Supporting Growth

Redhills Arterial Transport Network

Assessment of Construction Noise and Vibration

Version 1.0

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TE TUPU NGĀTAHI Supporting Growth

WAKA KOTAHI NZ TRANSPORT AGENCY

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Acronyms

Acronym/Term	Description
AEE	Assessment of Environmental Effects
AT	Auckland Transport
AUP:OP	Auckland Unitary Plan Operative in Part 2016
BPO	Best Practicable Option
CNVMP	Construction Noise and Vibration Management Plan
DIN	Deutsches Institut Für Normung e.V. (German Institute for Standardisation)
NoR	Notice of Requirement
Receivers	Noise sensitive areas such as dwellings, hospitals, school and commercial properties
RMA	Resource Management Act 1991
Waka Kotahi	Waka Kotahi NZ Transport Agency

1 Executive Summary

Construction noise levels have been assessed using the method recommended in NZS 6803 in accordance with the Auckland Unitary Plan Operative in Part (AUP:OP). As construction of each Project is expected to last for more than 20 weeks, the “long-duration” noise limits are applicable.

Noisy activities will typically be carried out between 7am – 6pm on weekdays. Night-time and weekend works will be limited and only occur for critical activities.

Construction vibration levels have been assessed against the requirements of the AUP:OP, which refer to the criteria in DIN 4150-3:1999 for the avoidance of cosmetic building damage (DIN criteria). The AUP:OP also details amenity criteria, which act as a trigger for consultation if predicted to be exceeded.

Construction noise setback distances and vibration emission radii have been determined (based on assumptions of construction activities and equipment) for each of the NoR sections. The construction boundary is assumed to be the edge of the proposed alignment. Affected receivers have been identified using construction noise setback distances and vibration emission radii. The construction noise setback distances and vibration emission radii were used to determine where any potential construction noise and vibration exceedances of the relevant criteria could occur. It should also be noted that the emission radii are conservative and vibration levels measured on site tend to be much lower than those predicted at the NoR stage of a project.

Potential effects of construction noise and vibration have then been assessed and construction management and mitigation measures identified where appropriate. To avoid and/or minimise exceedances of the Project construction noise and vibration criteria, Best Practicable Option (BPO) mitigation and management measures should be utilised.

NoR 1 Redhills North-South Arterial Corridor

Results of assessment and recommended measures

The noise environment is dominated by road traffic noise from vehicles on Don Buck Road and the surrounding road network.

Receivers are located at varying distances from the construction boundary along the alignment with the closest existing receiver being 2m from the alignment. With mitigation in place, as set out in Section 5.2, noise levels of up to 90 dB LA_{eq} could still occur intermittently at the closest receivers, if high noise generating activities occur on the construction boundary. At this level effects could include loss of concentration, annoyance, and a reduction in speech intelligibility.

Operation of construction equipment will be intermittent in nature. Construction will be linear so as the equipment moves away from the receiver noise levels will reduce. The worst-case situations, where mitigated noise levels could reach 90 dB LA_{eq} at the closest receivers, are not expected to be frequent, due to the setback distances to the majority of the proposed works and the use of equipment with lower source noise levels for large portions of the works. It is therefore predicted that mitigated noise levels can comply with the 70 dB LA_{eq} noise criterion for most of the construction works.

Vibration levels could exceed the Category B criteria at 73 existing dwellings prior to mitigation being implemented, if high vibration generating equipment, such as the roller compactor, is used on the construction boundary at the closest position to the receivers. At these receivers there is potential for cosmetic damage to buildings (such as cracking) and annoyance from perception of vibration. Vibration can typically be tolerated inside buildings if it occurs intermittently during the day, is of limited duration and where there is effective prior engagement.

A CNVMP is the most effective way to avoid, remedy or mitigate construction noise and vibration effects on receivers.

NoR 2A Redhills East-West Arterial Corridor – Dunlop Road

Results of assessment and recommended measures

The existing noise environment is dominated by road traffic noise from vehicles on Fred Taylor Drive and the surrounding road network

At the time of writing of this assessment, there were no dwellings identified in proximity of the NoR designation boundary.

However, future dwellings within 90m of the works could experience unmitigated noise levels that exceed the daytime noise criterion during high noise generating activities such as the pavement works. The exclusion zone distance reduces to 28m with noise barriers implemented effectively around working sites.

The extent of effects from construction noise will be dependent on the distance that the dwellings are located from the works.

Operation of construction equipment will be intermittent in nature. Construction will be linear so as the equipment moves away from the receiver noise levels will reduce. The worst-case situations, where mitigated noise levels could reach 90 dB LA_{eq} at the closest receivers, are not expected to be frequent, due to the setback distances to the majority of the proposed works and the use of equipment with lower source noise levels for large portions of the works. It is therefore predicted that mitigated noise levels can comply with the 70 dB LA_{eq} noise criterion for most of the construction works.

If the roller compactor is used at the edge of the construction boundary, future dwellings within 8m of the works and commercial buildings within 4m of the works may experience vibration levels above the daytime Category B criterion, if the roller compactor is used on the construction boundary in the closest position to them.

NoR 2B – Redhills East-West Arterial Corridor – Baker Lane

Results of assessment and recommended measures

The existing noise environment is dominated by road traffic noise from vehicles on Fred Taylor Drive and the surrounding road network

Receivers are located at varying distances from the construction boundary along the alignment with the closest existing receiver being 30m from the alignment. Receivers within 90m of the works could

experience unmitigated noise levels that exceed the daytime noise criterion during high noise generating activities such as the pavement works.

Operation of construction equipment will be intermittent in nature. Construction will be linear so as the equipment moves away from the receiver noise levels will reduce. The worst-case situations are not expected to be frequent, due to the setback distances to the majority of the proposed works and the use of equipment with lower source noise levels for large portions of the works. It is therefore predicted that mitigated noise levels can comply with the 70 dB LA_{eq} noise criterion for most of the construction works.

If the roller compactor is used at the edge of the construction boundary, dwellings within 8m of the works and commercial buildings within 4m of the works may experience vibration levels above the daytime Category B criterion, if the roller compactor is used on the construction boundary in the closest position to them. Based on the designation boundary footprint, there are no existing dwellings where the Category B criterion is predicted to be exceeded.

The Category B criteria would be met at any further buildings constructed that are 8m or more from the proposed works and commercial structures that are 4m or more from the proposed works.

NoR 2C – Redhills East-West Arterial Corridor – Nixon Road connection

Results of assessment and recommended measures

The existing noise environment is dominated by road traffic noise from the surrounding road network. Although the existing land use is rural, the works could take place in a more urbanised environment, and some future dwellings could be located close to the works.

Receivers are located at varying distances from the construction boundary along the alignment with the closest existing receiver being 2m from the alignment. Receivers within 90m of the works could experience unmitigated noise levels that exceed the daytime noise criterion during high noise generating activities such as the pavement works. We note that the existing receivers may not be present at the time of construction.

With mitigation in place, as set out in section 7.2, noise levels of up to 90 dB LA_{eq} could still occur intermittently at the closest receivers, if high noise generating activities occur on the construction boundary. At this level effects could include loss of concentration, annoyance, and a reduction in speech intelligibility.

Operation of construction equipment will be intermittent in nature. Construction will be linear so as the equipment moves away from the receiver noise levels will reduce. The worst-case situations, where mitigated noise levels could reach 90 dB LA_{eq} at the closest receivers, are not expected to be frequent, due to the setback distances to the majority of the proposed works and the use of equipment with lower source noise levels for large portions of the works. It is therefore predicted that mitigated noise levels can comply with the 70 dB LA_{eq} noise criterion for most of the construction works.

Vibration levels could exceed the Category B criteria at two existing dwellings prior to mitigation being implemented, if high vibration generating equipment, such as the roller compactor, is used on the construction boundary at the closest position to the receivers. At these receivers there is potential for cosmetic damage to buildings (such as cracking) and annoyance from perception of vibration.

Vibration can typically be tolerated inside buildings if it occurs intermittently during the day, is of limited duration and where there is effective prior engagement.

Summary

Construction noise and vibration can be mitigated and managed, utilising the measures set out in Section 7.2, to generally comply with the applicable limits as defined in the AUP:OP. Exceedances of the criteria could occur intermittently over a short duration if high noise or vibration generating equipment are used near occupied buildings. Where an exceedance is predicted at any receiver that exists at the time of construction, the effects will be mitigated and managed through the CNVMP and Schedules.

A CNVMP is the most effective way to avoid, remedy or mitigate construction noise and vibration effects on receivers.

2 Introduction

2.1 Background

Auckland's population is growing rapidly; driven by both natural growth (more births than deaths) and migration from overseas and other parts of New Zealand. The Auckland Plan 2050 anticipates that this growth will generate demand for an additional 313,000 dwellings and require land for approximately 263,000 additional employment opportunities.

In response to this demand, the Auckland Unitary Plan Operative in Part (**AUP:OP**) identifies 15,000 hectares of predominantly rural land for future urbanisation. To enable the urban development of greenfield land, appropriate bulk infrastructure needs to be planned and delivered.

The Supporting Growth Programme is a collaboration between Auckland Transport (**AT**) and Waka Kotahi NZ Transport Agency (**Waka Kotahi**), to investigate, plan and deliver the transport services needed to support Auckland's future urban growth areas over the next 30 years.

2.2 Purpose of this Report

The Supporting Growth Programme has identified the need for a new arterial transport network in Redhills to support the urban development of the area. This report has been prepared to support AT's notices of requirement (**NoRs**) for the Redhills Arterial Transport Network (the **Project**). The NoRs under the Resource Management Act (**RMA**) are to designate land to enable the future construction, maintenance and operation of the Project.

This report provides an assessment of the actual and potential noise and vibration effects associated with the construction of the Project on the existing and likely future environment, and recommends measures that may be implemented to avoid, remedy and/or mitigate these effects.

This assessment has been prepared to inform the Assessment of Environmental Effects (**AEE**) for the NoRs. Effects associated with traffic noise are assessed against different standards and criteria and are discussed in a separate report.

The key matters addressed in this report are as follows:

a. Description of the Project as it relates to construction noise and vibration;
b. Overview of the methodology used to undertake the assessment and identification of the assessment criteria and any relevant standards or guidelines;
c. Identification and description of the existing and likely future noise environment;
d. Description of the actual and potential noise and vibration effects of construction of the Project;
e. Recommended measures to avoid, remedy or mitigate potential adverse construction noise and vibration effects (including any conditions/management plan required); and
f. Overall conclusion of the level of potential construction noise and vibration effects of the Project after recommended measures are implemented.

2.3 Project Description

The Project consists of two new arterial corridors through the Project area, providing sufficient space for two-lanes for vehicles, new footpaths and dedicated cycleways on both sides of the road. The Project has been broken down into the following NoRs:

Table 2-1: List of Notices of Requirement

Notice	Project	Description
NoR1	Redhills North-South Arterial Corridor	New urban arterial transport corridor and upgrade of Don Buck and Royal Road intersection.
NoR2a	Redhills East-West Arterial Corridor – Dunlop Road	New urban arterial transport corridor that intersects with Fred Taylor Drive and connects to the remaining East-West corridor (NoR2c) at the intersection with the Redhills North-South arterial corridor.
NoR2b	Redhills East-West Arterial Corridor – Baker Lane	New urban arterial transport corridor that intersects with Fred Taylor Drive and connects to the intersection of the remaining East-West corridor and Dunlop Road (NoR2a).
NoR2c	Redhills East-West Arterial Corridor – Nixon Road connection	New urban arterial transport corridor that intersects with the Redhills East-West Arterial Corridor – Dunlop Road. This includes the upgrade of the existing Red Hills Road/Nelson Road/Nixon Road intersection, and the existing Nixon Road/Henwood Road intersection.

To safely tie into the existing road network, the Project includes the upgrade of existing intersections where the new corridors will connect, as follows:

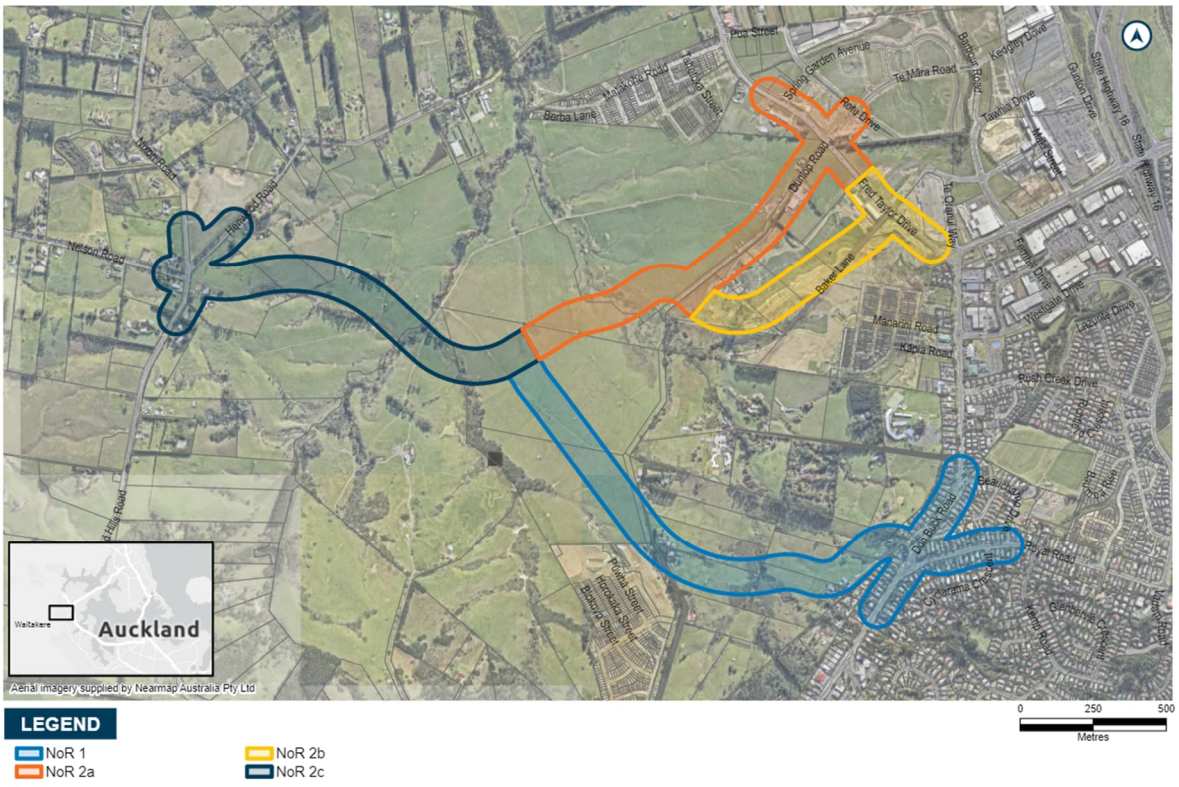
- Signalisation of the intersection at Don Buck Road and Royal Road (NoR1);
- Signalisation of the intersection at Fred Taylor Drive and Dunlop Road (NoR 2a);
- Signalisation of the intersection at Fred Taylor Drive and Baker Lane (NoR 2b); and
- A new roundabout at the intersection of Red Hills Road, Nixon Road and Nelson Roads (NoR 2c).

The Project also provides a footprint for new stormwater wetlands for the treatment and attenuation of stormwater from the new corridors.

This report has primarily considered the Project area as a whole. Where relevant, NoR1 is referred to as the N-S Project, and NoR2a, NoR2b and NoR2c are collectively referred to as the E-W Project.

The Project has been split into four NoRs to reflect the likely implementation of the Project. It may also be possible for each designation to delivered in stages as the Project area develops.

An overview of the Project is provided in Figure 2-1. This design, along with the wider designation boundary, is referred to as the Project area throughout this report.



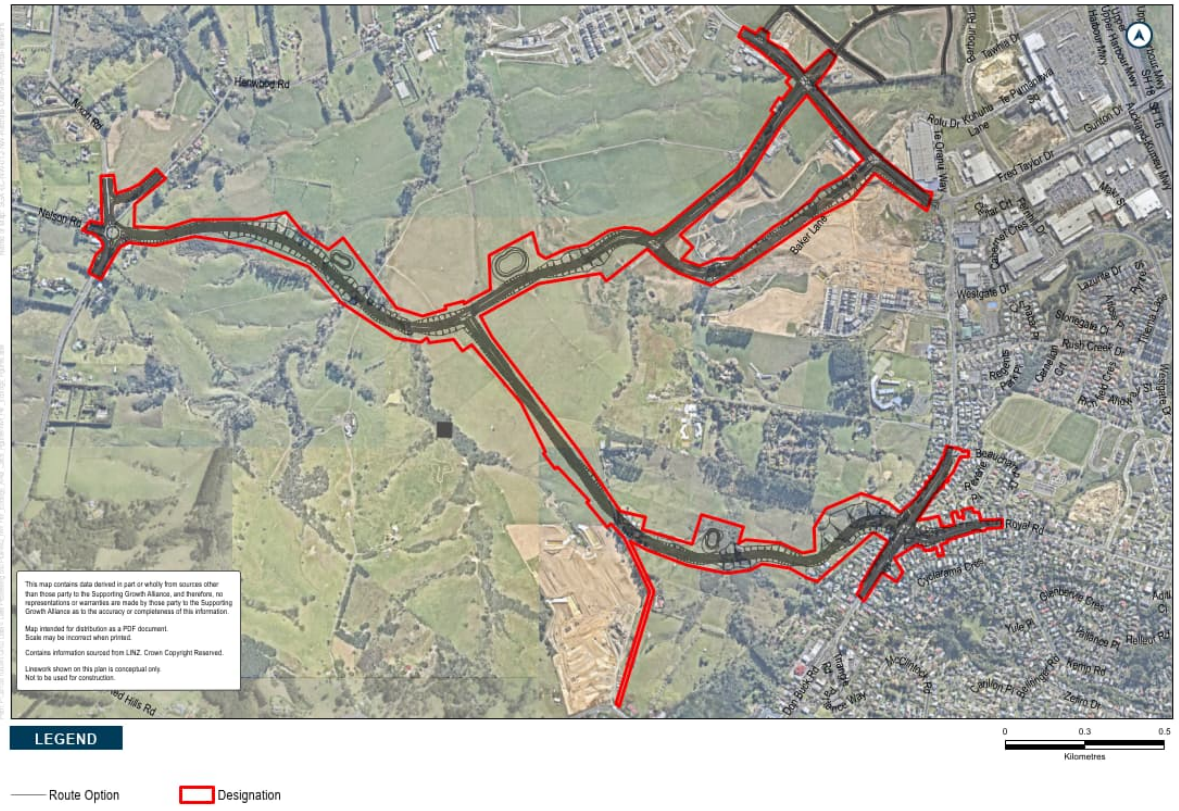


Figure 2-1: Redhills Arterial Transport Network

3 Assessment Framework

3.1 Statutory Context

3.1.1 Notice of Requirement

This assessment has been prepared to support the NoR process for the Project. Section 171 of the RMA sets out the matters that must be considered by a territorial authority in making a recommendation on a NoR. This includes consideration of the actual or potential effects (including positive effects) on the environment of allowing the requirement.

No regional resource consents are currently being applied for. The necessary regional resource consents will be sought prior to construction of the corridors, at which time any regional consenting matters will be assessed.

3.1.2 Resource Management Act

Under the provisions of the RMA there is a duty to adopt the Best Practicable Option (**BPO**) to ensure that the noise from any development does not exceed a reasonable level. Specifically, sections 16 and 17 RMA reference noise effects as follows:

Section 16 *"every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level".*

Section 17 *"every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person, whether or not the activity is in accordance with a national environmental standard, a rule, a resource consent or a designation, or relevant sections of the RMA".*

3.2 Relevant Standards and Guidelines

3.2.1 Construction Noise

Rule E25.6.1(3) of the AUP:OP states that "The noise from any construction activity must be measured and assessed in accordance with the requirements of *New Zealand Standard NZS6803:1999 Acoustics – Construction noise"*. Rules E.25.6.27(1) and E.25.6.27(2) contain construction noise limits for sensitive and all other receivers.

Furthermore, Rule E25.6.29 specifies that construction noise levels for work within the road for construction, maintenance and demolition activities must meet the relevant noise levels in the relevant table E25.6.27.1 or E25.6.27.2 (as replicated in below), with some relaxation of the compliance requirement for certain times and durations.

The construction noise standards provided by Rules E25.6.27(1) and E25.6.27(2) of the AUP:OP have been adopted for the purpose of this assessment.

The applicable construction noise criteria are detailed in Table 3-1 for sensitive receivers and in Table 3-2 for all other receivers.

Construction of the Project is likely to occur in stages, however as it is anticipated that each stage of works will likely take longer than 20 weeks, the long duration limits have been adopted in Table 3-1 and Table 3-2 below.

Table 3-1: Construction noise criteria for sensitive receivers (outside of Business – City Centre Zone and the Business – Metropolitan Centre Zone)

		Noise level for Construction duration >20 weeks	
Time of week	**Time period**	**LA_{eq} dB**	**LA_{max} dB**
Weekdays	06:30 – 07:30	55	75
	07:30 – 18:00	70	85
	18:00 – 20:00	65	80
	20:00 – 06:30	45	75
Saturdays	06:30 – 07:30	40	70
	07:30 – 18:00	70	85
	18:00 – 20:00	40	70
	20:00 – 06:30	40	70
Sunday and public holidays	06:30 – 07:30	40	70
	07:30 – 18:00	50	80
	18:00 – 20:00	40	70
	20:00 – 06:30	40	70

Table 3-2: Construction noise criteria for all other receivers (outside of Business – City Centre Zone) and the Business – Metropolitan Centre Zone)

Time period	Noise level LA_{eq} dB
07:30 – 18:00	70
18:00 – 07:30	75

Exemptions to these levels are provided in Rule E25.6.29(2) and E25.6.29(3). Under E25.6.29 (2) noise levels specified (as replicated above) do not apply for planned works in the road between the hours of 10pm and 7am where:

a. the number of nights where the noise generated by the works exceeds the relevant noise levels at any one receiver is for 3 nights or less; and
b. the works cannot practicably be carried out during the day or because the road controlling authority requires this work to be done at night time; or
c. because of the nature of the works the noise produced cannot be practicably be made to comply with the relevant noise levels.

Under E25.6.29(3), noise levels specified (as replicated above) do not apply for planned works in the road between the hours of 7am and 10pm where:

a. the number of days where the noise generated by the works exceeds the relevant noise levels at any one receiver is 10 days or less; or
b. because of the nature of the works and the proximity of receivers the noise generated cannot practicably made to comply with the relevant noise levels.

If situations fall under the exemption rules then a copy of the works access permit issued by AT or approval from Waka Kotahi must be provided to Auckland Council five days prior to work commencing; and a Construction Noise and Vibration Management Plan (**CNVMP**) must be provided to Auckland Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5). These exemptions apply to works within a road, however the Project includes works to widen roads and construct new roads, therefore the exemptions would not apply to these works that take place outside of the road corridor. For the Project, construction noise standards and management of any non-compliances will form part of the management plan regime discussed later in this report.

3.2.2 Construction Vibration

The main objective of controlling construction vibration is to avoid vibration-related damage to buildings, structures, and services, in the vicinity of the works. Any adverse effects of construction vibration on human comfort would typically only be experienced for short durations, for most types of construction work.

It should be noted that the level of vibration perceived by humans, and the level of vibration that is likely to result in annoyance for some people, are magnitudes lower than the level of vibration capable of damaging structures. This means that vibration levels which readily comply with the cosmetic building damage criteria will likely cause annoyance and adverse reaction from building occupants who mistakenly believe that their building is sustaining damage.

Construction vibration has only been assessed against the limits of Table 3-4 which relate to the avoidance of potential cosmetic building damage. Potential exceedances of the amenity criteria will be considered when assessing the construction vibration effect on nearby receivers. However, it is recommended that the limits relating to human comfort detailed in Table 3-3 should be used as trigger for communication and consultation and should be included in the construction management plan.

3.2.2.1 Auckland Unitary Plan (Operative in Part)

The AUP:OP contains rules relating to construction vibration that cover both building damage and amenity. Rule E25.6.30 states that construction activities must be controlled to ensure any resulting vibration does not exceed:

a. The limits set out in German Industrial Standard DIN 4150-3 (1999): *Structural vibration – Part 3 Effects of vibration on structures* when measured in accordance with that Standard on any structure not on the same site; and
b. The limits set out in Table 3-3 in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500mm of ground level at the foundation of a single storey building.

Table 3-3: AUP:OP Table E25.6.30.1 Vibration limits in buildings

Receiver	Period	Peak Particle Velocity (PPV) mm/s
Occupied activity sensitive to noise or vibration	Night-time 10pm to 7am	0.3
	Daytime 7am to 10pm	2.0
Other occupied buildings	At all times	2.0

3.2.2.2 DIN 4150-3:1999 – Structural vibrations: Effects of vibrations on structures

Deutsches Institut für Normung e.V. (German Institute for Standardisation) (**DIN**) publishes standards including DIN 4150 that contains guideline vibration limits for buildings, which when complied with "will not result in damage that will have an adverse effect on the structure's serviceability". These limits are set out in Table 3-4.

Different criteria are given for "short-term" (transient) vibration sources such as blasting and pile driving, and "long-term" sources such as vibrocompaction or sheet piling. Note that the definition of "short-term" and "long-term" in DIN 4150-3:1999 differ from those in NZS 6803:1999 and do not strictly relate to the duration of the works, but rather how a building responds to the construction vibration. Short term vibration will not result in a significant increase in vibration due to resonance in the structure.

Table 3-4: Vibration velocity guideline values for structures (DIN 4150)

Type of structure	Short term vibration				Long Term Vibration**
	PPV at foundation, frequency of:			Vibration at horizontal plane of highest floor at all frequencies (mm/s)	PPV at horizontal plane of highest floor (mm/s)
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz*		
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	10
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15	5
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value	3	3 to 8	8 to 10	8	2.5

** At frequencies above 100 Hz, the values given in this column may be used as minimum values*
*** The Standard defines short-term vibration as "vibration which does not occur often enough to cause structural fatigue, and which does not produce resonance in the structure being evaluated". Long-term vibration is defined as all other vibration types not covered by the short-term vibration definition.*

Clause 5.1 of DIN 4150-3 notes that a vibration level in excess of the DIN criterion does not necessarily result in building damage. The definition of 'damage' in DIN 4150-3 is: "any permanent effect of vibration that reduces serviceability of a structure or one of its components".

Examples of a 'reduction of serviceability' include:

- the impairment of stability of the building and its components;
- a reduction in the bearing capacity of floors.

For dwelling type buildings (Table 3-4 – line 2) and structures sensitive to vibration (Table 3-4– line 3), the serviceability is considered to have been reduced if:

- cracks form in plastered surfaces of walls;
- existing cracks in the building are enlarged;
- partitions become detached from loadbearing walls or floors.

These effects are deemed 'minor damage'.

There are no buildings within 100m of the Project, which are considered to be sensitive to vibration, in accordance with line 3 of Table 3-4.

3.2.3 Auckland Transport construction vibration criteria

The following criteria are the recommended Project construction vibration criteria for both building damage and amenity applicable for all NoRs.

The two category criteria, detailed in Table 3-5 are to facilitate a progressive management response to the increasing risks and effects during construction.

Category A sets the criteria for the amenity effects where vibrations may be perceived by occupants within a building, as adopted from the AUP:OP, and an indicator of when communication and consultations should be initiated to manage effects. Category B are based on DIN 4150 building damage criteria for daytime.

Table 3-5: Auckland Transport Construction vibration criteria

Vibration Level	Effect	Category A	Category B
Occupied Activities sensitive to noise	Night-time 2000h – 0630	0.3mm/s ppv	2mm/s ppv
	Daytime 0630h – 2000h	2mm/s ppv	5mm/s ppv
Other occupied buildings	Daytime 0630h – 200h.	2mm/s ppv	5mm/s ppv
All other buildings	All other times	Tables 1 and 3 of DIN4150-3:1999	

Where compliance with the vibration standards set out in Table 3-5 is not practicable, and unless otherwise provided for in the CNVMP (refer Section 7.2.1), a schedule (refer Section 7.2.2) will be required.

4 Receiving Environment

4.1 Existing Ambient Environment

Construction noise criteria and assessments are not dependent on existing noise levels. In addition, by the time of construction of the Project, the existing environment in the Project area is likely to have changed due to urbanisation of the area and the ambient conditions would be different. Instead, construction noise must comply with the relevant limits as set out in the AUP:OP taking into account receivers that exist at the time of construction.

4.2 Noise Monitoring Procedure

Noise survey equipment, meteorological conditions, data analysis and results are described below.

The noise monitoring was undertaken in general accordance with the relevant requirements of NZS 6801[1], 6802[2] and 6806. This meant the results could adequately inform both the operational and construction noise assessments, whilst providing a robust baseline dataset for the Project.

A measurement position at 440 Don Buck Road was selected that was free-field to avoid reflections from buildings or extraneous factors which could influence the sound levels, where practicable. Measurement and calibration details required by NZS 6801 are held on file.

The unattended noise monitoring results can be found in Appendix 1. Monitoring was undertaken for approximately 7 days.

4.2.1 Meteorological Conditions

During the surveys, meteorological data was obtained from Auckland, Motat Ews (41351) weather station operated by NIWA. This is the closest station where data was available at an hourly resolution or less.

The meteorological data from this weather station was used to identify periods when conditions were likely to have been outside the meteorological restrictions given in NZS 6801, and therefore data measured during these periods has been excluded from the noise analysis.

4.2.2 Data Analysis

Road traffic was the dominant noise source with birdsong clearly audible. There is a natural variation in the noise environment throughout the day, and often variations for the weekends. Each day's data was analysed, and abnormal events excluded. A summary of the measured noise levels has been included in Table 4-1. The times in the table reflect the key periods for construction noise as assessed against the criteria in section 3.2.1.

[1] New Zealand Standard 6801:2008 Acoustics – Measurement of environmental sound

[2] New Zealand Standard 6802:2008 Acoustics – Environmental noise

Table 4-1: Summary of measured noise levels

Date	Time Periods	LA_{eq} (dB)	LA_{max} (dB)	LA_{90} (dB)
19/11/19	7:30 – 18:00	60	81	54
	18:00 – 20:00	61	90	52
	20:00 – 06:30	57	86	38
20/11/19	06:30 – 7:30	62	81	57
	7:30 – 18:00	63	98	54
	18:00 – 20:00	61	88	54
	20:00 – 06:30	58	88	39
21/11/19	06:30 – 7:30	63	80	57
	7:30 – 18:00	64	95	56
	18:00 – 20:00	62	90	54
	20:00 – 06:30	58	89	41
22/11/19	06:30 – 7:30	62	78	57
	7:30 – 18:00	62	88	55
	18:00 – 20:00	63	92	54
	20:00 – 06:30	56	87	38
23/11/19	06:30 – 7:30	59	77	45
	7:30 – 18:00	61	96	51
	18:00 – 20:00	58	75	48
	20:00 – 06:30	54	80	33
24/11/19	06:30 – 7:30	55	78	38
	7:30 – 18:00	59	83	48
	18:00 – 20:00	59	82	48
	20:00 – 06:30	58	94	36
25/11/19	06:30 – 7:30	61	83	55
	7:30 – 18:00	62	94	53
	18:00 – 20:00	65	105	50
	20:00 – 06:30	57	85	37
26/11/19	06:30 – 7:30	61	81	57
	7:30 – 18:00	62	95	53
	18:00 – 20:00	60	89	52
	20:00 – 06:30	58	84	41
27/11/19	06:30 – 7:30	61	78	56
	7:30 – 18:00	61	97	54

	18:00 – 20:00	63	92	52
	20:00 – 06:30	58	88	40
28/11/19	06:30 – 7:30	61	80	56
	7:30 – 18:00	64	95	55

Measurements show that Don Buck Road noise levels are dominated by traffic and are already currently relatively high which is expected of an urban area.

5 Indicative Construction Methodology

An indicative construction methodology has been prepared to inform the assessment of the Project and, while subject to change, assists in determining the envelope of effects. An overview of the indicative construction methodology is set out in the AEE. The final construction methodology for the Project will be confirmed during the detailed design phase and finalised once a contractor has been engaged for the work.

A summary of the key components of the indicative construction methodology relevant for this report is outlined in the sub-sections below.

5.1 General Construction Overview

It is anticipated that the works will be broken down into separate construction stages based on the type of works required and the nature of the work environment. These anticipated stages are:

- **Stage 1**: Baker Lane from Fred Taylor Drive to the Dunlop Road intersection
- **Stage 2**: Dunlop Road from Fred Taylor Drive to the E-W Project junction
- **Stage 3**: E-W Project from Dunlop Road junction to Red Hills Road
- **Stage 4**: N-S Project from Don Buck Road to E-W Project

The expected duration for each stage ranges from 1.5 years to 3 years.

5.2 Indicative Construction Methodology

Each zone's specific construction activities will vary based on the type of work needing to be undertaken and the surrounding environment. However, in all cases the general sequence of construction is anticipated to be:

1. Bulk earthworks over summer months
2. Divert or remove services
3. Construct permanent and temporary stormwater drainage and controls
4. Move traffic away from works longitudinally (on live roads)
5. Construct earthworks and retaining structures and if applicable bridges
6. Construct new longitudinal drainage
7. Construct new pavement to half of the road
8. Move traffic onto newly constructed pavement (on live roads)
9. Complete longitudinal drainage
10. Complete pavement and median
11. Move traffic to new alignment (on live roads)
12. Complete footpath and cycleway

Please refer to the AEE for further details.

Relevant to this report, a proposed access to the site for Stage 4 will be off Don Buck Road opposite Royal Road, or via a local accessway off Red Hills Road at the southern end of the Project site (23 Red Hills Road, Massey).

5.3 Plant and Equipment

For the purposes of this report, Table 5-1 provides an indicative list of plant and equipment which may be required for construction across all stages of the Project.

Table 5-1: Redhills Arterial Transport Network plant and equipment summary

Construction Type	Construction Activity
Typical across all works	• Site and worker facilities • Light vehicles • Hiab truck (i.e. crane truck) • Small handheld tools and plant
Clearing	• 20T excavator • Mulcher • Tandem tipper
Overhead line relocation	• Line crew • Elevated work platform or cherry picker • Directional drilling equipment
Bulk Earthworks	• 30T excavator • 20T excavator • Compactor/Sheepsfoot roller • Water cart • Tippers/Articulated dump trucks
Drainage	• 20T excavator • Trench shields • Tandem tipper • Loader • Plate compactor
Pavement Construction	• Grader • Smooth drum roller • Tandem tippers • Kerbing machine • Plate compactor • Paver

5.4 Removal of Buildings

Based on the indicative construction area maps, it has been confirmed that the following properties will be demolished to make room for the Project and therefore these have not been considered in the construction assessment:

- 1 Royal Road
- 2 Royal Road
- 4 Royal Road
- 6 Royal Road
- 443 Don Buck Road
- 445 Don Buck Road
- 456 Don Buck Road
- 458A Don Buck Road

- 460 Don Buck Road
- 23 Red Hills Road
- 68 Fred Taylor Drive
- 1 Dunlop Road
- 25 Red Hills Road

6 Assessment Methodology

Predictions of construction noise have been undertaken for the Project in accordance with NZS 6803, and vibration emission radii determined, based on assumptions of construction type, activities and equipment as provided by the Project team as set out in section 5 of this report. The proposed designation boundary has been assumed as the construction boundary and a reasonable worst-case approach has been applied to assessing the level of effect from the predicted construction noise and vibration emission radii.

Affected receivers have been identified using construction noise setback distances and vibration emission radii. The construction noise setback distances and vibration emission radii were used to determine where any potential construction noise and vibration exceedances of the relevant criteria could occur. Potential effects of construction noise and vibration have then been assessed and construction management and mitigation measures identified where appropriate.

This report proposes a framework for construction noise and vibration management such that the most effective and practicable methods for mitigation will be planned and implemented, taking into account the extent of predicted effects. At the core of this framework is the Construction Noise and Vibration Management Plan (CNVMP) in Section 7.2.1 which will be developed prior to commencement of construction and updated as necessary throughout the duration of construction.

Construction of the Project is likely to occur in stages as urbanisation of the surrounding area occurs or is confirmed to occur. For some parts of the Project, construction could be several years into the future. Therefore, receivers are likely to have changed and there could potentially be new receivers in the vicinity of the Project due to increased development. Construction noise and vibration levels will therefore need to be re-considered when the CNVMP is prepared to take account of these receivers also.

6.1 Construction Noise

Construction of the Project is split between four zones as described in section 2.3 of this report with construction activities in each zone expected to last for a minimum of 12 months.

Predictions for the Project have been assessed against the “long-duration” noise criteria for works greater than 20 weeks under NZS6803:1999 as presented in Table 3-1 and Table 3-2. It is expected the majority of noisy works will be carried out between 7am – 6pm on weekdays with some night time and weekend works for the pavement and surfacing stage as required, especially to tie in to the existing network.

Various construction activities and pieces of equipment will act as noise sources on site during construction works. A list of the most dominant noise sources based on the equipment list provided by the Project team have been compiled in **Error! Reference source not found.** and an indicative sound power level for each construction type/activity has been provided in **Error! Reference source not found.**. Given construction will occur in the future, the current methodology may not be inclusive of all equipment used nearer the time of construction. Equipment tables will need to be updated to reflect selection at the development of the management plan. The minimum set back distance required from receivers for each activity to comply with the day-time noise criterion of 70 dB LA_{eq} without any mitigation has also been calculated.

6.1.1 Equipment Noise Levels

Table 6-1**Error! Reference source not found.** details the sound power levels from the equipment with the most likely significant noise sources and the various receiver setback distances required to achieve compliance with the 70 dB LA_{eq} day time noise criterion without any mitigation. The noise data has been taken from British Standard 5228-1:2009 "*Code of practice for noise and vibration control on construction and open sites*", manufacturers data or the AECOM database of noise measurements.

Table 6-1: Construction equipment sound levels and indicative compliance distance

Equipment	Source BS5228	Sound power level (dB LA_{eq})	Minimum set back distance from receivers to comply with day-time limit (70 dB LA_{eq}) without mitigation, meters
30T excavator	C.2.19	105	22
20T excavator	C.2.21	99	11
Roller Compactor	C.2.40	101	14
Tipper Truck	C.2.30	107	28
Bulldozer	C.5.14	114	63
Plate Compactor	C.5.29	110	40
Smooth Drum Roller	C.5.20	103	20
Paver	C.5.30	103	20

Table 6-2**Error! Reference source not found.** details the sound power levels from key construction activities/types. The equipment sound power levels in **Error! Reference source not found.** have been combined according to the various construction types as presented in Table 5-1 to provide an indicative activity sound power level. From this combined level a minimum set back distance at which compliance can be achieved has been determined.

Table 6-2: Activity sound power levels and indicative compliance distance

Construction Type	Activity Sound power level (dB LA_{eq})	Minimum set back distance from receivers to comply with day-time limit (70 dB LA_{eq}) without mitigation, meters
Typical across all works	110	40
Clearing	113	56
Overhead Line relocation	93	10
Bulk Earthworks	115	71
Drainage	117	90
Pavement construction	117	90

6.2 Construction Vibration

Vibration generation and propagation is highly site specific. The generation of vibration is dependent on the local site geology, the equipment being used, the nature of the works, and even the operator.

To account for the inaccuracy in the prediction of vibration, the likely worst-case vibration has been calculated based on the equipment and hard ground geology.

Vibration from a source transmits in a spherical pattern and reduces with distance. There will be a particular distance from each source at which the vibration level equals the relevant vibration criteria. This distance is called the 'emission radius'. The vibration criteria and emission radii for high vibration generating equipment are detailed in Table 6-3.

Table 6-3: Vibration sources and indicative emission radii

Equipment	Building Damage (DIN 4150) emission radii	
	Residential (5 mm/s)	Commercial (10 mm/s)
Plate Compactor	1 m	1 m
Roller Compacter	8 m	4 m
Excavator	6 m	2 m
Tipper Truck	1 m	0.5 m

We recommend that vibration measurements are undertaken at specific locations as identified through the CNVMP and schedules at the commencement of construction activities to establish vibration propagation site laws for vibration generating equipment. This approach will confirm the emission radii used in this assessment and ensure the applicable criteria are complied with. It has been found on other major construction projects, that the measured vibration levels for a particular activity are much lower than those predicted during the assessment stage.

7 Overview of Construction Effects and Mitigation

7.1 Overview of Construction Effects

Potential construction noise and vibration effects are summarised in this section.

7.1.1 Construction noise

Table 7-1 gives examples of the potential effects on receivers at different noise levels based on NZS6803 with most exposed façades providing a 20 dB reduction. Depending on the construction of the house, facades may provide up to a 25 – 30 dB reduction, therefore assumptions and effects provided below are based on a conservative approach.

Table 7-1: Potential construction noise effects on receivers

External Noise Level	Potential Daytime Effects Outdoors	Corresponding Internal Noise Level	Potential Daytime Effects Indoors
65 dB LA_{eq}	Conversation becomes strained, particularly over longer distances	45 dB LA_{eq}	Noise levels would be noticeable but unlikely to interfere with residential or office daily activities.
65 to 70 dB LA_{eq}	People would not want to spend any length of time outside, except when unavoidable through workplace requirements	45 to 50 dB LA_{eq}	Concentration would start to be affected. TV and telephone conversations would begin to be affected.
70 to 75 dB LA_{eq}	Businesses that involve substantial outdoor use (for example garden centres such as Bunnings) would experience considerable disruption.	50 to 55 dB LA_{eq}	Phone conversations would become difficult. Personal conversations would need slightly raised voices. Office work can generally continue, but 55 dB is considered by the experts to be a tipping point for offices. For residential activity, TV and radio sound levels would need to be raised.
75 to 80 dB LA_{eq}	Some people may choose protection for long periods of exposure. Conversation would be very difficult, even with raised voices.	55 to 60 dB LA_{eq}	Continuing office work would be extremely difficult and become unproductive. In a residential context, people would actively seek respite.
80 to 90 dB LA_{eq}	Hearing protection would be required for prolonged exposure (8 hours at 85 dB) to prevent hearing loss.	60 to 70 dB LA_{eq}	Untenable for both office and residential environments. Unlikely to be tolerated for any extent of time.

With effective management of construction activities, which includes consultation and communication with affected parties and scheduling noisy works during the daytime rather than night-time period,

noise levels can be controlled so that the effects on the nearest residential receivers are reduced. Barriers will not be effective at all locations, particularly where receivers are more than one storey. Where barriers are not going to be effective, the use of enclosures or local screening of equipment should be considered and implemented, where practicable. If noisy activities must take place during the night-time, and screening or other mitigation measures do not provide sufficient attenuation to meet the night-time noise criteria or are not practicable, it may be necessary to offer temporary relocation to affected residents. Temporary relocation should be considered on a case-by-case basis and as a last resort.

7.1.2 Construction Vibration

The vibration effects associated with construction of the Projects are considered in terms of human response and building damage. However, in our experience the main concern for building occupants during construction is damage to the building itself.

Humans can generally perceive vibrations at a much lower level than when building damage is likely to occur. The adverse effects of construction vibration on building occupants may be significant in some buildings adjacent to the areas of works. Adverse effects may range from annoyance to loss of amenity or inability to carry out work. Vibration effects will reduce with distance from the source, and the level of vibration transmission into a building will depend on a number of factors, such as the foundation type and building construction.

Potential effects and human perception of the vibration levels found within the AUP:OP/DIN criteria have been combined below and adopted for this assessment.

Table 7-2: Potential vibration effects on human perception summary against AUP:OP/DIN criteria

External Noise Level	Potential Daytime Effects Outdoors
0.14 mm/s	The threshold of perception for stationary people. Just perceptible in particularly sensitive environments.
0.3 mm/s	Can be just perceptible during normal residential activities, particularly for more sensitive receivers. Levels above may wake most people from their sleep. This is the AUP:OP limit for construction vibration generated at night-time for sensitive receivers.
1 mm/s	Is typically tolerable with prior notification. Complaint or adverse reaction is likely in office or residential environments, particularly if there is no prior warning. What people actually feel would be subject to the source but could include a steady vibration from sources such as vibratory compaction, or a small jolt such as from the movement of a large digger either of which could rattle crockery and glassware. Sleep disturbance would be almost certain for most people.
2 mm/s	Vibration would clearly be felt. However, it can typically be tolerated in indoor environments such as offices, houses and retail if it occurs intermittently during the day and where there is effective prior engagement. Effects experienced would be somewhere between levels of 1 and 5 mm/s.

	This is the AUP:OP limit for large construction projects generating vibration.
5 mm/s	Unlikely to be tolerable in a workplace. Highly unsettling for both workplaces and dwellings. If exposure is prolonged, some people may want to leave the building Computer screens would shake and items could fall off shelves if they are not level. This is the threshold below which no cosmetic damage will occur in the DIN standard.
10 mm/s	Likely to be intolerable for anything other than a very brief exposure.

The AUP:OP sets the criteria for amenity at 0.3mm/s for night time and 2 mm/s during the day. Based on the worst-case source of a roller compactor, any receiver within a 21m radius of the construction area may experience vibration of 2 mm/s inside their property. Whilst at this level building damage is highly unlikely to occur, human perception may result in slight concerns but can generally be tolerated if activity occurs intermittently and with prior notice.

At 0.3 mm/s the emission radii could be up to 140m from construction areas, and at this level people could feel slight vibrations especially during the night-time, which may cause sleep disturbance. High vibratory activities should therefore be avoided, where practicable, during the night-time and careful management of the type of equipment used at night should be included within the CNVMP (refer Section 7.2.1)

Construction vibration effects generally have a short timeframe, typically a few days at a time. The use of high vibratory equipment, such as a roller compactor, should be controlled through a CNVMP to limit potential vibration effects, and alternative equipment with lower vibratory effect should be used where practicable.

7.2 Recommended Measures to Avoid, Remedy or Mitigate Construction Effects

7.2.1 Construction Noise and Vibration Management Plan

Implementing noise management and mitigation measures via a CNVMP is the most effective way to control construction noise and vibration impacts. The objective of the CNVMP should provide a framework for the development and implementation of best practicable options to avoid, remedy or mitigate the adverse effects on receivers of noise and vibration resulting from construction.

E25.6.29(5) sets out the minimum level of information that must be provided in a CNVMP. Accordingly, as a minimum, we recommend that the CNVMP should include the following content:

- Description of the works and anticipated equipment/processes;
- Hours of operation, including times and days when construction activities would occur;
- The construction noise and vibration standards for the Projects;
- Identification of receivers where noise and vibration standards apply;
- A hierarchy of management and mitigation options, including any requirements to limit night works and works during other sensitive times, including Sundays and public holidays as far as practicable;
- Methods and frequency for monitoring and reporting on construction noise and vibration;

- Updates of the predicted noise and vibration levels based on the final methodology and construction activities;
- Confirmation of which buildings will be included in a pre and post building condition survey;
- Identification of appropriate monitoring locations for receivers of construction noise and vibration;
- Procedures to respond to complaints received on construction noise and vibration, including methods to monitor and identify noise and vibration sources;
- Procedures for responding to monitored exceedances; and
- Procedures for monitoring construction noise and vibration and reporting to the Auckland Council Consent Monitoring officer.
- Procedures for maintaining contact with stakeholders, notifying of proposed construction activities, the period of construction activities, and handling noise and vibration complaints;
- Contact details of the Project Liaison Person;
- Procedures for the regular training of the operators of construction equipment to minimise noise and vibration as well as expected construction site behaviours for all workers;
- Identification of areas where compliance with the noise and/or vibration standards will not be practicable and the specific management controls to be implemented and consultation requirements with owners and occupiers of affected sites;
- Procedures and requirements for the preparation of a Schedule to the CNVMP (Schedule) for those areas where compliance with the noise and/or vibration standards will not be practicable and where sufficient information is not available at the time of the CNVMP to determine the area specific management controls; and
- Procedures and timing of reviews of the CNVMP.

The construction noise and vibration level predictions will be confirmed at the time the CNVMP is prepared.

7.2.2 Schedules

In addition to a CNVMP, it may be necessary to produce Site Specific or Activity Specific Construction Noise and Vibration Management Schedules (“Schedules”) where noise and/or vibration limits are predicted to be exceeded for a more sustained period or by a large margin. A schedule to the CNVMP provides a specific assessment of an activity and/or location and should include details such as:

- Activity location, start and finish dates;
- The nearest neighbours to the activity;
- A location plan;
- Predicted noise/vibration levels and BPO mitigation for the activity and/or location;
- Communication and consultation with the affected neighbours;
- Location, times and type of monitoring; and
- Any pre-condition survey of buildings predicted to receive vibration levels exceeding the Category B criteria, which document their current condition and any existing damage.

7.2.3 Noise mitigation measures

A hierarchy of mitigation measures will be adopted through the CNVMP and Schedules (where produced), as follows:

- Managing times of activities to avoid night works and other sensitive times;
- Liaising with neighbours so they can work around specific activities;

- Selecting equipment and methodologies to restrict noise;
- Using screening/enclosures/barriers; and
- Offering neighbours temporary relocation.

By following this hierarchy, the BPO for mitigation will be implemented, whilst avoiding undue disruption to the community. In particular, temporary relocation of neighbours can cause significant inconvenience and should only be offered where other options have been exhausted and noise levels still require mitigation.

Some activities are likely to be set back a considerable distance from the nearest receivers and require very little or no mitigation to achieve compliance with the relevant Project noise limits. Alternative methodologies, careful equipment selection and use of noise barriers or localised screening (e.g. for concrete cutting) would be suitable management and mitigation measures and should be implemented where they are practicable and effective.

7.2.4 Vibration mitigation

Similar to noise, a hierarchy of vibration mitigation measures will be adopted through the CNVMP and Schedules (where produced) as follows:

- Managing times of activities to avoid night works and other sensitive times (communicated through community liaison);
- Liaising with neighbours so they can work around specific activities;
- Operating vibration generating equipment as far from sensitive sites as possible;
- Selecting equipment and methodologies to minimise vibration;
- Offering neighbours temporary relocation; and
- In specific situations, a cut-off trench may be used as a vibration barrier if located close to the source.

In general, there are less options available to mitigate vibration propagation and insulate receiver buildings, compared to noise. Mitigation will therefore focus on scheduling of activities, effective communication with neighbours, and selection of appropriate equipment and methods, where practicable.

Appropriate vibration mitigation measures for each activity will be listed in the CNVMP and Schedules (where produced).

7.2.5 Building Condition Survey

A detailed building precondition survey should be undertaken by a suitably qualified engineer prior to the start of construction at all buildings where the daytime Category B criteria may be exceeded. The survey shall include, but not be limited to, the following:

- Determination of building classification: commercial, industrial, residential or a historic or sensitive structure;
- Determination of building specific vibration damage risk thresholds; and
- Recording (including photographs) the major features of the buildings including location, type, construction (including foundation type), age and present condition, including existing levels of any aesthetic damage or structural damage.

A post-construction condition survey of the same buildings shall be conducted when construction is completed, and any damage shown to have been caused by the Project construction rectified by the Project Team.

7.2.6 Night Works

Night works have the potential to cause the greatest disturbance to residents and should be avoided where possible. However, it is possible that night works will be required during the construction period for critical activities. Before night works are programmed, it is important to determine if there are alternative options that would avoid working at night and, if so, whether those options are technically and practicably feasible.

Where there are no practicable alternative options to night works, it may be necessary to implement enhanced noise and vibration management measures, but this will depend on the location of the worksite and the proposed activities.

When work must be carried out at night, it may be necessary to:

- Increase the frequency of communications with stakeholders;
- Carry out regular noise and vibration monitoring to confirm noise and vibration levels; or
- Offer temporary relocation to neighbours if unreasonable noise and/or vibration levels cannot be avoided.

8 NoR 1: Redhills North-South Arterial Corridor

8.1 Existing and Likely Future Environment

8.1.1 Planning Context

Within the Project area there are a range of zones under the AUP:OIP which influence the existing and likely future land use patterns for assessment purposes.

Table 8-1 below provides a summary of the existing and likely future environment as it relates to the North-South Arterial Corridor within the RATN.

Table 8-1: North-South Arterial Corridor Existing and Likely Future Environment

Land use today	Zoning	Likelihood of Change for the environment[3]	Likely Future Environment[4]
Rural	Residential – Mixed Housing Suburban	High	Urban
	Residential – Mixed Housing Urban		
	Residential - Terrace Housing and Apartment Building Zone		
	Business - Local Centre Zone		
Residential	Business - Local Centre Zone	Moderate	Urban
	Residential – Mixed Housing Urban	Low	
	Residential - Terrace Housing and Apartment Building Zone		
Business	Business - Local Centre Zone	Low	Urban
Special Purpose	Special Purpose - School Zone	Low	Special Purpose

Please refer to the AEE for further information on the planning context.

[3] Based on AUP:OP zoning/policy direction

[4] Based on AUP:OP zoning/policy direction

8.1.2 Noise Environment

The works will take place within rural and suburban environments, with some dwellings located close to the road corridor along Don Buck Road. The existing noise environment is dominated by road traffic noise from vehicles on Don Buck Road and the surrounding road network.

8.2 Assessment of Construction Noise and Vibration Effects

8.2.1 Construction Noise Effects

Receivers are located at varying distances from the construction boundary along the alignment with the closest existing receiver being 2m from the alignment.

Receivers within 90m of the works could experience unmitigated noise levels that exceed the daytime noise criterion during high noise generating activities such as the pavement works. Based on the footprint of the designation boundary, this would correspond to 191 existing dwellings that could experience noise levels above the 70 dB LA_{eq} daytime noise criterion.

The exclusion zone distance reduces to 28m with noise barriers implemented effectively around working sites. This would correspond to 114 existing dwellings that could experience noise levels above the daytime 70 dB LA_{eq} daytime noise criterion.

We note that the existing receivers may not be present at the time of construction.

With mitigation in place, as set out in section 7.2, noise levels of up to 90 dB LA_{eq} could still occur intermittently at the closest receivers, if high noise generating activities occur on the construction boundary. At this level effects could include loss of concentration, annoyance, and a reduction in speech intelligibility.

Operation of construction equipment will be intermittent in nature. Construction will be linear so as the equipment moves away from the receiver noise levels will reduce. The worst-case situations, where mitigated noise levels could reach 90 dB LA_{eq} at the closest receivers, are not expected to be frequent, due to the setback distances to the majority of the proposed works and the use of equipment with lower source noise levels for large portions of the works. It is therefore predicted that mitigated noise levels can comply with the 70 dB LA_{eq} noise criterion for most of the construction works.

If a critical activity has to be carried out during the night-time in close proximity to residential receivers, consultation and mitigation measures will be essential. The use of noisy equipment should be avoided, where practicable, to prevent sleep disturbance. Any night-time works are likely to be limited in duration and will be managed through the CNVMP (as per Section 7.2.1) and a Schedule (as per Section 7.2.2).

Provided that the works are mitigated and managed through the CNVMP and Schedules at the time of construction, we consider that noise effects from construction works as currently planned will be reasonable.

8.2.2 Construction Vibration Effects

If the roller compactor is used at the edge of the construction boundary, dwellings within 8m of the works and commercial buildings within 4m of the works may experience vibration levels above the daytime Category B criterion, if the roller compactor is used on the construction boundary in the closest position to them. Based on the designation boundary footprint, 73 existing dwellings may experience vibration levels up to 5 mm/s.

Once the compactor is 8m away from the dwellings and 4m from commercial buildings the Category B criterion will be met. The Category B criteria would be met at future residential structures that are 8m or more from the proposed works and commercial structures that are 4m or more from the proposed works.

At buildings in close proximity to the proposed works, there is the potential for cosmetic damage to buildings (such as cracking) and annoyance from perception of vibration. Buildings where the daytime Category B criteria may be exceeded must be identified at the time of construction, and pre-condition surveys must be carried out at these buildings.

The Category A vibration amenity criteria could be exceeded in existing or future buildings if they are occupied during the works and within 21m of the roller compactor or within the emission radii identified for the other vibration generating equipment in Table 6-3. The effect on receivers would be subject to their respective proximity to the works but could include steady vibration from the roller compactor or a small jolt from a digger which could rattle crockery and glassware.

Vibration can typically be tolerated inside buildings if it occurs intermittently during the day, is of limited duration and where there is effective prior engagement.

High vibration generating activities should not occur during the night-time in close proximity to residential receivers to avoid sleep disturbance, unless it is a critical activity and there is no alternative.

It should also be noted that the emission radii are conservative and vibration levels measured on site tend to be much lower than those predicted at the NoR stage of a project.

Provided that the works are mitigated and managed through the CNVMP and Schedules at the time of construction, we consider that vibration effects from construction works as currently planned will be reasonable.

8.3 Conclusions

The predicted construction noise and vibration levels are based on indicative information provided by the Project team, as set out in Section 6, and any conclusions in this assessment should be confirmed during the detailed design stage, taking account of the receivers as they exist at the time of construction.

Construction noise and vibration can be mitigated and managed, utilising the measures set out in Section 7.2, to generally comply with the applicable limits as defined in the AUP. Exceedances of the criteria could occur intermittently over a short duration if high noise or vibration generating equipment are used near occupied buildings. Where an exceedance is predicted at any receiver that exists at the time of construction, the effects will be mitigated and managed through the CNVMP and Schedules.

A CNVMP is the most effective way to avoid, remedy or mitigate construction noise and vibration effects on receivers.

9 NoR 2A: Redhills East-West Arterial Corridor – Dunlop Road

9.1 Existing and Likely Future Environment

9.1.1 Planning context

Within the Project area there are a range of zones under the AUP:OIP which influence the existing and likely future land use patterns for assessment purposes.

Table 9-1 below provides a summary of the existing and likely future environment as it relates to the Dunlop Road Corridor within the RATN.

Table 9-1: Dunlop Road Corridor Existing and Likely Future Environment

Land use today	Zoning	Likelihood of Change for the environment[5]	Likely Future Environment[6]
Rural	Residential – Mixed Housing Urban	High	Residential
	Residential – Terraced Housing and Apartment Zone		
	Business – Town Centre		
Business	Business - Mixed Use Zone	Low	Business
	Business – Light Industry		
Residential	Residential – Mixed Housing Urban	Low	Urban
	Residential – Terraced Housing and Apartment Zone		

Please refer to the AEE for further information on the planning context.

9.1.2 Noise Environment

The works will take place in residential and business zones, with some dwellings located close to the road corridor along Fred Taylor Drive. The existing noise environment is dominated by road traffic noise from vehicles on Fred Taylor Drive and the surrounding road network.

[5] Based on AUP:OP zoning/policy direction

[6] Based on AUP:OP zoning/policy direction

9.2 Assessment of Construction Noise and Vibration Effects

9.2.1 Construction Noise Effects

At the time of writing of this assessment, there were no dwellings identified in proximity of the NoR designation boundary.

However, future dwellings within 90m of the works could experience unmitigated noise levels that exceed the daytime noise criterion during high noise generating activities such as the pavement works. The exclusion zone distance reduces to 28m with noise barriers implemented effectively around working sites.

The extent of effects from construction noise will be dependent on the distance that the dwellings are located from the works. Table 7-1 provides a summary of potential construction noise effects.

Operation of construction equipment will be intermittent in nature. Construction will be linear so as the equipment moves away from the receiver noise levels will reduce. Also, equipment with lower source noise levels than the worst-case will be used for large portions of the works. It is therefore predicted that mitigated noise levels can comply with the 70 dB LA_{eq} daytime noise criterion for most of the construction works at any future receivers.

If a critical activity has to be carried out during the night-time in close proximity to residential receivers, consultation and mitigation measures will be essential. The use of noisy equipment should be avoided, where practicable, to prevent sleep disturbance. Any night-time works are likely to be limited in duration and will be managed through the CNVMP (as per Section 7.2.1) and a Schedule (as per Section 7.2.2).

Provided that the works are mitigated and managed through the CNVMP and Schedules at the time of construction, we consider that noise effects from construction works as currently planned will be reasonable.

9.2.2 Construction Vibration Effects

If the roller compactor is used at the edge of the construction boundary, future dwellings within 8m of the works and commercial buildings within 4m of the works may experience vibration levels above the daytime Category B criterion, if the roller compactor is used on the construction boundary in the closest position to them.

At buildings in close proximity to the proposed works, there is the potential for cosmetic damage to buildings (such as cracking) and annoyance from perception of vibration. Buildings where the daytime Category B criteria may be exceeded must be identified at the time of construction, and pre-condition surveys must be carried out at these buildings.

The Category A vibration amenity criteria could be exceeded in existing or future buildings if they are occupied during the works and within 21m of the roller compactor or within the emission radii identified for the other vibration generating equipment in Table 6-3. The effect on receivers would be subject to their respective proximity to the works but could include steady vibration from the roller compactor or a small jolt from a digger which could rattle crockery and glassware.

Vibration can typically be tolerated inside buildings if it occurs intermittently during the day, is of limited duration and where there is effective prior engagement.

High vibration generating activities should not occur during the night-time in close proximity to residential receivers to avoid sleep disturbance, unless it is a critical activity and there is no alternative.

It should also be noted that the emission radii are conservative and vibration levels measured on site tend to be much lower than those predicted at the NoR stage of a project.

Provided that the works are mitigated and managed through the CNVMP and Schedules at the time of construction, we consider that vibration effects from construction works as currently planned will be reasonable.

9.3 Conclusions

The predicted construction noise and vibration levels are based on indicative information provided by the Project team, as set out in Section 6, and any conclusions in this assessment should be confirmed during the detailed design stage, taking account of the receivers as they exist at the time of construction.

Construction noise and vibration can be mitigated and managed, utilising the measures set out in Section 7.2, to generally comply with the applicable limits as defined in the AUP. Exceedances of the criteria could occur intermittently over a short duration if high noise or vibration generating equipment are used near occupied buildings. Where an exceedance is predicted at any receiver that exists at the time of construction, the effects will be mitigated and managed through the CNVMP and Schedules.

A CNVMP is the most effective way to avoid, remedy or mitigate construction noise and vibration effects on receivers.

10 NoR 2B: Redhills East-West Arterial Corridor – Baker Lane

10.1 Existing and Likely Future Environment

10.1.1 Planning Context

Within the Project area there are a range of zones under the AUP:OIP which influence the existing and likely future land use patterns for assessment purposes.

Table 10-1 below provides a summary of the existing and likely future environment as it relates to the Baker Lane Corridor within the RATN.

Table 10-1: Baker Lane Corridor Existing and Likely Future Environment

Land use today	Zoning	Likelihood of Change for the environment[7]	Likely Future Environment[8]
Rural	Residential – Mixed Housing Urban	High	Urban
	Residential – Terraced Housing and Apartment Zone		
Business	Business - Mixed Use Zone	Low	Business
	Business – Light Industry		
Residential	Residential – Mixed Housing Urban	Low	Urban
	Residential – Terraced Housing and Apartment Zone		
Special Purpose	Special Purpose - School Zone	Low	Special Purpose

Please refer to the AEE for further information on the planning context.

10.1.2 Noise Environment

The works will take place in residential and business zones, with some dwellings located close to the road corridor along Fred Taylor Drive. The existing noise environment is dominated by road traffic noise from vehicles on Fred Taylor Drive and the surrounding road network.

[7] Based on AUP:OP zoning/policy direction

[8] Based on AUP:OP zoning/policy direction

10.2 Assessment of Construction Noise and Vibration Effects

10.2.1 Construction Noise Effects

Receivers are located at varying distances from the construction boundary along the alignment with the closest existing receiver being 30m from the alignment.

Receivers within 90m of the works could experience unmitigated noise levels that exceed the daytime noise criterion during high noise generating activities such as the pavement works. Based on the footprint of the designation boundary, this would correspond to 9 existing dwellings that could experience noise levels above the 70 dB LA_{eq} daytime noise criterion when works are at their closest location to each receiver.

The exclusion zone distance reduces to 28m with noise barriers implemented effectively around working sites, and there are no existing dwellings within this exclusion zone distance from the designation boundary.

We note that the existing receivers may not be present at the time of construction.

Operation of construction equipment will be intermittent in nature. Construction will be linear so as the equipment moves away from the receiver noise levels will reduce. The worst-case situations are not expected to be frequent, due to the setback distances to the majority of the proposed works and the use of equipment with lower source noise levels for large portions of the works. It is therefore predicted that mitigated noise levels can comply with the 70 dB LA_{eq} noise criterion for most of the construction works.

If a critical activity has to be carried out during the night-time in close proximity to residential receivers, consultation and mitigation measures will be essential. The use of noisy equipment should be avoided, where practicable, to prevent sleep disturbance. Any night-time works are likely to be limited in duration and will be managed through the CNVMP (as per Section 7.2.1) and a Schedule (as per Section 7.2.2).

Provided that the works are mitigated and managed through the CNVMP and Schedules at the time of construction, we consider that noise effects from construction works as currently planned will be reasonable.

10.2.2 Construction Vibration Effects

If the roller compactor is used at the edge of the construction boundary, dwellings within 8m of the works and commercial buildings within 4m of the works may experience vibration levels above the daytime Category B criterion, if the roller compactor is used on the construction boundary in the closest position to them. Based on the designation boundary footprint, there are no existing dwellings where the Category B criterion is predicted to be exceeded.

The Category B criteria would be met at any further buildings constructed that are 8m or more from the proposed works and commercial structures that are 4m or more from the proposed works.

At buildings in close proximity to the proposed works, there is the potential for cosmetic damage to buildings (such as cracking) and annoyance from perception of vibration. Buildings where the daytime Category B criteria may be exceeded must be identified at the time of construction, and pre-condition surveys must be carried out at these buildings.

The Category A vibration amenity criteria could be exceeded in existing or future buildings if they are occupied during the works and within 21m of the roller compactor or within the emission radii identified for the other vibration generating equipment in Table 6-3. The effect on receivers would be subject to their respective proximity to the works but could include steady vibration from the roller compactor or a small jolt from a digger which could rattle crockery and glassware.

Vibration can typically be tolerated inside buildings if it occurs intermittently during the day, is of limited duration and where there is effective prior engagement.

High vibration generating activities should not occur during the night-time in close proximity to residential receivers to avoid sleep disturbance, unless it is a critical activity and there is no alternative.

It should also be noted that the emission radii are conservative and vibration levels measured on site tend to be much lower than those predicted at the NoR stage of a project.

Provided that the works are mitigated and managed through the CNVMP and Schedules at the time of construction, we consider that vibration effects from construction works as currently planned will be reasonable.

10.3 Conclusions

The predicted construction noise and vibration levels are based on indicative information provided by the Project team, as set out in Section 6, and any conclusions in this assessment should be confirmed during the detailed design stage, taking account of the receivers as they exist at the time of construction.

Construction noise and vibration can be mitigated and managed, utilising the measures set out in Section 7.2, to generally comply with the applicable limits as defined in the AUP. Exceedances of the criteria could occur intermittently over a short duration if high noise or vibration generating equipment are used near occupied buildings. Where an exceedance is predicted at any receiver that exists at the time of construction, the effects will be mitigated and managed through the CNVMP and Schedules.

A CNVMP is the most effective way to avoid, remedy or mitigate construction noise and vibration effects on receivers.

11 NoR 2C: Redhills East-West Arterial Corridor – Nixon Road Connection

11.1 Existing and Likely Future Environment

11.1.1 Planning Context

Within the Project area there are a range of zones under the AUP:OIP which influence the existing and likely future land use patterns for assessment purposes.

Table 11-1 below provides a summary of the existing and likely future environment as it relates to the Nixon Road Connection within the RATN.

Table 11-1: Nixon Road Connection Existing and Likely Future Environment

Land use today	Zoning	Likelihood of Change for the environment[9]	Likely Future Environment[10]
Rural	Residential – Single House	High	Urban
	Residential – Mixed Housing Suburban		
	Residential – Mixed Housing Urban		
	Residential – Terraced Housing and Apartment Zone		

Please refer to the AEE for further information on the planning context.

11.1.2 Noise Environment

The existing noise environment is dominated by road traffic noise from the surrounding road network. Although the existing land use is rural, the works could take place in a more urbanised environment, and some future dwellings could be located close to the works.

11.2 Assessment of Construction Noise and Vibration Effects

11.2.1 Construction Noise Effects

Receivers are located at varying distances from the construction boundary along the alignment with the closest existing receiver being 2m from the alignment.

Receivers within 90m of the works could experience unmitigated noise levels that exceed the daytime noise criterion during high noise generating activities such as the pavement works. Based on the footprint of the designation boundary, this would correspond to 8 existing dwellings that could experience noise levels above the 70 dB LA_{eq} daytime noise criterion.

[9] Based on AUP:OP zoning/policy direction

[10] Based on AUP:OP zoning/policy direction

The exclusion zone distance reduces to 28m with noise barriers implemented effectively around working sites. This would correspond to 7 existing dwellings that could experience noise levels above the 70 dB LA_{eq} daytime noise criterion.

We note that the existing receivers may not be present at the time of construction.

With mitigation in place, as set out in section 7.2, noise levels of up to 90 dB LA_{eq} could still occur intermittently at the closest receivers, if high noise generating activities occur on the construction boundary. At this level effects could include loss of concentration, annoyance, and a reduction in speech intelligibility.

Operation of construction equipment will be intermittent in nature. Construction will be linear so as the equipment moves away from the receiver noise levels will reduce. The worst-case situations, where mitigated noise levels could reach 90 dB LA_{eq} at the closest receivers, are not expected to be frequent, due to the setback distances to the majority of the proposed works and the use of equipment with lower source noise levels for large portions of the works. It is therefore predicted that mitigated noise levels can comply with the 70 dB LA_{eq} noise criterion for most of the construction works.

If a critical activity has to be carried out during the night-time in close proximity to residential receivers, consultation and mitigation measures will be essential. The use of noisy equipment should be avoided, where practicable, to prevent sleep disturbance. Any night-time works are likely to be limited in duration and will be managed through the CNVMP (as per Section 7.2.1) and a Schedule (as per Section 7.2.2).

Provided that the works are mitigated and managed through the CNVMP and Schedules at the time of construction, we consider that noise effects from construction works as currently planned will be reasonable.

11.2.2 Construction Vibration Effects

If the roller compactor is used at the edge of the construction boundary, dwellings within 8m of the works and commercial buildings within 4m of the works may experience vibration levels above the daytime Category B criterion, if the roller compactor is used on the construction boundary in the closest position to them. Based on the designation boundary footprint, two existing dwellings (59 Nelson Road and 315 Red Hills Road) may experience vibration levels up to 5 mm/s.

Once the compactor is 8m away from the dwellings and 4m from commercial buildings the Category B criterion will be met. The Category B criteria would be met at future residential structures that are 8m or more from the proposed works and commercial structures that are 4m or more from the proposed works.

At buildings in close proximity to the proposed works, there is the potential for cosmetic damage to buildings (such as cracking) and annoyance from perception of vibration. Buildings where the daytime Category B criteria may be exceeded must be identified at the time of construction, and pre-condition surveys must be carried out at these buildings.

The Category A vibration amenity criteria could be exceeded in existing or future buildings if they are occupied during the works and within 21m of the roller compactor or within the emission radii identified for the other vibration generating equipment in Table 6-3. The effect on receivers would be

subject to their respective proximity to the works but could include steady vibration from the roller compactor or a small jolt from a digger which could rattle crockery and glassware.

Vibration can typically be tolerated inside buildings if it occurs intermittently during the day, is of limited duration and where there is effective prior engagement.

High vibration generating activities should not occur during the night-time in close proximity to residential receivers to avoid sleep disturbance, unless it is a critical activity and there is no alternative.

It should also be noted that the emission radii are conservative and vibration levels measured on site tend to be much lower than those predicted at the NoR stage of a project.

Provided that the works are mitigated and managed through the CNVMP and Schedules at the time of construction, we consider that vibration effects from construction works as currently planned will be reasonable.

11.3 Conclusions

The predicted construction noise and vibration levels are based on indicative information provided by the Project team, as set out in Section 6, and any conclusions in this assessment should be confirmed during the detailed design stage, taking account of the receivers as they exist at the time of construction.

Construction noise and vibration can be mitigated and managed, utilising the measures set out in Section 7.2, to generally comply with the applicable limits as defined in the AUP. Exceedances of the criteria could occur intermittently over a short duration if high noise or vibration generating equipment are used near occupied buildings. Where an exceedance is predicted at any receiver that exists at the time of construction, the effects will be mitigated and managed through the CNVMP and Schedules.

A CNVMP is the most effective way to avoid, remedy or mitigate construction noise and vibration effects on receivers.

12 Conclusion

An assessment of the construction noise and vibration effects has been undertaken for the Projects considering a reasonable worst case scenario. The predicted noise levels and effects are based on indicative information as provided by the Project team and any assessment conclusions should be confirmed at the time the CNVMP is prepared, taking account of the final equipment selections, methodology and receivers as they exist at the time of construction.

Construction noise and vibration can be mitigated and managed, utilising the measures set out in Section 7.2, to comply with the applicable limits for the majority of the works. Exceedances of the criteria could occur intermittently across all NoRs, if high noise or vibration generating equipment is used near occupied buildings.

Night works will be limited to critical activities that cannot be carried out at any other time.

A CNVMP will be prepared prior to construction commencing in accordance with Section 7.2.1 of this report. The CNVMP will provide a framework for the development and implementation of best practicable options to avoid, remedy or mitigate the adverse effects of construction noise and vibration on receivers that exist at the time of construction. The construction noise and vibration level predictions will be confirmed and updated at the time the CNVMP will be prepared. Communication and consultation will occur with the affected receivers and a site specific schedule will be prepared if required.

Elevated noise levels should be avoided and mitigated where possible to reduce the likelihood of adverse effects such as loss of concentration, annoyance and sleep disturbance (for night works).

Whilst vibration levels at the Category A criterion of 2mm/s PPV can generally be tolerated if activity occurs intermittently and with prior notice, communication and consultation will be the key management measure to avoid annoyance and concern. Where vibration levels are predicted to exceed the Category B criteria, and where the construction methodology cannot be changed to reduce vibration levels, building conditions surveys are recommended.

Overall, construction noise and vibration can be controlled for all NoRs (NoRs 1, 2A, 2B and 2C) to reasonable levels with the implementation of appropriate mitigation and management measures.

Appendix 1. Noise Monitoring Results

Noise Logger Report

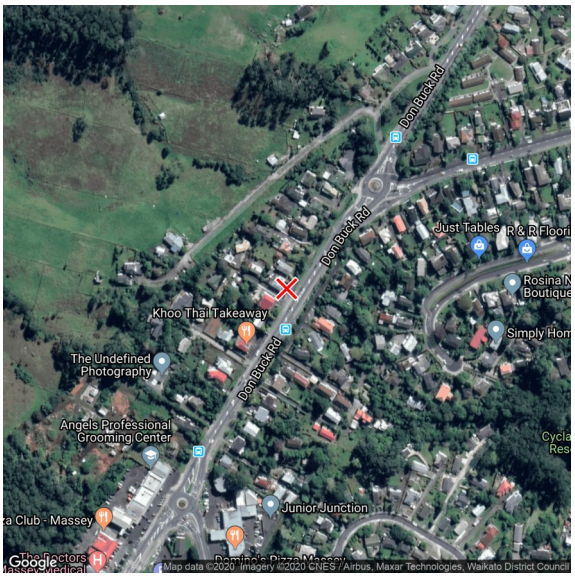
440 Don Buck Road, Whenuapai

Item	Information
Logger Type	Svan
Serial number	20614
Address	440 Don Buck Road, Whenuapai
Location	440 Don Buck Road, Whenuapai
Facade / Free Field	Free field
Environment	road

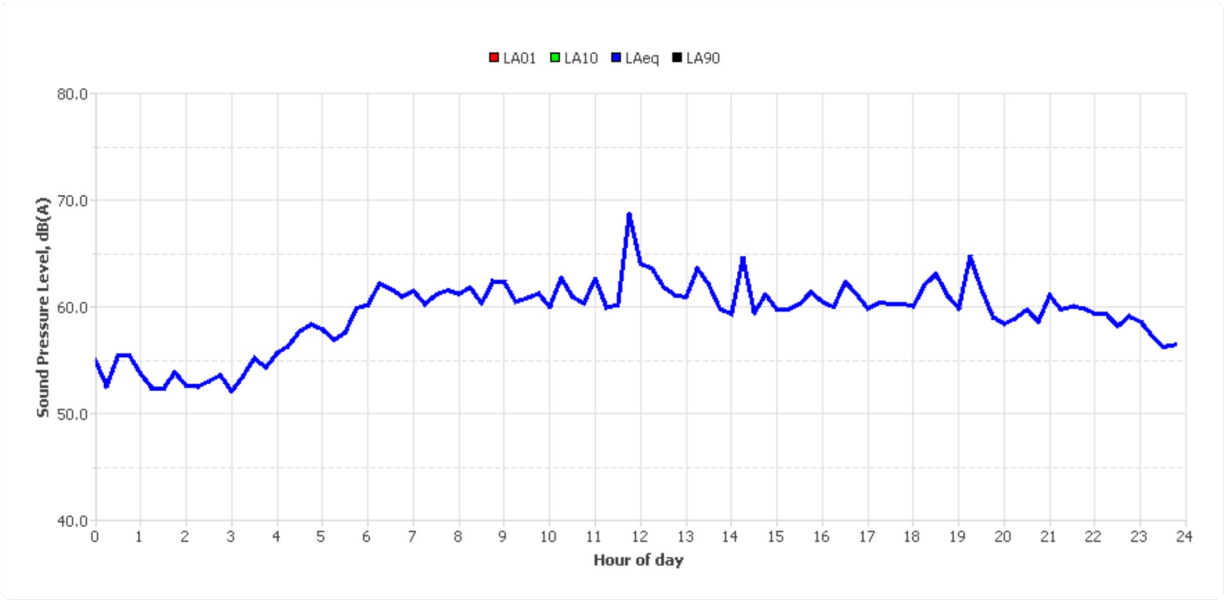
Measured noise levels

Logging Date	L_{Aeq} Day	Eve	Night	ABL Day	Eve	Night	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Tue Nov 19 2019	-	60	56	-	-	-	60	56
Wed Nov 20 2019	62	61	57	-	-	-	62	57
Thu Nov 21 2019	63	61	57	-	-	-	63	57
Fri Nov 22 2019	63	63	57	-	-	-	63	57
Sat Nov 23 2019	62	59	54	-	-	-	61	54
Sun Nov 24 2019	59	58	53	-	-	-	59	53
Mon Nov 25 2019	64	63	58	-	-	-	64	58
Tue Nov 26 2019	62	60	57	-	-	-	62	57
Wed Nov 27 2019	61	62	58	-	-	-	61	58
Thu Nov 28 2019	64	-	57	-	-	-	64	57
Summary	**62**	**61**	**57**	**-**	**-**	**-**	**62**	**57**

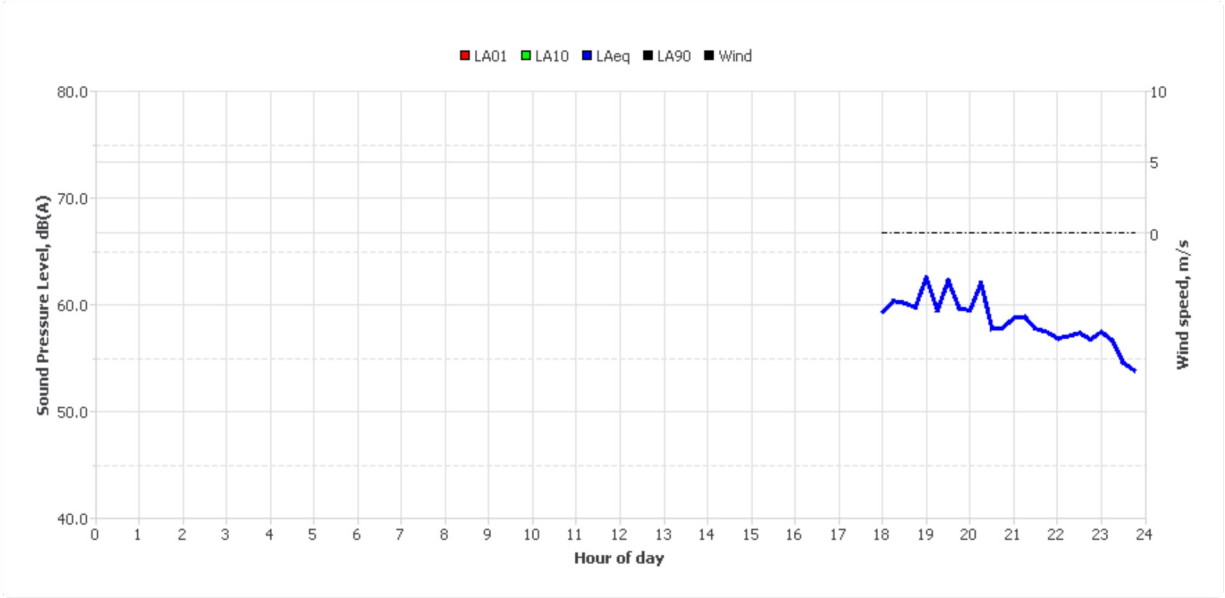
Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location	Logger Deployment Photo
	

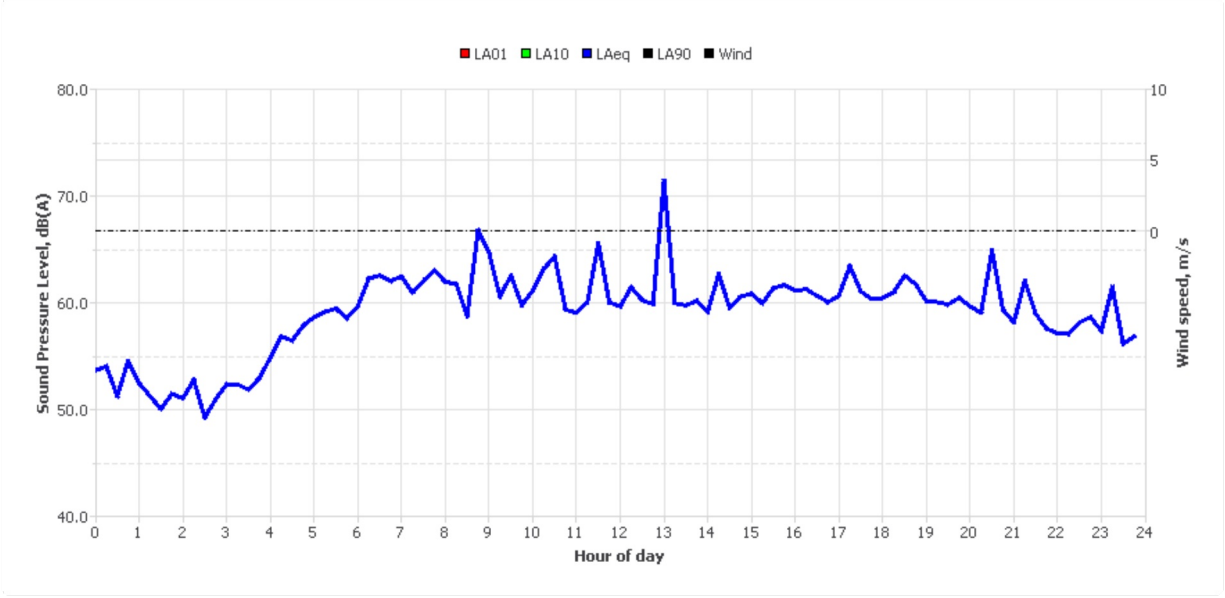
Typical Day



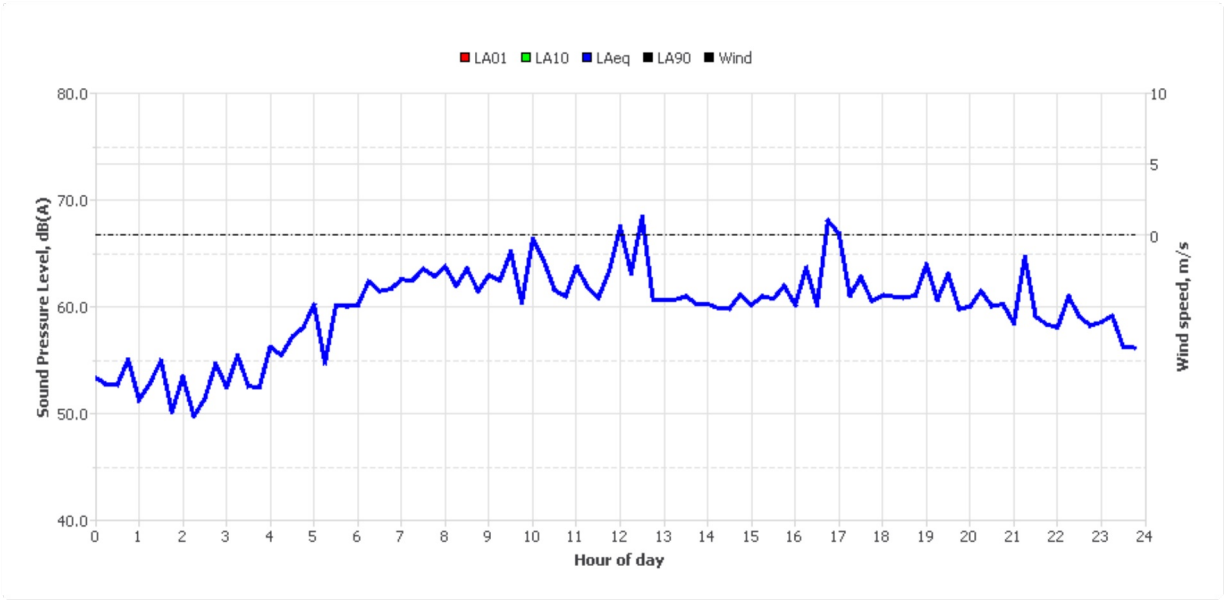
Tuesday, 19 Nov 2019



Wednesday, 20 Nov 2019



Thursday, 21 Nov 2019



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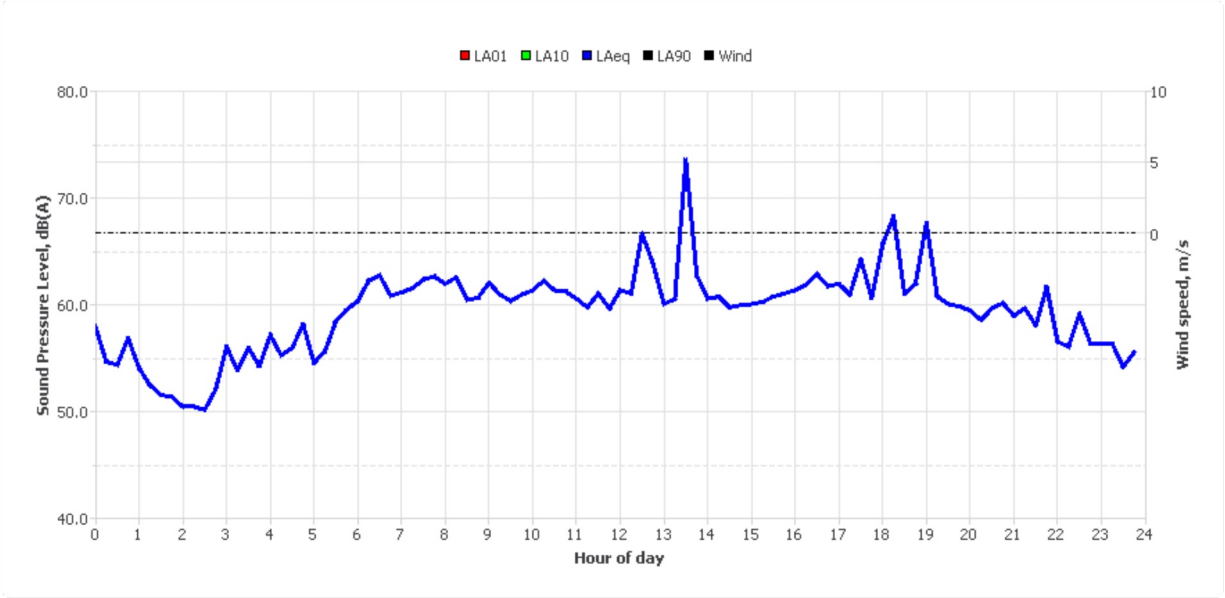
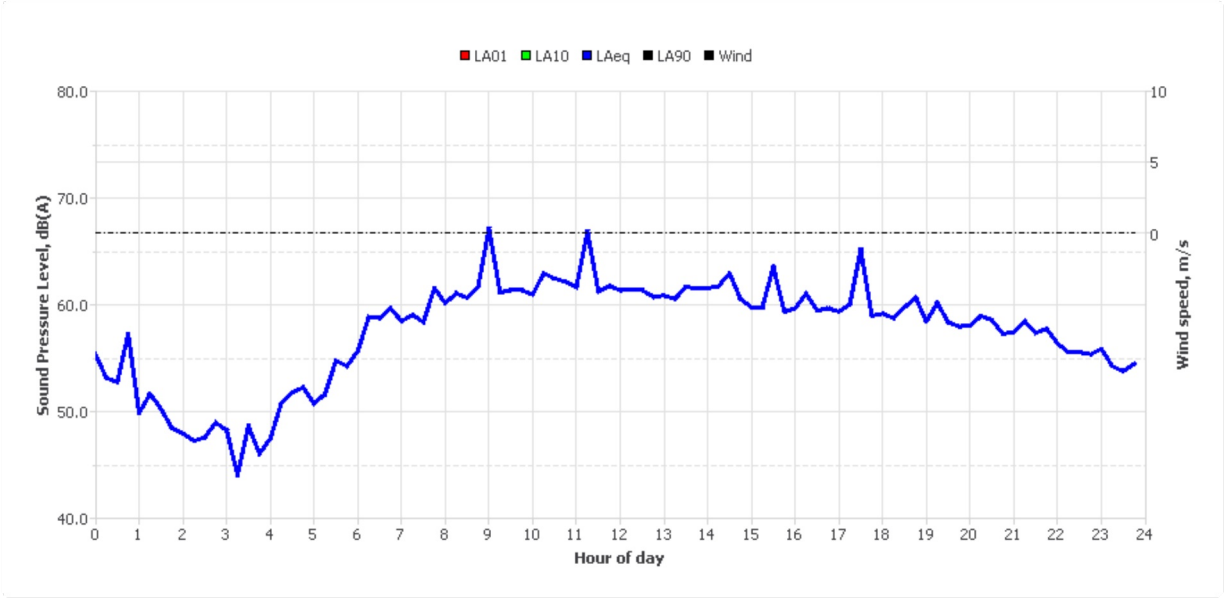
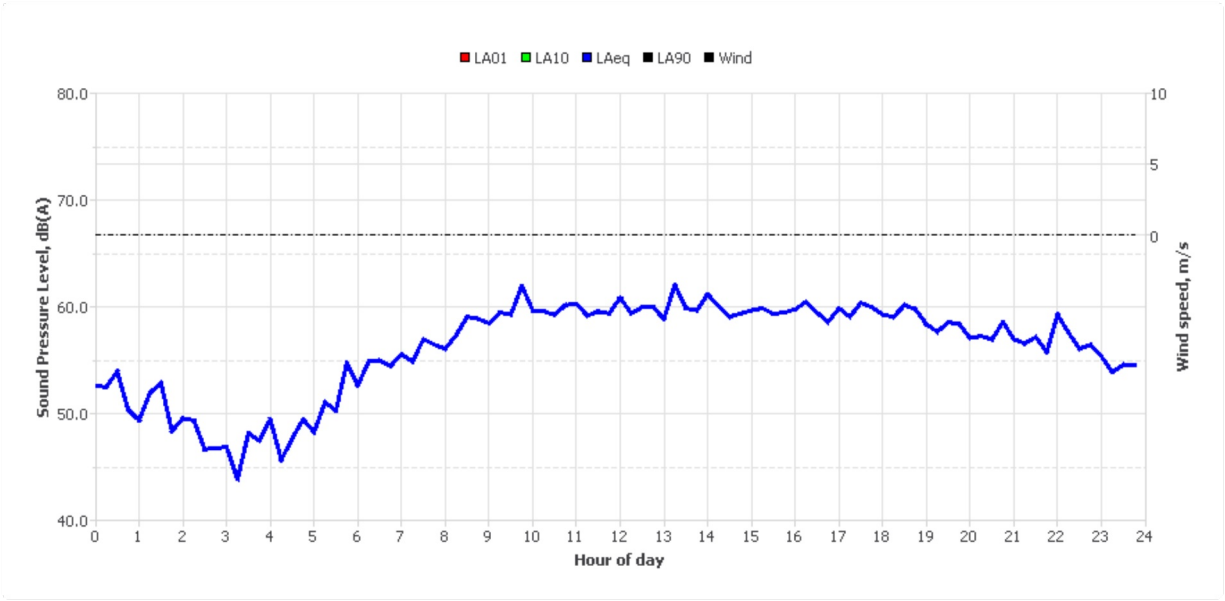


Saturday, 23 Nov 2019



Sunday, 24 Nov 2019



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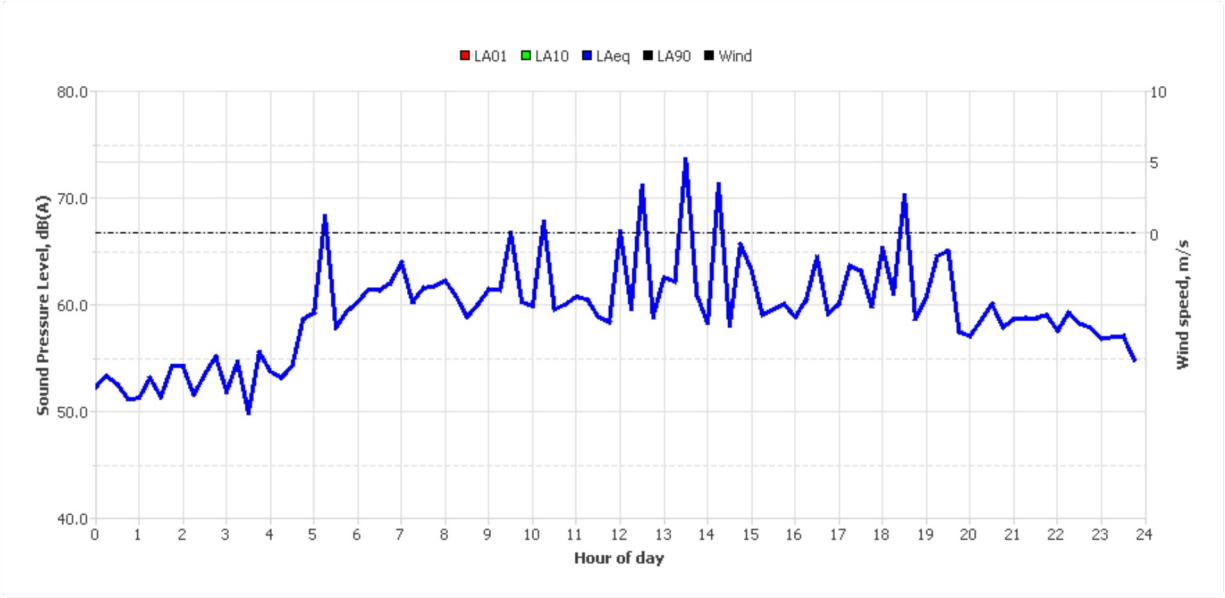
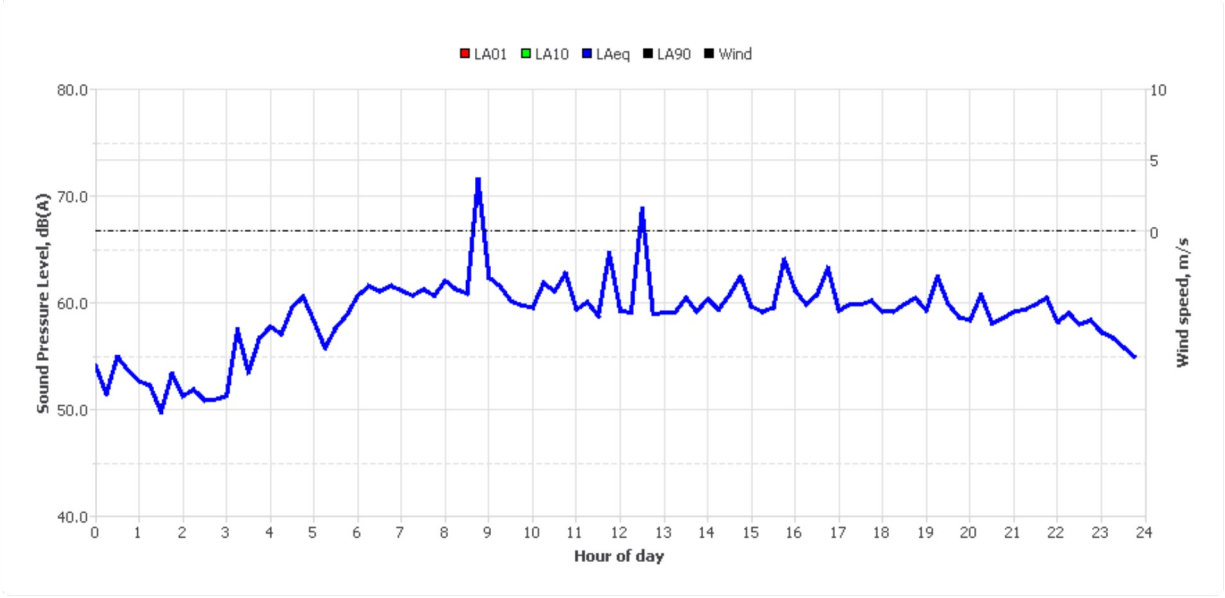
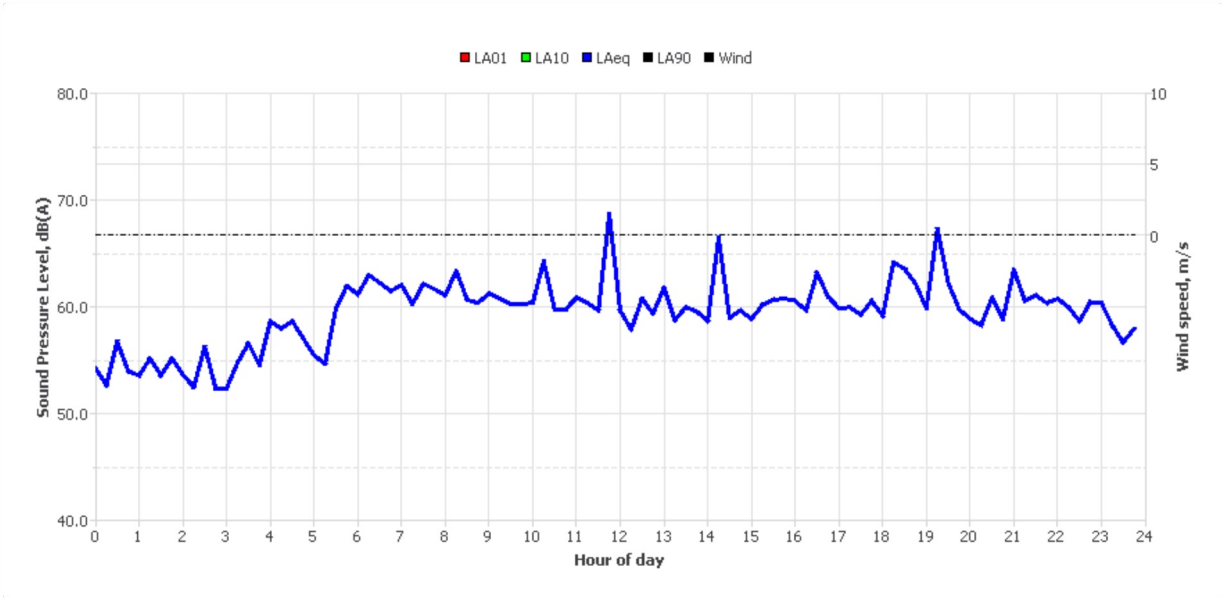


Tuesday, 26 Nov 2019



Wednesday, 27 Nov 2019



Thursday, 28 Nov 2019