Waikato Expressway Cambridge Section
Noise Assessment

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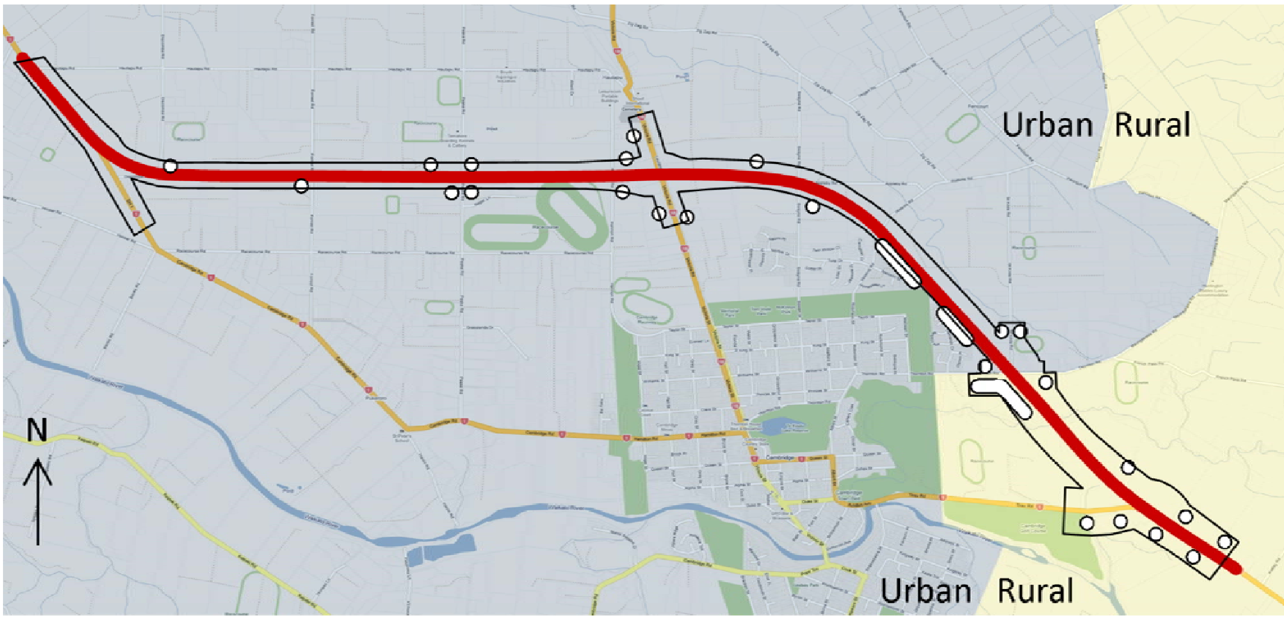
1 Introduction

1.1 Project overview

The Waikato Expressway Cambridge Section (WECS, "the Project"), as shown by the red line in Figure 1-1, is a new road approximately 11.6 km in length, with two lanes in each direction. It is part of the developing 102 km long Waikato Expressway, which is identified in the May 2009 Government Policy Statement on Land Transport Funding as one of the "Roads of National Significance".

At its northern end, the Project links with the existing State Highway 1 just south of Hautapu Road. It passes north and east of the main Cambridge Township and then links with the existing State Highway 1 south of Cambridge. Ongoing growth of Cambridge has seen residential subdivisions approach the existing designation east of Cambridge. Further subdivision plans are intended to expand Cambridge both eastwards and northwards so that over time residential development will surround a significant portion of the Project.

Figure 1-1 Project route



The objectives of the Waikato Expressway and of the Cambridge Section are discussed in detail in the Assessment of Environmental Effects for the Project.

A designation for the Project already exists and has been in place since 1973. To enable the Project to be completed to current design requirements, changes to the existing designation are now needed. The changes are primarily to widen the existing designation, with no change of route.

This report describes the assessment of the noise effects of the Project, for both its operation and its construction. The report outlines the development and recommendation of the noise mitigation for practicable minimisation of any adverse noise effects.

1.2 Noise assessment

The noise assessment gives regard to potential noise impacts of the Project on the general surrounding environment, including regard to the wider aims and aspects represented by other disciplines involved in the Project. The assessment's primary concern is noise impacts on existing premises that are located near the Project and may be generally impacted by noise, and focuses particularly on effects to residences. The white indicators on Figure 1-1 show the positions of such existing premises. Most premises along the Project alignment are individual residences or very small clusters of residences. However, in eastern Cambridge, there are several areas of residential subdivisions that may be impacted by noise effects.

The assessment establishes noise effects and noise mitigation options by following a process regularly adopted and accepted as good practice. This process includes:

- Measure and assess existing ambient noise levels;
- Calculate the noise levels expected once the Project is operational, using recognised noise prediction methods;
- Determine the impact of the changes in noise levels, with reference to the New Zealand Standard 6806: 2010 Acoustics - Road-traffic noise - New and altered roads and the New Zealand Standard 6803: 1999 Acoustics - Construction noise (NZS 6803); then
- Develop noise mitigation options to ensure that as far as is practicable the noise impacts are mitigated to meet the applicable New Zealand Standards, and thereby ensure that both the noise levels from the Project are reasonable and that the Best Practicable Option (or "BPO") has been used to mitigate the effects of the noise levels.

1.3 Report structure

This report has been prepared to inform the preparation of the Project's Notices of Requirement and the accompanying Assessment of Environmental Effects.

This report begins with an outline of the criteria against which noise impacts should be assessed, including a review of relevant documents relating to noise assessments.

The report describes the study area applicable to the noise assessment and the existing noise environment for the area. Table 5-1 in Section 5 provides a detailed listing of the addresses of properties for which noise impacts have been specifically assessed.

The report presents prediction and assessment of the operational noise effects of the Project on the study area and recommends a BPO for mitigation of the operational noise effects.

Noise effects during construction of the Project have been predicted and assessed. The report contains a set of recommended noise limits and times for construction activities and other recommendations for managing the effects of construction noise.

2 Noise criteria

2.1 Operational road-traffic noise

Noise Conditions of the existing designation

The existing designation has been in place for more than thirty years. As is common for older designations, the existing designation has no associated noise conditions specifying noise limits for the Project.

The overarching requirement for management of noise is established by the Resource Management Act, 1991 (RMA). Section 16 of the RMA requires land owners to ensure that noise emissions from their property are reasonable. "Reasonable" has no further definition under the Act. Section 16 of the RMA also requires land owners to use the BPO to limit noise emissions from their property.

Reasonable noise

The reaction of people to noise is broad. For any particular level of road-traffic noise, a portion of the population will find it disturbing and another portion will find that same noise level of little concern. This broad response is explained by various research findings. For example, some research indicates that acceptance of noise is influenced by the extent that the noise is perceived to be necessary or unavoidable. Other research indicates that tolerance of noise depends on the extent that the noise intrudes into the activities that are sought to be undertaken. The impacts of noise on amenity are therefore highly variable. Higher noise levels can also impact on health, indirectly by perhaps causing stress or, more directly, by reducing the quality of sleep.

In considering whether noise is reasonable, it is necessary to have regard to standards or guidelines in which noise limits are recommended. These limits represent the views of a range of stakeholders as to the acceptable level of community disturbance. In general, these standards and guidelines are targeted at reducing the worst of the noise impacts on amenity and in protecting health.

Noise guidelines and Standards

For a number of years, the NZTA Noise Guidelines[1] have had acceptance by Local Authorities and the Environment Court as a measure of "reasonable" traffic noise. Since 1991 the NZTA Noise Guidelines have been used on most capital projects on the State Highway network and also by many local road controlling authorities.

Following a decision by Cabinet in 2006, the Ministry of Transport sponsored the development of a New Zealand Standard for road-traffic noise. The Standard was developed with inputs from a wide range of stakeholders concerned with road-traffic noise; including from sectors of public health, local government, road controlling authorities, and acoustic professionals; and public input. The standard was published in April 2010 as NZS 6806: 2010 Acoustics - Road-traffic noise - New and altered roads. Given its official level of sponsorship, and the representation of stakeholders involved in its development, it is considered the NZS 6806 can be taken as authoritative guidance as to "reasonable" noise.

NZS 6806 excludes its application to designations established with specific noise conditions and such designations are expected to be constructed to those existing conditions. For this Project, there are no noise conditions attached to the existing designation, so NZS 6806 can be applied.

The effect of NZS 6806 in practice is to seek to manage most road-traffic noise situations to no more than about $L_{Aeq(24h)}$ 60 dB as a preference with about 67 dB tending to be regarded as the

[1] Appendix 6 of the 1999 edition of the Planning Policy Manual "Transit New Zealand's Guidelines for the Management of Road Traffic Noise"

upper limit of acceptability.[2] Application of NZS 6806 is therefore broadly in line with noise levels regarded as reasonable where previously the NZTA Noise Guidelines were applied.

An attribute of NZS 6806 is that it provides a stronger basis for establishing “practicability”. While both the NZTA Noise Guidelines and NZS 6806 limit mitigation to what is practicable, NZS 6806 offers improved clarity on the process for determining practicability and should allow for better overall outcomes to be achieved in roading projects.

NZTA Environmental Plan

The NZTA has an Environmental Plan[3] that includes investigating situations of high road-traffic noise and, if practicable, reducing the noise levels. It is noted that this Plan is primarily directed at existing roads. However when developing new roads it is preferable to avoid a situation where once the road is operational, it would need to be investigated under the Environmental Plan. There is an alignment between the noise management of NZS 6806 and the noise management that would be applied under NZTA’s Environmental Plan; so in applying NZS 6806, the NZTA Environmental Plan will also be fulfilled.

District Plan requirements

The District Plans of the Waipa District and of the Waikato District do not have specific requirements relating to operational road-traffic noise. However, Waipa District requires a 30 metre wide reserve between any future residential area and the Project designation. This is a requirement on the land owner but also affects the Project’s potential noise impacts because the extra separation distance will lessen both the noise levels and the noise impacts.

NZS 6806 noise criteria

The noise criteria of NZS 6806 have been set to avoid adverse health effects associated with noise on people and communities, but with regard to the potential benefits of new and altered roads. NZS 6806 identifies premises and facilities to be protected from road-traffic noise (Protected Premises and Facilities, “PPFs”) the NZS 6806 noise criteria shown in Table 2-1 are applicable to the Project

Table 2-1 NZS 6806 noise criteria

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

Pursuant to NZS 6806, noise mitigation options are to be assessed, and if practicable, the Category A criterion should be achieved. If this is not practicable, then mitigation should be assessed against Category B. However, if it is still not practicable to comply with Categories A or B, then mitigation should be implemented to ensure the internal criterion in Category C is achieved. Depending on the specific building, mitigation in Category C could include ventilation and/or noise insulation improvements ranging from upgraded glazing through to new wall and ceiling linings.

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2 The NZTA Noise Guidelines express noise levels in the facade position whereas NZS 6806 uses the free field position. Therefore, if comparing the NZTA Noise Guidelines and NZS 6806, a noise level in the NZTA Noise Guidelines is equal to the NZS 6806 noise level plus 2.5 dB.

3 The NZTA Environmental Plan establishes an environmental policy for State Highways. The Environmental Plan enables the NZTA to integrate environmental and social considerations, including mitigation of traffic noise, into all aspects of State Highway planning, construction, and maintenance. Version 2 of the NZTA Environmental Plan was published in June 2008.

The criteria apply to a design year 10 to 20 years after the completion of the new or altered road. For the Project, the completion year has been taken as 2016 and all noise predictions in this report relate to predicted traffic volumes in 2026.

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

2.2 Construction noise

The overarching requirement for noise from construction is established by Section 16 of the RMA- that noise levels shall be reasonable. With respect to construction, reasonable noise levels need to allow construction to occur in an efficient manner but protect the adjacent community from high levels of noise, especially when activities such as sleep are required.

Appropriate noise management and community liaison processes are also important in delivering acceptable construction noise levels. Normally these would be addressed in a Construction Noise Management Plan prepared as part of the construction contract.

NZS 6803

An extensive history of practice has established that construction undertaken within the noise limits set out in NZS 6803P: 1984 (since superseded by NZS 6803: 1999) is acceptable to the New Zealand public. These Standards recognise that construction noise is finite in duration. Established practice is that people will accept construction noise, even 25 to 30 dB above regular noise levels, set out in the District Planso long as the higher noise level is for a finite period and good noise management practices are being followed. However, a further proviso on construction noise acceptability relates to the hours of the day during which the construction noise occurs. Usually high levels of construction noise are acceptable only during daytime and only on weekdays, although construction noise on Saturdays can also be acceptable. Acceptance of construction noise during the night is particularly dependent on (public perception of) its necessity and appropriate notification of its occurrence.

The current version of the standard for noise of construction activity is NZS 6803: 1999 Acoustics - Construction Noise. This Standard notes in its title that it supersedes NZS 6803P: 1984. Both Standards need to be considered for the Project because the Waipa District Plan cites NZS 6803P: 1984 and the Waikato District Plan cites NZS 6803: 1999. It is also relevant that the “P” in the title of the NZS 6803P: 1984 version signified that it was provisional.

NZS 6803: 1999 notes in its foreword that it was the Ministry of Health who sponsored the revision of NZS 6803P: 1984 in its role of improving, promoting, and protecting public health. The foreword also notes that the RMA requires the adaption of the BPO for mitigation to ensure that noise levels are reasonable.

This reference to the BPO is important because the reasonableness of noise will be context-specific and therefore points to a context-specific consideration of which is the more appropriate standard to use. Whereas NZS 6803P: 1984 sets prescriptive construction noise limits, NZS 6803: 1999 is a guideline for setting noise limits that are specific to a project being undertaken and that are specific to the situation in which the project is located. Current ambient noise levels are an important factor in setting the construction noise limits. The practicality of achieving the work within particular limits is another important factor. NZS 6803: 1999 contains two tables of recommended construction noise limits; Table 2 for application in residential areas and Table 3 to apply in commercial areas. However, NZS 6803: 1999 expects that these sample tables will be modified according to the subject project's specifics.

Therefore, even though the Waipa District Plan cites the 1984 version of NZS 6803, it is considered appropriate to apply the 1999 version as being more relevant. Consequently, this assessment of construction noise follows the procedures of NZS 6803: 1999 for the full extent of the Project and uses the basic structure of Table 2 and Table 3 from that Standard as guidance to establish a set of recommended noise limits specific to this Project (discussed in Section 7 of this report).

NZTA Environmental Plan

The NZTA has set a formal objective to "manage construction and maintenance noise to acceptable levels."[4]

The Environmental Plan states that during construction of a project, potentially unreasonable construction noise effects will be managed and minimised, as far as is practicable, in accordance with NZS 6803: 1999. The preferred mechanism of construction noise management is a Construction Management Plan, or equivalent, which must include a noise management component. The Construction Noise Management Plan should detail consultant and contractor obligations during the construction phase in relation to:

- Monitoring and reporting requirements including results of risk assessments and noise measurements;
- Identifying appropriate noise mitigation measures to be implemented;
- Applicable noise limits;
- Necessity and justification to undertake construction works at night, if required; and
- Procedures for maintaining contact with stakeholders and managing noise complaints.

[4] Objective N3, NZTA Environmental Plan, June 2008

3 Noise study area and protected premises and facilities

Clause 1.3.1 (d) and clause 1.3.1 (e) of NZS 6806 limit the Standard's application to premises within 100 metres of a new or altered road in an urban area and premises within 200 metres of a new or altered road in a rural area. These distances then define the noise study area. Premises within the noise study area are protected based on their usage, including existing houses, schools, marae and various other locations defined in the Standard. These premises are termed Protected Premises and Facilities (PPFs). In accordance with NZS 6806, future (unbuilt) PPFs are not considered in the assessment, unless they have building consent.

The resulting noise study area for the Project is shown in Figure 1-1.

A common labelling of properties within the Project area has been used for this assessment, with these being numbered from 001 to 161. These properties have been matched to street addresses and this detail is contained in Figure 5-1.

"New roads" and "altered roads"

NZS 6806 applies only to limited types of roading projects,[5] namely "new roads" and "altered roads". NZS 6806 defines "new roads" as "any road which is to be constructed where no previously formed legal road existed".[6]

An "altered road" is defined in NZS 6806 as "an existing road that is subject to alterations of the horizontal or vertical alignment".[7] NZS 6806 is applied where the alterations (with no specific noise mitigation) would create a noise environment of 64 dB $L_{Aeq(24h)}$ or more and increase the road-traffic noise level for a PPF by 3 dB $L_{Aeq(24h)}$ above the noise level the PPF would experience if the alterations were not undertaken.[8] Or, NZS 6806 is applied where the alterations (with no specific noise mitigation) would create a noise environment of 68 dB $L_{Aeq(24h)}$ or more and increase the road-traffic noise level for a PPF by 1 dB $L_{Aeq(24h)}$ above the noise level the PPF would have if the alterations were not undertaken.[9]

NZS 6806 recognises that a project may contain criteria for both new and altered roads.[10] Clause 1.2.3 (e) expects the road controlling authority to identify within a project, which sections are "new roads" and which are "altered roads".

. In the Project, the majority of the Expressway itself, and ramps linking Victoria Road (State Highway 1B) and the Expressway to SH1are "new roads" but the immediate parts of these connections where the Expressway connects to the existing State highway network are "altered roads".

For those PPFs with "altered road" criteria, the assessment was extended to include the extent that the "altered road" was the dominant noise source contributor to noise for that PPF versus the extent that the noise level at the PPF was influenced by the Expressway. One way this was done was by comparing the scenario of traffic noise in 2026 (the design year) if the Project was not built (the do-nothing scenario) with the calculated noise for 2026 if the Project was built (the BPO scenario).

In the Project, some existing roads are altered by being severed around the Expressway. These roads are Discombe Road, Forrest Road, Hannon Road, and Watkins Road. The alterations of these roads do not increase the road-traffic noise level for any PPF so NZS 6806 is not applied.

In the Project, some roads are altered to form overbridges to cross the Expressway. These roads are Peake Road, Victoria Road, Swayne Road and Thornton Road. The noise study area boundary contains the works to form the overbridges. The alterations of these roads may increase the road-traffic noise level for any PPF by 3 dB $L_{Aeq(24h)}$ above the noise level the PPF would have if the

[5] NZS 6806 1.5.1
[6] NZS 6806 1.6
[7] NZS 6806 1.5.2
[8] NZS 6806 1.5.2 (a)
[9] NZS 6806 1.5.2 (b)
[10] NZS 6806 6.2.1

alterations were not undertaken, so the alterations of these roads could be considered as “altered roads” under NZS 6806.

In addition to the above, Clause 1.3.1 (d) of NZS 6806 states that the Standard does not apply to new and altered roads predicted to carry less than 2,000 AADT at the design year. Peake Road and Swayne Road have 2026 traffic volumes predicted to be less than 2,000 AADT. Victoria Road and Thornton Road have 2026 traffic volumes greater than 2,000 AADT so only these two roads are “altered roads” under NZS 6806.

“Urban environment” and “rural environment”

As noted above, NZS 6806 also has specific reference with regard to application of the Standard in urban and rural environments.

“Urban environment” and “rural environment” are defined in NZS 6806 in accordance with Statistics New Zealand definitions of urban zones and rural zones. Statistics New Zealand’s census meshblocks are coded according to urban/rural profiling. Meshblocks coded as “main urban area”, “satellite urban community”, or “independent urban community” are classified as “urban environment” under NZS 6806. A meshblock of any other code is classified as “rural environment” under NZS 6806. The resulting NZS 6806 “urban environment” classification can extend beyond the closely developed suburban areas of cities and towns if there is a high dependency of that surrounding land with the adjacent town. Figure 1-1 illustrates how the Project is classified as “urban environment” (in grey) and “rural environment” (in yellow) along the Project length. Even though most of the route is in open fields, much of that area is classed as being an urban environment.

Clause 1.3.1 of NZS 6806 states its application to PPFs located in urban environments and located within 100 metres from the edge of the closest traffic lane of a “new road” or “altered road” and PPFs located within 200 metres in rural environments.

The 100 metre and 200 metre threshold distances provide practical criteria to ensure the assessment is made at the most relevant receivers. Despite the threshold distances, potential noise effects of a project are still indirectly controlled at receivers further away by virtue of noise criteria applying at receivers nearest to the road. Invariably, if the properties nearest to the road meet the noise criteria, then the more distant ones will also meet the criteria.

4 Existing noise environment

The criteria in NZS 6806 for assessing road-traffic noise are not dependent on the existing noise levels. However, understanding the existing noise environment provides context for understanding the scale and likely impacts of changes to that noise environment.

While road-traffic noise is audible along most of the Project, many parts are currently at some distance from existing major roads, so road-traffic noise is only one contributor to the overall noise environment. In those circumstances, quantification of the existing noise environment is best established by measurement rather than by modelling. However, near the existing major roads, it is possible to establish the existing noise environment via modelling.

A survey of existing noise was undertaken for the Project to establish the noise levels particularly in those areas where traffic noise was a less dominant influence. Areas near the major roads were modelled. This section of the report describes the noise assessment by measurement. The modelling near the existing roads is described in section 5 following.

For the noise measurements, the Project area was subdivided into three smaller areas, which have similar noise environments. Each area includes a group of PPFs, which are characterised by similar factors, such as location relative to the designation and likely noise effect of the Project. The dominant existing noise source at most sites is traffic on adjacent roads or agricultural activities. Some sites have a significant noise contribution from agricultural activities or domestic activities such as day-to-day housekeeping work, home maintenance or barking dogs. However, road-traffic noise from the existing local roads is audible at most sites in this area.

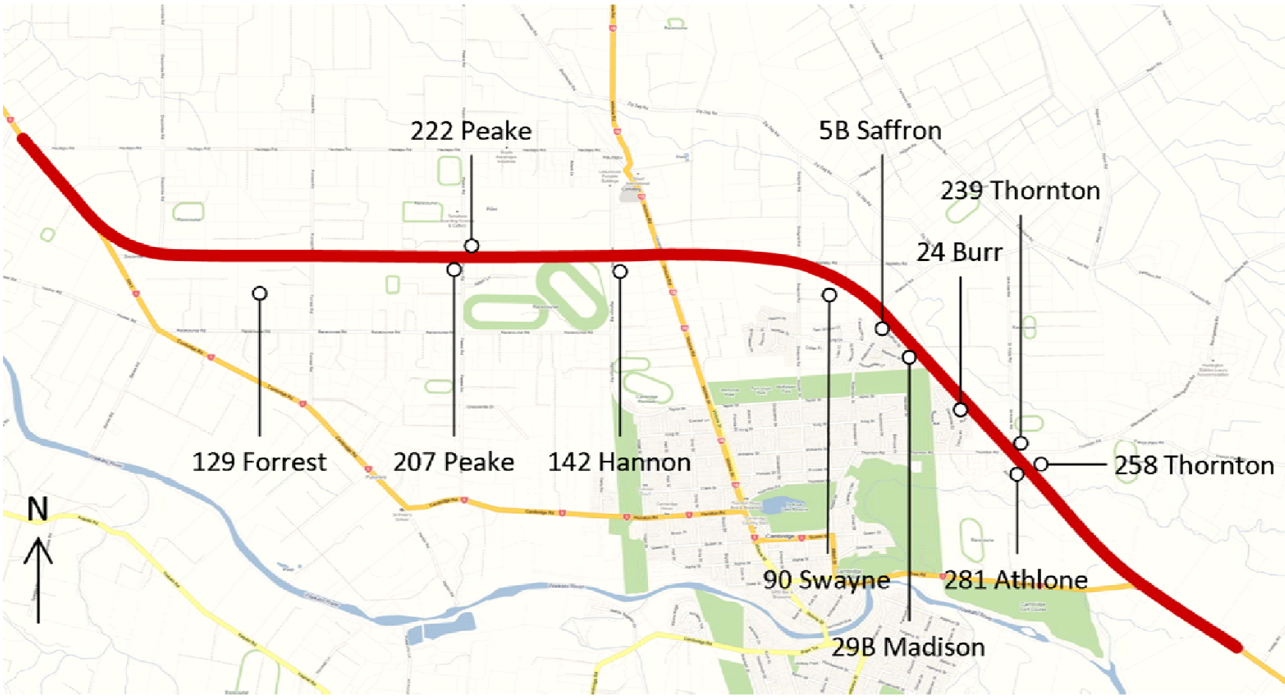
Noise monitoring sites were established at sites shown in Table 4-1 and Figure 4-1. Measurements of existing noise levels were undertaken at eleven sites, with four of those being used for continuous monitoring over 24 hours. At the other sites, noise levels were measured for at least one hour and up to several hours. For the sites where the shorter-term measurements were made, the 24 hour equivalent noise level was estimated using general relationships linking shorter-term measurements to 24 hour equivalent noise levels.[11]

[11] 24-hour noise levels were estimated from 1 hour measurements by subtracting 3 dB. Main Roads Western Australia, 1994. TNOISE Model User Manual. Main Roads Western Australia: Australia

Table 4-1 Noise monitoring sites

Address	Distance to designation	Features
258 Thornton Road	85 m	These sites are representative of properties located in the vicinity of the intersection of St Kilda and Thornton Roads and along Athlone Drive. Practically all properties in this area are exposed to traffic noise from Thornton Road
239 Thornton Road	20 m	
281 Athlone Drive	35 m	
24 Burr Street	48 m	These sites are representative of properties and PPFs located within the residential areas around Oaklands Drive and Madison Street. The most exposed PPFs will be those located at the boundary of the buffer zone, which will face the Project. Currently it is a relatively quiet area with dominant noise sources being household activities and occasional cars on local streets.
29B Madison Street	45 m	
5B Saffron Road	45 m	
90 Swayne Road	150 m	These sites are representative of a large area north of Racecourse Road and west of Victoria Road. This area is occupied by farms with few residential and agricultural dwellings on properties. Traffic on local roads and agricultural activities are the dominant noise sources in this area.
142 Hannon Road	75 m	
207 Peake Road	85 m	
222 Peake Road	10 m	
129 Forrest Road	35 m	

Figure 4-1 Approximate locations of noise monitoring sites



4.1 Noise measurements

At all sites (except 90 Swayne Road and 207 Peake Road), microphones were installed 1.4 to 1.5 metres above the ground level, and one metre in front of the façade facing the Project alignment.[12]

Traffic on local roads, which could affect monitoring sites, was considered to be normal during the survey with no roadworks in the immediate vicinity of monitoring sites.

Over the period of monitoring, 7 November 2007 to 9 November 2007, weather conditions were stable and within the meteorological restrictions of NZS 6801. Winds were either calm or light, less than 10 to 15 km/h, ambient temperatures were between 16 and 21°C, and atmospheric pressure was 1016 to 1020 hPa. All measurement periods have been included in the analysis. The 2007 measurements were used for this 2010 assessment as it is considered that there has been little change in the noise environment since 2007.

The results of the noise survey are listed in Table 4-2 in terms of the free-field $L_{Aeq(24h)}$ values and illustrated by the following four figures showing the 24 hour monitoring records. Note that the figures are showing noise levels measured in the facade position and so are higher than the noise levels in Table 4-2 shown for the free field position.[13] Further explanation on interpretation of this data is given in **Appendix A.**

Table 4-2 Noise survey results

Address	Measurement type	$L_{Aeq(24h)}$
258 Thornton Rd	24 hour	43 dB
239 Thornton Rd	Shorter term	48 dB
281 Athlone Dr	Shorter term	42 dB
24 Burr St	24 hour	40 dB
29B Madison St	Shorter term	36 dB
5B Saffron Rd	Shorter term	38 dB
222 Peake Rd	24 hour	50 dB
129 Forrest Rd	24 hour	47 dB
207 Peake Rd	Shorter term	42 dB
142 Hannon Rd	Shorter term	46 dB
90 Swayne Rd	Shorter term	45 dB

Table 4-2 shows that the existing noise levels at representative sites are between 40 and 50 dB. Figure 4-2 to Figure 4-5 show that the area has low night time noise levels, between 30 to 40 dB; and day noise levels are about 50 dB, but a little higher at the Peake Road site (Figure 4-5).

[12] The measurements were conducted in general accordance with NZS 6801:1999 Acoustics - Measurement of environmental sound. Since undertaking of the measurements, this version of the Standard has been superseded by NZS 6801: 2008, Acoustics – Measurement of environmental sound. The measurements taken in accordance with NZS 6801: 1999 are also in accordance with NZS 6801: 2008.

[13] Measurements were made according to the NZTA Noise Guidelines in the façade position (within one metre of a building), which increases the noise level by 2.5 dB. However, NZS 6806 uses free field measurements. Therefore, free-field noise levels were calculated by subtracting 2.5 dB from façade measurements.

Figure 4-2 Records from 24 hours of monitoring at 258 Thornton Road

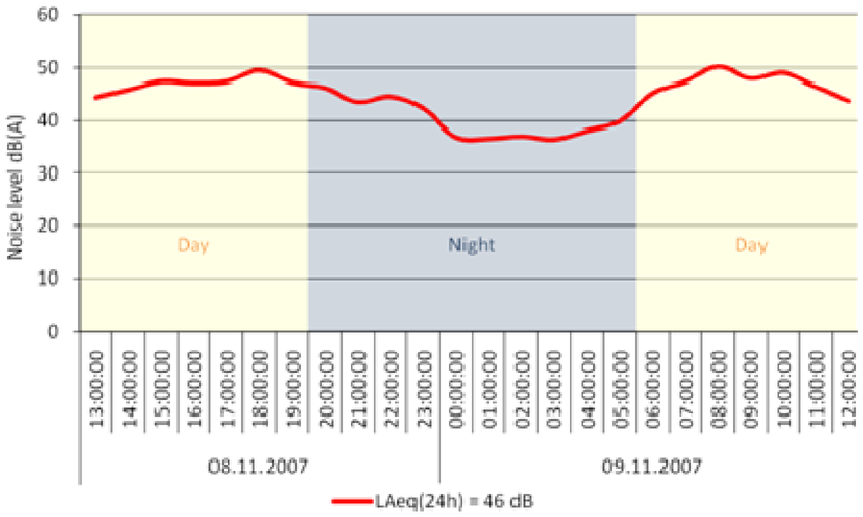


Figure 4-3 Records from 24 hours of monitoring at 24 Burr Street

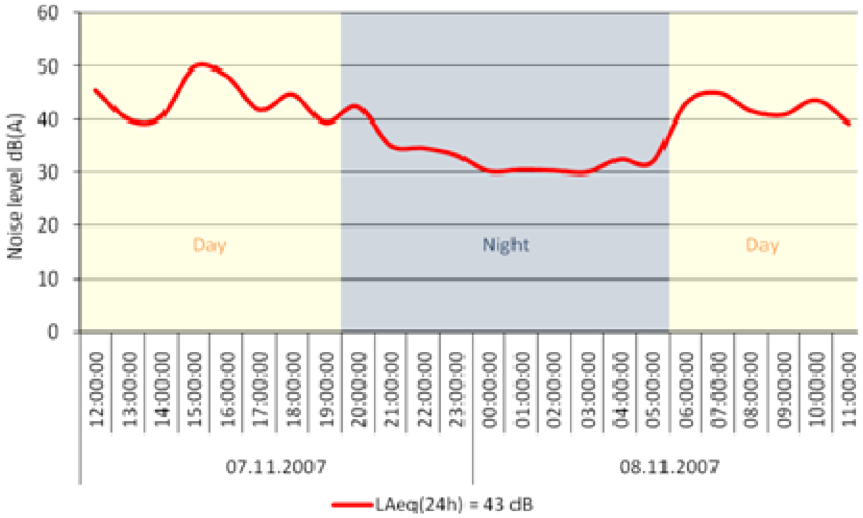


Figure 4-4 Records from 24 hours of monitoring at 129 Forrest Road

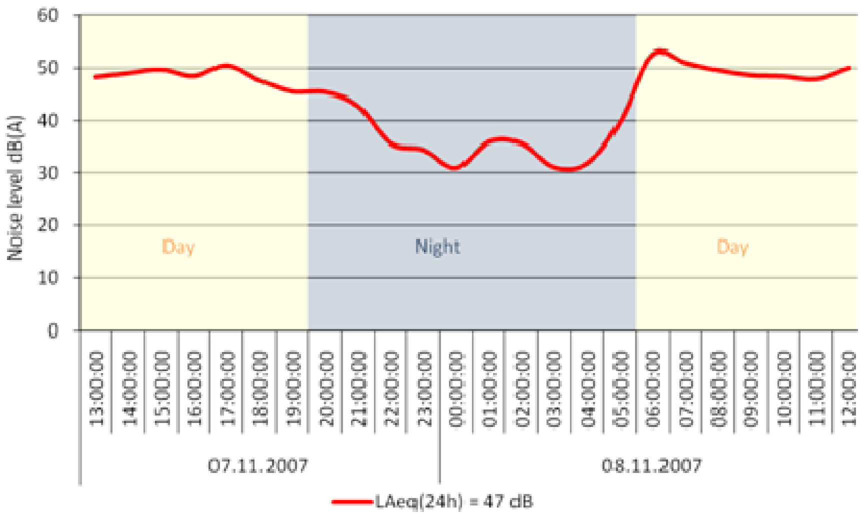
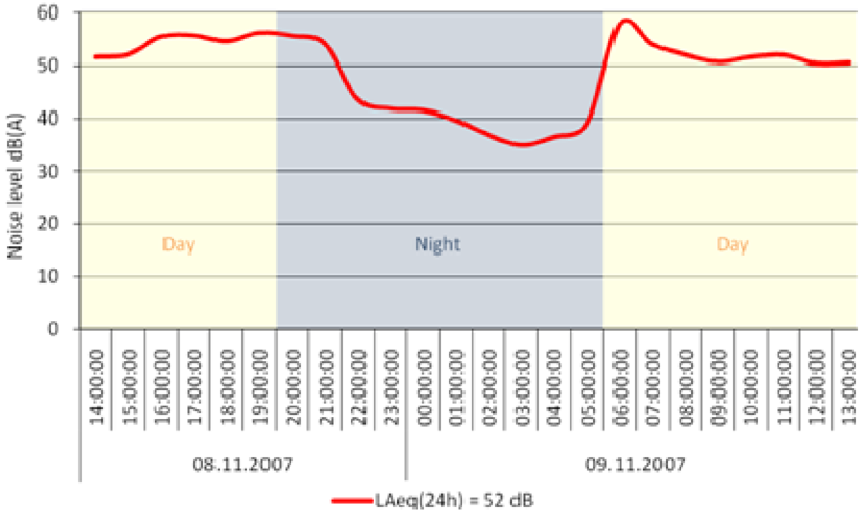


Figure 4-5 Records from 24 hours of monitoring at 222 Peake Road



5 Operational noise assessment

The cornerstone to assessing operational road-traffic noise is by representative modelling of road-traffic noise. This provides an objective basis to consider future (or altered) activity. The modelling techniques used in this assessment are well established in New Zealand, and are based on the Calculation of Road Traffic Noise (CRTN) model. This model was developed in the United Kingdom more than thirty years ago. However, research in New Zealand has also validated the model as appropriate in New Zealand so long as some New Zealand-specific adjustments are applied.

This section describes the modelling process and results, and explains the process used to determine the best practicable noise mitigation design features.

5.1 Meaning of the do-minimum scenario of NZS 6806

NZS 6806 makes a distinction between design features that are deliberately provided to reduce noise and those design features included in the Project for other purposes but which also have a noise reduction effect. The design that occurs prior to inclusion of any design features deliberately provided to reduce noise is referred to as the "do-minimum" design.

NZS 6806 defines the "do-minimum" noise assessment scenario as:

The predicted noise levels at the assessment position(s) of [Protected Premises and Facilities] at the design year with the project implemented including safety barriers and other structures (which may have an incidental noise mitigating effect). This assessment is not to include any measures undertaken for the sole purpose of reducing noise.

This clearly states the do-minimum design is not the design with nothing being done to mitigate noise effects. Rather, the do-minimum design separates out design features provided for another main purpose (but which have also a noise mitigation effect) from those design features that have noise mitigation as their main purpose.

It is important to recognise that the noise mitigation design features selected under NZS 6806 specifically flow from the do-minimum design of the Project. Therefore, if the do-minimum design changes, then the appropriate noise mitigation may also change. For example, south of Watkins Road, the Expressway level being below surrounding ground level and the choice of do-minimum road surface, are two crucial elements in the do-minimum design which have major bearing on the need for additional noise mitigation in this area. If those design elements were changed, then any additional noise mitigation would need to be evaluated in light of the changed do-minimum design.

5.2 Evolution of the do-minimum scenario

An important part of the do-minimum design is the choice of road surface. Usually for roads of the type of this Project, if there was no particular limitation on the choice of road surface, two-coat chipseal would be chosen. During the course of developing the design of this Project, the recommendation for the do-minimum surface has evolved. Originally the do-minimum road surface was to be two-coat chipseal. As such, early noise mitigation design features included sections of low noise open graded porous asphalt (OGPA) road surface. For the isolated PPFs, these sections of OGPA had very low benefit relative to cost. However, in addition to the noise benefits, further investigation recognised that OGPA road surface could offer a number of engineering benefits. Based on those engineering benefits, the OGPA road surface was adopted as part of the do-minimum design.

The significant change of road surface for the do-minimum design occurred subsequent to the Project noise workshops and subsequent to presentations and open days with the public.[14] Now that the do-minimum design for the Project uses OGPA road surface for the major length of the

[14] At public information days in August 2010, noise mitigation was shown as sections of OGPA road surface (between sections of two-coat chipseal) and some noise barriers.

route, the choice of noise mitigation design features was almost entirely focused on the practicability of noise barriers (as walls or bunds), at the few locations where the low noise OGPA road surfacing alone is insufficient to mitigate noise effects to the Category A of NZS 6806.

Outside of the major length of the route using OGPA road surface, there are other areas of the Project where the road surface has been selected for engineering reasons and also has noise reduction benefits. Stone mastic asphalt (SMA) has been selected for the connecting road sections that link between the Expressway and State Highway 1B at Victoria Road.

5.3 Assessment of the do-minimum scenario

All operational noise predictions have been modelled in line with NZS 6806. The noise modelling specifics are contained in **Appendix B**.

The Project do-minimum scenario was modelled and noise levels at all PPFs within the noise study area were compared with their applicable NZS 6806 Category A target noise level.[15] The do-minimum noise levels, at the most exposed receiver position for each assessed premise, are shown in Table 5-1.

The do-minimum noise level is shaded green if the noise level is within its NZS 6806 Category A limit, yellow if it is in Category B and red if it exceeds Category B.

Table 5-1 Predicted $L_{Aeq(24h)}$ noise levels (dB)

PPF	Address	NZS 6806 Cat. A limit	NZS 6806 Cat. B limit	Do-minimum (2026)
002	1328B SH1	64	67	61
006	251 Discombe Road	57	64	63
007	245A Discombe Road	57	64	62
008	109 Forrest Road	57	64	60
009	215 Peake Road	57	64	58
010	207 Peake Road	64	67	55
011	191 Peake Road	64	67	51
012	257 Peake Road	64	67	54
014	249 Peake Road	64	67	58
015	197 Peake Road	64	67	61
016	234 Peake Road	64	67	56
017	198 Peake Road	64	67	56
021	142 Hannon Road	57	64	55
023	162 Hannon Road	57	64	54
024	183 Victoria Road	64	67	56
032	115 Victoria Road	64	67	58
033	111 Victoria Road	64	67	62
034	99 Victoria Road	64	67	59
036	100 Laurent Road	64	67	62
037	137 Swayne Road	57	64	57
038	170 Swayne Road	64	67	53
040	100 Swayne Road	64	67	51
041	102 Swayne Road	64	67	52
042	116 Swayne Road	57	64	56
044	40 Watkins Road	57	64	58
045	38 Watkins Road	57	64	51
046	36 Watkins Road	57	64	47
047	3C Saffron Street	57	64	57
048	3B Saffron Street	57	64	53

15 Section 8.4 of NZS 6806 specifies that specific noise mitigation measures are not required where the noise is predicted to meet Category A at the design year.

PPF	Address	NZS 6806 Cat. A limit	NZS 6806 Cat. B limit	Do-minimum (2026)
049	3A Saffron Street	57	64	48
050	5B Saffron Street	57	64	57
051	5A Saffron Street	57	64	49
052	5 Saffron Street	57	64	46
053	7A Saffron Street	57	64	57
054	7 Saffron Street	57	64	52
055	9B Saffron Street	57	64	58
056	9 Saffron Street	57	64	54
057	11A Saffron Street	57	64	57
058	11 Saffron Street	57	64	48
059	13A Saffron Street	57	64	58
060	13 Saffron Street	57	64	48
061	15A Saffron Street	57	64	57
062	15 Saffron Street	57	64	48
063	17A Saffron Street	57	64	58
064	17 Saffron Street	57	64	49
065	19A Saffron Street	57	64	58
066	19 Saffron Street	57	64	47
067	21A Saffron Street	57	64	58
068	21 Saffron Street	57	64	47
069	23 Saffron Street	57	64	58
070	25 Saffron Street	57	64	50
071	27A Saffron Street	57	64	58
072	27 Saffron Street	57	64	49
073	29A Saffron Street	57	64	55
074	29B Madison Street	57	64	57
075	29A Madison Street	57	64	48
076	31B Madison Street	57	64	57
077	29 Madison Street	57	64	47
078	31A Madison Street	57	64	56
079	31 Madison Street	57	64	55
080	33 Madison Street	57	64	57
081	35 Madison Street	57	64	54
082	36A Madison Street	57	64	49
083	38A Madison Street	57	64	56
084	1 Soma Place	57	64	50
085	3 Soma Place	57	64	51
086	5 Soma Place	57	64	52
087	7 Soma Place	57	64	56
088	9 Soma Place	57	64	54
089	11 Soma Place	57	64	54
090	13 Soma Place	57	64	55
091	15 Soma Place	57	64	53
092	12 Soma Place	57	64	45
093	7A Durmast Court	57	64	55
094	7 Durmast Court	57	64	46
095	9 Durmast Court	57	64	54
096	10 Durmast Court	57	64	53
097	6 Durmast Court	57	64	46
098	8 Durmast Court	57	64	53
099	21 Burr Street	57	64	46
100	23 Burr Street	57	64	54
101	25 Burr Street	57	64	53
102	26 Burr Street	57	64	53
103	24 Burr Street	57	64	53

PPF	Address	NZS 6806 Cat. A limit	NZS 6806 Cat. B limit	Do-minimum (2026)
104	22 Burr Street	57	64	53
105	20 Burr Street	57	64	53
106	18/16 Burr Street	57	64	46
107	3/4 Walter Court	57	64	54
108	12/14 Burr Street	57	64	46
109	11/12 Walter Court	57	64	46
110	5/6 Walter Court	57	64	54
111	9/10 Walter Court	57	64	48
112	7/8 Walter Court	57	64	54
113	37 St Kilda Road	64	67	54
114	42 St Kilda Road	64	67	57
115	205 Thornton Road	64	67	56
116	30 St Kilda Road	64	67	58
117	213 Thornton Road	64	67	56
118	≈196 Thornton Road	64	67	59
120	1/213 Thornton Road	64	67	61
121	206 Thornton Road	64	67	62
122	204 Thornton Road	64	67	55
123	194 Thornton Road	64	67	50
125	202 Thornton Road	64	67	49
126	2/194 Thornton Road	64	67	47
128	212 Thornton Road	64	67	50
129	4/194 Thornton Road	64	67	45
130	218 Thornton Road	64	67	52
131	222 Thornton Road	64	67	56
132	2/218 Thornton Road	64	67	50
133	214 Thornton Road	64	67	49
135	1 Athlone Drive	64	67	58
136	220 Thornton Road	64	67	49
137	241 Thornton Road	64	67	61
138	65 Athlone Drive	64	67	52
139	115 Athlone Drive	64	67	50
140	252 Thornton Road	64	67	60
141	236 Thornton Road	64	67	56
142	201 Athlone Drive	64	67	51
143	196 Athlone Drive	57	64	47
144	260 Thornton Road	64	67	54
145	281 Athlone Drive	57	64	54
146	242 Athlone Drive	57	64	51
147	264 Thornton Road	64	67	59
148	258 Thornton Road	64	67	50
149	282 Athlone Drive	57	64	47
150	268 Thornton Road	64	67	50
152	330 Athlone Drive	57	64	49
153	270 Thornton Road	64	67	49
154	370 Athlone Drive	57	64	55
155	≈207 Tirau Road	57	64	55
156	178 Tirau Road	64	67	57
158	190 Tirau Road	64	67	55
159	246 Tirau Road	64	67	59
160	259 Tirau Road	64	67	57
161	276 Tirau Road	64	67	68

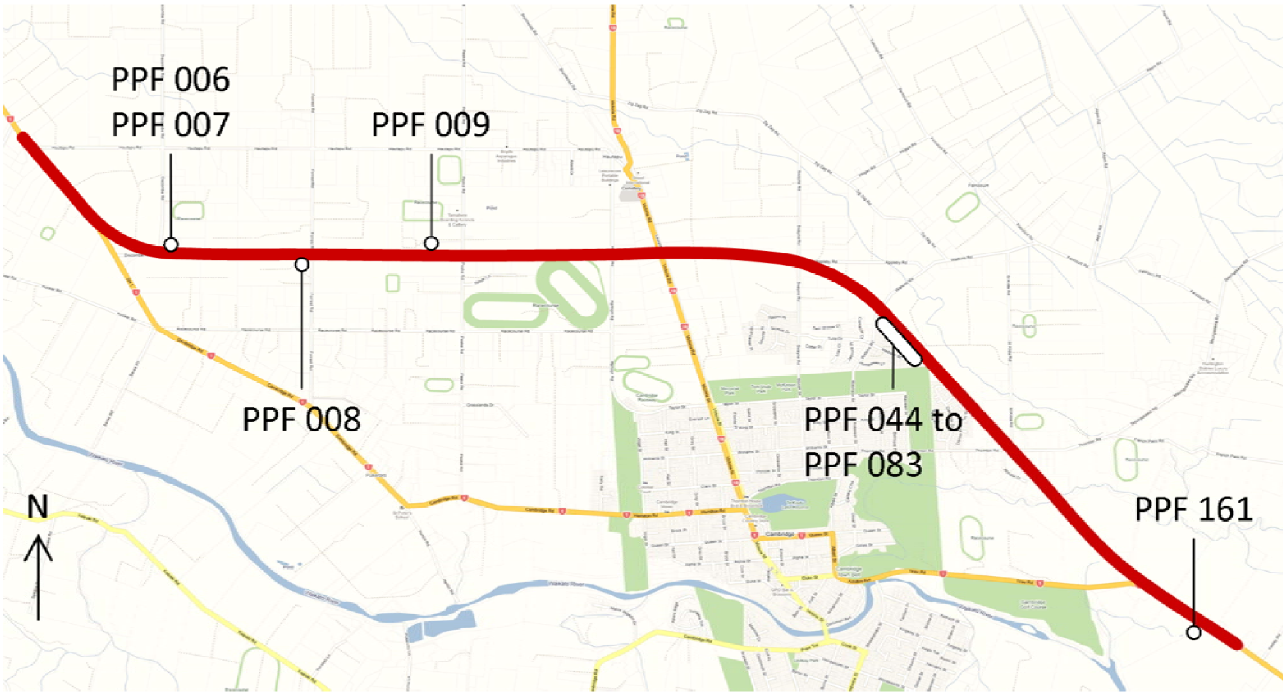
5.4 Design and assessment of the Best Practicable Option to mitigate noise

Table 5-1 shows (via the noise levels shaded yellow or red) the PPFs where the practicability of further noise mitigation needs to be investigated as required by NZS 6806. The PPFs are in five main locations, as summarised in Table 5-2 and shown in Figure 5-1. The PPFs are isolated houses except for one cluster of houses.

Table 5-2 PPFs and Clusters of PPFs

PPFs	Address	Comments
PPF 006 and PPF 007	251 Discombe Road and 245A Discombe Road	These two PPFs are located as neighbours and so are treated together.
PPF 008	109 Forrest Road	This PPF is individual and isolated. Noise mitigation for this PPF would have little impact on noise levels for any other PPF.
PPF 009	215 Peake Road	This PPF is individual and isolated. Noise mitigation for this PPF would have little impact on noise levels for any other PPF.
PPF 044 to PPF 083	Area of houses near Saffron Street	All PPFs between PPF 044 and PPF 083 are located in a subdivision and are treated together as a cluster.
PPF 161	276 Tirau Road	This PPF is individual and isolated. Noise mitigation for this PPF would have little impact on noise levels for any other PPF.

Figure 5-1 PPFs requiring further assessment



The development of the BPO for noise mitigation is a key stage within the application of NZS 6806. In developing this mitigation, NZS 6806 expects input from the Project's other specialist disciplines to identify how the potential mitigation option could have effects on other Project objectives or, alternatively, how noise mitigation options could enhance the Project's objectives.

The scale of this Project was appropriate for specialist input to be obtained via a workshop. Materials provided prior to the workshop allowed the specialists to assess the options. The specialists communicated their views of mitigation options by one or both of two methods:

- Specialists rated the mitigation options using a seven-point scale to score each option to the extent to which each mitigation option might conflict or complement other aims or aspects of the Project.

- Specialists attended a workshop where the locality of each PPF or cluster of PPFs requiring further assessment was discussed in terms of the constraints or opportunities available and how the mitigation options interacted with those factors.

In practice the workshop was the dominant mode by which the BPO was identified, with the scoring via the seven-point scale assisting the specialists formulate views which they brought to the workshop. The following issues received strong or common representation:

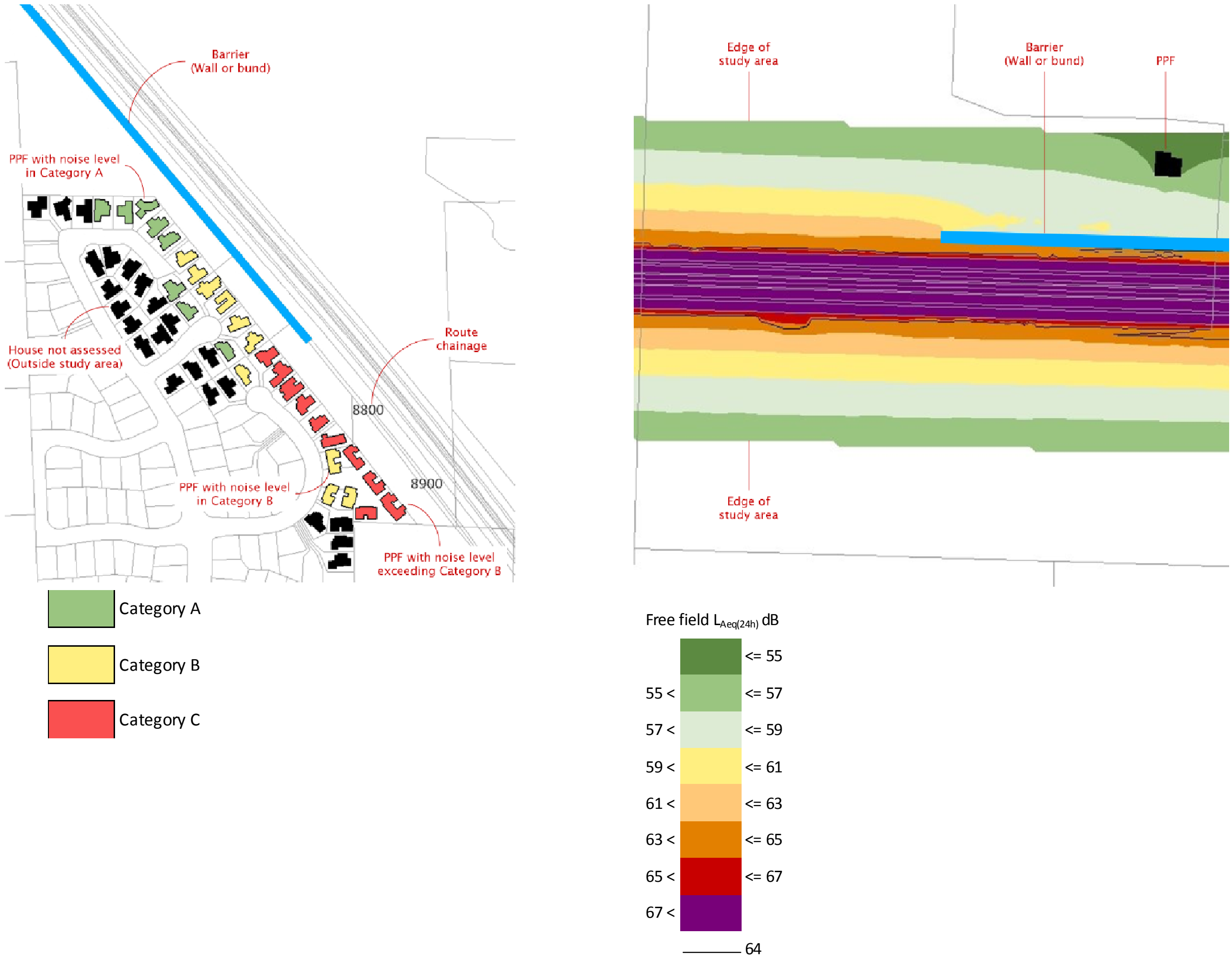
- Design requirements for a Road of National Significance (RONS) put constraints on the location of barriers on the edge of the road. Clear space of 9.5 metres from the road edge is the design expectation. A consistent road environment is also expected, so that a series of narrow constrictions to accommodate noise barriers also transgresses RONS design expectations. Barriers therefore need to be installed 10 metres or more from the road edge. For much of this route the corridor centreline is built up 1 to 2 metres above the adjacent terrain. Barriers placed 10 metres out from the road edge are low lying relative to the carriageway and therefore would need to have additional height to compensate for this positioning.
- The area is mainly flat and is low lying relative to watercourses that become active in periods of wet weather. Drainage via the swales located about 12 metres from the road edge is a key requirement. Barriers located inside the swales would provide drainage issues, which are complicated but not insurmountable.
- If barriers were required, landscape design would prefer barriers to be low. Bunds were preferred to walls as planting can readily mitigate the impact of the bunds. Social considerations also indicated that if barriers were to be used, a lower height is preferable, to reduce sense of exclusion and to avoid the formation of intimidating areas for adjacent pedestrians. To avoid graffiti, bunds were also preferred to walls.
- The Project design has been developed over a long period and there has been consultation with some affected groups. This consultation and consequent expectations were also considered in assessing the BPO.

Figure 5-3 to Figure 5-7, which follow, depict findings of the operational road-traffic noise assessment. Figure 5-2 provides a key to assist with interpreting these figures. Note however that Figure 5-2 is not a true representation of any of the noise findings but has been adapted so that each feature is illustrative only.

The diagram on the left shows the Project, noise mitigation design features such as noise barriers, and buildings in the study area. The buildings are shaded according to their NZS 6806 noise category, and buildings shaded black are outside the study area but are included as they help depict the area.

The diagram on the right shows the noise level contour lines as the noise spreads from the Expressway to the edge of the study area. Also shown are noise mitigation design features and buildings within and adjacent the study area.

Figure 5-2 An adapted example as key to Figure 5-3 to Figure 5-7



5.4.1 PPF 006 and PPF 007: 251 Discombe Road and 245A Discombe Road

PPF 006 and PPF 007 are located in close proximity and are assessed together. Both are close to the Expressway and are in Category B in the do-minimum scenario. Noise mitigation design features investigated included barriers, of heights 1 to 4 metres, either in the form of a wall or a bund.

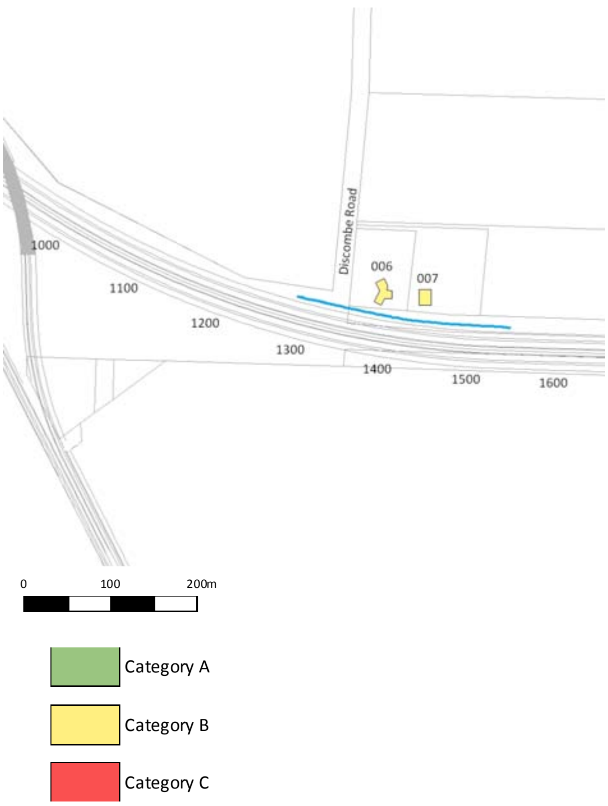
Through the investigation and workshop, a 250 metre long 3 metre high wall was nominated as the potential BPO, though this is to be subject to consultation with the affected residents. The height of 3 metres was considered to be the maximum height desirable without creating significant adverse visual or social effects. A wall was selected rather than a bund as there is not space for a bund within the designation.

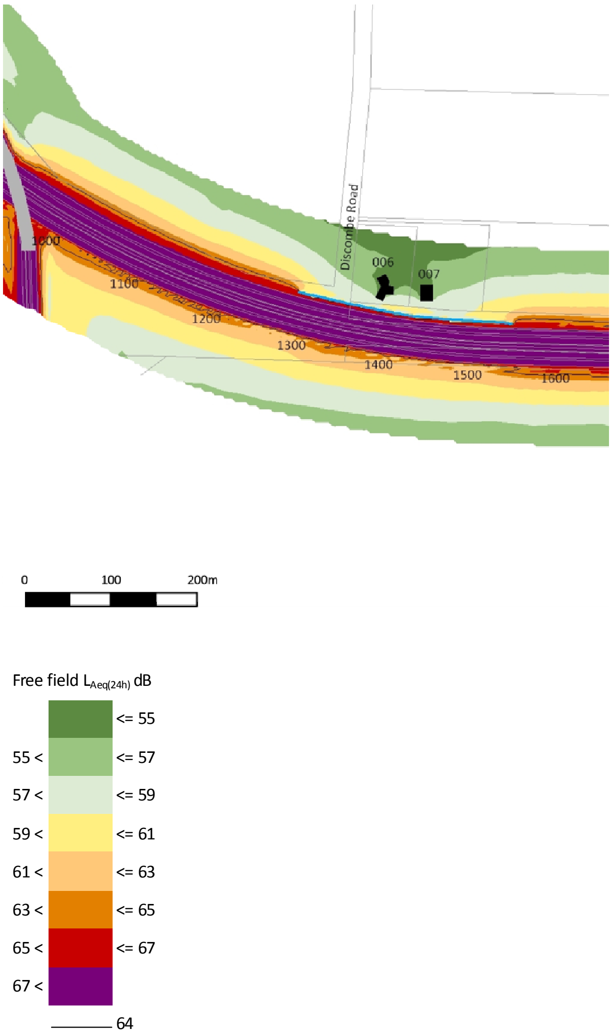
Best Practicable Option

The BPO is considered to be a 250 metre section of 3 metre high wall at the edge of the earthworks, chainage 1300 to 1550.

The BPO reduces the PPF 006 noise level by 5 dB and the PPF 007 noise level by 4 dB. The BPO is depicted in Figure 5-3. The left hand diagram shows the PPFs colour-coded according to the NZS 6806 noise category. The right hand diagram shows the noise contours of the BPO as modelled.

Figure 5-3 BPO for PPF 006 and PPF 007





5.4.2 PPF 008: 109 Forrest Road

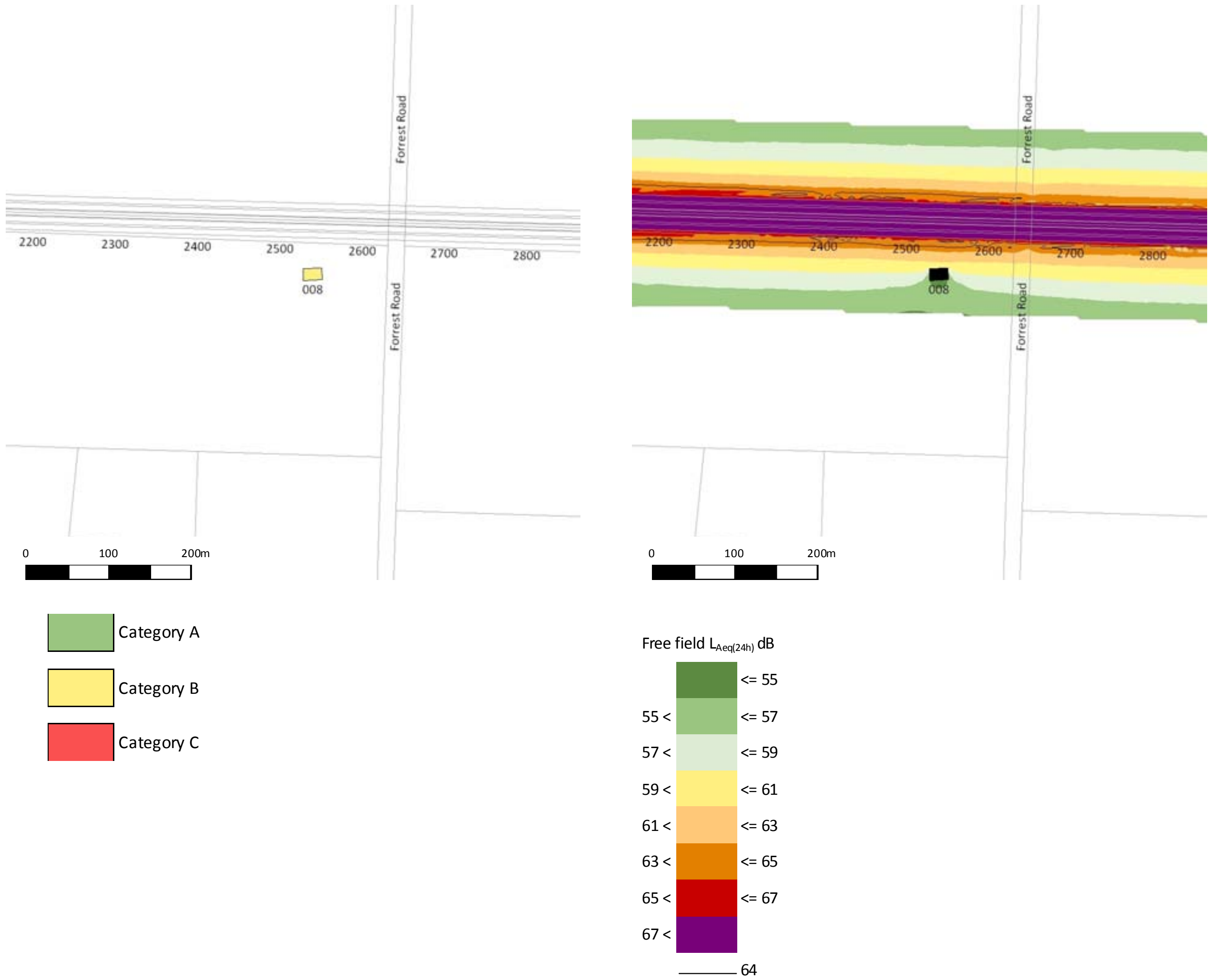
PPF 008 is isolated from other PPFs and is assessed on its own. The property is close to the Expressway and in Category B in the do-minimum scenario. Noise mitigation design features investigated included barriers, of heights 1 to 4 metres, either in the form of a wall or a bund.

Barriers had limited effectiveness unless 4 metres high. A wall of this height was considered by the Project team to create significant adverse visual and social effects; and there is not space for any effective bund to be contained within the designation. A bund would need to be located on private property but the residents of PPF 008 have planted their property boundary facing the existing designation and these plantings would be disturbed in providing the bund.

Best Practicable Option

Because of the limited effectiveness of barriers at this location, unless barriers are 4 metres high, the BPO was considered to be the do-minimum design, that is, no additional barrier. The BPO is depicted in Figure 5-4. The left hand diagram shows the PPFs colour-coded according to the NZS 6806 noise category. The right hand diagram shows the noise contours of the BPO as modelled.

Figure 5-4 BPO for PPF 008



5.4.3 PPF 009: 215 Peake Road

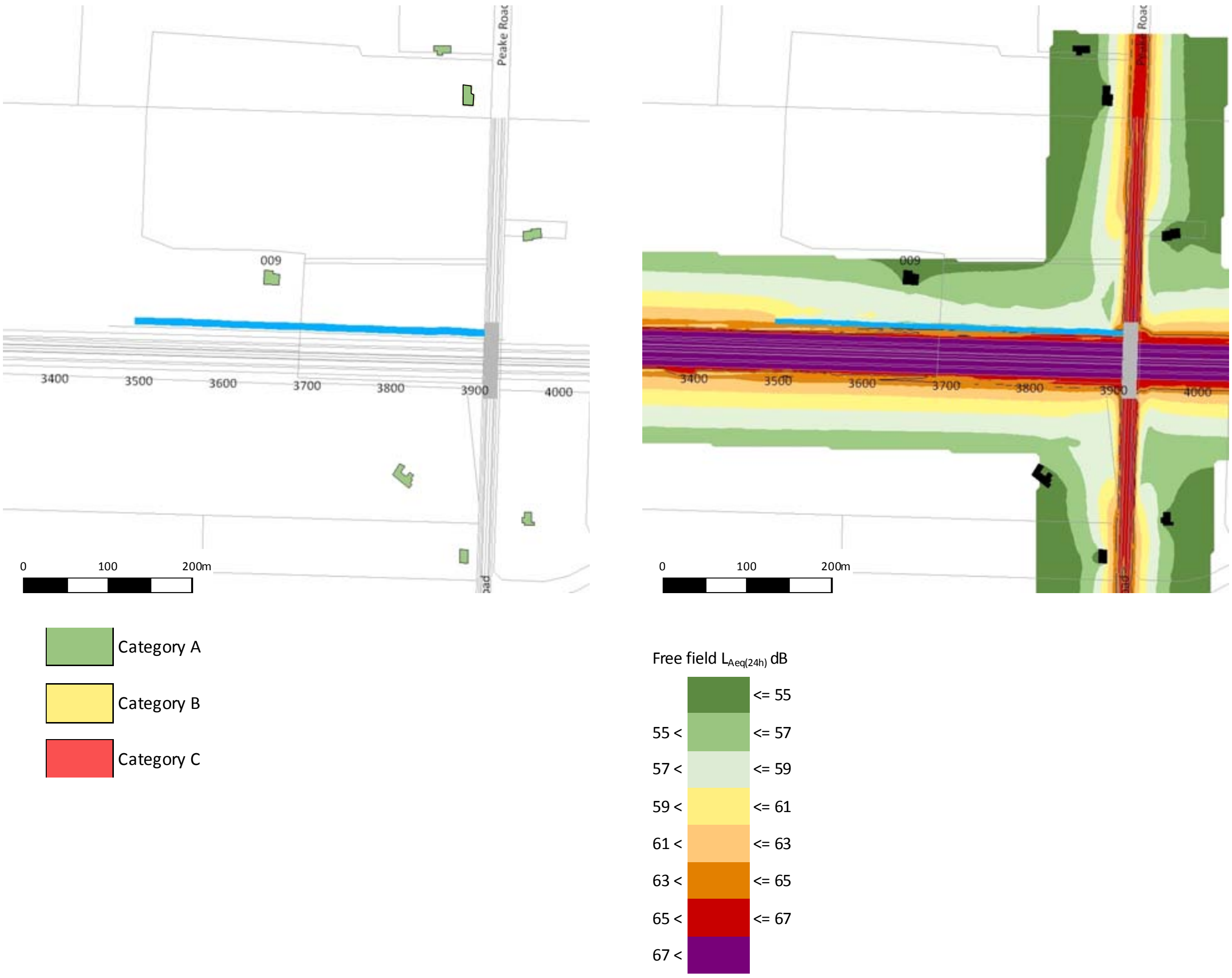
Though there are other PPFs relatively near to PPF 009, noise mitigation here has little impact on noise levels for any other PPF, so PPF 009 is assessed on its own. The property is close to the Expressway and in Category B in the do-minimum scenario. Noise mitigation design features investigated included barriers, of heights 1 to 4 metres, either in the form of a wall or a bund.

The minimum barrier height to achieve a Category A noise level is 3 metres. There is space for a bund of this height to be contained within the designation. A bund is preferred rather than a wall by the specialist team, because of the visual and social impacts of a wall; and a bund can be formed with some of the surplus fill expected from construction of the Project. A 3 metre high bund provides a 2 dB reduction in noise level for PPF 009. Whilst this noise reduction is not as large as that recommended in NZS 6806, this is deemed acceptable because of the additional costs that would be incurred if the surplus fill is not utilised.

Best Practicable Option

The BPO is a 400 metre section of 3 metre high bund north from the banking for the Peake Road overbridge, chainage 3500 to ≈3900. The BPO is depicted in Figure 5-5. The left hand diagram shows the PPFs colour-coded according to the NZS 6806 noise category. The right hand diagram shows the noise contours of the BPO as modelled.

Figure 5-5 BPO for PPF 009



5.4.4 PPF 044 to PPF 083: Area of houses near Saffron Street

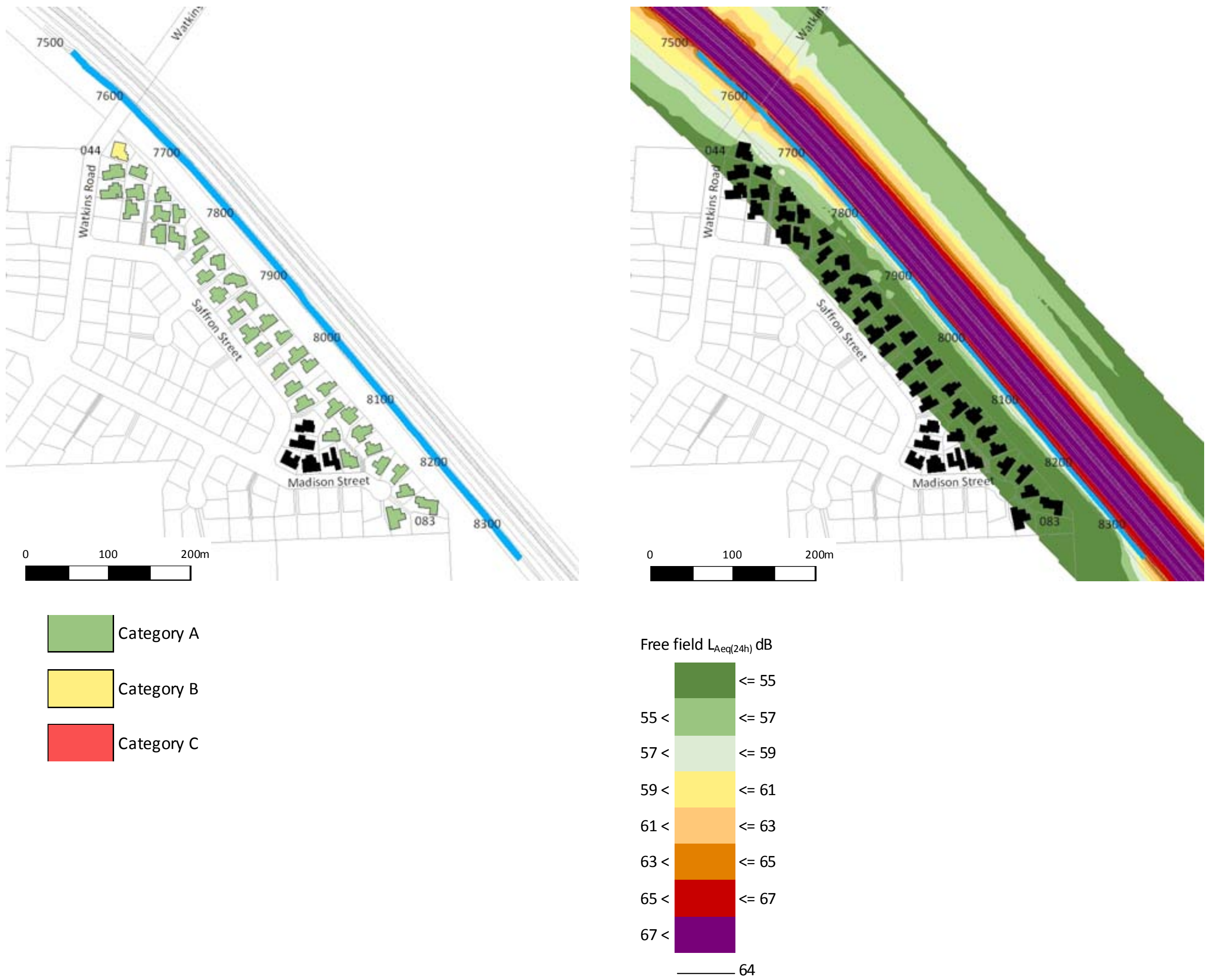
PPF 044 to PPF 083 are within a subdivision and are considered as a cluster as mitigation of the PPFs is interdependent. The majority of PPFs within the cluster are in Category A in the do-minimum scenario. A few PPFs are in Category B in the do-minimum scenario, with noise levels exceeding the Category A criteria by only 1 dB. Noise mitigation design features investigated included barriers, of heights 1 to 4 metres, either in the form of a wall or a bund.

Through the investigation and workshop, an 800 metre long 2 metre high bund was nominated as the BPO. The bund height of 2 metres achieves a Category A noise level for all PPFs in the cluster except PPF 044; and that single PPF in Category B exceeds Category A by only 1 dB. The Project team also considered a bund offered social benefits by providing distinct separation between the recreational/walking area (adjacent to the PPFs) and the Expressway. A bund is preferred rather than a wall from the perspectives of visual impacts as, with planting, it can be readily integrated into the landscape. A bund has practicability in that it can assist in containing flooding and can be formed with some of the surplus fill expected from construction of the Project.

Best Practicable Option

The BPO around PPF 044 to PPF 083 is an 800 metre section of 2 metre high bund, chainage 7550 to 8350. The BPO is depicted in Figure 5-6. The left hand diagram shows the PPFs colour-coded according to the NZS 6806 noise category. The right hand diagram shows the noise contours of the BPO as modelled.

Figure 5-6 BPO for PPF 044 to PPF 083



5.4.5 PPF 161: 276 Tirau Road

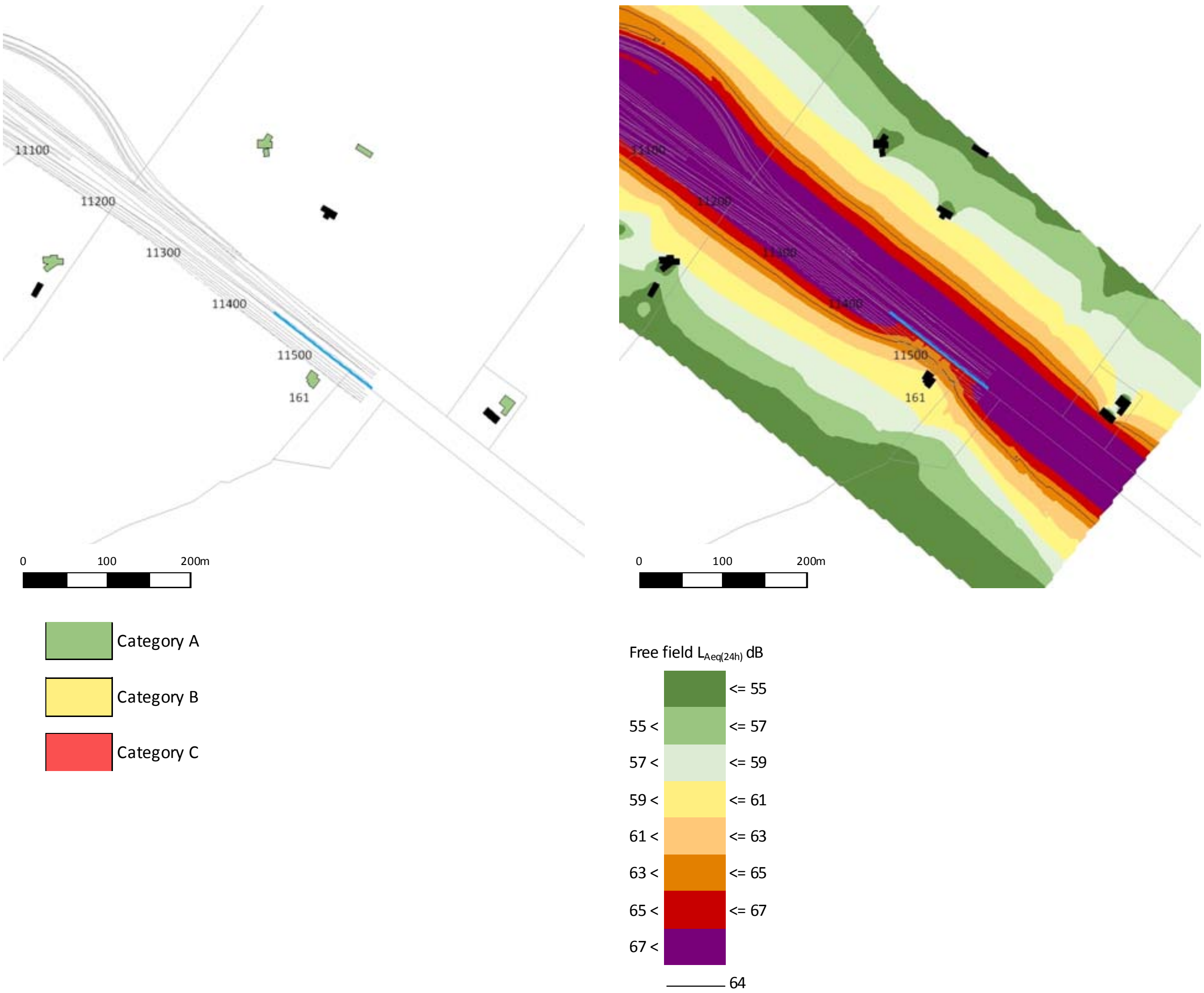
At the southern connection of the Project, a local access road will be provided. To prevent headlight glare, a screening barrier or separator is needed between the local access road and the Expressway. A separator will be provided as part of the do-minimum design, as it is required for reasons other than noise mitigation.

The noise level at PPF 161 exceeds Category B in the do-minimum scenario. The most practicable type of noise mitigation design feature for PPF 161 is to stipulate some height and length of the separator to be provided with noise attenuating properties. The separator was modelled as noise attenuating for a range of separator heights and lengths, to refine the best practicable noise mitigation design feature.

Best Practicable Option

The BPO for PPF 161 is to design the screening barrier/separator as noise attenuating for at least a 150 metre section of 2.5 metres high. The BPO reduces the PPF 161 noise level by 5 dB. The BPO is depicted in Figure 5-7. The left hand diagram shows the PPFs colour-coded according to the NZS 6806 noise category. The right hand diagram shows the noise contours of the BPO as modelled.

Figure 5-7 BPO for PPF 161



5.5 Best Practicable Option noise levels

The noise mitigation design features of the BPO are summarised in Table 5-3.

Table 5-3 Noise mitigation design features of BPO

General area	Chainage	Side	Type	Length (m)	Height (m)
Discombe Road	1300 to 1550	North	Wall	250	3
Peake Road	3500 to 3900	North	Bund	400	3
Saffron Street	7550 to 8350	Southwest	Bund	800	2
Southern interchange	11450 to 11600	Southwest	Wall/separator	150	2.5

Predicted road-traffic noise levels for the do nothing (for those PPFs on altered roads), do-minimum and BPO scenarios are shown in Table 5-4. The noise level is shaded green if the noise level is within its NZS 6806 Category A limit, yellow if it is in Category B and red if it exceeds Category B.

The spread of noise along the full length of the Project with the BPO set of noise mitigation design features implemented is illustrated in **Appendix D.**

Table 5-4 Do-minimum $L_{Aeq(24h)}$ noise levels and BPO $L_{Aeq(24h)}$ noise levels (dB)

PPF	Address	NZS 6806 Cat. A limit	NZS 6806 Cat. B limit	Do-minimum (2026)	BPO (2026)
002	1328B SH1	64	67	61	61
006	251 Discombe Road	57	64	63	58
007	245A Discombe Road	57	64	62	58
008	109 Forrest Road	57	64	60	60
009	215 Peake Road	57	64	58	56
010	207 Peake Road	64	67	55	55
011	191 Peake Road	64	67	51	51
012	257 Peake Road	64	67	54	54
014	249 Peake Road	64	67	58	58
015	197 Peake Road	64	67	61	61
016	234 Peake Road	64	67	56	56
017	198 Peake Road	64	67	56	56
021	142 Hannon Road	57	64	55	55
023	162 Hannon Road	57	64	54	54
024	183 Victoria Road	64	67	56	56
032	115 Victoria Road	64	67	58	58
033	111 Victoria Road	64	67	62	62
034	99 Victoria Road	64	67	59	59
036	100 Laurent Road	64	67	62	62
037	137 Swayne Road	57	64	57	57
038	170 Swayne Road	64	67	53	53
040	100 Swayne Road	64	67	51	51
041	102 Swayne Road	64	67	52	52
042	116 Swayne Road	57	64	56	56
044	40 Watkins Road	57	64	58	58
045	38 Watkins Road	57	64	51	51
046	36 Watkins Road	57	64	47	46
047	3C Saffron Street	57	64	57	56

PPF	Address	NZS 6806 Cat. A limit	NZS 6806 Cat. B limit	Do-minimum (2026)	BPO (2026)
048	3B Saffron Street	57	64	53	52
049	3A Saffron Street	57	64	48	48
050	5B Saffron Street	57	64	57	55
051	5A Saffron Street	57	64	49	48
052	5 Saffron Street	57	64	46	45
053	7A Saffron Street	57	64	57	55
054	7 Saffron Street	57	64	52	50
055	9B Saffron Street	57	64	58	55
056	9 Saffron Street	57	64	54	51
057	11A Saffron Street	57	64	57	53
058	11 Saffron Street	57	64	48	46
059	13A Saffron Street	57	64	58	54
060	13 Saffron Street	57	64	48	47
061	15A Saffron Street	57	64	57	54
062	15 Saffron Street	57	64	48	47
063	17A Saffron Street	57	64	58	54
064	17 Saffron Street	57	64	49	47
065	19A Saffron Street	57	64	58	54
066	19 Saffron Street	57	64	47	46
067	21A Saffron Street	57	64	58	54
068	21 Saffron Street	57	64	47	46
069	23 Saffron Street	57	64	58	54
070	25 Saffron Street	57	64	50	48
071	27A Saffron Street	57	64	58	54
072	27 Saffron Street	57	64	49	47
073	29A Saffron Street	57	64	55	52
074	29B Madison Street	57	64	57	54
075	29A Madison Street	57	64	48	46
076	31B Madison Street	57	64	57	53
077	29 Madison Street	57	64	47	46
078	31A Madison Street	57	64	56	52
079	31 Madison Street	57	64	55	52
080	33 Madison Street	57	64	57	53
081	35 Madison Street	57	64	54	51
082	36A Madison Street	57	64	49	48
083	38A Madison Street	57	64	56	52
084	1 Soma Place	57	64	50	49
085	3 Soma Place	57	64	51	50
086	5 Soma Place	57	64	52	51
087	7 Soma Place	57	64	56	56
088	9 Soma Place	57	64	54	54
089	11 Soma Place	57	64	54	54
090	13 Soma Place	57	64	55	55
091	15 Soma Place	57	64	53	53
092	12 Soma Place	57	64	45	45
093	7A Durmast Court	57	64	55	55
094	7 Durmast Court	57	64	46	46
095	9 Durmast Court	57	64	54	54
096	10 Durmast Court	57	64	53	53
097	6 Durmast Court	57	64	46	46

PPF	Address	NZS 6806 Cat. A limit	NZS 6806 Cat. B limit	Do-minimum (2026)	BPO (2026)
098	8 Durmast Court	57	64	53	53
099	21 Burr Street	57	64	46	46
100	23 Burr Street	57	64	54	54
101	25 Burr Street	57	64	53	53
102	26 Burr Street	57	64	53	53
103	24 Burr Street	57	64	53	53
104	22 Burr Street	57	64	53	53
105	20 Burr Street	57	64	53	53
106	18/16 Burr Street	57	64	46	46
107	3/4 Walter Court	57	64	54	54
108	12/14 Burr Street	57	64	46	46
109	11/12 Walter Court	57	64	46	46
110	5/6 Walter Court	57	64	54	54
111	9/10 Walter Court	57	64	48	48
112	7/8 Walter Court	57	64	54	54
113	37 St Kilda Road	64	67	54	54
114	42 St Kilda Road	64	67	57	57
115	205 Thornton Road	64	67	56	56
116	30 St Kilda Road	64	67	58	58
117	213 Thornton Road	64	67	56	56
118	≈196 Thornton Road	64	67	59	59
120	1/213 Thornton Road	64	67	61	61
121	206 Thornton Road	64	67	62	62
122	204 Thornton Road	64	67	55	55
123	194 Thornton Road	64	67	50	50
125	202 Thornton Road	64	67	49	49
126	2/194 Thornton Road	64	67	47	47
128	212 Thornton Road	64	67	50	50
129	4/194 Thornton Road	64	67	45	45
130	218 Thornton Road	64	67	52	52
131	222 Thornton Road	64	67	56	56
132	2/218 Thornton Road	64	67	50	50
133	214 Thornton Road	64	67	49	49
135	1 Athlone Drive	64	67	58	58
136	220 Thornton Road	64	67	49	49
137	241 Thornton Road	64	67	61	61
138	65 Athlone Drive	64	67	52	52
139	115 Athlone Drive	64	67	50	50
140	252 Thornton Road	64	67	60	60
141	236 Thornton Road	64	67	56	56
142	201 Athlone Drive	64	67	51	51
143	196 Athlone Drive	57	64	47	47
144	260 Thornton Road	64	67	54	54
145	281 Athlone Drive	57	64	54	54
146	242 Athlone Drive	57	64	51	51
147	264 Thornton Road	64	67	59	59
148	258 Thornton Road	64	67	50	50
149	282 Athlone Drive	57	64	47	47
150	268 Thornton Road	64	67	50	50
152	330 Athlone Drive	57	64	49	49

PPF	Address	NZS 6806 Cat. A limit	NZS 6806 Cat. B limit	Do-minimum (2026)	BPO (2026)
153	270 Thornton Road	64	67	49	49
154	370 Athlone Drive	57	64	55	55
155	≈207 Tirau Road	57	64	55	54
156	178 Tirau Road	64	67	57	57
158	190 Tirau Road	64	67	55	55
159	246 Tirau Road	64	67	59	59
160	259 Tirau Road	64	67	57	57
161	276 Tirau Road	64	67	68	63

Noise levels are calculated for traffic volumes modelled for the year 2026 with the do-minimum road surfacing of OGPA in place. The OGPA road surfacing has a significant noise reduction benefit and it should be installed as soon as practicable.

For the OGPA road surfacing, its soonest practicable installation is often approximately one year after installation of an initial road surface, to allow for settling of the pavement prior to laying of the premium OGPA road surfacing. However, for specific projects, this settling period duration will be set by the pavement design.

Traffic volumes and hence road-traffic noise levels just after Project completion will be less than those of the design year (2026), by about 1 dB. An interim road surface needs to be used over this settling period. If a small chipseal, for example a Grade 4 chipseal, was used, then the noise from this interim surfacing would be about 2 dB more than if OGPA had been used from the outset. Allowing for the effect of the initial lower traffic volume on noise, then noise for this interim period will be only about 1 dB more than the 2026 noise levels with OGPA in place.

5.6 The Best Practicable Option scenario outcomes near “altered roads”

NZS 6806 compares future noise levels with noise levels that would have occurred at 2026 but without the project having been built. These noise levels are referred to as the “Do nothing” option. This enables a better comparison of the effects of the project. Often in areas experiencing significant development traffic volumes and hence noise can increase from this local growth alone. In the Cambridge area there are some instances where there is expected to be a large growth in traffic on local roads by 2026. For example, Thornton Road has a large growth in traffic due to the St Kilda Waterways subdivision being developed.

Table 5-5 shows the noise levels of the do nothing scenario of 2026 calculated for those PPFs near local roads compared with the noise levels of the BPO scenario. This comparison is limited to only those properties near local roads, as it is both difficult and not reliable to predict future noise levels of properties at a distance from roads.

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

PPF	Address	Do-nothing (2026)	BPO (2026)
002	1328B SH1	59	61
010	207 Peake Road	49	55
011	191 Peake Road	49	51
012	257 Peake Road	52	54
014	249 Peake Road	57	58
015	197 Peake Road	60	61
016	234 Peake Road	57	56
017	198 Peake Road	56	56
024	183 Victoria Road	55	56
032	115 Victoria Road	58	58

PPF	Address	Do-nothing (2026)	BPO (2026)
033	111 Victoria Road	62	62
034	99 Victoria Road	59	59
036	100 Laurent Road	62	62
038	170 Swayne Road	51	53
040	100 Swayne Road	47	51
041	102 Swayne Road	45	52
113	37 St Kilda Road	53	54
114	42 St Kilda Road	57	57
115	205 Thornton Road	56	56
116	30 St Kilda Road	58	58
117	213 Thornton Road	56	56
118	≈196 Thornton Road	58	59
120	1/213 Thornton Road	61	61
121	206 Thornton Road	62	62
122	204 Thornton Road	55	55
123	194 Thornton Road	50	50
125	202 Thornton Road	48	49
126	2/194 Thornton Road	47	47
128	212 Thornton Road	49	50
129	4/194 Thornton Road	42	45
130	218 Thornton Road	51	52
131	222 Thornton Road	56	56
132	2/218 Thornton Road	46	50
133	214 Thornton Road	45	49
135	1 Athlone Drive	58	58
136	220 Thornton Road	48	49
137	241 Thornton Road	61	61
138	65 Athlone Drive	51	52
139	115 Athlone Drive	47	50
140	252 Thornton Road	59	60
141	236 Thornton Road	49	56
142	201 Athlone Drive	45	51
144	260 Thornton Road	54	54
147	264 Thornton Road	59	59
148	258 Thornton Road	49	50
150	268 Thornton Road	49	50
153	270 Thornton Road	48	49
156	178 Tirau Road	60	57
158	190 Tirau Road	56	55
159	246 Tirau Road	55	59
160	259 Tirau Road	53	57
161	276 Tirau Road	64	63

Table 5-5 shows the existing road is the dominant noise source for these PPFs. Comparing the do-nothing scenario with the BPO scenario shows the noise levels are in same in many cases. In most other cases, the change in noise is only 1 dB or 2 dB $L_{Aeq(24h)}$.

For these PPFs, the noise environment once the Project is completed will be much the same as what it would have been if the Project was not in place.

5.7 Future developments near the Project

There are several areas adjacent the existing designation that are currently undeveloped but are already zoned (or planned) for future residential development. On the eastern side of the Project, a residential development referred to as St. Kilda Waterways is planned for the generalised area between Watkins Road and Thornton Road. On the western and southern sides of the Project (between Victoria Road and Watkins Road), an area is zoned as deferred residential.

NZS 6806 focuses on the noise level at an affected premise rather than on the noise level at the boundary of a property on which a premise stands or may stand. It is necessary that there be some point in time that provides a cut-off for existing premises that can be considered in the project design. Where a designation is being sought, this cut-off point is usually the point at which the project Notice of Requirement is lodged.

There is necessity for this cut-off point in time. Noise propagation is highly dependent on any features that are in the propagation path. Therefore if the specific PPF location is not known, it is difficult to plan any necessary mitigation. Secondly, the purpose of the designation process is to advise the intended use of the land. In this case, the documentation around this process indicates the nature of the road design, traffic volumes, and consequently the expected road-traffic noise. This provides adequate information to be available for land developers to allow adaptation to their development and building designs or intentions to provide a highly liveable environment on their developments.

In the case of this Project, it is recognised that along large parts of the route, the new road will raise noise levels from the existing low ambient noise levels. However, the designation has been in place for the Project for over thirty years. All developments and land owners in this area have therefore either had the knowledge or the opportunity to learn a road would be constructed along this route at some time.

This current assessment has been undertaken because the designation is sought to be adjusted, particularly widened. Relative to the current designation the extent that the designation change will change the noise effects is minor for all PPFs along the route. Notably in the area where the road is in cut, noise levels will generally be less than expectations under the existing designation.

This noise assessment shows that for almost all locations along the route where buildings are not currently located, (if the Project is constructed with no further mitigation beyond the do-minimum design) then buildings could be built within a Category B noise environment. With minor bunding or by moving building locations slightly away from the designation, Category A noise environments could readily be achieved.

For the St. Kilda Waterway development, no premises exist (and none have a building consent) within the defined study area, so application of NZS 6806 requires no further consideration for that area. However, this report in its discussion of the BPO for PPF 044 to PPF 112 illustrates the noise levels that are likely to occur within the St. Kilda Waterways area. Noise levels at the closest possible position that a St. Kilda Waterways house could be built are well within the Category B target of NZS 6806. This is seen as a highly acceptable noise environment. It is a requirement on the St. Kilda Waterway development that no buildings are commenced until finalisation of the Expressway boundaries (or 1 January 2012).[16]

For the area of deferred residential zoning (between Watkins Road and Victoria Road), the contours illustrating spread of road-traffic noise (included in **Appendix D)** indicate that the Category A noise environment (57 dB) is achieved at about 60 metres from the carriageway edge.

[16] Section 2-164 Waipa district Plan

6 Conclusions on operational road-traffic noise effects

The Project will be built in an area which, away from the areas near existing major State highways, is currently a low noise environment ($L_{Aeq(24h)}$ 50 dB or less). Operation of road-traffic on the Project will increase noise levels for properties that are near to the Project, that is within approximately 100 to 200 metres, but which are currently distant from the State Highways or local roads.

A designation for the Project has existed for many years. A widened designation is now sought. Compared to noise levels that could arise from the existing designation, the changes in noise levels due to the Project in the proposed widened designation are very minor.

The operational noise impacts of the Project have been assessed using NZS 6806: 2010. With the route operational and with mitigation in place, 140 of the 144 of the assessed premises and facilities to be protected (PPFs) have noise environments in the best category of NZS 6806, Category A. Four of the PPFs assessed have noise levels in Category B, but towards the quieter portion of Category B.

On land currently undeveloped (but which could be developed in the future), the noise levels caused by operation of the Project are such that most housing would readily have a Category B noise environment. And, simple measures, such as set back or bunding or house location and design, could be provided by the developer for an even better noise environment.

The operational noise impacts of the Project are therefore slightly negative because noise levels will increase, but minor as the increased noise is still reasonable because it conforms to applicable New Zealand Standards. Therefore the proposed widening of the designation is not significant with respect to noise levels.

7 Construction noise assessment

The majority of the Project is to be constructed through a greenfields route from State Highway 1 near Discombe Road to south of the Cambridge Golf Course. The main construction activity is the earthworks, with excavation and road formation of this approximately 11.4 kilometre route. The Project involves closure of four local roads, construction of four defined drain crossing points (including the Karapiro Stream Bridge crossing), construction of seven bridges, and construction of several hundred metres of retaining walls. The Project also includes the construction of approximately 70 cross-highway culverts to provide conveyance of overland flows across the designation. The proposed programme of works shows construction extending over four years from September 2012 to May 2016, but this period may be shortened through innovative construction techniques.

Figure 7-1 and Figure 7-2 illustrate typical cross sections of the Project; first when the Project is in open ground as it is for most of its length, and second when the Project is in cut as it is in the vicinity of the Karapiro Stream Gully.

Figure 7-1 Typical cross section for the Project in open ground

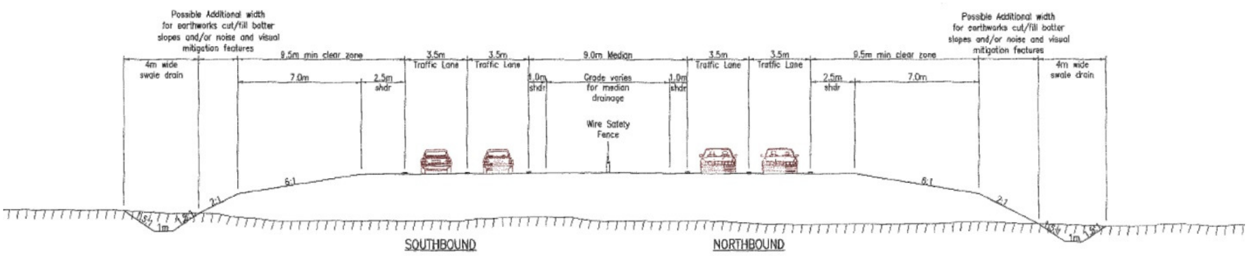


Figure 7-2 Typical cross section for the Project in cut

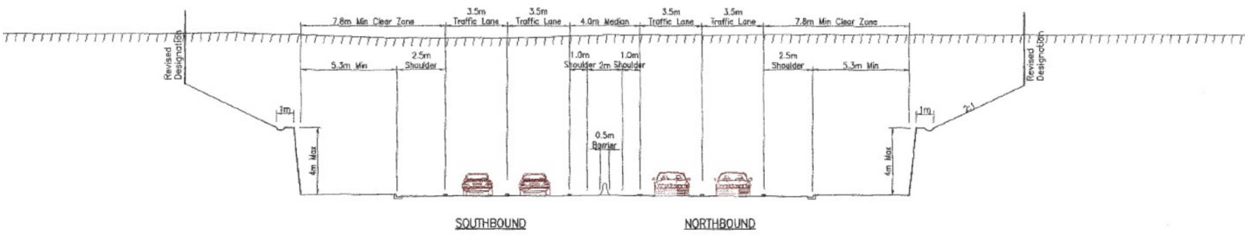


Figure 7-1 shows that construction of the carriageway starts 9.5 metres closer to the premises than the distance to the nearside road edgeline, and also extends a further 34.5 metres away from the nearside road edgeline to give a construction strip of about 44 metres wide. Minor construction of the swales comprises a further 4 metres on either side of this main construction strip.

Figure 7-2 is similar to Figure 7-1 except the edge of the major cut is 14 metres from the road edgeline and the width of the cutting is approximately 54 metres.

Forming the road corridor and building the road will require substantial amounts of materials to be moved both off site and onto the site. The total amount of material to be moved is calculated to be

- 200,000 m^3 of topsoil stripping to stockpile for re-spreading onto batters;
- 350,000 m^3 of cut material to be used as structural fill (with treatment);
- 230,000 m^3 of cut material to be used as structural fill (without treatment);
- 200,000 m^3 of cut to waste (these may be spread over the structural fill batters to flatten the slopes);

- 230,000 m^3 of imported structural fill.

Moving this material through the surrounding State highway road network is estimated to increase the number of heavy vehicles on the State highway network by 98 to 114 movements on any one particular road per day. The State highway network around Cambridge already carries from 500 heavy vehicles per day (State Highway 1B) to 2,000 heavy vehicles per day (State Highway 1). Although the additional truck movements associated with construction of the Project may appear numerous, they are only a minor proportion of existing flows.

In addition to the main Expressway, three overbridges need to be constructed to maintain the local road network. These overbridges require earth fill for approach ramps and concrete bridge structures. During construction of the overbridges, affected local roads will be temporarily realigned.

A major concrete bridge also needs to be constructed across the Karapiro Stream. At each end of the Project length an overbridge provides connection to the bypassed section of State Highway 1.

The operational road-traffic noise assessment has defined a study area, generally 100 metres (or 200 metres) from the edgeline of the Expressway. This study area includes a number of individual premises, or clusters of premises, close to the Project. These are also the premises that are most useful in considering the noise impacts of construction of the Project and setting appropriate construction noise limits. Table 7-1 shows the proximity of those premises closest to the Expressway nearside road edgeline.

Table 7-1 Premises, or clusters of premises, closest to the Project

Premise or cluster of premises	Expressway chainage	Metres to nearside road edgeline	Metres to main construction	Metres to bund/wall
PPF 006 and PPF 007	1420	16	6	10
PPF 008	2550	32	22	-
PPF 009	3660	65	55	40
PPF 021	5250	56	46	-
PPF 023	5300	80	70	-
PPF 037	6450	70	60	-
PPF 042 Childcare centre	6900	46	36	-
PPF 044 to PPF 083	7650 to 8250	54	44	29
PPF 084 to PPF 112	8400 to 8900	54	40	-
PPF 161	11550	35	25	-

7.1 Methodology for assessment of construction noise and identifying appropriate noise limits

The first part of the methodology is to determine the noise from a reasonable level of construction activity, so as to be certain that the noise limits adopted do not prevent construction taking place with a reasonable level of activity. At this time, the assessment of probable construction noise levels is a preconstruction assessment and is set out in **Appendix E.** It is expected that once a contractor is appointed and the actual construction equipment and method is determined, then this preconstruction assessment of noise levels would be recalculated as part of developing the Construction Noise Management Plan.

The probable noise levels calculated in the preconstruction assessment were compared with Table 2 or Table 3 of NZS 6803: 1999, as applicable. If the calculated noise was within the limits of NZS 6803: 1999 then Table 2 or Table 3 was adopted as the appropriate noise limit. If the calculated noise was greater than the NZS 6803: 1999 limits, this was taken as a strong indication that the desirable noise limits of NZS 6803: 1999 may be impractical and prevent reasonable construction. Therefore further consideration was given as to other factors that may warrant that higher noise limits be provided. This practice is in accord with Clause 7.4 of the NZS 6803: 1999 which gives emphasis that the BPO in managing noise be used, and that a local authority could approve construction with noise levels higher than the desirable limits of NZS 6803: 1999; it is in accord with the District Plans in that the District Plans reference NZS 6803; and in accord with the RMA's requirement to use the BPO to manage noise emissions.

7.2 Desirable noise levels

Table 2 of NZS6803:1999 sets out desirable noise limits for work of normal duration, and recommends that these limits be decreased for work of long duration, that is, more than 18 weeks. However, it is common for the noise limits for work of normal duration to be applied to road construction projects, even those of two to three years duration, because the noise of road construction differs from most other construction in several ways:

1. Most sites of road construction are long. The site for this Project is approximately11 kilometres long. Long sites often have construction activity occurring simultaneously at numerous areas along the site. Typically only one to four, but sometimes more, items of plant or machinery would be operating at any one area at any time, but many times there may be no activity nearby.
2. While the duration of a road construction may be long, in this case expected to be about 4 years, road construction over a long route is notable for its intermittent character. Phases of work will occur in one area, then pause either while that phase is continued in other sections and/or to allow periods for settling of any fill or underlying materials or for the hardening of structural elements to occur before continuing with the next phase.
3. Relative to any fixed (receiver) location, the construction activity centres move nearer and further away as different works progress. Thus, any one (receiver) location is affected by construction activity for only a portion of the full construction period.

Table 7-2 below is Table 2 from NZS 6803: 1999. This is the part of the table that is for work of normal duration as the acceptability of not applying the reduction for work of long duration identified. These noise limits are, as NZS 6803 describes, the desirable upper limits to construction noise for residential areas. These limits should not be exceeded unless it is not practical to achieve them or unless a higher general ambient noise level means that higher construction noise limits would, if necessary, be acceptable.

Table 7-2 which is part of Table 2 of NZS 6803

Time	Noise limits (dB)					
	Weekday		Saturday		Sunday/public hol.	
	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}
6:30 am through to 7:30 am	60	75	45	75	45	75
7:30 pm through to 6:00 pm	75	90	75	90	55	85
6:00 pm through to 8:00 pm	70	85	45	75	45	75
8:00 pm through to 6:30 am	45	75	45	75	45	75

The preconstruction assessment of construction noise, contained in **Appendix E**, shows that for most PPFs where construction activity is about 40 metres distant from PPFs, L_{Aeq} noise levels will be between 58 and 75 dB. For PPFs at closer distances, L_{Aeq} noise levels will be about 70 to 80 dB while work is centred close to these PPFs.

Setting aside PPF 006, because it is a special case, the construction activity near, for example PPF 008, the childcare centre at PPF 042, and PPF 161 could all be achieved if the noise limits were 80 dB as the daytime limit. This value is equivalent to the noise limit for work of short term duration, so is therefore not considered abnormal. It is recommended that this departure from the desirable noise limits be confined to the period that most people would consider the increased noise level most acceptable, that is the period 7:30 am to 6:00 pm Monday to Saturday. Outside of this period, the noise limits should be the normal desirable noise limits. These noise limits will therefore limit the timing of the noisiest activities so that they occur within the main daytime hours.

Table 7-3 and Table 7-4 show the noise limits therefore recommended.

Table 7-3 Construction noise limits recommended: General area

Time	Noise limits (dB)	
	L_{Aeq}	L_{Amax}
Monday through Friday 7:00 am through to 7:30 am	60	75
Monday through Friday 7:30 am through to 6:00 pm	75	90
Monday through Friday 6:00 pm through to 8:00 pm	70	85
Saturday 7:00 am through to 6:00 pm	75	90

Table 7-4 Construction noise limits recommended: Within 40 metres of PPFs

Time	Noise limits (dB)	
	L_{Aeq}	L_{Amax}
Monday through Saturday 7:00 am through to 7:30 am	60	75
Monday through Friday 7:30 am through to 6:00 pm	80	95
Monday through Friday 6:00 pm through to 8:00 pm	70	85
Saturday 7:30 am through to 6:00 pm	80	95

7.3 Building overbridges

The activities in building the overbridge approach ramps for the local roads at Peake Road, Swayne Road, and Thornton Road are similar to the construction activities for the main Expressway. Several PPFs, such as PPF 015, PPF 016, PPF 017, PPF 131, and PPF 135, will be close to the approach ramp and bridge construction activity, but the same noise limits to address high noise as proposed in the previous section will apply to building the overbridges and approach ramps.

7.4 Construction traffic on roads

The noise of construction traffic on public roads is not under special control but is generally controlled under the Land Transport: Vehicle Equipment Rules regulation for noise of individual vehicles. Using the traffic volumes and percentage heavy vehicles currently using the nearby road network and using the forecast increase from construction traffic, the relative noise increases for each of the State highways in the area have been calculated. These are:

SH21	0.2 dB increase to $L_{Aeq(24h)}$
SH1 north of works	0.2 dB increase to $L_{Aeq(24h)}$
SH1B	0.3 dB increase to $L_{Aeq(24h)}$
SH1 in Cambridge	0.1 dB increase to $L_{Aeq(24h)}$
SH1 south of works	0.7 dB increase to $L_{Aeq(24h)}$

These noise level increases are not at all significant and would not be detected by most people.

7.5 Night time work

No night time work is intended. However, should it be required by an emergency, NZS 6803 does not place noise limits on emergency work. If non-urgent work is required, the need for it and appropriate noise restrictions would normally be negotiated with Council officers at that time.

7.6 Construction Noise Management Plan

The most effective method to control construction noise is through proactive management. To ensure this occurs, it should be a requirement on the contractor to prepare a Construction Noise Management Plan as part of the Construction Management Plan. The Construction Noise Management Plan should detail consultant and contractor obligations during the construction, and will include details such as:

- Description of the works, anticipated equipment processes/durations;
- Identification of the most affected houses where noise limits apply;
- Applicable noise limits, including any consent/designation condition requirements;
- Assessment of construction noise levels;
- Appropriate noise mitigation measures to be implemented;
- Establishing a monitoring regime which targets both the more noisy activities and their potential occurrences near noise-sensitive locations;
- Staff training/awareness programme;
- Procedures for maintaining contact with stakeholders, including informing them when noisy activities may occur and providing summary reports of monitoring and investigations of any noise complaints;
- Process for managing noise complaints; and
- Contact telephone numbers for key construction staff, staff responsible for noise assessment and Council offices, plus a single point of contact to immediately advise of concerns about noisy activities.

8 Conclusions on construction noise effects

1. NZS 6803: 1999 is the appropriate standard to apply for assessing and limiting noise of construction activity.
2. The construction traffic using the public roads is expected to have almost no impact on noise levels.
3. Substantial construction activity is intended. Almost all of the work is expected to be undertaken within the desirable upper noise limits of NZS 6803.
4. Some work will occur close to premises. A moderate increase in noise limits for daytime work will allow the required work to proceed but still keep noise at reasonable levels.
5. Recommended construction noise limits are shown in Table 7-3 and Table 7-4.
6. A Construction Noise Management Plan should be prepared and implemented for the Project.

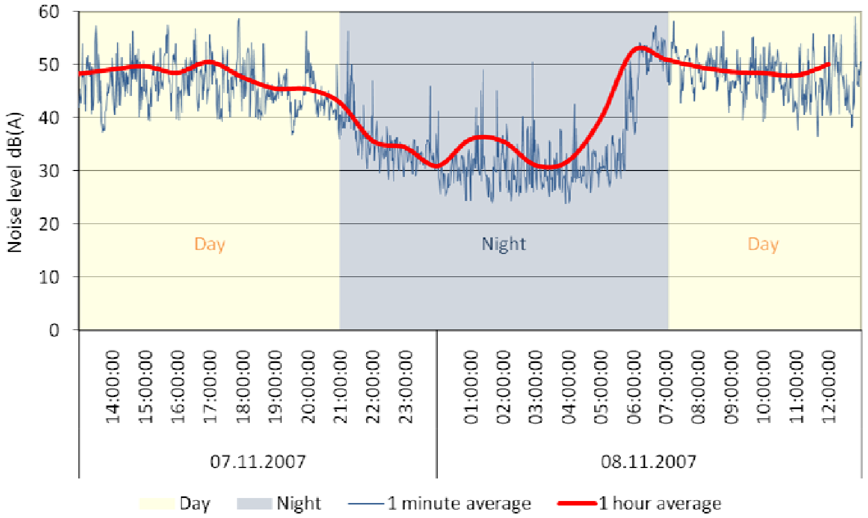
Glossary

Abbreviation	Meaning
AADT	Annual average daily traffic
AC	Asphaltic concrete
AEE	Assessment of effects on the environment
BCR	Benefit-cost ratio
BPO	Best practicable option
CNMP	Construction noise management plan
CRTN	Calculation of road traffic noise
dB	Decibels
HV	Heavy vehicle
Hz	Hertz
NoR	Notice of requirement for designation
NZS	New Zealand Standard
NZTA	NZ Transport Agency
OGPA	Open graded porous asphalt
PPF	Protected premises and facilities
RMA	Resource Management Act 1991
SH1	State Highway 1
SH1B	State Highway 1B
SMA	Stone mastic asphalt
WECS	Waikato Expressway Cambridge Section
vpd	Vehicles per day
Term	**Definition**
Annual average daily traffic	The total volume of traffic passing a roadside observation point over the period of a calendar year, divided by the number of days in that year (365 or 366 days). Measured in vehicles per day.
Asphaltic concrete	Asphaltic concrete is a blend of aggregate and bitumen, usually hot mixed in a special plant then laid hot by a paving machine. The aggregate in asphaltic concrete is continuously graded with an even distribution of aggregate size from coarse to fine. This type of road surface has a high load carrying capacity and a low design air void content.
Best practicable option	Defined in section 2 of the RMA as: "in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to - (a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and (b) the financial implications, and the effects on the environment, of that option when compared with other options; and (c) the current state of technical knowledge and the likelihood that the option can be successfully applied."
Centreline	The basic line, at or near the centre or axis of a road or other work, from which measurements for setting out or constructing the work can conveniently be made.
Chip seal	A single coat chip seal is an application of sealing binder followed immediately by an application of chip which is spread and rolled into place. Single coat chip seals tend to be used in areas of lower stress; two coat chip seals could be used in areas of higher stress.
Conditions	Conditions placed on a resource consent (pursuant to section 108 of the RMA) or conditions of a designation (pursuant to subsection 171(2)(c) of the RMA).
Design life	The period during which the performance of a pavement, e.g. riding quality, is expected to remain acceptable.
Design speed	A speed fixed for the design of minimum geometric features of a road.
Design year	The predicted year in which the design traffic volume would be reached.
Edgeline	The single continuous line at the left hand edge of the leftmost lane, usually between the trafficked lane and the road shoulder area.

Abbreviation	Meaning
Free-field	Description of a location which is at least 3.5 metres from any significant sound reflecting surface other than the ground.
Grade 3 chip	Sealing chips for use on roads are classified by size into grades. Grade 3 chips have average dimension between around 11 mm and 16 mm.
Grade 5 chip	Sealing chips for use on roads are classified by size into grades. Grade 5 chips have average dimension of between around 6 mm and 10 mm.
Hertz	Unit of frequency, used for sound and vibration.
$L_{Aeq(24h)}$	Time-average sound level over a twenty-four hour period, measured in dB.
$L_{Aeq(1h)}$	Time-average sound level over a one hour period, measured in dB.
L_{AFmax}	Maximum sound level, measured in dB.
Noise	Noise may be considered as sound that serves little or no purpose for the exposed persons and is commonly described as 'unwanted sound'.
Notice of requirement for designation	A notice given to a territorial authority (under section 168 of the RMA) or by a territorial authority (under section 168A of the RMA) of a requirement for land, water, subsoil or airspace to be designated.
Open graded porous asphalt	Open graded porous asphalt is a blend of aggregate and bitumen. The aggregate is mostly coarse and the air void content is relatively high. This type of road surface has low resistance to forces such as vehicle turning so it is not recommended for use at intersections.
Sound	Sound (pressure) levels are an objective measure of changes in pressure levels that may be heard by humans. Unwanted sound can be considered as noise.
Stone mastic asphalt	Stone mastic asphalt is a blend of aggregate and bitumen. The aggregate is gap graded with a mix of only coarse aggregate and very fine aggregate sizes. This type of road surface is suitable in areas of high stress such as signalised intersections or where traffic volumes are high.
Two coat chip seal	A two coat is a chipseal with an application of sprayed binder followed immediately with an application of large size chip; then a second application of sprayed binder, and a second application of smaller chip. Both coats are applied one after the other with little or no time delay between coats.
Vehicles per day	The number of vehicles observed passing a point on a road in both directions for 24 hours.

Appendix A Interpreting and using the noise monitoring data

The sound level meter measures the noise level every second. Every minute the sound level meter averages the sixty readings and produces a 1 minute average. The noise level readings for a 24 hour period of these 1 minute averages (1,440 minutes) is shown as the dark blue line in the figure below. This gives an overall picture of the noise and how it varies minute to minute and hour by hour over the day. Another view of the data is given by averaging over longer periods, such as hourly. 1 hour averages are shown as the red line in the figure.



Noise monitoring data can be used in the management of road-traffic noise under NZS 6806. NZS 6806 uses the 24 hour average noise level measured in a particular technical way, called the 24 hour equivalent noise level. This is not a simple arithmetic average of all the noise levels but a logarithmic average. The effect of this averaging technique can be understood by considering the 1 hour averages shown in the figure. The 24 hour equivalent noise level from the monitoring data shown is 47 dB, demonstrating that the 24 hour equivalent average noise level is about 2 dB less than the noisy day period quite irrespective of how low the noise level falls at night.17

NZS 6806, and other standards that are used to manage road-traffic noise, use the 24 hour equivalent noise level because research has shown this index closely matches how people feel about noise.

The minute-by-minute data and the hour-by-hour data are used in several ways. Firstly, to check that it fits an expected pattern, to help confirm the reliability of the measurements. Where the noise monitoring records show abnormal patterns is taken into account when applying the noise standards.

The noise monitoring data is also used to compare with modelled noise levels. The noise model predicts for only road-traffic noise so modelled noise levels may differ from the measured noise levels if other influences are present, such as farm machinery for example. An important caveat in comparing modelled noise levels with measured noise levels is that the noise model represents the noise level in what is known as "neutral" atmospheric conditions and is calculated based on the annual average daily traffic rate on all streets that influence noise levels at that subject receiver location.

[17] Each 1 minute average plotted in the figure is calculated logarithmically from sixty 1 second readings. Each 1 hour average plotted is calculated logarithmically from sixty 1 minute averages.

Noise monitoring conducted in a residential area is recording propagated noise levels. This propagation is influenced by weather conditions. Wind strength and wind direction influence the noise levels received, as does the extent of cloud cover and sunshine at the time of the noise measurement. The scale of the effect of weather conditions increases with distance further from the noise source. Under NZS 6806, in an urban area, noise levels will be modelled at 100 metres distant from the road edge. Over this propagation distance, weather conditions that still comply with NZS 6801: 2008 Acoustics - Measurement of Environmental Sound can cause a variation of about ±3 dB.

For monitoring sites with major influence from the highway, traffic flow variations from the annual average daily traffic rate at the time of the monitoring could probably cause a variation less than ±1 dB. Variation form the annual average daily traffic rate in flows on local streets could cause greater variation.

As there are multiple sources of variability in noise measurements, noise modelling is the primary tool used to investigate how a project will change road-traffic noise levels.

Appendix B Noise assessment and modelling specifics

General	
Noise measurement primary	Igor Kvatch
Noise modelling primary	Tiffany Lester
Noise assessment primary	Vince Dravitzki
NZS 6801	All noise measurements undertaken and used within this "WECS: Noise Assessment" comply with NZS 6801.
NZS 6806	The process and particulars of this "WECS: Noise Assessment" comply with NZS 6806. (In addition, sections of the assessment have separately been conducted according to the NZTA Noise Guidelines.)
The design year	2026
Noise model	Calculation of Road Traffic Noise (CRTN) with adjustments to suit New Zealand conditions made in accordance with NZTA research report 326 and using a surface correction of -2 as the base correction for asphaltic concrete. This meets the criteria stated in 5.3.2 of NZS 6806.
Noise modelling software	SoundPLAN version 7.0 This software meets the criteria stated in 5.3.2 of NZS 6806.
Noise measurements	Described in report
Assessment date	The noise assessment was conducted between May 2010 and July 2010.

Specifics of traffic flows

Traffic flow information was provided in May 2010, via "2010-05-07 kh Cambridge Express Way AADT data.pdf" and "2010-05-13 kh Cambridge Express Way Ramp AADT data.pdf".

Heavy vehicle percentage was advised as 12 percent on State highway roads and 10 percent on local roads.

	AADT		AADT
SH1 north of the project	29,700	Southbound SH1 to Cambridge	4,900
		Cambridge to northbound SH1	5,000
Expressway north of SH1B	17,600	Southbound Expressway to SH1B	2,200
		SH1B to northbound Expressway	2,700
Expressway south of SH1B	14,500	SH1B to southbound Expressway	800
		Northbound Expressway to SH1B	1,000
SH1 south of the project	21,800	Cambridge to southbound SH1	3,400
		Northbound SH1 to Cambridge	3,900
Hautapu Road	2,500		
Forrest Road	800		
Peake Road north of the Expressway	1,600	Peake Road south of the Expressway	800
SH1B north of the Expressway	13,600	SH1B south of the expressway	18,900
Swayne Road	1,000		
St. Kilda Road	2,300		
Thornton Road	4,600		

Road gradient	Road gradient was calculated by the SoundPLAN software based on the imported vertical road alignment
Road surface	Local roads were modelled with two coat chip seal (3/5) road surfacing. Expressway ramps were modelled with stone mastic asphalt road surfacing. The project was modelled with two coat chip seal (3/5) road surfacing for the "do-minimum" situation. Where the project has been modelled with other road surfacing, such as OGPA, this has been stated.

Horizontal and vertical road alignment	This information was provided in May 2010 and June 2010 via dxf files that were directly imported into the SoundPLAN software
Terrain data	Topography for the area within approximately 400 metres of the project was provided as contour lines at 1 metre intervals via a dxf file that was directly imported into the SoundPLAN software
Buildings and other structures	Buildings and other structures that may affect propagation of noise were identified via aerial photographs and input into the SoundPLAN software. All have been modelled as 6 metres uniform height. Sold safety barriers have been manually entered in the noise model as 0.85 m high barriers for the do-minimum scenario.

Landform and development	
Terrain data	As above: Topography for the area within approximately 400 metres of the project was provided as contour lines at 1 metre intervals via a dxf file that was directly imported into the SoundPLAN software
Road layout	As above: This information was provided in May 2010 and June 2010 via dxf files that were directly imported into the SoundPLAN software
PPFs affected by noise from an existing road	The SoundPLAN software permits investigation of the noise level at a single receiver, detailing directivity of the noise received or detailing how individual road elements contribute to the total noise level received at a single receiver. In accordance with 6.2.2 of NZS 6806, this enables that where PPFs are affected by noise from an existing road, mitigation is only required for road-traffic noise generated on the new or altered road.
Assessment positions	Receivers were modelled for all PPFs within the noise study area. Receivers were positioned 2.4 metres above ground level and 1 metre in front of the PPF-face most exposed to noise from the new or altered road. Where the face of most exposure was not obvious, more than one receiver position was modelled for that PPF, and the most exposed position determined. 1.7.2 of NZS 6806 states the assessment position should be 1.2 to 1.5 metres above each floor level of interest in the PPF. The 2.4 metres above ground level used in this noise assessment is intended to align with the height of the upper portion of windows, being about 1.9 metres above most floor levels. Relative to the 1.2 to 1.5 metres of NZS 6806, the assessment position 2.4 metres above ground level will be slightly conservative via noise levels being slightly higher and the effects of vertical-barriers being slightly less.

Appendix C Modelling results for design and assessment of the Best Practicable Option

Under NZS 6806, the practicality of further noise mitigation for the Project needed to be investigated in five main locations. This Appendix contains key information used in the design and assessment of the BPO at each of those locations.

Table of modelled noise levels

In the following tables of noise levels, the noise level is shaded green if the noise level is within its NZS 6806 Category A limit. The noise level is shaded yellow if it is in Category B and shaded red if it exceeds Category B.

The rightmost column of the table shows the modelling results for the BPO. The header of this column is shaded blue, and same for the column containing the noise mitigation design features that provide the BPO.

PPF 006 and PPF 007: 251 Discombe Road and 245A Discombe Road

PPF	Do-minimum	Barrier at roadside	Barrier at edge of earthworks			BPO
		1 metre	2 metre	3 metre	4 metre	
006	63	62	62	58	57	58
007	62	60	61	58	57	58
				BPO		BPO

PPF 008: 109 Forrest Road

PPF	Do-minimum	Barrier at roadside	Barrier at edge of earthworks			BPO
		1 metre	2 metre	3 metre	4 metre	
008	60	59	60	58	56	60
	BPO					BPO

PPF 009: 215 Peake Road

PPF	Do-minimum	Barrier at roadside	Barrier at edge of earthworks			BPO
		1 metre	2 metre	3 metre	4 metre	
009	58	57	57	56	54	56
				BPO		BPO

PPF 044 to PPF 083: Area of houses near Saffron Street

PPF	Do-minimum	Barrier at roadside	Barrier at edge of earthworks			BPO
		1 metre	2 metre	3 metre	4 metre	
044	58	58	58	55	54	58
045	51	51	51	51	51	51
046	47	47	46	46	45	46
047	57	57	56	53	52	56
048	53	53	52	49	48	52
049	48	48	48	46	46	48
050	57	57	55	53	51	55
051	49	49	48	47	46	48
052	46	46	45	45	44	45
053	57	57	55	52	50	55
054	52	52	50	48	47	50
055	58	58	55	53	51	55
056	54	54	51	49	48	51
057	57	57	53	51	49	53
058	48	48	46	46	45	46
059	58	58	54	52	50	54
060	48	48	47	46	46	47
061	57	57	54	52	50	54
062	48	48	47	46	46	47
063	58	58	54	53	51	54
064	49	49	47	46	46	47
065	58	58	54	53	51	54
066	47	47	46	46	46	46
067	58	58	54	54	52	54
068	47	47	46	46	45	46
069	58	58	54	54	52	54
070	50	50	48	48	47	48
071	58	58	54	54	52	54
072	49	49	47	47	46	47
073	55	55	52	52	50	52
074	57	57	54	54	52	54
075	48	47	46	46	46	46
076	57	57	53	54	52	53
077	47	47	46	46	46	46
078	56	56	52	53	51	52
079	55	55	52	53	51	52
080	57	57	53	54	52	53
081	54	54	51	52	50	51
082	49	49	48	48	48	48
083	56	56	52	54	52	52
			BPO			BPO

PPF 161: 276 Tirau Road

PPF	Do-minimum	Separator barrier		
		2 metre	3 metre	4 metre
161	68	66	63	61

PPF	Do-minimum	2.5 metre high separator barrier				BPO
		50 metres	100 metres	150 metres	200 metres	
161	68	68	65	63	63	63
				BPO		BPO

Appendix D Noise contour diagrams for the Best Practicable Option scenario in 2026

Diagram calculated at height of 2.4 metres and a grid resolution of 4 metres.

Figure D- 1 Noise contour diagrams for the BPO: Northern Interchange to Peake Road (chainage 700 to 4000)

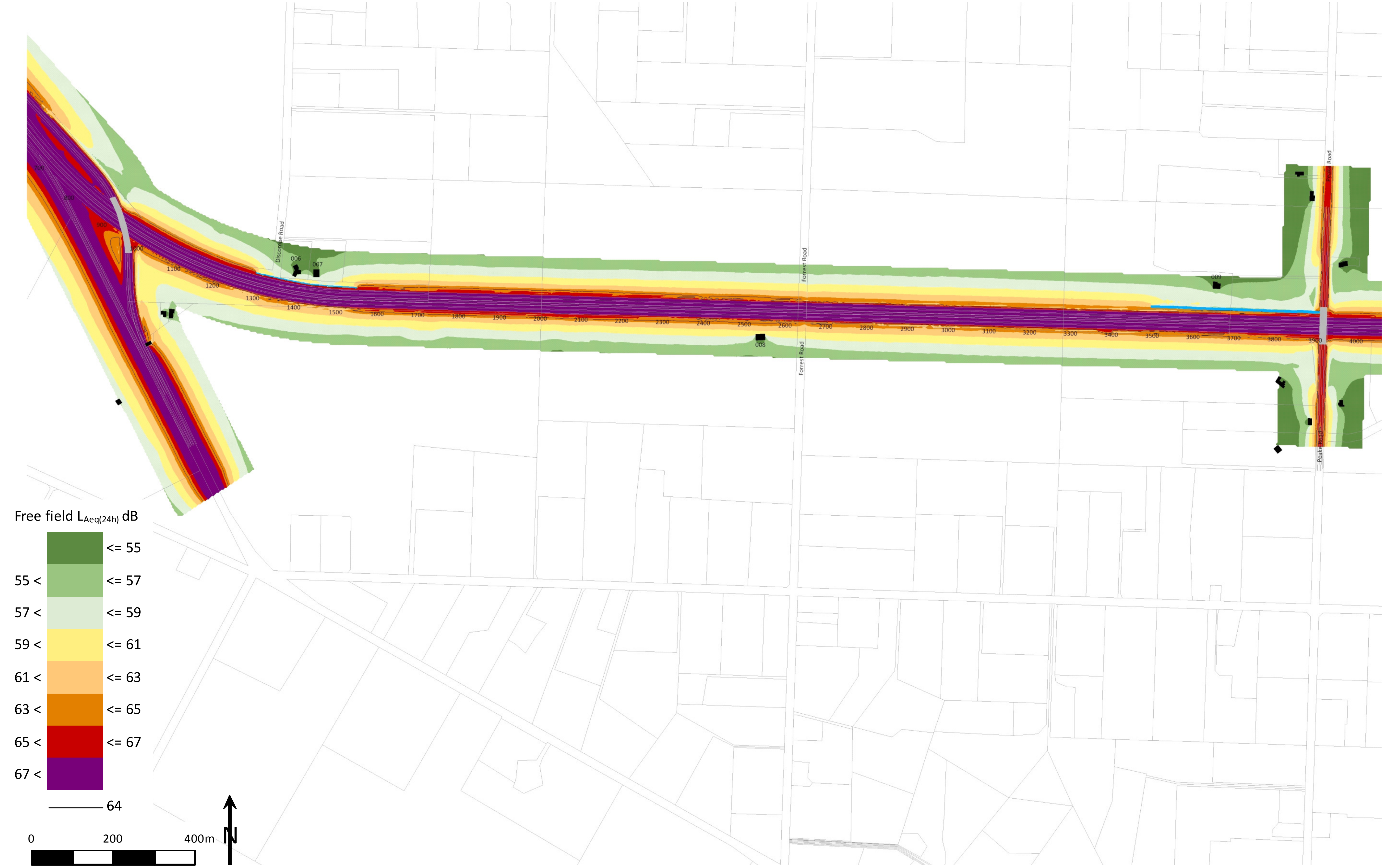


Diagram calculated at height of 2.4 metres and a grid resolution of 4 metres.

Figure D- 2 Noise contour diagrams for the BPO: Peake Road to Swayne Road (chainage 4000 to 7400)

Diagram calculated at height of 2.4 metres and a grid resolution of 4 metres.

Figure D- 3 Noise contour diagrams for the BPO: Victoria Road (SH 1B) to Thornton Road (chainage 5600 to 9100)

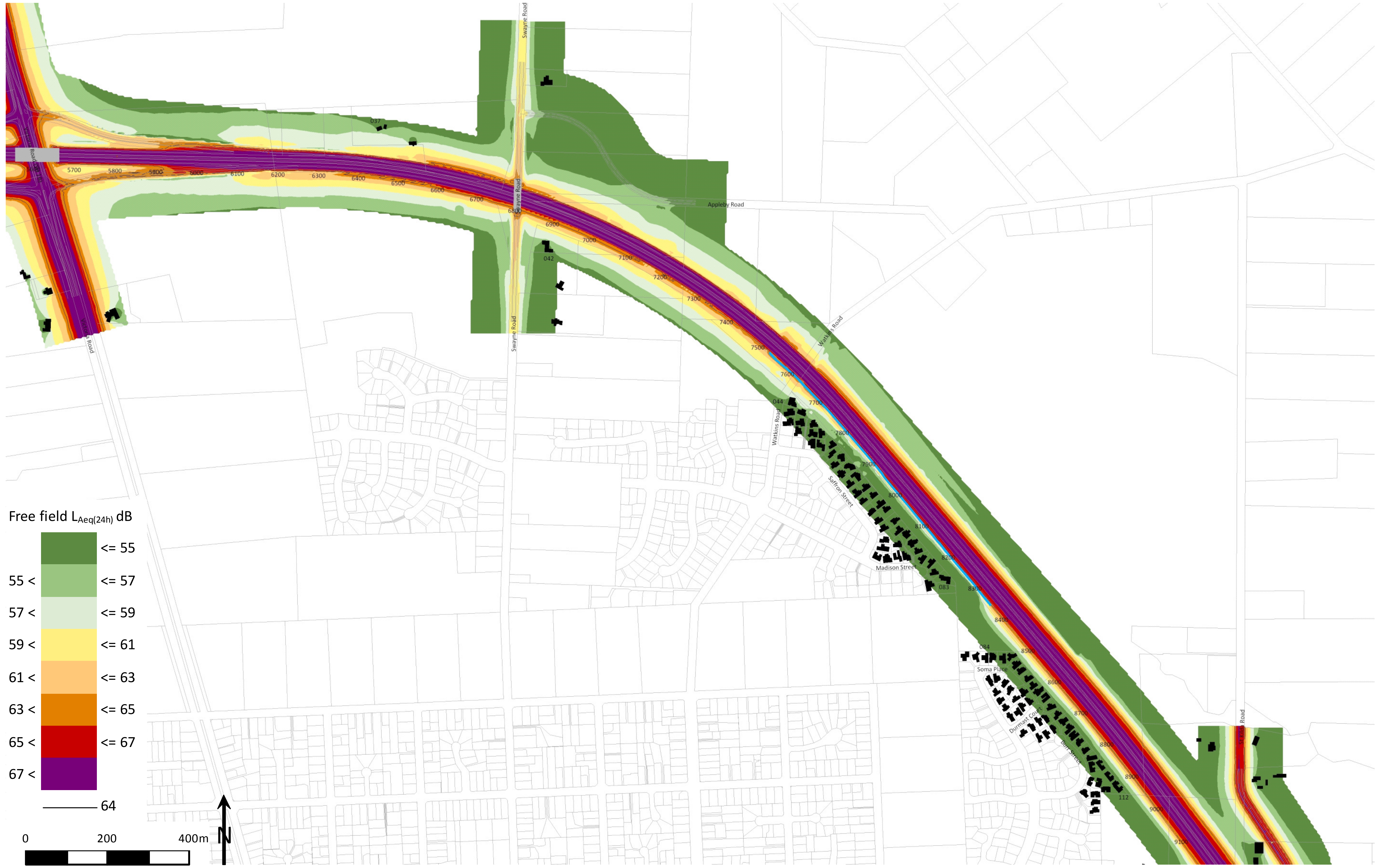
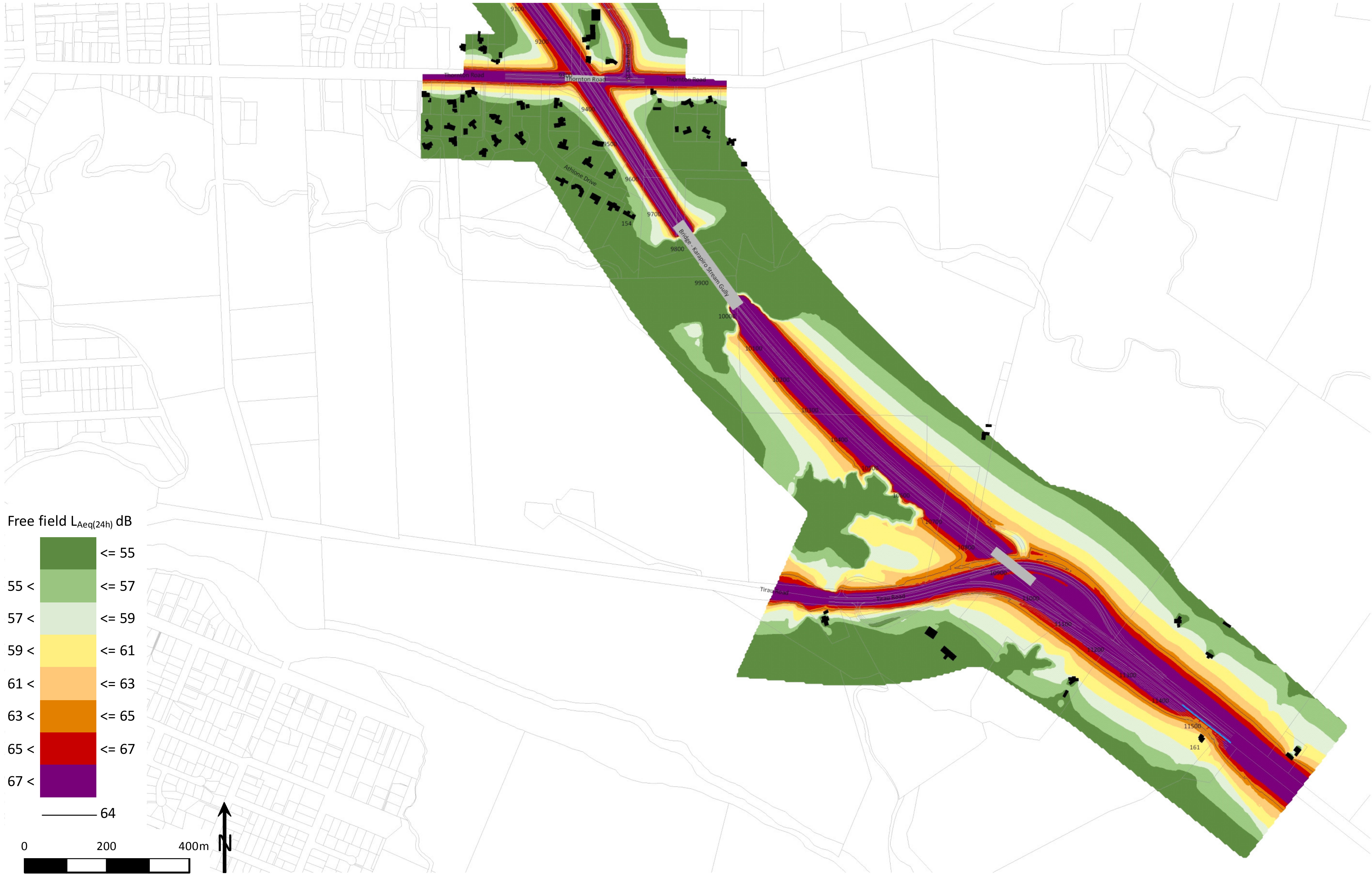


Diagram calculated at height of 2.4 metres and a grid resolution of 4 metres.

Figure D- 4 Noise contour diagrams for the BPO: Thornton Road to Southern Interchange (chainage 9100 to 11600)



Appendix E Preconstruction assessment of construction noise

Preconstruction calculations of noise levels from individual construction plant and machines

Data used for calculations

To assess the likely construction noise, an outline of the likely construction process has been provided by the Project Team, including an indication of the duration of work, the activities that are likely to take place, the machinery that is likely to be operating, and thus the consequent construction noise levels can be calculated. Construction noise levels were calculated via the noise of particular combinations of equipment operating at various typical working distances. The Construction Scenarios used in this assessment are considered adequate for identifying likely construction noise levels in order to establish appropriate construction noise limits. (Once determined, the construction contract will require compliance with these limits.)

The noise levels associated with operation of individual plant and machines were identified from NZS 6803: 1999 and combinations of equipment undertaking the various Construction Scenarios were calculated.

The assumed L_{Aeq} noise levels of running trucks and machinery obtained from NZS 6803: 1999 are summarised in Table E- 1. The values in NZS 6803: 1999 are taken from a British standard (BS 5228: 1997, Part 1).

Table E- 1 L_{Aeq} noise levels (in dBA) for heavy plant or machines (at 10 metres from noise source)

Plant or machine	NZS 6803: 1999	
	Range	Average
Bulldozer	76 - 98	87
Scraper	76 - 94	84
Dump truck	74 - 84	79
Water truck	68 - 80	74
Road roller	73 - 93	83
Grader	83 - 86	84
Excavator (wheeled/tracked)	75 - 85	80
Vibratory roller	74 - 86	80
Compactor	Estimated	80
Concrete pump - lorry-mounted		79
Tracked crane		81
Concrete mixer - truck	72 - 80	76
Loader	76 - 86	81

Calculated noise levels for clusters of construction machinery

In the preconstruction assessment, the average values of the range of values shown in column 2 of Table E- 1 are used. The effect of this is that the limits are developed around assumptions that the contractor is using equipment that is either average or better than average with respect to noise emissions.

For the residences adjacent to the Project construction sites, the noise level at the residence will be equal to the noise level at the source less any *distance effect* on the noise and less the effect of any barrier. In general, it has been assumed that there are no such potential barriers or other obstacles between the construction site and exposed PPF.

A *distance effect* adjustment factor was calculated according to NZS 6803: 1999:

Distance reduction =

in dBA, where R is distance between the source and receiver (such as a PPF located on an affected property).

Units of noise measurement

Construction noise is measured as L_{Amax}, the maximum instantaneous noise level, and L_{Aeq}, the equivalent noise level (a form of average noise level). Most standards and Council noise limits specify the measurement period over which L_{Aeq} is determined. However, this is not the case for construction noise and NZS 6803 is not specific about the measurement period for L_{Aeq}. Instead, it requires a measurement period that captures a representative sample of the noise. NZS 6803 however notes that measurement periods should not exceed 1 hour and in some circumstances 15 minute measurement periods can be sufficient. This helps frame thinking of the construction activity. This means that rather than how the activity is conducted in any short period of time, important is the patterns of machinery use over longer periods, such as one to several hours.

Factors in calculating noise levels

Road construction has a number of distinct aspects:

1. The site is long. The construction can be spread out at various points along the site. Any one residence would be close to typically only three to four (but occasionally more), items of plant or machinery
2. Relative to any fixed (receiver) location, the construction activity centres move nearer and further away as different works progress. Thus, any one (receiver) location is affected by construction activity for only a portion of the full construction period. For this type of construction it is usually acceptable to not reduce generated operating noise levels for long term duration of 18 weeks or more.
3. Maximum noise levels occur when a plant or machine item is at its closest approach to a (receiver) location. Where there are several items of plant or machinery working, they are usually spread over the immediate work area and cannot all simultaneously be located at the point of closest approach to any single (receiver) location. Therefore in calculating the noise levels, rather than using just the closest approach, it is more realistic to use a typical distance at which this cluster of machinery is located.

In addition to this, not *all* plant items will be operating on full power at any one time, as some will be paused in their activities to allow the activities of other plant items. For example, the loader will be on low power as it waits for the truck to drive up, then while being loaded the truck is on low power. To allow for this, a further 3 dBA could be deducted from the calculated noise levels. This equates to allowing that the "full power" construction activities occurs only 50 percent of the time.

It should be noted that the use of L_{Aeq} in the standard also allows for a fluctuation in noise of the equipment in operation. For example, the loader will generate a range of noise levels as it first scoops its load, part raises, reverses, then lifts its load to advance to the truck. L_{Aeq} averages out these fluctuations, but does not include the on/off operations described above.

NZS 6803 provides for a specific adjustment factor to be calculated if the construction method is fully known. The approach above provides for a similar adjustment which is easier to apply when calculating a scenario, and will provide a similar result.

Calculated noise levels results

Calculated construction noise levels from various combinations of construction equipment are shown in Table E- 2. Construction noise levels were assessed at a range of distances

Table E- 2 Ambient L_{Aeq} noise levels of various plant and machine items associated with construction of Expressway

Plant or machine combination in operation	L_{Aeq} noise levels based on groups of equipment from Table E- 1	Calculated likely free field L_{Aeq} noise levels (dB)					
		At 10 m	At 20 m	At 30 m	At 40 m	At 60 m	At 100 m
2 trucks, bulldozer, compactor and water cart	89	86	80	76	73	69	63
2 trucks, grader, and water truck	87	84	78	74	71	67	61
2 trucks and excavator and loader	86	83	77	73	70	66	60
1 trucks and excavator	80	77	71	67	64	60	54
3 trucks, paving machine, and road roller	87*	84	78	74	69	67	61
1 truck, paving machine, and road roller	86*	83	77	73	70	66	60
Concrete mixer and concrete pump	81	78	72	68	65	61	55
Truck and tracked crane	83	80	74	70	67	63	57
Vibratory roller	78*	75	69	65	62	58	52
Compactor	80	77	71	67	64	60	54

Those marked with * are pavement forming activities and for this area will occur only within the carriageway sections

For mobile sources of noise, such as the bulk of road construction, the equipment is moving around an area of often 50 to 100 metres in length, so that the effective separation distance is greater than the distance of closest approach when the equipment is directly opposite the receiver. Table E- 3 shows the typical effective separation distance versus the closest approach for a work area of 50 metres in length and for a work area of 100 metres in length.

Table E- 3 Typical effective separation distances

All measurements in metres

Closest approach	Typical effective separation for nominal length of working area	
	50 metres	100 metres
10	18	28
20	25	35
30	34	44
40	43	50

Table 7-1 shows that at its closest approach, the main construction is about 40 metres from the main clusters of PPFs, Therefore, construction will be within an area 40 to 85 or 95 metres from these PPFs when the centre of the construction is opposite these PPFs.

In NZS 6806: 1999, noise levels are measured in the facade position. Noise levels of Table E- 2 are ambient L_{Aeq} noise levels. The noise levels are increased by about 2.5 dB if measured in the facade position. Allowing for this effect, Table E- 2 and Table E- 3 show that L_{Aeq} noise levels for most construction activity will range between about 58 to 75 dB. However, in some locations, construction activity may be only 15 to 20 metres from a few of the PPFs and so for these PPFs at those times, L_{Aeq} noise levels will be about 73 to 80 dB while this work occurs.