Operational and Construction Noise and Vibration Assessment

Denmark Link Road Project
Riverstone, NSW

Prepared for: Hills Environmental
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MAC201108-01RP1V1

Muller Acoustic Consulting

Document Information

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Denmark Link Road Project

Riverstone, NSW

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1 Introduction

Muller Acoustic Consulting Pty Ltd (MAC) has been commissioned by Hills Environmental (Hills) on behalf of Transport for New South Wales (Transport for NSW) to complete an Operational and Construction Noise and Vibration Assessment (OCNVA) for the construction of the Denmark Link Road at Riverstone/Schofields, NSW (the 'proposal').

This report presents the results, findings and recommendations of the OCNVA and has been prepared to accompany the Review of Environmental Factors (REF) being prepared by Hills. The assessment has been completed in general accordance with the following standards and guidelines:

- Roads and Maritime Services (2016), Environmental Impact Assessment Procedure: Preparing an Operational Traffic and Construction Noise and Vibration assessment report;
- Roads and Maritime Services (2016), Construction Noise and Vibration Guideline (CNVG);
- Roads and Maritime Services (2015), Noise Criteria Guideline (NCG);
- Roads and Maritime Services (2015), Noise Mitigation Guideline (NMG);
- Roads and Maritime Services (2017), At-receiver Noise Treatment Guideline;
- Department of Environment and Climate Change (2009), Interim Construction Noise Guideline (ICNG);
- NSW Environment Protection Authority (2017), Noise Policy for Industry (NPI);
- AS IEC 61672.1-2019 Electroacoustics – Sound level meters – Specifications;
- Australian Standard – AS 1055:2018 Acoustics- Description and measurement of environmental noise;
- Australian Standard – AS 2436-2010 (R2016) Guide to Noise Control on Construction, Maintenance and Demolition Sites;
- Department of Environment and Conservation (2006), Assessing Vibration: A Technical Guideline; and
- British Standard BS 7385:Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2".

A glossary of terms, definitions and abbreviations used in this report is provided in **Appendix A**.

1.1 Assessment Objectives

The OCNVA quantifies potential construction noise and vibration impacts and operational road traffic noise intrusion to residential receivers along the proposal alignment.

Primary considerations in this assessment report include:

- Provide a technical document that can support the REF for the proposal;
- Identification of sensitive receivers;
- Quantifying potential operational road traffic noise based on the proposal concept design and concept design report;
- Quantifying construction noise and vibration impacts from the proposal based on the proposal brief information; and
- Review reasonable and feasible control measures to mitigate noise and vibration emissions with the aim of meeting noise management levels and relevant vibration criteria.

The structure and format of this report has been prepared in accordance with the Transport for NSW (formerly Roads and Maritime Services) document Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report (Roads and Maritime, 2016), with consideration to the Editorial Style Guide (Roads and Maritime, 2019).

2 Proposal Description

2.1 Proposal Area

The proposal area is located about 40km north west of Sydney, NSW within the Blacktown City Council Local Government Area (LGA). The study area for the proposal is illustrated in **Figure 1**.

Within the proposal area Denmark Road, Carlton Street and West Parade are described as narrow local roads with no through access. The pavement is generally considered to be in poor to fair condition with gravel shoulders and vegetated table drains. The speed limit is currently 50km/h.

2.2 Proposal Background

The NSW Government has proposed a road network to support the forecast growth in the North West Growth Area. Over the next ten years, 33,000 homes will be provided in the area and once fully developed, the area will be home to around 250,000 people.

To deliver the North West Growth Centre (NWGC) Road Network Strategy, Transport for New South Wales (Transport for NSW) is working with Blacktown City Council to develop local plans to improve traffic flow within the Riverstone Town Centre and to the Westminster Street bridge. A new local link road connection has been identified between Garfield Road West and the Westminster Street bridge at Schofields. The Denmark Link Road project, which forms part of the Riverstone Traffic Improvements Package, will provide a light vehicle bypass route around the existing rail level crossing in Riverstone. This package of works has been identified as part of short term works until a grade separation of the level crossing can be completed.

This proposal will provide an alternative local connection for light vehicles to cross the Richmond railway line and avoid the need to enter the Riverstone Town Centre. This will alleviate traffic congestion along Garfield Road West around the railway level crossing at Riverstone.

The operational objectives of the proposal include:

- Reducing the congestion and delays that are currently being experienced at the Garfield Road railway level crossing at Riverstone;
- Providing a second location road connection for motorists wishing to use Westminster Street;
- Bridge, alleviating congestion of Garfield Road; and
- Aligns with the future traffic needs for the area.

The key features included in the proposal design are:

- Two lane local road;
- A new right-turn bay along Garfield Road West for traffic waiting to enter Denmark Road at Riverstone;
- Improvements to the existing Denmark Road;
- A new link road between Denmark Road and Carlton Street;
- A new intersection at Carlton Road; and
- Extension of West Parade to connect near the Westminster Street Bridge at Schofields.

It is anticipated that the majority of the proposal would be constructed during standard construction hours. Out of hours (OOH) work may also be required to minimise disruptions to traffic along Garfield Road West. Works outside standard construction hours would be conducted in conjunction with community consultation to minimise noise and traffic impacts while meeting the proposal targets.

The key noise generating activities associated with the proposal include:

- Installation of environmental controls including erosion sand sediment controls;
- Site establishment including establishment of compound and stockpile sites;
- Removal of ground cover and trimming/removal of vegetation;
- Cleaning and shaping of existing table drains;
- Culvert extension and installation works;
- Pavement and drainage constructions;
- Site clean-up and rehabilitation of disturbed areas;
- Potential reinstatement of private accesses;
- Signage upgrades and improvements to pavement superelevation; and
- Potential minor utility adjustments.

Transport for NSW propose the establishment of a temporary compound site on a vacant parcel of land at the corner of Garfield Road West and Denmark Road.

The Concept Design for the proposal is provided in **Appendix B**.

FIGURE 1

Proposal Area

MAC201108

Denmark Link Road

KEY

Link Road Design

Compound Site

0 80 160 240 320 400 m

N

MAC

2.3 Identification of Sensitive Receivers

The noise environment surrounding the proposal site is typical of a rural environment on a suburban fringe, with dominant sources including road traffic noise from Garfield Road West and Railway Terrace, rail noise from the passage of trains, and general urban hum.

A review of aerial photography identifies numerous receivers within approximately 600m of the proposal site. The level of affectation for each receiver is influenced by the activity that is being undertaken and the distance and exposure of each receiver to the proposal site. The locality plan identifying the position of the potentially affected receivers is provided in **Figure 2**.

2.3.1 Residential Receivers

Residential receivers have been grouped into two Noise Catchment Areas (NCAs) based on receivers with similar Rating Background Levels (RBLs). These NCAs are presented visually in **Figure 2** along with noise monitoring locations. Residences in both NCAs are categorised as suburban receivers in accordance with the NPI.

2.3.2 Non-Residential Land Uses

Other, non-residential land uses within close proximity of the proposal are provided in **Table 1**.

Table 1 Other Receiver Types

Type	Description	Address
Commercial	Knights Garage & Gas	7 Garfield Road West
	Riverstone Hotel	1 Garfield Road West
	Wardina Demolition & Excavation	15 Carlton Street
Place of Worship	Life Anglican Church	19 Elizabeth Street
Active Recreation	Riverstone Trotting Track	Pacer Street (Lot 133 DP1485)
	Riverstone Park / Basil Andrews Park	Garfield Road West (Lot 11 DP900460)
	Riverstone Scouts Hall	17-19 Carlton Street

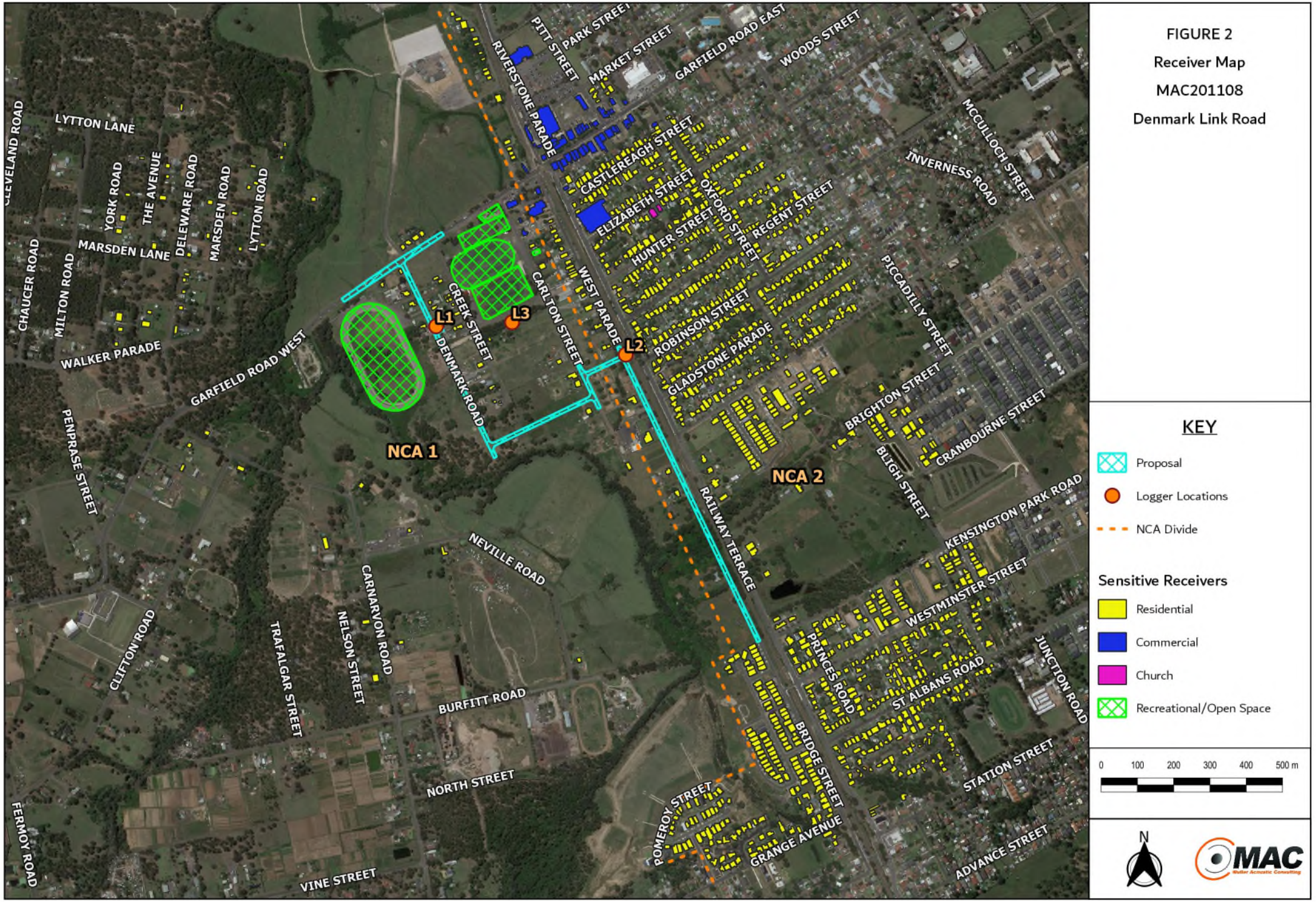
FIGURE 2
Receiver Map
MAC201108
Denmark Link Road
KEY
Proposal
Logger Locations
NCA Divide
Sensitive Receivers
Residential
Commercial
Church
Recreational/Open Space
0 100 200 300 400 500 m
N
MAC
NCA 1
NCA 2
L1
L2
L3
LYTTON LANE
YORK ROAD
THE AVENUE
DELEWARE ROAD
MARSDEN ROAD
LYTTON ROAD
MARSDEN LANE
CHAUCER ROAD
MILTON ROAD
WALKER PARADE
GARFIELD ROAD WEST
PENPRASE STREET
CLIFTON ROAD
TRAFALGAR STREET
NELSON STREET
CARNARVON ROAD
NEVILLE ROAD
BURFITT ROAD
NORTH STREET
FERMOY ROAD
VINE STREET
RIVERSTONE PARADE
PITT STREET
PARK STREET
MARKET STREET
GARFIELD ROAD EAST
WOODS STREET
CASTLEREAGH STREET
ELIZABETH STREET
HUNTER STREET
OXFORD STREET
REGENT STREET
INVERNESS ROAD
MCCULLOCH STREET
CREEK STREET
DENMARK ROAD
CARLTON STREET
WEST PARADE
ROBINSON STREET
GLADSTONE PARADE
PICCADILLY STREET
BRIGHTON STREET
CRANBOURNE STREET
BLIGH STREET
RAILWAY TERRACE
KENSINGTON PARK ROAD
WESTMINSTER STREET
PRINCES ROAD
ST ALBANS ROAD
JUNCTION ROAD
BRIDGE STREET
STATION STREET
ROMEROY STREET
GRANGE AVENUE
ADVANCE STREET

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3 Existing Environment

The community's reaction to noise from construction may be influenced by the time of day that work is carried out. Residents are potentially more affected by work that occurs during OOH periods (ie evening or night periods). Therefore, it is important to understand the existing noise environment surrounding the proposal to manage and minimise potential noise impact on the environment and local community.

3.1 Unattended Noise Monitoring

The unattended noise survey was conducted in general accordance with the procedures described in Australian Standard AS 1055:2018, "Acoustics - Description and Measurement of Environmental Noise". The selected monitoring locations are shown in **Figure 2**.

The measurements were carried out at monitoring locations L1 (NCA 1) and L2 (NCA 2) using two Svantek Type 1, Svan 977 noise monitors from Monday 27 July 2020 to Tuesday 4 August 2020. Due to a loss of data at L1 (due to vandalism), additional unattended monitoring was undertaken at monitoring location L3 (NCA 1) from Friday 4 September to Monday 14 September. Observations on-site identified the surrounding locality typical of an urban-rural fringe, with traffic noise the dominant audible noise source.

Calibration of all instrumentation was checked before and after measurements. Drift in calibration did not exceed ±0.5 dBA. All equipment carried appropriate and current National Association of Testing Authorities (NATA) (or manufacturer) calibration certificates.

Data affected by adverse meteorological conditions have been excluded from the results in accordance with methodologies provided in Fact Sheet A4 of the NPI. The results of long-term unattended noise monitoring are provided in **Table 2**. The measured noise levels were used to determine the Rating Background Level (RBL) for the assessment during the day, evening and night periods in accordance with the NPI. The noise monitoring charts for the background monitoring assessment are provided in **Appendix C**.

Table 2 Summary of Existing Background Noise Levels

Location	Measured background noise level, RBL, dBA			Measured dB LA_{eq}		
	Day 7am to 6pm	Evening 6pm to 10pm	Night 10pm to 7am	Day 7am to 6pm	Evening 6pm to 10pm	Night 10pm to 7am
L1	38	39	34	57	49	47
L2	42	41	34	56	53	54
L3	39	40	33	49	48	46

Note: Excludes periods of wind or rain affected data, meteorological data obtained from the Bureau of Meteorology Richmond RAAF AWS (33.6°S 150.78°E 19m AMSL).

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4 Construction Noise Impact Assessment

The assessment and management of noise from construction work is completed with reference to the Construction Noise and Vibration Guideline (CNVG). This guideline outlines the approach Transport for NSW takes when assessing and mitigating construction noise. The guideline provides the detail required to identify feasible and reasonable noise mitigation measures for construction, minor work and maintenance projects and needs to be considered for all Transport for NSW managed projects.

Construction noise impacts and mitigation measures need to be evaluated at various stages of a project to inform the concept design, environmental impact assessment, detail design and construction process.

The guideline describes the principles to be applied when reviewing and assessing construction noise, vibration and construction traffic. It also describes procedures to assist in reviewing noise and vibration mitigation.

The intention in all situations is to meet the following principles:

1. Good engagement with the community will be maintained to facilitate effective project delivery with balanced community impact.
2. Construction noise and vibration levels at sensitive receivers will be minimised where feasible and reasonable.
3. Feasible and reasonable mitigation will reflect the time of day, and/or the degree and duration of the impact.
4. The community will be informed of the dates for the intended work, sequencing and timing of noisy events. Where possible this will include an indicative schedule over a 24 hour period.
5. Minimising construction noise and vibration will be viewed as a continuous improvement exercise that is inclusive of stakeholders where no idea is too small to be considered.
6. Staff and community will be informed of the effort and methods undertaken to reduce noise and vibration for the work.
7. Any operational noise and vibration improvements resulting from the work will be promoted to the community.

4.1 Interim Construction Noise Guideline

In accordance with the CNVG, construction noise management levels are established with reference to the NSW Interim Construction Noise Guideline (ICNG). The ICNG is specifically aimed at managing noise from construction work regulated by the EPA and is used to help in setting statutory conditions in licences or other regulatory instruments. The types of construction regulated by the Environment Protection Authority (EPA) under the Protection of the Environment Operations Act 1997 (POEO Act), include construction, maintenance and renewal activities carried out by a public authority, such as road upgrades as described in Schedule 1 of the POEO Act.

The ICNG sets out procedures to identify and address the impact of construction noise on residences and other sensitive land uses. This section provides a summary of noise objectives that are applicable to the assessment. The ICNG provides two methodologies for the assessment of construction noise emissions:

- Quantitative, which is suited to major construction proposals with typical durations of more than three weeks
- Qualitative, which is suited to short term infrastructure maintenance (for proposals with a typical duration of less than three weeks).

The methodology for a quantitative assessment requires a more complex approach, involving noise emission predictions from construction activities to the relevant assessment locations, whilst the qualitative assessment methodology is a more simplified approach that relies more on noise management strategies.

This report has adopted a quantitative assessment approach. The assessment includes identification of potentially affected assessment locations, description of activities involved in the proposal, derivation of the construction noise criteria for standard and out of hours (OOH) periods, quantification of potential noise impacts at receivers and, provides management and mitigation recommendations.

4.1.1 Construction Hours

Table 3 summaries the ICNG recommended standard and out of hours periods for construction. Note, although not mandatory, strong justification is required to work outside of normal construction hours.

Table 3 Recommended Hours for Construction

Hour Commencing	12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM
Monday	OOH Period 2							Standard Hours											OOH Period 1					
Tuesday																								
Wednesday																								
Thursday																								
Friday																								
Saturday																								
Sunday									OOH Period 1										OOH Period 2					
Public Holiday																								

4.1.2 Out of Hours Construction

The ICNG suggests that any request to vary the hours of standard construction activities shall be:

- considered on a case by case basis or activity-specific basis;
- accompanied by details of the nature and need for activities to be undertaken during the varied construction hours; and
- accompanied by written evidence that activities undertaken during the varied construction hours are strongly justified; appropriate consultation with potentially affected receivers and notification of the relevant regulatory authorities has occurred; and all practicable and reasonable mitigation measures will be put in place.

Out of Hours (OOH) periods are divided into two categories generally representing evening and night periods and cover the hours listed below:

- **OOH Period 1 (evening/low risk period):** Monday to Friday – 6pm to 10pm, Saturdays – 7am to 8am & 1pm to 6pm, Sundays/Public Holidays – 8am to 6pm.
- **OOH Period 2 (night/medium to high risk period):** Monday to Friday – 10pm to 7am, Saturdays/Sundays/Public Holidays – 6pm to 7am (8am on Sunday mornings and Public Holidays).

4.1.3 Construction Noise Criteria

Table 4 reproduces the ICNG management levels for residential receivers. The construction Noise Management Level (NML) is the sum of the management level and relevant Rating Background Level (RBL) for each specific assessment period. **Table 5** reproduces the ICNG management levels for other receiver types.

Table 4 ICNG Residential Management Levels

Time of Day	Management Level $LA_{eq(15min)}$[1]	How to Apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays.	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 LAeq(15min) 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 75dBA.	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 5dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

Note 1: The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the construction NML for noise assessment purposes and is the median of the ABL's.

Table 5 Noise Management Levels for Other Noise Sensitive Receivers		
Land use	Where objective applies	Management Level $LA_{eq(15min)}$[1]
Classrooms at schools and other educational institutions	Internal noise level	45dB
Hospital wards and operating theatres	Internal noise level	45dB
Places of worship	Internal noise level	45dB
Active recreation areas	External noise level	65dB
Passive recreation areas	External noise level	60dB
Commercial premises	External noise level	70dB
Industrial premises	External noise level	75dB

Note 1: Noise management levels apply when receiver areas are in use only.

Where the predicted or measured $LA_{eq(15min)}$ noise level is greater than the NML, the proponent should apply all feasible and reasonable work practices to meet the relevant NML. Following the implementation of standard mitigation measures, where residual noise impacts occur, additional mitigation measures (AMMs) should be implemented.

4.1.4 Noise Management Levels

Construction NMLs for residential receivers are established from the prevailing background noise levels of the locality. The NMLs for standard and out of hours work periods are summarised in **Table 6** for residential receivers and **Table 7** for non-residential receivers.

Table 6 Construction NMLs – Residential Receivers				
Location	Assessment Period	RBL, dBA	NML dB $LA_{eq(15min)}$	Highly noise affected NML[1] dB $LA_{eq(15min)}$
NCA 1 (West of Carlton Street)	Day (Standard Hours)	39	49 (RBL+10dBA)	75 Standard Hours
	Evening (OOH Period 1)	40	45 (RBL+5dBA)	75 Outside Recommended Hours
	Night (OOH Period 2)	33	38 (RBL+5dBA)	75 Outside Recommended Hours
NCA 2 (East of Carlton Street)	Day (Standard Hours)	42	52 (RBL+10dBA)	75 Standard Hours
	Evening (OOH Period 1)	41	46 (RBL+5dBA)	75 Outside Recommended Hours
	Night (OOH Period 2)	34	39 (RBL+5dBA)	75 Outside Recommended Hours

Note 1: The highly noise affected NML is a hypothetical level that is adopted to ensure the avoidance of strong community reaction. Should this level be exceeded the construction methodology is to be reviewed to reduce the impact on surrounding sensitive receivers.

Table 7 Construction NMLs – Non-Residential Receivers			
Location	Assessment Period	Where NML Applies	NML dB $L_{Aeq(15min)}$
Educational Institution	When in Use	Internal Noise Level	45
Place of Worship	When in use	Internal Noise Level	40
Community Centre[1]	When in use	Internal Noise Level	50
Active Recreation	When in use	External Noise Level	65
Commercial Receivers	When in Use	External Noise Level	70
Industrial	When in Use	External Noise Level	75

Note 1: Based on the recommended 'maximum' internal noise levels for 'public spaces' (municipal buildings) as per AS2107.

4.1.5 Maximum Noise Level Assessment

The maximum noise level assessment (sleep disturbance) criterion of 65dB L_{Amax} is referred to in Section 3.1.5 of the Environmental Impact Assessment Procedure: Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report (Roads and Maritime, 2016) and Appendix E of the Construction Noise and Vibration Guideline (Roads and Maritime, 2016).

The maximum noise level assessment criterion relates to both operational phase and construction phase sleep disturbance impacts and has been adopted as the relevant assessment criterion for this assessment.

4.2 Noise Assessment Methodology

DGMR (iNoise, Version 2020) noise modelling software was used to quantify noise emissions from typical construction activities. iNoise is a new intuitive and quality assured software for industrial noise calculations in the environment. 3D noise modelling is considered industry best practice for assessing noise emissions from projects.

The model incorporated a three-dimensional digital terrain map giving all relevant topographic information used in the modelling process. Additionally, the model uses relevant noise source data, ground type, attenuation from barrier or buildings and atmospheric information to predict noise levels at the nearest potentially affected receivers.

The model calculation method used to predict noise levels was in accordance with ISO 9613-1 'Acoustics - Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere' and ISO 9613-2 'Acoustics - Attenuation of sound during propagation outdoors. Part 2: General method of calculation'. The ISO 9613 standard from 1996 is the most used noise prediction method worldwide. Many countries refer to ISO 9613 in their noise legislation. The ISO 9613 standard does not contain guidelines for quality assured software implementation, which leads to differences between applications in calculated results. In 2015 this changed with the release of ISO/TR 17534-3. This quality standard gives clear recommendations for interpreting the ISO 9613 method. iNoise fully supports these recommendations. The models and results for the 19 test cases are included in the software.

4.3 Proposed Works and Construction Scenarios

Construction activities considered to potentially have the greatest noise impact on nearby receivers were determined in consultation with the client, and with reference to the Construction and Maintenance Noise Estimator (CMNE) source list. The activities are discussed below. Typical plant and equipment, along with the fleet sound power level (SWL) for each of the activities during the construction stages are provided in **Table 8**.

It is noted that the precise locations and types of equipment used to construct the proposal is not known in detail at this stage. Furthermore, the typical construction plant and equipment provided in **Table 8** are unlikely to operate at the same time, but may be used sequentially across each part of the construction area. On that basis, this assessment provides a broad assessment of the likely worst-case impacts from each stage of the construction works.

Activity 1A – Establishment of Compound Site

A temporary construction compound site is proposed to be established on vacant land at the corner of Garfield Road West and Denmark Road (see **Figure 1**). Activities likely to occur during the establishment of the compound site include removal of vegetation, delivery of materials, preparation of all-weather access and hardstand and construction of site amenities.

Typical plant and equipment to be used during site establishment includes trucks, cranes, front end loaders, concrete trucks/pumps, light vehicles and power generators. It is anticipated that site establishment works would be undertaken during standard construction hours only.

Activity 1B – Operation of Compound Site

Activities associated with the operation of the compound site would include delivery of materials and equipment, parking of light vehicles and maintenance of amenities. It is assumed that the operation of the compound site would occur simultaneously with each of the other construction scenarios assessed.

Typical plant and equipment to be used during the operation of the compound site includes light vehicles, power generators, road/delivery trucks, and front-end loaders. It is anticipated that site compound operations would primarily occur during standard construction hours. It is noted that in circumstances where OOH works are required, such as intersection works on Garfield Road West, the operation of the compound site would also operate during these times.

Activity 2 – Local Road Works

The CMNE 'local road works' scenario has been adopted to quantify construction activities associated with clearing and grubbing, primary earthworks, formation of the road sub-base, and the construction of table drains.

Typical plant and equipment used during local road works would include chainsaws/mulchers, trucks, bulldozers, scrapers, excavators, graders, water carts and compactors. It is anticipated that local road works would primarily be undertaken during standard construction hours.

Activity 3 – Asphalt Paving

Following the construction of the road alignment, sub-base and base layers, asphalt paving works would be undertaken to install the surfacing layer. Typical plant and equipment used during asphalt paving works would include concrete agitator trucks, bitumen sprayers, material transfer vehicles, asphalt pavers, and rubber-tyred rollers.

It is anticipated that asphalt paving works would primarily be undertaken during standard construction hours, however, works during OOH work periods may be required for intersection works on Garfield Road West to minimise traffic impacts.

Activity 4 – Road Furniture Installation and Line Marking

Other works including road furniture installation and line marking would occur along the length of the proposal alignment. Typical equipment and plant include trucks, scissor lifts, line markers and small equipment.

It is anticipated that ancillary works would primarily be undertaken during standard construction hours, however, works during OOH work periods may be required for intersection works on Garfield Road West to minimise traffic impacts.

Table 8 Construction Scenarios & Fleet Sound Power Levels dB $LA_{eq(15min)}$ – Construction Phase						
Item	SWLs	Activity				
		1-Compound Site		2-Local Road Works	3-Asphalt Paving	4-Road Furniture
		Establishment	Operation			
Road/Delivery Truck	103	✓	✓			✓
Mobile Crane	110	✓				
35T Excavator	110			✓		
Front End Loader	112	✓	✓			
Chainsaw	114			✓		
Mulcher	116			✓		
Truck and Dog	108		✓	✓	✓	
Bulldozer	114			✓		
Dump Truck	110			✓		
Scraper	110			✓		
Scissor Lift	98					✓
Franna	98					✓
Water cart	107			✓		
Compactor	113			✓		
Rollers (20-30t)	109				✓	
Concrete Truck	109	✓			✓	
Paving machine	114				✓	
Asphalt Sprayer	103				✓	
Power Generator	103	✓	✓			
Light Vehicles	88	✓	✓			
Line Marking Truck	108					✓
Total Fleet SWL		116	114	120	117	110
Sleep disturbance assessment (LA_{max}), Night-time periods (10pm to 7am)						
Bitumen sprayer/paving machine				117		

Note: Items in **BOLD** will take place during the night-time to minimise disruptions to traffic.

4.4 Construction Noise Levels at Most Affected Receivers

Construction noise levels have been predicted for sensitive receiver locations for each of the construction scenarios described in **Section 4.3**. It is noted that the operation of the compound is assumed to occur during the local road works, asphalt paving and road furniture installation scenarios. A summary of the predicted $LA_{eq(15min)}$ noise emissions is presented for the most affected receiver location for each receiver type in **Table 9**. Predicted levels exceeding the NMLs are displayed **BOLD** text. For detailed mapping of the affected areas, noise contours for each modelled scenario are presented in **Appendix D**.

The results of the assessment demonstrate that $LA_{eq(15min)}$ noise emissions would be above the relevant NMLs for residential receivers during each stage of the construction works, with $LA_{eq(15min)}$ noise levels of up to 83dB at the most affected residential receivers during the daytime 'local road works' scenario.

The construction noise emissions are predicted to meet the NMLs for all commercial receivers and places of worship during each of the assessed construction scenarios. Noise levels are predicted to exceed the NML for active recreation areas at the Riverstone Trotting Track during local road works along Denmark Road. Noise levels at all other active recreation areas, including the nearby Riverstone Trotting Track are predicted to remain below the relevant NML for the remaining scenarios.

It is noted that construction noise levels are transient in nature and no one receiver is anticipated to experience the maximum modelled noise levels for the entirety of the construction program. Further assessment of affected receivers is provided for each of the construction scenarios in the following sections.

Table 9 Summary of Noise Assessment Results – Most Affected Receivers

Receiver Type	Period	NML (dB LA_{eq})	Highest Predicted dB LA_{eq} Per Scenario			
			Compound Establishment	Local Road Works	Asphalt Paving	Road Furniture
Residential	Standard	49[1]	**70**	**83**	**78**	**66**
	OOH1	44[1]	n/a	n/a	**73**	**66**
	OOH2	38[1]	n/a	n/a	**73**	**66**
Commercial	When in use	70	51	59	52	47
Place of Worship	When in use	45[2]	<30	41	<30	<30
Active Recreation	When in use	65	62	**70**	59	57

Note: Exceedance of relevant NMLs highlighted and shown in **BOLD**.

Note 1: NML taken as the most stringent of NCA 1 and NCA 2.

Note 2: Internal noise level. Assume 10dB reduction for external to internal attenuation through building façade as per ICNG.

4.4.1 Scenario 1 – Compound Establishment

As shown in **Table 9**, $LA_{eq(15min)}$ noise emissions are predicted to be above the standard hours NML for nearby residential receivers during establishment of the compound site, with the highest predicted noise levels of up to 70dBA at 47 Garfield Road and 5 Creek Street. It is noted that construction noise associated with the establishment of the compound would occur during the initial stage of the proposal only.

MAC understands that compound establishment works would be undertaken at the corner of Denmark Road and Garfield Road West and would occur during standard construction hours only. The affected distances and number of receivers within the affected area are provided in **Table 10**.

Table 10 – Affected Distances – Compound Establishment

Receiver Type	Assessment Period	NML dB $LA_{eq(15min)}$	Affected Distance (m)	Number of Receivers Affected
Residential	Standard Hours	49	~250m	~18
	OOH1	44	n/a	n/a
	OOH2	38	n/a	n/a
	Highly Affected	75	~15m	0

The results of the assessment demonstrate that during compound establishment, residential receivers located within 250m of the proposal site are anticipated to experience noise levels above the standard hours NML. Noise levels are not anticipated to exceed the highly affected NML at any of the adjacent receivers.

4.4.2 Scenario 2 – Local Road Works

As shown in **Table 9**, $LA_{eq(15min)}$ noise emissions are predicted to be above the standard hours NML for nearby residential receivers during local road works, with the highest predicted noise levels of up to 83dBA at 54 Carlton Street. Furthermore, noise levels are anticipated to exceed the active recreation areas NML at the nearby Riverstone Trotting Track for works occurring on Denmark Road.

MAC understands that local road works would involve corridor clearing, removal of redundant infrastructure, primary earthworks and formation of road base along the length of the Link Road alignment. It is anticipated that local road works would be undertaken during standard construction hours only. The affected distances and number of receivers within the affected area are provided in **Table 11**.

Table 11 – Affected Distances – Local Road Works				
Receiver Type	Assessment Period	NML dB $LA_{eq(15min)}$	Affected Distance (m)	Number of Receivers Affected
Residential	Standard Hours	49	~820m	~470
	OOH1	44	n/a	n/a
	OOH2	38	n/a	n/a
	Highly Affected	75	~50m	~13

The results of the assessment demonstrate that during local road works, residential receivers in NCA 1 located within 820m of the proposal site, and NCA 2 located within 640m of the proposal site are anticipated to experience noise levels above the standard hours NML. Noise levels are anticipated to exceed the highly affected NML at residential receiver locations within 50m of the proposal site.

4.4.3 Scenario 3 – Asphalt Paving

As shown in **Table 9**, $LA_{eq(15min)}$ noise emissions are predicted to be above the standard hours NML for nearby residential receivers during asphalt paving works, with the highest predicted noise levels at 47 Garfield Road of up to 78dBA during standard hours and up to 73dBA during OOH P1 and P2.

MAC understands that asphalt paving works would occur during standard hours only along the Link Road alignment, and OOH P1 and P2 along Garfield Road West. The affected distances and number of receivers within the affected area are provided in **Table 12**.

Table 12 – Affected Distances – Asphalt Paving				
Receiver Type	Assessment Period	NML dB $LA_{eq(15min)}$	Affected Distance (m)	Number of Receivers Affected
Residential	Standard Hours	49	~540m	~215
	OOH1	44	~530m	~40
	OOH2	38	~825	~100
	Highly Affected	75	~15m	~7

The results of the assessment demonstrate that during local road works, residential receivers in NCA 1 located within 540m of the proposal site, and NCA 2 located within 300m of the proposal site are anticipated to experience noise levels above the standard hours NML. During OOH P1 and OOH P2, residential receivers within 530m and 825m of Garfield Road West respectively are anticipated to experience noise levels above the relevant NMLs.

Furthermore, noise levels are anticipated to exceed the highly affected NML at residential receiver locations within 15m of the proposal site during standard hours only.

4.4.4 Scenario 4 – Road Furniture Installation

As shown in **Table 9**, $LA_{eq(15min)}$ noise emissions are predicted to be above the standard hours NML for nearby residential receivers during road furniture installation, with the highest predicted noise levels at 47 Garfield Road and 5 Creek Street of up to 66dBA during standard hours and OOH work periods.

MAC understands that road furniture installation works would occur during standard hours only along the Denmark Link Road alignment, and OOH P1 and P2 along Garfield Road West. The affected distances and number of receivers within the affected area are provided in **Table 13**.

Table 13 – Affected Distances – Road Furniture Installation

Receiver Type	Assessment Period	NML dB $LA_{eq(15min)}$	Affected Distance (m)	Number of Receivers Affected
Residential	Standard Hours	49	~175	~70
	OOH1	44	~250	~22
	OOH2	38	~515	~60
	Highly Affected	75	n/a	0

The results of the assessment demonstrate that during local road works, residential receivers in NCA 1 located within 175m of the proposal site, and NCA 2 located within 135m of the proposal site are anticipated to experience noise levels above the standard hours NML. During OOH P1 and P2, receivers in NCA 1 within 250m and 185m respectively, and receivers in NCA 2 within 515m and 290m respectively, are anticipated to anticipated to experience noise levels above the relevant NMLs.

Noise levels are not anticipated to exceed the highly affected NML at any residential receiver locations.

4.4.5 Maximum Noise Trigger Level Assessment Results

Out of hours construction activities occurring during the night-time have the potential to generate noise emissions that may cause sleep disturbance at receivers in proximity to the proposal site.

Noise modelling quantified the levels from maximum night-time events from the near point of each construction activity proposed to occur during OOH work periods to nearby receiver locations. Modelling adopted a sound power level of 117dB LA_{max} to represent emissions from transient sources such as impact noise from equipment during asphalt paving and road furniture installation.

Modelling identified that noise emissions have the potential to be above to maximum noise trigger level of 65dB LAmax at residential receivers located within approximately 170m of the proposal site (see **Figure 3**). It is noted that approximately 12 residential receivers are located within the potentially affected area. Therefore, it is recommended that the proposal proactively manages night-time noise emissions and implement reasonable and feasible noise control strategies to minimise and where possible, eliminate the occurrence of sleep disturbance within the surrounding locality.

4.4.6 Construction Road Traffic Noise

Construction traffic will generate noise over a relatively wide area and beyond the construction site itself. It would be expected that traffic noise would be greatest where there is a concentration of vehicle movements, such as the compound site and specific locations where construction is occurring at that time.

The expected number of employees on this proposal was not available at the time of assessment. Notwithstanding, a construction road noise levels assessment has been completed up to 40 light vehicles and 40 heavy vehicles per day.

Under the assessed construction road traffic conditions, it is anticipated that the road traffic noise would be negligible for the day period and up to 0.1dB $LA_{eq(9hr)}$ for the night period. Therefore, road traffic noise impacts from construction work employees are anticipated to be negligible when compared against existing traffic volumes on Garfield Road West.

4.4.7 Construction Impacts on Horses

Assessment of construction noise levels at the Riverstone Trotting Track indicate that at the most affected point of the trotting, $LA_{eq(15min)}$ noise levels of up to 70dB are anticipated to occur. It is also noted that horses may be stabled at residences in the vicinity of the Riverstone Trotting Track, including on Denmark Road. Road traffic noise levels for the 'no build option' at opening year are predicted in excess of 65dB $LA_{eq(15hr)}$.

It is therefore considered that the noise environment in the locality of the Riverstone Trotting Track is representative of a high noise environment, and adverse impacts on the wellbeing of horses is unlikely. Nevertheless, early and ongoing consultation with representatives of the Riverstone Trotting Track is recommended.

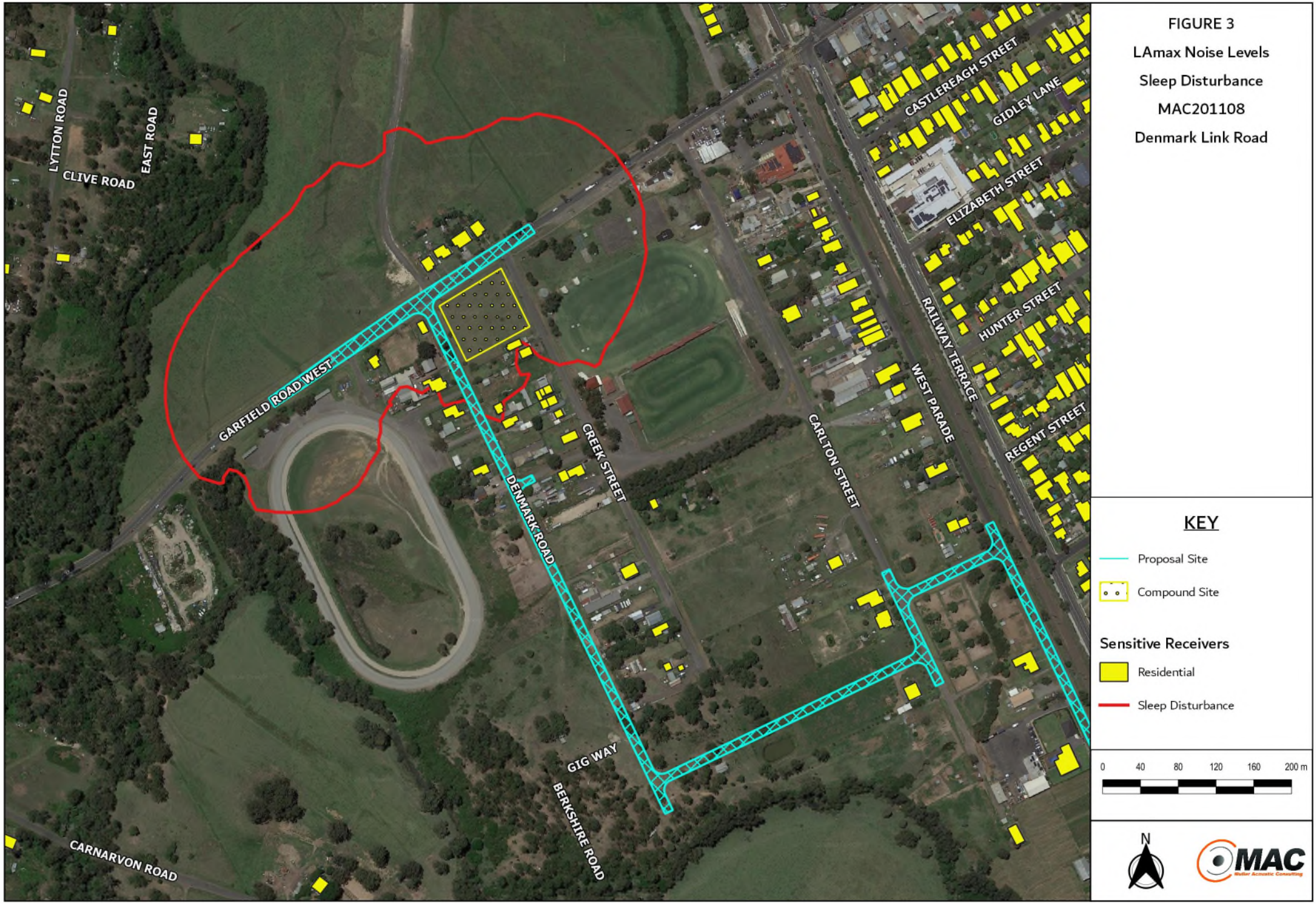

FIGURE 3

LAmax Noise Levels

Sleep Disturbance

MAC201108

Denmark Link Road

KEY

Proposal Site

Compound Site

Sensitive Receivers

Residential

Sleep Disturbance

0 40 80 120 160 200 m

N

MAC

4.5 Construction Noise Mitigation Measures

Noise modelling identifies that relevant NMLs for the proposal may be exceeded when construction activities pass the nearest point to the receivers. The CNVG and ICNG outline noise management and mitigation initiatives to minimise the impact and improve the acoustic amenity of receivers potentially affected by road construction proposals. The guideline suggests there are no prescribed noise controls for construction work, instead:

> *All feasible and reasonable work practices should be put in place to minimise noise impacts. This approach gives construction site managers and construction workers the greatest flexibility to manage noise.*

Seven key strategies in reducing construction noise emissions are outlined in Section 6 of the ICNG that should be applied on a case-by-case basis and include the following:

Strategy 1: Universal Work Practices;

Strategy 2: Consultation and Notification;

Strategy 3: Plant and Equipment;

Strategy 4: Onsite;

Strategy 5: Work Scheduling;

Strategy 6: Transmission Path;

Strategy 7: At residence (treatments) or other sensitive Land Uses (last resort).

In addition, Australian Standard AS 2436-2010 "Guide to Noise Control on Construction, Maintenance and Demolition Sites" sets out practical recommendations to assist in mitigating construction noise emissions.

Recommendations provided in the ICNG and AS2436 include combinations of operational strategies, source noise control strategies, noise barrier controls, and community consultation.

Adopting strategies contained in this standard may result in the following noise attenuation:

- Up to 10dBA where space requirements place limitations on the attenuation options available; and
- up to 20dBA in situations where noise source noise mitigation measures (silencers, mufflers, etc) can be combined with noise barriers and other management techniques.

The standard mitigation measures are provided in **Table 14**.

Table 14 Standard Mitigation Measures		
Action Required	Management Measures	Source
Universal Work Practices		
Pre-Construction / Site Inductions	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • relevant noise and vibration mitigation measures • licence and approval conditions • permissible hours of work • limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times • environmental incident procedures.	CNVG
	Implement a noise monitoring program to quantify noise emissions from construction activities and guide practical reasonable and feasible noise control measures.	CNVG / ICNG
Plan Worksites	Locate compounds away from sensitive receivers and discourage access from local roads.	CNVG
	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.	CNVG / ICNG
Site Practices / Behavioural Practices	Conduct toolbox talks pre-shift to communicate awareness regarding the importance of noise emission management.	ICNG
	Ensure site managers periodically check the site and nearby residences and other sensitive land uses for noise problems so that solutions can be quickly applied.	ICNG
	Include in tenders, employment contracts, subcontractor agreements and work method statements clauses that require minimisation of noise and compliance with directions from management to minimise noise	ICNG
	Avoid shouting and minimise talking loudly. Avoid dropping materials from height, throwing of metal items and slamming of doors.	CNVG / ICNG
	Keep truck drivers informed of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices	CNVG / ICNG
	Encourage workers to operate equipment in a conservative manner.	CNVG / ICNG

Table 14 Standard Mitigation Measures		
Action Required	Management Measures	Source
	Consultation and Notification	
Notification	Provide information to neighbours detailing work activities, dates and hours, impacts and mitigation measures, work schedule over the night period, any operational noise benefits from the works (where applicable) and contact telephone number.	CNVG / ICNG
	Notifications should be a minimum of 7 calendar days prior to the start of the works.	CNVG
	Use site information board at the front of the site with relevant details about site contacts, hours of operation and regular information updates.	ICNG
Complaints Handling	Have a documented complaints handling procedure with an escalation procedure so that if a complaint is not satisfied, there is a clear path to follow.	ICNG
	Implement all feasible and reasonable measures to address the source of the complaint.	ICNG
	Keep a register of any complaints including all relevant details and provide a quick response to all complaints.	ICNG
	Plant and Equipment	
Construction Method	Use quieter and less vibration emitting construction methods where feasible and reasonable (eg bore piles rather than impact driven piles).	CNVG / ICNG
Equipment / Maintenance	Select the quietest plant to perform a specific function and consider the noise levels of plant and equipment in rental or purchasing decisions.	CNVG / ICNG
	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms.	CNVG / ICNG
	Regularly inspect and maintain equipment to ensure that it is in good working order.	CNVG / ICNG
	Equipment must not be operated until it is maintained or repaired, where maintenance or repair would address an annoying character of noise identified.	ICNG
	Return any hired equipment that is causing noise that is not typical for the equipment – the increased noise may indicate the need for repair.	ICNG
Site Practices	The offset distance between noisy plant and adjacent sensitive receivers should be maximised and restrict areas that mobile plant can be operated during sensitive times.	CNVG / ICNG
	Maximise shielding between plant and adjacent sensitive receivers by making use of natural landforms, temporary structures and stockpiles, and barriers.	CNVG / ICNG
	Operate plant in a quiet and efficient manner. Reduce throttle settings and turn off equipment when not being used.	CNVG / ICNG

Table 14 Standard Mitigation Measures		
Action Required	Management Measures	Source
	Where practicable, avoid the coincidence of noisy plant/machinery working simultaneously in close proximity to sensitive receivers.	ICNG
	Minimise disturbance arising from delivery of goods to construction sites by: • avoid queuing of vehicles where practicable or ensure engines are switched off to reduce their overall noise impacts on receivers • minimise the use of engine brakes • fit delivery vehicles with straps rather than chains • select site access points and roads as far away as possible from sensitive receivers and provide shielding where practicable.	CNVG / ICNG
	Work Scheduling	
Work Scheduling	Where feasible and reasonable, construction should be carried out during standard construction hours (daytime period). Work generating high noise and/or vibration should be scheduled during less sensitive time periods.	CNVG / ICNG
	Where very noisy activities cannot be undertaken during standard construction hours, the works should be completed before 11:00pm.	CNVG
	Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impacts by concentrating noisy activities at one location and move to another as quickly as possible.	CNVG
	Works should be scheduled to avoid periods of major student exams such as before or during the Higher School Certificate.	CNVG / ICNG
	Schedule delivery of materials to occur during the day or early evening periods only.	CNVG / ICNG
	Organise deliveries and access to optimise the number of vehicle trips to and from the site – movements can be organised to amalgamate loads rather than using a number of vehicles with smaller loads.	ICNG
	Transmission Paths	
Physical Methods	Reduce the line-of-sight transmission from noise emissions sources to residences or other sensitive land uses using temporary barriers or mobile screens.	CNVG / ICNG
	Erect temporary noise barriers before work commences to ensure noise is minimised during the entire shift.	ICNG
	Consider the height of mobile screens and barriers to ensure adequate shielding to multistorey dwellings.	ICNG
	At Residence or other Sensitive Land Uses	

Table 14 Standard Mitigation Measures		
Action Required	Management Measures	Source
Structural Surveys	Pre-construction surveys of the structural integrity of vibration sensitive buildings may be required.	CNVG / ICNG
Temporary Relocation	Examine and implement, where feasible and reasonable, the option of relocating noise-affected occupants for short periods of time, such as when high noise levels from construction occur at night and there are no feasible and reasonable ways of reducing noise levels. For example, the proponent could offer alternative accommodation or other respite measures (such as movie tickets) where mitigation is sought and there are no feasible and reasonable work methods available.	ICNG
Architectural Treatments	Examine and implement, where feasible and reasonable, the option of acoustical treatment to residences affected by construction noise, such as to windows at the building façade. Note that the effectiveness of closing existing windows may be limited by the performance of the window seals.	ICNG

4.6 Additional Mitigation Measures

Standard noise mitigation and management measures in accordance with the ICNG would be implemented for the proposal where practicable.

The CNVG (Roads and Maritime, 2015) outlines a range of mitigation measures which are recommended in order to manage the potential impact. The CNVG additional measures reproduced in **Table 15** will be considered by Transport for NSW or the construction contractor following incorporation of feasible and reasonable mitigation measures for the proposal. **Appendix E** provides a definition of each additional mitigation measure listed below.

Table 15 CNVG Triggers for Additional Mitigation Measures - Airborne Noise

Perception	Predicted airborne $LA_{eq(15min)}$ noise level at receiver		Additional mitigation measures Type	Mitigation Levels
	dB(A) above RBL	dB(A) above NML		
All hours				
75dBA or greater			N, V, PC, RO	HA
Standard Hours: Mon - Fri (7am – 6pm), Sat (8am – 1pm), Sun/Pub Holidays (Nil)				
Noticeable	5 to 10	0	-	NML
Clearly Audible	10 to 20	< 10	-	NML
Moderately intrusive	20 to 30	10 to 20	N, V	NML+10
Highly intrusive	> 30	> 20	N, V	NML+20
OOH Period 1: Mon – Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Pub Hol (8am – 6pm)				
Noticeable	5 to 10	< 5	-	NML
Clearly Audible	10 to 20	5 to 15	N, R1, DR	NML+5
Moderately intrusive	20 to 30	15 to 25	V, N, R1, DR	NML+15
Highly intrusive	> 30	> 25	V, IB, N, R1, DR, PC, SN	NML+25
OOH Period 2: Mon – Fri (10pm – 7am), Sat (10pm – 8am), Sun/Pub Holidays (6pm – 7am)				
Noticeable	5 to 10	< 5	N	NML
Clearly Audible	10 to 20	5 to 15	V, N, R2, DR	NML+5
Moderately intrusive	20 to 30	15 to 25	V, IB, N, PC, SN, R2, DR	NML+15
Highly intrusive	> 30	> 25	AA, V, IB, N, PC, SN, R2, DR	NML+25

Notes: AA = Alternative accommodation, R1 = Respite Period 1, V = Validation of predicted noise levels (not required for projects less than 3 weeks), PC = Phone calls, IB = Individual briefings (not required for projects less than 3 weeks), SN = Specific notifications, N = Notification, R2 = Respite Period 2, DR = Duration Respite, Perception = relates to level above RBL, NML = Noise Management Level (see Appendix C), HA = Highly Affected (> 75 dB(A) - applies to residences only).

It is understood that the proposed construction activities along the Link Road alignment would primarily be completed during standard construction hours. Works undertaken along Garfield Road West however, including asphalt paving and road furniture installation would occur during OOH work periods.

The affected distances and the number of potentially affected receivers for each AMM category are presented in **Table 16**. It is noted that the derivation of affected distances has allowed for a conservative 10dB reduction to account for noise attenuation from the implementation of standard mitigation measures as per **Section 4.5**. **Figure 4** (standard hours), **Figure 5** (OOH P1) and **Figure 6** (OOH P2) provide a visual representation of the affected distances.

Table 16 – Additional Mitigation Measures – Affected Distances

Assessment Period	Noticeable		Clearly Audible		Moderately Intrusive		Highly Intrusive	
	Distance	Receivers	Distance	Receivers	Distance	Receivers	Distance	Receivers
Standard Hours	n/a	n/a	n/a	n/a	115m	55	40m	5
OOH1	n/a	n/a	125m	9	30m	6	5m	0
OOH2	370m	19	235m	12	70m	7	15m	0

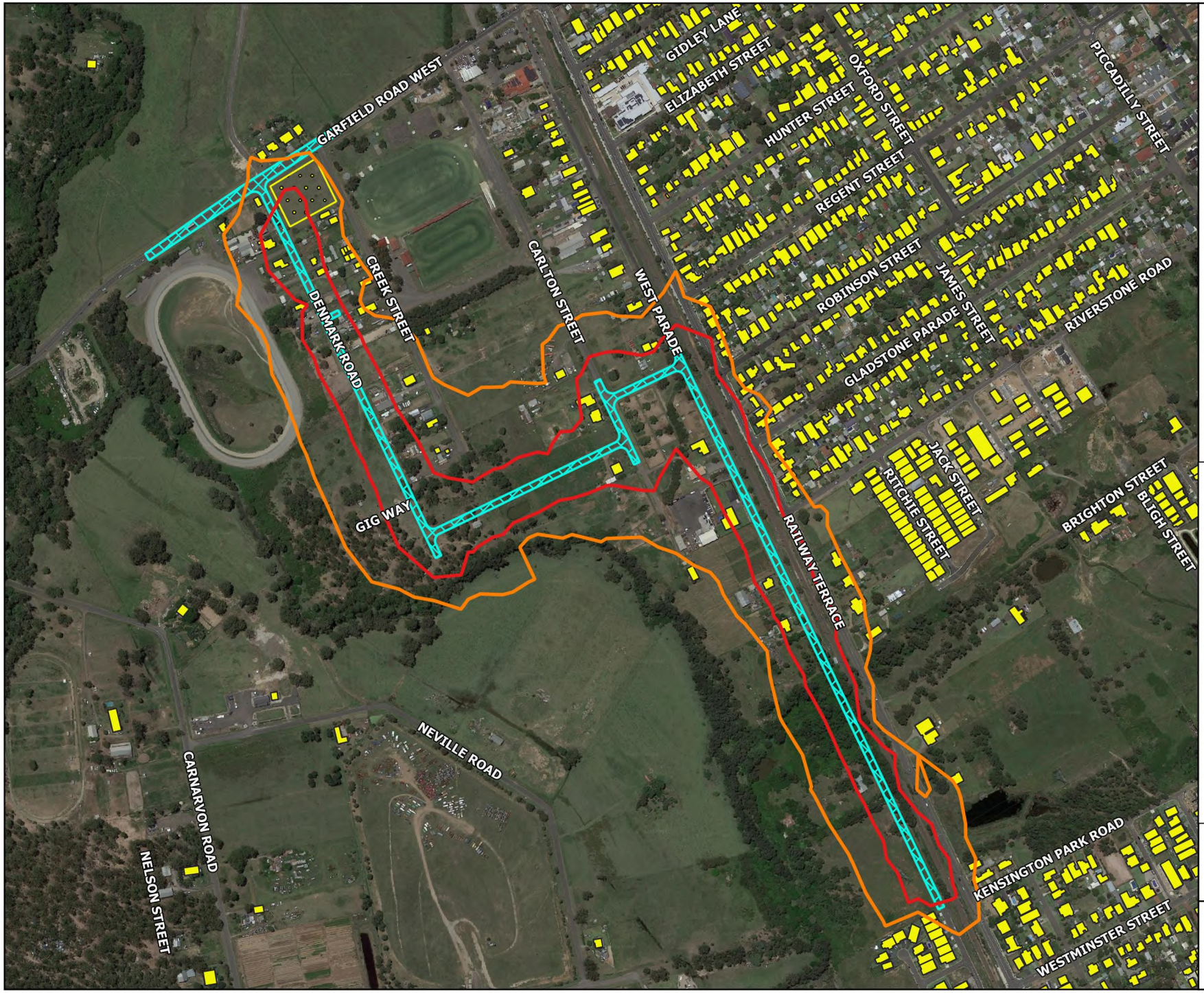

FIGURE 4

Construction AMMs

Standard Hours

MAC201108

Denmark Link Road

KEY

Proposal Site

Compound Site

Sensitive Receivers

Residential

AMM Category

Moderately Intrusive

Highly Intrusive

0 60 120 180 240 300 m

N

MAC
Muller Acoustic Consulting

FIGURE 5

Construction AMMs

OOH P1

MAC201108

Denmark Link Road

KEY

Proposal Site

Compound Site

Sensitive Receivers

Residential

AMM Cateogry

Clearly Audible

Moderately Intrusive

Highly Intrusive

0 40 80 120 160 200 m

N

MAC


DELEWARE ROAD
LYTTON ROAD
EAST ROAD
CLIVE ROAD
MARSDEN ROAD
MARSDEN LANE
GARFIELD ROAD WEST
RIVERSTONE PARADE
GARFIELD ROAD EAST
OXFORD STREET
CASTLEREAGH STREET
GIDLEY LANE
ELIZABETH STREET
HUNTER STREET
REGENT STREET
RAILWAY TERRACE
CARLTON STREET
WEST PARADE
CREEK STREET
DENMARK ROAD
GIG WAY
CLIFTON ROAD
CARNARVON ROAD
FIGURE 6
Construction AMMs
OOH P2
MAC201108
Denmark Link Road
KEY
Proposal Site
Compound Site
Sensitive Receivers
Residential
AMM Category
Noticeable
Clearly Audible
Moderately Intrusive
Highly Intrusive
0
50
100
150
200
250 m
N
MAC

4.7 Construction Vibration Criteria

British Standard BS 7385:Part 2-1993 “Evaluation and measurement for vibration in buildings Part 2”, gives guidance on the levels of vibration which building structures could be damaged. BS7385 also takes into consideration the frequency of the vibration which is critical when assessing the likelihood of building damage.

Guide values are set for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to result in a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and heavy commercial/industrial buildings are presented in **Table 17**. Where sources of continuous vibration may give rise to dynamic magnification due to resonance, the values provided in **Table 17** should be reduced by 50%, this is especially the case with respect to Peak Particle Velocity (PPV) at lower frequencies.

Table 17 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

4.7.1 Heritage Items

It is noted that the CNVG and BS7385 do not specify recommended vibration limits or minimum working distances for heritage items or other sensitive structures. BS7385 indicates that heritage buildings and structures should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is structurally unsound (following inspection) a more conservative cosmetic damage objective as per DIN 4150 would be applicable.

German Standard DIN 4150 - Part 3: 1999 provides guideline values for vibration velocity to be used with evaluating the effects of short-term vibration on structures, including for sensitive structures such as heritage items. The DIN 4150 values are summarised in **Table 18.**

Table 18 Structural Damage Guideline – DIN4150				
Type of Structure	Vibration Velocity in mm/s			
	Less than 10Hz	10Hz to 50 Hz	50Hz to 100Hz	… at horizontal plane of highest floor (all frequencies)
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that because of their particular sensitivity to vibration do not correspond to those above and have intrinsic value (e.g. heritage buildings)	3	3 to 8	8 to 10	8

Table 18 demonstrates that for sensitive buildings such as heritage structures, the guideline vibration values for effects on structures are typically half of those for dwellings. Therefore, based on the DIN 4150 structural damage guidelines, the minimum working distance for heritage structures that are found to be structurally unsound would be approximately equal to twice the minimum working distance for other building types. Human Comfort – Assessing Vibration a Technical Guideline

Humans are far more sensitive to vibration than is commonly realised and may detect vibration levels which are well below levels that may cause damage to buildings or structures. Assessing vibration: a technical guideline was published in February of 2006 by the DECC and is based on guidelines contained in BS 6472 – 1992, Evaluation of human exposure to vibration in buildings (1-80 Hz) and provides guidance on assessing vibration against human comfort.

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in **Table 19**.

Table 19 Examples of types of vibration (from Table 2.1 of the guideline)		
Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery)	Infrequent: Activities that create up to three distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990)	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

4.7.2 Continuous Vibration

Appendix C of the guideline outlines acceptable criteria for human exposure to continuous vibration (1-80 Hz), the criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. **Table 20** reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 20 Criteria for Exposure to Continuous Vibration			
Place	Time[1]	Peak Velocity (mm/s)	
		Preferred	Maximum
Critical working Areas (e.g. hospital operating theatres, precision laboratories)	Day or Night	0.14	0.28
Residences	Day	0.28	0.56
	Night	0.20	0.40
Offices	Day or Night	0.56	1.1
Workshops	Day or Night	1.1	2.2

Note: rms velocity (mm/s) and vibration velocity value (dB re 10^{-9} mm/s) values given for most critical frequency >8Hz assuming sinusoidal motion.

Note 1: Daytime is 7am to 10pm and Night-time is 10pm to 7am.

4.7.3 Impulsive Vibration

Appendix C of the guideline outlines acceptable criteria for human exposure to impulsive vibration (1-80 Hz), these criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. Impulsive vibration (as defined in Section 2.1 of the guideline) is generally associated with infrequent activities that create up to three (3) distinct vibration events in an assessment period e.g. occasional dropping of heavy equipment, occasional loading and unloading. **Table 21** reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 21 Criteria for Exposure to Impulsive Vibration			
Place	Time[1]	Assessment Criteria	
		Peak Velocity (mm/s)	
		Preferred	Maximum
Critical working Areas (e.g. hospital operating theatres, precision laboratories)	Day or Night-time	0.14	0.28
Residences	Daytime	8.6	17.0
	Night-time	2.8	5.6
Offices	Day or Night-time	18.0	36.0
Workshops	Day or Night-time	18.0	36.0

Note 1: Daytime is 7am to 10pm and Night-time is 10pm to 7am.

4.7.4 Intermittent Vibration

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Intermittent vibration is representative of activities such as impact hammering, rolling or general excavation work (such as an excavator tracking).

Section 2.4 of the Guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted RMS (root mean square) acceleration levels over the frequency range 1-80 Hz. To calculate VDV the following formula (refer section 2.4.1 of the guideline) was used:

$$VDV = \left[\int_0^T a^4(t)dt\right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, a (t) is the frequency-weighted RMS of acceleration in m/s^2 and T is the total period of the day (in seconds) during which vibration may occur.

The Acceptable Vibration Dose Values (VDV) for Intermittent Vibration is reproduced in **Table 22**.

Table 22 Acceptable Vibration Dose Values (VDV) for Intermittent Vibration				
Location	Daytime		Night-time	
	Preferred Value $m/s^{1.75}$	Maximum Value $m/s^{1.75}$	Preferred Value $m/s^{1.75}$	Maximum Value $m/s^{1.75}$
Critical Areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Note: Daytime is 7am to 10pm and Night-time is 10pm to 7am

Note: These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

4.8 Vibration Assessment

The major potential sources of construction vibration include vibrating rollers. Generally, rolling would take place along the alignment prior to road resurfacing, or when relocation of services has occurred. Peak levels of vibration from rolling typically occurs as the roller stops to change direction and a resonance is created as the roller (and vibrator) is stationary.

Table 23 provides the minimum working distances for the use of various vibration intensive sources to nearby receivers to meet cosmetic damage and human response criteria. It is important to note that the minimum working distances are indicative and will vary depending on the particular item of plant and local geotechnical conditions.

Table 23 Minimum Working Distances or Vibratory Plant (m)

Plant item	Rating / Description	Minimum working distance		
		Cosmetic damage (BS 7385)	Heritage Item (DIN 4150)	Human response (OH&E)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5m	10m	15m to 20m
	< 100 kN (Typically 2-4 tonnes)	6m	12m	20m
	< 200 kN (Typically 4-6 tonnes)	12m	24m	40m
	< 300 kN (Typically 7-13 tonnes)	15m	30m	100m
	> 300 kN (Typically 13-18 tonnes)	20m	40m	100m
	> 300 kN (> 18 tonnes)	25m	50m	100m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2m	4m	7m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7m	14m	23m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22m	44m	73m
Vibratory Pile Driver	Sheet piles	2m to 20m	up to 40m	20m
Pile Boring	≤ 800 mm	2m (nominal)	4m	4m
Jackhammer	Hand held	1m (nominal)	2m	2m

Note: Source, CNVG (Roads and Maritime, 2016).

For the greatest vibration intensive source (18t vibratory roller), the minimum offset distances to achieve the cosmetic damage and human response criteria are 25m and 100m respectively. A review of aerial photography indicates that there are multiple residential receivers located within 25m of the proposal alignment on Garfield Road, Denmark Road, Carlton Street and West Parade that may experience vibration levels above the cosmetic damage criteria.

Additionally, receivers on Creek Street, Carlton Street, Railway Terrace, Regent Street, Robinson Street, Gladstone Parade, Riverstone Road and Kensington Park Road, within 100m of the proposal alignment may experience vibration levels above the human response guideline values. The potential vibration affected areas are presented in **Figure 7**.

Once the final vibratory plant has been selected a review of minimum offset distances should be conducted. Where minimum working distances are exceeded, the additional mitigation measures in **Table 24** should be implemented where feasible and reasonable. **Appendix E** provides a definition of each additional mitigation measure listed below.

Table 24 Triggers for Additional Mitigation Measures - Vibration

Construction Period	Additional Mitigation Measures	
	Type	Apply to
Standard Hours	V, N, RP	All affected receivers
OOH1	V, IB, N, RO, PC, RP, SN	
OOH2	AA, V, IB, N, PC, RP, SN	

Notes: AA = Alternative accommodation, V = Validation of predicted levels, PC = Phone calls, IB = Individual briefings, SN = Specific notifications, N = Notification, RO = Project respite offer, SN = Specific notifications.

MAC understands that the Non-Aboriginal (Historical) Statement of Heritage Impact (artefact, 2020) noted one heritage item, listed as Hebe Farm (Hebe Cottage) at 14 Bridge Street (MGA 56H 0302053m E 6270106m S), and one potential heritage structure identified as a brick culvert of later 19th century date located within the rail corridor, immediately adjacent to the study area (MGA 56H 0302179m E 6270198m S). Additionally, a second brick culvert, which is not considered to be of heritage significance, was located within the rail corridor at MGA 56H 0301931m E 6270756m S.

A review of aerial imagery identifies that the separation distance between the proposal site and Hebe Cottage is approximately 130m. The minimum safe working for highly vibration intensive plant to heritage structures is approximately 50m (18t vibratory roller). Therefore, as Hebe Cottage is located beyond the minimum safe working distance, it is considered that vibration impacts to Hebe Cottage are unlike to occur during construction works.

During culvert construction activities in the vicinity of the brick culvert (potential heritage item), vibration intensive plant would likely be required for preparation work for the base slab of the culvert. Where vibration intensive work is planned to occur close to the brick culvert location, minimum offset distances should be reviewed following selection of final plant. Where the brick culvert is located with the minimum safe working distance and there is a risk of exceedance of the cosmetic damage objective, a different construction method with lower source vibration levels must be used where feasible and reasonable, or, vibration monitoring should be undertaken at the commencement and throughout the works.

It is also noted that the proposal would require works to be undertaken adjacent to a live rail line, and associated infrastructure. Vibration intensive activities near rail infrastructure would be closely monitored.

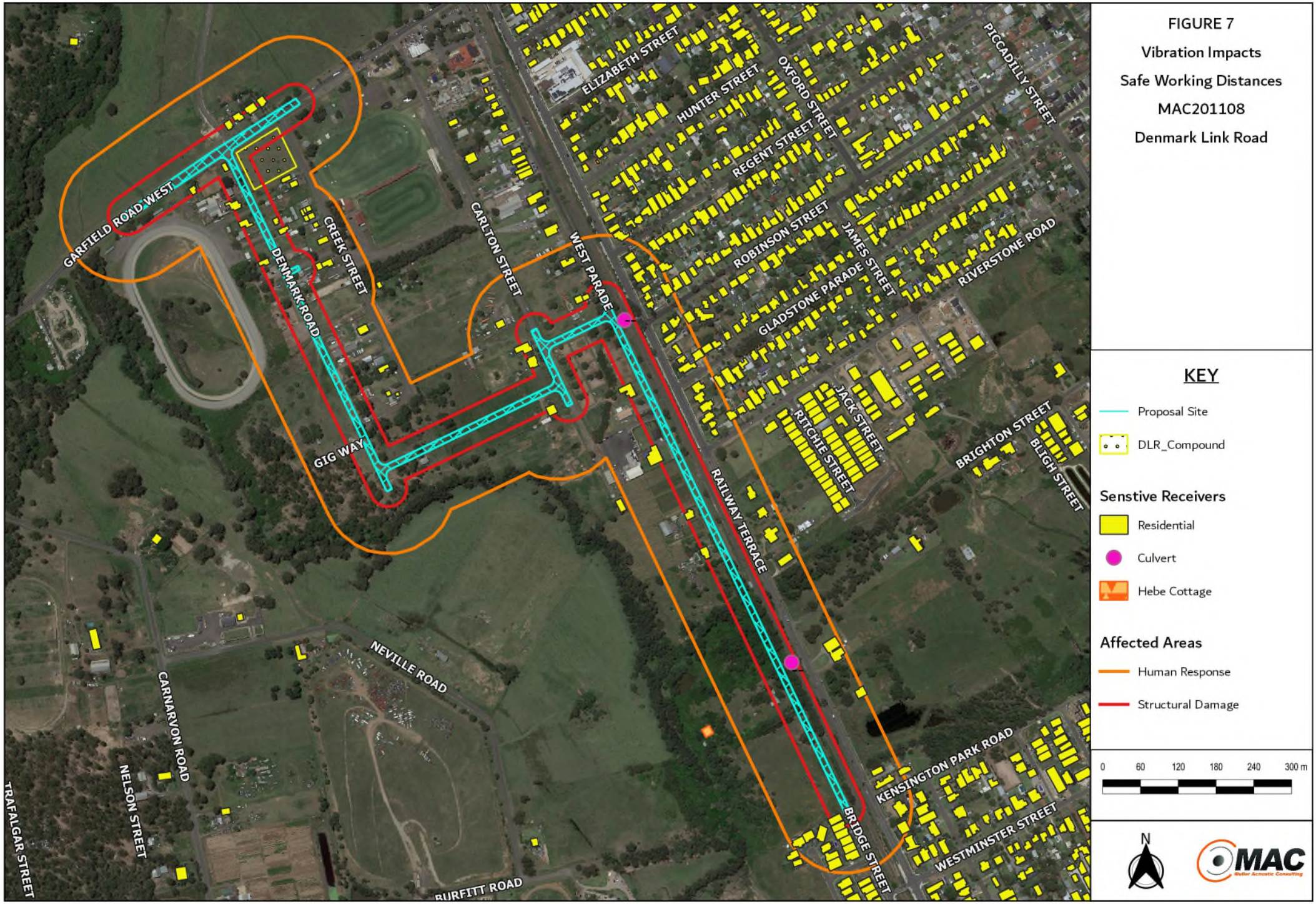

FIGURE 7

Vibration Impacts

Safe Working Distances

MAC201108

Denmark Link Road

KEY

- Proposal Site
- DLR_Compound

Senstive Receivers

- Residential
- Culvert
- Hebe Cottage

Affected Areas

- Human Response
- Structural Damage

0 60 120 180 240 300 m

N

MAC

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5 Assessment of Traffic Noise Impact

5.1 Operational Road Traffic Noise Criteria

Noise criteria are assigned to potentially sensitive receivers with reference to the NSW Road Noise Policy (RNP, 2011) and the Roads and Maritime Noise Criteria Guideline (NCG, 2015). The NCG provides practical guidance in applying the RNP and addresses specific situations relevant to Transport for NSW road projects.

The RNP provides two sets of criteria for each functional class of road, one for new roads and the other for redeveloped roads. Therefore, in determining the noise criteria for residential receivers, consideration is required of the functional class of the road and road project type.

In accordance with Section 5.2 of the NCG, a road is new for any of the following cases:

- A project proposes road construction in an undeveloped corridor;
- A road project changes the functional class of the road;
- A widening, curve straightening or adjustment of the corridor where the upgrade road pavement has been substantially realigned;
- A duplication where the new lands have been substantially realigned from the existing corridor in which case the existing lanes are also assessed as a new road development type; and/or
- A bypass where the upgraded road extends beyond the existing road corridor.

In constructing the bypass beyond the existing road corridor and changing the functional class of the corridor to a sub-arterial road, the proposal is deemed to be a new road development type. The applicable road traffic noise assessment criteria for residential land uses for the proposal are presented in **Table 25**.

Table 25 Road Traffic Noise Assessment Criteria for Residential Receivers

Road category	Type of Project/development	Land use	Assessment Criteria - dB(A)	
			Day (7am - 10pm)	Night (10pm - 7am)
Freeway/arterial/ sub-arterial road	Existing residences affected by noise from new freeway/arteria/sub-arterial road corridors.	Residential	55dB(A) $L_{Aeq(15hr)}$	50dB(A) $L_{Aeq(9hr)}$

Additionally, the RNP states where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to 2dB, which is generally accepted as the threshold of perceptibility to a change in noise level.

5.1.1 Relative Increase Criteria

In addition to meeting the assessment criteria, any significant increase in total traffic noise at receivers must be considered. Receivers experiencing increases in total traffic noise levels above those presented in **Table 26** should be considered for mitigation.

Table 26 Increase Criteria for Residential Land Uses

Road Category	Type of Project/Development	Total Traffic Noise Level Increase, dB(A)	
		Day (7am to 10pm)	Night (10pm to 7am)
Freeway/arterial/sub-arterial roads and transitways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road.	Existing traffic $LA_{eq(15hr)}$ +12dB (external)	Existing traffic $LA_{eq(9hr)}$ +12dB (external)

5.1.2 Cumulative Limit and Acute Noise Levels

When the total noise level in the build year is 5dBA or more above the NCG criterion it is considered to have exceeded the cumulative limit. Receivers where the exceedance occurs qualify for consideration of noise mitigation. The cumulative limit does not apply if the contribution from the road project is less than 2.0dBA in the build year. Instead, consideration should be given to whether the noise levels are acute at the receiver.

The road traffic noise levels are considered to be 'acute' where predicted noise levels at the receiver is greater than or equal to 65dB $LA_{eq(15hr)}$ (day) or 60dB $LA_{eq(9hr)}$ (night). If the contribution from the road project is acute then the residence is considered for mitigation regardless of the increase associated with the project.

5.2 Traffic Volumes

Existing traffic volumes were monitored using tube counters at Garfield Road West (eastbound and westbound) and Railway Terrace (northbound and southbound) between 20 July 2020 and 27 July 2020. The tube counts were used to obtain daily average and nightly average traffic volumes for all vehicle classes.

Traffic volume projections for 'Opening Year' (2023) and 'Design Year' (2033) were obtained from the Sydney GMA Strategic Traffic Forecasting Model (Transport for NSW, 2020) for Garfield Road West, Railway Terrace and the Denmark Link Road. A summary of the traffic volumes used for the operational noise modelling are provided in **Table 27**.

Table 27 Traffic Volume Summary for Noise Modelling

Road Segment	Direction	Time Period	Vehicle Class	Existing Conditions (2020)	Year of Opening (2023) 'No Build' Scenario	Year of Opening (2023) 'Build' Scenario	Design Year (2033) 'No Build' Scenario	Design Year (2033) 'Build' Scenario
Garfield Road West	East	Day 7am – 10pm	Light	3,428	6,713	6,432	14,516	12,521
			Heavy	968	1,238	1,225	2,476	2,385
			Total	4,396	7,951	7,657	16,992	14,906
		Night 10pm – 7am	Light	596	1,093	1,047	2,363	2,038
			Heavy	156	202	199	403	388
			Total	752	1,295	1,245	2,766	2,426
	West	Day 7am – 10pm	Light	3,802	6,179	5,673	12,186	10,445
			Heavy	1,074	1,104	1,080	2,069	1,990
			Total	4,877	7,283	6,753	14,255	12,435
		Night 10pm – 7am	Light	518	1,006	923	1,984	1,700
			Heavy	236	180	176	337	324
			Total	754	1,186	1,099	2,321	2,024
Railway Terrace	North	Day 7am – 10pm	Light	3,752	5,090	4,584	7,433	5,692
			Heavy	394	896	873	1,164	1,084
			Total	4,145	5,986	5,457	8,597	6,776
		Night 10pm – 7am	Light	472	829	746	1,210	927
			Heavy	55	146	142	189	176
			Total	527	975	888	1,399	1,103
	South	Day 7am – 10pm	Light	3,453	6,137	5,856	6,655	4,661
			Heavy	231	1,128	1,116	979	888
			Total	3,684	7,265	6,972	7,634	5,549
		Night 10pm – 7am	Light	403	999	953	1,083	759
			Heavy	43	184	182	159	145
			Total	445	1,183	1,135	1,242	904
Link Road	North	Day 7am – 10pm	Light	N/A	N/A	507	N/A	1,741
			Heavy	N/A	N/A	23	N/A	80
			Total	N/A	N/A	530	N/A	1,821
		Night 10pm – 7am	Light	N/A	N/A	83	N/A	283
			Heavy	N/A	N/A	4	N/A	13
			Total	N/A	N/A	87	N/A	296
	South	Day 7am – 10pm	Light	N/A	N/A	281	N/A	1,994
			Heavy	N/A	N/A	13	N/A	91
			Total	N/A	N/A	294	N/A	2,085
		Night 10pm – 7am	Light	N/A	N/A	46	N/A	325
			Heavy	N/A	N/A	2	N/A	15
			Total	N/A	N/A	48	N/A	340

5.3 Noise Modelling Parameters

The operational road traffic assessment has been completed utilising the Calculation of Road Traffic Noise (CoRTN) which was developed by the United Kingdom Department of Environment. The modelling methodology is widely accepted in Australia and the preferred method for assessing operational road traffic emissions by the NSW Environmental Protection Agency (EPA) and Transport for NSW.

Brüel and Kjær Predictor Type 7810 (Version 11.10) noise modelling software was used to assess operational traffic noise impacts from the proposal. The model incorporated three-dimensional ground contours and relevant features adjacent to proposed Link Road alignment. **Table 28** presents the parameters utilised in the modelling process.

Table 28 Road Traffic Noise Assessment Parameters

Parameter	Noise Model Details
Road Surface	Standard
Source Height	0.5m cars
	0.5m truck tyres
	3.6m truck exhaust
Speed Limit	Garfield Road West – 70km/h Railway Terrace – 50km/h Link Road – 50km/h
Receiver Height	1.5m above ground level
Receiver Location	1m from building facade
CoRTN Algorithm Correction	LAeq, = CoRTN L10, - 3dB
Receiver Façade Reflection	+2.5dB as per CoRTN
Receiver Façade Correction	-1.7dB as per ARRB

5.4 Operational Traffic Noise Results

5.4.1 Model Validation

The noise model was validated using the results of the unattended noise monitors located at Denmark Road (L1) and West Parade (L2). **Table 29** summaries the results of the validation modelling, outlining the modelled traffic noise levels for existing conditions compared to the measured traffic noise levels at each of the monitoring locations.

Predicted levels at L1 and L2 are within +/-2dB of the measured levels. The acoustic model is therefore considered to be validated.

Table 29 Road Traffic Noise Model Validation						
Location	dB $LA_{eq(15hr)}$ Daytime Noise Level			dB $LA_{eq(9hr)}$ Night-time Noise Level		
	Measured Level	Predicted Level	Variance	Measured Level	Predicted Level	Variance
L1 – Denmark Road	55.8	55.4	-0.4	47.4	47.0	-0.4
L2 – West Parade	55.0	55.2	+0.2	53.5	54.3	+0.8

5.4.2 Comparison of No Build and Build Scenario Traffic Noise Levels

In accordance with the Procedure for Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report (Roads and Maritime, 2016), an assessment of road traffic noise has been carried out for the 'no build' and 'build' options for the opening year (2023) and design year (2033) scenarios.

The results of the assessment are presented for all residential receivers directly adjacent the proposed Link Road alignment in **Appendix F**. The receiver locations and IDs are presented in **Figure F1** (see **Appendix F**). It is noted that the noise levels for residential receivers on Garfield Road West and east of the Richmond railway line have been excluded from the assessment results provided below as reduced traffic volumes on Garfield Road West and Railway Parade due to the proposal would result in decreased road traffic noise levels at these locations.

5.5 Consideration of Mitigation Measures

The Noise Mitigation Guideline (NMG) (Roads and Maritime, 2015) provides guidance on managing and controlling road traffic noise and describes the principles to be applied when reviewing noise mitigation. Additionally, the NMG recognises that the criteria provided in the NCG are not always practicably achievable and noise mitigation should be evaluated and installed where feasible and reasonable.

The NMG notes the most effective way of minimising road traffic noise is to control traffic noise at the source (eg quieter road surfaces). Where this is not possible, additional methods may include the use of barriers and/or at-property treatment in accordance with the At-receiver Noise Treatment Guideline (Roads and Maritime, 2017).

The NMG indicates that once noise has been minimised by feasible and reasonable methods during the corridor planning and road design stages receivers with residual exceedances of the NCG criteria can be assessed to determine if they qualify for noise mitigation. The NMG provides three triggers where a receiver may qualify for consideration of noise mitigation. These are:

- Trigger 1 – The total noise level at the receiver in the build scenario is greater than the NCG criterion, and the total noise level at the receiver in the build scenario minus the total noise level at the receiver in the no-build scenario is greater than 2dB; and
- Trigger 2 – The total noise level at the receiver in the build scenario is 5dB or greater than the NCG criterion ('Cumulative Limit'), and the contribution from the road project is greater than 2dB to the total noise level in the build year;
- Trigger 3 – The total noise level at the receiver in the build scenario is above the 'Acute Noise Level' and the dominant noise at the receiver is due to the project.

Based on the NMG triggers, 24 residential receivers within the study area would qualify for consideration of feasible and reasonable noise mitigation measures due to the proposal. Of the 24 receivers qualifying for consideration of noise mitigation measures, 14 receivers (R2, R3, R6, R7 & R34 to R43) exceed the Acute Noise Level, nine (9) receivers (R8 to R11, R24 to R26, R32 & R44) exceed the Cumulative Limit with an increase of greater than 2dB in the build year, and one (1) receiver (R29) exceeds the criteria with an increase of greater than 2dB in the build year. It is noted that three (3) receivers (R30, R31 & R33) exceeded the Cumulative Limit, however the noise contribution from the Proposal at the most affected façade is predicted to add less than 2dB to the total noise level in the build year. Furthermore, R20 and R21 are predicted to experience an increase in noise levels of greater than 2dB in the build year, however, total noise levels are predicted to remain below the relevant criteria.

A summary of the results for residential receivers qualifying for consideration of mitigation measures are presented in **Table 30** and are identified in **Figure 8**. It is noted that no non-residential receivers qualify for consideration of noise mitigation.

Full results tables and noise contours are provided in **Appendix F** and **Appendix G**.

Table 30 Predicted Road Traffic Noise Levels

Receiver[1]	Opening Year, dB(A)				Design Year, dB(A)				NCG Criteria, dB(A)		NCG Criteria Exceeded?		Change in Noise Level, dB(A)			
	'No Build'		'Build'		'No Build'		'Build'						Opening Year		Design Year	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R3	72.4	66.7	72.5	66.8	75.6	69.8	75.3	69.6	55	50	Yes	Yes	0.1	0.1	-0.3	-0.2
R4	73.1	67.3	73.3	67.7	76.3	70.4	76.2	70.5	55	50	Yes	Yes	0.2	0.4	-0.1	0.1
R6	69.1	63.2	69.2	63.4	72.1	66.6	72.5	66.8	55	50	Yes	Yes	0.1	0.2	0.4	0.2
R7	61.9	56.2	62.5	56.7	64.9	59.3	66.2	60.5	55	50	Yes	Yes	0.6	0.5	1.3	1.2
R8	59.8	54.2	61.0	55.1	62.9	57.3	65.1	59.5	55	50	Yes	Yes	1.2	0.9	2.2	2.2
R9	53.9	48.3	58.6	52.2	56.9	51.2	64.0	58.3	55	50	Yes	Yes	4.7	3.9	7.1	7.1
R10	55.3	49.6	57.8	51.7	58.4	52.7	63.1	57.4	55	50	Yes	Yes	2.5	2.1	4.7	4.7
R11	52.8	47.2	56.7	50.4	55.9	50.2	62.6	56.9	55	50	Yes	Yes	3.9	3.2	6.7	6.7
R24	53.4	47.7	57.4	50.4	54.4	48.7	63.1	57.4	55	50	Yes	Yes	4.0	2.7	8.7	8.7
R25	53.9	48.2	57.9	51.4	55.0	49.3	63.5	57.9	55	50	Yes	Yes	4.0	3.2	8.5	8.6
R26	53.8	48.2	56.6	50.7	55.1	49.4	61.0	55.3	55	50	Yes	Yes	2.8	2.5	5.9	5.9
R29	51.6	46.0	52.5	46.8	53.0	47.4	55.4	49.7	55	50	Yes	Yes	0.9	0.8	2.4	2.3
R32	61.6	55.9	62.4	56.5	62.6	56.9	64.8	59.2	55	50	Yes	Yes	0.8	0.6	2.2	2.3
R34	62.0	56.3	63.2	57.1	62.9	57.2	66.1	60.5	55	50	Yes	Yes	1.2	0.8	3.2	3.3
R35	61.9	56.3	63.3	57.2	62.9	57.2	66.3	60.7	55	50	Yes	Yes	1.4	0.9	3.4	3.5
R36	62.0	56.4	63.4	57.3	63.0	57.3	66.4	60.8	55	50	Yes	Yes	1.4	0.9	3.4	3.5
R37	62.2	56.6	63.8	57.6	63.2	57.5	67.0	61.3	55	50	Yes	Yes	1.6	1.0	3.8	3.8
R38	62.2	56.6	63.7	57.6	63.2	57.5	66.8	61.2	55	50	Yes	Yes	1.5	1.0	3.6	3.7
R39	62.2	56.7	63.7	57.6	63.3	57.6	66.7	61.0	55	50	Yes	Yes	1.5	0.9	3.4	3.4
R40	61.0	55.6	62.8	56.7	62.3	56.6	66.0	60.3	55	50	Yes	Yes	1.8	1.1	3.7	3.7
R41	60.6	55.3	62.8	56.6	61.9	56.2	66.3	60.7	55	50	Yes	Yes	2.2	1.3	4.4	4.5
R42	60.2	54.9	63.4	56.8	61.5	55.8	67.4	61.8	55	50	Yes	Yes	3.2	1.9	5.9	6.0

R43	59.6	54.2	61.8	55.4	60.9	55.1	65.2	59.6	55	50	Yes	Yes	2.2	1.2	4.3	4.5
R44	58.8	53.5	59.9	54.0	60.1	54.4	62.1	56.5	55	50	Yes	Yes	1.1	0.5	2.0	2.1

Note 1: Assessed at the most affected façade.

Figure 8: Receivers Qualifying for Mitigation

5.6 Maximum Noise Level Assessment

Section 3.1.5 of the Procedure for Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report (Roads and Maritime, 2016) suggests that a maximum noise levels assessment should be undertaken where noise impacts at night are expected to occur. The protocol for assessing maximum noise levels is provided in Practice Note iii of the Environmental Noise Management Manual (ENMM) (RTA, 2001).

The ENMM recommends that at locations where road traffic is continuous rather than intermittent, LAmax noise pass-by events that exceed the $L_{Aeq(1hr)}$ noise level by at least 15 dBA and are in excess of 65 dBA may lead to sleep disturbance impacts. It is noted that the ENMM advises that the maximum noise level should not be applied as a decisive noise criterion of the selection of mitigation treatments but can be used as a tool to prioritise and rank mitigation strategies.

The L_{Amax} and $L_{Aeq(1hr)}$ noise levels during the night-time period (10am to 7am) at the noise monitoring locations are provided in **Table 31**. The measured noise levels at logger location L1 include maximum noise level events from the passage of vehicles on Denmark Road and Garfield Road West, and West Parade and Railway Terrace at logger location L2.

Table 31 Summary of Measured Maximum Noise Levels, dBA

Location	LAmax Range	LAeq(1hr) Range	LAmax – LAeq(1hr)[1]
L1 – Denmark Road	63.7-79.1	48.6-50.2	22.2
L2 – West Parade	65.7-78.1	49.4-59.3	17.5

Note 2: Average LAmax – LAeq(1hr).

The current L_{Amax} noise levels exceed 65dBA and are greater than the $L_{Aeq(1hr)}$ noise levels by more than 15dBA. It is noted that at present Denmark Road and West Parade are local roads with no through traffic. The proposed link road would result in a significant increase in vehicles passing the existing receivers along the proposed alignment, which is anticipated to result in an increase in the number of maximum noise level events.

A maximum noise level assessment has been undertaken using the 3D noise model of the proposal alignment to receivers adjacent to the carriageway. The results of the model indicate that up to 26 receivers on Denmark Road (R6 to R9, R11), Carlton Parade (R24 to R26), West Parade R29 to R33) and Bridge Street (R34 to R45) would likely experience L_{Amax} noise levels above 65dBA during truck passby events.

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6 Discussion and Conclusion

An Operational and Construction Noise and Vibration Assessment has been prepared in accordance with Transport for NSW requirements to quantify potential noise and vibration impacts from the construction of the Denmark Link Road at Riverstone/Schofields, NSW.

The construction noise and vibration assessment indicates that noise from the construction works are anticipated to exceed the noise management levels at receivers adjacent to the proposal site during each of the construction activities.

During the local road works scenario, considered to be the loudest construction activity, up to 470 residential receivers are predicted to experience noise levels above the standard hours NML, and up to 13 receivers would experience noise levels above the 'highly affected' NML of 75dBA. Following implementation of standard mitigation measures, it is predicted that up to 55 residential receivers would experience noise levels above the trigger levels for the implementation of additional mitigation measures. It is noted that local road works are anticipated to occur during standard hours only.

To minimise road traffic impacts, some activities including asphalt paving and road furniture installation on Garfield Road West would likely be undertaken during out of hours work periods. For the loudest activity proposed for out of hours work periods, identified as asphalt paving works, up to 40 residential receivers would experience noise levels above the NML during out of hours period 1 (evening) and up to 100 residential receivers would experience noise levels above the NML during out of hours period 2 (night). No receivers are predicted to experience noise levels above the highly affected NML.

Following implementation of standard mitigation measures, up to nine (9) and 19 residential receivers would experience noise levels above the trigger levels for the implementation of additional mitigation measures during out of hours period 1 and out of hours period 2 respectively.

Predictive noise modelling identifies that the sleep disturbance trigger level has the potential to be exceeded at up to 37 residential receivers during asphalting works completed during the night period, however, the implementation of reasonable and feasible mitigation measures would significantly reduce received noise levels.

For non-residential receivers, noise levels were predicted above the 'active recreation' NML for the Riverstone Trotting Track during local road works only. Noise levels at all other receivers under each construction scenario were predicted to remain below the relevant NMLs.

A review of safe working distances for vibration intensive plant indicates that construction vibration levels would potentially exceed the criteria for cosmetic damage to buildings and human comfort for receivers 25m and 100m from the proposal site respectively. Hence, additional mitigation measures should be implemented for highly vibration intensive activities in close proximity to residential receivers.

An assessment of potential vibration impacts undertaken for the heritage item identified as Hebe Cottage indicated that given the separation distance of approximately 130m, vibration impacts during construction works are unlikely to occur. For vibration intensive works close to the rail corridor and brick culverts, one identified as a potential heritage item, a review of vibration intensive plant should be undertaken, and construction activities closely monitored.

The results of the predictive noise modelling indicates that up to 24 potentially sensitive receivers along the length of the proposed Link Road alignment qualify for consideration of acoustic treatment as part of the proposal. A summary of results are presented in **Section 5.5**, with full results tables and noise contours provided in **Appendix F** and **Appendix G** respectively. Mitigation measures will be considered further upon approval of the proposal and during detailed design stages.

Appendix A – Glossary of Terms

A number of technical terms have been used in this report and are explained in **Table A1**.

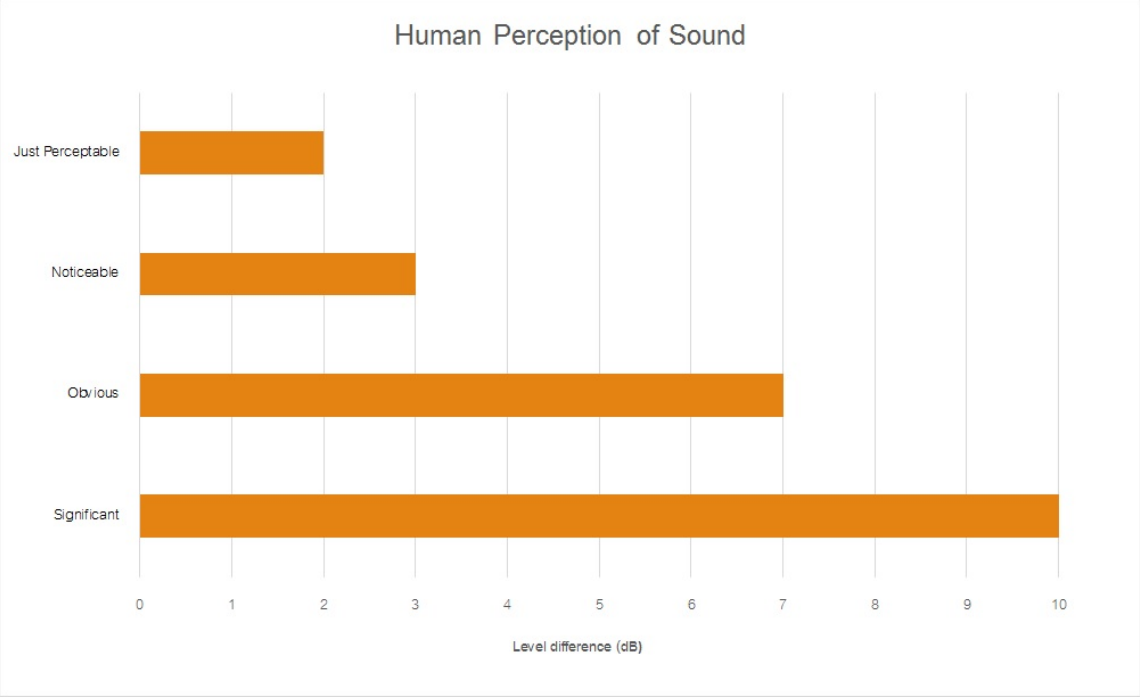
Table A1 Glossary of Terms

Term	Description
1/3 Octave	Single octave bands divided into three parts
Octave	A division of the frequency range into bands, the upper frequency limit of each band being twice the lower frequency limit.
ABL	Assessment Background Level (ABL) is defined in the NPI as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured LA90 statistical noise levels.
Ambient Noise	The noise associated with a given environment. Typically a composite of sounds from many sources located both near and far where no particular sound is dominant.
Extraneous Noise	Noise resulting from activities that are not typical of the area. Atypical activities include sources such as construction and holiday period traffic.
A Weighting	A standard weighting of the audible frequencies designed to reflect the response of the human ear to noise.
dBA	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dB(Z), dB(L)	Decibels Linear or decibels Z-weighted.
Hertz (Hz)	The measure of frequency of sound wave oscillations per second - 1 oscillation per second equals 1 hertz.
LA10	A noise level which is exceeded 10 % of the time. It is approximately equivalent to the average of maximum noise levels.
LA90	Commonly referred to as the background noise, this is the level exceeded 90 % of the time.
LAeq	The summation of noise over a selected period of time. It is the energy average noise from a source, and is the equivalent continuous sound pressure level over a given period.
LAmax	The maximum root mean squared (rms) sound pressure level received at the microphone during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the ABL's.
Sound power level (LW)	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental location of the source and is independent of the surrounding environment. Or a measure of the energy emitted from a source as sound and is given by : = 10.log10 (W/Wo) Where: W is the sound power in watts and Wo is the sound reference power at 10-12 watts.

Table A2 provides a list of common noise sources and their typical sound level.

Table A2 Common Noise Sources and Their Typical Sound Pressure Levels (SPL), dBA	
Source	Typical Sound Level
Threshold of pain	140
Jet engine	130
Hydraulic hammer	120
Chainsaw	110
Industrial workshop	100
Lawn-mower (operator position)	90
Heavy traffic (footpath)	80
Elevated speech	70
Typical conversation	60
Ambient suburban environment	40
Ambient rural environment	30
Bedroom (night with windows closed)	20
Threshold of hearing	0

Figure A1 – Human Perception of Sound



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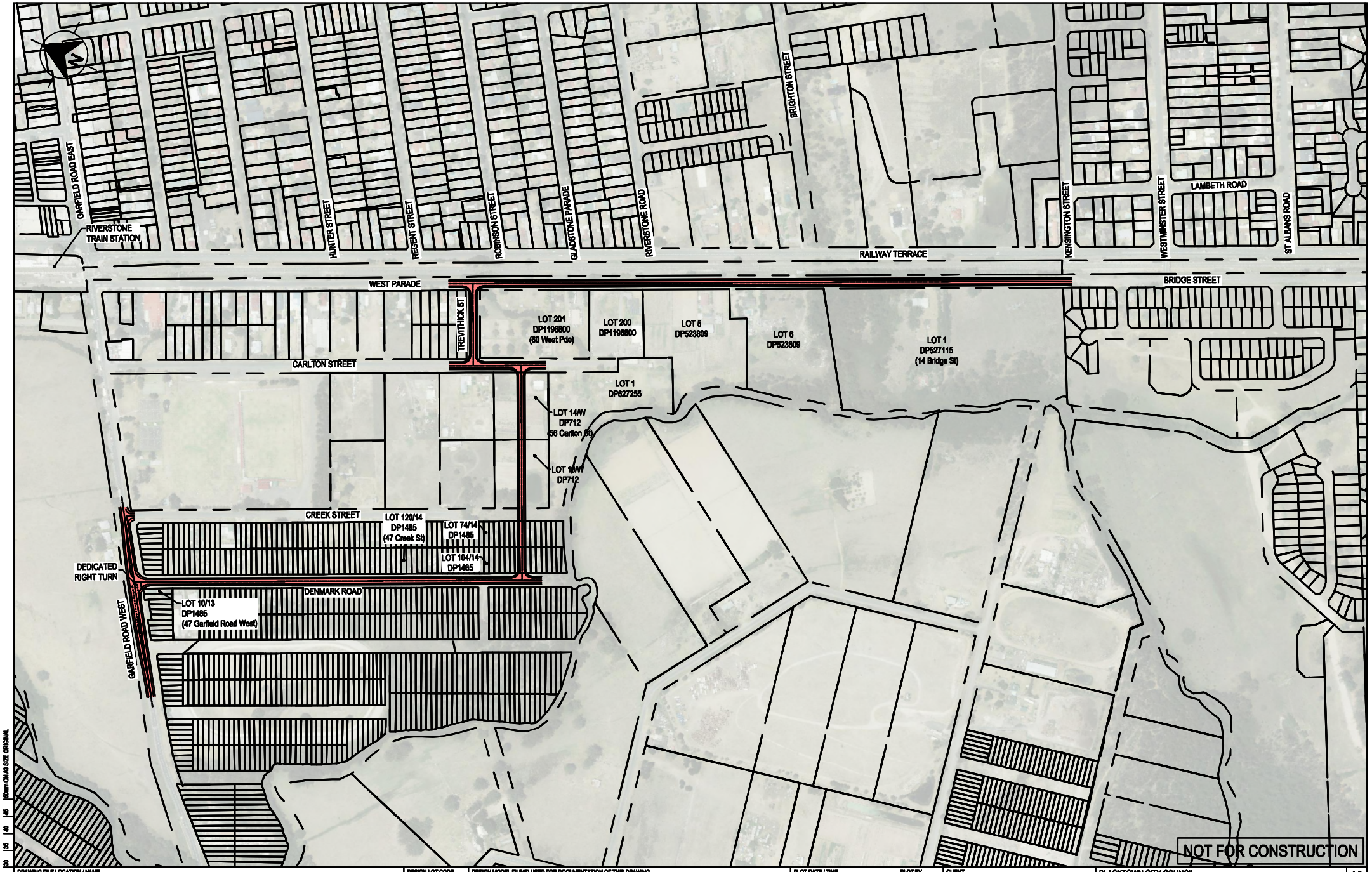
Appendix B – Concept Design



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						HEIGHT DATUM: AHD		DESIGN				
								DESIGN CHECK				
								DESIGN MNGR				
								PROJECT MNGR				

Transport Roads & Maritime Services

PREPARED FOR
INFRASTRUCTURE DELIVERY
INFRASTRUCTURE DEVELOPMENT
ROADS & MARITIME SERVICES

RMS REGISTRATION No. DS2017 / XXXXXX PART X

ISSUE STATUS: 20% DESIGN - CONCEPT PHASE | EDMS No.: XXXXXXXXX | SHEET No.: SK002 | ISSUE: A

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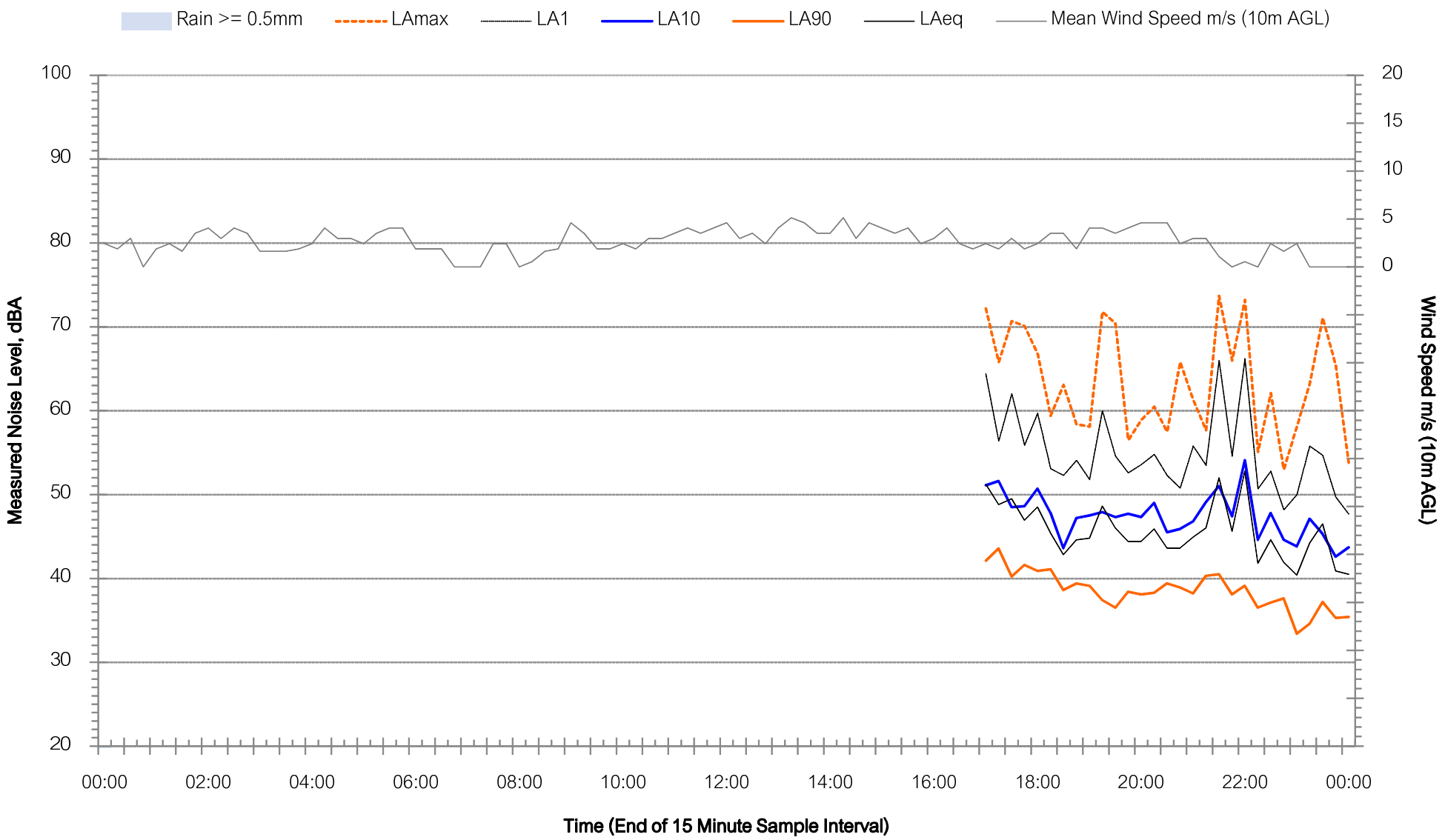
Appendix C – Background Noise Monitoring Charts

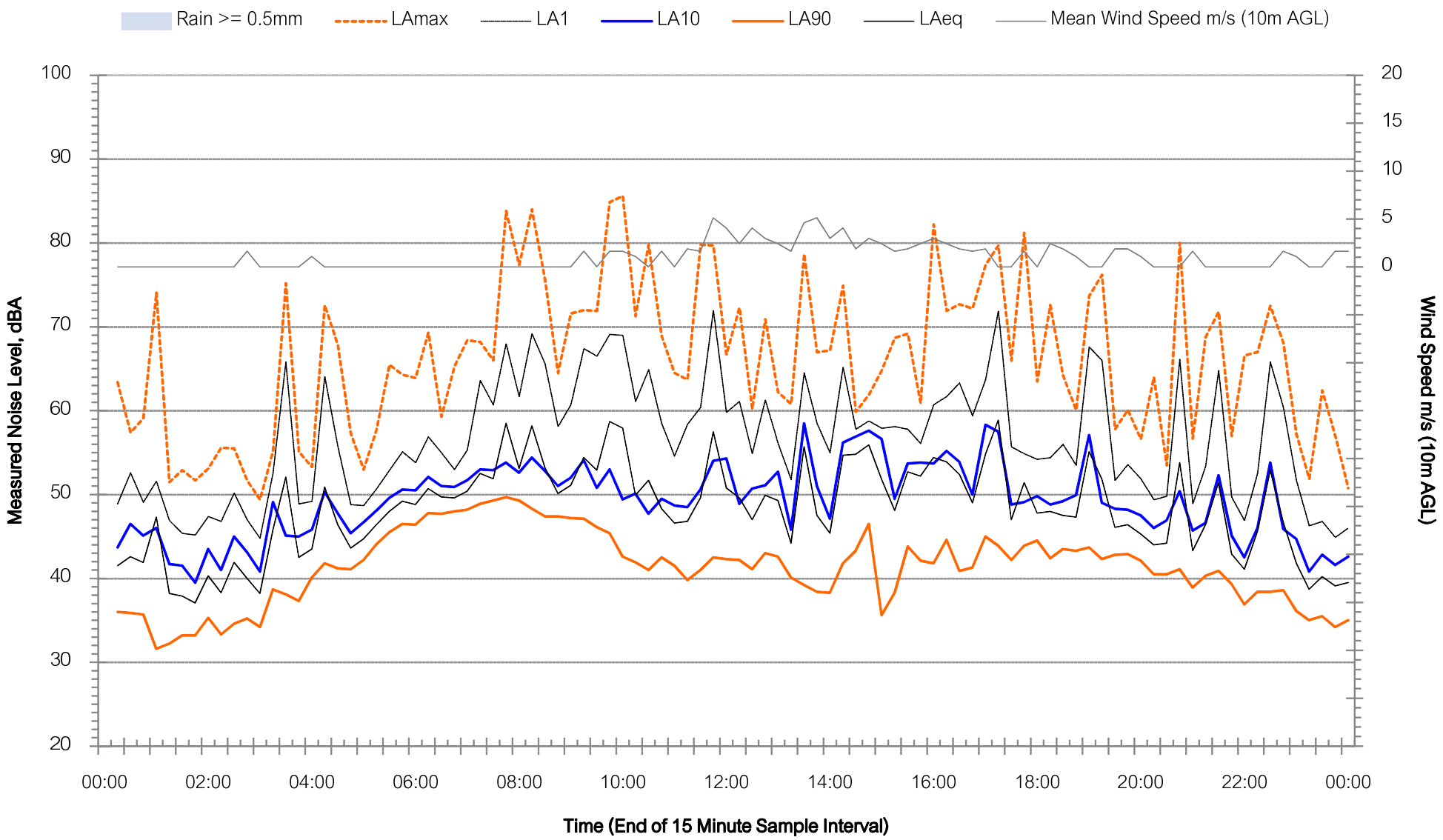
Background Noise Levels

Denmark Road, Riverstone - Monday 20 July 2020



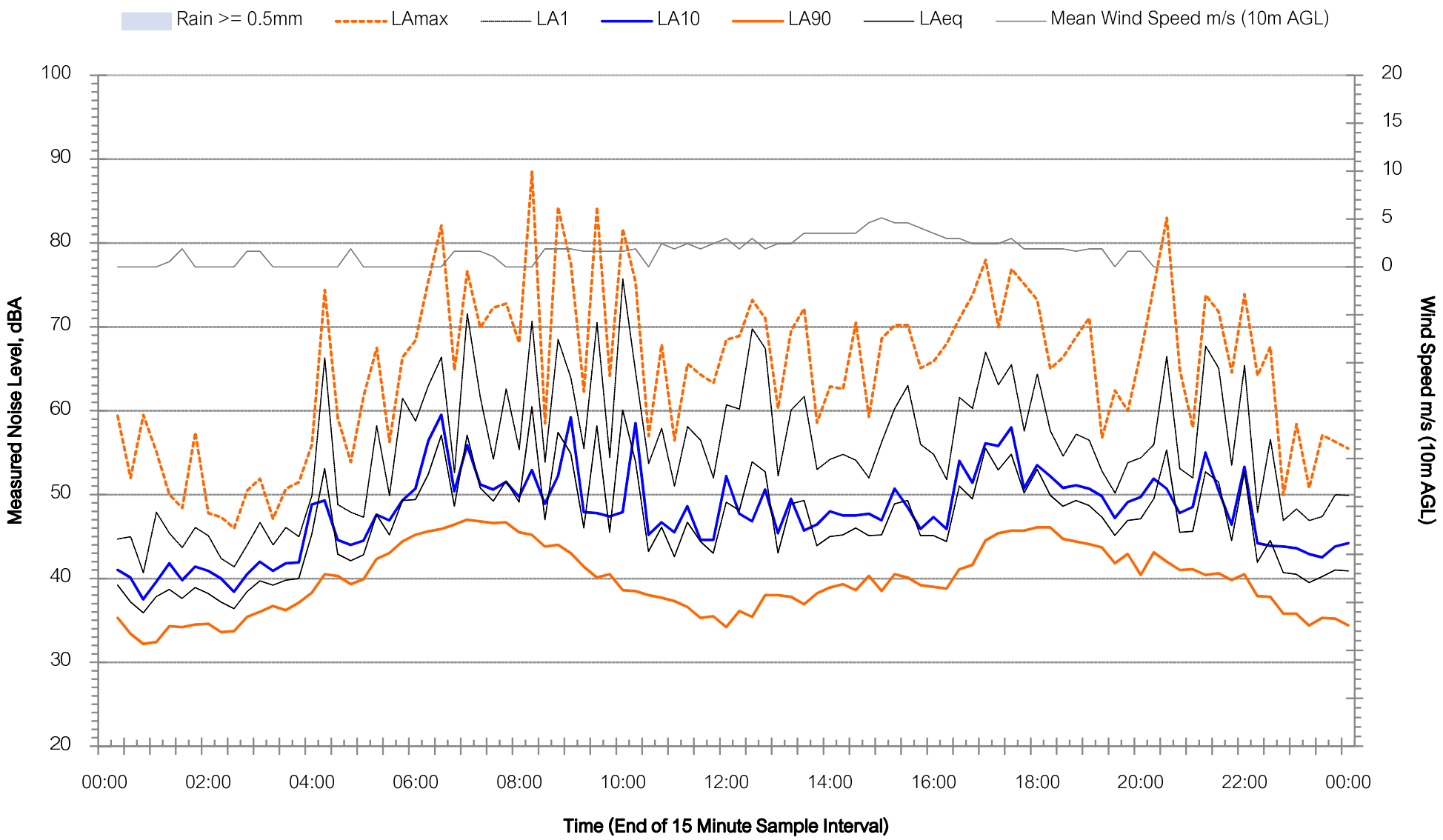
Background Noise Levels

Denmark Road, Riverstone - Tuesday 21 July 2020



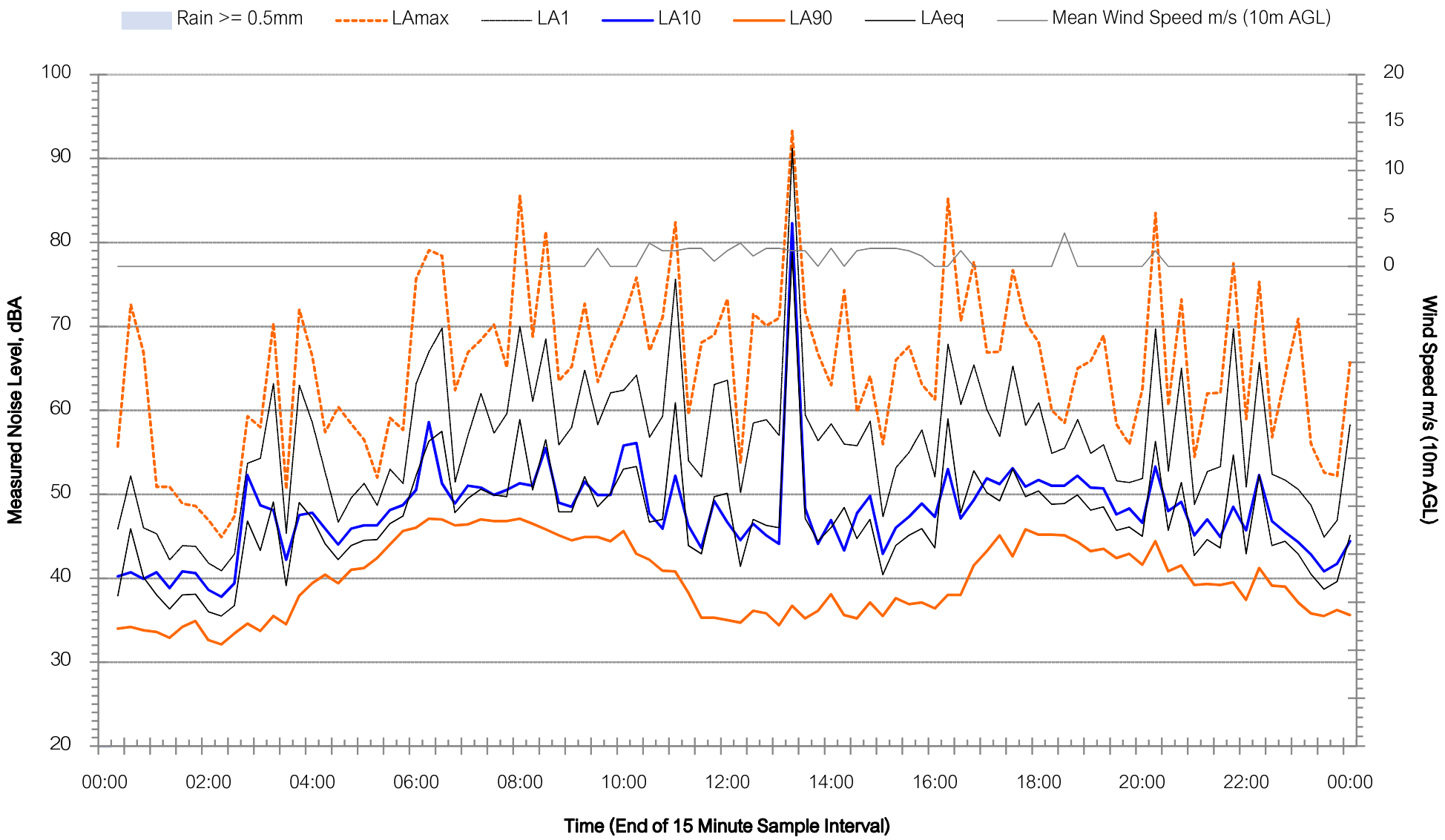
Background Noise Levels

Denmark Road, Riverstone - Wednesday 22 July 2020



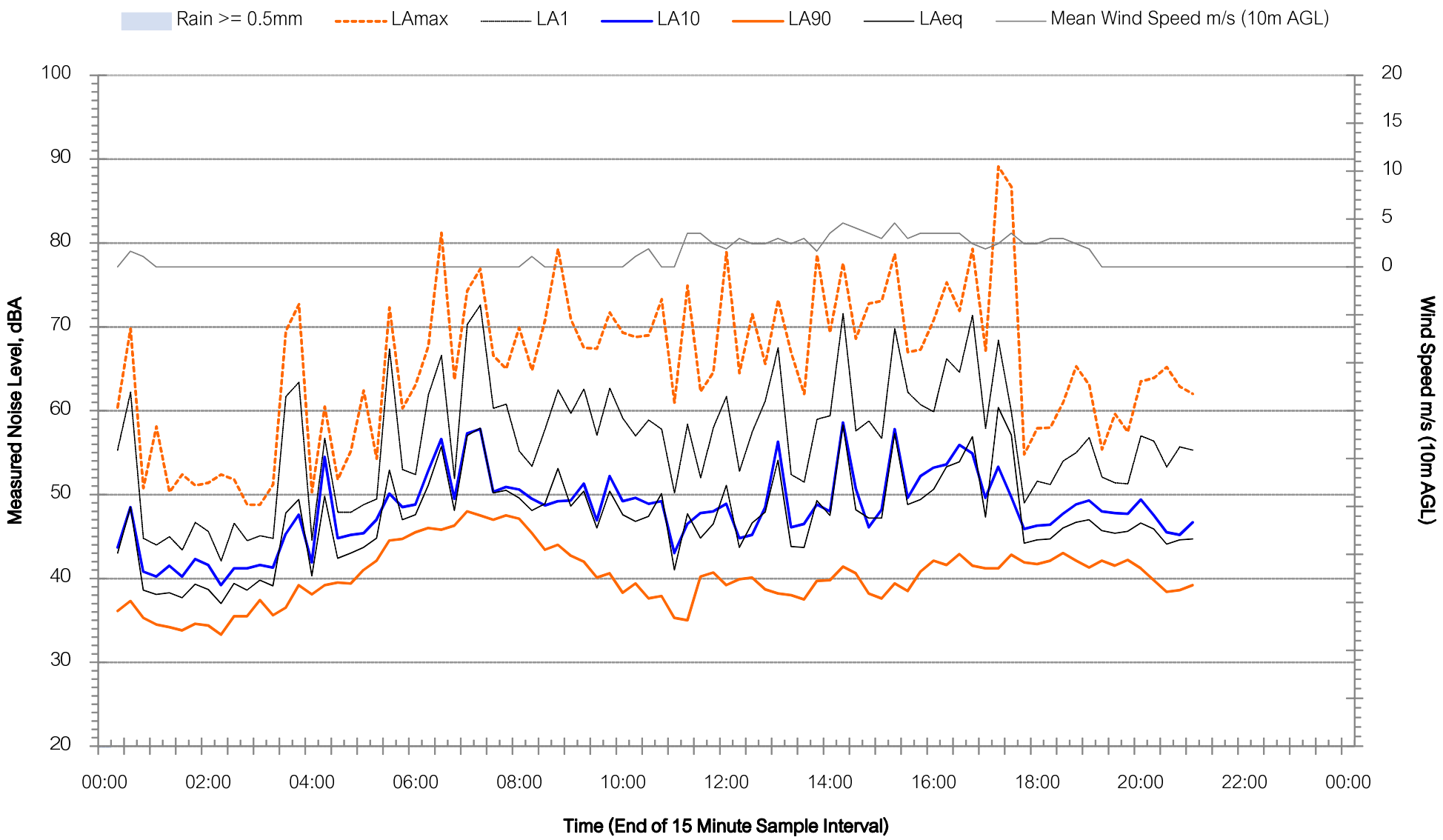
Background Noise Levels

Denmark Road, Riverstone - Thursday 23 July 2020



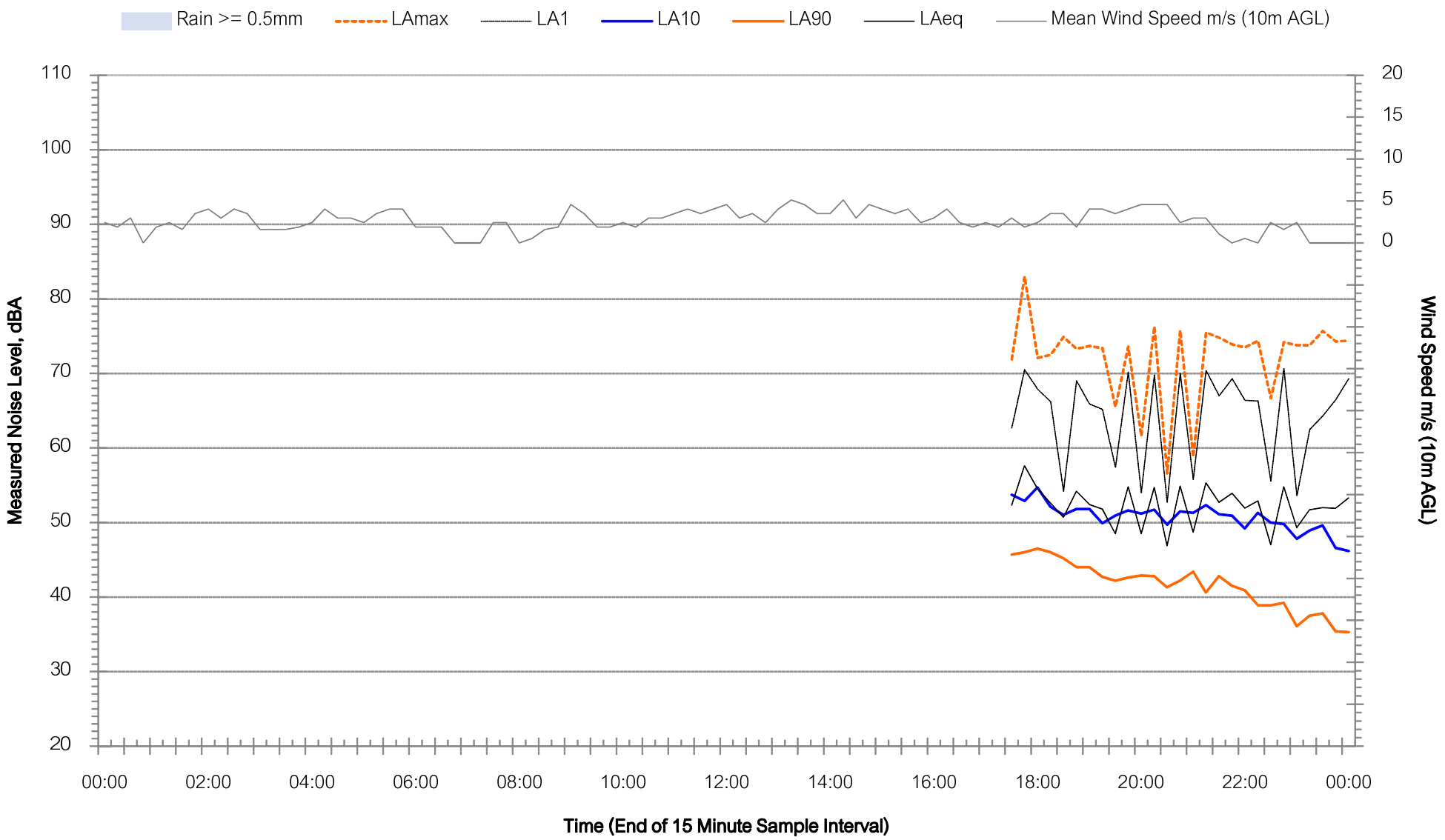
Background Noise Levels

Denmark Road, Riverstone - Friday 24 July 2020



Background Noise Levels

West Parade, Riverstone - Monday 20 July 2020



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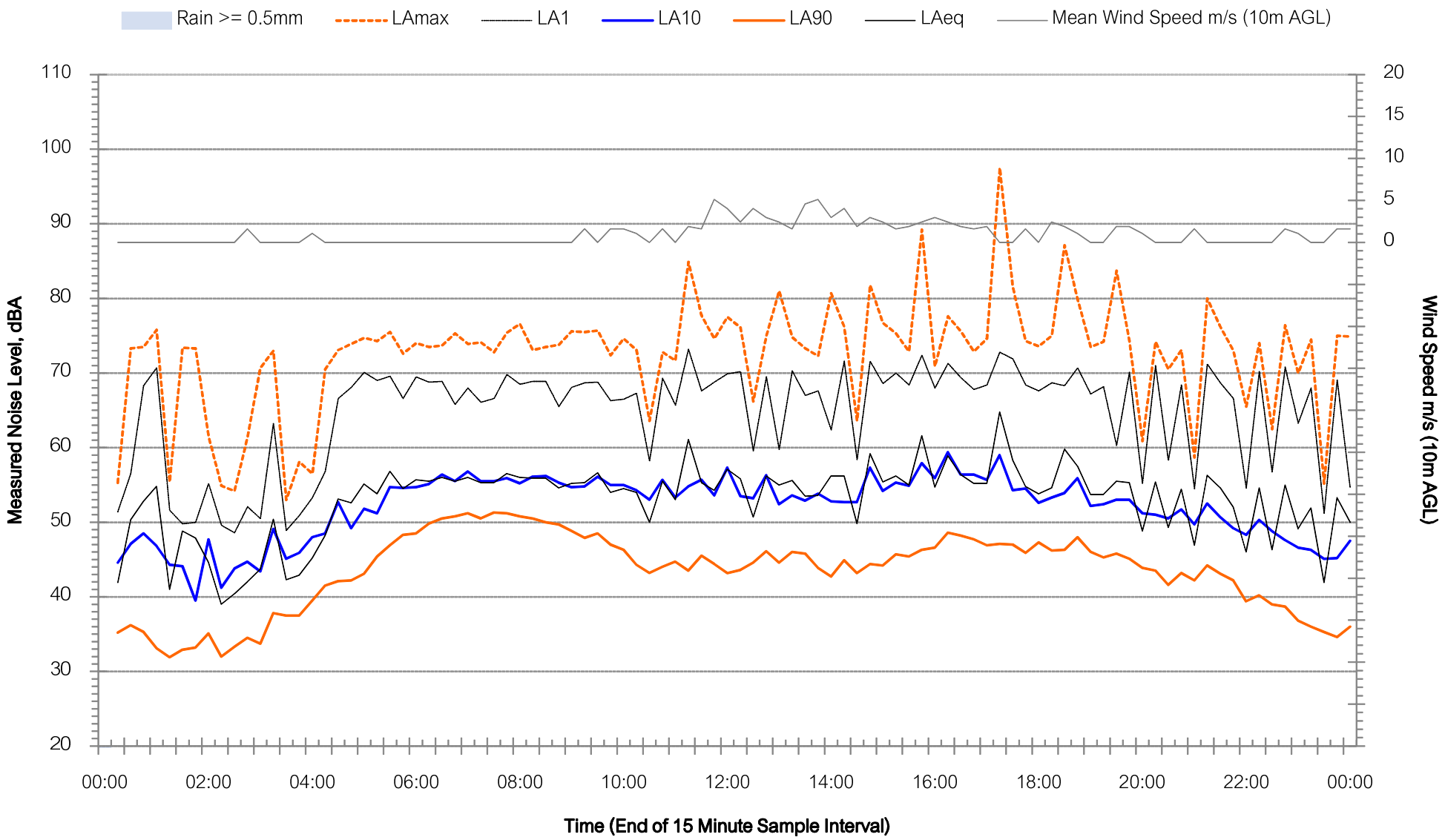

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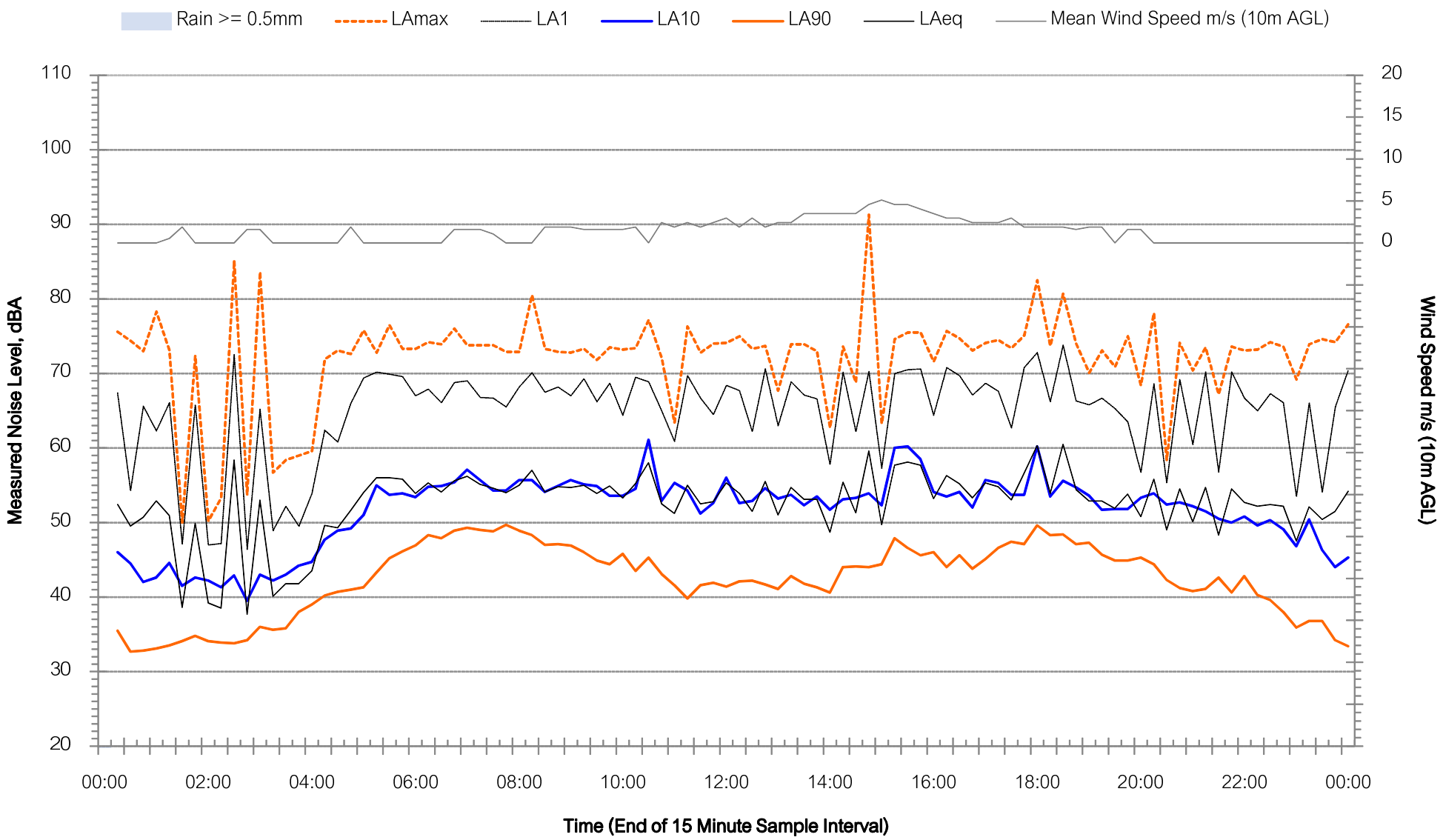
West Parade, Riverstone - Wednesday 22 July 2020



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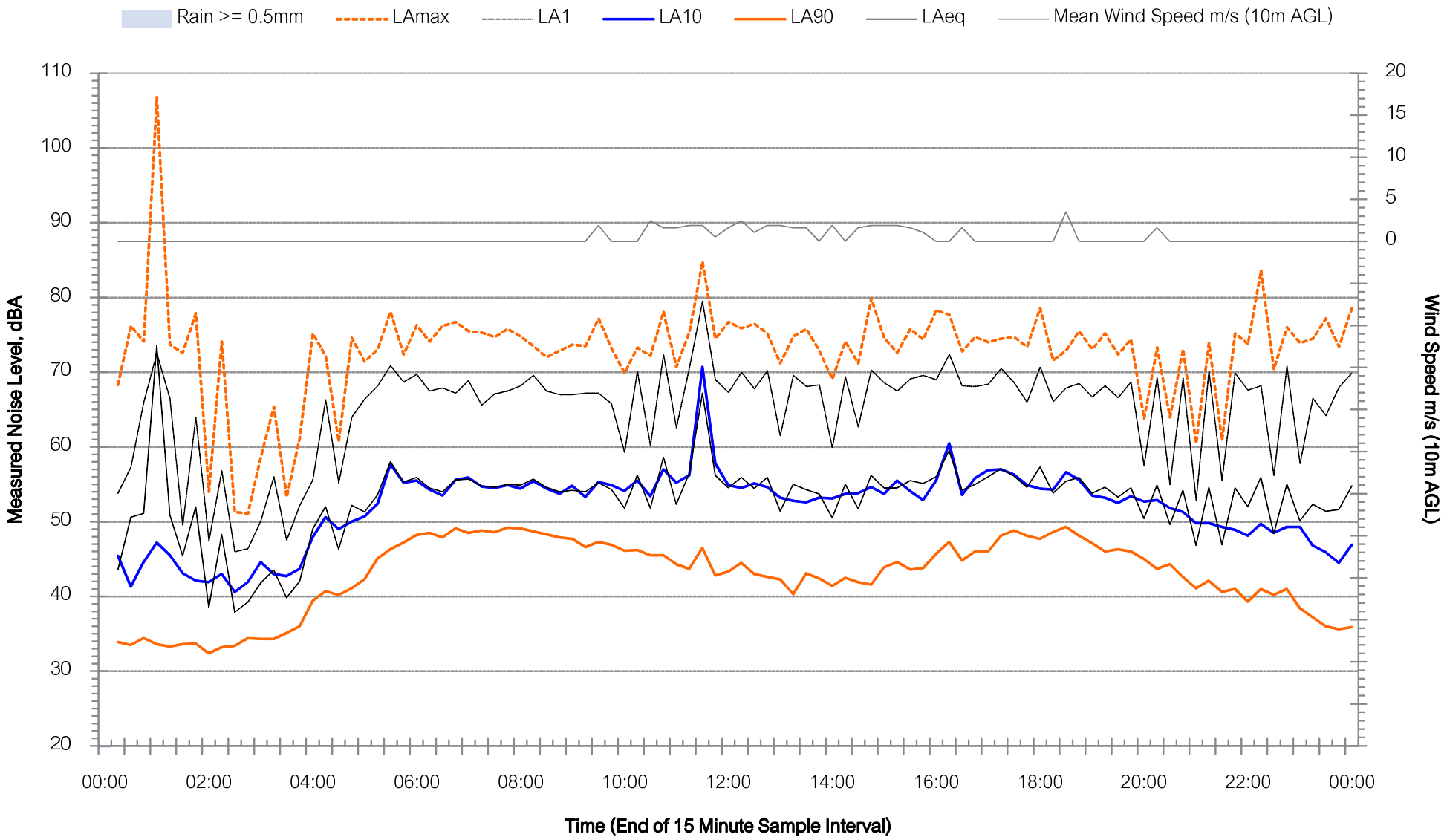
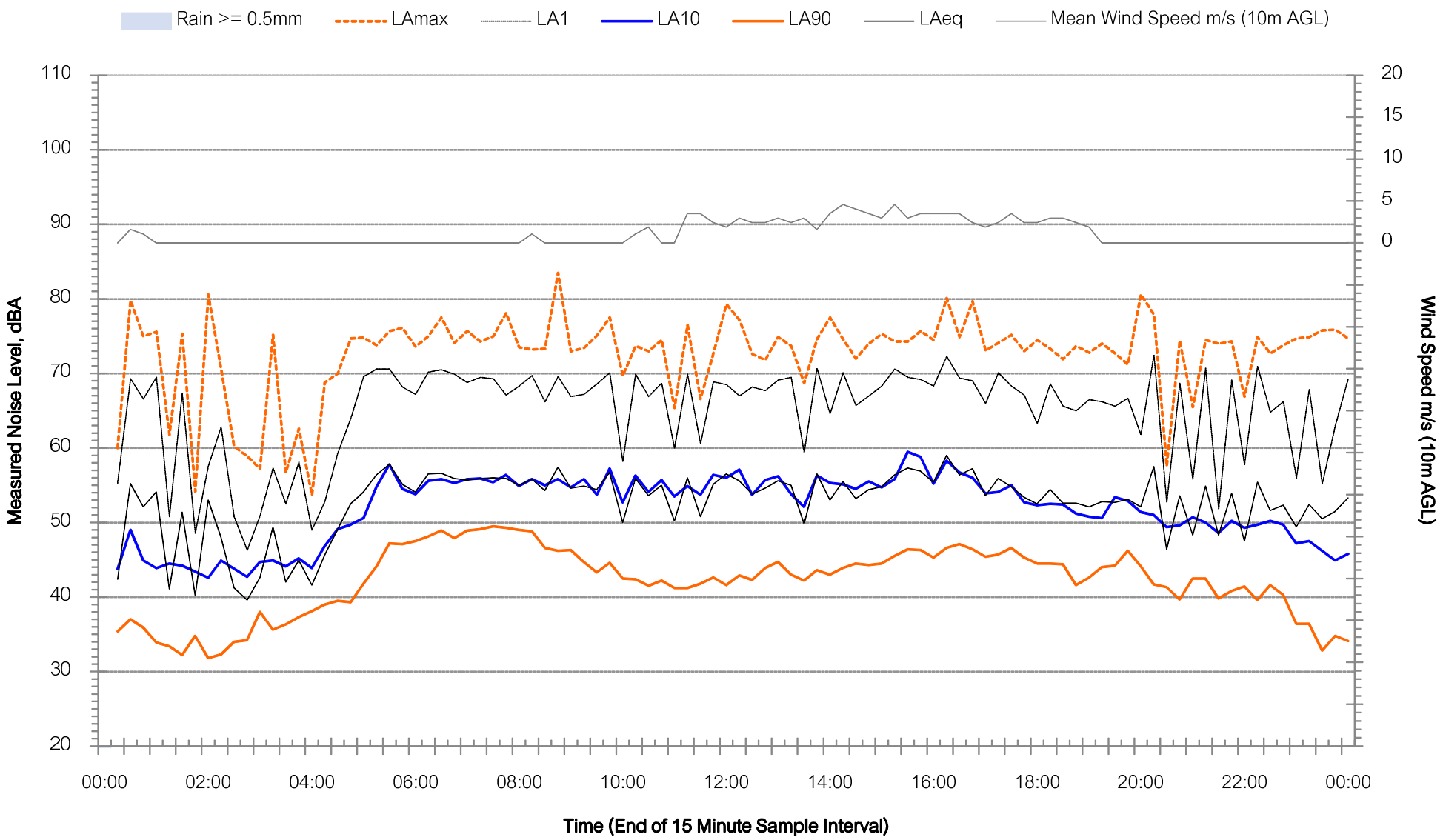


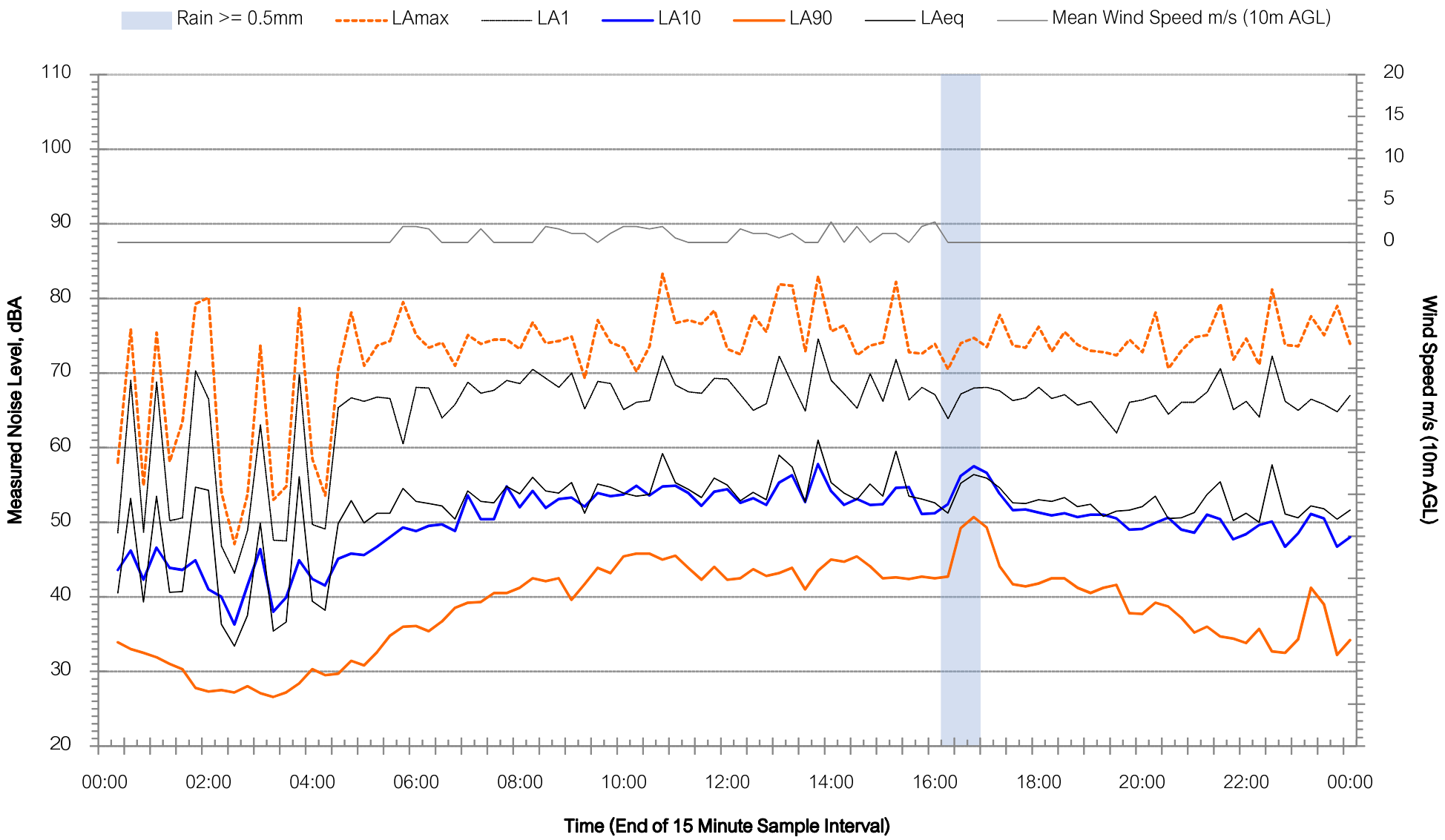
Background Noise Levels

West Parade, Riverstone - Friday 24 July 2020



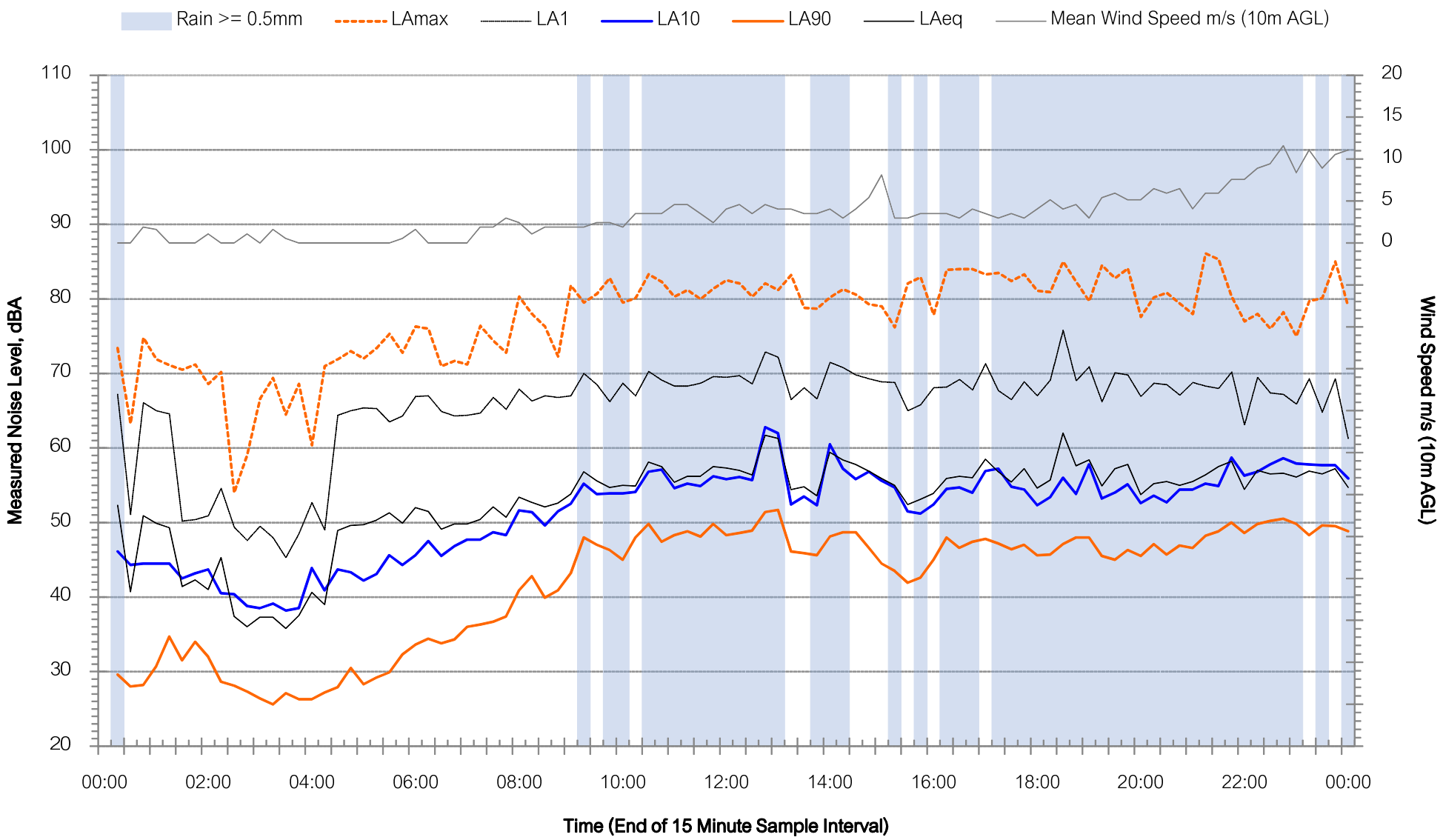
Background Noise Levels

West Parade, Riverstone - Saturday 25 July 2020



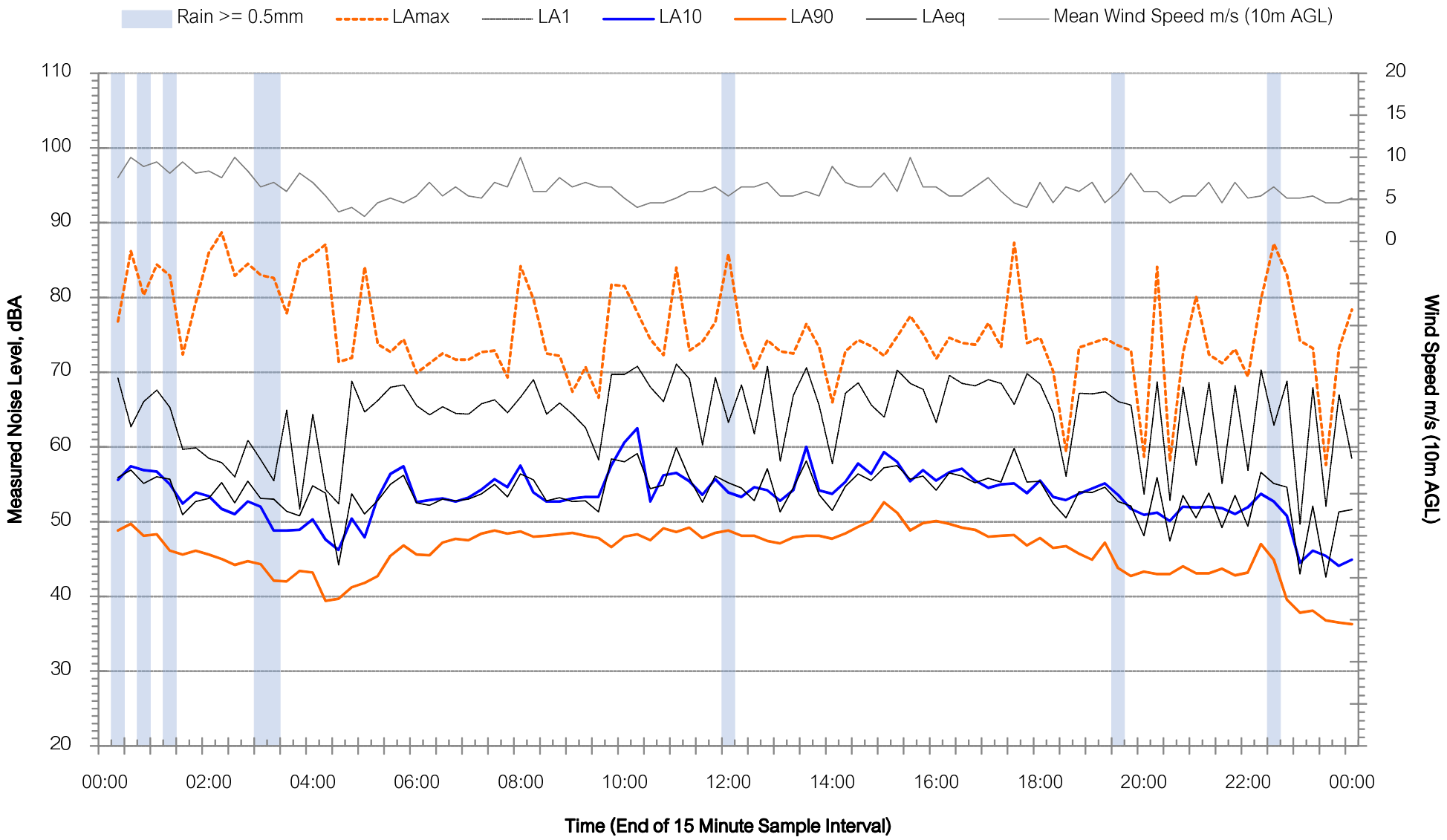
Background Noise Levels

West Parade, Riverstone - Sunday 26 July 2020



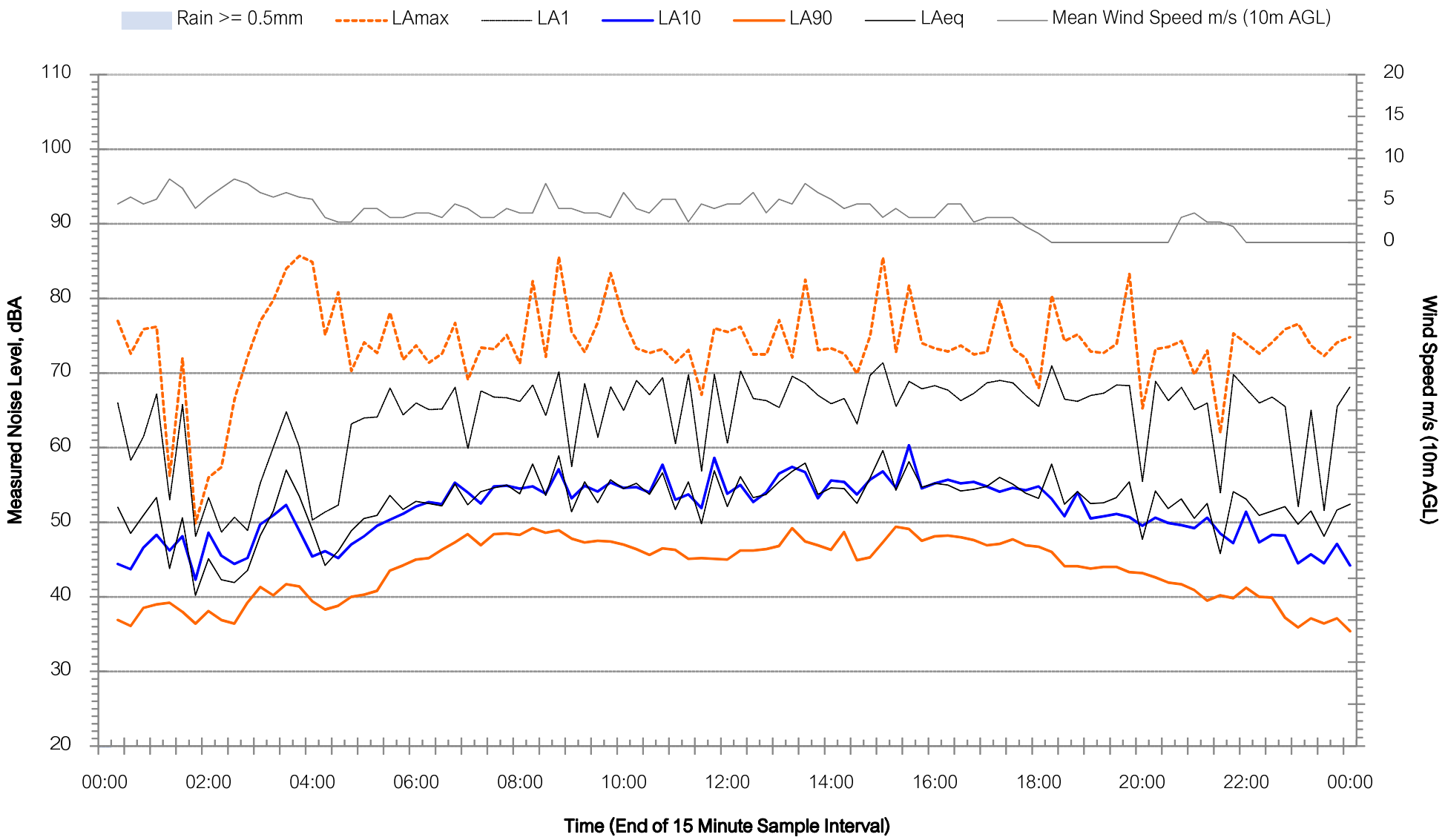
Background Noise Levels

West Parade, Riverstone - Monday 27 July 2020



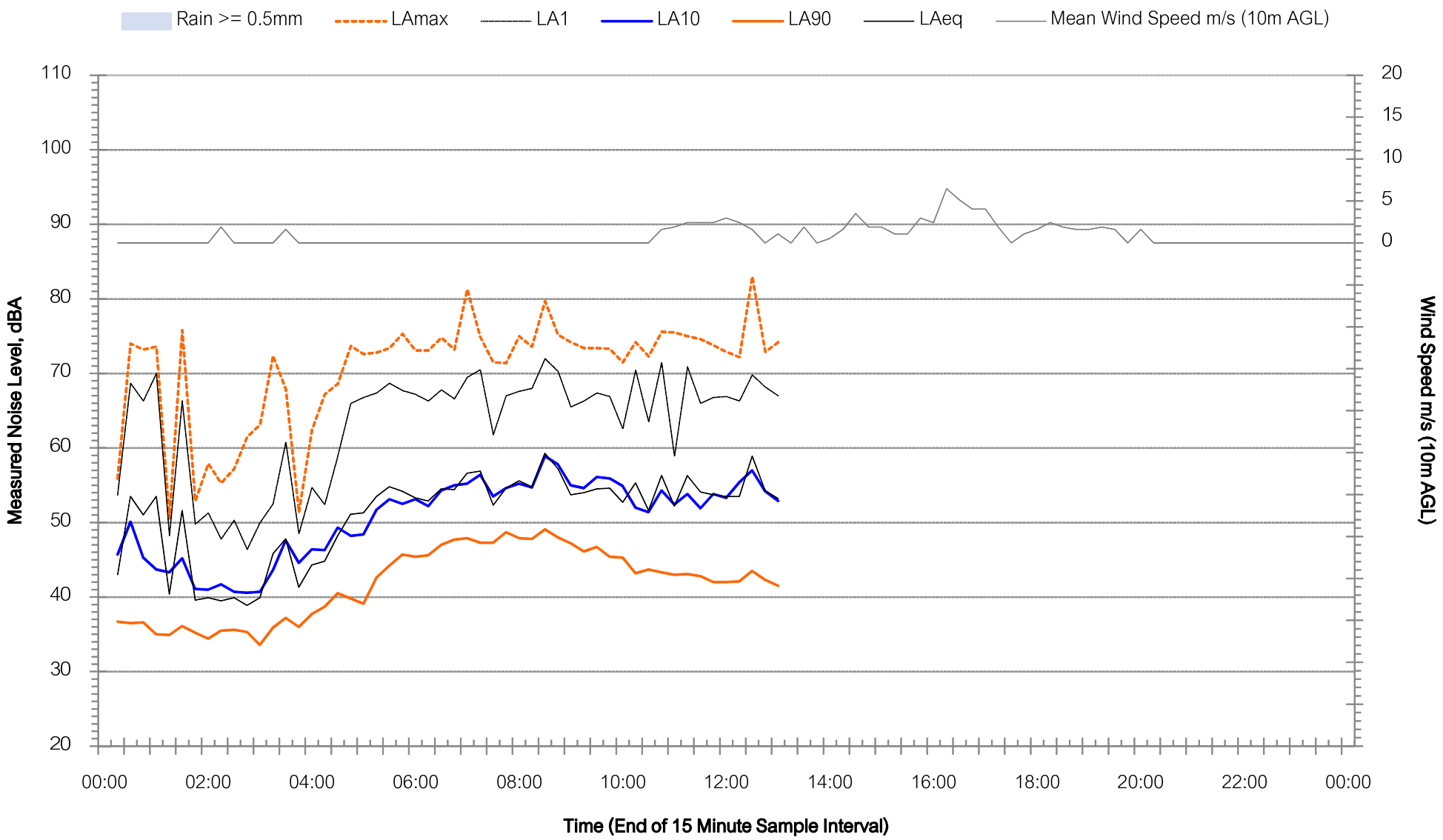
Background Noise Levels

West Parade, Riverstone - Tuesday 28 July 2020



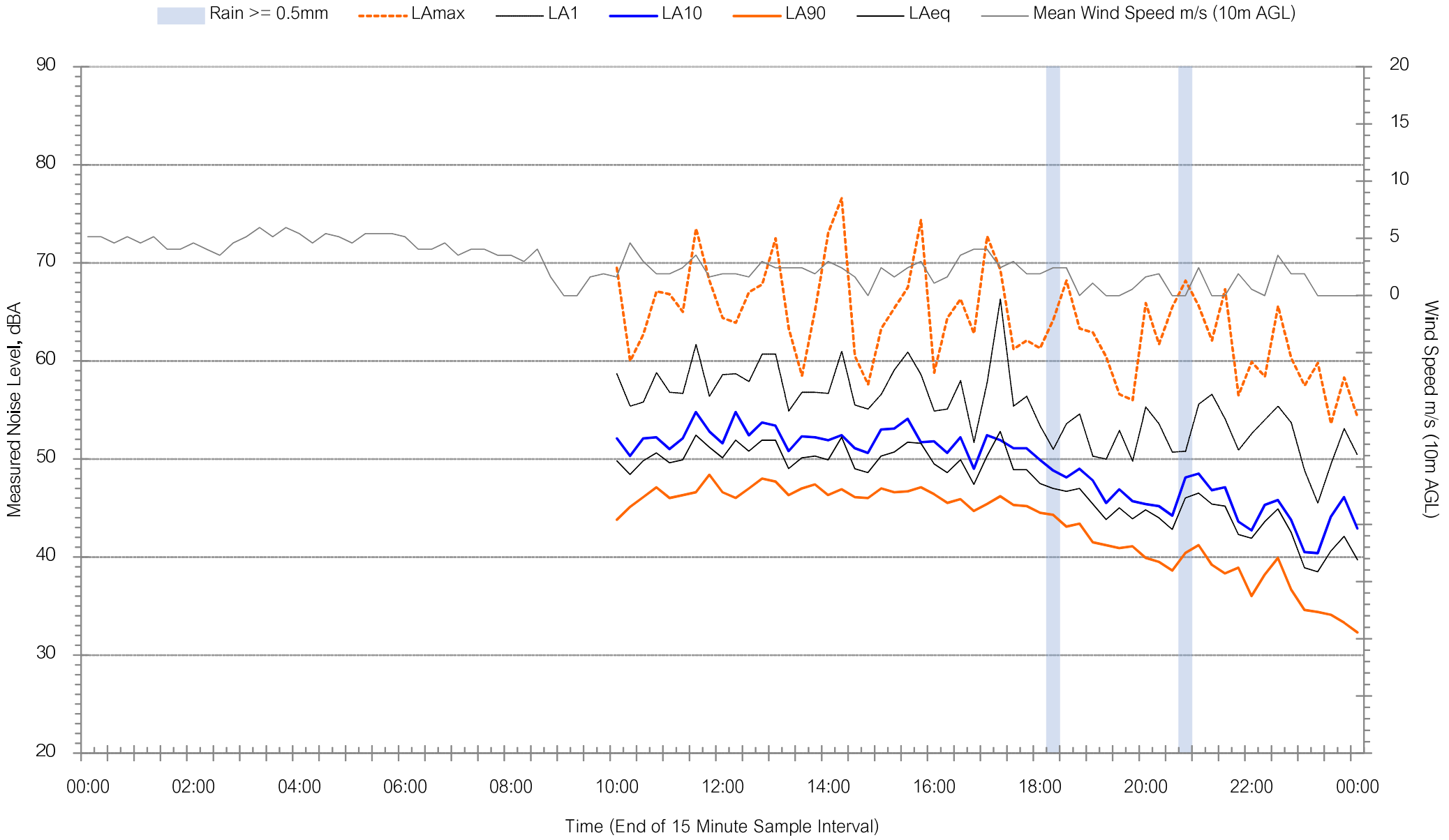
Background Noise Levels

West Parade, Riverstone - Wednesday 29 July 2020



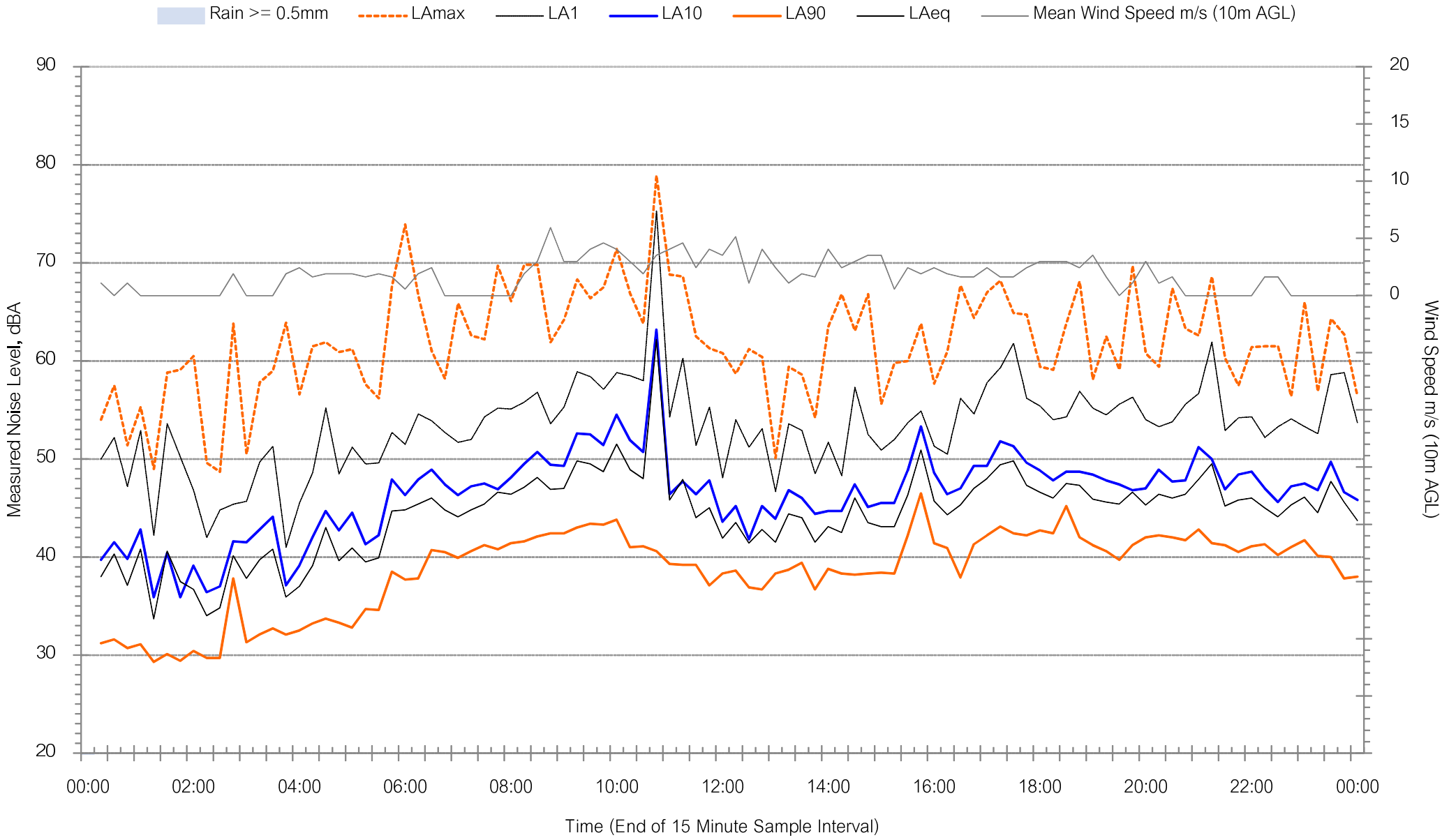
Background Noise Levels

Denmark Link Road, Riverstone - Friday 4 September 2020



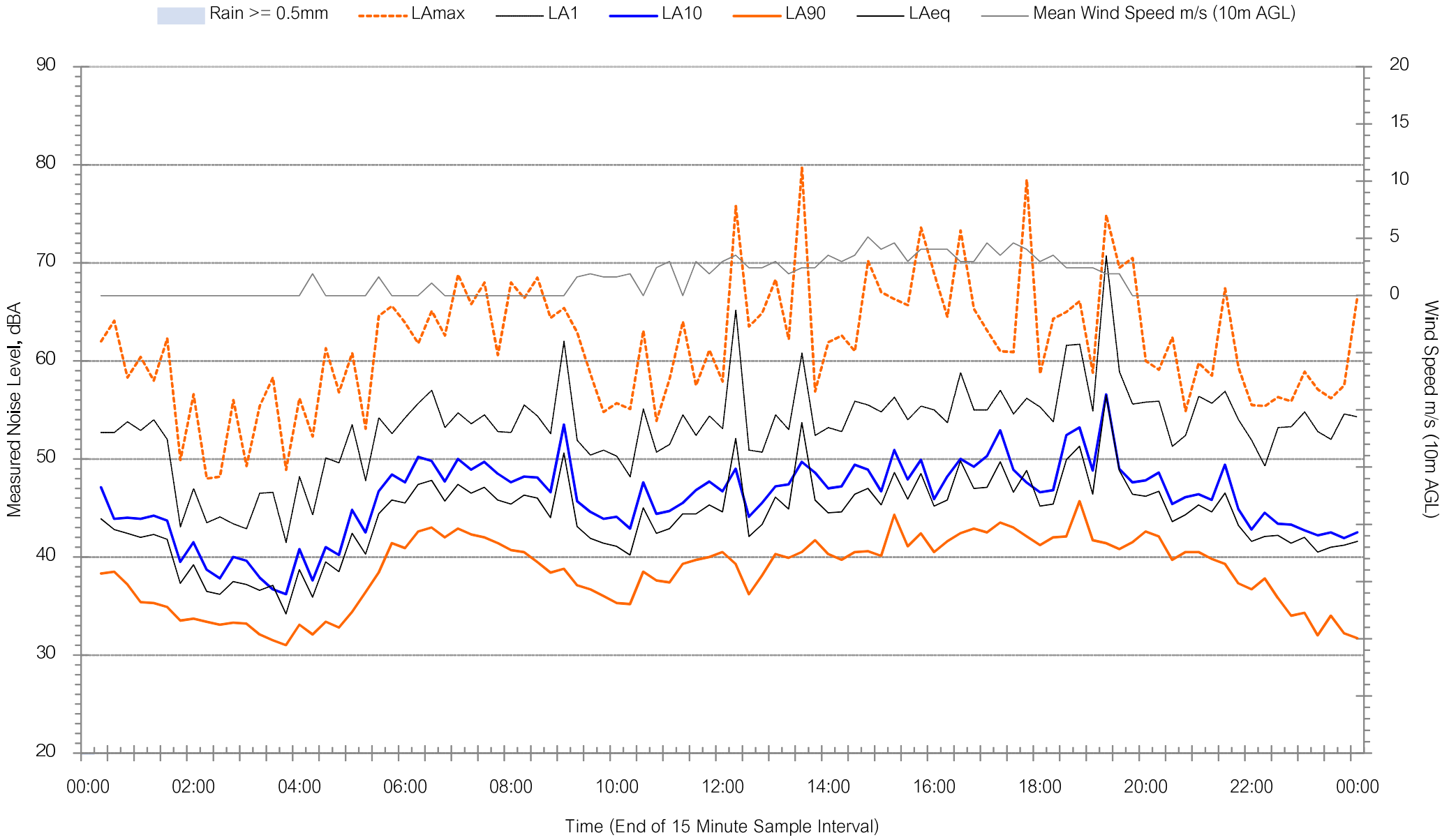
Background Noise Levels

Denmark Link Road, Riverstone - Saturday 5 September 2020



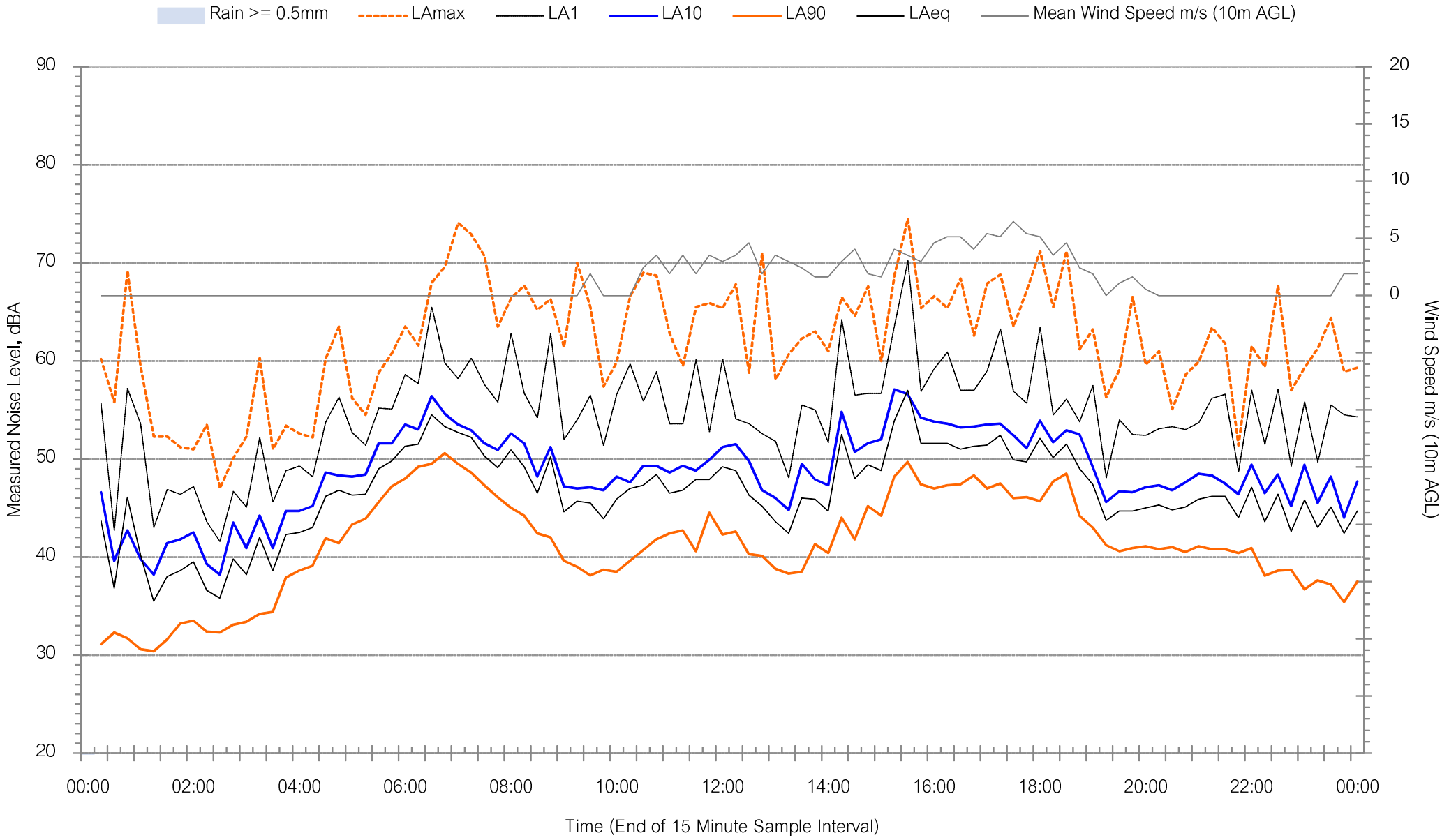
Background Noise Levels

Denmark Link Road, Riverstone - Sunday 6 September 2020



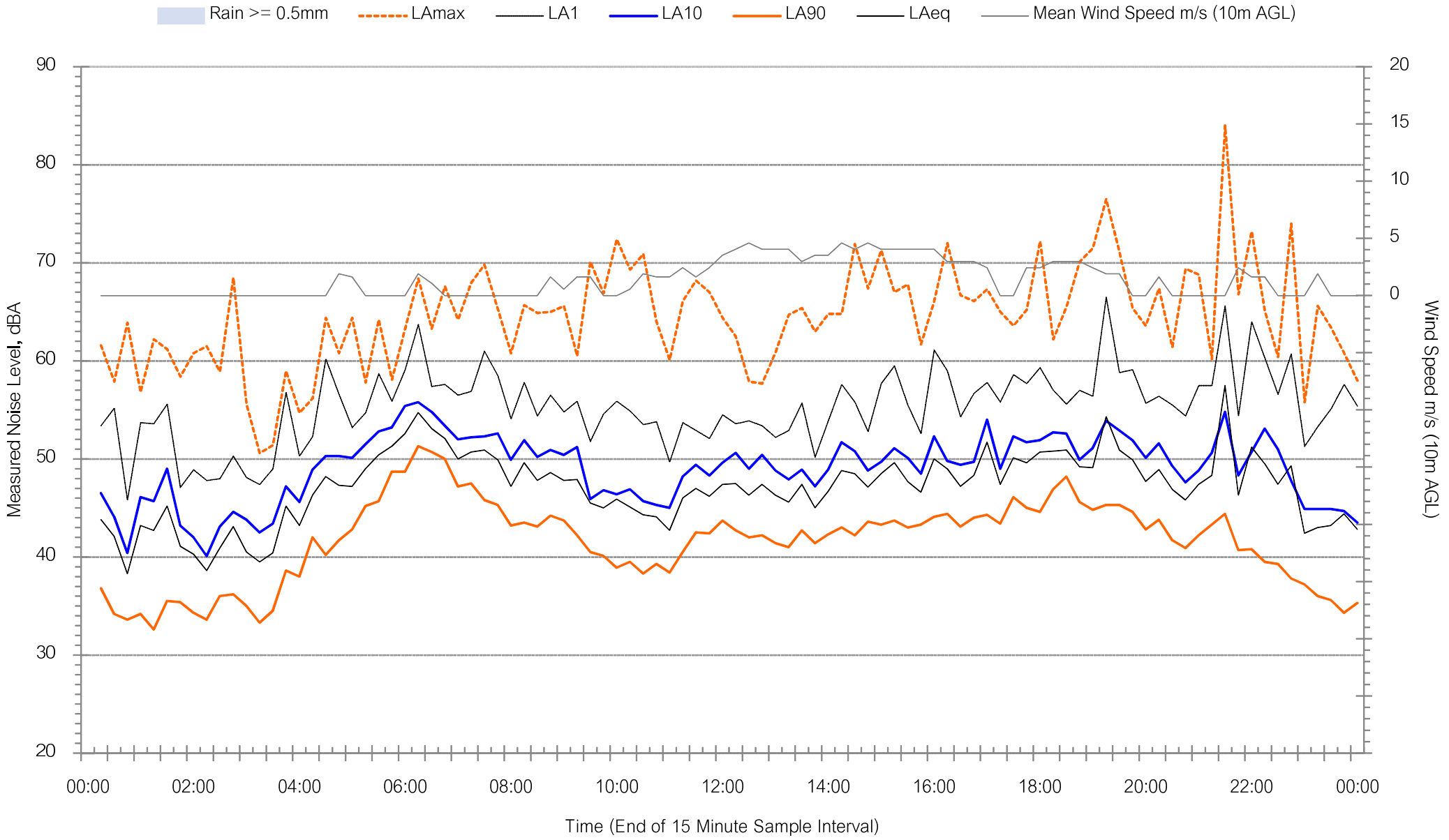
Background Noise Levels

Denmark Link Road, Riverstone - Monday 7 September 2020



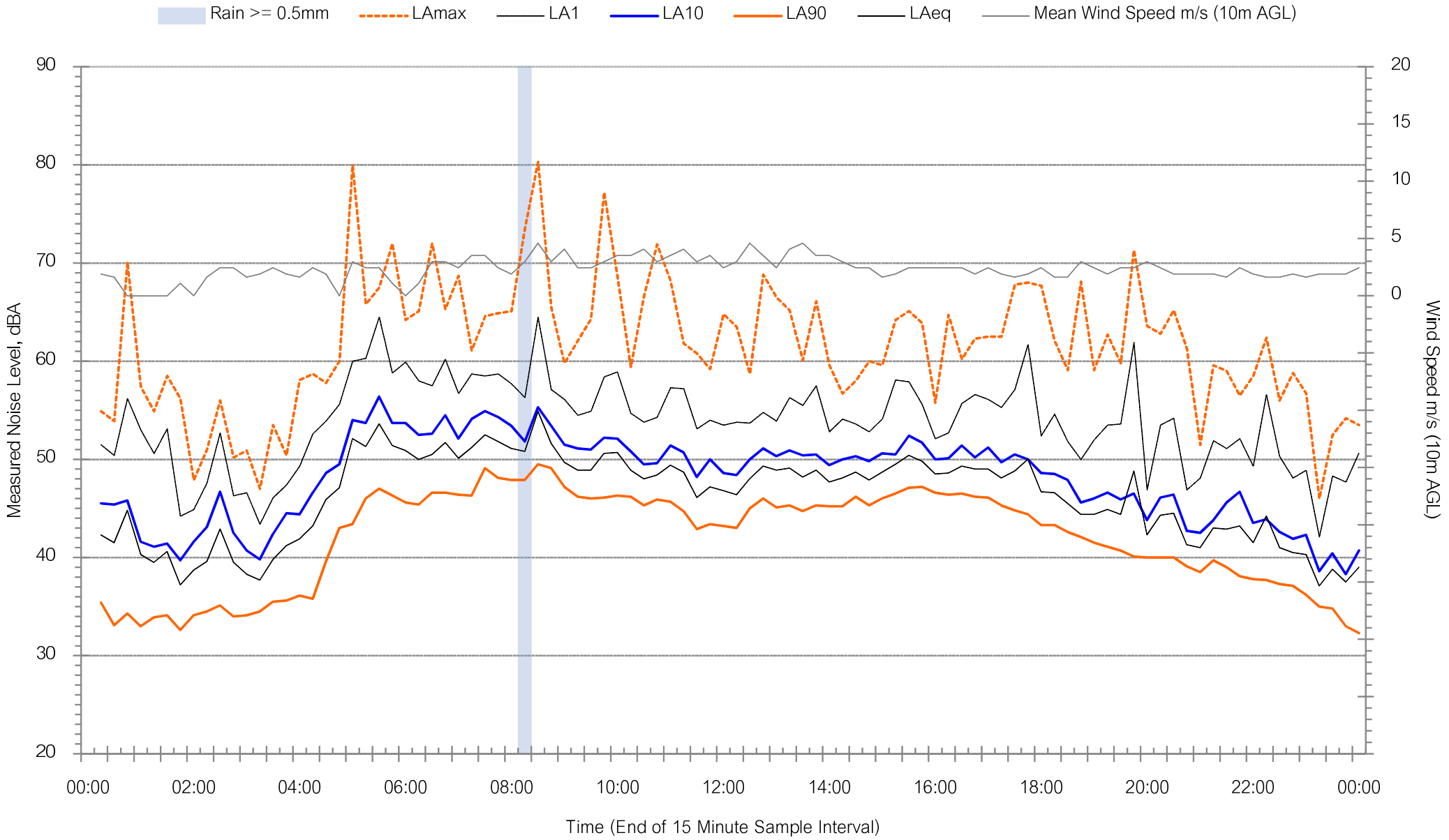
Background Noise Levels

Denmark Link Road, Riverstone - Tuesday 8 September 2020



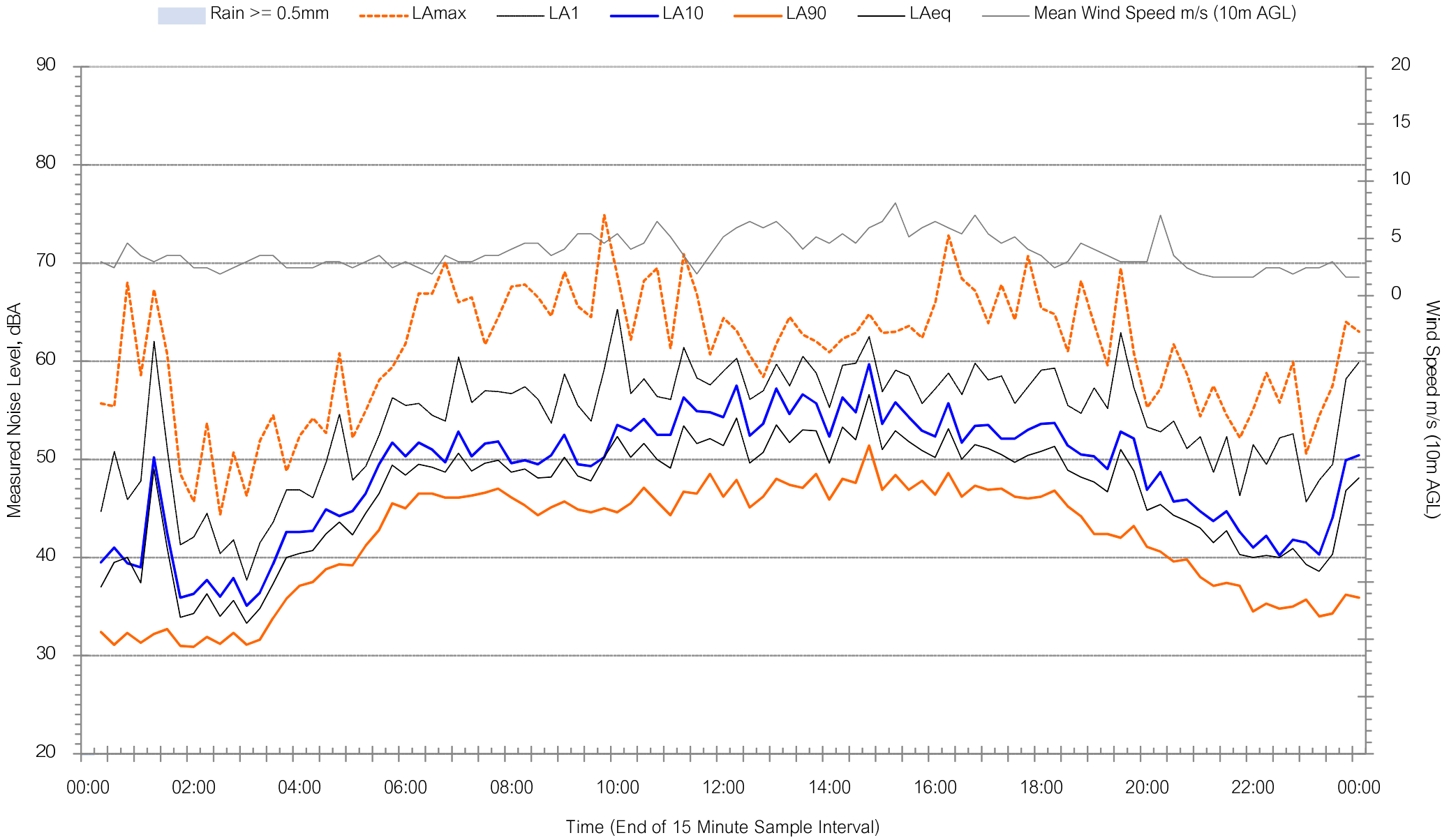
Background Noise Levels

Denmark Link Road, Riverstone - Wednesday 9 September 2020



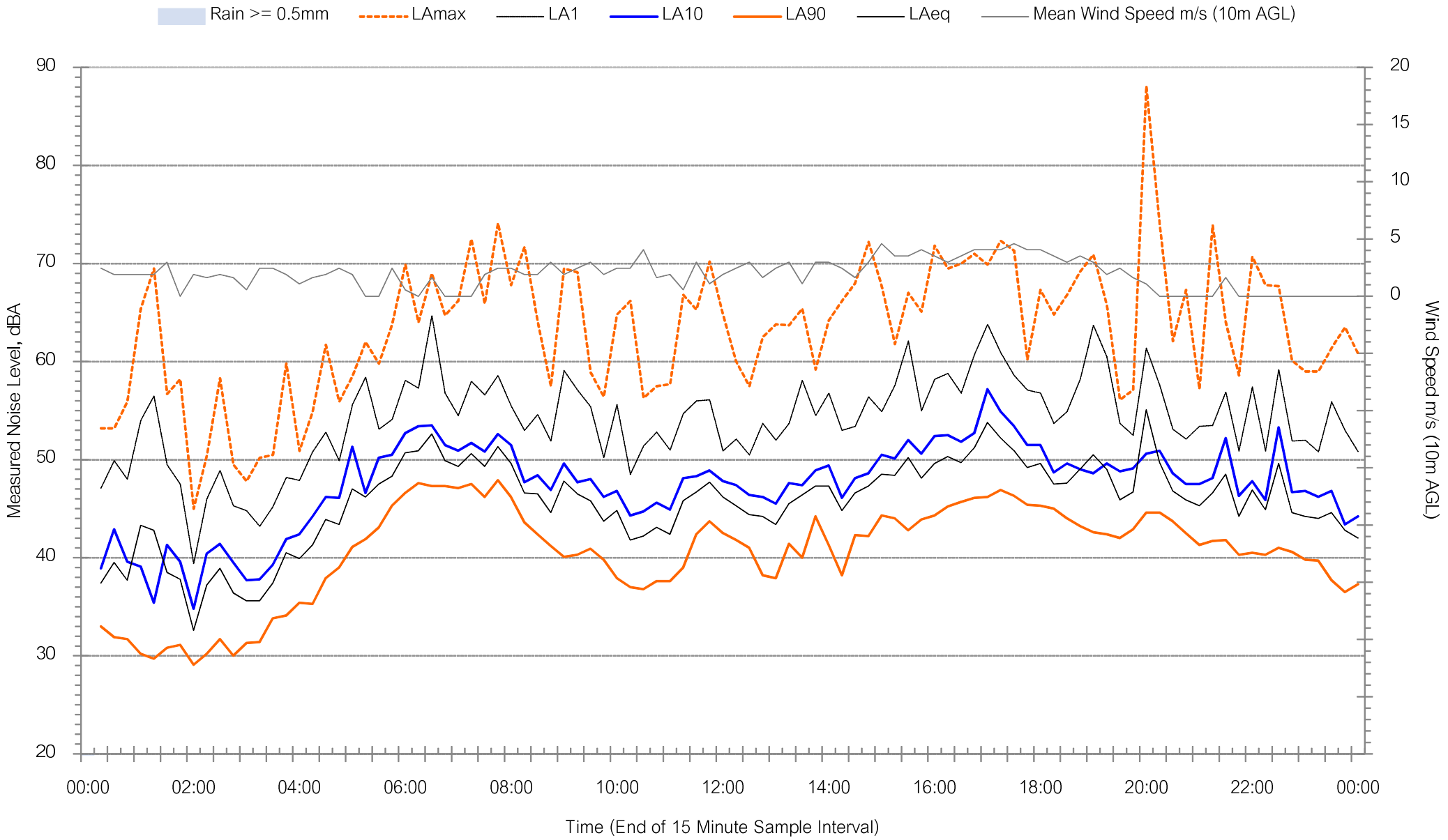
Background Noise Levels

Denmark Link Road, Riverstone - Thursday 10 September 2020



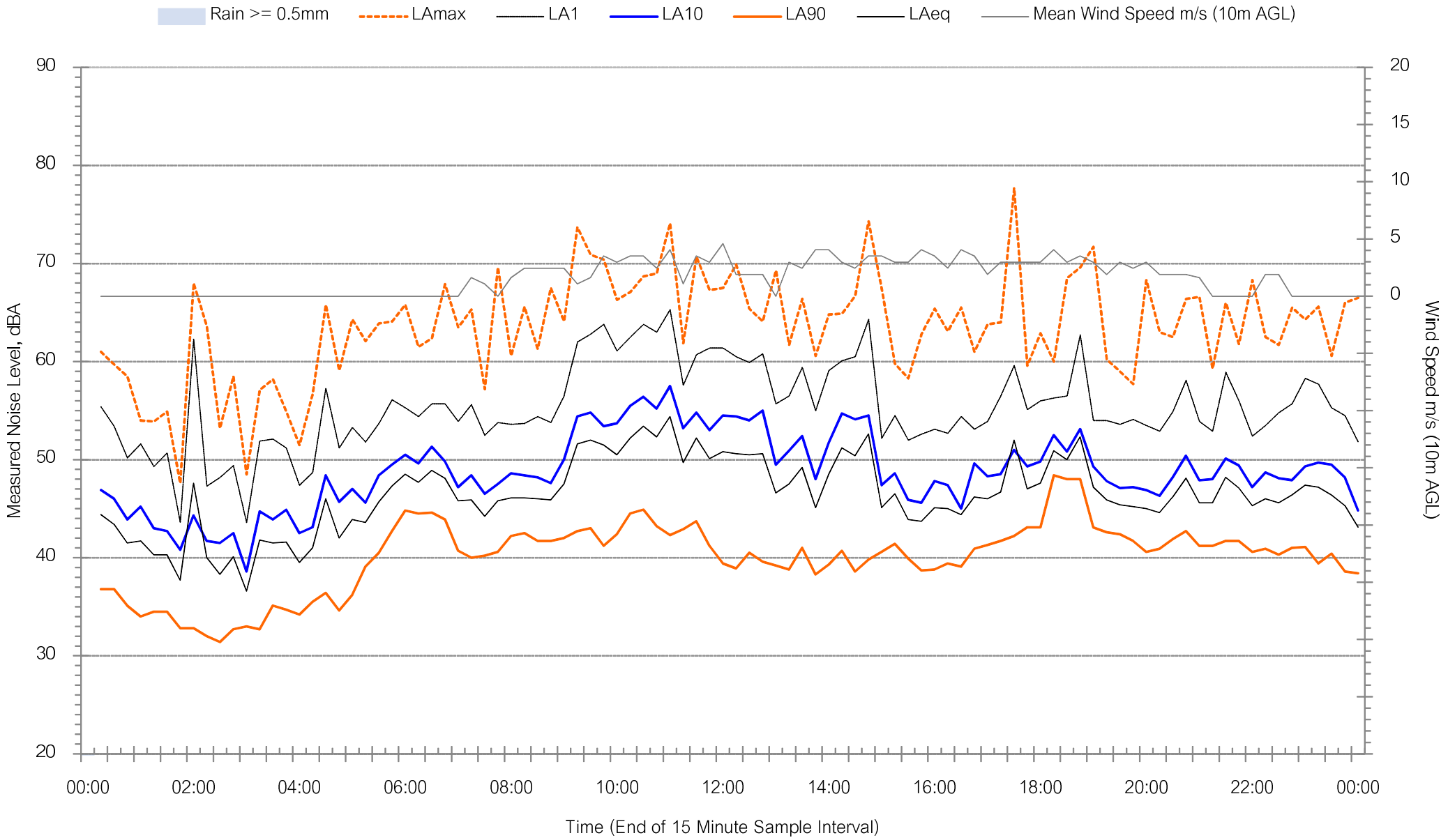
Background Noise Levels

Denmark Link Road, Riverstone - Friday 11 September 2020



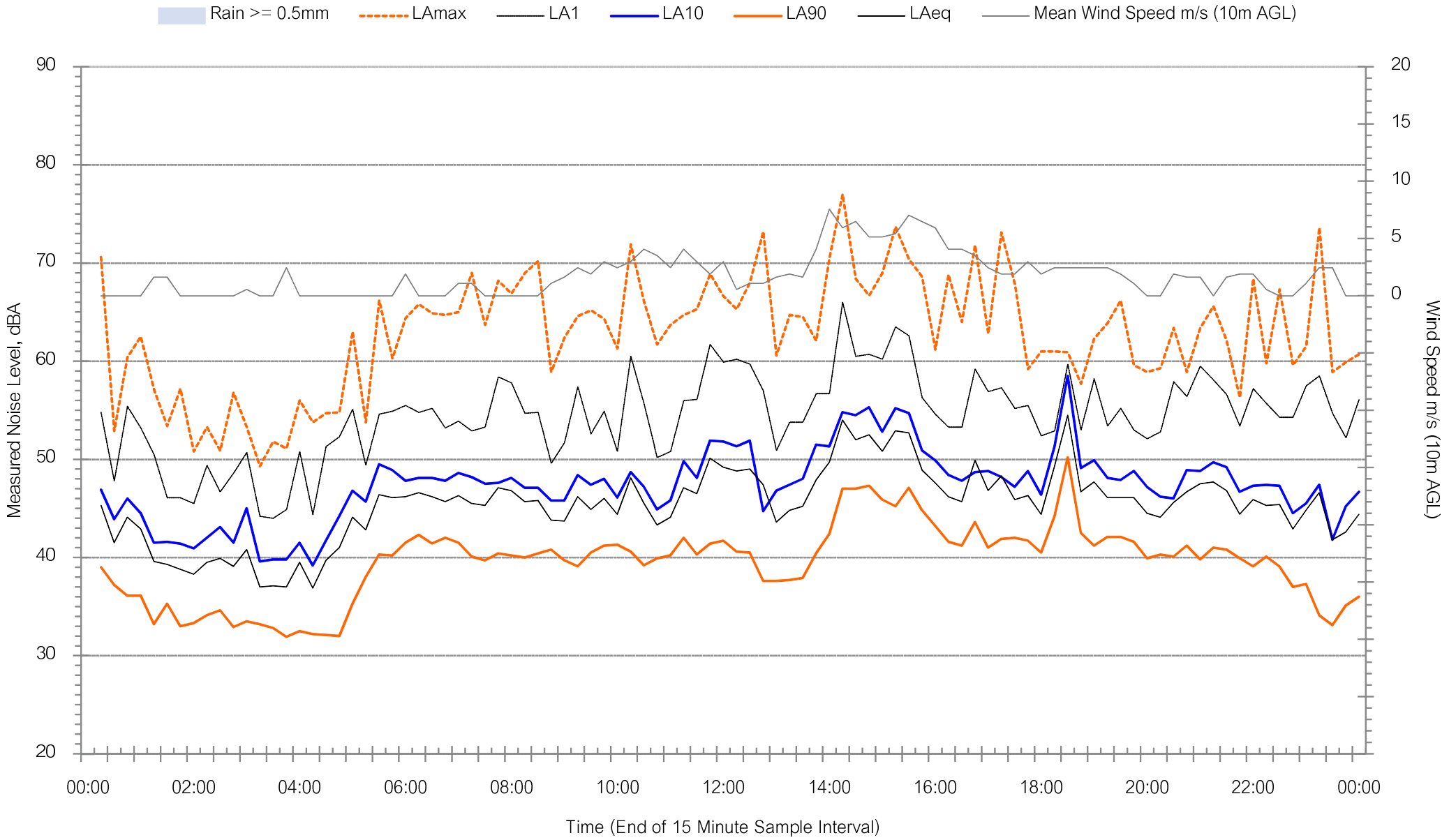
Background Noise Levels

Denmark Link Road, Riverstone - Saturday 12 September 2020



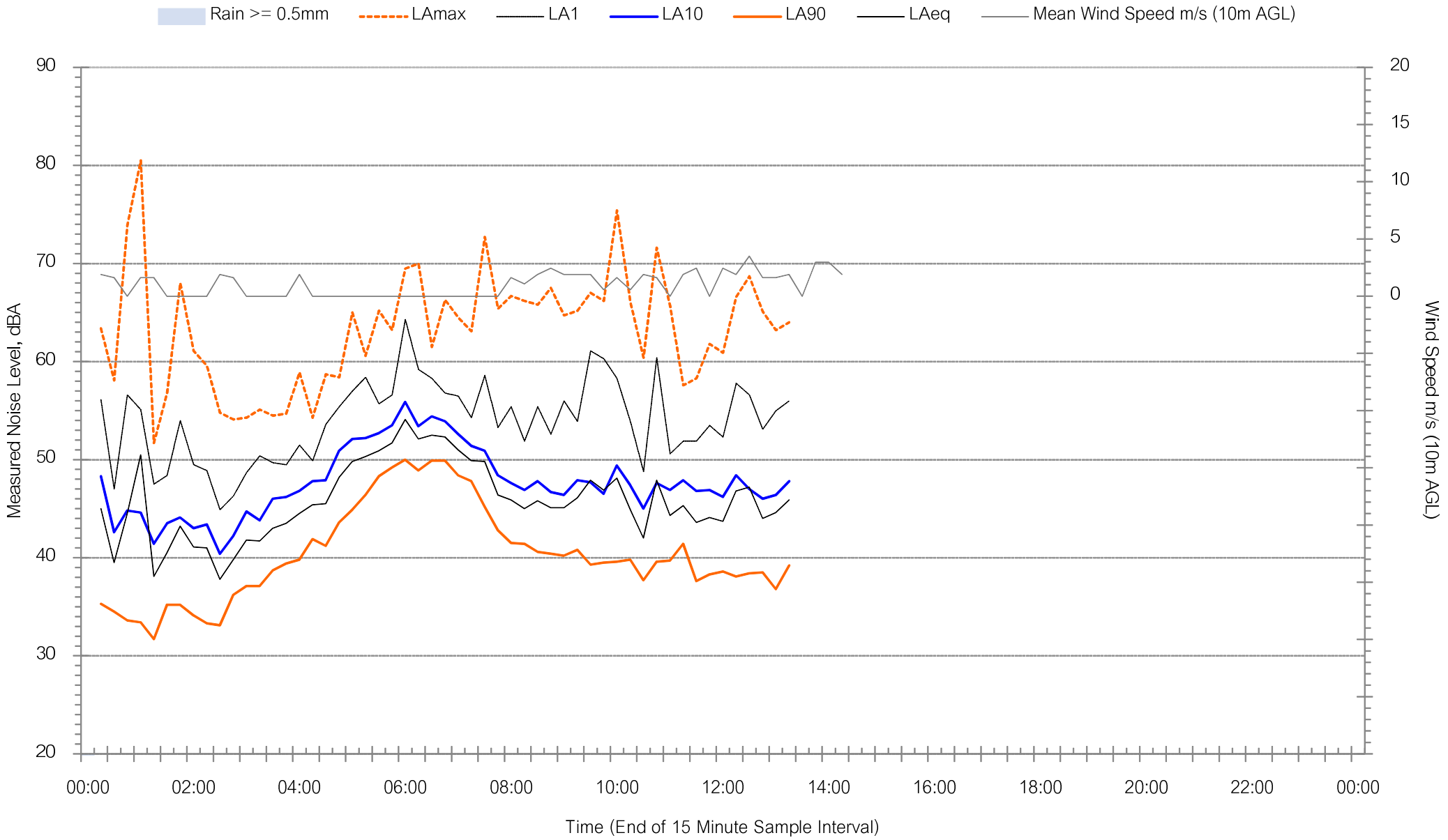
Background Noise Levels

Denmark Link Road, Riverstone - Sunday 13 September 2020



Background Noise Levels

Denmark Link Road, Riverstone - Monday 14 September 2020



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Appendix D – Construction Noise Contours

FIGURE D1

LAeq(15min) Noise Levels

Compound Establishment

MAC201108

Denmark Link Road

KEY

Proposal Site

Compound Site

Sensitive Receivers

Residential

NMLs

Standard Hours

Highly Noise Affected

0 80 160 240 320 400 m

N

MAC
Muller Acoustic Consulting


FIGURE D2
LAeq(15min) Noise Levels
Local Road Works
MAC201108
Denmark Link Road
KEY
Proposal Site
Compound Site
Sensitive Receivers
Residential
NMLs
Standard Hours
Highly Noise Affected
0 100 200 300 400 500 m
N
MAC
LYTTON LANE
YORK ROAD
THE AVENUE
DELEWARE ROAD
MARSDEN ROAD
LYTTON ROAD
MARSDEN LANE
CHAUCER ROAD
MILTON ROAD
WALKER PARADE
GARFIELD ROAD WEST
PENPRASE STREET
CLIFTON ROAD
TRAFALGAR STREET
NELSON STREET
CARNARVON ROAD
NEVILLE ROAD
BURFITT ROAD
NORTH STREET
RIVERSTONE PARADE
PITT STREET
GEORGE STREET
MARKET STREET
GARFIELD ROAD EAST
WOODS STREET
MCCULLOCH STREET
INVERNESS ROAD
RIVERSTONE ROAD
CASTLEREAGH STREET
ELIZABETH STREET
HUNTER STREET
OXFORD STREET
REGENT STREET
ROBINSON STREET
GLADSTONE PARADE
BRIGHTON STREET
CRANBOURNE STREET
BLIGH STREET
CREEK STREET
DENMARK ROAD
CARLTON STREET
WEST PARADE
RAILWAY TERRACE
KENSINGTON PARK ROAD
WESTMINSTER STREET
PRINCES ROAD
ST ALBANS ROAD
BRIDGE STREET
STATION STREET

FIGURE D3

LAeq(15min) Noise Levels

Asphalt Paving (Link Road)

MAC201108

Denmark Link Road

KEY

Proposal Site

Compound Site

Sensitive Receivers

Residential

NMLs

Standard Hours

Highly Noise Affected

0 100 200 300 400 500 m

N

MAC


FIGURE D4
LAeq(15min) Noise Levels
Asphalt Paving (Garfield Rd W)
MAC201108
Denmark Link Road
KEY
Proposal Site
Compound Site
Sensitive Receivers
Residential
NMLs
OOH P2
OOH P1
Highly Noise Affected
0 100 200 300 400 500 m
N
MAC
KING STREET
GEORGE STREET
CHURCH STREET
MILL STREET
PITT STREET
PARK STREET
MARKET STREET
DINGLE STREET
OLIVER STREET
GARFIELD ROAD EAST
WOODS STREET
MCCULLOCH STREET
INVERNESS ROAD
RIVERSTONE PARADE
CASTLEREAGH STREET
ELIZABETH STREET
HUNTER STREET
OXFORD STREET
REGENT STREET
ROBINSON STREET
GLADSTONE PARADE
RIVERSTONE ROAD
PICCADILLY STREET
WEST PARADE
CARLTON STREET
CREEK STREET
DENMARK ROAD
RAILWAY TERRACE
BLIGH STREET
KENSINGTON PARK ROAD
PRINCES ROAD
WESTMINSTER STREET
ST ALBANS ROAD
FARM ROAD
LYTTON LANE
CLEVELAND ROAD
YORK ROAD
THE AVENUE
DELEWARE ROAD
MARSDEN ROAD
LYTTON ROAD
MARSDEN LANE
CHAUCER ROAD
MILTON ROAD
WALKER PARADE
GARFIELD ROAD WEST
DAVIES STREET
LAMB STREET
PENPRASE STREET
HERBERT STREET
CARNARVON ROAD
NEVILLE ROAD
FERMOY ROAD
CLIFTON ROAD
TRAFALGAR STREET
NELSON STREET
BURFITT ROAD

FIGURE D5

LAeq(15min) Noise Levels

Road Furniture (Link Road)

MAC201108

Denmark Link Road

KEY

- Proposal Site
- Compound Site

Sensitive Receivers

- Residential

NMLs

- Standard
- Highly Noise Affected

0 100 200 300 400 500 m

N

MAC


MILL STREET
PARK STREET
PITT STREET
MARKET STREET
GARFIELD ROAD EAST
WOODS STREET
RIVERSTONE PARADE
LYTTON LANE
MILTON ROAD
YORK ROAD
THE AVENUE
DELEWARE ROAD
MARSDEN ROAD
LYTTON ROAD
MARSDEN LANE
CASTLEREAGH STREET
GIDLEY LANE
ELIZABETH STREET
PICCADILLY STREET
COE PLACE
HUNTER STREET
OXFORD STREET
REGENT STREET
ROBINSON STREET
JAMES STREET
GLADSTONE PARADE
RIVERSTONE ROAD
CREEK STREET
CARLTON STREET
WEST PARADE
DENMARK ROAD
GARFIELD ROAD WEST
WALKER PARADE
JACK STREET
RITCHIE STREET
BRIGHTON STREET
BLIGH STREET
RAILWAY TERRACE
PENRHASE STREET
CARNARVON ROAD
CLIFTON ROAD
NEVILLE ROAD
NELSON STREET
KENSINGTON PARK ROAD
WESTMINSTER STREET
FIGURE D6
LAeq(15min) Noise Levels
Road Furniture
(Garfield Road W)
MAC201108
Denmark Link Road
KEY
Proposal Site
Compound Site
Sensitive Receivers
Residential
NMLs
OOH P2
OOH P1
Highly Noise Affected
0
80
160
240
320
400 m
N
MAC

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Appendix E – Additional Mitigation Measures

Additional mitigation measures as outlined in Section 11.2.2 of the CNVG (Roads and Maritime, 2015) are summarised below. Many of these measures require communication with the community.

Notifications (letterbox drop or equivalent) (N)

Advance warning of works and potential disruptions can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of 5 working days prior to the start of works. The approval conditions for projects may also specify requirements for notification to the community about works that may impact on them.

Specific notifications (SN)

Specific notifications are letterbox dropped or hand distributed to identified stakeholders no later than seven days ahead of construction activities that are likely to exceed the noise objectives. The exact conditions under which specific notifications would proceed are defined in the relevant Additional Mitigation Measures (Tables C1 to C3). This form of communication is used to support periodic notifications, or to advertise unscheduled work.

Phone calls (PC)

Phone calls detailing relevant information would be made to identified/affected stakeholders within seven days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs etc.

Individual briefings (IB)

Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the proposal.

Respite Offer (RO)

Respite Offers should be made where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers.

Respite Period 1 (R1)

Out of hours construction noise in out of hours period 1 shall be limited to no more than three consecutive evenings per week except where there is a Negotiated Respite. For night work these periods of work should be separated by not less than one week and no more than 6 evenings per month

Respite Period 2 (R2)

Night time construction noise in out of hours period 2 shall be limited to two consecutive nights except for where there is a Negotiated Respite. For night work these periods of work should be separated by not less than one week and 6 nights per month.

Duration Respite (DR)

Respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration proposals. In this instance and where it can be strongly justified it may be beneficial to increase the number of evenings or nights worked through Negotiated Respite so that the proposal can be completed more quickly.

Pre-purchased movie tickets or a similar offer may also provide respite for the community while providing provision for additional out of hours work. This measure is determined on a proposal-by-proposal basis, and may not be applicable to all RMS proposals.

The receivers that should be liaised with to gain community support for Negotiated Respite include those where out of hours work exceed the NML.

Where there are few receivers above the NML each of these receivers should be visited to discuss the proposal to gain support for Negotiated Respite.

In instances where there are many receivers above the NML it may not be practical discuss the proposal with every receiver. Instead the community should be proactively engaged so they have an incentive to participate in discussion supporting Negotiated Respite. Support may be demonstrated from surveys, online feedback, contact phone numbers and community events.

Alternative accommodation (AA)

Alternative accommodation options should be provided to residents living in close proximity to construction work that are likely to incur noise levels significantly above the applicable level (Tables C1-C3). The specifics of the offer will be determined on a proposal-by-proposal basis.

Verification

Appendix F of the CNVG provides details about verification of Noise and Vibration levels following complaints and as part of routine checks of noise levels.

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Appendix F – Operational Noise Results

FIGURE F1

Receiver Locations

MAC201108

Denmark Link Road

KEY

Proposal Site

0 60 120 180 240 300 m

N

MAC
Muller Acoustic Consulting

Table F1 Predicted Road Traffic Noise Levels

Receiver	Opening Year, dB(A)				Design Year, dB(A)				NCG Criteria, dB(A)		NCG Criteria Exceeded?		Change in Noise Level, dB(A)			
	'No Build'		'Build'		'No Build'		'Build'						Opening Year		Design Year	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R1	72.7	67	72.6	66.9	75.8	70.1	75.4	69.7	55	50	Yes	Yes	-0.1	-0.1	-0.4	-0.4
R2	72.2	66.5	72.2	66.5	75.4	69.6	75	69.3	55	50	Yes	Yes	0	0	-0.4	-0.3
R3	72.4	66.7	72.5	66.8	75.6	69.8	75.3	69.6	55	50	Yes	Yes	0.1	0.1	-0.3	-0.2
R4	73.1	67.3	73.3	67.7	76.3	70.4	76.2	70.5	55	50	Yes	Yes	0.2	0.4	-0.1	0.1
R5	73.6	68	73.2	67.4	76.7	71.1	76	70.1	55	50	Yes	Yes	-0.4	-0.6	-0.7	-1
R6	69.1	63.2	69.2	63.4	72.1	66.6	72.5	66.8	55	50	Yes	Yes	0.1	0.2	0.4	0.2
R7	61.9	56.2	62.5	56.7	64.9	59.3	66.2	60.5	55	50	Yes	Yes	0.6	0.5	1.3	1.2
R8	59.8	54.2	61	55.1	62.9	57.3	65.1	59.5	55	50	Yes	Yes	1.2	0.9	2.2	2.2
R9	53.9	48.3	58.6	52.2	56.9	51.2	64	58.3	55	50	Yes	Yes	4.7	3.9	7.1	7.1
R10	55.3	49.6	57.8	51.7	58.4	52.7	63.1	57.4	55	50	Yes	Yes	2.5	2.1	4.7	4.7
R11	52.8	47.2	56.7	50.4	55.9	50.2	62.6	56.9	55	50	Yes	Yes	3.9	3.2	6.7	6.7
R12	50.7	45.1	50.7	45	53.6	47.9	53.6	47.9	55	50	No	No	0	-0.1	0	0
R13	51.2	45.6	51.4	45.7	54.3	48.7	54.7	49	55	50	No	No	0.2	0.1	0.4	0.3
R14	52.5	46.9	52.4	46.8	55.5	50	55.4	49.7	55	50	Yes	No	-0.1	-0.1	-0.1	-0.3
R15	51.3	45.6	51.4	45.7	54.3	48.7	54.6	48.9	55	50	No	No	0.1	0.1	0.3	0.2
R16	50.4	44.7	50.7	45	53.4	47.8	54.1	48.4	55	50	No	No	0.3	0.3	0.7	0.6
R17	50.2	44.6	50.6	44.9	53.3	47.7	54.2	48.5	55	50	No	No	0.4	0.3	0.9	0.8
R18	48.6	42.9	49.3	43.7	50.9	45.3	52.7	47.1	55	50	No	No	0.7	0.8	1.8	1.8
R19	50.6	44.9	50.8	45.2	53.2	47.5	53.8	48.1	55	50	No	No	0.2	0.3	0.6	0.6
R20	50.3	44.7	51.2	45.6	52.7	47	54.8	49.2	55	50	Yes	No	0.9	0.9	2.1	2.2
R21	47.8	42.1	49.3	43.6	49.8	44.1	53.4	47.7	55	50	No	No	1.5	1.5	3.6	3.6
R22	50.2	44.5	50.7	45	52.2	46.6	53.6	47.9	55	50	No	No	0.5	0.5	1.4	1.3

Table F1 Predicted Road Traffic Noise Levels

Receiver	Opening Year, dB(A)				Design Year, dB(A)				NCG Criteria, dB(A)		NCG Criteria Exceeded?		Change in Noise Level, dB(A)			
	'No Build'		'Build'		'No Build'		'Build'						Opening Year		Design Year	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R23	52.8	47.2	53.2	47.5	54.2	48.5	55.2	49.6	55	50	Yes	No	0.4	0.3	1	1.1
R24	53.4	47.7	57.4	50.4	54.4	48.7	63.1	57.4	55	50	Yes	Yes	4	2.7	8.7	8.7
R25	53.9	48.2	57.9	51.4	55	49.3	63.5	57.9	55	50	Yes	Yes	4	3.2	8.5	8.6
R26	53.8	48.2	56.6	50.7	55.1	49.4	61	55.3	55	50	Yes	Yes	2.8	2.5	5.9	5.9
R27	53.6	48	53.6	47.9	54.8	49.1	54.7	49	55	50	No	No	0	-0.1	-0.1	-0.1
R28	59.2	53.6	59.1	53.4	60.2	54.5	59.3	53.7	55	50	Yes	Yes	-0.1	-0.2	-0.9	-0.8
R29	51.6	46	52.5	46.8	53	47.4	55.4	49.7	55	50	No	No	0.9	0.8	2.4	2.3
R30	61.9	56.2	62.5	56.7	62.9	57.2	64.6	59	55	50	Yes	Yes	0.6	0.5	1.7	1.8
R31	61.2	55.6	61.8	56	62.2	56.5	63.7	58.1	55	50	Yes	Yes	0.6	0.4	1.5	1.6
R32	61.6	55.9	62.4	56.5	62.6	56.9	64.8	59.2	55	50	Yes	Yes	0.8	0.6	2.2	2.3
R33	60.9	55.3	61.5	55.7	61.9	56.2	63.6	58	55	50	Yes	Yes	0.6	0.4	1.7	1.8
R34	62	56.3	63.2	57.1	62.9	57.2	66.1	60.5	55	50	Yes	Yes	1.2	0.8	3.2	3.3
R35	61.9	56.3	63.3	57.2	62.9	57.2	66.3	60.7	55	50	Yes	Yes	1.4	0.9	3.4	3.5
R36	62	56.4	63.4	57.3	63	57.3	66.4	60.8	55	50	Yes	Yes	1.4	0.9	3.4	3.5
R37	62.2	56.6	63.8	57.6	63.2	57.5	67	61.3	55	50	Yes	Yes	1.6	1	3.8	3.8
R38	62.2	56.6	63.7	57.6	63.2	57.5	66.8	61.2	55	50	Yes	Yes	1.5	1	3.6	3.7
R39	62.2	56.7	63.7	57.6	63.3	57.6	66.7	61	55	50	Yes	Yes	1.5	0.9	3.4	3.4
R40	61	55.6	62.8	56.7	62.3	56.6	66	60.3	55	50	Yes	Yes	1.8	1.1	3.7	3.7
R41	60.6	55.3	62.8	56.6	61.9	56.2	66.3	60.7	55	50	Yes	Yes	2.2	1.3	4.4	4.5
R42	60.2	54.9	63.4	56.8	61.5	55.8	67.4	61.8	55	50	Yes	Yes	3.2	1.9	5.9	6
R43	59.6	54.2	61.8	55.4	60.9	55.1	65.2	59.6	55	50	Yes	Yes	2.2	1.2	4.3	4.5
R44	58.8	53.5	59.9	54	60.1	54.4	62.1	56.5	55	50	Yes	Yes	1.1	0.5	2	2.1

Table F1 Predicted Road Traffic Noise Levels																
Receiver	Opening Year, dB(A)				Design Year, dB(A)				NCG Criteria, dB(A)		NCG Criteria Exceeded?		Change in Noise Level, dB(A)			
	'No Build'		'Build'		'No Build'		'Build'						Opening Year		Design Year	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R45	56.7	51.5	57.2	51.6	58.1	52.4	58.1	52.5	55	50	Yes	Yes	0.5	0.1	0	0.1
R46	47.5	41.9	47.6	42	50	44.3	50.3	44.6	55	50	No	No	0.1	0.1	0.3	0.3
R47	47.2	41.5	47.4	41.7	49.1	43.5	49.6	44	55	50	No	No	0.2	0.2	0.5	0.5

Appendix G – Operational Noise Contours

FIGURE G1

LAeq(15hr) Noise Levels

Opening Year - No Build

MAC201108

Denmark Link Road

KEY

Proposal Site

Senstive Receivers

Residential

0 80 160 240 320 400 m

N

MAC


FIGURE G2
LAeq(15hr) Noise Levels
Opening Year - Build
MAC201108
Denmark Link Road
KEY
Proposal Site
Senstive Receivers
Residential
LAeq(15hr) Noise Contours
55
60
65
0
80
160
240
320
400 m
N
MAC
GARFIELD ROAD WEST
DENMARK ROAD
GREEK STREET
CARLTON STREET
WEST PARADE
RAILWAY TERRACE
RIVERSTONE PARADE
PITT STREET
GARFIELD ROAD EAST
MCCULLOCH STREET
INVERNESS ROAD
COE PLACE
ELIZABETH STREET
CASTLEREAGH STREET
GIDLEY LANE
HUNTER STREET
OXFORD STREET
REGENT STREET
ROBINSON STREET
JAMES STREET
GLADSTONE PARADE
RIVERSTONE ROAD
PICCADILLY STREET
BRIGHTON STREET
TITANIA STREET
KUNIC STREET
OBERON STREET
BLIGH STREET
CRANBOURNE STREET
JACK STREET
RITCHIE STREET
DELEWARE ROAD
MARSDEN ROAD
LYTTON ROAD
MARSDEN LANE
CARNARVON ROAD
CLIFTON ROAD
NEVILLE ROAD
TRAFALGAR STREET
NELSON STREET
BURFITT ROAD
KENSINGTON PARK ROAD
WESTMINSTER STREET
PRINCES ROAD
LAMBETH ROAD
ST ALBANS ROAD


FIGURE G3
LAeq(9hr) Noise Levels
Opening Year - No Build
MAC201108
Denmark Link Road
KEY
Proposal Site
Senstive Receivers
Residential
LAeq(9hr) Noise Contours
50
55
60
0 80 160 240 320 400 m
N
MAC
RIVERSTONE PARADE
PITT STREET
GARFIELD ROAD EAST
MCCULLOCH STREET
CASTLEREAGH STREET
GIDLEY LANE
ELIZABETH STREET
COE PLACE
INVERNESS ROAD
HUNTER STREET
OXFORD STREET
REGENT STREET
DELEWARE ROAD
MARSDEN ROAD
LYTTON ROAD
MARSDEN LANE
GARFIELD ROAD WEST
GREEK STREET
DENMARK ROAD
CARLTON STREET
WEST PARADE
ROBINSON STREET
JAMES STREET
GLADSTONE PARADE
RIVERSTONE ROAD
PICCADILLY STREET
BRIGHTON STREET
TITANIA STREET
KUNIC STREET
OBERON STREET
BLIGH STREET
CRANBOURNE STREET
JACK STREET
RITCHIE STREET
RAILWAY TERRACE
CARNARVON ROAD
CLIFTON ROAD
NEVILLE ROAD
KENSINGTON PARK ROAD
LAMBETH ROAD
WESTMINSTER STREET
PRINCES ROAD
ST ALBANS ROAD
TRAFALGAR STREET
NELSON STREET
BURFITT ROAD


FIGURE G4
LAeq(9hr) Noise Levels
Opening Year - Build
MAC201108
Denmark Link Road
KEY
Proposal Site
Senstive Receivers
Residential
LAeq(9hr) Noise Contours
50
55
60
0
80
160
240
320
400 m
N
MAC
Muller Acoustic Consulting
GARFIELD ROAD WEST
DENMARK ROAD
GREEK STREET
CARLTON STREET
WEST PARADE
RAILWAY TERRACE
RIVERSTONE PARADE
PITT STREET
GARFIELD ROAD EAST
MCCULLOCH STREET
INVERNESS ROAD
COE PLACE
CASTLEREAGH STREET
GIDLEY LANE
ELIZABETH STREET
HUNTER STREET
OXFORD STREET
REGENT STREET
ROBINSON STREET
JAMES STREET
GLADSTONE PARADE
RIVERSTONE ROAD
PICCADILLY STREET
BRIGHTON STREET
TITANIA STREET
KUNIC STREET
OBERON STREET
BLIGH STREET
CRANBOURNE STREET
JACK STREET
RITCHIE STREET
DELEWARE ROAD
MARSDEN ROAD
LYTTON ROAD
MARSDEN LANE
CARNARVON ROAD
CLIFTON ROAD
NEVILLE ROAD
TRAFALGAR STREET
NELSON STREET
BURFITT ROAD
KENSINGTON PARK ROAD
WESTMINSTER STREET
PRINCES ROAD
LAMBETH ROAD
ST ALBANS ROAD

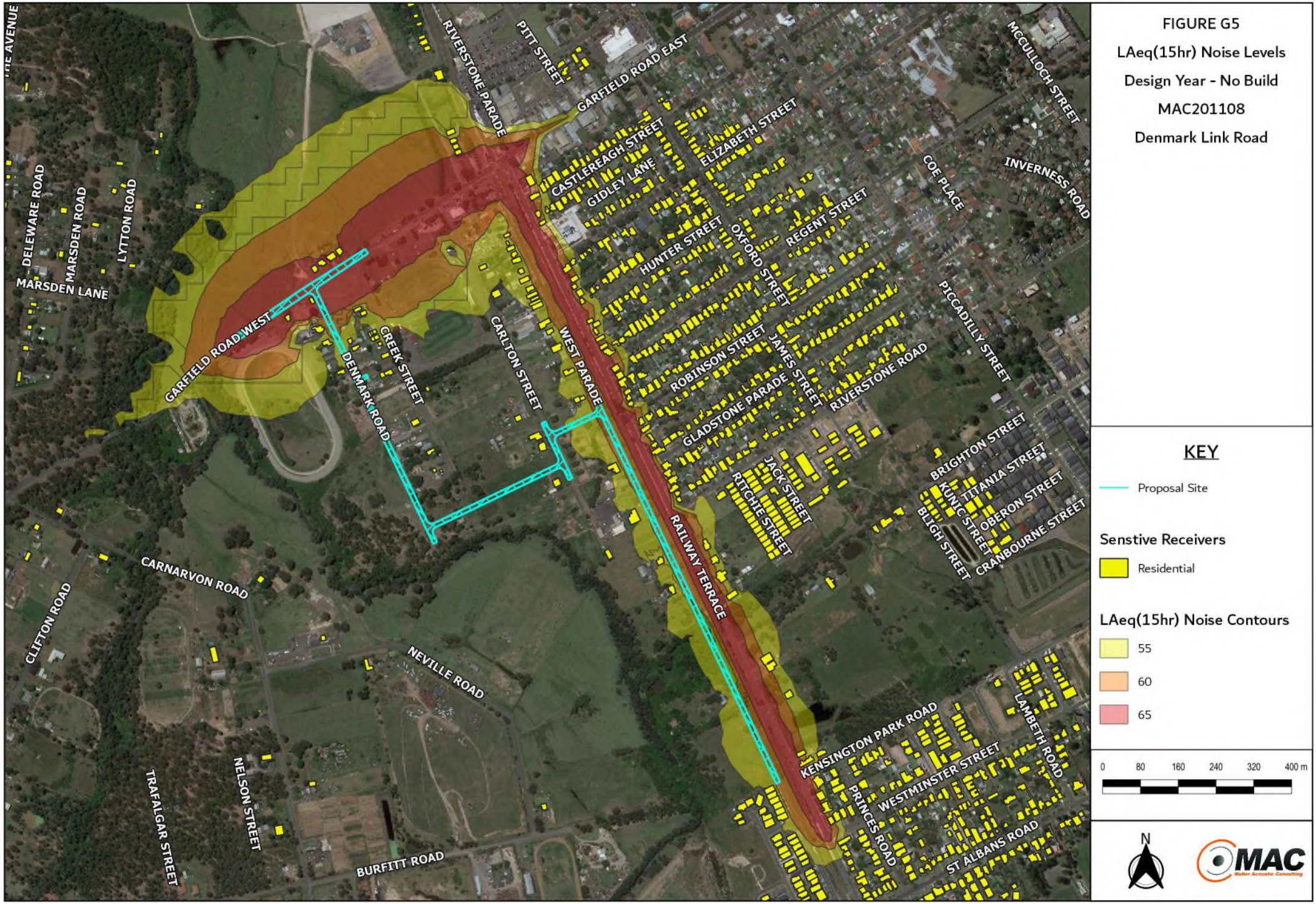

FIGURE G5

LAeq(15hr) Noise Levels

Design Year - No Build

MAC201108

Denmark Link Road

KEY

Proposal Site

Senstive Receivers

Residential

LAeq(15hr) Noise Contours

55

60

65

0 80 160 240 320 400 m

N

MAC

FIGURE G6

LAeq(15hr) Noise Levels

Design Year - Build

MAC201108

Denmark Link Road

KEY

Proposal Site

Senstive Receivers

Residential

LAeq(15hr) Noise Contours

55

60

65

0 80 160 240 320 400 m

N

MAC

FIGURE G7

LAeq(9hr) Noise Levels

Design Year - No Build

MAC201108

Denmark Link Road

KEY

Proposal Site

Senstive Receivers

Residential

LAeq(9hr) Noise Contours

50

55

60

0 80 160 240 320 400 m

N

MAC

FIGURE G8

LAeq(9hr) Noise Levels

Design Year - Build

MAC201108

Denmark Link Road

KEY

Proposal Site

Senstive Receivers

Residential

LAeq(9hr) Noise Contours

50

55

60

0 80 160 240 320 400 m

N

MAC

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