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M1 Pacific Motorway extension to Raymond Terrace

Noise and Vibration Working Paper

Transport for NSW | July 2021

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Executive summary

Background

Transport for New South Wales (Transport) proposes to construct the M1 Pacific Motorway extension to Raymond Terrace (the project). Approval is sought under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* and Part 9, Division 1 of the *Environment Protection and Biodiversity Conservation Act 1999*.

Performance outcomes

This assessment has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) (SSI 7319) relating to noise and vibration. In addition, the desired performance outcomes for the project in relation to noise and vibration as outlined in the SEARs (SSI 7319) are to:

- Minimise the adverse impacts of construction noise and vibration (including airborne noise, ground-borne noise and blasting) on acoustic amenity and the structural integrity of buildings and items including Aboriginal places and environmental heritage
- Manage increases in noise emissions affecting nearby properties and other sensitive receivers during operation of the project to protect the amenity and well-being of the community
- Manage increases in noise emissions and vibration affecting environmental heritage as defined in the *Heritage Act 1977* during operation of the project.

Overview of noise and vibration impacts

In accordance with the requirements of the NSW Interim Construction Noise Guideline, construction noise impacts are based on a realistic worst-case assessment. There would frequently be periods when construction noise levels are much lower than the worst-case levels or when no equipment is in use resulting in no impacts.

Key findings of the construction noise and vibration impact assessment include:

- Highest construction noise impacts at residential receivers located near the construction work or near the ancillary facilities, at Black Hill (NCA01B), Tarro (NCA04A, NCA04B and NCA07), Tomago (NCA09) and Heatherbrae (NCA14A)
- Highly intrusive noise impacts are predicted for up to 13 residential receivers closest to the construction work in NCA04A during most construction periods when noise intensive plant and equipment are operating
- Up to 24 residential receivers in total may be subject to construction noise levels above the Highly Noise Affected threshold (greater than 75 dB(A)) and these receivers are all located in NCA04A, directly north of the New England Highway in Tarro
- One educational facility (Tarro Public School) is predicted to experience clearly audible noise levels for some of the construction scenarios and activities being carried out near the receiver
- Two recreational facilities (Pasadena Crescent Reserve Soccer Fields and Hunter Region Botanic Gardens) are predicted to experience clearly audible impacts, moderately intrusive impacts or highly intrusive impacts, depending on the type of construction activity being carried out near the receivers
- Commercial and industrial receivers are located directly adjacent to the construction footprint of the project. Depending on the distance to and the type of construction, commercial and industrial receivers may experience clearly audible, moderately intrusive or highly intrusive noise impacts
- Residential, commercial and industrial receiver buildings are typically at distances of 50 metres or more from the construction work and therefore, would experience very low to low vibration impacts. However, some residential receiver buildings are located at less than 50 metres from the construction work, typically resulting in the potential of experiencing low or medium risk of structural damage and/or human

disturbance, in the absence of vibration mitigation. Residential receiver buildings in NCA04A are the closest to the construction work and may experience medium risk of structural damage and/or high risk of human disturbance where vibration mitigation isn't applied.
- Heritage-listed structures located in various areas near the project construction footprint were assessed and determined to be outside of the recommended minimum working distances. Therefore, cosmetic or structure damage to heritage items are not anticipated
- The proposed construction traffic routes and forecast redistribution of traffic is unlikely to result in a noticeable increase in traffic noise levels.

During operation, the assessment identified the following key findings:

- On average the project is predicted to result in reduced traffic noise for about 10 per cent of receivers
- Road traffic noise was predicted to impact a high number of receiver buildings in Tarro (NCA04A) and Heatherbrae (NCA14A), given the suburban settings and the close proximity of receivers to the project
- The change in road traffic noise exposure as a result of the project is predicted to be typically less than 2 dB(A) at about 83 per cent of the sensitive receivers
- An average of 17 per cent of receiver buildings within the operational study area are predicted to experience increases in traffic noise levels by over 2 dB(A)
- A total of 189 sensitive receiver buildings (out of 1671 receiver buildings assessed within the operational study area) were identified as being eligible for consideration for additional noise mitigation
- Where the project involves the widening of the existing road, the number of maximum noise level events experienced by residential receivers would potentially increase when compared to the existing traffic noise environment
- Where the project results in vehicles using the new carriageways, located further away from residential receivers, it was found that maximum noise level events would potentially reduce when compared to the existing traffic noise environment.

Management measures

A construction noise and vibration management plan would be prepared to mitigate and manage noise and vibration impacts during the construction of the project. The management plan would include consideration of different plant and equipment, scheduling of noise intensive equipment to less sensitive periods (i.e. standard hours), noise and vibration monitoring and building surveys.

The inclusion of potential noise management measures for operational traffic noise, such as quieter pavements, noise barriers and at-property noise mitigation treatment would be determined in accordance with Transport guidelines and would aid in reducing traffic noise levels to affected residential receivers during operation of the project. Based on the noise barrier assessment and feasibility constraints, the project would adopt the proposed barrier heights of about 3.8 metres (NB.02) and 4 metres (NB.03).

The application of these management measures into the project design would be investigated further during detailed design.

Conclusion

During the construction of the project, construction noise impact to receivers would vary depending on the construction scenario, the type of activities and/or the plant items used. Most receivers would experience noticeable construction noise impacts, with a few receivers potentially impacted by highly intrusive noise levels during some construction scenarios and activities. Construction vibration impacts to residential, commercial, industrial and/or heritage structures as well as buried utilities would generally be minimal and within the nominated vibration limits.

Operational road traffic noise from the project would potentially impact sensitive receivers surrounding the project. Noise mitigation measures in the form of quieter pavements, noise barriers and/or at-property treatment have been considered and the final reasonable and feasible noise mitigation options would be determined during the detailed design stage of the project.

Overall, these outcomes are consistent with the desired performance outcome for the project which, for noise and vibration, is to minimise noise and vibration impacts to the greatest extent practicable through the design, construction and operation of the project.

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1. Introduction

1.1 Background

Transport for New South Wales (Transport) proposes to construct the M1 Pacific Motorway extension to Raymond Terrace (the project). Approval is sought under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and Part 9, Division 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The project would connect the existing M1 Pacific Motorway at Black Hill and the Pacific Highway at Raymond Terrace within the City of Newcastle and Port Stephens Council local government areas. The project would provide regional benefits and substantial productivity benefits on a national scale. The project location is shown in **Figure 1-1** within its regional context.

1.2 Project description

The project would include the following key features:

- A 15 kilometre motorway comprised of a four lane divided road (two lanes in each direction)
- Motorway access from the existing road network via four new interchanges at:
  - Black Hill: connection to the M1 Pacific Motorway
  - Tarro: connection and upgrade (six lanes) to the New England Highway between John Renshaw Drive and the existing Tarro interchange at Anderson Drive
  - Tomago: connection to the Pacific Highway and Old Punt Road
  - Raymond Terrace: connection to the Pacific Highway.
- A 2.6 kilometre viaduct over the Hunter River flood plain including new bridge crossings over the Hunter River, the Main North Rail Line and the New England Highway
- Bridge structures over local waterways at Tarro and Raymond Terrace, and an overpass for Masonite Road in Heatherbrae
- Connections and modifications to the adjoining local road network
- Traffic management facilities and features
- Roadside furniture including safety barriers, signage, fauna fencing and crossings and street lighting
- Adjustment of waterways, including at Purgatory Creek at Tarro and tributary of Viney Creek
- Environmental management measures including surface water quality control measures
- Adjustment, protection and/or relocation of existing utilities
- Walking and cycling considerations, allowing for existing and proposed cycleway route access
- Permanent and temporary property adjustments and property access refinements
- Construction activities, including establishment and use of temporary ancillary facilities, temporary access tracks, haul roads, batching plants, temporary wharves, soil treatment and environmental controls.

A detailed project description is provided in Chapter 5 of the environmental impact statement (EIS). The locality of the project is shown in **Figure 1-1**, while an overview of the project is shown in **Figure 1-2**.

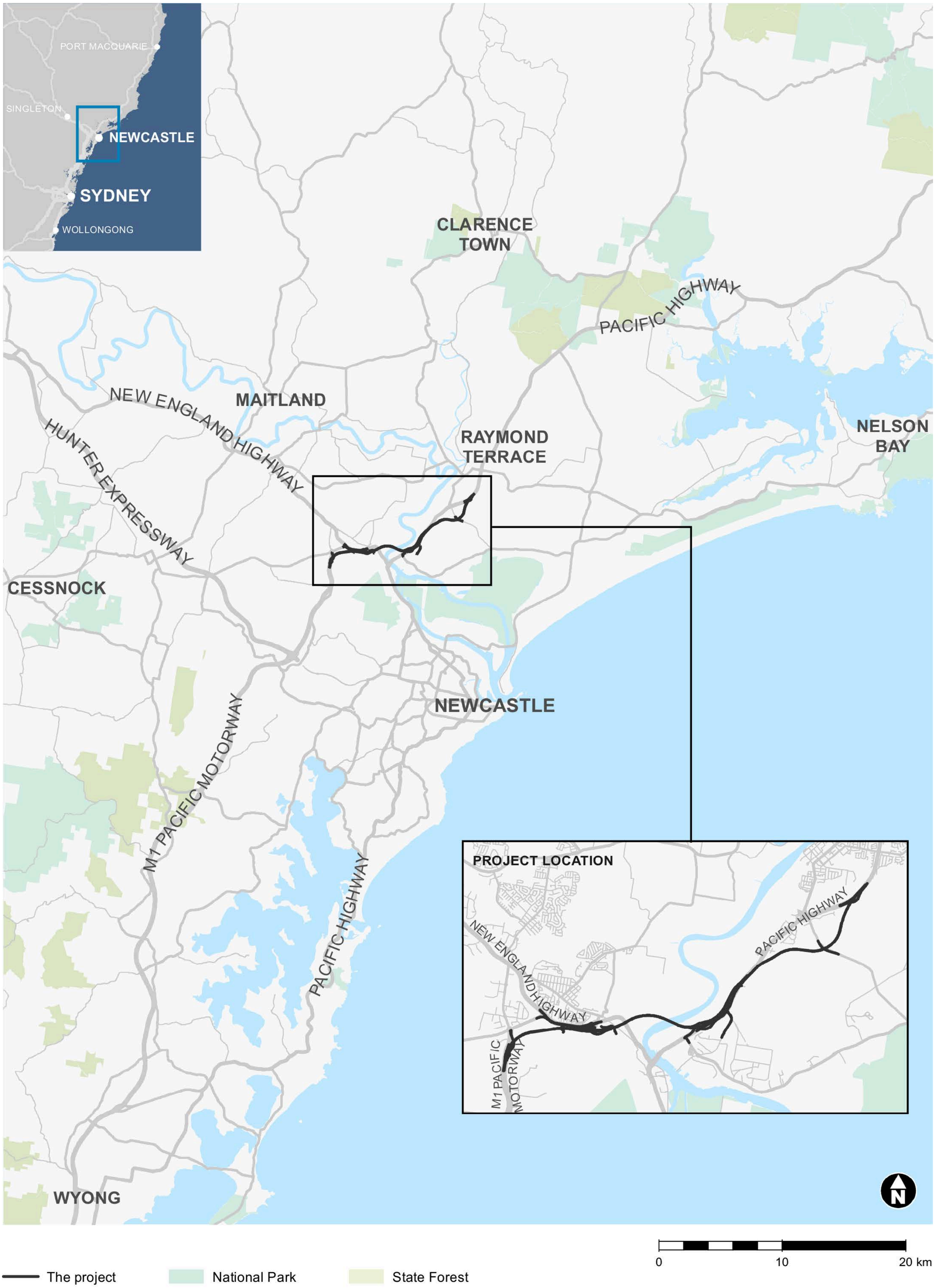

Figure 1-1 Regional context of the project

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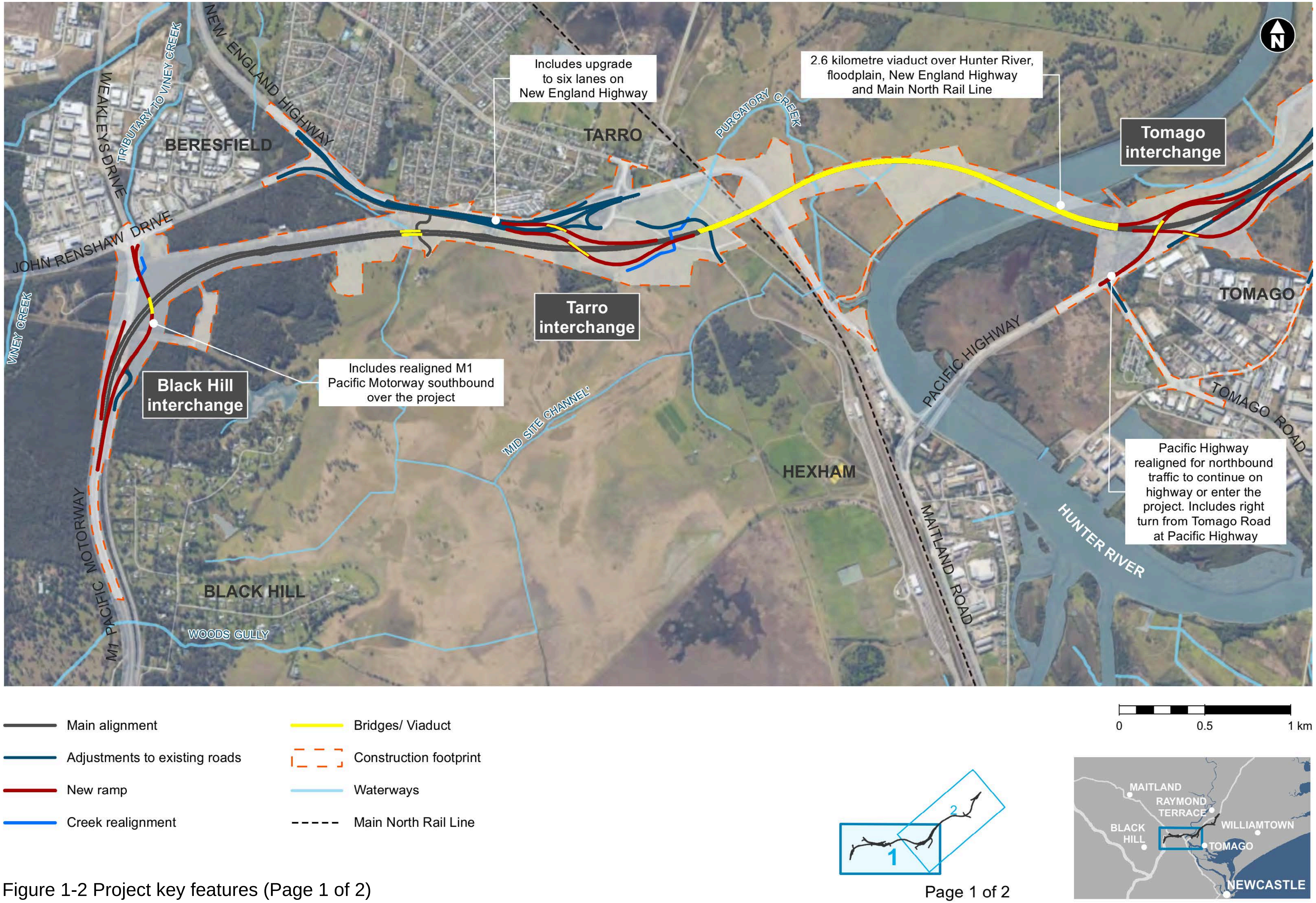

Figure 1-2 Project key features (Page 1 of 2)

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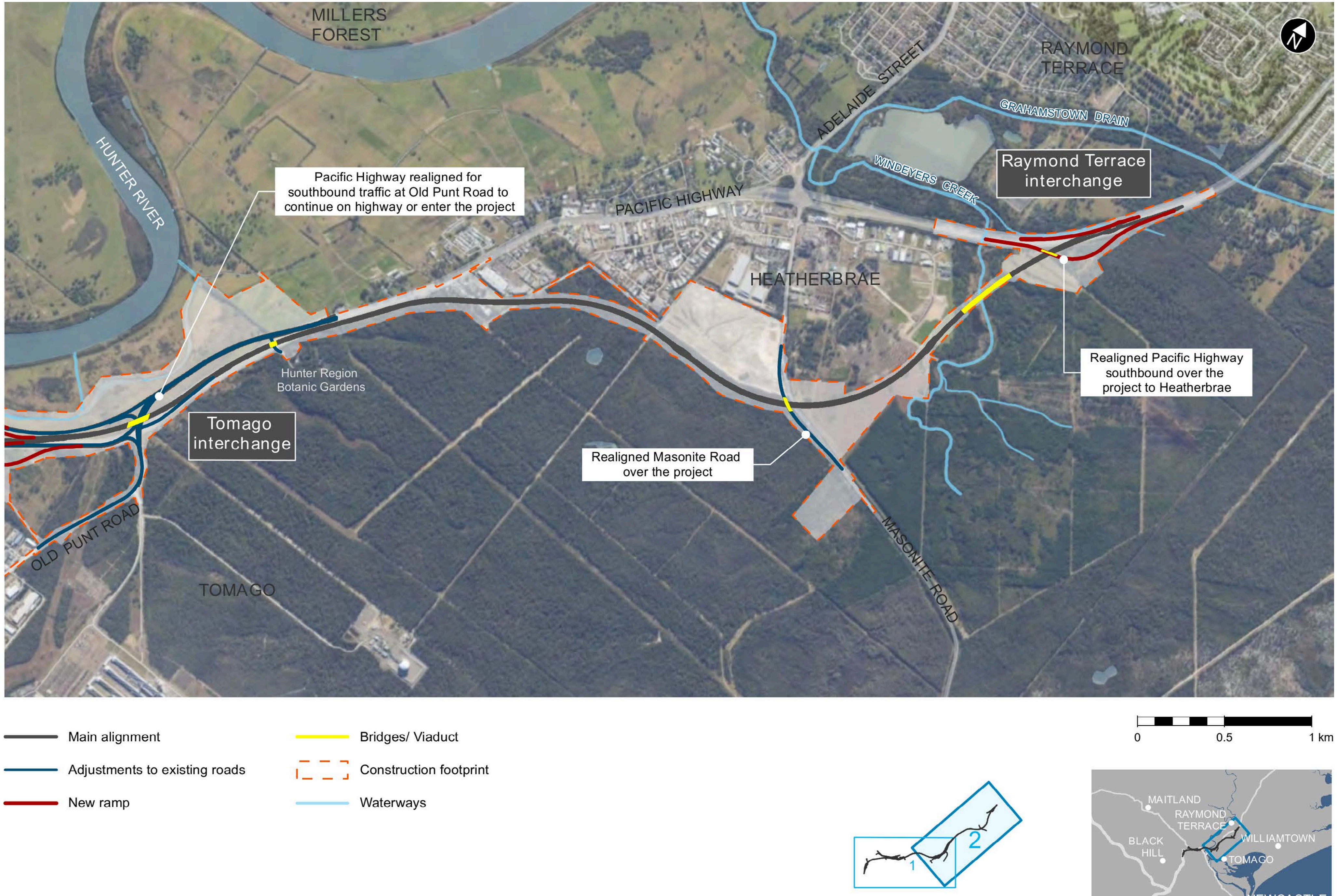

Figure 1-2 Project key features (Page 2 of 2)

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1.3 Performance outcomes

The desired performance outcomes for the project relating to noise and vibration are to:

- Minimise the adverse impacts of construction noise and vibration (including airborne noise, ground-borne noise and blasting) on acoustic amenity and the structural integrity of buildings and items including Aboriginal places and environmental heritage (refer to **Chapter 5** and **Chapter 8**)
- Manage increases in noise emissions affecting nearby properties and other sensitive receivers during operation of the project to protect the amenity and well-being of the community (refer to **Chapter 6** and **Chapter 8**)
- Manage increases in noise emissions and vibration affecting environmental heritage as defined in the *Heritage Act 1977* during operation of the project (refer to **Chapter 6** and **Chapter 8**).

1.4 Secretary's Environmental Assessment Requirements

This assessment forms part of the EIS for the project. The EIS has been prepared under Division 5.2 of the EP&A Act. This assessment has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) (SSI 7319) relating to noise and vibration and will assist the Minister for Planning and Public Spaces to make a determination on whether or not to approve the project. It provides an assessment of potential impacts of the project on noise and vibration and outlines proposed management measures.

In 2019 revised SEARs were issued for the project which included noise and vibration as a key issue. **Table 1-1** outlines the SEARs relevant to this assessment along with a reference to where these are addressed.

Table 1-1 SEARs relevant to noise and vibration

Secretary's requirement	Where addressed in this report
2. Noise and Vibration – Amenity	
1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration.	**Chapter 5** assesses construction noise and vibration impacts while **Chapter 6** assesses operational road traffic noise, in accordance with the guidelines as outlined in **Chapter 2.**
2. An assessment of construction noise and vibration impacts which must address:	
a) the nature of construction activities (including transport, tonal or impulsive noise-generating work and the removal of operational noise barriers, as relevant);	**Section 3.5.2** presents the proposed construction scenarios, which addresses activities with various noise characteristics. For annoying characteristics, such as tonal or impulsive noise, penalties have been included in the source noise levels for plant and equipment, which are detailed in **Appendix C.**
b) the intensity and duration of noise and vibration impacts (both air and ground borne);	Airborne noise is assessed in **Section 5.3**, while ground-borne noise is assessed in **Section 5.4**. **Section 3.5.3** presents the proposed construction hours and program, which is detailed in **Table 3-24**.

Secretary's requirement	Where addressed in this report
c) the need to balance timely conclusion of noise and vibration-generating work with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	**Section 3.5.3** presents the proposed construction hours, program and factors that may influence the timing and duration of construction activities. The environmental management measures presented in **Chapter 8** recommends a CNVMP to be prepared, which would incorporate standard and additional mitigation measures from the CNVG, such as respite periods.
d) the potential for extended standard construction hours and/or work outside standard construction hours, including predicted levels, exceedances and number of potentially affected receivers and justification for the activity in terms of the Interim Construction Noise Guideline (DECCW, 2009);	**Section 3.5.3** presents the proposed construction hours which include extended construction hours and out-of-hours work, and the justification and benefits for construction during extended hours **Section 5.3** presents the assessment of impacts for standard hours, extended hours and out-of-hours work.
e) potential noise and vibration mitigation measures, including timing of implementation; and	**Chapter 8** presents noise and vibration mitigation and management measures, including timing of implementation.
f) a cumulative noise and vibration assessment inclusive of impacts from other major development projects preparing for or commencing construction in the vicinity of the proposal.	A cumulative assessment of road traffic noise has been carried out for the project. **Section 3.6** outlines the methodology used and results of the assessment are included in **Chapter 5** and **Chapter 6**. **Chapter 7** presents an assessment of cumulative construction and operational noise and vibration impacts from the project and other projects in the vicinity.
3. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	**Section 5.7** presents the blasting impact assessment.
3. Noise and Vibration – Structural	
1. The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	**Section 3.6.1** addresses vibration impacts from operational traffic. However, vibration impacts from operational traffic travelling on the new and upgraded roads are negligible and have not been assessed further. **Section 5.6** presents the assessment of construction vibration impacts to nearby buildings and structures, including buried water, sewer and gas pipelines (**Section 5.6.4**), electrical and telecommunication utilities (**Section 5.6.5**) and heritage structures (**Section 5.6.6**) **Section 5.7** presents the assessment of blasting noise and vibration impacts with the potential of structural damage to nearby structures.
2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	**Section 5.7** presents the blasting impact assessment. Management measures are presented in **Chapter 8**.

1.5 Report structure

The report is structured as follows:

- Chapter 1 – Introduces the project with a summary of the project background and assessment objectives
- Chapter 2 – Sets out the relevant noise and vibration guidelines, standards and policies relevant to this assessment
- Chapter 3 – Describes the methodologies for assessing construction and operational noise and vibration
- Chapter 4 – Describes the existing environment, including sensitive receivers, noise catchment areas, noise monitoring locations and noise monitoring results
- Chapter 5 – Presents the outcomes of the construction noise and vibration impact assessment
- Chapter 6 – Presents the outcomes of the operational road traffic noise impact assessment
- Chapter 7 – Presents the qualitative assessment of potential cumulative construction and operational noise and vibration impacts with other projects near the project
- Chapter 8 – Presents the noise and vibration management measures applicable for the project
- Chapter 9 – Conclusion
- References
- Terms and acronyms.

2. Policy and planning setting

2.1 Construction noise and vibration policies, guidelines and standards

Transport's Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime Services, 2016) provides guidance for the assessment and management of construction noise and vibration and specifically provides guidance for determining the type of construction noise assessment to be carried out for the project. There are two parts of the CNVG that are used to determine the type of assessment required to be carried out:

- Duration of the impact on affected receivers
- Number of affected receivers.

The CNVG refers to the policies, guidelines and standards presented in **Table 2-1**, which have been adopted in the construction noise and vibration assessment for the project.

How these guidelines have been applied in the construction noise and vibration assessment methodology is detailed in **Section 3.5**.

Table 2-1 Construction noise and vibration policies, guidelines and standards

Guideline / policy document	Assessment aspect
Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime Services, 2016)	Airborne noise, ground-borne noise and vibration impacts (including construction traffic within the construction site boundary)
NSW Interim Construction Noise Guideline (ICNG) (Department of Environment and Climate Change, 2009)	Airborne noise and ground-borne noise impacts (including construction traffic within the construction site boundary)
Assessing Vibration: a technical guideline (Department of Environment and Climate Change, 2006)	Vibration amenity
British Standard BS 7385: Part 2-1993 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration (BSI 1993)	Vibration impacts to non-heritage structures
German Standard DIN 4150-3 (2016) Vibration in buildings – Part 3: Effects on structures (Deutsches Institut für Normung, 2016)	Vibration impacts to heritage sensitive structures, where structure is determined to be unsound
Australian Standard AS 2187.2-2006 Explosives – Storage and use – Part 2 Use of explosives	Blasting impacts
Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (ANZECC, 1990)	Blasting impacts
NSW Road Noise Policy (RNP) (Department of Environment, Climate Change and Water, 2011)	Construction road traffic noise impacts (on public roads)
Noise Criteria Guideline (NCG) (Roads and Maritime Services, 2015)	Construction road traffic noise impacts (on public roads)
Noise Policy for Industry (NPfI) (NSW Environment Protection Authority, 2017)	Background and ambient noise monitoring

2.2 Operational noise and vibration policies, guidelines and standards

The operational noise guidelines and policies, which have been adopted in the operational noise assessment for the project, are presented in **Table 2-2**. How these guidelines have been applied in the operational noise and vibration assessment methodology is detailed in **Section 3.6**.

Table 2-2 Operational noise policies, guidelines and standards

Guideline/policy document	Assessment aspect
NSW Road Noise Policy (RNP), Department of Environment, Climate Change and Water, 2011	Operational road traffic noise assessment
Noise Criteria Guideline (NCG), Roads and Maritime Services, 2015	Operational road traffic noise criteria based on Transport's interpretation and application of the RNP
Application Notes – Noise Criteria Guideline, Roads and Maritime Services, 2016	As above
Noise Mitigation Guideline (NMG), Roads and Maritime Services, 2015	Determining and applying operational road traffic noise mitigation measures
Noise Wall Design Guideline, Roads and Maritime Services, 2016	Guideline on the design of noise walls
At-Receiver Noise Treatment Guideline, Roads and Maritime Services, 2017	Overview and discussion of feasible and reasonable at-receiver noise mitigation measures
Noise Model Validation Guideline, Roads and Maritime Services, 2018	Operational road traffic noise model validation procedures
Environmental Noise Management Manual (ENMM), Roads and Traffic Authority, 2001	Operational road traffic noise impacts, including maximum noise level assessment
Australian Standard AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors	Provides recommended design sound levels for internal areas of occupied spaces

3. Assessment methodology

3.1 Overview

The methodology for the assessment of noise and vibration is outlined in the following sections and includes:

- Identification of receivers sensitive to noise and vibration during construction and operation of the project and associated noise catchment areas (**Section 3.3**)
- Noise monitoring to establish the existing background and ambient noise environment and to capture existing traffic noise levels prior to construction (**Section 3.4**)
- Identification of relevant criteria to inform the construction and operational noise and vibration assessments (**Section 3.5.1** and **Section 3.6.1**)
- Noise modelling of construction and operational noise impacts (**Section 3.5.4** and **Section 3.6.2** to **Section 3.6.5**)
- Identification of noise management measures to address operational traffic noise impacts (**Section 3.6.6**).

3.2 Study areas

The construction study area for the assessment of construction noise and vibration has been defined as 940 metres either side of the construction footprint, which represents the distance from the construction work where construction noise would not adversely impact sensitive receivers.

The operational study area for the assessment of operational traffic noise has been defined as 600 metres either side of the project roads (measured from the centreline of the outermost traffic lanes), as defined in the RNP and NCG.

The study areas for the assessment are shown on **Figure 3-1**.

3.3 Noise sensitive receivers and noise catchment areas

A land use survey was carried out to identify the receiver types and uses of buildings around the project that could potentially be impacted by noise or vibration from the project. The survey was carried out to assist with defining appropriate management objectives for the sensitive receivers.

Noise sensitive receivers were then grouped into noise catchment areas (NCAs) based on physical land use areas with similar acoustic environments to facilitate analysis. These NCAs are shown on **Figure 4-1**. A description of the NCAs in the context of the existing environment is provided in **Section 4.2**.

3.4 Noise monitoring

To quantify the existing noise environment, noise monitoring was carried out along the project extent in areas where receivers may potentially be affected by construction noise, and to determine the existing levels of road traffic noise along the project.

The noise monitoring data was analysed to determine an Assessment Background Level (ABL) for each day, evening and night period in each 24 hour period of noise monitoring. Based on the median of the individual ABLs, overall single Rating Background Levels (RBL) for the day, evening and night periods are determined over the entire monitoring period in accordance with the NSW EPA Noise Policy for Industry

(NPfI). The RBLs are used to establish project-specific Noise Management Levels (NMLs) for the assessment of construction noise impacts and in validating and calibrating the traffic noise model.

The noise monitoring equipment used for the long-term noise monitoring were ARL Ngara noise loggers, which continuously measures noise levels with data stored in memory for every 15-minute period. For the short term attended measurements, a SVAN 958 Type 1 sound level meter was used.

Field calibration checks of the equipment were carried out before and after measurements. All monitors carry current NATA calibration certification (or if less than two years old, manufacturer's certification).

Measurements affected by extraneous noise, wind (greater than five m/s) or rain were excluded from the recorded data. Determination of extraneous meteorological conditions was based on weather data obtained from the Bureau of Meteorology (BOM) at the most suitable weather station nearest to each monitoring location for the monitoring period. The wind data was adjusted to account for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10 metres above ground level, and the microphone location, which is typically 1.5 metres above ground level (and less than three metres). The correction factor applied to the data is based on Table C.1 of ISO 4354:2009 *'Wind actions on structures'*.

3.4.1 Unattended noise monitoring

Background noise monitoring

Long term unattended noise monitoring was conducted at 11 locations within the construction study area between 1 June and 15 July 2018, to establish existing background and ambient noise levels. A desktop review of the measured background and ambient noise level results suggests that the noise monitoring data was representative of the current noise environment within the construction study area. Therefore, additional unattended noise monitoring was not required.

The background noise monitoring locations are shown in **Figure 3-1**, and details are outlined in **Table 3-1**.

Table 3-1 Unattended background and ambient noise monitoring locations

ID	NCA[1]	Address
L01	NCA01A	23 Cahill Close, Black Hill
L02	NCA03	54 Weakleys Drive, Beresfield
L03	NCA07	51 New England Highway, Black Hill
L04	NCA04A	1/15 Quarter Sessions Road, Tarro
L05	NCA05A	11 Anderson Drive, Tarro
L06	NCA06	61 Redbill Drive, Woodberry
L07	NCA08	179 Old Maitland Road, Hexham
L08	NCA09	838 Tomago Road, Tomago
L09	NCA14A	2213 Pacific Highway, Heatherbrae
L10	NCA14B	14 Elizabeth Avenue, Raymond Terrace
L11	NCA12	2264 Pacific Highway, Heatherbrae

Note:

1. Refer to **Section 4.2** and **Figure 4-1** for location of NCAs

Traffic noise monitoring

Long term unattended noise monitoring of existing traffic noise levels was conducted at eight locations within the operational study area between 15 March and 24 March 2016. The traffic noise monitoring locations were selected based on their proximity to the existing major roads, to ensure that traffic noise was the main contributor to the noise levels measured.

On 12 March 2020, the World Health Organisation declared the coronavirus (COVID-19) as a pandemic. In response to these declarations, the Australian Government introduced a range of restrictions relating to travel, public gatherings and shut down of non-essential services. As such, the COVID-19 situation dramatically impacted traffic volumes, making it difficult to collect more recent and representative traffic noise data for a “typical” period. Therefore, data from 2016 was used to inform this assessment.

A desktop review of the noise monitoring results and the location of the monitoring indicated that traffic noise would be the main contributor at the monitoring locations and the noise data would be appropriate for validating the traffic noise model. Therefore, additional traffic noise monitoring was not required.

Where possible, traffic noise monitoring was conducted at one metre from the affected facade, in accordance with the RNP. Where this was not possible (e.g. due to space restrictions), the monitoring was conducted in the free field (i.e. at least 3.5 metres from any reflecting surfaces such as buildings). At free-field monitoring locations, a +2.5 dB(A) correction was added to the measured road traffic noise levels to represent an equivalent road traffic noise level at a distance of one metre from a building facade, in accordance with the requirements of the RNP.

Noise levels are described in accordance with the requirements of the NSW Road Noise Policy (RNP). The relevant descriptors for traffic noise are $L_{Aeq(15hr)}$ and $L_{Aeq(9hr)}$, which represent the existing day and night traffic noise levels, respectively.

The traffic noise monitoring locations are shown in **Figure 3-1**, and details are outlined in **Table 3-2**.

Table 3-2 Unattended traffic noise monitoring locations

ID	NCA[1]	Address
L13	NCA01A	11 Cahill Close, Black Hill
L14	NCA01B	23 Walter Parade, Black Hill
L15	NCA04A	70 New England Highway, Tarro
L16	NCA04A	44 Sapphire Drive, Tarro
L17	NCA04B	11 Central Avenue, Tarro
L18	NCA06	Proposed interchange at Tarro
L19	NCA14A	2207 Pacific Highway, Heatherbrae
L20	NCA13	Pacific Highway (north of Raymond Terrace Interchange)

Note:

1. Refer to **Section 4.2** and **Figure 4-1** for location of NCAs

3.4.2 Attended noise measurement locations

In addition, short term attended measurements were conducted during the day and night time periods, concurrently with the long term unattended noise monitoring in 2018. Results of the short term attended noise measurements were compared to the results of a nearby representative long term monitoring location to determine a correlation between the two measurement locations. Results of the correlation are used to establish equivalent background noise levels during the day, evening and night periods at the short term attended measurement locations.

The attended noise measurement locations are shown in **Figure 3-1**, and details are outlined in **Table 3-3.**

Table 3-3 Short term attended noise measurement locations

ID	NCA[1]	Address	Description
L01A	NCA01B	24 Walter Parade, Black Hill	Measured noise levels from this location compared to results from long term unattended monitoring location L01 to determine correlation
L04A	NCA04B	22 Lenox Street, Beresfield	Measured noise levels from this location compared to results from long term unattended monitoring location L04 to determine correlation
L05A	NCA05B	49 Beresford Avenue, Beresfield	Measured noise levels from this location compared to results from long term unattended monitoring location L05 to determine correlation
L10A	NCA14C	15 Brown Street, Raymond Terrace	Measured noise levels from this location compared to results from long term unattended monitoring location L10 to determine correlation
L12	NCA14C	53 Martens Avenue, Raymond Terrace	Measured noise levels from this location compared to results from long term unattended monitoring location L10 to determine correlation

Note:

1. Refer to **Section 4.2** and **Figure 4-1** for location of NCAs

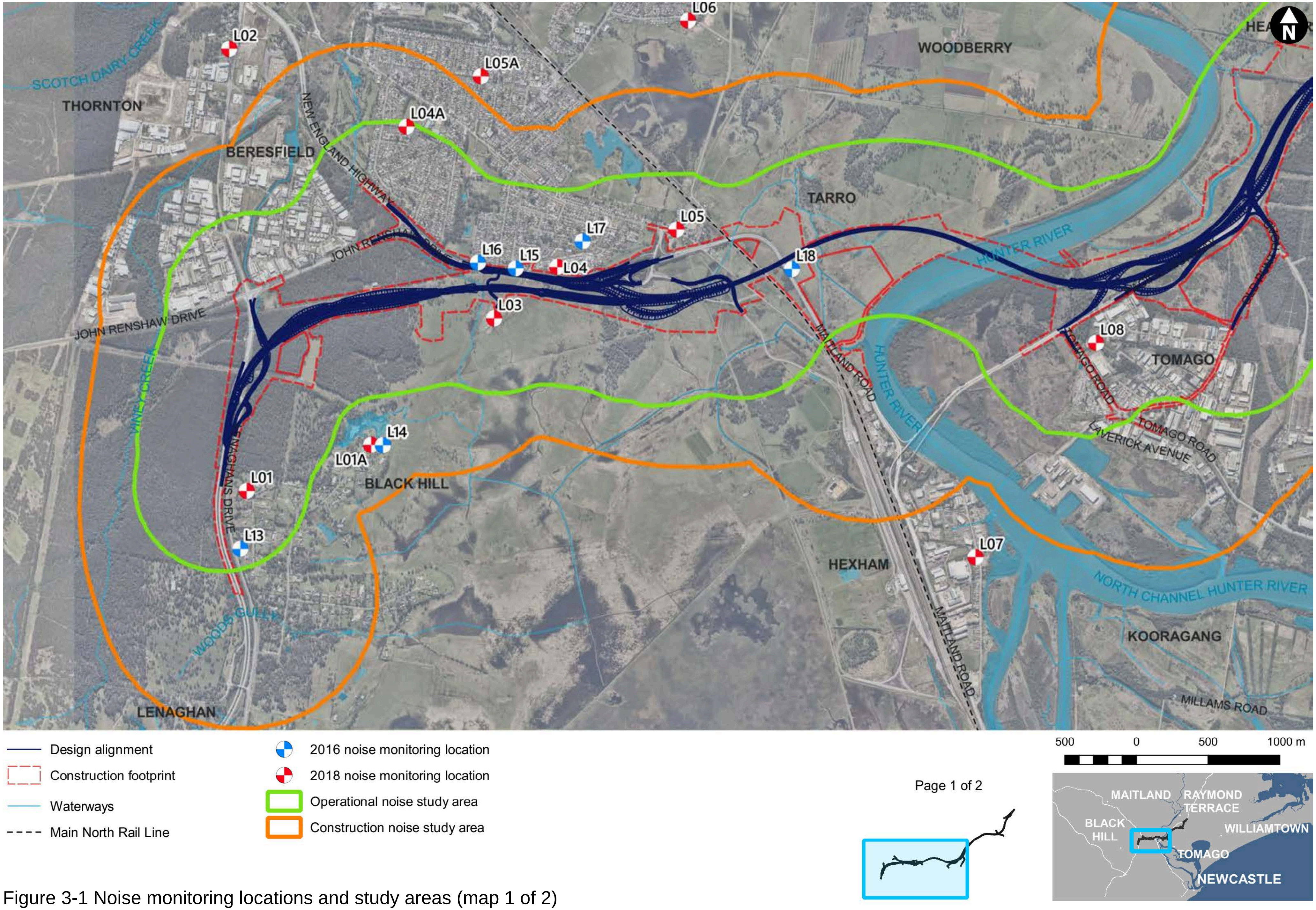

Figure 3-1 Noise monitoring locations and study areas (map 1 of 2)

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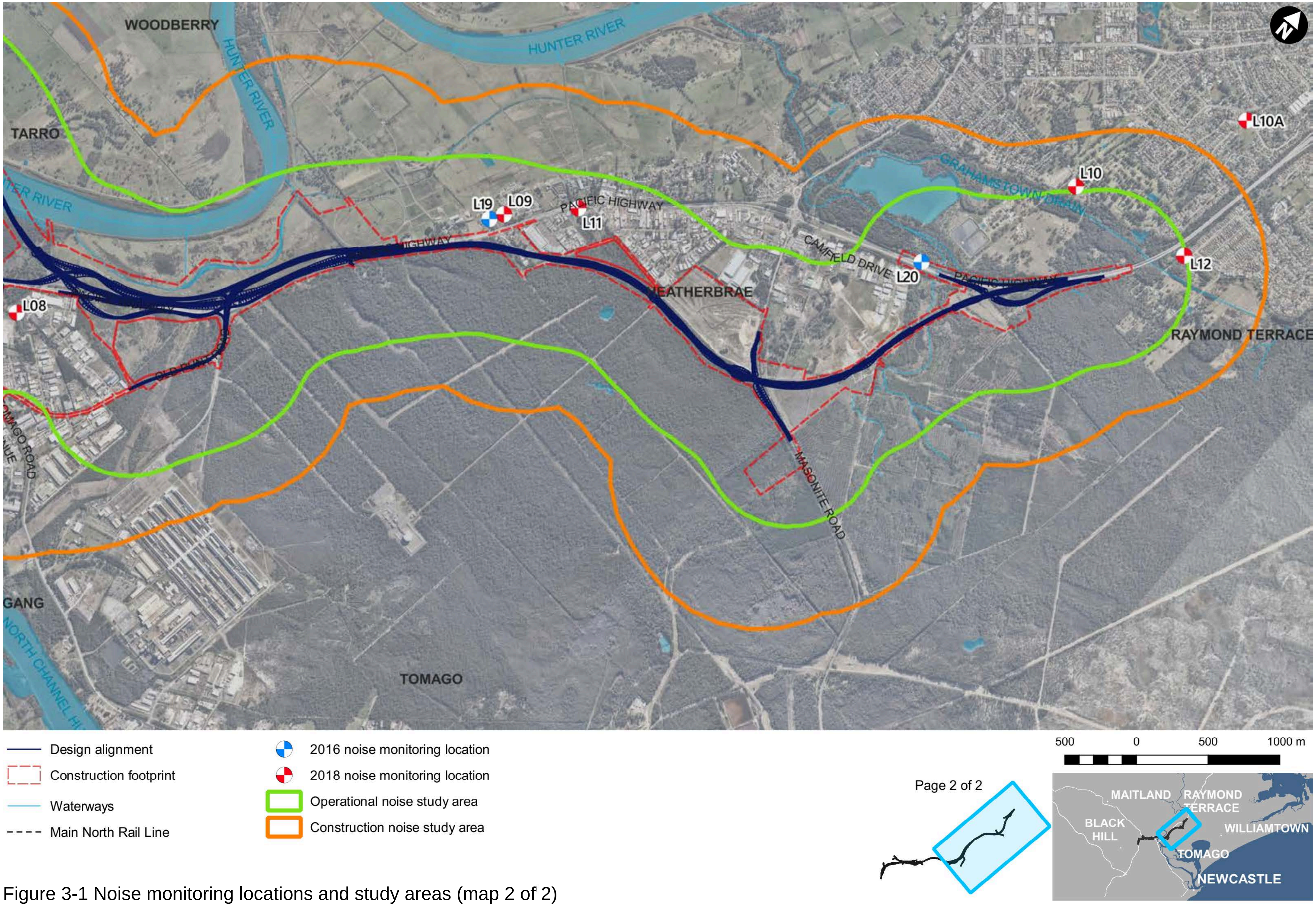

Figure 3-1 Noise monitoring locations and study areas (map 2 of 2)

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3.5 Construction noise and vibration assessment methodology

3.5.1 Construction noise and vibration criteria

Construction airborne noise

The CNVG refers to the ICNG for the assessment of airborne noise impacts due to construction work and the establishment of NMLs. NMLs are based on the RBL, the overall whole number background noise level measured in each assessment period (during or outside the recommended standard construction hours). It is derived from measurements of the existing noise environment of an area, excluding noise from the project.

Construction noise may be less distinguishable to a receiver when ambient noise levels are high. For example, during the day when existing road traffic noise is high, construction noise may be less noticeable than at night time when ambient noise levels are lower. At night, there are also times when ambient noise levels are typically higher, such as at the beginning of the night period between 10.00pm and 12.00am or at the end of the night period between 5.00am and 7.00am. Construction noise generated during these periods may be less noticeable than during the quietest period of the night, between 2.00am to 4.00am.

To assess construction noise against the NMLs, the assessment adopts the equivalent sound pressure level indicator, L_{Aeq}, which is the energy average of noise over the 15 minute measurement period. For screening potential sleep disturbance at night, the assessment also uses the maximum noise level indicator, L_{Amax}, which accounts for instantaneous noise events.

The outcome of this approach coupled with worst case construction noise prediction is that the emergence of construction noise above background noise would usually be over-estimated compared with typical noise levels generated by construction activities.

Based on the proposed duration of construction work and number of affected receivers, a quantitative assessment has been carried out for this project, in accordance with the CNVG.

Residential receivers

The CNVG intends to provide respite for residents exposed to excessive construction noise outside the recommended standard construction hours, while allowing construction during the recommended standard construction hours without unnecessary restrictions. **Table 3-4**, reproduced from the ICNG, sets out the NMLs and how they are applied at residential receivers.

Table 3-4 Noise management levels for residential receivers (ICNG, 2009)

Time of day	Management level $L_{Aeq\ (15\ minute)}$ *	How to apply
Recommended standard hours: Monday to Friday 7.00am to 6.00pm Saturday 8.00am to 1.00pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of work to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected (HNA) level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences) 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2 *(of the ICNG).*

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

Residential receivers are considered 'noise affected' where construction noise levels are greater than the NMLs. The noise affected level represents the point above which there may be some community reaction to noise. Where predicted and/or measured construction noise levels exceed NMLs, feasible and reasonable noise mitigation and/or management measures as presented in the CNVG would be considered in order to meet the NMLs. If construction noise is equal to or above $L_{Aeq(15\ minute)}$ 75 dB(A) at any residence at any time, that residential receiver is considered to be highly noise affected.

It is noted that for construction noise assessment purposes, caravan parks have been assessed as residential type receivers.

Other sensitive land uses

Table 3-5 sets out the NMLs for other noise-sensitive receiver locations located within the construction study area, including commercial and industrial premises, in accordance with the ICNG. These NMLs are absolute levels and are independent of the existing background and ambient noise environment.

Table 3-5 NMLs at other noise sensitive land uses

Land use	Where objective applies	Noise management level $L_{Aeq(15\ minute)}$[1]
Classrooms at schools, and other educational institutions	Internal noise level	45 dB(A)[2]
Places of worship	Internal noise level	45 dB(A)[2]
Childcare centre	External noise level	50 dB(A)[6]
Active recreation areas (e.g. sports fields/activities which generate their own noise and are generally less sensitive to external noise)	External noise level	65 dB(A)
Passive recreation areas (e.g. area used for low intensity and low noise producing activities which could be impacted by external noise such as reading or meditation)	External noise level	60 dB(A)
Commercial premises (including offices and retail outlets)	External noise level	70 dB(A)[5]
Industrial premises	External noise level	75 dB(A)[5]

Notes:

1. NMLs apply when receiver areas are in use only
2. As per the ICNG and NPfI, it has been assumed that the difference between an internal noise level and the external noise level is 10 dB(A), assuming windows are open for adequate ventilation. An external NML would be defined on this basis.
3. Medical centres and similar are classified as commercial premises
4. Community centres have been assessed to an external noise level of 60 dB(A). Depending on the intended use of the centre, the noise management level may vary
5. The NML applies at the most affected occupied point on the premises
6. Refer to further details relating to childcare centres below

Internal noise management levels

The ICNG states that:

> *"As a guide, the difference between the internal noise level and the external noise level is typically 10 dB with windows open for adequate ventilation"*

On the basis of the above and the general acceptance that most buildings provide a noise reduction of at least 10 dB(A) when windows are left at least 20 per cent open, where windows are operable and without providing additional treatment, a conservative 10 dB(A) reduction from external noise levels to internal noise levels has been adopted to determine equivalent external NMLs.

The external to internal noise reductions can vary largely for different buildings and facade construction types as there are a number of physical factors that can influence the level of noise reduction actually achieved from outside to inside a dwelling. For receiver buildings that are exposed to existing high levels of traffic noise, the facades would typically be sealed and consist of thick glazing and heavy facade construction materials. Sealed facades or facades with windows closed can provide external to internal noise reductions much greater than 10 dB(A). Noise reductions greater than 20–25 dB(A) are achievable where facades consist of standard to thick glazing and heavy facade construction (e.g. brick construction).

Based on the above, classrooms and places of worship would have the equivalent external NML of 55 dB(A).

Childcare centres

The ICNG and AS/NZS 2107:2016 do not provide specific construction noise criteria for childcare centres. Typically, sensitive areas within childcare centres are external/internal play areas and sleeping areas.

The Association of Australian Acoustical Consultants (AAAC) Guideline for Child Care Centre Acoustics Assessment (2013) recommends noise levels from external noise sources such as road, rail traffic and industrial sources that would be suitable for the various childcare centre spaces.

More detailed analysis may be required during detailed design to determine appropriate criteria for childcare centres depending on which spaces are noise affected, and if sleeping areas are close to the construction activities.

Considering the AAAC guideline and the conservative 10 dB(A) reductions from external to internal noise levels, an external screening level of $L_{Aeq(15\ minute)}$ 50 dB(A) has been adopted for assessing childcare centres.

Sleep disturbance

Major infrastructure projects often require certain work to be completed during the night. Where night work is located close to residential receivers there is the potential for sleep disturbance impacts to those residential receivers. The assessment against the NML and sleep disturbance screening level can be used as effective ways to identify when noise impacts need to be further mitigated and managed in order to protect receivers from annoyance for at least 90 per cent of the time.

The ICNG lists five categories of works that may be required to be carried out outside the recommended standard hours (discussed further in **Section 3.5.3**):

- The delivery of oversized equipment or structures that require special arrangements to transport on public roads
- Emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- Maintenance and repair of public infrastructure where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- Public infrastructure work that shorten the length of the project and are supported by the affected community
- Work where a proponent demonstrates and justifies a need to operate outside the recommended standard hours.

The ICNG references the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA 1999) for guidance relating to sleep disturbance, however the ECRTN has since been superseded by the NSW Road Noise Policy (RNP). Considering the ICNG and RNP guidance, an L_{Amax} sleep disturbance screening level of RBL + 15 dB(A) has been adopted for the project. Where predicted maximum noise levels are above the screening level, more detailed analysis is required.

A sleep disturbance screening assessment has been carried out for the residential receivers within each NCA potentially impacted by the various construction scenarios. Predicted construction noise levels for the assessment of sleep disturbance have been based on the plant item in each construction scenario with the highest L_{Amax} sound power level during peak and typical activities, as presented in Table C-1 in **Appendix C**.

Construction-related road traffic noise

Within the construction footprint

When heavy vehicles and other vehicles are operating within the construction footprint (including ancillary facilities), road vehicle noise contributions are included in the overall predicted $L_{Aeq(15\ minute)}$ construction noise emission and assessed against the corresponding NML.

Outside the construction footprint

When construction-related traffic moves onto the public road network, a different noise assessment methodology is considered appropriate, as vehicle movements are regarded as 'additional road traffic' rather than as part of the construction footprint (including ancillary facilities).

The CNVG requires an initial screening test to evaluate whether noise levels at sensitive residential and non-residential (i.e. other sensitive) receivers would increase by more than 2 dB(A) due to construction traffic or a temporary reroute due to a road closure. Where increases are 2 dB(A) or less then no further assessment is required. The RNP states that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB(A) represents a minor impact. Where noise levels increase by more than 2 dB(A), then further assessment is required using the NCG, and all feasible and reasonable noise mitigation and management measures would be implemented.

Consideration should be given, when determining feasible and reasonable mitigation measures, to the actual noise levels associated with construction traffic and whether these levels comply with the following road traffic noise criteria from the RNP:

- 60 dB(A) $L_{Aeq(15\ hour)}$ day and 55 dB(A) $L_{Aeq(9\ hour)}$ night for freeway/arterial/sub-arterial roads
- 55 dB(A) $L_{Aeq(1\ hour)}$ day and 50 dB(A) $L_{Aeq(1\ hour)}$ night for local roads.

Ground-borne construction noise

Ground-borne or regenerated noise as a result of construction activities is usually associated with vibration generating equipment, such as rock hammers, operating near residential buildings. Vibration can be transmitted through the ground and into the structure of nearby buildings, which can then create audible noise impacts inside buildings. Ground-borne noise is usually not a substantial disturbance to building occupants during construction as when plant and equipment are operating in close proximity to the building, airborne noise would be substantially higher which can mask the audibility of ground-borne noise emissions. Nevertheless, **Table 3-6** summarises the CNVG ground-borne construction noise objectives for residential receivers during the evening and night periods, which are consistent with the ICNG.

Table 3-6 Ground-borne noise objectives at residential premises

Period	Time	Internal $L_{Aeq(15\ minute)}$ ground-borne noise management level
Evening	6.00pm to 10.00pm	40 dB(A)
Night	10.00pm to 7.00am	35 dB(A)

Construction vibration objectives

For the project, construction vibration is associated with three main types of impact:

- Disturbance to building occupants (Human exposure)
- Potential damage to buildings (Structural or cosmetic damage to buildings)
- Potential damage to buried utilities.

Generally, if vibration levels are maintained so that they do not disturb building occupants, there is limited potential for structural damage to buildings. How construction vibration impacts are assessed for the project is detailed in the sections below.

Human exposure to vibration

Tactile vibration potentially disturbing human occupants of buildings is assessed and managed by reference to Assessing Vibration; a technical guideline (DECC, 2006). This document provides criteria which are based on the British Standard BS 6472-2008 Evaluation of human exposure to vibration in buildings (1-80Hz).

Vibration sources are defined as Continuous, Impulsive or Intermittent. **Table 3-7** provides a definition and examples of each type of vibration.

Table 3-7 Types of vibration (DECC, 2006)

Type of vibration	Definition	Examples
Continuous	Continues uninterrupted for a defined period (usually throughout the day-time and/or night time).	Machinery, steady road traffic, continuous construction activity (such as roadheader excavation).
Impulsive	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing the duration is short (typically less than 2 seconds).	Infrequent: Activities that create up to three distinct vibration events in an assessment period, e.g. Occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude.	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, they would be assessed against impulsive vibration criteria.

The criteria are applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis. When applying the criteria, it is important to note that vibration may enter the body along different orthogonal axes, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). The three axes are referenced to the human body. Thus, vibration measured in the horizontal plane should be compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z-axis criteria if the concern is for people in the lateral position.

Preferred and maximum values for continuous and impulsive vibration are defined in the guideline and are reproduced in **Table 3-8**.

Table 3-8 Preferred and maximum levels for human comfort (continuous and impulsive vibration)

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x and y-axis	z-axis	x and y-axis
Continuous vibration[3] (weighted rms acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night time	0.020	0.014	0.040	0.028
Workshops	Day or night time	0.04	0.029	0.080	0.058

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x and y-axis	z-axis	x and y-axis
Impulsive vibration[3] (weighted rms acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night time	0.64	0.46	1.28	0.92
Workshops	Day or night time	0.64	0.46	1.28	0.92

Notes:

1. Daytime is 7.00am to 10.00pm and night time is 10.00pm to 7.00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) and should be referred to. Source: BS 6472-2008
3. Caravan parks considered as residential type receivers
4. Source: Table 2.2, Assessing Vibration; a technical guideline, Department of Environment and Climate Change 2006.

The acceptable vibration dose values (VDV) for intermittent vibration are defined in the guideline and are reproduced in **Table 3-9**.

Table 3-9 Preferred and maximum levels for human comfort (intermittent vibration)

Location	Assessment period[1]	Preferred values	Maximum values
Intermittent vibration[3] (vibration dose values, VDV, $m/s^{1.75}$, 1-80Hz)			
Critical areas[2]	Day or night time	0.10	0.20
Residences	Daytime	0.20	0.40
	Night time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night time	0.40	0.80
Workshops	Day or night time	0.80	1.60

Notes:

1. Daytime is 7.00am to 10.00pm and night time is 10.00pm to 7.00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas, as noted in BS 6472–1992
3. Caravan parks considered as residential type receivers
4. Source: Table 2.4, Assessing Vibration; a technical guideline, Department of Environment & Climate Change 2006.

Structural and cosmetic damage to buildings

Potential structural damage of buildings by vibration is typically managed by ensuring vibration impacting the structure does not exceed certain limits and standards, such as British Standard 7385: Part 2 and German Standard DIN 4150-3. As outlined in the CNVG, guidance for cosmetic damage of structures is provided in the British Standard 7385: Part 2, while German Standard DIN 4150-3 has criteria of particular reference for heritage structures.

There is no current Australian Standard for assessing structural building damage caused by vibration.

British Standard BS 7385: Part 2 *Evaluation and measurement of vibration in buildings* can be used as a guide to assess the likelihood of building damage from ground vibration. The standard suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur. Damage consists of minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load-bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS 7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4 Hz to 250 Hz, being the range usually encountered in buildings. At frequencies below 4 Hz, a maximum displacement value is recommended. The values set in the standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50 per cent. **Table 3-10** sets out the BS 7385 safe limits for cosmetic damage.

Table 3-10 BS 7385 cosmetic damage safe limits

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Un-reinforced 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

For structures where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be done during detailed design to determine the applicable safe vibration level and approach to construction near the structure.

Heritage items

Heritage items are considered on a case by case basis, and care should be taken as these structures can be difficult to repair in the case of damage. It should be noted that British Standard BS 5228-2:2009 states that '*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*' (p.39) when compared to other structures.

Where a structure is found to have defects, or is structurally unsound following an inspection, maximum vibration criteria are to be established for that specific structure for construction work to not further damage the structure. As stated previously, German Standard DIN 4150: Part 3 provides guidance for heritage structures that are sensitive to vibration (i.e. structurally unsound) and the relevant values are nominated under Line 3 in **Table 3-11**, which has been reproduced from DIN 4150: Part 3 (2016).

Table 3-11 DIN 4150-3 structural damage guideline values for short-term vibration on structures

Line	Type of Structure	Guideline values – vibration velocity, mm/s				
		Foundation, all directions at a frequency of			Topmost floor, horizontal	Floor slabs, vertical
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies	All frequencies
3	Structures that because of their particular sensitivity to vibration, cannot be classified under Groups 1 and 2 <u>and</u> are of great intrinsic value (e.g. listed buildings)	3	3 to 8	8 to 10	8	20

Damage to buried utilities

Section 5.3 of DIN 4150: Part 3 sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values, which apply at the wall of the pipe, are reproduced and presented in **Table 3-12**. As part of detailed design, these vibration limits would be considered to minimise damage to any buried utilities potentially impacted by the construction work.

Table 3-12 DIN 4150-3 structural damage guideline values for short-term vibration on buried pipework

Line	Pipe material	Vibration velocity at the pipe, mm/s
1	Steel, welded	100
2	Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

Recommended vibration goals for electrical cables and telecommunication utilities such as fibre optic cables range from 50 mm/s to 100 mm/s. Although cables may sustain these vibration levels, the utilities they are connected to, such as transformers and switch blocks, may not. If such equipment is encountered during the construction process, an individual vibration assessment would be carried out addressing impact on the utility, and consultation with the utility provider, to confirm specific vibration requirements.

Blasting noise and vibration management levels

Guidance in relation to acceptable overpressure and vibration from blasting is referenced in the ICNG, which specifies that the assessment should be based on the levels in the Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZEC 1990). The CNVG refers to Australian Standard AS 2187.2-2006 Explosives - Storage and use - Part 2 Use of explosives.

The blast vibration criteria identified in ANZEC 1990 are considered too conservative and not practical for application to this project. The criteria in the ANZEC guideline do not take into account the timeframe of the blasting in terms of annoyance. That is, a short term project (e.g. blasting for road construction) is assessed with the same criteria as a long term project (e.g. a mine site that may operate with blasting for several years). As such, Australian Standard AS 2187.2-2006 has therefore been adopted for the project.

Table 3-13 and **Table 3-15**, reproduced in the following sections, provide vibration and overpressure limits designed to safeguard human comfort from blasting, with consideration of the required duration of blasting for a project.

Airblast overpressure

Airblast overpressure generated by blasting associated with the construction of the project should be carried out so that the criteria specified in AS 2187.2-2006, reproduced in **Table 3-13** and **Table 3-14**, are not exceeded when measured at the most affected residence or other sensitive receiver.

Table 3-13 Recommended airblast limits for human comfort (Table J5.4(A), AS 2187.2)

Category	Type of blasting operations	Peak sound pressure level, dBL
Sensitive site[1]	Operations lasting longer than 12 months or more than 20 blasts	115 dBL for 95 per cent blasts per year. 120 dBL maximum unless agreement is reached with occupier that a higher limit may apply
Sensitive site[1]	Operations lasting for less than 12 months or less than 20 blasts	120 dBL for 95 per cent blasts. 125 dBL maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	125 dBL maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Notes:

1. A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people
2. The recommendations in Table J5.4(A) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

Table 3-14 Recommended airblast limits for damage control (Table J5.4(B), AS 2187.2)

Category	Type of blasting operations	Peak sound pressure level, dBL
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All blasting	133 dBL maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables located above the ground	All blasting	Limit to be determined by structural design methodology

Notes:

1. The recommendations in Table J5.4(B) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

Blast vibration – human comfort

The human response to vibration from blasting is considered in terms of the likelihood of complaint, so that an appropriate community consultation program can be initiated to advise potentially affected receivers of the likely impacts from blasting. AS 2187.2-2006 suggests a limit of 10 mm/s PPV for human comfort for operations lasting less than 12 months, as shown in **Table 3-15**.

Table 3-15 Ground vibration limits for human comfort (AS 2187.2)

Category	Type of blasting operations	Peak component particle velocity, mm/s
Sensitive site[1]	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95 per cent blasts per year 10mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site[1]	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Notes:

1. A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people
2. The recommendations in Table J4.5(A) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions
3. The recommendations in Table J4.5(A) do not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations, which may necessitate taking additional measurements on the structure itself, to detect any magnification of ground vibrations that might occur within the structure. Particular attention should be given to the response of suspended floors.

Blast vibration – structural damage

Ground vibration limits for control of damage to structures (excluding heritage structures) from blasting as required under AS 2187.2-2006 is shown in **Table 3-16**.

Table 3-16 Ground vibration limits for control of damage to structures (AS 2187.2)

Category	Type of blasting operations	Peak component particle velocity, mm/s
Other structures or architectural elements that include masonry, plaster and plasterboard in their construction	All blasting	Frequency-dependent damage limit criteria Table J4.4.2.1
Unoccupied structures of reinforced concrete or steel construction	All blasting	100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables	All blasting	Limit to be determined by structural design methodology

Note:

1. The recommendations in Table J4.5(B) do not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations, which may necessitate taking additional measurements on the structure itself, to detect any magnification of ground vibrations that might occur within the structure. Particular attention should be given to the response of suspended floors.

In accordance with the first row in the above table, further reference is made to Table J4.4.2.1 of AS 2187.2-2006 which is based on the limits for cosmetic damage in BS 7385: Part 2 and previously presented in **Table 3-10**.

For the assessment of vibration impact due to blasting on buried pipelines, the screening levels used to assess vibration impact from general construction activities on buried pipework, as presented in **Table 3-12** would be adopted.

To assess the likelihood of damage to unsound heritage structures due to blasting, and in the absence of specific unsound structure limits or limits for structures with particular sensitivity to vibration impacts, the structural damage screening level from general construction vibration impacts on unsound heritage structures (DIN4150-03) presented in **Table 3-11** would be adopted for vibration impacts due to blasting.

3.5.2 Construction scenarios

Representative scenarios have been developed to assess the likely impacts from the main construction phases of the project, and described in **Table 3-17**. The location of the various construction activities associated with the work scenarios are presented in **Figure 3-2**.

The assessment uses ‘realistic worst-case’ scenarios to determine the impacts from the noisiest 15-minute period that is likely to occur for each work scenario, as required by the ICNG.

The scenarios have been assessed for ‘peak impact’ and ‘typical impact’ work. An example of ‘peak impact’ work includes the use of noise intensive equipment like rock-breakers or concrete saws for some scenarios. While ‘peak impact’ work would be required at certain times in most locations, the noisiest work would only last for relatively short periods throughout the overall work duration. The ‘typical impact’ work represent typical noise emissions from the project when noise intensive equipment is not in use. ‘peak impact’ and ‘typical impact’ work are discussed further in **Section 5.2**.

In general, construction work would not occur continuously at a location and it is expected that there would be relatively long periods where construction noise levels are much lower than the worst-case levels presented in this assessment. There would also be many instances when no noisy work are occurring.

Table 3-17 Construction scenarios

ID	Scenario	Description
1	Pre-construction and site establishment	• Property adjustments, including property access changes • Detailed investigations and survey work including geotechnical investigative drilling and excavations • Road dilapidation and building condition surveys • General site clearance, site establishment work, fencing and signage • Temporary traffic management arrangements including construction of minor access roads • Progressive installation of environmental controls including temporary or permanent fencing, and erosion and sediment control measures • Construction of temporary drainage controls including temporary creek crossings • Minor clearing and removal of vegetation • Relocation, protection and connection to minor utilities • Heritage investigations / Aboriginal heritage salvage.
2	Ancillary facility (establishment)	Establishment of temporary ancillary facilities, including: • Initial site survey • Installation of erosion and sediment control measures • Clearing and grubbing • Establishment of construction site fencing, signage and lighting • Establishment of construction site access points, traffic management measures, minor road modifications (if required) • Establishment of hardstand (as required) • Establishment of temporary facilities, e.g. site offices and amenities (where required) • Establishment of an emergency evacuation points • Delivery of materials, plant and equipment • Connection and installation of services • Preparation of bridge work areas including access tracks, piling and crane pads, access platforms • Construction of site access roads (including culvert work).

ID	Scenario	Description
3	Ancillary facility (operation)	Operation of main and satellite compounds including: • Operation and maintenance of material stockpiles • Delivery and operation of plant and equipment such as generators • Delivery and storage of materials (e.g. reinforcing steel, formwork, pre-fabricated components, precast concrete units, quarried and fill material) • Storage of hazardous and dangerous goods (such as paints, adhesives, concrete curing compounds, cleaning products, small quantities of fuel) • Storage of waste (office waste, construction waste, waste bulk materials, recyclables) • Arrival and departure of workers including parking of heavy and light vehicles.
4	Batch plant operation	Operation of batch plant and pre-cast fabrication including: • Crushing and screening of excavated material • Delivery of materials • Operation and maintenance of material stockpiles • Loading of material into silos • Mixing of materials • Loading of trucks • Cleaning and maintaining plant and equipment • Truck and agitator wash down. Two types of batch plants to be used: • Concrete batch plant • Asphalt batch plant Location of batch plants have not been finalised, so for modelling and assessment purposes it is assumed that batch plants could be located at any ancillary facility.
5	Clearing, grubbing and demolition	• Clearing and grubbing of vegetation (broad scale) • Mulching of vegetation • Stripping of topsoil and stockpiling • Demolition of built structures (above and below ground), dwellings and minor structures.
6	Utility works	• Relocation and/or protection of utilities including open trenching or underboring (or similar) • Utility crossings of existing roads, including out of hours work • Installation of poles and other associated utility network infrastructure.
7	Bulk earthworks – cuttings	• Excavation of cuttings, including stockpiling • Stabilisation of cut batters • Establishment of crushing plant • Crushing and screening • Haulage of materials • Rock removal using rock breakers / hammers.
8	Blasting	• Drilling of blast holes • Blasting.
9	Bulk earthworks (fill)	• Haulage of materials • Construction of fill embankments and earth mounds including foundation drainage • Ground improvement techniques including preloading and the installation of prefabricated vertical drains • Removal of excess earthworks at the end of soft soil preload periods • Placement of selected material zone.

ID	Scenario	Description
10	Concrete pavement (including pavement drainage)	• Construction of pavement drainage • Construction of sub surface drainage • Construction of pavement layers including wearing surface • Road tie-in work.
11	Asphalt pavement (including pavement drainage)	• Construction of pavement drainage • Construction of sub surface drainage • Construction of pavement layers including wearing surface • Road tie-in work.
12	Bridge work (excluding piling)	• Construction of wharf areas for loading / unloading of plant and equipment from Hunter River (including sheet piling) • Installation of silt fences and other environmental controls • Construction of temporary platforms to enable construction of Hunter River bridge piers located near the banks of the river • Construction of pile caps • Construction of bridge abutments and piers • Construction of bridge structure including deck and road surface (cast in situ or precast bridge elements) • Construction of drainage and scour protection (where required) • Construction of reinforced soil walls (where required) • Associated civil work for bridges, abutments and associated work • Dewatering – including overnight operation of pumps.
13	Piling for bridges and bridge approaches	• Construction of bridge and abutment foundations (bored or driven piles) • Installation of embankment/utility services piles (at required locations).
14	Roadside furniture and finishing work	• Construction of concrete barriers, wire rope safety barrier and guardrails • Installation of traffic lights, road markings, signposting, roadside furniture, lighting, variable message signs (VMS) and intelligent transport systems (ITS) • Removal of temporary work • Restoration and landscaping • Restoration of construction access roads (where required) • General site clean up • Removal of temporary environmental controls.
15	Traffic management and control	• Temporary traffic barrier installation and movement - including anchor drilling • Temporary pavement construction • Temporary traffic control activities • Traffic switches.
16	Landscaping	• Progressive landscaping and tree planting • Landscape maintenance.
17	Cross drainage	• Installation of cross drainage including culverts, inlet and outlet work (including channel diversions and scour protection) • Installation of longitudinal and vertical drainage in cuttings and embankments • Construction of water quality basins and swales • Dewatering – including overnight operation of pumps.

Note:

1. Equipment lists for each scenario and corresponding sound power level data are provided in **Appendix C**

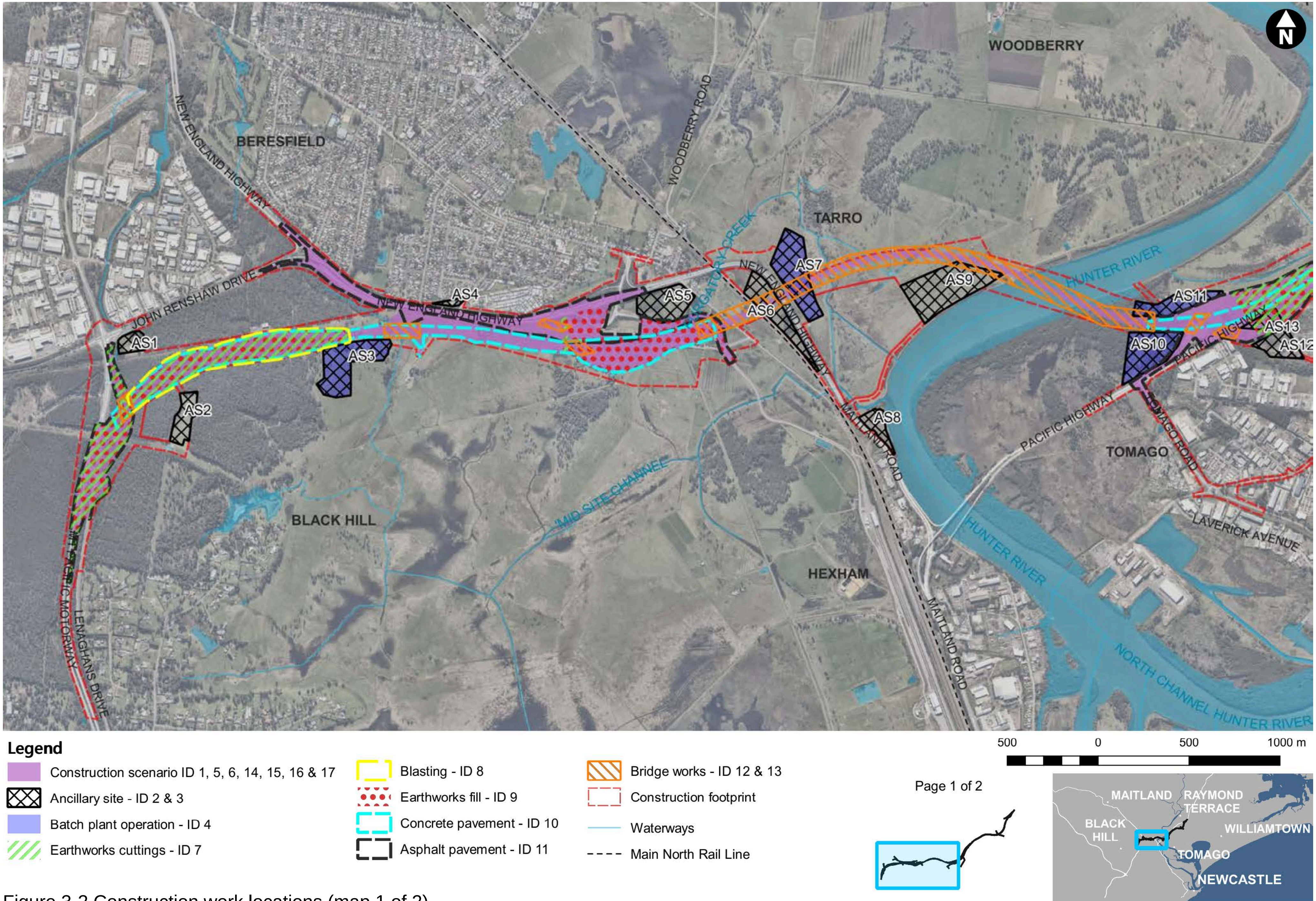

Figure 3-2 Construction work locations (map 1 of 2)

Date: 02/03/2021 Project path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

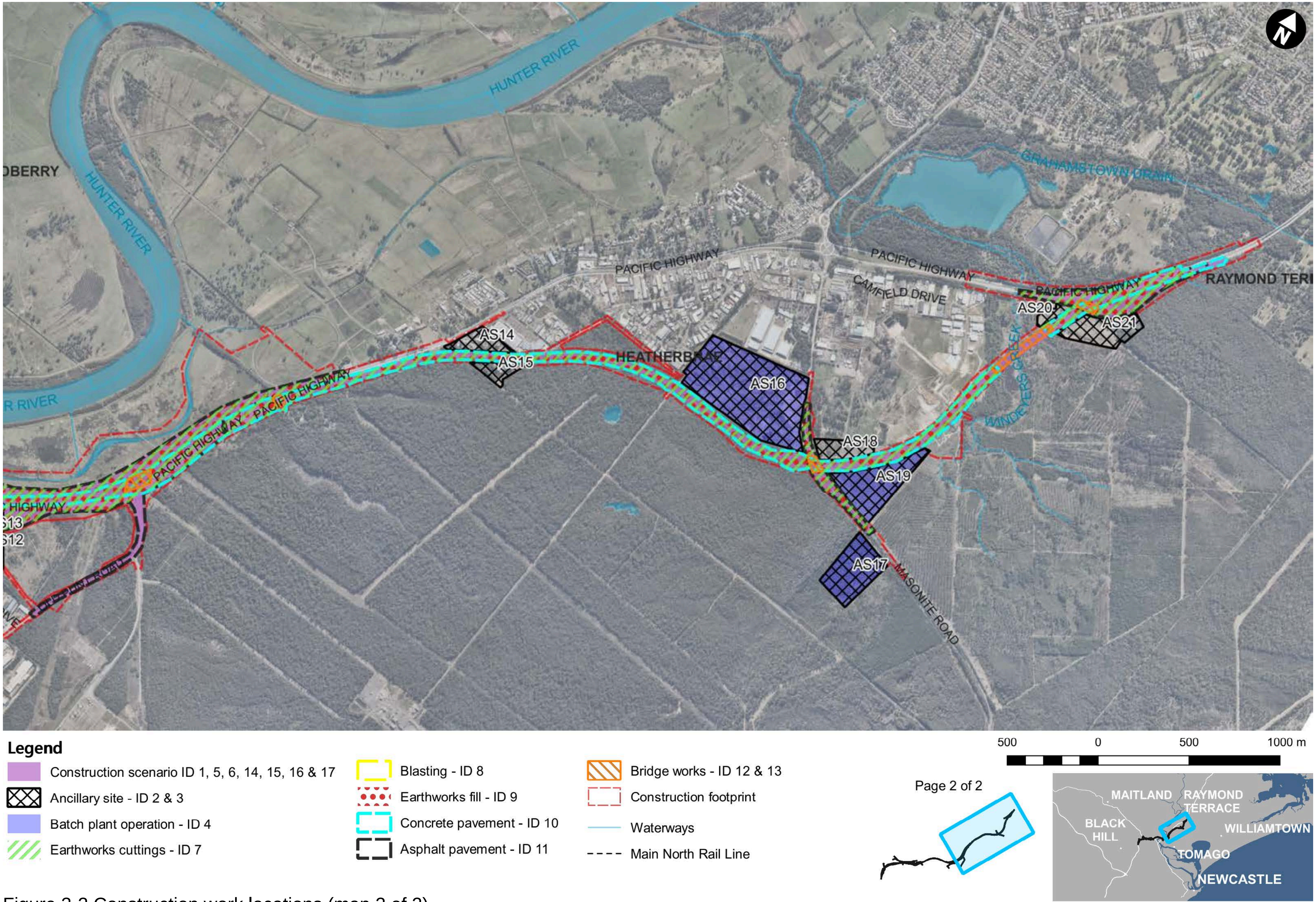

Figure 3-2 Construction work locations (map 2 of 2)

Date: 02/03/2021 Project path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

3.5.3 Proposed construction working hours

Standard construction work hours

The standard hours for construction as noted in the ICNG are shown in **Table 3-18**.

Table 3-18 Standard construction work hours

Day	Start time	Finish time
Monday to Friday	7.00am	6.00pm
Saturday	8.00am	1.00pm
Sunday and public holidays	No work	

Extended construction work hours

As the majority of the construction work would be away from residences and sensitive receivers (e.g. between the proposed interchange at Tarro and the Tomago interchange) as shown in **Figure 3-2**, construction noise impacts to sensitive receivers are expected to be minimal. Therefore, extended construction work hours for the project are proposed.

The proposed extended construction work hours include an extra hour at the start and end of each day Monday to Saturday, an extra four hours at the end of Saturday, and work on Sunday and public holidays, as shown in **Table 3-19**. The extended construction work hours would apply across the project.

Table 3-19 Extended construction work hours

Day	Start time	Finish time
Monday to Friday	6.00am	7.00pm
Saturday	7.00am	5.00pm
Sunday and public holidays	7.00am	5.00pm

To justify the extended working hours, the following have been considered:

- To ensure the health and safety or the public and construction crews during construction
- To minimise disruption to existing traffic flows during the day.

In addition, the benefits of extended working hours would include the following:

- Reducing the volume of traffic on roads during peak hours due to construction staff and construction vehicles travelling to and from the construction site outside of peak traffic periods
- Time benefits, including potentially bringing forward the opening date for the project by increasing the allowable construction hours
- Less disruption to sensitive receivers, the community, local business, motorists, pedestrians and cyclists as work would be completed earlier than currently planned
- Enable greater flexibility in project scheduling. This would enable the contractor to make allowances for adverse weather and potential flooding events.

The proposed extended construction hours would apply to normal construction activities. If required, blasting would only be carried out during the recommended standard construction hours.

Out-of-hours work

To ensure the health and safety of the public and construction crews and to minimise disruption to existing traffic flows, some construction activities would need to be carried out outside of standard working hours and extended construction hours. These construction activities would be carried out during evening and night time periods, defined as 'out-of-hours work'. Out-of-hours work would be implemented with strategies to safely complete works alongside reduced traffic volumes. The activities that may need to be carried out during out-of-hours and relevant justifications, in accordance with the ICNG, are provided in **Table 3-20**.

Table 3-20 Justification for out-of-hour activities

Out-of-hours activity	Justification
Delivery of oversized plant and materials	Delivery of oversize and/or overmass equipment and materials to construction sites could occur after hours for safety reasons and to avoid disruptions and increase of heavy vehicles on the existing road network during peak volume. Such activities would be carried out in line with NSW Police, NSW Traffic Management Centre and Transport for NSW requirements.
Installation of traffic controls, such as concrete barriers	Some of these activities require works on or near major and local roads. As such, these activities would occur out-of-hours when traffic volumes are lower, to protect the health and safety of the public and construction crews and to minimise disruption to existing traffic flows. This work would be carried out in accordance with Transport for NSW and local council requirements. For utility works, where the utility authority only allows works to be carried out during a shutdown period, works would be coordinated with the utility authority and may occur out-of-hours.
Traffic switches between each construction phase	
Utility modifications, relocations or protection measures work	
Removal of existing static signage and installation of new signs	
Removal of existing traffic barriers and installation of temporary and permanent traffic barriers	
Removal of existing lane marking and application of new lane marking on existing roads	
Resurfacing of asphalt pavement on existing roads and concrete and asphalt pouring	
Operation of concrete and asphalt batching plants within ancillary facilities	Concrete and asphalt batching plants would be required to support out-of-hours works and project construction, particularly during construction of the viaduct.
Construction work interfacing with the M1 Pacific Motorway, New England Highway and the Pacific Highway, including construction of overbridge piers for the M1 Pacific Motorway entry and exit ramps and ramp tie-ins with the M1 Pacific Motorway, cross drainage below existing roads, pavement, surfacing, line markings, kerbs and traffic islands, traffic signs and signals	Completing or installing these items at night when traffic flows are low would minimise disruption to traffic and minimise any potential safety conflict between construction personnel and traffic. Such activities would be carried out in line with NSW Traffic Management Centre and Transport for NSW requirements.
Short-term traffic diversions along the existing road network (M1 Pacific Motorway, New England Highway, John Renshaw Drive, Masonite Road, and the Pacific Highway)	

Out-of-hours activity	Justification
Bridge construction work over the Main North Rail Line and existing roads including the New England Highway, Pacific Highway and Old Punt Road (including establishing temporary protection work, installation of girders, sealing of joints, establishing temporary screens to enable construction to continue on the deck, and removal of temporary work)	For bridge construction that can be carried out offline of the existing road network, construction can be carried out during normal working hours. Where bridge construction is required over the existing road network, activities would be carried out as out-of-hours work to ensure health and safety of public and construction workers, and to minimise disruption to motorists. Where bridge construction is required over the existing rail network, activities would be carried out during a rail shutdown, coordinated with the rail authority, and would require out-of-hours work. For the bridge over Hunter Region Botanic Gardens access road (B09), the access road would need to be closed for lifting of the girders. As the Hunter Region Botanic Gardens is only open during normal working hours, there is not expected to be any issues with closing the road out-of-hours. Any closures would be managed in consultation with Hunter Region Botanic Gardens.
Any work that does not cause noise emissions to be audible at any sensitive receiver	In locations where sensitive receivers are not susceptible to noise emissions, out-of-hours work would result in schedule benefits, flexibility in regard to programming of work around the various constraints of the project, such as capitalising on dry periods and thereby maximising construction on the flood plain, and reducing the impact to the existing road network by carrying out additional work during out-of-hours.
Emergency work to avoid the loss of lives, property and/or to prevent environmental harm.	To protect the health and safety of the public and construction crews any emergency work would be carried immediately which may include out-of-hours.

Out-of-hours construction activities would be supported by out-of-hours operation of ancillary facilities. The exact timing of out-of-hours work would depend on construction activities, construction techniques and constraints imposed by the relevant authorities (utility authorities or road/motorway operators) and would be subject to the requirements of the construction contractor.

The periods in which the construction work are expected to be carried out are shown in **Table 3-25**. At this early stage of the project, out-of-hours work have been assumed for a number of construction scenarios, with the anticipated duration of each activity also provided in the table, noting that noisy activities would not occur at full capacity for the entire duration and would not be carried out every day.

Furthermore, given that most of the construction work are outside of the existing road and rail networks and operational assets (e.g. utilities), out-of-hours work would usually be required only when construction work are to interface with the networks and assets.

Extended and out-of-hours work would be managed through the implementation of a Construction Noise and Vibration Management Plan. This is discussed further in **Chapter 8**.

Summary of working hours

Table 3-22 following presents a summary of the construction hours in accordance with the CNVG for a ‘normal’ project scenario. In addition, **Table 3-23** presents a summary of the proposed construction hours, including extended construction hours, based on an approved ‘extended hours’ project scenario.

Construction blasting hours

The recommended standard construction hours of blasting in accordance with the CNVG are presented in **Table 3-21**.

Table 3-21 Construction blasting hours

Day	Start time	Finish time
Monday to Friday	9.00am	5.00pm
Saturday	9.00am	1.00pm
Sunday and public holidays	No blasting	

Construction work program

Construction of the project is expected start in 2023, with completion expected in 2028, subject to funding and approval. The indicative construction program for the project is shown in **Table 3-24**.

Table 3-22 Standard construction hours and out-of-hours work periods under a 'normal' project scenario

Hour commencing	12 am	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm
Monday																								
Tuesday																								
Wednesday													**Standard day**								**OOHW evening**			
Thursday				**OOHW**									**Construction hours**								**Period 1**			
Friday				**Period 2**																				
Saturday																								
Sunday														**OOHW day**								**OOHW**		
Public Holiday														**Period 1**								**Period 2**		

Key: ☐ Standard construction hours ■ Out-of-hours work (day) ■ Out-of-hours work (evening) ■ Out-of-hours work (night)

Table 3-23 Standard and extended construction hours and out-of-hours work periods under an approved 'extended hours' project scenario

Hour commencing	12 am	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm
Monday																								
Tuesday																								
Wednesday													**Standard day**								**OOHW evening**			
Thursday			**OOHW**										**Construction hours**								**Period 1**			
Friday			**Period 2**																					
Saturday																								
Sunday												**Extended**										**OOHW**		
Public Holiday												**Hours**										**Period 2**		

Key: ☐ Standard construction hours ■ Extended construction hours ■ Out-of-hours work (day) ■ Out-of-hours work (evening) ■ Out-of-hours work (night)

Table 3-24 Indicative construction program

Scenario	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pre-construction and site establishment																				
Ancillary facility (establishment)																				
Ancillary facility (operation)																				
Batch plant operation																				
Clearing, grubbing and demolition																				
Utility works																				
Bulk earthworks (cuttings)																				
Blasting																				
Bulk earthworks (fill)																				
Concrete pavement (including pavement drainage)																				
Asphalt pavement (including pavement drainage)																				
Bridge work (excluding piling)																				
Piling for bridges and bridge approaches																				
Roadside furniture and finishing work																				
Traffic management and control																				
Landscaping																				
Cross drainage																				

Based on the proposed construction scenarios, construction work hours (standard, extended and out-of-hours) and construction program, indicative details of the construction work are presented in **Table 3-25.** In accordance with **Table 3-20**, out of hours work may also be carried out where that work does not cause noise emissions to be audible at any sensitive receiver.

Table 3-25 Construction scenarios, indicative work durations and periods

ID	Scenario	Indicative duration (months)	Work period			Comments
			Day	Evening	Night	
1	Pre-construction and site establishment	20				Carried out during the day period* and evening and night out-of-hours. Out of hours work include infrequent ROL work for road connections
2	Ancillary facility (establishment)	13				As above
3	Ancillary facility (operation)	50				The operation of some ancillary facility would be carried out during the day period and would also include out of hours evening and night work
4	Batch plant operation	7				As above
5	Clearing, grubbing and demolition	21		-	-	Typically carried out during day period, however some infrequent evening and night out of hours work would be required for work associated with the existing road network.
6	Utility works	40				Carried out during the day period with evening and night out of hours work limited to utility work associated with the existing road network and shutdowns for work on operational assets
7	Bulk earthworks (cuttings)	10		-	-	Typically carried out during day period
8	Blasting	10		-	-	Carried out during day period
9	Bulk earthworks (fill)	40		-	-	Typically carried out during day period
10	Concrete pavement (including pavement drainage)	24				Carried out during the day period with evening and night out of hours work limited to tie-in to existing road network or infrequent out of hours work periods for extended concrete pours
11	Asphalt pavement (including pavement drainage)	28				Carried out during the day period with evening and night out of hours work limited to widening and tie-in to existing road network or infrequent out of hours work periods for extended asphalt laying
12	Bridge work (excluding piling)	26				Carried out during the day period with evening and night out of hours work required for extended concrete pours, work near existing road and rail network, and where the work does not cause noise emissions to be audible at sensitive receivers

ID	Scenario	Indicative duration (months)	Work period			Comments
			Day	Evening	Night	
13	Piling for bridges and bridge approaches	23		-	-	Carried out during the day period with evening and night out of hours work limited to work on existing road network
14	Roadside furniture and finishing work	28				Carried out during the day period with evening and night out of hours work limited to where work are required to be carried out on existing road network
15	Traffic management and control	26				Traffic management and control for all day period and out of hours work on existing road network
16	Landscaping	11		-	-	Typically carried out during day period
17	Cross drainage	17				Carried out during the day period with evening and night out of hours work limited to installation of cross drainage beneath the existing road network

*Note: The 'day period' includes standard construction hours and daytime out-of-hours periods

3.5.4 Construction noise modelling

The Cadna-A computer noise modelling software was used to develop a construction noise model for the prediction of noise from the construction work associated with the project to surrounding sensitive receivers. The Cadna-A software incorporates the ISO 9613 noise prediction algorithms to calculate the construction noise impacts.

Noise sources, receiver locations, buildings, structures and topographical features of the intervening area were digitised in the noise model to develop a three-dimensional representation of the construction study area and surrounding areas.

3.5.5 Construction vibration assessment

Vibration impacts from construction activities are assessed against the vibration objectives listed in **Section 3.5.5** for human exposure, structural or cosmetic damage to structures, and damage to buried utilities; in accordance with the relevant vibration guidelines and standards identified in **Table 2-1**.

The vibration generated from construction would vary depending on the level and type of activity carried out during each scenario and at each ancillary facility. Unlike noise, it is difficult to 'predict' vibration. There are many variables from site to site, for example soil type and conditions; sub-surface rock; building types and foundations; and actual plant on-site.

The data relied on in this assessment are taken from a database of vibration levels measured at various sites or obtained from other sources (e.g. BS 5228-2:2009). They are not specific to this project as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

The assessment is based on vibration intensive plant and equipment being operated at the closest location to the nearby buildings in each NCA. When vibration intensive equipment operates further from the closest point, vibration levels would reduce along with the risk of structural damage and probability of adverse comment.

3.5.6 Construction road traffic

Construction traffic movements along the proposed routes have been compared to the future traffic volumes during the peak construction period to determine if the additional traffic would increase noise levels by more than 2 dB(A) at residential receivers.

The construction road traffic noise calculations were carried out using the Calculation of Road Traffic Noise (CoRTN) (UK Department of Transport, 1988) algorithms to predict the change in road traffic noise levels due to construction traffic. As discussed in **Section 3.5.1**, where the predicted increase in traffic noise level is greater than 2 dB(A), the predicted noise level is compared to the RNP road traffic noise criteria.

Construction road traffic would access the construction footprint via the ancillary facilities. Traffic accessing each ancillary facility is expected to travel along the following roads, which have been assessed for construction traffic noise impacts:

- AS1 would be accessed via John Renshaw Drive and an alternative access via the New England Highway
- AS2 and AS3 would be accessed via Lenaghans Dr and an alternative access via the New England Highway
- AS4 would be accessed via Quarter Sessions Road and the New England Highway. However, the section of Quarter Sessions Road where construction traffic would travel on is minimal and no sensitive receivers would be impacted upon
- AS5 would be accessed via the Aurizon access road and the New England Highway. However, no sensitive receivers are located along the Aurizon access road
- AS6, AS7, AS8 and AS9 would be accessed via the New England Highway
- AS10, AS11, AS14, AS15, AS20 and AS21 would be accessed via the Pacific Highway
- AS12 and AS13 would be accessed via the Pacific Highway and an alternative access via Old Punt Road. However, no sensitive receivers are located along Old Punt Road
- AS16, AS17, AS18 and AS19 would be accessed via Masonite Road.

The future traffic volumes during construction along the proposed construction traffic routes and the proposed construction traffic volumes are presented in **Appendix C**.

Assessed vehicle movements are based on the maximum projected number of movements during construction of the project, when construction work is at peak production. During other stages of the project, there would be a reduced number of vehicles, and a corresponding reduction in noise levels.

3.5.7 Construction blasting

The assessment of noise and vibration impacts to sensitive receivers due to blasting associated with construction activities was carried out against the requirements for airblast overpressure and basting vibration impacting human response to structural damage.

Specific blasting information and seismic details for the area to be blasted is unavailable. General guidance has therefore been developed to estimate likely 'minimum distance limits' from blasting in terms of the air blast overpressure and ground vibration limits described in **Section 3.5.1**, for a range of blast Maximum Instantaneous Charge (MIC) quantities. The sections below detail how these general limits were identified for the project.

Air blast overpressure

Distance limits relating to air blast overpressure were determined using the following formula derived from blasting measurements carried for previous projects in the Hunter Valley region.

$$P = 167 + 6.5\, log_{10}\, Q - 23\, log_{10}\, R$$

where:

P = pressure, in decibels
Q = effective charge mass per delay or maximum instantaneous charge in kilograms
R = distance between charge and point of measurement in metres.

Ground vibration

Distance limits relating to ground vibration were determined using the formula in Australian Standard AS 2187.2-2006, which presents information for estimating free face blasting in 'average field conditions'. The applicable equation is:

$$V = 1140\left(\frac{R}{Q^{1/2}}\right)^{-1.6}$$

where:

V = ground vibration as peak particle velocity in mm/s
R = distance between charge and point of measurement in metres
Q = effective charge mass per delay or maximum instantaneous charge in kilograms.

3.6 Operational noise and vibration assessment methodology

3.6.1 Operational noise and vibration criteria

Operational road traffic noise

Operational road traffic noise criteria for the assessment of traffic noise impacts to sensitive receivers are defined in the RNP. The NCG provides interpretation and guidance on the application of the RNP when establishing the traffic noise criteria applicable to the project.

The noise criteria provided by the RNP and NCG for residential and other sensitive land uses (non-residential) receivers are non-mandatory. Where the traffic noise levels due to the operation of the project are predicted to be above the establish noise criteria, feasible and reasonable noise mitigation measures should be investigated to minimise the impacts to the sensitive receivers.

The RNP and NCG assesses traffic noise impacts based on the following scenarios:

- **'No Build'** – the assessment scenario if the project were not to go ahead (i.e. status quo)
- **'Build'** – the assessment scenario with the project constructed and operating.

The RNP and NCG require noise to be assessed at project opening and for a future design year which is typically 10 years after opening. For this project, the opening year is 2028 and the design year is 2038.

Residences may be assigned new, redeveloped, transition zone or relative increase criteria depending on how the project would influence traffic noise levels. The most stringent applicable criteria would be used in the assessment for each facade of the residence.

For assessment purposes, a receiver building has been defined as a residential or non-residential building that has noise sensitive areas potentially impacted by operational road traffic noise. An individual receiver building is considered as a single receiver for the purposes of this assessment. For example, one double-storey residential building is represented by one receiver building.

Transition zones

The project consists of both redeveloped roads and new roads. A road is ‘redeveloped’ where the proposed alignment is in an existing road corridor and the existing road is not substantially realigned. A road is classified as being ‘new’ if the alignment is in an undeveloped corridor (e.g. a bypass) or is substantially realigned from the existing road. The NCG defines substantial realignment of an existing road as a distance beyond a tolerance band that is six times the existing road’s total lane width.

The project forms a deviation from the M1 Pacific Motorway at the proposed Black Hill interchange and connects to the Pacific Highway at the proposed Tomago interchange before deviating from the Pacific Highway at Heatherbrae and connecting back onto the Pacific Highway at the proposed Raymond Terrace interchange.

According to the NCG, the proposed deviations from the Black Hill interchange to the Tomago interchange and from the Pacific Highway at Heatherbrae to the Raymond Terrace interchange are classed as ‘new roads’ as they transverse through greenfield areas and extend beyond the existing road corridor. The section between the Tomago interchange and the deviation from the Pacific Highway at Heatherbrae and the section of the New England Highway between John Renshaw Drive and the existing Tarro interchange at Tarro are duplications of the existing highways and are classed as ‘redeveloped roads’ as the upgraded roads would increase the traffic carrying capacity.

The roads which form the project are classified as motorway or arterial roads because they handle through traffic bound for another locality and have characteristically heavy and continuous traffic flows.

The NCG requires transition zones to be applied at the point where road categories change from new to redeveloped, or vice versa, to provide a smooth transition in noise criteria. As such, the project contains the 'new road', 'redeveloped road' and 'transition zone' noise categories. The location of new, redeveloped roads and transition zones are shown in **Appendix D**.

Traffic noise criteria for residential receivers

A summary of the applicable traffic noise criteria in accordance with the NCG for residential receivers is presented in **Table 3-26**.

Table 3-26 NCG criteria for residential receivers

Road category	Type of project / land use	Assessment criteria, dB(A)	
		Daytime (7.00am – 10.00pm)	Night time (10.00pm – 7.00am)
Freeway / arterial / sub-arterial roads	1. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	$L_{Aeq(15\ hour)}$ 55 (external)	$L_{Aeq(9\ hour)}$ 50 (external)
	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial road corridors	$L_{Aeq(15\ hour)}$ 60 (external)	$L_{Aeq(9\ hour)}$ 55 (external)
	3. Existing residences affected by both new roads and the redevelopment of existing freeway/arterial/sub-arterial roads in a Transition Zone[1]	Between $L_{Aeq(15\ hour)}$ 55-60 (external)	Between $L_{Aeq(9\ hour)}$ 50-55 (external)

Road category	Type of project / land use	Assessment criteria, dB(A)	
		Daytime (7.00am – 10.00pm)	Night time (10.00pm – 7.00am)
	4. Existing residences affected by increases in traffic noise of 12dB(A) or more from new freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15\ hour)}$ 42-55 (external)	Between $L_{Aeq(9\ hour)}$ 42-50 (external)
	5. Existing residences affected by increases in traffic noise of 12dB(A) or more from redevelopment of existing freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15\ hour)}$ 42-60 (external)	Between $L_{Aeq(9\ hour)}$ 42-55 (external)

Note:

1. The applicable noise criteria for a particular receiver would be dependent on its location relative to where the new road joins the redeveloped road (transition zone). See Section 7.1 and Table 1 of the Transport for NSW 'Noise Criteria Guideline' for further information
2. The criteria at each facade are determined from the existing traffic noise level plus 12 dB(A)

It is noted that for operational noise assessment purposes, caravan parks have been assessed as residential type receivers as permanent residents may reside within the caravan parks. However, it is understood that the Tomago Village Van Park located in NCA09 does not accommodate permanent residents and therefore, this caravan park has not been assessed for operational traffic noise impacts.

Traffic noise criteria for non-residential receivers

A summary of the applicable traffic noise criteria in accordance with the NCG for non-residential sensitive land uses receivers is presented in **Table 3-27**.

Table 3-27 NCG criteria for non-residential sensitive land uses

Existing sensitive land use	Assessment criteria, dB(A)		Additional considerations
	Daytime (7.00am – 10.00pm)	Night time (10.00pm – 7.00am)	
School classrooms	$L_{Aeq(1\ hour)}$ 40 (internal) when in use	–	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000).
Places of worship	$L_{Aeq(1\ hour)}$ 40 (internal)	$L_{Aeq(1\ hour)}$ 40 (internal)	The criteria are internal, i.e. the inside of a church. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established what in these areas may be affected by road traffic noise. For example, if there is a church car park between a church and the road, compliance with the internal criteria inside the church may be sufficient. If, however, there are areas between the church and the road where outdoor services may take place such as weddings and funerals, external criteria for these areas are appropriate. As issues such as speech intelligibility may be a consideration in these cases, the open space (passive use) criteria may be applied.

Existing sensitive land use	Assessment criteria, dB(A)		Additional considerations
	Daytime (7.00am – 10.00pm)	Night time (10.00pm – 7.00am)	
Open space (active use)	$L_{Aeq(15\ hour)}$ 60 (external) when in use	–	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion. Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading. In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.
Open space (passive use)	$L_{Aeq(15\ hour)}$ 55 (external) when in use	–	
Childcare facilities	Sleeping rooms $L_{Aeq(1\ hour)}$ 35 (internal) Indoor play areas $L_{Aeq(1\ hour)}$ 40 (internal) Outdoor lay areas $L_{Aeq(1\ hour)}$ 55 (external)	–	Multi-purpose spaces, e.g. shared indoor play/sleeping rooms should meet the lower of the respective criteria. Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility.

For non-residential receivers such as school classrooms, places of worship and childcare centres the criteria are applicable to internal areas. It is generally accepted that most buildings provide a noise reduction of at least 10 dB(A) when windows are left 20 per cent open, without providing additional noise mitigation treatment. Therefore, where the noise goals are internal, a 10 dB(A) reduction from external noise levels to internal noise levels has been adopted to allow for an external assessment.

For childcare centres, it is noted that two internal noise criteria are applicable, representing sleeping rooms and indoor play areas. For the purpose of a conservative assessment, the equivalent external criterion of 45 dB(A) (i.e. 35 dB(A) + 10 dB(A)) for sleeping rooms has been applied as part of the noise assessment for childcare centres. Detailed information on floorplans of childcare centres determined to exceed the NCG criteria should be obtained during design development to confirm the use of the internal areas adjacent to facades determined to exceed the assigned sleeping room criterion. Where the internal areas are indoor play areas and not sleeping rooms, then a reassessment of the predicted noise levels should be carried out against the equivalent external noise criterion for indoor play areas (i.e. 50 dB(A)).

Road traffic noise impacts from existing roads

The NCG provides guidance for assessing traffic noise from existing roads not subject to any redevelopment work but is predicted to increase traffic noise levels by more than 2 dB(A) as a result of the project. An example of this is when traffic from the project uses the existing road as a detour resulting in an increase in traffic volumes on the existing road, which in turn increases the traffic noise levels at affected receivers by more than 2 dB(A).

Maximum road traffic noise levels

Maximum noise levels generated by road traffic noise have the potential to cause disturbance to sleep. Although noise goals are not provided in the RNP, the RNP includes a review of internal sleep arousal research. The RNP concludes that there appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise. Nevertheless, Transport recognises the potential impacts and requires an assessment of maximum noise levels be made where impacts may occur during the night.

Guidance for assessing maximum noise levels is provided in Practice Note iii of the Environmental Noise Management Manual (RTA 2001) (ENMM). The maximum noise assessment should be used as a tool to help prioritise and rank mitigation strategies. It should not be used as a decisive criterion in itself and should not be used to aid in designing the degree of mitigation required.

The purpose of a maximum noise level assessment is to determine where maximum noise levels are likely to change as a result of a project.

The assessment considers the extent to which the maximum noise levels for individual passing vehicles exceed the L_{Aeq} noise level for each hour of the night; where a maximum noise level event occurs when:

- L_{Amax} noise levels greater than 65 dB(A)
- L_{Amax} – $L_{Aeq(1\ hour)}$ greater than or equal to 15 dB(A).

Heritage buildings

There are no specific road traffic noise criteria for heritage buildings. The assessment of operational road traffic noise is based on the use of a receiver, rather than the classification of the receiver. For example, if a heritage building is used for residential purposes, then it is assessed as a residential receiver.

Therefore, heritage buildings identified in this study have been assessed accordingly for road traffic noise impacts based their use, where applicable.

Operational road traffic vibration

The potential for operational ground-borne noise and tactile vibration impacts on nearby sensitive receivers, including heritage items, from traffic on project roads (as presented in **Appendix D**) has been reviewed. Vibration emissions from traffic travelling on roads typically occur where there are irregularities in the road surface (e.g. pot holes). As the new and upgraded roads associated with the project would be designed and constructed to avoid road irregularities, operational ground-borne noise and tactile vibration impacts from operation traffic are not expected.

Therefore, vibration impacts from traffic travelling on the new and upgraded roads are considered negligible and are unlikely to result in ground-borne noise or tactile vibration impacts to sensitive receivers, including heritage items, directly adjacent to these roads, and have not been assessed further in this working paper.

3.6.2 Noise modelling scenarios

Operational road traffic noise impacts were assessed for the roads associated with the project. To conduct the road traffic noise assessment, a number of specific traffic scenarios were required to be modelled and compared. The assessment considers both the ‘Build’ (with the project) and ‘No Build’ (without the project) scenarios for the year of opening (assumed to be 2028) and 10 years after opening (2038) **Table 3-28** summarises the scenarios modelled. Detailed noise modelling results for the above scenarios and the assessment against the NCG requirements are provided in **Appendix D**.

Table 3-28 Traffic noise modelling scenarios

Modelled scenario	Description
2028 Opening year	
'Do minimum 2028'	**'No Build'** opening year of the project but **WITHOUT** the project constructed and operating, including other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed.
'With project 2028'	**'Build'** opening year of the project **WITH** the project constructed and operating, including other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed.
2038 Design year (10 years after opening)	
'Do minimum 2038'	**'No Build'** design year of the project but **WITHOUT** the project constructed and operating, including other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed.
'With project 2038'	**'Build'** design year of the project **WITH** the project constructed and operating, including other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed.

3.6.3 Noise modelling inputs

Building heights and land use information

Building height information in the operational study area based on LiDAR data was used for the assessment. Details of single and multi-storey buildings including building footprints were input into the noise model based on the supplied building height, supplemented by desktop reviews. As part of the building height information, land use information for each building was also supplied and entered into the noise model.

For multi storey buildings, all floor levels which accommodate noise sensitive receivers have been included as part of the road traffic noise assessment. A separate receiver has been assigned to each floor level of a multi storey building; for example, assessment of a two-storey residential dwelling covers each of the two levels of the building.

Road pavement

Road pavement information was sourced from the road design information. The road pavement surfaces for the project would typically consist of the following:

- Plain concrete pavement (PCP) wearing course along the main alignment
- Dense graded asphalt (DGA) wearing course along the section of the New England Highway that is being upgraded around the proposed interchange at Tarro.

Appropriate noise corrections were used in the prediction of future traffic noise levels. For dense graded asphalt pavements, no corrections are applied, while a correction reflecting a noise increase was applied for concrete pavements. More details on the applicable pavement noise corrections are presented in **Table 3-29.**

Traffic flow and composition summary

Traffic classification surveys were carried out at the following locations along the project route concurrently with the long term traffic noise monitoring:

- M1 Pacific Motorway, Beresfield

- New England Highway, Tarro
- Pacific Highway, Tomago
- Pacific Highway, Heatherbrae.

In accordance with Transport procedures, the traffic data obtained were used for the validation process of the traffic noise model. Results of the traffic classification surveys are presented in **Appendix D**.

The traffic volumes used for the traffic noise predictions and assessment for the scenarios presented in **Table 3-28** have been based on traffic data in the Traffic and Transport Working Paper (Appendix G of the EIS). The forecast traffic data used in the operational noise assessment takes into account numerous current and future road projects and land use changes based on other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed. This has therefore allowed for consideration of cumulative operational road traffic noise impacts from the project along with other sources of road traffic in the area. Details of the traffic data used for the predictions are presented in **Appendix D**.

3.6.4 Noise modelling methodology

Noise modelling was carried out using the Road Traffic Noise Module in the SoundPLAN (version 8.0) noise modelling software. This noise modelling software is recognised and accepted by both Transport and the NSW EPA.

The traffic noise prediction model is based on a method developed by the United Kingdom Department of Environment entitled Calculation of Road Traffic Noise (1988) known as the CoRTN88 method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board, The University of New South Wales and Transport. The model predicts noise levels for free flowing traffic and a modified method has been developed which enables an accurate prediction of noise from high heavy vehicle exhausts to be taken into account.

The method predicts the $L_{A10(1\ hour)}$ noise levels, and a correction of -3 dB(A) is applied to obtain the $L_{Aeq(1\ hour)}$ noise levels. The $L_{Aeq(1\ hour)}$ noise levels for the daytime 15 hour period from 7.00am to 10.00pm are then determined to derive the daily $L_{Aeq(15\ hour)}$ noise level. Similarly, the $L_{Aeq(1\ hour)}$ noise levels for the night time nine hour period from 10.00pm to 7.00am are then determined to derive the night time $L_{Aeq(9\ hour)}$ noise level.

Parameters and assumptions used in the noise model are presented in **Table 3-29**.

Table 3-29 Summary of noise modelling parameters and assumptions

Parameters	Input
Model geometry	
Source height	Three source heights: • 0.5 m for car exhausts/engines and car/heavy vehicle tyre noise • 1.5 m for heavy vehicle engines • 3.6 m for heavy vehicle exhausts.
Ground topography at receiver and road	• Topographic contours presented in one metre intervals within road corridor • Topographic contours presented in two metre intervals outside road corridor.
Road geometry	Reference design models
Operational study area	The operational study area extends to a distance of 600 metres on each side of the project roads (measured from the centreline of the outermost traffic lanes), as defined in the RNP and NCG. It is noted that receivers within NCA03, NCA06 and NCA08 lie outside of 600 m from project roads and have not been considered in the operational assessment

Parameters	Input
Noise sensitive receiver locations, building heights, angle of view	• Detailed building height surveys provided by project team • Other details from aerial and terrestrial photography.
Receiver heights	• 1.5 m above ground level to represent 1.5 m above ground floor level • 4.5 m above ground level to represent 1.5 m above first floor level for double storey premises
Existing noise barriers	Existing noise barrier heights and locations based on aerial and terrestrial photography and site checks where necessary
Road pavement surface	Proposed road surface design comprises the following: • Dense Graded Asphalt (DGA) • Plain Concrete Pavement (PCP).
Reflections from existing barriers, structures and cuttings on opposite side of road	• Determined from review of design drawings and aerial photography complemented with site checks • Detailed within CoRTN algorithms.
Traffic parameters	
Traffic volumes and mix	Traffic volumes for daytime 15 h and night time 9 h periods, and corresponding light and heavy vehicle mix in accordance with the project traffic model and presented in **Appendix D**.
Vehicle speeds	Detailed posted speed data provided by project team and presented in **Appendix D**.
Non-project arterial roads	Non-project arterial roads up to 600 m from the project have been considered
Corrections to model	
L_{A10} to L_{Aeq} correction	-3 dB
Road surface correction	Where applicable, the following corrections were applied relative to standard DGA: • 0 dB(A) for DGA • 0 dB(A) for Low Noise Diamond Ground Concrete Pavement (LNDG) • -2 dB(A) for Open Graded Asphalt (OGA) • +3 dB(A) for Concrete Pavement (PCP).
Facade correction	+2.5 dB(A), when modelling to one metre from building facades [RNP Table 7 (p17)]
Traffic mix correction	Corrections to account for the composition of heavy vehicle types along the road are determined based on a method developed by Transport and implemented on this project (J. Peng *et al*, 2017)
SoundPlan noise model settings	
Calculation method	Ray tracing method
Ground absorption factor	0 for water surfaces and 0.5 for other areas
Maximal search radius	3000 m for contours and for individual predictions
For noise contour maps	• Grid space = 50 m • Height above ground = 1.5 m and 4.5 m • Grid Interpolation = Not used

3.6.5 Noise model validation

The noise model validation process provides confidence that the noise model prepared for the existing situation represents the real world as accurately as possible within the limitations of the traffic noise prediction algorithms used in the computer noise modelling software. The validated noise model would be used to predict and assess the future traffic noise levels from the project and provide confidence in recommending applicable noise mitigation measures.

The noise model was validated using the long term traffic noise monitoring results at the noise monitoring locations and the concurrent traffic classification counts presented in **Appendix D**. **Table 3-30** summarises the results of the traffic noise model validation for the project, providing a comparison between the modelled traffic noise levels for existing conditions and the measured traffic noise levels during the daytime (7.00am to 10.00pm) and night time (10.00pm to 7.00am) periods.

Table 3-30 Noise model verification results

Monitoring Location	$L_{Aeq(15\ hour)}$ Daytime noise level			$L_{Aeq(9\ hour)}$ Night time noise level		
	Measured	Modelled	Diff.	Measured	Modelled	Diff.
L13 – 11 Cahill Close, Black Hill	54.0	54.6	0.6	50.9	50.5	-0.4
L14 – 23 Walter Parade, Black Hill	50.2	50.2	0.0	45.4	45.5	0.1
L15 – 70 New England Highway, Tarro	71.9	72.3	0.4	68.8	68.0	-0.8
L16 – 44 Sapphire Drive, Tarro	61.0	61.2	0.2	57.3	56.9	-0.4
L17 – 11 Central Avenue, Tarro	54.3	52.2	-2.1	48.5	47.9	-0.6
L18 – Proposed interchange at Tarro	69.2	70.1	0.9	66.7	65.8	-0.9
L19 – 2207 Pacific Highway, Heatherbrae	59.7	60.0	0.3	56.4	55.7	-0.7
L20 – Pacific Highway (north of Raymond Terrace Interchange)	72.7	73.4	0.7	68.9	67.9	-1.0
Mean			**0.1**			**-0.6**

Note:

1. Difference is Modelled minus Measured. A negative difference indicates the modelled level of road traffic noise is lower than the measured data, a positive difference indicates the modelled noise level is higher.

The noise model validation results presented in the above tables show that the noise model output results for each assessment area are generally in good agreement with noise monitoring for the daytime and night time periods, so a reasonable level of confidence can be placed on the noise model for predicting future traffic noise levels for the daytime and night time periods.

The exception is Location L17, where the daytime difference is -2.1 dB(A) indicating that the noise model predicts traffic noise levels lower than actual noise levels measured at the monitoring location. A review of the site information suggests that this monitoring location is located within a built up suburban area at a large distance (greater than 250 metres) from the road where concurrent traffic counting was conducted (i.e. New England Highway), resulting in measured noise levels being influenced by noise sources other than road of concern.

Overall, the mean differences between measured and modelled results for the daytime and night time periods are within the ±2 dB(A) allowance for traffic noise validation. Therefore, for the prediction of daytime and night time traffic noise levels, no calibration factors are required to be included when generating the operational noise predictions for future traffic noise scenarios.

3.6.6 Operational traffic noise mitigation

In determining the applicable road traffic noise mitigation measures for the project, the results of the assessment between the 'Do minimum' (without the project) and the 'With project' (with the project) scenarios for the design year 2038 have been used for the affected receivers impacted by the project.

The NMG provides guidance in managing and controlling road traffic generated noise and describes the principles to be applied when reviewing noise mitigation. The NMG recognises that the criteria recommended by the NCG are not always practicable and that it is not always feasible or reasonable to expect that they should be achieved.

The NMG notes that the most effective way of minimising noise from vehicles and traffic is to control vehicle noise at the source. Where source measures are not practical, or do not provide sufficient noise reduction, additional methods are required to reduce levels to within acceptable margins. Such additional methods may include the use of noise barriers and/or consideration for at-property treatment of residences.

The NMG provides three triggers where a receiver may qualify for consideration of noise mitigation (beyond the adoption of road design and traffic management measures). These triggers are shown in **Figure 3-3**.

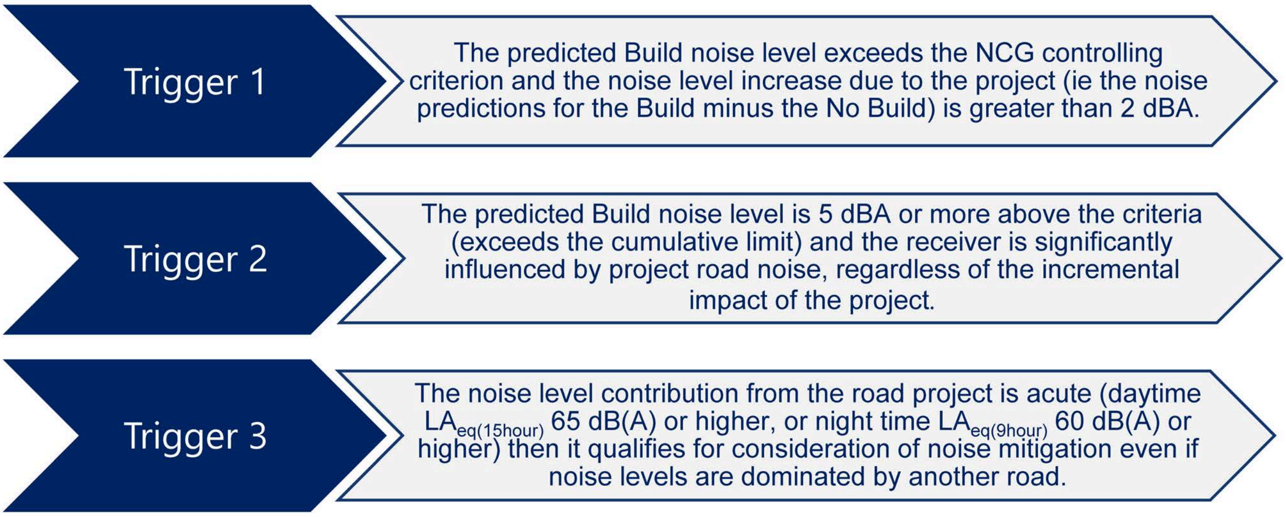

Figure 3-3 NMG noise mitigation triggers

The eligibility of receivers for consideration of additional noise mitigation is determined before the benefit of additional noise mitigation (quieter pavement and noise barriers) is included. The requirement for the proposal is to provide feasible and reasonable additional mitigation for these eligible receivers to meet the NCG controlling criterion.

The NMG provides a methodology in relation to determining and recommending acoustic treatments for road projects. In accordance with the NMG, once noise has been minimised by feasible and reasonable methods during the corridor planning and road design stages, receivers with residual exceedances of the NCG criteria are assessed to determine if these receivers qualify for consideration of additional noise mitigation.

Potential noise mitigation measures are identified for receivers that qualify for consideration of noise mitigation measures, in the order of preference as follows:

1. Quieter pavement surfaces
2. Noise mounds
3. Noise walls
4. At property treatments.

The priority of mitigation measures recognises the importance of providing protection to both external and internal areas of a receiver and also the degree of visual impact. For it to be considered reasonable to provide quieter pavement surfaces, noise mounds and/or noise walls, there needs to be four or more closely spaced receivers that would benefit from these mitigation measures. At property noise mitigation may replace at road mitigation, subject to a reasonable and feasible assessment.

A combination of at road mitigation and at-property treatment can provide the most reasonable overall noise reduction for an affected community when consideration is given to cost, urban design, shadowing and engineering constraints with the maximum barrier. The process of deriving the most effective combination of noise barrier height and at property treatment is described in detail in Section 8 of the NMG.

Quieter pavements

The NMG sets out that a quieter pavement surface is the preferred form of noise mitigation as it reduces source noise levels and provides protection to both external and internal sensitive areas and also has the least visual impact. Quieter pavements may be considered where there are groups of four or more closely spaced receivers (i.e. facades are separated by less than 20 metres) that exceed the NCG criteria.

With the general exception of motorcycles, for all vehicles in a reasonable state of maintenance, tyre/road interaction represents the main source of noise at constant speeds in excess of around 30 to 50 kilometres per hour for cars and 40 to 80 kilometres per hour for trucks (RTA, 2001). The type of road surface can have a substantial impact on traffic noise generated by pavement tyre/road interaction.

Pavement design for the project would include DGA or PCP. For asphalt pavements, the use of quieter pavement surfaces such as OGA could yield noise reduction of up to 2 dB(A) when compared to DGA. For concrete pavements, applying LNDG methods to the PCP, for example, could reduce noise levels to match the acoustic performance of DGA pavements.

Noise barriers

Following the adoption of a quieter pavement as the first method of noise mitigation, noise barriers (mounds or walls) are the next preferred form of mitigation in accordance with the NMG. The NMG states the following key points in relation to noise barriers:

> *"Noise barriers should be considered where there are four or more closely spaced receivers."*
>
> AND
>
> *"Barrier heights above 8 metres will not be considered"*
>
> AND
>
> *"As a guide noise walls or mounds are considered to be a reasonable noise mitigation option where they are capable of providing an insertion loss of:*
>
> - *5 dB(A) at representative receivers for heights up to 5 metres high*
> - *10 dB(A) at representative receivers for heights above 5 metres and up to 8 metres high."*

Noise barrier effectiveness assessments are carried out where noise barriers are feasible options for reducing road traffic noise at affected receivers. Assessments are carried out in accordance with the process described in Section 8 of the NMG. The outcomes of the barrier assessment determine whether the barriers are reasonable to implement, and if so, the optimum barrier height.

When optimising the noise barrier height in the noise abatement design, the process described in the NMG identifies three heights. These are the maximum barrier height, initial design barrier height and design barrier height. The optimising process is completed in three steps:

- **Step 1** – identify the maximum barrier height, which is the barrier height that strives to result in external noise criteria being met at all receivers. Transport's policy is that barrier heights above eight metres would not be assessed as part of the noise abatement design
- **Step 2** – define the initial barrier height, which is a height between zero and maximum barrier height, where the trend in noise benefit is characterised by a rapid reduction in the number of properties that are eligible for consideration of additional noise mitigation
- **Step 3** – determine the design barrier height, between the initial barrier and maximum design barrier heights. The design barrier height is identified by also taking into consideration the area of noise barrier and noise reduction benefits across the broader community.

The design barrier height forms the acoustic recommendation and is further evaluated in a multi-criteria decision making process to determine the feasible and reasonable combination of noise mitigation measures.

Where existing barriers may be increased in height, the higher barrier should provide a minimum insertion loss increase of 2 dB(A) over the existing barrier height to be considered a reasonable noise mitigation option. It is also important to note that where the predicted total diffraction attenuation exceed 20 dB(A) for single diffraction, further increase in noise barrier height is not considered in the aforementioned process as this level of noise reduction is nearly impossible to attain in practice.

Generally speaking, the higher the barrier, the greater the level of noise reduction. However, as identified in Transport's Noise Wall Design Guideline (March 2016), noise barriers that are excessively high can bring about the potential for visual intrusion, reduction of sunlight, loss of character and view and social alienation, compromising on urban design and resulting in unacceptable visual impacts. In addition, a noise barrier that is reasonable may not always be feasible to build, on account of roadway and stormwater flow obstruction, access requirements (e.g. driveways), space limitations as well as wind loading and unsuitable ground conditions. As such, the aforementioned non-acoustical design factors are evaluated at each assessed location and the appropriate allowable barrier heights recommended for further consideration during further design development. Taking into account community preferences, the final design barrier height with acceptable visual impact would be confirmed during further design development for construction, conforming to Transport's Design Specification QA R271 'Design and Construction of Noise Walls'.

At-property treatments

At property traffic noise mitigation measures may replace or supplement at road mitigation, only in the following circumstances, subject to a reasonable and feasible assessment:

- Isolated single residences or isolated groups of closely spaced residences as defined in the NMG
- Where the affected community expresses a preference for at property treatment and the cost is less than a combination of a barrier and at property treatment
- Where noise barriers or quieter pavements alone do not achieve the level of noise mitigation (insertion loss) required
- Where the only applicable noise criteria are internal (e.g. places of worship, schools or childcare centres where play areas meet external criteria)
- Where other noise mitigation measures have been shown not to be feasible or reasonable.

These treatments are generally limited to acoustic treatment of the building elements (doors, windows, vents, etc) or courtyard fences where they reduce noise to habitable rooms. The installation of courtyard fences close to the dwelling may also provide some mitigation for outdoor living spaces.

For non-residential noise sensitive receivers such as schools, places of worship and childcare centres equivalent external noise goals based on a 10 dB(A) reduction from external noise levels to internal noise levels when windows are left 20 per cent open, have been conservatively adopted to allow external assessments. Therefore, residual non-residential receivers triggered for additional noise mitigation because they still exceed the equivalent external traffic noise criteria, have been identified for at-property treatment based on this conservative assessment.

4. Existing environment

4.1 Overview

Most of the project traverses large open land spaces with minimal nearby residential receivers. Semi-rural residential receivers are scattered in the Black Hill area at the southern end of the project. In the Tarro area, near the proposed interchange at Tarro, suburban residential receivers including a caravan park and other sensitive receivers are located north of the New England Highway. Towards the northern end of the project in Heatherbrae and Raymond Terrace, suburban residential receivers including caravan parks and motels are located to the west of the existing Pacific Highway. The suburban residential areas in Heatherbrae and Raymond Terrace are located at large distances (greater than 800 metres) from the project and noise impacts to these areas are unlikely to be substantial.

Large concentrated areas of commercial and industrial receivers are located in the areas of Beresfield, Tomago and Heatherbrae. In Heatherbrae the commercial and industrial receiver buildings provide a buffer between the project and the nearest residential receivers.

The existing acoustic environment surrounding the project varies. The acoustic environment in the residential areas is mostly influenced by noise from:

- Roads: Predominantly the major arterial roads and motorway including the M1 Pacific Motorway, John Renshaw Drive, New England Highway and the Pacific Highway
- Local transport activities: Especially in commercial and industrial areas, where the noise generated by these activities can contribute to higher ambient noise levels which locally mask road traffic noise.

4.2 Noise sensitive receivers and noise catchment areas

Noise and vibration sensitive receivers around the project are generally separated into the following major categories:

- Residential receivers (including caravan parks)
- Other sensitive (non-residential) receivers, including:
  - Classrooms at schools
  - Places of worship
  - Childcare centres
  - Active recreation areas (e.g. sports fields/activities which generate their own noise and are generally less sensitive to external noise)
  - Passive recreation areas (e.g. areas used for low intensity and low noise producing activities which have the potential to be impacted by external noise such as reading or meditation).
- Commercial premises (including offices and retail outlets)
- Industrial premises.

All sensitive receivers within the construction and operational study areas, based on the above categories, are presented in **Appendix B**.

Noise catchment areas group noise sensitive receivers into areas with similar acoustic environments (refer to **Section 3.2**). The project has been divided into 19 NCAs and sub-NCAs. Various receiver types and land uses are located within each NCA.

A description of each NCA is provided in **Table 4-1**. The locations of NCAs relative to the project are shown in **Figure 4-1**.

Table 4-1 Noise catchment area descriptions

NCA	Description
NCA01A	Located in Black Hill, directly to the west and east of the M1 Pacific Motorway and the project. Rural residential receivers and a single non-residential receiver are located within this NCA. Noise environment typically dominated by traffic noise from the M1 Pacific Motorway.
NCA01B	Located in Black Hill, east of the M1 Pacific Motorway and south of the project. Rural residential receivers are located within this NCA. Noise environment includes distant traffic noise from the M1 Pacific Motorway.
NCA02	Located in Beresfield, north of John Renshaw Drive and the project. Commercial and industrial receivers and a single non-residential receiver are located within this NCA. Noise environment includes general industrial noise and traffic noise from John Renshaw Drive.
NCA03	Located in Beresfield, north of John Renshaw Drive and the project. Commercial and industrial receivers are located within this NCA. Noise environment includes general industrial noise and traffic noise from the New England Highway.
NCA04A	Located in Beresfield and Tarro, directly to the north of the New England Highway and the project. Suburban residential receivers and two non-residential receivers are located within this NCA. Noise environment typically dominated by traffic noise from the New England Highway.
NCA04B	Located in Beresfield and Tarro, north of the New England Highway and the project. Suburban residential receivers and two non-residential receivers are located within this NCA. Noise environment includes distant traffic noise from the New England Highway.
NCA05A	Located in Tarro, directly to the north of the New England Highway and the project. Suburban residential receivers and some industrial receivers are located within this NCA. Noise environment includes traffic noise from the New England Highway.
NCA05B	Located in Beresfield and Tarro, north of the New England Highway and the project. Suburban residential receivers and seven non-residential receivers are located within this NCA. Noise environment includes distant traffic noise from the New England Highway.
NCA06	Located in Woodberry, north and west of the New England Highway and the project. Suburban residential receivers and two non-residential receivers are located within this NCA. Noise environment includes distant traffic noise from the New England Highway.
NCA07	Located in Black Hill and Tarro, directly south of the New England Highway and the project. Two rural residential receivers and some industrial receivers are located within this NCA. Noise environment dominated by traffic noise from the New England Highway.
NCA08	Located in Hexham, directly west of the New England Highway, east of the Pacific Highway and south of the project. Four residential receivers and numerous commercial and industrial receivers are located within this NCA. Noise environment dominated by general industrial noise and traffic noise from the New England Highway and Pacific Highway.
NCA09	Located in Tomago, directly south of the Pacific Highway and the project. One residential receiver and a caravan park are located within this NCA. Noise environment dominated by nearby industrial noise and traffic noise from the Pacific Highway.
NCA10	Located in Tomago, southeast of the Pacific Highway and the project. Commercial and industrial receivers are located within this NCA. Noise environment includes general industrial noise and traffic noise from the Pacific Highway.
NCA11	Located in Tomago, east of the Pacific Highway and the project. One non-residential receiver is located within this NCA. Noise environment typically dominated by traffic noise from the Pacific Highway.
NCA12	Located in Heatherbrae, directly east of the Pacific Highway and west of the project. Residential receivers and commercial and industrial receivers are located within this NCA. Noise environment dominated by general industrial noise and traffic noise from the Pacific Highway.
NCA13	Located in Raymond Terrace, directly east and west of the Pacific Highway and at the northern end of the project. Residential receivers and commercial and industrial receivers are located within this NCA. Noise environment includes traffic noise from the Pacific Highway.

NCA	Description
NCA14A	Located in Heatherbrae, directly west of the Pacific Highway and the project. Residential receivers, two non-residential receivers and commercial and industrial receivers are located within this NCA. Noise environment typically dominated by traffic noise from the Pacific Highway.
NCA14B	Located in Raymond Terrace, northeast of the Pacific Highway and the project. Suburban residential receivers and two non-residential receivers are located within this NCA. Noise environment includes traffic noise from the Pacific Highway.
NCA14C	Located in Raymond Terrace, east and west of the Pacific Highway and at the northern end of the project. Suburban residential receivers and one non-residential receiver are located within this NCA. Noise environment typically dominated by traffic noise from the Pacific Highway.

Figure 4-1 Noise catchment areas (map 1 of 2)

Date: 02/03/2021 Project path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

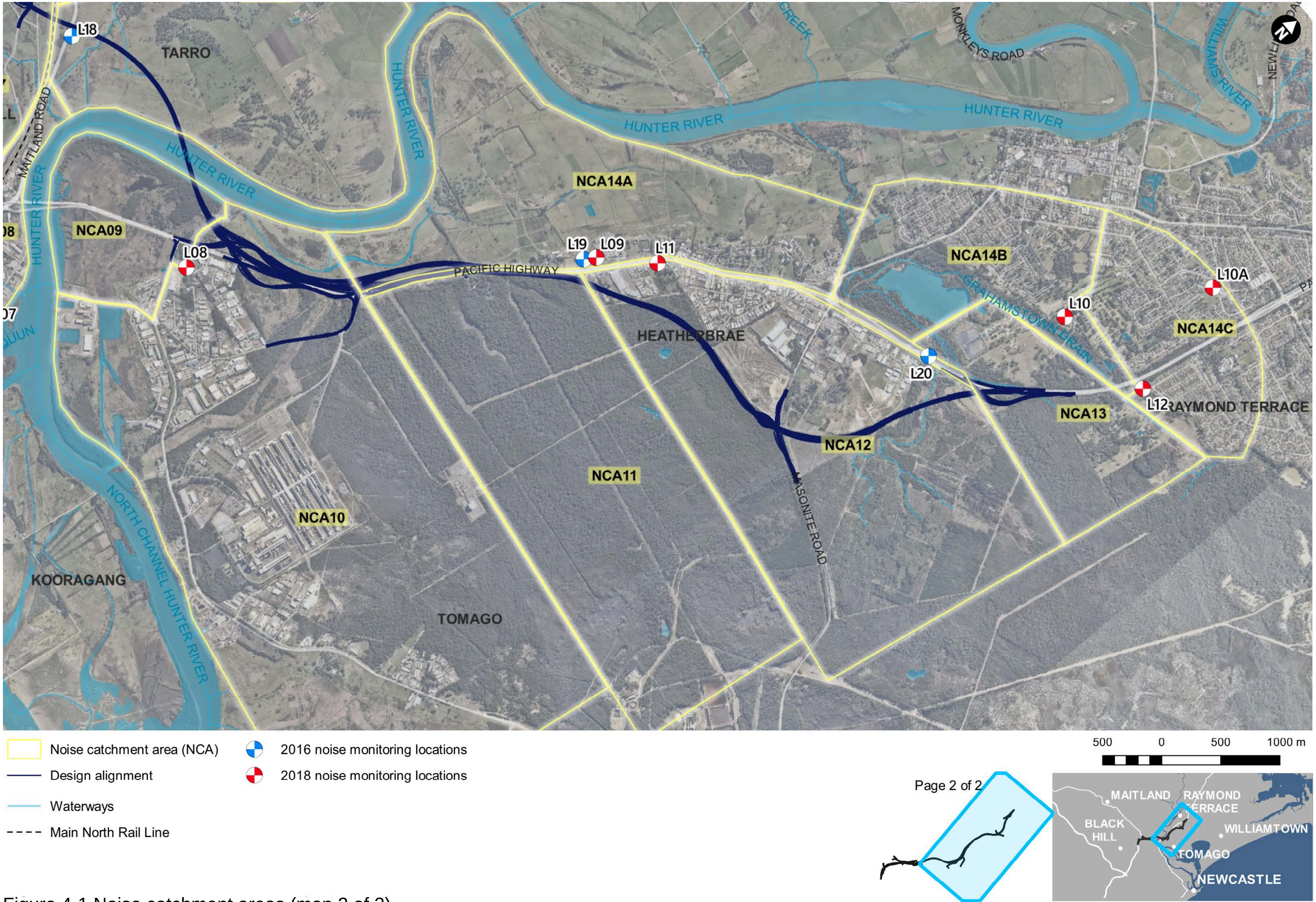

Figure 4-1 Noise catchment areas (map 2 of 2)

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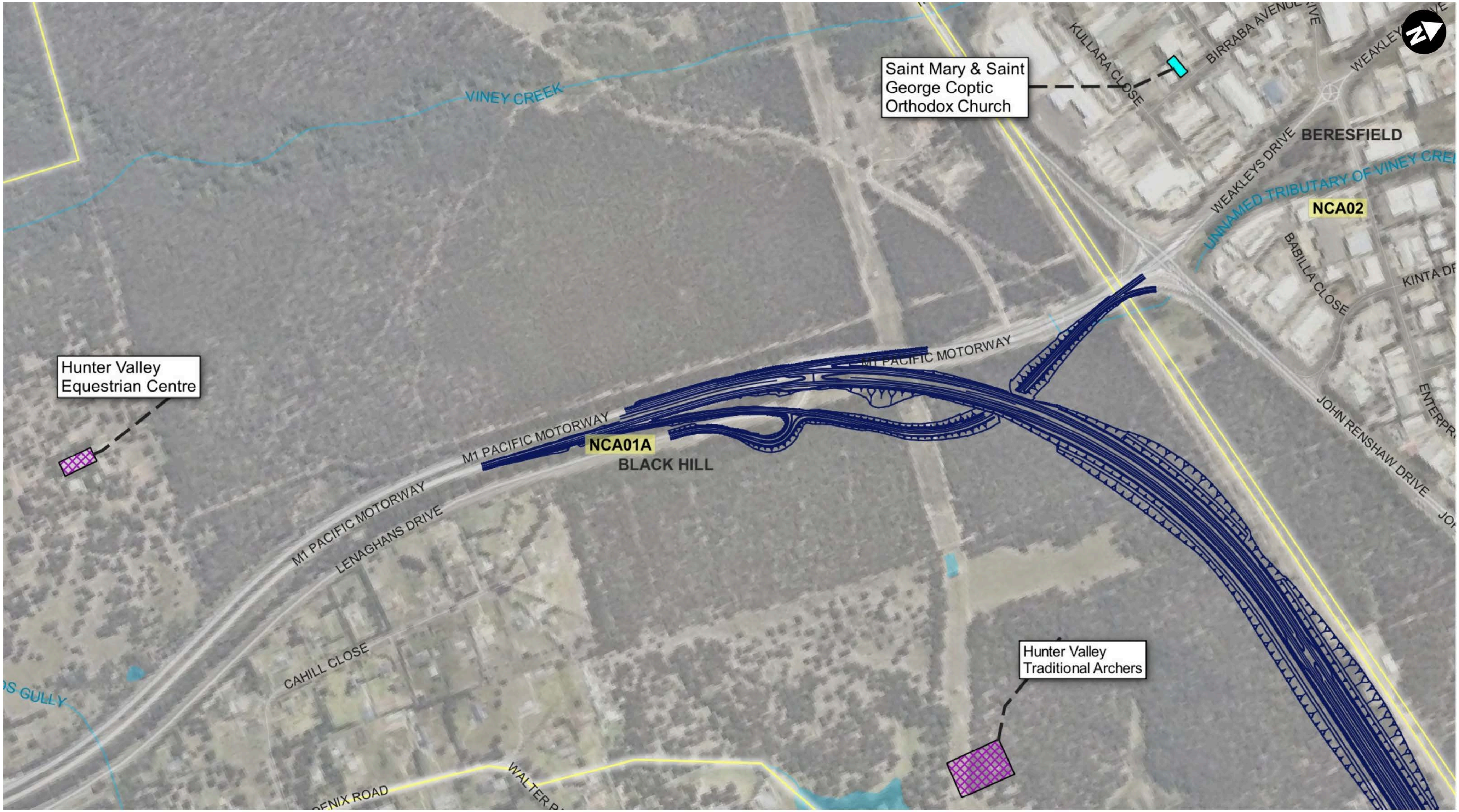
Other sensitive (non-residential) receivers such as schools, places of worship, childcare centres and recreational areas within the construction and operational study areas are presented in **Table 4-2** and **Figure 4-2**.

Table 4-2 Non-residential sensitive receivers within the study areas

NCA	Description	Address	Type of receiver
NCA01A	Hunter Valley Equestrian Centre	2 Black Hill Road, Black Hill	Active recreation
NCA01B	Hunter Valley Traditional Archers	Pacific Motorway, Black Hill	Active recreation
NCA02	Saint Mary & Saint George Coptic Orthodox Church	1 Pippita Close, Beresfield	Place of worship
NCA04A	Pasadena Crescent Reserve Soccer Fields	Pasadena Crescent, Beresfield	Active recreation
NCA04A	Our Lady of Lourdes Primary School	Anderson Drive, Tarro	Educational
NCA04A	Our Lady of Lourdes Church	Anderson Drive, Tarro	Place of worship
NCA04A	Tarro Public School	5 Eastern Avenue, Tarro	Educational
NCA04B	Fiona John Park	11 Beverley Close, Tarro	Passive recreation
NCA04B	Newcastle Memorial Park	176 Anderson Drive, Beresfield	Place of worship
NCA04B	Baptist Church	150 Anderson Drive, Beresfield	Place of worship
NCA04B	Tarro Uniting Church of Australia	12 Northern Avenue, Tarro	Place of worship
NCA05B	Tarro Recreation Area	22 Anderson Drive, Tarro	Active recreation
NCA05B	Beresfield Community Children's Education Centre	6 Milton Street, Beresfield	Childcare
NCA05B	Goodstart Beresfield	9 Milton Street, Beresfield	Childcare
NCA05B	Beresfield Public School	181 Anderson Drive, Beresfield	Educational
NCA05B	Beresfield Library	34 Lawson Avenue, Beresfield	Educational
NCA05B	Our Lady of Lourdes Beresfield Church	Anderson Drive and Delprat Ave, Beresfield	Place of worship
NCA05B	Saint Paul's Anglican Church	2A Beresford Avenue, Beresfield	Place of worship
NCA05B	Saint David's Presbyterian Church	24 Beresford Avenue, Beresfield	Place of worship
NCA11	Hunter Region Botanic Gardens	2100 Pacific Highway, Heatherbrae	Passive recreation
NCA14A	Hunter River High School	36 Elkin Avenue, Heatherbrae	Educational
NCA14A	Ryans at Newcastle Equestrian Centre	2273 Pacific Highway, Heatherbrae	Active recreation
NCA14B	St Brigid's Primary School	52 Irrawang Street, Raymond Terrace	Educational
NCA14B	St Brigid's Catholic Church	65 William Street, Raymond Terrace	Place of worship
NCA14C	Irrawang High School	80 Mount Hall Road, Raymond Terrace	Educational



Other sensitive receivers

Childcare
Educational
Place of worship
Active recreation
Passive recreation
Noise catchment area (NCA)
Design alignment
Waterways
Main North Rail Line

150 0 150 300 m

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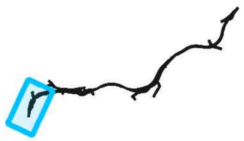

Figure 4-2 Other sensitive (non-residential) receivers (map 1 of 4)

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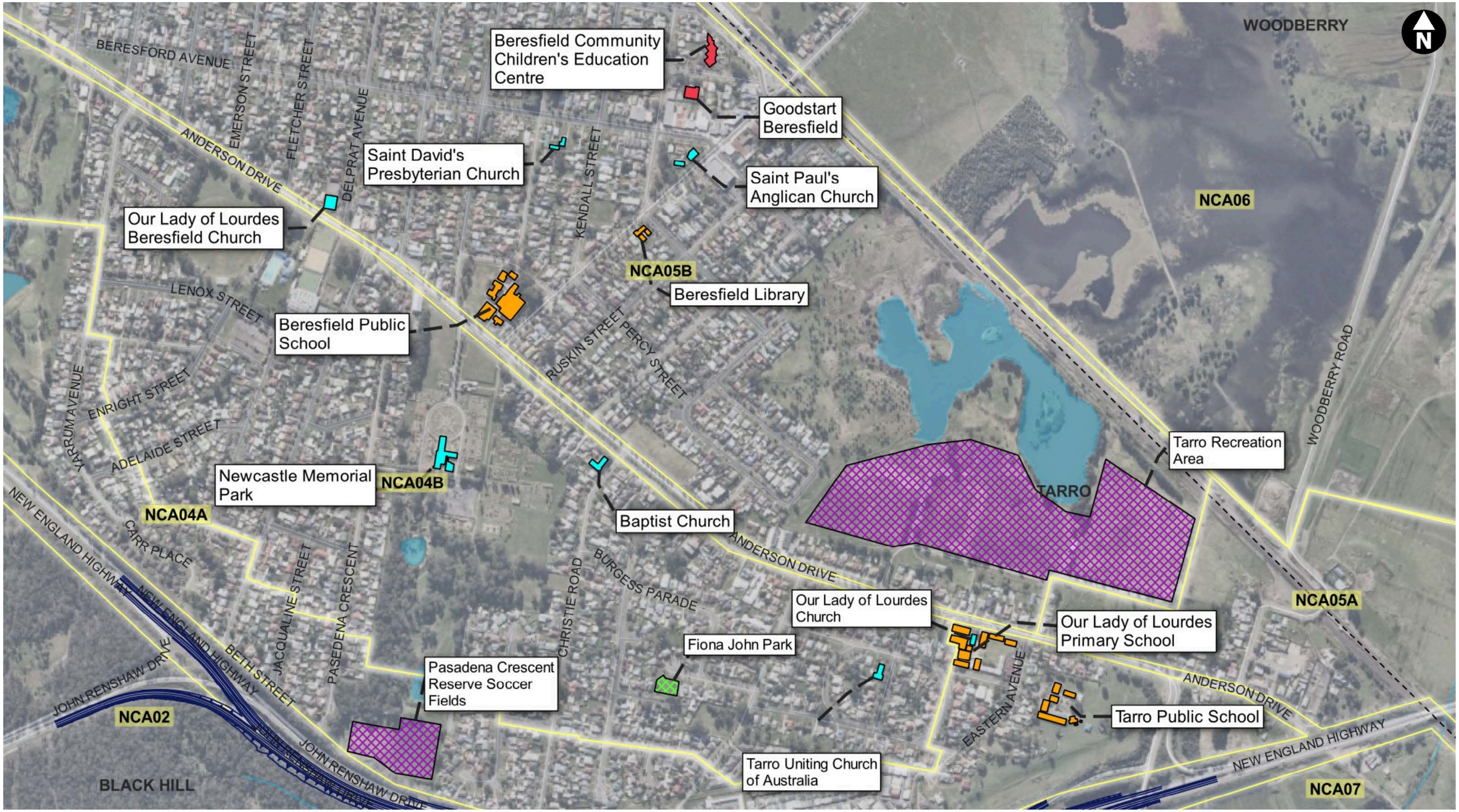

Other sensitive receivers

- Childcare
- Educational
- Place of worship
- Active recreation
- Passive recreation
- Noise catchment area (NCA)
- Design alignment
- Waterways
- Main North Rail Line

150 0 150 300 m

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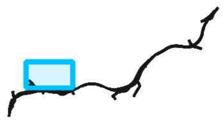

Figure 4-2 Other sensitive (non-residential) receivers (map 2 of 4)

Date: 05/03/2021 Proejct path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

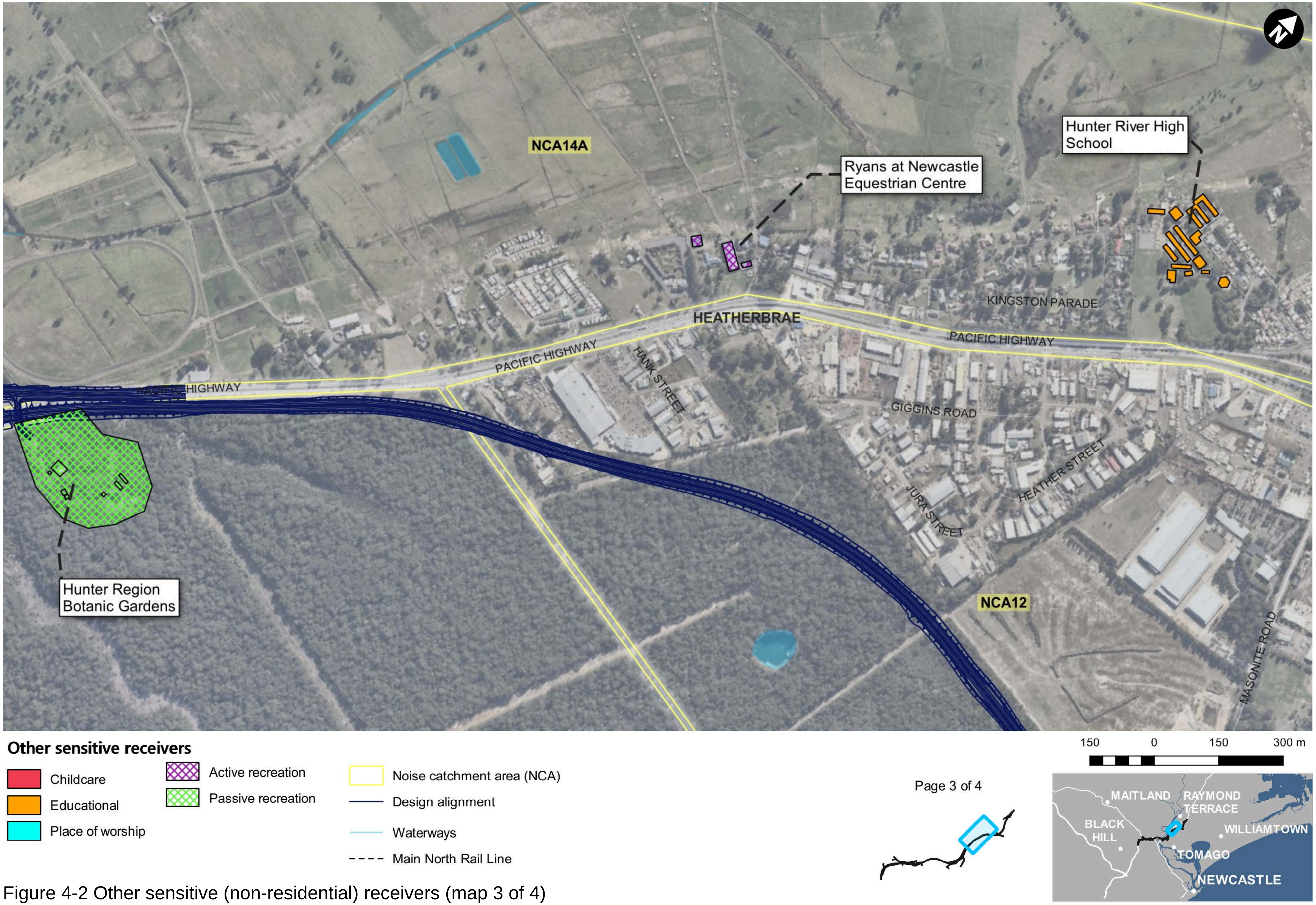

Figure 4-2 Other sensitive (non-residential) receivers (map 3 of 4)

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Other sensitive receivers

- Childcare
- Educational
- Place of worship
- Active recreation
- Passive recreation
- Noise catchment area (NCA)
- Design alignment
- Waterways
- Main North Rail Line

150 0 150 300 m

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Figure 4-2 Other sensitive (non-residential) receivers (map 4 of 4)

Date: 05/03/2021 Project path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

4.3 Existing background noise environment

As detailed in **Section 3.4** and presented in **Figure 3-1**, noise monitoring was carried out at various locations along the project to quantify the existing noise environment in areas where receivers may potentially be affected by construction noise, and to determine the existing levels of road traffic noise along the project.

The RBLs for each monitoring location were determined in accordance with the NPfI and are summarised in **Table 4-3**. The graphical recorded outputs (noise -vs- time graphs) from the long term noise monitoring at the monitoring locations are presented in **Appendix B**.

Table 4-3 Summary of background noise monitoring results

Monitoring location ID	NCA	Address	Measured L_{A90} RBL[1], dB(A)				
			Morning shoulder[2]	Day[3]	Evening[4]	Evening shoulder[5]	Night[6]
L01	NCA01A	23 Cahill Close, Black Hill	56	54	53	56	45
L01A	NCA01B	24 Walter Parade, Black Hill	46	44	43	46	35
L02	NCA03	54 Weakleys Drive, Beresfield	37	37	40	40	37
L03	NCA07	51 New England Highway, Tarro	53	53	51	51	46
L04	NCA04A	1/15 Quarter Sessions Road, Tarro	59	57	54	57	46
L04A	NCA04B	22 Lenox Street, Beresfield	48	46	43	46	35
L05	NCA05A	11 Anderson Drive, Tarro	51	50	44	47	37
L05A	NCA05B	49 Beresford Avenue, Beresfield	44	43	37	40	30
L06	NCA06	61 Redbill Drive, Woodberry	44	38	40	42	38
L07	NCA08	179 Old Maitland Road, Hexham	45	41	43	41	44
L08	NCA09	838 Tomago Road, Tomago	56	53	52	55	47
L09	NCA14A	2213 Pacific Highway, Heatherbrae	52	53	49	52	41
L10	NCA14B	14 Elizabeth Avenue, Raymond Terrace	41	37	40	41	37
L10A	NCA14C	15 Brown Street, Raymond Terrace	46	42	45	46	42

Monitoring location ID	NCA	Address	Measured L_{A90} RBL[1], dB(A)				
			Morning shoulder[2]	Day[3]	Evening[4]	Evening shoulder[5]	Night[6]
L11	NCA12	2264 Pacific Highway, Heatherbrae	62	63	52	57	43
L12	NCA13	53 Martens Avenue, Raymond Terrace	46	42	45	47	42

Notes:

2. RBL periods based on the extended construction work hours presented in **Section 3.5.1**
3. Morning shoulder: 6.00am to 7.00am Monday to Friday
4. Day: 7.00am to 6.00pm Monday to Saturday and 8.00am to 6.00pm Sundays & Public Holidays
5. Evening: 6.00pm to 10.00pm Monday to Sunday and Public Holidays
6. Evening shoulder: 6.00pm to 7.00pm Monday to Friday
7. Night: 10.00pm to 7.00am Monday to Saturday and 10.00pm to 8.00am Sundays and Public Holidays
8. Background noise levels for locations L01A, L04A, L05A, L10A and L12 based on correlation with nominated long term monitoring locations, as discussed in **Section 3.4.2**.

4.4 Existing road traffic noise levels

The existing traffic noise levels at the monitoring locations presented in **Table 3-2**, where road traffic was the dominating noise source, are summarised in **Table 4-4**. The graphical recorded outputs (noise -vs- time graphs) from the long term noise monitoring at the monitoring locations are presented in **Appendix B**.

Table 4-4 Monitored road traffic noise levels

Monitoring location ID	NCA	Address	Monitored traffic noise levels, dB(A)	
			$L_{Aeq(15\ hour)}$ Day (7.00am to 10.00pm)	$L_{Aeq(9\ hour)}$ Night (10.00pm to 7.00am)
L13	NCA01A	11 Cahill Close, Black Hill	56	53
L14	NCA01B	23 Walter Parade, Black Hill	50	45
L15	NCA04A	70 New England Highway, Tarro	74	72
L16	NCA04A	44 Sapphire Drive, Beresfield	64	60
L17	NCA04B	11 Central Avenue, Tarro	57	51
L18	NCA06	Proposed interchange at Tarro	72	70
L19	NCA14A	2209 Pacific Highway, Heatherbrae	62	59
L20	NCA13	Pacific Highway (north of Raymond Terrace interchange)	75	72

Note: Noise levels presented are representative of road traffic noise level at one metre from a building facade, as per RNP.

5. Construction noise and vibration

5.1 Overview

The outcomes of the assessment of construction noise and vibration impacts are outlined in the following sections:

- Construction airborne noise to residential, other (non-residential) sensitive receivers and commercial and industrial receivers within the construction study area (**Section 5.3**)
- Sleep disturbance due to construction noise for residential receivers (**Section 5.3.5**)
- Ground-borne noise impacts (if any) due to the proposed construction activities (**Section 5.4**)
- Noise impacts from construction traffic accessing the ancillary facilities (**Section 5.5**)
- Structural damage, cosmetic damage and human exposure to vibration impacts from the proposed construction activities (**Section 5.6**)
- Vibration impacting buried utilities such as water, sewer and gas pipelines (**Section 5.6.4**)
- Vibration impacting electrical and telecommunication utilities (**Section 5.6.5**)
- Vibration impacting heritage structures (**Section 5.6.6**)
- Noise and vibration impacts from proposed blasting activities (**Section 5.7**).

5.2 Predicted worst-case noise impacts

Due to the large number and size of work areas and the variability of the types of construction activities associated with the project, the assessment of construction noise impacts is based on a ‘worst case’ construction scenario. However, the reality of construction noise impacts is that they would vary greatly depending on the location of the construction work within the work area, the distance between the noise sources and the nearby receivers, the noise intensity of the work, the time of day these specific activities take place, existing attenuation and the changing noise character with all these variables. This is illustrated in **Figure 5-1**, which shows noise levels experienced at a sensitive receiver near major construction work over a full day and how construction noise levels vary over the work period.

The worst case assessment scenarios are considered conservative, in that they assume:

- All the equipment identified within a scenario would operate simultaneously, while in reality only some equipment would operate at the same time
- The equipment operates at its loudest (full load), in its worst case orientation without consideration of directivity, while in reality equipment would only operate at full load in rare instances and for short periods of time
- All plant are operating in one location, while in reality plant may be scattered around the work area
- All plant are at the closest location to each receiver, while in reality plant would move around the work area and noise levels would reduce as plant moves away from a receiver.

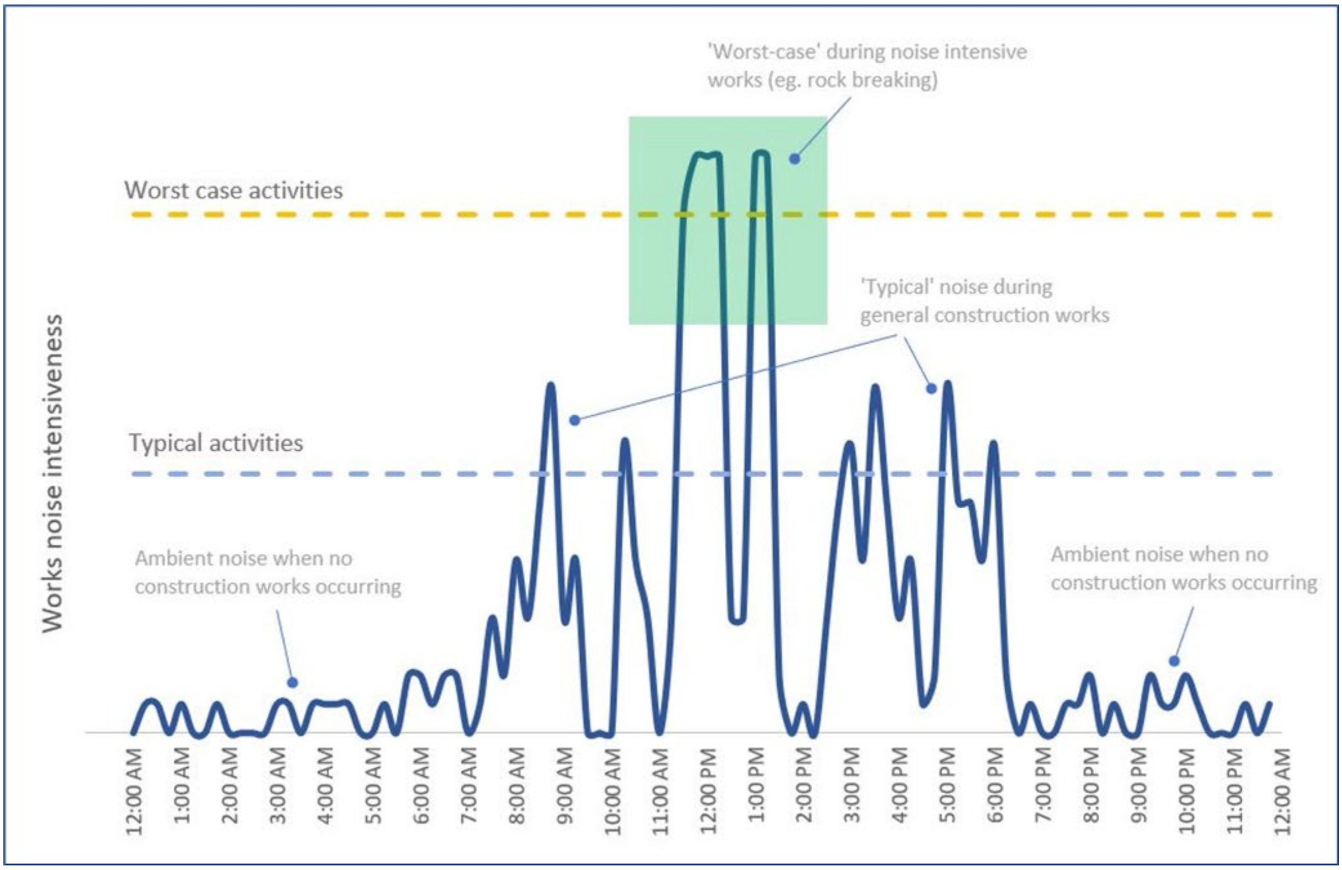


Figure 5-1 Example of indicative construction noise over a full day

In the example illustrated in **Figure 5-1**, the worst-case activities only occur for part of the work period and for assessment purposes have been categorised as ‘peak impact’. For the period where noise intensive work is not occurring and the activities are typical for the work period, it has been categorised as ‘typical impact’, which result in much lower noise impacts. There are also periods when no work is occurring, and noise levels are at the existing background level (e.g. road traffic and general urban hum).

Traffic noise on the major arterial roads and motorway is more continuous, rather than intermittent. Construction activities that generate sounds with similar characteristics to road traffic noise are likely to be less noticeable than sounds that are intermittent, impulsive or tonal, as the traffic noise would somewhat mask the construction noise.

The receivers most affected by construction noise are typically closest to the work, with direct line of sight. For receivers further away, or at places that do not have line of sight (e.g. noise barrier in between), construction noise generally decreases faster with distance than road traffic noise.

The results in the following sections are based on the predicted noise impacts at the most affected receivers in each NCA and is representative of the worst-case (peak impact) and typical (typical impacts) scenarios, as described above. Predicted noise impacts are based on the exceedance of the NML, as per the categories presented in **Table 5-1** and in accordance with the CNVG. The likely subjective perception from the community affected by the impacts is also shown in the table. It is noted that the perception of the impacts are in accordance with Table C.1 of the CNVG and are based on how loud the construction noise levels are above the RBL or how the noise levels are “perceived” over the background noise environment.

It is noted that predicted noise impacts in the following sections are based on no noise mitigation measures implemented. Therefore, once mitigated the construction noise impacts would be reduced.

Table 5-1 NML exceedance bands and corresponding perception of impacts

Symbol	Perception	Exceedance of NML	
		Standard hours	Extended hours and out-of-hours
•	Noticeable	No exceedance	< 5 dB
●	Clearly audible	1 dB to 10 dB	5 dB to 15 dB
◆	Moderately intrusive	11 dB to 20 dB	16 dB to 25 dB
■	Highly intrusive	> 20 dB	> 25 dB

Note: Based on Table C.1 of the CNVG

These results are considered conservative and during actual construction work, noise levels are likely to be lower. Overall, the actual noise emissions from the work and resulting noise levels at nearby receivers would be influenced by:

- The location/distance of the plant/equipment with respect to the receiver
- The on/off time of the plant/equipment
- The intensity with which the plant/equipment is working.

5.3 Construction airborne noise

5.3.1 Residential receivers

The NMLs and sleep disturbance screening levels for residential receivers are presented in **Table 5-2** and are based on the existing background noise environment (refer to **Section 4.3**) and the criteria provided **Table 3-4.**

Table 5-2 NMLs and sleep disturbance screening levels for residential receivers

NCA[1, 2]	Monitoring location	$L_{Aeq(15 minute)}$ NML, dB(A)						Sleep disturbance screening level (RBL + 15dB) [9]
		Standard hours (RBL + 10dB)	Out-of-hours (RBL + 5dB)					
		Day[3]	Morning shoulder[4]	Day[5]	Evening[6]	Evening shoulder[7]	Night[8]	
NCA01A	L01	64	59	59	58	58	50	60
NCA01B	L01A	54	49	49	48	48	40	50
NCA03	L02	47	42	42	45	45	42	52
NCA04A	L04	67	62	62	59	59	51	61
NCA04B	L04A	56	51	51	48	48	40	50
NCA05A	L05	60	55	55	49	49	42	52
NCA05B	L05A	53	48	48	42	42	35	45
NCA06	L06	48	43	43	43	43	43	53
NCA07	L03	63	58	58	56	56	51	61
NCA08	L07	51	46	46	48	46	48	59

NCA[1, 2]	Monitoring location	$L_{Aeq(15\ minute)}$ NML, dB(A)						Sleep disturbance screening level (RBL + 15dB) [9]
		Standard hours (RBL + 10dB)	Out-of-hours (RBL + 5dB)					
		Day[3]	Morning shoulder[4]	Day[5]	Evening[6]	Evening shoulder[7]	Night[8]	
NCA09	L08	63	58	58	57	57	52	62
NCA12	L11	73	67	68	57	57	48	58
NCA13	L12	52	47	47	47	47	47	57
NCA14A	L09	63	58	58	54	54	46	56
NCA14B	L10	47	42	42	42	42	42	52
NCA14C	L10A	52	47	47	47	47	47	57

Notes:

1. Refer to **Section 4.2** and **Figure 4-1** for location of NCAs
2. NCA02, NCA10 and NCA11 comprise of commercial and industrial type receivers and are not presented in this table
3. Day standard construction hours: 7.00am to 6.00pm Monday to Friday and 8.00am to 1.00pm Saturday
4. Morning shoulder: 6.00am to 7.00am Monday to Friday. Where morning shoulder RBL is higher than day RBL, the day RBL is adopted
5. Day out-of-hours: 7.00am to 8.00am and 1.00pm to 6.00pm Saturday, and 8.00am to 6.00pm Sunday and public holidays
6. Evening: 6.00pm to 10.00pm Monday to Sunday and Public Holidays. Where the evening RBL is higher than the day RBL, the day RBL is adopted
7. Evening shoulder: 6.00pm to 7.00pm Monday to Friday. Where the evening shoulder RBL is higher than the evening RBL, the evening RBL is adopted
8. Night: 10.00pm to 7.00am Monday to Saturday and 10.00pm to 8.00am Sundays and Public Holidays. Where the night RBL is higher than the evening RBL, the evening RBL is adopted
9. Sleep disturbance assessed for night time period only
10. Caravan parks assessed as residential type receivers.

The predicted construction noise impacts with no noise mitigation at residential receivers in each NCA are described in the following sections for standard hours, the proposed extended hours and out-of-hours periods. Detailed noise level predictions and summaries of the number of receivers predicted to experience ‘noticeable’, ‘clearly audible’, ‘moderately intrusive’ and ‘highly intrusive’ unmitigated noise levels are provided in **Appendix C**.

The predicted unmitigated construction noise impacts are presented for the most affected receivers within each NCA. Receivers which are further away and/or shielded from the work would have lower noise impacts. Where noise impacts are predicted, the methods for controlling the impacts through the use of construction noise management measures are discussed in more detail in **Chapter 8**.

Standard hours noise impacts

Table 5-3 following presents the unmitigated construction noise impacts and the likely community perceptions in the nominated NCAs for each of the construction scenarios during standard construction hours.

Table 5-3 Predicted construction noise exceedances standard daytime – residential receivers

Key: • Noticeable (no exceedance) ● Clearly audible (1 dB to 10 dB) ◆ Moderately intrusive (11 dB to 20 dB) ■ Highly intrusive (> 20 dB)

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
1	Pre-construction and site establishment	Peak impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	•	●	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	●	◆	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	•	•	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	◆	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	•	●	•
6	Utility works	Peak impact	•	•	•	■	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	•	●	•
7	Bulk earthworks – cuttings	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9	Bulk earthworks – fill	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	●	•	•	•	•	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	•	•	•	•	●	●	•	•	•	●	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	•	•	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•

Note: NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

Table 5-3 shows that residential receivers are impacted during standard construction hours as follows:

- The highest impacts are during the 'peak impact' activities, which is due to all plant and equipment operating concurrently including noise intensive equipment such as rock hammers or concrete saws. For most scenarios, the 'peak impact' activities would only occur for a relatively short period. Noise levels and impacts during the 'typical impact' activities would occur more often and are lower and affect fewer receivers
- The highest impacts at residential receivers are generally in catchments where receivers are located close to the construction footprint. This includes NCA04A and NCA08, which are directly to the north and west of the construction footprint, respectively. Receivers in NCA04A are within suburban areas and are therefore densely distributed, resulting in relatively large number of receivers being impacted by construction noise in this NCA
- 'Highly intrusive' noise levels (i.e. greater than 20 dB exceedance) are predicted in NCA04A during clearing, grubbing and demolition work, utility works and bridge piling work when 'peak impact' activities are being carried out. This would be expected as residential receivers in NCA04A are close to the construction footprint at the proposed interchange at Tarro
- Noise impacts from batch plant operations (concrete and asphalt), bulk earthworks (fill) and asphalt pavement work are not predicted to exceed the NMLs at any residential receivers in all NCAs during peak or typical impact activities. Noise impacts from bulk earthworks (cuttings) and concrete pavement work are not predicted to exceed the NMLs at any residential receivers during typical activities
- Clearing, grubbing and demolition work, and utility work generally impact the highest amount of residential receivers and with the highest exceedances. This is due to these works being carried out over the entire length of the project
- Construction noise impacts are predicted to be 'Noticeable' (i.e. no exceedance of NML) at all residential receivers in NCA01A, NCA03, NCA05B, NCA06, NCA12, NCA13 and NCA14C for all construction work scenarios during standard construction work hours.

Extended hours noise impacts

Table 5-4, **Table 5-5** and **Table 5-6** present the unmitigated extended hours construction noise impacts and the likely community perceptions in the nominated NCAs. Noise impacts are presented for each of the construction scenarios during the morning shoulder (6.00am to 7.00am), daytime out-of-hours (7.00am to 8.00am and 1.00pm to 5.00pm on Saturday; and 7.00am to 5.00pm on Sundays and Public Holidays) and evening shoulder (6.00pm to 7.00pm) periods, respectively.

Table 5-4 Predicted construction noise exceedances morning shoulder – residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
Key:	• Noticeable (< 5 dB)	● Clearly audible (5 dB to 15 dB)	◆ Moderately intrusive (16 dB to 25 dB)	■ Highly intrusive (> 25 dB)														
1	Pre-construction and site establishment	Peak impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	●	◆	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	●	•	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	◆	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	●	•	•	●	●	●	•	●	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
6	Utility works	Peak impact	•	•	•	■	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
7	Bulk earthworks – cuttings	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9	Bulk earthworks – fill	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	●	•	•	•	●	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	●	•	•	•	●	●	•	●	•	●	•
		Typical impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•

Note: NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

Table 5-5 Predicted construction noise exceedances daytime out-of-hours – residential receivers

Key: • Noticeable (< 5 dB) ● Clearly audible (5 dB to 15 dB) ◆ Moderately intrusive (16 dB to 25 dB) ■ Highly intrusive (> 25 dB)

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
1	Pre-construction and site establishment	Peak impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	●	◆	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	●	•	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	◆	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	●	•	•	●	●	●	•	●	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
6	Utility works	Peak impact	•	•	•	■	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
7	Bulk earthworks – cuttings	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9	Bulk earthworks – fill	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	●	•	•	•	●	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	●	•	•	•	●	●	•	●	•	●	•
		Typical impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•

Note: NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

Table 5-6 Predicted construction noise exceedances evening shoulder – residential receivers

Key: • Noticeable (< 5 dB) ● Clearly audible (5 dB to 15 dB) ◆ Moderately intrusive (16 dB to 25 dB) ■ Highly intrusive (> 25 dB)

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
1	Pre-construction and site establishment	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	◆	◆	•	•	•	●	•	•
		Typical impact	•	•	•	●	●	●	•	•	●	●	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	●	•	•	•	●	●	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	●	●	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
6	Utility works	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
7	Bulk earthworks – cuttings	Peak impact	•	•	•	●	●	•	●	•	•	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	•	•
9	Bulk earthworks – fill	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	●	●	●	•	●	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	●	•	•	•	•	●	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	●	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	●	●	•	•	●	●	•	●	•	●	•
		Typical impact	•	•	•	◆	●	●	•	•	•	•	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	●	•	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	●	●	•	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•

Note: NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

The above tables show that residential receivers are impacted during the extended construction hours as follows:

- Similar to the impacts during ‘standard working hours’, the highest impacts are during the ‘peak impact’ activities, however for most scenarios, the ‘peak impact’ activities would only occur for a relatively short period. Noise levels and impacts during the ‘typical impact’ activities would occur more often and are lower and affect fewer receivers
- The highest impacts at residential receivers are generally in catchments where receivers are located close to the construction footprint. This includes NCA04A, NCA04B and NCA08, which have receivers directly adjacent to the New England Highway at Tarro and Hexham. In addition, receivers in NCA04A and NCA04B are within suburban areas and are therefore densely distributed, resulting in relatively large number of receivers being impacted by construction noise
- During the morning shoulder and daytime out-of-hours periods, ‘Highly intrusive’ noise levels (i.e. greater than 25 dB exceedance of NML) are predicted in NCA04A during clearing, grubbing and demolition work, utility work and bridge piling work when peak impact activities are being carried out
- Noise impacts during the morning shoulder and daytime out-of-hours periods from batch plant operations (concrete and asphalt), bulk earthworks (fill) and asphalt pavement work are predicted to be ‘Noticeable’ (i.e. less than 5 dB exceedance of NML) at all residential receivers in all NCAs during peak or typical impact activities. Noise impacts from bulk earthworks (cuttings) and concrete pavement work are predicted to be ‘Noticeable’ at all residential receivers during typical impact activities
- During the evening shoulder period, ‘Highly intrusive’ noise levels are predicted in NCA04A during the following scenarios:
  - Pre-construction and site establishment during peak activities
  - Clearing, grubbing and demolition work during peak and typical activities
  - Utility work during peak and typical activities
  - Bridge piling work during peak activities.
- Noise impacts during the evening shoulder period from batch plant operations (concrete and asphalt) are predicted to be ‘Noticeable’ at all residential receivers in all NCAs during peak or typical activities
- During the extended construction hours pre-construction site establishment work, clearing, grubbing and demolition work, utility work and bridge piling work generally impact the highest number of residential receivers and result in the highest exceedances. This is due to these works being carried out over the entire length of the project
- Construction noise impacts are predicted to be ‘Noticeable’ at all residential receivers in NCA01A, NCA03, NCA05B, NCA06, NCA12 and NCA14C for all construction work scenarios during the extended work hours. During the morning shoulder and daytime out-of-hours periods, all residential receivers in NCA05B also have ‘Noticeable’ noise impacts
- When compared to standard construction hours, the morning shoulder and daytime out-of-hours periods would typically have similar impacts at residential receivers. Some NCAs may experience additional construction noise impacts during the morning shoulder and daytime out-of-hours periods, however, the additional impacts are considered to be ‘Noticeable’ only. Therefore, noise impacts from the proposed construction work scenarios during the morning shoulder and daytime out-of-hours periods would be similar to the impacts during standard construction hours
- For the evening shoulder period, most construction work scenarios would have similar construction noise impacts as the standard construction hours period. Some NCAs may experience additional ‘Noticeable’ or ‘Moderately intrusive’ impacts during the evening shoulder period when compared to the standard construction hours period
- Additional ‘Highly intrusive’ construction noise impacts may be experienced at NCA04A during the evening shoulder period for pre-construction site establishment work (peak impact), clearing, grubbing and demolition work (typical impact) and utility work (typical impact), when compared to standard construction hours.

Out-of-hours noise impacts

Table 5-7 and **Table 5-8** following presents the unmitigated out-of-hours construction noise impacts and the likely community perceptions in the nominated NCAs. These noise impacts are presented for each of the construction scenarios during the evening (7.00pm to 10.00pm) and night time (10.00pm to 6.00am) periods, respectively.

Table 5-7 Predicted construction noise exceedances evening – residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
Key:	• Noticeable (< 5 dB)	● Clearly audible (5 dB to 15 dB)	◆ Moderately intrusive (16 dB to 25 dB)	■ Highly intrusive (> 25 dB)														
1	Pre-construction and site establishment	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	◆	◆	•	•	•	●	•	•
		Typical impact	•	•	•	●	●	●	•	•	●	◆	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	●	•	•	•	●	◆	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	●	●	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
6	Utility works	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
7	Bulk earthworks – cuttings	Peak impact	•	•	•	●	●	•	●	•	•	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	•	•
9	Bulk earthworks – fill	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	●	●	●	•	●	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	●	•	•	•	•	●	•	•
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	●	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	●	●	•	•	●	●	•	●	•	●	•
		Typical impact	•	•	•	◆	●	●	•	•	•	●	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	●	•	•	•	●	●	•	•	●	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	●	●	•	•	•	●	●	•	•	●	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•

Note: NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

Table 5-8 Predicted construction noise exceedances night time – residential receivers

Key: • Noticeable (< 5 dB) ● Clearly audible (5 dB to 15 dB) ◆ Moderately intrusive (16 dB to 25 dB) ■ Highly intrusive (> 25 dB)

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
1	Pre-construction and site establishment	Peak impact	●	●	•	■	◆	◆	●	•	●	●	◆	•	•	◆	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	•	●	•	•	●	•	•
2	Ancillary facility – establishment	Peak impact	•	●	•	■	◆	◆	●	•	◆	◆	●	•	•	●	•	•
		Typical impact	•	•	•	◆	●	●	•	•	●	●	•	•	•	●	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	◆	◆	●	●	•	●	◆	•	•	•	●	•	•
		Typical impact	•	•	•	◆	●	●	•	•	●	●	•	•	•	●	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	●	●	●	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	●	●	●	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	●	●	•	■	◆	◆	◆	•	●	●	◆	•	●	◆	●	•
		Typical impact	●	●	•	■	◆	◆	●	•	●	●	◆	•	•	◆	●	•
6	Utility works	Peak impact	●	●	•	■	◆	◆	●	•	●	●	◆	•	•	◆	●	•
		Typical impact	●	●	•	■	◆	◆	●	•	●	●	◆	•	•	◆	●	•
7	Bulk earthworks – cuttings	Peak impact	●	●	•	●	◆	●	●	•	•	•	●	•	●	◆	●	•
		Typical impact	●	•	•	●	●	●	●	•	•	•	•	•	•	●	•	•
9	Bulk earthworks – fill	Peak impact	●	●	•	●	●	●	●	•	•	•	•	•	•	◆	•	•
		Typical impact	•	•	•	●	●	●	●	•	•	•	•	•	•	●	•	•
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	●	◆	●	●	•	●	•	●	•	●	◆	●	•
		Typical impact	•	•	•	●	●	●	●	•	●	•	•	•	•	●	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	●	●	●	●	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	●	●	●	●	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	●	•	•	■	◆	●	●	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	■	●	●	●	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	●	●	•	■	◆	◆	◆	•	●	●	◆	•	●	●	●	•
		Typical impact	●	•	•	■	◆	●	●	•	•	•	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	●	•	•	■	◆	●	●	•	●	•	●	•	•	●	•	•
		Typical impact	•	•	•	■	●	●	●	•	•	•	●	•	•	●	•	•
15	Traffic management and control	Peak impact	•	•	•	◆	●	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	●	•	•	■	◆	●	●	•	●	•	●	•	•	●	•	•
		Typical impact	•	•	•	■	●	●	•	•	•	•	●	•	•	●	•	•
17	Cross drainage	Peak impact	•	•	•	■	◆	●	●	•	●	•	●	•	•	●	•	•
		Typical impact	•	•	•	■	●	●	●	•	●	•	●	•	•	●	•	•

Note: NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

The above tables show that residential receivers are impacted during out-of-hours construction work as follows:

- Similar to impacts during ‘standard working hours’ and ‘extended hours’, the highest impacts are during the ‘peak impact’ activities, however for most scenarios, the ‘peak impact’ activities would only occur for a relatively short period. Noise levels and impacts during the ‘typical impact’ activities would occur more often, are lower and affect fewer receivers
- The highest impacts at residential receivers are generally in catchments where receivers are located close to the construction footprint. This includes NCA04A and NCA04B, which are directly to the north of the New England Highway at Tarro
- During the evening period, ‘Highly intrusive’ noise levels (i.e. greater than 25 dB exceedance of NML) are predicted in NCA04A during the following scenarios:
  - Pre-construction and site establishment during peak impact activities
  - Clearing, grubbing and demolition work during peak and typical impact activities
  - Utility work during peak and typical impact activities
  - Bridge piling work during peak impact activities.
- Noise impacts during the evening period from batch plant operations (concrete and asphalt) are predicted to be ‘Noticeable’ at all residential receivers in all NCAs during peak or typical impact activities
- During the night time period, ‘Highly intrusive’ noise levels are predicted in NCA04A during the following scenarios:
  - Pre-construction and site establishment during peak and typical impact activities
  - Ancillary facility establishment work during peak impact activities
  - Clearing, grubbing and demolition work during peak and typical impact activities
  - Utility work during peak and typical impact activities
  - Bridge work (non-piling) during peak and typical impact activities
  - Bridge piling work during peak and typical impact activities
  - Roadside furniture and finishing work, landscaping work and cross drainage work during peak and typical impact activities.
- Noise impacts during the night time period from batch plant operations (concrete and asphalt) are predicted to be ‘Noticeable’ (i.e. less than 5 dB exceedance of NML) at all residential receivers in all NCAs during typical activities
- During out-of-hours, the following activities generally impact the highest number of residential receivers and with the highest exceedances; pre-construction site establishment work, ancillary facility establishment work, clearing, grubbing and demolition work, utility work, bridge work (non-piling), bridge piling work, roadside furniture and finishing work, landscaping work and cross drainage work
- Construction noise impacts are predicted to be ‘Noticeable’ at all residential receivers in NCA03, NCA06, NCA12 and NCA14C for all construction work scenarios during out-of-hours construction work. During the evening period, all residential receivers in NCA01A also have ‘Noticeable’ noise impacts.

5.3.2 Highly noise affected residential receivers

Residential receivers that are subject to noise levels of more than 75 dB(A) are considered to be highly noise affected. Receivers can be highly noise affected when noise intensive equipment is being used in close proximity.

Residential receivers which are predicted to potentially be highly noise affected during the different construction scenarios and activities are summarised in **Table 5-9**.

Figure 5-2 presents all the residential receivers that are predicted to be highly noise affected regardless of the construction scenario or activity and the corresponding receiver IDs are presented in **Appendix C**.

However, in reality the construction work would occur in isolated locations and the number of highly noise affected receivers during any single work scenario would likely be less than shown. It should be noted that all highly noise affected receivers are located in Tarro as the construction activities are closest to receivers at this location.

The majority of residential receivers are not predicted to be highly noise affected during the construction work. Residential receivers predicted to be highly noise affected (up to 24 receivers in total) are all located within NCA04A, which is expected as residential receivers in NCA04A are close to construction activities (in some cases, may have direct line of sight).

Table 5-9 Number of highly noise affected residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NCA12	NCA13	NCA14A	NCA14B	NCA14C
1	Pre-construction and site establishment	Peak impact	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
2	Ancillary facility – establishment	Peak impact	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Ancillary facility – operation	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4A	Batch plant operation (concrete batch plant)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4B	Batch plant operation (asphalt batch plant)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Clearing, grubbing, and demolition	Peak impact	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-
6	Utility works	Peak impact	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-
7	Bulk earthworks – cuttings	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Bulk earthworks – fill	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NCA12	NCA13	NCA14A	NCA14B	NCA14C
10	Concrete pavement (including pavement drainage)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Asphalt pavement (including pavement drainage)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Bridge work (excluding piling)	Peak impact	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
13	Piling for bridges and bridge approaches	Peak impact	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
14	Roadside furniture and finishing work	Peak impact	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
15	Traffic management and control	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Landscaping	Peak impact	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
17	Cross drainage	Peak impact	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-

Notes: Highly noise affected noise levels of more than 75 dB(A) only applicable to residential receivers.

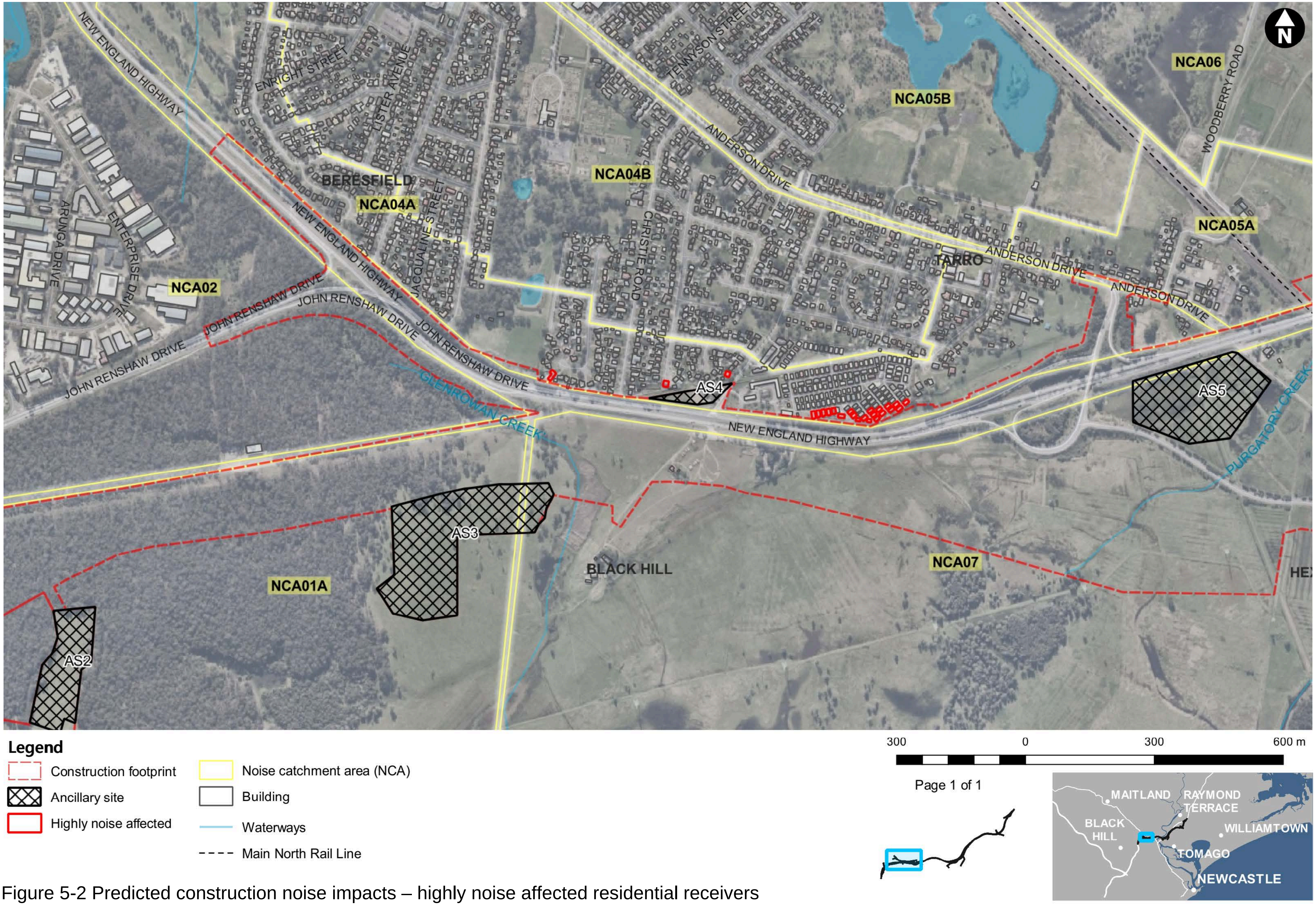


Figure 5-2 Predicted construction noise impacts – highly noise affected residential receivers

5.3.3 Other sensitive receivers

Twenty-one other sensitive receivers and associated buildings such as classrooms, places of worship, childcare centres and recreation areas, were identified as being potentially impacted by construction noise. These are presented in **Figure 4-2**.

The number of other sensitive receiver buildings predicted to exceed the relevant NML for each receiver type during each construction scenario are summarised in **Table 5-10**. The summary is for all NCAs on the project and shows the impacts in bands of 10 dB above the corresponding NML.

Table 5-10 Number of other sensitive receiver buildings exceeding NML

ID	Scenario	Activity	Educational			Childcare centre			Place of worship			Remaining		
			Daytime			Daytime			Daytime			Daytime		
			1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB
1	Pre-construction and site establishment	Peak impact	6	-	-	-	-	-	-	-	-	1	1	-
		Typical impact	-	-	-	-	-	-	-	-	-	1	-	-
2	Ancillary facility – establishment	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-
3	Ancillary facility – operation	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-
4A	Batch plant operation (concrete batch plant)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-
4B	Batch plant operation (asphalt batch plant)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-
5	Clearing, grubbing, and demolition	Peak impact	7	-	-	-	-	-	-	-	-	1	1	-
		Typical impact	6	-	-	-	-	-	-	-	-	1	1	-
6	Utility works	Peak impact	6	-	-	-	-	-	-	-	-	1	1	-
		Typical impact	6	-	-	-	-	-	-	-	-	1	1	-
7	Bulk earthworks – cuttings	Peak impact	-	-	-	-	-	-	-	-	-	-	1	-
		Typical impact	-	-	-	-	-	-	-	-	-	1	-	-

ID	Scenario	Activity	Educational			Childcare centre			Place of worship			Remaining		
			Daytime			Daytime			Daytime			Daytime		
			1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB
9	Bulk earthworks – fill	Peak impact	-	-	-	-	-	-	-	-	-	1	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	1	-	-
10	Concrete pavement (including pavement drainage)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	1
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	1
11	Asphalt pavement (including pavement drainage)	Peak impact	-	-	-	-	-	-	-	-	-	1	1	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	1	-
12	Bridge work (excluding piling)	Peak impact	1	-	-	-	-	-	-	-	-	1	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	1	-	-
13	Piling for bridges and bridge approaches	Peak impact	7	-	-	-	-	-	-	-	-	1	-	-
		Typical impact	1	-	-	-	-	-	-	-	-	1	-	-
14	Roadside furniture and finishing work	Peak impact	1	-	-	-	-	-	-	-	-	1	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	1	-	-
15	Traffic management and control	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-
16	Landscaping	Peak impact	1	-	-	-	-	-	-	-	-	1	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	1	-	-
17	Cross drainage	Peak impact	1	-	-	-	-	-	-	-	-	1	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	1	-	-

Notes:

1. "Remaining receivers" refers to outdoor active recreational areas and outdoor passive recreational areas
2. Cell shading based on exceedance of NML during standard construction hours and corresponding perception of impacts, as per **Table 5-1**; **green** = clearly audible (1-10 dB), **orange** = moderately intrusive (11-20 dB), **red** = highly intrusive (greater than 20 dB)
3. Numbers represent individual receiver buildings or outdoor areas (for "remaining receivers").

From **Table 5-10**, the receiver identified as exceeding the NML are:

- Tarro Public School (educational receiver)
- Pasadena Crescent Reserve Soccer Fields (active recreation receiver)
- Hunter Region Botanic Gardens (passive recreation receiver).

It is noted that a total of eight receiver buildings have been identified for Tarro Public School and **Table 5-1** presents the number of buildings out of the eight that would exceed the NML for the corresponding construction scenario and activity.

No other sensitive receivers were predicted to exceed the NML during the proposed construction scenarios.

The key noise impacts associated with other sensitive receivers are:

- Ancillary facility establishment and operation, batch plant operation (concrete and asphalt), and traffic management and control are not predicted to result in exceedances at any other sensitive receiver locations
- The majority of construction scenarios are predicted to result in exceedances of the NMLs at Tarro Public School, Pasadena Crescent Reserve Soccer Fields and the Hunter Region Botanic Gardens, where 'Clearly audible' noise levels (i.e. 1 dB to 10 dB exceedance of NML) are typically predicted
- 'Moderately intrusive' noise levels (i.e. 11 dB to 20 dB exceedance of NML) are predicted at the Hunter Region Botanic Gardens during asphalt pavement work, pre-construction and site establishment work, clearing, grubbing and demolition work, utility work and bulk earthworks for cuttings
- The Hunter Region Botanic Gardens is predicted to experience 'Highly intrusive' noise levels (i.e. greater than 20 dB exceedance of NML) during peak and typical concrete pavement work.

Noise levels during peak activities and the impacts on the other sensitive receivers would only be apparent for relatively short durations of the work.

5.3.4 Commercial and industrial receivers

A summary of the predicted construction noise impacts in each NCA for commercial and industrial receivers (including small businesses) is presented in **Table 5-11**.

The key noise impacts associated with commercial and industrial receivers are:

- Construction noise impacts in NCA04A are predicted to be 'Clearly audible' (i.e. 1 dB to 10 dB exceedance of NML) during different construction scenarios and activities
- Construction noise impacts in NCA10, NCA12 and NCA14A are predicted to be 'Clearly audible' and 'Moderately intrusive' (11 dB to 20 dB exceedance of NML) during different construction scenarios and activities
- 'Highly intrusive' noise levels are predicted in NCA10 and NCA12 during pre-construction and site establishment work, ancillary facility establishment and operation, clearing, grubbing and demolition work, and utility work. These impacts occur when peak and/or typical activities are carried out
- Other NCAs either have no commercial or industrial receivers, or the receivers are of sufficient distance from the construction footprint to comply with the noise goals.

Table 5-11 Predicted construction noise exceedances – commercial and industrial receivers

Key: • Noticeable (no exceedance) ● Clearly audible (1 dB to 10 dB) ◆ Moderately intrusive (11 dB to 20 dB) ■ Highly intrusive (> 20 dB)

ID	Scenario	Activity	NCA01A	NCA01B	NCA02	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NCA10	NCA11	NCA12	NCA13	NCA14A	NCA14B	NCA14C
1	Pre-construction and site establishment	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	■	•	●	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	●	•	●	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	■	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	■	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	■	•	◆	•	●	•	•
		Typical impact	•	•	•	•	●	•	•	•	•	•	•	•	■	•	●	•	●	•	•
6	Utility works	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	■	•	◆	•	●	•	•
		Typical impact	•	•	•	•	●	•	•	•	•	•	•	•	■	•	●	•	●	•	•
7	Bulk earthworks – cuttings	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	●	•	•
9	Bulk earthworks – fill	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	●	•	•
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA02	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NCA10	NCA11	NCA12	NCA13	NCA14A	NCA14B	NCA14C
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	•	•	•	•	•
12	Bridge and viaduct superstructure	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	◆	•	•	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	•	•	●	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	■	•	•	•	◆	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	•	•	●	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	◆	•	●	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	●	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	●	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	●	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	◆	•	●	•	●	•	•

Notes:

1. NML for commercial type receivers = 70 dB(A)
2. NML for industrial type receivers = 75 dB(A)

5.3.5 Sleep disturbance

The number of residential receivers identified as exceeding the sleep disturbance screening level are presented in **Table 5-12**.

The results show the following for sleep disturbance:

- NCA04A and NCA04B have the highest number of residential receivers that would exceed the sleep disturbance screening level. This would be expected given that NCA04A and NCA04B have the highest number of residential receivers located close to the construction footprint
- Residential receivers located within NCA05A and NCA05B are predicted to exceed the sleep disturbance screening level, however, fewer exceedances are expected due to the distance between the NCAs and construction
- Although the results for NCA01A, NCA01B, NCA07, NCA08, NCA09 and NCA14A show low numbers of residential receivers exceeding the sleep disturbance screening level, it is noted that there are minimal number of residences located within these NCAs
- Utility work causes highest number of exceedances of the sleep disturbance screening level, which is what would be expected given the transient nature of the work along the entire project.

Sleep disturbance impacts are dependent on a number of factors including the existing facade performance of affected residential receiver buildings. Noise mitigation measures that would be used to attenuate L_{Aeq} noise levels would also attenuate maximum (L_{Amax}) noise levels, resulting in compliance of the sleep disturbance screening levels at some residential receivers. The exceedances described in this section are therefore a conservative estimate and are likely to be less in reality.

The requirements for construction work at night would be determined during the detailed design stage. The likelihood of sleep disturbance impacts would be reviewed during detailed design.

Table 5-12 Number of residential receivers exceeding L_{Amax} sleep disturbance screening level

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NCA12	NCA13	NCA14A	NCA14B	NCA14C
1	Pre-construction and site establishment	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Ancillary facility – establishment	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Ancillary facility – operation	Peak impact	-	-	-	18	38	4	-	-	1	3	-	-	-	3	-	-
		Typical impact	-	-	-	18	38	4	-	-	1	3	-	-	-	3	-	-
4A	Batch plant operation (concrete batch plant)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4B	Batch plant operation (asphalt batch plant)	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Clearing, grubbing, and demolition	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Utility works	Peak impact	1	1	-	206	333	21	40	-	1	-	1	-	-	8	-	-
		Typical impact	1	1	-	206	333	21	40	-	1	-	1	-	-	8	-	-
7	Bulk earthworks – cuttings	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Bulk earthworks – fill	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Concrete pavement (including pavement drainage)	Peak impact	-	-	-	17	138	3	16	-	1	-	-	-	-	8	-	-
		Typical impact	-	-	-	17	138	3	16	-	1	-	-	-	-	8	-	-

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NCA12	NCA13	NCA14A	NCA14B	NCA14C
11	Asphalt pavement (including pavement drainage)	Peak impact	-	-	-	35	117	3	16	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	35	117	3	16	-	-	-	-	-	-	-	-	-
12	Bridge work (excluding piling)	Peak impact	-	1	-	96	66	6	-	-	-	-	1	-	-	-	-	-
		Typical impact	-	1	-	96	66	6	-	-	-	-	1	-	-	-	-	-
13	Piling for bridges and bridge approaches	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Roadside furniture and finishing work	Peak impact	-	1	-	93	67	6	-	-	-	-	1	-	-	4	-	-
		Typical impact	-	1	-	93	67	6	-	-	-	-	1	-	-	4	-	-
15	Traffic management and control	Peak impact	-	1	-	93	67	6	-	-	-	-	1	-	-	4	-	-
		Typical impact	-	1	-	93	67	6	-	-	-	-	1	-	-	4	-	-
16	Landscaping	Peak impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Typical impact	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	Cross drainage	Peak impact	-	1	-	93	67	6	-	-	-	-	1	-	-	4	-	-
		Typical impact	-	1	-	93	67	6	-	-	-	-	1	-	-	4	-	-

Notes:

1. NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table
2. Sleep disturbance L_{Amax} screening level = RBL + 15dB(A).

5.4 Construction ground-borne noise

Construction can cause ground-borne noise impacts in nearby buildings when vibration generating equipment is in use. Ground-borne noise impacts should be considered where the ground-borne noise levels are likely to be higher than airborne noise (i.e. noise transmitted through the air) in internal areas of the affected buildings. This may occur where a building near the construction footprint has high performing facades which sufficiently attenuate the airborne noise component.

The majority of receivers are sufficiently distant from the work for ground-borne noise impacts to be minimal. Where residential receivers are located near construction work, airborne noise levels would typically be dominant over the ground-borne noise component.

Therefore, ground-borne noise is not expected to cause any impacts to nearby sensitive receivers.

5.5 Construction road traffic noise

A large number of light and heavy vehicles already use the existing motorway, arterial and sub-arterial roads that would be used as construction traffic routes.

Construction traffic has the potential to increase road traffic noise levels at receivers located near the construction traffic routes. Where feasible and reasonable, haulage routes associated with the construction of the project would use the existing motorway, arterial and sub-arterial roads.

The future traffic volumes during construction along the proposed construction traffic routes and the proposed construction traffic volumes are presented in **Appendix C**.

The proposed increases in traffic noise levels due to the additional construction traffic are presented in **Table 5-13.** Grey shaded cells identify increases in existing traffic noise level of more than 2 dB(A) at residential receivers.

Table 5-13 Predicted road traffic noise increase due to construction traffic

Ancillary facility	Road	Predicted noise increase due to construction traffic, dB(A)	
		Day (15 hour)	Night (9 hour)
AS1	John Renshaw Drive, Beresfield	< 0.5	< 0.5
	New England Highway (west of existing Tarro interchange)	< 0.5	< 0.5
AS2	M1 Pacific Motorway / Lenaghans Drive, Black Hill	< 0.5	< 0.5
	New England Highway (west of existing Tarro interchange)	< 0.5	< 0.5
AS3	M1 Pacific Motorway / Lenaghans Drive, Black Hill	0.5	0.5
	New England Highway (west of existing Tarro interchange)	< 0.5	< 0.5
AS4	New England Highway (west of existing Tarro interchange)	< 0.5	< 0.5

Ancillary facility	Road	Predicted noise increase due to construction traffic, dB(A)	
		Day (15 hour)	Night (9 hour)
AS5	New England Highway (east of existing Tarro interchange)	< 0.5	< 0.5
AS6	New England Highway (east of existing Tarro interchange)	< 0.5	< 0.5
AS7	New England Highway (east of existing Tarro interchange)	< 0.5	< 0.5
AS8	New England Highway (east of existing Tarro interchange)	< 0.5	< 0.5
AS9	New England Highway (east of existing Tarro interchange)	< 0.5	< 0.5
AS10	Pacific Highway (north of Hexham Bridge)	< 0.5	0.6
AS11	Pacific Highway (north of Hexham Bridge)	< 0.5	< 0.5
AS12	Pacific Highway (north of Hexham Bridge)	< 0.5	< 0.5
AS13	Pacific Highway (north of Hexham Bridge)	< 0.5	< 0.5
AS14	Pacific Highway, Heatherbrae	< 0.5	< 0.5
AS15	Pacific Highway, Heatherbrae	< 0.5	< 0.5
AS16	Masonite Road, Heatherbrae	1.6	5.9
AS17	Masonite Road, Heatherbrae	0.8	3.5
AS18	Masonite Road, Heatherbrae	0.5	2.5
AS19	Masonite Road, Heatherbrae	0.8	3.8
AS20	Pacific Highway (north of Masonite Road)	< 0.5	< 0.5
AS21	Pacific Highway (north of Masonite Road)	< 0.5	< 0.5

Table 5-13 indicates that construction traffic associated with the project is not expected to increase traffic noise levels by more than 2 dB(A) on most of the roads along the proposed construction traffic routes. However, increases of up to 5.9 dB(A) during the night time period have been predicted along Masonite Road in Heatherbrae when accessing AS16, AS17, AS18 and AS19. It is noted that only commercial and industrial premises are located along Masonite Road and there are no residential or other sensitive receivers. Therefore, although an increase in traffic noise levels of more than 2 dB(A) is predicted, no sensitive receivers are impacted.

5.6 Construction vibration

5.6.1 Vibration source levels

Typical vibration levels from vibration intensive plant and equipment likely to be used for the construction of the project are summarised in **Table 5-14** based on library data and measurements from past projects.

Table 5-14 Typical ground vibration generated by construction plant

<table>
<tr><th>Construction plant</th><th>Typical ground vibration</th></tr>
<tr><td>Vibratory / impact piling</td><td>Vibratory piling typically generates 5 mm/s to 10 mm/s (ppv) at distances greater than 15 metres and 1 mm/s to 1.5 mm/s (ppv) at distances greater than 30 m, depending on soil conditions. Vibration is usually below 0.1 mm/s (ppv) beyond 60 m.</td></tr>
<tr><td>Sheet piling</td><td>Sheet piling is capable of generating relatively high levels of vibration, depending on soil conditions and blow energy, as indicated below.
<table>
<tr><td rowspan="2">Piling blow energy (joules)</td><td colspan="6">Vibration (mm/s) at given distance</td></tr>
<tr><td>10 m</td><td>15 m</td><td>20 m</td><td>30 m</td><td>50 m</td><td>100 m</td></tr>
<tr><td>60,000</td><td>40</td><td>25</td><td>20</td><td>12</td><td>7.5</td><td>3.5</td></tr>
<tr><td>20,000</td><td>20</td><td>14</td><td>10</td><td>7</td><td>4</td><td>2</td></tr>
</table>
Source: Richard Heggie Associates</td></tr>
<tr><td>Hydraulic rock hammer</td><td>Typical ground vibration levels at various distances from rock hammer operating in hard sandstone are summarised below. Use of smaller machines can reduce levels of vibration significantly.
<table>
<tr><td rowspan="2">Plant size</td><td colspan="6">Vibration (mm/s) at given distance</td></tr>
<tr><td>5 m</td><td>10 m</td><td>20 m</td><td>30 m</td><td>40 m</td><td>50 m</td></tr>
<tr><td>Heavy rock hammer</td><td>4.5</td><td>1.3</td><td>0.4</td><td>0.2</td><td>0.15</td><td>0.1</td></tr>
<tr><td>Light rock hammer</td><td>1</td><td>0.3</td><td>0.1</td><td>0.05</td><td>0.01</td><td>-</td></tr>
</table>
Source: Richard Heggie Associates</td></tr>
<tr><td>Jackhammers</td><td>Typical ground vibration from jackhammers is 2 mm/s at distances of about 5 m and at distances greater than 10 m, vibration levels are usually below 1 mm/s.</td></tr>
<tr><td>Excavators</td><td>Typical ground vibration from excavators and graders range from 1 mm/s to 2 mm/s at distances of approximately 5 m and at distances greater than 20 m, vibration levels are usually below 0.2 mm/s.</td></tr>
<tr><td>Vibratory rollers</td><td>Ground vibration caused by vibratory rollers can range up to 1.5 mm/s at distances of 25 m. The highest levels of vibration usually occur as the roller is brought to rest and the frequency of the centrifugal forces passes through resonance with the natural frequency of the roller/ground/structure. Machinery should therefore not be brought to rest when in the vicinity of susceptible buildings, such as heritage structures and/or dwellings.
Higher levels could occur at closer distances; however, no damage would be expected for any building at distances greater than approximately 12 m (for a medium to heavy roller).</td></tr>
</table>

Construction plant	Typical ground vibration
Truck traffic	Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels in the range of 0.01 mm/s to 0.2 mm/s at the footings of buildings located 10 to 20 m from a roadway. Very large surface irregularities can cause levels up to five to ten times higher. In general, ground vibration from trucks is usually imperceptible in nearby buildings. The rattling of windows and other loose fittings that is sometimes reported is more likely to be caused by airborne acoustic excitation from very low frequency (infrasonic) noise radiated by truck exhausts and truck bodies. While this may cause concern to the occupants, the phenomenon is no different from the rattling caused by wind or people walking or jumping on the floor and fears of structural damage or even accelerated ageing are usually unfounded.

5.6.2 Minimum working distances

As a guide, indicative minimum working distances for typical items of vibration intensive plant and equipment are provided in **Table 5-15** from the CNVG. The minimum working distances are indicative only potential vibration experienced by receivers would be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. Where construction activities involving the above vibration intensive plant are carried out within the minimum working distances presented above, vibration monitoring should be conducted at the impacted receivers to confirm vibration levels are within acceptable limits during the work.

The minimum working distances are quoted for the purpose of minimising:

- Cosmetic damage (referenced from British Standard BS 7385 Part 2-1993 and German Standard DIN 4150-2016)
- Human response (referenced from Assessing Vibration: a technical guideline (DEC, 2006)).

Table 5-15 Recommended minimum working distances for vibration intensive plant and equipment

Plant item	Rating/activity description	Recommended minimum working distances		
		Cosmetic damage		Human response [3]
		Structurally sound [1] (e.g. residential & light commercial)	Structurally unsound [2] (e.g. unsound heritage structures)	
Vibratory roller	< 50 kN (typically 1-2 t)	5 m	11 m	15 m to 20 m
	< 100 kN (typically 2-4 t)	6 m	13 m	20 m
	< 200 kN (typically 4-6 t)	12 m	15 m	40 m
	< 300 kN (typically 7-13 t)	15 m	31 m	100 m
	> 300 kN (typically 13-18 t)	20 m	40 m	100 m
	> 300 kN (typically > 18 t)	25 m	50 m	100 m

Plant item	Rating/activity description	Recommended minimum working distances		
		Cosmetic damage		Human response [3]
		Structurally sound [1] (e.g. residential & light commercial)	Structurally unsound [2] (e.g. unsound heritage structures)	
Small hydraulic hammer	300 kg – 5 to 12 t excavator	2 m	5 m	7 m
Medium hydraulic hammer	900 kg – 12 to 18 t excavator	7 m	15 m	23 m
Large hydraulic hammer	1600 kg – 18 to 34 t excavator	22 m	30 m[4]	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	5 m to 30 m	20 m to 50 m
Pile boring	≤ 800 mm	2 m	5 m	5 m
Jackhammer	Handheld	1 m	3 m	5 m
Blasting operations [4]		Based on charge size – see Note 4		

Notes:

1. Referenced from either the CNVG or against the criteria in the British Standard BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2
2. Criteria referenced from DIN 4150-3:2016 Vibration in buildings – Effects on structures (including heritage items)
3. Referenced from either the CNVG or the criteria referenced in the EPA's Assessing Vibration: a technical guideline (December 2006)
4. To be determined during test blasts to establish appropriate propagation characteristics for the site and increase the accuracy of blasting predictions and confirmed, refer to **Chapter 7**.

5.6.3 Potential vibration impacts

Based on the recommended working distances presented in **Table 5-15**, an assessment of potential vibration impacts was estimated and summarised in **Table 5-16**. The assessment is relevant to all residential and commercial / industrial use buildings, and other similar type structures in the vicinity of the construction work.

Table 5-16 Potential vibration for residential/commercial properties

NCA	Approx. distance to nearest buildings from work	Type of nearest sensitive buildings	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
NCA01A	160 m – 180 m	Residential	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.
NCA01B	590 m – 610 m	Residential	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.
NCA02	70 m – 80 m	Commercial / Industrial	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.

NCA	Approx. distance to nearest buildings from work	Type of nearest sensitive buildings	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
NCA03	1150 m – 1200 m	Commercial / Industrial	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.
NCA04A	10 m – 15 m	Residential	Medium risk of structural damage.	High risk of adverse comment.	Vibration monitoring may be considered.
NCA04B	80 m – 90 m	Residential	Very low risk of structural damage.	Low risk of adverse comment.	Vibration monitoring may be considered.
NCA05A	100 m – 110 m	Residential / Commercial / Industrial	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.
NCA05B	300 m – 310 m	Residential	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.
NCA06	1350 m – 1400 m	Residential	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.
NCA07	35 m – 40 m	Residential	Low risk of structural damage.	Medium risk of adverse comment.	Vibration monitoring may be considered.
NCA08	40 m – 45 m	Residential	Low risk of structural damage.	Medium risk of adverse comment.	Vibration monitoring may be considered.
NCA09	55 m – 60 m	Residential	Very low risk of structural damage.	Low risk of adverse comment.	Vibration monitoring may be considered.
NCA10	5 m – 10 m	Industrial	Low risk of structural damage.	Medium risk of adverse comment.	Vibration monitoring may be considered.
NCA11	70 m – 80 m	Recreational structure	Very low risk of structural damage.	Low risk of adverse comment.	Vibration monitoring may be considered.
NCA12	10 m – 15 m	Industrial	Low risk of structural damage.	Low risk of adverse comment.	Vibration monitoring may be considered.
NCA13	290 m – 300 m	Residential	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.
NCA14A	10 m – 15 m	Commercial	Low risk of structural damage.	Low risk of adverse comment.	Vibration monitoring may be considered.

NCA	Approx. distance to nearest buildings from work	Type of nearest sensitive buildings	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration / monitoring
NCA14B	520 m – 540 m	Residential	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.
NCA14C	460 m – 480 m	Residential	Very low risk of structural damage.	Very low risk of adverse comment.	Not required.

5.6.4 Buried water, sewer and gas pipelines

A number of buried water, sewer mains and the Hunter Water Chichester Trunk Gravity Main (CTGM) are located within the construction footprint at Black Hill, Tarro, Tomago, Heatherbrae and Raymond Terrace. Additionally, high and medium pressure gas mains are located within the construction footprint near the proposed Tomago interchange at the Pacific Highway and Old Punt Road. Vibration intensive plant and equipment could be used near the water, sewer and gas pipelines including hydraulic rock breakers / hammers, vibratory pile drivers, bored piling rigs and vibratory rollers.

It is understood that the CTGM and the high and medium pressure gas mains are typically of iron / steel construction, while the water and sewer mains are likely steel, metal or plastic construction. Therefore, in accordance with the structural damage limit in DIN 4150-3 (presented in **Table 3-12**) for steel, metal and/or plastic buried pipework, a peak vibration velocity level of between 50 mm/s and 100 mm/s would apply. Based on the nominated vibration limits, the vibration intensive plant and equipment likely to be used on site are not expected to cause exceedances of the limits.

5.6.5 Electrical and telecommunication utilities

Numerous buried low and high voltage electrical lines and optical fibre cables are located within the construction footprint. As discussed in **Section 3.5.1**, vibration limits of 50 mm/s to 100 mm/s would be applicable for buried electrical cables and telecommunication utilities. Based on these limits, the vibration intensive plant and equipment likely to be used on site are not expected to cause exceedances of the limits. However, further assessment and consultation with the utility providers would be carried out during detailed design.

For aboveground high voltage electrical transmission lines, vibration impacts to the associated structures such as the stanchions and associated footings are not referred to in the nominated standards, policies and guidelines presented in **Table 2-1** and **Section 3.5.1**. Nevertheless, the stanchions and associated footings would be significant as other impacts such as wind loads encountered by the stanchions would be a major factor in their design. Therefore, the vibration limits nominated for buildings would not be applicable for these structures and higher limits would likely be relevant. As a result, the vibration intensive plant and equipment likely to be used on site are not expected to cause adverse impacts to the stanchions and associated footings.

5.6.6 Heritage structures

Heritage within or near the construction footprint comprises Aboriginal and non-Aboriginal heritage. Non-Aboriginal heritage within the construction study area comprises above ground structures and below ground archaeological sites, while Aboriginal heritage within the construction study area comprises surface and subsurface (below ground) artefacts. Below ground archaeological sites (non-Aboriginal heritage) and both surface and subsurface artefacts (Aboriginal heritage) are not subject to potential vibration impacts and so are not considered further in this assessment.

Heritage items with the potential to be impacted by construction vibration are identified in **Table 5-17**.

As described in **Section 3.5.1**, BS 7385 states that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*" and therefore, buildings or structures should not be assumed to be sensitive to vibration on the basis of being classed as a heritage item.

Nevertheless, for a conservative assessment the approximate distances of each heritage item listed in **Table 5-17** are typically outside of the recommended minimum working distances presented in **Table 5-15** for 'structurally unsound' structures. The exception is Item 1 (Hannell Family Vault), which is within the recommended working distances for large vibratory rollers, large hydraulic hammers and vibratory pile drivers. However, given that the closest construction activities to this heritage item would be associated with ancillary facility AS8, it is not expected that the vibration intensive equipment listed would be used at the ancillary facility.

Therefore, the vibration intensive plant and equipment associated with the proposed construction activities are not expected to cause cosmetic damage to the nearest affected heritage listed structures.

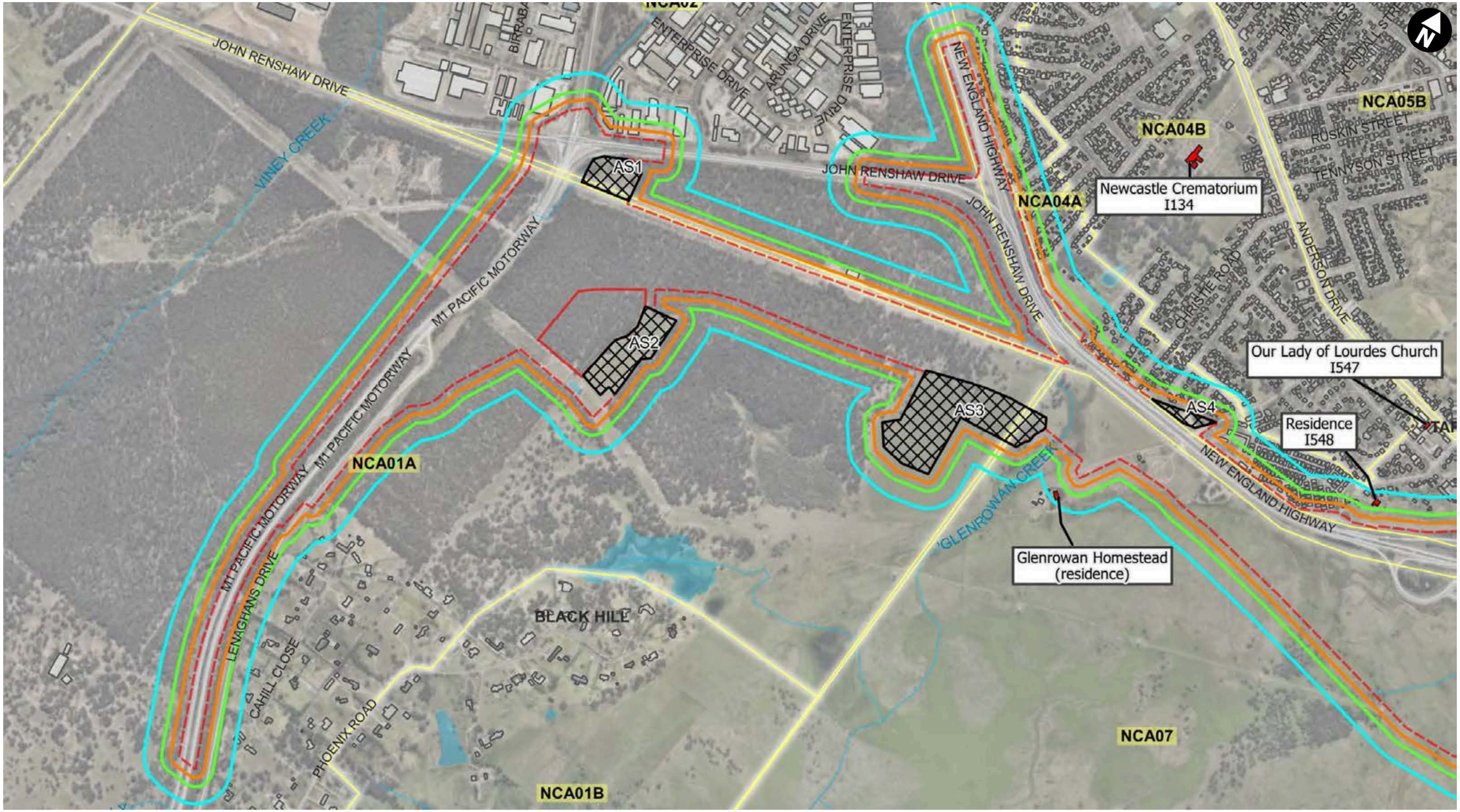
Table 5-17 Heritage items identified within or next to the construction footprint that are subject to vibration

Heritage item[1]	Heritage item name	NCA	Location	Approx. distance to vibration intensive work[2]
Item 1	Hannell Family Vault (I179)	NCA08	398B Maitland Road, Hexham	> 100 metres
Item 3	Glenrowan Homestead (residence)	NCA07	51 New England Highway, Black Hill	85 metres
Item 4	Residence (I548)	NCA04A	29 Eastern Avenue, Tarro	75 metres
Item 7	Tarro Substation (I546)	NCA04A	6A Anderson Drive, Tarro	100 metres
Item 8	Pumping Station (I550)	NCA05A	3 Woodberry Road, Tarro	> 100 metres
Item 9	Newcastle Crematorium (I34)	NCA04B	176 Anderson Drive, Beresfield	> 500 metres
Item 10	Our Lady of Lourdes Church (I547)	NCA04A	42 Anderson Drive, Tarro	250 metres

Note:

1. Heritage item number specified in the Non-Aboriginal Heritage Working Paper (Appendix Q of the EIS) for the project. Numbers in parenthesis represent listed heritage ID number on relevant local environment plan
2. Distances presented represent distance to construction work areas where vibration intensive plant and equipment would be operating

Based on the above, heritage listed structures are unlikely to be impacted by vibration from the construction activities. However, heritage listed structures that are within 100 metres from vibration intensive works would be considered on a case by case basis and further investigation would be carried out during detailed design to confirm the structural integrity (i.e. structurally sound or unsound) of all potentially affected structures. Management measures for potential vibration impacts to heritage items are presented in **Chapter 8** and Non-Aboriginal Heritage Working Paper (Appendix Q of the EIS).



Legend

- Construction footprint
- Ancillary site
- Heritage items
- Noise catchment area (NCA)
- Building
- Waterways
- Main North Rail Line

Minimum working distances

- 25m Buffer - cosmetic damage (residential & light commercial)
- 50m Buffer - cosmetic damage (DIN4150 group 3)
- 100m Buffer - human comfort

300 0 300 600 m

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Figure 5-3 Heritage items and minimum working distances (map 1 of 3)

Date: 05/03/2021 Project path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

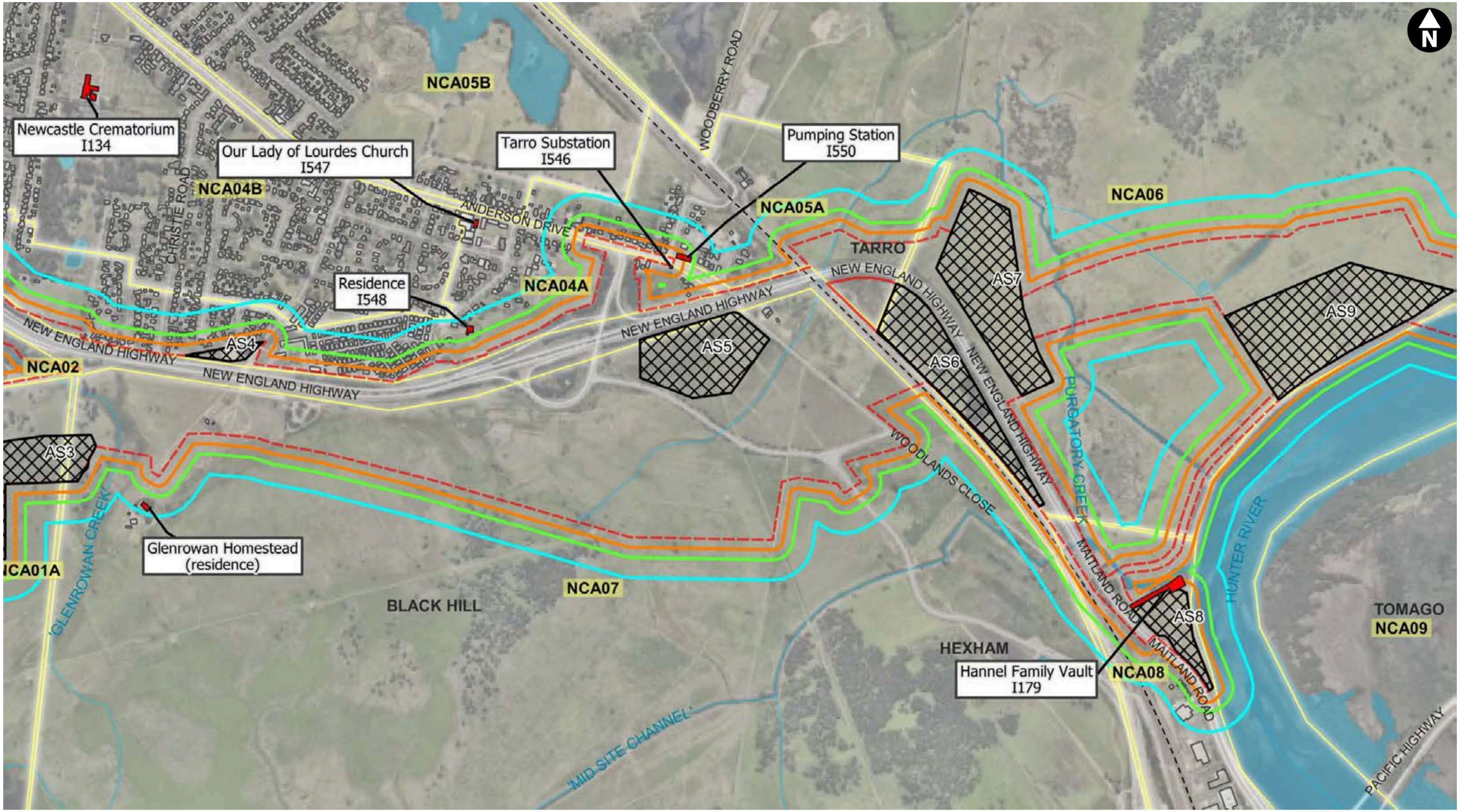

Figure 5-3 Heritage items and minimum working distances (map 2 of 3)

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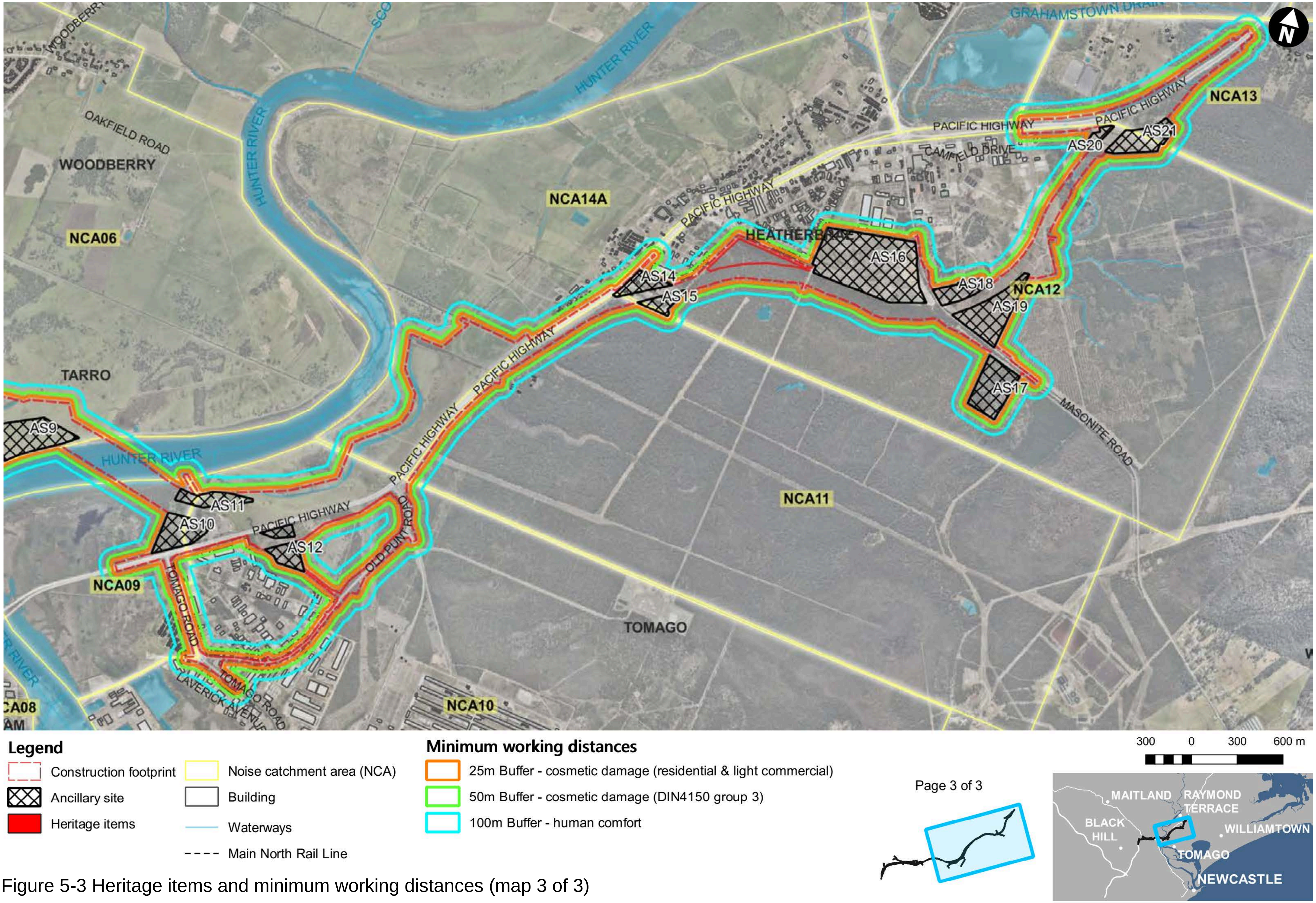

Figure 5-3 Heritage items and minimum working distances (map 3 of 3)

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5.7 Construction blasting noise and vibration

Blasting may be required during construction. If required, blasting would occur during construction of the cutting in the Black Hill area, south of John Renshaw Drive. Receivers within NCA01A, NCA01B, NCA02, NCA04A and NCA07 may be impacted by the blasting activities.

The MIC quantities from blasting activities required to achieve compliance with the blasting management levels for the corresponding nearest affected receiver types in each NCAs are presented in **Table 5-18**. The MIC quantities have been determined for both air blast overpressure and ground vibration using a calculation model developed by Renzo Tonin & Associates and on the assumption that the geology of the blasting area consist of hard or highly structured rock (refer to **Section 3.5.7**).

Table 5-18 Allowable MIC to comply with blasting management levels at different distances

Assessment	Management level	Allowable MIC (kg)				
		NCA01A	NCA01B	NCA02[1]	NCA04A	NCA07
Airblast overpressure	120 dBL (sensitive site)[2] 125 dBL (non-sensitive site)	2424 (1,000 m)	1805 (920 m)	347 (350 m)	95 (400 m)	209 (500 m)
Ground vibration	3 mm/s (unsound heritage)[3]	-[6]	-[6]	-[6]	-[6]	149 (500 m)
	15 mm/s (residential)[4]	4456 (1,000 m)	3772 (920 m)	-[6]	713 (400 m)	-[6]
	10 mm/s (human comfort)[2]	2685 (1,000 m)	2272 (920 m)	329 (350 m)	430 (400 m)	671 (500 m)
	50 mm/s (commercial/industrial)[4]	-[6]	-[6]	129 (80 m)	-[6]	-[6]
	80 mm/s (buried metal flanged pipework)[5]	-[6]	-[6]	33 (30 m)	-[6]	-[6]

Notes:

1. Only commercial and industrial type receivers / buildings and the Hunter Water CTGM are located in NCA02
2. Management level based on blasting occurring for less than 12 months or less than 20 blasts
3. Vibration management level for unsound heritage structures based on German Standard DIN4150-3
4. In accordance with Table J4.4.2.1 of AS 2187.2-2006 and based on vibration limits in BS 7385-2
5. Vibration management level for buried metal flanged pipework based on German Standard DIN4150-3
6. Nearest affected receivers in NCA do not fall under this receiver type
7. Distance shown in parentheses represents the distance from the blasting activities to the nearest affected receiver.

The results in **Table 5-18** show that the limiting factor for the maximum MIC quantity that could be used for blasting is controlled by the assessment of the buried pipework in NCA02, namely the CTGM, which is directly next to the proposed blast site.

The overpressure and vibration levels generated by blasting are dependent on site specific factors, local ground conditions and the blast design. The MIC that would achieve the overpressure and/or vibration management levels at distances from the blasting area can vary from the values indicated in **Table 5-18**.

The need for blasting would be determined as part of the pre-construction and detailed design stages of the project. If blasting is required, site specific noise and vibration investigations would be carried out, which would consider charge and blast configuration design. Analyses would be carried out identify actual buffer zones associated with the project, and assist in identifying appropriate measures to limit overpressure and vibration to acceptable levels at critical locations. Blast charge and blast configurations would be identified to ensure that the blast management levels not exceeded. If blasting is to be included as part of the construction work, a blast management plan would be developed before construction to confirm allowable MIC as detailed in **Chapter 8**.

6. Operational road traffic noise

6.1 Overview

The outcomes of the assessment of operational road traffic noise impacts are outlined in the following sections:

- Traffic noise impacts to sensitive receivers (residential and non-residential) prior to any noise mitigation measures implemented (**Section 6.2**)
- Assessment of noise mitigation measures including quieter pavements, noise barriers and/or at-property noise treatment for sensitive receivers impacted by traffic noise (**Section 6.3**)
- Assessment of maximum noise levels with the potential to cause sleep disturbance (**Section 6.4**).

6.2 Operational road traffic noise predictions without mitigation

As described in **Section 3.6.2**, operational noise impacts on noise sensitive receiver buildings have been predicted from road traffic for the 'Do minimum' ('No Build') and the 'With project' ('Build') scenarios. These scenarios do not include any noise mitigation measures, other than the existing measures (e.g. existing noise barriers) and those that are incorporated into the road design.

Table 6-1 presents the number of receiver buildings that have been predicted to exceed the NCG noise criteria levels for the 'Do minimum' (without the project) and 'With project' (with the project) unmitigated scenarios for the opening year and design year.

It is noted that if a receiver building is predicted to exceed the NCG noise criteria, it may not necessarily be eligible for additional noise mitigation. Eligibility for additional noise mitigation measures is subject to the processes and criteria discussed in **Section 3.6.6**.

Table 6-1 Number of receiver buildings exceeding the NCG noise criteria without mitigation

NCA	2028 'Do minimum		2028 'With project'		2038 'Do minimum'		2038 'With project'	
	Day	Night	Day	Night	Day	Night	Day	Night
NCA01A	13	14	14	18	13	16	18	20
NCA01B	0	0	0	0	0	0	0	0
NCA02	1	1	1	1	1	1	1	1
NCA04A	249	249	280	258	279	275	323	321
NCA04B	19	27	52	59	29	41	81	101
NCA05A	30	27	30	30	30	30	30	30
NCA05B	10	0	10	1	10	1	11	7
NCA07	2	2	2	2	2	2	2	2
NCA09	1	1	1	1	1	1	1	1
NCA12	7	7	7	7	7	7	7	7
NCA13	2	6	4	5	2	6	6	6
NCA14A	104	115	115	131	112	123	137	156
NCA14B	0	5	3	7	2	6	7	22

NCA	2028 'Do minimum		2028 'With project'		2038 'Do minimum'		2038 'With project'	
	Day	Night	Day	Night	Day	Night	Day	Night
NCA14C	56	85	60	79	70	101	81	114
TOTAL	**494**	**539**	**579**	**599**	**558**	**610**	**705**	**788**

Note:
1. Includes residential and non-residential sensitive receivers
2. NCA03, NCA06 and NCA08 are located outside the operational study area for operational traffic noise and are not included in this table
3. No sensitive (residential and non-residential) receivers are located within NCA10 and NCA11 and are therefore not included this table

From **Table 6-1**, it can be seen that NCA04A has the highest number of receiver buildings that would experience exceedances of the NCG noise criteria. This is expected given that the receivers in NCA04A are in a suburban setting and are located close to the project, in particular, the New England Highway in Tarro. A high number of receiver buildings in NCA14A are also predicted to exceed the NCG noise criteria as affected receivers in this NCA are located next to the existing Pacific Highway in Heatherbrae.

6.2.1 Change in traffic noise levels due to the project

Table 6-2 summarises the number of receivers in each NCA that are predicted to experience reductions and increases in existing traffic noise, when comparing 'Do minimum' with the 'With project' unmitigated scenarios for 2038.

Table 6-2 Predicted changes in noise levels (2038 'With Project' – 'Do Minimum')

NCA	Number of receiver buildings					
	< 0 dB(A)		0 dB(A) to 2 dB(A)		> 2 dB(A)	
	Day	Night	Day	Night	Day	Night
NCA01A	15	17	20	23	7	2
NCA01B	1	1	28	28	0	0
NCA02	0	0	1	1	0	0
NCA04A	66	59	359	366	0	0
NCA04B	0	0	602	583	13	32
NCA05A	3	3	28	28	0	0
NCA05B	5	0	26	31	5	5
NCA07	1	1	1	0	0	1
NCA09	0	0	1	1	0	0
NCA12	7	7	0	0	0	0
NCA13	0	0	7	8	2	1
NCA14A	75	79	45	48	60	53
NCA14B	0	0	27	54	57	30
NCA14C	0	0	208	209	1	0
TOTAL	**173**	**167**	**1353**	**1380**	**145**	**124**

Notes
1. Based on no mitigation measures implemented, except existing noise barriers
2. Includes non-residential sensitive receivers (e.g. school classrooms, places of worship, etc), where applicable
3. An individual receiver building is considered as a single receiver for the purposes of this assessment; i.e. one double-storey residential building = one receiver building.

The results indicate the following:

- Some receivers are predicted to experience a decrease in traffic noise levels when the project is operational, mainly due to traffic using the project and bypassing the existing roads near these receivers. On average the project is predicted to result in reduced traffic noise for about 10 per cent of receivers
- The project is predicted to typically increase traffic noise levels by no more than 2 dB(A) at the majority of receivers surrounding the project, which is considered to be a minor impact. An average of about 82 per cent of receivers within the noise catchment areas are predicted to experience traffic noise level increases of less than 2 dB(A), which is described by the RNP as a minor impact and is barely perceptible
- Some receivers may experience increases of more than 2 dB(A) in traffic noise levels due to traffic from the project moving closer to these residences or increasing the exposure to more traffic lanes. An average of about eight per cent of receiver buildings within the noise catchment areas are predicted to experience increases in traffic noise of more than 2 dB(A) due to the project.

For the majority of receiver buildings within the operational study area there is either a reduction or relatively minor change in traffic noise levels due to the project. As such, any requirement for additional noise mitigation is likely to be a result of the high existing road traffic noise levels resulting in exceedances of the cumulative limit criterion or traffic noise levels being acute (day $L_{Aeq(15hour)}$ greater than or equal to 65 dB(A) or night $L_{Aeq(9hour)}$ greater than or equal to 60 dB(A)).

6.2.2 Receivers triggered for consideration of additional noise mitigation

The results for the number of receiver buildings impacted upon and triggered as qualifying for consideration of additional noise mitigation in accordance with the NMG, for the design year 2038 due to the 'With project' scenario, are summarised in **Table 6-3**.

Table 6-3 Number of receiver buildings impacted due to the project for design year 2038

NCA [1]	Total Number of receiver buildings assessed	Day period – number of receiver buildings				Night period – number of receiver buildings				Requiring consideration of additional noise mitigation [6]
		Exceed NCG noise criteria level [2]	> 2 dB(A) Increase and exceed NCG criteria [3,4]	Exceed cumulative noise limit	Experience acute noise levels (≥ 65 dB(A)) [5]	Exceed NCG noise criteria level [2]	> 2 dB(A) Increase and exceed NCG criteria [3,4]	Exceed cumulative noise limit	Experience acute noise levels (≥ 60 dB(A)) [5]	
NCA01A	42	8	6	2	0	8	1	2	0	8
NCA01B	29	0	0	0	0	0	0	0	0	0
NCA02	1	1	0	1	0	1	0	0	0	1
NCA04A	425	103	0	94	71	85	0	83	79	103
NCA04B	615	4	1	2	0	4	3	0	0	4
NCA05A	31	2	2	0	0	2	2	0	0	2
NCA05B	36	0	0	0	0	0	0	0	0	0
NCA07	2	1	0	1	0	1	1	1	1	1
NCA09	1	1	0	1	0	1	0	1	1	1
NCA12	7	6	2	6	0	6	2	6	0	6
NCA13	9	2	2	0	0	2	1	0	0	2
NCA14A	180	50	34	29	6	59	28	34	8	59
NCA14B	84	1	2	0	0	2	1	0	0	2
NCA14C	209	0	0	0	0	0	0	0	0	0
TOTAL	**1671**	**179**	**49**	**136**	**77**	**171**	**39**	**127**	**89**	**189**

Notes

1. NCA03, NCA06 and NCA08 located outside the operational study area for operational traffic noise, and no sensitive (residential and non-residential) receivers in NCA10 and NCA11; hence, not included this table
2. NCG noise criteria level based on 'New Road', 'Redeveloped Road', 'Transition Zone' or 'Relative Increase' criteria as per RNP
3. Greater than 2 dB(A) increase based on comparison between 'With project' scenario and 'Do minimum' scenario for the design year 2038
4. Exceedance of NCG noise criteria AND increase of more than 2 dB(A) are required to be eligible for noise mitigation
5. Acute noise levels due to contribution from the project only
6. A receiver building qualifies for noise mitigation if it falls under any of the three NMG noise mitigation triggers (i.e. Greater than2 dB(A) increase, exceed cumulative or acute noise) or a multiple of triggers
7. An individual receiver building is considered as a single receiver for the purposes of this assessment; i.e. one double-storey residential building = one receiver building.

Table 6-4 shows that 189 receiver buildings out of the 1671 receiver buildings assessed (about 11 per cent) are eligible for consideration for additional noise mitigation in accordance with the NMG requirements as presented in **Section 3.6.6**.

The 189 receiver buildings were identified based on the following assumptions:

- The predicted 'With project' (Build) traffic noise levels in the design year (2038) would exceed the NCG project road noise criteria and would also increase by more than 2 dB(A) as a result of the project at 49 and 39 receiver buildings during the day and night periods, respectively
- The cumulative limit (5 dB(A) above the NCG project road criterion) would be exceeded at 136 and 127 receiver buildings during the day and night periods, respectively
- There are 77 and 89 receiver buildings predicted to experience acute (day $L_{Aeq(15hour)}$ greater than or equal to 65 dB(A) or night $L_{Aeq(9hour)}$ greater than or equal to 60 dB(A)) noise levels due to the project during the day and night periods, respectively.

Some receiver buildings eligible for consideration for additional noise mitigation may fall into more than one of the NMG noise mitigation triggers and have multiple triggers. For example, an eligible receiver building may exceed the cumulative noise limit and also be exposed to acute noise levels.

Other sensitive receivers

Of the 189 receiver buildings identified as being eligible for consideration for additional noise mitigation, 21 receiver buildings are associated with the following other sensitive (non-residential) receivers:

- NCA02 – Saint Mary & Saint George Coptic Orthodox Church (place of worship)
- NCA04A – Our Lady of Lourdes Primary School (educational)
- NCA04A – Our Lady of Lourdes Church (place of worship)
- NCA04A – Tarro Public School (educational)
- NCA04B – Newcastle Memorial Park (place of worship)
- NCA04B – Tarro Uniting Church of Australia (place of worship).

The above other sensitive receivers were identified based on the predicted traffic noise levels exceeding the cumulative limit and/or experiencing acute noise levels due to the project.

6.3 Operational road traffic noise predictions for mitigation measures

Operational noise impacts on noise sensitive receivers have been predicted with quieter pavement surfaces, noise barriers and at-property noise treatments. The following sections describe the operational road traffic noise mitigation measures that have been assumed for the purposes of the assessment and the receivers triggered for consideration of additional noise mitigation.

6.3.1 Quieter pavement surfaces

For the purpose of this assessment and in accordance with the NMG, the following quieter pavements have been considered as the first form of noise mitigation measure to be implemented:

- OGA along the New England Highway section to be upgraded, which would achieve a 2 dB(A) noise reduction compared to DGA
- LNDG of the concrete pavements along sections of the main carriageways of the project, which would reduce the noise from the concrete pavement equivalent to that of DGA (i.e. 0 dB(A) pavement correction).

Figure 6-1 resents the location of the quieter pavements considered.

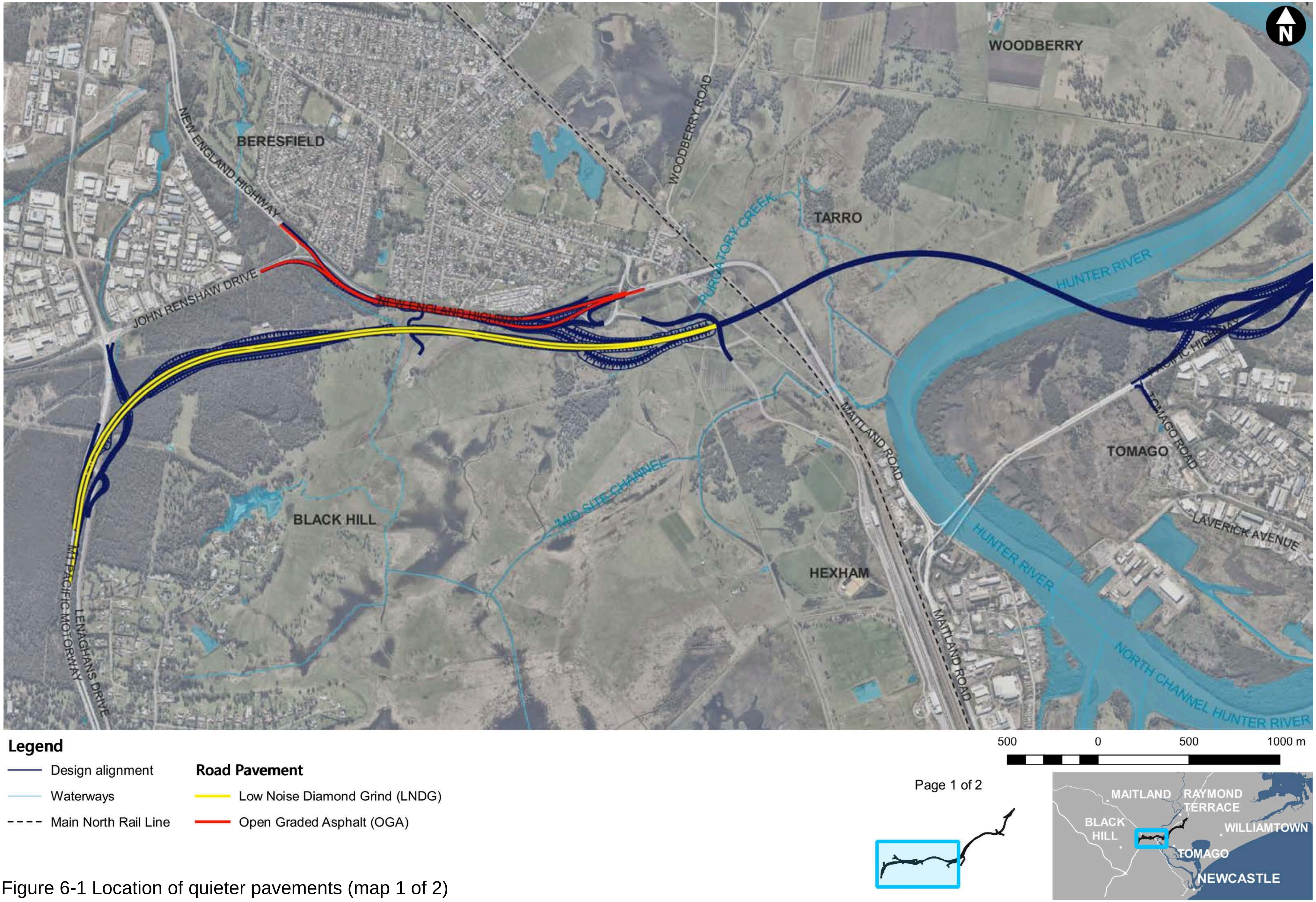

Figure 6-1 Location of quieter pavements (map 1 of 2)

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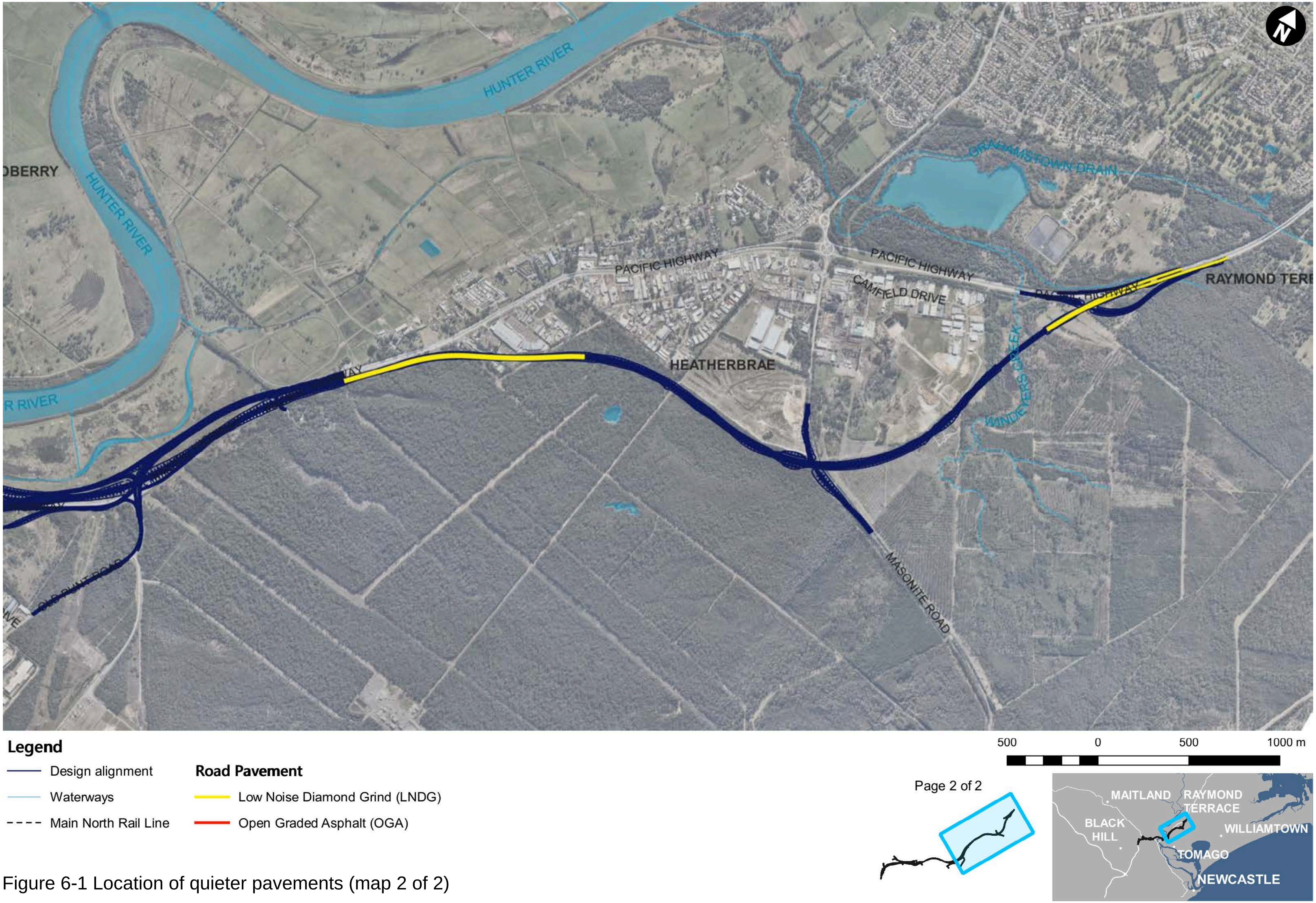

Figure 6-1 Location of quieter pavements (map 2 of 2)

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To investigate the potential benefits of implementing quieter pavements, a comparison of the number of receiver buildings with and without mitigation in the form of quieter pavements was carried out for design year 2038 traffic noise modelling scenarios.

A comparison of the number of triggered receiver buildings with and without noise mitigation in the form of quieter pavements is provided in **Table 6-4**.

Table 6-4 Number of triggered receiver buildings with and without noise mitigation with quieter pavements

NCA	Number of triggered receiver buildings	
	Without quieter pavements	With quieter pavements
NCA01A	8	4
NCA01B	0	0
NCA02	1	1
NCA04A	103	103
NCA04B	4	2
NCA05A	2	2
NCA05B	0	0
NCA07	1	1
NCA09	1	1
NCA12	6	6
NCA13	2	2
NCA14A	59	38
NCA14B	2	1
NCA14C	0	0
TOTAL	**189**	**161**

Notes:

1. Only receiver buildings eligible for consideration of additional noise mitigation in accordance with NMG requirements have be included
2. Includes non-residential sensitive receivers, where applicable
3. An individual receiver building is considered as a single receiver for the purposes of this assessment; i.e. one double-storey residential building = one receiver building.

From the results presented above, by implementing the proposed quieter pavements the number of receiver buildings eligible for consideration of additional noise mitigation reduces from 189 to 161 (about a 15 per cent reduction). In addition to the number of receiver buildings being reduced, implementing the quieter pavements would also provide an overall noise reduction at all receivers within the operational study area.

The final road pavement surface used for the project would be subject to various requirements besides acoustic benefits, including structural integrity, skid resistance, water dispersion, maintenance and design life.

6.3.2 Noise barriers

Noise barriers have been proposed for the project and have undergone the NMG barrier analysis, with results of the analysis and recommended reasonable and feasible barrier heights for each location summarised in **Table 6-5**.

The NMG barrier analysis results for each proposed noise barrier are detailed in **Appendix D**.

It is noted that the barrier heights indicated in **Table 6-5** are based on the height above the local ground where the proposed barrier is to be located. Furthermore, receiver counts presented in **Table 6-5** refer to receiver points, where a receiver point is representative of each habitable floor level of a residence. For example, a double storey residence would be represented by two receiver points.

Figure 6-2 and **Figure 6-3** show the proposed noise barriers considered to be a reasonable and feasible noise mitigation option.

Table 6-5 Summary of NMG noise barrier analysis

Barrier ID	NMG noise barrier analysis						Alternative barrier height (metres) [2, 3]	Comments
	Barrier considered	Approx. length (metres)	Design height (metres) [1, 3]	Total number of benefitting receivers [4]	Triggered receivers with no barrier [4]	Remaining triggered receivers with design barrier [4]		
NB.01	Existing barrier (relocated)	265	-	5	3	3	Retain relocated existing noise barrier	A barrier in this location would not provide acoustic benefits to impacted receivers as the number of receivers identified for at-property treatment would not reduce by two thirds at any barrier height (i.e. no initial design barrier height). Therefore, the existing noise barrier with the same top of barrier height is to be relocated. Increasing the height of the relocated barrier in this location is not reasonable and feasible and is not recommended.
NB.02	Existing barriers (about 3.8 metres) + new barriers	1105	7	172	36	10	3.8 (consistent with existing barrier heights)	Design barrier height of 7 m would provide more than 10 dB(A) insertion loss as required for barriers over 5 m. Maintaining the same 3.8 m barrier height as the existing barriers would provide more than 5 dB(A) insertion loss as required for barriers 5 m and under. Although the design barrier height of 7 m would achieve the insertion loss requirements, an alternative barrier height consistent with the lower existing noise barriers may be considered. Constraints affecting the feasibility of the barrier such as the integration with existing structures, removal of vegetation (e.g. well established urban/native trees) as well as urban design and visual amenity impacts would be further investigated during further design development. It is noted that this noise barrier consists of existing barriers and new barriers to fill in the gaps between the existing barriers.

Barrier ID	NMG noise barrier analysis						Alternative barrier height (metres) [2, 3]	Comments
	Barrier considered	Approx. length (metres)	Design height (metres) [1, 3]	Total number of benefitting receivers [4]	Triggered receivers with no barrier [4]	Remaining triggered receivers with design barrier [4]		
NB.03	New	741	8	56	35	19	4	Design barrier height of 8 m would provide more than 10 dB(A) insertion loss as required for barriers over 5 m. The alternative barrier height of 4 m achieves the required insertion loss of 5 dB(A) for barriers 5 m and under. Therefore, the alternative barrier height of 4 m has been considered and would provide a reasonable balance between addressing noise impacts and visual amenity impacts for adjacent receivers. Constraints affecting the feasibility of the barrier such as removal of vegetation (e.g. well established urban/native trees) as well as urban design and visual amenity impacts would be further investigated during further design development.

Note:

1. Calculated noise barrier height following the process described in Section 8 of the NMG without considering urban design, visual impacts and/or engineering constraints
2. Alternative noise barrier height determined based on urban design, visual impacts and/or engineering constraints
3. Height of barrier based on the height above the local ground where the proposed barrier is to be located
4. Receiver counts based on receiver points, where a receiver point is representative of each habitable floor level of a residence. For example, a double storey residence would be represented by two receiver points.

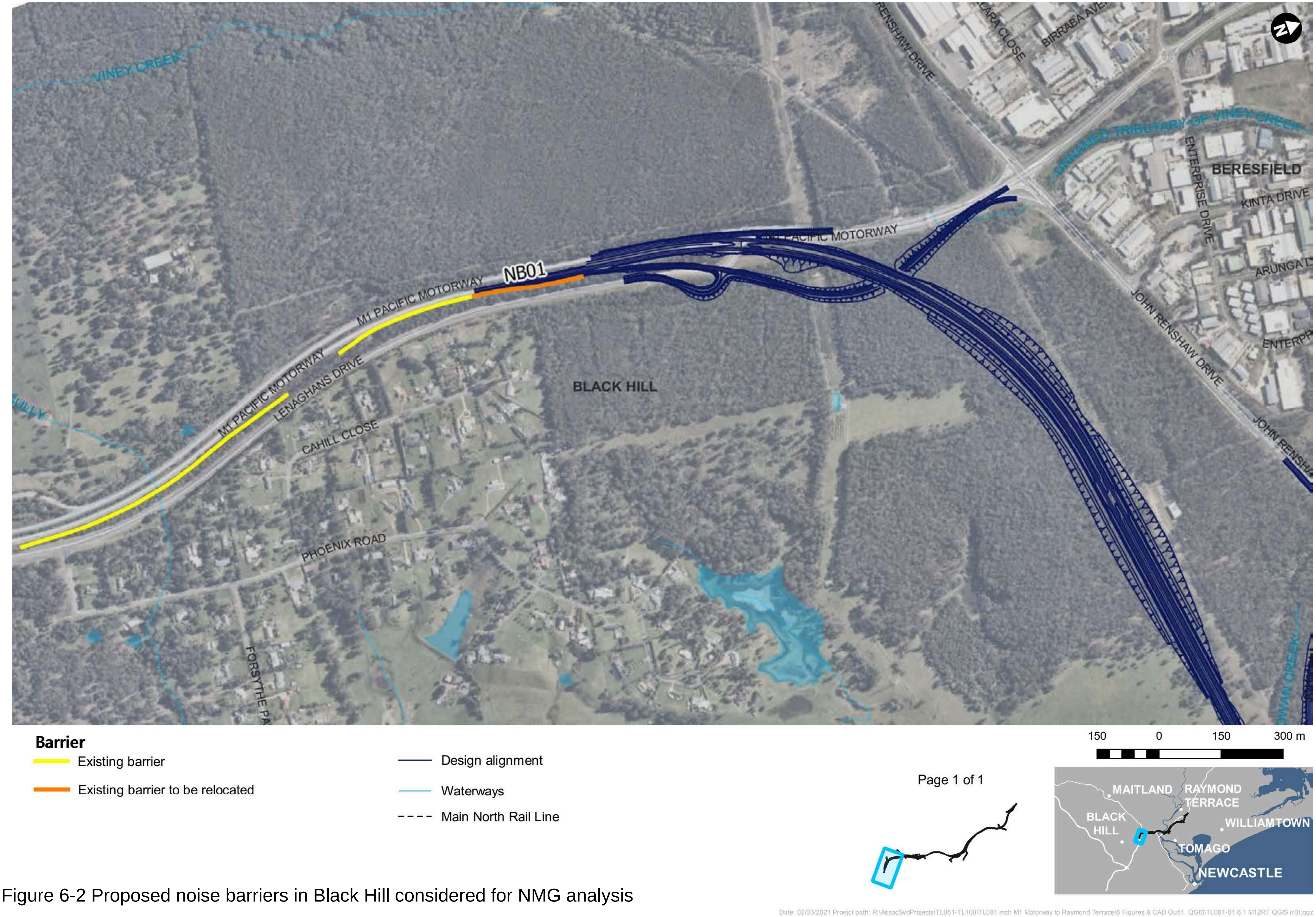
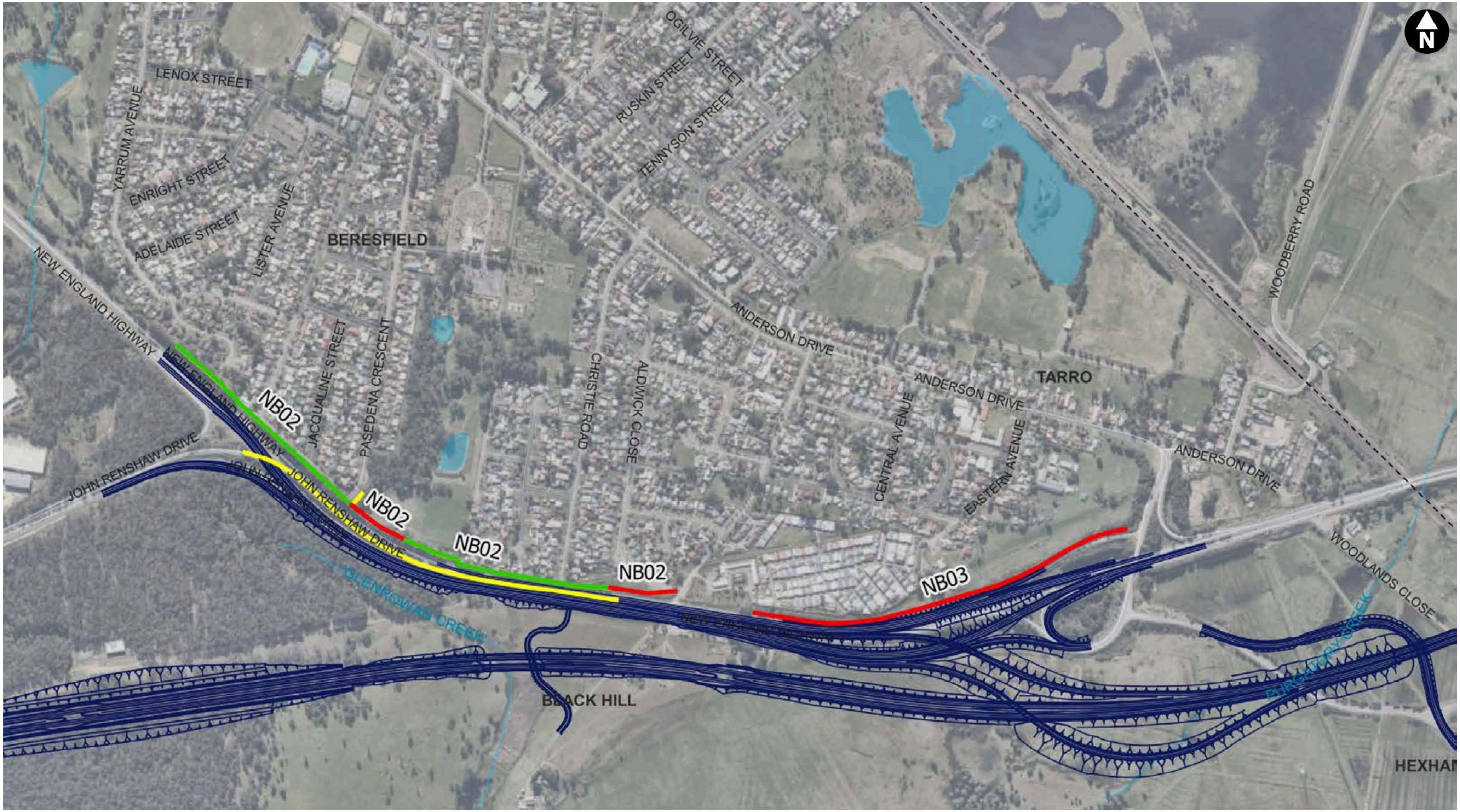


Figure 6-2 Proposed noise barriers in Black Hill considered for NMG analysis



Barrier

- Existing barrier
- Existing barrier to be retained / repaired as needed
- New barrier
- Design alignment
- Waterways
- Main North Rail Line

150 0 150 300 m

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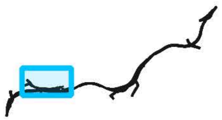

Figure 6-3 Proposed noise barriers in Tarro considered for NMG analysis

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6.3.3 Receiver buildings considered for at-property noise treatment

Following the NMG noise barrier analysis, any residual residential and non-residential sensitive receivers triggered for additional noise mitigation and still exceeding the relevant NCG traffic noise criteria would be considered for at-property treatment. A summary of the number of receiver buildings identified as being eligible for consideration of at-property treatment based on the design barrier and alternative barrier heights is presented in **Table 6-6**.

Receiver buildings identified as potentially eligible for at-property treatment are presented in **Appendix D**.

Table 6-6 Number of receiver buildings potentially eligible for at-property noise mitigation treatment

NCA	Design barrier height		'Alternative' barrier height	
	Number of residential receiver buildings[1, 2]	Number of non-residential receiver buildings[1. 2]	Number of residential receiver buildings[1, 3, 4]	Number of non-residential receiver buildings[1, 3, 4]
NCA01A	4	0	4	0
NCA01B	0	0	0	0
NCA02	0	1	0	1
NCA04A	44	18	85	18
NCA04B	0	2	0	2
NCA05A	1	0	1	0
NCA05B	0	0	0	0
NCA07	1	0	1	0
NCA09	1	0	1	0
NCA12	6	0	6	0
NCA13	2	0	2	0
NCA14A	38	0	38	0
NCA14B	1	0	1	0
NCA14C	0	0	0	0
TOTAL	**98**	**21**	**139**	**21**

Notes:

1. A receiver building represents the individual building outlines as shown in **Appendix D**
2. Based on the implementation of quieter pavements and the design barrier heights nominated in **Table 6-5**
3. Based on the implementation of quieter pavements and the alternative barrier heights nominated in **Table 6-5**
4. Only receiver buildings in NCA04A, NCA04B and NCA05A are protected by the 'alternative' barrier.

As expected, the lower alternative barrier heights would result in more receiver buildings requiring at-property treatment for the NCAs in comparison to if noise barriers were built to design barrier heights nominated in **Table 6-5**.

The number of receivers considered for at-property treatment would be confirmed during the design development stage. During further design development, site inspections of these receivers would be carried out to confirm:

- Internal layout and location of habitable areas and/or noise sensitive spaces
- Construction type of the building structure
- Locations and sizes of windows and doors.

Given that the predicted traffic noise levels are external levels, the above information would assist in determining a conversion from external to internal levels, which would help determine the appropriate at-property treatment required. Additional investigations to consider at-property noise treatments are presented in **Chapter 8**.

Other sensitive receivers

From **Table 6-6** the non-residential receiver buildings identified as being eligible for consideration of at-property treatment are associated with the following other sensitive receivers:

- NCA02 – Saint Mary & Saint George Coptic Orthodox Church (place of worship)
- NCA04A – Our Lady of Lourdes Primary School (educational)
- NCA04A – Our Lady of Lourdes Church (place of worship)
- NCA04A – Tarro Public School (educational)
- NCA04B – Newcastle Memorial Park (place of worship)
- NCA04B – Tarro Uniting Church of Australia (place of worship).

It is noted that the introduction of quieter pavements and noise barriers do not provide sufficient benefits to the above other sensitive receivers and associate receiver buildings to allow traffic noise impacts to comply with the corresponding NCG project road criterion. This is due to these receivers being located at distances greater than 100 metres from the traffic noise source, resulting in marginal noise mitigation benefits.

Furthermore, given that other sensitive receivers are assessed against internal noise criteria, further investigation during further design development would be required for non-residential receiver buildings considered for at-property treatment to confirm the extent of noise impact and eligibility for consideration of noise mitigation. This is because the difference in noise from outside to inside can increase to more than 30 dB(A) depending on the building construction type, location of the room within the building, window type and whether the use of the space requires the window to be fully opened, slightly opened or closed. Additional investigations to consider at-property noise treatments are presented in **Chapter 8**.

6.3.4 Final noise mitigation treatment

Final noise mitigation treatment would be carried out in accordance with Transport guidelines and may include quieter pavements, noise barriers or at-property treatments. Noise barriers, in the form of noise walls, screens or mounds, would be installed as part of the suite of noise mitigation treatments where required to address operational noise impacts.

Based on feasibility constraints including integration with existing noise barriers, as well as interactions with existing utilities, established landscaping and vegetation, heritage, landscape character, visual amenity and constructability, the project would consider the assessed alternative height for barriers NB.02 (about 3.8 metres) and NB.03 (about 4 metres).

6.4 Maximum noise level assessment

The maximum noise level results and assessment are presented in **Appendix D** and a summary is presented in **Table 6-7**. The results are based on the noise monitoring carried out at the locations listed in **Table 3-2**, where road traffic noise dominated the noise environment and was not shielded by other buildings (i.e. first row of houses).

Table 6-7 Summary of measured maximum noise level events

Monitoring location[1]	Monitoring period	Total L_{Amax} events during monitoring period	Measured maximum noise level (L_{Amax}), dB(A)	
			Range	Average
L13 – 11 Cahill Close, Black Hill	15/03/2016 - 23/03/2016	30	68-76	72
L15 – 70 New England Highway, Tarro	15/03/2016 - 23/03/2016	180	80-85	83
L16 – 44 Sapphire Drive, Beresfield	15/03/2016 - 23/03/2016	179	69-74	73
L18 – Proposed interchange at Tarro	15/03/2016 - 23/03/2016	298	78-83	82
L19 – 2207 Pacific Highway, Heatherbrae	15/03/2016 - 23/03/2016	30	68-76	72
L20 – Pacific Highway (north of Raymond Terrace interchange)	15/03/2016 - 23/03/2016	1769	83-87	86

Notes:

1. Only monitoring locations where road traffic noise dominated the noise environment are presented.

The results presented in **Table 6-7** show that maximum noise levels range from 68 dB(A) up to 87 dB(A) at the noise monitoring locations. The higher maximum noise levels were typically at locations near or adjacent to the M1 Pacific Motorway, New England Highway or the Pacific Highway.

Maximum noise levels are typically observed from a passing vehicle, with high maximum noise levels generally due to heavy vehicles passing the monitoring location.

Future changes in the maximum noise levels and the number of events would depend on changes in traffic volumes and compositions forecast for the project. Final road alignment design or width, leading to traffic moving closer to or further from the assessment location compared to existing conditions would result in the existing maximum noise levels and number of events to increase or decrease, accordingly.

The project is predicted to potentially change maximum noise levels and events at the following noise catchment areas (see **Figure 4-1** for NCA locations):

- NCA01A – receivers to the east of the M1 Pacific Motorway may experience an increase in maximum noise levels and the number of events compared to the existing situation. This is due to the widening of the M1 Pacific Motorway and the introduction of the Black Hill interchange moving traffic closer to receivers in this NCA. Furthermore, the receivers in the northern section of this NCA may also experience increases in maximum noise levels and number of events due to the introduction of new carriageways to the north as part of the project
- NCAs 04A, 04B and 05A – receivers to the north of the New England Highway may experience a reduction in the number of maximum noise level events due to vehicles using the project's new carriageways, and the widening of the New England Highway toward the south. However, maximum

noise levels would likely remain the same as the northern side of the New England Highway would remain the same as the existing
- NCAs 14A and 14B – receivers to the west of the Pacific Highway and the project may experience a reduction in the number of maximum noise level events due to vehicles using the project's new carriageways located east of the Heatherbrae industrial precinct. However, maximum noise levels would likely remain the same as the existing Pacific Highway road corridor would remain the same.

For the noise catchment areas where maximum noise levels and the number of events would increase due to the project, the affected receivers would likely be considered for additional noise mitigation measures including noise barriers and/or at-property treatment. With the implementation of noise mitigation measures, overall traffic noise levels would reduce, including L_{Amax} noise levels.

7. Cumulative impacts

Cumulative noise and vibration impacts may arise from the interaction of construction and operation activities of the project, and other approved or proposed projects in the area. When considered in isolation, specific project impacts may be considered minor. These minor impacts may; however, be more substantial, when the impact of multiple projects on the same receivers is considered.

The projects detailed in **Table 7-1** are in varying stages of delivery and planning. This chapter provides an assessment of cumulative noise and vibration impacts based on the most current and publicly available information for these projects. In many instances this is a high-level qualitative assessment.

The contribution of the project to cumulative impacts on noise and vibration in the area is generally minor, given the distances to the impacted receivers and the type of receivers potentially impacted.

Table 7-1 Assessment of potential cumulative impacts for relevant identified projects

Project (approval status)	Relevance in consideration of cumulative impacts	Potential cumulative impacts
Black Hill Employment Lands (Northern Estates) (In planning)	• Located south of John Renshaw Drive and west of M1 Pacific Motorway. • Likely to be some overlap in construction program, meaning likelihood of concurrent (simultaneous) construction • Likely to be concurrent (simultaneous) operation.	The industrial development is located to the west of the residential receivers in NCA01A and across the M1 Pacific Motorway. Given that the distance of the industrial development is greater than the distance the project's construction footprint is to the affected receivers, construction noise from the development would be substantially less than the construction noise from the project. Therefore, there would not be cumulative construction noise impacts to the nearest affected receivers in NCA01A. Additional traffic servicing the Black Hill development would typically travel along the M1 Pacific Motorway, John Renshaw Drive and/or the New England Highway. In terms of cumulative operational traffic noise impacts, additional traffic due to the Black Hill development has been considered in the traffic modelling for the design year 2038. Therefore, cumulative traffic noise impacts to affected receivers have been considered as part of this study.
Kinross Industrial Heatherbrae/ Weathertex (Approved)	• Located within the project's construction footprint (AS16) on Masonite Road, Heatherbrae. • Likely to be some overlap in construction program, meaning likelihood of concurrent (simultaneous) construction.	The industrial development is proposed on land identified for AS16. If the Kinross Industrial development is developed prior to or during construction, this ancillary facility would be unavailable to the project for use. However, construction noise from the project and the Kinross Industrial development may potentially result in cumulative construction noise impacts to commercial and industrial receivers immediately adjacent to the development site.

Project (approval status)	Relevance in consideration of cumulative impacts	Potential cumulative impacts
Black Hill Hunter Business Park, Cessnock (in planning)	• Located south of John Renshaw Drive and west of the M1 Pacific Motorway. • Unknown timeframe, but may be some overlap in construction program, meaning likelihood of concurrent (simultaneous) construction.	This development is currently in planning and is anticipated to be similar to the Northern Estates development. Due to the differing time frames involved, it is not expected there would be any cumulative impacts during construction. However, if construction were to occur at the same time as the construction of the project, the distance of the development is greater than the distance the project's construction footprint is to the affected receivers and, construction noise from the development would be substantially less than the construction noise from the project.
Newcastle Power Station (In planning)	• Located within the project's construction footprint at Tomago near Old Punt Road. • Potential to be consecutive (back to back) construction and concurrent (simultaneous) operation.	AGL propose to construct a 250 Mega Watt (MW) gas fired power station at Tomago, with gas pipelines and electricity transmission lines. Construction of the power station is due to commence in 2021 with the power station expected to be operational in 2022. The site for the proposed power station is located between the Pacific Highway and Old Punt Road, north of the Tomago industrial area (AGL, 2019). Given that construction of the power station would be completed by 2022 and the project would begin construction in 2023, there would be no cumulative construction noise impacts. In terms of cumulative vibration impacts during construction of the project, it is not expected that the operation of the power station would add to the vibration emissions from the construction works associated with the project. However, there may be a potential for construction vibration emissions from the project impacting sensitive areas of the power station. Therefore, construction vibration impacts to the power station should be reviewed during the detailed design stage of the project. For operational noise impacts, the power station would generate very low volumes of traffic and cumulative operational noise impacts would be negligible. Furthermore, once operational, noise from the power station may contribute to the overall noise environment for the surrounding area, potentially increasing the ambient noise and masking traffic noise from the project.
Hexham Straight (In planning)	• Located about one kilometre south of the project at Hexham • Potential to be consecutive (back to back) construction and concurrent (simultaneous) operation.	Given the location and distance of the Hexham Straight project, cumulative noise impacts to sensitive receivers from the construction and operation of the Hexham Straight project and the project would not occur.

Project (approval status)	Relevance in consideration of cumulative impacts	Potential cumulative impacts
Lower Hunter Freight Corridor (in planning)	Investigation area includes Hexham.	The Transport Lower Hunter Freight Corridor (LHFC) website (TfNSW, July 2018) indicates that in 2018 preliminary investigations were being carried out to assess options for a dedicated freight rail line between Fassifern and Hexham. No options were available on the website to review. An investigation areas figure between Fassifern and Hexham was available. As corridor options and environmental assessment are not available for the LHFC, the level of impact on land use and property generated by this project is currently unknown. Consequently, cumulative noise impacts associated with the construction or operation of the project is unknown.
Richmond Vale Rail Trail to Shortland, including Shortland to Tarro cycleway (In planning)	Intersects the project at Tarro	The construction methodology and equipment used to construct this project would be minimal compared to the project's construction. Therefore, there would not be any cumulative construction noise impacts.

8. Environmental management measures

The following management measures detailed in **Table 8-1** have been developed to specifically manage potential noise and vibration impacts which have been predicted during construction and operation of the project.

Table 8-1 Noise and vibration mitigation and management measures

Impact	Reference	Environmental management measure	Responsibility	Timing
General construction noise and vibration	NV01	A Construction Noise and Vibration Management Plan (CNVMP) would be prepared for the project to mitigate and manage noise and vibration impacts. The CNVMP would include: • All potential significant noise and vibration generating activities associated with the activity • Measures to be implemented during construction to minimise noise and vibration impacts, such as restrictions on working hours, respite periods, staging, placement and operation of ancillary facilities, temporary noise barriers, haul road maintenance, and controlling the location and use of vibration generating equipment • A monitoring program to assess performance against relevant noise and vibration criteria • Process for the implementation of respite periods to provide residents with respite from ongoing impact • Arrangements for consultation with affected receivers, including notification and complaint handling procedures • Contingency measures to be implemented in the event of noncompliance with noise and vibration criteria.	Contractor	Prior to construction/ construction
	NV02	Where reasonable and feasible, implementation of recommended operational noise mitigation would be carried out within 12 months of construction activities commencing.	Transport / Contractor	Prior to construction/ construction
Vibration impacts to residential and commercial structures	NV03	Where vibration generating activities will be carried out within minimum working distances for cosmetic damage, vibration monitoring will be carried out. Where monitoring indicates cosmetic damage criteria are exceeded, alternative low vibration work practices will be investigated and implemented.	Contractor	Construction
Vibration impacts to utilities	NV04	Where works are within 25m of utilities consultation will be carried out with the relevant utility authorities to establish site specific mitigation measures to manage potential vibration impacts.	Contractor	Construction

Impact	Reference	Environmental management measure	Responsibility	Timing
Vibration impacts to heritage structures	NV05	Heritage items within 100m of vibration intensive work are to be considered on a case by case basis and further investigation would be carried out during detailed design to confirm the structural integrity (i.e. structurally sound or unsound) of all potentially affected structures. Where items are considered sensitive to vibration, appropriate vibration criteria would be determined after detailed inspections have been completed.	Contractor	Prior to construction/ construction
Blasting	NV06	If blasting is to be included as part of the construction work, the CNVMP would include a Blast Management Plan (BMP). The BMP would be prepared in consultation with the EPA, demonstrating that all blasting and associated activities would be carried out in a manner that would not generate unacceptable noise and vibration impacts or pose a substantial risk impact to residences and sensitive receivers.	Contractor	Prior to construction/ construction
Operational road traffic noise impacts	NV07	Operational noise and vibration mitigation measures would be identified in an Operational Noise and Vibration Review (ONVR). Requirements for mitigation measures, including quieter noise pavements, noise barriers, and at-property treatments, would be reviewed as part of the ONVR and as the detailed design progresses. Detailed information on floorplans and facade construction for school classrooms, places of worship and childcare centres determined to exceed the applicable Noise Criteria Guideline (NCG) (Roads and Maritime Services, 2015) internal noise criteria will be obtained during design development. The implementation of treatments would be carried out in accordance with the Noise Mitigation Guideline (NMG) (Roads and Maritime Services, 2015).	Transport / Contractor	Detailed design/ construction/ prior to operation
Operational road traffic noise impacts	NV08	Within 12 months of starting project operation, actual operational noise performance would be compared to predicted operational noise performance to analyse the effectiveness of the operational road traffic noise mitigation measures. Additional reasonable and feasible mitigation would be considered where any additional receivers are identified as qualifying for consideration of noise mitigation under the NMG.	Transport / Contractor	Operation

Impact	Reference	Environmental management measure	Responsibility	Timing
Impacts from Out of Hours Works	NV09	An Out of Hours Work Procedure will be included as part of the CNVMP. The procedure will follow the approach in Roads and Maritime Services' Construction Noise and Vibration Guideline (Roads and Maritime Services 2016b) and include, but not be limited to: • Scheduling of noise intensive or high noise impact work to evening periods where feasible • Use of alternative plant and equipment and/or construction techniques to minimise noise • Notification and consultation requirements including preparation of a 'look ahead' program for likely out of hours work • Use of temporary noise barriers • Respite periods • Representative noise monitoring • Offers of reasonable and temporary alternative accommodation or an act of good will • Use of negotiated agreements.	Contractor	Construction

9. Conclusion

Construction noise and vibration

The construction noise and vibration assessment identified the following key findings:

- Construction noise impacts are the highest when ‘peak impact’ activities are occurring, which is when all plant and equipment are operating concurrently. ‘peak impact’ activities would typically only occur for relatively short periods, compared to ‘typical impact’ activities, which would occur more often with lower noise impacts and affecting fewer receivers
- Up to 24 residential receivers located within NCA04A and directly adjacent to the construction footprint have been identified as being highly noise affected (i.e. greater than 75 dB(A)) during the construction of the project.

Standard hours of construction

- During standard construction hours, the highest impacts are generally predicted at residential receivers located in NCA04A and NCA08, which are directly north and east of the construction footprint. Receivers in NCA04A are within suburban areas and are therefore densely distributed, resulting in relatively large number of receivers being impacted by construction noise in this NCA
- While impacts across the project as a whole are relatively low during standard construction hours, ‘highly intrusive’ impacts are likely at the nearest receivers to the project when noise intensive equipment such as rock hammers or concrete saws are in use. Noise intensive equipment would however generally only be required for relatively short periods and noise levels and impacts during typical impact activities generally result in either ‘noticeable’, ‘clearly audible’ or ‘moderately intrusive’ noise impacts.

Extended hours of construction

- During the extended construction hours, the highest impacts at residential receivers are generally in NCA04A, NCA04B and NCA08, which have receivers directly adjacent to the New England Highway. Receivers in NCA04A and NCA04B are within suburban areas and are therefore densely distributed, resulting in relatively large number of receivers being impacted by construction noise
- During the morning shoulder, daytime out-of-hours and evening shoulder periods, ‘highly intrusive’ noise impacts are predicted in NCA04A during some ‘peak impact’ and ‘typical impact’ activities
- Noise impacts during the extended construction hours would generally be ‘noticeable’ at most NCAs, with a few NCAs predicted to experience ‘clearly audible’ or ‘moderately intrusive’ noise impacts for some construction scenarios and activities.

Out-of-hours construction

- During out-of-hours construction work in the evening and night time periods, the highest impacts at residential receivers are generally in NCA04A and NCA04B. Receivers in NCA04A and NCA04B are within suburban areas and are therefore densely distributed, resulting in relatively large number of receivers being impacted by construction noise
- ‘Highly intrusive’ noise impacts are predicted for residential receivers closest to the construction footprint in NCA04A for some construction scenarios and activities during the evening and night time periods
- Noise impacts during the out-of-hours construction work would generally be ‘noticeable’ at most NCAs, with a few NCAs predicted to experience ‘clearly audible’ or ‘moderately intrusive’ noise impacts for some construction scenarios and activities.

Other sensitive receivers

- The construction noise impacts at other sensitive receivers are generally predicted to be comply with the NMLs, with ‘clearly audible’ noise impacts at some school receiver buildings of Tarro Public School, Pasadena Crescent Reserve Soccer Fields and the Hunter Region Botanic Gardens. 'Moderately intrusive' noise impacts are predicted at the Hunter Region Botanic Gardens during some construction scenarios, while only during concrete pavement works the same receiver is predicted to experience 'highly intrusive' noise impacts.

Commercial and industrial receivers

- Commercial and industrial receivers in NCA04A are predicted to experience 'clearly audible' construction noise impacts during different construction scenarios and activities, while commercial and industrial receivers in NCA10, NCA12 and NCA14A are predicted to experience 'clearly audible' and 'moderately intrusive' construction noise impacts
- Construction noise impacts are predicted to be 'highly intrusive' at commercial and industrial receivers in NCA10 and NCA12 during some construction scenarios and activities. Commercial and industrial receivers in other NCAs are located at sufficient distances from the construction footprint resulting in compliance with the NMLs.

Construction road traffic

- Traffic associated with the construction of the project is not expected to increase existing traffic noise levels by more than 2 dB(A) along most of the proposed traffic routes. Increases of up to 5.9 dB(A) in traffic noise levels are predicted along Masonite Road in Heatherbrae, however, only commercial and industrial premises are located along the construction traffic route and therefore no sensitive receivers are impacted.

Construction vibration

- The distance between the construction work and the nearest sensitive receivers is generally sufficient for most buildings to be unlikely to suffer cosmetic damage from construction vibration. Residential buildings in NCA04A closest to the construction work and within the recommended minimum working distances may potentially be at risk of cosmetic damage or human disturbance
- Heritage items located within the construction study area are typically outside of the recommended minimum working distances and are unlikely to be impacted from construction vibration. One heritage item (Hannel Family Vault) was identified as being within the minimum working distances for vibratory pile drivers and large vibratory rollers and hydraulic hammers however, it is not expected that these plant items would be used at the ancillary facility that is adjacent to this heritage item. Therefore, vibration impacts are unlikely
- Construction blasting activities may impact receivers within NCA01A, NCA01B, NCA02, NCA04A and NCA07 if blasting were to occur. The limiting factor for the maximum MIC quantity that could be used for blasting is based on the assessment of the CTGM buried pipework in NCA02. However, the need for blasting and the charge and blast configuration design would be investigated and determined during the pre-construction and detailed design stage of the project.

Operational road traffic noise

The operational road traffic noise assessment identified the following key findings:

- Traffic noise levels are predicted to impact the highest number of receivers in NCA04A given that receivers in NCA04A are closest to the New England Highway and the project. A high number of receivers in NCA14A are also predicted to be impacted by traffic noise due to their proximity to the existing Pacific Highway
- The project is predicted to increase traffic noise levels by no more than 2 dB(A) at the majority of receivers within the operational study area, which is considered to be a minor impact and is barely perceivable in accordance with the RNP
- 189 receiver buildings (out of a total of 1671 receiver buildings assessed) were identified as being eligible for consideration for additional noise mitigation in accordance with the NMG requirements

- Of the 189 receiver buildings identified as being eligible for additional noise mitigation, 21 receiver buildings are associated with other sensitive (non-residential) receivers. These receivers are the Saint Mary & Saint George Coptic Orthodox Church, Our Lady of Lourdes Primary School, Our Lady of Lourdes Church, Tarro Public School, Newcastle Memorial Park and the Tarro Uniting Church of Australia
- The use of quieter pavements, namely open graded asphalt along the New England Highway and low noise diamond grinding of concrete pavements along sections of the main carriageway of the project, was considered and implemented as the first noise mitigation measure applied to the project
- Following the consideration of quieter pavements, noise barrier options were considered. Two reasonable and feasible barriers were determined along the New England Highway in Tarro to protect the impacted receivers located within NCA04A. Based on the noise barrier assessment and feasibility constraints, the project would adopt the proposed barrier heights of about 3.8 metres for NB.02 (consistent with the existing barrier height) and 4 metres for NB.03
- By implementing the quieter pavements and the proposed barrier heights of 3.8 metres and 4 metres, 139 residential and 21 non-residential receiver buildings would be eligible for at-property treatment.

The final reasonable and feasible noise mitigation options (quieter pavements, noise barriers, at-property treatments, or a combination of these) will be determined in accordance with Transport guidelines during detailed design taking into account whole-of-life engineering considerations and the overall social, economic and environmental benefits. The preference will be given to noise mitigation measures that reduce outdoor noise levels and the number of at-property treatments.

10. References

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Terms and acronyms

Term / Acronym	Description
Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30 per cent of the time in any assessment period in any season and/or temperature inversions occurring more than 30 per cent of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated.
A-weighted	See dB(A) below
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L_{A90} noise level (refer below).
CNVMP	Construction noise and vibration management plan
CNVIS	Construction noise and vibration impact statement
CNVG	Construction Noise and Vibration Guideline (Roads and Maritime Services, 2016)
CTGM	Hunter Water Chichester Trunk Gravity Main
Decibel (dB)	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 110dB Operating a chainsaw or jackhammer 120dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the “A” filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
ECRTN	Environmental Criteria for Road Traffic Noise (EPA, 1999)
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the

Term / Acronym	Description
	sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
HNA	Highly noise affected
ICNG	Interim Construction Noise Guideline (DECC, 2009)
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
km/h	Kilometres per hour
L_{Amax}	The maximum A-weighted sound pressure level measured over a given period.
L_{AMin}	The minimum A-weighted sound pressure level measured over a given period.
L_{A1}	The A-weighted sound pressure level that is exceeded for 1 per cent of the time for which the given sound is measured.
L_{A10}	The A-weighted sound pressure level that is exceeded for 10 per cent of the time for which the given sound is measured.
L_{A90}	The level of noise exceeded for 90 per cent of the time. The bottom 10 per cent of the sample is the L_{A90} noise level expressed in units of dB(A).
L_{Aeq}	The A-weighted “equivalent noise level” is the summation of noise events and integrated over a selected period of time.
MIC	Maximum instantaneous charge
m/s	Metres per second
mm/s	Millimetres per second
NCA	Noise Catchment Area. Noise Catchment Areas are logical groupings of noise and vibration sensitive receivers for the project based on areas with a similar acoustic environment.
NCG	Noise Criteria Guideline (RMS, 2015)
NMG	Noise Mitigation Guideline (RMS, 2015)
NML	Noise management level
NPfI	Noise Policy for Industry (EPA, 2017)
OOHW or OOH	Out-of-hours work, which is construction work which take place outside of the standard construction hours specified by the NSW Environment Protection Authority (EPA) Interim Construction Noise Policy (ICNG) (2009).
RBL	Rating background level
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
ROL	Road Occupancy Licence
RMS	Roads and Maritime Services
RNP	Road Noise Policy (DECCW, 2011)
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L_{Aeq} sound levels over any period of time and can be used for predicting noise at various locations.

Term / Acronym	Description
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level (SPL or L_p)	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone. Reference for sound pressure level is conventionally chosen as 20 μPa (20 x 10^{-6} Pa) for airborne sound.
Sound power level (SWL or L_w)	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power. Reference for sound power level is conventionally chosen as 1pW (10^{-12} watts) for airborne sound.
TfNSW	Transport for NSW
Transport	Transport for NSW
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

Appendix A Acoustic concepts

A.1 Sound and noise

The terms ‘sound’ and ‘noise’ are almost interchangeable, except that in common usage ‘noise’ is often used to refer to unwanted sound. Sound is a vibration that travels as an audible wave of pressure through the air from a source to a receiver location such as the human ear. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) is a unit of measurement used to express the ratio of a quantity to another on a logarithmic scale to make the wide range of sound pressure more manageable.

Sound power is the rate at which a source emits acoustic energy and is unaffected by the environment. It is a property of the source that is emitting acoustic energy.

In contrast, **sound pressure** is the effect, and it is affected by factors associated with the built and natural environment such as distance, direction, obstacles etc. The sound pressure is the acoustic energy or ‘noise level’ at a distance away from the noise source. The relationship between sound power and sound pressure can be explained by considering the analogy of an electric heater, which radiates heat into a room and temperature is the effect. Like sound pressure, temperature also reduces with distance from the source following the inverse square law.

In this technical working paper, **sound power level** is identified by the symbols **SWL** or $\mathbf{L_w}$, while **sound pressure level** is represented by **SPL** or $\mathbf{L_p}$, and both have the same scientific unit in dB.

A.2 Individual's perception of sound

The loudness of sound depends on its sound pressure level. The A-weighted decibel (dB(A)) is generally used for the purposes of environmental noise impact assessment as it has been adjusted to account for the varying sensitivity of the human ear to different frequencies of sound. People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dB(A) is a good measure of the loudness of environmental noise to the human ear as it considers this frequency dependant sensitivity.

Different noise sources having the same dB(A) level generally sound equally loud. However, the frequency of a sound is what gives it a distinctive pitch or tone – for example, the rumble of distant thunder is an example of a low frequency sound and a whistle is an example of a high frequency sound. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 to 90 dB(A). **Table A-1** provide some points of reference, measured in dB(A), of familiar sounds and those from construction activities.

Table A-1 Perception of sound - familiar sounds and construction noise

Common sounds	Construction noise	Sound pressure
Leaf blower at operator's ear	Concrete saw or jack hammer 7 metres away	90 dB(A)
Airplane cabin during cruise (Airbus 321)	Excavator (with bucket) 7 metres away	80 dB(A)
General traffic noise kerbside next to Military Road	Towable compressor 7 metres away	75 dB(A)
Normal conversation at 1 metre		60 dB(A)
Outdoor air conditioning unit 1 metre away	Towable compressor 50 metres away	55 dB(A)
General office		50 dB(A)

In terms of sound perception, a change of 1 dB(A) or 2 dB(A) in the sound pressure level is difficult for most people to detect, while a 3 dB(A) to 5 dB(A) change corresponds to a small but noticeable change in loudness. An increase in sound level of 10 dB(A) is perceived as a doubling of loudness. However, individuals may perceive the same sound differently since many factors can influence an individual's response, including:

- The specific characteristics of the noise (e.g. frequency, intensity, duration of the noise event)
- Time of day noise events occur
- Individual sensitivities and lifestyle
- Reaction to an unfamiliar sound
- Understanding of whether the noise is avoidable and the notions of fairness.

A.3 Environmental noise assessment indicators

Environmental noise is an accumulation of noise pollution that occurs outside and is most commonly attributed to various modes of transport as well as industrial and construction activities. Environmental noise has been shown to have an adverse effect on the quality of life, especially following long-term exposure. The focus of the present technical assessment is on annoyance and sleep disturbance as they constitute most of the burden related to the impact of environmental noise on health outcomes. Noise annoyance is defined by the World Health Organization as a feeling of displeasure, nuisance, disturbance or irritation caused by a specific sound. Sleep disturbance relates to difficulty with sleep initiation, consolidation as well as awakening and reduced quality of sleep.

In New South Wales, contemporary environmental noise assessment criteria for addressing noise annoyance and sleep disturbance are specified by the Environment Protection Authority (EPA). Potential road traffic noise impact is assessed in accordance with the NSW Road Noise Policy. For enabling construction activities which are temporary in nature and highly variable, EPA's Interim Construction Noise Guideline provides the underlying assessment principles for the determination of potential construction noise impact. Each policy/guideline is discussed in detail in the body of this report:

- **Section 3.6.1** details the NSW Road Noise Policy
- **Section 3.5.1** details the EPA's Interim Construction Noise Guideline.

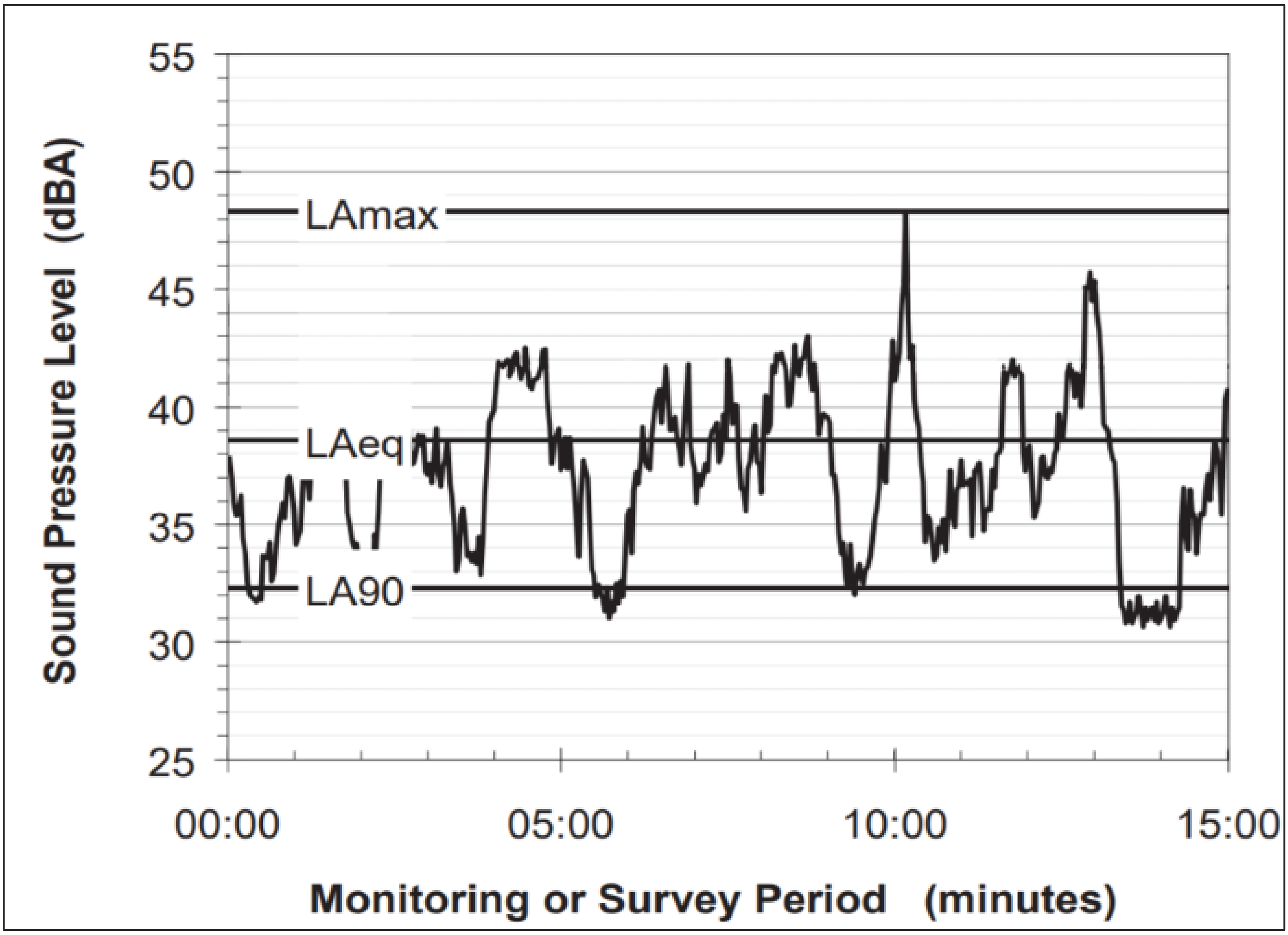
L_{Aeq} – To protect against long-term repeated noise exposure, the indicator for assessing the cumulative noise exposure level over a specific time interval is the equivalent sound pressure level, denoted as L_{Aeq}. The L_{Aeq} indicator accounts for the total energy content from all sources of sound under consideration. The fact that the L_{Aeq} is a cumulative measure means that louder activities have greater influence of the L_{Aeq} level than do quieter ones, and activities that last longer in time have greater L_{Aeq} than do shorter ones. An increase in the number of events also increases the L_{Aeq}. Further, people react to the duration of noise events, judging longer events to be more annoying than shorter ones, assuming equal maximum noise levels.

L_{Amax} – It is important to note that even though L_{Aeq} levels are numerically lower than maximum noise levels (denoted as L_{Amax}). None of the noise is ignored, just as all the rain that falls in the rain gauge in one hour counts toward the total. In the case of noisy but short-lived maximum noise events, which can sometime result in immediate short term awakening reaction, potential impact is assessed using the L_{Amax} indicator in which its emergence above the background noise environment is evaluated.

L_{A90} – The L_{A90} is the level of noise that is present almost constantly, or for 90 percent of the time and is commonly referred to as the background noise. Typical examples of what types of noise may contribute to the background noise levels are continuously flowing traffic or air conditioner noise.

These three noise indicators of L_{Amax}, L_{Aeq} and L_{A90} are presented in **Figure A-1**, for example, where the noise monitoring survey period shows the sound pressure level of a varying noise environment such as environmental noise.

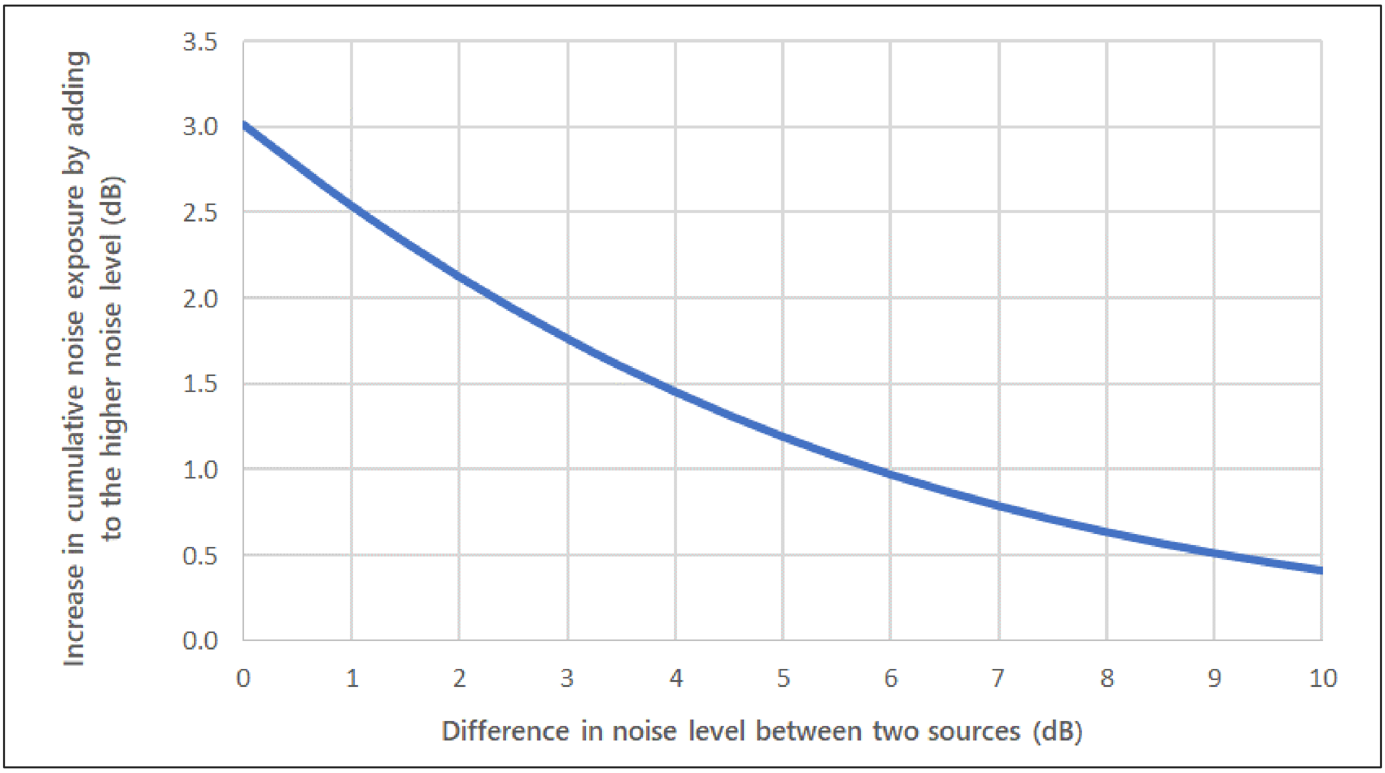
Figure A-1 Environmental noise assessment indicators



A.4 Cumulative sound exposure

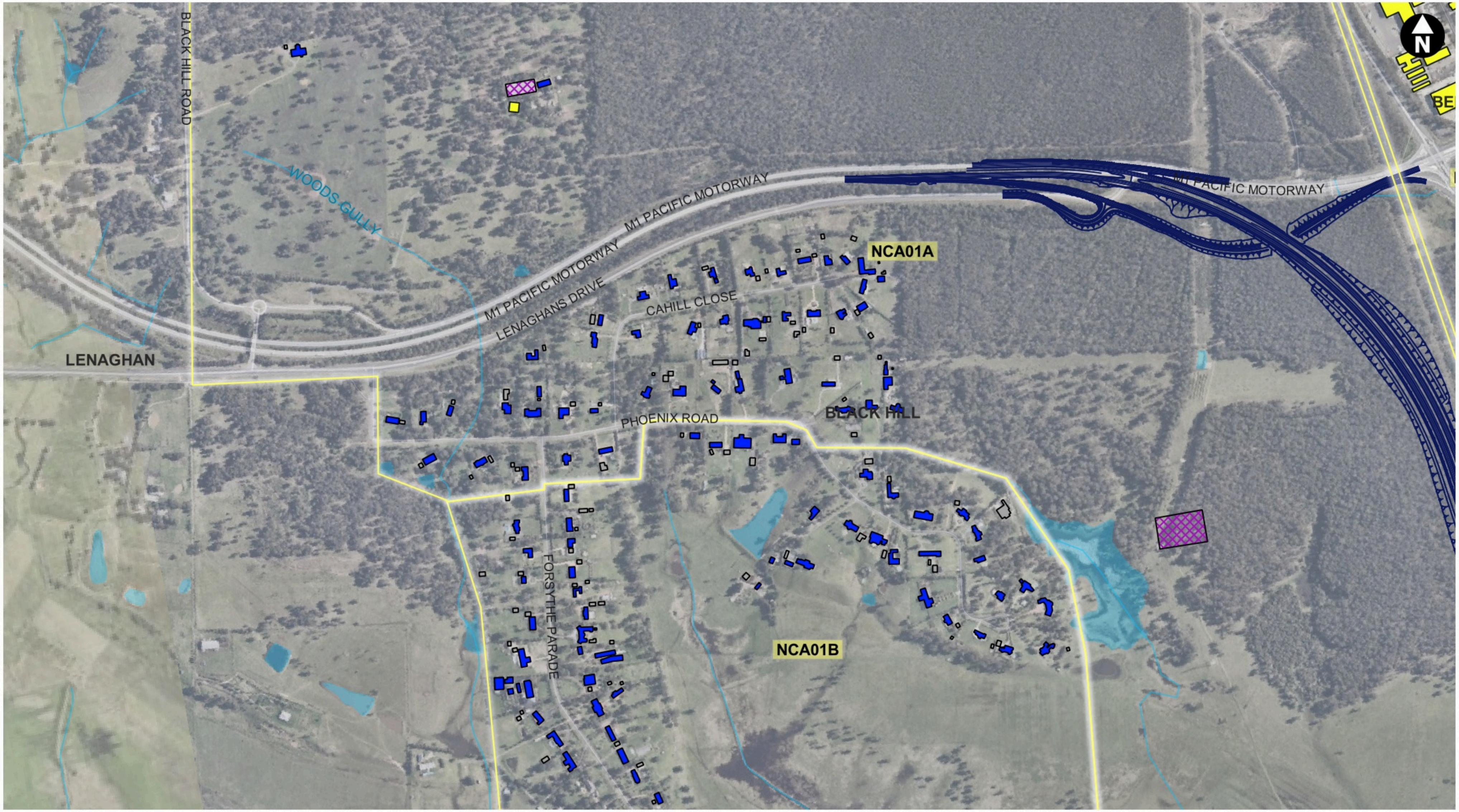
As illustrated in **Figure A-2**, for two activities that result in the same amount of acoustical energy or noise level at a receiver location, the cumulative sound exposure level would be 3 dB higher than the level of just one single activity. This is because the decibel (dB) scale is logarithmic. Conversely, if the activity closer to your home results in noise exposure level that is 10 dB higher than the activity occurring further away, the quieter work would contribute very little to the cumulative noise exposure level.

Figure A-2 Difference in noise level between two sources



Appendix B Existing environment

B.1 Site plan and sensitive receivers



Sensitive receiver

- Residential
- Commercial / industrial
- Childcare
- Educational
- Place of Worship
- Active recreation
- Passive recreation
- Non-receiver building
- NCA
- Design alignment
- Waterways
- Main North Rail Line

Page 1 of 7

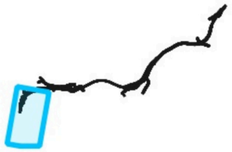


Figure TL081-01.6.2.1.1 Q31 (r5) Sensitive receivers surrounding project

Date: 05/03/2021 Proejct path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

Figure TL081-01.6.2.1.1 Q31 (r5) Sensitive receivers surrounding project

Date: 05/03/2021 Project path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

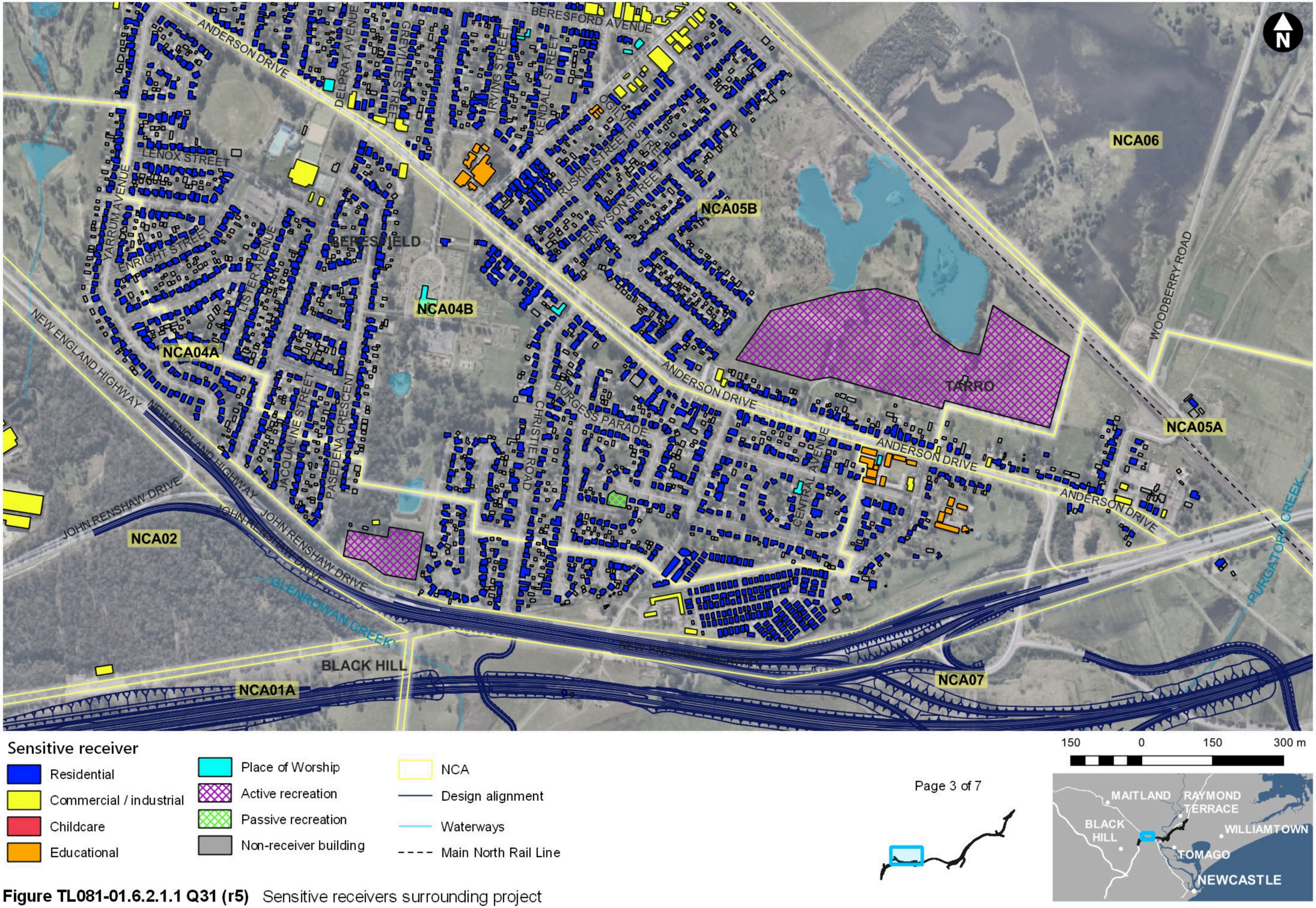


Figure TL081-01.6.2.1.1 Q31 (r5) Sensitive receivers surrounding project

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Sensitive receiver

- Residential
- Commercial / industrial
- Childcare
- Educational
- Place of Worship
- Active recreation
- Passive recreation
- Non-receiver building
- NCA
- Design alignment
- Waterways
- Main North Rail Line

150 0 150 300 m

Page 4 of 7

Figure TL081-01.6.2.1.1 Q31 (r5) Sensitive receivers surrounding project

Date: 05/03/2021 Project path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

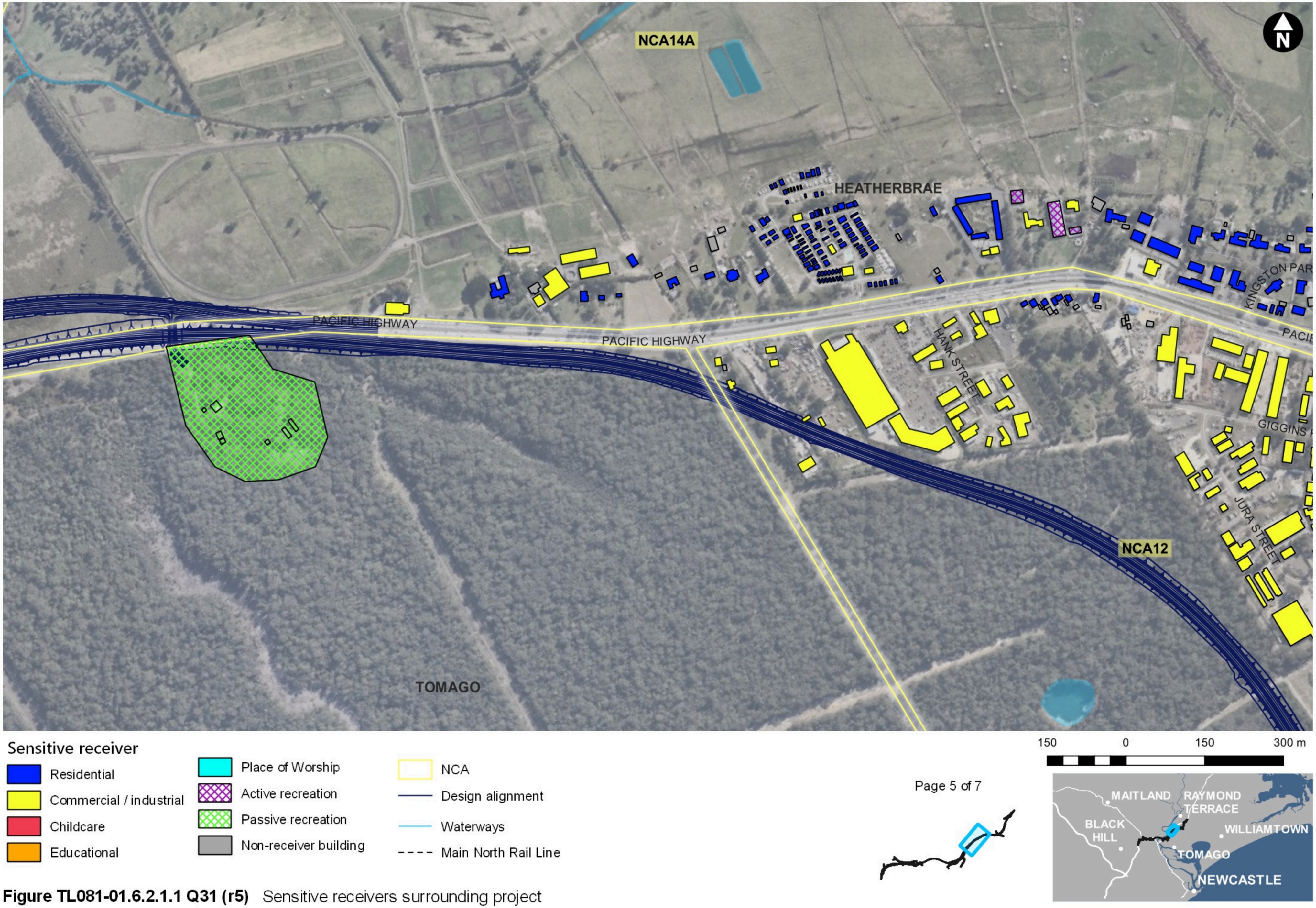

Figure TL081-01.6.2.1.1 Q31 (r5) Sensitive receivers surrounding project

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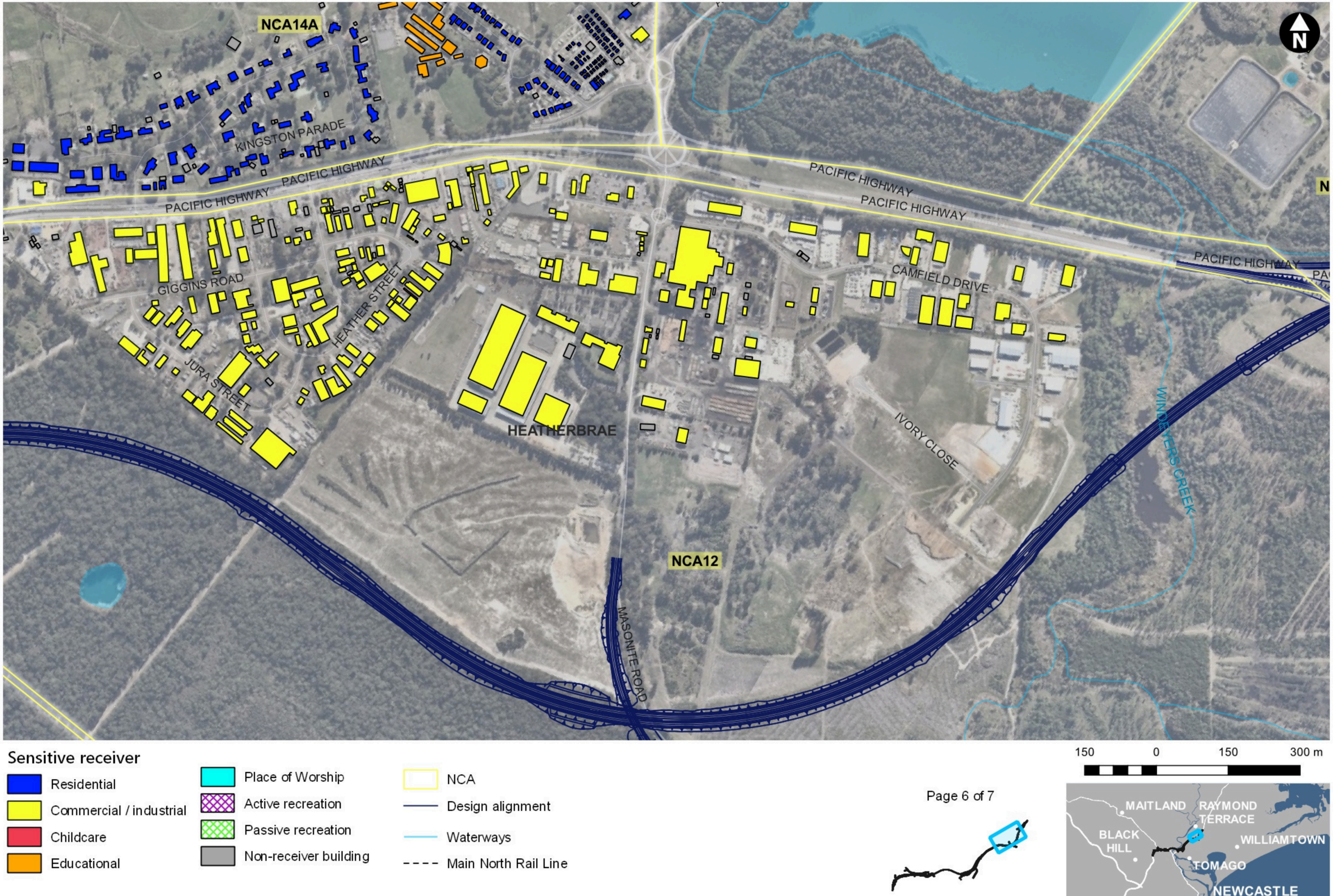

Figure TL081-01.6.2.1.1 Q31 (r5) Sensitive receivers surrounding project

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Sensitive receiver

- Residential
- Commercial / industrial
- Childcare
- Educational
- Place of Worship
- Active recreation
- Passive recreation
- Non-receiver building
- NCA
- Design alignment
- Waterways
- Main North Rail Line

150 0 150 300 m

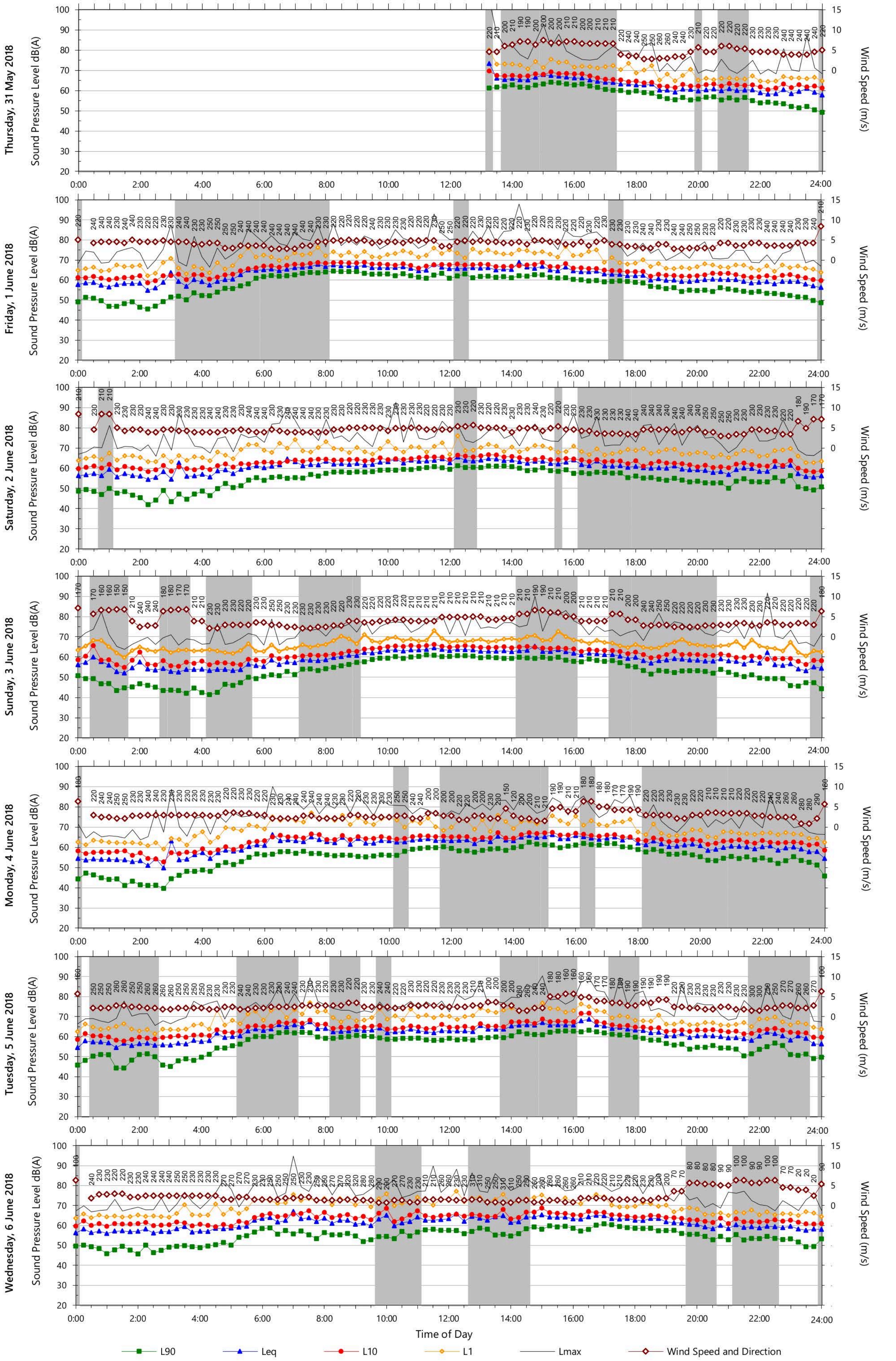
Page 7 of 7

Figure TL081-01.6.2.1.1 Q31 (r5) Sensitive receivers surrounding project

Date: 05/03/2021 Project path: R:\AssocSydProjects\TL051-TL100\TL081 mch M1 Motorway to Raymond Terrace\6 Figures & CAD Out\1. QGIS\TL081-01.6.1 M12RT QGIS (r0).qgz

B.2 Long term noise monitoring results

Unattended Monitoring Results **Location: L01 - 23 Cahill Close, Black Hill**



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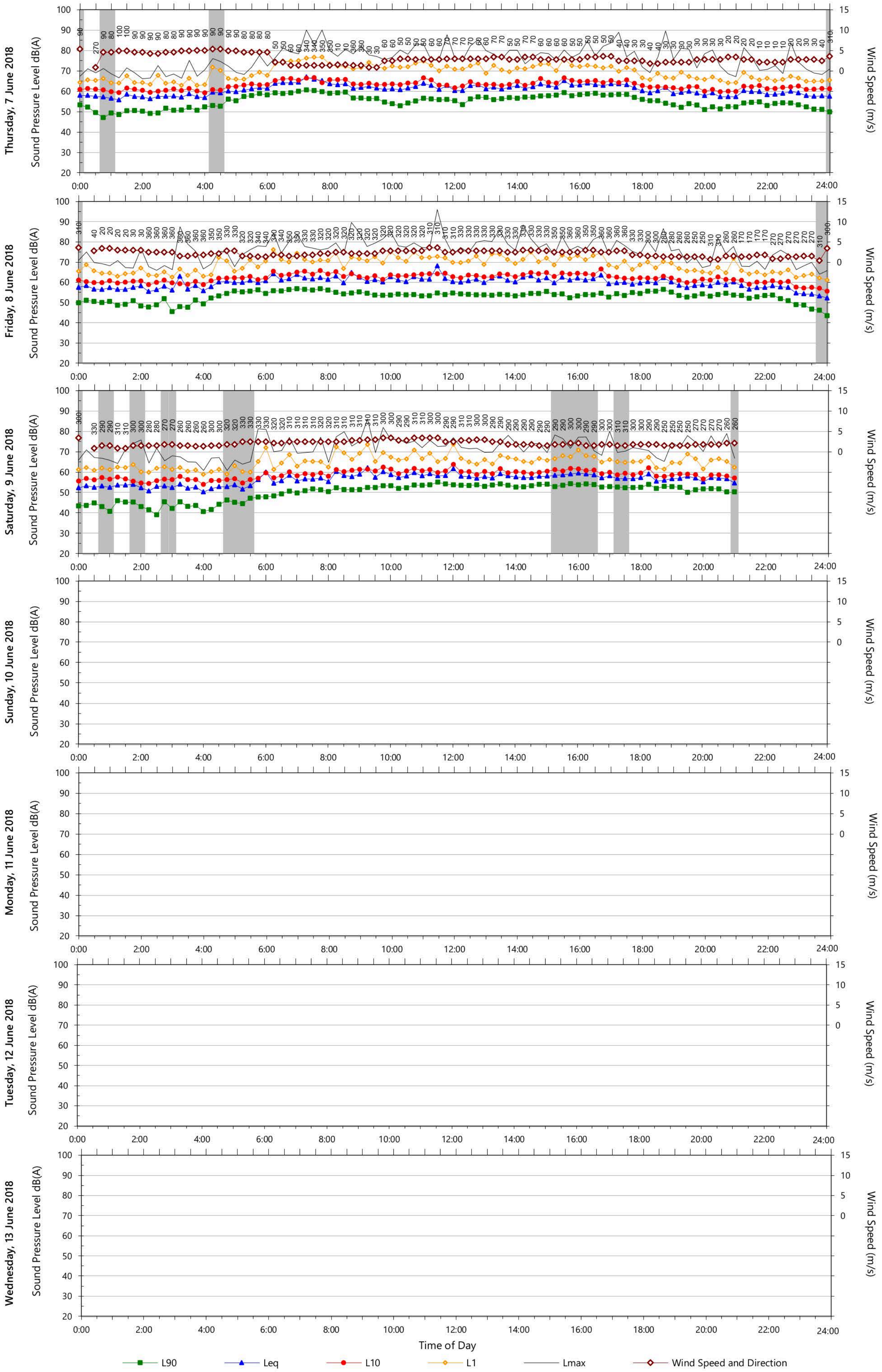

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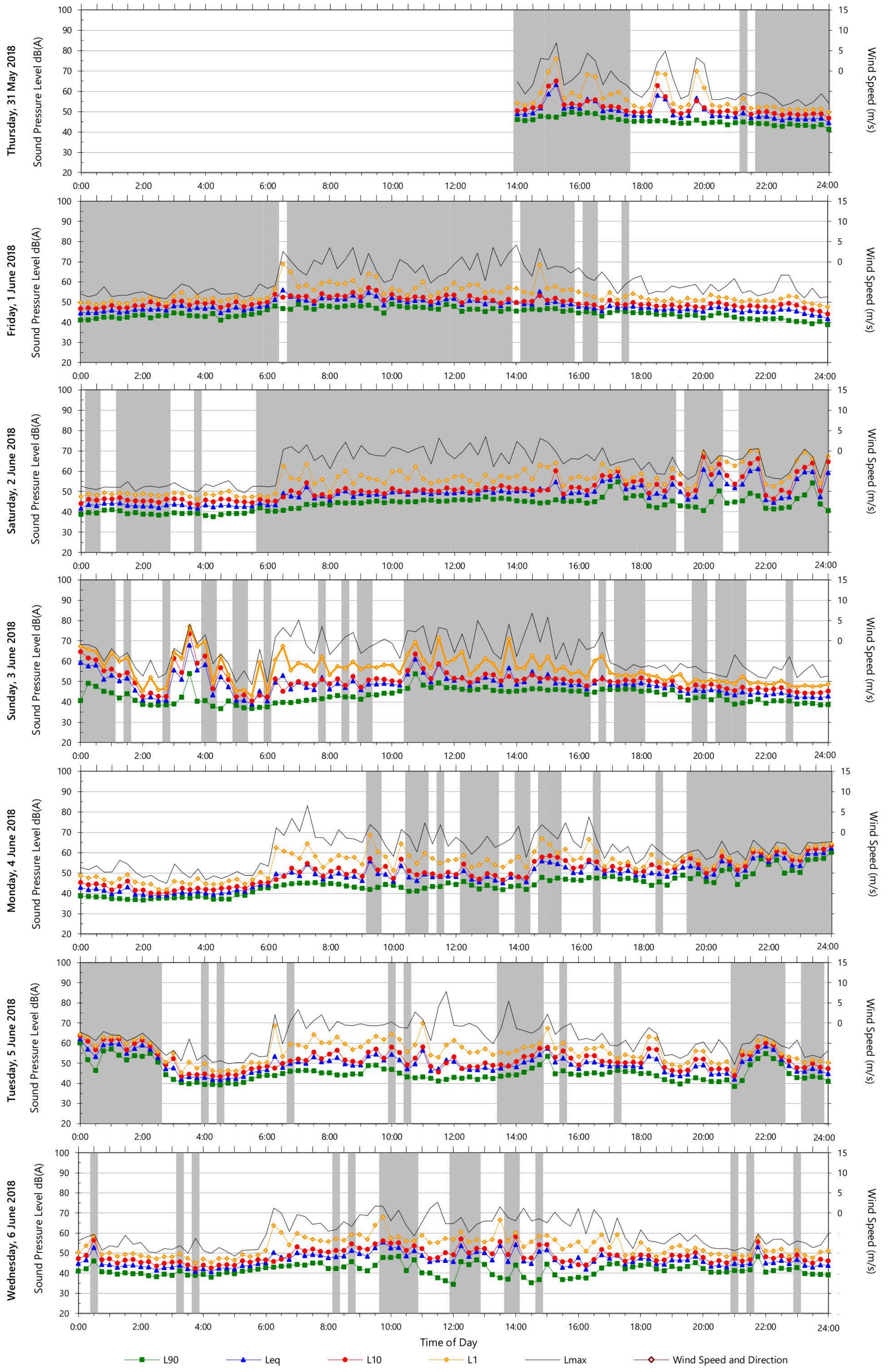
Unattended Monitoring Results **Location: L02 - 54 Weakleys Drive, Beresfield**



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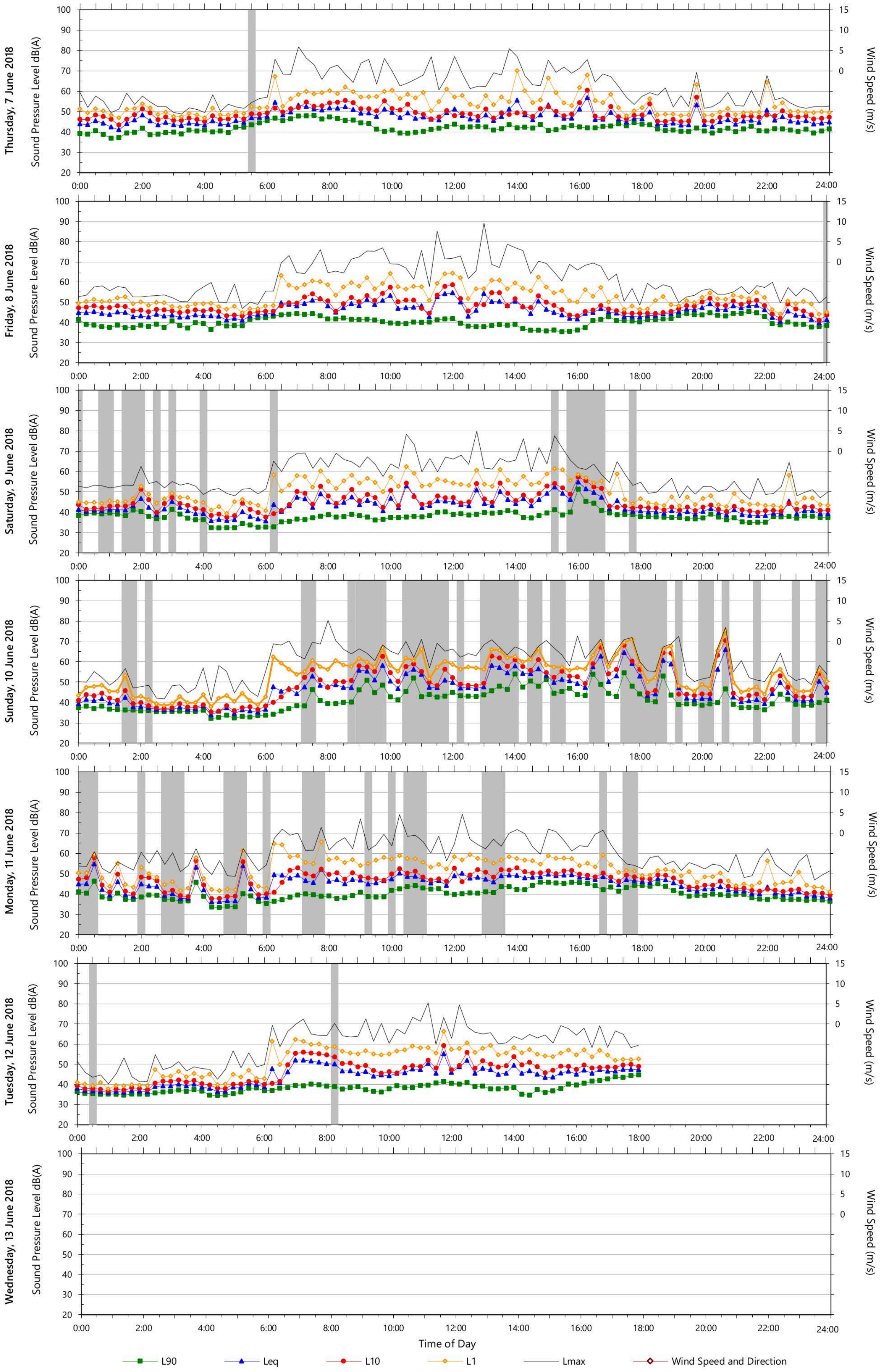
Unattended Monitoring Results **Location: L02 - 54 Weakleys Drive, Beresfield**



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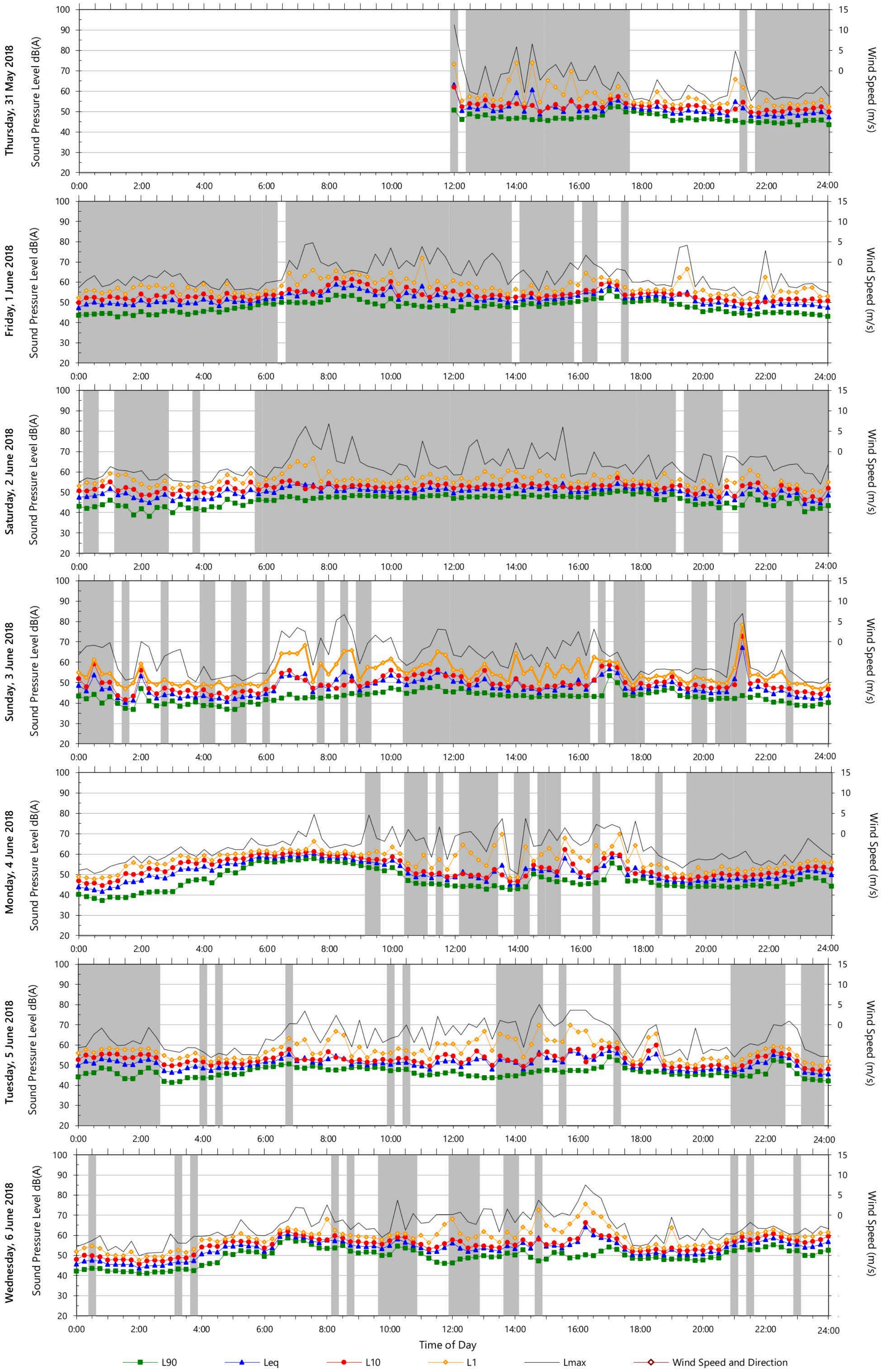
Unattended Monitoring Results **Location: L03 - 51 New England Highway, Tarro**



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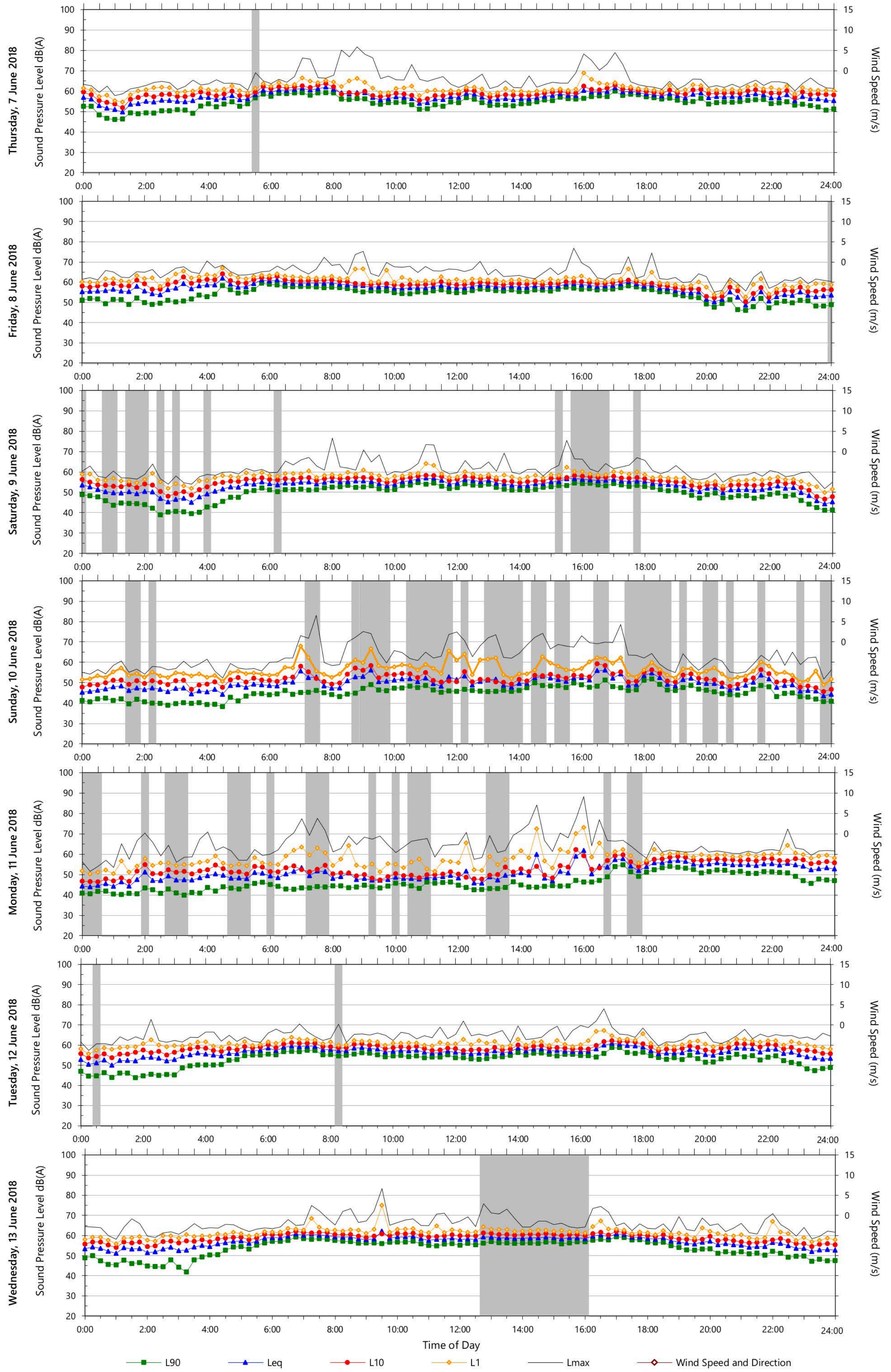
Unattended Monitoring Results

Location: L03 - 51 New England Highway, Tarro



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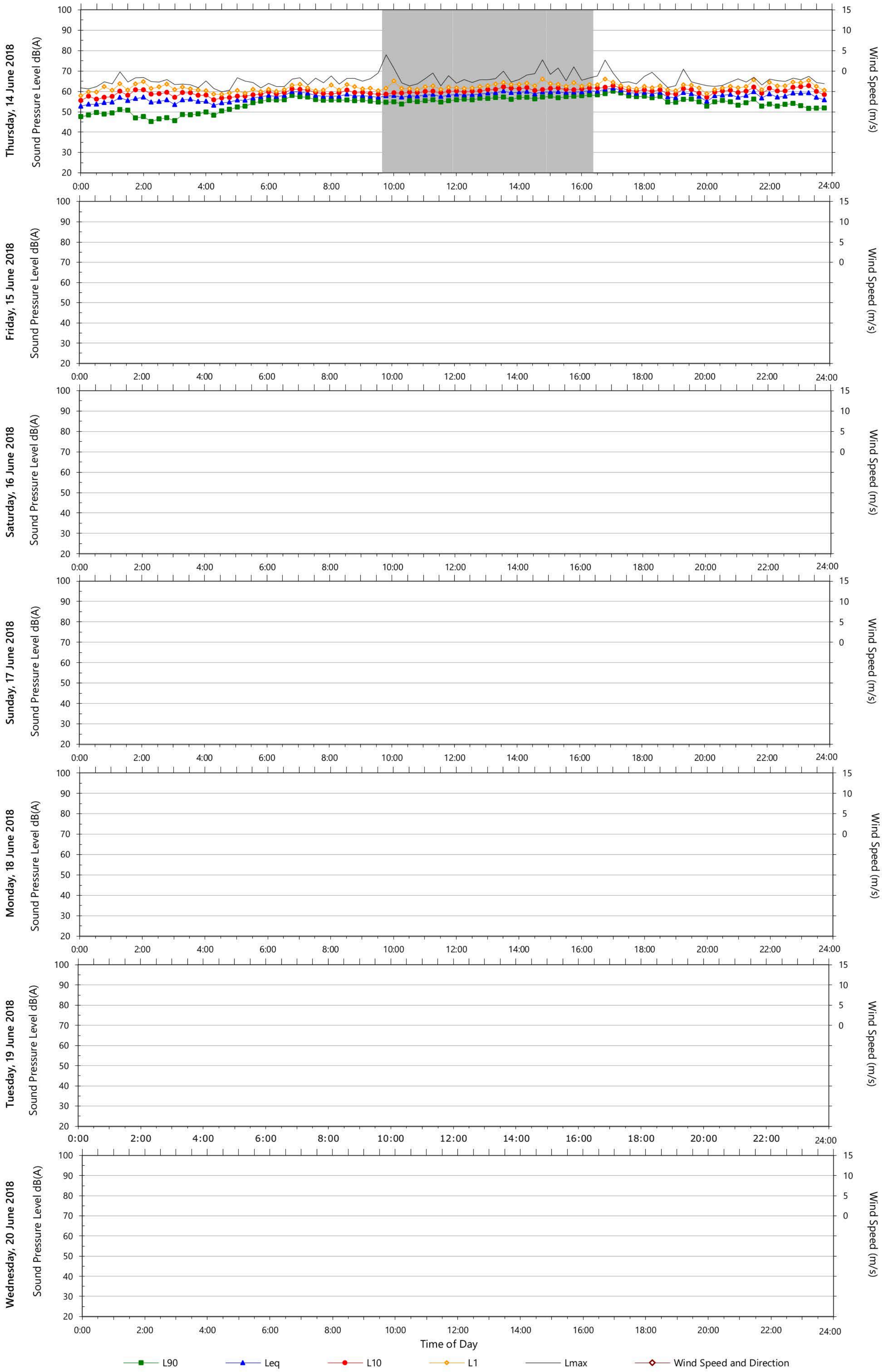
Unattended Monitoring Results **Location: L03 - 51 New England Highway, Tarro**



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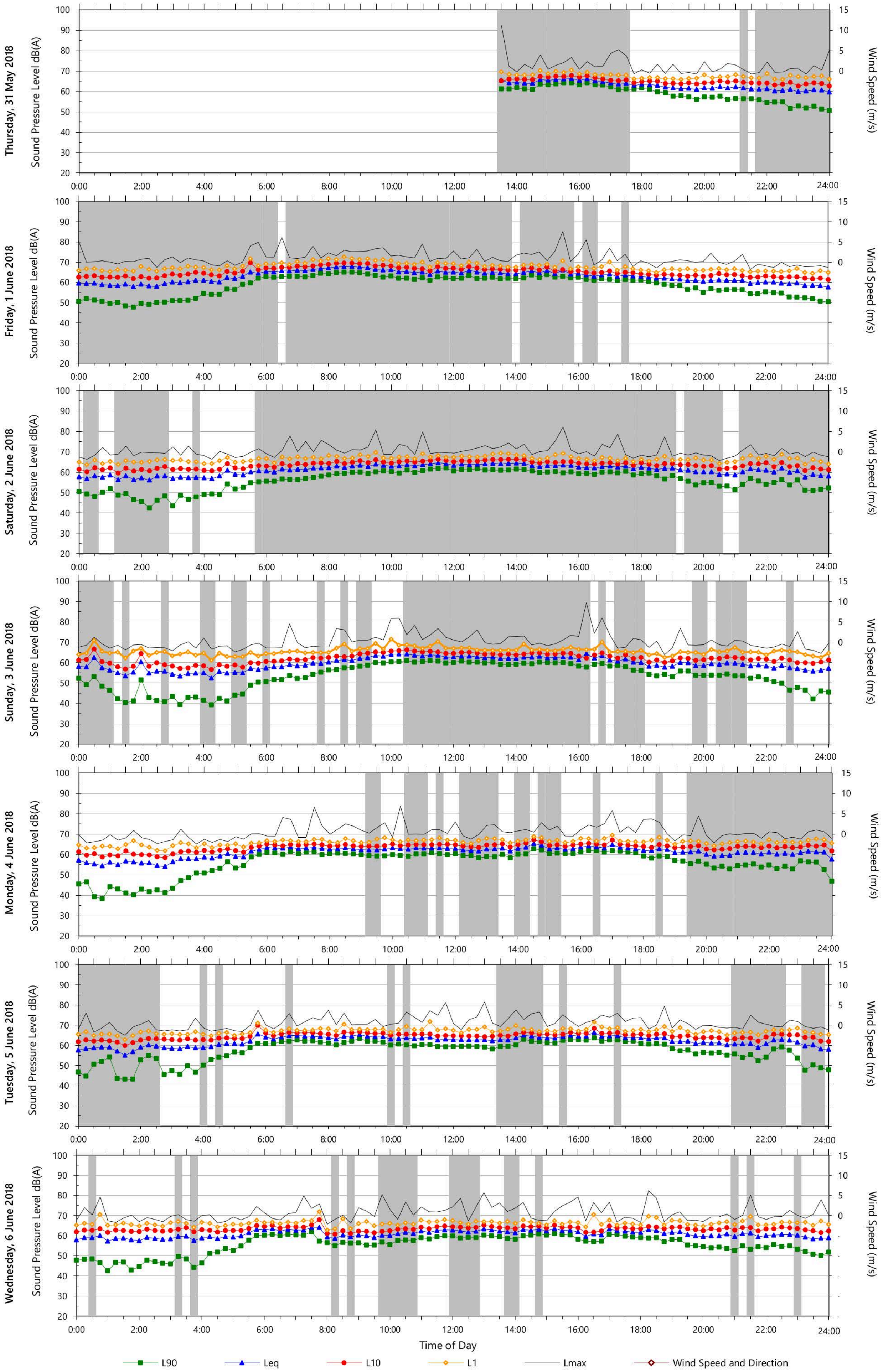

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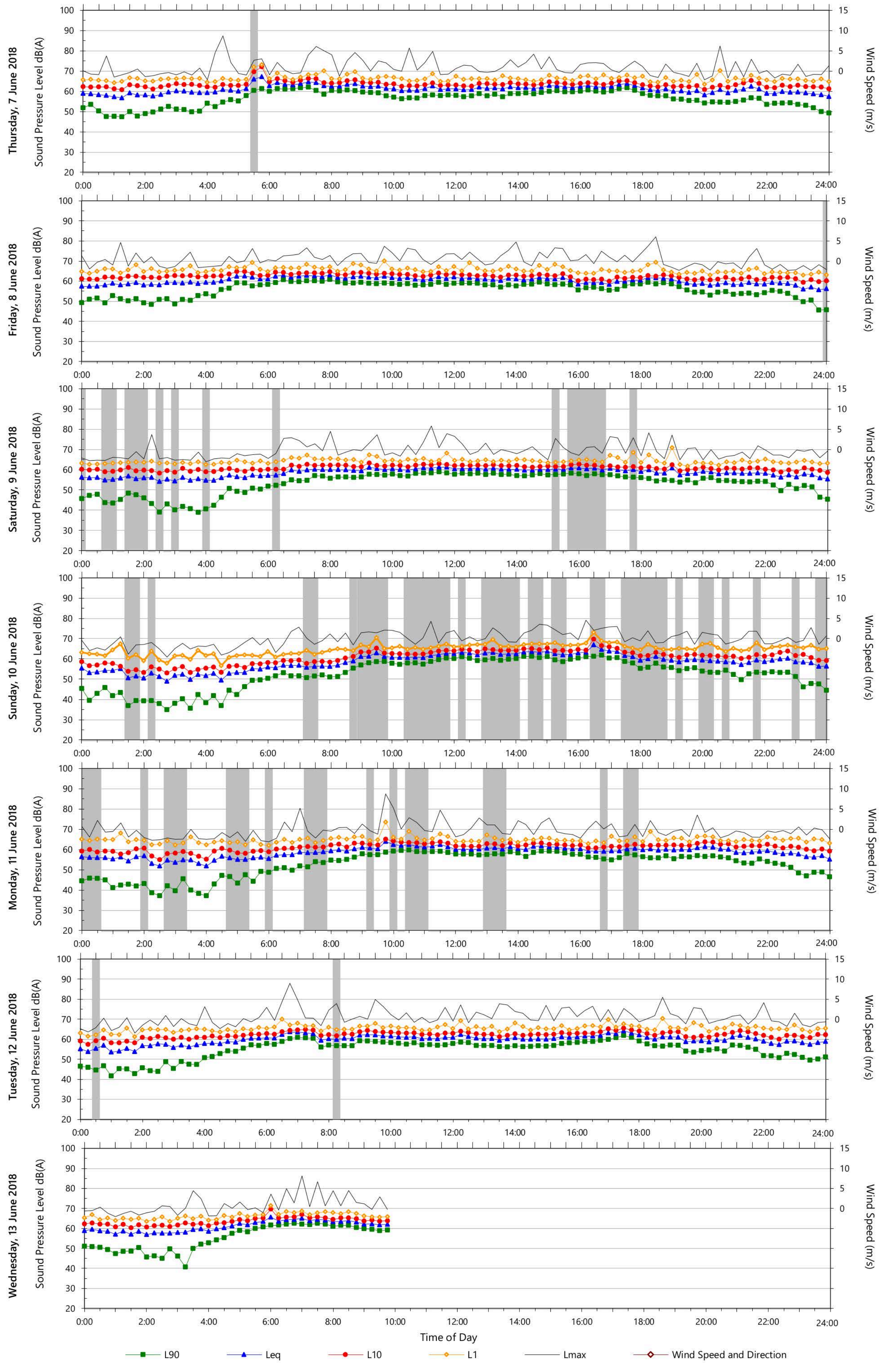

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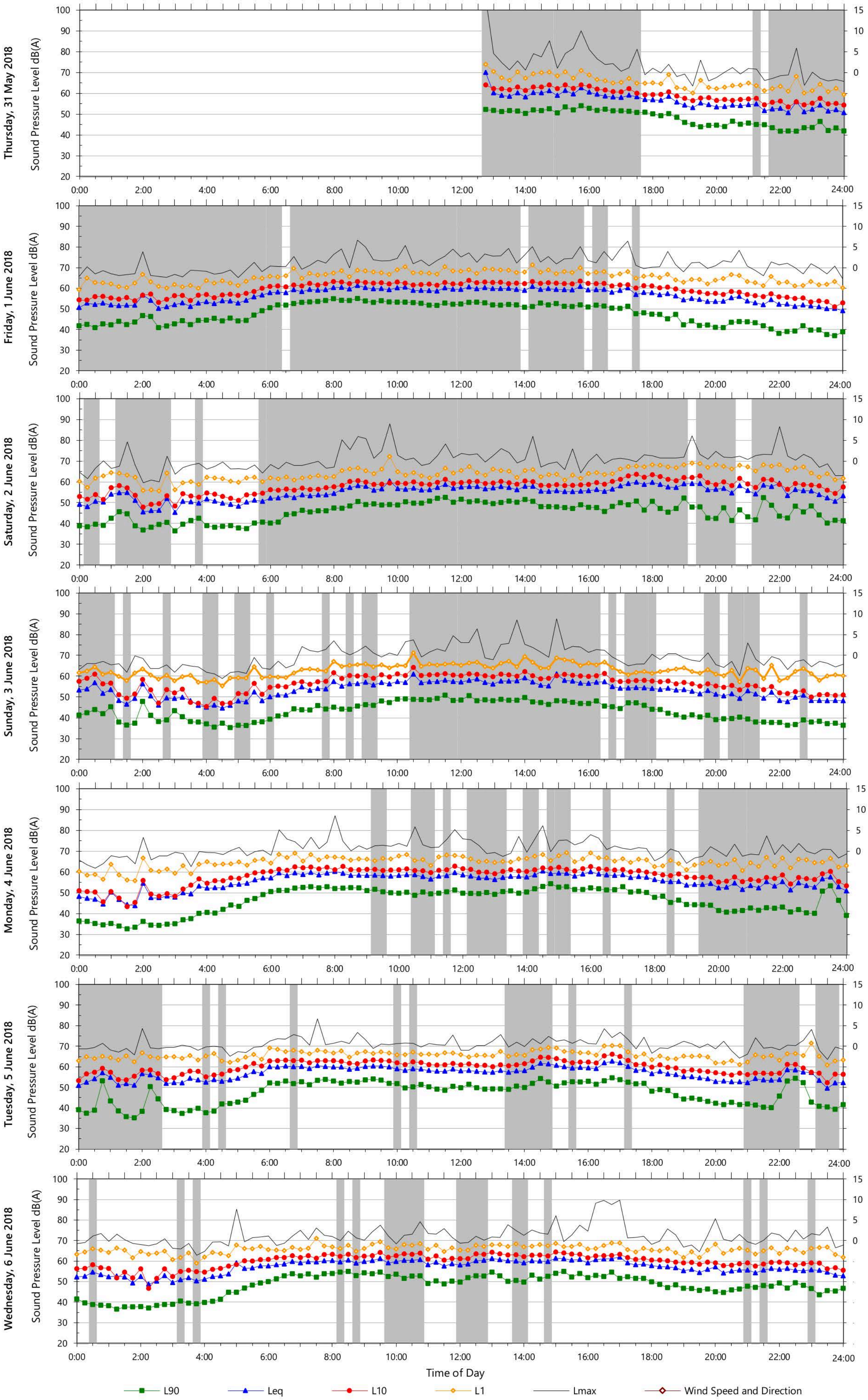
Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results

Location: L05 - 11 Anderson Drive, Tarro, Tarro



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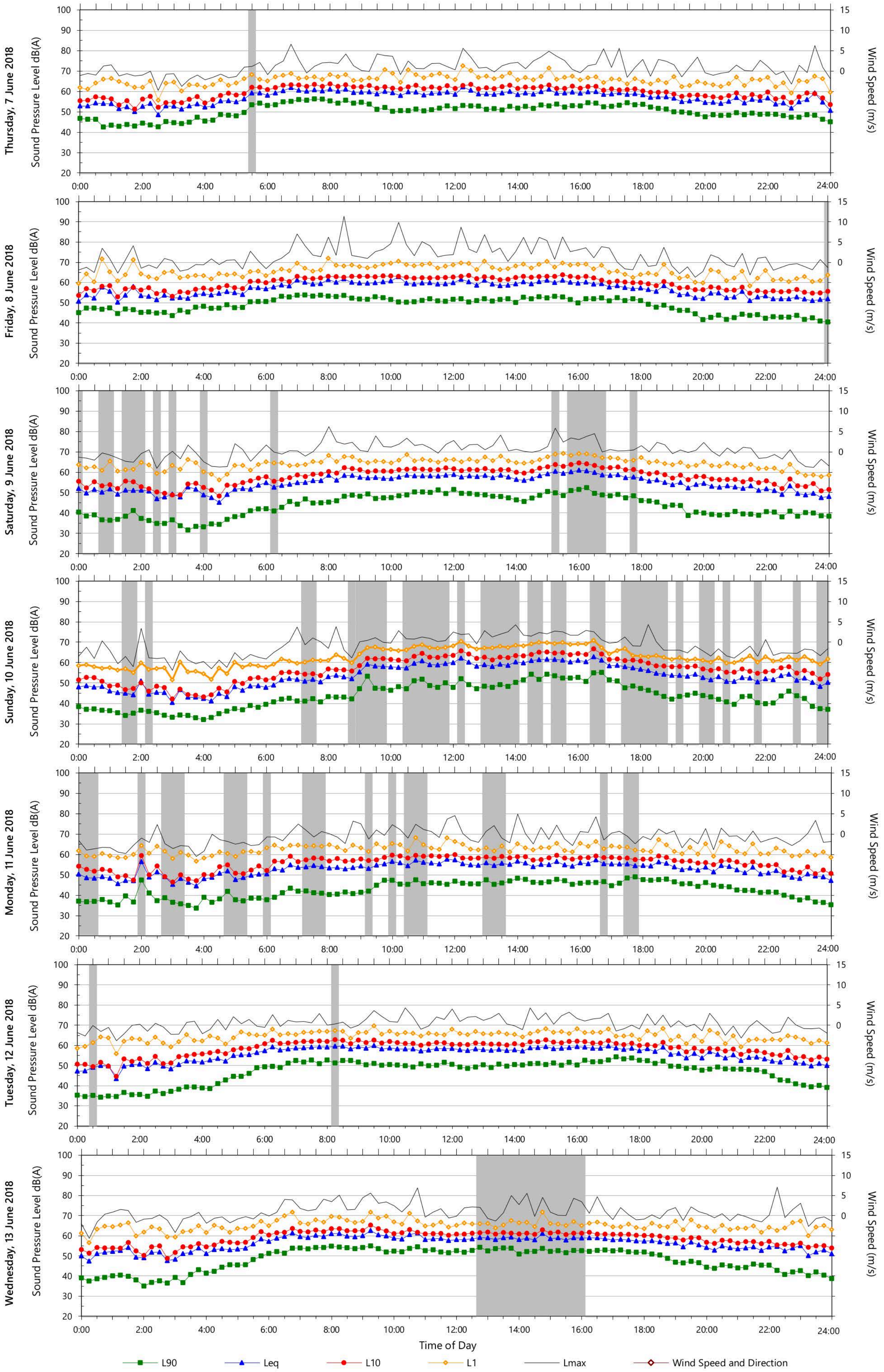

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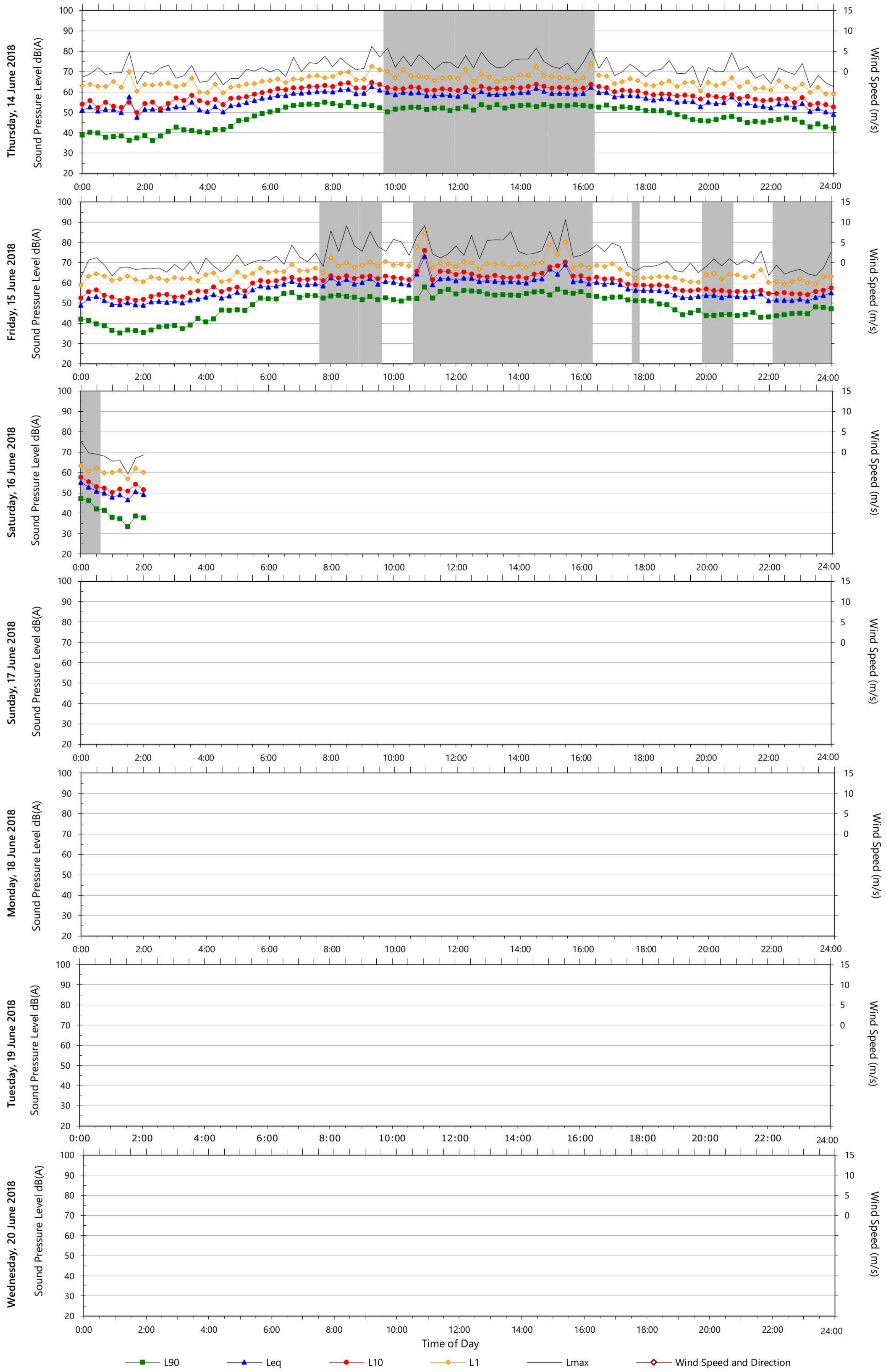
Unattended Monitoring Results **Location: L05 - 11 Anderson Drive, Tarro, Tarro**



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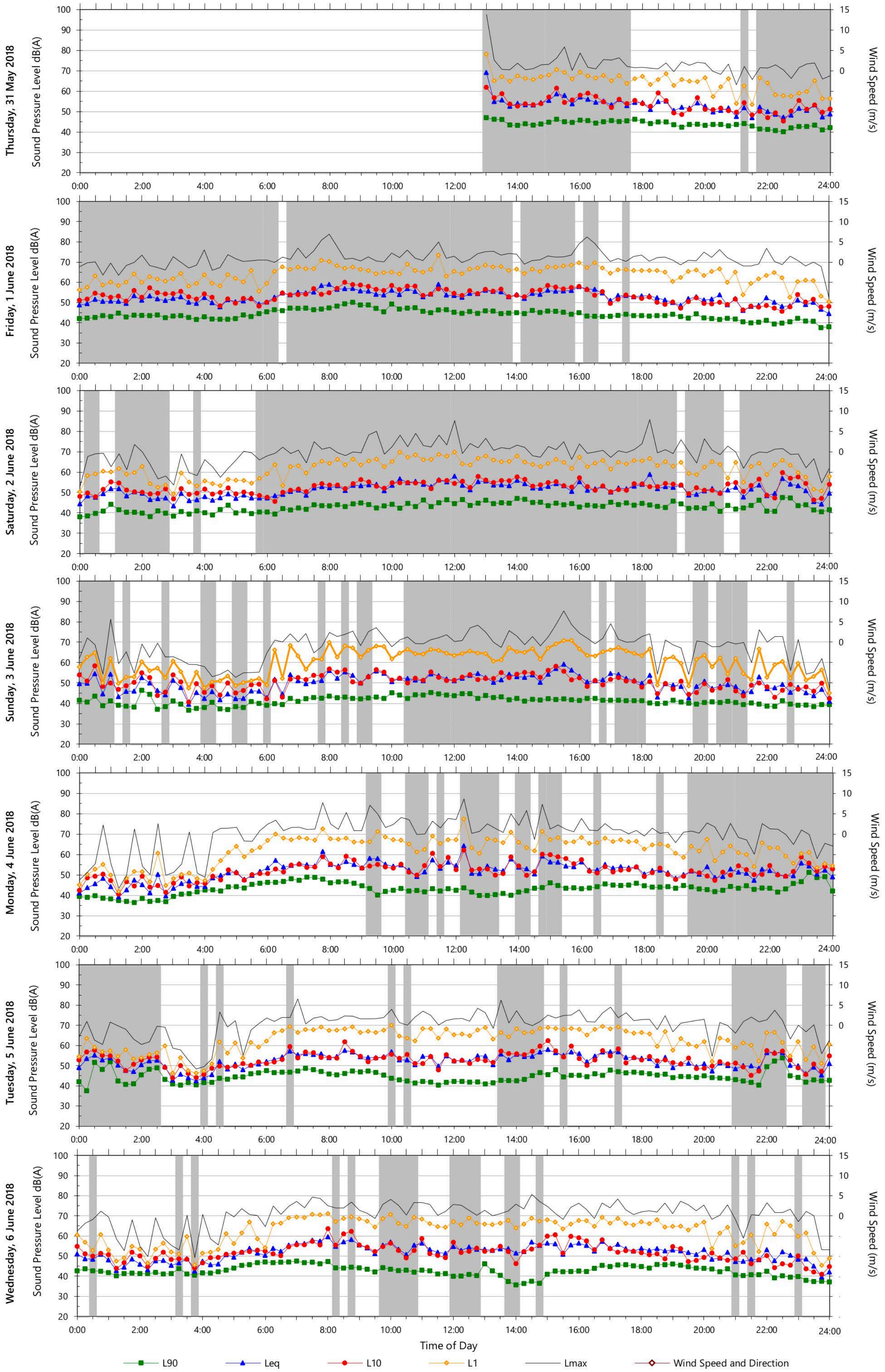
Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results **Location: L06 - 61 Redbill Drive, Woodberry**



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Unattended Monitoring Results

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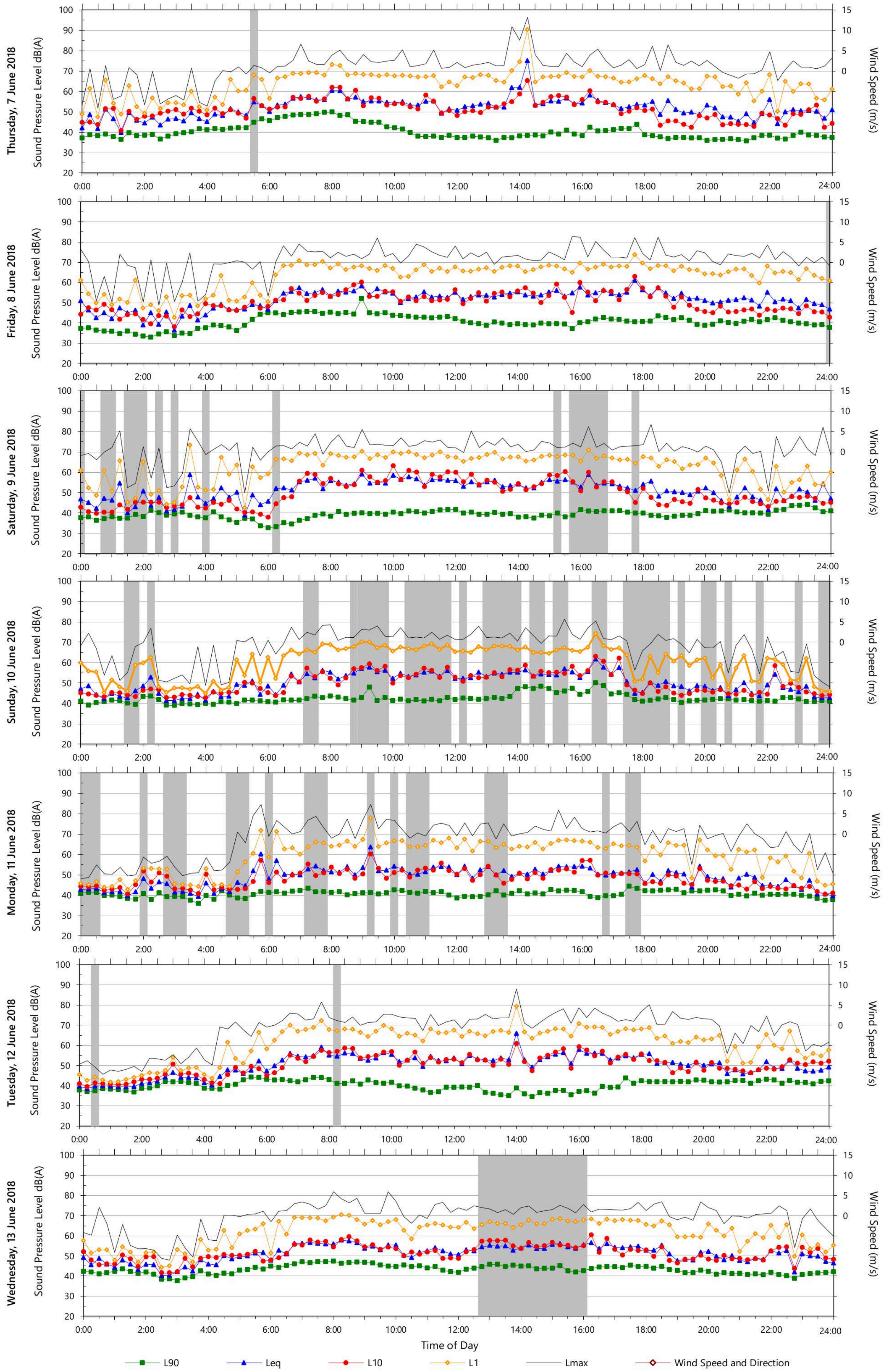

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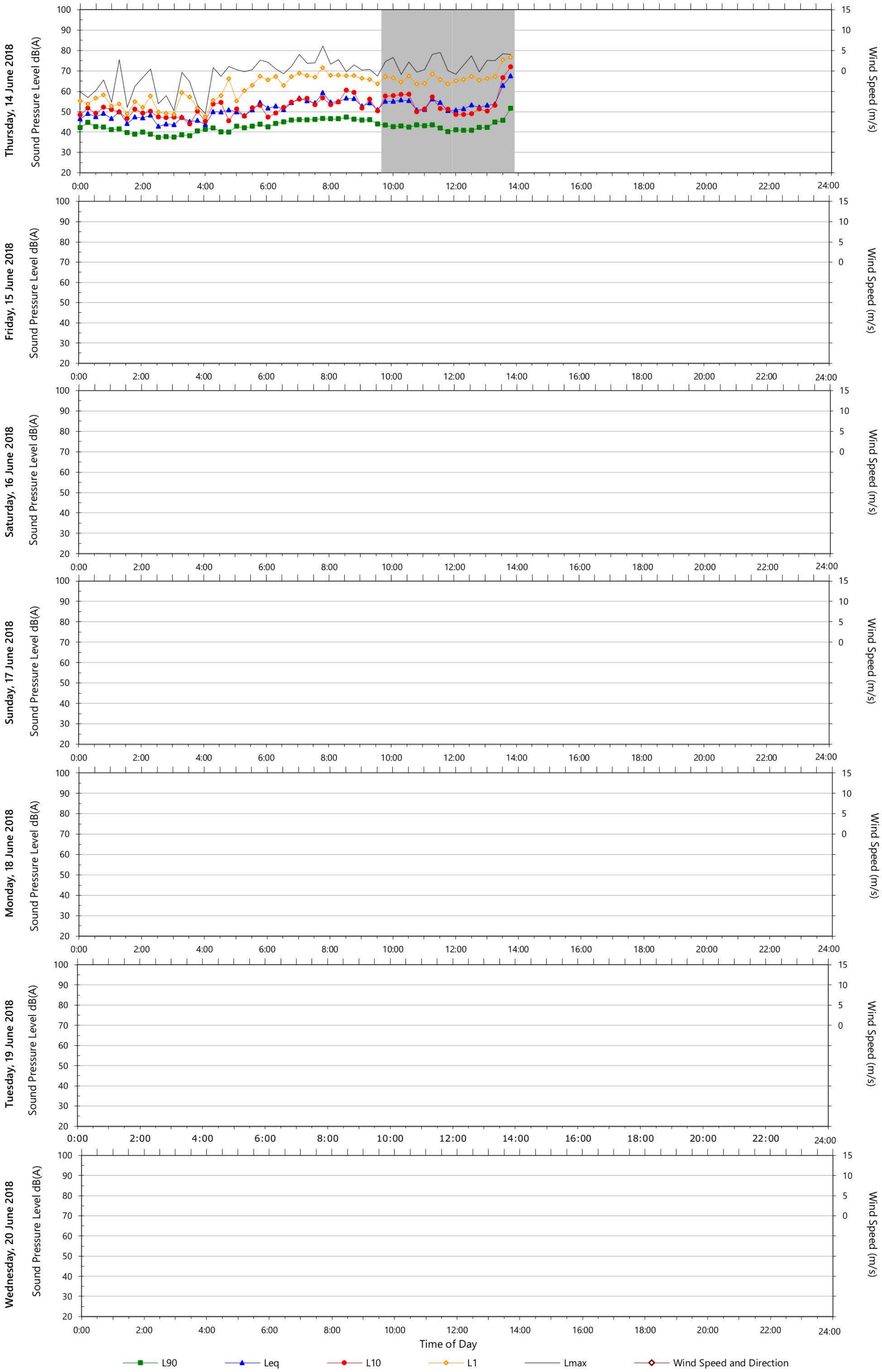

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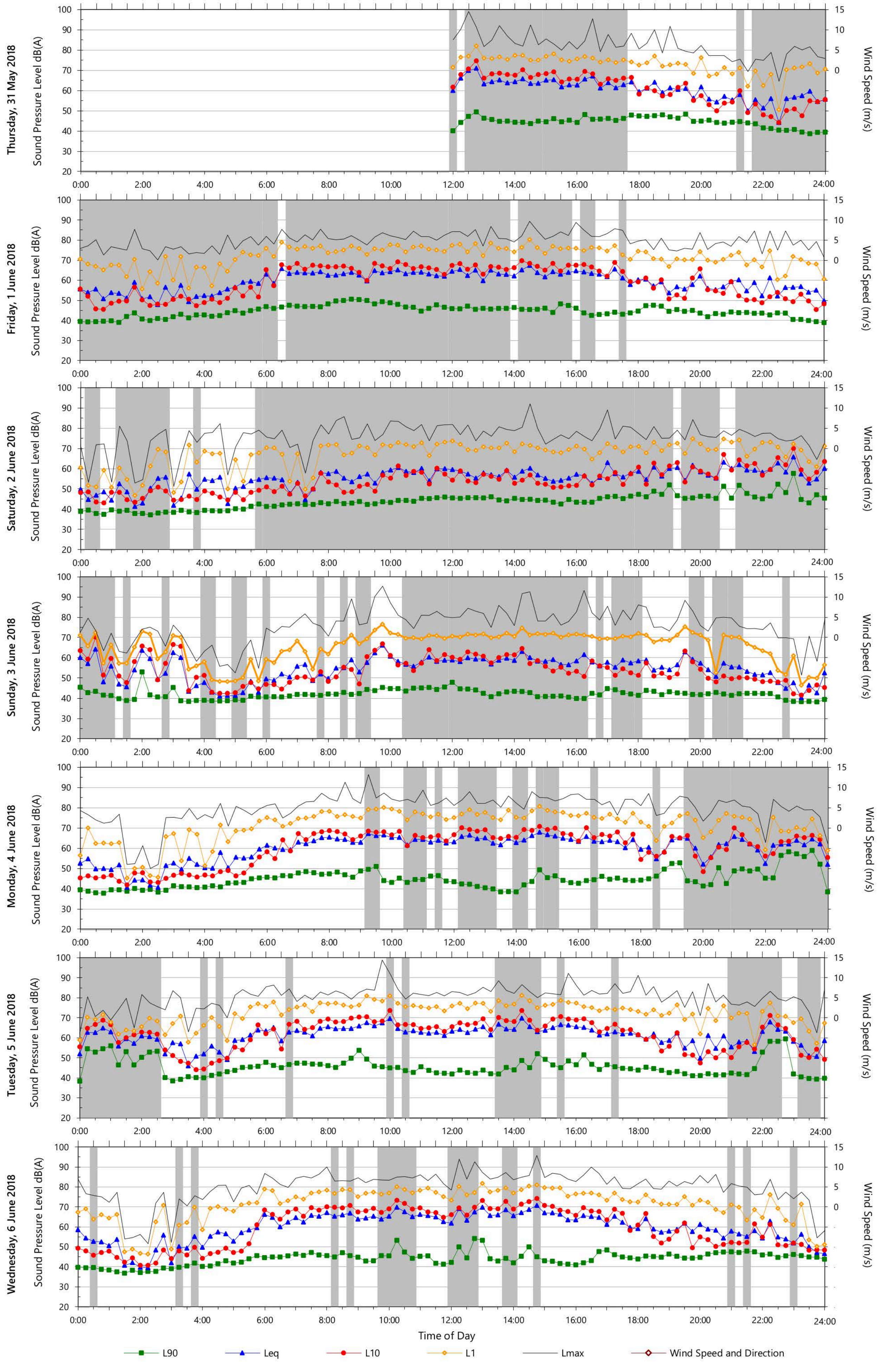
Unattended Monitoring Results

Location: L07 - 179 Old Maitland Road, Hexham



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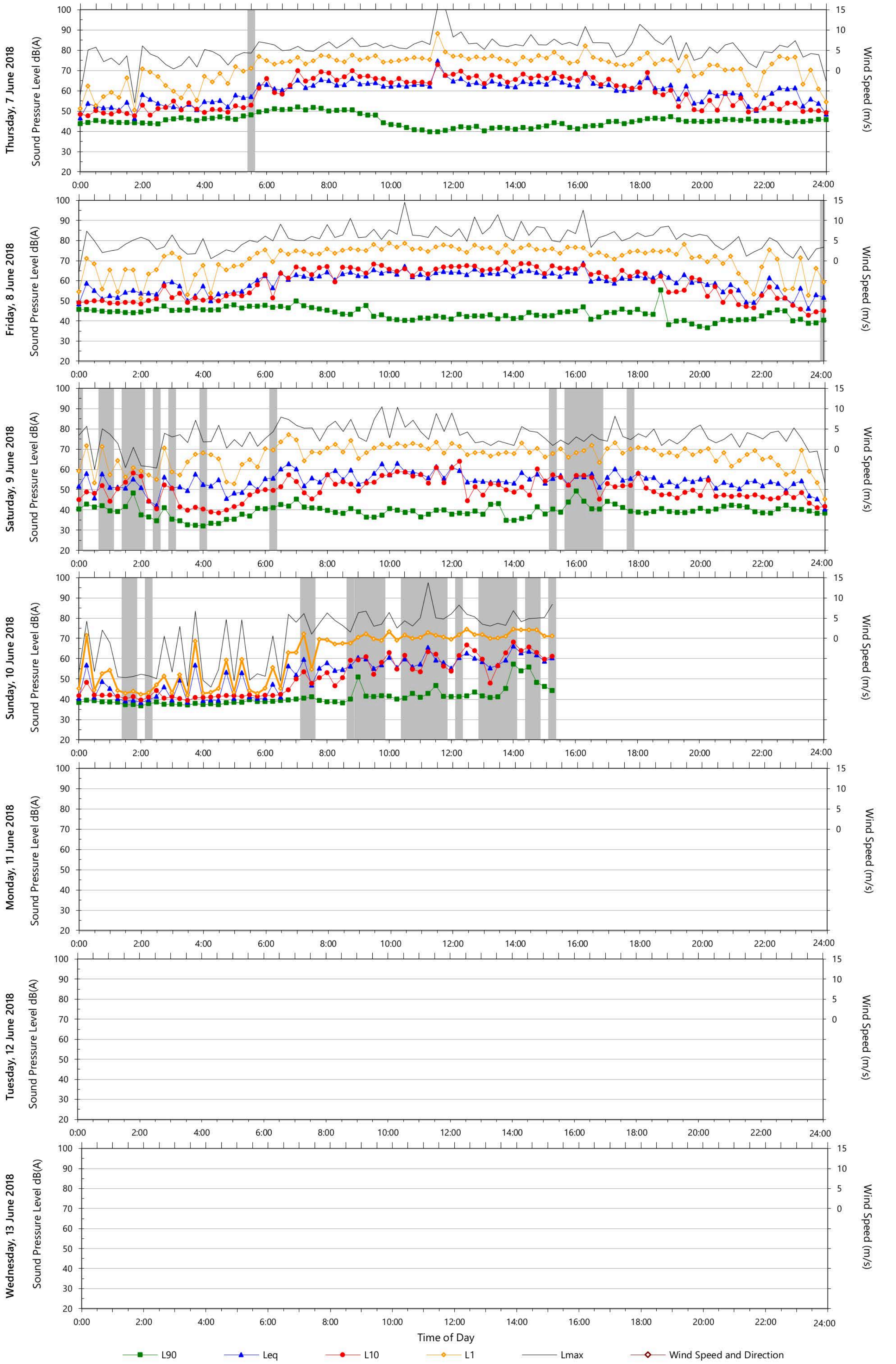
Unattended Monitoring Results **Location: L07 - 179 Old Maitland Road, Hexham**



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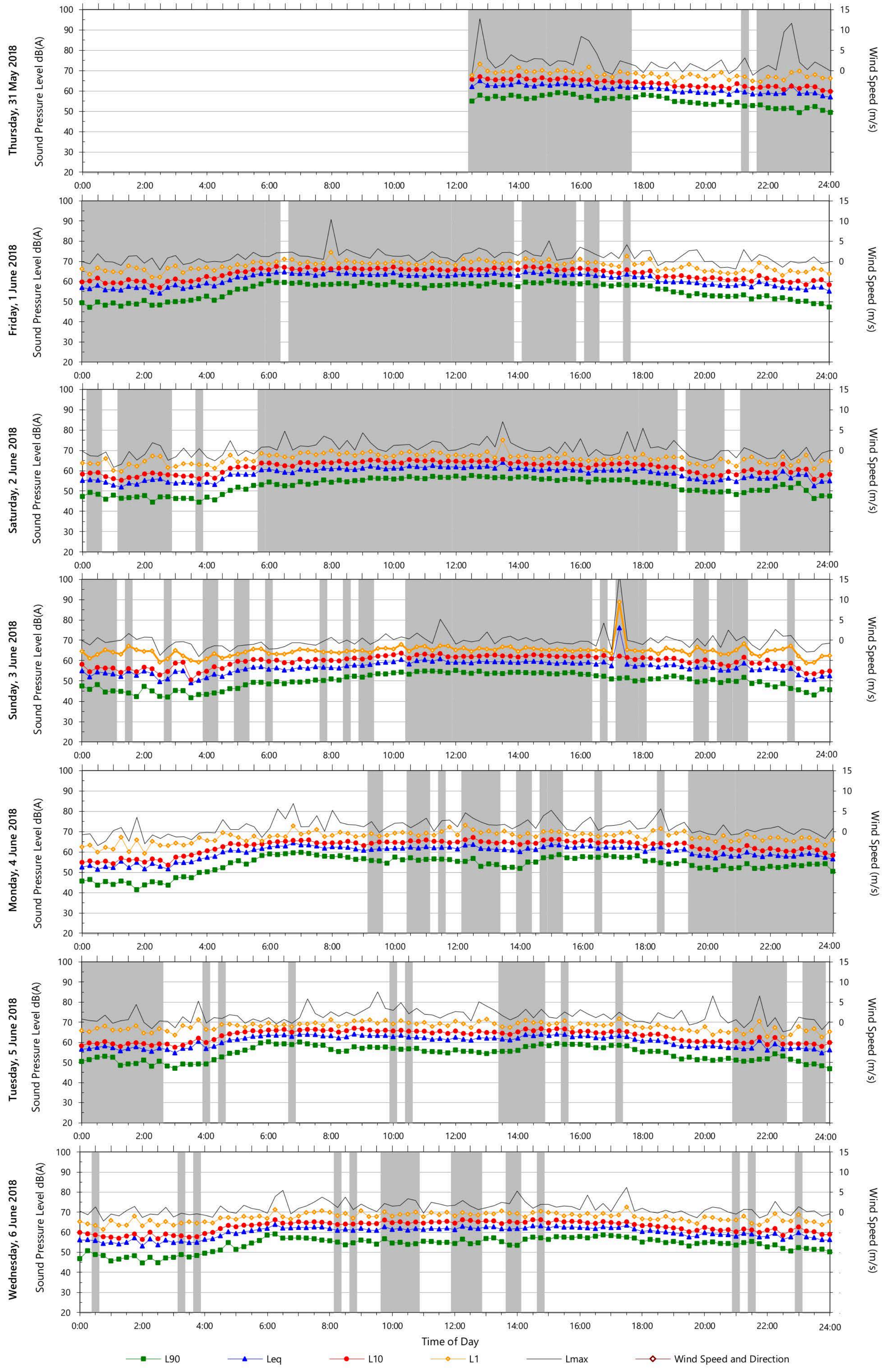
Unattended Monitoring Results **Location: L08 - 838 Tomago Road, Tomago**



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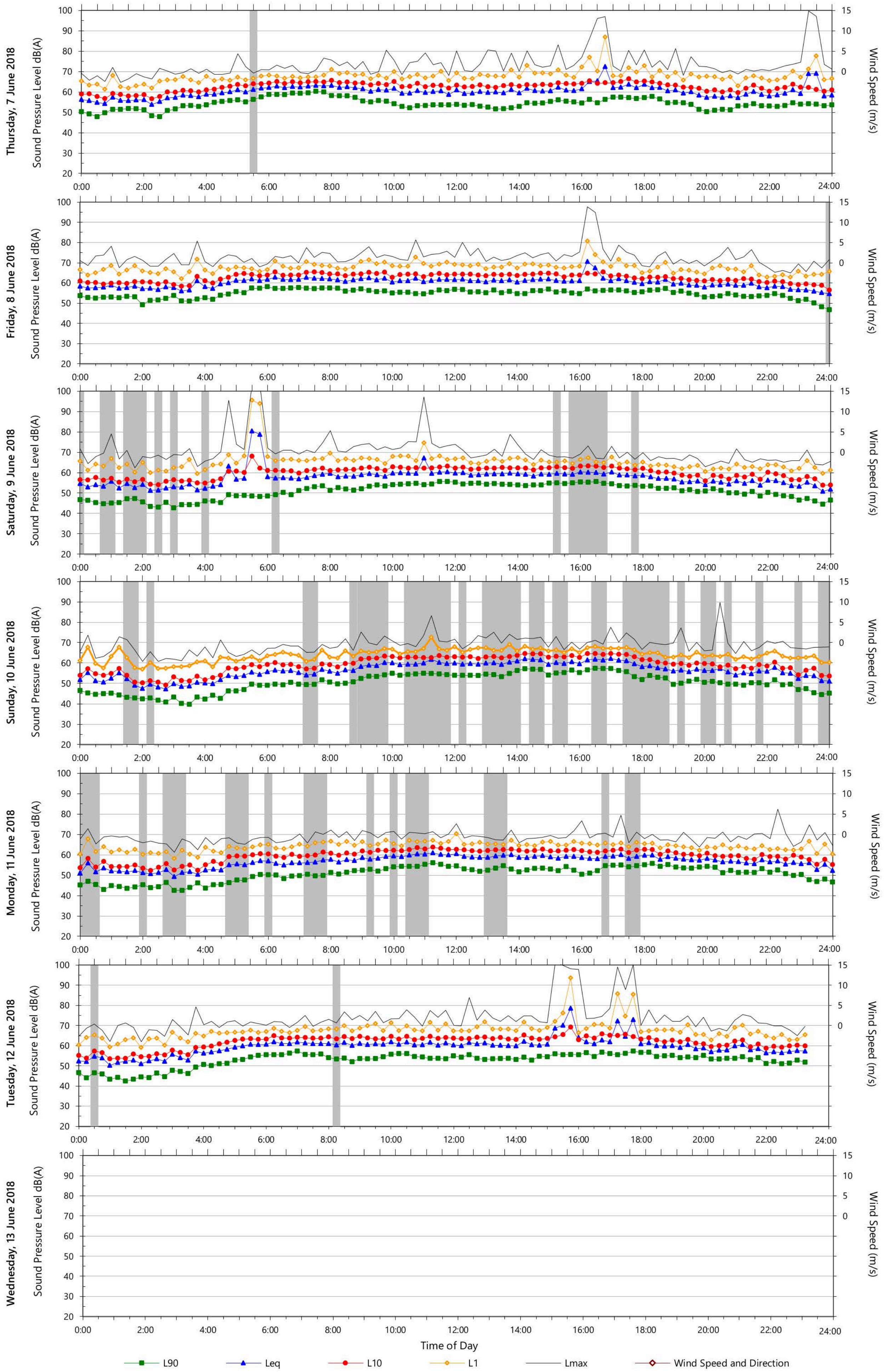

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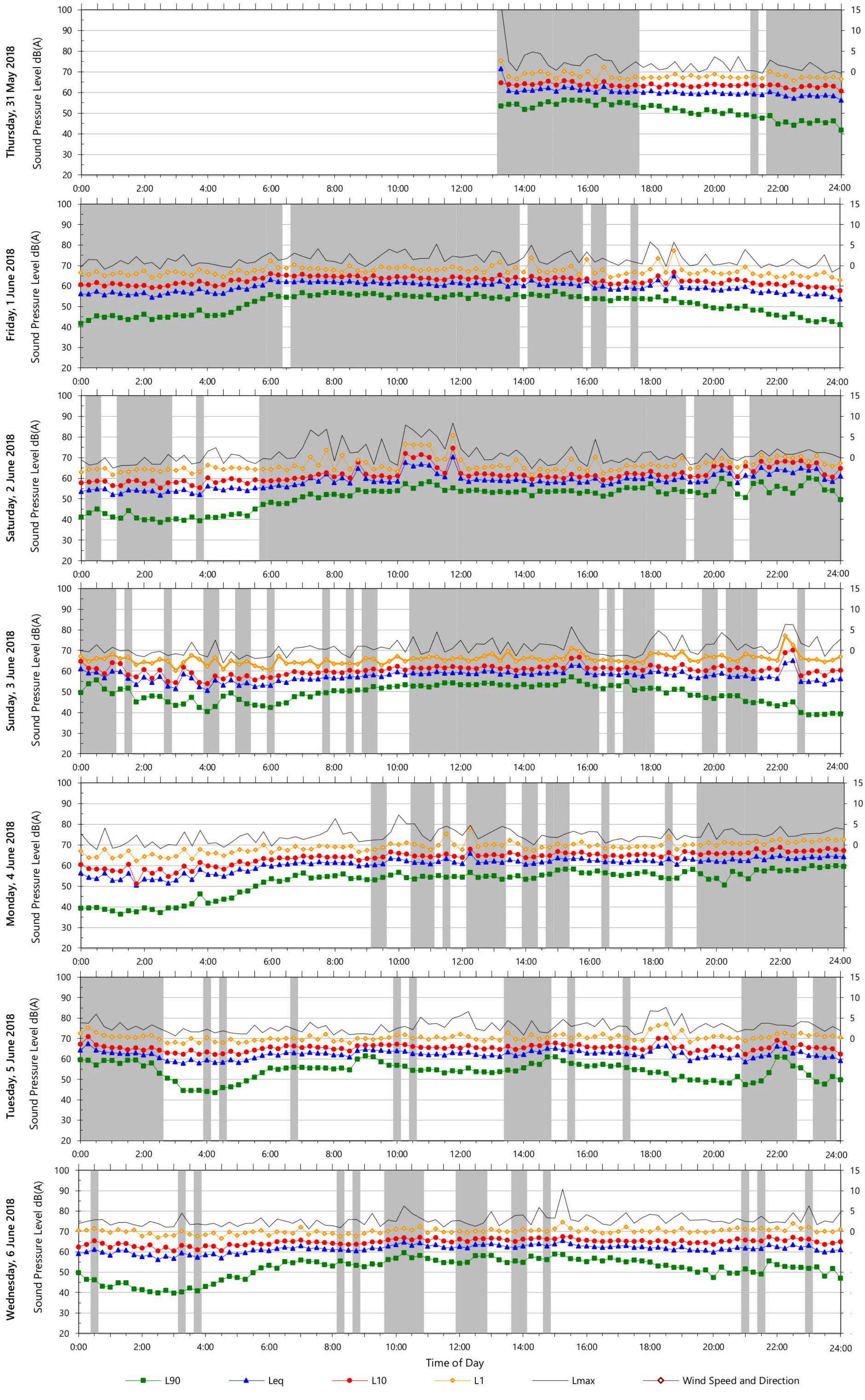
Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results **Location: L09 - 2213 Pacific Highway, Heatherbrae**



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Unattended Monitoring Results

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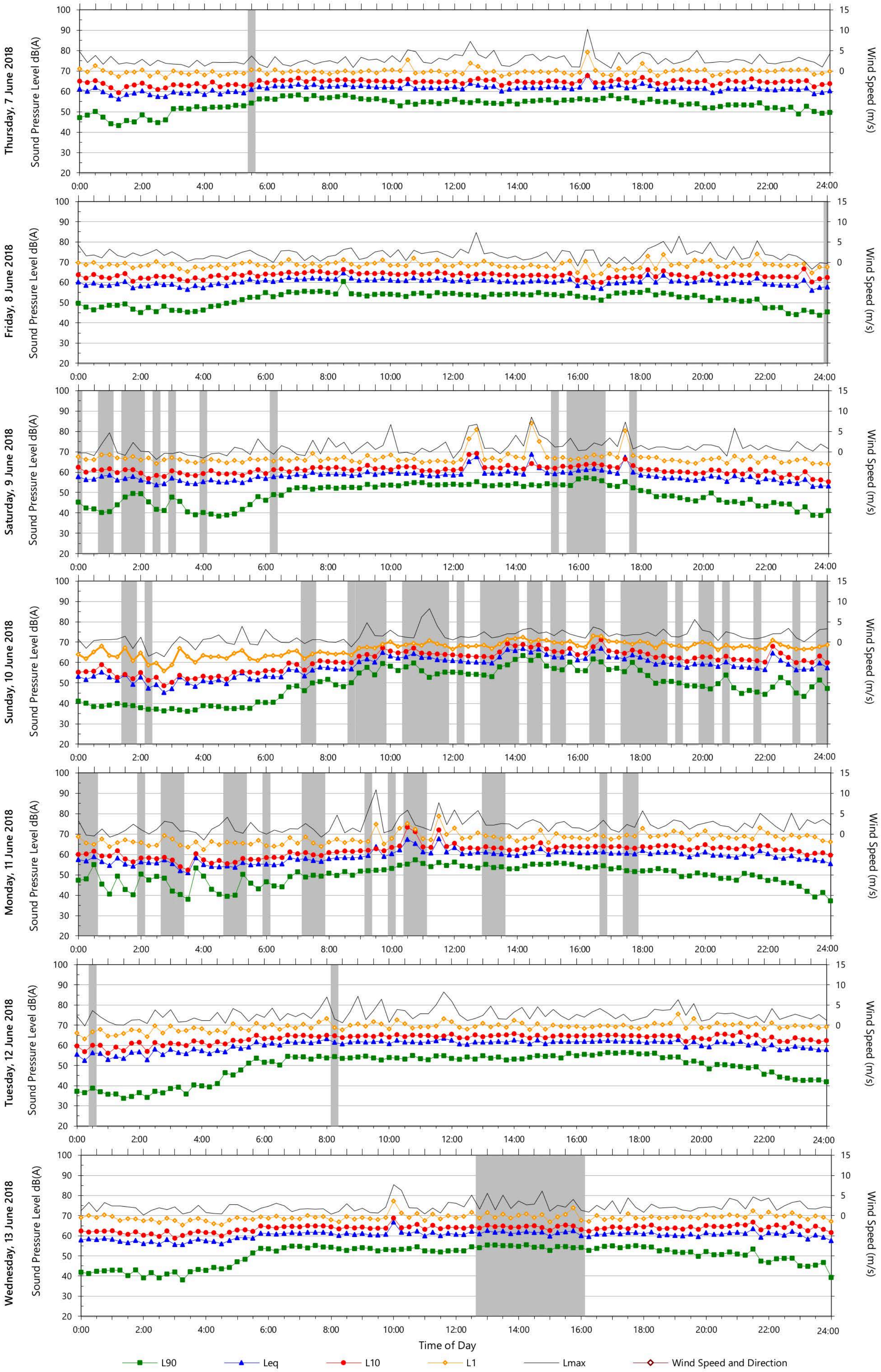

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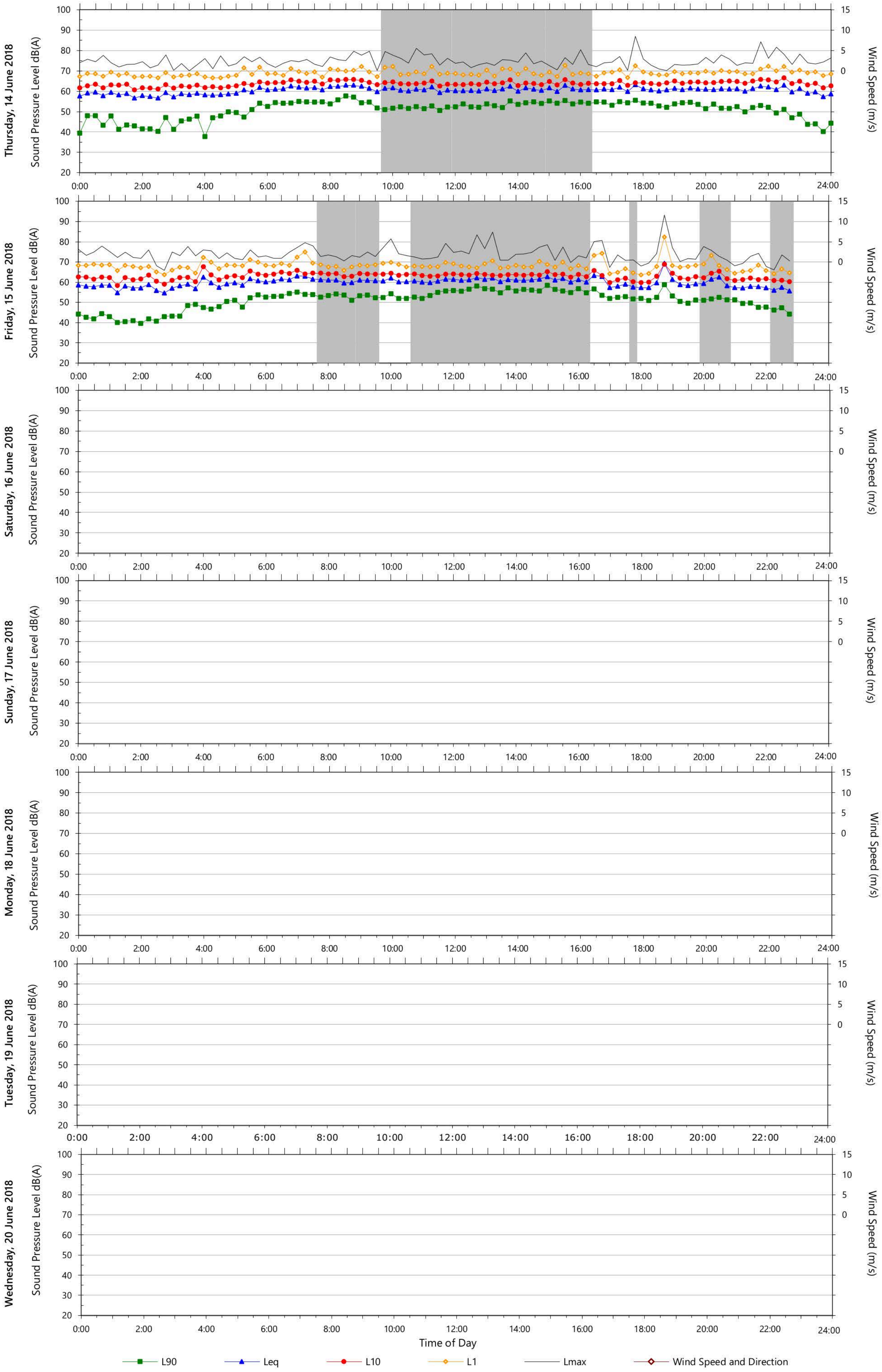
Unattended Monitoring Results **Location: L09 - 2213 Pacific Highway, Heatherbrae**



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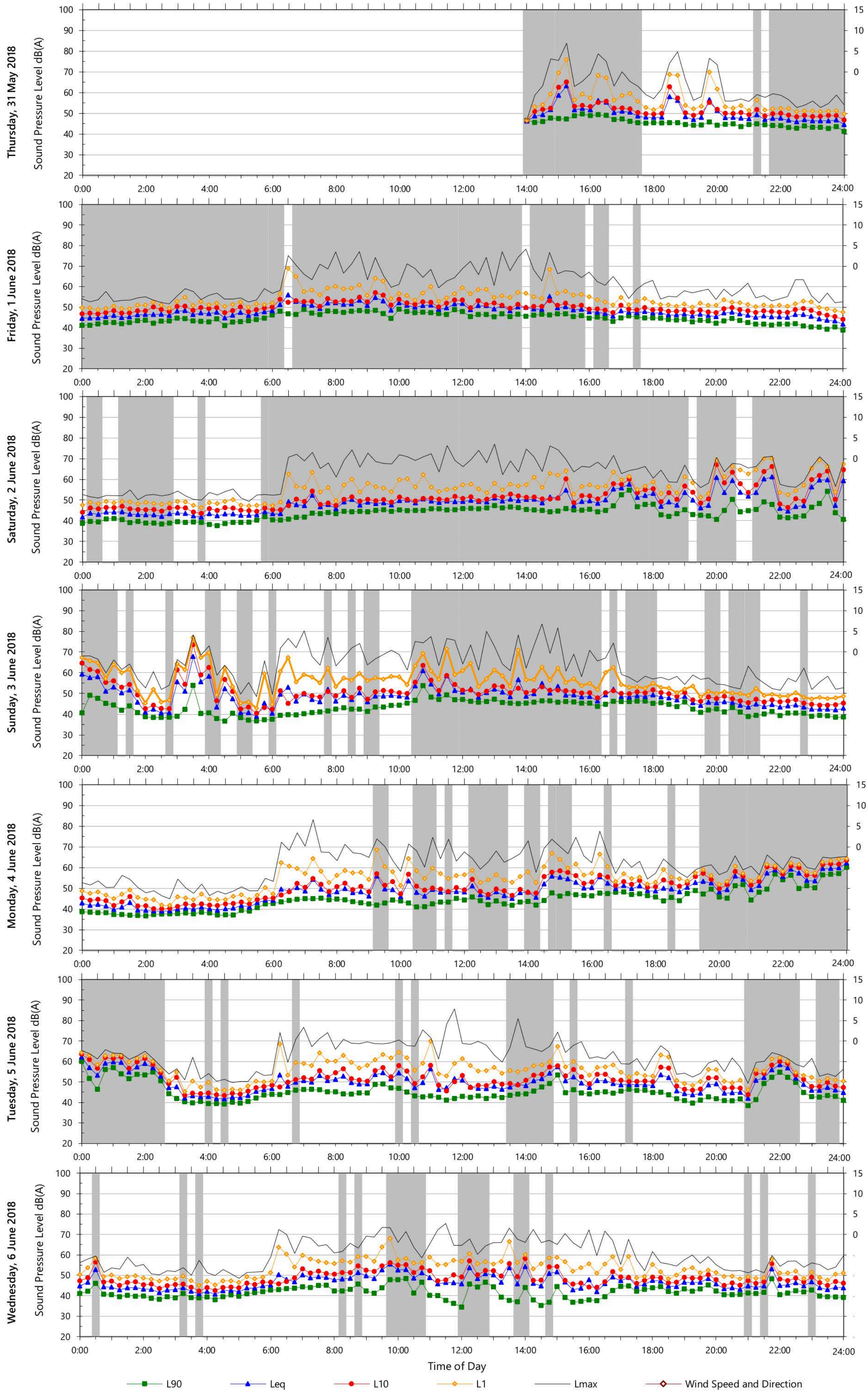
Unattended Monitoring Results **Location: L10 - 14 Elizabeth Avenue, Raymond Terrace,**



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Unattended Monitoring Results

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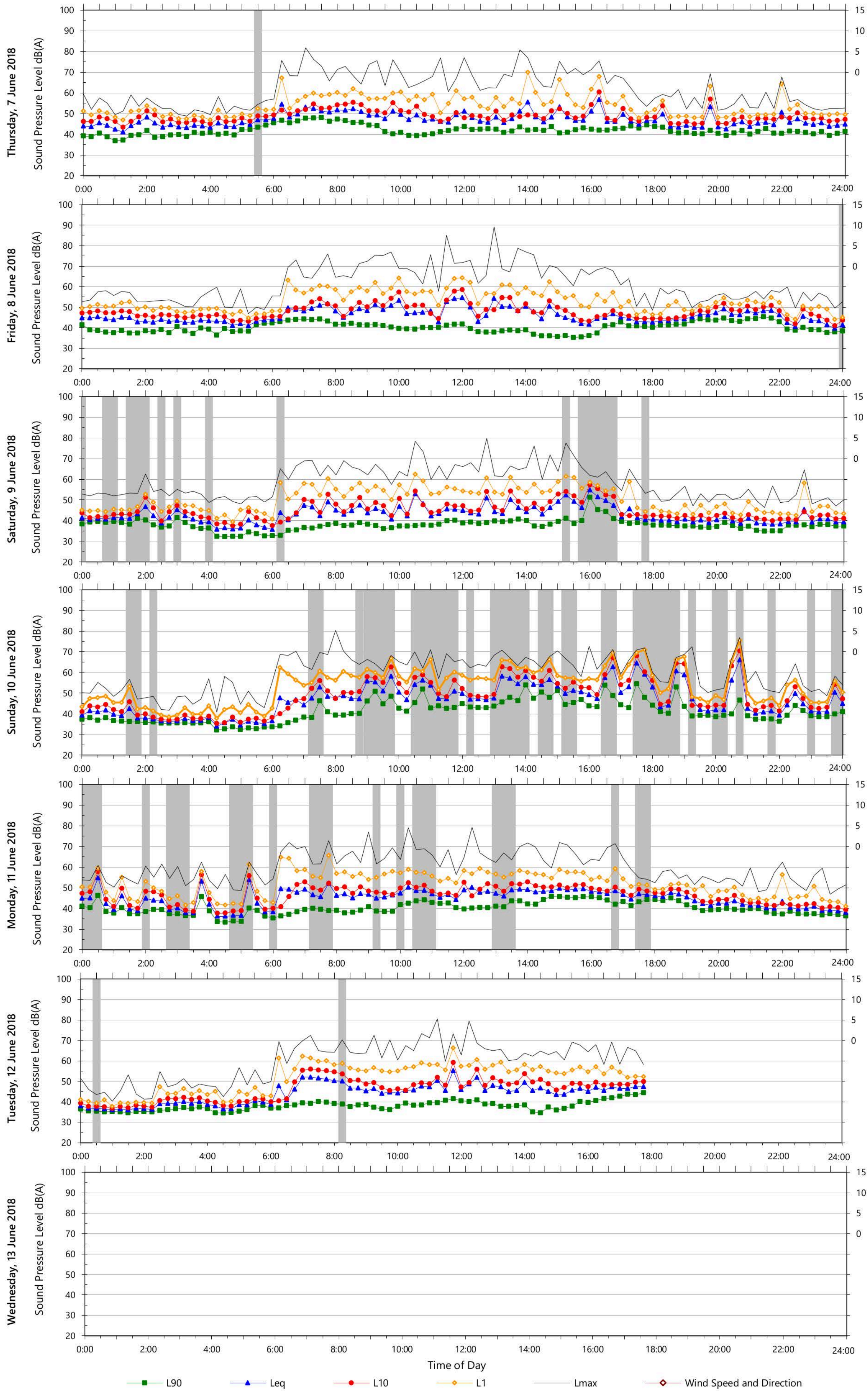

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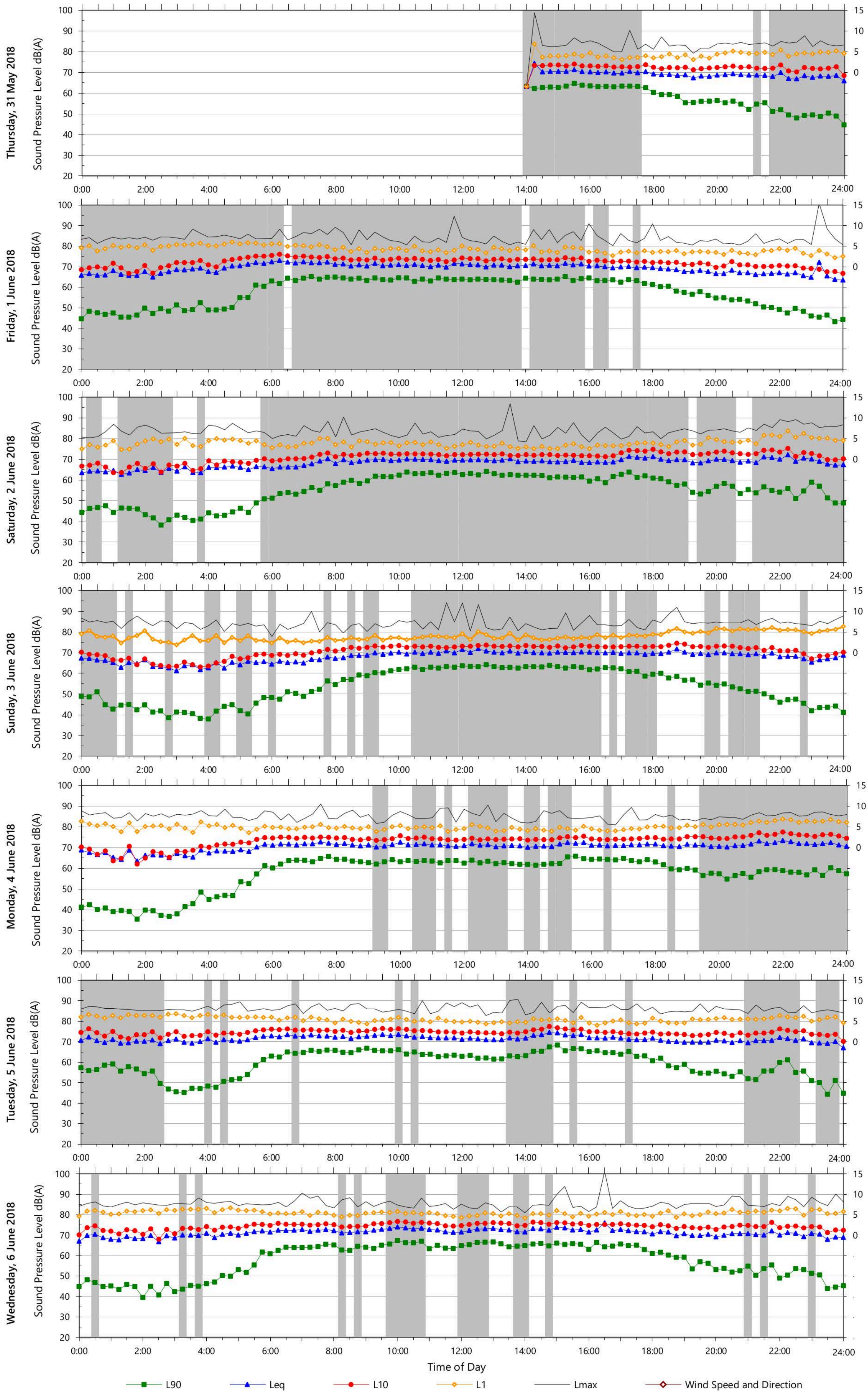
Unattended Monitoring Results

Location: L11 - 2264 Pacific Highway,



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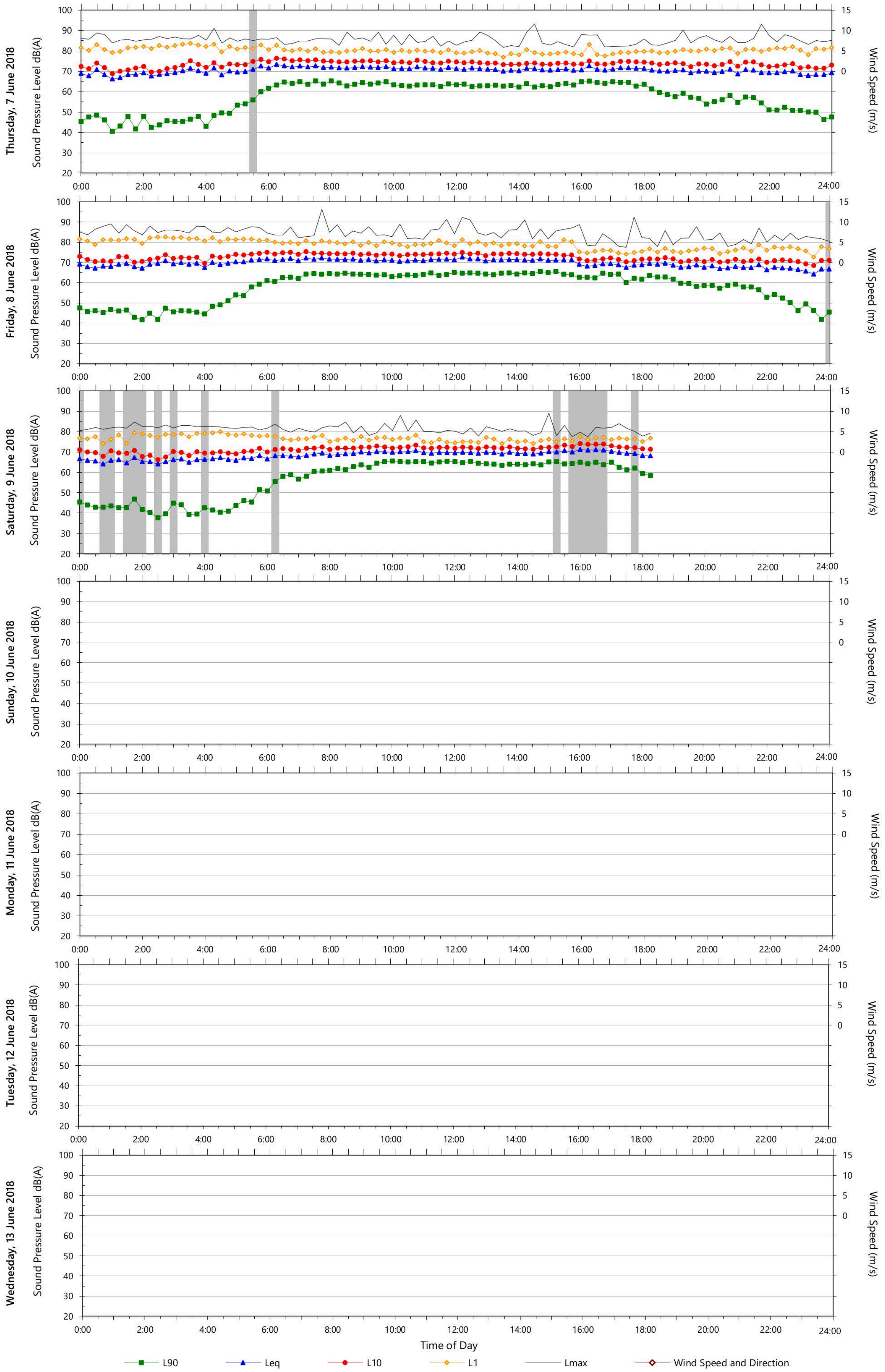

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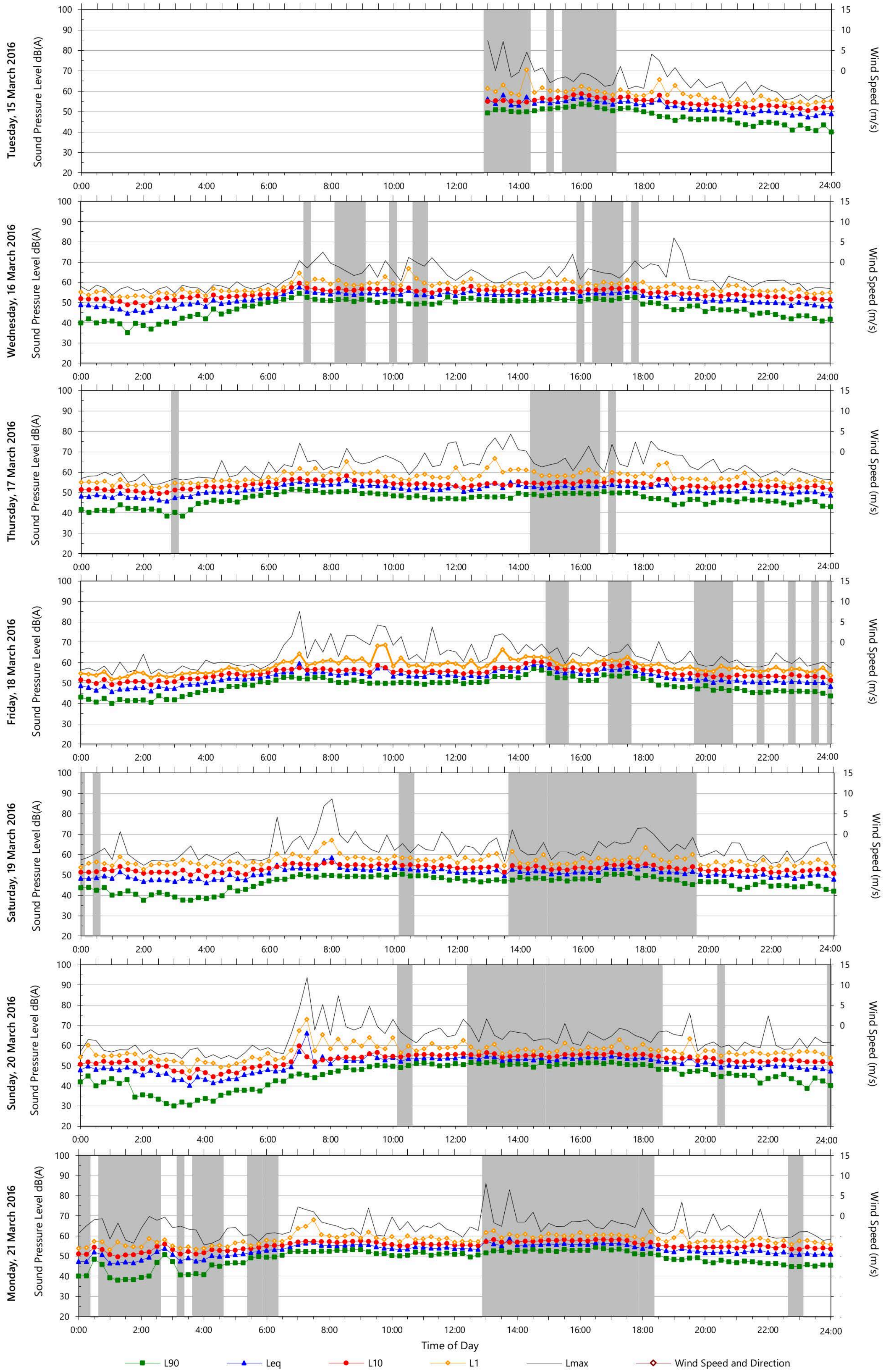
Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results **Location: L13 - 11 Cahill Close, Black Hill,**



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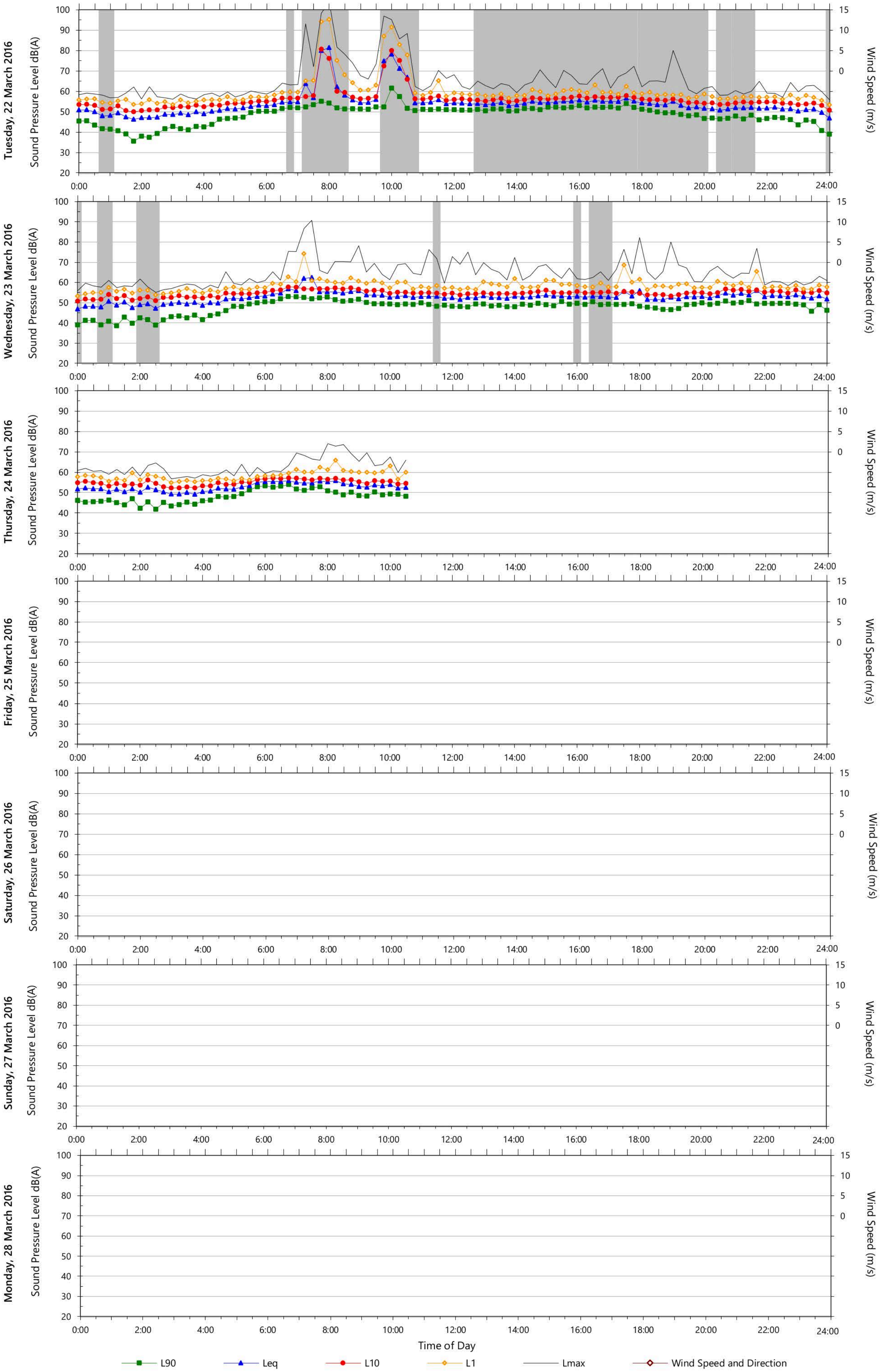
Unattended Monitoring Results **Location: L13 - 11 Cahill Close, Black Hill,**



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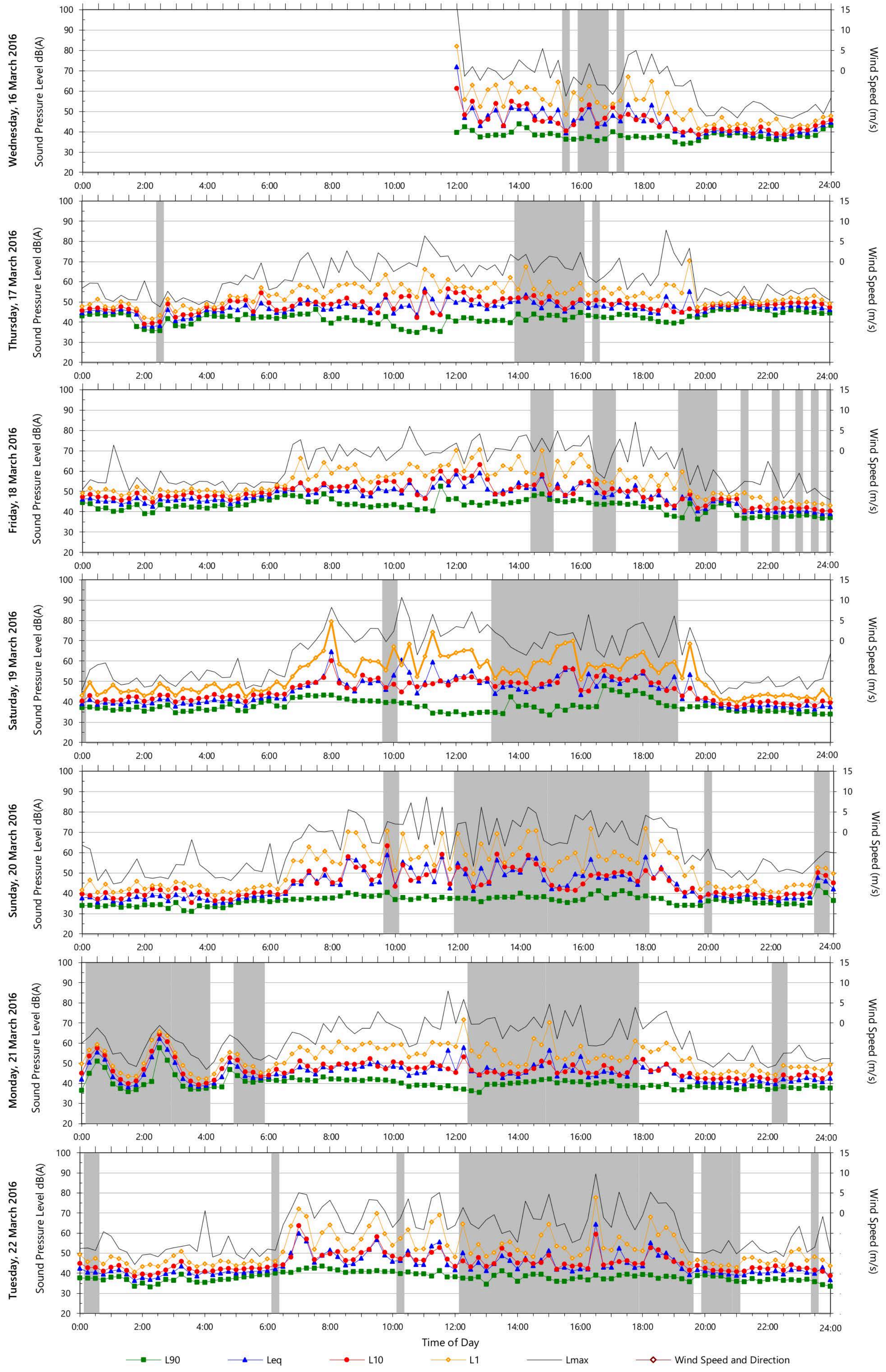
Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results

Location: L14 - 23 Walter Parade, Black Hill,



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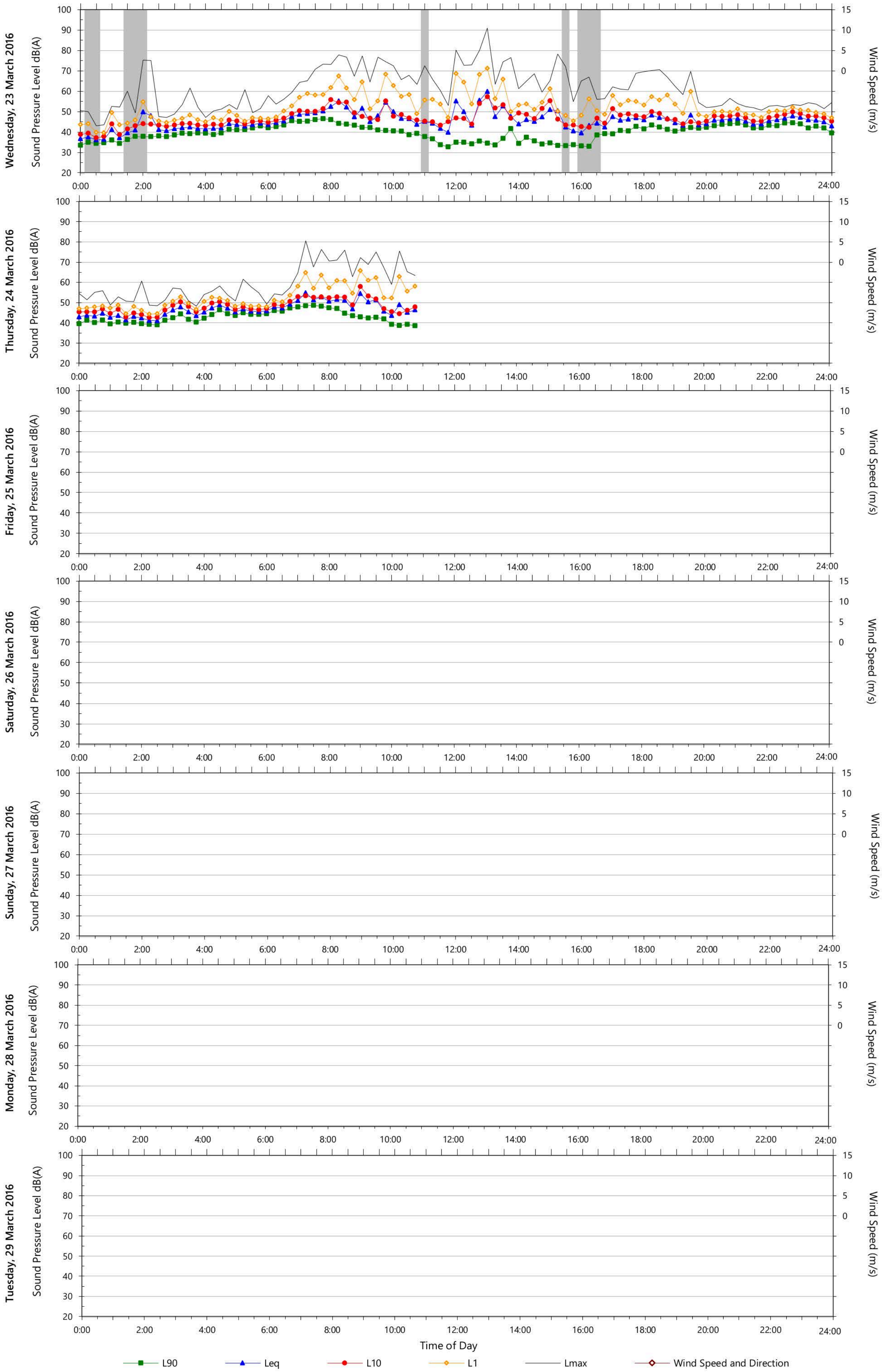
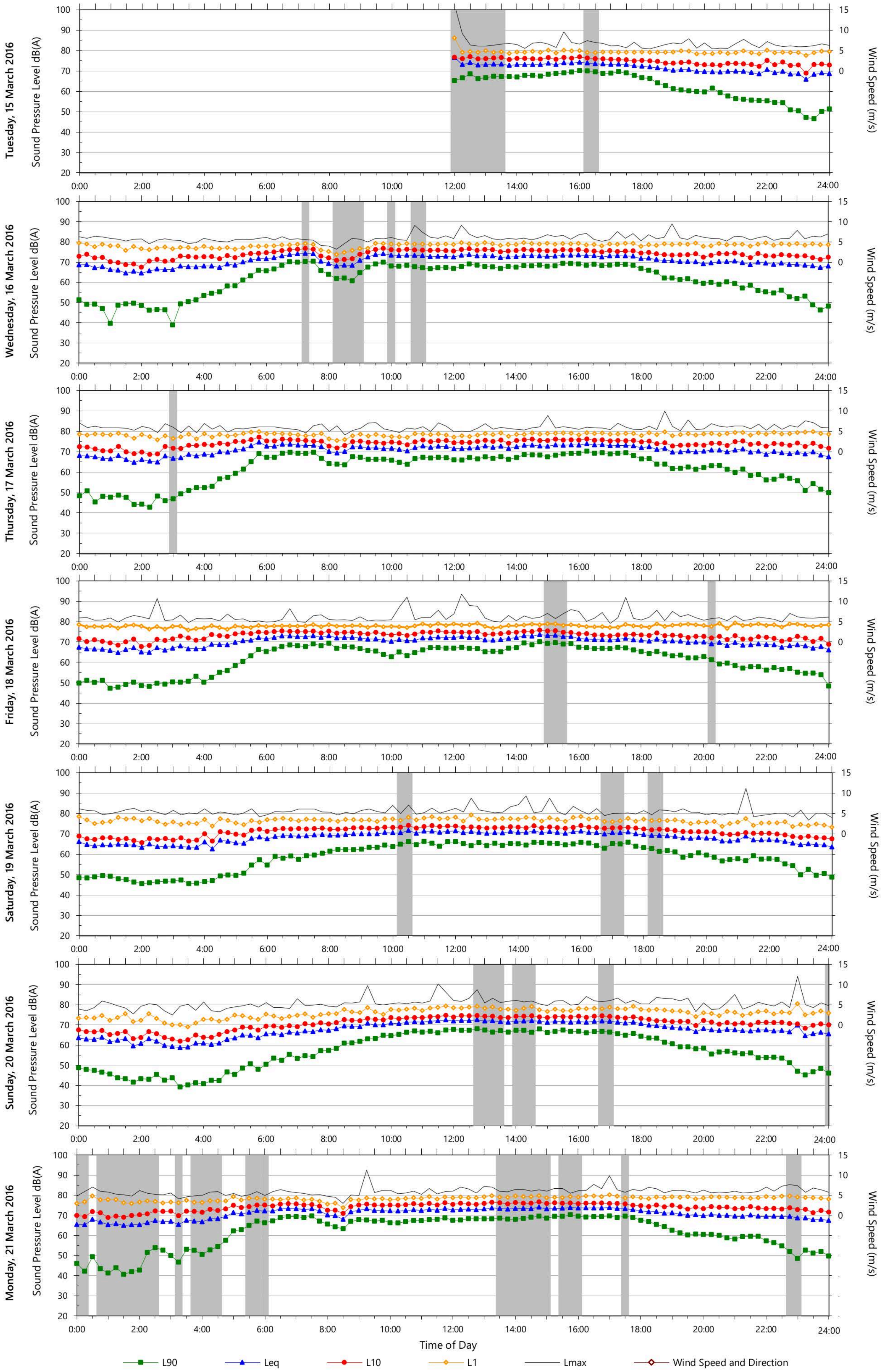


Data File:

Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results

Location: L15 - 70 New England Highway, Tarro



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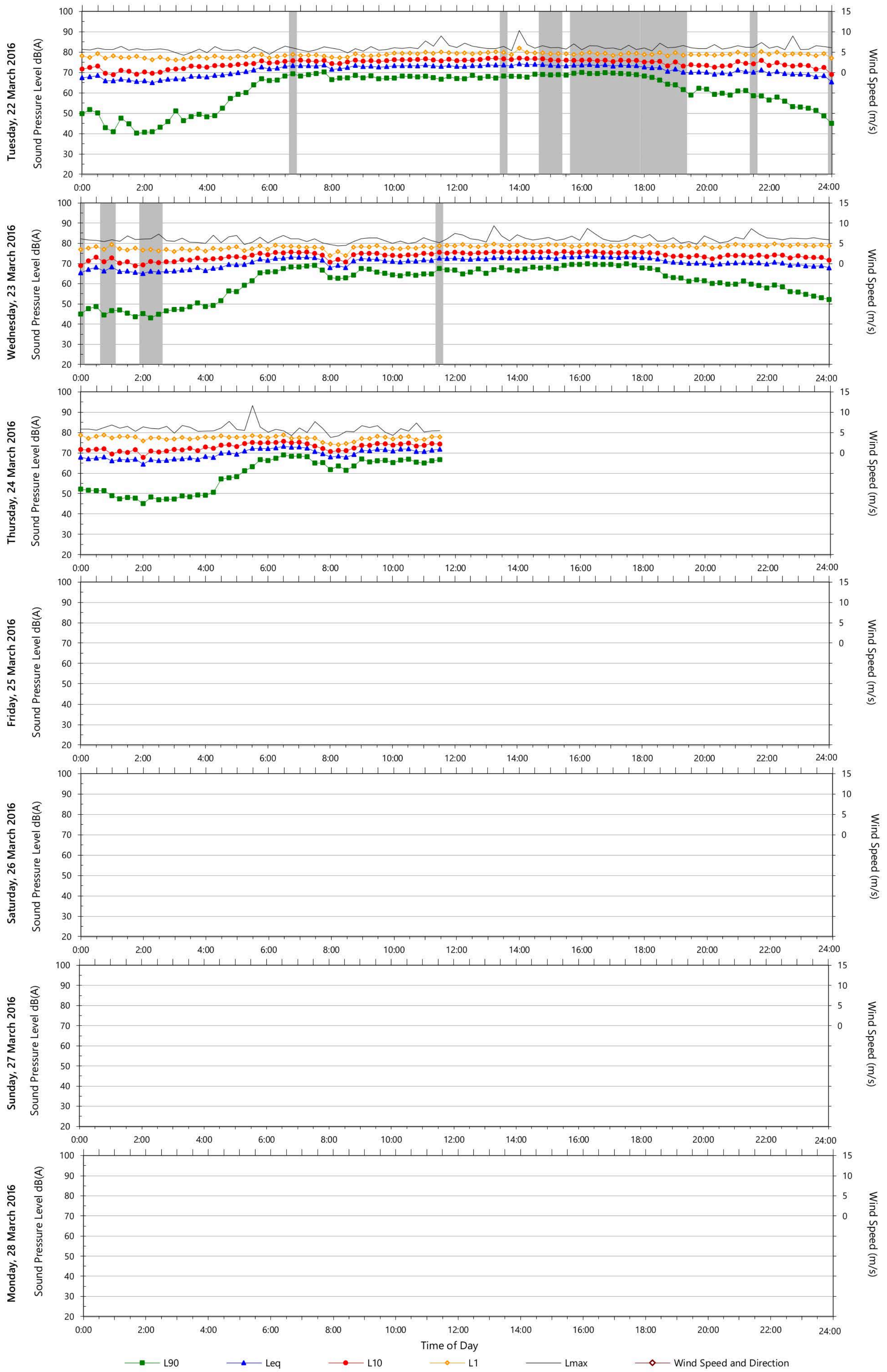
Unattended Monitoring Results

Location: L15 - 70 New England Highway, Tarro



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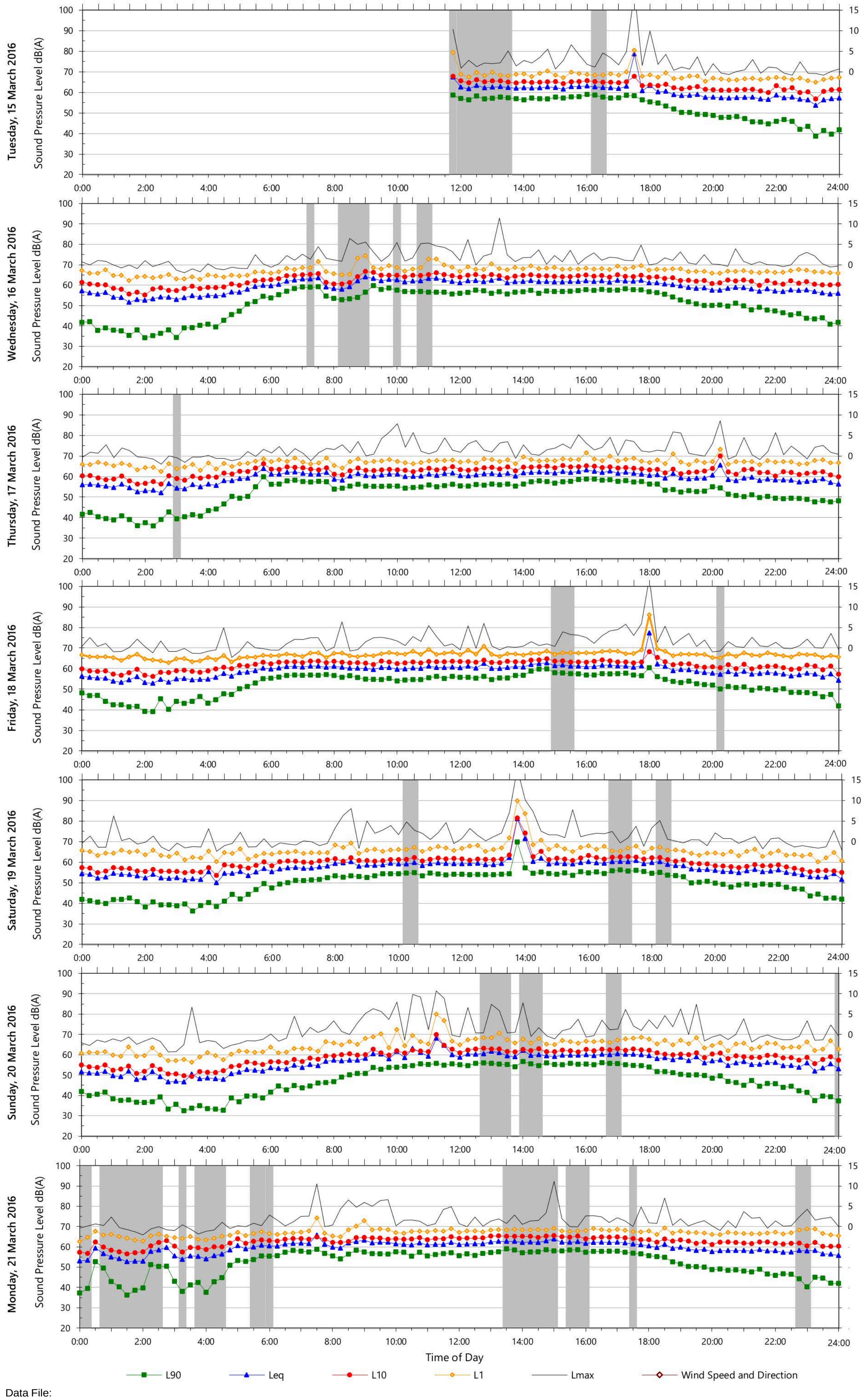

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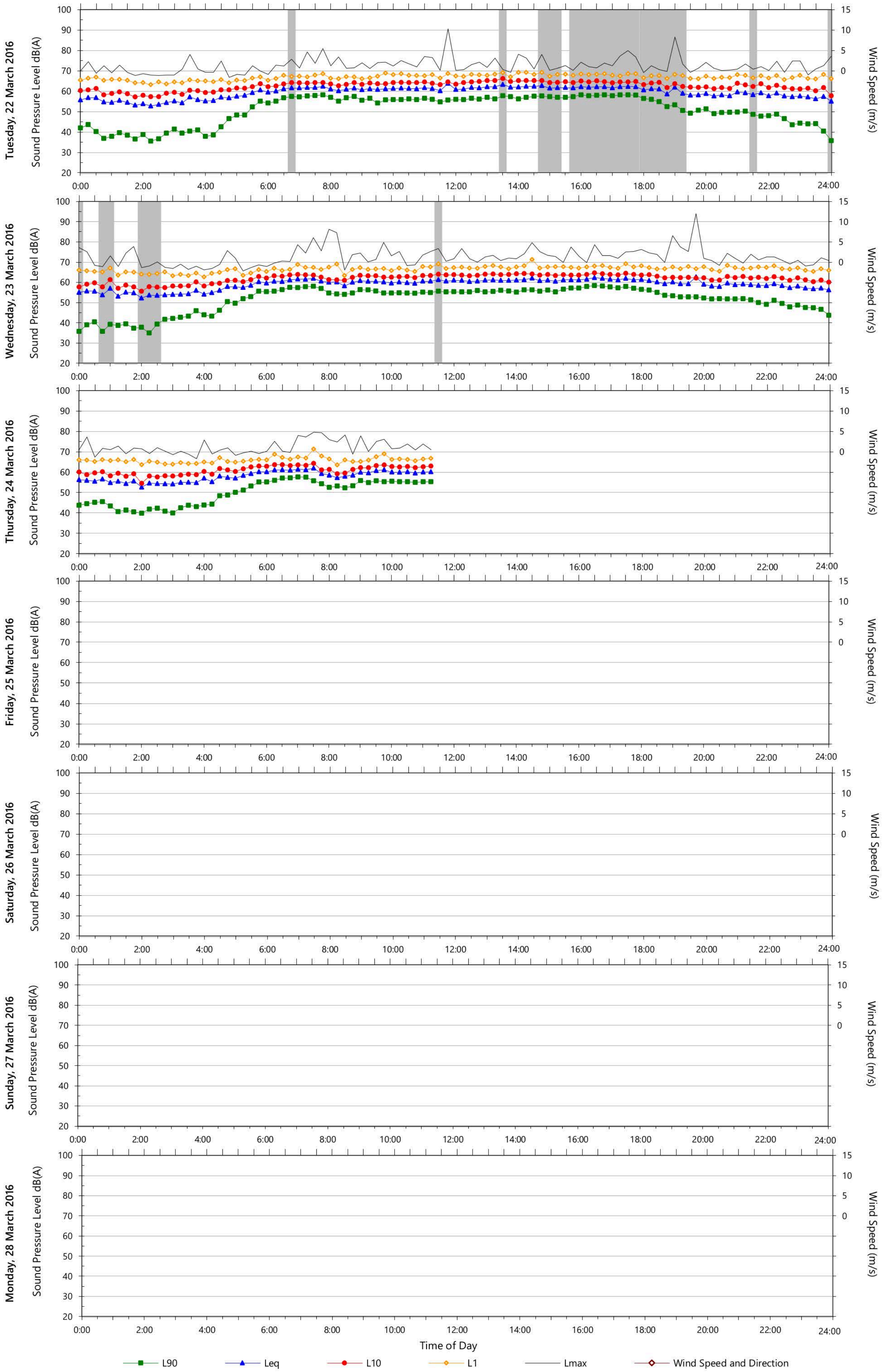
Unattended Monitoring Results **Location: L16 - 44 Sapphire Drive, Tarro**



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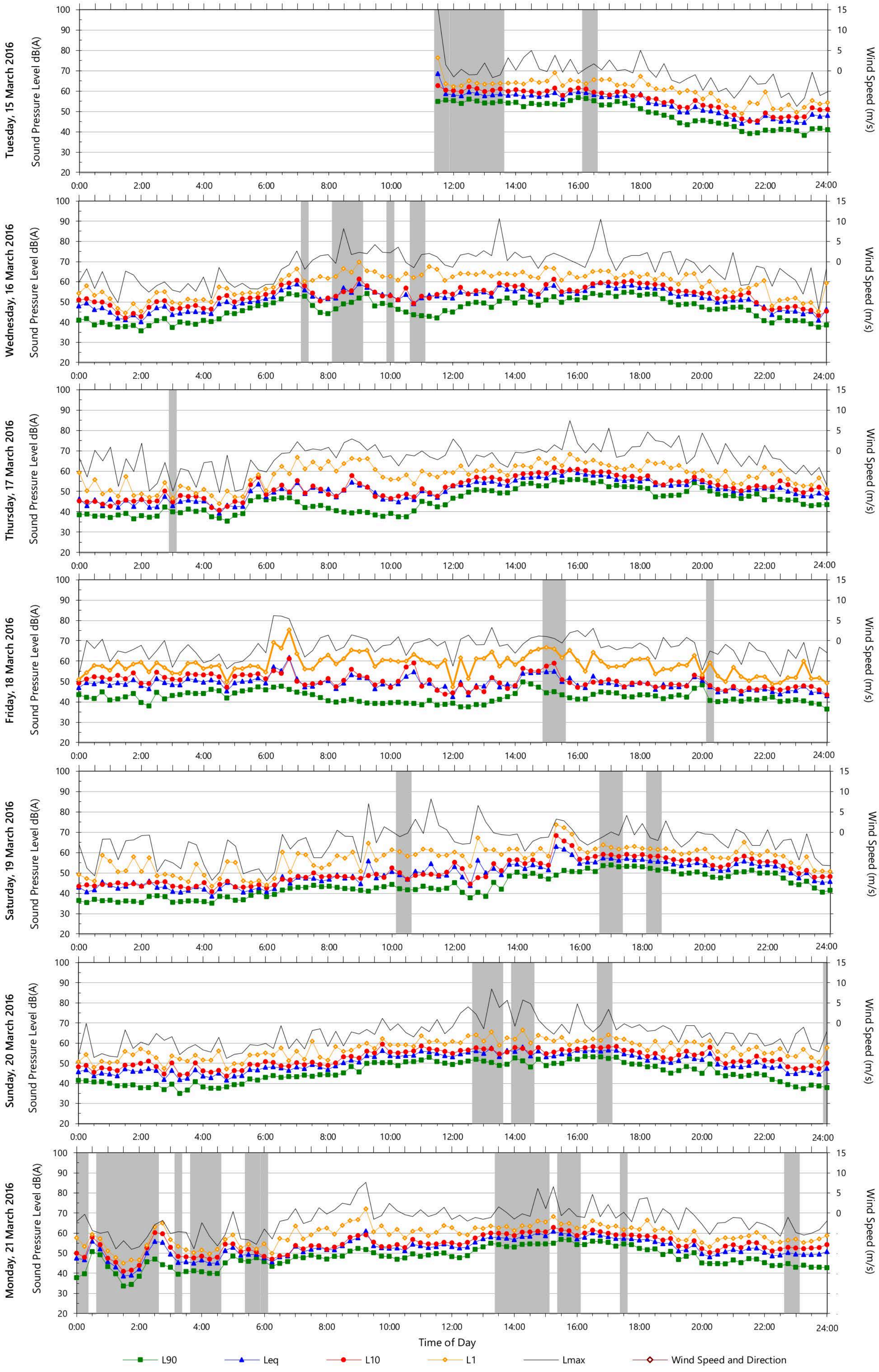
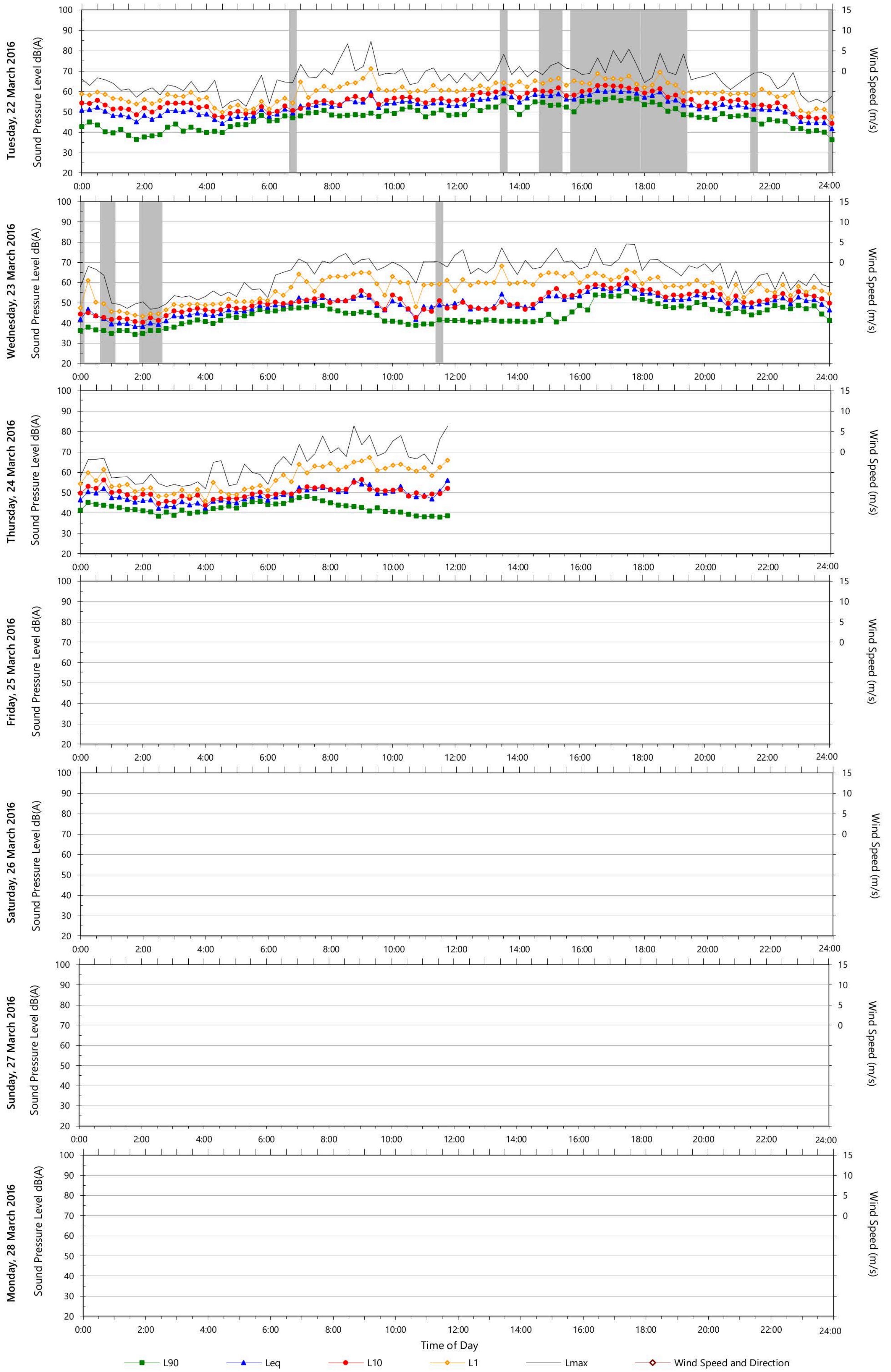


Data File:

Template: QTE-26 Logger Graphs Program (r32)

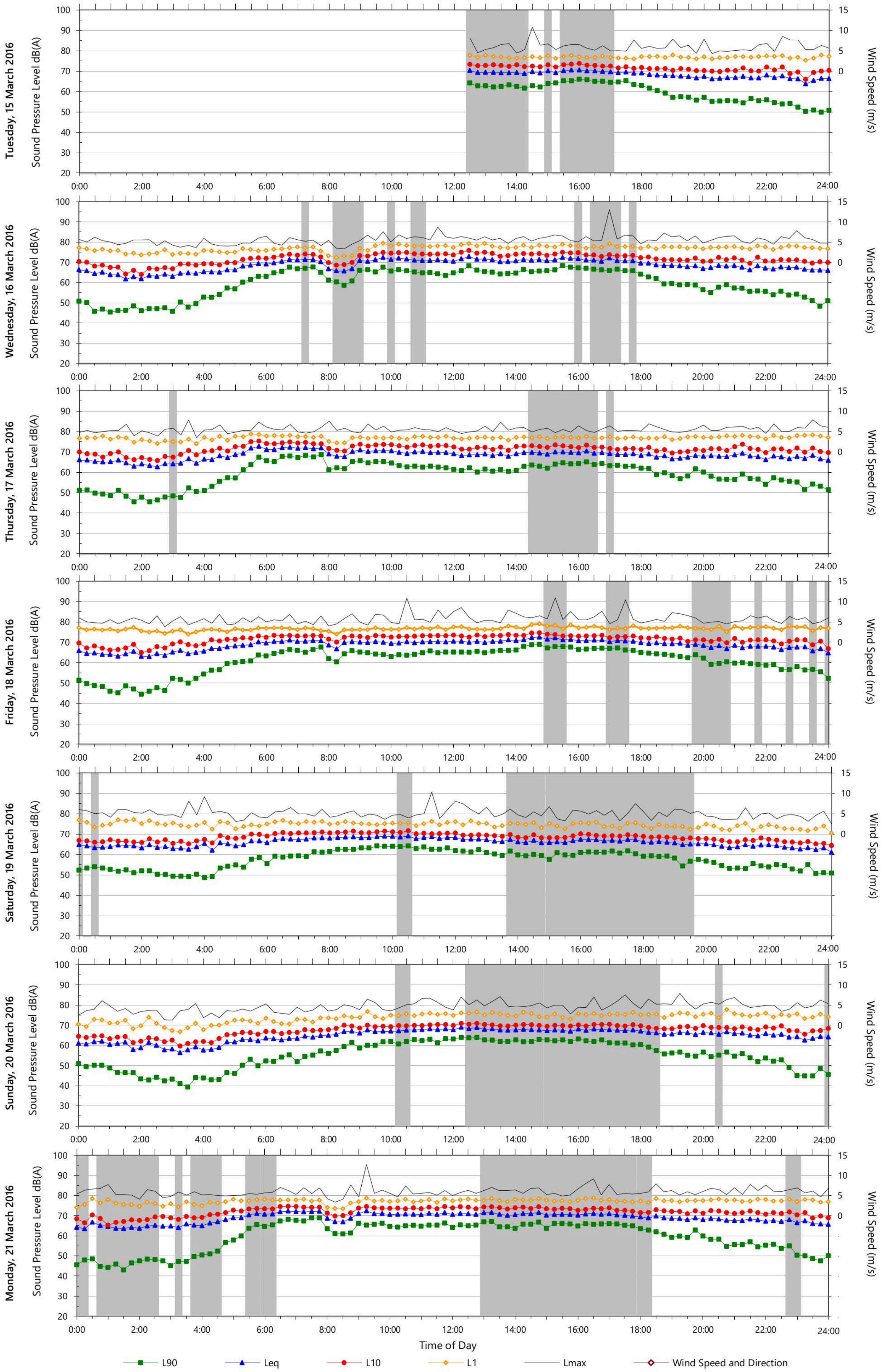
Unattended Monitoring Results

Location: L17 - 11 Central Avenue, Tarro



Data File:

Template: QTE-26 Logger Graphs Program (r32)

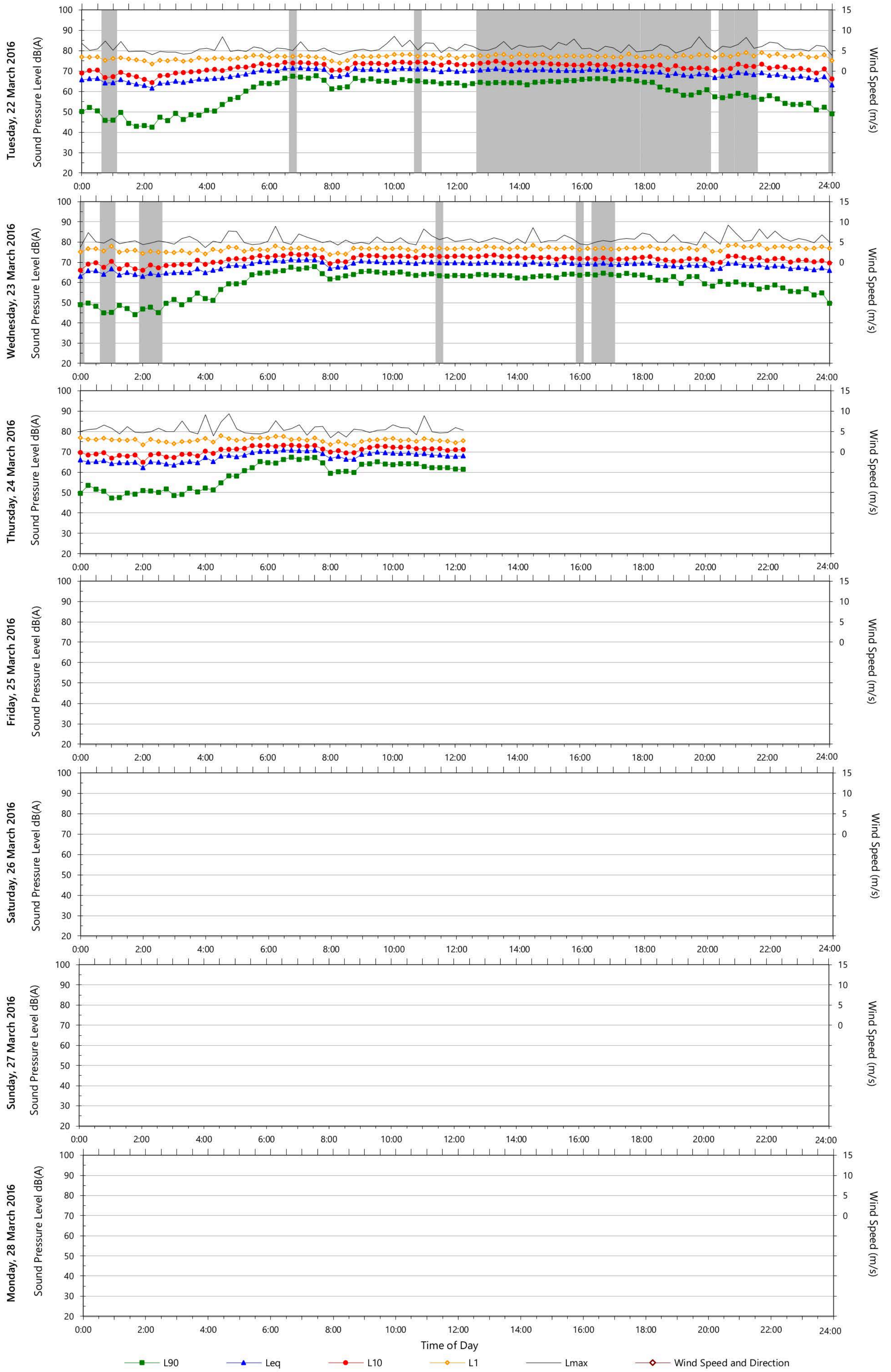


Data File:

Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results

Location: L18 - Tarro Interchange, Tarro

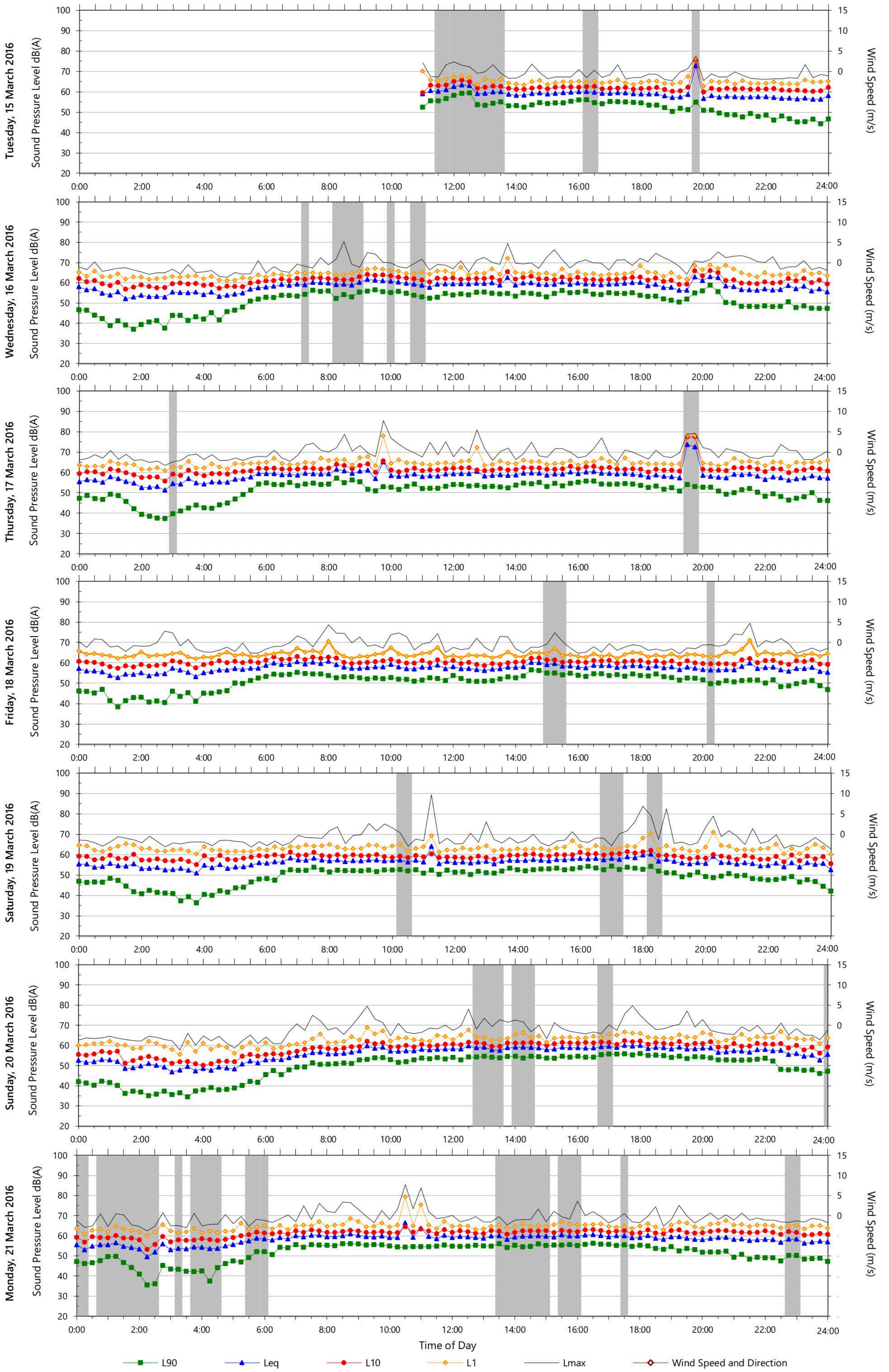


Data File:

Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results

Location: L19 - 2207 Pacific Highway,

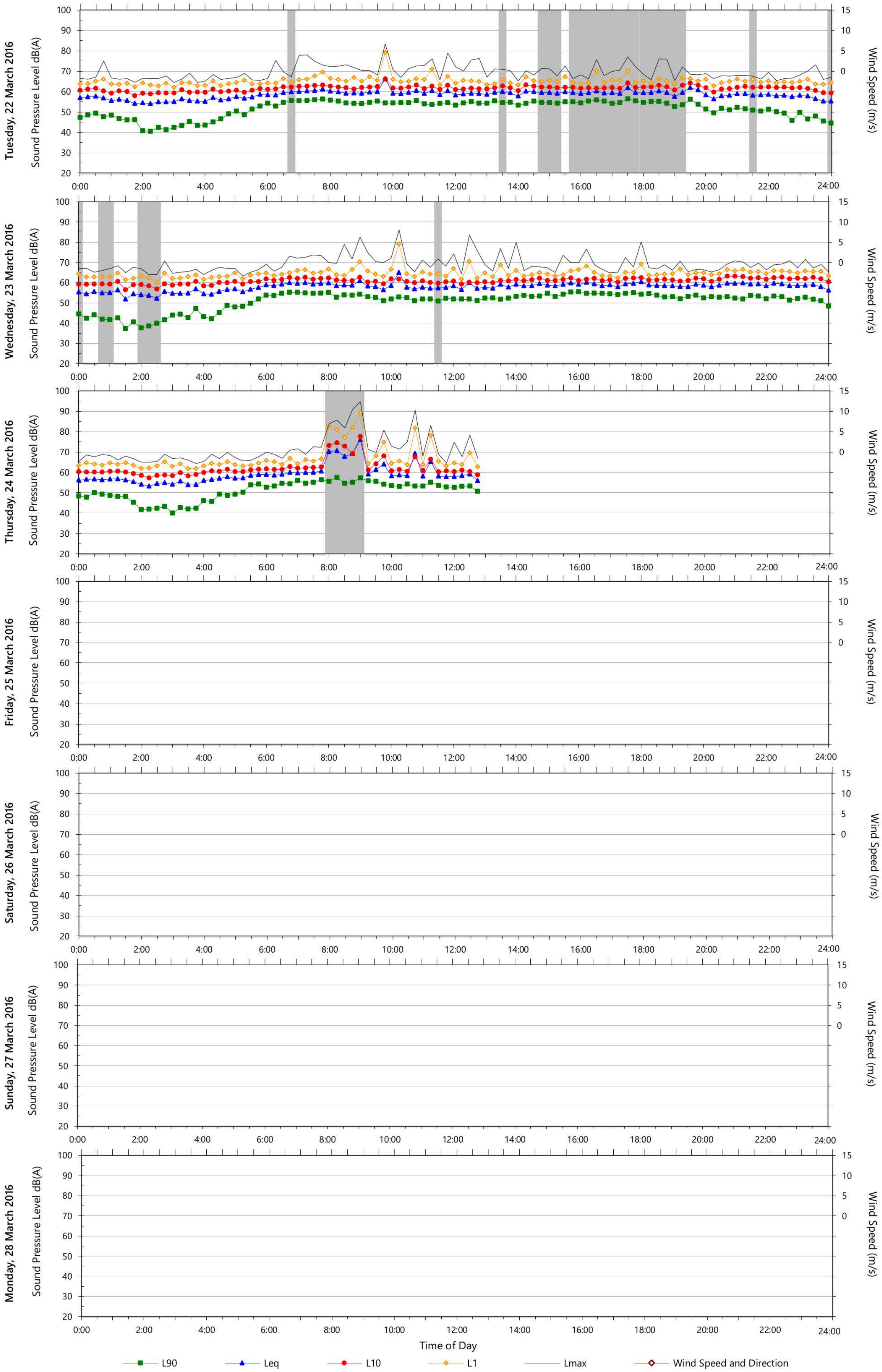


Data File:

Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results

Location: L19 - 2207 Pacific Highway,

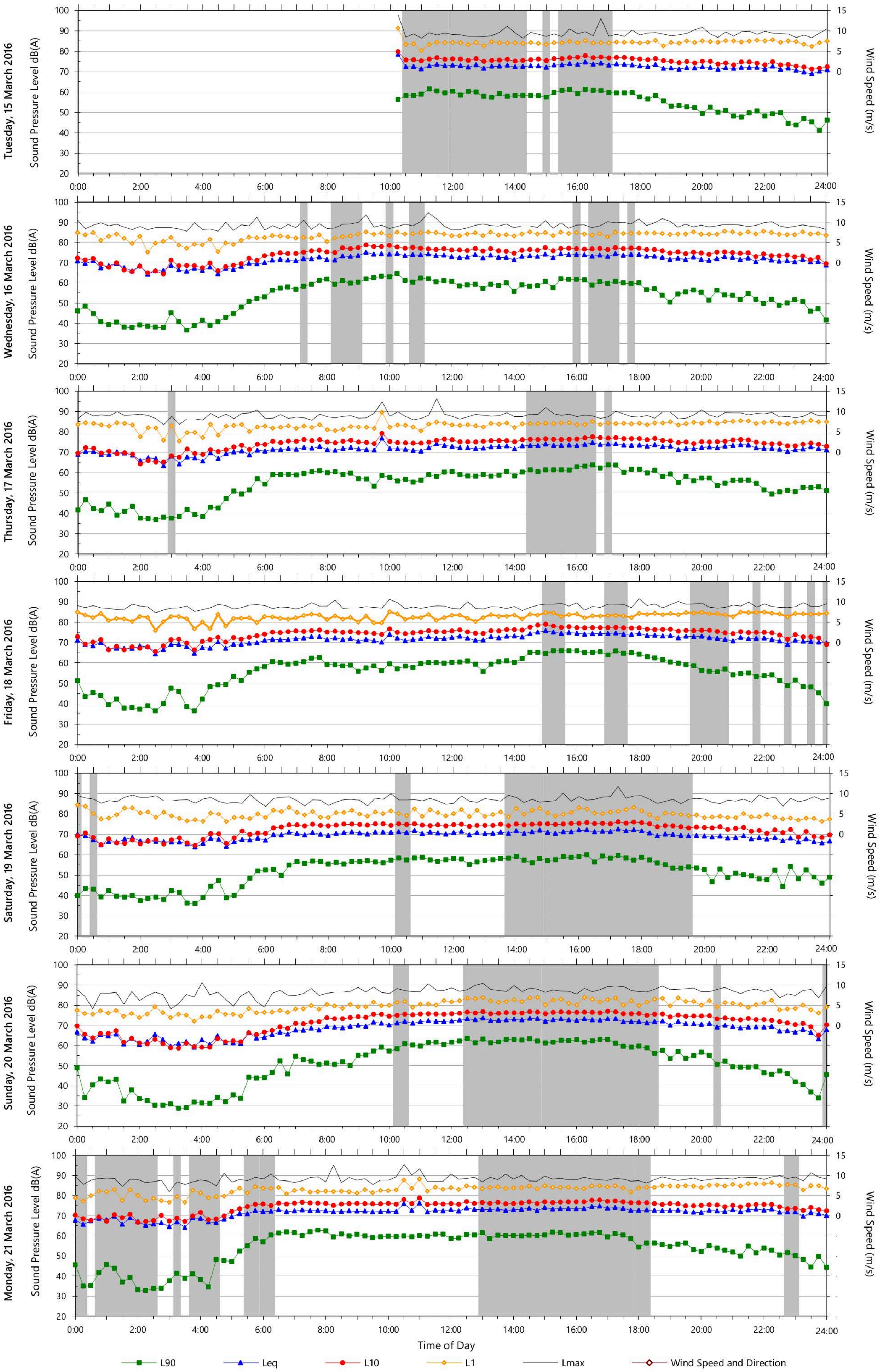


Data File:

Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results

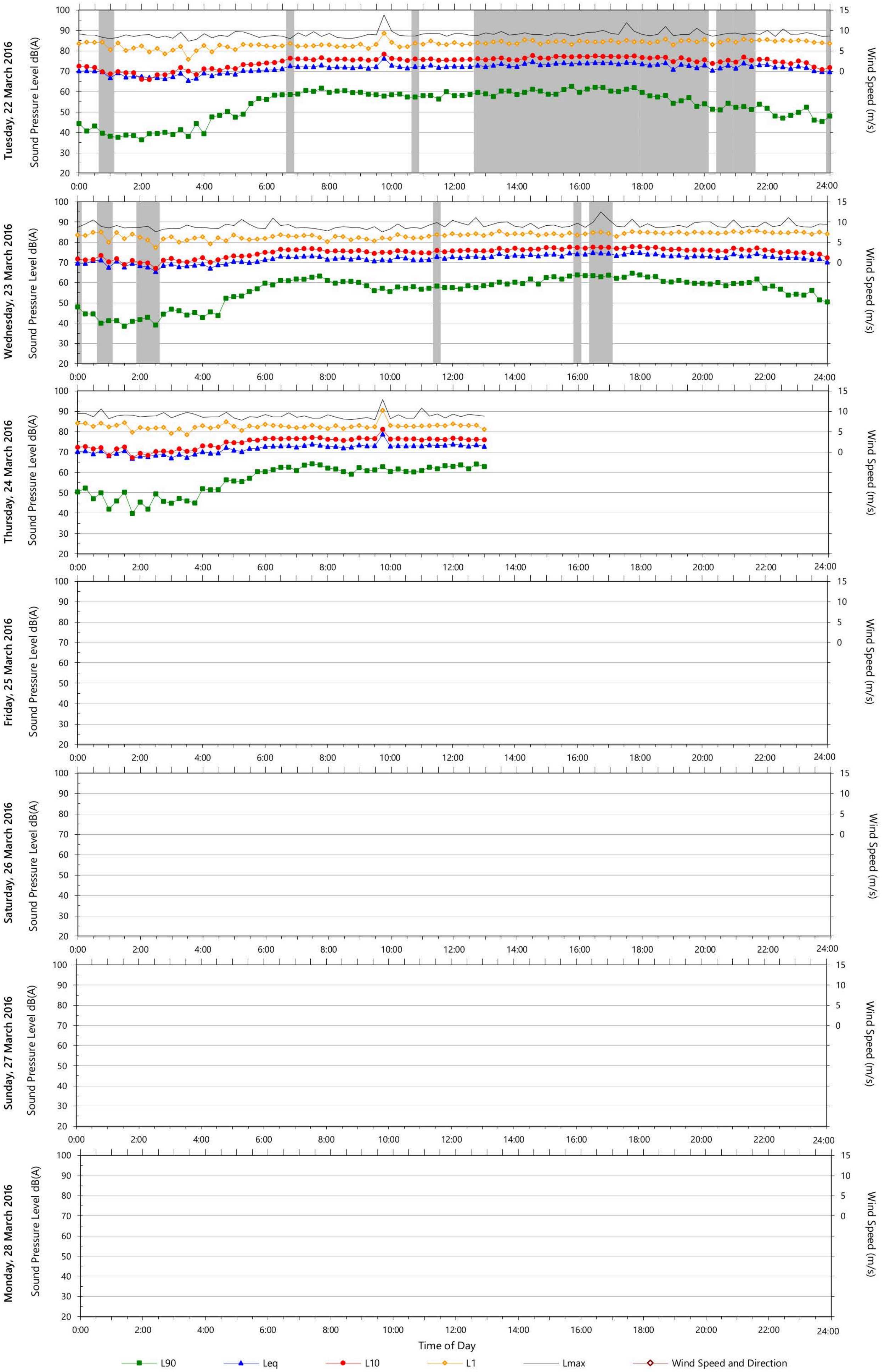
Location: L20 - Pacific Highway, north of Heatherbrae roundabout, Heatherbrae



Data File:

Template: QTE-26 Logger Graphs Program (r32)

Unattended Monitoring Results **Location: L20 - Pacific Highway, north of Heatherbrae roundabout, Heatherbrae**



Data File:

Template: QTE-26 Logger Graphs Program (r32)