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State Highway 1 and State Highway 29 Intersection Upgrade

Assessment of Noise and Vibration Effects

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Contact Details

Richard Jackett
WSP
WSP Research, 33 The Esplanade
Petone, Lower Hutt
Richard.jackett@wsp.com

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Prepared by

Richard Jackett
Principal Engineering Scientist

Iain McIver,
Engineering Scientist

Reviewed by

Peter Cenek
Research Manager Environment

Approved for release by

Zaid Essa
Project Manager

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Contents

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This report (**Report**) has been prepared by WSP exclusively for NZ Transport Agency Waka Kotahi (**Client**) in relation to an application for notices of requirement and regional resource consents (**Purpose**) and in accordance with our contract with the Client dated May 2020. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

Glossary of Abbreviations

Abbreviation / Term	Term / Definition
BPO	Best Practicable Option
dB	decibel
m	metres
mm	millimetres
mm/s	millimetres per second
NZS	New Zealand Standard
PPF	Protected Premises and Facilities
DIN	German Standard
NS	Norwegian Standard
SH1	State Highway 1
SH29	State Highway 29
SMA	Stone Mastic Asphalt

Glossary of Defined Terms

Term	Definition
Best Practicable Option	Defined in section 2 of the RMA, in relation to a discharge of a contaminant or an emission of noise, as meaning the best method for preventing or minimising the adverse effects on the environment, having regard to various stated factors
dB	Decibel is the unit of sound level. Expressed as a logarithmic ratio of sound pressure (P) relative to a reference pressure (Pr), where level, L = 20 x $\log_{10}(P/Pr)$ dB.
dB $L_{Aeq(T)}$	The A-weighted equivalent continuous sound level in decibels, $L_{Aeq(T)}$, measured over a stated period of time, T.
NAASRA	National Association of Australian State Road Authorities roughness count. A measure of road roughness.
Project	Proposed three-legged roundabout and tie-ins at the intersection of SH1 and SH29 near Piarere in the Waikato region.
PPF	As defined in section 1.4 of NZS 6806. Essentially residential dwellings or accommodation, schools, Marae, and medical premises with overnight facilities.
Sensitive Receiver	Sensitive Receivers of construction noise are occupied dwellings. Sensitive Receivers of construction vibration include occupied and unoccupied buildings.
Waka Kotahi	Waka Kotahi NZ Transport Agency

1 Executive Summary

This report assesses noise and vibration effects associated with construction and operation of the proposed roundabout for the upgrade of the intersection of State Highway 1 (SH1) and State Highway 29 (SH29) near Piarere in the Waikato. The proposed roundabout alignment will move the intersection to the north-west, away from the closest receivers, although slightly closer to a single receiver to the north-west. This single sensitive receiver still maintains a long separation distance from the Project.

Consistent with the requirements of the Resource Management Act and the Matamata-Piako and South Waikato District Plans, the effects of noise and vibration have been assessed.

Road traffic noise has been assessed for nearby sensitive receivers using the New Zealand Standard NZS 6806. This assessment used a noise model that has been validated with on-site measurements. This assessment has found that the noise levels with the Project as proposed will not increase significantly over the Do-Nothing scenario, and noise impacts will be negligible. No noise mitigation is required. The roundabout may have a different audible character to the existing T-intersection, but the long-term experience of road traffic noise for nearby residents should not change significantly.

Vehicle-induced vibration has been assessed. Vibration measurements were taken on site to assess vibrations from the existing alignment, and assessment of the data using two standards found that the existing vibration levels are at acceptable magnitudes. With the proposed new alignment not moving traffic closer to any of the nearby sensitive receivers, and with the requirement for the construction of a smooth road, the traffic induced vibration levels from the Project operating are predicted to be similar to existing vibration levels and residents are very unlikely to detect an increase in traffic induced vibration.

A high-level indicative assessment of construction noise suggests that NZS 6803 'long-term duration' criteria will not be regularly exceeded for day-time work. Vibration is similarly unlikely to cause negative effects for the majority of the Project duration, although cannot be discounted during the closest approaches to sensitive receivers. It is recommended that a Construction Noise and Vibration Management Plan (CNVMP) be prepared prior to commencement of construction.

2 Introduction

2.1 Purpose and scope of this report

This report gives an assessment of noise and vibration effects from construction and operation of the proposed State Highway 1 (SH1) and State Highway 29 (SH29) Intersection Upgrade Project (the Project).

This report forms part of a suite of technical reports prepared for Waka Kotahi NZ Transport Agency (Waka Kotahi) for the Project. These technical reports are to inform the Assessment of Effects on the Environment Report (AEE) and support the two Notices of Requirement (NoRs) for alterations to designations to Matamata-Piako District Council (MPDC) and South-Waikato District Council (SWDC) and applications for regional resource consents to Waikato Regional Council (WRC).

A full description of the NoRs and regional resource consents required for the Project is provided in Section 4 of the AEE. A full description of the background and strategic context for the Project is provided in Section 2 of the AEE.

2.2 Background

The overarching requirement for the management of noise and vibration is established by the Resource Management Act 1991 (RMA). Sections 171 and 181 require that the environmental effects of new and altered designations are considered. Section 104 requires that effects from construction are also considered.

The response of people to noise is broad. For any particular level of noise, a proportion of the population will find it disturbing and a proportion will find that same noise level of little disturbance. As noise levels change, there is a progressive change in these proportions of population that are disturbed and those that are undisturbed, with the proportion disturbed increasing as noise levels increase.

Because the response to noise is broad, noise tends to be managed at the level of the response of a typical community rather than on individual responses.

Population response is similarly broad for the scale of vibration levels typically associated with traffic and many road construction activities. A particular vibration level that some individuals find disturbing will be of little disturbance to other individuals.

Therefore, in considering noise and vibration effects, it is important to have regard to guidelines or standards in which limits are recommended. Given the development process for those guidelines and standards, the limits they contain represent the view of stakeholders and experts as to the acceptable level of community disturbance. In general, guidelines or standards for noise are targeted at protecting people's health and reducing noise effects on amenity.

This Report describes the methodology of investigating the potential noise and vibration levels, how those levels may be assessed as effects, and what mitigation should be implemented, if required.

3 Project Description

The Project is the construction and operation of a new two lane roundabout connecting SH1 and SH29, north-west of the existing intersection of SH1 and SH29 at Piarere. The key components of the Project are:

a) A two-lane roundabout with a 60 m diameter central island.

b) Realignment of parts of the SH1 and SH29 approaches to connect to the new roundabout.

c) The roundabout will be elevated approximately 3.5 m above the existing ground level to provide for cycle and pedestrian underpasses.

d) A stormwater management system, including a wetland pond, wetland and planted swales and a discharge structure and associated rip rap armour

e) Construction activities, including a construction compound, lay down area and establishment of construction access.

A full description of the Project including its current design, construction and operation is provided in Section 6 of the AEE and shown in the Project Drawings in Volume 4: Drawing Set.

The final design of the Project (including the design and location of ancillary components such as stormwater treatment devices), will be refined and confirmed at the detailed design stage.

4 Existing Environment

Currently, SH1 and SH29 meet at a T-intersection. SH1 traffic is the priority movement, flowing approximately west-east through the intersection. A slip lane is provided for SH1 traffic to ease left on a large radius curve from SH1 eastbound to SH29 approximately northbound. The speed limit is generally 100 km/h but an electronic variable speed limit operates in the area of the intersection to drop the speed limit from 100 km/hr to 60 km/hr when the intersection is busy.

Noise and vibration measurements in the vicinity of the existing intersection were undertaken in February 2021. These measurements were required to establish the existing noise and vibration environment and to aid with noise and vibration modelling. Details of the measurements can be found in Appendix A.

These measurements found that daytime environmental noise in the vicinity of the existing intersection is dominated by road traffic noise at all of the locations monitored. At night there is still a relatively high volume of traffic on the road, which continues to dominate the ambient noise level for most of the night. There are no other permanent sources of significant noise in the area, though intermittent noise sources typical of a rural environment will contribute to the ambient noise from time to time (e.g. livestock, wind, farm equipment). The proximity of SH1 and SH29 mean this area is noisier than a typical rural environment.

Vibration levels measured are accepted as unlikely to be noticeable for most people and are considered to have negligible effect.

4.1 Sensitive receivers

Sensitive receivers for noise are referred to as "Protected Premises and Facilities" (PPFs). PPFs are defined in NZS 6806[1] as buildings used for noise-sensitive activities such as residential activities, marae, some education activities, and overnight patient medical care. The same receivers are considered sensitive to vibration. In addition, vibration sensitive structures close to the Project have been included.

There is one structure identified as sensitive to vibration (but not sensitive to noise). It is the power pylon structure immediately to the east of SH29, approximately 335 m north of the existing SH1/SH29 intersection.

The sensitive receivers identified for this noise and vibration assessment are shown below in Table 4-1. The Project design, existing layout, and location of the sensitive receivers is shown in Figure 4-1.

Table 4-1: Sensitive receivers (PPFs)

Address	Type	Distance to nearest part of Project alignment [m]
Receivers sensitive to noise and vibration		
5969A SH29	PPF	200
5969B SH29	PPF	300
2 SH1	PPF	80
36 SH1	PPF	55
38 SH1	PPF	60
1831A Tirau Rd	PPF	260
Receivers sensitive to vibration only		
Power pylon	Structure (vibration only)	30

[1] New Zealand Standard NZS 6806:2010. Acoustics – Road-traffic noise – New and altered roads.

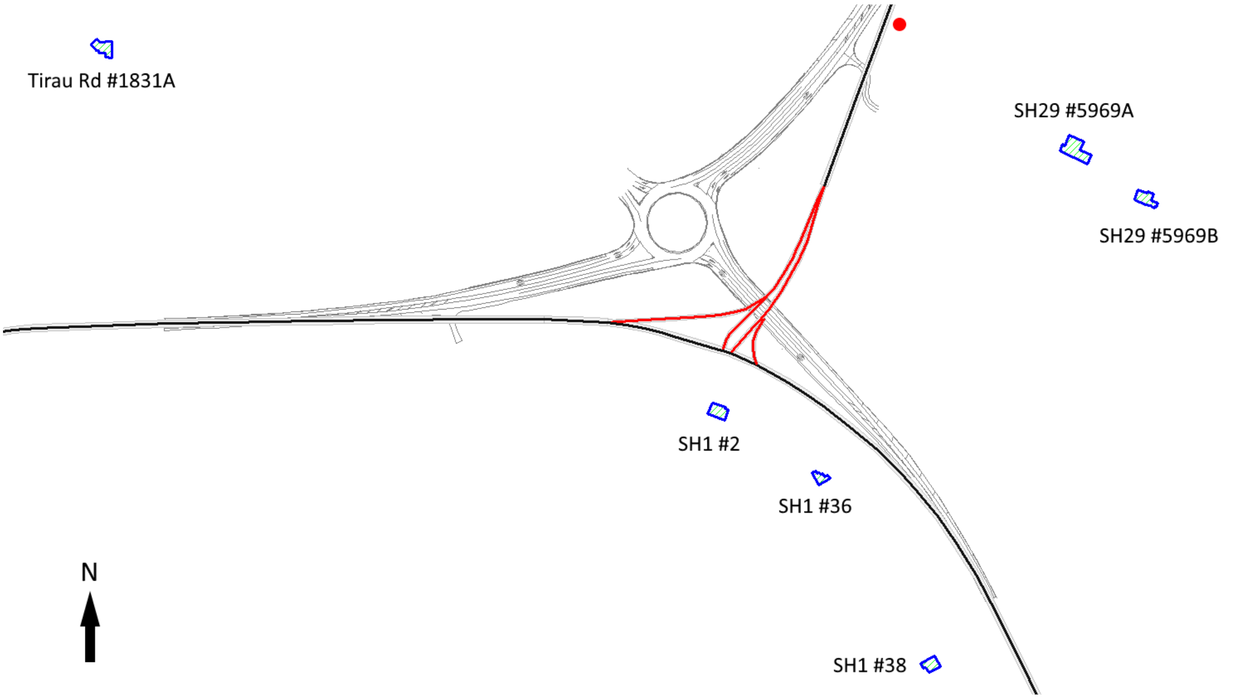


Figure 4-1: Project layout, showing existing roads (bold black and red lines), the proposed roundabout layout (grey), PPFs (blue), and the closest power pylon (red dot)

5 Road-Traffic Noise Assessment

To assess road-traffic noise effects, we have used NZS 6806 *Acoustics – Road-traffic noise – new and altered roads*[1] (NZS 6806).

The relevant District Plans, South-Waikato District Plan (Rule 15.4) and Matamata-Piako District Plan (at Rule 1.4.2) also provide that NZS 6806 should be used to assess road traffic noise.

NZS 6806 has been extensively applied to state highway improvement projects over the last 10 years and is considered appropriate for assessment of road traffic noise effects that may arise from this Project.

5.1 Methodology

5.1.1 NZS 6806: Acoustics – Road-traffic noise – New and altered roads

The New Zealand Standard NZS 6806[1] provides a methodology and criteria for assessing the effects of road traffic noise on PPFs, and outlines a process to determine if mitigation is required.

As set out in NZS 6806, as the Project is located in a rural area, we have assessed all PPFs within 200 m of the Project. We have included a couple of additional dwellings located outside the 200 m assessment area.

NZS 6806 requires that noise levels are predicted with the Project in place and operating with the traffic volumes forecast for a future year (the “design year”) between 10 and 20 years after opening. For this assessment the design year has been taken as 2042.

As mentioned, the assessment under NZS 6806 involves creating noise models and predicting noise levels for two future scenarios. These scenarios are:

- The 2042 Project noise level (NZS 6806 refers to this as the ‘Do-Minimum level’). This is the predicted noise level, in the design year, with the Project fully operational. The Do-Minimum does not include any noise mitigation that is provided specifically for that purpose.

- The 2042 Do-Nothing noise level. This is the predicted noise level, in the design year, assuming that the Project does not go ahead. This is used as a baseline, and it includes factors such as predicted traffic growth and non-Project-related changes to the road network (though in this case we are not aware of any of the latter).

5.1.2 Noise Criteria

NZS 6806 provides criteria for mitigating noise from new and altered roads, and there are 3 tiers, or "Categories", of noise limits: A, B, and C. Where it is consistent with the Best Practicable Option (BPO), the Category A noise levels should be achieved (for Do-Minimum). If achieving Category A cannot practicably be achieved, then Category B should be achieved with mitigation. If achieving Category A or Category B is inconsistent with the BPO, then the criteria of Category C should be achieved to the extent that it is practicable.

NZS 6806 assesses noise from altered roads differently to noise from new roads. Receivers are generally less sensitive to noise from an existing road that has been altered, and therefore NZS 6806 noise criteria for altered roads are generally higher than the noise criteria for new roads. In this Project there are no new roads, but several roads will have their horizontal and vertical alignments altered. NZS 6806 gives a specific definition for the term altered road. An altered road is one that has its horizontal and/or vertical alignment altered to an extent affecting the road-traffic noise levels received from the road.

Table 5-1 shows NZS 6806 noise criteria for altered roads. The second column shows the NZS 6806 altered road criteria as an absolute noise level to achieve at PPFs for each Category A, B, and C.

The third and fourth columns in Table 5-1 show the noise levels and noise level changes that NZS 6806 uses in its definition of altered roads. Unless both are met, the road is not considered an altered road. The noise level changes attributed to the physical alterations of the road are determined through a comparison of the Do-Nothing and Do-Minimum (Project) noise levels.

Table 5-1: NZS 6806 noise level criteria for altered roads

Category	**Noise Level to Achieve** [dB $L_{Aeq(24h)}$]	**Noise level *and* noise level change criteria for NZS 6806 definition of altered roads**	
		Do Minimum Project noise level	**Noise level change of Do Minimum minus Do Nothing for road to be considered 'altered'** [dB]
A (free-field external noise)	64	64 or more	+3
B (free-field external noise)	67	68 or more	+1
C (internal noise)	40		

5.1.3 Noise Model

The noise modelling process is used to predict noise levels at PFFs for three scenarios:

1. The existing road layout with traffic in the current year, 2021. Used for model validation.
2. The 2042 Project noise (Do-Minimum) level. Used for assessment against NZS 6806.
3. The 2042 Do-Nothing noise level. Used for assessment against NZS 6806.

The Do Minimum level (scenario 2) and the Do Nothing level (scenario 3) are compared in the NZS 6806 definition of altered roads, as discussed above.

The Project area has been modelled in SoundPLAN software (version 8.2), which uses Calculation of Road Traffic Noise (CRTN) noise algorithms to predict road traffic noise levels. This is a well-recognised method of modelling road traffic noise in New Zealand and meets the requirements of NZS 6806.

The noise model has been developed to account for the various factors that affect the propagation of road-traffic noise: assessed buildings, incidental buildings, ground cover, and several layers for the various roads and versions thereof. The model includes data to define the topography of the project area.

The majority of the modelled area is flat, except for in the south where the topography drops steeply towards the Waikato River / Lake Karapiro. Building locations and footprints have been provided by the Project GIS team, and verified against recent high resolution aerial photographs. PPFs have been identified by manual examination of aerial and 'street view' imagery, and reviewed by the project property team where there was any uncertainty about building occupation or usage. In total, 6 PPFs have been identified for assessment for this Project.

The Do-Nothing 2042 scenario has been modelled using the current 100 km/h speed limit. The Project Do-Minimum 2042 scenario has been modelled assuming a 110 km/h speed limit is in place (a worst case scenario for noise).

Details of the noise model source data are given in Appendix B.

5.1.4 Noise model validation

Assessment under NZS 6806 is based on modelling the noise of a future road layout, but aspects of the wider noise model can be validated by comparing a noise model built to represent the existing 2021 scenario with field measurements. NZS 6806 (§5.3.4.2) suggests that the difference between measured and predicted/modelled levels should not exceed ± 2 dB.

Short-term noise measurements to validate the performance of the noise modelling process were undertaken in February 2021 at four locations, with simultaneous traffic counts, and one longer measurement made at a fifth location to determine the 24-hour noise pattern for the area. Details of the field measurements and measurement locations are provided in Appendix A. Table 5-2 below shows the comparison of noise measurements with the noise model's predictions of the existing 2021 scenario for those same locations based on the actual traffic volumes observed during the measurements.

Table 5-2: Validation of noise model using measurements

Site ID	Location	Predicted $L_{Aeq(t)}$ dB	Measured $L_{Aeq(t)}$ dB	Difference dB	Outcome
N1	5969A SH29	55.4	53.7	+1.7	Acceptable agreement
N2	2 SH1 near house	62.9	61.1	+1.8	Acceptable agreement
N3	2 SH1 driveway	65.4	65.3	+0.1	Good agreement
N4	38 SH1 driveway	66.7	67.0	-0.3	Good agreement
N5	Piarere Hall, SH29	61.8	60.6	+1.2	Acceptable agreement

All five sites had predictions that were within ± 2 dB of the corresponding field measurement. The agreement between the noise model and the short-term noise measurements is good, which provides confidence in the model's ability to accurately predict the 2042 noise levels.

5.2 NZS 6806 Assessment

5.2.1 Protected Premises and Facilities

In rural areas, NZS 6806 requires assessment of all PPFs within 200 m of the Project. For this Project it is practicable to also include two additional dwellings that sit outside that radius, 5969B SH29 and 1831A Tirau Rd.

Table 4-1 lists all the PPFs and dwellings that were assessed for noise effects from the Project. All PPFs are occupied dwellings.

5.2.2 Predicted Noise Levels

As required by NZS 6806, external free-field equivalent levels[2] in dB $L_{Aeq(24h)}$ have been predicted (see section 5.1.3 of this report) for the PPFs identified in section 5.2.1 of this report for the design year of 2042, with and without the Project in place. The upper limit of the 95% confidence interval for each PPF has been taken as its representative level in each case. The predicted noise levels and the outcome of the assessment for each location assessed are presented in Table 5-3.

Table 5-3: Predicted road traffic noise levels (dB $L_{Aeq(24h)}$)

PPF	Do Nothing 2042	Project Do Minimum 2042	Noise level change of Do Minimum minus for road to be considered 'altered'	Noise level change: Do Minimum minus Do Nothing	Mitigation Required?
5969A SH29	58	58	+3	+0.2	No
5969B SH29	56	56	+3	+0.3	No
2 State Highway 1	66	64	+3	-2.7	No
36 State Highway 1	66	64	+3	-1.9	No
38 State Highway 1	65	66	+3	+1.1	No
1813A Tirau Rd	58	59	+3	+1.1	No

There are no PPFs where the NZS 6806 definition of altered roads is achieved.

The predicted 2042 Project noise levels for PPFs adjacent to State Highway 1 (at 2, 36, and 38 SH1) are more than 64 dB $L_{Aeq(24h)}$ but do not increase by more than 3 dB over the Do-Nothing level and therefore do not meet the NZS 6806 definition of altered road (see section 5.1.2). NZS 6806 does not require further investigation of effects or mitigation.

The assessment against the established criteria is therefore that noise levels will remain acceptable at all PPFs with the Project in place, and no investigation of noise mitigation is required.

Noise levels at the dwellings in Table 5-3 are predicted to be very similar in 2042 with or without the Project in place. Human hearing is insensitive to changes in level of less than about 2 dB, so there will be no noticeable noise level increase at any dwelling.

5.3 Other Aspects of the Design Affecting Noise

NZS 6806 considers the long-term 'average' road-traffic noise levels, but there are also other features that can drive annoyance. This section discusses such features.

[2] These are 24-hour "average" noise levels calculated at the locations of the most-exposed exterior PPF façades, but with any sound reflections from the façade removed.

5.3.1 The quality of the road surface

The quality and condition of the road surface have a significant effect on road traffic noise. Surfaces should be durable and competently laid. Any joins between surfaces should be smooth and flat, without discontinuities.

If pre-cast sections are necessary for the proposed cycleway/pedestrian underpasses then the seal joints should be designed to be smooth so they don't generate impact noise as tyres pass over them.

5.3.2 Acceleration and deceleration associated with the intersection design

The Project will introduce a roundabout to replace a T-intersection. Currently about 50% of vehicles passing through the intersection make a turn, and even vehicles travelling straight-through on SH1 may need to adjust speed to obey the temporary speed limit signs (from 100 km/hr to 60 km/hr) that operate when the intersection is busy. With the roundabout in place 100% of vehicles will need to adjust their speed.

Vehicles decelerating and accelerating influence both the absolute noise emission level and the character of the traffic noise. The noise emission level has been considered in the NZS 6806 noise assessment by following best practice in noise modelling, concluding that no investigation of noise mitigation is required. There is no established method or criteria available to assess the character of the noise.

A large proportion of traffic, including heavy traffic, already slows for the existing intersection, so the sounds associated with decelerating and accelerating vehicles already form part of the noise environment. Under the Project, these sounds will become more prominent and the sound of high-speed through-traffic less prominent, but it will be a shift rather than a step-change in noise characteristics. We expect that once the different noise characteristics of the roundabout become familiar, their impact on receivers will be at most minor, and as such, no mitigation is necessary.

6 Vibration Assessment

The environmental effects of vibrations generated by vehicles operating on the proposed roundabout have been assessed. This has been done by measuring vibration levels generated by vehicles on the current road alignment in the area and using these measurements to predict the vibration effects from the new alignment at the nearby PPFs. Vibration effects have been assessed using international standards with an established history of use in New Zealand.

6.1 Traffic Induced Vibration

Vibrations are generated by all vehicles travelling on the road. The level of vibration, at the source, is affected by the vehicle dynamic characteristics (suspension etc), vehicle mass, speed, soil/road characteristics, and road roughness. Once these vibrations have been generated at the source, their propagation to nearby receivers is dependent on the magnitude and frequency of the source vibrations and the attenuating characteristics of the soils between the source and the receiver.

Traffic induced vibrations are dominated by those from heavy commercial vehicles. There are two main types of vibration generation from heavy commercial vehicles. The first is caused by a deflection bowl caused by the mass of the vehicle. This slight deflection bowl moves along with the vehicle and can generate vibrations in a similar way to that of a bow wave, or wake, from a boat.

The second type of vibration from heavy vehicles comes from (mainly vertical) disturbances in the road surface. These may be small local discontinuities in the seal surface right through to large potholes. The main cause of complaints about traffic induced vibrations are caused by disturbances in the road surface, mainly related to sunken service covers, seal joints, and potholes or surface shoving.

6.2 Assessment Criteria

The Matamata Piako District Plan states that traffic induced vibrations may cause adverse effects and that these effects should be assessed. The South Waikato District Plan states that vibrations should be measured and assessed in accordance with DIN 4510-3:1999[3], or alternate standards where the council agrees.

There are no New Zealand Standards for assessing the effect of vibrations on people or structures, although two international standards are commonly used and have wide acceptance in New Zealand. These being the Norwegian standard (NS 8176.E 2017[4]) for effects on people and the German Standard (DIN 4150-3:1999) for effects on Structures.

For PPFs, vibrations have been assessed against only the Norwegian Standard as this is the more conservative standard and exceedances of the criteria in DIN 4150-3 are very rare near newly constructed roads, The effect of road-traffic induced vibrations on the pylon structure adjacent to SH29 have been considered against the criteria of DIN 4150-3.

6.3 Vibration Measurements and Analysis

Vibration measurements were made in three locations adjacent to the Project. The details of these measurements are given in Appendix A.

Two of the measurement locations (V1 and V2) are associated with PPFs, and measurement data for these two locations has been assessed against the NS 8176.E criteria for effects on people below in Table 6-1.

Table 6-1: Vibration measurements analysed against NS 8176.E:2017

Site ID	Location	Distance to road [m]	$V_{w95,X}$ [mm/s]	$V_{w95,Y}$ [mm/s]	$V_{w95,Z}$ [mm/s]	Class, X	Class, Y	Class, Z
V1	#2 SH1	34	0.134	0.130	0.155	B	B	B
V2	#38 SH1	24	0.134	0.173	0.228	B	B	C

NS 8176.E:2017 grades the level of vibration recorded into 4 classes as given below in Table 6-2.

Table 6-2: Norwegian standard vibration classes

Class	$V_{w,95}$ limits [mm/s]
A	0 to 0.1
B	0.1 to 0.2
C	0.2 to 0.3
D	0.3 to 0.6

For the assessment of roading projects, vibration levels at PPFs should remain within Class C (or better) as assessed against NS 8176.E:2017. It can be seen in Table 6-1 above that the vibration levels measured at Locations V1 and V2 are Class C or better and this suggests that vibration levels at PPFs near these locations, which are further from the road, will also have Class C or better vibration levels.

Vibration measurements were taken at a third location (V3) close to the road to understand the potential for exceedances of the DIN 4150-3 criteria for effects on structures. These show that the

[3] German Standard DIN 4150-3:1999. Structural Vibration, Part 3. Effects of vibration on structures.
[4] Norwegian Standard NS 8176.E:2017, Vibration and shock

traffic vibrations on the pylon structure are likely to be well below the levels required to have any effect on the structure.

6.4 Assessment of Effects

Vibration measurements near PPFs close to the Project have shown that, at worst, the current vibration levels are at the lower/better end of Class C, as assessed against NS 8176.E:2017 for effects on people. These current vibration levels are considered reasonable in that they are unlikely to be causing disturbance to the vast majority of people.

The proposed alignment of the roundabout will generally move traffic further away from PPFs or maintain a similar separation distance. The PPF at 1831A Tirau Road is the only PPF where the road of the proposed alignment moves traffic closer than the existing separation. This PPF will be approximately 250 m from the proposed alignment and will experience no vibration effects. There will be no effect on the other PPFs for whom the traffic does not get closer.

The new Stone Mastic Asphalt (SMA) surface of the roundabout will be constructed to Waka Kotahi's requirements, so that the roughness of the road surface does not exceed 60 NAASRA counts. This will also likely lead to reduced vibration levels near the proposed alignment.

The traffic induced vibrations from the Project have been assessed as being reasonable and are expected to decrease at nearby sensitive receivers relative to the existing situation, though the change may be unnoticeable to people.

7 Construction Noise and Vibration

The construction programme for the Project has not yet been planned, but is expected to be typical of road construction projects of similar magnitude undertaken elsewhere in the country. The construction period is expected to extend beyond one year but that total duration comprises different activities occurring at different locations.

Neither construction noise nor construction vibration have been assessed in detail as part of this report, but a high-level indicative assessment is provided in section 7.2.

7.1 NZS 6803

The South Waikato (rule 15.3.2) and Matamata Piako (rule 5.2.1) District Plans provide for construction noise to be assessed in accordance with NZS 6803. Assessment in accordance with that standard is typical for state highway construction projects of comparable magnitude to the Project. It will be appropriate for the most recent version of NZS 6803 (currently version NZS 6803:1999) to be applied to construction of this Project.

Table 2 of NZS 6803 sets out desirable noise limits for work of normal duration, and recommends that these limits be decreased for work of long duration (more than 20 weeks). Our view is that the long duration noise limits of NZS 6803:1999 are appropriate for construction of this Project. It is common for the noise limits for work of normal duration to be applied to road construction projects affecting kilometres of road because that often more closely reflects the experience of individual sensitive receivers that are only exposed to noise for a few weeks at a time. However, this Project will be constructed over a smaller area so some receivers may be affected by construction effects continuously over the construction period.

The night-time noise limits recommended in NZS 6803 are strict, and often mean that no night-time work can take place without an exceedance. If the appointed contractor considers night time work is required, the need for it and appropriate noise levels for that specific work would normally be negotiated with the Councils as the situation arises.

7.2 High level Assessment

Road construction projects typically involve activities that can be broadly classified into four stages: enabling works, earthworks, paving, and general site works (incl. stormwater, services, etc).

Our experience from other state highway construction projects of a similar scale, including rural roundabouts, is that the first 3 stages are likely to generate similar noise levels, and the general works a slightly lower level on average. Conservative estimates of the noise emission of each activity, evaluated against the 'long duration' day-time criteria, result in a critical distance of approximately 70 metres. Therefore, if the distance between activity and receiver is less than 70 metres during the first 3 stages of work there is a chance of an exceedance. No dwellings are within 70 metres of the main area of works for this Project, and therefore construction noise is likely to be within either the 'normal' or 'long-duration' day-time limits of NZS 6803 for most activities. However, some activities occurring around the tie-ins to existing roads may exceed the noise limits at adjacent receivers unless noise is managed.

Piling work is not expected to be required for construction of the Project, and therefore the primary sources of vibration are expected to be bulldozers, excavators, and vibratory rollers. There is no New Zealand standard for managing vibration, but the limits in the NZTA State Highway Construction and Maintenance Noise and Vibration Guide are often used for similar projects. Extrapolating from similar projects (albeit with potentially different soils), vibration effects on people are unlikely for separation distances of greater than 50 metres, and vibration effects on buildings are unlikely for distances greater than 20 metres. Vibration is therefore unlikely to cause negative effects for the majority of the Project duration, although cannot be discounted during the closest approaches to sensitive receivers.

Some night-work may be required to manage the tie-ins with the existing network, which may exceed the NZS 6803 night time noise limits. Whether or not an exceedance is expected, night-work should be managed via site specific plans.

7.3 Construction Noise and Vibration Management

Noise associated with the construction of the Project has the potential to cause annoyance and disruption to sensitive receivers in proximity to the Project. The most effective method to mitigate the effects of construction noise is through proactive management. To ensure this occurs, it is recommended that there be a designation condition requiring a Construction Noise and Vibration Management Plan (CNVMP) be prepared following the guidance in NZS 6803 and approved prior to the start of construction works.

Provided that an appropriate CNVMP is produced and adhered to, and good construction practices are followed, the construction of the Project should be achieved without significant construction noise or vibration effects.

Special attention and potential vibration monitoring may be required for works occurring in close proximity (within approximately 10 metres) to the power pylon structure adjacent to SH29. The specific mitigation measures required to manage construction vibrations to a reasonable level will be provided in the CNVMP.

8 Management of Effects

While our assessment has found that vehicle-induced noise and vibration effects from the Project are likely to be reasonable, there are still some simple measures that can be used to avoid the unnecessary generation of noise and vibration.

- The road surface should be constructed to Waka Kotahi's requirements for roughness of bituminous surfaces, not exceeding a maximum roughness of 60 NAASRA.

- Special attention should be paid to the construction of seal joints to avoid any large vertical discontinuities.
- Any service covers should ideally be located outside of the carriageway, and particularly outside of the wheel paths. If service covers must be in the carriageway, they should be constructed so that they are flush with the road surface and do not subside over time.

9 Conclusion and Recommendations

- Road traffic noise has been assessed using NZS 6806, in accordance with best practice and consistent with the Matamata Piako and South Waikato District Plans. This assessment has found that the noise levels under the Project will either not increase significantly over the Do-Nothing scenario or will decrease. Noise effects will be negligible. No noise mitigation is required. Whilst the roundabout may have a different audible character to the existing T-intersection, the long-term experience of road traffic noise of nearby residents should not dramatically change.
- Traffic-induced vibration has been assessed against DIN 4150-3:1999 and NS 8176.E:2017 in accordance with best practice and consistent with the Matamata Piako and South Waikato District Plans. This assessment has found that road traffic vibration effects will be reasonable at all sensitive receivers.
- A high-level construction noise and vibration has been undertaken, which indicates that noise and vibration are unlikely to regularly exceed limits. The Project is typical of other state highway construction projects of a similar scale, and it is recommended that the effects of construction noise and vibration are managed through a CNVMP.

Appendix A: Site measurements

For the Project-model validation, the area of the proposed roundabout was visited on 8th and 9th of March 2021 for noise and vibration measurements.

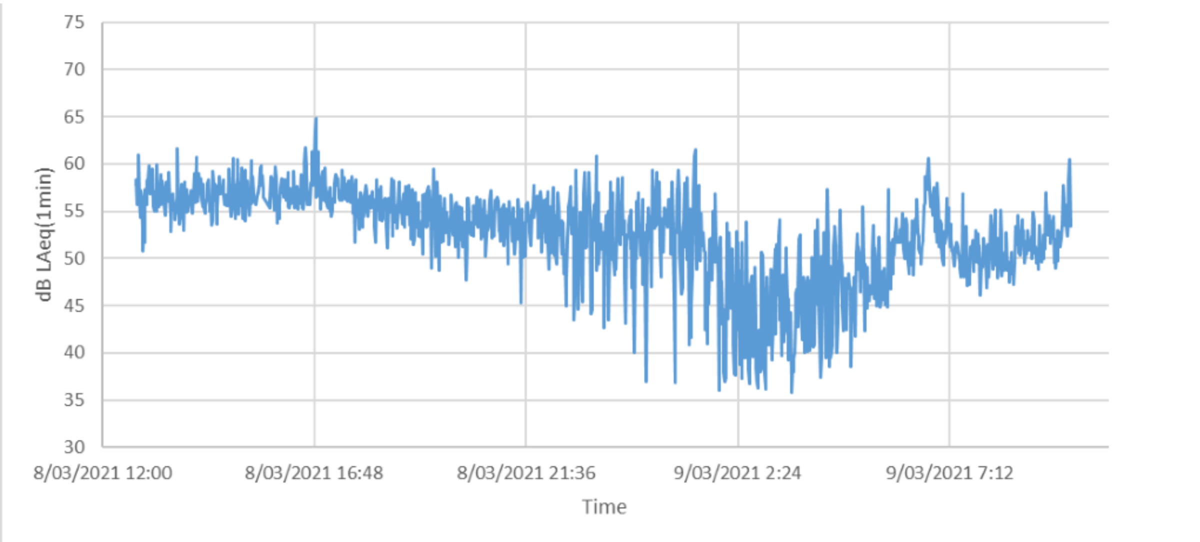
The noise measurements were in accordance with the New Zealand Standard for measurement of environmental sound, NZS 6801: 2008. The measurements were made using three Class 1 Rion sound level meters (SN: 00541654, 00851394, 00472127). The sound level meters were in calibration and checked using a Norsonic Nor1256 field calibrator (SN: 125626168) and confirmed without adjustments. At each measurement location, the sound level meter was mounted on a tripod with the microphone 1.5 m above ground level at that location.

Traffic induced vibrations were measured using a calibrated Syscom MR3000C triaxial geophone-based sensor with built in logging. Vibrations were sampled at a rate of 1,000 Hz. The vibration logger was set with triggered recording, meaning that individual measurements were created for each vibration event over a certain threshold.

On the 8th of March there was a strong westerly wind, particularly in the afternoon, averaging around 3-4 m/s but gusting to around 10 m/s. On the 8th and the morning of the 9th the weather was generally overcast with occasional very light drizzle. On the 9th the westerly wind had dropped to be around 1-2 m/s and in the afternoon the sky was clear.

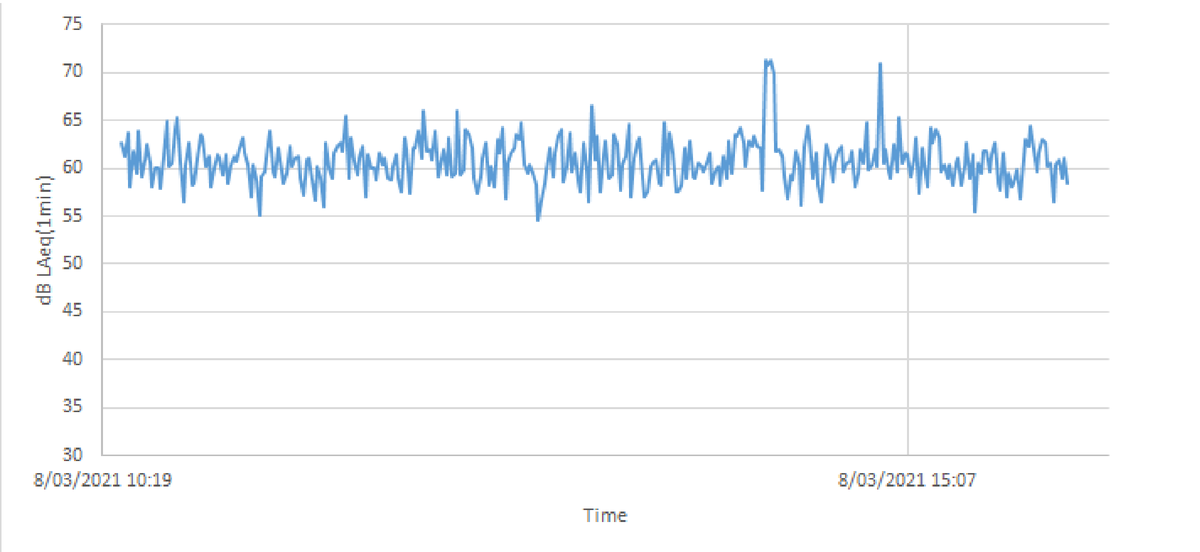
Location N1 – Noise at 5969A SH29

Noise measurements were made at Location N1 from 12:45 on the 8th of March until 09:56 on the 9th of March. The L_{Aeq} for the entire period recorded was 53.7 dBA. A plot of the 1-minute L_{Aeq} noise levels are shown below.



Location N2 – Noise near house at 2 SH1

Noise measurements were made between 10:26 and 16:04 on the 8th of March at Location N2. The L_{Aeq} for the entire period recorded was 61.1 dBA. A plot of the 1-minute L_{Aeq} noise levels are shown below.



Location V1 – Vibration near house at 2 SH1

Vibration measurements were made at Location V1 between 10:10 and 11:30 on the 9th of March. The vibration data has been analysed against the NS 8176.E:2017 and the results are shown below.

$V_{w95,X}$ [mm/s]	$V_{w95,Y}$ [mm/s]	$V_{w95,Z}$ [mm/s]
0.134	0.130	0.155

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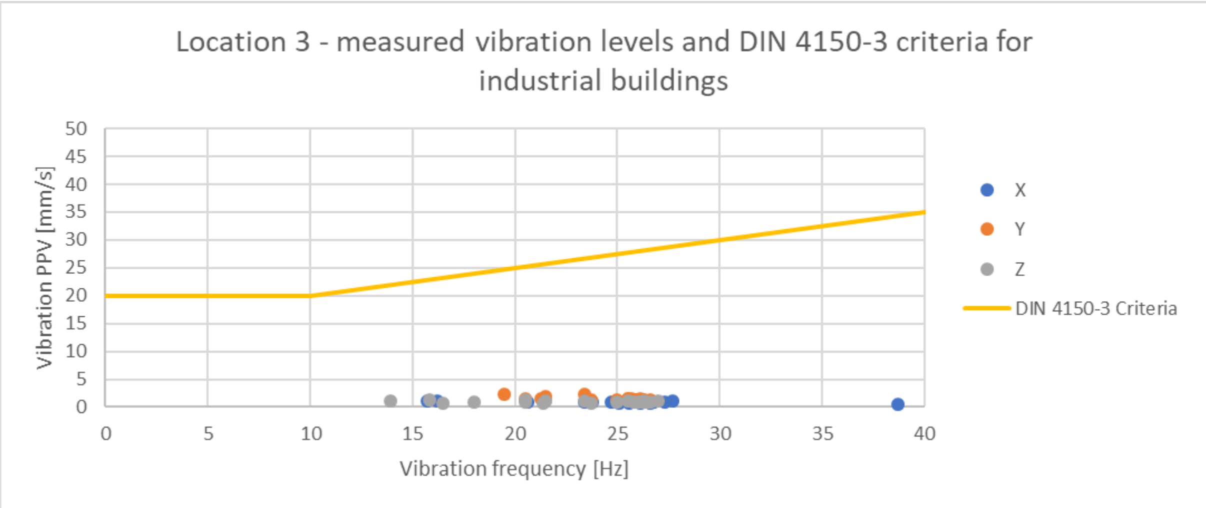
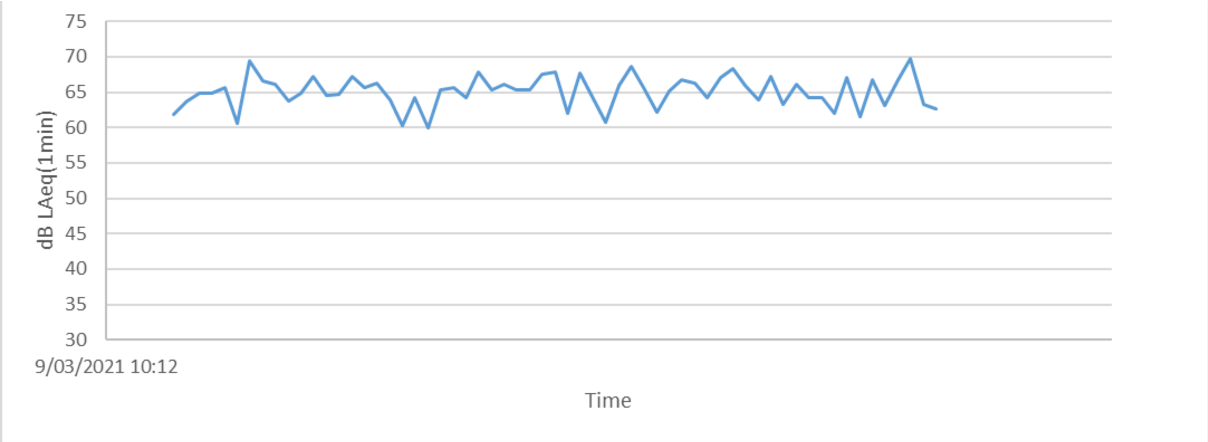
Location V3 – Vibration close to the road to understand potential for effects on structures

Vibration measurements were made at Location V3 between 11:30 and 12:50 on the 8th of March. The vibration data has been analysed against DIN 4150-3:1999 with the results shown against the criteria for a potential reduction in serviceability of particularly vibration sensitive buildings.



Location N3 – Noise at 2 SH1 driveway

Noise measurements were made at Location N3 between 10:17 and 11:17 on the 9th of March. The L_{Aeq} for the entire period recorded was 65.3 dBA. A plot of the 1-minute L_{Aeq} noise levels are shown below.

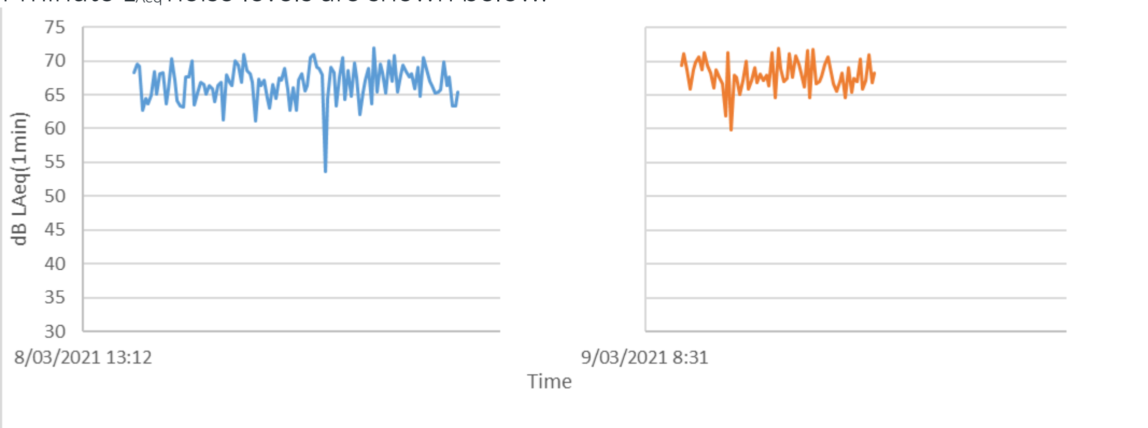


A 30-minute traffic count was performed during the measurements at Location N3. The traffic count data is shown below.

Direction	Vehicles	%HCV
Eastbound	256	13.7
Westbound	295	18.6

Location N4 – Noise at 38 SH1 driveway

Noise measurements were made at two separate times at Location N4. Firstly between 13:29 and 15:21 on the 8th of March and secondly between 08:43 and 09:49 on the 9th of March. Two measurements were done, due to strong wind during the first set of measurements. The L_{Aeq} for the entire first recording was 66.8 dBA and for the second recording was 68.2 dBA. A plot of the 1-minute L_{Aeq} noise levels are shown below.



30-minute traffic counts were performed during the measurements at Location N4. The traffic count data is shown below.

	8th of March		9th of March	
Direction	Vehicles	% HCV	Vehicles	% HCV
Eastbound	143	7.5	163	12.9
Westbound	166	13.7	131	12.2

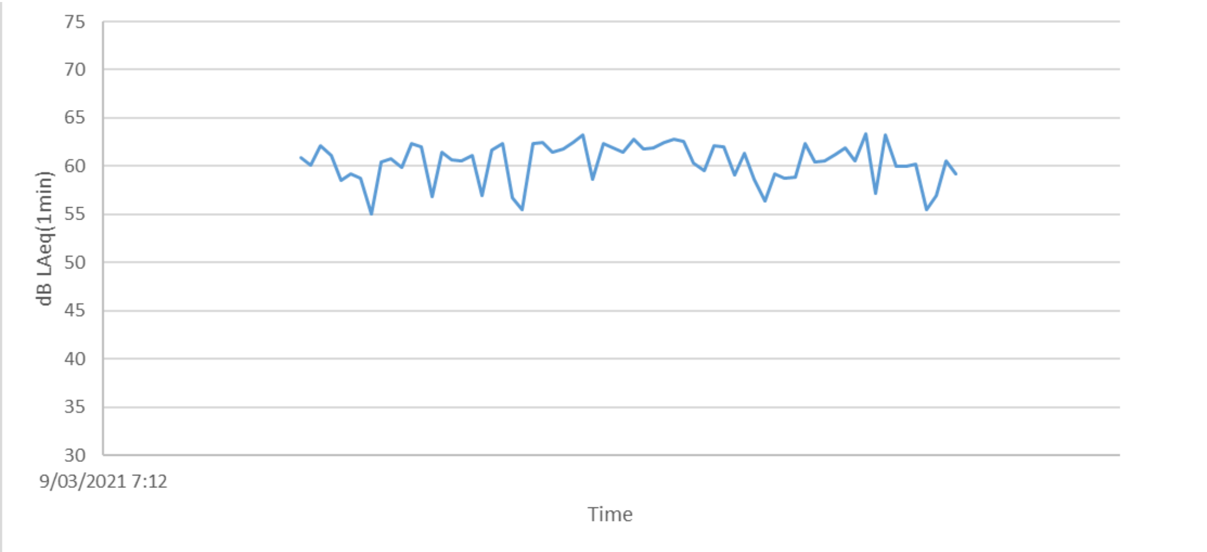
Location V2 - Vibration

Vibration measurements were made at Location V2 between 09:00 and 10:00 on the 9th of March. The vibration data has been analysed against the NS 8176.E:2017 and the results are shown below.

$V_{w95,X}$ [mm/s]	$V_{w95,Y}$ [mm/s]	$V_{w95,Z}$ [mm/s]
0.134	0.173	0.228

Location N5 – Noise at Piarere Hall, SH29

Noise measurements were made at Location N5 between 07:31 and 08:36 on the 9th of March. The L_{Aeq} for the entire period recorded was 60.6 dBA. A plot of the 1-minute L_{Aeq} noise levels are shown below.



A 30-minute traffic count was performed during the measurements at Location N5. The traffic count data is shown below.

Direction	Vehicles	%HCV
Northbound	137	16.1
Southbound	149	18.1

Appendix B: Noise Modelling Details

General	
Modelling and assessment	Richard Jackett & Iain McIver, March 2021
Design year	2042 Based on the expectation that construction could commence in 2022.
Noise model	NZS 6806:2010 provides guidance on the process and particulars expected of road-traffic noise assessments and noise modelling. All road-traffic noise modelling for this assessment has been in line with NZS 6806:2010. The modelling techniques used are well established in New Zealand. The model used is based on the Calculation of Road Traffic Noise (CRTN) model. The CRTN model was developed in the United Kingdom more than thirty years ago. Research in New Zealand has validated the model as appropriate in New Zealand so long as some New Zealand-specific adjustments are applied. Adjustments to suit New Zealand conditions are made in accordance with *Dravitzki, V. and Kvatch, I. (2007) Road surface effects of traffic noise: Stage 3 selected bituminous mixes, Land Transport NZ Research Report No. 326*. As recommended in *Barnes, J., Ensor, M., Beca Carter Hollings and Ferner Ltd and Hegley Acoustic Consultants Ltd (1994) Traffic noise from uninterrupted traffic flows, Transit New Zealand Research Report No. 28*, a road surface correction of -2 dB was used as the base correction for asphaltic concrete. Extensive validation has established the reliability of noise modelling for assessing changes in noise levels, including New Zealand-specific calibration and validation, as reported in *Barnes, J., Ensor, M., Beca Carter Hollings and Ferner Ltd and Hegley Acoustic Consultants Ltd (1994) Traffic noise from uninterrupted traffic flows, Transit New Zealand Research Report No. 28*; and *Dravitzki, V. and Wood, C. (1999) Validation of Leq models for road noise assessment in New Zealand, Transfund Research Report No. 121.*
Noise modelling software	The noise modelling software used is SoundPLAN version 8.2 (the most recent version). SoundPLAN takes into account the effects of terrain and buildings on the propagation of noise from the road-traffic into the surrounding environment and assumes neutral propagation conditions (i.e. does not account for day to day variations in environmental conditions). Noise can be predicted for identified assessment locations (such as building façades) or over a grid for transformation into noise contour maps.
Uncertainty	NZS 6806:2010 C5.3.4.2 states that “CRTN is known to predict noise levels to within 2 dB of the measured levels [and] this is considered to be the appropriate degree of accuracy to apply to prediction methods”. We have taken ± 2 dB as an indicative 95% uncertainty interval around each CRTN modelled noise level, and in this report our predicted noise levels represent the upper bound of this uncertainty interval.

Traffic and layout	
In the modelling of the Project, the NZS 6806:2010 definition of the do-minimum design is used. This is “the project implemented including safety barriers and other structures (which may have an incidental noise mitigating effect)” but without “any measures undertaken for the sole purpose of reducing noise.” The do-minimum project design is the project without any noise-specific mitigation.	
Road gradient	Road gradient was calculated by the SoundPLAN software for each road segment. The horizontal road alignments have been draped over the 3D terrain model to get 3D road alignments (see Terrain Data below).
Road layout, horizontal and vertical alignment	The Project road horizontal alignment was taken from the lane markings in drawing file *ACAD-X-RAB DESIGN LAYOUT4(17-2-21).dxf*. The horizontal alignment of existing roads was taken from Open Street Map.
Terrain data	The existing 3D terrain model has been taken from a LiDAR scan of the area, represented in the DEM file *Combined lidar + road.tif* (17/02/2021). The future 3D terrain model is the existing terrain plus the changes required for the Project, represented in the file *DG-RAB MODEL_TOP17-2-21.tif*.
Buildings	Building outlines and locations have been taken from the LINZ “NZ Building Outlines” layer. PPFs were identified from aerial photographs which were cross-referenced with the latest Google Earth and Google Streetview images where possible. All rural PPFs within 200 m of the new alignment have been modelled (consistent with NZS 6806). Note that in application of NZS 6806, “urban” and “rural” have specific definitions that follow *“New Zealand: An urban/rural profile”, Statistics NZ, 2004* and are determined from the current Statistics NZ urban/rural profile data. Identified PPFs have also been reviewed by the Project team’s property specialist for accuracy and completeness.
Assessment positions	NZS 6806 1.7.2 states the assessment position should be 1.2 to 1.5 metres above each *floor* level of interest in the building of the Protected Premise or Facility. Receivers have been modelled on all external building walls at a height of approximately 2.5 metres above *ground* level for one storey buildings and about 5 metres above ground level for two storey buildings, which reflects a conservative approach. The sound level is a free-field level, excluding any reflections from a building façade (using a correction of -2.5 dB if necessary).
Traffic volumes	Existing traffic volumes have been taken from *mobileroad.org*. Project and Do-nothing traffic volumes (AADT) and traffic mix (%HCV) for the year 2042 have been provided by the Transportation team. For each road in 2042, the AADT and %HCV are projected to be the same with or without the Project. The AADT and %HCV estimates are provided in Table B-1 below.
Road surfaces	The Project team advises that the surface specification of the RAB itself is SMA-10, which will be continued for approximately 100 metres along each

	leg. Beyond that distance the existing road surface specification is assumed to apply. Surfaces of existing roads have been taken from the most recent surface recorded in mobileroads.org unless a visual inspection indicated a different specification. The modelled surface types and the corresponding road surface corrections, in decibels, are detailed in Table B-1 below.
Traffic speeds	The speed limit for all Project roads is currently 100 km/h and is expected to remain so. However, noise modelling has used the more conservative estimate of 110 km/h to cover the possibility that this speed limit is introduced in future. One road section (approx. SH1 RS 594 RP 0.0-0.07) has a variable speed limit that reduces to 60 km/h under some circumstances. Observations on site were that this was rarely adhered to by motorists. For the purposes of noise modelling, an average speed of 85 km/h has been conservatively assumed through this section. The modelled vehicle speeds are detailed in Table B-1 below.

Table B-1: Road traffic and surface data used for noise model

Road Section	AADT			%HCV	Surface	Surface Correction (dB)	Speed (km/h)
	Existing 2021	Do Nothing 2042	Project 2042				
Existing and Do-Nothing							
SH1 RS591 RP 0-1.427	18295	31000	--	10.7	2/4 Chip	+2.5	100
SH1 RS591 RP 1.427-1.623	14238	24100	--	10.7	SMA-10	-1.5	85*
SH1 RS 594 RP 0-0.07	11757	18100	--	13.5	SMA-10	-1.8	85*
SH1 RS 594 RP 0.07-0.51	11757	18100	--	13.5	2/4 Chip	+2.3	100
SH1 RS593 - RAMP	4057	6900	--	15.2	SMA-10	-1.8	100
SH29 RS61 RP 13.240-13.38	4117	7000	--	15.2	SMA-10	-1.8	100
SH29 RS61 RP 13.000-13.240	8174	12500	--	15.2	3/5 Chip	+2.1	100
SH29 RS61 RP 11.600-13.000	8174	12500	--	15.2	2/4 Chip	+2.1	100
Project (Do-minimum)							
SH1 RS591 RP 0-1.050	--	--	31000	10.7	2/4 Chip	+2.6	110
Roundabout	--	--	24100	13.5	SMA-10	-1.8	80
SH1 RS 594 RP 0.360 – 0.510	--	--	18100	13.5	2/4 Chip	+2.3	110
SH29 RS61 RP 11.600-12.840	--	--	12500	15.2	2/4 Chip	+2.2	110

* variable speed limit: 60 km/h to 100 km/h

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