Acoustics Assessment

Transmission Gully Project

Technical report 12

26 JULY 2011

Prepared for

NZ Transport Agency and Porirua City Council

Level 9 PSIS House
20 Ballance Street
P O Box 5084
Wellington 6145

URS

Project Manager:

…………………………….
Dr Stephen Chiles
Principal

URS New Zealand Limited

Level 1, 31 Orchard Road
Christchurch Airport 8053
PO Box 4479, Christchurch 8140
New Zealand
T: 64 3 374 8500
F: 64 3 377 0655

Project Director:

…………………………….
Daniel Murray
Principal

Author:

…………………………….
Dr Stephen Chiles
Principal

Reviewer:

N.H.
…………………………….
Nevil Hegley
Hegley Acoustic Consultants

Date: **26 July 2011**
Reference: 42172147/R168/H
Status: Final

Version history**:**

Version	Date	Reason and brief description of revision
A	19/03/10	Initial draft with criteria and methodology
B	04/05/10	Added survey results, construction noise and vibration, road vibration
C	06/08/10	Added road-traffic sound level predictions, assessment and conclusions
D	24/08/10	CNMP updated, NZTA comments addressed
E	23/03/11	Updated mitigation from consultation, minor updates, glossary added, vibration/historic structures added
F	31/03/11	Minor revisions
G	20/05/11	Minor revisions, CNVMP updated and moved, bridge numbers updated
H	26/07/11	Blasting airblast and vibration added

Table of Contents

Appendix

Tables

Figures

Executive Summary

Introduction

This report documents the assessment of road-traffic and construction sound and vibration for the Transmission Gully Project, including both the Main Alignment and Link Roads. For each of these acoustics topics this report provides details of: the criteria adopted, an assessment of existing and future conditions, and proposed mitigation where appropriate.

Criteria

For different aspects of the sound and vibration assessment a range of different criteria are discussed. The following standards which all contain guideline sound and vibration levels are adopted as representing good practice:

- Road-traffic sound – NZS 6806:2010
- Road-traffic vibration – NS 8176E:1995
- Construction sound – NZS 6803:1999
- Construction vibration – BS 5228-2:2009
  - Blasting – AS 2187-2:2006

In addition to these main parts of the assessment, engine braking sound has been assessed with reference to the maximum noise limit in NZS 6802:2008 and the Transit Noise Guidelines.

The conditions associated with the old designation have not been used as the assessment methodology and standards have been updated.

Existing environment

An extensive sound survey is presented including measurements at representative locations along the entire route. Near existing roads the existing sound levels are controlled by those roads, but in the more remote areas natural sounds dominate. All areas have typical sound levels for those environments. The sound from existing State highways was also modelled, and found to correlate well with measurements near those roads.

Vibration levels by State Highway 1 in Linden were measured at a range of distances from the road. Levels were found to be relatively low due to the good condition of the road surface and local geology.

Modelling

An extensive acoustics computer modelling exercise has been undertaken using an assessment year of 2031, 10 years after the planned opening of the Project. The modelling includes the scenario without the Project (do-nothing) the scenario with the Project (do-minimum) and various noise mitigation options.

Predictions of construction sound and vibration levels have been undertaken for typical construction activities anticipated at a range of representative distances.

Road-traffic vibration predictions have been made and compared to the existing measured vibration levels at Linden.

Design and mitigation

An extensive noise mitigation options assessment has been undertaken in accordance with the method set by NZS 6806. For each area of the Project a number of options have been developed and assessed by all relevant members of the project team to determine the best practicable option for noise mitigation. This process involved circulation of options and a workshop to review each team member's assessment. NZS 6806 has fundamentally changed the way in which noise mitigation measures are designed. Rather than dogmatic adherence to a specific noise limit, regardless of practicality or adverse effects such as shading by barriers, NZS 6806 promotes an integrated design process to establish the best practicable option. NZS 6806 requires significantly more design work during the acoustics assessment, and consequently the noise mitigation is more refined at this stage in the project.

For the majority of the Project no specific noise mitigation was found to be required, other than a short section of bund. Around Linden there are both low noise road surfaces and extensive noise barriers, to control road-traffic sound to within reasonable levels. In three instances building-modification mitigation is proposed.

Standard NZTA processes for road maintenance are considered to provide appropriate control of road-traffic vibration.

Construction sound and vibration requires a range of standard good practice management and control measures. These are outlined in the report and detailed in a draft management plan.

Assessment of acoustics effects

The Project has been found to increase road-traffic sound levels throughout the project area. There will be a significant change in acoustics amenity in areas remote from existing roads, but the road-traffic sound will be at reasonable levels defined by NZS 6806. This change in amenity has been signalled by the existing designation. At the interchanges with the existing State highways and local roads there will be an increase in noise levels, but with the mitigation proposed this will again be at a reasonable level defined by NZS 6806.

Engine braking sound levels on downhill gradients steeper than 4% are within the recommended limits.

Road-traffic vibration levels will increase at Linden where the road is moved slightly closer to houses, but levels will remain within the thresholds in NS 8176E.

The majority of the construction activity is remote from residential areas and while construction sound may be audible it will be controlled to within reasonable levels, defined by NZS 6803, with good practice construction noise management. This will be achieved through the use of a construction noise management plan. At Linden and other areas with houses closer to construction works there is the potential for greater construction sound and vibration effects, due to the proximity of neighbours and the likely need for some night-works. Additional control measures have been proposed such as the early construction of road-traffic noise barriers and increased communications with neighbours. Construction traffic on local roads is to be minimised by the potential programming and use of remote parking and shuttle buses for staff transport, which will be detailed in a construction traffic management plan.

Conclusions

The Transmission Gully Project has significant potential road-traffic and construction sound and vibration effects. All aspects of these potential effects have been investigated. Road-traffic noise mitigation measures have been proposed where required, and construction sound and vibration management and control measures have been identified. With the mitigation proposed, all road-traffic and construction sound and vibration should be restricted to within reasonable levels, defined by the relevant standards.

Introduction

1.1 Overview

The Transmission Gully Project (the Project) consists of three components:

- The Transmission Gully Main Alignment (the Main Alignment) involves the construction and operation of a State highway formed to expressway standard from Linden to MacKays Crossing. The NZ Transport Agency (NZTA) is responsible for the Main Alignment.
- The Kenepuru Link Road involves the construction and operation of a road connecting the Main Alignment to existing western Porirua road network. The NZTA is responsible for the Kenepuru Link Road.
- The Porirua Link Roads involves the construction and operation of two local roads connecting the Main Alignment to the existing eastern Porirua road network. Porirua City Council (PCC) is responsible for the Porirua Link Roads.

1.2 Transmission Gully Main Alignment

The Main Alignment will provide an inland State highway between Wellington (Linden) and the Kapiti Coast (MacKays Crossing). Once completed, the Main Alignment will become part of State Highway 1 (SH1). The existing section of State Highway 1 between Linden and MacKays Crossing will likely become a local road.

The Main Alignment is part of the Wellington Northern Corridor (Wellington to Levin) Road of National Significance (RoNS). The Wellington Northern Corridor is one of the seven RoNS that were announced as part of the Government Policy Statement on Land Transport Funding in May 2009. The focus of the RoNS is on improved route security, freight movement and tourism routes.

The Main Alignment will be approximately 27 kilometres in length and will involve land in four districts: Wellington City, Porirua City, Upper Hutt City, and Kapiti Coast District.

The key design features of the Main Alignment are:

- Four lanes (two lanes in each direction with continuous median barrier separation);
- Rigid access control;
- Grade separated interchanges;
- Minimum horizontal and vertical design speeds of 100 km/h and 110km/hr respectively; and
- Maximum gradient of 8%;
- Crawler lanes in some steep gradient sections to account for the significant speed differences between heavy and light vehicles.

1.3 Kenepuru Link Road

The Kenepuru Link Road will connect the Main Alignment to western Porirua. The Kenepuru Link Road will provide access from Kenepuru Drive to the Kenepuru Interchange and will be approximately 600 m long. This road will be a State highway designed to following standards:

- Two lanes (one in each direction);
- Design speeds of 50 km/h;
- Maximum gradient of 10%; and
- Limited side access

1.4 Porirua Link Roads

The Porirua Link Roads will connect the Main Alignment to the eastern Porirua suburbs of Whitby (Whitby Link Road) and Waitangirua (Waitangirua Link Road). The Porirua Link Roads will be local roads designed to the following standards:

- Two lanes (one in each direction);
- Design speeds of 50 km/h;
- Maximum gradient of 10%; and
- Some side access will be permitted.

1.5 Purpose and scope of this assessment

This report presents the findings of the acoustics (sound and vibration) assessment conducted by URS as part of the environmental assessment of the Project.

The purpose of the acoustics assessment was to:

- Measure existing sound levels,
- Predict and assess future road-traffic sound levels,
- Measure, predict and assess road-traffic vibration,
- Predict and assess construction sound and vibration, and
- Determine measures required to avoid, remedy or mitigate potential construction and operational noise and vibration effects.

A comprehensive study has been undertaken to address this scope and is presented in this report. The work was conducted between January 2010 and March 2011.

This acoustics assessment considers the whole project including both the Main Alignment and Link Roads, although the Main Alignment could be constructed without or prior to the Porirua Link Roads.

Without the Link Roads, there would be less traffic than modelled on the Main Alignment. This would result in slightly lower road-traffic sound levels, and therefore the assessment in this report and noise mitigation options would remain valid.

The construction periods would change if the two parts of the Project did not proceed simultaneously, but the local construction activities at any particular location within the scheme would not be significantly affected. Therefore the assessment of construction sound and vibration also remains valid regardless of the timing of the two parts of the Project.

This report is part of a suite of documents in support of the notices of requirements for designations and applications for resource consents for the Project.

Criteria

2.1 Receivers

This assessment has considered all noise sensitive locations (receivers) within certain distances of new or altered roads associated with the Project. In accordance with NZS 6806[1] these are known as Protected Premises and Facilities (PPFs), and include existing houses, schools, the marae and various other locations defined in the Standard. The distance from the road within which PPFs are considered is set in NZS 6806 as:

- Urban areas – 100 metres from the edge of the nearside traffic lane
- Rural areas – 200 metres from the edge of the nearside traffic lane

The extents of rural and urban areas are defined by Statistics New Zealand[2]. Under this definition, the Greater Wellington urban area encompasses all of the project area to the south of Battle Hill. Therefore the 100 metre distance is used in all locations other than at the north of the scheme around MacKays Crossing where the 200 metre distance is used. Outside of these areas there are no PPFs that require assessment.

These distances provide practical criteria to ensure the assessment is made at the most relevant receivers. Potential noise effects are still controlled at receivers further away by virtue of noise criteria applying at receivers nearest to the road.

The selection of receivers described above is on the basis of road-traffic noise assessment. Compared to road-traffic sound, operational and construction vibration effects are only relevant closer to the road, and therefore the same receivers are also appropriate for vibration assessment.

For construction sound the potential effects could extend further, particularly for any night-time works. While receivers within 200 metres of the road in the rural area or 100 metres of the road in urban areas still control the construction noise assessment, some more distant receivers have been considered, where there are no receivers nearer to the works.

In accordance with NZS 6806, future (unbuilt) PPFs are not considered in this assessment, unless they are consented. The Project planning consultants checked with all district councils in February/March 2011 and confirmed that there have been no building consents issued for future PPFs additional to those included in this assessment. Any new PPFs arising prior to the hearing for the Project will be addressed in acoustics evidence at the hearing.

Two structures of historic interest have been specifically identified for assessment of vibration: St Josephs Church by State Highway 58 and a brick containment vessel in the Te Puka valley.

2.2 Road-traffic sound

2.2.1 General traffic

Due to the long gestation of the Project, several criteria for road-traffic noise could be considered:

- The designation conditions from the existing Transmission Gully Project designation[3],
- Agreement between Transit and the Tawa Community Board[4],
- Transmission Gully Scheme Assessment Report (SAR)[5],

[1] NZS 6806:2010, Acoustics – Road-traffic noise – New and altered roads
[2] New Zealand: An urban/rural profile, Statistics New Zealand
[3] Decisions on commissioners' recommendations on requirements for the proposed Transmission Gully Motorway and Kenepuru Link, Transit New Zealand, 12 September 1997
[4] Agreement, Transit New Zealand, Tawa Community Board, August 2002
[5] Contract 236PN Transmission Gully: Scheme assessment, Noise assessment, Opus, February 2009

2 Criteria

- Transit Guidelines[6],
- NZS 6806:2010 Acoustics – Road-traffic noise, and
- Silverwood subdivision noise assessments[7,8].

Existing designation conditions

The existing designation conditions are relatively complex and, as discussed in detail in the SAR, they do not represent current good practice. It appears that the designation conditions were based on a specific mitigation option rather than an actual performance requirement, but they were then written as performance requirements. The conditions also give rise to anomalies due to a step change in requirements depending on existing sound levels. The conditions only apply to receivers built before 12 July 1996.

It is proposed that the Transmission Gully Project will now be authorised by a new designation and therefore the existing conditions no longer apply. Given the deficiencies identified with these conditions, they have not been used as a basis for this assessment, or for conditions proposed for the new designation.

Tawa Community Board agreement

During appeals on the existing designation an agreement was reached between Transit and the Tawa Community Board. This agreement required Transit to provide various measures such as safety barriers south of the Linden interchange, some of which have already been implemented. In addition to any performance requirements determined in this assessment, barriers in this area will need to comply with the agreement.

Scheme Assessment Report (SAR)

The SAR was written on the basis that the existing designation conditions would remain. However, recognising that this did not apply to receivers built after 12 July 1996, the SAR proposed additional targets for those locations. This approach is no longer required as for a new designation consistent criteria should be applied to all receivers. In any event, the criteria from NZS 6806 discussed below are similar to the targets proposed in the SAR.

The SAR and original designation conditions were written in terms of 'façade' sound levels. This is the sound level one metre in front of a building, including sound reflected from the building. The method for assessing road-traffic sound has been changed by NZS 6806, and now the 'free-field' sound level is used, which relates solely to the level incident on a building with no additional reflections. All sound levels in this report are given as free-field levels. For comparison with levels quoted in the SAR, the free-field levels in this report should be increased by +2.5 dB.

Transit Guidelines

The Transit Guidelines had been the basis for road noise assessment in New Zealand for over a decade. A weakness of the Guidelines was that they focus simply on achieving a specific sound level. There was little consideration required as to what mitigation is practicable in the circumstances, or of potential adverse effects from excessively high noise barriers for example. The assessment method

[6] Transit New Zealand's Guidelines for the Management of Road Traffic Noise. 1999
[7] Traffic noise assessment, Silverwood residential subdivision development stage 2, Malcolm Hunt Associates, July 2008
[8] Acoustic report – Silverwood subdivision (stage 2) Whitby, Wellington, Malcolm Hunt Associates, April 2005

2 Criteria

used by the NZTA for sound from new and altered roads changed in 2010 from the Transit Guidelines to NZS 6806:2010.

The main criterion in the Transit Guidelines was an average noise design level. However, unlike NZS 6806, the Transit Guidelines also referred to a single event noise design level of 75 dB L_{AFmax}, without a façade reflection. This criterion was designed to protect sleep. NZS 6806 explicitly excludes maximum noise criteria on the basis that peaks of sound are determined by emissions from individual vehicles, which are beyond the control of the roading authority. Therefore, this assessment does not consider single event levels, other than engine braking discussed in section 2.2.2, where the maximum value from the Transit Guidelines is used as a reference.

NZS 6806:2010

The current criteria and assessment method for road-traffic sound are set out in NZS 6806:2010. The method provides performance targets and requires assessment of a number of different options for noise mitigation (often including barriers). These options are subject to an integrated design process in which the costs and benefits are considered. For this project the following noise criteria from NZS 6806 are applicable:

Table 12-1 NZS 6806 noise criteria

Category	Criterion	Altered roads	New road
A	Primary	64 dB $L_{Aeq(24h)}$	57 dB $L_{Aeq(24h)}$
B	Secondary	67 dB $L_{Aeq(24h)}$	64 dB $L_{Aeq(24h)}$
C	Internal	40 dB $L_{Aeq(24h)}$	40 dB $L_{Aeq(24h)}$

For the Transmission Gully Project the altered road criteria apply for all receivers at the intersections with the existing State Highway 1, State Highway 58, Kenepuru Drive, Warspite Avenue and James Cook Drive. Beyond 100 metres from these intersections the new road criteria apply, other than at MacKays Crossing where the distance is 200 metres.

Noise mitigation options are to be assessed, and if practicable, the category A criterion should be achieved. If this is not practicable then mitigation should be assessed against category B. However, if it is still not practicable to comply with categories A or B then mitigation should be implemented to ensure the internal criterion in category C is achieved. Depending on the specific building, mitigation in category C could include ventilation and/or sound insulation improvements ranging from upgraded glazing through to new wall and ceiling linings. In category C there is no protection of outdoor amenity. The NZS 6806 criteria are consistent with the NZTA Environmental Plan[9].

NZS 6806 provides a procedure for assessing the benefits and costs of mitigation options to help determine the Best Practicable Option.

The criteria apply to a design year 10 to 20 years after the completion of the new or altered road. In this case the design year has been taken as 2031 and all sound predictions in this report relate to predicted traffic volumes in 2031.

[9] Environmental Plan, version 2, Transit New Zealand. June 2008

The criteria in NZS 6806 are set to be 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.

Silverwood

The developers of the Silverwood subdivision entered into an agreement with the NZ Transport Agency to address potential reverse sensitivity effects. As part of this agreement there have been two acoustics assessments undertaken for different stages of the Silverwood subdivision, considering the effects of road-traffic sound from the Main Alignment. For the first stage of the subdivision the sound insulation design of houses is based on a predicted 62 dB $L_{Aeq(24h)}$ contour from road-traffic on the Main Alignment. For the second stage, rather than a contour there are (façade) sound levels predicted at specific house sites within 100 metres of the Main Alignment. For stage one the internal levels in houses are to be limited to 38 dB $L_{Aeq(24h)}$, and for stage two internal levels were to be designed to 35 dB $L_{Aeq(24h)}$ in bedrooms and 40 dB $L_{Aeq(24h)}$ in other habitable spaces.

Summary

The main criteria for road-traffic sound will be from NZS 6806. Account will be taken of the reverse sensitivity agreement with the Silverwood subdivision, and also the barriers agreed with the Tawa Community Board.

2.2.2 Engine braking

Some trucks have audible engine/exhaust brakes, which can be in the order of 10 dB louder than trucks without such brakes. This issue is generally not considered on a project basis as it requires action at a national level to influence the vehicle fleet. However, the Project has numerous sections with relatively steep gradients and therefore engine braking has been considered in this instance. An assessment has been made for all sections of the Project where road gradients are greater than 4%.

As noted above, the Transit Guidelines include a 75 dB L_{AFmax} single event noise design level. This is identical to the night-time noise limit suggested in NZS 6802[10], and has been adopted as a criterion for assessing engine braking sound in this project.

2.3 Road-traffic vibration

Vibration has not historically been assessed on many road schemes in New Zealand. There are no standardised criteria. There are International Standards that relate to vibration in general, but few that relate specifically to road-traffic vibration.

Vibration has been identified as a potential effect that requires assessment for the Project. A relevant vibration assessment Standard that has been used in New Zealand and that is referenced in the NZTA Environmental Plan is Norwegian Standard NS 8176[11]. This Standard provides methods for measuring vibration from road-traffic and also contains guideline criteria.

[10] NZS 6802:2008, Acoustics – Environmental noise

[11] NS 8176.E:2005, Vibration and shock – Measurement of vibration in buildings from landbased transport and guidance to evaluation of its effects on human beings

NS 8176 allows for vibration to be assessed as either acceleration or velocity, and, for ease of measurement, velocity has been used. The Standard also defines a procedure to determine the statistical maximum weighted velocity $v_{w,95}$, which is the parameter adopted in this report.

In Appendix B to NS 8176 there are classes of vibration criteria defined, relating to different degrees of annoyance. Class C is recommended when planning and building new transport infrastructure, and corresponds to a level where about 15% of people can be expected to be disturbed by vibration. This has been adopted for the Project and the resulting vibration criterion is $v_{w,95}$ 0.3 mm/s. However, at Linden where houses are affected by existing road-traffic vibration Class D (disturbance to 25% of people) may be appropriate which has a criterion of $v_{w,95}$ 0.6 mm/s.

For road-traffic vibration to affect buildings and cause cosmetic or structural damage the thresholds are an order of magnitude higher than the criteria for human perception, even when considering historic buildings. Therefore, consideration of the human perception limits will also address building damage.

2.4 Construction

2.4.1 Sound

There are existing designation conditions addressing construction sound, but as for road-traffic sound, these conditions do not automatically apply to the new designation. As the existing conditions reference an outdated provisional Standard, this assessment is instead based on the current construction sound Standard NZS 6803:1999[12].

NZS 6803 contains guideline noise limits which are shown in Table 12-2. However, in many instances it is not practicable to meet these limits. For certain works on the existing State highways, daytime closures will not be possible and some works will have to be conducted at night due to high traffic volumes and potential delays due to road works. It is unlikely that the guideline night-time noise limits could be achieved at nearby residential receivers. Also, where daytime works are very close to receivers there may be times when it is not practicable to comply with the limits. In such cases construction sound should still be managed to reasonable levels through construction best practice, such as reducing the sound of reversing alarms on trucks, but also greater emphasis will be needed on effective stakeholder engagement.

[12] NZS 6803:1999, Acoustics – Construction noise

2 Criteria

Table 12-2 Guideline construction noise limits

Time of week	Time period	Duration of construction work at any one location					
		less than 2 weeks		less than 20 weeks		more than 20 weeks	
		$L_{Aeq(1h)}$	L_{AFmax}	$L_{Aeq(1h)}$	L_{AFmax}	$L_{Aeq(1h)}$	L_{AFmax}
Residential							
Weekdays	0630-0730	65 dB	75 dB	60 dB	75 dB	55 dB	75 dB
	0730-1800	80 dB	95 dB	75 dB	90 dB	70 dB	85 dB
	1800-2000	75 dB	90 dB	70 dB	85 dB	65 dB	80 dB
	2000-0630	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
Saturdays	0630-0730	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
	0730-1800	80 dB	95 dB	75 dB	90 dB	70 dB	85 dB
	1800-2000	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
	2000-0630	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
Sundays and public holidays	0630-0730	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
	0730-1800	55 dB	85 dB	55 dB	85 dB	55 dB	85 dB
	1800-2000	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
	2000-0630	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
Industrial and commercial							
All days	0730-1800	80 dB	-	75 dB	-	70 dB	-
	1800-0730	85 dB	-	80 dB	-	75 dB	-

For the Transmission Gully Project, the NZS 6803 guideline limits apply where practicable. These are set as reasonable limits for construction noise, also providing protection of sleep. In cases where compliance is not practicable, alternative control methods are identified in this assessment.

Criteria for sound (airblast) from blasting rock is addressed in the following section together with vibration from blasting.

2.4.2 Vibration

As for road-traffic vibration, there are no standardised criteria in New Zealand for construction vibration. A German Standard (DIN 4150-3) is often referenced in New Zealand for building damage criteria, but for this assessment the criteria in British Standard BS 5228-2:2009[13] are used as they cover building damage, damage to other objects and human perception. The main issue for daytime construction vibration is building damage. Table 12-3, Table 12-4 and Table 12-5 give a summary of the BS 5228-2 criteria. Vibration levels are given as the peak particle velocity. BS 5228-2 also provides guidance for vibration affecting sensitive electronic instruments. However, there are no receivers near the Project where this is known to be relevant.

[13] BS 5228-2:2009, Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration

2 Criteria

Table 12-3 Human response to construction vibration

Vibration level	Response
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10.0 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

Table 12-4 Transient vibration guide values for cosmetic building damage

Building type	Peak component particle velocity in frequency range of predominant pulse, at base of building
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4Hz and above
Unreinforced or light framed structures Residential or light commercial buildings	(maximum displacement of 0.6mm below 4 Hz) 15 mm/s at 4 Hz, 20 mm/s at 15 Hz, 50 mm/s at 40 Hz and above

*Guide values would be reduced for continuous rather than transient vibration

Table 12-5 Vibration guide levels for other structures

Structure	Peak particle velocity
Retaining walls – slender and potentially sensitive masonry walls	10 mm/s at toe 40 mm/s at crest (reduced for continuous vibration)
Underground services	30 mm/s transient vibration 15 mm/s continuous vibration

Blasting

Guideline criteria for airblast and vibration from blasting are provided in Australian Standard AS 2187-2:2006[14], which is referenced by NZS 6803.

[14] AS 2187-2:2006, Explosives – Storage and use – Use of explosives

Existing environment

3.1 Overview

Unlike previous standards, the criteria in NZS 6806 to assess road-traffic sound are not dependent on the existing sound levels. Measurements of existing levels are therefore not required to determine the criteria. However, an appreciation of the existing environment is required to judge the potential road-traffic and construction noise effects. Therefore, the existing environment has been assessed in detail through both modelling and measurements.

The Project is in a wide variety of different environments ranging from built-up to open areas. To obtain a reasonable representation of the sound environment in each of these different areas has required measurements at a large number of receivers along the route. This has included measurements at some locations over a number of days to capture temporal variations, and also spot measurements at a larger number of locations to capture spatial variations. Reference has also been made to sound monitoring conducted for the SAR.

For the existing State highways at the three intersections with the Main Alignment, acoustics computer modelling has been used to predict existing road-traffic sound levels to supplement measurements. This also forms the basis for comparisons with modelling of the Project.

The last aspect of quantifying the existing environment has been measurements of road-traffic vibration. This has been conducted in Linden where the Main Alignment will be closest to receivers. The measurements serve both to assess existing road-traffic vibration and also to validate the theoretical prediction model used for future road-traffic vibration.

3.2 Sound survey

3.2.1 Procedure

Four noise loggers were used over a period of approximately two months with each logger being located at a different receiver each week. Loggers were configured to continuously make consecutive fifteen minute measurements. A portable sound analyser was used to conduct 'spot' fifteen minute daytime measurements at additional positions while the loggers were being redeployed each week. During these times observations were made to identify dominant sound sources. All measurements were selected to be free-field where possible.

The measurements were conducted in general accordance with NZS 6801[15]. Measurement and calibration details required by that Standard are held on file by URS.

Equipment

The following instrumentation was used for the survey:

- Four Acoustical Research Laboratories Type EL316 noise loggers, and
- One Brüel & Kjær Type 2250 sound level analyser.

[15] NZS 6801:2008, Acoustics – Measurement of environmental sound

Meteorological conditions

During the survey, meteorological data was obtained from existing weather stations in the general area, as shown in Table 12-6.

Table 12-6 Weather stations

Location	Operator	Data
Tawa	Greater Wellington Regional Council	Wind speed, wind direction, temperature, pressure, humidity, rainfall
Seton Nossiter Park	Greater Wellington Regional Council	Rainfall
Whitby	Private	Wind speed, wind direction, temperature, pressure, humidity
Mana Island	MetService	Wind speed, wind direction, temperature, humidity, rainfall
Paraparaumu Airport	MetService	Wind speed, wind direction, temperature, pressure, humidity, rainfall

The meteorological data from all of these weather stations has been used to identify periods when conditions were likely to have been outside the meteorological restrictions in NZS 6801, and these periods have been excluded from the sound analysis. The timing of the survey from January to March, which generally coincides with favourable weather conditions in terms of reduced wind speed and rainfall, minimised the quantity of sound data that had to be excluded.

Traffic data

For measurements dominated by road-traffic sound from existing State Highways 1 and 58, to provide a level representative of the average exposure over the year, the results have been adjusted to account for the actual traffic flow during the survey. This has been done by using the daily traffic counts from the nearest permanent count station and adjusting the sound measurements to correspond to the 2009 Annual Average Daily Traffic (AADT).

Analysis

There is a natural variation in the acoustic environment throughout the day, and often significant variation between days. Areas close to traffic sources generally have a more consistent sound profile than locations dominated by natural sounds. Each day's data was analysed and abnormal events excluded. For example, events like a neighbour mowing the lawn will result in a clear 'spike' in the sound levels, and while the exact source is not identifiable, it is clearly not road-traffic. The $L_{Aeq(24h)}$ was then calculated for each day where there is sufficient data after bad weather and abnormal events are excluded. For unattended logger measurements, the arithmetic average $L_{Aeq(24h)}$ over all valid days has been used. All data from each noise logger location has been averaged to obtain the $L_{Aeq(24h)}$ sound level at that location.

For spot measurements, the daily variations in sound levels at nearby noise logger locations have been used to estimate the $L_{Aeq(24h)}$ sound level.

A discussion of the measurement uncertainty is provided in section 3.2.3.

3.2.2 Results

The results of the sound survey are listed in Table 12-7, with a description of the observed environment. In the case of unattended loggers, the notes about the sound environment should only be taken as a guide, as observations were only made at the start and end of the measurement cycle.

Table 12-7 Sound survey results

Dates	Address	Type	$L_{Aeq(24h)}$	Notes
26/01/2010	306 SH1	Spot	60	Traffic (dominant), cicadas, dogs barking
26/01/2010	378 SH1	Spot	53	Traffic (dominant), cicadas, planes
26/01/2010	330 SH1	Spot	52	Cicadas (dominant), traffic
26/01/2010	516 Paekakariki Hill Road	Spot	46	Cicadas (dominant), traffic, birds
3/02/2010	347 SH1	Spot	57	Traffic (dominant), cicadas, birds
3/02/2010	370 SH1	Spot	53	Cicadas (dominant), traffic, sheep, birds, plane, dog bark
3/02/2010	SAR ref 6 SH1	Spot	56	Cicadas (dominant), traffic
3/02/2010	SAR ref 9 Paekakariki Hill Road	Spot	47	Cicadas (dominant), traffic, birds
3/02/2010	504B Paekakariki Hill Road	Spot	41	Cicadas (dominant), traffic, birds
3/02/2010	528 Paekakariki Hill Road	Spot	47	Cicadas (dominant), traffic (dominant when present), birds
11/02/2010	462 Paekakariki Hill Road	Spot	43	Birds and trees (dominant), horses, cicadas, traffic
11/02/2010	436A Paekakariki Hill Road	Spot	39	Trees (dominant), cicadas, birds, traffic
11/02/2010	436E Paekakariki Hill Road	Spot	38	Cicadas (dominant), trees, birds
15/02/2010	Adjacent 19 The Mainsail	Spot	46	Cicadas (dominant), traffic, birds
15/02/2010	247B Flightys Road	Spot	54	Cicadas (dominant), chainsaws, birds
15/02/2010	247 Flightys Road	Spot	43	Cicadas (dominant), chainsaws, birds
15/02/2010	247C Flightys Road	Spot	40	Chainsaws (dominant), birds, cicadas, plane
15/02/2010	317 Flightys Road	Spot	53	Chainsaws (dominant), trucks, cicadas, birds
15/02/2010	Opposite 66 Spyglass Lane	Spot	50	Cicadas (dominant), birds, heavy machinery
23/02/2010	412 Flightys Road	Spot	45	Cicadas (dominant), trees, birds, plane
23/02/2010	390 Flightys Road (top)	Spot	44	Cicadas (dominant), trees, birds, logging trucks
23/02/2010	390 Flightys Road (bottom)	Spot	45	Cicadas (dominant), trees, birds, logging trucks
23/02/2010	53A Paremata-Haywards Road	Spot	43	Traffic (dominant), cicadas, birds, trees
23/02/2010	75B Paremata-Haywards Road	Spot	43	Cicadas (dominant), traffic, birds, plane
23/02/2010	75E Paremata-Haywards Road	Spot	54	Cicadas (dominant), traffic, birds, plane
23/02/2010	450 Flightys Road	Spot	47	Cicadas (dominant), birds, trees
23/02/2010	350 Flightys Road	Spot	47	Cicadas (dominant), birds, trees, chainsaws

3 Existing environment

Dates	Address	Type	$L_{Aeq(24h)}$	Notes
23/02/2010	344A Flightys Road	Spot	44	Wind in trees (dominant), birds, cicadas, chainsaws, dogs
23/02/2010	328 Flightys Road	Spot	43	Cicadas (dominant), birds, trees, chainsaws
3/03/2010	Porirua Park Mungavin Avenue	Spot	53	Traffic (dominant), birds, occasional dogs, trees and planes
3/03/2010	Cheshire Street Playground	Spot	45	Cicadas (dominant), trees, birds, traffic, chainsaw
3/03/2010	Arahura Crescent Playground	Spot	45	Cicadas and birds (dominant), traffic dominant when present, occasional dogs, people, cows, music, rubbish truck and chainsaw
11/03/2010	Bluff Road Reserve	Spot	51	Cicadas (dominant), traffic, trees, birds, train, planes
11/03/2010	Opposite 9 Bluff Road	Spot	55	Traffic (dominant), lawn mower (sometimes dominant), cicadas, trees
11/03/2010	Mahoe Park	Spot	57	Traffic (dominant), cicadas, trees
11/03/2010	Arthur Carman Park	Spot	50	Traffic (dominant), cicadas, trees, plane
11/03/2010	Kowhai Park	Spot	53	Traffic (dominant), trees, cicadas, birds, plane, train dominant at 12:02-04
11/03/2010	Wall Park	Spot	53	Traffic (dominant), cicadas, trees, trains
11/03/2010	Woodman Drive Reserve	Spot	53	Traffic (dominant), birds, plane
19/03/2010	Adjacent to 38 Mexted Terrace	Spot	53	Traffic (dominant), birds, cicadas, trees
19/03/2010	Gillies Place Playground	Spot	45	Cicadas (dominant), traffic, birds, trees, plane
19/03/2010	Ernest Street Reserve	Spot	57	Birds and trees (dominant), plane, cicadas, traffic (dominant when present)
19/03/2010	Takapu Road (east end)	Spot	42	Cicadas (dominant), trees, birds
12/03/2010 – 18/03/2010	1 Raroa Terrace	Logger	53	Cicadas, traffic, trees
12/03/2010 – 18/03/2010	11 Rangatira Road	Logger	50	Cicadas, birds, horses, traffic
24/02/2010 – 02/03/2010	130 Warspite Avenue	Logger	45	Cicadas (dominant), traffic, trees
24/02/2010 – 02/03/2010	14 Carnevon Place	Logger	51	Trees, cicadas, people
16/02/2010 – 17/02/2010	18 Japonica Crescent	Logger	59	Traffic, cicadas, trees
16/02/2010 – 22/02/2010	207 Flightys Road	Logger	48	Cicadas, birds, power tools from adjacent paddock
24/02/2010 – 02/03/2010	298C Paekakariki Hill Road	Logger	55	Cicadas, birds, trees, lawn mower
12/03/2010 – 18/03/2010	30 Mexted Terrace	Logger	49	Traffic
26/01/2010 – 03/02/2010	324 SH1	Logger	54	Cicadas, traffic
04/03/2010 – 10/03/2010	34 Tremewan Street	Logger	58	Traffic, cicadas

3 Existing environment

Dates	Address	Type	$L_{Aeq(24h)}$	Notes
27/01/2010 – 02/02/2010	366 SH1	Logger	55	Cicadas, birds, traffic
16/02/2010 – 22/02/2010	394 SH1	Logger	57	Cicadas, traffic
16/02/2010 – 22/02/2010	436 East Paekakariki Hill Road	Logger	50	Cicadas, other insects
04/03/2101 – 10-03/2010	5 Bluff Road	Logger	53	Traffic, cicadas, birds, trees
19/03/2010 – 29/03/2010	500 Takapu Road	Logger	43	Cicadas, birds, trees, intermittent local traffic
04/02/2010 – 10/02/2010	504a Paekakariki Hill Road	Logger	52	Traffic, cicadas
04/02/2010 – 10/02/2010	510 Paekakariki Hill Road	Logger	46	Trees, traffic, cicadas, birds
04/02/2010 – 10/02/2010	525 SH1	Logger	52	Traffic, cows
24/02/2010 – 02/03/2010	53B Paremata-Haywards Road	Logger	53	Cicadas, trees, traffic (SH58), birds
04/03/2010 – 10/03/2010	6 Matai Street	Logger	56	Traffic (dominant), cicadas
16/02/2010 – 22/02/2010	66 Exploration Way	Logger	42	Birds, traffic
19/02/2010 – 29/03/2010	66 Tremewan Street	Logger	55	Traffic, cicadas, birds, trees
19/03/2010 – 24/03/2010	88 Ernest Street	Logger	48	Cicadas, traffic

3.2.3 Discussion

By performing a measurement, the true value of a parameter is only known to within a measurement uncertainty. An uncertainty budget is presented in Table 12-8 for the sound survey, based on the methodology proposed by Craven and Kerry[16].

It is also important to recognise the contributions of other sound sources, particularly cicadas. The sound survey was scheduled during January to March to minimise the effect of rain, however this is the peak season for cicadas. As cicada noise is predominantly high frequency, it is possible to identify sites where cicada noise was significant. Figure 12-1 shows the high-frequency contributions of the 45 spot measurements. The x-axis shows the level with high frequencies excluded (i.e. without cicadas), and the y-axis shows the increase when the high frequencies are added back on (i.e. with cicadas). From this we conclude that for the majority of sites the contribution was less than 2 dB, and for a smaller proportion, sound levels increase by over 10 dB due to high-frequency contributions. The increases in sound levels are more pronounced in areas with a lower background sound level. When considering existing levels, all measurements in an area near a receiver have been considered and the higher levels likely to be influenced by cicadas have been excluded.

[16] N.J. Craven and G. Kerry. *A good practice guide on the sources and magnitude of uncertainty arising in the practical measurement of environmental noise.* University of Salford. 2001.

3 Existing environment

Table 12-8 Measurement uncertainty budget

Source of uncertainty	Value (half width)	Conversion	Distribution	Standard uncertainty
Source				
Traffic flow	1000 in 22000	0.2 dB	Rectangular	0.11 dB
% HGV and Mean speed	5% at 90km/hr to 15% at 110km/hr	3.1 dB	Rectangular	1.8 dB
Transmission path				
Weather	3 dB	3.0 dB	Rectangular	1.7 dB
Ground	min inc in weather			
Topography	No change	0.0 dB	Rectangular	0.0 dB
Receiver				
Position	1 m in 100 m	0.9 dB	Rectangular	0.50 dB
Instrumentation	1.9 dB	1.9 dB	Rectangular	1.1 dB
Background	Minimal			
Reflective surfaces	1.25 dB	1.25 dB	Rectangular	0.72 dB
Combined uncertainty				2.9 dB
Expanded uncertainty (95% confidence)				5.7 dB

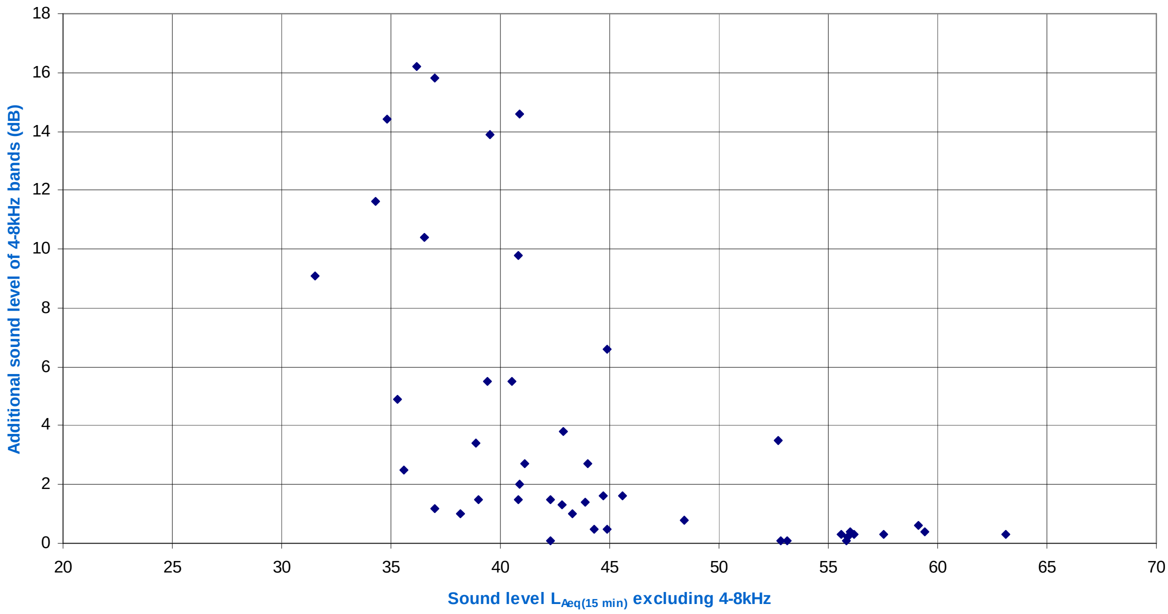

Figure 12-1 Estimated contributions of cicada sound

3.2.4 Engine braking

To provide data for an assessment of engine braking, measurements have been made of this sound source from existing roads. Locations were identified in the Wellington region with steep gradients remote from houses, where engine brakes are likely to be used. Two of these locations with the steepest gradients were selected for measurements: State Highway 1 at Ngauranga Gorge (8% gradient) and State Highway 58 at Haywards Hill (7% gradient).

Measurements of engine braking sound were conducted on 4 June 2010 with the Brüel & Kjær Type 2250 sound level analyser, 5 metres from the nearside downhill traffic lane at Ngauranga Gorge and 6 metres at Haywards Hill. An operator attended the measurements on-site, and for each downhill truck pass-by that could be isolated from general traffic, the maximum sound level (L_{AFmax}) was recorded. It was noted whether engine brakes were audible.

Over a two hour period at Ngauranga Gorge there were only three trucks recorded using audible engine brakes. The average of the maximum sound levels was 93 dB L_{AFmax}, and the sound power spectrum in Table 12-9 is from one of the measurements adjusted to the average level. These trucks were in the order of 10 dB louder than the majority of trucks not using audible engine brakes. Over a one hour period at Haywards Hill, no trucks were observed to be using audible engine brakes.

The small number of trucks using audible engine brakes at both locations reflects the changing composition of the heavy vehicle fleet in New Zealand, with fewer trucks having audible engine brakes.

Table 12-9 Engine braking sound power level spectrum

Octave band (Hz)	16	31.5	63	125	250	500	1 K	2 K	4 K	8 K
Engine braking spectra (dB)	102	106	115	118	118	113	109	103	100	95

3.3 Existing road-traffic sound

3.3.1 Modelling

Section 4 of this report describes the extensive acoustics computer modelling undertaken for road-traffic sound. One of the scenarios modelled is ‘do-nothing’, which comprises the existing roads with traffic flows predicted for 2031. For the receivers near to existing State highways where measurements have been conducted, the do-nothing model results have been adjusted for traffic volumes to give sound levels relating to the 2009 AADT.

3.3.2 Results

A comparison of the measured sound levels discussed in Section 3.2.2 with the results of the computer modelling using 2009 parameters is provided in Table 12-10. The comparison has been limited to unattended logger locations where several days of data have been used to estimate the daily average. It can be seen that there is good agreement for the majority of sites. For the measurement locations further from the road, the traffic component of the measured sound level becomes a smaller proportion. This results in the computer model predicting a lower sound level than measured.

NZS 6806 requires modelled results to be within ±2 dB of measurements. The CRTN method used in these predictions has previously been shown to provide the required accuracy under controlled conditions. However, in this instance, contamination of measurements by other sounds, localised screening not included in the model, and uncertainty in the acoustics performance of existing road surfaces, have led to greater differences between measured and predicted levels. The issues of contamination and road surfaces do not affect the predictions for future scenarios, and the omission of localised screening provides a conservative assessment.

Table 12-10 Comparison of measured and predicted road-traffic sound levels

Measurement location	Measured $L_{Aeq(24h)}$	Predicted $L_{Aeq(24h)}$	Difference	Comment
324 SH1	54	56	2	
366 SH1	55	40	-15	Significant setback from road. Measured levels dominated by other sources
394 SH1	57	33	-24	Significant setback from road. Measured levels dominated by other sources
525 SH1	52	56	4	
53B Paremata-Haywards Road	53	45	-8	
1 Raroa Terrace	53	56	3	
11 Rangatira Road	50	54	4	
130 Warspite Avenue	45	43	-2	
18 Japonica Crescent	59	62	3	
30 Mexted Terrace	49	53	4	Logger located amongst building with several small fences which have not been modelled individually
34 Tremewan Street	58	59	1	
5 Bluff Road	53	52	-1	
6 Matai Street	56	57	1	
66 Tremewan Street	55	58	3	
88 Ernest Street	48	45	-3	

3.4 Vibration

3.4.1 Procedure

Measurements were conducted in general accordance with the requirements of NS 8176. An Instantel Minimate Pro6 vibration monitor was used with geophones to obtain tri-axial velocity levels. At each measurement position vibration velocity levels were stored to the vibration monitor's memory for subsequent processing. Traffic was observed and the times of at least fifteen heavy vehicle pass-bys were recorded during measurements at each position. Fifteen is the minimum number of events for analysis specified by NS 8176E. The stored vibration data was analysed to obtain the maximum weighted one-second average velocity for each of the heavy vehicle pass-bys. For each position the statistical maximum weighted velocity $v_{w,95}$ was then calculated. The vibration monitor has six channels with two triaxial geophones, so for all measurements two positions were recorded simultaneously.

Measurements were made at two houses adjacent to the existing State highway in Linden, and also in a reserve at various distances from the State highway.

3.4.2 Results

The measured vibration levels are shown graphically in Figure 12-2 for different distances from the State highway at Linden in the reserve, and a summary table is provided in Table 12-11. It can be seen that the NS 8176 criterion of $v_{w,95}$ 0.3 mm/s is achieved at a distance of less than 7 metres from the road.

Table 12-11 Vibration measurement results

Parameter	Value			
Distance from road (m)	5	7	12	15
Average velocity (mm/s)	0.21	0.14	0.06	0.06
Standard deviation (mm/s)	0.13	0.07	0.04	0.04
Statistical maximum weighted velocity $v_{w,95}$ (mm/s)	0.45	0.28	0.14	0.13

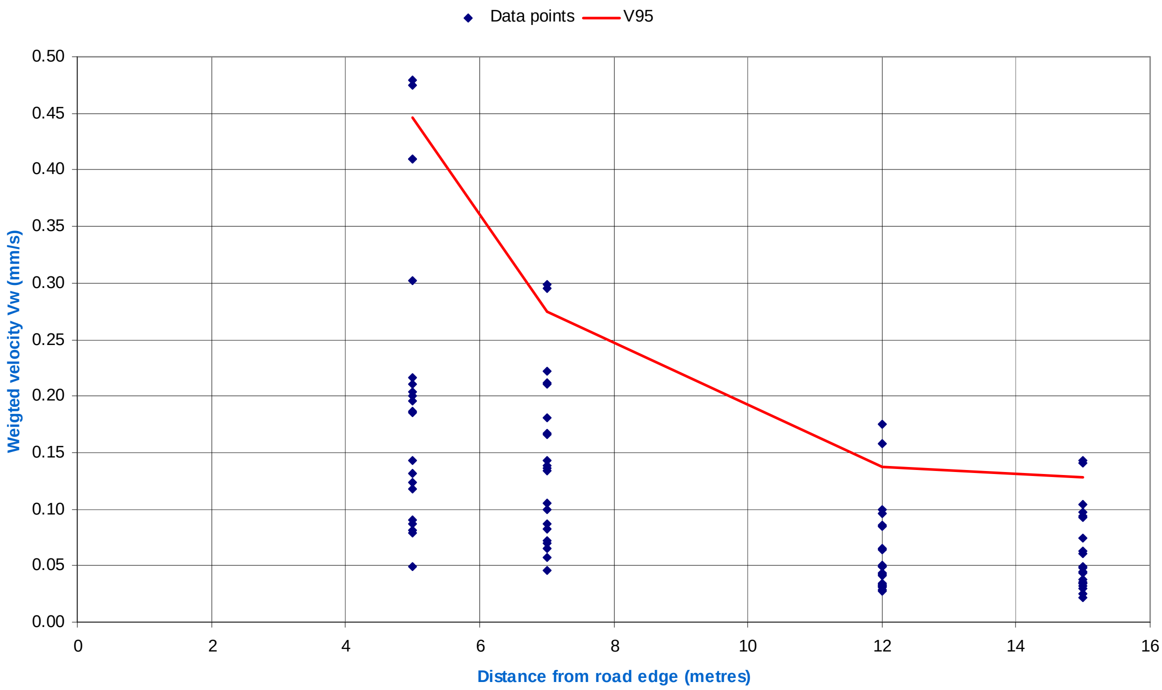

Figure 12-2 Vibration measurement results

The most recent measured surface roughness for the nearest lane to the vibration measurement location is shown in Figure 12-3. The NAASRA roughness value is approximately 20 counts/km, which is consistent with a surface in good condition with few imperfections.

3 Existing environment

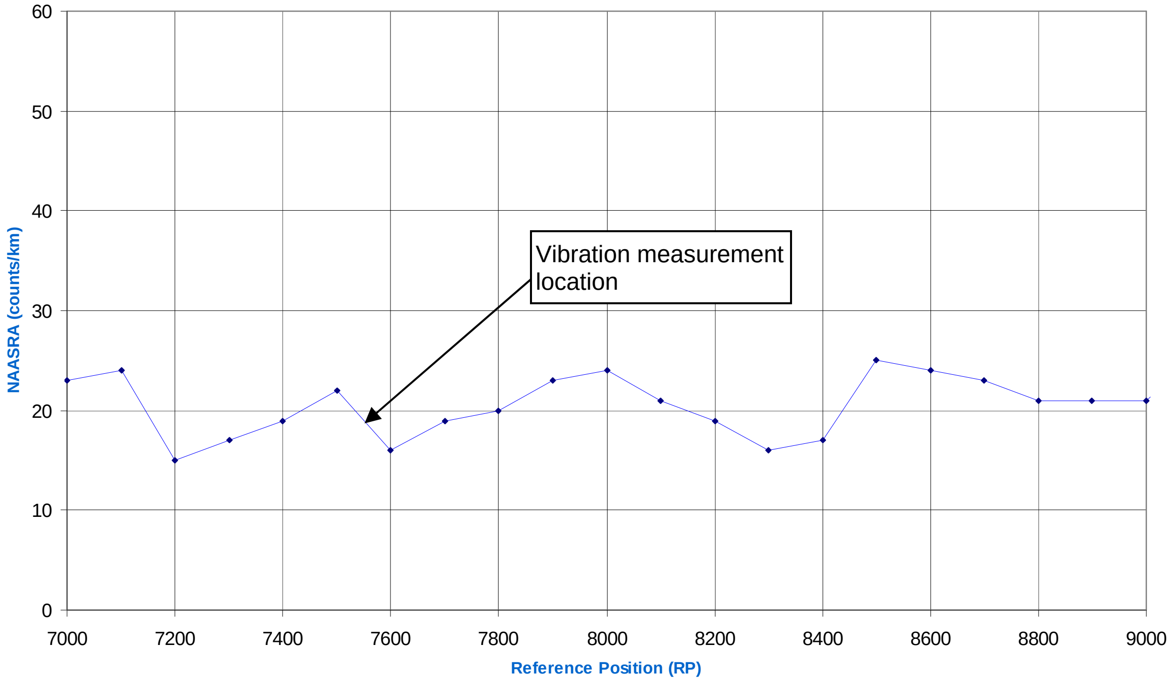

Figure 12-3 Existing State Highway 1 surface roughness

Modelling

4.1 Road-traffic sound model

The cornerstone of this assessment is acoustics modelling of road-traffic sound, which provides an objective basis to consider future activity. The modelling techniques used are well established in New Zealand and have been shown to be accurate. The discrepancies in Table 12-10 relate mainly to contamination by other sources and measurement uncertainty rather than modelling uncertainty.

4.1.1 Procedures

The first two scenarios to be modelled were:

- Do-nothing – the Project not constructed; the existing roads with 2031 traffic; and
- Do-minimum – the Project constructed; 2031 traffic; no specific noise mitigation.

The do-minimum alignment for the Project is a development of the 'preferred option' from the SAR. That option has since been adjusted to form the current do-minimum scenario as a result of further investigations and workshops. URS contributed to those workshops.

Comparison of do-nothing and do-minimum sound levels shows that the Project meets the threshold criteria to be considered as both a new and altered road in accordance with NZS 6806. Having assessed the do-minimum scenario, the Project was then considered in discrete areas, listed in Table 12-12 and shown on Figure 12-4, relating to the locations of Protected Premises and Facilities (PPFs). Three to six noise mitigation options were investigated for each area, as summarised in Table 12-13. Where no mitigation options are listed it is because all PPFs are in NZS 6806 category A in the do-minimum scenario. For each option modelled predictions were made at all individual receivers.

Table 12-12 Acoustics assessment areas

Acoustics assessment area	Protected Premises and Facilities	Project sections	
A	SH1 Paraparaumu Paekakariki Road	1	MacKays Crossing
B	(Battle Hill)	4	Battle Hill
C	Paekakariki Hill Road	4 5	Battle Hill Golf Course
D	Flightys Road	5 6	Golf Course State Highway 58
E	SH58 Paremata Haywards Road	6	State Highway 58
F	Brady Road Silverwood	6 7	State Highway 58 James Cook
G	James Cook Drive Spyglass Lane	7	James Cook
H	Warspite Avenue Corinna Street Niagara Street Loongana Street	7	James Cook
I	Takapu Road	8	Cannons Creek
J	Bluff Road	9	Linden

4 Modelling

Acoustics assessment area	Protected Premises and Facilities	Project sections	
K	Japonica Crescent Apple Terrace Huanui Street	9	Linden
L	Tremewan Street Mexted Terrace Collins Avenue Roberts Street Coates Street North Street	9	Linden
M	Rangatira Road	9	Linden
N	Little Collins Avenue Collins Avenue Allen Terrace Mahoe Street Raroa Terrace	9	Linden
O	Ranui Terrace South Street Matai Street	9	Linden

Table 12-13 Noise mitigation options

Area	Noise mitigation options
A	1. 2 m high roadside barriers 2. Open graded porous asphalt surface 3. 2 m bund, 1.5 m high wall and open graded porous asphalt surface
B	1. Grade 6 chipseal surface
C	1. Grade 6 chipseal surface 2. Open graded porous asphalt surface 3. 2 m high barrier
D	1. Grade 6 chipseal surface 2. Open graded porous asphalt surface 3. 3 m high barrier 4. 3.5 m / 4 m high barriers and grade 6 chipseal surface 5. 2.5 m high barrier and open graded porous asphalt surface 6. 2 m high bund by one PPF
E	1. Open graded porous asphalt surface (part only) 2. 1.5 m / 3 m high barriers and open graded porous asphalt surface (part only) 3. 2 m high barriers and open graded porous asphalt surface (part only) 4. 2 m / 4 m barriers and open graded porous asphalt surface (part only)
F	1. Grade 6 chipseal surface 2. Open graded porous asphalt surface 3. 3 m high barrier
G	n/a
H	(do-minimum has open graded porous asphalt surface) 1. 1 m high roadside barrier 2. 1.5 m high roadside barrier 3. 1 m high roadside barrier (part only) 4. 2.5 m high roadside barrier
I	n/a
J	n/a

Area	Noise mitigation options
K	(do-minimum has open graded porous asphalt surface) 1. 2 m high barrier at boundary 2. 3 m high barrier at boundary 3. 2 m / 2.5 m / 3 m / 3.5 m / 5 m high barriers at boundary 4. 2 m high barrier at boundary (part only) 5. 2.5 m / 3 m / 3.5 m / 5 m high barriers at boundary
L	(do-minimum has open graded porous asphalt surface) 1. 2.5 m high roadside barrier 2. 2 m high roadside barrier (part only) 3. 2 m high roadside barrier (part only)
M	n/a
N	(do-minimum has open graded porous asphalt surface) 1. 2 m high barrier at boundary 2. 3 m high barrier at boundary 3. 5 m high barrier at boundary 4. 5 m high barrier partly at roadside 5. 2 m / 2.5 m / 3 m high barriers
O	(do-minimum has open graded porous asphalt surface) 1. 1.5 m high roadside barrier 2. 2 m high roadside barrier 3. 3 m / 3.5 m high roadside barriers 4. 1.5 m / 2 m / 3 m / 3.5 m high barriers 5. 2 m / 3 m roadside barriers

At the end of the assessment of mitigation options, the selected options were combined and the entire scheme was remodelled as the final 'Notice of Requirement (NoR) scenario', with 2031 traffic. A summary matrix of all the assessment scenarios considered is provided in Table 12-14.

Table 12-14 Assessment scenarios

Scenario	Year	Assessment Area														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Existing	2009	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Do-nothing	2031	✓				✓		✓	✓		✓	✓	✓	✓	✓	✓
Do-minimum	2031	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mitigation Option 1	2031	✓	✓	✓	✓	✓	✓		✓			✓	✓		✓	✓
Mitigation Option 2	2031	✓		✓	✓	✓	✓		✓			✓	✓		✓	✓
Mitigation Option 3	2031	✓		✓	✓	✓	✓		✓			✓	✓		✓	✓
Mitigation Option 4	2031				✓	✓			✓			✓			✓	✓
Mitigation Option 5	2031				✓							✓			✓	✓
Mitigation Option 6	2031				✓											

As a visual aid, graphical sound level contours have been produced. Sound level values should not be taken directly from the contours as they are interpolated from a 20 metre grid resulting in some localised inaccuracies. Sound levels have been calculated separately at individual receivers.

Table 12-15 lists the key model settings.

4 Modelling

Table 12-15 Model settings

Parameter	Setting/source
Software	Cadna/A v4.1.137
Algorithm	CRTN[17] (NZ modified as detailed in 4.1.2) ISO 9613-2[18] (engine braking only)
Order of reflections	1
Parameter	$L_{Aeq(24h)}$ L_{AFmax}(engine braking only)
Ground absorption	1
Receiver height	1.5 m (4.5 m upper floors) – most exposed façade
Sound contour grid	1.5 m height, 20 m resolution
Receivers and grid position	free-field

The CRTN algorithm gives results in terms of the $L_{A10(18h)}$. To convert this to $L_{Aeq(24h)}$ a –3 dB adjustment has been made. This adjustment has been implemented in the software in conjunction with the road surface adjustment detailed below.

[17] Calculation of Road Traffic Noise (CRTN). UK Department of Transport and the Welsh Office. ISBN 0115508473. 1988
[18] ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors. Part 2 General method of calculation.

URS New Zealand Limited
Level 1, 31 Orchard Road
Christchurch Airport 8053
PO Box 4479, Christchurch 8140
New Zealand
T: 64 3 374 8500
F: 64 3 377 0655

www.urscorp.co.nz