NSW GOVERNMENT

Roads and Maritime Services

F6 Extension Stage 1

New M5 Motorway at Arncliffe to President Avenue at Kogarah

Environmental Impact Statement

Appendix G
Noise and Vibration Technical Report

Volume 5

G

(blank page)

Contents

Glossary of terms and abbreviations

Term	Definition
Sound power level	The total sound emitted by a source.
Sound pressure level	The amount of sound at a specified point.
Decibel [dB]	The measurement unit of sound.
A Weighted decibels [dB(A)]	The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1 kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB(A) increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB(A) increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows: 0 dB(A) Threshold of human hearing 30 dB(A) A quiet country park 40 dB(A) Whisper in a library 50 dB(A) Open office space 70 dB(A) Inside a car on a freeway 80 dB(A) Outboard motor 90 dB(A) Heavy truck pass-by 100 dB(A) Jack hammer / subway train 110 dB(A) Rock concert 115 dB(A) Limit of sound permitted in industry 120 dB(A) 747 take off at 250 metres
Frequency [f]	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.
Equivalent continuous sound level [Leq]	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.
Insertion loss	Reduction in noise by inserting a barrier between the source and receiver.
L_{max}	The maximum sound pressure level measured over the measurement period.
L_{min}	The minimum sound pressure level measured over the measurement period.
L_{10}	The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.

Term	Definition
L_{90}	The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L_{90} sound pressure level is used to quantify background noise.
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Day	Construction noise: The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays. Road traffic noise: The period from 0700 to 2200 h every day of the week.
Evening	Construction noise: The period from 1800 to 2200 h Monday to Sunday and Public Holidays. Road traffic noise: Not applicable.
Night	Construction noise: The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays. Road traffic noise: The period from 2200 to 0700 h every day of the week.
Assessment background level [ABL]	The overall background level for each day, evening and night period for each day of the noise monitoring.
Rating background level [RBL]	The overall background level for each day, evening and night period for the entire length of noise monitoring.

Executive summary

The F6 Extension forms Stage 1 of the F6 project. It would comprise a new multi-lane road connecting the New M5 Motorway underground at Arncliffe to a new intersection at President Avenue in Kogarah. Future stages of the project would continue southward.

The project would include approximately four kilometres of twin motorway tunnels, each two lanes wide. Mainline tunnel stubs would allow for connections to future stages of the F6 project. A new intersection at President Avenue with entry and exit ramps would connect President Avenue to the underground tunnels. Road improvements on President Avenue and Princes Highway including lane widening and line marking would be undertaken to improve the traffic flows around the intersections.

This technical paper provides a detailed report assessing potential noise and vibration impacts from both the construction and operational phases of the project. Relevant guidelines and assessment procedures have been followed to ensure all applicable state requirements have been considered. The project's Secretary's Environmental Assessment Requirements (SEARs) and agency comments have also been referenced in the assessment to ensure that all potential impacts have been adequately considered.

A survey has been undertaken of the existing conditions throughout the project area. Buildings throughout the project area have been visually inspected (from the outside) to identify their likely use and the number of storeys. Background noise levels have been monitored at a total of 16 locations to identify the existing noise environment throughout the project area. The existing noise environment allows this assessment to define appropriate noise criteria and validate the operational road noise model.

A construction noise assessment has been conducted in accordance with the *Interim Construction Noise Guideline* and *Construction Noise and Vibration Guideline*. Reasonable worst case construction scenarios have been assessed. Construction of the project is likely to primarily occur during standard construction hours with the exception of the tunnelling and associated support activities, bridge works, and diaphragm wall construction (by exception only). Other out of hours work, such as road works and traffic changes to minimise impacts to the road network, relocation of utilities and delivery and removal of over-sized plant and equipment, would be required and would be subject to the processes outlined in section 5.2.2.

The assessment of noise associated with the construction of the project indicates some exceedances of the *Interim Construction Noise Guideline* noise management levels at the most affected sensitive receivers. The magnitude and number of exceedances are detailed in Chapter 5. Exceedances of the noise management levels occur during the day and night at the most affected sensitive receivers during certain activities. The magnitude of these impacts is consistent with other major works projects and highlights the need for effective noise mitigation and management planning.

Measures have been recommended to mitigate the construction noise impact at adjacent sensitive receivers. The implemented measures would ultimately be selected by the contractor and be largely dependent on the construction strategy and work undertaken. Specific noise management and mitigation measures would be detailed in the contractor's Construction Noise and Vibration Management Plan. The recommended management and mitigation measures which would be considered in the plan include:

- Effective community consultation
- Training of construction site workers
- Use of noise barriers
- Noise monitoring
- Appropriate selection and maintenance of equipment
- Scheduling of work for less sensitive time periods
- Situating plant in less noise sensitive locations
- Construction traffic management
- Respite periods.

Minimum working distances for vibration intensive construction works have been presented. Equipment size would be selected by the contractor taking into account the minimum working distances and the distance between the area of construction and the most affected sensitive receiver. If works need to be undertaken within minimum working distances, vibration monitoring would be undertaken.

Blasting may be used to excavate the bench within the tunnels. Controlled blasting may be undertaken along the length of the alignment during the excavation of the tunnel, at depths greater than 30 m, where the geology is suitable (i.e. not soft ground). Blasting methods can significantly reduce exposure to noise and vibration for residents and businesses above the tunnels. Blasting can also shorten excavation timeframes.

If blasting is to be used, it would be undertaken to comply with the relevant guidelines and criteria. An appropriate blasting contractor would be engaged to plan and carry out the blasts, ensuring minimal disruption to surrounding sensitive receivers.

Construction traffic would increase road traffic noise level in some areas, but this would largely remain less than 2 dB(A). An increase of 2 dB(A) or less is compliant with the traffic noise increase criterion in the *Road Noise Policy*. Noise levels at one location have been identified to potentially exceed the traffic noise increase criterion. The future traffic movements on Bruce Street, Brighton-le-Sands, are associated with the construction of the shared pedestrian and cycle path, which would have a very limited time scale compared to the overall project. This is unlikely to have a significant impact to the local community and should be managed through effective communication with those that may potentially be affected.

Ground-borne noise and vibration from tunnelling activities has been assessed in accordance with the applicable guidelines. Through residential areas the alignment is quite deep, meaning that the sensitive receivers are unlikely to be adversely impacted by the proposed works. Vibration would be well below criteria, and ground-borne noise is expected to meet the criteria at all but a single location where an exceedance of 1 dB(A) is predicted. While compliance has been identified, receivers directly above the alignment should be communicated with to make them aware works are taking place and during times of low ambient noise it may be possible to hear ground-borne noise associated with the project.

Cumulative construction noise impacts may occur as a result of other major projects occurring within proximity to the project. Consultation would be undertaken between the projects to minimise potential impacts where feasible and reasonable.

The proposed Arncliffe construction facility is currently being used for the construction of the New M5 Motorway. The continuation of construction works in this area has the potential to cause construction fatigue, increasing the perceived severity of any impacts. Considering the construction requirements (including spoil haulage) are significantly lower (spoil haulage would be expected to be less than half the movements per day required for the New M5 Motorway), the noise generated by the work is expected to be appreciably less. It is likely that the local community would perceive this project as a tapering off of work rather than a continuation of construction. While the impacts would be lower, it is acknowledged that individuals are affected differently and there is the potential for construction fatigue. A comprehensive communication plan would be developed to consult with those potentially affected and develop strategies to ameliorate impacts with residents that may be affected.

An operational road traffic noise assessment has been completed in accordance with the Environment Protection Authority's *NSW Road Noise Policy* and Roads and Maritime's *Noise Criteria Guideline* and *Noise Mitigation Guideline*.

Noise levels have been predicted at sensitive receiver locations throughout the project area for both the daytime and night-time scenarios. This project would move some existing traffic from The Grand Parade and the Princes Highway, onto this route. The additional traffic would cause a moderate increase in noise (less than 2 dB(A)) on President Avenue.

Exceedances of the applicable noise criteria have been identified. The majority of these exceedances are exceedances of the Cumulative Noise Limit. These exceedances are generated by existing high noise levels throughout the project area. A small number of receivers would exceed the RNP criteria and increase by more than 2 dB(A). These exceedances occur due to the new on and off ramps and portals at the President Avenue intersection. Appropriate noise mitigation has been recommended to minimise adverse impacts on the community by the project, in accordance with the Road and Maritime's draft *At-Receiver Noise Treatment Guideline*.

The cumulative operational road traffic noise has been considered by assessing this project in the Year 2036 with a range of other Roads and Maritime projects that may be built in the future. This is a worst-case situation and assumes many projects that do not have funding, and have not been approved would proceed. The recommended noise mitigation has considered this scenario, ensuring that should all these projects proceed appropriate noise mitigation measures would be provided to the affected community.

Noise mitigation in the form of low noise pavements, noise barriers, and architectural treatments have been considered to protect the community. Due to the very limited benefit, low-noise pavements and noise barriers were not found to be reasonable for this project. There were also very limited locations that noise barriers could be installed as access would need to be maintained to the existing properties. Ultimately architectural treatment was recommended at all sensitive receivers that were found eligible for the consideration of noise mitigation. These requirements would be clarified at the detailed design phase when more information would be available.

This project has the potential to generate additional traffic through other routes, creating large increases in noise on roads that are not within the extent of the project (or parallel routes). An assessment of the road network surrounding the project identified that increases in noise of more than 2 dB(A) may occur on O'Connell Street, Monterey and Civic Avenue, Kogarah. Significant increases in traffic movements have been identified on these roads as alternative routes heading south towards Rocky Point Road. Local area traffic management planning has been considered to minimise these impacts, however this would need to be agreed with the local council. In the event that a strategy to remove these impacts is not developed, noise mitigation in the form of architectural treatments would be provided.

Operational traffic noise would be monitored at sensitive receivers between six months and one year after opening. If the traffic noise levels are above the levels as predicted during detailed design, consideration of additional feasible and reasonable mitigation measures would be undertaken.

An assessment of operational facilities, was undertaken in accordance with the Environment Protection Authority's *Noise Policy for Industry*. This assessment has found that noise levels from the operational facilities would comply with the applicable criteria at the most affected noise sensitive receivers, with appropriate noise controls in place. A more detailed assessment would need to be undertaken at the detailed design phase to confirm the noise source assumptions and required attenuation to meet the applicable noise criteria.

1 Introduction

The project would comprise a new multi-lane road between the New M5 Motorway at Arncliffe and President Avenue at Kogarah. The project would connect underground with the New M5 Motorway tunnel and to a new surface level intersection at President Avenue, Kogarah.

1.1 Overview of the project

Key components of the project would include:

- An underground connection to the existing stub tunnels at the New M5 Motorway at Arncliffe
- Twin motorway tunnels (around four kilometres in length) between the New M5 Motorway at Arncliffe and President Avenue, Kogarah
- A tunnel portal and entry and exit ramps connecting the tunnels to a surface intersection with President Avenue
- Intersection improvements at the President Avenue / Princes Highway intersection
- Mainline tunnel stubs to allow for connections to future stages of the F6 Extension
- Shared pedestrian and cycle pathways connecting Bestic Street, Rockdale to Civic Avenue, Kogarah via Rockdale Bicentennial Park (including an on-road cycleway)
- An Operational Motorway Control Centre to be located off West Botany Street, Rockdale
- Ancillary infrastructure and operational facilities for signage (including electronic signage), ventilation structures and systems at Rockdale, fire and safety systems, and emergency evacuation and smoke extraction infrastructure
- A permanent power supply connection from the Ausgrid Canterbury subtransmission substation
- Temporary construction ancillary facilities and temporary works to facilitate the construction of the project.

Once complete, the F6 Extension Stage 1 would improve connections and travel times between Sydney and the Princes Highway and enhance connections for residents and businesses within the broader regional area as well as promote and support economic development in areas to the south, such as Sutherland and the Illawarra.

Approval for the project is being sought under Part 5, Division 5.2 of the EP&A Act. Future stages of the F6 Extension would be subject to separate planning applications and assessments would be undertaken accordingly.

The configuration and design of the project will be further developed to take into consideration the outcomes of community and stakeholder engagement.

1.2 Project location

This project would be generally located within the Bayside local government area. The project commences about 8 kilometres south west of the Sydney central business district (CBD). The proposed President Avenue intersection would be located about 11 kilometres south east of the Sydney CBD.

1.3 Purpose of this report

This technical report provides a noise and vibration impact assessment of the project and has been prepared to support the EIS. The construction and operational phases of the report have been assessed using the applicable noise and vibration guidelines.

1.4 SEARs and Agency comments

Table 1-1 SEARs – NOISE AND VIBRATION

Assessment requirements	Where addressed in this report
• The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must take into consideration and address the redistribution of traffic (including on local feeder roads) and operational plant and equipment, and must include consideration of impacts to sensitive receivers and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	Relevant NSW noise and vibration guidelines are outlined in section 4.1. Potential noise impacts during construction and operation (including but not limited to road traffic noise, sleep disturbance and low frequency noise) are assessed in section 5 and section 6 respectively.
• An assessment of construction noise and vibration impacts must include:	
a) the nature of construction activities (including transport, tonal or impulsive noise-generating works and the removal of operational noise barriers, as relevant);	The nature of construction activities is outlined in section 4 and section 5
b) the intensity and duration of noise and vibration impacts (both air and ground borne). This must include consideration of extended impacts associated with ancillary facilities and activities (and the like) and construction fatigue;	The intensity and duration of potential noise and vibration impacts are considered throughout the assessment of construction and operational noise impacts in section 5 and section 6
c) the identification of receivers, existing and likely under approved developments, during the construction period;	Sensitive receivers are identified in section 3.3
d) the nature, sensitivity and impact to receivers;	The nature and severity of potential noise impacts to sensitive receivers is assessed in section 5 and section 6
e) the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	Respite periods are discussed in section 8.1
f) the potential for works outside standard construction hours, including predicted levels, exceedances, number of potentially affected receivers, and justification for the activity in terms of the Interim Construction Noise Guideline (DECCW, 2009);	The potential for works outside standard construction hours is discussed in section 5.2.2
g) a cumulative noise and vibration assessment inclusive of impacts from the project (including concurrent project construction activities);	Potential cumulative noise impacts are assessed in section 7
h) a cumulative noise and vibration assessment of the impacts from the project and the construction of other transport infrastructure and development in the vicinity of the project including taking into account the installation and removal of temporary noise walls;	Potential cumulative noise impacts are assessed in section 7
i) details and analysis of the predicted effectiveness of mitigation measures to adequately manage identified impacts, including cumulative impacts as identified in (g) and (h) and a clear identification of residual noise and vibration following application of mitigation measures; and	Mitigation measures are discussed in section 8

Assessment requirements	Where addressed in this report
j) description of how community preferences could be taken into account in the design of mitigation measures and consider tailored mitigation, management and communication strategies.	Community consultation for the development of noise mitigation, management and communication strategies are outlined in section 8.1.2
• The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Potential impacts from blasting are assessed in section 4.5 and section 5.5.4

1.5 Structure of this report

This report is structured as follows:

- Chapter 1 – Introduction – This chapter introduces the project and describes the project area
- Chapter 2 – The project – This chapter provides a description of the project during construction and operation as relevant to this impact assessment
- Chapter 3 – Existing ambient environment. This chapter provides a description of the existing noise environment within the study area
- Chapter 4 – Assessment methodology. This chapter summarises the assessment criteria that applies to this assessment
- Chapter 5 – Assessment of construction noise and vibration impacts. The chapter provides the results of the construction noise and vibration impact assessment
- Chapter 6 – Assessment of operational noise impacts. This chapter provides the results of the construction noise impact assessment for road traffic noise and operational facilities
- Chapter 7 – Assessment of cumulative impacts. This chapter provides the results of the cumulative impact assessment considering other concurrent projects
- Chapter 8 – Management of impacts. The chapter outlines the recommended mitigation and management measures for potential construction and operational noise, subject to detailed design
- Chapter 9 – Conclusion. This chapter presents the conclusion to the report.

2 The Project

2.1 Project features

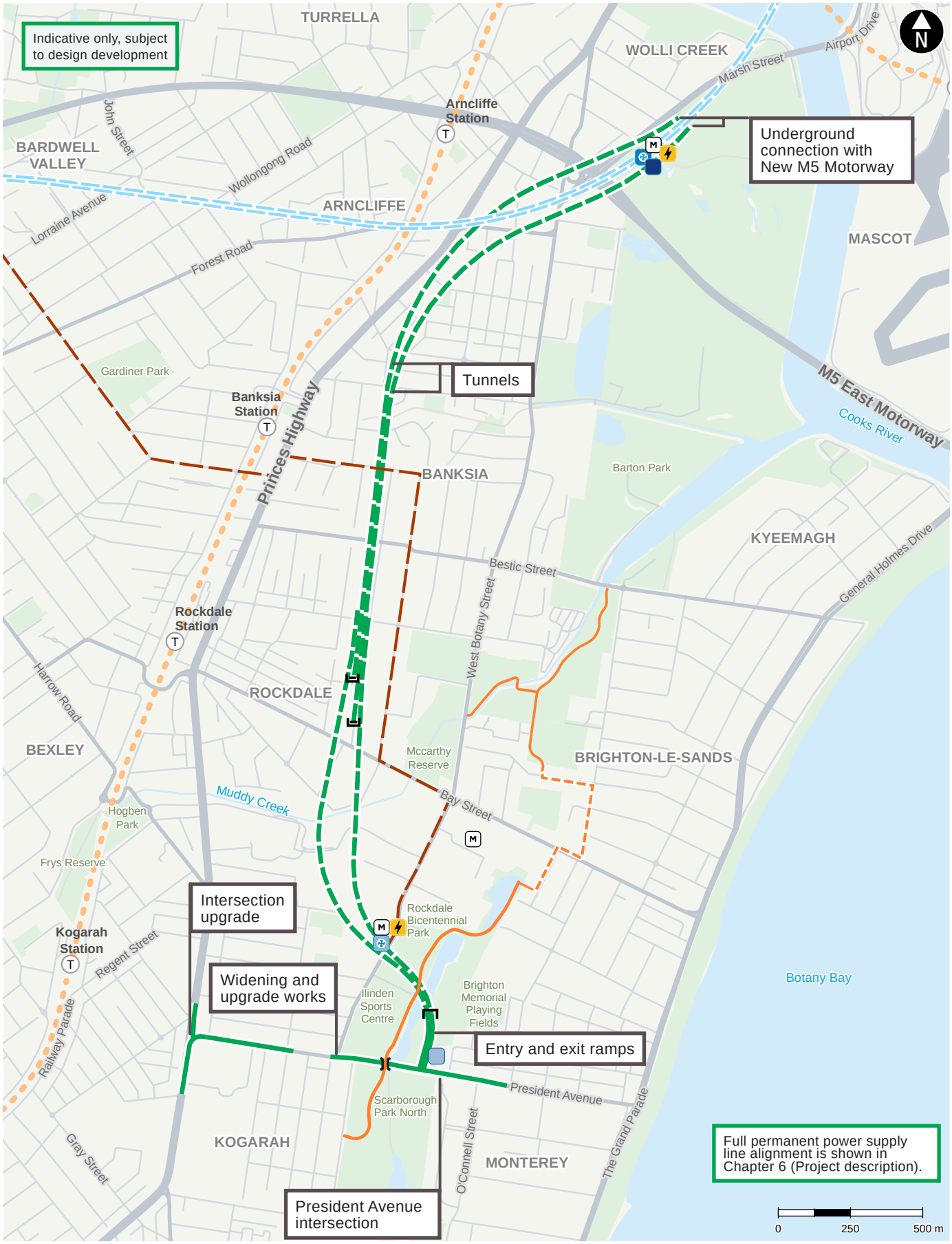
The project would comprise a new multi-lane road between the New M5 Motorway at Arncliffe and President Avenue at Kogarah.

Key components of the project would include:

- Twin mainline tunnels. Each mainline tunnel would be around 2.5 kilometres in length, sized for three lanes of traffic, and line marked for two lanes as part of the project
- A tunnel-to-tunnel connection to the New M5 Motorway southern extension stub tunnels, including line marking of the New M5 Motorway tunnels from St Peters interchange to the New M5 Motorway stub-tunnels
- Entry and exit ramp tunnels about 1.5 kilometres long (making the tunnel four kilometres in length overall) and a tunnel portal connecting the mainline tunnels to the President Avenue intersection
- An intersection with President Avenue including entry and exit ramps and the widening and raising of President Avenue
- Upgrade of the President Avenue / Princes Highway intersection to improve intersection capacity
- Shared cycle and pedestrian pathways connecting Bestic Street, Brighton-Le-Sands to Civic Avenue, Kogarah (including an on-road cycleways)
- Three motorway operation complexes:
  - Arncliffe, including a water treatment plant, substation and fitout (mechanical and electrical) of a ventilation facility currently being constructed as part of the New M5 Motorway project
  - Rockdale (north), including a motorway control centre, deluge tanks, a workshop and an office
  - Rockdale (south), including a ventilation facility, substation and power supply.
- Reinstatement of Rockdale Bicentennial Park and recreational facilities
- In-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities
- Drainage infrastructure to collect surface water and groundwater inflows for treatment
- Ancillary infrastructure for electronic tolling, traffic control and signage (both static and electronic signage)
- Emergency access and evacuation facilities (including pedestrian and vehicular cross and long passages); and fire and life safety systems
- A permanent power supply connection from the Ausgrid Canterbury subtransmission substation, to Rockdale (south) motorway operations complex.
- New service utilities, and modifications and connections to existing service utilities.

The project does not include ongoing motorway maintenance activities during operation or future upgrades to other intersections in the vicinity during operation. These works are permitted under separate existing approvals and are subject to separate assessment and approval in accordance with the EP&A Act.

The key features of the project are shown on **Figure 1**.



LEGEND

- The project in tunnel
- The project on surface
- On-road cycleway
- Shared cycle and pedestrian pathways
- President Avenue shared cycle and pedestrian bridge
- Tunnel stub
- Tunnel portal
- Water quality basin
- Water treatment facility
- Rockdale ventilation facility
- Motorway operations complex
- Substation
- Permanent power supply line
- New M5 Tunnel
- Arncliffe ventilation facility*
- * Under construction as part of the New M5 Motorway project
- Road
- Waterway
- Railway line
- Railway station
- Parks and recreation

Figure 1 Project features

2.2 Construction

2.2.1 Construction activities

Construction activities would be undertaken within the construction boundary discussed in **section 2.2.2**, which includes the following six construction ancillary facilities:

- Arncliffe construction ancillary facility (C1) at Arncliffe, within the Kogarah Golf Course currently being used for the construction of the New M5 Motorway
- Rockdale construction ancillary facility (C2) at Rockdale, within a Roads and Maritime depot at West Botany Street
- President Avenue construction ancillary facility (C3) at Rockdale, north and south of President Avenue within Rockdale Bicentennial Park and part of Scarborough Park North, and a site west of West Botany Street
- Shared cycle and pedestrian pathways construction ancillary facilities (C4 and C5) at Brighton-le-Sands, within the recreation area between West Botany Street and Francis Avenue, near Muddy Creek
- Princes Highway construction ancillary facility (C6), on the north-east corner of the President Avenue and Princes Highway intersection.

Construction activities required for the project can be grouped into the following areas:

- Tunnelling and tunnel construction activities
  - Primary excavation of the tunnel using roadheaders and possibly blasting
  - Spoil handling and removal
  - Excavation of benches within the tunnels
  - Excavation of the cross passages between the twin road tunnels
- Construction activities associated with the Arncliffe construction ancillary facility (C1), including:
  - Establishment of temporary noise attenuation measures
  - Construction of a spoil shed
  - Tunnelling works, spoil handling and removal, as well as stockpiling of excavated material which would occur within the shed
  - Construction of a new water treatment plant and substation (separate to the New M5 Motorway infrastructure which is currently under construction)
  - Fitout of the Arncliffe motorway operations complex (MOC)
  - Rehabilitation and landscaping
- Construction activities associated with the Rockdale construction ancillary facility (C2):
  - Establishment of temporary noise attenuation measures
  - Demolition and clearing of structures, including buildings within the existing compounds
  - Construction of an acoustic shed for stockpiling
  - Construction of the decline tunnel by cut and cover
  - Tunnelling works, spoil handling and removal, as well as stockpiling of excavated material which occurs within the shed
  - Construction of the Rockdale motorway operations complex (MOC) and Motorway Control Centre (MCC) buildings
  - Fitout, testing and commissioning of the Rockdale (north) MOC and MCC
  - Rehabilitation and landscaping (including reconfiguration of the site to enable ongoing/future use for maintenance activities)

- Construction activities associated with the cut and cover ramp structure north of President Avenue (part of the President Avenue construction ancillary facility (C3) site):
  - Site establishment, including the commissioning of a bentonite plant for use in construction of the diaphragm walls
  - Temporary stockpiling of spoil and fill materials for later re-use or prior to off-site removal
  - Excavation of a temporary deviation of the existing waterway and construction of a working platform to facilitate works
  - Installation of bored piles
  - Construction of diaphragm wall, guide walls and panels
  - Excavate to soffit of roof slab
  - Construction of the cut and cover structure
  - Construction of the base slab of the ramps
  - Return of the waterway to the original alignment
  - Rehabilitation and landscaping
- Construction of the MOC facility at Rockdale (south) (at the President Avenue construction ancillary facility (C3)):
  - Construction of the MOC
  - Fitout, testing, and commissioning of the MOC
  - Site rehabilitation and landscaping
- President Avenue Roadworks and shared pedestrian and cycle pathways overpass works (both within and outside the defined extent of the President Avenue construction ancillary facility (C3)):
  - Relocation of utilities/services
  - Demolition and clearing of structures, including buildings
  - Pavement works
  - Culverts installation
  - Final asphalting and line marking
  - Construction of the shared pedestrian and cycle pathways overpass over President Avenue
  - Site rehabilitation and landscaping
- Construction activities associated with the Shared pedestrian and cycle pathways east construction ancillary facility (C4):
  - Operation of the shared pedestrian and cycle pathways east construction compound
  - Pavement works associated with the construction of the shared pedestrian and cycle pathways
- Construction activities associated with the Shared pedestrian and cycle pathways west construction ancillary facility (C5):
  - Operation of the shared pedestrian and cycle pathways west construction compound
  - Pavement works
- Princes Highway Intersection upgrade works:
  - Relocation of utilities and services
  - Demolition and clearing of structures, including buildings
  - Excavate to subgrade level
  - Pavement works
  - Final asphalting and line-marking

- Rehabilitation and line marking.

- Construction activities associated with the Princes Highway construction ancillary facility (C6)
  - Construction compound establishment
  - Site compound operations
  - Rehabilitation and landscaping.

An overview of the project's construction boundary and construction ancillary facilities is provided in **Figure 2**.

Tunnelling works and associated surface support works including spoil haulage would be undertaken 24 hours per day and seven days per week.

While every effort would be made to restrict construction activities to standard construction hours (7am to 6pm, Monday to Friday and 8am to 1pm, Saturday, with no works on Sunday or public holidays) in some cases this may not be possible. Works which are undertaken near active roads may be required to be undertaken out of hours to maximise the safety of workers and efficiency of the road network. In addition it is noted that standard hours road occupancy licences are unlikely to be permitted by the Roads and Maritime Transport Management Centre (TMC). Justification for the requirement of works undertaken during out of hours periods is provided in **section 5.2.2**.

Works that would be required to be undertaken during out of hours periods would include activities such as:

- Relocation of utilities (where the location is in close proximity to traffic)
- Pavement and temporary median works
- Asphalt works and line-marking
- Use of construction ancillary facilities to support out of hours works
- Shared pedestrian and cycle pathways overpass installation
- Diaphragm wall construction (evening and by exception only).

Other works that would need to be undertaken outside of standard daytime construction hours and do not require any further approval would include any of the following circumstances:

- Works which are determined to comply with the relevant Noise Management Level (NML) at the most affected sensitive receiver
- The delivery of materials as required by the Police or other authorities for safety reasons
- Where it is required to avoid the loss of lives, property and/or to prevent environmental harm in an emergency
- Where agreement is reached with affected receivers work may also be undertaken where explicitly approved through an Environment Protection Licence.

The remainder of construction activities would take place within standard construction hours. Assessed construction activities are presented in **section 5.1**. The construction activities which are likely to be noisiest at noise sensitive receivers have been considered as part of this assessment to provide a conservative approach. Construction noise levels will at times be quieter than predicted in this assessment.

2.2.2 Construction boundary

The area required for project construction is referred to as the 'construction boundary'. This comprises the surface construction works area, and construction ancillary facilities (refer to **Figure 2**). Utility works to support the project would occur within and outside the construction boundary (refer to **Chapter 7** (Construction) of the EIS).

In addition to these works, the underground construction boundary (including mainline tunnel construction and temporary access tunnels) is also shown on **Figure 2**.

C1

- Tunnelling and spoil handling
- Construction of MOC1 (Water treatment plant, substation)
- Fitout, testing and commissioning of tunnels and MOC 1

C2

- Construction of the decline tunnel
- Tunnelling and spoil handling
- Pavement works for internal access road
- Construction of MOC2
- Reconfiguration of the site to enable ongoing/future use for maintenance activities

C3

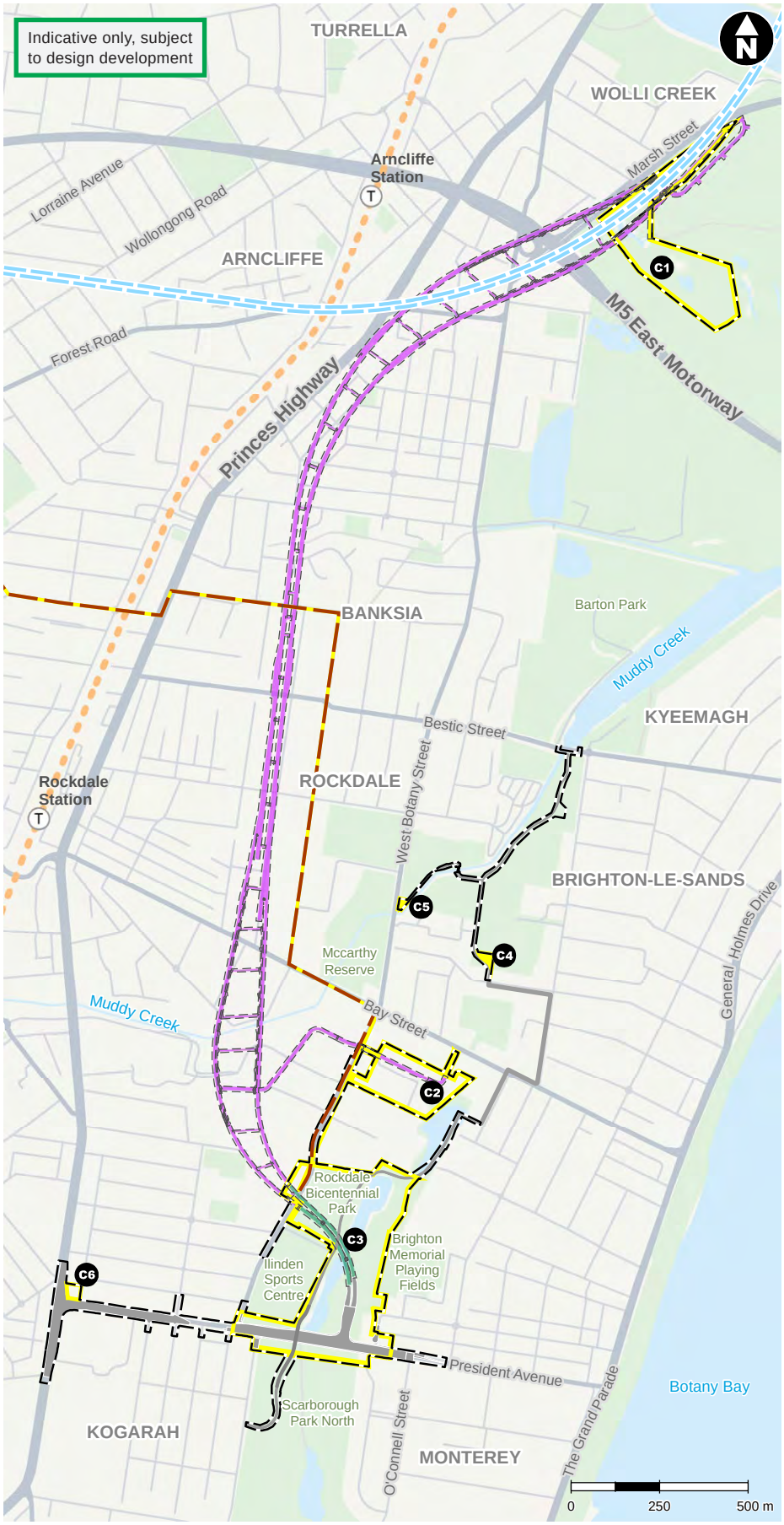
- Demolition of buildings and vegetation clearing and removal
- Relocation of utilities
- Temporary stockpiling of spoil and fill materials
- Management of any contaminated land, including acid sulphate soils
- Construction of cut-and-cover structures
- Construction of MOC3 (Rockdale ventilation facility and substation)
- President Avenue intersection upgrade works
- Construction of shared pedestrian and cyclist path and overpass

C4/C5

- Site establishment
- Vegetation clearing and removal, topsoil stripping areas and land-form shaping
- Temporary stockpiling of materials
- Construction of the shared pedestrian and cyclist path
- Finishing works including lighting, line marking and signage installation

C6

- Property adjustment and demolition
- Relocation of utilities, stormwater infrastructure, underground storage tanks and substation
- Laydown and parking of construction vehicles and equipment
- Reinstatement of site



LEGEND

- Surface works
- Construction boundary
- Cut-and-cover structures
- Underground construction
- Construction ancillary facility
- Permanent power supply line
- Permanent power supply construction route
- New M5 Tunnel
- Road
- Waterway
- Railway line
- Railway station
- Parks and recreation

Figure 2 Construction boundary and construction ancillary facilities

2.2.3 Construction program

The project would be constructed over a period expected to be around four years, including commissioning which would occur concurrently with the final stages of construction (refer to **Figure 3**).

The project is expected to be completed towards the end of 2024. A more detailed construction program, including indicative timings for specific activities is provided in **section 5.1**.

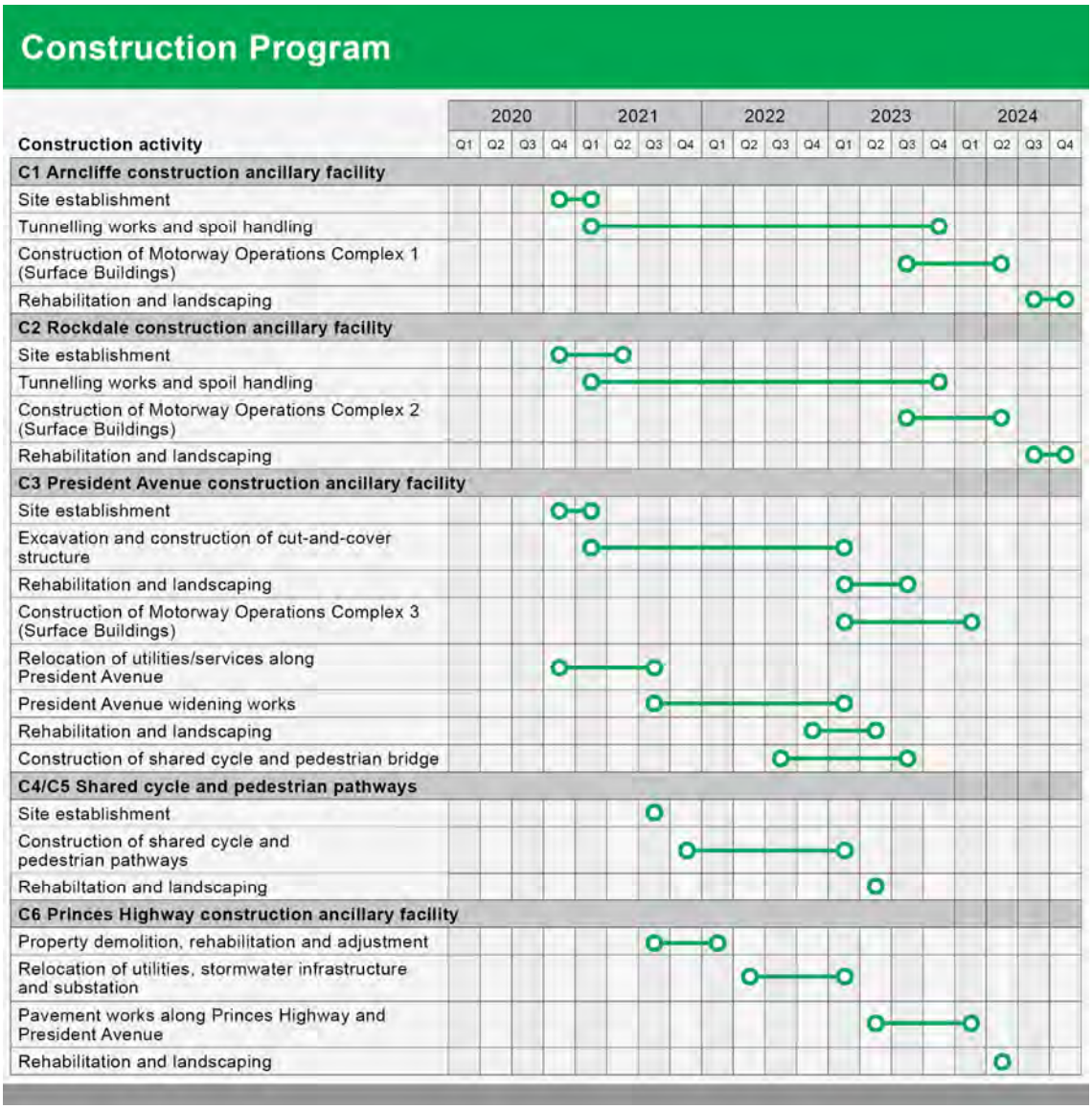


Figure 3 Indicative construction program

2.3 Permanent operational facilities

Operational infrastructure would be established at three main motorway operations complexes:

- The New M5 Motorway (MOC) at Arncliffe, located between Marsh Street and the south western corner of Kogarah Golf Course, on land previously occupied by the Arncliffe construction compound for the New M5 Motorway project
- The Rockdale (north) MOC, located off West Botany Street and south of Bay Street
- The Rockdale (south) MOC, located on West Botany Street and north of French Street.

Infrastructure that would be located within each MOC is summarised in **Table 2-1**.

Further details of the ventilation facilities, motorway control centre and maintenance facility is provided in the following sections.

Table 2-1 Summary of motorway operations complexes and operational ancillary infrastructure

Operational ancillary facilities	Motorway operations complex		
	Arncliffe	Rockdale (north)	Rockdale (south)
Ventilation facility	✓		✓
Emergency smoke extraction facilities / air injection inlets	✓		
Emergency response system			✓
Water treatment plant	✓		
Deluge water tanks		✓	
Car parking	✓	✓	✓
Substation/ power supply	✓		✓
Workshop/ offices		✓	
Motorway control centre		✓	

2.3.1 Ventilation system

Operational ventilation facilities would be provided at Arncliffe and Rockdale (south). The Arncliffe exhaust fans would use the exhaust ventilation shaft constructed as part of the New M5 Motorway project. The key components of the tunnel ventilation systems are summarised in **Table 2-2**.

Table 2-2 Summary of the tunnel ventilation system

Ventilation system component	Description
Jet fans	Installed in the ceiling of the project tunnels (mainline and entry/exit ramps) to draw in additional air when the traffic slows down and for smoke control under emergency conditions. Mounted in triples, with each separated by about 120 metres, operated to maintain acceptable in-tunnel air quality
Supply and exhaust fans	Axial supply and exhaust fans are used to inject air into the tunnel, and to eject air out of the tunnel and for emergency smoke extraction
Ventilation facilities	Ventilation facilities would be provided at Arncliffe and Rockdale (south) and include elevated ventilation outlets

2.3.2 Motorway control centre

A motorway control centre would be provided within the Rockdale (north) MOC.

The motorway control centre would be the central building for all communications and control of the project's operational management and control systems. The motorway control centre would be staffed 24 hours per day, seven days per week. The peak workforce would be around 26 full time equivalent staff.

2.3.3 Water treatment plant

A new water treatment plant would be built at the Arncliffe MOC to treat water collected within the tunnel prior to discharge to the Cooks River.

2.3.4 Maintenance facilities

The Rockdale (north) MOC would include a maintenance facility to support the project.

This facility would require a peak workforce of up to about 10 workers and would include a workshop, storage for spare parts and equipment, parking for up to 15 vehicles, a second storage area for bulky equipment and spare parts and an office building including kitchen facilities and amenities.

3 Existing Environment

3.1 Overview

The study area would traverse the suburbs of Wolli Creek, Arncliffe, Banksia, Rockdale, Brighton-Le-Sands and Kogarah.

The study area includes a mixture of receivers sensitive to noise and vibration such as, residential properties, educational establishments, hospitals, recreational areas, commercial and industrial properties.

Existing key sources of noise within the study area include transport infrastructure, such as the M5 East Motorway, the arterial road network, Sydney Airport and freight and passenger railway lines.

3.2 Existing noise environment

At the northern end of the study area the noise environment is dominated by heavy traffic flows on Marsh Street, West Botany Street, the Princes Highway and the M5 East Motorway. The M5 East Motorway portals are also located within close proximity to sensitive receivers. Sydney Airport is located to the east of this area. Aircraft noise is a key source of noise for receivers within this area.

The noise environment in the mid-section of the study area is considered to be suburban. Significant noise sources include arterial and sub-arterial roads such as the Princes Highway, West Botany Street, Bestic Street and Bay Street. Noise at receivers located further away from these arterial/sub-arterial roads would be exposed to local traffic noise and general suburban noise sources, making this area comparatively quieter. Other key noise sources include industry, overhead aircraft movements and railway movements on the Eastern Suburbs and Illawarra railway line to the west of the project.

At the southern end of the study area the noise environment is dominated by traffic flows on West Botany Street, President Avenue and the Princes Highway. Residential areas that back onto the Rockdale Bicentennial Park or the Scarborough and Kings wetlands area would have comparatively lower levels of noise. To the west of the Princes Highway receivers are also affected by the movements on the Eastern Suburbs and Illawarra railway line and industry.

3.3 Noise sensitive receivers

Noise sensitive receivers were identified using aerial photography. The occupational uses of all buildings within the project area were determined through a ground-truthing site survey exercise. This exercise, in conjunction with cadastral information, was used to determine the classification of residential, commercial, industrial, educational, recreational and other uses (unoccupied sheds and the like) buildings.

A small number of properties at the intersection of President Avenue and O'Neill Street have been identified to be acquired as part of the project. These have not been assessed in the construction noise modelling. They have been included in the existing road traffic model and in the do minimum operational noise models but have not been included in the build operational noise model.

Noise catchment areas (NCA) have been determined for the construction and operational facility noise and vibration assessment (as detailed in **section 4.2.1**). The NCAs are identified in **Annexure A**.

Part of Kogarah Golf Course located at the corner of Marsh Street and the M5 East Motorway would comprise a construction facility during the construction phase of the project. During the operational phase part of this facility land would be occupied by a substation and water treatment plant in addition to land occupied by the operational infrastructure of the New M5 Motorway. Sensitive receivers located along West Botany Street and the north western side of Marsh Street are predominantly residential.

The shared pedestrian and cycle path (a new and upgraded shared path) would be located in existing public open space south of Bestic Street in Brighton-Le-Sands. Sensitive receivers in this area are predominantly one and two-storey residential properties.

The Rockdale (north) MOC would be located within an existing industrial site in Rockdale. Specifically this would be within an existing Roads and Maritime maintenance depot that fronts onto West Botany Street (with a secondary access to Bay Street). Single and double storey residential receivers are located directly to the north and east of the MOC site.

The Rockdale (south) MOC and ventilation facility would be located on West Botany Street opposite Memorial Fields. There are no sensitive receivers located directly next to the site. The nearest residential receivers are located around 115 m to the south. Brighton-Le-Sands Primary School is located around 350 metres east of the facility.

The proposed upgrades to surface roads are located in areas of existing road traffic noise exposure. Along President Avenue residential properties comprise both single storey dwelling and multi-level apartment complexes. Educational facilities include the St George College TAFE, located at the intersection of Princes Highway and President Avenue, as well as the Brighton-Le-Sands public school, located to the north-east of the proposed tunnel portals at President Avenue.

Noise sensitive receivers other than residential receivers are listed in **Table 3-1**.

Table 3-1 Notable sensitive receivers within the project area (non-residential)

Receiver	Receiver Type
Ilinden Sports Centre	Active Recreation
PCYC St George	Active Recreation
Memorial Fields	Active Recreation
Moorefield Bowling and Sports Club	Active Recreation
St George District Netball Association	Active Recreation
Brighton-Le-Sands Amateur Fishing Association	Active Recreation
Sunnyhaven Disability Services	Community Centre
St George Hospital	Hospital
St George Private Hospital	Hospital
St George Mental Health Centre	Hospital
Brighton-Le-Sands Library	Library
Kogarah Town Square Library and Cultural Centre	Library
St Thomas More Catholic Church	Place of Worship
Uniting Church In Australia Brighton-Le-Sands	Place of Worship
Christ Living Church	Place of Worship
Jesus Is Lord Church	Place of Worship
Saint Paul's Anglican Church, Kogarah	Place of Worship
Kogarah Uniting Church	Place of Worship
St Patrick's Catholic Church, Kogarah	Place of Worship
Greek Orthodox Parish and Community of Kogarah	Place of Worship
Kirkplace Presbyterian Church	Place of Worship
Grace Chinese Christian Church	Place of Worship
Society of St Pius X	Place of Worship
Mary Help of Christians Convent	Place of Worship
Masjid Darul Imaan	Place of Worship
TAFE NSW St George College, Main Campus	School
James Cook Boys Technology High School	School
Moorefield Girls High School	School

Receiver	Receiver Type
St George School	School
Cairnsfoot Special School	School
St Thomas More's Catholic School	School
Brighton-Le-Sands Public School	School
St George Girls High School	School
Kogarah High School	School
Kogarah Intensive English Centre	School
Kogarah Public School	School
St Patrick's Catholic Primary School, Kogarah	School
Global Education Academy	School
TAFE NSW St George College, Hogben Street	School
TAFE NSW St George College, Montgomery Street	School
Arncliffe Public School	School

3.4 Ambient noise monitoring

Ambient noise monitoring was undertaken at 16 locations throughout the study areas generally within the following three noise monitoring periods:

- June 2015 (as part of the New M5 Motorway project)
- November/December 2017
- February 2018.

Concurrent traffic counts were undertaken during the November/December 2017 monitoring period. These data have been used to validate the operational road traffic noise model. Results from the monitoring periods have been used to establish construction noise management levels and operational noise criteria for operational facilities.

The locations for the unattended noise loggers were determined through examination of aerial photography and site inspections. Attended noise measurements were also undertaken to determine the nature of the local noise environment and confirm road traffic was the controlling noise source (for the validation of the operational noise model).

The noise logging locations are illustrated in **Annexure A**. The noise logging results are provided graphically in **Annexure B**.

A noise logger measures the noise level over the 15 minute sample period and then determines L_{A1}, L_{A10}, L_{A90}, L_{Amax} and L_{Aeq} levels of the noise environment. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1 per cent, 10 per cent and 90 per cent of the sample period respectively. The L_{Amax} level is the maximum noise levels due to individual noise events. The L_{A90} level is taken as the background noise level. The L_{Aeq} level is the energy averaged noise level over a defined period.

The results of the noise monitoring have been processed in accordance with the procedures contained in the *NSW Road Noise Policy* (RNP) and the *Noise Policy for Industry* (NPfI). Weather data recorded during the noise monitoring survey periods were obtained from the Bureau of Meteorology weather station, located at Canterbury. The Sydney Airport wind data were appreciably affected by wind, which was not considered to be characteristic of the study area. On this basis, Canterbury weather data were used when considering the logger data. Periods which were affected by noise from extraneous wind and rain were omitted from the results.

Details of each noise logging location and the purpose of each noise logger are provided in **Table 3-2** below. As the study area includes receivers up to 600 metres from the alignment of surface roads, noise loggers have been located at varying distances from the existing road alignments. This allows the accuracy of the model to be confirmed over the extent of the project.

Table 3-2 Noise logging locations

Ref No.	Address	Purpose				Measurement period
		Construction	Operational road noise	Maximum noise	Operational facility	
NL01	20 Marsh Street, Arncliffe	✓			✓	12 - 20 June 2015
NL02	6 Eve Street, Arncliffe	✓			✓	17 - 25 June 2015
NL03	25 Firmstone Garden, Arncliffe	✓			✓	12 - 24 June 2015
NL04	82 Francis Avenue, Brighton-Le-Sands	✓				6 - 16 February 2018
NL05	CA Redmond Field (Rear of 103 Bruce Street, Brighton-Le-Sands)	✓				6 - 16 February 2018
NL06	19 England Street, Brighton-Le-Sands	✓			✓	28 November - 8 December 2017
NL07	1B Kings Road, Brighton-Le-Sands	✓			✓	28 November - 8 December 2017
NL08	Ilinden Sports Centre, Rockdale (468 West Botany Street, Rockdale)	✓			✓	11 - 18 December 2017
NL09	53 Crawford Road, Brighton-Le-Sands	✓			✓	28 November - 8 December 2017
NL10	48 President Avenue, Kogarah		✓			28 November - 8 December 2017
NL11	66 O'Neill Street, Brighton-Le-Sands				✓	28 November - 7 December 2017
NL12	23 President Avenue, Kogarah		✓			28 - 29 December 2017
NL13	63 President Avenue, Kogarah		✓			28 November - 8 December 2017
NL14	138 President Avenue, Brighton-Le-Sands	✓	✓		✓	11 - 18 December 2017
NL15	TAFE, 750 Princes Highway, Kogarah	✓		✓	✓	06 - 11 February 2018
NL16	Scarborough Park North, Monterey (Rear of 19 Colson Crescent, Monterey)	✓			✓	06 - 16 February 2018

3.5 Unattended background noise monitoring results

The background noise monitoring results are provided in **Table 3-3**. These noise levels were used to define the appropriate construction noise management levels, consistent with the *Interim Construction Noise Guideline* (ICNG). They were also used to define the applicable noise criteria for operational ancillary facilities such as the ventilation and tunnel support facilities, in accordance with the *Noise Policy for Industry* (NPfI).

The assessment background levels (ABL) were established by determining the lowest tenth-percentile level of the L_{A90} noise data acquired over each assessment period of interest. The background noise level or rating background levels (RBL) representing the day, evening and night-time assessment periods were based on the median of individual ABLs determined over the entire monitoring duration.

Table 3-3 also presents the ambient L_{Aeq} levels at each monitoring location. The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels.

The noise levels presented in **Table 3-3** indicate that the noise environment at the measurement locations are typical of those located along major transport corridors in suburban/urban noise areas, where day time and evening background levels are high due to heavy and continuous traffic flows. The night time background levels tend to decrease as a result of reduced traffic flows.

Table 3-3 Ambient and background noise measurements

Noise logger		RBL[1], dB(A)			Ambient noise level dB(A)		
		Day (7am to 6pm) $L_{A90,15\ min}$	Evening (6pm to 10pm) $L_{A90,15\ min}$	Night (10pm to 7am) $L_{A90,15\ min}$	Day (7am to 6pm) $L_{Aeq,15\ hour}$	Evening (6pm to 10pm) $L_{Aeq,4\ hour}$	Night (10pm to 7am) $L_{Aeq,9\ hour}$
NL01	20 Marsh Street, Arncliffe	55	56[2]	45	61	62	59
NL02	6 Eve Street, Arncliffe	49	48	42	54	55	50
NL03	25 Firmstone Garden, Arncliffe	47	49[2]	39	55	54	50
NL04	82 Francis Avenue, Brighton-Le-Sands	38	37	31	49	47	44
NL05	CA Redmond Field (Rear of 103 Bruce Street, Brighton-Le-Sands)	39	39	34	56	49	45
NL06	19 England Street, Brighton-Le-Sands	41	41	33	56	55	53
NL07	1B Kings Road, Brighton-Le-Sands	39	40[2]	36	53	51	46
NL08	Ilinden Sports Centre, Rockdale (468 West Botany Street, Rockdale)	53	47	38	64	62	60
NL09	53 Crawford Road, Brighton-Le-Sands	38	38	32	52	51	47
NL10	48 President Avenue, Kogarah	52	52	38	65	65	63
NL11	66 O'Neill Street, Brighton-Le-Sands	42	41	35	53	51	49

Noise logger		RBL[1], dB(A)			Ambient noise level dB(A)		
NL12	23 President Avenue, Kogarah	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
NL13	63 President Avenue, Kogarah	56	53	39	65	63	62
NL14	138 President Avenue, Brighton-Le-Sands	57	50	37	71	66	65
NL15	TAFE, 750 Princes Highway, Kogarah	66	66	56	72	70	68
NL16	Scarborough Park North, Monterey (Rear of 19 Colson Crescent, Monterey)	42	40	32	58	53	44

Notes:
1 Rating Background Level
2 Application notes to the NPfI indicate that the community generally expects a greater control of noise during the evening and night as compared to the day time. Therefore the rating background level for the evening is set to no more than that for the daytime and the night-time to no more than the evening.
3 Insufficient data was collected by this noise logger for NPfI purposes. Therefore this noise logger was not used to set environmental noise criteria.

3.6 Operational road noise monitoring results

Provided in **Table 3-4** are the logarithmically averaged noise levels measured at each noise monitoring location which have been used for the assessment of road traffic noise. Monitoring locations NL10, NL12, NL13, and NL14 were used to validate the road traffic noise model.

The measured noise levels have been compared to the predicted noise levels from the validation noise model. The good correlation that has been identified between these measured noise levels and the predicted noise levels in the validation model provides confidence that the future road traffic noise levels can be accurately predicted for the operational noise assessment. Further information on the noise modelling and validation of noise model outputs is provided in **section 6.1.3**.

Table 3-4 Measured road traffic noise levels

Noise	Ambient road traffic noise level, dB(A)	
	Day (7am to 10pm) $L_{Aeq,15\ hr}$	Night (10pm to 7am) $L_{Aeq,9\ hr}$
NL10	66	63
NL12	68	66
NL13	64	63
NL14	70	65

4 Assessment methodology

4.1 Relevant guidelines and policies

The following guidelines have been used for the noise and vibration assessment:

- Construction noise:
  - *Construction Noise and Vibration Guideline* (CNVG) (Roads and Maritime 2016)
  - *Interim Construction Noise Guideline* (ICNG) (DECC 2009)
- Construction vibration:
  - *Assessing Vibration: a technical guideline* (NSW Department of Environment and Conservation (DEC) 2006a)
  - *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (Australian and New Zealand Environment and Conservation Council (ANZECC) 1990)
  - DIN 4150:Part 2-1999 Structural vibration – Effects of vibration on structures (*Deutsches Institut für Normung* 1999)
  - DIN 4150:Part 3-1999 Structural vibration – Effects of vibration on structures (*Deutsches Institut für Normung* 1999)
  - Evaluation and Measurement for Vibration in Buildings Part 2, (British Standard (BS) 7385:Part 2-1993) (BS 7385)
  - Explosives − Storage and Use − Part 2: Use of Explosives (Australian Standard (AS) 2187:Part 2-2006) (AS 2187)
  - Mechanical vibration - Ground-borne noise and vibration arising from rail systems (International Standard 14837-1:2005 (ISO14837)
- Operational traffic noise:
  - *NSW Road Noise Policy* (RNP) (DECCW 2011)
  - *Noise Criteria Guideline* (NCG) (Roads and Maritime 2015a)
  - *Noise Mitigation Guideline* (NMG) (Roads and Maritime 2015b)
  - *Noise Model Validation Guideline* (Roads and Maritime 2016)
  - *Application Notes – Noise Criteria Guideline* (Roads and Maritime 2015a)
  - *Environmental Noise Management Manual* (Roads and Maritime 2001)
  - *Procedure for Preparing an Operational Noise and Vibration Assessment* (Roads and Maritime 2011b)
  - *Draft At-Receiver Treatment Guideline (ARTG) (Roads and Maritime 2017)*
- Noise from operational ancillary facilities:
  - *Noise Policy for Industry* (NPfI) (NSW Environment Protection Authority (NSW EPA) 2017)
- Sleep disturbance during construction and operation:
  - *NSW Road Noise Policy* (RNP) (DECCW 2011)
  - *Noise Policy for Industry* (NPfI) (NSW Environment Protection Authority (NSW EPA) 2017)

The above policies and guidelines are detailed further in the following sections, including how they have been employed for the purposes of this assessment.

4.2 Construction noise

The potential risk of adverse impact of construction noise on a receiver is determined by the extent of its emergence above the existing background noise level, the duration of the event and the characteristics of the noise.

The ICNG is a NSW Government document that sets out ways to deal with the impacts of construction noise on residences and other sensitive land uses. It presents assessment approaches tailored to the scale of the construction project and identifies practices to minimise noise impacts. The ICNG recommends that a quantitative assessment is carried out for all major construction proposals that are typically subject to the environmental impact assessment processes. A quantitative assessment, based on the likely construction scenarios, has been carried out for the project.

Predicted noise levels at nearby noise sensitive receivers (e.g. residences, schools, hospitals, places of worship, passive and active recreation areas) are compared to the levels provided in the ICNG. Where an exceedance of the management levels is predicted the ICNG advises that receivers can be considered 'noise affected' and the proponent should apply all feasible and reasonable work practices to minimise the noise impact. The proponent should also inform all potentially affected residents of the nature of the works to be carried out, the expected noise level and duration, as well as contact details should they wish to make a complaint.

Where construction noise levels at the receiver reach 75 dB(A) residential receivers are considered to be 'highly noise affected' and the proponent should, in consultation with the community, consider restrictions to the hours of construction to provide respite periods.

The ICNG defines what is considered to be feasible and reasonable as follows:

- Feasible - a work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.
- Reasonable - selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.

Additionally the ICNG notes that strong justification is required for work that is proposed outside of standard working hours.

Noise management levels for the project for residential receivers are derived using the information in **Table 4-1**.

Table 4-1 Construction noise management levels – Residential receivers (from the ICNG)

Time of day	Construction noise management level $L_{Aeq,15min}$	How to apply
Recommended standard hours: • Monday to Friday 7am to 6pm • Saturday 8am to 1pm • No work on Sundays or public holidays	Noise affected RBL + 10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15\ min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: – Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. – If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB(A)	• 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.

Notes:
1 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.

4.2.1 Noise catchment areas

The study area has been divided into 17 distinct noise catchment areas (NCAs). The noise environment at each of the sensitive receivers within a noise catchment area is considered to have a similar noise environment to the unattended monitoring location within that NCA. As such each of these sensitive receivers is assigned the same background noise level and noise management level. The location of each NCA is provided graphically in **Annexure A**. Details of the construction noise management levels in each NCA are provided in **Table 4-2**.

Table 4-2 Noise catchment areas and construction noise management levels

NCA	Representative logger	Period	Rating background level, dB(A)	Construction noise management level (NML)[2,3]
NCA01	NL01	Day	55	65
		Evening	55[1]	60
		Night	45	50
NCA02	NL02	Day	49	59
		Evening	48	53
		Night	42	47
NCA03	NL03	Day	47	57
		Evening	47[1]	52
		Night	39	44
NCA04	NL04	Day	38	48
		Evening	37	42
		Night	31	36
NCA05	NL05	Day	39	49
		Evening	39	44
		Night	34	39
NCA06	NL06	Day	41	51
		Evening	41	46
		Night	33	38
NCA07	NL06	Day	41	51
		Evening	41	46
		Night	33	38
NCA08	NL07	Day	39	49
		Evening	39[1]	44
		Night	36	41
NCA09	NL09	Day	38	48
		Evening	38	43
		Night	32	37
NCA10	NL08	Day	53	63
		Evening	47	52
		Night	38	43
NCA11	NL08	Day	53	63
		Evening	47	52
		Night	38	43
NCA12	NL15	Day	66	76
		Evening	66	71
		Night	56	61

NCA	Representative logger	Period	Rating background level, dB(A)	Construction noise management level (NML)[2,3]
NCA13	NL15	Day	66	76
		Evening	66	71
		Night	56	61
NCA14	NL15	Day	66	76
		Evening	66	71
		Night	56	61
NCA15	NL16	Day	42	52
		Evening	40	45
		Night	32	37
NCA16	NL14	Day	57	67
		Evening	50	55
		Night	37	42
NCA17	NL16	Day	42	52
		Evening	40	45
		Night	32	37

Notes:
1 Application notes to the Industrial Noise Policy indicate that the community generally expects a greater control of noise during the evening and night as compared to the daytime. Therefore the rating background level for the evening is set to no more than that for the daytime and the night-time to no more than the evening.
2 Day noise management levels = RBL + 10 dB(A)
3 Evening/night noise management levels = RBL + 5 dB(A)

4.2.2 Non-residential criteria

Noise management levels recommended by the ICNG for non-residential sensitive land uses, such as schools, hospitals or places of worship are provided in **Table 4-3**. Noise management levels for commercial and industrial premises are provided in **Table 4-4**.

Table 4-3 Construction noise management levels – non-residential sensitive land uses

Land use	Management level, $L_{Aeq(15\ min)}$
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Community centres	Depends on the intended use of the centre. Refer to the recommended "maximum" internal levels in AS2107 for specific uses.

Table 4-4 Construction noise management levels – Commercial and industrial land uses

Land use	Management level, $L_{Aeq(15min)}$
Industrial premises	External noise level 75 dB(A)
Offices, retail outlets	External noise level 70 dB(A)

4.2.3 Sleep disturbance

The ICNG requires a sleep disturbance assessment to be undertaken where construction works are planned to extend over more than two consecutive nights. The ICNG makes reference to the EPA's NSW *Environment Criteria for Road Traffic Noise* (ECRTN), now superseded by the NSW *Road Noise Policy*, for assessment of sleep disturbance. The RNP references the recommendations in the ECRTN as providing the most appropriate assessment guidance.

The guidance provided in the RNP for assessing the potential for sleep disturbance recommends that to minimise the risk of sleep disturbance during the night-time period (10pm to 7am), the $L_{A1(1\ min)}$ noise level outside a bedroom window should not exceed the $L_{A90(15\ min)}$ background noise level by more than 15 dB(A). The EPA considers it appropriate to use this metric as a screening criterion to assess the likelihood of sleep disturbance. If this screening criterion is found to be exceeded then a more detailed analysis must be undertaken that should include the extent that the maximum noise level exceeds the background noise level and the number of times this is likely to happen during the night-time period.

The RNP contains a review of research into sleep disturbance which represents NSW EPA advice on the subject of sleep disturbance due to noise events. It concludes that having considered the results of research to date that, 'Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions'. Therefore, given that an open window provides around 10 dB(A) in noise attenuation from outside to inside, external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions.

Table 4-5 presents the sleep disturbance screening and sleep disturbance awakening reaction criteria.

Table 4-5 Construction noise sleep disturbance criteria

NCA	Rating background level, dB(A)	Sleep disturbance screening $L_{A1(1min)}$ criteria, dB(A)	Sleep disturbance awakening reaction $L_{A1(1min)}$ criteria, dB(A)
NCA01	45	60	65
NCA02	42	57	65
NCA03	39	54	65
NCA04	31	46	65
NCA05	34	49	65
NCA06	33	48	65
NCA07	33	48	65
NCA08	36	51	65
NCA09	32	47	65
NCA10	38	53	65
NCA11	38	53	65
NCA12	56	71	65
NCA13	56	71	65
NCA14	56	71	65
NCA15	32	47	65
NCA16	37	52	65
NCA17	32	47	65

4.2.4 Construction road traffic noise

Noise from construction traffic on public roads is not covered by the ICNG. However the ICNG does refer to the ECRTN, which is now superseded by the RNP, for the assessment of noise arising from construction traffic on public roads.

To assess noise impacts from construction traffic, an initial screening test has been undertaken by evaluating whether existing road traffic noise levels would increase by more than 2 dB(A). Where the predicted noise increase is 2 dB(A) or less, then no further assessment is required. However, where the predicted noise level increase is greater than 2 dB(A), and the predicted road traffic noise level exceeds the road category specific criterion then noise mitigation should be considered for those receivers affected. The RNP does not require assessment of noise impact to commercial or industrial receivers.

4.3 Construction vibration criteria

The relevant standards/guidelines for the assessment of construction vibration are summarised in **Table 4-6**.

Table 4-6 Standards / guidelines used for assessing construction vibration

Item	Standard/guideline
Structural damage	German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (DIN 4150)
Human comfort (tactile vibration) 1	Assessing Vibration: A Technical Guideline (AVATG) [1]
Human comfort (ground-borne noise)	Interim Construction Noise Guideline (ICNG)

Notes:

1 This document is based upon the guidelines contained in British Standard 6472:1992, "Evaluation of human exposure to vibration in buildings (1-80 Hz)". This British Standard was superseded in 2008 with BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting" and the 1992 version of the Standard was withdrawn. Although a new version of BS 6472 has been published, the Environment Protection Authority still requires vibration to be assessed in accordance with the 1992 version of the Standard at this point in time.

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent as follows:

- Continuous vibration continues uninterrupted for a defined period and includes sources such as machinery and continuous construction activities for example, a tunnel boring machine
- Impulsive vibration is a rapid build up to a peak followed by a damped decay. It may consist of several cycles at around the same amplitude, with a duration of typically less than two seconds and no more than three occurrences in an assessment period. This may include occasional dropping of heavy equipment or loading activities
- Intermittent vibration occurs where there are interrupted periods of continuous vibration, repeated periods of impulsive vibration or continuous vibration that varies significantly in magnitude. This may include intermittent construction activity, impact pile driving, jack hammers.

4.3.1 Structural damage

At present, no Australian Standards exist for the assessment of building damage caused by vibration.

DIN 4150 provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are presented in **Table 4-7**. DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage.

Table 4-7 DIN 4150: Structural damage safe limits for building vibration

Group	Type of structure	Vibration velocity in mm/s			
		At foundation at a frequency of:			Vibration at the horizontal plane of the highest floor
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15

Group	Type of structure	Vibration velocity in mm/s			
		At foundation at a frequency of:			Vibration at the horizontal plane of the highest floor
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

4.3.2 Human comfort

Humans are sensitive to vibration such that they can detect vibration levels well below those required to cause any risk of damage to a building or its contents. Criteria to avoid annoyance are therefore more stringent than those to prevent structural damage.

Intermittent vibration

The assessment of intermittent vibration outlined in *Assessing Vibration: A Technical Guideline* (DEC, 2006) is based on Vibration Dose Values (VDVs). The VDV accumulates the vibration energy received over the day time and night time periods.

Maximum and preferred VDVs for intermittent vibration arising from construction activities are listed in **Table 4-8**. The VDV criteria are based on the likelihood that a person would be annoyed by the level of vibration over the entire assessment period.

Table 4-8 Preferred and maximum vibration dose values for intermittent vibration (m/s$^{1.75}$)

Location	Day time		Night time	
	Preferred	Max	Preferred	Max
Critical areas[1]	0.10	0.20	0.10	0.20
Residences[2]	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:
1 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria.
2 Criteria for residences are lower than schools as people expect to be able to relax/sleep in their homes without annoyance and are generally more concerned about structural damage than would be the case within schools and offices.

Continuous and impulsive vibration

Acceptable levels of human exposure to continuous and impulsive vibration are dependent on the time of day and the activity taking place in the occupied space. *Assessing Vibration: A Technical Guideline* provides the preferred values for continuous and impulsive vibration. These are presented in **Table 4-9**.

There is low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values in **Table 4-9**. Situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances and infrequent events of short duration. Vibration levels above those indicated in **Table 4-9** may be dealt with through negotiation with the regulator of the affected community. The following axes are defined in relation to the human body:

- x – back to chest
- y – right side to left side

- z – foot to head.

Table 4-9 Peak particle velocity for continuous and impulsive vibration acceleration (mm/s)

Location	Assessment period	Preferred	Maximum
		z axis	
Continuous vibration			
Critical areas[1]	When in use	0.14	0.28
Residences[2]	Day Night	0.28 0.20	0.56 0.40
Offices, schools, educational institutions and places of worship	When in use	0.56	1.1
Workshops	When in use	1.1	2.2
Impulsive vibration			
Critical areas[1]	When in use	0.14	0.28
Residences[2]	Day Night	8.6 2.8	17.0 5.6
Offices, schools, educational institutions and places of worship	When in use	18.0	36.0
Workshops	When in use	18.0	36.0

Notes:
1 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria.
2 Criteria for residences are lower than schools as people expect to be able to relax/sleep in their homes without annoyance and are generally more concerned about structural damage than would be the case within schools and offices.

4.4 Ground-borne noise

Vibration generated by activities such as tunnelling may enter buildings via the ground. This may cause the floors, walls and ceilings to vibrate and to radiate noise. This noise is commonly referred to as ground-borne noise. Ground-borne noise is typically low frequency and if audible, is perceived as a 'rumble'.

In general, ground-borne noise level values are relevant only where they are higher than the airborne noise. Ground-borne noise from construction would typically be masked by airborne noise associated with surface construction activities and/or traffic.

The magnitude of ground-borne noise experienced by receivers located close to tunnelling activities is influenced by a number of factors including:

- The tunnel construction technique
- The depth of tunnelling work
- Geological ground conditions
- The timing and duration of construction activities.

The ground-borne noise management levels as outlined in the ICNG were adopted for this project and are presented in **Table 4-10**. These levels are applicable during the evening and night-time periods only in residential properties, as the objective is to protect the amenity and sleep of people when they are at home.

Table 4-10 Recommended ground–borne noise goals for construction activities

Time	Ground-borne noise goals
Evening (6pm to 10pm)	40 dB(A) $L_{Aeq(15\ min)}$
Night-time (10pm to 7am)	35 dB(A) $L_{Aeq(15\ min)}$

4.5 Blasting

Construction blasting can result in two adverse environmental effects – airblast and ground vibration. The airblast and ground vibration produced may cause human discomfort and may have the potential to cause damage to structures, architectural elements and services.

Two guidelines have been considered as part of this assessment:

- Australian and New Zealand Environment Council (ANZEC) Guidelines – Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration.
- Australian Standard 2187.2-2006 Explosives - Storage and Use Part 2: Use of Explosives – Appendix J.

The ANZEC *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* has been adopted by the Environment Protection Authority as comfort criteria to minimise annoyance and discomfort to persons at noise sensitive sites (e.g. residences, hospitals, schools etc.) as a result of blasting. The guidelines are not intended to provide structural damage criteria. However they do provide a conservative approach to the assessment of potential impacts on structures as minimising human annoyance and comfort would inherently minimise structural damage.

AS 2187.2 recommends ground vibration limits which are consistent with the ANZEC guidelines but provides more detail with respect to criteria for human comfort and structural damage. This includes consideration of different types of structures such as more sensitive masonry and plasterboard buildings and less sensitive reinforced concrete buildings. AS 2187.2-2006 notes that damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133 dB (linear peak).

4.5.1 Blasting criteria

In relation to airblast overpressure, the following criteria have been adopted:

- Less than or equal to 115 dB(linear) peak for 95 per cent of total blasts over 12 months.
- Less than 120 dB(linear) peak for any blasts.

For the purposes of this project, the AS 2187.2 ground vibration criteria have been considered and are summarised in **Table 4-11**. AS 2187.2 recommends that if the prescribed limits in **Table 4-11** cannot be achieved, an agreement may be reached with the landowner permitting higher levels.

The blast vibration criteria identified in the ANZEC are considered conservative and were originally developed to protect communities exposed to long-term blasting operations such as mining sites. For projects such as this, with a shorter duration of blasting of two months or less, a higher vibration criterion may be reasonable.

For this project, the location of the blast moves along the alignment such that any one receiver is affected for short period of time. Table J4.5(A) in Appendix H of AS2187.2 presents vibration limits designed to safeguard human comfort in relation to blasting that have been used by some authorities, as it defines clearer vibration limits which are dependent on the specific duration of the project. Based on the limitations of the ANZEC guideline and further guidance in AS2187.2, a human comfort vibration limit of 10 millimetres per second (peak particle velocity) for blasting operations lasting less than 12 months has been adopted for this project.

Table 4-11 Blasting ground vibration criteria summary

Category	Human comfort	Structural damage[1]
Sensitive structures (e.g. residential, theatres, schools etc.)	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply[2]	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Occupied non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	25 mm/s 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 manufacture's specifications or levels that can be shown to adversely affect the equipment operation.	50 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply*
Occupied non-sensitive structures that include masonry, plaster and plasterboard in their construction (e.g. factories and commercial premises)	25 mm/s 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 manufacture's specifications or levels that can be shown to adversely affect the equipment operation.	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Unoccupied non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	N/A	50 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply*
Unoccupied non-sensitive structures that include masonry, plaster and plasterboard in their construction	N/A	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Services structures, such as pipelines, power lines and cables	N/A	Limit to be determined by structural design methodology. Special consideration may be required for high pressure gas pipelines.

Notes:

1 The values above are less stringent than those in DIN 4150. This is because DIN 4150 considers resonance in buildings from continuous vibration. Due to the short duration of blasting events the propensity for resonance within buildings is minimal, giving rise to higher criteria

2 The blast vibration criteria identified in the ANZEC are considered conservative and were originally developed to protect communities exposed to long-term blasting operations such as mining sites. For projects such as this, with a shorter duration of blasting of 2 months or less, a higher vibration criterion may be reasonable. For this project, the location of the blast moves along the alignment such that any one receiver is affected for short period of time. Table J4.5(A) in Appendix H of AS2187 presents vibration limits designed to safeguard human comfort in relation to blasting that have been used by some authorities, as it defines clearer vibration limits which are dependent on the specific duration of the project. Based on the limitations of the ANZEC guideline and further guidance in AS2187, a human comfort vibration limit of 10 mm/s (peak particle velocity) for blasting operations lasing less than 12 months has been adopted for this project.

The measurement of vibration should be taken at any point on 'noise sensitive sites' which is at least the longest dimension of the foundation of a building or structure away from such buildings or structure.

These requirements 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. Particular attention should be given to the response of suspended floors.

4.5.2 Recommended hours and frequency of blasting activities

The ANZEC guidelines recommend that:

- Blasting should generally only be permitted during the hours of 9am – 5pm Monday to Saturday. Blasting should not take place on Sundays or public holidays
- Blasting should generally take place no more than once per day.

The recommended restrictions on times and frequency of blasting do not apply to those premises where the effects of the blasting are not perceived at noise sensitive sites. In addition it should be noted that the recommendation of blasting taking place no more than once per day is taken to mean no one sensitive receiver should not be affected by blasting more than once per day.

It is noted that for this project, blasting may be required and would only occur 9am – 5pm Monday to Friday and 9am to 1pm Saturday. No blasting would occur on Sundays or public holidays.

4.6 Operational assessment criteria

4.6.1 Operational road traffic noise criteria

Noise criteria are assigned to sensitive receivers using the Roads and Maritime's *Noise Criteria Guideline* (NCG). The NCG provides guidance on how to apply the RNP.

The RNP requires the consideration of two scenarios, the do minimum option (without the project) and the' do something option (with the project). The do minimum option represents the scenario if the project was not to proceed. The do something option represents the scenario if the project was to proceed. Each of these scenarios must be considered at two points in time, the year of opening and the design year, typically ten years after opening. For this project, the year 2026 has been assessed as the year of opening, and 2036 has been assessed as the design year.

The operational road traffic noise assessment area extends to where noise levels are dominated by other roads that are not being assessed as part of this project, as detailed in the NCG. For urban areas this is up to a maximum distance of 600 metres from the project works. Residential receivers may be assigned new, redeveloped, transition zone or relative increase criteria depending on how the project would influence their noise levels. For each façade of the residential receiver the most stringent applicable criteria is used in the assessment.

Criteria are based on the road development type which is affecting the residential receiver. In some instances residential receivers may be exposed to noise from both new and redeveloped roads. Where this occurs, the proportion of noise from each road is used to establish transition zone criteria.

A further check is made to prevent large increases in noise level using the relative increase criteria.

Other receivers throughout the project area are also subject to existing noise from major arterial roads, hence the eligibility of these receivers is considered in their highly urban context, in accordance with the NCG.

Table 4-12 Road traffic noise assessment criteria for residential land use

Road category	Type of project/land use	Assessment criteria dB(A)	
		Day (7 am – 10 pm)	Night (10 pm – 7 am)
Freeway/ arterial/sub-arterial	Existing residences affected by noise from new freeways/arterial/sub-arterial road corridors	$L_{Aeq(15\ hr)}$ 55 (external)	$L_{Aeq(9\ hr)}$ 50 (external)
	Existing residences affected by noise from redevelopment of existing freeways/arterial/sub-arterial roads Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments Existing residences affected by noise from existing freeway/arterial/sub-arterial roads where no redevelopment is taking place	$L_{Aeq(15\ hr)}$ 60 (external)	$L_{Aeq(9\ hr)}$ 55 (external)
	Existing residences affected by both new roads and the redevelopment of existing freeway/arterial/sub-arterial roads in a Transition Zone[1]	Between $L_{Aeq(15\ hr)}$ 55-60 (external)	Between $L_{Aeq(9\ hr)}$ 50-55 (external)
	Existing residences affected by increases in traffic noise of 12 dB(A) or more from new freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15\ hr)}$ 42-55 (external)	Between $L_{Aeq(15\ hr)}$ 42-50 (external)

Notes:
1 The criteria assigned to a façade depend on the proportion of noise coming from the existing road. Please see Roads and Maritimes' NCG for further information.
2 The criteria at each façade are determined from the existing traffic noise level plus 12 dB(A).

The criteria for other sensitive receivers are presented in **Table 4-13**.

For other sensitive receivers such as schools, places of worship and childcare facilities, the NCG criteria are based on internal noise levels. A conservative minimum outside-to-inside attenuation of 10 dB(A), on the basis of open windows for natural ventilation, has been assumed to allow for an external noise assessment at the other sensitive receivers. However, as details are not currently available to allow the building-specific façade noise reduction to be identified it is recommended that this should be investigated further at detailed design.

The noise model predicts noise levels for $L_{Aeq(15\ hr)}$ and $L_{Aeq(9\ hr)}$ periods for day and night-time respectively. It has been found that for the sensitive receivers to which $L_{Aeq(1\ hr)}$ criteria apply, the $L_{Aeq(15\ hr)}$ noise level is consistent with the $L_{Aeq(1\ hr)}$ noise level. This is due to the hours of usage typically occurring during traffic peak periods.

Table 4-13 Road traffic noise assessment criteria for non-residential land use

Existing sensitive land use	Assessment criteria		Additional considerations
	Day (7am – 10pm)	Night (10pm – 7am)	
1. School classrooms	$L_{Aeq(1\ hr)}$ 40 (internal)	-	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)
2. Hospital wards	$L_{Aeq(1\ hr)}$ 35 (internal)	$L_{Aeq(1\ hr)}$ 35 (internal)	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)
3. Places of worship	$L_{Aeq(1\ hr)}$ 40 (internal)	$L_{Aeq(1\ hr)}$ 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 passive recreation criteria (see row 5 Open space (passive use) of this table) may be applied.
4. Open space (active use)	$L_{Aeq(15\ hr)}$ 60	-	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.
5. Open space (passive use)	$L_{Aeq(15\ hr)}$ 55	-	

Existing sensitive land use	Assessment criteria		Additional considerations
8. Child care facilities	Sleeping rooms $L_{Aeq(1\ hr)}$ 35 Indoor play areas $L_{Aeq(1\ hr)}$ 40 (internal) Outdoor play areas $L_{Aeq(1\ hr)}$ 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.
9. Aged care facilities	-	-	Residential land use noise assessment criteria should be applied to these facilities.

4.6.2 Guidance for the evaluation of feasible and reasonable noise mitigation measures

Where the NCG criteria are exceeded, the Roads and Maritime's *Noise Mitigation Guideline* (NMG) provides further discussion of situations where provision of additional controls, such as noise barriers, architectural treatments and quieter pavements, would be considered 'feasible and reasonable'. It should be acknowledged that these considerations apply only if it can be demonstrated that all 'feasible and reasonable' traffic management and other road design opportunities for reduction of traffic noise at the source have been exhausted.

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

The NMG provides two triggers where a receiver may qualify for consideration of noise mitigation (beyond the adoption of road design and traffic management measures). These are:

- The predicted do something noise level exceeds the NCG controlling criterion and the noise level increase due to the project (i.e. the noise predictions for the do something minus the do minimum) is greater than 2.0 dB(A), or
- The predicted do something noise level is 5 dB(A) or more above the criteria (meets or exceeds the cumulative limit) and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the project
- In addition if the noise level contribution from the road project is acute (daytime $L_{Aeq(15\ hr)}$ 65 dB(A) or higher, or night time $L_{Aeq(9\ hr)}$ 60 dB(A) or higher) then it qualifies for consideration of noise mitigation even if noise levels are dominated by another road.

The eligibility of receivers for consideration of additional noise mitigation, such as at-property treatments, is determined before the benefit of noise mitigation such as quieter pavement and noise barriers is included. If the NCG criterion cannot be satisfied with quieter pavement and noise barriers, then the receiver is eligible for consideration of at-property treatment.

4.6.3 Maximum 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, it does include 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, Roads and Maritime 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 are provided in Practice Note iii of the *Environmental Noise Management Manual* (ENMM). The maximum noise assessment should be used as a tool to help prioritise and rank mitigation strategies, but 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 assessment considers the following:

- Calculation of maximum noise levels
- The extent to which the maximum noise levels for individual vehicle pass-bys exceed the L_{Aeq} noise level for each hour of the night (i.e. L_{Amax} noise levels greater than 65 dB(A) where $L_{Amax} - L_{Aeq(1hr)} \geq 15$ dB(A))
- The number of times the maximum noise levels for individual vehicle pass-bys exceed the L_{Aeq} noise level for each hour of the night.

4.6.4 Operational facilities noise criteria

The *Noise Policy for Industry* (NPfI) provides noise levels for assessing the potential impact of noise from industry and includes a framework for considering feasible and reasonable noise mitigation measures. The NPfI applies to all noise emissions from the permanent operational ancillary facilities (fixed' facilities) for the project. The assessment procedure for industrial noise sources has two components that must be considered:

- Controlling intrusive noise impacts in the short term for residences; and
- Maintaining noise level amenity for residences and other land uses.

Intrusive noise impacts

The NPfI states that the intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source (L_{Aeq} level), measured over a 15 minute period, does not exceed the background noise level measured by more than 5 dB.

The background noise levels for the project have been measured in accordance with procedures set out in the policy. Adjustments are to be applied to the level of noise produced if the noise at the receiver contains annoying characteristics such as tonality or impulsiveness.

The RBLs for the NCAs potentially affected by the operation of the motorway operations complexes, ventilation facilities and tunnel support facilities are presented in **Table 4-14**.

Table 4-14 Rating background levels for selected noise catchment areas

Facility	Location	Rating background level, dB(A)		
		Day[1]	Evening[2]	Night[3]
Arncliffe MOC	NCA01	55	55	45
	NCA02	49	48	42
	NCA03	47	47	39
Rockdale (north) MOC	NCA07	41	41	33
	NCA08	39	39	36
	NCA09	38	38	32
Rockdale (south) MOC	NCA09	38	38	32

Facility	Location	Rating background level, dB(A)		
		Day[1]	Evening[2]	Night[3]
	NCA11	53	47	38
	NCA14	66	66	56
	NCA15	42	40	32
	NCA16	57	50	37
	NCA17	42	40	32

Notes:
1 Day is defined as 7am to 6pm Monday to Saturday and 8am to 6pm Sundays and Public Holidays
2 Evening is defined as 6pm to 10pm Monday to Sunday and Public Holidays
3 Night is defined as 10pm to 7am Monday to Saturday and 10pm to 8am Sundays and Public Holidays.

Protecting noise amenity

To limit continuing increases in noise levels, the maximum ambient noise level resulting from all industrial noise sources in an area should not normally exceed the acceptable noise levels specified in Table 2.2 of the NPfI. As per the definitions of receiver types within the NPfI, residences within this area are classified as being in urban and suburban areas. **Table 4-15** presents details of the NCAs which are potentially affected by noise from the operational facilities. These details are used to determine the amenity criteria.

Table 4-15 Factors affecting existing ambient noise levels within NCAs

Facility	Location	Category	Existing/future industry present	High levels of traffic noise		
				Day	Evening	Night
Arncliffe MOC	NCA01	Urban	✓	-	✓	✓
	NCA02	Urban	✓	-	-	-
	NCA03	Urban	✓	-	-	-
Rockdale (north) MOC	NCA07	Urban	✓	-	-	-
	NCA08	Urban	✓	-	-	-
Rockdale (south) MOC	NCA09	Suburban	None	-	-	-
	NCA11	Urban	✓	-	✓	✓
	NCA14	Urban	✓	✓	✓	✓
	NCA15	Suburban	None	-	-	-
	NCA17	Suburban	None	-	-	-

Notes:
1 Day is defined as 7am to 6pm Monday to Saturday and 8am to 6pm Sundays and Public Holidays.
2 Evening is defined as 6pm to 10pm Monday to Sunday and Public Holidays.
3 Night is defined as 10pm to 7am Monday to Saturday and 10pm to 8am Sundays and Public Holidays.

For residential receivers, the cumulative amenity criteria are shown in **Table 4-16**. Amenity noise level for other nearby receiver types are also presented in **Table 4-16**.

Table 4-16 Recommended L_{Aeq} noise levels

Type of receiver	Indicative noise amenity area	Time of day	Recommended L_{Aeq} noise level, dB(A)	
			Acceptable	Recommended maximum
Residence	Suburban	Day[1]	55	60
		Evening[2]	45	50
		Night[3]	40	45
	Urban	Day[1]	60	65
		Evening[2]	50	55
		Night[3]	45	50
School classroom —internal	All	Noisiest 1-hour period	35	40
Hospital ward internal external	 All All	 Noisiest 1-hour period Noisiest 1-hour period	 35 50	 40 55
Place of worship —internal				
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Active recreation area (e.g. school playground, golf course)	All	When in use	55	60
Commercial	All	When in use	65	70
Industrial	All	When in use	70	75

Notes:
1 Day is defined as 7am to 6pm Monday to Saturday and 8am to 6pm Sundays and Public Holidays.
2 Evening is defined as 6pm to 10pm Monday to Sunday and Public Holidays.
3 Night is defined as 10pm to 7am Monday to Saturday and 10pm to 8am Sundays and Public Holidays.

The amenity level applicable to a project is equal to the recommended amenity level minus 5 dB(A). However if the cumulative industrial noise is not a necessary consideration at a certain receiver location as no other industries are present or likely to be introduced then the relevant noise amenity level from **Table 4-16** is assigned as the project amenity noise level.

The level of transport noise, road traffic noise in particular, may be high enough to make noise from an industrial source effectively inaudible, even though the L_{Aeq} noise level from that industrial noise source may exceed the project amenity noise level. If all the conditions below are satisfied, the ANL becomes $L_{Aeq,traffic}$ minus 15 dB(A).

- The road traffic noise is the dominant noise source
- The existing noise is 10 dB(A) or more above the acceptable ANL for the area
- It is highly unlikely the road traffic noise levels would reduce in the near future.

The project amenity level is then converted to a 15 minute period by adding 3 dB(A).

4.6.5 Final environmental noise criteria

A summary of the intrusive and amenity criteria for the operational facilities is given in **Table 4-17**. These criteria must be applied at the most affected boundary or 30 metres from the residential building (whichever is closer). The more stringent background noise levels have been used to determine the criteria, which have resulted in a conservative assessment.

Table 4-17 Summary of environmental noise criteria

Facility	Location	$L_{Aeq,15\ min}$ Intrusiveness criterion, dB(A)	$L_{Aeq,15\ min}$ Amenity criterion, dB(A)	Project specific noise criteria dB(A)
Daytime				
Arncliffe MOC	NCA01	60	58	58
	NCA02	54	58	54
	NCA03	52	58	52
Rockdale (north) MOC	NCA07	46	58	46
	NCA08	44	58	44
Rockdale (south) MOC	NCA09	43	58	43
	NCA11	58	58	58
	NCA14	71	60	60
	NCA15	47	58	47
	NCA17	47	58	47
Evening				
Arncliffe MOC	NCA01	60	50	50
	NCA02	53	48	48
	NCA03	52	48	48
Rockdale (north) MOC	NCA07	46	48	46
	NCA08	44	48	44
Rockdale (south) MOC	NCA09	43	48	43
	NCA11	52	50	50
	NCA14	71	58	58
	NCA15	55	48	48
	NCA17	45	48	45
Night				
Arncliffe MOC	NCA01	50	47	47
	NCA02	47	43	43
	NCA03	44	43	43
Rockdale (north) MOC	NCA07	38	43	38
	NCA08	41	43	41

Facility	Location	$L_{Aeq,15\ min}$ Intrusiveness criterion, dB(A)	$L_{Aeq,15\ min}$ Amenity criterion, dB(A)	Project specific noise criteria dB(A)
Rockdale (south) MOC	NCA09	37	43	37
	NCA11	43	48	43
	NCA14	61	56	56
	NCA15	37	43	37
	NCA17	37	43	37

Notes:
1 Based on site observations and logging results amenity criterion has been adjusted in accordance with the INP due to existing industrial noise contributions.

Tonality and Noise Policy for Industry modifying factors

As per the NPfI, penalties to the overall predicted noise levels apply if it is found that they possess annoying characteristics such as tonality, impulsiveness, intermittency, irregularity or dominant low frequency content.

Sleep disturbance (operational facility operational noise)

The NPfI requires the potential for sleep disturbance to be assessed by considering maximum noise levels events during the night-time period.

Where the night-time noise levels of the proposed development of the proposed development at a residential location exceed the following screening levels, a detailed maximum noise level event assessment should be undertaken:

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

The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period.

Based on the measured background noise levels during the night, the sleep disturbance criteria for the nearest noise sensitive residential receivers are presented in **Table 4-18**.

Table 4-18 Summary of sleep disturbance noise criteria

Facility	Location	Sleep disturbance screening	
		$L_{Aeq,15\ min}$ criteria, dB(A)	$L_{A,max}$, dB(A)
Arncliffe MOC/Ventilation facility	NCA01	50	60
	NCA02	47	57
	NCA03	44	54
Rockdale (north) MOC Ventilation facility	NCA07	40	52
	NCA08	41	52
Rockdale (south) MOC	NCA09	40	52
	NCA11	43	53
	NCA14	61	71
	NCA15	40	52
	NCA17	40	52

5 Assessment of construction noise and vibration impacts

5.1 Construction scenarios and equipment

Provided below in **Table 5-1** is a matrix summary of the works to be undertaken and the corresponding indicative timing for each works package.

Table 5-1 Construction works and programme

Construction activity	2020		2021				2022				2023			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
C1 - Arncliffe construction ancillary facility														
Establishment of temporary noise attenuation measures		■												
Construction of stockpiling shed		■	■											
Tunnelling works and spoil handling			■	■	■	■	■	■	■	■	■			
Construction of MOC (operational facilities)										■	■			
Fitout, testing, and commissioning of the MOC										■	■			
Rehabilitation and landscaping											■			
C2 - Rockdale construction ancillary facility														
Establishment of temporary noise attenuation measures		■	■											
Demolition and clearing of structures, including buildings		■	■											
Construction of stockpiling acoustic shed		■	■											
Construction of the decline tunnel			■	■										
Tunnelling works and spoil handling				■	■	■	■	■	■	■	■			
Construction of the MOC/MCC										■	■	■		
Fitout, testing, and commissioning of the MOC/MCC												■	■	

Construction activity	2020		2021				2022				2023			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Rehabilitation and landscaping														
C3 – Cut and cover construction														
Relocation of utilities														
Site establishment including establish and commission bentonite plant														
Excavate a temporary creek deviation and build working platform														
Temporary stockpiling of spoil and fill materials														
Construction of diaphragm wall guide-walls and panels														
Excavate to soffit of roof slab														
Installation of bored piles														
Construction of the cut and cover structure														
Return creek to original alignment														
Install/modify stormwater and/or pavement														
Rehabilitation and landscaping														
C3 - MOC Construction														
Construction of the MOC Rockdale (south)														
Fitout, testing, and commissioning of the MOC														
Rehabilitation and landscaping														

Construction activity	2020		2021				2022				2023			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
C3 - President Avenue Roadworks														
Relocation of utilities/services														
Demolition and clearing of structures, including buildings														
Culverts installation														
Stormwater installation														
Pavement works														
Final asphalt and line marking														
Construction of the shared pedestrian and cycle pathways overpass														
Princes Highway intersection works														
Relocation of utilities/services														
Property adjustments														
Demolition and clearing of structures, including buildings														
Excavate to subgrade level														
Install/modify stormwater and footpath pavement														
Pavement works														
Final asphalt and line marking														
Rehabilitation and landscaping														
C4 and C5 - Shared pedestrian and cycle path														
Site establishment														
Shared pedestrian and cycle pathways construction														
Rehabilitation and landscaping														

Construction activity	2020		2021				2022				2023			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
C6 Construction ancillary facility														
Site establishment														
Construction ancillary facility operations														
Site rehabilitation														

Construction equipment and associated sound power levels typically used in these work packages are identified in **Table 5-2**. The listed sound power levels are typical values taken from data provided in:

- Australian Standard AS2436-2010, Guide to noise control on construction, demolition and maintenance sites
- UK Department for Environment, Food and Rural Affairs (DEFRA) noise database.

It has been assumed that all equipment is modern and in good working order. Based on experience with other projects, L_{A1} sound power levels are typically up to 8 dB(A) above L_{Aeq} sound power levels.

During the detailed design local site conditions and changes in work practices may cause some variation in the equipment used. While the equipment may vary, other major infrastructure projects have shown that due to the conservative approach to noise predictions, received noise levels are unlikely to be appreciably higher than those predicted in this assessment.

This approach is used at this point in the assessment to ensure that identified impacts are not under-predicted and adequate noise management and mitigation measures are considered early in the project.

Table 5-2 Sound power levels of typical construction plant and equipment

Scenario	Equipment	SWL, dB(A)	Overall[1] SWL, dB(A)
Relocation of utilities/services			116
	Concrete saw	115	
	Excavator	98	
	Vacuum sucker truck	103	
	Tipper truck	105	
	Backhoe	97	
	Roller	105	

Scenario	Equipment	SWL, dB(A)	Overall[1] SWL, dB(A)
Establishment of temporary noise attenuation measures			113
	Excavator	98	
	Backhoe	97	
	Mobile crane	98	
	Concrete truck/Agitator	106	
	Concrete pump	106	
	Bored piling rig	105	
	Roller	105	
	Water cart	104	
	Tipper truck	105	
Site establishment including establish and commission bentonite plant			113
	Excavator	98	
	Backhoe	97	
	Mobile crane	98	
	Concrete truck/Agitator	106	
	Concrete pump	106	
	Bored piling rig	105	
	Roller	105	
	Water cart	104	
	Tipper truck	105	
Construction of stockpiling shed			113
	Excavator	98	
	Backhoe	97	
	Mobile crane	98	
	Concrete truck/Agitator	106	
	Concrete pump	106	
	Bored piling rig	105	
	Roller	105	
	Water cart	104	
	Tipper truck	105	
Demolition and clearing of structures, including buildings			117
	Excavator	98	
	Tipper truck	105	
	Concrete saw	115	
	Hydraulic rock hammer (Excavator mounted)	112	

Scenario	Equipment	SWL, dB(A)	Overall[1] SWL, dB(A)
Construction of the decline tunnel			117
	Bored piling rig	105	
	Mobile crane	98	
	shotcrete rig	106	
	Jumbo drill rig	114	
	Concrete truck/Agitator	106	
	Tipper truck	105	
	Roadheader	112	
Excavate a temporary creek deviation and build working platform			109
	Vacuum sucker truck	103	
	Front end loader	98	
	Excavator	98	
	Mobile crane	98	
	Franna crane	98	
	Roller	105	
	Daymaker	98	
	Hand tools	94	
Construction of diaphragm wall guide-walls and panels			112
	Bentonite plant	105	
	Hydraulic extractor	90	
	Mobile crane	98	
	Excavator	98	
	Concrete truck/Agitator	106	
	Tipper truck	105	
	Diesel generator	94	
	Water pump	106	
	Tipper truck	105	
	Backhoe	97	
	Sheet piling (hydraulic jacking)	96	
Temporary stockpiling of spoil and fill materials for later reuse or prior to offsite removal			107
	Front end loader	98	
	Tipper truck	105	
	Backhoe	97	

Scenario	Equipment	SWL, dB(A)	Overall[1] SWL, dB(A)
Excavate to soffit of roof slab			114
	Excavator	98	
	Hydraulic rock hammer (Excavator mounted)	112	
	Bulldozer	109	
	Tipper truck	105	
Installation of bored piles			111
	Bored piling rig	105	
	Concrete pump	106	
	Excavator	98	
	Concrete truck/Agitator	106	
	Air compressor	103	
Construction of the cut and cover structure			117
	Bored piling rig	105	
	Mobile crane	98	
	Shotcrete rig	106	
	Jumbo drill rig	114	
	Concrete truck/Agitator	106	
	Tipper truck	105	
	Roadheader	112	
Return creek to original alignment			114
	Excavator	98	
	Hydraulic rock hammer (Excavator mounted)	112	
	Bulldozer	109	
	Tipper truck	105	
Install/modify stormwater and/or pavement			118
	Asphalt paver	105	
	Daymaker	98	
	Franna crane	98	
	Tipper truck	105	
	Pavement profiler	108	
	Asphalt truck and sprayer	103	
	Roller	105	
	Concrete truck/Agitator	106	
	Concrete saw	115	
	Line marking truck	103	
	Water cart	104	

Scenario	Equipment	SWL, dB(A)	Overall[1] SWL, dB(A)
Tunnelling works and spoil handling, as well as stockpiling of excavated material and spoil haulage			117
	Bored piling rig	105	
	Mobile crane	98	
	Shotcrete rig	106	
	Jumbo drill rig	114	
	Concrete truck/Agitator	106	
	Tipper truck	105	
	Roadheader	112	
Construction of the MOC/MCC			113
	Excavator	98	
	Backhoe	97	
	Mobile crane	98	
	Concrete truck/Agitator	106	
	Concrete pump	106	
	Bored piling rig	105	
	Roller	105	
	Water cart	104	
	Tipper truck	105	
Fitout, testing and commissioning of the MOC/MCC			102
	Small truck	98	
	Utility and light vehicles	90	
	Hand tools	94	
	Franna crane	98	
Excavate to subgrade level			114
	Excavator	98	
	Hydraulic rock hammer (Excavator mounted)	112	
	Bulldozer	109	
	Tipper truck	105	
Install culverts			110
	Backhoe	97	
	Franna crane	98	
	Excavator	98	
	Air compressor	103	
	Roller	105	
	Tipper truck	105	

Scenario	Equipment	SWL, dB(A)	Overall[1] SWL, dB(A)
Pavement works			117
	Tipper truck	105	
	Concrete saw	115	
	Grader	108	
	Roller	105	
	Backhoe	97	
Final asphalt and line marking			109
	Line marking truck	103	
	Utes and light vehicles	90	
	Asphalt truck and sprayer	103	
	Tipper truck	105	
Construction of the shared pedestrian and cycle pathways			117
	Tipper truck	105	
	Concrete saw	115	
	Grader	108	
	Roller	105	
	Backhoe	97	
Construction of the shared pedestrian and cycle pathways without concrete saws			111
	Tipper truck	105	
	Grader	108	
	Roller	105	
	Backhoe	97	
Construction of the shared pedestrian and cycle pathways overpass over President Avenue			112
	Mobile Crane	98	
	Concrete truck/Agitator	106	
	Concrete pump	106	
	Tipper truck	105	
	Franna crane	98	
	Diesel generator	94	
	Daymaker	98	
	Bored piling rig	105	

Scenario	Equipment	SWL, dB(A)	Overall[1] SWL, dB(A)
Site compound operations			109
	Front end loader	98	
	Excavator	98	
	Tipper truck	105	
	Air compressor	103	
	Welding equipment	105	
	Utility and light vehicles	90	
	Diesel generator	91	
	Flatbed Truck	105	
	Hand/Electric tools	98	
Rehabilitation and landscaping			107
	Tipper truck	105	
	Hand tools	94	
	Franna crane	98	
	Mobile crane	98	
	Backhoe	97	

Notes:

1 The overall level is the logarithmic sum of all equipment that has been assumed to be operating simultaneously

5.2 Construction noise modelling and prediction

Noise levels due to the construction activities have been predicted at nearby residences using SoundPLAN noise modelling software v7.3. The modelling used the ISO 9613-2 algorithm and includes ground topography, buildings and structures and representative construction noise sources. **Table 5-1** and **Table 5-2** provide a summary of the works to be undertaken and the location of the works. Free field point receivers at 1.5 metres high were assumed, source heights are dependent on the equipment but typically two metres above ground.

It can be expected that there may be differences between predicted and measured noise levels due to variations in instantaneous operating conditions, plant in operation during the measurement and also the location of the plant equipment. The acoustic shielding calculated in the model due to fixed building structures would also vary as the construction equipment moves around the site. Neutral weather conditions were assumed for all construction scenarios.

Noise barriers and hoarding around the perimeter of construction ancillary facilities are proposed for the Arncliffe construction ancillary facility (C1) and the Rockdale (north) construction ancillary facility (C2). The proposed noise barriers and hoarding are four metres in height for the Arncliffe site and three metres for the Rockdale (north) site. Noise barriers are currently not proposed at the Rockdale (south) site.

An acoustic stockpiling shed has been included at the Rockdale (north) construction ancillary facility (C2). The stockpile shed at Arncliffe has conservatively been assumed to be a standard non-acoustic construction. The timing of construction of these sheds is identified in **Table 5-1**. All tunnelling operations and loading of trucks with tunnel spoil would be completed with the sheds in place.

Construction works located within a spoil shed (non-acoustic) at the Arncliffe construction ancillary facility (C1) have been modelled with a 10 dB(A) insertion loss. Construction works located within an acoustic shed at the Rockdale construction ancillary facility (C2) have been modelled with a 25 dB(A) insertion loss.

Blasting has been considered in **section 5.5.4** of this report.

The following sections tabulate all residential receiver impacts. Discussion regarding the impacts to any other sensitive receivers (such as schools and places of worship) is presented below the tables.

5.2.1 Standard hours works activities

The noise modelling results for standard hours of construction are provided in **Table 5-3** to **Table 5-11**.

The tables present the noise management levels and the highest predicted construction noise levels at a noise sensitive receiver for each noise catchment area. The tables also present the number of receivers where the construction noise levels are predicted to exceed the NML (and to what extent) and the highly noise affected level for each noise catchment area. The predicted construction noise levels are also provided graphically in **Annexure D**.

It is important to consider that this assessment is representative of the worst case 15 minute period of construction activity, while the construction equipment is at the nearest location to each sensitive receiver location. The assessed scenario does not represent the ongoing day to day noise impact at noise sensitive receivers for an extended period of time.

Particularly noisy activities, such as rock hammering and use of concrete saws, are likely to persist for only a fraction of the overall construction period. In addition the predictions use the shortest separation distance to each sensitive receiver, however in reality separation distances would vary between plant and sensitive receivers. For linear works (works that move along the road alignment, rather than works located at a construction ancillary facility) noise exposure at each receiver would reduce due to increases in distance loss as the works progress along the alignment. Typical noise levels could be five to 10 dB(A) lower dependent on the site and nature of works.

The reported maximum noise level is for the highest noise level during that construction scenario. The reported number of receivers where noise levels are expected to exceed the noise management levels is based on the reported maximum noise level. Typically the number of sensitive receivers exceeding the noise management levels will be reduced appreciably depending instantaneous operating conditions.

The ICNG states that where a construction noise impact level of greater than 75 dB(A) is predicted, a receiver is considered to be 'highly noise affected' and afforded additional consideration for mitigation. The receivers where noise levels exceed 75 dB(A) can be identified on the noise contours provided in **Annexure D**. The potential for highly noise affected receivers would be confirmed during detailed construction planning. These receivers would receive additional consultation with regards to specific timing and impacts of construction works. Respite periods would also be considered for these receivers in accordance with the ICNG.

The predictions outlined below indicate that noise levels at commercial and industrial receivers would generally remain compliant with the applicable noise management levels. This would be confirmed in more detail by the contractor in the Construction Noise and Vibration Management Plan (CNVMP).

Arncliffe construction ancillary facility (C1)

Table 5-3 Arncliffe construction ancillary facility (C1) – Standard hours work

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Highly noise affected
Establishment of temporary noise attenuation measures						
NCA1	65	74	12	0	0	0
NCA2	59	53	0	0	0	0
NCA3	57	52	0	0	0	0
Construction of stockpiling						

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Highly noise affected
Shed						
NCA1	65	54	0	0	0	0
NCA2	59	51	0	0	0	0
NCA3	57	50	0	0	0	0
Tunnelling works and spoil handling						
NCA1	65	54	0	0	0	0
NCA2	59	51	0	0	0	0
NCA3	57	51	0	0	0	0
Construction of the MOC						
NCA1	65	56	0	0	0	0
NCA2	59	53	0	0	0	0
NCA3	57	52	0	0	0	0
Fitout and testing of the MOC						
NCA1	65	45	0	0	0	0
NCA2	59	42	0	0	0	0
NCA3	57	41	0	0	0	0
Rehabilitation and landscaping						
NCA1	65	63	0	0	0	0
NCA2	59	47	0	0	0	0
NCA3	57	46	0	0	0	0

Construction noise levels associated with the Arncliffe construction ancillary facility (C1) would meet the NMLs in all but one scenario. The greatest impacts would be generated by the establishment of temporary noise attenuation measures, which are expected to take up to six months. Once these measures are installed construction noise levels would generally comply with the applicable NMLs.

Apart from residential receivers, there are no other sensitive receiver types that would be impacted by the works at the Arncliffe facility.

Rockdale construction ancillary facility (C2)

Table 5-4 Rockdale construction ancillary facility (C2) – Standard hours work

NCA	L_{Aeq} NML dB(A)	Max L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Establishment of temporary noise attenuation measures						
NCA5	49	60	125	1	0	0
NCA6	51	54	5	0	0	0
NCA7	51	97	92	33	33	21
NCA8	49	65	65	7	0	0
NCA9	48	50	10	0	0	0
Demolition and clearing of structures, including buildings						
NCA5	49	58	160	0	0	0
NCA6	51	55	9	0	0	0
NCA7	51	74	99	53	7	0
NCA8	49	63	74	5	0	0
NCA9	48	56	75	0	0	0
Construction of stockpiling acoustic shed						
NCA5	49	56	68	0	0	0
NCA6	51	53	2	0	0	0
NCA7	51	75	99	22	5	0
NCA8	49	59	48	0	0	0
Construction of the decline tunnel						
NCA5	49	59	141	0	0	0
NCA6	51	55	8	0	0	0
NCA7	51	91	103	45	7	5
NCA8	49	62	60	3	0	0
NCA9	48	51	25	0	0	0
Tunnelling works and spoil handling						
NCA7	51	57	13	0	0	0

NCA	L_{Aeq} NML dB(A)	Max L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Construction of the MOC/MCC						
NCA5	49	56	93	0	0	0
NCA6	51	53	2	0	0	0
NCA7	51	83	98	36	12	3
NCA8	49	61	48	3	0	0
Fitout of the MOC/MCC						
NCA7	51	72	30	6	1	0
NCA8	49	50	2	0	0	0
Rehabilitation and landscaping						
NCA5	49	54	24	0	0	0
NCA7	51	91	58	26	16	4
NCA8	49	59	26	0	0	0

Noise levels from the works associated with the Rockdale construction ancillary facility (C2) would exceed the NMLs at nearby receivers during a number of scenarios. The most affected catchment area would be NCA7 due to the close proximity of sensitive receivers in this area. Hoarding three metres in height is currently proposed to minimise these impacts, in addition to an acoustic stockpiling shed and has been included as part of the modelling presented above.

Tunnelling works and spoil handling would extend for the longest period (up to two years), but would also have the lowest noise impacts. The stockpiling shed and enclosed decline tunnel would ensure that noise levels are limited with exceedances of the NMLs being less than 10 dB(A).

The scenarios resulting in the highest construction noise levels would be establishment of the temporary noise attenuation measures and construction of the decline tunnel. Twenty one and five receivers would be highly affected by these works respectively. Construction and fitout works of the MOC would also result in a relatively small number of receivers being highly noise affected.

The establishment of temporary noise attenuation measures would have a relatively short timeframe in comparison to the length of the project. This scenario is likely to last for around six months.

Located north east of the Rockdale (north) facility is the St Thomas More Catholic Church. During normal construction hours mass is held at St Thomas More Catholic Church at 9am Monday to Friday. External noise levels could be as high as 55 dB(A), however internal noise levels should generally be compliant with the internal noise criteria of 45 dB(A) (during times of use).

Schools within the area include the Brighton-Le-Sands public school to the south-east, St Thomas More's Catholic School and Cairnsfoot Special School. Given the offset and shielding provided by other buildings, the highest noise levels are predicted to be 55 dB(A) (external). This would comply with the internal noise criteria of 45 dB(A).

Cut and cover construction (part of the President Avenue construction ancillary facility (C3))

Table 5-5 C3 Cut and cover construction – Standard hours work

NCA	L_{Aeq} NML dB(A)	Max L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Relocation of utilities						
NCA8	49	55	29	0	0	0
NCA9	48	55	61	0	0	0
NCA11	63	67	5	0	0	0
Site establishment						
NCA7	51	59	16	0	0	0
NCA8	49	72	51	10	1	0
NCA9	48	94	90	9	5	4
NCA11	63	65	3	0	0	0
NCA14	76	97	3	5	1	9
NCA15	52	57	17	0	0	0
NCA16	67	99	13	9	5	18
NCA17	52	60	37	0	0	0
Establish and commission bentonite plant						
NCA7	51	52	1	0	0	0
NCA8	49	60	40	1	0	0
NCA9	48	56	56	0	0	0
Temporary stockpiling of spoil and fill materials						
NCA8	49	50	1	0	0	0
NCA9	48	72	27	2	3	0
NCA16	67	75	1	0	0	0
Excavate a temporary creek deviation and build working platform						
NCA8	49	50	1	0	0	0
NCA9	48	56	18	0	0	0

NCA	L_{Aeq} NML dB(A)	Max L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Construct diaphragm wall guide walls and panels						
NCA8	49	51	7	0	0	0
NCA9	48	65	55	5	0	0
NCA17	52	54	4	0	0	0
Excavate to soffit of roof slab						
NCA8	49	53	39	0	0	0
NCA9	48	69	82	6	1	0
NCA16	67	68	1	0	0	0
NCA17	52	54	4	0	0	0
Install bored piles						
NCA8	49	50	1	0	0	0
NCA9	48	62	37	3	0	0
Construction of the cut and cover structure						
NCA7	51	53	8	0	0	0
NCA8	49	56	73	0	0	0
NCA9	48	71	126	6	3	0
NCA11	63	64	4	0	0	0
NCA15	52	53	4	0	0	0
NCA16	67	70	2	0	0	0
NCA17	52	56	15	0	0	0
Return creek to original alignment						
NCA8	49	54	35	0	0	0
NCA9	48	61	78	3	0	0

NCA	L_{Aeq} NML dB(A)	Max L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Install/modify stormwater and/or pavement						
NCA7	51	54	23	0	0	0
NCA8	49	57	80	0	0	0
NCA9	48	71	135	14	3	0
NCA11	63	65	5	0	0	0
NCA15	52	57	20	0	0	0
NCA16	67	71	4	0	0	0
NCA17	52	60	58	0	0	0
Rehabilitation and landscaping						
NCA7	51	53	1	0	0	0
NCA8	49	66	14	3	0	0
NCA9	48	88	31	2	4	3
NCA14	76	91	5	1	0	7
NCA16	67	93	11	5	2	9
NCA17	52	54	2	0	0	0

A significant number of clearly audible (1 to 10 dB(A)) exceedances of the NMLs have been predicted at receivers due to the construction works associated with the cut and cover construction, with a smaller number of impacts greater than 10 dB(A) identified in NCA9. Site establishment and landscaping are predicted to incur the greatest number of exceedances for residential receivers within NCA9, NCA14 and NCA16. Some of these receivers are likely to be highly noise affected. While these activities are of limited duration compared to the overall program, they would need to be carefully managed to minimise impacts.

Across the majority of scenarios a small number of receivers would experience noise levels which would result in highly intrusive (greater than 20 dB(A))exceedances whilst a large number of receivers would experience noise levels which represent clearly audible (1 to 10 dB(A)) and moderately intrusive (11 to 20 dB(A)) exceedances. Further work should be undertaken at the detailed design phase to minimise these impacts as much as practicable when further details are understood.

Due to the proximity noise impacts from site establishment activities are predicted to reach 65 dB(A) within the most affected school buildings at Brighton-Le-Sands Public School. This would exceed the applicable noise criteria. Noise intensive site establishment works are unlikely to exceed one or two months, however the works would need to be carefully managed to ensure impacts are minimised.

Longer term works such as stockpiling of materials and diaphragm wall construction would have much lower impacts with external noise levels of 55 dB(A), internal noise levels are expected to be around 45 dB(A), complying with the applicable noise criteria.

Due to the proximity of the playing fields the active and passive recreation criteria would exceeded at the nearby playing fields at times.

Rockdale (south) MOC facility (at the President Avenue construction ancillary facility (C3))

Table 5-6 Rockdale (south) MOC facility – Standard hours work

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Construction of the MOC						
NCA8	49	51	6	0	0	0
NCA9	48	52	18	0	0	0
Rehabilitation and landscaping						
NCA8	49	45	0	0	0	0
NCA9	48	46	0	0	0	0

Standard hours noise levels would generally meet the NMLs at most receivers. There are up to 24 clearly audible (1 to 10 dB(A)) exceedances identified during the construction of the MOC scenarios, which is attributed to the close proximity of the works to residences. No exceedances have been predicted for the rehabilitation and landscaping of the site.

There are no other sensitive non-residential properties which would be impacted by the works from the construction of the Rockdale (south) MOC facility.

President Avenue intersection roadworks (both within and outside the defined extent of the President Avenue construction ancillary facility (C3))

Table 5-7 President Avenue Intersection works – Standard hours work

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Relocation of utilities/services						
NCA8	49	51	7	0	0	0
NCA9	48	64	51	6	0	0
NCA14	76	99	3	2	1	6
NCA15	52	58	28	0	0	0
NCA16	67	97	16	3	2	9
NCA17	52	60	44	0	0	0

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Demolition and clearing of structures, including buildings						
NCA8	49	52	21	0	0	0
NCA9	48	72	64	10	4	0
NCA15	52	54	6	0	0	0
NCA16	67	107	17	8	1	11
NCA17	52	59	50	0	0	0
Culverts installation						
NCA9	48	55	8	0	0	0
NCA17	52	53	2	0	0	0
Stormwater installation						
NCA8	49	55	78	0	0	0
NCA9	48	70	136	13	3	0
NCA11	63	64	1	0	0	0
NCA14	76	96	3	10	0	14
NCA15	52	60	70	0	0	0
NCA16	67	94	26	3	12	17
NCA17	52	63	81	1	0	0
Pavement works						
NCA8	49	53	21	0	0	0
NCA9	48	67	85	11	0	0
NCA14	76	92	2	5	0	7
NCA15	52	59	42	0	0	0
NCA16	67	94	22	3	12	16
NCA17	52	61	67	0	0	0

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Final asphalting and line marking						
NCA9	48	60	42	3	0	0
NCA14	76	89	4	3	0	9
NCA15	52	53	1	0	0	0
NCA16	67	89	8	33	3	39
NCA17	52	68	28	5	0	0
Construction of the shared pedestrian and cycle pathways overpass on President Avenue						
NCA9	48	55	10	0	0	0
NCA15	52	61	18	0	0	0
NCA17	52	55	5	0	0	0

A significant number of clearly audible (1 to 10 dB(A)) exceedances of the NMLs have been predicted for these scenarios due to the construction activities associated with the President Avenue Intersection roadworks. This is due to the close proximity of receivers, which are directly adjacent to the proposed works area. Residences in NCA14 and NCA16 are the most affected receivers with a small number of highly noise affected receivers being predicted across almost all construction scenarios. The works would be progressive so that not all receivers would be affected at any one time, or for the overall duration of the works.

Due to large offset distances construction works on President Avenue would generally comply with the internal noise criteria at the Brighton-Le-Sands Public School and TAFE St George College.

Princes Highway Intersection works and Princes Highway construction ancillary facility (C6)

Table 5-8 Princes Highway Intersection works – Standard hours work

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Relocation of utilities/services						
NCA14	76	95	0	5	0	5
Property adjustments						
NCA14	76	95	7	16	0	23
NCA15	52	57	11	0	0	0
Demolition and clearing of structures, including buildings						
NCA14	76	103	1	1	1	4
C6 construction ancillary facility establishment						
NCA14	76	99	1	1	1	4
C6 construction ancillary facility operation						
NCA14	76	95	1	1	0	2
C6 construction ancillary facility rehabilitation						
NCA14	76	97	1	0	1	2
Excavate to subgrade level						
NCA12	76	77	1	0	0	1
NCA14	76	91	14	14	0	31
NCA15	52	57	26	0	0	0

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Install/modify stormwater and footpath pavement						
NCA12	76	79	5	0	0	5
NCA14	76	96	8	23	0	31
NCA15	52	60	38	0	0	0
Pavement works						
NCA12	76	78	1	0	0	5
NCA14	76	95	8	23	0	31
NCA15	52	59	35	0	0	0
Final asphalt and line marking						
NCA14	76	86	24	0	0	26
Rehabilitation and landscaping						
NCA14	76	89	27	5	0	33

A large number of clearly audible (1 to 10 dB(A)) exceedances of the NMLs have been predicted due to the construction works associated with the Princes Highway Intersection works. This is due to the close proximity of receivers to the proposed works. Residences in NCA14 are the most affected receivers with a number of highly noise affected receivers being predicted across almost all construction scenarios. A number of scenarios will result in moderately intrusive (11 to 20 dB(A)) and highly intrusive (greater than 20 dB(A)) exceedances for a large number of receivers however these works are not expected to be of long duration. Generally the works would be progressive so that not all receivers would be affected at any one time or for the overall duration of the works.

Construction works at Princes Highway have the potential to impact the TAFE St George College. Dependent on the location of the works, noise levels could be highly intrusive. Works would need to be co-ordinated with the TAFE to ensure the works are managed appropriately.

Noise impacts within the hospital are likely to be audible in some locations, however due to inoperable windows at the most affected locations, the internal noise levels are likely to be compliant with the internal noise criteria of 45 dB(A). Further work should be undertaken during the detailed design phase to investigate the existing façade design and location of sensitive rooms to confirm this assumption.

Shared cyclist and pedestrian pathways construction ancillary facilities (C4 and C5)

Table 5-9 Shared cyclist and pedestrian pathways east construction ancillary facility (C4) – Standard hours work

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Site establishment						
NCA4	48	51	11	0	0	0
NCA5	49	84	88	19	7	3
NCA7	51	53	5	0	0	0

Whilst a large number of receivers would be likely to be affected by construction works associated with the Shared cyclist and pedestrian pathways east construction ancillary facility (C4), the NML exceedances would be mostly clearly audible (1 to 10 dB(A)). However receivers within NCA5 would experience noise levels resulting in moderately intrusive (11 to 20 dB(A)) and highly intrusive (greater than 20 dB(A)) exceedances. The works are not expected to have long term impacts given that the likely duration is up to three months.

The works are assumed to occur without hoarding or noise barriers.

These works are not expected to impact any other sensitive non-residential receivers.

Table 5-10 Shared cyclist and pedestrian pathways West construction ancillary facility (C5) – Standard hours work

NCA	**L_{Aeq} NML dB(A)**	**Max L_{Aeq} noise level dB(A)**	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	**Number of highly noise affected receivers**
Site establishment						
NCA4	48	54	53	0	0	0
NCA5	49	75	63	4	2	0
NCA7	51	55	1	0	0	0

Whilst a large number of receivers are likely to be affected by construction works associated with the Shared pedestrian and cycle pathways west construction ancillary facility (C5), the NML exceedances would be mostly clearly audible (exceedance of 1 to 10 dB(A)). However some receivers within NCA5 would experience noise levels resulting in moderately intrusive (11 to 20 dB(A)) and highly intrusive (greater than 20 dB(A)) exceedances. These receivers would not be the same as those affected by the Shared cyclist and pedestrian pathways east construction ancillary facility (C4) works. The works are not expected to have long term impacts given the duration of the scenario would be up to 3 months. The works are assumed to occur without hoarding or noise barriers.

The Cairnsfoot Special School has the potential to be impacted by this work. Works would need to be co-ordinated with the school to ensure noise impacts are managed appropriately.

Table 5-11 Shared cyclist and pedestrian pathways construction (C3, C4 & C5) – Standard hours work

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Shared cyclist and pedestrian pathways construction						
NCA4	48	105	524	118	24	13
NCA5	49	102	266	68	39	24
NCA6	51	53	18	0	0	0
NCA7	51	91	131	17	9	5
NCA8	49	94	63	29	10	7
NCA9	48	62	131	4	0	0
NCA15	52	84	85	15	5	4
NCA17	52	60	70	0	0	0
Shared cyclist and pedestrian pathways construction (no concrete saw)						
NCA4	48	99	284	31	13	7
NCA5	49	96	164	29	24	12
NCA7	51	85	48	8	3	2
NCA8	49	88	36	12	7	5
NCA9	48	56	34	0	0	0
NCA15	52	78	30	6	4	2
NCA17	52	54	6	0	0	0
Rehabilitation and landscaping						
NCA4	48	95	118	16	8	5
NCA5	49	92	68	22	17	8
NCA7	51	81	17	7	2	2
NCA8	49	84	29	5	5	4
NCA9	48	52	4	0	0	0
NCA15	52	15	3	2	0	4

Construction of the shared cyclist and pedestrian pathways is predicted to be the worst case construction scenario for residential receivers for these works. Due to the close proximity of the construction site to residences and the comparatively large geographic extents of the shared cyclist and pedestrian pathways (when compared to site compounds), a large number of residential receivers have been identified as being affected by the works. It is important to note that the number of receivers where noise levels may exceed the NMLs over the entire construction works would not all be affected at the same time or for the duration of these works, depending on the location of construction equipment in use.

The use of the concrete saws would be of very limited duration. Construction scenarios have been modelled with and without the use of a concrete saw. The construction scenario without the concrete saw is considered more typical of the maximum noise impacts experienced across the extents of the project.

While the construction program currently identifies the works taking place for up to six months, this is over the entire extent of the shared cyclist and pedestrian pathways. The duration in any one location would be much more limited.

While some maximum impacts may be appreciable, the short duration of the construction of the shared cyclist and pedestrian pathways would minimise the associated overall impact upon the affected community. Long-term mitigation is not justified in this area, and noise mitigation such as hoarding may be difficult to implement due to the progressive nature of the works. Effective noise management measures will be the key to the successful minimisation of impacts in this area.

Due to the physical extents of the work the Cairnsfoot Special School, and the Brighton-Le-Sands Public School is likely to be impacted by the works. Due to the linear nature of the construction of the path, the works are not expected to occur for an extended duration. While noise impacts may at times be intrusive, the duration should be limited. The works should be co-ordinated with the school so that where possible, noise intensive works occur outside school hours. Passive and active recreation park area surrounding the works would also be impacted.

5.2.2 Out of hours work activities

While all opportunities have been investigated to limit work to standard working hours, on major infrastructure projects, there are some works which must be undertaken outside of standard working hours. The most common reasons for out of hours work include:

- Work requiring road closures – these include utilities relocations, permanent power supply connection, bridge installations, pavement works and road tie-ins. These works would be undertaken outside standard hours to minimise impacts to the local road network during normal transit periods
- Safety constraints – these are constraints which have the potential to create safety issues to the general public, or to the workers on site. All other approaches to the work would be considered before working during out of hours periods
- Work which would not exceed applicable stringent noise limits – some work which would be undertaken underground, within acoustic sheds, or does not generate noise may proceed during out of hours work if it can be proven that the work would not adversely impact the local community
- Works which cannot be undertaken during standard work hours – deliveries and some pavement works (due to curing times) can only be undertaken during out of hours work periods.

The types of activities that would be undertaken outside standard construction hours for this project are outlined in **section 5.1**. This would include tunnelling works which would be undertaken on a 24 hour basis. Other work may be required to be undertaken out of hours work for health and safety reasons, to prevent traffic congestion on major roads during peak periods, or for particular construction requirements.

Scenarios which include out of hours works, including a justification for these works are identified in **Table 5-12**.

Table 5-12 Out of hours work scenarios

Works scenario	Requirement for out of hours works
Relocation of utilities (where the location is in close proximity to traffic)	Where utilities are located in close proximity to road traffic, work would need to be undertaken outside standard hours to partially close lanes and create a safe working environment for construction works.
Pavement and temporary median works	Some pavement works would be required to be undertaken outside standard hours to partially close lanes and create a safe working environment for construction works.
Asphalt works and line-marking	Some asphalt and line-marking works would be required to be undertaken outside standard hours to partially close lanes and create a safe working environment for construction works.
Use of construction ancillary facilities to support out of hours works	These facilities would be required to provide office space and vehicle movements to and from the sites.
Construction of the shared cyclist and pedestrian pathways overpass	President Avenue would need to be closed during the night-time period while the overpass bridge is craned into place. This will be required to maintain a safe environment for both the public and construction workers. The works cannot be undertaken during the daytime period due to operational constraints on the road network.
Diaphragm wall construction (Evening only)	Once started, the diaphragm wall construction cannot be put on hold until the section of works is complete. As the cut gets deeper (toward West Botany Street) it is possible that some works would not be able to be completed by the end of the daytime period. In this case the works would need to extend into the early evening period. Works are not expected to be extended into the night-time period. All efforts would be made to contain works within the daytime period. These works would occur by exception only and are not expected to occur regularly.
Tunnel works and spoil handling (Arncliffe construction ancillary facility (C1))	Tunnelling works would need to be undertaken 24hours. The spoil would be trucked up the decline and deposited in the spoil shed.
Temporary stockpiling of spoil and fill materials (C3)	Stockpiling of spoil and fill materials would be associated with the diaphragm wall construction. Where the diaphragm wall activities are completed during the daytime period, these activities would not be required during out of hours work periods.

The out of hours work construction noise modelling results are provided in **Table 5-13** to **Table 5-18**. The results are also provided graphically in **Annexure D**.

The preliminary assessment is based on the activities detailed in **section 5.1**. In practice the scale of works may be reduced during the night-time period and therefore this assessment presents a conservative approach.

All feasible and reasonable mitigation measures, as provided in **Chapter 8**, would be implemented to ensure that the potential for adverse impact on the local community is minimised. These mitigation measures would be further developed during detailed design by the contractor and provided in the CNVMP. Example measures that may be implemented are outlined in **section 8.1** of this report.

It is important to consider that this assessment is representative of the worst case 15 minute period of construction activity and does not necessarily represent the noise impact at noise sensitive receivers for an extended period of time. Particularly noisy activities, such as rock hammering and use of concrete saws, are likely to persist for only a fraction of the overall construction period. In addition the predictions use the shortest separation distance to each sensitive receiver, however in reality separation distances would vary between plant and sensitive receivers. For linear works (works that move along the road alignment, rather than works located at a construction ancillary facility) noise exposure at each receiver would reduce due to increases in distance loss as the works progress along the alignment.

Arncliffe construction ancillary facility (C1)

Table 5-13 Arncliffe construction ancillary facility (C1) – Out of hours work (night)

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 - 15 dB(A)	NML exceedance 16 – 25 dB(A)	NML exceedance > 25 dB(A)
Tunnelling works and spoil handling						
NCA1	50	54	26	0	0	0
NCA2	47	51	40	0	0	0
NCA3	44	51	16	20	0	0

Night-time construction noise levels associated with the Arncliffe construction ancillary facility (C1) are predicted to exceed the relevant NML for all NCAs. Whilst the exceedances are generally clearly audible (5 to 15 dB(A)), the works would continue for an extended period. An effective communication plan and noise management measures would be developed at the detailed design stage to appropriately manage these impacts.

Rockdale construction ancillary facility (C2)

Table 5-14 Rockdale construction ancillary facility (C2) – Out of hours work (evening)

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 - 15 dB(A)	NML exceedance 16 – 25 dB(A)	NML exceedance > 25 dB(A)
Construction of decline tunnel						
NCA5	44	59	150	180	0	0
NCA6	46	55	17	9	0	0
NCA7	46	91	38	120	45	7
NCA8	44	62	20	66	3	0
NCA9	43	51	70	42	0	0

A large number of exceedances of the NMLs have been predicted due to the evening-time construction works associated with the Rockdale construction ancillary facility (C2). A number of moderately intrusive (16 to 25 dB(A)) and highly intrusive (greater than 25 dB(A)) exceedances are also predicted within NCA7. The exceedances are attributed to the close proximity of the construction site to residences, and the nature of the works. These works would only occur during the evening period, and only when the works cannot be completed during standard working hours. At this stage it is not envisaged that these works would be a regular occurrence, and are expected to be required by exception only.

Table 5-15 Rockdale construction ancillary facility (C2) – Out of hours work (night)

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 - 15 dB(A)	NML exceedance 16 – 25 dB(A)	NML exceedance > 25 dB(A)
Tunnelling works and spoil handling						
NCA5	39	44	32	1	0	0

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 - 15 dB(A)	NML exceedance 16 – 25 dB(A)	NML exceedance > 25 dB(A)
NCA6	38	41	5	0	0	0
NCA7	38	57	36	65	10	0
NCA8	41	44	4	0	0	0

A number of exceedances of the NMLs have been predicted due to the night-time construction works associated with Rockdale construction ancillary facility (C2). Exceedances of the NMLs range between clearly audible (5 to 15 dB(A)) at NCA5 to moderately intrusive (16 to 25 dB(A)) at NCA7. The exceedances are attributed to the close proximity of the construction site to residences. As part of the detailed design an effective communication plan and noise management measures would be important to ensure that impacts are minimised for affected sensitive receivers.

Cut and cover construction (part of the President Avenue construction ancillary facility (C3))

Table 5-16 Cut and cover construction – Out of hours work (night)

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 - 15 dB(A)	NML exceedance 16 – 25 dB(A)	NML exceedance > 25 dB(A)
Relocation of utilities/services						
NCA7	38	50	33	169	0	0
NCA8	41	55	45	77	0	0
NCA9	37	55	5	156	8	0
NCA10	43	53	0	1	0	0
NCA11	43	67	55	116	13	0
NCA15	37	50	50	158	0	0
NCA16	42	52	64	103	0	0
NCA17	37	49	63	213	0	0
Construction of diaphragm wall guide walls and panels						
NCA7	46	48	13	0	0	0
NCA8	44	51	55	20	0	0
NCA9	43	65	67	73	5	0
NCA11	52	60	14	5	0	0
NCA15	45	51	31	4	0	0
NCA16	55	65	18	10	0	0
NCA17	45	54	76	17	0	0

A number of receivers are predicted to exceed the NMLs due to night-time works associated with the cut and cover construction works at Rockdale Bicentennial Park. As previously identified these works would only occur by exception and are unlikely to proceed past 8 pm.

President Avenue intersection roadworks (both within and outside the defined extent of the President Avenue construction ancillary facility (C3))

Table 5-17 President Avenue Roadworks – Out of hours work (night)

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 - 15 dB(A)	NML exceedance 16 – 25 dB(A)	NML exceedance > 25 dB(A)
Relocation of utilities/services						
NCA7	38	46	0	2	0	0
NCA8	41	51	53	78	0	0
NCA9	37	64	7	143	15	4
NCA10	43	50	0	1	0	0
NCA11	43	62	84	74	4	0
NCA14	61	99	16	9	3	3
NCA15	37	58	4	187	28	0
NCA16	42	97	24	94	37	21
NCA17	37	60	9	237	44	0
Pavement works						
NCA7	38	48	0	2	0	0
NCA8	41	53	46	90	0	0
NCA9	37	67	1	133	29	6
NCA10	43	51	0	1	0	0
NCA11	43	63	74	90	9	0
NCA14	61	92	26	16	2	5
NCA15	37	59	2	175	42	0
NCA16	42	94	15	93	39	37
NCA17	37	61	4	219	67	0
Final asphalt and line marking						
NCA7	38	40	1	0	0	0
NCA8	41	46	63	4	0	0
NCA9	37	60	17	132	18	0
NCA10	43	45	1	0	0	0
NCA11	43	58	36	34	0	0
NCA14	61	89	9	9	4	3
NCA15	37	53	72	138	1	0
NCA16	42	89	25	52	41	44
NCA17	37	68	46	199	28	5

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 - 15 dB(A)	NML exceedance 16 – 25 dB(A)	NML exceedance > 25 dB(A)
Construction of the shared cyclist and pedestrian pathways overpass						
NCA4	36	37	3	0	0	0
NCA5	39	41	11	0	0	0
NCA6	38	42	7	0	0	0
NCA7	38	44	121	10	0	0
NCA8	41	46	70	7	0	0
NCA9	37	55	26	137	4	0
NCA10	43	45	1	0	0	0
NCA11	43	56	64	39	0	0
NCA14	61	63	8	0	0	0
NCA15	37	61	12	185	18	0
NCA16	42	56	61	77	0	0
NCA17	37	55	63	216	5	0

A number of night-time work scenarios would result in moderately intrusive (16 to 25 dB(A)) and highly intrusive (greater than 25 dB(A)) NML exceedances. Careful consideration of noise management and mitigation measures would be required at the detailed design phased of the project to ensure minimal impacts to nearby sensitive receivers. These are discussed further in section 8.

Night-time construction activities associated with the shared cyclist and pedestrian pathways would include the installation of the deck units/girders and would occur for one or two nights only. Longer term noise impacts associated with this work scenario are not expected.

Princes Highway Intersection works

Table 5-18 Princes Highway Intersection works – Out of hours work (night)

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 - 15 dB(A)	NML exceedance 16 – 25 dB(A)	NML exceedance > 25 dB(A)
Relocation of utilities/services						
NCA11	43	48	28	1	0	0
NCA12	61	74	8	13	0	0
NCA14	61	95	4	5	0	5
NCA15	37	44	128	17	0	0
Excavate to subgrade level						
NCA11	43	60	16	115	5	0
NCA12	61	77	8	13	1	0
NCA14	61	91	22	24	14	14
NCA15	37	57	2	191	26	0
Install/modify stormwater and footpath pavement						
NCA11	43	63	32	109	22	0
NCA12	61	79	8	13	5	0
NCA14	61	96	26	37	8	23
NCA15	37	60	0	181	38	0
Pavement works						
NCA11	43	62	24	111	15	0
NCA12	61	78	9	16	1	0
NCA14	61	95	30	32	8	23
NCA15	37	59	0	184	35	0
Final asphalt and line marking						
NCA11	43	55	50	62	0	0
NCA12	61	72	4	7	0	0
NCA14	61	86	11	10	24	0
NCA15	37	52	58	159	0	0

A large number of exceedances of the NMLs have been predicted due to the night-time construction works associated with the Princes Highway Intersection works. Exceedances of the NMLs range between clearly audible (5 to 15 dB(A)) and highly intrusive (greater than 25 dB(A)) dependent on the proximity of the NCA to the site. Mitigation measures would need to be applied at the detailed design phase to limit impacts to nearby sensitive receivers.

5.3 Sleep disturbance

Sleep disturbance is assessed using an $L_{A1(1\ min)}$ parameter, which is considered to be the maximum noise level excluding extraneous noise events. A sleep disturbance assessment has been undertaken for the proposed night works with the construction information available to date. The noise modelling results are provided in **Table 5-19** to **Table 5-23** with predicted noise levels compared with the sleep disturbance screening criteria and the awakening reaction criteria.

Table 5-19 Arncliffe construction ancillary facility (C1) – Out of hours work – Sleep disturbance

NCA	Sleep disturbance criteria	Maximum $L_{A1(1min)}$ noise level dB(A)	Number of Sleep disturbance exceedances	Awakening reaction
Tunnelling works and spoil handling				
NCA1	60	55	0	0
NCA2	57	51	0	0
NCA3	54	51	0	0

No potential for sleep disturbance is expected as a result of night-time works associated with the Arncliffe construction ancillary facility (C1).

Table 5-20 Rockdale (north) ancillary construction facility (C2) – Out of hours work –sleep disturbance

NCA	Sleep disturbance criteria	Maximum $L_{A1(1min)}$ noise level dB(A)	Number of sleep disturbance exceedances	Awakening reaction
Tunnelling works and spoil handling				
NCA5	49	44	0	0
NCA6	48	41	0	0
NCA7	48	56	20	0
NCA8	51	45	0	0
NCA9	47	33	0	0
NCA11	53	32	0	0
NCA14	71	32	0	0

Exceedances of the sleep disturbance criteria have been predicted at up to 20 properties within NCA7 due to night-time construction activities associated with tunnel works and spoil handling. These exceedances are attributed to the close proximity of the construction site to residences. No exceedances of the awakening reaction criterion are expected.

The night-time tunnelling works and spoil handling scenario is expected to have longer term impacts hence an effective communication plan and noise management measures will be important to ensure that impacts are minimised for affected sensitive receivers. This is discussed further in section 8.

Table 5-21 Cut and cover construction (C3) – Out of hours work – sleep disturbance

NCA	Sleep disturbance criteria	Maximum $L_{A1(1min)}$ noise level dB(A)	Number of Sleep disturbance exceedances	Awakening reaction
Relocation of utilities/services				
NCA5	49	32	0	0
NCA7	48	50	28	0
NCA8	51	55	12	0
NCA9	47	55	90	0
NCA10	53	53	0	0
NCA11	53	67	28	4
NCA12	71	48	0	0
NCA14	71	58	0	0
NCA15	47	50	7	0
NCA16	52	52	0	0
NCA17	47	49	9	0

A number of exceedances of the sleep disturbance screening criteria have been predicted due to the night-time construction works associated with the cut and cover roadworks. Noise levels at up to four receivers may exceed the awakening reaction criterion during utility relocation works. The night-time relocation of utilities/services scenario is expected to occur for up to nine months hence an effective communication plan and noise management measures will be important to ensure that impacts are minimised for affected sensitive receivers. This is discussed further in section 8.

Table 5-22 President Avenue Roadworks (C3) – Out of hours work – sleep disturbance

NCA	Sleep disturbance criteria	Maximum $L_{A1(1min)}$ noise level dB(A)	Number of Sleep disturbance exceedances	Awakening reaction
Relocation of utilities/services				
NCA7	48	46	0	0
NCA8	51	51	0	0
NCA9	47	64	83	0
NCA10	53	50	0	0
NCA11	53	62	22	0
NCA12	71	48	0	0
NCA14	71	99	8	15
NCA15	47	58	159	0
NCA16	52	97	90	31
NCA17	47	60	164	0
Pavement works				
NCA7	48	48	0	0
NCA8	51	53	5	0
NCA9	47	67	122	4
NCA10	53	51	0	0

NCA	Sleep disturbance criteria	Maximum $L_{A1(1min)}$ noise level dB(A)	Number of Sleep disturbance exceedances	Awakening reaction
NCA11	53	63	30	0
NCA12	71	48	0	0
NCA14	71	92	12	23
NCA15	47	59	168	0
NCA16	52	94	107	42
NCA17	47	61	199	0
Final asphalt and line marking				
NCA7	48	40	0	0
NCA8	51	46	0	0
NCA9	47	60	52	0
NCA10	53	45	0	0
NCA11	53	58	5	0
NCA12	71	42	0	0
NCA14	71	89	11	16
NCA15	47	53	20	0
NCA16	52	89	96	48
NCA17	47	68	99	3
Construction of the shared cyclist and pedestrian pathways overpass				
NCA4	46	37	0	0
NCA5	49	41	0	0
NCA6	48	42	0	0
NCA7	48	44	0	0
NCA8	51	46	0	0
NCA9	47	55	23	0
NCA10	53	45	0	0
NCA11	53	56	3	0
NCA12	71	44	0	0
NCA14	71	63	0	0
NCA15	47	61	69	0
NCA16	52	56	17	0
NCA17	47	55	52	0

A large number of exceedances of the sleep disturbance screening criteria have been predicted due to the night-time construction works associated with the President Avenue Roadworks. In addition noise associated with some of the works will exceed the awakening reaction screening criterion. The exceedances are attributed to the close proximity of the construction site to residences.

The President Avenue Roadworks night-time construction works are expected to have limited noise impact due to the short duration (approximately nine months) of the works. Nonetheless, an effective communication plan and noise management measures will need to be developed during detailed design to minimise the impacts upon affected sensitive receivers.

Table 5-23 Princes Highway Intersection works – Out of hours work – sleep disturbance

NCA	Sleep disturbance criteria	Maximum $L_{A1(1min)}$ noise level dB(A)	Number of Sleep disturbance exceedances	Awakening reaction
Relocation of utilities/services				
NCA11	53	48	0	0
NCA12	71	74	6	13
NCA13	71	57	0	0
NCA14	71	95	7	10
NCA15	47	44	0	0
Excavate to subgrade level				
NCA11	53	60	46	0
NCA12	71	77	6	14
NCA13	71	56	0	0
NCA14	71	91	31	52
NCA15	47	57	118	0
Install/modify stormwater and footpath pavement				
NCA11	53	63	75	0
NCA12	71	79	10	18
NCA13	71	60	0	0
NCA14	71	96	37	68
NCA15	47	60	162	0
Pavement work				
NCA11	53	62	65	0
NCA12	71	78	7	17
NCA13	71	59	0	0
NCA14	71	95	35	63
NCA15	47	59	135	0
Final asphalt and line marking				
NCA11	53	55	5	0
NCA12	71	72	1	7
NCA13	71	51	0	0
NCA14	71	86	28	34
NCA15	47	52	26	0

The potential for a large number of exceedances of the sleep disturbance screening criteria have been predicted due to the night-time construction works associated with Princes Highway Intersection works. The night-time works are essential due to the close proximity to a major road intersection. A significant number of potential awakening reactions have been predicted in NCA12 and NCA14 which are attributed to the close proximity of the construction site to residences. An effective communication plan and noise management measures will be important to ensure that impacts are minimised for affected sensitive receivers. This is discussed further in section 8.

5.4 Construction road traffic noise

Construction road traffic noise would be generated by vehicles associated with the construction of the project, including heavy vehicles transporting spoil and light vehicle movements generated by construction workers.

For the purposes of the construction traffic impact assessment, the period of construction activity that generates the peak volume of heavy vehicles was assessed to represent the worst case scenario.

The nominated construction vehicles routes to/from construction ancillary facilities are identified in **Appendix D** (Traffic and Transport technical report). The majority of traffic flows would occur on major roads and construction ancillary facilities have been selected to minimise the use of local roads.

For the purposes of the construction road traffic noise assessment, the following assumptions have been made:

- The hourly construction traffic movements during the peak and off-peak periods would remain at a constant rate per hour during the nominated period.
- The traffic movements predicted to occur during that hour would be occurring on all nominated construction vehicle routes
- During off-peak periods, the minimum hourly movement for existing traffic volumes has been applied
- All construction vehicles would be on the road network at the same time (presenting a cumulative impact).
- The existing traffic flows were based on traffic count data collected between 2015 and 2017. For streets where heavy vehicle percentages or off-peak traffic counts were not available these were estimated from the heavy vehicle percentages and peak/off-peak ratios of similar roads.
- Spoil haulage would occur 24 hours per day and seven days per week.
- Morning peak periods were typically 6am to 8 am, with afternoon peaks occurring 4 pm to 6 pm. Off peak periods occurred outside this time. The night-time peak assessed for noise would occur 6 am to 7 am.

As a result, this assessment has assumed a worst case scenario.

5.4.1 Daytime movements

Table 5-24 and **Table 5-25** present summaries of the existing, forecasted additional traffic flow and the resultant noise increases for the daytime peak and off peak periods.

Table 5-24 Construction road traffic during daytime peak period

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
Arncliffe construction ancillary facility (C1)					
Marsh Street	3,829	183	76	26	0.2
Rockdale construction ancillary facility (C2)					
West Botany Street (South Bestic)	1,463	15	75	24	0.7

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
President Avenue	2,605	28	75	24	0.4
The Grand Parade	5,252	65	75	24	0.2
Princes Highway	3,347	30	75	24	0.3
Wickham Street	1,122	56	75	24	0.7
Bestic Street	1,262	63	75	24	0.7
West Botany Street (North Bestic)	1,651	83	75	24	0.5
Marsh Street	3,829	183	75	24	0.2
President Avenue construction ancillary facility (C3)					
West Botany Street (South Bestic)	1,463	15	114	30	1.0
President Avenue	2,605	28	114	30	0.6
The Grand Parade	5,252	65	114	30	0.3
Princes Highway	3,347	30	114	30	0.4
Wickham Street	1,122	56	114	30	0.9
Bestic Street	1,262	63	114	30	0.8
West Botany Street (North Bestic)	1,651	83	114	30	0.7
Marsh Street	3,829	183	114	30	0.3
Shared cyclist and pedestrian pathways east construction ancillary facility (C4)					
West Botany Street (South Bestic)	1,463	15	8	2	0.1
President Avenue	2,605	28	8	2	0.0
The Grand Parade	5,252	65	8	2	0.0
Princes Highway	3,347	30	8	2	0.0
Wickham Street	1,122	56	8	2	0.1
Bestic Street	1,262	63	8	2	0.1
West Botany Street (North Bestic)	1,651	83	8	2	0.0
Marsh Street	3,829	183	8	2	0.0
Shared cyclist and pedestrian pathways west construction ancillary facility (C5)					
Bruce Street	100	1	10	3	1.4
The Grand Parade	5,252	65	10	3	0.0
Bestic Street	1,262	63	10	3	0.1
West Botany Street (North Bestic)	1,651	83	10	3	0.1
Marsh Street	3,829	183	10	3	0.0
Bestic Street					
Bestic Street	1,262	63	2	2	0.0
West Botany Street (North Bestic)	1,651	83	2	2	0.0
Marsh Street	3,829	183	2	2	0.0

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
Princes Highway construction ancillary facility (C6)					
President Avenue	2,605	28	9	2	0.1

Table 5-25 Construction road traffic during daytime off-peak period

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
Arncliffe construction ancillary facility (C1)					
Marsh Street	1,823	87	5	26	0.4
Rockdale construction ancillary facility (C2)					
West Botany Street (South Bestic)	697	7	2	24	1.1
President Avenue	1,240	13	2	24	0.7
The Grand Parade	2,501	31	2	24	0.3
Princes Highway	1,594	14	2	24	0.5
Wickham Street	534	27	2	24	1.1
Bestic Street	613	31	2	24	1.0
West Botany Street (North Bestic)	1,034	52	2	24	0.6
Marsh Street	1,823	87	2	24	0.4
President Avenue construction ancillary facility (C3)					
West Botany Street (South Bestic)	697	7	32	30	1.5
President Avenue	1,240	13	32	30	0.9
The Grand Parade	2,501	31	32	30	0.5
Princes Highway	1,594	14	32	30	0.7
Wickham Street	534	27	32	30	1.5
Bestic Street	613	31	32	30	1.3
West Botany Street (North Bestic)	1,034	52	32	30	0.8
Marsh Street	1,823	87	32	30	0.5
Shared cyclist and pedestrian pathways east construction ancillary facility (C4)					
West Botany Street (South Bestic)	697	7	5	2	0.1
President Avenue	1,240	13	5	2	0.1
The Grand Parade	2,501	31	5	2	0.0
Princes Highway	1,594	14	5	2	0.1
Wickham Street	534	27	5	2	0.1
Bestic Street	613	31	5	2	0.1

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
West Botany Street (North Bestic)	1,034	52	5	2	0.1
Marsh Street	1,823	87	5	2	0.0
Shared cyclist and pedestrian pathways west construction ancillary facility (C5)					
Bruce Street	48	0	7	3	2.4
The Grand Parade	2,501	31	7	3	0.1
Bestic Street	613	31	7	3	0.2
West Botany Street (North Bestic)	1,034	52	7	3	0.1
Marsh Street	1,823	87	7	3	0.1
Bestic Street					
Bestic Street	613	31	2	2	0.1
West Botany Street (North Bestic)	1,034	52	2	2	0.1
Marsh Street	1,823	87	2	2	0.0
Princes Highway construction ancillary facility (C6)					
President Avenue	1,240	13	9	2	0.1

5.4.2 Night-time movements

Night-time spoil haulage may be required. This assessment has considered the maximum night-time spoil haulage movements that could occur.

Presented in **Table 5-26** and **Table 5-27** are summaries of the existing, forecasted worst-case additional traffic flow and the resultant noise increases for the night-time peak and off peak periods.

Table 5-26 Construction road traffic during night-time peak period

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
Arncliffe construction ancillary facility (C1)					
Marsh Street	3136	150	60	14	0.2
Rockdale construction ancillary facility (C2)					
West Botany Street (South Bestic)	1,255	13	80	13	0.6
President Avenue	1,858	20	80	13	0.4
The Grand Parade	3,765	47	80	13	0.2
Princes Highway	2,794	25	80	13	0.3
Wickham Street	267	13	80	13	1.8
Bestic Street	425	21	80	13	1.2
West Botany Street (North Bestic)	967	48	80	13	0.6
Marsh Street	3,136	150	80	13	0.2

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
President Avenue construction ancillary facility (C3)					
West Botany Street (South Bestic)	1,255	13	116	2	0.4
President Avenue	1,858	20	116	2	0.3
The Grand Parade	3,765	47	116	2	0.1
Princes Highway	2,794	25	116	2	0.2
Wickham Street	267	13	116	2	1.3
Bestic Street	425	21	116	2	0.8
West Botany Street (North Bestic)	967	48	116	2	0.4
Marsh Street	3,136	150	116	2	0.1
Shared cyclist and pedestrian pathways east construction ancillary facility (C4)					
West Botany Street (South Bestic)	1,255	13	8	0	0.0
President Avenue	1,858	20	8	0	0.0
The Grand Parade	3,765	47	8	0	0.0
Princes Highway	2,794	25	8	0	0.0
Wickham Street	267	13	8	0	0.1
Bestic Street	425	21	8	0	0.1
West Botany Street (North Bestic)	967	48	8	0	0.0
Marsh Street	3,136	150	8	0	0.0
Shared cyclist and pedestrian pathways west construction ancillary facility (C5)					
Bruce Street	50	1	10	0	0.7
The Grand Parade	3,765	47	10	0	0.0
Bestic Street	425	21	10	0	0.1
West Botany Street (North Bestic)	967	48	10	0	0.0
Marsh Street	3,136	150	10	0	0.0
Bestic Street					
Bestic Street	425	21	2	0	0.0
West Botany Street (North Bestic)	967	48	2	0	0.0
Marsh Street	3,136	150	2	0	0.0
Princes Highway construction ancillary facility (C6)					
President Avenue	1,858	20	4	4	0.1

Table 5-27 Construction road traffic during night-time off-peak period

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
Arncliffe construction ancillary facility (C1)					
Marsh Street	251	12	10	14	1.4
Rockdale construction ancillary facility (C2)					
West Botany Street (South Bestic)	100	1	15	13	3.5
President Avenue	149	2	15	13	2.6
The Grand Parade	301	4	15	13	1.5
Princes Highway	224	2	15	13	1.9
Wickham Street	21	1	15	13	7.3
Bestic Street	75	4	15	13	3.5
West Botany Street (North Bestic)	121	6	15	13	2.5
Marsh Street	251	12	15	13	1.4
President Avenue construction ancillary facility (C3)					
West Botany Street (South Bestic)	100	1	4	1	0.5
President Avenue	149	2	4	1	0.3
The Grand Parade	301	4	4	1	0.2
Princes Highway	224	2	4	1	0.2
Wickham Street	21	1	4	1	1.5
Bestic Street	75	4	4	1	0.5
West Botany Street (North Bestic)	121	6	4	1	0.3
Marsh Street	251	12	4	1	0.2
Shared cyclist and pedestrian pathways east construction ancillary facility (C4)					
West Botany Street (South Bestic)	100	1	0	0	0.0
President Avenue	149	2	0	0	0.0
The Grand Parade	301	4	0	0	0.0
Princes Highway	224	2	0	0	0.0
Wickham Street	21	1	0	0	0.0
Bestic Street	75	4	0	0	0.0
West Botany Street (North Bestic)	121	6	0	0	0.0
Marsh Street	251	12	0	0	0.0
Shared cyclist and pedestrian pathways west construction ancillary facility (C5)					
Bruce Street	4	0	0	0	0.0
The Grand Parade	301	4	0	0	0.0

Route/Direction	Existing (hourly)		Additional (hourly)		Relative increase
	Light	Heavy	Light	Heavy	dB(A)
Bestic Street	75	4	0	0	0.0
West Botany Street (North Bestic)	121	6	0	0	0.0
Marsh Street	251	12	0	0	0.0
Bestic Street					
Bestic Street	75	4	0	0	0.0
West Botany Street (North Bestic)	121	6	0	0	0.0
Marsh Street	251	12	0	0	0.0
Princes Highway construction ancillary facility (C6)					
President Avenue	149	2	4	4	1.0

5.4.3 Discussion

Increases in road traffic noise of 2.4 dB(A) (exceeding the 2 dB(A) goal) have been identified at Bruce Street during daytime off-peak periods when share cyclist and pedestrian path works. This assumes seven light vehicles and two heavy vehicles would access the Shared cyclist and pedestrian pathways West construction ancillary facility (C5) every hour. Considering the size of size and nature of the site, these movements are considered to be conservative (overestimated). This impact is likely only to occur during times of peak construction periods. Work is expected to last for no longer than three months at this location, so the impact when compared to the overall construction program is small.

Due to potential night-time spoil haulage activities, appreciable increases in noise (up to 7 dB) are predicted to occur surrounding the Rockdale (north) facility. Other locations would generally not require heavy vehicle movements and would not exceed the applicable noise criteria. The most impacted time is the off-peak period where new spoil trucks would have a much more noticeable impact when compared to existing traffic flows. Night-time haulage should be avoided where practical and feasible during night-time off-peak traffic periods to minimise noise impacts.

5.5 Construction vibration

5.5.1 Surface works

In order to comply with the cosmetic/structural damage and human discomfort criteria presented in **section 4.3** the minimum working distances presented in **Table 5-28** should not be encroached.

Table 5-28 Recommended minimum working distances for vibration intensive plant

Plant	Rating/description	Cosmetic damage (metres)	Human response (metres)
Vibratory roller	< 50 kN (Typically 1-2 T)	5	15-20
	< 100 kN (Typically 2-4 T)	6	20
	< 200 kN (Typically 4-6 T)	12	40
	< 300 kN (Typically 7-13 T)	15	100
	> 300 kN (Typically 13-18 T)	20	100
	> 300 kN (> 18 T)	25	100
Small hydraulic rock hammer	(300 kg – 5-12 T excavator)	2	7
Medium hydraulic rock hammer	(900 kg – 12-18 T excavator)	7	23

Plant	Rating/description	Cosmetic damage (metres)	Human response (metres)
Large hydraulic rock hammer	(1,600 kg – 18-34 T excavator)	22	73
Vibratory pile driver	Sheet piles	2-20	20
Pile boring	≤ 800 mm	2 nominal	N/A
Jack hammer	Handheld	Avoid contact with structure	Avoid contact with structure

Note:
1. More stringent conditions may apply to heritage or other sensitive structures. Any heritage property would need to be considered on a case by case basis and assessed in accordance with DIN4150:3 Structural vibration - Effects of vibration on structures.

Depending on the construction equipment that is used, the minimum working distances outlined in **Table 5-28** may be encroached. The primary form of mitigation of vibration would be ensuring vibration intensive works do not occur within the minimum working distances. If vibration intensive works are planned within the minimum working distances identified, alternative equipment would be identified and vibration monitoring would be implemented. Further mitigation of vibration would not be required where the minimum working distances are adhered to.

In some circumstances, construction activity within the minimum working distance cannot be avoided due to the work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced, resulting in a potential change in operating equipment. Approaches to manage such circumstances are discussed in **section 8.3**.

To provide an indication of the potential for vibration impacts associated with construction vibration, the minimum working distances are provided graphically in **Annexure E**.

Using a large hydraulic hammer at the nearest point to sensitive receiver locations has identified approximately 97 receivers where vibration could exceed the cosmetic damage criteria, and a further 257 where the human comfort criteria could be exceeded. The noise catchment areas that these receivers fall into are presented in **Table 5-29**.

It should be noted that these impacts are very unlikely as the contractor would select appropriate equipment based on the works location, nature of the required work and proximity to sensitive receivers.

Table 5-29 Number of buildings within minimum working distances

NCA	Cosmetic damage (metres)	Human response (metres)
NCA1	0	0
NCA2	0	0
NCA3	0	0
NCA4	0	0
NCA5	0	0
NCA6	0	0
NCA7	9	51
NCA8	0	0
NCA9	0	1
NCA10	10	21
NCA11	0	0
NCA12	2	19
NCA13	5	9
NCA14	45	95
NCA15	0	0

NCA	Cosmetic damage (metres)	Human response (metres)
NCA16	26	61

5.5.2 Ground-borne noise and vibration generated by roadheaders

The ground-borne noise experienced in any building would be dependent on the generation and propagation of vibration associated with tunnelling activities. For this project vibration would be generated during tunnelling from the operation of roadheaders. Up to 4 roadheaders would be operated from the Arncliffe construction ancillary facility (C1) and Rockdale construction ancillary facility (C2). The operational locations of the roadheaders would ensure that the most affected sensitive receivers would only be impacted by one roadheader at any time.

From the source, vibration propagates through the ground and decreases over distance. The rate at which the vibration decreases is highly variable and dependent on factors such as the soil or rock type, the consistency of the medium (such as the presence of voids), and the water table. These factors affect the speed of wave propagation and the vibration damping of the system. As the vibration excites a building, it is also subject to a coupling loss changing from one medium (the rock and soil) to another (the building foundations which are typically concrete). The vibration would then be transmitted throughout the building, with further losses as it moves up between floors. The excitation of the walls and ceiling of a room results in the generation of low-frequency noise, which can be audible if the vibration levels are great enough. The noise generated is often described as a low rumble.

The noise that is generated within a room is highly dependent on the soil and rock strata, the distance to the source and the construction of the building. The prediction of ground-borne noise for this project has been based on previous measurements of tunnelling activities from roadheaders and tunnel-boring machines in Sydney, using methods in accordance with ISO14837: *Mechanical vibration - Ground-borne noise and vibration arising from rail systems*, where relevant. The measurements demonstrate an exponential relationship.

The results of the ground-borne noise assessment indicating where the criteria would be exceeded within residential properties are provided in **Table 5-30**. The maximum exceedance would be up to 1 dB(A) during the night-time period at 24 Aboukir Street, Rockdale, which is relatively minor. The results are also provided graphically in **Annexure F**.

Table 5-30 Ground-borne noise– tunnelling activities

Ground borne noise criteria		Number of receivers where criteria are exceeded	
Evening	Night-time	Evening	Night-time
40 dB(A)	35 dB(A)	0	1

Tunnelling would typically progress around a maximum of seven metres per day. It is likely that ground-borne noise would be discernible for up to five days at each affected receiver with the exceedance occurring for up to two days. Tunnelling advance rates would reduce to two to five metres a day around the portals, which may increase the duration of exposure for receivers in these areas. As tunnelling moves towards and away from each receiver the noise levels experienced would be increase and decrease respectively.

It is noted that there is no daytime criterion for ground-borne noise. However, noise levels during the daytime would be consistent with predicted levels at evening and night-time.

5.5.3 Vibration generated by roadheaders

Vibration associated with the use of roadheaders has been calculated for properties located above the main tunnel alignments. The number of receivers where the criteria are exceeded is provided in **Table 5-31**. The results are also provided graphically in **Annexure G**.

This assessment relates to human comfort. The structural damage criteria would not be exceeded by the tunnelling activities.

Table 5-31 Vibration assessment – tunnelling activities

	Human comfort peak particle velocity criteria		Number of receivers where criteria are exceeded	
	Evening	**Night-time**	**Evening**	**Night-time**
Preferred	0.28 mm/s	0.2 mm/s	0	0
Maximum	0.56 mm/s	0.4 mm/s	0	0

The preferred and maximum criteria relate to how sensitive people may be to the vibration generated. By proper management such as informing affected receivers that they may feel vibration and providing complaint hotlines, the sensitivity to vibration can be reduced.

As identified in **Table 5-31**, the tunnelling activities are predicted to be compliant with both the preferred and maximum criteria.

5.5.4 Blasting

One option available to the contractor to excavate the tunnel bench would be to use controlled blasting. Controlled blasting may be undertaken along the length of the alignment during the excavation of the tunnel, at depths greater than 30 m, where the geology is suitable (i.e. not soft ground). Blasting methods can significantly reduce exposure to noise and vibration for residents and businesses above the tunnels. Blasting can also shorten excavation timeframes.

Impacts created by blasting are largely dependent on the blast methodology. The size of the charge, spaces between charge and timing between charges results in a large variability in the vibration generated by a blast. This variability necessitates the use of a specialised blast consultant to design blasts to achieve compliance with the applicable vibration criteria.

Using the equation J7.3 provided in AS2187.2-2006, the maximum effective charge mass per delay to achieve compliance with the vibration criteria is calculated to be 7 kilograms at a depth of 30 metres. This is based on site and rock property constants as determined during blasting of the northern section of the Sydney Harbour Tunnel[1]. Geotechnical conditions at the Sydney Harbour Tunnel site included sandstone rock which is considered comparable to the worst case conditions for any blasting on this project.

It is recommended that a certified blast engineer undertake test blasts when undertaking blasting in new areas across the project. The blast should be designed to ensure compliance with the blast criteria specified in **section 4.5**.

5.5.5 Heritage and other sensitive structures

Heritage and other sensitive structures (including any with Aboriginal significance) have the potential to be more sensitive to vibration than those identified in **Table 5-28**. Some structures such as piped infrastructure and Muddy Creek constructed channel are unlikely to be more sensitive to vibration than the cosmetic damage criteria identified in **Table 5-28**. Typically these structures have very high (>50 mm/s vibration velocity) tolerances to vibration. Considering the types of activities proposed in the vicinity of the Muddy Creek channel (construction of the shared cycle and pedestrian pathways), vibration generated by the project is very unlikely to exceed these vibration levels.

However due to the uncertain nature of the condition of each of these structures, and given their importance, a detailed investigation into each identified structures sensitivity to vibration should be undertaken during the detailed design phase of the project. Structure specific vibration criteria should be applied based on the integrity of the structure.

Where potential for sensitivity is identified, vibration monitoring should be undertaken during all vibration intensive works to ensure that appropriate thresholds are not exceeded.

[1] WestConnex M4 East Project – *Noise and Vibration Impact Assessment*, Report Number 610.13569-R2 dated 4 September 2015

5.6 Power supply connection

A permanent power supply connection would be installed from the Ausgrid Canterbury subtransmission substation to the Rockdale (south) motorway operations complex. This would be used to service both the construction and operation of the project.

The connection would be either installed underground either by trenching or, where required, under-boring. Where the power line crosses waterways or railways, the connection would be installed in a conduit attached to an existing bridge. The power line would be located within the existing road reserve with the exception of where it would cross Bardwell Valley Golf Club, Silver Jubilee Park and the Banksia Railway Line.

The power supply cable would, for the most part, be constructed and installed during standard construction hours, due to the nature of the roads along the selected route. However, the following locations would require night works to avoid traffic impacts associated with road closures during the day:

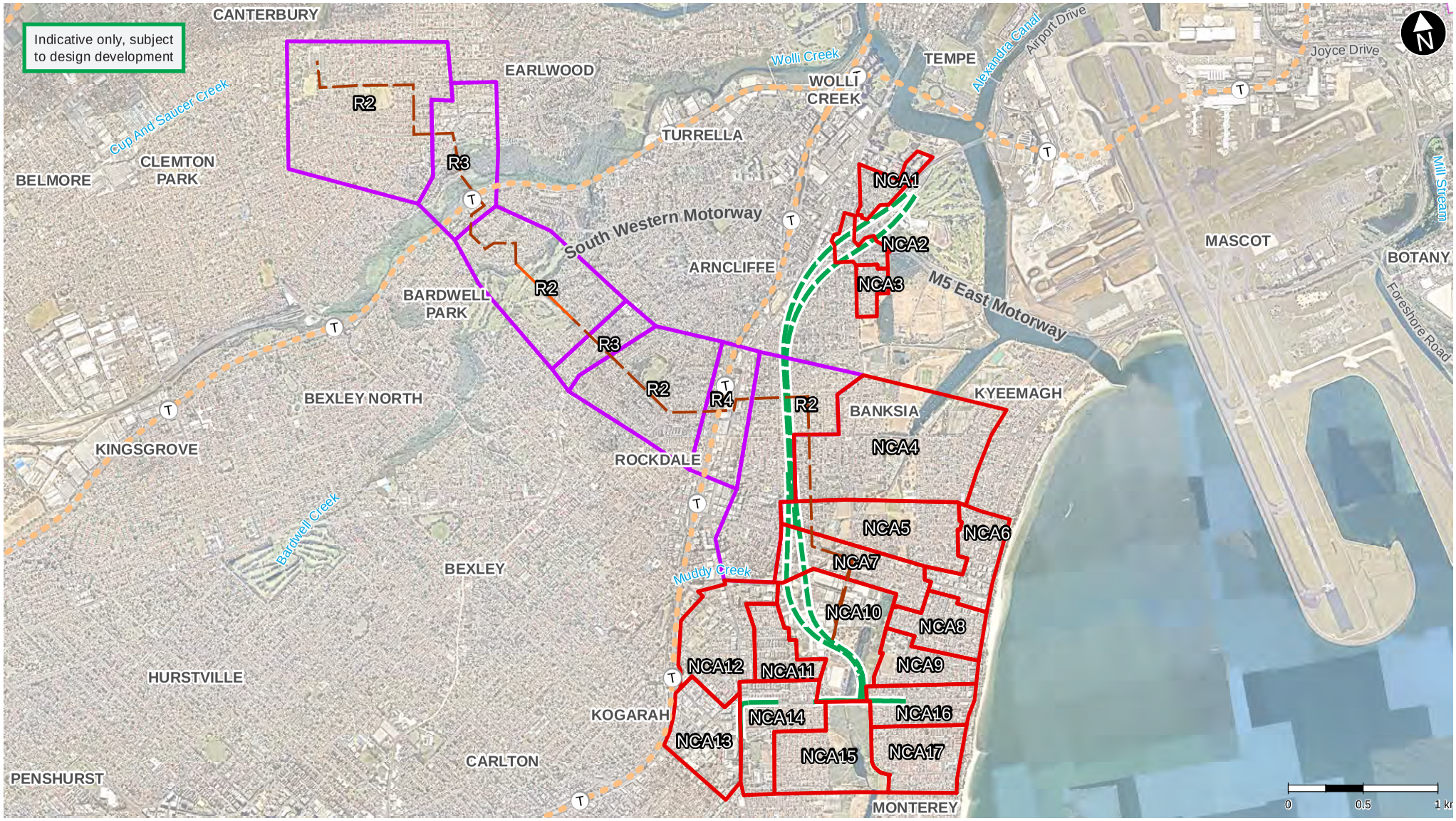
- William Street from the Homer Street intersection to Cameron Avenue
- Wolli Creek Road between Forest Road and Wollongong Road
- Princes Highway, between Tabrett Street and Kimpton Street
- Intersection at Bestic Street and Farr Street
- Bay Street between West Botany St and Farr Street.

The likely construction noise impacts from works which may be undertaken during the night-time period have been modelled using SoundPLAN. Impacts from daytime works have been assessed using the Roads and Maritime's Construction Noise Estimator tool, due to the short term impacts (relative to the works associated with the rest of the project).

5.6.1 Assumptions

The final alignment of the power line would be refined and developed further during detailed design. The concept design for the power line has been assessed using the following assumptions:

- Works occur along the centre of the road pavement
- Where noise monitoring has not been carried out, appropriate noise area categories (R2 - R4) detailed in the Construction Noise Estimator have been adopted for nearby noise sensitive receivers. The power line alignment and noise area categories are shown in **Figure 4**
- Construction scenarios and associated sound power levels detailed in the Construction Noise Estimator tool have been used
- Construction ancillary facilities are currently not proposed to be used in conjunction with the power line construction works
- Only noise impacts on residential receivers have been assessed
- The works are assumed to occur without hoarding or noise barriers.



LEGEND

- The project in tunnel
- The project on surface
- Permanent power supply - Above gound
- Permanent power supply - Underground
- Noise catchment areas
- RMS construction noise estimator noise area categories (R2 - R4)
- Railway station
- Railway line

Figure 4 Power line alignment and associated noise area categories (R2 - R4)

5.6.2 Construction scenarios

Provided below is a summary of the proposed works and construction equipment for the construction of the power supply connection.

Table 5-32 Sound power levels of typical construction plant and equipment for power line

Scenario	Equipment	SWL, dB(A)	Overall[1] SWL, dB(A)
Mobilisation and site establishment			115
	Truck	103	
	Road truck	98	
	Scissor lift	103	
	Franna crane	105	
Trenching			115
	Backhoe	110	
	Franna Crane	98	
	Excavator	110	
	Concrete truck	109	
	Truck compressor	75	
	Vibratory roller	109	
	Road truck	108	
Paving / asphalting			118
	Dump truck	110	
	Asphalt truck and sprayer	103	
	Concrete truck	109	
	Smooth drum roller	107	
	Concrete saw	118	

5.6.3 Construction noise management levels

Provided below is a summary of the NMLs applicable to each noise category area presented in Figure 4.

Table 5-33 Power line alignment noise criteria

Area category	Time period	Rating background level	Noise management level
R2	Daytime	45	55
	Evening	40	45
	Night-time	35	40
R3	Daytime	50	60
	Evening	45	50
	Night-time	40	45
R4	Daytime	55	65
	Evening	50	55
	Night-time	45	50

Note: NMLs for NCA4 to NCA12 are defined in **Section 4.2.1**.

5.6.4 Construction noise assessment

It can be expected that there may be differences between predicted and measured noise levels due to variations in instantaneous operating conditions, plant in operation during the measurement and also the location of the plant equipment.

Construction of the power line would generally be carried out during standard daytime construction hours, however some activities may need to be undertaken outside of standard work hours. Works which may be completed during the night-time have been assessed against both the daytime and night-time criteria. Timing of activities would be refined during detailed design.

Provided below in **Table 5-34** and **Table 5-35** is a summary of the noise modelling results for each scenario. The scenarios have been sourced from the Roads and Maritime construction noise estimator tool. Construction noise contours are presented in **Annexure D**.

Where works are to be completed during the daytime only a highly affected noise contour is presented in **Annexure D**.

Table 5-34 Power line alignment construction noise assessment – Standard hours work

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
Mobilisation and site establishment						
NCA4	48	84	202	28	10	2
NCA5	49	66	183	20	0	0
NCA6	51	47	0	0	0	0
NCA7	51	90	71	49	42	31
NCA8	49	48	0	0	0	0
NCA9	48	47	0	0	0	0
NCA10	63	60	0	0	0	0
NCA11	63	52	0	0	0	0
NCA12	76	54	0	0	0	0
R2	55	88	255	52	28	24
R3	60	90	77	25	21	26
R4	65	87	14	5	1	6
Trenching						
NCA4	48	84	202	28	10	2
NCA5	49	66	183	20	0	0
NCA6	51	47	0	0	0	0
NCA7	51	90	71	49	42	31
NCA8	49	48	0	0	0	0
NCA9	48	47	0	0	0	0
NCA10	63	60	0	0	0	0
NCA11	63	52	0	0	0	0
NCA12	76	54	0	0	0	0
R2	55	88	255	52	28	24
R3	60	90	77	25	21	26

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance 1 - 10 dB(A)	NML exceedance 11 – 20 dB(A)	NML exceedance > 20 dB(A)	Number of highly noise affected receivers
R4	65	87	14	5	1	6
Paving/asphalting						
NCA4	48	87	284	56	17	5
NCA5	49	69	197	57	3	0
NCA6	51	50	0	0	0	0
NCA7	51	93	90	49	60	32
NCA8	49	51	2	0	0	0
NCA9	48	50	1	0	0	0
NCA10	63	63	0	0	0	0
NCA11	63	55	0	0	0	0
NCA12	76	57	0	0	0	0
R2	55	91	445	89	36	31
R3	60	93	97	36	25	37
R4	65	90	28	4	5	7

Noise levels from the works associated with the power line alignment construction would exceed the NMLs at nearby receivers during a number of scenarios. The most affected catchment areas would be NCA4 and NCA5. A large number of noise sensitive receivers within Noise Area Category R2 would also be affected. Most of the NML exceedances would be up to 10 dB(A).

The scenario resulting in the highest construction noise levels would be paving/ asphalting. Sensitive receivers are likely to be highly affected when the works are directly adjacent. The severity of the exceedances is due to the small offset distance. As the works move further away from receivers, noise levels would reduce significantly. High noise impacts at any one receiver are unlikely to last for more than a few weeks for each sensitive receiver.

Table 5-35 Power line alignment construction noise assessment – Out-of-hours work (night)

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 – 15 dB(A)	NML exceedance 16-25 dB(A)	NML exceedance > 25 dB(A)
Mobilisation and site establishment						
NCA4	36	84	11	301	149	22
NCA5	39	66	22	210	79	5
NCA6	38	47	3	14	0	0
NCA7	38	90	11	100	61	77
NCA8	41	48	37	3	0	0
NCA9	37	47	3	6	0	0
NCA10	43	60	9	18	1	0
NCA11	43	52	13	19	0	0
NCA12	61	54	0	0	0	0
R2	40	88	194	1161	255	76

NCA	L_{Aeq} NML dB(A)	Maximum L_{Aeq} noise level dB(A)	NML exceedance <5 dB(A)	NML exceedance 5 – 15 dB(A)	NML exceedance 16-25 dB(A)	NML exceedance > 25 dB(A)
R3	45	90	49	175	77	43
R4	50	87	44	49	14	6
Trenching						
NCA4	36	84	11	301	149	22
NCA5	39	66	22	210	79	5
NCA6	38	47	3	14	0	0
NCA7	38	90	11	100	61	77
NCA8	41	48	37	3	0	0
NCA9	37	47	3	6	0	0
NCA10	43	60	9	18	1	0
NCA11	43	52	13	19	0	0
NCA12	61	54	0	0	0	0
R2	40	88	194	1161	255	76
R3	45	90	49	175	77	43
R4	50	87	44	49	14	6
Paving / asphalting						
NCA4	36	87	0	244	202	37
NCA5	39	69	3	170	133	13
NCA6	38	50	0	17	0	0
NCA7	38	93	4	80	75	91
NCA8	41	51	12	35	0	0
NCA9	37	50	2	9	0	0
NCA10	43	63	10	23	2	0
NCA11	43	55	6	31	0	0
NCA12	61	57	0	0	0	0
R2	40	91	62	1084	445	120
R3	45	93	45	177	97	58
R4	50	90	52	65	28	7

Noise levels from the works associated with the power line alignment construction would exceed the NMLs at nearby receivers during a number of scenarios where works are required to be carried out during the night-time period. The most affected catchment areas would be NCA4, NCA5 and NCA7. Noise sensitive receivers within Noise Area Category R2 would also be affected when works are being undertaken in close proximity.

As with works to be undertaken during the daytime noise levels would reduce significantly as the works move further away from receivers and are unlikely to last for more than a few weeks for each sensitive receiver.

To minimise adverse impacts generated by these works, noise mitigation measures would be applied in accordance with standard noise mitigation measures identified in **Section 8.1**. Noise mitigation would be detailed further in the contractor's CNVMP.

5.6.5 Construction vibration assessment

Depending on the construction equipment that is used, the minimum working distances outlined in **Table 5-28** may be encroached during construction of the power supply connection. The primary form of mitigation of vibration would be ensuring vibration intensive works do not occur within the minimum working distances. If vibration intensive works are planned within the minimum working distances identified, alternative equipment would be identified and vibration monitoring would be implemented. Further mitigation of vibration would not be required where the minimum working distances are adhered to.

In some circumstances, construction activity within the minimum working distance cannot be avoided due to the work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced, resulting in a potential change in operating equipment. Approaches to manage such circumstances are discussed in **section 8.3**.

Using a large vibratory roller at the nearest point to sensitive receiver locations has identified approximately 25 receivers where vibration could exceed the cosmetic damage criteria, and a further 653 where the human comfort criteria could be exceeded. The areas that these receivers fall into are presented in **Table 5-36**. The relatively large number of affected receivers is due to the extent of the power supply connection works.

It should be noted that these impacts are very unlikely as the contractor would select appropriate equipment based on the works location, nature of the required work and proximity to sensitive receivers.

Table 5-36 Number of buildings within minimum working distances

NCA	Cosmetic damage (metres)	Human response (metres)
NCA4	71	7
NCA5	38	0
NCA6	0	0
NCA7	65	1
NCA8	0	0
NCA9	0	0
NCA10	5	0
NCA11	0	0
NCA12	0	0
R2	349	10
R3	91	2
R4	34	5

6 Assessment of operational noise impacts

6.1 Road traffic noise assessment

Operational road traffic noise generated by the project would only be discernible at locations surrounding the project where it is at the surface. This would include President Avenue and the Princes Highway. Therefore the assessment of operational road traffic noise, in accordance with the RNP, is limited to these areas. The project also has the potential to change traffic flows on the surrounding network. A more general level of assessment of these impacts has been undertaken in **section 6.1.9**.

The assessment method takes into consideration both the infrastructure that would carry vehicles and any additional traffic generated by the project. Two separate years, in addition to three separate traffic scenarios have been assessed.

The assessment of road traffic noise has been completed in accordance with the RNP, the NCG and the NMG. The NCG and the NMG provide details of the practical application of the criteria presented in the RNP.

To assess the potential impact of the project on noise sensitive receivers, the following steps have been completed:

- Existing road traffic noise levels have been modelled with existing (2017/2018) road traffic volumes. This model has been validated with noise measurements and road traffic surveys. This is discussed further in **section 6.1.3**.
- Future road traffic noise levels have been modelled for the do minimum (without project), do something (with project), and Cumulative (with other major infrastructure projects) scenarios for the year of opening (2026) and design year (2036). This is discussed further in **section 6.1.5** and results are presented in **section 6.1.7**.

6.1.1 Road traffic noise modelling methodology

Road traffic noise levels were calculated using SoundPLAN v7.4 software, which implements the Calculation of Road Traffic Noise (CoRTN) algorithm. The UK Department of Transport devised the CoRTN algorithm and with suitable corrections, this method has been shown to give accurate predictions of road traffic noise under Australian conditions.

The modelling parameters which are included in the model are detailed below in **Table 6-1**.

Table 6-1 Modelling noise parameters

Parameter	Comment
Traffic volumes and mix	The number of vehicles using the road and the percentage of heavy vehicles. A higher percentage of heavy vehicles would increase the road traffic noise levels. Existing traffic volumes were obtained from traffic count data recorded at various locations along the proposed alignment. Predicted traffic volumes for the year of opening (2026) and for the design year (2036) for the do minimum, do something, and cumulative scenarios were sourced from traffic modelling as presented within the technical working paper: Traffic and transport (AECOM, 2018). In accordance with the Austroads vehicle classification, light vehicles are considered to be Class 1 and 2 and Heavy vehicles are Class 3 through to 12.
Traffic speeds	An increase in speed generally causes an increase in road traffic noise. Traffic speeds have been based on posted road speeds for existing roads and proposed speeds for the new ramps (60 kilometres per hour).
Traffic noise source heights	Road traffic noise is generally considered to generated at three main source heights: • Light vehicles: 0.5 metres. • Truck tyres and engines: 1.5 metres. • Truck exhausts: 3.6 metres. Corrections were made to the road traffic noise model to take account of the relative source contributions of the truck tyres and engines (-0.6 dB(A)) and truck exhausts (-8.6 dB(A)) compared with light vehicle sources.
Roadway gradient	Road traffic noise levels vary dependent on the gradient of the roadway compared with a flat roadway. CoRTN calculates this variation, however it does not take into account noise from heavy vehicle engine braking.
Road surface	Road surface characteristics would determine the level of road / tyre interfacial noise created. Dense graded asphalt (DGA) is accepted as the standard road surface with other road surfaces such as open graded asphalt (OGA) being considered a 'low noise' surface. Transversely tyned concrete road surfaces generate more road / tyre interfacial noise than DGA. • DGA surfaces were modelled for all road surfaces. • Corrections were applied to the road traffic noise model to account for the proposed road surfaces in accordance with direction provided by Roads and Maritime. The following corrections were applied: • DGA: 0 dB(A)
Ground absorption	Road traffic noise levels reduce with increasing distance from the noise source along the ground. Ground absorption factors of 0.75 through areas of vegetation and 0.5 through urban areas were applied.
Terrain	Natural topographical features such as hills and valleys can shield sensitive receivers from road traffic noise. These effects are taken account of in the model which incorporates one metre terrain contours.
Buildings	The height of receiver buildings in the study area affects the road traffic noise exposure. It can also affect the amount of acoustic shielding provided to other nearby buildings. The height of all buildings within the study area was determined through a ground-truthing exercise and the heights were then included in the road traffic noise model.
Noise barriers	No existing noise barriers were identified for this project
Facade	A correction of 2.5 dB(A) was added to all road traffic noise levels to take account of façade reflection effects in accordance with the NSW RNP. Noise levels have been calculated and assessed at each façade of each sensitive receiver location. Only the noise level at the most affected façade for each receiver is presented in this report.

Parameter	Comment
Road network	All existing and proposed major roads were included in the noise model. For this project noise levels at sensitive receiver locations are predominantly controlled by the main alignment of the project roads and other arterial roads. This was verified by attended noise measurements throughout the study extent of the project. On this basis local roads have been excluded in the noise modelling.
Standard corrections	CoRTN provides L_{A10} road traffic noise levels. The industry standard correction of -3 dB(A) was applied to convert the L_{A10} levels to L_{Aeq} road traffic noise levels to allow assessment of the results against the RNP and NCG criteria. An adjustment of -1.7 dB(A) has been applied to daytime noise levels (with reference to the ARRB's Australian condition correction). No correction has been applied to night-time noise levels. Further discussion is provided in section 6.1.3.
Portal noise	Portal noise from road traffic has been assessed in accordance with Nord2000 algorithm which uses traffic volumes and the opening size to determine the noise contribution from the portal opening. Portal noise from fans has been assessed in the operational facilities section.

6.1.2 Study areas

The RNP defines the study areas as comprising locations within a distance of 600 metres from the centre line of the outermost traffic lane on each side of the each road under consideration. However in highly urban areas such as around President Avenue and Princes Highway, a boundary width either side of the project of 600 metres may include other significant roads with noise levels that dominate at nearby receivers. In accordance with the NCG the width of the study area has been reduced to where the noise levels from the project contribute slightly less than half of the total noise level. This is considered to be where the project adds no more than 2.0 dB(A) to the total noise level.

The study area boundary has been individually assessed for each receiver and each scenario based on the highly urban principle. Receivers that have been found to be outside the study area are not considered for treatment. These receivers have an existing high exposure to noise, are not expected to increase in the future as a result of the project, and are not located adjacent to any major roadworks associated with the project.

6.1.3 Validation noise model

An existing road traffic noise model was developed incorporating the existing traffic flows and alignment for validation with road traffic noise measurements. The traffic flows used in the model were provided by tube counts that were deployed concurrently with noise logging for the project. Noise logging charts are provided in **Annexure B**. Road traffic volumes are presented in **Annexure C**.

If it can be proven that the predicted road traffic noise levels are accurate at discrete locations across the extent of a project, then it is reasonable to assume that the road traffic noise levels are accurate at all modelled receivers.

Furthermore, it can be assumed that if the same road traffic noise model is updated to include the project design model parameters (e.g. including alignment, traffic flow etc), then the design noise model would predict to the same level of accuracy.

As discussed in **section 6.1.1**, the CoRTN algorithm was utilised to calculate road traffic noise. For a project corridor of 600 metres either side of the road, this algorithm has a well-documented accuracy of ±2 dB(A). If the differences between measured and predicted road traffic noise levels fall within this margin, then the model is considered to have a suitable level of accuracy for that location. Attention should be given to noise measurements that fall outside this range. Common reasons for poor validation of road traffic noise models include extraneous noise sources and poor logger placement. Although the aim during logger deployment was to minimise these issues, they may still occur.

A summary of the noise logger validation results are provided in **Table 6-2** below.

Table 6-2 Noise logger validation

Noise logger	Daytime $L_{Aeq(15\ hr)}$, dB(A)			Night-time $L_{Aeq(9\ hr)}$, dB(A)		
	Measured	Predicted	Difference	Measured	Predicted	Difference
NL10	65.9	67.9	2.0	63.1	65.0	1.9
NL12	68.4	68.6	0.2	66.1	65.4	-0.7
NL13	64.3	65.7	1.4	62.6	62.5	-0.1
NL14	69.6	69.0	-0.6	65.4	66.0	0.6
Average			0.8			0.4

The model validation presented in **Table 6-2** indicates that the model is functioning within the CoRTN accepted accuracy of ±2 dB at all logger locations.

It should be noted that although an adjustment of -1.7dB has been used for daytime noise levels (with reference to ARRB), this has not been incorporated during the night-time period in the modelling (**Table 6-1**). Given the validation results in **Table 6-2** and the fact that it is generally preferable to have a slightly conservative noise model, this approach is considered appropriate. A slightly conservative noise model means that noise mitigation measures are not likely to be underestimated. This approach has been implemented successfully across other projects throughout NSW ensuring a greater degree of modelling accuracy.

6.1.4 Project noise criteria

This project includes both the redevelopment of existing surface roads (President Avenue and Princes Highway) and the construction of new surface roads (the F6 President Avenue on and off ramps).

The NCG provides guidance on transition zones. Transition zones are areas where a graduation between the redeveloped and new road noise criteria applies. They ensure that a gradual change in criteria is applied to noise sensitive receivers, rather than a step change.

To determine the applicable transition zone noise criteria, the contribution from the new road segments and the redeveloped road segments are calculated at individual noise sensitive receivers. The difference in contribution defines the applicable transition zone noise criteria. Provided below in **Table 6-3** is a summary of the applicable transition zone noise criteria.

Table 6-3 Transition zone noise criteria

Contribution difference dB(A)	Total noise level, dB(A)	
New road segments minus redeveloped road segments	Daytime criteria	Night-time criteria
Contribution difference ≥ +3.0	55	50
+3.0 > Contribution difference ≥ +1.5	56	51
+1.5 > Contribution difference ≥ +0.0	57	52
+0.0 > Contribution difference ≥ -1.5	58	53
-1.5 > Contribution difference ≥ -3.0	59	54
-3.0 > Contribution difference	60	55

Noise contours have been used to calculate the transition zones in accordance with the NCG. The transition zone noise contours are provided in **Annexure H**. These contours identify that due to the relatively low level of noise from the new road segment, “transition zone criteria do not apply to any sensitive receivers. Accordingly, the redeveloped noise criteria are applicable to all sensitive receivers for this project.

6.1.5 Noise modelling scenarios

As previously noted the RNP requires the assessment of road traffic noise at the year of opening and at the design year. To determine the appropriate noise mitigation, only results from the more stringent year (for each receiver) have been discussed within this report. For each result presented, the applicable period is also provided. In **Annexure I** the predicted road traffic noise levels with the recommended noise mitigation have been presented for all operational scenarios.

Noise levels for both the daytime and night-time periods have been assessed. The assessed situations are:

- **Do Minimum –**This scenario is assessed for both the year of opening (2026) and the design year (2036) and incorporates the existing alignment and traffic flows for the applicable year. All major existing arterial roads have been included in the noise modelling. It represents the design if the project was not to be built. The RNP, NCG, and NMG refer to this as the No Build scenario.

  It is called Do Minimum rather than Do Nothing as it assumes that ongoing improvements would be made to the broader road and public transport network including some new infrastructure and intersection improvements to improve capacity and cater for traffic growth.

- **Do Something** – These scenarios incorporate the project design alignment, including the portals, ramps and all existing major arterial roads. The RNP, NCG, and NMG refer to this as the Build scenario.

The detailed scenarios which have been assessed include:

- **Year 2026 Do Minimum scenario -** a future network including NorthConnex, the WestConnex program of works, King Street Gateway, Sydney Gateway, and some upgrades to the broader road and public transport network over time to improve capacity and cater for traffic growth
- **Year 2026 Do Something scenario -** with the 2026 do minimum projects completed and the F6 Extension Stage 1 (New M5 Motorway, Arncliffe to President Avenue, Kogarah) complete and open to traffic
- **Year 2036 Do Minimum scenario –** a future network including NorthConnex, the WestConnex program of works, King Street Gateway, Sydney Gateway, and some upgrades to the broader road and public transport network over time to improve capacity and cater for traffic growth
- **Year 2036 Do Something scenario -** with the 2036 do minimum projects completed and the F6 Extension Stage 1 (New M5 Motorway, Arncliffe to President Avenue, Kogarah) complete and open to traffic
- **Year 2036 Cumulative scenario -** With the 2036 do something projects completed and Western Harbour Tunnel and Beaches Link, and future stages of the F6 Extension between Kogarah and Loftus complete and open to traffic.

There is no Year 2026 Cumulative scenario as there are no additional (uncommitted) projects which would be operational by 2026.

The noise mitigation requirements have been assessed based on the most stringent scenario for each noise sensitive receiver. Generally noise sensitive receivers are most noise affected during the 2036 Cumulative scenario, however noise levels at some receivers only exceed the applicable noise criteria in other scenarios. To ensure all receivers are considered each one has been assessed for all scenarios and receivers reported if the noise levels exceed the criteria.

6.1.6 Project impact

Noise sensitive receivers within the study area of the project are currently affected by appreciable levels of road traffic noise. This project is only required to mitigate noise impacts resulting from and directly associated with this project. Existing noise issues outside the extent of the project, such as residential receivers exceeding acute noise levels ($L_{Aeq(15\ hr)}$ ≥65 dB(A) or $L_{Aeq(9\ hr)}$ ≥60 dB(A)), are addressed through the Roads and Maritime noise abatement program (NAP).

The project would alter the volumes of traffic throughout the project area. As the L_{Aeq} road traffic noise levels are largely controlled by traffic volumes this project may result in an appreciable reduction in noise levels along the existing Princes Highway, north of President Avenue. These reductions are not identified in this assessment as they occur outside the study area.

6.1.7 Noise modelling results

Noise levels have been predicted for each assessment scenario across the extent of the project. Detailed noise prediction results are provided in **Annexure I.** Road traffic noise contours maps are presented in **Annexure J**.

Considering the impacts in both Year 2026 and Year 2036 during the daytime period only:

- Daytime road traffic noise levels are predicted to exceed the $L_{Aeq(15\ hr)}$ noise criterion at a total of 148 sensitive receivers
- Noise levels that exceed the applicable daytime noise criterion are predicted to increase by more than 2 dB(A) at 19 sensitive receivers
- Noise levels are predicted to exceed the cumulative limit at 90 sensitive receivers. (i.e. ≥ $L_{Aeq(15\ hr)}$ noise criterion + 5 dB(A))
- Two receivers which are located outside the highly urban boundary are identified as being acute (i.e. the project contributes less than 2.0 dB(A) to the overall level and noise levels are equal to or greater than $L_{Aeq(15hour)}$ 65 dB(A).
- 107 sensitive receivers are considered to be eligible for the consideration of feasible and reasonable noise mitigation measures.

Considering the impacts in both Year 2026 and Year 2036 during the night-time period only:

- Night-time road traffic noise levels are predicted to exceed the $L_{Aeq(9\ hr)}$ noise criterion at a total of 135 sensitive receivers
- Noise levels are predicted to exceed the applicable night-time noise criterion and increase by more than 2 dB(A) at 14 noise sensitive receivers
- Noise levels are predicted to exceed the cumulative limit at 80 sensitive receivers. (i.e. ≥ $L_{Aeq(9\ hr)}$ noise criterion + 5 dB(A)
- Two receivers which are located outside the highly urban boundary are identified as being acute (i.e. the project contributes less than 2.0 dB(A) to the overall level and noise levels are equal to or greater than $L_{Aeq(9hour)}$ 60 dB(A))
- 92 sensitive receivers are considered eligible for the consideration of feasible and reasonable noise mitigation measures.

In some areas, the daytime and night-time scenarios have been identified to affect different sensitive receivers. Considering the combined impacts from the daytime and night-time periods:

- Traffic noise levels are predicted to exceed either the daytime $L_{Aeq(15\ hr)}$ noise criterion, the night-time $L_{Aeq(9\ hr)}$ noise criterion, or both criterion at a total of 159 sensitive receivers
- Noise levels are predicted to exceed the applicable daytime noise criterion and increase by more than 2 dB(A), exceed the night-time noise criterion and increase by more than 2 dB(A), or exceed both of these combined criteria at 19 noise sensitive receivers
- Noise levels are predicted to exceed the cumulative limit at 92 sensitive receivers
- Two receivers which are located outside the highly urban boundary are identified as being acute (i.e. the project contributes less than 2.0 dB(A) to the overall level and noise levels are equal to or greater than $L_{Aeq(15hour)}$ 65 dB(A) or $L_{Aeq(9hour)}$ 60 dB(A)).
- 109 sensitive receivers are considered eligible for the consideration of feasible and reasonable noise mitigation measures.

As discussed in **section 4.6.2**, a sensitive receiver would be considered eligible for the consideration of noise mitigation where:

- The predicted do something noise level exceeds the NCG controlling criterion and the noise level increase due to the project (i.e. the noise predictions for the Do Something minus the Do Minimum) is greater than 2.0 dB(A), or
- The predicted Do Something noise level is 5 dB(A) or more above the criteria (exceeds the cumulative limit) and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the project.

- The noise level contribution from the road project is acute (daytime $L_{Aeq(15\ hr)}$ 65 dB(A) or higher, or night time $L_{Aeq(9\ hr)}$ 60 dB(A) or higher) then it qualifies for consideration of noise mitigation even if noise levels are dominated by another road.

6.1.8 Noise sensitive receivers eligible for consideration of additional noise mitigation

Provided below is a summary of all sensitive receivers where road traffic noise levels exceed the applicable noise criteria. Recommended noise mitigation measures for sensitive receivers are considered further in **section 8.4**. Locations of eligible locations are provided graphically in **Annexure J**.

Table 6-4 Receivers eligible for consideration of additional mitigation measures

ID	Address	Use	Scenario	$L_{Aeq(period)}$	dB(A)[1]			Reason for non-compliance
				Criteria	Do Minimum	Do Something	Change	
1056	17 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.9	Exceeds cumulative noise limit
1057	21 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.9	Exceeds cumulative noise limit
1058	23 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	75	0.8	Exceeds cumulative noise limit
1060	1 Traynor Ave, Kogarah	Residential	2036 Cumulative Day	60	64	65	0.6	Exceeds cumulative noise limit
1075	59 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	76	1.0	Exceeds cumulative noise limit
1076	61 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	1.0	Exceeds cumulative noise limit
1077	3 Civic Ave, Kogarah	Residential	2036 Do Something Night	55	58	60	1.4	Exceeds cumulative noise limit
1133	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	62	62	-0.4	Exceeds cumulative noise limit
1135	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	60	59	-0.6	Exceeds cumulative noise limit
1136	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	62	63	0.5	Exceeds cumulative noise limit
1137	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	59	59	-0.5	Exceeds cumulative noise limit
1138	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	67	66	-0.5	Exceeds cumulative noise limit
1139	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	69	68	-0.4	Exceeds cumulative noise limit
1140	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	74	75	0.8	Exceeds cumulative noise limit
1141	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	76	76	0.6	Exceeds cumulative noise limit
1144	800 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	66	65	-0.7	Exceeds cumulative noise limit
1162	732 Princes Hwy, Kogarah	Residential	2036 Cumulative Day	60	74	74	-0.1	Exceeds cumulative noise limit
1163	2 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	75	0.4	Exceeds cumulative noise limit
1164	4-6 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	74	0.4	Exceeds cumulative noise limit

ID	Address	Use	Scenario	$L_{Aeq(period)}$	dB(A)[1]			Reason for non-compliance
				Criteria	Do Minimum	Do Something	Change	
1165	12-14 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.6	Exceeds cumulative noise limit
1166	18 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.7	Exceeds cumulative noise limit
1167	20 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.6	Exceeds cumulative noise limit
1168	22-24 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.6	Exceeds cumulative noise limit
1169	34-36 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.7	Exceeds cumulative noise limit
1170	38-40 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	75	0.8	Exceeds cumulative noise limit
1171	42 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.8	Exceeds cumulative noise limit
1172	7-9 Cross St, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.7	Exceeds cumulative noise limit
1173	74 President Ave, Kogarah	Residential	2036 Cumulative Day	60	76	77	1.3	Exceeds cumulative noise limit
2302	35 Crawford Rd, Brighton-Le-Sands	School	2036 Cumulative Day	53[2]	51	54	2.6	Exceeds the RNP and increases by more than 2.0 dB(A)
2329	146 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	76	1.4	Exceeds cumulative noise limit
2330	156 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	76	1.5	Exceeds cumulative noise limit
2331	160 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	75	1.1	Exceeds cumulative noise limit
2332	162 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	74	0.9	Exceeds cumulative noise limit
2334	62 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	60	66	5.8	Exceeds the RNP and increases by more than 2.0 dB(A) and exceeds cumulative noise limit
2335	52 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	58	62	4.5	Exceeds the RNP and increases by more than 2.0 dB(A)
2336	50 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	57	62	4.7	Exceeds the RNP and increases by more than 2.0 dB(A)
2516	137 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	-0.2	Exceeds cumulative noise limit
2517	139 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	0.0	Exceeds cumulative noise limit

ID	Address	Use	Scenario	$L_{Aeq(period)}$	dB(A)[1]			Reason for non-compliance
				Criteria	Do Minimum	Do Something	Change	
2518	141 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	0.1	Exceeds cumulative noise limit
2519	143 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	0.2	Exceeds cumulative noise limit
2520	145 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	0.3	Exceeds cumulative noise limit
2521	147 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	0.4	Exceeds cumulative noise limit
2522	149 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	0.3	Exceeds cumulative noise limit
2523	151 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	0.3	Exceeds cumulative noise limit
2524	153 President Ave, Monterey	Residential	2036 Cumulative Day	60	72	73	0.3	Exceeds cumulative noise limit
2525	155 President Ave, Monterey	Residential	2036 Cumulative Day	60	73	73	0.2	Exceeds cumulative noise limit
2526	157-159 President Ave, Monterey	Residential	2036 Cumulative Day	60	72	73	0.4	Exceeds cumulative noise limit
2527	157-159 President Ave, Monterey	Residential	2036 Cumulative Day	60	73	73	0.4	Exceeds cumulative noise limit
2528	161-163 President Ave, Monterey	Residential	2036 Cumulative Day	60	73	73	0.4	Exceeds cumulative noise limit
2529	165-169 President Ave, Monterey	Residential	2036 Cumulative Day	60	74	74	0.3	Exceeds cumulative noise limit
2893	1A Civic Ave, Kogarah	Residential	2036 Cumulative Day	60	67	68	1.3	Exceeds cumulative noise limit
3127	1 Lachal Ave, Kogarah	Residential	2036 Do Something Night	55	59	60	1.0	Exceeds cumulative noise limit
3128	19 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.9	Exceeds cumulative noise limit
3129	25 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	76	0.7	Exceeds cumulative noise limit
3130	27 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.6	Exceeds cumulative noise limit
3158	2 Traynor Ave, Kogarah	Residential	2036 Cumulative Day	60	66	66	0.5	Exceeds cumulative noise limit
3161	1 Oakdale Ave, Kogarah	Residential	2036 Cumulative Day	60	66	66	0.5	Exceeds cumulative noise limit
3170	57 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	1.1	Exceeds cumulative noise limit
3171	63 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	76	1.1	Exceeds cumulative noise limit
3173	1 Civic Ave, Kogarah	Residential	2036 Cumulative Day	60	64	65	1.4	Exceeds cumulative noise limit

ID	Address	Use	Scenario	$L_{Aeq(period)}$	dB(A)[1]			Reason for non-compliance
				Criteria	Do Minimum	Do Something	Change	
3302	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	77	77	-0.2	Exceeds cumulative noise limit
3303	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	61	61	0.3	Exceeds cumulative noise limit
3304	750 Princes Hwy, Kogarah	School	2036 Cumulative Day	53[2]	75	75	0.5	Exceeds cumulative noise limit
3314	8-10 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.5	Exceeds cumulative noise limit
3315	30-32 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.7	Exceeds cumulative noise limit
3316	48 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	75	0.7	Exceeds cumulative noise limit
3317	50 President Ave, Kogarah	Residential	2036 Cumulative Day	60	73	74	0.7	Exceeds cumulative noise limit
3318	52 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	74	0.7	Exceeds cumulative noise limit
3319	54 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	75	0.7	Exceeds cumulative noise limit
3320	56 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	74	0.8	Exceeds cumulative noise limit
3321	58 President Ave, Kogarah	Residential	2036 Cumulative Day	60	74	74	0.8	Exceeds cumulative noise limit
3323	62 President Ave, Kogarah	Residential	2036 Cumulative Day	60	73	73	0.7	Exceeds cumulative noise limit
3324	64 President Ave, Kogarah	Residential	2036 Cumulative Day	60	77	77	0.9	Exceeds cumulative noise limit
3325	66 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	75	0.8	Exceeds cumulative noise limit
3326	68 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	75	0.9	Exceeds cumulative noise limit
3327	70 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	76	1.0	Exceeds cumulative noise limit
3328	72 President Ave, Kogarah	Residential	2036 Cumulative Day	60	75	76	1.1	Exceeds cumulative noise limit
3329	467 W Botany St, Kogarah	Residential	2036 Cumulative Day	60	71	72	1.2	Acute
3332	730 Princes Hwy, Kogarah	Residential	2036 Cumulative Day	60	74	74	-0.3	Exceeds cumulative noise limit
3333	726-728 Princes Hwy, Kogarah	Residential	2036 Cumulative Day	60	74	74	-0.4	Exceeds cumulative noise limit
3334	726-728 Princes Hwy, Kogarah	Residential	2036 Cumulative Day	60	74	74	-0.4	Acute
3648	35 Crawford Road, Brighton-Le-Sands	School	2036 Cumulative Day	53[2]	51	53	2.1	Exceeds the RNP and increases by more than 2.0 dB(A)

ID	Address	Use	Scenario	$L_{Aeq(period)}$	dB(A)[1]			Reason for non-compliance
				Criteria	Do Minimum	Do Something	Change	
3649	35 Crawford Rd, Brighton-Le-Sands	School	2036 Cumulative Day	53[2]	52	54	2.2	Exceeds the RNP and increases by more than 2.0 dB(A)
3650	35 Crawford Rd, Brighton-Le-Sands	School	2036 Cumulative Day	53[2]	52	54	2.1	Exceeds the RNP and increases by more than 2.0 dB(A)
3651	35 Crawford Rd, Brighton-Le-Sands	School	2036 Cumulative Day	53[2]	51	53	2.4	Exceeds the RNP and increases by more than 2.0 dB(A)
3664	49 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	57	62	4.1	Exceeds the RNP and increases by more than 2.0 dB(A)
3665	51 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	59	63	4.0	Exceeds the RNP and increases by more than 2.0 dB(A)
3666	51 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	58	61	3.7	Exceeds the RNP and increases by more than 2.0 dB(A)
3667	51 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	57	61	3.6	Exceeds the RNP and increases by more than 2.0 dB(A)
3671	148 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	76	1.7	Exceeds cumulative noise limit
3672	150 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	76	1.6	Exceeds cumulative noise limit
3673	152 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	76	1.6	Exceeds cumulative noise limit
3674	154 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	76	1.5	Exceeds cumulative noise limit
3675	158 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	75	1.3	Exceeds cumulative noise limit
3676	164 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	73	73	0.7	Exceeds cumulative noise limit
3677	166 President Ave, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	74	74	0.6	Exceeds cumulative noise limit
3680	66 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	62	67	5.3	Exceeds the RNP and increases by more than 2.0 dB(A) and exceeds cumulative noise limit
3681	64 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	59	66	6.4	Exceeds the RNP and increases by more than 2.0 dB(A)

ID	Address	Use	Scenario	$L_{Aeq(period)}$	dB(A)[1]			Reason for non-compliance
				Criteria	Do Minimum	Do Something	Change	
								and exceeds cumulative noise limit
3682	60 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	57	64	6.7	Exceeds the RNP and increases by more than 2.0 dB(A)
3683	58 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	59	65	5.8	Exceeds the RNP and increases by more than 2.0 dB(A) and exceeds cumulative noise limit
3684	56 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	57	63	6.4	Exceeds the RNP and increases by more than 2.0 dB(A)
3685	54 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	58	63	5.1	Exceeds the RNP and increases by more than 2.0 dB(A)
3686	48 O'Neill St, Brighton-Le-Sands	Residential	2036 Cumulative Day	60	58	62	3.7	Exceeds the RNP and increases by more than 2.0 dB(A)
3827	38 Gladstone St, Kogarah	Residential	2036 Cumulative Day	60	67	67	-0.5	Exceeds cumulative noise limit
3886	1-5 Hogben St, Kogarah	Other	2036 Cumulative Day	60	66	65	-0.7	Exceeds cumulative noise limit
3903	69 Gladstone St, Kogarah	Residential	2036 Cumulative Day	60	71	70	-0.4	Exceeds cumulative noise limit
3904	58 Premier St, Kogarah	Residential	2036 Cumulative Day	60	65	65	-0.2	Exceeds cumulative noise limit
3907	63-67 Gladstone St, Kogarah	Residential	2036 Cumulative Day	60	68	67	-0.5	Exceeds cumulative noise limit
3936	79-103 Princes Hwy, Kogarah	Other	2036 Cumulative Day	60	79	78	-0.8	Exceeds cumulative noise limit

Notes:

1 Daytime parameter is $L_{Aeq(15\ hr)}$. Night-time parameter is $L_{Aeq(9\ hr)}$. Schools are $L_{Aeq(1\ hr)}$, during school hours.

2 The applicable school classroom criteria is $L_{Aeq(1\ hr)}$ 40dB(A), internal. Assuming a conservative external to internal reduction of 10 dB(A) for the purpose of this assessment, this makes an equivalent 50 dB(A) external. The noise predictions add façade reflection of 2.5 dB(A) to the overall noise level on the façade, which is not included when calculating the internal noise level. To account for the façade reflection included in the predictions, 2.5 dB(A) has been added to the criteria. No correction has been applied from a $L_{Aeq(15\ hr)}$ to $L_{Aeq(1\ hr)}$. Due to traffic flows hours of use (9am to 3pm), the $L_{Aeq(1\ hr)}$ peak noise levels do not significantly diverge from the $L_{Aeq(15\ hr)}$ noise levels.

6.1.9 Parallel routes assessment

The project is expected to generate additional traffic throughout the local area. Increased congestion has the potential to force some traffic to take alternative routes, leading to increases in road traffic noise levels. These routes comprise roads which have not been considered as project roads. The NCG considers any project to be a traffic generating development if it is predicted to increase noise levels by greater than 2.0 dB(A) on any other road. Therefore an assessment of the potential impacts is required.

A screening assessment of all roads has been undertaken and identified potential issues at two locations, Civic Avenue and O'Connell Street. Each of these locations is discussed in more detail below.

This project also has the potential to affect traffic flows on surface roads surrounding the St Peters interchange. An assessment of noise generated on these roads was also undertaken, however noise levels were not predicted to increase by more than 2.0 dB(A) on any road.

Civic Avenue

The use of local streets for non-local trips has been identified for westbound President Avenue traffic, turning left onto Civic Avenue, then right onto Marshall Street, and left onto Rocky Point Road. This route has been identified in preference to traffic travelling east on President Avenue, south on The Grand Parade and then accessing Rocky Point Road from Ramsgate Road or Sandringham Street.

Provided below in **Table 6-5** is a summary of the night-time noise impacts on Civic Avenue.

Table 6-5 Civic Avenue night-time (10pm to 7am) noise impacts

Scenario	Do Minimum		Do Something		Criteria	$L_{Aeq(9hr)}$, dB(A)			Exceeds
	LV	HV	LV	HV		Do Minimum	Do Something	Increase	
Year 2026	905	4	1,136	38	60	61	63	2.0	No
Year 2036	896	13	1,129	75	60	61	64	2.6	Yes

Noise mitigation measures are discussed in **section 8.4.2**.

O'Connell Street

The existing dominant southbound heavy vehicle route in this area is south on Grand Parade, westbound on Ramsgate Road or Sandringham Street, then continuing southbound on Rocky Point Road. With the new F6 off ramps at President Avenue, the strategic model predicts heavy vehicles would travel down O'Connell Street/Chuter Avenue until Ramsgate Road, rather than using The Grand Parade.

An existing 4.5 tonne limit is in operation on Barton Street and O'Connell Street south of President Avenue. This means that many of the heavy vehicles that the strategic model is predicting to travel on O'Connell Street would not legally be allowed to do so. The strategic model is unable to differentiate in different heavy vehicle weight classes, hence the model conservatively predicts that all heavy vehicle traffic would use this route.

The existing weight classes on The Grand Parade have been analysed and results show approximately 45% of the heavy vehicle traffic is over 4.5 tonne. As such it is likely that at least 45% of heavy vehicles that are predicted to use O'Connell Street would be forced by this restriction to continue to use The Grand Parade, or head west to the Princes Highway, dependent on their ultimate destination, rather than use O'Connell Street.

The project design includes a single right hand turn lane from President Avenue into O'Connell Street. Dependent on the timing of traffic signals, if The Grand Parade provides a faster route it is likely that the majority of both heavy and light vehicles would travel on The Grand Parade, rather than queueing at the O'Connell Street intersection. The impacts associated with this scenario have not been assessed here as the traffic changes associated with light timings and potential queueing are beyond the capability of the strategic traffic modelling.

Provided below in **Table 6-6** is a summary of the potential night-time noise impacts on O'Connell Street.

Table 6-6 O'Connell Street Do Something night-time (10pm to 7am) noise impacts

Data source	Do Minimum		Do Something		Criteria	$L_{Aeq(9hr)}$ dB(A)			Exceeds
	LV	HV	LV	HV		Do Minimum	Do Something	Increase	
Year 2026									
Strategic Traffic Data	577	14	1,061	55	60	60	63	3.5	Yes
Modified Traffic[1]	577	14	1,061	30	60	60	62	2.8	Yes
Year 2036									
Strategic Traffic Data	638	16	1,114	60	60	60	63	3.3	Yes
Modified Traffic[1]	638	16	1,114	33	60	60	63	2.6	Yes

Notes:
1 This assumes the 4.5 tonne limit remains in place on Barton Street and O'Connell Street south of Barton Street.

The results in **Table 6-6** indicate that exceedances occur as a result of both light and heavy vehicles, with the revised heavy vehicle flows ensuring the impacts are less pronounced. However residual noise levels indicate that an exceedance of the applicable noise criteria would still be experienced. Noise mitigation and management measures are discussed further in **section 8.4.2**.

Maximum noise level assessment

The RNP includes a review of international sleep arousal research and concludes that at the current level of understanding, it is not possible to establish absolute noise level criteria that would correlate to an acceptable level of sleep disturbance.

The ENMM considers a maximum noise level event to be defined as a vehicle pass-by event for which the $L_{A,max}$ noise level is equal to or greater than 15 dB(A) above the $L_{Aeq(1hr)}$. Maximum noise level events have been considered at 750 Princes Highway, Kogarah. This location is considered to be representative of receivers along the future proposed alignment.

Maximum noise levels are generally dependent on truck engine braking events, however loud exhausts and horns may also contribute. A truck may engage its engine brakes at any location on the project alignment, however the likelihood is dependent on a range of factors. Maximum noise events are less likely further away from the alignment, as maximum noise levels decrease at a faster rate with distance than is the case for L_{Aeq} road traffic noise levels.

Although it is not possible to state that any given location is generally representative of the whole project, this location is considered to present the typical worst case scenario.

Provided below in **Figure 5** is a summary of the typical and maximum number of maximum noise level events recorded over the measurement period. Maximum noise levels were typically as high as 90 to 95 dB(A), however measurements were recorded as high as 115 dB(A). While the area is controlled by road traffic noise, it cannot be confirmed that noise associated with each maximum noise level is attributable to road traffic.

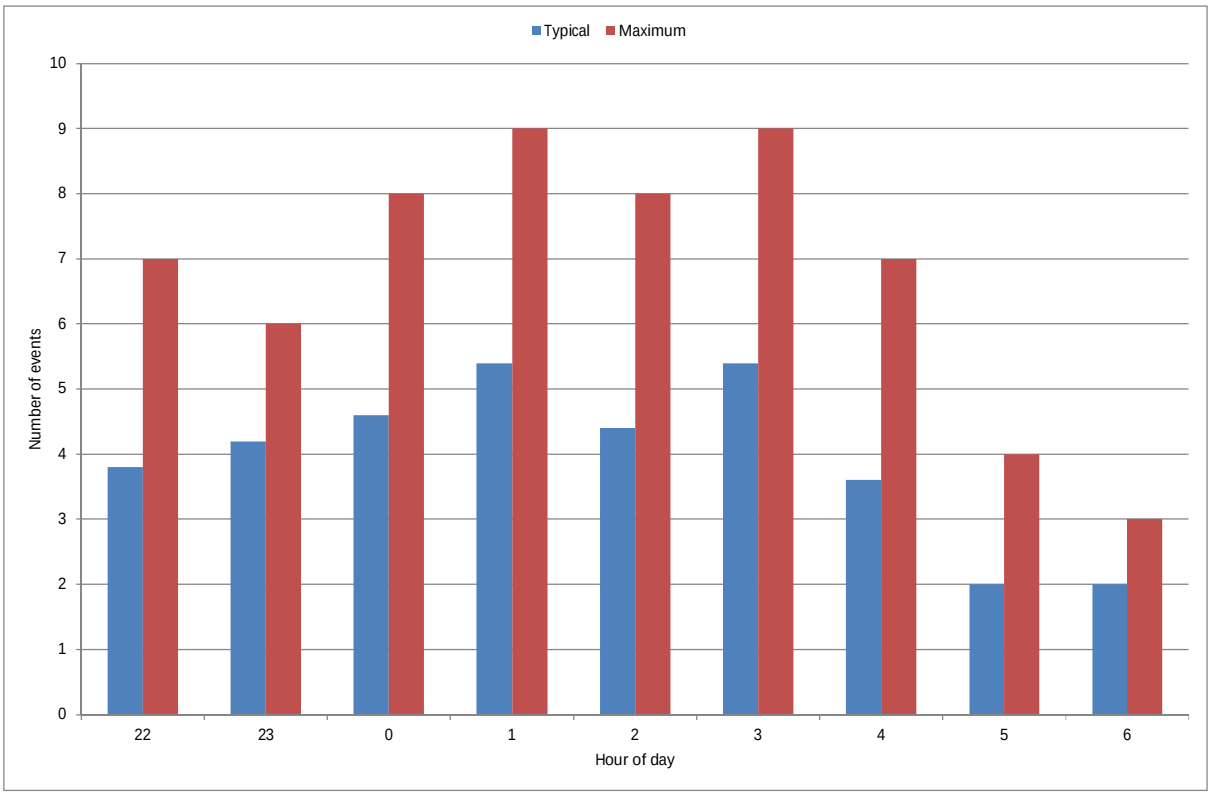


Figure 5 Typical and maximum noise level events

The maximum noise level events illustrated in **Figure 5** identify that the area is already exposed to maximum noise level events that have the potential for awakening reactions.

In future scenarios overall traffic noise levels are predicted to increase, resulting in higher L_{Aeq} noise levels. The overall level associated with maximum noise events is driven by the type of truck, and speed to a lesser degree. This is unlikely to change significantly during the night-time period in the future, so with the increase L_{Aeq} noise levels, the difference between L_{Aeq} and maximum noise levels would decrease. However with an increase in the heavy vehicle percentage, the likelihood of engine braking events would increase.

There is the potential for additional maximum noise level events in the future. However there is no criterion associated with these impacts. Roads and Maritime do not provide any requirements to provide noise mitigation options on the basis of the maximum noise level assessment. Rather, maximum noise level assessments can be used to prioritise the application of noise mitigation measures. Roads and Maritime have long term strategies which are being employed to ensure noise levels from trucks are reduced across the entire network.

6.2 Industrial noise assessment (operational facilities)

Operational facilities that would operate as part of the project include:

- Arncliffe motorway operations complex:
  - Ventilation facility (air intake, outlet and smoke extraction)
  - Distribution substation
  - Water treatment plant
  - Car parking
- Rockdale (north) motorway operations complex:
  - Motorway Control Centre (MCC) office building
  - Car parking
  - Fire pump room and deluge water tanks
  - Maintenance facility (including workshop activities)
  - Motorway bulky equipment store and yard
- Rockdale (south) motorway operations complex:
  - Ventilation facility (exhaust)
  - Distribution substation
  - Car parking
  - Disaster recovery system
- President Avenue tunnel portals
  - Jet fans.

The noise sources from these operational facilities are summarised as:

- Axial ventilation fans housed within buildings, noise emissions would be via the external outlets/inlets
- In-tunnel jet fans noise break-out from tunnel portal openings
- Switches within switch rooms of the substations
- Transformers within substations
- Noise associated with car parking facilities such as accelerating cars, door/boot slamming and people talking
- Pumps and blowers within the water treatment facilities
- Maintenance facility including operation of operational and mobile plant, truck movements and deliveries.

The operational facilities assessed within this section are presented in **Figure 1**. Three operational scenarios within the tunnels have been assessed under neutral and adverse weather (wind speed and temperature inversion) conditions:

- Normal traffic conditions, i.e. when traffic speeds are around the posted speed limit
- Low speed traffic conditions, i.e. when traffic speeds slow towards 40 kilometres per hour or less
- Emergency conditions, invoked in the event of a fire incident.

Emergency operations are not typically regulated through the application of noise limits; however, the potential noise impacts of emergency operations have been assessed as good practice.

Each set of conditions would invoke different equipment operating modes which are described below. An assessment of the noise from the operation of these facilities is presented in **section 6.2.4**.

6.2.1 Normal traffic conditions

Normal tunnel traffic conditions occur when traffic in the tunnel is travelling around the posted speed limit. During normal traffic conditions the ventilation facilities would be used to control portal emissions. Additionally, the jet fans within the tunnels would be turned off, as the vehicle piston effect generates sufficient tunnel airflow to meet the air quality criteria.

Ventilation facilities

During normal operating conditions tunnel exhausts at Arncliffe and Rockdale (south) would be used to capture the vitiated tunnel air and disperse the pollutants into the atmosphere via ventilation outlets.

At Arncliffe the ventilation facility would be located within the Arncliffe motorway operations complex near Marsh Street. This ventilation facility is being built by the New M5 Motorway project, however fitout work would be undertaken during the construction phase of this project.

The Arncliffe ventilation facility would have a fan room with three operational fans and one stand-by fan. The fan room would be connected to four ventilation ducts, which would be merged into two outlets. The ventilation outlets would be about 35 metres above local ground level. The project's supply system would have two operational and one standby fan, connected to the existing New M5 Motorway supply ventilation stack, with its inlet at 6 metres above local ground level.

The Rockdale (south) ventilation facility would be located above the south-bound tunnel on West Botany Street. The ventilation facility would house a fan room with four operational fans, and one stand-by fan. The fan room would be connected to four ventilation ducts, which would each be merged into two outlets. The ventilation outlets would be about 35 metres above local ground level.

For both facilities, all fans would be provided with baffle-type attenuators.

The noise assessment assumes that the building fabric (i.e. walls, roof, doors and louvres) housing the ventilation equipment, would reduce the noise emission from the building to be at least 10 dB(A) lower than the contribution from the outlets. The final noise emission from the building fabric may change subject to the detailed design but in any case when considered in combination with the noise from the outlets would be controlled to satisfy the appropriate operational noise criteria.
The sound power of each fan is provided in **Table 6-7**, and attenuation details for the intake and discharge sides are provided in **Table 6-8**.

Table 6-7 Ventilation facilities equipment sound power levels, dB (per fan)

Facility	Equipment	Octave band centre frequency, Hz								Overall level
		63	125	250	500	1000	2000	4000	8000	dB(A)
Arncliffe	Exhaust fan (3 operational + 1 standby)[1]	118	116	117	114	110	106	101	97	116
Rockdale (south)	Exhaust fan (4 operational + 1 standby)[1]	118	116	117	114	110	106	101	97	116

Notes:

1 The fan selections are indicative and may change subject to detailed design

Table 6-8 Ventilation facilities attenuator insertion loss, dB

Facility	Octave band centre frequency, Hz							
	63	125	250	500	1000	2000	4000	8000
Arncliffe[1]	23	41	54	57	64	60	49	35
Rockdale (south[1])	23	41	54	57	64	60	49	35

Notes:
1 The attenuator selections are indicative and may change subject to detailed design

Substations

The project would have two substations to supply the main line tunnels and ramps. There would be one substation at each ventilation facility: Arncliffe and Rockdale (south).

Each substation would contain several switch rooms and a transformer yard. All switches would be located within the switch rooms and consequently any environmental noise emission, from the operation of the switches, would be insignificant.

The dominant noise sources within the substations would be the transformers (six at each substation). The sound power of a transformer is a function of its capacity. The overall sound power levels of the transformers have been calculated using *Australian/New Zealand Standard – Power Transformers – Part 10 Determination of sound levels (IEC 90076-10, Ed.1 (2001) MOD).* The sound power spectrum for a 25 MVA transformer was measured previously by AECOM and has been applied to the substations sound power levels. The sound power spectra and levels are presented in **Table 6-9**. For this assessment it is assumed that the transformers would be located on the ground with no housing. This represents a worst-case scenario. The noise source is assumed to be 1.5 metres above ground level.

Table 6-9 Transformer sound power level, dB (per transformer)

Facility	MVA	Octave band centre frequency, Hz						Overall level
		63	125	250	500	1000	2000	dB(A)
Arncliffe	5	78	86	76	70	70	68	76
Rockdale (south)	5	78	86	76	70	70	68	76

It is anticipated that fans and other mechanical cooling equipment would be included into the design of the substations; however, any acoustic issues associated with these fans are expected to be treated with standard engineering solutions during the detailed design stage. Engineering solutions to treat noise emission from the fans would include:

- Re-selection of fans with minimised noise
- Orientation and location of the fan
- In-duct noise attenuation
- Noise enclosures for case radiated noise.

Car parking

The Arncliffe ventilation facility, the Rockdale (north) motorway control centre, and the Rockdale (south) ventilation facility incorporate car parks with around six, 39, and 11 car spaces respectively. The car park of the Arncliffe facility is in addition to the New M5 Motorway car parking capacity. All parking facilities are at ground level and are located adjacent to respective facilities' built forms.

The noise sources associated with car parking which have been assessed are:

- Door/boot slamming
- People talking
- Car accelerating.

Time weighting reductions have been applied to the sound power levels to account for the duration which these events would occur.

Motorway control centre

The motorway control centre at the Rockdale (north) MOC is located off West Botany Street and south of Bay Street. The centre comprises an office building which would include heating, ventilation and air conditioning services (HVAC) similar to a commercial building; the acoustic issues associated with building HVAC are expected to be treated with standard engineering solutions during the detailed design stage.

The motorway control centre site includes a motorway maintenance facility, a motorway bulky equipment store, and a motorway yard. **Table 6-10** presents the sound power levels of the proposed activities and equipment anticipated for these. These sound power levels are typical values taken from data provided in the Australian Standard *AS2436-2010, Guide to noise control on construction, demolition and maintenance sites* and the UK Department for Environment, Food and Rural Affairs (DEFRA) noise database and assume equipment is modern and in good working order. Based on experience of other projects, L_{A1} sound power levels are typically up to 8 dB(A) above L_{Aeq} sound power levels. The range and types of equipment used may be subject to change and would be confirmed during the detailed design phase.

Table 6-10 Sound power levels for maintenance facility activities and equipment at Rockdale (north)

Facility	Activity	Equipment	Sound power	level, dB(A)
			Per plant	Total
Maintenance facility[1]	Workshop	Compressor	60	102
		Workshop Hand Tools	94	
		Light vehicle	90	
		Forklift, gas	100	
Maintenance yard[1]	Deliveries, mobile plant	Road truck (deliveries to site)	102	105
		Compressor	60	
		Franna crane (20T)	93	
		Light vehicle	90	
		Forklift, gas	100	
Maintenance storage[1]	Storage	Forklift, gas	100	100

Equipment was modelled as being located in a shed, with an insertion loss of 20 dB(A). The site also includes a pump station and pump room; data for this equipment is given in **Table 6-11**.

Water treatment facility

A water treatment plant is located at the Arncliffe MOC, near Marsh Street (MOC), serving the New M5 Motorway. This project would require an additional water treatment plant to treat water collected within the tunnel prior to discharge to the Cooks River. The assessment of the cumulative noise arising from the F6 water treatment plant alongside that of the New M5 Motorway has been undertaken and is presented in **section 6.2.6**.

The assumed noise sound power levels for equipment in the water treatment plant are provided in **Table 6-11**.

Table 6-11 Water treatment plant at Arncliffe, source sound power level, dB)

Equipment	Octave	band	centre	frequency				Overall level, dB(A)
	63	125	250	500	1000	2000	4000	
Blower	90	87	80	81	76	72	69	82
Pump	71	72	74	74	77	74	70	80
Total	90	87	81	82	80	76	73	84

Notes
1 The equipment selections are indicative and may change subject to detailed design.

6.2.2 Low speed traffic conditions

At low traffic speeds, the piston effect created by moving vehicles would no longer be adequate to ventilate the tunnel and a number of tunnel jet fans would be used in direction of travel to generate more tunnel airflow. When traffic speeds further reduce and the tunnel becomes congested, additional fresh air can be supplied through the Arncliffe motorway operations complex. All equipment operating during normal traffic conditions would continue to operate during low speed traffic conditions. This includes the air intake facility at the Arncliffe motorway operations complex.

Jet fans

The noise emission due to jet fans would propagate from within the tunnels through the portal openings. The project comprises two portal openings – one eastbound and one westbound portal at Kogarah.

It is assumed that the jet fans would be located at a minimum distance of 50 metres from the portal entrances. Consecutive fans thereafter would be located at 120 metre intervals. It is assumed that the jet fans are installed in banks of three.

The jet fans would be selected by the contractors to meet the in-tunnel noise level of Noise Rating 85 (NR 85) at 1.5 metres above centreline of the road at any point, with all fans running. Concrete surfaces have been assumed for floor, ceiling and tunnel walls. The sound power levels for the selected jet fans are presented in **Table 6-12**. During low speed traffic conditions, up to ten jet fans per tunnel would be in operation, operating in forward mode.

The portal opening sound power levels and dimensions have been shown in **Table 6-13**.

Table 6-12 Jet fan sound power levels, dB (per fan)

Equipment	Octave band centre frequency, Hz							Overall level, dB(A)
	63	125	250	500	1000	2000	4000	
Jet fans[1]	95	100	101	102	100	96	88	104

Notes:
1 The fan selections are indicative and may change subject to detailed design.

Table 6-13 Assessed sound power level at opening – low traffic flow, dB

Equipment	Area	Octave band centre frequency, Hz							Overall level, dB(A)
	m^2	63	125	250	500	1000	2000	4000	
Kogarah eastbound portal	69	75	80	81	82	80	75	67	84
Kogarah westbound portal	69	75	80	81	82	80	75	67	84

Air exhaust

During congested traffic conditions, the ventilation facilities at Arncliffe and Rockdale (south) would continue to exhaust air from the tunnels; however, the number of exhaust fans in operation would reduce to two and three exhaust fans respectively.

Air intake

During congested traffic conditions, the air intake facility at Arncliffe would supply fresh air to the tunnels during normal and congested conditions.

The air intake facility at the Arncliffe motorway operations complex would have one fan room, located below ground level, with two operational fans and one stand-by fan. The fan room would be connected to the New M5 Motorway rectangular vent shaft. The top of the vent would be located about six metres above local ground level.

The ventilation facility would be connected to both the eastbound and westbound tunnels. Additionally, all fans would be provided with baffle-type attenuators.

The sound power levels of the selected fans at their maximum flow capacity have been provided for the intake in **Table 6-14** and attenuation details for the intake and discharge sides are provided in **Table 6-15**.

It is likely that the fans would run at a reduced capacity during normal operations and therefore would have a reduced sound power level. A reduction has not been applied to the assessment to provide a conservative approach.

Table 6-14 Ventilation facilities supply fan sound power levels, dB (per fan)

Facility	Equipment	Octave band centre frequency, Hz							Overall level, dB(A)
		63	125	250	500	1000	2000	4000	
Arncliffe[1]	Supply fan (2 operational + 1 standby)[1]	118	116	117	114	110	106	101	116

Notes:
1 The fan selections are indicative and may change subject to detailed design.

Table 6-15 Ventilation facilities attenuator insertion loss, dB

Facility	Octave band centre frequency, Hz							Overall level, dB(A)
	63	125	250	500	1000	2000	4000	
Arncliffe[1]	23	41	54	57	64	60	49	66

Notes:
1 The attenuator selections are indicative and may change subject to detailed design

6.2.3 Emergency operating conditions

Emergency operation is activated in the event of an incident where smoke control is required. During the emergency operation mode the ventilation facilities at Arncliffe and Rockdale (south) would continue to extract air from the tunnel and they would produce similar noise levels to the normal traffic conditions.

During emergency conditions, all the installed jet fans would be operated in the direction of the nearest exhaust facility in order to get the smoke out of the tunnel. This means that jet fans could be operating in reverse mode. The sound power level for jet fans operating in reverse mode is assumed to be the same as the sound power level for the jet fans operating in forward mode, as given in **Table** 6-12.

The portal opening sound power levels under emergency conditions and dimensions have been shown in **Table 6-16**.

Table 6-16 Assessed sound power level at opening – emergency conditions, dB(A)

Equipment	Area	Octave band centre frequency, Hz							Overall level, dB(A)
	m^2	63	125	250	500	1000	2000	4000	
Kogarah eastbound portal	69	75	80	81	82	80	75	67	84
Kogarah westbound portal	69	75	80	81	82	80	75	67	106

The frequency of this mode of operation being activated is unknown. All equipment which operates under normal operating conditions would continue to run during emergency operating conditions.

6.2.4 Assessment

Noise modelling has been undertaken of the operational facilities using SoundPLAN v7.4, incorporating the CONCAWE noise propagation algorithm. CONAWE has been used to model the adverse weather conditions, which is required by the NPfI.

Adverse weather is considered to be the worst-case of the 3 m/s downwind and temperature inversion conditions. In all cases the 3 m/s downwind scenario has been found to be the worst-case. The operations of the facility and associated noise levels would not change dependent on the time period. The noise levels have been compared to the most stringent night-time criteria. Compliance with the night-time criteria would ensure compliance during all other periods.

The NCAs used in this assessment are identical to the construction noise assessment as identified in **Annexure A**. Each NCA potentially affected by each operational facility and their corresponding criteria have been presented in the following section. For each noise catchment area the highest predicted noise level has been presented, in addition to the number of receivers where noise levels exceed the criteria. Operational noise contours are presented in **Annexure K**.

The operational facilities in the Rockdale area are relatively close together. To ensure the cumulative noise impacts of the project have been appropriately considered, the facilities have been assessed together as a single model.

Arncliffe Facility

Presented below in **Table 6-17** and **Table 6-18** are the predicted noise levels for the operations of the Arncliffe ventilation facility. These tables identify the predicted noise level for the most affected receiver in each NCA. Compliance for the most affected receiver ensures compliance at all receivers in the NCA.

Table 6-17 Arncliffe normal traffic and emergency - predicted $L_{Aeq(15min)}$ night-time noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA01	32 Valda Avenue, Arncliffe	47	44	45	0
NCA02	61 West Botany Street, Arncliffe	43	25	29	0
NCA03	104 West Botany Street, Arncliffe	43	22	26	0

Table 6-18 Arncliffe low flow traffic - predicted $L_{Aeq(15min)}$ night-time noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA01	32 Valda Avenue, Arncliffe	47	44	45	0
NCA02	61 West Botany Street, Arncliffe	43	25	29	0
NCA03	104 West Botany Street, Arncliffe	43	22	26	0

The results presented above in **Table 6-17** and **Table 6-18** indicate that the facility would comply with the applicable noise criteria. While mitigation is not specifically required, the assumptions made in this report should be confirmed at the detailed design stage to ensure this is still the case at that time.

Rockdale (north) Facility

Presented below in **Table 6-19** and **Table 6-20** are the predicted noise levels during the daytime and night-time periods. At this facility maintenance activities would be undertaken during the daytime, but not during the evening and night-time periods. The evening and night-time periods are the same operational scenarios, however only the more stringent night-time criteria has been presented. Compliance with the night-time criteria would ensure compliance during all other times.

Table 6-19 Rockdale (north) - predicted $L_{Aeq(15min)}$ daytime noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA07	371 West Botany Street, Rockdale	46	42	43	0
NCA08	30 Kurnell Street, Brighton-Le-Sand	44	26	30	0

Table 6-20 Rockdale (north) - predicted $L_{Aeq(15min)}$ night-time noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA07	371 West Botany Street, Rockdale	38	32	33	0
NCA08	1 Kings Rd, Brighton-Le-Sands	41	27	22	0

Rockdale (south) Facility

Presented below in **Table 6-21**, **Table 6-22**, and **Table 6-23** are the noise modelling results for the Rockdale (south) facility and the portal openings. Three separate scenarios have been presented, normal traffic flow, low traffic flow and emergency conditions.

Table 6-21 Rockdale (south) normal traffic - predicted $L_{Aeq(15min)}$ night-time noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA09	53 O'Neill Street, Kogarah	38	22	27	0
NCA11	79 French St, Kogarah	47	31	34	0
NCA14	465 W Botany St, Kogarah	66	22	27	0
NCA15	6 Annette Ave, Kogarah	40	17	22	0
NCA17	44 Solander St, Monterey	40	15	19	0

Table 6-22 Rockdale (south) low flow traffic - predicted $L_{Aeq(15min)}$ night-time noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA09	51 O'Neill Street, Kogarah	37	32	33	0
NCA11	79 French St, Kogarah	43	32	34	0
NCA14	465 W Botany St, Kogarah	56	23	27	0
NCA15	6 Annette Ave, Kogarah	37	18	23	0
NCA17	24 Colson Crescent St, Monterey	37	25	28	0

Table 6-23 Rockdale (south) normal and emergency traffic - predicted $L_{Aeq(15min)}$ night-time noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA09	53 O'Neill St, Brighton-Le-Sands	37	32	33	0
NCA11	79 French St, Kogarah	43	32	34	0
NCA14	465 W Botany St, Kogarah	56	23	27	0
NCA15	6 Annette Ave, Kogarah	37	18	23	0
NCA17	24 Colson Crescent St, Monterey	37	25	28	0

6.2.5 Discussion

The noise emissions from permanent operational facilities and from the jet fans within the tunnels were assessed for neutral and adverse weather conditions. The predicted noise levels presented in **section 6.2.4** demonstrate that during both normal traffic conditions, low speed traffic conditions and emergency conditions the operational noise criteria would not be exceeded during neutral or adverse weather conditions.

Operational noise levels at all non-residential sensitive receivers comply with the appropriate criteria.

The characteristics of operational facility operational noise have been assessed at noise sensitive receiver locations in accordance with the procedures set out in the NPfI. The assessment has been completed for the night-time period when background noise levels are lowest. The assessment has also considered worst-case weather and operational conditions.

The assessment found that the noise would not contain any low-frequency or tonal characteristics at any of the sensitive receivers. Tonality and low frequency corrections apply at the receiver (rather than at the source). The operational facilities are located in close proximity to major roads and the ambient noise levels are relatively high at residential receivers potentially affected, including during the night time period. These ambient noise levels, generally caused by road traffic noise, have been found to effectively mask any low frequency or tonal characteristics. In addition, given the nature of the sources, they are also not considered to be impulsive or intermittent. Therefore, in accordance with the requirements of the NPfI no modification factors are required.

Final selections of all plant should be assessed during the detailed design phase and appropriate noise mitigation measures incorporated.

Emergency operations are not typically regulated through the application of noise limits; however, the potential noise impacts of emergency operations have been predicted as good practice. The noise levels from these facilities during emergency operations are the same as the levels predicted during low speed traffic conditions which have been demonstrated to result in an acceptable noise outcome.

Given the steady nature of the noise sources associated with the operational facilities, $L_{A1(1min)}$ levels would be less than 3 dB(A) higher than L_{Aeq} levels. The $L_{A1(1min)}$ levels at all receivers from all facilities would comply with the sleep disturbance noise screening criteria as presented in **Table 4-18**. Therefore no further sleep disturbance assessment is required.

6.2.6 Arncliffe facility assessment – combined New M5 Motorway and this project

The noise emissions from this project alone and from the Arncliffe facility with the plant and equipment for both the New M5 Motorway project and this project in operation have been assessed.

For each noise catchment area in the vicinity of the Arncliffe facility, the highest predicted combined noise level has been presented. Results for residential receivers are presented within **Table 6-24** to **Table 6-25**.

Table 6-24 Arncliffe normal traffic and emergency - predicted $L_{Aeq(15min)}$ night-time noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA01	32 Valda Avenue, Arncliffe	47	46	47	0
NCA02	61 West Botany Street, Arncliffe	43	28	32	0
NCA03	104 West Botany Street, Arncliffe	43	24	29	0

Table 6-25 Arncliffe low flow traffic - predicted $L_{Aeq(15min)}$ night-time noise levels

NCA	Most affected receiver	Criteria, dB(A)	Neutral conditions dB(A)	Adverse conditions dB(A)	Number of exceedances
NCA01	32 Valda Avenue, Arncliffe	47	46	47	0
NCA02	61 West Botany Street, Arncliffe	43	28	32	0
NCA03	104 West Botany Street, Arncliffe	43	24	29	0

The noise emissions from permanent combined operational facilities at Arncliffe were assessed for neutral and adverse conditions, and for normal, low speed and emergency traffic situations. The predicted noise levels demonstrate that during both normal traffic conditions and low speed traffic conditions the operational noise criteria would not be exceeded during neutral or adverse weather conditions.

Operational noise levels at all non-residential sensitive receivers comply with the appropriate criteria.

7 Assessment of cumulative impacts

7.1 Operational noise impacts - other motorway projects

The cumulative noise impacts from other motorway projects have been assessed in section 6.1. The assessment has included a cumulative scenario in the Design Year (2036). The cumulative scenario takes into consideration other major road projects throughout the network.

7.2 Construction noise impacts

Simultaneous noise from works within a construction ancillary facility and road construction works associated with the project has the potential to increase noise levels at nearby sensitive receivers. Noise levels as a result of the cumulative impact could increase by as much as 3 dB(A) higher than the maximum noise level of the site compound works and alignment works individually. Although 3 dB(A) is generally considered just discernible, the cumulative impact of noise would be managed as far as possible by the contractor to ensure that the potential for adverse impacts at sensitive receivers is minimised.

It is understood that the New M5 Motorway major works is due for completion January 2020, with some tasks extending until 2021. Generally significant concurrent works are not expected. However, both projects would be operating within the same compound so careful management of the planned works would be required to ensure that increases in noise are minimised.

Other developments (subject to planning approval) may occur in the vicinity of the project especially in the area around President Avenue and the Princes Highway, such as new residential apartment blocks. However given the work is in the future these projects are unknown.

A search of Bayside Council's development application (DA) registers, the NSW major project tracking system and the Joint Regional Planning Panels development and planning register found the following proposed future major development relevant to land in the vicinity of the project:

- A DA for the construction of a two storey child care centre at 47-47A Bestic Street, Rockdale, approximately 700 m to the west of the shared pedestrian and cycle path at Muddy Creek. The DA comprises accommodation of 50 children, ten staff, operating 7am - 7pm Monday to Friday with basement carparking accessed from Cameron Street and demolition of existing structures. It was submitted to Bayside Council on 2 March 2017. This application is currently under assessment.
- A DA for the construction of a seven storey mixed use development at 648-652 Princes Highway and 1-3 Ashton Street, Rockdale, approximately 600 m to the west of the ventilation facilities at West Botany Street. The DA comprises 63 residential units (including 22 units as affordable housing), three commercial units, basement car parking and demolition of existing structures. The DA was lodged with Bayside Council on 14 December 2016. This application is currently under assessment.
- A DA for the construction of a ten storey mixed use development at 295 Bay Street Brighton-Le-Sands, approximately 300 m to the east of the shared pedestrian and cycle path at Rockdale Bicentennial Park. The DA comprises a boarding house containing 79 rooms (including manager's room), two levels of basement car parking and demolition of existing structures. It was submitted to Bayside Council on the 2 December 2016. This application is currently under assessment.

Due to the distance between the identified developments and construction sites, construction noise associated with any of these developments would not appreciably increase overall construction noise.

Sydney Water is considering future rehabilitation of Muddy Creek, around the proposed shared cyclist and pedestrian pathways in Brighton-Le-Sands. There are currently no publicly available plans or a timeline so it is not possible to determine if the projects would coincide. Considering the severity of the works, it is likely that noise associated with the Muddy Creek rehabilitation would be more significant than the construction of the shared cyclist and pedestrian pathways. If the works do coincide, both projects would be managed to ensure that impacts to the local community are minimised.

Assuming that the noisiest stages of any other construction project were to coincide with this project construction, the greatest increase in noise levels from either project would be a maximum of 3 dB(A) on the levels presented in this assessment, where this project is the dominant source. Where receivers are impacted to a greater extent by other construction projects, then overall construction noise levels at any receiver could be increased by as much as 3 dB(A) from those projects' noise levels. In the case of construction traffic, a maximum noise level increase of 3 dB(A) is also predicted.

The cumulative noise impacts of nearby major projects should be further considered by the contractor when a detailed construction schedule becomes available for the project. Consultation should be undertaken with other contractors to manage cumulative impacts on sensitive receivers within common areas. Feasible and reasonable mitigation measures should be detailed in the CNVMP.

7.2.1 Construction fatigue

The Arncliffe ventilation facility is currently being built as part of the New M5 Motorway project. While the main civil works will be completed before the F6 Stage 1 project commences, meaning cumulative noise impacts are not likely to be an issue, there is the potential for construction noise fatigue at nearby receivers due to the increased duration of the construction period. Given the expected construction duration of the F6 Stage 1 project of around four years, cumulatively with the works at this site for the New M5 motorway project, some receivers may be potentially affected by construction noise for up to eight years.

The New M5 Motorway EIS expected 60 heavy vehicle movements an hour, while this project is expecting 26, less than half the spoil haulage movements. As such, rather than the continuation of construction the impacts associated with this project would likely be perceived as the construction works tapering off, with a reduction in works and associated noise.

Construction fatigue would predominantly be managed through discussions with the affected community. Where practicable respite would be provided and the total duration of works would be minimised as far as practicable.

8 Management of impacts

8.1 Management of construction impacts

The construction noise and vibration assessment presented in **Chapter 5** detailed a number of exceedances of the noise management levels within this project. These were predicted as a result of various different construction activities. A number of exceedances of the 'highly noise affected' criteria have also been predicted within the study area. As a result of these exceedances, and potential exceedances of vibration criteria, the following generic and receiver specific mitigation measures have been identified.

8.1.1 Construction noise and vibration management plan

A Construction Noise and Vibration Management Plan (CNVMP) would be prepared. The CNVMP would include the following:

- Identify relevant performance criteria in relation to noise and vibration
- Identify noise and vibration sensitive receptors and features in the vicinity of the project
- Include standard and additional mitigation measures from the Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime 2016) and details about when each will be applied
- Describe the process(es) that will be adopted for carrying out location and activity specific noise and vibration impact assessments to assist with the selection of appropriate mitigation measures
- Consider cumulative construction noise impacts and construction noise fatigue
- Include protocols that will be adopted to manage works required outside standard construction hours, in accordance with relevant guidelines including for management of respite periods
- Detailed monitoring that will be carried out to confirm project performance in relation to noise and vibration performance criteria.

The CNVMP should include consideration of the following issues:

- Cumulative construction noise impacts
- Construction noise fatigue.

The cumulative noise impacts of any nearby major projects should be further considered by the contractor when a detailed construction schedule becomes available for the project. Consultation should be undertaken with the relevant contractors to manage cumulative impacts on sensitive receivers within common areas. Feasible and reasonable mitigation measures should be detailed in the CNVMP.

Feasible and reasonable mitigation measures would be detailed within the CNVMP to manage predicted noise levels at sensitive receivers and areas where construction fatigue could occur. Consultation with the affected community would also occur prior to and during construction.

8.1.2 Community consultation and complaints handling

All residents affected by noise from the project which are expected to experience an exceedance of the construction NMLs should be consulted about the project prior to the commencement of the particular activity, with the highest consideration given to those that are predicted to be most affected as a result of the works.

The information provided to the residents should include:

- Programmed times and locations of construction work
- The hours of the project works
- Construction noise and vibration impact predictions
- Construction noise and vibration mitigation measures being implemented on site.

Community consultation regarding construction noise and vibration would be detailed in the Community Involvement Plan for the construction of the project and would include a 24 hour hotline and complaints management process.

Consultation would also be undertaken with all schools likely to be affected, and in particular Cairnsfoot Special School, to determine suitable mitigation measures where necessary.

For out of hours works, consultation would take place with consideration to Practice note vii of the ENMM and Strategy 2 of the ICNG.

8.1.3 Work practices

Induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise and vibration.

8.1.4 Construction hours and work scheduling

Details of all out of hours work required would form part of the CNVMP.

Noisy work would be scheduled to be undertaken during the standard hours as far as possible. Noisy activities that cannot be undertaken during standard construction hours are to be scheduled as early as possible during the evening and/or night-time periods.

Particularly noisy activities such as the use of impact piling rigs, road and concrete saws, rock hammers, should be scheduled where feasible and reasonable around times of high background noise to provide masking.

Deliveries would be carried out during standard construction hours where feasible and reasonable.

Respite measures are to be implemented for noisy work and vibration intensive activities in a manner consistent with EPL and Roads and Maritime guideline requirements.

8.1.5 Respite

A protocol would be developed to identify the need for and provision of respite measures for residential receivers in accordance with the ICNG. Respite measures may include the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as alternative accommodation.

The protocol would form part of the Construction Noise and Vibration Management Plan.

8.1.6 Early installation of architectural treatments

Where properties have been identified for architectural treatment and these properties would be impacted by noise from construction works, Roads and Maritime would consult with those property owners on the early installation of treatments to provide noise mitigation during the construction of the project. This approach would assist in managing noise through all phases of the project.

The installation of architectural treatments for this project would be separate to the Noise Abatement Program currently being implemented by Roads and Maritime.

8.1.7 Standard mitigation measures

Appendix B of the Roads and Maritime's *Construction Noise and Vibration Guideline* (CNVG) Version 1.0 dated August 2016 lists a number of standard actions and mitigation measures which should be implemented on all construction projects. The strategies are centred on management, training and the attenuation of noise at the source.

8.2 Construction noise

8.2.1 Construction traffic

The following measures would be implemented to reduce and manage noise and vibration impacts:

- Truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising the use of engine brakes, and no extended periods of engine idling). Vehicle routes should be reviewed and final selections should consider noise impacts on noise sensitive receivers.
- Site access and egress points would be located away from residences and other sensitive land uses, where feasible and reasonable
- Deliveries and spoil removal would be planned to avoid queuing of trucks on or around the construction ancillary facilities

- Construction sites would be arranged to limit the need for reversing associated with regular / repeatable movements (e.g. trucks transporting spoil) to minimise the use of reversing alarms
- Where feasible and reasonable, non-tonal reversing alarms would be used, taking into account the requirements of the Workplace Health and Safety legislation.

Spoil would be moved during the day where practical, and feasible and reasonable management strategies would be investigated in consultation with the NSW EPA to minimise the volume of heavy vehicle movements at night. Mitigation measures for vehicle movements outside of standard construction hours would be included in the CNVMP.

8.2.2 Construction ancillary facilities

The noise associated with the operation of construction ancillary facilities would primarily result from the operation of fixed and mobile plant and truck movements. Consideration would be given to the layout of the site in order to maximise distance and shielding to nearby receivers.

Sheds would be erected at the construction ancillary facilities that are proposed to support 24 hour tunnelling activities. An acoustic shed would be utilised at Rockdale construction ancillary facility (C2) (north) and a non-acoustic spoil shed would be utilised at the Arncliffe construction ancillary facility (C1), construction ancillary facilities. The indicative insertion loss of the acoustic shed would be around 25 dB(A) and 10 dB(A) for the non-acoustic shed, however this would be confirmed during the detailed design phase. During night time tunnelling activities, all works would be located within the sheds and doors would be kept closed as far as practicable.

8.2.3 Plant and equipment selection and location

The selection of plant and equipment can have a significant impact on construction noise levels. Appropriate plant would be selected for each task to minimise the noise contributions.

Alternative works methods such as use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function (such as rubber wheeled plant) would be considered in place of steel tracked plant.

Equipment would be regularly inspected and maintained to ensure it is in good working order.

Plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable.

8.2.4 Noise barriers

Detailed noise assessments will be carried out for all ancillary facilities required for construction of the project. The requirement for temporary noise walls within ancillary facilities and adjacent to construction works, and the requirement for other appropriate noise management measures, is to be assessed and implemented prior to the commencement of activities which have the potential to cause noise or vibration impacts.

8.2.5 Additional mitigation measures

Additional mitigation measures are provided in Appendix C of the CNVG Version 1.0, dated August 2016. These measures are applied after standard noise mitigation measures (Appendix B of the above mentioned document) have been applied and where the noise levels are still exceeding the noise management levels. The guideline recommends following the approach in Table C.1 where reasonable and feasible.

Table 8-1 Triggers for Additional Mitigation Measures – Airborne Noise (Roads and Maritime Construction noise and Vibration Guideline 2016 Table C.1)

Perception	dB(A) above NML	Additional mitigation measures type[1, 2]
All hours		
> 75 dB(A)	-	N, V, PC, RO
Standard hours[3]		
Noticeable	0	-
Clearly audible	1 - 10	-
Moderately intrusive	11 – 20	N,V
Highly intrusive	> 20	N,V
OOHW Period 1[4]		
Noticeable	1 - 5	-
Clearly audible	6 - 15	N, R1, DR
Moderately intrusive	16 – 25	V, N, R1, DR
Highly intrusive	> 25	V, IB, N, R1, DR, PC, SN
OOHW Period 2[5]		
Noticeable	1 - 5	N
Clearly audible	6 - 15	V, N, R2, DR
Moderately intrusive	16 – 25	V, IB, N, PC, SN, R2, DR
Highly intrusive	> 25	AA, V, IB, N, PC, SN, R2, DR

Notes:
1. Refer to sectionbelow for detailed descriptions of the mitigation types
2. These additional mitigation measures are applicable to the number of exceedances of the NMLs presented in the construction noise prediction tables in section 5
3. Standard Hours refers to Monday – Friday (7am – 6pm), Sat (8am – 1pm)
4. OOHW Period 1 refers to Monday – Friday (6pm – 10pm), Saturday (7am – 8am and 1pm – 10pm), Sunday /public holiday (8am – 6pm)
5. OOHW Period 2 refers to Monday – Friday (10pm – 7am), Saturday (10pm – 8am), Sunday /public holiday (6am – 7am)

Overview of additional mitigation measures

Notification (letterbox drop or equivalent) (N)

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

Specific notifications (SN)

Specific notifications are letterbox dropped (or equivalent) to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. The specific notification provides additional information when relevant and informative to more highly affected receivers than covered in general letterbox drops. This form of communication is used to support periodic notifications, or to advertise unscheduled works.

Phone calls (PC)

Phone calls detailing relevant information made to identified/affected stakeholders within seven calendar days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs. Where the resident cannot be telephoned then an alternative form of engagement should be used.

Individual briefings (IB)

Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that would be implemented. Project representatives would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. Where the resident cannot be met with individually then an alternative form of engagement should be used.

Respite Offers (RO)

Respite Offers should be considered made where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis, and may not be applicable to all projects.

Respite Period 1 (R1)

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

Respite Period 2 (R2)

Night time construction noise in out of hours period 2 shall be limited to two consecutive nights except for where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and 6 nights per month. Where possible, high noise generating works would be completed before 11pm.

Duration Respite (DR)

Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite. Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite.

Alternative Accommodation (AA)

Alternative accommodation options may be offered to residents living in close proximity to construction works that are likely to experience highly intrusive noise levels. The specifics of the offer would be identified on a project-by-project basis. Additional aspects for consideration shall include whether the highly intrusive activities occur throughout the night or before midnight.

Verification (V)

Verification should include measurement of the background noise level and construction noise. A noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during the construction program as the works progress. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with Australian Standard 1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures.

A noise monitoring program would be presented in the CNVMP.

If ground-borne noise is reported to be a problem during vibration intensive works, attended and/or unattended noise measurements would be undertaken in the relevant building spaces to determine the level of ground-borne noise.

8.3 Construction vibration

In some circumstances, construction activity within the minimum working distance cannot be avoided due to the work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced. For vibration intensive activities that occur within the minimum working distances, management methods to mitigate should include:

- Equipment selection and maintenance
- Construction scheduling
- Building condition surveys
- Supplementary vibration monitoring.

8.3.1 Building condition surveys

Prior to the commencement of tunnelling or other vibration intensive work at each site, existing condition surveys would be undertaken on all properties and structures within the preferred project corridor (the zone on the surface equal to 50 metres from the outer edge of the tunnels) and within 50 metres from surface works.

8.3.2 Equipment selection and maintenance

Equipment size would be selected taking into account the minimum working distances and the distance between the area of construction and the most affected sensitive receiver.

The use of less vibration intensive methods of construction or equipment would be considered where feasible and reasonable when working in proximity to existing structures.

Equipment would be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse vibration impacts.

8.3.3 Works scheduling

Wherever reasonable and reasonable, vibration intensive works should be limited to the least sensitive times of the day.

8.3.4 Supplementary vibration monitoring

If the use of vibration intensive plant cannot be avoided within the minimum working distance for cosmetic damage the following procedure would occur as a minimum:

- Notification of the works to the affected residents and community.
- Works would not proceed until attended vibration measurements are undertaken. Vibration monitors are to provide real-time notification of exceedances of levels approaching cosmetic damage criteria.

If ongoing works are required a temporary relocatable vibration monitoring system would be installed, to warn operators (via flashing light, audible alarm, short message service (SMS) etc) when vibration levels are approaching the cosmetic damage objective.

8.3.5 Heritage and other sensitive structures

A detailed survey would be undertaken prior to vibration intensive construction commencing to identify all nearby vibration sensitive buildings. Applicable vibration criteria and construction strategies would need to be included in the CNVMP for each of the identified locations, ensuring that the works' impacts would be appropriately controlled.

8.4 Management of operational impacts

Where feasible and reasonable, road traffic noise levels from the operation of redeveloped and new roads should be reduced to meet the noise criteria in accordance with Roads and Maritime procedures. In many instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land-use developments, reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles, greater use of public transport, and alternative methods of freight haulage.

The hierarchy of noise mitigation is firstly to consider at-source noise mitigation measures such as road design and traffic management, then the use of quieter pavements. If these measures cannot be designed to meet the noise criteria the use of 'in corridor' mitigation measures should be considered, which are generally noise barriers and mounds. Finally, if the applicable noise criteria cannot be met by using a combination of all these methods, at-receiver mitigation measures can be considered such as architectural treatments and property boundary walls.

As discussed in **section 6.1**, a sensitive receiver would be considered eligible for the consideration of noise mitigation where:

- The predicted Do Something noise level exceeds the NCG controlling criterion and the noise level increase due to the project (i.e. the noise predictions for the Do Something minus the Do Minimum) is greater than 2.0 dB(A); or
- The predicted Do Something noise level is 5 dB(A) or more above the criteria (meets or exceeds the cumulative limit) and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the project.
- The noise level contribution from the road project is acute (daytime $L_{Aeq(15\ hr)}$ 65 dB(A) or higher, or night time $L_{Aeq(9\ hr)}$ 60 dB(A) or higher) then it qualifies for consideration of noise mitigation even if noise levels are dominated by another road.

In this assessment, the total noise at all receivers considered is controlled by the project.

When designing noise mitigation, the target noise level is the lowest applicable noise criterion or controlling criterion, however it may not be feasible and reasonable to achieve these levels.

The assessment in **section 6.1** has identified that a total of 107 sensitive receivers are eligible for the consideration of noise mitigation. A total of 92 of these receivers exceed the cumulative noise limit and are at least 5 dB above the criteria. When implementing noise mitigation, mitigation is applied to meet the base noise criteria (rather than the cumulative or increase in noise limits).

A quieter road surface was initially considered within the project area. The project area comprises a number of intersections. The location of these intersections would mean that generally traffic speeds would be decelerating or accelerating and not free-flowing. While low-noise pavements would provide some noise reduction, the reduction would be limited due to the low speeds. The application of a low noise pavement is not considered reasonable due to the limited reduction in noise it would provide.

Access needs to be maintained to receivers located on President Avenue and Princes Highway. As a result for the majority of the project area noise barriers are not feasible. However a noise barrier has been considered on the east side of the F6 on and off ramps at the intersection of President Avenue.

The detailed noise barrier assessment found that a 3 metre noise barrier would provide an insertion loss of 1.5 dB(A). A 5 metre noise barrier would provide a noise insertion loss of 2.8 dB(A). To be considered reasonable 3 metre and 5 metre noise barriers are required to provide an insertion loss of 5 dB(A) and 10 dB(A) respectively. For impacted receivers noise emitted from the project ramps are in cut, which provides inherent shielding to nearby noise sensitive receivers. The road traffic noise levels at the nearby sensitive receivers are controlled by President Avenue rather than the project ramps, resulting in the relatively minor noise reduction. Given this noise barriers are not considered reasonable.

8.4.1 Recommended noise mitigation

The assessment has identified that predominantly due to the need to maintain access to houses; noise barriers are not a suitable solution to traffic generated noise impacts, and noise mitigation has not been able to be confined within the road corridor. As a consequence, the residual receivers identified in **Table 6-4** would be eligible for the consideration of at-property noise mitigation

In accordance with the Roads and Maritime NMG, the actual noise mitigation that would be incorporated in the project design would be confirmed at the detailed design phase. Controlling noise at the source is always the preferred approach to noise control, and changes in the design may mitigate the design sufficiently so that at-receiver noise mitigation is no longer required, or a lower level of treatment required instead. Specific details regarding noise mitigation for each 'eligible' property would be confirmed in the Operational Noise and Vibration Review (ONVR) which would be developed at the detailed design phase of the project.

Where properties have been identified for architectural treatment and these properties would be impacted by noise from construction works, Roads and Maritime would consult with those property owners about bringing forward the installation of treatments to provide noise mitigation during the construction of the project. This approach would assist in managing noise through all phases of the project.

8.4.2 Parallel routes noise impacts

Civic Avenue

Heavy vehicles have been identified as the dominant source of the noise criteria exceedance. Installation of a 4.5 tonne limit on this road has the potential to reduce impacts to comply with the applicable criteria. A road traffic analysis throughout the area has identified that a 4.5 tonne limit would reduce heavy vehicle movements by 45% on Civic Avenue. Provided below is a traffic analysis with the 4.5 tonne limit installed.

Table 8-2 Civic Avenue night-time (10pm to 7am) noise impacts – 4.5 tonne restriction

Scenario	Do Minimum		Do Something		Criteria	$L_{Aeq(9hr)}$, dB(A)			Exceeds
	LV	HV	LV	HV		Do Minimum	Do Something	Increase	
Year 2026	905	4	1136	21	60	61	62	1.5	No
Year 2036	896	13	1,129	41	60	61	63	1.7	No

This option would need to be discussed, and agreed upon with Bayside Council and other stakeholders before it can be committed to. This process would be undertaken during the detailed design phase. In the event that a 4.5 tonne limit could not be installed, an alternative approach to controlling noise impacts would be considered and documented in the operational noise and vibration report (ONVR).

O'Connell Street

To manage noise impacts on O'Connell Street, the preference would be to limit traffic movements through Local Area Traffic Management (LATM) planning. This could involve providing a more attractive route via The Grand Parade by improving the timing of traffic signals for the right-turn from President Avenue onto The Grand Parade. However any proposed measures would need to be discussed with the local council and other stakeholders prior to being committed to. More detailed traffic and associated noise studies would also need to be undertaken to understand the likely improvements to noise impacts.

In the event that LATM measures cannot be committed to, or are not found to be successful, at-property treatment would be considered for receivers on O'Connell Street, 600 metres down from President Avenue. This distance represents the RNP required assessment offset. The extent of consideration would include all residential receivers on O'Connell Street between President Avenue and Bath Street.

Confirmation of noise management and mitigation measures would be provided in the ONVR at the detailed design phase of the project once discussions with the Bayside Council and other stakeholders has taken place.

8.4.3 Operational noise monitoring

Within 12 months of the commencement of the operation of the project, actual operational noise performance will be compared to predicted operational noise performance. The need for additional mitigation or management measures to address identified operational performance issues and meet relevant operational noise criteria would be assessed and implemented where reasonable and feasible.

The monitoring regime would include sensitive receivers located on Civic Avenue and O'Connell Street. The Operational Noise Compliance Report would be made available to the public.

9 Conclusion

Roads and Maritime is seeking approval to construct and operate a new motorway between the New M5 Motorway at Arncliffe and President Avenue at Kogarah.

Construction Impacts

A construction noise impact assessment has been conducted in accordance with the *Interim Construction Noise Guideline* and *Construction Noise and Vibration Guideline*. Reasonable worst case construction scenarios have been assessed. Construction of the project is likely to primarily occur during standard construction hours with the exception of the tunnelling and associated support activities, bridge works, and diaphragm wall construction. Other out of hours work, such as road works and traffic changes to minimise impacts to the road network, relocation of utilities and delivery and removal of over-sized plant and equipment, would be required and would be subject to the processes outlined in Section 5.

The assessment of noise associated with the construction of the project indicates some exceedances of the *Interim Construction Noise Guideline* noise management levels at some sensitive receivers. The magnitude and number of exceedances are detailed in Section 5. Exceedances of the noise management levels occur during the day and night at the most affected sensitive receivers during certain activities.

The road works on Princes Highway would have the overall greatest impacts (considering timing, duration, and noise impacts). Much of this work would need to be undertaken during the night-time period to keep the road operational during peak periods. There are a number of residential apartment blocks resulting in a large number of potentially affected sensitive receivers in this area. Effective noise mitigation and management measures would need to be developed by the contractor to minimise the potential noise impacts from the works.

The magnitude of these impacts is consistent with other major works projects and highlights the need for effective noise mitigation and management planning. This project is significantly smaller than current major projects such as WestConnex with a smaller tunnel length resulting in less operational roadheaders. This results in both a shorter duration and significantly lower haulage requirements. For Arncliffe residents, the noise impacts and associated disturbance to the local community is expected to be appreciably smaller when compared to the New M5 Motorway.

Measures have been recommended to mitigate construction noise impacts upon nearby sensitive receivers. The final number, degree and nature of these measures would ultimately be selected by the contractor and be largely dependent on the construction strategy and work undertaken. Specific noise management and mitigation measures would be detailed in the contractor's Construction Noise and Vibration Management Plan. The recommended management and mitigation measures which would be considered in the plan include:

- Effective community consultation
- Training of construction site workers
- Use of noise barriers
- Noise monitoring
- Appropriate selection and maintenance of equipment
- Scheduling of work for less sensitive time periods
- Situating plant in less noise sensitive locations
- Construction traffic management
- Respite periods.

Minimum working distances for vibration intensive construction works have been presented. Equipment size would be selected by the contractor taking into account the minimum working distances and the distance between the area of construction and the most affected sensitive receiver. If works need to be undertaken within minimum working distances, vibration monitoring would be undertaken. Heritage and other sensitive structures would need to be considered on a case-by-case basis, dependent on their sensitivity.

Blasting may be used to excavate the bench within the tunnels. Controlled blasting may be undertaken along the length of the alignment during the excavation of the tunnel, at depths greater than 30 m, where the geology is suitable (i.e. not soft ground). Blasting methods can significantly reduce exposure to noise and vibration for residents and businesses above the tunnels. Blasting can also shorten excavation timeframes. An appropriate blasting contractor would be engaged to plan and carry out the blasts, ensuring minimal disruption to surrounding sensitive receivers.

Construction traffic would increase road traffic noise levels in some areas, but this would largely remain less than 2 dB(A). An increase of 2 dB(A) or less is compliant under the applicable target criterion in accordance with the *Road Noise Policy*.

Traffic movements at Bruce Street are predicted to increase noise levels by as much as 2.4 dB during daytime off-peak periods. Construction traffic is expected to be very minor on Bruce Street, and last only for the duration of the shared cyclist and pedestrian pathways. Considering the limited duration, and the ultimate benefit of the shared cyclist and pedestrian pathways to the local community, there is unlikely to be a significant impact to the local community. Potential changes to the traffic in the area should be managed through effective communication with the local community.

Night-time spoil haulage may be required at times. Noise levels are predicted to increase by more than 2 dB(A) along spoil haulage routes associated with the project. The most affected road would be Wickham Street during off-peak traffic periods, with a predicted increase of more than 7 dB(A). Night-time spoil haulage should be minimised where practical and feasible to limit these noise impacts.

Ground-borne noise and vibration from tunnelling activities has been assessed in accordance with the applicable guidelines. Through residential areas the tunnel alignment is quite deep, ensuring that sensitive receivers are unlikely to be adversely impacted by the tunnelling activity. Vibration would be clearly compliant, and ground-borne noise is expected to exceed the criteria at a single location (while all other locations comply). While compliance has been identified, receivers directly above the alignment should be consulted with to ensure they are aware works are taking place and that during times of low ambient noise they may be able to hear some ground-borne noise associated with the project.

Cumulative construction noise impacts may occur as a result of other major projects occurring within proximity to the project. Assuming that the noisiest stages of any other construction project were to coincide with this project construction, the greatest increase in noise levels from either project would be a maximum of 3 dB(A) on the levels presented in this assessment, where this project is the dominant source. Where receivers are affected to a greater extent by other construction projects, then overall construction noise levels at any receiver could be increased by as much as 3 dB(A) from those projects' noise levels. In the case of construction traffic, a maximum noise level increase of 3 dB(A) is also predicted.

The cumulative noise impacts of nearby major projects should be further considered by the contractor when a detailed construction schedule becomes available for the project. Consultation should be undertaken with other contractors to manage cumulative impacts on sensitive receivers within common areas. Feasible and reasonable mitigation measures would be detailed in the CNVMP.

The proposed Arncliffe construction facility is currently being used for the construction of the New M5 Motorway. The continuation of construction works in this area has the potential to cause construction fatigue, increasing the perceived impact of noise overall. The construction of the New M5 Motorway has been carefully considered with this project in mind. A single ventilation facility and water treatment plant, shared by both projects, would ensure that minimal construction would need to be undertaken by this project. Considering the construction requirements (including spoil haulage) are significantly smaller for this project, the noise generated by the work at this location is expected to be appreciably less. It is likely that the local community would perceive this project as a tapering off of work rather than a continuation of construction. While the impacts would be appreciably lower, it is acknowledged that individuals are affected differently and there is still a potential for construction fatigue. A comprehensive consultation plan would be developed to communicate with those potentially affected and to develop strategies to ameliorate impacts with residents that may be affected.

Operational Impacts

An operational road traffic impact noise assessment has been completed in accordance with the Environment Protection Authority's *NSW Road Noise Policy* and Roads and Maritime's *Noise Criteria Guideline* and Noise Mitigation Guideline.

Noise levels have been predicted at sensitive receiver locations throughout the project area for both the daytime and night-time scenarios. This has been prepared on the assumption that this project would move existing traffic from The Grand Parade, onto this route. The additional traffic would cause a moderate increase in noise (less than 2 dB(A)) on President Avenue.

The cumulative operational road traffic noise has been considered by assessing this project in the Year 2036 with a range of other Roads and Maritime projects that may be built in the future. This is a worst-case situation and assumes many projects that do not have funding, and have not been approved would proceed. The recommended noise mitigation has considered this scenario, ensuring that should all these projects proceed appropriate noise mitigation measures would be provided to the affected community.

Exceedances of the applicable noise criteria have been identified. Generally the Year 2036 Cumulative Daytime scenario was the scenario where most noise sensitive receivers were affected. The majority of these exceedances are exceedances of the Cumulative Noise Limit, with noise levels at 92 sensitive receivers exceeding. These exceedances are generated by existing high noise levels throughout the project area. Noise levels at a total of 19 sensitive receivers would exceed the RNP criteria and increase by more than 2 dB(A) as a result of the project. Two residual receivers would be acute. These exceedances occur due to the new on and off ramps and portals at the President Avenue intersection. Noise levels at some of these receivers exceeded both the CNL and the RNP and increased by more than 2 dB(A), resulting in a total of 109 receivers eligible for the consideration of noise mitigation measures (rather than 92 CNL + 19 RNP + 2 acute, which would equal a total of 113 receivers).

Appropriate noise mitigation has been recommended to minimise impacts on the community from the project. Noise mitigation in the form of low noise pavements, noise barriers, and architectural treatments have been considered. Low-noise pavements were concluded to be ineffective due to the intersection arrangement and associated low traffic speeds throughout the area. Noise barriers would only provide a very minor (less than 3 dB) reduction in noise, so were not considered reasonable.

Ultimately architectural treatment was recommended at all 109 sensitive receivers that were found eligible for the consideration of noise mitigation. These requirements would be reviewed and confirmed at the detailed design phase when more detailed information would be available.

Where properties have been identified for architectural treatment and these properties would be impacted by noise from construction works, Roads and Maritime would consult with those property owners about bringing forward the installation of treatments to provide noise mitigation during the construction of the project.

This project has the potential to generate additional traffic through other local roads, creating large increases in noise on roads that are not within the extent of the project (discussed in the assessment of traffic noise on parallel routes). An assessment of the road network surrounding the project identified that increases in noise of more than 2 dB may occur on O'Connell Street, Monterey and Civic Avenue, Kogarah.

During the night-time period, traffic noise levels from Civic Avenue are predicted to increase by 2.6 dB(A). This increase in noise is predominantly controlled by an increase in heavy vehicle movements heading southbound towards Rocky Point Road. Traffic calming and/or other control measures are recommended to encourage heavy vehicles to take major routes (such as President Avenue, Princes Highway, and The Grand Parade). This would reduce the predicted increase in noise levels and noise mitigation for sensitive receivers may not be required.

Similarly during the night-time period, traffic noise levels from O'Connell Street are predicted to increase by 2.8 dB(A) as a result of both light and heavy vehicle traffic increases. These impacts could be mitigated by providing a more attractive route via The Grand Parade. Through improving the timing of traffic signals for the right-turn from President Avenue onto The Grand Parade, traffic could be encouraged away from O'Connell Street. These operational management measures could assist in keeping noise increases below the 2 dB(A) threshold. These measures would need to be refined during the detailed design and operational phases of the project.

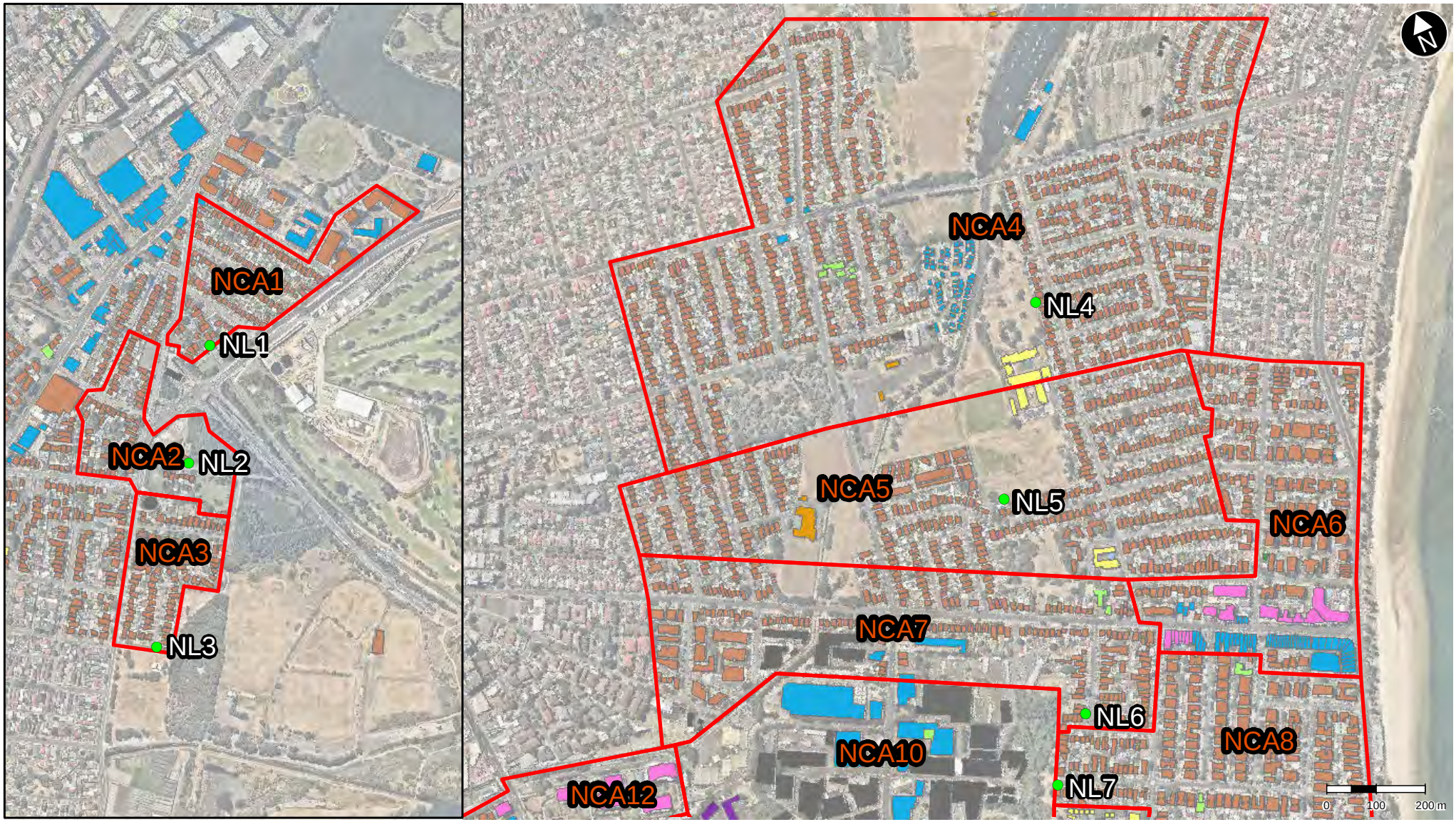
Operational traffic noise would be monitored at sensitive receivers between six months and one year after opening. If the traffic noise levels are above the levels as predicted during detailed design, consideration of additional feasible and reasonable mitigation measures would be undertaken to meet the applicable criteria.

An assessment of operational facilities was undertaken in accordance with the Environment Protection Authority's *Noise Policy for Industry*. This assessment has found that noise levels from the operational facilities would comply with the applicable criteria at the most affected residential receivers, with appropriate noise controls in place. A more detailed assessment would need to be undertaken at the detailed design phase to confirm the noise source assumptions and required attenuation to meet the applicable noise criteria.

10 References

- Australian Standard 1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures
- Australian Standard AS2436-2010, Guide to noise control on construction, demolition and maintenance sites; and
- UK Department for Environment, Food and Rural Affairs (DEFRA) noise database.
- Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime 2016)
- Interim Construction Noise Guideline (ICNG) (DECC 2009)
- Assessing Vibration: a technical guideline (NSW Department of Environment and Conservation (DEC) 2006a)
- Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (Australian and New Zealand Environment and Conservation Council (ANZECC) 1990)
- DIN 4150:Part 2-1999 Structural vibration – Effects of vibration on structures (Deutsches Institut für Normung 1999)
- DIN 4150:Part 3-1999 Structural vibration – Effects of vibration on structures (Deutsches Institut für Normung 1999)
- Evaluation and Measurement for Vibration in Buildings Part 2, (British Standard (BS) 7385:Part 2-1993) (BS 7385)
- Explosives − Storage and Use − Part 2: Use of Explosives (Australian Standard (AS) 2187:Part 2-2006) (AS 2187)
- NSW Road Noise Policy (RNP) (DECCW 2011)
- Noise Criteria Guideline (NCG) (Roads and Maritime 2015a)
- Noise Mitigation Guideline (NMG) (Roads and Maritime 2015b)
- Noise Model Validation Guideline (Roads and Maritime 2016)
- Application Notes – Noise Criteria Guideline (Roads and Maritime 2015a)
- Environmental Noise Management Manual (Roads and Maritime 2001)
- Procedure for Preparing an Operational Noise and Vibration Assessment (Roads and Maritime 2011b)
- Draft At-Receiver Treatment Guideline (ARTG) (Roads and Maritime 2017)
- Noise Policy for Industry (NPfI) (NSW Environment Protection Authority (NSW EPA) 2017)
- NSW Road Noise Policy (RNP) (DECCW 2011)
- Noise Policy for Industry (NPfI) (NSW Environment Protection Authority (NSW EPA) 2017)

Annexure A – Noise logging and catchment areas



LEGEND

F6 Extension S1

- Logger Locations
- Noise Catchment Areas
- Active Recreation
- Commercial
- Community Centre
- Hospital
- Industrial
- Library
- Military
- Mixed Use
- Place of Worship
- Residential
- School

Figure A-1 Noise Catchment Areas

Figure A-2 Noise Catchment Areas

Annexure B – Noise logging results

NL1 - 20 Marsh Street - 12/06/15 - 20/06/15

Logger Setup

Logger Type: ARL 215

Serial No : 194531

Address: 20 Marsh Street , Arncliffe

Location: Front Yard

Facade / Free Field: Free Field

Environment:

Logger Setup Photo

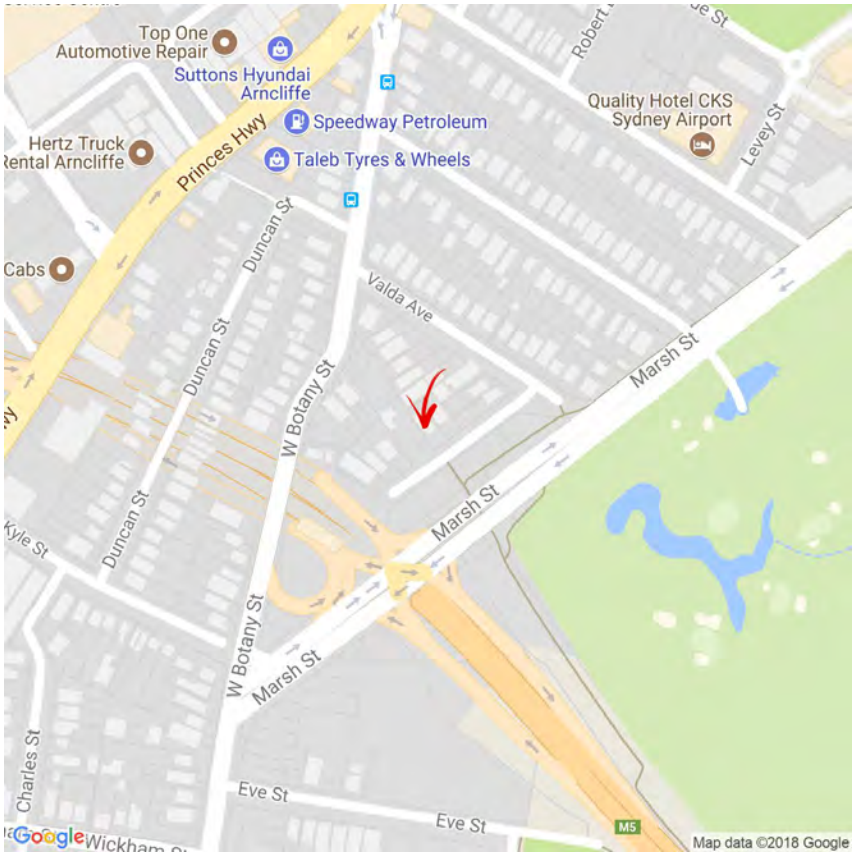
INP Noise Level, dB(A)

	Log Average	RBL
Day	61	55
Evening	62	56
Night	59	45

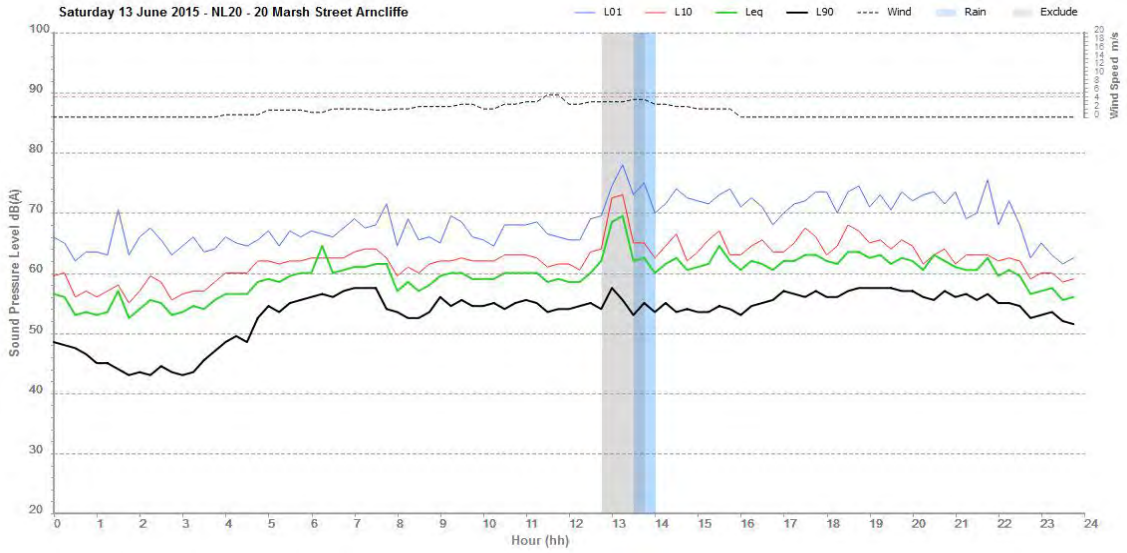
RNP Noise Level, dB(A)

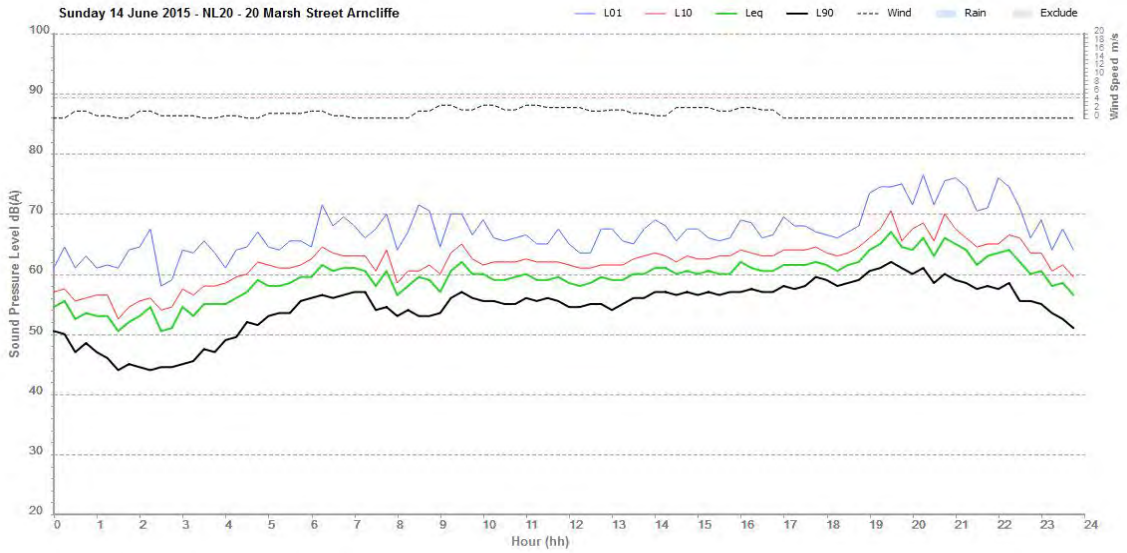
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

Logger Location Map

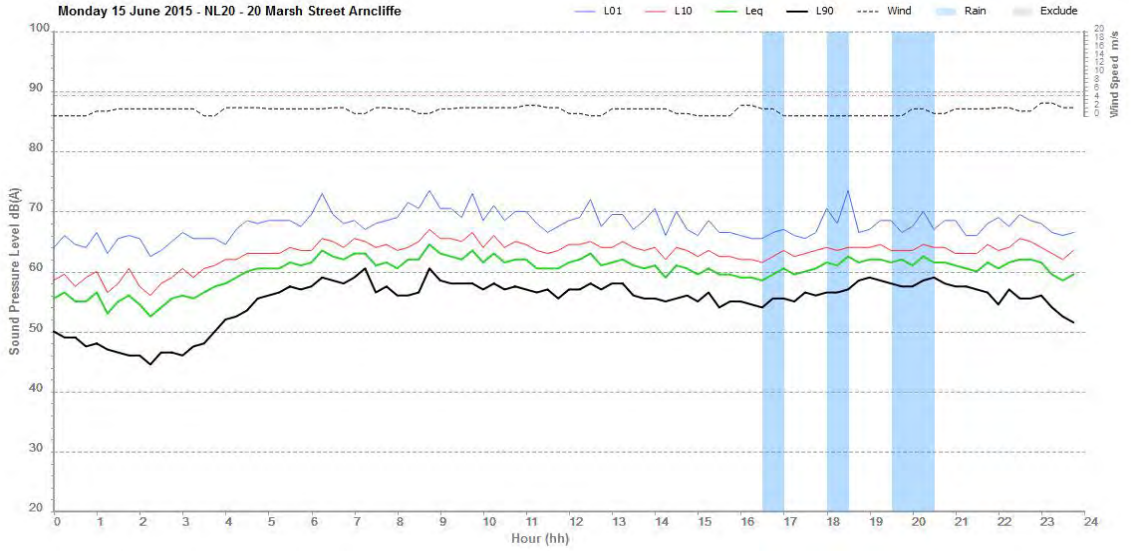


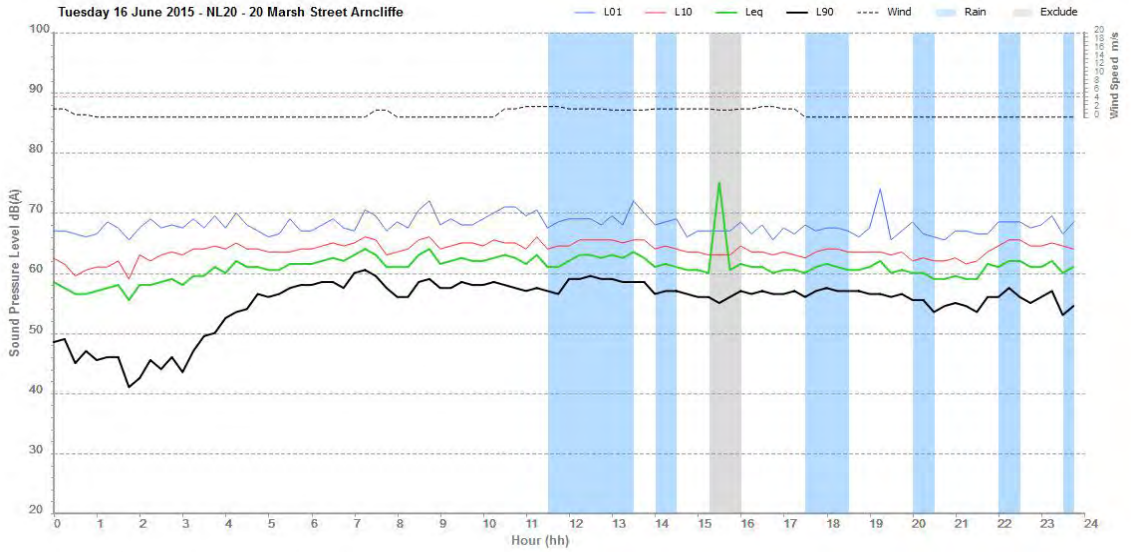
Logger Graphs

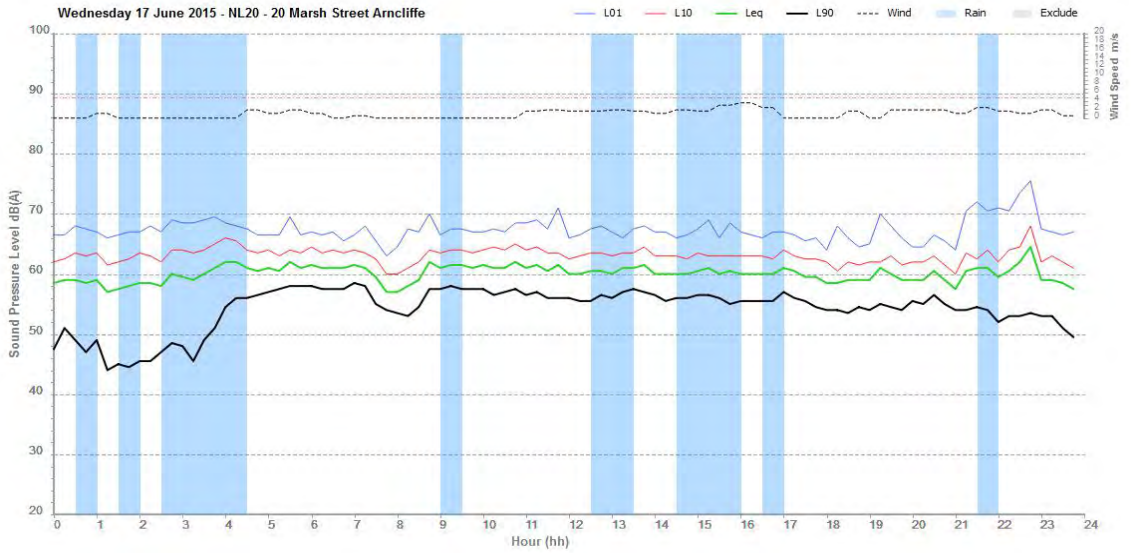




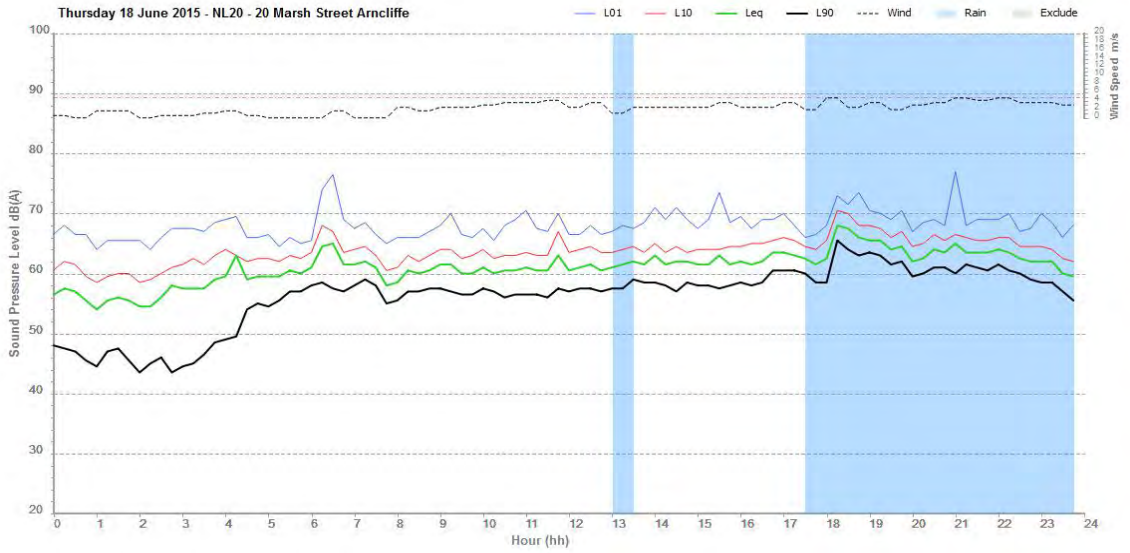
Logger Graphs

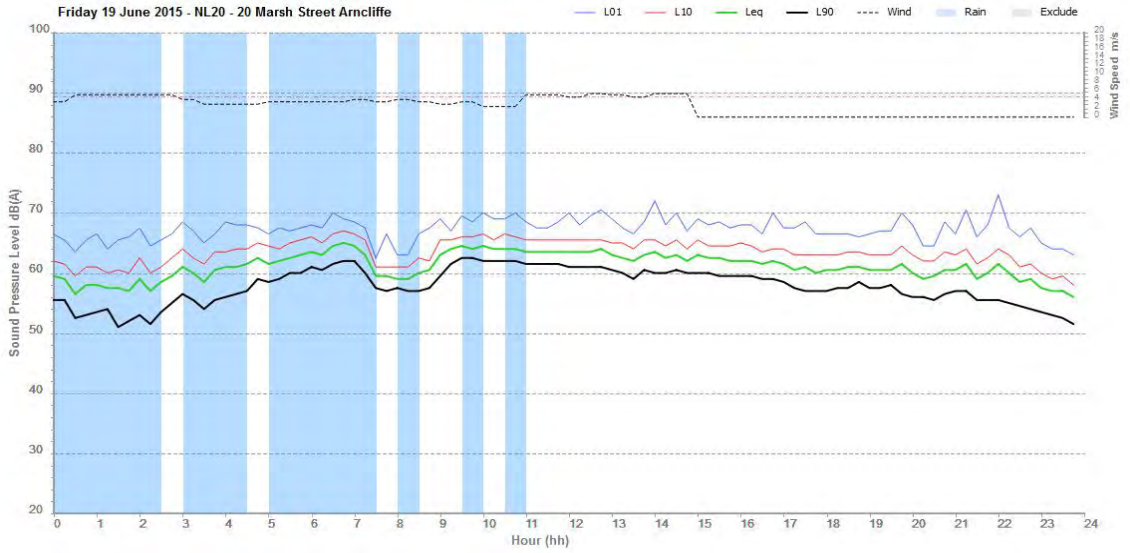


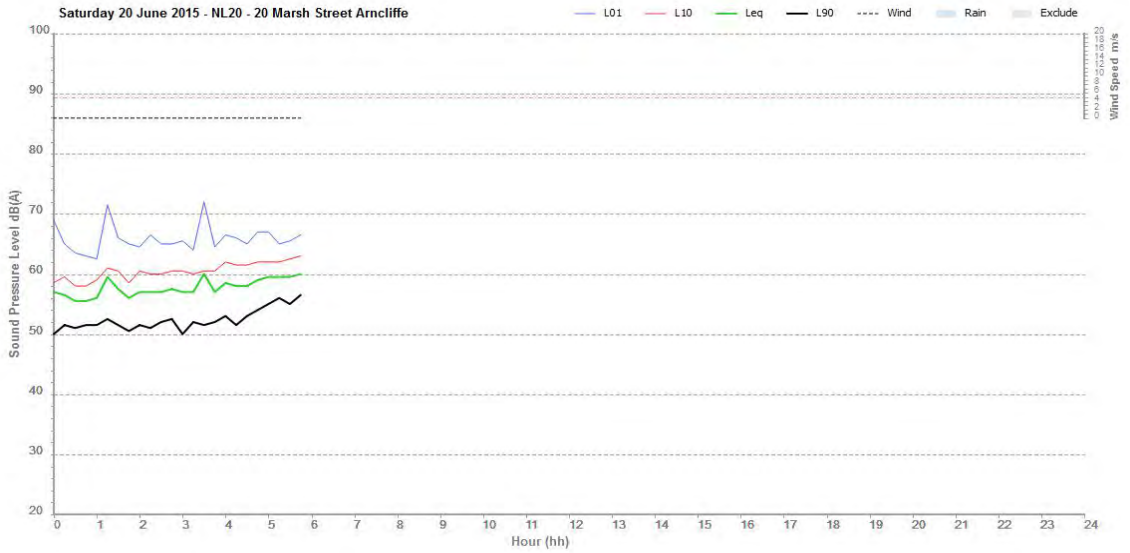




Logger Graphs







NL2 - 6 Eve Street - 17/06/15 - 25/06/15

Logger Setup

Logger Type: Rion NL21

Serial No : 00765699

Address: 6 Eve Street, Arncliffe

Location: Garden

Facade / Free Field: Free Field

Environment:

Logger Setup Photo

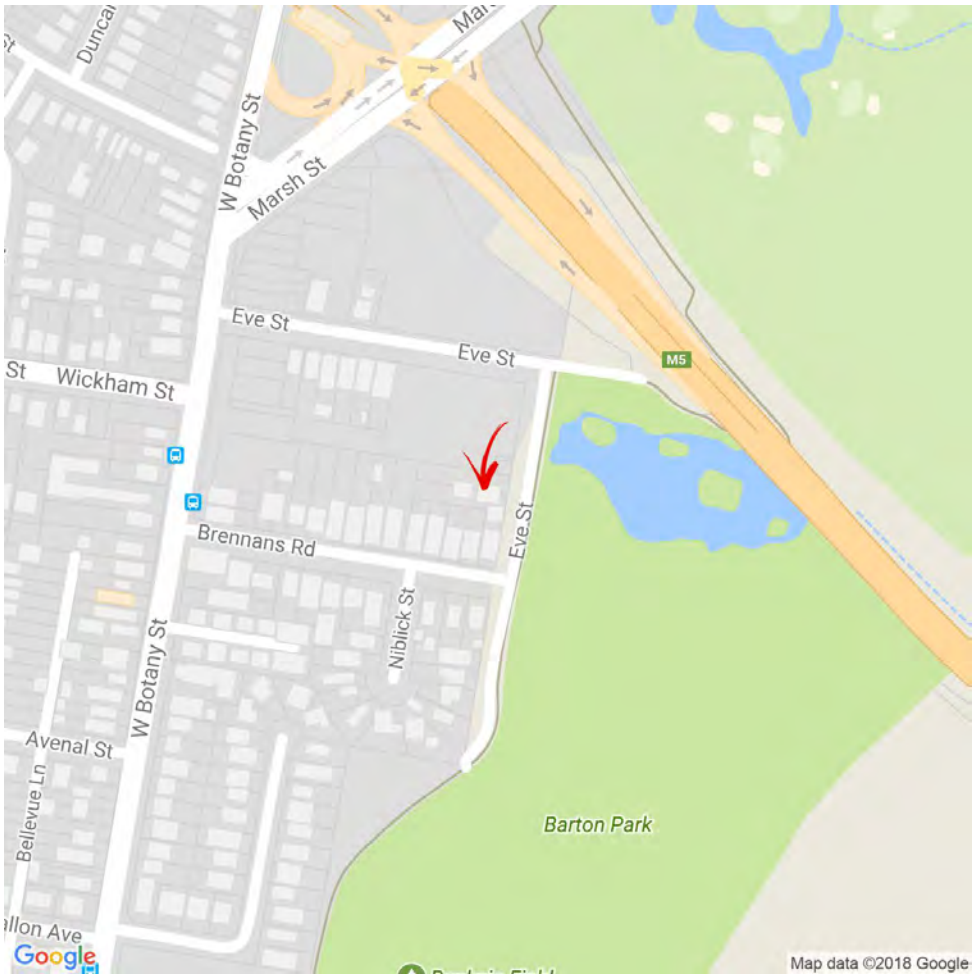
INP Noise Level, dB(A)

	Log Average	RBL
Day	54	48
Evening	55	48
Night	50	42

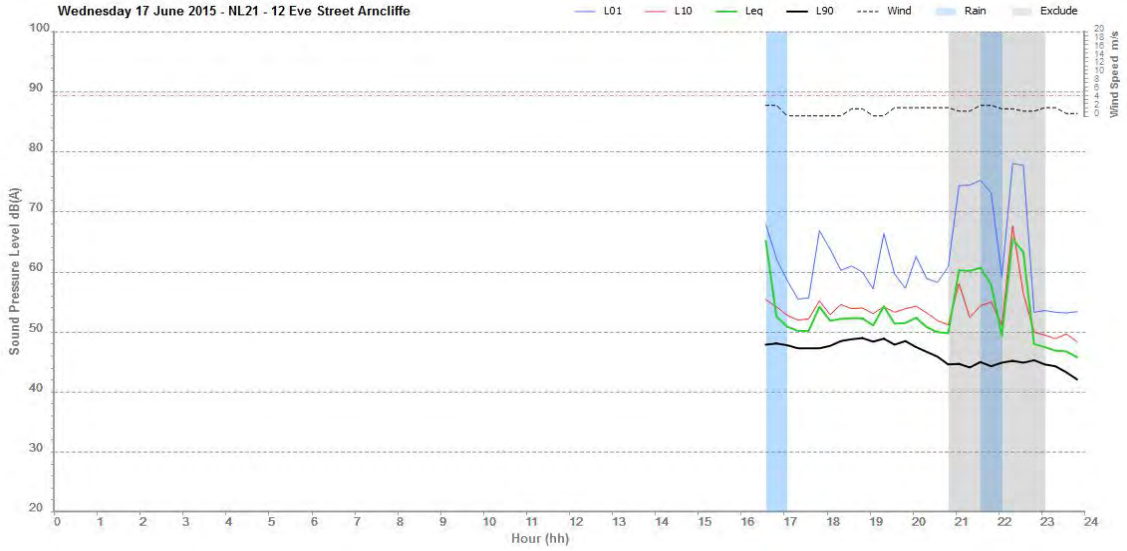
RNP Noise Level, dB(A)

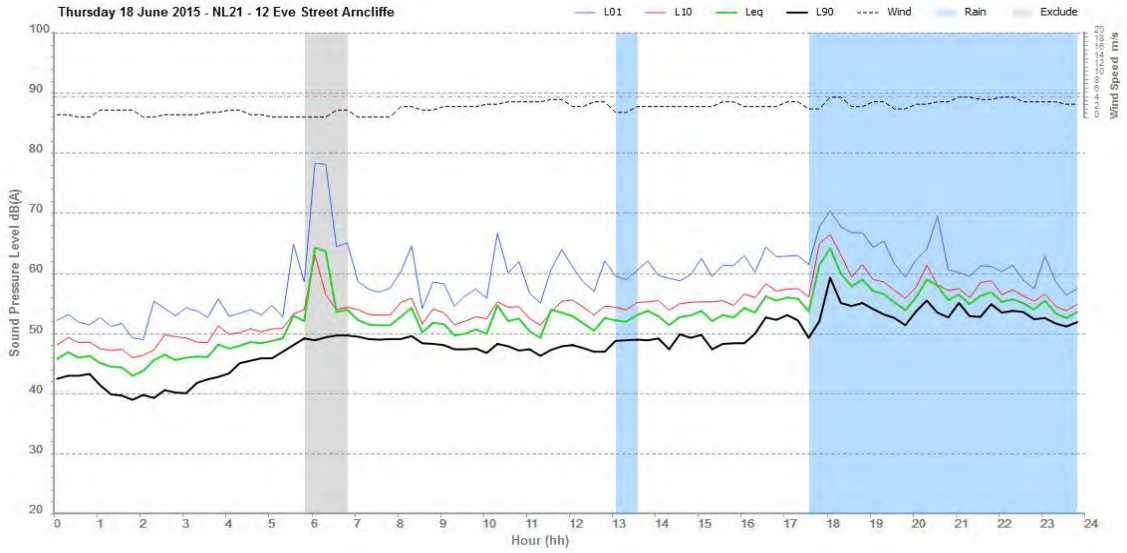
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

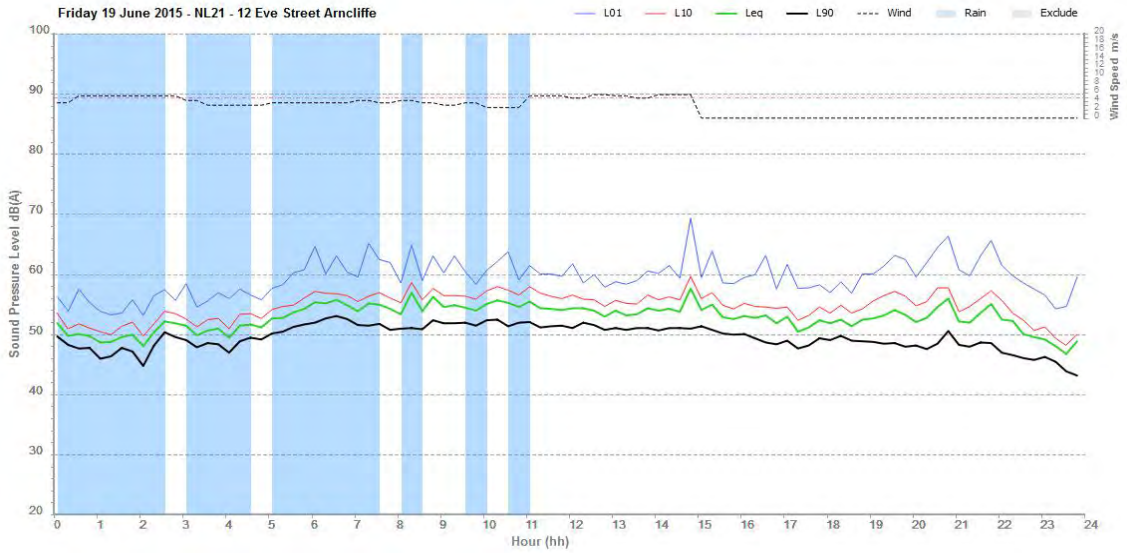
Logger Location Map



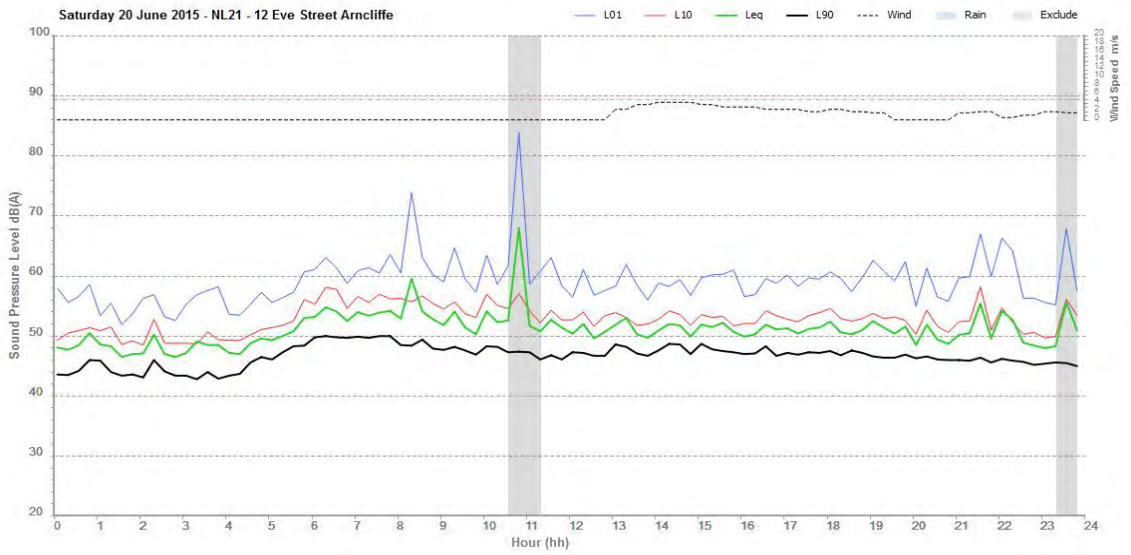
Logger Graphs

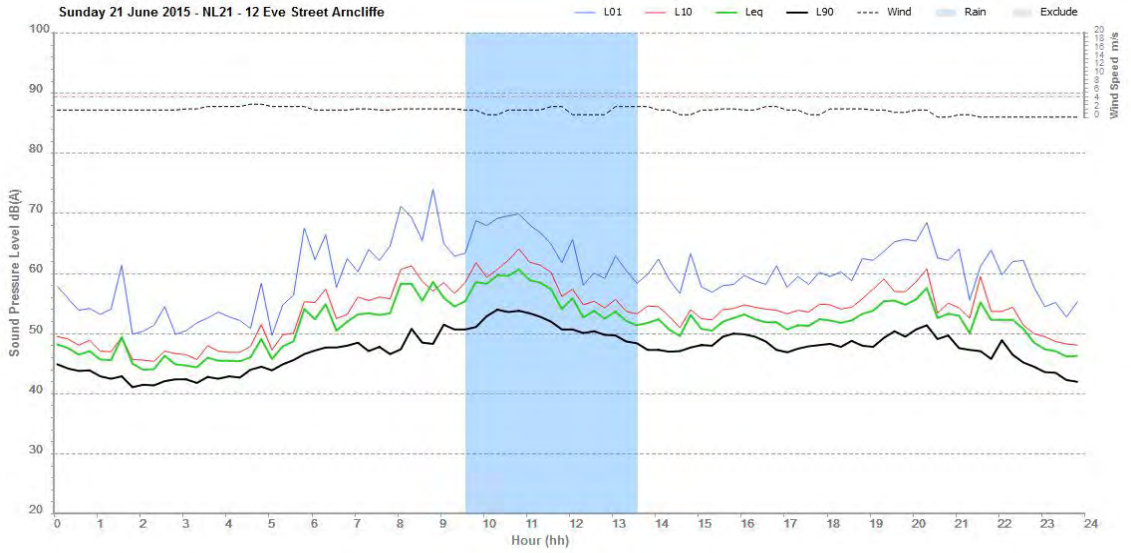


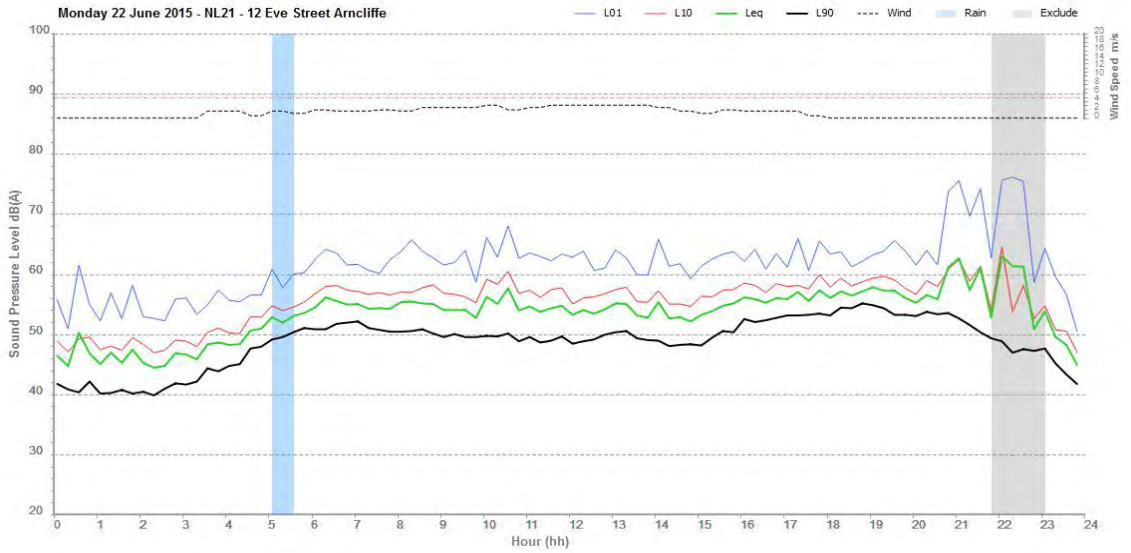




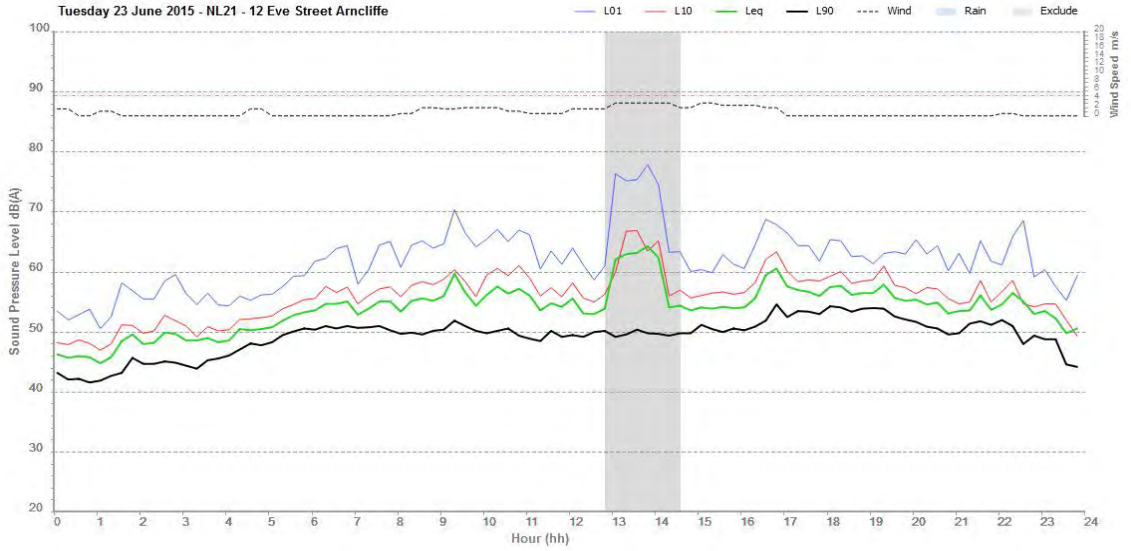
Logger Graphs

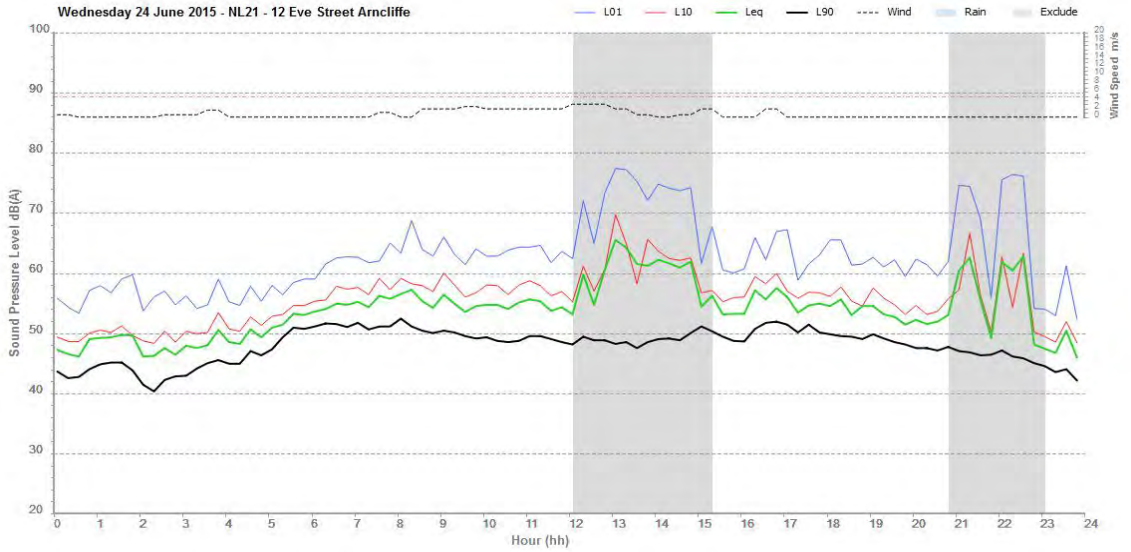


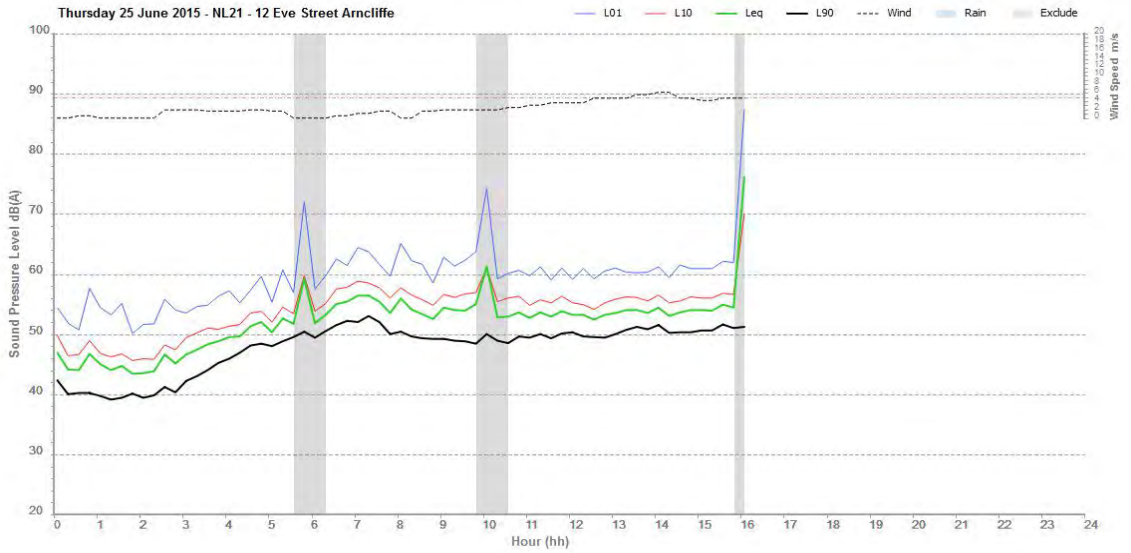




Logger Graphs







NL3 - 25 Firmstone Garden - 12/06/15 - 24/06/15

Logger Setup

Logger Type: ARL 215

Serial No : 194803

Address: 25 Firmstone Garden , Arncliffe

Location: Front Yard

Facade / Free Field: Free Field

Environment:

Logger Setup Photo

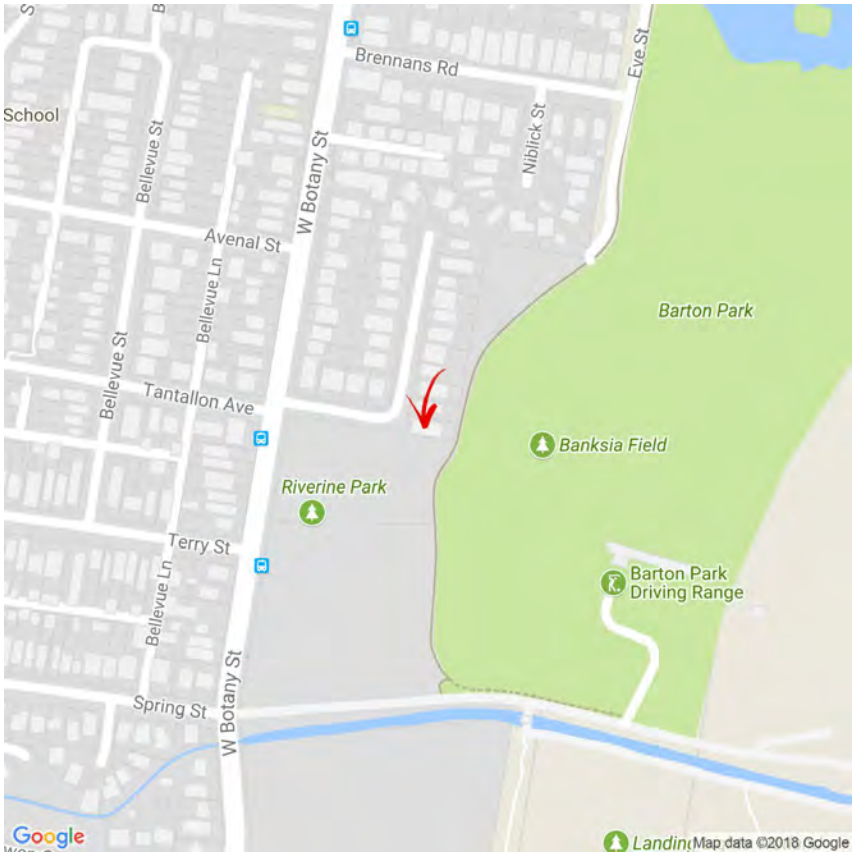
INP Noise Level, dB(A)

	Log Average	RBL
Day	55	47
Evening	54	48
Night	50	39

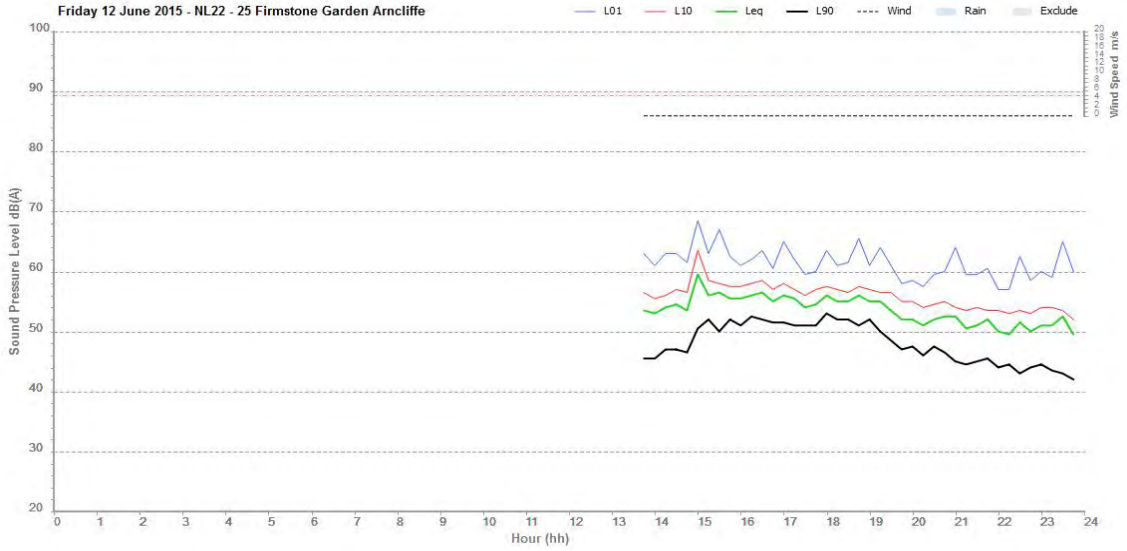
RNP Noise Level, dB(A)

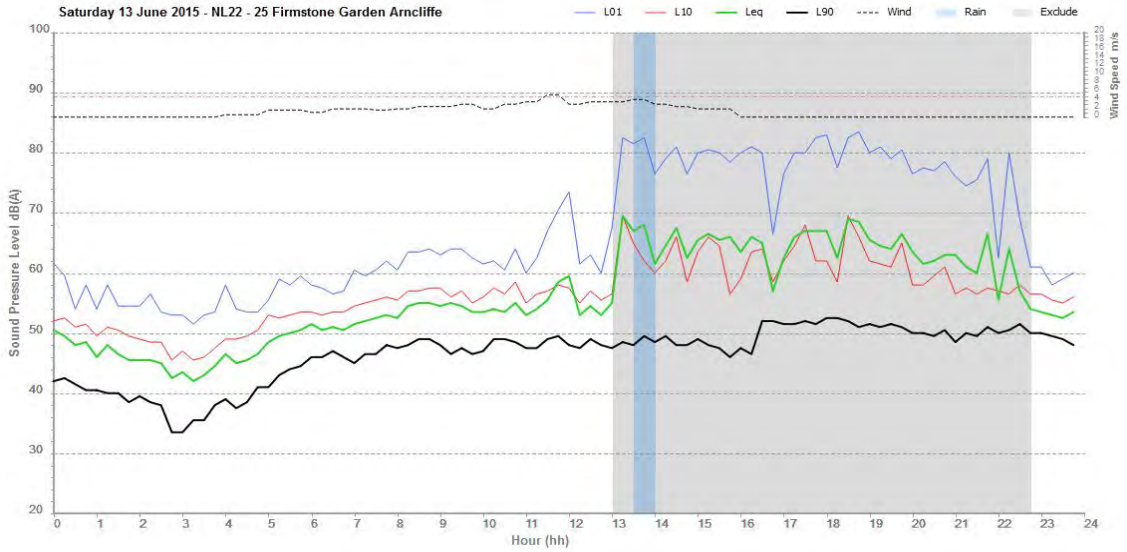
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

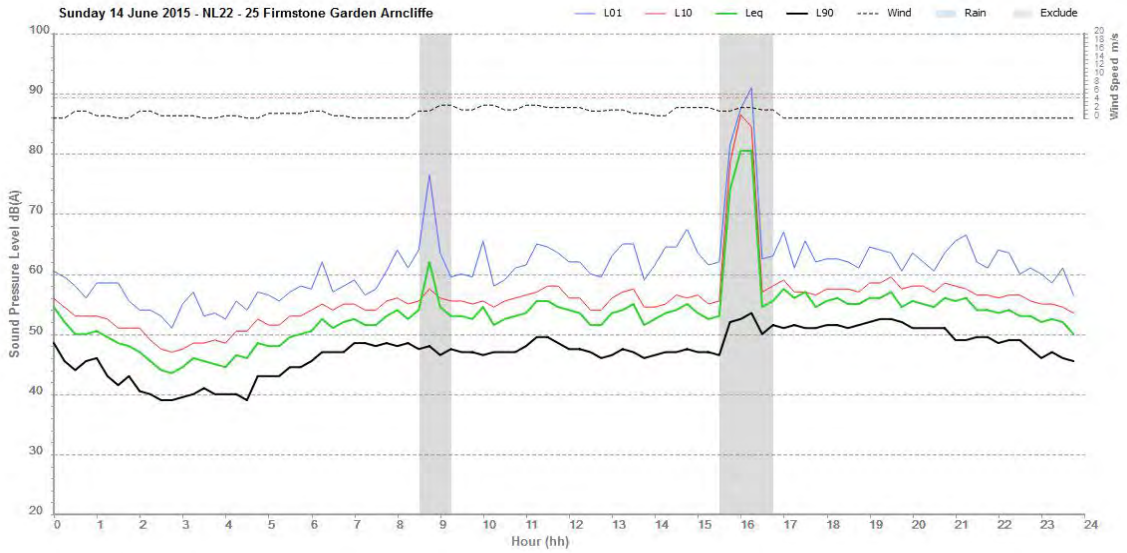
Logger Location Map



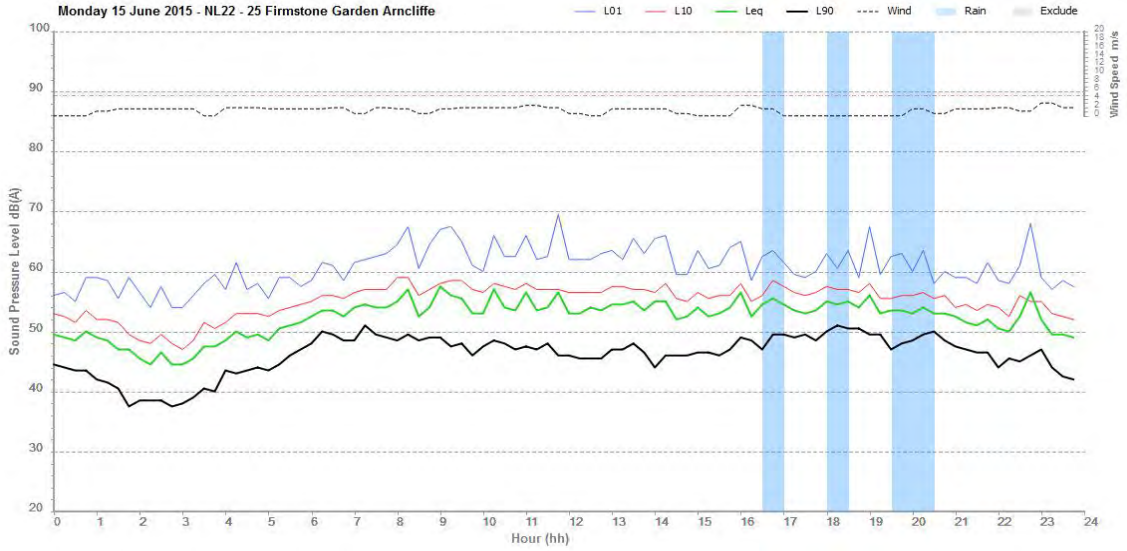
Logger Graphs

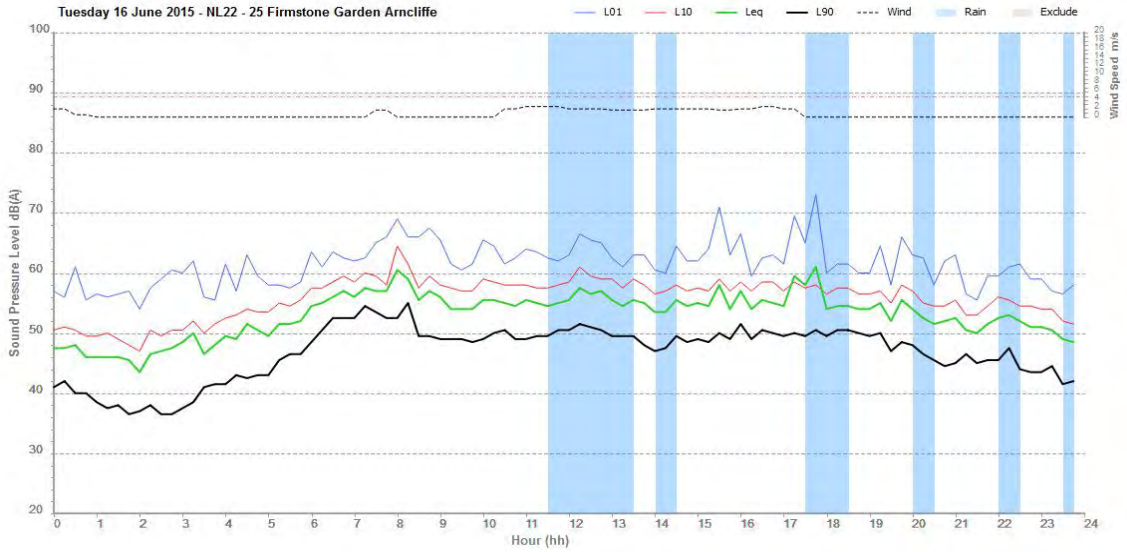


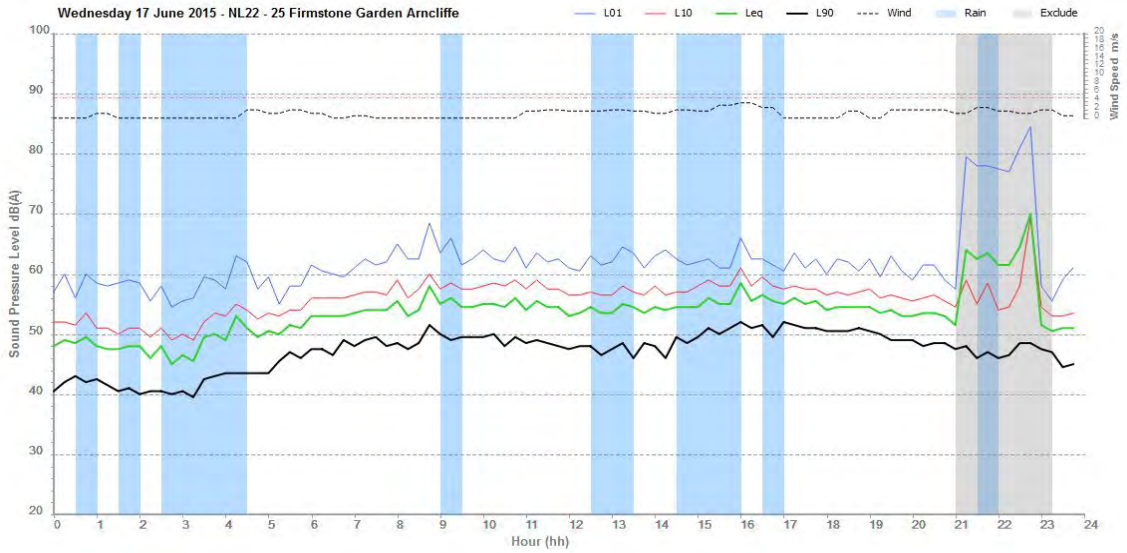




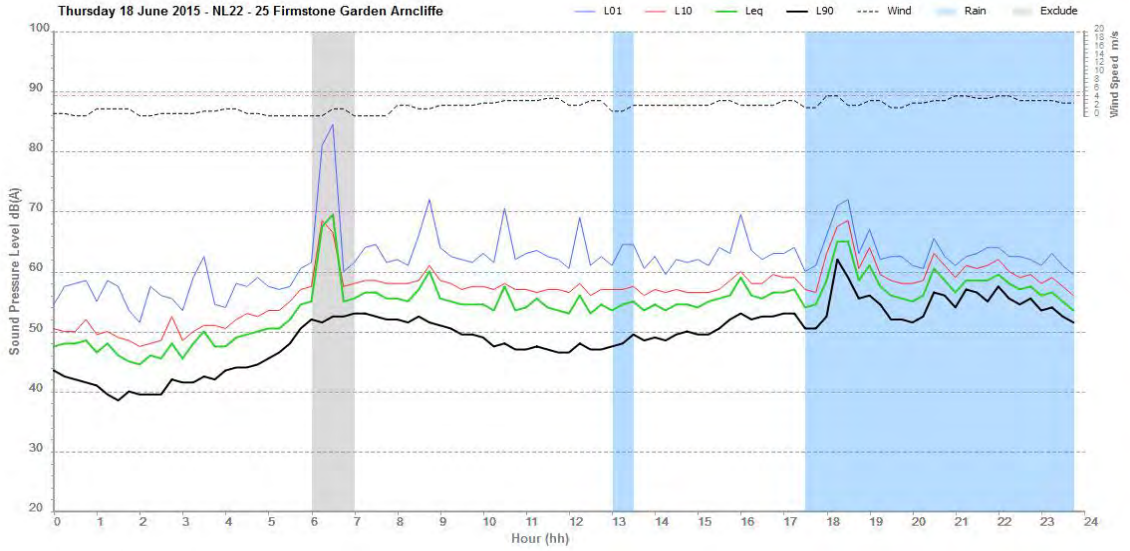
Logger Graphs

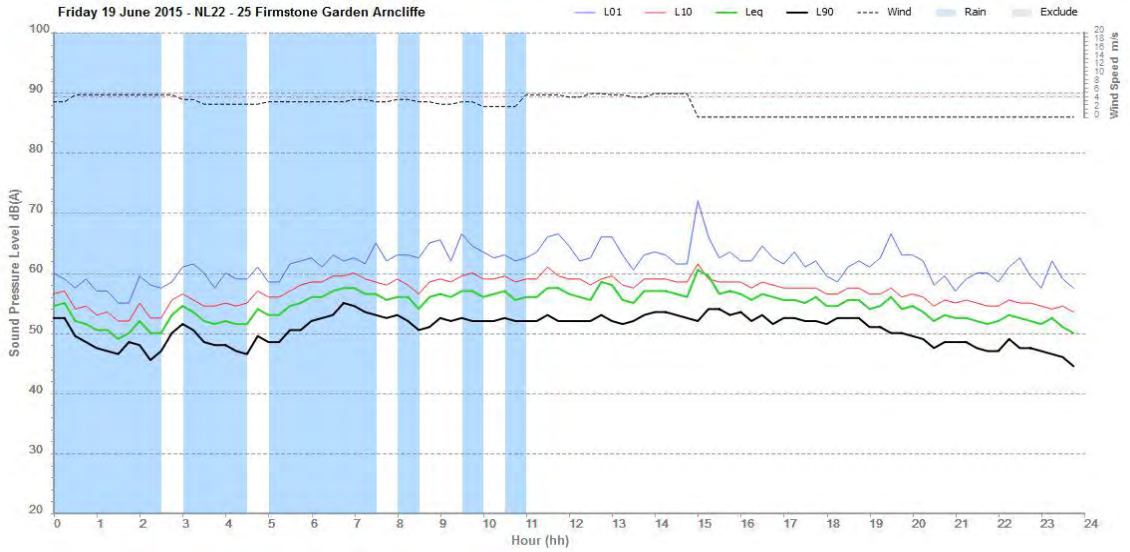


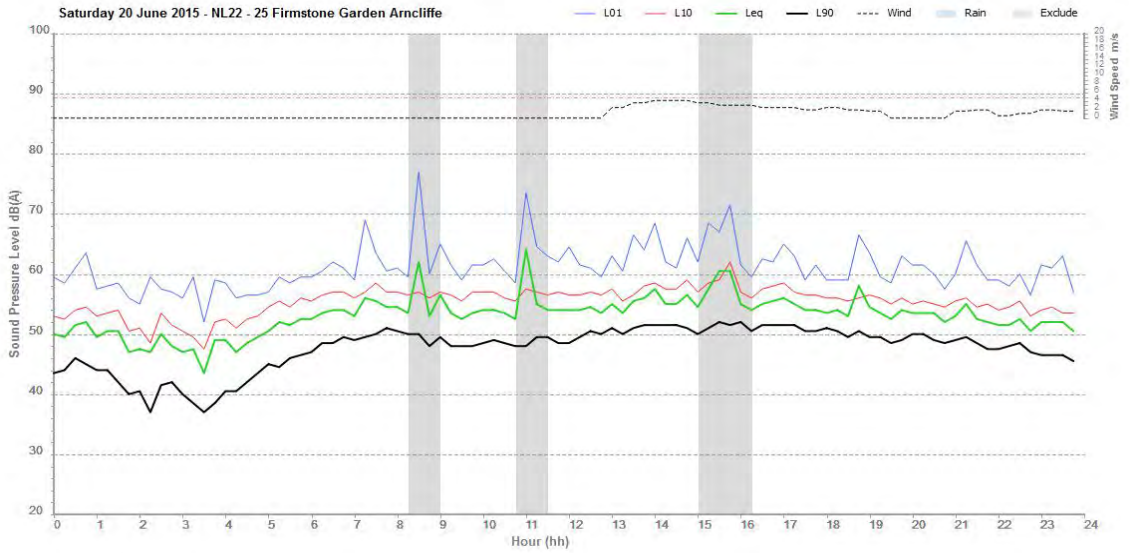




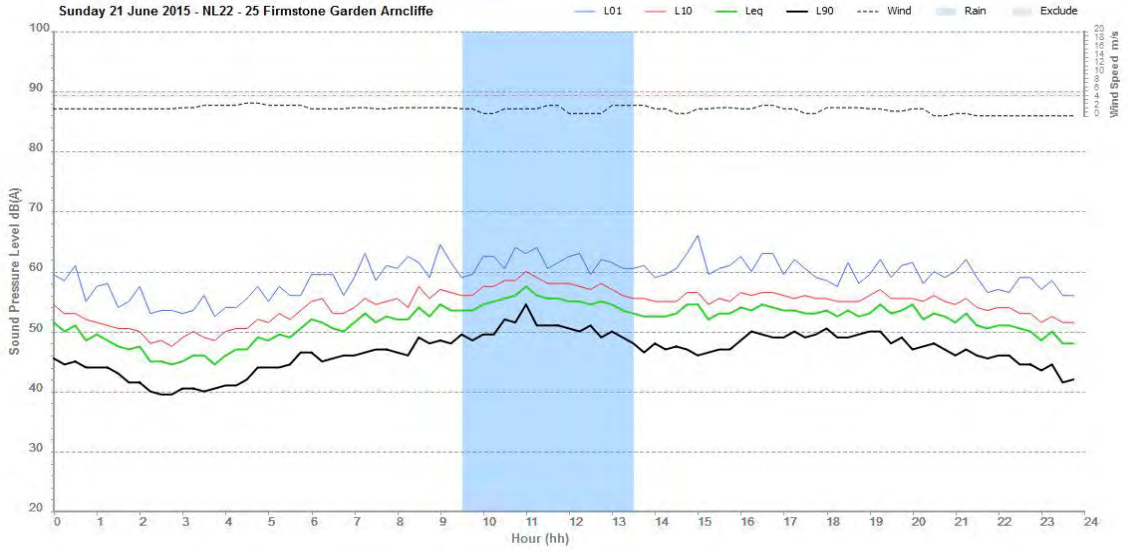
Logger Graphs

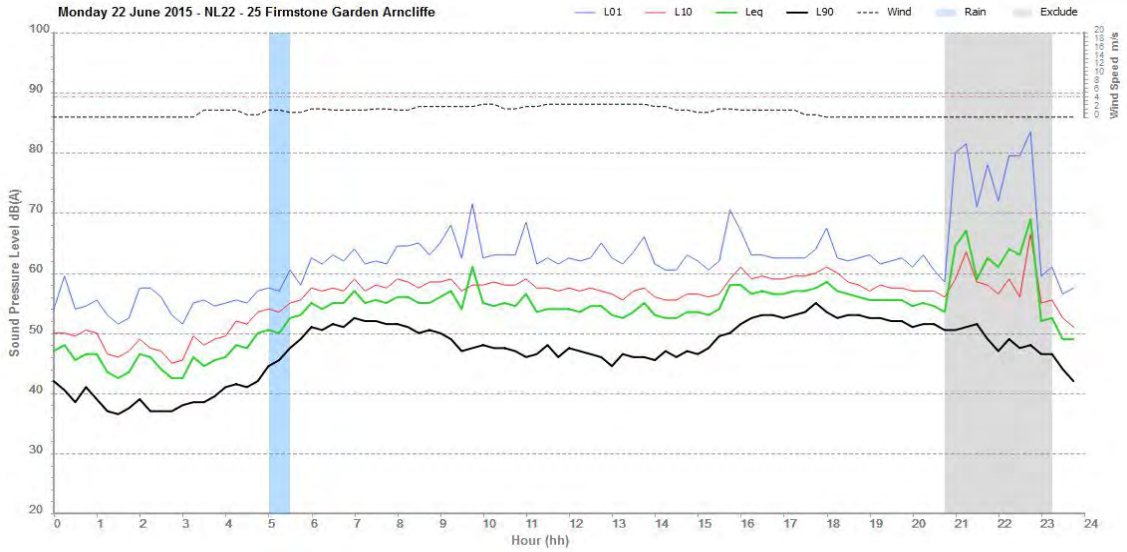


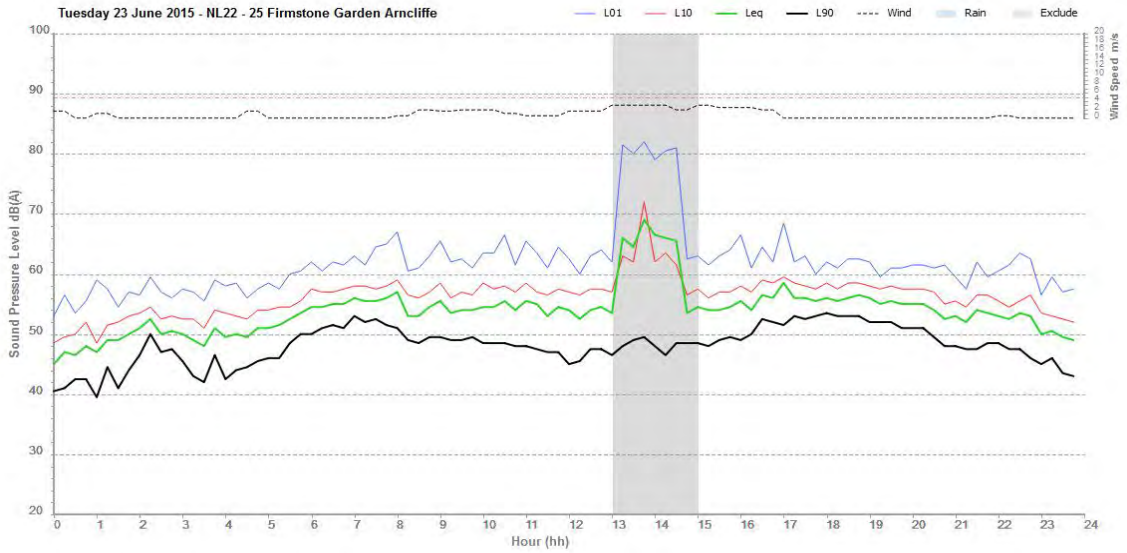




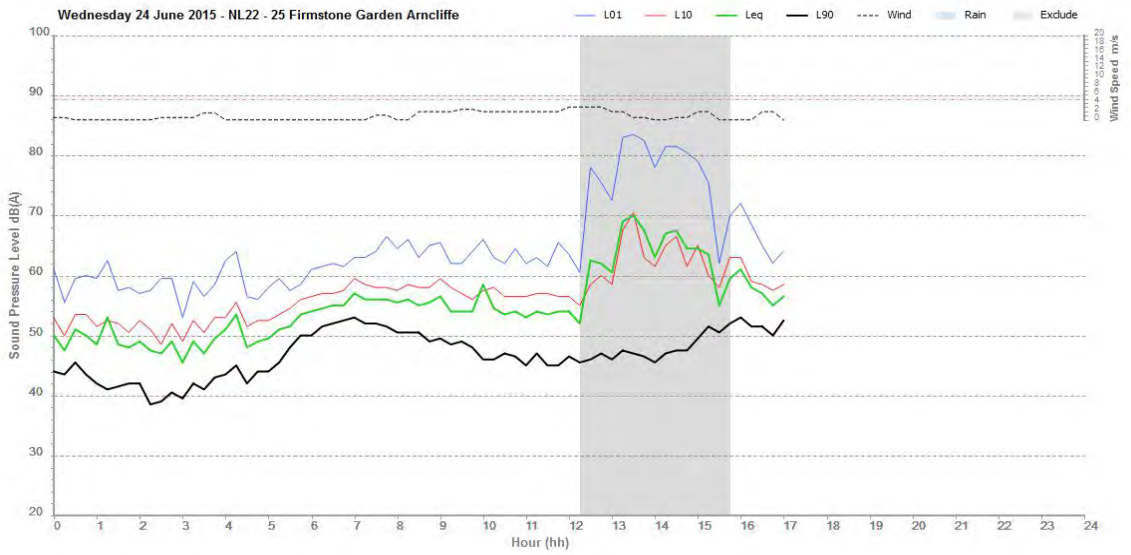
Logger Graphs







Logger Graphs



NL4 - 82 Frances Avenue - 06/02/18 - 16/02/18

Logger Setup

Logger Type: ARL 316

Serial No : 16-707-037

Address: 82 Francis Avenue,
Brighton Le-Sands

Location: Back Yard

Facade / Free Field: Free Field

Environment: General suburban noise environment. Distant sounds of children playing, barely audible. Insect noise 45-50 dB. Light wind noise in trees. Road traffic occasional from Frances Avenue 45 dB. Distant aircraft noise occasional. Bouncing basketball audible

Logger Setup Photo

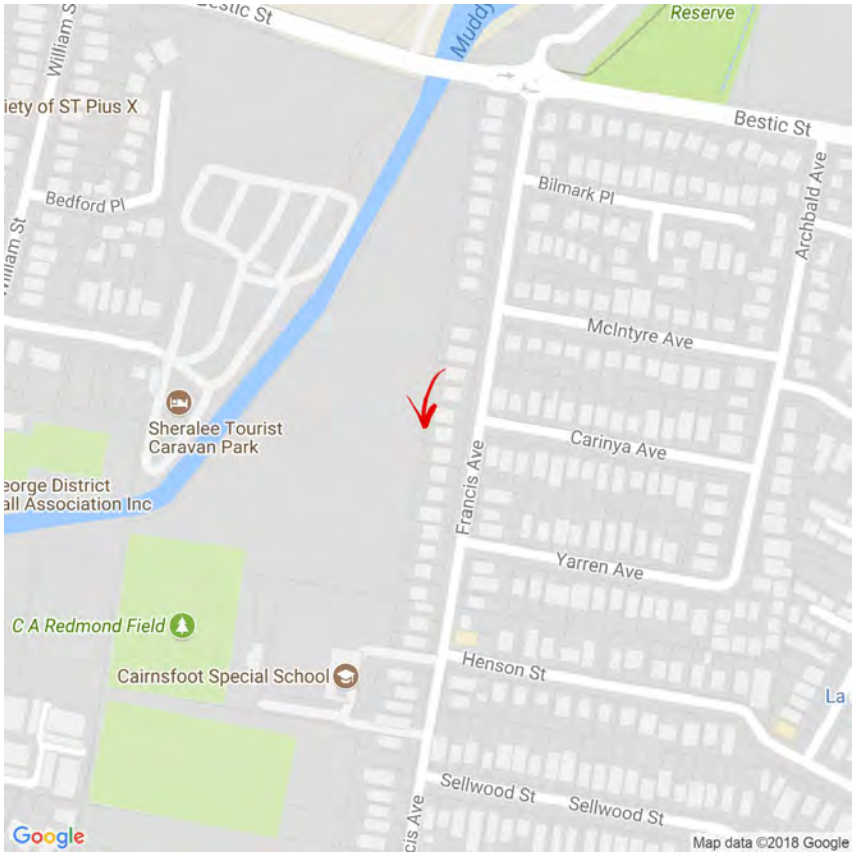
INP Noise Level, dB(A)

	Log Average	RBL
Day	49	38
Evening	47	37
Night	44	31

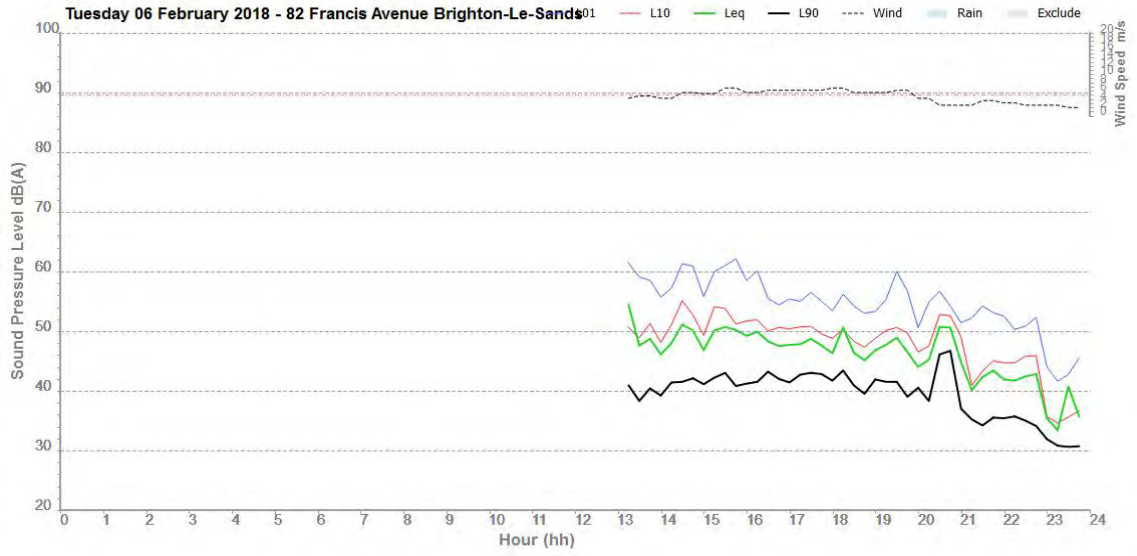
RNP Noise Level, dB(A)

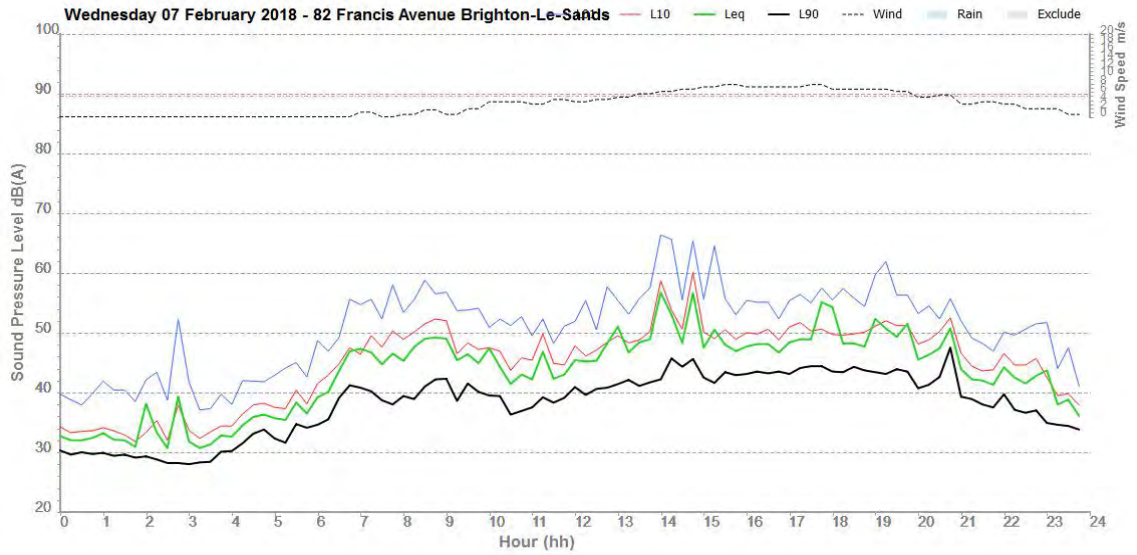
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

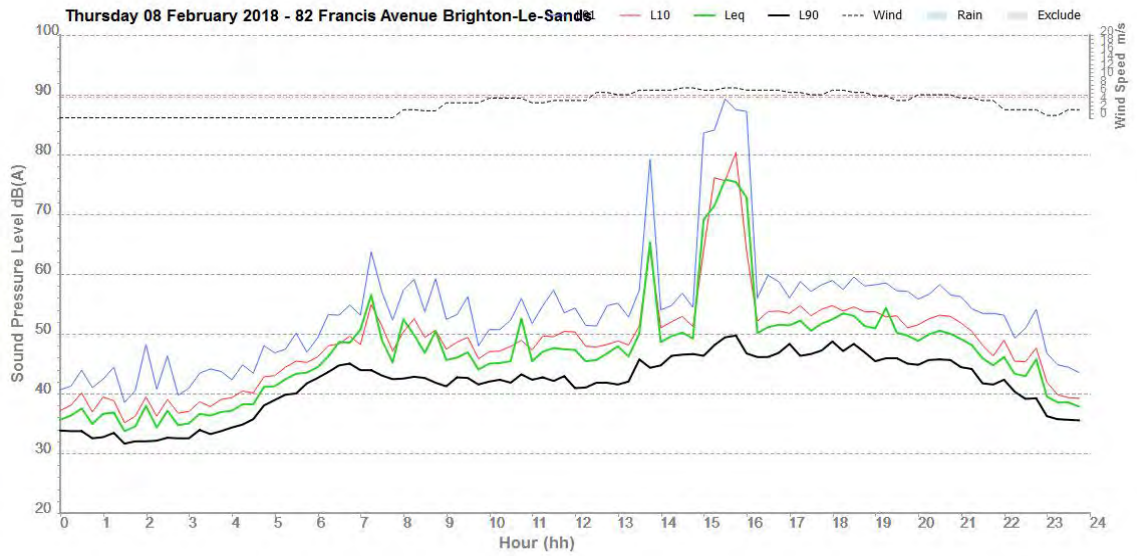
Logger Location Map



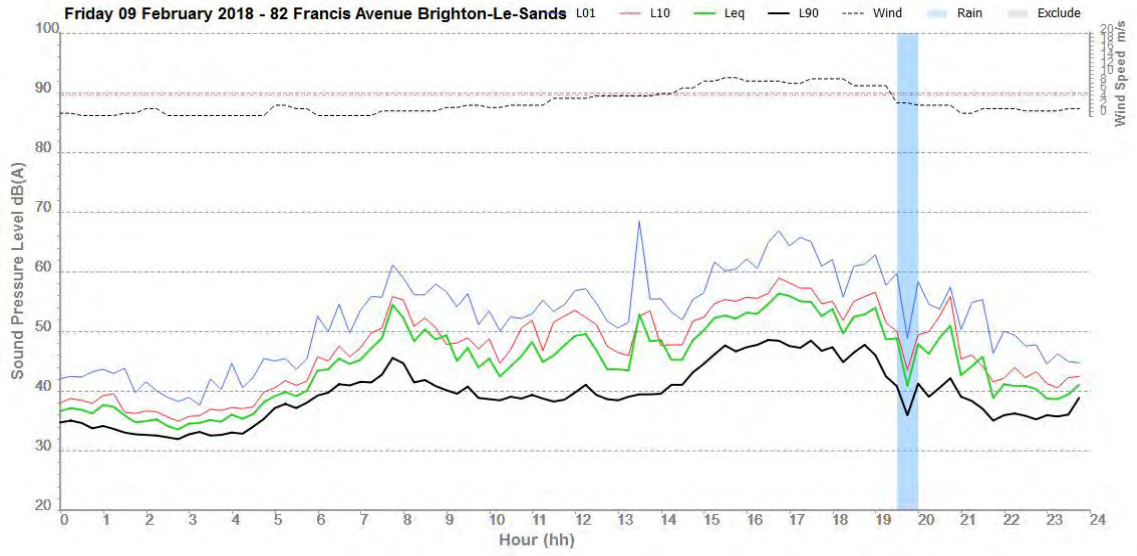
Logger Graphs

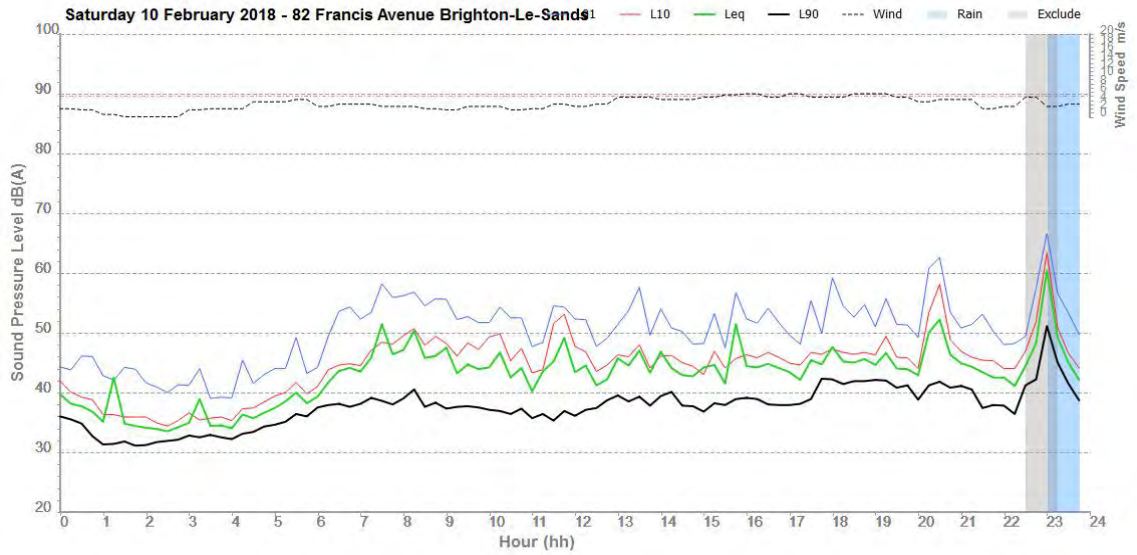


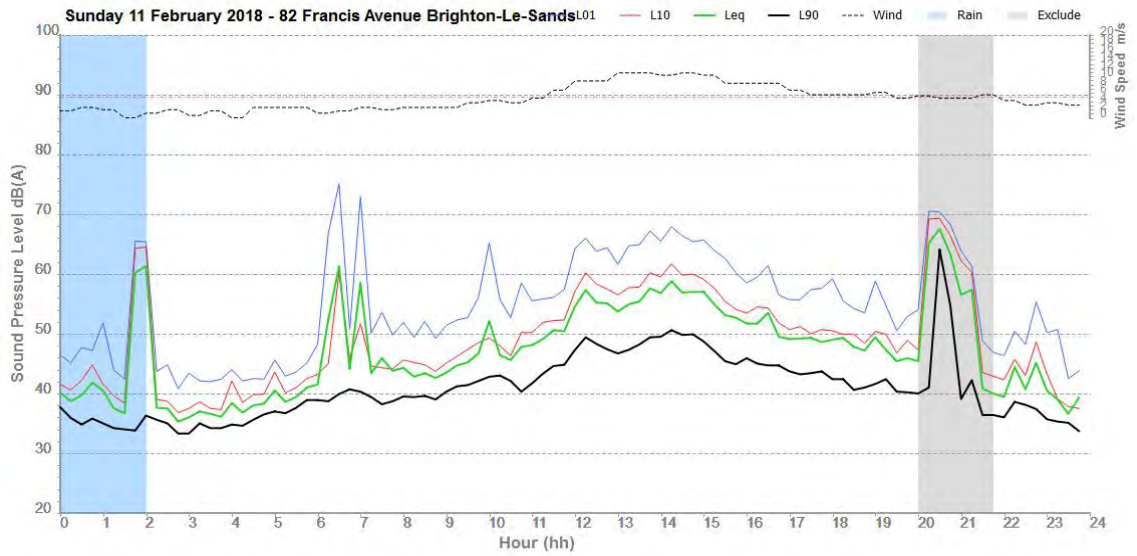




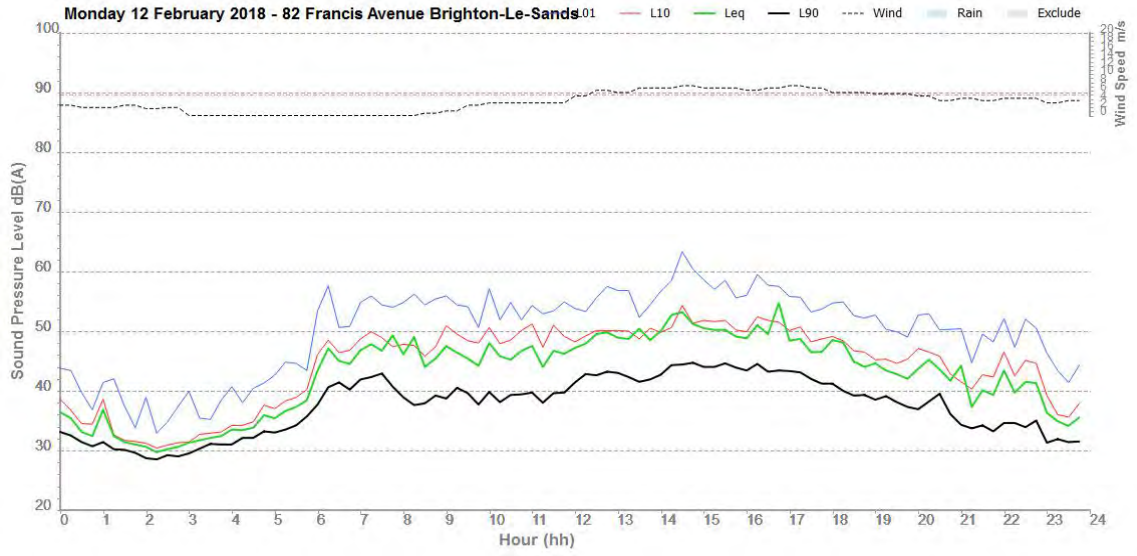
Logger Graphs

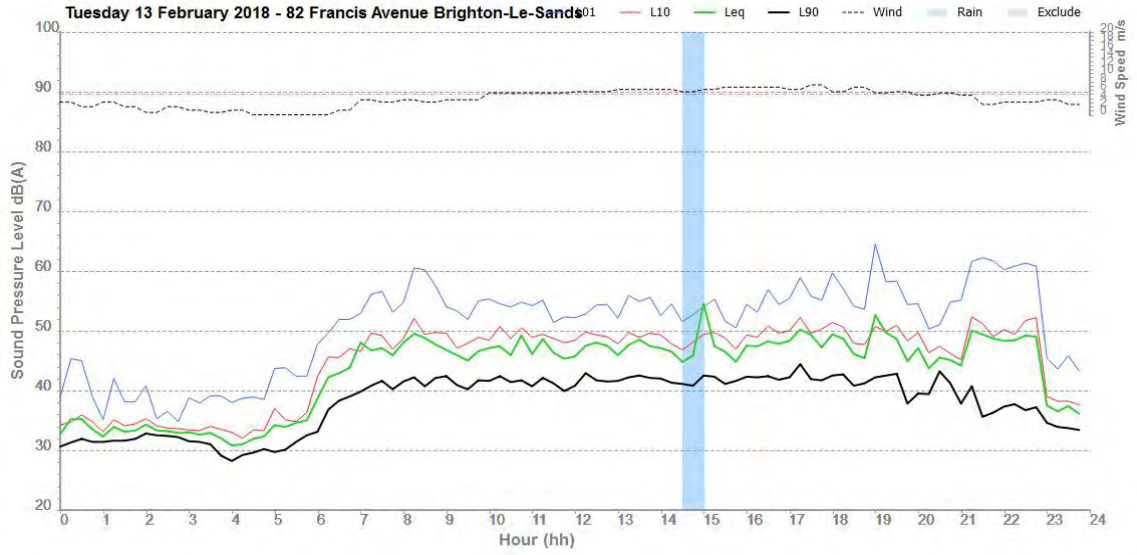


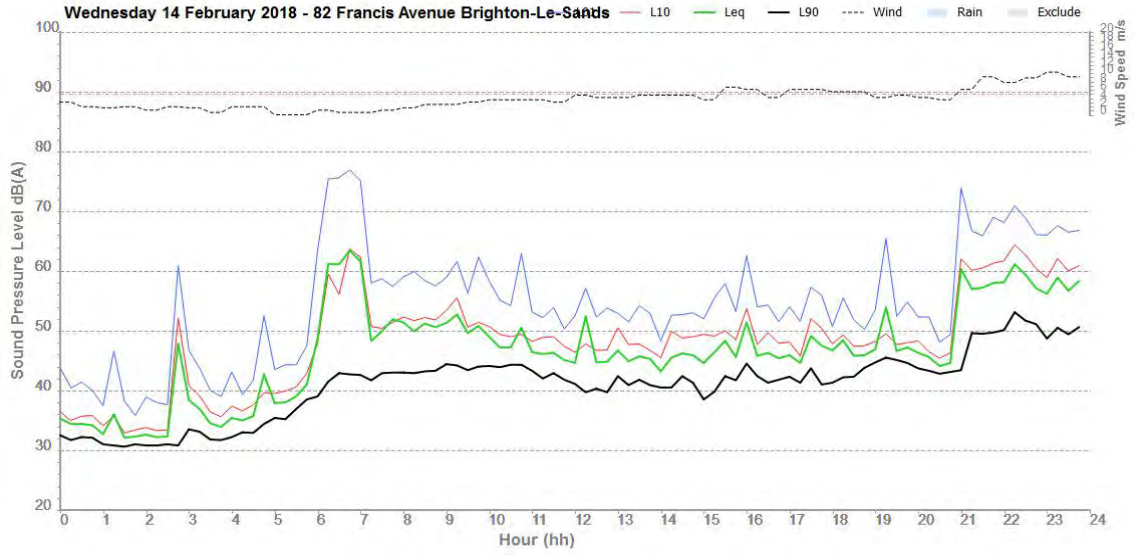




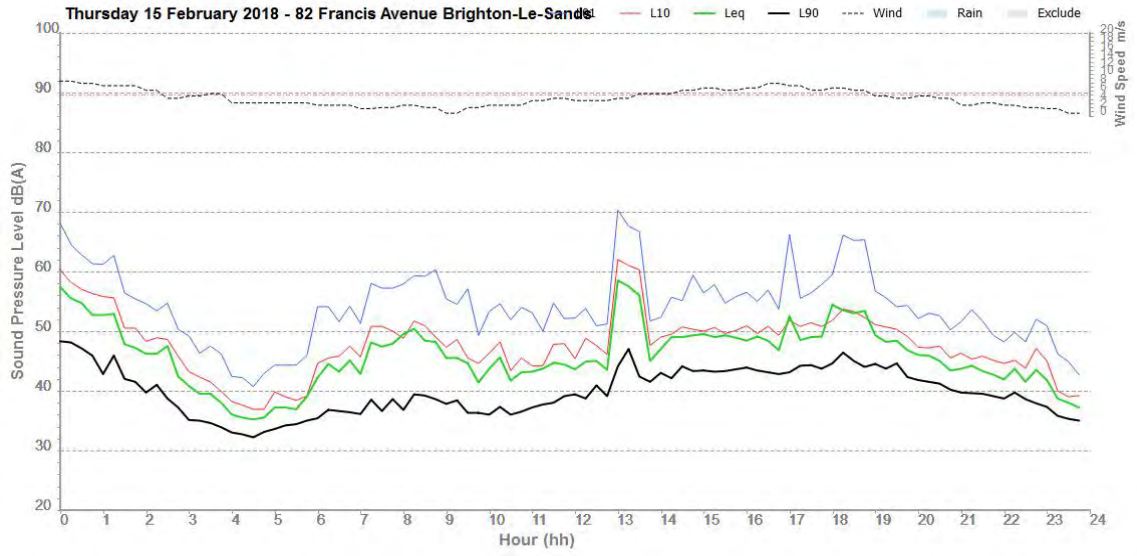
Logger Graphs

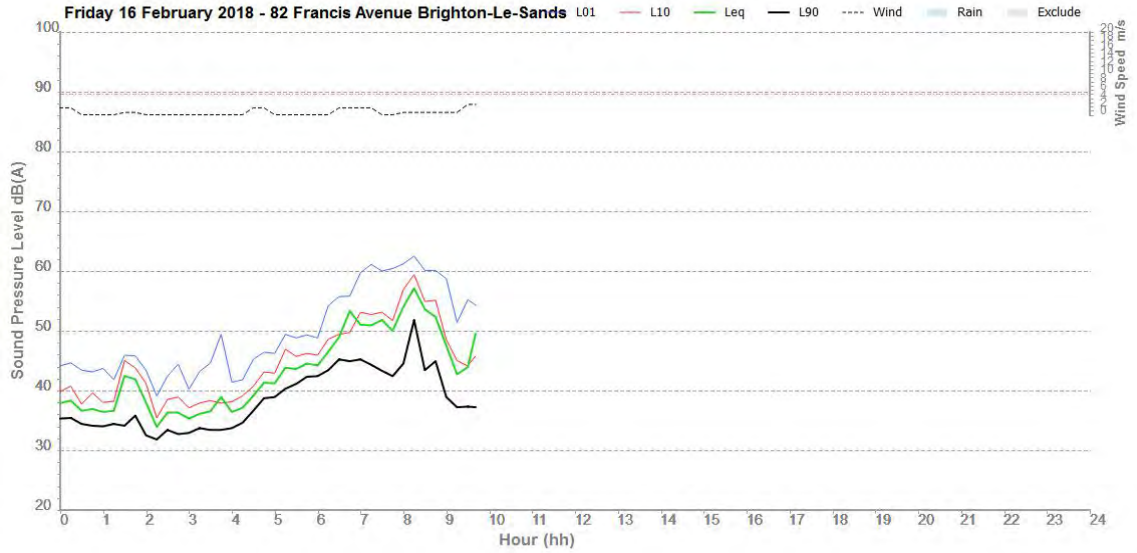






Logger Graphs





NL5 - C A Redmond Field - 06/02/18 - 16/02/18

Logger Setup

Logger Type: ARL 215

Serial No : 16-306-036

Address: C A Redmond Field,
Brighton Le-Sands

Location: In Park

Facade / Free Field: Free Field

Environment: Light-moderate breeze from northeast tending east. Air traffic noise from aircraft approaching Sydney Airport flying west-east 58-60 dB. Distant indecernible road traffic noise from the east. Distant whine barely audible, likely from jet turbines. No activities occurring in park during measurement.

Logger Setup Photo

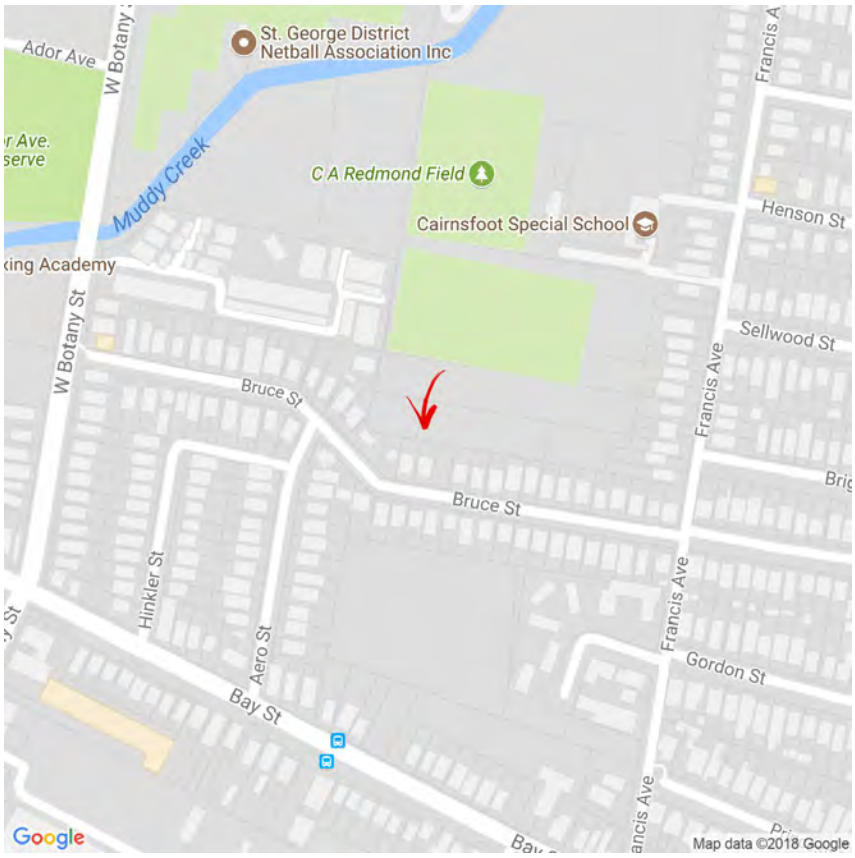
INP Noise Level, dB(A)

	Log Average	RBL
Day	56	39
Evening	49	39
Night	45	34

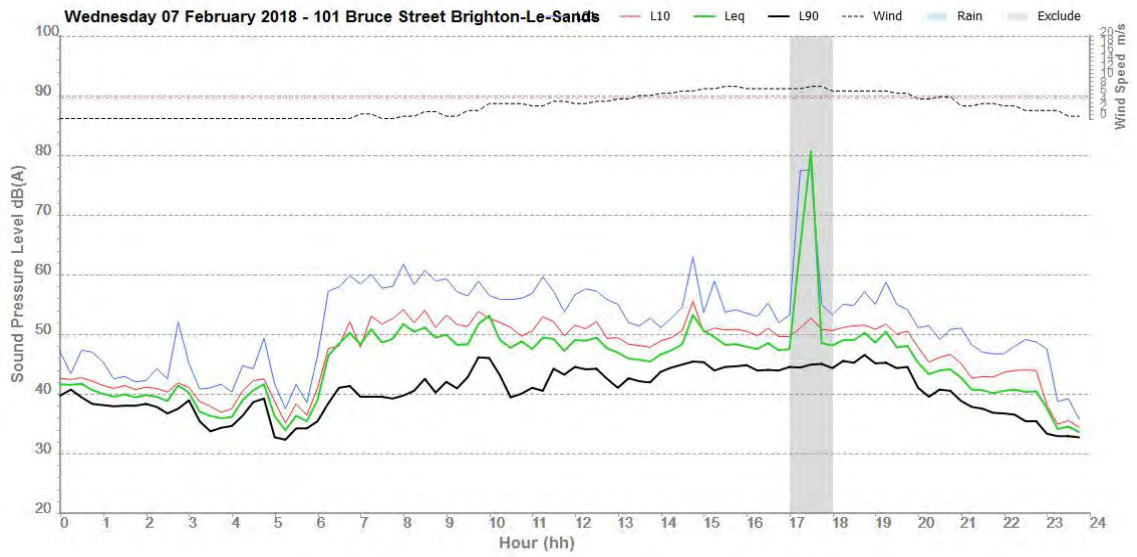
RNP Noise Level, dB(A)

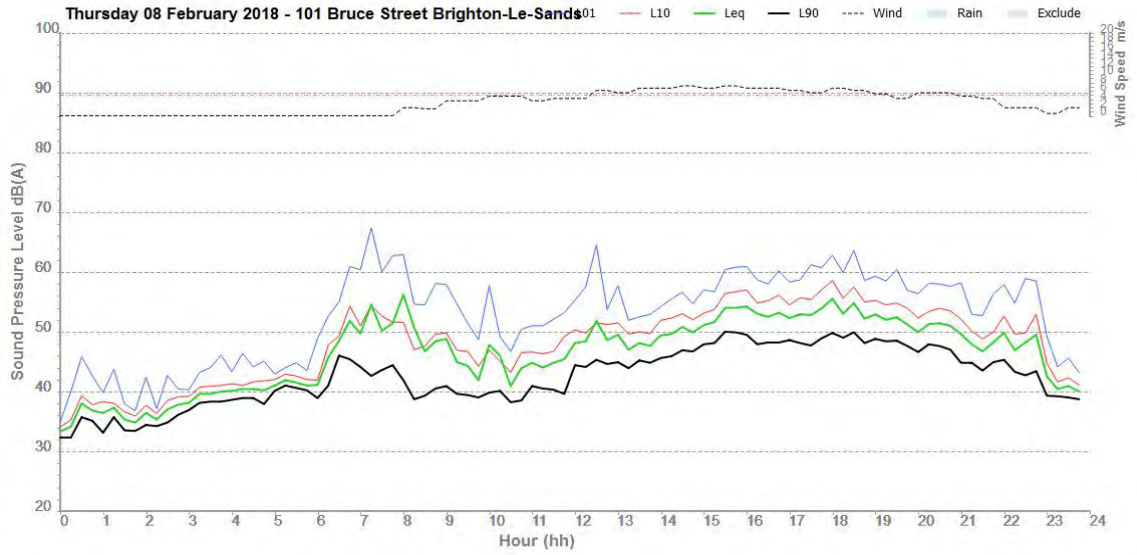
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

Logger Location Map

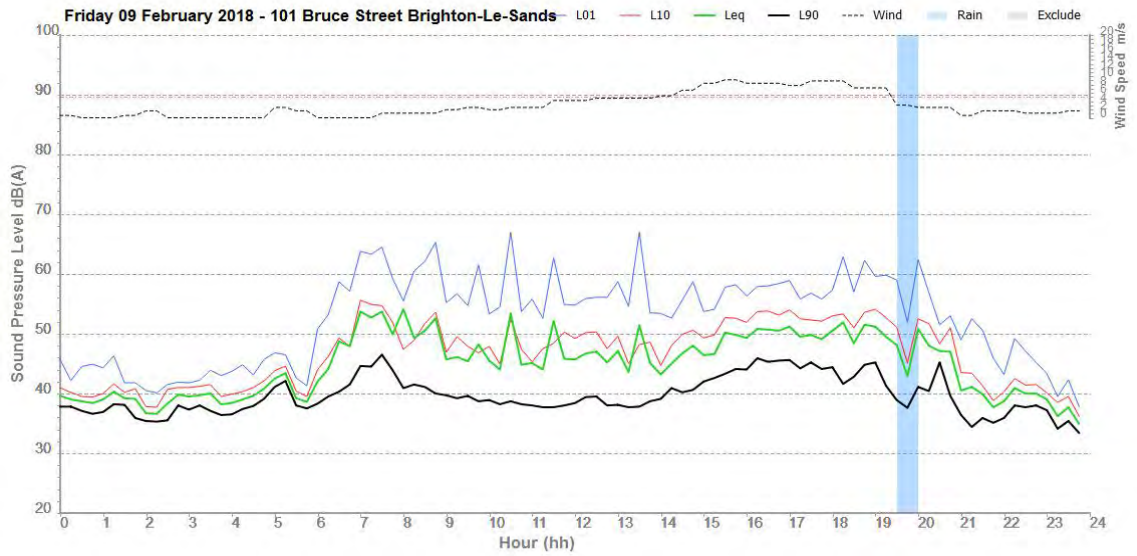


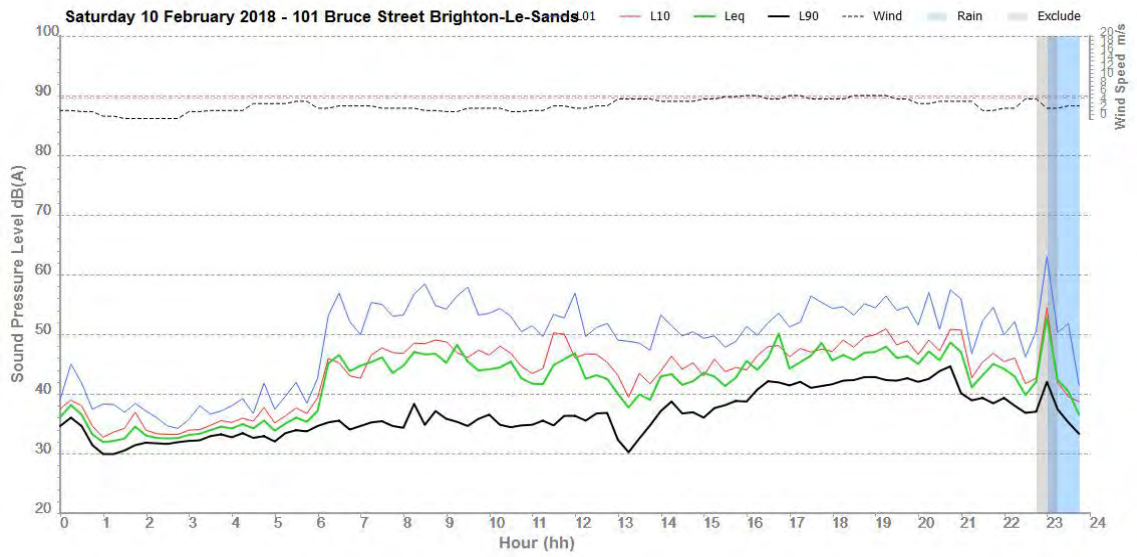
Logger Graphs

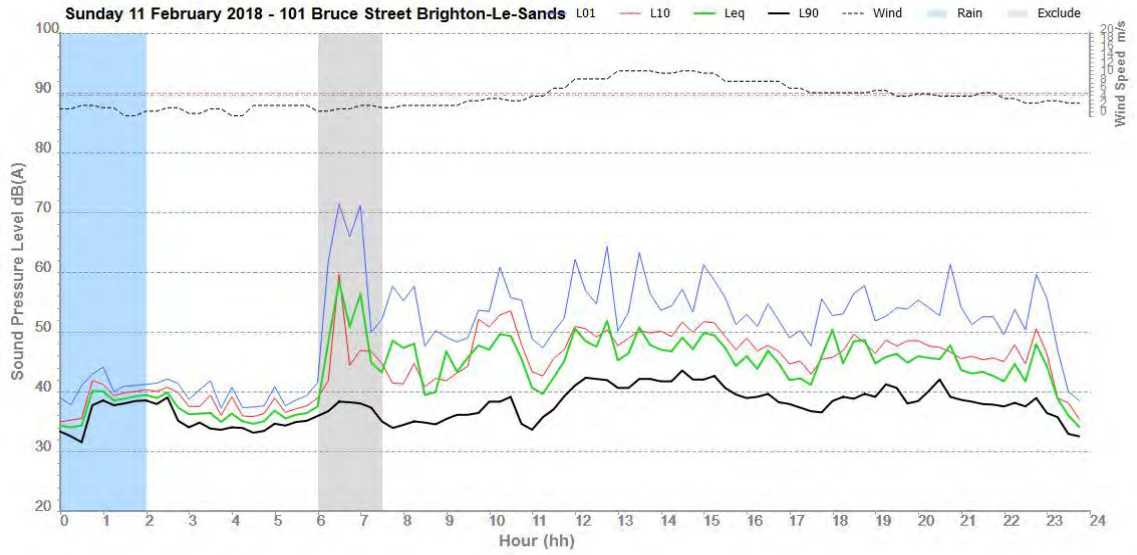




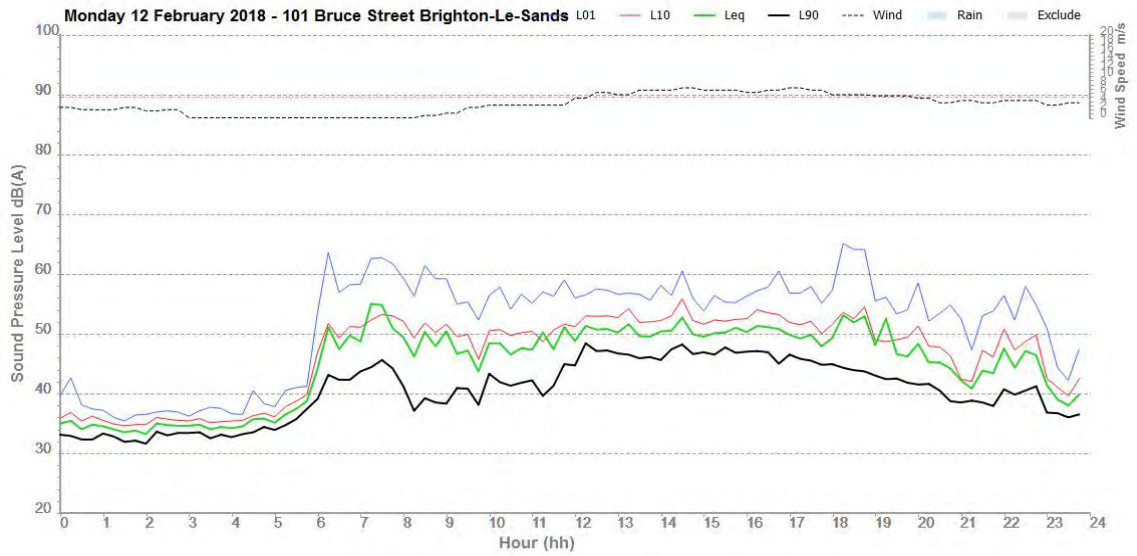
Logger Graphs

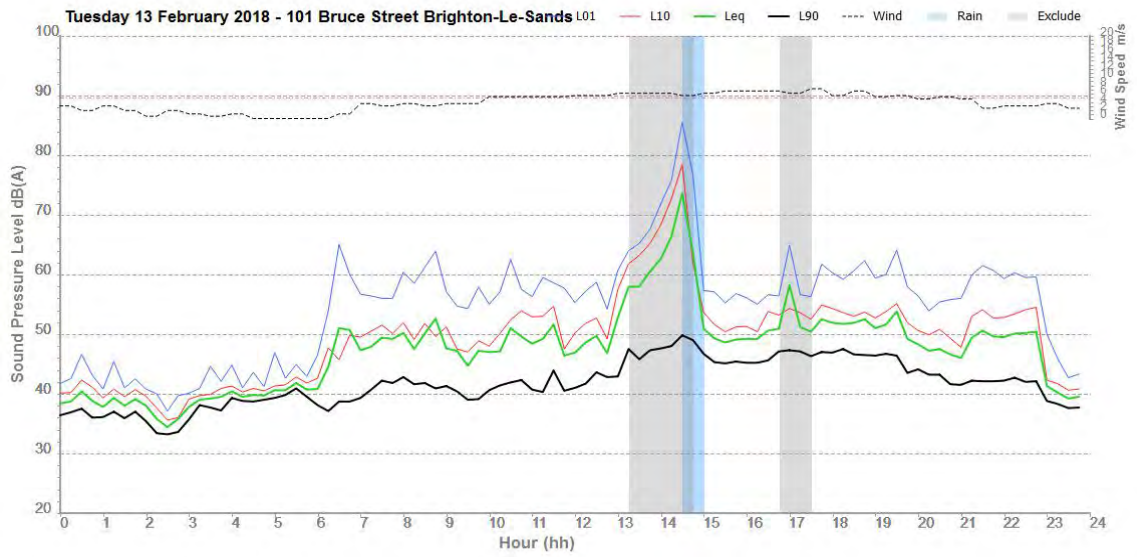




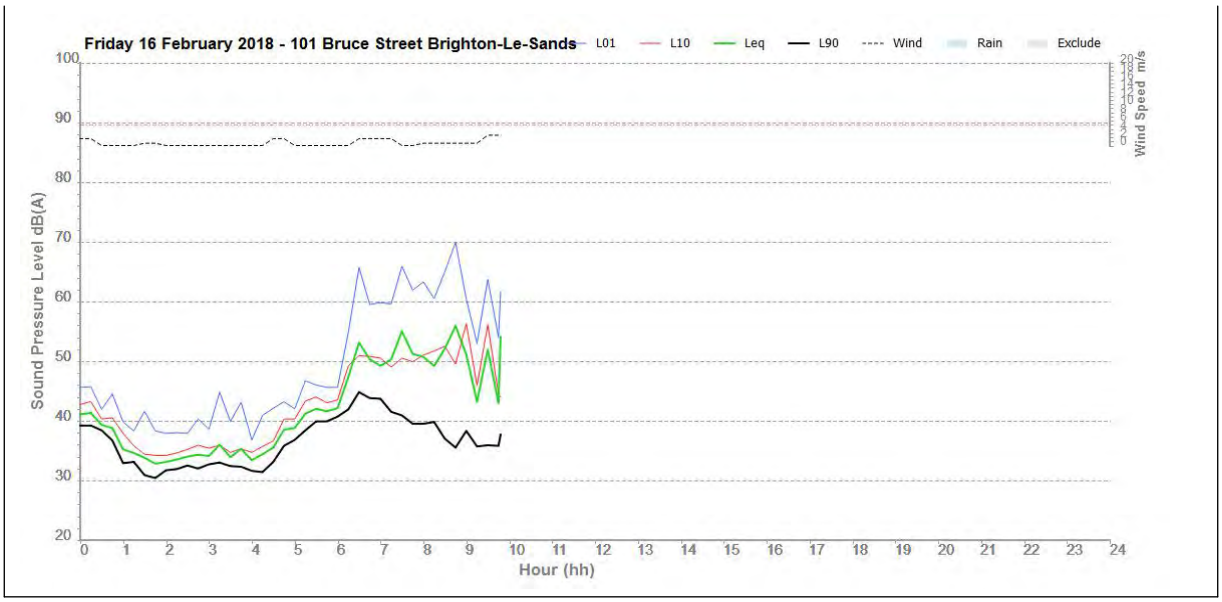


Logger Graphs





Logger Graphs


Friday 16 February 2018 - 101 Bruce Street Brighton-Le-Sands
L01
L10
Leq
L90
Wind
Rain
Exclude
Sound Pressure Level dB(A)
Wind Speed m/s
Hour (hh)

NL9 - 19 England Street - 28/11/17 - 08/12/17

Logger Setup

Logger Type: Rion NL52

Serial No : 1043455

Address: 23 England Street,
Brighton Le-Sands

Location: Front Yard

Facade / Free Field: Free Field

Environment: Noise environment dominated by aircraft noise and local road traffic along England street. Rubbish truck pass by 85db

Logger Setup Photo

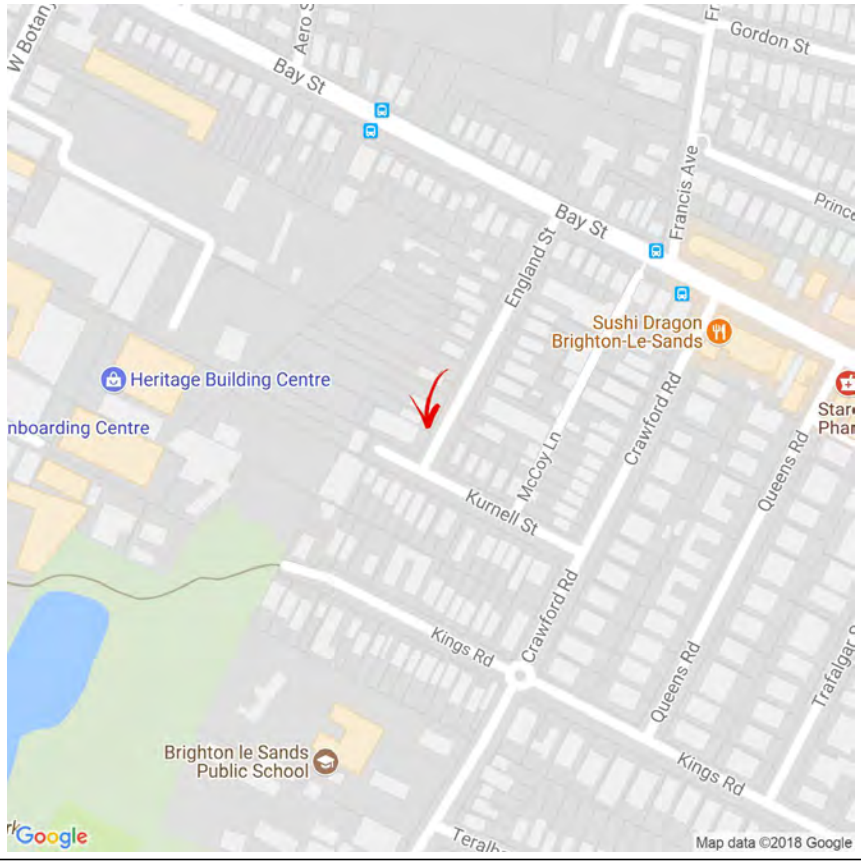
INP Noise Level, dB(A)

	Log Average	RBL
Day	56	41
Evening	55	41
Night	53	33

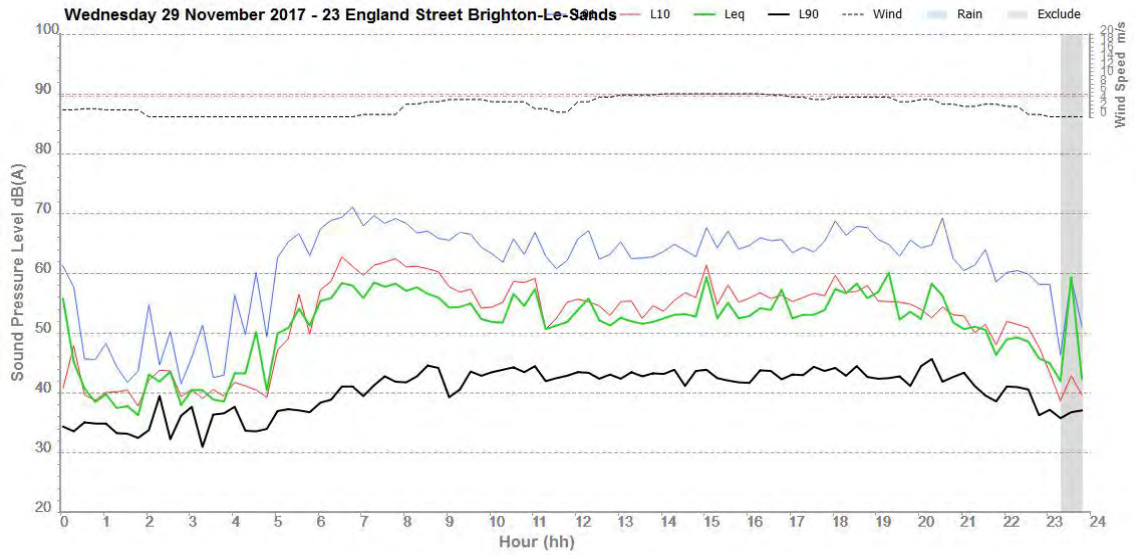
RNP Noise Level, dB(A)

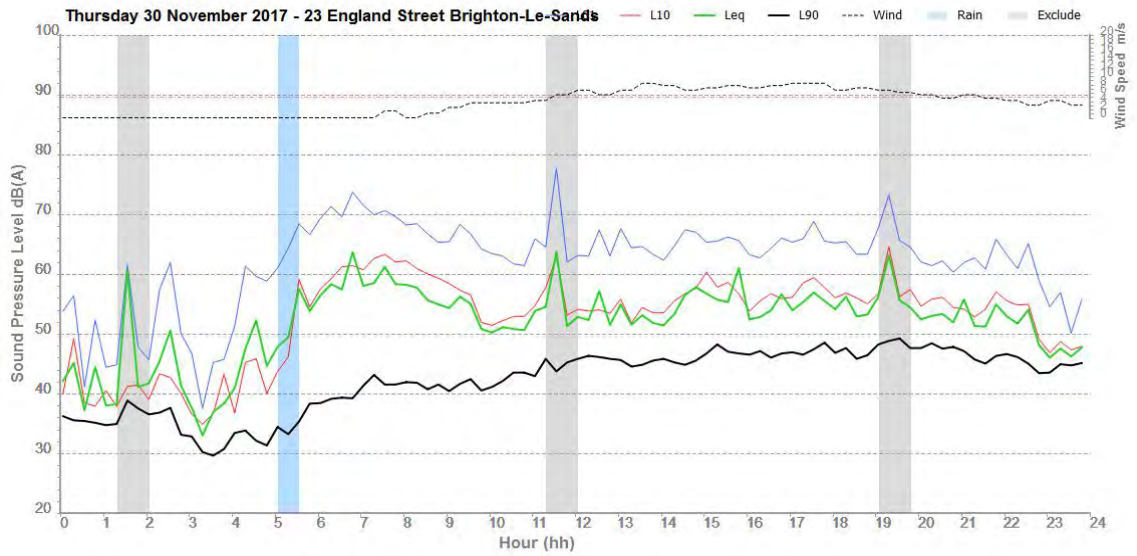
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

Logger Location Map

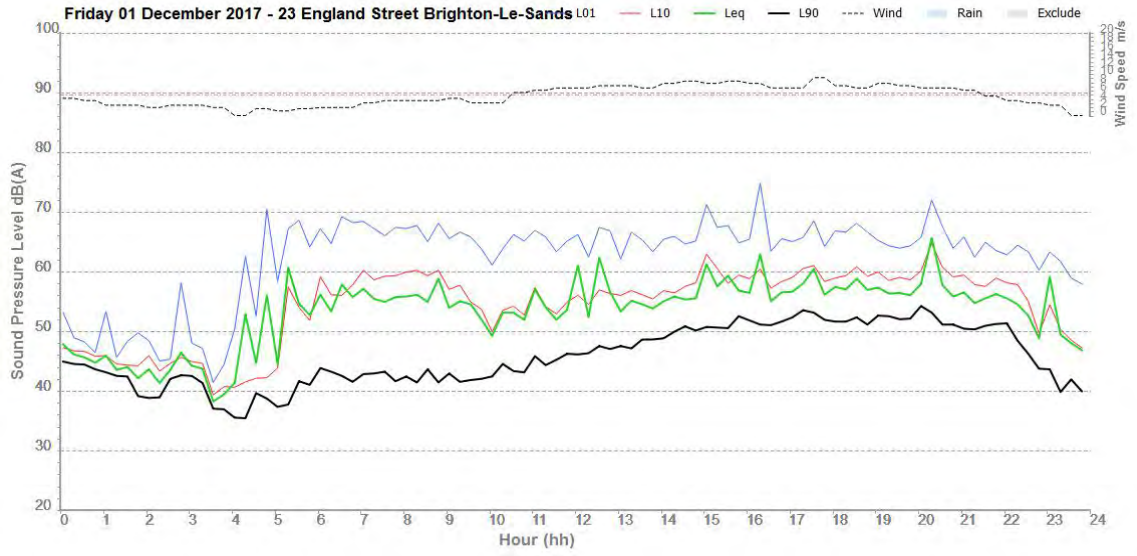


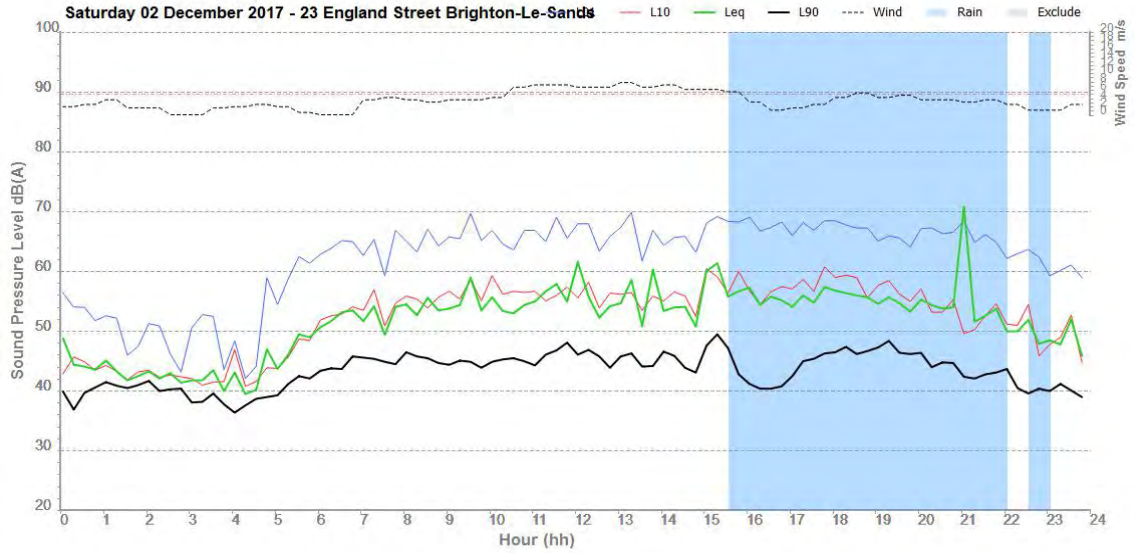
Logger Graphs

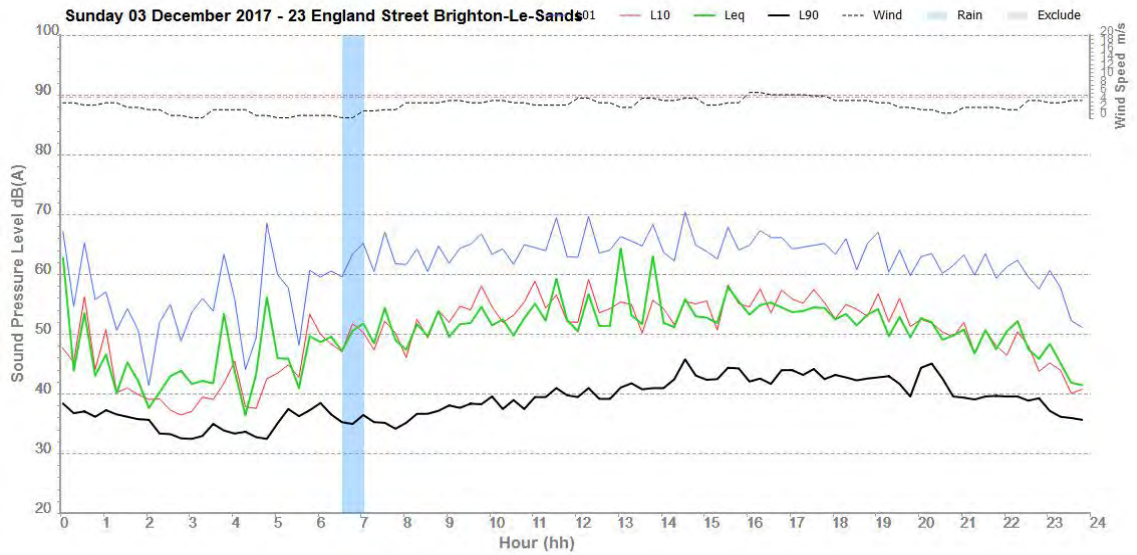




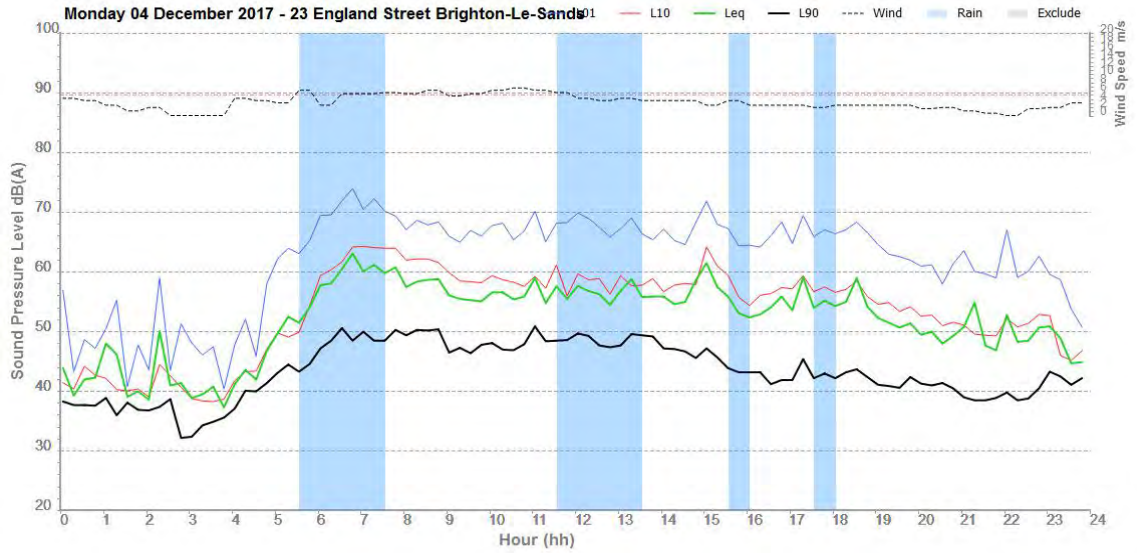
Logger Graphs

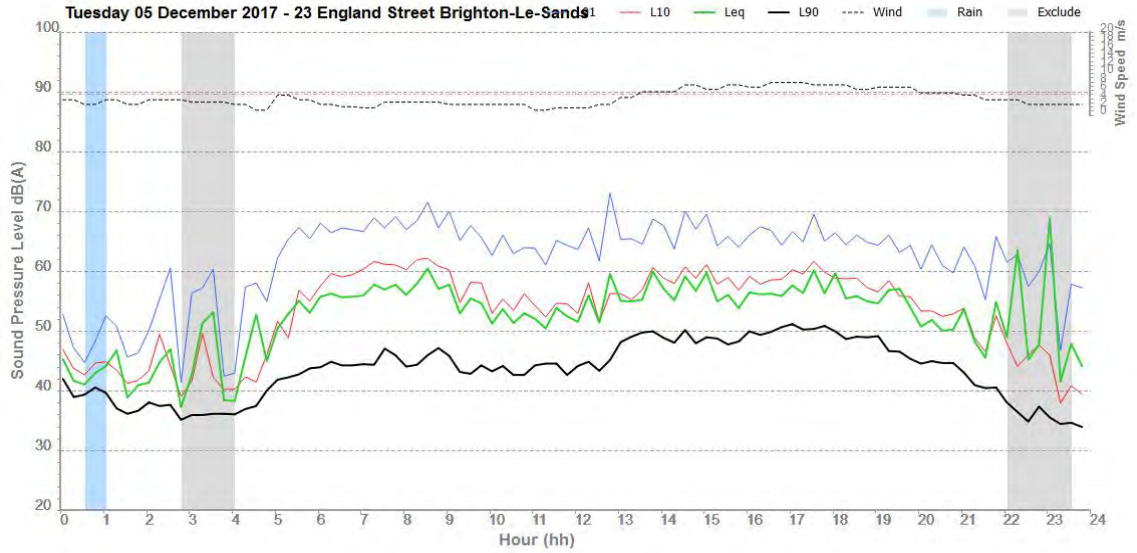


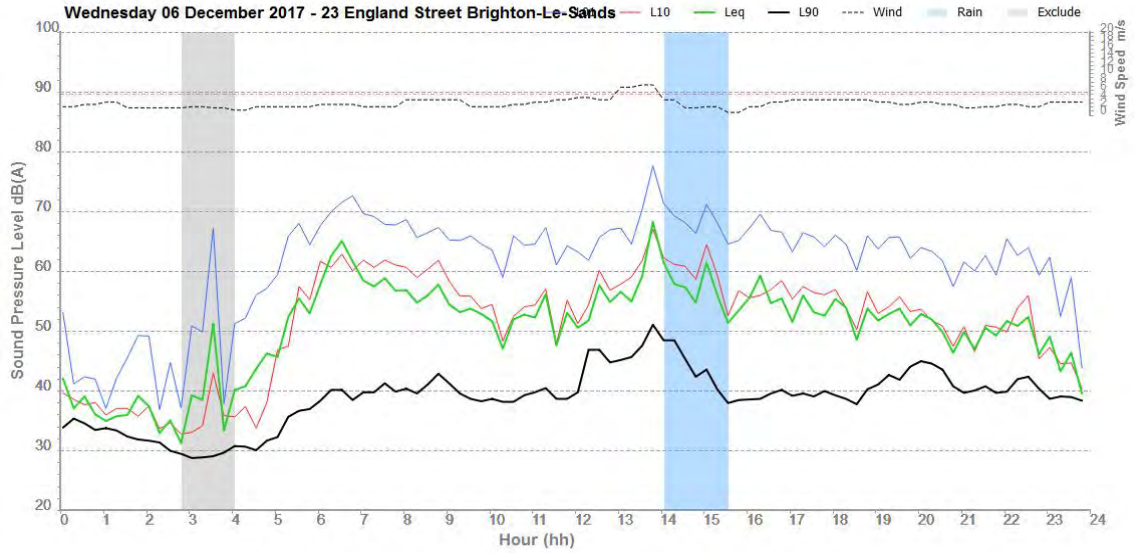




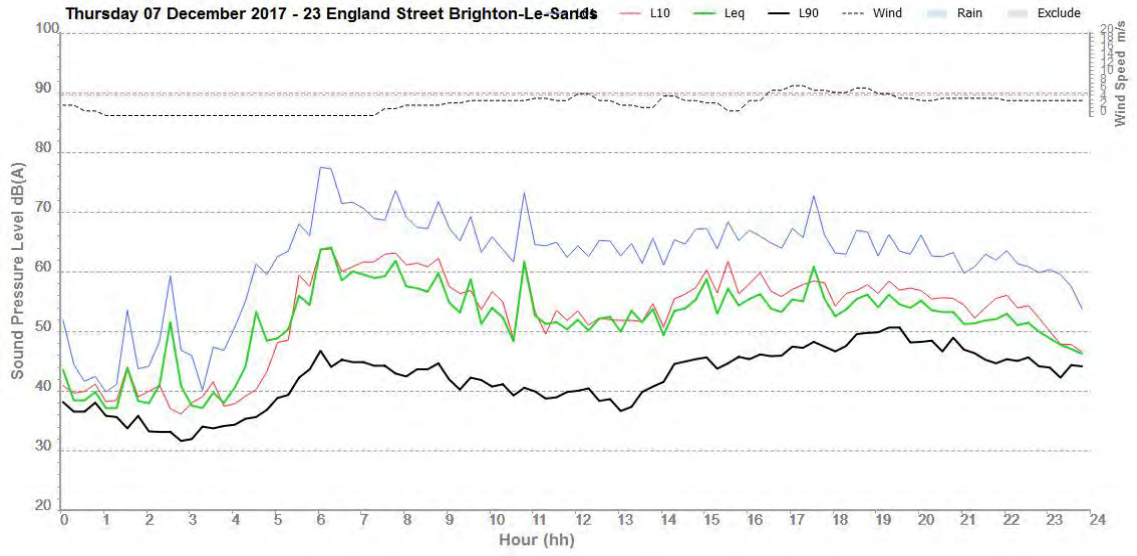
Logger Graphs

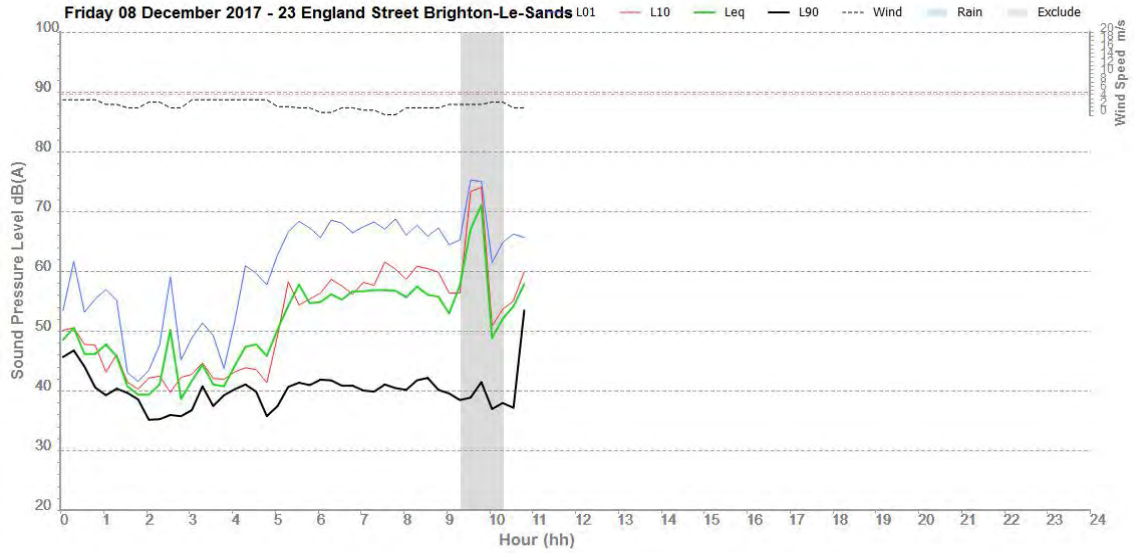






Logger Graphs





NL7 - 1B Kings Road - 28/11/17 - 08/12/17

Logger Setup

Logger Type: SVAN 977

Serial No : 45416

Address: 1B Kings Road, Brighton Le-Sands

Location: Front Yard

Facade / Free Field: Free Field

Environment: Local noise environment dominated by bird noise and local road traffic, in addition to traffic noise from Crawford street

Logger Setup Photo

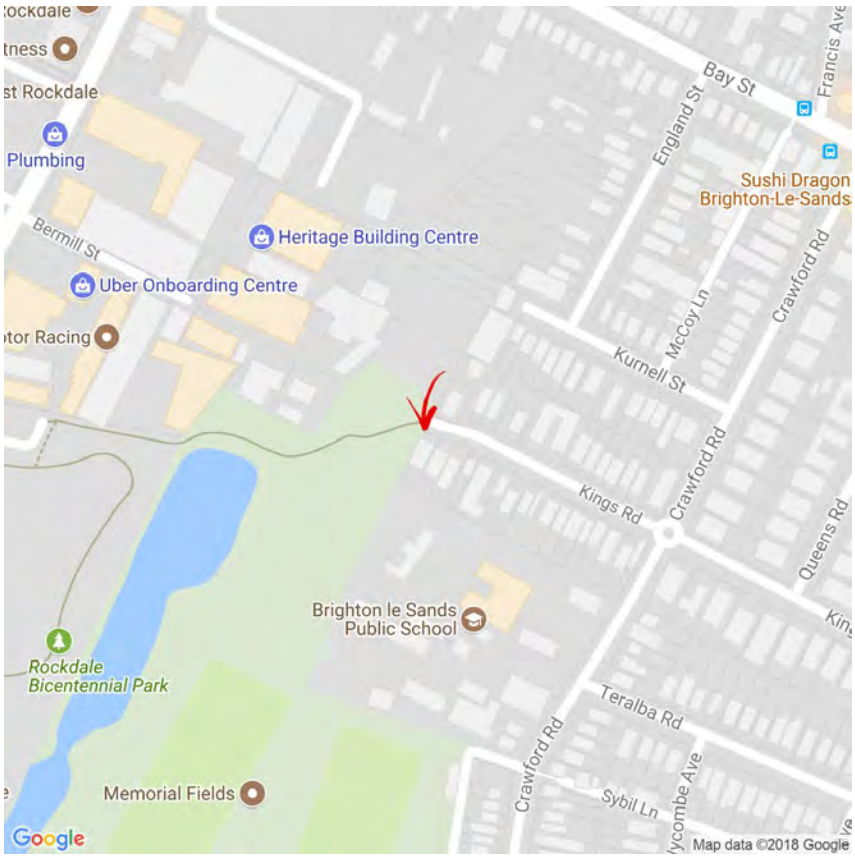
INP Noise Level, dB(A)

	Log Average	RBL
Day	53	39
Evening	51	40
Night	46	36

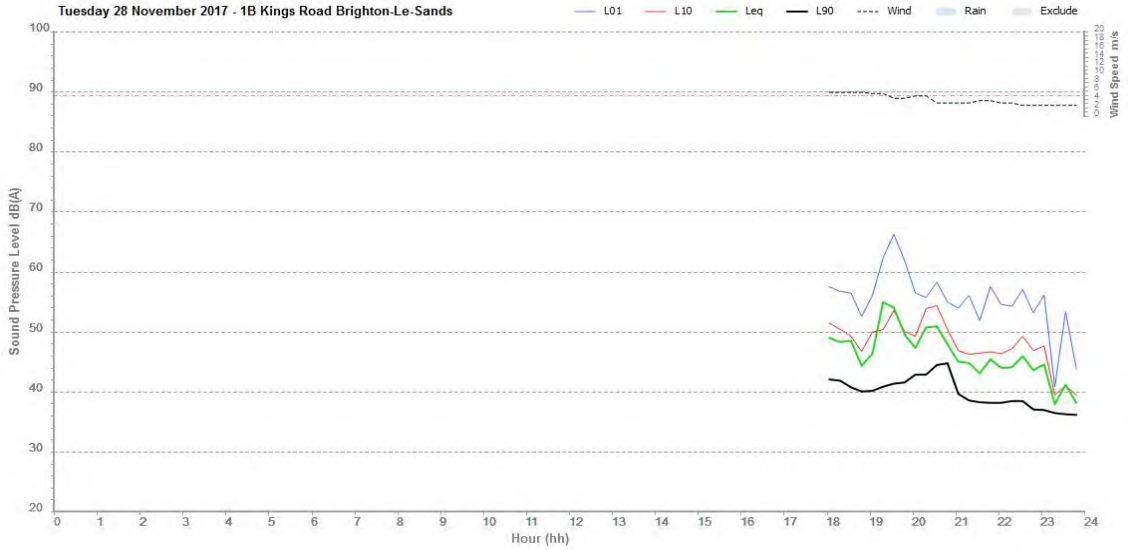
RNP Noise Level, dB(A)

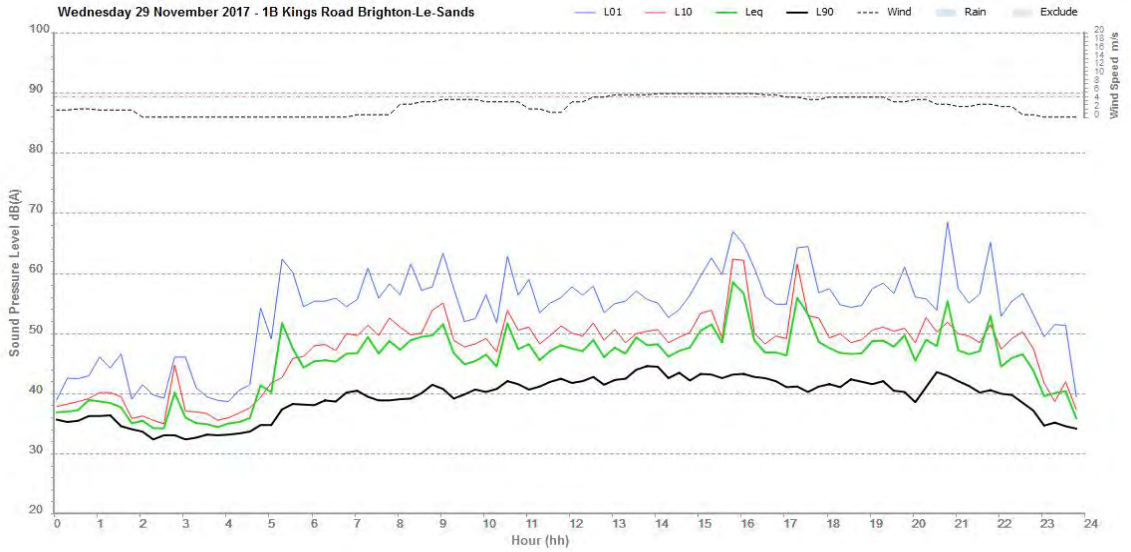
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

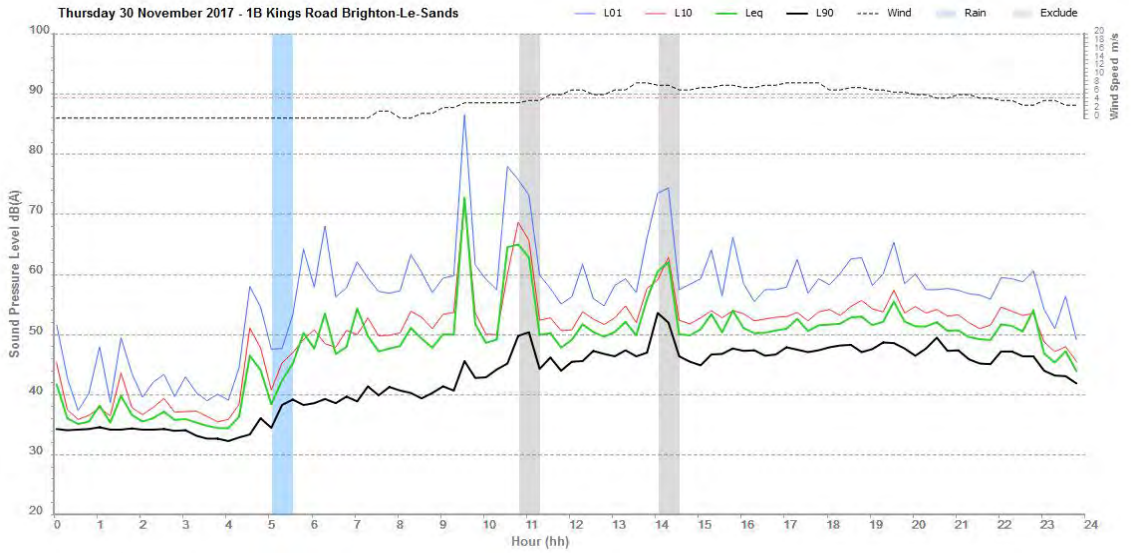
Logger Location Map



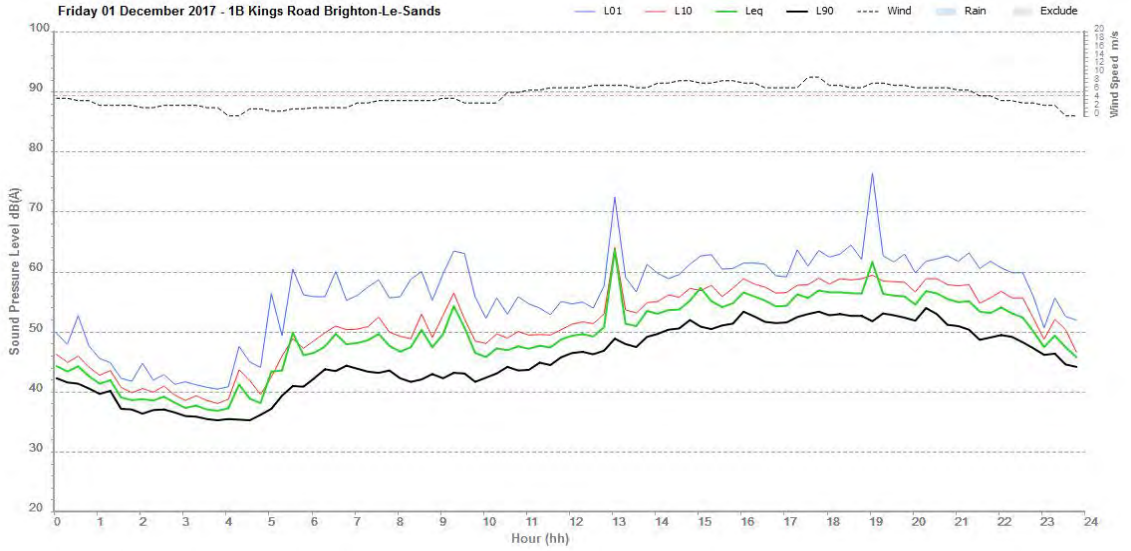
Logger Graphs

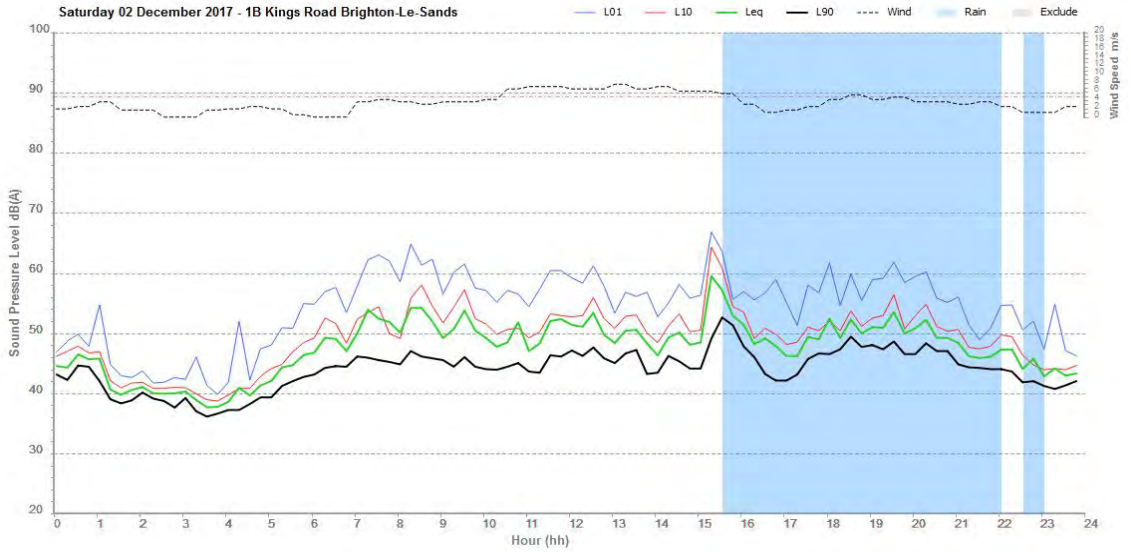


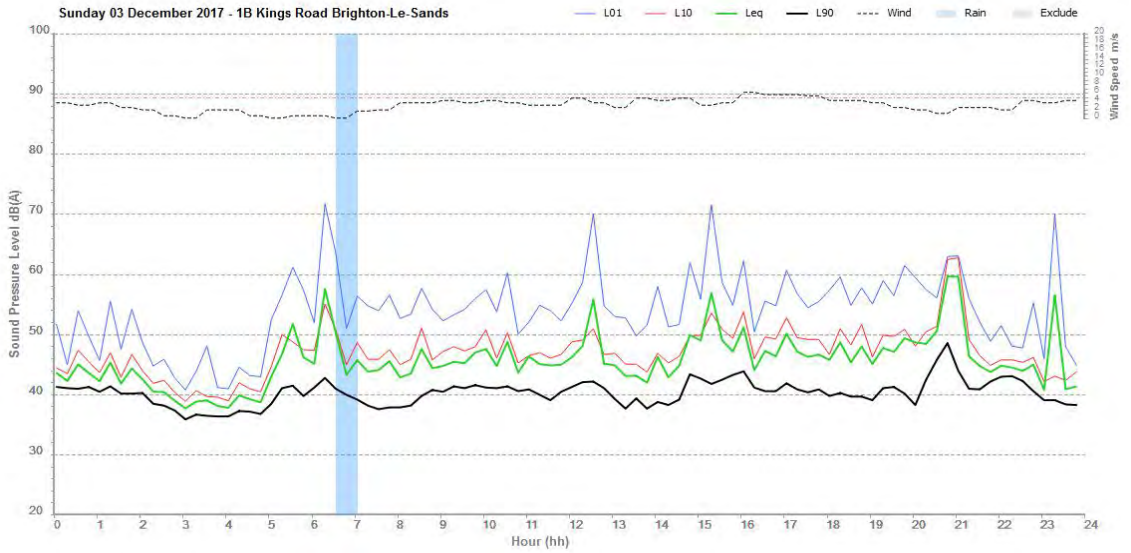




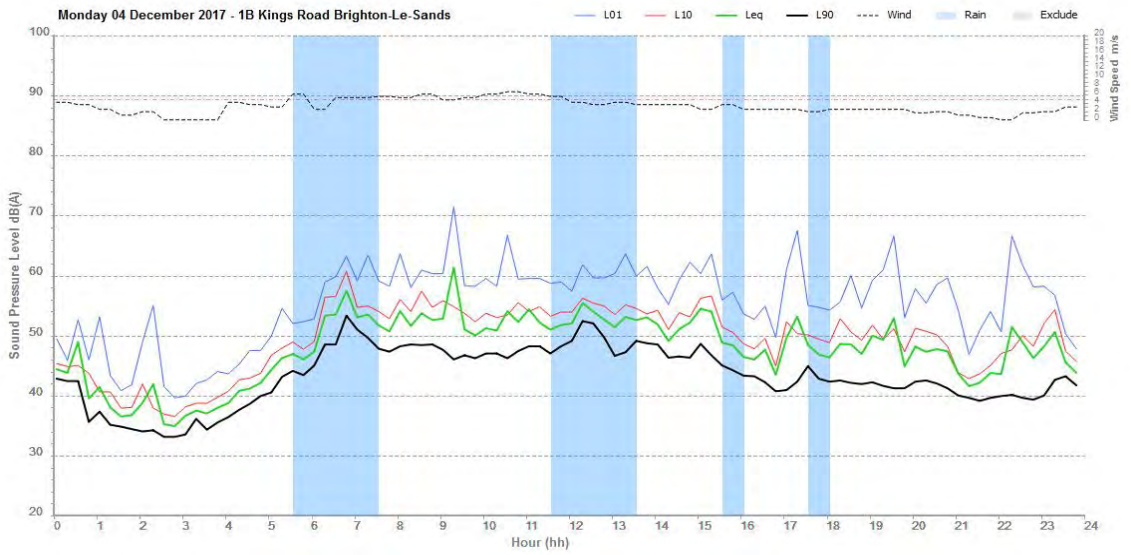
Logger Graphs

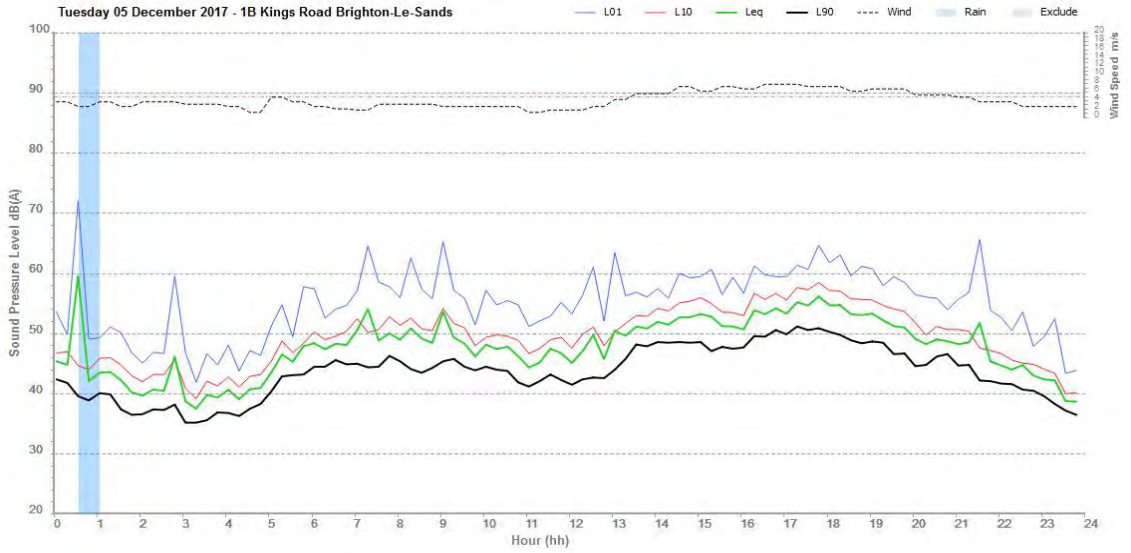




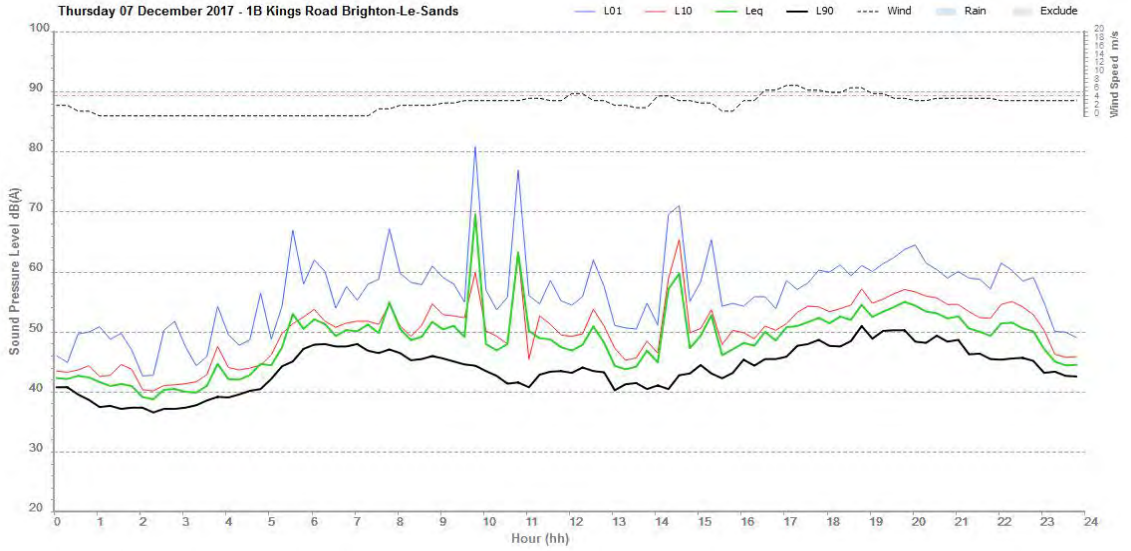


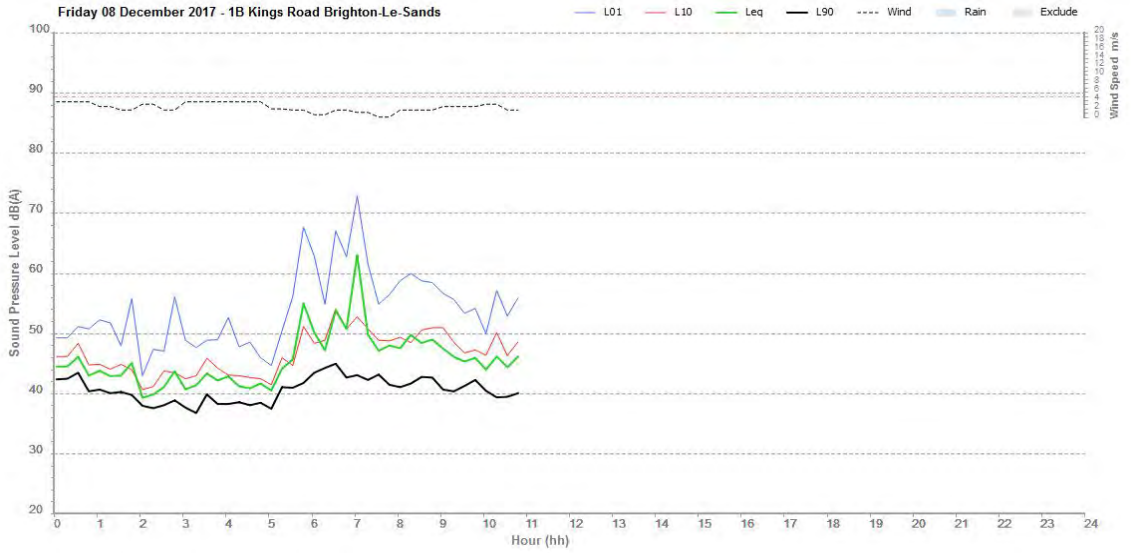
Logger Graphs





Logger Graphs





NL8 - Illinden Sports Centre - 11/12/17 - 18/12/17

Logger Setup

Logger Type: Rion NL-52

Serial No : 164395

Address: Illinden Sports Centre, Rockdale

Location: Side of road

Facade / Free Field: Free Field

Environment: Noise environment dominated by road traffic from West Botany Road, approximately 60dBA. Reversing sound from forklift can be heard approx 50m away in site compound. Moderate wind noise from nearby trees.

Logger Setup Photo

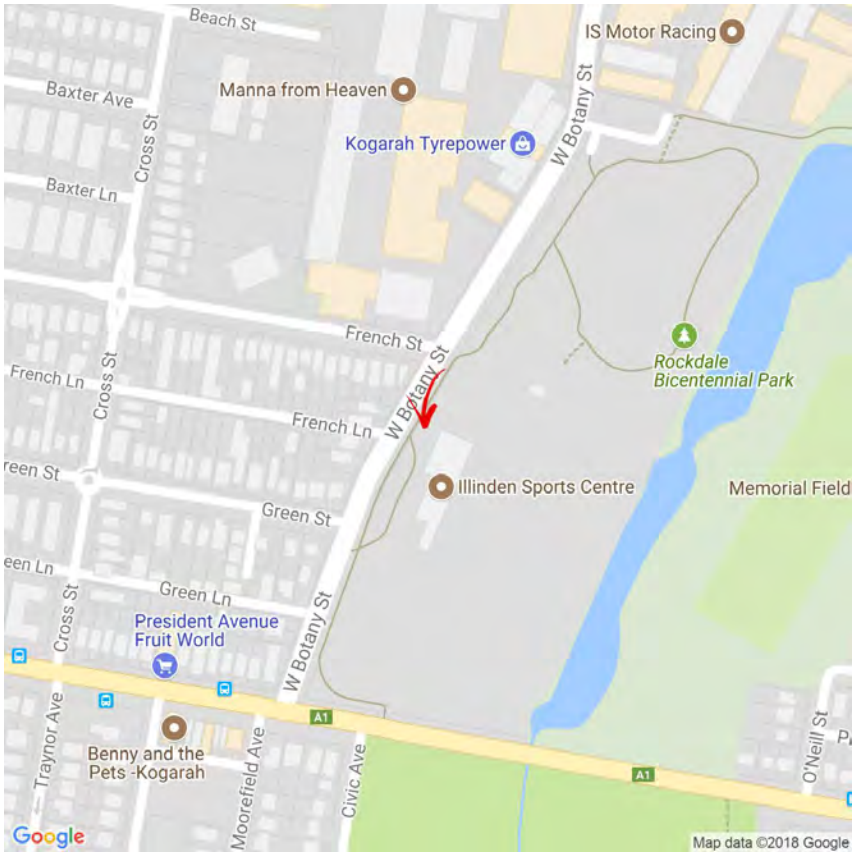
INP Noise Level, dB(A)

	Log Average	RBL
Day	64	53
Evening	62	47
Night	60	38

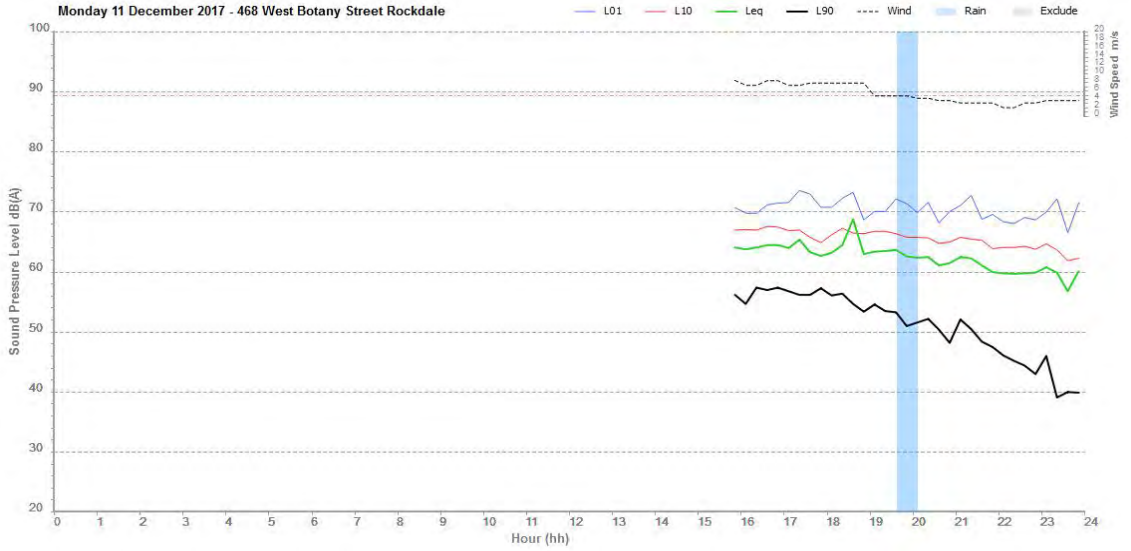
RNP Noise Level, dB(A)

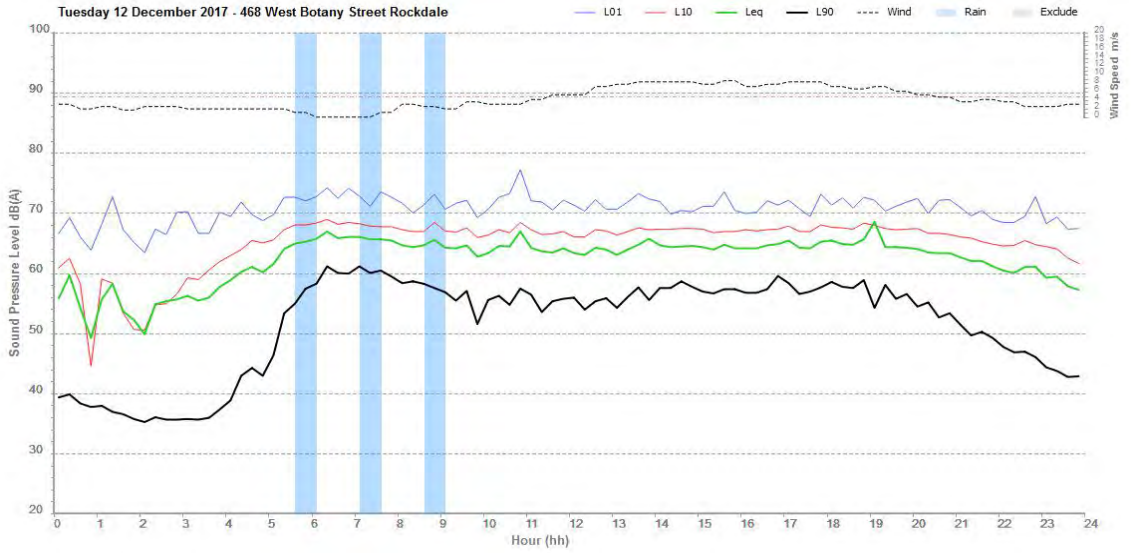
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

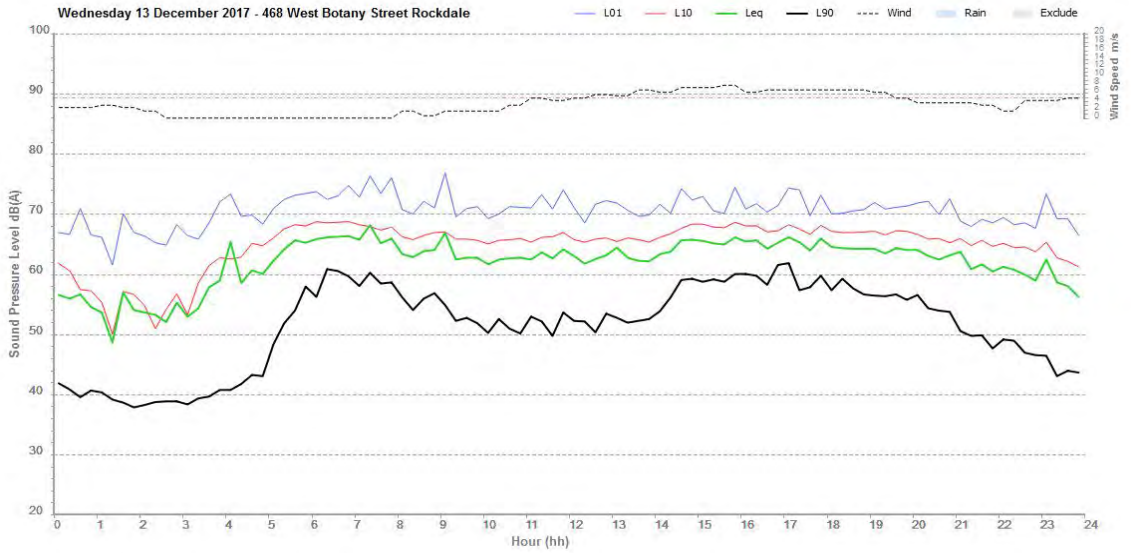
Logger Location Map



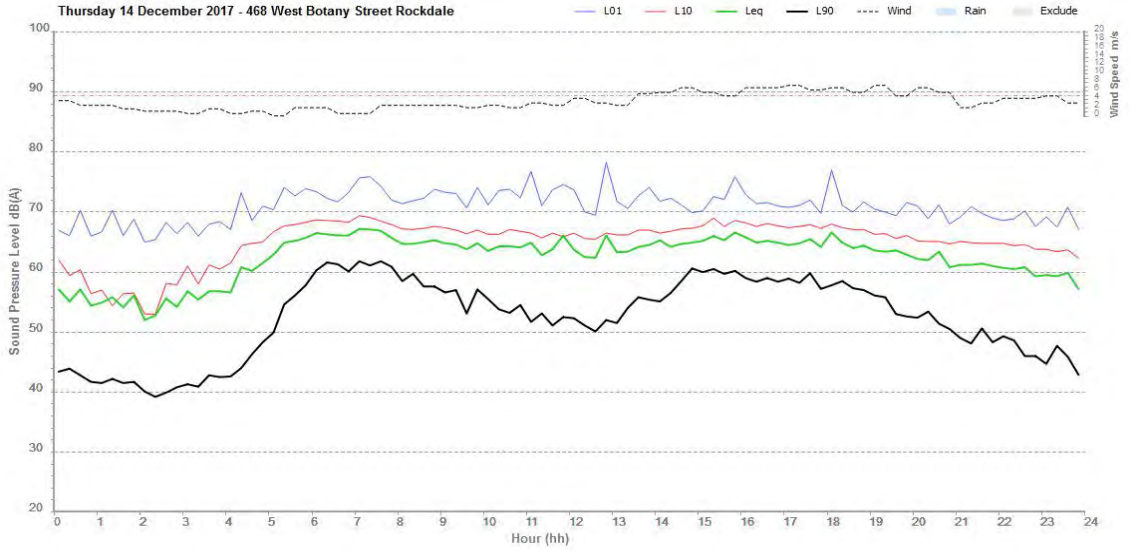
Logger Graphs

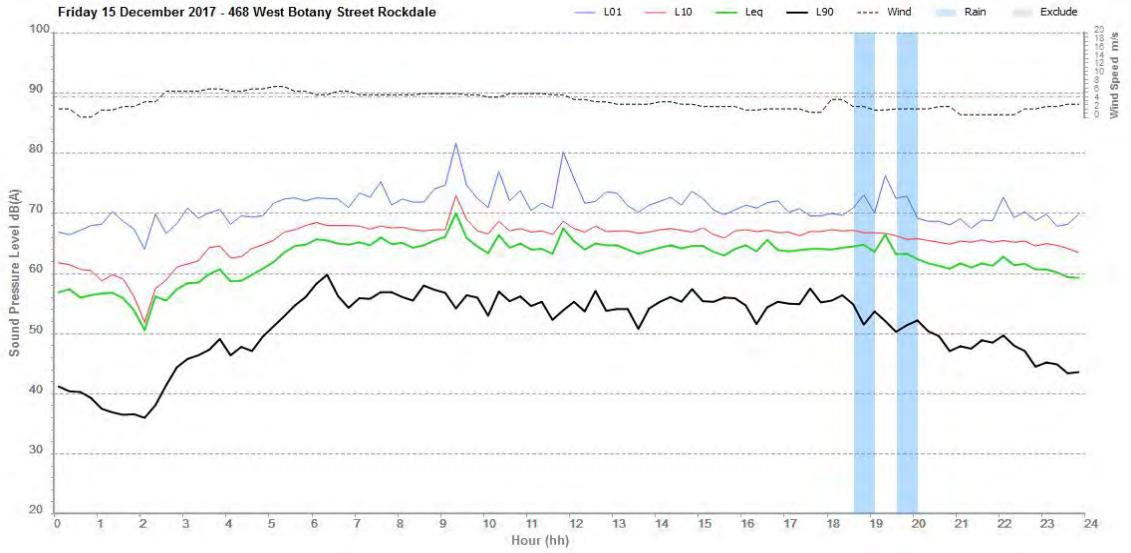


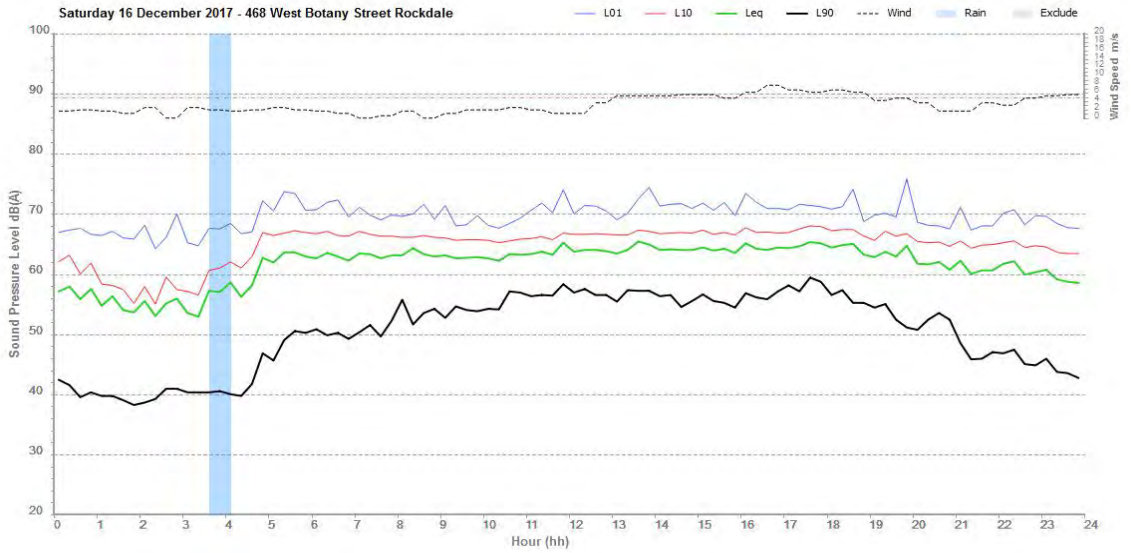




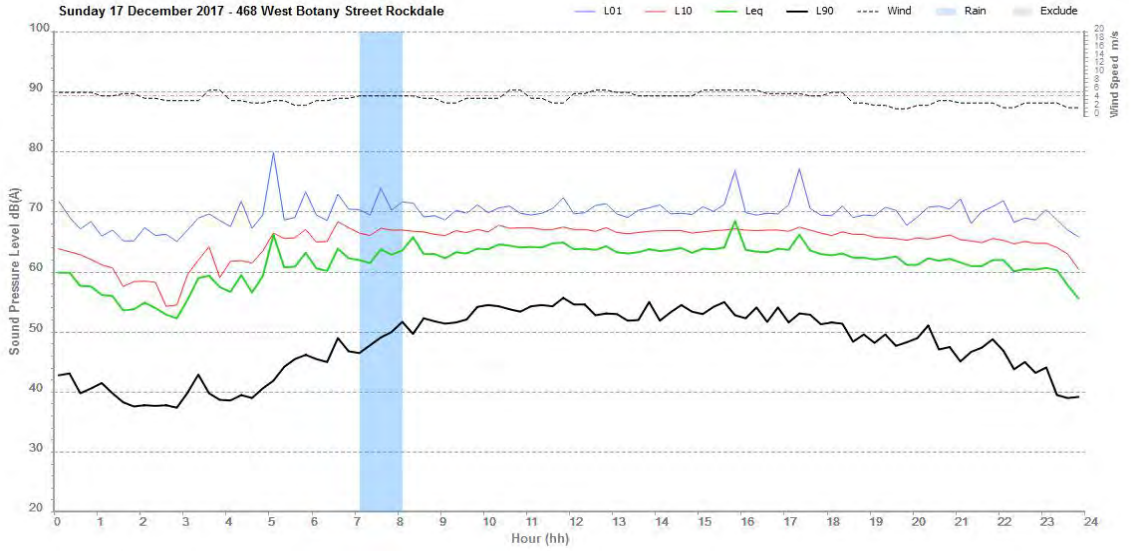
Logger Graphs

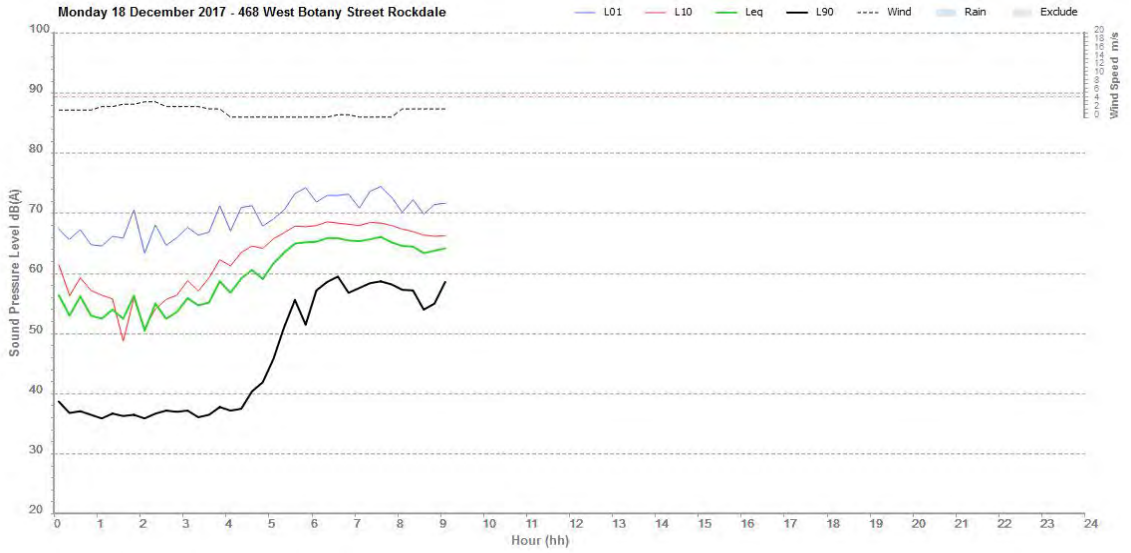






Logger Graphs





NL9 - 53 Crawford Road - 28/11/17 - 08/12/17

Logger Setup

Logger Type: Rion NL52

Serial No : 553966

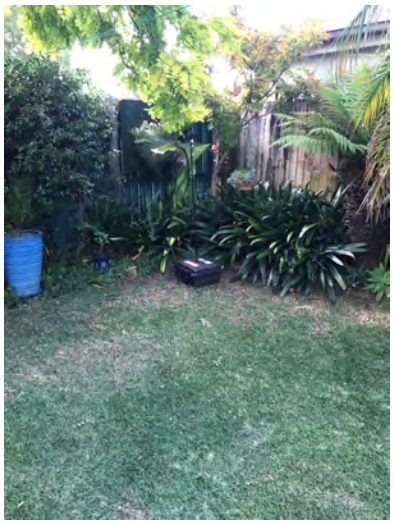
Address: 53 Crawford Road,
Brighton Le-Sands

Location: Back Yard

Facade / Free Field: Free Field

Environment: Distant road traffic noise can be heard in direction of Crawford street, just audible. Noise environment dominated by bird noise. Light wind noise in trees. Car can be heard on western side of fence possibly hitting speed bump/whistling brakes.

Logger Setup Photo



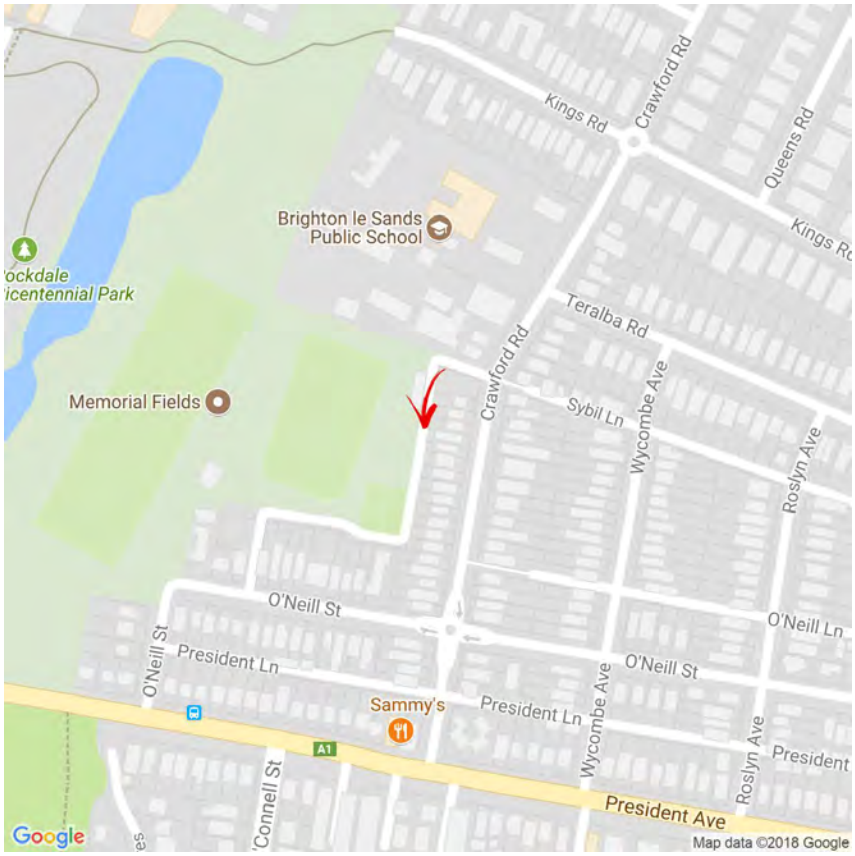
INP Noise Level, dB(A)

	Log Average	RBL
Day	52	38
Evening	51	38
Night	47	32

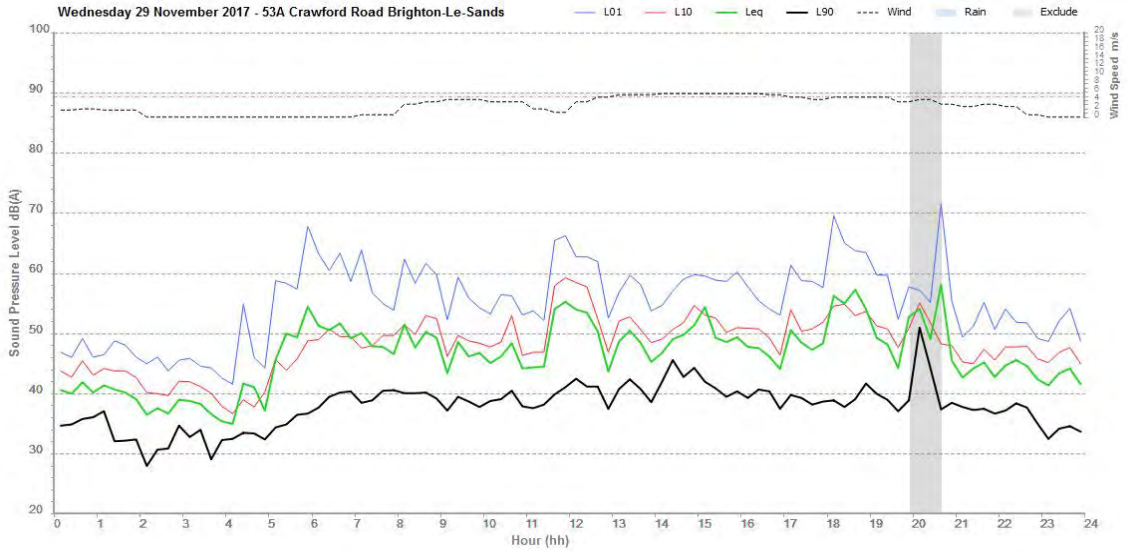
RNP Noise Level, dB(A)

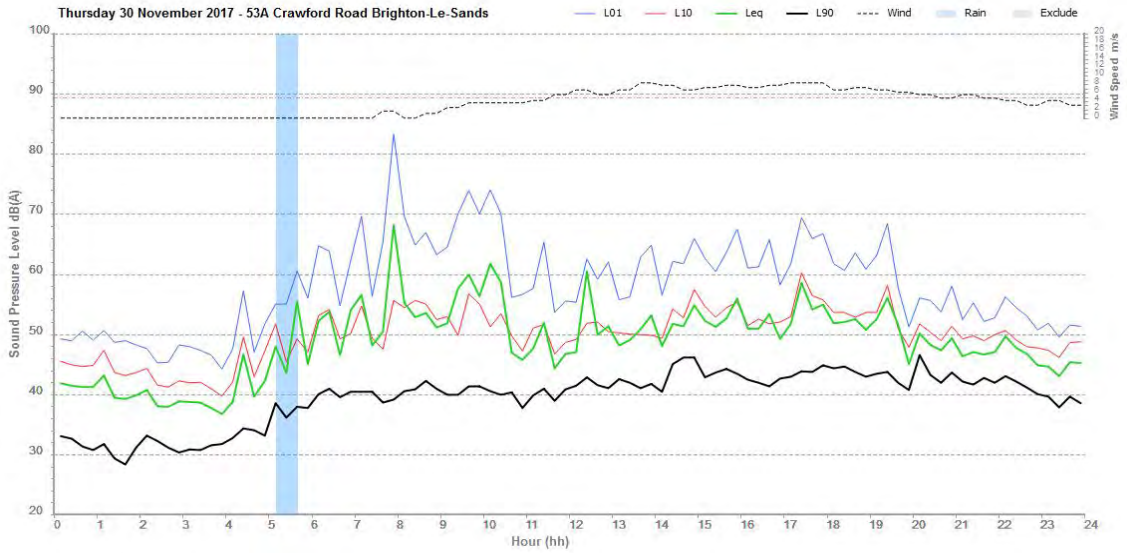
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

Logger Location Map

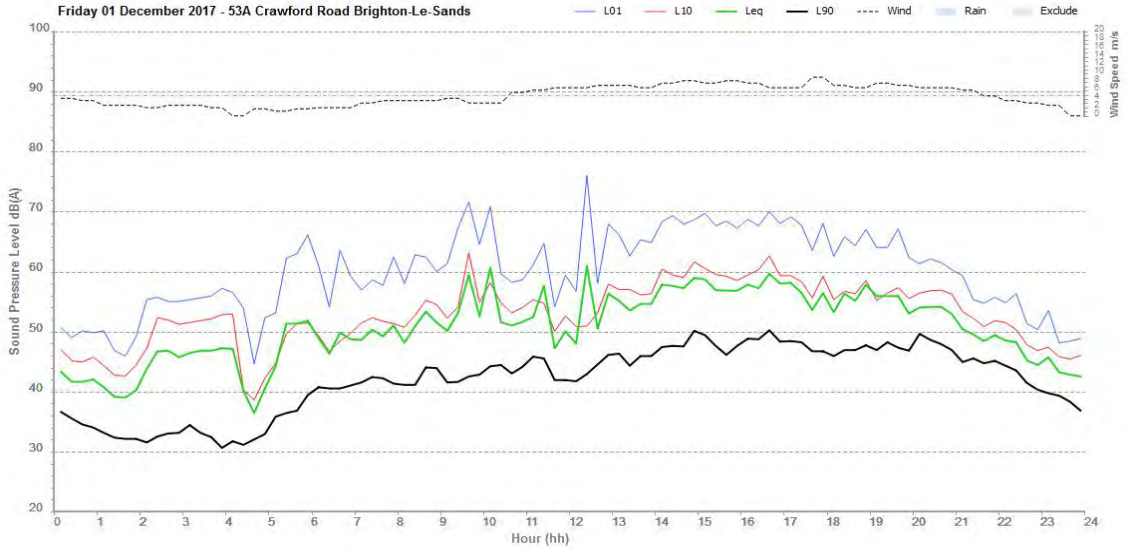


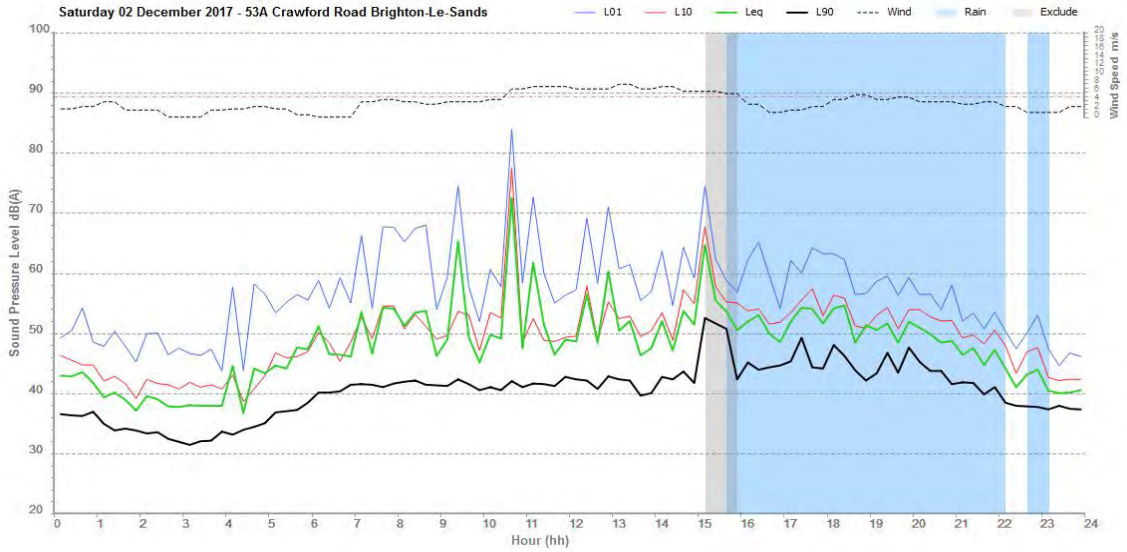
Logger Graphs

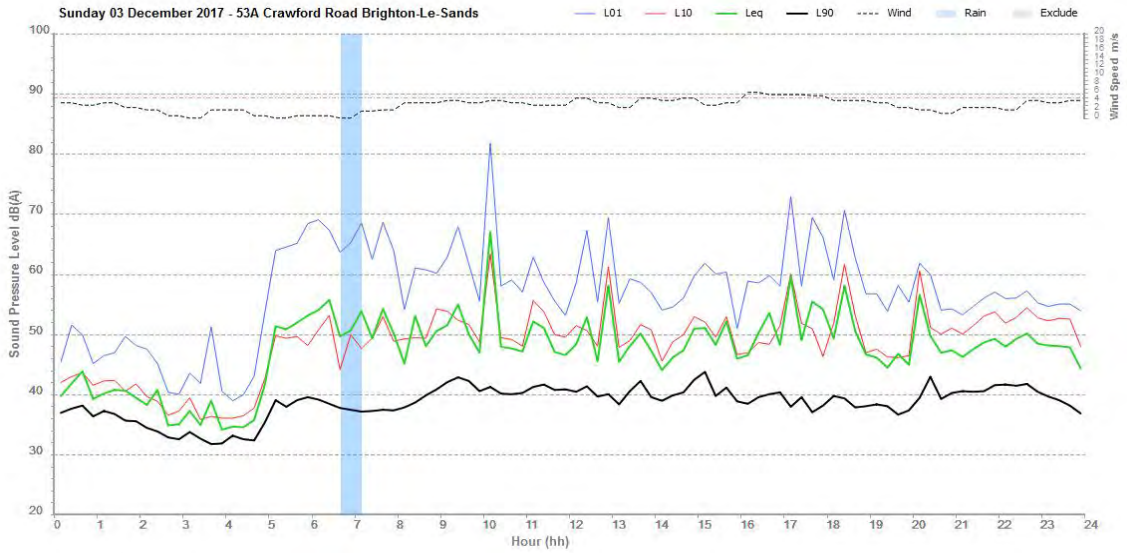




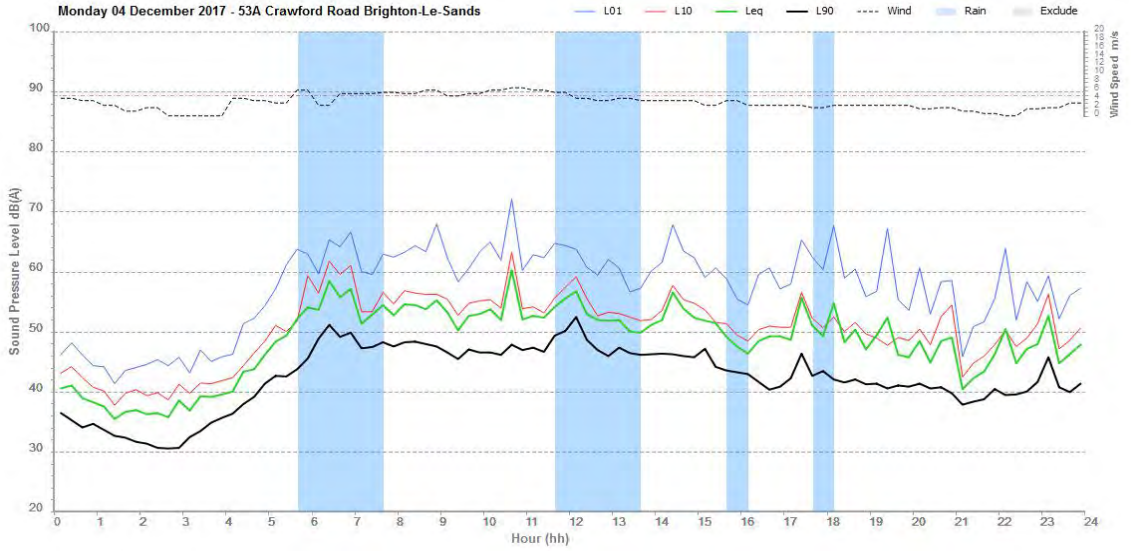
Logger Graphs

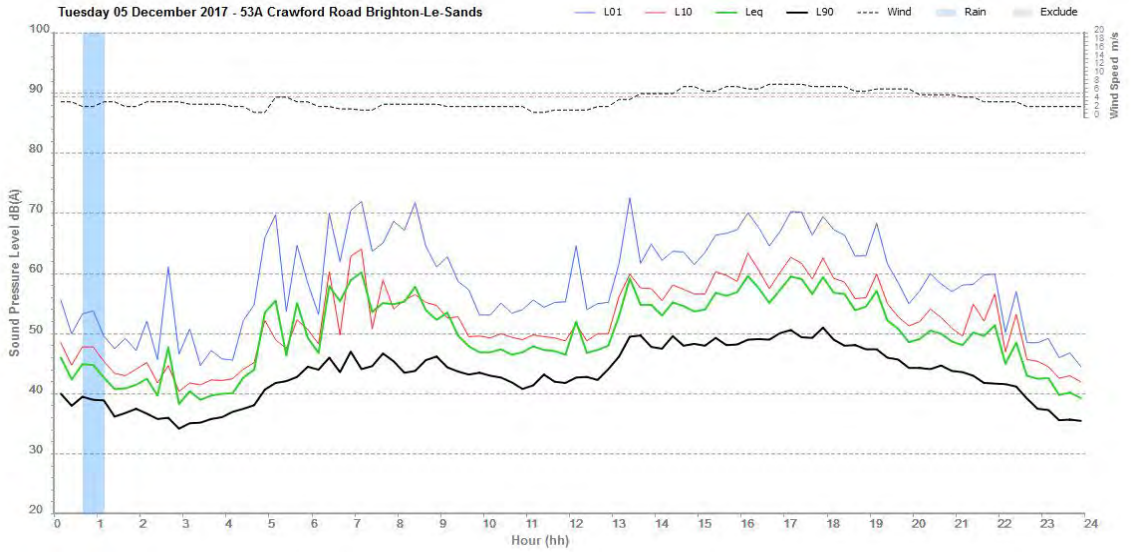


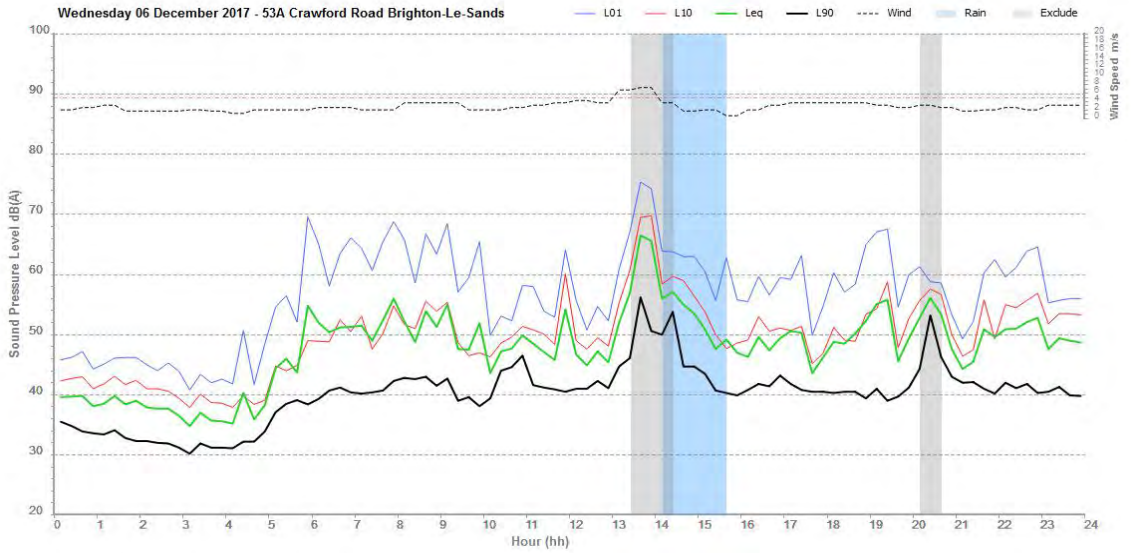




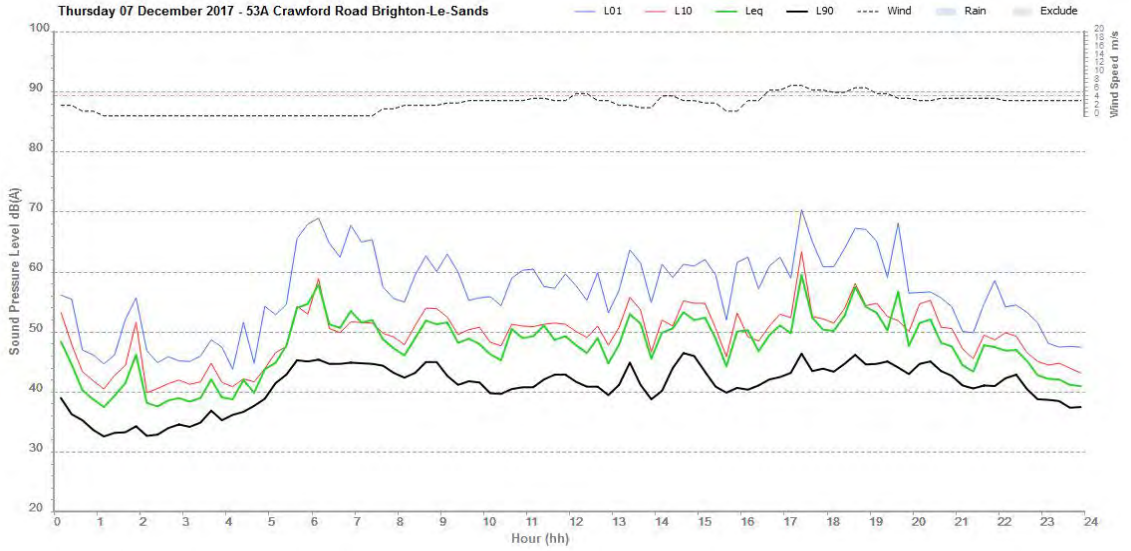
Logger Graphs

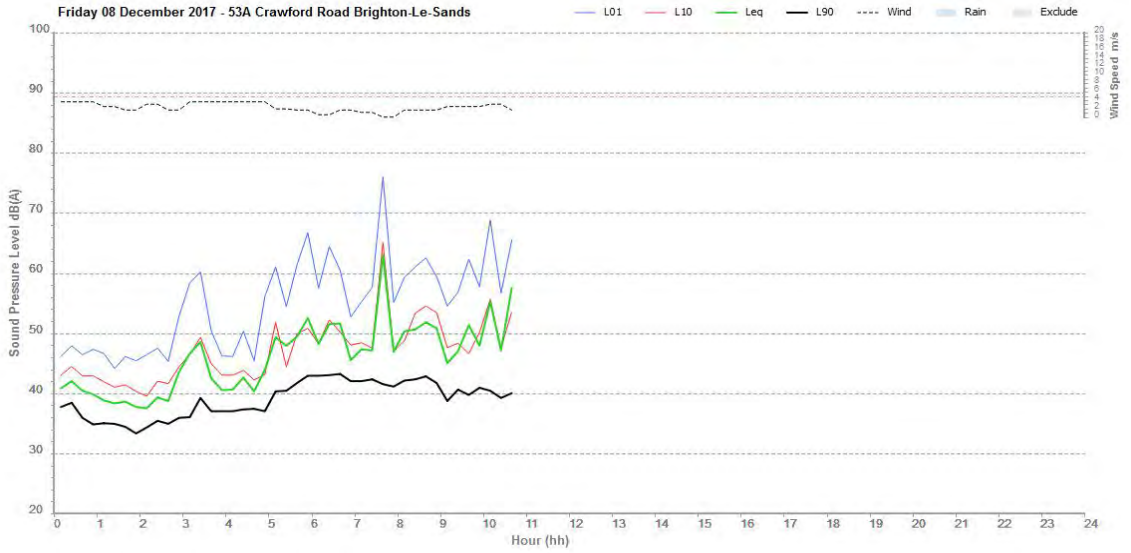






Logger Graphs





NL2 - 48 President Avenue - 28/11/17 - 08/12/17

Logger Setup

Logger Type: SVAN 957

Serial No : 23855

Address: 48 President Avenue, Kogarah

Location: Front Yard

Facade / Free Field: Free Field

Environment: Noise environment heavily dominated by road traffic from President Avenue. Light pedestrian traffic inaudible. Many heavy vehicles and buses.

Logger Setup Photo

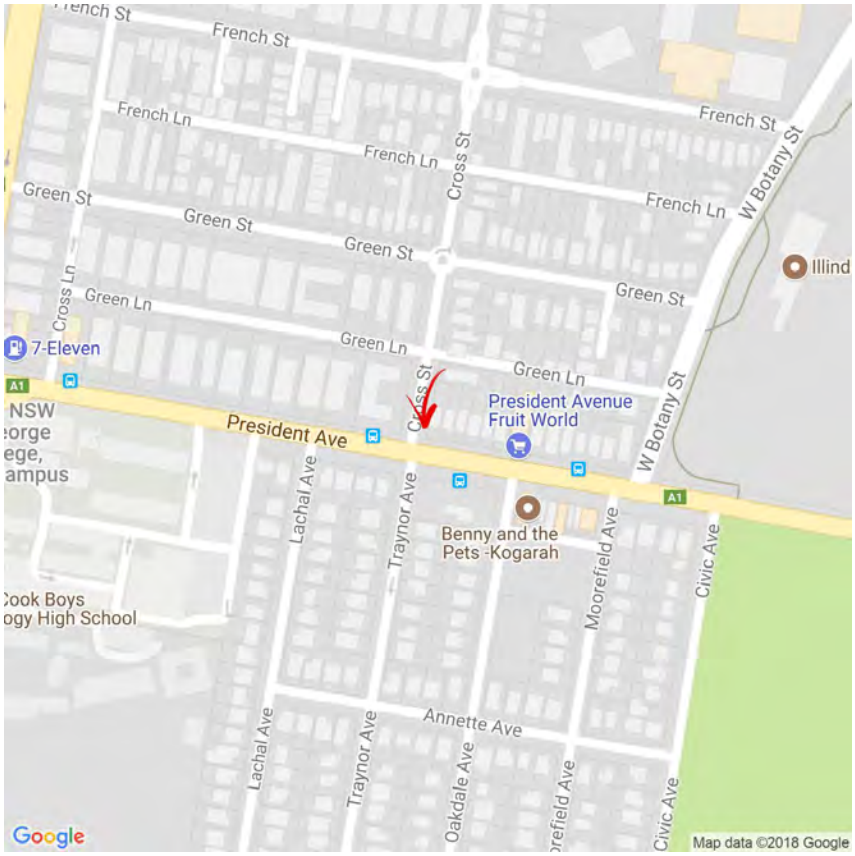
INP Noise Level, dB(A)

	Log Average	RBL
Day	65	52
Evening	65	52
Night	63	38

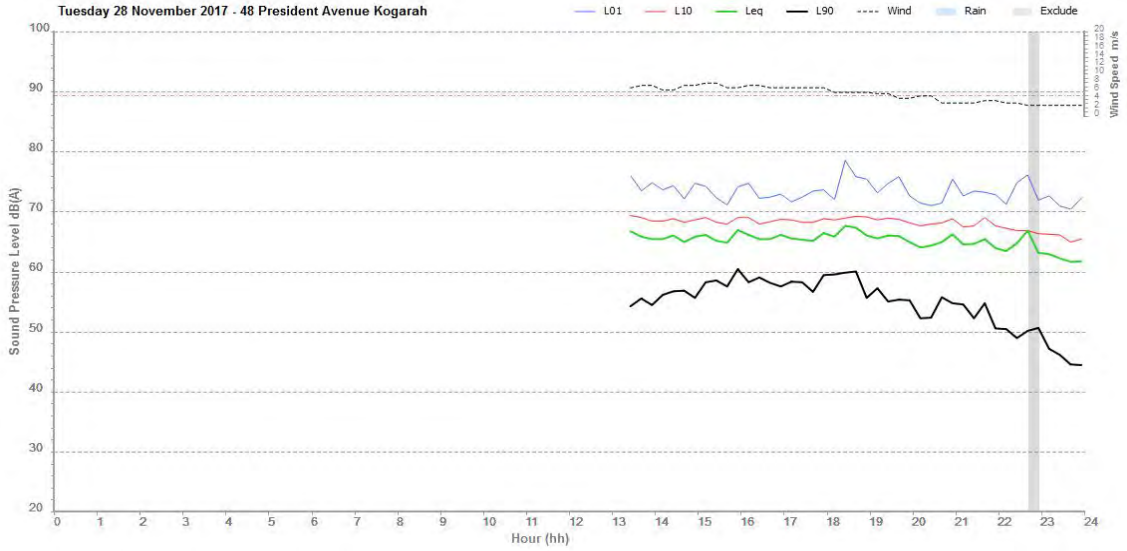
RNP Noise Level, dB(A)

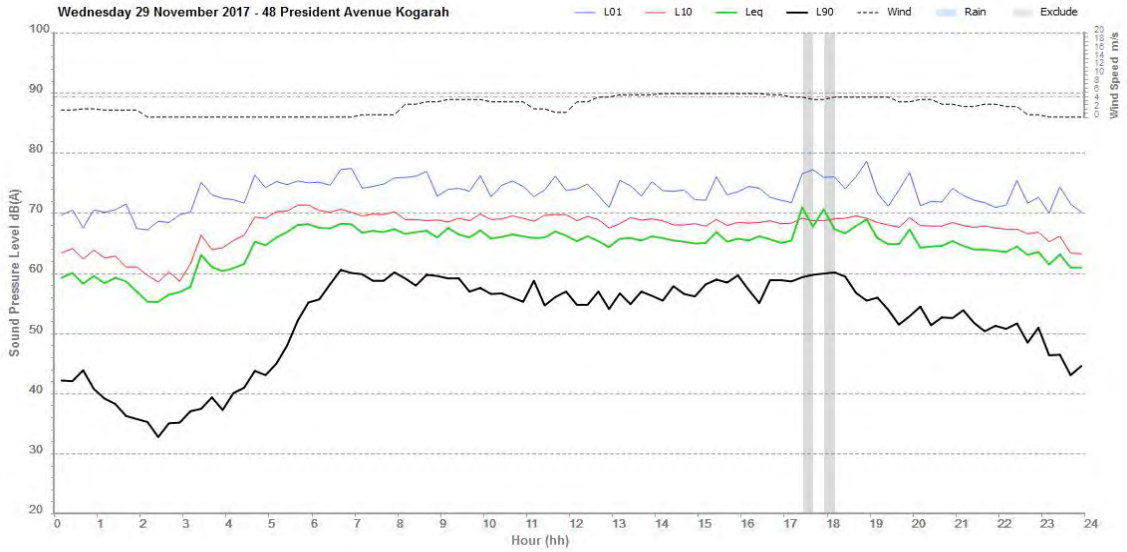
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	66.8	65.8
Night (10pm - 7am)	66.6	63.1

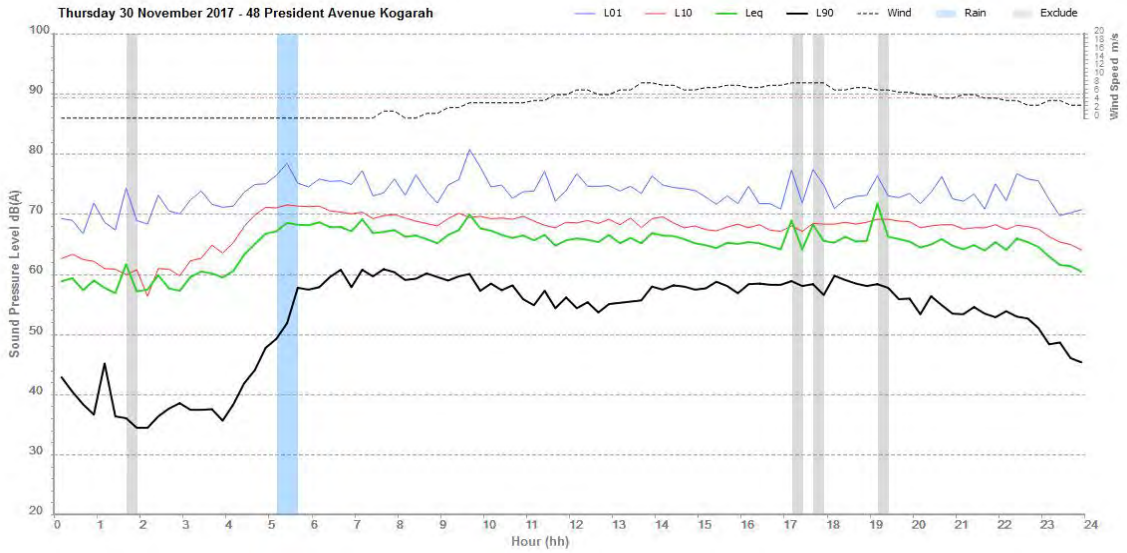
Logger Location Map



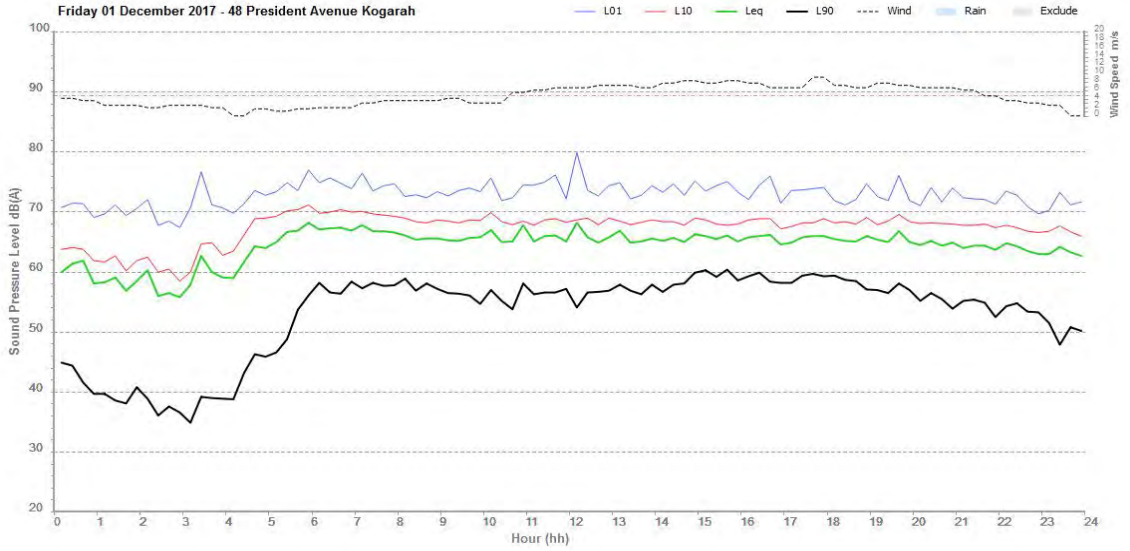
Logger Graphs

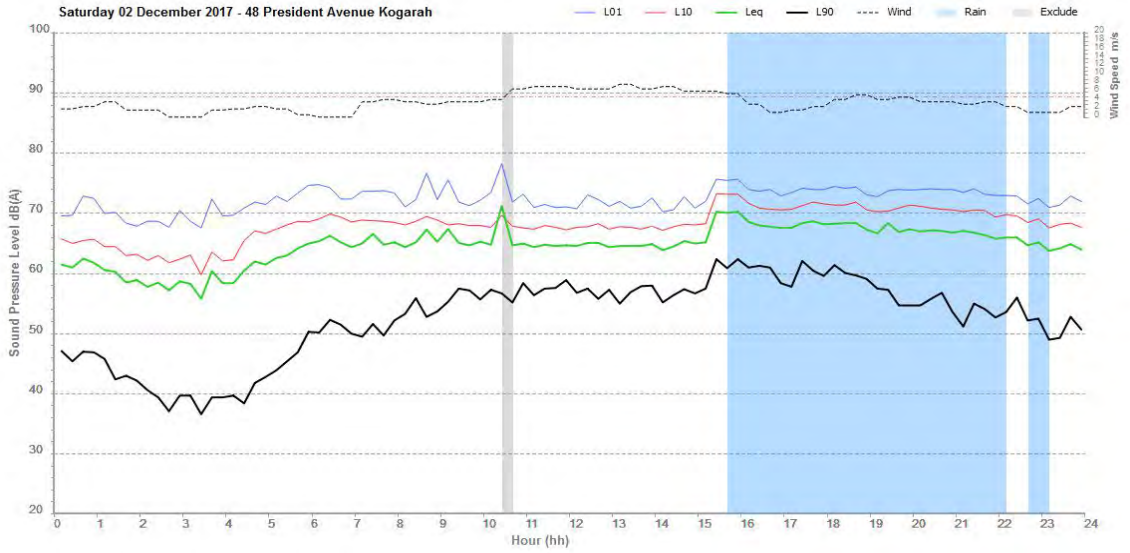


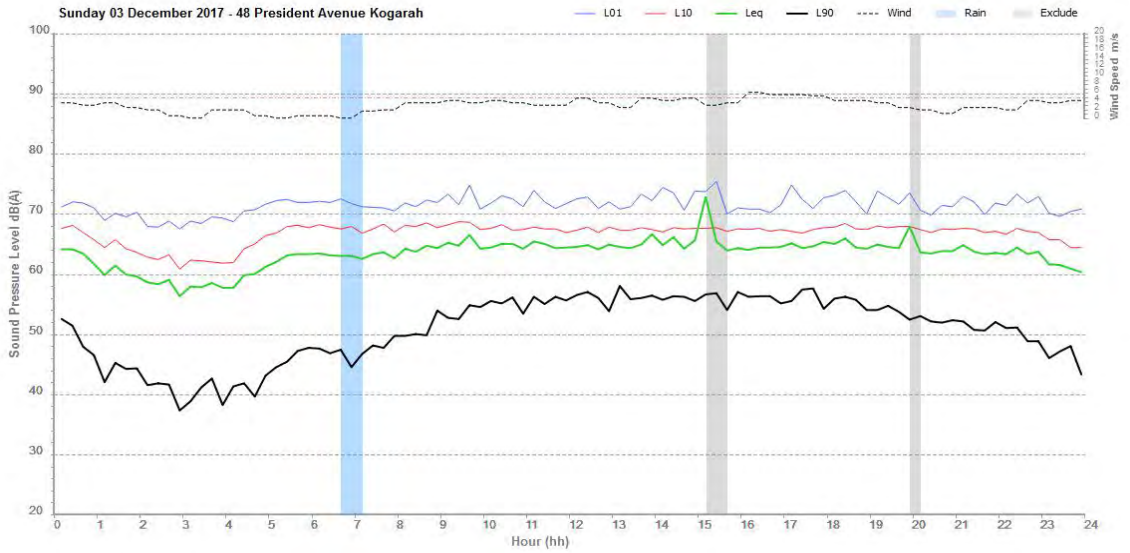




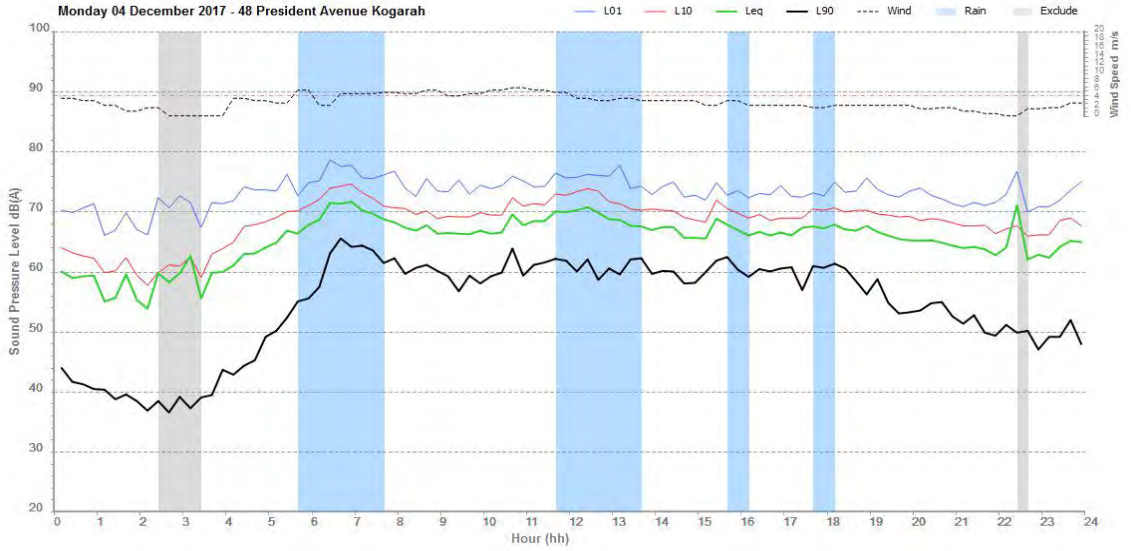
Logger Graphs

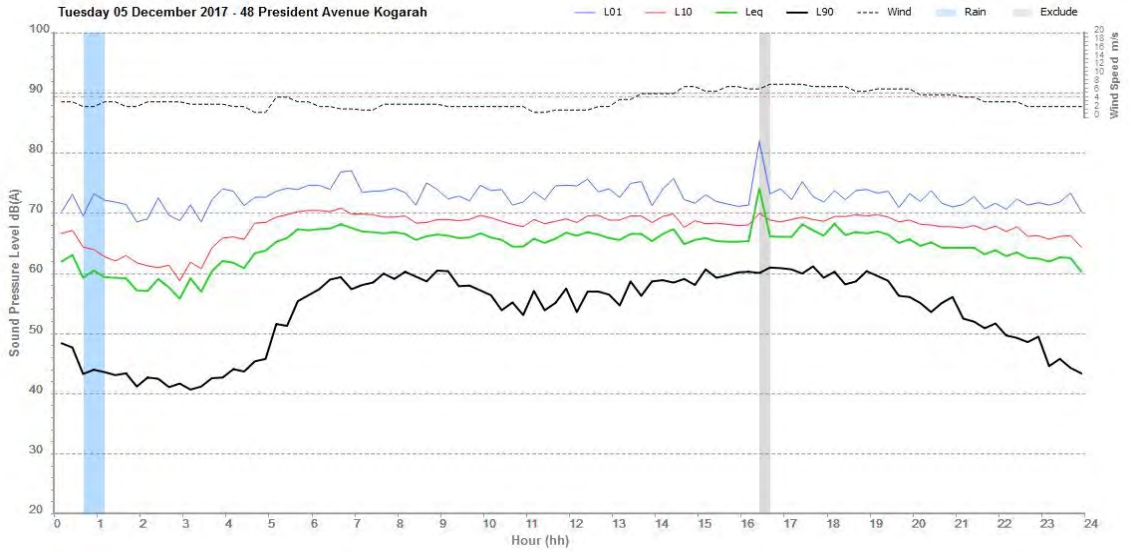


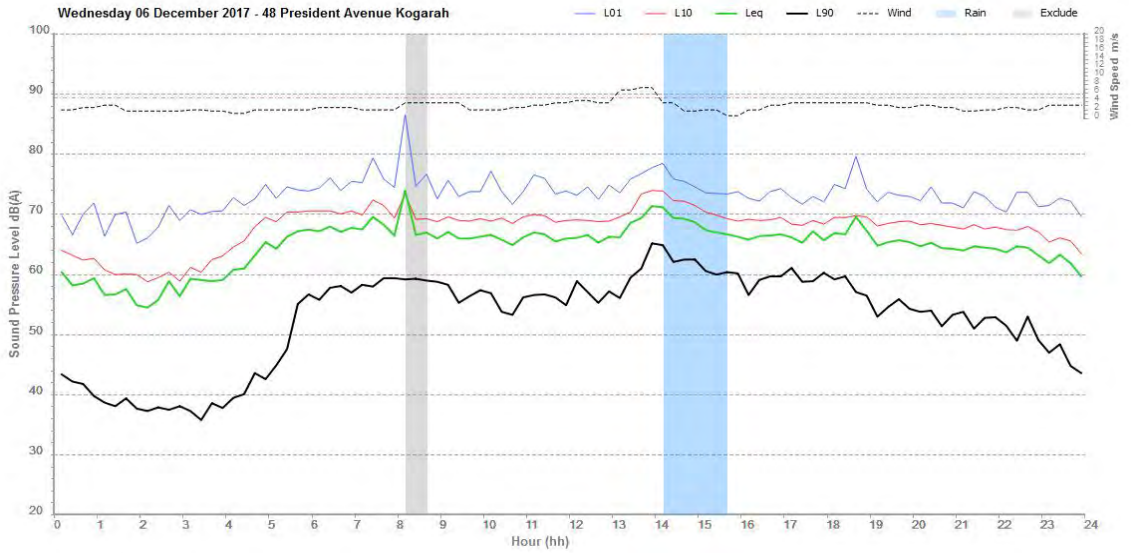




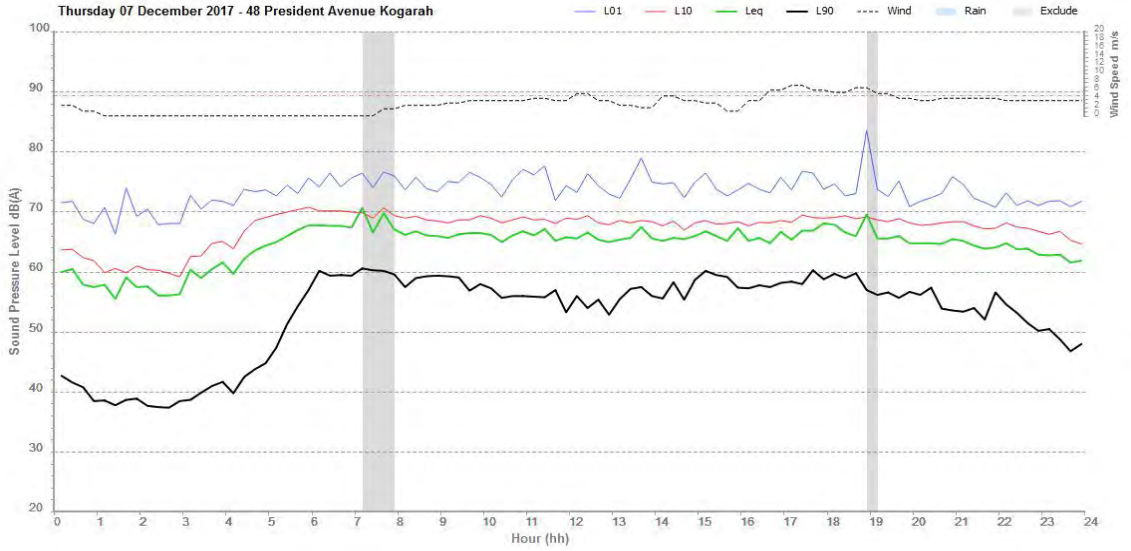
Logger Graphs

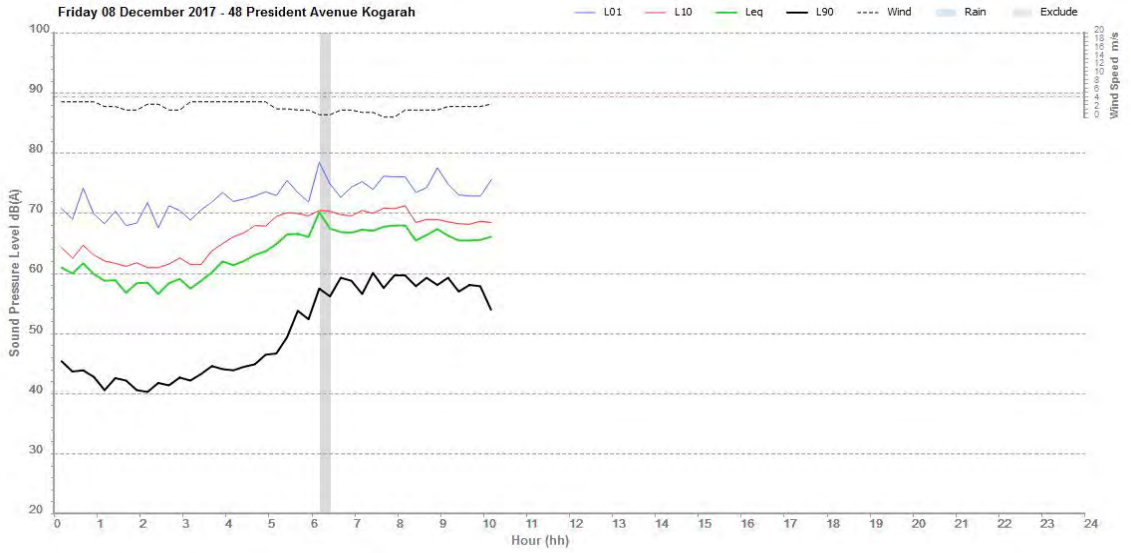






Logger Graphs





NL11 - 66 O'Neill Street - 28/11/17 - 07/12/17

Logger Setup

Logger Type: SVAN 957

Serial No : 27542

Address: 66 O'Neill Street , Brighton Le-Sands

Location: Front Yard

Facade / Free Field: Free Field

Environment: Distant traffic from President Avenue can be heard. Light vehicle traffic on O'Neill street. Aircraft noise can be heard.

Logger Setup Photo

INP Noise Level, dB(A)

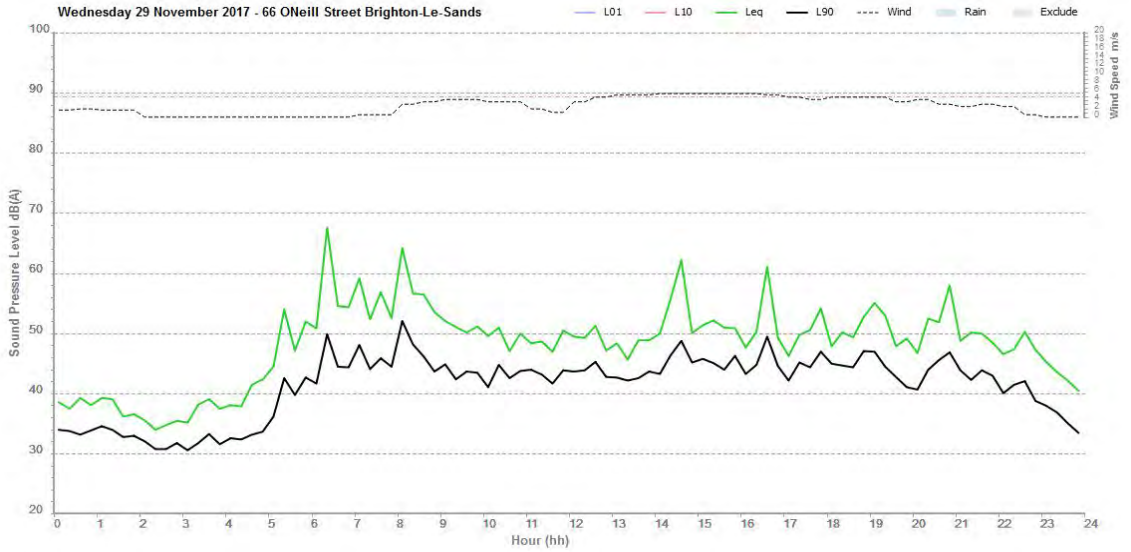
	Log Average	RBL
Day	53	42
Evening	51	41
Night	49	35

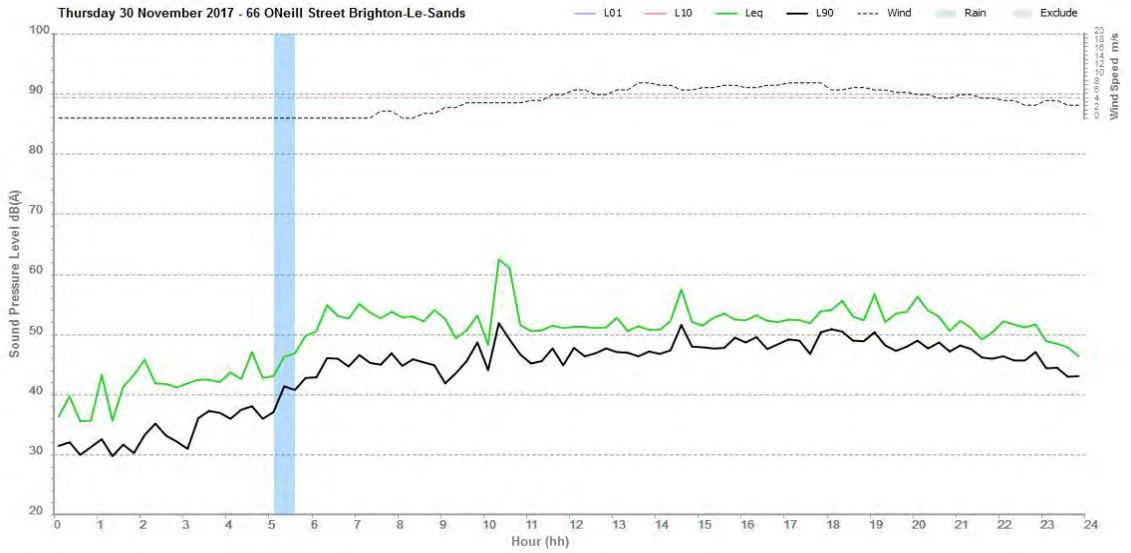
RNP Noise Level, dB(A)

	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

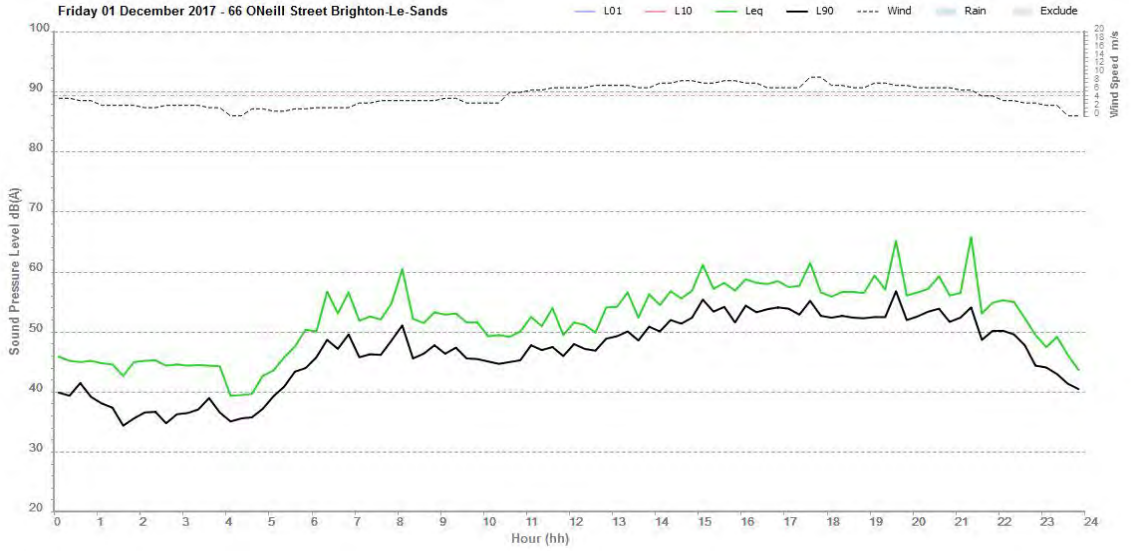
Logger Location Map

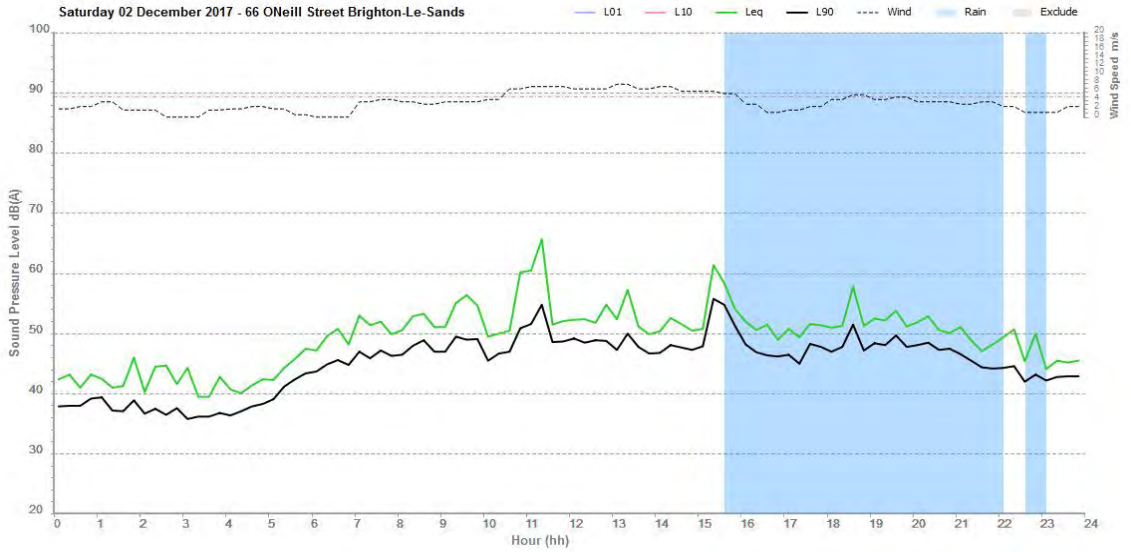
Logger Graphs

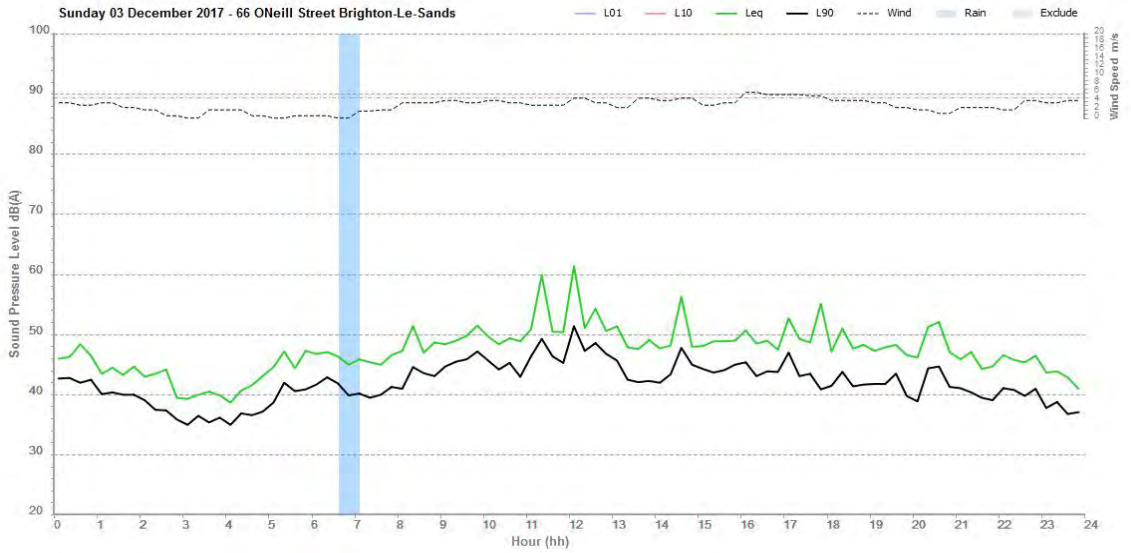




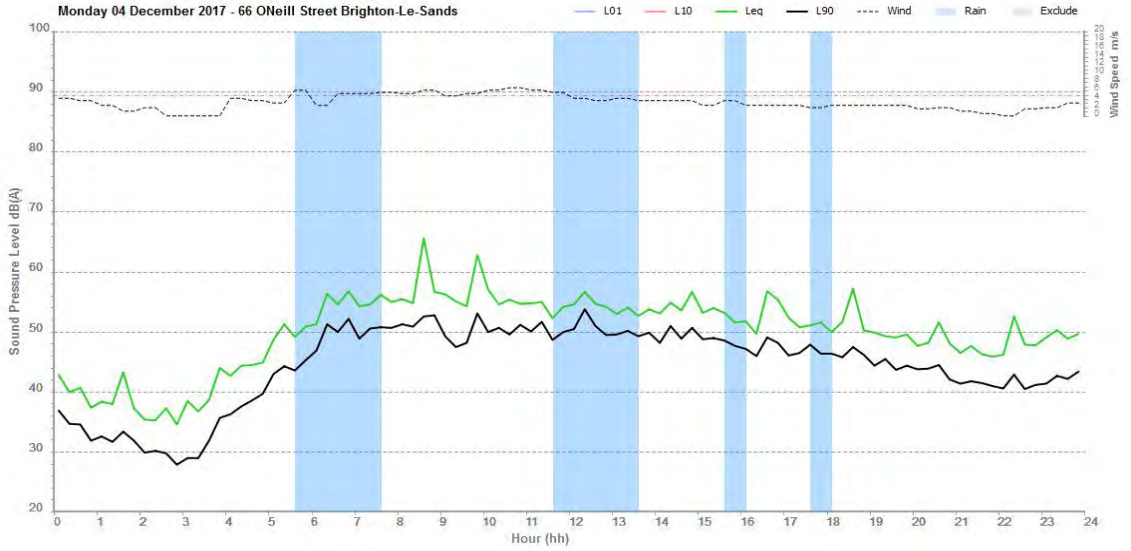
Logger Graphs

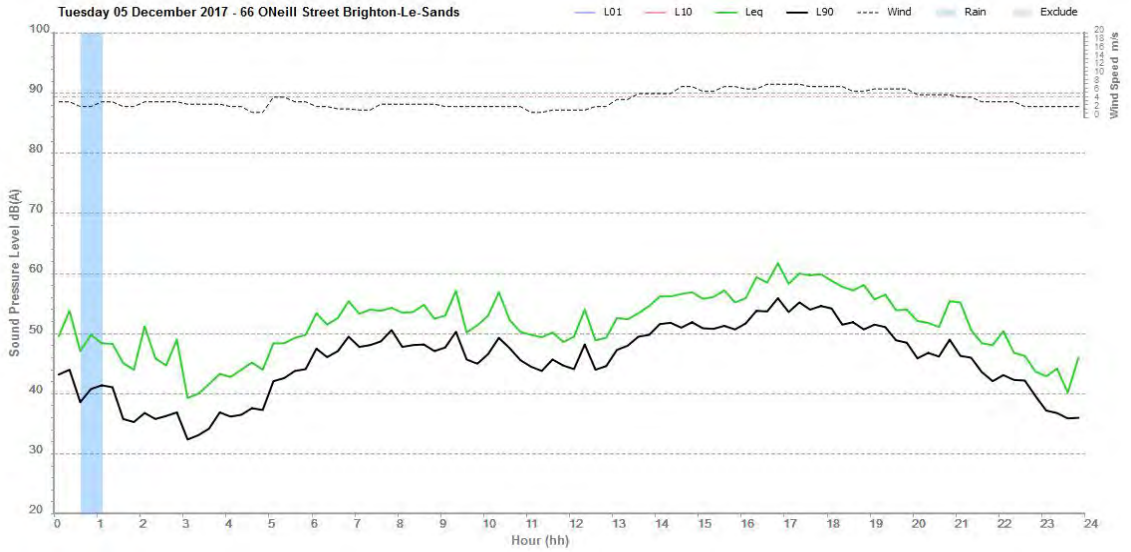




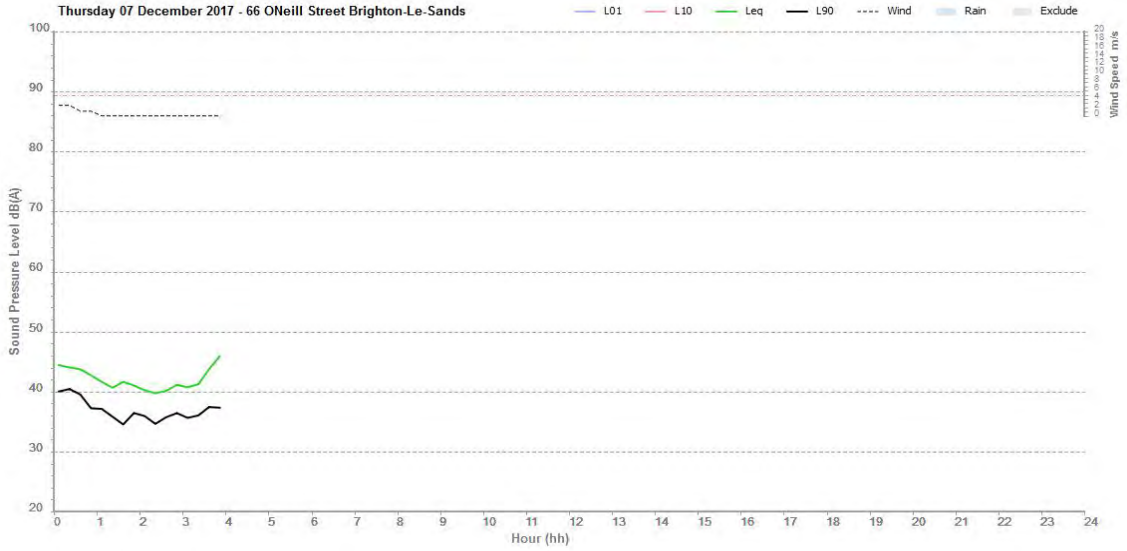


Logger Graphs





Logger Graphs



NL12 - 23 President Avenue - 28/11/17 - 29/11/17

Logger Setup

Logger Type: Rion NL21

Serial No : 765701

Address: 23 President Avenue, Kogarah

Location: Front Yard

Facade / Free Field: Free Field

Environment: Noise environment dominated heavily by road traffic noise from President Avenue. Traffic comes in waves with high number of heavy vehicles and buses. Light wind noise and some bird noise can also be audible when no traffic present.

Logger Setup Photo

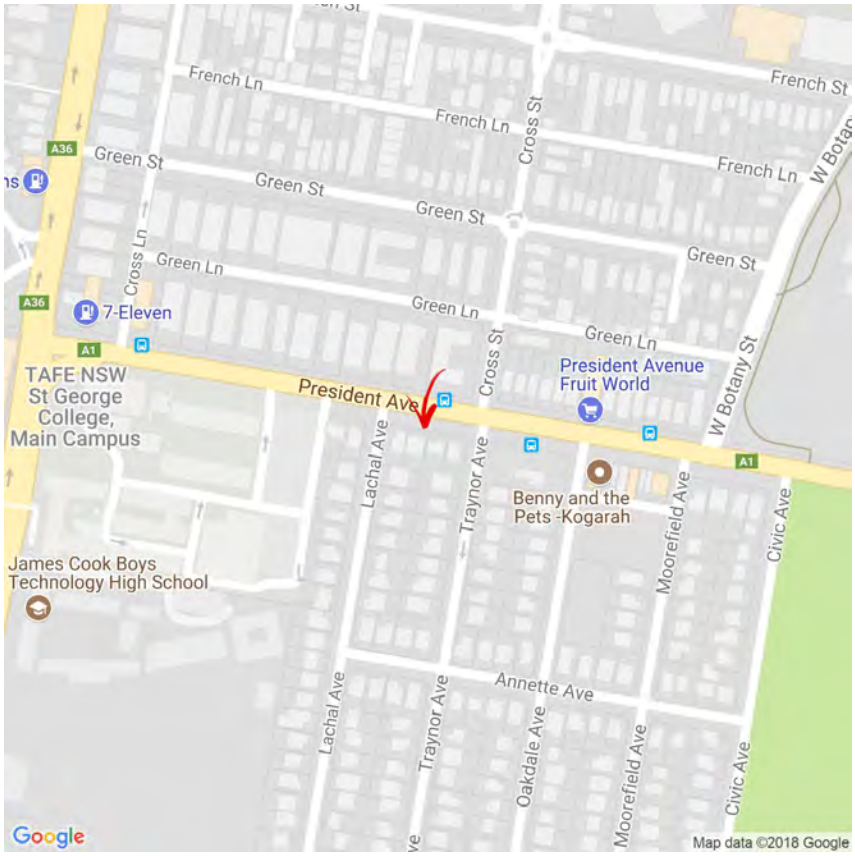
INP Noise Level, dB(A)

	Log Average	RBL
Day	-	-
Evening	-	-
Night	-	-

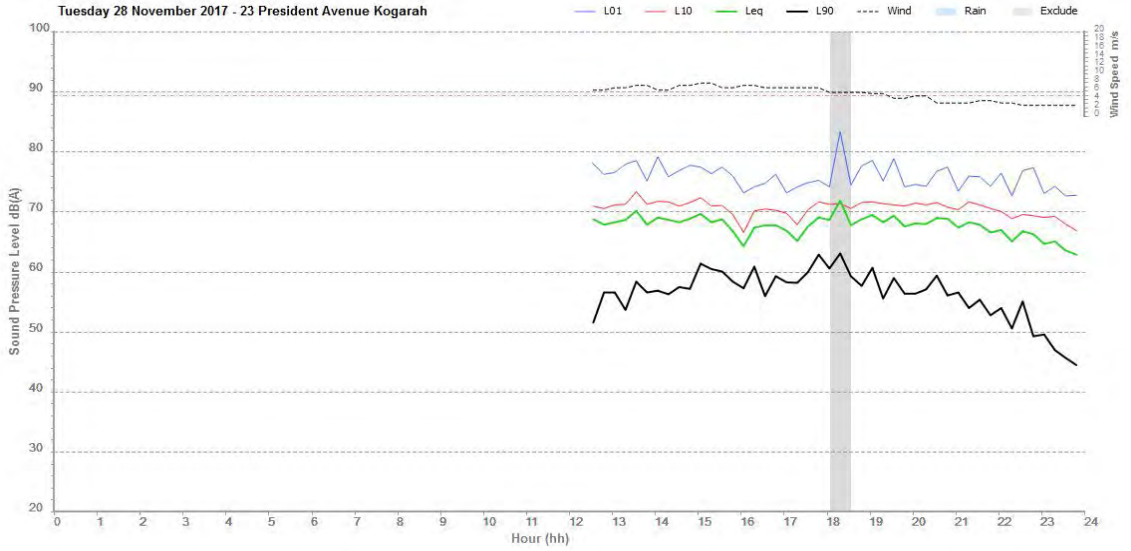
RNP Noise Level, dB(A)

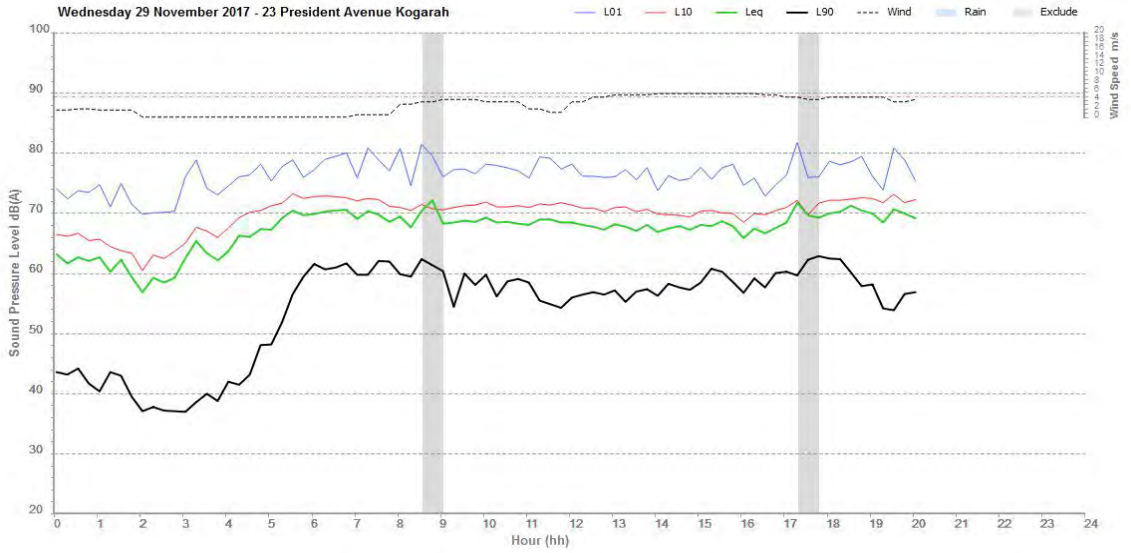
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	69.1	68.4
Night (10pm - 7am)	70.0	66.1

Logger Location Map



Logger Graphs





NL13 - 63 President Avenue - 11/12/17 - 18/12/17

Logger Setup

Logger Type: Rion NL21

Serial No : 00265112

Address: 63 President Avenue, Kogarah

Location: Front Yard

Facade / Free Field: Free Field

Environment: Road traffic noise from President Ave dominant. Light vehicle traffic from Civic Ave as vehicles accelerate from President Ave. Some bird noise audible. Television from inside residence also audible through open window.

Logger Setup Photo

INP Noise Level, dB(A)

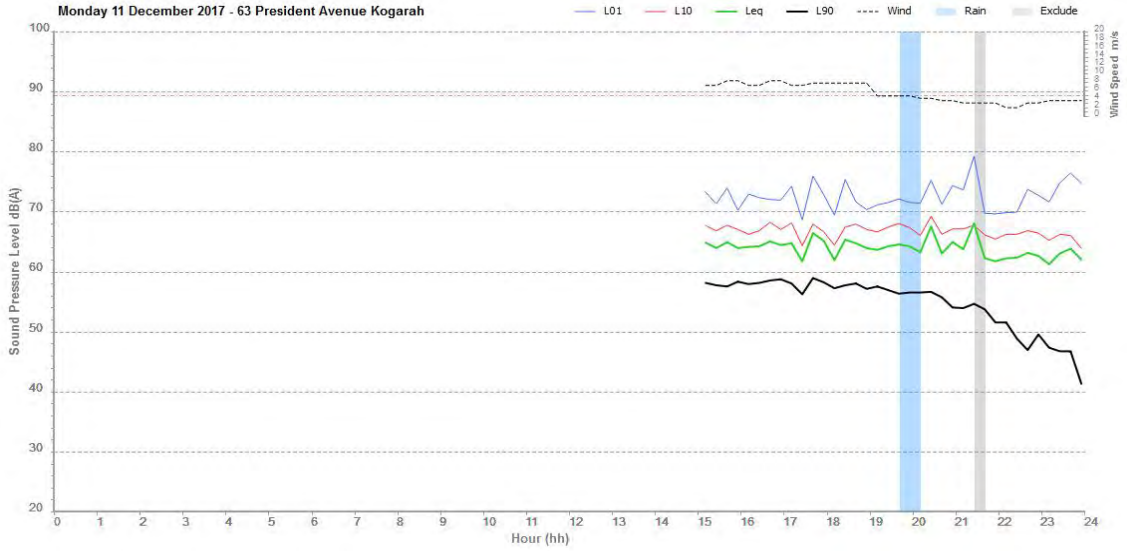
	Log Average	RBL
Day	65	56
Evening	63	53
Night	62	39

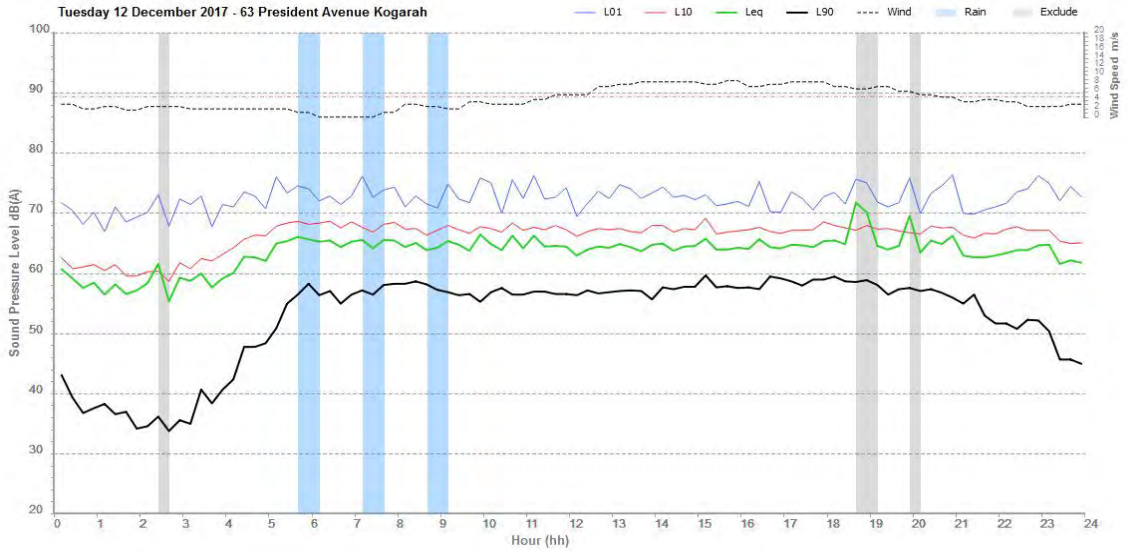
RNP Noise Level, dB(A)

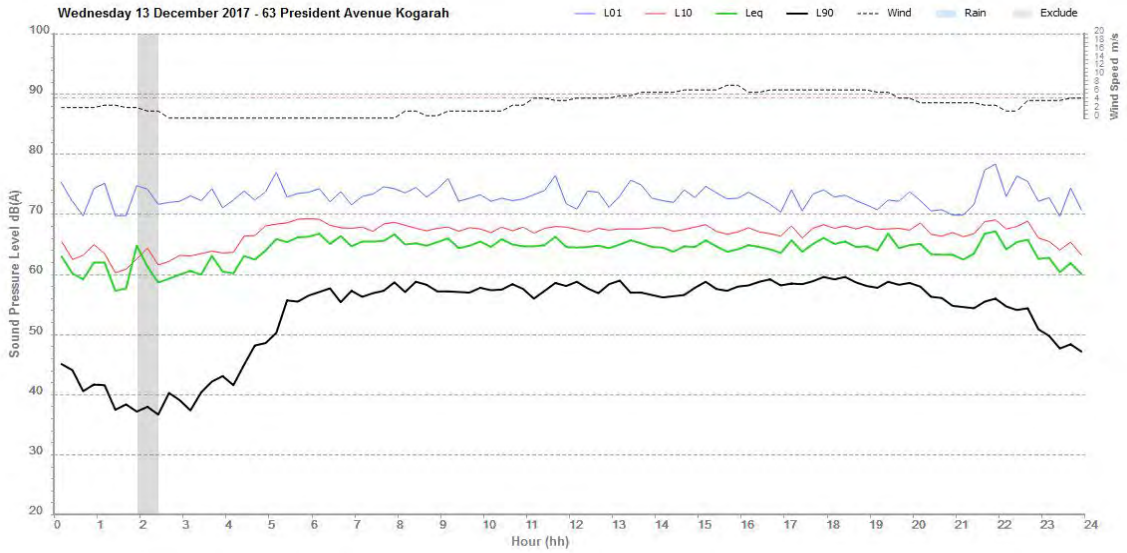
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	65.2	64.3
Night (10pm - 7am)	65.1	62.6

Logger Location Map

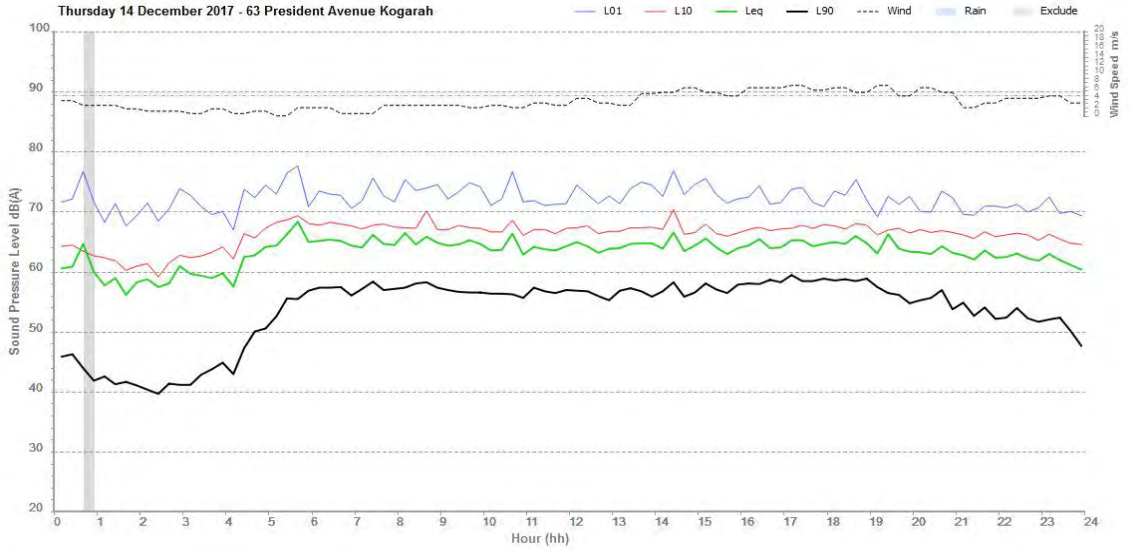
Logger Graphs

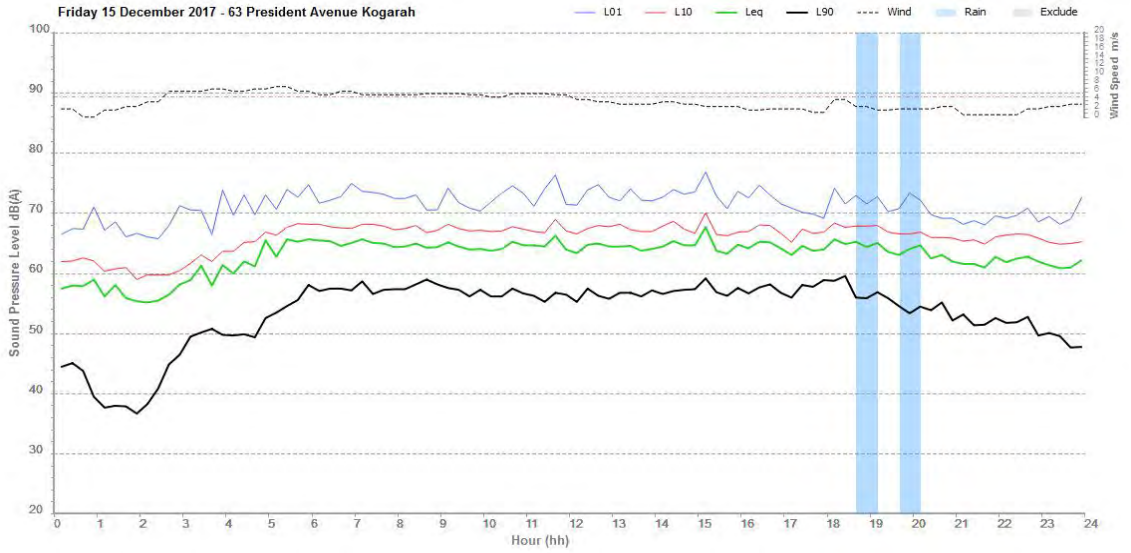


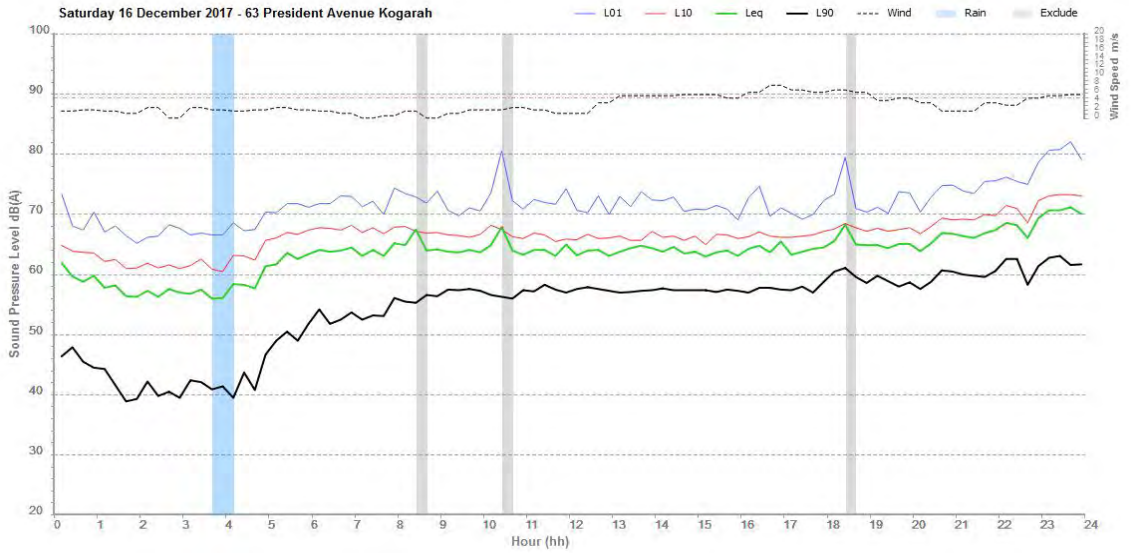




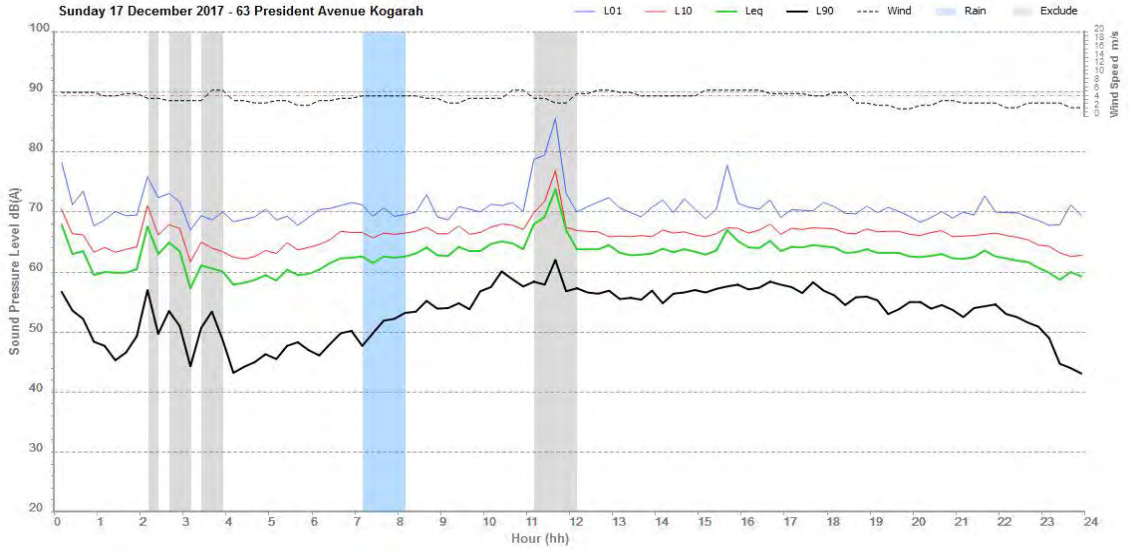
Logger Graphs

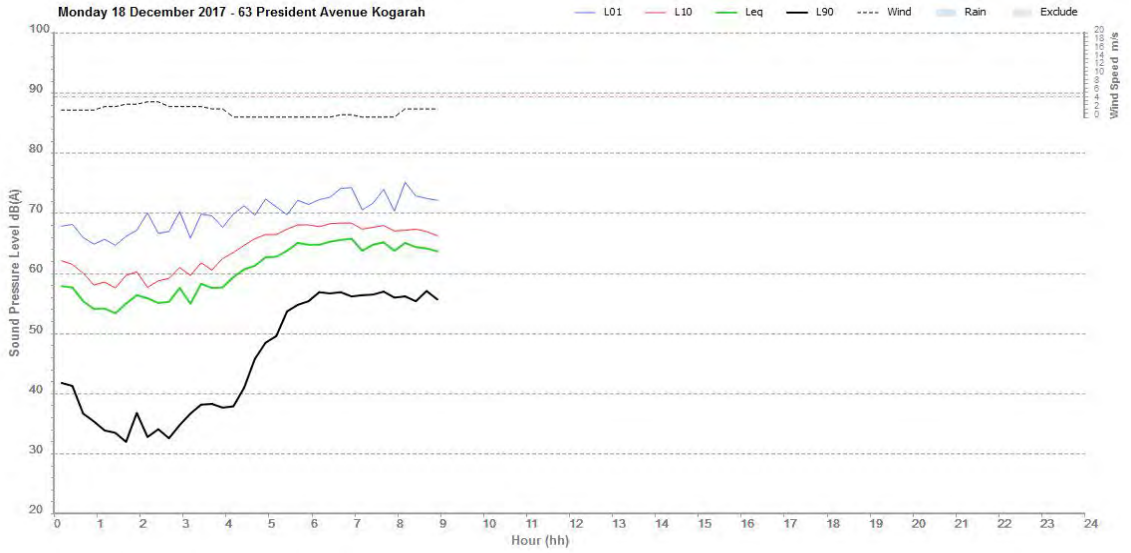






Logger Graphs





NL14 - 138 PresidentAavenue - 11/12/17 - 18/12/17

Logger Setup

Logger Type: Rion NL52

Serial No : 553966

Address: 138 President Avenue, Brighton Le-Sands

Location: Front yard

Facade / Free Field: Free Field

Environment: Noise environment dominated from road traffic noise from President Avenue. Occasional loud vehicle accelerating hard from lights at O'Connell Street. Average single car pass-by event 70 dBA. 50dBA background with no cars on road.

Logger Setup Photo

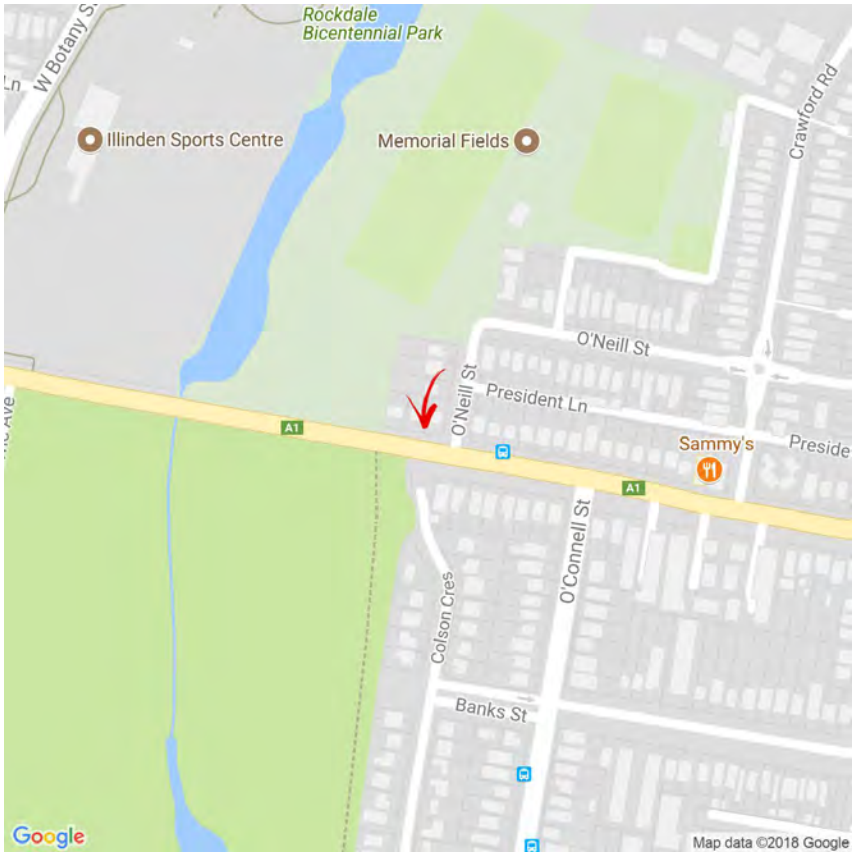
INP Noise Level, dB(A)

	Log Average	RBL
Day	71	57
Evening	66	50
Night	65	37

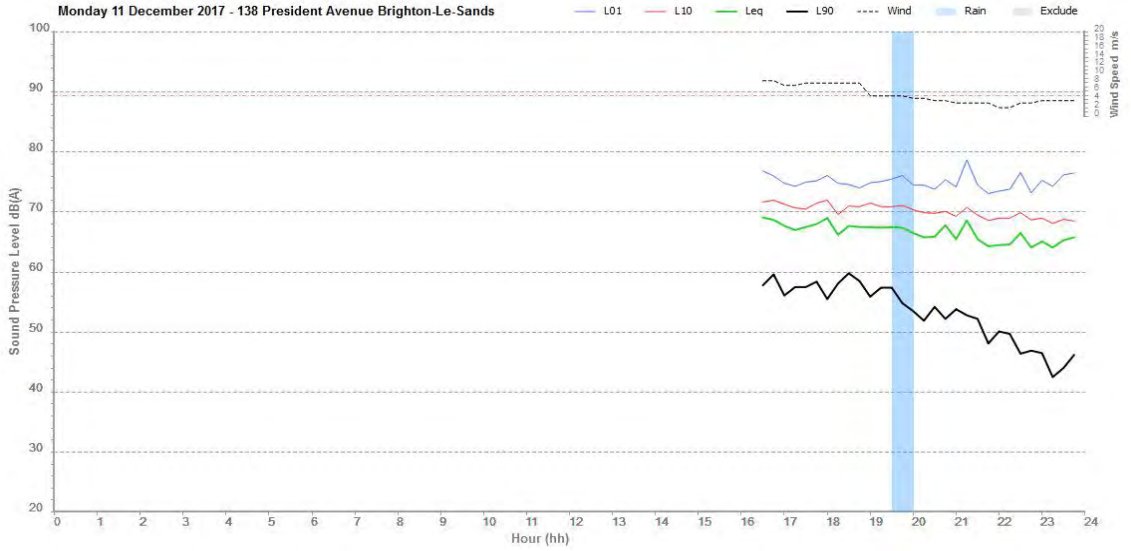
RNP Noise Level, dB(A)

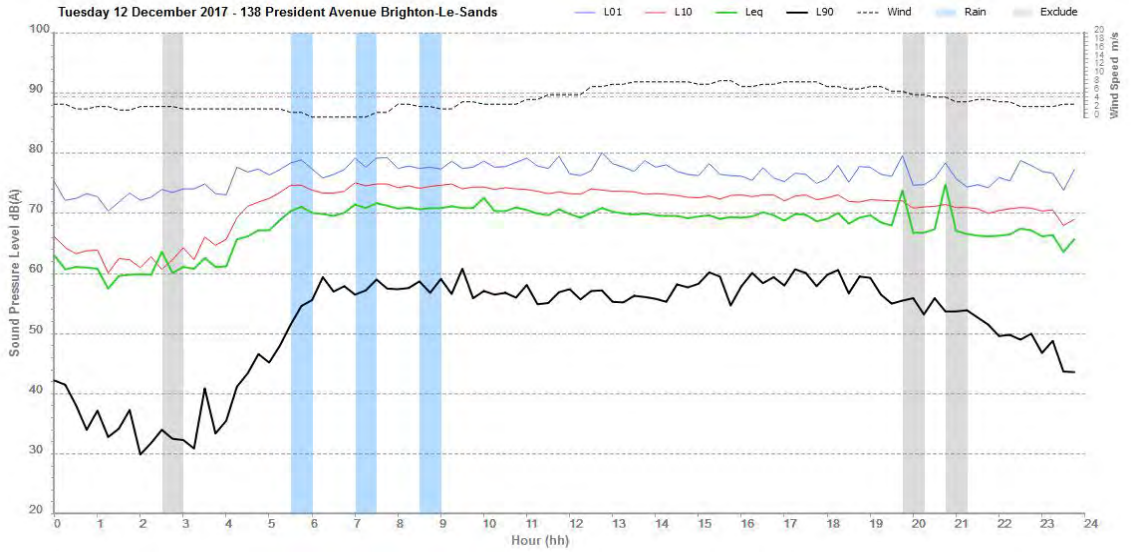
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	70.9	69.6
Night (10pm - 7am)	68.1	65.4

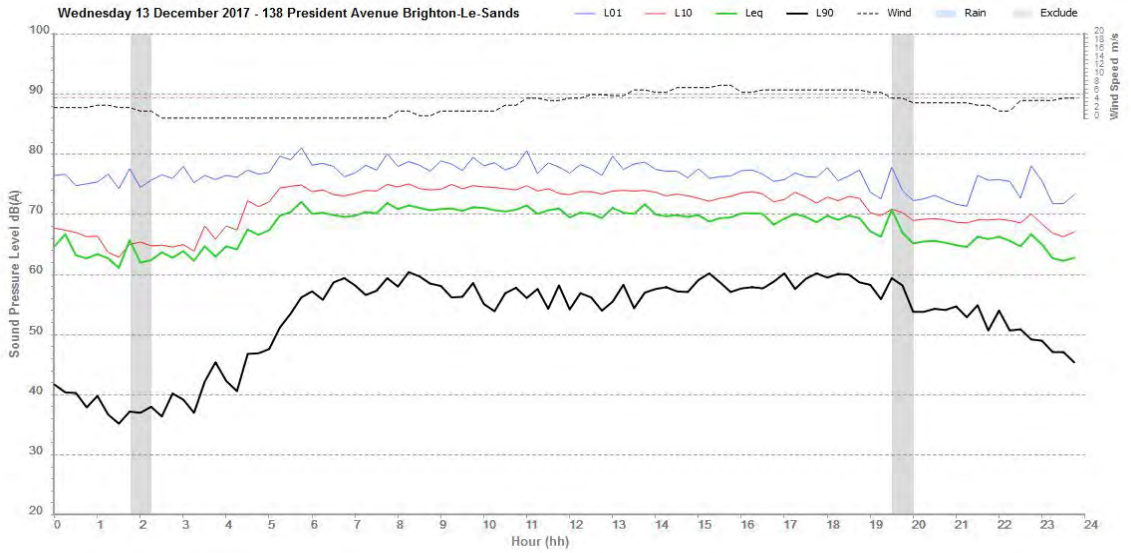
Logger Location Map



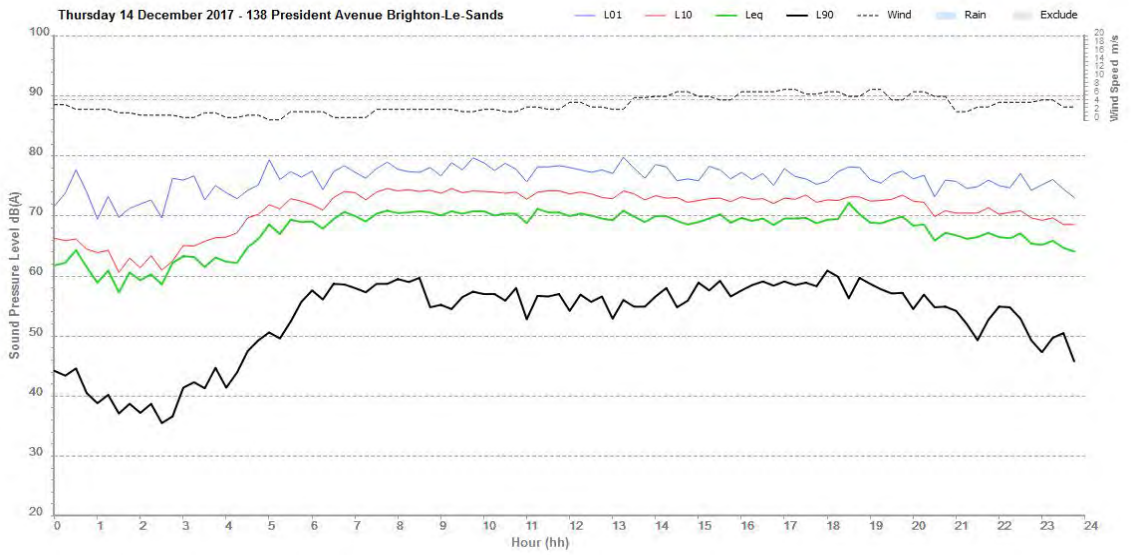
Logger Graphs

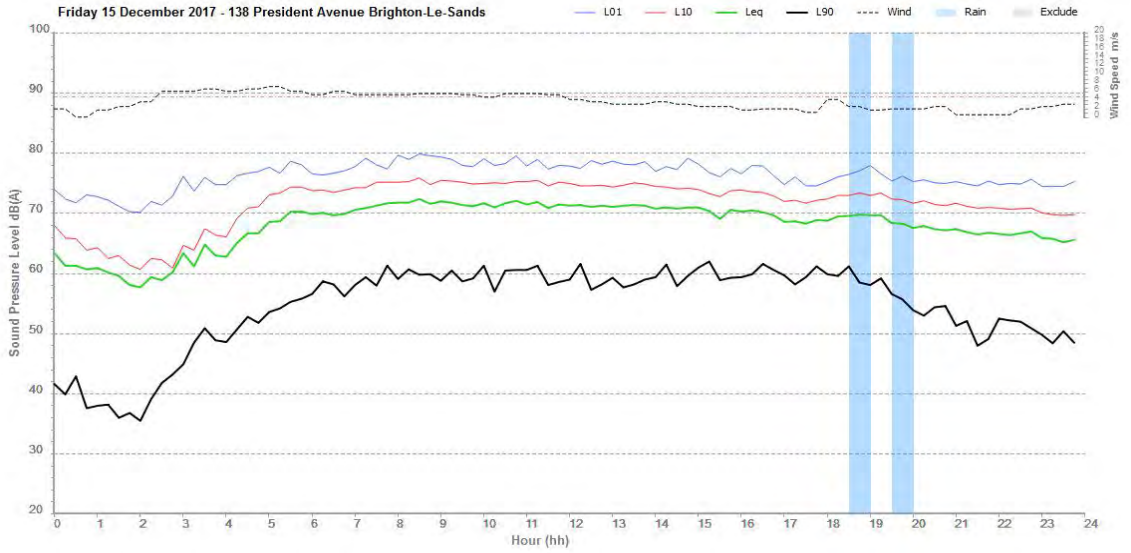


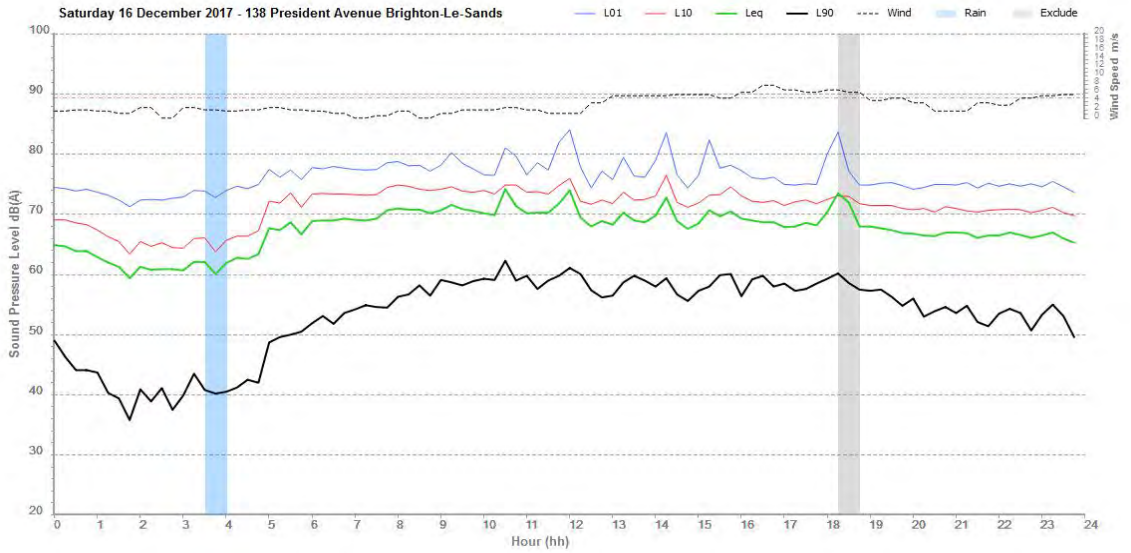




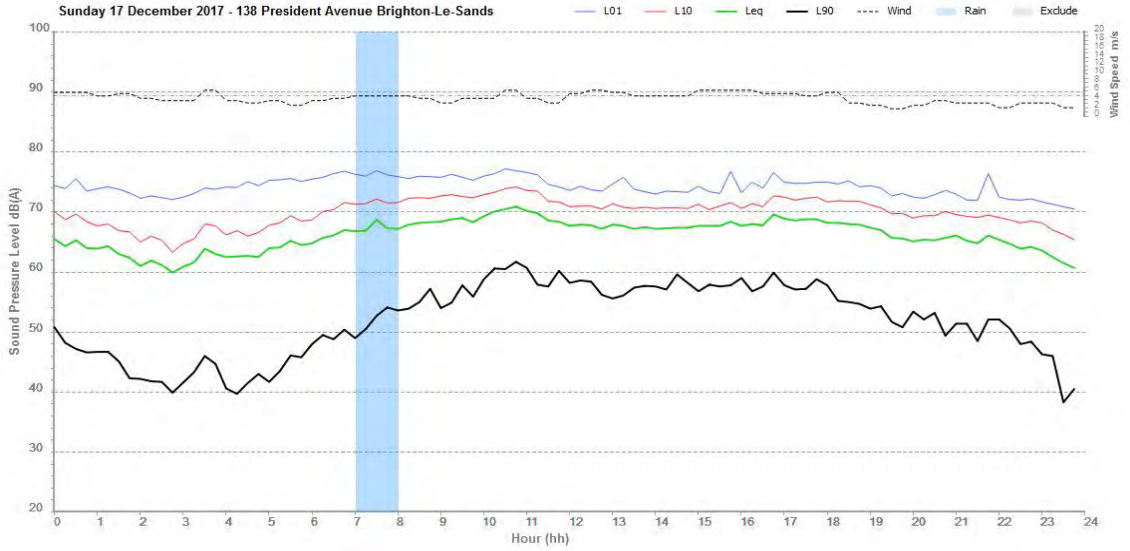
Logger Graphs







Logger Graphs



NL15 - TAFE - Princes Hwy - 06/02/18 - 11/02/18

Logger Setup

Logger Type: ARL 215

Serial No : 16-306-035

Address: 750 Princes Highway , Kogarah

Location: In Garden

Facade / Free Field: Free Field

Environment: Noise environment dominated by heavy road traffic noise approx 70dBA. Light pedestrian traffic from tafe in normal voice conversation passing by approx once every minute. Insect noise barely audible.

Logger Setup Photo

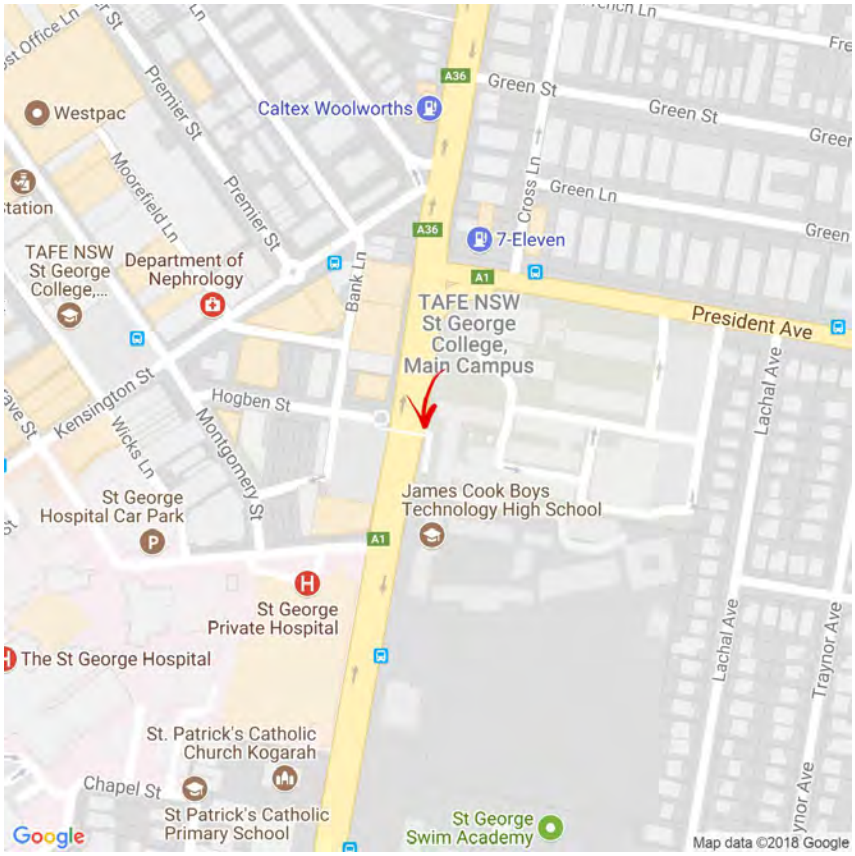
INP Noise Level, dB(A)

	Log Average	RBL
Day	72	66
Evening	70	66
Night	68	56

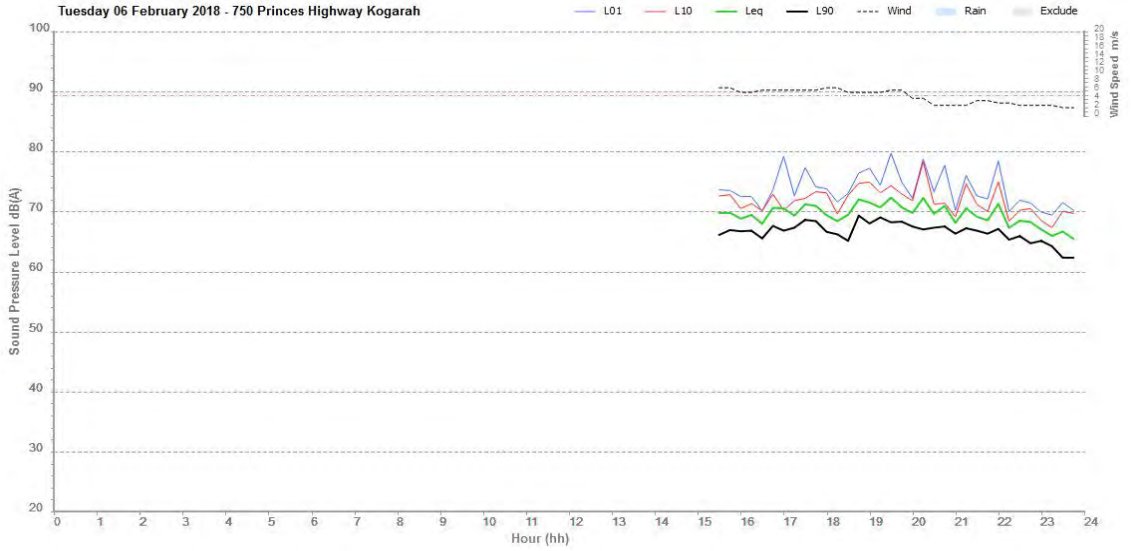
RNP Noise Level, dB(A)

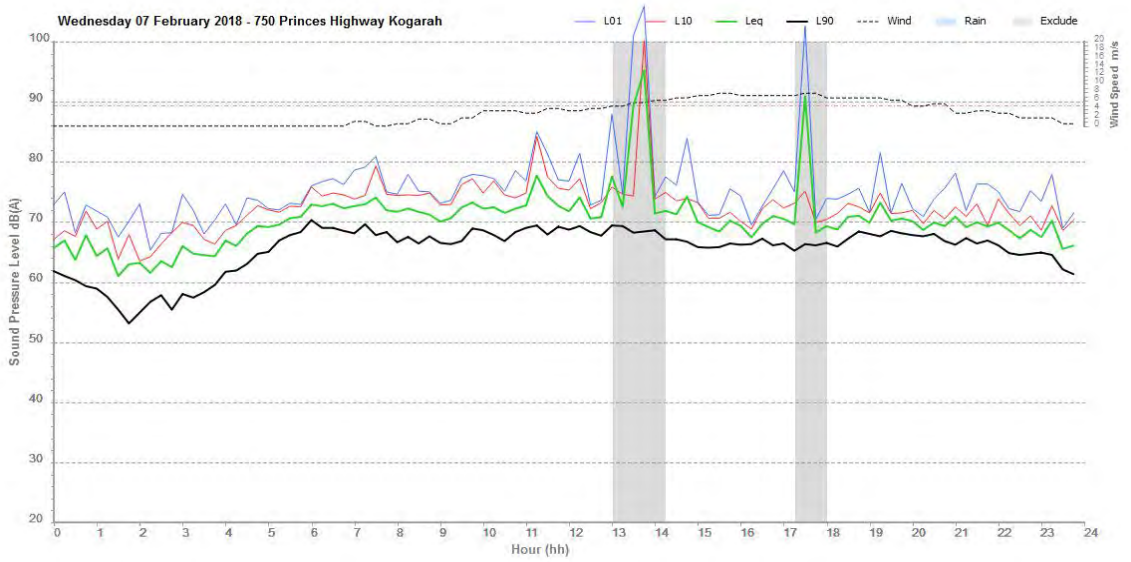
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	72.8	71.2
Night (10pm - 7am)	70.8	67.9

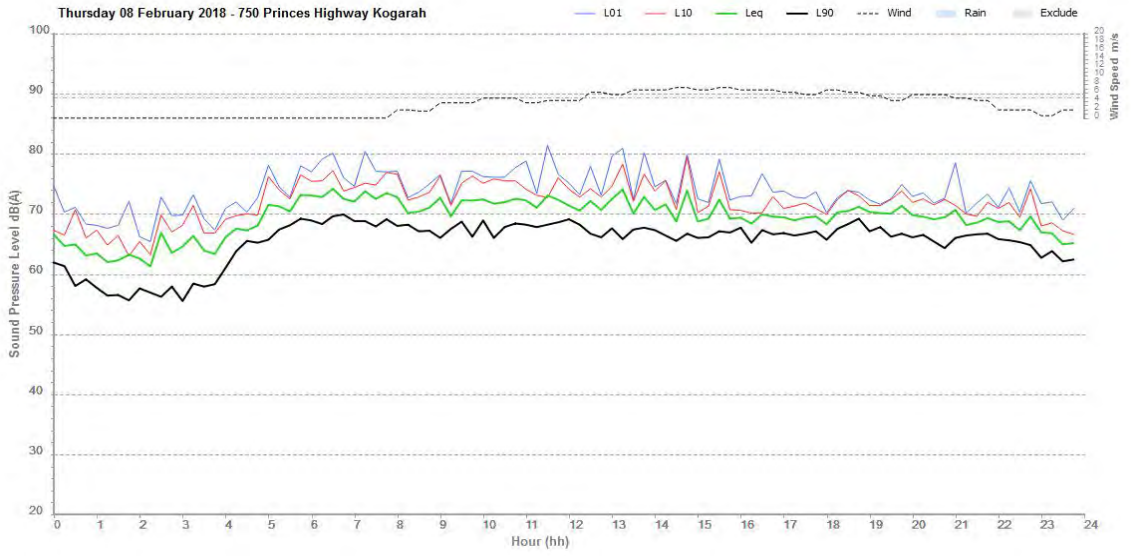
Logger Location Map



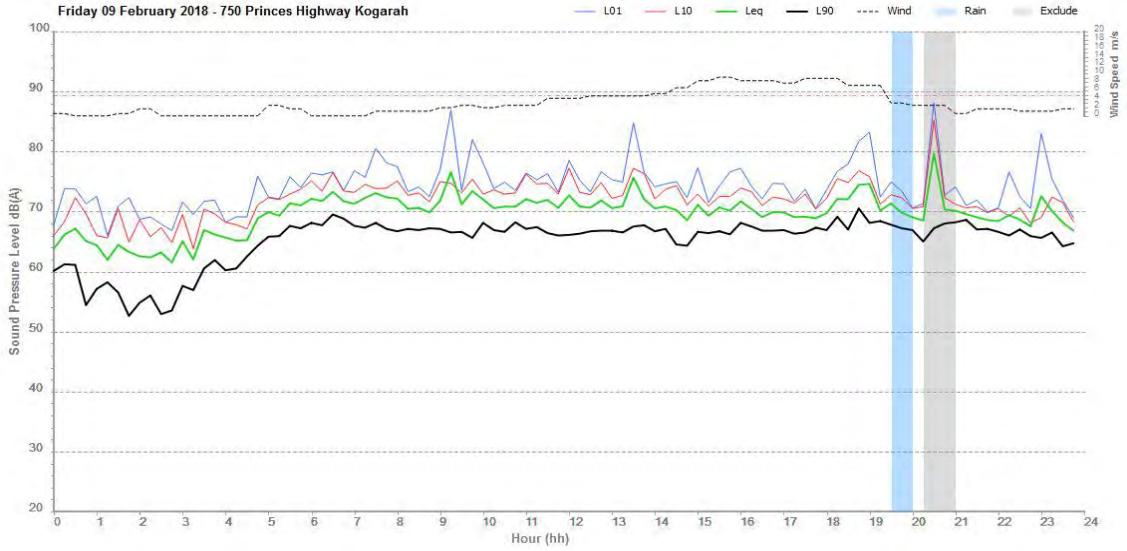
Logger Graphs

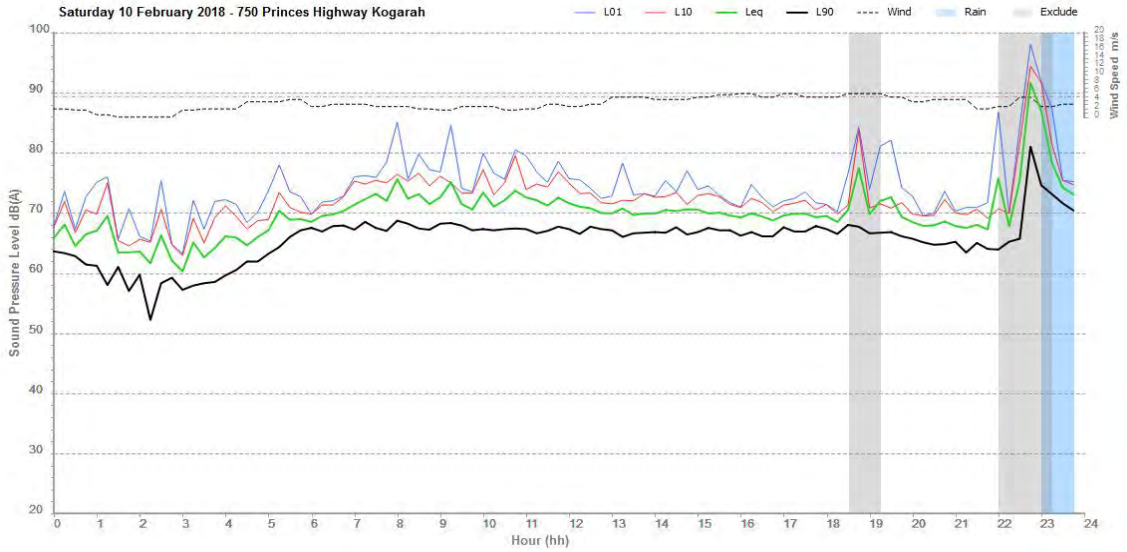


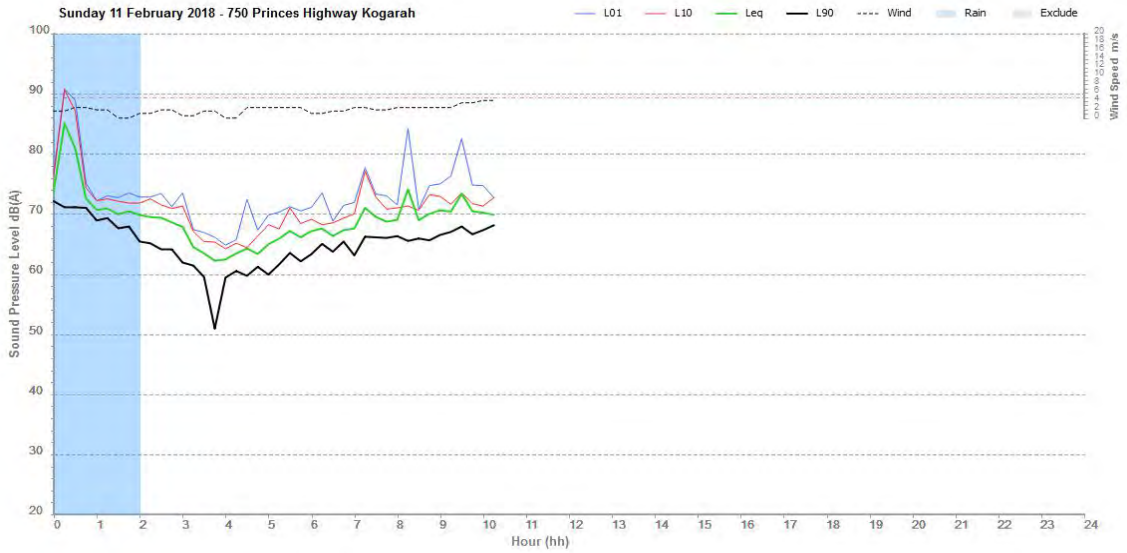




Logger Graphs







NL16 - Scarborough Park North - 06/02/18 - 16/02/18

Logger Setup

Logger Type: ARL 316

Serial No : 16-707-042

Address: Scarborough Park North, Monterey

Location: In Park

Facade / Free Field: Free Field

Environment: Noise environment controlled by distant aircraft noise from airport, in addition to insect and bird noise from nearby trees and marshland. Light wind noise in nearby trees. Road traffic noise from President Avenue just audible through clearing. Occasional close by cicadas quite loud 65db.

Logger Setup Photo

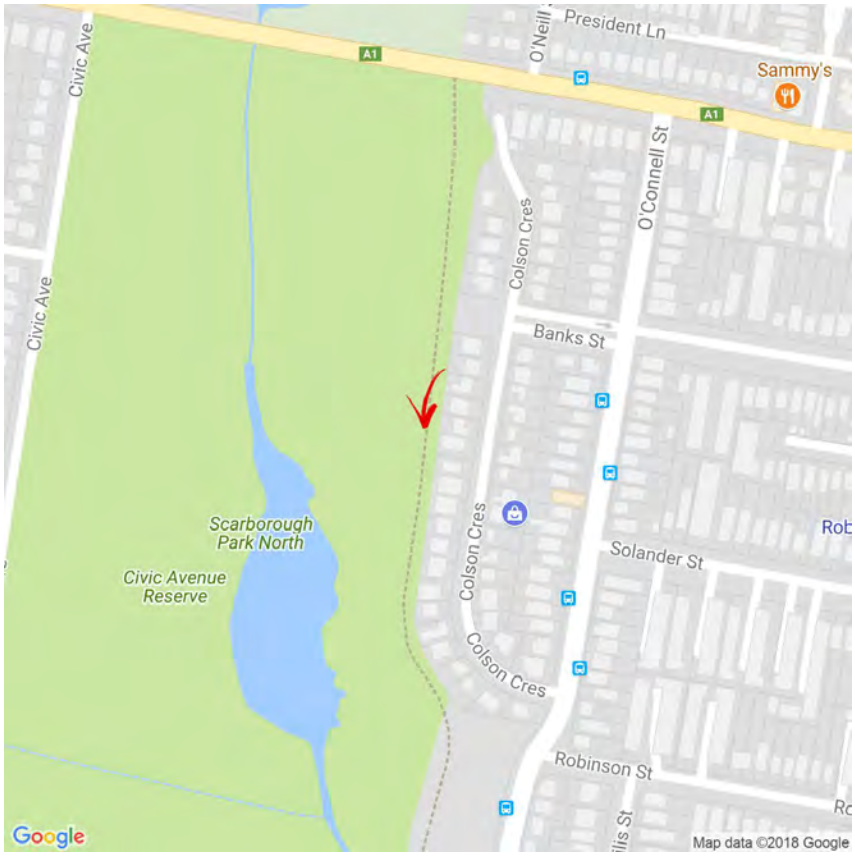
INP Noise Level, dB(A)

	Log Average	RBL
Day	58	42
Evening	53	40
Night	44	32

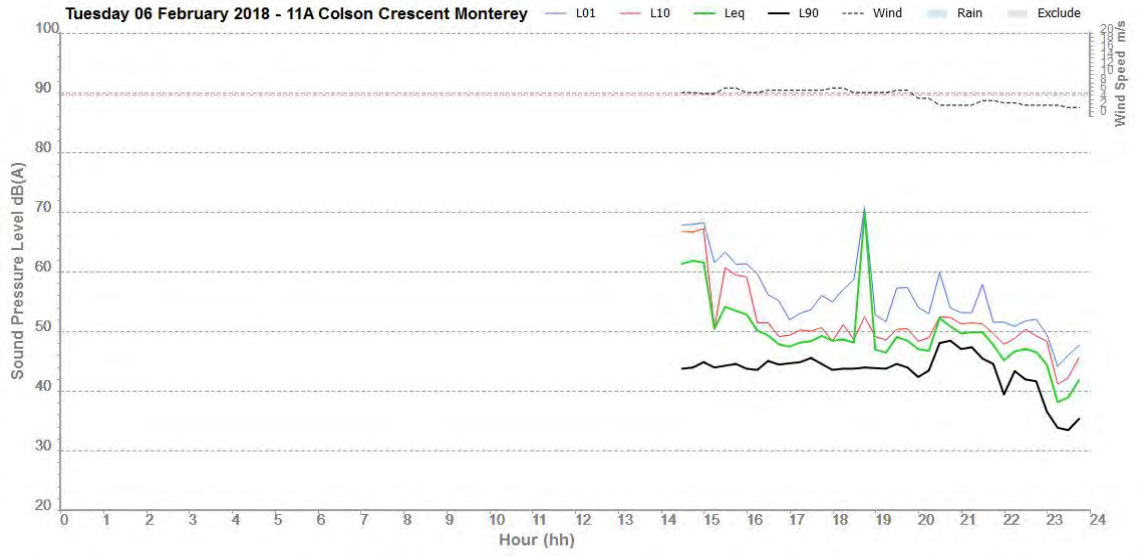
RNP Noise Level, dB(A)

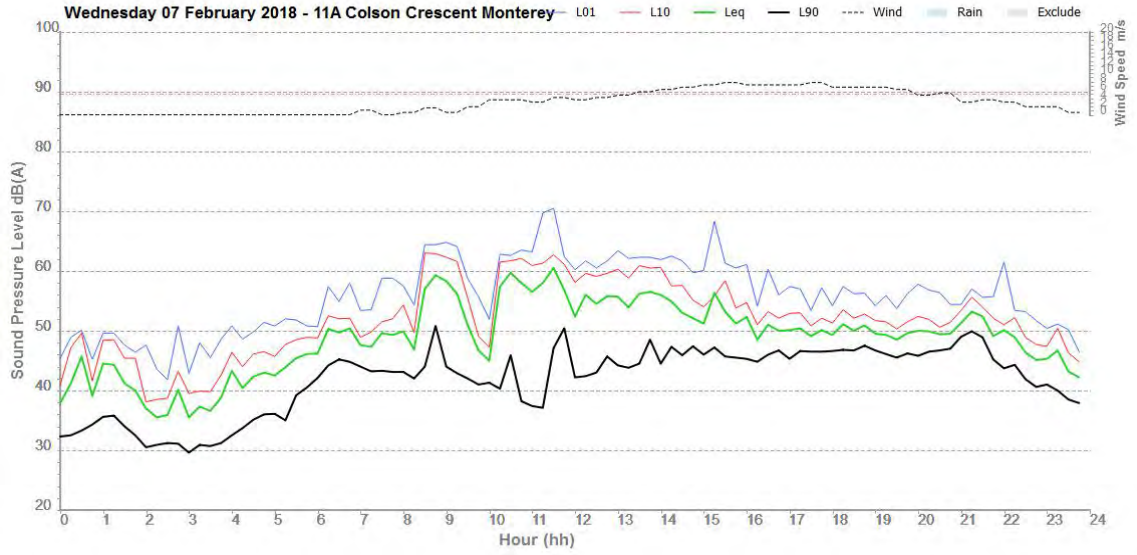
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

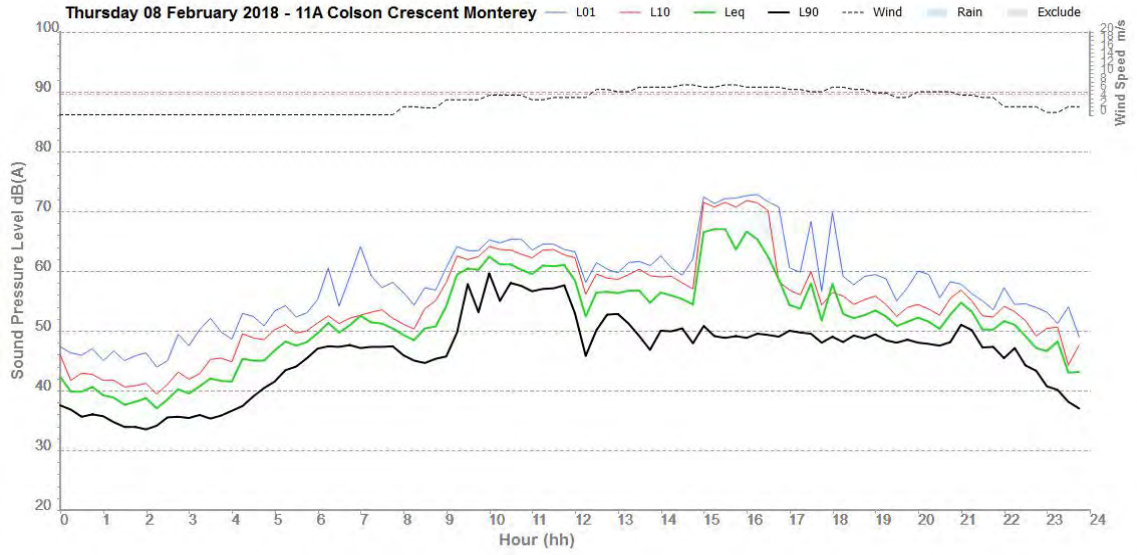
Logger Location Map



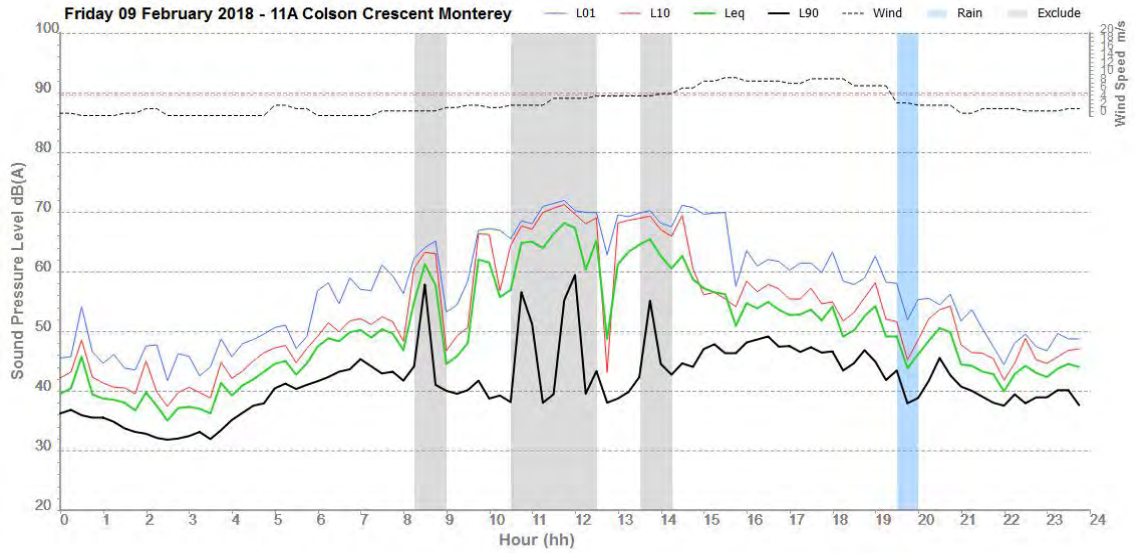
Logger Graphs

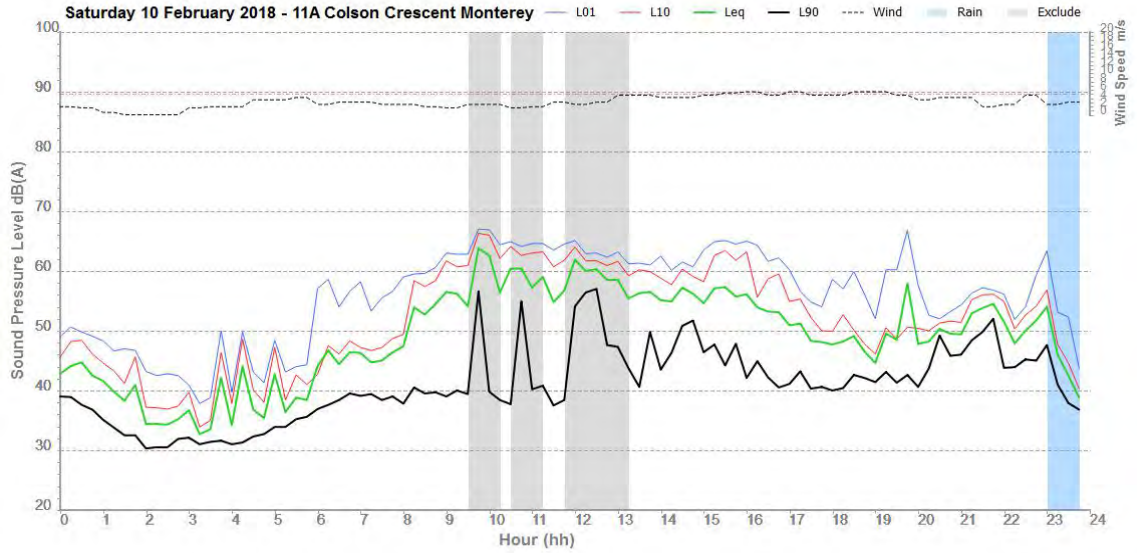


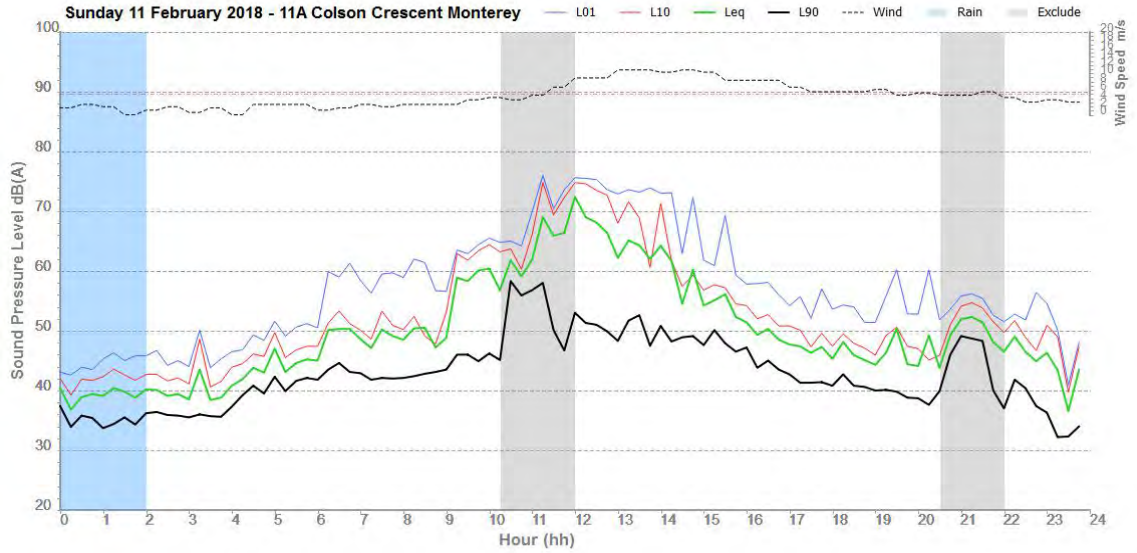




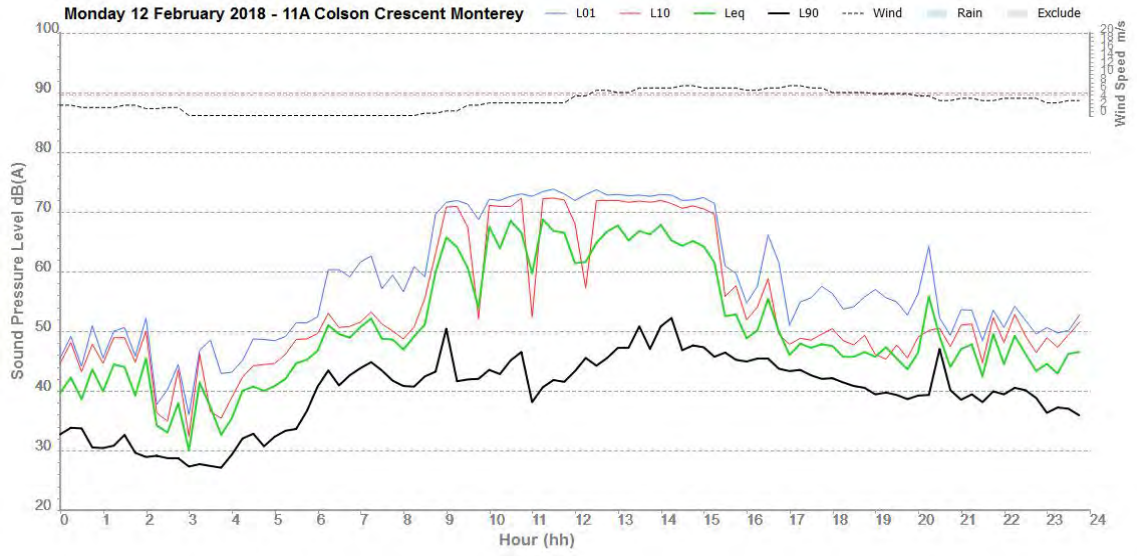
Logger Graphs

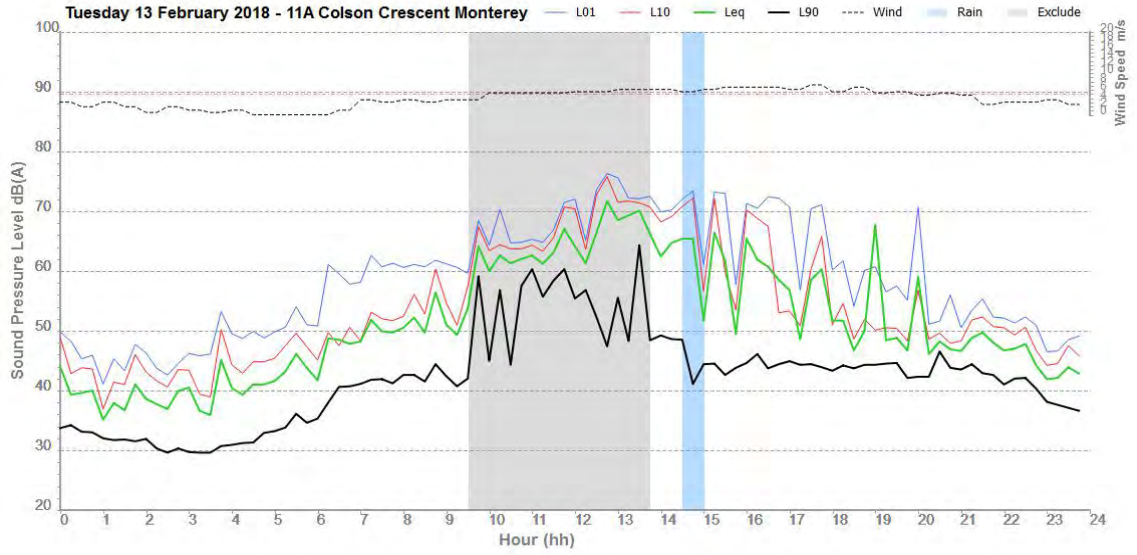


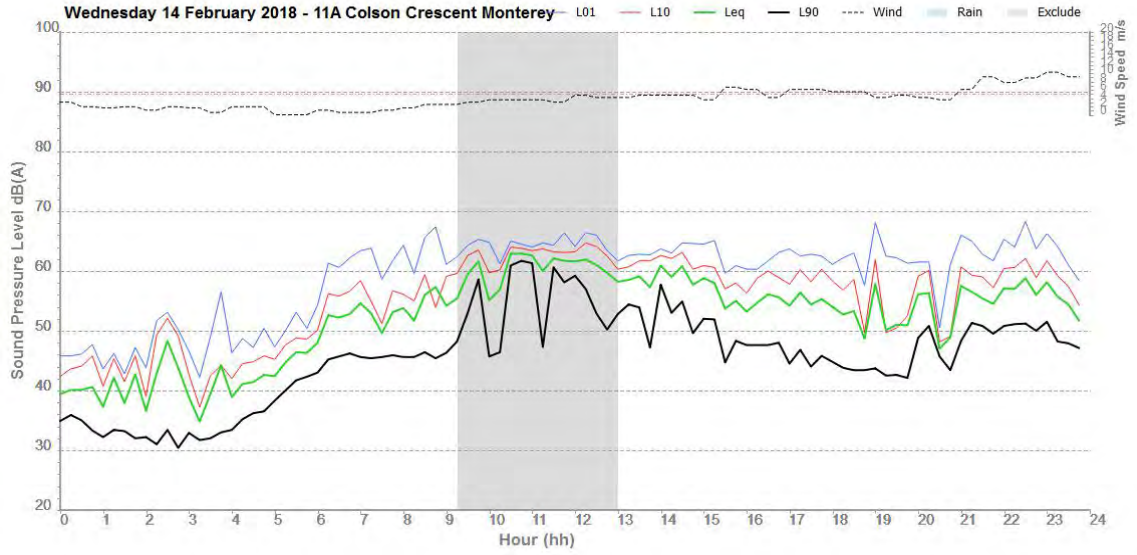




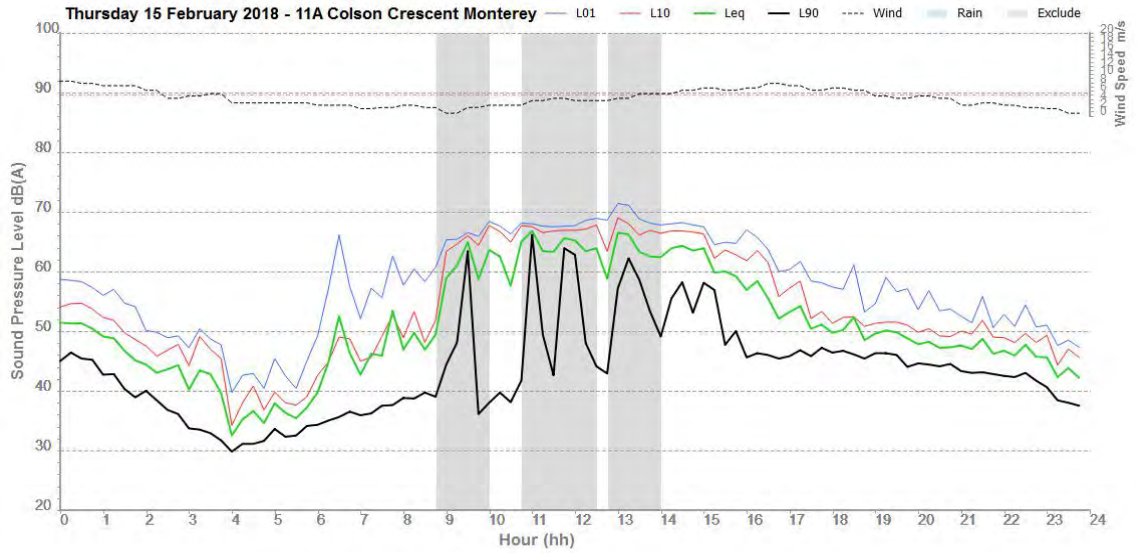
Logger Graphs

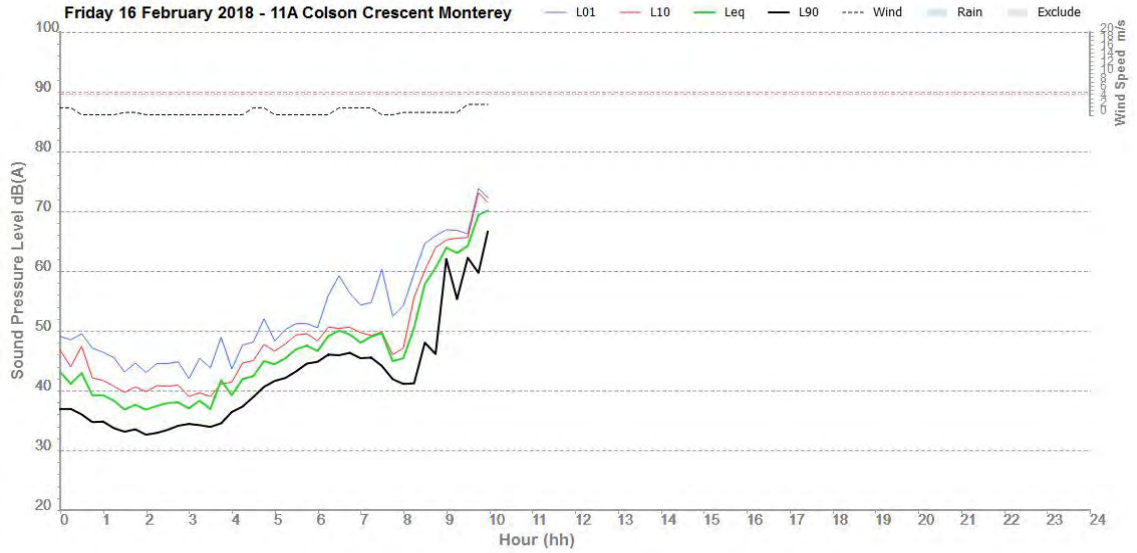






Logger Graphs





Annexure C – Traffic volumes

This annexure provides the road traffic volumes that have been modelled in this assessment. The volumes have been sourced from the strategic model. Provided below in **Table 10-1** is a summary of the modelled scenarios, the included projects, and the strategic model reference.

Table 10-1 Traffic model descriptions

Scenario	Description	Strategic model reference
Year 2026 Do Minimum	• WestConnex Stages 1, 2, and 3 • King Street Gateway	2026_M0930
Year 2026 Do Something	• WestConnex Stages 1, 2, and 3 • King Street Gateway • F6 Stage 1	2026_M1080
Year 2036 Do Minimum	• WestConnex Stages 1, 2, and 3 • King Street Gateway	2036_M0932
Year 2036 Do Something	• WestConnex Stages 1, 2, and 3 • King Street Gateway • F6 Stage 1	2036_M1082
Year 2036 Cumulative	• WestConnex Stages 1, 2, and 3 • Sydney Gateway • King Street Gateway • F6 Stage 1, 2, and 3 • Western Harbour Tunnel • Beaches Link	2036_M1090

Provided below in **Table 10-2** to **Table 10-6** is a summary of the modelled traffic volumes in each of the traffic scenarios described in **Table 10-1**.

Table 10-2 Year 2026 do minimum traffic movements

Location	Daytime		Night		AADT		
	Light	Heavy	Light	Heavy	Light	Heavy	Total
Princes Highway North NB	15,559	635	3,083	81	18,642	716	19,358
Princes Highway North SB	17,713	910	3,938	114	21,651	1,024	22,675
Princes Highway South NB	31,218	1,445	7,205	236	38,423	1,681	40,104
Princes Highway South SB	28,421	1,703	6,785	239	35,206	1,942	37,148
President Avenue West1 EB	24,083	899	5,680	172	29,763	1,071	30,834
President Avenue West1 WB	19,135	884	4,406	142	23,541	1,026	24,567
President Avenue East2 EB	22,052	754	4,814	136	26,866	890	27,756
President Avenue East2 WB	19,317	607	4,294	101	23,611	708	24,319
West Botany Street NB	5,742	448	1,200	56	6,942	504	7,446
West Botany Street SB	6,611	286	1,408	50	8,019	336	8,355

Notes:
1 West of West Botany Street
2 East of West Botany Street

Table 10-3 Year 2026 do something traffic movements

Location	Daytime		Night		AADT		
	Light	Heavy	Light	Heavy	Light	Heavy	Total
Princes Highway North NB	15,061	559	2,956	84	18,017	643	18,660
Princes Highway North SB	17,893	698	3,887	90	21,780	788	22,568
Princes Highway South NB	34,895	1,957	7,868	311	42,763	2,268	45,031
Princes Highway South SB	28,281	1,752	6,726	238	35,007	1,990	36,997
President Avenue West1 EB	30,007	1,711	6,822	277	36,829	1,988	38,817
President Avenue West1 WB	20,561	1,364	4,750	198	25,311	1,562	26,873
President Avenue Mid2 EB	28050	1712	6167	262	34,217	1,974	36,191
President Avenue Mid2 WB	23676	1694	5379	214	29,055	1,908	30,963
President Avenue East3 EB	22448	1043	4773	165	27,221	1,208	28,429
President Avenue East3 WB	15230	504	3250	70	18,480	574	19,054
West Botany Street NB	6346	303	1307	49	7,653	352	8,005
West Botany Street SB	3796	282	714	52	4,510	334	4,844
F6 NB On Ramp	12264	1319	2129	146	14,393	1,465	15,858
F6 SB Off Ramp	15106	1843	2864	194	17,970	2,037	20,007

Notes:
1 West of West Botany Street
2 Between West botany Street and the F6 Stage 1 intersection
3 East of the F6 Stage 1 intersection

Table 10-4 Year 2036 do minimum traffic movements

Location	Daytime		Night		AADT		
	Light	Heavy	Light	Heavy	Light	Heavy	Total
Princes Highway North NB	16479	739	3413	100	19,892	839	20,731
Princes Highway North SB	18929	1037	4173	129	23,102	1,166	24,268
Princes Highway South NB	32359	1601	7472	316	39,831	1,917	41,748
Princes Highway South SB	29234	2157	7076	302	36,310	2,459	38,769
President Avenue West[1] EB	24813	956	5743	233	30,556	1,189	31,745
President Avenue West[1] WB	19238	1214	4588	191	23,826	1,405	25,231
President Avenue East[2] EB	23092	754	4927	188	28,019	942	28,961
President Avenue East[2] WB	19933	740	4446	136	24,379	876	25,255
West Botany Street NB	7145	347	1424	61	8,569	408	8,977
West Botany Street SB	6862	677	1243	81	8,105	758	8,863

Notes:
1 West of West Botany Street
2 East of West Botany Street

Table 10-5 Year 2036 do something traffic movements

Location	Daytime		Night		AADT		
	Light	Heavy	Light	Heavy	Light	Heavy	Total
Princes Highway North NB	16032	629	3277	98	19,309	727	20,036
Princes Highway North SB	19303	789	4009	102	23,312	891	24,203
Princes Highway South NB	35665	2386	8242	404	43,907	2,790	46,697
Princes Highway South SB	29217	2147	6788	298	36,005	2,445	38,450
President Avenue West[1] EB	31306	2113	6974	360	38,280	2,473	40,753
President Avenue West[1] WB	21588	1714	4788	249	26,376	1,963	28,339
President Avenue Mid[2] EB	29264	2103	6426	337	35,690	2,440	38,130
President Avenue Mid[2] WB	23791	1997	5475	291	29,266	2,288	31,554
President Avenue East[3] EB	22926	1242	4891	217	27,817	1,459	29,276
President Avenue East[3] WB	15333	644	3048	108	18,381	752	19,133
West Botany Street NB	6581	649	1260	64	7,841	713	8,554
West Botany Street SB	4934	414	739	71	5,673	485	6,158
F6 NB On Ramp	15528	1731	2323	171	17,851	1,902	19,753
F6 SB Off Ramp	17650	2221	3215	235	20,865	2,456	23,321

Notes:
1 West of West Botany Street
2 Between West Botany Street and the F6 Stage 1 intersection
3 East of the F6 Stage 1 intersection

Table 10-6 Year 2036 cumulative traffic movements

Location	Daytime		Night		AADT		
	Light	Heavy	Light	Heavy	Light	Heavy	Total
Princes Highway North NB	16216	607	3181	84	19397	691	20,088
Princes Highway North SB	19072	603	3869	86	22,941	689	23,630
Princes Highway South NB	33696	1165	6871	214	40,567	1,379	41,946
Princes Highway South SB	26211	1109	6407	197	32,618	1,306	33,924
President Avenue West[1] EB	30641	9989	5932	184	36,573	10,173	46,746
President Avenue West[1] WB	20301	936	4779	166	25,080	1,102	26,182
President Avenue Mid[2] EB	32598	1451	6243	270	38,841	1,721	40,562
President Avenue Mid[2] WB	23962	1447	5087	217	29,049	1,664	30,713
President Avenue East[3] EB	24256	1117	5122	218	29,378	1,335	30,713
President Avenue East[3] WB	18359	947	3915	146	22,274	1,093	23,367
West Botany Street NB	8621	483	1492	85	10,113	568	10,681
West Botany Street SB	9150	874	1468	119	10,618	993	11,611
F6 NB On Ramp	13437	767	1693	92	15,130	859	15,989
F6 SB Off Ramp	10694	932	1743	111	12,437	1,043	13,480

Notes:
1 West of West Botany Street
2 Between West botany Street and the F6 Stage 1 intersection
3 East of the F6 Stage 1 intersection