Northern Corridor Improvements

Assessment of Operational Noise and Vibration Effects

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Executive summary

Purpose of report

Marshall Day Acoustics has undertaken an assessment of traffic noise and vibration effects from the Northern Corridor Improvements Project (the Project) for the operational phase of the Project, in order to inform the Notices of Requirement and Assessment of Environmental Effects (AEE).

Assessments Undertaken

The operational noise effects on people have been assessed using a three-pronged approach:

- Assessment of compliance with NZS 6806 following the Best Practicable Option (BPO) process for noise mitigation and focussing on achieving the most stringent noise criteria category practicable;
- Assessment of noise effects (both beneficial and adverse) through determination of noise level changes; and
- Assessment of effects by comparing the number of people that may be highly annoyed by traffic noise with and without the Project.

Assessment Results

Traffic vibration is not considered to be an issue. The Auckland Motorway Alliance (AMA) has no record of traffic vibration complaints in the Project area, and with well-maintained road surfaces vibration levels will be well within accepted limits.

The Project will be surfaced with Open Graded Porous Asphalt (OGPA) on the main alignment, and dense asphalt on ramps. These are low noise generating road surface materials. In addition, where practicable, noise barriers of varying heights have been recommended. Where no barriers are recommended, reasons include:

- The lay of the dwelling in relation to the road (e.g. where dwellings are significantly elevated and cannot be effectively shielded);
- Multi storey dwellings where the upper floor cannot be mitigated; and
- The need for barriers that may be too high in a residential context.

The noise level change due to the Project for dwellings will generally be small (up to 4 decibels). This change is either unnoticeable or just perceptible. For some dwellings, noise levels are predicted to increase by more than 4 decibels. Generally, those dwellings would still receive noise levels within the most stringent noise criteria Category A, so resultant noise levels are considered to be appropriate for residential use. New dwellings, particularly adjacent to State Highway 1 (SH1) and the new Metlifecare retirement village adjacent State Highway 18 (SH18), have been designed and constructed to take account of the existing high noise levels from the existing roads, under the High Noise Route

provisions of the operative North Shore Operative District Plan. For those dwellings, no further improvements may be required.

With the mitigation in place, noise levels are predicted to be generally within the same noise criteria category as would be the case without the Project (do-nothing scenario).

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Glossary of Abbreviations

Item	Description
AEE	Assessment of Environmental Effects
AMA	Auckland Motorway Alliance
AUP	Auckland Unitary Plan Operative in Part (15 November 2016)
BCR	Benefit Cost Ratio
BPO	Best Practicable Option
HA	%highly annoyed
HCV	Heavy Commercial Vehicle
NZS	New Zealand Standard
OGPA	Open Graded Porous Asphalt
PPF	Protected premises and facilities in accordance with NZS 6806:2010
RMA	Resource Management Act
SH(x)	State Highway (number)
SMA	Stone Mastic Asphalt
SUP	Shared Use Path
UHH	Upper Harbour Highway

Terms and Definitions

Item	Description
Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 μPa i.e. dB = 20 x log(P/Pr)
$L_{Aeq\ (t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.
$L_{A90\ (t)}$ or $L_{A95\ (t)}$	The A-weighted noise level equalled or exceeded for 90% or 95% of the measurement period. This is commonly referred to as the background noise level.
$L_{A10\ (t)}$	The A-weighted noise level equalled or exceeded for 10% of the measurement period. This is commonly referred to as the average maximum noise level.
L_{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
Noise	A sound that is unwanted by, or distracting to, the receiver.
NZS 6801:2008	New Zealand Standard NZS 6801:2008 *"Acoustics – Measurement of environmental sound"*
NZS 6802:2008	New Zealand Standard NZS 6802:2008 *"Acoustics – Environmental Noise"*
NZS 6806:2010	New Zealand Standard NZS 6806:2010 *"Acoustics - Road-traffic noise - New and altered roads"*
Project area	The area within the proposed designation(s) corridor for the Northern Corridor Improvements Project and that area abutting this corridor
Project	Refers to the Northern Corridor Improvements Project including the extension to the Northern Busway and proposed Shared Use Pathway.
(t)	The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
Vibration	When an object vibrates, it moves up and down or from side to side. Vibration magnitude can be expressed in terms of acceleration, velocity and displacement. Velocity (in millimetres per second) is the most common metric used, particularly in relation to building response.

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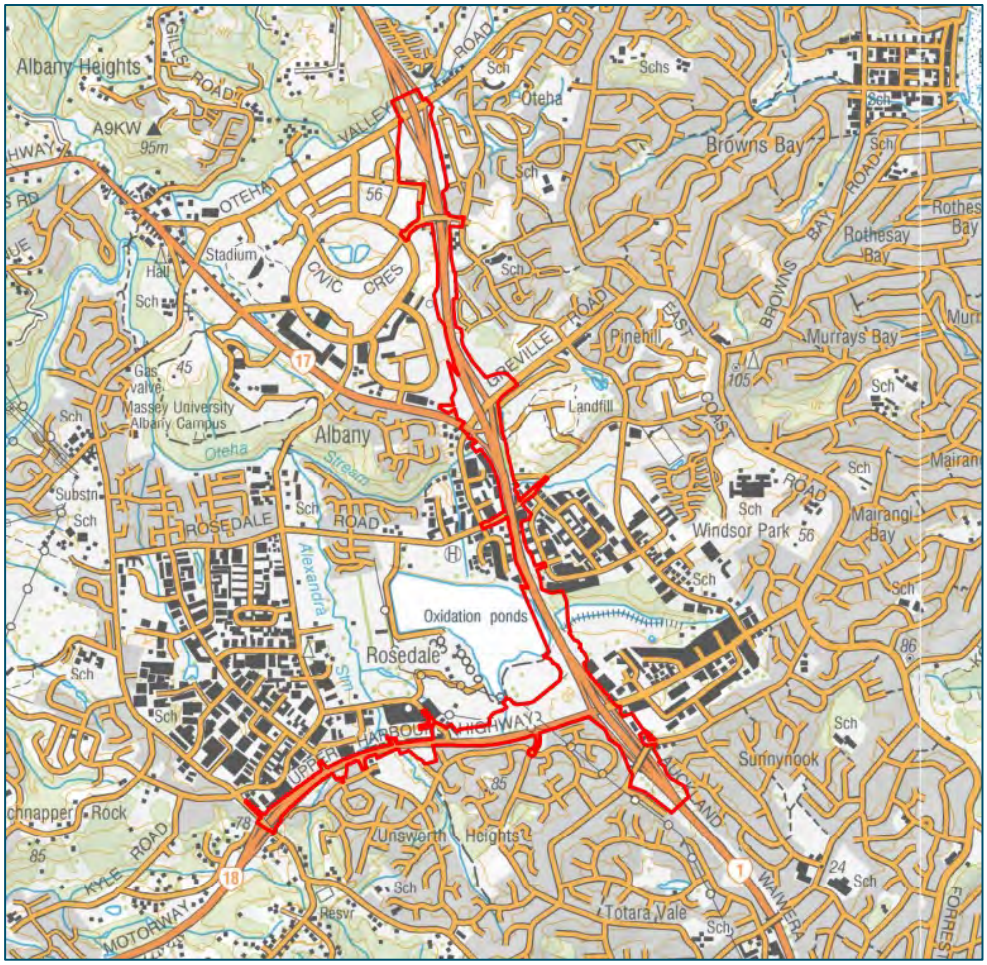
1 Description of Project

1.1 Project Background

The Northern Corridor Improvements Project (the Project) is an accelerated project. The Project area covers the area of SH18 between Albany Highway and Constellation Drive, and SH1 between Upper Harbour Highway (UHH) interchange to just beyond the Oteha Valley Road Interchange as indicated on **Figure 1** below and confirmed in the suite of plans provided in **Volume 5**.

Figure 1 Extent of Project Area



Source: Base Map from LINZ

The Project proposes to upgrade the existing State highways within the Project area. In summary, the key elements of the Project are as follows:

- North and West Motorway Interchange connections – SH1/SH18;
- State highway capacity and safety improvements;
- Northern busway extension from Constellation Bus Station and connection to Albany Bus Station;
- Reconfiguration of Constellation Bus Station converting it from a terminus station to a dual direction station;

- Shared Use Path (SUP) provision along existing SH1 and SH18 routes for the full extent of the Project corridor:
  - Constellation Bus Station to Oteha Valley Road;
  - Constellation Drive to Albany Highway; and
  - Intermediate linkages to local network.

A full description of the Project, including its components and construction, is contained in section 5 of the Assessment of Environmental Effects (AEE).

1.2 Purpose of this Report

This report is one of a suite of technical reports that has been prepared to inform the AEE for the Project.

The particular focus of this report is assessment of the traffic noise and vibration effects of the Project on sensitive receivers. A separate report (See **Volume 3 – Technical Assessment 3**) addresses construction noise and vibration effects of the Project.

Existing ambient noise levels within the Project area are described, the scale and severity of potential effects of the Project on these levels are assessed, and measures to mitigate adverse acoustic effects are identified where required.

2 Acoustic Performance Standards

The Project area contains six existing NZ Transport Agency designations, three of which contain noise performance standards (the designations for the busway up to Constellation Bus Station, Constellation Bus Station itself, and SH18 west of Paul Matthews Road). These are discussed below in respect to their areas of influence.

In addition, other appropriate documents have been reviewed for applicability, and are discussed.

2.1 Noise

2.1.1 Existing Designations

Three existing designations subject to noise conditions are partially within the Project area: Designation 6756 for SH18 UHH, Designation 6758 for Constellation Bus Station, and Designation 6757 for the North Shore Busway. The designations were confirmed for projects that have been completed, namely the North Shore Busway up to and including Constellation Bus Station, and the upgrade of the UHH from west of Paul Matthews Road to Upper Harbour Bridge.

All designations reference Transit New Zealand's *Draft Guidelines for the Management of Traffic Noise for State Highway Improvements*, November 1994, with the Busway and Station designations also making reference to the noise assessment report by Marshall Day Acoustics which was submitted as part of the assessment of environmental effects when the designation was obtained.

It is noted that the Transit Guidelines have since been superseded as the industry standard by the New Zealand Standard NZS 6806:2010 *'Acoustics - Road-traffic noise - New and altered roads',* which is discussed in Section 2.1.3.

The Transit Guidelines as referenced by the existing designations contain effects-based criteria that permit a certain amount of sound level increase, depending on the existing ambient sound level. The criteria – termed the *'Average Noise Design Level'* in the guidelines – must be achieved at 1 metre from the façade of any dwelling (including a façade reflection) and are shown in **Table 1**.

Table 1 Transit Noise Design Levels

Noise Area	**Ambient Noise Level dB $L_{Aeq(24h)}$**	**Average Noise Design Level dB $L_{Aeq(24h)}$**
Low	Less than 43 43 – 50	55 Ambient + 12
Medium	50 – 59	62
High	59 – 67 67 – 70 More than 70	Ambient + 3 70 Ambient

The Transit Guidelines provide no protection for dwellings in high noise areas, with the only control being that no increase in noise level is permitted above 70 dB $L_{Aeq(24h)}$. However, no reduction in noise level is required.

For low noise areas, the outcome would be slightly better than would be the case with NZ6806:2010, however, this Project does not include such low noise areas, which are generally only found in rural areas away from major roads.

For dwellings receiving mid-level noise levels, similar outcomes are achieved through NZS6806:2010.

Overall, the current road traffic noise standard NZS6806:2010 is considered to be appropriate to be applied to this Project.

2.1.2 District and Unitary Plans

In most instances, traffic noise criteria are not set in District or Regional Plans. This is also the case for this Project.

The Auckland Council District Plan – Operative North Shore Section includes road traffic noise rules in relation to new noise sensitive activities being established adjacent to high noise roads (such as SH1 and UHH), but no requirements in regards to road traffic noise to existing dwellings. Rule 10.5(b) of the Operative District Plan regarding appropriate insulation of new dwellings close to High Noise Routes requires that for any site that would receive noise level in excess of 65 dB $L_{Aeq(6am-10pm)}$ an internal noise level of 40 dB $L_{Aeq(6am-10pm)}$ shall not be exceeded within habitable rooms with windows open.

The Auckland Unitary Plan – Operative in Part (15 November 2016) (AUP) states:

> *Section E25.6.33 Noise levels for traffic from new and altered roads*
>
> *1. All new roads and all altered roads that are within the scope of New Zealand Standard NZS 6806:2010 Acoustics – Road traffic noise – New and altered roads must comply with the requirements of New Zealand Standard NZS 6806:2010 Acoustics – Road traffic noise – New and altered roads.*

Relevant excerpts of these Plans are included in **Appendix A**.

2.1.3 Road Traffic Noise Standard NZS 6806:2010

The New Zealand Road Noise Standard (NZS 6806:2010 "*Acoustics – Road-traffic noise – New and altered roads*") (Standard) is intended for noise assessments of roads with more than 2000 vehicles per day. The NZ Transport Agency has adopted this Standard for all recent roading projects, and the provisions of the Standard have generally been confirmed, with some slight alterations, by Boards of Inquiry.[1]

It is considered appropriate that the assessment of this Project should be based on the provisions of the Standard.

2.1.3.1 Assessment positions

The Standard specifies 'protected premises and facilities' (PPFs), which are to be protected against traffic noise in accordance with the provisions of the Standard. PPFs include dwellings, educational facilities, marae, hospitals which contain in-patient facilities, motels and hotels in residential zones and playgrounds within 20 metres of educational facilities.

Buildings with commercial and business use are not PPFs as they are not considered to be noise sensitive. For this Project, significant parts of the widened road and interchanges as well as Constellation Bus Station are in the vicinity of business premises.

Outdoor areas are not in themselves protected; rather, protection afforded to PPFs will provide incidental mitigation to outdoor areas surrounding the PPF. This is one of the reasons why NZS 6806 requires structural (external) mitigation to be implemented in preference to building modification mitigation.

[1] For instance Waterview Connection, MacKays to Peka Peka, Pūhoi to Warkworth

NZS 6806 stipulates that, in urban areas, only PPFs within 100 metres of the alignment shall be assessed.

The Project alignment has been divided into eight assessment areas. Assessment areas have been determined by identifying dwellings that are:

- Located on the same side of SH1 or Upper Harbour Highway (i.e. either adjacent to northbound or southbound lanes only);
- In neighbourhood clusters; or
- Adjacent to a section of SH1 or SH18 with the same traffic volume (i.e. located between ramps and not crossing over ramps).

A figure showing the assessment areas is contained in **Appendix B**.

2.1.3.2 Assessment criteria

The noise criteria in the Standard differ depending on whether it is a new or altered road. This Project has been assessed as an altered road because for most of the Project existing roads are being altered (e.g. widened). Where the road deviates from existing roads, i.e. the new ramps connecting SH1 with SH18, PPFs are in closer proximity to the existing roads being altered than the new roads to be formed (e.g. UHH) and therefore would be assessed against the altered road criteria. This is considered to be appropriate as existing noise levels are controlled by traffic on the existing (and to be altered) roads.

There are three noise criteria categories (A, B and C) as set out in **Table 2.**

Table 2 NZS 6806 Assessment Criteria Categories: Altered Roads

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

* This criterion applies only for those habitable rooms where the internal noise level would be 45 dB $L_{Aeq(24h)}$ or higher following the implementation of the project and all structural mitigation such as road noise barriers or a low noise road surface.

The criterion to be achieved depends on the application of the best practicable option (BPO) test. The Category A criterion must be met (or bettered) if this is consistent with the BPO. If it is not achievable then the Category B criterion must be met. If the Category B criterion is not achievable with the BPO, then the Category C criterion must be achieved.

2.1.3.3 Assessment Scenarios and Design Year

The Standard requires that several operational scenarios for the design year be assessed and compared. The design year is a year at least 10 years after the opening of the Project. For this Project, the design year is 2031, as completion of the Project is anticipated to be approximately 2021. It is noted that if the completion of the Project were delayed a few years, it would not have a noticeable effect on the predicted noise levels at the revised design year.[2]

The operational scenarios that have been assessed include:

[2] Refer Section 3.1 which explains what kind of traffic volume increase would be required for a noticeable noise level increase.

- The “existing sound environment” which, for altered roads, represents the current road layout and traffic volume (for this Project, traffic volumes for the year 2011 have been used for comparison with the existing noise levels);
- A future “do-nothing” scenario, which represents a scenario at the design year where the Project has not been implemented. However, traffic volumes and subsequent sound levels have changed - generally increased - over time;
- A future “do-minimum” scenario, which represents a scenario at the design year where a Project has been implemented without any specific noise mitigation. This means that the selection of road surface material does not consider sound generation, and the only barriers included are safety barriers; and
- Future “mitigation option” scenarios, which represent the circumstance in the design year where the Project has been implemented and specific noise mitigation measures added, e.g. barriers or specific road surface material. Generally, one or two scenarios have been assessed.

2.1.3.4 Application and Limitations of the Standard

As described in Section 2.1.3.2, the Standard adopts the BPO methodology to mitigate noise which, in our opinion, is a pragmatic and balanced approach.

One aspect of the BPO is that a noticeable noise level reduction should be achieved by any structural mitigation.[3]

Therefore, NZS 6806 includes a threshold for the effectiveness of structural mitigation. In areas where mitigation benefits more than one PPF, it *“should only be implemented if the combination for the structural mitigation measures used would achieve … an average reduction of at least 3 dB $L_{Aeq(24h)}$.*[4] The reason for this requirement is that mitigation varies depending on a PPF’s location in relation to the mitigation.

It is noted that in some areas, PPFs may not require mitigation but are still assessed as part of the “average” noise level reduction requirement. Because of this, the overall mitigation for an area can be artificially reduced. This has been taken into consideration when deciding on the BPO.

Section 7.2.4 of the Standard recommends that up to four mitigation options be developed for large scale projects involving more than 50 PPFs. However, for this Project, the use of OGPA as the road surface material already provides significant mitigation in itself (compared with chip seal). For that reason, mitigation has been restricted to two options:

- The use of road side barriers (which is the preferred mitigation option after road surface material)
- Building modification (i.e. installing ventilation systems to homes so their windows can be kept shut, or upgrading the window glazing to improve acoustic performance)

For this Project, a combination of barriers and building modification mitigation is considered to be the BPO as described in Section 5.

2.1.3.5 Best Practicable Option Determination – Preferred Mitigation Option

A number of mitigation options were developed and reviewed for those assessment areas where PPFs were predicted to move into a less stringent noise criteria category as a result of the Project. Mitigation options generally involved barriers of varying heights and lengths, which were designed using the SoundPLAN computer noise model (refer Section 3.3) as well as previous experience and feedback from other Project team members. These mitigation options were evaluated by the Project

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3 NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.2.

4 NZS 6806 Acoustics – Road-traffic noise – New and altered roads, Section 8.2.2(a), page 41.

team in a meeting on 20 July 2016 and subsequent email exchanges, and feedback was given. The disciplines of urban design, landscape architecture, stormwater engineering and planning were represented at these discussions.

Taking into consideration the input from the Project team, a BPO mitigation option was selected for each assessment area to ensure acceptable noise levels for affected residents.

2.1.4 NZ Transport Agency Guide

The NZ Transport Agency has released its *"Guide to assessing road-traffic noise using NZS 6806 for state highway asset improvement projects (Version 1.1, September 2016)"* (Guide). The Guide describes how NZS 6806 is to be implemented. In addition, some NZ Transport Agency specific processes are described. For this Project, the Guide assessment procedures were used for each assessment area, including the calculation of the benefit cost ratio (BCR) and predicted noise levels are shown in **Appendix C**.

Overall, the NZ Transport Agency Guide provides background on how to implement NZS 6806, and is therefore a useful complimentary document to the Standard itself.

2.2 Vibration

2.2.1 District and Unitary Plans

None of the Plans contain traffic vibration performance standards.

2.2.2 NZ Transport Agency Road Maintenance Policy

Traffic vibration is generated when the road surface is not smooth and has bumps and or dips (e.g. potholes, surface changes etc.). Traffic vibration does not generally cause adverse effects when roads are well maintained. The NZ Transport Agency has a comprehensive road maintenance policy that ensures that roads remain smooth and any defects are fixed within short timeframes.

Should assessment of traffic vibration be required, the Norwegian Standard NS 8176.E:2005 is the appropriate Standard, as recommended in the NZ Transport Agency Technical Memorandum NV3.[5]

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

3 Assessment Methodology

3.1 Assessment of effects and compliance

The operational noise effects on people have been assessed using a three-pronged approach:

- Assessment of compliance with NZS 6806 following the BPO process for noise mitigation and focussing on achieving the most stringent noise criteria category practicable;
- Assessment of noise effects (both beneficial and adverse) through determination of noise level changes; and
- Assessment of effects by comparing the number of people that may be highly annoyed by traffic noise with and without the Project.

The requirements of the NZS 6806 Standard are discussed in Section 2.1.3. The other two assessment methodologies are described in Sections 3.1.1 and 3.1.2.

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

Overall, it is noted that any traffic noise effects (positive or negative) are generally temporary. People typically become habituated to a change in their environment, including noise levels, particularly where the character of the sound does not change (i.e. if existing traffic noise increases).

3.1.1 Subjective Perception of Noise Level Changes

The subjective impression of changes in noise level can generally be correlated with the numerical change. While every person reacts differently to noise level changes, research[6] shows a general correlation between noise level changes and subjective responses. **Table 3** shows subjective responses that relate to the noise level changes discussed in this report. From experience, the subjective perception of a noise level change can be approximately translated into a Resource Management Act (RMA) effect. This is based on people's annoyance reaction to noise level changes (refer Section 3.1.2 below).

The perception of these noise level changes generally applies to immediate changes in noise level, unlike for this Project which is an altered road. However, for changes to an existing road people may subjectively still have an annoyance reaction to a greater or lesser degree, depending on their perception of the Project.

Table 3 Noise level change compared with general subjective perception

Noise level change	General subjective perception	Possible effect
1 – 2 decibels	Insignificant change	Negligible
3 – 4 decibels	Just perceptible change	Slight
5 – 8 decibels	Appreciable change	Moderate

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

9 – 11 decibels	Halving/doubling of loudness	Significant
> 11 decibels	More than halving/doubling of loudness	Serious

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

The increase caused by this Project is predicted to be less than 3 decibels.

3.1.2 Annoyance Effects

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

The most notable studies include that of Shultz,[7] and those of Miedema and Oudshoorn[8] shown in **Figure 2** below. This study (M&O) combines the results of several different studies to produce a 'curve' of the percentage of people highly annoyed (%HA) versus external noise level (L_{dn})[9]. Their studies involved a number of different transportation types including trains, road traffic and aircraft. Only the curve for road traffic noise is shown in **Figure 2**.

When assessing annoyance effects, only the number of people "highly annoyed" is assessed, rather than those less annoyed. The reason is that there is less correlation of noise level and annoyance, resulting in more uncertainty of assessment results. Historically, and successfully, annoyance has been described based on the people highly annoyed. Considering the assessment is a relative assessment comparing various scenarios of the same road, using the parameter of "high annoyance" is considered the most appropriate.

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

For an external noise level of 67 dB $L_{Aeq(24h)}$ (equivalent to 69 dB L_{dn}), which is the upper end of Category B for altered roads, about 25% of people would be highly annoyed.

[7] Schultz T J (1978) "Synthesis of social surveys on noise annoyance" J.Acoust. Soc. Am. 64, 2, 337-405.

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

[9] Ldn levels can be converted into $L_{Aeq(24h)}$ by subtracting 2.5 dB. Ldn levels are energy average levels where the night time sound is adjusted by adding 10 decibels to represent the added annoyance of night time noise.

Figure 2 Miedema & Oudshoorn Dose-Response Relationship

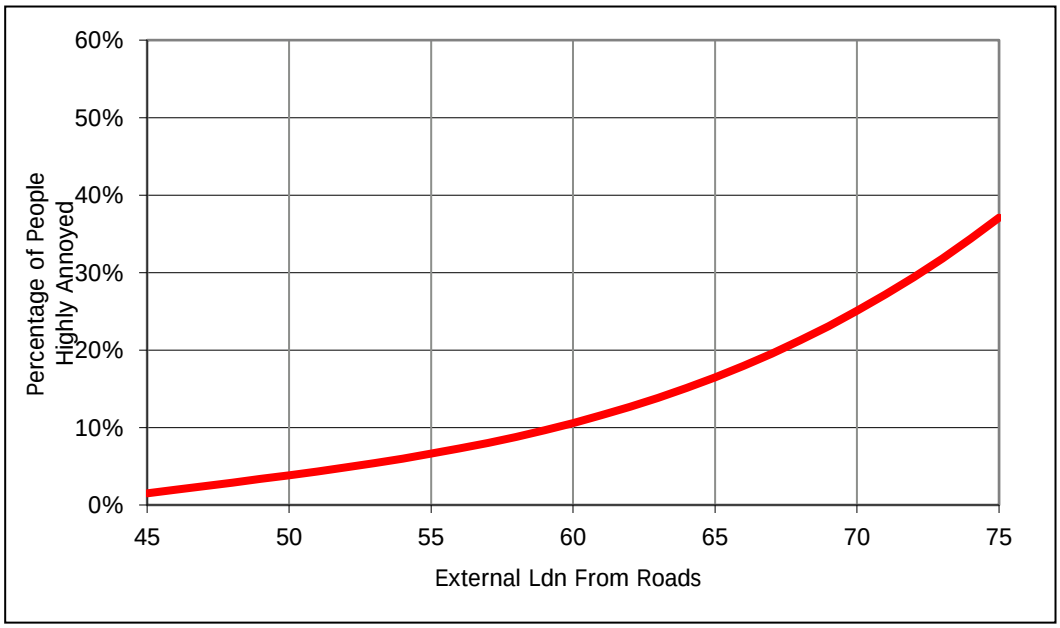


Table 4 below shows this dose-response relationship, as applied to 5 decibel noise bands which are shown in the figures in **Appendix E**:

Table 4 Percentage of people highly annoyed

Noise band	Average percentage of people highly annoyed
55 to 60 dB $L_{Aeq(24h)}$	10%
61 to 65 dB $L_{Aeq(24h)}$	17%
66 to 70 dB $L_{Aeq(24h)}$	25%
> 70 dB $L_{Aeq(24h)}$	37%

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

In order to calculate the number of people highly annoyed, the number of dwellings (within 100 metres of the Project) was counted. Then, the number of people affected was estimated based on Statistics New Zealand data.[10] For the Project area, the average number of persons per dwelling have been obtained and multiplied with the assessed dwellings in each assessment area.

Note that the difference between Category A and Category C noise levels for altered roads in NZS 6806 is only 3 decibels (64 to 67 dB $L_{Aeq(24h)}$). Therefore, the slight change in noise level does not necessarily result in a change in the number of people highly annoyed, but may move PPFs from Category A or B into Category C.

For each assessment area, the results are summarised in Section 5.

[10] http://www.stats.govt.nz/StatsMaps/Home/Maps/2013-census-population-dwelling-map.aspx.

3.2 Surveys

Sound level surveys of the existing ambient environment have been undertaken in each assessment area (as outlined in **Appendix B**) and further detail provided at section 4.1. The results of the surveys were also used to verify the computer noise model.

Two methodologies were used to measure the existing sound environment along the length of the Project:

- Short duration measurements, between 10 and 30 minutes long, during daytime and attended throughout so that the environment can be observed and described;
- Long duration measurements, generally between six and seven days (access dependent), which continuously record noise levels and are unattended (i.e. no person is with the equipment throughout the survey period).

Unattended long duration measurements were undertaken using noise data loggers. The loggers continuously measured $L_{Aeq(15min)}$ sound levels for the monitoring duration. The 15-minute survey results were then converted into $L_{Aeq(24h)}$ values, which are relevant to NZS 6806 (refer Section 2.1.3 above).

The short duration attended surveys were all undertaken in the vicinity of SH1 and Upper Harbour Highway, during daytime. As the diurnal variation in traffic noise is known (refer **Appendix D**) it was possible to derive an $L_{Aeq(24h)}$ noise level from these measurements with acceptable accuracy. The measured and derived noise levels are shown in **Table 6** in Section 4.1.

Surveys were undertaken in accordance with the requirements of NZS 6801:2008 “Acoustics – Measurement of Environmental Sound” and NZS 6802:2008 “Acoustics – Environmental Noise”, and took account of the NZTA document “Noise monitoring requirements”, V1.0 dated June 2012.

3.3 Computer noise modelling

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

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

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

3.3.1 Model input

The software SoundPLAN® was used, which is an internationally recognised[11] computer noise modelling programme. SoundPLAN® uses a digital terrain map of the area as its base which for the Project included the following:

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

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

- Elevations of the area surrounding the Project at vertical distances of 0.5 metres and extending 130 - 500+ metres from either side of the road edge.

In addition, all existing buildings and structures within the overall assessment area and beyond were entered into the model.

Road traffic noise sources were entered into the computer noise model, with each road lane located on the terrain file. The software then calculated traffic noise generation in all directions, allowing for topography, shielding and meteorological conditions.

All bridges are assumed to have TL5 concrete safety barriers of 0.8m height on the outside edges.

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

The adjustments for New Zealand road conditions as outlined in the NZ Transport Agency Guide, specifically road surface types, are also included in the model.

3.3.2 Road parameters

The computer noise model includes a variety of input parameters that describe the environment in the vicinity of the Project. The main parameters are road surface material, traffic volume and speed, and safety and existing noise barriers.

Traffic volumes were provided by consultant Flow NZ, the Project's Transportation Specialist and are more conservative than those used in the Assessment of Transport Effects.

3.3.3 Model verification

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

As described in Section 3.2 above, existing noise levels have been measured along the Project alignment. In the computer model the existing noise levels from traffic on SH1 and UHH have been predicted at the locations where ambient levels were measured, and compared with those measurements to verify the accuracy of the model.

Table 5 below shows the comparison of measured and predicted noise levels for the Project area.

Table 5 Computer noise model validation: measured and predicted noise levels

Measurement Position	Measured noise level	Predicted noise level	Difference
	dB $L_{Aeq(24h)}$	**dB** $L_{Aeq(24h)}$	**decibels**
Long duration surveys			
14 Wren Place	61	61	±0
49 Barbados Drive	61	62	+1
21 Cabello Place	61	63	+2
16 Lavender Garden Lane	60	60	±0
18/71 Spencer Road	60	60	±0

Measurement Position	Measured noise level	Predicted noise level	Difference
	dB $L_{Aeq(24h)}$	**dB $L_{Aeq(24h)}$**	**decibels**
Short duration surveys	**Derived noise level**		
112 Unsworth Drive (Medical Centre)	68	66	-2
82 Bluebird Crescent	62	63	+1
16 Saturn Place (Childcare Centre)	65	64	-1
29 Arrenway Drive (businesses)	68	66	-2
17 Tawa Drive (SH17)	63	61	-2
80 Paul Matthews Road (Hockey)	66	64	-2
Rook Place - Reserve	63	63	±0

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

A comparison of the measured and predicted levels shows that for all positions there is good agreement between measured and predicted levels, with a difference of no more than 2 decibels. This accuracy fulfils the requirements of NZS 6806:2010 which states in Section 5.3.4.2: *"The difference between measured and predicted levels should not exceed ± 2 dB."*

3.3.4 Individual receiver noise levels

Noise effects need to be assessed for sensitive locations (PPFs) e.g. dwellings and teaching areas, rather than vacant land. To provide for appropriate mitigation, the location of dwellings needs to be known. As discussed in Section 2.1.3 above, the Standard provides protection for PPFs, including for existing dwellings and those unconstructed dwellings that have building consent.

Noise levels have been predicted for each individual PPF. In addition, the results of the single point calculations have been combined in categories as follows:

- Number of PPFs in NZS 6806 noise criteria categories A, B or C;
- Number of PPFs in 5 decibel noise bands (from 55 to 75 dB LAeq(24h)) in order to assess the number of people potentially highly annoyed.

All results are shown in the tables in Section 5.

Noise criteria categories for the PPFs are shown graphically by colouring the buildings according to their NZS 6806 Category. Category A buildings are shown in green, Category B buildings in yellow and Category C buildings in red. Any non-coloured buildings on the figures are outside the assessment area of 100 metres from the road alignment, or are not PPFs, e.g. garages, sheds or business premises. These figures are shown in **Appendix F**.

Annoyance noise bands are shown graphically in the figures in **Appendix E**. In these figures, PPFs are coloured according to the noise band they fall into (e.g. 55 to 60 dB $L_{Aeq(24h)}$, 65 to 70 dB $L_{Aeq(24h)}$ etc.).

3.3.5 Noise contour plans

Noise contour plans are contained in **Appendix G**. These plans show contours at 5 decibel intervals from 45 dB to 70 dB $L_{Aeq(24h)}$.

Noise contour plans are a useful tool to obtain a graphical overview of a project area and the potential effects of a noise source. The contours are calculated in SoundPLAN at a large number of individual points. However, they are less accurate than individual noise receiver levels so should not be used to determine individual noise levels for specific locations.

3.4 Traffic Noise Mitigation

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

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

The first two methods involve “structural mitigation” as described by NZS 6806, while the third involves building modification mitigation.

3.4.1 Road surface material

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

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

The Auckland motorway system uses OGPA as the standard road surface material. OGPA is the most common low-noise road surface used in New Zealand. It is generally used in densely populated areas and on high capacity and high speed roads, including SH1 and Upper Harbour Highway. It provides good drainage due to its porosity but needs more frequent maintenance and replacement compared with dense asphalt.

Appendix B of NZS 6806 contains extensive discussion of the application of low noise road surfaces. It states that OGPA, a porous and smooth layered asphalt surface, can reduce noise levels by around six decibels when compared with chip seal, the noisiest surface. This is an appreciable difference.

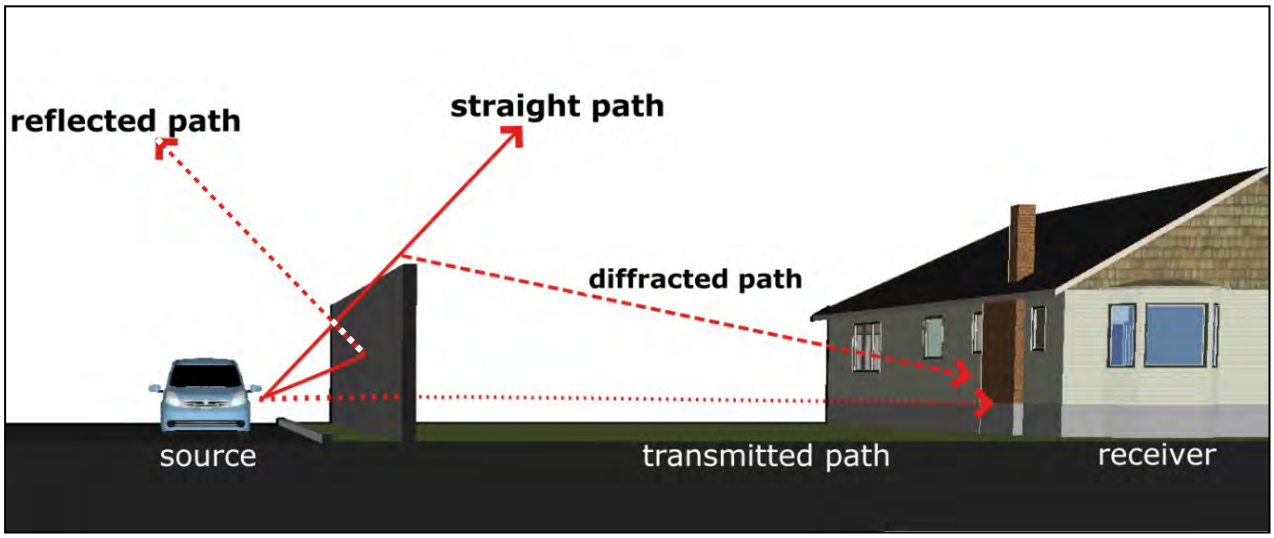
For some areas where increased shear resistance for the pavement is required (e.g. where vehicles brake, accelerate or turn) a stronger structural road surface material is required. This includes the on and off ramps. In these instances, Stone Mastic Asphalt (SMA) or similar dense asphalt material may be utilised. This material is smooth but non-porous, so combined traffic noise levels generated by SMA are slightly higher than those for OGPA.

3.4.2 Barriers and bunds

Acoustic barriers work by breaking acoustic line-of-sight from the noise source to the receiver. In order to provide the most effective noise level reduction, an acoustic barrier must be of solid material (i.e. have no gaps) and have a minimum surface weight of 15 kg/m^2 (e.g. 17mm ply sheeting, 9 mm fibre cement, concrete, earth bunds etc.).

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

Figure 3 Acoustic Barrier Performance



Source: NZ Transport Agency State Highway Noise Barrier Design Guide Version 1.0/August 2010

Barriers are the second most common form of noise mitigation after road surface material. They should be installed immediately beside the road, to ensure that the widest surrounding area is protected. Alternatively, barriers can be installed along property boundaries close to dwellings. Positioning a barrier mid-way between source and receiver is the least effective in terms of noise reduction.

3.4.3 Building envelope improvements

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

The Category C assessment is triggered if the noise level inside habitable rooms would be 45 dB $L_{Aeq(24h)}$ or more, with the implementation of the selected structural mitigation measures. In that instance, at least a five decibel noise level reduction is required to achieve an internal noise level of no more than 40 dB $L_{Aeq(24h)}$. However, The NZ Transport Agency provides building modification mitigation for all Category C buildings where the internal noise level would otherwise be above 40 dB $L_{Aeq(24h)}$, irrespective of the internal trigger level of 45 dB $L_{Aeq(24h)}$ being reached.

The improvements required would vary from building to building. While some buildings have already been designed to achieve suitable internal noise environments, by using heavy building materials, high performance glazing, insulation, and well-fitting doors and windows, other buildings may not. Therefore, a case-by-case assessment is required for those buildings within Category C.

Often, improvements to glazing, seals and joinery may be sufficient to achieve the required internal noise levels.

Any insulation or other building envelope improvements have to achieve the requirements of Clause G4 of the New Zealand Building Code, which governs the ventilation requirements for buildings. Therefore, in many instances an alternative mechanical ventilation system would be required.

It is noted that the NZ Transport Agency guidelines provide for better ventilation than is required to be achieved by G4. While G4 purely relates to fresh air intake, thermal comfort of the indoor living environment also has to be taken into consideration. This is included in the relevant information that

can be found here: http://nzta.govt.nz/resources/state-highway-guide-to-acoustic-treatment-of-buildings/

This Project is predicted to result in an improvement over existing noise levels, due to the proposed installation of barriers. However, in many instances noise levels are predicted to remain within Category C, despite a significant reduction in noise level. These houses should be assessed on a case by case basis to determine if building modification mitigation would be required to achieve internal noise levels of 40 dB $L_{Aeq(24h)}$.

Some recently built dwellings adjacent to the Project have been constructed in accordance with the requirements of the North Shore District Plan. Dwellings adjacent to High Noise Routes (which includes SH1 and SH18/Upper Harbour Highway) have to comply with an internal noise limit of 40 dB $L_{Aeq(6am-10pm)}$. This would include all dwellings between Oteha Valley Road and Greville Road adjacent to the southbound lanes of SH1, and the dwellings on the Metlifecare site adjacent to SH18. Whether further mitigation is required will be determined once testing has been completed inside each PPF.

3.5 Determination of preferred mitigation option

NZS 6806 requires that a number of mitigation options are developed and evaluated by the Project team. This generally involves the following steps, which have been followed for the Project:

- Mitigation options were developed for individual assessment areas as appropriate
- The mitigation options were discussed by relevant persons in the Project team (namely representatives for the urban design team, stormwater design, planning and construction), and provided to the wider Project team for comment and feedback
- Feedback on the options was provided in a round table discussion, enabling fine tuning of the initial mitigation options. In some instances, further mitigation options were developed
- The interim preferred mitigation was chosen by the team to be put forward to community consultation and within the scheme design report. This noise mitigation is considered to be the best practicable option by the team

The notes from the round table team discussion are attached in **Appendix H**.

4 Existing Noise Environment

The existing noise environment provides the baseline for assessing effects of a project. Subjective responses of people and possible annoyance can then be related to the change in noise environment. The existing noise environment is controlled by traffic on SH1 and SH18/Upper Harbour Highway, and to a lesser degree from traffic on local roads and businesses in the area.

Existing noise levels have been determined by means of measurement (both long and short duration) and computer noise modelling. Results are discussed below.

4.1 Noise level surveys

As discussed in Section 3.1 above, both long and short duration noise level surveys were undertaken in the vicinity of the Project.

Long duration surveys were undertaken in April and May 2016. Surveys were undertaken in accordance with the requirements of NZS 6801:2008 “Acoustics – Measurement of Environmental Sound” and NZS 6802:2008 “Acoustics – Environmental Noise”.

Short duration attended surveys were located in the vicinity of the Project area, including along local roads crossing SH1 and SH18. As traffic distribution over the day is known, the short duration survey results can be used to derive a 24-hour traffic noise level.

All noise level survey results are shown in **Table 6** below. For each long duration noise level survey, the diurnal variation in level is also shown in **Appendix D**. Measured and derived noise levels ranged from 60 to 68 dB $L_{Aeq(24h)}$. These levels show the impact of the proximity of major roads in the area (SH1 and SH18).

Table 6 Noise level survey results

Item	Measured noise level	Derived noise level
Long duration measurements	**dB $L_{Aeq(24h)}$**	**dB $L_{Aeq(24h)}$**
14 Wren Place	61	n/a
49 Barbados Drive	61	n/a
21 Cabello Place	61	n/a
16 Lavender Garden Lane	60	n/a
18/71 Spencer Road	60	n/a
Short duration measurements	**dB $L_{Aeq(15min)}$**	**dB $L_{Aeq(24h)}$**
112 Unsworth Drive (Medical Centre)	70	68
82 Bluebird Crescent	64	62
16 Saturn Place (Childcare Centre)	67	65
29 Arrenway Drive (businesses)	70	68
17 Tawa Drive (SH17)	65	63
80 Paul Matthews Road (Hockey)	68	66

Item	Measured noise level	Derived noise level
Rook Place - Reserve	65	63

4.2 Computer noise modelling

In addition to measuring the noise levels at a number of locations along the alignment, computer noise modelling enables the prediction of existing noise levels at all dwellings within the overall assessment area (100 metres from the edge of the carriageway for urban areas in accordance with NZS 6806 – refer Section 2.1.3 above).

Individual assessment areas are described in **Table 7** below and are shown on the figure in **Appendix B**. While only those buildings are PPFs that already have building consent or are existing, we have assessed in Area 2a receivers that are in the process of obtaining building consent for some of the sites at the residential subdivision at Colliston Rise, while for other sites in the subdivision building consent has not been granted yet. Our assumption is that all dwellings will be double storey. Based on the building consent application information received from Council, all dwellings closest to SH1 have been designed with mechanical ventilation so that windows and doors facing SH1 can remain shut. These dwellings have been designed to meet appropriate internal noise levels without additional mitigation, and our assessment has been undertaken for completeness.

Table 7 Traffic noise assessment areas

Adjacent to	Direction	Area number	Area name
SH1	Southbound	1	SH1 North of McClymonts Road
		2	SH1 South of McClymonts Road
		2a	SH1 Colliston Rise (generally not yet consented)
SH1	Northbound	3	SH1 South of SH18
SH18	Westbound	4	SH18 Cabello Place
		5	SH18 Barbados Drive
		6	SH18 Metlifecare Retirement Village
		7	SH18 Bluebird Crescent
SH18	Eastbound	8	SH18 Childcare Saturn Place

For each of these areas, the noise levels received by all PPFs have been calculated. Results have been combined for each area, using two methodologies:

- Noise levels currently received by dwellings as sorted into Categories A, B and C in accordance with NZS 6806; and
- Noise levels in 5 decibel bands from less than 55 dB to more than 70 dB LAeq(24h) to assess the number of people potentially highly annoyed by road traffic noise.

A total 304 PPFs have been assessed. The results show that only a small number of PPFs receive noise levels within Category C. All of these PPFs are adjacent to SH1 in Assessment Areas 1, 2, 2a and 3.

The number of PPFs in each NZS 6806 noise criteria category have been summarised for the entire Project in **Table 8** below.

Table 8 Number of PPFs in each NZS 6806 noise criteria category (including Area 2a)

Situation	Category A	Category B	Category C
Existing (2016)	285	17	2
Do-nothing (2031)	276	23	5
Do-minimum (2031)	253	21	30
Preferred Mitigation Option (2031)	261	20	23

Appendix F contains figures showing a graphic representation of the noise criteria categories, by colouring the buildings within NZS 6806 Category A in green, Category B in yellow and Category C in red. Any barriers are shown in turquoise.

5 Effects Assessment: Operation of Project

This section of the report describes the assessment of operational noise effects from the Project on PPFs within 100 metres of the Alignment against “altered” road criteria of NZS 6806.

When comparing the do-nothing scenario (where the Project is not built) with the do-minimum scenario (where the Project in place, but without mitigation), noise levels would increase by up to 5 decibels in some areas at the design year. The do-minimum scenario (where the Project is built with no noise mitigation) allowed for an OGPA road surface on the entire alignment (except ramps). A number of PPFs would fall into Categories B and C, which is not a desirable outcome.

The main mitigation option considered involved barriers of varying height. Barriers would achieve effective mitigation for most PPFs. A preferred mitigation option is put forward for each area.

Each assessment area is discussed separately in the sections below in relation to NZS 6806, change in noise level, and the number of people potentially highly annoyed.

5.1 Area 1 – SH1 north of McClymonts Road

5.1.1 NZS 6806

Assessment Area 1 is between the southbound lanes of SH1 and Masons Road. There are 39 PPFs within this area, generally three storey town houses.

All of these dwellings are relatively new and would have been constructed under the requirements of the Auckland Council District Plan - North Shore Section as described in Section 2.1.1. Some bunding and fencing has been installed between the residential development and SH1. This is acoustically effective for lower floors, but does not provide shielding for upper floors.

Two dwellings are predicted to currently receive noise levels within Category C, i.e. above 67 dB $L_{Aeq(24h)}$, all in Masons Road. These dwellings are multi storey, with the upper floors being most affected by traffic noise.

Two barrier options were tested. Mitigation option 1 involved a 5 metre barrier extending along the western boundary of 60 Masons Road with SH1, with a small return on the northern side. This barrier was found to be insufficient for reducing noise levels to Category B for five PPFs.

In Mitigation option 2, the barrier height was increased to 8 metres at the northern and southern ends of the boundary, in the vicinity of the closest PPFs. This higher barrier would result in four PPFs in Category C, compared with the do-minimum scenario.

In discussion with the Project team, it was decided that neither of these barrier options represented the BPO. The busway would be located on an elevated level, held by a retaining wall, with further retaining between the busway and 60 Masons Road. Any barrier on top of the retaining wall would be difficult to construct and result in adverse visual effects. A stormwater drain would also need to be installed in this area, which would interfere with the barrier installation. Overall, there is not sufficient space to construct a barrier high enough to mitigate noise levels sufficiently.

For those reasons, and the fact that the dwellings will have been constructed with specific insulation in response to the existing high noise levels, no structural mitigation is proposed in this area.

Mitigation option 3 identifies any PPFs that receive noise levels within Category C, and assess them for building modification where the internal noise level would exceed 40 dB $L_{Aeq(24h)}$. For this mitigation option, the external noise levels are not reduced, therefore, they remain in the noise criteria categories

the same as the do-minimum option, but Category C PPFs are assessed for building modification to achieve a suitable internal noise environment. It is noted that the majority of PPFs in this area are reasonably new and are likely to have been designed taking account the presence of SH1.

The number of PPFs in each noise category is summarised in **Table 9** below, and figures showing the location of the PPFs are included in **Appendix F**.

Table 9 Area 1: Summary of NZS 6806 Assessment

Scenario	Number of PPFs			Comment
	Category A	Category B	Category C	
Existing	30	7	2	
Do-nothing	29	5	5	
Do-minimum	21	7	11	
Mitigation Option 1	29	5	5	5m barrier
Mitigation Option 2	33	2	4	5 to 8 m barrier
Mitigation Option 3	21	7	11	Building modification mitigation investigated for 11 PPFs – Preferred option

5.1.2 Assessment of Effects

Noise levels are predicted to increase by up to 4 decibels at some PPFs with the implementation of the Project. The reason is the introduction of the busway in close proximity to some PPFs that overlook both SH1 and the busway. Overall, however, the noise environment will remain similar to what would be experienced without the Project, and it is unlikely that a change in noise level would be perceived, particularly given that the character of the noise remains unchanged.

Table 10 Area 1: Change in noise level

Change in noise level (Preferred mitigation option – Do-nothing scenario)	Number of PPFs	Effect
3 – 4 decibels reduction	2	Slight positive
1 – 2 decibels reduction	7	Negligible
Less than 1 decibel change	8	None
1 – 2 decibels increase	6	Negligible
3 – 4 decibels increase	16	Slight adverse
5 – 8 decibels increase	0	Moderate adverse

5.1.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 2.2 people per dwelling in Area 1. This number has been used to determine the number of people potentially highly

annoyed. Detailed numbers of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in **Table 11** overleaf.

The table shows that the number of people highly annoyed would increase slightly over time. The reason is that traffic volume will increase from 2016 to 2031, and that the new busway will take traffic closer to dwellings.

Table 11 Area 1: Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24j)}$)					Number of people potentially highly annoyed	Notes
	< 55	55 – 60	60 – 65	65 – 70	>70		
	Number of PPFs						
Existing	1	19	13	6	0	13	
Do-nothing	0	11	19	9	0	15	
Do-minimum	0	12	14	8	5	17	
Mitigation Option 1	0	20	11	4	4	14	
Mitigation Option 2	0	22	12	4	1	13	
Mitigation Option 3	0	12	14	8	5	17	Preferred option

5.2 Area 2 – SH1 south of McClymonts Road

5.2.1 NZS 6806

Assessment Area 2 is between the southbound lanes of SH1 and Spencer Road. There are 24 PPFs in this area, generally three storey town houses.

All of these dwellings are relatively new and would have been constructed under the requirements of the Auckland Council District Plan - North Shore Section as described in Section 2.1.1. Some bunding and fencing has been installed between the residential development and SH1. This is acoustically effective for lower floors, but does not provide shielding for upper floors.

All dwellings are predicted to currently receive noise levels within Category A, due to the shielding provided by bunds and fence, and the distance to the road. In the do-nothing scenario, PPFs closest to SH1 are predicted to receive noise levels within Category B.

The introduction of the busway and widening of SH1 results in an increase in noise levels for some PPFs closest to SH1, with four PPFs predicted to receive noise levels within Category C, and a further five PPFs receiving noise levels within Category B. While one of these PPFs (71 Spencer Road, the unit closest to SH1) cannot practicably be shielded, particularly upper floors, we have tested a 5 metre high barrier along the site boundary of 106, 126, 128 and 128A McClymonts Road and the northern units at 71 Spencer Road. With this barrier in place, all PPFs in that area are predicted to receive noise levels below 67 dB $L_{Aeq(24h)}$ (Category C).

However, in the meeting discussing the practicability of mitigation options, feedback from the Project team was that a barrier of this height is impracticable to install, has adverse visual effects from the

road side due to its height combined with the required retaining wall in this area, may lead to shading and adverse visual effects for residents in McClymonts and Spencer Roads and may interfere with stormwater requirements.

In addition, the benefit cost analysis shows that only marginal benefits would be achieved, with a BCR of less than 1. Therefore, any higher barriers (which would need to be higher than 6 metres) would be at higher costs, which may be able to move all PPFs from Category C into Categories A or B, would result in lesser BCR values and higher adverse visual and construction effects.

For that reason, structural mitigation is not considered to be the BPO for this area. Any PPFs that are identified as receiving noise levels within Category C will need to be assessed for building modification mitigation where the internal noise level would exceed 40 dB $L_{Aeq(24h)}$. It is noted that the majority of PPFs in this area are reasonably new and are likely to have been acoustically designed, taking account the existing sound from SH1.

The number of PPFs in each noise category is summarised in **Table 12** below, and figures showing the location of the PPFs are included in **Appendix F**.

Table 12 Area 2: Summary of NZS 6806 Assessment

Scenario	Number of PPFs			Comment
	Category A	Category B	Category C	
Existing	24	0	0	
Do-nothing	21	3	0	
Do-minimum	15	5	4	
Mitigation Option 1	18	5	1	5m barrier
Mitigation Option 2	15	5	4	Building modification mitigation investigated for 4 PPFs – Preferred Option

5.2.2 Assessment of Effects

Noise levels in this area are predicted to increase generally by 3 to 4 decibels due to the widening of SH1 and the introduction of the busway. This change in noise level would be just noticeable, but since the character of the noise remains unchanged, it is unlikely that effects are any more than slight.

Table 13 Area 2: Change in noise level

Change in noise level (Preferred mitigation option – Do-nothing scenario)	Number of PPFs	Effect
3 – 4 decibels reduction	0	Slight positive
1 – 2 decibels reduction	0	Negligible
Less than 1 decibel change	0	None
1 – 2 decibels increase	0	Negligible
3 – 4 decibels increase	22	Slight adverse
5 – 8 decibels increase	2	Moderate adverse

5.2.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 2.2 people per dwelling in Area 2. This number has been used to determine the number of people potentially highly annoyed. Detailed numbers of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in **Table 14** overleaf.

The table shows that the number of people highly annoyed would slightly increase over time. The reason is that the busway and motorway widening will bring traffic closer to the PPFs. Even with the modelled 5 m high barrier option, only a marginal reduction in the number of people highly annoyed is predicted.

Table 14 Area 2: Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24j)}$)					Number of people potentially highly annoyed	Notes
	< 55	55 – 60	60 – 65	65 – 70	>70		
	Number of PPFs						
Existing	2	12	10	0	0	7	
Do-nothing	2	11	11	0	0	7	
Do-minimum	0	3	14	7	0	10	
Mitigation Option 1	0	3	17	4	0	9	
Mitigation Option 2	0	3	14	7	0	10	Preferred option

5.3 Area 2a – SH1 Colliston Rise

5.3.1 Indicative - NZS 6806

Assessment Area 2a is a new subdivision between Spencer Road and Greville Road. While for some lots, applications for building consent have been lodged, most sites are not yet developed to that level.

Building consent documentation shows that all of the sites for which building consent has been sought (six sites[12] of the total of 49 sites within the subdivision) will be constructed in accordance with the High Noise Route provisions of the North Shore District Plan, and with include mechanical ventilation for habitable rooms facing SH1.

We have assumed that all future dwellings in this area will be double storey, based on the six dwellings that have building consent, and have therefore predicted noise levels to the upper floor at an elevation of 4.5m above ground.

The future 43 dwellings can be designed to take account of the existing high noise environment and make provisions for insulation and ventilation, and are for that reason not PPFs. Particularly for multi-storey dwellings, mitigation in the form of barriers is ineffective for upper floors, and therefore building

[12] Nos. 3, 5, 7, 9 and 50 Colliston Rise and 1 Coxton Terrace

modification (thus ensuring that dwellings are designed appropriately to avoid reverse sensitivity effects) are the most practicable option, which should be incorporated in the initial design of the dwellings.

Ground floors can be mitigated with the installation of noise barriers, particularly if such barrier is installed on top of the embankment. It is assumed that such barrier will be part of the development and installed during the construction of the dwellings.

This section of the report discusses the not yet consented dwellings as well as the PPFs, though the assumptions mean that there is no certainty in the results and therefore no recommendation of mitigation.

It is noted that all PPFs are predicted to receive noise levels within Category A for all assessment scenarios.

Table 15 Area 2a: Summary of NZS 6806

Scenario	Number of PPFs / Future Dwellings			Comment
	Category A	Category B	Category C	
Existing	6 / 42	1	0	
Do-nothing	6 / 38	5	0	
Do-minimum	6 / 35	2	6	Preferred Option*

* Assumed that dwellings will include noise mitigation in the form of appropriate façade design and on-site mitigation such as boundary fencing

5.3.2 Indicative Assessment of Effects

While the future dwellings are not strictly PPFs, we have assessed the potential effects of change in traffic noise level of change. Many of the dwellings have not yet been constructed, and we are therefore unsure what noise mitigation will be incorporated into the site layout, i.e. where exactly dwellings will be constructed, if all dwellings will be single or double storey and if there will be a boundary fence installed facing SH1. For those reasons, this part of the report is indicative only and should not be given the same weight as the assessment of effects of other areas.

We note that these uncertainties are one of the reasons why NZS 6806 does not include buildings prior to building consent stage as PPFs. Any estimation of effects has been based on a number of assumptions which can lead to incorrect results, and should be read as such.

Table 16 Area 2a: Indicative change in noise level

Change in noise level (Preferred option – Do-nothing scenario)	Number of PPFs / Future dwellings	Effect
3 – 4 decibels reduction	0 / 1	Slight positive
1 – 2 decibels reduction	0 / 3	Negligible
Less than 1 decibel change	0 / 4	None
1 – 2 decibels increase	5 / 14	Negligible
3 – 4 decibels increase	1 / 18	Slight adverse
5 – 8 decibels increase	0 / 3	Moderate adverse

5.3.3 Estimated number of people highly annoyed

We have assessed effects on the future dwellings based on an assumed number of people per dwelling that may potentially be highly annoyed. It is noted that, as the dwellings are not yet constructed, the population density is unknown. For that reason, we have assumed a population density of 3 persons per dwelling. The proposed dwellings are free standing, i.e. different to the apartment buildings in Mason and McClymonts Road are more similar to the dwellings in Areas 3 to 7.

Table 17 Area 2a: Estimated number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24j)}$)					Number of people potentially highly annoyed*	Notes
	< 55	55 – 60	60 – 65	65 – 70	>70		
	Number of PPFs / Future dwellings						
Existing	1 / 9	5 / 20	0 / 14	0 / 0	0 / 0	16	
Do-nothing	0 / 2	6 / 25	0 / 14	0 / 2	0 / 0	18	
Do-minimum	0 / 0	6 / 23	0 / 12	0 / 8	0 / 0	21	Preferred option

* Assumed 3 people per PPF and future dwelling, combined number

5.4 Area 3 – SH1 south of SH18

5.4.1 NZS 6806

Assessment Area 3 is adjacent to the northbound lanes of SH1 and south of SH18/Upper Harbour Highway. There are 28 PPFs in this area, generally single and double storey dwellings.

These dwellings are in an established residential area and would likely have been built prior to the requirements of the District Plan High Noise Route rules.

All but two dwellings are predicted to receive existing ambient noise levels within Category A, due to the shielding provided by terrain. The remaining two dwellings are in Category B.

With the introduction of the Project, those two Category B PPFs (59B and 63 Santiago Crescent) are predicted to receive noise levels within Category C. The dwellings are double storey and look over the partial bund shielding them from SH1, so the upper floor is most affected. In order to provide reasonable shielding, a 3 metre barrier has been modelled along the eastern boundary. This barrier is predicted to reduce noise levels by 1 to 1.6 decibels, a marginal and generally unnoticeable change.

During the BPO meeting, feedback from the urban design and landscape specialists was that such a barrier is likely to have adverse visual and shading effects, particularly for lower floors. The BCR for such a barrier is marginal, at 0.42, well below what would be considered practicable and appropriate.

For these reasons, the Project team decided that a barrier did not constitute the BPO, and building modification mitigation should be investigated for the two identified PPFs.

The number of PPFs in each noise category is summarised in **Table 18** overleaf, and figures showing their location are included in **Appendix F**.

Table 18 Area 3: Summary of NZS 6806 Assessment

Scenario	Number of PPFs			Comment
	Category A	Category B	Category C	
Existing	36	2	0	
Do-nothing	36	2	0	
Do-minimum	35	1	2	
Mitigation Option 1	35	3	0	3m barrier
Mitigation Option 2	35	1	2	Building modification mitigation investigated for 2 PPFs – Preferred Option

5.4.2 Assessment of Effects

The Project finishes north of this assessment area, i.e. there are no changes to the road in the vicinity of these PPFs. However, the PPFs within this assessment area are still within 100 metres of the Project and are thus required to be assessed.

Noise levels are only predicted to change marginally, by up to 2 decibels, which would most likely be unnoticeable to residents. Minor changes in traffic volume with and without the Project, and slight effects from the new interchange, are the reasons for the small noise level changes predicted.

Table 19 Area 3: Change in noise level

Change in noise level (Preferred mitigation option – Do-nothing scenario)	Number of PPFs	Effect
3 – 4 decibels reduction	0	Slight positive
1 – 2 decibels reduction	0	Negligible
Less than 1 decibel change	3	None
1 – 2 decibels increase	35	Negligible
3 – 4 decibels increase	0	Slight adverse
5 – 8 decibels increase	0	Moderate adverse

5.4.3 Number of people highly annoyed

Based on the information provided in the 2013 census, there are on average 3.2 people per dwelling in Area 3. This number has been used to determine the number of people potentially highly annoyed. Detailed numbers of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in **Table 20** overleaf.

The table shows that the number of people highly annoyed would increase marginally by the design year. The reason is the increase in traffic volume from 2016 to 2031, and the associated marginal increase in noise level. However, there is very little difference in noise levels between the do-nothing scenario and the scenario with the Project. It is noted that the number of PPFs in the highest noise bands remains unchanged with two PPFs receiving noise levels between 65 and 70 dB $L_{Aeq(24h)}$.

Table 20 Area 3: Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24j)}$)					Number of people potentially highly annoyed	Notes
	< 55	55 – 60	60 – 65	65 – 70	>70		
	Number of PPFs						
Existing	8	19	9	2	0	14	
Do-nothing	4	21	11	2	0	15	
Do-minimum	2	21	13	2	0	16	
Mitigation Option 1	2	21	13	2	0	16	3m barrier
Mitigation Option 2	2	21	13	2	0	16	Preferred option

5.5 Area 4 – SH18 Cabello Place

5.5.1 NZS 6806

Assessment Area 4 is adjacent to SH18/Upper Harbour Highway closest to SH1. There are 30 PPFs within this area, generally single and double storey dwellings.

These dwellings are in an established residential area and would likely have been built prior to the requirements of the District Plan High Noise Route rules.

All but one dwelling (21 Cabello Place) are predicted to receive existing ambient noise levels within Category A. An existing earth bund with some residential fencing is currently in place between the PPFs and SH18. The residential fences are of varying quality and have not been included in the computer noise modelling as many are not acoustically effective.

Existing noise levels for most dwellings are below 60 dB $L_{Aeq(24h)}$.

The PPF at 21 Cabello Place is located on the corner of Upper Harbour Highway and SH1 and is predicted to receive an existing ambient noise level within Category B.

With the introduction of the Project, traffic will move further away from the PPFs, with the ramps located at a greater distance, elevated and tilted away from the dwellings. Therefore, even with the Project traffic volumes, noise levels are predicted to remain similar, and therefore noise criteria categories also remain the same. No mitigation was considered for this assessment area as no change in noise environment is predicted.

The number of PPFs in each noise category is summarised in **Table 21** below, and figures showing the location of the PPFs are included in **Appendix F**.

Table 21 Area 4: Summary of NZS 6806 Assessment

Scenario	Number of PPFs			Comment
	Category A	Category B	Category C	
Existing	29	1	0	
Do-nothing	29	1	0	
Do-minimum	29	1	0	Preferred option

5.5.2 Assessment of Effects

Noise levels are predicted to remain relatively unchanged, with the vast majority of PPFs predicted to experience noise level changes of no more than 2 decibels (increase or reduction). Only two PPFs (12 Cabello Place and 53 Meadowood Drive) are predicted to receive noise level increases of 3 decibels.

All of these PPFs are predicted to receive noise levels in the mid-50 decibels, at the low end of noise levels in the area. Effects for most PPFs are predicted to be negligible, and up to slight for these three identified receivers.

Table 22 Area 4: Change in noise level

Change in noise level (Preferred mitigation option – Do-nothing scenario)	Number of PPFs	Effect
3 – 4 decibels reduction	0	Slight positive
1 – 2 decibels reduction	8	Negligible
Less than 1 decibel change	6	None
1 – 2 decibels increase	14	Negligible
3 – 4 decibels increase	2	Slight adverse
5 – 8 decibels increase	0	Moderate adverse

5.5.3 Number of people highly annoyed

Based on the information provided in the 2013 census, there are on average 2.9 people per dwelling in Area 4. This has been used to determine the number of people potentially highly annoyed. Detailed numbers of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in **Table 23** below.

The table shows that the number of people highly annoyed would remain unchanged with the introduction of the Project. The majority of PPFs are in noise bands below 60 dB $L_{Aeq(24h)}$ where the percentage of highly annoyed people is lower. For that reason, the shift in noise levels, which is only slight, has no effect on the number of people highly annoyed.

Table 23 Area 4: Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24j)}$)					Number of people potentially highly annoyed	Notes
	< 55	55 – 60	60 – 65	65 – 70	>70		
	Number of PPFs						
Existing	13	6	10	1	0	10	
Do-nothing	12	7	10	1	0	10	
Do-minimum	5	15	10	0	0	10	Preferred Option

5.6 Area 5 – SH18 Barbados Drive

5.6.1 NZS 6806

Assessment Area 5 is between SH18/Upper Harbour Highway and Barbados Drive. This is the largest assessment area with 86 PPFs, generally established single and double storey dwellings.

All but three dwellings (1A Caribbean Drive, 9 and 11 Wren Place) are predicted to receive existing ambient noise levels within Category A, due to the shielding provided by an earth bund between Upper Harbour Highway and Barbados Drive. The remaining three dwellings receive ambient noise levels just within Category B, at 65 dB $L_{Aeq(24h)}$. Existing residential fences have not been included in the modelling due to their varying quality. Noise levels are predicted to remain similar for the do-nothing scenario.

With the Project in place, but no mitigation, a small number of PPFs is predicted to receive noise levels within Category C (9, 11, 13 and 14 Wren Place). Those PPFs are at the western end of the assessment area, in Wren Place. PPFs are in the vicinity of the new ramps and connection to the existing Upper Harbour Highway. Some of the dwellings are elevated above the road, with the ground floor overlooking their fences.

Mitigation has been modelled in the form of a 3 metre high barrier. Lower barriers would not break line of sight from the dwellings to the road and have therefore not been tested. With this barrier, all PPFs except one (14 Wren Place) would receive noise levels within Category A. This barrier is considered to constitute the BPO for noise mitigation.

At 14 Wren Place, noise levels are predicted to be within Category B. In order to reduce noise levels at this PPF to Category A, a barrier return along the northern boundary (outside designation) would be required, and views to the north across the open space would need to be blocked in order to break line of sight to the road. This is considered to be impracticable and cause visual and shading effects, and has therefore not been modelled.

The number of PPFs in each noise category is summarised in **Table 24** below, and figures showing the location of the PPFs are included in **Appendix F**.

Table 24 Area 5: Summary of NZS 6806 Assessment

Scenario	Number of PPFs			Comment
	Category A	Category B	Category C	
Existing	83	3	0	
Do-nothing	82	4	0	
Do-minimum	81	1	4	
Mitigation Option 1	85	1	0	3m barrier – Preferred option

5.6.2 Assessment of Effects

The Project (with mitigation at the western end of the assessment area) is predicted to result in a wide range of noise level changes, from a reduction of 5 decibels to an increase of 5 decibels. The PPF with the highest noise level (14 Wren Place, at 65 dB $L_{Aeq(24h)}$) is predicted to receive a 1 decibel noise level increase, which is unnoticeable. Overall, for the majority of PPFs the effects from the change in noise level are predicted to be slight.

Table 25 Area 5: Change in noise level

Change in noise level (Preferred mitigation option – Do-nothing scenario)	Number of PPFs	Effect
5 – 8 decibels reduction	5	Moderate positive
3 – 4 decibels reduction	2	Slight positive
1 – 2 decibels reduction	5	Negligible
Less than 1 decibel change	7	None
1 – 2 decibels increase	39	Negligible
3 – 4 decibels increase	28	Slight adverse
5 – 8 decibels increase	0	Moderate adverse
9 – 11 decibels increase	0	Significant

5.6.3 Number of people highly annoyed

Based on the information provided in the 2013 census, there are on average 3.3 people per dwelling in Area 5. This number has been used to determine the number of people potentially highly annoyed. Detailed numbers of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in **Table 26**.

The table shows that the number of people highly annoyed would remain generally stable over time. Only a small number of PPFs are within the higher noise bands of 65 dB $L_{Aeq(24h)}$ or above. At lower noise bands, a smaller percentage of people are generally highly annoyed, so the slight change in noise level has only marginal effects on the number of people highly annoyed.

Table 26 Area 5: Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24j)}$)					Number of people potentially highly annoyed	Notes
	< 55	55 – 60	60 – 65	65 – 70	>70		
	Number of PPFs						
Existing	18	44	24	0	0	34	
Do-nothing	45	24	14	3	0	28	Excludes local roads such as Barbados Dr
Do-minimum	24	34	23	5	0	33	
Mitigation Option 1	28	32	25	1	0	30	Preferred Option

5.7 Area 6 – SH18 Metlifecare

5.7.1 NZS 6806

Assessment Area 6 consists of the new Metlifecare aged care facility. The site was developed in accordance with the of the North Short District Plan High Noise Route requirements. An acoustic barrier was installed along the SH18 frontage, providing effective shielding to the closest residences, all of which are single storey.

All dwellings are predicted to receive existing ambient noise levels within Category A. With the introduction of the Project, the increase in traffic speed from 80 to 100 km/h, and traffic lanes moving closer, two PPFs (on the north eastern corner of the site) are predicted to receive noise levels within Category B.

Two mitigation options were modelled. Option 1 involved a 2 metre high noise barrier just east of the site, extending for some 70 metres from the north eastern corner of the site along SH18. This option, while achieving noise levels within Category A at all PPFs, would cause issues with the stormwater treatment and flow.

Option 2 involved an extension of the Metlifecare barrier by approximately 32 metres along the eastern boundary to shield two additional PPFs within the site. Since the terrain falls away towards a natural creek, the barrier extension would need to compensate in height to achieve sufficient shielding, resulting in a 4.5 metre height at the eastern end of the barrier. This is considered to be impracticable by the urban designer and landscape architect.

Based on feedback from the Project team and considering that both barrier options achieve noise Category A for all PPFs, Mitigation Option 1 was chosen as the preferred mitigation option.

The number of PPFs in each noise category is summarised in **Table 27** below, and figures showing the location of the PPFs are included in **Appendix F**.

Table 27 Area 6: Summary of NZS 6806 Assessment

Scenario	Number of PPFs			Comment
	Category A	Category B	Category C	
Existing	23	0	0	
Do-nothing	23	0	0	
Do-minimum	21	2	0	
Mitigation Option 1	23	0	0	2m barrier along SH18 – Preferred option
Mitigation Option 2	23	0	0	2.5 to 4.5m barrier along the eastern Metlifecare boundary

5.7.2 Assessment of Effects

As discussed above, the Project is predicted to result in noise level increases due to the increase in speed and traffic volume, and traffic lanes moving closer. The majority of PPFs are predicted to receive noise level increases of up to 5 decibels, which is a noticeable change. However, PPFs are predicted to receive noise levels of up to 62 dB $L_{Aeq(24h)}$ which, with windows closed, would translate to no more than 40 dB $L_{Aeq(24h)}$ inside dwellings during daytime and significantly less during night time. These noise levels are considered appropriate for residential use and provide good amenity.

Table 28 Area 6: Change in noise level

Change in noise level (Preferred mitigation option – Do-nothing scenario)	Number of PPFs	Effect
3 – 4 decibels reduction	0	Slight positive
1 – 2 decibels reduction	0	Negligible
Less than 1 decibel change	0	None
1 – 2 decibels increase	3	Negligible
3 – 4 decibels increase	10	Slight adverse
5 – 8 decibels increase	10	Moderate adverse
9 – 11 decibels increase	0	Significant adverse

5.7.3 Number of people highly annoyed

Since the development is still under construction, no census data is available, so it has been assumed that two persons per villa will reside in the development. This number has been used to determine the number of people potentially highly annoyed. Detailed numbers of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in **Table 29**.

The table shows that the number of people highly annoyed would be slightly increasing over time. Generally, all PPFs receive less than 65 dB $L_{Aeq(24h)}$.

Table 29 Area 6: Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24j)}$)					Number of people potentially highly annoyed	Notes
	< 55	55 – 60	60 – 65	65 – 70	>70		
	Number of PPFs						
Existing	14	9	0	0	0	4	
Do-nothing	8	14	1	0	0	4	
Do-minimum	0	12	10	1	0	6	
Mitigation Option 1	0	12	11	0	0	6	Preferred option
Mitigation Option 2	0	14	9	0	0	6	

5.8 Area 7 – SH18 Bluebird Crescent

5.8.1 NZS 6806

Assessment Area 7 is located at the western end of the Project adjacent to SH18. Dwellings in that area are generally single storey. This is an established residential area that was likely developed prior to the High Noise Route requirements of the North Shore District Plan.

All dwellings except two are predicted to receive existing ambient noise levels within Category A, with the remaining two dwellings within Category B.

With the Project in place, noise levels are predicted to increase due to the increase in traffic speed and volume. Two PPFs would receive noise levels within Category C, and one within Category B. However, with mitigation, these noise levels can be reduced noticeably.

Two mitigation options were modelled. Mitigation option 1 would be a 2.4m high barrier extending some 85 metres from the north eastern corner of the Albany Basin Physiotherapy Care Clinic (96 Bluebird Crescent) to the west. This would result in two PPFs receiving noise levels within Category B, and all remaining PPFs within Category A.

Option 2 was a barrier of the same length and location, ranging in height from 2.4 to 3.6 meters, and all PPFs were predicted to receive noise levels within Category A. However, feedback from the urban design and landscape specialists was that such barrier heights would be out of character with the residential use of the sites and, due to the barrier being to the north of the residential sites, shading and other adverse effects could occur. For that reason, Option 1 was the preferred mitigation option.

The number of PPFs in each noise category is summarised in **Table 30** below, and figures showing the location of the PPFs are included in **Appendix F**.

Table 30 Area 7: Summary of NZS 6806 Assessment

Scenario	Number of PPFs			Comment
	Category A	Category B	Category C	
Existing	11	2	0	
Do-nothing	11	2	0	
Do-minimum	10	1	2	
Mitigation Option 1	11	2	0	2.4m barrier – Preferred Option
Mitigation Option 2	13	0	0	2.4 to 3.6m height

5.8.2 Assessment of Effects

Most PPFs in this area receive noise levels below 60 dB $L_{Aeq(24h)}$. The introduction of the Project, even with mitigation in place, is predicted to result in a noticeable noise level increase for the majority of PPFs. Noise levels are predicted to increase by up to 5 decibels. However, resultant noise levels are predicted to remain below 65 dB $L_{Aeq(24h)}$ for all but two PPFs. Those two PPFs (94 and 102 Bluebird Crescent) would receive less or the same noise level as for the do-nothing scenario, so there will be no effect for them.

Table 31 Area 7: Change in noise level

Change in noise level (Preferred mitigation option – Do-nothing scenario)	Number of PPFs	Effect
3 – 4 decibels reduction	0	Slight
1 – 2 decibels reduction	1	Negligible
Less than 1 decibel change	1	None
1 – 2 decibels increase	1	Negligible
3 – 4 decibels increase	6	Slight
5 – 8 decibels increase	4	Moderate

5.8.3 Number of people highly annoyed

Based on the information provided in the 2013 census, there are on average 4.2 people per dwelling in Area 7. This number has been used to determine the number of people potentially highly annoyed. Detailed numbers of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in **Table 32** below.

The table shows that the number of people highly annoyed would increase due to the Project because noise levels are predicted to increase by up to 5 decibels.

All but one PPFs are predicted to remain in noise bands below 65 dB $L_{Aeq(24h)}$ and remain in similar noise bands to the existing and do-nothing scenarios.

Table 32 Area 7: Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24j)}$)					Number of people potentially highly annoyed	Notes
	< 55	55 – 60	60 – 65	65 – 70	>70		
	Number of PPFs						
Existing	2	8	1	2	0	6	
Do-nothing	2	8	1	2	0	7	
Do-minimum	0	4	6	1	2	10	
Mitigation Option 1	0	2	10	1	0	9	Preferred option
Mitigation Option 2	0	2	11	0	0	8	

5.9 Area 8 – SH18 Childcare Centres

5.9.1 NZS 6806

Assessment Area 8 consists of only two PPFs; a childcare centre at Saturn Place and another in Omega Street, both adjacent to SH18. The centre buildings are double storey, with play areas facing SH18.

The centre at Saturn Place is separated from SH18 by its car park. Existing noise levels are predicted to be within Category A. The upper floor has no windows facing SH18; they are perpendicular to the motorway.

Outdoor play areas are located to the south, west and north of the building, with the closest play area approximately 25 metres from SH18. While the childcare centre play areas are surrounded by a 1.8 m high fence, it is not acoustically effective due to the gaps between palings.

Existing noise levels are predicted to be up to 60 dB $L_{Aeq(24h)}$ and would increase by 1 decibel for the do-nothing scenario. With the Project in place, noise levels up to 66 dB $L_{Aeq(24h)}$ are predicted due to the increase in speed and traffic volume, amongst other things.

A 2.4m barrier was modelled along the common boundary of SH18 and the childcare carpark. With this barrier in place, a noise level of 64 dB $L_{Aeq(24h)}$ is predicted, which is within Category A. This barrier has been put forward as the preferred option.

The centre at Omega Street is immediately beside SH18, with only the play area separating the building from the road. An existing boundary fence between the road and the play area and centre is not considered acoustically effective as there are gaps between the timber palings. Existing noise levels are predicted to be within Category B at 66 dB $L_{Aeq(24h)}$. With the increase in traffic volume on SH18 in the do-nothing scenario, a noise level within Category C (67 dB $L_{Aeq(24h)}$) is predicted in the design year.

With the implementation of the Project, a noise level of 71 dB $L_{Aeq(24h)}$ is predicted for the do-minimum scenario.

A 2.4m barrier was modelled along the common boundary of SH18 and the childcare play area, with a return connecting to the building. The barrier would have an overall length of approximately 50 m, and extend beyond the play area to the east to provide effective shielding. With this barrier in place, a noise level of 66 dB $L_{Aeq(24h)}$ is predicted, similar to existing noise levels in 2016. This barrier is considered to be the preferred option, as a higher barrier would appear overbearing for the small space between the building and SH18.

A figure showing the location of the PPF is included in **Appendix F**.

5.9.2 Assessment of Effects

The change in noise level at the Saturn Place centre is predicted to be a 3 decibel increase when comparing the do-nothing option and the Project with preferred mitigation option. This is a slight change that may just be noticeable. However, the character of the noise will not change. At the Omega Street centre a noise level reduction of 1 decibel is predicted. This would be an unnoticeable noise level reduction and maintain the current level of noise.

5.9.3 Number of people highly annoyed

The Saturn Place centre is licensed for 148 children, including 50 under two year olds[13] and the Omega Street centre is licensed for 30 children between 2 and 6 years of age. In addition there will be a number of staff on site.

The facilities are not dwellings, and it is noted that children react differently to noise compared with the general (adult) population. While in the play area, children would create noise of their own, while during nap time children will be inside.

The Miedema and Outshoorn study referenced in Section 3.1.2 does not specifically apply to children, and no relevant study has been found. For this reason, no assessment of the number of people highly annoyed has been undertaken. Rather, effects have been mitigated by the proposal to install noise barriers that protect not only the buildings, but also the outdoor play areas.

[13] Education Review Office, http://www.ero.govt.nz/review-reports/learning-tree-early-childcare-centre-26-06-2015/

6 Mitigation Measures

Traffic noise mitigation has been investigated for all assessment areas in the vicinity of the Project, and recommendations of BPO mitigation have been made.

As a low noise road surface is already proposed, no further noise mitigation was able to be incorporated into the road surface design.

Barriers are the next preferred mitigation measure and have been recommended at varying heights and lengths for some areas along the Project where appropriate. Where these barriers are not sufficient to achieve noise levels within Categories A and B, building modification mitigation may also have to be implemented.

Table 33 summarises the recommended barrier heights and lengths for each assessment area, as well as the number of PPFs that are predicted to receive noise levels within Category C. Figures showing the preferred barrier locations and heights are included in **Appendix F**.

Table 33 Preferred Noise Mitigation Measures

Area	Mitigation option	Barrier heights and lengths	Number of PPFs considered for building modification mitigation
1 – SH1 north of McClymonts Rd	Do-minimum	n/a	11
2 – SH1 south of McClymonts Rd	Do-minimum	n/a	4
2a – SH1 Colliston Rise	Do-minimum	n/a	0
3 – SH1 south of SH18	Do-minimum	n/a	2
4 – SH18 Cabello Place	Do-minimum	n/a	n/a
5 – SH18 Barbados Drive	Mitigation option 1	3m height, 128m length	n/a
6 – SH18 Metlifecare	Mitigation option 1	2m height, 71m length	n/a
7 – SH18 Bluebird Crescent	Mitigation option 1	2.4m height, 84m length	n/a
8 – SH18 Childcare Centres	Mitigation option 1	2.4m height, 40m and 50m length	n/a

7 Traffic Vibration

The Auckland Motorway Alliance (AMA) is responsible for the maintenance of the Auckland State highway network and receives any complaints in regards to these roads. Complaints data for the Project area has been requested from the AMA. In response, it is understood that no complaints have been received in regards to traffic vibration, which indicates that the current level of traffic vibration is likely acceptable and expected.

Traffic vibration is usually only generated when heavy commercial vehicles (HCV) drive over bumps or dips in the road.

Traffic vibration risk has been assessed by reviewing data of HCVs travelling on existing roads with a range of surface conditions. Assessing this data against suitable traffic vibration criteria (Class C of the Norwegian Standard NS 8176.E:2005) indicates that compliance with the criteria can be achieved at 25 metres from the road edge, even for roads in a degraded state. For a newly sealed OGPA pavement, the risk contour may be as small as 2 metres from the road edge. There are no receivers this close to the traffic lane edge.

With the implementation of the NZ Transport Agency road maintenance policy, it is unlikely that the Project road surface will ever degrade significantly so effects are predicted to be negligible for all receivers. However, if the road does degrade, the effects would still only be minor provided that compliance with the Project traffic vibration criterion is maintained.

8 Summary and Conclusions

Marshall Day Acoustics has undertaken an assessment of traffic noise and vibration from the Northern Corridor Improvement Project. The Project is situated between Oteha Valley Road in the north and Upper Harbour Highway in the south, and extending along SH18 from SH1 in the east to in Albany Highway in the west. All noise sensitive receivers within 100 metres of the Project area have been assessed. The assessment is based on the relevant Standard (NZS 6806:2010), the potential subjective response of people to the change in noise level and the number of people likely to be highly annoyed by the traffic noise levels received.

Noise barriers of varying heights have been recommended for some sections of the Project area in the vicinity of PPFs.

No barriers are recommended where they are not considered to be the BPO. Reasons may involve:

- The lay of the dwelling in relation to the road (e.g. where dwellings are significantly elevated and cannot be effectively shielded);
- Multi-storey dwellings where the upper floor cannot be mitigated;
- Effective barriers may be impractical for engineering (e.g. geotechnical, groundwater, stormwater, constructability) reasons;
- Effective barriers may be too high in a residential (e.g. urban design) context; and
- Dwellings are not yet consented and/or have been constructed in accordance with the High Noise Route provisions of the North Shore District Plan, thus already incorporating building modification mitigation.

The Project will be surfaced with OGPA on the main alignment, and dense asphalt on ramps. These are low noise generating road surface materials.

The noise level change due to the Project for dwellings will generally be small (less than 4 decibels). For most areas, noise levels would change by no more than 2 decibels. This change would be imperceptible, particularly as the noise source (i.e. traffic) does not change.

Noise mitigation (both structural and building modification) has been recommended for most areas, to ensure that noise levels remain within Category A where practicable.

Traffic vibration has been addressed through a review of complaints about current traffic vibration from SH1 and SH18 in the assessment area. No complaints have been recorded by the AMA. Maintaining a smooth road surface will avoid traffic vibration. The NZ Transport Agency has appropriate measures in place that ensures the quality of the road will be maintained to a high level.

Overall, this Project will result in similar effects for most people adjacent to the road, compared with current and do-nothing scenarios. While high noise levels cannot be mitigated at all dwellings, the proposed mitigation will maintain noise levels within the same noise criteria category despite the increase in traffic volume and speed over time

Appendices

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Appendix A
Excerpts from District, Regional and Unitary Plans

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Auckland Council District Plan – Operative North Shore Section 2002

The North Shore District Plan contains noise rules in Section 10.5.

The Plan does not contain noise rules that relate to the management of traffic on roads, however, it contains a requirement for new dwellings constructed adjacent to existing High Noise Routes to be insulated. Both SH1 and the Upper Harbour Highway are classed as High Noise Routes in the District Plan.

Existing High Noise Routes

In circumstances where a residential unit is to be constructed on any site near to an existing and/or potential high noise route as specified in Appendix 10D and subject to a daily noise exposure level (Leq (6am-10pm)) as defined in New Zealand Standard 6801:1991 equal to or greater than (Leq (6am-10pm)) 65 dBA on any part of the site, an Acoustic Design Report is to be obtained from a suitably qualified Acoustic Engineer confirming that the building will be constructed not to exceed a daily noise exposure of (Leq (6am-10pm)) 40 dBA in all habitable rooms with ventilating windows open.

Auckland Unitary Plan (Operative in Part – 15 November 2016)

E25.6.33 Noise levels for traffic from new and altered roads

1. *All new roads and all altered roads that are within the scope of New Zealand Standard NZS 6806:2010 Acoustics – Road traffic noise – New and altered roads must comply with the requirements of New Zealand Standard NZS 6806:2010 Acoustics – Road traffic noise – New and altered roads*

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Appendix B
Assessment Areas

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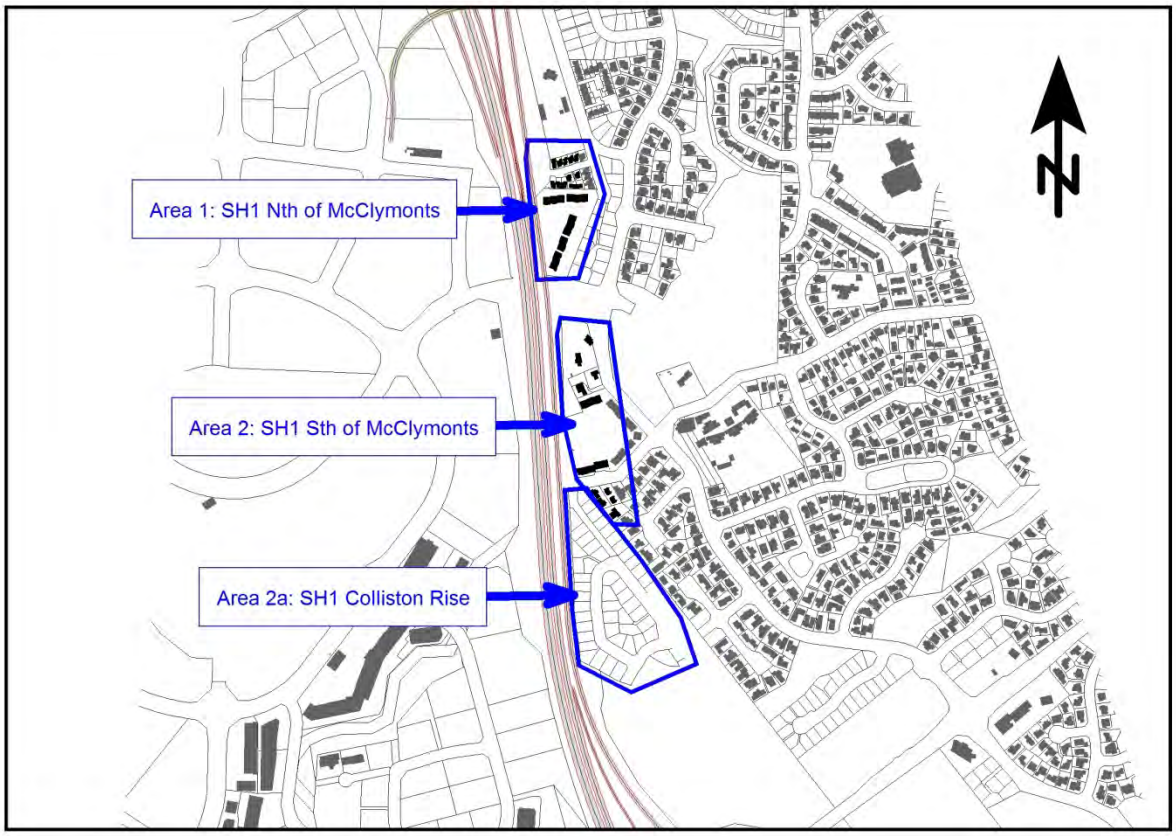
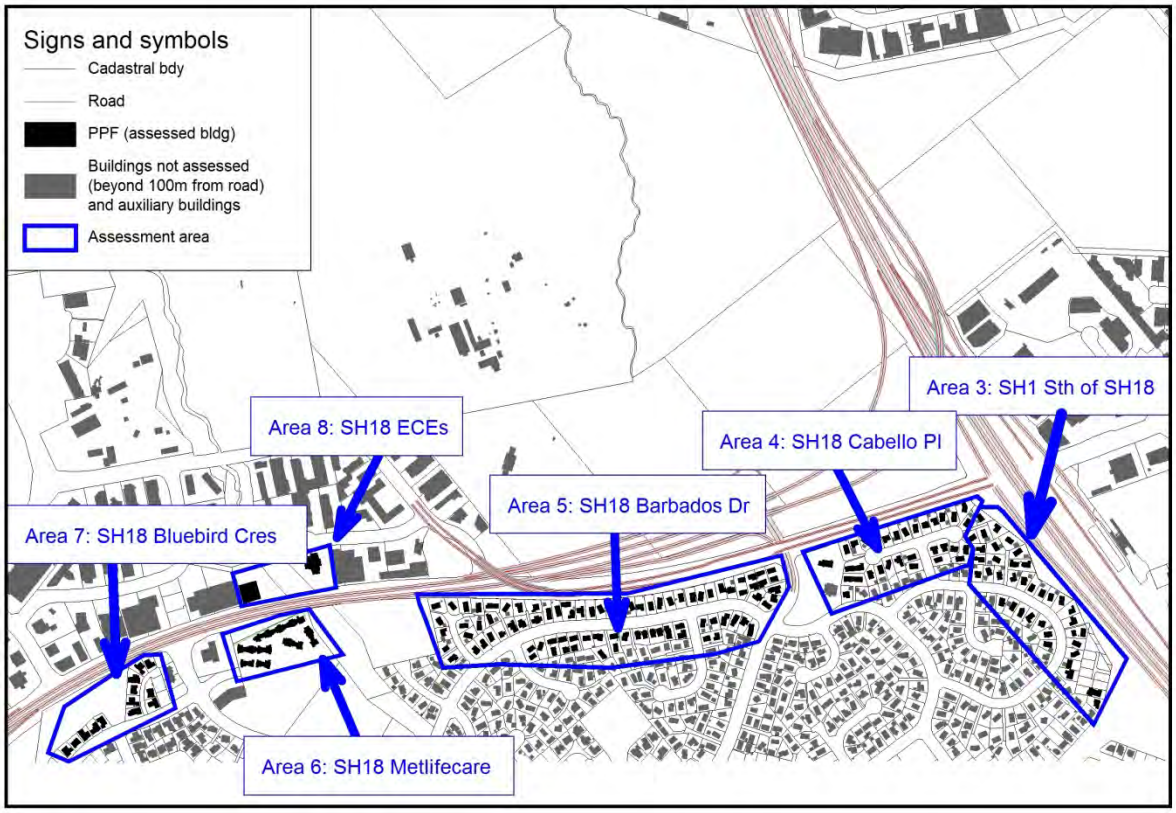

Area 1: SH1 Nth of McClymonts
Area 2: SH1 Sth of McClymonts
Area 2a: SH1 Colliston Rise
N


Signs and symbols
Cadastral bdy
Road
PPF (assessed bldg)
Buildings not assessed (beyond 100m from road) and auxiliary buildings
Assessment area
Area 3: SH1 Sth of SH18
Area 8: SH18 ECEs
Area 4: SH18 Cabello Pl
Area 5: SH18 Barbados Dr
Area 7: SH18 Bluebird Cres
Area 6: SH18 Metlifecare

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Appendix C
NZS 6806 Assessment: BCR and BPO

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Project
Northern Corridor Improvements
Area 1 – SH1 Nth of McClymonts Rd

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	○	◉	○	○	○
Category A	30	29	21	29	33	21	0	0	0
Category B	7	5	7	5	3	7	0	0	0
Category C	2	5	11	5	4	11	0	0	0
Total			39	39	39	39	0	0	0

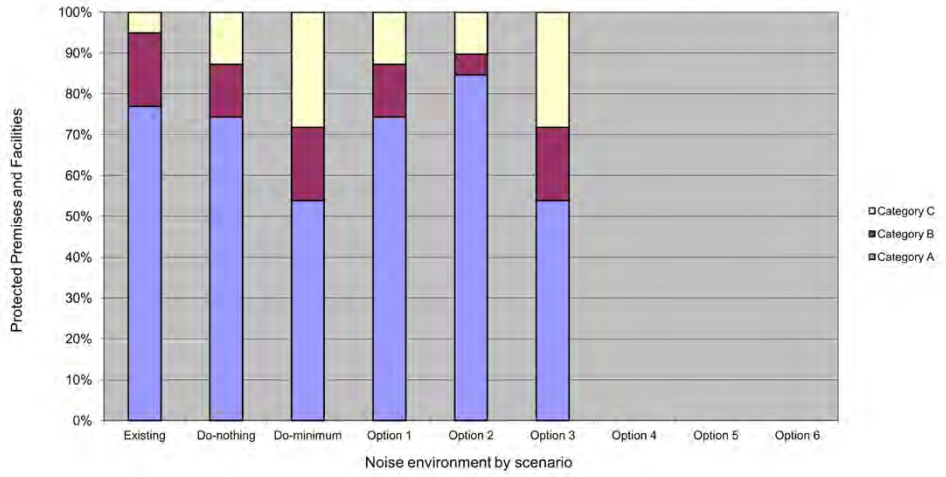
Benefit-Cost Ratio

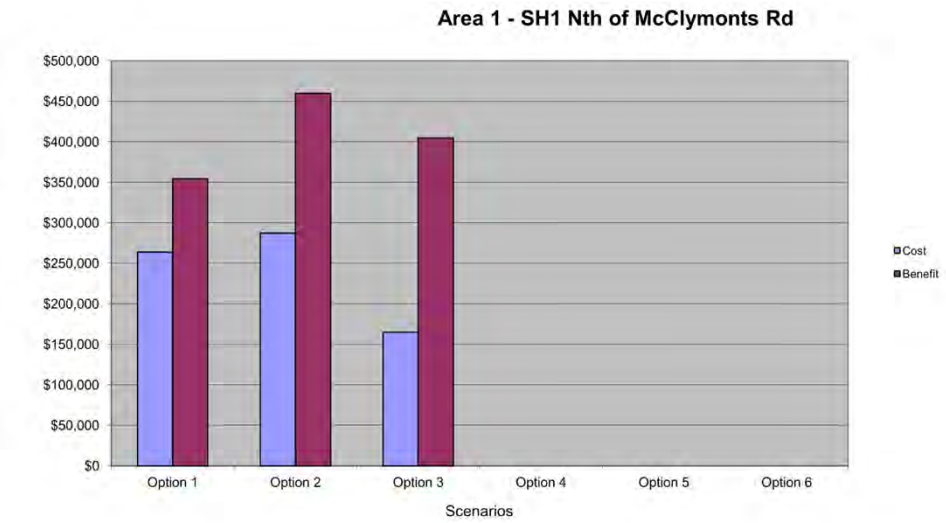
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$264,000	$287,110	$165,000	$0	$0	$0
Benefit	$354,240	$459,756	$404,676	$0	$0	$0
BCR	1.34	1.60	2.45	–	–	–
Structural	2.1 dB	4.2 dB	0.0 dB			

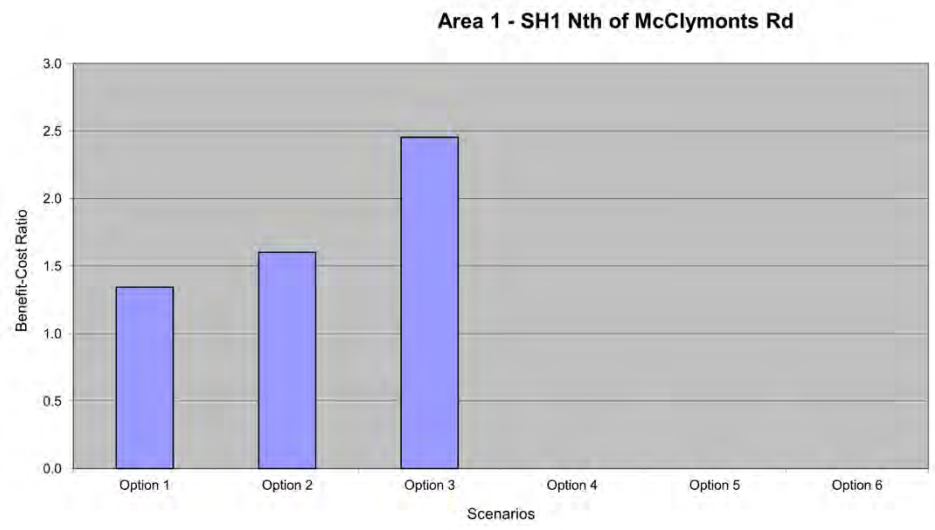
Assessment matrix

	Option 1	Option 2	Option 3
NZS 6806 compliance	---	---	---
Structural mitigation	–	+	
BCR	+ +	+ + +	+ + +

Graphs







Project: Northern Corridor Improvements
Area: Area 1 - SH1 Nth of McClymonts Rd
AADT: (•) 2,000 to 75,000 vehicles per day
( ) More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities					Results from noise model for design year								
Reference	Street address	Floor	New or Altered	Existing $L_{Aeq(24h)}$ dB	Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
1	Lavender Garden Lane 03	1.FL	Altered	57.6	58.9	59.0	58.6	58.6	59.0			
2	Lavender Garden Lane 04	1.FL	Altered	57.1	58.4	57.5	57.1	57	57.5			
3	Lavender Garden Lane 05	1.FL	Altered	58.1	59.4	58.3	58.1	58.1	58.3			
4	Lavender Garden Lane 06	1.FL	Altered	53.8	55.1	55.1	54.8	54.8	55.1			
5	Lavender Garden Lane 07	1.FL	Altered	58.9	60.2	59.9	59.5	59.5	59.9			
6	Lavender Garden Lane 08	1.FL	Altered	57.9	59.3	59.1	58.5	58.4	59.1			
7	Lavender Garden Lane 09	1.FL	Altered	59.6	61.0	60.7	60.2	60.2	60.7			
8	Lavender Garden Lane 10	1.FL	Altered	59.4	60.7	58.8	58.5	58.5	58.8			
9	Lavender Garden Lane 11	1.FL	Altered	62.9	64.2	61.4	60.7	60.7	61.4			
10	Lavender Garden Lane 12	1.FL	Altered	59.6	61.0	59.3	58.9	58.9	59.3			
11	Lavender Garden Lane 14	1.FL	Altered	59.9	61.2	57.5	57.5	57.5	57.5			
12	Lavender Garden Lane 16	1.FL	Altered	62.7	64.0	61.8	60.9	60.8	61.8			
13	Masons Road 60 A (1)	2.FL	Altered	57.1	58.5	58	57	57	58			
14	Masons Road 60 A (2)	2.FL	Altered	57.6	59.0	58	58	57.5	58			
15	Masons Road 60 A (3)	2.FL	Altered	58.0	59.3	59	58	57.9	59			
16	Masons Road 60 A (4)	2.FL	Altered	57.6	59.0	60	58	57.8	60			
17	Masons Road 60 A (5)	2.FL	Altered	59.3	60.7	61	59	59	61			
18	Masons Road 60 A (6)	2.FL	Altered	59.9	61.2	62	60	59.5	62			
19	Masons Road 60 B (1)	2.FL	Altered	60.8	62.2	63	61	60.1	63			
20	Masons Road 60 B (2)	2.FL	Altered	61.8	63.2	63	62	61.2	63			
21	Masons Road 60 B (3)	2.FL	Altered	61.7	63.1	65	62	60.9	65			
22	Masons Road 60 B (4)	2.FL	Altered	62.8	64.1	65	63	62	65			
23	Masons Road 60 B (5)	2.FL	Altered	62.9	64.2	68	63	62	68			
24	Masons Road 60 B (6)	2.FL	Altered	67.0	68.3	71	65	65.2	71			
25	Masons Road 60 C (1)	2.FL	Altered	58.8	60.2	64.2	59.2	58.4	64.2			
26	Masons Road 60 C (2)	2.FL	Altered	59.3	60.6	64.6	59.5	58.7	64.6			
27	Masons Road 60 C (3)	2.FL	Altered	59.7	61.0	65	59.8	59.1	65			
28	Masons Road 60 C (4)	2.FL	Altered	59.9	61.3	65.1	59.7	59.3	65.1			
29	Masons Road 60 C (5)	2.FL	Altered	61.6	62.9	66.4	61.4	60.3	66.4			
30	Masons Road 60 C (6)	2.FL	Altered	62.2	63.5	66.8	62	60.7	66.8			
31	Masons Road 60 D (1)	2.FL	Altered	64.1	65.3	68	64.8	63	68			
32	Masons Road 60 D (2)	2.FL	Altered	64.6	65.8	68.5	65.7	63.6	68.5			
33	Masons Road 60 D (3)	2.FL	Altered	64.9	66.1	68.7	66.3	64	68.7			
34	Masons Road 60 D (4)	2.FL	Altered	65.2	66.4	69	67	64.4	69			
35	Masons Road 60 E (1)	2.FL	Altered	66.3	67.4	70	70	67.2	70			
36	Masons Road 60 E (2)	2.FL	Altered	66.8	67.8	71	70	68.2	71			
37	Masons Road 60 E (3)	2.FL	Altered	67.2	68.2	71	71	69.2	71			
38	Masons Road 60 E (4)	2.FL	Altered	67.6	68.6	72	71	69.8	72			
39	Masons Road 60 E (5)	2.FL	Altered	68.1	69.1	72	72	71.1	72			

Project
Northern Corridor Improvements
Area 2 - SH1 Sth of McClymonts Rd

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	◉	○	○	○	○
Category A	24	21	15	18	15	0	0	0	0
Category B	0	3	5	5	5	0	0	0	0
Category C	0	0	4	1	4	0	0	0	0
Total			24	24	24	0	0	0	0

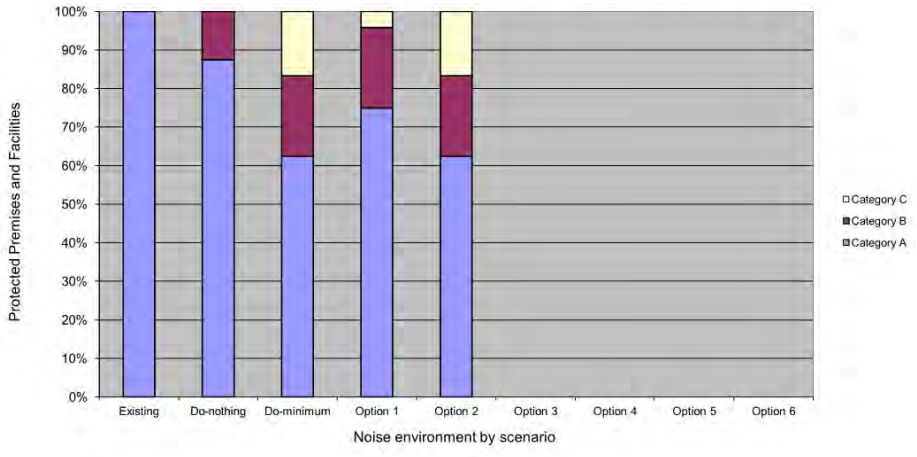
Benefit-Cost Ratio

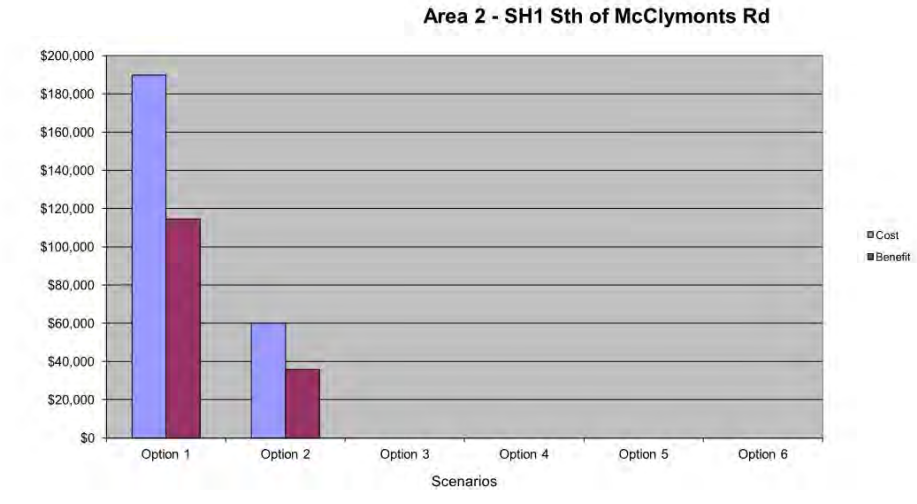
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$190,000	$60,000	$0	$0	$0	$0
Benefit	$114,588	$35,748	$0	$0	$0	$0
BCR	**0.60**	**0.60**	-	-	-	-
Structural	1.4 dB					

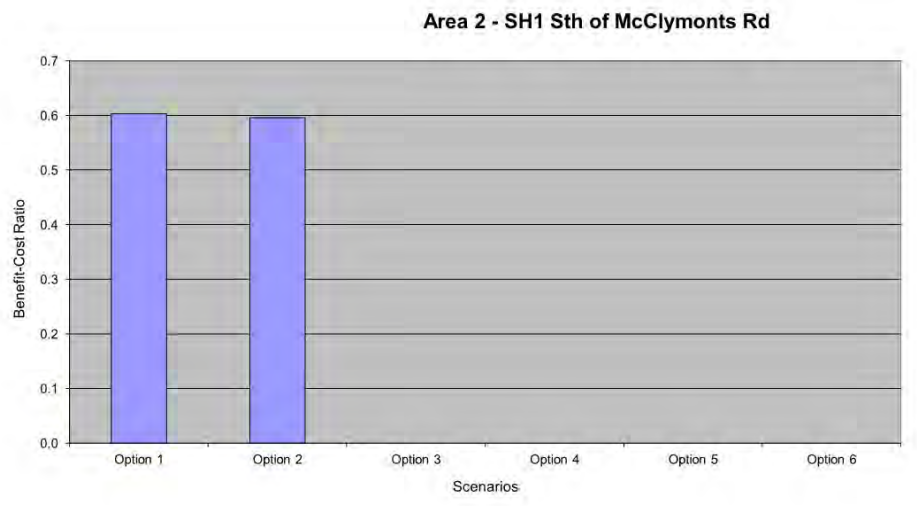
Assessment matrix

	Option 1	Option 2
NZS 6806 compliance	-	---
Structural mitigation	- -	
BCR	-	-

Graphs







Project: Northern Corridor Improvements
Area: Area 2 - SH1 Sth of McClymonts Rd
AADT:
- (•) 2,000 to 75,000 vehicles per day
- ( ) More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year: Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
Reference	Street address	Floor										
1	Carrowmore 14	1.FL	Altered	55.3	56.5	60.1	60.1	60.1				
2	McClymonts Road 106	GF	Altered	60.7	61.5	65.5	62.9	65.5				
3	McClymonts Road 126	1.FL	Altered	63.8	64.9	68.5	66.6	68.5				
4	McClymonts Road 128	GF	Altered	61.3	59.9	63.7	60.6	63.7				
5	McClymonts Road 128A	GF	Altered	63.0	64.2	68.0	63.1	68.0				
6	Spencer Road 64A	1.FL	Altered	52.7	53.2	56.3	56.0	56.3				
7	Spencer Road 64B	1.FL	Altered	52.6	53.9	57.4	57.4	57.4				
8	Spencer Road 66A	1.FL	Altered	56.7	57.8	63.2	63.2	63.2				
9	Spencer Road 66B	1.FL	Altered	55.2	56.5	61.7	61.7	61.7				
10	Spencer Road 71 (01)	2.FL	Altered	57.7	58.6	62.1	61.0	62.1				
11	Spencer Road 71 (02)	2.FL	Altered	58.1	59.1	62.6	61.6	62.6				
12	Spencer Road 71 (03)	2.FL	Altered	58.7	59.8	63.2	62.2	63.2				
13	Spencer Road 71 (04)	2.FL	Altered	59.4	60.5	64	63.2	64				
14	Spencer Road 71 (05)	2.FL	Altered	59.8	60.9	64.3	63.6	64.3				
15	Spencer Road 71 (06)	2.FL	Altered	60.4	61.5	65.1	64.6	65.1				
16	Spencer Road 71 (07)	2.FL	Altered	61.0	62.2	65.6	65.2	65.6				
17	Spencer Road 71 (08)	2.FL	Altered	61.7	62.8	66.1	65.9	66.1				
18	Spencer Road 71 (09)	2.FL	Altered	63.6	64.9	68.7	68.7	68.7				
19	Spencer Road 71 (10)	2.FL	Altered	60.1	58.4	61.9	61.1	61.9				
20	Spencer Road 71 (11)	2.FL	Altered	59.3	58.6	61.6	61.4	61.6				
21	Spencer Road 71 (12)	2.FL	Altered	59.3	59.1	62.6	61.7	62.6				
22	Spencer Road 71 (13)	2.FL	Altered	59.9	60.2	63	62	63				
23	Spencer Road 71 (14)	2.FL	Altered	60.7	61.5	65	63	65				
24	Spencer Road 71 (15)	2.FL	Altered	63.5	64.6	68	66	68				

Project

Northern Corridor Improvements
Area 2a - SH1 Colliston Rise

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			◉	○	○	○	○	○	○
Category A	48	44	41	0	0	0	0	0	0
Category B	1	5	2	0	0	0	0	0	0
Category C	0	0	6	0	0	0	0	0	0
Total			49	0	0	0	0	0	0

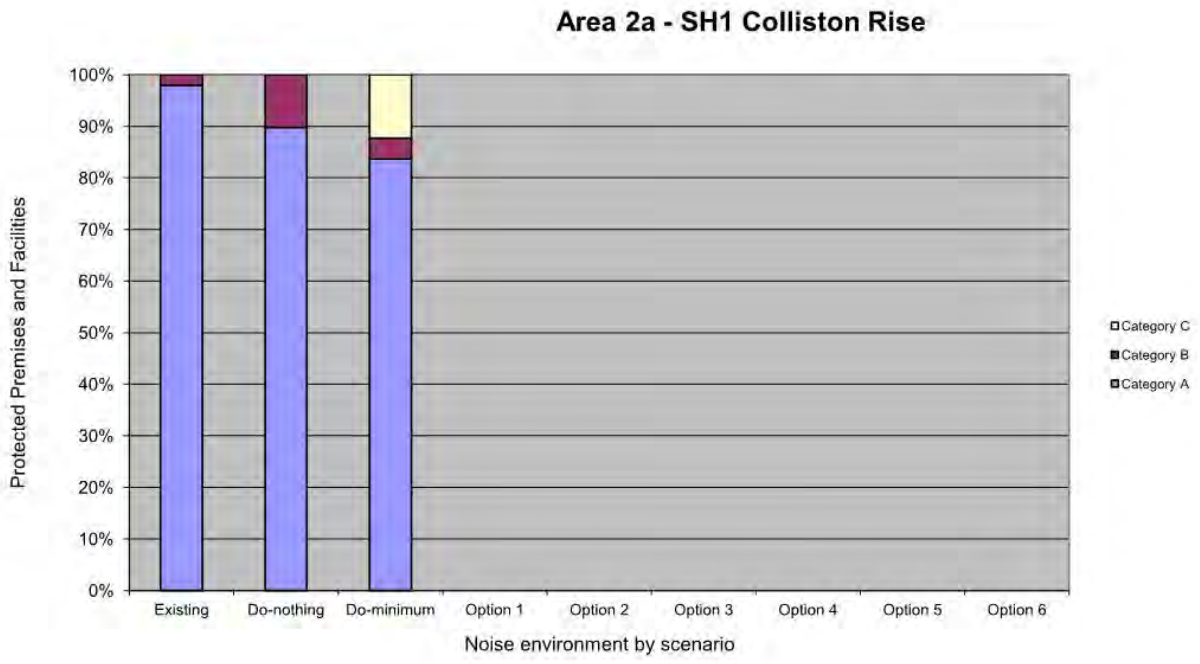
Benefit-Cost Ratio

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$0	$0	$0	$0	$0	$0
Benefit	$0	$0	$0	$0	$0	$0
BCR	-	-	-	-	-	-
Structural						

Assessment matrix

NZS 6806 compliance
Structural mitigation
BCR

Graphs



Project: Northern Corridor Improvements
Area: Area 2a – SH1 Colliston Rise
AADT: (•) 2,000 to 75,000 vehicles per day ( ) More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year: Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
Reference	Street address	Floor										
1	Colliston Rise 001	1.FL	Altered	53.6	54.5	56.8						
2	Colliston Rise 003	1.FL	Altered	54.0	54.9	56.7						
3	Colliston Rise 005	1.FL	Altered	55.5	56.5	57.9						
4	Colliston Rise 007	1.FL	Altered	55.0	56.1	57.6						
5	Colliston Rise 009	1.FL	Altered	54.5	55.6	56.9						
6	Colliston Rise 011	1.FL	Altered	54.9	56.0	57.7						
7	Colliston Rise 012	1.FL	Altered	54.0	54.9	56.9						
8	Colliston Rise 013	1.FL	Altered	55.2	56.3	58.9						
9	Colliston Rise 014	1.FL	Altered	54.2	55.2	57.8						
10	Colliston Rise 015	1.FL	Altered	55.4	56.5	59.3						
11	Colliston Rise 016	1.FL	Altered	54.2	55.2	57.9						
12	Colliston Rise 017	1.FL	Altered	55.7	56.9	60.7						
13	Colliston Rise 018	1.FL	Altered	54.2	55.2	57.8						
14	Colliston Rise 019	1.FL	Altered	56.7	57.9	60.3						
15	Colliston Rise 020	1.FL	Altered	57.1	58.3	63.4						
16	Colliston Rise 021	1.FL	Altered	57.0	58.2	60						
17	Colliston Rise 022	1.FL	Altered	64.2	65.4	68.3						
18	Colliston Rise 023	1.FL	Altered	56.9	58.1	58.8						
19	Colliston Rise 024	1.FL	Altered	63.9	65.1	68.2						
20	Colliston Rise 025	1.FL	Altered	56.4	57.5	58.8						
21	Colliston Rise 026	1.FL	Altered	63.8	65	68.4						
22	Colliston Rise 027	1.FL	Altered	55.9	57	59						
23	Colliston Rise 028	1.FL	Altered	62.2	63.5	68						
24	Colliston Rise 029	1.FL	Altered	54.6	55.6	58.3						
25	Colliston Rise 030	1.FL	Altered	62.1	63.3	68.1						
26	Colliston Rise 031	1.FL	Altered	54.0	55.0	57.7						
27	Colliston Rise 034	1.FL	Altered	61.8	63.0	66.8						
28	Colliston Rise 036	1.FL	Altered	62.9	64.1	61.7						
29	Colliston Rise 038	1.FL	Altered	62.1	63.2	60.4						
30	Colliston Rise 040	1.FL	Altered	61.7	62.9	60.5						
31	Colliston Rise 042	1.FL	Altered	60.9	61.9	60.4						
32	Colliston Rise 044	1.FL	Altered	61.6	62.7	62.2						
33	Colliston Rise 046	1.FL	Altered	60.1	61.2	61.5						
34	Colliston Rise 048	1.FL	Altered	59.0	60.2	60.4						
35	Colliston Rise 050	1.FL	Altered	57.2	58.3	59.7						
36	Colliston Rise 052	1.FL	Altered	51.9	52.8	56.9						
37	Colliston Rise 054	1.FL	Altered	52.5	53.3	56.2						
38	Coxton Lane 001	1.FL	Altered	55.7	56.9	60.1						
39	Coxton Lane 002	1.FL	Altered	54.3	55.3	57.3						
40	Coxton Lane 003	1.FL	Altered	56.6	57.8	61.4						
41	Coxton Lane 004	1.FL	Altered	54.5	55.5	57.7						
42	Coxton Lane 005	1.FL	Altered	59.4	60.7	63.8						
43	Coxton Lane 006	1.FL	Altered	54.6	55.7	57.6						
44	Coxton Lane 007	1.FL	Altered	63.4	64.6	67.3						
45	Coxton Lane 008	1.FL	Altered	54.9	56.0	57.9						
46	Coxton Lane 009	1.FL	Altered	64.6	65.8	68.4						
47	Coxton Lane 010	1.FL	Altered	56.7	57.9	58.4						
48	Coxton Lane 012	1.FL	Altered	56.9	58.1	59.3						
49	Coxton Lane 014	1.FL	Altered	61.6	62.9	61.7						

Project
Northern Corridor Improvements
Area 3 - SH1 Sth of SH18

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	◉	○	○	○	○
Category A	36	36	35	35	35	0	0	0	0
Category B	2	2	1	3	1	0	0	0	0
Category C	0	0	2	0	2	0	0	0	0
Total			38	38	38	0	0	0	0

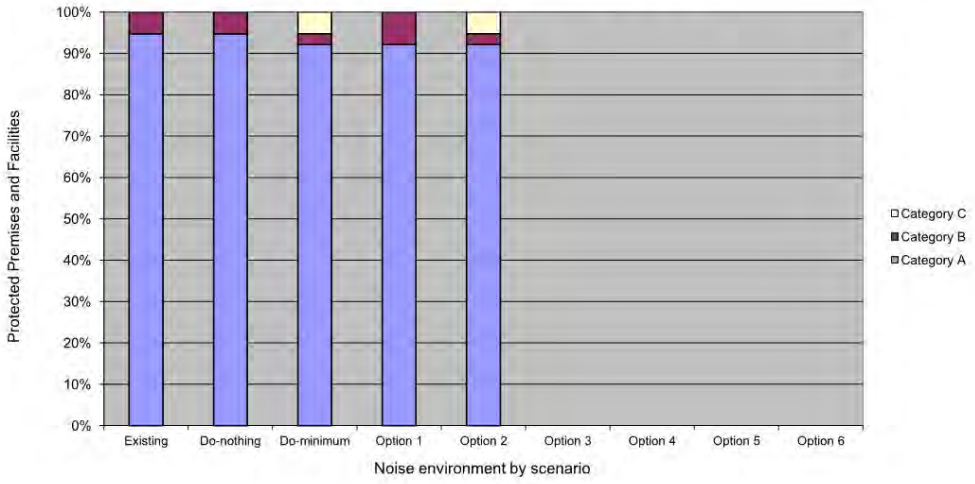
Benefit-Cost Ratio

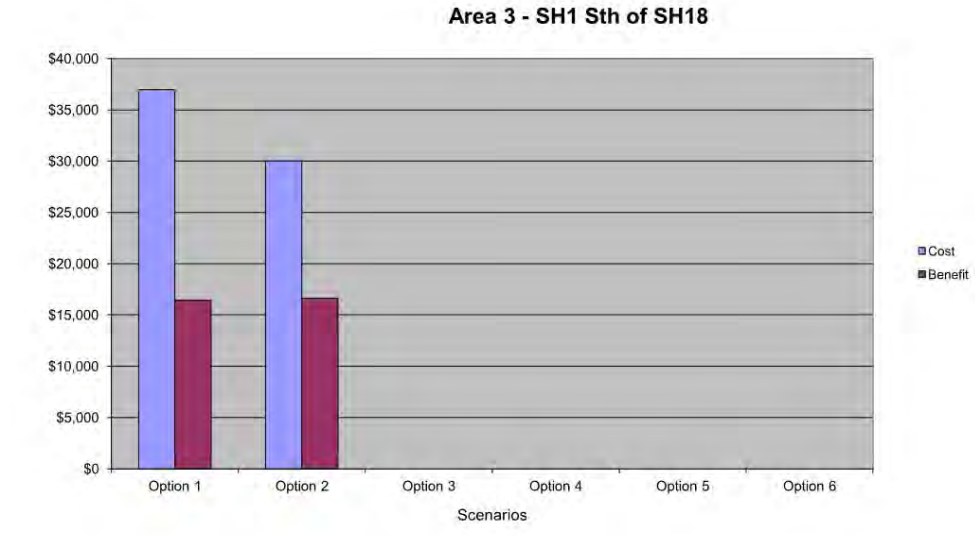
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$36,960	$30,000	$0	$0	$0	$0
Benefit	$16,416	$16,632	$0	$0	$0	$0
BCR	**0.44**	**0.55**	–	–	–	–
Structural	1.3 dB					

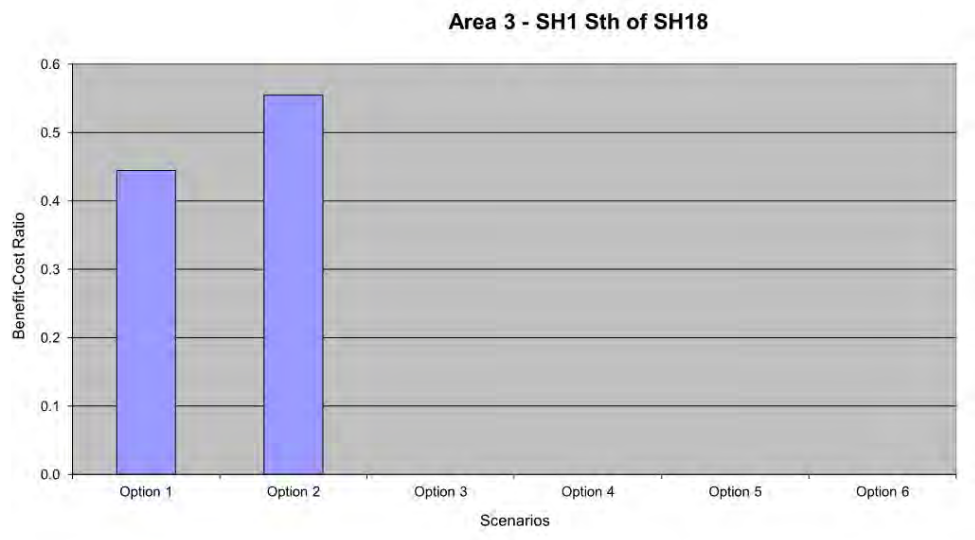
Assessment matrix

NZS 6806 compliance	+	--
Structural mitigation	- -	
BCR	- -	-

Graphs







Project: Northern Corridor Improvements
Area: Area 3 - SH1 Sth of SH18
AADT: ○ 2,000 to 75,000 vehicles per day
● More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year: Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
Reference	Street address	Floor										
1	Cabello Place 11	GF	Altered	54.3	55.4	56.3	56.3	56.3				
2	Cabello Place 13	GF	Altered	57.5	58.3	59.3	59.3	59.3				
3	Cabello Place 15	GF	Altered	61.1	61.9	62.6	62.5	62.6				
4	Cabello Place 17	GF	Altered	61.4	62.2	62.9	62.9	62.9				
5	Santiago Crescent 26	GF	Altered	53.2	53.8	54.8	54.7	54.8				
6	Santiago Crescent 28	GF	Altered	56.5	57.3	58.6	58.3	58.6				
7	Santiago Crescent 30	GF	Altered	57.5	58.3	59.4	59.1	59.4				
8	Santiago Crescent 34	GF	Altered	56.4	57.2	58.2	58.1	58.2				
9	Santiago Crescent 36	GF	Altered	56.1	57.0	58.0	58.0	58.0				
10	Santiago Crescent 38	GF	Altered	55.2	56.2	57.3	57.3	57.3				
11	Santiago Crescent 40	GF	Altered	54.8	55.6	56.9	56.8	56.9				
12	Santiago Crescent 51	1.FL	Altered	56.9	57.7	59.6	59.6	59.6				
13	Santiago Crescent 53	1.FL	Altered	57.6	58.5	60.2	60.2	60.2				
14	Santiago Crescent 55	1.FL	Altered	58.3	59.1	60.8	60.8	60.8				
15	Santiago Crescent 57	1.FL	Altered	58.0	58.8	60.8	60.7	60.8				
16	Santiago Crescent 59A	GF	Altered	55.1	56.0	58.2	58.1	58.2				
17	Santiago Crescent 59B	1.FL	Altered	65.8	66.6	67.6	65.9	67.6				
18	Santiago Crescent 61	1.FL	Altered	62.6	63.3	64.2	61.4	64.2				
19	Santiago Crescent 63	1.FL	Altered	65.9	66.7	67.8	67.2	67.8				
20	Santiago Crescent 65	GF	Altered	63.6	64.4	65.2	65.2	65.2				
21	Santiago Crescent 67	GF	Altered	61.7	62.6	63.2	63.2	63.2				
22	Santiago Crescent 69	GF	Altered	60.7	61.5	62.0	62.0	62.0				
23	Santiago Crescent 71	GF	Altered	59.8	60.6	61.1	61.1	61.1				
24	Santiago Crescent 73	GF	Altered	57.6	58.4	59.0	59.0	59.0				
25	Santiago Crescent 75	GF	Altered	52.0	53.4	54.6	54.5	54.6				
26	Santiago Crescent 77A	GF	Altered	55.9	58.0	58.5	58.5	58.5				
27	Santiago Crescent 77B	GF	Altered	59.6	60.4	60.7	60.7	60.7				
28	Santiago Crescent 79	GF	Altered	61.1	61.9	62.3	62.3	62.3				
29	Santiago Crescent 81	GF	Altered	61.4	62.1	62.6	62.6	62.6				
30	Santiago Crescent 83	GF	Altered	56.4	57.3	58.0	58.0	58.0				
31	Santiago Crescent 85	GF	Altered	55.9	57.6	58.3	58.3	58.3				
32	Santiago Crescent 87	GF	Altered	54.0	55.3	56.1	56.1	56.1				
33	Santiago Crescent 89	GF	Altered	53.9	55.1	55.9	55.9	55.9				
34	Santiago Crescent 91	GF	Altered	51.7	52.8	54.2	54.1	54.2				
35	Santiago Crescent 93A	GF	Altered	52.7	54.5	55.3	55.3	55.3				
36	Santiago Crescent 93B	GF	Altered	54.4	55.5	56.5	56.5	56.5				
37	Sunset Road 170	GF	Altered	55.7	53.8	54.4	54.4	54.4				
38	Sunset Road 172	1.FL	Altered	60.8	60.9	62.4	62.3	62.4				

Project
Northern Corridor Improvements
Area 4 – SH18 Cabello Pl

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			◉	○	○	○	○	○	○
Category A	29	29	29	0	0	0	0	0	0
Category B	1	1	1	0	0	0	0	0	0
Category C	0	0	0	0	0	0	0	0	0
Total			30	0	0	0	0	0	0

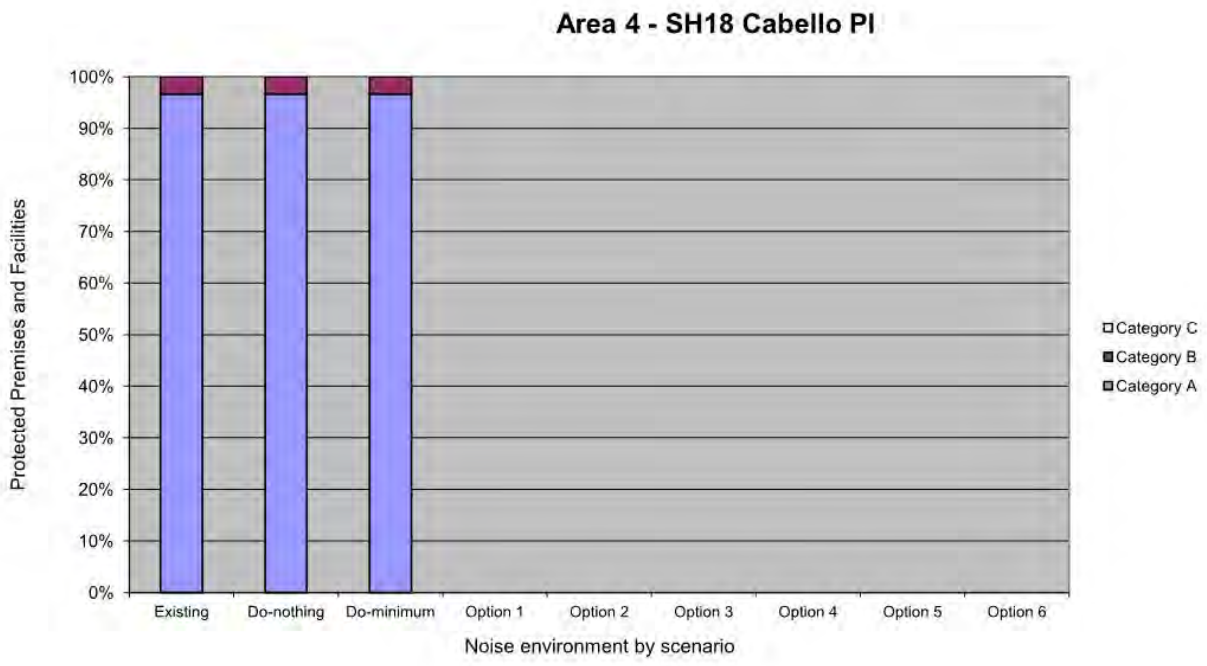
Benefit-Cost Ratio

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$0	$0	$0	$0	$0	$0
Benefit	$0	$0	$0	$0	$0	$0
BCR	-	-	-	-	-	-
Structural						

Assessment matrix

NZS 6806 compliance
Structural mitigation
BCR

Graphs



Project: Northern Corridor Improvements
Area: Area 4 – SH18 Cabello Pl
AADT: (•) 2,000 to 75,000 vehicles per day
( ) More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year: Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
Reference	Street address	Floor										
1	Cabello Place 03	GF	Altered	51.4	52.1	53.0						
2	Cabello Place 04	GF	Altered	51.8	52.5	53.3						
3	Cabello Place 05	GF	Altered	53.4	54.2	55.4						
4	Cabello Place 05A	GF	Altered	54.2	55.2	56.2						
5	Cabello Place 06	GF	Altered	52.5	53.2	54.7						
6	Cabello Place 07	GF	Altered	54.1	55.1	56.4						
7	Cabello Place 08	GF	Altered	52.7	53.1	54.8						
8	Cabello Place 09A	GF	Altered	52.9	54.3	55.1						
9	Cabello Place 09B	GF	Altered	51.9	52.6	53.4						
10	Cabello Place 10	GF	Altered	53.1	53.3	55.4						
11	Cabello Place 12	GF	Altered	52.0	52.2	54.7						
12	Cabello Place 14	GF	Altered	50.8	51.0	53.2						
13	Cabello Place 16	GF	Altered	56.6	56.5	57.7						
14	Cabello Place 18	GF	Altered	63.2	63.0	62.3						
15	Cabello Place 19	GF	Altered	55.4	57.1	57.9						
16	Cabello Place 20	GF	Altered	64.4	64.2	63.1						
17	Cabello Place 21	GF	Altered	66.5	66.4	65.2						
18	Cabello Place 22	GF	Altered	64.2	63.9	63.1						
19	Cabello Place 23	GF	Altered	59.5	59.7	59.1						
20	Cabello Place 24	GF	Altered	61.8	61.7	60.5						
21	Cabello Place 25	GF	Altered	62.7	62.7	61.6						
22	Cabello Place 26	GF	Altered	60.6	60.4	60.1						
23	Cabello Place 27	GF	Altered	60.5	60.6	60.1						
24	Cabello Place 28	GF	Altered	61.7	61.6	61.4						
25	Cabello Place 29	GF	Altered	60.3	60.3	60.0						
26	Cabello Place 30	GF	Altered	61.6	61.5	61.3						
27	Cabello Place 31	GF	Altered	60.3	60.2	60.4						
28	Meadowood Drive 51	GF	Altered	54.5	53.9	56.1						
29	Meadowood Drive 53	GF	Altered	51.1	51.1	53.6						
30	Meadowood Drive 56 (Childcare)	GF	Altered	61.2	61.0	60.6						

Project
Northern Corridor Improvements
Area 5 - SH18 Barbados Dr

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	◉	○	○	○	○	○
Category A	83	82	81	85	0	0	0	0	0
Category B	3	4	1	1	0	0	0	0	0
Category C	0	0	4	0	0	0	0	0	0
Total			86	86	0	0	0	0	0

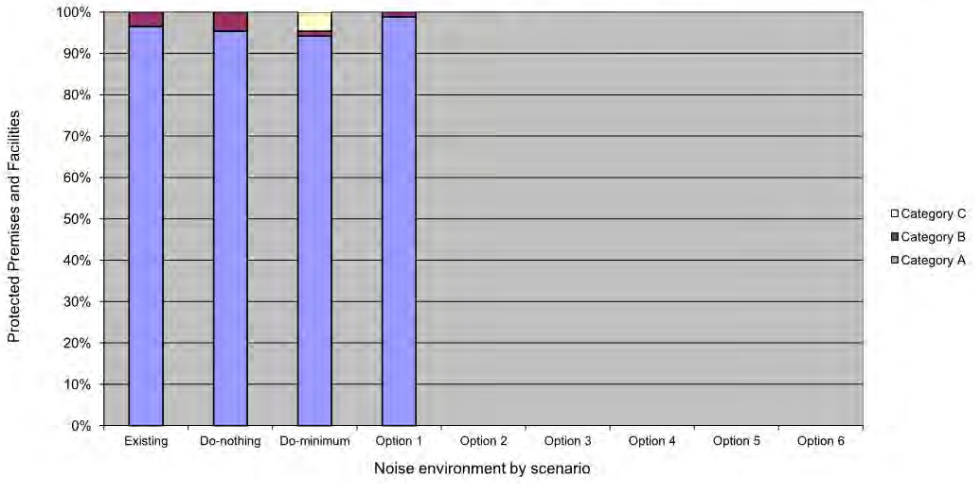
Benefit-Cost Ratio

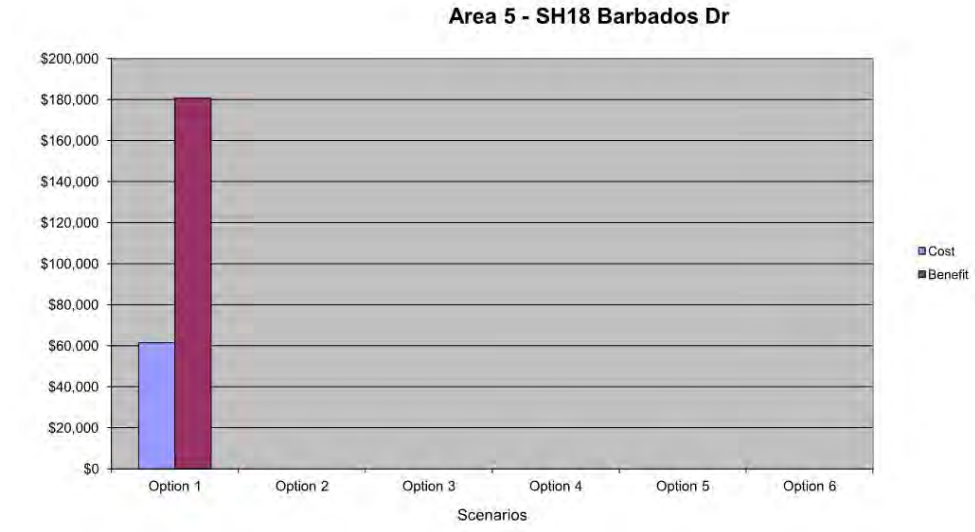
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$61,440	$0	$0	$0	$0	$0
Benefit	$180,576	$0	$0	$0	$0	$0
BCR	**2.94**	-	-	-	-	-
Structural	0.8 dB					

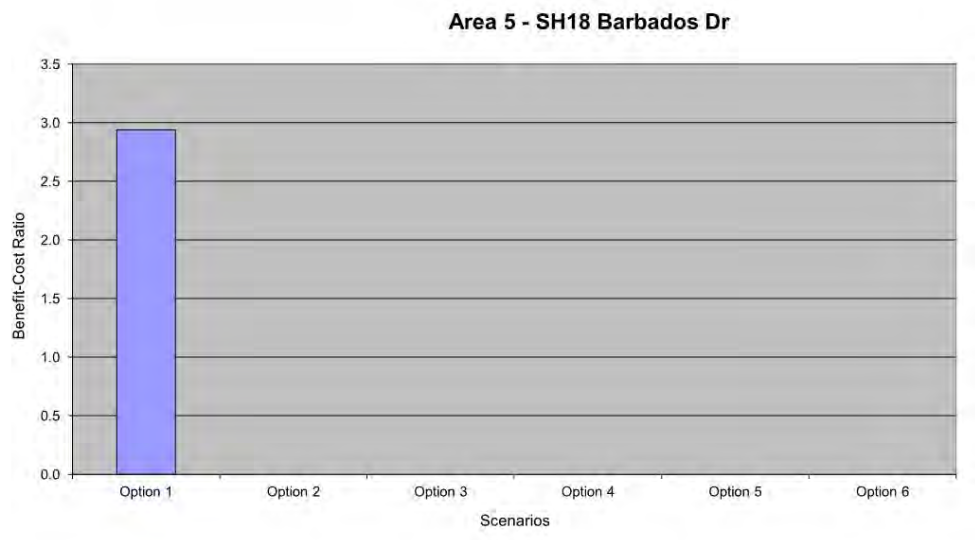
Assessment matrix

NZS 6806 compliance	++
Structural mitigation	- -
BCR	+ + +

Graphs







Project: Northern Corridor Improvements
Area: Area 5 - SH18 Barbados Dr
AADT: ○ 2,000 to 75,000 vehicles per day ● More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities					Results from noise model for design year							
Reference	Street address	Floor	New or Altered	Existing $L_{Aeq(24h)}$ dB	Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
1	Barbados Drive 01	GF	Altered	61.8	49.6	50.8	50.5					
2	Barbados Drive 03	GF	Altered	57.8	50.9	51.9	51.7					
3	Barbados Drive 04	GF	Altered	59.1	51.4	54.3	54.0					
4	Barbados Drive 05A	GF	Altered	52.3	52.2	53.2	53.0					
5	Barbados Drive 05B	GF	Altered	63.8	63.7	63.2	62.9					
6	Barbados Drive 06	GF	Altered	58.5	51.8	54.9	54.6					
7	Barbados Drive 07A	GF	Altered	57.8	51.8	54.7	54.2					
8	Barbados Drive 07B	GF	Altered	62.5	62.3	62.8	62.5					
9	Barbados Drive 08	GF	Altered	59.4	52.4	55.4	55.0					
10	Barbados Drive 09 (Childcare)	GF	Altered	56.4	56.1	58.6	58.1					
11	Barbados Drive 10	GF	Altered	58.6	52.3	55.6	55.2					
12	Barbados Drive 11	GF	Altered	61.5	61.4	62.6	62.2					
13	Barbados Drive 13	GF	Altered	59.6	59.6	61.5	61.1					
14	Barbados Drive 14	GF	Altered	60.0	52.9	55.9	55.5					
15	Barbados Drive 15	GF	Altered	59.4	59.3	61.5	61.1					
16	Barbados Drive 16	1.FL	Altered	61.2	54.6	58.4	58.0					
17	Barbados Drive 17	GF	Altered	60.0	59.9	61.8	61.4					
18	Barbados Drive 18A	GF	Altered	59.9	52.5	55.7	55.2					
19	Barbados Drive 18B	GF	Altered	60.1	52.5	55.5	55.1					
20	Barbados Drive 19	GF	Altered	60.5	60.3	61.8	61.4					
21	Barbados Drive 20A	GF	Altered	60.1	52.5	55.5	55.1					
22	Barbados Drive 20B	GF	Altered	60.1	52.3	55.1	54.8					
23	Barbados Drive 21	GF	Altered	59.8	59.7	61.6	61.2					
24	Barbados Drive 23	GF	Altered	60.5	60.4	62.0	61.6					
25	Barbados Drive 25	GF	Altered	59.0	58.9	61.1	60.6					
26	Barbados Drive 27	GF	Altered	59.1	59.0	61.2	60.7					
27	Barbados Drive 28	1.FL	Altered	60.9	54.4	57.6	57.2					
28	Barbados Drive 29	GF	Altered	59.6	59.6	61.9	61.4					
29	Barbados Drive 30A	GF	Altered	59.6	52.6	55.3	54.8					
30	Barbados Drive 30B	GF	Altered	53.0	52.8	55.8	55.4					
31	Barbados Drive 31	GF	Altered	60.0	60.1	62.3	61.9					
32	Barbados Drive 33	GF	Altered	60.4	60.5	62.6	62.2					
33	Barbados Drive 35	GF	Altered	59.2	59.7	62.5	62.0					
34	Barbados Drive 36	GF	Altered	53.7	53.7	57.8	57.4					
35	Barbados Drive 37	GF	Altered	59.4	60.0	62.7	62.3					
36	Barbados Drive 38	GF	Altered	58.8	52.2	54.7	54.3					
37	Barbados Drive 39	GF	Altered	59.2	60.0	63.1	62.7					
38	Barbados Drive 40	1.FL	Altered	60.1	55.1	58.1	57.7					
39	Barbados Drive 41A	GF	Altered	58.9	55.3	58.2	57.8					
40	Barbados Drive 41B	GF	Altered	60.2	61.6	63.8	63.5					
41	Barbados Drive 43	GF	Altered	58.5	60.2	59.0	58.7					
42	Barbados Drive 44A	1.FL	Altered	60.3	54.2	57.0	56.6					
43	Barbados Drive 44B	GF	Altered	51.5	51.1	53.8	53.4					
44	Barbados Drive 45	GF	Altered	58.6	57.9	58.3	57.9					
45	Barbados Drive 46A	1.FL	Altered	60.5	54.1	56.5	56.2					
46	Barbados Drive 46B	GF	Altered	51.3	50.9	53.3	52.9					
47	Barbados Drive 47	GF	Altered	59.7	52.6	52.8	52.5					
48	Barbados Drive 48A	GF	Altered	59.0	52.1	53.9	53.8					
49	Barbados Drive 48B	GF	Altered	50.5	50.8	53.1	52.8					
50	Barbados Drive 49	GF	Altered	60.1	61.6	58.0	57.5					
51	Barbados Drive 50	GF	Altered	58.2	50.4	52.7	52.3					
52	Barbados Drive 51	GF	Altered	62.2	63.7	59.9	59.3					
53	Barbados Drive 53	GF	Altered	59.5	52.0	51.7	51.3					
54	Barbados Drive 55	GF	Altered	60.5	49.4	50.7	50.4					
55	Barbados Drive 57	GF	Altered	63.0	64.5	61.9	61.6					
56	Barbados Drive 59	GF	Altered	64.0	65.5	65.7	60.1					
57	Barbados Drive 63	GF	Altered	59.2	47.5	49.8	49.3					
58	Barbados Drive 65	GF	Altered	58.6	47.0	48.9	48.5					
59	Barbados Drive 67	GF	Altered	59.5	46.7	49.8	49.2					
60	Barbados Drive 69	GF	Altered	59.0	44.9	48.4	48.0					
61	Bardados Drive 61	GF	Altered	51.5	52.7	55.3	54.5					
62	Caribbean Drive 01A	GF	Altered	64.7	64.4	63.7	63.4					
63	Caribbean Drive 01B	GF	Altered	62.3	60.9	60.9	60.8					
64	Caribbean Drive 03A	GF	Altered	53.9	53.7	54.3	54.1					
65	Caribbean Drive 03B	GF	Altered	64.2	64.0	63.4	63.2					
66	Caribbean Drive 05A	GF	Altered	62.1	59.8	60.2	60.1					
67	Caribbean Drive 05B	GF	Altered	55.8	55.3	55.7	55.5					
68	Caribbean Drive 07	GF	Altered	62.6	55.2	55.7	55.7					
69	Caribbean Drive 09	GF	Altered	60.7	51.8	54.5	54.3					
70	Grenadine Place 02A	GF	Altered	58.1	50.1	52.1	52.0					
71	Grenadine Place 02B	GF	Altered	52.2	48.4	51.2	51.2					
72	Jumento Place 01	GF	Altered	52.8	50.6	54.1	53.7					
73	Jumento Place 02	GF	Altered	59.2	52.3	55.3	55.0					
74	Jumento Place 04	GF	Altered	51.6	50.8	54.0	53.7					
75	Jumento Place 04B	GF	Altered	51.2	50.8	53.6	53.2					
76	Wren Place 03	GF	Altered	48.0	49.0	51.6	50.9					
77	Wren Place 04	GF	Altered	49.4	48.3	51.7	51.2					
78	Wren Place 05	GF	Altered	52.3	53.7	56.4	55.0					
79	Wren Place 07	GF	Altered	49.1	50.5	54.7	54.0					
80	Wren Place 08	1.FL	Altered	52.9	54.7	58.7	58.2					
81	Wren Place 09	GF	Altered	64.5	66.0	68.3	60.7					
82	Wren Place 10	GF	Altered	53.6	55.0	59.1	58.6					
83	Wren Place 11	GF	Altered	64.9	66.4	69.6	61.4					
84	Wren Place 12	GF	Altered	56.5	58.0	62.3	61.5					
85	Wren Place 13	GF	Altered	62.4	63.6	67.7	59.1					
86	Wren Place 14	GF	Altered	63.1	64.4	68.4	65.4					

Project
Northern Corridor Improvements
Area 6 - Metlifecare

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	◉	○	○	○	○	○
Category A	23	23	21	23	23	0	0	0	0
Category B	0	0	2	0	0	0	0	0	0
Category C	0	0	0	0	0	0	0	0	0
Total			23	23	23	0	0	0	0

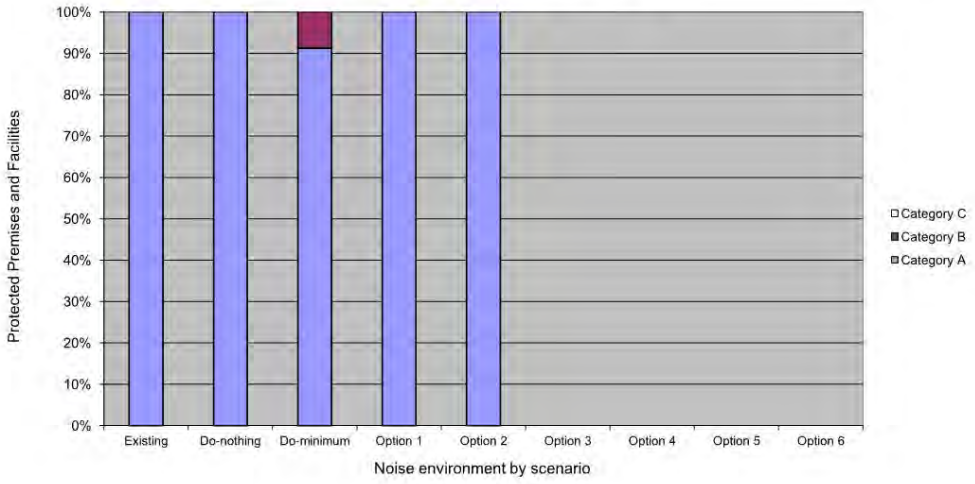
Benefit-Cost Ratio

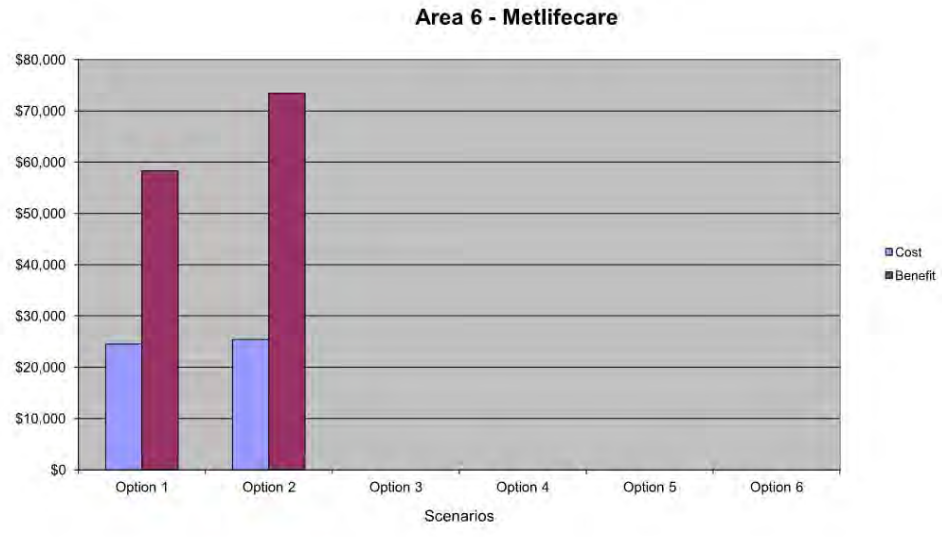
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$24,500	$25,380	$0	$0	$0	$0
Benefit	$58,320	$73,440	$0	$0	$0	$0
BCR	**2.38**	**2.89**	–	–	–	–
Structural	2.3 dB	3.5 dB				

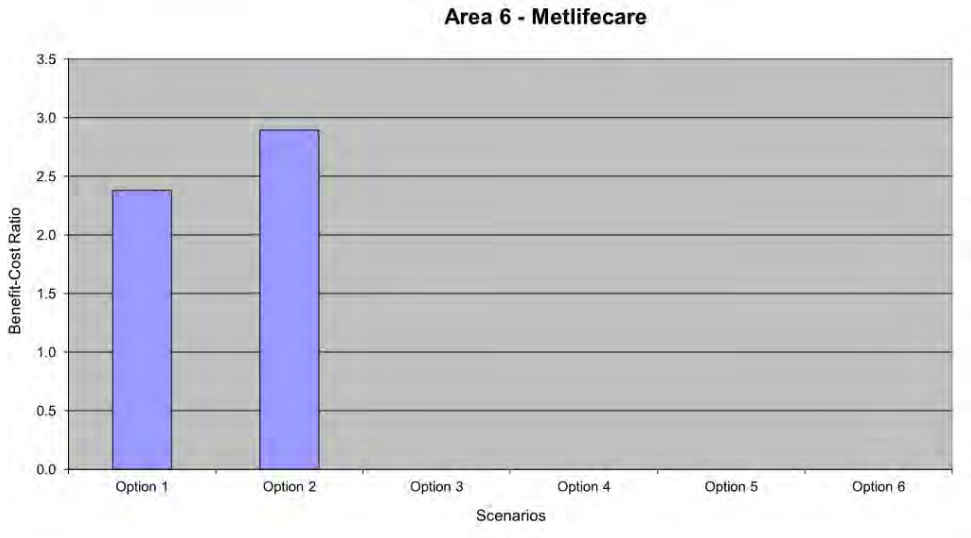
Assessment matrix

NZS 6806 compliance	+++	+++
Structural mitigation	–	o
BCR	+ + +	+ + +

Graphs







Project: Northern Corridor Improvements
Area: Area 6 – Metlifecare
AADT: (•) 2,000 to 75,000 vehicles per day ( ) More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year: Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
Reference	Street address	Floor										
1	Jacaranda Close 14	GF	Altered	55.7	57.0	61.8	61.8	61.8				
2	Jacaranda Close 15	GF	Altered	55.4	56.7	61.4	61.4	61.4				
3	Jacaranda Close 16	GF	Altered	55.1	56.4	61.2	61.2	61.2				
4	Jacaranda Close 17	GF	Altered	55.2	56.5	61.3	61.3	61.3				
5	Jacaranda Close 18	GF	Altered	53.8	55.1	60.2	60.2	60.2				
6	Jacaranda Close 19	GF	Altered	54.3	55.6	60.8	60.8	60.8				
7	Jacaranda Close 20	GF	Altered	53.8	55.1	60.4	60.4	60.4				
8	Jacaranda Close 21	GF	Altered	54.8	56.2	61.0	61.0	61.0				
9	Jacaranda Close 22	GF	Altered	59.8	61.1	66.2	62.7	58.4				
10	Jacaranda Close 23	GF	Altered	59.0	60.3	65.3	61.7	56.0				
11	Jacaranda Close 24	GF	Altered	57.6	58.9	63.7	60.6	62.9				
12	Jacaranda Close 25	GF	Altered	49.5	50.7	54.8	54.6	54.7				
13	Jacaranda Close 26	GF	Altered	51.9	53.2	57.8	56.3	56.5				
14	Jacaranda Close 27	GF	Altered	52.2	53.5	58.1	56.8	56.8				
15	Magnolia Way 09	GF	Altered	55.4	56.6	61.3	61.3	61.3				
16	Magnolia Way 10	GF	Altered	54.3	55.4	59.9	59.9	59.9				
17	Magnolia Way 11	GF	Altered	53.7	54.9	59.3	59.3	59.3				
18	Magnolia Way 12	GF	Altered	52.5	53.7	57.9	57.8	57.9				
19	Magnolia Way 13	GF	Altered	51.5	52.8	57.1	56.6	56.8				
20	Pohutukawa Drive 1	1.FL	Altered	53.3	54.5	58.4	58.4	58.4				
21	Pohutukawa Drive 2	1.FL	Altered	52.3	53.4	57.2	57.2	57.2				
22	Pohutukawa Drive 3	1.FL	Altered	52.1	53.2	57.2	57.2	57.2				
23	Pohutukawa Drive 4	1.FL	Altered	52.7	53.9	57.7	57.6	57.7				

Project
Northern Corridor Improvements
Area 7 – SH18 Bluebird Cres

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	◉	○	○	○	○	○
Category A	11	11	10	11	13	0	0	0	0
Category B	2	2	1	2	0	0	0	0	0
Category C	0	0	2	0	0	0	0	0	0
Total			13	13	13	0	0	0	0

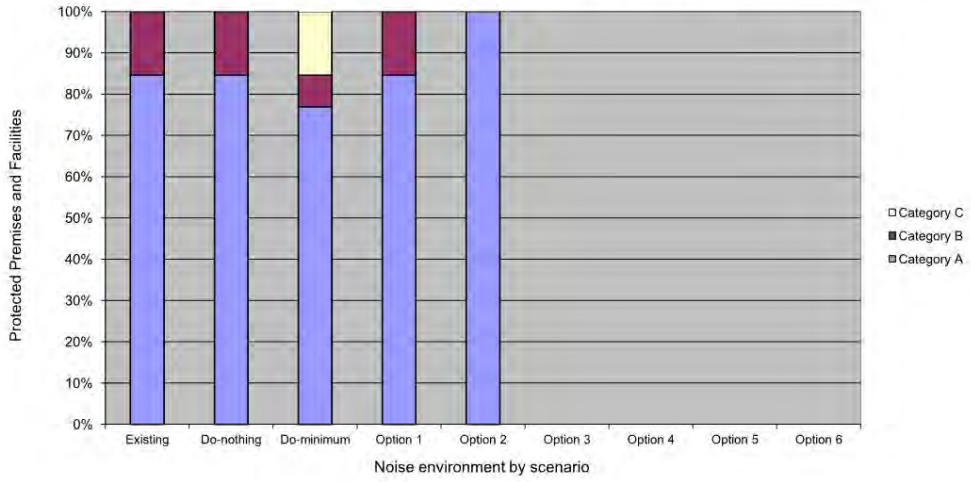
Benefit–Cost Ratio

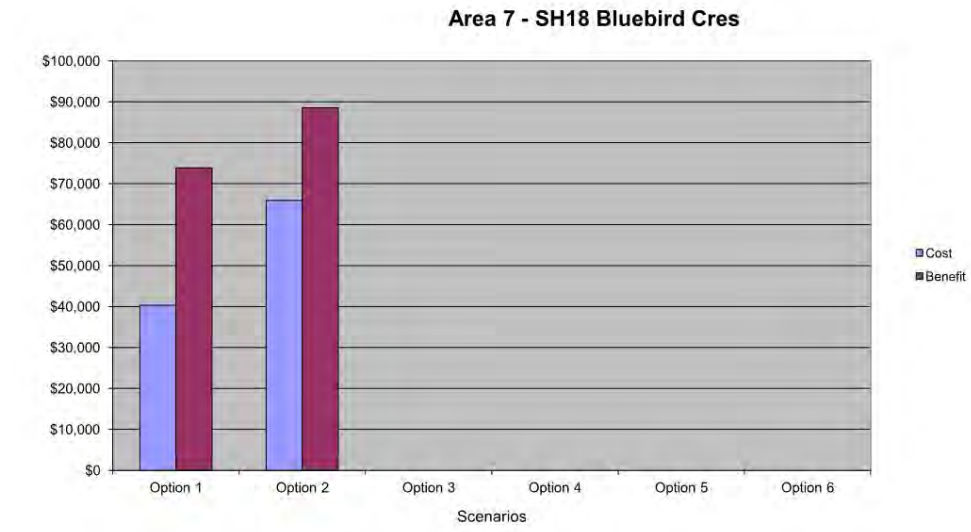
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$40,320	$65,910	$0	$0	$0	$0
Benefit	$73,872	$88,560	$0	$0	$0	$0
BCR	**1.83**	**1.34**	–	–	–	–
Structural	2.1 dB	3.1 dB				

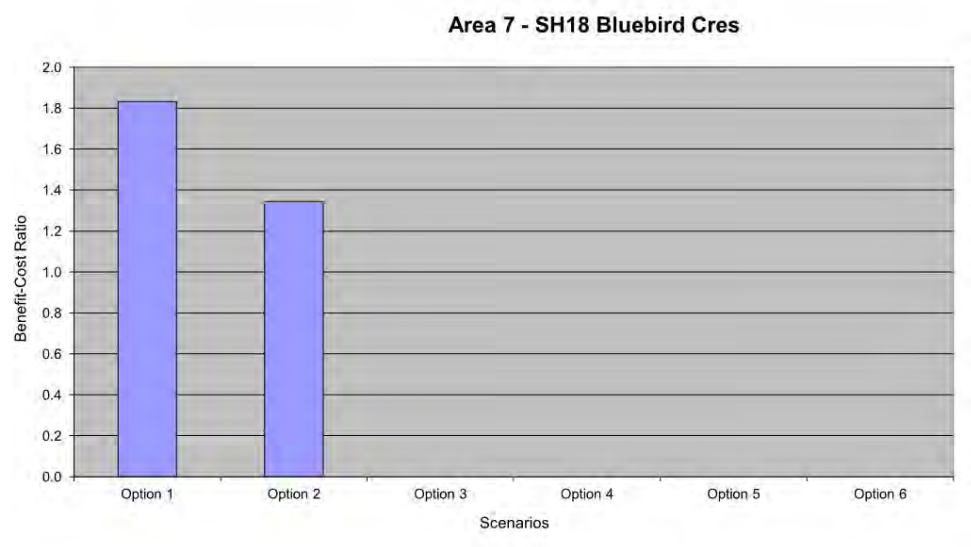
Assessment matrix

NZS 6806 compliance	+	+++
Structural mitigation	–	o
BCR	+ + +	+ +

Graphs







Project: Northern Corridor Improvements
Area: Area 7 – SH18 Bluebird Cres
AADT: (•) 2,000 to 75,000 vehicles per day ( ) More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities					Results from noise model for design year							
Reference	Street address	Floor	New or Altered	Existing $L_{Aeq(24h)}$ dB	Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
1	Bluebird Crescent 072	GF	Altered	55.1	56.7	59.2	61.0	61.0				
2	Bluebird Crescent 074	GF	Altered	55.4	57.0	59.8	61.7	61.7				
3	Bluebird Crescent 076	GF	Altered	56.3	57.8	61.5	62.3	62.3				
4	Bluebird Crescent 078	GF	Altered	56.8	58.3	62.2	62.8	62.8				
5	Bluebird Crescent 080	GF	Altered	57.1	58.5	62.5	62.9	62.9				
6	Bluebird Crescent 084	GF	Altered	54.6	56.0	60.5	60.7	60.7				
7	Bluebird Crescent 086	GF	Altered	56.2	57.6	62.1	61.7	61.7				
8	Bluebird Crescent 088	GF	Altered	57.3	58.7	63.5	62.6	62.6				
9	Bluebird Crescent 090	GF	Altered	60.4	61.7	67.0	63.5	63.4				
10	Bluebird Crescent 092	GF	Altered	65.4	66.8	72.2	65.2	64.0				
11	Bluebird Crescent 094	GF	Altered	66.0	67.4	72.8	67.4	63.4				
12	Bluebird Crescent 102	GF	Altered	52.0	53.1	58.1	57.0	56.3				
13	Bluebird Crescent 104	GF	Altered	50.3	51.6	55.7	55.8	55.6				

Appendix D
Noise level survey results – Diurnal variation

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Logger Measurements

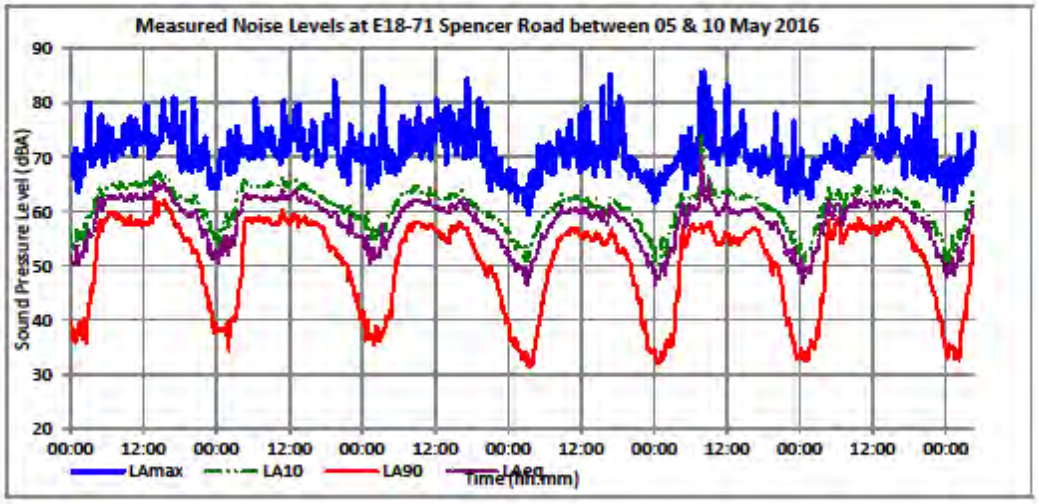
Date: Wednesday, 18 May 2016
File name: J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[E18-71 Spencer Rd.xlsx]Logger_Summary

Job number:	2016013A
Job name:	Northern Corridor Improvements
Initials:	SW
Measurement Dates:	Thursday, 05 May 2016 to Tuesday, 10 May 2016
Weather during Measurement:	No adjustment for adverse weatehr conditions was required.
Notes:	E18-71 Spencer Road

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A90}	L_{Amax}
Day (0700-1800)	Lowest	57	59	50	66
	Average	62	64	57	73
	Highest	70	74	62	86
Evening (1800-2200)	Lowest	52	56	39	62
	Average	58	61	51	71
	Highest	61	63	56	84
Night (2200-0700)	Lowest	46	49	31	59
	Average	57	60	43	68
	Highest	63	66	59	83

$L_{Aeq\ 24\text{-}hr}$ 60 dB



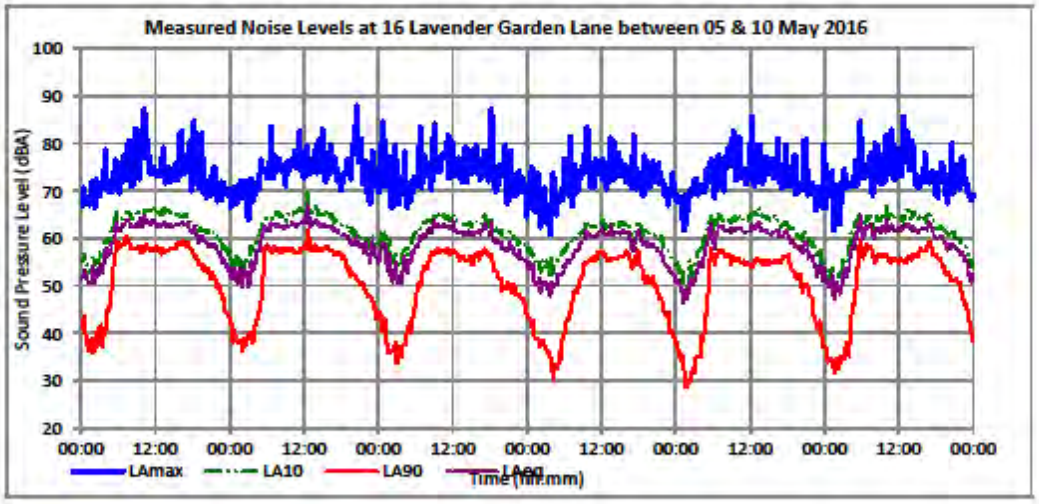
Logger Measurements

Date:	Wednesday, 18 May 2016
File name:	J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[16 Lavender Garden Ln.xlsx]Logger_Summary
Job number:	2016013A
Job name:	Northern Corridor Improvements
Initials:	SW
Measurement Dates:	Thursday, 05 May 2016 to Tuesday, 10 May 2016
Weather during Measurement:	No adjustment for adverse weaterh conditionsw was required.
Notes:	16 Lavender Garden Lane

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A90}	L_{Amax}
Day (0700-1800)	Lowest	56	58	44	67
	Average	62	64	56	75
	Highest	67	70	62	87
Evening (1800-2200)	Lowest	56	59	47	67
	Average	59	61	52	74
	Highest	64	64	57	88
Night (2200-0700)	Lowest	46	49	29	61
	Average	56	59	42	71
	Highest	65	66	59	86

$L_{Aeq\ 24\text{-}hr}$ 60 dB



Logger Measurements

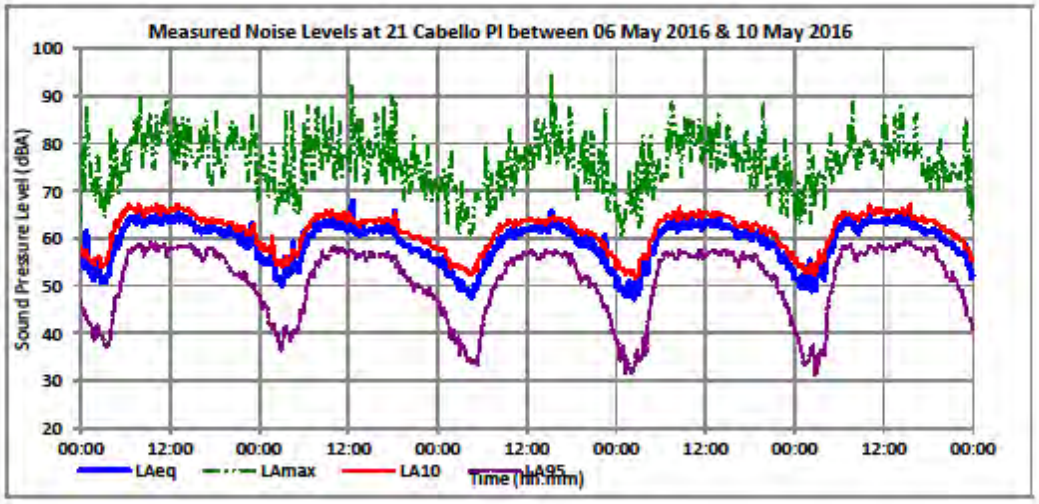
Date: Wednesday, 18 May 2016
File name: J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[21 Cabello Place.xlsx]Logger_Summary

Job number:	2016013A
Job name:	Northern Corridor Improvements
Initials:	SW
Measurement Dates:	Friday, 06 May 2016 to Tuesday, 10 May 2016
Weather during Measurement:	No adjustment for adverse weather conditions was required.
Notes:	21 Cabello Pl

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A95}	
Day (0700-1800)	Lowest	56	59	47	66
	Average	63	65	57	79
	Highest	68	67	60	94
Evening (1800-2200)	Lowest	57	59	48	67
	Average	60	62	53	76
	Highest	66	65	58	89
Night (2200-0700)	Lowest	47	51	31	60
	Average	56	59	43	72
	Highest	64	66	59	88

$L_{Aeq\ 24\text{-}hr}$ 61 dB



Logger Measurements

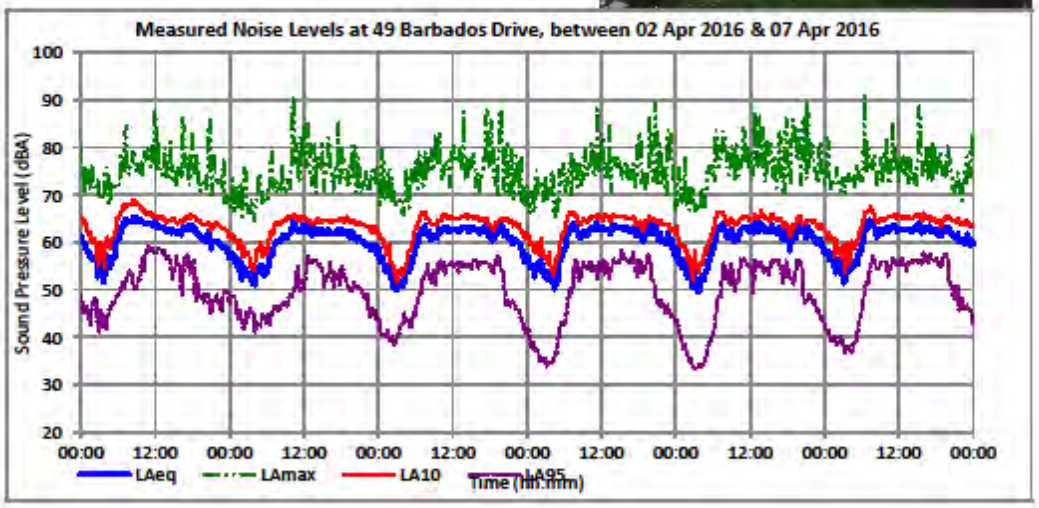
Date: Wednesday, 18 May 2016
File name: J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[49 Barbados Drive.xlsx]Logger_Summary

Job number:	2016013A
Job name:	Northern Corridor Improvements
Initials:	SW
Measurement Dates:	Saturday, 02 April 2016 to Thursday, 07 April 2016
Weather during Measurement:	No adjustment for adverse weather conditions was required.
Notes:	49 Barbados Drive, Unsworth Heights

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A95}	L_{Amax}
Day (0700-1800)	Lowest	58	62	45	70
	Average	63	65	54	77
	Highest	65	69	59	91
Evening (1800-2200)	Lowest	58	61	45	69
	Average	62	64	52	76
	Highest	65	66	58	90
Night (2200-0700)	Lowest	50	52	33	65
	Average	57	61	42	72
	Highest	65	67	52	91

$L_{Aeq\ 24\text{-}hr}$ 61 dB



Logger Measurements

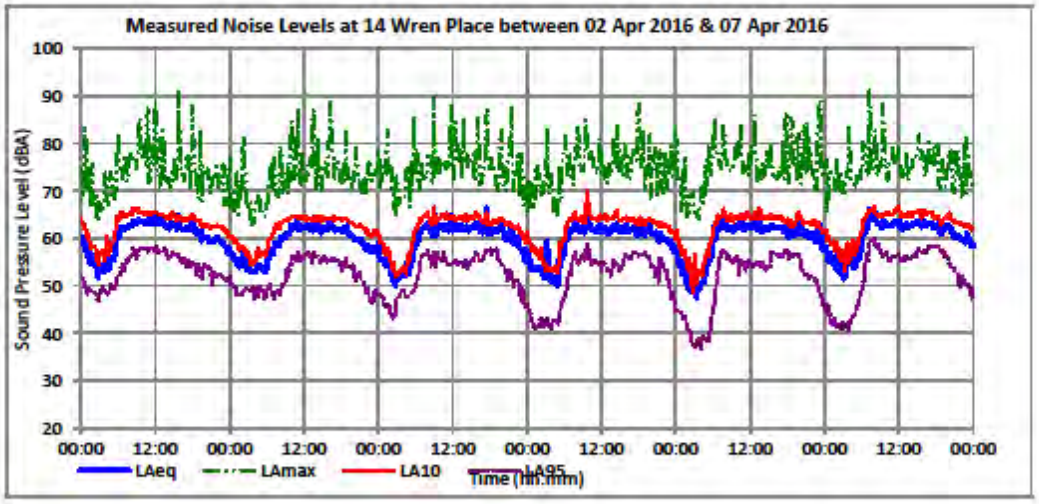
Date: Wednesday, 18 May 2016
File name: J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[14 Wren Place.xlsx]Logger_Summary

Job number:	2016013A
Job name:	Northern Corridor Improvements
Initials:	SW
Measurement Dates:	Saturday, 02 April 2016 to Thursday, 07 April 2016
Weather during Measurement:	No adjustment for adverse weather conditions was required.
Notes:	14 Wren Place, Unsworth Heights

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A95}	
Day (0700-1800)	Lowest	57	61	47	69
	Average	63	65	56	76
	Highest	67	70	60	91
Evening (1800-2200)	Lowest	59	62	50	68
	Average	61	64	54	75
	Highest	64	65	59	88
Night (2200-0700)	Lowest	48	49	37	63
	Average	57	60	46	72
	Highest	63	65	57	89

$L_{Aeq\ 24\text{-}hr}$ 61 dB



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Appendix E
Noise levels – Annoyance Bands

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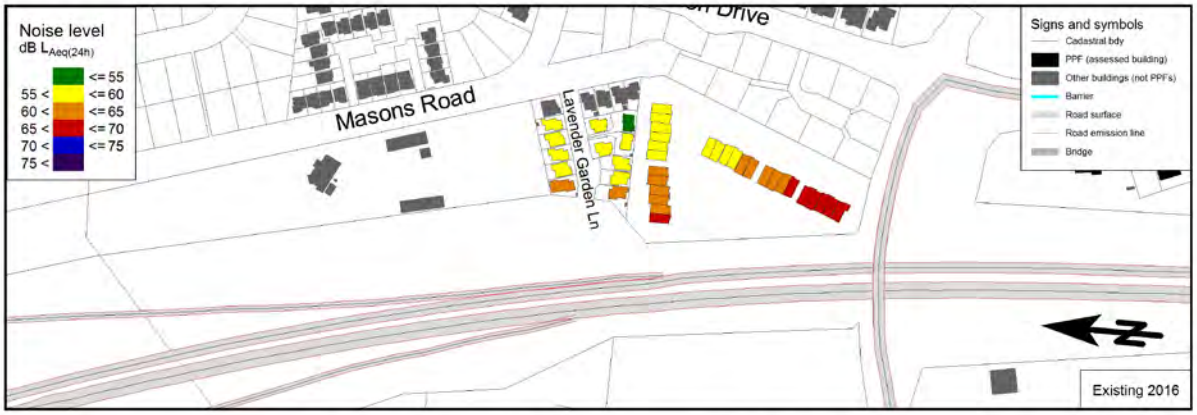
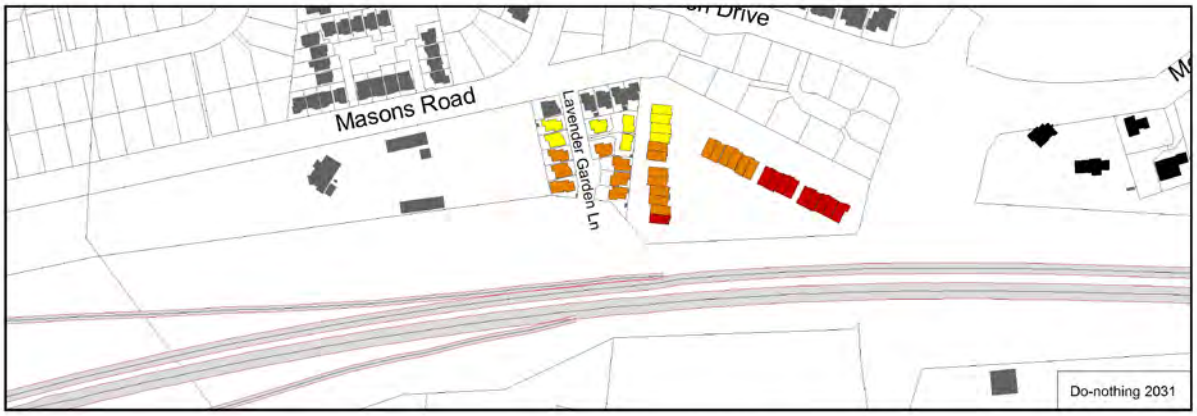
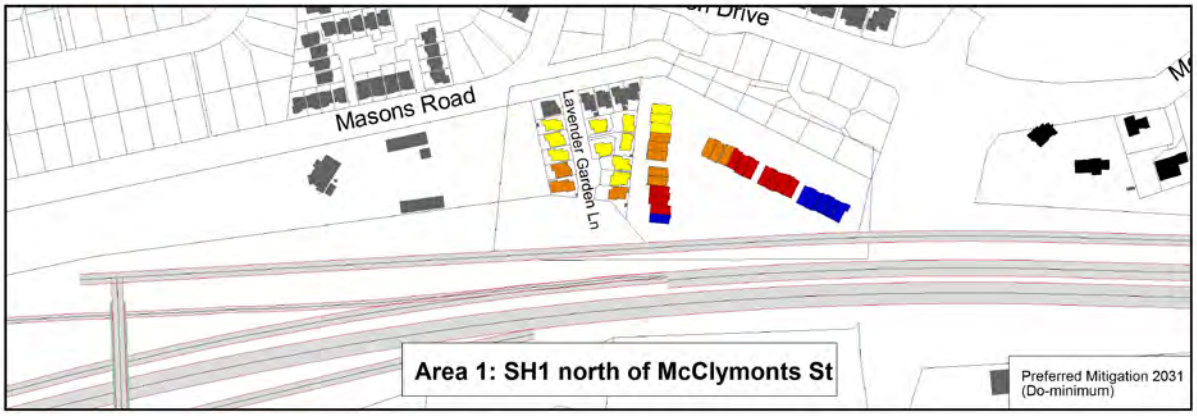
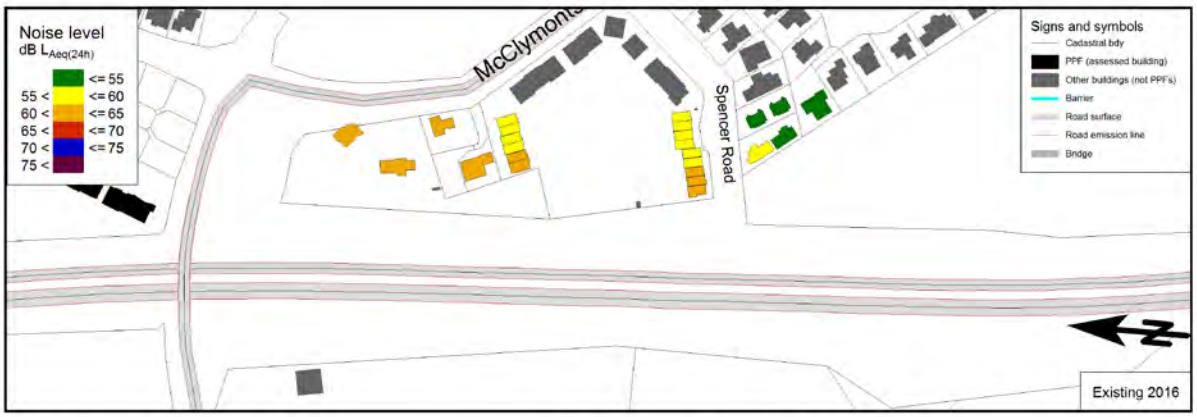

Noise level
dB $L_{Aeq(24h)}$
55 < <= 55
60 < <= 60
65 < <= 70
70 < <= 75
75 < <= 75
Masons Road
Lavender Garden Ln
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
N
Existing 2016


Masons Road
Lavender Garden Ln
Do-nothing 2031

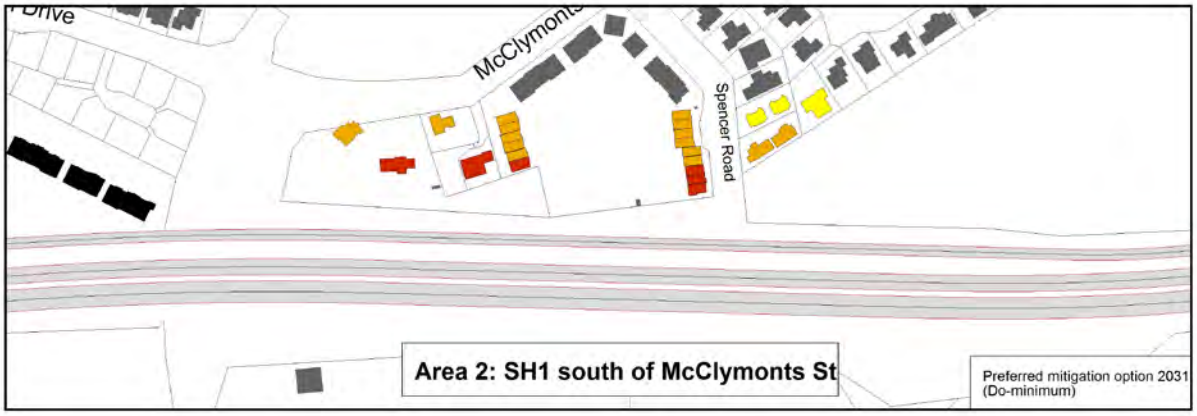

Masons Road
Lavender Garden Ln
Do-minimum 2031

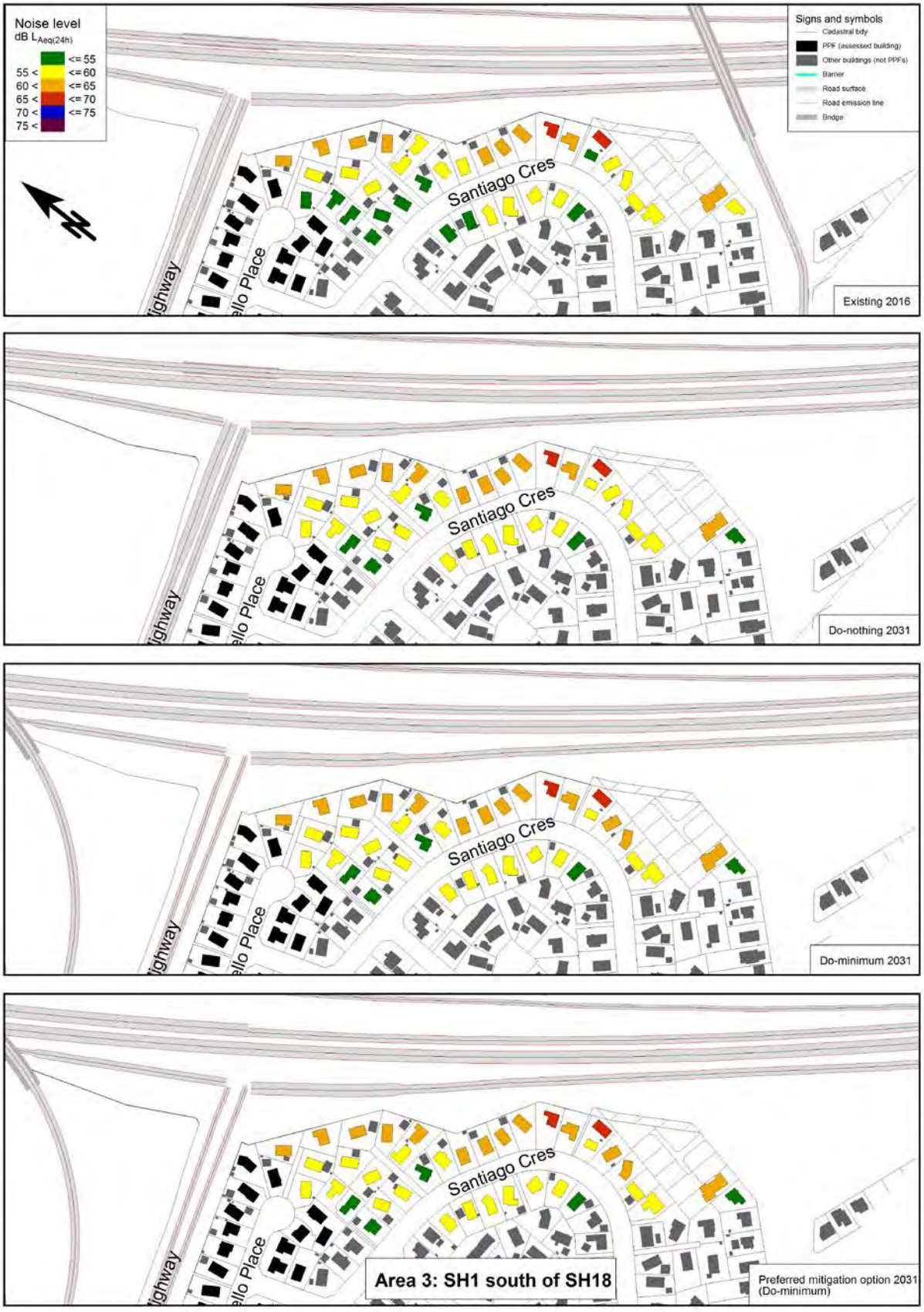

Masons Road
Lavender Garden Ln
Area 1: SH1 north of McClymonts St
Preferred Mitigation 2031
(Do-minimum)

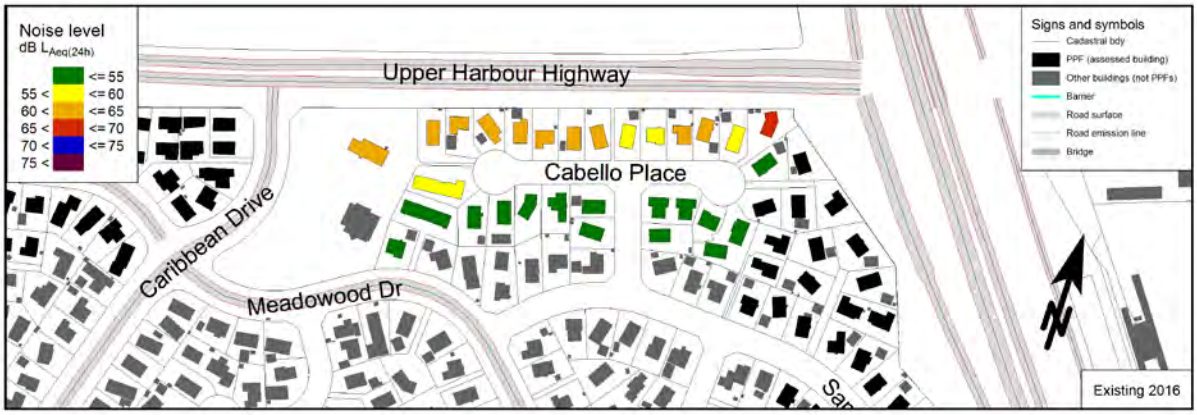

Noise level
dB $L_{Aeq(24h)}$
<= 55
55 < <= 60
60 < <= 65
65 < <= 70
70 < <= 75
75 <
McClymonts
Spencer Road
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
N
Existing 2016


McClymonts
Spencer Road
Do-nothing 2031

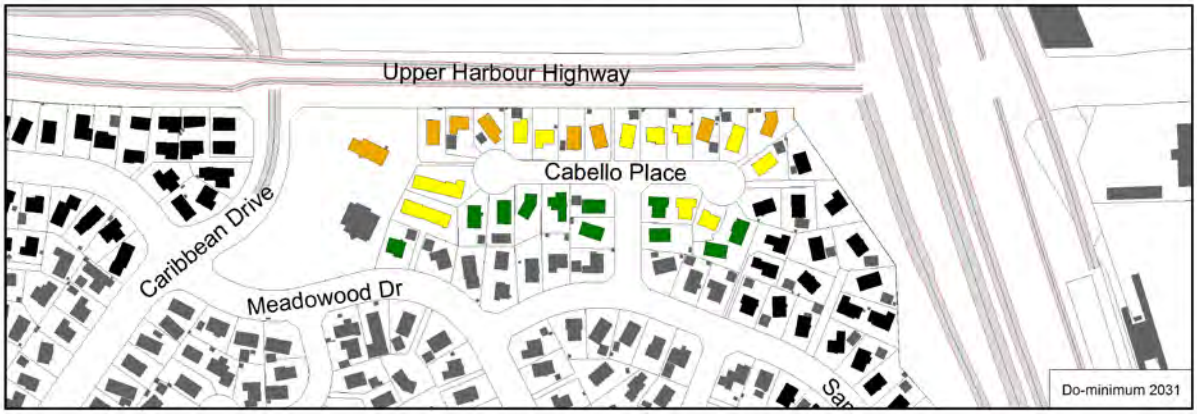

McClymonts
Spencer Road
Do-minimum 2031

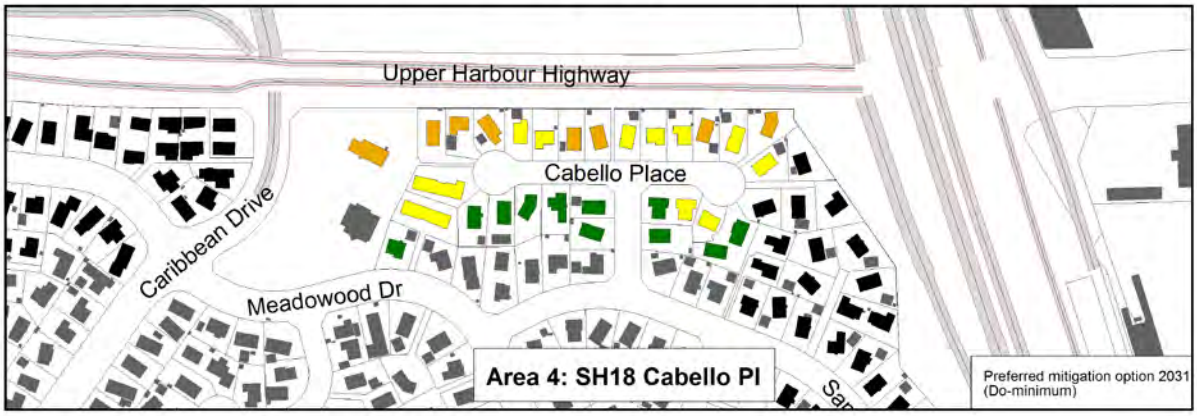

McClymonts
Spencer Road
Area 2: SH1 south of McClymonts St
Preferred mitigation option 2031
(Do-minimum)

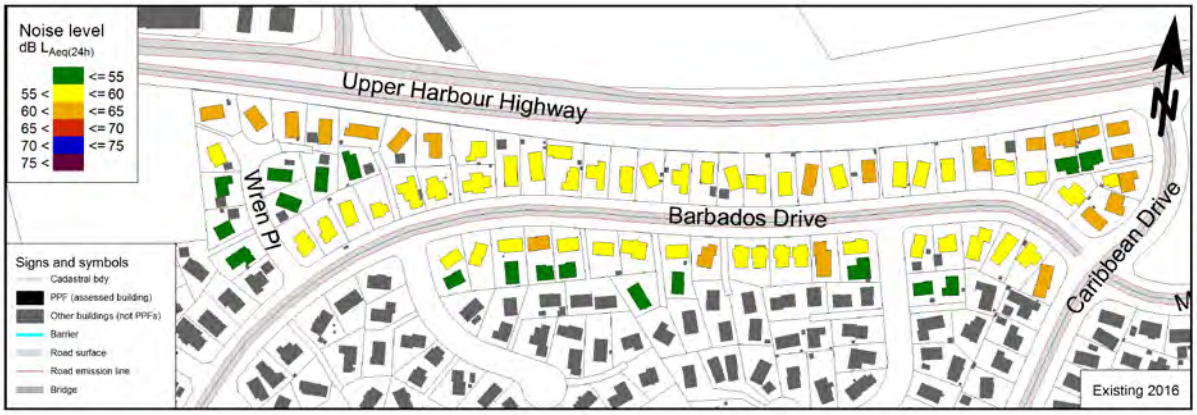

Noise level
dB $L_{Aeq(24h)}$
<= 55
55 < <= 60
60 < <= 65
65 < <= 70
70 < <= 75
75 <
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Santiago Cres
Existing 2016
Do-nothing 2031
Do-minimum 2031
Area 3: SH1 south of SH18
Preferred mitigation option 2031
(Do-minimum)

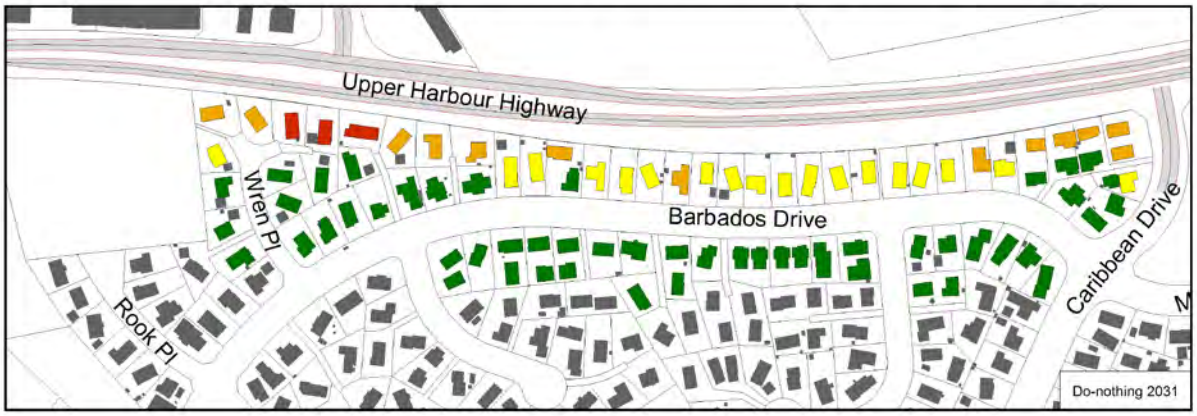

Noise level
dB $L_{Aeq(24h)}$
55 < <= 55
60 < <= 60
65 < <= 65
70 < <= 70
75 < <= 75
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Cabello Place
Caribbean Drive
Meadowood Dr
Existing 2016

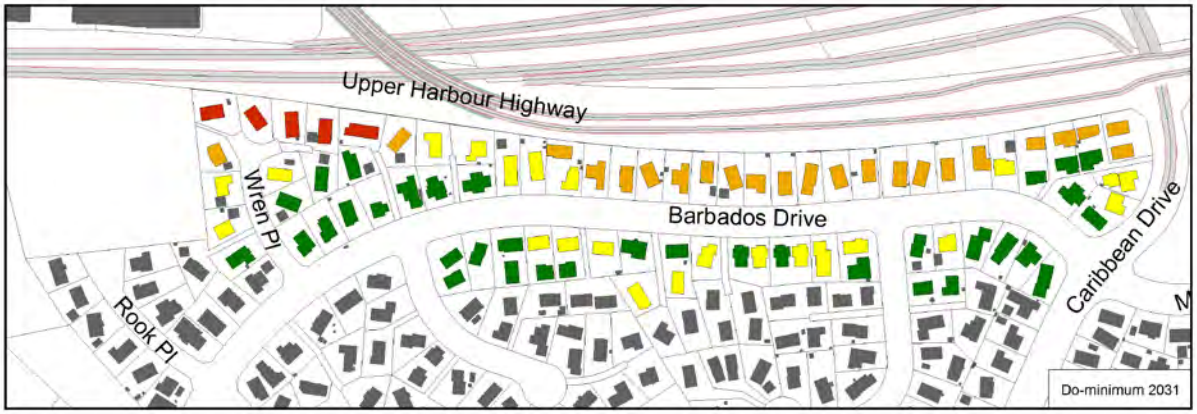

Upper Harbour Highway
Cabello Place
Caribbean Drive
Meadowood Dr
Do-nothing 2031

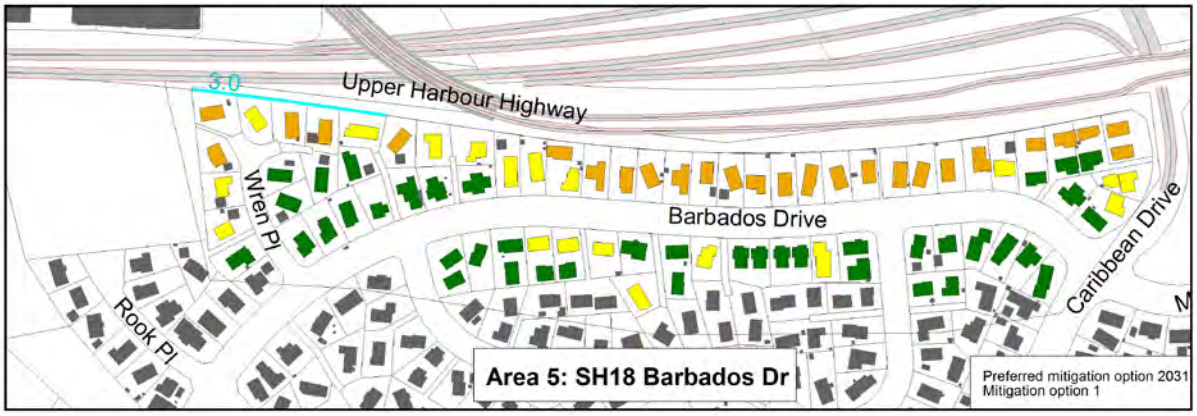

Upper Harbour Highway
Cabello Place
Caribbean Drive
Meadowood Dr
Do-minimum 2031


Upper Harbour Highway
Cabello Place
Caribbean Drive
Meadowood Dr
Area 4: SH18 Cabello Pl
Preferred mitigation option 2031
(Do-minimum)


Noise level
dB $L_{Aeq(24h)}$
55 < <= 55
60 < <= 60
65 < <= 65
70 < <= 70
75 < <= 75
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Barbados Drive
Wren Pl
Caribbean Drive
N
Existing 2016

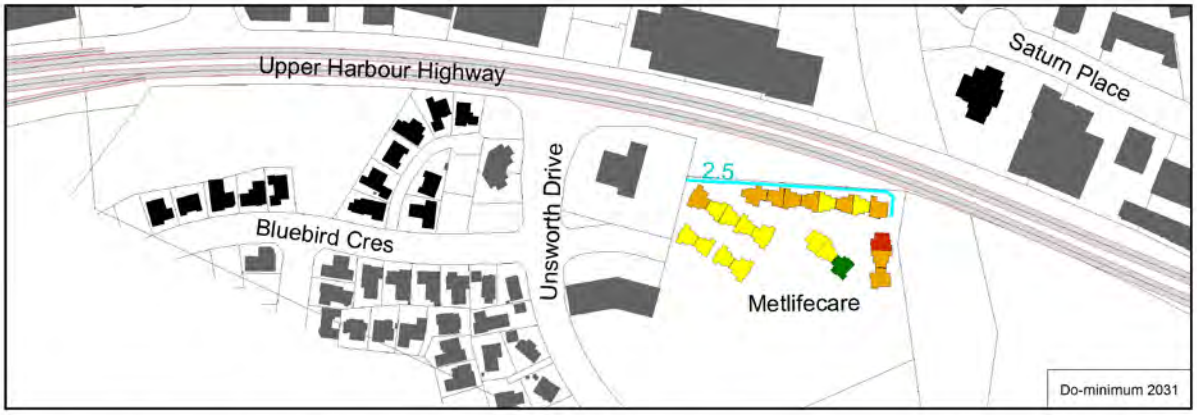

Upper Harbour Highway
Barbados Drive
Wren Pl
Rook Pl
Caribbean Drive
Do-nothing 2031

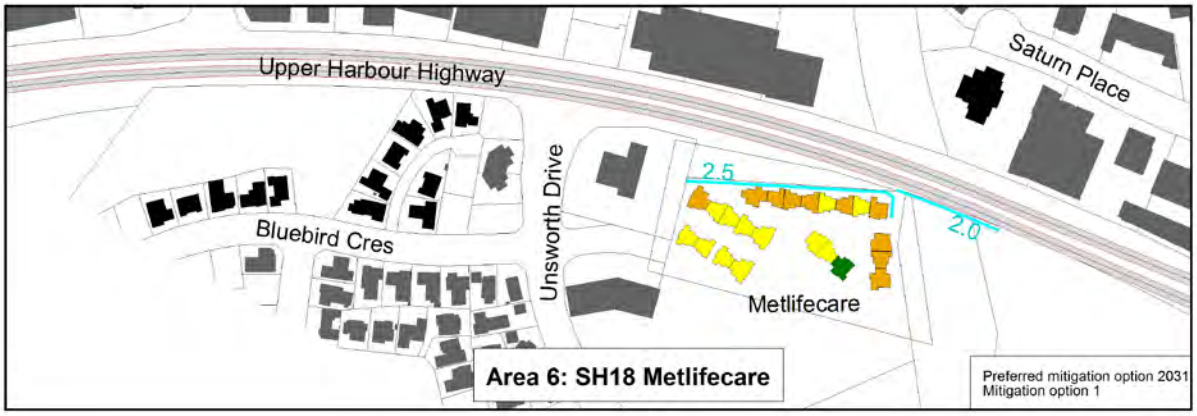

Upper Harbour Highway
Barbados Drive
Wren Pl
Rook Pl
Caribbean Drive
Do-minimum 2031

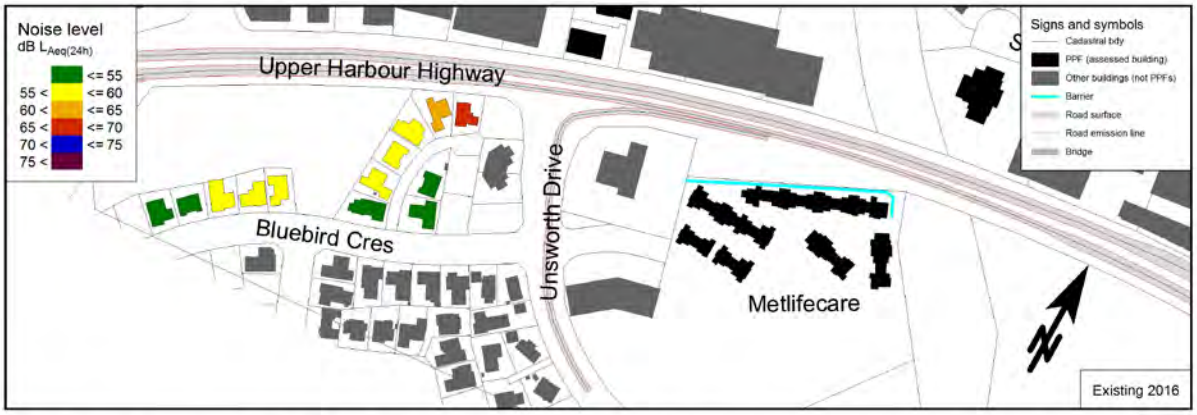

3.0
Upper Harbour Highway
Barbados Drive
Wren Pl
Rook Pl
Caribbean Drive
Area 5: SH18 Barbados Dr
Preferred mitigation option 2031
Mitigation option 1


Noise level
dB $L_{Aeq(24h)}$
<= 55
55 < <= 60
60 < <= 65
65 < <= 70
70 < <= 75
75 <
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Bluebird Cres
Unsworth Drive
2.5
Metlifecare
Existing 2016

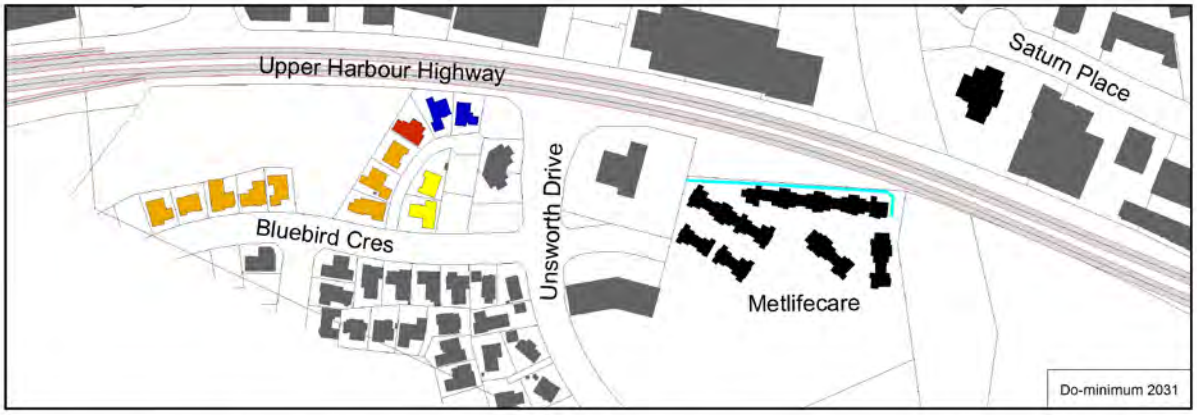

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
2.5
Metlifecare
Do-nothing 2031

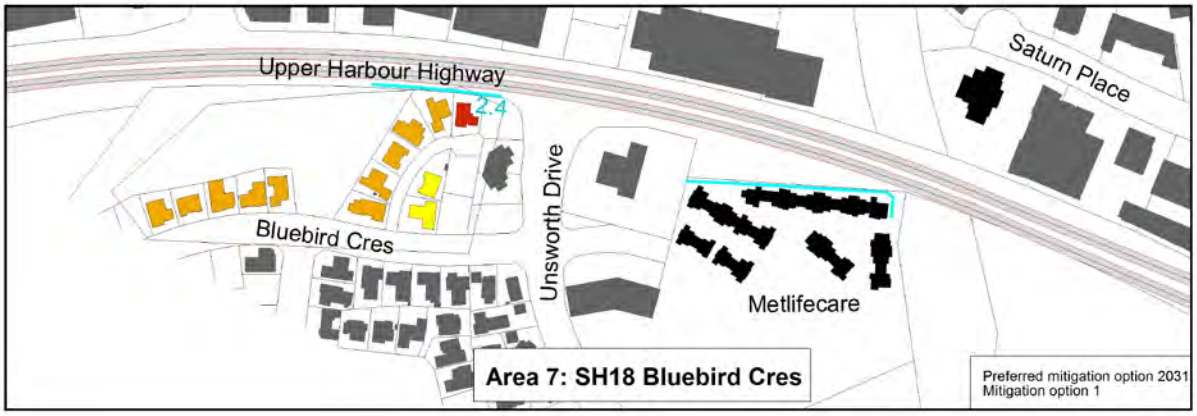

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
2.5
Metlifecare
Do-minimum 2031

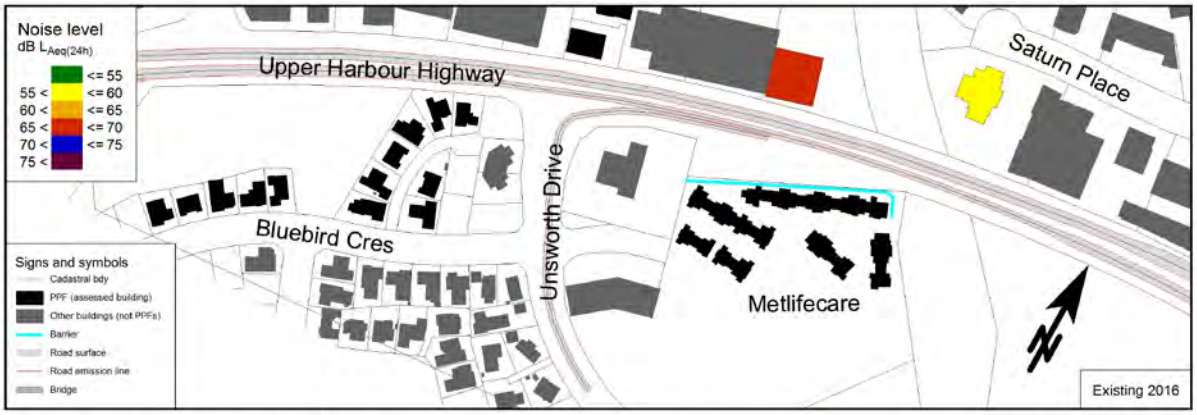

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
2.5
2.0
Metlifecare
Area 6: SH18 Metlifecare
Preferred mitigation option 2031
Mitigation option 1

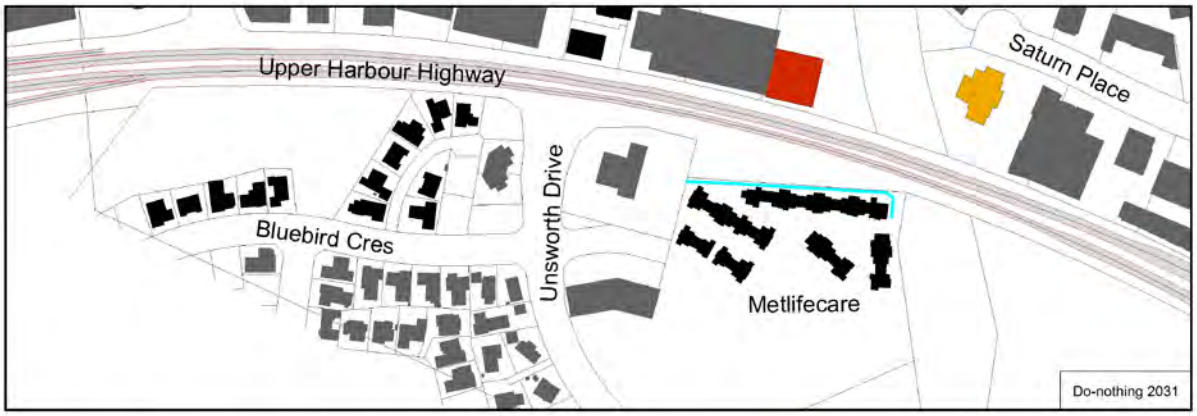

Noise level
dB $L_{Aeq(24h)}$
<= 55
55 < <= 60
60 < <= 65
65 < <= 70
70 < <= 75
75 <
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Bluebird Cres
Unsworth Drive
Metlifecare
N
Existing 2016

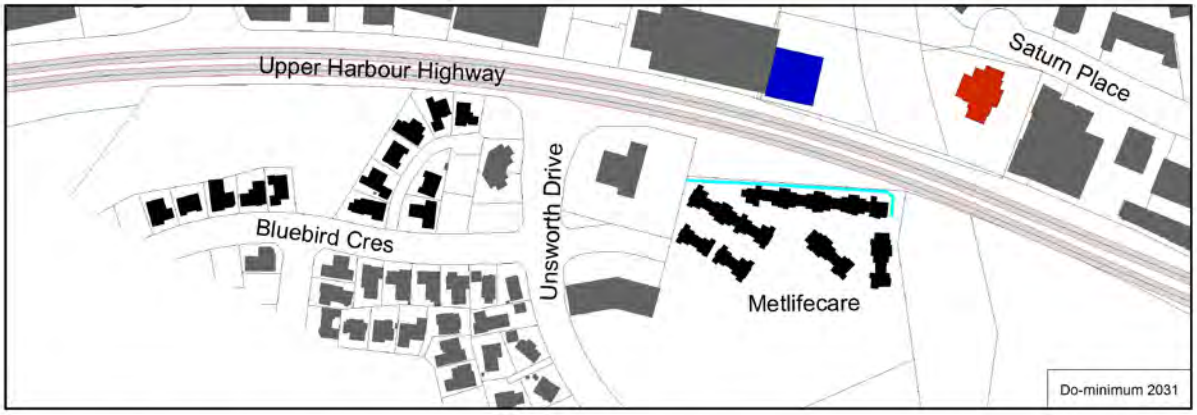

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
Do-nothing 2031

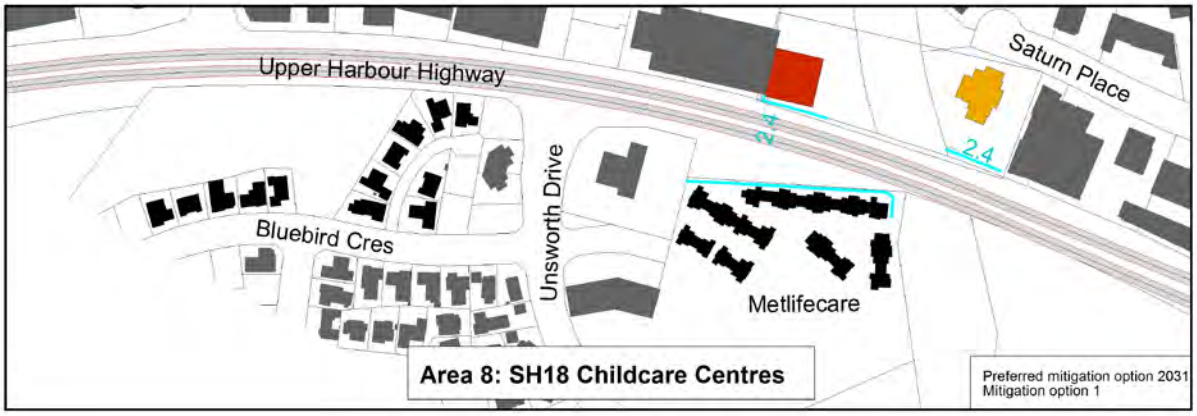

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
Do-minimum 2031


Upper Harbour Highway
2.4
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
Area 7: SH18 Bluebird Cres
Preferred mitigation option 2031
Mitigation option 1


Noise level
dB $L_{Aeq(24h)}$
<= 55
55 < <= 60
60 < <= 65
65 < <= 70
70 < <= 75
75 <
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
N
Existing 2016


Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
Do-nothing 2031


Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
Do-minimum 2031


Upper Harbour Highway
Saturn Place
2.4
2.4
Bluebird Cres
Unsworth Drive
Metlifecare
Area 8: SH18 Childcare Centres
Preferred mitigation option 2031
Mitigation option 1

Appendix F
Noise criteria categories – NZS 6806 assessment

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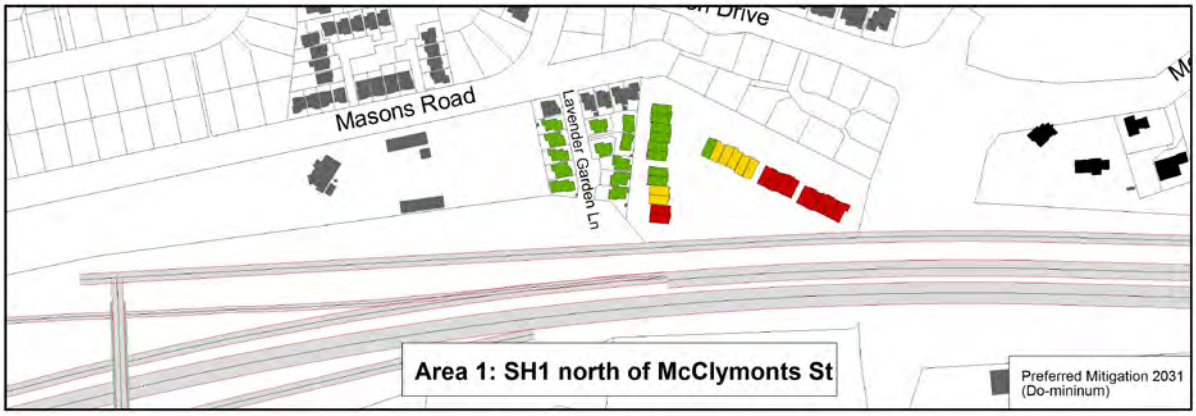
Noise level
dB $L_{Aeq(24h)}$
<= 64 Category A
64 < <= 67 Category B
67 < Category C
Masons Road
Lavender Garden Ln
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
N
Existing 2016


Masons Road
Lavender Garden Ln
Do-nothing 2031

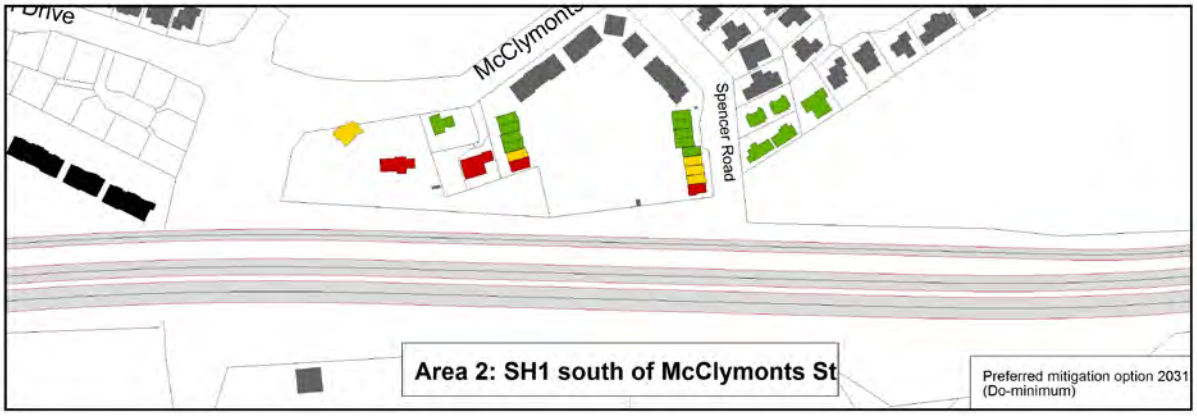

Masons Road
Lavender Garden Ln
Do-minimum 2031


Masons Road
Lavender Garden Ln
Area 1: SH1 north of McClymonts St
Preferred Mitigation 2031
(Do-mininum)


Noise level
dB $L_{Aeq(24h)}$
<= 64 Category A
64 < <= 67 Category B
67 < Category C
McClymonts
Spencer Road
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
N
Existing 2016


McClymonts
Spencer Road
Do-nothing 2031

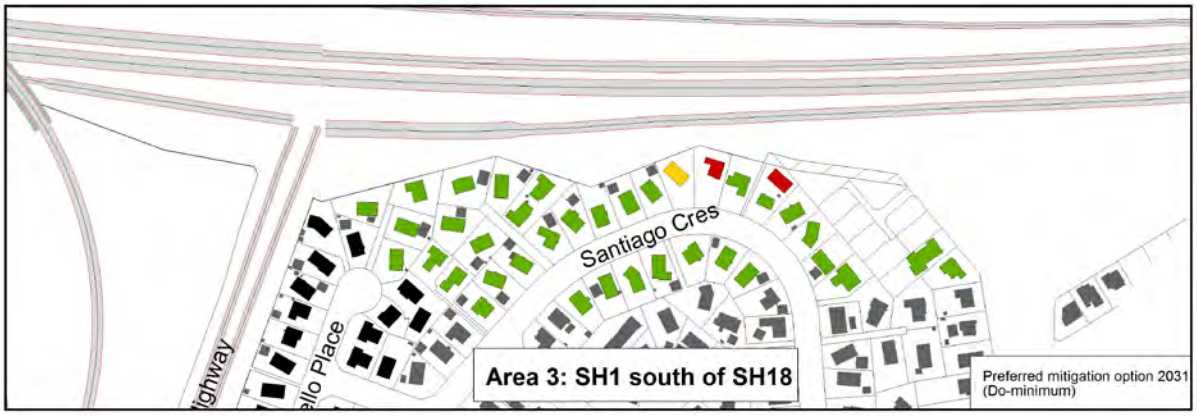

McClymonts
Spencer Road
Do-minimum 2031


McClymonts
Spencer Road
Area 2: SH1 south of McClymonts St
Preferred mitigation option 2031
(Do-minimum)

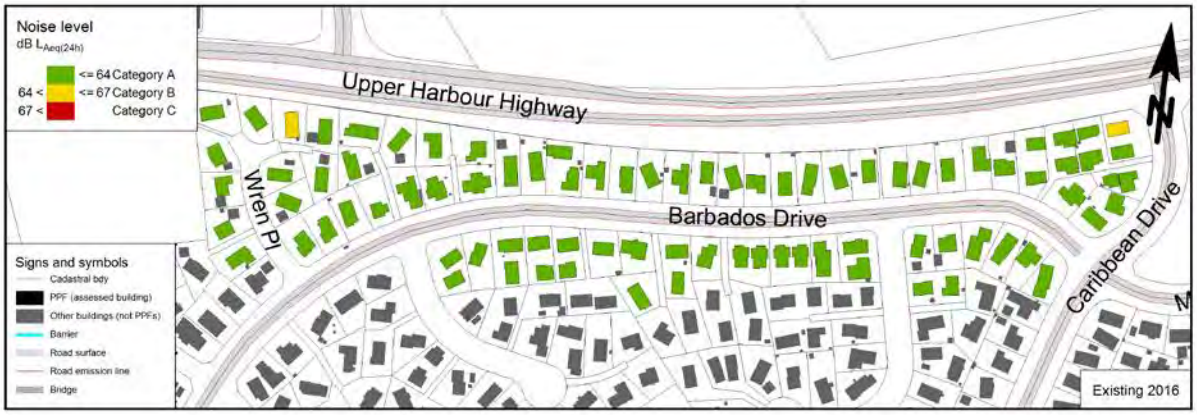

Noise level
dB $L_{Aeq(24h)}$
<= 64 Category A
64 < <= 67 Category B
67 < Category C
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Santiago Cres
Existing 2016

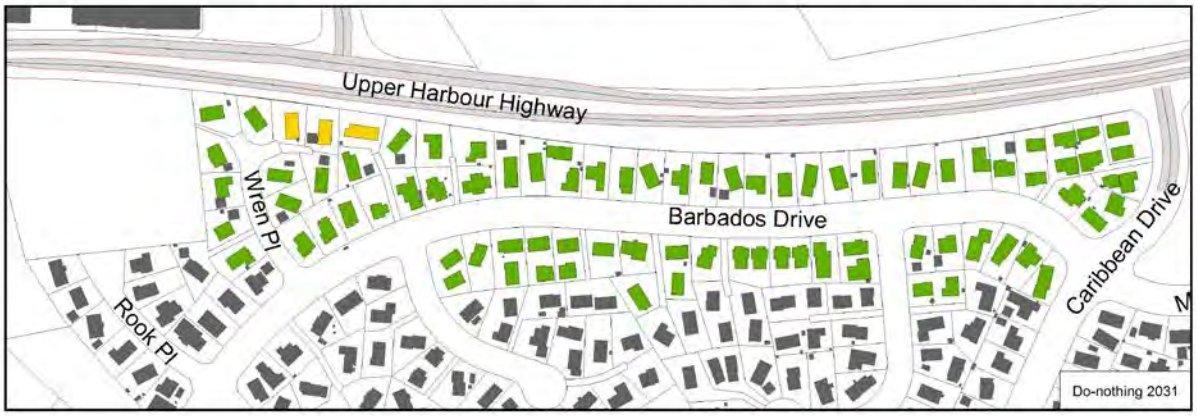

Santiago Cres
Do-nothing 2031

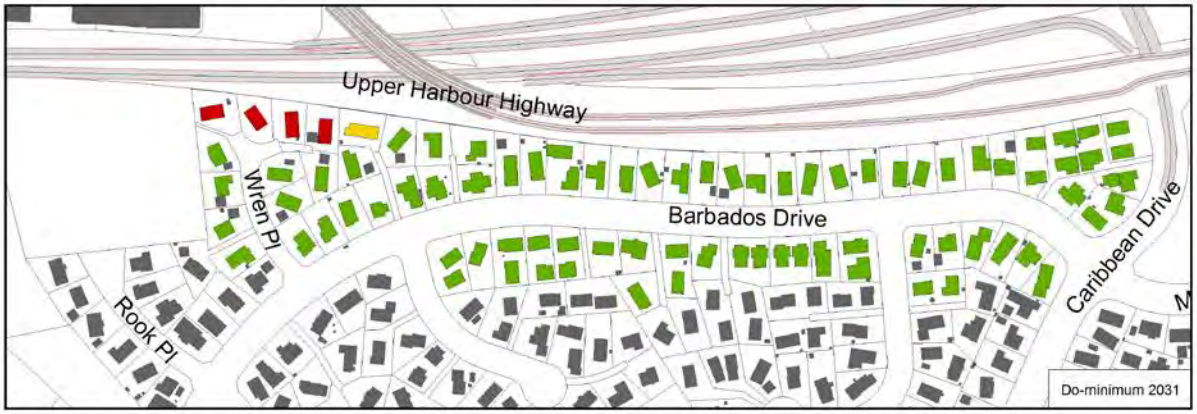

Santiago Cres
Do-minimum 2031

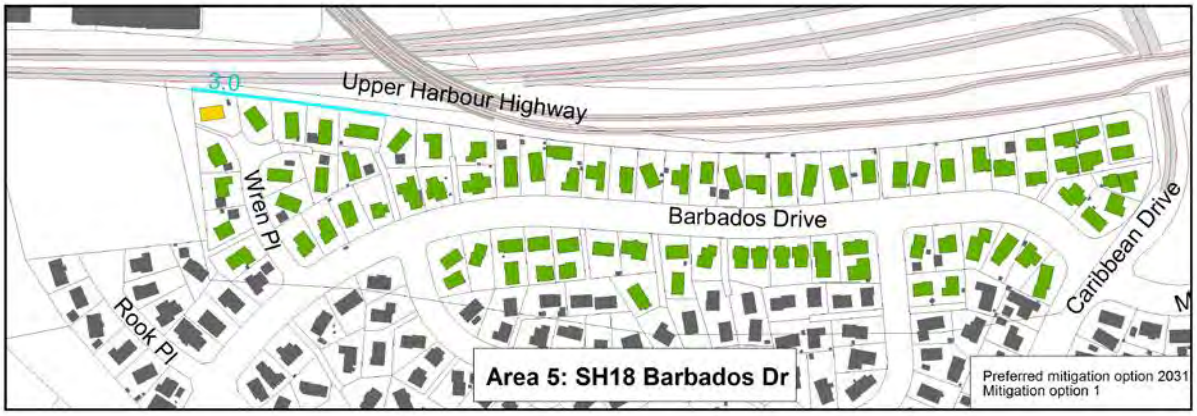

Santiago Cres
Area 3: SH1 south of SH18
Preferred mitigation option 2031
(Do-minimum)


Noise level
dB $L_{Aeq(24h)}$
<= 64 Category A
64 < <= 67 Category B
67 < Category C
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Cabello Place
Caribbean Drive
Meadowood Dr
Existing 2016
Upper Harbour Highway
Cabello Place
Caribbean Drive
Meadowood Dr
Do-nothing 2031
Upper Harbour Highway
Cabello Place
Caribbean Drive
Meadowood Dr
Do-minimum 2031
Upper Harbour Highway
Cabello Place
Caribbean Drive
Meadowood Dr
Area 4: SH18 Cabello Pl
Preferred option 2031
(Do-minimum)


Noise level
dB $L_{Aeq(24h)}$
<= 64 Category A
64 < <= 67 Category B
67 < Category C
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Barbados Drive
Wren Pl
Caribbean Drive
Existing 2016


Upper Harbour Highway
Barbados Drive
Wren Pl
Rook Pl
Caribbean Drive
Do-nothing 2031

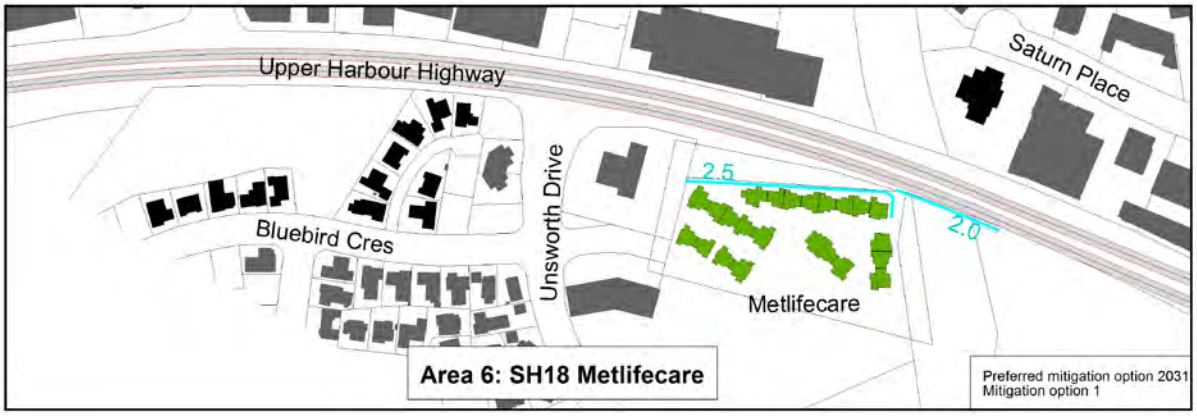

Upper Harbour Highway
Barbados Drive
Wren Pl
Rook Pl
Caribbean Drive
Do-minimum 2031


3.0
Upper Harbour Highway
Barbados Drive
Wren Pl
Rook Pl
Caribbean Drive
Area 5: SH18 Barbados Dr
Preferred mitigation option 2031
Mitigation option 1


Noise level
dB $L_{Aeq(24h)}$
<= 64 Category A
64 < <= 67 Category B
67 < Category C
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Bluebird Cres
Unsworth Drive
2.5
Metlifecare
Existing 2016

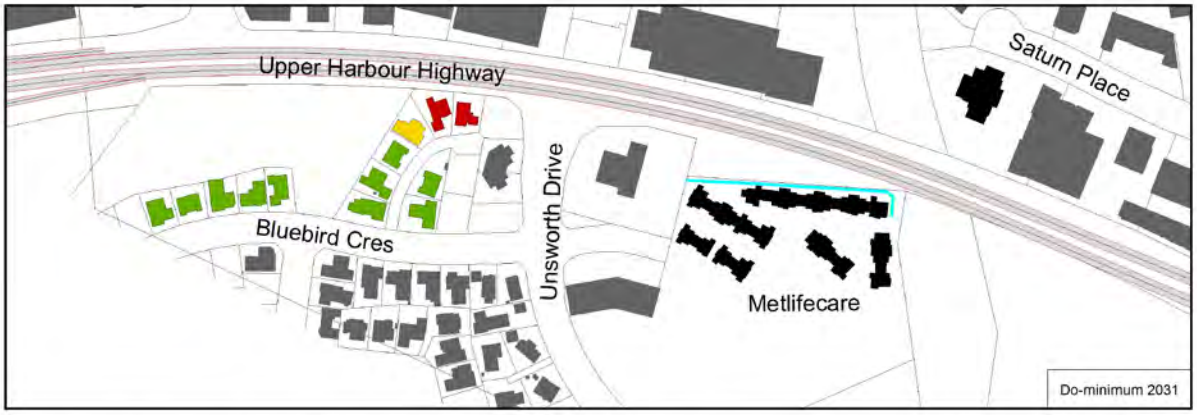

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
2.5
Metlifecare
Do-nothing 2031

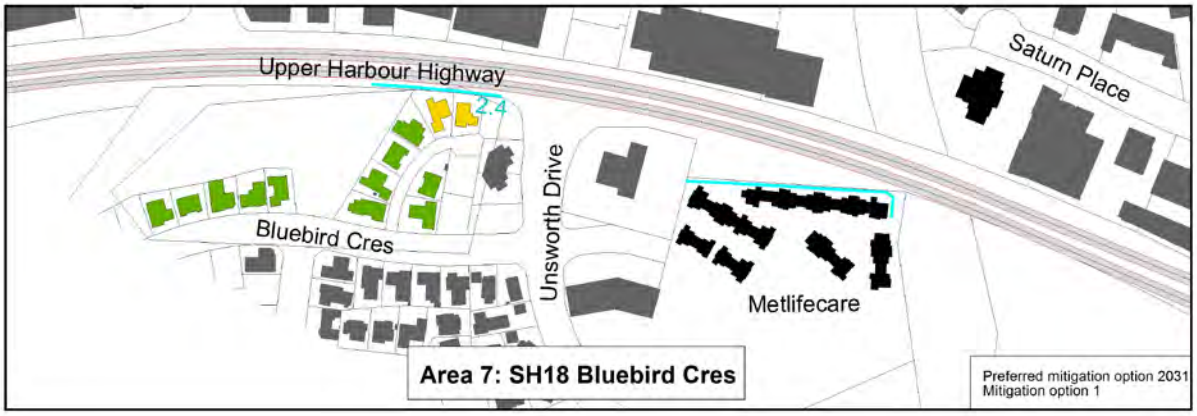

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
2.5
Metlifecare
Do-minimum 2031

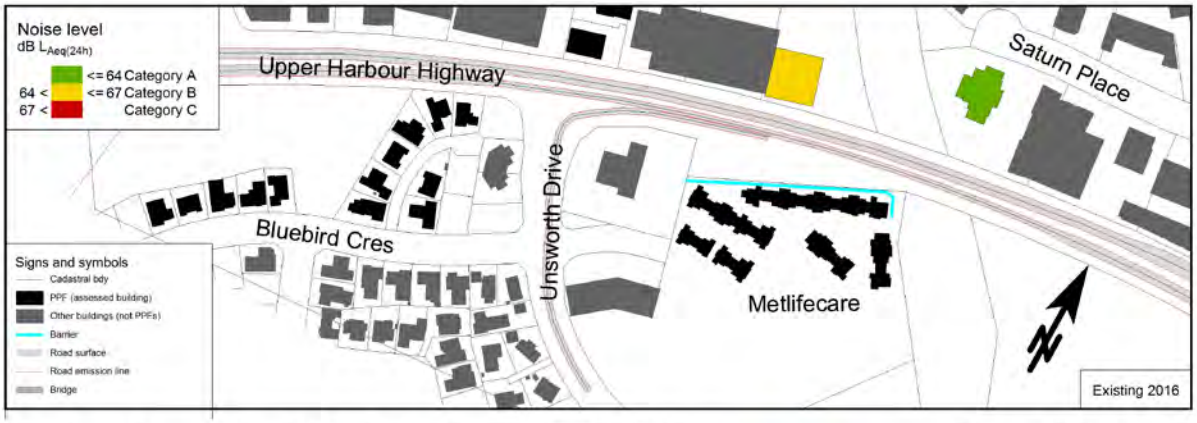

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
2.5
2.0
Metlifecare
Area 6: SH18 Metlifecare
Preferred mitigation option 2031
Mitigation option 1

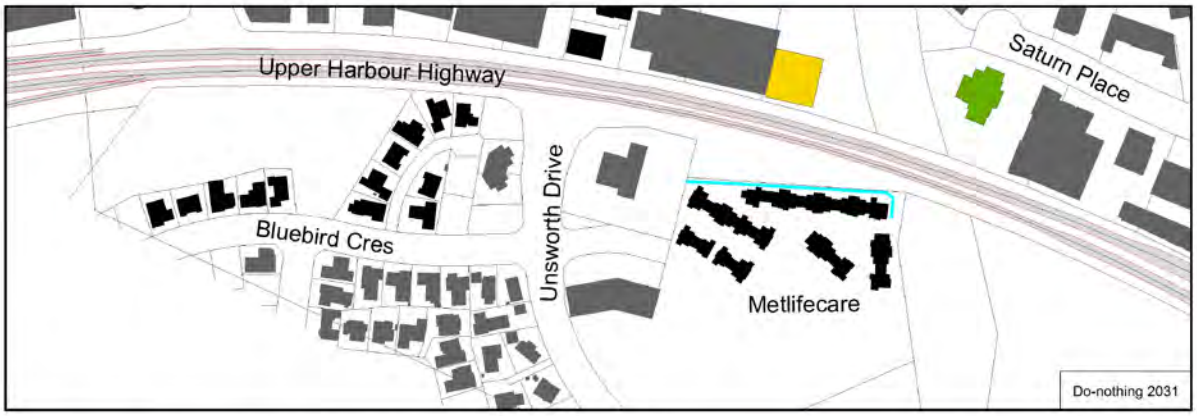

Noise level
dB $L_{Aeq(24h)}$
<= 64 Category A
64 < <= 67 Category B
67 < Category C
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Bluebird Cres
Unsworth Drive
Metlifecare
Existing 2016

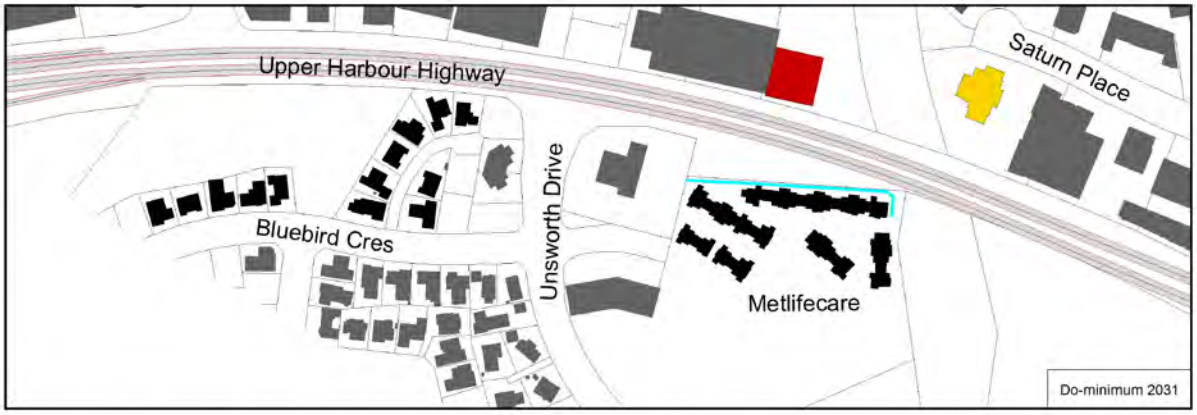

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
Do-nothing 2031

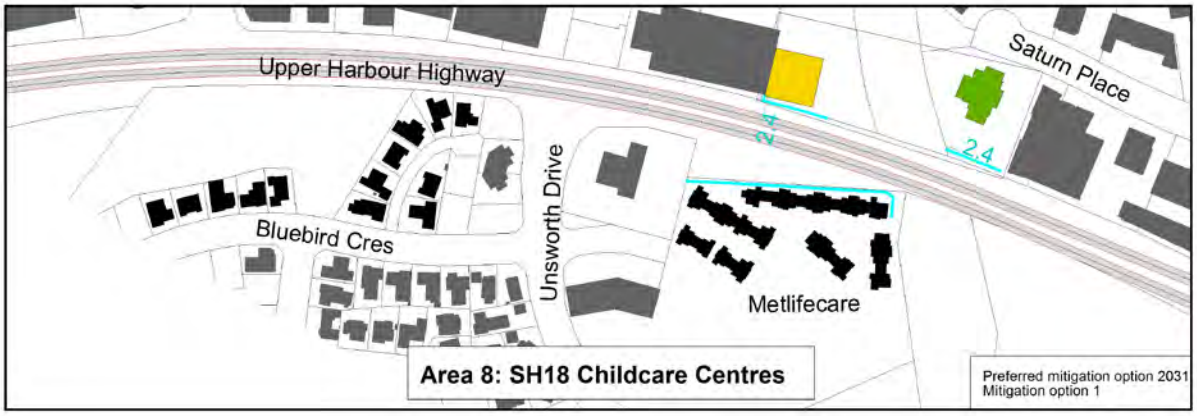

Upper Harbour Highway
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
Do-minimum 2031


Upper Harbour Highway
2.4
Saturn Place
Bluebird Cres
Unsworth Drive
Metlifecare
Area 7: SH18 Bluebird Cres
Preferred mitigation option 2031
Mitigation option 1


Noise level
dB $L_{Aeq(24h)}$
<= 64 Category A
64 < <= 67 Category B
67 < Category C
Signs and symbols
Cadastral bdy
PPF (assessed building)
Other buildings (not PPFs)
Barrier
Road surface
Road emission line
Bridge
Upper Harbour Highway
Saturn Place
Unsworth Drive
Bluebird Cres
Metlifecare
N
Existing 2016


Upper Harbour Highway
Saturn Place
Unsworth Drive
Bluebird Cres
Metlifecare
Do-nothing 2031


Upper Harbour Highway
Saturn Place
Unsworth Drive
Bluebird Cres
Metlifecare
Do-minimum 2031


Upper Harbour Highway
Saturn Place
Unsworth Drive
Bluebird Cres
Metlifecare
2.4
2.4
Area 8: SH18 Childcare Centres
Preferred mitigation option 2031
Mitigation option 1

Appendix G
Noise level contours

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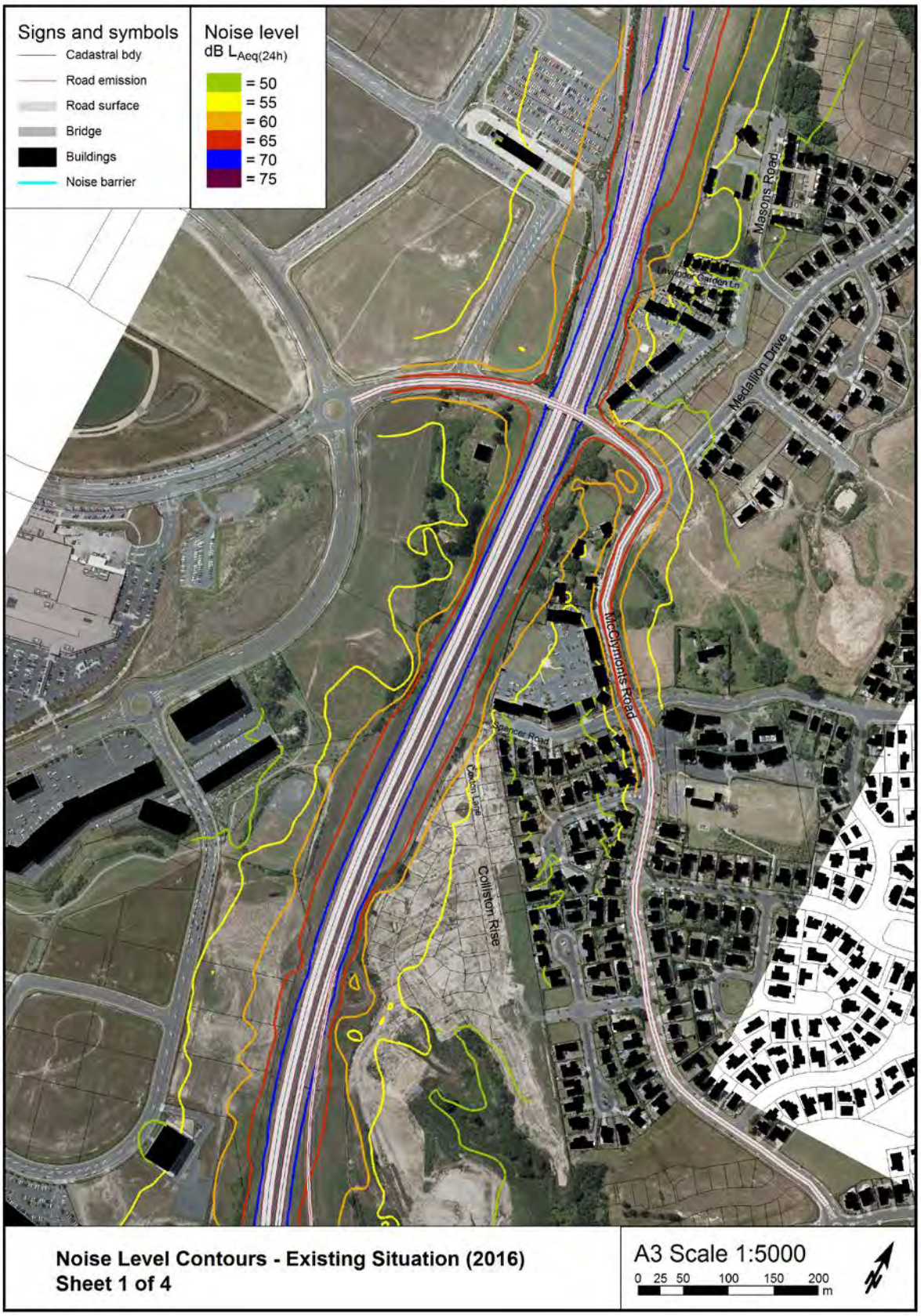
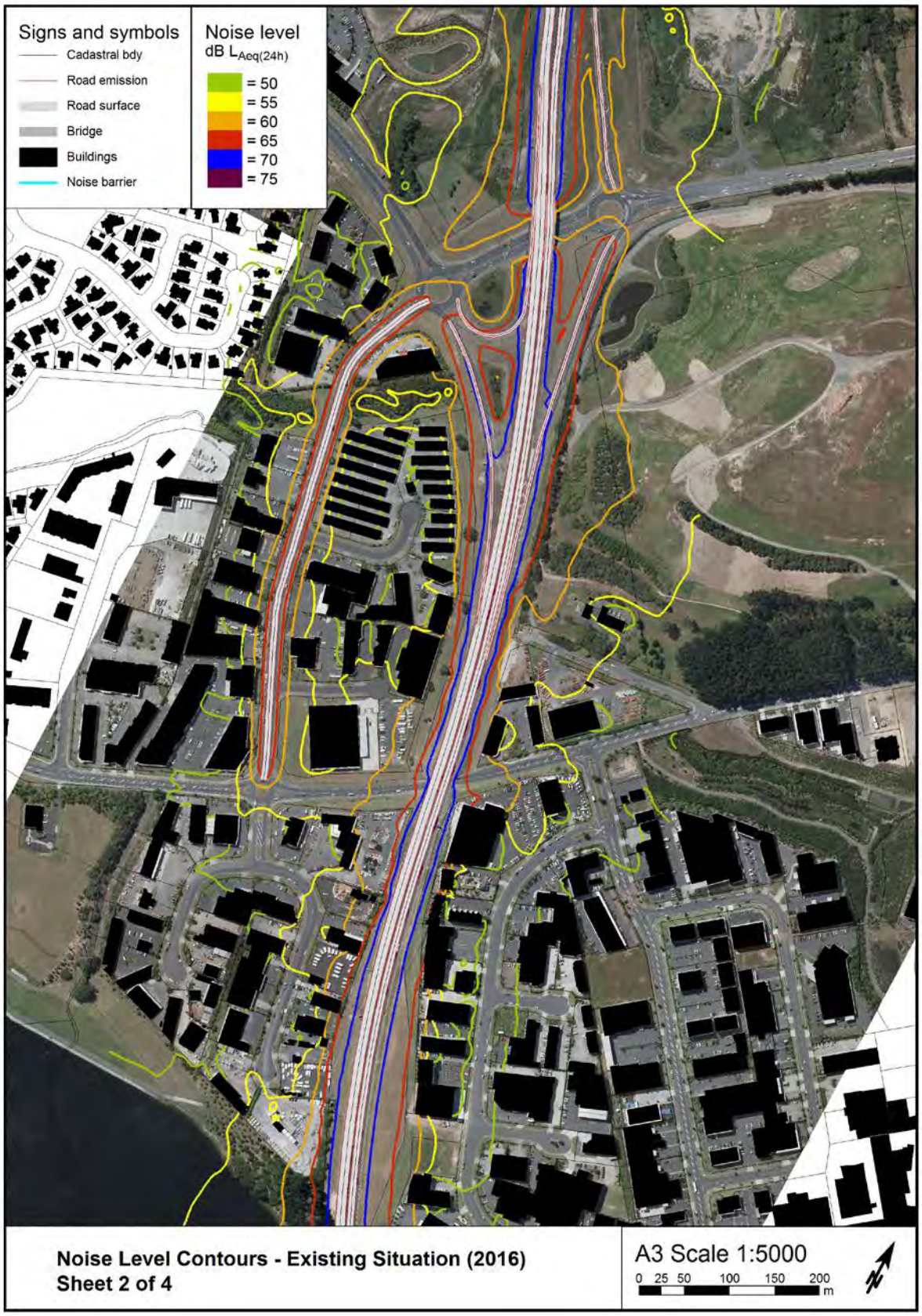
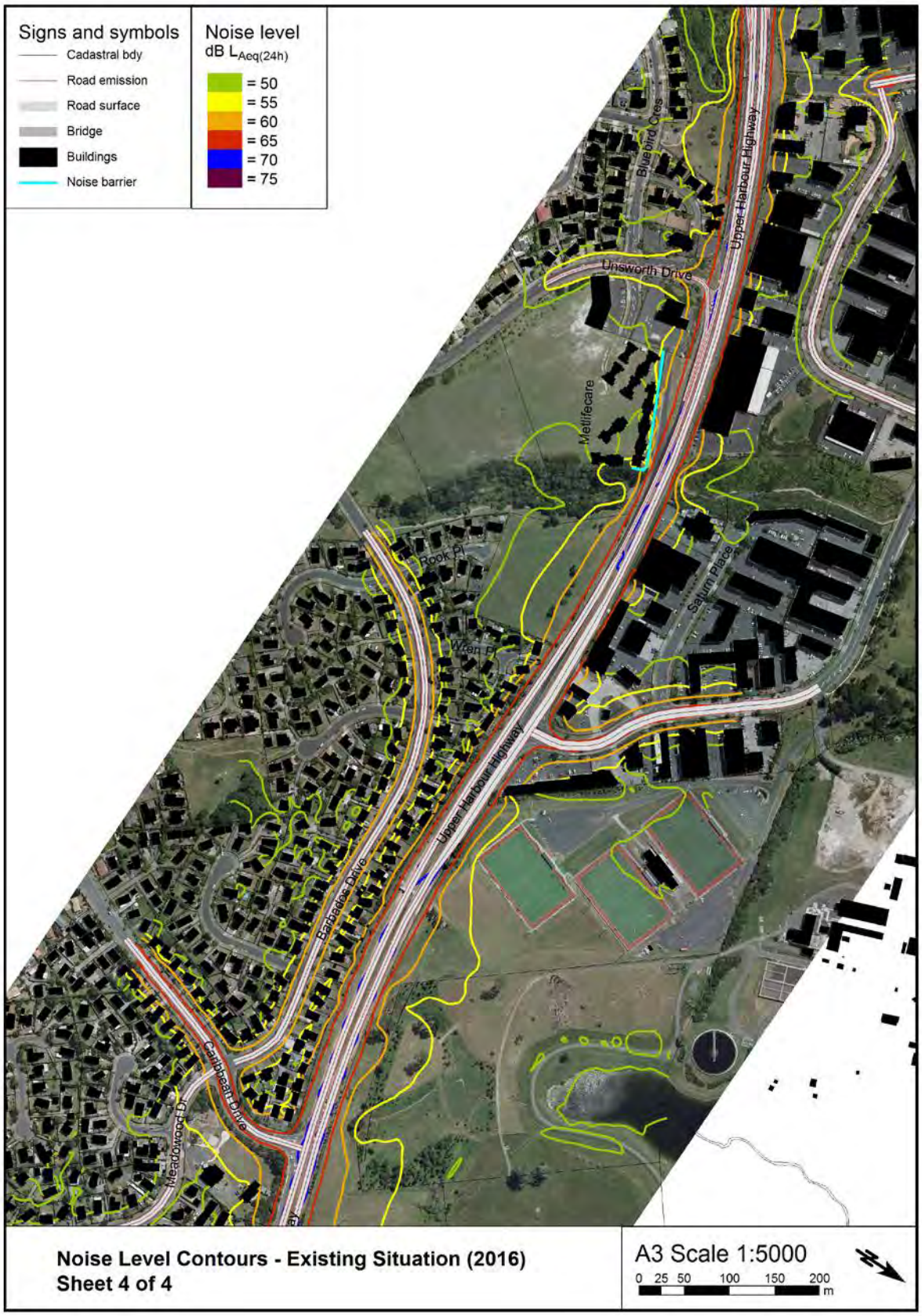
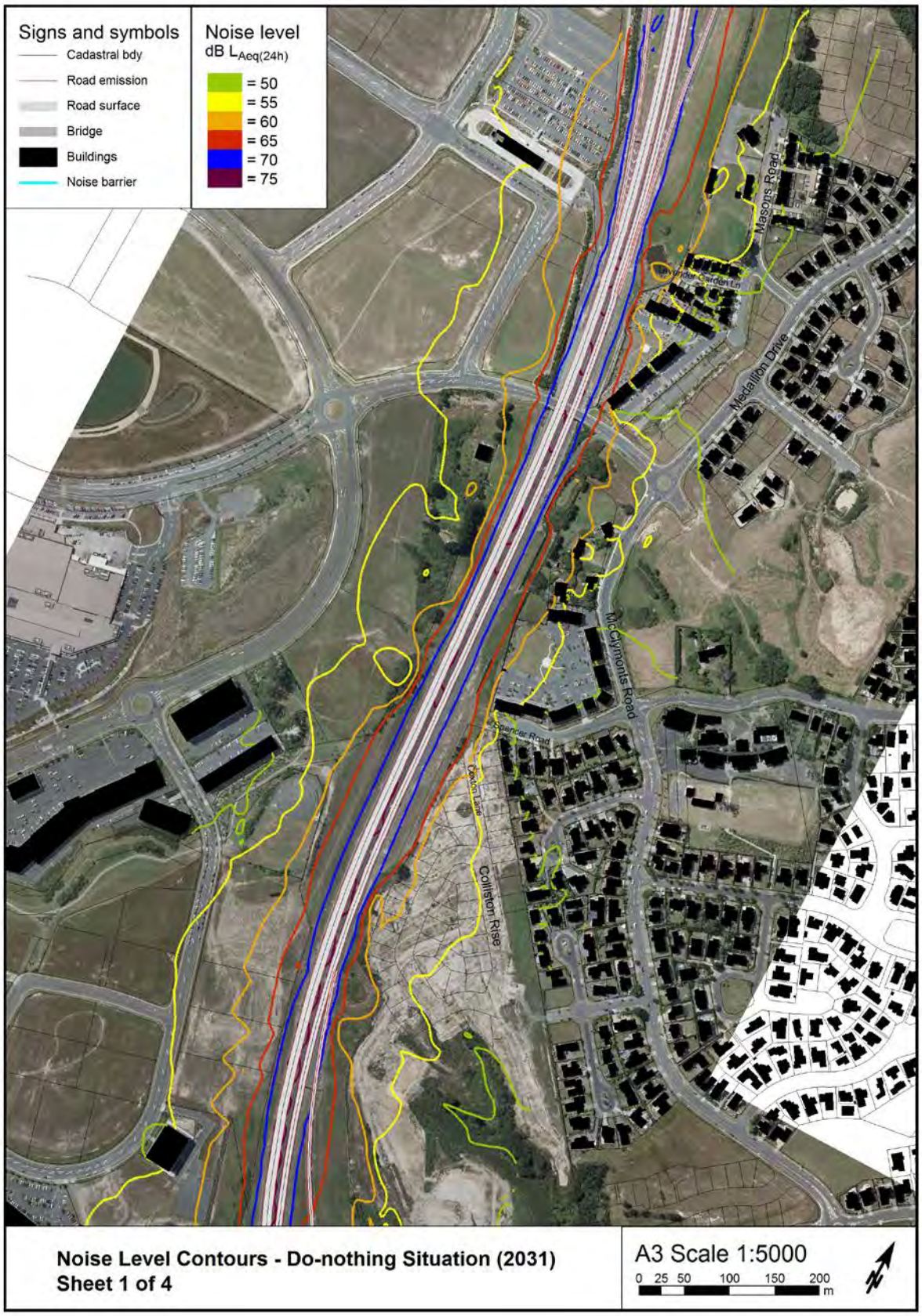

Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Masons Road
Medallion Drive
McClymonts Road
Spencer Road
Collston Lane
Collston Rise
Noise Level Contours - Existing Situation (2016)
Sheet 1 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m

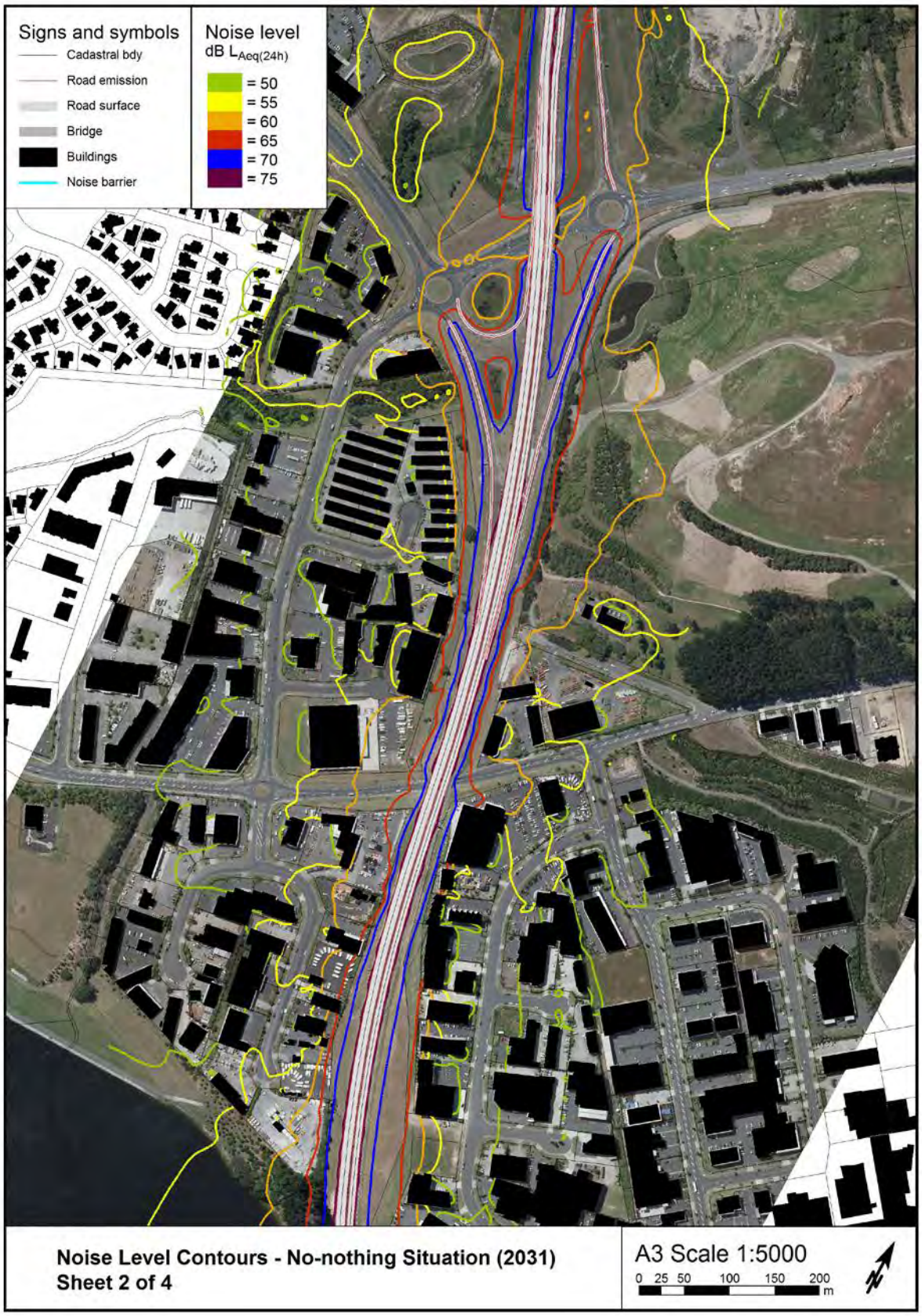

Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Noise Level Contours - Existing Situation (2016)
Sheet 2 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Upper Harbour Highway
Caribbean Drive
Cabello Place
Meadowood Dr
Santiago Close
Noise Level Contours - Existing Situation (2016)
Sheet 3 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Bluebird Cres
Upper Harbour Highway
Unsworth Drive
Metlifecare
Rook Pl
Wren Pl
Saturn Place
Upper Harbour Highway
Barbados Drive
Caribbean Drive
Greenwood Pl
Noise Level Contours - Existing Situation (2016)
Sheet 4 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m

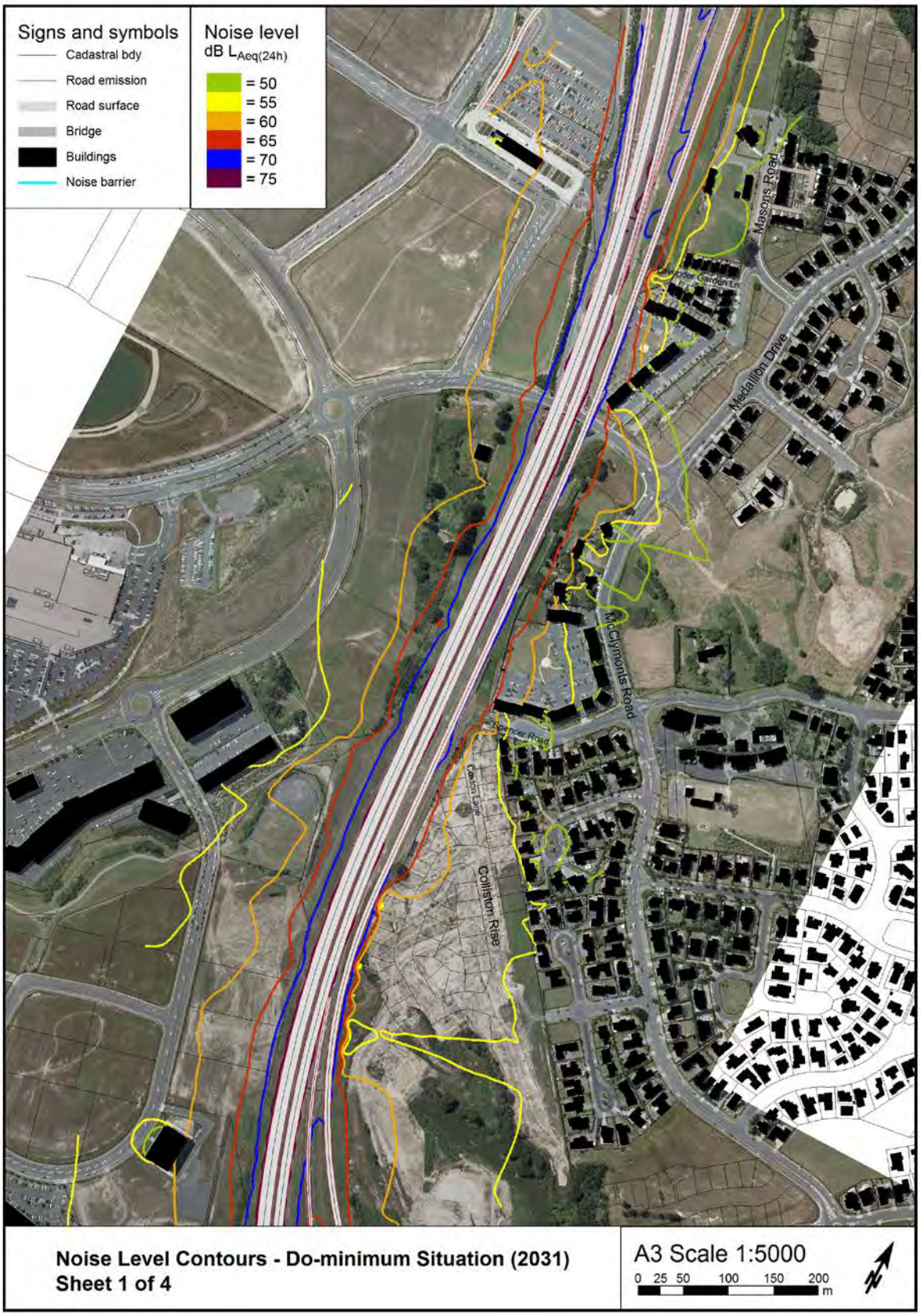


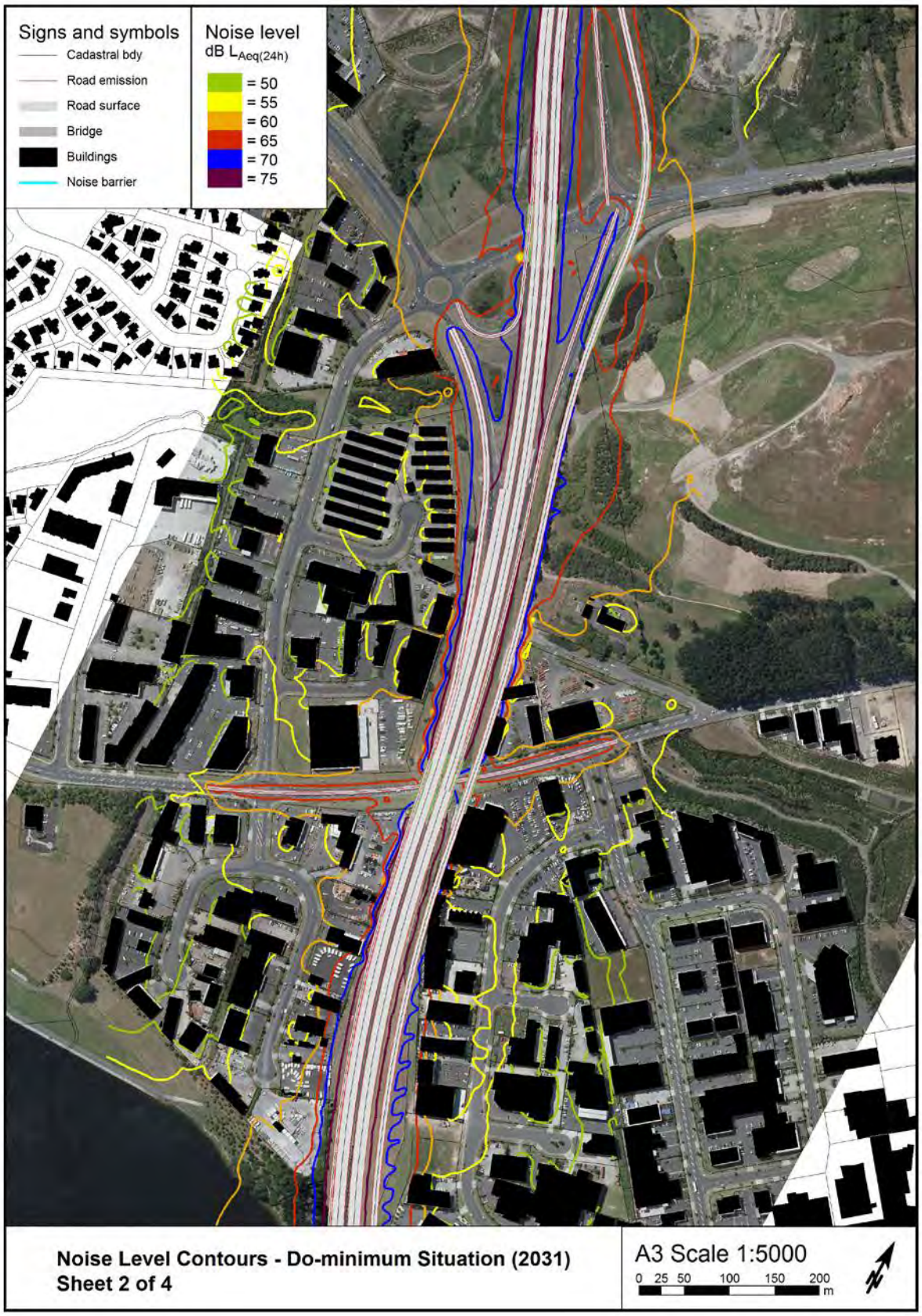
Noise Level Contours - Do-nothing Situation (2031)
Sheet 1 of 4


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Noise Level Contours - No-nothing Situation (2031)
Sheet 2 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m

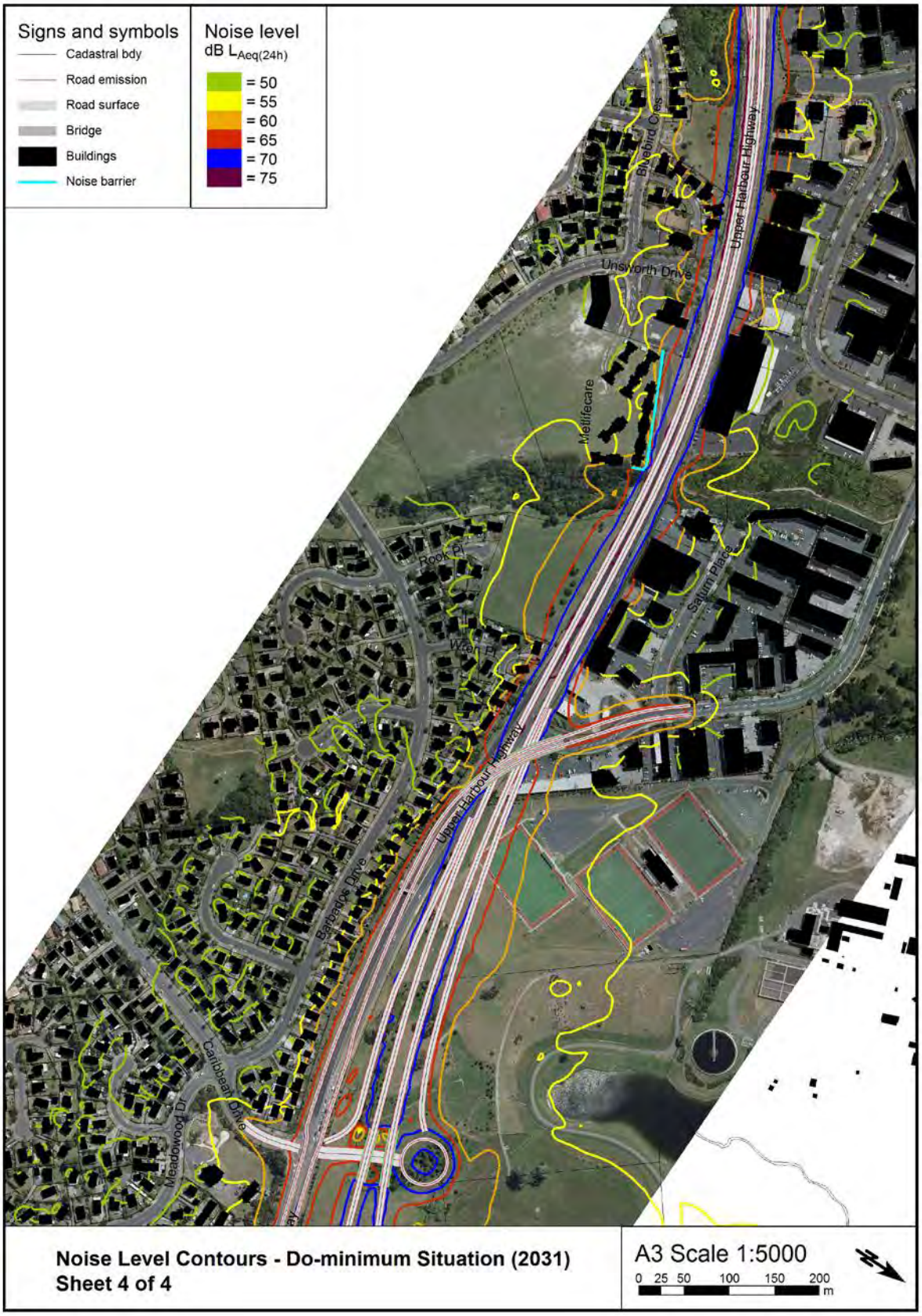

Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Upper Harbour Highway
Caribbean Drive
Cabello Place
Meadowood Dr
Santiago Close
Noise Level Contours - Do-nothing Situation (2031)
Sheet 3 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m

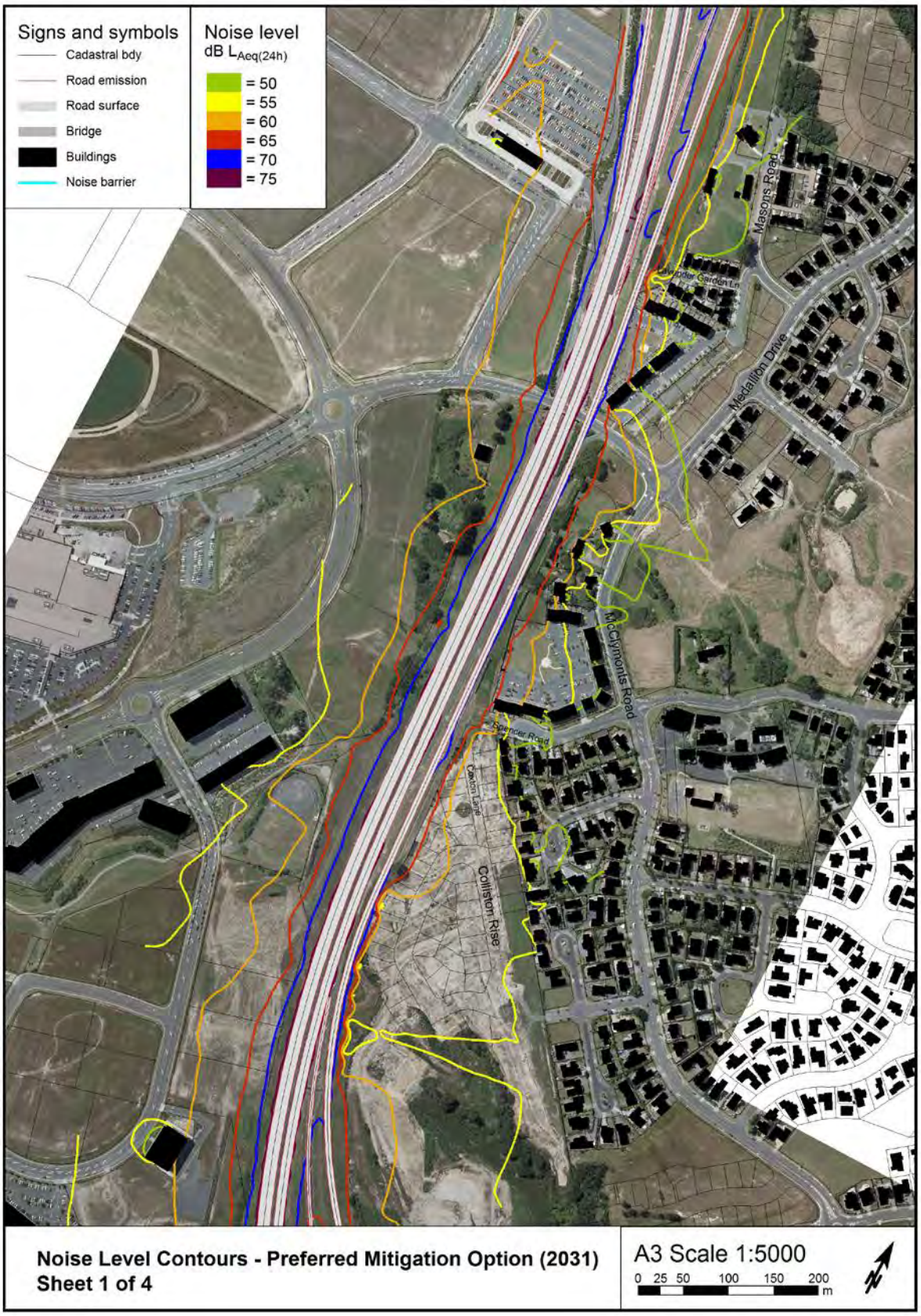

Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Bluebird Cres
Upper Harbour Highway
Unsworth Drive
Metlifecare
Rook Pl
Wren Pl
Salum Place
Upper Harbour Highway
Barbados Drive
Caribbean Drive
Meadowood Dr
Noise Level Contours - Do-nothing Situation (2031)
Sheet 4 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m

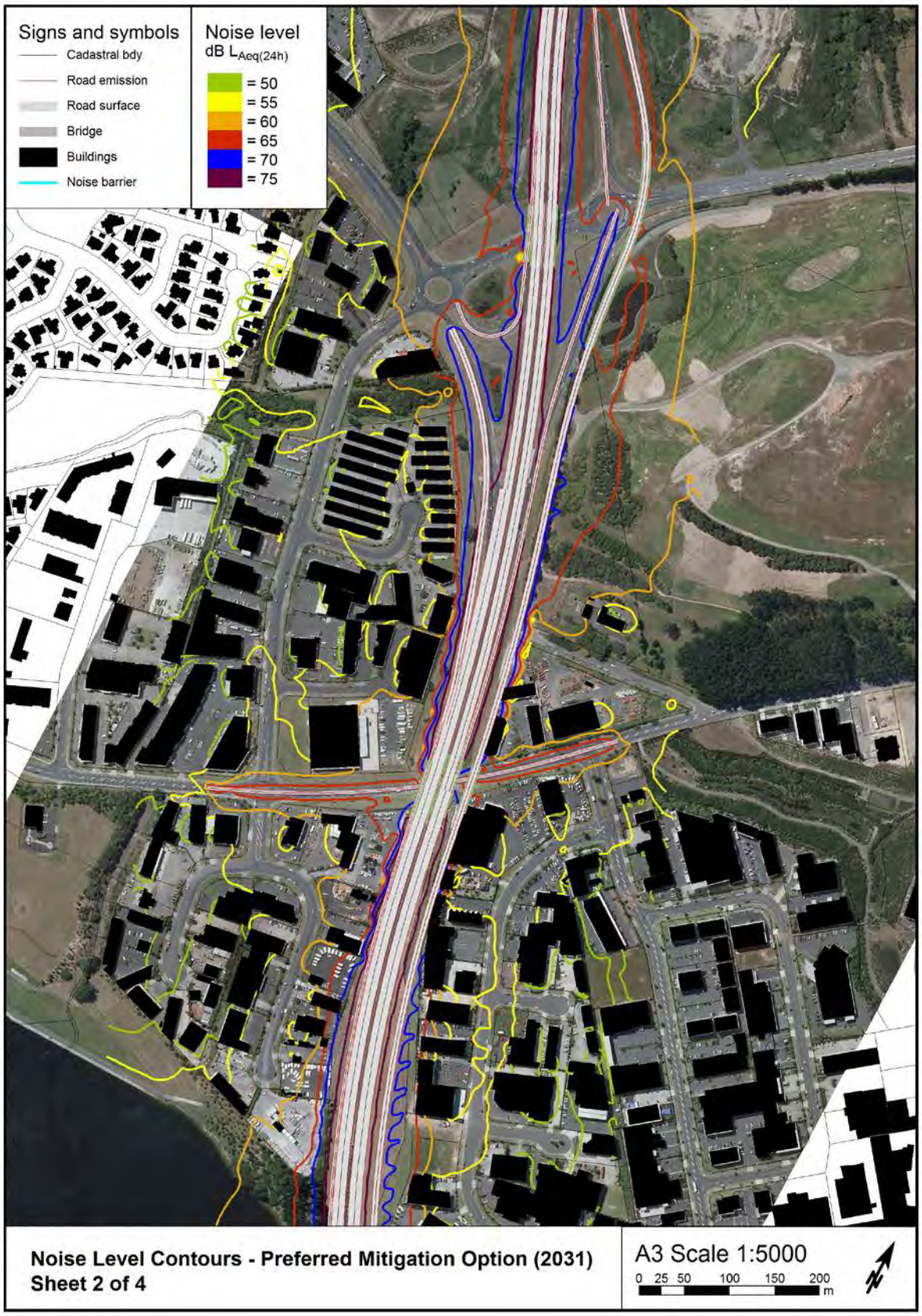

Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Masons Road
Medallion Drive
McClymonts Road
Collston Rise
Noise Level Contours - Do-minimum Situation (2031)
Sheet 1 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Noise Level Contours - Do-minimum Situation (2031)
Sheet 2 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m

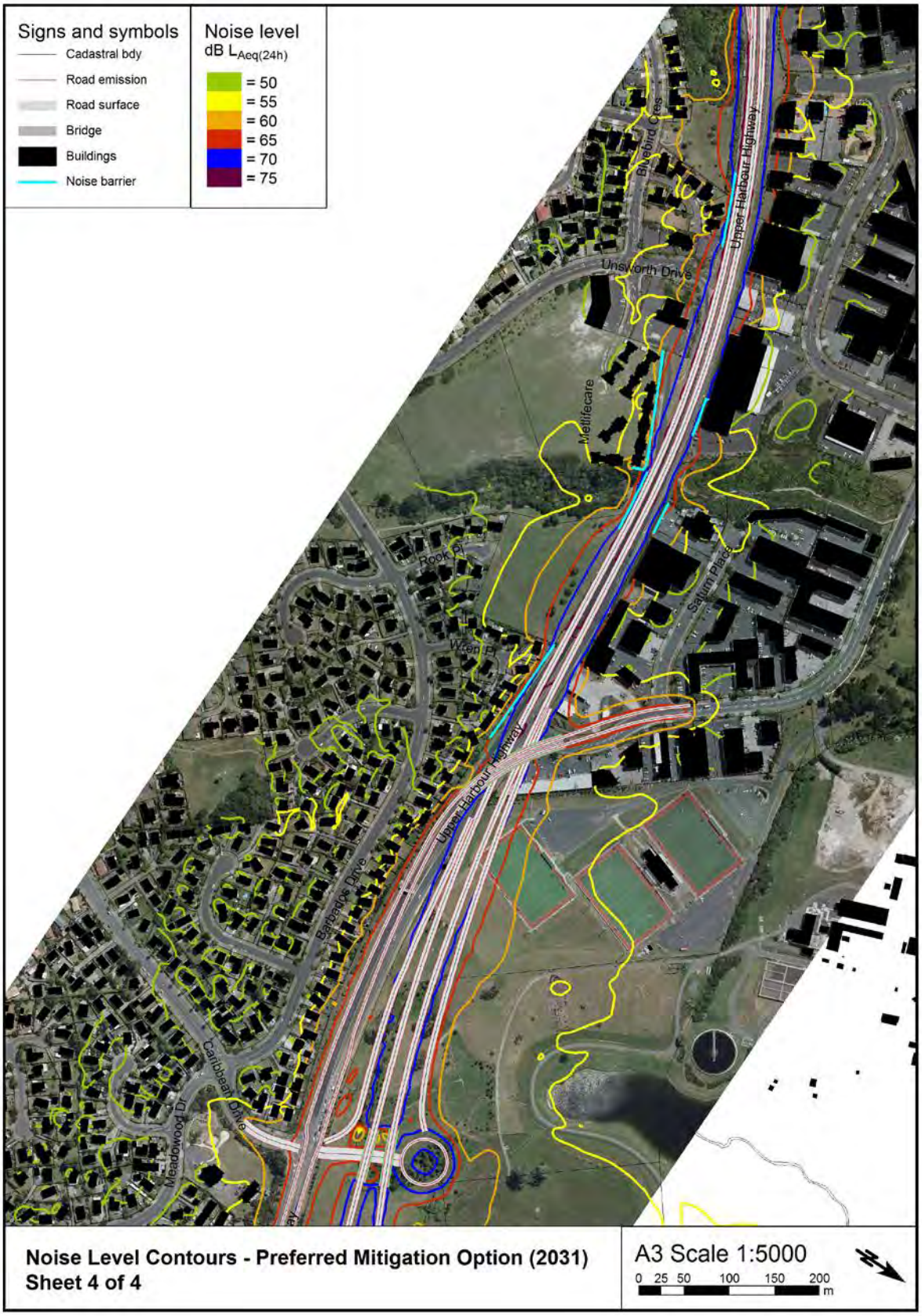

Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Upper Harbour Highway
Caribbean Drive
Cabello Place
Meadowood Dr
Santiago Cres
Noise Level Contours - Do-minimum Situation (2031)
Sheet 3 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Unsworth Drive
Upper Harbour Highway
Melifecare
Saturn Place
Rook Pl
Wren Pl
Barbados Drive
Caribbean Drive
Meadowood Dr
Noise Level Contours - Do-minimum Situation (2031)
Sheet 4 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Masons Road
Medallion Drive
McClymonts Road
Collston Rise
Noise Level Contours - Preferred Mitigation Option (2031)
Sheet 1 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Noise Level Contours - Preferred Mitigation Option (2031)
Sheet 2 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Upper Harbour Highway
Caribbean Drive
Cabello Place
Meadowood Dr
Santiago Cres
Noise Level Contours - Preferred Mitigation Option (2031)
Sheet 3 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m


Signs and symbols
Cadastral bdy
Road emission
Road surface
Bridge
Buildings
Noise barrier
Noise level
dB $L_{Aeq(24h)}$
= 50
= 55
= 60
= 65
= 70
= 75
Bluebird Cres
Upper Harbour Highway
Unsworth Drive
Metlifecare
Rook Pl
Wren Pl
Saturn Place
Upper Harbour Highway
Barbados Drive
Caribbean Drive
Meadowood Dr
Noise Level Contours - Preferred Mitigation Option (2031)
Sheet 4 of 4
A3 Scale 1:5000
0 25 50 100 150 200
m

Appendix A

Appendix H

Team Discussion Notes – Best Practicable Mitigation Option

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Meeting Records

Project number	**250310**	Meeting date	**20 July 2016**
Project name	**Northern Corridor Improvements**	Recorded by	**LS**
Meeting/subject	**Acoustic Barrier BPO Discussion**	Pages	**5**

Present	Apology	Copy	Name	Organisation	Discipline
☒	☐	☒	Siiri Wilkening (SW)	Marshall Day	Acoustic Specialist
☒	☐	☒	Chris Bentley (CB)	Boffa Miskell	Urban Design Specialist
☒	☐	☒	John Goodwin (JG)	Boffa Miskell	Landscape and Visual Specialist
☒	☐	☒	Dillon Smith (DS)	Aurecon	Highways Engineer
☒	☐	☒	Matthew Yu (MY)	Aurecon	Stormwater Engineer
☒	☐	☒	Louise Strogen (LS)	Aurecon	Planner
☐	☐	☒	Deepak Rama	NZ Transport Agency	Project Planning Lead
☐	☐	☒	Kenny See	NZ Transport Agency	Project Manager

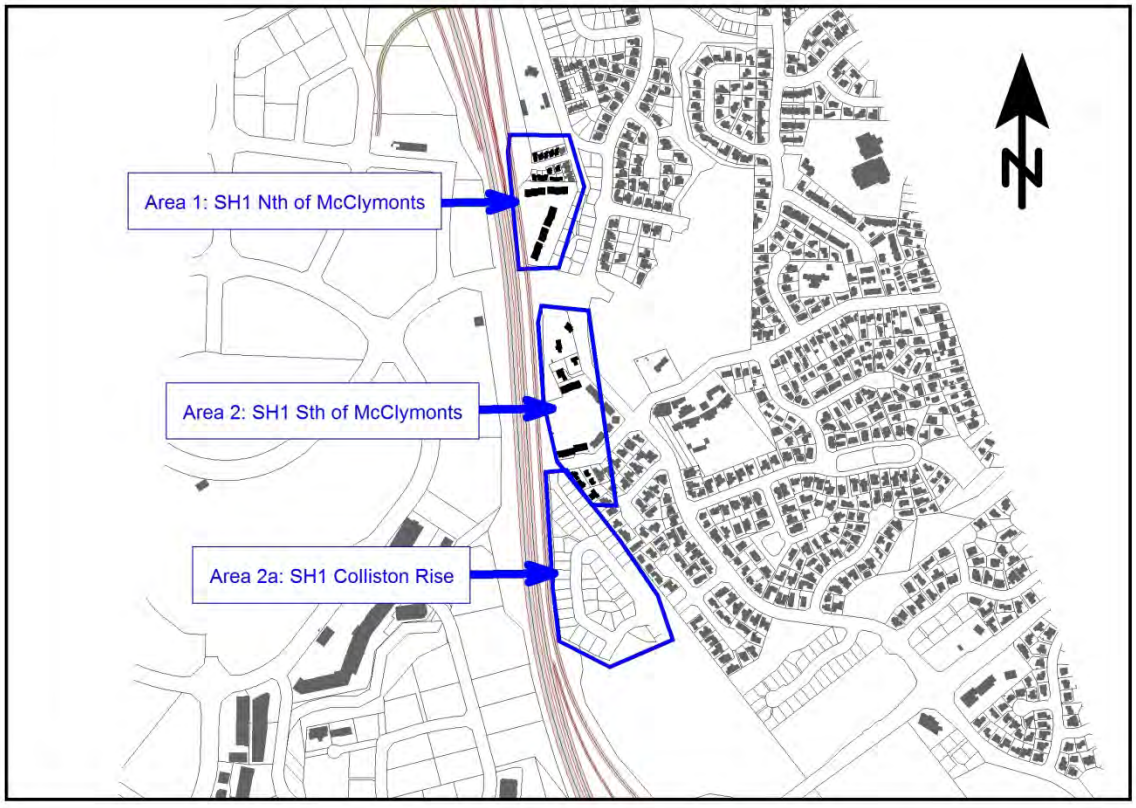
Item	Topic				
Assessment Area 1 : SH1 North of McClymont's Road					
	SW	**CB**	**JG**	**DS**	**MY**
Mitigation option 1: 5m barrier	Five PPFs in Cat. C	Isolated structure in prominent position	Would be visually dominant at this location	Difficult construction due to retaining wall	No issues for Stormwater
Mitigation option 2 : 8m barrier	Four PPF in Cat. C	Isolated structure in prominent position	Would be visually dominant at this location	Difficult construction due to retaining wall	No issues for Stormwater
Score:	✕	✕	✕	✕	-
	Noted that dwellings built within last 5 years and should comply with District Plan internal acoustic requirements next to high noise routes. No structural mitigation proposed.				

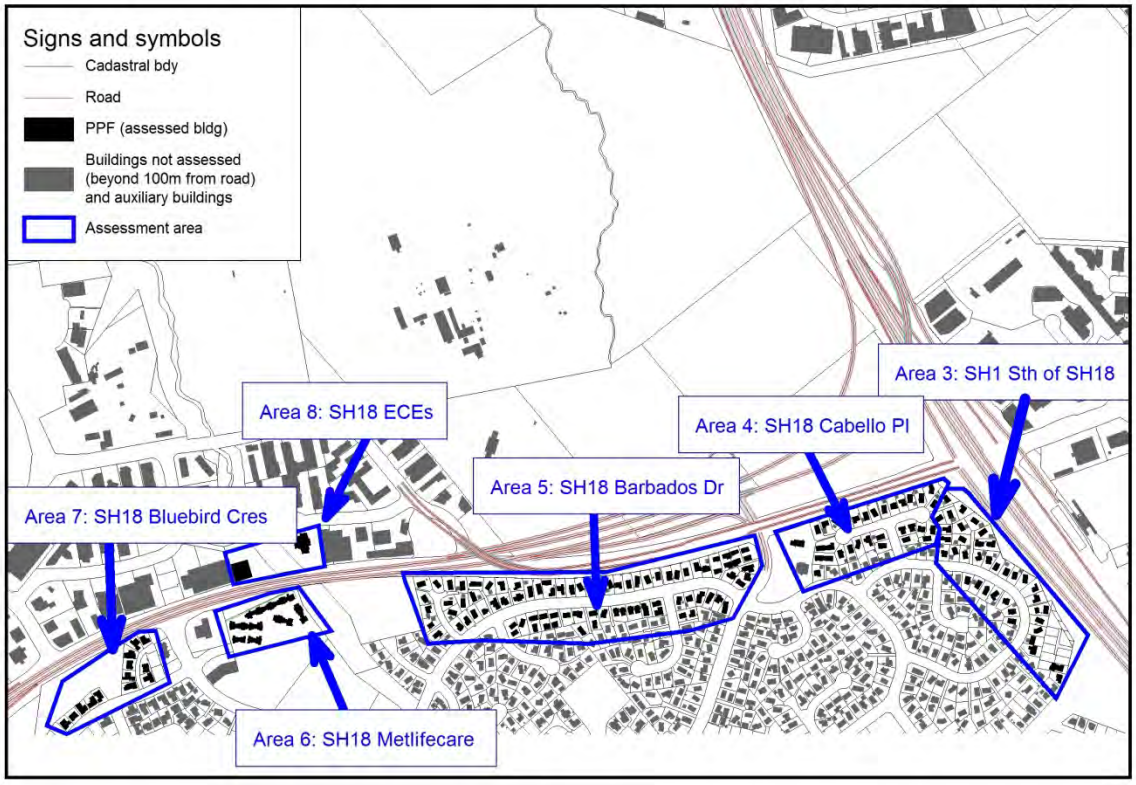
Assessment Area 2 : SH1 South of McClymont's Road					
	SW	**CB**	**JG**	**DS**	**MY**
Mitigation option 1: 5m barrier	1 property cannot be shielded. (1 PPF in Cat. C)	Isolated structure in prominent position; risk of shading to adjacent properties	Would be visually dominant at this location, risk of shading to residential properties	Difficult construction due to retaining wall	No issues for Stormwater
Score:	✗	✗	✗	✗	-
	Noted that dwellings built within last 5 years and should comply with District Plan internal acoustic requirements for dwellings next to a high noise route. No structural mitigation proposed.				
Assessment Area 3 : SH1 south of SH18					
	SW	**CB**	**JG**	**DS**	**MY**
Mitigation option 1: 3m barrier	All PPFs are in Categories A or B, Barrier for 2 double storey PPFs only. Only minimal noise level reduction.	Proximity to dwelling leading to shading to residential properties	Proximity to dwelling leading to shading to residential properties	No issues for roading design / constructability	No issues for Stormwater
Score:	✓	✗	✗	-	-
	No structural mitigation proposed.				
Assessment Area 4 : SH18 Cabello Place					
	SW	**CB**	**JG**	**DS**	**MY**
No mitigation proposed as all PPFs are in Category A, or B	Only 1 PPF in Category B, all others in Cat. A. No change to categories, so no structural mitigation proposed.	No comments	No comments	No comments	No comments
Score:	✓	-	-	-	-
	No barrier required				

Assessment Area 5 : SH18 Barbados Drive					
	SW	**CB**	**JG**	**DS**	**MY**
Mitigation option 1: 3m barrier	No PPFs in Category C (barrier for 4 PPFs that would otherwise be in Cat. C)	Would read as property enclosure, set back from dwelling. Only shielding of road, not open space.	Siting of dwelling would not result in shading risk. Views to park retained	No issues for roading design / constructability	No issues for Stormwater
Score:	✓	✓	✓	-	-
	Option 1 - 3m barrier to be pursued.				
Assessment Area 6 : Metlifecare					
	SW	**CB**	**JG**	**DS**	**MY**
Mitigation option 1: 2m barrier along SH18	All PFFs reduced to Category A	No urban form concerns. Tie in with Retirement Village boundary wall.	No visual amenity issues. Recommend compliments Retirement Village structure	No issues for roading design / constructability	Potential for stormwater flow but design of wall could address issue
Score:	✓	✓	✓	-	?
Mitigation option 2 : 2.5 - 4.5m barrier along eastern property boundary	**All PFFs reduced to Category A**	Proximity to dwelling leading to shading and amenity effects to residential properties	Proximity to dwelling leading to shading to residential properties	No issues for roading design/ proximity to bank may cause construction difficulties	No issues for Stormwater
Score:	✓	×	×	×	-
	Option 1 - 2m barrier to be pursued.				
Assessment Area 7 : SH18 Bluebird Crescent					
	SW	**CB**	**JG**	**DS**	**MY**
Mitigation option 1: 2.4m barrier	No PPFs in Cat. C, but two PPFs remain in Cat. B (similar to existing	Would read as property enclosure.	Would read as boundary fence/wall. May cause some shading	No issues for roading design / constructability	No issues for Stormwater
Score:	✓	✓	?	-	-

Mitigation option 2 : 2.4m to 3.6m barrier	All PPFs in Category A	A staggered structure would be out of character. Uniform 3.6m too high resulting in shading and amenity issues.	Proximity to dwelling leading to shading to residential properties	No issues for roading design / constructability	No issues for Stormwater
Score:	✓	×	×	-	-
	Option 1 – 2.4m barrier to be pursued.				
Assessment Area 8 : Childcare Centres					
	SW	**CB**	**JG**	**DS**	**MY**
Mitigation option 1: 2.4m barrier	PPFs remain in their existing noise categories (1x Cat. A, 1x Cat. B)	Would read as property enclosure, set back from building.	No visual concerns.	No issues for roading design / constructability	No issues for Stormwater
Score:	✓	✓	✓	-	-
	Option 1 – 2.4m barrier to be pursued.				

Rating Score	✓	Support
	?	Support conditional
	-	Neutral
	×	Not supported


Area 1: SH1 Nth of McClymonts
Area 2: SH1 Sth of McClymonts
Area 2a: SH1 Colliston Rise
N


Signs and symbols
Cadastral bdy
Road
PPF (assessed bldg)
Buildings not assessed (beyond 100m from road) and auxiliary buildings
Assessment area
Area 3: SH1 Sth of SH18
Area 8: SH18 ECEs
Area 4: SH18 Cabello Pl
Area 5: SH18 Barbados Dr
Area 7: SH18 Bluebird Cres
Area 6: SH18 Metlifecare

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