WHEN SOUND MATTERS

SEARS ACOUSTIC REPORT

NOISE AND VIBRATION ASSESSMENT FOR PROPOSED ALTERATIONS AND ADDITIONS TO PRESIDENT PRIVATE HOSPITAL

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1. INTRODUCTION

Acoustic Directions has been retained by Imagescape Design Studio to undertake an acoustic assessment of the proposed alteration and additions to President Private Hospital at Kirrawee.

As this project is classified as a state-significant development, Secretary's Environmental Assessment Requirements (SEARs) are imposed on this development. This report addresses the acoustical requirements contained in SEARs Item 9.

As part of addressing SEARs Item 9, the following guidelines and policies will also be addressed:

- NSW Noise Policy for Industry 2017 (EPA)
- Interim Construction Noise Guideline (DECC)
- Assessing Vibrations: A Technical Guideline 2006
- Development Near Rail Corridors and Busy Roads - Interim Guideline (Department of Planning 2008)
- NSW Road Noise Policy (2011)

The assessment presented in this report is based on the following information provided to Acoustic Directions:

- Architectural drawings by Imagescape Design Studio, project number "MacHealth-06" and dated 03/05/2019.
- Traffic Report by ML Traffic Engineers dated June 2020 (ref. N1815947N ver.2b)
- Mechanical drawings by Erbas and Associates

2. SITE DESCRIPTION AND PERTINENT DETAILS

2.1. Pertinent Details of Site

The proposed alterations and additions to President Private Hospital amalgamates five separate allotments into one site. The existing separate allotments are as follow:

a) 369-381 President Avenue, Kirrawee — existing President Private Hospital

b) 63-65 Hotham Road, Kirrawee — a single dwelling used for inpatient rehabilitation

c) 61 Hotham Road, Kirrawee — a single dwelling used for hospital administration

d) 2 Bidurgal Avenue, Kirrawee — a single dwelling

e) 4 Bidurgal Avenue, Kirrawee — a single dwelling

The amalgamated site will contain two new precincts, known as the North and South Precincts:

a) The North Precinct will include two storeys of in-patient accommodation, in-patient support areas and ancillary areas required by the Department of Health.

b) The South Precinct will include three storeys of patient accommodation and support services, new Recovery rooms and a new entry and reception area accessed via Hotham Road.

Figure 1 shows the location of the amalgamated hospital site and surroundings roads and land uses.

Additional on-grade and basement car parking are proposed for use by patients, emergency services and patient drop off and pickup bay.

The site is bound by the following roads:

- President Avenue to the south, which is an arterial road
- Hotham Road to the east, which is a local road
- Bidurgal Avenue to the north, which is a local road

Figure 1. Aerial view of the proposed site and surrounding land users with location of noise measurements

Given the increased magnitude of operations on site, an increased level of noise is expected. As such, surrounding land users may be adversely affected by this noise increase if noise on site is not adequately controlled and managed. The sources of noise identified to potentially cause disturbance to surrounding receivers are:

a) Increased on-site vehicular traffic accessing the expanded car parking facility.

b) Increased vehicular noise on roads surrounding site from vehicles accessing site facilities and services.

c) Increased mechanical noise from additional mechanical plant and equipment servicing new building areas on site.

The proposed site is bound by the following land uses:

a) Low-density residential housing to the north, south and west

b) Medium-density residential dwellings to the east

c) A skin clinic to the east of site at the corner of President Avenue and Hotham Road

The above locations near site will be most affected by the noise and vibration generated during construction and the noise produced by future operations of the redeveloped hospital. As such, construction and operational noise and vibration to these receivers is assessed to ensure that they meet the acoustic criteria imposed by the relevant authorities. These applicable acoustic criteria are presented in Section 4 of this report.

3. EXISTING SITE NOISE LEVELS

3.1. Background Noise Levels

3.1.1 Unattended Noise Logging

Unattended automatic logging of background noise levels was conducted on site using two loggers as shown in Figure 1 and labelled as Logger 1 and Logger 2.

- Logger 1 was installed on site from 4th March 2020 to 13th March 2020 on the rooftop of the east wing of the existing building. This logger had direct line-of-sight to President Avenue and provides a good indication of traffic noise levels for noise receivers with exposure to President Avenue.
- Logger 2 was installed on site from 13th March 2020 to 20th March 2020 at the rear of site on the ground near the back of site. This logger is shielded from traffic noise from surrounding roads and provides a good indication of background noise levels for noise receivers surrounding site.

Both noise loggers are equipped with an NTI-Audio XL2 sound analyser with a Class 1 measurement microphone set to log data of each 15-minute interval. Calibration checks were done prior and after the logging to ensure the validity of data.

Background noise levels on site are presented in Table 1 as Rating Background Levels (RBLs), which were calculated according to the procedure described in the NSW EPA Noise Policy for Industry. RBLs are commonly described for three time periods, which are daytime, evening and night. These periods are defined as follow:

- Daytime — 7:00 am – 6:00 pm Monday to Saturday and 8:00 am – 6:00 pm for Sundays and Public Holidays
- Evening — 6:00 pm – 10:00 pm every day
- Night — remaining periods.

Table 1. Existing background noise levels at logger locations on site

Logger No.	Location	EPA Time Period	Rating Background Level (RBL)
Logger 1	Rooftop above the east wing of the existing hospital building	Daytime	55 dB
		Evening	53 dB
		Night	48 dB
Logger 2	Ground level near the back of the hospital, adjacent to staff parking	Daytime	45 dB
		Evening	45 dB
		Night	43 dB

We note:

a) Upon reviewing the audio data captured by the noise loggers, Logger 1 data was found to be affected by noise from mechanical plant and equipment on site, especially in the late-evening and night time period, when traffic noise is lower. Noise data from Logger 2 was substantially less affected by this mechanical noise.

b) For the purpose of determining the RBLs to represent the noise environment surrounding site, it is noted that the hospital has been operating for the past 35 years. During this period, noise emitted by these rooftop mechanical plant and equipment could be considered as part of the noise environment of the area. As such, it is reasonable to use the logger data that includes this mechanical noise to establish the RBL.

c) However, to remain conservative in our noise assessment, we have decided to use the data from Logger 2 to establish the noise criteria, which was less affected by the existing mechanical equipment.

3.1.2 Attended Noise Measurements

To obtain RBLs at receiver locations, supplementary attended background noise measurements were undertaken at other receivers while the loggers were logging the site noise levels. The representative RBLs for each noise receiver area were then determined by applying the difference between the attended and logging noise levels to the logger RBLs.

Attended measurements at various locations surrounding site were undertaken at the following times:

- Bidurgal Avenue between 5:00 am and 5:16 am
- Hotham Road between 4:50 am and 5:00 am
- N W Arm Road between 4:20 am and 4:30 am
- President Avenue between 4:32 am and 4:44 am, and between 5:21 and 5:31 am

Attended noise measurements were taken using an NTI Audio XL2 sound analyser equipped with a Class 1 microphone. Calibration checks were undertaken before and after the measurement to ensure the validity of the data.

Table 2 presents the difference in measured noise levels between the attended measurement and the noise logger. We note that a negative number indicates that the attended measurement measured a lower background noise level than the logger, and vice versa.

Table 3 presents the determined RBLs at noise receiver locations considering this difference in measured levels between the attended measurement and the noise logger at each location.

Table 2. Measured background noise levels at the attended measurement and logger positions

Receiver Location	Noise Level Difference between Attended Measurement and Logger $L_{A90,15min}$
Bidurgal Avenue	-6 dB
Hotham Road	-2 dB
NW Arm Road	+1 dB
President Avenue	-5 dB

Table 3. Representative RBLs at noise receiver locations

Receiver Area Location	Rating Background Level (RBL)		
	Daytime	Evening	Night-time
Bidurgal Avenue	39 dB	39 dB	37 dB
Hotham Road, away from President Avenue	43 dB	43 dB	41 dB
NW Arm Road, away from President Avenue	40 dB	40 dB	38 dB
President Avenue	46 dB	46 dB	44 dB

3.2. Traffic Noise levels surrounding Site

Existing traffic noise levels surrounding site have been measured as part of our site noise survey. Unattended noise logging and attended measurements of traffic noise were made.

Unattended noise logging was undertaken using a logger equipped with an NTI-Audio XL2 with a Class 1 microphone. The noise logger was installed on the rooftop near the south-eastern part of the building as indicated in Figure 1.

Existing traffic noise levels are presented in Table 4 below.

Table 4. Road noise levels measured on roads surrounding site.

Location	Period	Measured Noise Level
South-east rooftop of the hospital, 32 m from President Avenue	Day: 7:00 am – 10:00 pm	Whole period: 62 dB $L_{Aeq,15hr}$ Highest 1-hr period: 63 dB $L_{Aeq,1hr}$
	Night: 10:00 pm – 7:00 am	Whole period: 56 dB $L_{Aeq,9hr}$ Highest 1-hr period: 59 dB $L_{Aeq,1hr}$
President Avenue, 7 metres from the road kerb	Morning peak: 8:15 am – 8:30 am	69 dB $L_{Aeq,15min}$
Hotham Rd, 3 metres from the road kerb	Morning peak: 8:37 am – 8:52 am	61 dB $L_{Aeq,15min}$
Hotham Rd, 4 metres from the road kerb	Representative loudest period within the night period: 6:47 am – 7:00 am	62 dB $L_{Aeq,15min}$

4. ACOUSTIC CRITERIA

Item 9 from the project SEARs states:

9. Noise and Vibration

- *Identify and provide a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation, construction. Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land.*
- *Identify and assess operational noise, including consideration of mechanical services (e.g. air conditioning plant), ambulance movements, patient and visitor arrival/departures. Outline measures to minimise and mitigate the potential noise impacts of the development on surrounding occupiers of land.*

To meet Item 9 of SEARs, the acoustic criteria presented below are adopted for this project.

4.1. Noise and Vibration Criteria during Construction

4.1.1 Noise Criteria — Interim Construction Noise Guideline (DECC)

The NSW EPA issued a document in 2009 titled "Interim Construction Noise Guidelines (ICNG), which is specifically aimed at managing noise from construction works.

The main objectives of the Guideline are to:

- promote a clear understanding of ways to identify and minimise noise from construction works;
- focus on applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts;
- encourage construction to be undertaken only during the recommended standard hours (Table 5), unless approval is given for works that cannot be undertaken during these hours;
- streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage;

- provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts.

Table 2 of the above document is reproduced in Table 5 below and provides management noise levels and how they are to be applied.

A. Residences

Table 5. EPA Guidelines for construction noise levels at the boundary of affected residences.

Time of day	Management level LAeq (15 min) *	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 $LA_{eq\ (15\ min)}$ 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: 1. 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 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times
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 dBA above the noise affected level, the proponent should negotiate with the community.

The ICNG notes that the predicted noise levels from activities such as power saws, grinders (metal and concrete) jack hammering and impact piling should be increased by 5 dB to reflect the annoyance of these sounds to residents.

B. Commercial Premises

Section 4.1.3 in the ICNG recommends 70 dB $L_{Aeq,15min}$ management level criterion for offices, which should be assessed at the most-affected occupied point of the premise. This noise goal has been adopted for the skin clinic (marked C1 in Figure 1) to the east of site.

C. Adopted Noise Goals During Construction

Table 6 presents the adopted noise goals at each receiver, which are based on the RBLs stated in Table 1.

Table 6 Adopted goals for construction noise.

Receiver Locations	Time Period	RBL	Management Level $L_{Aeq,15min}$
Receivers along President Avenue	Monday to Friday: 7 am to 6 pm Saturday: 8 am to 1 pm	46 dB	56 dB
Receivers along Hotham Road	Monday to Friday: 7 am to 6 pm Saturday: 8 am to 1 pm	43 dB	53 dB
Receivers along NW Arm Road	Monday to Friday: 7 am to 6 pm Saturday: 8 am to 1 pm	40 dB	50 dB
Receivers along Bidurgal Avenue	Monday to Friday: 7 am to 6 pm Saturday: 8 am to 1 pm	39 dB	49 dB
Commercial premises (e.g., skin clinic)	When in operation	(N/A)	70 dB

4.1.2 Vibration Criteria — Assessing Vibrations: A Technical Guideline 2006 (EPA)

This EPA document presents preferred and maximum vibration criteria as a guideline to protect people from disturbances from sources of vibration such as from construction equipment.

The guideline presents different vibration criteria depending on the vibration type, i.e., continuous, intermittent and impulsive

- Table 2.2 in the guideline presents vibration criteria for continuous and impulsive vibration based on acceleration
- Table 2.4 in the guideline presents vibration criteria for intermittent vibration based on vibration dose values

Applicable criteria for this project are taken from the above tables and reproduced in Table 7 and Table 8 below.

Table 7. Continuous and impulsive vibration criteria from Assessing Vibrations: A Technical Guideline (2006)

Location	Assessment period	Preferred weighted RMS acceleration values, 1-80 Hz (m/s^2)		Maximum weighted RMS acceleration values, 1-80 Hz (m/s^2)	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices	Day- or night-time	0.020	0.014	0.040	0.028
Impulsive vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices	Day- or night-time	0.64	0.46	1.28	0.92

Table 8. Intermittent vibration criteria from Assessing Vibrations: A Technical Guideline (2006)

Location	Assessment period	Preferred vibration dose value ($m/s^{1.75}$)	Maximum vibration dose value ($m/s^{1.75}$)
Residences	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices	Day- or night-time	0.40	0.80

Note:

- Daytime is defined as 7:00 am to 10:00 pm and Night-time is defined as 10:00 pm to 7:00 am.
- Details of the weighting is contained in the EPA document and is also defined in British Standard BS 6841-1987.

As long as vibration acceleration remains below the preferred values in Table 7 above, disturbance to building occupants will be minimised, although there remains a low probability of adverse disturbance to people who are sensitive to vibrations.

4.2. Noise and Vibration Criteria During Hospital Operations

4.2.1 EPA Noise Policy for Industry

Mechanical noise generated from the development is required to comply with the NSW EPA Noise Policy for Industry (NPI). Although there is no specific policy relating to vehicle noise intrusion for affected residents, we have also adopted the requirements of the NPI for this type of noise.

Noise produced by the vehicles once they are on the roadway is subject to the NSW Road Noise Policy.

The NPI provides a clear framework for assessing noise impacts from noise-emitting premises. To support the goal of minimising noise impacts to surrounding noise-sensitive receivers through available feasible and reasonable noise mitigation measures, the policy sets out a procedure to determine a benchmark noise level, called the "project noise trigger level", above which noise management measures are required to be considered. The project noise trigger level is specific to each noise-receiver, and considers the background noise environment, the time of day of the activity, the character of the noise and the type of receiver (e.g. residential or commercial). The project noise trigger level has been adopted in this assessment as the noise threshold of which operational noise on site should remain below.

The project noise trigger level is an $L_{Aeq,15min}$ level that is determined as the lower of the "project intrusiveness noise level" and "project amenity noise level". These levels are calculated as follows:

- The *project intrusiveness noise level* is determined by adding 5 dB to the RBL and is represented as an $L_{Aeq,15min}$ level. We note that the intrusiveness noise level only applies to residential receivers.
- The *project amenity noise level* is generally determined by subtracting 5 dB from the recommended $L_{Aeq,period}$ amenity noise levels in Table 2.2 of the policy. (The 5 dB factor is to limit noise-creep in the area). This project amenity noise level is then converted to an $L_{Aeq,15min}$ level by adding 3 dB.

With the measured/estimated rating background noise levels, the project noise trigger levels for the most-affected noise receivers were calculated and are presented in Table 9 below.

Table 9. Project noise trigger level at receivers most affected by site mechanical noise and vehicles entering/leaving the site.

Receiver location	Receiver type	Time of day	Project intrusiveness noise level ($L_{Aeq,15min}$)	Project amenity noise level ($L_{Aeq,15min}$)	Project noise trigger level ($L_{Aeq,15min}$)
Receivers along President Avenue (R5, R7, R8, R9)	Residential (Suburban)	Daytime	51 dB	53 dB	**51 dB**
		Evening	51 dB	43 dB	**43 dB**
		Night	49 dB	38 dB	**38 dB**
Receivers along Hotham Road (R2, R3, R4)	Residential (Suburban)	Daytime	48 dB	53 dB	**48 dB**
		Evening	48 dB	43 dB	**43 dB**
		Night	46 dB	38 dB	**38 dB**
Receivers along NW Arm Road (R6)	Residential (Suburban)	Daytime	45 dB	53 dB	**45 dB**
		Evening	45 dB	43 dB	**43 dB**
		Night	43 dB	38 dB	**38 dB**
Receivers along Bidurgal Avenue (R1, R10)	Residential (Suburban)	Daytime	44 dB	53 dB	**44 dB**
		Evening	44 dB	43 dB	**43 dB**
		Night	42 dB	38 dB	**38 dB**
Commercial premises (e.g., skin clinic)		When In Use	(N/A)	63 dB	**63 dB**

A. Sleep Arousal

a) Section 2.5 of the NPI relates to the disturbance of sleep and states that a detailed maximum noise level event assessment should be undertaken where the night-time noise levels at a residential location exceed

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

b) Should the night-time noise levels exceed the noise thresholds listed in a) above and a maximum noise level event assessment is required, the assessment should assess i) the maximum noise level, ii) the extent to which the maximum noise level exceeds the RBL and iii) the number of occurrences during the night-time period.

The NPI refers the reader to a review of research results in the NSW Road Noise Policy. Section 5.4 of that Policy provides the following guidelines from the World Health Organisation.

i. "Where noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided".

ii. "As a rule for planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dBA L_{AMax} more than 10 or 15 times per night."

4.2.2 Road Noise Increase of Surrounding Roads — EPA Road Noise Policy

Road noise increase on surrounding roads as a result of the hospital redevelopment is required to comply with the NSW EPA Road Noise Policy (RNP).

The criteria in the RNP aim to provide noise protection to residences and other sensitive land uses from road traffic noise.

Table 10 presents the applicable criteria for noise on roads impacting land uses from the hospital redevelopment. We note that there are no criteria for commercial receivers, which are generally more tolerant of traffic noise.

Table 10. Assessment noise criteria for additional traffic generated on roads surrounding the site from the NSW Road Noise Policy.

Road category	Receiver type	Assessment Criteria	
		Day (7 am – 10 pm)	Night (10 pm – 7 am)
Arterial Roads i.e., President Avenue	Residential	≤ 60 dB $L_{Aeq,15hour}$ (external)	≤ 55 dB $L_{Aeq,9hour}$ (external)
Local Roads i.e., Hotham Road	Residential	≤ 55 dB $L_{Aeq,1hr}$ (external)	≤ 50 dB $L_{Aeq,1hr}$ (external)

In addition to the criteria above, the RNP also contains a relative-increase criterion, which requires consideration for any increase in the total traffic noise level from a traffic-generating development at residential land uses. This consideration is presented in Table 11 below.

Table 11. Relative increase criteria for residential land uses

Road category	Receiver type	Assessment Criteria	
		Day (7 am – 10 pm)	Night (10 pm – 7 am)
Freeway/arterial/sub-arterial roads and transitways	Residential	Existing traffic $L_{Aeq,15hour}$ + 12 dB (external)	Existing traffic $L_{Aeq,9hour}$ + 12 dB (external)

We note that this relative increase criterion does not apply to local roads, e.g. Hotham Road to the east of site.

4.2.3 Traffic Noise Intrusion onto Site — NSW Department of Planning "Development Near Rail Corridors and Busy Roads — Interim Guideline"

Table 3.1 in the "Development Near Rail Corridors and Busy Roads — Interim Guideline" contains noise criteria for internal noise levels within hospital wards and other sensitive receivers, which is presented in Table 12 below.

Table 12. Noise criteria for hospitals from Table 3.1 in NSW Department of Planning's "Development Near Rail Corridors and Busy Roads — Interim Guideline"

Hospital Room Type	Recommended Maximum Level	
	Day 7am-10pm	Night 10pm-7am
Wards	35 dB $L_{Aeq,15hour}$	35 dB $L_{Aeq,9hour}$
Other noise sensitive areas	45 dB $L_{Aeq,15hour}$	45 dB $L_{Aeq,9hour}$

We note that the recommended maximum internal noise levels in Table 12 can be achieved by incorporating heavy wall constructions on the facades exposed to traffic noise and by optimising window constructions through area of glass, glass thickness and the use of double-glazing with large separation between the two panes.

Rather than conducting an indicative assessment at this stage, we recommend that a comprehensive traffic noise intrusion assessment should be undertaken during detailed design stage.

5. ASSESSMENT OF MECHANICAL NOISE EMISSIONS

A preliminary assessment of mechanical noise emissions against the EPA Noise Policy for Industry is presented below based on the mechanical drawings provided by Erbas and Associates.

The assessment presented below is only indicative of the noise levels as the selections of mechanical plant have not yet been finalised. A detailed review of mechanical noise emissions shall be undertaken at detailed design stage.

5.1. Assessed Plant and Equipment

A large number of mechanical plant and equipment items are proposed on the rooftop of the hospital, which have the potential to disturb surrounding receivers.

A significant proportion of this equipment will be housed within a plantroom that is open to the east and west, with the remaining directly exposed to the external environment.

The plant and equipment that will located within the plantroom are:

- 32 x VRV condensers
- 4 x packaged air conditioning units
- 2 x car park exhaust fans

The following equipment will be located on the rooftop and will be directly exposed to the external environment:

- Emergency-activated fans such as stair pressurisation and stair pressurisation relief fans.
- Energy recovery ventilators (ERVs)

Figure 2 shows the indicative layout of equipment assumed in this assessment, which is taken from the mechanical drawings provided to us.

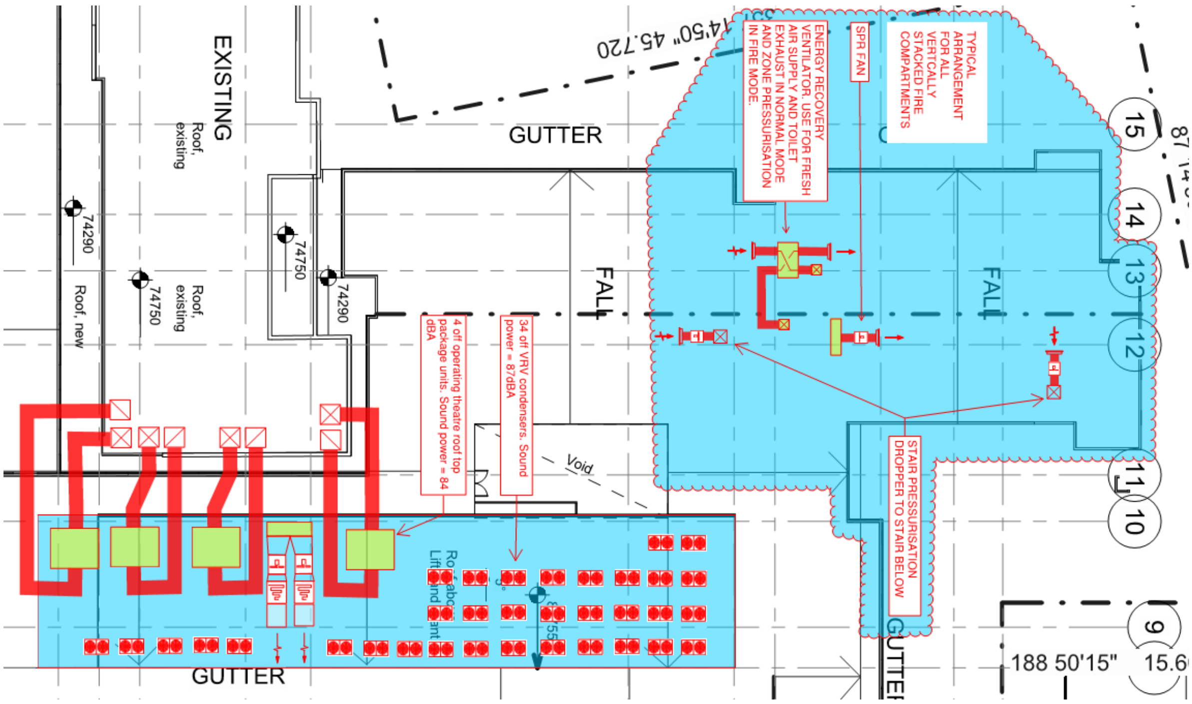


Figure 2. Layout of equipment within the plantroom in the mechanical drawings provided by Erbas

We note the following:

- Equipment noise associated with emergencies is not included in this assessment (e.g. stair pressurisation fans).
- We understand additional ERVs to those presented in Figure 2 are likely to be installed on the rooftop. As these ERV items have not been finalised, they are not included it in this assessment. However, we note that noise levels from these units can be effectively reduced by a combination of housing the ERV within a solid enclosure and using long lengths of acoustically-lined ductwork for the intakes and discharges of the units.

Other mechanical plant and equipment that is located internally will have less impact on surrounding receivers provided that reasonably quiet fans and appropriate noise mitigation measures are implemented, such as the use of inline silencers, lined ductwork and appropriate placement of external discharge and intake points. As such, no assessment of these equipment is undertaken at this stage. Assessment of these equipment items shall be done during the detailed design stage.

5.2. Noise Modelling

A numerical noise model based on the plant and equipment above has been constructed to predict the level of mechanical noise at the most-affected noise receivers as identified in Figure 1.

Pertinent details of our noise model are as follows:

a) Assumed sound power levels of plant and equipment are shown in Table 13.

b) Noise spectra are based on information provided by Erbas and Associates where available or are otherwise based on typical spectra of similar equipment.

Table 13. Sound power levels assumed in noise model

Equipment	Sound Power Level (dB)								
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Broadband A-weighted
VRV	91	89	88	86	81	77	74	66	87
Packaged air conditioner units	72	72	82	79	80	76	73	74	84
Car park exhaust fan	96	89	92	89	89	90	89	84	96
Energy recovery ventilator (ERV)	65	72	74	87	80	81	79	68	88

c) To remain conservative in our assumptions, all equipment is assumed to be operating at full capacity.

d) Solid walls within the plantroom are lined with 100 mm acoustic insulation to control reverberation within the plantroom.

e) Plantroom walls are constructed of high transmission loss material such as masonry or concrete. As such, the bulk of noise from the plantroom transmits to the external environment via full-height acoustic louvres, which are located along the entire length of the east and west walls as shown in the architectural drawings.

The assumed noise insertion loss performance of the acoustic louvres is shown in Table 14.

Table 14. Assumed noise insertion loss performance of acoustic louvres installed on the plantroom walls

Construction	Insertion Loss (dB)						
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Acoustic Louvre	9	14	22	27	33	33	30

f) Noise propagating to the noise receiver is attenuated by distance loss and the self-shielding of the hospital building from the receiver locations.

5.3. Results

The predicted noise levels at the most-affected noise receivers are presented in Table 15 below with the most stringent criteria from the EPA Noise Policy for Industry (i.e., night-time noise criteria).

Table 15. Predicted mechanical noise levels at most-affected noise receiver locations

Noise Receiver	Predicted Noise Level ($L_{Aeq,15min}$)	EPA Noise Criteria ($L_{Aeq,15min}$)	Compliance?
R1 — residential	35 dB	38 dB	Yes
R2 — residential	34 dB	38 dB	Yes
R3 — residential	26 dB	38 dB	Yes
R4 — residential	32 dB	38 dB	Yes
R5 — residential	32 dB	38 dB	Yes
R6 — residential	29 dB	38 dB	Yes
R7 — residential	29 dB	38 dB	Yes
R8 — residential	25 dB	38 dB	Yes
R9 — residential	32 dB	38 dB	Yes
R10 — residential	36 dB	38 dB	Yes
C1 — commercial	30 dB	63 dB	Yes

5.4. Discussion

a) Table 15 above shows that based on our assumptions, mechanical noise on site complies with the noise criteria from the EPA Noise Policy for Industry (NPI).

b) As compliance with the NPI is achieved, mechanical noise from the hospital is unlikely to cause significant disturbance to surrounding noise receivers.

c) We note that our assessment has assumed that all equipment is operating at full capacity. However, in day-to-day operations, the rooftop equipment is expected to operate with reduced speed or cycle on and off to meet the heating/cooling and ventilation requirements of the hospital. As such, noise levels are expected to be lower than stated in Table 15.

d) We reiterate that our assessment of mechanical noise is only indicative at this stage, as actual equipment selections are not finalised. A full review of mechanical noise emissions from the hospital shall be undertaken during detailed design stage to determine the extent of acoustic treatment required to meet the EPA NPI criteria.

6. ASSESSMENT OF VEHICULAR NOISE EMISSIONS ON SITE DURING OPERATION

Noise generated by vehicular movement within the hospital has the potential to cause disturbance to surrounding noise receivers. Noise on roads within hospitals is typically from cars from visitors and patients, ambulances and delivery trucks.

A total of 158 car spaces is provided on site via ground floor and four levels of basement parking:

- 17 car spaces on the ground floor car park adjacent to President Avenue
- 10 car spaces on the ground floor car park to the north of site and directly accessible via Hotham Road
- 131 car spaces on basement levels

In addition, an ambulance bay is provided on Basement Level 2.

An assessment of the following vehicular noise scenarios on site are presented in the following sections:

a) Vehicles from patients/visitors accessing the hospital via President Avenue and Hotham Road (Section 6.1)

b) Use of loading dock on site during deliveries (Section 6.2)

c) Ambulance accessing the hospital via President Avenue and Hotham Road (Section 6.3)

6.1. Assessment of Noise from General Vehicular Traffic on Site

Vehicles from patients, visitors and staff all contribute to the general vehicular flow on site, which cumulatively can create noise disturbance to surrounding noise receivers and should be assessed.

To be conservative, our assessment of these vehicular noise to surrounding receivers is based on the highest traffic flow period, which is assumed to be during peak hour.

According to the traffic report, vehicular access to site during the morning and afternoon peak are as per Table 16 below.

Table 16. Peak hour vehicular flows into and out of the hospital (taken from the traffic report)

Journey Type	Journeys during Morning Peak Hour	Journeys during Afternoon Peak Hour
Vehicles entering via President Avenue	30	5
Vehicles leaving via President Avenue	7	20
Vehicles entering via Hotham Road	22	6
Vehicles leaving via Hotham Road	6	21

The table above shows that the morning peak generates the most traffic, i.e., 37 journeys via President Avenue and 28 journeys via Hotham Road, and as such these journeys are used in our assessment.

To address the $L_{Aeq,15min}$ noise criteria, a 15-minute assessment period is used.

Our assessment is based on the following items and assumptions:

a) All cars entering or leaving President Avenue during the peak period (9 vehicle journeys per 15 minutes) are assumed to park in or depart from the western car parking area on the ground floor.

b) Cars entering or leaving Hotham Road during the peak period (7 vehicle journeys per 15 minutes) are assumed to park in or depart from the ground floor parking via the northern driveway.

The scenarios in a) and b) are worst-case and combine the highest assumed traffic flows with the travel path on site that will generate the most noise to surrounding receivers.

c) General vehicular traffic on site travels at 10 kph.

d) The most-affected receivers from vehicles accessing via Hotham Road are receivers R2 and R4.

e) The most-affected receivers from vehicles accessing via President Avenue are receivers R7 and R9.

f) A boundary fence of 1.8 m is constructed along the southern boundary of R2, which provides some acoustic shielding to the ground floor and only minor shielding to the second storey of that residence.

g) The hospital building provides acoustic shielding of vehicular noise to receiver R2 for part of the travel path for vehicles traversing along the road connected to the northern driveway on Hotham Road.

Based on the assumptions above, vehicle noise from patient and visitors is predicted at the most-affected noise receiver locations and is presented in Table 17 below.

Table 17. Predicted levels of general vehicular noise from patients and visitors at most-affected receivers

Noise Description	Receiver location	Predicted Noise Level at Receiver ($L_{Aeq,15min}$)	EPA Noise Criteria ($L_{Aeq,15min}$) Day/Evening/Night	Compliance?
Vehicles accessing Hotham Road	R2	41	48/43/38 dB	Yes/Yes/Yes*
	R4	36	48/43/38 dB	Yes/Yes/Yes
Vehicles accessing President Avenue	R7	35	51/43/38 dB	Yes/Yes/Yes
	R9	27	51/43/38 dB	Yes/Yes/Yes

* see discussion below

From the results above, we note:

a) Based on peak traffic flows, noise from general vehicular traffic access via President Avenue complies with the EPA noise criteria for all time periods.

b) Based on peak traffic flows, noise from general vehicular traffic access via Hotham Road complies with the noise criteria for the day and evening time periods, but exceeds the night time criterion by 3 dB when assessed at R2.

c) However, given that the assessment is based on peak-period traffic flows, it is likely that traffic volumes during the night period will be more than half of the expected peak traffic flow. Realistically, only a trickle of traffic is expected to access the hospital at night as the hospital does not accept visitors at night time.

d) If the traffic flow at night time is half of peak traffic flow, an approximate reduction in traffic noise level of 3 dB is expected, resulting in a 38 dB L_{Aeq} level of traffic noise at R2, which complies with the EPA noise criteria.

e) As such, we expect that full compliance with the EPA noise criteria will be achieved in operation and noise amenity for surrounding residences will be maintained.

6.2. Assessment of Loading Dock Noise

The loading dock is located within the ground level car park. This space is partially enclosed but with an opening to the west, which is close to the receiver R10.

Figure 3 shows the location of the loading dock and the opening to the west.

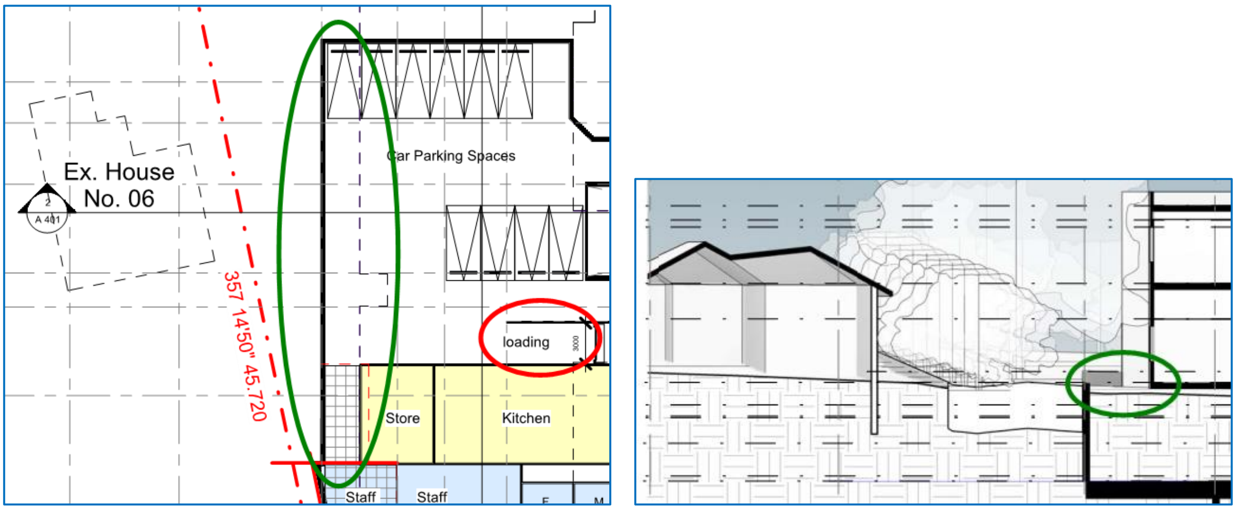


Figure 3. Plan (left panel) and section (right panel) drawings showing the loading dock (red) and the opening to the west (green).

Noise generated from the use of the loading dock has the potential to cause noise disturbance to this noise receiver via this opening. An assessment of this noise is presented below.

Our assessment of the loading dock noise to R10 is based on the following items and assumptions:

a) Refrigerated trucks parked and idling in the loading bay will be typically the loudest source of noise. Other sources of noise are generally quieter or are transient in nature and do not contribute significantly to the long-term level of noise.

b) The refrigerated truck is parked at the loading dock and emits a sound power level of 100 dB L_{WA} with the following noise spectrum:

Table 18. Assumed sound power level spectrum of an idling refrigerated truck.

Equipment	Sound Power Level (dB)						
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Refrigerated truck (idling)	68	88	92	97	97	91	80

c) The noise reverberates within the basement enclosure and creates a reverberant sound field at the opening to the west.

d) Acoustic louvres providing the following sound insertion loss are installed along this opening to reduce the radiated sound transmitted from the basement to the external environment:

Table 19. Assumed sound insertion loss performance of acoustic louvres installed at the western opening.

Construction	Insertion Loss (dB)						
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Acoustic Louvre	9	14	22	27	33	33	30

e) Noise is emitted from the basement via acoustic louvres to the external environment and propagates towards receiver R10.

f) A solid barrier of 1.8 m height is located along the boundary between the hospital and the noise receiver to provide noise shielding

Based on the assumptions above, noise from the loading dock has been predicted at the most-affected noise receiver R10 and is presented in Table 20 below.

Table 20. Predicted levels of loading dock noise at the most-affected receiver (R10)

Scenario	Receiver Location	Predicted Noise Level at Receiver ($L_{Aeq,15min}$)	EPA Noise Criteria ($L_{Aeq,15min}$) Day/Evening/Night	Compliance?
Loading Dock Noise (refrigeration truck parked and idling)	R10	41	44/43/38 dB	Yes/Yes/No*

Results above show that with the use of acoustic louvres to reduce the level of noise through the western opening, use of the loading dock during the daytime and evening is likely to meet the EPA Noise Policy for Industry criteria.

We note that as deliveries typically occur during the day, non-compliance with the night-time criterion at night is not relevant.

6.3. Assessment of Ambulance Noise

Assessment of ambulance noise emissions on site are based on the following assumptions:

a) Ambulances enter site via President Avenue or Hotham Road to access the ambulance bay located within the basement carpark next to the lifts.

b) The ambulance will be travelling at approximately 10 km/hr.

c) Within any 15 minute time window, an ambulance either arrives to or departs from the hospital.

d) Ambulances are unlikely to have its siren on as the hospital does not take emergency patients.

e) Ambulance on site will be emitting a sound power level of 90 dB L_{Aeq}

Based on the proposed hospital layout, the most-affected noise receivers are identified as:

a) Receivers R2 and R4 for ambulance access via Hotham Road.

b) Receiver R7 and R9 for ambulance access via President Avenue.

Based on the assumptions above, ambulance noise has been predicted at the most affected noise receivers and are presented in Table 21 below.

Table 21. Predicted levels of ambulance noise at most-affected receivers

Scenario	Receiver Location	Predicted Noise Level at Receiver ($L_{Aeq,15min}$)	EPA Noise Criteria ($L_{Aeq,15min}$) Day/Evening/Night	Compliance?
Ambulance access via Northern Hotham Road Entry	R2	43	48/43/38 dB	Yes/Yes/**No**
	R4	38	48/43/38 dB	Yes/Yes/Yes
Ambulance access via Southern Hotham Road Entry	R2	30	48/43/38 dB	Yes/Yes/Yes
	R4	37	48/43/38 dB	Yes/Yes/Yes
Ambulance access via President Avenue Entry	R7	37	51/43/38 dB	Yes/Yes/Yes
	R9	24	51/43/38 dB	Yes/Yes/Yes

Results above show that ambulance noise generally complies with the EPA Noise Policy for Industry criteria except for the scenario where ambulances access the hospital at night via the northern Hotham Road Entry. We therefore recommend that if the hospital receives ambulances at night that they should only access the hospital via the southern entry of Hotham Road or President Avenue.

We further note that as long as ambulances use the southern Hotham Road or President Avenue entry for access at night, ambulance noise levels at surrounding most-affected receivers are relatively low and sleep disturbance is unlikely to occur.

6.4. Sleep Disturbance

Average noise levels (L_{Aeq}) generated by vehicular movements within the hospital site are unlikely to cause sleep disturbance to surrounding residential noise receivers based on the distance between vehicular paths and receivers. However, transient events such as car engines starting and doors slamming on site may possibly disturb surrounding noise receivers and therefore is assessed for its potential to disturb sleep.

The following vehicle locations on site are identified to likely cause disturbance to nearest residences:

- Vehicles within the western area of the ground floor car park along President Avenue.
- Vehicles within the drop-off area accessible via the southern entry off Hotham Road.

Given these locations, the most-affected noise receivers are identified as receivers R2, R4, R7 and R9.

Our assessment is based on the following items and assumptions:

a) The sound pressure levels of a car door slamming and engine starting are as per Table 22 below, which are based on measurements made of a standard Toyota mid-size sedan by Acoustic Directions.

Table 22. Measured sound power level of a car-door slam and engine start.

Noise Source	Sound Power Level (dB)							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Car slam measured at 2 metres from the noise source	86	79	74	76	73	67	63	53
Starting engine measured at 2 metres from the noise source	77	72	66	62	62	65	63	61

b) The noise transmits from the source to the receiver and undergoes propagational loss.

c) Additional shielding losses are provided by the boundary fences assumed to be 1.8 m high between the hospital and receivers R2 and R9.

Based on the assumptions above, maximum levels from these two transient noise sources were predicted at the most-affected building facade of the most-affected noise receivers and are presented in Table 23 below.

Table 23. Predicted levels of transient noises from vehicles at most-affected receivers.

Receiver Location	Predicted Noise Level at Receiver (L_{AFMax})		Sleep Disturbance Assessment Noise Threshold (L_{AFMax})	Compliance?
	Car-Door Slam	Engine Starting		
R2	53 dB	45 dB	56 dB	Yes
R4	55 dB	47 dB	56 dB	Yes
R7	55 dB	47 dB	59 dB	Yes
R9	48 dB	38 dB	59 dB	Yes

Results above show that the L_{AFmax} noise levels at noise receivers lie below the threshold of noise at which sleep disturbance is required to be assessed. Given these relative low levels of noise from transient car noise events, sleep disturbance is unlikely to surrounding residential noise receivers.

7. ASSESSMENT OF VEHICULAR NOISE ON SURROUNDING ROADS

An assessment of vehicular contributions to road surrounding President Private Hospital against the criteria from the NSW Road Noise Policy (2011) is presented below.

7.1. Existing Façade Traffic Noise Levels at Residences Along President Avenue and Hotham Road

Using the measured road traffic noise levels presented in Table 4, traffic noise levels at a typical façade distance from President Avenue and Hotham Road have been calculated. Based on our site survey, we note that the closest facades of residences are typically 12 metres from President Avenue and 9 metres from Hotham Road.

The calculated façade levels are presented in

Table 24 below. In accordance with the RNP, these levels include a façade reflection that increases the measured noise level in the absence of façade reflections by 2.5 dB.

Table 24. Existing noise levels on roads surrounding President Private Hospital.

Description		President Avenue	Hotham Road
Distance of typical closest residence facades from road kerb		12 m	9 m
Existing Traffic Noise Level at Facades	Day (7 am – 10 pm)	69 dB $L_{Aeq,15hour}$	59 $L_{Aeq,1hour}$
	Night (10 pm – 7 am)	63 dB $L_{Aeq,9hour}$	61 $L_{Aeq,1hour}$
RNP Noise Criteria	Day (7 am – 10 pm)	60 dB $L_{Aeq,15hour}$	55 $L_{Aeq,1hour}$
	Night (10 pm – 7 am)	55 dB $L_{Aeq,9hour}$	50 $L_{Aeq,1hour}$
Existing Levels compliant with RNP?	Day (7 am – 10 pm)	No	No
	Night (10 pm – 7 am)	No	No

Table 24 indicates that existing traffic noise levels on President Avenue and Hotham Road already exceeds the fixed noise limits from the RNP, and as such, residences along these roads are already subjected to high levels of traffic noise.

Given that existing traffic noise levels already exceed the RNP criteria, compliance with the RNP is unachievable even if the redevelopment contributes no vehicular noise to these surrounding roads. As such it will be unreasonable to impose RNP noise assessment levels to the hospital redevelopment.

To address situations where existing traffic noise levels already exceed the RNP noise criteria, the RNP applies a "relative increase of noise criteria" for assessment to protect against excessive decreases in noise amenity (see Table 11). An assessment of the noise increase from traffic generated by the hospital redevelopment is presented below.

7.2. Assessment of Relative Noise Increase from Hospital Vehicular Traffic

a) We note that the RNP states that the relative noise increase criteria only apply to major roads, and as such it is not mandatory to assess Hotham Road, which is a local road.

b) Based on traffic noise levels from Table 4, we estimate the average traffic flows on President Avenue using CoRTN, which is an industry standard traffic noise prediction model.

c) Assumptions of traffic contributions from the hospital to surrounding roads are taken from the peak hour traffic flow information contained in the traffic report by ML Traffic Engineers (ref. N1815947N ver.2b).

d) As a conservative estimate, we have extrapolated the vehicular contributions from the hospital during non-peak hours to be the same as the peak hour periods.

e) The increase in traffic noise levels have been calculated based on the increase in vehicular movement events according to the following equation:

$$level\ change\ in\ dB = 10 * \log\left(\frac{projected\ traffic\ movement}{existing\ traffic\ movements}\right)$$

f) Based on the calculated traffic increase and using the mathematical formula above, the predicted traffic noise level increases on surrounding roads are as per Table 25, which shows compliance with the RNP Relative Increase criteria.

Table 25. Predicted noise increase on surrounding roads

Description	President Avenue	
	Day 7am - 10 pm	Night 10 pm - 7 am
Estimated Average Existing Flow (vph)	Approx. 400-500	approx. 180-230
Additional flow from hospital from traffic report (vph)	39 (peak hour)	39 (peak hour)
Increase in traffic noise level (dB)	0.4	0.9
Complies with RNP Relative Increase Criteria?	Yes	Yes

g) We note that the RNP considers a road traffic noise increase of up to 2 dB as a minor impact that is considered barely perceptible to the average person.

h) Given there is a negligible increase (< 1 dB) of traffic noise level from future hospital operations, the increases in traffic noise levels shown in Table 25 are likely to be imperceptible by residents living along President Avenue and Hotham Road.

7.3. Further Discussion of Night-Time Vehicle Contributions from the Hospital

In addition to the assessment above in Section 7.2, we further note that the contribution of vehicles on roads at night from the hospital will likely be minimal due to a significant reduction of hospital activity occurring at night. In particular,

- Night shifts with a reduction of staffing generally start at 9:00 pm and ends at 7:00 am. Therefore, there is unlikely to be any significant flow of staff vehicles onto surrounding roads during the night period.
- The hospital is not open to visitors at night.
- The hospital does not accept emergency patients.

Given the above, there is unlikely any significant amount of vehicular contribution from the hospital on surrounding roads at night.

8. ASSESSMENT OF NOISE AND VIBRATION DURING CONSTRUCTION

As the details of construction methods and timeline are not finalised at this stage, only an indicative assessment of noise and vibration during construction could be undertaken. This indicative assessment is made in accordance with the EPA's Interim Construction Noise Guidelines (ICNG) and Assessing Vibrations: A Technical Guideline.

8.1. Construction Phasing

Construction on site is proposed in three phases, as indicated in Figure 4and described below.

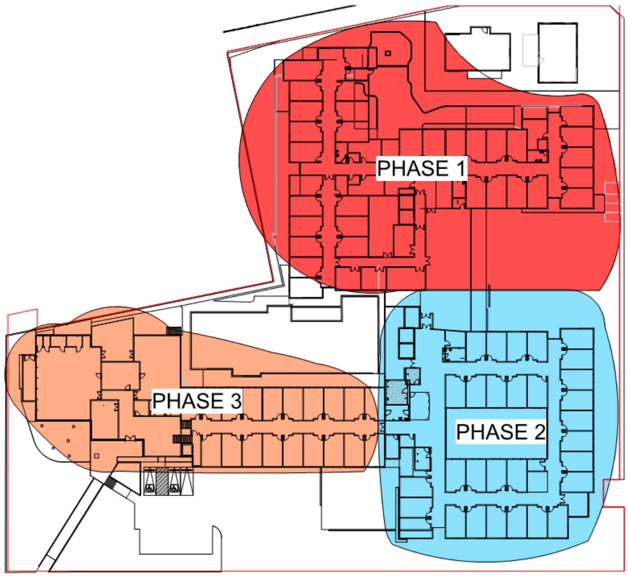


Figure 4. Diagram showing proposed phases of construction

- Phase 1 — construction of the north wing of the hospital, which includes the store, kitchen, loading dock, staff areas and admin on the ground floor and 36 beds on the first floor.
- Phase 2 — construction of the east wing of the hospital, which includes 30 beds on the ground floor and 36 beds on the first floor
- Phase 3 — construction of the west wing of the hospital, which includes the wellness centre, operating theatre refurbishment, the group psychoeducation (GPE) and radiology

Each of these stages involves the demolition of existing structures, excavation of earth, erection of building structures and fit-out.

Of all these phases, excavation and demolition on site is expected to generate the highest level of noise and vibration. Heavy machineries used during these phases can emit sound power levels of approximately 118 dB L_{wA}.

During the erection of the building structure, concrete pumps and hand tools such as angle grinders will emit the highest sound power levels of approximately 105 dB L_{wA}.

After the building shell has been erected, construction noise levels are expected to be further reduced as tools and equipment with lower power output are used to fit-out the building. The noise emitted by these tools are further reduced by shielding provided by the erected building. It is unlikely that noise levels at this stage will exceed EPA guideline levels.

8.2. Duration

At the time of writing, the estimated duration of construction works was not known.

8.3. Working Hours

The proposed construction hours are in accordance with the EPA's ICNG recommended standard hours, which are,

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

8.4. Construction Equipment

As construction method and equipment has not been finalised at this stage, we have assessed the noisiest construction equipment that is likely to be used during the demolition, excavation and construction stages. Table 26 lists the A-weighted sound power levels (long-term energy average) of this machinery.

Machine	Sound Power Level L_{wA}
Excavator with rock breaker	118
Excavator with bucket attachment	118
Concrete Pump	108
Concrete Mixer/Truck	109
Hand-held Power Tools	103
Roller / Vibrating Compactor	113
Truck (>20 tonnes)	107

Table 26 Sound power levels (SWL) of machinery estimated to be employed.

It is sometimes possible to equate a lower period of use of a particular machine with a lower effective noise level over a fifteen-minute period. For example, if an excavator was used for half of a fifteen-minute period, then its effective noise level over the full fifteen-minute period would be 3 dB lower than stated in Table 26. Although the use of these machines is intermittent, there is a possibility that they could be used for a complete given fifteen-minute sampling period and therefore no adjustments are made to the levels to account for reduced operation.

8.5. Estimated Construction Noise Levels

Using the sound power level data for the machines shown in Table 26, the levels reaching surrounding receivers were estimated using the distances between the receiver and the closest and furthest position that the machines are likely to occupy. We have assumed that concrete pumps will be positioned along either President Avenue or Hotham Road.

As the results showed significant exceedances of the noise goals, a noise barrier of 2.4 m height was introduced into the calculations surrounding each of the phases of construction. The selection of this height is based on a typical height of hoarding. Such a barrier would be implemented using a temporary hoarding or screen.

The estimated levels were then compared with the noise goals of Section 4.1.1.

The following tables show the results.

- Table 27 and Table 28: Phase 1 calculated levels of construction noise to nearest receivers with 2.4 m high barrier around Phase 1 site.
- Table 29 and Table 30: Phase 2 calculated levels of construction noise to nearest receivers with 2.4 m high barrier around Phase 2 site.
- Table 31 and Table 32: Phase 3 calculated levels of construction noise to nearest receivers R1-R6 with 2.4 m high barrier around Phase 3 site.

Note (*): for presentation, an external criterion for the hospital is presented in the tables below, which assumes that an open window provides approximately 10 dB of noise reduction and thus resulting in a 55 dB external criterion.

Table 27. Phase 1 calculated levels of construction noise to nearest receivers R1-R6 with 2.4 m high barrier around Phase 1 site.

ESTIMATED $L_{Aeq,15min}$ NOISE LEVELS - PHASE 1, R1-R6						
Receiver	Machine	Level with closest source	Level with furthest source	Noise Affected Threshold	Exceedance with closest source	Exceedance with furthest source
	Excavator with rock breaker	77	63		28	14
	Excavator with bucket attachment	77	63		28	14
	Concrete Pump	52	53		3	4
R1	Concrete Mixer/Truck	53	54	49	4	5
	Hand-held Power Tools	61	47		12	-2
	Roller / Vibrating Compactor	71	57		22	8
	Truck >20 tonnes	65	51		16	2
	Excavator with rock breaker	88	67		35	14
	Excavator with bucket attachment	88	67		35	14
	Concrete Pump	58	59		5	6
R2	Concrete Mixer/Truck	59	60	53	6	7
	Hand-held Power Tools	71	51		18	-2
	Roller / Vibrating Compactor	81	61		28	8
	Truck >20 tonnes	76	55		23	2
	Excavator with rock breaker	71	62		18	9
	Excavator with bucket attachment	71	62		18	9
	Concrete Pump	58	59		5	6
R3	Concrete Mixer/Truck	59	60	53	6	7
	Hand-held Power Tools	55	46		2	-7
	Roller / Vibrating Compactor	65	56		12	3
	Truck >20 tonnes	59	50		6	-3
	Excavator with rock breaker	74	62		21	9
	Excavator with bucket attachment	74	62		21	9
	Concrete Pump	64	66		11	13
R4	Concrete Mixer/Truck	65	67	53	12	14
	Hand-held Power Tools	57	46		4	-7
	Roller / Vibrating Compactor	67	56		14	3
	Truck >20 tonnes	62	50		9	-3
	Excavator with rock breaker	67	60		11	4
	Excavator with bucket attachment	67	60		11	4
	Concrete Pump	58	59		2	3
R5	Concrete Mixer/Truck	59	60	56	3	4
	Hand-held Power Tools	50	43		-6	-13
	Roller / Vibrating Compactor	60	53		4	-3
	Truck >20 tonnes	55	48		-1	-8
	Excavator with rock breaker	59	57		9	7
	Excavator with bucket attachment	59	57		9	7
	Concrete Pump	50	52		0	2
R6	Concrete Mixer/Truck	51	53	56	1	3
	Hand-held Power Tools	43	41		-7	-9
	Roller / Vibrating Compactor	53	51		3	1
	Truck >20 tonnes	47	46		-3	-4

Table 28. Phase 1 calculated levels of construction noise to nearest receivers R7-R10 and Commercial receivers with 2.4 m high barrier around Phase 1 site. Exceedances are shown in red.

ESTIMATED $L_{Aeq,15min}$ NOISE LEVELS - PHASE 1, R7-R10 & COMMERCIAL RECEIVERS						
Receiver	Machine	Level with closest source	Level with furthest source	Noise Affected Threshold	Exceedance with closest source	Exceedance with furthest source
R7	Excavator with rock breaker	62	59	56	6	3
	Excavator with bucket attachment	62	59		6	3
	Concrete Pump	52	52		-4	-4
	Concrete Mixer/Truck	53	53		-3	-3
	Hand-held Power Tools	45	43		-11	-13
	Roller / Vibrating Compactor	55	53		-1	-3
	Truck >20 tonnes	49	47		-7	-9
R8	Excavator with rock breaker	62	57	56	6	1
	Excavator with bucket attachment	62	57		6	1
	Concrete Pump	49	49		-7	-7
	Concrete Mixer/Truck	50	50		-6	-6
	Hand-held Power Tools	45	41		-11	-15
	Roller / Vibrating Compactor	55	51		-1	-5
	Truck >20 tonnes	50	46		-6	-10
R9	Excavator with rock breaker	64	58	56	8	2
	Excavator with bucket attachment	64	58		8	2
	Concrete Pump	49	50		-7	-6
	Concrete Mixer/Truck	50	51		-6	-5
	Hand-held Power Tools	48	42		-8	-14
	Roller / Vibrating Compactor	58	52		2	-4
	Truck >20 tonnes	52	47		-4	-9
R10	Excavator with rock breaker	88	64	49	39	15
	Excavator with bucket attachment	88	64		39	15
	Concrete Pump	53	55		4	6
	Concrete Mixer/Truck	54	56		5	7
	Hand-held Power Tools	71	48		22	-1
	Roller / Vibrating Compactor	81	58		32	9
	Truck >20 tonnes	76	52		27	3
C1	Excavator with rock breaker	69	61	70	-1	-9
	Excavator with bucket attachment	69	61		-1	-9
	Concrete Pump	60	63		-10	-7
	Concrete Mixer/Truck	61	64		-9	-6
	Hand-held Power Tools	53	44		-17	-26
	Roller / Vibrating Compactor	63	54		-7	-16
	Truck >20 tonnes	57	49		-13	-21
Hospital	Excavator with rock breaker	86	64	55* (see note on page 21)	31	9
	Excavator with bucket attachment	86	64		31	9
	Concrete Pump	61	63		6	8
	Concrete Mixer/Truck	62	64		7	9
	Hand-held Power Tools	70	47		15	-8
	Roller / Vibrating Compactor	80	57		25	2
	Truck >20 tonnes	74	52		19	-3

Table 29. Phase 2 calculated levels of construction noise to nearest receivers R1-R6 with 2.4 m high barrier around Phase 2 site. Exceedances are shown in red.

ESTIMATED $L_{Aeq,15min}$ NOISE LEVELS - PHASE 2, R1-R6						
Receiver	Machine	Level with closest source	Level with furthest source	Noise Affected Threshold	Exceedance with closest source	Exceedance with furthest source
R1	Excavator with rock breaker	64	60	49	15	11
	Excavator with bucket attachment	64	60		15	11
	Concrete Pump	49	50		0	1
	Concrete Mixer/Truck	50	51		1	2
	Hand-held Power Tools	48	43		-1	-6
	Roller / Vibrating Compactor	58	53		9	4
	Truck >20 tonnes	52	48		3	-1
R2	Excavator with rock breaker	68	62	53	15	9
	Excavator with bucket attachment	68	62		15	9
	Concrete Pump	52	53		-1	0
	Concrete Mixer/Truck	53	54		0	1
	Hand-held Power Tools	51	46		-2	-7
	Roller / Vibrating Compactor	61	56		8	3
	Truck >20 tonnes	56	51		3	-2
R3	Excavator with rock breaker	66	60	53	13	7
	Excavator with bucket attachment	66	60		13	7
	Concrete Pump	50	51		-3	-2
	Concrete Mixer/Truck	51	52		-2	-1
	Hand-held Power Tools	49	44		-4	-9
	Roller / Vibrating Compactor	59	54		6	1
	Truck >20 tonnes	54	48		1	-5
R4	Excavator with rock breaker	75	63	53	22	10
	Excavator with bucket attachment	75	63		22	10
	Concrete Pump	55	56		2	3
	Concrete Mixer/Truck	56	57		3	4
	Hand-held Power Tools	58	47		5	-6
	Roller / Vibrating Compactor	68	57		15	4
	Truck >20 tonnes	63	52		10	-1
R5	Excavator with rock breaker	69	61	56	13	5
	Excavator with bucket attachment	69	61		13	5
	Concrete Pump	54	55		-2	-1
	Concrete Mixer/Truck	55	56		-1	0
	Hand-held Power Tools	52	45		-4	-11
	Roller / Vibrating Compactor	62	55		6	-1
	Truck >20 tonnes	57	50		1	-6
R6	Excavator with rock breaker	66	61	56	10	5
	Excavator with bucket attachment	66	61		10	5
	Concrete Pump	54	56		-2	0
	Concrete Mixer/Truck	55	57		-1	1
	Hand-held Power Tools	50	44		-6	-12
	Roller / Vibrating Compactor	60	54		4	-2
	Truck >20 tonnes	54	49		-2	-7

Table 30. Phase 2 calculated levels of construction noise to nearest receivers R7-R10 and Commercial receivers with 2.4 m high barrier around Phase 2 site. Exceedances are shown in red.

ESTIMATED $L_{Aeq,15min}$ NOISE LEVELS - PHASE 2, R7-R10 & COMMERCIAL RECEIVERS						
Receiver	Machine	Level with closest source	Level with furthest source	Noise Affected Threshold	Exceedance with closest source	Exceedance with furthest source
R7	Excavator with rock breaker	71	63	56	15	7
	Excavator with bucket attachment	71	63		15	7
	Concrete Pump	61	62		5	6
	Concrete Mixer/Truck	62	63		6	7
	Hand-held Power Tools	54	46		-2	-10
	Roller / Vibrating Compactor	64	56		8	0
	Truck >20 tonnes	58	51		2	-5
R8	Excavator with rock breaker	65	60	56	9	4
	Excavator with bucket attachment	65	60		9	4
	Concrete Pump	53	53		-3	-3
	Concrete Mixer/Truck	54	54		-2	-2
	Hand-held Power Tools	49	43		-7	-13
	Roller / Vibrating Compactor	59	53		3	-3
	Truck >20 tonnes	53	48		-3	-8
R9	Excavator with rock breaker	61	60	56	5	4
	Excavator with bucket attachment	61	60		5	4
	Concrete Pump	50	52		-6	-4
	Concrete Mixer/Truck	51	53		-5	-3
	Hand-held Power Tools	45	44		-11	-12
	Roller / Vibrating Compactor	55	54		-1	-2
	Truck >20 tonnes	49	48		-7	-8
R10	Excavator with rock breaker	72	63	49	23	14
	Excavator with bucket attachment	72	63		23	14
	Concrete Pump	53	54		4	5
	Concrete Mixer/Truck	54	55		5	6
	Hand-held Power Tools	56	47		7	-2
	Roller / Vibrating Compactor	66	57		17	8
	Truck >20 tonnes	60	51		11	2
C1	Excavator with rock breaker	72	65	70	2	-5
	Excavator with bucket attachment	72	65		2	-5
	Concrete Pump	58	67		-12	-3
	Concrete Mixer/Truck	59	68		-11	-2
	Hand-held Power Tools	55	49		-15	-21
	Roller / Vibrating Compactor	65	59		-5	-11
	Truck >20 tonnes	60	53		-10	-17
Hospital	Excavator with rock breaker	82	63	55* (see note on page 21)	27	8
	Excavator with bucket attachment	82	63		27	8
	Concrete Pump	52	54		-3	-1
	Concrete Mixer/Truck	53	55		-2	0
	Hand-held Power Tools	66	47		11	-8
	Roller / Vibrating Compactor	76	57		21	2
	Truck >20 tonnes	70	51		15	-4

Table 31. Phase 3 calculated levels of construction noise to nearest receivers R1-R6 with 2.4 m high barrier around Phase 3 site. Exceedances are shown in red.

ESTIMATED $L_{Aeq,15min}$ NOISE LEVELS - Phase 3, R1-R6						
Receiver	**Machine**	**Level with closest source**	**Level with furthest source**	**Noise Affected Threshold**	**Exceedance with closest source**	**Exceedance with furthest source**
R1	Excavator with rock breaker	63	60	49	14	11
	Excavator with bucket attachment	63	60		14	11
	Concrete Pump	48	50		-1	1
	Concrete Mixer/Truck	49	51		0	2
	Hand-held Power Tools	47	44		-2	-5
	Roller / Vibrating Compactor	57	54		8	5
	Truck >20 tonnes	51	48		2	-1
R2	Excavator with rock breaker	63	59	53	10	6
	Excavator with bucket attachment	63	59		10	6
	Concrete Pump	50	52		-3	-1
	Concrete Mixer/Truck	51	53		-2	0
	Hand-held Power Tools	46	43		-7	-10
	Roller / Vibrating Compactor	56	53		3	0
	Truck >20 tonnes	51	47		-2	-6
R3	Excavator with rock breaker	64	58	53	11	5
	Excavator with bucket attachment	64	58		11	5
	Concrete Pump	51	51		-2	-2
	Concrete Mixer/Truck	52	52		-1	-1
	Hand-held Power Tools	50	44		-3	-9
	Roller / Vibrating Compactor	60	54		7	1
	Truck >20 tonnes	54	48		1	-5
R4	Excavator with rock breaker	64	59	53	11	6
	Excavator with bucket attachment	64	59		11	6
	Concrete Pump	49	50		-4	-3
	Concrete Mixer/Truck	50	51		-3	-2
	Hand-held Power Tools	47	42		-6	-11
	Roller / Vibrating Compactor	57	52		4	-1
	Truck >20 tonnes	52	47		-1	-6
R5	Excavator with rock breaker	61	58	56	5	2
	Excavator with bucket attachment	61	58		5	2
	Concrete Pump	49	50		-7	-6
	Concrete Mixer/Truck	50	51		-6	-5
	Hand-held Power Tools	45	42		-11	-14
	Roller / Vibrating Compactor	55	52		-1	-4
	Truck >20 tonnes	49	46		-7	-10
R6	Excavator with rock breaker	63	57	56	7	1
	Excavator with bucket attachment	63	57		7	1
	Concrete Pump	50	51		-6	-5
	Concrete Mixer/Truck	51	52		-5	-4
	Hand-held Power Tools	46	41		-10	-15
	Roller / Vibrating Compactor	56	51		0	-5
	Truck >20 tonnes	51	46		-5	-10

Table 32. Phase 3 calculated levels of construction noise to nearest receivers R7-R10 and Commercial receivers with 2.4 m high barrier around Phase 3 site. Exceedances are shown in red.

ESTIMATED $L_{Aeq,15min}$ NOISE LEVELS - Phase 3, R7-R10 & Commercial Receivers						
Receiver	Machine	Level with closest source	Level with furthest source	Noise Affected Threshold	Exceedance with closest source	Exceedance with furthest source
R7	Excavator with rock breaker	70	62	56	14	6
	Excavator with bucket attachment	70	62		14	6
	Concrete Pump	60	62		4	6
	Concrete Mixer/Truck	61	63		5	7
	Hand-held Power Tools	54	45		-2	-11
	Roller / Vibrating Compactor	64	55		8	-1
	Truck >20 tonnes	58	50		2	-6
R8	Excavator with rock breaker	70	63	56	14	7
	Excavator with bucket attachment	70	63		14	7
	Concrete Pump	60	62		4	6
	Concrete Mixer/Truck	61	63		5	7
	Hand-held Power Tools	53	47		-3	-9
	Roller / Vibrating Compactor	63	57		7	1
	Truck >20 tonnes	58	51		2	-5
R9	Excavator with rock breaker	87	64	56	31	8
	Excavator with bucket attachment	87	64		31	8
	Concrete Pump	56	58		0	2
	Concrete Mixer/Truck	57	59		1	3
	Hand-held Power Tools	71	47		15	-9
	Roller / Vibrating Compactor	81	57		25	1
	Truck >20 tonnes	75	52		19	-4
R10	Excavator with rock breaker	86	66	49	37	17
	Excavator with bucket attachment	86	66		37	17
	Concrete Pump	54	57		5	8
	Concrete Mixer/Truck	55	58		6	9
	Hand-held Power Tools	70	50		21	1
	Roller / Vibrating Compactor	80	60		31	11
	Truck >20 tonnes	74	54		25	5
C1	Excavator with rock breaker	62	59	70	-8	-11
	Excavator with bucket attachment	62	59		-8	-11
	Concrete Pump	48	51		-22	-19
	Concrete Mixer/Truck	49	52		-21	-18
	Hand-held Power Tools	46	42		-24	-28
	Roller / Vibrating Compactor	56	52		-14	-18
	Truck >20 tonnes	50	47		-20	-23
Hospital	Excavator with rock breaker	86	62	55* (see note on page 21)	31	7
	Excavator with bucket attachment	86	62		31	7
	Concrete Pump	56	58		1	3
	Concrete Mixer/Truck	57	59		2	4
	Hand-held Power Tools	70	46		15	-9
	Roller / Vibrating Compactor	80	56		25	1
	Truck >20 tonnes	74	50		19	-5

8.5.1 Discussion of Construction Noise at Surrounding Receivers

a) The estimated noise levels show that all receivers will receive noise levels from construction work exceeding the “Noise Affected” management level of the ICNG.

b) Residences at R5 and R6, which are furthest away from site will be least affected by noise from construction works and will only receive levels exceeding the “Noise Affected” level during use of loud machinery such as excavators during demolition and excavation. At other times, these receivers are likely to receive levels below the “Noise Affected” threshold and adverse reaction to construction noise is unlikely.

c) Residences separated from site by either Bidurgal Avenue, Hotham Road or President Avenue (R1, R3, R4, R5, R7, R8) will receive higher levels of construction noise and will receive noise exceeding the “Noise Affected” level during construction. Predictions show that when loud machinery such as excavators are used close to these receivers, levels may exceed the “Highly Noise Affected” level (>75 dB $L_{Aeq,15min}$)

d) Residences adjacent to hospital with no distance separation (R2, R9 R10) and the hospital itself will receive the highest levels of construction noise. The noise prediction indicates that when high-noise construction activities occur close to these noise receivers, noise levels may exceeding 80 dB $L_{Aeq,15min.}$

e) The skin clinic (C1) opposite Hotham Street will be the least affected noise receiver due to the higher tolerance of noise for work-related activities on site rather than being a place of rest. Construction noise levels at this receiver are expected to be below the “Noise Affected” level for Phase 1 and 3, but may at times exceed this level during Phase 2 when demolition and excavation works occur closer towards the Hotham Road boundary.

f) As construction noise levels are likely to exceed the “Noise Affected” level at surrounding noise receivers, there may be some community reaction to works on site. Communication with these affected receivers (including but not limited to those identified in this assessment) should be undertaken to inform them of the nature of construction works to be carried out, and the expected level of noise and duration. All noisy activities on site shall be reviewed to minimise the extent of noise impact to surrounding receivers via all feasible and reasonable work methods, e.g., erection of temporary enclosures around noisy equipment or substituting noisy machineries or work methods with quieter alternatives.

g) Where high-noise activities must occur on site that is likely to result in noise levels above 75 dB $L_{Aeq,15min}$ at noise receivers, i.e., above the ICNG Highly Noise Affected Level threshold, a proactive approach must be taken to manage the level of noise impact the activities will have on surrounding neighbours. Respite periods should be considered and arranged in consultation with the affected noise receivers to identify times where these activities can occur with the least noise impact, such as when there are less noise-sensitive activities occurring within the hospital, or when occupants of surrounding residences are least likely to be at home.

Recommendations for managing construction noise are provided in Section 9.3.

8.6. Vibration Levels

Demolition of the existing structure and excavation works will be the primary vibration generating activity on site during construction. In comparison, the erection of the building structure and fit-out stages of construction will generate vibration levels of a lower magnitude.

Given that the hospital is proposed to continue to operate at a reduced capacity during construction works, construction activities that are likely to generate high levels of vibration will occur concurrent to the operations of the hospital, affecting staff, visitors and patients within the hospital. These vibration levels are likely to exceed the EPA criteria.

Other receivers that are likely to receive high levels of vibration are receivers directly adjacent to the hospital, i.e., R2, R9 and R10. Other receivers will receive a lower level of vibration as they are separated from the construction site by a road.

A review of construction methods shall be undertaken so that reasonable and feasible measures to reduce vibration levels to surrounding receivers are undertaken. Vibration monitoring is also recommended at sensitive vibration receiver locations, i.e., at the hospital boundaries and residences adjacent to the construction site. so that any exceedances to the EPA guideline can be logged and monitored and prompt action can be taken where exceedance to EPA vibration levels occur to protect the amenity of occupants near the construction site.

Recommendations for managing construction vibration is provided in Section Section 9.3.

9. RECOMMENDATIONS

9.1. Design Recommendations

9.1.1 Acoustic Louvres

To minimise noise emissions from the loading dock, acoustic louvres shall be installed along the western opening on the ground floor car park between the loading dock area and receivers along Bidurgal Street (receiver R10). The acoustic louvres shall be rated to provide the following noise insertion loss:

Table 33. Required noise insertion loss performance of acoustic louvres

Construction	Insertion Loss (dB)						
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Acoustic Louvre	9	14	22	27	33	33	30

9.1.2 Mechanical Review at Detailed Design Stage

A full review of mechanical noise emissions from the hospital shall be undertaken during detailed design stage to determine in conjunction with equipment selections the extent of acoustic treatment required to comply with EPA NPI requirements.

9.1.3 Traffic Noise Review at Detailed Design Stage

A detailed assessment of traffic noise intrusion and mechanical noise intrusion into the internal areas of the hospital shall be undertaken in detailed design stage to meet the design requirements from NSW Planning "Development Near Rail Corridors and Busy Roads" and AS2107-2016.

9.2. Operational Recommendations

9.2.1 Ambulance Access at Night

To protect the noise amenity of residences at night, ambulances shall only access the hospital via the entry along President Avenue or the southern entry along Hotham Road.

9.2.2 Loading Dock

To protect the noise amenity of residence adjacent to the loading dock, the usage of the loading dock for delivery shall be limited to the following hours:

- Between 7 am and 6 pm Monday to Saturday or
- Between 8 am and 6 pm Sunday or public holidays.

9.3. Noise and Vibration Management Actions During Construction

Given that the estimated construction noise levels indicate a considerable risk for receivers to be highly affected by noise from construction machinery, it is essential that noise produced during construction be rigorously managed.

Vibration levels shall also be rigorously managed given the close proximity of construction site to the hospital and other surrounding vibration receivers.

This section identifies a range of noise and vibration measures that should be implemented to minimise adverse impacts to nearby residences.

9.3.1 General

a) Equipment shall be well maintained.

b) Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.

c) Stationary equipment shall be located as far as possible from residence as practicable and are to be screened by enclosures.

9.3.2 Involve workers in minimising noise

a) Avoid dropping materials from a height.

b) Talk to workers about how noise and vibration can be reduced.

c) Avoid any unnecessary noise when carrying out the work. Site supervisors should be made aware to implement this seemingly obvious action.

d) Any equipment not in use for extended periods should be switched off.

9.3.3 Noise Barrier

Hoarding or a noise barrier of at least 2.4 m high should be installed along the perimeter of the construction site during each phase of works to provide noise shielding to surrounding noise receivers.

Where practical and possible, loud mobile equipment located near noise receivers should be enclosed in a temporary acoustic screen.

The barrier should be constructed from heavy material such as 15 mm thick plywood or 9 mm fibre cement.

9.3.4 Respite Periods

Consultation with the hospital, the skin clinic and surrounding residences shall be undertaken to negotiate whether a respite period can provide any benefit during construction, especially during works that emit high levels of noise and vibration such as excavating or hammering.

As an example, noisy activities-such as pneumatic hammering and excavation can be restricted to the periods of 9 am to 12 pm Monday to Saturday and 2pm to 5pm Monday to Friday to provide respite to surrounding residents.

We note that at certain instances, allowing the construction activities to proceed without a respite period despite the noise exceedance may be the preferred method, so the total period in which the surrounding community are exposed to noise is minimised.

9.3.5 Truck Movements

a) Access to the site for trucks should be along President Avenue near Hotham Street where possible.

b) Trucks shall not arrive to site earlier than permitted construction hours.

c) Concrete mixer and pumping trucks should deliver concrete from within the boundary of the construction site and close to President Avenue where possible so that the acoustic barrier effect of the hoarding is maximised and the vehicles are positioned away from quieter areas of the neighbourhood.

d) Large trucks and concrete trucks should turn off their engines when parked.

9.3.6 Community Liaison and Management of Complaints

a) Good relations with the hospital, residents and any other surrounding businesses should be established at the beginning of the works and be maintained through the works as this is of paramount importance.

b) Consult with the most affected neighbours about how effective the proposed noise mitigation measures will be in addressing their concerns.

c) Ensure the community is informed about:

- periods when noisy work such as pneumatic hammering or excavation will occur and respite times
- total construction period
- what is being done to minimise noise
- construction progress
- the contractor's contact details for the community liaison managing any complaints

d) A contact number for complaints should be established for the community to inform the site of unsatisfactorily high noise levels. This number should be displayed clearly on signs at the site perimeter.

e) A person with the correct skills should be selected to liaise with community.

f) Ensure the staff who receive telephone complaints are informed about current and upcoming works and the relevant contacts for these works.

g) A complaint-handling procedure should be implemented and a complaint form prepared.

h) Complaints made by the surrounding community should be taken seriously and addressed quickly.

Each complaint should be investigated to determine if the specified and agreed construction processes have been followed. If the noise level that is causing the complaint is found to be unexpected, appropriate noise amelioration measures should be investigated and if feasible and reasonable, those measures should be implemented.

i) Keep a register of any complaints, including details of the complaint such as date, time, person receiving complaint, complainant's contact number, person referred to, description of the complaint, time of verbal response and timeframe for written response where appropriate.

j) In the event of a number of complaints being received, the process shown graphically in Appendix B should be followed.

9.3.7 Noise and Vibration Monitoring

a) If complaints from the community are received concerning noise or vibration levels or authorities have concerns regarding the noise and/or vibration impact on the community, it is recommended that attended measurements of construction noise and/or be undertaken in the early stages of construction.

b) Measurements shall be undertaken in accordance with the procedure outlined in Section 9.3.8 below and Section 5.6 in Australian Standard AS 2436-2010 "Guide to noise and vibration control on construction, demolition and maintenance sites".

c) Operator-attended measurements should be conducted near or at the locations of concern.

d) If noise or vibration levels require ongoing management, a logger should be installed at the location of concern.

9.3.8 Requirements for Noise Measurements

A noise measuring equipment must be at least a Type 2 instrument as described in Australian Standard 1259.2-1990 ''Acoustics - Sound Level Meters'' and calibrated to standards that are traceable to Australian physical Standards held by the National Measurement Laboratory (CSIRO division of Applied Physics). The calibration of the monitoring equipment shall also be checked in the field before and after the noise measurement period, and in the case of noise loggers, calibration levels shall be checked at minimum weekly intervals.

The operator may either retrieve the data at the location of each monitoring period either in person or via remote access via the internet or phone.

All noise measurements shall be taken with the following meter settings:

- Time constant - Fast (i.e. 125 milliseconds)
- Frequency weightings - A-weighting
- Sample period - 15 minutes
- All outdoor noise measurements shall be undertaken with a windscreen over the microphone.

The minimum range of noise to be measured by an operator or noise logger is $L_{Aeq,}$ $L_{Amax,}$ L_{A1} and L_{A90}. Noise measurements should be discarded when it is raining or if the wind speed exceeds 5 m/s (18 km/hr).

The following data shall be recorded by the operator:

- Wind velocity and weather conditions
- Date and time of measurement
- Location
- Instrument field calibration checks
- Description of audible noise sources

10. CONCLUSIONS

This report presents the findings of our acoustic assessment of the proposed additions and alterations to President Private Hospital, Kirrawee. Our assessment has considered acoustical issues arising from the operation and construction of the proposed hospital complex and has addressed the requirements from SEARs Items 9.

We conclude that with our recommendations provided in Section 9 of this report, that:

a) Mechanical noise emissions from the future hospital complies with the criteria from the EPA Noise Policy for Industry.

b) The increase of vehicular traffic on surrounding roads resulting from the proposed changes to tge hospital is unlikely to contribute to a noticeable increase in noise level and as such, complies with the EPA Road Noise Policy.

c) Vehicular noise on site including from ambulance movements, the use of the loading dock and other general vehicle access will not generate levels exceeding the noise criteria from the EPA Noise Policy for Industry and is unlikely to adversely disturb noise receivers surrounding the hospital.

Due to the proximity of the hospital to surrounding land uses, noise and vibration levels emitted from work activities during construction are likely to cause adverse reaction from the community and should be proactively managed and monitored to minimise the impacts on nearby residents.

11. APPENDIX A – GLOSSARY OF ACOUSTIC TERMS

11.1. Index to Terms

The glossary is arranged alphabetically to assist readers to find the required information by clicking on the link.

11.2. Glossary

SOUND

Sound is an instantaneous fluctuation in air pressure over the static ambient pressure, and is transmitted as a wave through air or solid structures.

SOUND PRESSURE LEVEL

Commonly known as "sound level", the sound pressure level in air is the sound pressure relative to a standard reference pressure of 20µPa (20x10-6 Pascals) when converted to a decibel scale.

DECIBEL (dB)

A scale for comparing the ratios of two quantities, including sound pressure and sound power.

The ratio of sound pressures which we can hear is a ratio of 106:1 (one million to one). To measure this huge range in pressure, a logarithmic measurement scale is used with the associated unit being the decibel (dB).

An increase or decrease of approximately 10 dB corresponds to an approximate subjective doubling or halving of the loudness of a sound. A change of 2 to 3 dB is subjectively a small change and may sometimes be difficult to perceive.

As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply to dB values.

The difference in level between two sounds s1 and s2 is given by 20 log10 (s1 / s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa.

SOUND POWER

The sound power level (Lw) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (Lp) varies as a function of distance from a source or other factors such as shielding. However, the sound power level is an intrinsic characteristic of a source.

FREQUENCY

Frequency is the rate of repetition of a sound wave. The subjective equivalent of frequency in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to the number of cycles per second. A thousand hertz is often denoted kiloHertz (kHz), e.g. 2 kHz = 2000 Hz.

Human hearing ranges from approximately 20 Hz to 20 kHz.

OCTAVE BAND

The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the octave band below it. In subjective terms, it corresponds to a doubling of pitch.

For design purposes, the octave bands ranging from 31.5 Hz to 8 kHz are generally used. For more detailed analysis, each octave band may be split into three one-third octave bands or, in some cases, narrow frequency bands.

A-WEIGHTED SOUND LEVEL dBA

The unit of sound level, weighted according to the A scale, which takes into account the increased sensitivity of the human ear at some frequencies. The unit is generally used for measuring environmental, traffic or industrial noise is the A weighted sound pressure level in decibels, denoted dBA.

A weighting is based on the frequency response of the human ear at moderate and low sound levels and has been found to correlate well with human subjective reactions to various sounds.

Sound level meters usually have an A-weighting filter network to allow direct measurement of A-weighted levels.

C-WEIGHTED SOUND LEVEL dBC

As the sound level increases, the ear is better able to hear low frequency sounds, The C-weighting filter allow low frequencies to contribute to the measurement much more than the A weighting filter.

Z-WEIGHTING dBZ

The Zero-weighting is equivalent of non-frequency shaping or weighting the measured sound level, and as no filter is applied to the sound before measurement, it is sometimes referred to as "linear" weighting.

SOUND LEVEL INDICES

Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.

Examples of sound level indices are L_{eq},T Lmax, L_{90}, L_{10} and L_1, which are described below. The reference time period (T) is normally included, e.g. $dBL_{A10,\ 5min}$ or $dBLA_{90,8hr}$.

EQUIVALENT CONTINUOUS SOUND LEVEL (L_{eq})

Another index for assessment for overall noise level is the equivalent continuous sound level, L_{eq}. This is a notional steady level, which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. This allows fluctuating sound levels to be described as a single figure level, which assists description, design and analysis.

The L_{eq} is often A-weighted to remove the contribution of low frequencies, which may be less audible and is written as L_{Aeq}. It can also have no weighting as L_{Zeq} or C-weighting as L_{Ceq}.

L_{max},T - MAXIMUM SOUND LEVEL

A noise level index defined as the maximum noise level during the measurement period duration T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.

L_{90}(T)

A noise level index. The L_{A90} is the sound pressure level measured in dBA that is exceeded for 90% of the time over the measurement period T. In other words, the measured noise levels during the period were greater than this value for 90% of the measurement time period.

L_{90} can be considered to be the "average minimum" noise level and in its A weighted form is often used to describe the background noise a L_{A90}.

L_{A10}(T)

A noise level index. The L_{A10} is the sound pressure level measured in dBA that is exceeded for 10% of the time interval (T). In other words, the measured noise levels during the period were only greater than this value for 10% of the measurement time period.

This is often referred to as the average maximum noise level.

L_{A1}(T)

Refers to the sound pressure level measured in dBA, exceeded for 1% of the time interval (T). This is often used to represent the maximum noise level from a period of measurement, but is not the same as L_{Amax}.

RATING BACKGROUND LEVEL (RBL)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.

ASSESSMENT BACKGROUND LEVEL (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Reverberation Time

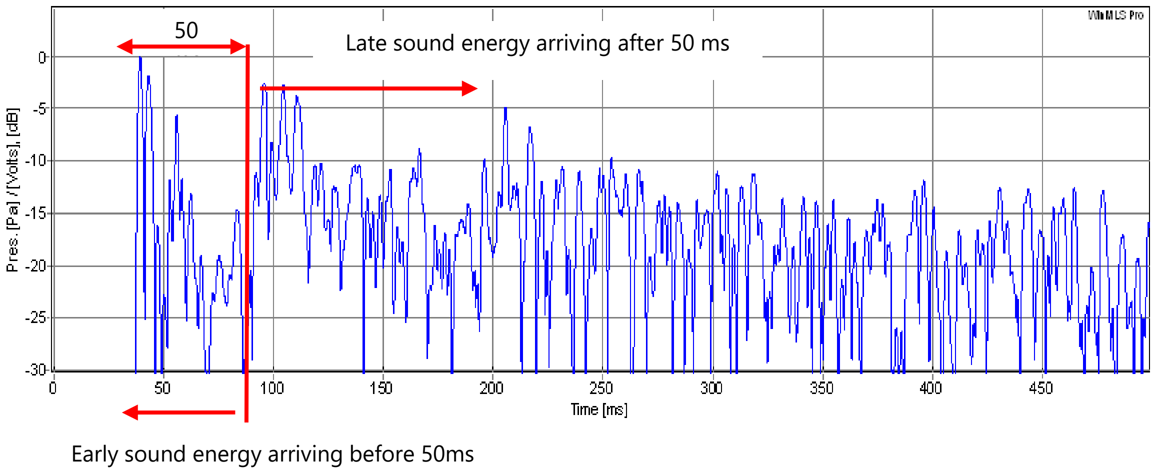
The time in seconds required for the sound at a given frequency to decay away (or reduce to) to one-thousandth of its initial steady-state value after the sound source has been stopped. This degree of reduction is equivalent to 60 decibels.

CLARITY RATIO

The clarity ratio is a metric that is used to assess the degradation in speech intelligibility due to the temporal effects of reverberation and echo. It is defined as the ratio of the sound energy of early-arriving sound that is useful for intelligibility to the energy of late-arriving sound which is not useful. Early-arriving sound consists of the direct sound and some reflections, while late arriving sound consists of reverberation and echoes.

Early-arriving sound consists of sound that arrives between the start of an extremely short pulse (an impulse) up to 50 ms after the start of the pulse, while late arriving sound is the total sound energy arriving later than 50 ms after the start of the pulse.

The following figure shows a typical impulse response and illustrates the dividing period of 50 ms between early and late arriving sound, which is used to compute the C_{50} clarity ratio.



Typical impulse response illustrating how the clarity ratio C_{50} is computed.

As the ear and therefore subjective intelligibility is sensitive to the amount of reverberation and echo at different frequencies, the C_{50} ratios must be as high as possible at all frequencies to maximise intelligibility.

STI - SPEECH TRANSMISSION INDEX

The Speech Transmission Index (STI) is one of the better available metrics to assess the capability of a transmission system to transmit intelligible speech. STI is a single number that ranges between 0 and 1. It attempts to assess the degradation in intelligibility caused by reverberation/echoes and background noise by measuring the reduction in modulation of the speech-like waveform. Phonemes in speech are produced by modulating vocal sounds in a specific pattern, and when perfect transmission of the modulation pattern is present at a listening location, the clarity is perfect. When modulations are corrupted by reverberation or noise, the time pattern of the phonemes is changed and the clarity is degraded.

However, STI has three fundamental weaknesses:

i) It is almost blind to the effects of tonal balance on intelligibility.

ii) It is partially blind to the effects of echo on intelligibility.

iii) It reduces many complex factors (frequency/level/time) into to a single number, thereby concealing important and audible components that contribute to the degradation of speech intelligibility.

To accommodate these weaknesses in STI, Acoustic Directions uses two other metrics (clarity ratios and frequency response) in conjunction with STI to assess speech intelligibility produced by a sound system.

The STI value is computed from weighted MTI values, which represent the loss of modulation in each octave-wide frequency range. When assessing STI performance, it is instructive to assess the loss of modulation in each frequency range by inspecting the associated MTI values.

Given that the majority of speech sounds occur in the 250 Hz and 500 Hz frequency ranges, the MTI values in these frequency ranges are a direct indicator of the smearing or degradation in vowel sounds. In turn, this indicates the extent to which long vowel sounds will subjectively mask sounds with higher frequency content such as consonants.

FREQUENCY RESPONSE

Subjective tonal balance is measured as a system's frequency response at each location. As the ear is very sensitive to the direct sound field (the first-arriving part of the sound before reflections arrive), the response of the direct field with speech must be as consistent as possible over the listening area in the frequency range of 100 Hz to 12 kHz.

EQUIVALENT ACOUSTIC DISTANCE

By amplifying a talker's speech, a sound system reduces the apparent acoustic distance between a talker and distant listener. The equivalent acoustic distance defines the resulting acoustic distance between the talker and listener and is a direct measure of the amount of voice amplification that the system can provide before the onset of acoustic feedback. Feedback is often heard as a strong colouration to the voice or howling sound.

We are accustomed to holding conversations in relatively close proximity, and to produce similar conditions in a courtroom and allow soft talkers to be heard, the EAD should be less than 2.2 m and typically 1.8 m without any trace of feedback or tonal ringing in the sound.

EAD is associated with speech intelligibility as it directly relates to the amount of speech amplification that the system can provide in order to deliver a satisfactory level of speech signal above the noise to each listener.

Factors affecting the EAD include:

- The number of microphones switched on at any time.
- The relationships between the directional response characteristics of the microphone and loudspeaker.
- The sound level reaching the audience at the critical mid and mid-high frequencies.
- Room acoustic behaviour.

VIBRATION

Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structure-borne noise or human comfort issues respectively. Vibration amplitude may be quantified as a peak value, or as a root mean squared (rms) value.

Vibration amplitude can be expressed as an engineering unit value e.g. 1mms-1 or as a ratio on a logarithmic scale in decibels:

Vibration velocity level, LV (dB) = 20 log (V/Vref),

(where the preferred reference level, Vref, for vibration velocity = 10-9 m/s).

The decibel approach has advantages for manipulation and comparison of data.

SOUND ABSORPTION

This is the removal of sound energy from a room or area by conversion into heat.

SOUND ABSORPTION CO-EFFICIENT

Sound absorption co-efficient indicate the extent to which a material absorbs sound power at a specific frequency, and is expressed on a scale of 0 to 1, with a value of 1 representing the maximum possible absorption.

SOUND INSULATION

The sound insulation is the capacity of a structure such as a wall or floor to prevent sound from reaching a receiving location.

SOUND REDUCTION INDEX

This parameter is used to describe the sound insulation properties of a partition, and is the decibel ratio of the airborne sound power incident on the partition to the sound power transmitted by the partition and radiated on the other side. It is usually measured in specific frequency bands, such as octave or one-third octave.

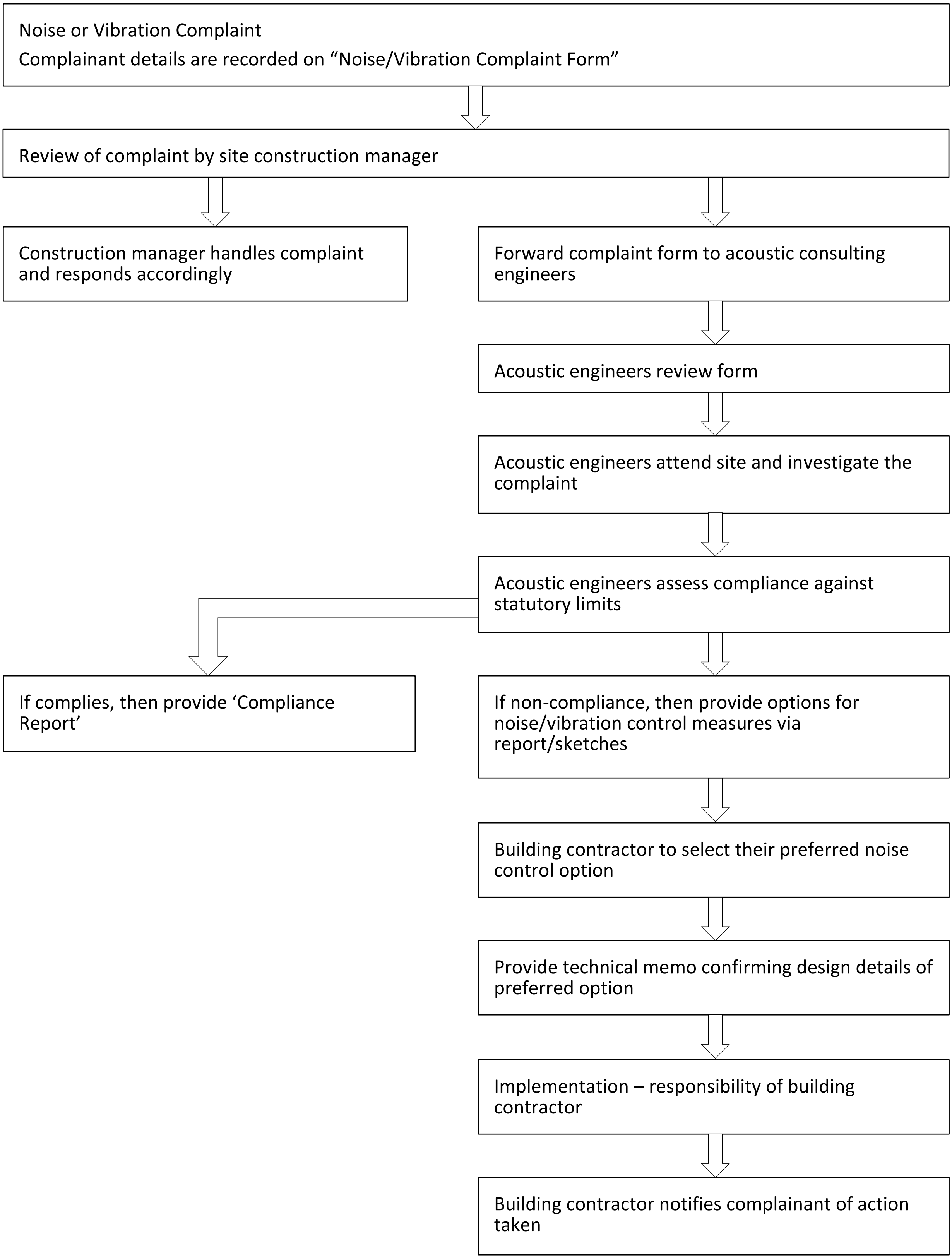
$D_{nT,w}$

The single number quantity that characterises sound insulation between rooms over a range of frequencies with airborne sound.

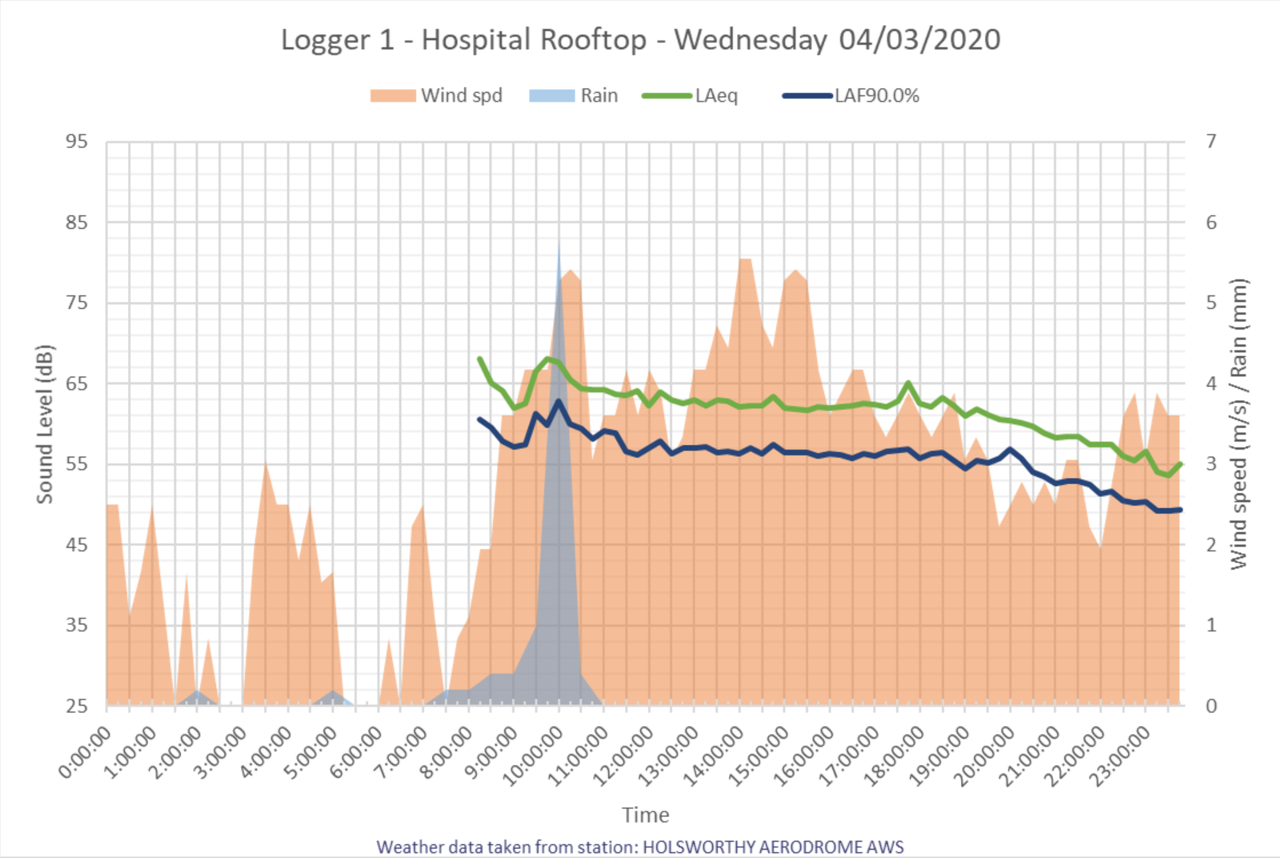
R_w

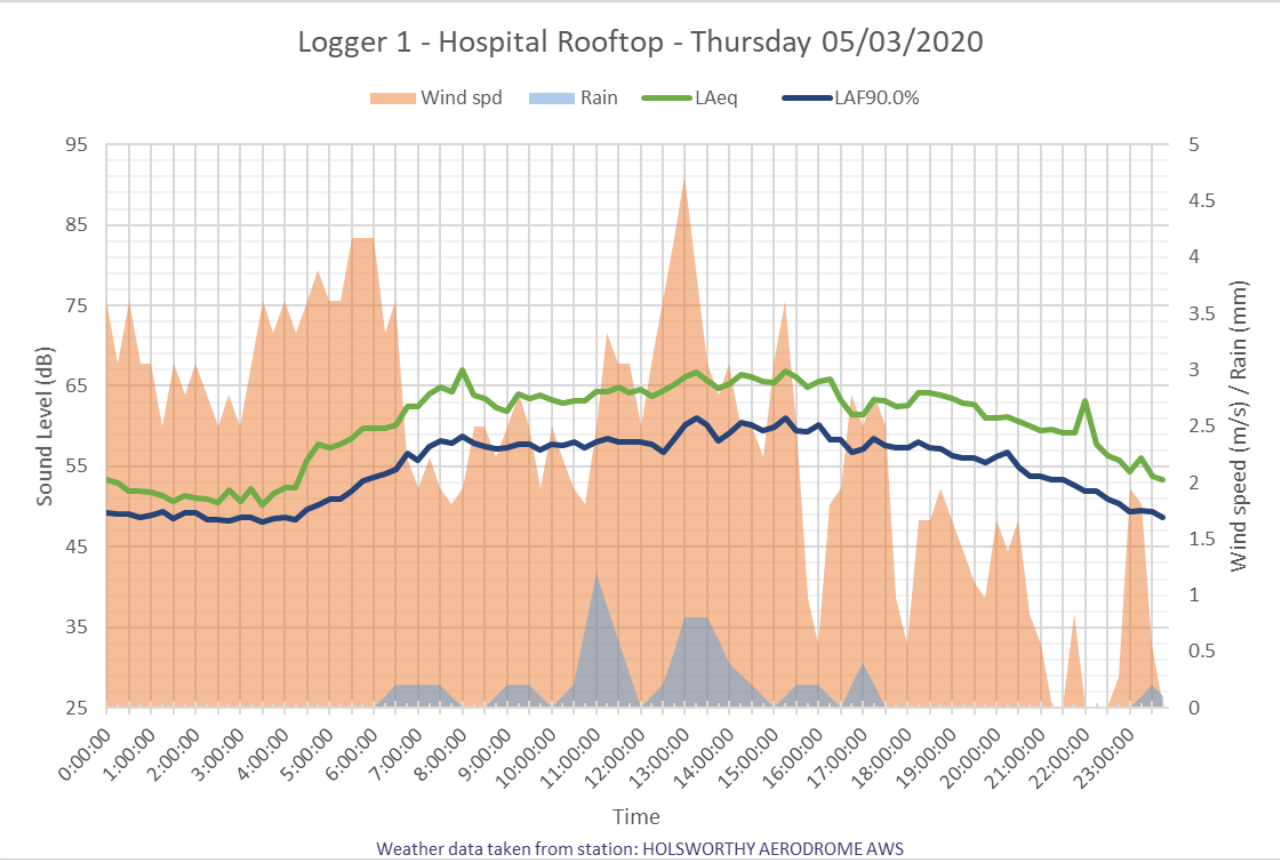
Single number quantity that characterises the sound-insulating properties of a material or construction element over a range of frequencies with airborne sound.

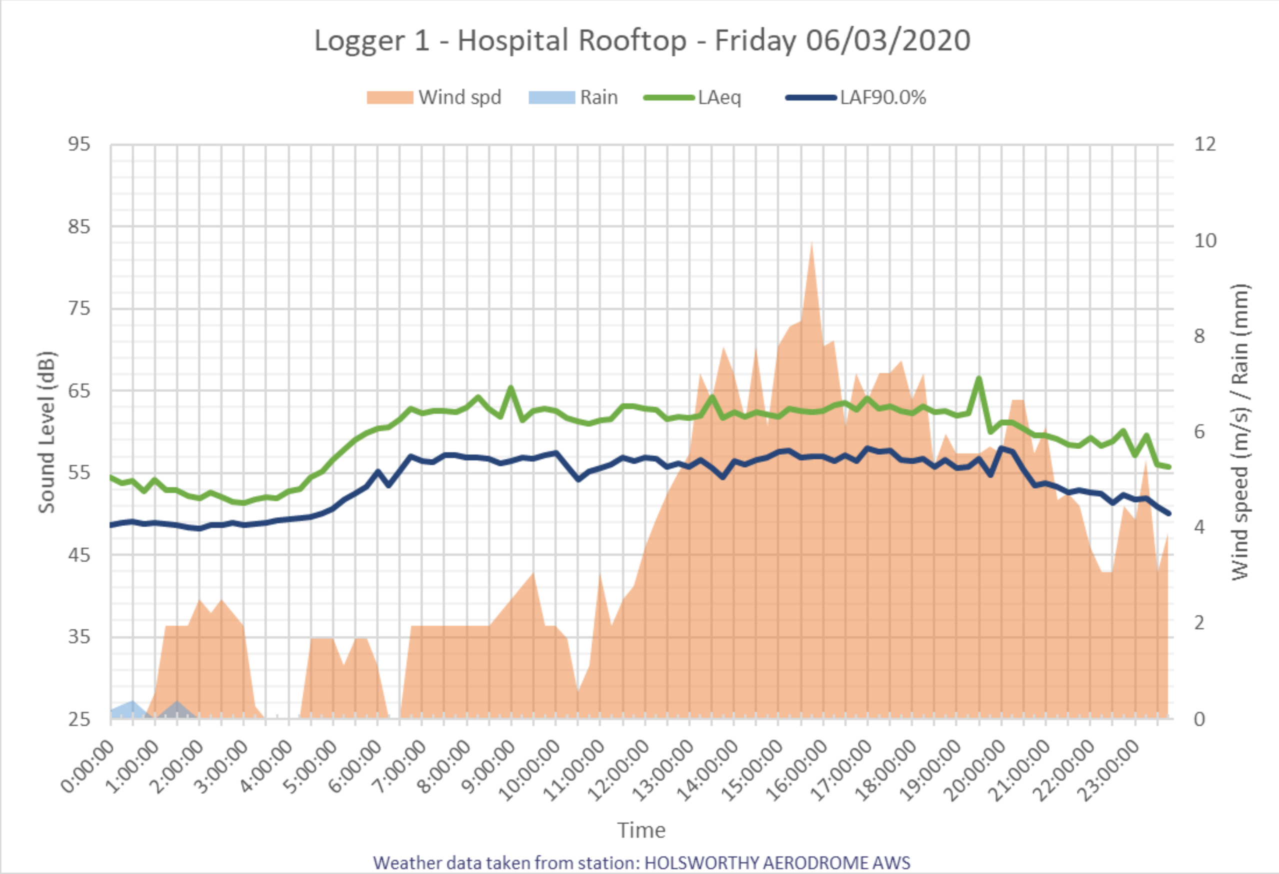
12. APPENDIX B – FLOW CHART FOR MANAGEMENT OF NOISE COMPLAINTS



13. NOISE LOGGER GRAPHS



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Time
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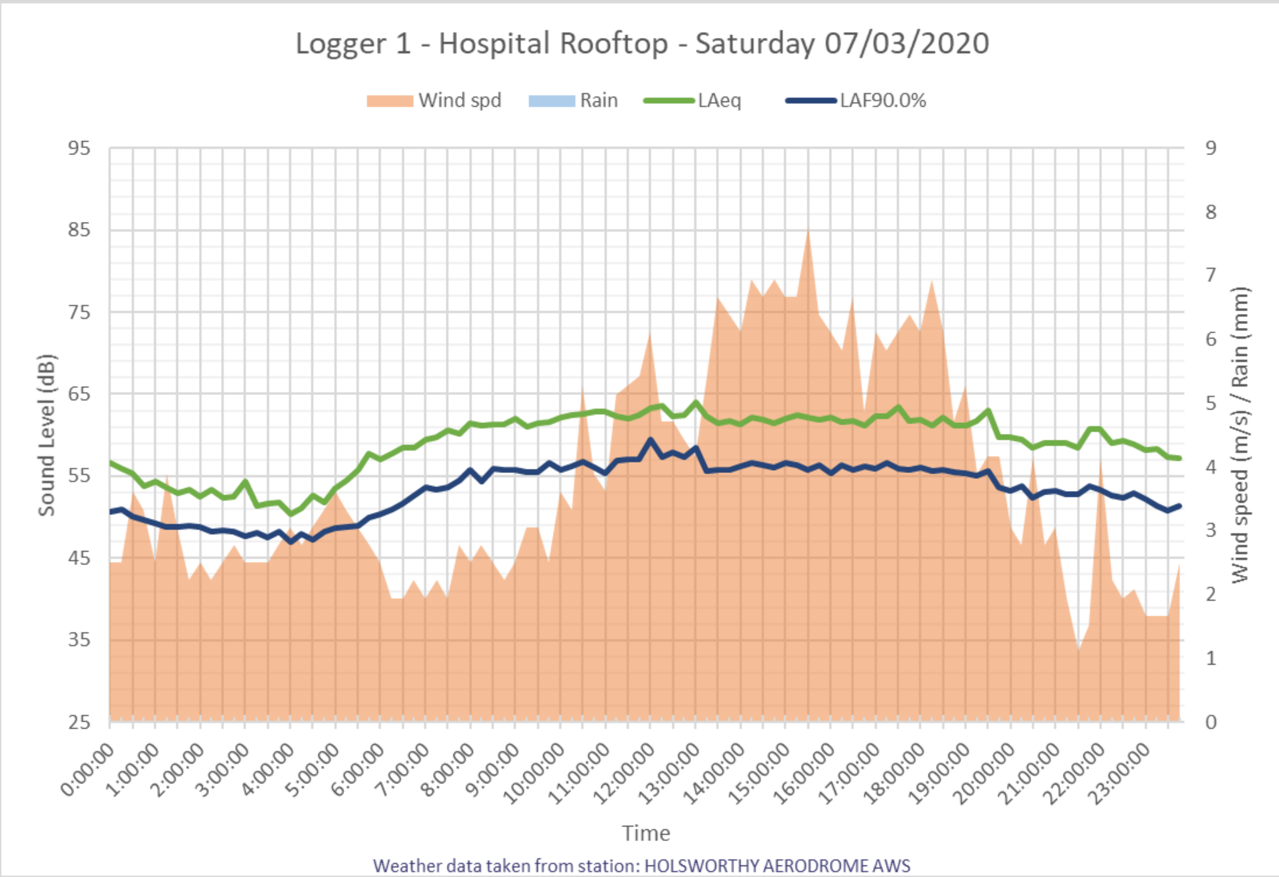
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Sound Level (dB)
Wind speed (m/s) / Rain (mm)
Time
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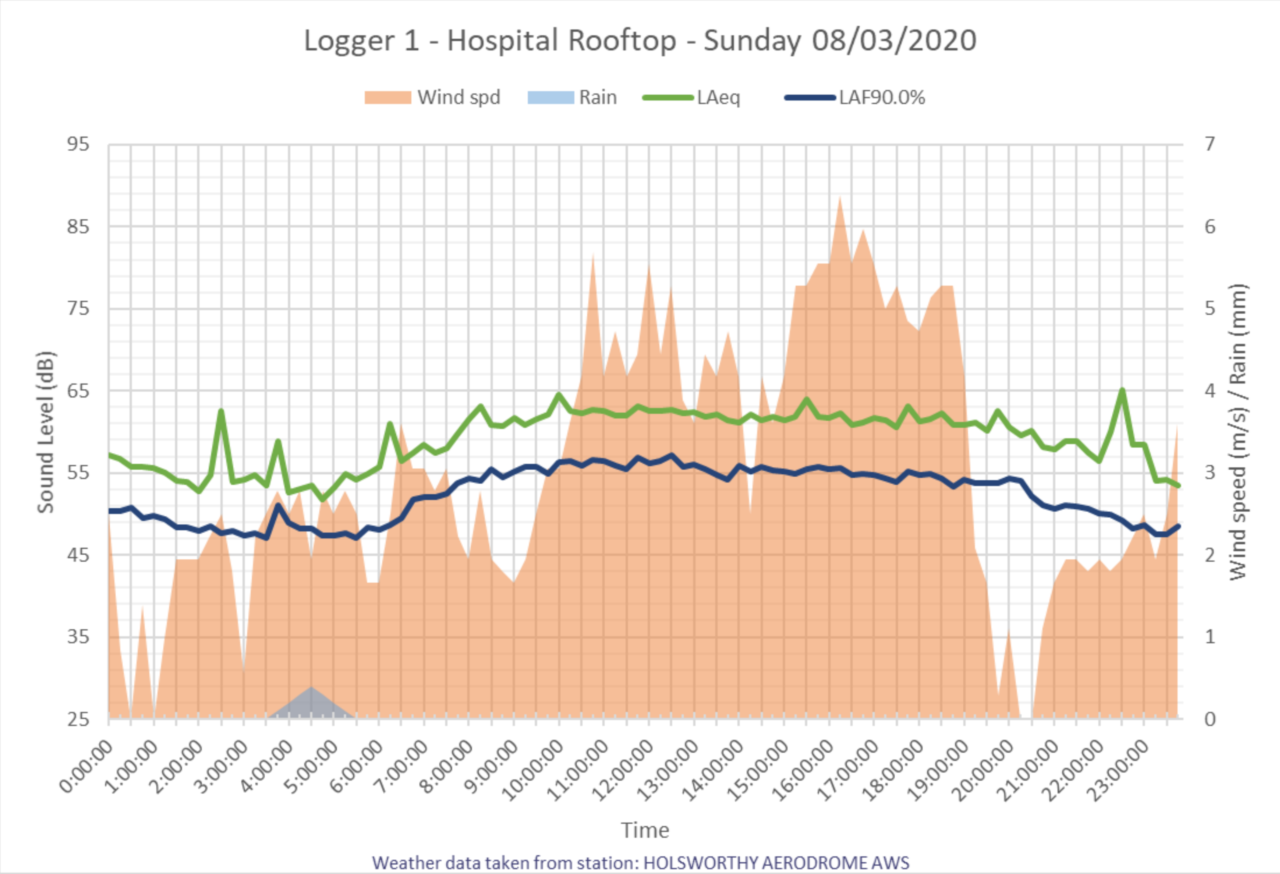
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Sound Level (dB)
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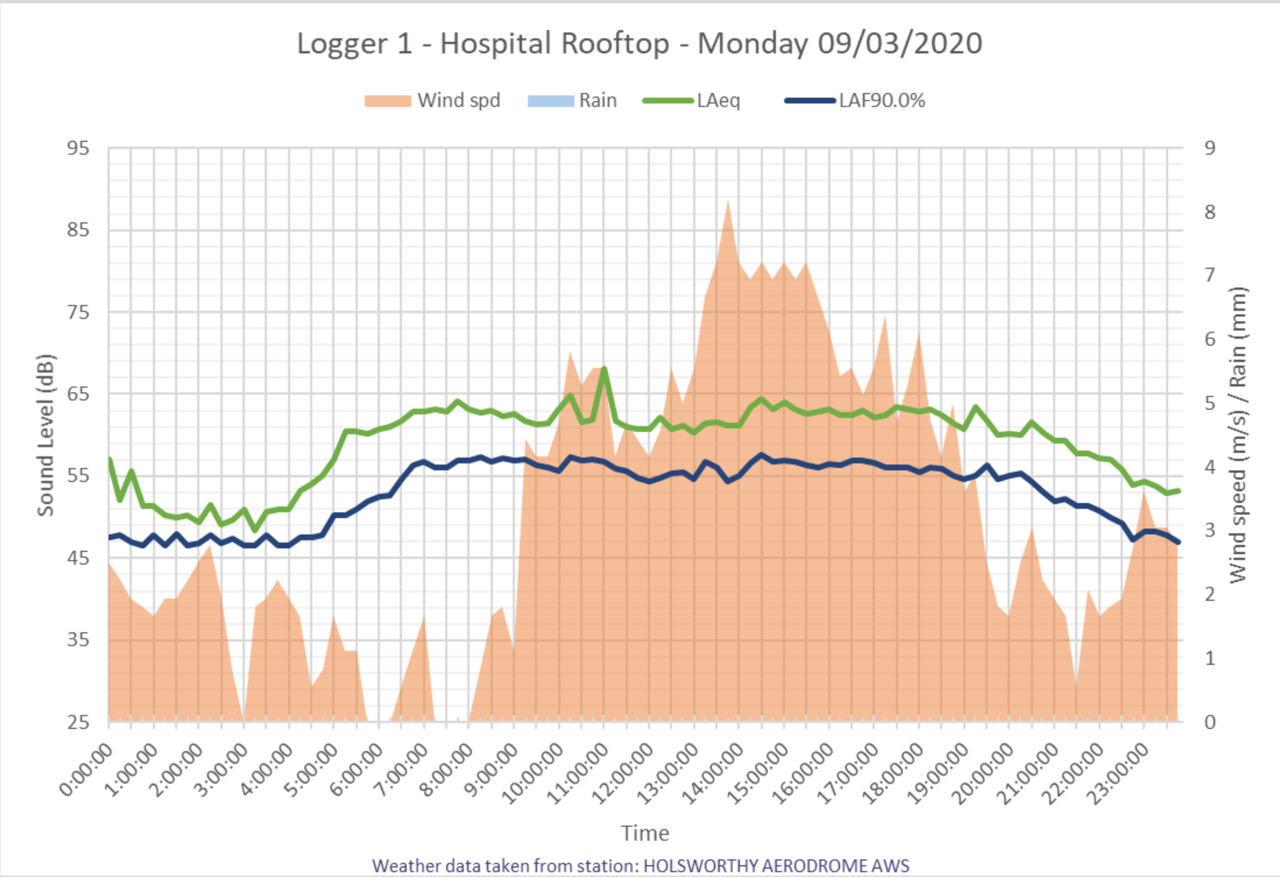
Logger 1 - Hospital Rooftop - Monday 09/03/2020
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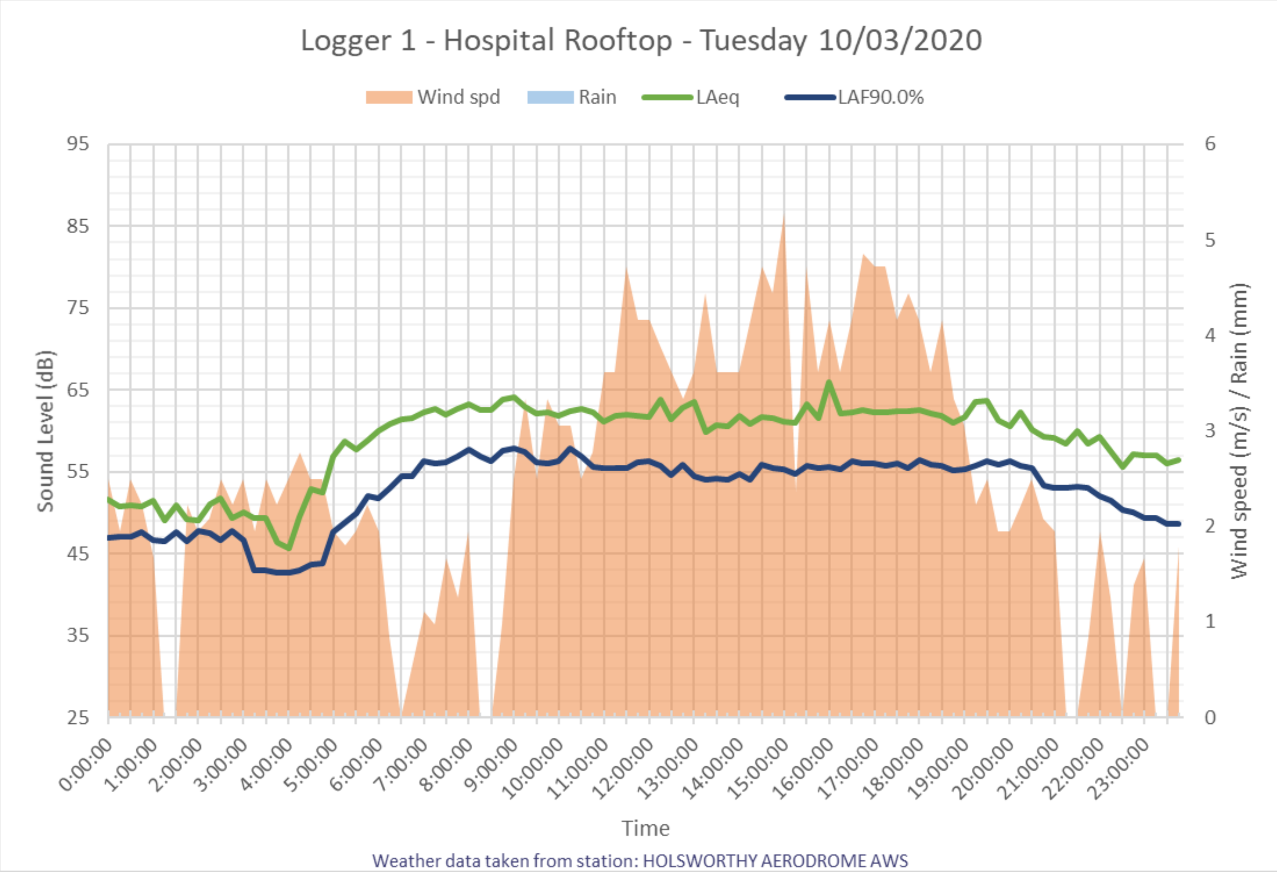
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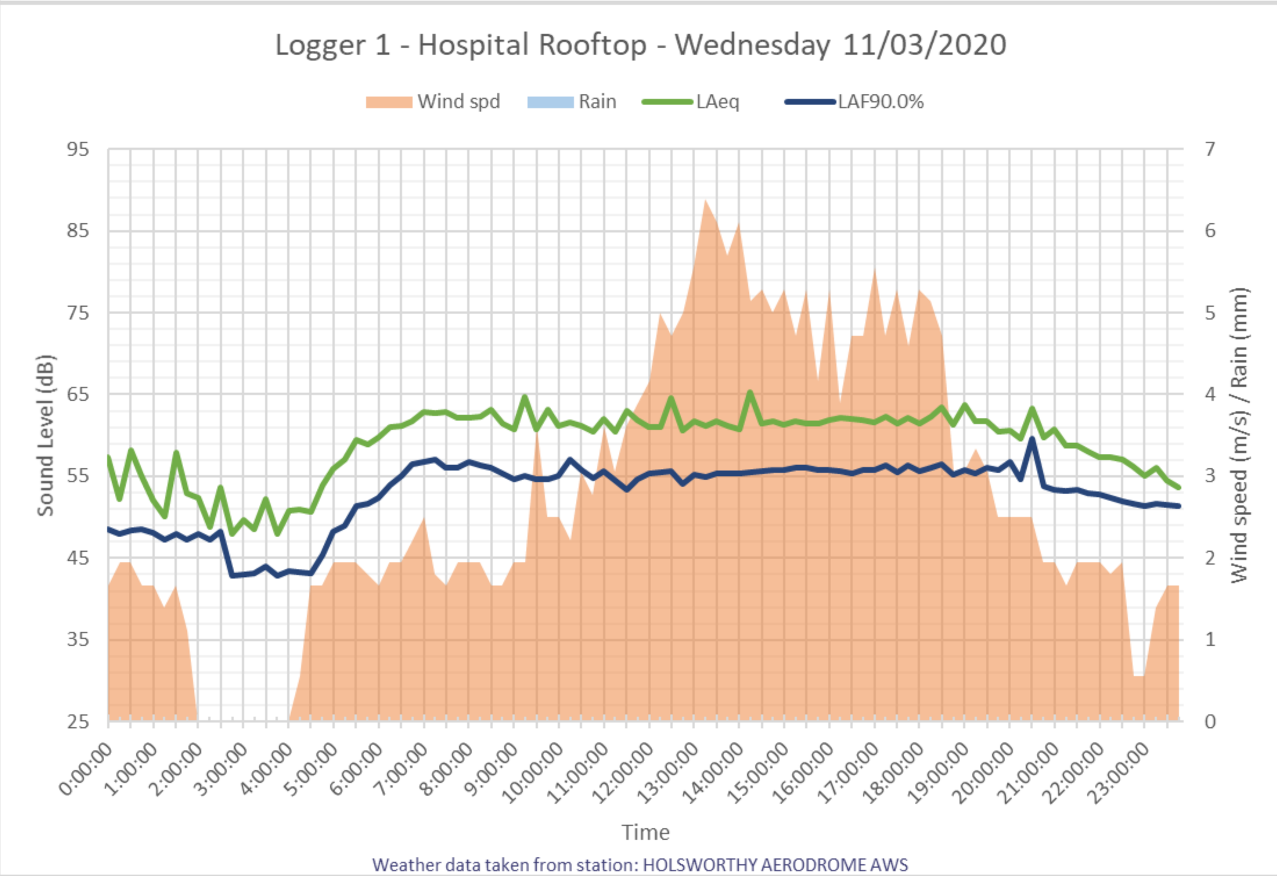
Logger 1 - Hospital Rooftop - Wednesday 11/03/2020
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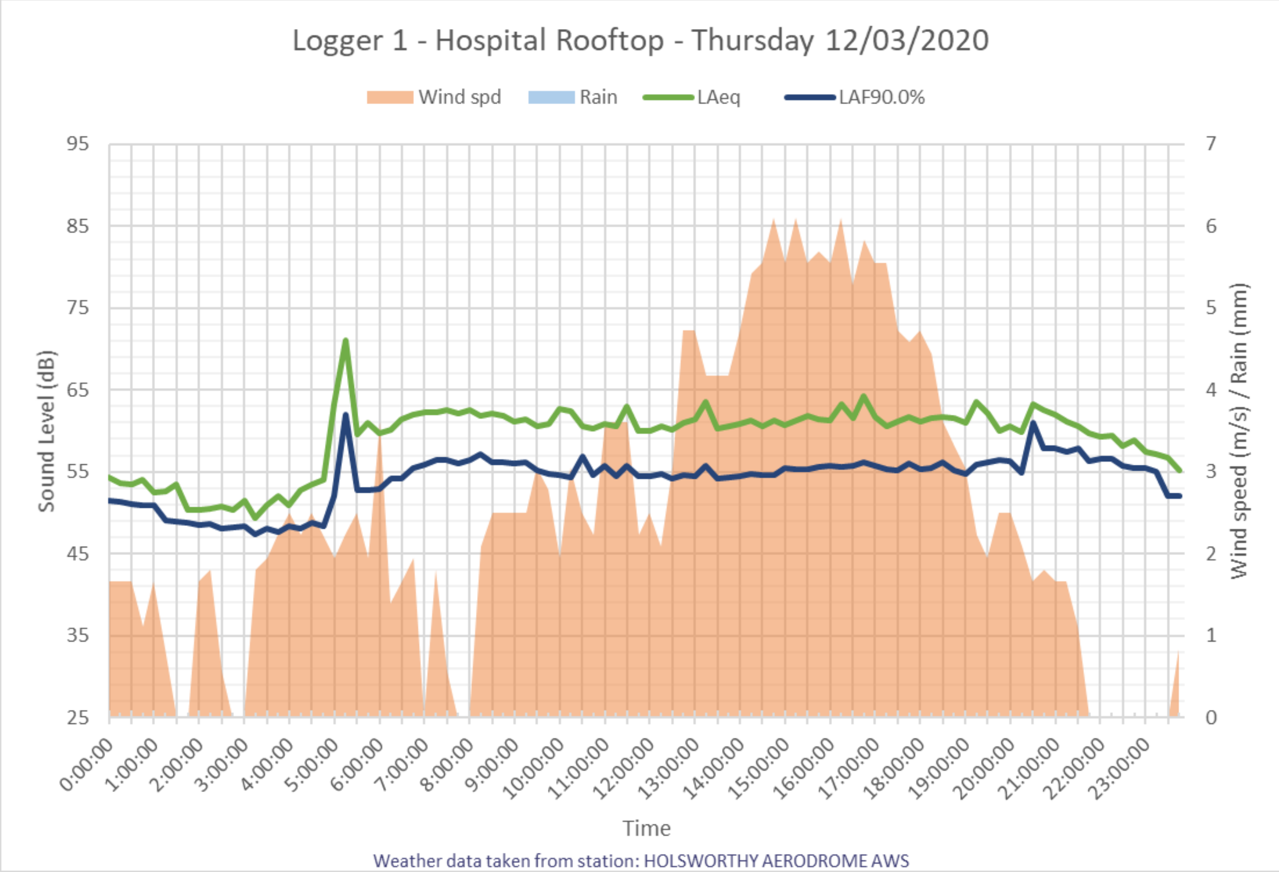
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Sound Level (dB)
Wind speed (m/s) / Rain (mm)
Time
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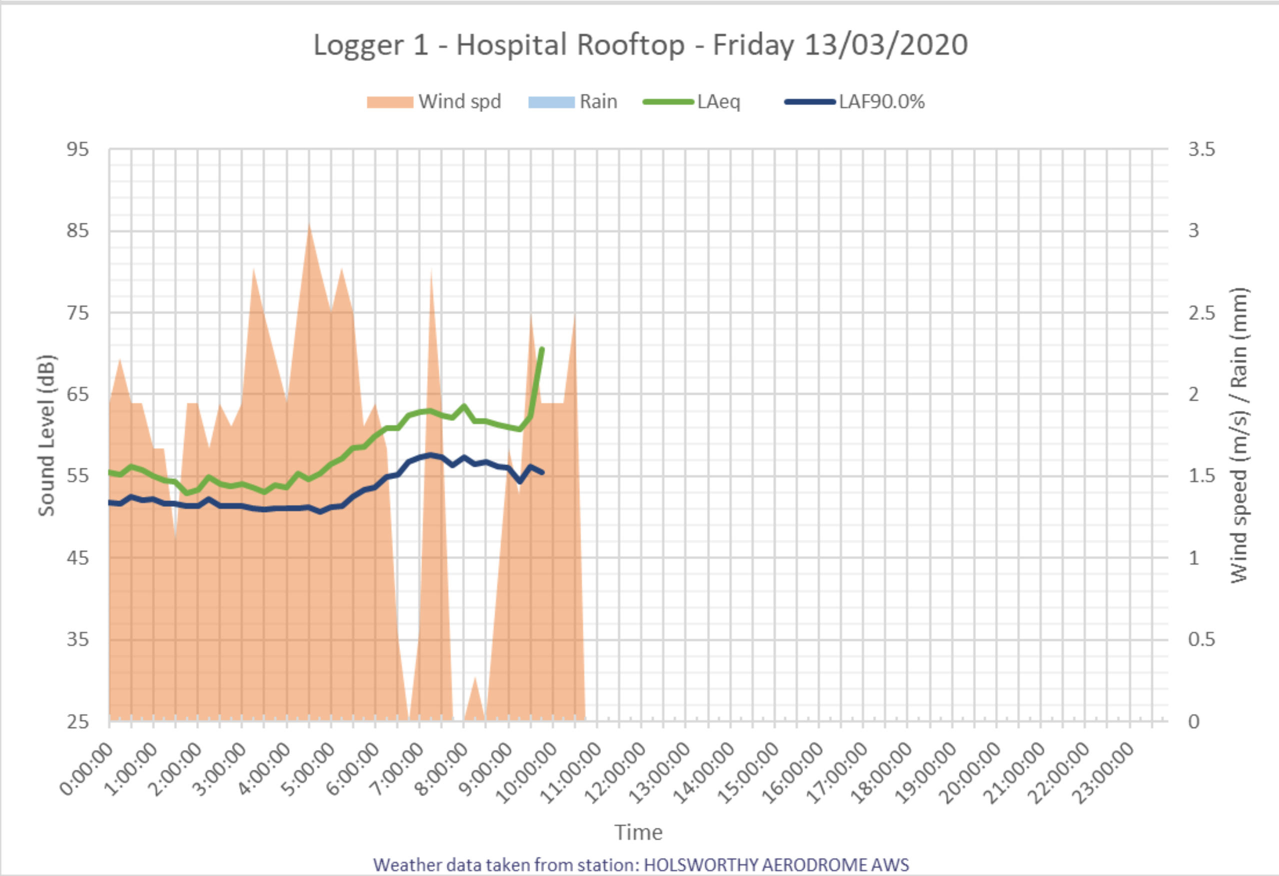
Logger 1 - Hospital Rooftop - Friday 13/03/2020
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Sound Level (dB)
Wind speed (m/s) / Rain (mm)
Time
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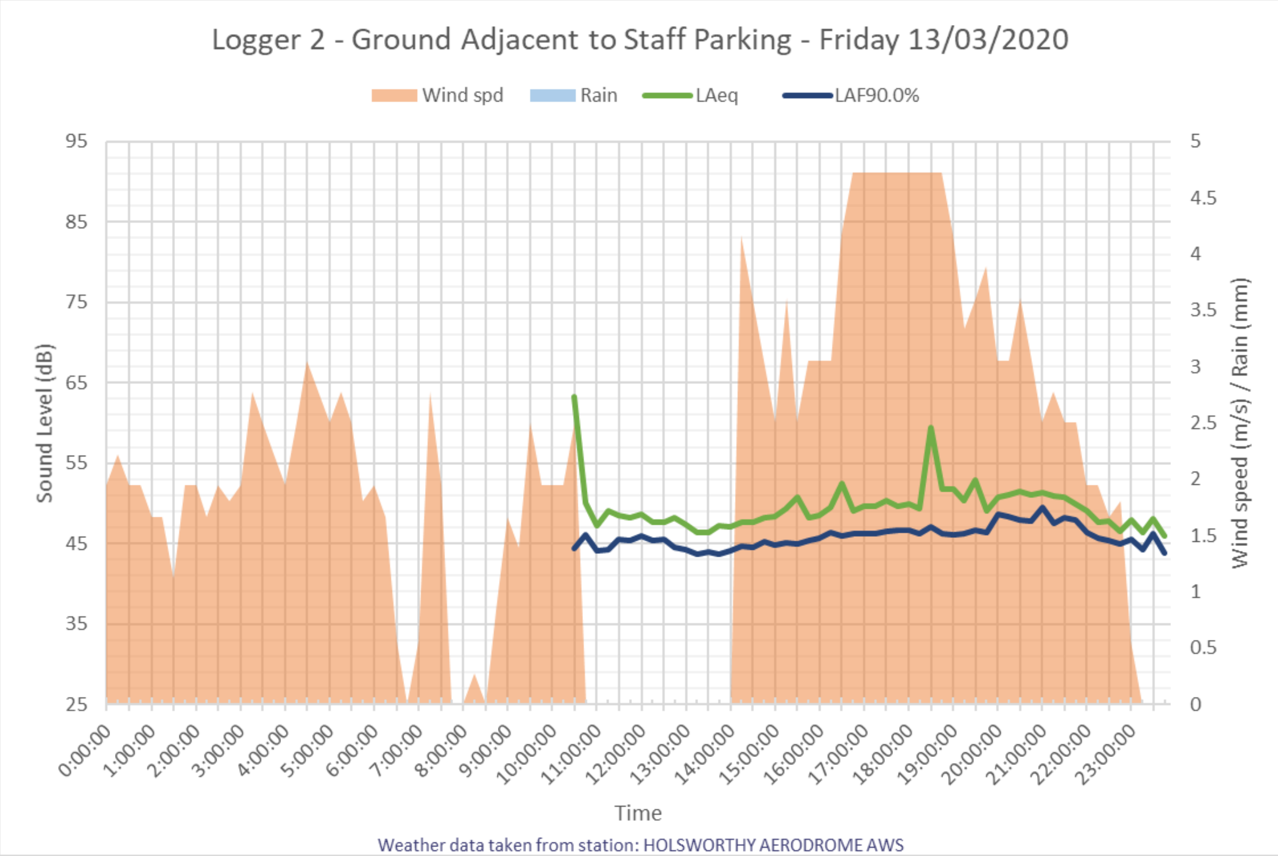
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Sound Level (dB)
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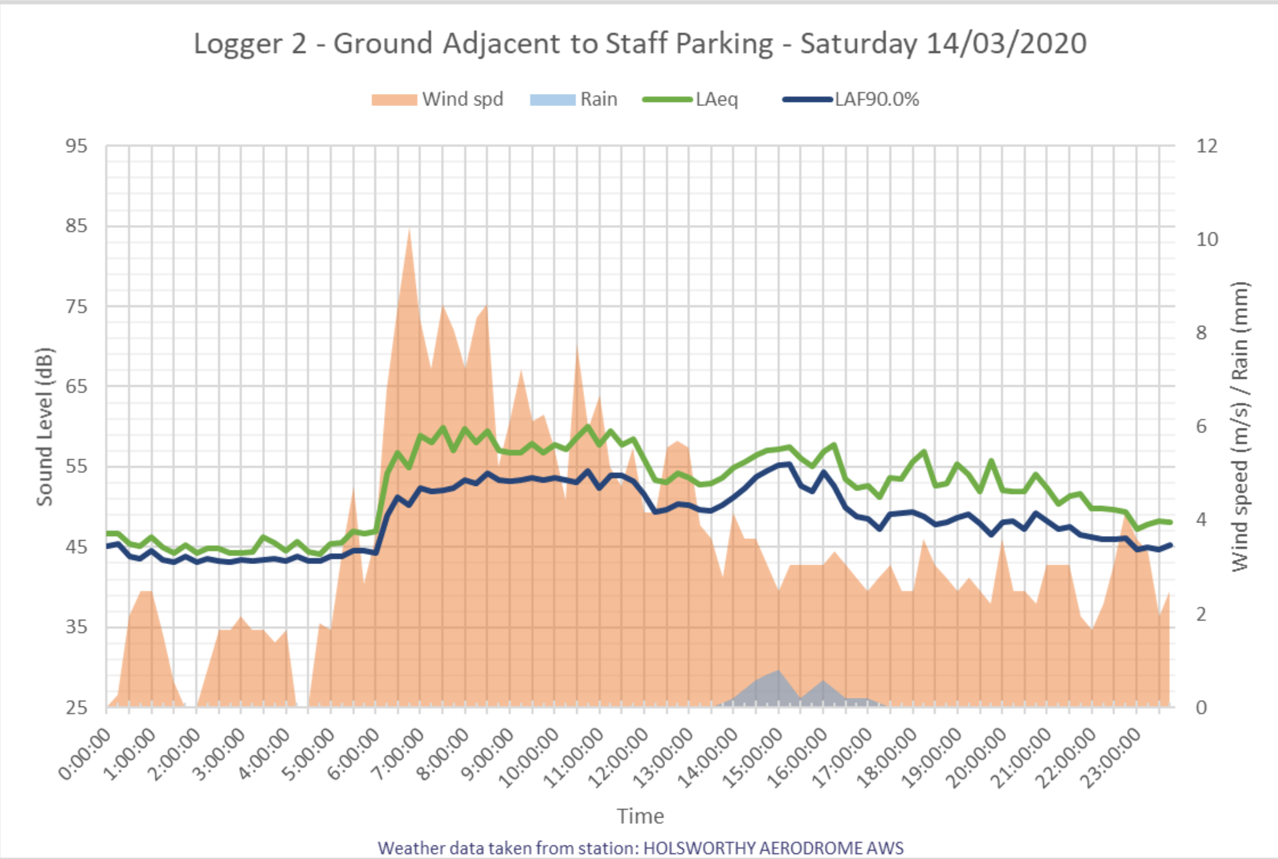
Weather data taken from station: HOLSWORTHY AERODROME AWS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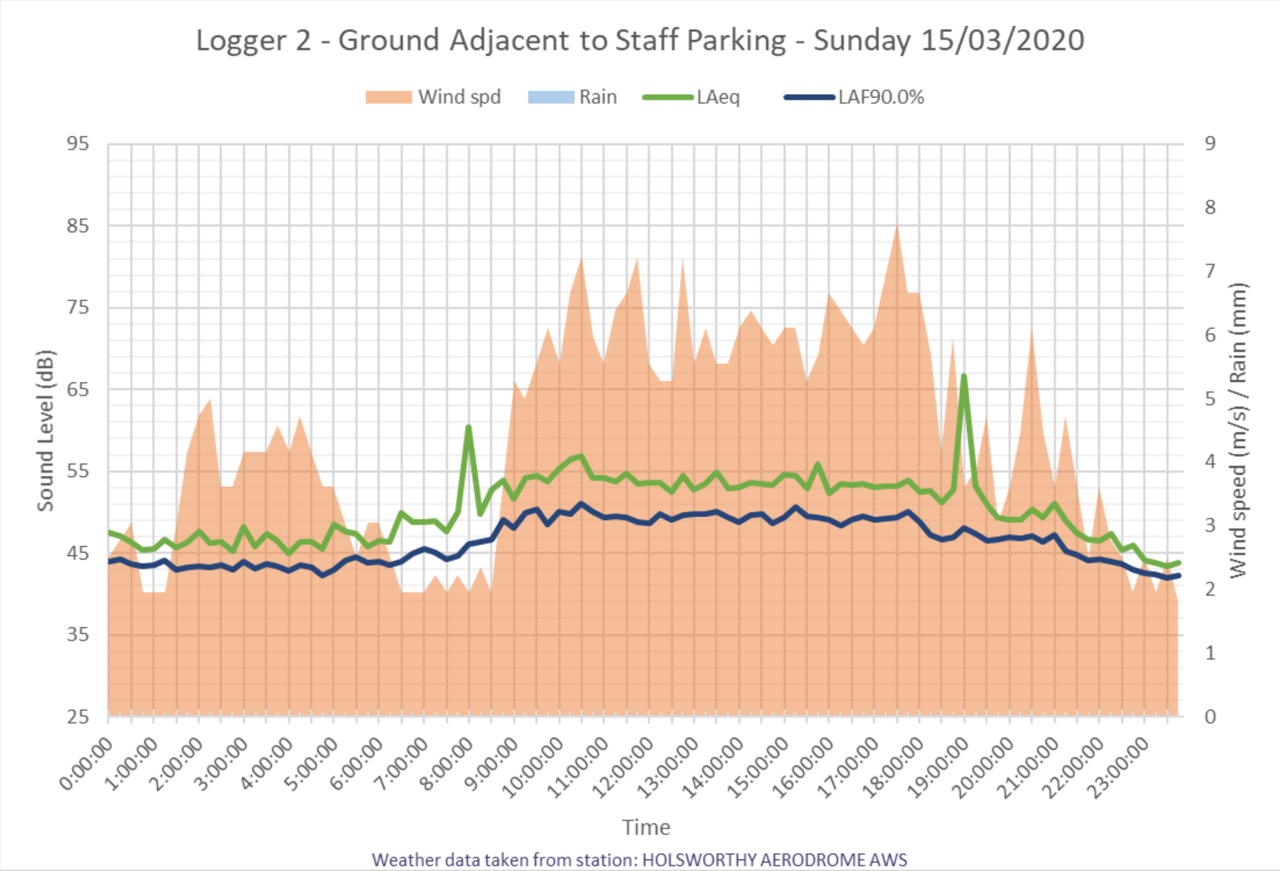
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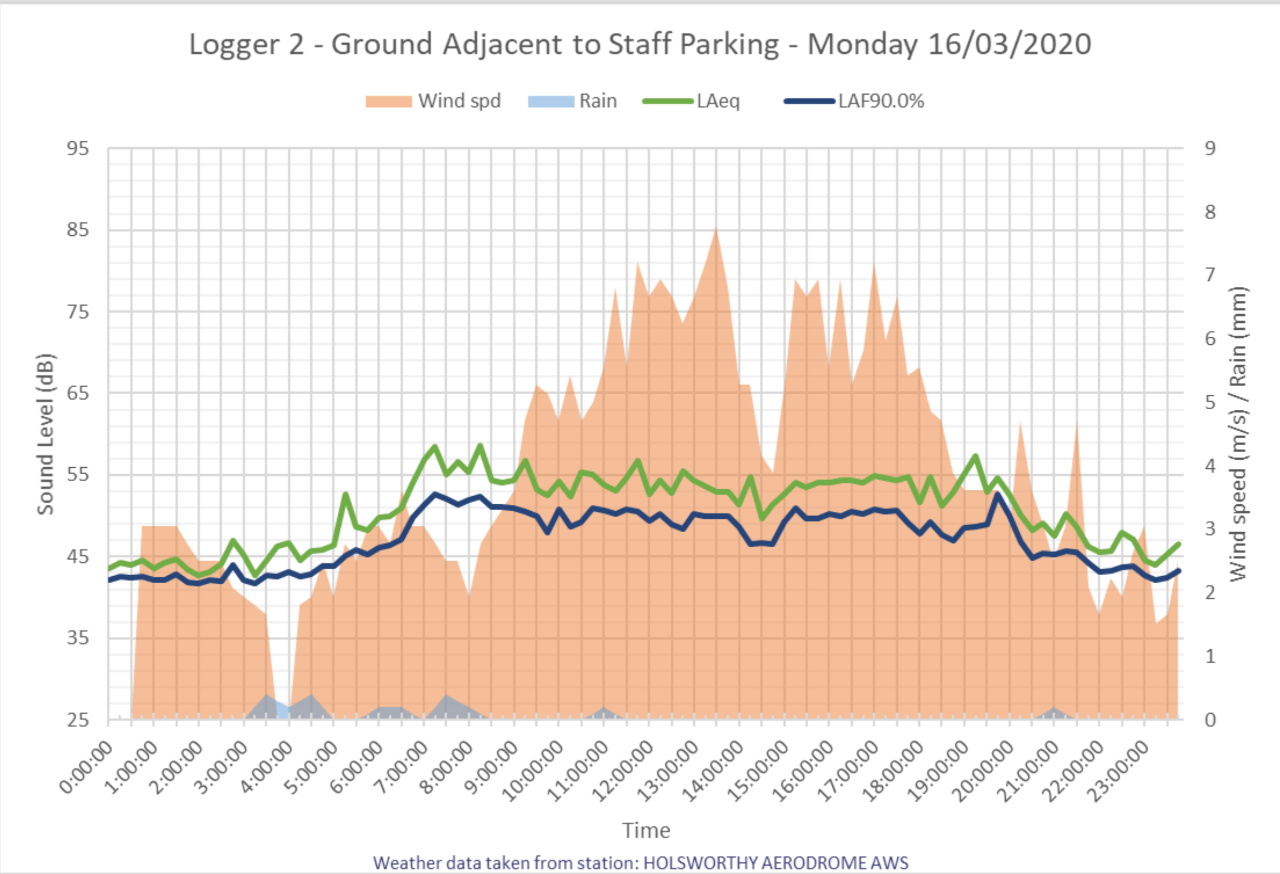
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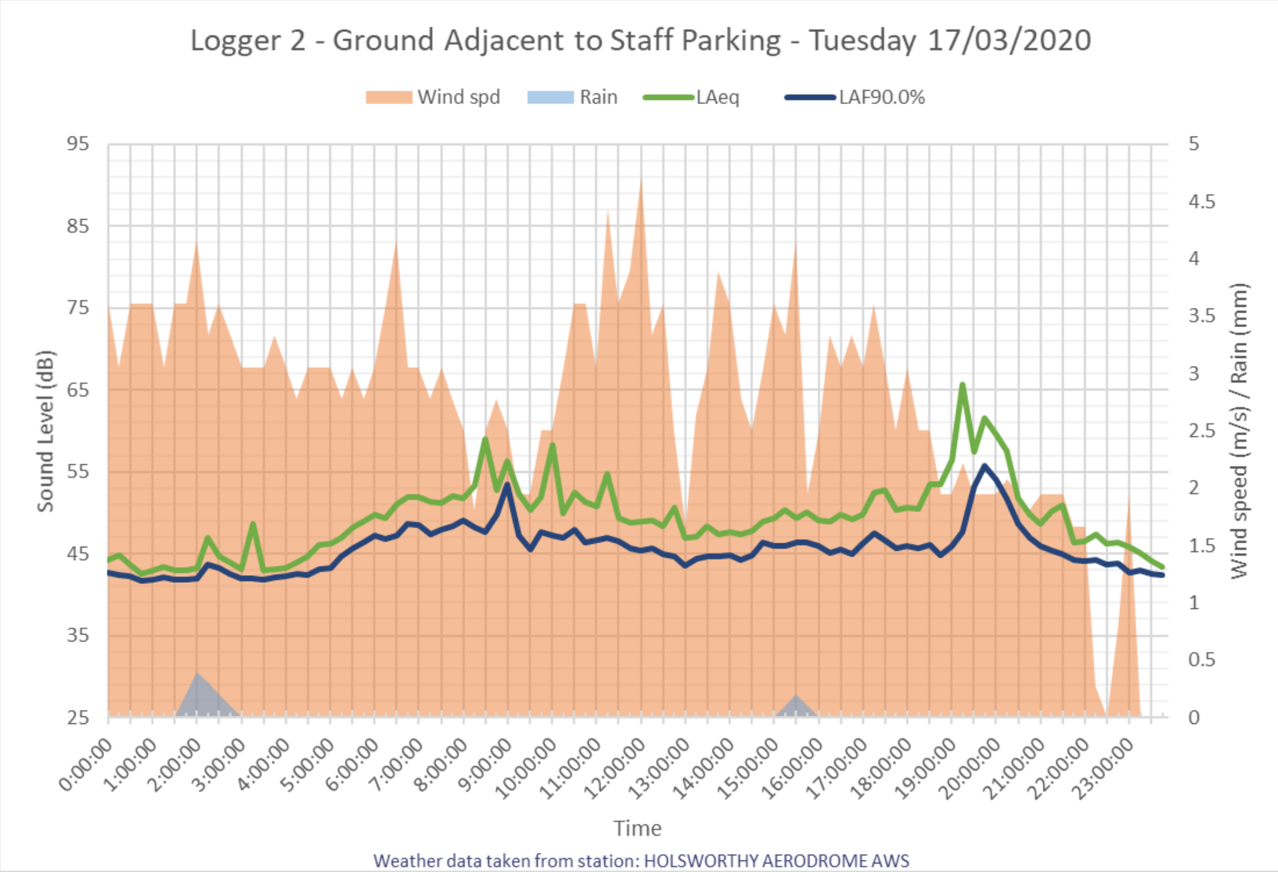
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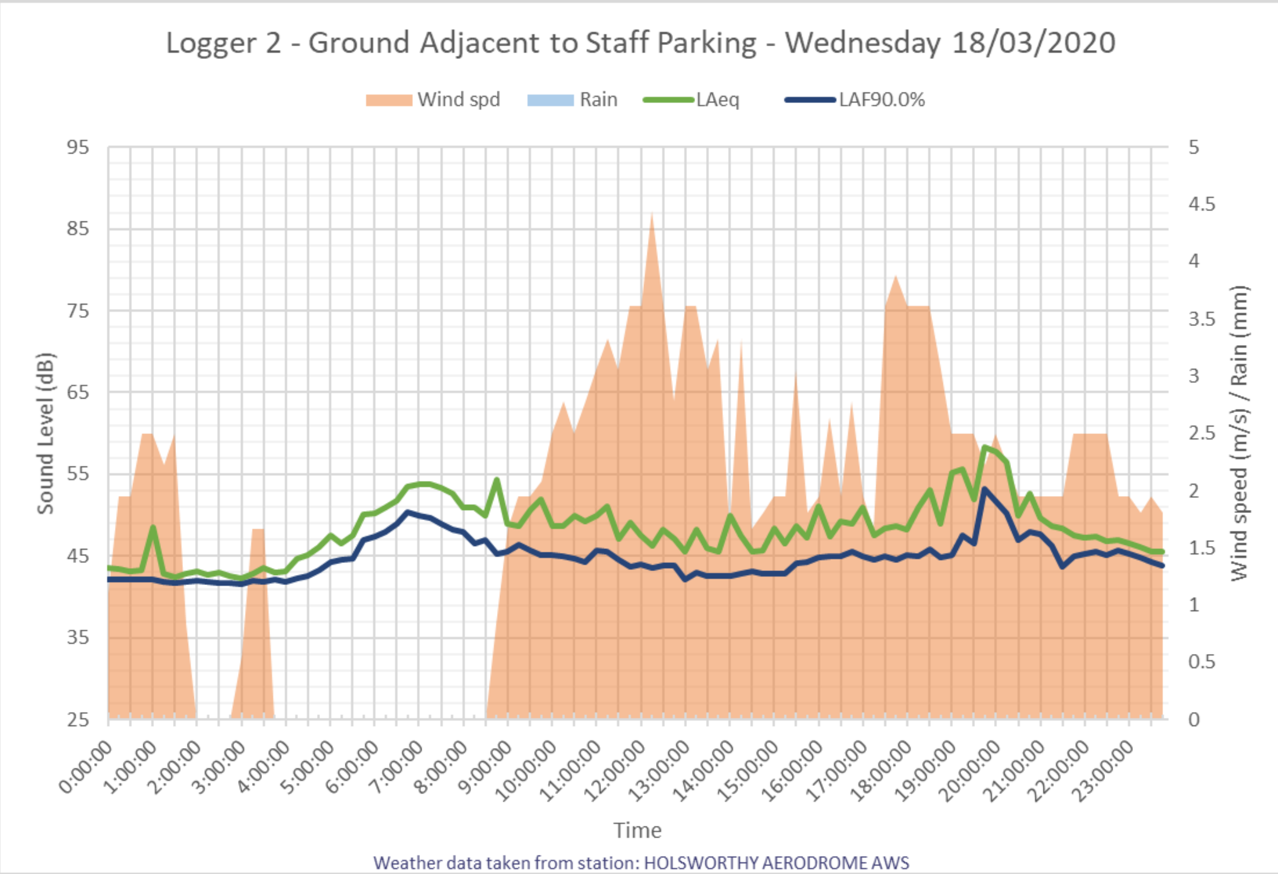
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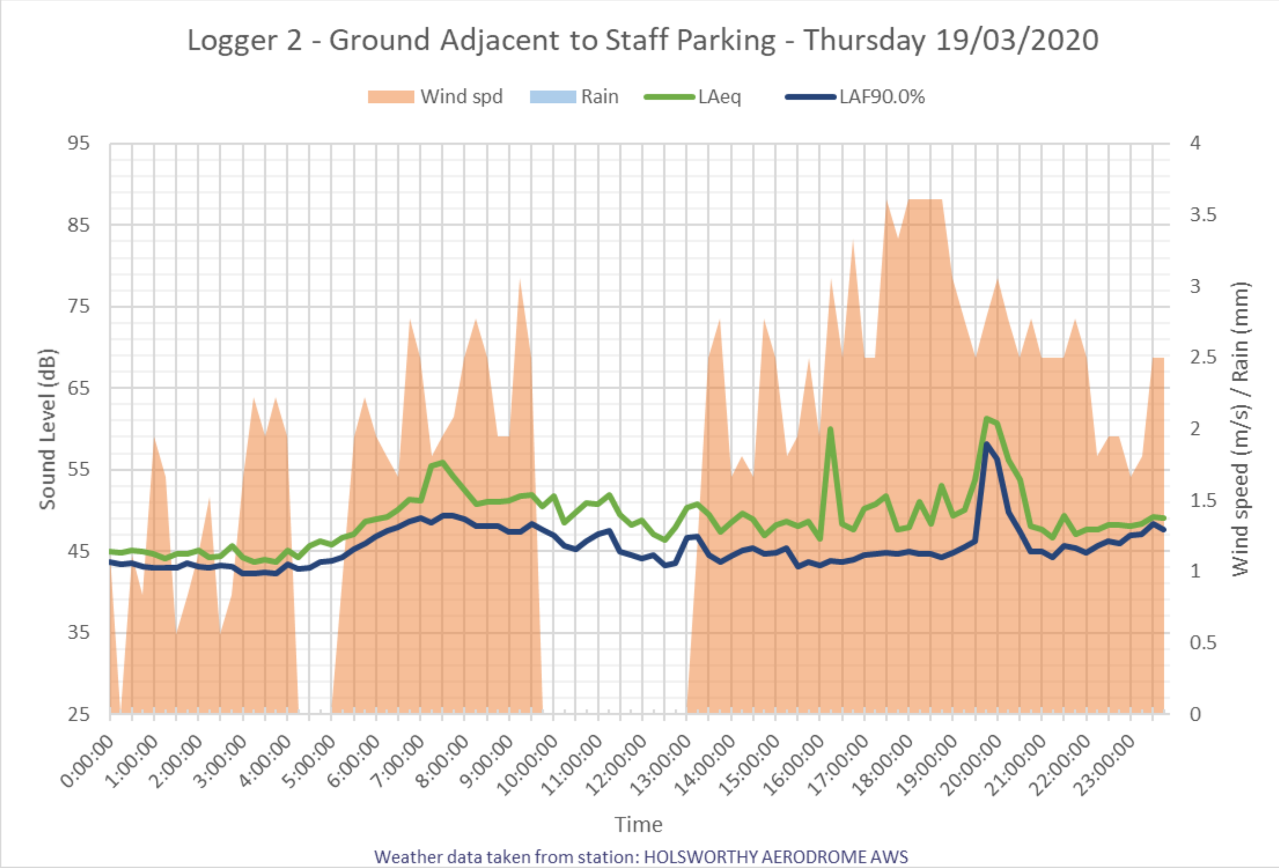
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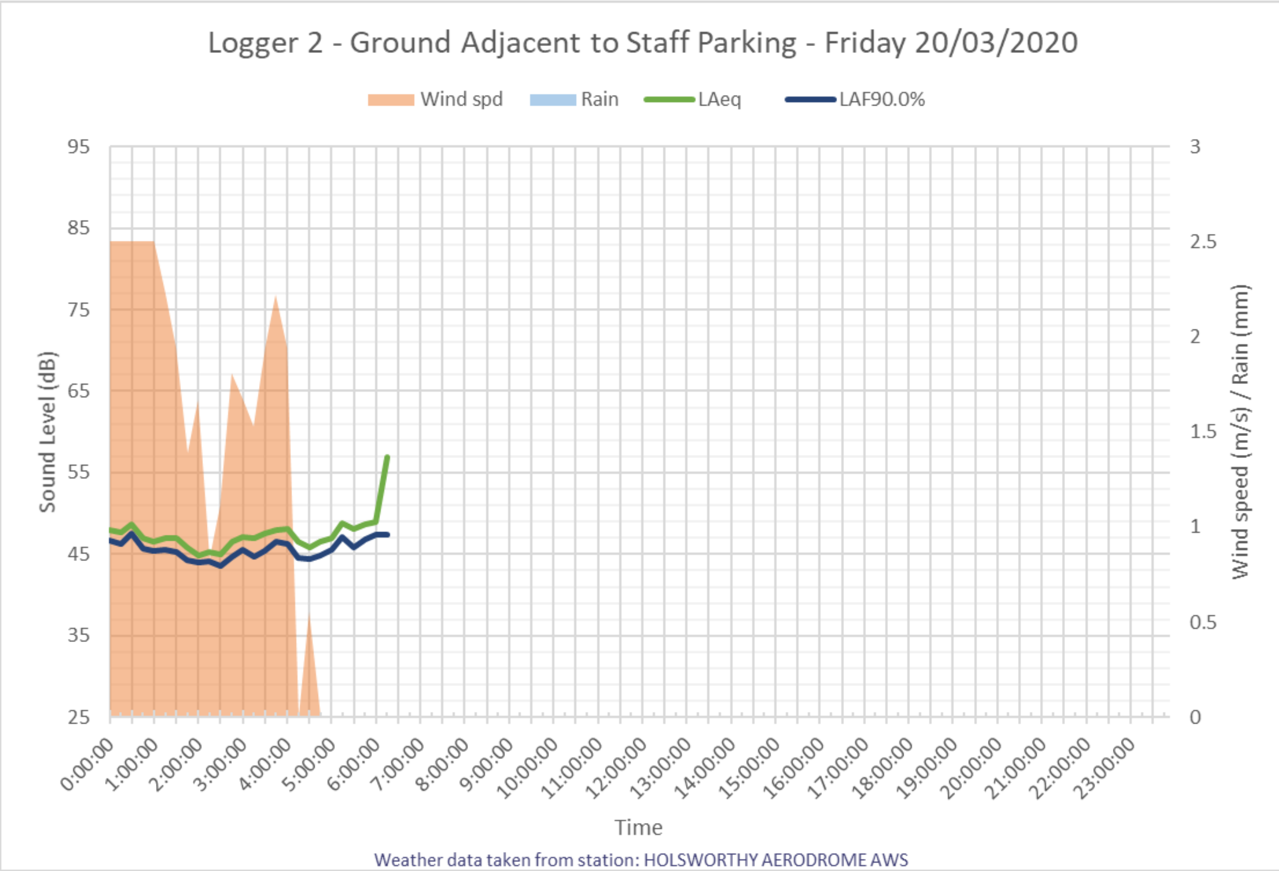
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Sound Level (dB)
Wind speed (m/s) / Rain (mm)
Time
Weather data taken from station: HOLSWORTHY AERODROME AWS