Supporting Growth

Trig Road Corridor Upgrade

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
PPC5	Proposed Plan Change 5
Receivers	Noise sensitive areas such as dwellings, hospitals, school and commercial properties
RMA	Resource Management Act 1991
SH18	State Highway 18
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.

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

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 135 existing dwellings that could experience noise levels up to 70 dB LA_{eq}.

The exclusion zone distance reduces to 28m with noise barriers implemented effectively around working sites. This would correspond to 69 existing dwellings that could experience noise levels up to 70 dB LA_{eq}.

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 36 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.

Conclusion

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 2016 (**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 networks needed to support Auckland's future urban growth areas over the next 30 years.

2.2 Purpose of this Report

Trig Road, Whenuapai has been identified in the Supporting Growth Programme as a future arterial corridor that is needed to support the urban development of Whenuapai.

This report has been prepared to support AT's notice of requirement (**NoR**) and application for resource consents for the Trig Road Corridor Upgrade (the **Project**). The NoR under the Resource Management Act 1991 (**RMA**) is to designate land for the construction, operation and maintenance of the Project.

Funding for the upgrade of Trig Road between Hobsonville Road and State Highway 18 (**SH18**) has been made available through the Housing Infrastructure Fund[1]. As there is funding available for construction, AT are also applying for the necessary resource consents under the RMA, concurrently with the NoR process.

This report provides an assessment of noise and vibration effects associated with the construction and operation of the Project. This assessment has been prepared to inform the Assessment of Environmental Effects (**AEE**) for the NoR and resource consent application.

The key matters addressed in this report are as follows:

a. Identify and describe the existing noise environment;

b. Overview of the methodology used to undertake the assessment and identification of the assessment criteria and any relevant standards or guidelines;

c. Describe the actual and potential adverse construction noise and vibration effects of construction of the Project;

[1] See North West Housing Infrastructure Fund Assessment of Environmental Effects for further detail regarding the Housing Infrastructure Fund.

d. Recommend measures as appropriate to avoid, remedy or mitigate potential adverse construction noise and vibration effects (including any conditions/management plan required); and

e. Present an overall conclusion of the level of actual and potential adverse construction noise and vibration effects of the Project after recommended measures are implemented.

2.3 Project Description

The Project consists of the widening and upgrade of Trig Road between the SH18 off-ramps and Hobsonville Road. The widening has capacity to provide for a two-lane arterial standard corridor including new footpaths on both sides of the road and a cycleway which is indicatively shown as a dedicated bi-direction cycleway on the eastern side of the corridor. The Project will upgrade the current rural standard corridor to an urban standard, which is appropriate to support the soon to be urban environment on either side of Trig Road.

To tie into the existing road network, the Project also includes the signalisation of the intersections at Trig Road/Hobsonville Road and Luckens Road/Hobsonville Road and upgrade of Hobsonville Road between these intersections. This will require some localised widening of the road corridor along Hobsonville Road.

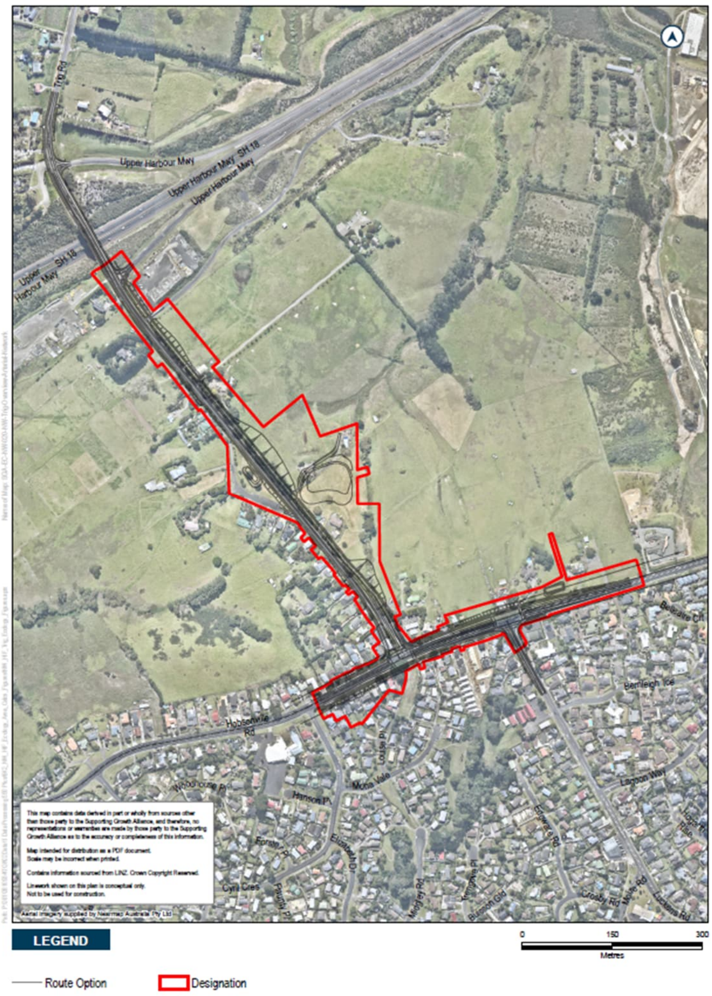


Figure 2-1: Whenuapai – Trig Road Corridor Upgrade

3 Assessment Criteria

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.

3.1.2 Resource Management Act – Noise

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 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.

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**	45	75
	07:30 – 18:00	70	85
	18:00 – 20:00	45	75
	20:00 – 06:30	45	75
Sunday and public holidays	**06:30 – 07:30**	45	75
	07:30 – 18:00	55	85
	18:00 – 20:00	45	75
	20:00 – 06:30	45	75

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 exceeds the relevant noise levels 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.

For situations that fall under the exemption rules then a copy of the works access permit issued by AT must be provided to Auckland Council five days prior to work commencing; or 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).

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 somewhat lower than the level of vibration capable of damaging structures. This means that vibration levels which readily comply with the cosmetic building damage criteria may cause annoyance and adverse reaction from building occupants who mistakenly believe that their building is sustaining damage.

Therefore, construction vibration has only been assessed against the limits of section 3.2.2.2 which relate to the avoidance of potential building damage. Potential exceedances of the amenity criteria will

be considered when assessing the construction vibration effect on nearby receptors. 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 impact piling, and "long-term" sources such as vibrocompaction. 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 alignment 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[2], 6802[3] and 6806. This meant the results could adequately inform the operational and construction noise assessments, whilst providing a robust baseline dataset for the Project.

A measurement position at 22 Trig 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 location 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 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 also 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 and operational noise as assessed against the criteria in section 3.

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

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

Table 4-1: Summary of measured noise levels

Date	Time Periods	LA_{eq} (dB)	LA_{FMax} (dB)	LA_{90} (dB)
19/11/2019	7:30 – 18:00	65	84	49
	18:00 - 20:00	63	89	46
	20:00 – 06:30	58	87	39
20/11/2019	06:30 – 7:30	67	89	55
	7:30 – 18:00	65	91	50
	18:00 - 20:00	63	83	46
	20:00 – 06:30	58	88	35
21/11/2019	06:30 – 7:30	66	80	51
	7:30 – 18:00	65	90	49
	18:00 – 20:00	63	83	45
	20:00 – 06:30	58	87	35
22/11/2019	06:30 – 7:30	66	91	52
	7:30 – 18:00	65	90	48
	18:00 – 20:00	63	89	46
	20:00 – 06:30	56	86	35
23/11/2019	06:30 – 7:30	60	82	43
	7:30 – 18:00	64	94	45
	18:00 – 20:00	61	78	45
	20:00 – 06:30	57	93	32
24/11/2019	06:30 – 7:30	56	80	39
	7:30 – 18:00	61	81	44
	18:00 – 20:00	61	87	48
	20:00 – 06:30	58	95	35
25/11/2019	06:30 – 7:30	67	88	51
	7:30 – 18:00	64	88	48
	18:00 – 20:00	62	86	45
	20:00 – 06:30	57	87	33
26/11/2019	06:30 – 7:30	66	84	53
	7:30 – 18:00	63	93	47
	18:00 – 20:00	63	88	46
	20:00 – 06:30	58	88	36
27/11/2019	06:30 – 7:30	67	87	56

	7:30 – 18:00	63	97	48
	18:00 – 20:00	63	85	47
	20:00 – 06:30	58	87	36
28/11/2019	06:30 – 7:30	65	83	51
	7:30 – 18:00	63	91	47

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 that are relevant to this report are outlined in the sub-sections below.

5.1 General Construction Overview

The total construction phase of the Project is expected to take approximately 18 to 24 months. It is anticipated that the works will be broken down into separate construction zones based on the type of works required and the nature of the work environment. These anticipated zones are:

- **Zone 1:** Trig Road North of the SH18 bridge
- **Zone 2:** Trig Road South including the SH18 bridge
- **Zone 3:** Hobsonville Road.

Each zone has different construction activities depending on the type of work to be done and the surrounding environment. In all cases the general sequence of construction is likely to be:

1. Divert or remove services
2. Construct permanent and temporary stormwater drainage and controls
3. Move traffic away from works longitudinally
4. Construct earthworks and any retaining structures
5. Construct new longitudinal drainage
6. Construct new pavement to half of the road
7. Move traffic onto newly constructed pavement
8. Complete longitudinal drainage
9. Complete pavement and median
10. Move traffic to new alignment
11. Complete footpath and cycleway

5.2 Plant and equipment

Table 5-1 provides an indicative list of plant and equipment which may be required for the construction across the three zones. This list of equipment has been used to identify a preliminary worst case scenario in the construction noise assessment below.

Table 5-1: Trig Road Corridor Upgrade plant and equipment summary

Construction Type	Construction Activity
Typical across all works	• Site facility • Light vehicles • Hiab truck

	• Small 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/ADT's
Drainage	• 20T excavator • Trench shields • Tandem tipper • Loader • Plate compactor
Pavement Construction	• Grader • Smooth drum roller • Tandem tippers • Kerbing machine • Plate compactor • Paver

Buildings located within the designation boundary have not been included within the construction assessment as these will be removed to accommodate Project works as confirmed by the Project team. The buildings on property addresses not included within the assessment are identified in **Error! Reference source not found.** below.

Table 5-2: Building addresses not included within assessment

Buildings removed
2-4 Trig Road
72C Hobsonville Road
19 Trig Road

6 Assessment Methodology

Predictions of the construction noise and vibration have been undertaken for the Project in accordance with NZS 6803 based on assumptions of construction type, activities and equipment as provided by the Project team in section **Error! Reference source not found.**. The 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 effects will therefore need to be recalculated at the time of construction to take account of these receivers also.

6.1 Construction Noise

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 Table 6-1Table 6-1 and an indicative sound power level for each construction type/activity has been provided in Table 6-2Table 6-2. 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.

Table 6-1 details the sound power levels from the 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 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 (based on propagation over soft ground)
30T excavator	C.2.19	105	30
20T excavator	C.2.21	99	13
Roller Compactor	C.2.40	101	20
Tipper Truck	C.2.30	107	36
Loader	C.5.14	114	69
Plate Compactor	C.5.29	110	45
Smooth Drum Roller	C.5.20	103	25
Paver	C.5.30	103	25

Table 6-2 details the sound power levels from key construction activities/types. The equipment sound power levels in Table 6-1 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	45
Clearing	113	65
Overhead Line relocation	93	10
Bulk Earthworks	115	76
Drainage	117	95
Pavement construction	117	95

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 **Error! Reference source not found.**.

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.

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 Construction Noise and Vibration Assessment

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 provides a summary of the existing and likely future environment as it relates to the Project area.

Table 8-1: Existing and Future Environment Likelihood of Change

Project area	Environment today	Current Zoning	Likelihood of Change	Likely Future Environment
Context A	Rural	Future Urban	High	Urban
Context B	Urban – Low Density	Future Urban	High	Urban
Context C	Urban – Medium Density	Urban	Moderate	Urban
Context D	Urban	Urban	Moderate	Urban

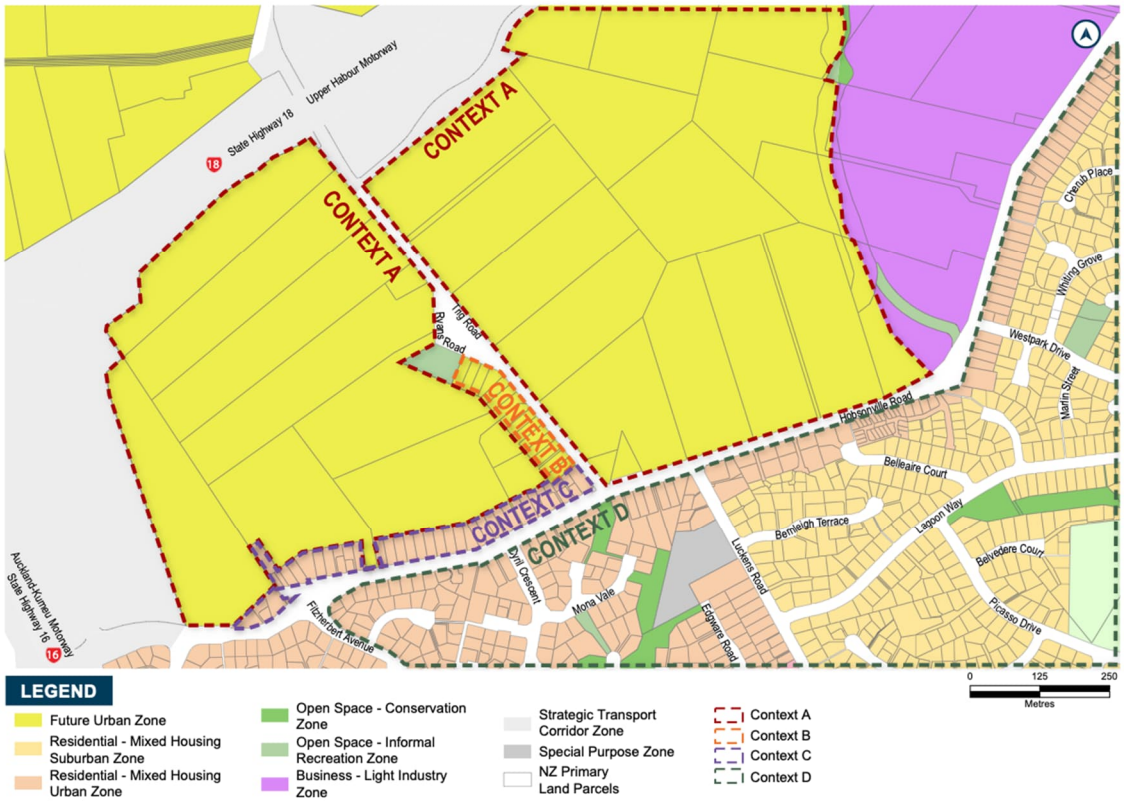


Figure 8-1: Existing and Future Zoning

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

8.1.2 Noise Environment

Trig Road is an existing urban corridor with development still occurring in the surrounding area. The noise environment is dominated by road traffic noise from vehicles on Hobsonville Road. Although development is still occurring in the area, ambient noise levels are unlikely to increase significantly above their current level.

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 135 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 69 existing dwellings that could experience noise levels up to 70 dB LA_{eq}.

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, 36 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 **Error! Reference source not found.**. 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 Conclusion

An assessment of the construction noise and vibration effects has been undertaken for the Project 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 when 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. 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 to reasonable levels with the implementation of appropriate mitigation and management measures.

Appendix 1. Noise Monitoring Results

Noise Logger Report

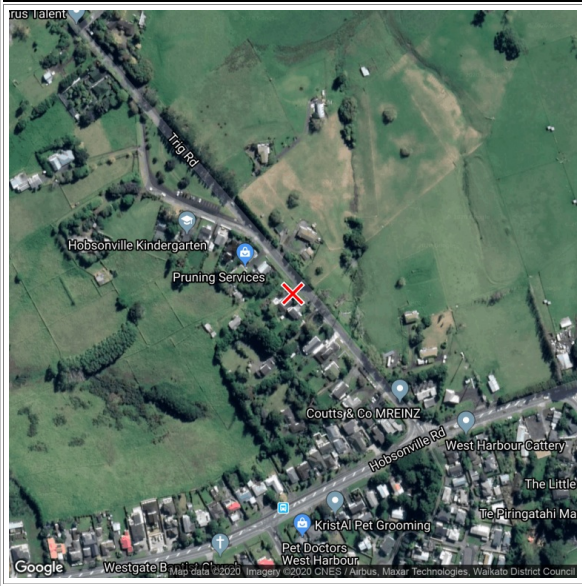
22 Trig Road, Whenuapai

Item	Information
Logger Type	NL-52
Serial number	898331
Address	22 Trig Road, Whenuapai
Location	Front yard
Facade / Free Field	Free field
Environment	Ambient nosie controlled by Trig Road

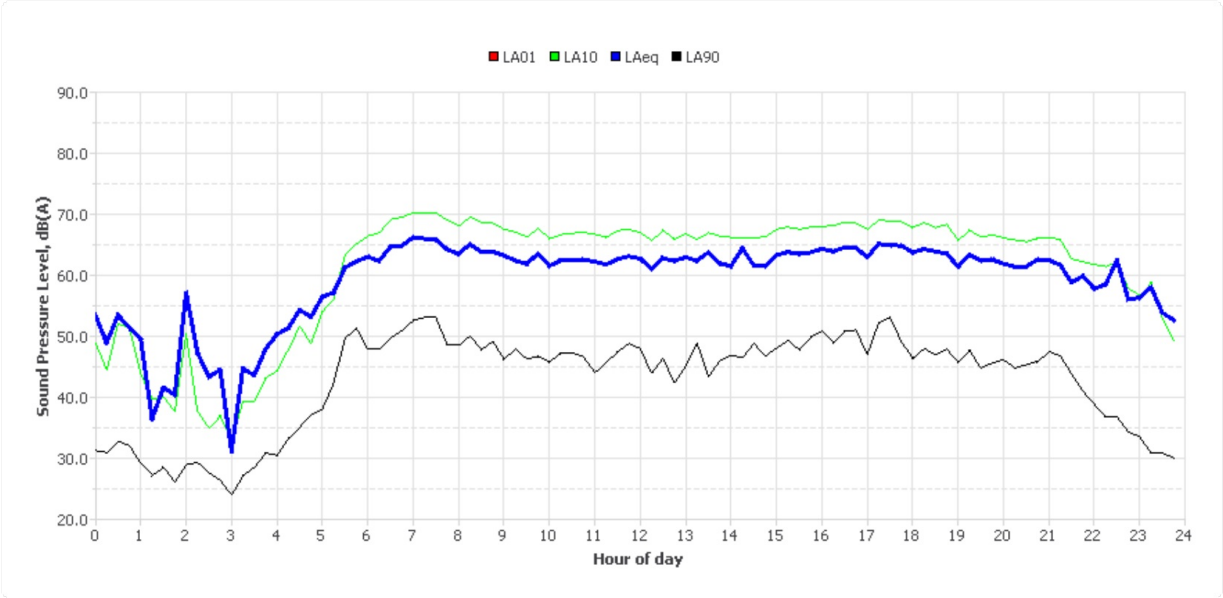
Measured noise levels

Logging Date	$L_{Aeq,24hr}$	$L_{Aeq,day}$ 7am-6pm	$L_{Aeq,evening}$ 6pm-10pm	$L_{Aeq,night}$ 10pm-7am	ABL Day	Eve	Night
Tue Nov 19 2019	62	65	62	58	-	42	-
Wed Nov 20 2019	63	65	62	58	48	38	31
Thu Nov 21 2019	63	64	62	58	45	38	28
Fri Nov 22 2019	62	64	62	58	45	40	26
Sat Nov 23 2019	61	63	61	56	42	39	28
Sun Nov 24 2019	60	62	62	54	41	40	23
Mon Nov 25 2019	62	64	61	58	45	36	27
Tue Nov 26 2019	62	63	62	58	43	39	24
Wed Nov 27 2019	62	63	63	58	45	42	28
Thu Nov 28 2019	-	63	-	58	44	-	26
Summary	**62**	**64**	**62**	**58**	**45**	**39**	**27**

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



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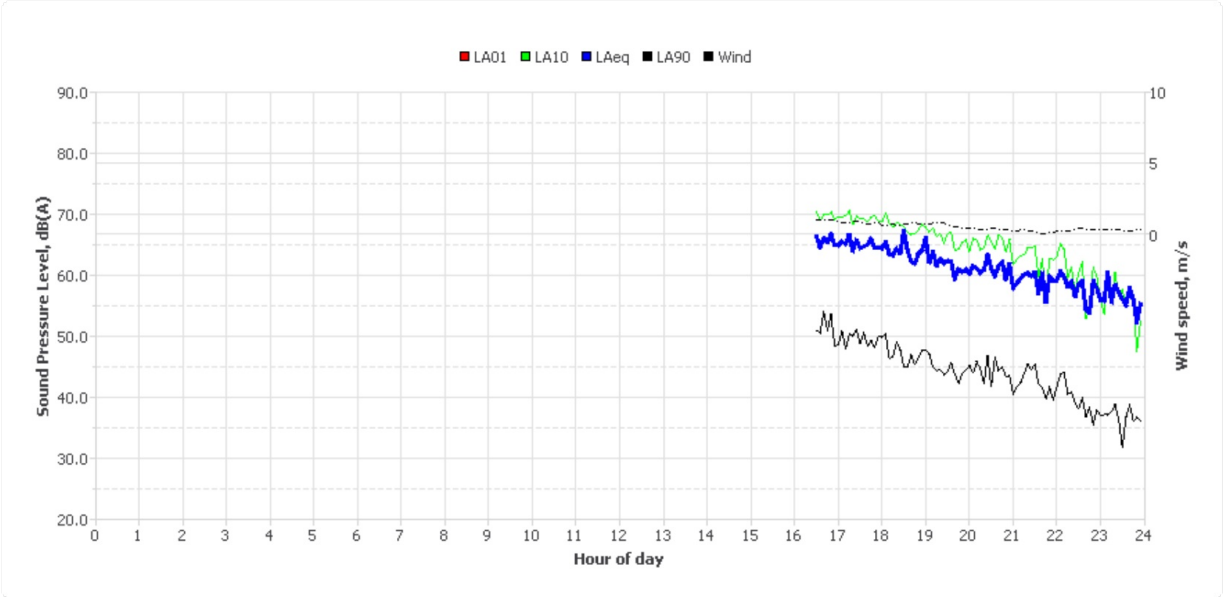

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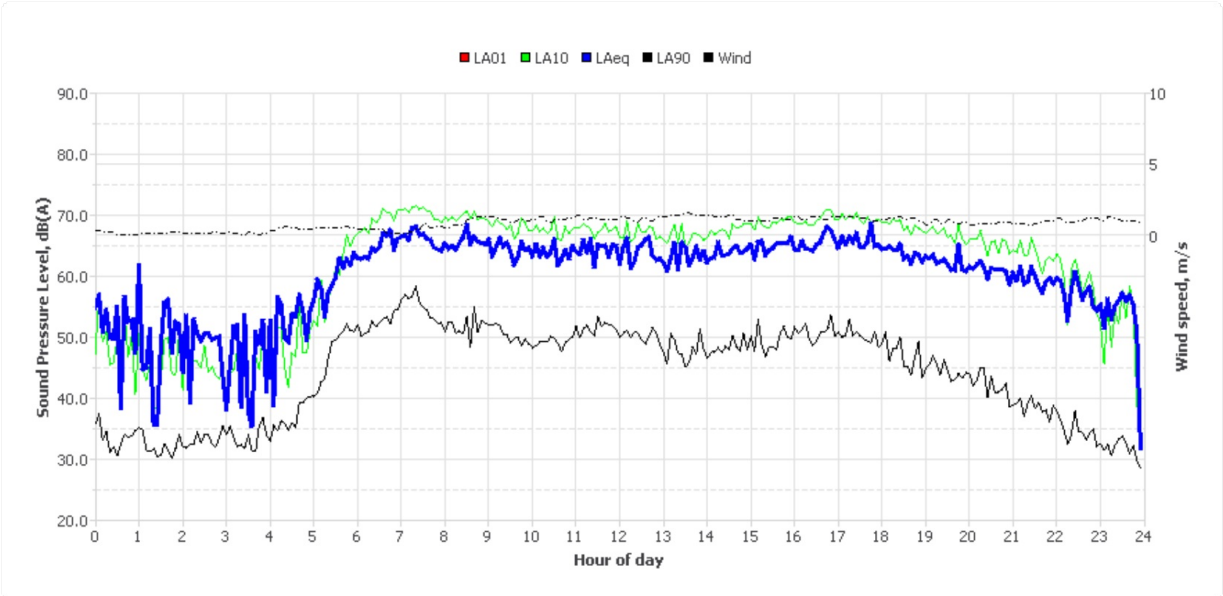

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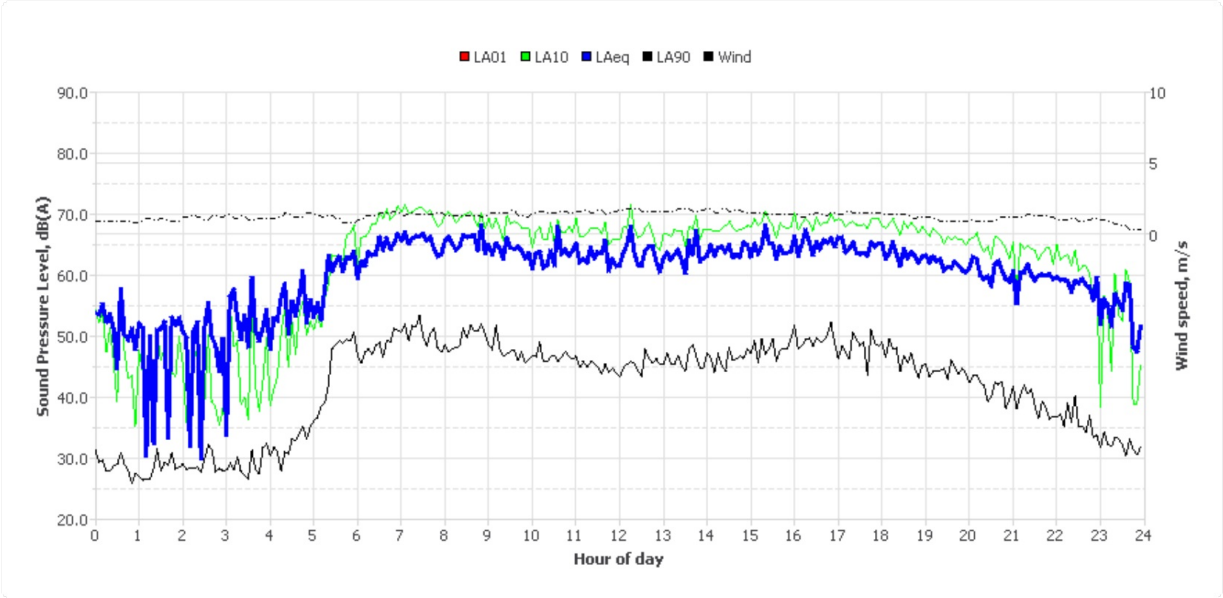

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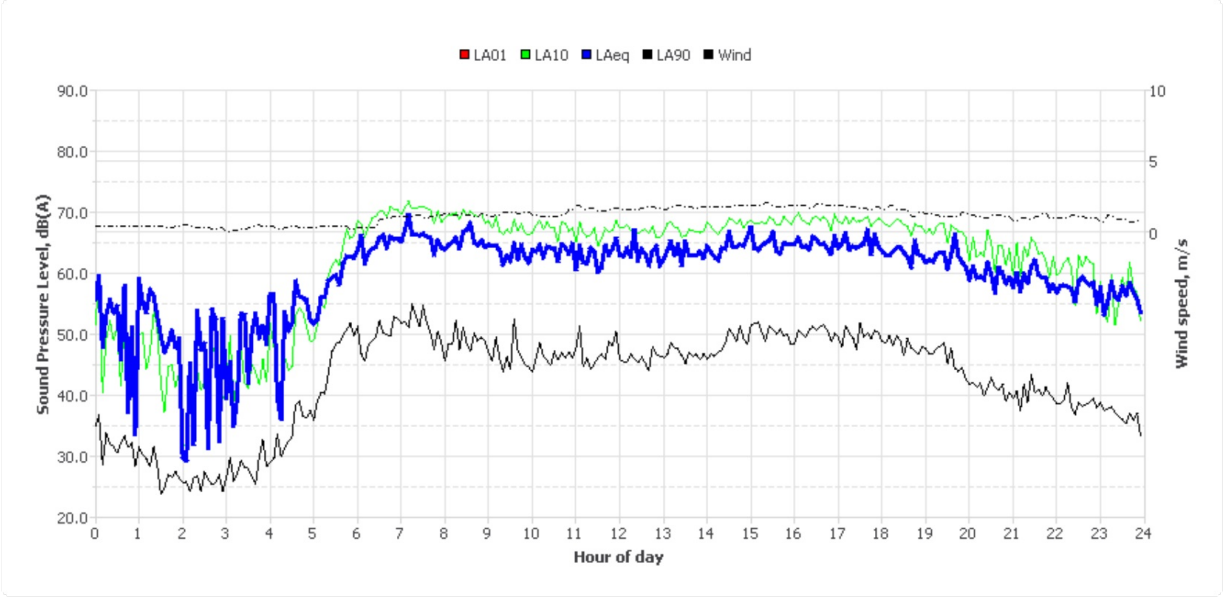

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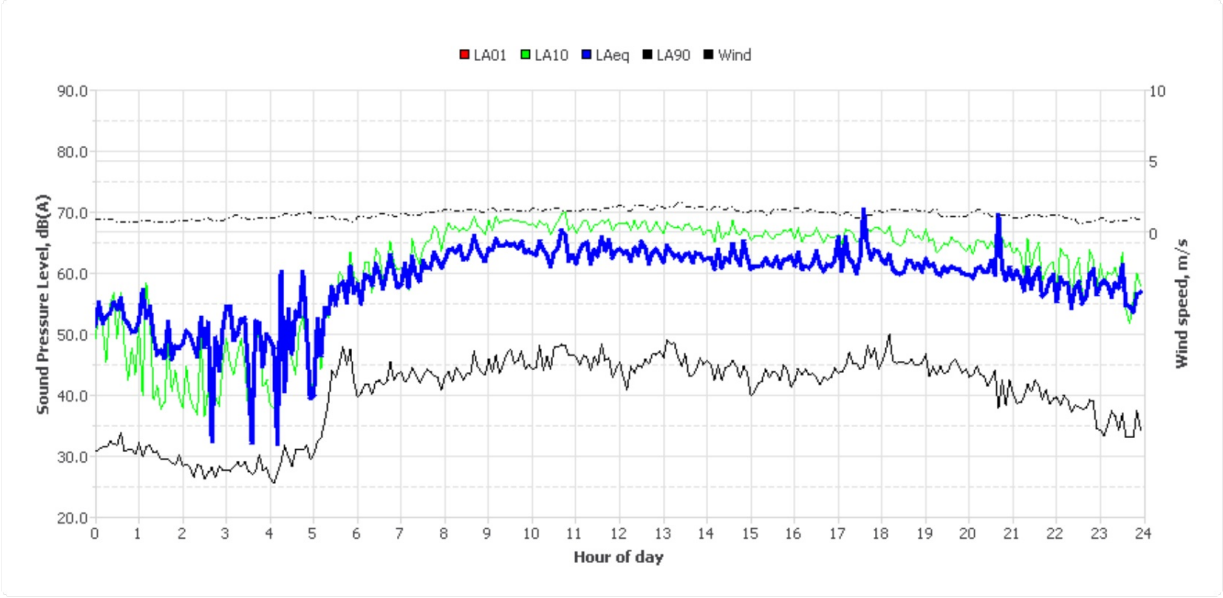

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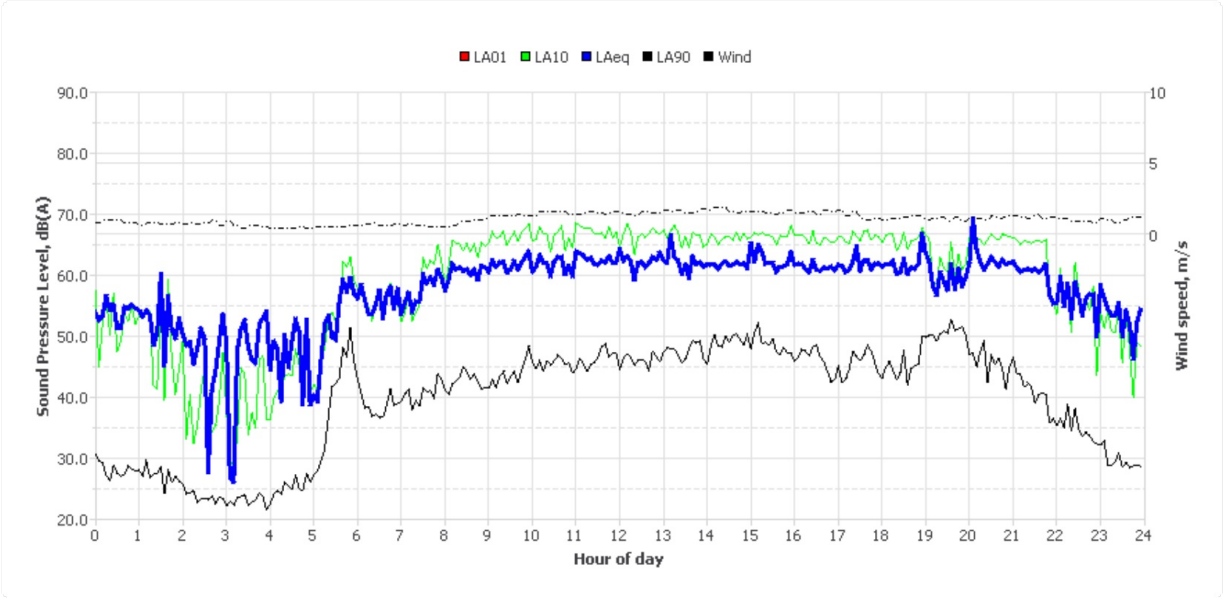

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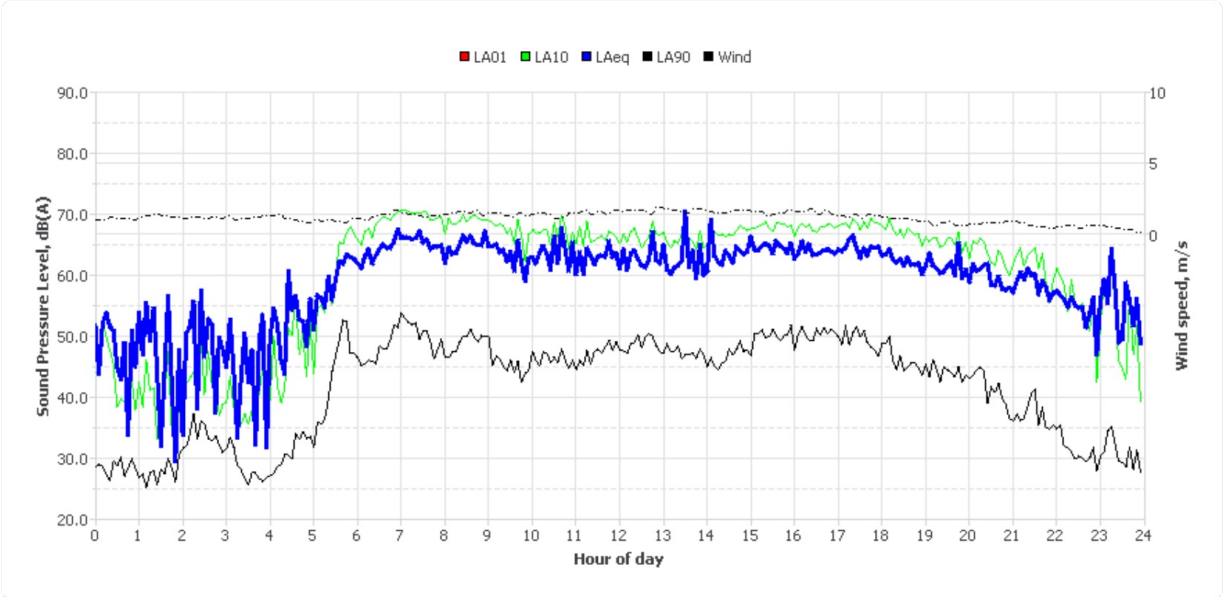

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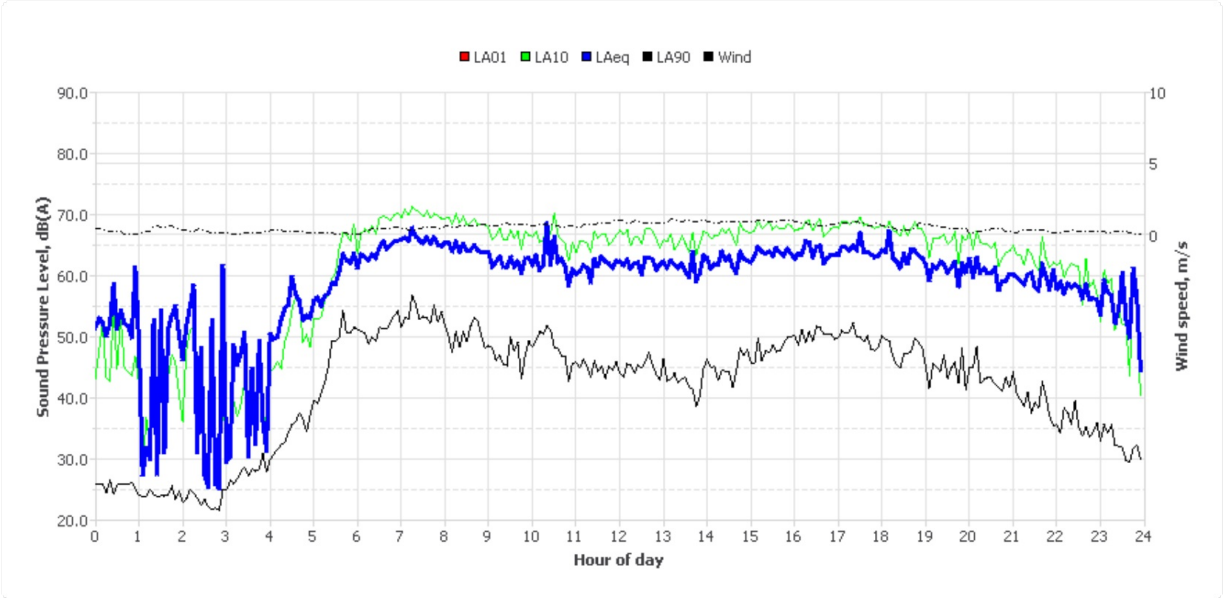

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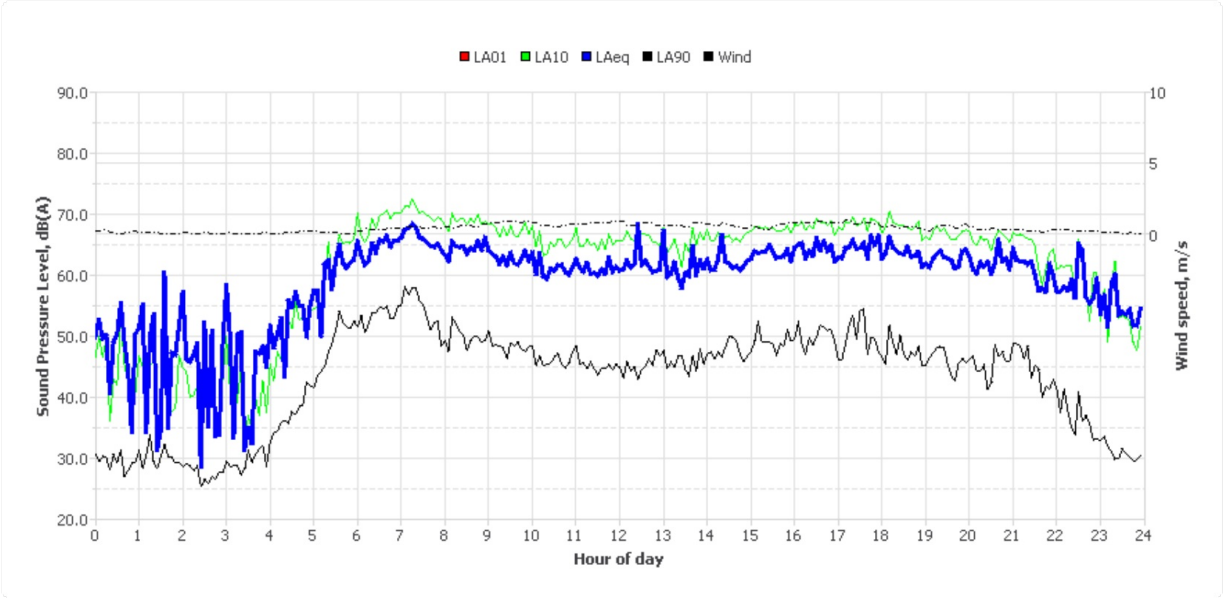

Thursday, 28 Nov 2019