Health Infrastructure

New Macksville Hospital

SSD9103 - Construction and Operational Noise and Vibration Assessment

AC04

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Job number 249368

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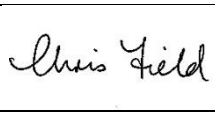
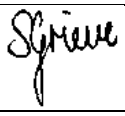
		Signature			
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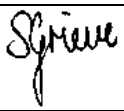
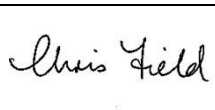
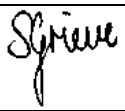
		Signature			
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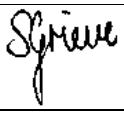
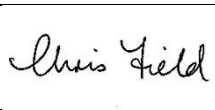
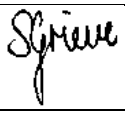
		Signature			
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Unattended Monitoring Results

1 Introduction

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

The Application (referred to as SSDA 9103) seeks approval for the construction of the New Macksville Hospital (NMH) as described in the Proposed Development Description section of this report.

1.1 Background

The existing Macksville Hospital is located in Boundary Street, Macksville on the Mid North Coast of NSW. Services located on the Macksville Health Campus include Macksville Hospital and the Macksville Community and Allied Health Centre. Macksville Hospital provides a 24 hour emergency department service, a 28 bed inpatient service for acute and subacute care, a low complexity low risk birthing service and a perioperative unit providing day only surgery. The Macksville Community and Allied Health Centre provide a range of community and allied health services.

Macksville Health Service is located in the Nambucca Local Government Area (LGA) and is part of the Coffs Clinical Network. The Coffs Clinical Network forms a network of clinical services within the Bellingen, Coffs Harbour and Nambucca LGAs and includes health services at Coffs Harbour Health Campus, Macksville Health Campus, Bellinger River District Hospital, Dorrigo Multipurpose Service, Nambucca HealthOne, Woolgoolga and a linked network of community and primary health services.

In August 2016, the Business Case was prepared for a $50 million redevelopment on the current hospital site. Following the completion of the Independent Assurance Review of the business case, a feasibility assessment was completed for an alternative option to fully replace the existing Macksville District Hospital on a Greenfield site located about 3.5 km north of Macksville Township.

On the 6 June 2017 the Ministry of Health supported the proposed scope of services for the redevelopment of Macksville Hospital on a Greenfield site and the project budget was confirmed in 2017-18. Additional funding of $23 million was provided in the 2017-18 State Budget, totalling $73 million for the project. Health Infrastructure intends to acquire the site, complete planning and commence early/enabling works in the current year (2017-18).

1.2 Site description

The subject site is located just north of Macksville, between Macksville and Nambucca Heads. It is currently partially occupied by Roads and Maritime Services/ contractors for construction of the Pacific Highway Upgrade and includes various buildings and infrastructure associated with the on-going construction of the Pacific Highway. The site is located approximately 2.5 km

north-east of the Macksville town centre and approximately eight kilometres south-southwest of Nambucca Heads, on the Mid North Coast of NSW.

Other land uses in proximity to the site include Newee Creek and associated State Environmental Planning Policy (SEPP) No. 14 Wetlands (located approximately 250-400 m west of the site), surrounding rural/agricultural land, forest and scattered rural residential dwellings north and south of the site.

The study area for the proposed new hospital is made up of a number of adjoining lots described as:

Lot 11 DP883264;

Lots 2-5 and 8 DP258324;

Lot 4 DP 809906.

The final determination of what land that would need to be acquired to accommodate the hospital and future needs has yet to be confirmed and will be determined in the preparation of the SSD Application and is therefore subject to change. An aerial image of the aforementioned lots as they exist at present is shown as Figure 1 and the preliminary site plan is identified in Figure 2.

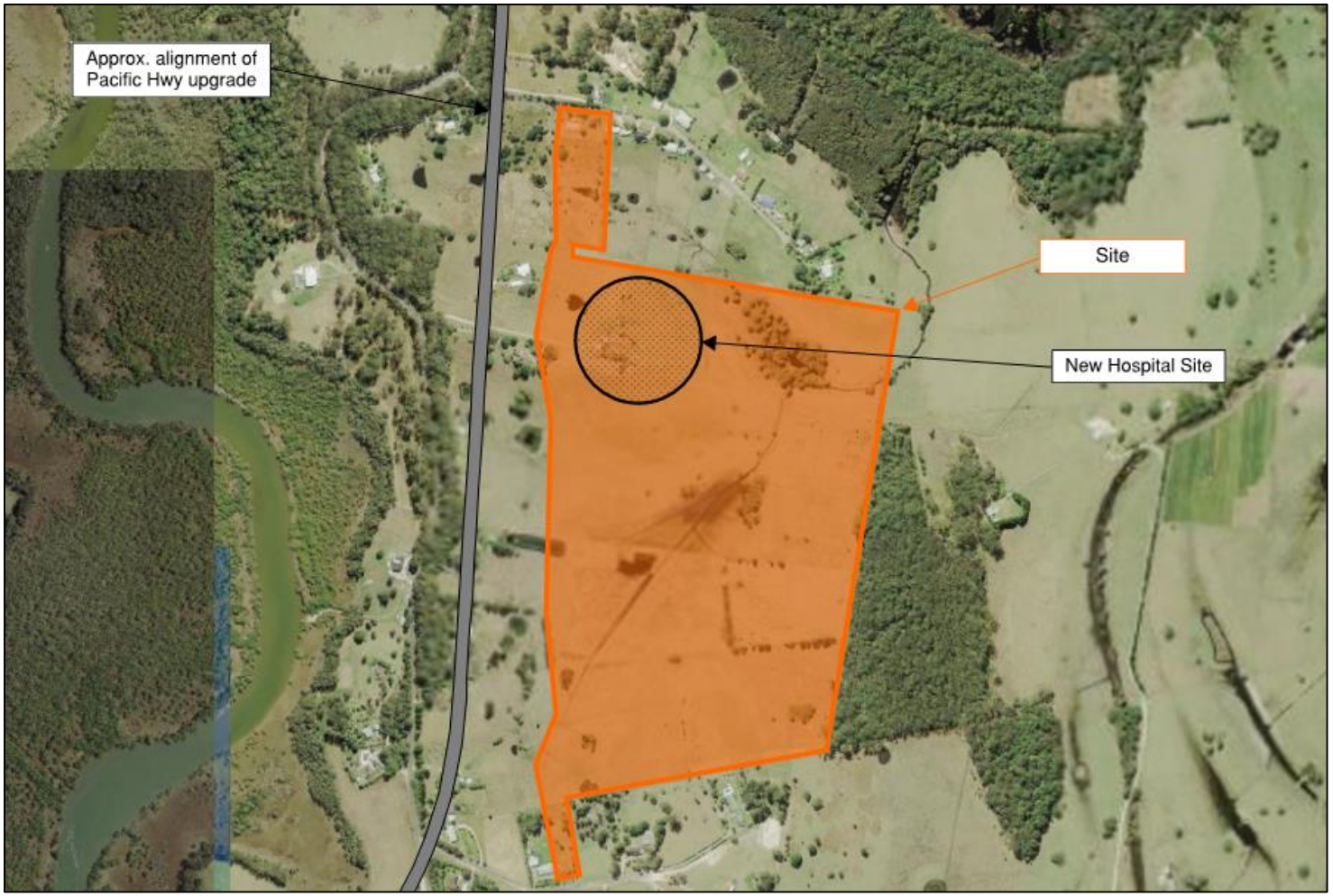


Figure 1: Subject site and approximate location of new hospital building

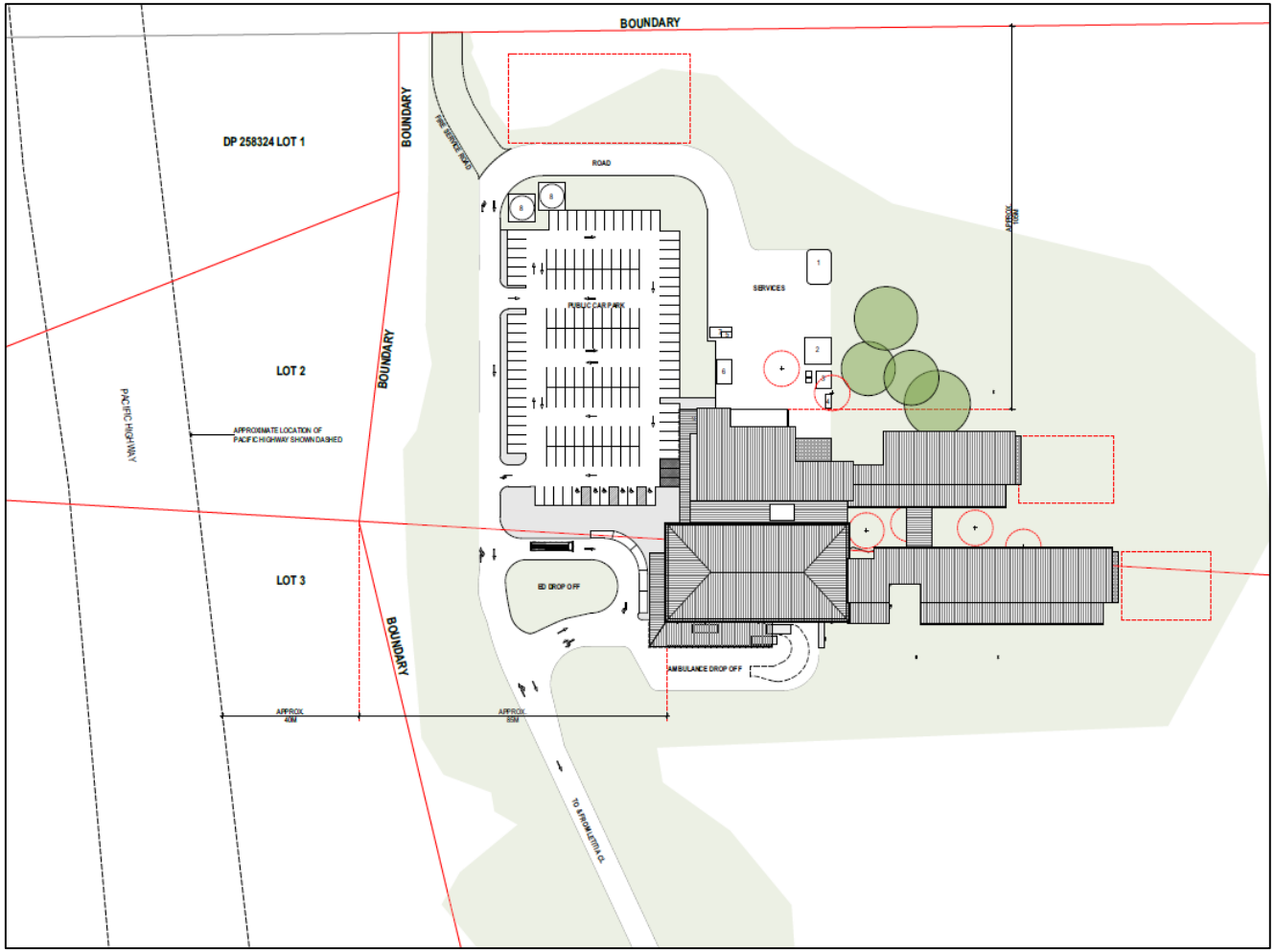


Figure 2: Preliminary site plan

1.3 Proposed development description

This SSDA seeks approval for the following:

At this stage the proposed new Greenfield Macksville Hospital would include:

- *A hospital precinct that would include:*
  - *Community Health*
  - *Sub-Acute in-patient unit*
  - *Acute in-patient unit*
  - *A main entry area*
  - *Maternity Unit*
  - *Emergency Department*
  - *Operating Theatres*
  - *Back of house*
  - *Administration building*
- *Car parking*
- *Future expansion areas*

It is understood that further definition of the scope of the project will be documented in the SSD application.

1.4 Acoustic assessment requirements

Arup Acoustics has been engaged to prepare a construction and operational noise and vibration assessment to address the requirements for the SSD 9103 application for the New Macksville Hospital.

Key Issue 9 of the SEARs for application SSD 9103 sets out the following requirements with regards to the assessment of noise and vibration:

The EIS must address the following specific matters:

Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation and outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land.

Relevant Policies and Guidelines:

Noise Policy for Industry 2017 (EPA)

Interim Construction Noise Guideline (DECC)

Assessing Vibration: A Technical Guideline 2006

Development Near Rail Corridors and Busy Roads – Interim Guideline (Department of Planning 2008)

The above policies and guidelines have been addressed in this report as follows:

Table 1: Identification of report section addressing relevant policy and guideline

Acoustic aspect	Policy or guideline	Report section
Operational noise from site	NSW Industrial Noise Policy (NSW Environmental Protection Authority, 1999)	Section 4
Road traffic noise impacts onto site	Development Near Rail Corridors and Busy Road-Interim Guideline	Section 5
Construction noise & vibration	Interim Construction Noise Guideline (Department of Environment and Climate Change NSW, 2009)	Section 6
	Assessing Vibration: A Technical Guideline (Department of Environment and Conservation (NSW), 2006)	

1.5 Scope of assessment

The following procedure outlines the scope of assessment with respect to the above acoustic aspects and relevant policies and guidelines:

- Examine the proposed development plans to identify acoustic aspects of the construction and operation of the developments.
- Identify the developments surrounding the site, which are to be assessed with regards to construction and operational activities.
- Conduct background noise monitoring to quantify the existing acoustic environment at relevant surrounding receiver locations to set project targets in accordance with relevant policy.
- Where appropriate, carry out a preliminary quantitative acoustic assessment of potential impacts and compare against the relevant noise and vibration targets.
- Identify where further input to the project design development is required, and identify in-principle mitigation or management methods for the control of noise and vibration where required.
- Outline the processes to be adopted for the continued design development of acoustic aspects for the project.

2 Surrounding land uses

The site and location of main works for the project are surrounded by existing residential premises in all directions however it is expected that residential receivers situated to the north of the site along Mattick Road will determine noise control requirements. There, are no other sensitive receiver types within proximity to the site.

The nearest most potentially affected land uses surrounding the development have been identified in Table 2 and Figure 3.

Table 2: Receiver and logger locations

Type	ID	Address
Residential	R1	28 Mattick Road, North Macksville
	R2	64 Mattick Road, North Macksville
	R3	73 Champions Lane, North Macksville
	R4	41 Letitia Close, North Macksville
	R5	51 Old Coast Road, North Macksville
	R6	83 Old Coast Road, North Macksville
	R7	133 Old Coast Road, North Macksville
	R8	4 Mattick Road, North Macksville
Logger	L1	18 Mattick Road, North Macksville
	L2	122 Old Coast Road, North Macksville

Note:

L1 – monitoring location used for the measurement of background noise level.

L2 – monitoring location used for the measurement of existing road traffic noise.

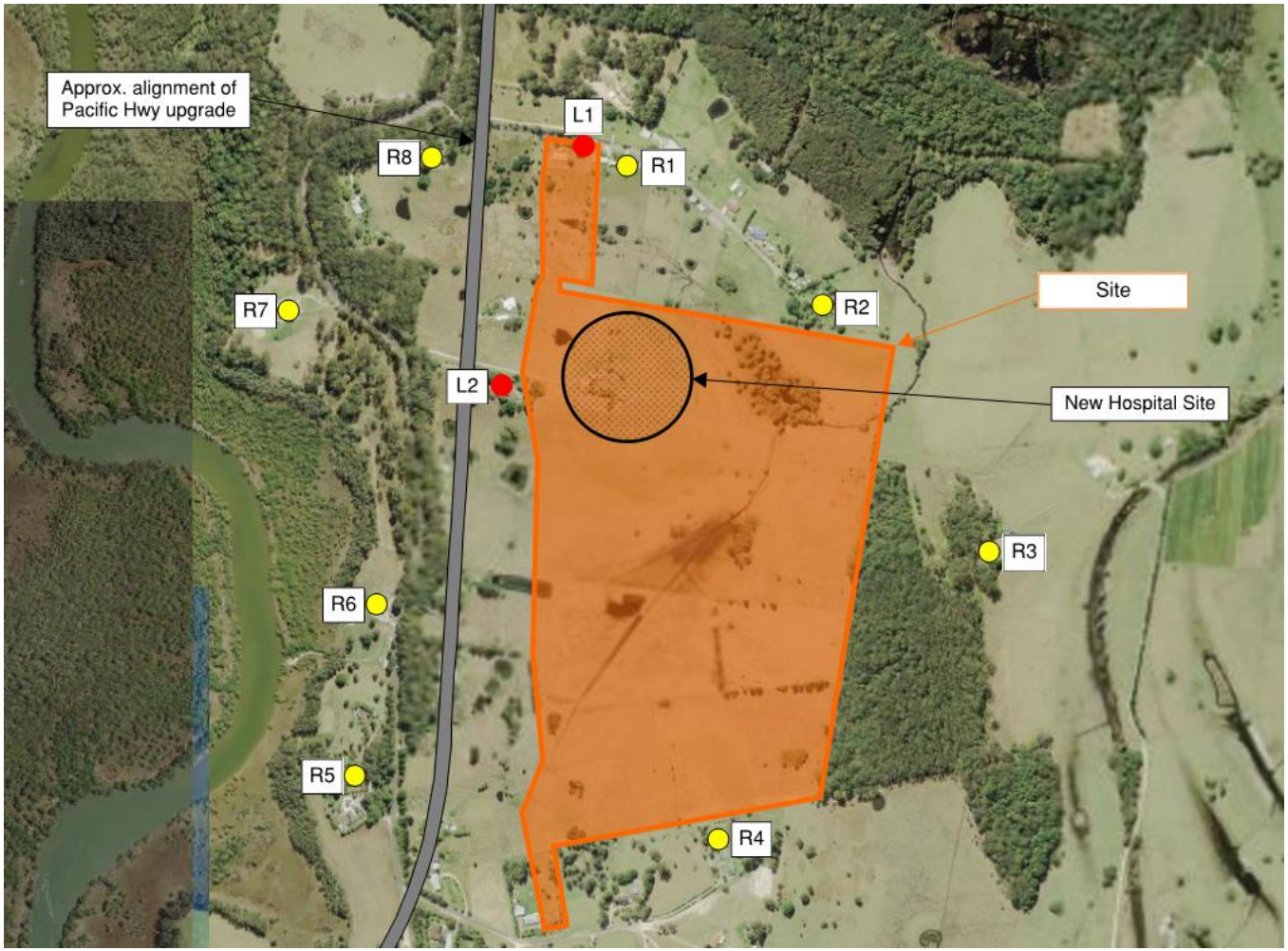


Figure 3: Site aerial, receiver locations and noise monitoring locations

3 Existing noise environment

Criteria for the assessment of operational and construction noise are usually derived from the existing noise environment of an area, excluding noise from the subject development.

Appendix A of the NSW *Noise Policy for Industry* (NPI) (EPA, 2017) outlines two methods for determining the background noise level of an area, being 'Long-term' and 'Short-term' background noise methods. This assessment has used long-term noise monitoring.

3.1 Noise measurement locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or if a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site.

The long-term measurement locations are outlined in Table 3 and shown in Figure 3.

Table 3: Noise monitoring location

ID	Address	Description
L1	18 Mattick Road, North Macksville	Monitoring location used for the measurement of background noise levels.
L2	122 Old Coast Road, North Macksville	Monitoring location used for the measurement of existing road traffic noise.

Further to the above, it is noted that measurement data obtained at L1 has only been applied to those residential receiver locations within a similar proximity to the Pacific Highway (i.e. R1, R5-R8). Further detail is provided in Section 4.2.

3.2 Long-term noise measurement results

Long-term noise monitoring was carried out from Monday, 29 January 2018 to Tuesday, 6 February 2018. The long-term noise monitoring methodology and noise level-vs-time graphs of the data are included in Appendix B.

Table 4 presents the overall single Rating Background Levels (RBL) and representative ambient L_{eq} noise levels for each assessment period, determined in accordance with the NPI.

Table 4: Long-term noise monitoring results, dB(A)

Location	**Time period**	**Rating Background Level** **RBL L_{A90}**	**Average L_{Aeq}**
L1 – North of site	Day[1]	42	59
	Evening[2]	41	51
	Night[3]	43	50
L2 – West of site	Day	52	65
	Evening	44	64
	Night	39	63

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Eve is 6:00pm to 10:00pm
3. Night is the remaining periods

4 Operational noise emissions

4.1 Overview

The primary operational noise sources with the potential to impact upon surrounding noise sensitive uses has been identified as building services (i.e. mechanical, electrical and hydraulic plant and equipment) and to a lesser extent usage of the loading dock.

Below is a summary of the primary noise generating equipment in connection to building services.

Mechanical Services

- Cooling towers (2 off) located in louvred plantroom open to sky on level 1, north east facing
- CDW pumps (3 off) located in basement plantroom
- Magnetic bearing chillers (2 off) and associated water pumps (3 off)
- Gas fire hot water units (2 off) and associated water pumps (3 off)
- 3 x medical grade compressors in level 1 plantroom
- 3 x medical suction pumps in level 1 plantroom
- Air handling units (AHUs) and associated fans:
    - AHUs (19 off) located first floor plant room with outside air louvres in building envelope (north and east facing)
    - AHUs (3 off) located basement level with fully louvered façade (north facing)

Electrical Services

- Diesel generator set with acoustic enclosure located basement level (north of new building)
- Kiosk substation located basement level (north of new building)

Hydraulic Services

- Fire hydrant and sprinkler pumps located basement level (fully enclosed)
- Domestic hot water plant located first floor plant room (fully enclosed)

4.2 Environmental noise criteria

Operational noise emissions from the project have been assessed in accordance with the Noise Policy for Industry (NPI), which is primarily concerned with controlling intrusive noise impacts in the short-term for residences, and maintaining long-term noise level amenity for residences and other land uses.

The NPI sets out the procedure to determine the project noise trigger levels relevant to an industrial development. The project noise trigger level is a level that, if exceeded would indicate a potential noise impact on the community and so 'trigger' a management response.

4.2.1 Intrusive noise trigger level

The intrusiveness noise trigger level is applicable to residential premises only and is summarised as follows:

$L_{Aeq,15minute} \leq$ Rating Background Level (RBL) plus 5 dB

(where $L_{Aeq,15minute}$ represent the equivalent continuous noise level of the source)

Note that as the Intrusive Noise Trigger Level is established from the prevailing background noise levels at the residential receiver location, the existing background noise level is to be measured.

Background noise level measurements undertaken at L1 will form the fundamental basis for the establishment of intrusive noise trigger levels at residential receiver locations R1, R5-R8. However, recourse to the minimum assumed RBLs provided in Section 2.3 of the NPI will be taken to derive intrusive noise trigger levels for residential receiver locations R2-R4.

4.2.2 Recommended and project amenity noise level

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from **all** industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 of the NPI where feasible and reasonable. An extract from the policy is given below in Table 5.

Table 5: NPI recommended amenity noise levels (RANLs)

Receiver	**Noise Amenity Area**	**Time of day[1]**	**Recommended amenity noise levels (RANLs) L_{Aeq}, dB(A)**
Residence	Suburban	Day	55
		Evening	45
		Night	40
	Rural	Day	50
		Evening	45

Receiver	Noise Amenity Area	Time of day[1]	Recommended amenity noise levels (RANLs) L_{Aeq}, dB(A)
		Night	40

Notes: The recommended amenity noise levels (RANLs) refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated.

1. The NPI defines day, evening and night time periods as:
    - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
    - Evening: the period from 6 pm to 10 pm.
    - Night: the remaining period.

(These periods may be varied where appropriate. In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable L_{Aeq} noise level may be increased to 40 dB $L_{Aeq(1hr)}$

The recommended amenity noise levels (RANLs) represent the objective for **total** industrial noise at a receiver location, whereas the **project amenity noise level (PANL)** represents the objective for noise from a **single** industrial development at a receiver location.

To ensure that any new industrial source of noise is within the RANLs for an area, the PANL applies for each new source of industrial noise as follows:

Project Amenity Noise Level (PANL) = Recommended Amenity Noise Level (RANL) minus 5 dB(A)

The NPI also provides the following exceptions to the above method for deriving the project amenity noise level:

1. *In areas with high traffic noise levels.*
2. *In proposed developments in major industrial clusters.*
3. *Where the resultant project amenity noise level is 10 dB or more lower than the existing industrial noise level. In this case the project amenity noise levels can be set at 10 dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.*
4. *Where cumulative industrial noise is not a necessary consideration because no other industries are present in the area, or likely to be introduced into the area in the future. In such cases the relevant amenity noise level is assigned as the project amenity noise level for the development.*

The area surrounding the site can be categorised as a combination of 'Suburban' and 'Urban' under the NPI. The NPI sets the PANLs to $L_{Aeq(period(traffic))}$ minus 15 dB(A) in the case that the level of transport $L_{Aeq(period(traffic))}$ exceeds the RANL by 10 dB or more.

Table 6 summarises the RANLs and the PANLs applicable for the project.

Table 6: NPI RANLs and PANLs

Receiver	Indicative Noise Amenity Area	Time of day[1]	Recommended Amenity Noise Level (RANL) $L_{Aeq(period)}$	Existing Traffic $L_{Aeq(period)}$ [2]	Project Amenity Noise Level (PANL) $L_{Aeq(period)}$
Residence R1, R5-R8	Suburban	Day	55	59	50
		Evening	45	51	40
		Night	40	50	35[2]
Residence R2-R4	Rural	Day	50	-	45
		Evening	45	-	40
		Night	40	-	35

Notes

1. The NPI defines day, evening and night time periods as:
   - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
   - Evening: the period from 6 pm to 10 pm.
   - Night: the remaining period.
2. Traffic noise is the dominant source of noise at the receiver location if:
   a. the existing traffic noise is 10 dB(A) or more above the ANL for the area; and
   b. it is unlikely that traffic noise will reduce over time

4.2.3 Sleep disturbance

The NSW NPI recommends the following screening criteria for the assessment of potential sleep disturbance, for the period between 10 pm and 7 am:

$L_{Aeq,15min}$ 40 dB(A) 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

4.2.4 NPI project specific noise levels

Based on the background and ambient noise monitoring, Table 7 summarises the derived project noise trigger level based on the NPI. The project noise trigger level is the lower value of the intrusive noise trigger level and the project noise level shown in bold.

Table 7: NPI project noise criteria

Receiver	Time Period	Project Noise Trigger Levels		
		Intrusive Noise Trigger Levels $L_{Aeq,15min}$	Project Amenity Noise Level (PANL) $L_{Aeq,period}$	Sleep Disturbance $L_{Amax(night)}$
Residence R1, R5-R8	Day	**47**	50	N/A[2]
	Evening	46	**40**	N/A[2]
	Night	48	**35**	**58**

Receiver	Time Period	Project Noise Trigger Levels		
		Intrusive Noise Trigger Levels $L_{Aeq,15min}$	**Project Amenity Noise Level (PANL)** $L_{Aeq,period}$	**Sleep Disturbance** $L_{Amax(night)}$
Residence R2-R4	Day	**40**[3]	45	N/A[2]
	Evening	**35**[3]	40	N/A[2]
	Night	**35**[3]	35	**52**

Notes

1. The NPI defines day, evening and night time periods as:
   - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
   - Evening: the period from 6 pm to 10 pm.
   - Night: the remaining period.
2. N/A Not Applicable
3. Based on minimum assumed RBLs and intrusiveness noise levels provided in Section 2.3 of the NSW NPI.

4.3 Operational noise review

4.3.1 Building services noise

The primary operational noise associated with the new hospital building relates to building services equipment as outlined above. Building service equipment (e.g. mechanical, electrical and hydraulic plant and equipment) for the development has not been selected at this stage of design. During ongoing design of the development, building services equipment will be selected and provided with noise and vibration attenuation measures as required to meet the Project goals. Where low noise equipment selection alone is insufficient, standard noise control methods can be adopted such as attenuators, acoustic louvres, acoustic screening around plant areas, acoustic enclosures and use of sound absorptive treatments to screens and plant rooms.

Further detailed acoustic design will be required following confirmation of the building services equipment selections. However, preliminary guidance concerning primary sources of building services noise has been provided below.

4.3.1.1 Mechanical Services

- The cooling towers are to be located in a fully louvred plantroom open to sky on level 1. The plant room faces north and therefore consideration should be given to the control of noise impacts upon receiver locations along Mattick Road (i.e. R1, R2, etc.). Typical cooling tower sound power levels (L_w) would require considerable noise abatement in order to achieve the particularly onerous night-time project noise trigger level of 35 dB(A) at the above identified receivers. Therefore, attenuators and acoustic louvres are expected to be required for the treatment of the cooling towers.

- The magnetic bearing chillers and associated water pumps are located in the south west corner of the basement plant room. They are entirely enclosed by the masonry building envelope to the west, south and east and separated from the louvered northern façade by approximately 30 m.
- The large majority of AHUs and associated fans servicing the building are to be located in the level 1 plant room. Outside air louvres will be required in the plant room façade, however the size and quantity is yet to be determined. It is anticipated that noise control of the level 1 plant room will be determined primarily by the need to minimise impacts upon the hospital site.

4.3.1.2 Electrical Services

- The diesel generator set is located on basement level separated from the northern building façade by approximately 20 m. It is noted that the diesel generator set is proposed to be house within an acoustic enclosure which will be designed to achieve the internal noise level targets applicable to the New Hospital Building.
- The kiosk substation is similarly located on basement level separated from the northern building façade by approximately 7 m directly south of the diesel generator. Initial review of typical kiosk substations indicate that operational noise levels are likely to be below the existing ambient noise environment of the area.

5 Impacts upon development

5.1 Road traffic noise and vibration

It is noted that the NSW Department of Planning *Development in Rail Corridors and Busy Roads – Interim Guideline* is not directly relevant to the New Macksville Hospital development on the basis that existing (2013) and projected (2026) traffic volumes along the adjacent section of the Pacific Highway do not exceed the trigger AADT[1] volume of 40,000.

Traffic volume data was obtained from a 2015 report[2] prepared for Roads and Maritime Services (RMS) in connection with the Warrell Creek to Nambucca Heads—Pacific Highway upgrade. Table 8 summarises the existing (2013) and projected (2026) traffic volume data for this section of the Pacific Highway.

Table 8: Existing and projected average traffic volumes along the Pacific Highway

Location	**Direction**	**Total Vehicles**			
		Existing (2013)		**Projected (2026)**	
		Day	**Night**	**Day**	**Night**
North of Bald Hill interchange	NB	5192	692	5325	1197
	SB	4988	583	5475	1161
	Total	10180	1275	10800	2358
		11455		13158	

Notes:
NB – North bound
SB – South bound

Notwithstanding, it is expected that during the detailed design of the building, noise intrusion from external sources, such as road traffic will be considered. Vibration impacts from vehicles travelling along the Pacific Highway are not expected to impact the development.

5.2 Road traffic noise levels

Long-term road traffic noise measurements were carried out approximately 40 m from the nearest carriageway of the recently completed Warrell Creek to Nambucca Heads—Pacific Highway upgrade. The measurement location (L2) is identified in Figure 3 and shown in Figure 4 below, while detailed measured road traffic noise results are presented in Appendix B.

Table 9 presents a summary of the measured road traffic noise levels for the Day and Night time, determined in accordance with the RNP. The one-hour

[1] Annual Average Daily Traffic
[2] RENZO TONIN & ASSOCIATES, *Pacific Highway Upgrade – Warrell Creek to Nambucca Heads Operational Noise Modelling & Assessment, TG100-01F04 (REV 10) Operational Noise Modelling Assessment Report, March 2015*

assessment period has been selected in observance of the acoustic requirements of the NSW ESG (July 2017).

Table 9: L2 - Road noise monitoring results, dB(A)

Location	**Time period**	**$L_{Aeq\ (1hr)}$, dB** [3, 4]
L2 – West of site	Day[1]	66
	Night[2]	64

1 Day: 07:00-22:00

2 Night: 22:00-07:00

3 Logarithmic average of daily L_{Aeq}

4 The external road traffic noise levels presented are free-field noise levels. [i.e. no façade reflection]

Figure 4: Long-term noise monitoring location (Pacific Highway in view)

The noise levels presented in Table 9 are representative of road traffic noise at the logger location (L2) not the nearest Macksville Hospital facade. The precise siting

of the Macksville Hospital is yet to be determined therefore an exact adjustment to the measured road traffic noise levels cannot be applied.

Notwithstanding, the new Hospital building is expected to be located approximately 80 m east of the logger location (i.e. approximately 120 m from the Pacific Highway) as indicated on the preliminary site plan (refer Figure 2). On this basis, adjustments have been made to the above $L_{Aeq\ (1hr)}$ noise levels in order to account for the ratio of distances.

Table 10 presents the adjusted road noise monitoring results considered for building envelope and façade design.

Table 10: Adjusted road noise monitoring results, dB(A)

Location	**Time period**	**$L_{Aeq\ (1hr)}$, dB** [3, 4]
Approximate Macksville Hospital Façade (120 m from Pacific Highway)	Day[1]	61
	Night[2]	59

1 Day: 07:00-22:00

2 Night: 22:00-07:00

3 Logarithmic average of daily L_{Aeq}

4 The external road traffic noise levels presented are free-field noise levels. [i.e. no façade reflection]

Initial calculations indicate that the design specifications can be achieved through the application of standard single glazed units (i.e. 6 – 10 mm thickness SGU) subject to surface area ratios (window to wall) and area designation (design specification).

At this early stage of design, no further adjustments or reductions to the measured road traffic noise levels have been considered. However, it is possible that the local topography and building siting may lead to addition reductions in road traffic noise due to shielding.

6 Construction

This assessment should be used to inform the proposed work practices and management measures contained in the preliminary Construction Management Plan (CMP). The preliminary CMP will be further developed as the construction methodologies and processes are confirmed during the design development process.

6.1 Construction stages and activities

It is noted that there are two approvals underway for this project:

- **Council DA** — to construct the access road, undertake bulk earthworks (benching) of proposed hospital site and complete services adjustments/removal. This is referred to as Early Works; and
- **SSD** — construction of the proposed hospital building.

Table 11 gives a high-level outline of the general stages of work and an outline of the activities that will be carried out as part of the construction works associated with the SSD application.

Table 11: General Stages of Work

Element	Description	Indicative plant items
Site Establishment Works	Construction of temporary construction site offices and storage area and associated works for the Main Works Contractor	Generators Trucks Hammers Hand tools
New hospital building	Construction of the new hospital building	Truck Crane Concrete pump truck Hand tools Removal of building waste

6.2 Indicative program and schedule

The indicative construction schedule associated with the SSD application is outlined in Table 12.

Table 12: Indicative construction schedule

Element	Duration
Site establishment works	Approx. 1 month from June 2018
New hospital building	Approx. 20 months from SSD approval

6.3 Construction hours

Working hours for the construction of the New Macksville Hospital are currently proposed as summarised in Table 13.

Table 13: Proposed construction hours

Day	Recommended standard hours
Monday to Friday	7 am to 6 pm
Saturday	8 am to 1 pm

The above construction hours adhere to the recommended standard hours prescribed in the *Interim Construction Noise Guideline* (ICNG). At this stage, it is not expected that any out of hours works will be required.

6.4 Construction noise criteria

The ICNG provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction management noise levels above which all feasible and reasonable work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG provides two methods for assessing construction noise, varying typically on the basis of the project duration, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement of background noise levels for determination of management levels and prediction of construction noise levels. A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

The size of the New Macksville Hospital development and indicative construction schedule warrant a quantitative assessment including prediction of construction noise levels. A preliminary screening quantitative assessment has been carried out, however it is expected that a more detailed quantitative assessment be undertaken prior to commencement of works, so as to confirm mitigation and management processes.

6.4.1 Management levels

The ICNG sets out management levels for noise at sensitive receivers, and how they are to be applied. The management noise levels for residential receivers are reproduced below in Table 14.

Table 14: Construction noise management levels at residential receivers

Time of day	**Management level [1]** $L_{Aeq\ (15\ min)}$	**How to apply**
Recommended standard hours: Refer to Section 6.3	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	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 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

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

For work within standard construction hours, if after implementing all ‘feasible and reasonable’ noise levels the site still exceeds the noise affected level, the ICNG does not require any further action – since there is no further scope for noise mitigation.

For out-of-hours work, the ICNG uses a noise level 5 dB above the noise-affected level as a threshold where the proponent should negotiate with the community.

However, it is further noted that out of hours' works are not expected to be required.

6.4.2 Project construction noise targets

Based on the ICNG guideline and the monitoring carried out, Table 15 outlines the project specific targets for the surrounding receivers.

Table 15: Construction noise management levels

Receiver	Standard hours $L_{Aeq(15\ min)}$[1]		Outside recommended standard hours
	Noise affected	Highly affected	
Residence R1, R5-R8	52	75	46 (evening) / 48 (night)
Residence R2-R4	45	75	35 (evening) / 35 (night)

Notes: 1 – Refer to Section 6.3

6.5 Construction vibration criteria

6.5.1 Disturbance to building occupants

Concerns regarding impacts on human occupants to buildings would generally be assessed in accordance with the 'intermittent' vibration criteria outlined in the DEC Guideline (Department of Environment and Conservation (NSW), 2006). However, due to the low vibration intensity works proposed, focus for management purposes is on structural damage, as outlined below.

6.5.2 Structural damage

6.5.2.1 Definition

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2 (Bristish Standard Institution, 1993) and/or German Standard DIN4150-3 (Deutsches Institut fur Normung, 1999). British Standard 7385 Part 1: 1990, defines different levels of structural damage as:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

Table 1 of British Standard 7385 Part 2 (1993) sets limits for the protection against cosmetic damage, however the following guidance on minor and major damage is provided in Section 7.4.2 of the Standard:

> *7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.*

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components"* (p.2). The Standard also outlines:

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> - *cracks form in plastered surfaces of walls;*
> - *existing cracks in the building are enlarged;*
> - *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)*

While the DIN Standard defines the above damage as 'minor', the description aligns with BS7385 cosmetic damage, rather than referring to structural failures.

6.5.2.2 British Standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 16 sets out the BS7385 criteria for cosmetic, minor and major damage.

Table 16: BS 7385-2 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s[1]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		

Group	Type of structure	Damage level	Peak component particle velocity, mm/s[1]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

1 - Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

2 - Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

6.5.2.3 German Standard DIN 4150

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure'* are generally recognised to be conservative and is often referred to for the purpose of assessing structurally sensitive buildings. For the subject site, surrounding buildings are not deemed structurally sensitive and therefore the British Standard is considered appropriate for vibration management.

6.5.3 Buried services

It is not expected that the proposed works will impact upon buried services, however the following is nonetheless provided for guidance. DIN 4150-2:1999 sets out guideline values for vibration effects on buried pipework (see Table 17).

Table 17: Guideline values for short-term vibration impacts on buried pipework

	Pipe material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50

Note: For gas and water supply pipes within 2m of buildings, the levels given in DIN4150-3 (Deutsches Institut fur Normung, 1999) should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

In addition, specific limits for vibration affecting high-pressure gas pipelines is provided in the UK National Grid's *Specification for Safe Working in the Vicinity of National Grid High Pressure Gas Pipelines and Associated Installations – Requirements for Third Parties* (report T/SP/SSW/22, UK National Grid, Rev 10/06, October 2006). This specification states that no piling is allowed within 15 meters of a pipeline without an assessment of the vibration levels at the pipeline. The PPV at the pipeline is limited to a maximum level of 75 mm/s, and where PPV is predicted to exceed 50 mm/sec the ground vibration is required to be monitored.

Other services that maybe encountered include electrical cables and telecommunication services such as fibre optic cables. While these may sustain vibration velocity levels from between 50mm/s and 100mm/s, the connected services such as transformers and switchgear, may not. Where encountered, site specific vibration assessment in consultation with the utility provider should be carried out.

6.6 Construction noise and vibration assessment

6.6.1 Construction works – noise impact

As detail of the construction equipment / plant to be used during the construction stages of the project is not known at the time of this assessment, a generic approach has been adopted and noise sources normally found on construction sites similar to the new Macksville Hospital have been considered.

The anticipated airborne noise levels for the likely construction noise sources are listed in Table 18. Equipment sound power levels (L_w) have been sourced from AS2436 – 2010 Guide to noise and vibration control on construction, demolition and maintenance sites. It should be noted that during the different construction stages, it is unlikely that all machinery would be operating at the same time (like the prediction assumes), but taking a 'worse-case' scenario approach helps to identify where noise impacts could be a concern and assists in the design of mitigation measures.

Table 18: Assumed construction equipment and sound power levels

Equipment	Sound power level (per unit), dB(A)
Concrete agitator truck	109
Concrete pump truck	108
Concrete vibratory screed	115
Crane (mobile)	104
Forklift	106
Front end loader	113
Generator (diesel)	99
Hand tools (electric)	102
Hand tools (pneumatic)	116
Jack hammers	121
Truck (> 20 tonne)	107
Vehicle (light commercial e.g. 4WD)	106
Welder	105

Three scenarios have been considered for the prediction of construction noise and are summarised in Table 19.

Table 19: Construction noise prediction scenarios

Scenario	Equipment
1	All equipment[1]
2	Concrete agitator truck Concrete pump truck Concrete vibratory screed Crane (mobile) Truck (> 20 tonne) Vehicle (light commercial e.g. 4WD)
3	Forklift Front end loader Hand tools electric Hand tools pneumatic Jack hammers Welder

1. Scenario 1 is considered an absolute worst case and therefore actual construction noise levels are likely to be lower than those predicted for scenario 1.

Predicted construction noise levels considering standard construction hours are provided in Table 20. Noise levels have been compared to the receiver's Noise Management Level and exceedances have been highlighted. It should be noted that in general construction works are temporary in nature therefore any potential noise impact on the community and the surrounding environment will not be permanent. However, where possible the impacts due to construction noise should be minimised.

Where the predicted $L_{Aeq(15min)}$ noise level is greater than the noise management levels, all feasible and reasonable work practices should be applied (and are provided in Section 6.7 below). It is unlikely, however, that mitigation measures would reduce the received noise levels below the noise management levels.

The magnitude of construction noise impacts is dependent upon a number of factors including the intensity and location of activities, the type of equipment used and background noise levels during the construction period. Based on these factors, the predicted construction noise levels are generally conservative and do not represent a constant noise emission that would be experienced by the community on a daily basis throughout the entire project construction period. The predicted noise levels would only be experienced for limited periods of time when works are occurring and should not be experienced for full daytime, evening or night time periods. It is also emphasised that all the equipment listed in Table 18 is very unlikely to operate continuously for 15 minutes and concurrently (no adjustment for duration has been made in the predicted construction noise levels).

Table 20: Predicted construction noise levels, dB(A)

Rec. ID	Receiver Type	Predicted Noise Level, $L_{Aeq,15min}$, dB(A)			Management level – standard hours $L_{Aeq,15min}$, dB(A)	
		Scenario 1	Scenario 2	Scenario 3	Noise affected	Highly noise affected
R1	Residential	70	64	69	52	75
R2	Residential	68	61	67	45	75
R3	Residential	60	54	59	45	75
R4	Residential	58	52	57	45	75
R5	Residential	59	52	58	52	75
R6	Residential	62	56	61	52	75
R7	Residential	64	58	63	52	75
R8	Residential	67	61	66	52	75

Note:

Noise affected management level compliance

Noise affected management level exceeded, highly noise affected management level compliance

Highly noise affected management level exceeded

6.6.2 Construction works – vibration

Given that the main works are not expected to involve vibration intensive activities (i.e. rock breaking, pile driving, etc.) it is expected that the vibration impact to sensitive ‘off-site’ receivers will be negligible.

6.7 Construction noise and vibration mitigation

Noise mitigation measures for each major construction activity are discussed in the following sections. These mitigation measures are considered to represent ‘feasible and reasonable’ mitigation measures suitable for implementation during construction of the project.

6.7.1 Construction noise and vibration management plan

For all construction works, the contractor would be expected to prepare a detailed Construction Noise and Vibration Management Plan (CNVMP). This plan should include but not be limited to the following:

- Roles and responsibilities
- Noise and vibration sensitive receiver locations

- Areas of potential impact
- Mitigation strategy
- Monitoring methodology
- Community engagement strategy.

General guidance on the control of construction noise and vibration impacts relevant to this study are discussed in the following sections.

6.7.2 General

In general, practices to reduce construction noise impacts will be required, and may include;

- Adherence to the standard approved working hours as outlined in the Project Approval.
- Manage noise from construction work that might be undertaken outside the recommended standard hours
- The location of stationary plant (concrete pumps, air-compressors, generators, etc.) as far away as possible from sensitive receivers
- Using site sheds and other temporary structures or screens/hoarding to limit noise exposure where possible.
- Sealing of openings in the building (temporary or permanent) prior to commencement of internal works to limit noise emission.
- The appropriate choice of low-noise construction equipment and/or methods
- Modifications to construction equipment or the construction methodology or programme. This may entail programming activities to occur concurrently where a noisy activity will mask a less noisy activity, or, at different times where more than one noisy activity will significantly increase the noise. The programming should also consider the location of the activities due to occur concurrently.
- Carry out consultation with the community during construction including, but not limited to; advance notification of planned activities and expected disruption/effects, construction noise complaints handling procedures.

6.7.3 Universal work practices

The following noise mitigation work practices are recommended to be adopted at all times on site:

- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Site managers to periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors.
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.

- Turn off all plant and equipment when not in use.

6.7.4 Vibration – minimum working distances

Recommended minimum working distances for vibration intensive plant, which are based on international standards and guidance and reproduced in Table 21 for reference. With regard to the proposed development works, vibration is not expected to impact upon surrounding development.

Table 21: Recommended minimum working distances for vibration intensive plant

Plant Item	**Rating / Description**	**Minimum working distance**	
		Cosmetic damage (BS 7385)	**Human response (OH&E Vibration Guideline)**
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

7 Conclusion

Arup has completed an acoustic and vibration assessment for the proposed New Macksville Hospital to address the SEARs for SSD 9103, which relate to operational and construction related environmental noise and vibration emissions.

With regard to operations, the assessment concludes that the proposed development is capable of satisfying the standard NSW EPA noise policy requirements. Notwithstanding, further detailed acoustic assessment is warranted during the design development, particularly with regard to building services noise control.

Regarding construction, the proposed works are predicted to result in exceedance of the relevant noise management levels at all assessment locations and accordingly mitigation and management procedures will need to be considered for the works. However, the predicted exceedances are only expected during periods of intense activity subject to the type of equipment used.

A detailed Construction Noise and Vibration Assessment for the project will be required, in which specific attention should be given to controlling noise impacts upon the considered residential receiver locations. It is expected that the detailed Construction Noise and Vibration Management Plan would be prepared by the contractor prior to the commencement of works.

Appendix A

Glossary

Ambient Noise Level

The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.

Background Noise Level

The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects.

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 time 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.

Rating Background Level (RBL / min$L_{A90,1hour}$)

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. This parameter is denoted RBL in NSW, and min$L_{A90,1hour}$ in QLD.

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting ("A-weighting") to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the "average maximum" level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an

example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the "average minimum" or "background" level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB $L_{Aeq.}$ Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

L_{max}

The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

Since L_{max} is often caused by an instantaneous event, L_{max} levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as "pitch". Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or "low-pitched" and sounds with a higher frequency are perceived as "treble" or "high pitched".

Peak Particle Velocity (PPV)

Peak Particle Velocity (PPV) is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure *root mean squared* (RMS) values; it is common to approximate the PPV based on an RMS measurement.

PPV is commonly used as a vibration criteria, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Vibration

Waves in a solid material are called “vibration”, as opposed to similar waves in air, which are called “sound” or “noise”. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s²) or else using a decibel scale.

Appendix B

Unattended Monitoring Results

B1 Noise monitoring equipment

Unattended monitoring was carried out using the following equipment:

Measurement location	Equipment/model	Serial No.	SLM Type
L1	ARL Ngara	878042	Type 1
L2	ARL Ngara	878007	Type 1

Notes:

All meters comply with AS IEC 61672.1 2004 “Electroacoustics - Sound Level Meters” and designated either Type 1 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed.

B2 Extraneous/weather affected data

Measurement samples affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the procedures outlined in Fact Sheet A of the NSW Noise Policy for Industry (NPI).

Data provided by the Bureau of Meteorology (BOM), for the nearest representative weather station to noise monitoring location(s). Wind speed data was adjusted to account for the difference in measurement height and surrounding environment between the BOM weather station (measured 10 m above ground) and the microphone location based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

B3 Logger graphs

The following noise level vs time graphs present overall dB(A) levels recorded by the unattended noise loggers for a range of noise descriptors, including L_{Aeq}, L_{A90}, L_{A10} and L_{Amax}, while line graphs are presented, sampling is typically at 15 minute intervals.

Wind speeds are also show where relevant, and periods of excluded data are shaded grey.

Table 22: L1 - Background and ambient noise monitoring results

Date	L_{A90} Background noise levels, dB(A)[4]			L_{Aeq} Ambient noise levels, dB(A)		
	Day[1]	Eve[2]	Night[3]	Day[1]	Eve[2]	Night[3]
Monday-29-January-2018	-	41	43	-	51	51
Tuesday-30-January-2018	40	40	43	50	51	50
Wednesday-31-January-2018	42	42	41	51	52	50
Thursday-01-February-2018	43	41	38	51	49	48
Friday-02-February-2018	43	41	-	52	50	-
Saturday-03-February-2018	-	-	42	-	-	50
Sunday-04-February-2018	41	42	46	52	53	51
Monday-05-February-2018	44	-	43	66	-	50
Tuesday-06-February-2018	-	-	-	-	-	-
Representative Weekday[5]	**43**	**41**	**43**	**60**	**50**	**50**
Representative Weekend[5]	**41**	**42**	**44**	**52**	**53**	**50**
Representative Week[5]	**42**	**41**	**43**	**59**	**51**	**50**

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Eve is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Table 23: L1 - Road noise monitoring results

Date	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
	Day[1]	Night[2]	Day	Night
Monday-29-January-2018	50	51	53	56
Tuesday-30-January-2018	50	50	53	53
Wednesday-31-January-2018	51	50	53	56
Thursday-01-February-2018	50	48	53	51
Friday-02-February-2018	52	49	55	55
Saturday-03-February-2018	50	50	53	51
Sunday-04-February-2018	52	51	55	52
Monday-05-February-2018	65	50	71	55
Tuesday-06-February-2018	51	-	56	-
Representative Weekday[3]	**57**	**50**	**63**	**55**
Representative Weekend[3]	**51**	**50**	**54**	**52**
Representative Week[3]	**57**	**50**	**62**	**54**

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Table 24: L2 - Background and ambient noise monitoring results

Date	L_{A90} Background noise levels, dB(A)[4]			L_{Aeq} Ambient noise levels, dB(A)		
	Day[1]	Eve[2]	Night[3]	Day[1]	Eve[2]	Night[3]
Monday-29-January-2018	-	46	41	-	66	64
Tuesday-30-January-2018	51	44	40	65	64	63
Wednesday-31-January-2018	53	45	39	65	64	63
Thursday-01-February-2018	53	43	36	66	64	63
Friday-02-February-2018	52	44	-	64	62	-
Saturday-03-February-2018	-	-	38	-	-	60
Sunday-04-February-2018	49	44	37	66	64	60
Monday-05-February-2018	52	-	40	66	-	63
Tuesday-06-February-2018	-	-	-	-	-	-
Representative Weekday[5]	**52**	**44**	**40**	**65**	**63**	**63**
Representative Weekend[5]	**49**	**44**	**37**	**66**	**64**	**60**
Representative Week[5]	**52**	**44**	**39**	**65**	**64**	**63**

6. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
7. Eve is 6:00pm to 10:00pm
8. Night is the remaining periods
9. Assessment Background Level (ABL) for individual days
10. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

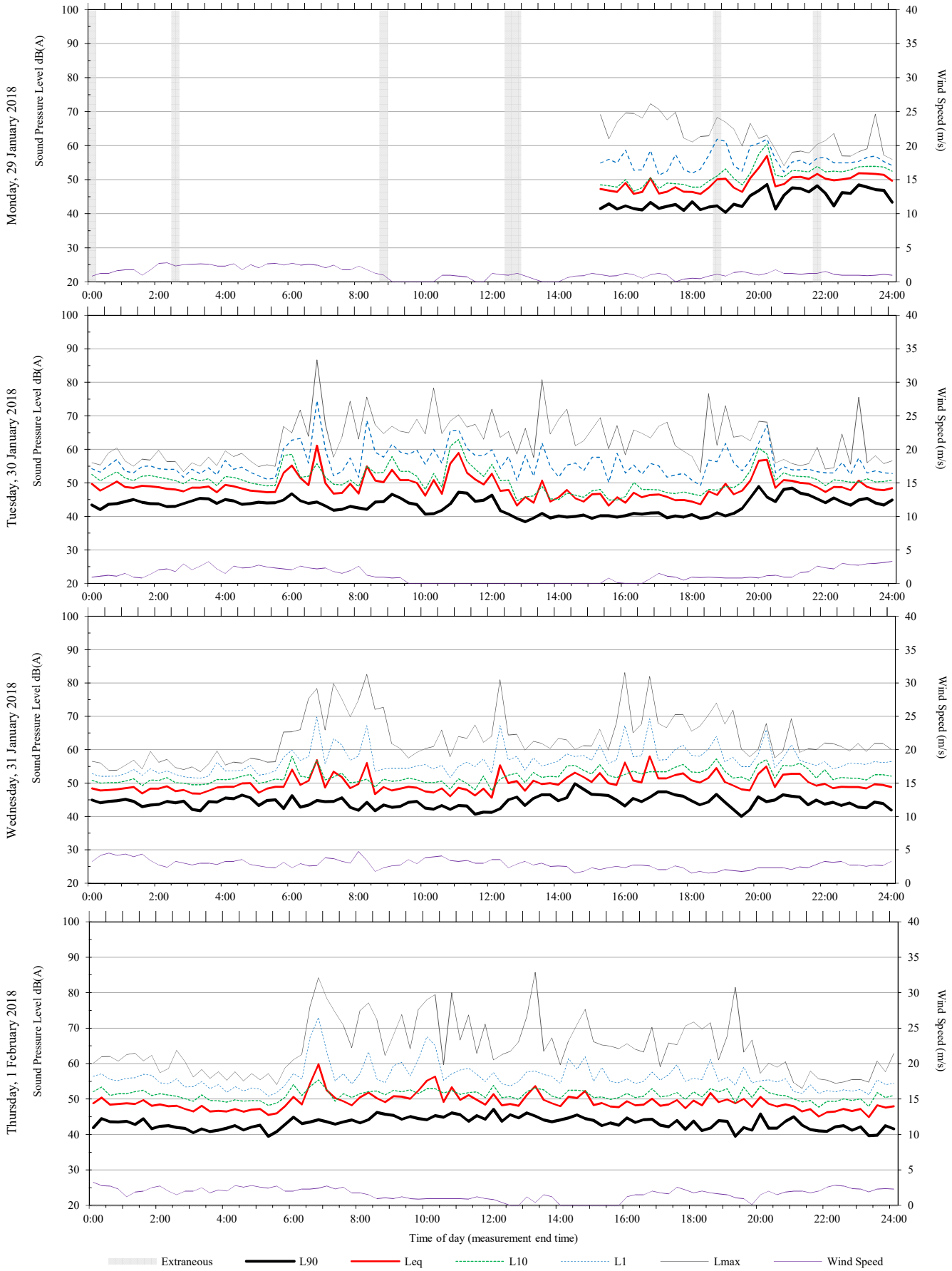
Table 25: L2 – Road noise monitoring results

Date	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
	Day[1]	Night[2]	Day	Night
Monday-29-January-2018	66	64	67	65
Tuesday-30-January-2018	65	63	66	64
Wednesday-31-January-2018	65	63	65	65
Thursday-01-February-2018	65	63	67	65
Friday-02-February-2018	64	62	65	63
Saturday-03-February-2018	64	60	65	62
Sunday-04-February-2018	65	60	66	64
Monday-05-February-2018	66	63	68	65
Tuesday-06-February-2018	67	-	68	-
Representative Weekday[3]	**65**	**63**	**66**	**65**
Representative Weekend[3]	**64**	**60**	**66**	**63**
Representative Week[3]	**65**	**62**	**66**	**64**

4. Day is 7:00am to 10:00pm
5. Night is 10:00pm to 7:00am
6. Logarithmic average of daily L_{Aeq}

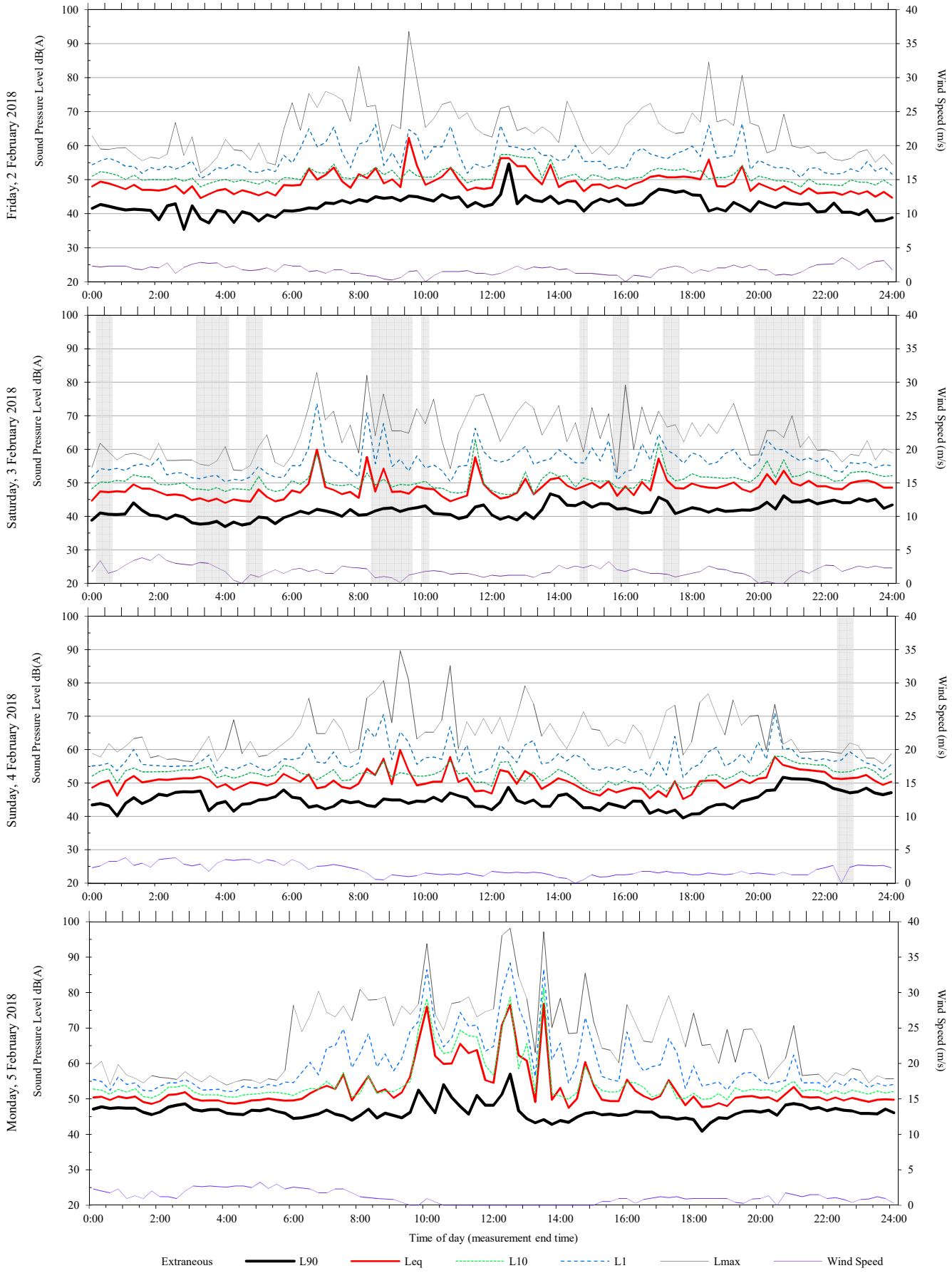
Unattended monitoring: L1 (Free Field)

ARUP



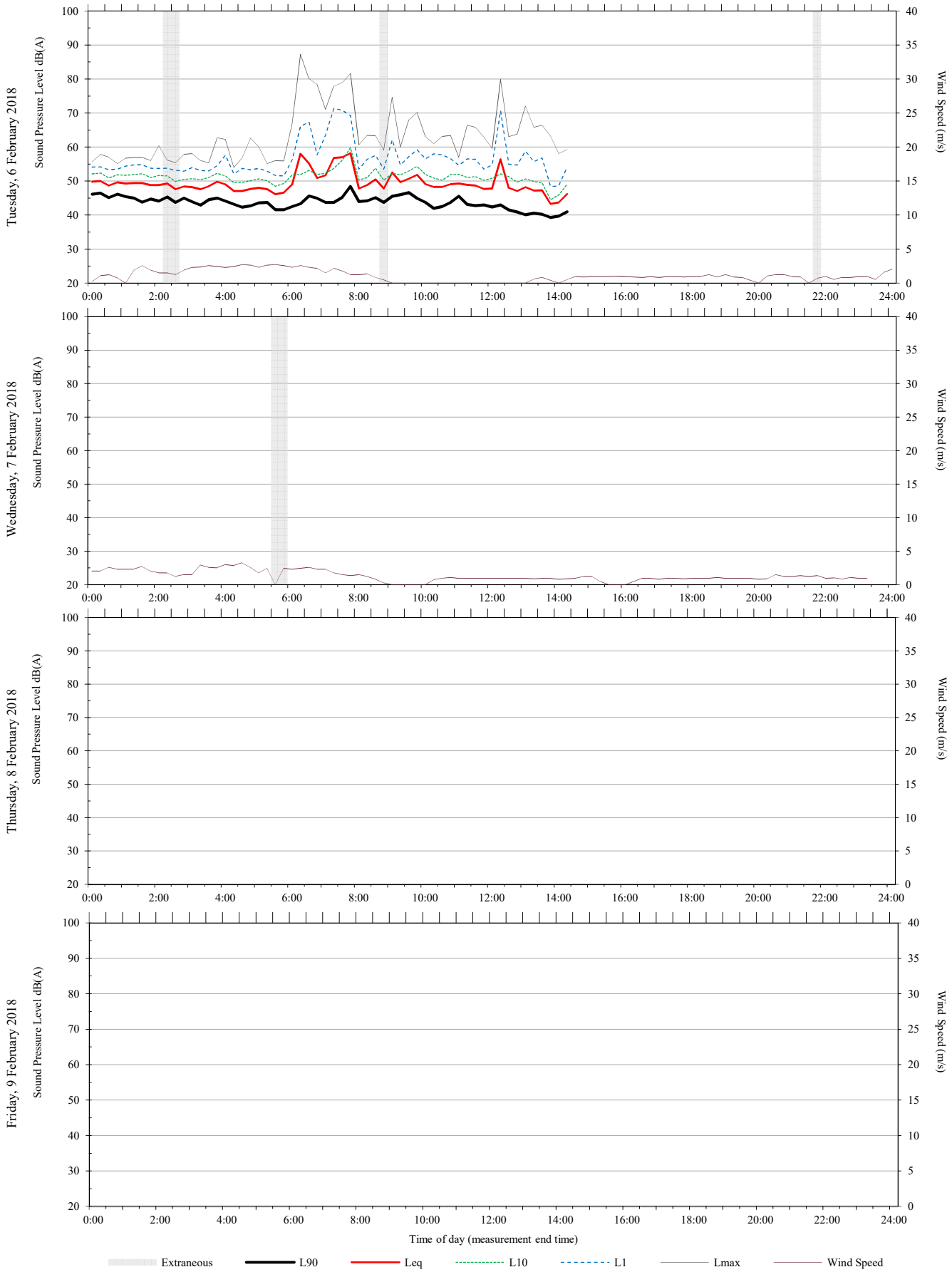
Unattended monitoring: L1 (Free Field)

ARUP



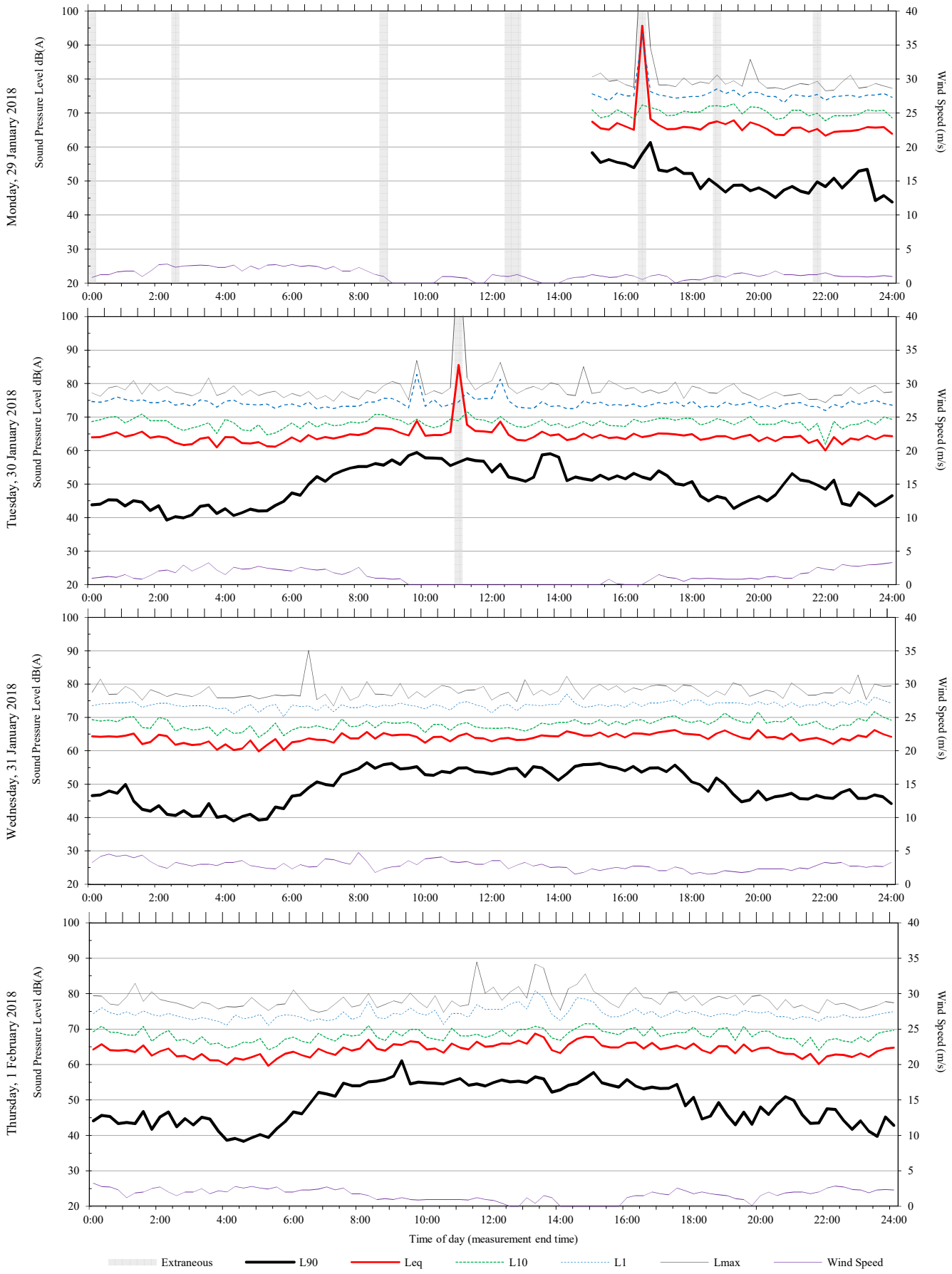
Unattended monitoring: L1 (Free Field)

ARUP



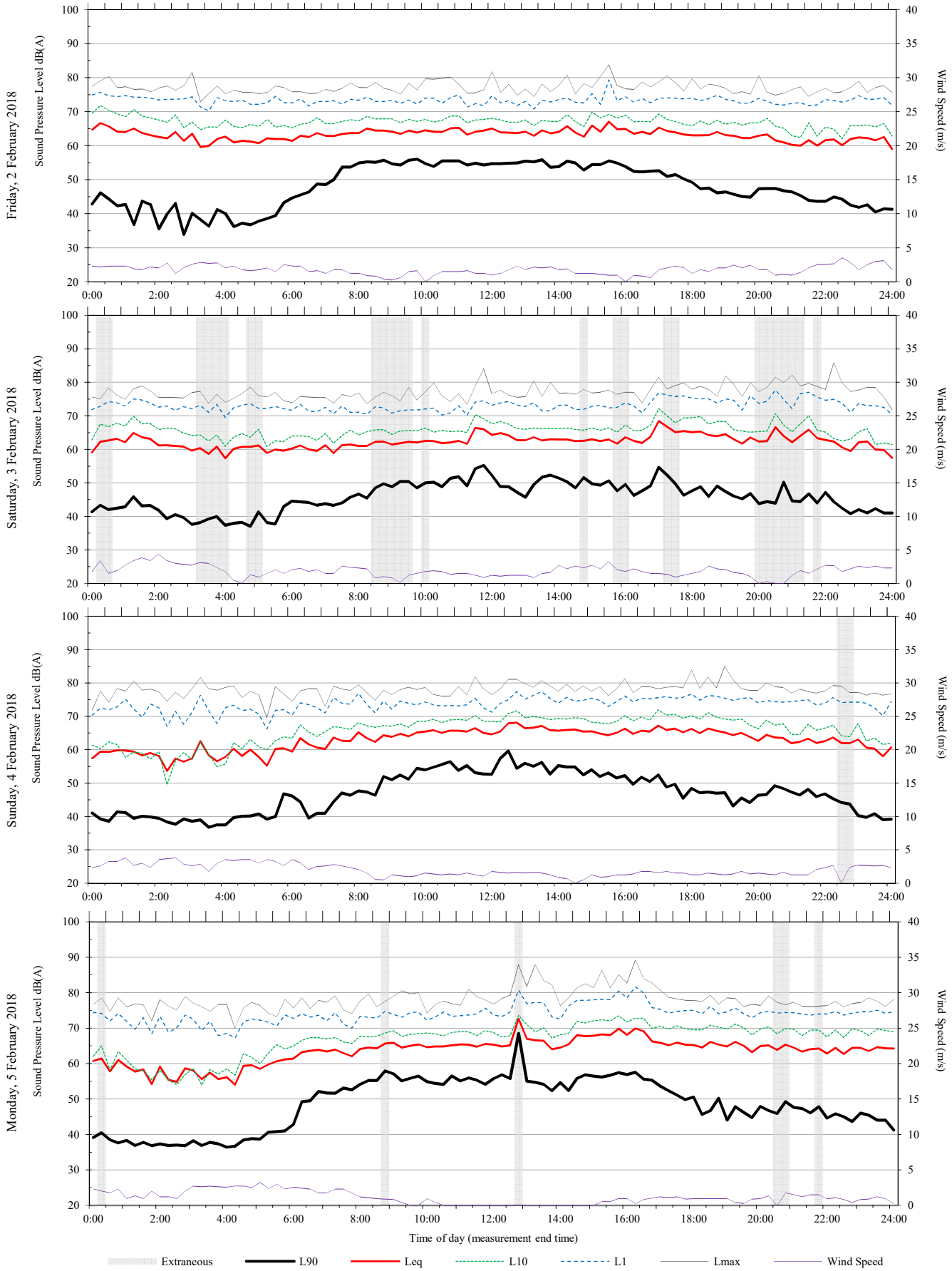
Unattended monitoring: L2 (Free Field)

ARUP



Unattended monitoring: L2 (Free Field)

ARUP



Unattended monitoring: L2 (Free Field)

ARUP