4150 - Part 3 - Structural Vibration in Buildings - Effects on Structures.
- British Standard 7385: Part 2 1993 Evaluation and Measurement of Vibration in Buildings.
- NSW Road Noise Policy, Department of Climate Change, Environment and Water, NSW (RNP, DECCW 2011).

1.4.2 Operation

- Director-General Requirements for Science Research and Education Facility (SSD 5087-2011).
- NSW Protection of the Environment Operations Act 1997 (PoEOA 1997).

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- NSW Industrial Noise Policy, NSW Environment Protection Authority, Sydney (INP, EPA 2000)
- Application notes - NSW industrial noise policy, (EPA, 2013).
- NSW Road Noise Policy, Department of Climate Change, Environment and Water, NSW (RNP, DECCW 2011).

1.5 Reference documents

This assessment has been undertaken using the following drawings:

- 7326/M016/LAY/4/ZONE revision C, dated 16 April 2013 issued by M+W Australia;
- ED01023 revision 01, dated 10 July issued by Norman Disney and Young;
- The following architectural drawings all revision 1 dated 19 June 2013 issued by Architectus:
 - DA-1000
 - DA-1001
 - DA-1002
 - DA-1003
 - DA-1004
 - DA-2000
 - DA-2001
 - DA-2002

1.6 Site description

The site of the proposed development is bounded by the existing School of Physics building to the north, Wesley College to the west, the Edward Ford Building to the east and the proposed St Pauls College development to the south. The site location is presented in Figure 1.

1.6.1 Sensitive receivers

Aerial imagery of the proposed site is provided in Figure 1 noting all nearby sensitive receiver locations and unattended measurement locations. Details of each noise sensitive receiver are included in Table 2.

DRAFT**Figure 1** Site location unattended noise monitoring locations and noise sensitive receiver assessment locations**1.1 Assessment receivers**

The locations of the AIN Facility site and nearby receivers are shown in Figure 1. The representative receiver locations and the associated receiver areas for assessment purposes, along with the land use classification (as defined in the INP) of each receiver are presented in Table 2.

Table 2 Assessment receiver locations

Receiver	Address	Land use classification
R1	Physics Building	Education
R2	Edward Ford Building	Education
R3	Animal House	Education
R4	St Pauls College	Residential
R5	Wesley College	Residential

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2.0 Noise Monitoring

2.1 Unattended noise measurements

Noise monitoring has been conducted in the vicinity of the proposed AIN development site to determine existing background and ambient noise levels. A SVAN 949 noise logger was located on the roof top of the existing A29 Physics Annex building (Logger 1, in Figure 1). It was noted that the main noise sources consisted primarily of mechanical plant from various locations. A significant, but intermittent noise source was the existing mechanical plant located between the existing Physics Building and the Physics Annex building. Other mechanical noise sources were noted from a number of directions on the campus. The noise logger monitored noise levels continuously from Friday 9 March to Friday 16 March 2012.

A second SVAN 949 noise logger was located in the north western corner of the field area (Logger 2 in Figure 1). Notable noise sources in this location were the nearby car park servicing Wesley College, distant City Road traffic and mechanical services from the existing Physics Building. The noise logger monitored noise levels continuously from Friday 9 March to Sunday 18 March 2012.

The loggers measured the noise levels over the sample period and then determined L_{A10} , L_{A90} , L_{Amax} , and L_{Aeq} levels of the noise environment. The L_{A10} and L_{A90} levels are the levels exceeded for 10% and 90% of the sample period respectively. The L_{Amax} is indicative of the maximum noise levels due to individual noise events such as the pass-by of a heavy vehicle. The L_{A90} is taken as the background noise level. The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels.

The background noise level is defined by the Environment Protection Authority (EPA) as '*the underlying level of noise present in ambient noise when all unusual extraneous noise is removed*'. It can include sounds that are normal features of a location and may include birds, traffic, insects etc. The background noise level is considered to be represented by the L_{A90} descriptor. The noise levels measured at the proposed development site were analysed to determine a single assessment background level (ABL) for each day, evening and night period in accordance with the EPA's NSW Industrial Noise Policy (INP), for each monitoring location.

The ABL is established by determining the lowest ten-percentile level of the L_{A90} noise data acquired over each period of interest. Table 3 presents individual ABL's for each day's assessment periods.

The background noise level or rating background level (RBL) representing the day, evening and night-time assessment periods is based on the median of individual ABLs determined over the entire monitoring period. Table 3 also presents the existing L_{Aeq} ambient noise level selected for each day, evening and night-time period, in accordance with the INP. An overall representative L_{Aeq} noise level is determined by logarithmically averaging each assessment period for the entire monitoring period.

Table 3 Existing background (L_{A90}) and ambient (L_{Aeq}) noise levels

Measurement Date	L_{A90} Background Noise Levels, dB(A)			L_{Aeq} Ambient Noise Levels, dB(A)		
	Day	Evening	Night	Day	Evening	Night
Logger 1 – Physics Annex Building rooftop						
Friday 09 March, 2012	50	50	47	56	55	50
Saturday 10 March, 2012	47	47	46	52	55	48
Sunday 11 March, 2012	46	49	47	51	56	52
Monday 12 March, 2012	50	49	46	56	55	50
Tuesday 13 March, 2012	50	51	47	54	55	50
Wednesday 14 March, 2012	50	51	47	54	58	52
Thursday 15 March, 2012	51	53	47	56	56	51
Friday 16 March, 2012	50	51	48	56	53	51
RBL	50	50	47	-	-	-

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Measurement Date	L _{A90} Background Noise Levels, dB(A)			L _{Aeq} Ambient Noise Levels, dB(A)		
	Day	Evening	Night	Day	Evening	Night
Log Average	-	-	-	55	56	51
Logger 2 – North west corner of field						
Friday 09 March, 2012	48	48	48	57	56	54
Saturday 10 March, 2012	45	48	46	56	56	50
Sunday 11 March, 2012	44	47	46	51	54	51
Monday 12 March, 2012	46	48	46	58	55	51
Tuesday 13 March, 2012	46	50	48	56	53	52
Wednesday 14 March, 2012	47	50	47	54	60	51
Thursday 15 March, 2012	48	50	46	56	54	50
Friday 16 March, 2012	47	49	46	55	52	50
Saturday 17 March, 2012	49	48	46	54	53	51
Sunday 18 March, 2012	46	47	-	51	56	-
RBL	46	48 (46)⁴	46	-	-	-
Log Average	-	-	-	55	56	51

Notes:

- 1) Day is defined as 7:00 am to 6:00 pm Monday to Saturday and 8:00 am to 6:00 pm Sundays and Public Holidays.
- 2) Evening is defined as 6:00 pm to 10:00 pm Monday to Sunday and Public Holidays.
- 3) Night is defined as 10:00 pm to 7:00 am Monday to Saturday and 10:00 pm to 8:00 am Sundays and Public Holidays.
- 4) NSW INP Application notes recommend that when higher background noise levels (RBL) occur in the night time or evening assessment periods, the criteria are generally set to the lower evening or daytime criteria in accordance with community expectations.

Noise logging results are presented in Appendix D.

2.2 Instrumentation

The long-term unattended noise logging was conducted using SVAN 949 Sound analyser equipment, designated as Type 1 instruments having an accuracy suitable for field measurements. The long-term noise loggers were calibrated before and after the measurements with no drift in calibration exceeding ± 0.5 dB.

Attended noise measurements were conducted using a Brüel & Kjær Type 2250 and a Brüel & Kjær Type 2270, both being integrating sound level meters. Both the Brüel & Kjær Type 2250 and the Brüel & Kjær Type 2270 integrating sound level meters are also designated as Type 1 accuracy. The sound level meters were calibrated before and after the measurements with no drift in calibration exceeding ± 0.5 dB.

All equipment used for this assessment has current calibration certificates (i.e. calibrated in the last two years).

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3.0 Construction Noise and Vibration Criteria

3.1 Construction noise criteria

The EPA's Interim Construction Noise Guidelines (ICNG, DECCW, 2009) provides the basis for construction noise assessments in NSW. This document replaces the previous publication, the Environmental Noise Control Manual, and is used as the basis for establishing construction noise management levels.

The ICNG recommends that a quantitative assessment is carried out for all 'major construction projects that are typically subject to the EIA process'. A quantitative assessment, based on a likely 'worst case' construction scenario, has been carried out for the AIN Facility. Predicted noise levels at nearby receivers are compared to the levels provided in Section 4 of the ICNG. Where an exceedance of the management levels is predicted the ICNG advises that the proponent should apply all feasible and reasonable work practises to minimise the noise impact.

The ICNG defines what is considered to be feasible and reasonable as follows:

Feasible

A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.

Reasonable

Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure."

Construction noise management levels (NMLs) for residential receivers are set using the information in Table 4.

Table 4 Noise management levels at residences using quantitative assessment

Time of Day	Management Level $L_{Aeq} (15min)^1$	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. - Where the predicted or measured $L_{Aeq} (15 min)$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. - The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. - Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: - times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. - If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

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Time of Day	Management Level L_{Aeq} (15min) ¹	How to Apply
Outside recommended standard hours	Noise affected RBL + 5 dB	- A strong justification would typically be required for works outside the recommended standard hours. - The proponent should apply all feasible and reasonable work practices to meet the noise affected level. - Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. - For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Notes:

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

3.1.1 Construction noise management levels

We have been advised that the construction activities will take place predominantly during recommended standard working hours (7:00 am – 6:00 pm Monday to Friday and 8:00 am – 1:00 pm Saturday). However, oversized loads and emergency work may need to be conducted outside recommended standard working hours.

Construction noise management levels for the nearest sensitive residential receiver areas are shown in Table 5. The more stringent background noise levels have been used to determine the noise management levels, resulting in a conservative assessment.

Table 5 Construction noise management levels – Residential receivers

Daytime RBL L_{A90} dB(A)	Construction Works Period	Daytime Noise Management Levels L_{Aeq} dB(A)
46	ICNG standard construction hours	56
	Outside ICNG standard construction hours	51

Noise management levels for other sensitive land uses around the AIN Facility, such as schools, places of worship are shown in Table 6.

Table 6 Construction noise management levels – Sensitive land uses other than residential

Land Use	Noise management level, L_{Aeq} (15 min) (applies when premises are in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)

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Land Use	Noise management level, L_{Aeq} (15 min) (applies when premises are in use)
Community centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS2107 for specific uses.

Criteria for industrial and commercial premises, are shown below:

- Industrial premises: external L_{Aeq} (15min) 75 dB(A), and
- Commercial (e.g. Offices, retail outlets): external L_{Aeq} (15min) 70 dB(A).

3.2 Construction vibration criteria

Unlike the criteria applicable to noise emissions, vibration criteria are the same for both the construction and operation phases of this project. EPA's 'Assessing Vibration: a technical guideline', (DECCW, 2006) has been designed to be used in evaluating and assessing the effects on amenity of vibration emissions from industry, transportation and machinery. The guideline is used in assessments of vibration impacts caused by the construction and operation of new developments.

Vibration criteria are set primarily according to whether the particular activities of interest are continuous in nature or intermittent, whether they occur during the daytime or night-time and the type of receiver to be assessed e.g. commercial or residential.

The effects of vibration in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed, i.e. human disturbance or discomfort;
- Those in which the integrity of the building or the structure itself may be prejudiced; and
- Those where the building contents may be affected.

Therefore, vibration levels at sensitive receiver locations must be controlled so as to prevent discomfort and regenerated noise, and in some cases, structural damage.

3.2.1 Building exposure to vibration - Structural damage

Vibration generated by operation and construction activities can travel through the ground and causing nearby building structures to vibrate. This may cause damage to the building structure ranging from minor hairline cracking to major structural cracking.

Two guidelines have been considered as part of this assessment:

- DIN Standard 4150 - Part 3 - Structural Vibration in Buildings - Effects on Structures.
- British Standard 7385: Part 2 1993 Evaluation and Measurement of Vibration in Buildings.

DIN 4150 provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. It should also be noted that these levels are "safe limits", up to which no damage due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits will not necessarily result in damage, the limits are generally recognised as being conservative.

BS 7385 quantifies three different levels of damage to structures:

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

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- **Major** – Damage to structural elements of the building, cracks in support columns, loosening of joints, spalling of masonry cracks, etc.

BS 7385-1993 provides guidance on assessing the possibility of vibration-induced damage in buildings due to a variety of sources and sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95 per cent probability of no effect.

The standard states that there is a major difference between the sensitivity of people in feeling vibration and the onset of levels of vibration which may damage the structure. The levels of vibration at which people are likely to comment are below levels of vibration which damage buildings, except at lower frequencies.

3.2.2 Human exposure to tactile vibration

Long term exposure to vibration in buildings may cause annoyance. The levels at which annoyance occurs are much lower than the structural damage criteria in buildings.

British Standard 6472-1992 Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz) and NSW EPA publication 'Assessing Vibration – A Technical Guideline' provides guidance on human response to vibration are used to set guideline vibration levels for this project. BS 6472-1992 has recently been superseded by BS 6472-2008 however the EPA still requires vibration to be assessed in accordance with the 1992 version of the Standard at this point in time and accordingly the 1992 version is referred to in this document.

EPA guideline is based on Vibration Dose Values (VDVs). VDV level can be directly related to vibration discomfort experienced by a person.

The VDV is a cumulative measure and increases as the exposure duration increases.

3.2.3 Construction and operation vibration criteria summary

The recommended criteria presented in BS 7385-1993, DIN 4150 and BS 6472 have been summarised below in Table 7. Measurement of vibration should be taken at the base of the building facing the source of the vibration in the vertical and two horizontal directions. For multi-storey structures where vibration amplification is likely measurements should also be made on the floor with the highest vibration level.

Table 7 Construction and operation vibration criteria summary

Category	Human Comfort, VDV ($\text{m/s}^{1.75}$)		Structural Damage (mm/s)
	Day	Night	
Particularly sensitive structures (e.g. listed buildings under preservation order)	0.2 – 0.8 (depending on its use)	0.13 – 0.8 (depending on its use)	3
Residential structures	0.2	0.13	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Offices, schools, educational institutions and places of worship	0.4	0.4	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Occupied non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	0.8	0.8	50 mm/s at 4 Hz and above
Occupied non-sensitive, light framed structures	0.8	0.8	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at

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Category	Human Comfort, VDV ($\text{m/s}^{1.75}$)		Structural Damage (mm/s)
	Day	Night	
			40 Hz and above
Unoccupied non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	N/A	N/A	50 mm/s at 4 Hz and above
Unoccupied non-sensitive, light framed structures	N/A	N/A	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

3.2.4 Research Animal criteria

High vibration levels may adversely affect the health and well-being of laboratory animals. The National Institute of Health Design Requirements Manual (Version 5-13, United States) provides vibration limits for animal research facilities and rodent behavioural and holding rooms. These criteria are provided in Table 8 below.

Table 8 Research animal criteria

Space	Vibration velocity limits (mm/s)
Animal research facilities	0.1
Rodent behavioural and holding rooms	0.05

3.3 Construction traffic noise criteria

The EPA's Interim Construction Noise Guideline (ICNG) does not provide direct reference to an appropriate criterion to assess the noise arising from construction traffic on public roads. However, as the EPA's Road Noise Policy (RNP, 2011) is the current state policy document for assessing road traffic noise and in absence of any alternate guidance it has been used to assess the noise arising from construction traffic movements generated by the proposed development. The RNP does not require assessment of noise impact to commercial or industrial receivers.

3.3.1 Road traffic noise levels

The road that will provide access to the site and has nearby sensitive receivers will be City Road. This road would be classified as sub-arterial road in accordance with the RNP. Table 9 presents the road traffic noise criteria from the RNP. The external noise criteria are applied 1 m from the external facade of the affected building.

Table 9 Road traffic noise criteria – Sub-arterial roads

Period	Parameter	Criterion
Sub-arterial roads		
Day (7:00 am – 10:00 pm)	L_{Aeq} (15hr)	60 dB(A)
Night (10:00 pm – 7:00 am)	L_{Aeq} (9hr)	55 dB(A)

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4.0 Operation Noise Criteria

4.1 Protection of the Environment Operations Act 1997 – Section 139

The main acoustic requirement of Protection of the Environment Operations Act 1997 (PoEOA) is to ensure that “a noise is not offensive”. The definition for an offensive noise is included below:

offensive noise is:

- (d) *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*
- (e) *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.*

To determine if a noise source is offensive, a primary consideration is to determine whether the noise source is intrusive. The EPA provides guidelines for external noise emissions from developments in its *Industrial Noise Policy*. The INP recommends a method which can be used to ascertain the intrusiveness of noise emissions.

EPA states that the relationship between the statutory definition of offensive noise and intrusive noise is that intrusive noise can represent offensive noise, but whether this is always true can depend on the source of the noise, noise characteristics and cumulative noise levels. Therefore to avoid the emission of an offensive noise, noise emissions should not be intrusive as defined by the EPA in the following manner:

“A noise source is generally considered to be intrusive if noise from the source, when measured over a 15 minute period, exceeds the background noise by more than 5 dB(A).”

Any noise generated within the AIN Facility site boundary, including noise from plant and mechanical services associated with site buildings has been assessed in accordance with the EPA's INP.

4.2 Industrial Noise Policy

The Department of Planning and Infrastructure have advised, under the Director General's Requirements, that the EPA's INP should be used to assess noise emission from developments. The INP sets out guidelines for the assessment and control of industrial noise. These guidelines will apply to all mechanical plant installed at the proposed development.

The assessment procedure for industrial noise sources has two components:

- Controlling intrusive noise impacts in the short term for residences; and
- Maintaining noise level amenity for particular land uses including residences.

4.3 Intrusive noise impacts

The INP states that the noise from any single source should not intrude greatly above the prevailing background noise level. Industrial noise sources are generally considered to be acceptable if the equivalent continuous (energy-averaged) A-weighted level of noise from the source (L_{Aeq}), measured over a 15 minute period, does not exceed the background noise level measured in the absence of the source by more than 5 dB(A). This is often termed the Intrusiveness Criterion.

The 'Rating Background Level' (RBL) is the background noise level to be used for assessment purposes and is determined by the methods given in the INP. Using the rating background noise level approach results in the intrusiveness criterion being met for 90% of the time. Adjustments are to be applied to the level of noise produced by the source that is received at the assessment point where the noise source contains annoying characteristics such as tonality or impulsiveness.

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4.4 Protecting noise amenity

To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in the INP. That is, the background noise level should not exceed the level appropriate for the particular locality and land use. This is often termed the Background Creep or Amenity Criterion.

For a residential receiver in a suburban area, the recommended amenity criteria are shown in

Table 10 Recommended L_{Aeq} noise levels

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A)	
			Acceptable	Recommended Maximum
Residential	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
Commercial	All	When in use	65	70
School Classroom—internal	All	Noisiest 1-hour period when in use	35	40

When the existing noise level from *industrial noise sources* is close to the “Acceptable Noise Level” (ANL) given above, noise from the new source must be controlled to preserve the amenity of the area in line with the requirements of the INP.

Attended noise measurements were undertaken at the site and industrial noise has been identified as a feature of the area. Based on the measurements and logging results, the contribution from industrial noise is presented in Table 11.

Table 11 Existing industrial noise contribution

Location	Logged L_{Aeq} dB(A)			Industrial Contribution dB(A)		
	Day	Evening	Night	Day	Evening	Night
Logger 1 – Physics Annex Building rooftop	55	56	51	52	53	51
Logger 2 – North west corner of field	55	56	51	52	53	51

4.5 Resultant environmental noise criteria

A summary of the intrusive and amenity criteria is given in Table 12. These criteria must be applied at the most affected boundary. In this case, the most affected boundary is the proposed St Pauls College development to the south of the AIN Facility. The more stringent background noise levels have been used to determine the criteria, resulting in a conservative assessment.

Table 12 Summary of environmental noise criteria

Period	RBL (L_{A90})	Intrusiveness Criterion	Amenity Criterion, dB(A) ¹	Final Environmental Criterion, dB(A)
Day	46	51	52	51
Evening	46	51	43	43
Night	46	51	41	41

Notes:

- 1) Modifications to the amenity criteria have been made in accordance with Table 2.2 of the INP.

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These criteria apply to environmental noise emissions from the development including mechanical services and other building services plant noise.

4.6 Sleep disturbance criteria

The EPA's INP has been updated with application notes which discuss sleep disturbance and its objective assessment.

To minimise the risk of sleep disturbance as a result of industrial type operations during the night-time period, the INP application notes recommends that, the $L_{A1(1 \text{ minute})}$ noise level outside a bedroom window should not exceed the L_{A90} background noise level by more than 15 dB(A) during the night-time period (10.00 pm to 7.00 am). EPA considers it is appropriate to use this metric as a screening criterion to assess the likelihood of sleep disturbance. If this screening criterion is found to be exceeded then a more detailed analysis must be undertaken and include the extent that the maximum noise level exceeds the background noise level and the number of times this is likely to happen during the night-time period.

The INP application notes reference *Environmental Criteria for Road Traffic Noise* (ECRTN) (EPA, 1999) for some guidance in assessing the potential for sleep disturbance. The ECRTN contains an assessment of sleep disturbance which represents NSW EPA advice on the subject of sleep disturbance due to noise events. Section B5 of Appendix B concludes, having considered the results of four research papers by Pearson et al (1995), Bullen et al (1996), Griefahn (1992) and Finegold et al (1994) with the statement, '*Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions*'. Therefore, given that an open window provides 10 dB(A) noise attenuation from outside to inside, external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions.

Based on the measured background noise levels during the night, the sleep disturbance criteria for the nearest noise sensitive residential receivers are presented in Table 13.

Table 13 Night-time sleep disturbance criteria

Location	Measured RBL $L_{A90, 15 \text{ mins}}$ dB(A)	Sleep disturbance screening criterion $L_{A1 (1 \text{ minute})}$ dB(A)
Residential	46	51

4.7 Summary of operational noise limits

4.7.1 Operational noise limits – Normal operations

The following noise limits have been set in accordance with the INP and the application notes to the INP.

The Contractor shall ensure that the noise contributed by the AIN project and its operation does not exceed the following noise limits as assessed in accordance with the following tests:

Table 14 Operational noise limits – Normal operations

Type of Receiver	Time of Day	Noise Limits	
		Level – dB(A)	Descriptor
Residence-[external]	Day	51	$L_{Aeq, 15 \text{ minutes}}$
	Evening	43	$L_{Aeq, 15 \text{ minutes}}$
	Night	41	$L_{Aeq, 15 \text{ minutes}}$
	Night	61	Sleep disturbance $L_{A1, 1 \text{ min}}$
Classroom-[internal]	When in use	40	Noisiest 1-hour period $L_{Aeq, 1 \text{ hour}}$

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For the purpose of Table 14:

1. Day is defined as the period from 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays and Public Holidays.
2. Evening is defined as the period from 6:00 pm to 10:00 pm, Monday to Sunday and Public Holidays.
3. Night is defined as the period from 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays and Public Holidays.

For the purposes of complying with the noise limits set out in the Table 14:

1. For Residences:
 - The $L_{Aeq, 15 \text{ minutes}}$ noise levels must be measured or predicted at the most-affected point on the Residential Property Boundary. If the Residential Property Boundary is more than 30 m from the Residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the Residence. The $L_{Aeq, 15 \text{ minutes}}$ is to be determined as a “free-field” noise level.
 - The $L_{A1, 1 \text{ minute}}$ noise levels must be measured or predicted within 1 m of a bedroom window. The $L_{A1, 1 \text{ minute}}$ is to be determined as a “free-field” noise level (i.e. the $L_{A1, 1 \text{ minute}}$ incident noise level impinging on the bedroom window).
2. For Classrooms:
 - a) The $L_{Aeq, 1 \text{ hour}}$ must be measured or predicted at the centre of the room.
3. The modification factors in Section 4 of the NSW Industrial Noise Policy must be applied, as appropriate, to the measured or predicted $L_{Aeq, 15 \text{ minute}}$ noise levels.

4.7.2 Operational noise limits – Emergency operations

Noise criteria for the site have been derived in accordance with the NSW INP. It is understood that brown-outs and black-outs are infrequent for the area and therefore the standby generator is unlikely to be in frequent use. For this reason and in the absence of any relevant NSW guideline for emergency generators and equipment, it is recommended that noise limits for intrusive noise for emergency plant equipment be relaxed by 5 dB(A). Therefore, the noise emission from emergency plant and equipment be set to 10 dB(A) above the background (RBL). Table 15 presents operational noise limits for emergency operations.

In addition, it is recommended that all emergency plant and equipment be tested during the daytime period (i.e. 7 am to 6 pm).

Table 15 Operational noise limits – Emergency operations

Type of Receiver	Time of Day	Noise Limits (RBL + 10 dB)	
		Level – dB(A)	Descriptor
Residence-[external]	Day	56	$L_{Aeq, 15 \text{ minutes}}$
	Evening	56	$L_{Aeq, 15 \text{ minutes}}$
	Night	56	$L_{Aeq, 15 \text{ minutes}}$
Classroom-[internal]	When in use	45	$L_{Aeq, 1 \text{ hour}}$

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5.0 Construction Noise and Vibration Assessment

5.1 Details of project

Construction works for project are proposed to take place over a period of 21 months. It is understood that the construction works associated with this project will be broken into the following three stages:

- **Stage 1** - Site Establishment, Civil and Structural Works (Month 3 to Month 11)
- **Stage 2** - Façade, Roofing and Fit-Out Works (Month 9 to Month 20)
- **Stage 3** - Commissioning, External and Landscape Works (Month 16 to Month 21)

Although some stages overlap in duration, it is assumed that construction stages would generally occur during separate time periods.

5.2 Noise modelling methodology

Noise levels due to the construction activities shown in Section 5.3.1 have been predicted at nearby noise sensitive receivers using SoundPLAN 7.0 (industry standard) noise modelling software. The propagation algorithm used for the assessment is The General Prediction Method, with neutral meteorological conditions. Due to the close vicinity of receivers, adverse weather conditional will have a negligible effect on the assessment.

The modelling includes:

- Ground topography
- Buildings and structures
- All sources behave as point, or moving point sources
- All sources are 'on' during any 15 minute period to simulate a worst case
- Ground absorption (set at hard ground)
- Representative construction noise sources as required.

It can be expected that there may be differences between predicted and measured noise levels due to variations in instantaneous operating conditions, plant in operation during the measurement and also the location of the plant equipment.

5.2.1 Modelling assumptions

The following assumptions have been made in modelling all construction noise scenarios:

- For all scenarios all equipment will be operating at the same time, which is unlikely, and is a conservative assumption.
- Neutral atmospheric conditions i.e. relatively calm no temperature inversion.

5.3 Construction noise assessment

5.3.1 Construction scenarios

Three construction scenarios have been modelled, for the purpose of this assessment.

The acoustic impact at sensitive receptors resulting from construction activities has been assessed based on the construction scenarios provided by LLPM&C. The scenarios are considered to be representative of likely site activities and the impact has been assessed based on the 'worst case' i.e. the shortest distance between source and receivers. These scenarios were developed in consultation with the site contractor LLPM&C.

The predicted noise impacts have been calculated based upon the typical sound power levels for the construction equipment included in Table 16.

Typical sound power levels used for the construction noise assessment are presented in Table 16.

DRAFT**Table 16 Construction activities and plant equipment**

Equipment Type	Sound Power Level, dB(A)
Stage 1 – Site Establishment, Civil and Structural works	
Bobcat	104
Circular Rock Saw	110
Compressor	109
Concrete Boom Pump	106
Concrete Truck	105
Concrete Vibrator	97
Delivery Truck	98
Excavator (12t)	94
Excavator (30t)	105
Excavator Hammer/Rock Breaker Attachment	112
Forklift/Telehandler	93
Generator	101
Grinder	108
Hand and Power Tools	108
Jackhammer	108
Maeda Crane (6t)	104
Mobile Crane	104
Piling Rig (35t)	103
Rattle Gun	105
Scaffold	110
Sump Pump	96
Tower Crane (Electric 70m jib)	100
Truck and Trailer/Haulage	98
Vibrating Roller / Compactor	109
Welder	101
Stage 2 – Façade, Roofing and Fit-Out works	
Boom Lifts and Scissor Lifts	100
Delivery Truck	98
Floor Grinder	108
Grinder	108
Hand and Power Tools	108
Maeda Crane (6t)	104
Mobile Crane	104
Scaffold	110
Tower Crane	100
Welder	101

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Equipment Type	Sound Power Level, dB(A)
Stage 3 – Commissioning, External and Landscape works	
Asphalt Paver	106
Bobcat	104
Boom Lifts and Scissor Lifts	100
Compactor/Roller	109
Compressor	109
Concrete Pump	106
Concrete Truck	105
Concrete Vibrator	97
Delivery Truck	98
Excavator (12t)	94
Grinder	108
Hand and Power Tools	108
Mobile Crane	104
Scaffold	110
Truck and Trailer/Haulage	98

The predicted construction noise levels at nearby sensitive receivers for all construction scenarios are shown in Table 17.

1.2 Predicted construction noise levels

The noise from the AIN construction works has been predicted at nearby representative residential and educational receivers. The predicted construction noise levels are provided in Table 17.

DRAFT**Table 17 Predicted construction noise levels**

Receiver	NML, dB(A)			Predicted Noise Level, dB(A)	Exceedance, dB			Is Receiver Highly Noise Affected?
	Day	Evening	Night		Day	Evening	Night	
Stage 1 - Site Establishment, Civil and Structural Works								
Physics Building	55 ¹	55 ¹	55 ¹	94	39	39	39	N/A
Edward Ford Building	55 ¹	55 ¹	55 ¹	105	50	50	50	N/A
Animal House	55 ¹	55 ¹	55 ¹	87	32	32	32	N/A
St Pauls	56	51	51	73	17	22	22	No
Wesley College	56	51	51	83	27	32	32	Yes
Stage 2 - Façade, Roofing and Fit-Out Works								
Animal House	55 ¹	55 ¹	55 ¹	90	35	35	35	N/A
Edward Ford Building	55 ¹	55 ¹	55 ¹	79	24	24	24	N/A
Madsen Building	55 ¹	55 ¹	55 ¹	79	24	24	24	N/A
Physics Building	56	51	51	65	9	14	14	No
St Pauls	56	51	51	79	23	28	28	Yes
Stage 3 - Commissioning, External and Landscape Works								
Physics Building	55 ¹	55 ¹	55 ¹	92	37	37	37	N/A
Edward Ford Building	55 ¹	55 ¹	55 ¹	103	48	48	48	N/A
Animal House	55 ¹	55 ¹	55 ¹	85	30	30	30	N/A
St Pauls	56	51	51	71	15	20	20	No
Wesley College	56	51	51	81	25	30	30	Yes

Notes:

- 1) Educational receiver criteria applies only when the receiver is in use. This would be self-managed by The University of Sydney.

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5.4 Construction vibration assessment

Construction activities that can generate high levels of vibration include:

- 1 Site Establishment
- 2 Civil
- 3 Structure
- 4 External/Landscape.

This construction vibration assessment focuses on ground compaction and rock breaking activities as these are significantly more vibration intensive than the site establishment, façade/roofing and fit-out works.

5.4.1 Structural damage

Table 18 lists the estimated setbacks for plant items which are likely to be required to ensure that a peak particle velocity of 3 mm/s (historic/heritage), 5 mm/s (residential) and 20 mm/s (commercial) is not exceeded.

The safe working distances for vibratory rollers, rock breakers and jackhammers are based upon the safe working distances presented in the Transport for New South Wales (TfNSW) (formerly, Transport Construction Authority) publication *Construction Noise Strategy (CNS) (Rail Projects)* (February 2010), which relate to dwellings. The distances presented in the CNS are then scaled to relate to sensitive structures based upon measured results¹.

Table 18 Recommended setbacks to limit PPVs

Plant	Rating	Required Setback to Limit PPV to Less 3 mm/s (Historical/Heritage)	Required Setback to Limit PPV to less 5 mm/s (Residential)	Required Setback to Limit PPV to Less 20 mm/s (Commercial)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	9 m	5 m	2 m
	< 100 kN (Typically 2-4 tonnes)	11 m	6 m	3 m
	< 200 kN (Typically 4-6 tonnes)	20 m	12 m	6 m
	< 300 kN (Typically 7-13 tonnes)	27 m	15 m	7 m
	> 300 kN (Typically 13-18 tonnes)	36 m	20 m	10 m
	> 300 kN (Typically >18 tonnes)	45 m	25 m	12 m
Rock Breaker/Hydraulic Hammer	(300 kg - 5 to 12t excavator)	4 m	2 m	2 m
	(900 kg – 12 to 18t excavator)	13 m	7 m	3 m
	(1600 kg – 18 to 34t excavator)	40 m	22 m	11 m
Jackhammer	Handheld	1 m	1 m	1 m

The distances in Table 18 assume individual items of plant operating independently. Concurrent operation of vibration intensive equipment should be avoided, however if it is necessary to operate multiple items of plant concurrently close to the safe working distance then vibration monitoring is recommended.

The nearest buildings are presented in Figure 1, Table 19 presents nearest building and respective offset distance from construction works. The construction vibration assessment indicates that, the PPV limits may be exceeded at Wesley College, the Physics Building, the Edward Ford building and Animal House during particular construction scenarios.

¹ Construction Vibrations, Charles H. Dowding, 2000

DRAFT**Table 19** Nearby building distances

Building	Type	Offset Distance from Construction Works (m)	Exceedance of PPV Limits
St Pauls College	Heritage and Residential	65 - 120	Unlikely
Wesley College	Heritage and Residential	15 - 120	Possible
Physics Building	Heritage and Educational	3 - 55	Possible
Edward Ford Building	Heritage and Educational	13 - 130	Possible
Animal House	Heritage and Educational	10 - 140	Possible

If vibration intensive equipment is to be used within the safe working distances, then it is recommended that attended vibration measurements are undertaken at the commencement of the works in order to determine site specific safe working distances. Vibration intensive work should not proceed within the safe working distances unless a permanent vibration monitoring system is installed, to warn operators (via flashing light, audible alarm, SMS etc.) when vibration levels are approaching the peak particle velocity objective. If PPV vibration levels at the building are seen to approach the criteria then the following measures should be considered to reduce vibration levels:

- Operate rock hammer in short bursts only.
- Maintain rock hammer orientation towards the face, breaking small wedges off the face.
- Use experienced excavation contractors.
- Operate rollers with vibratory setting off.
- Use alternative construction techniques.

It is advisable to carry out dilapidation surveys of the nearby buildings before construction works begin.

The estimated setbacks must be considered as preliminary since they depend on geological and other factors. This preliminary study should be refined following early works once initial construction vibration monitoring is undertaken

5.4.2 Human comfort

5.4.2.1 Tactile vibration

In general the human response to vibration is found to be a complex phenomenon. There are wide variations in vibration tolerance of humans and accordingly acceptance goals for human comfort are hard to define and quantify. Acceptable values of human exposure to vibration are primarily dependent on the activity taking place in the occupied space (e.g. workshop, office, or residence) and the character of vibration (e.g. continuous or intermittent). In addition, specific values are dependent upon social and cultural factors, psychological attitudes, expected interference with privacy, and ultimately the individual's perceptibility.

The safe working distances for vibratory rollers, rock breakers and jackhammers are based upon the safe working distances presented in the Transport for New South Wales (TfNSW) (formerly, Transport Construction Authority) publication *Construction Noise Strategy (CNS) (Rail Projects)* (February 2010).

Table 20 Recommended setback distances to minimise tactile vibration

Plant	Rating	Required Setback to Limit Tactile Vibration (Residential)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	20 m
	< 100 kN (Typically 2-4 tonnes)	20 m
	< 200 kN (Typically 4-6 tonnes)	40 m
	< 300 kN (Typically 7-13 tonnes)	100 m
	> 300 kN (Typically 13-18 tonnes)	100 m
	> 300 kN (Typically >18 tonnes)	100 m
Rock Breaker/Hydraulic	300 kg - 5 to 12t excavator	7 m

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Plant	Rating	Required Setback to Limit Tactile Vibration (Residential)
Hammer	900 kg – 12 to 18t excavator	23 m
	1600 kg – 18 to 34t excavator	73 m
Jackhammer	Handheld	Avoid contact with structure

The closest residential receivers are located at Wesley College, approximately 15 m from the AIN site. It is deemed possible that residential receivers within Wesley College may be adversely affected by construction activities. In addition the educational buildings nearby (Physics Building, Edward Ford Building, Animal house) may be adversely affected during class and exam periods. These receivers will require careful management during construction activities.

The management and mitigation methods are likely to include but not restricted to:

1. Source controls
 - a. Use of less noise and vibration intensive equipment;
 - b. Respite periods;
2. Management methods
 - a. Community consultation;
 - b. Complaint response;
 - c. Site layout;
 - d. Avoiding work during sensitive time periods (e.g. night work or exam periods);
 - e. Vibration logging and attended measurements;
 - f. Training;
3. Path controls
 - a. Avoid vibration intensive works in a concentrated area and try to work over a large area in order to reduce maximum vibration dose values.

The mitigation measures should be further developed in a “*Construction Noise and Vibration Management Plan*” (CNVMP) framework that takes into account relevant documents including EPA’s “*Interim Construction Noise Guideline*”, and the Director General’s Requirements as specified by the Department of Planning.

5.4.3 Ground-borne noise

Vibration generated by compacting or rock breaking enters buildings via the ground. This causes the floors, walls and ceilings to vibrate and to radiate noise. This noise is commonly referred to as structure- or ground-borne noise or regenerated noise. Ground-borne noise is low frequency and if audible is perceived as a ‘rumble’.

In general, ground-borne noise level values are relevant only where they are higher than the airborne noise from the construction activities. Regenerated noise levels will be masked by air-borne noise associated with the construction activities.

5.4.4 Research animals

It is possible the vibration limits provided in section 3.2.1 could be exceeded within Animal House during the construction works as listed in Section 5.0. In order to minimise the impact upon animals kept within Animal House the following mitigation measures should be considered:

- Training of machinery operators.
- Ensure periods of respite.
- Consultation with staff working within Animal House.
- Permanent vibration monitoring.
- The use of less vibration intensive equipment.

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- Temporary relocation of particularly vibration sensitive animals.

5.5 Traffic noise assessment (construction and operation)

Review of the Transport Impact Assessment report, prepared by Arup (issued 22 November 2012) indicates the following:

Operational traffic:

- It is proposed to provide approximately 12 car parking spaces including two spaces for drivers with mobility impairments. Given that there are 12 vehicle car parking spaces proposed, it is considered that 12 vehicle movements are likely to occur in or before the peak hour as a result of the proposed development.
- Low parking provision and a university campus that encourages high pedestrian connectivity are expected to result in negligible increases in traffic.

Construction traffic (heavy vehicle routes):

- The primary constructions access/leaving the AIN construction site will along major arterial roads with existing large traffic volumes (e.g. Parramatta Road, King Street, Cleveland Street Wattle Street and Victoria Road).
- Estimated number of construction vehicle movements approximately 8 vehicles movements per peak hour trips.
- It is expected that the peak expected vehicle movements of 8 vehicles per hour is unlikely to result in significant traffic impacts on the wider road network.
- A detailed construction traffic control plan will be issued by the contractor stating the proposed management strategy within the university and site. The plan will be submitted prior to construction.

Based on the findings presented in the Traffic Impact Assessment report it is anticipated that traffic generation during the construction and operational phase of the project will have an insignificant acoustic impact.

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6.0 Operational Noise and Vibration Assessment

6.1 Operational noise methodology

Operational noise modelling has been undertaken using SoundPlan v7.0. The propagation algorithm used for the assessment is The General Prediction Method, with neutral meteorological conditions. Due to the close vicinity of receivers, adverse weather conditional will have a negligible effect on the assessment.

Modelling information has been based on information provided to AECOM by LLPM&C. All modelling has taken a conservative approach and the worst case scenario has been adopted where noisy equipment are operating at the same time for a full 15 minute period.

The AIN building and all St Pauls College buildings have been modelled as 4 storey buildings with the receiver located on the most affected land boundary between the two developments.

Indicative sound power levels for the proposed equipment and the time of operation are presented in Appendix B. All sound power data is based on manufacturer specifications.

6.2 Mitigation treatment

All locations for the plant are based on the following drawings issued by M+W Australia and Norman Disney and Young:

- 7326/M016/LAY/4/ZONE revision C, dated 16 April 2013 issued by M+W Australia;
- ED01023 revision 01, dated 10 July issued by Norman Disney and Young;

6.2.1 Plant room acoustic louvers

The plant room acoustic louvered areas are presented in Table 21 and in Appendix C, with the minimum insertion loss requirements presented in Table 22. All other surfaces have been modelled as solid walls and plant rooms internally lined (acoustic absorption), producing a mid-frequency reverberation time of approximately 1.0 seconds.

Table 21 Plant rooms louvered areas

Location	Description	Indicative Louvre Area (L x H) m ²	Louvre Facade	Louvre Selection
Western Plant Room	AHU Room 1	7 m x 4.5 m = 31.5 m ²	North	Architectural Louvres
Centre Plant Room	AHU Room 3	9.5 m x 2.25 m = 21.4 m ²	North	Architectural Louvres
Centre Plant Room	Fan Room 2/Scrubber Room	16.5 m x 2.25 m = 37.1 m ²	North	Stage 2 Acoustic Louvres
Eastern Plant Room	AHU Room 4	3.5 m x 2.25 m = 7.9 m ²	North	Architectural Louvres
Eastern Plant Room	Cooling Tower Room	18.0 m x 4.5m = 81 m ²	North	Stage 2 Acoustic Louvres
Eastern Plant Room	Chiller Room	2.0 m x 2.25 m = 4.5 m ²	East	Stage 1 Acoustic Louvres

DRAFT**Table 22 Acoustic louvres insertion loss**

Make/Model	Insertion Loss (Noise Reduction) dB, per Octave Band, Hz							
	63	125	250	500	1000	2000	4000	8000
Architectural	-	-	-	-	-	-	-	-
Stage 1 Acoustic Louvres Fantech SBL1 or equivalent	10	13	15	19	20	18	18	14
Stage 1 Acoustic Louvres Fantech SBL2 or equivalent	11	16	20	28	33	31	27	23

6.2.2 Plant equipment attenuators

Attenuators have been selected for the cooling tower discharge and the intake and discharge of the generator room. A silencer has been selected for the generator exhaust. Minimum insertion loss for each attenuator and silencer is presented in Table 23.

Table 23 Attenuator insertion loss

Selection Make/Model ¹	Equipment for Attenuation	Insertion Loss dB, per Octave Band, Hz							
		63	125	250	500	1000	2000	4000	8000
NAP H40/180 500	Cooling Towers 1, 2 and 3	10	17	28	39	40	29	21	17
Fantech C2P-125QS	Scrubber Fan	7	9	15	24	25	22	15	12
NAP H33/300 450	Generator Intake	18	29	52	59	60	56	44	31
NAP H50/300 600	Generator Discharge	12	19	36	43	47	28	18	16
NAP RIE 250mm	Generator Exhaust	18	22	24	26	26	21	14	11

Notes:

- 1) Or an equivalent selection that meets the required insertion loss.

6.3 Operational noise assessment - Normal operations

Presented in Table 24 are the results of the assessment under normal operating conditions, incorporating the recommended mitigation treatment outlined in Section 6.2.

Table 24 Operational assessment results – Normal operations

Receiver Location	Period	Predicted Noise Levels $L_{Aeq, 15 \text{ minute}}$	Criteria $L_{Aeq, 15 \text{ minute}}$	Exceedance dB(A)
Saint Pauls College (worst affected point along the boundary)	Day	48	51	-
	Evening	41	43	-
	Night	41	41	-
Existing University buildings	Day	59	60 ¹	

Notes:

- 1) Typical outdoor to indoor noise reductions provided by standard (i.e. without special acoustical treatment) is generally accepted as being 20 dB(A) with windows closed. Therefore the internal noise criterion of 40 dB(A) for class rooms is equivalent to 60 dB(A) external noise criterion.

With the inclusion the acoustic treatment presented in section 6.1, the development complies with the operational noise criteria under normal operating conditions.

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6.4 Sleep disturbance assessment

The NSW INP application notes recommend that sleep disturbance is assessed based on the emergence of the L_{A1} (1 minute) noise level over the corresponding L_{A90} (15 minute) noise level.

The following screening criterion for sleep disturbance is recommended for the assessment of sleep disturbance:

$$L_{A1} (1 \text{ minute}) < L_{A90} (15 \text{ minute}) + 15 \text{ dB(A)}$$

The night-time noise emissions from the plant would generally be associated with relatively constant activities. Therefore no significant peak noise events would be expected. However for the purpose of assessing sleep disturbance, the L_{A1} (1 minute) noise levels from the rooftop plant equipment have been predicted by adding 8 dB to the steady state sound power levels quoted in Table 26, Appendix B. This 8 dB correction is to account for start-up noise associated with cooling towers, pumps, and fans.

The sleep disturbance assessment indicates compliance with the night-time noise emission criterion at (the L_{A1} (1 minute) 61 dB(A)) at the nearest residential receiver (i.e. Future St Pauls development).

6.5 Operational noise assessment - Emergency operations

Presented in Table 25 are the results of the assessment under emergency operating conditions, incorporating the recommended mitigation treatment outlined in Section 6.2.

Table 25 Operational assessment results – Emergency operations

Receiver location	Period	Predicted Noise Levels $L_{Aeq, 15 \text{ minute}}$	Criteria $L_{Aeq, 15 \text{ minute}}$	Exceedance dB(A)
Saint Pauls College (worst affected point along the boundary)	Day	56	56	-
	Evening	56	56	-
	Night	56	56	-

With the inclusion the acoustic treatment presented in section 6.1, the development complies with the emergency operational noise criteria at all times.

6.6 Operational vibration assessment

All plant equipment proposed to be used during the operation of the AIN Facility will be vibration isolated to meet very stringent vibration requirements to protect sensitive equipment to be housed in specialist laboratories. Vibration isolation solutions will be developed during the detailed design and final equipment selection phase of the project. Therefore, vibration impacts on nearby vibration sensitive receivers are consequently expected to be negligible.

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7.0 Noise and Vibration Management and Mitigation Strategies

The noise and vibration management and mitigation strategies apply to both construction and operations of the proposed AIN Facility.

The ICNG accepts the fact that large scale construction often results in excessive noise, albeit on a temporary basis, and where physical mitigation options are limited, stresses the importance of community engagement in a frank and upfront manner.

The ICNG recommends that the contractor demonstrate best practicable means of controlling noise and include noise mitigation measures in the construction management plan to minimise the noise impact at sensitive receivers. This may include the work practices described below.

7.1 Standard mitigation measures

All construction and operational activities associated with the site should be subject to the standard noise and vibration mitigation measures described below:

Where reasonable and feasible, apply best practice noise mitigation measures including:

- Maximise the offset distance between noisy plant items and nearby noise sensitive receivers
- Avoid the coincidence of noisy plants working simultaneously close together and adjacent to sensitive receivers would be avoided, where practicable.
- Where possible, orient equipment with directional noise emissions away from sensitive receivers.
- Locate noisy plant away from potentially noise affected neighbours or behind barriers, such as sheds or walls.
- Load and unload away from sensitive receivers, where practicable.
- Select site access points taking into account the proximity of noise sensitive receivers;
- Carry out maintenance work on construction plants with the potential to generate noise impacts away from noise sensitive receivers and confine to standard daytime construction hours, where possible.
- Minimise consecutive works in the same locality, where practicable.
- Turn off plant that is not being used.
- Examine, and implement where feasible and reasonable, alternative work practices which generate less noise – for example, use electric equipment instead of diesel or petrol powered equipment.
- Examine, and implement where feasible and reasonable, the use of silenced equipment and noise shielding around stationary plant (such as generators), subject to manufacturers' design requirements.
- Ensure plant is regularly maintained, and repair or replace equipment that becomes noisy.
- Arrange the work site to minimise the use of movement alarms on vehicles and mobile plant.
- Undertake the construction activities in accordance with the approved hours of work.

7.2 Respite periods

- There are potential high impact noise activities proposed to take place, such as those likely to generate noise levels above L_{Aeq} 75 dB(A) or activities likely to generate noise with intermittent, impulsive, tonal or low-frequency characteristics which have the potential to affect the amenity of adjacent noise receivers.
- In the case that high impact noise activities or activities likely to generate noise with intermittent, impulsive, tonal or low-frequency characteristics are required appropriate notification prior to works commencing and respite periods would have to be implemented.

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7.3 Local road traffic – heavy vehicles noise mitigation

The following mitigation measures are proposed in order to minimise and manage the impact from heavy vehicles on local roads:

- All trucks would be fitted with mufflers and any other noise control equipment in good working order.
- As far as practical and safety consideration, truck drivers would avoid:
 - Heavy acceleration and braking
 - Compression braking
 - Reversing as far as practicable
 - High speeds
 - Pick-ups and deliveries outside standard construction hours
 - Idling outside noise sensitive receivers.

Truck routes to and from the worksite will be via major roads where possible, in accordance with the Traffic Management Protocol and Traffic Management Plan.

7.4 Reversing alarms

The use of broadband reversing alarms or other non-tonal vehicle movement and warning alarms is recommended. The potential noise impact associated with reversing alarms can be managed and minimised via a combination of proactive driver/operator training and operational procedures. The following additional mitigation strategies would be undertaken, taking into account that WorkCover OH&S requirements would need to be satisfied with respect to safety surrounding construction vehicles.

- The primary means for minimising reversing alarm noise would be through a dedicated effort on the part of all drivers to minimise, wherever feasible, the amount of reversing of their vehicles.
- Wherever feasible, turning circles would be created at the end points of vehicle work legs, which would allow trucks and the like, to turn and avoid the need for reversing.
- Emphasis would be placed during driver training and site induction sessions on the potential adverse impact of reversing alarms and the need to minimise their use.

7.5 Equipment selection and maintenance

When carrying out operations at the AIN Facility and during construction works the contractor should select equipment taking into account noise and vibration emissions, such as (but not limited to):

- Smaller equipment options or rubber-tracked equipment where equipment is fit-for-purpose and economically feasible.
- All equipment would be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse noise and vibration impacts.
- Regular checks of equipment noise levels would be made to ensure that noise levels do not increase as a result of poor maintenance practice or say the replacement of individual items of equipment with alternatives which have higher noise emissions.

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8.0 Conclusion

This report presents the results of an assessment of the potential noise and vibration impacts associated with the construction and operation of the proposed new Australian Institute of Nanoscience Facility (AIN Facility) at the University of Sydney, Camperdown Campus, NSW.

Construction noise and vibration

Noise producing construction activities with typical associated equipment have been modelled at the project site to give an indication of the noise emissions that the nearest residential and commercial receivers will experience.

The construction noise and vibration assessment was conducted in accordance with NSW Environment Protection Authority (EPA) 'Interim Construction Noise Guidelines' (ICNG, 2009).

The construction noise assessment indicates general compliance with ICNG acoustic requirements at all assessment locations during the daytime periods (i.e. during ICNG's daytime standard and out of hour construction periods). However, the assessment also indicates that some construction activities might generate high impact noise levels above L_{Aeq} 75 dB(A).

The construction vibration assessment indicates that, established vibration limits may be exceeded at Wesley College, the Physics Building, the Edward Ford building and Animal House during vibration intensive construction scenarios.

General recommendations have been presented in this report to manage and mitigate potential noise and vibration impacts.

Operational noise and vibration

The operational environmental noise emission criteria for the development have been quantified in Section 6.0 of this report and have been established to comply with the EPA's Industrial Noise Policy.

The operational noise impact assessment, which includes standard mitigation measures (e.g. acoustic louvres, plant room enclosures, attenuators, silencers, etc.) indicates compliance at all assessment locations during the daytime, evening and night-time periods. The results of this assessment assume that the equipment installed produce noise levels similar or less than those shown in Appendix B.

All plant equipment used during the operation of the AIN Facility will be vibration isolated to meet very stringent vibration requirements to protect sensitive equipment to be housed in specialist laboratories. Therefore, vibration impacts on nearby vibration sensitive receivers are consequently expected to be negligible.

Sleep disturbance

A sleep disturbance assessment has been conducted, and indicates compliance at all assessment locations during the night-time period.

Road traffic noise

Based on the findings presented in the Traffic Impact Assessment report it is anticipated that traffic generation during the construction and operation phase of the project will have an insignificant acoustic impact.

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Appendix A

Acoustic Terminology

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Appendix A Acoustic Terminology

The following is a brief description of acoustic terminology used in this report.

Sound power level	The total sound emitted by a source																						
Sound pressure level	The amount of sound at a specified point																						
Decibel [dB]	The measurement unit of sound																						
A-weighted decibels [dB(A)]	The A-weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).																						
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows: <table> <tr><td>0 dB(A)</td><td>Threshold of human hearing</td></tr> <tr><td>30 dB(A)</td><td>A quiet country park</td></tr> <tr><td>40 dB(A)</td><td>Whisper in a library</td></tr> <tr><td>50 dB(A)</td><td>Open office space</td></tr> <tr><td>70 dB(A)</td><td>Inside a car on a freeway</td></tr> <tr><td>80 dB(A)</td><td>Outboard motor</td></tr> <tr><td>90 dB(A)</td><td>Heavy truck pass-by</td></tr> <tr><td>100 dB(A)</td><td>Jackhammer / subway train</td></tr> <tr><td>110 dB(A)</td><td>Rock concert</td></tr> <tr><td>115 dB(A)</td><td>Limit of sound permitted in industry</td></tr> <tr><td>120 dB(A)</td><td>747 take off at 250 m</td></tr> </table>	0 dB(A)	Threshold of human hearing	30 dB(A)	A quiet country park	40 dB(A)	Whisper in a library	50 dB(A)	Open office space	70 dB(A)	Inside a car on a freeway	80 dB(A)	Outboard motor	90 dB(A)	Heavy truck pass-by	100 dB(A)	Jackhammer / subway train	110 dB(A)	Rock concert	115 dB(A)	Limit of sound permitted in industry	120 dB(A)	747 take off at 250 m
0 dB(A)	Threshold of human hearing																						
30 dB(A)	A quiet country park																						
40 dB(A)	Whisper in a library																						
50 dB(A)	Open office space																						
70 dB(A)	Inside a car on a freeway																						
80 dB(A)	Outboard motor																						
90 dB(A)	Heavy truck pass-by																						
100 dB(A)	Jackhammer / subway train																						
110 dB(A)	Rock concert																						
115 dB(A)	Limit of sound permitted in industry																						
120 dB(A)	747 take off at 250 m																						
Frequency [f]	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.																						
Equivalent continuous sound level [Leq]	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.																						
Lmax	The maximum sound pressure level measured over the measurement period																						
Lmin	The minimum sound pressure level measured over the measurement period																						
L10	The sound pressure level exceeded for 10 per cent of the measurement period. For 10 per cent of the measurement period it was louder than the L10.																						
L90	The sound pressure level exceeded for 90 per cent of the measurement period. For 90 per cent of the measurement period it was louder than the L90.																						

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Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L90 sound pressure level is used to quantify background noise.
Traffic noise	The total noise resulting from road traffic. The Leq sound pressure level is used to quantify traffic noise.
Day	The period from 7am to 6pm Monday to Saturday and 8am to 6pm Sundays and Public Holidays.
Evening	The period from 6pm to 10pm Monday to Sunday and Public Holidays.
Night	The period from 10pm to 7am Monday to Saturday and 10pm to 8am Sundays and Public Holidays.
Assessment background level [ABL]	The overall background level for each day, evening and night period for each day of the noise monitoring.
Rating background level [RBL]	The overall background level for each day, evening and night period for the entire length of noise monitoring.

*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 "Acoustics – Glossary of terms and related symbols", EPA NSW Industrial Noise Policy and EPA Road Noise Policy.

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Appendix B

Building Services Equipment and the Time of Operation

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Unit Description	Time of Operation			Sound Power Level (dB), per Octave Band Hz								Total Sound Power Level dB(A)	Area Served	Comments
	Day	Evening	Night	63	125	250	500	1000	2000	4000	8000			
Location - AHU Room 1														
AHU-1-C1	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type C	Duty
AHU-1-C2	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type C	Duty
AHU-4-1	Yes	Yes	No	89	93	98	98	94	90	85	81	99	L1 to L3 Cafe, Corridors & Breakout	Duty
AHU-4-A0	Yes	Yes	Yes	74	79	84	85	81	77	73	69	86	Level 1 Lab Type A	Duty
AHU-4-A1	Yes	Yes	Yes	83	87	92	93	89	85	81	76	94	Level 1 Lab Type A	Duty
AHU-4-A2	Yes	Yes	Yes	83	87	92	93	89	85	81	76	94	Level 1 Lab Type A	Duty
AHU-4-A3	Yes	Yes	Yes	83	87	92	93	89	85	81	76	94	Level 1 Lab Type A	Duty
AHU-4-BC1	Yes	Yes	Yes	83	87	92	93	90	86	82	77	95	Level 1 Lab Type B & C	Duty
FFU-4-1	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Grey Space to all Labs	Duty
MSSB-4-1	N/A	N/A	N/A	-	-	-	-	-	-	-	-	-	Level 4 Plant Area	Duty
PEF-4-1	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Grey Space to all Labs	Duty
Location - AHU Room 2														
AHU-1-B1	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type B	Duty
AHU-1-B2	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type B	Duty
AHU-1-B3	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type B	Duty
AHU-1-B4	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type B	Duty

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Unit Description	Time of Operation			Sound Power Level (dB), per Octave Band Hz								Total Sound Power Level dB(A)	Area Served	Comments
	Day	Evening	Night	63	125	250	500	1000	2000	4000	8000			
AHU-1-B5	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type B	Duty
AHU-1-B6	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type B	Duty
AHU-1-B7	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type B	Duty
AHU-1-C7	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type C	Duty
AHU-4-2	Yes	Yes	Yes	79	83	88	88	85	81	77	72	90	L2 to L3 Offices - Outside Air	Duty
AHU-4-4	Yes	Yes	Yes	73	77	82	82	79	75	70	66	84	Level 2 Case Study Lecture	Duty
FFU-4-2	Yes	Yes	Yes	79	83	88	88	85	81	77	72	90	Level 1 Grey Space to all Labs	Duty
Location - AHU Room 3														
AHU-1-C3	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type C	Duty
AHU-1-C4	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type C	Duty
AHU-1-C5	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type C	Duty
AHU-1-C6	Yes	Yes	Yes	79	83	88	89	86	82	77	73	90	Level 1 Lab Type C	Duty
AHU-4-3	Yes	Yes	Yes	81	85	90	97	87	83	79	74	92	Level 3 Learning Studio	Duty
AHU-4-BC0	Yes	Yes	Yes	83	87	92	93	90	86	82	77	95	Level 1 Lab Type B & C	Duty
Location - AHU Room 4														
AHU-4-6	Yes	Yes	Yes	80	85	89	90	87	83	78	74	92	Level 3 Lecture Theatre	Duty
AHU-4-7	Yes	Yes	Yes	80	85	89	90	86	82	78	74	91	Level 3 Large Seminar Room	Duty
AHU-4-8	Yes	Yes	Yes	86	91	95	95	91	87	82	78	96	Level 4 3rd Year Lab/Commons	Duty

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Unit Description	Time of Operation			Sound Power Level (dB), per Octave Band Hz								Total Sound Power Level dB(A)	Area Served	Comments
	Day	Evening	Night	63	125	250	500	1000	2000	4000	8000			
FFU-4-3	Yes	Yes	Yes	79	83	88	88	85	81	77	72	90	Level 1 Grey Space to all Labs	Duty
Location - Boiler Room														
B-1	N/A	N/A	N/A	-	-	-	-	-	-	-	-	-	Whole Building	Duty
B-2	N/A	N/A	N/A	-	-	-	-	-	-	-	-	-	Whole Building	Duty
CDV-3	N/A	N/A	N/A	-	-	-	-	-	-	-	-	-	Whole Building	Duty
EV-1	N/A	N/A	N/A	-	-	-	-	-	-	-	-	-	Whole Building	Duty
Location - Boiler Room/Chiller Room														
CDV-1	N/A	N/A	N/A	-	-	-	-	-	-	-	-	-	Whole Building	Duty
CH-1	Yes	Yes	Yes	89	87	89	85	85	81	74	73	89	Whole Building	Duty
CH-2	Yes	Yes	Yes	89	87	89	85	85	81	74	73	89	Whole Building	Duty
CH-3	Yes	Yes	No	89	87	89	85	85	81	74	73	89	Whole Building	Duty
CWP-1	Yes	Yes	Yes	-	-	-	-	-	-	-	-	69	Whole Building	Duty
CWP-2	No	No	No	-	-	-	-	-	-	-	-	69	Whole Building	Standby
CWP-3	Yes	Yes	Yes	-	-	-	-	-	-	-	-	69	Whole Building	Duty
CWP-4	No	No	No	-	-	-	-	-	-	-	-	69	Whole Building	Standby
CWP-5	Yes	Yes	Yes	-	-	-	-	-	-	-	-	66.7	Whole Building	Duty
CWP-6	No	No	No	-	-	-	-	-	-	-	-	66.7	Whole Building	Standby
CWP-7	Yes	Yes	Yes	-	-	-	-	-	-	-	-	69	Whole Building	Duty
CWP-8	No	No	No	-	-	-	-	-	-	-	-	69	Whole Building	Standby
PCHWP-1	Yes	Yes	Yes	-	-	-	-	-	-	-	-	69	Whole Building	Duty

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Unit Description	Time of Operation			Sound Power Level (dB), per Octave Band Hz								Total Sound Power Level dB(A)	Area Served	Comments
	Day	Evening	Night	63	125	250	500	1000	2000	4000	8000			
PCHWP-2	No	No	No	-	-	-	-	-	-	-	-	69	Whole Building	Standby
PCHWP-3	Yes	Yes	Yes	-	-	-	-	-	-	-	-	69	Whole Building	Duty
PCHWP-4	No	No	No	-	-	-	-	-	-	-	-	66.7	Whole Building	Standby
PCHWP-5	Yes	Yes	Yes	-	-	-	-	-	-	-	-	61.8	Whole Building	Duty
PCHWP-6	No	No	No	-	-	-	-	-	-	-	-	61.8	Whole Building	Standby
SCHWP-1A	Yes	Yes	Yes	-	-	-	-	-	-	-	-	65	Whole Building	Duty
SCHWP-1B	No	No	No	-	-	-	-	-	-	-	-	65	Whole Building	Standby
SCHWP-2A	Yes	Yes	Yes	-	-	-	-	-	-	-	-	65	Whole Building	Duty
SCHWP-2B	No	No	No	-	-	-	-	-	-	-	-	65	Whole Building	Standby
Location - Cooling Tower Plantroom														
CDV-2	N/A	N/A	N/A	-	-	-	-	-	-	-	-	-	Whole Building	Duty
CT-1	Yes	Yes	Yes	99	97	95	95	93	90	85	82	98	Whole Building	Duty
CT-2	Yes	Yes	Yes	99	97	95	95	93	90	85	82	98	Whole Building	Duty
CT-3	Yes	Yes	No	99	97	95	95	93	90	85	82	98	Whole Building	Duty
Location - Fan Room 1														
EF-FC-C1	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type C	Duty
EF-FC-P1	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Specimen Prep Lab	Duty
EF-FC-P2	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Specimen Prep Lab	Duty
GEF-4-1	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Grey Space to all Labs	Duty
Location - Fan Room 2/Scrubber Room														

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Unit Description	Time of Operation			Sound Power Level (dB), per Octave Band Hz								Total Sound Power Level dB(A)	Area Served	Comments
	Day	Evening	Night	63	125	250	500	1000	2000	4000	8000			
CR-GEX-1	Yes	Yes	Yes	85	83	78	75	68	69	69	62	77.5	Level 1 CleanRoom	Duty
CR-GEX-2	Yes	Yes	No	85	83	78	75	68	69	69	62	77.5	Level 1 CleanRoom	Duty
CR-GEX-3	Yes	Yes	Yes	85	83	78	75	68	69	69	62	77.5	Level 1 CleanRoom	Duty
EF-FC-B1	Yes	Yes	No	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type B	Duty
EF-FC-B2	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type B	Duty
EF-FC-B3	Yes	Yes	No	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type B	Duty
EF-FC-B4	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type B	Duty
EF-FC-C2	Yes	Yes	No	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type C	Duty
EF-FC-C3	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type C	Duty
EF-FC-C4	Yes	Yes	No	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type C	Duty
EF-FC-C5	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type C	Duty
EF-FC-C6	Yes	Yes	No	54	64	69	70	68	61	54	43	71.5	Level 1 Lab Type C	Duty
EF-FC-CM1	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Chem Store	Duty
EF-FC-CM2	Yes	Yes	No	54	64	69	70	68	61	54	43	71.5	Level 1 Chem Store	Duty
GEF-4-2	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Grey Space to all Labs	Duty
GEF-4-3	Yes	Yes	No	54	64	69	70	68	61	54	43	71.5	Level 1 Grey Space to all Labs	Duty
PEF-4-2	Yes	Yes	Yes	54	64	69	70	68	61	54	43	71.5	Level 1 Grey Space to all Labs	Duty
TEF-4-1	Yes	Yes	No	76	75	82	85	84	80	76	63	87.8	Whole Building	Duty
Scrubber Fan 1	Yes	Yes	Yes	95	91	90	86	86	81	71	-	90	Level 1 CleanRoom	Duty

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Unit Description	Time of Operation			Sound Power Level (dB), per Octave Band Hz								Total Sound Power Level dB(A)	Area Served	Comments
	Day	Evening	Night	63	125	250	500	1000	2000	4000	8000			
Scrubber Fan 2	No	No	No	95	91	90	86	86	81	71	-	90	Level 1 CleanRoom	Standby
Location – Generator Room														
Generator – Mechanical	Yes ¹	Yes ¹	Yes ¹	117	123	115	111	111	108	104	93	116	Whole Building	Standby Emergency
Generator - Exhaust	Yes ¹	Yes ¹	Yes ¹	119	116	118	118	115	112	113	105	121	Whole Building	Standby Emergency

Notes:

- 1) Generator would operate during an emergency situation only. Generator testing would occur for a short period of time infrequently during the daytime only.
- 2) For the purpose of assessing sleep disturbance, the L_{A1} noise levels have been predicted by adding 8 dB to the steady state sound power levels quoted in Table 26. This 8 dB correction is to account for start-up noise associated with cooling towers, pumps, and fans.

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Appendix C

Plant Room Louvre Requirements Mark-up Drawing

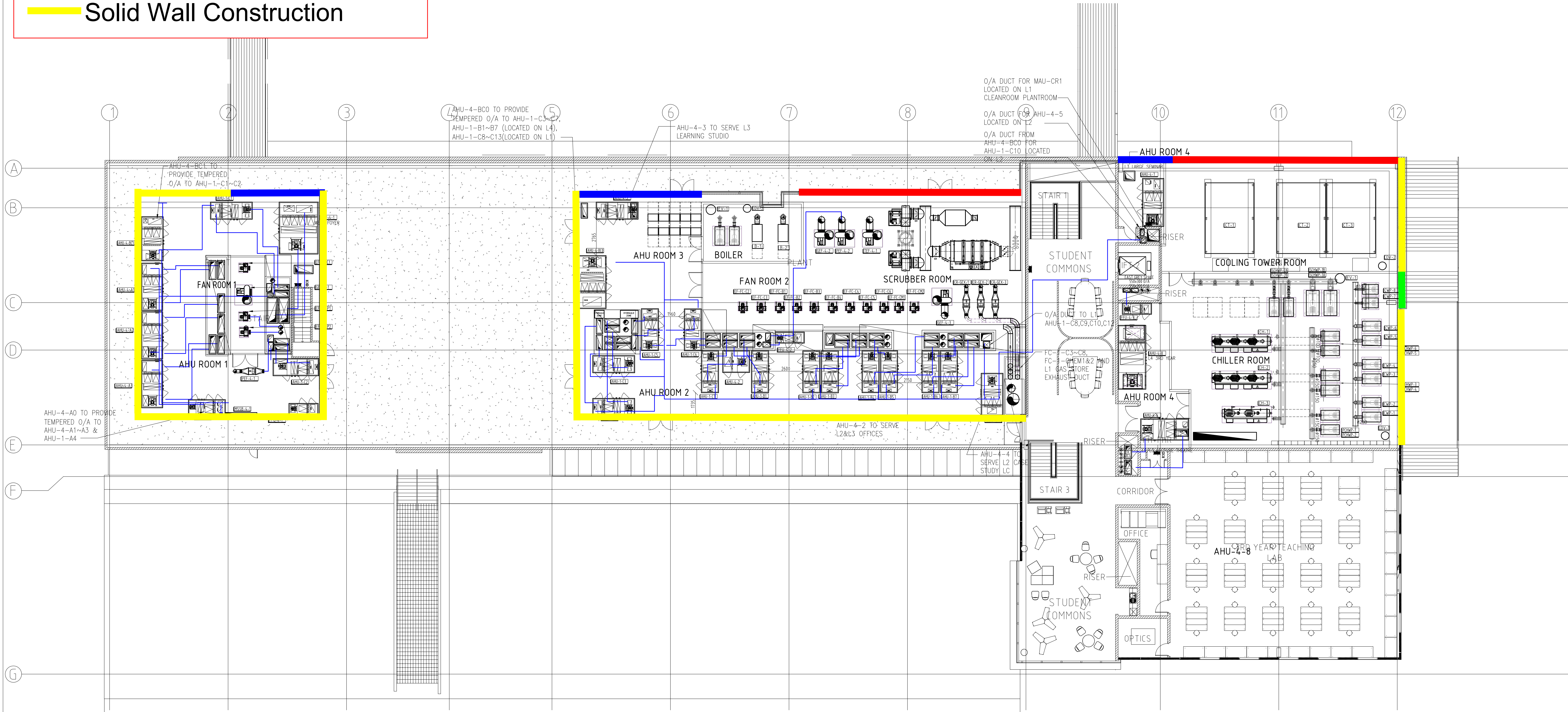
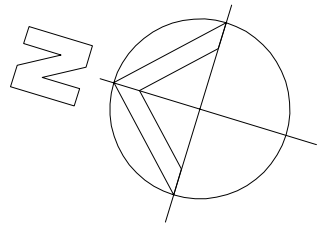
Acoustic Louvre Specification

Architectural louvres

Stage 1 acoustic louvres

Stage 2 acoustic louvres

Solid Wall Construction

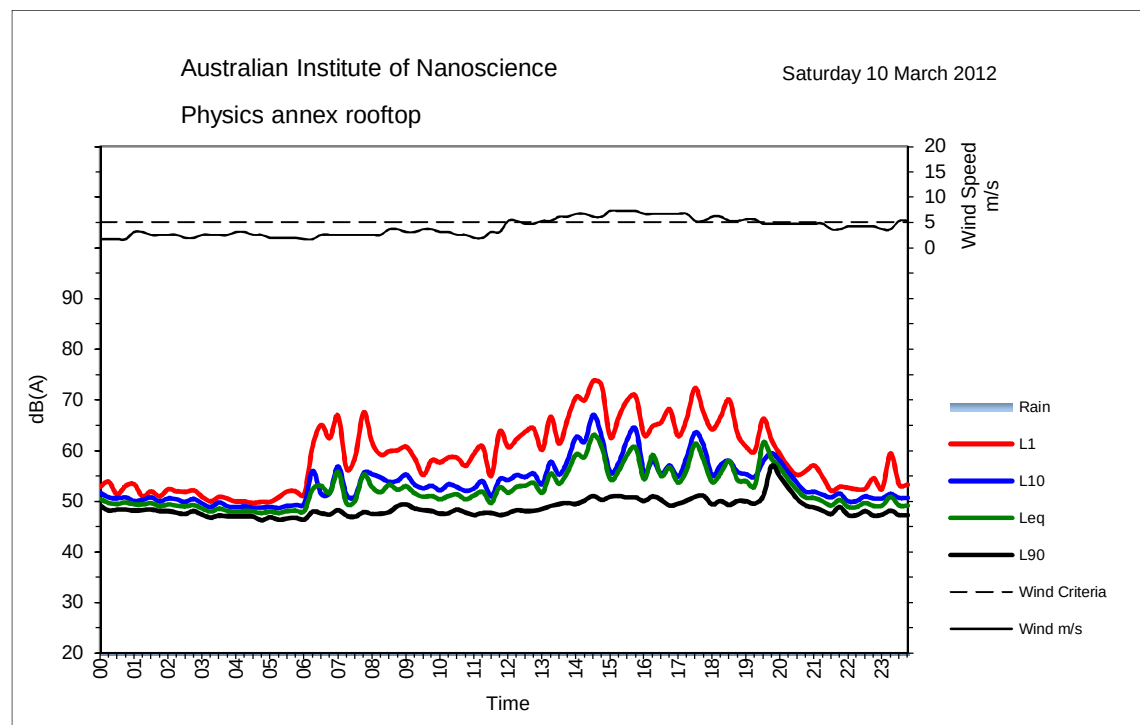
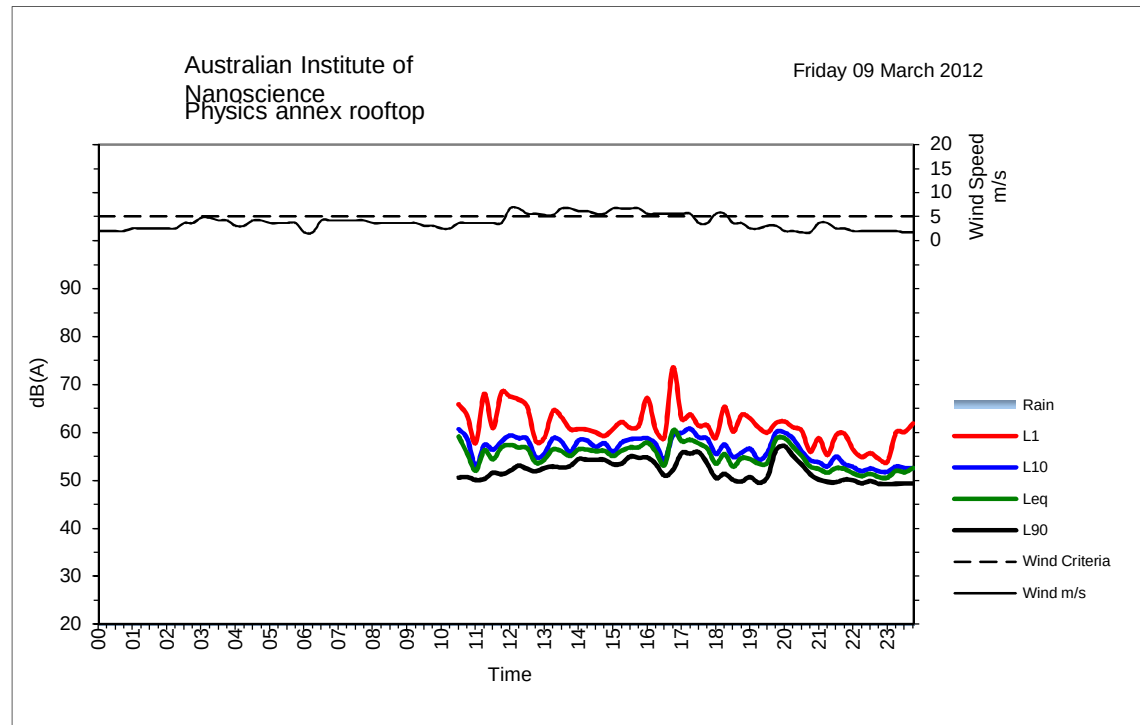


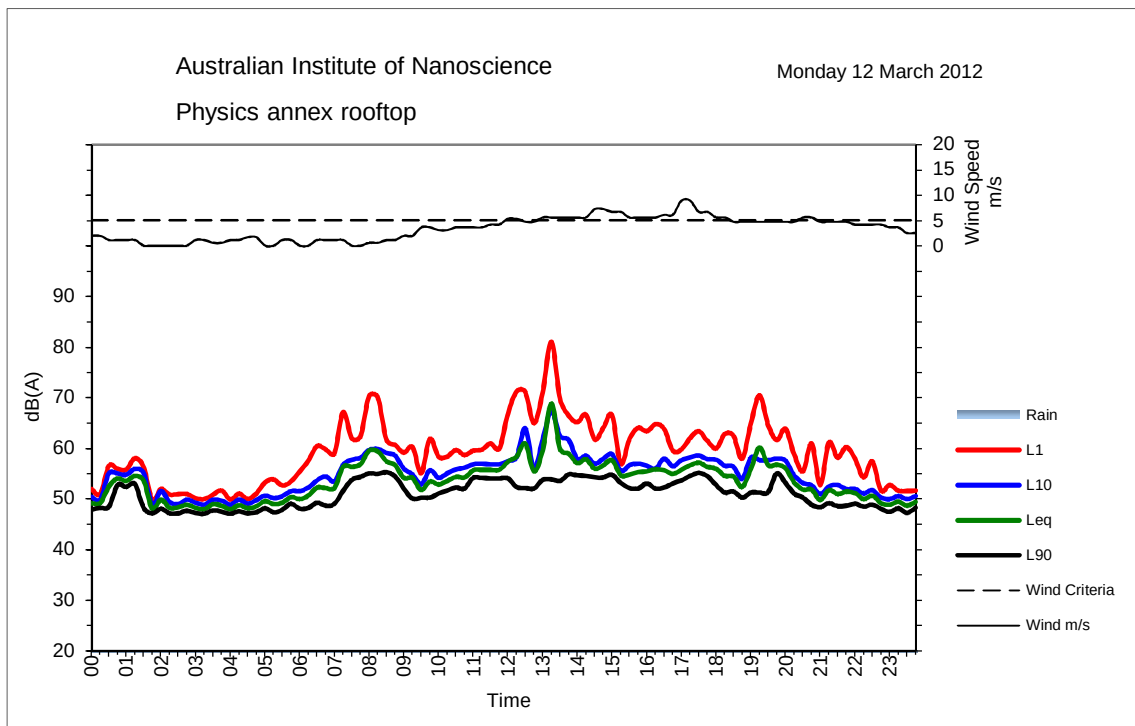
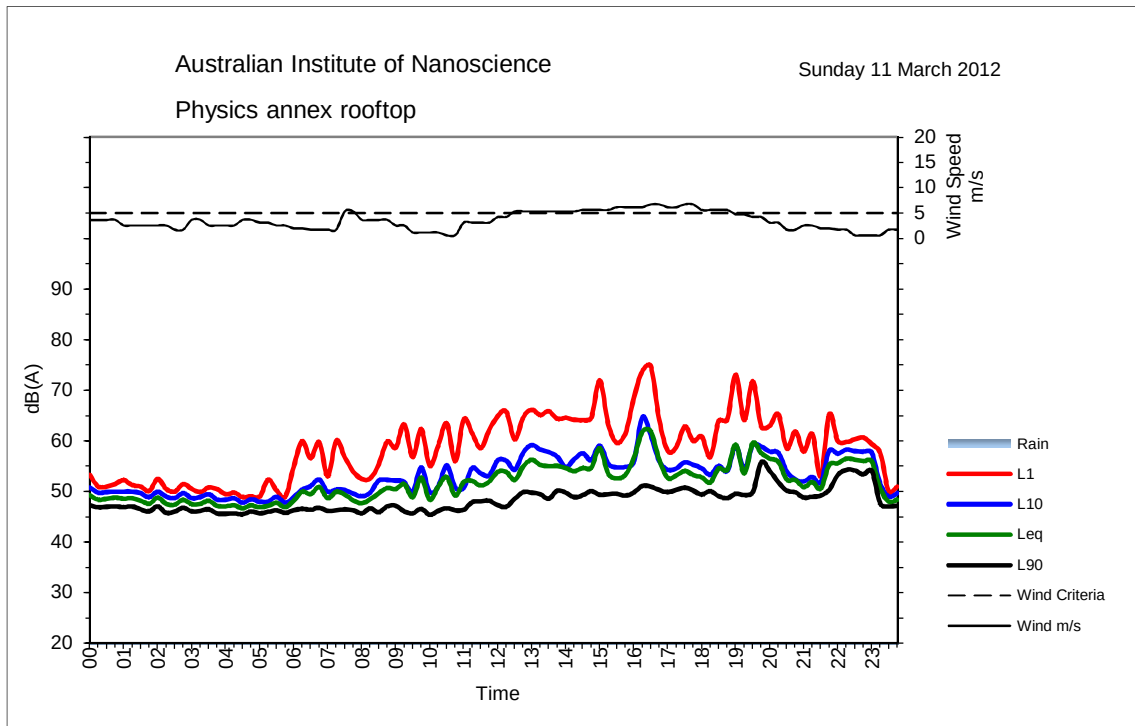
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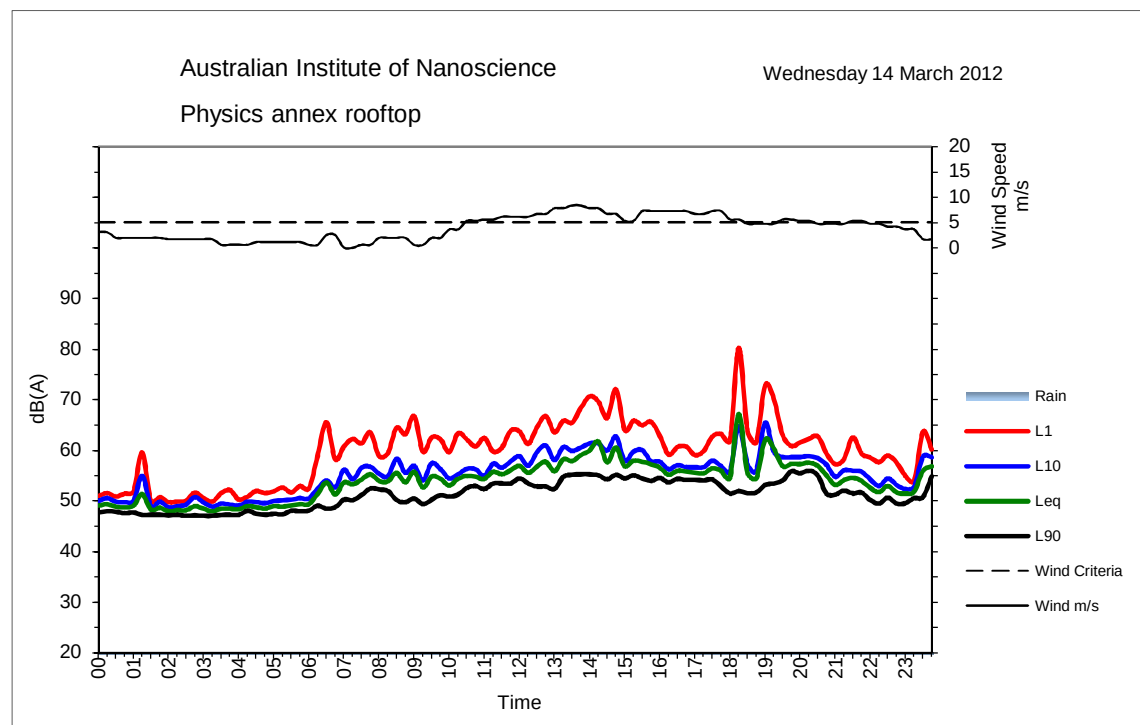
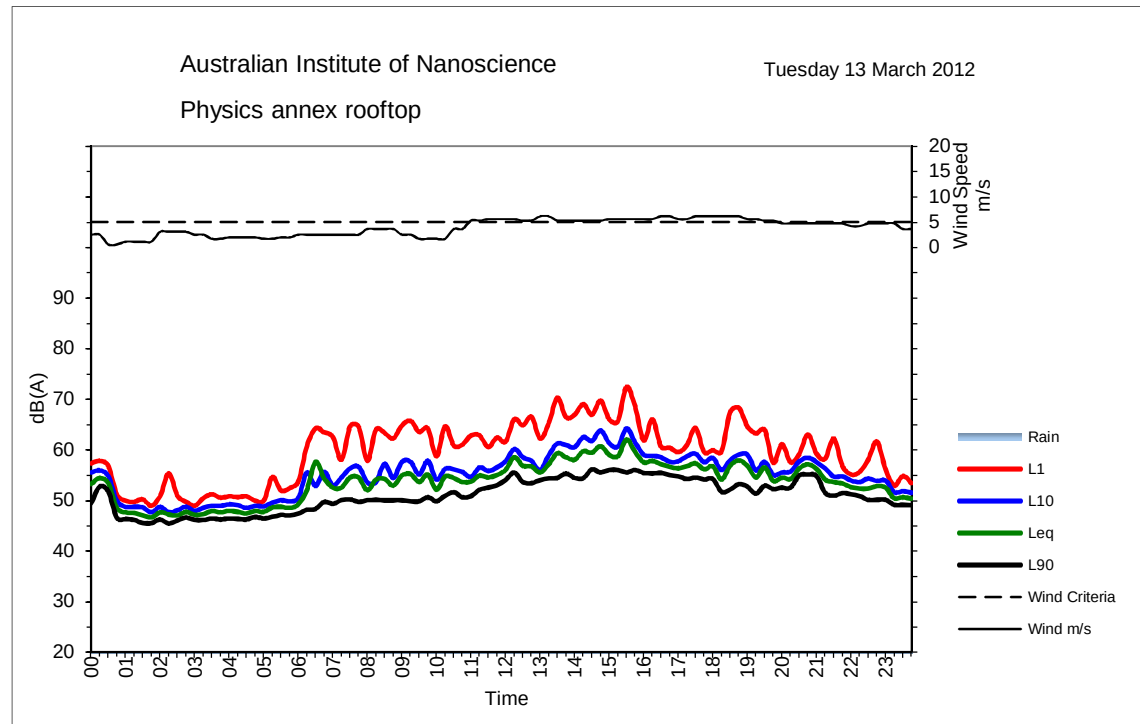
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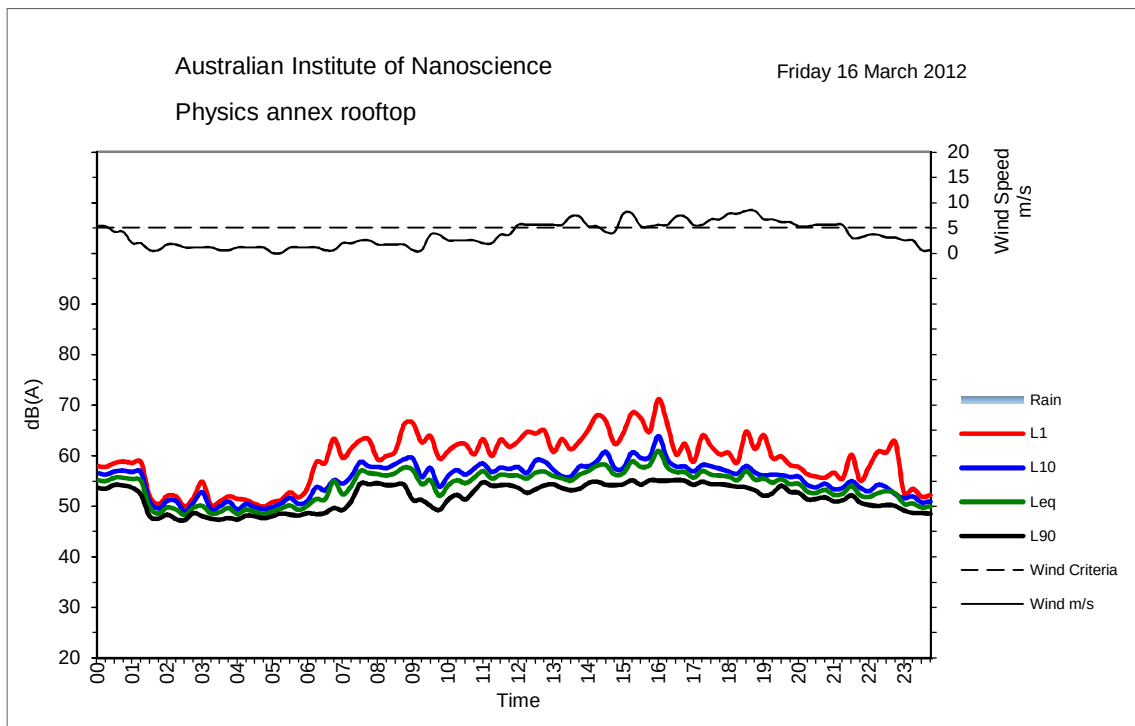
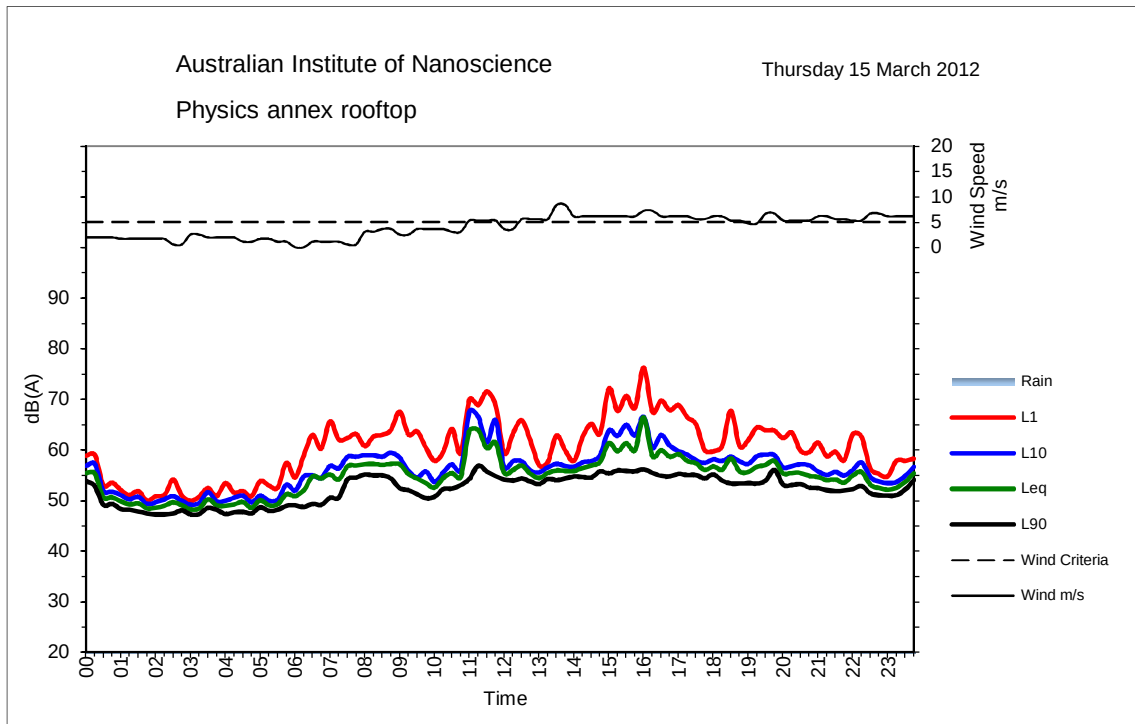
Appendix D

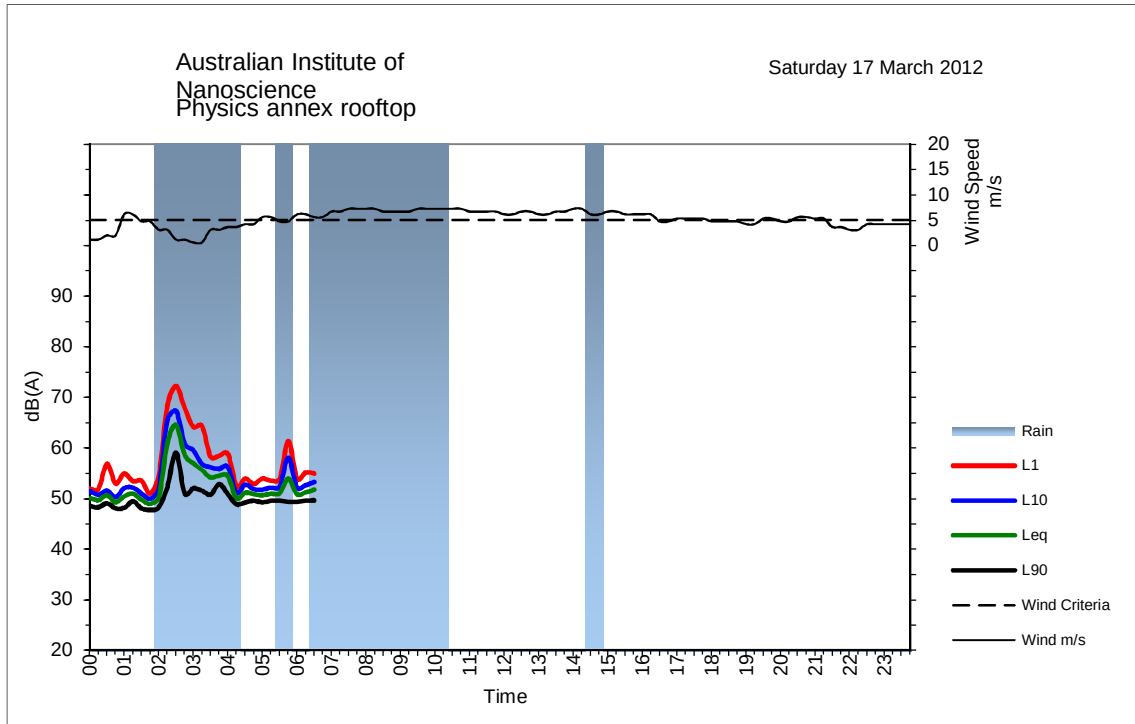
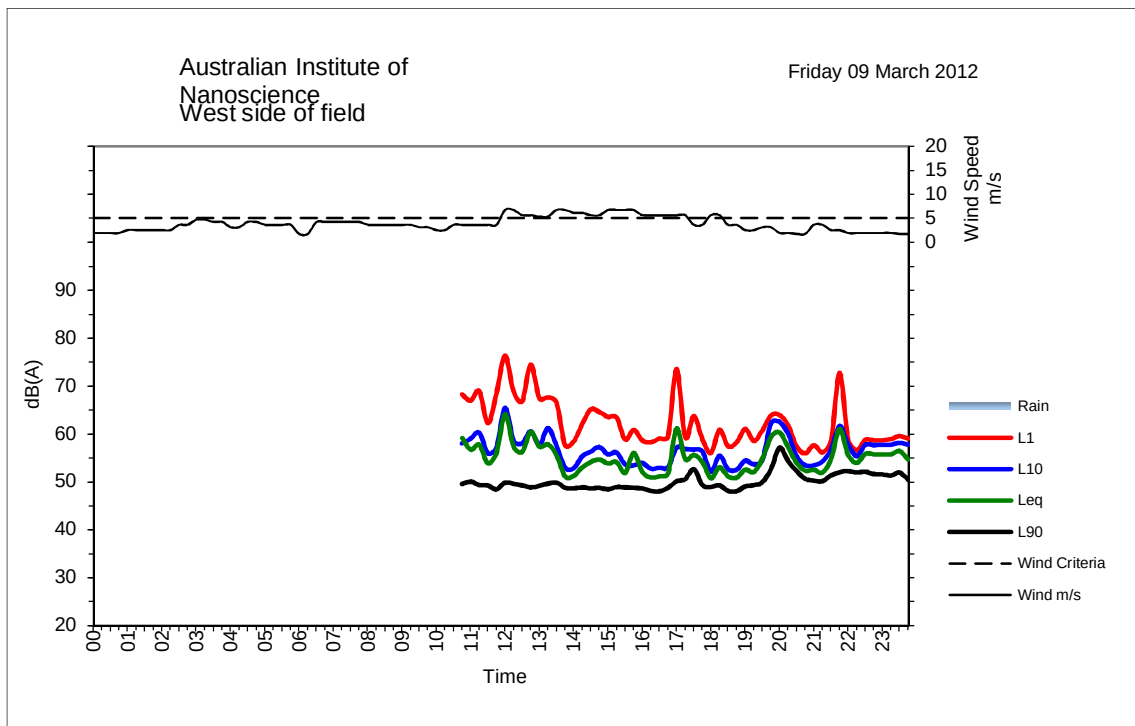
Noise Logging Results

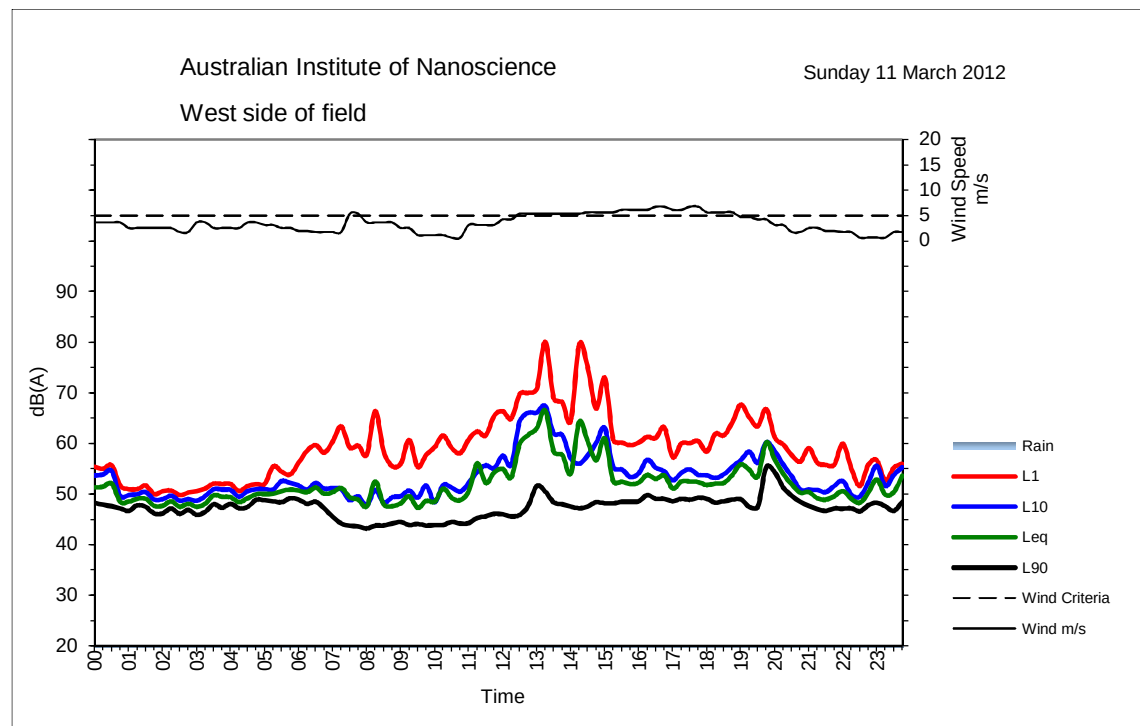
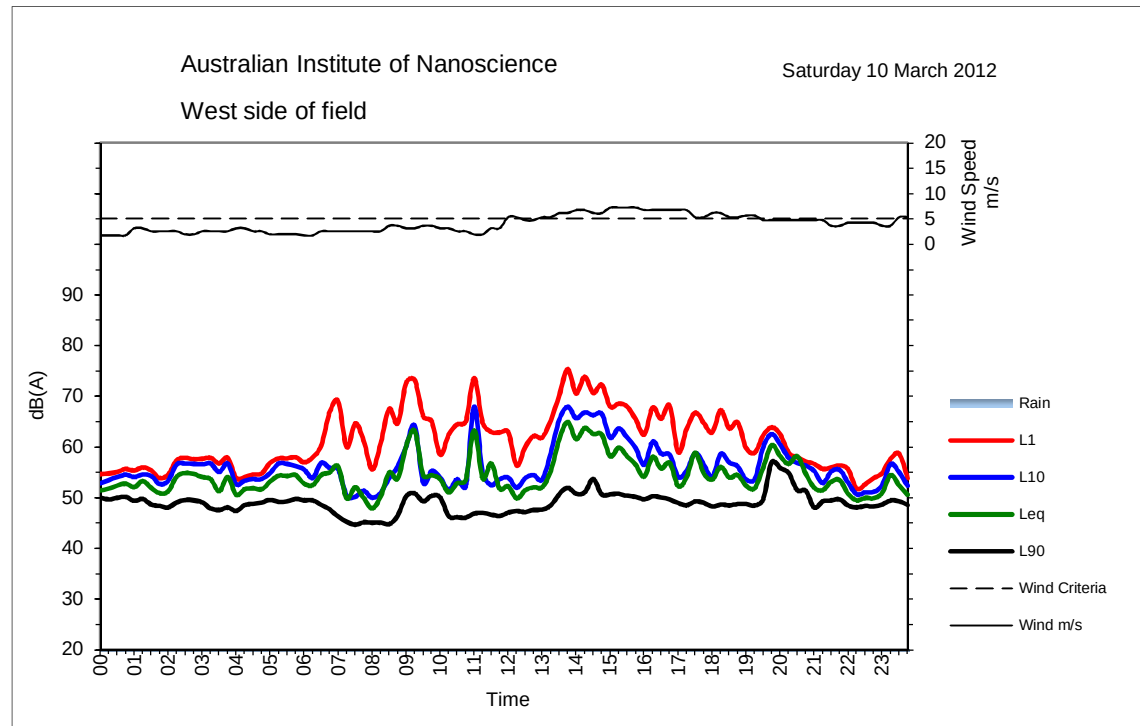
DRAFT**Appendix D Noise logging results****Logger 1: Physics Annex Building rooftop**

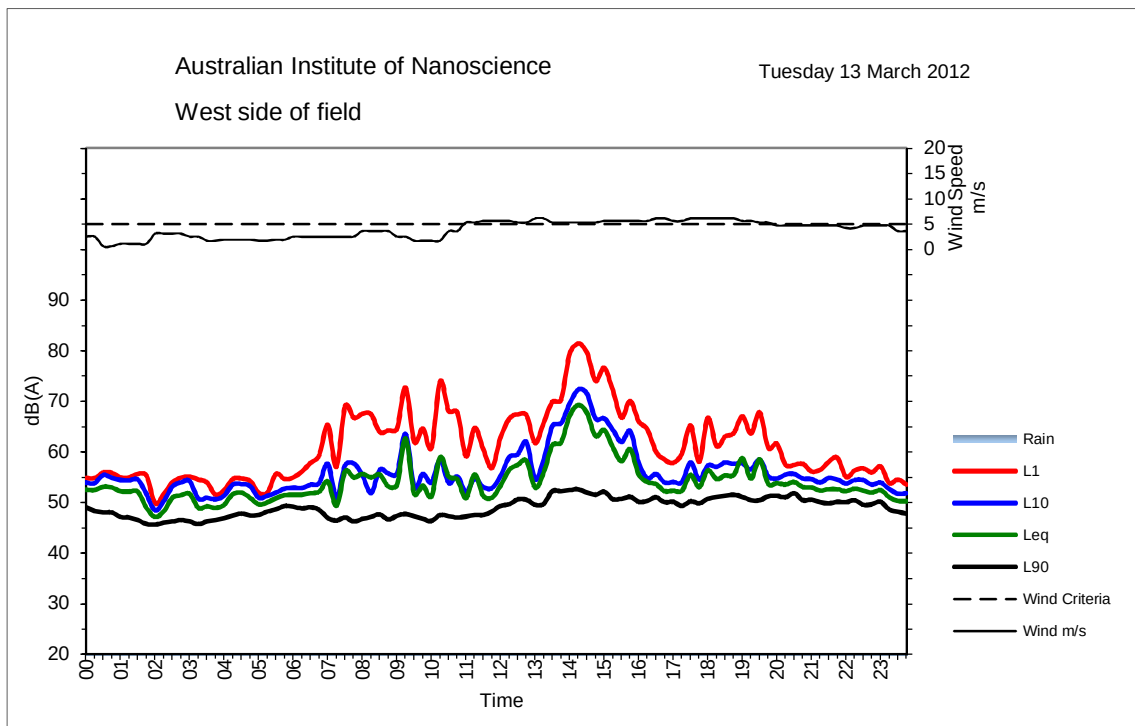
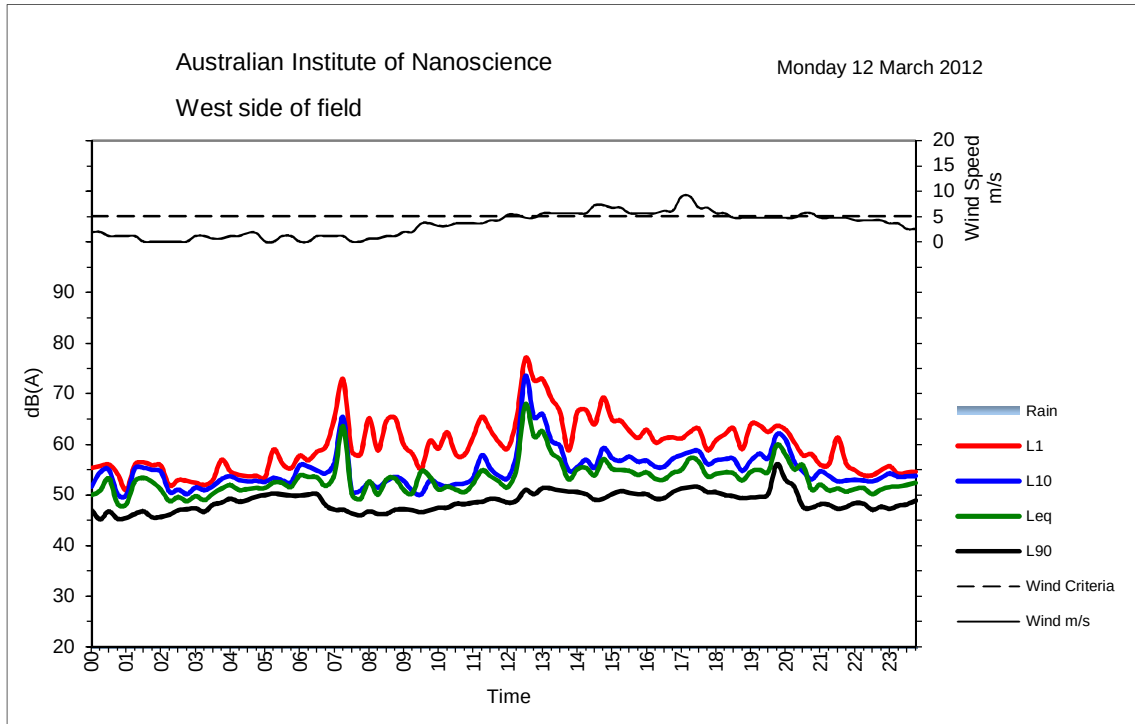
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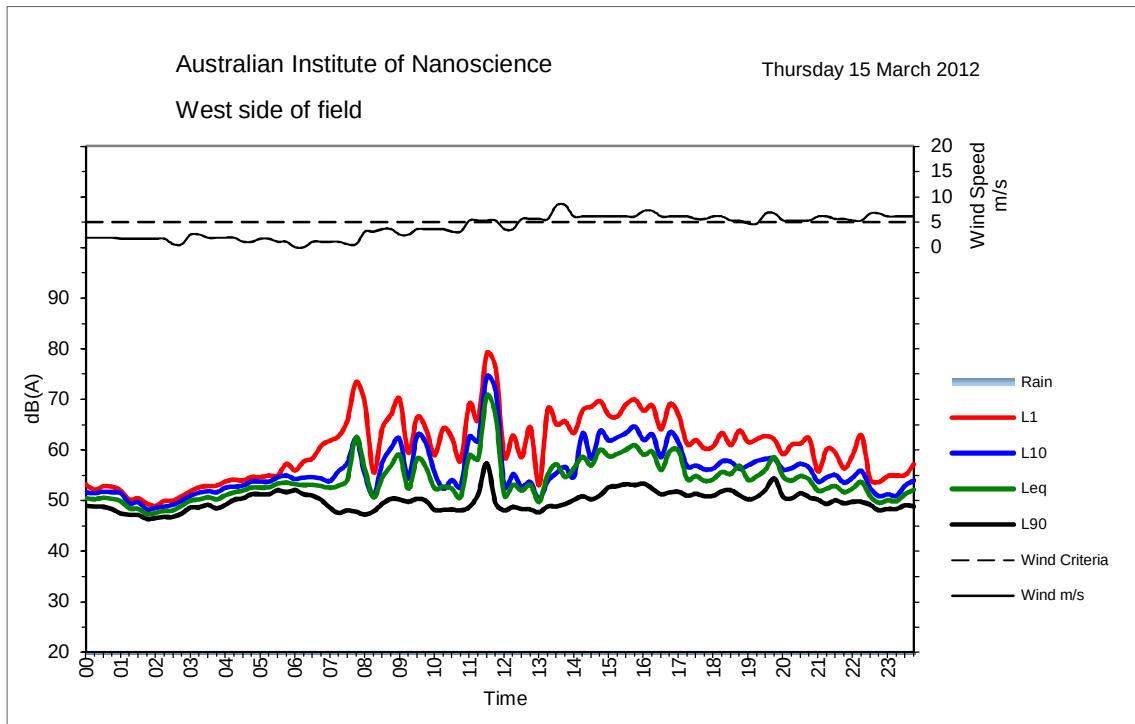
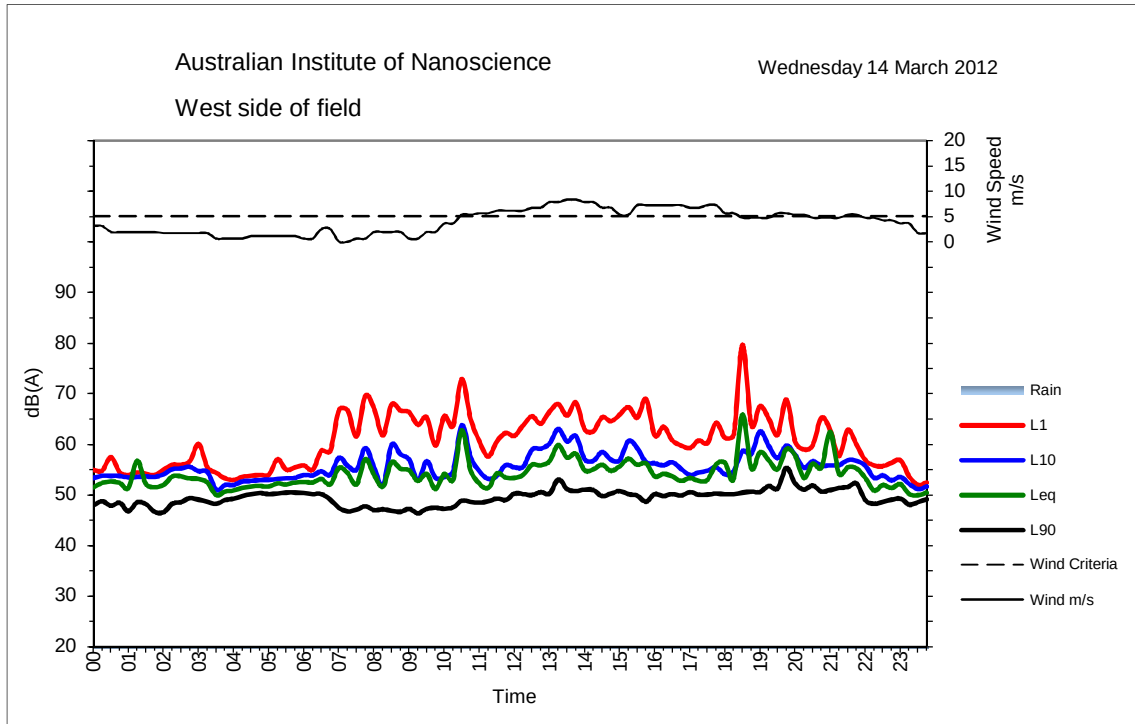
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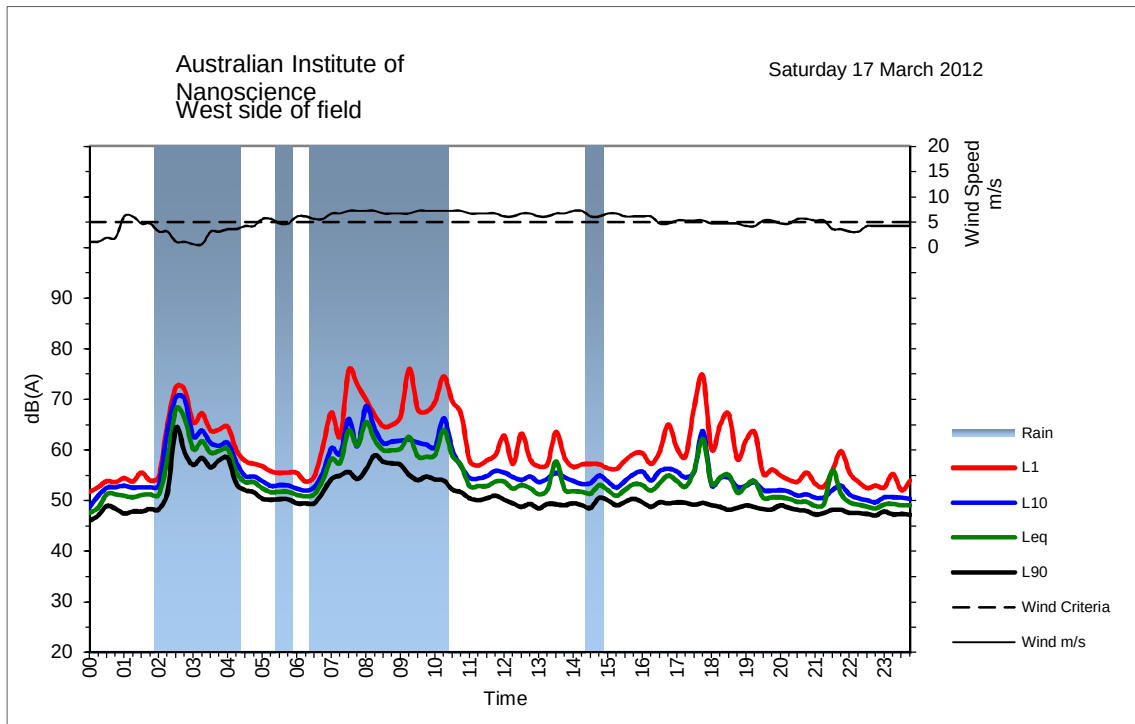
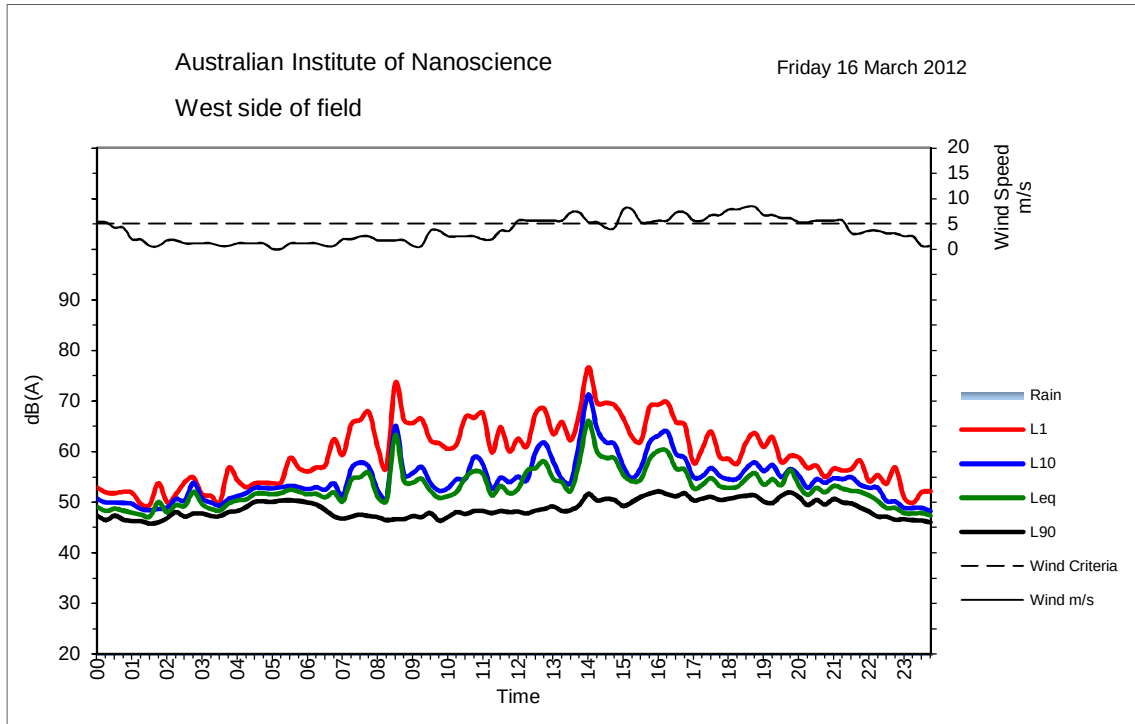
DRAFT

DRAFT**Logger 2: North west corner of field**

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