Warkworth to Wellsford

Construction Noise and Vibration Assessment

July 2019

QUALITY ASSURANCE

Prepared by

Jacobs GHD Joint Venture in association with Chiles Ltd. Prepared subject to the terms of the Professional Services Contract between the Client and Jacobs GHD Joint Venture for the Route Protection and Consenting of the Warkworth to Wellsford Project.

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GLOSSARY OF ABBREVIATIONS

The table below sets out the technical abbreviations.

Abbreviation/ acronym	Term
AEE	Assessment of Effects on the Environment
AUP(OP)	Auckland Unitary Plan Operative in Part
BPO	Best Practicable Option
CNVMP	Construction Noise and Vibration Management Plan
dB	Decibel
km	Kilometres
km^2	Square kilometres
km/h	Kilometres per hour
m	Metres
NoR	Notice of Requirement
NZS 6801	New Zealand Standard NZS 6801:2008 "*Acoustics – Measurement of environmental sound*"
NZS 6802	New Zealand Standard NZS 6802:2008 *"Acoustics – Environmental Noise"*
NZS 6803	New Zealand Standard NZS 6803:1999 *"Acoustics – Construction Noise"*
NZS 6806	New Zealand Standard NZS 6806:2010 *"Acoustics – Road traffic noise – New and altered roads"*
PPFs	Protected Premises and Facilities
ppv	Peak particle velocity
RMA	Resource Management Act 1991
SH(x)	State highway (number)
Transport Agency	NZ Transport Agency

GLOSSARY OF DEFINED TERMS

The table below sets out the defined terms (and some acronyms above apply)

Term	Definition
Ambient noise/ vibration	The total noise or vibration existing at a specified point and time associated with a given environment, excluding the sound or vibration requiring control. It is a composite of all noise or vibration sources, near and far.
Amenity values	Defined in section 2(1) of the RMA as "those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes."
Best practicable option	Defined in section 2(1) of the RMA, as "in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among others things, to – (a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and (b) the financial implications, and the effects on the environment, of that option when compared with other options; and (c) the current state of technical knowledge and the likelihood that the option can be successfully applied."
Conditions	Conditions placed on a resource consent (pursuant to section 108 of the RMA) or conditions of a designation (pursuant to subsection 171(2)(c) of the RMA).
Construction works	Activities undertaken to construct the Project.
dB	A unit for measuring sound levels.
Designation	Defined in section 166 of the RMA, as "a provision made in a district plan to give effect to a requirement made by a requiring authority under section 168 or section 168A or clause 4 of Schedule 1 of the RMA."
Earthworks	Defined in section J1 of the AUP, as disturbance of soil, earth or substrate land surfaces. Includes: blading, boring (greater than 250mm diameter); contouring; cutting; drilling (greater than 250mm diameter); excavation; filling; ripping; moving; placing; removing; replacing; trenching; and thrusting (greater than 250mm diameter). Excludes: ancillary forest earthworks; and ancillary farming earthworks.

Term	Definition
Heavy vehicle	A motor vehicle having a gross laden weight exceeding 3500 kg.
Indicative Alignment	An indicative road design alignment assessed by the technical experts that may be refined on detailed design within the designation boundary. The Indicative Alignment is a preliminary alignment of a state highway that could be constructed within the proposed designation boundary. The Indicative Alignment has been prepared for assessment purposes, and to indicate what the final design of the Project may look like. The final alignment for the Project will be refined and confirmed at the detailed design stage.
$L_{Aeq(t)}$	The average, A-weighted, sound pressure level over the measurement period, t.
$L_{A90(t)}$	The A-weighted sound pressure level equalled or exceeded for 90% of the measurement period, t. This is commonly referred to as the background noise level.
L_{AFmax}	The maximum fast time-weighted A-frequency-weighted sound pressure level which occurs during the measurement period.
Peak particle velocity (ppv)	The instantaneous maximum velocity reached by a vibrating surface as it oscillates about its normal position.
Project	The Ara Tūhono Pūhoi to Wellsford Project: Warkworth to Wellsford section, which extends from Warkworth in the south, to the north of Te Hana.
Project works	All proposed activities associated with the Project.
Proposed designation boundary	The boundary of the land to which the notice of requirement applies.
Protected Premises and Facilities (PPF)	Spaces in buildings used for: • residential activities • marae • overnight medical care • teaching (and sleeping) in educational facilities • playgrounds that are part of educational facilities that are within 20 m of buildings used for teaching purposes. PPFs are the locations where road-traffic noise is assessed and for which noise mitigation measures may be required.

Term	Definition
	NZS 6806 does not apply to PPFs in urban areas that are located more than 100m from the edge of the closest traffic lane for the new or altered road, or PPFs in rural areas located more than 200 m from the edge of the closest traffic lane.
State highway	A road, whether or not constructed or vested in the Crown, that is declared to be a state highway under section 11 of the National Roads Act 1953, section 60 of the Government Roading Powers Act 1989 (formerly known as the Transit New Zealand Act 1989), or under section 103 of the LTMA.
The Dome	The highest elevation within the Dome Forest Conservation Area.

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1 INTRODUCTION

1.1 Overview of the Project

The NZ Transport Agency (Transport Agency) is lodging a Notice of Requirement (NoR) and applications for resource consent (collectively referred to as "the Application") for the Warkworth to Wellsford Project (the Project).

This report is part of a suite of technical assessments prepared to inform the Assessment of Effects on the Environment (AEE) and to support the Application. This assessment report addresses the actual and potential construction noise and vibration effects arising from the Project. The assessment considers the effects of an Indicative Alignment and other potential effects that could occur if that alignment shifts within the proposed designation boundary when the design is finalised in the future.

1.2 Project description

The Project involves the construction, operation and maintenance of a new four lane state highway. The route is approximately 26 km long. The Project commences at the interface with the Pūhoi to Warkworth project (P-Wk) near Woodcocks Road. It passes to the west of the existing State Highway 1 (SH1) alignment near The Dome, before crossing SH1 just south of the Hōteo River. North of the Hōteo River the Project passes to the east of Wellsford and Te Hana, bypassing these centres. The Project ties into the existing SH1 to the north of Te Hana near Maeneene Road.

The key components of the Project, based on the Indicative Alignment, are as follows:

a) A new four lane dual carriageway state highway, offline from the existing State Highway 1, with the potential for crawler lanes on the steeper grades.

b) Three interchanges as follows:

   i. Warkworth Interchange, to tie-in with the Pūhoi to Warkworth section of SH1 and provide a connection to the northern outskirts of Warkworth.

   ii. Wellsford Interchange, located at Wayby Valley Road to provide access to Wellsford and eastern communities including Tomarata and Mangawhai.

   iii. Te Hana Interchange, located at Mangawhai Road to provide access to Te Hana, Wellsford and communities including Port Albert, Tomarata and Mangawhai.

c) Twin bore tunnels under Kraack Road, each serving one direction, which are approximately 850 metres long and approximately 180 metres below ground level at the deepest point.

d) A series of steep cut and fills through the forestry area to the west of the existing SH1 within the Dome Valley and other areas of cut and fill along the remainder of the Project.

e) A viaduct (or twin structures) approximately 485 metres long, to span over the existing SH1 and the Hōteo River.

f) A tie in to existing SH1 in the vicinity of Maeneene Road, including a bridge over Maeneene Stream.

g) Changes to local roads:

   i. Maintaining local road connections through grade separation (where one road is over or under the other). The Indicative Alignment passes over Woodcocks Road, Wayby Valley Road, Whangaripo Valley Road, Silver Hill Road, Mangawhai Road and Maeneene Road. The Indicative Alignment passes under Kaipara Flats Road, Rustybrook Road and Farmers Lime Road.

   ii. Realignment of sections of Wyllie Road, Carran Road, Kaipara Flats Road, Phillips Road, Wayby Valley Road, Mangawhai Road, Vipond Road, Maeneene Road and Waimanu Road.

   iii. Closing sections of Phillips Road, Robertson Road, Vipond Road and unformed roads affected by the Project.

h) Associated works including bridges, culverts, stormwater management systems, soil disposal sites, signage, lighting at interchanges, landscaping, realignment of access points to local roads, and maintenance facilities.

i) Construction activities, including construction yards, lay down areas and establishment of construction access and haul roads.

For description and assessment purposes in this report, the Project has been divided into the following areas (as shown in Figure 1 below):

a) Hōteo South: From the southern extent of the Project at Warkworth to the Hōteo River.

b) Hōteo North: Hōteo River to the northern tie in with existing SH1 near Maeneene Road.

For construction purposes, the Hōteo South section is divided into two subsections being:

- South – from the southern tie in with P-Wk to the northern tunnel portals; and
- Central – from the northern tunnel portals to the Hōteo River.

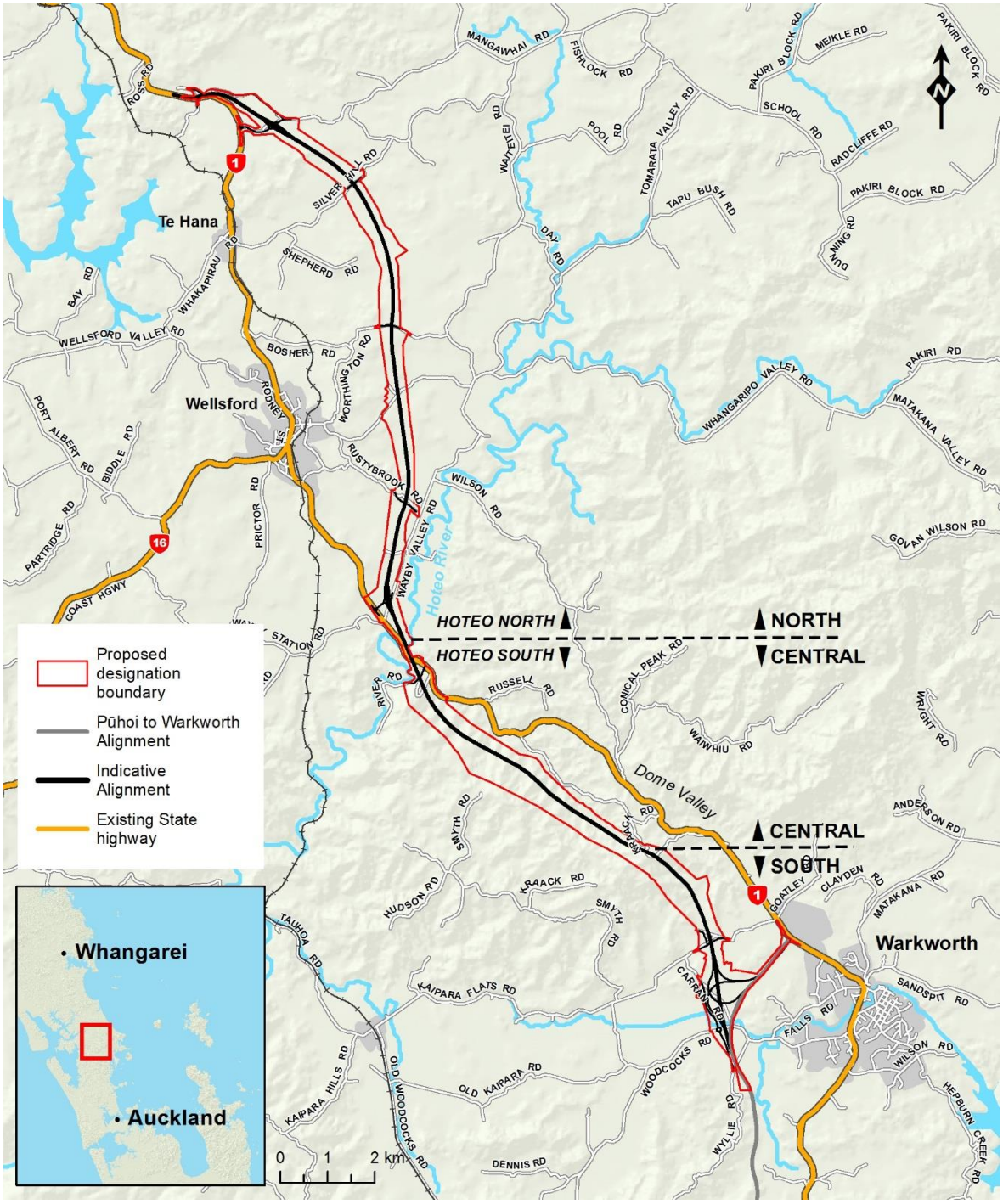

Figure 1 – Project area

The Indicative Alignment shown on the Project drawings is a preliminary alignment for a state highway that could be constructed within the proposed designation boundary. The Indicative Alignment has been prepared for assessment purposes, and to indicate what the final design of the Project may look like. The final alignment for the Project (including the design and location of associated works including bridges, culverts, stormwater management systems, soil disposal sites, signage, lighting at interchanges, landscaping, realignment of access points to local roads, and maintenance facilities), will be refined and confirmed at the detailed design stage.

A full description of the Project including its design, construction and operation is provided in Section 4: Description of the Project and Section 5: Construction and Operation of the AEE contained in Volume 1 and shown on the Drawings in Volume 3.

1.3 Purpose and scope of this report

This report presents our assessment of noise and vibration effects associated with the construction of the Project.

We have based our construction noise assessment on the *State highway construction and maintenance noise and vibration guide* [1] prepared by the NZ Transport Agency (Transport Agency Guide). The Transport Agency Guide relies on the current New Zealand standard *NZS 6803:1999 Acoustics – Construction Noise* (NZS 6803), which is widely used and accepted in New Zealand. The Standard has been applied to all recent large scale roading and other infrastructure construction projects in New Zealand.

We have based our construction vibration assessment on information in the Transport Agency Guide, which in turn refers to accepted international standards.

The purpose of this report is to assess the potential construction noise and vibration effects of the Projects, and recommend measures to ensure that any adverse effects are adequately managed and / or mitigated. The scope of our assessment involves the following:

- Review of the relevant construction noise and vibration standards;
- Determination of appropriate Project noise and vibration criteria;
- Determination of potential construction activities and equipment;
- Identification of potentially affected sensitive receivers (it is assumed that all dwellings within the proposed designation boundary will be unoccupied during construction); and
- Examination of specific areas to determine required mitigation measures.

Our assessment is based upon the construction methodology outlined in section 5 of the AEE. The contractor awarded the construction of the Project may use different methodologies. We consider the construction methodology relied on in this assessment to be suitably indicative of the potential noise effects that could arise from alternate construction methodologies a contractor would use.

[1] *State highway construction and maintenance noise and vibration guide,* August 2013, Version 1.0.

2 EXISTING ENVIRONMENT

Existing environment summary

Ambient noise levels in the vicinity of the Project are generally low for those areas away from the existing SH1, although they do increase close to the existing SH1.

We have carried out measurements of ambient noise at representative locations in the vicinity of the Project. Ambient noise levels range from 28 dB $L_{Aeq(24h)}$ in quieter areas to 54 dB $L_{Aeq(24h)}$ closer to the existing SH1.

We have not carried out vibration monitoring as no relevant vibration sources have been identified that would influence the perception or other effects of potential construction vibration.

2.1 Receivers

For operational road-traffic, noise is assessed at Protected Premises and Facilities (PPFs), as defined in NZS 6806 as buildings used for: residential activities; marae; overnight medical care; teaching (and sleeping) in educational facilities; and playgrounds that are part of educational facilities that are within 20 m of buildings used for teaching purposes.

Under NZS 6806 only buildings within 200 metres of a road traffic lane in a rural area are PPFs. However, for this Project all buildings within 200 metres of the designation boundary have been assessed as PPFs, allowing for movement of the road alignment within the designation and allowing for construction activity at any location in the designation.

For consistency with the operational noise assessment for this Project we have also used the term PPFs to define locations for assessment of construction noise and vibration in this report. For this Project all PPFs are residential houses.

The AUP(OP) defines "activities sensitive to noise" to have a similar meaning to PPFs. Slight differences between the definitions of PPF (NZS 6806) and activities sensitive to noise (AUP(OP)) are immaterial for this Project as all receivers are residential dwellings, which are included in both definitions.

2.2 Survey procedure

We have measured ambient noise levels at various PPFs in the vicinity of the proposed designation. The monitoring locations as shown in Figure 2 were chosen to be representative of both PPFs exposed to existing road traffic noise (along the existing SH1), and PPFs that are not currently within proximity to road traffic noise. The selected locations were distributed along the proposed designation to provide a sample that illustrates the range of conditions currently experienced by PPFs in the area.

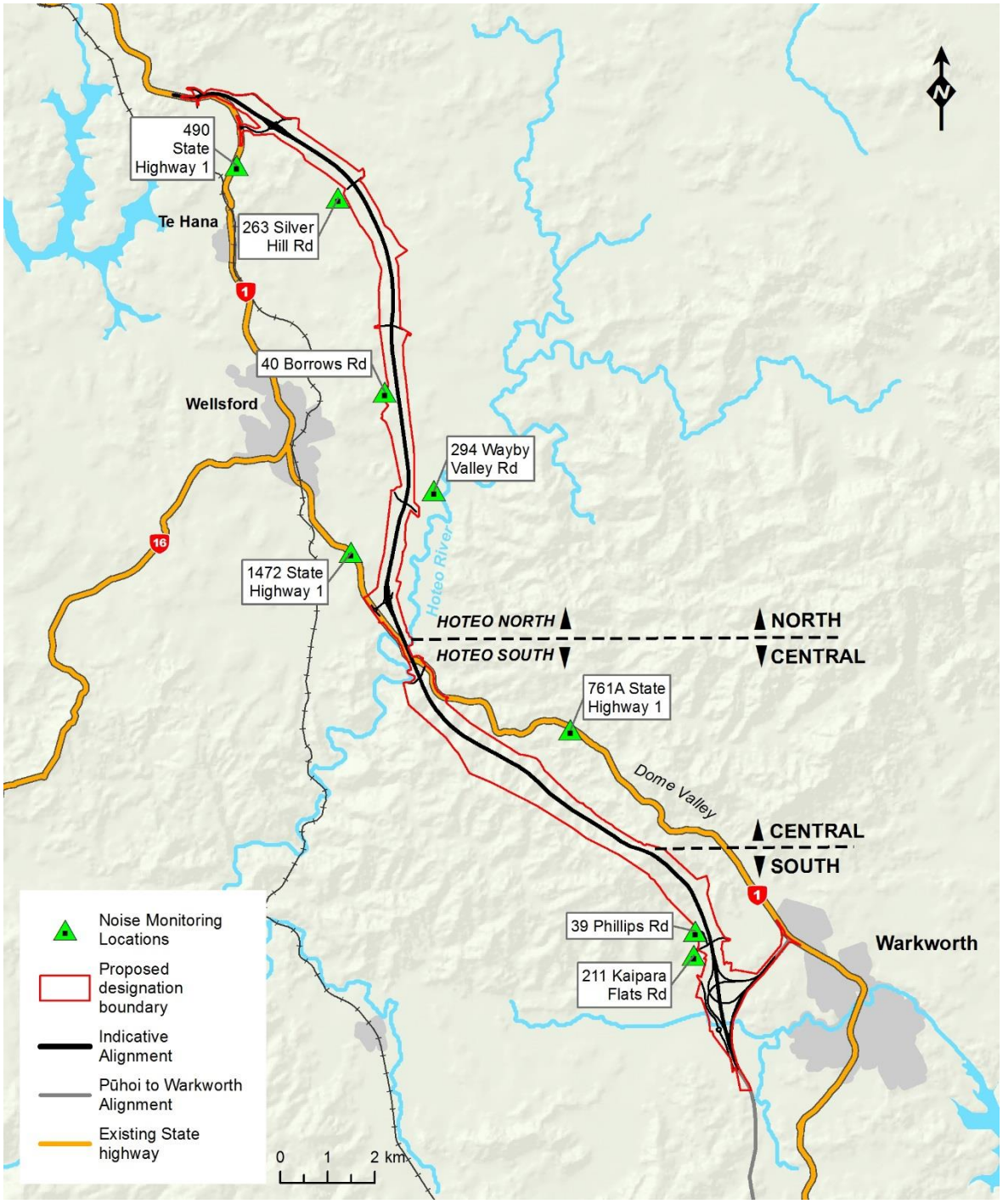

Figure 2: Locations of noise monitoring

We undertook the noise monitoring in accordance with NZS 6801. Following Section 6.1.2 of NZS 6801, microphone locations were 1.2 to 1.5 m above the ground and at least 3.5 m away from any reflecting surface, to give free-field sound levels. Distances of measurement positions from houses varied depending on where a convenient location could be identified to install each logger.

2.3 Survey results

Detailed results from the survey are included in Appendix A and summary results are shown in Table 1 below.

Table 1 – Summary of noise monitoring results

Measurement location	Noise level, dB $L_{Aeq(24h)}$	Comments
490 SH1, Wellsford, NZ, 0975	47	**Location:** The noise logger was located approximately 20 m east of the existing SH1, and approximately 12 m north of the PPF. **Noise sources:** Road traffic noise was audible from SH1; the water system (pump) servicing the dwelling was also audible at logger location. **Surroundings:** No direct line of sight of the existing SH1 to the west, open view of fields to the east.
1472 SH1, Wellsford, NZ, 0975	54	**Location:** The noise logger was located approximately 150 m north east of the existing SH1 and approximately 30 m north of the PPF. **Noise sources:** SH1 road traffic noise was audible at the logger location. **Surroundings:** No direct line of sight to the existing SH1.
263 Silver Hill Road, Wellsford, NZ, 0975	35	**Location:** The noise logger was located approximately 10 m to the north of Silver Hill Road and approximately 35 m to the east of the PPF. The existing SH1 is approximately 2.5 km from the PPF to the west. **Noise sources:** Music was audible from neighbour at the time of setup, but not over the majority of the measurement period. Farm animals were in close proximity to the noise logger and a milk tanker was audible at the noise logger. **Surroundings:** No direct line of sight of Silver Hill Road.
40 Borrows Road, Wellsford, NZ, 0974	32	**Location:** The noise logger was located approximately 10 m from the PPF and 130 m south west of Whangaripo Valley Road. **Noise sources:** Cows were in direct proximity of the noise logger and were audible at times. **Surroundings:** Terrain is inclined up to the PPF from Whangaripo Valley Road, with the logger placed on top of the incline.

Measurement location	Noise level, dB $L_{Aeq(24h)}$	Comments
294 Wayby Valley Road, Wayby Valley, NZ, 0972	34	**Location:** The noise logger was located approximately 50 m east of Wayby Valley Road and 30 m west of the PPF.The existing SH1 is 2 km away to the south west of the logger location. **Noise sources:** Tree branches rustling were audible. **Surroundings:** No direct line of sight to Wayby Valley Road.
761 A SH1, Dome Forest, NZ, 0981	34	**Location:** The noise logger was located approximately 130 m south of the existing SH1, and approximately 10 m south east of PPF **Noise sources:** Farm animals were present on property but were inaudible during the logger setup and measurement period, road traffic noise was audible from SH1. **Surroundings:** No direct line of sight to the existing SH1.
39 Philips Road, Dome Forest, NZ, 0981	28	**Location:** The noise logger was located approximately 40 m south of Philips Road and 40 m north east of the PPF. SH1 was approximately 1.5 km away from the logger location to the north east. **Noise sources:** A chicken coop was located in the near vicinity of the logger location. **Surroundings:** Open farm land around noise logger location.
211 Kaipara Flats Road, Warkworth, NZ 0981	24	**Location:** The noise logger was located approximately 20 m north east of the PPF and approximately 200 m to the east of Kaipara Flats road. There was no line of sight from the logger to any roads. **Noise sources:** Trees rustling and birds. **Surroundings:** Forest to the east of the noise logger location.

The existing ambient noise environment at many PPFs in the vicinity of the Project is dominated by natural sounds at relatively low levels, due to the absence of major local roads and industry. Exceptions are the connections of the Project with the existing SH1, where traffic on SH1 affects ambient noise levels. Other anthropogenic sounds in the wider environment such as freight trains on the North Auckland Line and aircraft using Springhill Airfield were not heard when the noise loggers were installed but are present and will at times contribute to the aural character of the area.

2.4 Ambient vibration

Vibration monitoring has not been undertaken because no vibration sources have been identified that would materially influence the perception or other effects of potential construction vibration, which generally occur at higher levels than typical ambient road-traffic vibration for example. At most locations near the Project, we have assumed that existing vibration levels are below thresholds for disturbance to people or damage to buildings as set out in Section 3.2.

3 ASSESSMENT METHODOLOGY

Assessment methodology summary

Our assessment of effects of construction noise and vibration was undertaken with the following methodology:

- We determined noise and vibration criteria to manage noise and vibration to appropriate levels comparing relevant reference documents;
- Drawing on literature and our own experience, we identified typical noise levels and vibration levels for a range of construction equipment, likely to be used to construct the Project;
- For indicative construction activities, we determined typical setback distances from the activity to PPFs that would be needed to meet the noise and primary (Category A) vibration criteria, if no specific mitigation were put in place;
- Due to the relatively sparse nature of PPFs around the majority of the designation we found construction noise and vibration can generally be managed to within relevant criteria using standard site practices; and
- We then examined discrete areas where enhanced mitigation may be required to achieve construction noise and vibration criteria at some PPFs. We considered potential mitigation methods and their practicability in these areas.

As is typical for assessments of large infrastructure projects, the calculations undertaken in this report are indicative and it will be necessary for the Contractor to verify noise and vibration levels for construction activities with on-site measurements at the time of construction, once the detailed design and construction sequencing are known.

3.1 Overview

While the Project is of a significant scale, its construction will involve commonly used and standard methods with key noise and vibration sources being related to routine earthworks, bridge construction, off-site traffic and staging areas/compounds. The Project includes tunnelling, which is a less common process, but that is remote from PPFs and is not significant in this assessment.

As standard good practice, the construction industry uses well-established and robust processes for managing noise and vibration. These processes have been successfully applied on numerous current and recent state highway construction projects of a similar scale and nature to this Project[2]. Our focus in this assessment has been to determine the extent to which those standard processes will be adequate, and to identify areas where enhanced mitigation might be required to maintain acceptable noise effects.

[2] For example: Pūhoi to Warkworth, Waikato Expressway (several separate sections), Mackays to Peka Peka, Christchurch Southern Motorway, Tauranga Eastern Link, Transmission Gully

In general, the proposed designation passes through a relatively sparsely populated rural area and therefore construction noise and vibration is more straight-forward to manage than near a more constrained built-up area (such as is the case for several other current/recent state highway construction projects). However, there will still be an impact at some PPFs, which we have sought to quantify and to determine appropriate mitigation.

For this assessment we have:

1) Determined relevant noise and vibration criteria;

2) Determined indicative construction activities and corresponding noise and vibration levels;

3) Identified PPFs within a 200 metre buffer distance whereby they are likely to be affected but where compliance with noise and vibration criteria will generally be achieved using standard practices; and

4) Identified PPFs within a 50 metre buffer distance whereby enhanced mitigation might be required to maintain compliance with noise and vibration criteria.

3.2 Criteria

3.2.1 Noise

The following documents were reviewed in relation to this construction noise assessment:

- NZS 6803;
- AUP(OP) (rule E25.6.27);
- Transport Agency Guide.

Both the AUP(OP) and the Transport Agency Guide reference NZS 6803 and base criteria on the recommendations in NZS 6803. As such, all three of these documents generally set the same construction noise criteria and all require the same approach to assessment in accordance with NZS 6803.

NZS 6803 recommends higher noise criteria for construction activities during daytime hours (Monday to Saturday) for residential areas and rural dwellings, while for Sundays and public holidays lower noise criteria are set to provide days of rest from construction noise. Similarly, night-time criteria are low to avoid sleep disturbance.

There is a slight difference between noise criteria in the AUP(OP) and NZS 6803. For construction longer than 20 weeks the AUP(OP) (E25.6.27.4) reduces all standard criteria by 5 dB, but NZS 6803 only reduces daytime criteria by 5 dB. The reason for the approach in NZS 6803 is that the standard night-time criterion of 45 dB L_{Aeq} has already been set to avoid undue sleep disturbance and therefore does not require further reduction for longer duration works. As a point of reference, this night-time criterion is the same as the guideline value recommended in NZS 6802 for permanent operational noise sources for general activities (not operational roads). The same applies to the L_{AFmax} criteria.

From a technical standpoint in terms of managing noise effects, we consider the long-term noise limits from NZS 6803 as shown in Table 2 to be appropriate, without the further reduction at night included in the AUP(OP). To our knowledge the NZS 6803 noise limits have been applied to all other current and recent similar road construction projects including P-Wk, without any issues relating to night-time noise disturbance arising.

Table 2 - NZS 6803 guideline long-term criteria for construction noise received in residential zones and dwellings in rural areas

Time of week	Time period	Long Term Duration	
		dB $L_{Aeq(t)}$	dB L_{AFmax}
Weekdays	0630 - 0730	55	75
	0730 - 1800	70	85
	1800 - 2000	65	80
	2000 - 0630	45	75
Saturdays	0730 - 1800	70	85
	1800 - 0730	45	75
Sundays and Public Holidays	0730 - 1800	55	85
	1800 - 0730	45	75

The NZS 6803 criteria apply at a distance of 1 m from occupied buildings, or, where external measurement is not appropriate, inside the building with doors and windows closed. Where the measurement location is internal the criteria are reduced by 20 dB.

Noise levels ($L_{Aeq(t)}$) are time-based. All criteria and levels quoted in this report are referenced to (t), with t being a representative assessment duration between 10 and 60 minutes (with 15 minutes duration typically adopted for road construction activities). Separate noise limits are used for blasting to account for the impulsive characteristics of that specific source as discussed in Section 3.2.3 below.

NZS 6803 considers that while every effort shall be made by the contractor to comply with the construction noise criteria in Table 2, it does not anticipate that full compliance will be achieved at all times and at all receivers. Its approach is for the implementation of the Best Practicable Option (BPO) for construction noise management and mitigation rather than requiring that the criteria must be achieved. Management options and the BPO are discussed in Section 5.

3.2.2 Vibration

The following standards and plans were reviewed in relation to this construction vibration assessment:

- AUP(OP) (rule E25.6.30);
- Transport Agency Guide.

The AUP(OP) and the Transport Agency Guide both draw vibration criteria from the same source documents: DIN 4150-3[3] and BS 5228-2[4], and as such their criteria are broadly consistent.

The AUP(OP) has a single stage of construction vibration criteria, whereas the Transport Agency Guide has "Category A" and "Category B" criteria, with Category A being more stringent. The AUP(OP) criteria are approximately the same as the "Category A" criteria in the Transport Agency Guide.

The vibration criteria in the Transport Agency Guide have been used in this assessment as they provide a more refined process accounting for substantial variabilities in vibration sensitivities. The inclusion of higher "Category B" criteria allows a graduated response whereby more intense assessment and monitoring is required above the Category B criteria than between the Category A and B criteria.

The construction vibration criteria from the Transport Agency Guide are provided in Table 3, which cross references additional more detailed criteria in Table 4 and as shown in Figure 3. Separate criteria in relation to blasting is detailed in Section 3.2.3.

Table 3 - Construction vibration criteria

Receiver	Location	Details	Category A mm/s PPV	Category B mm/s PPV
Occupied PPFs	Inside the building Free-field	Night time 2000 h to 0630 h	0.3	1
		Daytime 0630 h to 2000 h	1	5
Other occupied buildings	Inside the building	Daytime 0630 h to 2000 h	2	5
Unoccupied buildings	Building foundation	Vibration transient	5	Table 4
		Vibration continuous		50% of Table 4 values

Notes:

1. Construction vibration should be managed to comply with the Category A criteria as far as practicable, and then Category B criteria as far as practicable.
2. Depending on individual vibration sensitivities of people and buildings, it may be practicable to manage adverse effects of vibration exceeding the Category B criteria. To determine whether this is the case, before any exceedance of the Category B criteria a suitably qualified expert must confirm adverse effects should remain acceptable and must monitor vibration during the activity to confirm vibration remains within predicted levels.

[3] German Standard DIN 4150-3 Structural Vibration Part 3 Effects of vibration on structures

[4] BS5228-2:2009 Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration

Table 4 – Category B vibration criteria in unoccupied buildings

Line (see Figure 3 below)	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s
2	Unreinforced or light framed structures Residential or light commercial buildings	15 mm/s at 4Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Notes:

1. Values referred to are at the base of the building.
2. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) is not to be exceeded

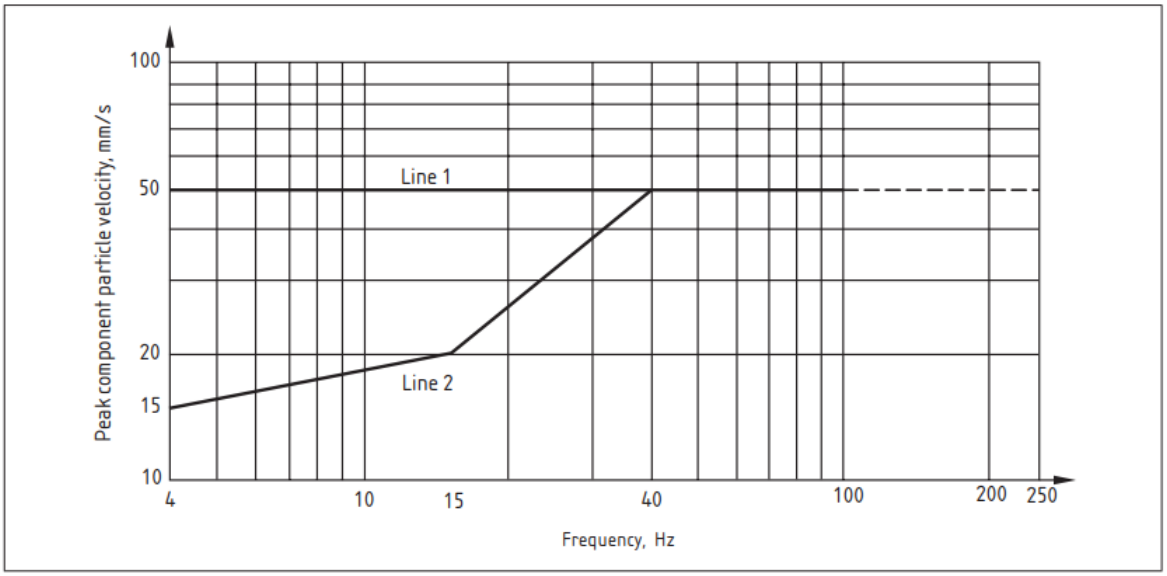

Figure 3: Category B vibration criteria in unoccupied buildings

3.2.3 Blasting

There are no New Zealand standards specifically for blasting noise and vibration although NZS 6803 references Australian Standard AS 2187-2[5]. The Transport Agency Guide includes criteria for blasting based on AS 2187-2 adopting the same format as the general construction vibration criteria set out above.

The AUP(OP), Rule E25.6.31 states a criterion for blasting of 120 dB $L_{Zpeak,}$ which is consistent with recommendations of the Transport Agency Guide. Again, the Transport Agency Guide

[5] Australian Standard AS2187-2: 2006 Explosives – Storage and use – Use of explosives

provides a more nuanced graduated set of criteria, which we consider appropriate. Table 5 sets out the criteria from the Transport Agency Guide.

Table 5 – Blasting noise and vibration criteria

Receiver	Location	Details	Category A	Category B
Occupied PPFs	Inside the building	Blasting – vibration	5mm/s ppv	10 mm/s ppv
	Free-field	Blasting – air blast	120 dB L_{Zpeak}	–
Unoccupied buildings	Building foundation	Vibration transient	5mm/s PPV	Table 4
	Free-field	Blasting – air blast	–	133 dB L_{Zpeak}

Notes:

1. Construction should be managed to comply with the Category A criteria as far as practicable, and then Category B criteria as far as practicable.
2. Depending on individual vibration sensitivities of people and buildings, it may be practicable to manage adverse effects of blasting exceeding the Category B criteria. To determine whether this is the case, before any exceedance of the Category B criteria a suitably qualified expert must confirm adverse effects should remain acceptable and must monitor vibration during the activity to confirm vibration remains within predicted levels.

3.3 Noise and vibration sources

Predictions of construction noise and vibration are based on a construction methodology as outlined in Section 5 of the AEE. Once a contractor is appointed they will determine the actual construction methodology for the Project. This may differ from the construction methodology presented in this report and therefore the predictions in this report are indicative only. The management and mitigation measures that we discuss later in this report are designed to adapt to variations in the construction methodology.

3.3.1 Construction activities

The main construction activities that influence construction noise and/or vibration are detailed below:

- Construction traffic – For most residents in the wider area the most noticeable construction noise and vibration source may be heavy vehicles on public roads travelling to and from the various access points to the site.

- Bulk Earthworks – For residents near the Project, the bulk earthworks usually generate the greatest noise. There are a number of items of earth moving equipment involved in bulk earthworks due to the overall topography of the Project area. The hauling of the material along the Indicative Alignment would also contribute to construction noise.

- Rock breaking – Generally, rock breaking is directly related to the bulk earthworks. Noise and vibration emanating from rock breaking is considered quite high in the immediate vicinity, however can be managed with careful planning. Where material cannot be removed by ripping or direct excavation, breaking may be necessary using excavators fitted with rock breakers.

- Bridges – The construction of bridges/viaducts occurs throughout the Project as it intercepts existing local roads, SH1 and watercourses. These areas will not only be exposed to noise generated by the general earth moving activities but also to the construction of the bridges, including piling and other activities.

- Pavement Construction – Pavement construction will occur along the entire Indicative Alignment and also some of the existing SH1 as it is being modified to accommodate the new Project. The compactors and graders both contribute to construction noise and vibration.

- Staging Area – These areas may be used throughout the overall construction of the Project or just during certain local works. In forming staging areas graders are likely to be the main source of construction noise and vibration.

- Mineral Extraction (rock borrow sites) – This process involves earth moving equipment such as excavators and potentially rock breaking or blasting depending on the material characteristics.

- Blasting – Where rock or earth is difficult to extract with construction equipment alone, blasting assists by breaking up the earth into more manageable pieces. Effects of blasting are managed through trial detonations and selection of charge sizes as required to comply with the criteria set out above.

- Rock Crushing – Generally, rock crushing is directly related to the bulk earthworks. Where it may be necessary, mobile rock crushers would be used physically break down material. These can be located so as to manage noise at PPFs.

- Tunnelling – While tunnelling is a major component of the overall construction programme, in terms of construction noise and vibration the separation of the indicative tunnels from neighbours is such that it is not a significant noise and vibration source in this assessment. Even if the tunnel entrances were to move within the proposed designation the noise and vibration criteria should still be achieved with no specific mitigation.

Based on these activities, for the purposes of this assessment the equipment identified in Table 6 has been considered as typical for the construction of the Project. The construction process will involve a myriad of other ancillary equipment, but the items listed provide an appropriate basis for this assessment of effects, generally representing the noisier activities.

Table 6 – Construction equipment

Equipment type	Estimated no. of items of equipment in each area		
	North section	Central section	South section
20 T excavator	4	2	2
20 T excavator	4	4	4
30T excavator	3	3	2
45T excavator	3	3	2
80T excavator	2	2	1
110T excavator	1	2	1
30T, 40T, 50T dump trucks articulated	15	20	8
Rigid dump trucks	4	4	2
12T / 15 T roller compactors	6	6	5
Motor scrapers	7	0	5
D10 bulldozer	1	3	1
825 Compactors (25 T)	2	3	4
Forestry loaders, chipers etc	0	10	4
D8 bulldozer	3	3	3
Drill and blast rigs**	1	5	3
Rock milling machine (tunnel floor)	0	0	2
Road header (tunnel roof and arches)	0	0	2
Cranes (including with piling equipment)	5	4	5
Stabilisers	2	2	2
Crane overhead gantry	0	1	0
Rock saws	0	1	1
Pavers	2	2	2
Motor grader	3	3	3
Water cart 5,000l / 10,000l	5	4	3

3.3.2 Noise levels

Typical source noise levels for individual items of construction equipment are provided in Table 7. These noise levels are based on standards and other literature[6].

[6] Data sources includes:

- British Standard BS5228-2:2009 Code of practice for noise and vibration on construction and open sites – Part 1 Noise
- DEFRA, Department for Environment, Food and Rural Affairs, UK, Update of Noise Database for Prediction of Noise on Construction and Open Sites

Table 7 – Typical source noise levels for equipment

Equipment type	Sound Pressure at 10 m, dB L_{Ap}	Data source
Excavator (>20T)	82	NZS 6803
Dump truck (35T)	84	NZS 6803
Dump truck (50T)	92	NZS 6803
Roller compactor	84	DEFRA
Motor scrapers	95	NZS 6803
Bulldozer	88	DEFRA
Grader	82	AS 2436-2010
Water cart	79	AS 2436-2010
Rock breaker	90	AS 2436-2010
Drill rig	88	AS 2436-2010
Crawler crane	76	DEFRA
Crane	78	DEFRA
Air compressor	77	NZS 6803
Rock saw	87	AS 2436-2010
Paver	80	AS 2436-2010
Carpentry machine tool	74	AS 2436-2010
Concrete vibrator	74	NZS 6803
Mobile rock crusher	97	DEFRA

We have considered construction noise levels at PPFs for a range of scenarios involving the above equipment. We have made basic (conservative) calculations and reviewed these in the light of our experience with actual noise levels typically achieved in practice.

On this basis we estimate that the range of construction activities associated with this Project should comply with noise criteria within the following distances, without specific mitigation:

- Weekday/Saturday daytime criterion (70 dB L_{Aeq}) 100 metres
- Weekday evening criterion (65 dB L_{Aeq}) 200 metres

- AS 2436-2010. Australian Standard- Guide to noise and vibration control on construction, demolition and maintenance sites
- NZS 6803:1999 'Acoustics – Construction Noise'.

- Night-time noise criterion (45 dB L_{Aeq}) >500 metres

With standard good site management practices, such as screening noisier equipment and keeping it away from boundaries, these distances are likely to be approximately halved.

3.3.3 Vibration levels

The propagation of vibration is dependent on localised ground conditions and levels should be confirmed during trials in initial stages of construction. While it generally is not reliable to predict vibration at this stage in a project, for the purposes of this assessment Table 8 shows indicative vibration levels from basic calculations at different distances from equipment.

Table 8 – Vibration levels at various distances from construction equipment

Equipment type	Predicted / measured ppv (mm/s) Distance from vibration source (m)									Data source
	4	7.6	10	16	32	64	128	256	450	
Excavator	15.4	11.1	9.6	7.4	5.0	3.2	1.9	0.9	0.4	Sumitomo SH120 – Transport Agency Guide
Dump trucks	0.8	0.6	0.5	0.4	0.3	0.2	0.1	0.0	0.0	Semi Trailer – Jacobs Database
Roller compactors	3.4	2.4	2.1	1.6	1.1	0.7	0.4	0.2	0.1	Caterpillar CB544 – Transport Agency Guide
Motor scrapers	4.4	3.2	2.7	2.1	1.4	0.9	0.5	0.3	0.1	Scraper – Jacobs Database
Bulldozers	8.0	5.8	5.0	3.9	2.6	1.7	1.0	0.5	0.2	Komatsu DP31P – Transport Agency Guide
Motor grader	1.5	1.1	1.0	0.7	0.5	0.3	0.2	0.1	0.0	Volvo G726B – Transport Agency Guide
Water cart 5,000l / 10,000l	0.8	0.6	0.5	0.4	0.3	0.2	0.0	0.0	0.0	Semi trailer – Jacobs database
Rock breaking	9.3	6.6	5.8	4.5	3.0	1.9	0.5	0.5	0.2	Rock breaker 50T – Jacobs database
Large drill rigs	6.0	4.3	3.7	2.9	1.9	1.2	0.7	0.4	0.1	Drill rig 70T – Jacobs database
Crawler cranes 75T	2.1	1.5	1.3	1.0	0.7	0.4	0.3	0.1	0.1	Tracked mobile plant (100+ tonnes) traversing (moving) – Jacobs database
Cranes up to 220T	2.1	1.5	1.3	1.0	0.7	0.4	0.3	0.1	0.1	Tracked mobile plant (100+ tonnes) traversing (moving) – Jacobs database
Air compressors	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Minimal vibration
Carpentry machine tools	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Minimal vibration
Concrete vibrators	11.3	8.1	7.0	5.5	3.7	2.4	1.4	0.7	0.3	Compactor – Jacobs database
Impact piling	24.2	17.4	15.1	11.7	7.9	5.1	3.0	1.4	0.6	Impact piling – Jacobs database
Mobile rock crusher	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Minimal vibration

As for noise levels, based on these indicative predictions we estimate that the range of construction activities associated with this Project should comply with Category A vibration criteria within the following distances, without specific mitigation:

- Unoccupied buildings criterion (5 mm/s) 50 metres
- Daytime occupied PPFs criterion (1 mm/s) 200 metres
- Night-time vibration criterion (0.3 mm/s) >500 metres

With standard good site management practices, such as use of lower powered equipment, these distances should be significantly reduced.

3.3.4 Blasting levels

Blasting noise and vibration cannot be reliably predicted or represented by indicative values as sufficient details are not available at this stage. This assessment has been made on the basis that if blasting is required, the contractor will undertake initial trials (using smaller charge sizes) to determine to site specific blast response characteristics (i.e. the site constants) to define allowable blast sizes to maintain compliance with the criteria in Section 3.2.3 above.

3.4 Affected PPFs

Other than quieter ancillary construction activities and construction in remote areas such as tunnelling in the Central Section, compliance with the night-time noise criteria generally cannot practicably be achieved. As such, PPFs affected by night-time activity have not been identified here because there will be no significant night-works near PPFs. Where night-works are essential, such as might be required at tie-ins to the existing SH1 then noise criteria may be exceeded and specific management of effects would be required.

As set out above, using standard site management practices, weekday/Saturday daytime noise criteria should be achieved within a distance of 50 metres of the proposed designation. However, close attention will be required to potential daytime effects at PPFs within approximately 200 metres of the proposed designation. Likewise, for construction vibration, the unoccupied buildings criterion will be achieved within 50 metres, but attention will be required to potential for exceedance of the limit at occupied PPFs within 200 metres.

The following figures show PPFs identified within 200 metres (yellow area) and 50 metres (red area) of the proposed designation boundary. These are also listed in Table 9 with distances to each PPF.

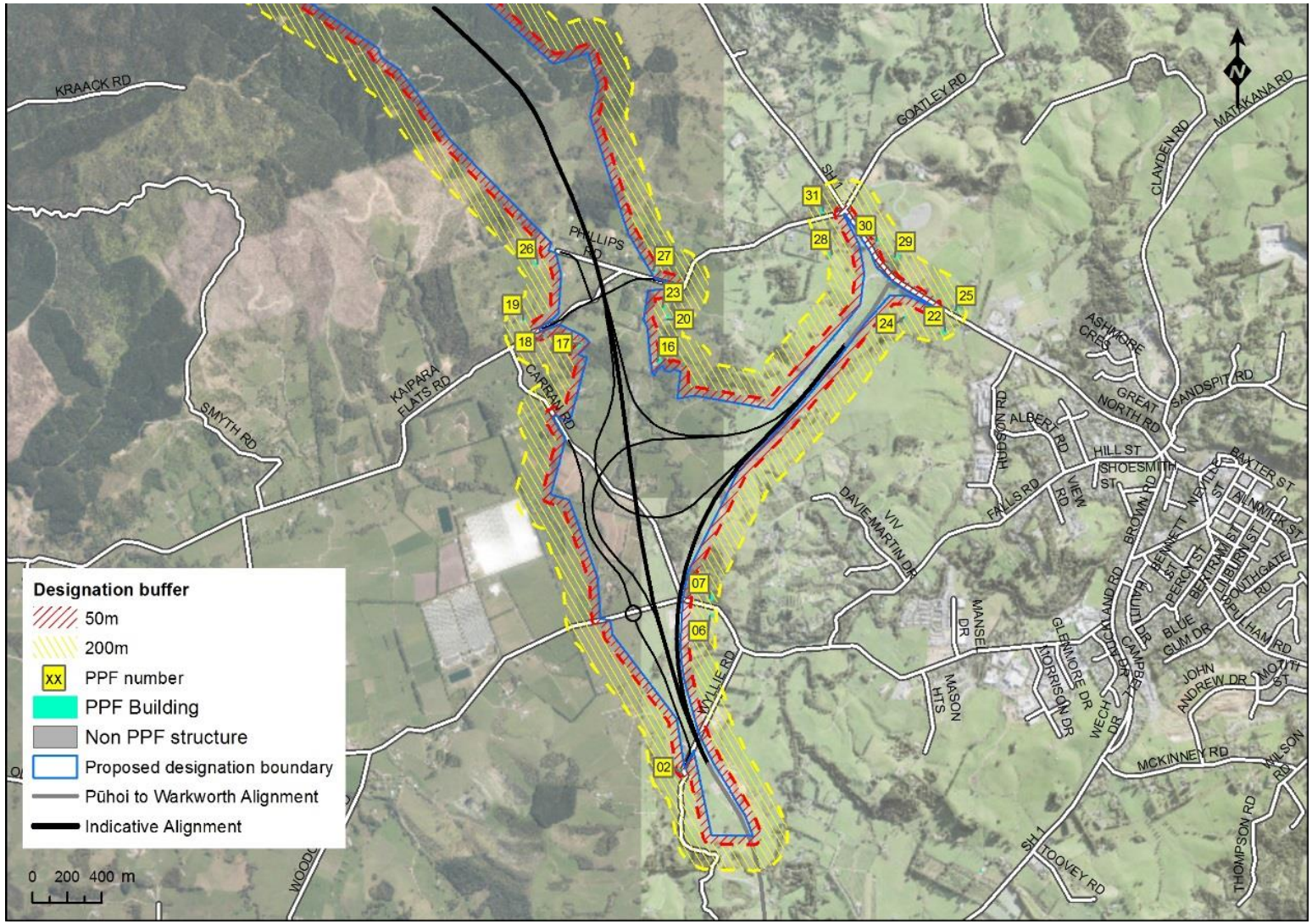

Figure 4 – Location of PPFs with respect to 50 m and 200 m buffers around the proposed designation boundary – South section

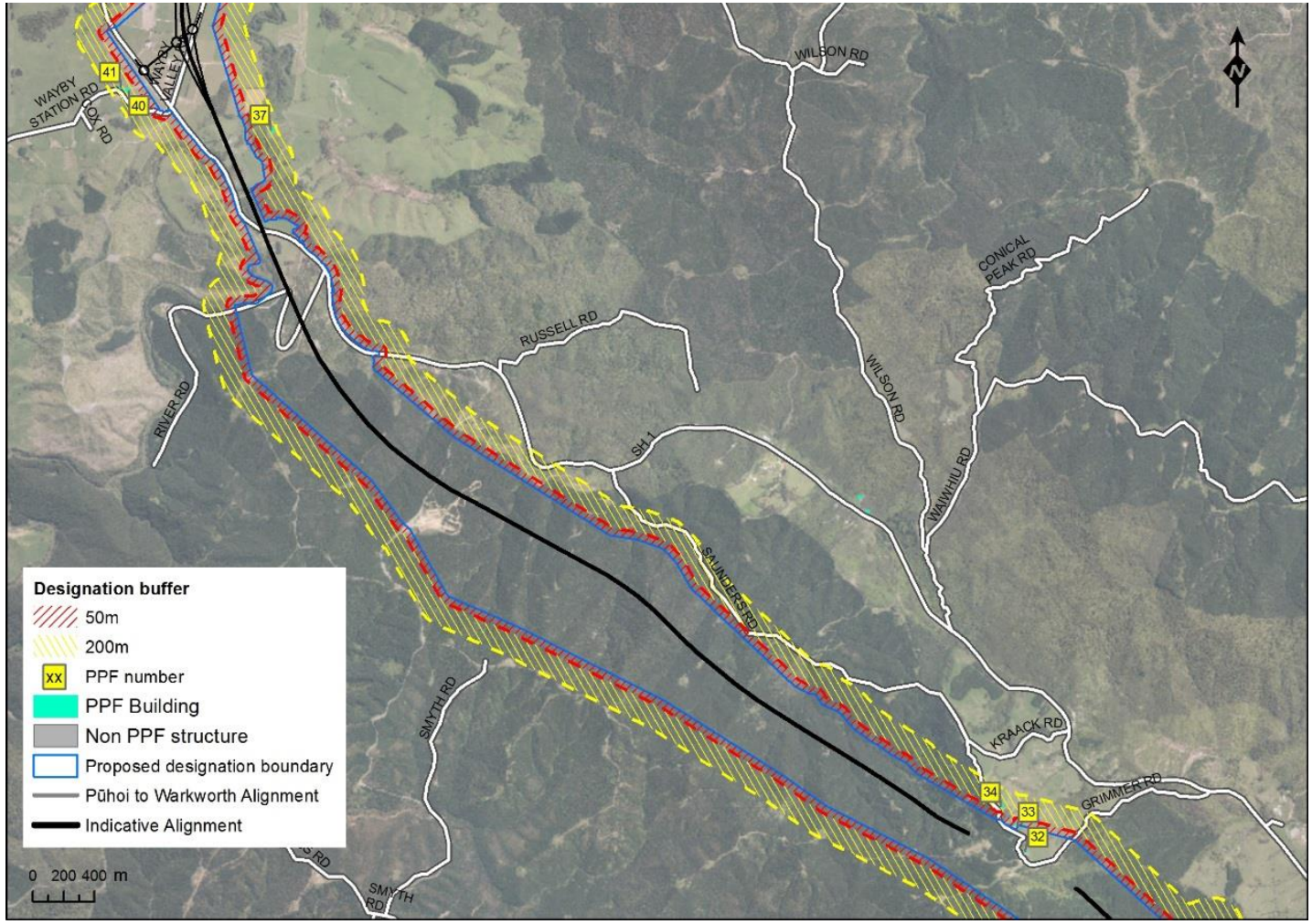

Figure 5 – Location of PPFs with respect to 50 m and 200 m buffers around the proposed designation boundary – Central section

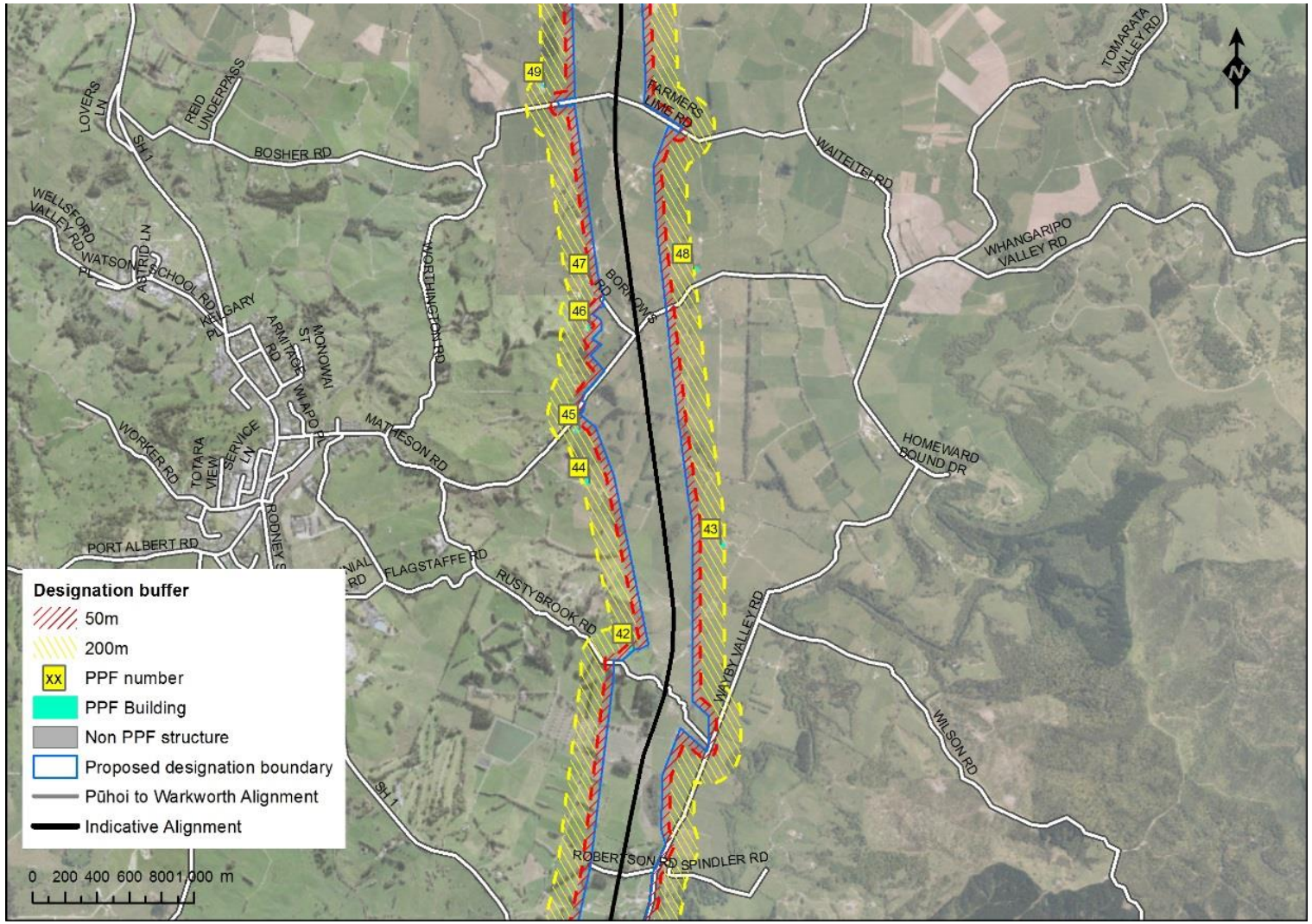

Figure 6 – Location of PPFs with respect to 50 m and 200 m buffers around the proposed designation boundary – Northern Section Whangaripo Valley Road

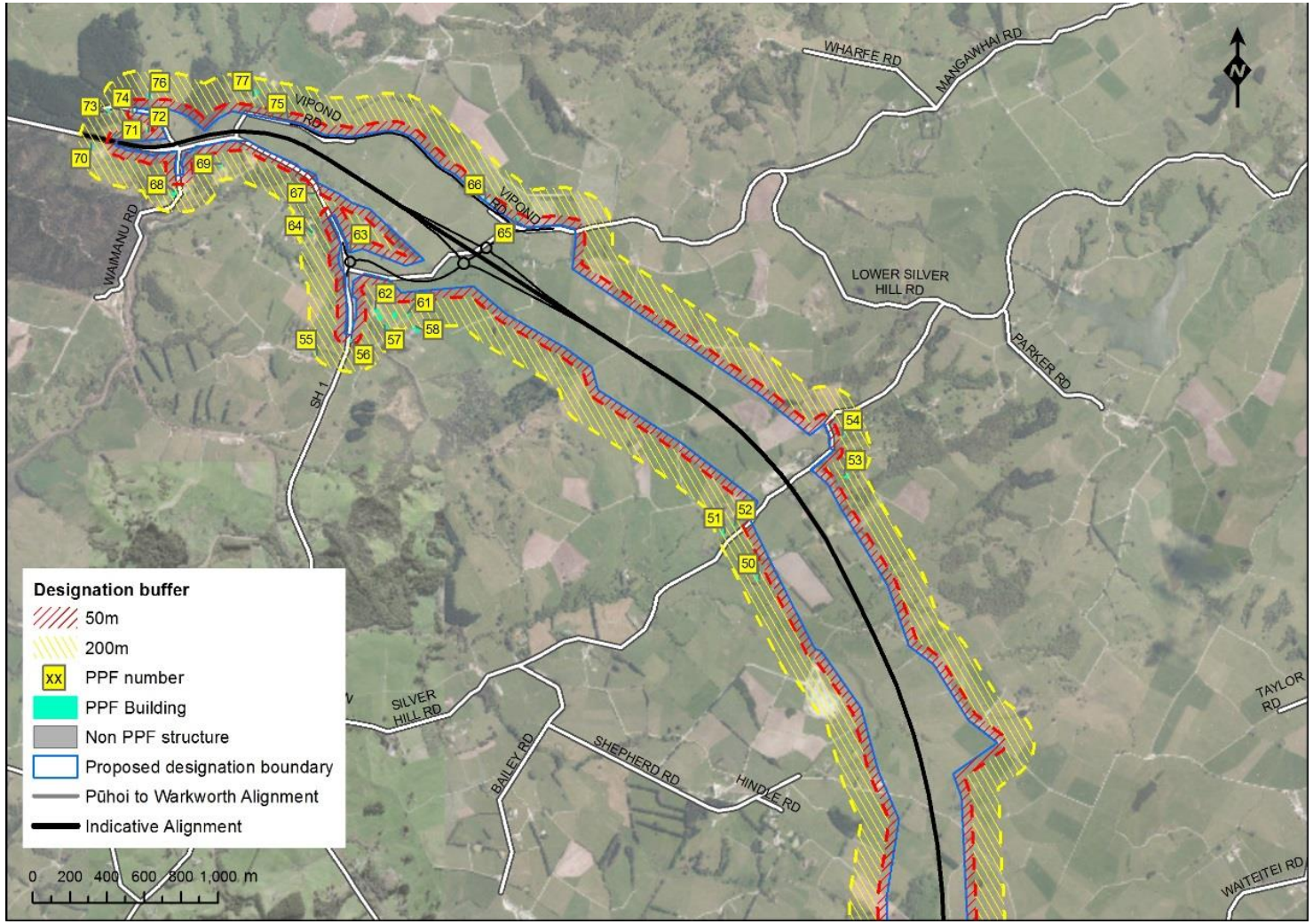

Figure 7 – Location of PPFs with respect to 50 m and 200 m buffers around the proposed designation boundary – Northern Section Mangawhai Interchange

Table 9 – PPFS within 200 m of the proposed designation boundary

Section	PPF	Address	Approximate distance to designation boundary (m)
South Section	02	74 Wyllie Rd, Streamlands	34
	06	371 Woodcocks Rd, Warkworth	162
	07	372 Woodcocks Rd	154
	16	131 Kaipara Flats Rd	37
	17	211 Kairpara Flats Rd	36
	18	215 Kaipara Flats Rd	30
	19	214 Kaipara Flats Rd	104
	20	115 Kaipara Flats Rd	120
	22	27 SH-1, Warkworth	161
	23	115 – 2 Kaipara Flats Rd	99
	24	63 SH-1, Warkworth	123
	25	42 SH-1, Warkworth	138
	26	39 Phillips Rd, Streamlands	99
	27	130 Kaipara Flats Rd	16
	28	105 SH1, Warkworth	168
	29	102 SH-1, Warkworth	116
	30	104 SH1, Warkworth	65
	31	6 Kaipara Flats Road, Dome Valley	120
Central Section	32	161 Kraack Rd	Within proposed designation
	33	145 Kraack Rd,	1
	34	127 Kraack Rd	85
North Section	37	1232A SH-1, Wayby Valley	165
	40	4 Wayby Station Rd, Wellsford	103
	41	44 Wayby Station Rd, Wellsford	130
	42	177 Rustybrook Rd, Wellsford	9
	43	351 Wayby Valley Rd, Wellsford	179
	44	64 Whangaripo Valley Rd, Wellsford	156
	45	96 Whangaripo Valley Rd, Wellsford	75
	46	40 Borrows Rd, Wellsford	69
	47	47 Borrows Rd, Wellsford	51
	48	213 Whangaripo Valley Rd, Wellsford	198
	49	263 Worthington Rd, Wellsford	118
	50	250 Silver Hill Rd, Wellsford	96
	51	263 Silver Hill Rd, Wellsford	152
	52	273 Silver Hill Rd, Wellsford	86
	53	332 Silver Hill Rd	102
	54	344 Silver Hill Rd, Wellsford	67
	55	469 SH-1, Te Hana	188
	56	490 SH-1, Wellsford	30
	57	10 Charis Lane, Wellsford	155
	58	13 Charis Lane, Wellsford	188
	59	8 Charis Lane, Wellsford	122
	60	8 Charis Lane, Wellsford	115

Section	PPF	Address	Approximate distance to designation boundary (m)
	61	9 Charis Lane, Wellsford	114
	62	8 Charis Lane, Wellsford	101
	63	542 SH-1, Topuni	12
	64	557 SH1, Wellsford	118
	65	139 Vipond Road	19
	66	129 Vipond Rd	10
	67	575 SH-1, Topuni	58
	68	28 Waimanu Rd, Topuni	87
	69	641 SH-1, Wellsford	114
	70	705 SH-1, Wellsford	132
	71	704 SH-1, Wellsford	22
	72	17 Maeneene Rd	46
	73	45 Maeneene Rd, Wellsford	154
	74	33 Maeneene Rd	22
	75	35 Vipond Road, Wellsford	17
	76	18 Maeneene Rd	60
	77	17 Vipond Rd, Wellsford	104

3.5 Focus areas

From the above figures and table there are 16 PPFs within 50 metres of the proposed designation boundary and therefore requiring specific attention to determine whether mitigation is practical to achieve construction noise and vibration criteria. These are detailed below for each section of the Project.

3.5.1 Southern Section

74 Wylie Road

A PPF at 74 Wyllie Road is within 50 metres of the proposed designation. However, this property is within proximity of the P-Wk works and separated from the main works for this Project. Daytime construction noise and vibration criteria should be achieved with standard practice.

Kaipara Flats Road

There are four PPFs on Kaipara Flats Road within 50 metres of the proposed designation boundary. Mitigation in this area may comprise localised screening of activities. It may also be necessary to maintain separation distances of noisy activities within the proposed designation. Alternatively, specific arrangements could be made with individual residents to avoid works at times that would cause undue disturbance, either by scheduling of the works or potentially by temporarily relocating the residents.

Long-term staging areas should be avoided in the vicinity of these PPFs (and PPFs in other areas). Figure 8 below highlights the locations of the PPFs within the vicinity of Kaipara Flats Road in relation to the proposed designation boundary.

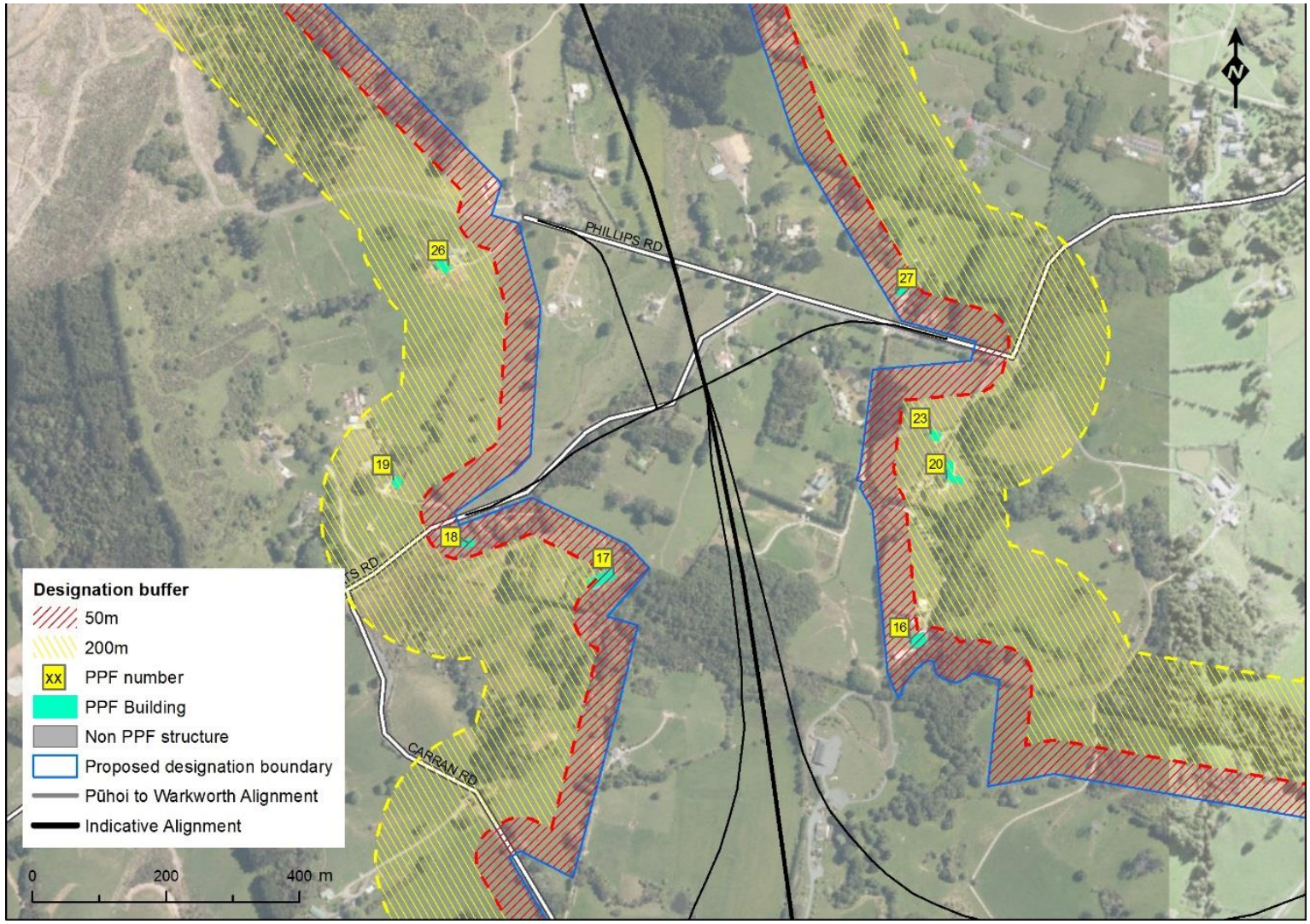

Figure 8 – Location of PPFs with respect to 50 m and 200 m buffers around the proposed designation boundary – Kaipara Flats Road

3.5.2 Central section

There are two PPFs on Kraack Road which are within the 50 metres of the proposed designation boundary (including 161 Kraack Road which is a house within the proposed designation boundary over the tunnel).

These PPFs are screened from the main works by the terrain and construction noise criteria should be achieved with no specific mitigation.

Ancillary construction traffic may pass these PPFs as it accesses the site. Effects could be managed by haul routes avoiding Kraack Road and it only being used as an access for light vehicles.

3.5.3 Northern section

177 Rusty Brook Road

There is one PPF on Rusty Brook Road that is within 50 metres of the proposed designation boundary. Given this is an isolated location the primary noise mitigation is that it generally should be practicable to locate noisy activities within the proposed designation boundary away from this PPF. In this manner the daytime construction noise and vibration criteria should be achieved. If key activities such as piling for structures was required closer to this PPF then options such as scheduling and or temporary relocation may be required. The same noise mitigation is applicable for the PPF at 47 Borrows Road that is only marginally further than 50 metres from the proposed designation boundary.

SH1

Two PPFs are at the edge of the proposed designation boundary near to the tie-in of the new Mangawhai Road with the existing SH1. Project works should be minor in the areas nearest these PPFs such that daytime construction noise and vibration criteria should be achieved with standard practice.

129/139 Vipond Road

These two PPFs are near the proposed designation boundary at the Mangawhai interchange. The main works cannot be immediately adjacent to these PPFs due to the space needed for Vipond Road within the proposed designation boundary. Also, due to the topography within the proposed designation these PPFs should be partly screened from most works by the terrain such that daytime construction noise and vibration criteria should be achieved with standard practice.

Northern tie-in

At the Northern tie-in with the existing SH1 there are 4 PPFs within 50 metres of the designation. Of these, 35 Vipond Road is separated from the works by Vipond Road within the proposed designation boundary and it generally should be practicable to locate noisy activities within the proposed designation boundary away from this PPF.

The remaining three PPFs are on SH1 and Maeneene Road near the existing SH1. In this area there will not be substantial earthworks, rather slight horizontal and vertical realignment of the existing road. The new structure over the Maeneene Stream is slightly further from these PPFs such that daytime construction noise and vibration criteria should be achieved with standard practice.

Figure 9 below highlights the locations of the PPFs within the Northern tie-in in relation to the proposed designation boundary.

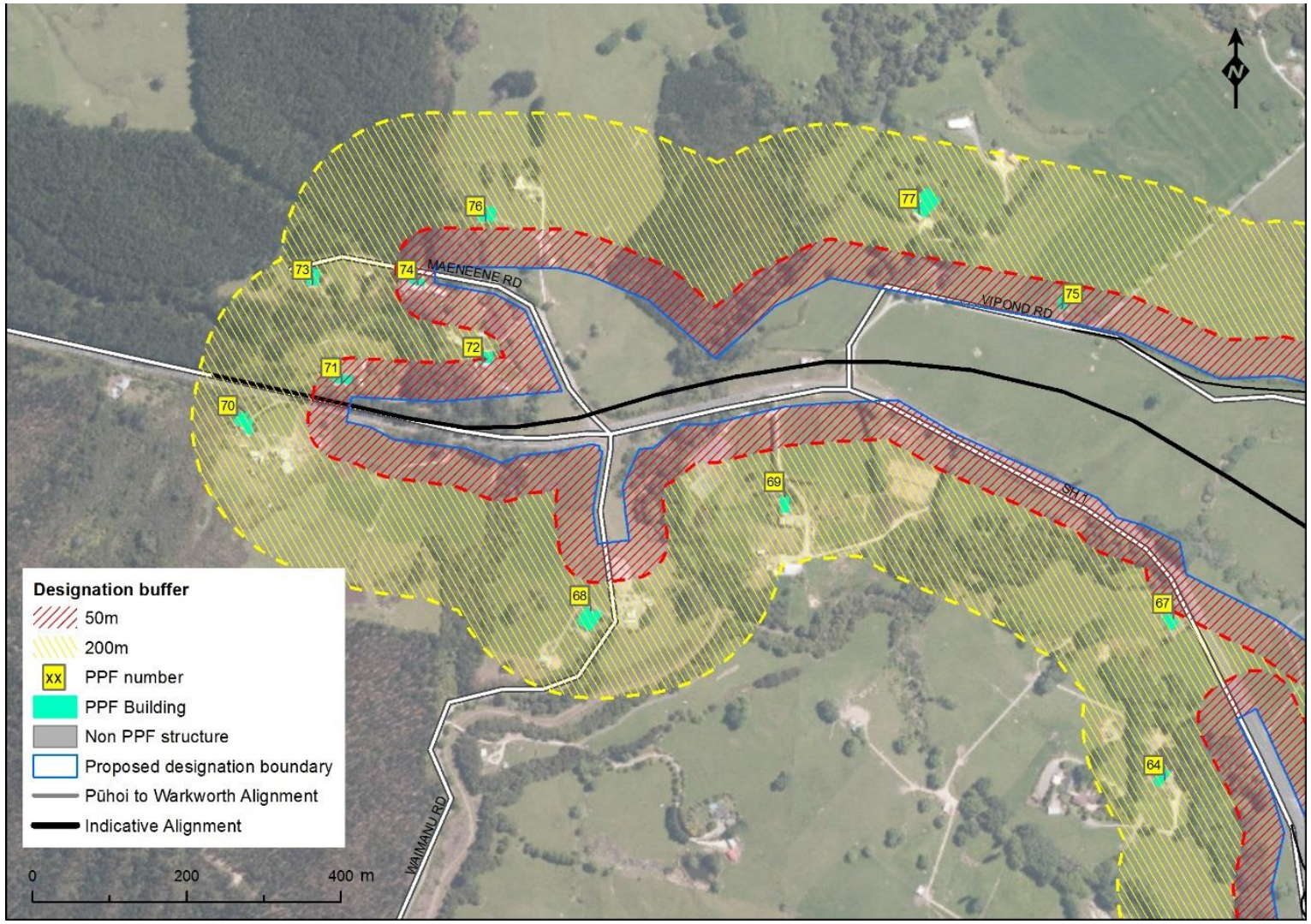

Figure 9: Location of PPFs with respect to 50 m and 200 m buffers around the proposed designation boundary – Northern tie in

4 ASSESSMENT OF EFFECTS

Assessment of effects summary

Construction noise and vibration will be heard and felt respectively at many locations in the vicinity of the Project. Noise and vibration will often be significantly above existing ambient levels and will cause some disturbance and alteration of the rural amenity during relevant construction periods. However, on the basis of this assessment noise and vibration levels can be managed to generally maintain compliance with relevant criteria. As such, the effects should be acceptable for most people who should be able to continue normal activities with minor adjustments. To comply with noise and vibration criteria construction activity will need to be significantly limited at night such that sleep disturbance effects should be avoided.

4.1 Noise

Figure 10 illustrates where typical construction noise levels fit within a scale of reference activities.

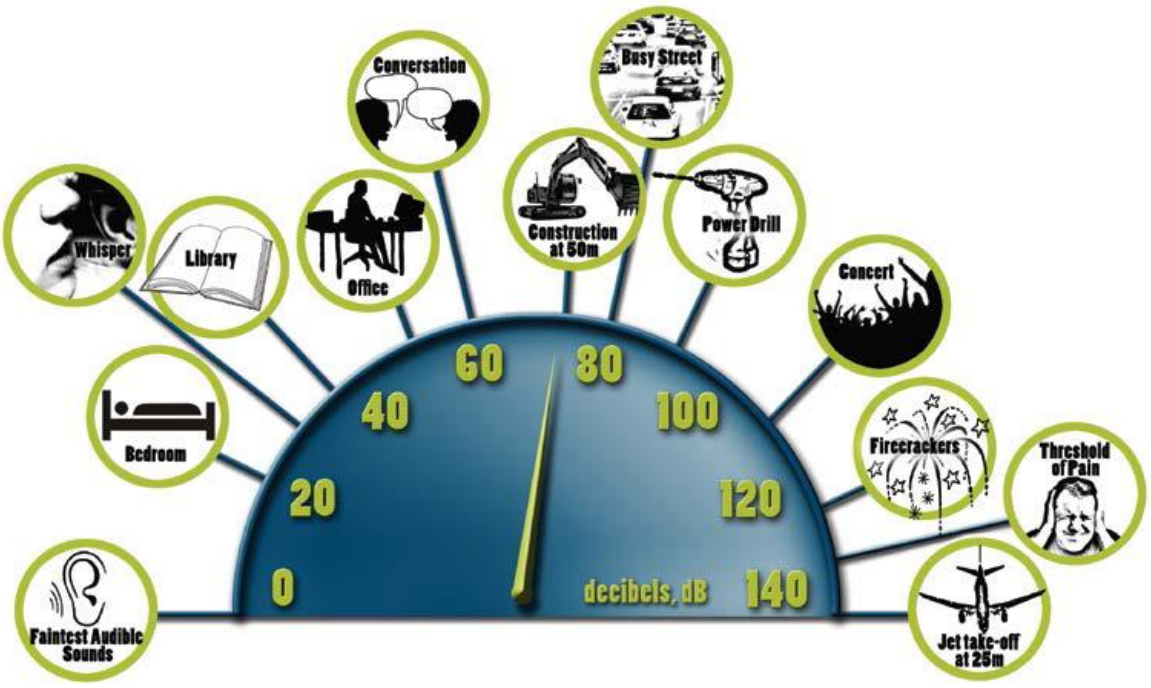

Figure 10 – Typical noise levels for various activities (source: Transport Agency Guide)

From this figure it is clear that even compliance with the daytime construction noise criterion (70 dB L_{Aeq}) may still result in noise levels above those desirable for noise sensitive activities such as conversations, relaxation or concentration, particularly for people outside. However, most normal domestic activities could continue inside, and most people would be able to adapt their routines to accommodate a degree of disruption from the construction activities, if levels remain in compliance with the noise limits most of the time. The above assessment shows this should be the case.

Due to the low existing noise levels of the wider Project area, even though compliance with limits will generally be achieved, at times during the construction period the noise levels experienced at PPFs would be considerably higher than the existing ambient levels and there will be a change in amenity during relevant construction periods. To some extent this effect is unavoidable, but it is kept within reasonable extents by the criteria that result in the most intense activity occurring in core weekday, daytime hours.

The construction noise criteria are consistent with World Health Organisation guidelines for protection from sleep disturbance. To maintain compliance with the night-time criterion, only limited works would be practical near houses at night. As such, the works should not result in any material sleep disturbance effects at night. Construction noise can potentially disturb sleep for shift workers and other people sleeping during the day. Situations where this may occur need to be identified through consultation in advance of construction so the effects for specific individuals can be managed.

While the Project has a relatively long construction timeframe, the nature and locations of construction activities will vary throughout this period. Therefore, noise effects at individual PPFs will fluctuate between the typical worst cases considered in this assessment, and at other times periods with no material noise effects.

In summary, while there will be adverse construction noise effects, this assessment has shown it is practicable for noise levels to be controlled to comply with appropriate criteria most of the time. On this basis people should be able to continue their normal activities with minor adjustments, and are likely to consider the disturbance during relevant construction periods acceptable.

4.2 Vibration

People react differently to vibration, but Table 10 presents a description of typical effects occurring at certain vibration levels.

Table 10 – Guideline values for perception of vibration (source: Transport Agency Guide)

Vibration Level (mm/s) (component ppv)	Effect
0.14	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction
0.3	Vibration might be just perceptible in residential environments
1	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents
10	Vibration is likely to be intolerable for any more than a very brief exposure to this level

Even at low levels, vibration can be perceptible and can cause disturbance. To cause damage to buildings vibration levels would need to be significantly higher. Consequently, the vibration criteria provided for amenity are different to the criteria that relate to damage to buildings.

The Category A vibration criteria are set at a level that should maintain a good level of residential amenity and should avoid any building damage. Even if these are exceeded at

times, for vibration up to the Category B criteria although vibration may be clearly perceptible, people generally should not be unduly disturbed if forewarned of the activity.

Construction vibration like construction noise should not cause sleep disturbance as activity will need to be limited at night to maintain compliance with the criterion.

4.2.1 Fixed infrastructure

In addition to the primary assessment of vibration effects on people and buildings, we have considered potential vibration effects on fixed infrastructure and major services. Transpower, Refining NZ and First Gas have assets that may be affected by the construction of the Project.

Transpower pylons should not be unduly sensitive to vibration but precaution will be made in the management plans working in conjunction with Transpower.

In terms of the Refining NZ and First Gas pipelines, the rerouting of the high pressure fuels and gas pipelines will be a part of the construction work, and any vibration effects from any of the works will be managed through that process.

4.3 Exceedances of criteria

At times during construction of the Project, construction activities will occur in close proximity to PPFs and in some instances there is the potential for noise and/ or vibration levels to temporarily exceed the criteria, after the best practicable option for mitigation has been implemented. For most large-scale construction projects, minor temporary exceedances of the noise and vibration criteria are common, and practices are in place to address adverse effects of those exceedances. These practices vary on a case-by-case basis but may include consultation with affected parties, provision of respite and potentially temporary relocation. With this management, adverse noise effects arising from exceedances of the criteria should remain acceptable for most people.

5 RECOMMENDED MITIGATION

Recommended mitigation summary

This assessment is based on the adoption of good practice construction noise and vibration management for the Project. We recommend a number of general noise and vibration management measures required to maintain this assumption.

While specific mitigation generally cannot be determined at this stage, we recommend adoption of a CNVMP as providing a robust framework for detailed assessment of noise and vibration effects and implementation of mitigation at the appropriate time.

5.1 Overview

As set out in Section 3, our assessment has been based on standard good practice construction noise and vibration management being adopted for the Project. We have summarised key measures required to achieve good practice below. The Transport Agency Guide contains further explanation on most of these measures, and should assist the Contractor to determine the BPO mitigation and management prior to, and throughout, construction.

As set out in Section 3, there are numerous PPFs within 200 metres of the proposed designation boundary where construction noise and vibration will require particular attention and ongoing assessment. At this stage of the Project there is not enough detail available to formulate specific mitigation measures for individual receiver positions. Such detail will be available once the Contractor has been appointed. A vital element of good practice construction noise and vibration management is the preparation and implementation of a Construction Noise and Vibration Management Plan (CNVMP) by the Contractor. This is a standard document that forms a framework within which detailed assessment is made at the appropriate time and mitigation implemented.

The construction methodologies may change prior to, and even throughout, construction. This is not unusual for a project of this scale and nature, however this uncertainty reinforces the need for a management approach that includes appropriate checks and establishes processes to deal with methodology changes. The CNVMP would deal with such changes and apply the most appropriate mitigation options to maintain compliance with criteria as far as practicable, and to manage adverse effects from any unavoidable exceedances of the criteria.

5.2 General measures

The following outlines general good practice measures that we recommend in accordance with the assumptions we have made in our assessment:

- Public liaison and communication is a critical management measure, even when noise and vibration is fully compliant with limits. Communication should ensure potentially affected people are reasonably informed of where and when construction activity will occur. A site representative should be available for residents to contact at all times when construction is being carried out;

- Training / inductions should be given for all construction personnel with regard to considerate behaviour and operating procedures. e.g. avoid using the truck horn to indicate when a truck is fully laden, avoid shouting or use of radios for music;
- Equipment should be selected and maintained to limit noise and vibration levels;
- Stationary equipment should be enclosed if necessary and where practicable;
- Broadband reversing alarms should be used on all vehicles and equipment;
- Equipment and activity should be separated from PPFs as far as practicable;
- Night operation should only occur when noise and vibration criteria can be met, unless daytime operation is not practicable (e.g. road closures are required);
- Noise and vibration levels should be monitored when specific equipment is first used to confirm compliance with criteria, and to refine predictions of future construction noise and vibration levels. Additional monitoring should be made at PPFs when significant works such as bridge piling are occurring in the vicinity;
- Temporary relocation should be offered where other practicable mitigation measures have been implemented and levels of noise or vibration are still predicted to exceed the criteria for a period of time. Such a measure should be considered generally as a last resort;
- Temporary noise barriers / hoardings should be used to screen activities that would otherwise exceed noise criteria where practicable. These should be erected prior to commencement of the relevant construction activity and could be near the construction activity or near the sensitive receiver;
- Vibration isolation systems should be used for stationary plant (e.g. generators, pumps, compressors) where required for compliance with vibration criteria.
- Blasting in the vicinity of PPFs should only occur once a day between 9 am to 5pm Monday to Saturday. Affected PPFs should be forewarned of each blast;
- Initial blasting should use small charges to confirm site parameters, and then charge sizes should be limited so that criteria are achieved as far as practicable;
- Haulage routes should be located away from PPFs where practicable. Drivers operating on public roads should ensure audible engine brakes are not used near PPFs and speeds are restricted as required to avoid unnecessary engine and body sounds that would cause disturbance;
- Temporary relocation should be offered to residents where other practicable mitigation measures have been implemented and levels of noise or vibration are still predicted to exceed the criteria for a period of time. Such a measure should be considered generally as a last resort.

5.3 Specific measures

While there generally is not sufficient detail available at this stage to determine specific mitigation measures, as discussed in Section 3, two restrictions are recommended:

- Any long-term construction staging areas should be at least 200 metres from PPFs;
- Kraack Road should not be used as a haulage route.

As set out above, we recommend that all construction should be undertaken in accordance with a CNVMP, that based on NZS 6803 should as a minimum include:

- The construction noise and vibration criteria set out in Section 3.2;
- Description of the work, equipment/processes and their scheduled durations;
- Hours of operation, including times and days of the week when construction activities causing noise and vibration would occur;
- Identification of affected PPFs and other areas where construction noise and vibration management and mitigation would be required;
- Management and mitigation measures that would be employed to achieve compliance with the Project noise and vibration criteria where practicable;
- Methods for communicating and consulting with affected parties, and for responding to complaints; and
- Methods for dealing with specific circumstances where full compliance with the Project noise criteria cannot be achieved, to ensure acceptable outcomes;
- Methods for monitoring and reporting on noise and vibration, including when full compliance cannot be achieved, or in response to complaints.

The Transport Agency has provided a template for CNVMPs on its website[7] and has a basic online construction noise calculator. The contractor should refer to these tools when preparing the CNVMP.

[7] http://nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/noise-and-vibration/standards-guidelines-and-specifications/

6 CONCLUSIONS

Ambient noise levels have been measured in the vicinity of the Project and found to be relatively low in rural areas remote from the existing SH1.

To assess construction noise and vibration effects of the Project, criteria have been proposed that are the same as previously used for numerous other current and recent state highway construction projects, and are broadly consistent with rules in the AUP(OP).

Based on typical construction equipment, the distances at which noise and vibration criteria will be achieved have been estimated. It has been found that in general night works cannot comply with the criteria unless remote from PPFs. For daytime works the criteria should generally be achieved within around 50 metres of the works, but will require further review during construction for PPFs within 200 metres. All PPFs within 200 metres of the designation boundary have been identified.

Further examination of 16 PPFs identified as being within 50 metres of the proposed designation has shown that in most instances no specific noise mitigation beyond standard good practice should be required to maintain compliance with the noise and vibration criteria. In the remaining cases the practicable mitigation options have been identified.

Construction activity in compliance with the noise and vibration criteria will cause a degree of disturbance and alter the amenity in the area during relevant construction periods. However, these effects should be to an acceptable degree for most people, who will be able to continue with normal activities subject to some adjustments. Night-time criteria are designed to avoid causing sleep disturbance.

This assessment is dependent on the implementation of good practice noise and vibration management. It is recommended that this be achieved through the use of a CNVMP.

APPENDIX A: NOISE MONITORING

Noise monitoring has been conducted at 8 locations as detailed in Table 11. The monitoring has been conducted in general compliance with NZS 6801 and NZS 6806.

Table 11 – Noise monitoring locations

Location No	Address	Measurement Dates
1	761 A SH1, Dome Forest, NZ, 0981	29/06/17 – 06/07/17
2	1472 SH1, Wellsford, NZ, 0975	29/06/17 – 06/07/17
3	263 Silver Hill Road, Wellsford, NZ, 0975	29/06/17 – 06/07/17
4	490 SH1, Wellsford, NZ, 0975	06/07/17 –13/07/17
5	40 Borrows Road, Wellsford, NZ, 0974	06/07/17 – 13/07/17
6	211 Kaipara Flats Road, Warkworth, NZ 0981	13/07/17 – 20/07/17
7	39 Philips Road, Dome Forest, NZ, 0981	13/07/17 – 20/07/17
8	294 Wayby Valley Road, Wayby Valley, NZ, 0972	13/07/17 – 20/07/17

Details of the acoustic equipment used to conduct these measurements are provided in Table 12. All acoustic equipment had current calibration certificates. The noise loggers were checked for calibration before and after each set of measurements. A windshield was fitted to the microphone for all measurements.

Table 12 – Acoustic equipment

Manufacturer	Type	Serial No	Last calibration date
Acoustic Research Labs	NGARA Noise Logger	87813F	17/05/2017
Acoustic Research Labs	NGARA Noise Logger	87805E	03/12/2015
Acoustic Research Labs	NGARA Noise Logger	8780B6	11/01/2016
Acoustic Research Labs	Logger Calibrator	C17208	18/05/2017

Meteorological conditions during the measurements have been recorded by Cliflo weather stations in Warkworth and Leigh Auckland. This information, in addition to subjective observations, audio recordings, and review of the noise monitoring results, has been used to assess the impact of weather at all properties. It is likely that the wind speed will be higher at the weather stations than at the monitoring locations which are generally more shielded. As such, the measurements have been assessed and judgement used to determine if it is affected by a weather event. Where anomalous or weather effected data is identified it has been excluded in the determination of acoustic parameters.

The $L_{Aeq(24h)}$ results have been presented on Figure 11 to Figure 18 . The calculated parameter presented has been determined from the measured weekday data, excluding periods of inclement weather and anomalous data.

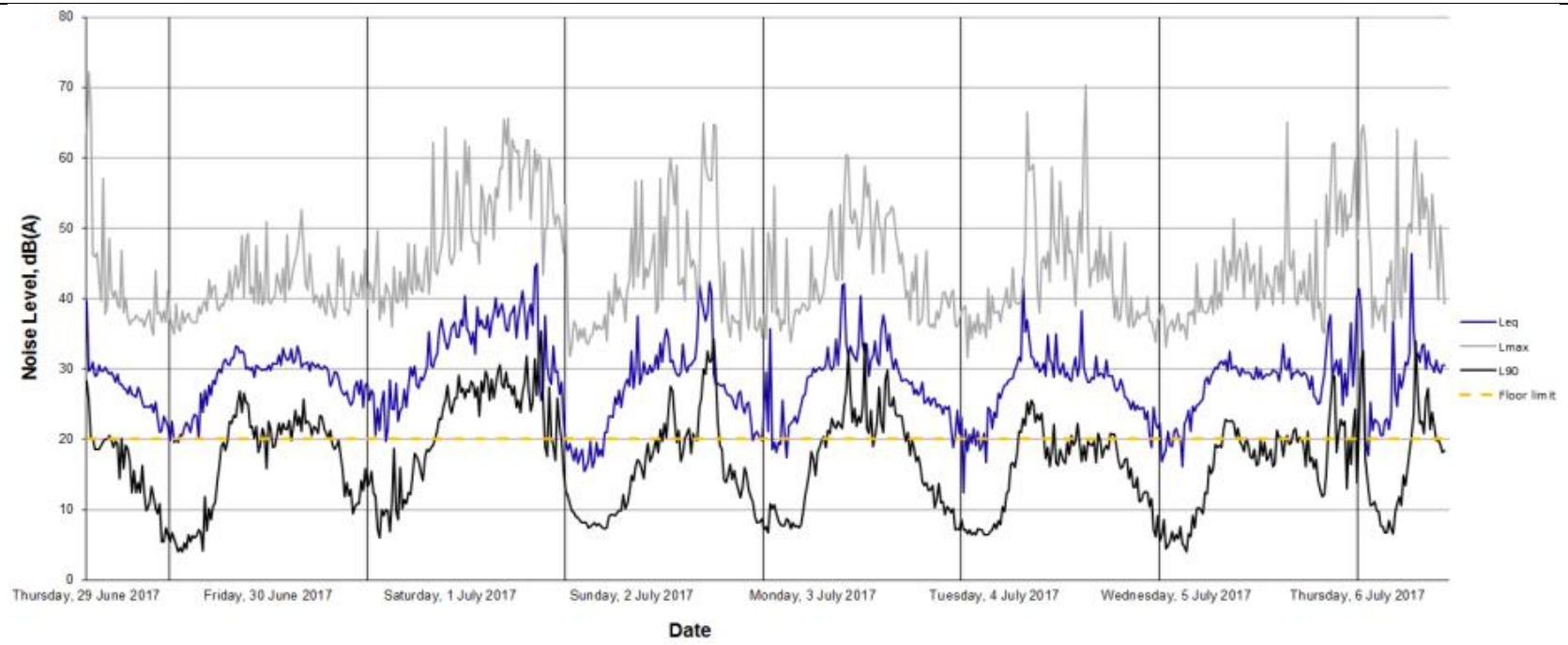

Image 1: In the direction of Alignment

Image 2: In the direction of SH1

Image 3: Measurement location

$L_{Aeq(24h)}$: 35 dB

Comments: Farm chickens present at the property. Logger is located approximately 143 m south of SH1.

Measurement location: Next to a retaining wall approximately 3.5 m away from the south facade of the property.

Meteorology: 15°C Sunny, RH: 70%, Wind: 7 km/h, W, Rain: 0 mm.

Figure 11 – Noise monitoring results at 761A SH1, Dome Forest

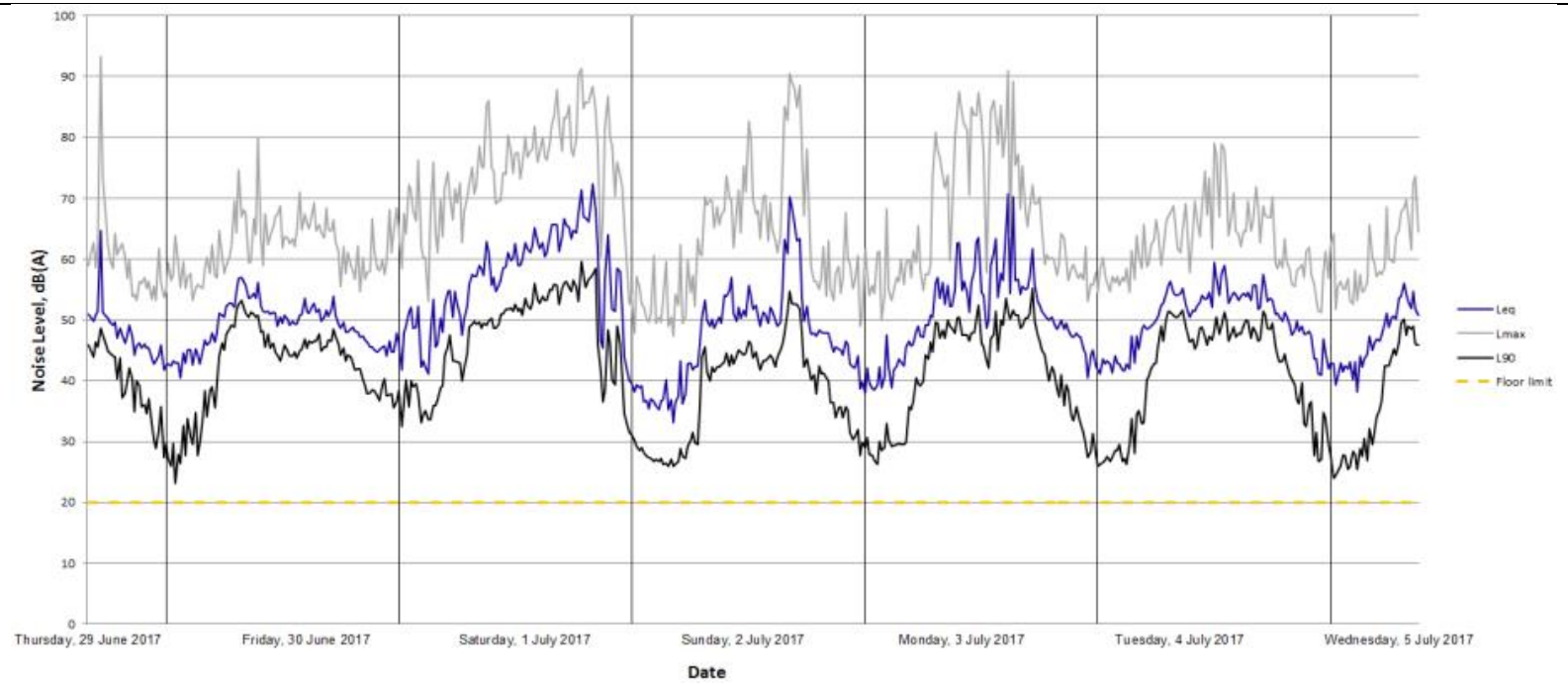

Image 1: In the direction of SH1

Image 2: In the direction of alignment

Image 3: Measurement location

$L_{Aeq(24h)}$: 57 dB

Comments: Farm animals present at the property (dogs, chickens, horses and cows). Logger located approximately 140 m north of SH1.

Measurement location: Approximately 30 m from the northern facade along the north boundary of the property to minimise impact of animal noise.

Meteorology: 14°C Cloudy, RH: 69%, Wind: 9 km/h, NE, Rain: 0 mm.

Figure 12 – Noise monitoring results at 1472 SH1, Wellsford

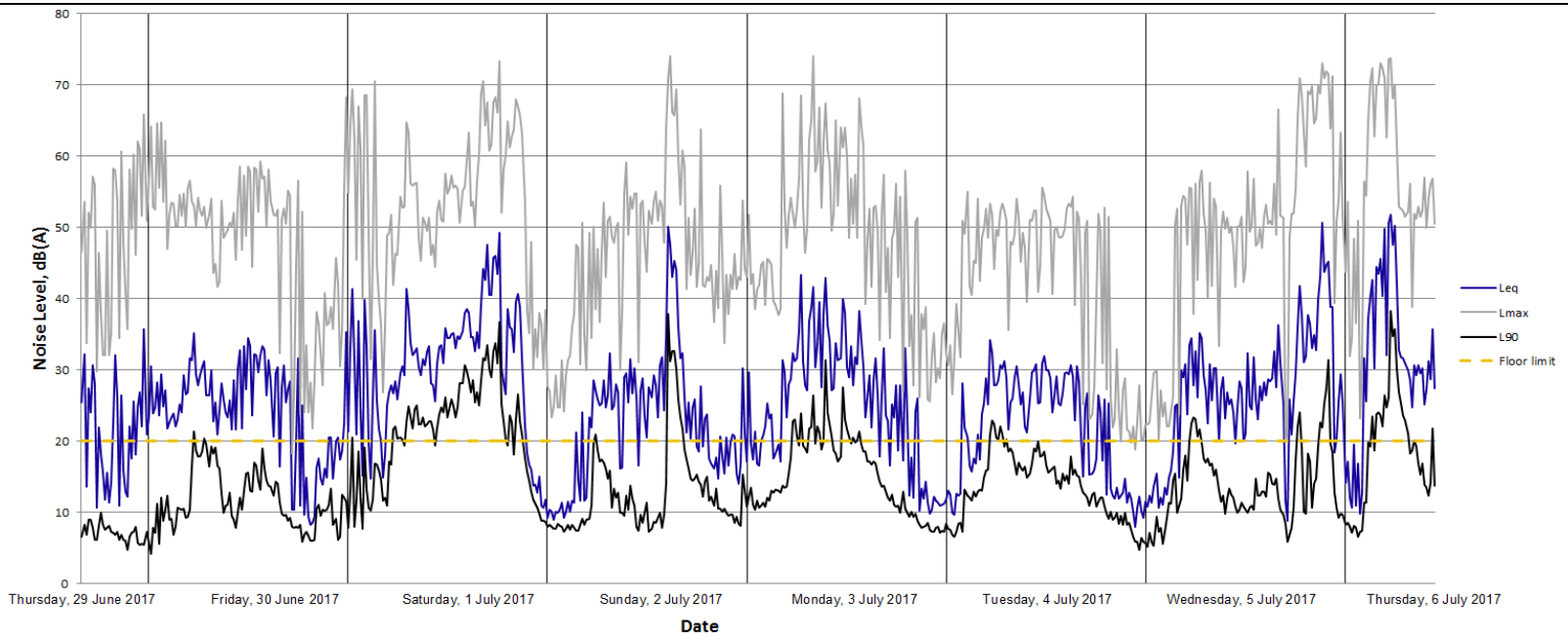

Image 1: View towards property

Image 2: In the direction of SH1 and alignment

Image 3: Measurement location

$L_{Aeq(24h)}$: 37 dB

Comments: Loud music played from neighbour at the time of setup. Nearby farm animals are also present. A milk tanker operates daily.

Measurement location: Approximately 37 m from the facade of the property near the edge of Silver Hill Road, Wellsford.

Meteorology: 14°C, Drizzle, RH: 68%, Wind: 7 km/h, N, Rain: 0 mm.

Figure 13 – Noise monitoring results at 263 Silver Hill Road, Wellsford

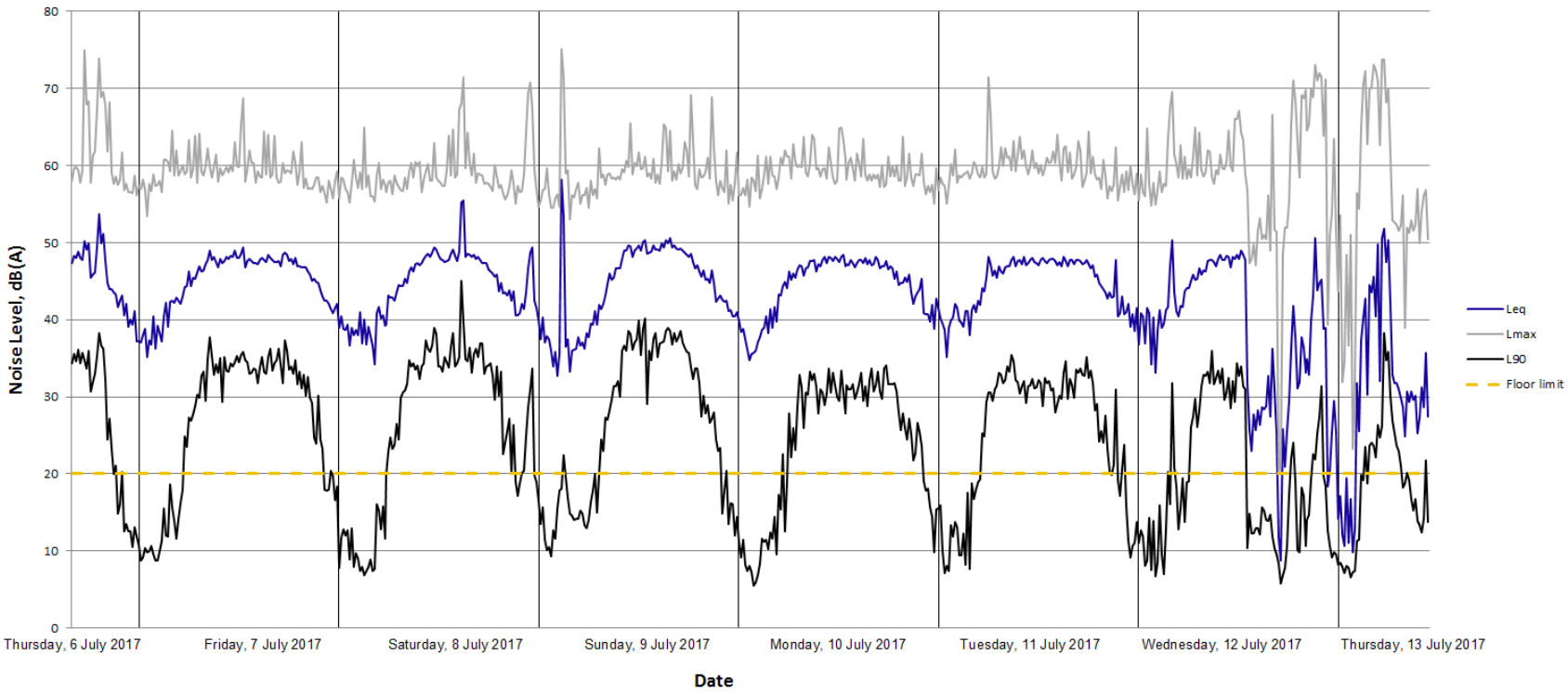

Image 1: In direction of alignment

Image 2: In direction of SH1

Image 3: Measurement location

$L_{Aeq(24h)}$: 47 dB

Comments: Audible water system nearby logger and approximately 21 m east of SH1. The logger is located in open land with the property being 10 m south.

Measurement location: Approximately 14 m from the northern facade of the property.

Meteorology: 11°C Drizzle, RH: 83%, Wind: 5 km/h, W, Rain: 0 mm.

Figure 14 – Noise monitoring results at 490 SH1, Wellsford

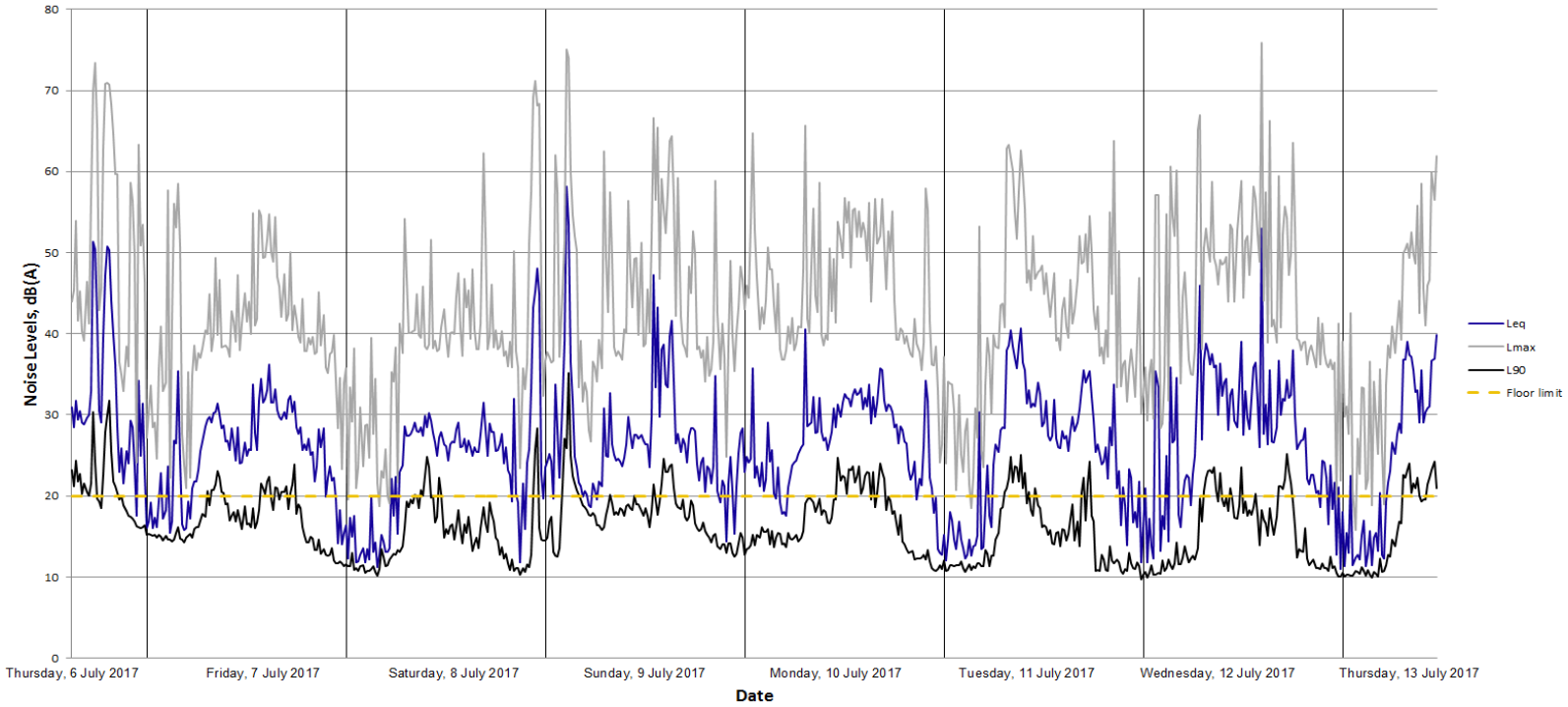

Image 1: In direction of alignment

Image 2: view towards property

Image 3: Measurement location

$L_{Aeq(24h)}$: 40 dB

Comments: Located north of vegetation surrounding the swimming pool and west of a paddock containing a herd of cows.

Measurement location: Approximately 5 m away from the northeast facade of the property.

Meteorology: 15°C Cloudy, RH: 81%, Wind: 17 km/h, SW, Rain: 0 mm.

Figure 15: Noise monitoring results at 40 Borrows Road, Wellsford

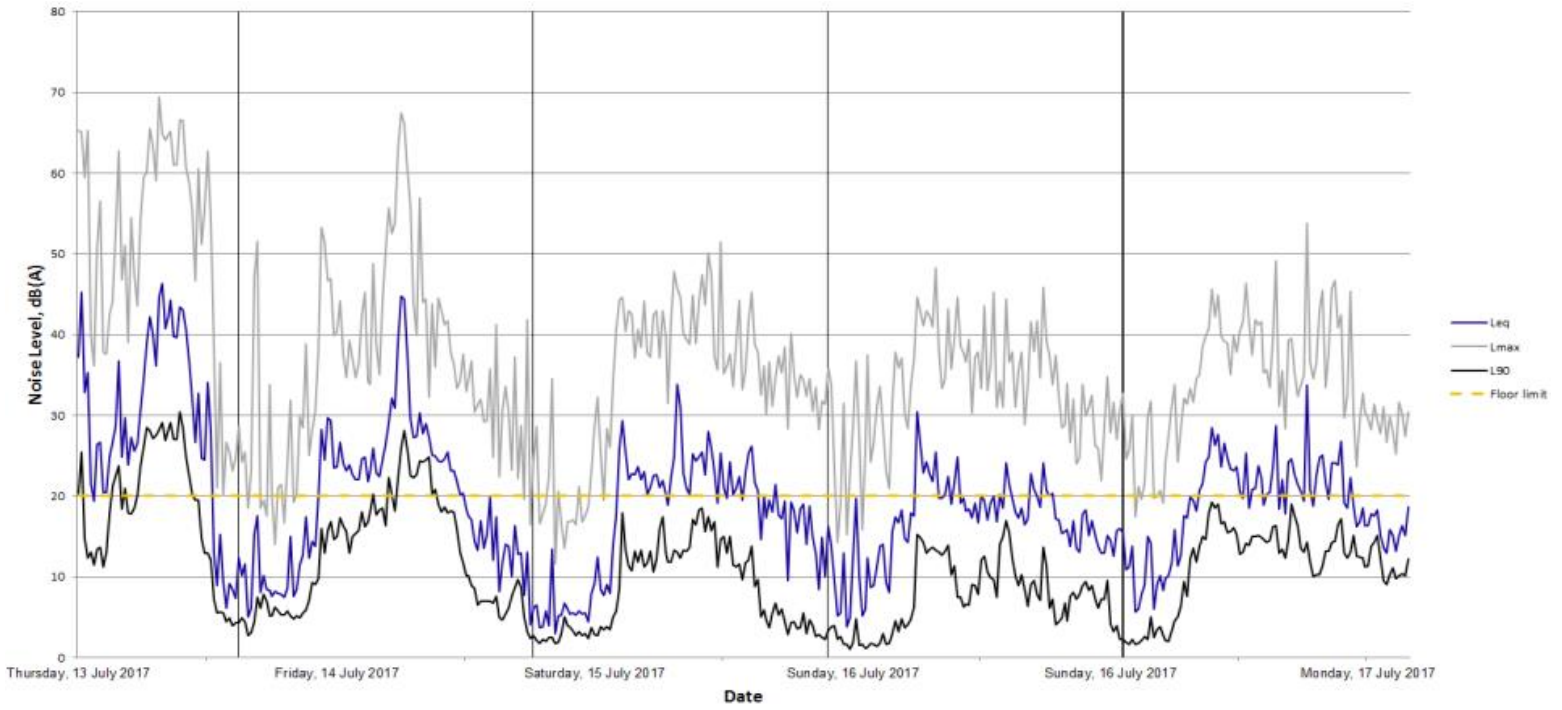

Image 1: In direction of alignment

Image 2: view towards property

Image 3: Measurement location

$L_{Aeq(24h)}$: 30 dB (Max)

Comments: Logger failure occurred on Monday the 17th. Located along north east boundary of property.

Measurement location: Approximately 22 m front the northeast facade of the property facing the alignment.

Meteorology: 9°C Sunny, RH: 66%, Wind: 14 km/h, NW, Rain: 0 mm.

Figure 16: Noise monitoring results at 211 Kaipara Flats Road, Warkworth

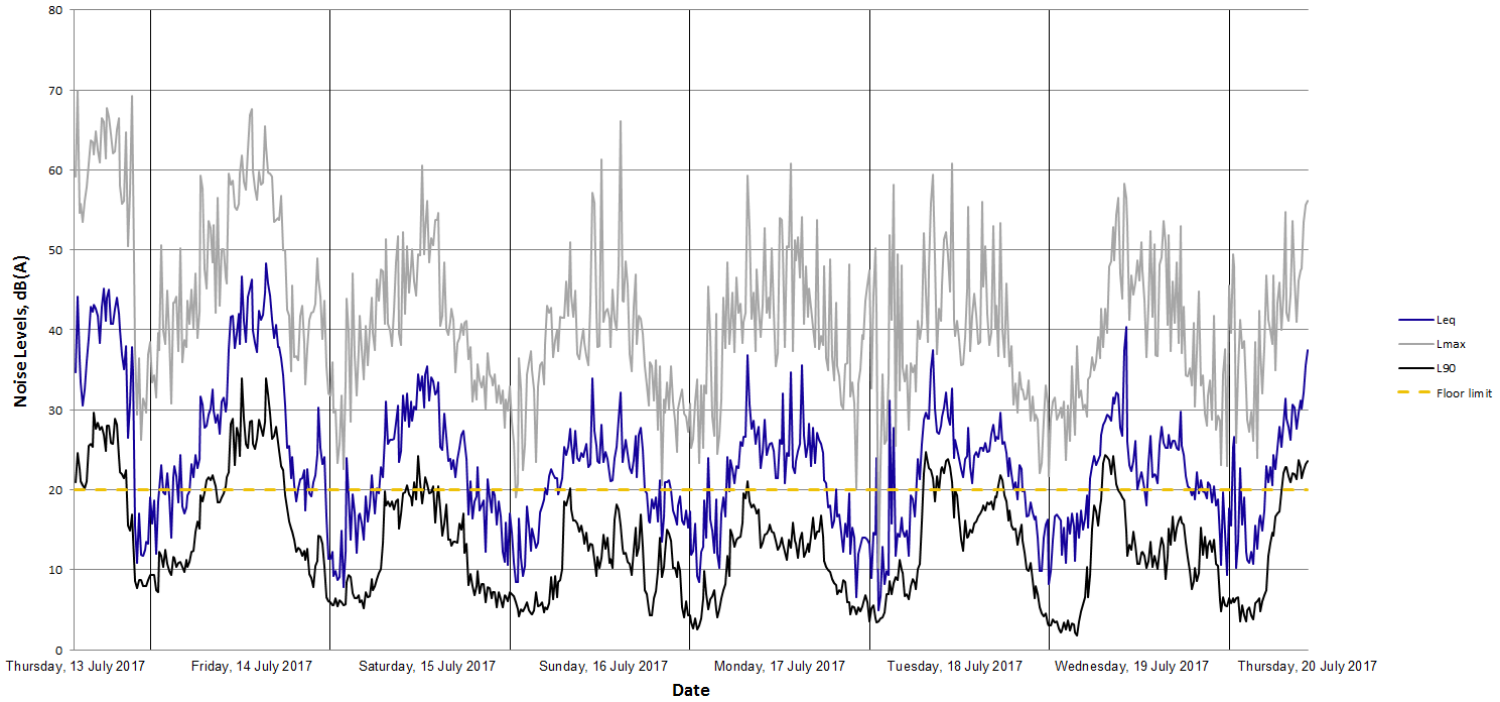

Image 1: In direction of alignment and SH1

Image 2: In direction of property

Image 3: Measurement location

$L_{Aeq(24h)}$: 38 dB

Comments: Logger location was moved further along the entrance driveway to avoid noise from animals (chickens. sheep, cows) within the property boundary.

Measurement location: Approximately 43 m from the northeast facade of the property.

Meteorology: 9°C Cloudy, RH: 76%, Wind: 13 km/h, SW, Rain: 0.6 mm.

Figure 17: Noise monitoring results at 39 Phillips Road, Dome Forest

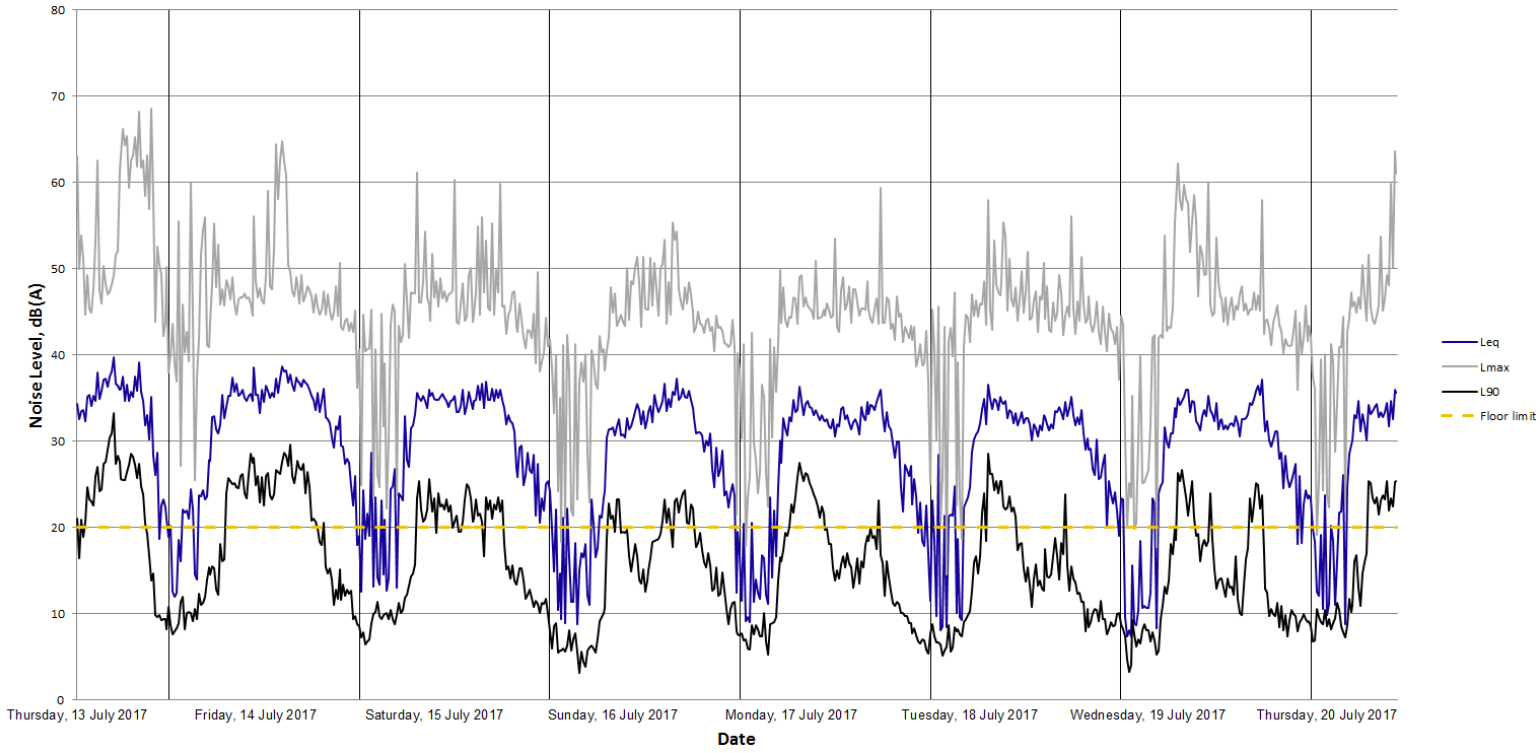

Image 1: In direction of alignment

Image 2: in direction of property

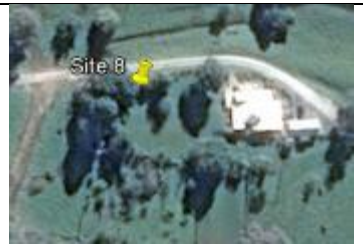

Image 3: Measurement location

$L_{Aeq(24h)}$: 34 dB

Comments: Located adjacent to the driveway with SH1 directly south and Wayby Valley Road to the west of the logger location.

Measurement location: Approximately 28 m from the west facade of the property.

Meteorology: 9°C Cloudy, RH: 75%, Wind: 18 km/h, SW, Rain: 0.3 mm.

Figure 18: Noise monitoring results at 294 Wayby Valley Road, Wayby Valley