



NZ TRANSPORT AGENCY  
WAKA KOTAHI

Roads of national significance



Ara Tūhono – Pūhoi to Wellsford



## ***Pūhoi to Warkworth***

Operational Noise Assessment Report  
August 2013

MARSHALL DAY  
Acoustics 

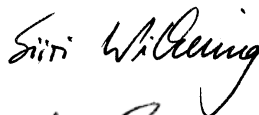
## Pūhoi to Warkworth

Document title: **Operational Noise Assessment Report**

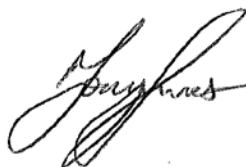
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## Glossary of abbreviations

Abbreviation	Definition
<b>AADT</b>	Average Annual Daily Traffic
<b>ACDP</b>	Auckland Council District Plan (Rodney Section) 2011
<b>AEE</b>	Assessment of Environmental Effects
<b>BPO</b>	Best Practicable Option
<b>NGTR</b>	Northern Gateway Toll Road
<b>NOR</b>	Notice of Requirement
<b>NZS 6801:2008</b>	New Zealand Standard NZS 6801:2008 " <i>Acoustics – Measurement of environmental sound</i> "
<b>NZS 6802:2008</b>	New Zealand Standard NZS 6802:2008 " <i>Acoustics – Environmental Noise</i> "
<b>NZS 6806:2010</b>	New Zealand Standard NZS 6806:2010 " <i>Acoustics – Road-traffic noise – New and altered roads</i> "
<b>NZTA</b>	NZ Transport Agency
<b>OGPA</b>	Open Grade Porous Asphalt
<b>OPW</b>	Outline Plan of Works
<b>PPFs</b>	Protected premises and facilities
<b>RMA</b>	Resource Management Act 1991
<b>SHx</b>	State Highway (number)



## Glossary of defined terms

Term	Definition
<b>Alignment</b>	The route or position of a motorway or state highway.
<b>Ambient (or total) sound / vibration</b>	The total sound or vibration existing at a specified point and time associated with a given environment, excluding the sound or vibration requiring control. It is a composite of all noise or vibration sources, near and far.
<b>Auckland Council</b>	The unitary authority that replaced eight councils in the Auckland Region as of 1 November 2010.
<b>Building modification mitigation</b>	Measures designed to reduce the internal traffic noise levels at PPFs which involve changes to buildings. Such measures include acoustic insulation, voice amplification and building relocation.
<b>dB</b>	A decibel is a unit of sound level.
<b>L<sub>Aeq(t)</sub></b>	<p>The time averaged noise level (on a log/energy basis). This is commonly referred to as the average noise level.</p> <p>The "A" represents A – weighting whereby the value has had its frequency characteristics modified by a filter so as to more closely approximate the frequency bias of the human ear.</p> <p>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 the period between 10 pm and 7 am.</p>
<b>L<sub>A10(t)</sub></b>	<p>The noise level which is equalled or exceeded for 10% of the measurement period. This is commonly referred to as the average maximum noise level.</p> <p>The "A" represents A – weighting as described for L<sub>Aeq(t)</sub> above.</p> <p>The suffix "t" represents the time period to which the noise level relates as described for L<sub>Aeq(t)</sub> above.</p>
<b>L<sub>A95(t)</sub></b>	<p>The noise level which is equalled or exceed for 95% of the measurement period. This is commonly referred to as the background noise level.</p> <p>The "A" represents A – weighting as described for L<sub>Aeq(t)</sub> above.</p> <p>The suffix "t" represents the time period to which the noise level relates as described for L<sub>Aeq(t)</sub> above.</p>
<b>L<sub>Amax</sub></b>	<p>The maximum sound pressure level measured during the sampling period.</p> <p>The "A" represents A – weighting as described for L<sub>Aeq(t)</sub> above.</p>

Term	Definition
<b>L<sub>dn</sub></b>	The day night noise level which is calculated from the 24 hour L <sub>Aeq</sub> with a 10 dB penalty applied to the night-time (2200-0700 hours) L <sub>Aeq</sub> . Can be converted into an L <sub>Aeq(24h)</sub> : $L_{Aeq(24h)} = L_{dn} - 2.5 \text{ dB}$
<b>Noise mitigation</b>	An activity or structure which reduces/mitigates the impact or effect of noise.
<b>Project area</b>	From the Johnstone's Hill tunnel portals in the south to Kaipara Flats Road in the north.
<b>Structural mitigation</b>	Measures designed to reduce the external traffic noise levels at PPFs, including barriers, bunds and low-noise road surface materials.

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# 1. Introduction

This report provides an assessment of the road traffic noise effects of the Pūhoi to Warkworth Project (the Project). We have based our assessment on accepted New Zealand standards and guidelines, and international research on subjective response to road traffic noise.

The purpose of the operational noise assessment is to assess whether, and to what extent, the Project can be designed and constructed so that adverse traffic noise effects can be avoided or mitigated. Adverse effects may include amenity effects, sleep disturbance and health impacts

## 1.1 Purpose and scope of this report

This report describes our assessment of road traffic noise effects of the Pūhoi to Warkworth Project (the Project). The report forms part of a suite of technical reports prepared for the NZ Transport Agency's Ara Tūhono Pūhoi to Wellsford Road of National Significance (RoNS) Pūhoi to Warkworth Section. Its purpose is to inform the Assessment of Environmental Effects (AEE) and to support the resource consent applications and Notices of Requirement for the Project.

We have based our assessment on accepted New Zealand standards and guidelines, and international research on subjective response to road traffic noise.

The purpose of the operational noise assessment is to assess whether, and to what extent, the Project can be designed and constructed so that adverse traffic noise effects can be avoided or mitigated. Adverse traffic noise effects may include:

- Amenity effects on residents in the vicinity;
- Annoyance;
- Sleep disturbance; and
- Health impacts associated with the effects above.

The scope of our work involved the following:

- Determining the existing noise environment along the designation;
- Calculating future noise levels from traffic on the Project and, for completeness, on the existing SH1;
- Determining the areas that may be adversely affected by road traffic noise from the Project;
- Determining whether mitigation that would reduce these effects can be practicably implemented and assessing the level of reduction that can be achieved;
- Reviewing the overall effects of the Project for the wider area, based on likely annoyance reaction from residents in the area.

This report deals with operational noise only. Construction noise and operational and construction vibration are addressed in separate reports.

The indicative alignment shown on the Project drawings has been developed through a series of multi-disciplinary specialist studies and refinement. A NZTA scheme assessment phase was

completed in 2011, and further design changes have been adopted throughout the AEE assessment process for the Project in response to a range of construction and environmental considerations.

It is anticipated that the final alignment will be refined and confirmed at the detailed design stage through conditions and outline plans of works (OPW). For that reason, this assessment has addressed the actual and potential effects arising from the indicative alignment, and covers the proposed designation boundary area.

Except as noted in this report:

- We consider that the sites we have selected for surveys and testing are generally representative of all areas within the proposed designation boundary; and
- The recommendations we propose to mitigate adverse effects are likely to be applicable to other similar areas within the proposed designation boundary, subject to confirmation of their suitability at the detailed design stage.

## 1.2 Project description

This Project description provides the context for this assessment. Sections 5 and 6 of the Assessment of Environment Effects (Volume 2) further describe the construction and operational aspects of the Project and should be relied upon as a full description of the Project.

The Project realigns the existing SH1 between the Northern Gateway Toll Road (NGTR) at the Johnstone's Hill tunnels and just north of Warkworth. The alignment will bypass Warkworth on the western side and tie into the existing SH1 north of Warkworth. It will be a total of 18.5 km in length. The upgrade will be a new four-lane dual carriageway road, designed and constructed to motorway standards and the NZTA RoNS standards.

## 1.3 Project features

Subject to further refinements at the detailed design stage, key features of the Project are:

- A four lane dual carriageway (two lanes in each direction with a median and barrier dividing oncoming lanes);
- A connection with the existing NGTR at the Project's southern extent;
- A half diamond interchange providing a northbound off-ramp at Pūhoi Road and a southbound on-ramp from existing SH1 just south of Pūhoi;
- A western bypass of Warkworth;
- A roundabout at the Project's northern extent, just south of Kaipara Flats Road to tie-in to the existing SH1 north of Warkworth and provide connections north to Wellsford and Whangarei;
- Construction of seven large viaducts, five bridges (largely underpasses or overpasses and one flood bridge), and 40 culverts in two drainage catchments: the Pūhoi River catchment and the Mahurangi River catchment; and
- A predicted volume of earthworks being approximately 8M m<sup>3</sup> cut and 6.2M m<sup>3</sup> fill within a proposed designation area of approximately 189 ha earthworks.



The existing single northbound lane from Waiwera Viaduct and through the tunnel at Johnstone's Hill will be remarked to be two lanes. This design fully realises the design potential of the Johnstone's Hill tunnels.

The current southbound tie in from the existing SH1 to the Hibiscus Coast Highway will be remarked to provide two way traffic (northbound and southbound), maintaining an alternative route to the NGTR. The existing northbound tie in will be closed to public traffic as it will no longer be necessary.

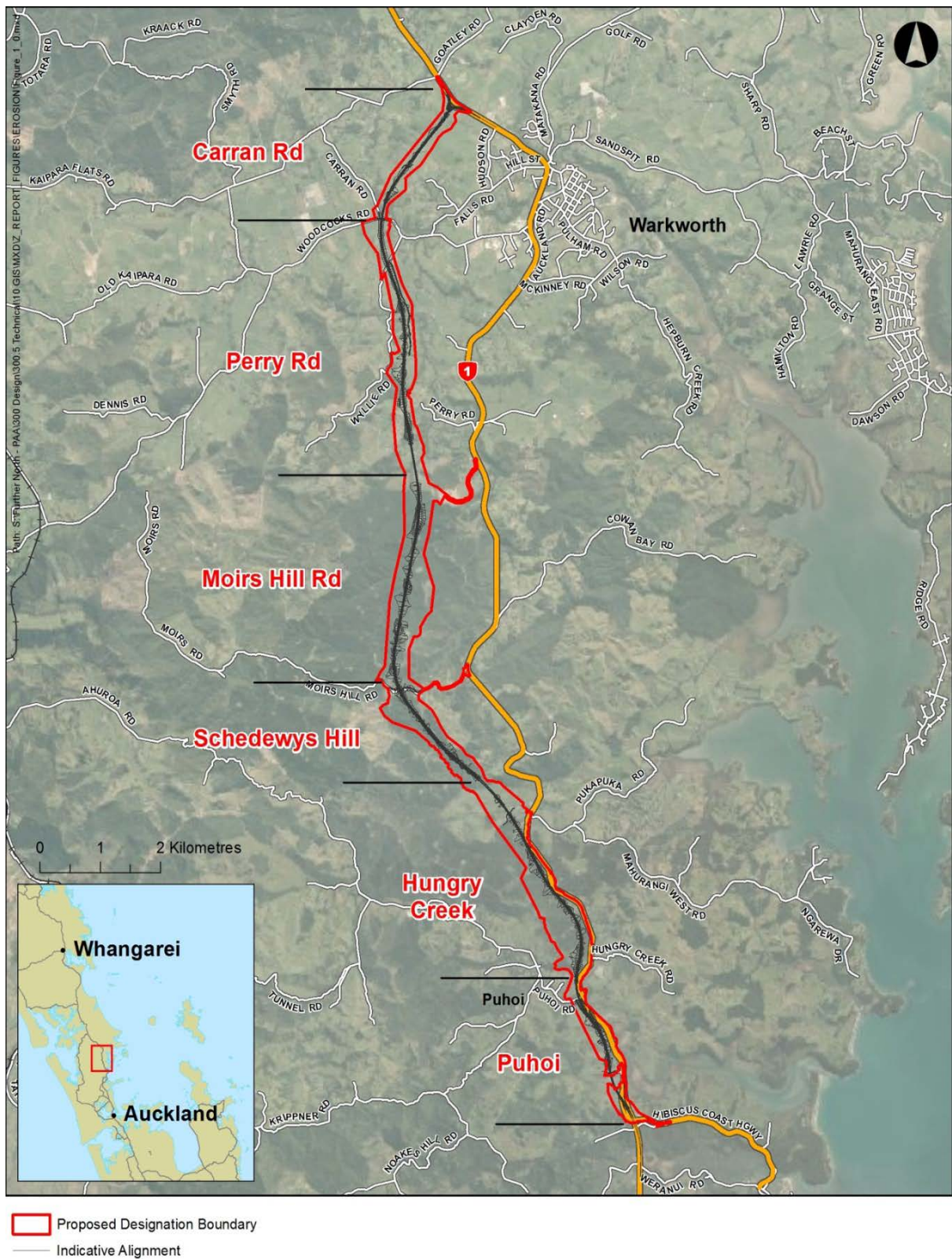
## 1.4 Interchanges and tie-in points

The Project includes one main interchange and two tie-in points to the existing SH1, namely:

- The Pūhoi Interchange;
- Southern tie-in where the alignment will connect with the existing NGTR; and
- Northern tie-in where the alignment will terminate at a roundabout providing a connection with the existing SH1, just south of Kaipara Flats Road north of Warkworth.

## 1.5 Route description by Sector

For assessment and communication purposes, the Project has been split into six sectors, as shown in Figure 1. Section 5.3 of the AEE describes these sectors.



**Figure 1: Project sectors**

## 2. Noise assessment criteria

Road traffic noise effects can be assessed by applying various standards and guidelines. We have reviewed the methodologies most commonly used in New Zealand and have chosen New Zealand Standard NZS 6806:2010 "Acoustics – Road-traffic noise – New and altered roads" (NZS6806 or the Standard) as the guiding document for our assessment.

We consider conformance with NZS 6806:2010 will achieve reasonable noise levels for all affected residents in the vicinity of the Project. The methodologies for noise level measurement, prediction and assessment set out in this Standard ensure an equitable management of noise effects for all assessment positions. The Standard is based on the best practicable option (BPO) approach, which aligns with Resource Management Act 1991 (RMA) requirements.

Furthermore, we have assessed traffic noise effects on residents by interpreting the general subjective response to predicted noise level changes, both along the Project alignment and along SH1 (where a reduction in noise level will occur). We compared the percentage of people predicted to be "highly annoyed" by traffic noise along the alignment and SH1, for the existing and predicted future circumstances. This comparison allowed us to weigh up potential positive and negative effects based on their significance and the number of people affected.

We have reviewed the following standards and guidelines in relation to road traffic noise assessment:

- NZS 6806:2010;
- NZTA Environmental Plan (June 2008);
- Auckland Council District Plan (Rodney Section) 2011;
- Auckland Regional Plan: Coastal; and
- Resource Management Act 1991.

Based on this review, we consider that NZS 6806 is the most current, integrated and appropriate document to assess road traffic noise in New Zealand. Therefore, we recommend that NZS 6806 be used for the assessment of road traffic noise from this Project.

### 2.1 New Zealand Standard NZS 6806:2010

Road traffic noise in New Zealand is generally assessed and controlled through NZS 6806:2010. This Standard was issued as a full New Zealand Standard in April 2010 and has been applied to several major roading projects since its release. As noted above, we consider it appropriate that traffic noise from this Project is assessed and controlled based on the provisions of this Standard.

NZS 6806 is the first New Zealand road-traffic noise standard and was developed by an independent multidisciplinary committee led by Standards New Zealand.

We consider 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 roading project needs to have a noticeable effect before mitigation is 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, we have included only key concepts for the purposes of this report.

### 2.1.1 Assessment positions

Pursuant to the Standard, noise effects need to be assessed at noise sensitive locations only, compared with the RMA which considers a broader receiving environment. 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 20 metres 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. Therefore they are not assessed as PPFs and are excluded from this assessment.

We have assessed noise levels at all existing PPFs within 200 metres of the indicative alignment, and have identified all existing potential PPFs within 200 metres of the designation boundary, should the alignment shift within the designation boundary. Our assessment is in accordance with the Standard, which, in Section 1.4.1, states that *“PPFs do not include: (g) Premises and facilities which are not yet built, other than premises and facilities for which a building consent has been obtained which has not yet lapsed.”*

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.<sup>1</sup>

In particular, the assessment of traffic noise levels at façades requires knowledge of the locations of PPFs onsite. For a PPF that has been granted building consent, the location on-site is known and can be used for noise level prediction. Other developments, e.g. where a future development area has been identified or where a subdivision consent has been granted, do not provide the same level of accuracy potentially leading to unnecessary or inadequate mitigation.

Once a roading project has been notified through the lodgement of the Notice of Requirement (NOR), there are several opportunities for a future development or dwelling to be designed to accommodate the future noise source. For future development areas, buffers can be provided, e.g. green belts between the road and the development. Dwellings can be located on the sites to have non-habitable<sup>2</sup> and noise-insensitive<sup>3</sup> rooms facing the road or can be located on a site at a

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<sup>1</sup> NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads: Section C1.4.1 and Appendix B.

<sup>2</sup> For instance, garage, laundry or walk in wardrobes.

<sup>3</sup> For instance, bathrooms or hallways.



greater distance from the road. In addition, under current Building Code requirements a new dwelling would be required to incorporate elements such as substantial glazing and acoustic insulation in its construction, which also effectively mitigates internal noise from all external sources.

NZS 6806 stipulates that in rural areas<sup>4</sup>, all PPFs within 200 metres 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.

We have undertaken the noise assessment for this Project generally in accordance with this limitation because from our experience, noise levels beyond the 200 metre extent are below a level that we consider would require mitigation. Nevertheless, we have in some instances included additional buildings outside the 200 metre assessment area. Where this has been undertaken, it is noted in the report (refer Section 6.2).

As the alignment for the Project has not been finalised, we have based our assessment on one potential alignment option, but have listed all PPFs within 200 metres of the designation boundary. The inclusion of these PPFs means that our assessment is conservative as it includes PPFs that may be well outside 200 metres of the final alignment.

### 2.1.2 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.<sup>5</sup>

We have selected the year 2031 as the design year for the Project, which allows for an opening year up to 2021.

Should construction, and subsequent opening, of the Project be delayed, there is a potential for traffic volumes to increase over time. However, noise level predictions are relatively insensitive to changes in traffic volume. For instance, a 20 % increase in traffic volume would result in a less than 1 decibel increase in noise level, and a 50% increase in traffic volume would result in less than 2 decibels increase. Therefore, we consider that the chosen design year of 2031 provides an appropriate indication of future traffic noise effects.

### 2.1.3 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).<sup>6</sup>

For the Project, the relevant categories are those of the altered roads and new roads with traffic volumes below 75,000 vehicles per day (i.e. columns two and three respectively in Table 1 below).

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<sup>4</sup> Rural areas are defined in NZS 6806 as being “not an urban environment” as defined by Statistics New Zealand. NZS 6806:2010, Section 2.

<sup>5</sup> NZS 6806:2010: Acoustics – Road-traffic noise – New and altered roads, Section 2.2.

<sup>6</sup> NZS 6806:2010: Acoustics – Road-traffic noise – New and altered roads, Section 6.1.2.



**Table 1: NZS 6806 Relevant Noise Criteria categories**

Category	Altered Roads	New Roads with a predicted traffic volume of 2,000 to 75,000 AADT <sup>7</sup> at the design year
	dB L <sub>Aeq</sub> (24h)	dB L <sub>Aeq</sub> (24h)
A primary external noise criterion	64	57
B secondary external noise criterion	67	64
C internal noise criterion*	40	40

\* This criterion is triggered if habitable rooms would receive internal noise levels greater than 45 dB L<sub>Aeq</sub>(24h) despite mitigation such as bunds, barriers and road surface materials being used.

We have applied the new road criteria to all PPFs along the alignment, except for PPFs where the Project is within the area of influence of the existing State Highway 1 (SH1). While the criteria categories in NZS 6806 are not dependent on ambient noise levels, the Standard allows for special circumstances where *“PPFs are already significantly affected by noise from another existing road in the vicinity”*,<sup>8</sup> e.g. for this Project the existing SH1. This provision in the Standard avoids unreasonably stringent noise criteria being applied, for example, noise criteria that are lower than existing ambient noise levels. We determined the areas where the existing SH1 contributes significantly to the overall noise level by applying the following methodology:

- We entered 200 metre buffer areas around the existing SH1 and around the Project.
- Where these two areas intersect, we applied the “altered road” criteria (for roads with less than 75,000 vehicles per day) to the Project. In these situations, the existing SH1 is close to the Project and will add, or even dominate, the existing and future noise environment.
- Where the two areas diverge, we applied the “new road” criteria to the Project.

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 met 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.<sup>9</sup>

The Standard is clear that preference is to be given to structural mitigation over building modification mitigation.<sup>10</sup> Structural mitigation involves the use of structural elements such 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. We agree that it is preferable to install mitigation as close to the road as possible so as to provide the largest area of noise level reduction practicable. Building modification mitigation provides noise level reduction for the indoor environment only and does not protect outdoor living areas.

<sup>7</sup> AADT means average annual daily traffic. Refer Definitions.

<sup>8</sup> NZS 6806:2010: Acoustics – Road-traffic noise – New and altered roads, Section 6.2.1(c).

<sup>9</sup> NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 6.1.2.

<sup>10</sup> NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 8.1.2.

NZS 6806 also requires achievement of the lowest external noise level with practicable structural mitigation, before considering building modification to mitigate internal noise levels.<sup>11</sup>

#### 2.1.4 Assessment scenarios

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 SH1 at the design year, with increased traffic volume. Noise levels predicted from the Do-nothing scenario apply for PPFs assessed against the “altered road” criteria only.<sup>12</sup>
- 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. Local roads that are not proposed to be altered by the project are not included in the assessment.
- Future Project with mitigation: consists of the project road at the design year, and includes mitigation that is designed specifically to reduce noise levels.

The mitigation option chosen as the selected option may not provide the greatest noise level reduction, but is considered optimal and practicable on balance, when evaluated against all relevant criteria.<sup>13</sup>

#### 2.1.5 Mitigation requirements

As described in Section 2.1.3 above, the Standard adopts the BPO methodology to noise mitigation, which, in our opinion, is a pragmatic and balanced approach.

One aspect of the BPO is that a noticeable noise level reduction is to be achieved by any structural mitigation.<sup>14</sup>

Barriers, while often effective for noise reduction purposes, can cause adverse effects, such as shading, visual or safety issues. While these are outside the area of expertise of an acoustic consultant, and are dealt with by other disciplines through the BPO process, any structural noise mitigation measures need to be designed so that they result in meaningful noise level reductions.

Therefore, NZS 6806 includes a criterion for the effectiveness of structural mitigation measures. In areas where mitigation benefits more than one PPF, it *“should only be implemented if the combination for the structural mitigation measures used would achieve ... an average reduction of at least 3 dB  $L_{Aeq(24h)}$ ”*<sup>15</sup>. The reason for the minimum requirement that an average of 3 decibels

<sup>11</sup> NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 8.3.4.

<sup>12</sup> Drawings ON-100 to ON-108 show the noise criteria categories for all PPFs and assessed dwellings for the various assessment scenarios. For those PPFs assessed against the “new road” criteria, the do-minimum noise criteria category is not shown.

<sup>13</sup> NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 6.3 “Best Practicable Option” sets out factors that should be considered and weighed up when determining the BPO for noise mitigation.

<sup>14</sup> NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.2.

<sup>15</sup> NZS 6806 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.2(a), page 41.

mitigation should be achieved is that, where many PPFs are in close proximity to each other, and a barrier or low noise road surface would benefit more than just one or two PPFs, the noise level reductions for individual assessment positions would vary. For positions located closest to the mitigation it may be significant, and for those at a greater distance, lesser reduction.

Where houses are located sporadically along the alignment, and structural mitigation would benefit only individual dwellings, mitigation should achieve *"a minimum reduction of 5 dB  $L_{Aeq(24h)}$  at any assessment position(s)"*.<sup>16</sup> In these areas, due to the large distance from one dwelling to the next, barriers and a low-noise road surface would generally provide mitigation for individual dwellings only. Therefore a significant noise level reduction should be achieved to justify the installation of any mitigation measure.

### 2.1.6 Recommendation

Our assessment of traffic noise from the Project is based on New Zealand Standard NZS 6806:2010 because we consider it to be the most appropriate and applicable New Zealand document. The Standard has been tested in several Hearings (both Council and Board of Inquiry) and has, with minor modifications, been accepted and applied to major roading projects.

We recommend that, should the designation be confirmed, conditions should reference NZS 6806:2010 and its approach to noise mitigation and outcomes. Any condition relating to the Standard would then ensure that the BPO for noise mitigation be implemented to achieve appropriate outcomes for noise sensitive uses adjacent to the Project.

## 2.2 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<sup>17</sup> shows a general correlation between noise level changes and subjective responses. Table 2 below shows indicative subjective responses to explain the noise level changes discussed in this report. From experience, we have found 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 (refer Section 2.3 below).

The perception of these noise level changes generally applies to immediate changes in noise level, as would be the case for a new road such as this Project. However, people may subjectively have an annoyance reaction to a greater or lesser degree, depending on their perception of the Project.

<sup>16</sup> NZS 6806 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.2(b), page 41.

<sup>17</sup> 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 2: Noise level change compared with general subjective perception**

Noise level change	General subjective perception <sup>18</sup>	Impact/RMA Effect <sup>19</sup>
1 – 2 decibels	Insignificant change	Negligible/Less than minor
3 – 4 decibels	Perceptible change	Slight/Minor
5 – 8 decibels	Appreciable change	Moderate
9 – 11 decibels	Halving/doubling of loudness	Significant/Substantial
> 11 decibels	More than halving/doubling of loudness	Serious/Severe

Noise is measured on a logarithmic scale, meaning that a doubling in traffic volume (e.g. from 10,000 vehicles per day to 20,000 vehicles per day) results in a noise level increase of 3 decibels, a just perceptible change. A tenfold increase in traffic volume (e.g. from 10,000 to 100,000 vehicles per day) would result in a noise level increase of 10 decibels, which would sound twice as loud.

### 2.3 Annoyance effects

People's responses to a particular level of road traffic noise can vary greatly. A large number of studies have been carried out overseas in an attempt to determine a general relationship of response to noise of a residential community as a whole.

The most notable studies include that of Shultz<sup>20</sup> and those of Miedema and Oudshoorn<sup>21</sup>, as shown in Figure 2 below. These studies combined the results of several different studies to produce a 'curve' of the percentage of people highly annoyed (%HA) versus external noise level ( $L_{dn}$ )<sup>22</sup>. The studies involved a number of different transportation noise sources including trains, road traffic and aircraft. Only the curve for road traffic noise is shown below.

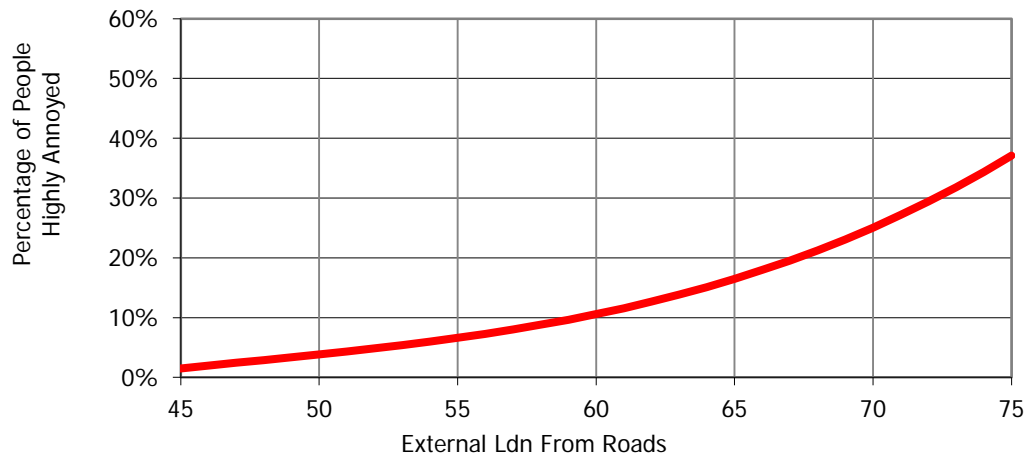
<sup>18</sup> Based on research by Zwicker & Scharf (1965); and Stevens (1957, 1972).

<sup>19</sup> The descriptions in this column are based on our understanding of the perception in change in noise level. We have used these descriptions for several roading projects to explain the effects in RMA terms.

<sup>20</sup> Schultz T J (1978) "Synthesis of social surveys on noise annoyance" J.Acoust. Soc. Am. 64, 2, 337-405.

<sup>21</sup> Miedema, H M E and Oudshoorn, G M (2001) "Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals." Environmental Health Perspectives 109 (4) 409 – 416.

<sup>22</sup>  $L_{dn}$  levels can be converted into  $L_{Aeq(24h)}$  by subtracting 2.5 dB.



**Figure 2: Miedema & Oudshoorn Dose-Response Relationship**

The curve shows that about 10% of people would be highly annoyed at an external road traffic noise level of 57 dB  $L_{Aeq(24h)}$  (equivalent to 59 dB  $L_{dn}$ ), which is the upper end of the NZS 6806 Category A for new roads. For an external noise level of 64 dB  $L_{Aeq(24h)}$  (equivalent to 66 dB  $L_{dn}$ ), the upper end of Category B for new roads, 18 % of people would be highly annoyed.

We have calculated the average<sup>23</sup> percentage of people highly annoyed for the noise bands shown on Drawings ON-301 to ON-305, ON-307 to ON-311 and ON-331 to ON-335 as follows:

**Table 3: Percentage people highly annoyed**

Noise band	Average percentage of people highly annoyed
55 to 60 dB $L_{Aeq(24h)}$	10%
60 to 65 dB $L_{Aeq(24h)}$	17%
Above 65 dB $L_{Aeq(24h)}$	26%

Accordingly, using BPO mitigation to achieve the lowest practicable noise levels will ensure better amenity for people and that a smaller number of people will be annoyed by road traffic noise.

<sup>23</sup> We have converted the  $L_{dn}$  noise levels into  $L_{Aeq}$  noise levels. Then, for each noise level from 55 to 60 dB  $L_{Aeq(24h)}$  (i.e. 55, 56, 57, 58, 59 and 60 dB) we have obtained the percentage of people highly annoyed from the graph in Figure 2 (i.e. 8%, 9%, 10%, 11%, 12% and 13%) and taken the arithmetic average (i.e. 10%). We have then applied the 10% highly annoyed people to the number of persons within the 55 to 60 dB  $L_{Aeq(24h)}$  noise band. We obtained an average percentage for the three noise bands 55 to 60 dB, 60 to 65 dB and 65 to 73 dB.



### 3. Noise assessment methodology

We undertook both short and long duration surveys to determine the existing noise environment along the length of the Project.

Computer noise modelling allowed us to take account of the many factors that affect the propagation of road traffic noise. The computer noise model includes information on the form of the terrain, the road alignment and dwelling locations. The road information includes traffic volume, speed, road surface material, gradient and percentage of heavy vehicles.

The computer noise model is verified against measured noise levels to ensure that future noise levels are predicted accurately. We found that the computer noise model performed within the required accuracy of  $\pm 2$  decibels.

The computer noise model results are expressed as individual receiver noise levels at the PPFs and noise contours over a larger area. We use the individual receiver noise levels to assess compliance with NZS 6806 and to determine the noise level change at each dwelling assessed. The noise level contours provide a wider picture of the road noise effects of the Project. We used the contours to determine the number of people that may be highly annoyed by road traffic noise. We also used the noise contours to visually represent the extent of road traffic noise in the wider area.

Our assessment is three-pronged:

- Assessment of compliance with NZS 6806 following the BPO process and focussing on achieving the most stringent Noise Criteria Category A, where practicable.
- Assessment of noise effects (both positive and adverse) through determination of noise level changes and likely annoyance of people; and
- Assessment of effects over the wider area affected by the Project. This is done by comparing the number of people that may be highly annoyed by traffic noise with and without the Project. This comparison takes into account noise level reductions and increases in the wider Project area.

#### 3.1 Noise level surveys

##### 3.1.1 Survey methodology

Noise levels can be measured with two different methodologies:

- Short duration measurements, generally between 5 and 30 minutes long, during daytime and attended throughout so that the actual environment can be observed and described; and
- Long duration measurements, generally between one and seven days, which continuously record noise levels and are unattended (i.e. no person is with the equipment throughout the survey period).

We used both of these methodologies to determine the existing noise environment along the length of the Project. Unattended long duration measurements were undertaken using Noise Data Loggers. The loggers continuously measured  $L_{Aeq(15min)}$  sound levels over the monitoring duration. We then converted these levels into  $L_{Aeq(24h)}$  values, which are relevant to NZS 6806 (refer Section 2.1.3 above).

For the short duration attended surveys, the majority of surveys were located in the vicinity of the designation, including those areas distant from the existing SH1. The noise levels at locations where the existing State highway is not the dominant noise source would be generated by natural sounds such as wind in trees, birds and insects. All of these factors are not quantifiable by means of formulae. Accordingly, it is not possible to calculate an  $L_{Aeq(24h)}$  noise level from these measurements with acceptable accuracy. We show these levels unadjusted in Table 6 below.

Surveys were undertaken in accordance with the requirements of NZS 6801:2008 "Acoustics – Measurement of Environmental Sound" and NZS 6802:2008 "Acoustics – Environmental Noise".

### 3.1.2 Route selection surveys – July 2010

We undertook attended short duration noise measurements in July 2010 to provide input into the route selection phase of the Project. Measurements were performed at five representative locations between Pūhoi and Warkworth. The survey positions included locations close to the existing SH1 and areas that are currently unaffected by road traffic noise. These locations allowed us to gain an understanding of the different noise environments under consideration. This 2010 information has also been used for this assessment of noise effects.

### 3.1.3 Assessment of noise effects surveys – May 2013

For completeness, and to confirm that previous noise level survey results remain valid, we undertook a number of attended short-duration noise level measurements along the Project alignment in May 2013. In addition to those locations previously measured, additional survey locations included Perry Road and SH1 in the vicinity of Billing Road, Carran Road and SH1 at Warkworth.

## 3.2 Computer noise modelling

The propagation of road traffic noise is affected by multiple factors, amongst them:

- Terrain elevations, including shielding from intervening hills 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 all of the factors potentially affecting noise propagation.

We used the software 'SoundPLAN', which is an internationally recognised<sup>24</sup> computer noise modelling programme. In summary, SoundPLAN uses a digital topographical terrain map of the area as its base which for the Project included the following:

- Elevations of the Project alignment, including important aspects of the proposed road (e.g. edge of seal, median, traffic lane markings, bridges and solid safety edge barriers); and

<sup>24</sup> SoundPLAN is used by over 5000 users in more than 40 countries.

- Elevations of the area surrounding the Project at vertical distances of 2 metres and extending generally beyond 1 km from either side of the road edge.

In addition, we entered data into the model for all existing buildings and structures (including auxiliary buildings) within the assessment area.

We digitised road traffic noise sources, with each road lane located on the terrain file. The software then calculates traffic noise generation for multiple directions, allowing for topography, shielding and meteorological conditions.

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.

### 3.2.1 Modelling parameters

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

#### (a) Road surface material

The major source of traffic noise is road tyre interaction for traffic speeds above 40 km/h. Therefore, the choice of road paving material has a significant effect on traffic noise generation.

A correction to a base surface of asphalt is entered into the model, which differs depending on the road surface material chosen. For this Project, the surface corrections were:

- -5.3 dB for Open Graded Porous Asphalt (OGPA), e.g. used for the main alignment for noise mitigation purposes;
- -1.7 dB for Asphalt, e.g. used for on and off ramps and roundabouts;
- +1.3 dB for Chip seal, e.g. used for the main alignment as the base option.

These corrections include a conversion from  $L_{A10}$  to  $L_{Aeq}$ .

#### (b) 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. We have used this speed in the computer noise modelling. On-ramp speed has been modelled at 70 km/h and off-ramp speed as 60 km/h, taking account of the acceleration and reduction in speed respectively.

Traffic flows generally increase with time. Since the assessment is based on the design year 2031, the increase over this 18 year period is included in the predictions.

For the Project, the operation of the new road will also result in decreased traffic flows on the existing SH1. This decrease in traffic will provide a beneficial reduction in noise level for most

residences adjacent to SH1, e.g. traffic volumes are predicted to reduce by up to 65%, which equates to a 4 decibel noise level reduction (refer Section 2.2 above for subjective perception).

We have described, in Sections 6.5 and 6.6 of this report, the benefit of the traffic reduction on SH1 by comparing the numbers of people “highly annoyed” with and without the Project, as set out in Section 2.3 above.

Traffic volumes were provided by the team’s traffic modelling specialist<sup>25</sup> and are described in Section 4.1 of the “Transportation and Traffic Assessment Report”.

### (c) Safety barriers

For safety requirements, all viaducts along the alignment will include edge safety barriers. These barriers provide acoustically effective shielding to PPFs in the vicinity. We have included all solid concrete safety barriers of 820 mm in height on both sides of the road in assessment of all viaducts in our modelling.

### 3.2.2 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.

We have measured existing noise levels along the Project alignment (refer Section 5). In the computer model, for the measurement locations, we predicted the existing noise levels from traffic on SH1 and any major local roads. During the surveys, traffic on these roads was observed to be the controlling noise source. We then compared the measured and predicted existing noise levels for the relevant locations in order to verify the accuracy of the model.

Table 4 below shows the comparison of measured and predicted noise levels for the Project area.

**Table 4: Computer noise model validation – Measured and predicted noise levels**

Position	Measured Noise Level	Predicted Noise Level	Difference*
	dB L <sub>Aeq</sub> (24h)	dB L <sub>Aeq</sub> (24h)	decibel
87 Perry Road, Warkworth	49	47	-2
40 Wyllie Road, Warkworth	52	50	-2
8 Pūhoi Close, Pūhoi	51	51	0
815 State Highway 1, Pūhoi	51	51	0

\* The noise level difference has been rounded to the nearest full number.

<sup>25</sup> Andrew Bell of the Further North Alliance. Determined by linearly interpolating between the 2009, 2026 and 2051 modelled traffic volumes. Note that the 2051 modelled traffic volumes are not reported in the Transportation and Traffic Assessment Report.

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 2 decibels. This accuracy fulfils the requirements of NZS 6806:2010 which states in Section 5.3.4.2: *"The difference between measured and predicted levels should not exceed  $\pm 2$  dB."*

### 3.2.2 Individual receiver noise levels

Noise effects need to be assessed for sensitive locations, e.g. dwellings, rather than vacant land. This restriction of assessment is particularly significant in rural areas where large sites generally only contain one dwelling. To provide for appropriate mitigation, the location of dwellings needs to be known. As discussed in section 2.1.1 above, the Standard provides protection for PPFs, including for existing dwellings and those unconstructed dwellings that have building consent.

We have included predicted noise levels for all PPFs, for the design year, in the table in Appendix A. The locations of these dwellings are shown on Drawings ON-100 to ON-108.

These levels have been calculated for each PPF within 200 metres of the Project, as required by NZS 6806. Additionally, we have predicted noise levels for the dwelling at 26 Billing Road because, although it is outside the 200 m assessment area, it is close to the dwelling at 24 Billing Road, which is a PPF. The design of selected noise mitigation measures has been based on the application of the BPO with the objective of meeting the criteria of Category A at all PPFs.

Noise criteria categories for the PPFs are shown as a graphic representation by colouring the buildings with a colour scale showing NZS 6806 Category A buildings in green, Category B buildings in yellow and Category C buildings in red. Any buildings not shown in these three colours on the figures are outside the assessment area of 200 metres from the road alignment, or are not PPFs, e.g. garages, sheds or business premises. Refer to Drawings ON-100 to ON-108 for figures showing the noise criteria categories of the PPFs.

### 3.2.3 Noise contour plans

Noise contour plans are a useful tool to obtain a graphical overview of a project area and the potential effects of a noise source. The contours are calculated by the computer programme by interpolating a large number of individual points. Therefore, noise contour maps should not be used to determine individual noise levels for specific locations. For such individual levels, the receiver noise levels in the tables should be used (refer Appendix A).

For this Project, we used the noise level contours to determine the number of dwellings and affected people inside the wider area. These numbers were then used to determine the percentage of people who would be highly annoyed (refer Section 2.3 above).

Noise contour plans are contained in Drawings ON-301 to ON-305, ON-307 to ON-311 and ON-331 to ON-335. These plans show interpolated noise level bands at 5 decibel intervals from 45 dB to 75 dB  $L_{Aeq(24h)}$ .

## 3.3 Assessment of effects and compliance

We have used the computer modelling results to assess the operational noise effects on people based on a three-pronged approach:

- Assessment of compliance with NZS 6806 following the BPO process for noise mitigation and focussing on achieving the most stringent Noise Criteria Category A, where practicable;



- Assessment of noise effects (both beneficial and adverse) through determination of noise level changes; and
- Assessment of effects over the wider area affected by the Project. This assessment is completed by comparing the number of people that may be highly annoyed by traffic noise with and without the Project. This comparison takes into account noise level reductions and increases in the overall area.

The reason for the three pronged approach is that in some circumstances, compliance with the Standard does not necessarily mean that the effects of a project will be minor.

Potentially, the effects of a noise level increase can be significant (e.g. a noise level increase of more than 5 decibels). At the same time, the resulting noise environment can be appropriate for residential use and not cause sleep disturbance or difficulty undertaking noise sensitive activities such as holding a conversation or watching TV.

It is also important to provide an overarching view of traffic noise effects over the wider area affected by the Project, weighing up benefits and disbenefits to people through noise level increases and decreases.

Overall, we note 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). This habituation may exclude noise effects on sleep. However, the noise levels predicted for PPFs for the Project that are currently in the “low noise” environments (e.g. Wyllie Road), where the change in noise level would involve a change in character also, are below those that would generally cause sleep disturbance.<sup>26</sup>

This report provides an assessment of all of these aspects.

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<sup>26</sup> Generally, internal average night-time noise levels of 40 dB  $L_{Aeq(night-time)}$  are recognised to be appropriate to avoid sleep disturbance.

## 4. Traffic noise mitigation

Road traffic noise from the Project has been avoided, remedied or mitigated by the following means:

- Avoidance of noise effects through route selection. A number of routes were assessed during the scheme assessment phase, and noise considerations have influenced the current Project alignment.
- Mitigation of noise effects through choice of low noise road surface material.

Mitigation of traffic noise is most effective at source, i.e. at or as close to the road as possible. Therefore, choosing low noise road surface material is the preferred mitigation method as it protects the widest possible area. Following this preferred mitigation method, barriers can be used to break acoustic line-of-sight from the noise source (the road) to the receiver (the PPFs). The barriers should be as close as possible to the road or the PPF. Only if these measures are not sufficient to achieve suitable noise levels at the PPFs, should building modification be considered. Building modification involves the installation of insulation, improved glazing and sealing or other upgrades to the façade, and alternative ventilation. Such building improvements would lead to improving internal noise levels only and therefore would not protect the outdoor environment around the houses.

The Standard clearly requires that external mitigation be employed first, before building improvements be considered. We have assessed mitigation based on this requirement.

### 4.1 Avoidance of noise effects through alignment design

The most effective noise reduction option is through appropriate alignment selection at the outset of a project's planning. For example, an alignment could be selected that avoids populated areas or the road alignment could be lowered to achieve increased shielding through terrain features.

As part of the scheme assessment for the Project, the Project team considered a number of different road alignments. Initially, this process involved consideration of either an "inland route" or an "eastern route". A long list of road corridor options was then developed along these routes. From these, a short list of three corridor options was selected. The final route option selected was the result of consideration of all engineering, environmental and social constraints along these route options.<sup>27</sup>

Noise considerations have contributed to the selection of the current alignment. We provided analysis and advice for each stage of the road corridor selection process. As a result, parts of the road have been realigned where noise effects could be avoided. An example is where a more westerly alignment was adopted to reduce noise effects on the rural/residential area of Perry Road.

### 4.2 Noise mitigation options

There are three general methods that can be used to control traffic noise generation or propagation. These are:

- Selecting noise reducing road surface material;

<sup>27</sup> Refer to the AEE, Section 7 on further discussion regarding previous route options.

- Installing traffic noise barriers; or
- Upgrading building envelopes, e.g. by upgrading glazing, insulation or seals around doors and windows, and installing alternative ventilation options so that windows can remain closed.

We discuss these options in more detail below. (A large number of other management measures are set out in NZS 6806 in Appendix B.)

#### 4.2.1 Road surface material

The noise mitigation measure with the largest influence on the generation of road traffic noise is the road surface material. Mitigating traffic noise through the road surface material reduces noise at the source, i.e. the largest possible area receives the benefit of this mitigation measure.

The smoothness and porosity of road surface materials affect the noise generation, with smooth porous materials reducing noise generation and rough non-porous materials increasing noise generation.

Chip seal is most commonly used on the open road in lightly populated areas. It is one of the noisiest road surface materials but provides good adhesion and is durable and cost effective.

OGPA is the most common low-noise road surface used in New Zealand. It is generally used in densely populated areas and on high capacity and high speed roads. It provides good drainage due to its porosity but needs frequent maintenance and replacement to maintain its noise reducing characteristics.

Appendix B of NZS 6806 contains extensive discussion of the application of low noise road surfaces. It states that OGPA, a porous and smooth layered asphalt surface, can reduce noise levels by around six decibels when compared with chip seal, the noisiest surface. This is a noticeable difference. However, in order for this reduction in noise level to be achieved and maintained, OGPA must be laid to a sufficient depth, properly drained and regularly cleaned.

OGPA requires more frequent maintenance and relaying than chip seal. This maintenance requirement results in considerable cost associated with the noise benefit. Therefore, the base option for most roads is chip seal.

Chip seal is proposed to be used for this Project as the Do-minimum scenario (refer Section 2.1.4), with OGPA being considered as a mitigation measure where appropriate.

For some areas where increased shear resistance for the pavement is required, e.g. for areas where vehicles brake, accelerate or turn, a more substantial structural road surface material is required. This includes the on and off ramps. In these instances, Stone Mastic Asphalt (SMA) or similar may be utilised. This material, while also smooth and therefore generating less noise than chip seal, is non-porous. Therefore, noise levels for SMA are slightly higher than those for OGPA.

#### 4.2.2 Barriers and bunds

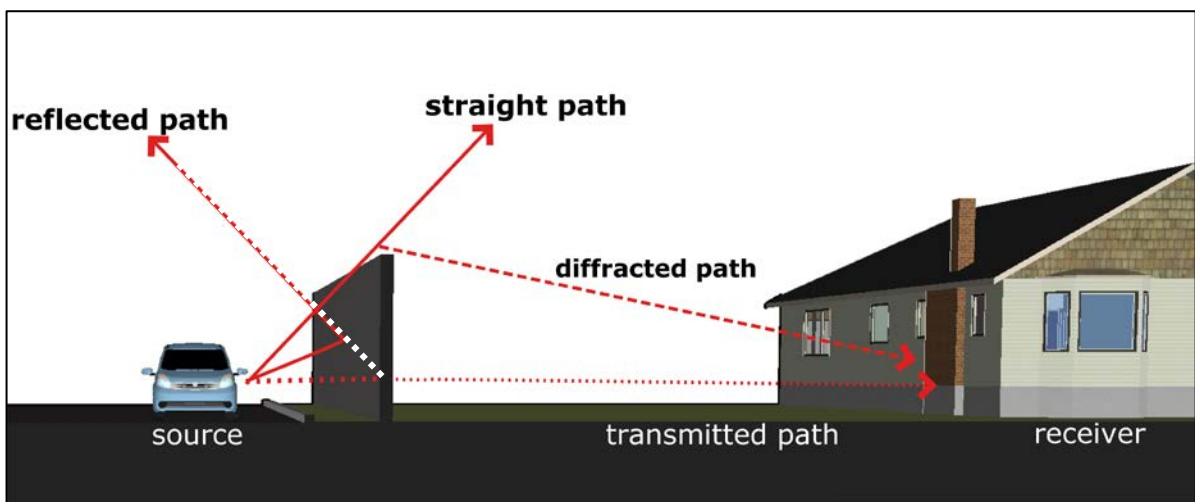
Acoustic barriers work by breaking acoustic line-of-sight from the noise source to the receiver. In order to provide the most effective noise level reduction, an acoustic barrier must be of solid material (i.e. have no gaps) and have a minimum surface weight of 10 to 12 kg/m<sup>2</sup> (e.g. 20 mm timber, 9 mm fibre cement, concrete etc).

Traffic noise barriers can take a variety of forms such as:

- Earth bunds (if space is available);
- Solid barrier walls: Concrete; fibre cement; bio barriers (planted walls);
- Transparent barriers: Acrylic; polycarbonate; glass;

Tunnels/Trenches: Below ground; above ground (full enclosure); trenches/cuts: fully open or partially covered (i.e. trench tunnel combination).

Figure 3 shows how traffic noise barriers mitigate noise by reducing its transmission through the barrier to a negligible level so that the main contribution of received noise is due to bending of sound waves over and around the ends of the barrier (diffracted path).



(Source: NZTA State Highway Noise Barrier Design Guide Version 1.0/August 2010)

**Figure 3: Acoustic Barrier Function**

Barriers are the most common form of noise mitigation after the choice of road surface material. They can be installed immediately beside the road, which means that the widest surrounding area can be protected. Alternatively, barriers are installed along property boundaries close to dwellings. Such placement generally provides noise level reductions for those properties only.

There are several viaducts along the Project route. Viaducts are elevated above the ground and often do not benefit from screening provided by topography, cuttings or ground absorption. However, bridges and viaducts are generally required to include crash barriers, which typically consist of 820mm high solid concrete barriers. These barriers can provide noticeable noise attenuation. As discussed in Section 3.2.1(c) above, all acoustically effective safety barriers are included in the Do-minimum scenario in the computer noise modelling. In general, bridges and viaducts generate the same level of noise from their surfacing as do on-grade roads.

#### 4.2.3 Building envelope improvements

Where the relevant external noise criteria at PPFs cannot be achieved with “external” structural mitigation in the road corridor, further mitigation may be required if they are within Category C (refer Section 2.1.3 above).

The Category C assessment is triggered if the noise level inside habitable rooms would be 45 dB  $L_{Aeq(24h)}$  or more, with the implementation of the selected structural mitigation measures. In that instance, at least a five decibel noise level reduction is required to achieve an internal noise level of no more than 40 dB  $L_{Aeq(24h)}$ .

The improvements required would vary from building to building. While some buildings have already been designed to achieve suitable internal noise environments, with the choice of heavy building materials, improved glazing and insulation, and well fitting doors and windows, other building structures may not provide sufficient attenuation. Therefore, a case-by-case assessment is required for those buildings identified to fall within Category C.

Often, improvements to glazing and joinery may be sufficient to achieve the required internal noise levels. In some instances, mechanical ventilation may be necessary so windows can remain closed.

Any insulation or other building envelope improvements have to be implemented concurrently with the achievement of the requirements of Clause G4 of the New Zealand Building Code, which governs the ventilation requirements for buildings. Therefore, in many instances an alternative mechanical ventilation system would be required in order to ensure sufficient ventilation is provided while maintaining suitable internal noise levels to comply with the NZS 6806 Category C requirements.

#### 4.2.4 Maintenance of mitigation measures

The acoustic performance of noise mitigation measures, i.e. the effectiveness and extent of noise level reduction, needs to be maintained over time. NZS 6806 states that “*structural mitigation measures should be designed in such a way that they retain the same noise-reduction properties up to the design year*”.<sup>28</sup>

This means that in order to achieve the same noise reducing qualities as at initial installation, up to the design year 2031 for the Project:

- Any barriers proposed should not develop gaps or other openings;
- Bunds should not reduce in height through settlement; and
- Porous road surface materials should be maintained to retain their porosity.

In relation to barriers, this means that any damage, vandalism, or material failure resulting in openings in the barrier or between the barrier and the ground, would need to be repaired or remedied.

Road surface materials would require maintenance in the event of cracks or settlement causing uneven surfaces (which would result in increased noise level generation). Porous road surfaces, including OGPA, rely to some extent on their porosity to absorb sound. Therefore, porosity needs to be retained at a high level in order to achieve the noise reduction performance assumed in the noise level predictions. Porosity of road surfaces can be retained for extended duration through

<sup>28</sup> NZS6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.5.



high pressure water cleaning and regular resurfacing, should the material deteriorate excessively, i.e. should cracks appear or the surface warp.

We recommend that a condition should be formulated for the Project that ensures that mitigation measures be maintained to retain their noise reducing capabilities as far as is practicable.

## 5. Existing environment

The existing ambient noise environment provides a baseline for assessing noise effects due to noise level changes in terms of the RMA. For the Project, we measured and predicted existing noise levels along the alignment.

Ambient noise measurements show that noise levels extend over a wide range. Beside the existing SH1, noise levels are elevated, generally above 60 dB  $L_{Aeq(24h)}$ . In areas removed from SH1 and other noise sources, e.g. Pūhoi Township and to the west of Warkworth, noise levels are low. However, noise levels in the quiet areas are generally above 43 dB  $L_{Aeq(24h)}$ .

The long-duration unattended noise measurements show that  $L_{Aeq(24h)}$  levels are around 50 dB at the four survey locations.

The existing noise environment of the Project area provides a baseline for assessing noise effects. The existing environment is one factor in determining the potential effects of a change in noise level that may be experienced by people. This change in noise environment can then be interpreted in relation to subjective responses of people and possible annoyance.

For this reason, we have determined the existing noise environment in the vicinity of the Project through noise level surveys and computer noise modelling of the existing situation (i.e. SH1 and surrounding topography).

Refer to Drawing ON-401 showing the long duration survey locations.

Measured noise levels  $L_{Aeq(24h)}$  are shown in Table 5 below. Detailed summaries of the unattended long-duration measurements are included in Appendix B.

**Table 5: Long-duration noise level survey results**

Measurement Position	Project Sector	Noise level measurement result dB $L_{Aeq(24h)}$
87 Perry Road, Warkworth	Perry Road	49
40 Wyllie Road, Warkworth	Perry Road	52
8 Pūhoi Close, Pūhoi	Pūhoi	51
815 State Highway 1, Pūhoi	Hungry Creek	51

The results of the short-duration noise level surveys are shown in Table 6 below. The year in which the survey was undertaken is included in the table.

**Table 6: Short-duration noise level surveys**

Measurement Position	Project Sector	Noise level measurement results dB L <sub>Aeq</sub>
<b>Measurement Year 2010</b>		
Pūhoi township	Pūhoi	45
Pūhoi Close	Pūhoi	40
Mahurangi West Road near SH1	Hungry Creek	63
Moirs Hill Road	Schedewys Hill/Moirs Hill	48
464 Woodcocks Road	Carran Road	45
<b>Measurement Year 2013</b>		
Billing Road	Pūhoi	57
Pūhoi Close	Pūhoi/Hungry Creek	42
815 SH1	Hungry Creek	56
Moirs Hill Road	Schedewys Hill/Moirs Hill	40
Perry Road	Perry Road	56
40 Wyllie Road	Perry Road	49
229 Wyllie Road	Perry Road	51
Viv Davie-Martin Drive	Carran Road	46
SH1, Warkworth	Carran Road	73
Carran Road	Carran Road	60

Ambient noise measurements show that existing noise levels in the Project area extend over a wide range. Beside the existing SH1, noise levels are elevated, generally above 60 dB L<sub>Aeq(24h)</sub>. In areas removed from SH1 and other noise sources, e.g. Pūhoi Township and to the west of Warkworth, noise levels are low. However, noise levels in the quiet areas are generally above 43 dB L<sub>Aeq(24h)</sub>.

The long-duration unattended noise measurements show that L<sub>Aeq(24h)</sub> levels are around 50 dB at the four survey locations.

Further discussion of existing noise levels in specific areas adjacent to the Project is contained in Section 6 below.

## 6. Operational noise effects assessments

We have assessed the operational noise effects from the Project on PPFs within 200 metres of the indicative alignment. The Project area is sparsely populated. More densely populated areas are in the Pūhoi and Hungry Creek Sectors, and in the Perry Road and Carran Road Sectors.

We assessed the PPFs against “new” or “altered” road criteria of NZS 6806, depending on the influence of the existing SH1 on the PPFs. Approximately half of the PPFs were assessed against “new” and the other half against “altered” NZS 6806 criteria.

The do-nothing scenario (where the Project is not built) showed that noise levels would increase by approximately 3 to 4 decibels along SH1 as at the design year. The do-minimum scenario (where the Project is built with no noise mitigation) allowed for a chip seal road surface on the entire alignment. A number of PPFs would fall into Categories B and C, which is not a desirable outcome.

The main mitigation option we considered involved the use of OGPA road surfacing on those sections of the Project where several PPFs will benefit from it, i.e. at the southern and northern ends of the Project. This option achieved effective mitigation for almost all PPFs. Most PPFs will receive noise levels within the most stringent Noise Criteria Category A. We consider that noise levels within Category A are appropriate for residential use and will not result in sleep disturbance or adverse effects on noise sensitive activities such as watching TV.

We also considered other mitigation options, namely the use of road-side or boundary barriers. However, due to the difficult terrain, the distance of PPFs from the road and the low population density, we considered that barriers would not present the BPO for mitigation for this Project. Barriers would need to be very high (5 metres and more) and relatively long to achieve any noticeable noise level reduction at a small number of PPFs. These barriers would create visual and urban design problems for only marginal acoustic benefit.

Therefore, our selected mitigation option is the use of OGPA at either end of the alignment, where higher population density will benefit from its noise reduction.

For each area, we considered the potential for noise level changes, should the alignment be moved within the designation boundary during detailed design, e.g. for reasons of safety or geotechnical considerations. We cannot make statements regarding potential mitigation for such changed alignments, apart from commenting on potential options for mitigation, should the need arise. In general, mitigation in addition to the low noise road surface would need to involve barriers, which in many instances would not be practicable due to the height and length of barrier required. Therefore, it is unlikely that mitigation other than that which we have recommended would be practicable.

Notwithstanding that the selected mitigation will bring most PPFs into the most stringent Category A, for some currently quiet areas the introduction of the Project will result in a significant increase in noise level. While the predicted noise level increase is over 10 decibels for a small number of PPFs (equivalent to a perceived doubling in noise level), e.g. along Wyllie Road, we consider that the resultant noise levels at these PPFs will be appropriate for residential use.

We assessed the overall noise effects of the Project by comparing existing and do-nothing noise levels with the predicted noise levels of the Project when implemented (including mitigation). The results of this comparison showed that with the Project in operation, a smaller number of people will receive traffic noise levels that have been shown to cause annoyance, than for the existing circumstance. This result is due to the fact that the traffic will be moved away from densely

populated areas of Warkworth township to sparsely populated areas. The modest decrease in noise level from traffic reduction on SH1 will benefit many residents. A significant increase in noise level with the Project implementation will affect a comparatively small number of residents, while resulting noise levels will generally fall within the range where approximately 10% of residents will be highly annoyed.

## 6.1 Project alignment and sectors

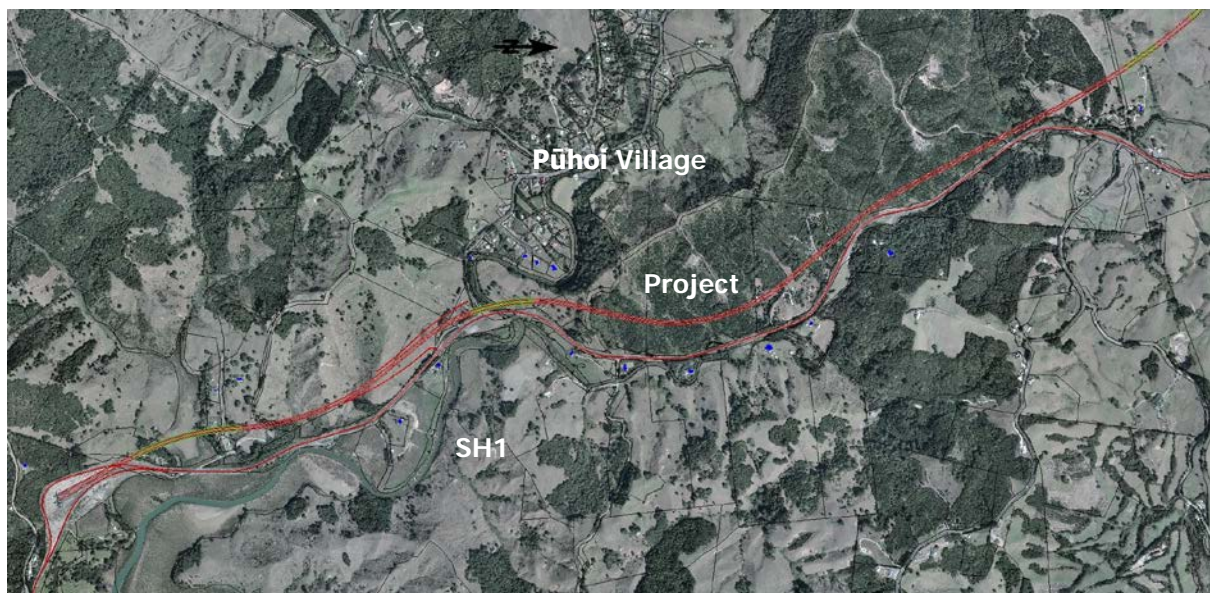
The Project alignment traverses generally rural and forestry land, with small pockets of residential and rural/residential uses. The areas with most dwellings are in the vicinity of Pūhoi and SH1 (Pūhoi and Hungry Creek Sectors), Wyllie Road (Perry Road Sector) and SH1 (Carran Road Sector). In the following sections we discuss these areas, and the PPFs along the remaining alignment.

In total, there are 30 PPFs, of which 16 are assessed against the altered road criteria of NZS 6806. The other 14 are assessed against the new road criteria (refer Section 2.1.3).

## 6.2 Pūhoi area (Pūhoi and Hungry Creek Sectors)

We have assessed the southern end of the alignment around Pūhoi against new and altered road criteria. There are 14 PPFs in this assessment area. However, we have also included 26 Billing Road (which is just outside the 200 metre assessment area) in the assessment because of its close proximity to 24 Billing Road. Therefore, we have assessed 16 locations in this area.

Figure 4 shows the location of Pūhoi village in relation to the Project and the existing SH1.<sup>29</sup>



**Figure 4: Overview – Pūhoi Area**

<sup>29</sup> For figures showing the area at a larger scale, refer to Drawings ON-102 to ON-104.

### 6.2.1 Existing noise environment

Pūhoi Village is more densely populated than the remainder of the alignment, with a new residential area around Pūhoi Close facing SH1. Only three dwellings are within 200 metres of the assessed alignment. However, there are a number of dwellings within 200 metres of the designation boundary. These are listed in Appendix C.

Other PPFs at the southern end of the road are in Billing Road, Fowler Access Road and adjacent to the existing SH1.

Pūhoi Village receives some traffic noise from SH1, as do PPFs in Billing Road and Fowler Access Road. For these PPFs we predict existing noise levels ranging from 52 to 64 dB  $L_{Aeq(24h)}$ . Dwellings adjacent to the existing SH1 are also currently affected by traffic noise with existing ambient noise levels ranging from 65 to 69 dB  $L_{Aeq(24h)}$ .

Many of the PPFs already receive noise levels at or above the Category A criteria. Only seven of the 16 PPFs we assessed currently receive noise levels within Category A, and one currently receives noise levels above Category B (i.e. 642 SH1).

### 6.2.2 NZS 6806 Assessment

#### (a) Do-nothing scenario

As some of the PPFs are assessed against the NZS 6806 altered road criteria, we entered a do-nothing computer noise model for the year 2031. The basis for this model is that the Project is not implemented but that traffic on SH1 continues to increase over time up to the Design year.

Generally, traffic noise would increase by approximately 3 decibels from traffic increase on the existing SH1.

#### (b) Do-minimum scenario

With the Project implemented without specific noise mitigation, we predicted noise levels ranging from 52 dB to 66 dB  $L_{Aeq(24h)}$  with traffic on the Project only. These noise levels would mean that all PPFs would be within Categories A and B.

#### (c) Selected mitigation option

Due to the terrain around the Project, with many hills and valleys, and the distance of PPFs to the Project, the most effective mitigation measure is, in our opinion, the use of low noise road surface OGPA. It protects the widest possible area and will provide blanket protection of all PPFs and other dwellings outside the assessment area.

We allowed for OGPA to be used from the tunnel portals in the south to chainage 62360, approximately 130m north of Pūhoi Close. A noticeable noise level reduction can be achieved by using a low noise road surface in this area. Only one PPF (682 SH1) will remain in Category B. All other PPFs will be within the NZS 6806 most stringent Category A. As the dwelling at 682 SH1 is elevated above SH1 and the Project, there is no practicable mitigation option that will achieve effective noise level reduction at this dwelling.

We consider that the acoustic outcome for the Pūhoi area with the use of OGPA is acceptable and will result in a good level of mitigation of traffic noise for the Project, when assessed against the requirements of NZS 6806.



#### (d) Other mitigation options

During the scheme assessment, additional mitigation options were assessed, including barriers. In our opinion, barriers would not be practicable in the Pūhoi area due to the terrain and the location of the dwellings in relation to the Project. Since the noise levels at all PPFs in this area (with OGPA) are within Category A, with only one PPF predicted to receive noise levels within Category B, the use of building modification mitigation is not appropriate in our opinion.

Therefore, we did not assess any further mitigation options.

#### 6.2.3 Assessment of noise effects

This Project is somewhat unusual because the existing SH1 has a considerable influence on the noise environment in this Sector. Therefore, in order to accurately assess the noise effects on PPFs in the vicinity, we calculated additional scenarios describing the noise levels as they would be received from the Project and SH1 together. While an assessment in accordance with NZS 6806 has been undertaken, which requires only the inclusion of Project traffic (refer Section 6.2.2 above), the results would be somewhat theoretical. In reality, some traffic will continue to use SH1 and affect (and in some instances dominate) traffic noise levels at receivers in the vicinity.

Therefore, we also calculated all scenarios with traffic on both the Project and SH1. This approach allowed us to determine for which dwellings the existing SH1 is the controlling noise source, where the Project is the dominant noise source, and to assess the effects of the noise levels which actually would be received at the dwellings.

For the do-minimum scenario (with SH1 and Project traffic) we predicted noise levels ranging from 58 to 68 dB  $L_{Aeq(24h)}$ .

With the proposed mitigation in place, we predicted noise levels ranging from 54 to 68 dB  $L_{Aeq(24h)}$ . All but four dwellings would receive noise level reductions when compared with the existing or do-nothing scenarios. The predicted noise level increases of up to 4 decibels generally occur for those PPFs assessed against the “new” road criteria. Those dwellings assessed against the “new” road criteria are currently little affected by traffic noise. The introduction of the Project will result in a noise level increase, as would be expected when a new road is introduced into an area that does not currently contain a road.

Overall, there will be betterment for several PPFs. Generally, noise levels reduce or remain similar to existing noise levels. A small number of dwellings will receive modest noise level increases, some of which can be attributed in equal parts to the Project and the existing SH1.

With the recommended use of OGPA, the traffic noise effects from the Project will range from moderately positive to moderately adverse.

The following table shows the predicted change in noise level for the 16 dwellings assessed in this area. These changes can be related to the descriptions in Table 2 in the preceding Section 2.2.

**Table 7: Pūhoi Area – Change in noise level**

Change in noise level	Number of PPFs	Effect
3 – 4 decibels reduction	8	Slight
1 – 2 decibels reduction	0	Negligible
Less than 1 decibel change	4	None
1 – 2 decibels increase	3	Negligible
3 – 4 decibels increase	1	Slight
5 – 8 decibels increase	0	Moderate
9 – 11 decibels increase	0	Significant
> 11 decibels increase	0	Serious

The above table shows that the majority of dwellings will receive a just noticeable noise level reduction. Only one dwelling (26 Billing Road) will receive a slight noise level increase of 3 decibels. The predicted noise level at this dwelling is 56 dB  $L_{Aeq(24h)}$ . We consider this noise level to be appropriate for residential use and would not cause sleep disturbance or adverse effects on noise sensitive activities such as watching TV.

We have examined if there may be practicable mitigation options that would reduce the noise effect on this dwelling further. Due to its location adjacent to, and below, the Okahu Viaduct, we have not found additional effective noise mitigation measures. The edge barriers on the viaduct already achieve a good degree of noise level reduction, and increasing the height of the edge safety barriers from the standard 0.8 m would have a marginal effect of up to 1 decibel only. Once the road arrives at the northern end of the viaduct, the carriageway will be well shielded from the Billing Road dwelling through the cut in the hill. Therefore, barriers would not achieve any additional shielding.

With the predicted external noise level at 26 Billing Road, we do not consider that building modification mitigation would be warranted as these noise levels are within appropriate levels.

We consider that the resultant noise levels are suitable for residential use, despite the increase in noise level predicted, and that additional mitigation will be unnecessary, impracticable and will not achieve sufficient further reduction of noise levels at the Billing Road dwelling.

#### 6.2.4 Alignment adjustment within the Designation

The Project alignment may need to be adjusted slightly during the detailed design phase to take account of topographical, geological or other considerations. The close proximity to SH1 and the narrow designation area in the Pūhoi Sector somewhat restrict the potential for moving the alignment. Such a shift may affect which dwellings are within 200 metres of the alignment and the requirement for assessment.

We have determined all dwellings that will be within 200 metres of the designation (refer Appendix C). It is highly unlikely that the road edge could practicably be moved immediately to the edge of the designation, considering that associated earthworks will need to be accommodated within the designation. Nevertheless, including all dwellings within the 200 metre buffer around the designation ensures that all potential PPFs are recorded.

For instance, if the alignment was moved closer to Pūhoi Village, noise levels may be higher than those predicted in our computer noise model. In that circumstance, the use of low noise road surface material may not be sufficient to achieve noise levels within Category A for all receivers, and noise level increases may be higher.

The only areas where a move in alignment could have a noticeable influence on traffic noise levels would be in the vicinity of Billing Road and Pūhoi Village. For either area the use of barriers or earth bunds could be investigated in conjunction with low noise road surface. However, we consider that it is unlikely that additional mitigation such as barriers would be practicable or achieve effective noise level reductions in this area.

#### 6.2.5 Summary of assessment

A table of detailed noise levels for each PPF in the Pūhoi Area is contained in Appendix A and figures ON-102 to ON-104 show the noise criteria categories for each PPF. In summary, noise levels in the Pūhoi area will remain largely similar, with eight PPFs experiencing noticeable noise level reductions and one PPF experiencing noticeable noise level increases. The existing SH1 has a considerable influence on existing and future noise levels in this Sector.

The following Table 8 contains a summary of all PPFs in the Pūhoi Area. For each PPF the assessment criterion (i.e. "new" or "altered" road) and the dominant traffic noise source are reported. Generally, for PPFs where the existing SH1 is the dominant noise source, these PPFs have been assessed against the "altered" road criteria due to the close proximity to an existing major road. The NZS 6806 Noise Criteria Category for each PPF is shown, for the Project including mitigation.

In addition, we compared the design year circumstance including SH1, without and with the Project, and show the predicted noise level change at each PPF.

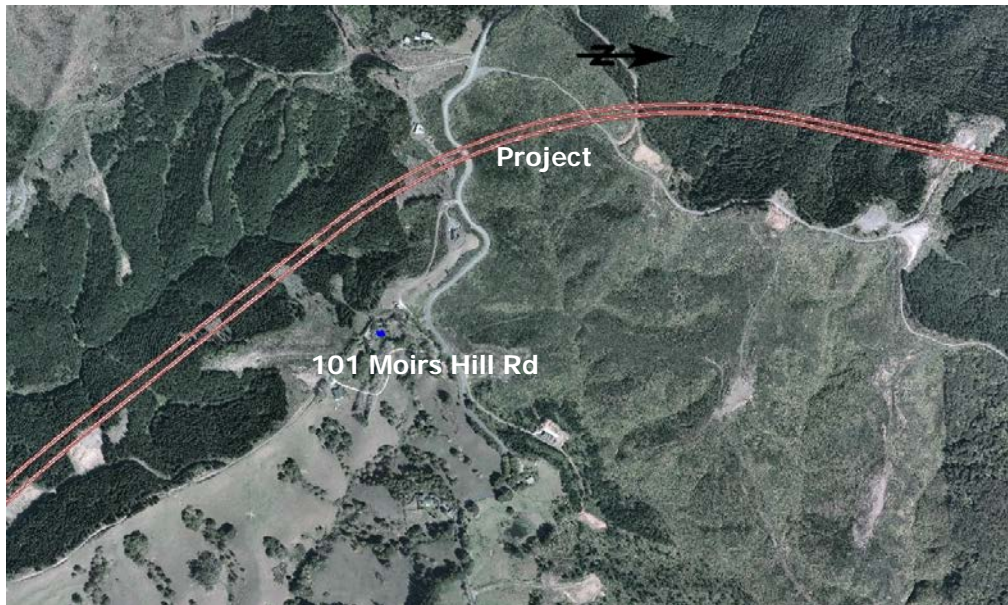
**Table 8: PPFs Pūhoi Area**

Street address	Assessment basis (type of road)	Dominant traffic noise source	NZS 6806 Category with mitigation	Do-nothing versus Project implemented with mitigation: Noise level change (decibels)
			Project only (no SH1 or local roads)	Project and SH1 combined
Billing Rd 24	New	Project	A	2
Billing Rd 26	New	Project	A	3
Fowler Access Rd 72	New	Project	A	2
Hungry Creek Rd 5 (B&B)	Altered	SH1	A	-3
Hungry Creek Rd 6	Altered	SH1	A	-3
Pūhoi CI 12	New	Project	A	0
Pūhoi CI 16	New	Project	A	0
Pūhoi CI 20	New	Project	A	0
Pūhoi Rd 28	New	Pūhoi Road	A	0
SH1 430	Altered	SH1	A	-3
SH1 466	Altered	SH1	A	-3
SH1 600	Altered	SH1	A	-4
SH1 616 (not yet built)	Altered	SH1	A	-4
SH1 642	Altered	SH1	A	-4
SH1 654	Altered	SH1	A	-4
SH1 682	Altered	SH1/Project	B	1

### 6.3 Moirs Hill Road (Schedewys Hill Sector)

One PPF is located to the south of Moirs Hill Road, in the Schedewys Hill Sector. There are only a few dwellings in this area, and only this one dwelling falls within the 200 metre assessment area.

Figure 5 and Drawing ON-105 show the location of the dwelling at 101 Moirs Hill Road in relation to the Project.



**Figure 5: Overview – Moirs Hill Road**

#### 6.3.1 Existing noise environment

The existing noise environment at the dwelling at 101 Moirs Hill Road is predicted to be 47 dB  $L_{Aeq(24h)}$ . This is a low noise level due to the absence of any major roads and other noise sources in the area.

#### 6.3.2 NZS 6806 Assessment

With the introduction of the Project, but without noise mitigation measures (the do-minimum scenario), we predict the noise level at 101 Moirs Hill Road to be 56 dB  $L_{Aeq(24h)}$  from Project traffic only. This noise level is 9 decibels higher than the existing noise level.

The dwelling overlooks the alignment, which is some 8 metres below the house. While this difference in height proves effective shielding for the area beyond the cut, the dwelling is immediately at the upper end and is therefore less protected.

We predict this dwelling will be within Category A and will receive a noise level which we consider to be appropriate for residential use at all times. Therefore we do not recommend further mitigation measures.

### 6.3.3 Assessment of noise effects

As discussed above, our predictions show that the Project by itself will cause a significant increase in noise level at the dwelling at 101 Moirs Hill Road (refer Table 2). To assess the effect of the change in noise level from the existing situation to the design year, we have also predicted noise levels from traffic on the Project alignment and SH1 combined. The combined noise level increase from traffic on the Project and SH1 would be similar to that of the Project only, indicating that the Project noise level would be the principal noise source.

We have reviewed options for providing a barrier for the dwelling at 101 Moirs Hill Road in order to reduce the noise level increase. However, due to the terrain (the large cut and the location of the dwelling on the upper edge of the cut) we have not been able to determine a practicable solution. A 250 metre long and 5 metre high barrier would achieve a noise level reduction of 4 decibels. While this is a noticeable noise level reduction, other adverse effects caused by the barrier (e.g. visual) would likely outweigh its limited acoustic benefits (refer Section 5.4.3 of the Landscape and Visual Assessment Report).

We consider that the resultant noise level will be well within an acceptable noise level range and will not adversely affect noise sensitive activities being carried out, in and around the dwelling.

Nevertheless, the character of the noise environment will change with the introduction of the Project into the Moirs Hill Road area, which is currently largely unaffected by road traffic noise.

### 6.3.4 Alignment adjustment within the Designation

The Project alignment may need to be adjusted slightly during the detailed design phase to take account of topographical, geological or other considerations. It may also affect which dwellings are within 200 metres of the alignment and the requirement for further acoustic assessment.

Considering the size of the cuts required to construct the road below Moirs Hill Road, we do not anticipate any significant shift in alignment in this area. Even if the road was to move slightly closer to the dwelling at 101 Moirs Hill Road, noise levels would remain similar at the dwelling. This is because of the significant cut that cannot be moved any closer to the dwelling.

Therefore, we consider that no additional mitigation would be required to achieve what we have assessed to be appropriate noise levels at the PPF.

Nevertheless, we have determined all dwellings that will be within 200 metres of the designation boundary. This captures the widest possible extent of assessment and includes all dwellings that may become PPFs in the event of an alignment shift within designation (refer Appendix C).

## 6.4 Perry Road to Warkworth (Perry Road and Carran Road Sectors)

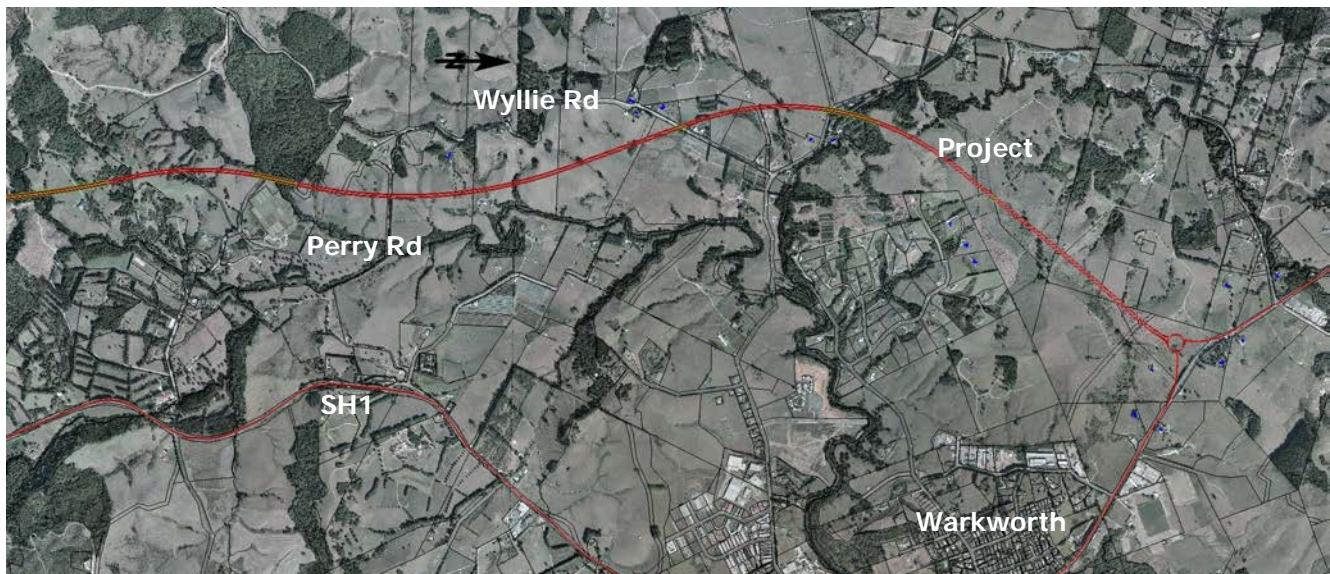
The northern section of the Project is more densely populated than the Schedewys Hill and Moirs Hill Sectors, similar to the southern Pūhoi and Hungry Creek Sectors. While rural lifestyle dwellings extend over an area of about 5.5 km within the Project Area, they are grouped in several clusters: Wyllie Road, Woodcocks and Carran Roads and SH1.

In response to potential effects on dwellings in Viv Davie-Martin Drive, the indicative alignment was moved west, so that all dwellings in Viv Davie-Martin Drive are more than 200 metres from that alignment. These dwellings are therefore not assessed in this report.



We have assessed the northern end of the Project alignment around Warkworth against new and altered road criteria. There are 13 PPFs included in this assessment area. For figures showing the area at a larger scale, refer to Drawings ON-106 to ON-108.

Figure 6 shows the location of the PPFs in relation to the Project and also SH1. For figures showing the area at a larger scale, refer to Drawings ON-106 to ON-108.



**Figure 6: Overview – Perry Road to Warkworth Area**

#### 6.4.1 Existing noise environment

A number of dwellings are inside the 200 metre assessment area. The area around the existing SH1 is already affected by traffic noise, as are PPFs in Woodcocks, Kaipara Flats and Carran Roads. For the remaining PPFs in Wyllie Road existing noise levels are low due to the absence of noise sources.

Existing noise levels range from 48 dB at Carran Road to 67 dB  $L_{Aeq(24h)}$  close to SH1.

#### 6.4.2 NZS 6806 Assessment

##### (a) Do-nothing scenario

Generally, for PPFs in this area (assessed against the “altered road” criteria) traffic noise would increase by approximately 3 decibels due to increased traffic on the existing SH1. This increase would be just noticeable (refer Table 2).

##### (b) Do-minimum scenario

We predicted noise levels ranging from 56 dB to 70 dB  $L_{Aeq(24h)}$  with traffic from the Project only (i.e. excluding SH1). These noise levels would mean that three PPFs located at Wyllie Road and SH1<sup>30</sup> would be in the “backstop” Category C, which is not a desirable outcome.

<sup>30</sup> 42 SH1, 75 and 75A Wyllie Road.

Four dwellings in Wyllie, Carran and Woodcocks Roads are predicted to receive noise levels up to 63 dB  $L_{Aeq(24h)}$  and one dwelling on SH1 would receive noise levels up to 67 dB  $L_{Aeq(24h)}$  (Category B for new and altered roads respectively).

### (c) Selected mitigation option

As PPFs are at considerable distances from each other (between 60 and 200 metres) and due to the varying terrain around the Project, the most effective mitigation measure is, in our opinion, the use of low noise road surface OGPA.

In order to mitigate the predicted noise levels, we allowed for OGPA to be used from approximately chainage 50840 to the northern termination of the Project at the roundabout at SH1. A noticeable noise level reduction can be achieved by using a low-noise road surface in this area. With the use of OGPA as discussed above, only one of the PPFs will be within Category C, and only three PPFs will be in Category B (refer Table 10 in Section 6.4.5 for more detailed information).

Overall, we consider that the acoustic outcome for the northern Project area with the use of OGPA is appropriate. For existing low noise areas (e.g. at and Wyllie Road) the recommended mitigation will result in a good level of traffic noise reduction for the Project. For high noise areas (at SH1) the implementation of the Project with the recommended mitigation will result in similar noise levels as currently experienced, and therefore the effects will be minor.

### (d) Other mitigation options

One PPF (42 SH1 in close proximity to the roundabout) is predicted to receive a noise level of 70 dB  $L_{Aeq(24h)}$  from the Project, which is within Category C, with the implementation of OGPA mitigation. This PPF has an existing noise level of 68 dB  $L_{Aeq(24h)}$  and will therefore not experience a noticeable change in overall noise level. For this reason, we consider that the Project has no significant effect on the noise environment of this dwelling. The dwelling is close to SH1 (approximately 30 m) and has driveway access from SH1. Traffic noise mitigation for this dwelling will be difficult due to its location.

In accordance with NZS 6806, we have reviewed potential mitigation options for this dwelling as it is located in a high noise environment. In order to provide effective shielding for this dwelling, a 2 metre high boundary fence would need to be installed along the boundary facing SH1, including a well fitting gate, and returns along the eastern and western boundary for approximately 20 metres each. This may achieve a noise level reduction of 3 to 5 decibels at most. We do not consider this to be a practicable mitigation option for two reasons. The requirement of a gate means that cars need to be able to wait "off-line" from SH1 before being able to turn into the property. From experience, it has also been shown to be difficult to provide for a gate without gaps, as would be required to achieve the most effective noise level reduction. Accordingly, we do not recommend implementing additional mitigation for the dwelling at 42 SH1.

During the scheme assessment, additional mitigation options for this Sector were investigated, namely barriers and bunds in addition to the use of OGPA. We have revisited those options during this assessment.

Barriers of varying heights from 3.5 metres to 5 metres and earth bunds with heights between 5 and 8 metres were assessed. All of these barriers would achieve some amount of noise level reduction, generally achieving noise levels within Category A for most of the PPFs in Wyllie Road. However, predicted noise level reductions were generally less than 5 decibels. For individual PPFs, in order to be practicable, a noise level reduction of at least 5 dB should be achieved as is stipulated in NZS 6806.

In our opinion, barriers in general would not be practicable in this area due to the terrain and consequently the location of the dwellings in relation to the Project. The distance between dwellings and Project are large, and barriers can generally not be effectively located along the road (due to dwellings overlooking the road) or along the property boundaries (due to dwellings being a considerable distance from the boundary). Due to these factors, the reduction in noise level achieved would be comparatively small, while adverse visual effects would be introduced.

#### 6.4.3 Assessment of noise effects

Similar to the Pūhoi area, the northern end of the Project connects with the existing SH1. Therefore, traffic on SH1 contributes noticeably to the overall noise level that is received by some dwellings. We calculated additional scenarios for the combined noise levels from the Project and SH1 together.

These calculations allowed us to determine those dwellings for which the existing SH1 is the controlling noise source, and those dwellings for which the Project will be the main noise source. The change in noise level for these scenarios has been used to assess the effects of the noise levels actually received by the dwellings.

For the do-minimum scenario (with SH1 and Project traffic) we predicted noise levels ranging from 59 to 70 dB  $L_{Aeq(24h)}$ . With the proposed OGPA surface mitigation on the Project, we predicted noise levels ranging from 53 to 70 dB  $L_{Aeq(24h)}$ . The limited reduction in noise level is due to some PPFs receiving noise levels dominated by the existing SH1. Since SH1 does not form part of the Project, the effects from this road are not being mitigated. (Nevertheless, indirect mitigation is achieved through a displacement of traffic from the existing SH1 onto the Project.)

The traffic noise effects from the Project with mitigation will range from slightly positive to significantly adverse at individual dwellings (refer Table 9 for predicted noise level changes).

A considerable number of dwellings in this area are currently little affected by traffic or other noise sources. Therefore, the introduction of the Project into this area will result in a significant increase in noise level (with noise level increases up to 10 decibels<sup>31</sup>). This increase is expected as the Project comprises a major road which will result in noise effects in any low noise area. It is generally not possible to fully mitigate the effects in such circumstance.

Therefore, the most practicable mitigation must be implemented, and in our opinion, this consists of the use of OGPA. The resulting noise levels are acceptable for residential use and will not interfere with normal residential activities or cause sleep disturbance.

Those dwellings currently adjacent to the existing SH1 are predicted to receive increases in road traffic noise, generally irrespective of the mitigation applied to the Project. This is because the existing SH1 is the main traffic noise source for these dwellings and will still carry a significant amount of traffic. For some dwellings, the existing SH1 is closer to the dwellings than the Project alignment (e.g. for the dwelling at 6 Kaipara Flats Road). For all dwellings in the vicinity of the existing SH1, noise level changes will be negligible, ranging from 1 to 3 decibels, compared with the do-nothing scenario.

The following table shows the predicted change in noise level for the 13 dwellings assessed in this area.

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<sup>31</sup> Refer Table 2 in Section 2.2.

**Table 9: Perry Road to Warkworth Area – Change in noise level**

Change in noise level	Number of PPFs	Effect
3 – 4 decibels reduction	0	Slight
1 – 2 decibels reduction	0	Negligible
Less than 1 decibel change	0	None
1 – 2 decibels increase	6	Negligible
3 – 4 decibels increase	3	Slight
5 – 8 decibels increase	2	Moderate
9 – 11 decibels increase	2	Significant
> 11 decibels increase	0	Serious

#### 6.4.4 Alignment adjustment within the Designation

If the Project alignment was to be adjusted slightly during the detailed design phase to take account of topographical, geological or other considerations, this may affect the noise generation. It may also affect which dwellings are within 200 metres of the alignment and the requirement for further acoustic assessment.

Any significant (more than 30 metre) shift in alignment in areas such as those adjacent to Wyllie Road, Perry Road and Viv Davie-Martin Drive is likely to have a noticeable effect on the noise levels received at dwellings in these areas. The Project will be the main traffic noise source in these areas, which are currently unaffected by other traffic noise. Therefore, any change to the distance from, or shielding of, the road will have a noticeable effect.

If the alignment was to be moved to either side at the approach to SH1, the effects would be less noticeable. This is because the existing SH1 already has a significant influence on the noise levels in the vicinity. The Project, while contributing to the overall noise environment, will generally not be the main traffic noise source and therefore of lesser importance where it is close to SH1.

Should a significant alignment change be required at a later stage, we recommend that mitigation measures be confirmed prior to construction during the Outline Plan of Works (OPW) stage. This will ensure that all PPFs are appropriately assessed and mitigation provided where this would be required to achieve a reasonable noise environment.

The table in Appendix C contains all dwellings within 200 metres of the designation. These dwellings may become PPFs should the alignment be adjusted.

#### 6.4.5 Summary of assessment

A table of detailed noise levels for each PPF in the Perry Road and Carran Road Sectors is contained in Appendix A and Drawings ON-106 to ON-108 show the noise criteria categories for each PPF. A summary of our assessment for this area is shown in Table 10 below.

**Table 10: PPFs Perry Road to Warkworth Area**

Street address	Assessment basis (type of road)	Dominant traffic noise source	NZS 6806 Category with mitigation	Do-nothing versus Project implemented with mitigation: Noise level change (decibels)
			Project only (no SH1 or local roads)	Project and SH1 combined
Carran Rd 141	New	Project	A	5
Kaipara Flats Rd 6	Altered	SH1	A	1
SH1 027	Altered	Project/SH1	A	3
SH1 042	Altered	SH1	C	3
SH1 063	Altered	SH1	A	4
SH1 102	Altered	Project/SH1	A	2
SH1 104	Altered	Project/SH1	B	1
SH1 105	Altered	Project/SH1	A	2
Woodcocks Rd 371	New	Woodcocks Road	A	1
Woodcocks Rd 372	New	Woodcocks Road	A	1
Wyllie Rd 074	New	Project	A	7
Wyllie Rd 075	New	Project	B	9
Wyllie Rd 075A	New	Project	B	10

## 6.5 Effects around the existing SH1

The Project is predicted to take approximately 60% of the traffic from SH1.<sup>32</sup> This will result in noise levels along SH1 being reduced by up to 4 decibels, which is a noticeable reduction.

The number of dwellings along SH1 is significant because SH1 travels through Warkworth Township which is densely populated. There is a considerably greater number of dwellings adjacent to SH1 than the number of dwellings within the 200 metre assessment area adjacent to the Project.

In order to portray this change in noise level, we have produced noise contour maps showing the noise level contours for an area extending from 200 metres west of the Project to 200 metres east of SH1. The noise contour maps have been calculated for the existing and do-nothing scenarios,

<sup>32</sup> Refer Transportation and Traffic Assessment Report, Section 4 Assessment of operational effects, by Andrew Bell.



and for the Project, including OGPA road surface mitigation at the southern and northern sections. When comparing these noise level contour maps (Drawings ON-301 to ON-305, ON-307 to ON-311 and ON-331 to ON-335), the change in noise level for the different areas affected by the Project becomes evident.

This effect of spreading the traffic noise from one area to another is also evident in the results of our assessment of annoyance (discussed in Section 6.6 below).

## 6.6 Annoyance effects

As described in Section 2.3 above, we have determined the number of people potentially “highly annoyed” by the noise effects of the Project, by comparing the results of the do-nothing scenario, with the results of the Project scenario including mitigation. The number of affected dwellings was obtained by counting the dwellings within an area extending 200 metres east of the Project alignment to 200 metres west of the existing SH1.

In Warkworth township, due to the large number of dwellings, we have estimated the number of residential properties within the annoyance assessment area based on property boundaries.

Based on information found on the Statistics New Zealand website, there are on average 2.5 persons per dwelling in Warkworth.<sup>33</sup> We have used this number to determine the number of people potentially highly annoyed, based on the graph in Figure 2.

Our results are summarised in Table 11 below.

**Table 11: Number of people highly annoyed**

	<b>55-60 dB</b> <b>L<sub>Aeq</sub>(24h)</b>	<b>61-65 dB</b> <b>L<sub>Aeq</sub>(24h)</b>	<b>&gt;65 dB</b> <b>L<sub>Aeq</sub>(24h)</b>	<b>Number of people</b> <b>highly annoyed</b>
Existing circumstance 2013	248 dwellings 620 people	128 dwellings 320 people	51 dwellings 128 people	149
Do-nothing circumstance 2031	356 dwellings 890 people	143 dwellings 358 people	105 dwellings 263 people	218
Project including mitigation 2031	251 dwellings 627 people	135 dwellings 338 people	79 dwellings 198 people	171

Table 11 shows that the number of people highly annoyed by road traffic noise will increase by 15% compared with the existing situation, and reduce by 27% compared with a future do-nothing circumstance that would retain the status quo.

The numbers of dwellings and persons in Table 11 do not take account of the projected increase in population from now to the design year (2031). Statistics NZ estimates an increase in population from 2010 to 2031 of more than 40 % for Warkworth township. If this population increase was taken into consideration, the do-nothing circumstance would show even higher numbers due to the high population density in Warkworth.

<sup>33</sup> <http://apps.nowhere.com.au/StatsNZ/Maps/default.aspx>, Interactive Boundary Maps, based on 2006 Census.



The reduction in people highly annoyed by the Project (compared to the do-nothing scenario) is due to the diversion of considerable traffic volume away from densely populated areas in Warkworth into sparsely populated areas. A larger number of people will receive a benefit from the Project through a reduction in noise levels, while a smaller number of people will receive a noise level increase due to the new road being introduced into a currently quiet area.

## 7. Recommendations and conclusions

We have assessed the operational noise effects from the Project on sensitive receivers within 200 metres of the alignment. Our assessment is based on the relevant Standard (NZS 6806), the potential subjective response of people to the change in noise level and the number of people likely to be highly annoyed by the traffic noise levels received.

We recommend applying OGPA road surfacing to the Project from the southern end to approximately chainage 62360 (north of Pūhoi) and again from chainage 50840 the roundabout connecting the Project with SH1 at Warkworth. The use of OGPA will result in most PPFs receiving noise levels in the most stringent Category A of NZS 6806 and provide effective and noticeable noise level reductions when compared with the Project being implemented without mitigation.

The noise level change for some areas of the alignment will be significant, particularly in areas where there is currently no influence from existing roads (e.g. Wyllie Road and Viv Davie-Martin Drive). In these areas, we predict noise level increases of more than 10 decibels. Nevertheless, the resultant noise levels will not cause sleep disturbance or adversely affect residential activities.

For dwellings along the existing SH1, we predict noise level reductions of up to 4 decibels, which will be noticeable positive effect.

In order to weigh the benefit of many against the disbenefit of few, we have also assessed the number of people “highly annoyed” by road traffic noise based on published results of reactions to road traffic noise. Our assessment predicts that the number of people within the wider Project area (including the alignment and existing SH1) who are highly annoyed by road traffic noise will reduce with the implementation of the Project when compared with the future traffic on the existing SH1.

From our assessment, we conclude that the Project can be operated so as to achieve reasonable noise levels at affected dwellings, while reducing the overall noise level for a large number of dwellings in the Project area.

In order to ensure that appropriate traffic noise outcomes are achieved, we recommend that designation conditions should cover the following issues:

- The application of the BPO methodology in determining the most appropriate traffic noise mitigation once the alignment design is finalised;
- A requirement to install, where appropriate, noise mitigation measures prior to opening of the Project to the public; and
- A requirement to maintain noise mitigation measures within the designation to the degree practicable to retain their noise reducing capabilities.

## 8. References

NZS 6806:2010 *Acoustics – Road-traffic noise – New and altered roads*. Standards New Zealand, 2010

Schultz T J (1978) *Synthesis of social surveys on noise annoyance*” *Journal of the Acoustical Society of America*, 1978, 64, 337-405.

Miedema, H M E and Oudshoorn, G M *Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals*. *Environmental Health Perspectives*, 2001, 109 (4) 409 – 416.

LTNZ Research Report No. 292 *Road traffic noise: determining the influence of New Zealand Road surfaces on noise levels and community annoyance*, 2006, Table 18

Zwicker, E. and Scharf, B. *A model of loudness summation*, 1965

Stevens, S. S. *Perceived level of noise by mark VII and decibels (E)*, *Journal of the Acoustical Society of America*, 1972, 51, 575-601.

Bies, D. A. and Hansen, C. H. *Engineering Noise Control, Theory and Practice*, 2010, Table 2.1.

## Appendix A. Individual receiver noise level predictions

Street address	New or	Existing	NZS 6806		Do-nothing		Do-minimum				Proposed Mitigation Option			
	Altered road	2013 dB L <sub>Aeq</sub> (24h)	Category A B		(altered road only)	Change to existing	Project only	NZS6806	Project + SH1	Change in noise level	Project only	NZS6806	Project + SH1	Change in noise level
					2031 dB L <sub>Aeq</sub> (24h)	decibels	2031 dB L <sub>Aeq</sub> (24h)	Category	2031 dB L <sub>Aeq</sub> (24h)	decibels	2031 dB L <sub>Aeq</sub> (24h)	Category	2031 dB L <sub>Aeq</sub> (24h)	decibels
Billing Rd 24	New	54	57	64			60	B	61	7	53	A	56	2
Billing Rd 26	New	53	57	64			61	B	62	9	55	A	56	3
Fowler Access Rd 72	New	56	57	64			60	B	62	6	54	A	58	2
Hungry Creek Rd 5	Altered	67	64	67	70	3	52	A	67	-3	50	A	67	-3
Hungry Creek Rd 6	Altered	65	64	67	68	3	59	A	65	-3	53	A	65	-3
Pūhoi Cl 12	New	54	57	64			58	B	59	5	52	A	54	0
Pūhoi Cl 16	New	55	57	64			58	B	59	4	52	A	55	0
Pūhoi Cl 20	New	53	57	64			57	A	58	5	51	A	54	0
Pūhoi Rd 28	New	64	57	64			58	B	65	1	51	A	64	0
SH1 430	Altered	65	64	67	65	0	62	A	64	-1	55	A	62	-3
SH1 466	Altered	67	64	67	67	0	65	B	67	0	58	A	64	-3
SH1 600	Altered	66	64	67	69	3	55	A	65	-4	55	A	65	-4
SH1 616	Altered	66	64	67	69	3	56	A	66	-4	56	A	66	-4

Street address	New or	Existing	NZS 6806		Do-nothing		Do-minimum				Proposed Mitigation Option			
	Altered				(altered road only)	Change to existing	Project only	NZS6806	Project + SH1	Change in noise level	Project only	NZS6806	Project + SH1	Change in noise level
	road	2013	Category		2031		2031	Category	2031		2031	Category	2031	
		dB L <sub>Aeq</sub> (24h)	A	B	dB L <sub>Aeq</sub> (24h)	decibels	dB L <sub>Aeq</sub> (24h)		dB L <sub>Aeq</sub> (24h)	decibels	dB L <sub>Aeq</sub> (24h)		dB L <sub>Aeq</sub> (24h)	decibels
SH1 642	Altered	69	64	67	72	3	59	A	68	-4	59	A	68	-4
SH1 654	Altered	67	64	67	70	3	56	A	66	-4	56	A	66	-4
SH1 682	Altered	64	64	67	66	3	66	B	67	1	66	B	67	1
Moirs Hill Rd 101	New	47	57	64			56	A	56	9	56	A	56	9
Carran Rd 141	New	48	57	64			59	B	59	12	53	A	53	5
Kaipara Flats Rd 6	Altered	58	64	67	59	2	56	A	60	1	56	A	60	1
SH1 027	Altered	56	64	67	59	2	61	A	62	3	61	A	62	3
SH1 042	Altered	67	64	67	68	1	70	C	71	3	70	C	71	3
SH1 063	Altered	56	64	67	58	2	63	A	63	5	62	A	62	4
SH1 102	Altered	58	64	67	60	3	63	A	64	3	62	A	62	2
SH1 104	Altered	62	64	67	66	3	67	B	67	2	67	B	67	1
SH1 105	Altered	55	64	67	57	3	59	A	59	2	59	A	59	2
Woodcocks Rd 371	New	63	57	64			63	B	66	3	56	A	64	1
Woodcocks Rd 372	New	61	57	64			63	B	65	4	56	A	62	1
Wyllie Rd 074	New	49	57	64			62	B	62	13	56	A	56	7

Street address	New or	Existing	NZS 6806		Do-nothing	Do-minimum				Proposed Mitigation Option			
	Altered				(altered	Project	NZS6806	Project	Change	Project	NZS6806	Project	Change
	road	2013	Category		road only)	only	Category	+ SH1	in noise level	only	Category	+ SH1	in noise level
		dB	A	B	2031	2031	2031	2031	decibels	2031	2031	2031	decibels
		L <sub>Aeq</sub> (24h)			L <sub>Aeq</sub> (24h)	L <sub>Aeq</sub> (24h)	L <sub>Aeq</sub> (24h)	L <sub>Aeq</sub> (24h)		L <sub>Aeq</sub> (24h)	L <sub>Aeq</sub> (24h)	L <sub>Aeq</sub> (24h)	
Wyllie Rd 075	New	49	57	64		65	C	65	16	58	B	58	9
Wyllie Rd 075A	New	49	57	64		66	C	66	17	60	B	60	10



## Appendix B. Long duration noise level survey summaries

### Logger Measurements

MARSHALL DAY  
Acoustics

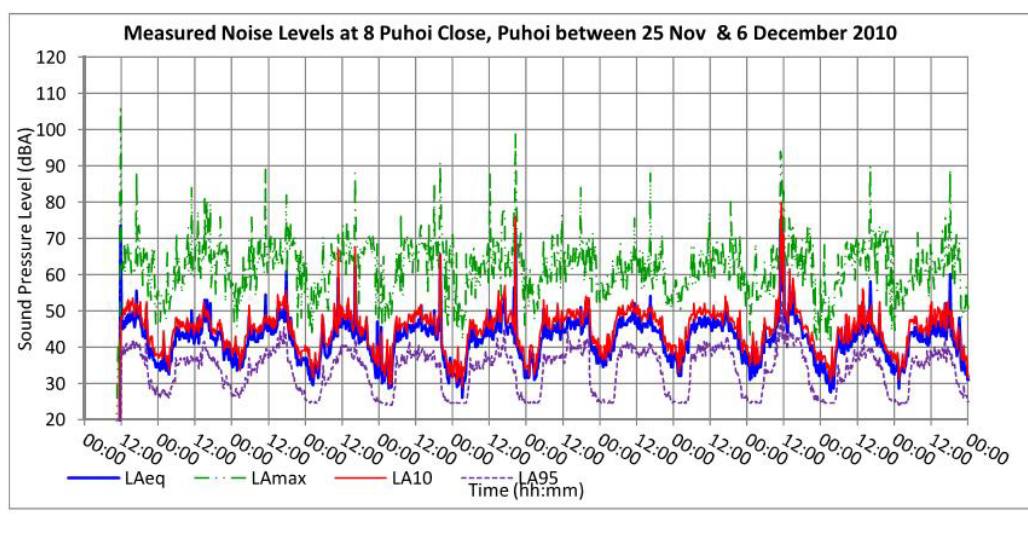
Date: Thursday, 9 May 2013  
 File name: J:\JOBS\2010\2010100A\03 Survey Data & Measurements\Ambient Noise Measurements 101125 to 101207\[8 Puhoi Close - Processed.xls]Logger\_Summary  
 Job number: 2010100A  
 Job name: Puhoi Warkworth Route Evaluation  
 Initials: JJM  
 Measurement Dates: Thursday, 25 November 2010 to Monday, 6th December 2010

Notes: 8 Puhoi Close, Puhoi

### OVERVIEW SUMMARY SHEET

Noise Level, dB		$L_{Aeq}$	$L_{A10}$	$L_{A95}$	$L_{Amax}$
Day (0700-1800)	Lowest	15	16	15	17
	Average	53	47	37	63
	Highest	76	80	53	107
Evening (1800-2200)	Lowest	35	38	25	45
	Average	51	45	34	66
	Highest	72	76	43	100
Night (2200-0700)	Lowest	26	29	24	42
	Average	40	40	27	56
	Highest	54	53	40	77

$L_{Aeq}$  24-hr 51 dB



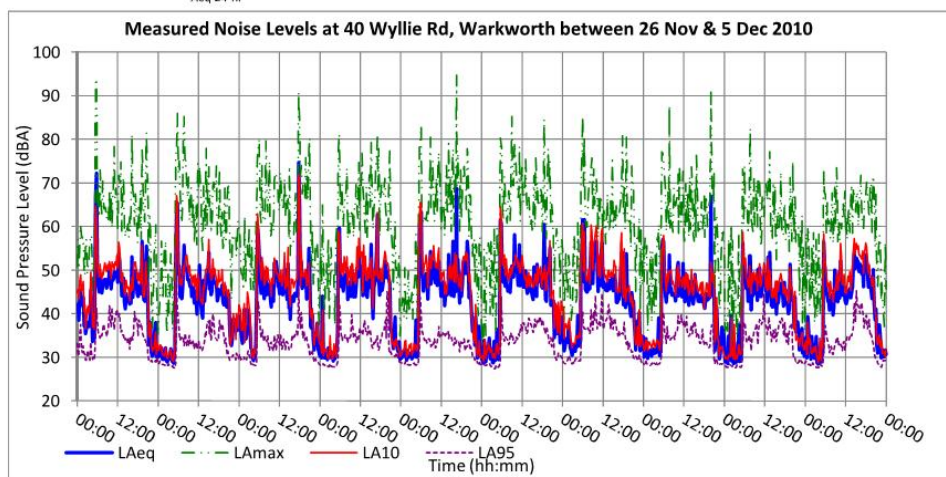
## Logger Measurements

**MARSHALL DAY**  
Acoustics

Date: Thursday, 9 May 2013  
 File name: J:\JOBS\2010\2010100A\03 Survey Data & Measurements\Ambient Noise Measurements 101125 to 101207\40 Wyllie Road - processed.xls\Logger\_Summary  
 Job number: 2010100A  
 Job name: Puhoi Warkworth Route Evaluation  
 Initials: JJM  
 Measurement Dates: Friday, 26 November 2010 to Sunday, 5th December 2010  
 Weather during Measurement:  
 Notes: 40 Wyllie Road, Warkworth

### OVERVIEW SUMMARY SHEET

Noise Level, dB		L <sub>Aeq</sub>	L <sub>A10</sub>	L <sub>A95</sub>	L <sub>Amax</sub>
Day (0700-1800)	Lowest	39	41	31	52
	Average	52	49	36	66
	Highest	75	72	46	95
Evening (1800-2200)	Lowest	31	33	28	43
	Average	50	45	34	64
	Highest	67	70	45	91
Night (2200-0700)	Lowest	28	29	27	33
	Average	49	37	30	53
	Highest	65	67	46	90

L<sub>Aeq</sub> 24-hr 52 dB

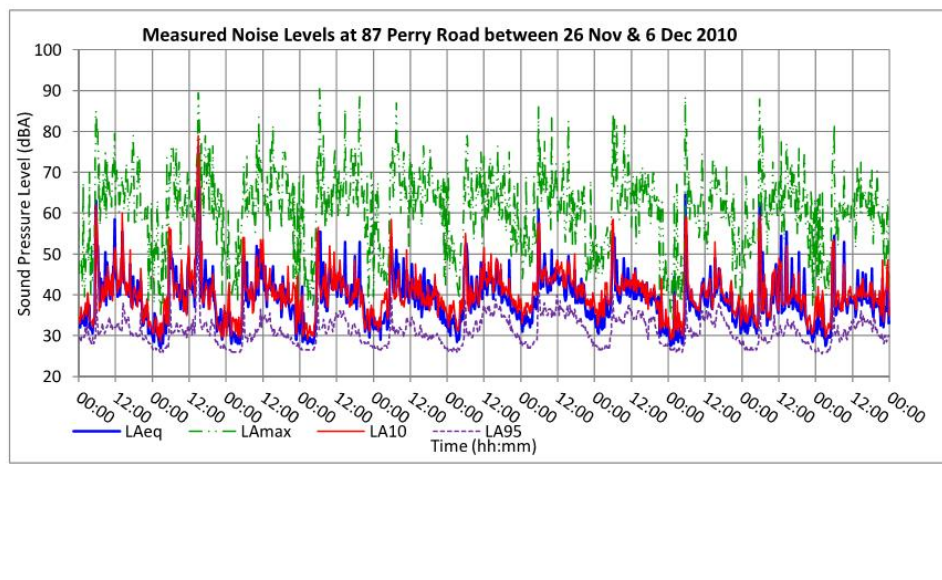
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 Job number: 2010100A  
 Job name: Puhoi Warkworth Route Evaluation Tender  
 Initials: JJM  
 Measurement Dates: Friday, 26 November 2010 to Monday 6th December 2010  
 Weather during Measurement:  
 Notes: 87 Perry Road, Warkworth

### OVERVIEW SUMMARY SHEET

Noise Level, dB		L <sub>Aeq</sub>	L <sub>A10</sub>	L <sub>A95</sub>	L <sub>Amax</sub>
Day (0700-1800)	Lowest	33	34	28	50
	Average	51	42	33	65
	Highest	76	79	60	90
Evening (1800-2200)	Lowest	30	32	28	39
	Average	41	39	31	63
	Highest	53	49	36	89
Night (2200-0700)	Lowest	27	29	26	34
	Average	47	38	29	54
	Highest	68	71	42	91

L<sub>Aeq</sub> 24-hr 49 dB



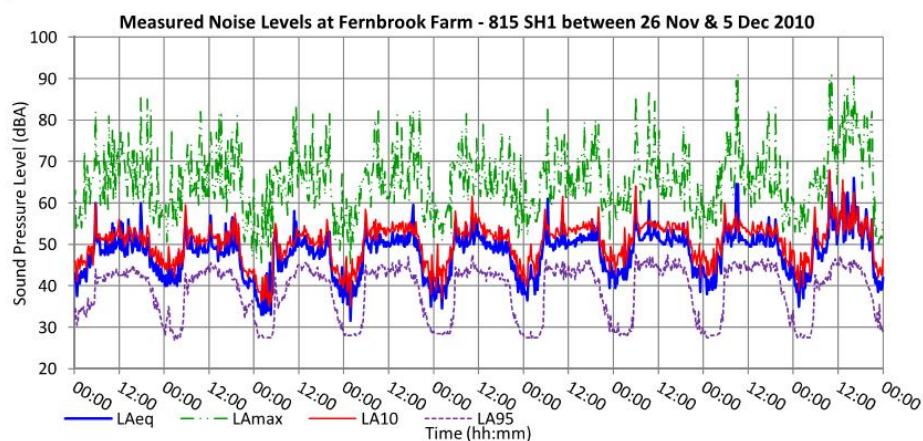
## Logger Measurements

Date: Thursday, 9 May 2013  
 File name: J:\JOBS\2010\2010100A\03 Survey Data & Measurements\Ambient Noise Measurements 101125 to 101207\[815 State Highway 1 - Fernbrook Farm - processed.xls]Logger\_Summary  
 Job number: 2010100A  
 Job name: Puhoi Warkworth Route Evaluation  
 Initials: JJM  
 Measurement Dates: Friday, 26 November 2010 to Sunday, December 5th 2010  
 Weather during Measurement:  
 Notes: Fernbrook Farm - 815 State Highway 1

### OVERVIEW SUMMARY SHEET

Noise Level, dB		L <sub>Aeq</sub>	L <sub>A10</sub>	L <sub>A95</sub>	L <sub>Amax</sub>
Day (0700-1800)	Lowest	44	46	36	57
	Average	53	53	44	68
	Highest	68	68	48	92
Evening (1800-2200)	Lowest	40	43	32	51
	Average	51	51	40	67
	Highest	60	59	46	85
Night (2200-0700)	Lowest	32	35	27	45
	Average	48	46	31	60
	Highest	61	64	48	85

L<sub>Aeq</sub> 24-hr 51 dB





## Appendix C. Dwellings within 200m of designation boundary

Sector	Address
1	72 Fowler Access Road 24, 26 Billing Road 430, 466 SH1 28, 44, 46, 1/46, 52, 53, 58, 60 Pūhoi Road 4, 8, 12, 16, 20, 24 Pūhoi Close 17, 18, 19, 22, 24, 25, 26, 27, 28 Slowater Lane
2	5, 6 Hungry Creek Road 600, 616, 628, 642, 656 682, 844, 851 SH1
3	70, 99, 101, 187. 209, 215 Moirs Hill Road
5	83, 91, 97, 109, 120, 122, 124 Perry Road 2, 12, 74, 75, 161, 162, 188, 217, 221, 283 Wyllie Road 83, 123, 125 Valerie Close 346, 371, 372 Woodcocks Road
6	141, 151. 152 Carran Road 77B, 78, 78A, 78B, 79A Viv Davie-Martin Drive 27, 42, 63, 91, 102, 104, 105 SH1 6, 91 Kaipara Flats Road

This table excludes dwellings that are within 200 metres of the access roads to construction yards only. Following completion of construction, we expect that the access roads may be closed. Should they be retained for maintenance work, only insignificant numbers of vehicles would use these access roads. Therefore, no operational noise assessment is required.