Environmental Noise and Vibration Assessment

December 2017

Marshall Day Acoustics Ltd

Technical Report 10

NZ TRANSPORT AGENCY WAKA KOTAHI
Mt Messenger Bypass
New Zealand Government

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Glossary

Abbreviation	Description
Noise	A sound that is unwanted by, or distracting to, the receiver
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 μPa i.e. dB = 20 x log(P/Pr)
$L_{Aeq\ (t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
$L_{A90\ (t)}$	The A-weighted noise level equalled or exceeded for 90% of the measurement period. This is commonly referred to as the background noise level. The suffix "t" is described in $L_{Aeq(t)}$ above.
L_{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
MMA	Mount Messenger Alliance. The Project is being delivered for the NZ Transport Agency by an Alliance comprising Downer, Heb, Opus International, and Tonkin + Taylor.
Vibration	When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity. Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into the vertical direction (up and down vibration), the horizontal transverse direction (side to side) and the horizontal longitudinal direction (front to back).
PPV	Peak Particle Velocity For Peak Particle Velocity (PPV) is the measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment.

Executive Summary

This report assesses the traffic and construction noise and vibration effects of the proposed alignment of the Mt Messenger Highway upgrade project (the Project).

Assessments have been carried out considering; the obligations in sections 16 and 17 of the RMA to avoid unreasonable noise and avoid remedy or mitigate adverse effects, the relevant New Zealand Standards (NZS6806:2010 in respect to road traffic noise; NZS6803:1999 in respect to construction noise), and the NZ Transport Agency guidelines in terms of construction and traffic vibration. The New Plymouth District Plan is either silent in terms of construction and traffic noise and vibration, or relies on the relevant New Zealand Standards.

In general accordance with New Zealand Standard NZS6806:2010, three dwellings have been identified for assessment of traffic noise effects. It is predicted that there will be a noticeable change in the noise environment of 3072 Mokau Road. However, the traffic noise levels at all three dwellings will be acceptable, and are predicted to be within the most stringent Category A of the New Zealand Standard NZS6806:2010. There will be negligible traffic vibration effects at all dwellings.

Construction noise levels at the nearby dwellings are predicted comply with the daytime criteria set out in New Zealand Standard NZS6803:1999, with the possible exception of 2397 Mokau Road, which is in close proximity to a spoil disposal area and may require management, including if required installing a solid site hoarding and appropriate on site management to avoid unnecessary noise. Construction vibration levels are predicted to comply with the NZ Transport Agency guidelines. Construction noise and vibration effects are considered to be acceptable. It is recommended that a Construction Noise Management Plan be implemented for the construction phase.

Considering this assessment, no mitigation is required for the management of traffic noise and vibration effects.

1 Introduction

1.1 Purpose and scope of this report

This report forms part of a suite of technical reports prepared for the Project. Its purpose is to inform the Assessment of Effects on the Environment Report (AEE) and to support the resource consent applications and Notice of Requirement to alter the existing State Highway designation, which are required to enable the Project to proceed.

This report assesses the traffic noise and vibration effects of the proposed alignment of the Project as shown on the Project Drawings in Volume 2: Drawing Set. This report also assesses the construction noise and vibration effects during the construction phase of the Project.

The purpose of this report is to:

- Determine the existing noise environment that is currently received by noise sensitive buildings in the vicinity of the Project;
- Assess the change in noise level with the Project in place;
- Determine the NZS 6806 noise criteria category for each dwelling within 200 m of the Project and determine if mitigation is required and practicable;
- Assess traffic vibration in general terms; and
- Assess construction noise and vibration.

1.2 Project description

The Project involves the construction and ongoing operation of a new section of State Highway 3 (SH3), generally between Uruti and Ahititi to the north of New Plymouth. This new section of SH3 will bypass the existing steep, narrow and winding section of highway at Mt Messenger. The Project comprises a new section of two lane highway, approximately 6 km in length, located to the east of the existing SH3 alignment.

The primary objectives of the Project are to enhance the safety, resilience and journey time reliability of travel on SH 3 and contribute to enhanced local and regional economic growth and productivity for people and freight.

A full description of the Project including its design, construction and operation is provided in the Assessment of Effects on the Environment Report, contained in Volume 1: AEE, and is shown on the Drawings in Volume 2: Drawing Set.

2 Statutory / Standards framework

The following standards and guidelines have been reviewed in relation to the road traffic noise, traffic vibration, construction noise and construction vibration assessments:

- Resource Management Act 1991
- New Plymouth District Plan
- NZS 6806:2010 *"Acoustics – Road-traffic noise – New and altered roads"*
- NZS 6803: 1999 *"Acoustics – Construction Noise"*
- BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites* Part 2: Vibration
- DIN 4150-3:1999 *"Structural Vibration – Effects of Vibration on Structures"*
- NZTA State highway construction and maintenance noise and vibration guide (August 2013)

2.1 Resource Management Act 1991

The overarching RMA obligations relating to noise are set out in Sections 16 and 17 as follows:

Section 16: Duty to avoid unreasonable noise

1 *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.*

2 *A national environmental standard, plan, or resource consent made or granted for the purposes of any of sections 9, 12, 13, 14, 15, 15A, and 15B may prescribe noise emission standards, and is not limited in its ability to do so by subsection (1).*

Section 17: Duty to avoid, remedy, or mitigate adverse effects

1 *Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of that person, whether or not the activity is in accordance with a rule in a plan, a resource consent, a designation, section 10, section 10A, or section 20A.*

2.2 Traffic noise and vibration

2.2.1 New Plymouth District Plan

Appendix 12.1 STD 7.11 and 7.12 of the New Plymouth District Plan contains noise limits for activities within the Rural Environment Area (the entire Project area and the surrounding properties are in this zone). Rule number Rur92 requires the noise limits to be measured and assessed in accordance with NZS 6801:1991 and NZS 6802:1991. These standards expressly exclude transportation noise. There are no other District Plan rules relating to

traffic noise. Therefore, noise limits in the District Plan do not apply to traffic noise from the Project.

2.2.2 New Zealand Standard NZS 6806:2010

Road traffic noise in New Zealand is generally assessed and controlled through NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads (NZS 6806 or the Standard). MDA considers that NZS 6806 is the most current, integrated and appropriate document to assess road traffic noise in New Zealand.

The intent of the Standard is to provide a pragmatic and sensible approach to the use of noise mitigation. This approach includes the requirement that a road project needs to have a noticeable effect before mitigation must be considered, and that any mitigation needs to achieve a noticeable reduction in noise level.

NZS 6806 applies to traffic noise assessments where a project falls within the thresholds of the Standard. These thresholds are explained in the following subsections. As the Standard is an extensive and complex document, only key concepts for the purposes of this report have been included.

2.2.2.1 Assessment positions

The Standard assesses noise effects at noise sensitive locations only. The Standard specifies types of protected premises and facilities (PPFs), at which noise levels shall be assessed for changes in noise level and against noise criteria. These PPFs are:

- Dwellings (including those not yet built but having obtained building consent);
- Educational facilities and play grounds within 20m of educational facilities;
- Boarding houses;
- Homes for the elderly and retirement villages;
- Marae;
- Hospitals that contain in-patient facilities; and
- Motels and hotels in residential zones.

Noise effects are assessed at the façade (external wall) of the PPFs. The Standard does not consider commercial and business uses to be noise sensitive.

NZS 6806 stipulates that in rural areas, all PPFs within 200m of a project road alignment shall be assessed. Locations outside this area are excluded because at larger distances, noise levels will generally be below the most stringent noise criteria due to the distance attenuation of noise[1].

[1] It is noted that the dwelling at 2750 Mokau Road is outside this distance and therefore not considered a PPF in accordance with NZS 6806, but has been considered a PPF for this Project at the request of the project team.

The Standard excludes future land use from assessment, on the basis that land use planning is the preferred tool to manage the location of PPFs rather than pre-empting the location and use of future PPFs.[2]

2.2.2.2 Design year

The design year is a concept that is used for several engineering disciplines. It requires that the design of a road is based on a future year, making an allowance for an increase in traffic volumes over that time. The Standard requires that the design year shall be between 10 and 20 years after the opening of a new road to the public.[3]

The year 2037 has been selected as the design year for the Project, which allows for an opening year up to 2027.

2.2.2.3 Noise criteria

The noise criteria of the Standard are dependent on traffic volume and distinguish between "new" and "altered" roads. There are three noise criteria categories (A, B and C).[4]

For this Project, the relevant category is 'Altered roads'.

Where the Project would be classified as a 'New road', there are no dwellings within 200m due to its remote location. Table 2.1below presents the Standards for traffic noise categories for altered roads.

Table 2.1: NZS 6806 Traffic Noise Categories

Category	Altered Roads (dB $L_{Aeq(24h)}$)
A (primary external noise criterion)	≤64
B (secondary external noise criterion)	64-67
C (internal noise criterion)*	40

**This criterion is triggered if habitable rooms would receive internal noise levels greater than 45 dB $L_{Aeq(24h)}$ despite structural mitigation such as bunds, barriers and road surface materials being used.*

Under the Standard, the applicable criterion at any PPF depends on the best practicable option (BPO) test. Where noise levels within Category A can be achieved with the implementation of the BPO for noise mitigation, then Category A applies. Where Category A cannot practicably be achieved, then mitigation to achieve the noise criteria within Category B is subject to the BPO test. If the noise criteria of Categories A or B are not practicably achievable, then the "backstop" Category C shall be met with the adoption of the BPO.[5]

The Standard is clear that preference is to be given to structural mitigation over building modification mitigation.[6] Structural mitigation involves the use of structural elements such

[2] NZS 6806:2010 Acoustics-Road-traffic noise-New and altered roads: Section C1.4.1 & Appendix B.
[3] NZS 6806:2010: Acoustics-Road-traffic noise-New and altered roads, Section 2.2.
[4] NZS 6806:2010: Acoustics-Road-traffic noise-New and altered roads, Section 6.1.2.
[5] NZS 6806:2010 Acoustics-Road-traffic noise-New and altered roads, Section 6.1.2.
[6] NZS 6806:2010 Acoustics-Road-traffic noise-New and altered roads, Section 8.1.2.

as bunds, barriers or the choice of road surface material. Building modification mitigation refers to mitigation that is applied to a building, e.g. improving glazing or providing mechanical ventilation. Building modification mitigation provides noise level reduction for the indoor environment only and does not protect outdoor living areas.

NZS 6806 also requires achievement of the lowest external noise level with practicable structural mitigation, before considering building modification to mitigate internal noise levels.[7]

2.2.2.4 Assessment scenarios

At a minimum, NZS 6806 requires several operational scenarios to be assessed and compared. These include:

- The existing noise environment: for altered roads this consists of the current road layout and traffic volume, and for new roads consists of the current ambient noise level;
- A future Do-nothing scenario: consists of the existing SH3 at the design year, with increased traffic volume; and
- A future Do-minimum scenario: consists of the Project road at the design year, but without any specific noise mitigation. This scenario means that the choice of road surface material is independent from its noise generating characteristics. It also means that the only barriers included are solid safety barriers, which are required for reasons other than noise mitigation.

2.2.3 Traffic vibration

Traffic vibration does not generally cause adverse effects in situations where roads are well-maintained. The Transport Agency has a comprehensive road maintenance policy that ensures that roads remain smooth and any defects are fixed within short timeframes.

The responsibilities of the NZ Transport Agency are set out succinctly in Technical Memorandum Noise and Vibration No. 3[8].

2.3 Construction noise and vibration

2.3.1 New Plymouth District Plan

Appendix 12.1 STD 7.11 and 7.12 of the New Plymouth District Plan contains noise limits relating to construction within the Rural Environment Area. Rule number Rur88 requires the construction noise limits to be measured in accordance with NZS 6803P:1984.

The construction noise limits specified by the Plan are;

7am to 7pm: 70 dB L_{A10}

[7] NZS 6806:2010 Acoustics-Road-traffic noise-New and altered roads, Section 8.3.4.

[8] https://www.nzta.govt.nz/assets/Highways-Information-Portal/Technical-disciplines/Noise-and-vibration/Standards/Technical-memoranda/Tech-memo-NV3-State-highway-noise-and-vibration-management-v1.0.pdf

7pm to 10pm: 50 dB L_{A10}

10pm to 7am: 45 dB L_{A10} & 70 dB L_{Amax}

These limits are loosely based on the superseded provisional construction noise standard NZS 6803P:1984. This standard has since been replaced by NZS 6803:1999 "Acoustics – Construction Noise". It is recommended that construction noise be assessed in accordance with the latest standard, which is considered best practice.

The New Plymouth District Plan does not contain any vibration limits for construction activities.

2.3.2 New Zealand Standard NZS 6803:1999

The most appropriate document for the assessment of construction noise is NZS 6803:1999, which integrates with the relevant noise survey and assessment standards (NZS 6801 and 6802). This is also the criteria referenced in the *NZTA State Highway Construction and Maintenance Noise and Vibration Guide*.

As most aspects of the Project construction will exceed 20 weeks' duration, the "long-term duration" criteria are most appropriate for this Project, in accordance with Section 7.2.1 of the Standard. The long-term criteria are five decibels more stringent during day-time than the criteria for "typical duration" (up to 20 weeks' duration).

The relevant noise criteria of the Standard are summarised in Table 2.2.

Table 2.2: Recommended upper limits for long duration construction noise received in residential zones and dwellings in rural areas

Time of week	Time period	dB L_{Aeq}	dB L_{AFmax}
Weekdays	0630–0730	55	75
	0730–1800	70	85
	1800–2000	65	80
	2000–0630	45	75
Saturday	0630–0730	45	75
	0730–1800	70	85
	1800–2000	45	75
	2000–0630	45	75
Sunday and Public Holidays	0630–0730	45	75
	0730–1800	55	85
	1800–2000	45	75
	2000–0630	45	75

The Standard does not anticipate that full compliance with the construction noise criteria of Table 2.2 will necessarily be achieved at all times and at all receivers. It focuses on the implementation of the best practicable option (BPO) for construction noise management and mitigation rather than requiring that the criteria must be achieved.

2.3.3 Construction vibration

The NZ Transport Agency (the Transport Agency) has released the "State highway construction and maintenance noise and vibration guide (August 2013)", (the NZ Transport Agency Guide). The NZ Transport Agency Guide[9] adopts the German (DIN 4150) and British standards (BS 5228-2) noted in Section 2.0, and applies them in a progressive manner that addresses both annoyance and building damage effects. Prior to the development of this Guide, annoyance criteria were not usually applied to construction works, so the Guide adds this additional level of protection for receivers.

A summary of the relevant vibration criteria is shown in Table 2.3 below.

Table 2.3: Construction Vibration Criteria

Receiver	Details	Category A	Category B
Occupied PPFs	Night (2000h – 0630h)	0.3 mm/s PPV	1 mm/s PPV
	Day (0630h – 2000h)	1 mm/s PPV	5 mm/s PPV
Other occupied buildings	Daytime (0630h – 2000h)	2 mm/s PPV	5 mm/s PPV
All other buildings	Transient vibration	5 mm/s PPV	BS 5228-2 Table B.2
	Continuous vibration		BS 5228-2 50% of Table B.2 Values

In general terms, the Category A criteria of the NZ Transport Agency Guide aim to avoid annoyance of receivers. Because these criteria are conservative, there is a provision in the Guide to relax them if they cannot be practicably met, provided a vibration expert is engaged to assess and manage construction vibration to comply with the Category A criteria as far as practicable. If Category A is not practicably achievable, the focus is then shifted to avoiding building damage rather than annoyance by applying the Category B criteria.

If the Category B criteria are achieved, then building damage is unlikely to occur, but if they are predicted to be exceeded, then monitoring of vibration levels and building condition must occur to allow an assessment of and response to any effects.

The DIN 4150-3:1999 Standard, which the 5mm/s Category B criterion is taken from, is a conservative standard designed to avoid all damage to buildings, i.e. even superficial

[9] http://www.nzta.govt.nz/assets/resources/sh-construction-maintenance-noise/docs/construction-maintenance-noise-vibration-guide.pdf

damage like cracking in plaster. Significantly higher limits would be applied if damage to structural foundations was the only consideration.

These construction vibration criteria are suitable to assess annoyance and building damage effects, and have been adopted for assessing vibration effects in relation the Project.

3 Assessment methodology

3.1 Traffic noise

3.1.1 Background

The assessment of the traffic noise effects is based on a two stage approach:

- Assessment in accordance with NZS 6806 following the BPO process for noise mitigation and focussing on achieving the most stringent noise criteria category practicable; and
- Assessment of noise effects (both beneficial and adverse) through determination of noise level changes

The requirements of NZS 6806 are discussed above in Section 2.2.2. The subjective perception of noise level change is discussed below in Section 3.1.2.

The reason for the two stage approach is that in some circumstances, achieving noise levels within the most stringent Category A of the Standard does not necessarily mean that the effects of a project will be minor. Potentially, the overall noise level can be low (e.g. less than 57 dB $L_{Aeq(24h)}$, but there could be a large level increase due to a project where a receiver being in a relatively quiet area.

Overall, it is noted that any traffic noise effects (positive or negative) are generally somewhat temporary. People typically become habituated to their environment, including noise levels, particularly where the character of the sound does not change (i.e. if existing traffic noise increases). Nevertheless, high noise levels can result in adverse health effects, and mitigation is required to avoid such levels irrespective of the change in noise level.

This report provides an assessment of these two aspects.

3.1.2 Subjective perception of noise changes

The subjective impression of changes in noise can generally be correlated with the numerical change in noise level. While every person reacts differently to noise level changes, research shows a general correlation between noise level changes and subjective responses.[10]

MDA experience has shown that the subjective perception of a noise level change can be translated into a RMA effect. This effect is based on people's annoyance reaction to noise level changes. It is noted that people may have an annoyance reaction to a greater or lesser degree, depending on their perception of the Project.

Table 3.1 shows the indicative subjective responses to explain the noise level changes discussed in this report.

[10] For instance, LTNZ Research Report No. 292: Road traffic noise: determining the influence of New Zealand Road surfaces on noise levels and community annoyance, Table 18.

Table 3.1: Noise level change compared with general subjective perception

Noise level change	General subjective perception[11]	Impact[12]
1–2 decibels	Insignificant/imperceptible change	Negligible
3–4 decibels	Perceptible change	Slight
5–8 decibels	Appreciable change	Noticeable
9–11 decibels	Halving/doubling of loudness	Substantial
>11 decibels	More than halving/doubling of loudness	Serious

3.1.3 Noise level surveys

Noise level surveys of the ambient existing noise environment have been undertaken to determine the current noise environment for the area under consideration. The results of the surveys are also used to verify the computer noise model.

Only short term traffic noise measurements in the road reserve have been used to determine the existing noise environment along the length of the Project. The existing noise environment at the existing PPFs is low, which would have reduced the accuracy of the model varication. The calibrated noise model has then been used to determine the existing noise environment.

Surveys were undertaken in accordance with the requirements of NZS 6801:2008 and NZS 6806:2010.

3.1.4 Computer noise modelling

The propagation of road traffic noise is affected by multiple factors, which include;

- Terrain elevations, including shielding from intervening terrain and exposure due to elevation;
- Ground condition, including absorptive ground such as meadows or reflective ground such as water;
- Atmospheric conditions, including wind or temperature inversions; and
- Road parameters, including road surface, traffic speed, vehicle types and gradient.

Because of the multiple factors and their interaction, computer noise modelling is a vital tool in predicting traffic noise impacts in the vicinity of major roads and for the determination of mitigation measures. Modelling enables a comprehensive and overall picture of noise impacts to be produced, taking into consideration the factors potentially affecting noise propagation.

[11] Based on research by Zwicker & Scharf (1965); and Stevens (1957, 1972).

[12] The descriptions in this column are based on MDA understanding of the perception in change in noise level. MDA have used these descriptions for several roading projects to explain the effects in RMA terms.

The software 'SoundPLAN' has been used on the Project, which is an internationally recognised[13] computer noise modelling programme. The SoundPLAN model includes the following:

- Elevations of the Project alignment[14], including important aspects of the proposed road (e.g. edge of seal, median, traffic lane markings, bridges and solid safety edge barriers);
- Elevations of the area surrounding the Project[15] at vertical distances of 1.0m and extending generally beyond 200m from either side of the road edge; and
- Buildings and structures within the assessment area.

The SoundPLAN model uses the calculation algorithms of the "Calculation of Road Traffic Noise" methodology which is referenced in NZS 6806 in Section 5.3.2. The calculation algorithms take account of all of the factors set out above, including relevant atmospheric and ground conditions within appropriate parameters.

The adjustments for New Zealand road conditions, specifically road surface types, are also included in the model. Therefore, modelling results can be compared with the relevant criteria without further adjustment.

3.1.5 Modelling parameters

The computer noise model includes a variety of input parameters that describe the local environment and the Project. The main parameters, their origin and value are described below.

3.1.5.1 Road surface material

The major source of traffic noise is road tyre interaction for traffic speeds above 40 km/h. A correction to a base surface of asphalt is entered into the model, which differs depending on the road surface material chosen, the speed and percentage of heavy vehicles.

The Project road is proposed to be constructed using two coat chip seal.

3.1.5.2 Traffic volume and speed

The speed and volume of traffic on a road are key factors in determining the level of traffic noise generated. The Project will have a posted speed of 100 km/h, which has been used in the modelling.

Traffic flows generally increase with time. Since the assessment is based on the design year 2037, the increase over this 20-year period is included in the predictions. Table 3.2 presents the traffic volumes used in the model.

[13] SoundPLAN is used is used by over 5000 users in more than 40 countries.

[14] Base on details presented on the Drawings in Volume 2: Drawing Set

[15] Provided to MDA by the MMA

Table 3.2: SH3 Traffic Volumes[16]

Year	AADT	% Heavy Vehicles
2017 (Existing)	2364	18.6%
2037 (Do Nothing & Do Minimum)	3798	16.2%

3.1.6 Model verification

Computer noise models are useful tools in determining potential noise effects from a proposal. However, models are only an approximation of the real world. They are dependent on the quality of the input data and the calculation methodologies that convert the input data into predicted noise levels.

The measured and predicted existing noise levels have been compared for the relevant locations to verify the accuracy of the model. Table 3.3 shows the comparison of measured and predicted noise levels for the Project area.

Table 3.3: Computer noise model validation–measured and predicted noise levels

Position	Measured noise level	Predicted noise level	Difference
	dB $L_{Aeq(24h)}$	dB $L_{Aeq(24h)}$	decibel
Road reserve opposite 3072 Mokau Road (5m from kerb)	68	69	+1
Road reserve opposite 2528 Mokau Road (5m from kerb)	69	69	0

A comparison of the measured and predicted levels shows that for all positions there is good agreement between measured and predicted levels, with a difference of no more than 1 decibel. This accuracy fulfils the requirements of NZS 6806 which states in Section 5.3.4.2: *"The difference between measured and predicted levels should not exceed ± 2 dB."*

3.2 Construction noise and vibration

The assessment of construction noise and vibration effects is based on Marshall Day Acoustics' experience with previous large scale infrastructure projects of a similar kind and discussions with the MMA project team. Further details on construction method are set out in the AEE report.

3.2.1 Assessment methodology

The following assessment methodology has been used for the construction noise and vibration assessment:

- A review of noise and vibration emission data for each construction task / process has been performed. Data previously obtained by Marshall Day Acoustics has informed

[16] Data provided to MDA by MMA

this process. In addition, data from appropriate noise and vibration standards has also been considered, where relevant;

- A review of relevant criteria has been performed. These criteria are set out in this report and Project limits have been recommended; and
- Predictions of noise and vibration levels from each construction task / process have been performed and setback distances determined to determine whether the Project criteria can be achieved.

3.2.2 Construction noise

Noise level predictions for construction projects consider the sound power levels of each item of equipment, and model the noise propagation characteristics over distance, including the effects of ground and air absorption. Indicative noise levels were calculated in accordance with International Standard ISO 9613-2:1996 *"Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation"* for all relevant construction scenarios, assuming multiple items of equipment operating simultaneously. This approach is deliberately conservative in order to represent the reasonable worst-case noise levels that may infrequently occur.

Other than the variations in noise level due to the factors discussed above, there are numerous additional factors that affect construction noise generation. Some of these factors are variations among individual items of equipment, the state of equipment repair, exact locations of each item and operator skill. Generally, these factors cannot be accounted for as they cannot be reasonably quantified. However, the conservative approach outlined above is considered to generally provide for these variables.

3.2.3 Construction vibration

Construction vibration is a separate issue from construction noise. Construction equipment that produces high noise levels do not necessarily also produce high vibration levels.

Vibration prediction is less reliable than noise prediction due to issues with accurate modelling of ground conditions that are non-homogeneous and complex in three-dimensions, and consequently difficult to quantify on site.

As a result, safe distances have been based on vibration measurements[17] previously performed for high vibration sources such as vibropiling and vibrating rollers. These have been cross-checked against empirically derived relationships as contained in BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites* Part 2: Vibration.

The results from these measurements and predictions have been used to determine risk radii within which buildings are at low, medium or high risk of building damage. The risk radii also consider human annoyance effects.

[17] Measurements performed at State highway 18 and as used in the Waterview Project.

4 Description of environment

The existing noise environment provides a baseline for assessing noise effects. Effects can be assessed by quantifying the noise levels that people would experience due to the implementation of a project. The change in noise environment can then be interpreted in relation to subjective responses of people and possible annoyance.

Existing noise levels have been determined by means of measurement and computer noise modelling. The results are discussed below in Section 4.1 and 4.2.

4.1 Noise level surveys

Short term noise level surveys were undertaken at two locations adjacent the existing SH3. A map showing the measurement locations has been included in Appendix A. The noise level survey results are presented in Table 4.1.

Table 4.1: Summary of Environmental Noise Level Measurements

Measurement Position and Location		Measured Noise Levels (dB)			Noise Sources and Comments
		$L_{Aeq(1h)}$	$L_{A90(1h)}$	L_{Amax}	
1	Road reserve opposite 3072 Mokau Road (5m from kerb)	70	34	90	Dominated by traffic noise, background noise included birds, occasional dog barks and stream.
2	Road reserve opposite 2528 Mokau Road (5m from kerb)	71	40	94	Dominated by traffic noise. Background noise included wind in foliage and birds.

4.2 Computer noise modelling

In addition to the short term noise levels surveys, computer noise modelling enables the prediction of existing noise levels at the three PPFs within the assessment area. Table 4.2 below presents the predicted existing traffic noise levels at each PPF.

Table 4.2: Existing Traffic Noise Level

Receiver	Existing Traffic Noise Level, dB $L_{Aeq(24h)}$
3072 Mokau Road	49
2750 Mokau Road	46
2528 Mokau Road	55

The ambient noise environment is considered low to medium at the three PPFs.

Noise maps of the existing noise environment are included in Appendix B.

5 Assessment of effects

5.1 Traffic noise

5.1.1 NZS 6806

The predicted Do-nothing (existing road with future 2037 traffic volumes) and Do-minimum noise levels (proposed road with no noise mitigation) are presented in Table 5.1. All receivers are predicted to comply with Category A of NZS 6806. No mitigation has been proposed as full compliance with Category A of NZS 6806 has been achieved.

Table 5.1: Predicted Future Traffic Noise Levels

Receiver	Traffic Noise Level, dB $L_{Aeq(24h)}$		NZS 6806 Category
	Do Nothing	Do Minimum	
3072 Mokau Road	51	54	A
2750 Mokau Road	48	44	A
2528 Mokau Road	57	56	A

Noise maps for the Do-nothing and Do-minimum scenarios are presented in Appendices C and D.

5.1.2 Assessment of effects

The dwelling at 3072 Mokau Road is understood to be purchased prior to construction. However, it is possible that it may be used for residential purposes following construction, and is therefore included as a PPF in this assessment. At 3072 Mokau Road the effects will vary depending on the part of the house in question. This is the result of the altered orientation of the house in relation to the highway following construction of the Project:

- It is predicted that traffic noise at the worst affected façade (north-eastern) will increase by 3 decibels to 54 dB $L_{Aeq(24h)}$, which is considered a just perceptible change
- At the south-eastern façades, which are currently exposed to lower levels of traffic noise, it is predicted that traffic noise will increase by up to 17 decibels to 53 dB $L_{Aeq(24h)}$. An increase of 17 decibels is more than a doubling of loudness and overall is considered a substantial increase in traffic noise for these façades.
- Conversely the north-western façades of the dwelling are currently exposed to traffic noise and a decrease of up to 12 decibels is predicted. Subjectively noise at this façade will be approximately half what it currently is.

Overall, the change in noise effects at 3027 Mokau Road will be a noticeable effect. However, this effect is considered acceptable due to the low overall traffic noise level received. The level of noise at all facades will be substantially lower than the NZS6806 Category A standard.

At 2750 Mokau Road the traffic noise level is predicted to reduce by 4 decibels which is considered a slight improvement.

At 2528 Mokau Road the traffic noise level is predicted to reduce by 1 decibel which is considered a negligible change.

Overall, the predicted Do-minimum traffic noise levels at the nearest receivers are low to medium, are considered acceptable and would not result in adverse effects on residential activities.

5.2 Traffic vibration

Traffic vibration risk has been assessed by reviewing data of heavy vehicles travelling on existing roads with a range of surface conditions. Assessing this data against the Project traffic vibration criterion (Class C of the Norwegian Standard NS 8176.E:2005) indicates that compliance with the criteria can be achieved at 25 m from the road edge, even for roads in a degraded state. There are no dwellings within 25 m of the Project alignment.

With the implementation of the NZ Transport Agency's road maintenance policy, it is unlikely that the Project road surface will ever degrade significantly so effects are predicted to be negligible for all receivers. However, if the road does degrade, the effects would still only be negligible due to the PPFs' large setbacks from the road.

5.3 Construction noise

It is understood that the dwelling at 3072 Mokau Road will be purchased and will be vacant during construction. Therefore, no effects assessment of construction noise and vibration is required.

All other dwellings in the vicinity of works have been included in the assessment. This includes 2750 Mokau Road and 2528 Mokau Road, along with 2397 Mokau Road which is the closest dwelling to the spoil disposal area located at the southern end of the Project (for the location of the proposed spoil disposal area, see the Drawings in Volume 2: Drawing Set).[18]

The day-time and night-time compliance distance for various road construction activities are presented in Table 5.2.

[18] As set out in Section 2.2.2 above, all PPFs within 200m of a project road alignment have been assessed in relation to operational traffic. 2397 Mokau Road is not considered to be a PPF in relation to operational traffic as it will be located over 200m from the altered road once the road is constructed.

Table 5.2: Activity sound power levels and compliance distance

Activity	Activity Sound Power Level	Distance beyond which compliance with day-time limit (70 dB L_{Aeq}) is achieved without noise barriers (direct line of sight)	Distance beyond which compliance with night-time limit (45 dB L_{Aeq}) is achieved without noise barriers (direct line of sight)
	dB L_{WA}	metres	metres
Earthworks	118	65	700
Vibropiling or hammer piles	<120	80	800
Typical retaining wall construction	107	20	280
Structures piling/foundations	110	40	370
Above ground bridge works	107	20	280
Pavement construction	110	40	370
Staging area/construction yard	100	10	150

Construction noise is predicted to comply with the day-time limits at all dwellings. The construction noise effects during the day-time are considered acceptable.

The MMA team has indicated that 24/7 construction is proposed for the tunnel and that general construction activities are proposed for Monday to Sunday 6:30am to 9pm. There is the potential that construction works outside Monday to Saturday 7:30am to 6:00pm will exceed the limits. However, a significant proportion of the proposed route has large setbacks to the nearest receivers and shielding from the local topography, which will enable compliance with the night-time noise limits. The MMA team has indicated that works in close proximity of the nearest dwellings would be scheduled to only occur Monday to Saturday 7:30am to 6:00pm when compliance can be achieved.

If night works are required in close proximity of a dwelling, it is recommended that consultation be undertaken with the occupants prior to the works occurring. Also, night works in excess of the limits should not occur near any one dwelling for an extended period of time (greater than 3-5 nights).

The closest dwelling to one of the spoil disposal areas is 2397 Mokau Road. In order to achieve compliance with the daytime noise limits, a solid site hoarding may be required, and appropriate on site management to avoid unnecessary noise.

Night-time works in the spoil area in the vicinity of 2397 Mokau Road should be limited as far as practicable. This may be possible by avoiding night-time truck movements into the area and restricting any transport to daytime only.

It is recommended that a Construction Noise Management Plan (CNMP) be implemented during the construction phase of the project. At a minimum, the CNMP must address the

relevant measures in Annex E of NZS6803:1999 "Acoustics – Construction Noise" and Appendix B of DIN 4150-3:1999 "Structural vibration – Part 3 Effects of vibration on structures".

The CNMP will enable the construction team to determine the necessary setbacks, mitigation measures and procedures to enable compliance with the limits. The CNMP should also outline the management and communication procedures for night works in excess of the noise limits.

With the adoption of a CNMP and scheduling night works so that general compliance with the limits is achieved, the construction noise is considered acceptable.

5.4 Construction vibration

Vibration generating construction activities along the alignment are understood to generally be limited to vibrating roller compactors. Vibropiling or impact piling has not been specifically referenced along the route, however it is possible that these activities may be required for bridge construction and risk distances have been calculated on this basis.

The risk categories in Table 5.3 relate to the risk of exceeding the Project criteria at various distances from the vibration inducing works. The risk categories are defined as follows:

High Risk	Predicted to exceed Category A and B Project criteria
Medium Risk	Predicted to exceed Category A criteria, but comply with the Category B criteria
Low Risk	Predicted to comply with Category A and B Project criteria

Table 5.3: Activity and risk zones

Equipment	Risk Zones	
	Occupied Dwellings (Residential)	All Other Buildings
Vibrating Roller	High: <20m Med: 20-90m Low: >90m	High: <5m Med: 5-20m Low: >20m
Vibropiling	High: <20m Med: 20-120m Low: >120m	High: <5m Med: 5-20m Low: >20m
Impact Piling	High: <20m Med: 20-150m Low: >150m	High: <5m Med: 5-20m Low: >20m

It is predicted that the Category A and B project criteria will be achieved for all buildings near the proposed extent of works. The construction vibration effects are considered acceptable.

6 Conclusion

An assessment of traffic noise and vibration and construction noise and vibration has been undertaken for the SH3 Mt Messenger Highway upgrade project. Project criteria have been defined using the relevant Standards, Guidelines and the Resource Management Act.

Traffic noise is predicted to comply with Category A of NZS 6806 at nearby noise sensitive receivers without any specific mitigation. It is predicted that the dwelling at 3072 Mokau Road will experience a noticeable change in noise levels at the dwelling, but the change is considered acceptable due to the low overall level. At all other dwellings, the change in noise level is considered negligible and the overall levels acceptable.

A review of traffic vibration adjacent major roads has shown that the risk of the Project criteria (NS 8176) being exceeded is low. Overall the traffic vibration effects are considered negligible.

Construction noise and vibration levels are predicted to comply with the Project criteria at all dwellings, with the possible exception of 2397 Mokau Road, which is in close proximity to a spoil disposal area. It is recommended that a CNMP be implemented during the construction. The construction noise and vibration effects are considered acceptable.

No mitigation is required in respect of the traffic noise and vibration effects of the Project.

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Appendix A: Noise Survey Locations

Appendix B: Existing Noise Maps

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 1: Existing - Overall

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:20000
0 0.1 0.2 0.4 0.6 0.8 1 km

N

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

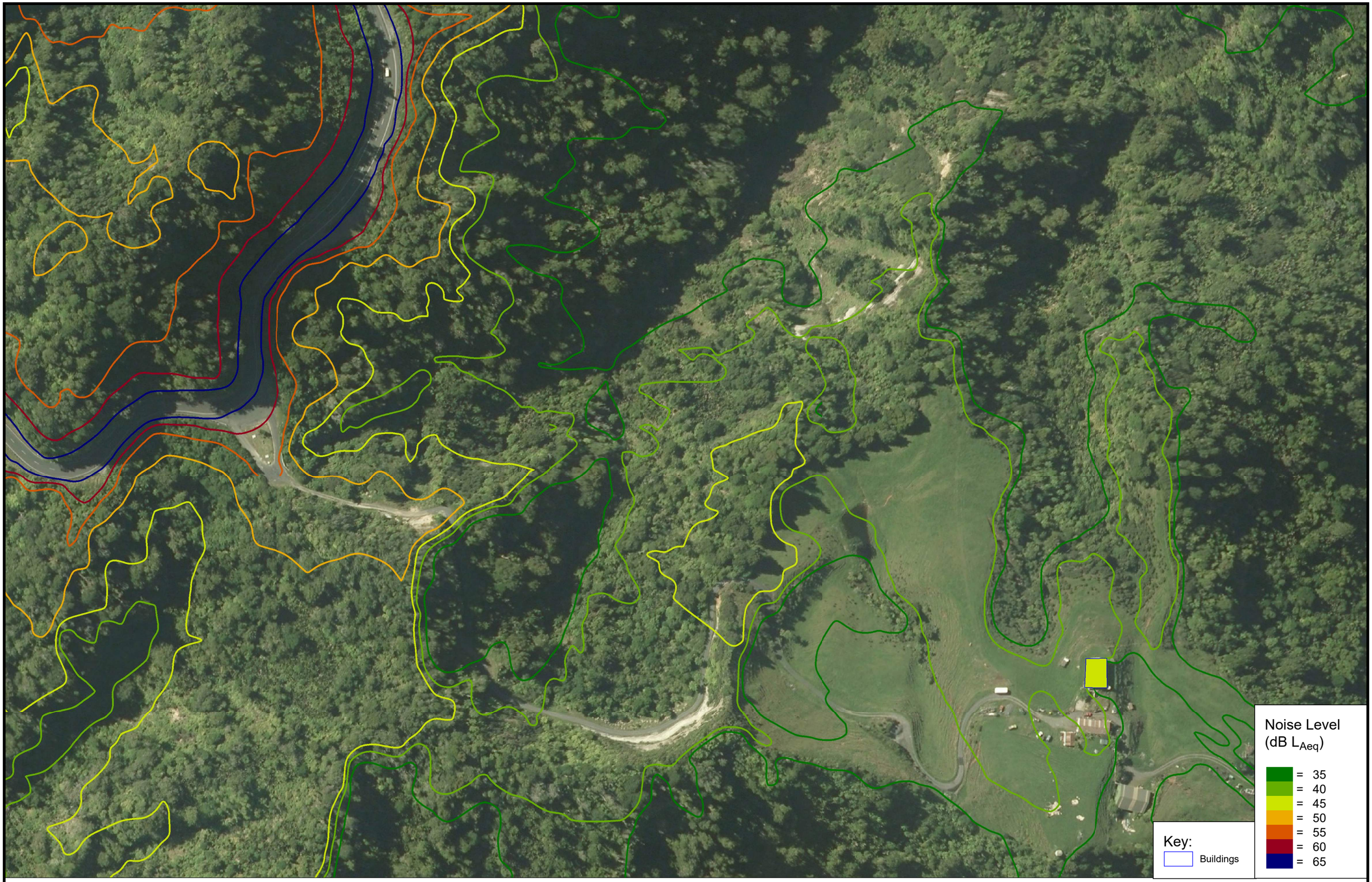
MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 1A: Existing - 3072 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 5 10 20 30 40 50 m

N



MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 1B: Existing - 2750 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 5 10 20 30 40 50 m

N

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 1C: Existing - 2528 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 5 10 20 30 40 50
m

N

Appendix C: Do Nothing Noise Maps

Noise Level (dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 2: Do Nothing - Overall

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:20000

0 0.1 0.2 0.4 0.6 0.8 1 km

N

Noise Level (dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 2A: Do Nothing - 3072 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 510 20 30 40 50 m

N

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 2B: Do Nothing - 2750 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 5 10 20 30 40 50 m

N

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 2C: Do Nothing - 2528 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 5 10 20 30 40 50
m

N

Appendix D: Do Minimum Noise Maps

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 3: Do Minimum - Overall

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:20000
0 0.1 0.2 0.4 0.6 0.8 1 km

N

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 3A: Do Minimum - 3072 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 510 20 30 40 50 m

N

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 3B: Do Minimum - 2750 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 5 10 20 30 40 50
m

N

Noise Level
(dB L_{Aeq})

= 35
= 40
= 45
= 50
= 55
= 60
= 65

Key:
Buildings

MARSHALL DAY Acoustics

Te Ara o Te Ata / Mt Messenger
Figure 3C: Do Nothing - 2528 Mokau Road

Client: New Zealand Transport Agency
Date: 31/10/2017
The noise contours in this Figure were obtained by computer interpolation between calculated grid points. There is an interpolation accuracy of +/- 1.5dB. For precise noise levels at specific location, refer to point receiver calculations.

Scale @ A3 1:2000
0 510 20 30 40 50
m

N