Tuggerah Station Upgrade

Construction Noise Impact Assessment

Final | 02

18 February 2022

Transport for NSW

Tuggerah Station Upgrade

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01	21/12/2021	Draft	DD	LS	TC	TC
02	18/02/2022	Final	DD	LS	TC	TC

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Executive Summary

Noise impacts from the demolition and construction activities associated with the Tuggerah Station Upgrade (the Proposal) have been predicted and assessed.

Noise level objectives for management of construction noise impacts were determined in accordance with the *TfNSW Construction Noise and Vibration Strategy* (CNVS) based on background noise levels measured at nearby residential noise receivers.

Noise levels have been predicted at potentially affected receivers from noise emitted by site activities and construction traffic within and outside standard construction hours.

The assessment indicates that noise impacts during standard construction hours will be minor, due to the large separation distances between the construction activities and the receivers, and the existing high background noise levels in the receiving noise environment.

Noise impacts from site activities and construction traffic during time periods outside of standard hours have also been predicted and assessed. Since some site activities can only be undertaken during track Possessions, it is necessary for some high noise generating works to occur outside of standard hours. The noise levels and the character of the noise have been considered in terms of the likelihood to cause noise intrusion and/or sleep disturbance at receivers during time periods outside of standard hours.

The results of the noise impact assessment for works to be conducted outside of standard hours indicate that the works are likely to result in periods of noise annoyance and/or sleep disturbance at some potentially affected receivers.

Standard and Additional noise mitigation measures have been recommended in accordance with the TfNSW CNVS.

1. Introduction

Transport for NSW (TfNSW) proposes to upgrade the Tuggerah Railway Station as part of its ongoing Transport Access Program (TAP) for accessible public transport infrastructure. The objective of the Proposal is to deliver a station upgrade that achieves *Disability Standards for Accessible Public Transport* (DSAPT) compliance, improves pedestrian amenity and connectivity across the rail and road corridor. The Proposal will involve a new aerial concourse, lifts and platform widening, including the demolition of the existing station footbridge, ramps, stairs and station buildings.

The program of demolition and construction works of the Proposal is expected to take approximately 16 months.

This Report identifies key construction noise and vibration risks associated with the Proposal, based on the proposed demolition and construction activities and key relevant features of the existing environment. The report also provides recommendations for mitigation and management of noise and vibration impacts based on relevant policies, standards and guidelines.

2. Methodology

The noise impact assessment has been undertaken in accordance with the requirements described in TfNSW published documentation, as described in the following pages.

2.1 Regulatory framework

Noise in NSW is governed under the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Protection of the Environment (Operations) Act 1997* (PoEO Act).

Consistent with the EP&A Act and the PoEO Act, the NSW Government has published the following regulatory documents regarding the management of construction noise in NSW:

- *Interim Construction Noise Guideline* (ICNG, Department of Environment and Climate Change, 2009)
- *Assessing Vibration: A technical guideline* (AVTG, Department of Environment and Conservation, 2006).

Consistent with regulatory obligations, Transport for NSW (TfNSW) has published the *Construction Noise and Vibration Strategy* (Version 4.2, TfNSW, 2019) (CNVS), which describes TfNSW's policies regarding the management of construction noise and vibration on TfNSW projects. The CNVS refers to several source documents regarding the methodology to be followed, and the relevant documents used in this assessment are as follows:

- Construction Noise Estimator Tool FT-150 (Microsoft Excel native electronic file)
- Australian Standard AS1055:2018 – *Acoustics – Description and measurement of environmental noise*
- Australian Standard AS2436:2010 – *Guide to noise and vibration control on construction, demolition and maintenance sites*
- British Standard BS5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Part 1 - Noise*
- British Standard BS7385-2:1993 *Evaluation and measurement for vibration in buildings*
- *Construction Noise & Vibration Impact Assessment, a supporting assessment to the Environmental Impact Assessment required under the Environmental Planning & Assessment Act 1979*
- German Institute for Standardisation, DIN4150-3:2016 *Vibration in Buildings – Part 3: Effects on Structures*
- *Environmental Noise Management Manual* (NSW Roads & Traffic Authority, December, 2001)
- *Noise Policy for Industry* (NSW Environment Protection Authority, 2017)
- *Rail infrastructure noise guideline* (NSW Environment Protection Authority, 2013)
- *Road Noise Policy* (NSW Department of Environment, Climate Change and Water, 2011)
- *Construction Noise and Vibration Guideline* (NSW Roads and Maritime Services, 2016).

2.2 TfNSW Construction Noise and Vibration Strategy

Transport for NSW Infrastructure and Place Division (IP) leads the procurement and delivery of public transport infrastructure in NSW. The construction noise and vibration emissions associated with IP projects can often cause disturbance to commuters, pedestrians, adjacent communities and other stakeholders. The CNVS outlines the approach to be taken to mitigate and manage construction noise and vibration from IP projects.

TfNSW is committed to avoiding or minimising noise and vibration impacts from all construction projects under its control. The CNVS provides the methodology by which noise and vibration from IP construction projects can be assessed and mitigation measures identified and applied.

2.2.1 Application of Construction Noise and Vibration Strategy

The CNVS may be applied at any stage of project assessment and delivery but will primarily be applicable during the Environmental Impact Assessment (EIA), development of the construction noise and vibration management plan and when assessing Outside of Standard Hours Works (OOHW).

2.2.2 Assessment of construction noise and vibration impacts

The CNVS states that as part of the EIA process, the impacts on nearby receivers of airborne noise, ground borne noise and ground borne vibration generated during the construction of a project are required to be evaluated.

A Construction Noise and Vibration Impact Assessment (CNVIA) known as a 'quantitative assessment' may be undertaken as part of the EIA process. A CNVIA must be prepared in accordance with the requirements of CNVS Appendix A. The construction noise and vibration assessment:

- Is based on an initial design, scope and construction methodology for the project
- Identifies sensitive receivers, the existing background noise levels and construction noise and vibration objectives
- Identifies the feasible and reasonable noise and vibration mitigation measures (including any project specific measures) that are required to mitigate any predicted exceedance of the construction noise and vibration objectives.

2.2.3 Construction noise and vibration impact assessment (CNVIA)

The information to be provided in the CNVIA includes:

- Determine the existing noise environment(s) at the potentially affected receiver(s)
- Determine the construction noise & vibration impacts and noise objectives
- Identify the CNVIA assessment method (either a Simple CNVIA, or a Detailed CNVIA)
- Identify standard and additional mitigation measures to be implemented during the construction phase.

The level of detail for a CNVIA/S will vary depending on the scale of the works and the likely noise and vibration impacts. The assessment may be conducted as a simple or detailed assessment, as outlined below:

- Simple assessment: Where noise and vibration objectives are unlikely to be exceeded.
- Detailed assessment: Larger projects, where noise and vibration objectives will likely be exceeded

2.3 Construction noise and vibration impact assessment methodology

Based on the requirements described in the CNVS, the process to assess the potential impacts from construction noise and vibration, and to recommend appropriate mitigation and management measures is shown in **Table 1**, along with the section in this report where each element is addressed.

Table 1: Assessment Method

Assessment Element	Section of this Report
1) Describe the proposed demolition, construction and/or maintenance works	**Section 3**

Assessment Element	Section of this Report
2) Describe the sensitivity of the acoustic environment ▪ Identify the potentially affected sensitive receivers ▪ Determine the sensitivity of the receivers according to: - Land Use type (e.g. Rural; Residential; Education; Health; Community; Recreation; Commercial, Industrial, etc.) - Building occupancy type (e.g. Residential; Education; Health; Community; Commercial (typical); Commercial (sensitive); Industrial(typical); Industrial (sensitive), etc.) - Building construction type (e.g. Residential/Lightweight; Commercial; Heavy Industrial; Heritage (vibration-sensitive); etc.) - Existing ambient noise levels (Measured or estimated)	**Section 4**
3) Determine the noise and vibration impact assessment objectives and guideline values against which the anticipated impacts can be quantitatively compared	**Section 5**
4) Determine if the CNVIA should be a simple (qualitative) or a detailed (quantitative) assessment	**Section 6**
5) Predict the approximate noise and vibration levels from the demolition, construction and/or maintenance activities at the appropriate receivers	**Section 7**
6) Compare the predicted noise and vibration levels against the assessment objectives and guideline values	**Section 8**
7) Based on the assessed impacts, recommend standard mitigation measures (and additional mitigation measures if required) to be implemented during the construction phase	**Section 9.1**
8) Describe further construction noise and vibration impact assessment and/or management steps required, e.g. preparation of Construction Noise and Vibration Management Plan, steps required to verify and manage noise and vibration in the construction phase, when assessing Outside of Hours Works during the construction phase,	**Section 9.2**

2.3.1 Noise prediction calculation method

Noise levels were predicted using the proprietary environmental noise modelling calculation software Cadna/A (version 2021 MR2). Within Cadna/A, the selected prediction algorithm method was the International Standard ISO9613-1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*. The model included the acoustic propagation effects of topographical shielding by terrain features and building structures that obstruct the line-of-sight between the noise sources and the receivers, the absorption of sound by the ground surface covering and by the atmosphere, and the noise enhancement effects caused by wind and/or temperature gradients.

3. Proposal description

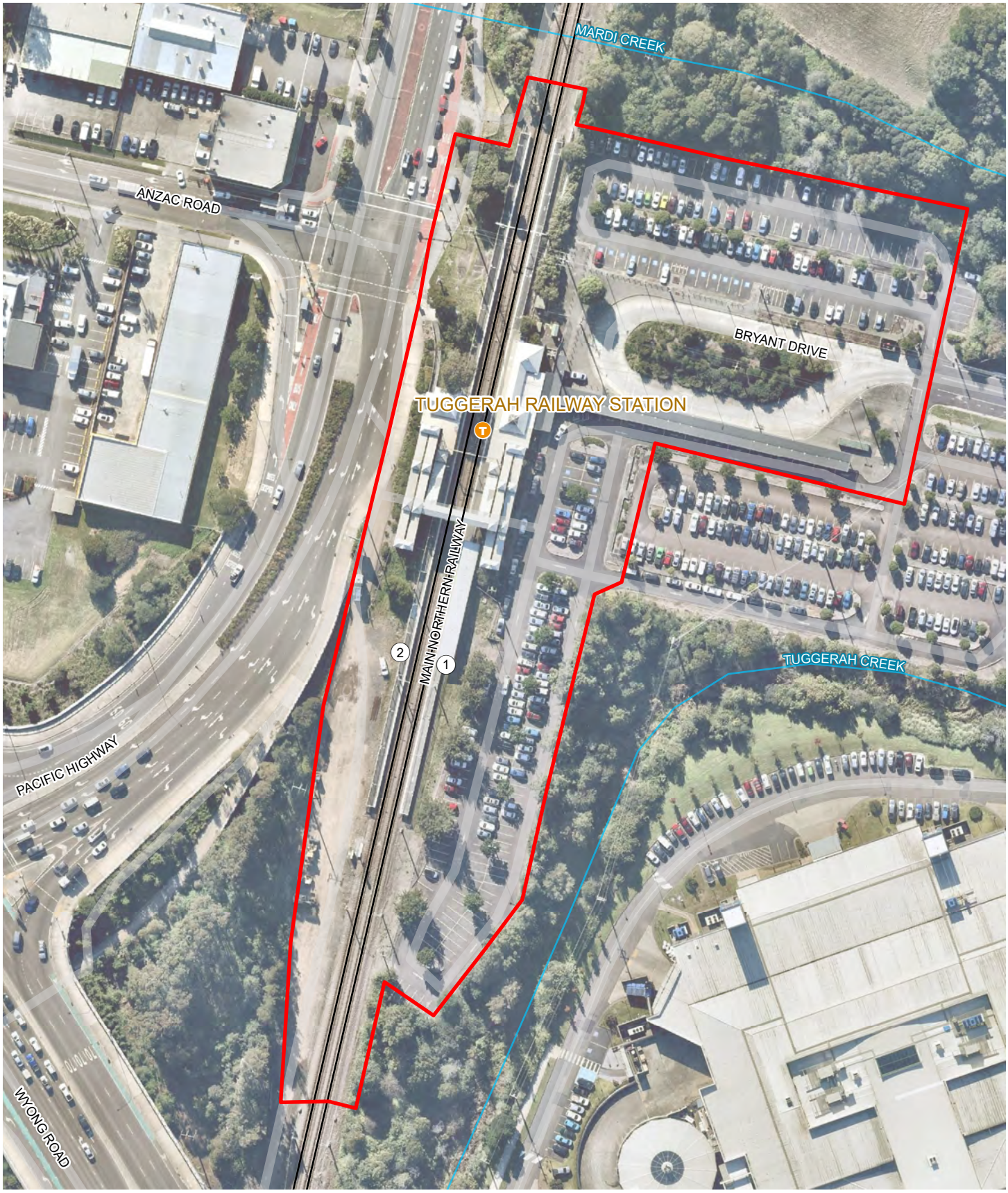
TfNSW proposes to upgrade Tuggerah Railway Station, on the NSW Central Coast, as part of the NSW Government's Transport Access Program, a NSW Government Initiative to provide a better experience for public transport customers by delivering accessible, modern secure and integrated transport infrastructure. As part of this program, the Tuggerah Station Upgrade (the Proposal) would aim to provide a station precinct that is accessible to those with a disability, limited mobility, parents/carers with prams, and customers with luggage. The description of the Proposal is based on the reference design and is subject to detailed design.

3.1 The Proposal

The Proposal would include the following key elements:

- construction of a new pedestrian footbridge north of the existing footbridge with new stairs connecting the Pacific Highway, the commuter car park and the station platforms with canopies for weather protection over the footbridge and all stairs
- installation of a two-stop lift connecting Platform 1 and the new pedestrian footbridge, and installation of a three-stop lift connecting the Pacific Highway station entrance, Platform 2 and the new pedestrian footbridge
- removal of the existing non-compliant ramps, stairs and pedestrian footbridge
- removal of the existing Station Master's office, and construction of a new Station Master's office
- widening and lengthening of Platforms 1 and 2 to achieve compliant platform widths, improve accessibility and space for station customers and allow for future rolling stock
- construction of a family accessible toilet on Platform 1 and a unisex ambulant toilet on Platform 1
- interchange upgrade work including provision of new bike parking facilities at the new station entrances, provision of 15 DDA compliant accessible parking spaces to replace 19 existing non-compliant parking spaces in the commuter car park, new accessible footpaths on both eastern and western side of the station, and upgrade to the existing Pacific Highway southbound bus stop to be DSAPT compliant
- landscaping work including public domain improvements at the station forecourt areas, new lighting, and enhancement of sightlines between Anzac Road and Bryant Drive
- ancillary work including station power supply upgrade, replacement of existing 11kV and 66kV overhead power lines with underground cables, construction of new equipment room, provision of new or reinstated tactile pavement markings where required and improvements to station communication systems including CCTV and hearing loops.

The Proposal area is situated at Tuggerah, approximately 65 kilometres north of Sydney and 53 kilometres south of Newcastle, on the main Sydney-Newcastle railway line. The locality is characterised by mixed commercial and light industrial development associated with the Tuggerah town centre, surrounded by low density residential suburban development, open space and the Tuggerah Lake system to the east. **Figure 1** shows the Proposal area for this assessment.



Data sources

Jacobs 2021
Department Finance, Services and Innovation 2020

Figure 1 Site locality map

3.2 Scope of work

This section provides a more detailed explanation of the scope of the Proposal as outlined in **Section 3.1.**

3.2.1 Station upgrade and platform modifications

Details of the proposed work to take place at the station to improve accessibility and customer experience are provided below:

- installation of a new covered pedestrian footbridge, and stairs connecting Platform 1 and Platform 2
- construction and installation of two new passenger lifts to provide access to the new pedestrian footbridge and platforms. This would include:
  - a new two-stop lift connecting Platform 1 and the new pedestrian footbridge
  - a new three-stop lift connecting the Pacific Highway station entrance, Platform 2 and the new pedestrian footbridge
  - lift landings with canopies for weather protection at the waiting areas
- removal of the existing non-compliant ramps, stairs and pedestrian footbridge
- removal of the existing Station Master's office and associated canopy on Platform 1, and construction of a new Station Master's office
- widening and lengthening of Platforms 1 and 2 (where required) to provide compliant platform widths and lengths for future rolling stock
- construction of a family accessible toilet on Platform 1 and a unisex ambulant toilet on Platform 1
- removal of the existing canopy at the Pacific Highway station entrance on Platform 2 and installation of a new canopy extending from the boarding assistance zone (BAZ) on Platform 2 to the station entrance
- installation of new canopies over station entrances and forecourts
- new landscaping and upgrades to the station forecourts, including incorporating water sensitive urban design (WSUD) on both eastern and western sides of the station.

3.2.2 Interchange facilities

Interchange upgrade works to improve connectivity within the station precinct would comprise:

- fifteen accessible (DDA compliant) parking spaces within the existing commuter carpark
- installation of new bicycle hoops near the Pacific Highway station entrance and the commuter carpark station entrance, under cover, with overall provision for 27 bikes
- a new footpath on the eastern side of the station to provide an accessible path of travel from the station entrance to the new accessible parking spaces
- a new footpath on the western side of the station to provide an accessible path of travel from the Pacific Highway station entrance to the new lift and to the Pacific Highway southbound bus stop
- upgrade of the existing Pacific Highway southbound bus stop features to become DSAPT compliant
- new seating next to the existing kiss and ride bays and taxi bays on the eastern side of the station
- regrading of kerb ramps at the existing kiss and ride bays on the eastern side of the station.

3.2.3 Ancillary work

The Proposal would require additional ancillary works within the station precinct including:

- upgrades to the station power supply to cater for the new lifts, comprising:
  - decommissioning of redundant power supply and electrical equipment

  - installation of two padmount transformers within the rail corridor adjacent to the southern end of Platform 1
  - relocation of Sydney Trains 11kV and 66kV feeder to underground supply and decommissioning of existing pole top transformer
- construction of a new Communication Equipment Room (CER) adjacent to Platform 1
- installation of new lighting on station platforms, entrances and walkways, awnings, indoor areas, pedestrian footbridge and accessible parking bays
- improvements to station security and communication systems, including CCTV modifications, public address system upgrades, modification to station passenger information systems and new hearing induction loops within the station platforms
- installation of new tactile pavement markers where required
- landscaping work and adjustments to wayfinding
- new stormwater drainage connections from the new lifts and canopies to the existing Central Coast Council stormwater system
- adjustments to the existing boundary fencing
- provision of portable fire extinguishers throughout all new areas of the station.

3.3 Construction methodology and schedule

Subject to approval, construction is expected to commence in 2022 and take around 16 months to complete. The construction methodology would be further developed during the detailed design of the Proposal by the nominated Contractor in consultation with TfNSW.

The proposed construction activities for the Proposal are identified in **Table 2**. This staging is indicative and is based on the current reference design and may change once the detailed design methodology is finalised. The staging is also dependent on the Contractor's preferred methodology, program and sequencing of work.

Table 2: Indicative construction staging for key activities

Stage	Activities
Site establishment and enabling works	▪ Establish site compounds at Pacific Highway South, Pacific Highway North and the commuter car park off Bryant Drive ▪ Remove trees and vegetation and protect the remaining trees not affected by construction works ▪ Install temporary stairs and ramps to both station entrances to include new foundations steel supports adjustments to lighting, CCTV and Opal card readers. ▪ Install timber hoardings on platforms to segregate passengers from construction works on the platforms. ▪ Install temporary buildings for station staff and station amenities on the southern side of the station.
Construction of pedestrian bridge lift stairs	▪ Demolish existing station buildings ▪ Construction of footings to support a new pedestrian bridge including columns and lift shafts ▪ Construction of new pedestrian bridge spanning from Pacific Highway to Bryant Street ▪ Construction of retaining walls and stormwater drainage works ▪ Construction of lifts (shaft and lift base) ▪ Installation of lifts (fit out)

Stage	Activities
	▪ Construction of stairs canopies balustrades handrails and anti-throw screens.
Demolish existing station structures	▪ Demolish existing station buildings, footbridge, ramps, canopies and stairs following the completion of the new pedestrian footbridge, unless equivalent temporary facilities are provided (subject to detailed design).
Platform/buildings works & station entry	▪ Construction of new staff operations building to include a new communications equipment room and station amenities on Platform 1 & 2. ▪ Construction of new canopies to platforms and station entry ▪ Installation of new fixtures, lighting, Public Address system (PA), Closed Circuit Television (CCTV) ▪ Widen existing platforms and improve cross falls and drainage. ▪ Construct new station forecourt to both the Pacific Highway and Bryant Street entries.
Interchange works	▪ Reconfiguration of sections of the southern carpark for improved accessible parking spaces, ▪ Construction of accessible pathways, ramps, bicycle hoops and landscaping to both sides of the station. ▪ Installation of new wayfinding signage ▪ Construct new electrical power supply for the station.
Testing and commissioning	▪ Various activities to test and commission power supply, lifts, lighting, new/modifications to station services, ticketing systems and communication and security systems.
Demolition of existing assets	▪ Demolish existing footbridge, ramps and canopies ▪ Site demobilisation including removal of temporary pedestrian ramps and booking office site facilities including site sheds

3.3.1 Plant and equipment

The plant and equipment likely to be used during construction includes:

- Hand tools
- Demolition saw
- Chainsaw
- Vacuum truck
- Jack hammer
- Petrol pressure washer
- Street sweeper
- 5 - 30 t excavator
- Concrete trucks and concrete pump
- 35 - 40 t excavator with demolition shear attachment
- 4 x 10 t dump trucks
- 30 t truck and trailer
- D4 skid steer loader
- Smooth drum roller
- Crane truck
- Telescopic Forklift
- Articulated dump truck
- Road sweeper
- Elevated work platforms (EWP)
- Concrete ground line pump
- Water cart
- Asphalt trucks
- 10 Tonne Hydreamers
- 300 - 400 t mobile crane
- 30 t piling rig
- 20 - 50 t mobile crane
- Concrete boom pump
- Demolition wire saw
- Solar/generator powered light towers
- Directional bore machine (for HV underground conduits)

3.3.2 Working hours

Work required for the Proposal would be undertaken during standard (NSW) Environment Protection Authority (EPA) construction hours, which are as follows:

- 7.00 am to 6.00 pm Monday to Friday
- 8.00 am to 1.00 pm Saturdays
- No work on Sundays or public holidays.

Work would also occur outside standard hours and would include night work and works during routine rail Possessions which are scheduled closures that would occur regardless of the Proposal when part of the rail network is temporarily closed and trains are not operating.

Out of hours work is required in some cases to minimise disruptions to customers, pedestrians, motorists and nearby sensitive receivers; and to ensure the safety of railway workers and operational assets.

Out of hours work may also be scheduled outside weekend rail possession periods. Approval from TfNSW would be required for any out of hours work and the affected community would be notified as outlined in TfNSW's *Construction Noise and Vibration Strategy* (TfNSW, 2019),

3.3.3 Traffic access and vehicle movements

During construction, road access to and from the Proposal area for construction-related traffic would be via main roads including the Pacific Highway, Wyong Road and the M1 Pacific Motorway. Construction-related traffic would gain access to the eastern side of Tuggerah Station via Wyong Road and Bryant Drive. All of these routes are via main or arterial roads only, all of which are of suitable standard and capacity to accommodate the likely types and volumes of traffic expected during the Proposal's construction. While Bryant Drive passes by the edge of a residential area at its intersection with Lake Road, the construction access route does not pass through a residential area.

3.3.4 Ancillary facilities

Four temporary construction ancillary facilities would be required during the construction period, to accommodate a site office, amenities, laydown and storage area for materials. All of the land within the four proposed ancillary facility sites is owned by TfNSW.

A brief description of each ancillary facility site is given as follows:

- Pacific Highway South – main ancillary facility, on the western side at the southern end, within the rail corridor. Access would be from the left lane of the Pacific Highway heading south. This area would be used for construction compounds with site sheds
- Pacific Highway North – on the western side, adjacent to the intersection of Anzac Road and the Pacific Highway. Access would be from the left lane of the Pacific Highway heading south. This area would be used for construction plant and equipment laydown only
- Bryant Drive South – on the eastern side, at the southern end of the commuter car park area. Site access would be from Wyong Road via Bryant Drive and through the existing bus interchange. This area would be used for construction compounds with site sheds
- Bryant Drive North – on the eastern side, at the northern end of the commuter car park area. Site access would be from Wyong Road via Bryant Drive and past the existing bus interchange. This area would be used during rail possession weekend periods only.

3.3.5 Property

TfNSW does not propose to acquire or lease any property as part of the Proposal.

3.4 Construction program

The Proposal's construction phase is divided into two Stages:

- Stage 1: Enabling Works; and
- Stage 2: Major Works.

The final few weeks of the Enabling works will occur concurrently with the first few weeks of the Major Works, resulting in an overall construction period of approximately 16 months.

4. Existing environment

The potential for noise impacts depends on the type(s) of potentially affected sensitive receivers, and the existing ambient noise levels in the receiving environment. Sensitive receiver types typically include residences, schools, childcare centres, hospitals, educational facilities, recreational areas, and places of worship. Business and industrial receivers are often considered as less sensitive but can also be impacted by construction noise.

The Proposal is located within a developed, urban environment, influenced by major highways, rail and industrial areas. As such, the existing background noise environment is characterised by typical urban noise sources, with a strong rail influence.

The sensitivity of the existing acoustic environment depends on the land use zone(s) in which the receivers are located and the background noise levels in those areas at different times of day.

4.1 Receivers

The land use zones immediately surrounding the Proposal are a combination of Infrastructure (SP2), Business Development (B5), Enterprise Corridor (B6), Public Recreation (RE1), Light Industrial (IN2), Environmental Conservation (C2) and Environmental Management (C3). Tuggerah Station is zoned as Infrastructure (SP2).

4.1.1 Residential receivers

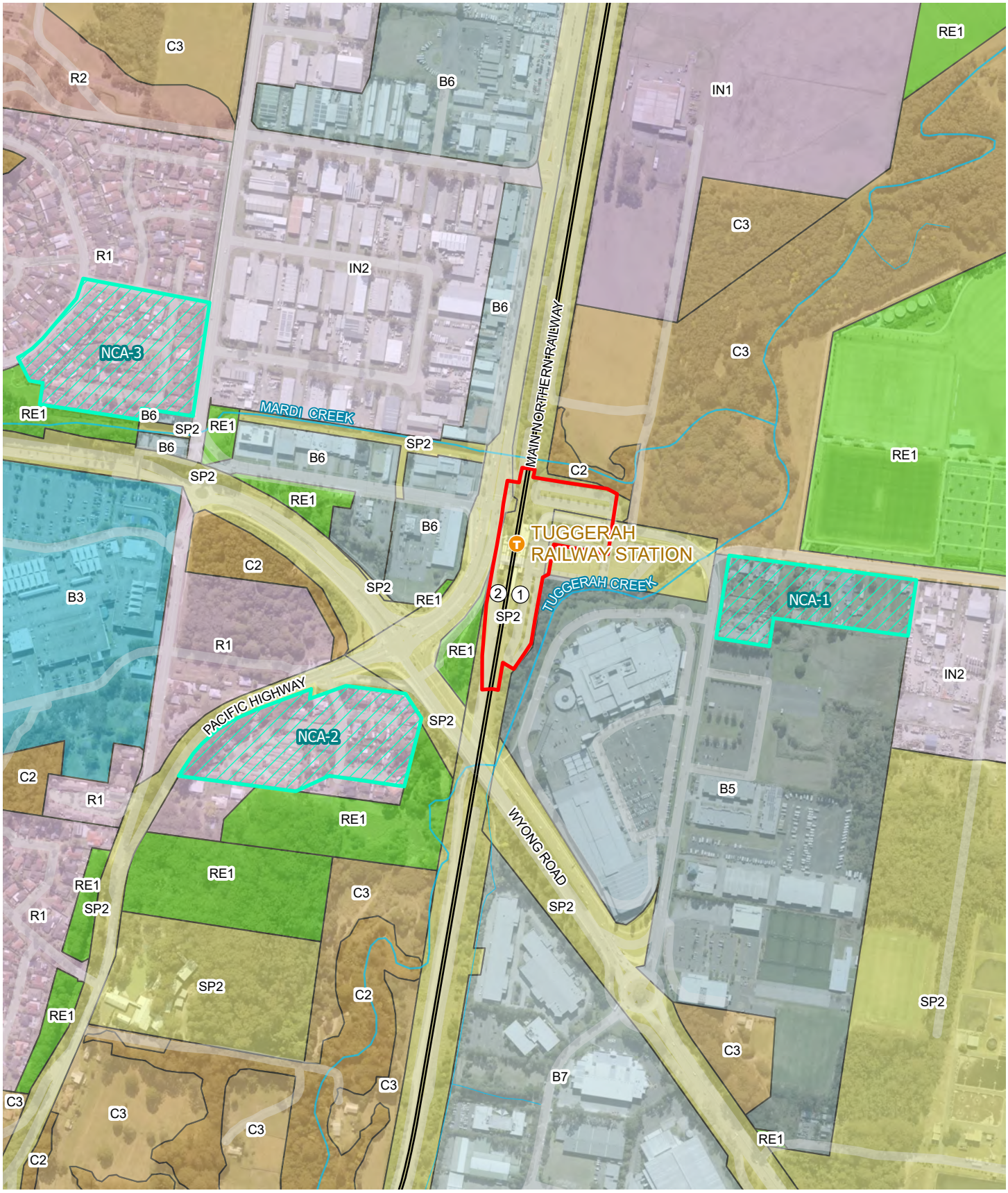
The most sensitive receivers potentially impacted by the Proposal are several areas of residential receivers located approximately 270 metres east, 190 metres south west and 460 metres west north west of the Proposal area. The Noise Catchment Areas (NCA) of the three areas containing residential receivers are shown in **Figure 2**.

NCAs are generally ascribed only to those land use zones containing sensitive receivers, such as residential dwellings, schools or child care facilities, and hospitals. Other (e.g. non-residential) land uses such as commercial or industrial premises are generally not considered to be receivers for construction noise – unless they accommodate a use that may be sensitive to noise or vibration, such as a recording studio or a laboratory that uses vibration-sensitive instruments.

The land use zones and the closest distances of the NCA from Tuggerah Station are shown in **Table 3** and **Figure 2.**

Table 3: Land use zones of Noise Catchment Areas containing residential receivers, and closest distances to primary construction works at Tuggerah Station

Noise Catchment Area	Land use zone	Closest distance and direction from the location of primary construction works at Tuggerah Station
NCA-1	B5 – Business Development	270 metres; east
NCA-2	R1 – General Residential	190 metres; south west
NCA-3	R1 – General Residential	460 metres; west north west



- Proposal area
- Railway Station
- (1) Platform number
- Road
- Railway
- Noise catchment areas

Land zoning

- B3 Commercial Core
- B5 Business Development
- B6 Enterprise Corridor
- B7 Business Park
- C2 Environmental Conservation
- C3 Environmental Management
- IN1 General Industrial
- IN2 Light Industrial
- R1 General Residential
- R2 Low Density Residential
- RE1 Public Recreation
- SP2 Infrastructure

0 70 140 210 m

1:7,000 at A4

GDA 1994 MGA Zone 56

Data sources

Jacobs 2021
Aerometrex 2021
Department Finance, Services and Innovation 2020

Figure 2 Land use zoning and noise catchment areas

4.1.2 Non-residential receivers

Aside from the residential receivers in the nearby area described above, there are also several non-residential types of developments that may include noise sensitive receivers. For instance, there are a number of commercial and light industrial receivers in the nearby area, including several large retail outlets. However, commercial and industrial buildings are generally not considered to be receivers for construction noise impacts unless the building contains sensitive occupancy such as a recording studio. Furthermore, commercial and industrial buildings are also generally not considered to be sensitive receivers in terms of vibration impact for human comfort unless the occupants are particularly sensitive to vibration e.g. medical surgeries. However all buildings, regardless of occupancy are considered to be valid receivers for the purposes of assessing vibration in terms of potential damage to structural elements.

It is noted in the Land Use Zone Plan that there are several Public Recreation (RE1) area near the Proposal however only the sporting fields on Lake Road opposite NCA-1 would be classified as either Active Recreation or Passive Recreation as defined in the ICNG and/or the CNVS.

It is noted, as reported in Section 6 of the Tuggerah Station Upgrade Review of Environmental Factors (REF), that no heritage structures have been identified in the surrounding area.

4.2 Background noise levels

Background noise was measured in accordance with the requirements of the CNVS in order to quantify the sensitivity of the existing receiving environment.

The background noise monitoring locations were selected in consultation with TfNSW, on the basis that they would be representative of the noise environment throughout the Noise Catchment Areas in which the loggers were placed. The noise monitoring locations were selected within the cluster of receivers as these locations were deemed to be the most suitable for the purposes of determining the representative RBL throughout the entire cluster. In some cases, the background noise levels (RBL) at receivers located in closer proximity to the proposed works may be higher than elsewhere in the cluster, as they may be closer to extraneous noise sources such as major road(s). If the background noise were to be measured at those receivers closer to the noise source(s), the measured RBL would erroneously indicate an elevated RBL for the entire cluster of receivers and would thereby result in a higher noise management level (ie. a more lenient maximum noise goal) for the entire cluster.

The details of the background noise measurements are shown in **Table 4**, and the measurement locations are shown in **Figure 3**.

Table 4: Background Noise Measurement Details

Noise Measurement Location ID (Street Address)	**Representing Noise Catchment Area(s)**	**Start – Stop Date/ Time**	**Duration**	**Sampling period**	**Monitoring Equipment Details**
NM-1 (25 Lake Road)	NCA-1	2021-10-18 to 2021-10-25	7 Days	15 minutes	Manufacturer: Acoustic Research Laboratories Type: Ngara Serial Number: 8780B7 Calibration: 6 Sep 2021 Next due: 5 Sep 2023

Noise Measurement Location ID (Street Address)	Representing Noise Catchment Area(s)	Start – Stop Date/ Time	Duration	Sampling period	Monitoring Equipment Details
NM-2 (4 Arunta Road)	NCA-2 & NCA-3	2021-10-28 to 2021-11-04	7 Days	15 minutes	Manufacturer: Acoustic Research Laboratories Type: Ngara Serial Number: 8780B7 Calibration: 6 Sep 2021 Next due: 5 Sep 2023

Proposal area

Railway Station

1 Platform number

Road

Railway

Noise monitoring locations

Noise catchment areas

0 70 140 210 m

1:7,000 at A4

GDA 1994 MGA Zone 55

N

Data sources

Jacobs 2021
Aerometrex 2021
Department Finance, Services and Innovation 2020

Figure 3 Noise catchment areas and noise monitoring locations

The background noise monitoring location NM-2 is considered to be suitable for the purposes of determining the background noise levels within both NCA-2 and NCA-3, since both Noise Catchment Areas are considered likely to have generally similar acoustic environments due to their proximity to major roads, commercial, or industrial noise sources.

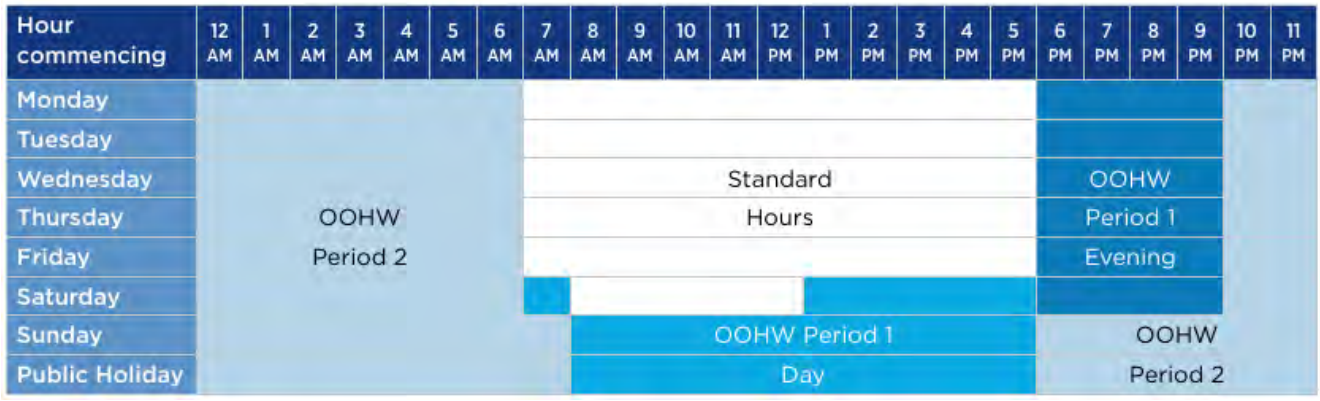
NM-2 is also considered suitable because the monitoring locations need to be representative of a wider cluster of receivers. In some cases, the background noise levels at receivers located in closer proximity to the proposed works may be higher than elsewhere in the cluster, as they may be closer to extraneous noise sources such as a major road. If the background noise were to be measured at those receivers closer to the noise source, the measured background level would erroneously indicate an elevated background level for the entire cluster of receivers, and would therefore result in a higher noise management level (i.e. a more lenient maximum noise goal) for the whole cluster.

The measured background noise levels were analysed in accordance with the CNVS, which requires that the analysis follows the method given in the NSW EPA's *Noise Policy for Industry* (2017) (NPfI).

The measured background noise levels have been analysed to determine the rating background level (RBL) as defined in the NPfI according to the time periods that are applicable to the assessment of TfNSW construction works as defined in the CNVS.

The time periods defined in the CNVS for the assessment of construction noise and vibration are shown in **Table 5**. Construction hours are defined in the CNVC as either "Standard Hours" or several different types of "Outside of Standard Hours", as shown in **Table 5**.

Table 5: Construction hours defined in TfNSW CNVS



Note:

1. Standard construction hours are defined as: Monday to Friday 7:00am to 6:00pm and Saturdays from 8:00am to 1:00pm.
2. Work outside of standard construction hours is defined as Out-of-Hours Work (OOHW) and can be divided into 2 periods of sensitivity. OOHW Period 1 is defined as Monday to Saturday 6:00pm to 10:00pm (evenings), Saturday 7:00am to 8:00am and 1:00pm to 10:00pm (day & evening) and Sunday and public holidays 8:00am to 6:00pm (days). OOHW Period 2 is defined as Monday to Saturday 10:00pm to 7:00am (nights) and Sundays and public holidays 6:00pm to 8:00am (nights).

In addition to the above, construction activities with special audible characteristics (high noise impact, intensive vibration, impulsive or tonal noise emissions) should be limited to standard hours, starting no earlier than 8am; and to continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block, unless otherwise approved by TfNSW.

A summary of the measured background noise levels is presented in **Table 6**. Detailed noise measurement results are provided in **Appendix B**. In preparing the data shown in **Table 5**, the data was analysed in accordance with the CNVS and the NPfI which requires that noise data recorded during periods of unsuitable meteorological conditions be removed from the measured data set. Accordingly, noise data measured during periods of wind exceeding five metres per second and/or during periods of precipitation were excluded from the measurement data set.

Table 6: Background noise level measurement results

Noise measurement location	Measurement	Measured noise level – dB(A)		
		Standard hours (7am - 6pm Monday to Friday, 8am - 1pm Saturday)	Out of hours work 1 (6pm - 10pm Monday to Friday, 7am - 8am & 1pm - 10pm Saturday, 8am - 6pm Sunday and Public Holiday)	Out of hours work 2 (10pm - 7am Monday to Friday, 10pm - 8am Saturday, 6pm - 7am Sunday and Public Holiday)
NM-1 25 Lake Road	L_{Aeq}[1]	48	44	45
	RBL	37	36	35
NM-2 4 Arunta Road	L_{Aeq}[1]	54	50	47
	RBL	45	41	33

Note:

1) LAeq: The equivalent-continuous noise level, which is the noise level that would have the same average acoustic energy as the fluctuating noise level over the time period. Also called the "energy-average" or "logarithmic average" noise level.
2) As per the NPfI, RBL during Standard Hours should not be less than 35 dB(A), and RBL during other time periods should not be less than 30 dB(A).
3) RBL during Outside of Standard hours Period 1 should not be less than RBL during Standard hours, and RBL during Outside of Standard hours Period 2 should not be less than RBL during Outside of Standard hours Period 1.
   That is: $\mathbf{RBL_{Standard\ hours} \geq RBL_{OOHW1} \geq RBL_{OOHW2}}$

5. Noise management levels and objectives

NMLs and objectives depend on the type of land use and occupancy of receivers. The following subsections present the NMLs and objectives developed for residential and non-residential sensitive receivers around the Proposal.

5.1 Airborne noise objectives for residential receivers

In accordance with Appendix A, Table 12 of the CNVS, based on the measured rating background noise levels presented above in **Table 6**, the NML for surrounding residential receivers were derived as shown in **Table 7**.

Table 7: Derivation of noise management levels at residential receivers in noise catchment areas

Noise Catchment Area	RBL (Background L_{A90})– dB(A)			Noise Management Level – dB(A)			
				Standard Hours		Out of Hours Work 1 (RBL+5)	Out of Hours Work 2 (RBL+5)
	Standard Hours	Out of Hours Work 1	Out of Hours Work 2	Noise Affected (RBL+10)	Highly Noise Affected		
NCA-1	37	36	35	47	75	41	40
NCA-2	45	41	33	55	75	46	38
NCA-3							
Note: $NML_{Standard\ hours} \geq NML_{OOHW1} \geq NML_{OOHW2}$							

5.1.1 Sleep disturbance

Where construction works are planned over two or more consecutive nights, the potential for sleep disturbance and awakenings should be considered in the assessment.

For construction noise impacts (except for traffic noise) during the periods outside of standard working hours, the NSW EPA's sleep disturbance screening level is that the $L_{AF1\ (1\ minute)}$ level (equivalent to the L_{Amax}) of a noise event should not exceed the ambient L_{A90} noise level by more than 15 dB.

The Sleep Disturbance assessment thresholds derived for the NCAs are shown in **Table 8**.

Table 8: Sleep Disturbance assessment threshold noise levels in Noise Catchment Areas $L_{AF1(1\ minute)}$

Time Period	NCA-1	NCA-2	NCA-3
OOHW1[1]	56	61	61
OOHW2[1]	55	53	53

Note:
1. OOHW periods 1 and 2, as defined in Table 5.

5.2 Air-borne noise objectives for receivers other than residential

In accordance with Appendix A, Table 13 of the CNVS, the airborne noise objectives at sensitive land uses (other than residential) are as shown in **Table 9**.

Table 9: Noise Management Levels at Non-Residential Receivers

Land Use	**Management Level, L_{Aeq} (applies when premises being utilised/occupied)**
Classrooms at schools and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of Worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Community Centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS2107 for specific uses.

5.3 Construction traffic noise objectives

Depending on project-specific factors such as the expected frequency of heavy vehicle movements, the proximity of the project site to receivers, and the existing traffic volumes on the construction vehicle access routes, it may be sufficient to undertake a qualitative assessment of the potential noise impacts associated with construction traffic movements.

However, if a quantitative assessment is required, construction-related traffic noise objectives should be based on the guidance contained in the *NSW Road Noise Policy* (RNP, NSW Department of Environment, Climate Change and Water 2011).

The RNP states that in assessing feasible and reasonable mitigation measures, an increase of up to2 dB represents a minor impact that is considered barely perceptible to the average person. For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments (in this case the construction area), any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario. If the heavy vehicle movements occur during the 10 pm to 7 am night-time period, the noise impacts should also be assessed in terms of the potential for causing sleep disturbance following a suitable methodology such as comparing the number of L_{Amax} noise events above 65 dB(A) from existing traffic against the number of events during the proposed construction works.

5.4 Ground borne noise objectives

Ground borne construction noise is usually present on tunnelling projects when equipment such as tunnel boring machines, road headers, rock hammers and drilling rigs are operated underground. The ground borne noise inside buildings initially propagates as ground borne vibration, before entering the building, which causes floors, walls and ceilings to gently vibrate and hence radiate noise. Sometimes the vibration may be perceptible within the building. For some critical spaces such as recording studios and cinemas, which are designed to reduce airborne noise intrusion, an assessment of ground borne construction noise for surface construction may also be required. Ground borne noise is usually not a significant disturbance to building occupants during daytime periods due to higher ambient levels which mask the audibility of ground borne noise emissions. During night-

time periods however, when ambient noise levels are often much lower, ground borne noise is more prominent and may result in adverse comment from building occupants. **Table 10** provides a summary of the ground borne construction noise objectives.

Table 10: Ground borne noise objectives

Time of Day	**Ground borne noise objectives $L_{Aeq(15\ minute)}$**
Daytime 7.00am to 6.00pm	None (Human comfort vibration objectives only)
Evening 6.00pm to 10.00pm	40 dBA – Internal
Night-time 10.00pm to 7.00am	35 dBA – Internal

5.5 Vibration objectives

Construction activities that generate vibration may affect receivers by causing one or more of the following impacts:

- Disturbance of human comfort
- Detrimentally affecting the contents within a receiver building, or
- Causing minor cosmetic damage or structural damage to the receiver building or other type of receiver structure (e.g. a heritage-protected structure (whether occupied or not), or a buried utility service, etc.)

5.5.1 Human comfort vibration objectives

Guidance in relation to acceptable vibration levels for human comfort are provided in EPA's *Assessing Vibration: a technical guideline* (EPA, 2006). This document is based on the guidelines contained in British Standard BS 6472-1992.

5.5.2 Objectives for vibration-sensitive contents within buildings

Buildings containing equipment that is highly sensitive to vibration, e.g. some recording studios, high technology facilities and buildings with scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort. Where appropriate, objectives for the satisfactory operation of critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives.

Where manufacturer's data is not available, some guidance where building contents contain sensitive equipment may be found in these references:

- Generic vibration criterion (VC) curves as published by the Society of Photo-Optical Instrumentation Engineers (Colin G. Gordon – 28 September 1999).
- Gordon CG Generic Vibration Criteria for Vibration Sensitive Equipment Proceedings of International Society for Optical Engineering (SPIE), Vol. 1619, San Jose, CA, November 4-6, 1991, pp. 71-85
- Australian Standard 2834-1995 Computer Accommodation, Chapter 2.9 Vibration, p16
- ASHRAE Applications Handbook (SI) 2003, Chapter 47 Sound and Vibration Control, pp47.39-47.40
- ISO 8569 1996 Measurement & Evaluation of Shock & Vibration Effects on Sensitive Equipment in buildings.

5.5.3 Objectives for protection of buildings against damage

CNVS refers to the criteria given in British Standard BS7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2*. The recommended limits (guide values) from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented in **Table 11**.

Table 11: Transient vibration guide values – minimal risk of cosmetic damage

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

The Standard states that the guide values in **Table 11** relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 11** may need to be reduced by up to 50 per cent.

For unreinforced or light framed structures or residential or light commercial type buildings, at frequencies below 4 Hz a maximum displacement of 0.6 mm (zero to peak) is recommended.

The Standard BS7385 states that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 11** and major damage to a building structure may occur at values greater than four (4) times the tabulated values in **Table 11**.

5.5.4 Objectives for special structures

5.5.4.1 Heritage

Heritage buildings and structures would be assessed as per the screening criteria in CNVS Section A.3.4 as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound (following inspection) a more conservative cosmetic damage objectives of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered.

It is noted that no heritage buildings or structures have been identified in the vicinity of the Proposal, within the minimum working distances for cosmetic damage to buildings.

5.5.4.2 Buried pipework and services

The British Standard BS 7385-2:1993 *Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration* notes that structures below ground are known to sustain higher levels of vibration and are very resistant to damage unless in very poor condition (British Standard BS 7385-2:1993, p5).

Further guidance is taken from the German Standard DIN 4150: Part 3-2016 *Vibration in Buildings – Part 3: Effects on Structures*, which sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values are reproduced and presented in **Table 12** below.

Table 12: DIN 4150-3 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

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

5.5.4.3 Other vibration sensitive structures and utilities

Some structures and utilities located in the vicinity of the Proposal may be particularly sensitive to vibration. A vibration goal which is more stringent than structural damage objectives presented in **Table 10**, **Table 11** and **Table 12** may need to be adopted. Examples of such structures and utilities include:

- Tunnels
- Gas pipelines
- Fibre optic cables.

Specific vibration objectives should be determined on a case-by-case basis. An acoustic consultant should be engaged by the construction contractor to liaise with the structure or utility's owner to determine acceptable vibration levels.

6. Assessment method

TfNSW states in the CNVS that construction noise and vibration impact should be assessed for all construction works. The assessment identifies the potential impact of airborne noise, ground borne noise and/or ground borne vibration on nearby receivers. Appropriate mitigation measures can then be determined depending on the level of impact, the duration of the works and the time at which the noise or vibration activity occurs. There are two types of noise and vibration assessment that can be completed under the CNVS:

- Simple noise and vibration assessment
- Detailed noise and vibration assessment.

The determination of whether the CNVIA can be a simple assessment or needs to be a detailed assessment is established by following the procedures given in CNVS Section 7, which can include using the TfNSW *Construction Noise Estimator Tool* as a Screening Tool.

Section 7 of the CNVS indicates that a detailed assessment is required if any of the following criteria are met:

- If the noise and/or vibration objectives are likely to be exceeded
- If the construction activity will take longer than six weeks
- If receivers are located within the minimum working distances for cosmetic damage to buildings
- If the works are within the minimum working distances for human disturbance
- If noise impacts will have special audible characteristics
- If there will be a moderate to large number of impacted receivers, including moderate to high-density residential or commercial buildings
- If exceedance of construction traffic noise objectives is likely
- If exceedance if sleep disturbance objectives is possible.

Due to the nature of the proposed works, which will include works during OOHW1 and OOHW2 periods (refer to **Table 5**), and the construction works being scheduled to take longer than six weeks (scheduled for 16 months), the CNVS indicates that a detailed assessment is required.

In accordance with the detailed assessment requirements of the CNVS, the following sections of this report provide information on the noise source emission levels, relevant construction scenarios, predicted noise and vibration at sensitive receivers and demonstration how noise and vibration impact on sensitive receivers will be minimised.

7. Prediction of noise and vibration impacts

7.1 Noise prediction scenarios

The worst-case noise emission scenarios during the construction works have been identified from the Constructability Report, for which the construction activities, duration in weeks and the expected major noise sources are shown in **Table 13**.

Table 13: Noise modelling scenarios: expected dominant noise generating construction activities

Noise modelling scenario (Stage)	Activity	Possession	Weeks	Expected major noise sources
1 (Enabling Works)	Platform station piles foundation supports, columns, capping beam and resurfacing works at the City end of Platforms 1 and 2	Yes (P1)	7 to 11	▪ Smooth drum roller ▪ Concrete trucks ▪ Concrete pump ▪ 30 t piling rig ▪ 20 to 50 t mobile crane ▪ Chipping hammer ▪ Percussion drill
2 (Major Works)	Platform station piles foundation supports, columns, capping beam and resurfacing works at the Country end of Platforms 1 and 2 Construct pile caps, lift wells, support columns, head stock & stairs on down side	Yes (P3 and P4)	30 to 44	▪ Smooth drum roller ▪ Elevated work platforms (x3) ▪ Concrete trucks ▪ Concrete pump ▪ 30 t piling rig ▪ 20 to 50 t mobile crane ▪ Percussion drill
3 (Major Works)	Construct pile caps, lift wells, support columns, head stock & stairs on down side	No	45 to 62	▪ Elevated work platforms (x3) ▪ 20 to 50 t mobile crane ▪ Chipping hammer ▪ Percussion drill
4 (Major Works)	Removal of slip lane, corner of Anzac Road and Pacific Highway Construct & commission new Station Masters Office and station facilities Complete station entry and forecourt modifications and landscaping	Yes (P6 and P7)	66 to 87	▪ 5 to 30 t excavator ▪ 35 to 40 t excavator with demolition shear attachment ▪ 4 to 10 t dump trucks ▪ Smooth drum roller ▪ Elevated work platforms ▪ Water cart ▪ Asphalt trucks ▪ Percussion Drill

In addition to the noise modelling scenarios shown in **Table 13**, other construction activities may also result in noise impacts, however, they have not been modelled for this current noise assessment since their noise emissions will be relatively lower than the worst-case scenarios listed in **Table 13**. As discussed in **Section 10**, it is recommended that further noise modelling and assessment be undertaken in the construction phase for all works proposed to occur outside of standard hours (including, but not limited to, weekend rail possessions).

7.2 Noise sources

Estimated sound power levels of each of the noise sources included in the worst-case noise modelling scenarios shown in **Table 13** are shown in **Table 14**. Sound power levels were estimated from equipment of matching size and power given in British Standard BS5228-1:2009 + A1:2014 *Code of practice for noise and vibration control on construction and open sites – Part 1- Noise*.

Table 14: Sound Power Levels of Modelled Noise Sources

Noise modelling scenario	Noise sources	Data source (British Standard BS5228-1:2009 + A1:2014)	Sound Power Level dB(A) re: 10^{-12}W
1	Smooth drum roller	Table C5 #23	111
	Concrete truck	Table C4 # 20	108
	Concrete pump	Table C4 #29	108
	30 *t* bored piling rig	Table C3 #22	108
	20 to 50 *t* mobile crane	Table C4 #43	98
	Chipping hammer	Table D5 #49	106
	Percussion Drill	Table D6 #54	104
2	Smooth drum roller	Table C5 #23	111
	Elevated Work Platforms (x3) (each)	Table C4 #59	106
	Concrete trucks	Table C4 # 20	108
	Concrete pump	Table C4 #29	108
	30 t bored piling rig	Table C3 #22	108
	20 to 50 t mobile crane	Table C4 #43	98
	Percussion Drill	Table D6 #54	104
3	Elevated Work Platforms (x3) (each)	Table C4 #59	106
	20 to 50 t mobile crane	Table C4 #43	98
	Chipping hammer	Table D5 #49	106
	Percussion Drill	Table D6 #54	104
4	5 to 30 t excavator	Table C2 #15	104
	35 to 40 t excavator with demolition shear attachment	Table C1 #15	112
	4 to 10 t dump trucks	Table C4 #4	104
	Smooth drum roller	Table C5 #23	111
	Elevated work platforms	Table C4 #59	106
	Water cart	Table D11 #51	113
	Asphalt trucks	Table C5 #32	112
	Percussion Drill	Table D6 #54	104

7.3 Predicted noise levels

Predicted noise levels contours for each of the four noise modelling scenarios are shown in **Figure 4** to **Figure 7**.

Additionally, noise levels have been predicted using the computer noise model at each of the Noise Catchment Areas. The predicted noise levels at the nearby residential noise receivers from the above noise modelling scenarios are shown in **Table 15**.

Table 15: Predicted worst-case construction noise levels $L_{Aeq(15\ minute)}$ dB(A)

Noise modelling scenario	Predicted noise levels at Noise Catchment Areas (worst-case, maximum 15-minute L_{Aeq}) dB(A)		
	NCA-1	NCA-2	NCA-3
1	57	52	45
2	53	50	43
3	57	51	44
4	55	53	46

The significance of the predicted noise levels shown in **Table 15** and in **Figure 4** to **Figure 7** is discussed in the assessment of noise impacts provided in **Section 8**.

It should be noted that the predicted noise levels shown in **Table 15** are worst-case noise levels that may occur, as they assume that all noise sources are operating concurrently. It should also be noted that the predicted noise levels shown in **Table 15** do not include any allowance for special audible characteristics of the noise, as the noise sources included in the modelling scenarios are not expected to include particularly noticeable or annoying audible characteristics. In practice, if the actual noise sources exhibited tonality, impulsiveness, low-frequency components or intermittency then the noise emissions may attract a penalty adjustment up to a total of 10 dB(A) higher than the noise levels shown in **Table 15**.

7.4 Road traffic noise impacts during construction

The construction traffic associated with the proposal is expected to be minor in comparison to the existing traffic volumes in the area. The road haul routes described in the Constructability Report demonstrate that the proposed traffic routes would utilise main roads to access and depart the Proposal area. The proposed temporary site compounds, laydown areas, car parks, etc., are within the Proposal area, consequently there would be negligible additional traffic movements and therefore negligible additional traffic noise at any residential receivers.

7.5 Predicted vibration levels during construction

The construction equipment to be used on site that may generate high vibration levels are:

- Pile borer
- Asphalt paver
- Smooth drum roller (possibly vibrating-type).

The vibration levels resulting from these types of plant depend on the size and power rating of the plant and the vibration propagation characteristics of the soil being bored through and/or beneath the plant.

Typical vibration levels from these types of plant are provided in the CNET and the Roads and Maritime Services (RMS) *Construction Noise and Vibration Guideline* (CNVG, Roads and Maritime Services, 2016). The typical

vibration levels are given in terms of minimum working distances from sensitive receivers for typical items of vibration intensive plant as listed in **Table 16**.

Table 16: Ground vibration – minimum working distances from sensitive receivers

Plant item	**Rating / Description**	**Minimum working distance**	
		Cosmetic damage[1] (BS 7385)	**Human response (AVTG)**
Vibratory roller	< 50 kN (Typically 1-2 t)	5 m	15 to 20 m
	< 100 kN (Typically 2-4 t)	6 m	20 m
	< 200 kN (Typically 4-6 t)	12 m	40 m
	< 300 kN (Typically 7-13 t)	15 m	100 m
	> 300 kN (Typically 13-18 t)	20 m	100 m
	> 300 kN (> 18 t)	25 m	100 m
Small hydraulic hammer	(300 kg – 5 to 12 t excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg – 12 to 18 t excavator)	7 m	23 m
Large hydraulic hammer	(1600 kg – 18 to 34 t excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m
Profiler[2]	Wirtgen W210	4 m	
Asphalt paver[2]	Vogele Super 1800-3	1 m	
Steel drum roller[2]	Hamm HD70 (Oscillating Mode)	2 m	
Steel drum roller[2]	Hamm HD70 (Static Mode)	1 m	

Note 1: More stringent conditions may apply to heritage or other sensitive structures

Note 2: Minimum working distances for human response for profiler, asphalt paver or steel drum rollers are not provided in the CNET or the CNVG however these plant are assumed to be comparable to a vibratory roller i.e. worst-case 25 metres for cosmetic building damage and 100 metres for human comfort.

As shown in **Table 16**, the highest values of any of the recommended minimum safe working distances from the proposed vibration-generating plant to be used during the site works is:

- To prevent cosmetic damage to buildings: 25 metres from the smooth drum roller, and
- To prevent human discomfort: 100 metres from the smooth drum roller.

Figure 4 Predicted Noise Levels – Noise Modelling Scenario 1, worst-case L_{Aeq}(15 minute) dB(A)

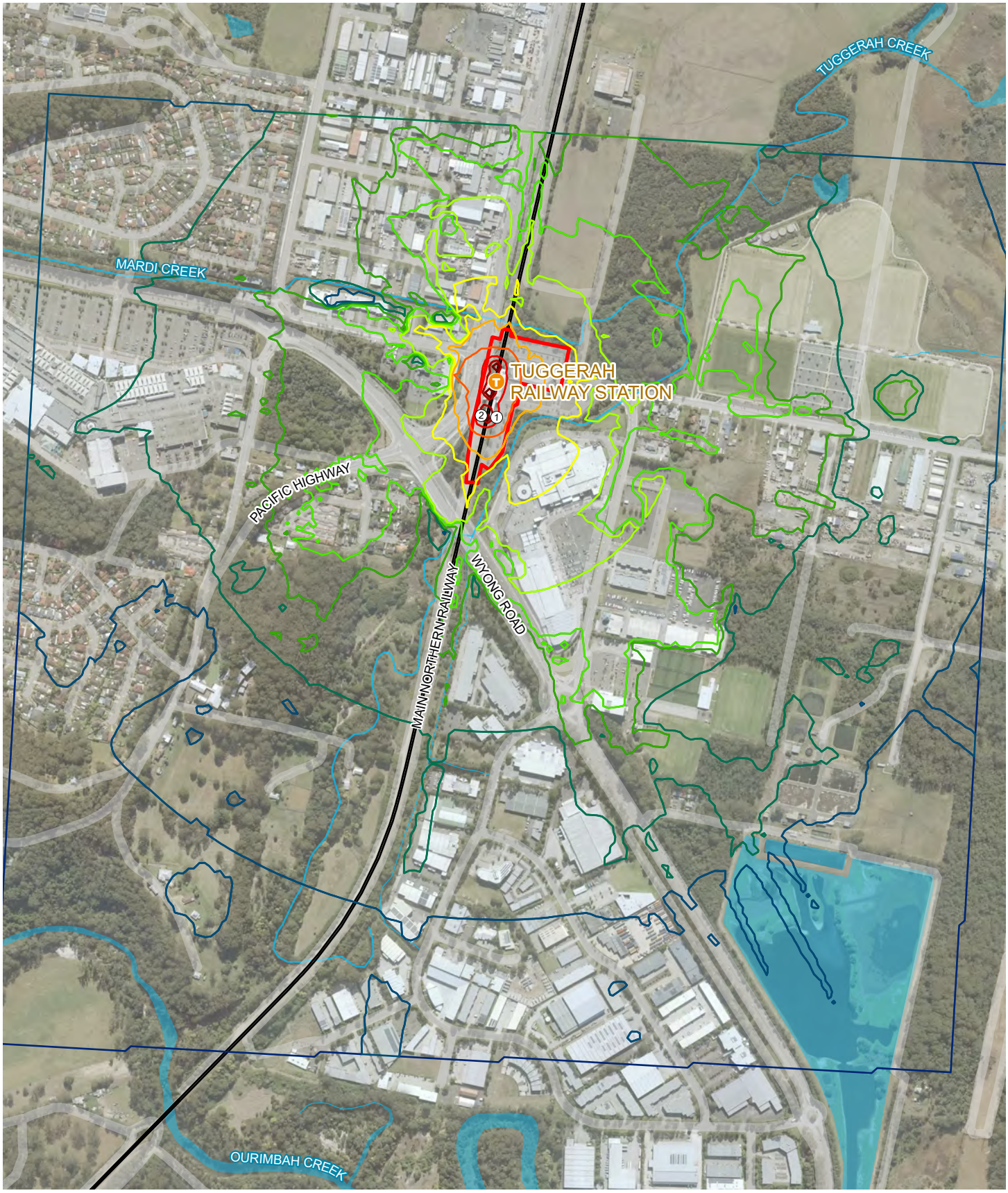


Figure 5 Predicted Noise Levels – Noise Modelling Scenario 2, worst-case L_{Aeq}(15 minute) dB(A)

Figure 6 Predicted Noise Levels – Noise Modelling Scenario 3, worst-case L_{Aeq}(15 minute) dB(A)

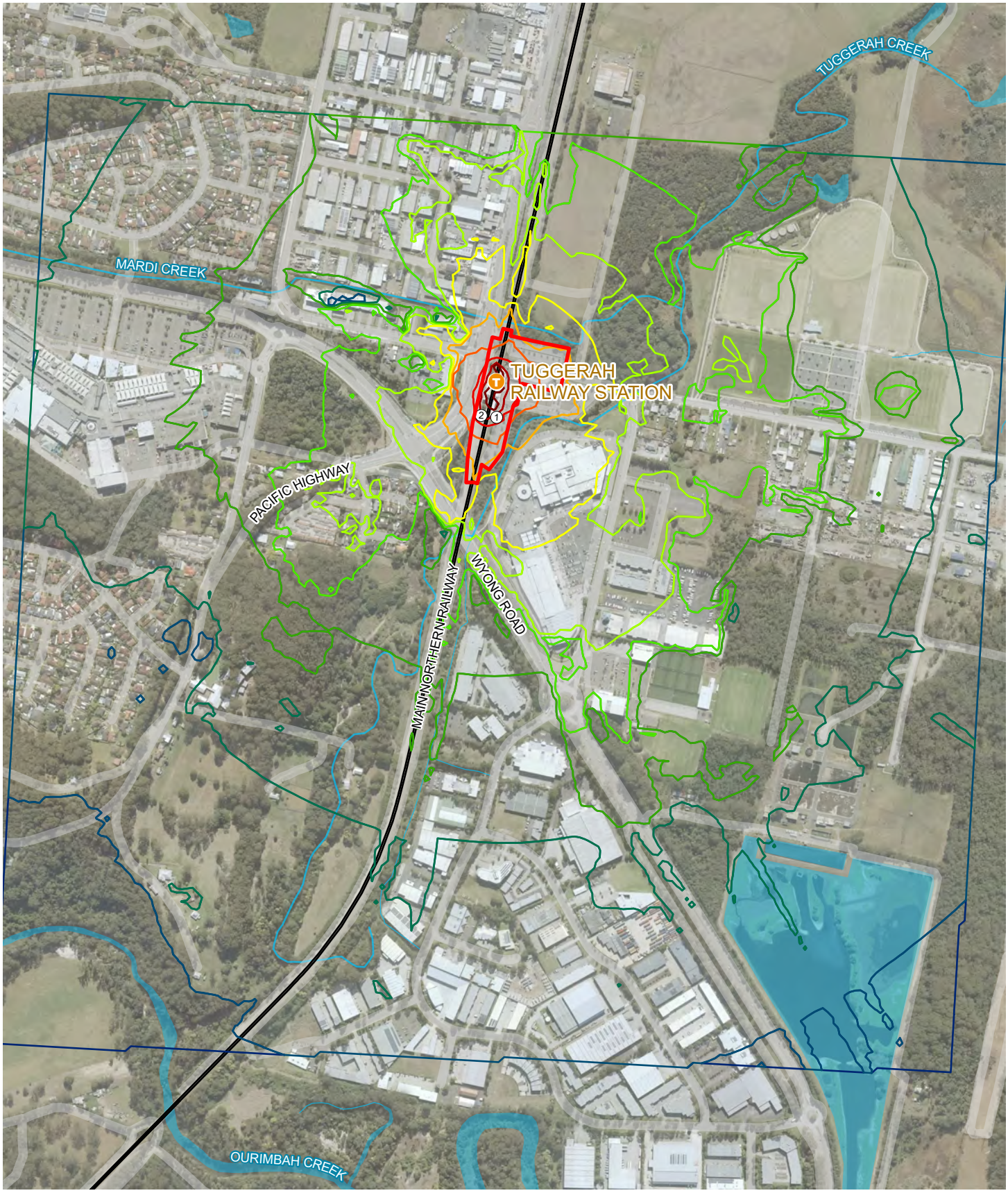


Figure 7 Predicted Noise Levels – Noise Modelling Scenario 4, worst-case L_{Aeq}(15 minute) dB(A)

8. Assessment of predicted impacts

8.1 Noise impacts

The predicted worst-case noise levels from the construction works are compared against the noise management level objectives in **Table 17**.

Table 17: Assessment of predicted worst-case construction noise levels

Noise modelling scenario	**Predicted noise levels at receivers (worst-case, maximum 15-minute L_{Aeq}) dB(A)**			
	NCA-1	**NCA-2**	**NCA-3**	**Sporting Fields on Lake Road**
1 (Enabling works)	57	52	45	45
2 (Major works – Including P3, P4 Possessions)	53	50	43	43
3 (Major works – non-Possession)	57	51	44	44
4 (Major works – including P6, P7 Possessions)	55	53	46	46
Noise Management Levels (NML, dB(A))				
Standard working hours	47	55	55	65
OOHW1	41	46	46	65
OOHW2	40	38	38	65
OOHW1 Sleep Disturbance $L_{AF1\ (1\ minute)}$ or L_{Amax}	56	61	61	n/a
OOHW2 Sleep Disturbance $L_{AF1\ (1\ minute)}$ or L_{Amax}	55	53	53	n/a

It can be seen in **Table 17** that the predicted noise levels do not exceed the Highly Affected noise objective of 75 dB(A) at any residential receiver during the standard working hours time periods. Additional details on exceedance above NML and noise mitigation measures are provided in **Table 18**.

As shown in **Table 17**, the predicted noise levels at NCA-1 exceed the NML during Standard Hours by up to 10 dB(A) for each of the four noise modelling scenarios. The predicted noise levels at NCA-2 and NCA-3 do not exceed the NML during Standard Hours any of the four noise modelling scenarios.

During the OOHW1 period:

- The predicted noise levels during all modelling scenarios exceed the NML by up to 16 dB(A) at receiver NCA-1, and by up to 6 dB(A) at receiver NCA-2.
- The predicted noise levels do not exceed the NML at receiver NCA-3.

During the OOHW2 period:

- The predicted noise levels during all modelling scenarios exceed the NML by up to 17 dB(A) at receiver NCA-1
- The predicted noise levels during all modelling scenarios exceed the NML by up to 15 dB(A) at receiver NCA-2
- The predicted noise levels during all modelling scenarios exceed the NML by up to 8 dB(A) at receiver NCA-3.

As also shown in **Table 17**, the worst-case noise levels are not predicted to exceed the noise management level at the sporting fields on Lake Road at any time.

8.1.1 Predicted exceedances above NML

The assessment indicates that the residential receivers in Noise Catchment Area NCA-1 on Lake Road are likely to experience the highest noise impacts. Noise levels at NCA-1 may exceed the NML during standard construction hours by up to 10 dB(A) during worst-case noise events.

The predictions indicate that even though the worst-case construction noise impacts may exceed the NML at some locations during Standard construction hours, the exceedances are not significant and no additional noise mitigation measures would be required to be implemented.

If the worst-case noise producing construction activities occur during the OOHW1 and/or the OOHW2 time periods, the L_{Amax} noise levels in the locations of the NCA-1 residential receivers may exceed the Sleep Disturbance assessment threshold.

However, if the worst-case construction noise events occur outside of standard construction hours, the predicted noise levels at some or all of the NCA may exceed the NML sufficient to trigger the requirement to implement additional noise mitigation measures.

Based on the predicted noise levels from the worst-case construction activities, if the worst-case construction noise emissions occur during the OOHW1 time period, it will be necessary to provide Project Notification to receivers in Noise Catchment Areas NCA-1 and NCA-2, and to undertake Verification Monitoring near the receivers in NCA-1.

Furthermore, if the worst-case noise events are expected to occur during the OOHW2 time period, it will be necessary to provide Project Notification to receivers and to undertake Verification Monitoring within each of the Noise Catchment Areas NCA-1, NCA-2 and NCA-3. In this case, the following additional noise mitigation measures would also be required for receivers in NCA-1:

- Specific Notification, individual briefings, or phone call
- Respite Periods
- Duration Reduction

Detailed descriptions of the above additional mitigation measures are provided in **Appendix C**.

8.1.2 Assessment of sleep disturbance

It is expected that the predicted worst-case $L_{Aeq(15\ minute)}$ noise level is approximately the same as the L_{Amax} noise level that may be received at a receiver. In that case, the predicted L_{Amax} noise level would also exceed the objective for prevention of Sleep Disturbance at the receivers in NCA-1 during both the OOHW1 period and OOHW2 period. However, the predicted noise levels do not indicate potential exceedance of the Sleep Disturbance objectives during OOHW1 or OOHW2 in either of the receiver clusters in NCA-2 or NCA-3.

8.2 Construction traffic noise impacts

The construction traffic associated with the project is expected to be minimal, consequently the construction traffic noise impacts are expected to be negligible at all residential receivers. As construction traffic noise is typically not considered for commercial receivers, the potential for construction traffic noise impact at any receivers is also considered to be negligible.

8.3 Vibration impacts

8.3.1 Cosmetic damage to buildings

As shown in **Table 16**, the highest value of minimum working distances for any of the listed plant is 25 metres.

Since the nearest potentially affected structure is more than 55 metres from the site (the commercial building to the west), and the nearest residential buildings are approximately 190 metres from the site (NCA-2 to the south-west), it is considered that the risk of any construction or demolition works associated with the Project causing any cosmetic damage to any nearby building is negligible.

8.3.2 Human annoyance

As shown in **Table 16,** the highest value of minimum working distances for human comfort for any of the listed plant is 100 metres.

There are two buildings within 100 metres that contain occupants who may potentially be disturbed by vibration from the construction activities on site. These are:

- 2 Anzac Road, Tuggerah [Lot 50, DP1099463] – about 55 metres west of the construction works
- 2 Bryant Drive, Tuggerah [Lot 101, DP1209157] – about 80 metres south east of the construction works

Both of the above buildings are commercial (retail sales) buildings.

Commercial (retail sales) buildings are generally not discussed as being sensitive receivers for human comfort due to vibration in any of the guidelines that are used for the assessment of vibration from construction in NSW. Consequently, neither of these buildings is considered to be a receiver for the purposes of this assessment.

There are no other receiver buildings within the 100 metre safe working distance zone from the construction works, therefore the risks associated with construction vibration causing human discomfort at any receiver buildings is assessed to be negligible.

8.3.3 Special structures

No structures have been identified in the nearby area that might be particularly sensitive to vibration, therefore no special assessment has been required for the Proposal.

9. Recommended mitigation measures

The results of the noise modelling provided in this CNVIA should be used to guide decisions on the planning of construction activities to reduce community noise impacts, particularly during OOHW1 and OOHW2 periods.

It is expected that construction works will be required during Outside of Standard Hours periods during some of the scheduled Possessions. However, Outside of Standard Hours works may also occasionally be required for some construction activities that are not associated with Possessions. In either case, noise modelling should be undertaken as part of the OOHW approvals process.

The CNVS describes standard construction noise and vibration mitigation measures that are to be implemented on all TfNSW projects. Additionally, if the predicted noise levels exceed the NML at any receiver(s) at any time period(s), the CNVS also described additional noise and vibration measures that are to be implemented, depending on the magnitude of the exceedance above the NML.

The standard mitigation measures and the additional mitigation measures that are required to be implemented for the Proposal are described below.

9.1 Standard mitigation measures

Standard mitigation measures that should be implemented on all TfNSW projects are listed in the CNVS as described below.

9.1.1 Action-based standard noise and vibration mitigation measures

- Implementation of any project specific mitigation measures required
- Implement stakeholder consultation measures (refer to CNVS Sections 8.2.1 and 8.3 for further details of community consultation measures)
- Register of noise and vibration sensitive receivers
- Construction hours and scheduling
- Construction respite period
- Site inductions
- Behavioural practices
- Monitoring
- Attended vibration measurements
- Update Construction Environmental Management Plans
- Building condition surveys

9.1.2 Standard mitigation measures (noise control) that should be applied at the source(s) of noise

- Plan worksites and activities to minimise noise and vibration
- Equipment selection
- Maximum noise levels
- Rental plant and equipment
- Use and siting of plant
- Non-tonal reversing alarms
- Minimise disturbance arising from delivery of goods to construction sites
- Construction Related Traffic

- Silencers on Mobile Plant
- Prefabrication of materials off-site
- Engine compression brakes.

9.1.3 Standard mitigation measures (noise controls) in the intervening path between the source(s) and the receiver(s).

- Shield stationary noise sources such as pumps, compressors, fans etc.
- Shield sensitive receivers from noisy activities

9.2 Additional mitigation measures

Based on Table 9 in the CNVS, since the expected noise levels do not exceed the NML by more than 10 dB(A), it would not be necessary to implement any additional mitigation measures for noise impacts during standard working hours.

However, if the proposed noisy activities are scheduled to occur during OOHW1 and/or OOHW2 periods, then based on the predicted exceedances at each location, during each time period, the additional noise mitigation measures for the relevant construction activities will need to be implemented as shown in **Table 18**.

Table 18: Additional Mitigation Measures

Receptor	Time period	Scenario	dB(A) above RBL	Exceedance above NML	Perception	Additional mitigation measures[1]
NCA-1	Standard	1	20	10	Clearly Audible	-
		2	16	6	Clearly Audible	-
		3	20	10	Clearly Audible	-
		4	18	8	Clearly Audible	-
	OOHW1	1	21	16	Moderately Intrusive	PN, V
		2	17	12	Clearly Audible	PN
		3	21	16	Moderately Intrusive	PN, V
		4	19	14	Clearly Audible	PN
	OOHW2	1	22	17	Moderately Intrusive	PN, V, SN, RP, DR
		2	18	13	Clearly Audible	PN, V
		3	22	17	Moderately Intrusive	PN, V, SN, RP, DR
		4	20	15	Clearly Audible	PN, V
NCA-2	Standard	1	7	-	Noticeable	-
		2	5	-	Noticeable	-
		3	6	-	Noticeable	-
		4	8	-	Noticeable	-
	OOHW1	1	11	6	Clearly Audible	PN
		2	9	4	Noticeable	-
		3	10	5	Clearly Audible	PN

Receptor	Time period	Scenario	dB(A) above RBL	Exceedance above NML	Perception	Additional mitigation measures[1]
		4	12	7	Clearly Audible	PN
	OOHW2	1	19	14	Clearly Audible	PN,V
		2	17	12	Clearly Audible	PN,V
		3	18	13	Clearly Audible	PN,V
		4	20	15	Clearly Audible	PN,V
NCA-3	Standard	1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	1	-	-	-
	OOHW1	1	4	-	-	-
		2	2	-	-	-
		3	3	-	-	-
		4	5	-	-	-
	OOHW2	1	12	7	Clearly Audible	PN,V
		2	10	5	Noticeable	PN
		3	11	6	Clearly Audible	PN,V
		4	13	8	Clearly Audible	PN,V

The codes for the additional mitigation measures that might be required are:

PN = Project Notification

V = Verification Monitoring

SN = Specific Notification, individual briefings, or phone call

RP = Respite Period

DR = Duration Reduction

Detailed descriptions of the terms used for the additional mitigation are provided in **Appendix C**.

As shown in **Table 18**, if the proposed worst case noise modelling scenarios represent construction noise activities that may occur during the OOHW1 and/or OOHW2 time periods, additional noise mitigation measures would be required to be implemented.

10. Further noise and vibration assessment and management

During the construction phase, any proposed construction works that may include noise-producing activities during OOHW1 and OOHW2 periods should have noise modelling and assessment undertaken as part of the OOHW Approvals process. It is understood that several of the possessions would include works in OOHW periods. As the construction activities to be undertaken during each of the possessions would be different, the noise impacts during each of the possessions would likely also be different, therefore noise modelling and assessment for possessions should be undertaken on a case-by case basis.

11. Conclusion

The predicted noise and vibration levels and the assessment of their impacts against the environmental noise and vibration management objectives indicate that the Proposal may potentially result in construction noise impacts at some sensitive receivers during some time periods.

The assessment indicates that the residential receivers in Noise Catchment Area NCA-1 on Lake Road are likely to experience the highest noise impacts. Noise levels at NCA-1 may exceed the NML during standard construction hours by up to 10 dB(A) during worst-case noise events.

The predictions indicate that even though the worst-case construction noise impacts may exceed the NML at some locations during Standard construction hours, the exceedances are not significant and no additional noise mitigation measures would be required to be implemented.

If the worst-case noise producing construction activities occur during the OOHW1 and/or the OOHW2 time periods, the L_{Amax} noise levels in the locations of the NCA-1 residential receivers may exceed the Sleep Disturbance assessment threshold.

However, if the worst-case construction noise events occur outside of standard construction hours, the predicted noise levels at some or all of the NCAs may exceed the NML sufficient to trigger the requirement to implement additional noise mitigation measures.

Based on the predicted noise levels from the worst-case construction activities, if the worst-case construction noise emissions occur during the OOHW1 time period, it will be necessary to provide Project Notification to receivers in Noise Catchment Areas NCA-1 and NCA-2, and to undertake verification monitoring near the receivers in NCA-1.

Further, if the worst-case noise events are expected to occur during the OOHW2 time period, it will be necessary to provide Project Notification to receivers and to undertake verification monitoring within each of the Noise Catchment Areas NCA-1, NCA-2 and NCA-3. In this case, the following additional noise mitigation measures would also be required for receivers in NCA-1:

- Specific notification, individual briefings, or phone call
- Respite periods
- Duration reduction.

Detailed descriptions of the above additional mitigation measures are provided in **Appendix C**.

12. References

Central Coast Council (2021). *Central Coast Council Online Mapping.* https://maps.centralcoast.nsw.gov.au/public/

BSI Standards Publication (1993). *BS7385-2:1993 Evaluation and Measurement for Vibration in Buildings*

BSI Standards Publication (2014). *BS5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites*

DEC (2006). *Assessing Vibration: A Technical Guideline*.

DECC (2009). *Interim Construction Noise Guideline*.

DECCW (2011). *Road Noise Policy.*

EPA (2013). *Rail Infrastructure Noise Guideline.*

EPA (2017). *NSW Noise Policy for Industry.*

German Institute for Standardisation (2016). *DIN4150-3:2016 Vibration in Buildings – Part 3: Effects on Structures.*

International Organisation for Standardisation (1996). *ISO9613-2:1996: Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation*

RMS (2016a). *Construction Noise Estimator Tool FT-150* (Microsoft® Excel native electronic file)

RMS (2016b). *Construction Noise and Vibration Guideline.*

RTA (2001). *Environmental Noise Management Manual.*

Standards Australia (2010). *AS2436:2010 – Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*

Standards Australia (2018). *AS1055:2018 – Acoustics – Description and Measurement of Environmental Noise*

TfNSW (2019). *Construction Noise and Vibration Strategy, DMS-ST-157. Version 4.2, 18 Oct 2019*

12.1 Project Documentation References

- FutureRail More Trains More Services – *Tuggerah Definition Design Report* (Doc No. TUGST-FURL-TUG-GN-RPT-380001), Rev B, 19 Aug 2021
- FutureRail More Trains More Services – *Tuggerah Station – Constructability Assessment* (Doc No. TUGST-FURL-TUG-CX-MEM-380001), Rev B, 17 Aug 2021
- FutureRail More Trains More Services – Tuggerah Station – *Environmental Constraints Memo* (Doc No. TUGST-FURL-TUG-EN-MEM-380001), Rev B ,19 Aug 2021

Appendix A. Glossary of terms

<table>
<tr><th>Term</th><th>Description</th></tr>
<tr><td>dB</td><td>Sound pressure levels are expressed in decibels as a ratio between the measured sound pressure level and the reference pressure. The reference pressure is 20×10^{-6} Pascal (Newtons per square metre). Some typical noise levels are presented below:
<table>
<tr><th>Sound Pressure Level, dB(A)</th><th>Example</th></tr>
<tr><td>130</td><td>Threshold of pain</td></tr>
<tr><td>120</td><td>Jet aircraft take-off at 100 m</td></tr>
<tr><td>110</td><td>Power tool at 1 m</td></tr>
<tr><td>100</td><td>Nightclub</td></tr>
<tr><td>90</td><td>Heavy trucks at 5 m</td></tr>
<tr><td>80</td><td>Kerbside of busy street</td></tr>
<tr><td>70</td><td>Loud radio (in typical domestic room)</td></tr>
<tr><td>60</td><td>Office</td></tr>
<tr><td>50</td><td>Domestic fan heater at 1m</td></tr>
<tr><td>40</td><td>Living room</td></tr>
<tr><td>30</td><td>Theatre</td></tr>
<tr><td>20</td><td>Rural environment on still night</td></tr>
<tr><td>10</td><td>Sound insulated test chamber</td></tr>
<tr><td>0</td><td>Threshold of hearing</td></tr>
</table></td></tr>
<tr><td>dB(A)</td><td>The A-weighted sound pressure level in decibels, denoted dB(A) is the unit generally used for the measurement of environmental, transportation or industrial noise. The A-weighting scale approximates the sensitivity of the human ear when it is exposed to normal levels and correlates well with subjective perception over a number of different types of sounds.
An increase or decrease in sound level of approximately 10 dB corresponds to a subjective doubling or halving in loudness. A change in sound level of 3dB is considered to be just noticeable.</td></tr>
<tr><td>dB©</td><td>The unit used for measuring occupational health and safety maximum industrial noise levels in Australia is the C-weighted sound pressure level in decibels, denoted dB©. C-weighting has a relatively flat response when compared to an A-weighting network.</td></tr>
<tr><td>L_1</td><td>The L_1 statistical level is sometimes used to represent the maximum level of a sound that varies with time. Mathematically, the L_1 level is the level exceeded for 1% of the measurement period.</td></tr>
<tr><td>$L_{AF1(1\ minute)}$</td><td>The A-weighted sound pressure level measured using the ‘Fast’ response time setting, exceeded for 1% of the time interval, where the time interval is 1 minute.</td></tr>
<tr><td>L_{A10}</td><td>The A weighted sound pressure level that is exceeded for 10% of the measurement period. It is often referred to as the average of the maximum values.</td></tr>
</table>

Term	Description
L_{A90}	The A weighted sound pressure level that is exceeded for 90% of the measurement period. Usually used to represent the background noise level.
L_{eq}	The equivalent continuous sound level. The steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.
L_{Aeq}	The A weighted equivalent continuous sound level is denoted $L_{Aeq.}$
L_{Max}, L_{Fmax}, L_{Smax} L_{Amax}, L_{AFMax}, L_{ASMax}	The maximum measured linear (un-weighted or Z) sound pressure level. The L_{Max} variations, L_{Fmax}, L_{Smax} are the L_{Max} levels using the "Fast" and "Slow" networks respectively. The A-weighted variations are also used in various guidelines and standards, L_{Amax}, L_{AFMax} and L_{ASMax}.
Frequency	The rate of repetition of a sound wave. The unit of frequency is the Hertz (Hz), defined as one cycle per second. Human hearing ranges approximately from 20 Hz to 20,000 Hz. For design purposes, the octave bands between 63 Hz to 8 kHz are generally used. The most commonly used frequency bands are octave bands. For more detailed analysis each octave band may be split into three one-third octave bands or in some cases, narrow frequency bands.
L_W	The sound power level of a source is a measure of the total acoustic power radiated by a source. It is a characteristic of the sound source which is not affected by the environment within which the source is located.
Ambient Noise Level	The prevailing noise level at a location due to all noise sources but excluding the noise from the specific noise source under consideration. Generally measured as a dB(A) noise level.
Sound Level Meter	An instrument consisting of a microphone, amplifier and data analysis package for measuring and quantifying noise.
NATA	National Association of Testing Authorities
Background Noise Level	The lower ambient noise level, usually defined as the value of the time varying ambient noise level exceeded for 90% of the measurement time. Usually defined in the dB(A) scale – L_{A90}.
Vibration	Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structureborne noise or human comfort respectively. Vibration amplitude may be quantified as a peak value, or as a root mean squared (rms) value. Vibration amplitude can be expressed as an engineering unit value e.g. $1mm \times s^{-1}$ or as a ratio on a logarithmic scale in decibels: vibration velocity level = $20 \times \log_{10} (V/V_{ref})$ (dB). The preferred reference level, V_{ref}, for vibration velocity = 10^{-9} m/s. The Vibration Dose value (VDV) is also becoming an accepted measure of vibration, being the cumulative vibration level received over a continuous 8-hour or 16-hour period.
Ground Vibration	The level of vibration measured in the ground anywhere on a sensitive site. The measurement point should be at least the longest dimension of the foundations of a building or structure away from the building or structure if possible. If this is not possible, the site should be chosen to be as far from the building or structure as is practical.
Ground borne noise	Noise generated inside a building by ground borne vibration generated by the passby of a vehicle on rail.

Term	Description
Suitably qualified acoustic consultant	An acoustic consultant who is a full member of the Australian Acoustical Society (or equivalent)
PPV	Peak Particle Velocity – the highest instantaneous sum of velocity vectors (measured in millimetres per second, mm/s) of the ground movement caused by the passage of vibration.
Lin Peak	Linear Peak – the maximum level of air pressure fluctuation measured in decibels without frequency weighting. Frequency weightings are often applied to sound measurements to ensure the measured parameter is indicative of the level experienced by the human auditory system. Weighting is not applied to airblast measurements as much of the sound from an airblast is at inaudible frequencies.
Airblast	The maximum noise level in dB Linear Peak due to a blast measured anywhere on a sensitive site which is located at least 3.5 metres from any building or other acoustically reflective surface (other than ground).
Acoustic Spectrum	The sound pressure level (or sound power level) as a function of frequency (e.g. octave band, ⅓ octave or narrow band). Generally used to identify noise sources or items contributing disproportionately to an overall noise level.
Heavy Vehicle	A truck or other transport vehicle with a gross vehicle weight above a specified level (for example: over 8 tonnes).
Noise Logger	A data logger which records the measured noise level (and audio in some cases). Usually used for unattended noise monitoring of background or ambient noise.
Barriers	Generally a wall or an earth mound that obstructs or restricts the passage of sounds waves from a noise source. Barriers usually require a surface density of not less than 15 kg/m^2 and an overall weighted Sound Reduction Index (R_w) of no less than 30 dB when tested in accordance with ISO 10140-2:2021[1] to be considered effective. The barriers are also assumed to be installed without holes or gaps (eg underneath the barrier), to prevent noise transmission.
$L_{Aeq(15hr)}$	The L_{Aeq} noise level for the period 7:00 hours to 22:00 hours. It is the equivalent continuous noise level over a 15 hour period.
$L_{Aeq(9hr)}$	The L_{Aeq} noise level for the period 22:00 hours to 07:00 hours. It is the equivalent continuous noise level over a 9 hour period.
Assessment Background Level, (ABL)	The single figure background level representing each relevant assessment measurement period (day, evening and night), equal to the tenth percentile (lowest 10%) of the measured background noise levels (L_{A90}) in each period.
Rating Background Level (RBL)	Defined in the NSW Noise Policy for Industry published by the Environment Protection Authority, 2017. The overall single figure background noise level representing each assessment period (Day/Evening/Night) over the whole monitoring period. This is the level used for assessment purposes. It is defined as the median of Assessment Background Noise Levels (ABLs) for each of the measurement periods (Day / Evening / Night).
Noise immission	Received noise at a receiver (either internally within a building or external at an outdoor receiver)

[1] ISO 10140-2:2021 Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation.

Appendix B. Background noise measurement data

Background Noise Level Measurement Results – NM-1: 25 Lake Road, Tuggerah

Measurement Date	Standard Hours	ABL	LEQ
Monday 18 October 2021	07:00-18:00	36	47
Tuesday 19 October 2021	07:00-18:00	36	48
Wednesday 20 October 2021	07:00-18:00	41	49
Thursday 21 October 2021	07:00-18:00	38	48
Friday 22 October 2021	07:00-18:00	37	48
Saturday 23 October 2021	08:00-13:00	35	44
Sunday 24 October 2021			
Monday 25 October 2021	07:00-18:00	38	48
Median (RBL)		**37**	
Logarithmic Average (Leq)			**48**

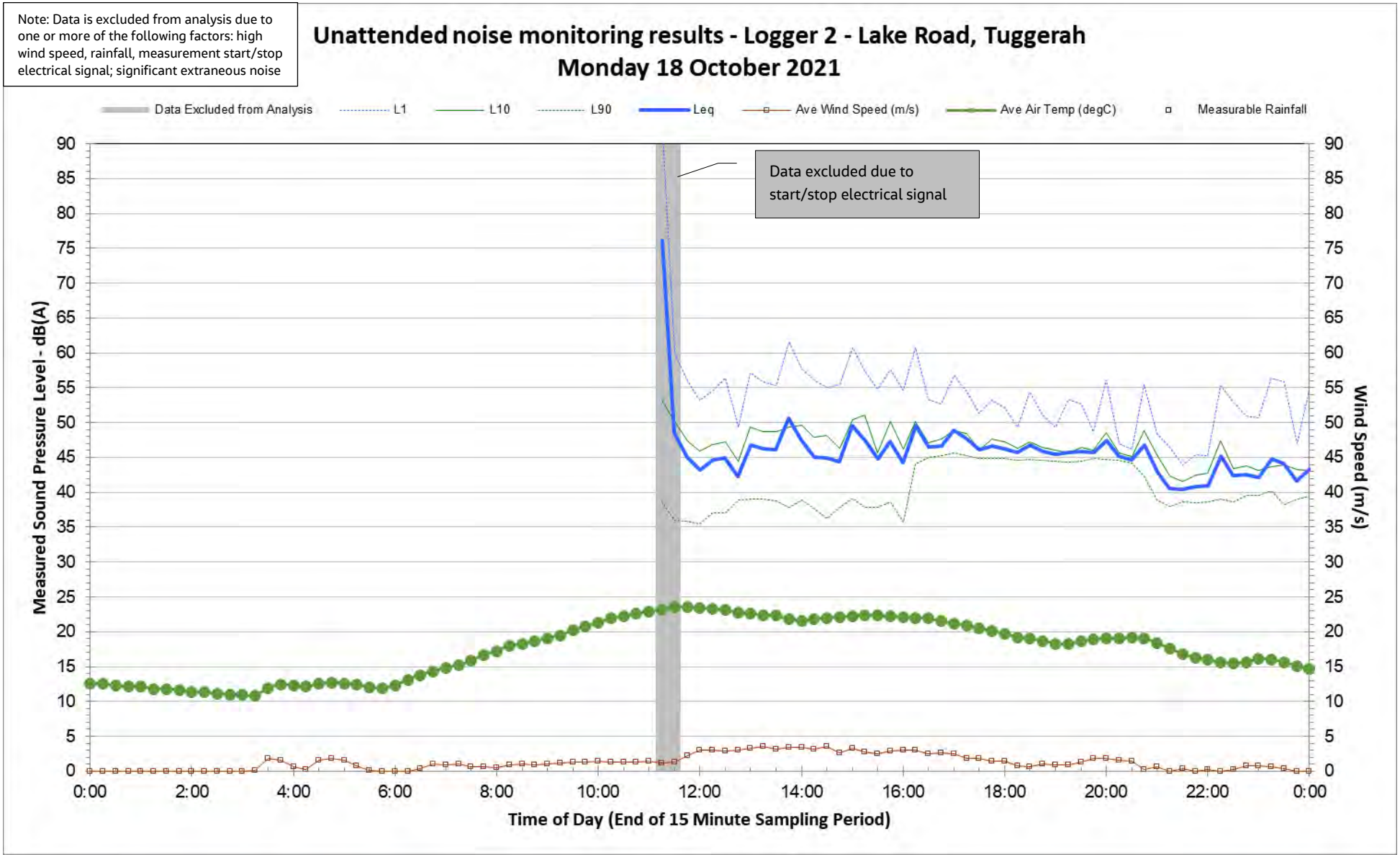
Measurement Date	OOHW1	ABL	LEQ
Monday 18 October 2021	18:00-22:00	39	45
Tuesday 19 October 2021	18:00-22:00	40	47
Wednesday 20 October 2021	18:00-22:00	38	47
Thursday 21 October 2021	18:00-22:00	36	42
Friday 22 October 2021	18:00-22:00	34	42
Saturday 23 October 2021	07:00-8:00 & 13:00-22:00	35	44
Sunday 24 October 2021	08:00-18:00	41	46
Monday 25 October 2021	18:00-22:00	39	46
Median (RBL)		**38**	
Logarithmic Average (Leq)			**45**

Measurement Date	OOHW2	ABL	LEQ
Monday 18 October 2021	22:00-07:00	37	47
Tuesday 19 October 2021	22:00-07:00	36	46
Wednesday 20 October 2021	22:00-07:00	36	45
Thursday 21 October 2021	22:00-07:00	35	45
Friday 22 October 2021	22:00-07:00	33	43
Saturday 23 October 2021	22:00-08:00	33	39
Sunday 24 October 2021	18:00-07:00	34	41
Monday 25 October 2021	22:00-07:00	37	44
Median (RBL)		**35**	
Logarithmic Average (Leq)			**44**

Background Noise Level Measurement Results – NML-2: 4 Arunta Road, Tuggerah

Measurement Date	**Standard Hours**	**ABL**	**LEQ**
Thursday 28 October 2021	07:00-18:00	44	55
Friday 29 October 2021	07:00-18:00	46	54
Saturday 30 October 2021	08:00-13:00	32	44
Sunday 31 October 2021			
Monday 1 November 2021	07:00-18:00	45	54
Tuesday 2 November 2021	07:00-18:00	45	54
Wednesday 3 November 2021	07:00-18:00	45	54
Thursday 4 November 2021	07:00-18:00	44	54
Median (RBL)		**45**	
Logarithmic Average (Leq)			**54**
Measurement Date	**OOHW1**	**ABL**	**LEQ**
Thursday 28 October 2021	18:00-22:00	41	49
Friday 29 October 2021	18:00-22:00	39	48
Saturday 30 October 2021	07:00-8:00 & 13:00-22:00	39	49
Sunday 31 October 2021	08:00-18:00	40	50
Monday 1 November 2021	18:00-22:00	39	48
Tuesday 2 November 2021	18:00-22:00	42	50
Wednesday 3 November 2021	18:00-22:00	43	51
Thursday 4 November 2021	18:00-22:00	42	48
Median (RBL)		**41**	
Logarithmic Average (Leq)			**49**
Measurement Date	**OOHW2**	ABL	LEQ
Thursday 28 October 2021	22:00-07:00	38	48
Friday 29 October 2021	22:00-07:00	37	44
Saturday 30 October 2021	22:00-08:00	31	42
Sunday 31 October 2021	18:00-07:00	34	44
Monday 1 November 2021	22:00-07:00	33	47
Tuesday 2 November 2021	22:00-07:00	33	48
Wednesday 3 November 2021	22:00-07:00	32	48
Thursday 4 November 2021	22:00-07:00		
Median (RBL)		**33**	
Logarithmic Average (Leq)			**47**

Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise



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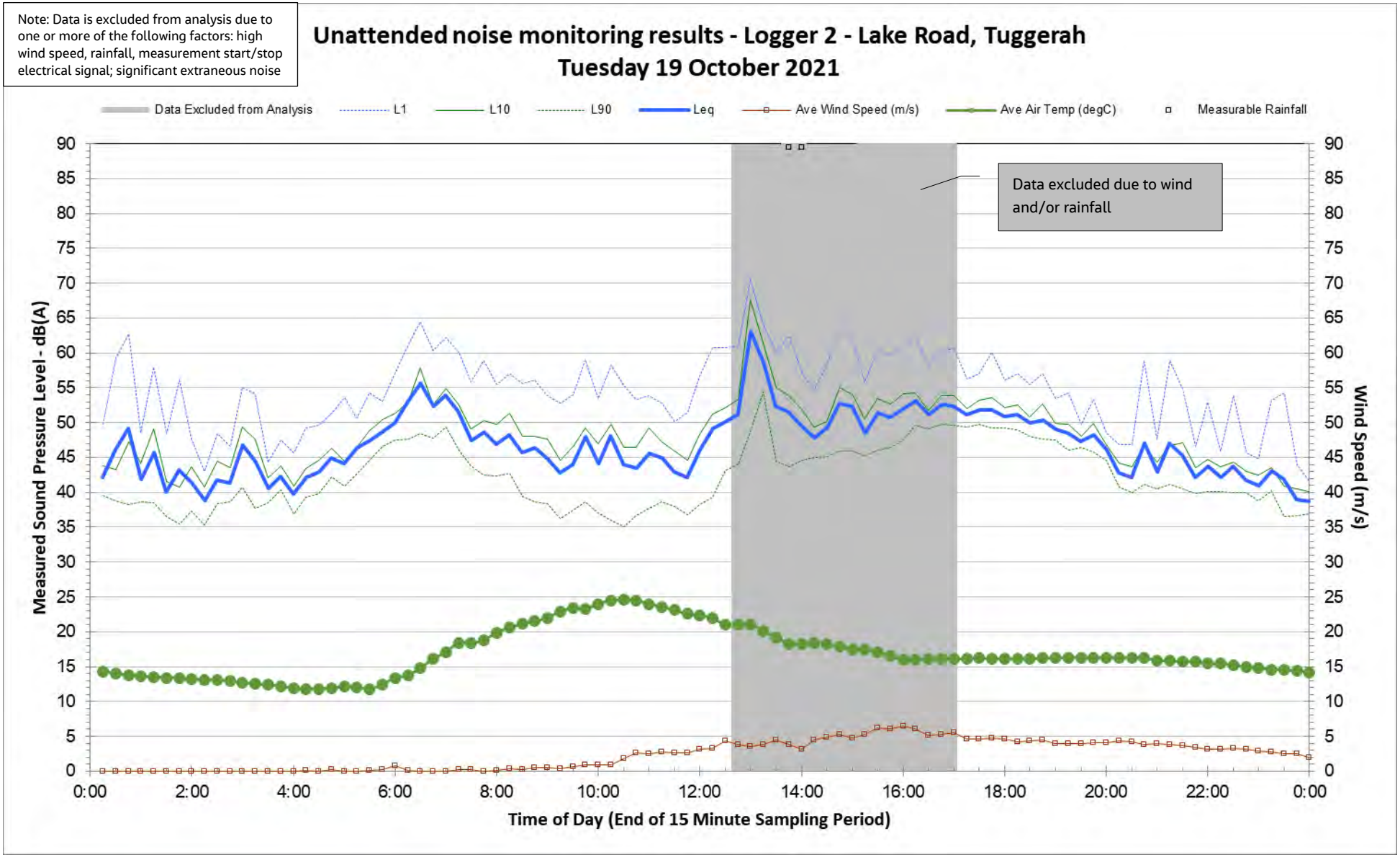
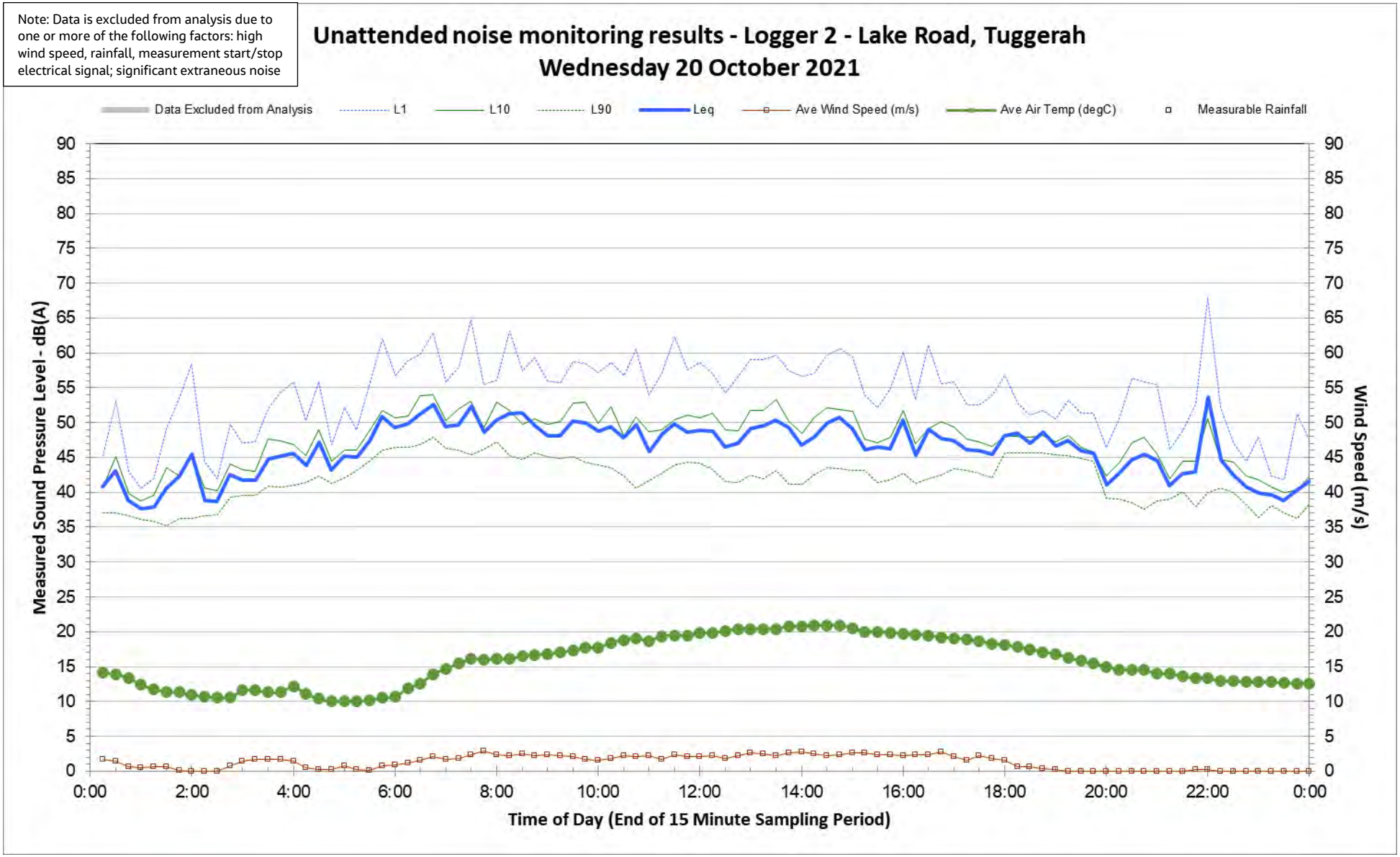
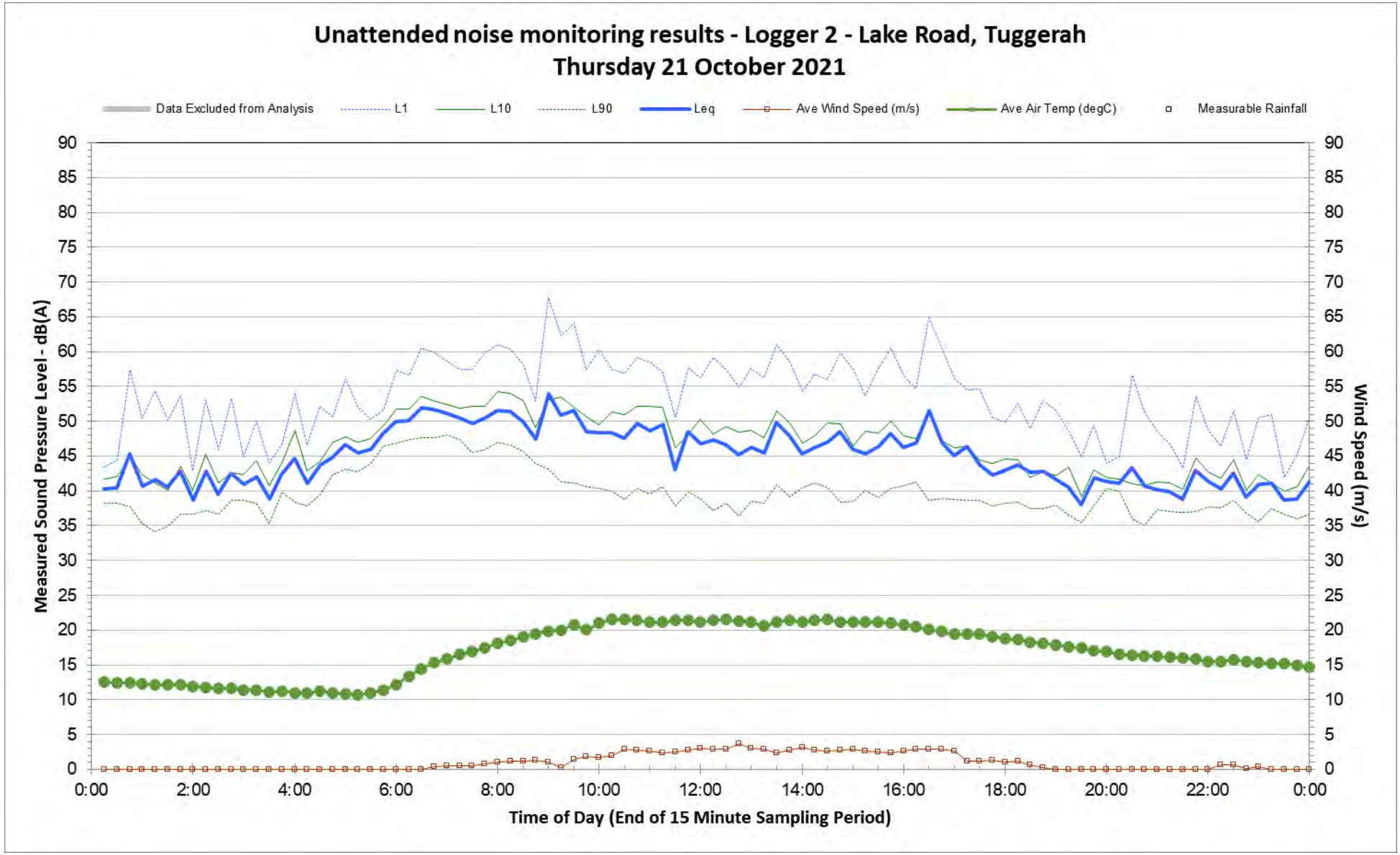
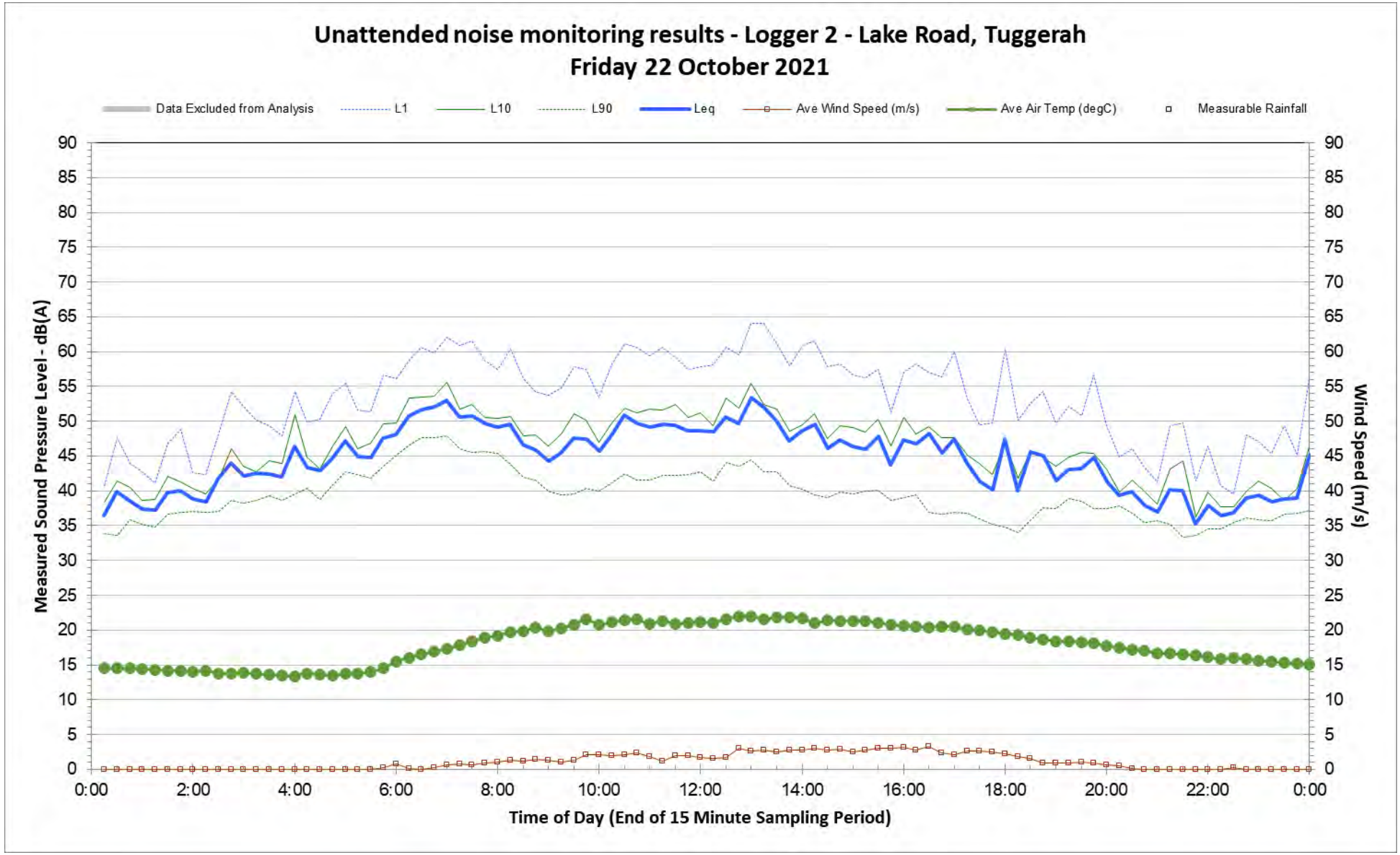


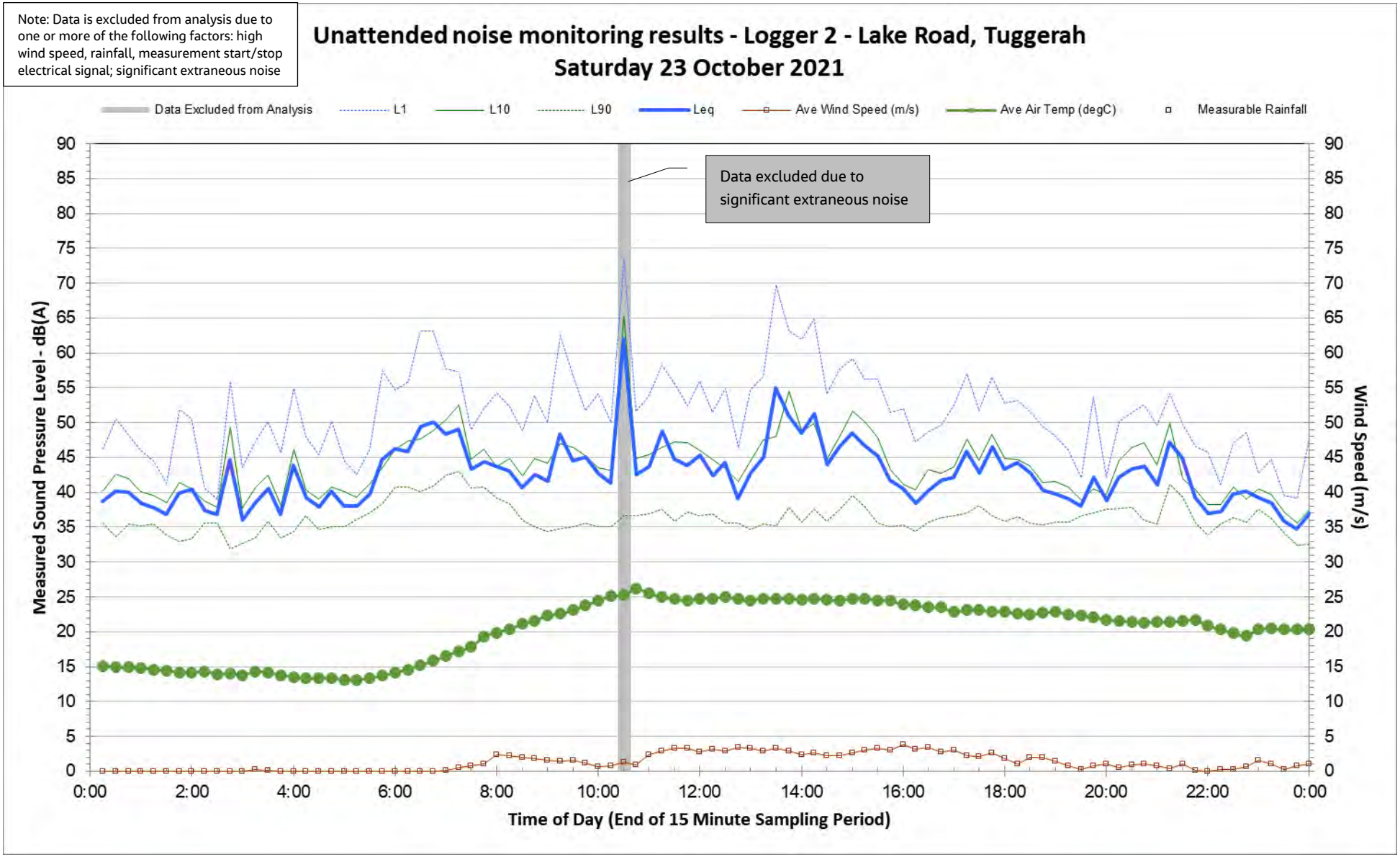
Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise



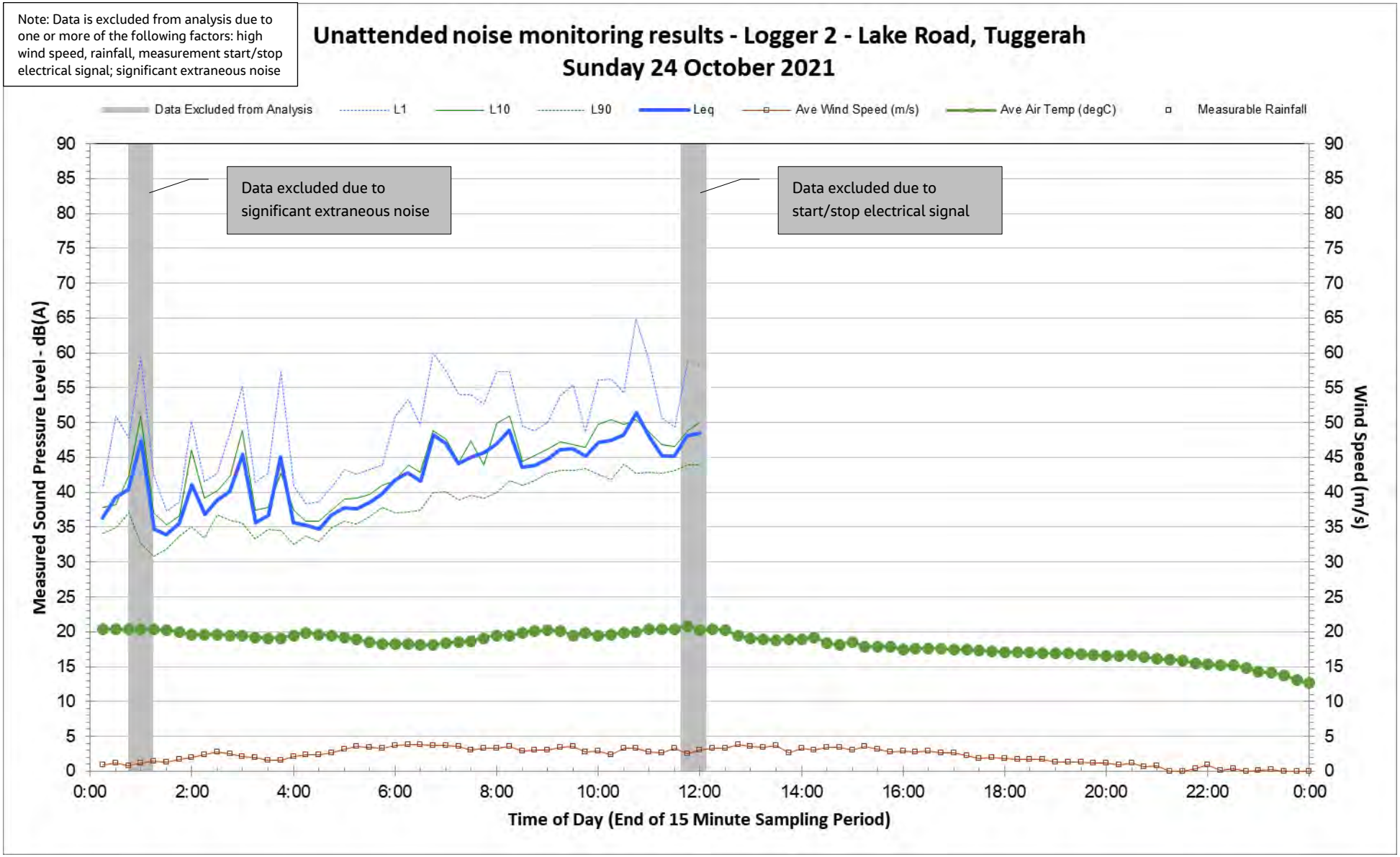

Unattended noise monitoring results - Logger 2 - Lake Road, Tuggerah
Thursday 21 October 2021
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Unattended noise monitoring results - Logger 2 - Lake Road, Tuggerah
Friday 22 October 2021
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sampling Period)

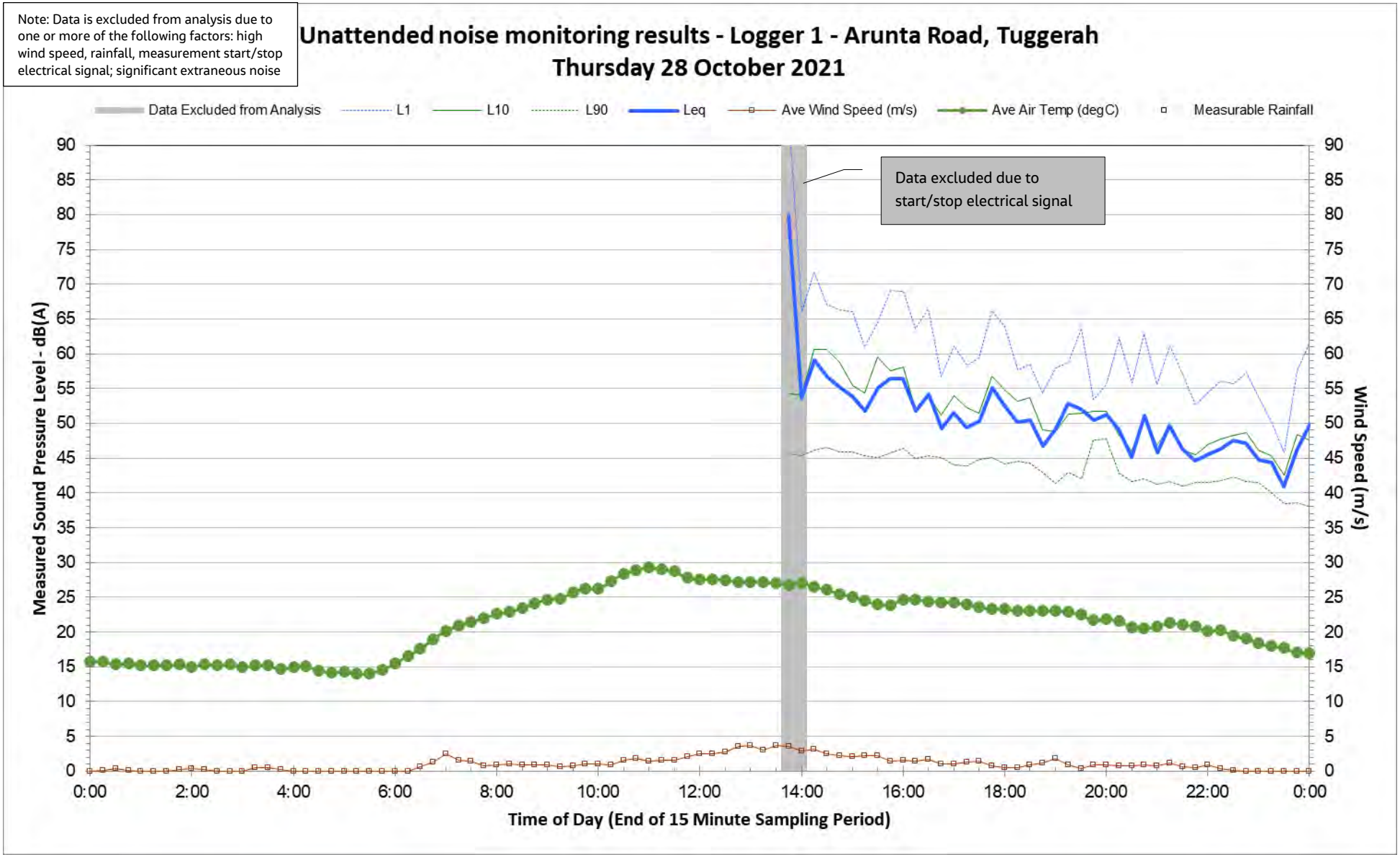
Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise



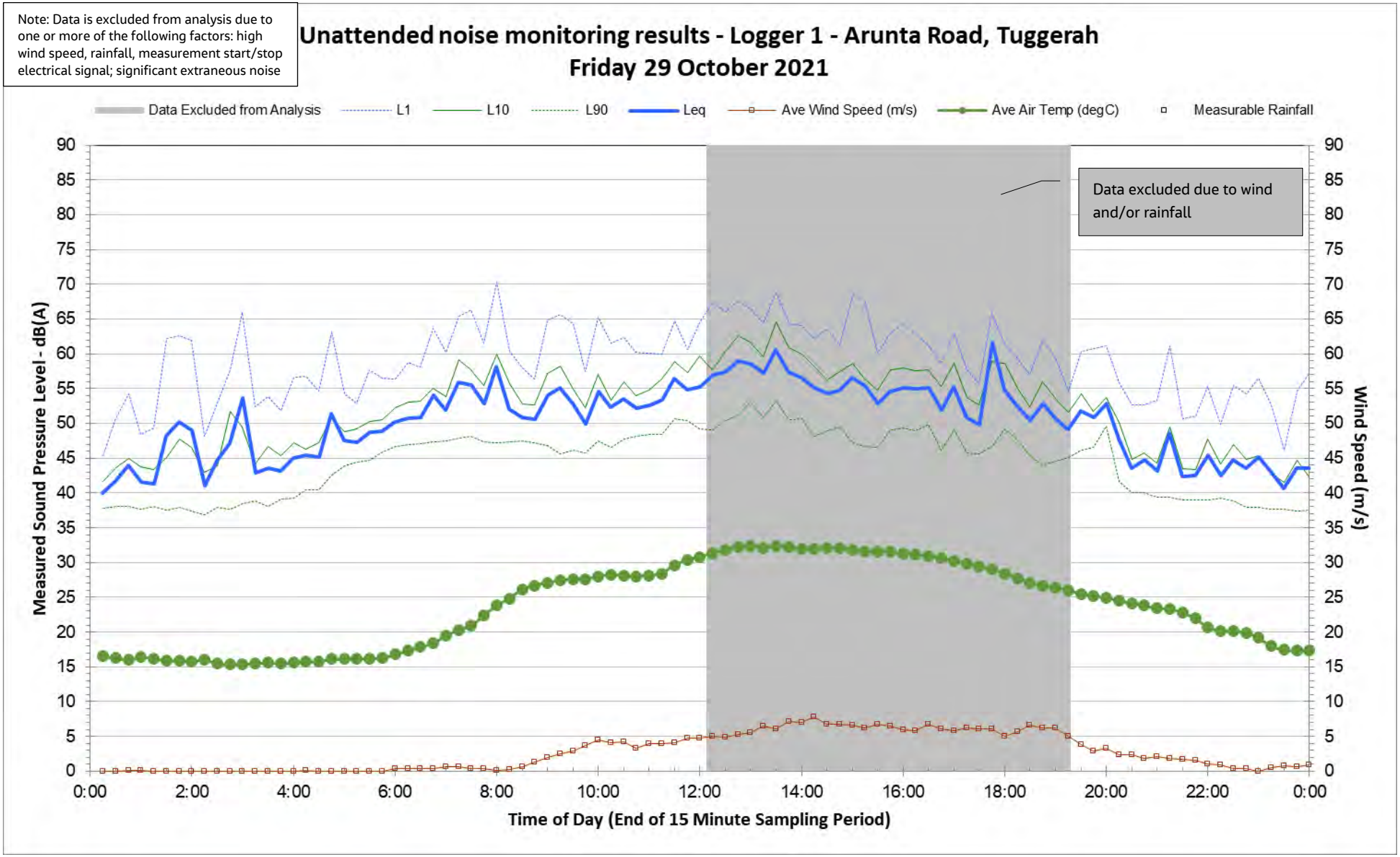
Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise

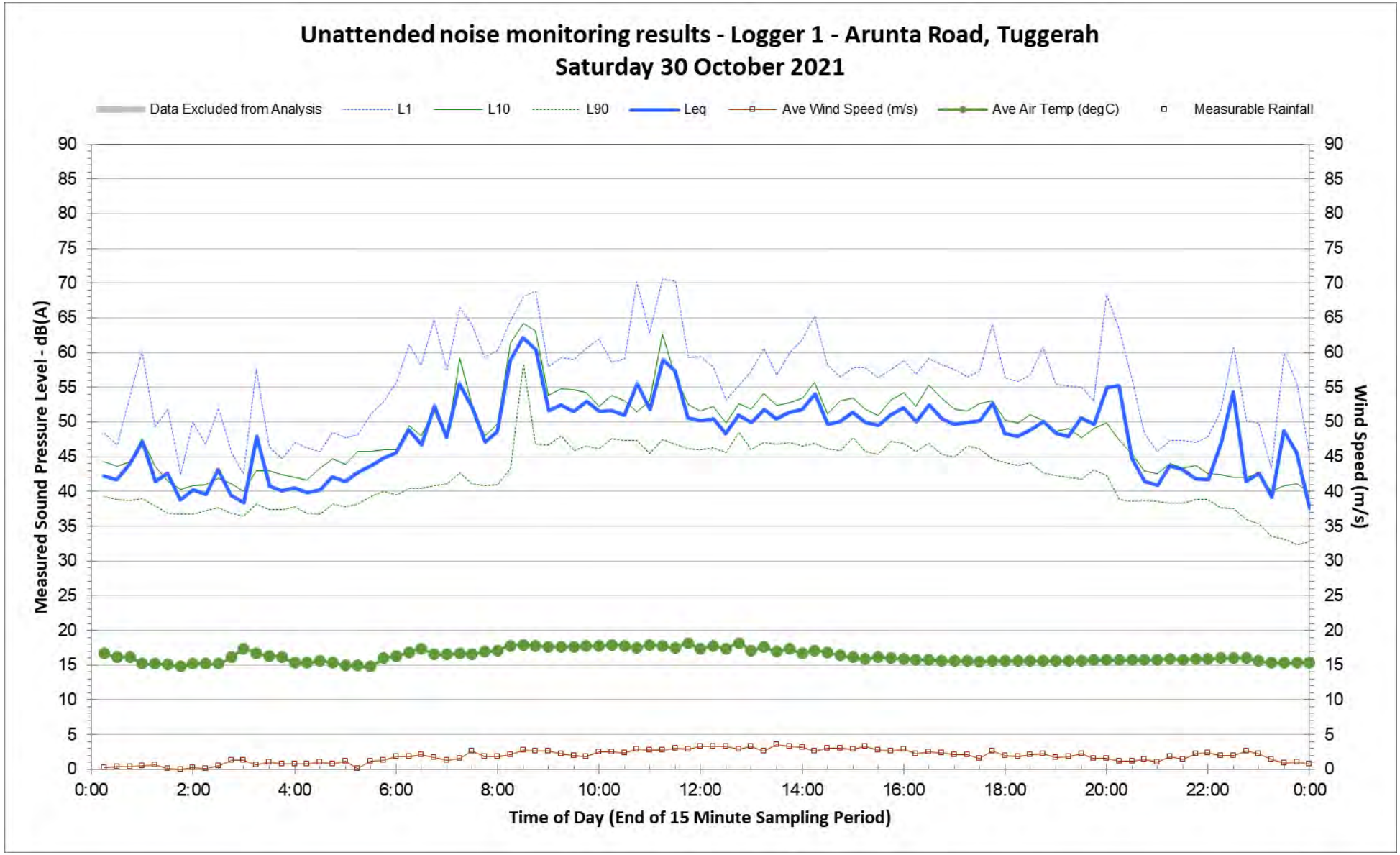


Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise

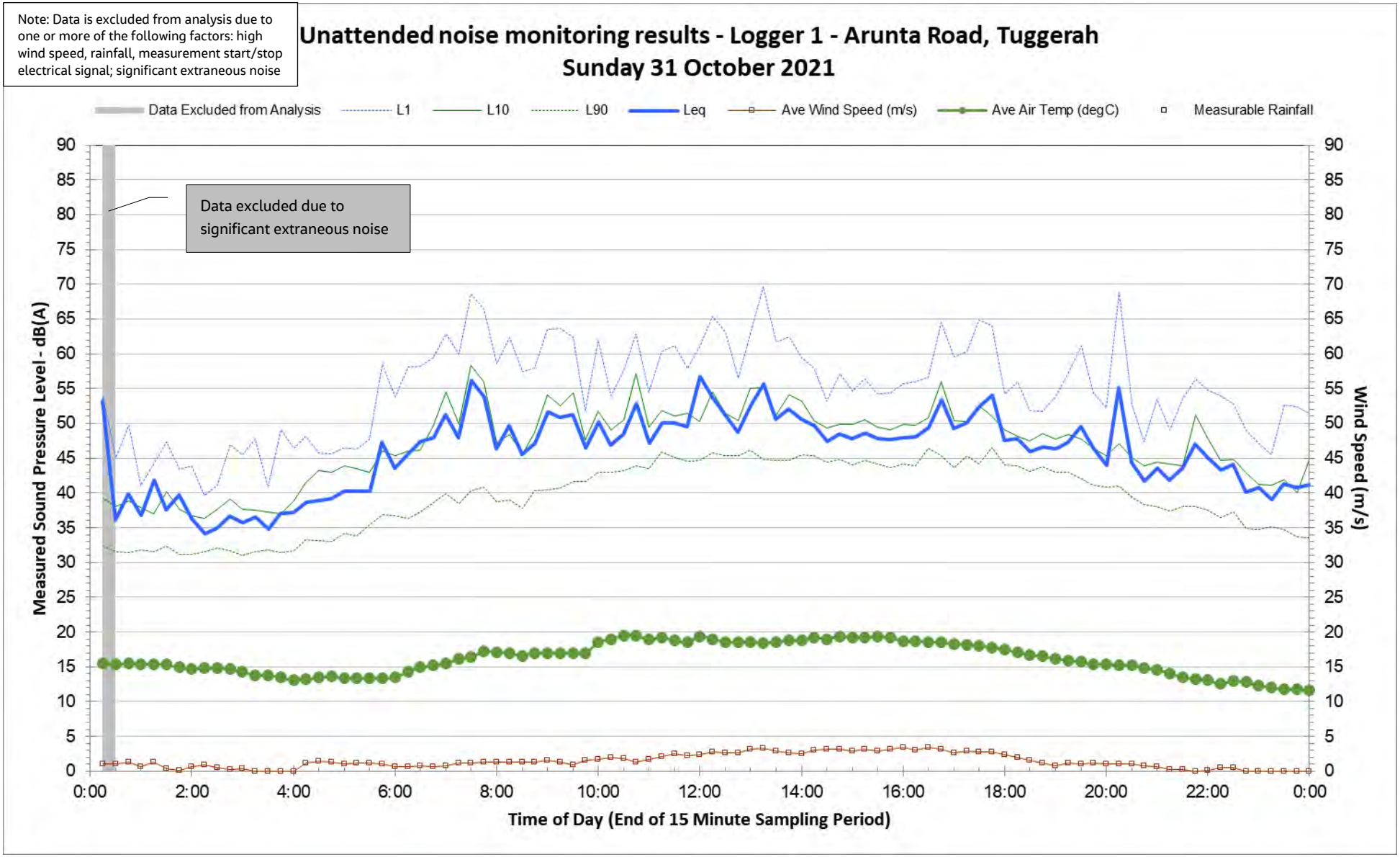


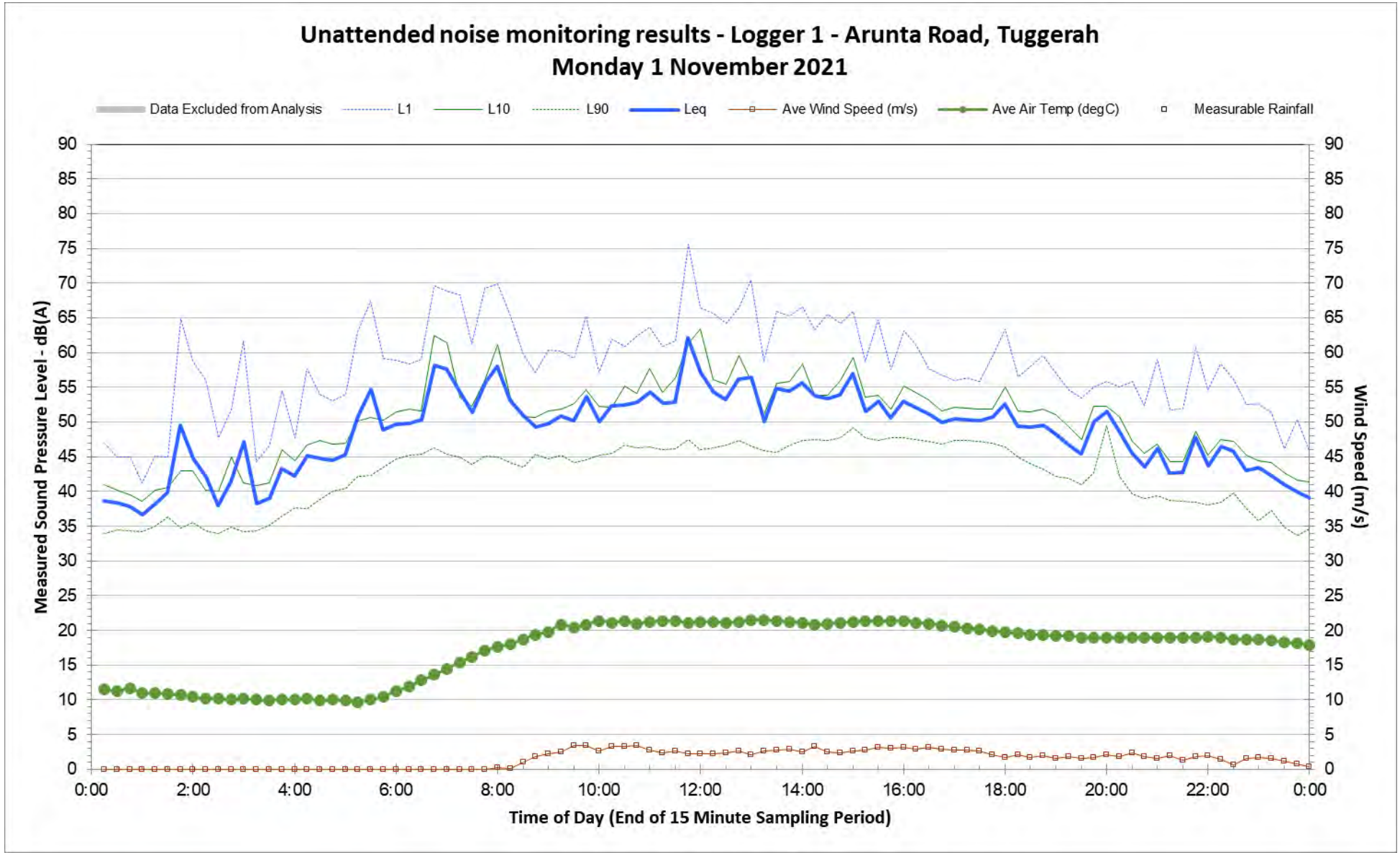
Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise

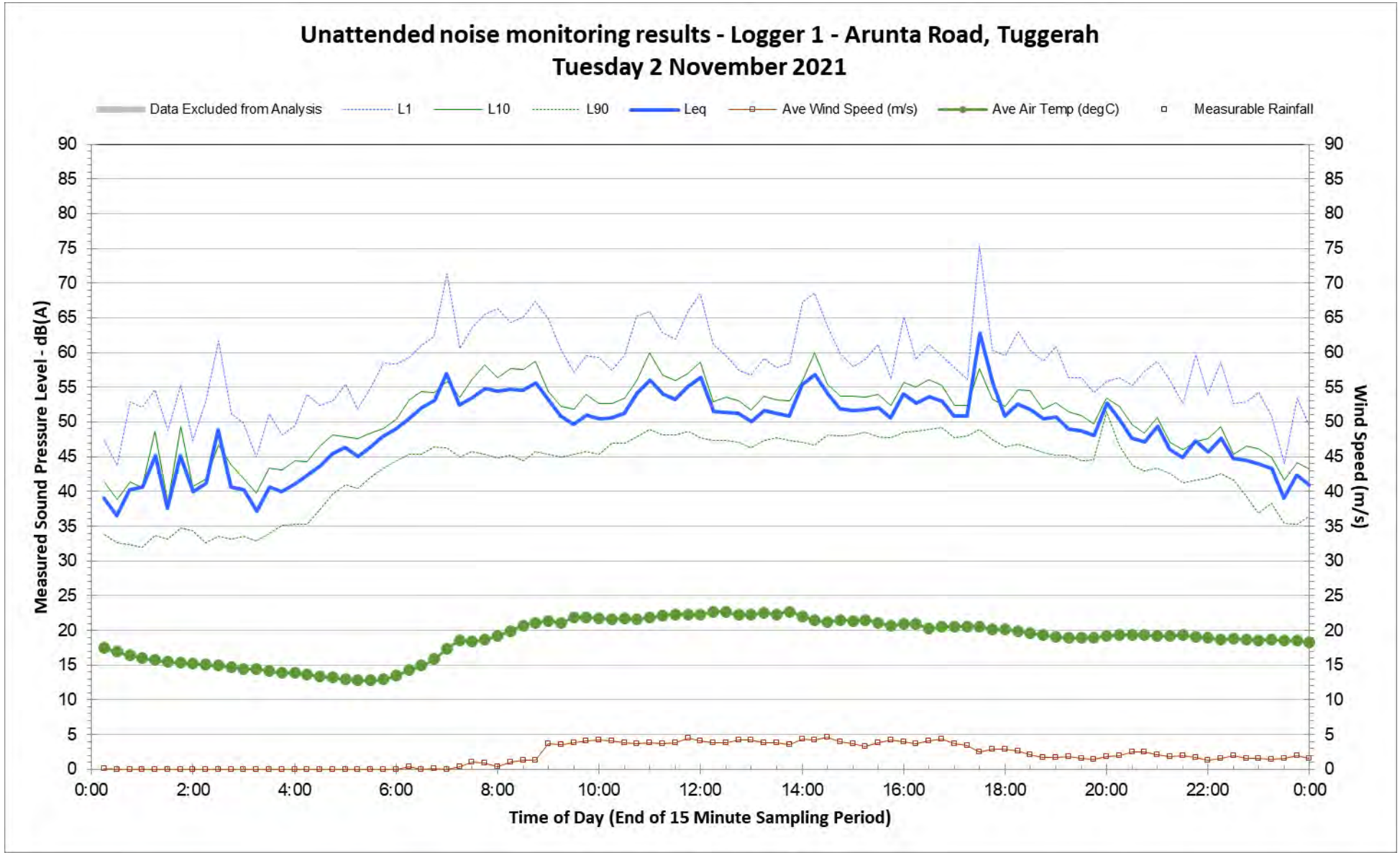



Unattended noise monitoring results - Logger 1 - Arunta Road, Tuggerah
Saturday 30 October 2021
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

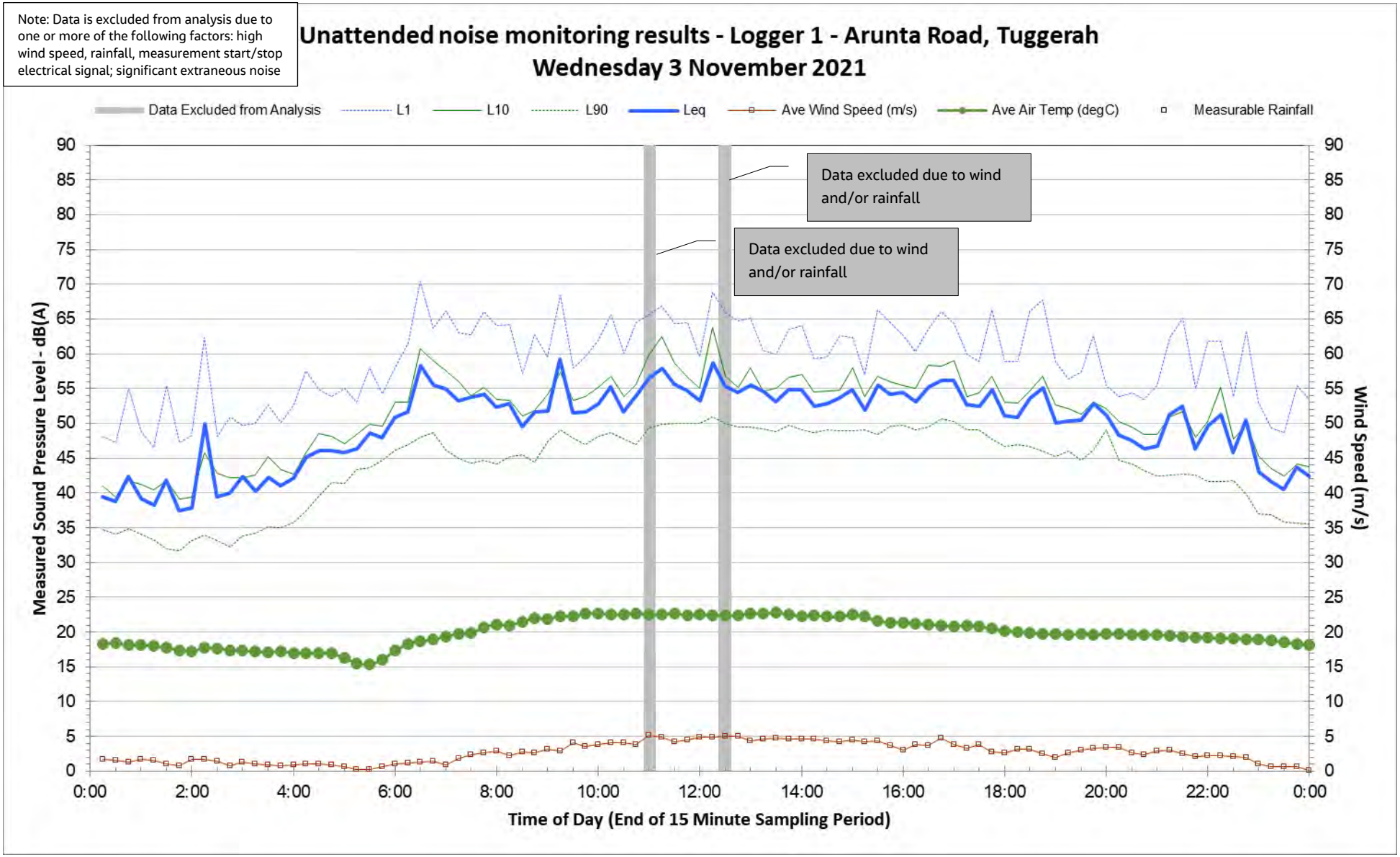
Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise



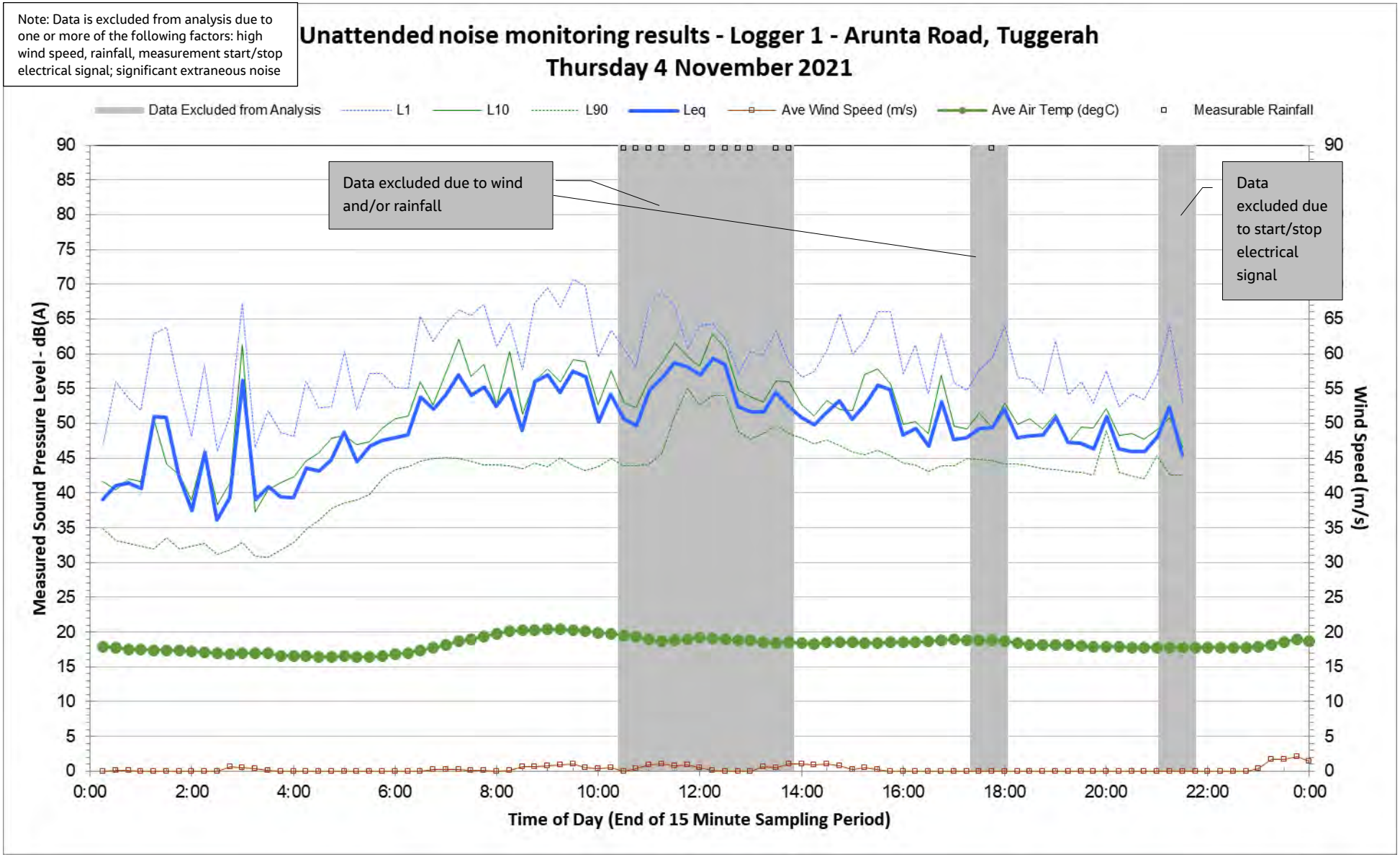

Unattended noise monitoring results - Logger 1 - Arunta Road, Tuggerah
Monday 1 November 2021
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Unattended noise monitoring results - Logger 1 - Arunta Road, Tuggerah
Tuesday 2 November 2021
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sampling Period)

Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise



Note: Data is excluded from analysis due to one or more of the following factors: high wind speed, rainfall, measurement start/stop electrical signal; significant extraneous noise



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Sound Level Meter
IEC 61672-3.2013
Calibration Certificate

Calibration Number C21575

Client Details	Jacobs Level 4/12 Stewart Avenue Newcastle West NSW 2303
Equipment Tested/ Model Number :	ARL Ngara
Instrument Serial Number :	8780B7
Microphone Serial Number :	318497
Pre-amplifier Serial Number :	27995

Pre-Test Atmospheric Conditions		**Post-Test Atmospheric Conditions**	
Ambient Temperature :	20.5°C	**Ambient Temperature :**	20.9°C
Relative Humidity :	44.8%	**Relative Humidity :**	44.9%
Barometric Pressure :	101.3kPa	**Barometric Pressure :**	101.3kPa

Calibration Technician :	Lucky Jaiswal	**Secondary Check:**	Max Moore
Calibration Date :	6 Sep 2021	**Report Issue Date :**	7 Sep 2021

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
12: Acoustical Sig. tests of a frequency weighting	*Pass*	17: Level linearity incl. the level range control	*Pass*
13: Electrical Sig. tests of frequency weightings	*Pass*	18: Toneburst response	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	19: C Weighted Peak Sound Level	*N/A*
15: Long Term Stability	*Pass*	20: Overload Indication	*Pass*
16: Level linearity on the reference level range	*Pass*	21: High Level Stability	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2013 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013 and because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in IEC 61672-1:2013.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
125Hz	*0.13dB*	*Temperature*	*0.2°C*
1kHz	*0.13dB*	*Relative Humidity*	*2.4%*
8kHz	*0.14dB*	*Barometric Pressure*	*0.015kPa*
Electrical Tests	*0.10dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

Acoustic Research Labs Pty Ltd is NATA Accredited Laboratory Number 14172.
Accredited for compliance with ISO/IEC 17025 - calibration.

The results of the tests, calibrations and/or measurements included in this document are traceable to SI units.

NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration and inspection reports.

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Appendix C. Descriptions of additional mitigation measures

Measure	Description	Abbreviation
Periodic Notification	For each IP project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders . The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the IP Community Engagement Team in cases where AMMM are not triggered as shown in Tables 9 to 11, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the IP Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	PN
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise). The purpose of monitoring is to confirm that: ▪ Construction noise and vibration from the project are consistent with the predictions in the noise assessment ▪ Mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIA amended. Refer to Section 8 for more details.	V
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. ▪ Letters may be letterbox dropped or hand distributed ▪ Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs ▪ Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented.	SN

Measure	Description	Abbreviation
	Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	
Respite Offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre- purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all IP projects.	RO
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative construction methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week, except where there is a Duration Respite. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6). Note; this management measure does not apply to OOHW Period 1 – Days (See Table 1).	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all IP projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with IP Community Engagement Representatives.	DR