Northern Corridor Improvements

Assessment of Construction Noise and Vibration Effects

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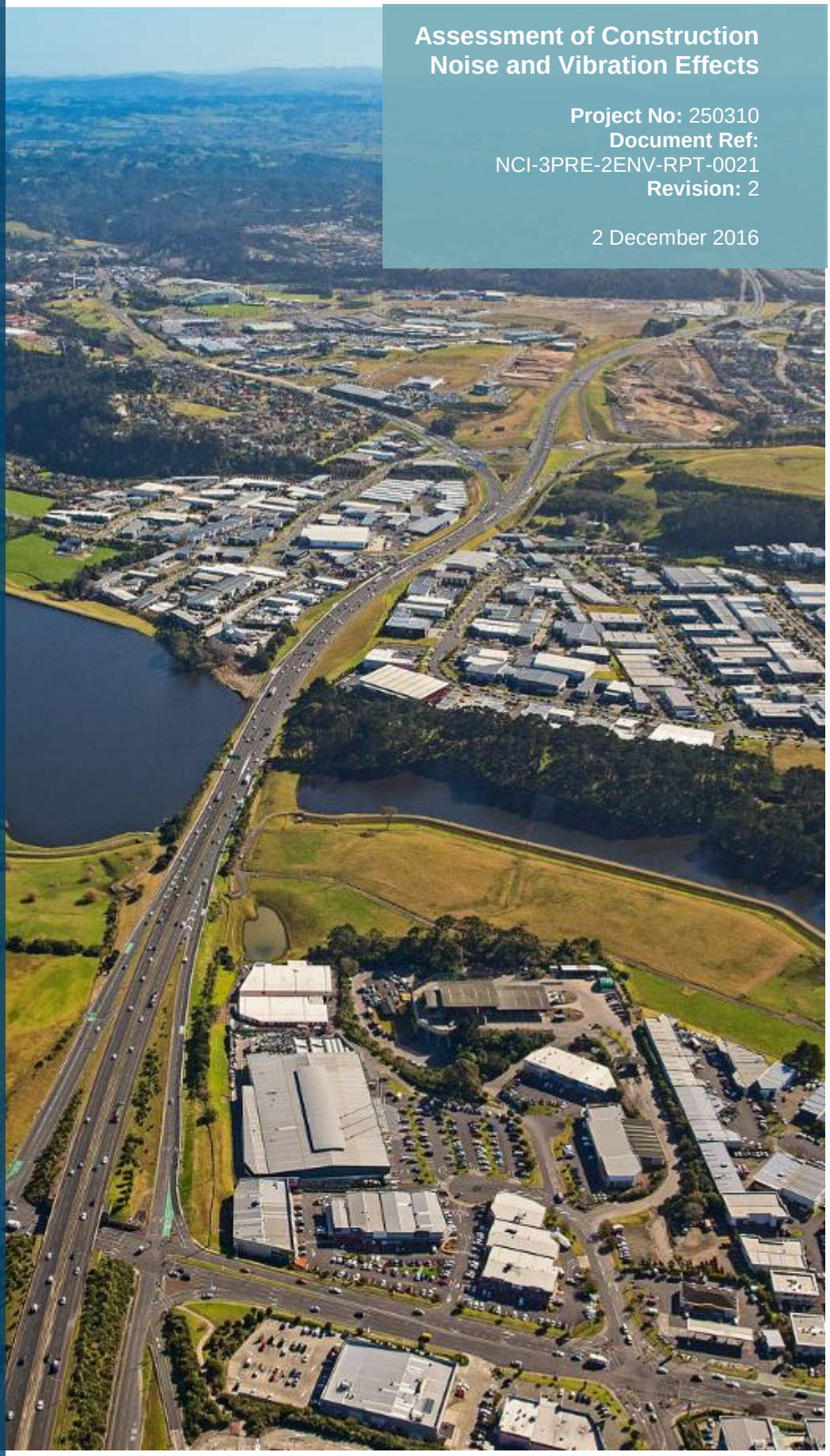

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Executive summary

Purpose of report

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

Assessments Undertaken

Construction noise is always higher than noise levels from ongoing operations on a site. For that reason, construction noise is assessed against relevant Standard criteria which balance the need for development with the amenity requirements of neighbouring sensitive receivers. Similarly, vibration levels from construction are higher than ongoing vibration levels, which are allowed for in the relevant standards.

Recommended construction noise and vibration criteria for the Project are provided. These have been based on:

- NZS 6803:1999 (with correction to night-time levels for high background noise); and
- Vibration criteria of the NZ Transport Agency Guide (refer **Appendix C**).

Assessment Results

Due to the close proximity of dwellings and businesses to the construction works, there are many locations where there is potential for daytime and night-time noise limits to be exceeded. Night-time works are expected to be required at several bridge locations along the Project. Where night-time works are required, the works should be minimised in areas where residential dwellings are in close proximity, such as on State Highway 18 (SH18) and at the northern end of State Highway 1 (SH1).

A risk assessment of construction vibration and noise effects has been performed for the Project. This has shown that there is a medium to high level of risk that vibration guidelines will be exceeded for some residential and commercial buildings adjacent to the Project. This is because buildings are located within 20 metres from the site works in some instances. Within such distances, vibration levels from some activities may be above 5 mm/s (which is the Category A limit for superficial building damage risk).

Mitigation

As noise and vibration from construction activities has the potential to exceed the limits, a thorough regime of noise management will be required to ensure that noise and vibration effects are mitigated as far as practicable. This would be anchored in the Construction Noise and Vibration Management Plan (CNVMP). This management will include noise and vibration monitoring along the route, clear

communication with the public, condition surveys of dwellings likely to receive high levels of vibration and strategies for mitigation such as resident relocation where necessary.

Noise and vibration management procedures should be detailed in zone or activity specific Noise and Vibration Management Schedules for the Project. Noise and vibration monitoring is an essential part of ensuring construction activities comply with the noise and vibration limits. Successful management of noise and vibration effects from construction activities will rely heavily on good procedures and awareness of the noise and vibration effects of different construction machinery.

Overall, the Project can be constructed in such a way that any adverse construction noise and vibration effects are either mitigated or specifically managed to reduce effects as far as practicable.

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Glossary of Abbreviations

Item	Description
AEE	Assessment of Effects on the Environment
AUP	Auckland Unitary Plan Operative in Part (15 November 2016)
BPO	Best Practicable Option
BS	British Standard
CNVMP	Construction Noise and Vibration Management Plan
The NZ Transport Agency	New Zealand Transport Agency
NZS	New Zealand Standard
SH(x)	State Highway (number)
UHH	Upper Harbour Highway

Terms and Definitions

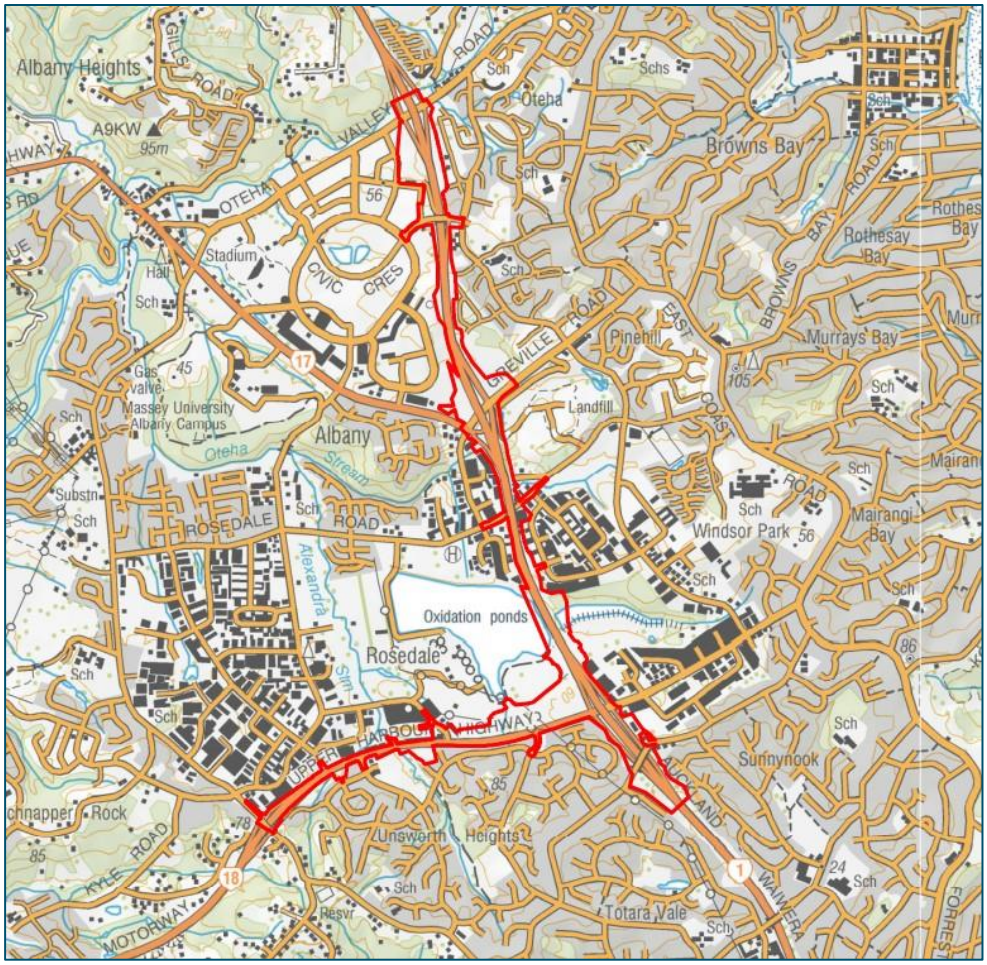
Item	Description
Noise	A sound that is unwanted by, or distracting to, the receiver.
Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
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)
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
(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.
$L_{Aeq\ (t)}$	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.
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 6803:1999	New Zealand Standard NZS 6803: 1999 *"Acoustics - Construction 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.
Vibration	When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity. Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into the vertical direction (up and down vibration), the horizontal transverse direction (side to side) and the horizontal longitudinal direction (front to back).

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 construction noise and vibration effects of the Project on sensitive receivers. A separate report (**Volume 3 – Technical Assessment 9**) addresses operational traffic 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 will generally be constructed within the existing designation footprints of SH1 and SH18. However, in some areas the widening of the road, provision of the busway and SUP, new interchanges and ramps will result in the need to alter and extend the designation.

The existing designations are subject to some conditions. However, the construction noise and vibration conditions imposed on these designations need to be replaced by conditions developed specifically for the Project. Therefore, relevant standards, plans and guidelines have been reviewed and appropriate acoustic performance standards recommended.

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.

Designations 6756, 6757 and 6758 reference the provisional construction noise standard NZS 6803P:1984 “The measurements and assessment of noise from construction, maintenance and demolition work”. This standard is more than 30 years old and has been superseded by the full Standard NZS 6803:1999 “Acoustics – Construction “Noise”, which is more appropriately integrated with the most up to date international and New Zealand standards on the measurement and assessment of environmental noise.

The designations also require the preparation of Construction Noise Management Plan, which is recommended in an extended form for this Project (refer Section 3.4).

2.1.2 Auckland Unitary Plan

In the Auckland Unitary Plan Operative in Part (15 November 2016) (AUP) reference is made to the New Zealand construction noise standard NZS 6803:1999.

For the AUP, noise requirements were discussed through the expert conferencing, mediation and hearing processes. The Independent Hearings Panel decision has been issued and Auckland Council publicly notified its decisions on 19 August 2016. The appeal period closed on 16 September 2016. All references in this report to the AUP are to the version which was made operative in part on 15 November 2016.

The AUP references NZS 6803:1999 in regards to construction noise. While general compliance with the noise criteria of NZS 6803 is required, the AUP provides for an exemption of compliance with the noise criteria if works are of limited duration (e.g. between 3 nights and 20 days). Since the Project will require works in excess of these time frames, the exemptions will not apply.

Relevant excerpts from the AUP are included in **Appendix B**.

2.1.3 Construction Noise Standard NZS 6803:1999

The most appropriate document for the assessment of construction noise is the 1999 Standard, which integrates with the relevant noise survey and assessment standards (NZS 6801 and 6802) and has

been used for all major infrastructure projects in recent years. This noise standard is referenced by both the AUP and the NZ Transport Agency's *State Highway construction and maintenance noise and vibration guide* (August 2013)[1]. The key elements of this standard are described below. The recommended noise criteria of NZS 6803:1999 are summarised in **Table 1** and **Table 2** below.

As most aspects of the Project construction will exceed 20 weeks' duration, the "long-term duration" criteria are most appropriate for the Project, in accordance with Section 7.2.1 of NZS 6803:1999. The long-term criteria are five decibels more stringent during day-time than the criteria for "typical duration" (up to 20 weeks' duration). While construction in specific areas may take less than 20 weeks, we recommend applying the same criteria to the entirety of the Project. Retaining the same noise criteria for the entire Project will avoid confusion as to where each noise criterion will apply, and will be more practicably managed and measured as equipment passes from one area of the works to another.

Table 1 Recommended construction noise criteria in residential zones & dwellings in rural areas

Time of week	Time period	dB L_{Aeq}	dB L_{Amax}
Weekdays	0630-0730	55	75
	0730-1800	70	85
	1800-2000	65	80
	2000-0630	45	75
Saturdays	0630-0730	45	75
	0730-1800	70	85
	1800-2000	45	75
	2000-0630	45	75
Sundays and Public Holidays	0630-0730	45	75
	0730-1800	55	85
	1800-2000	45	75
	2000-0630	45	75

Note: Night-time (low noise) periods are highlighted in accordance with NZS 6803:1999

Table 2 Recommended duration construction noise criteria in industrial/commercial areas

Time period	dB L_{Aeq}
0730 - 1800	70
1800 – 0730	75

Notwithstanding the above limits, NZS6803:1999 states in section 7.2.6:

"One major factor which should be considered is whether there is a relatively high background sound level (L_{90}) due to noise from sources other than construction work at the location under investigation.

[1] This guide was developed by NZ Transport Agency with assistance from Marshall Day Acoustics.

In such cases limits should be based on a determination of the existing level of noise in the area (a "background plus" approach)."

For the Project, the ambient noise environment, while impacted by the existing road traffic noise, is not elevated to a degree that warrants elevated night-time construction noise criteria (refer Section 4 below). This is because although the average level of background noise is around 40 to 45 dB L_{A95} at locations adjacent to SH1 and SH18, there are periods where the background noise level drops to around 30 to 35 dB L_{A95} (typically at around 2am). During these periods, the night-time noise guideline would still be 45 dB L_{Aeq} even if a "background plus" approach was taken.

For commercial and industrial areas, NZS6803:1999 sets out less stringent noise criteria during night-time when it is less likely that persons or business activities would be affected by construction noise. In these commercial areas, criteria for day-time and night-time are consistently high, seven days per week, as businesses are generally less noise sensitive than residences.

NZS6803:1999 does not anticipate that full compliance with the construction noise criteria of **Table 1** and **Table 2** will necessarily be achieved at all times and at all receivers. It focuses on the implementation of the Best Practicable Option (BPO) for construction noise management and mitigation rather than requiring that the criteria must be achieved. Management measures are further discussed in Section 8 of this report.

2.2 Vibration

2.2.1 Existing Designations

The existing designations 6757 and 6758 reference DIN 4150 and require that building condition surveys be undertaken at "at risk" buildings as per a report provided by Riley Consultants.

Designation 6756 does not contain vibration criteria, but requires that adjacent land owners and occupiers be notified of ground vibration during construction.

2.2.2 Auckland Unitary Plan

The AUP references the construction vibration criteria in E25.6.30 Vibration. This section of the AUP requires construction and demolition activities must be controlled to ensure any resulting vibration does not exceed:

a) The limits set out in German Industrial Standard DIN 5140-3 (1999): Structural Vibration – Part 3 "Effects of vibration on structures" when measured in accordance with that Standard on any structure not on the same site; and

b) The limits in Table E25.6.30.1 Vibration limits in buildings.

Excerpts from the AUP, including Table E25.6.30.1 are contained in **Appendix B.**

2.2.3 NZ Transport Agency Guide

As discussed in the previous section, the NZ Transport Agency issued in August 2013 the *State Highway construction and maintenance noise and vibration guide*[2] (the NZ Transport Agency Guide). The NZ Transport Agency Guide adopts the German (DIN 4150-3:1999 *Structural Vibration – Part 3 – Effects of vibration on structures*) and British standards (BS 5228-2:2009 *Code of practice for noise*

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

and vibration control on construction and open sites – Part 2: Vibration) and applies them in a progressive manner that addresses both annoyance and building damage effects. Prior to the development of the NZ Transport Agency Guide, annoyance criteria were not usually applied to construction works, so it adds an additional level of protection for receivers.

An excerpt from the NZ Transport Agency Guide, which contains the vibration and overpressure criteria, is shown in **Appendix C**.

In general terms, the Category A criteria of the NZ Transport Agency Guide aims to avoid annoyance to receivers. Because these criteria are conservative, there is a provision in the Guide to relax the criteria if they cannot be practicably met, provided a vibration expert is engaged to assess and manage construction vibration and airblast to comply with the Category A criteria as far as practicable. The focus is then shifted to avoiding building damage rather than annoyance by applying the Category B criteria. If the Category B criteria are achieved, then building damage is unlikely to occur, but if they are predicted to be exceeded, then monitoring of vibration levels and building condition must occur to allow assessment and response to any effects.

The DIN 4150-3:1999 Standard, which the 5mm/s Category B criteria are taken from, is a conservative standard designed to avoid all damage to buildings, i.e. even superficial cosmetic damage like cracking in plaster. Significantly higher limits would be applied if damage to structural foundations was the only consideration. It is noted that DIN 4150-3:1999 provides criteria for long and short duration vibration. As the vibration effects are not always known at the onset of the vibration inducing activity, the NZ Transport Agency has chosen to apply the most stringent (long term vibration) criteria to all construction vibration to ensure that no building damage will occur. The criteria for short term vibration as received at dwellings are higher than 5 mm/s for frequencies above 10 Hz.

The guide contains an airblast overpressure criterion of 120 dB L_{Zpeak}. This is consistent with most construction guidelines and the criteria contained within the AUP (refer **Appendix B**: E25.6.31. Noise Levels from Blasting). However, no blasting is proposed for this Project.

2.2.4 Recommended Project construction vibration criteria

It is recommended that the vibration criteria of the NZ Transport Agency Guide are applied to construction vibration from the Project. These are set out in **Appendix C**.

3 Assessment Methodology

3.1 Assumptions

This assessment of construction noise and vibration effects is based on assumptions of construction activities and equipment with reference to construction information as provided in the Design and Construction Report (**Volume 3 – Technical Assessment 15**) and based on Marshall Day Acoustics' experience with previous large scale infrastructure projects of a similar kind.

As a contractor has not been appointed for each stage of the construction works, the methodology for the works is not confirmed. This is important with regard to night-time works; the construction information available during design states that the following is required with regard to night-works:

- General traffic switching along SH1 and SH18;
- Albany Bus Station Busway Bridge construction over SH1;
- McClymonts Road Bridge Replacement over SH1 Watercare Pond Link Bridge construction beneath SH1;
- SH1-SH18 Westbound Ramp construction over SH1;
- Paul Matthews Rd Bridge construction over SH18;
- Busway Bridges construction over local roads;
- Existing SH1 Bridges widening over local roads; and
- Rosedale Road lowering.

If the contractor determines that night-time works are required for other activities, consideration will need to be given to the effects of these works and the noise management required.

This assessment is based on similar construction projects Marshall Day Acoustics has worked on, including the Southern Corridor Improvements, Waterview Connection, MacKays to Peka Peka, East-West Link and Pūhoi to Warkworth motorway projects. Although contractors have not been appointed, it is considered that the methodology set out in the Design and Construction Report is representative of activity that has occurred in these previous projects and is accurate for the purposes of assessment at this stage of the Project.

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

- A review of noise and vibration emission data for each construction task / process has been performed. Data previously obtained by Marshall Day Acoustics has informed this process. In addition, data from appropriate noise and vibration standards has also been considered, where relevant;
- A review of relevant criteria has been performed. These criteria are set out in this report and Project limits have been recommended;
- Noise measurements along the route have been performed as part of the operational and construction noise assessment. This information has also been considered in determining a reasonable night-time noise limit for the construction activity; and
- Predictions of noise and vibration levels from each construction task / process have been performed and setback distances calculated to determine whether the Project criteria can be

achieved. These setback distances have been plotted as mark-ups of the drawings and are shown in **Appendix E** for noise and **Appendix F** for vibration.

Where the Project cannot meet the noise or vibration criterion, mitigation is considered.

3.2 Construction noise

A list of likely equipment has been assembled that would be used on a large scale roading project throughout New Zealand similar to the Project. **Appendix A** contains this list of equipment and its respective sound power levels. This list is indicative only and is essentially the "best estimate" of equipment that could be used. Although the contractor may use different plant from what is on this list, it is known from experience on other infrastructure construction projects that noise emissions will be similar for each activity.

Typical noise level predictions consider the sound power levels of each item of equipment, and model the noise propagation characteristics over distance, including the effects of ground and air absorption. Indicative noise levels were calculated for all relevant construction scenarios, assuming multiple items of equipment operating simultaneously. This approach is deliberately conservative in order to represent the reasonable worst-case noise levels that may infrequently occur.

In addition to these definable variations in noise level, there are numerous additional factors that affect construction noise generation. Some of these factors are variations among individual items of equipment, the state of equipment repair, exact locations of each item and operator idiosyncrasies. Generally, these factors cannot be accounted for as they cannot be reasonably quantified. These are instead considered as matters for noise management.

Based on the sound power levels in the table in **Appendix A**, combined "activity sound power levels" have been predicted. From the activity sound power levels, the distance at which the 70 dB L_{Aeq} day-time noise criterion can be complied with, without mitigation by noise barriers, has been determined.

3.3 Construction vibration

Construction vibration is a wholly separate issue from construction noise and thus is addressed as such in this assessment. Construction equipment that produces high noise levels does not necessarily also produce high vibration levels.

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

As a result, safe distances have been based on vibration measurements[3] previously performed for high vibration sources such as vibropiling and vibrating rollers, and vibration prediction tools as contained in Hassan (2006)[4]. These have been cross-checked against empirically derived relationships as contained in British Standard BS5228-2:2009.

The results from these measurements and predictions have been used to determine risk radii within which buildings are at medium or high risk of building damage.

[3] Measurements performed at State Highway 18 and as used in the Waterview Project.
[4] Hassan, O., "Train Induced Groundborne Vibration and Noise in Buildings", Multi-Science Publishing Co. Ltd, ISBN 0906522 439, 2006.

3.4 Mitigation and Management

The most effective way to control construction noise is through good on-site management and communication between managers and other staff. Therefore, recommended measures are included in this report, based on the assumed construction equipment and methodologies.

In order to set out all general and predetermined mitigation and management, a Construction Noise and Vibration Management Plan (CNVMP) is generally used. CNVMP examples and guidance are contained in the NZ Transport Agency's guidance online: http://acoustics.nzta.govt.nz/management-plans.

A CNVMP contains the overall information about acoustic rules, effects management and mitigation, equipment, activities of a construction project. NZS 6803:1999 contains guidance as to the required content in Annex E.2. A CNVMP would contain information such as the responsible person at the construction site, equipment noise levels, communication with affected neighbours, complaints and monitoring procedures.

Where compliance with the relevant criteria cannot be achieved with practicable mitigation, additional Management Schedules should be prepared, that are attached to the CNVMP. The Schedules contain activity or site specific information on management, mitigation, communication etc., that show that the best practicable option has been chosen to proceed with the works, even if compliance with the criteria may not be achieved at all times.

4 Existing Noise Environment

Both long and short duration noise level surveys were undertaken in the vicinity of the Project area.

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”.

At the same time, short duration attended surveys were undertaken in the vicinity of the Project area, including along local roads crossing SH1. Generally, noise levels were controlled by traffic on SH1 and SH18/Upper Harbour Highway, with some contribution from local roads. 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 3** below. Results at individual measurement locations are summarised in **Appendix D.** Measured and derived noise levels ranged from 60 to 68 dB $L_{Aeq(24h)}$, clearly showing the significant impact that road traffic noise has in the area.

Table 3 Noise level survey results

Address	**Measured noise level range dB $L_{Aeq(15min)}$**			**dB $L_{A90(15min)}$**
	Daytime (7am – 6pm)	**Evening (6pm – 10pm)**	**Night time (10pm – 7am)**	**Night time (10pm – 7am)**
14 Wren Place	57 – 67	59 – 64	48 – 63	37 – 57
49 Barbados Drive	58 – 65	58 – 65	50 – 65	33 – 52
21 Cabello Place	56 – 68	57 – 66	47 – 64	31 – 59
16 Lavender Garden Lane	56 – 67	56 – 64	46 – 65	29 – 59
18/71 Spencer Road	57 – 70	52 – 61	46 – 63	31 – 59

The ambient noise environment, while impacted by the existing road traffic noise, is not elevated to a degree that warrants elevated night-time construction noise criteria (refer Section 2.1.3). This is because although the average level of background noise is around 40 to 45 dB L_{A95} at locations adjacent to SH1 and SH18, there are periods when the background noise level drops to around 30 to 35 dB L_{A95} (typically at around 2am). During these periods, the night-time noise guideline would still be 45 dB L_{Aeq} even if a “background plus” approach was taken.

Therefore, where night-time construction is required for safety or road operation reasons, these occurrences will need to be managed through specific Management Schedules (refer Sections 3.4 and 8).

5 Effects Assessment: Construction of Project

5.1 Main Construction Activities

The Project has been broken up into eight construction zones as listed below and further described in the following sections.

- Zone1 – SH18/SH1 Interchange;
- Zone 2 – Upper Harbour Highway – SH1 to Albany Highway;
- Zone 3 – SH1 Northbound;
- Zone 4 – SH1 Southbound;
- Zone 5 – SH1 Median;
- Zone 6 – Albany Park & Ride;
- Zone 7 – Busway Albany to Greville Road; and
- Zone 8 – Busway Greville Road to Constellation Station.

The zones are grouped into sectors and the main construction activities required on each Sector are set out in **Table 4** as follows:

Table 4 Construction Activities per Sector

Area of Works / Sector	Significant Construction Activities
SH1 between Oteha Valley Road and Greville Road Zones 3, 4, 5, 6, 7[5]	■ Earthwork cut and fill at several locations as well as earthwork preparation for new busway and path ■ Construction of retaining walls at multiple points along busway, including vibro or hammer piles, bored piles, L-shape, MSE walls, etc. ■ Piling for overbridge foundations and placement or launching of beams, girders and caps for bridge widening and construction at Greville Road, the busway near Albany Park and Ride and McClymonts Road ■ Precast overbridge construction (McClymonts Road overbridge, Albany Busway overbridge, busway over Greville Road and local bridge widening may require night-time works) ■ Crushing of aggregate within construction yards. General construction yard activity including earthworks ■ Pavement preparation and surfacing for new and widened roads and busway / shared path ■ Construction of wetland

[5] Refer Section 5 of the Design and Construction Report for description of zones and map illustrating each zone.

Area of Works / Sector	Significant Construction Activities
SH1 between Greville Road and Rosedale Road Zones 3, 4, 5, 8	■ Realignment of northbound on-ramp at Greville Road ■ Earthwork cut and fill at several locations as well as earthwork preparation for new busway and shared path ■ Construction of retaining walls at multiple points along busway and SH1, including bored piles and MSE walls ■ Piling for overbridge foundations and placement or launching of beams, girders and caps for bridge widening and construction at Rosedale Road (Rosedale Road overbridge may require night-time works) ■ Precast overbridge construction ■ Pavement preparation and surfacing for new and widened roads and busway / shared path ■ General construction yard activity including earthworks ■ Construction of wetland ■ Lowering of Rosedale road under the SH1 bridge
SH1 Between Rosedale Road and Sunset Road Zones 2, 3, 4, 5, 8	■ Earthwork cut and fill around WWTP settlement ponds. Earthwork preparation for new busway and shared path. Significant earthworks around SH1/SH18 overbridges ■ Construction of retaining walls at multiple points along busway and SH1, including vibro or hammer piles, bored piles and MSE walls ■ Piling for new SH1 to SH18 overbridge foundations and placement or launching of beams, girders and caps. Piling for Constellation Drive busway and shared use path overbridge. The bridges are expected to require night-works. ■ Precast overbridge construction ■ Reconfiguration of Constellation Drive Northbound Onramp ■ Reconfiguration of Constellation Bus Station platforms and busway ■ Pavement preparation and surfacing for new and widened roads and busway / shared path ■ General construction yard activity including earthworks ■ Construction of wetlands

Area of Works / Sector	Significant Construction Activities
SH18 Upper Harbour Highway Zones 1, 2	▪ Earthwork cut and fill around SH1/SH18 overbridges at interface with SH18. Significant earthwork cut and fill around SH18 realignment works ▪ Construction of retaining walls including vibro or hammer piles, bored piles and MSE walls ▪ Piling and placement or launching of beams, girders and caps for new SH18 overbridge, Constellation Drive bridges, and Paul Matthew Road bridge (These bridges may require night-works) ▪ Precast overbridge construction ▪ Pavement preparation and surfacing for new roads and shared use path as well as at intersection realignment ▪ Construction of wetlands ▪ General construction yard activity including earthworks

5.2 Equipment

A list of likely equipment has been assembled that would be used on a large scale roading project throughout New Zealand. **Appendix A** contains this list of equipment and it its respective sound power levels. This list is indicative only and is essentially the "best estimate" of equipment that could be used. Although the contractor may use different plant from what is on this list, it is known from experience on other infrastructure construction projects that noise emissions will be similar for each activity.

Based on the sound power levels in the table in **Appendix A** combined "activity sound power levels" have been predicted (refer **Table 5**). From the activity sound power levels, the distance at which the 70 dB L_{Aeq} day-time noise criterion can be complied with, without mitigation by noise barriers, has been determined.

Table 5 Activity Sound Power Level and Compliance Distance

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

6 Assessment of Noise Levels and Effects

Construction noise is generally higher than ongoing operational noise from a site. This is acknowledged in the noise criteria set in NZS 6803:1999, which is higher than zone noise limits for ongoing operations.

While the criteria permit higher noise levels to be generated, adverse effects may still be experienced by neighbours. The criteria represent a balance between the need for construction to occur and neighbouring activities to continue without major disruption.

As a general guideline, with windows closed, building facades reduce noise levels by at least 20 decibels, and in most instances by 25 decibels or more. Therefore, effects on activities inside buildings could be summarised as follows:

Table 6 Approximate noise effects inside buildings

External noise level	Internal noise level	Potential effects
Up to 65 dB L_{Aeq}	Up to 45 dB L_{Aeq}	No effects on normal office and residential activities, including watching TV or telephone conversations
Up to 70 dB L_{Aeq}	Up to 50 dB L_{Aeq}	Potential minor disturbance of noise sensitive activities, sleep disturbance
Up to 75 dB L_{Aeq}	Up to 55 dB L_{Aeq}	Disturbance of noise sensitive activities such as telephone conversations etc., effects on concentration in offices
Up to 80 dB L_{Aeq}	Up to 60 dB L_{Aeq}	Disturbance of normal office and residential activities, adverse effects on day to day activities that would normally be carried out inside

External noise levels up to 65 dB L_{Aeq} result in internal noise levels of approximately up to 45 dB L_{Aeq}. At these levels, normal office and residential activities can be undertaken without disturbance, including telephone calls, watching TV etc.

External noise levels of 65 to 70 dB L_{Aeq} would result in internal levels of approximately up to 50 dB L_{Aeq}. At these levels, minor disturbance may occur for the most noise sensitive activities, and sleep may be disturbed.

Compliance with the relevant construction noise criteria (at 1m from building façades) does not take account of outdoor businesses. Elevated external noise levels may cause activities that take place outside to be impacted. Such activities may include businesses such as garden centres where much of the activity is undertaken outdoors. Mitigation and management should be investigated, including consultation, in order to achieve suitable outcomes for all parties.

Many buildings are located within close proximity to the works. Land use is a mix of residential and commercial activities. The following summarises the local land use adjacent to the Project:

- A commercial / business area is located to the west of SH1 at the northern extent of the works between Greville Road and Oteha Valley Road. This area is zoned as Business – Business Park Zone and Business – Metropolitan Centre Zone in the AUP;

- A residential area is located to the east of State Highway 1 at the northern extent of the works between Greville Road and Oteha Valley Road. This area is zoned as Residential – Mixed Housing Suburban Zone and Residential – Mixed Housing Urban Zone in the AUP;
- Residential dwellings are located to the south of Upper Harbour Highway. This area is zoned Residential – Mixed Use Housing Suburban Zone in the AUP; and
- Commercial and open space areas are located to the north of Upper Harbour Highway. This area is zoned as a mix of Business – Heavy Industry Zone and Open Space – Sport and Active Recreation Zone in the AUP. This area is also to the west of SH1 between Constellation Drive and Greville Road.

Residential areas are located in two specific areas: to the east of SH1 at the northern extent of works and to the south of SH18. Many dwellings are within close proximity to the works. Some of these dwellings receive acoustic screening from cutting escarpments or noise barriers; however some areas will have direct line-of-sight to the Project construction works (and therefore no acoustic screening).

Where noise barriers are proposed as part of the operational noise assessment, these will assist in reducing construction noise levels further provided that, where possible, they are constructed as early as possible in the construction period. Note that in most situations, limited screening from potential noise barriers or earthwork cuttings has been assumed.

Based on the likely level of noise emission from various stages of construction, effects envelopes have been developed to demonstrate distances beyond which compliance with the daytime and/or night-time noise criteria can be achieved. These distances have been plotted onto aerial photographs to show those areas where mitigation would need to be considered and implemented (refer **Appendix E** and **Table 7** to **Table 10** in Section 6.1).

It is recommended that these figures be included in the Schedules (provided that they are revised as necessary to ensure they reflect the proposed scope of works).

6.1 Construction noise risk assessment

6.1.1 SH1 between Oteha Valley and Greville Roads (Zones 3, 4, 5, 6, 7)

In this sector, predominantly residential land use is located on the eastern side of the Project. Commercial / business land use is predominantly located on the western side of the Project in this area.

Many buildings are likely to be exposed to noise levels in excess of 70 dB L_{Aeq} during the daytime based on current construction methodology assumptions. However, with the implementation of mitigation, the number of buildings may be reduced. Equally, if alternative equipment is used, or different construction methodologies applied, the number of buildings could change.

Night-time works are indicated for bridge launching works at McClymonts Road, Greville Road and at the Albany Busway Overbridge / Oteha Valley Road overbridge. For these activities, a significant number of dwellings may be exposed to noise levels greater than 45 dB $L_{Aeq.}$ These activities will require good noise management and communication with potentially affected parties. Mitigation measures such as completing works prior to midnight or operating on non-consecutive nights may be required to reduce annoyance as far as practicable.

The effects of noise on commercial activities will vary. Insensitive activities such as bus parks will be almost entirely unaffected by noise levels of above 75 dB L_{Aeq}, irrespective of whether this occurs during the daytime or night-time. Activity in this area on speech critical services such as District Court services (79 Corinthian Drive, Albany) may be affected to a greater extent where noise levels are in

excess of 70 dB L_{Aeq} due to the requirement for clear communication within these spaces during the daytime. The effect on these critical activities should be considered through communication with the affected parties. The primary effect is likely to be an interference with communication as well as general annoyance where concentration is interrupted.

Residential dwellings in this area are likely to be exposed to greater than 70 dB L_{Aeq} from construction works during daytime piling activity. The residential dwellings where this occurs are predominantly the townhouses located west of McClymonts Road and Masons Road, although future dwellings are likely to be constructed in the area before works begin that may also be exposed to greater than 70 dB L_{Aeq}.

Table 7 summarises the number and approximate location of commercial and residential buildings that are likely to receive noise levels in excess of the Project criteria.

Table 7 Addresses of buildings likely to receive noise levels in excess of the Project limits

Daytime		**Night-time**	
70 dB L_{Aeq} Residential	70 dB L_{Aeq} Commercial	45 dB L_{Aeq} Residential	75 dB L_{Aeq} Commercial
2,4,5,6 Lancia Way	98,113,125 McClymonts Road	1-6 Lancia Way	98,113,125 McClymonts Road
1 Masons Road	80 Don McKinnon Road	1-25 Meridian Court	80 Don McKinnon Road
7,9,11,13,15,17,17a,17b,17c, 17d,19,21,23,25,40 Masons Road	39,55,59,63,67,69,75,79 Corinthian Road	1,3,5,7,9,11,13,15,17,17a,17b,17c, 17d,19,21,23,25,40 Masons Road	39,55,59,63,67,69, 75,79 Corinthian Road
60 Masons Road (76 Dwellings)	40 Masons Road (commercial car club)	60 Masons Road (76 Dwellings)	40 Masons Road (commercial car club)
1-16 Lavender Garden Lane	51Corinthian Drive	1-16 Lavender Garden Lane	
138 McClymonts Road		138 McClymonts Road	
128,128a,128b McClymonts Road		128,128a,128b McClymonts Road	
71 Spencer Road (94 properties)		71 Spencer Road (94 properties)	
3,5,7,9 Coxton Lane		3,5,7,9 Coxton Lane	
		10,12,14,16,18,20,22,24,26, 28,30,32,34,36,37,39,43,45,47,139 ,141 Fernhill Way	
		1,3,5,13,15,17,18,21,23,25,27,69, 71,73,75,79,80,82,84,86, 88,89,90,91,92,93,94,95,96, 97,98,99,101,103 Medallion Drive	
		7,9,11,13,14,20,26,28 Lismore Way	
		Fairview lifestyle village south of Elm Haven and Kenitia Drive (70+ dwellings)	
		30-32 Sohlue Place	
		9,11,13,14,15,16,17,18,19,20,21, 22,23,24,25,26,27,28,29,30,3132 Lagonda Rise	

Daytime		Night-time	
70 dB L_{Aeq} Residential	70 dB L_{Aeq} Commercial	45 dB L_{Aeq} Residential	75 dB L_{Aeq} Commercial
		1-4 Allegro Way	
		135,137,141,143,154 Oteha Valley Road	
TOTAL			
214	**14**	**327**	**13**

It can be seen that there are a significant number of dwellings that will be exposed to daytime noise levels in excess of 70 dB L_{Aeq}. A significant number of dwellings around the McClymonts Road bridge and Albany busway area / Oteha Valley Road bridge works may be exposed to night-time noise levels in excess of 45 dB L_{Aeq}. These dwellings should be considered for site or activity specific noise mitigation measures. Management Schedules should be used to ensure that noise effects are avoided, remedied or mitigated wherever practicable.

The effects of noise on industrial and commercial receivers should also be considered on a case-by-case basis where a submission is received from an activity likely to receive noise levels in excess of the Project noise criterion. Many industrial and commercial receivers will not be sensitive to elevated noise levels. Schedules should also be used to manage the effects on industrial and commercial receivers who are concerned about elevated noise levels.

Refer to Section 8 for further information on noise management.

6.1.2 SH1 between Greville Road and Rosedale Road (Zones 3, 4, 5, 8)

This area is adjacent to the Rosedale landfill which is a large area of land undeveloped for residential or commercial activity. This land is zoned Open Space – Sport and Active Recreation Zone in the AUP.

The remainder of the area adjacent to the construction works is used as a commercial area mostly comprising of noise insensitive activity such as commercial storage or bulk retail. Some trade centres comprising office activity are located in this area as are other retail stores to the east of SH1.

Many of these commercial buildings are likely to be exposed to noise levels in excess of 70 dB L_{Aeq} during the daytime.

Night-time works have been indicated in this area at Rosedale Road and for the Greville Road overbridges. Noise from bridge works is likely to be received by mainly commercial activities. It is expected that night-time works in this area would not result in significant noise effects; however this will require assessment on a case-by-case basis through consultation with potentially affected parties.

Table 8 summarises the number and approximate location of commercial and residential buildings that are likely to receive noise levels in excess of the Project criteria.

Table 8 **Addresses of buildings likely to receive noise levels in excess of the Project limits**

Daytime		**Night-time**	
70 dB L_{Aeq} Residential	**70 dB L_{Aeq} Commercial**	**45 dB L_{Aeq} Residential**	**75 dB L_{Aeq} Commercial**
-	17,18 Tawa Drive	-	17,18 Tawa Drive
	5 Miro Place (12 premises)		5 Miro Place (12 premises)
	6 Titoki Place		6 Titoki Place
	62 Greville Road (landfill)		62 Greville Road (landfill)
	117 Rosedale Road		117 Rosedale Road
	121 Rosedale Road (14 premises)		121 Rosedale Road (14 premises)
TOTAL			
0	**31**	**0**	**31**

6.1.3 SH1 between Rosedale Road and Sunset Road

This area is predominantly business in character. All land is zoned "Business" in the AUP. The Watercare settlement ponds comprise a large portion of this area.

Commercial activities to the north of the settlement ponds are mainly retail or retail/manufacture based outlets. Distribution or contractor based premises are also in operation. Churches, cafes and indoor leisure activities are also located in this area.

Commercial activities to the south of the settlement ponds include building supply retail, storage operations, supermarkets and the Constellation Drive busway.

Several of the commercial buildings adjacent to the motorway are likely to be exposed to noise levels in excess of 70 dB L_{Aeq} during the daytime. Night-time works have been indicated as required for the Rosedale Road overbridge and are discussed in the preceding section. Night-time works will also be required for the SH1 / SH18 Westbound Ramp construction as well as widening of SH1 and the busway overbridge over Constellation Drive.

A residential area is located adjacent to the Project at the southern extent of the works, i.e. between Sunset and Constellation Drive. During the daytime only modest works appear to be required in this area such as realignment of the exit ramp lane, and it is expected that noise levels may exceed the daytime noise limit of 70 dB L_{Aeq} at the first row of dwellings facing the motorway. During night-works, the noise level of 45 dB L_{Aeq} may be exceeded at a number of dwellings within this area.

Table 9 summarises the number and approximate location of commercial and residential buildings that are likely to receive noise levels in excess of the Project criteria.

Table 9 **Addresses of buildings likely to receive noise levels in excess of the Project limits**

Daytime		**Night-time**	
70 dB L_{Aeq} Residential	**70 dB L_{Aeq} Commercial**	**45 dB L_{Aeq} Residential**	**75 dB L_{Aeq} Commercial**
11,13,15,17,19 Cabello Place	1,4,6 Arrenway Drive	1,3,5,7,9,11,13,15,17,19 Cabello Place	11,13,15,17,19,21,23,25,31,35 Arrenway Place
59,61,63,65,67,69,71,73,75, 77,79,81,83 Santiago Crescent	11,13,15,17,19,21,23,25 ,31,35, 39, 41Arrenway Place	59,61,63,65,67,69,71,73, 75,77,79,81,83,,85,87,89, 91,93A,93B,95,97 Santiago Crescent	6,8,10,12,14,16,18,20, 22 Cowley Place
184,186,188 Sunset Road	6,8,10,12,14,16,18,20,22 Cowley Place	1-21 Sabana Place	12,15-17 Home Place
	12,15-17 Home Place	4,6,8,10,12,14,16,18,20, 22,24,26,28,30,32,34,36, 38,40,42,44,46,48,50,52, 54,56 Santiago Crescent	60,61 Constellation Drive (8 premises)
	60,61 Constellation Drive (8 premises)	29,31,33,35,37,41 Meadowood Drive	
TOTAL			
21	**35**	**86**	**30**

6.1.4 SH18 Upper Harbour Highway

In this sector, residential land use is located on the southern side of the Project. Commercial and business land use is predominantly located on the northern side of the Project to the east of Paul Matthews Drive. A large sports field recreation area is located to the north of the proposed ramps.

Many buildings are likely to be exposed to noise levels in excess of 70 dB L_{Aeq} during the daytime.

Night-time works are indicated in this area for bridge works at Paul Matthews Drive. If night works are required for other activities, a significant number of dwellings may be exposed to noise levels greater than 45 dB $L_{Aeq.}$ Such activity would require good noise management and communication with potentially affected parties.

The effects of noise on commercial activities will vary. Insensitive activities such as service stations and automotive servicing yards will be almost unaffected by noise levels of above 75 dB L_{Aeq}, irrespective of whether this occurs during the daytime or night-time. Activity in this area such as childcare services may be affected to a greater extent where noise levels are in excess of 70 dB L_{Aeq} due to the requirement for clear communication within these spaces during the daytime. The effect on these critical activities would require specific assessment. The primary effect is likely to be an interference with communication as well as general annoyance where concentration is interrupted.

Residential dwellings in this area are likely to be exposed to greater than 70 dB L_{Aeq} from construction works during daytime piling activity. The residential dwellings where this occurs are predominantly the dwellings adjacent to SH18.

Table 10 summarises the number and approximate location of commercial and residential buildings that are likely to receive noise levels in excess of the Project criteria.

Table 10 Addresses of buildings likely to receive noise levels in excess of the Project limits

Daytime		Night-time	
70 dB L_{Aeq} Residential	**70 dB L_{Aeq} Commercial**	**45 dB L_{Aeq} Residential**	**75 dB L_{Aeq} Commercial**
17,18,19,20,21,22,23,24,25, 26,27,28,29,30,31 Cabello Place	159 Upper Harbour Highway	19,21,23,25,27,29,31,33, 35,37,39,41,43,45,47,49, 51,53,55,57,59,61,63,65, 67,69,71,73,75,77 Barbados Drive	159 Upper Harbour Highway
55 Meadowood Drive	1 Unsworth Drive	14,16,18,20,22,24,26,28, 30,32,34,36,38,40,42,44, 46,48,50 Barbados Drive	1 Unsworth Drive
5 Caribbean Drive	65,68,70,72,74,75 Paul Matthews Drive	3,5,7,8,9,10,11,12,13,14 Wren Place	65,68,70,72,74,75 Paul Matthews Drive
1,3,5,7,9,11,13,15,17,19,21, 23,25,27,29,31,33,35,37,39, 41,43,45,47,49,51,53,55,57, 59,61,63,65,67,69 Barbados Drive	1,7,15 Saturn Drive	3,5,7,9,11,13,15,17,19,21, 23,25,28,30 Jumento Place	1,7,15 Saturn Drive (15 Saturn Dr – childcare)
3,5,7,8,9,10,11,12,13,14 Wren Place	1A, 5-7,9-11,13-17,21-27,29-31 Omega Street	1-25 Grenadine Place	1A, 5-7,9-11,13-17,21-27,29-31 Omega Street (29-31 Omega St – childcare)
5 Greenwich Way	16-22 Omega Street	1-27 Mallard Place	
108-112 Unsworth Drive		2-12 Rook Place	
84,86, 88,90, 92,94,96,100, 102,104,106 Bluebird Cres			
TOTAL			
86	**28**	**136**	**24**

6.2 Overall Noise Effects Assessment

During construction of the Project, construction activities will occur in close proximity to noise sensitive receivers. In many instances, as outlined above, there is the potential for noise levels to exceed the construction noise criteria. For most large scale construction projects in metropolitan areas, exceedances of the construction noise criteria for brief periods of time are common.

NZS6803:1999 anticipates that at times construction noise cannot be made to comply with the recommended criteria. Statements such as “construction noise from any site should not generally exceed the numerical noise limits” suggest that intermittent exceedances are not unreasonable, as long as the BPO has been applied to the management and mitigation of that construction noise.

Whether the duration of a construction activity, which exceeds the criteria, can be considered reasonable depends on site specific circumstances and may vary from site to site and activity to activity. For instance, where day-time noise criteria are exceeded for several days, but neighbouring residents are not at home, no one would be affected and therefore mitigation may not be required beyond communication with the residents.

In the event that night-time works occur for one or two nights, this may be acceptable provided that residents have been informed and a clear time frame has been provided. However, if night-time works are expected to be ongoing for several consecutive nights, and at a noise level that affects residents’

ability to sleep, then alternative strategies should be implemented, such as offering temporary relocation for those affected residents or operating only in the early part of the night period. For the Project, there is the potential for a significant number of dwellings to be affected by night-works in the immediate vicinity of bridge construction.

The following activities have the potential to result in exceedances of the Project noise criteria:

- Piling, construction and demolition of bridges may generate high noise levels at nearby dwellings due to the proximity of these works to buildings and the likely direct line-of-sight between dwellings and machinery. In addition, the construction of retaining walls and noise barriers would generate relatively high levels of noise at dwellings; however the construction of noise barriers early in the Project will reduce overall construction noise levels received at dwellings.
- Retaining wall works are required at many locations along the Project. Many of these are expected to require high noise generating piling rigs at times.
- Bulk earthworks would generate noise levels of above 70 dB L_{Aeq} within 65 metres of operations where direct line-of-sight occurs between dwellings and earthworks. Typically however, noise levels would be much lower than this at such distances due to acoustic screening provided by intervening dwellings or by noise barriers or topography. Because of this, bulk earthworks will typically generate noise levels of above 70 dB L_{Aeq} within the first few rows of dwellings in built-up areas.
- Construction of structures and pavements is potentially less noisy than bulk earthworks, notwithstanding that these activities still have the potential to generate noise levels of above 70 dB L_{Aeq} within 40 metres of the works depending on acoustic screening.

The effects of noise on industrial and commercial receivers should be considered on a case-by-case basis where a submission is received from an activity likely to receive noise levels in excess of the Project noise criterion. In many cases, commercial or industrial receivers may be completely insensitive to noise, especially during the night-time.

Management Schedules should be developed prior to any construction activities proposed to occur at night-time in residential areas and within noise sensitive commercial areas as required. The Schedules should identify the noise and/or vibration risks and establish the management procedures that will be used in each area. These may involve the use of temporary noise mitigation (barriers or bunds), reduction of operating equipment or rescheduling activity to occur during the day period. Noise management plans are further discussed in Section 8.

7 Assessment of Construction Vibration Levels and Effects

7.1 Equipment vibration levels

The activities that pose the greatest risk of exceeding the Project vibration criteria (human annoyance and building damage as set out in the NZ Transport Agency Guide) are vibratory rolling, vibropiling and impact piling. This assessment has focused on these activities. Vibration level data has been sourced from previous measurements carried out by Marshall Day Acoustics, the British Standard BS 5228-2:2009 and the Transport Research Laboratory Report referenced by that standard.

There are many retaining walls along the Project involving the use of driven piles. This is likely to involve the use of vibrating piling rigs or hammer piling rigs.

7.2 Assessment of vibration effects

In a residential environment, people can usually perceive vibration at a level of 0.3 mm/s[6], but the risk of building damage only exists above 5 mm/s[7]. So, vibration is felt at levels significantly lower than those that would cause building damage.

This fact is not well understood by the general public, and it is common for people to become concerned about building damage at levels well below the relevant threshold. As a result, most complaints during construction activities are borne out of concern about potential building damage.

British Standard BS 5228-2:2009 includes the following table (**Table 11**) which sets out perception of vibration levels and likely reactions:

Table 11 Guidance on effects of vibration levels

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

The NZ Transport Agency Guide incorporates both perception and damage thresholds, and applies them in such a way that annoyance is considered in the first instance, but in areas of high-vibration construction, building condition is the bottom line. This approach to applying the criteria is a pragmatic

[6] From BS 5228-2:2009, Annex B. Refer Category A criteria in Section 2.2

[7] From DIN 4150-3:1999. Refer Category B criteria in Section 2.2

way to ensure that projects do not become unnecessarily constrained by potential vibration effects, while at the same time ensuring that people's expectations and concerns are addressed.

7.3 Vibration risk assessment

Vibration generating construction activities along the Project alignment are likely to include vibrating roller compactors and vibropiling or impact piling rigs.

No areas of rock have been noted as requiring removal using explosives.

The risk categories in **Table 12** relate to the risk of exceeding the Project criteria at various distances. The all other buildings zone has been calculated under the worst case assumption that all of these buildings are light weight structures. The risk categories are defined as follows:

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

Table 12 Activity and Risk Zones

Equipment	Risk Zones		
	Occupied Dwellings (Residential)	Other Occupied Dwellings (Commercial)	All Other Buildings
Vibrating Roller	High: < 20m Med: 20 - 90m Low: > 90m	High: < 20m Med: 20 - 50m Low: > 50m	High: < 5m Med: 5 - 20m Low: > 20m
Vibropiling	High: < 20m Med: 20 - 120m Low: > 120m	High: < 20m Med: 20 - 55m Low: > 55m	High: < 5m Med: 5 - 20m Low: > 20m
Impact Piling	High: < 20m Med: 20 - 150m Low: > 150m	High: < 20m Med: 20 - 60m Low: > 60m	High: < 5m Med: 5 - 20m Low: > 20m

Drawings showing the approximate risk zones for the identified equipment along the project extents are included in **Appendix F**. There is a risk that the Project criteria will be exceeded at several locations along the Project extents. **Table 13** outlines the properties likely to be affected by the works.

Table 13 Addresses of buildings with risk of vibration effects – Piling operations

Residential		Commercial	
High Risk	Medium Risk	High Risk	Medium Risk
Vibro or Hammered Piles			
40 Masons Road	2,4,5,6 Lancia Way	1,7,15 Saturn Place	125 McClymonts Road
60 Masons Road	5,7,9,11,13,15,17,17a,17b,17c,17d,19, 21,23,25,40 Masons Road		59,63,67,69 Corinthian Drive
92,94,96 Bluebird Crescent	6-32 Lagonda Rise		11,13,15,17,19 Arrenway Drive

Residential		Commercial	
High Risk	Medium Risk	High Risk	Medium Risk
5 Greenwich Way	19-65 Masons Road		14,16,18,22 Cowley Place
	1,3,5,7,9,11 Lavender Garden Lane		31,35 Arrenway Drive
	53,55,57,63,69,71,73,75,77 Medallion Drive		12 Holder Place
	60 Masons Road (76 dwellings)		74-76 Paul Matthew Road
	75,77,79,89,90,91,92,94,95,96,97,98, 99,101,103,105,107,109 Medallion Dr		75 Paul Matthew Road
	47 Fernhill Way		1,7,15 Saturn Place (15 Saturn Pl – childcare)
	128,128A,138 McClymonts Road		21-27,29-31 Omega Street (29-31 Omega St – childcare)
	71 Spencer Road (93 dwellings)		1A, 5-7,9-11,13-17 Omega Street
	62,64,66 Spencer Road		
	14,16 Carrowmore Road		
	Colliston Rise Subdivision (refer plans)		
	37,39,41,43,45,47,49,51,53,55,57,59, 61,63,65,67,69 Barbados Drive		
	3,4,5,6,7,8,9,10,11,12,13,14 Wren Pl		
	1,3 Geraldine Place		
	7,12 Rook Place		
	125 Unsworth Place		
	5 Greenwich Way		
	104,106,108-112 Unsworth Drive		
	2,4,6,8,10,12 Black Teal Close		
	76,77,78,80,83,84,85,86,87,88,89,90, 91,92,94,100,102,104,106 Bluebird Crescent		
TOTAL			
6	**258+**	**3**	**36**

Table 14 Addresses of buildings with risk of vibration effects – Vibrocompaction

Residential		Commercial	
High Risk	Medium Risk	High Risk	Medium Risk
Vibrocompaction			
60 Masons Road	6-32 Lagonda Rise	59,63,67,69 Corinthian Drive	125 McClymonts Road
138 McClymonts Road	19,21,23,25,40,45,47,49,51,60 Masons Road	13, 18 Tawa Drive	59,63,67,69 Corinthian Drive
5,7,9 Colliston Rise	1,3,4,5,7,9,10,11,12,14,16 Lavender Garden Lane	5 Miro Place (11 properties)	13,18 Tawa Drive
22,24,28,30,32,21 Rathmullen Drive (refer figures also)	95,97,99,101,103,105,107,109 Medallion Drive	6 Titoki Place	5 Miro Place (11 properties)
79,81Santiago Crescent	50,52,54,60 Masons Road	9, 11,13,15,17,19,21 Arrenway Drive	6 Titoki Place
15,17,18,20-31 Santiago Crescent	128,128A,138 McClymonts Road	6,8,10,12,14,16 Cowley Place	121 Rosedale Road
55 Meadowood Drive	71 Spencer Road (93 dwellings)	12 Holder Place	9,11,13,15,17,19,21,23,25 Arrenway Drive
1,3,5,7,9,11,13,15,17,19,21,23,25,27,29,31,33,35,37,39,41,43,45,49,51,57,59 Barbados Drive	62,64,66 Spencer Road	15-17 Home Place	6,8,10,12,14,16,18,22 Cowley Place
9,11,13,14 Wren Place	14,16 Carrowmore Road	60 Constellation Drive	29, 31,35 Arrenway Drive
5 Greenwich Way	Colliston Rise Subdivision (refer plans)	65,66,68,70,72,75 Paul Matthews Road	12 Holder Place
108-112 Unsworth Drive	65,67,69,71,73,75,79,81,83,85 Santiago Crescent	1,7,15 Saturn Place	15-17 Home Place
90,92,94,96 Bluebird Crescent	5-31 Cabello Place	16-22,21-27,29-31,37-39 Omega Street	60 Constellation Drive
	55 Meadowood Drive	5-7,9-11,13-17 Omega Street	65,66,68,70,74-76,75 Paul Matthew Road
	1-69 Barbados Drive		1,7,15 Saturn Place
	3,4,5,6,7,8,9,10,11,12,13,14 Wren Place		16-22,21-27,29-31,37-39 Omega Street (29-31 Omega St – childcare)
	1,3 Geraldine Place		1A, 5-7,9-11,13-17 Omega Street
	7,12 Rook Place		

Residential		Commercial	
High Risk	Medium Risk	High Risk	Medium Risk
	125 Unsworth Place		
	5 Greenwich Way		
	100,102,104,106,108-112 Unsworth Drive		
	14 Black Teal Close		
	78,80,86,87,88,89,90,91,92,94, 100,102,104,106,108 Bluebird Crescent		
TOTAL			
67	**337**	**62**	**72**

Residential buildings are in some instances located very close to the works, i.e. less than 20 metres from retaining wall or potential vibrocompaction. The main areas where dwellings are located adjacent to areas of works is at the northern end of the Project (near McClymonts Road) and along SH18. At these locations, significant numbers of dwellings will be located within the high and medium risk zones. In general only the closest of dwellings would be located within the high risk zone and the majority of the first and second row of dwellings adjacent SH1 and SH18 would be within the medium risk zone.

The Project criteria are significantly more stringent at dwellings during the night-time and have the potential to be exceeded at distances greater than 200m from the Project area. On this basis, vibration intensive activities adjacent residential areas should be generally scheduled for the daytime wherever practicable. It is understood that vibration intensive activities would not occur at night-time, and only low vibration bridge works are considered likely to occur during the night-time period.

Commercial buildings vary in their proximity to construction works. However, many are located close to retaining wall construction areas or near large cuts/fills. There are several commercial buildings in the high risk category and these require careful management when vibration intensive activity is occurring nearby.

The Project criteria do not provide amenity (Category A) vibration limits for commercial buildings during the night-time on the basis that these buildings are not normally occupied during these times. On this basis, vibration intensive activities should be generally scheduled for the night-time in commercial areas wherever practicable. Construction vibration should still be controlled to comply with the higher unoccupied Category B Project criteria (building damage).

Blasting is not provided for in the above table. Blasting vibration is required to comply with a criterion of 5mm/s or the ground borne vibration limits as set out in BS5228-2. Compliance with these criteria can often be achieved at relatively short distances from construction blasting, however the level of overpressure and ground borne vibration is related to the maximum instantaneous charge mass and the specific site constants for the propagation of vibration. It is typical for blasting to be designed around the noise and vibration limits within consent conditions. It is noted that no areas of blasting have been indicated as being required for this Project.

For construction activities within the High and Medium Risk zone of a building it is recommended that low vibration methods of construction, such as using screw piling methods and non-vibrating rollers, be investigated and implemented wherever practical with the aim of achieving Category A compliance.

If low vibration methodologies are not deemed practical to obtain the required retaining wall pile strength, it is recommended that the following process be implemented before construction commences for buildings in the High Risk zone:

- Engage with the building owner and occupier to discuss the proposed construction activities and likely vibration effects;
- Undertake a pre-construction building condition survey. This will be required where the blast design cannot achieve the Project criteria overpressure or ground borne vibration limits; and
- Monitor vibration levels during the construction activities which are within the High Risk distance.

If low vibration methodologies are not deemed practical for buildings in the Medium Risk Zone of a construction activity, it is recommended that all buildings within the Medium Risk Distance be notified of the works in advance via a letter drop which outlines the proposed construction activities and likely vibration effects.

Other vibration management measures will also be required and these are discussed in Section 8.3.

8 Construction Noise and Vibration Management

Given the proximity of dwellings to the works and the potential for relatively high noise and vibration levels throughout the day and night-time, good management of noise and vibration will be essential in reducing the effects of noise and vibration as far as practicable.

8.1 Management Methodology

The most effective way to control construction noise is through good on-site management and communication between managers and other staff. Such management and mitigation is most appropriately set out in a CNVMP, which should generally include information set out in NZS 6803:1999 in Section 8 and Annex E.2 such as:

- Summary of Project criteria contained within this assessment;
- Summary of assessments/predictions contained within this assessment;
- General construction practices, management and mitigation;
- Liaison with potentially affected parties;
- Noise management and mitigation measures specific to activities and/or receiving environments;
- Specific blast overpressure noise reduction methods if blasting is required;
- Monitoring and reporting requirements;
- Procedures for handling complaints; and
- Procedures for review of the CNVMP throughout the Project.

It is recommended that a CNVMP be prepared and implemented for each construction zone (refer Section 5.1). The construction methodology has not been finalised at this stage, therefore, construction noise management schedules should be prepared for each area of work once details of construction equipment and locations have been confirmed. Within the CNVMP, the NZ Transport Agency standard procedures for the management of construction noise should be implemented. These will be relied on to avoid, remedy and mitigating adverse effects where appropriate.

The following section discusses potential noise mitigation measures that should be included in the CNVMP.

Specific Management Schedules are a useful tool in determining how the noise effects from specific activities or in specific areas will be managed and potentially affected parties communicated with. Schedules would generally be prepared where there is a high risk of exceeding the noise and/or vibration criteria. The Schedule would contain communication, management and mitigation specific to a certain task or area and be attached to the CNVMP, providing additional information that would sit alongside the general management and mitigation options within the CNVMP.

8.2 General Mitigation Measures

The following general noise mitigation measures will be required to be implemented throughout the construction of the Project. These measures should be implemented as a matter of good practice, and are considered to be the baseline mitigation for most circumstances.

Where an exceedance of the Project construction noise criteria is identified to be likely due to a specific activity in a specific area and the general mitigation measures as discussed below are not sufficient to achieve full compliance with the Project criteria further mitigation should be investigated

and implemented where practicable.

Mitigation measures should be implemented generally in order of the following hierarchy depending on the extent of predicted effects:

- Managing times of activities to avoid night works and other sensitive times;
- Liaising with neighbours so they can work around specific activities;
- Selecting equipment and methodologies to restrict noise;
- Using screening/enclosure/barriers; and
- Offering neighbours temporary relocation.

More discussion regarding the management of construction noise is published at:

https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/noise-and-vibration/construction-and-maintenance-noise/

General mitigation measures that should be implemented are set out below:

- Training of personnel with regard to quiet and low vibration operating procedures shall be given;
- Maintenance of equipment to ensure noise and vibration levels remain as low as practicable;
- Noise barriers, temporary or otherwise, are considered where necessary. Where operational noise barriers are proposed, these should be implemented at the start of the construction period to reduce construction noise effects as far as practicable;
- Enclosures of noisy stationary equipment should be implemented if necessary and where practicable;
- Low noise plant should be selected wherever practical. Noisy plant shall have noise mitigation measures (such as silencers or enclosures) fitted;
- Night-time operation shall only occur when Project criteria can be complied with or where all practicable measures have been implemented to reduce noise emissions as per the CNVMP. Tonal reversing alarms shall be deactivated or replaced with a suitable alternative such as a visual or broadband alarm if required for night-time works. This approach has been successfully implemented on a number of NZ Transport Agency projects;
- Offer of temporary resident relocation in specific circumstances. Such a measure shall be considered generally as a last resort;
- Public liaison and communication to ensure potentially affected dwellings are reasonably informed. A contractor environmental manager or appointed representative shall be available for residents to contact. Guidance contained in https://acoustics.nzta.govt.nz should be referred to where relevant; and
- Noise barrier screening and appropriate management of temporary construction yard compounds.

8.3 Vibration management and mitigation

Typical measures for mitigating and managing construction vibration effects include:

- Liaison with affected parties;
- Monitoring of building condition prior to construction and in response to complaints;
- Monitoring of vibration levels received by buildings during the first use of high-vibration activities in

their vicinity and in response to complaints;

- Using low-vibration techniques and managing the timing of activities where practicable to avoid disturbance; and
- Low vibration plant should be selected wherever practical. Where practicable, plant that generates low levels of vibration will be used in preference to vibration intensive plant (e.g. using auger piling methods rather than vibropiling where ground conditions permit).

Detailed management and mitigation options for Project construction vibration should be contained in the CNVMP.

For the Project, there is an identified risk that vibration levels may be above the Category B levels of vibration as set out in the NZ Transport Agency guidelines that form the Project criteria. For these "high risk" dwellings, care will need to be taken to ensure that vibration does not damage structures. Construction activities should always comply with the Category B criteria where practicable. This should be confirmed through vibration measurement in high risk areas, together with condition surveys as required. If any construction-induced damage were shown to have occurred as a result of Project construction activities, this should be required to be remedied in full.

9 Summary and Conclusions

Marshall Day Acoustics has undertaken a review of the noise effects associated with the construction of the proposed Northern Corridor Improvements.

Due to the close proximity of dwellings and businesses to the works, there are many locations where there is potential for daytime and night-time Project noise criteria to be exceeded. Due to the practical and safety constraints of the Project, night-time construction is likely to be required for several specific bridge works locations. Where possible, night-time works should be minimised in areas where residential dwellings are in close proximity such as on SH1 and SH18. Where these night-time works cannot be avoided, site specific noise management will be required for night-time construction activities.

A risk assessment of construction vibration and noise effects has been performed for the Project. This has shown that there is a medium to high level of risk that vibration guidelines will be exceeded for some residential and commercial buildings adjacent to the Project. This is because buildings are located within 20 metres from the site works in some instances. Within such distances, careful vibration management will be required as set out in the report.

As noise and vibration from construction activities has the potential to exceed the Project criteria, a thorough regime of noise management will be required to ensure that noise and vibration effects are mitigated as far as practicable. This would be anchored in the CNVMP. Management will include noise and vibration monitoring along the route, clear communication with the public, condition surveys of dwellings likely to receive high levels of vibration and strategies for mitigation such as resident relocation where necessary.

Noise and vibration management procedures should be detailed in Management Schedules for the Project. Noise and vibration monitoring is an essential part of ensuring construction activities comply with the Project criteria. Successful management of noise and vibration effects from construction activities will rely heavily on good procedures and awareness of the noise and vibration effects of different construction machinery

Overall, the Project can be constructed in such a way that any adverse construction noise and vibration effects are either mitigated or specifically managed to reduce effects as far as practicable.

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Appendices

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Appendix A

Sound Power Level of Northern Corridor Improvement Construction Activities

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Activity	Plant type	Sound power level (dB L_{WA})
Earthworks, cuts and fills	Dump truck	106
	Hydraulic excavator	113
	Bulldozer	114
	Compactor	112
	Grader	110
	Water truck	105
Bridge foundations (piling)	Rotary bored piling rig	111
	Concrete trucks	107
Concrete foundations and structures	Crane	106
	Concrete pump	100
	Vibratory pokers	114
	Concrete trucks	107
Precast bridge construction, lifting, etc.	Straddle Carrier	102
	Low Loader	107
	Launching Gantry	85
	Crane	106
	Hydraulics	107
	Concrete pump	102
	Concrete vibrators	115
	Segment carrier	100
	On road trucks	100
	Concrete trucks	107
Retaining Wall Construction (MSA and L-shaped walls)	Concrete trucks	107
	Crane	106
	On road trucks	100
Retaining Wall Construction (Drilled rock anchor walls)	Drilling rig	120
	Concrete trucks	107
	Crane	106
	On road trucks	100
Rammed Pile Walls or Vibropiled Walls	Vibration piling rig	120
	Rammed pile rig	120

	Rotary Piling Rig	111
	Concrete trucks	107
	Crane	106
	On road trucks	100
Pavement preparation	Grader	110
	Dozer	114
	Vibratory roller	108
	Water trucks	105
Surfacing	Paver	113
	Road rollers	106
	Asphalt delivery trucks	108
Yard activities	Vehicle movements	102
	Material handling	105
	Minor Earthworks	110
	Administration area	50
	Workshop	80

Appendix B
Regional and Unitary Plan Excerpts

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Auckland Unitary Plan

E25 Noise and Vibration

E25.6.1 General Standards

(3) The noise from any construction work activity must be measured and assessed in accordance with the requirements of New Zealand Standard NZS 6803:1999 Acoustics – Construction noise. Construction work is defined in New Zealand Standard NZS 6803:1999 Acoustics – Construction noise.

Construction noise

E25.6.27. Construction noise levels in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone

1) Noise from construction activities in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone must not exceed the levels in Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone when measured 1m from the façade of any building that contains an activity sensitive to noise that is occupied during the works.

Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone

Time of week	Time Period	Maximum noise level (dBA)	
		L_{eq}	L_{max}
Weekdays	6:30am - 7:30am	60	75
	7:30am - 6:00pm	75	90
	6:00am - 8:00pm	70	85
	8:00pm - 6:30am	45	75
Saturdays	6:30am - 7:30am	45	75
	7:30am - 6:00pm	75	90
	6:00am - 8:00pm	45	75
	8:00pm - 6:30am	45	75
Sundays and public holidays	6:30am - 7:30am	45	75
	7:30am - 6:00pm	55	85
	6:00pm - 8:00pm	45	75
	8:00pm - 6:30am	45	75

2) Noise from construction activities in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone must not exceed the levels in Table E25.6.27.2 Construction noise levels for noise affecting any other activity when measured 1m from the façade of any other building that is occupied during the works.

Table E25.6.27.2 Construction noise levels for noise affecting any other activity

Time Period	Maximum noise levels Leq dBA
7:30am – 6:00pm	75
6:00pm – 7:30am	80

3) For a project involving a total duration of construction work that is less than 15 calendar days, the noise levels in Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.27.2 Construction noise levels for noise affecting any other activity above may be increased by 5dB in all cases.

4) For a project involving a total duration of construction work that is more than 20 weeks the noise limits in Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.27.2 Construction noise levels for noise affecting any other activity above may be decreased by 5dB in all cases.

E25.6.28. Construction noise levels in the Business – City Centre Zone and the Business – Metropolitan Centre Zone

1) Construction activities in the Business – City Centre Zone and the Business – Metropolitan Centre Zone must comply with Standard E25.6.27(1) above for any receiver not in a Business – City Centre Zone or a Business – Metropolitan Centre Zone and must not exceed the levels in Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone when measured for any 30 minute period 1m from the façade of any building in the Business – City Centre Zone or the Business – Metropolitan Centre Zone that is occupied during the work.

Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone

Construction of less than 15 consecutive calendar days duration (total duration of works)		
Time	**$L_{Aeq(30\ min)}$**	**L_{AFmax}**
Monday to Friday 6.30am - 10.30pm	80 dB	90 dB
Saturday 7am - 11pm	85 dB	90 dB
Sunday 9am - 7pm	80 dB	90 dB
All other times (night time)	60 dB	75 dB
All other times in the City Centre Residential Precinct and the Learning Precinct	55 dB	75 dB

Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone

Construction of 15 consecutive calendar days or more (total duration of works)		
Time	**$L_{Aeq(30\ min)}$**	**L_{AFmax}**
Monday to Friday 6.30am-10.30pm	75 dB	90 dB
Saturday 7am-11pm	80 dB	90 dB
Sunday 9am-7pm	65 dB	85 dB
All other times (night time)	60 dB	75 dB
All other times in the City Centre Residential Precinct and the Learning Precinct	55 dB	75dB

Where external measurement of construction noise is impractical or inappropriate, the upper limits for the noise measured inside the building will be 20dB less than the relevant levels in Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone above.

E25.6.29. Construction noise levels for work within the road

1) Noise from any construction, maintenance and demolition activities in the road must meet the relevant noise levels in the following relevant table:
   a) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
   b) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or
   c) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
   d) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone.
2) The noise levels specified in Standard E25.6.29(1) above do not apply to unplanned repair or maintenance works or planned works in the road between the hours of 10pm and 7am where:
   a) the number of nights where the noise generated by the works exceeds the relevant noise levels in the following tables:
      i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
      ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or

iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone;

at any one receiver is 3 nights or less; and

b) the works cannot practicably be carried out during the day or because the road controlling authority requires this work to be done at night-time; or

c) because of the nature of the works the noise produced cannot be practicably be made to comply with the relevant noise levels of the following tables:

i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or

iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

d) for planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council five days prior to work commencing;

e) for minor planned works a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5) below.

3) The noise levels specified in Standard E25.6.29(1) above do not apply to unplanned repair or maintenance works or planned works in the road between the hours of 7am and 10pm where:

a) the number of days where the noise generated by the works exceeds the relevant noise levels in the following tables:

i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or

iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; at any one receiver is 10 or less; or

b) because of the nature of the works and the proximity of receivers the noise generated cannot practicably made to comply with the relevant noise levels of the following tables:

i) Table E25.6.27.1 Construction noise limits for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

ii) Table E25.6.27.2 Construction noise limits for noise affecting any other activity; or

iii) Table E25.6.28.1 Construction noise limits for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

iv) Table E25.6.28.2 Construction noise limits for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

c) for planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council five days prior to work commencing; or

d) for planned works where the works will take more than 8 hours to complete a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5) below.

4) The noise levels specified in Standard E25.6.29(1) do not apply to road rehabilitation works that comprise the substantial removal and replacement of the road structural base and pavement in the road where:

a) the number of nights where the noise generated by the works exceeds the relevant noise levels in the following tables:

i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or

iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone;

at any one receiver is 20 days or less; and

b) milling, concrete cutting, percussive demolition are completed by 10.30pm; and

c) the works cannot practicably be carried out during the day or because the road controlling authority requires this work to be done at night time; and

d) because of the nature of the works the noise produced cannot be practicably be made to comply with the relevant noise levels of the following tables:

i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or

iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; and

e) a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council five days prior to work commencing; and

f) a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5) below.

5) A construction noise and vibration management plan must be prepared by a suitably qualified and experienced person and include the following:

a) details of the community consultation to be undertaken to advise the occupiers of properties located within 100m of the proposed works of all of the following:

i) the area affected by the work;

ii) why the work is required to be undertaken at night (where relevant);

iii) the times and days when the noise and vibration is likely to be generated;

iv) a contact name and number of the works supervisor who can be contacted if any issues arise; and

v) how noise and vibration complaints will be managed and responded to;

b) a description of the works and its duration, anticipated equipment to be used and the processes to be undertaken; and

c) identification of the best practicable options that will be undertaken to mitigate and minimise any noise being produced that is likely to exceed the relevant levels of the following tables:

i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or

iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone.

6) For the purpose of Standards E25.6.29(1) to E25.6.29(4) above:

a) planned work means work that has been planned to take place at least seven days before the work commences; and

b) the measurement and assessment of all construction noise must be in accordance with New Zealand Standard NZS 6803:1999 Acoustics – Construction noise.

Vibration

E25.6.30. Vibration

1) Construction and demolition activities must be controlled to ensure any resulting vibration does not exceed:

a) the limits set out in German Industrial Standard DIN 4150-3 (1999): Structural vibration – Part 3 Effects of vibration on structures when measured in accordance with that Standard on any structure not on the same site; and

b) the limits in Table E25.6.30.1 Vibration limits in buildings in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500mm of ground level at the foundation of a single storey building.

Table E25.6.30.1 Vibration limits in buildings

Receiver	Period	Peak Particle Velocity Limit millimetres/second
Occupied activity sensitive to noise	Night-time 10pm to 7am	0.3 mm/s
	Daytime 7am to 10pm	2 mm/s
Other occupied buildings	At all times	2 mm/s

Works generating vibration for three days or less between the hours of 7am to 6pm may exceed the limits in Table E25.6.30.1 Vibration limits in buildings above, but must comply with a limit of 5mm/s peak particle velocity in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500mm of ground level at the foundation of a single storey building, where:

i) all occupied buildings within 50m of the extent of the works generating vibration are advised in writing no less than three days prior to the vibration-generating works commencing; and

ii) the written advice must include details of the location of the works, the duration of the works, a phone number for complaints and the name of the site manager.

2) Permanently installed stationary vibrating, reciprocating and rotating machinery and all piping, ducting and other equipment attached to such machinery must be installed and maintained so that any resulting vibration does not exceed the limits of Table E25.6.30.2 Vibration levels for stationary machinery when measured in any occupied room of any building on another site or in any occupied unit under different ownership from the source of the vibration. Vibration must be measured in accordance with ISO 2631-2:2003 Mechanical vibration and shock – Evaluation of human exposure to whole body vibration – Part 2: Vibration in buildings (1Hz to 80Hz):

Table E25.6.30.2 Vibration levels for stationary machinery

Affected occupied building or area	Time of day	Maximum vibration level in root mean square velocity (mm/s) between 8 and 80Hz
Noise sensitive spaces	7am-10pm	0.20
Bedrooms and sleeping areas only within activities sensitive to noise	10pm-7am	0.14

Appendix C
NZ Transport Agency Guide Vibration Criteria

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Criteria

On the basis of the standards discussed above, the criteria in table 2.3 can be used to manage the effects of construction vibration and airblast[23]. These are structured as part of a process whereby construction should be managed to comply with the Category A criteria. If measured or predicted vibration and airblast levels exceed the Category A criteria then a suitably qualified expert should be engaged to assess and manage construction vibration and airblast to comply with the Category A criteria as far as practicable (see figure 2.5). If the construction vibration exceeds the Category B criteria then construction activity shall only proceed if there is appropriate monitoring of vibration levels and effects on those buildings at risk of exceeding the Category B criteria, by suitably qualified experts.

TABLE 2.3 | Construction vibration criteria

Receiver	Location	Details	Category A	Category B
Occupied PPFs	Inside the building	Night-time 2000h - 0630h	0.3mm/s ppv	1mm/s ppv
		Daytime 0630h - 2000h	1mm/s ppv	5mm/s ppv
		Blasting – vibration	5mm/s ppv	10mm/s ppv
	Free-field	Blasting – airblast	120dB L_{Zpeak}	-
Other occupied buildings	Inside the building	Daytime 0630h - 2000h	2mm/s ppv	5mm/s ppv
All other buildings	Building Foundation	Vibration - transient (including blasting)	5mm/s ppv	BS 5228-2 Table B.2
		Vibration - continuous		BS 5228-2 50% of Table B.2 values
	Free-field	Airblast	-	133dB L_{Zpeak}

TABLE 2.4 | Table B.2 from BS 5228-2

Type of building	Peak component velocity in frequency range of predominant pulse	
	4 to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s
Unreinforced or light framed structures Residential or light commercial buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Additional criteria should be used in the case of historic, vibration-sensitive or multi-storey buildings. Advice on such buildings is given in BS 5228-2[07] and DIN 4150-3[18]. Similarly, if there is history of foundation settlement, then expert geotechnical advice should be sought regarding specific vibration criteria.

Note that this excerpt refers to 'Figure 2.5' which has not been transcribed here. It contains a flow diagram outlining the management steps described in the text. It also uses the term 'PPFs' (protected premises and facilities). The New Zealand Road Traffic Noise Standard NZS 6806:2010 defines PPFs as: dwellings, educational facilities and play grounds within 20m of educational facilities, boarding houses, homes for the elderly and retirement villages, marae, hospitals that contain in-house patient facilities and temporary accommodation (e.g. motels and hotels) in residential zones. For the purposes of this vibration assessment, playgrounds are not sensitive receivers, and motels and hotels outside residential zones are.

Appendix D
Noise level survey results – Diurnal variation

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Logger Measurements

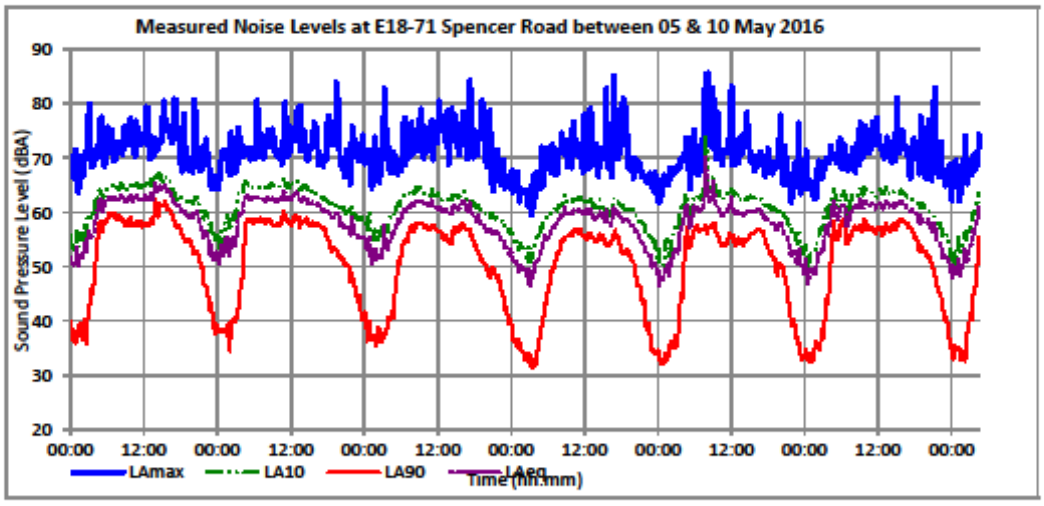
Date: Wednesday, 18 May 2016
File name: J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[E18-71 Spencer Rd.xlsx]Logger_Summary

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



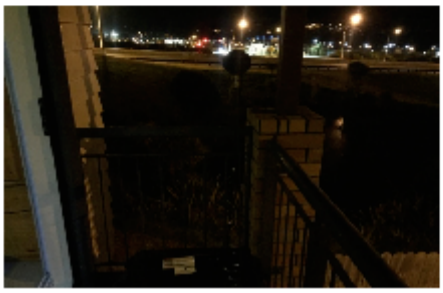
Logger Measurements

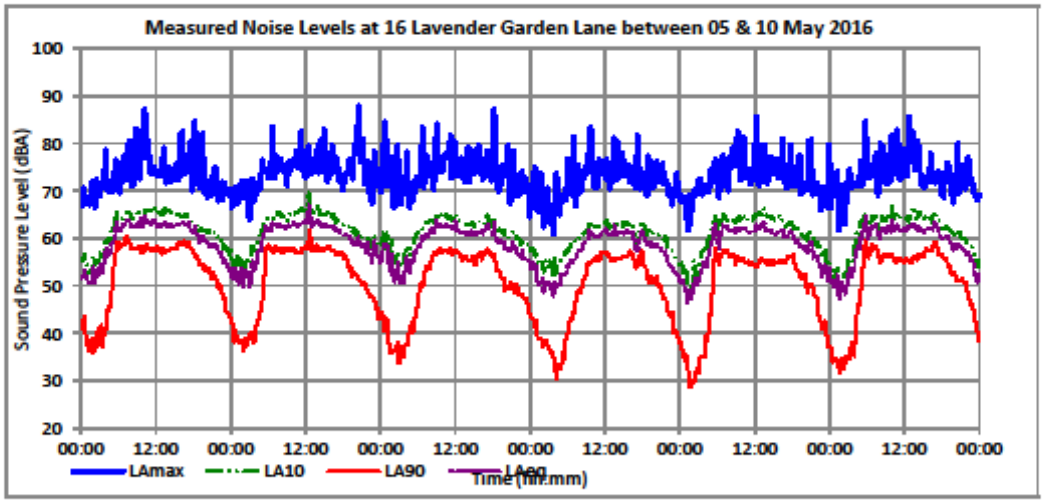
Date:	Wednesday, 18 May 2016
File name:	J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[16 Lavender Garden Ln.xlsx]Logger_Summary
Job number:	2016013A
Job name:	Northern Corridor Improvements
Initials:	SW
Measurement Dates:	Thursday, 05 May 2016 to Tuesday, 10 May 2016
Weather during Measurement:	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

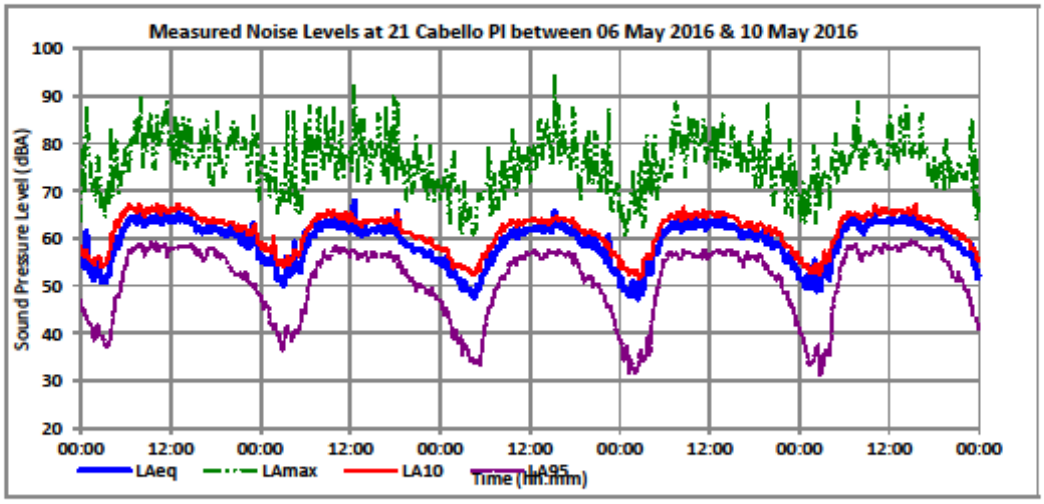
Date: Wednesday, 18 May 2016
File name: J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[21 Cabello Place.xlsx]Logger_Summary

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	Lowest	56	59	47	66
(0700-1800)	Average	63	65	57	79
	Highest	68	67	60	94
Evening	Lowest	57	59	48	67
(1800-2200)	Average	60	62	53	76
	Highest	66	65	58	89
Night	Lowest	47	51	31	60
(2200-0700)	Average	56	59	43	72
	Highest	64	66	59	88

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



Logger Measurements

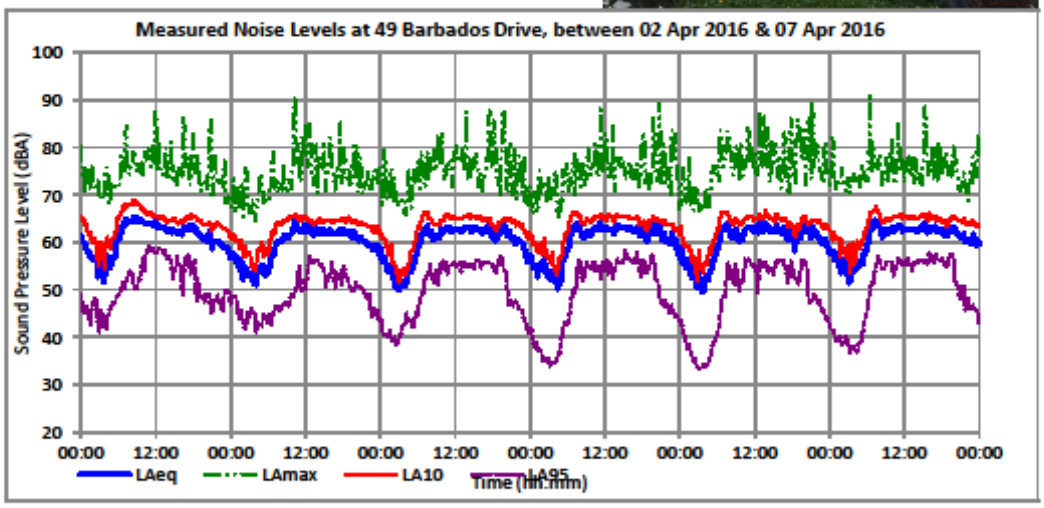
Date: Wednesday, 18 May 2016
File name: J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[49 Barbados Drive.xlsx]Logger_Summary

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

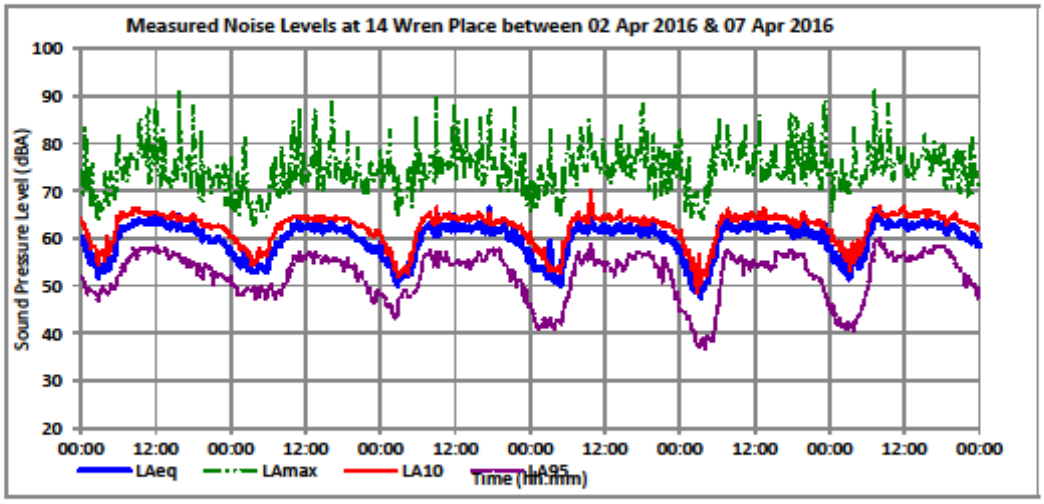
Date: Wednesday, 18 May 2016
File name: J:\JOBS\2016\2016013A\03 Survey Data & Measurements\[14 Wren Place.xlsx]Logger_Summary

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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