New Beaumont Bridge

Assessment of Noise and Vibration Effects

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Document Details:

Date: 19/09/2019
Reference: 6-CT012.01
Status: Issue 3

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Contents

Document history and status

Revision	Date	Author	Reviewed by	Approved by	Status
Issue 1	27/05/2019	I. McIver	T. Lester	P. Cenek	Draft
Issue 2	20/08/2019	I. McIver	T. Lester	P. Cenek	Second Issue
Issue 3	19/09/2019	I. McIver	T. Lester	P. Cenek	Third Issue

Revision details

Revision	Details
Issue 1	Initial draft of assessment.
Issue 2	Updated for NZTA comments
Issue 3	Updated for additional comments

1 Introduction

There is a proposal to install a new bridge over the Clutha River in Beaumont, Central Otago, and to re-align SH8 to allow traffic to use this new bridge. In this report the new bridge and realignment of SH8 will be referred to as the Project. The NZ Transport Agency is seeking a designation for the Project and this report describes assessment of the noise and vibration effects of the proposed designation and Project.

The new bridge will be installed slightly to the south of the existing bridge, which will be retained. An image of the proposed Project is shown below in Figure 1-1.

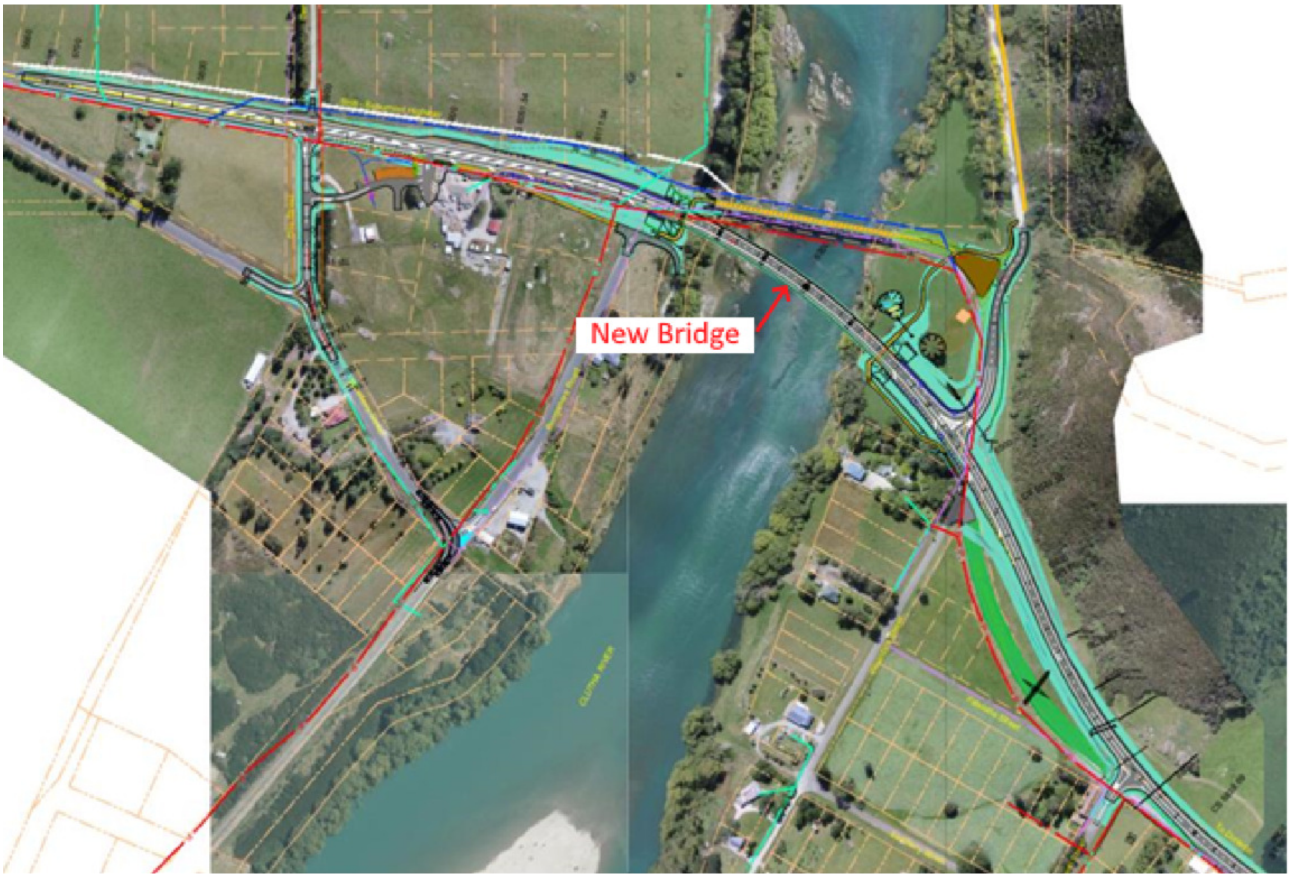

Figure 1-1. Image of the proposed new bridge and the realignment of SH8.

This assessment of noise and vibration effects is based on the understanding that the Project design is well-developed and substantive changes are unlikely. The Project road surface on the bridge approaches is to be finished with a chipseal (Grade 4, 5 or 6 single coat seal) and the bridge deck on the new structure will incorporate asphalt surfacing. This assessment assumes any bridge joints or road surface joins are constructed so that vehicle passes generate no significant additional noise or vibration effects.

1.1 Defining 'reasonable' noise and vibration effects

This noise and vibration assessment looks at the effects, both from an operational and construction perspective, of the Project. The overarching requirement for management of noise and vibration effects is established by the Resource Management Act, 1991 (RMA), as reinforced in section 1.2.4 of the Clutha District Plan. Section 16(1) of the RMA states

> *Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal*

marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level.

Noise includes vibration when interpreting the RMA.[1]

'Reasonable' noise and vibration levels are not defined in the RMA, so other sources of noise and vibration limits or recommendations are used for assessment of the noise and vibration effects of the project.

The Clutha District Plan identifies the potential for adverse noise and vibration effects from operation and construction of the roading network. The Clutha District Plan recognises 'operation of transport systems is defined as a land use activity by virtue of Section 9(4) of the RMA'[2] and states Council shall 'exercise control' in respect of noise[3] but road-traffic noise limits are not provided. The Clutha District Plan does not provide construction noise limits, considering existing New Zealand Standards are adequate controls and referring to NZS 6803: 1984 *The measurement and assessment of noise from construction, maintenance and demolition work*[4]. The Clutha District Plan provides a general rule that vibration levels are assessed in accordance with NZS 4403: 1976 *Code of practice for storage, handling and use of explosives*[5] and for Infrastructure requires vibration from construction activity shall comply with the peak particle velocity limits in table 1 of German Standard DIN 4150-3: 1999 *Structural vibration – Effects of vibration on structures*.

NZS 6806: 2010 *Acoustics – Road-traffic noise – New and altered roads* is proposed as appropriate for management of operational road-traffic noise effects of the Project. This standard provides noise level criteria with a procedure for determining how those criteria apply to premises and facilities near a roading project. The NZ Transport Agency supports the use of NZS 6806 for assessing and, where required, determining appropriate mitigation for road-traffic noise.[6]

NZS 6803: 1999 *Acoustics – Construction noise* is proposed as appropriate for management of construction noise effects of the Project. This standard provides guideline noise limits and management practices for construction and maintenance works. NZS 6803: 1999 has superseded NZS 6803: 1984 referenced in the Clutha District Plan.

Vibration levels from the Project operation and construction are assessed for effects on structures using the German Standard DIN 4150-3: 1999 *Structural vibration – Effects of vibration on structures*, which is the standard referenced in the Clutha District Plan rule for vibration from infrastructure construction activity. Traffic induced vibration effects on people are assessed using the Norwegian Standard NS 8176.E: 2005 *Vibration and shock - Measurement of vibration in buildings from land-based transport and guidance to evaluation of its effects on human beings*. There are no applicable New Zealand Standards for vibration from road-traffic. The Clutha District Plan rule for vibration from general activity references the NZS 4403: 1976 Code of practice for the storage, handling and use of explosives (Explosives Code) but the applicable limits in DIN 4150-3: 1999 and NS 8176.E: 2005 are more stringent than the applicable limits of NZS 4403: 1976.

[1] RMA Part 1 Section 2

[2] Clutha District Plan section 3.3.1

[3] Clutha District Plan section 3.3.5, rule TRAN.1 Roading activity status

[4] Clutha District Plan section 3.13.4, rule NSE.2 Construction noise

[5] Clutha District Plan section 3.13.4, rule NSE.3 Vibration

[6] NZTA (2016) *Guide to assessing road-traffic noise using NZS 6806 for state highway asset improvement projects, version 1.1*. Available at https://www.nzta.govt.nz/assets/resources/guide-to-assessing-road-traffic-noise/docs/guide-to-assessing-road-traffic-noise.pdf

2 Current environment

A site visit was made to Beaumont on the 1st of May 2019 to take noise and vibration measurements. Figure 2-1 shows the locations used for the on-site noise and vibration measurements. Noise measurements were made at Locations A, B, D, E, F and G. Measurements were made of traffic induced vibrations at two locations, C and H, while measurements of soil vibration attenuation were made at Location E.

Figure 2-1. Noise and vibration measurement locations.

Noise measurements were made on site using a calibrated sound level meter[7] and generally in accordance with New Zealand Standard NZS 6801: 1991 *Measurement of sound*. Each noise measurement duration ranged from 15 minutes to 60 minutes, with traffic counted during the noise measurement. The noise measurements were intended to be used to validate the predictive road-traffic noise model rather than to establish the typical or representative noise levels at the locations.

The results of these noise measurements are shown in Table 2-1. For these measurements, traffic noise was the dominant source of noise although birds and the Clutha River were also audible (particularly at Location F). Near the bridge the sound of vehicles rattling the planks on the existing bridge was also audible (particularly at Location F). The measured noise levels are reported using the L_{Aeq} index, which represents the time-average sound pressure level or the equivalent continuous sound level over the measurement duration. $L_{Aeq(24h)}$ is known as the 24-hour average sound level and is the descriptor used in NZS 6806 for road-traffic noise. The L_{A10}, representing the

[7] B&K Type 2250 Sound Level Meter. Calibrated 10/01/2019.

noise level equalled or exceeded for 10 percent of the measurement duration, is also reported as this is the descriptor used in the Clutha District Plan.

Table 2-1. Measured noise levels from site visit.

Location	Distance to edge of SH8 [m]	Measured noise level [dB L_{Aeq}}	[dB L_{A10}]	Notes
A	21	60.4	63.2	Dee Street just North of SH8.
B	13	63.8	65.8	Carpark of Beaumont Hotel
D	55	49.7	52.2ᵇ	Rongahere Road
E	24	56.9	59.2	Picnic area
F	83	48.9	51.6	10 Weardale Street
G	21	55.1	57.6ᵇ	Near intersection of SH8 and Weardale Street.

ᵇ *Estimated from L_{Aeq} measurement.*

Vibration measurements were made using triaxial accelerometers that were sampled at a rate 1,000 Hz. The measured accelerations were filtered between 1 Hz and 80 Hz and numerically integrated to give vibration velocities in mm/s. The maximum vibration velocity from each event has been calculated as the Peak Particle Velocity (PPV). Traffic was monitored during the vibration measurements so that large vibrations could be matched with the source vehicles/events. The measurements at Location C found that the vibration levels were below the sensitivity of the accelerometers and as such have not been reported. Table 2-2 shows the five largest vibrations measured at Location H, with information on the source vehicle/event also given.

Table 2-2. The five largest traffic induced vibration signals measured at location H.

Location	Distance to road edge [m]	PPV [mm/s]	Vehicle / Event
H	9	0.45	Full logging truck
		0.42	Empty logging truck
		0.35	Hiab truck
		0.33	Two cars
		0.31	Empty logging truck

Vibration measurements were also taken at Location E and these have been used to calculate the soil vibration attenuation. These measurements found that the frequency independent attenuation coefficient, ρ, was between 1.11×10^{-3} and 1.77×10^{-3}. From NZTA Research Report 485[8], these attenuation coefficients relate to weak or soft soils. This matches well with the GNS Geology Web Map[9] which gives the local soils as ‘IQa’ or *unconsolidated to poorly consolidated mud, sand, gravel and peat of alluvial and colluvial origin*.

3 Assessment of effects

The properties assessed are shown below in Figure 3-1. For operational noise and vibration, properties within approximately 200 m of the Project have been assessed (all properties shown in Figure 3-1 other than PPF 4). All of the properties shown in Figure 3-1 have been assessed for construction noise and vibration. Predictive models of operational and construction noise and

[8] Cenek, P.D., Sutherland, A.J. and McIver, I.R. (2012) Ground Vibration from Road Construction, NZ Transport Agency Research Report 485, downloadable from: http://www.nzta.govt.nz/resources/research/reports/485/index.html
[9] https://data.gns.cri.nz/geology/

vibration are used, with data collected from measurements performed on site used to validate these models.

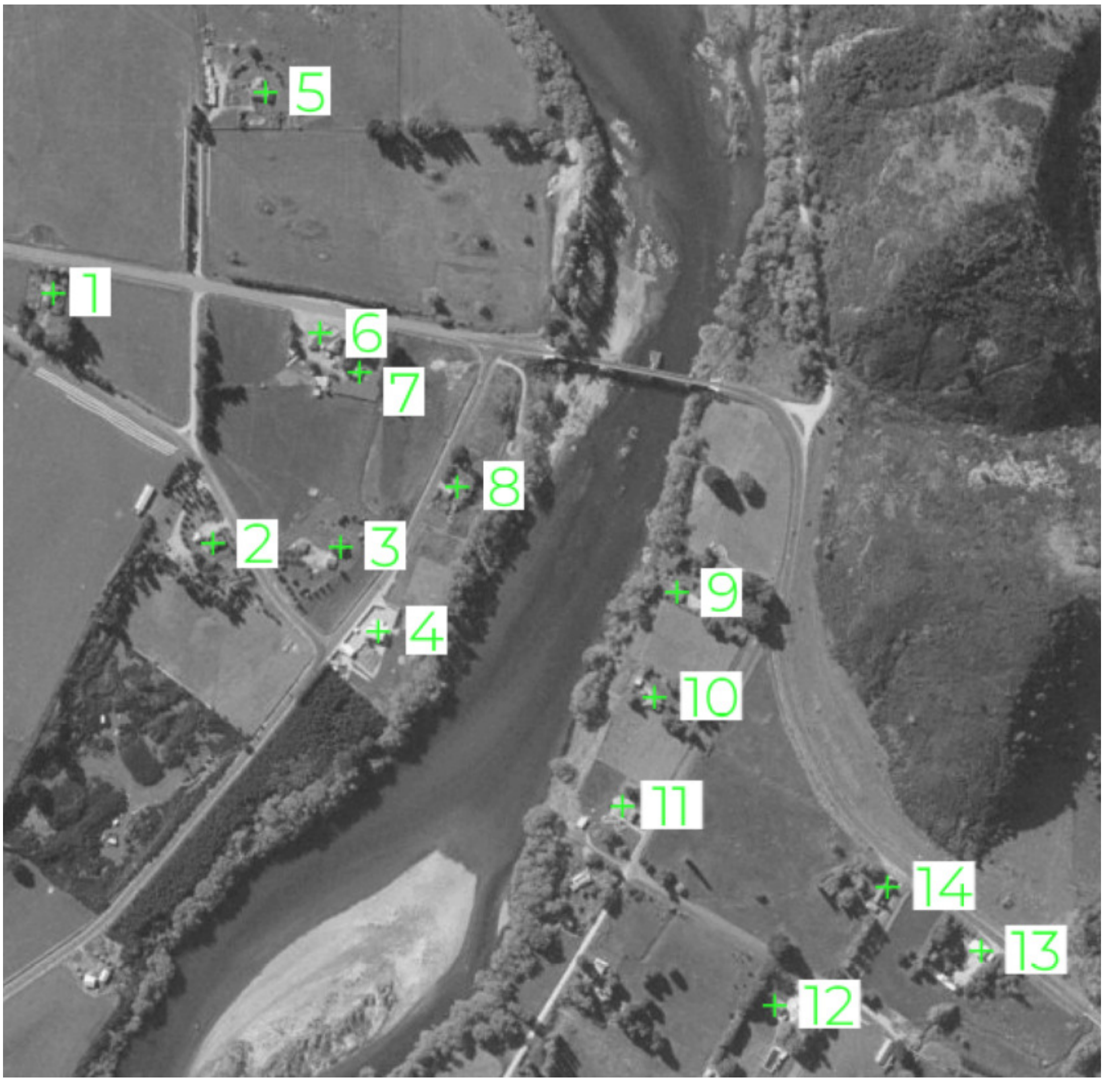

Figure 3-1. Locations of property buildings assessed for noise and/or vibration effects.

3.1 Operational noise assessment

The operational noise of the project has been assessed using the methodology of the current New Zealand Standard for road-traffic noise NZS 6806:2010.

The NZS 6806 methodology compares noise levels for different modelled situations, such as the existing situation and the situation with a project built, so the total road-traffic noise level and noise level changes can be considered. NZS 6806 considers how the physical works of a project affect the road-traffic noise environment through classifying roads or road sections as:

- 'new' where a section of road is to be constructed where no previously formed legal road existed[10], which may be interpreted as where a road or road section physically affected by a project would introduce a new road-traffic noise source, or
- 'altered' based on combinations of the total road-traffic noise level and noise level increase, which may be interpreted as where a road or road section physically affected by a project would be judged by the NZS 6806 criteria as altering a road-traffic noise source, or

[10] NZS 6806: 2010 clause 1.6

- some road sections physically affected by a project may be unclassifiable as either 'new' or 'altered', which may be interpreted as where a road or road section physically affected by a project would be judged by the NZS 6806 criteria as not altering the road-traffic noise.

The terms 'new' and 'altered' are used in this road-traffic noise assessment with the specific meanings of NZS 6806 clause 1.5 and clause 1.6. It is noted the terms may be used differently colloquially and by other disciplines or assessments.

NZS 6806 sets out criteria for mitigating noise from 'new' and 'altered' roads. 'The criteria are reasonable taking into account adverse health effects associated with noise on people and communities, the effects of relative changes in noise levels, and the potential benefits of new and altered roads.'[11] NZS 6806 does not provide criteria for mitigating noise from road sections unclassifiable as either 'new' or 'altered', from which it is interpreted as implying that road-traffic noise from those road sections can be considered reasonable without (further) assessment or mitigation.[12]

The first tasks of the operational noise assessment using the NZS 6806 methodology are to classify the Project road sections as 'new', 'altered', or unclassifiable.

3.1.1 Different situations to model for the NZS 6806 methodology

The NZS 6806 methodology uses three noise environments or situations. These are the 'existing', the 'do-nothing' and the 'do-minimum', each of which is explained below for the Project:

- The existing noise environment is the 'typical' road-traffic noise levels which currently exist in the area, i.e. the existing speed limits, existing road layout with the existing Beaumont Bridge and the existing road surfacing types, operating with the current (2019) average daily traffic volumes.
- The do-nothing noise environment is the situation that would exist in the future 'design year'[13], in this case 2036, as though nothing has changed from the existing built situation but operating with the design year traffic volumes, i.e. the existing speed limits, existing road layout with the existing Beaumont Bridge and the existing road surfacing types, operating with the design year (2036) traffic volumes.
- The do-minimum noise environment is the situation that would exist in the future 'design year' with the proposed Project layout with the new bridge and operating with the design year traffic volumes, i.e. the proposed speed limits, proposed road layout with the proposed new Beaumont Bridge and the proposed road surfacing types, operating with the design year (2036) traffic volumes.

'Do-minimum' means the Project implemented with features which may provide incidental noise mitigation (such as safety barriers or special road surfacing types) but not including any mitigation measures that would be undertaken for the sole purposes of reducing noise effects.[14]

NZS 6806 defines the premises and facilities considered to be potentially affected by road-traffic noise and to be included in the different situations modelled. 'Protected Premises and Facilities' (PPFs) is the NZS 6806 term for noise-sensitive receivers to which the Standard applies. PPFs include buildings used for residential activities and buildings used as temporary accommodation in residentially zoned areas, including hotels and motels, but excluding camping grounds.[15]

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[11] NZS 6806: 2010 C6.1.1

[12] See NZS 6806: 2010 clause 1.5.1 and clause 1.3.2, and see also Dravitzki, V., Walton, D., and Wood, C. 2006. Road Traffic Noise – Determining the Influence of New Zealand Road Surfaces on Noise Levels and Community Annoyance. *Land Transport New Zealand Research Report 292*. 76 pp.

[13] The design year is selected at not less than 10 years but not more than 20 years after the opening of the project, as per the NZS 6806 definition.

[14] NZS 6806: 2010 clause 2.2

[15] NZS 6806: 2010 clause 1.4.1

3.1.2 Project road section classifications of the NZS 6806 methodology

The Beaumont Bridge replacement realigns SH8 close to the existing route, so it is considered not to be a 'new road'.

Table 3-1 shows how NZS 6806 considers the combination of total noise level and noise level change for classifying a road section as an 'altered' road where there is 'an existing road that is subject to alterations of the horizontal or vertical alignment'[16].

Table 3-1. Combination of total noise level and noise level change for altered' road classification as per NZS 6806[17].

Total noise level of the 'do-minimum' noise environment		Noise level increase of 'do-minimum' over 'do-nothing'	Comment
≥ 64 dB $L_{Aeq(24h)}$	and	≥ 3 dB increase	Both criteria required for classification as an 'altered' road.
≥ 68 dB $L_{Aeq(24h)}$	and	≥ 1 dB increase	Both criteria required for classification as an 'altered' road.

3.1.3 NZTA Road Traffic Noise Calculator for modelling of noise levels

The NZTA Road Traffic Noise Calculator[18] is used for modelling of noise levels at the PPFs. This tool is based on the CRTN[19] model which is an accepted method for modelling road-traffic noise in New Zealand and NZS 6806 recommends use of the tool for 'screening' whether a project includes 'altered' roads or roads unclassifiable as either 'new' or 'altered'.

For assurance that the NZTA Road Traffic Noise Calculator is suitable for modelling for the Project, the noise environment during the site visit has been modelled with the calculator and compared to the actual noise measurements. More information on the input data used for this modelling is available in Appendix A while the results of the comparison are shown below in Table 3-2. The values shown in Table 3-2 are for validating the modelling procedure only and not used directly for assessment of road-traffic noise at the PPFs. The measured noise levels do not necessarily represent the 'existing noise environment' as the noise measurements capture only a short-term snapshot of noise levels. The 'existing noise environment' is modelled with inputs such as average annual daily traffic volumes to represent the typical road-traffic noise levels, whereas the modelled noise levels in Table 3-2 are modelled with inputs, such as traffic volumes, as observed/counted during the noise measurements.

The final column in Table 3-2 shows the difference between the road-traffic noise level modelled and the noise level measured at the same location. The NZS 6806 methodology expects the difference between noise levels measured and modelled should not exceed ±2 dB.[20]

[16] NZS 6806: 2010 clause 1.5.2
[17] Tabulated version of NZS 6806: 2010 clause 1.5.2(a) and 1.5.2(b)
[18] https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/tools/road-traffic-noise-calculator/
[19] Calculation of Road Traffic Noise 1988. Department of Transport, Welsh Office.
[20] NZS 6806: 2010 clause 5.3.4.2

Table 3-2. Validation of the NZTA Road Traffic Noise Calculator by comparison of noise levels measured and noise levels modelled with inputs as observed during the noise measurements.

Location	Measured Noise Level [dB L_{Aeq}]	Modelled Noise Level [dB L_{Aeq}]	Modelled minus measured noise level [dB]
A	60.4	61	0.6
B	63.8	64	0.2
D	49.7	53	3.3
E	56.9	58	1.1
F	48.9	48	-0.9
G	55.1	56	0.9

The NZTA Road Traffic Noise Calculator generally shows good representation of the noise environment and is therefore considered suitable for modelling noise from the Project. The larger differences between modelled and measured noise levels at locations D and E are expected, as these locations are positioned at each end of the existing bridge and the actual vehicle speeds observed are lower than the minimum allowable in the calculator (50 km/h). This discrepancy in speed is likely to be the main source of the difference between the modelled and measured noise levels.

3.1.4 'Do-nothing' and 'do-minimum' noise environments for the NZS 6806 methodology

The NZTA Road Traffic Noise Calculator has been used to model the do-nothing and do-minimum noise levels for the Project at the properties within approximately 200 m of the Project. The results are presented in Table 3-3 while the inputs used for the modelling are shown in Appendix A.

Table 3-3. Results of modelling using the NZTA Road Traffic Noise Calculator

PPF	Do-nothing [dB L_{Aeq}]	Do-minimum [dB L_{Aeq}]	Noise level change of 'do minimum' over 'do nothing' [dB]
1	60	57	-3
2	44	43	-1
3	44	44	0
5	46	44	-2
6	64	64	0
7	57	56	-1
8	49	51	2
9	49	52	3
10	47	47	0
11	46	45	-1
12	47	44	-3
13	67	65	-2
14	65	63	-2

From Table 3-3, no PPFs achieve the *combination* of total noise level *and* noise level change for classification as an 'altered' road following the NZS 6806 criteria as shown in Table 3-1. Where the total noise level of the do-minimum noise environment is greater than or equal to 64 dB $L_{Aeq(24h)}$ (PPFs 6 and 13), the noise level change of 'do minimum' over 'do nothing' is not greater than or equal to +3 dB, so the NZS 6806 criteria for 'altered' classification are not met. Where the noise level change of 'do minimum' over 'do nothing' is greater than or equal to +3 dB (PPFs 3, 9 and 10), the total noise level of the do-minimum noise environment is not greater than or equal to 64 dB $L_{Aeq(24h)}$, so the NZS 6806 criteria for the 'altered' classification are not met

The Project road sections do not meet the NZS 6806 criteria for classification as either 'altered' or 'new'; they are unclassifiable as either 'new' or 'altered' using the NZS 6806 methodology. Therefore, it is interpreted that the road-traffic noise from the project can be considered reasonable without (further) assessment or mitigation.[21].

It is accepted that the NZTA Road Traffic Noise Calculator assumes a steady traffic flow. i.e. there is no contribution from acceleration and deceleration engine noise nor for the reduced tyre noise associated with vehicles slowing for the bridge. The NZTA Road Traffic Noise Calculator was used to only model the single dominant road-traffic noise source for each PPF and does not account for noise from other segments of road that will have some contribution to the total road-traffic noise level. The conclusions made from the Table 3-3 results are not affected by this. Through the route realignment, the Project is expected to increase traffic speeds, the effects of which have been modelled. The Project is expected to also reduce the acceleration and deceleration engine noise and bridge surface noise (provided bridge joints are specified and constructed appropriately), the effects of which have not been modelled.

3.2 Operational vibration assessment

Vibration levels from the measurements taken on the 1st of May and also those calculated from a predictive model (Section 3.2.2) are used to assess the vibration effects of the Project against the criteria from DIN 4150-3: 1999 and NS 8176E: 2005.

3.2.1 DIN 4150-3 and predicted Project vibration levels

The relevant criteria from DIN 4150-3: 1999 are shown in Table 3-4 below.

Table 3-4. DIN 4150-3: 1999 criteria for vibration effects on structures.

Type of Structure	Vibration thresholds for structural damage, PPV [mm/s]				
	Short-term				Long-term
	At foundation			Uppermost floor	Uppermost floor
	0 – 10 Hz	10 – 50 Hz	50 – 100 Hz	All frequencies	All frequencies
Commercial / Industrial	20	20 – 40	40 – 50	40	10
Residential	5	5 – 15	15 – 20	15	5
Sensitive / Historic	3	3 - 8	8 – 10	8	2.5

Note: when a range of velocities is given, the limit increases linearly over the frequency range.

3.2.2 Prediction of traffic induced vibrations

The probable maximum ground vibrations at a distance from the lane edge arising from heavy vehicle traffic were calculated using an approach developed for the US Federal Highway Administration (FHWA)[22]. This allows the effect of vehicle speed, vehicle mass, vehicle suspension type, surrounding soil type and road roughness on the calculated ground vibration level to be investigated.

[21] See NZS 6806: 2010 clause 1.5.1 and clause 1.3.2, and see also Dravitzki, V., Walton, D., and Wood, C. 2006. Road Traffic Noise – Determining the Influence of New Zealand Road Surfaces on Noise Levels and Community Annoyance. *Land Transport New Zealand Research Report 292.* 76 pp.

[22] Rudder, F.F. (1978) *Engineering Guidelines for the Analysis of Traffic-Induced Vibration.* Report No FHWA-RD-78-166, US Department of Transportation, Washington, D.C.

For the Project, the following inputs were used with the FHWA model:

- Mass of vehicle = 50 tonnes
- Suspension = leaf spring/walking beam
- Speed = 90 km/h
- Road roughness:
  Minimum = 70 NAASRA counts/km
  Maximum = 110 NAASRA counts/km.

The minimum roughness value used is the NZ Transport Agency's roughness specification for the construction of new chipseal surfaces[23]. The maximum roughness value is the target maximum value adopted by the NZ Transport Agency for state highways classified as "Regional Strategic".

The FHWA vibration model has been used to predict the separation distances required for vibrations to reach levels specified in DIN 4150-3 and also 'rule of thumb' levels typically accepted for human perception and complaint. These levels were:

- 0.3 mm/s – level of human perception.
- 1 mm/s – expected to result in complaints.
- 3 mm/s – minimum level for structural damage to sensitive receivers as per DIN 4150-3. While the PPFs near to the road would not be classified as historic or sensitive taking this level is a conservative approach.

The results of the modelling are shown in Table 3-5, showing the required offset from the edge of the road to achieve certain vibration levels.

Table 3-5. Results of operational vibration predictions.

Vehicle	Speed [km/h]	Road roughness [NAASRA]	Vibration level [mm/s]	Minimum required offset from road edge [m]
50 t HCV	90	70	0.3	3.1
			1	1.0
			3	<1
		110	0.3	4.1
			1	1.7
			3	<1

From Table 3-5, receivers must be very close to the road edge to experience vibration levels expected to cause complaint or structural damage, even assuming the most sensitive receivers (i.e. historic/sensitive as per DIN 4150-3). These predicted vibration levels are lower than what was measured during the site visit although those measurements still indicate that operational vibration levels will be low near the Project.

3.2.3 NS 8176E and measured vibration levels

For this Project the vibration levels should be within Class D from NS 8176E: 2005 which has an upper limit of 0.6 mm/s ($V_{w,95}$). However, the standard also states that an effort should be made to lower vibration levels at dwellings achieving Class D levels to bring them into Class C. For this reason, Class C criteria have been used for this assessment with an upper limit of 0.3 mm/s ($V_{w,95}$). It

[23] NZTA (2006). Network Operations Technical Memorandum No: TNZ TM7003 v1, *Roughness Requirements for Finished Pavement Construction.*

should be noted that this level is not a peak value but is a measure where levels in each 1/3 octave band are weighted and averaged by Root Mean Square (RMS).

Assessment against NS 8176E: 2005 is done through a complex calculation based on actual measured data. As this data cannot be collected before the Project is completed, another approach is required.

The vibration measurements taken during the site visit on the 1st of May 2019 indicate that the traffic induced vibrations are currently low with levels at Location C being around 0.2 mm/s and below while at Location H, they were no higher than 0.45 mm/s. The application of the NS 8176E: 2005 calculation to the vibration data measured at Location H results in a calculated vibration level $V_{w,95}$ of 0.21 mm/s. This indicates that vibration levels would fall comfortably within the Class C criteria.

The data collected during the site visit on the 1st of May was used with the NS 8176E analysis to give an idea of how vibrations from the existing road match with the standard's criteria. This is a practicable approach though it is noted that this approach does not strictly follow the procedure of the standard and the following deviations have been made:

- The standard requires 15 heavy vehicle passes to be assessed for the calculation. This assessment has used the five largest vibration recordings for heavy vehicles as 15 heavy vehicle passes were not recorded. This approach is reasonable as it provides information on where the current vibration levels sit with respect to the criteria in the standard.
- The standard requires measurements at a sensitive receiver. Measurements were made at Location H, 9 m from the road edge, which is comparable to the separation distance for the closest PPFs (13, 6 and 14 at distances of 8 m, 11 m and 12 m respectively). Again, this is reasonable for providing an indication of how the vibration levels are likely to compare to the criteria from the standard.

The Project's operational vibration effects on people are expected to be reasonable based on the operational vibration measurements made on site on the 1st of May 2019. It is also noted that for the majority of the dwellings the new road alignment is largely similar to the existing alignment, with the largest change being seen at PPF 9 where the new road is approximately 22 m closer than the existing road.

3.3 Construction noise and vibration assessment

Preliminary estimates of construction noise and vibration are assessed here to recommend an approach to management that will ensure construction noise and vibration effects are reasonable. The assessment considers the likely scale of noise and vibration levels if construction was undertaken without additional management and then recommends appropriate options to manage construction noise and vibration effects to be reasonable while also allowing practicable undertaking of construction.

The Project construction methodologies, equipment to be used, and scheduling are not known at this stage prior to consenting of the Project, however estimates have been made and these are considered robust for the purpose of this assessment.

The expected construction activities considered most likely to generate noise and vibration are:

- Piling activities for new bridge piers and temporary staging construction. Piling activities are known to generate high noise and vibration levels. Percussive piling has been assumed for a conservative assessment.
- Excavation / boring of sockets in rock for new bridge piers. No information is available on the likely noise and vibration effects from this activity. There is more discussion of this activity below.

- Earthworks associated with the realignment of SH8. These works involve construction of fill embankments on the bridge approaches and pavement construction/carriageway widening along the state highway corridor. The works will occur close to some of the nearby receivers and the noise and vibration from simultaneous operation of multiple pieces of construction equipment have been considered.
- Noise associated with laying the new road surface. Again, this is likely to occur near to some of the nearby receivers.

For the preliminary estimates of earthworks construction noise and vibration levels, it is assumed the same plant and equipment will be used for bulk earthworks (approach embankment fills) and pavement construction (state highway tie-in works and pavement construction/carriageway widening). It is noted that larger plant and higher compacting efforts are anticipated for the approach fill construction compared to the pavement works. The Project works also include carriageway widening/pavement construction along the Dee Street/Westferry Street/Rongahere Road corridor. These are more minor in nature and are therefore immaterial to the preliminary estimates of construction noise and vibration levels.

Construction noise has been assessed using NZS 6803: 1999. NZS 6803 recommends limits on construction noise are set based on the duration of the works, the day/time and the existing noise environment. For this preliminary assessment of construction noise effects, the works are assumed to have a duration exceeding 20 weeks ('long-term' for NZS 6803) and that the works will occur between 0730 and 1800 Monday to Saturday. This assessment uses the recommended upper noise limits from NZS 6803: 70 dB L_{Aeq} and 85 dB L_{Amax}. Construction noise has been estimated using the process detailed in NZS 6803 and using the construction equipment noise levels given in the standard.

In a similar way to the assessment of the operational vibrations, the vibrations have been assessed against limits derived from commonly accepted levels for vibration perception, vibration complaint and the onset of structural damage for historic/sensitive receivers. These vibration levels are 0.3 mm/s, 1 mm/s and 3 mm/s respectively (see Section 3.2.2). Vibration levels have been modelled using the equations and levels for construction equipment given in the NZTA Research Report 485.

For the preliminary estimates of likely vibration levels from construction activities, calculations have been based on generic vibration data assumed for similar activities. This is appropriate for this assessment as part of the Project's consenting and consideration of appropriate designation conditions.

From preliminary estimates of the likely scale of noise and vibration levels from construction of the Project, Table 3-6 indicates receivers where potential limits may be exceeded if no additional management is exercised, and therefore where additional management of construction noise and vibration effects should be investigated. The results are shown graphically in Appendix B. These estimates do not show that there *will* be a noise or vibration effect from construction activities, but rather the preliminary estimates are the basis for recommending where additional management of construction activities should be assessed further, prior to construction, and potential mitigation options investigated.

Table 3-6. Preliminary assessment of receivers that should be addressed in a Construction Noise and Vibration Management Plan. (Receiver numbers reference Figure 3-1.)

Construction Activity	Vibration (Potential)			Noise
	0.3 mm/s	1 mm/s	3 mm/s	75 dB $L_{Aeq(24h)}$
Percussive Piling	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14	7, 8, 9	none	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Earthworks	1, 6, 7, 9, 13, 14	1, 6, 7, 9, 13, 14	1, 6, 7, 13, 14	1, 6, 7, 9, 13, 14
Sealing	--	--	--	1, 2, 6, 7, 9, 13, 14

It is good practice and expected by the NZ Transport Agency and NZS 6803: 1999 that the contractor has a Construction Noise and Vibration Management Plan (CNVMP) for the construction works. This management plan can be prepared after project consenting, at a time closer to the actual works and once construction methodologies can be finalised. It is recommended that a CNVMP is required as part of the designation conditions to ensure that construction noise and vibration effects are managed to be reasonable. CNVMPs are common for large roading projects and there is good guidance from the NZ Transport Agency and contained within NZS 6803 on what CNVMPs should include.

Potential mitigation for noise and vibration is best considered in the CNVMP once decisions have been finalised about the construction methodologies to be used. However, for mitigating effects from the Project some of the following options could be considered:

- Use of smaller equipment for earthworks and resealing works near to PPFs noting that pavement works along the state highway and local road corridors will likely use smaller plant than that adopted for the fill embankments on the bridge approaches.
- Consultation with residents to time works generating large noise or vibration levels to minimise effects. For instance, doing works while people are at work, or avoiding works near PPFs during children's nap times etc.
- Use of a piling method generating less noise and vibration than percussive piling (if practicable). Vibratory pile driving may be an option.
- The CNVMP should propose some form of noise (and potentially vibration) measurements during various activities to check compliance with limits. Noise and vibration monitoring with automated alerts could also be used to inform contractors when limits are being exceeded so methodologies can be adapted.
- Building condition surveys can be used as part of management of vibration effects. The CNVMP should consider appropriate timing for such condition surveys, if used, and it is recommended that condition surveys should be undertaken proactively, say before major construction activities start, rather than in response to concerns.
- No specific analysis has been performed here on construction works required to form sockets in the river rock for some of the bridge piles. These works have the potential to generate significant noise and vibration levels depending on the methodology selected. This construction activity should be specifically covered in the CNVMP with trial works with noise and vibration monitoring performed if necessary.

On the basis that a CNVMP is prepared and implemented for the Project, it is expected that noise and vibration can be readily managed to be reasonable. This should be confirmed as part of the noise and vibration level estimates and assessments completed as part of preparation and implementation of the CNVMP.

3.3.1 Vibration effects on existing bridge

The existing bridge will currently be exposed to high levels of vibration due to the traffic using it. During the construction of the new bridge, the existing bridge will be particularly close to some of the construction activities expected to generate the largest vibration levels, particularly pile driving. While it is not anticipated that vibrations from the construction activities will cause damage to the bridge, it is recommended that some regular condition monitoring of the bridge is outlined in the CNVMP. This condition monitoring may range from visual inspections to instrumentation to check for settlement etc.

4 Conclusion and summary

Operational and construction noise and vibration effects for the SH8 New Beaumont Bridge Project have been assessed.

This assessment has been performed for a specific Project geometry, design speed, traffic volume, road surfacing etc, understood to be well-developed and unlikely to substantively change. Any deviation from the design of the Project used for this assessment could lead to differing effects at nearby receivers.

Operational noise and vibration effects are expected to be reasonable without additional mitigation or management. However, it is recommended that specification and construction of any bridge joints, road surfacing joins or service covers, by example, be given special attention to minimise potential adverse noise and vibration effects.

Construction noise and vibration effects should be managed to be reasonable through preparation and implementation of a Construction Noise and Vibration Management Plan (CNVMP) in accordance with NZS 6803: 1999.

4.1 Operational noise

The operational noise effects of the Project are expected to be reasonable without additional mitigation or management.

The modelling done with the NZTA Road Traffic Noise Calculator has found that the Project does not meet the NZS 6806 definitions for classification as 'new' road or 'altered' road for which criteria for mitigating noise are given, so it is interpreted that the road-traffic noise from the project can be considered reasonable without (further) assessment or mitigation.

This assessment is based on the Project specifics as modelled and noted in Table A-3 of Appendix A. Any changes to these details may result in changes to the Project noise levels and alter this assessment.

It is noted that the PPFs at 8 and 9 are predicted to see increases in noise due to the Project. These increases in noise may be perceptible or noticeable but the increases are still considered reasonable given the total noise level of the environment, using the NZS 6806 methodology, and therefore no further specific road-traffic noise mitigation is considered necessary.

4.2 Operational vibration

The operational vibration effects of the Project are expected to be reasonable without additional mitigation or management.

The modelling and measured vibration levels have shown that traffic induced vibrations from the Project will not result in vibration levels exceeding the most stringent limits for the onset of structural damage as per DIN 4150-3. We have also shown that it is very unlikely that traffic induced vibrations will exceed the Class C criteria from NS 8176.E.

This assessment has assumed that the Project will be constructed to meet the NZTA requirements for road roughness (70 NAASRA). It is also assumed that the Project will not contain any large changes in road level from poor seal joints, poorly specified or constructed bridge joints or sunken service covers. If any of these features are present, they have the ability to generate large vibration levels. We would recommend that special attention is given to specifying low noise/vibration bridge joints for the project as these can have a significant noise and vibration effect. This could be managed through suitable designation conditions and/or contract requirements.

4.3 Construction noise and vibration

Preparation and implementation of a Construction Noise and Vibration Management Plan (CNVMP) is expected to manage construction noise and vibration effects of the Project to be reasonable while also allowing practicable undertaking of construction.

The assessment of construction noise and vibration is based on preliminary estimates of construction methodologies, although the fundamental construction techniques are unlikely to vary significantly. The preliminary estimates of construction noise and vibration levels indicates that additional management of construction noise and vibration effects should be investigated. The preliminary estimates do not show that there *will* be noise or vibration effects from construction activities, but rather the preliminary estimates are the basis for recommending that additional management of construction activities should be assessed further, prior to construction, and potential mitigation options investigated.

Therefore, it is recommended that preparation and implementation of a CNVMP is required as part of the designation conditions to ensure that construction noise and vibration effects are managed to be reasonable.

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Appendix A

Table A-1 shows the inputs used for modelling to validate the use of the NZTA Road Traffic Noise Calculator. These noise levels were calculated using traffic volumes and speeds based on traffic counts performed concurrent with the noise measurements during the site visit on the 1st of May 2019.

Table A-1. Inputs for noise modelling of the existing situation.

Location	A	B	D	E	F	G
AADT	1764	1958	2160	2565	1782	1782
HCV [%]	16	28	12	24	15	15
Speed [km/h]	90	70	50*	50*	70	70
Grdient [%]	1	3	1	2	0	0
Surface	3/5 chip	3/5 chip	3/5 chip	3/5 chip	4/6 chip[†]	4/6 chip[†]
Height above road [m]	1.5					
Distance to receiver [m]	21	13	55	24	83	24
Barrier	No					
Reflective surface opposite [°]	0					
View of road segment [°]	180	180	180	90	180[♭]	180
Propogation height [m]	1					
Ground absorption [%]	40-60	<10	40-60	<10	>90	>90
Measured level LAeq [dB]	60.4	63.8	49.7	56.9	48.9	55.1
Modelled level LAeq [dB]	61	64	53	58	48	56
Difference [dB]	-0.6	-0.2	-3.3	-1.1	0.9	-0.9

* Lowest modellable speed

† Modelled as grade 2 or 3 single coat

♭ highest modellable view of road segment

Table A-2 shows the inputs used to model the do-nothing situation required for NZS 6806 assessment. Table A-3 shows the inputs used to model the do-minimum situation required for NZS 6806 assessment.

Table A-2. Inputs for modelling the do-nothing situation.

PPF	1	2	3	5	6	7	8	9	10	11	12	13	14
AADT	2230												
HCV [%]	13												
Speed [km/h]	90	70	70	90	70	70	50*	70	70	80	90	90	90
Grdient [%]	1	3	3	1	3	3	1	0	0	0	1	1	1
Surface	3/5 chip	3/5 chip	3/5 chip	3/5 chip	3/5 chip	3/5 chip	3/5 chip	3/5 chip	4/6 chip†	4/6 chip†	4/6 chip†	4/6 chip†	4/6 chip†
Height above road [m]	1.5												
Distance to PPF [m]	21	205	197	185	11	41	122	85	110	160	160	8	12
Barrier	No												
Reflective surface opposite [°]	0												
View of road segment [°]	180	180	180	180	180	180	180	180ħ	180	180	180	180	180
Propogation height [m]	1												
Ground absorption [%]	>90	>90	>90	>90	<10	40-60	40-60	>90	>90	>90	>90	<10	<10
Modelled level LAeq [dB]	60	44	44	46	64	57	49	49	47	46	47	67	65

* Lowest modellable speed
† Modelled as grade 2 or 3 single coat
ħ highest modellable view of road segment

Table A-3. Inputs used for modelling the do-minimum situation.

PPF	1	2	3	5	6	7	8	9	10	11	12	13	14
AADT	2230												
HCV [%]	13												
Speed [km/h]	100												
Grdient [%]	1	1	1	1	1	1	1	1	1	1	1	1	1
Surface	Chipseal single-coat grades 4-6												
Height above road [m]	1.5	1.5	1.5	1.5	1.5	1.5	-2.0	-2.0	-2.0	-2.0	1.5	1.5	1.5
Distance to PPF [m]	21	205	197	185	11	41	112	68	130	200	180	8	12
Barrier	No												
Reflective surface opposite [°]	0												
View of road segment [°]	180	180	180	180	180	180	180	180ħ	180ħ	180ħ	180	180	180
Propogation height [m]	1	1	1	1	1	1	1.5	1.5	1.5	1.5	1	1	1
Ground absorption [%]	>90	>90	>90	>90	<10	40-60	40-60	>90	>90	>90	>90	<10	<10
Modelled level LAeq [dB]	57	43	44	44	64	56	51	52	47	45	44	65	63

* Lowest modellable speed
† Modelled as grade 2 or 3 single coat
ħ highest modellable view of road segment

Appendix B

This appendix shows the noise and vibration contours used for assessing the construction noise and vibration effects if no additional management is exercised. Figure B-1 shows the contour for 75 dB L_{Aeq} estimated for piling operations while Figure B-2 shows the vibration contours estimated for the same activity. The highlighted areas on these plots show the areas where the stated level is predicted to be exceeded, if no additional management is exercised.

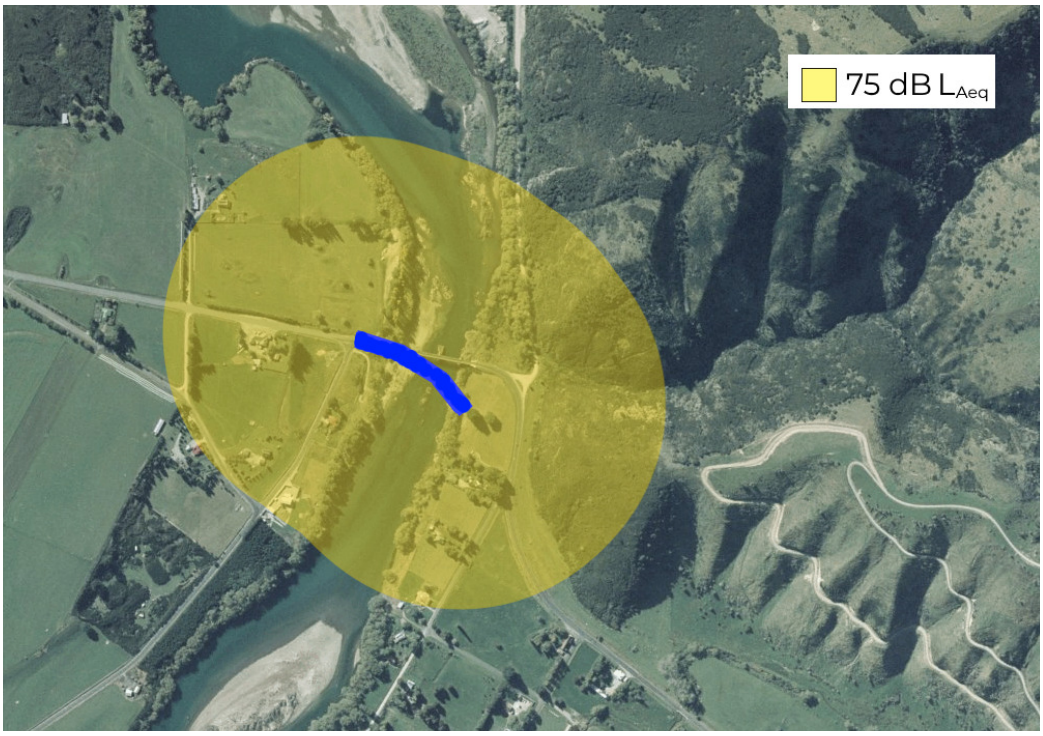

Figure B-1. Construction noise contour for percussive piling.

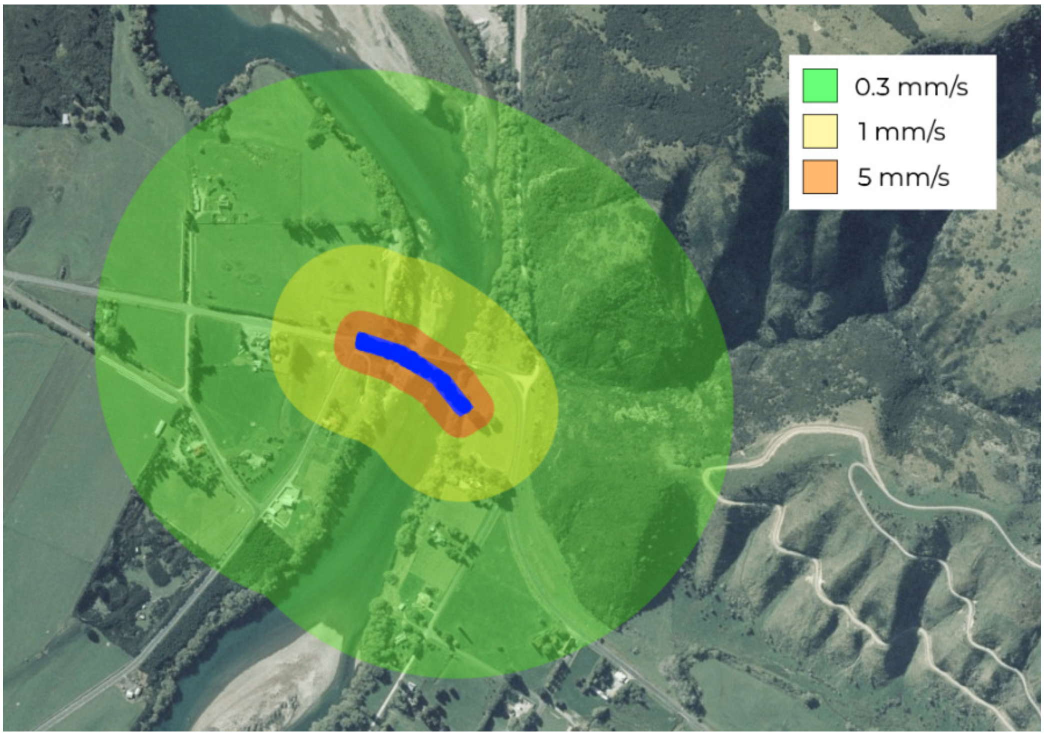

Figure B-2. Construction vibration contour for percussive piling.

Figure B-3 shows the construction noise contour estimated for earthworks and Figure B-4 shows the construction vibration contours estimated for the same activity, if no additional management is exercised.

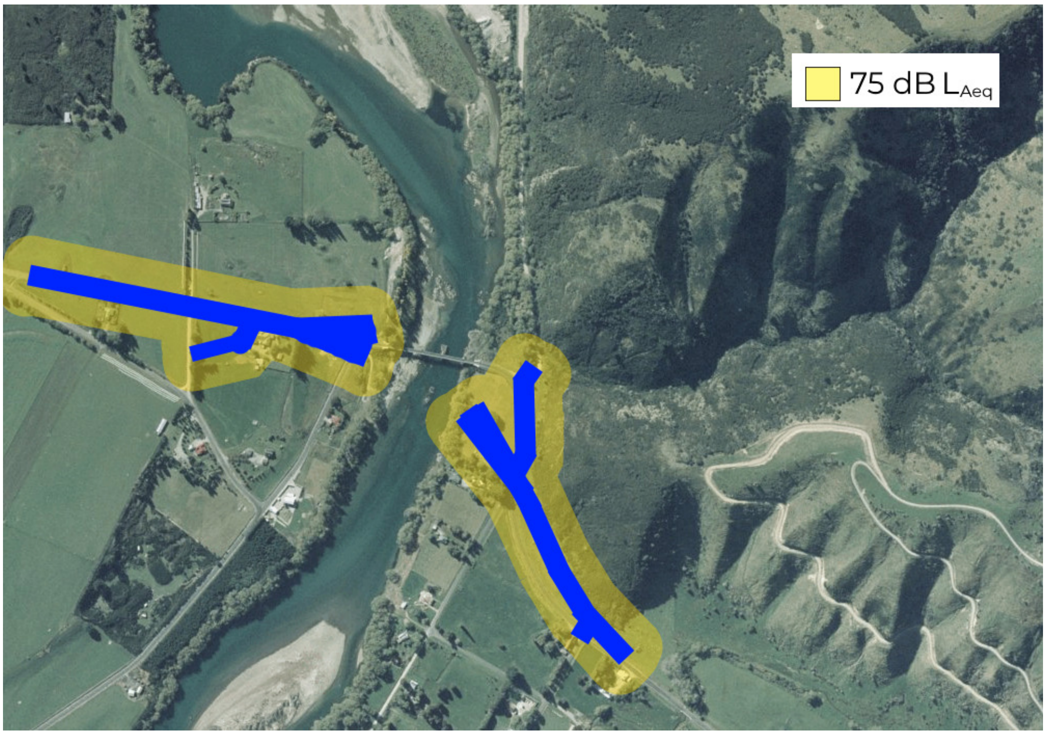

Figure B-3. Construction noise contour for earthworks activities.

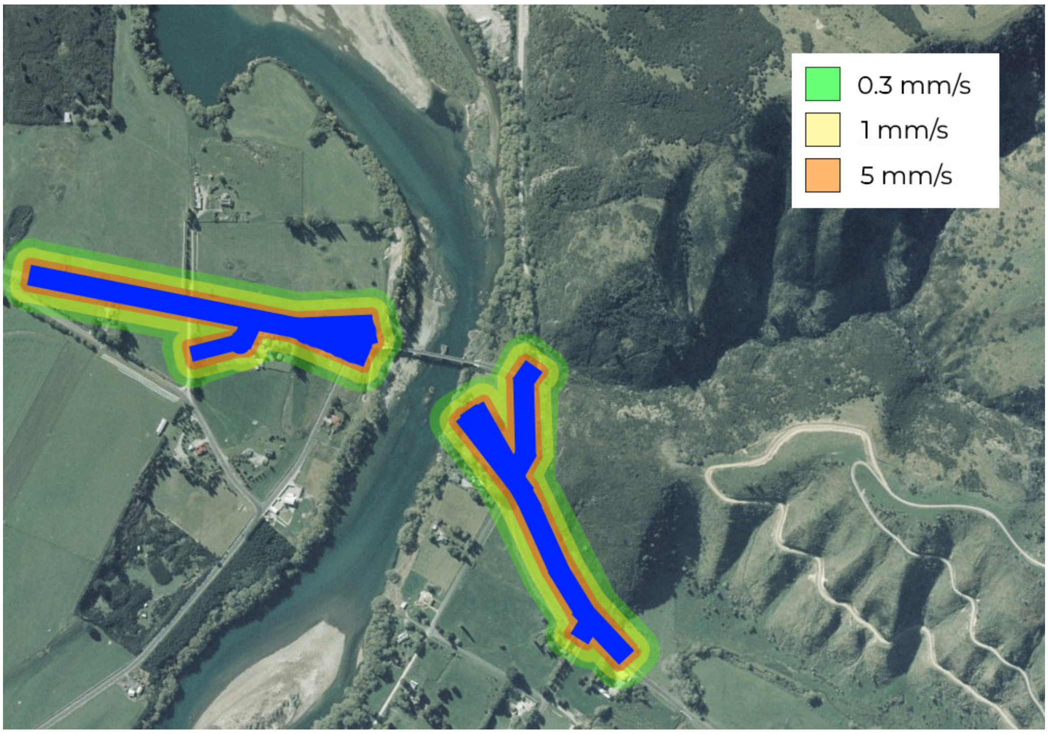

Figure B-4. Construction vibration contour for earthworks activities.

Figure B-5 shows the construction noise contour estimated for sealing activities, if no additional management is exercised.

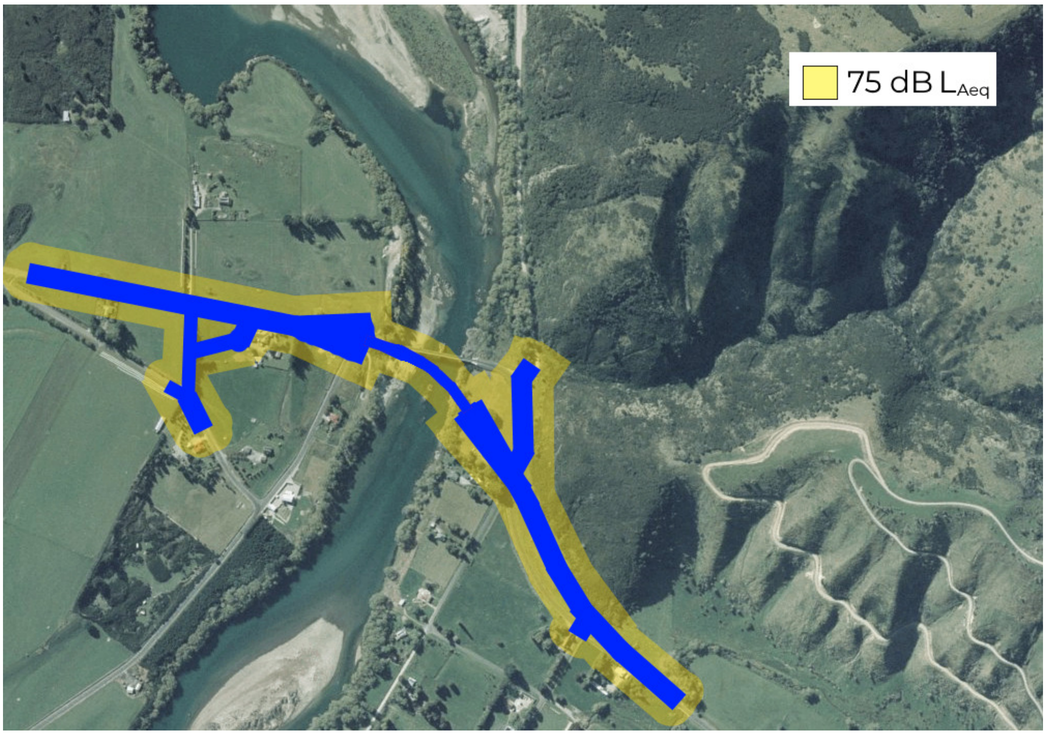

Figure B-5. Construction noise contour for sealing activities.

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