Urbis Pty Ltd

Sydney Swans HQ & Community Centre

Noise and Vibration Impact Assessment

April 2019

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1. Introduction

1.1 Overview

GHD has prepared a noise and vibration impact assessment (NVIA) for the proposed Sydney Swans Headquarters and Community Centre project at the Royal Hall of Industries (the Proposal). This NVIA was prepared in support of an Environmental Impact Statement (EIS) for SSD 9627.

This NVIA assesses construction and operation of the proposed extension and alterations and supplies appropriate mitigation measures to minimise off site impacts.

1.2 Scope of work

GHD has undertaken the following works as part of this NVIA.

- Conduct long term noise monitoring at a location that is representative of the area surrounding the Proposal site
- Identification of surrounding sensitive receivers potentially impact by construction noise
- Determination of the rating background level (RBL) for the Proposal from the noise monitoring data
- A quantitative assessment of construction noise and vibration
- Reviewing the potential noise impacts due to construction traffic generation
- An assessment of operational noise impacts
- Providing construction noise and vibration mitigation measures to minimise impacts on the community.

This report has been prepared with consideration to the following documents:

- *Interim Construction Noise* Guideline (DECCW, 2009) (ICNG)
- *Road Noise Policy* (DECCW, 2011) (RNP)
- *Assessing Vibration: a technical guideline* (EPA, 2006) (AVTG)
- *Noise Policy for Industry* (EPA, 2017) (NPI)
- *City of Sydney* Council general noise requirements
- *Construction Noise and Vibration Guideline* (TfNSW, 2016) (CNVG)

1.3 Secretary's Environmental Assessment Requirements (SEARs)

The specific Secretary's Environmental Assessment Requirements (SEARs) addressed in this report are summarised in Table 1-1.

Table 1-1 SEARs

Assessment requirements	Section(s) of this report where addressed
7. Environmental Amenity The EIS shall address how the Proposal achieves a high level of environmental amenity, both internally and on the surrounding area, including acoustic impacts	Sections 4 and 5
13. Noise and Vibration The EIS shall include a noise and vibration assessment prepared in accordance with the relevant EPA guidelines. This assessment must detail construction and operational noise impacts on nearby noise sensitive receivers and outline proposed noise mitigation and monitoring procedures	Entire report

1.4 Limitations

This report: has been prepared by GHD for Urbis Pty Ltd and *may only be used and relied on by Urbis Pty Ltd for the purpose agreed between GHD and the Urbis Pty Ltd as set out in section 1.2 of this report.*

GHD otherwise disclaims responsibility to any person other than Urbis Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Urbis Pty Ltd and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.5 Assumptions

The following assumptions have been made in this NVIA:

- Site plans, the construction methodology and operational processes of the Hall have been provided to GHD by APP, Aurecon and Douglas Partners
- Construction modelling was undertaken assuming the proposed plant and equipment provided by Douglas Partners
- Operational noise and vibrational impacts were assessed based on a description of operations provided by the client

2. Existing environment

2.1 Proposal location

The Proposal is located around 1.5 kilometres south of the Sydney CBD, and is fronted by Driver Avenue (West), Lang Road (South) and Errol Flynn Boulevard (East). The noise environment is typical of an urban area with consistent road traffic noise along Lang Road. The general site and noise monitoring locations is shown in Figure 2-1.

2.2 Sensitive receivers and land uses

Noise and vibration sensitive receivers are defined by the type of occupancy and the activities performed within the land parcel. The receivers are classified within the following categories:

- residential premises
- commercial or industrial premises.
- educational institutes
- hospitals and medical facilities
- places of worship
- passive and active recreational areas

These receivers and their classifications are presented in Figure 2-1.

2.3 Unattended noise monitoring

Long term monitoring was undertaken at one location for a period of 13 days between 5 March 2019 to 18 March 2019. The location is situated within the Proposal site on the north-eastern boundary. Attended noise monitoring was conducted in conjunction at the nearest residential receiver and details of such is presented in Section 0

2.3.1 Noise monitoring methodology

The methodology of the unattended noise monitoring data was:

- The noise logger were set to record L_{A90}, L_{A10}, L_{Aeq} and L_{Amax} noise descriptors. The instrument was programmed to accumulate environmental noise data continuously over a sampling period of 15 minutes over the entire monitoring period
- A calibration check was performed on the noise monitoring equipment using a sound level calibrator with a sound pressure level of 94 dBA at 1 kHz. At completion of the measurements, the meter's calibration was re-checked to ensure the sensitivity of the noise monitoring equipment had not varied. The noise loggers were found to be within the acceptable tolerance of ± 0.5 dBA
- Meteorological data for the monitoring period was sourced from the Bureau of Meteorology (BoM) Sydney Observatory Hill (station number: 066062). The automatic weather station (AWS) is located about 4.4 km north of the Proposal site.
- Noise levels were excluded during periods of extraneous noise, periods where average wind speeds were greater than 7 m/s (height adjusted) or when rainfall occurred.

A summary of the noise monitoring location and noise monitoring equipment details are provided in Table 2-1.

Table 2-1 Long term unattended monitoring details

Parameter	Value
Monitoring location	Royal Hall of Industries
Logger type / Serial No.	RION NL-52 / SN: 00131632
Measurement started	1:15 pm, 5 March 2019
Measured ceased	1.15 pm, 18 March 2019
Calibration variance	-0.1 dB @ 1kHz
Freq. weighting	A
Time response	Fast
Photograph	

2.3.2 Noise monitoring results

The measured noise monitoring data was used to determine the Rating Background Levels (RBL) for the assessment during the day, evening and night-time periods in accordance with the *Noise Policy for Industry* (NPI) (EPA, 2017). A summary of the measured rating background levels and ambient noise levels is provided in Table 2-2. Daily noise level charts are provided in Appendix B. Night period data has been excluded from 5 March to 10 March due to monitoring influenced by extraneous noise factors. This is likely due to mechanical plant which was not detected during monitoring from 11 March onwards.

Table 2-2 Summary of long term noise monitoring results, dB(A)

Location	Rating background level L_{A90}, dB(A)			Ambient level, L_{Aeq}, dB(A)		
	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am
Royal Hall of Industries	54	54	44	65	62	58

The criteria presented in Section 3.4 requires the assessment of noise emission in octave bands. Octave band background noise levels are presented in Table 2-3.

Table 2-3 Summary of octave band noise monitoring results, dB(A)

Time period	RBL L_{A90} in octave bands [Hz], dB(A)								
	31.5	63	125	250	500	1000	2000	4000	8000
Day (7 am – 6 pm)	24	36	42	46	48	49	47	41	30
Evening (6 pm – 10 pm)	22	33	41	47	49	49	46	40	30
Night (10 pm – 7 am)	20(18)[1]	27	35	37	37	38	36	31	22

1) Certain octave band levels have been increased to align with the human threshold of hearing, as presented in Table 1 from ISO 22226-2003 Acoustics – Normal equal-loudness-level contours

2.4 Short term attended noise monitoring

Short term attended noise monitoring was conducted at 112 Lang Road, Sydney. A summary of the noise monitoring location and equipment details is presented below in Table 2-4. This was used to compare the measured background noise levels to that at the nearest residential receiver.

Table 2-4 Short term attended monitoring details

Parameter	Value
Monitoring location	112 Lang Road
Logger type / Serial No.	SVAN 977 / SN: 45733
Measurement started	12:44 pm, 18 March 2019
Measured ceased	1.01 pm, 18 March 2019
Calibration variance	-0.02 dB @ 1kHz
Freq. weighting	A
Time response	Fast

Parameter	Value
Photograph	

Table 2-5 Summary of short term noise monitoring results, dB(A)

Location	Rating background level L_{A90} dB(A)	Ambient level L_{Aeq}, dB(A)
112 Lang Road, Sydney	57	68

The measured background noise levels at the nearest residential receiver located at 112 Lang Road were higher compared to that measured from the long term noise monitoring. This was due to the high road traffic noise emanating from Lang Road. As such no correction will be added to the background noise levels taken from long term noise monitoring as it represents a conservative representation of background noise levels at sensitive receivers.

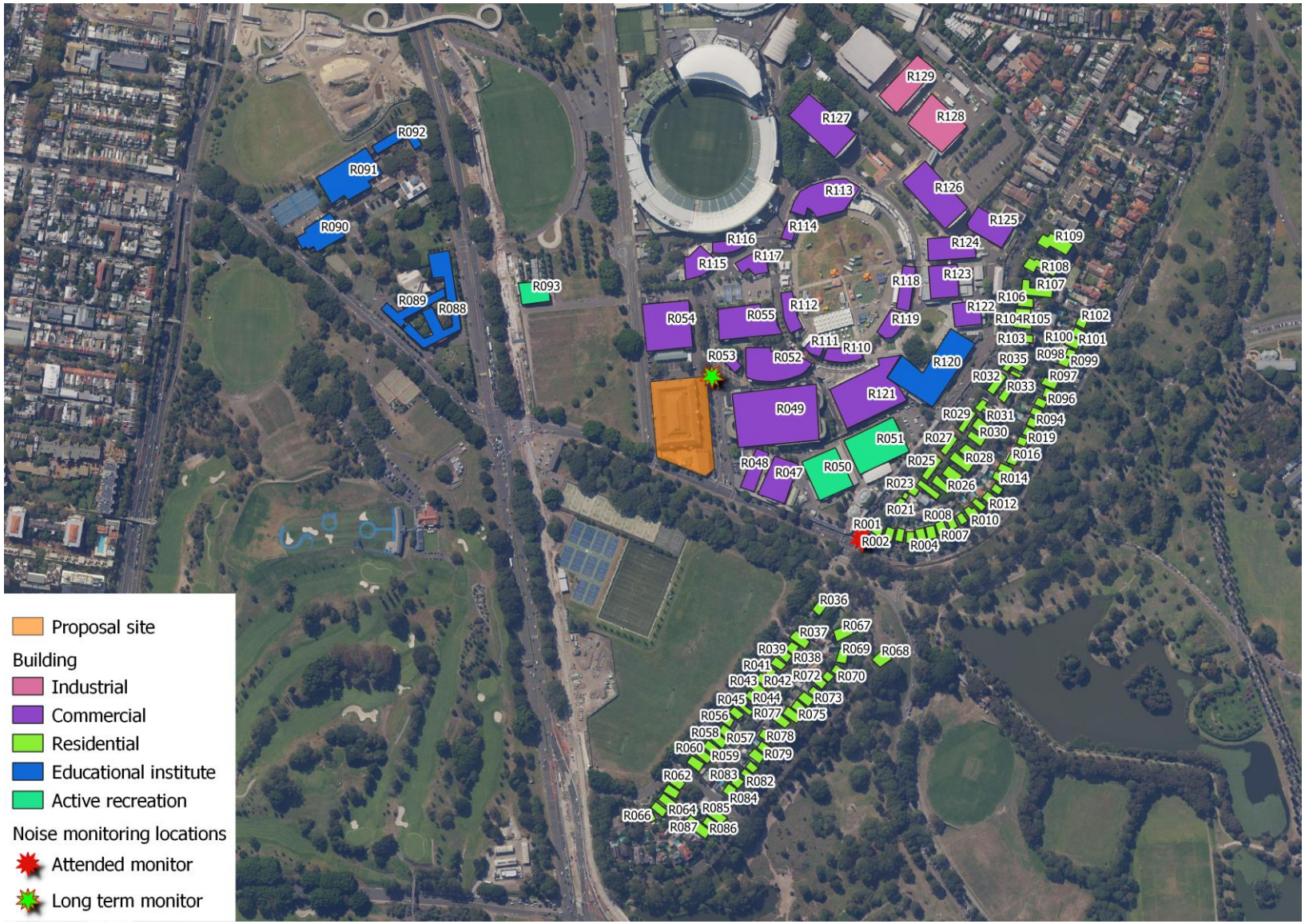


Figure 2-1 Sensitive receivers and noise monitoring locations

3. Compliance criteria

3.1 Construction noise

3.1.1 Proposed construction hours

Construction noise management levels for the Proposal are based on the *Interim Construction Noise Guideline* (ICNG) (DECCW, 2009). Construction works would be conducted during standard construction hours and certain out-of-hours periods.

The construction hours periods are presented below in Table 3-1.

Table 3-1 Construction hours

Construction hours	Monday to Friday	Saturday	Sunday/Public holiday
Standard hours	7 am to 6 pm	8 am to 1 pm	No work
Outside recommended standard hours	6 pm to 7 am	1 pm to 8 am	All times

The ICNG acknowledges that the following activities have justification to be undertaken outside the standard construction hours assuming all feasible and reasonable mitigation measures are implemented to minimise the impacts to the surrounding sensitive land uses:

- the delivery of oversized plant, equipment and materials that police or other authorities determine require special arrangements to transport along public roads
- emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- maintenance and repair of public infrastructure where disruption to essential services or considerations of worker safety do not allow work within standard hours
- public infrastructure works that shorten the length of the Proposal and are supported by the affected community
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours
- works which maintain noise levels below the noise management levels outside of the recommended standard construction hours.

Works required outside standard construction hours would be identified during construction planning and nearby residents would be notified before possession work is expected.

3.1.2 Construction noise management levels

Construction noise management levels for residential premises and other sensitive land uses are provided in the ICNG.

The method to determine the noise management levels for residential receivers in accordance with the ICNG is outlined in Table 3-2.

Table 3-2 Noise management levels for residential receivers

Time of day	Noise management level, $L_{Aeq(15\ min)}$	Application notes
Recommended standard hours	Noise affected: RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise.

Time of day	Noise management level, $L_{Aeq(15\ min)}$	Application notes
		• 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 dBA	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 proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. • If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected: RBL + 5 dBA	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 measures have been applied and noise is more than 5 dBA above the noise affected level, the proponent should consult with the community.

Noise management levels for other sensitive land uses are provided in Table 3-3 and only apply when the properties are in use.

Table 3-3 Noise management levels for other sensitive land uses

Land use	Noise management level, $L_{Aeq(15\ min)}$
Commercial premises	70 dB(A) (external)
Industrial premises	70 dB(A) (external)
Educational institutes	45 dB(A) (internal)
Hospital wards and operating theatres	45 dB(A) (internal)
Places of worship	45 dB(A) (internal)
Active recreation areas	65 dB(A) (external)
Passive recreation areas	60 dB(A) (external)

3.1.3 Sleep disturbance

The ICNG recommends that where construction works are planned to extend over two or more consecutive nights, the Proposal should consider maximum noise levels and the extent and

frequency of maximum noise level events exceeding the RBL. The potential for both sleep disturbance and awakenings should be considered in the assessment.

The NPI provides the latest EPA guidance for the assessment of sleep disturbance. The NPI recommends a maximum noise level assessment to assess the potential for sleep disturbance impacts which include awakenings and disturbance to sleep stages. An initial screening test for the maximum noise levels events should be assessed to the following levels.

- $L_{Aeq(15\ min)}$ 40 dBA or the prevailing RBL plus 5 dB, whichever is greater, and/or
- L_{AFmax} 52 dBA or the prevailing RBL plus 15 dB, whichever is greater.

If the screening test indicates there is a potential for sleep disturbance then a detailed maximum noise level assessment should be undertaken. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period.

3.1.4 Proposal noise management levels

A summary of the Proposal construction noise management levels for each identified sensitive receiver type is provided in Table 3-4.

Table 3-4 Proposal construction noise management levels

Receiver Type	Time of day	Management level, dB(A)
Residential	Recommended standard hours	Noise affected: 64
		Highly affected: 75
	Outside recommended standard hours[1]	Day: 59
		Evening: 59
		Night: 49
Commercial	When in use	70 (external)
Educational institutes		45 (internal)
Hospital wards and operating theatres		45 (internal)
Places of worship		45 (internal)
Active recreation areas		65 (external)

Note 1: The *Noise Policy for Industry* (EPA, 2017) defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday or 8 am to 6 pm on Sundays and public holidays.
- Evening: the period from 6 pm to 10 pm.
- Night: the remaining periods.

3.2 Construction traffic

The *Road Noise Policy* (RNP) (DECCW, 2011) provides road traffic noise criteria for residential land uses affected by construction traffic on the public road network.

Section 3.4.1 of the RNP states that any increase in the total noise level at existing residences and other sensitive land uses affected by land use development traffic generation on existing roads should be limited to 2 dBA above current levels. This limit only applies when the noise level without the development is within 2 dBA or exceeds the road traffic noise criterion provided in the RNP.

This has been used to identify potential impacts as a result of noise produced by construction traffic. If road traffic noise increases as a result of construction works within 2 dBA of current levels then the objectives of the RNP are considered to be met and no specific mitigation measures would be required.

Where construction traffic increases the existing road traffic noise levels by more than 2 dBA then further assessment against the road traffic noise criteria in Table 3-5 is required.

Table 3-5 Road traffic noise criteria, dBA

Type of development	Day 7 am to 10 pm	Night 10 pm to 7 am
Existing residence affected by additional traffic on arterial roads generated by land use developments	60 $L_{Aeq(15\ hour)}$	55 $L_{Aeq(9\ hour)}$
Existing residence affected by additional traffic on local roads generated by land use developments	55 $L_{Aeq(1\ hour)}$	50 $L_{Aeq(1\ hour)}$

3.3 Construction vibration

3.3.1 Human comfort

Acceptable vibration levels for human comfort have been set with consideration to *Assessing Vibration: a technical guideline* (DEC, 2006) which is based on the guidelines contained in British Standard *BS 6472 – 1992, Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*.

Typically, construction activities generate ground vibration of an intermittent nature. Intermittent vibration is assessed using the vibration dose value. Acceptable values of vibration dose are presented in Table 3-6 for sensitive receivers.

Table 3-6 Human comfort intermittent vibration limits

Receiver type	Period	Intermittent vibration dose value ($m/s^{1.75}$)	
		Preferred value	Maximum value
Residential	Day (7 am and 10 pm)	0.2	0.4
	Night (10 pm and 7 am)	0.13	0.26
Offices, schools, educational institutes and places of worship	When in use	0.4	0.8

Whilst the assessment of response to vibration in *BS 6472:1992* is based on vibration dose value and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of a peak value, since this parameter is likely to be more routinely measured based on the more usual concern over potential building damage.

Humans are capable of detecting vibration at levels which are well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in British Standard, *BS 5228.2 – 2009, Code of Practice Part 2 Vibration for noise and vibration on construction and open sites – Part 2: Vibration* and are shown below in Table 3-7.

Table 3-7 Guidance on effects of vibration levels for human comfort

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments will cause complaints, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

3.3.2 Guidelines for general structures

The effects of transient vibration on structures is considered in *BS 7385 Part 2 – 1993 Evaluation and measurement for vibration in buildings*. The criteria provided in BS 7385 are presented in Table 3-8.

Table 3-8 Transient vibration guide values – minimal risk of cosmetic damage

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	50 mm/s at 4 Hz and above
Unreinforced or light framed structures. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above.

The guide values in Table 3-8 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings. Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at lower frequencies, then the guide values may need to be reduced by up to 50 per cent.

The predominant vibration for most construction activities involving intermittent vibration sources such as rock breakers, piling rigs, vibratory rollers and excavators occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). However, a conservative vibration damage screening level per receiver type is given below:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s

3.3.3 Guidelines for vibration sensitive structures

Heritage buildings and structures would be assessed using the guide values in Table 3-8. A heritage building or structure should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound (following inspection) a more conservative cosmetic damage criterion of 2.5 mm/s peak component particle velocity (from DIN 4150) should be considered.

3.4 Operational noise criteria

3.4.1 City of Sydney requirements

The City of Sydney *Standard Conditions of Development Consent* used on previous projects provides the following requirements for noise emission for mechanical plant associated with the development

NOISE - GENERAL

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

> *i) The $L_{Aeq(15m)}$ 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.*
>
> *ii) Project specific noise levels shall be determined by establishing the existing environmental noise levels, in complete accordance with the assessment $L_{A90(15m)}$ / rating $L_{A90(15m)}$ 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 AS 1055-1997 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 $L_{Aeq(15m)}$ noise level emitted from the use must not exceed the $L_{A90(15m)}$ noise level by more than 3dB in any Octave Band Centre Frequency (31.5Hz – 8kHz inclusive) when assessed inside any habitable room of any affected residence or noise sensitive commercial premises provided that;

> *i) Where the $L_{A90(15m)}$ noise level is below the threshold of hearing, Tf at any Octave Band Centre Frequency as defined in Table 1 of International Standard ISO 226 : 2006 – Normal Equal-Loudness-Level Contours then the value of Tf corresponding to that octave Band Centre Frequency shall be used instead.*
>
> *ii) The $L_{Aeq(15m)}$ noise level and the $L_{A90(15m)}$ noise level shall both be measured with all external doors and windows of the affected residence closed;*
>
> *iii) The relevant background noise level ($L_{A90(15m)}$) 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 AS 1055-1997 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.*
>
> *v) 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.*

It has been assumed that if the predicted external noise level for residential receivers is lower than the background noise level +3 dB in octave bands then it will be compliant with the City of Sydney internal octave band noise criteria presented above. The resulting criteria is presented below in Table 3-9.

Table 3-9 Octave band noise criteria

	Noise level in octave bands [Hz], dB(A)								
	31.5	63	125	250	500	1000	2000	4000	8000
Background noise level[1]	22	33	41	47	49	49	46	40	30
External noise criteria	25	36	44	50	52	52	49	43	33

1) The background noise level from the evening period has been selected. Compliance during this period will ensure compliance during all other times of operation

3.4.2 International standard ISO 226 : 2003

The ISO 226 :2003 – Normal Equal-Loudness-Level contours presents *Tf* values for the threshold of human hearing in 3rd octave bands. The *Tf* corresponding to each octave band centre frequency is presented in Table 3-10 below.

Table 3-10 Threshold of human hearing (ISO 226:2003 Table 1)

Weighting	dB in octave bands [Hz]								
	31.5	63	125	250	500	1000	2000	4000	8000
Z - weighted	59.5	37.5	22.1	11.4	4.4	2.4	-1.3	-5.4	12.6
A - weighted	20.1	11.3	6.0	2.8	1.2	2.4	-0.1	-4.4	11.5

Where internal background noise levels are below the threshold of human hearing, the A-weighted threshold of human hearing will be used.

3.4.3 Noise Policy for Industry, 2017

Operational noise is assessed in accordance with the *Noise Policy for Industry* (NPI). The NPI addresses noise emanating from fixed facilities through assessing its intrusiveness based on the rating background noise level, and is presented below in Table 3-11.

Table 3-11 NPI Noise intrusiveness criteria

Time of Day	RBL ($L_{A90,15min}$), dBA	Intrusiveness trigger level
7 am to 6 pm (daytime)	54	59 (RBL + 5 dB)
6 pm to 10 pm (evening)	54	59 (RBL + 5 dB)
10 pm to 7 am (night time)	44	49 (RBL + 5 dB)

The NPI also presents criteria for project amenity noise levels, which is defined as the recommended amenity noise level minus 5 dB. Table 3-12 presents the recommended amenity noise levels from the NPI.

Table 3-12 Recommended amenity noise levels, dB(A)

Receiver	Noise amenity area	Time of day	$L_{Aeq(period)}$, dB(A)
Residential	Urban	Day	60
		Evening	50
		Night	45
Commercial	All	When in use	65
Industrial	All	When in use	70
Educational	All	Noisiest 1 hour	35 (internal) 45 (external)[1]
Hospital/Medical	All	When in use	35 (internal) 50 (external)
Place of Worship	All	When in use	40 (internal)
Passive recreation	All	When in use	50
Active recreation	All	When in use	55

1) A + 10 dB correction has been added to convert internal to external criteria

Table 3-13 below presents both the intrusiveness and amenity criteria for external residential receivers, along with the project specific noise trigger level.

Table 3-13 NPI project noise trigger levels (residential)

Type of receiver	Time of day	$L_{Aeq(15min)}$ intrusiveness criteria, dB(A)	$L_{Aeq(15min)}$ amenity criteria, dB(A)[1]	$L_{Aeq(15min)}$ project noise trigger level, dB(A)
Residential	Day	59	**58**	***58***
	Evening	59	**48**	***48***
	Night	49	**43**	***43***

1) In order to convert the $L_{Aeq(period)}$ descriptor as presented in the NPI project amenity noise level criteria a correction factor of + 3 dB is added to convert it into a $L_{Aeq(15min)}$ descriptor

The Proposal specific criteria for the operational noise emission of the Proposal site is presented below in Table 3-14.

Table 3-14 Proposal specific operational noise criteria, dB(A)

Type of receiver	Assessment type	Time of day	Criteria $L_{Aeq(15min)}$, dB(A)
Residential	External	Day	58
		Evening	48
		Night	43

Type of receiver	Assessment type	Time of day	Criteria $L_{Aeq(15min)}$, dB(A)
Commercial	All	When in use	60
Industrial	All	When in use	65
Educational	All	Noisiest 1 hour	30 (internal)
Hospital/Medical	All	When in use	30 (internal) 45 (external)
Place of Worship	All	When in use	35 (internal)
Passive recreation	All	When in use	45
Active recreation	All	When in use	50

4. Construction impacts assessment

4.1 Construction noise assessment

4.1.1 Construction works program

The plant and equipment likely to be required throughout each proposed stage of construction have been used to predict the noise levels that would be expected during construction works. The predicted noise levels were assessed against the construction noise management levels identified in Section 3.1

Construction scenarios have been created based on construction equipment operating simultaneously at any given time. All works are located within or adjacent to the Proposal site. It is unlikely that construction machinery would be operating at the same time (as the modelling assumes), but analysing the 'worse-case' scenario helps to identify where noise impacts could be a concern and assists in the formulation of mitigation areas.

Construction activities

The construction hours for the Proposal is as follows:

- Monday – Friday: 7:00 am to 5:00 pm
- Saturday: 7:30 am – 3:00 pm
- Sunday: No work

The Proposal is anticipated to follow the following work methodology and staging provided in Table 4-1. These construction scenarios have been modelled to determine the potential construction noise impacts on the environment.

Table 4-1 Construction staging

Construction scenario	Construction phase	Time frame
CS01	Site establishment	Standard hours Outside of standard hours
CS02	Demolition	Standard hours Outside of standard hours
CS03	Earthworks	Standard hours Outside of standard hours
CS04	Piling and lift works	Standard hours Outside of standard hours

Noise generating equipment

Plant and equipment needed for the Proposal would be determined during the construction planning phase. Noise level data has been obtained from the Australian Standards *AS2436 – Guide to noise and vibration control on construction, demolition and maintenance sites.* Other equipment may be used, however, it is anticipated that they would produce similar net noise emissions when used concurrently with the equipment listed.

The magnitude of off-site noise impacts associated with construction is dependent upon a number of factors:

- the intensity and location of construction activities
- the type of equipment used
- existing background noise levels
- intervening terrain and structures
- prevailing weather conditions.

Construction machinery would likely move about the Proposal site altering the received noise for individual receivers. During any given period, the machinery items to be used would operate at maximum sound power levels for only brief stages. At other times, the machinery would produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any one time. Certain types of construction machinery would be present in the study area for only brief periods during construction. Therefore, noise predictions are considered conservative.

Table 4-2 below presents the number of construction equipment proposed for each construction scenario. The activity sound power level has been calculated based on the two noisiest plant to determine the worst-case noise impacts during construction. The activity noise levels have been used to predict the noise levels that would be expected during construction works.

Table 4-2 Construction scenarios sound power levels, dB(A)

Plant description	Sound power level	Construction scenario			
		CS01	CS02	CS03	CS04
Activity Sound Power Level, dBA		**110**	**122**	**117**	**113**
Concrete agitator truck	109			✓	
Concrete pump truck	108			✓	
Concrete saw (5 mins)[1]	122		✓		
Crane (mobile)	104	✓		✓	
Excavator	107	✓	✓	✓	
Hand tools (electric)	102	✓	✓		✓
Piling rig (bored)	111				✓
Roller	107		✓		
Truck (> 20 tonne)	107	✓			✓
Truck (dump)	117		✓	✓	
Welder	105		✓		✓

1) A 5 dB penalty has been added due to tonal annoyance in accordance with the NPI

4.1.2 Noise modelling inputs

Noise modelling was undertaken using SoundPlan Version 7.4. SoundPlan is a computer program for the calculation, assessment and prognosis of noise exposure. SoundPlan calculates environmental noise propagation according to *ISO 9613-2 'Acoustics – Attenuation of sound during propagation outdoors'.*

The following noise modelling assumptions were made:

- surrounding land was modelled assuming a mix of 50 per cent soft and 50 per cent hard ground with a ground absorption coefficient of 0.5
- atmospheric absorption was based on an average temperature of 10°C and an average humidity of 70%
- atmospheric propagation conditions were modelled with noise enhancing wind conditions for noise propagation (downwind conditions) or an equivalently well-developed moderate ground based temperature inversions
- modelled scenarios take into account the shielding effect from surrounding buildings and structures on and adjacent to the site
- noise sources for each scenario are in some cases modelled at different locations. As such the noise modelling assesses the noise source at multiple locations and takes the maximum L_{Aeq} received noise level.

4.1.3 Construction noise impacts

Predicted noise levels from the construction scenarios outlined in are presented in Appendix C. Construction noise contours for each modelled scenario is provided in Appendix D. A summary of the number of exceedances of the noise management levels for sensitive receivers is presented in Table 4-3 for residential receivers and Table 4-4 for non-residential receivers.

Exceedances of the construction noise management levels are typical for construction projects of this scale. The noise impacts would be limited to the construction period only and would not have lasting effects on the community. The maximum noise impacts would be expected during works at the platform level involving the use of a concrete saw. Impacted receivers would only experience the predicted worst case noise levels when construction works are located closest to the receiver. At other times, the receivers would experience levels below the worst case noise levels predicted as construction activities would move away from the receiver.

Due to the distance between the closest residential receivers and the Proposal site alongside the relatively higher background noise levels, no exceedances of the noise management level are predicted for residential receivers. Furthermore no exceedances of the noise management level for non-residential receivers are predicted. A summary of the results is presented below in for residential receivers and Table 4-4 for non-residential receivers. Noise contours for each construction scenario is presented in Appendix D.

Table 4-3 Residential receivers summary

	Construction scenario			
	CS01	CS02	CS03	CS04
Summary during standard construction hours				
Number of NAML[1] exceedances	0	0	0	0
Highest noise level, dB(A)	43	55	50	50
Worst affected receiver	R036, R110	R036	R036	R037
Summary during outside standard construction hours (day)				
Number of NAML exceedances	0	0	0	0
Highest noise level, dB(A)	43	55	50	50
Worst affected receiver	R036, R110	R036	R036	R037
Summary during outside standard construction hours (evening)				
Number of NAML exceedances	0	0	0	0
Highest noise level, dB(A)	43	55	50	50
Worst affected receiver	R036, R110	R036	R036	R037

1) Noise affected management level

Table 4-4 Non-residential receiver summary

	Construction scenario			
	CS01	CS02	CS03	CS04
Commercial				
Number of NAML exceedances	0	0	0	0
Highest noise level, dB(A)	59	62	59	68
Worst affected receiver	R054	R053	R053	R054
Industrial				
Number of NAML exceedances	0	0	0	0
Highest noise level, dB(A)	58	70	64	65
Worst affected receiver	R049	R048	R049	R049

	Construction scenario			
	CS01	CS02	CS03	CS04
Active recreation				
Number of NAML exceedances	0	0	0	0
Highest noise level, dB(A)	45	58	48	54
Worst affected receiver	R050	R050	R093	R093
Educational institute				
Number of NAML exceedances	0	0	0	0
Highest noise level, dB(A)	40	49	42	47
Worst affected receiver	R120	R088	R088	R088

4.1.4 Sleep disturbance impacts

No night works are scheduled in the construction works program, and as such no sleep disturbance impacts have been assessed. If any night works are to be scheduled during construction a sleep disturbance impacts assessment should be carried out.

4.2 Construction traffic impacts

The RNP recommends that "*any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario."* Construction of the Proposal would generate heavy vehicle movements associated with the transportation of construction machinery, equipment and materials to the site. Light vehicle movements would be associated with employees and smaller deliveries. Access to the construction site would be along Lang Road, Driver Avenue and Errol Flynn Boulevard. The site access route road classifications are as follows:

- Lang Road – Sub Arterial
- Driver Avenue and Errol Flynn Boulevard - Local

To increase road traffic noise by 2 dBA (a doubling in traffic roughly corresponds to a 3 dBA increase) a large increase in traffic volumes would be required along Lang Road. Due to the existing high traffic volumes along Lang Road[1], it is considered unlikely that construction traffic generation along these roads would cause construction traffic noise impacts. Therefore no further assessment is required along this route.

Access to the Proposal site would be along Driver Avenue and Errol Flynn Boulevard. This road is local however and is unlikely to experience construction road traffic noise impacts due to the high existing road traffic volumes.

[1] Based off traffic data from a traffic assessment conducted by GTA consultants, March 2019

4.3 Construction vibration assessment

4.3.1 Assessment methodology

The methodology for the construction vibration assessment included:

- vibration from surface construction plant and equipment was predicted and assessed with consideration to *Assessing Vibration: a Technical Guideline* and German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures*
- where vibration impacts are anticipated, appropriate construction noise and vibration mitigation measures were provided to minimise impacts from each construction phase.

Energy from construction equipment is transmitted into the ground and transformed into vibrations, which attenuates with distance. The magnitude and attenuation of ground vibration is dependent on the following:

- the efficiency of the energy transfer mechanism of the equipment (i.e. impulsive; reciprocating, rolling or rotating equipment)
- the frequency content
- the impact medium stiffness
- the type of wave (surface or body)
- the ground type and topography.

Construction and demolition works have the potential to impact human comfort and / or cause structural damage to buildings. Potential vibration inducing activities identified during construction and demolition works include:

- piling, grinding and cutting will generate impulsive vibration emissions
- bulk earthworks, construction traffic movements and demolition works will be a source of intermittent or continuous vibration.

Safe working buffer distances to comply with the human comfort and cosmetic damage criteria were taken from the CNVG and are provided in Table 4-5.

Table 4-5 Vibration safe working buffer distances, metres

Activity	Human comfort	Structural damage	
		Heritage building/structure	Standard dwellings
Piling rig – Bored	N/A	4 m (nominal)	2 m (nominal)
Piling rig–Hammer	50 m	30 m	15 m
Vibratory roller (>18 tonnes)	100 m	50 m	25 m
Vibratory roller (13-18 tonnes)	100 m	40 m	20 m
Vibratory roller (7-13 tonnes)	100 m	30 m	15 m
Vibratory roller (4-6 tonnes)	40 m	24 m	12 m
Vibratory roller (2-4 tonnes)	20 m	12 m	6 m
Vibratory roller (1-2 tonnes)	15 m	10 m	5 m
Large hydraulic hammer	73 m	44 m	22 m
Jackhammer	Avoid contact with structure	2 m (nominal)	1 m (nominal)

4.3.2 Construction vibration impacts

Structural damage impacts

The CNVG specifies a safe working buffer distance of 15 metres for standard structures (based off a Piling rig – Hammer). No standard structures other than the Proposal itself are within 15 metres of the construction and as such no further assessment for standard structures is required. Mitigation measures may be required depending on the location of the works in relation to the subject building.

The CNVG specifies a safe working buffer distance of 30 metres for standard structures (based off a Piling rig – Hammer). The only identified heritage listed structure is the members and lady's stands inside the Sydney Cricket Ground. This is over 450 metres away from construction activities and as such no further assessment for heritage structures is required.

Human comfort impacts

The CNVG specifies a buffer distance of 50 metres (based off a Piling rig – Hammer) in which residences may experience human comfort impacts. The closest residential receiver is over 240 metres away from construction activities and as such no further assessment for human comfort impacts is required.

5. Operational impact assessment

Noise generating components of the proposed additions and alterations is associated with additional mechanical plant. The mechanical plant to be added include cooling towers, air handling units (AHUs) and fans. All other operational noise impacts from the site (traffic entering/exiting, PA systems, general sporting activities) is expected to have a similar or lower noise emission.

The hours of operation for the Proposal site will be confined to 7:00 am to 9:00 pm, seven days a week. The time period selected for the assessment is the evening time period. This is considered the time of maximum impact (the time during which the difference between the background noise level and source noise level is at its greatest). Therefore if the noise emission from the Proposal is compliant during this time period for residential receivers then it is compliant during all other periods of operation. The following assumptions for the operational noise assessment is as follows:

- 1 Cooling tower located on the Royal Hall of Industries – Sound power level (SWL) 95 dB(A)
- 1 Pitch air conditioning unit located on the Royal Hall of Industries – SWL 95 dB(A)
- An air fan cluster located on the Royal Hall of Industries – SWL 85 dB(A)
- 2 Kitchen exhaust fans located on the Royal Hall of Industries – SWL 80 dB(A)
- 1 Netball court air conditioning unit located on the netball centre building – SWL 80 dB(A)
- An air cooled condenser fan located on Netball centre building – SWL_{max} 85 dB(A)

Locations for mechanical plant is presented in Appendix E.

Noise modelling was undertaken using SoundPlan Version 7.4. SoundPlan is a computer program for the calculation, assessment and prognosis of noise exposure. SoundPlan calculates environmental noise propagation according to *ISO 9613-2 'Acoustics – Attenuation of sound during propagation outdoors'.*

The following noise modelling assumptions were made:

- surrounding land was modelled assuming a mix of 50 per cent soft and 50 per cent hard ground with a ground absorption coefficient of 0.5
- atmospheric absorption was based on an average temperature of 10°C and an average humidity of 70%
- atmospheric propagation conditions were modelled with noise enhancing wind conditions for noise propagation (downwind conditions) or an equivalently well-developed moderate ground based temperature inversions
- modelled scenarios take into account the shielding effect from surrounding buildings and structures on and adjacent to the site
- noise sources for each scenario are in some cases modelled at different locations. As such the noise modelling assesses the noise source at multiple locations and takes the maximum L_{Aeq} received noise level.

Predicted noise levels for the operational noise assessment, both in octave bands and as an overall noise level, is presented in Appendix F and operational noise contours are presented in Appendix G.

GHD recognises that the NPI specifies an assessment for tonal and low frequency noise from operational noise sources. The equipment at this stage has not been selected and as such neither of these assessments has been carried out. When the selection of the mechanical plant has been finalised a tonal and low frequency noise assessment should be conducted.

6. Mitigation measures

6.1 Construction noise and vibration

The following mitigation recommendations are provided in Table 6-1 to reduce the noise levels from the construction activities.

Table 6-1 Construction noise and vibration mitigation measures

Action required	Details
Management measures	
Implementation of any Proposal specific mitigation measures required	In addition to the measures set out in this table, any Proposal specific mitigation measures identified in the EIA documentation (e.g. REF, submissions or representations report) or approval or licence conditions must be implemented.
Implement stakeholder consultation measures	The following strategies may be adopted on a case-by-case basis: • Proposal specific Website • Proposal Infoline • Construction Response Line • Email Distribution List • Social Media • Community Based Forums (if required by approval conditions)
Register of noise and vibration sensitive receivers	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: • Address of receiver • Category of receiver • Contact name and phone number The register may be included as part of the Proposal's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan.
Construction hours and scheduling	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating noise with special audible characteristics and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same Noise Catchment Area (NCA) over any 7-day period, unless otherwise approved by the relevant authority.

Action required	Details
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant Proposal specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors. No excessive revving of plant and vehicle engines. Controlled release of compressed air.
Monitoring	A noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Update Construction Environmental Management Plans	The Construction Environmental Management Plan (CEMP) must be regularly updated to account for changes in noise and vibration management issues and strategies.
Source control measures	
Plan worksites and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Equipment selection	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work, including delivery vehicles.

Action required	Details
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Construction related traffic	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
Prefabrication of materials off-site	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression brakes	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer that complies with the National Transport Commissions 'in-service test procedure' and standard.
Path control measures	
Shield stationary noise sources such as pumps	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436:1981 lists materials suitable for shielding
Shield sensitive receivers from noisy activities	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

6.2 Operational noise

Operational noise levels are expected to comply with the operational noise criteria at the worst affected receiver. Operational noise management measures have been presented in GHD's associated noise management plan (GHD, 2019). Should mechanical plant significantly change throughout the design process, a further acoustic assessment should be undertaken.

7. Conclusion

Noise and vibration impacts for the construction and operational phases of the Proposal have been assessed. Existing noise levels were identified through unattended and attended noise monitoring and used to establish construction and operational noise management levels.

7.1 Construction noise

Construction for the Proposal is expected to commence in late 2020. Construction activities are proposed to be undertaken during and outside standard construction hours and have been developed based on the Proposal construction staging.

The predicted noise levels are not expected to exceed the noise management levels during standard and out-of-hours construction hours.

Traffic noise impacts due to construction are not expected as noise levels along the construction traffic routes are not predicted to significantly increase road traffic noise levels.

7.2 Construction vibration

Safe working distances for vibration activities have been identified for standard and heritage listed structures. No standard or heritage listed structures were identified within these safe working distances, other than the Proposal building itself. Depending on the location and nature of construction activities, vibration mitigation measures may be required to reduce the impacts.

7.3 Operational noise

As stated in Section 6.2 the operation of the proposed additions and alterations is expected to comply with the operational noise criteria at the worst affected receiver. Operational noise management measures have been presented in GHD's noise management plan (GHD, 2019).

8. References

Australian Standards (1997), *AS1055.1:1997 Acoustics – Description and measurement of environmental noise*

Australian Standards (2010), *AS2436:2010 Guide to noise and vibration control on construction, demolition and maintenance sites*

British Standards (

British Standards (1993), *BS7385-2:1993 Evaluation and measurement for vibration in buildings*

DECC (2009), *Interim Construction Noise Guideline*

DECCW (2011), *Road Noise Policy*

EPA (2006), *Assessing Vibration: a technical guideline*

EPA (2017), *Noise Policy for Industry*

EPA (2013), *Rail Infrastructure Noise Guideline*

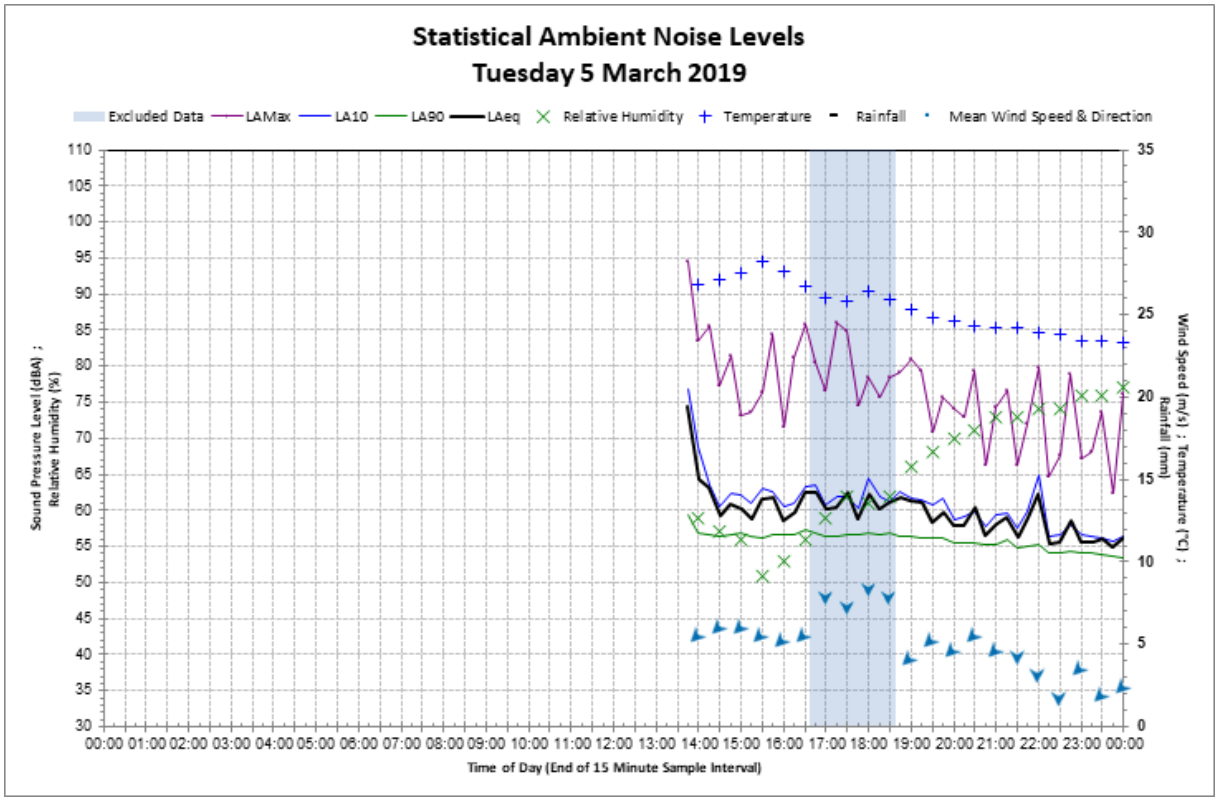
German Standards (1999), *DIN 4155-3 Structural Vibration Part 3: Effects of vibration on structures*

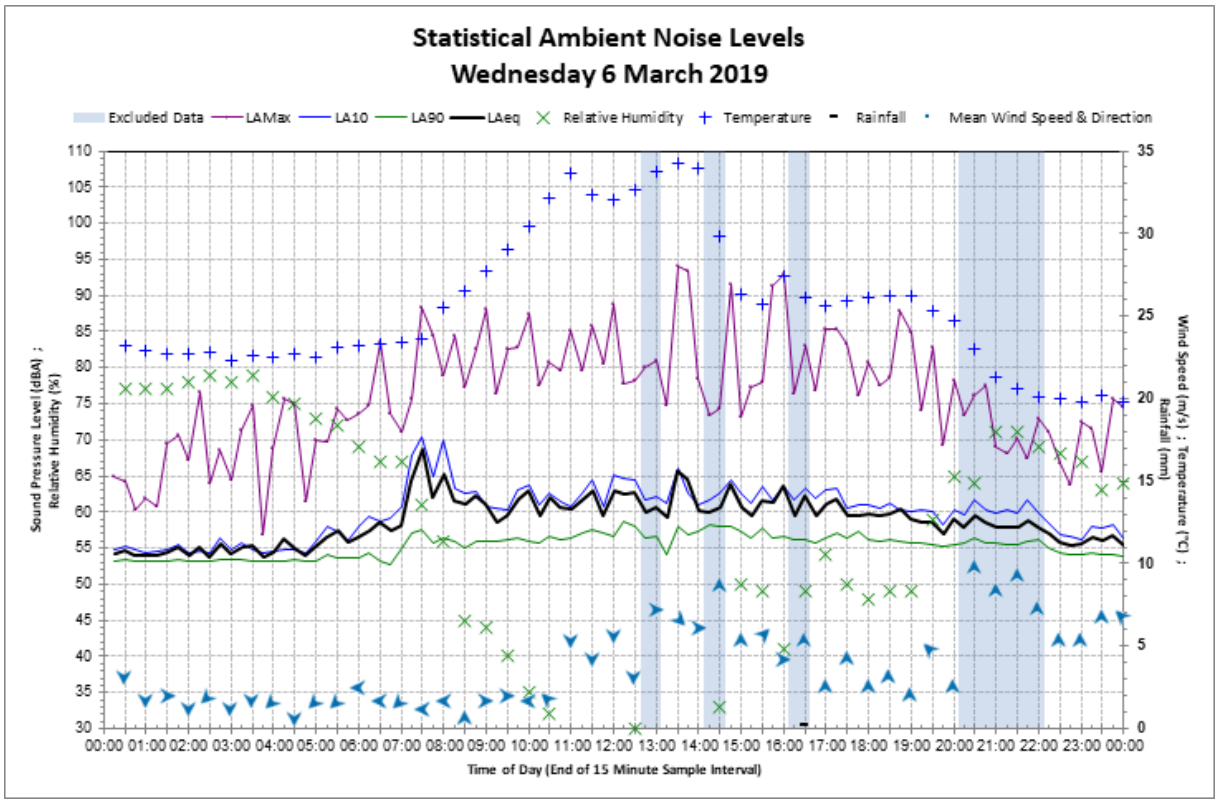
Appendices

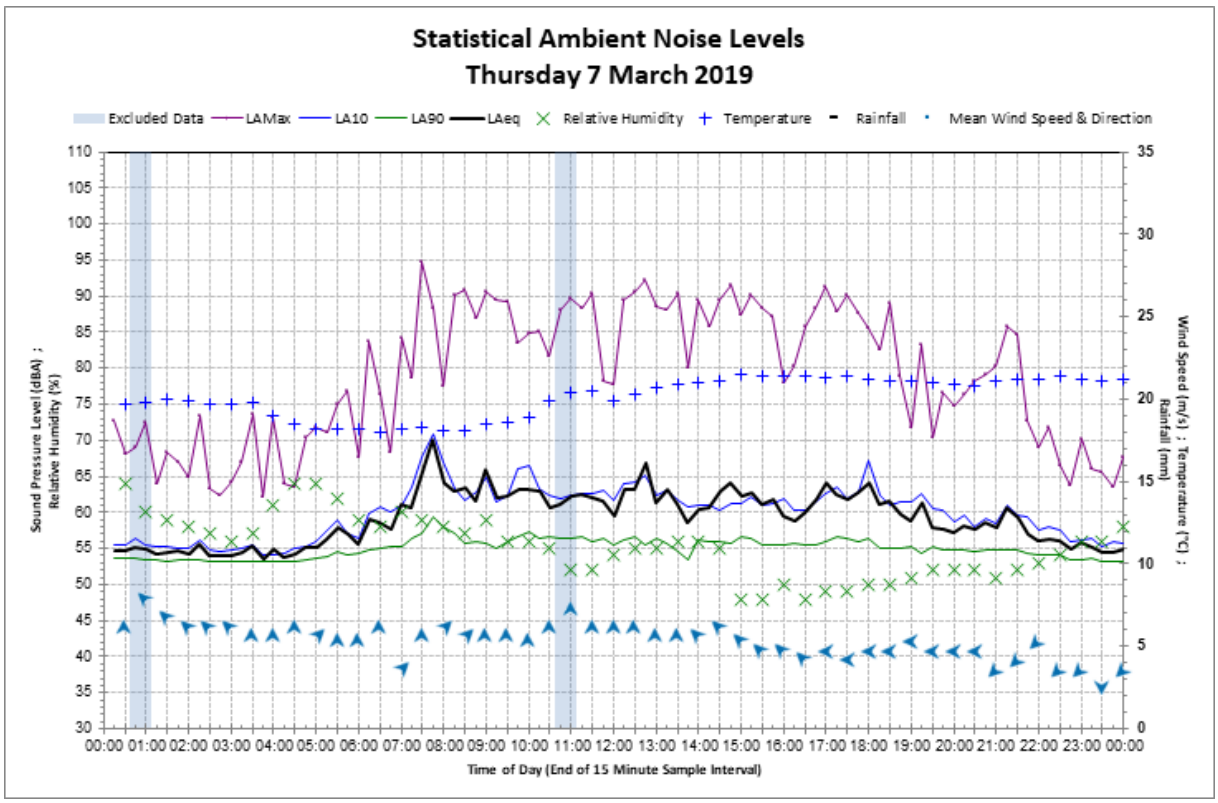
Appendix A - Glossary

Abbreviation	Definition
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.
dB	Decibel is the logarithmic unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics.
dB(A)	Frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at very low and very high frequencies.
dB(C)	Frequency weighting filter used to measure 'C-weighted' sound pressure levels, which is designed to be more response to low frequency noise
DECCW	Department of Environment, Climate Change and Water
EPA	Environment Protection Authority
ICNG	*Interim Construction Noise Guideline* (DECCW, 2009)
L_{Aeq}(period)	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{A90(period)}$	The sound pressure level exceeded for 90% of the measurement period.
L_{Amax}	The maximum sound level recorded during the measurement period.
$L_{Aeq(15hr)}$	The L_{Aeq} noise level for the period 7 am to 10 pm.
$L_{Aeq(9hr)}$	The L_{Aeq} noise level for the period 10 pm to 7 am.
$L_{Aeq(1hr)}$	The highest hourly L_{Aeq} noise level during the day and night periods.
Noise sensitive receiver	An area or place potentially affected by noise including residential dwellings, schools, child care centres, places of worship, health care institutions and active or passive recreational areas.
NPI	*Noise Policy for Industry* (EPA, 2017)
Rating background level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
RNP	*Road Noise Policy* (DECWW, 2011)

Appendix B – Noise monitoring charts



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Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
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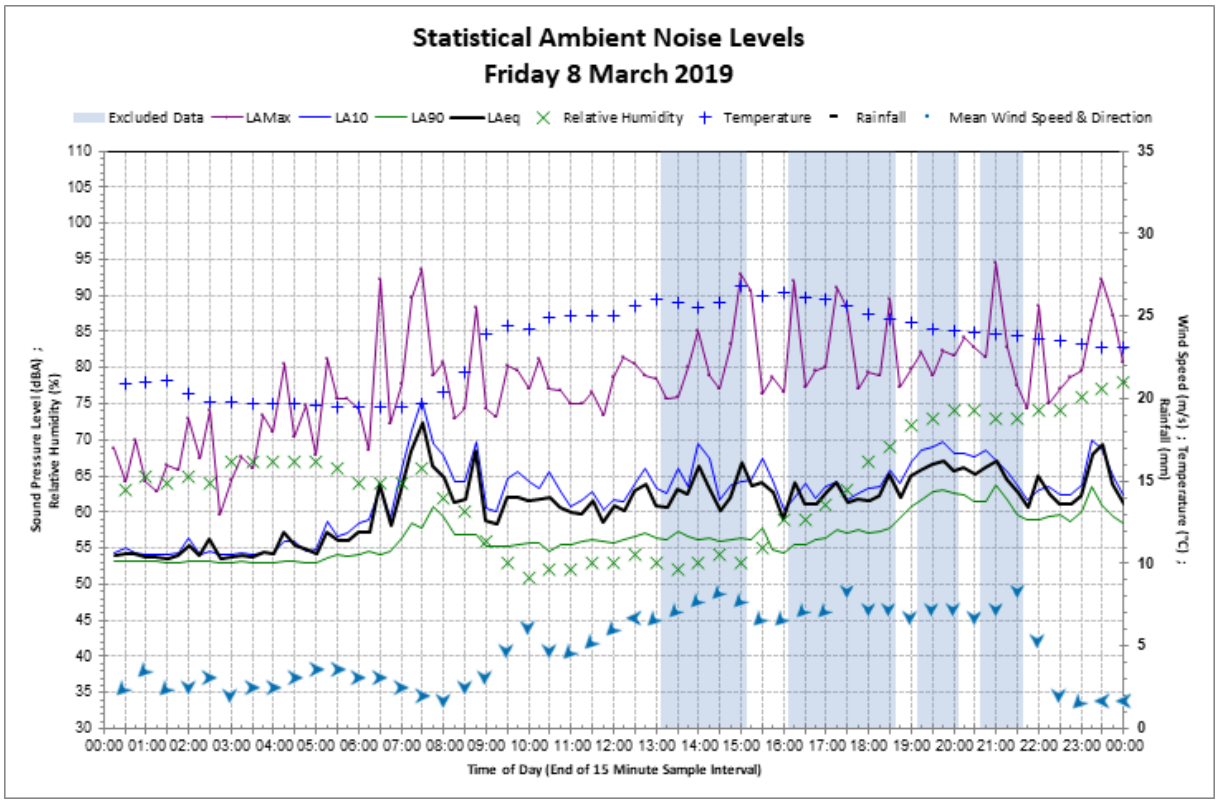
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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LAeq
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Temperature
Rainfall
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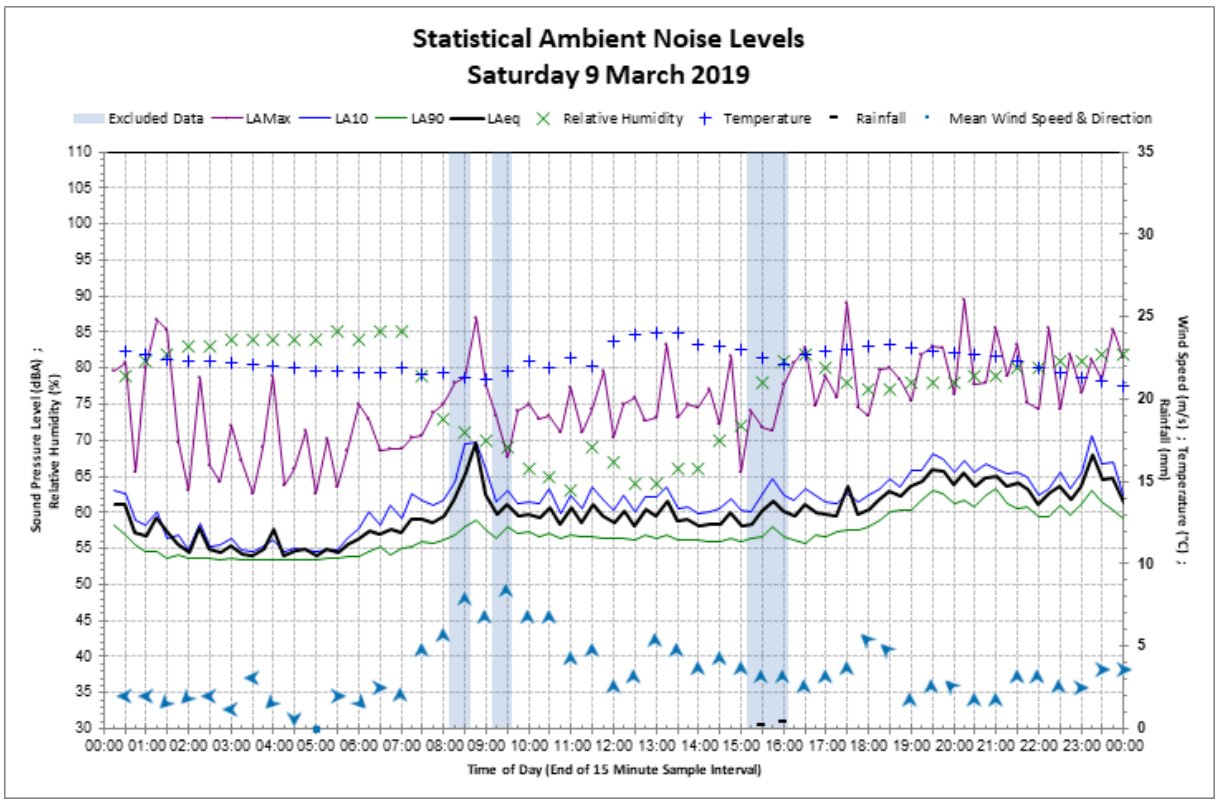
Time of Day (End of 15 Minute Sample Interval)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Temperature
Rainfall
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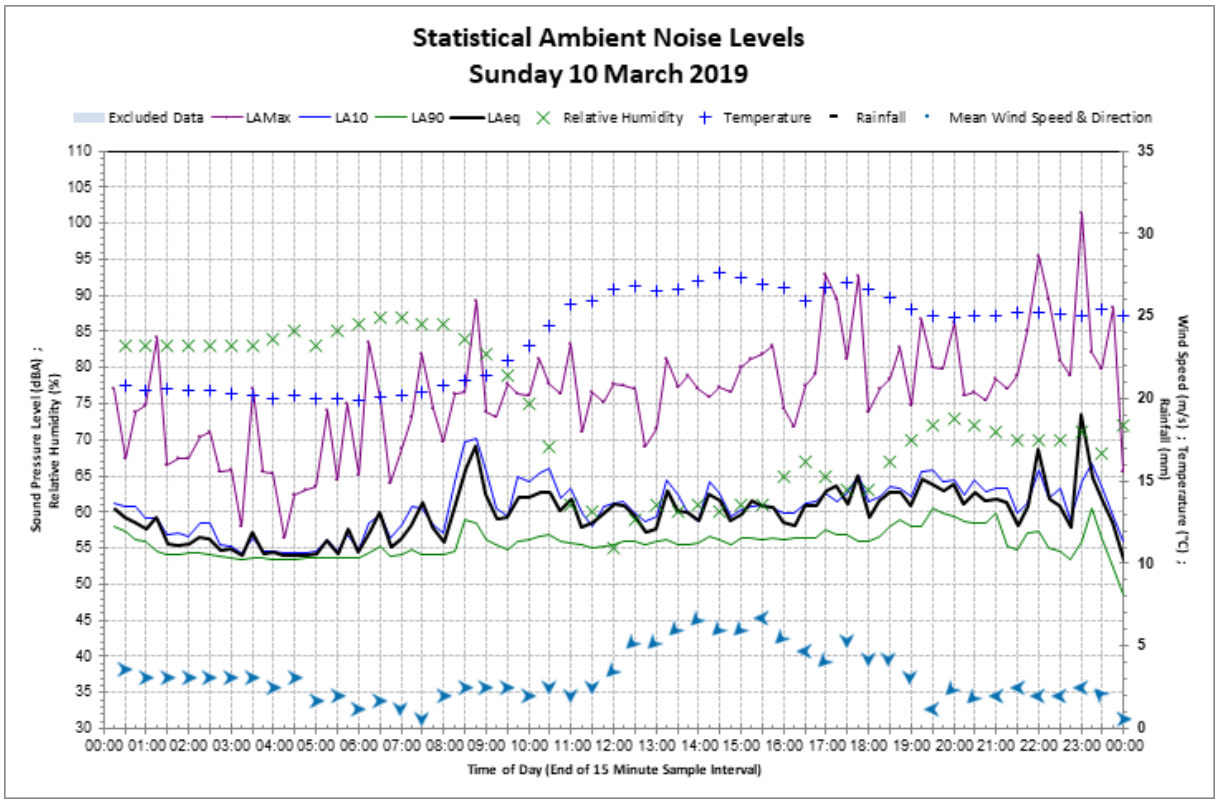
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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Temperature
Rainfall
Mean Wind Speed & Direction
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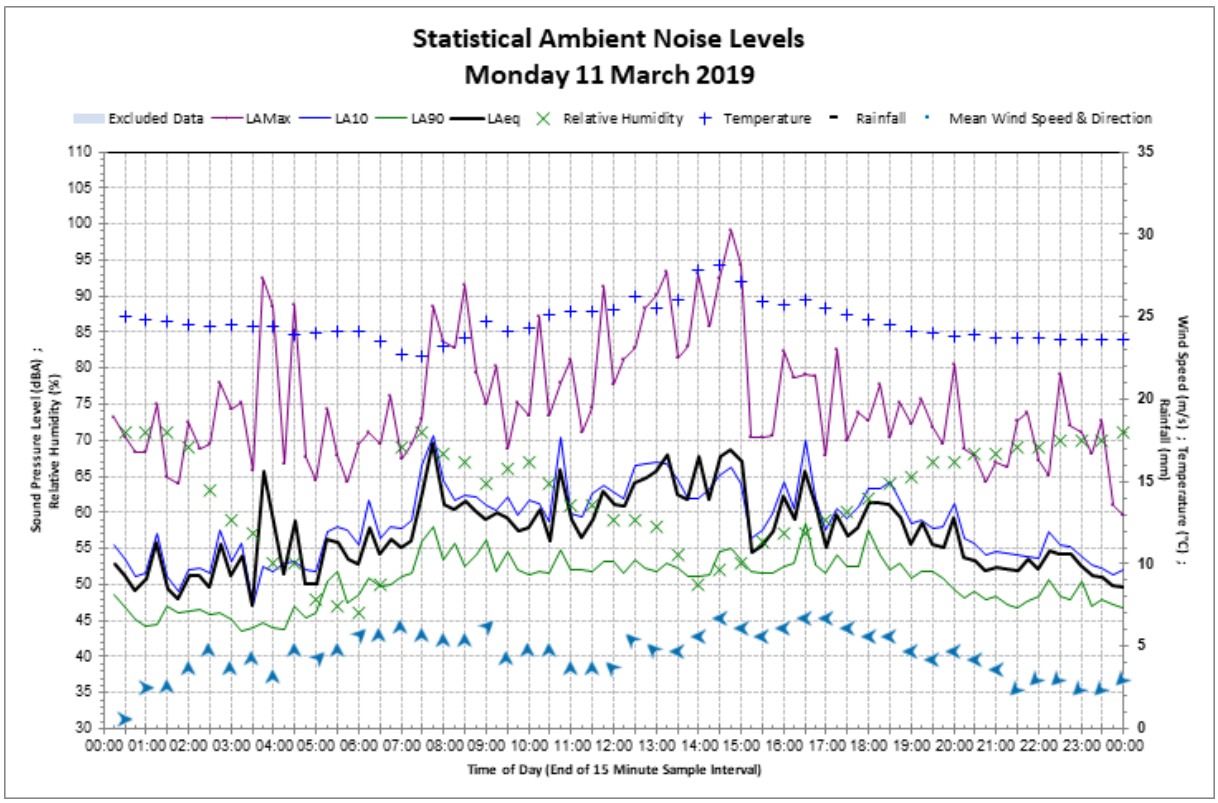
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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Temperature
Rainfall
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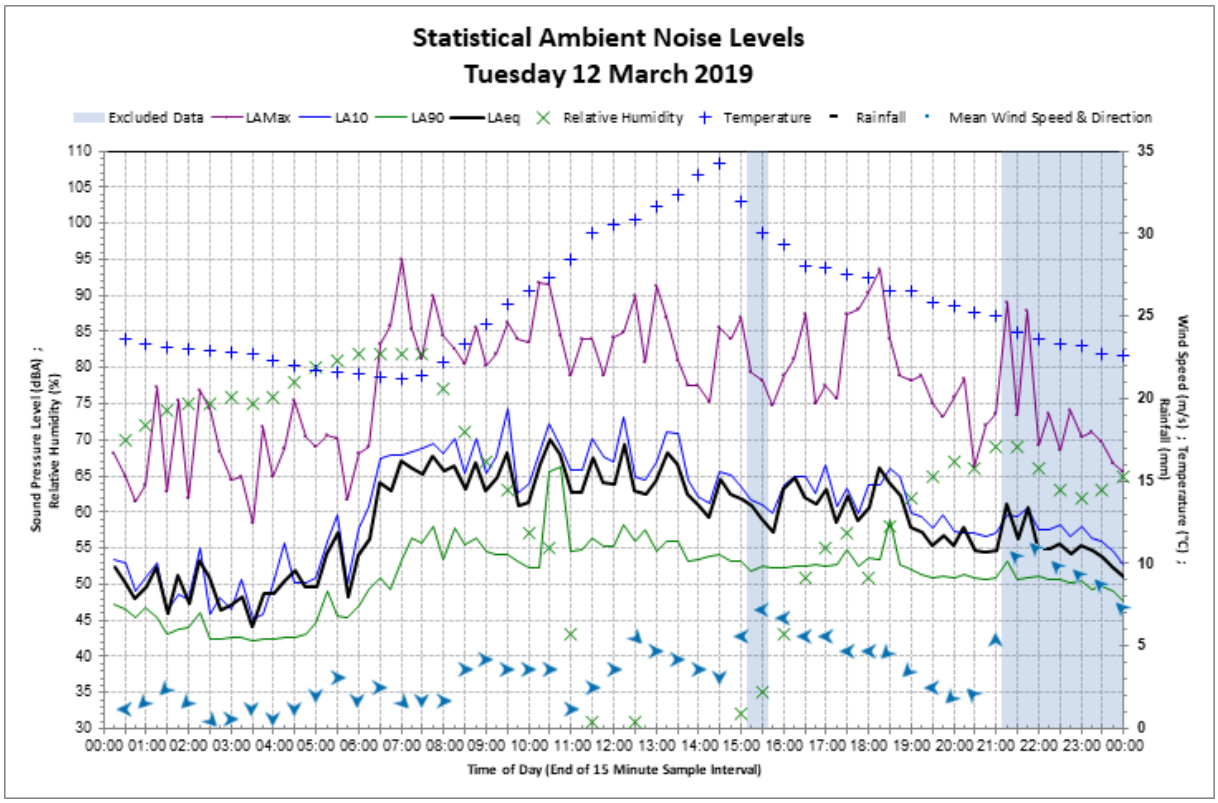
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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LA90
LAeq
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Temperature
Rainfall
Mean Wind Speed & Direction
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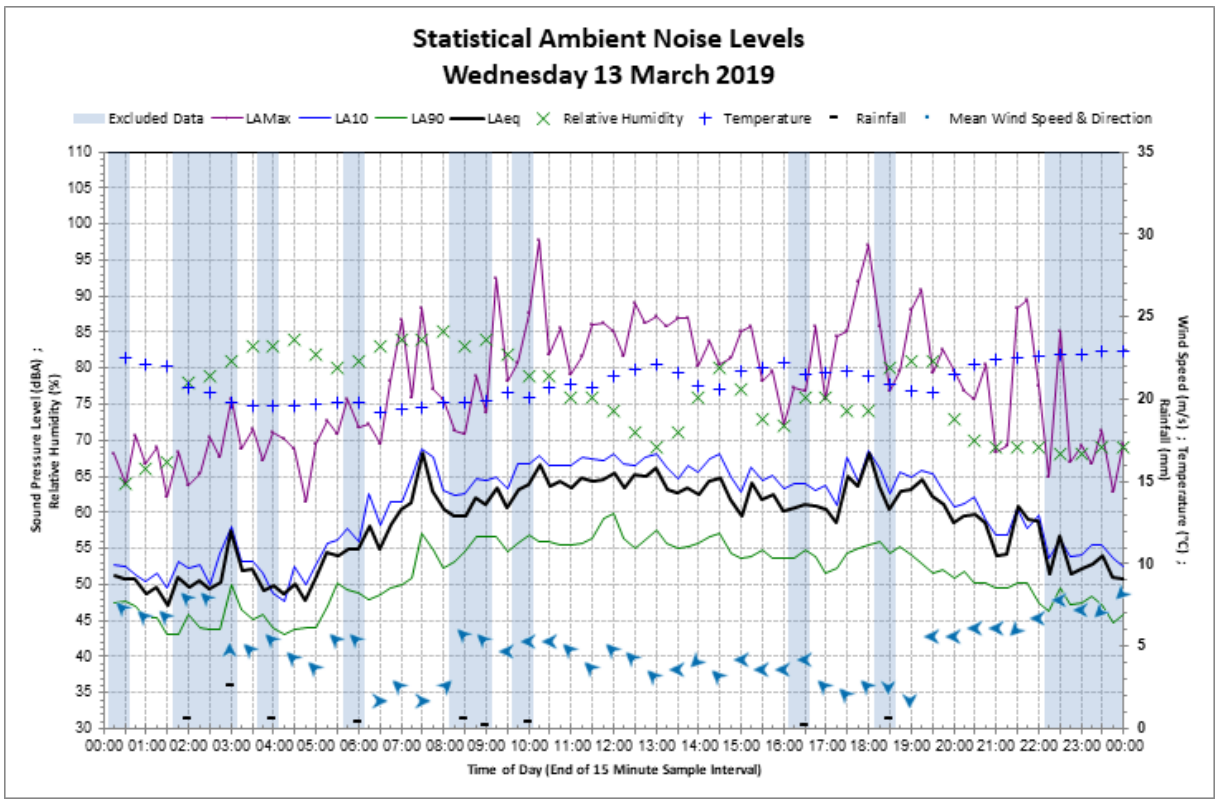
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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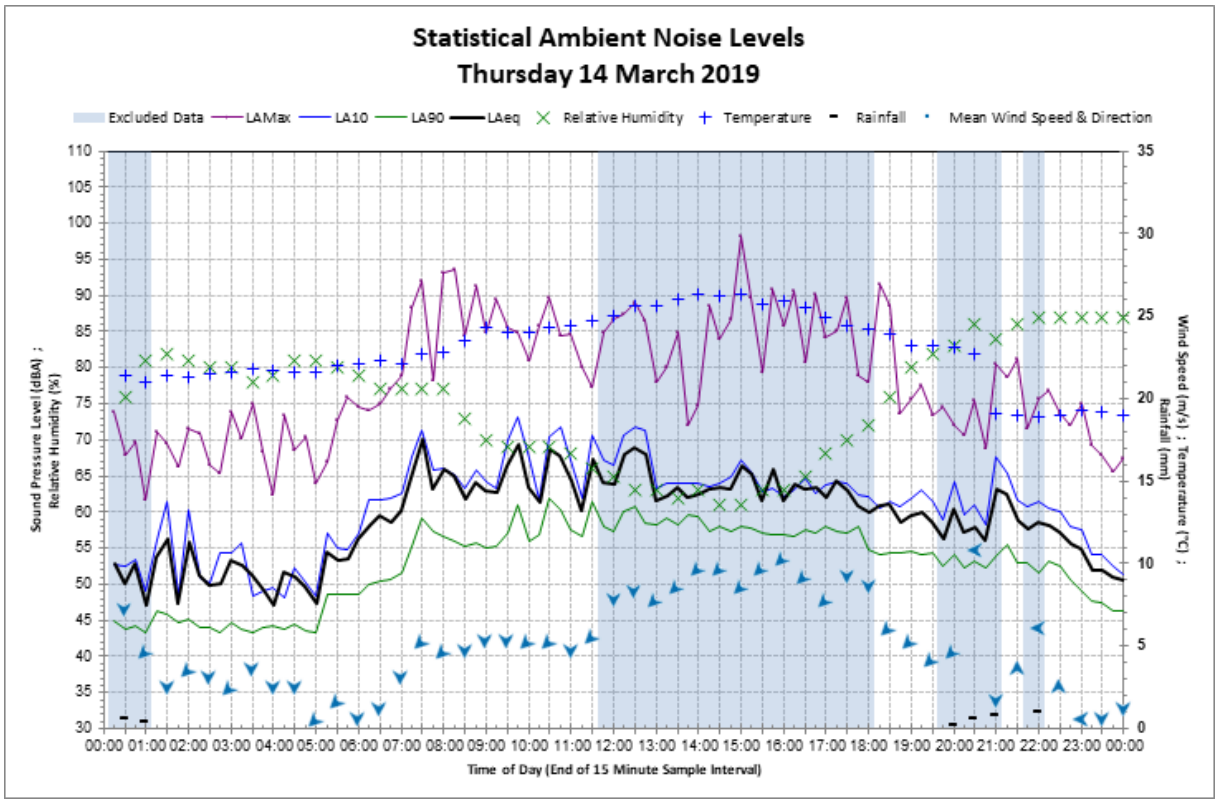
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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LAeq
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Temperature
Rainfall
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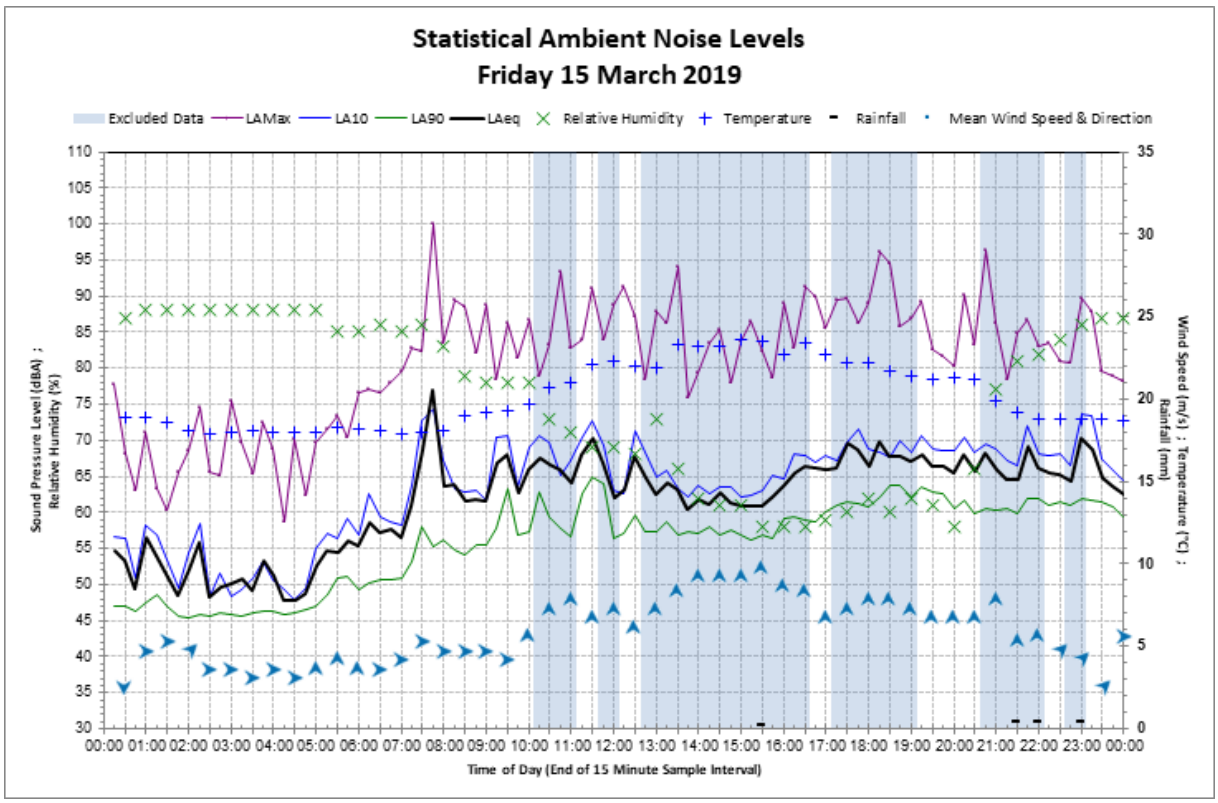
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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LAeq
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Temperature
Rainfall
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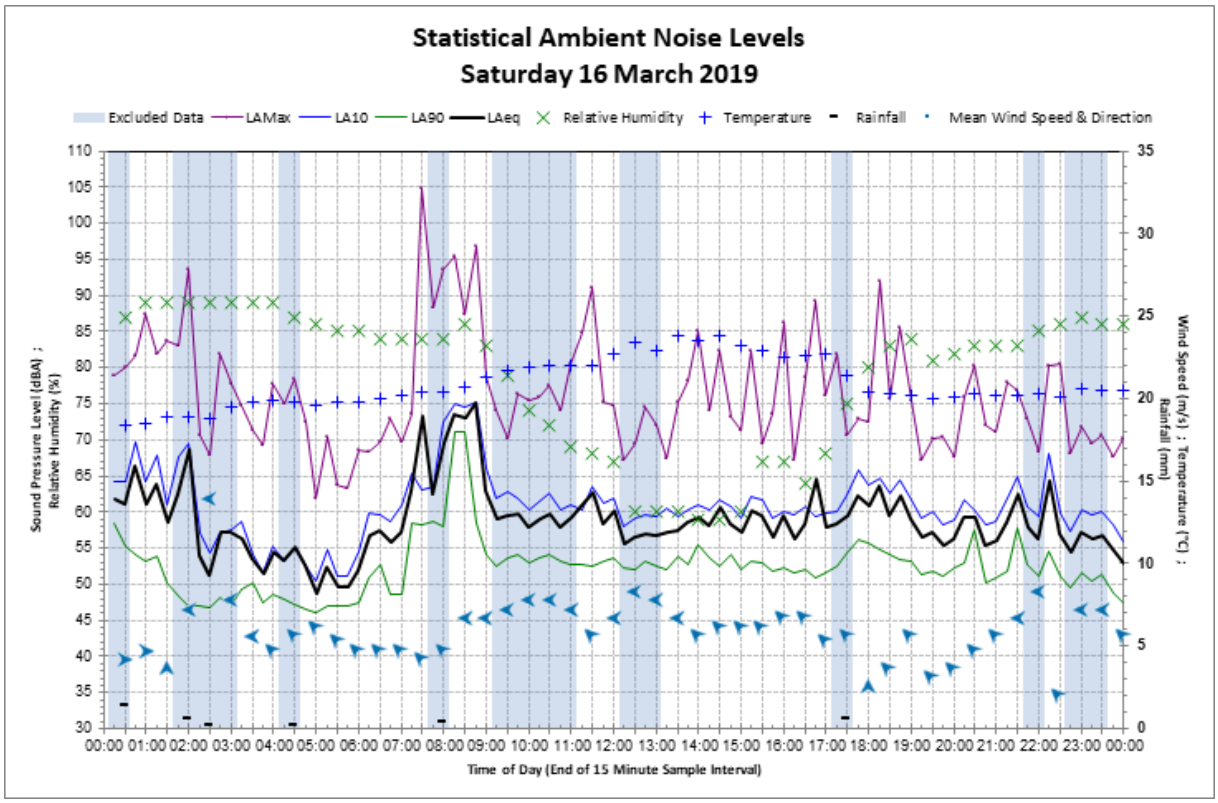
Time of Day (End of 15 Minute Sample Interval)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LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
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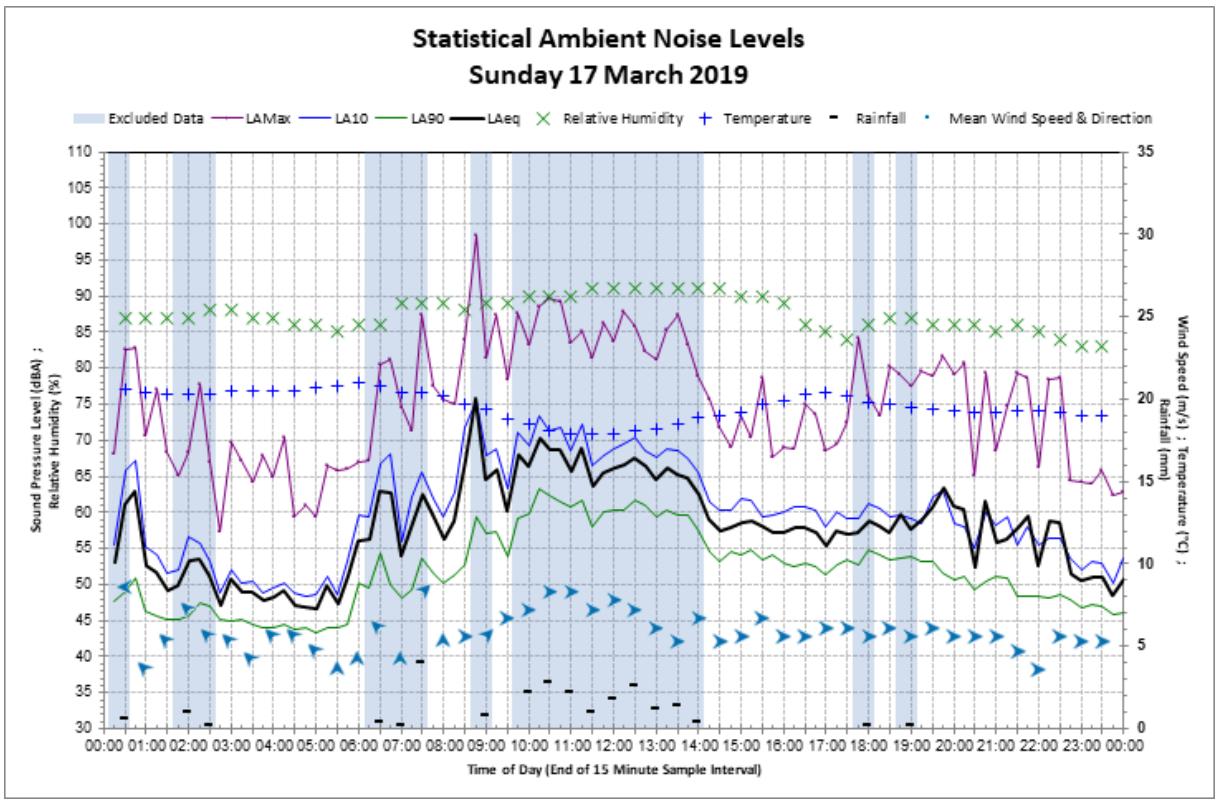
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Sunday 17 March 2019
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

Appendix C – Predicted construction noise levels, dB(A)

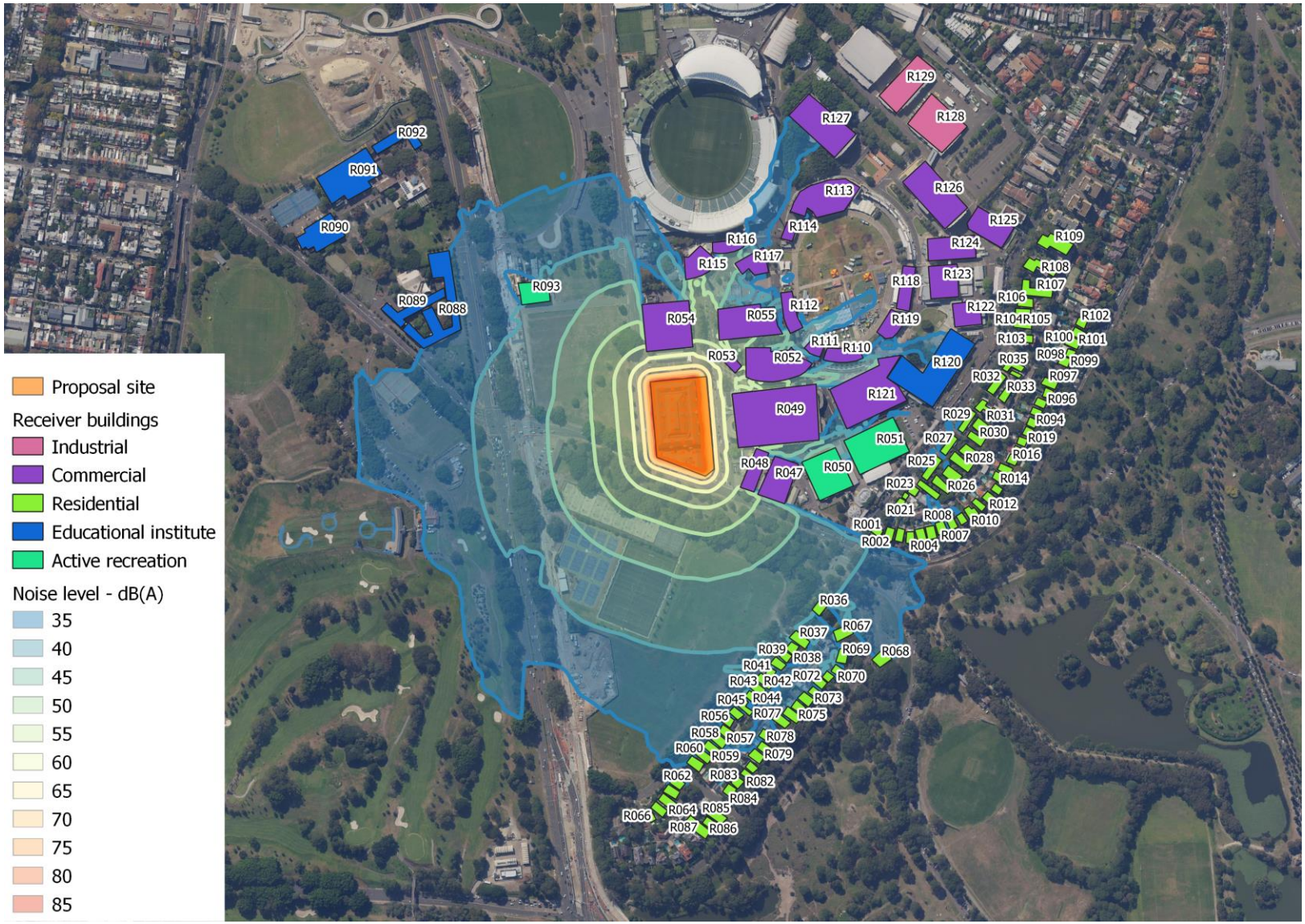
Receiver ID	Receiver type	CS01	CS02	CS03	CS04
R001	Residential	31	46	37	34
R002	Residential	31	47	36	33
R003	Residential	29	41	34	31
R004	Residential	31	42	35	34
R005	Residential	33	44	36	35
R006	Residential	32	44	36	35
R007	Residential	36	48	42	39
R008	Residential	35	47	41	38
R009	Residential	35	46	41	38
R010	Residential	32	45	39	36
R011	Residential	30	42	35	33
R012	Residential	24	36	30	29
R013	Residential	24	36	31	29
R014	Residential	26	37	30	29
R015	Residential	21	33	28	27
R016	Residential	21	33	27	28
R017	Residential	24	36	31	27
R018	Residential	24	36	30	27
R019	Residential	24	36	31	28
R020	Residential	25	37	31	26
R021	Residential	31	42	35	33
R022	Residential	31	44	36	34
R023	Residential	32	45	37	36
R024	Residential	34	46	37	35
R025	Residential	34	46	37	35
R026	Residential	32	44	37	32
R027	Residential	38	50	45	33
R028	Residential	31	44	34	30
R029	Residential	36	48	43	31
R030	Residential	33	46	41	30
R031	Residential	33	45	37	32
R032	Residential	28	44	36	37
R033	Residential	22	35	25	30
R034	Residential	22	31	24	32
R035	Residential	27	36	30	36
R036	Residential	43	55	50	45

Receiver ID	Receiver type	CS01	CS02	CS03	CS04
R037	Residential	43	55	49	50
R038	Residential	42	54	49	50
R039	Residential	42	54	48	50
R040	Residential	42	54	48	49
R041	Residential	41	54	48	49
R042	Residential	41	53	48	49
R043	Residential	41	53	47	49
R044	Residential	40	53	47	48
R045	Residential	40	53	47	48
R046	Residential	40	52	46	48
R047	Commercial	44	61	40	37
R048	Commercial	56	70	64	60
R049	Commercial	58	70	64	65
R050	Active recreation	45	58	43	41
R051	Active recreation	32	44	38	33
R052	Commercial	57	62	57	65
R053	Commercial	59	62	59	67
R054	Commercial	59	62	57	68
R055	Commercial	54	59	54	63
R056	Residential	40	52	46	48
R057	Residential	39	51	46	46
R058	Residential	39	51	46	46
R059	Residential	39	51	45	46
R060	Residential	38	51	45	45
R061	Residential	38	50	45	45
R062	Residential	37	49	43	44
R063	Residential	36	48	42	44
R064	Residential	35	47	41	43
R065	Residential	34	46	41	43
R066	Residential	34	46	41	43
R067	Residential	39	52	41	42
R068	Residential	39	52	46	44
R069	Residential	39	51	46	44
R070	Residential	41	54	47	47
R071	Residential	40	52	46	48
R072	Residential	40	52	46	48

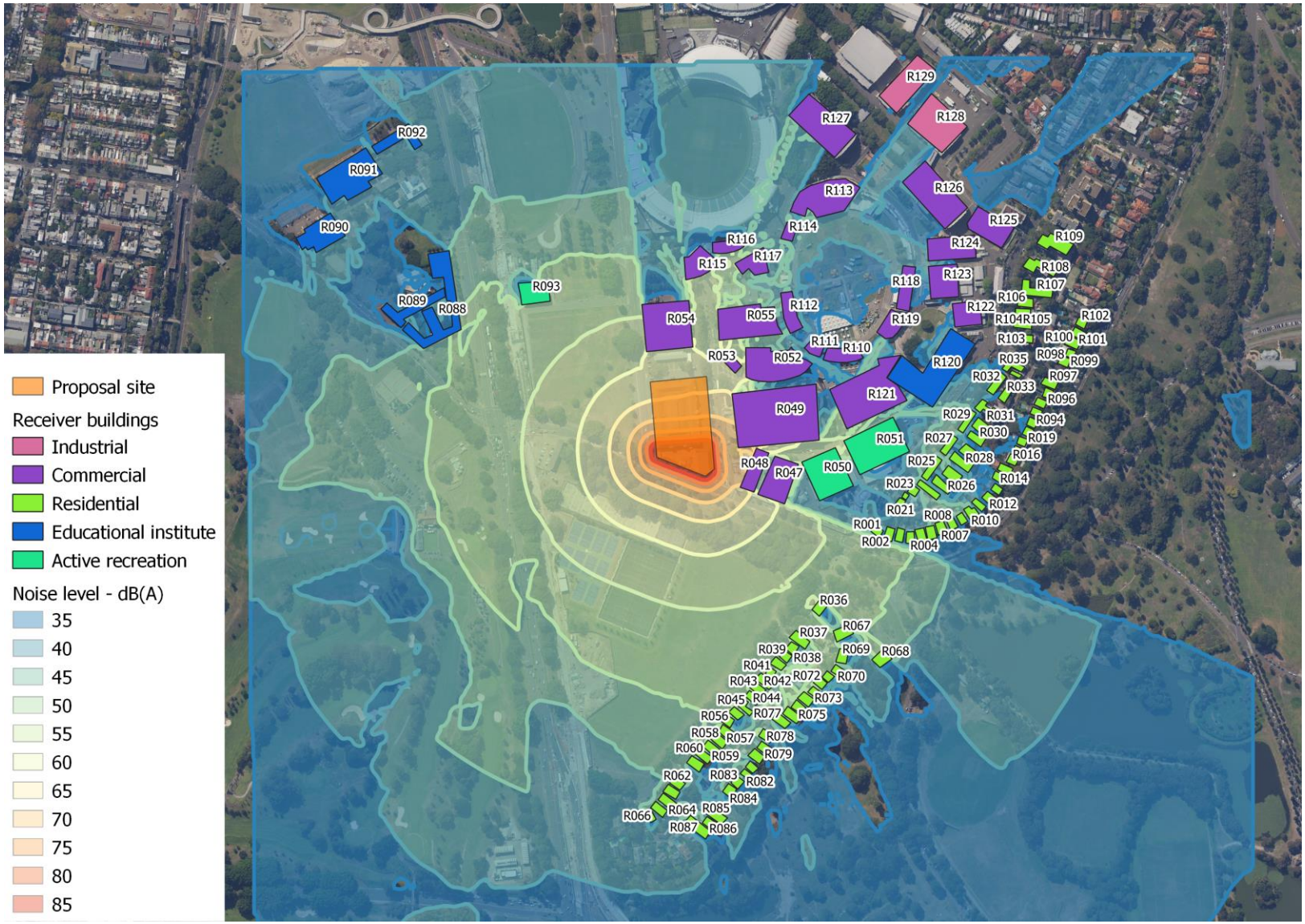
Receiver ID	Receiver type	CS01	CS02	CS03	CS04
R073	Residential	39	51	46	48
R074	Residential	40	52	46	48
R075	Residential	39	51	46	47
R076	Residential	36	48	42	43
R077	Residential	38	50	44	46
R078	Residential	38	50	44	46
R079	Residential	35	47	40	42
R080	Residential	35	47	41	44
R081	Residential	34	46	40	43
R082	Residential	34	46	40	43
R083	Residential	34	47	41	43
R084	Residential	34	46	40	42
R085	Residential	33	44	39	41
R086	Residential	34	46	39	41
R087	Residential	36	48	40	43
R088	Educational institute	37	49	42	47
R089	Educational institute	29	41	35	39
R090	Educational institute	35	44	39	44
R091	Educational institute	36	45	40	46
R092	Educational institute	33	45	38	43
R093	Active recreation	44	54	48	54
R094	Residential	19	31	25	26
R095	Residential	22	30	24	31
R096	Residential	24	30	23	31
R097	Residential	25	35	24	34
R098	Residential	25	32	25	33
R099	Residential	27	32	27	33
R100	Residential	28	32	28	32
R101	Residential	19	31	23	26
R102	Residential	28	28	23	32
R103	Residential	28	33	28	32
R104	Residential	28	30	23	32
R105	Residential	22	30	24	32
R106	Residential	23	31	24	31
R107	Residential	29	32	24	34
R108	Residential	31	34	26	36

Receiver ID	Receiver type	CS01	CS02	CS03	CS04
R109	Residential	30	34	26	39
R110	Commercial	43	42	42	54
R111	Commercial	44	36	31	47
R112	Commercial	43	46	41	53
R113	Commercial	35	47	39	42
R114	Commercial	34	45	39	42
R115	Commercial	50	58	52	59
R116	Commercial	46	54	49	57
R117	Commercial	46	53	47	57
R118	Commercial	32	44	31	37
R119	Commercial	40	43	40	46
R120	Educational institute	40	43	40	46
R121	Commercial	46	51	45	54
R122	Commercial	33	39	34	36
R123	Commercial	29	36	28	40
R124	Commercial	34	43	25	41
R125	Commercial	31	35	23	34
R126	Commercial	33	38	27	42
R127	Commercial	35	45	39	42
R128	Industrial	32	43	27	43
R129	Industrial	24	36	26	31

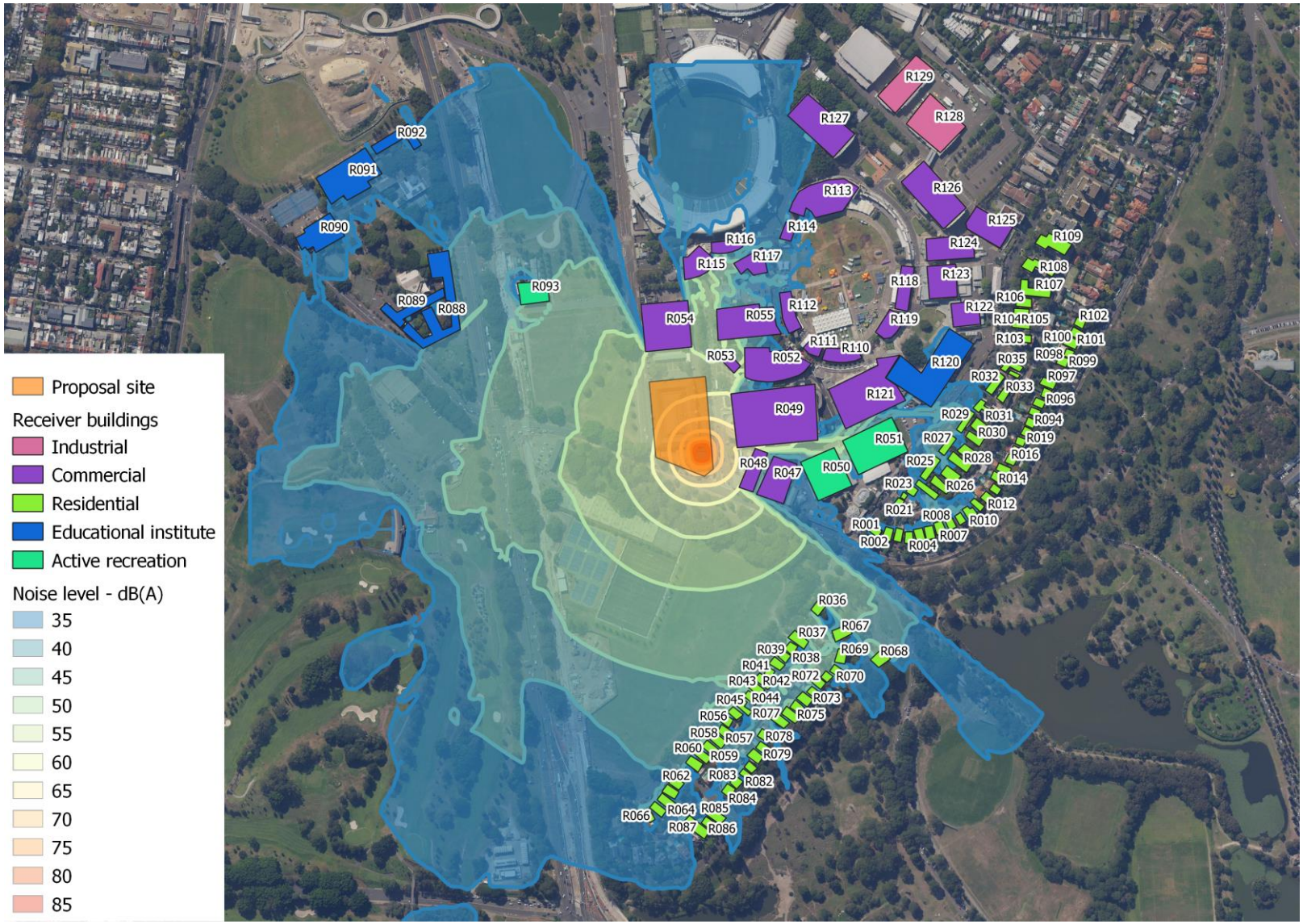
Appendix D – Predicted construction noise contours



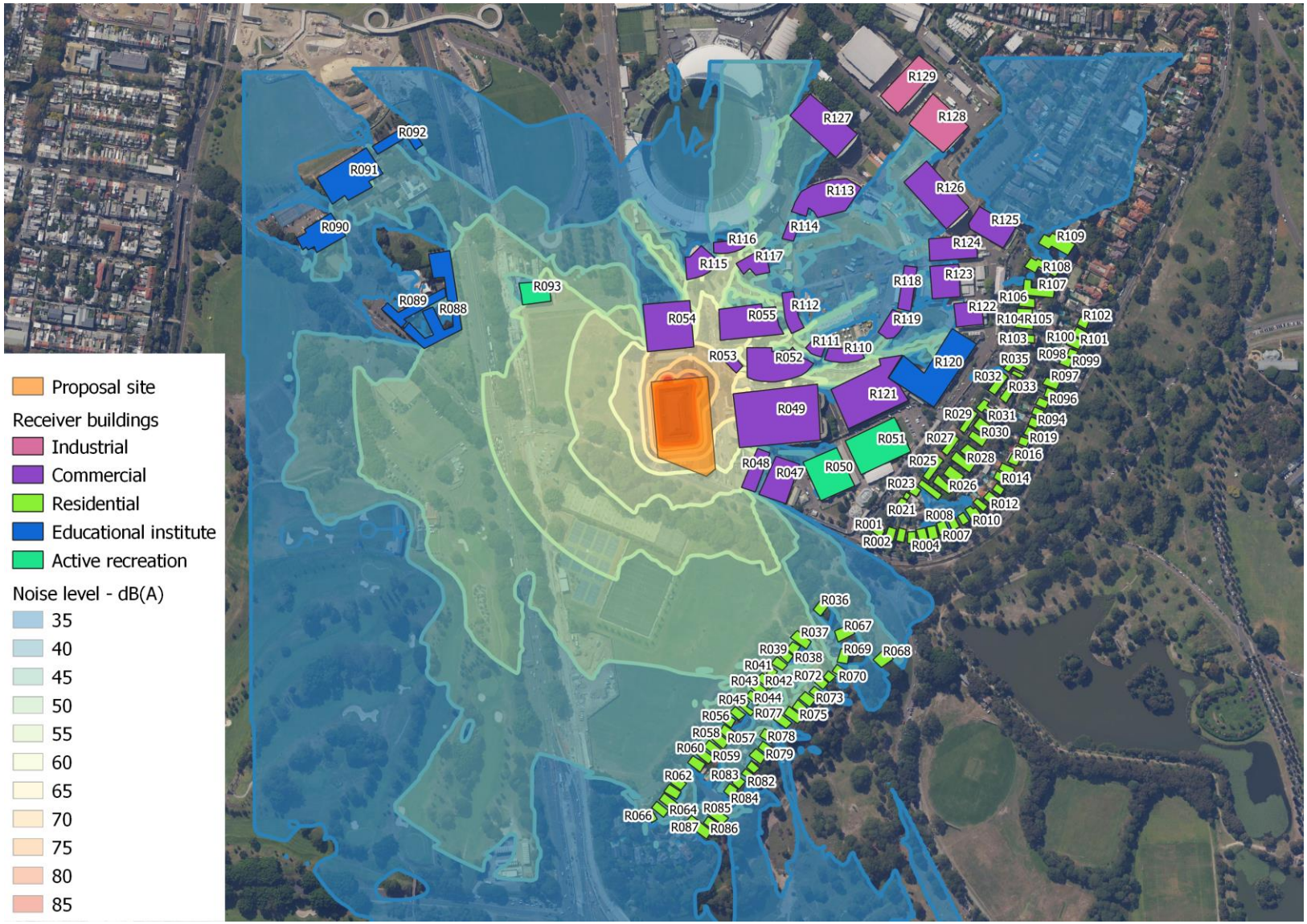
Appendix D 1 Predicted construction noise contours – CS01



Appendix D 2 Predicted construction noise contours – CS02

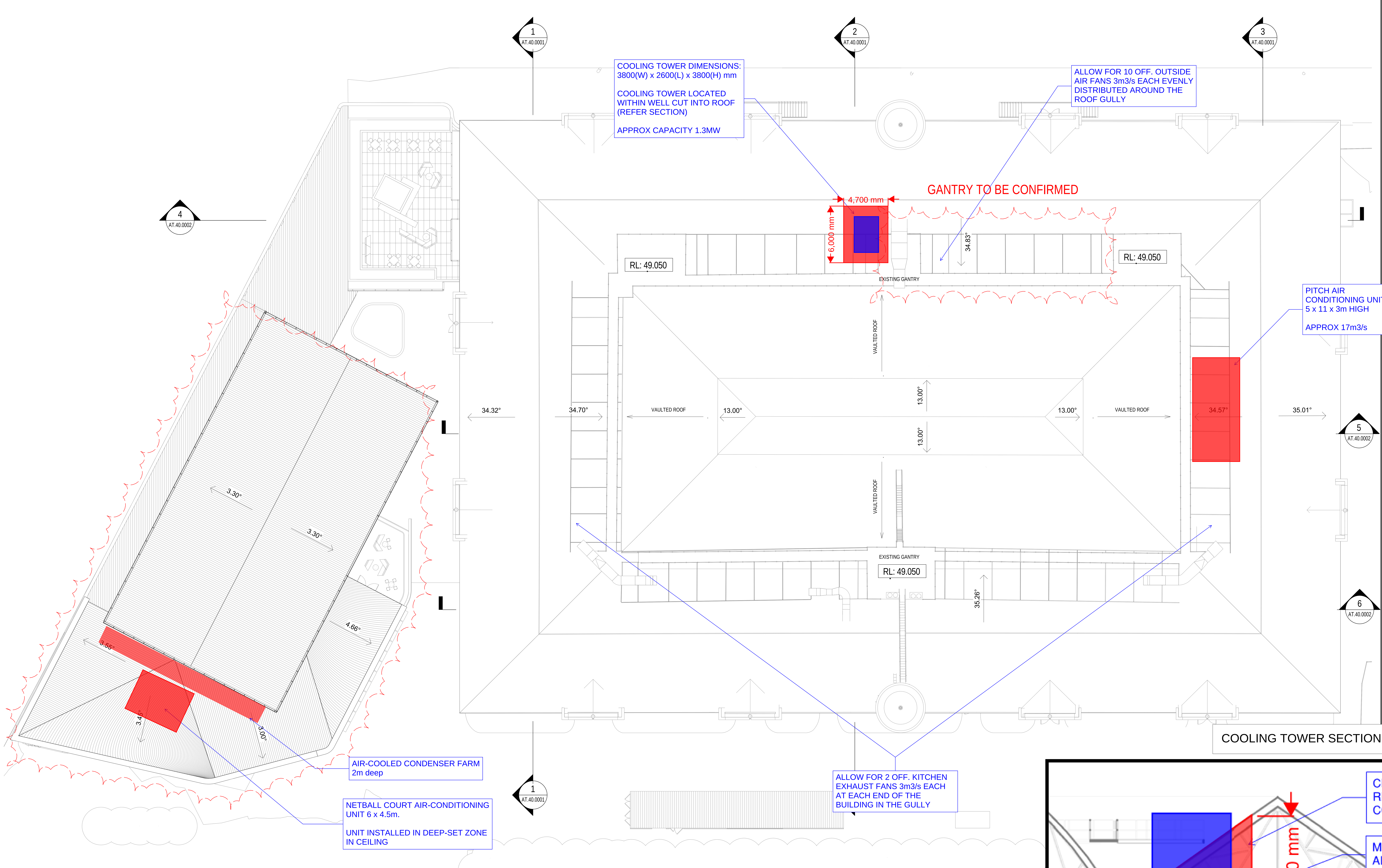


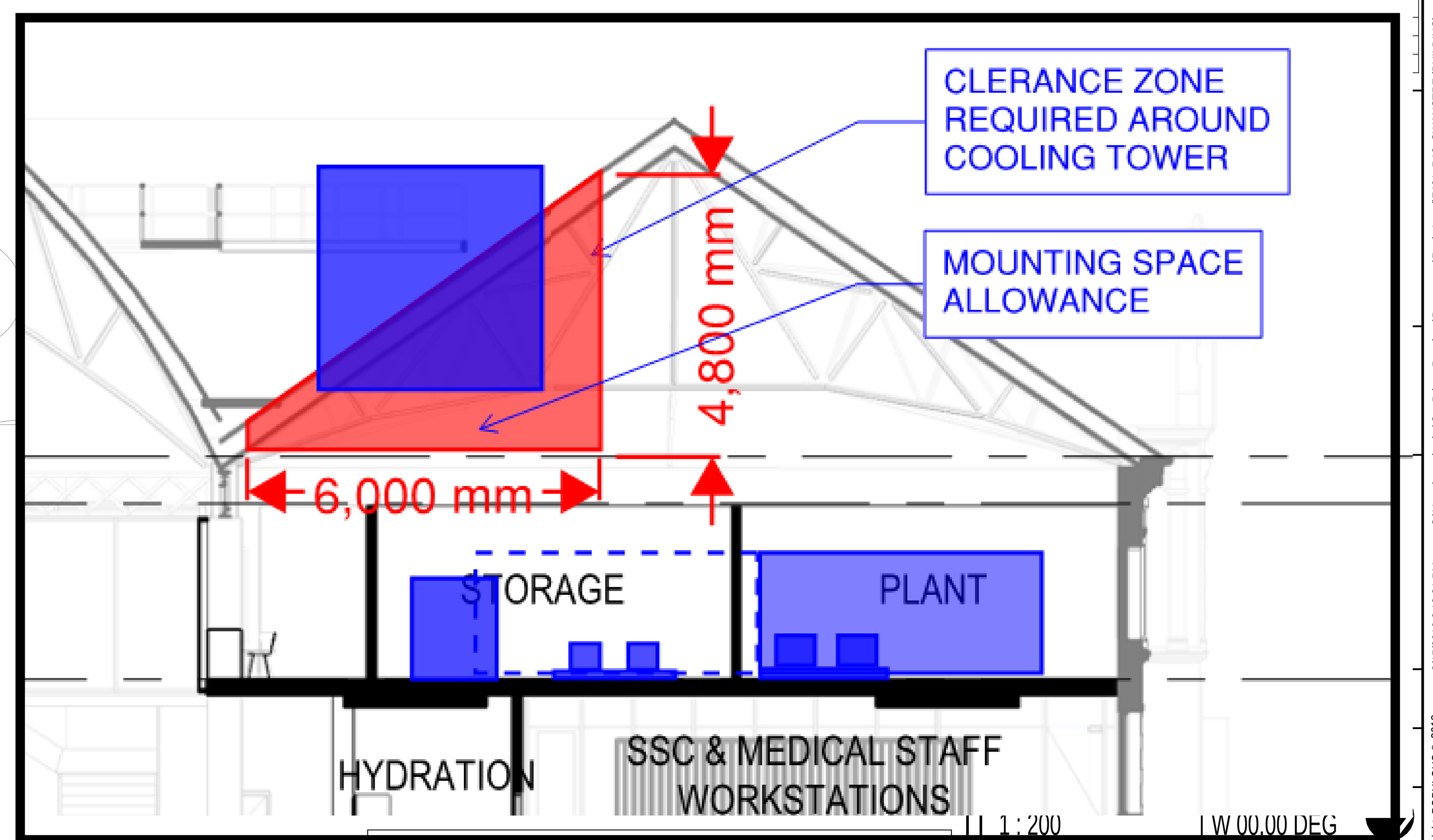
Appendix D 3 Predicted construction noise contours – CS03



Appendix D 4 Predicted construction noise contours – CS04

Appendix E – Mechanical plant detail





SYDNEY SWANS MECHANICAL ROOF PLANT
AURECON
505355

05/04/2019

REFERENCE MAP

1:200

CLIENT: SYDNEY SWANS

PROJECT MANAGER: APP

STRUCTURAL, CIVIL ENGINEER: TTW Taylor Thomson Whitting

SERVICES ENGINEER: aurecon

COST CONSULTANT: RLB Rider Levett Bucknall

NOTES

DISCLAIMER

USE FIGURED DIMENSIONS ONLY DO NOT SCALE FROM DRAWING CHECK & VERIFY ALL DIMENSIONS ON SITE BEFORE FABRICATION OR SET OUT.

This drawing is diagrammatic and shows general arrangements. Any information involving measurement of the works shall be taken from documented dimensions on the architectural and structural drawings, workshop drawings by others and conditions on site. The works shall comply with the contract conditions and Statutory Regulations.

REV	DESCRIPTION	DATE
A	FOR COORDINATION	15.03.2019

FOR INFORMATION

PHASE	DRAWING NUMBER	REVISION
SD	AT.20.0500	A

ORIGINAL SHEET SIZE A1 - 841mm x 594mm

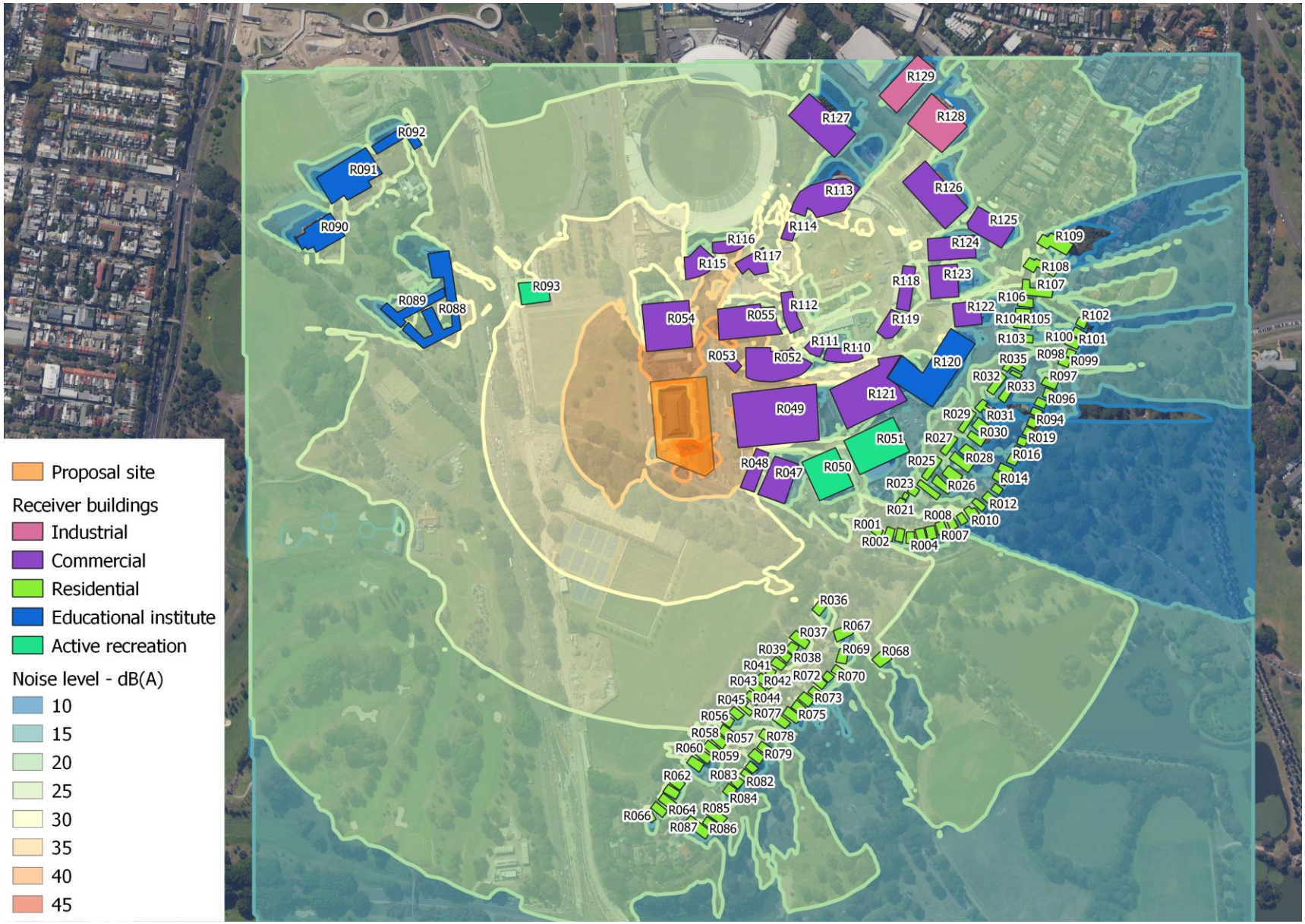
Appendix F – Predicted operational noise levels, dB(A)

Receiver building	Receiver type	Predicted noise level LA90 in octave bands [Hz], dB(A)₁									External noise criteria	Received external noise level	Compliance
		31.5	63	125	250	500	1000	2000	4000	8000			
Octave band criteria		25	36	44	50	52	52	49	43	33			
R001	Residential	8	21	21	26	26	24	20	10	-23	43	31	Yes
R002	Residential	5	18	18	24	25	23	19	10	-25	43	30	Yes
R003	Residential	5	18	18	22	22	21	17	7	-28	43	28	Yes
R004	Residential	5	19	20	24	24	23	19	8	-28	43	30	Yes
R005	Residential	5	20	20	25	24	23	19	9	-28	43	30	Yes
R006	Residential	5	20	20	25	24	23	19	8	-29	43	30	Yes
R007	Residential	6	19	19	24	24	22	18	7	-31	43	30	Yes
R008	Residential	7	20	20	24	25	23	18	6	-33	43	30	Yes
R009	Residential	7	20	20	24	24	22	16	3	-36	43	29	Yes
R010	Residential	4	18	17	20	18	16	13	1	-38	43	25	Yes
R011	Residential	3	17	17	20	18	14	9	-5	-47	43	25	Yes
R012	Residential	4	16	14	17	14	11	4	-10	-54	43	22	Yes
R013	Residential	2	14	14	17	15	12	5	-10	-56	43	22	Yes
R014	Residential	2	15	14	17	15	13	5	-10	-56	43	22	Yes
R015	Residential	2	13	11	13	11	7	8	-7	-54	43	19	Yes
R016	Residential	2	13	12	14	13	9	4	-8	-55	43	20	Yes
R017	Residential	2	14	12	14	13	11	4	-1	-52	43	20	Yes
R018	Residential	2	14	12	14	11	8	1	-1	-54	43	19	Yes
R019	Residential	2	14	12	14	11	9	2	-10	-59	43	19	Yes
R020	Residential	-4	7	10	13	10	7	2	-13	-60	43	17	Yes
R021	Residential	5	19	19	22	20	17	11	1	-32	43	27	Yes
R022	Residential	5	17	19	22	20	18	12	1	-32	43	26	Yes
R023	Residential	4	19	18	22	20	19	13	2	-32	43	27	Yes
R024	Residential	7	19	18	22	21	20	15	4	-31	43	27	Yes
R025	Residential	5	17	17	21	20	18	13	2	-34	43	26	Yes
R026	Residential	4	16	15	18	16	17	11	-4	-45	43	24	Yes
R027	Residential	7	19	19	23	23	20	15	4	-32	43	28	Yes
R028	Residential	5	17	16	20	17	17	11	-3	-46	43	25	Yes
R029	Residential	4	18	18	23	21	19	13	1	-37	43	27	Yes
R030	Residential	6	18	18	21	20	17	11	-1	-41	43	26	Yes
R031	Residential	5	17	17	20	18	17	10	-5	-50	43	25	Yes
R032	Residential	2	15	17	21	20	19	15	0	-49	43	26	Yes
R033	Residential	1	12	14	16	14	12	4	-11	-57	43	21	Yes
R034	Residential	1	12	11	14	16	14	7	-9	-57	43	21	Yes
R035	Residential	2	15	15	21	20	18	12	-3	-50	43	26	Yes
R036	Residential	9	22	23	28	29	28	25	16	-14	43	34	Yes
R037	Residential	8	21	22	28	28	28	24	15	-16	43	34	Yes
R038	Residential	8	21	22	27	28	28	24	14	-18	43	34	Yes
R039	Residential	8	21	22	27	28	27	24	14	-19	43	33	Yes
R040	Residential	5	18	22	27	28	27	23	14	-19	43	33	Yes
R041	Residential	7	20	22	27	27	27	23	13	-21	43	33	Yes
R042	Residential	5	21	22	27	27	27	23	13	-21	43	33	Yes
R043	Residential	5	20	21	27	27	26	22	12	-23	43	33	Yes
R044	Residential	5	18	21	26	27	26	22	12	-24	43	32	Yes
R045	Residential	7	20	21	26	27	26	22	11	-25	43	32	Yes
R046	Residential	7	20	21	26	26	26	22	11	-26	43	32	Yes
R047	Commercial	-	-	-	-	-	-	-	-	-	60	29	Yes
R048	Commercial	-	-	-	-	-	-	-	-	-	60	42	Yes
R049	Commercial	-	-	-	-	-	-	-	-	-	60	44	Yes
R050	Active Recreational	-	-	-	-	-	-	-	-	-	50	26	Yes
R051	Active Recreational	-	-	-	-	-	-	-	-	-	50	26	Yes
R052	Commercial	-	-	-	-	-	-	-	-	-	60	42	Yes
R053	Commercial	-	-	-	-	-	-	-	-	-	60	41	Yes
R054	Commercial	-	-	-	-	-	-	-	-	-	60	46	Yes
R055	Commercial	-	-	-	-	-	-	-	-	-	60	42	Yes
R056	Residential	4	17	20	26	26	26	21	10	-28	43	32	Yes
R057	Residential	4	17	20	25	26	25	21	10	-30	43	31	Yes
R058	Residential	4	17	20	25	26	26	21	9	-31	43	31	Yes
R059	Residential	6	19	20	25	25	25	20	9	-33	43	31	Yes
R060	Residential	6	19	20	25	25	25	20	8	-34	43	31	Yes
R061	Residential	3	16	19	25	25	24	20	8	-36	43	30	Yes
R062	Residential	3	16	19	24	24	24	19	7	-39	43	30	Yes
R063	Residential	3	16	18	24	24	24	19	6	-41	43	30	Yes
R064	Residential	3	16	18	24	24	23	18	5	-43	43	29	Yes
R065	Residential	3	16	17	24	24	23	18	4	-44	43	29	Yes
R066	Residential	3	18	18	23	24	23	18	4	-45	43	29	Yes
R067	Residential	8	21	22	27	27	26	21	10	-28	43	32	Yes
R068	Residential	3	19	20	26	26	26	22	11	-29	43	32	Yes
R069	Residential	4	17	21	26	26	27	23	12	-25	43	32	Yes
R070	Residential	6	19	21	26	27	28	24	13	-25	43	33	Yes
R071	Residential	4	18	21	26	27	26	22	11	-27	43	32	Yes
R072	Residential	6	19	21	26	27	26	22	12	-26	43	32	Yes
R073	Residential	6	19	21	26	26	26	23	12	-27	43	32	Yes
R074	Residential	6	19	20	26	27	26	22	11	-27	43	32	Yes
R075	Residential	6	19	20	26	26	26	23	11	-28	43	32	Yes
R076	Residential	6	19	20	25	25	24	20	9	-31	43	31	Yes
R077	Residential	3	19	20	25	25	25	21	10	-29	43	31	Yes
R078	Residential	3	19	20	25	25	25	22	10	-31	43	31	Yes
R079	Residential	4	19	20	25	25	25	21	8	-37	43	31	Yes
R080	Residential	6	19	19	25	25	24	19	6	-38	43	30	Yes
R081	Residential	3	16	19	24	24	23	18	4	-42	43	29	Yes
R082	Residential	3	18	19	24	24	23	18	4	-43	43	30	Yes
R083	Residential	3	16	19	24	24	23	18	5	-43	43	29	Yes
R084	Residential	3	16	18	23	22	21	15	1	-45	43	28	Yes
R085	Residential	5	18	18	23	22	21	15	0	-52	43	28	Yes
R086	Residential	2	17	17	22	22	24	18	3	-50	43	29	Yes
R087	Residential	3	15	19	24	25	23	18	3	-50	43	30	Yes
R088	Educational	-	-	-	-	-	-	-	-	-	40	34	Yes

Receiver building	Receiver type	Predicted noise level LA90 in octave bands [Hz], dB(A)[1]									External noise criteria	Received external noise level	Compliance
		31.5	63	125	250	500	1000	2000	4000	8000			
Octave band criteria		25	36	44	50	52	52	49	43	33			
R089	Educational	-	-	-	-	-	-	-	-	-	40	30	Yes
R090	Educational	-	-	-	-	-	-	-	-	-	40	31	Yes
R091	Educational	-	-	-	-	-	-	-	-	-	40	32	Yes
R092	Educational	-	-	-	-	-	-	-	-	-	40	30	Yes
R093	Active Recreational	-	-	-	-	-	-	-	-	-	50	37	Yes
R094	Residential	-4	9	6	8	6	4	-1	-12	0	43	14	Yes
R095	Residential	1	13	12	15	13	10	4	-12	0	43	20	Yes
R096	Residential	1	13	15	18	17	13	6	-11	0	43	23	Yes
R097	Residential	1	16	15	18	18	15	8	-10	0	43	24	Yes
R098	Residential	1	15	15	21	19	16	9	-9	0	43	25	Yes
R099	Residential	4	17	16	20	20	17	10	-7	0	43	25	Yes
R100	Residential	1	17	16	20	19	16	10	-7	0	43	25	Yes
R101	Residential	-2	9	6	12	13	11	6	-11	0	43	18	Yes
R102	Residential	2	14	13	17	20	19	13	-4	0	43	25	Yes
R103	Residential	2	15	16	20	19	16	9	-7	-57	43	25	Yes
R104	Residential	4	17	16	19	17	14	7	-9	-58	43	24	Yes
R105	Residential	4	16	15	18	16	13	5	-11	-60	43	23	Yes
R106	Residential	2	16	15	18	16	13	5	-11	0	43	23	Yes
R107	Residential	-5	16	17	23	25	24	19	4	-48	43	30	Yes
R108	Residential	5	18	19	24	26	24	19	5	-46	43	31	Yes
R109	Residential	6	18	18	23	23	22	17	2	-50	43	28	Yes
R110	Commercial	-	-	-	-	-	-	-	-	-	60	30	Yes
R111	Commercial	-	-	-	-	-	-	-	-	-	60	33	Yes
R112	Commercial	-	-	-	-	-	-	-	-	-	60	34	Yes
R113	Commercial	-	-	-	-	-	-	-	-	-	60	33	Yes
R114	Commercial	-	-	-	-	-	-	-	-	-	60	35	Yes
R115	Commercial	-	-	-	-	-	-	-	-	-	60	39	Yes
R116	Commercial	-	-	-	-	-	-	-	-	-	60	38	Yes
R117	Commercial	-	-	-	-	-	-	-	-	-	60	37	Yes
R118	Commercial	-	-	-	-	-	-	-	-	-	60	30	Yes
R119	Commercial	-	-	-	-	-	-	-	-	-	60	29	Yes
R120	Educational	-	-	-	-	-	-	-	-	-	40	29	Yes
R121	Commercial	-	-	-	-	-	-	-	-	-	60	35	Yes
R122	Commercial	-	-	-	-	-	-	-	-	-	60	30	Yes
R123	Commercial	-	-	-	-	-	-	-	-	-	60	29	Yes
R124	Commercial	-	-	-	-	-	-	-	-	-	60	33	Yes
R125	Commercial	-	-	-	-	-	-	-	-	-	60	30	Yes
R126	Commercial	-	-	-	-	-	-	-	-	-	60	30	Yes
R127	Commercial	-	-	-	-	-	-	-	-	-	60	32	Yes
R128	Industrial	-	-	-	-	-	-	-	-	-	65	31	Yes
R129	Industrial	-	-	-	-	-	-	-	-	-	65	23	Yes

1) Octave bands have only been assessed for residential receivers only

Appendix G – Predicted operational noise contours


Proposal site
Receiver buildings
Industrial
Commercial
Residential
Educational institute
Active recreation
Noise level - dB(A)
10
15
20
25
30
35
40
45
R129
R128
R127
R126
R125
R124
R123
R122
R121
R120
R119
R118
R117
R116
R115
R114
R113
R112
R111
R110
R109
R108
R107
R106
R105
R104
R103
R102
R101
R100
R099
R098
R097
R096
R094
R092
R091
R090
R089
R088
R093
R054
R055
R053
R052
R049
R051
R050
R048
R047
R035
R032
R033
R029
R031
R030
R027
R028
R025
R026
R023
R021
R019
R016
R014
R012
R010
R008
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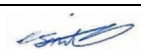
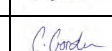
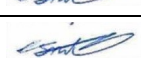
Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	A Bagby	C Gordon		E Milton		12/04/19
0	A Bagby	C Gordon		E Milton		17/04/19
1	A Bagby	C Gordon		E Milton		08/05/19

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