



Western Ring Route – Waterview Connection



Assessment of Construction Noise Effects



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1. Summary Statement

This document provides an assessment of construction noise effects for the Waterview Connection Project (the Project).

It contains a review of relevant construction noise criteria and the determination of appropriate criteria for the Project. The NZS 6803:1999 construction noise limits will generally be appropriate for the Project, except for Project Sectors where ambient night-time noise levels are elevated due to other noise sources such as traffic on existing major roads. For these Sectors, an adjusted night-time noise criterion is considered appropriate.

This assessment contains a prediction of noise emissions from construction activities. The results of the predictions show that for the majority of Sectors and activities, the relevant noise criteria can be complied with through the implementation of noise mitigation measures.

General and specific noise mitigation measures are recommended to ensure noise emissions are managed to a reasonable level. Mitigation measures include localised screening around, and enclosure of, noisy sources, selection of low-noise plant, restriction of the operation of noisy equipment to daytime and regular consultation with potentially affected residents. Subject to the implementation of these measures, it is considered that noise emissions can generally be suitably managed.

Selected night-time construction activities are critical to the successful completion of the Project. However, noise emissions from some of these activities have the potential to exceed the relevant construction noise criteria. While minor exceedances of the noise criteria may not be unreasonable, especially if these exceedances are of limited duration, where activities would be required to occur for a long duration, alternative and additional mitigation measures, such as resident relocation or provision of mechanical ventilation to bedrooms, may be required.

2. Introduction

This report provides an assessment of noise effects as they may arise from the construction of the NZ Transportation Agency's (the NZTA's) Waterview Connection Project.

Construction methodology and design of the Project are discussed, and mitigation and management measures recommended where required. Where currently available information contains a level of uncertainty, this has been stated, and alternative construction activities are discussed where these may be appropriate.

This noise report relates closely to reports pertaining to vibration¹ and operational noise², and is based on information provided by the extended Project team. The results of the construction noise assessment, specifically the management and mitigation measures, form part of the Construction Noise and Vibration Management Plan (CNVMP) (refer Appendix C).

The NZTA requires specific steps to be completed as part of any assessment and management of construction noise associated with any of its projects, in accordance with the NZTA's standard framework for construction noise management. The standard framework is divided into three sections, which are summarised as follows:

PLAN

- Identify potentially affected neighbours and appropriate noise limits for designation/consent conditions
- Predict construction noise levels for the likely construction methodology
- Assess whether night works are required
- Determine possible mitigation measures

DESIGN

- Confirm construction methodology and outline mitigation measures
- Determine communications strategy
- Prepare draft Construction Noise and Vibration Management Plan

BUILD

- Check methodology and refine construction noise predictions

¹ Technical Report No. G19 "Assessment of Vibration Effects", by Marshall Day Acoustics

² Technical Report No. G12 "Assessment of Operational Noise Effects", by Marshall Day Acoustics

- Finalise Construction Noise and Vibration Management Plan
- Organise construction noise information
- Establish web-based information management
- Prepare Construction Noise Management Schedules for specific locations or activities
- Conduct construction noise monitoring
- Record, investigate and resolve complaints

This report, and the accompanying draft CNVMP (Appendix C), form part of the above “PLAN” and “DESIGN” stages of the standard framework for the Project.

This report does not consider vibration (either construction or operational) or operational noise, which are assessed in other documents.^{3 4}

³ Technical Report No. G12 “Assessment of Operational Noise Effects”, by Marshall Day Acoustics Ltd

⁴ Technical Report No. G19 “Assessment of Vibration Effects”, by Marshall Day Acoustics Ltd

3. Description of Project

3.1 Overview

In 2009, the NZTA confirmed its intention that the 'Waterview Connection Project' would be lodged with the Environmental Protection Authority as a Proposal of National Significance. The key elements of the Waterview Connection Project are:

- Completing the Western Ring Route (which extends from Manukau to Albany via Waitakere);
- Improving resilience of the SH16 causeway between the Great North Road and Rosebank Interchanges to correct historic subsidence and "future proof" it against sea level rise
- Providing increased capacity on the SH16 corridor (between the St Lukes and Te Atatu Interchanges)
- Providing a new section of SH20 (through a combination of surface and tunnelled road) between the Great North Road and Maoro Street Interchanges and
- Providing a cycleway throughout the surface road elements of the Project corridor

The Project Sector diagram contained in Appendix B provides an overview of the extent of the Project. The Project is described in detail in Chapter 5 of the AEE 'Description of the Proposed Works Construction'. For the purposes of assessing potential construction noise effects, work occurring within each Sector has been considered and assessed in detail in Section 8 of this report.

3.2 Overview of Construction Noise Assessment

This noise assessment addresses the noise effects from the construction of the Project. Construction in each Sector involves different noise sources, sensitivities and effects. A diagram showing the Project Sectors is contained in Appendix A.

The construction of the Project will involve noisy machinery operating in relatively close proximity to noise sensitive receivers. Night-time construction is required in certain areas. Throughout construction of the Project, noise effects will be carefully managed through the use of management systems and plans (refer Section 6).

The areas which have the highest risk of adverse construction noise effects are outlined in the following Table 3-1, and described in detail in Section 8 of this report:

Table 3-1: Key Construction Noise Issues

Sector	Noise generating activities	Location of receivers
1	<ul style="list-style-type: none"> Base course/sealing of SH16 and Te Atatu Interchange Noise barrier construction, piling, etc 	Marewa St, Milich Tce, McCormick Rd, Royal View Rd and Alwyn Ave residences, Te Atatu Kohanga Reo (36 Titoki St).
2	<ul style="list-style-type: none"> Piling for bridge construction Road milling and sealing 	Alwyn Ave residences
3	<ul style="list-style-type: none"> Bridge construction and surfacing Road widening and sealing 	Rosebank Industrial Area
4	<ul style="list-style-type: none"> Causeway fill delivery for construction/reclamation Piling Road sealing 	Hemington St
5	<ul style="list-style-type: none"> Interchange ramp footing and segment construction Piling Concrete batching 	Waterbank Cres and Montrose St, St Francis School, UNITEC.
6	<ul style="list-style-type: none"> Piling and rock breaking for Carrington Rd bridge construction and retaining walls 	Carrington, Sutherland and Great North Rd residences
7	<ul style="list-style-type: none"> Piling for diaphragm wall Excavation Road realignment and resurfacing 	Great North Rd residences, and Waterbank Cres residences
8	<ul style="list-style-type: none"> Tunnelling (road header or excavators) 	Hendon Ave, Bollard Ave, Powell St, Cradock St, Waterview Downs, Oakley Ave, Herdman St and Great North Rd residences. Waterview Primary School and Kindergarten.
9	<ul style="list-style-type: none"> Blasting for portal construction Drilling for portal construction Rock breaking for portal construction Piling for portal construction Road base course and sealing Crushing of basalt Batch plant operation Noise barriers, piling, etc 	Hendon Ave and Methuen Rd residences, Christ the King School.

4. Methodology

The methodology for assessing the effects of construction noise from the Project can be divided into ten general steps:

- Review applicability of performance standards currently applied by the territorial authorities with jurisdiction in the Project area (Auckland City Council, Waitakere City Council and Auckland Regional Council) and other relevant standards and guidelines
- Establish, through measurement, the current ambient noise environment for sensitive receivers that may in future be affected by construction noise from the Project (refer Section 5.1.2 below)
- Determine appropriate construction noise criteria for the Project (Project construction noise criteria)
- Identify those construction activities with the potential to generate significant construction noise levels approaching or exceeding the Project noise criteria
- Determine distances from construction noise sources to sensitive receivers based on the proposed alignment and construction methodology
- Undertake noise level measurements of relevant machinery to be used for construction or, where this is impractical, source data from historical measurements for such sources or NZS 6803:1999 Annex C
- Analyse measured and obtained equipment data and calculate noise propagation between the source and sensitive receiver
- Assess predicted noise levels and determine if the Project can meet the Project noise criteria
- Assess the noise effects of the Project for sensitive receivers in the vicinity
- Develop best practicable option (BPO) noise management and mitigation measures

Note that while the indicative construction methodology on which this assessment is based provides a reasonable assumption for the assessment of effects (refer Chapter 5 of the AEE), it is possible that the actual construction methodology implemented for the Project may differ in some aspects. The chosen methodology during construction will need to be taken into consideration through inclusion in, and regular updating of, the CNVMP (Appendix C).

5. Noise Performance Criteria

Relevant construction noise standards and other performance criteria for the assessment of construction noise impacts are summarised in the following sections. A summary of the recommended Project noise criteria are contained in Section 5.6 below.

5.1 Construction Noise Standard NZS 6803:1999

5.1.1 Noise from Construction excluding Blasting

The New Zealand Construction Noise Standard NZS 6803:1999 contains recommended noise criteria that are appropriate and applicable to noise from construction operations, excluding blasting.

The criteria apply at a distance of 1 metre from closest façades. Average noise levels (L_{eq}) are time-based, i.e. NZS 6803:1999 provides for assessment and measurement of construction noise activities for periods between 10 minutes and 60 minutes. The Standard specifies that assessment cannot exceed 60 minute periods, but may be as short as 10 minutes. Therefore, the noise performance criteria are related to a time base (T) which is required to be stated during measurement and assessment.

This assessment assumes that noise generation for individual activities is relatively constant for at least the shortest assessment period (10 minutes). Therefore, all criteria and levels quoted in this report are referenced to (T) assuming to be between 10 minutes and 60 minutes.

The recommended noise criteria of NZS 6803:1999 are summarised in Tables 5-1 and 5-2 below.

Table 5-1: Recommended upper limits for construction noise received in residential zones⁵

Time of week	Time period	Duration of work					
		Typical duration (dB)		Short-term duration (dB)		Long-term duration (dB)	
		L _{Aeq} (T)	L _{AFmax}	L _{Aeq} (T)	L _{AFmax}	L _{Aeq} (T)	L _{AFmax}
Weekdays	0630-0730	60	75	65	75	55	75
	0730-1800	75	90	80	95	70	85
	1800-2000	70	85	75	90	65	80
	2000-0630	45	75	45	75	45	75
Saturdays	0630-0730	45	75	45	75	45	75
	0730-1800	75	90	80	95	70	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75
Sundays and public holidays	0630-0730	45	75	45	75	45	75
	0730-1800	55	85	55	85	55	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75

Table 5-2: Recommended upper limits for construction noise received in industrial or commercial areas for all days of the year⁶

Time period	Duration of work		
	Typical duration	Short-term duration	Long-term duration
	L _{Aeq} (T) (dB)	L _{Aeq} (T) (dB)	L _{Aeq} (T) (dB)
0730-1800	75	80	70
1800-0730	80	85	75

A Glossary of Technical Terminology is contained in Appendix B.

The Standard provides for higher noise criteria during normal working hours for construction noise received in residential areas to enable normal construction activity to take place. For commercial and industrial areas, higher noise criteria are allowed for during night-time when it is less likely that persons or business activities would be affected by construction noise.

The noise criteria of the Standard are widely acknowledged as being appropriate for the control of construction noise, and compliance with these criteria generally ensures acceptability of noise generated by construction activities.

⁵ NZS 6803:1999 Acoustics – Construction Noise, Section 7.2.3 Table 2

⁶ NZS 6803:1999 Acoustics – Construction Noise, Section 7.2.4 Table 3

The Standard provides lower noise criteria for construction activity in residential areas that occurs during Sundays (refer Table 5-1 above). It is generally accepted that the lower Sunday noise limits are intended to provide a day of rest from noise, as the 55 dB $L_{Aeq(T)}$ limit is such that only quieter operation would be possible. This approach is considered reasonable for the Project given the long duration of the construction programme. Alternatively, the application of the 70 dB $L_{Aeq(T)}$ weekday limit on Sunday would allow normal construction operation to occur 7 days per week and permit the Project works to be carried out in a shorter overall period, thus reducing the duration of impact on occupiers in the vicinity.

However, it is considered that nearby residents will benefit more from one day of rest from noise compared with the potential to reduce the overall construction period.

On this basis, it is considered that Sunday operation should only occur where the lower Sunday noise limits can be achieved, or where an elevated background noise level supports a higher noise criterion (refer Section 5.1.2 below).

5.1.2 Night-Time and Sunday Background Noise Level

For the Project, the underground tunnel construction process is continuous and will occur 24 hours per day, 7 days per week. Associated activities, such as concrete batching, must be able to occur 24 hours per day as required. In addition, night-time and Sunday construction is unavoidable for the Project as it is often impossible to close State highways during weekday daytime due to high traffic flows and lack of suitable detours. This is discussed in Section 8 of this report.

The Project cannot practicably be constructed without night works, although it is noted that night works will be generally limited to areas of high existing ambient noise level or to underground works. If night-time road operation was not permitted and daytime lane closures were required it is understood that substantial traffic congestion would ensue within Auckland.

While NZS 6803:1999 provides a recommended criterion for night-time and Sunday construction noise in residential areas (45 dB $L_{Aeq(T)}$), this criterion does not account for site specific circumstances such as elevated background noise levels due to other noise sources.

High ambient noise levels would change the perceived intrusiveness of construction noise. As an example of “perceived intrusiveness”, the operation of machinery creating a noise level of 70 dB $L_{Aeq(T)}$ at nearby receivers is less likely to cause annoyance if it occurred adjacent to a noisy motorway than if it occurred in a quiet rural area. Therefore, the night-time and Sunday criterion may reasonably be modified for projects in existing high noise areas, where this modification is unlikely to cause significant adverse overall effects.

Section 7.2.6 of NZS 6803:1999 recognises this and allows for the determination of an alternative noise criterion using the “background plus” approach, for instances for areas where high background noise levels exist. This approach allows the determination of an alternative $L_{Aeq(T)}$ noise criterion by adding 10 decibels to the measured background $L_{A90(T)}$ noise levels.

Background noise levels vary between Sectors, therefore, the potential annoyance arising from night-time or Sunday construction will also vary. Night-time and Sunday construction noise criteria will need to be reasonable in the context of the existing background noise environment.

The background noise levels have been measured at representative locations along the Project alignment. Measurements showed a wide range of noise levels from 29 to 73 dB L_{A90} , depending on the location of the survey position in relation to noise sources such as existing busy roads or industry. Generally, existing background noise levels are elevated in Sectors 1 to 6 due to the proximity of the existing SH16, and in Sector 7 due to proximity to Great North Road. Background noise levels in Sectors 8 and 9 are generally significantly lower as these Sectors are remote from major roads.

Based on the noise survey results, alternative night-time and Sunday construction noise criteria are considered to be reasonable for receivers in Sectors 1 to 7, which are adjacent to existing major roads. Noise criteria applicable to receivers in Sectors 8 and 9 are recommended to be those of NZS 6803:1999, without alteration. It is noted that irrespective of the applicable noise criteria, the requirements of Sections 16 and 17 of the RMA apply to all activities associated with the construction of the Project. Therefore, where lower noise levels can be achieved with the implementation of the best practicable mitigation measures, then this will be required to be achieved.

The recommended Project construction noise criteria are set out in Section 5.6 of this report.

5.1.3 Blasting Noise

Noise from explosives is normally described as “airblast” noise. Airblast noise is the pressure wave that radiates out from the blasting area. Airblast is caused by ground vibration, air movement around the rock face being blasted and air pressure venting from the holes that are drilled in the face. There is often sub-audible low-frequency noise associated with blasting, which can result in the rattling of structures even when the blast is not clearly audible outdoors.

Standard NZS 6803:1999 references Australian Standard AS 2187.2:2006 “Explosives – Storage and use - Part 2: Use of explosives” when discussing noise limits for explosives. AS 2187.2:2006 provides the following criteria, set out in Table 5-3, which include limits to avoid structural damage and to maintain human comfort.

Table 5-3: AS 2187 Peak Sound Pressure Level Limits

Category	Type of Blasting Operations	Peak Sound Pressure Level (L _{Zpeak} dB)
Human Comfort Limits		
Sensitive Site	Operations lasting longer than 12 months or more than 20 Blasts	115 dB for 95% blasts per year. 120 dB maximum unless agreement is reached with occupier that a higher limit may apply
Sensitive Site	Operations lasting less than 12 months or less than 20 Blasts	120 dB for 95% blasts per year. 125 dB maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites such as factories and commercial premises	All blasting	125 dB maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications of levels that can be shown to adversely affect the equipment operation
Damage Control Limits		
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All Blasting	133 dB unless agreement is reached with owner that a higher limit may apply.
Service structures such as pipelines, powerlines and cables located above ground	All Blasting	Limit to be determined by structural design methodology

5.2 Internal Noise Levels

5.2.1 District Plan Noise Limits

During night-time, the primary acoustic objective is to ensure that an activity does not give rise to undue sleep disturbance for any occupants in a dwelling. For this reason, some Councils in New Zealand have set internal noise limits in habitable spaces due to external noise sources. Those of the Auckland Region are summarised in Table 5-4 below.

Table 5-4: Council Internal Noise Limits for Habitable Spaces

City Council	District Plan Rule	Bedroom Internal Noise Limit (dB)
Auckland	7.8.2.11	35 L_{A10} (10.00 pm to 7:00 am)
Manukau	14.11.7.(b)	45 L_{dn} (35 L_{Aeq} 10.00 pm to 7:00 am)
Waitakere	1.2.1.i	35 L_{Aeq}
Papakura	1.10.10.(b)	35 L_{A10} (10.00 pm to 7:00 am)

Sound insulation studies of facades of New Zealand dwellings have shown that old villa type dwellings with wooden sash joinery provide approximately 25 decibels attenuation (with external doors and windows closed), whilst modern dwellings with aluminium joinery can provide up to 30 decibels attenuation with external doors and windows closed.

Where night-time construction noise does not exceed 60 dB $L_{Aeq(T)}$ at 1 metre from the façade, the resultant internal noise level of 30 to 35 dB $L_{Aeq(T)}$ is considered acceptable to avoid sleep disturbance. The World Health Organisation Guideline of 30 dB $L_{Aeq(8hr)}$ inside bedrooms at night represents a criterion that, if achieved, will ensure noise effects are no more than minor. This would assume that all external doors and windows would be required to be kept shut in order to achieve this amount of noise level reduction.

It is recognised that 60 dB $L_{Aeq(T)}$ is a relatively high noise level for night-time operation. The requirement for external windows to be closed would mean that adequate ventilation cannot be ensured. Residents may be tolerant of this circumstance for short-term activities, such as activities being required for two or three nights in succession. However, for circumstances where night-time construction would be required in close proximity of dwellings for extended periods, mechanical ventilation systems may need to be fitted to those dwellings affected to enable adequate ventilation.

Due to the difficulty and cost of implementing such a measure, all practicable steps will need to be taken to ensure that noise levels are reduced as far as practicable before the provision of ventilation is considered.

5.2.2 Re-radiated Noise from Vibration

Noise caused by vibrating structures is generally referred to as “re-radiated noise”. This type of noise is associated with ground borne vibration and may occur at vibration levels that are below those that would cause building damage. Whilst the “Assessment of Vibration Effects” (Technical Report No. G19) considers the potential for human annoyance and building damage due to ground borne vibration, it does not consider re-radiated noise from construction vibration.

The criteria of NZS 6803:1999 are considered inappropriate for this type of noise as its path into the dwelling is through the structure rather than the air.

There are no guidelines or standards that specifically address re-radiated noise from ground borne vibration. However, it is considered that the character of re-radiated noise is similar to intrusive airborne noise once inside dwellings. On this basis, it is considered that the World Health Organisation Guidelines of 30 dB $L_{Aeq(8hr)}$ inside bedrooms at night and 35 dB $L_{Aeq(16hr)}$ in living areas during the daytime represent criteria that, if achieved, will ensure noise effects are no more than minor. It is therefore recommended that these criteria are applied to the Project.

5.3 District and Regional Plans

Most of the Project (Sectors 2 to 9) is located within the jurisdiction of the Auckland City District Plan – Isthmus Section. The construction noise limits specified in this Plan are those of New Zealand Standard NZS 6803P:1984 “The Measurement and Assessment of Noise from Construction, Maintenance and Demolition Work”. Sector 1 falls within the jurisdiction of the Waitakere City District Plan which also references NZS 6803P:1984. Parts of the Project, in particular ramps and connections to SH16 and the Causeway, are located in the coastal marine area covered by the Auckland Regional Plan: Coastal. The construction noise limits specified in this Plan (Rule 38.5.5) are also those of NZS 6803P:1984.

The 1984 version of NZS 6803 is a 26-year old provisional Standard. It has been replaced by the full 1999 version of the Standard on which the recommended Project construction noise criteria are based (refer Section 5.6).

There is no significant difference between the two versions of NZS 6803, however, the current 1999 version is the most up-to-date Standard, which integrates with the newest versions of associated Standards such as NZS 6801:2008 and NZS 6802:2008, specifically including technical refinements such as the use of the $L_{Aeq(T)}$ parameter rather than the outdated L_{A10} reference.

5.4 NZTA Environmental Plan

The NZTA has developed an ‘Environmental Plan’ (June 2008). The Environmental Plan is intended to support environmental sustainability of the NZTA’s projects and contains sections on several issues, including construction noise. The Environmental Plan discusses a number of approaches designed to reduce construction noise effects on sensitive receiver positions.

The methods outlined in the Environmental Plan to manage construction noise include the following:

- Monitoring and reporting requirements, including results of risk assessments and noise measurements
- Identifying appropriate noise mitigation measures to be implemented and
- Procedures for maintaining contact with stakeholders and managing noise complaints

The Environmental Plan refers to situations where it is necessary and justified to undertake construction at night. It states that any night-time noise criteria should be reasonable and practicable. It is noted in the Environmental Plan that these may need to vary from NZS 6803:1999 depending on local conditions.

The NZTA has developed a set of tools and standard procedures for addressing construction noise to give effect to the Environmental Plan. These are contained within the website: <http://acoustics.nzta.govt.nz/>.

These tools will be used for the Project, and have been incorporated within the CNVMP for the Project (Appendix C).

5.5 Resource Management Act

Under the provisions of the Resource Management Act (Sections 16 and 17) there is a duty to adopt the best practicable option to ensure that noise does not exceed a reasonable level, and that any adverse effects shall be avoided, remedied or mitigated.

As discussed above, it is considered that the Standard's "weekday long term duration" guideline noise criteria generally represent a reasonable level of construction noise during the daytime (between Monday and Saturday).

Due to elevated background noise levels in Sectors 1 to 7 it is recommended that higher noise criteria during Sundays and at night-time be applied to those Sectors. Should long duration night-time construction be required in the vicinity of dwellings, mechanical ventilation shall be provided in order to enable windows to remain closed.

For Sectors 8 and 9, where background noise levels are considerably lower, the construction noise criteria of NZS 6803:199 are recommended to be retained.

5.6 Project Construction Noise Criteria

This section of the report contains all of the recommended Project construction noise criteria. These include external and internal noise criteria and criteria for airblasts.

Table 5-5 below summarises the recommended Project construction noise criteria that construction activity should, as far as practicable, comply with at residential receivers.

Table 5-6 summarises Project construction noise criteria that construction noise should comply with at commercial and industrial buildings.

Table 5-7 summarises internal noise criteria for airborne and re-radiated noise in habitable rooms.

Table 5-8 contains the relevant criteria to be complied with from airblast.

Table 5-5: Project Construction Noise Criteria: Residential Receivers

Time of week	Time period	Project Construction Noise Criteria (Long Term Construction) dB		
		Sectors 1 to 7	Sectors 8 and 9	All Sectors
		$L_{Aeq}(T)$	$L_{Aeq}(T)$	L_{AFmax}
Monday - Saturday	0630-0730	60	45	75
	0730-1800	70	70	85
	1800-2000	65	65	80
	2000-0630	60	45	75
Sundays and Public Holidays	0630-0730	45	45	75
	0730-1800	60	45	85
	1800-2000	45	45	75
	2000-0630	45	45	75

Table 5-6: Project Construction Noise Criteria: Commercial and Industrial Receivers

Time period	Project Construction Noise Criteria (Long Term Construction) dB
	$L_{Aeq}(T)$
0730-1800	70
1800-0730	75

Table 5-7: Project Construction Noise Criteria: Internal for Residential Receivers

Time period	Project Construction Noise Criteria (Inside)	Habitable Rooms
Daytime	35 dB $L_{Aeq}(16\text{ h})$	All habitable rooms
Night-time	30 dB $L_{Aeq}(8\text{ h})$	Bedrooms

Table 5-8: Project Construction Noise Criteria: Airblast

Category	Type of Blasting Operations	Peak Sound Pressure Level (L _{Zpeak} dB)
Human Comfort Limits		
Sensitive Site	Operations lasting longer than 12 months or more than 20 Blasts	115 dB for 95% blasts per year. 120 dB maximum unless agreement is reached with occupier that a higher limit may apply
Sensitive Site	Operations lasting less than 12 months or less than 20 Blasts	120 dB for 95% blasts per year. 125 dB maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites such as factories and commercial premises	All blasting	125 dB maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications of levels that can be shown to adversely affect the equipment operation
Damage Control Limits		
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All Blasting	133 dB unless agreement is reached with owner that a higher limit may apply.
Service structures such as pipelines, powerlines and cables located above ground	All Blasting	Limit to be determined by structural design methodology

It is recommended that the Project construction noise criteria contained in Tables 5-5 to 5-8 form the basis for designation conditions.

Construction will occur in close proximity to receivers in some Sectors, and during times when lower noise criteria are recommended. Therefore, in some instances, noise emissions will potentially exceed the recommended Project construction noise criteria. For most large scale construction projects, minor exceedances of the construction noise limits for brief periods of time are common. Provided these exceedances are temporary and brief, noise may not be unreasonable.

However, for exceedances of longer duration or greater magnitude, measures shall be implemented to reduce or avoid and mitigate noise generation as far as practicable. Where exceedances are still likely, alternative mitigation measures shall be implemented which achieve suitable outcomes for all parties affected. This may include mitigation and management measures such as temporary relocation of residents or provision of mechanical ventilation. This will be determined on a case-by-case basis throughout the construction process when construction equipment, methodologies and timing has been ascertained.

6. Construction Noise Management

The most effective way to control construction noise is through good on-site management. A draft CNVMP (Appendix C) has been produced for the Project. This management plan includes information required by NZS 6803:1999 in Section 8 and Annex E such as:

- A summary of the Project noise criteria contained within this assessment
- A summary of the assessments/predictions contained within this assessment
- General construction practices, management and mitigation
- Noise management and mitigation measures specific to activities and/or receiving environments
- Monitoring and reporting requirements
- Procedures for handling complaints and
- Procedures for review of the CNVMP throughout the Project

The CNVMP will be implemented on site for each specific area of work and some specific activities, such as blasting. The construction methodology has not been finalised this at stage, therefore, construction noise management schedules will be prepared for each area of work once details of construction equipment and locations have been confirmed. In addition to the CNVMP, the NZTA standard procedures for the management of noise will be implemented for the Project (refer Section 5.4).

The following Sections 7 'General Noise Mitigation Measures' and 8 'Assessment of Noise effects and Specific mitigation' discuss in detail mitigation and management measures appropriate for the Project.

7. General Noise Mitigation Measures

The following general noise mitigation measures will be required to be implemented throughout the construction of the Project. These general mitigation measures are included in the draft CNVMP and form the basis of good practice. They are considered to be the baseline mitigation for most circumstances. Where the implementation of the following 'general mitigation measures' is dependent on a best practicable approach, this is noted in the appropriate section of the assessment.

Where an exceedance of the Project construction noise criteria of Tables 5-5 to 5-8 is identified to be likely due to a specific activity (refer Section 8), and the general mitigation measures of this Section 7 are not sufficient to achieve full compliance, then further mitigation should be investigated and implemented where practicable.

7.1 Training of Personnel

All site personnel involved in construction of the Project will be made aware of the importance of operating in the quietest practicable manner. All personnel should be familiar with the CNVMP. All personnel working on the Project, including Contractor employees and subcontractors, will have the responsibility of following the requirements of the CNVMP at all times while on site or on the way to or from the site.

7.2 Maintenance of Equipment

Construction equipment noise levels correlate closely to the degree of maintenance of such equipment. Potential unnecessary noise sources include squeaking excavator or bulldozer chains, noisy engines and grinding conveyors.

All plant should be maintained to ensure that noise emissions remain as low as practicable.

7.3 Noise Barriers and Enclosures

Where noisy equipment is operating in close proximity to sensitive receivers and noise levels are predicted to exceed the Project noise criteria, consideration will be given as to whether it is practicable to screen the noise source from the sensitive receiver using an acoustic barrier.

Where practicable and effective, permanent (traffic) noise barriers required for operational noise mitigation following completion of the Project will be implemented early during construction. This is relevant for Sectors 1, 6 and 9 where substantial traffic noise barriers are required (refer Technical Assessment Report No. G12). Traffic noise barriers can be constructed in their final form utilising the proposed final materials, or final

supports can be constructed and temporary materials utilised throughout construction to avoid damage of final barriers. Suitable materials are those described below for temporary barriers.

Temporary noise barriers will be utilised for those areas where no permanent noise barriers are required or where these cannot be practicably implemented early during construction. Temporary barriers are typically constructed from plywood and should be of sufficient height to screen acoustic line-of-sight between the receiver and the noise source. Solid plywood site hoarding can often be effective as a temporary noise barrier.

Construction noise barriers should be implemented if effective and practicable. This would be decided on a case-by-case basis.

Where the use of barriers is not sufficient to mitigate noise levels, the erection of full or partial enclosures should be considered for noisy equipment, such as conveyors, crushers and batch plant machinery. The design of any enclosure should be performed by a suitably experienced acoustic specialist.

Enclosures should be implemented if effective and practicable. This would be decided on a case-by-case basis.

7.4 Selection of Low Noise Plant

Low noise plant will be selected and used wherever practicable. Where plant is identified as being particularly noisy, action should be taken to reduce noise emissions. This may involve the fitting of noise mitigation measures, such as silencers or enclosures.

In specific areas, noise and vibration emissions may be significantly reduced through the judicious selection and implementation of plant. One such area is Sector 8 where the deep tunnel will be constructed. If the use of hydraulic excavators and trucks is a practicable tunnelling method, this is likely to result in lower levels of re-radiated noise due to vibration.

It is noted that earthmoving equipment from certain manufacturers is markedly quieter than competitors' products. Preference should be given to procuring lower noise generating equipment for the Project.

7.5 Night-Time Operation

For the majority of Sectors, it is preferable to schedule noisy activities in the daytime where practicable and avoid noisy activities during night-time.

Where 24 hour operation is required, noisy processes close to sensitive receivers will, where practicable, be conducted during the daytime. In close proximity to schools and commercial buildings, noisy activities will be scheduled during the evening and night-time period where this is practicable.

For contractors yards located adjacent to noise sensitive receivers, noisy vehicles will enter and leave the site during daytime hours where practicable, and the layouts of the contractor yards take account of noise sensitive

receivers in the vicinity. Where this is not practicable, truck routes will be chosen so as to minimise disruption to sensitive receiver positions.

7.6 Reversing Alarms

All equipment operating on the construction site during night-time will be fitted with alternatives to tonal reversing alarms. Those alarms may include, but not be limited to, broad band auditory devices or visual rather than audible alarms.

7.7 Blasting

In the event of blasting being required, this will be notified at least 24 hours in advance to all receivers within 200 metres of the blast site. Blasts will be performed at set times during daytime only between 9 am and 5 pm, Monday to Saturday only. It is preferable that blasting occurs around midday.

Comprehensive airblast noise level calculations must be performed prior to any explosives being used and blasting will not be performed where overpressure levels would be above the Project noise criteria.

7.8 Provision of Mechanical Ventilation

Night-time works are required in Sector 9. In this Sector, ambient noise levels are lower than elsewhere along the Project and the recommended night-time noise limit is 45 dB $L_{Aeq(T)}$.

Concrete batching will be required in Sector 9 for approximately 4.5 years, 24 hours per day, 7 days per week. Noise emissions are predicted to potentially exceed the 45 dB $L_{Aeq(T)}$ night-time noise criterion at closest dwellings. Whether this criterion is exceeded will depend on the noise mitigation measures that can be included in the design of the batch plant.

In order to ensure that sleep disturbance is minimised for residents of these dwellings, all external windows will need to remain shut in bedrooms for times when external noise levels are above 45 dB $L_{Aeq(T)}$. Mechanical ventilation may need to be provided to affected residents in order to ensure adequate ventilation (refer Section 8).

7.9 Temporary Resident Relocation

Where all practicable noise mitigation measures, including specific mitigation measures discussed in Section 8 below, have been implemented and noise levels are predicted to be above the Project noise criteria (refer Section 5.6) for a significant duration or by a significant margin, temporary relocation of affected residents may need to be considered.

Such a measure will be considered only as a last resort. Before this mitigation measure is considered, the advice of a suitably qualified acoustic specialist should be sought.

7.10 Public Liaison and Communication

The Contractor Environmental Manager, or appointed representative, needs to be available on site at all times, and contactable by affected parties regarding noise.

7.11 Consultation with Affected Sensitive Receivers

Consultation with affected sensitive receivers will be carried out prior to commencement of construction activities. The level of consultation will depend on the distance of the sensitive receiver from the construction site.

Generally, the closer a receiver is to the construction site and noisy construction works, the more consultation and involvement will be required. As a rule, receivers more than 100 metres from the construction site are generally sufficiently distant to be considered unaffected. In addition, noise mitigation measures implemented to protect receivers closer to the construction site will also benefit those receivers at greater distances. For any receivers within 100 metres of the site, written notification of the Project and site contact details are considered sufficient. For blasting, receivers within 200 metres will need to be notified of the blasting schedule and locations.

Receivers within 50 metres, while generally sufficiently distant from construction works so that compliance with daytime noise criteria can be achieved without the implementation of specific mitigation, are likely to receive noise levels in exceeding the relevant night time noise criteria. Therefore, the general mitigation measures noted in the sections above will be implemented as practicable, and consultation with residents will involve individual discussions on a case-by-case basis should this be required by the receiver(s). In addition, specific activities may be managed or scheduled, as far as practicable, so that effects on receivers are minimised (e.g. outside teaching hours adjacent to a school).

For sensitive receivers within 20 metres of the construction area, individual discussions will be held and, if required, suitable alternatives and/or mitigation options explored which are acceptable to both parties. Ongoing consultation shall be carried out throughout the construction duration. Receivers within 20 metres of the construction site will be likely to be strongly adversely affected, and an ongoing close working relationship with these receivers will be required.

8. Assessment of Noise Effects and Specific Mitigation

The construction of the Project will result in temporary noise which will have some impact on occupiers in the vicinity of the required works. In the following sections, the key construction activities are described for each Sector, noise levels predicted for the nearest noise sensitive receiver positions, potential noise effects discussed and specific mitigation proposed.

While the construction methodology assumed provides a basis for assessment of effects (refer to Chapter 5 of the AEE), there is the potential that the actual methodology used may differ in some aspects, depending on the approach taken by the contractor. For some specific activities, noise levels may vary markedly for different methodologies (for instance re-radiated noise due to different tunnelling techniques).

However, it is expected for the majority of the Project that noise emissions will not vary significantly between methodologies where the equipment required for each is likely to be somewhat similar (e.g. using bulldozers or graders for earthworks). A range of construction methodologies is considered to address likely variations as far as possible.

Where the actual construction activities may differ from those described in the AEE and forming the basis for this assessment, the NZTA will be required to demonstrate that any resulting noise levels will be equal or lower than the proposed Project construction noise criteria.

In each of the tables in the following sections, noise levels are given for both the **nearest** and **average** distances that equipment will be from receivers (“**maximum average**” and “**typical average**” respectively). Of these, it is the “**maximum average**” noise levels that must be compared with the Project noise criteria, however, it is the “**typical average**” that would be received by residents for the majority of the time.

In each table, sound power levels (L_{AW}) are provided for each item of construction equipment. These sound power levels have been determined with reference to Marshall Day Acoustics’ noise source database. Cross-reference has also been made to data contained in NZS 6803:1999 and BS 5228-1:2009 where necessary.

An overall sound power “Group L_{AW} ” has been determined from this data. This takes into account the overall operation time of each item of equipment within the group. The overall “Group L_{AW} ” may be lower than the sound power level of the loudest item in the group where this item does not operate continuously. For instance in “span finishing and barrier installation” the Group L_{AW} is stated at 110 dB despite grinders and jack hammers contained in the group having sound power levels of around 120 dB L_{AW} . This is because these items of equipment would be used intermittently only.

8.1 Sector 1 – Te Atatu Interchange

Sector 1 provides for significant improvements to the Te Atatu Interchange and SH16 motorway widening, including enlargement and re-configuration of on- and off-ramps to accommodate additional lanes and to

provide for a bus shoulder. Modifications to the configuration of the Interchange provide for vehicle stacking due to ramp signalling, and improved pedestrian and cycle access. Vertical realignment of SH16 is also proposed.

The proposed works will require the removal of several buildings. Due to the close proximity of the works to residential buildings, there is the potential for elevated construction noise levels for a short duration, in addition to longer term (yet more distant) general construction noise impacts. Permanent traffic noise barriers are proposed for this Sector (refer Technical Report No. G12).

The area surrounding the Te Atatu Interchange is currently developed with mainly medium density residential dwellings. In general, these dwellings are located close to the existing motorway. The closest receivers to the works include dwellings on Alwyn Avenue, Titoki Street and Royal View Road.

8.1.1 On- and Off-Ramp Realignment

The realignment of the on- and off-ramps on the Te Atatu Interchange will require standard road construction techniques, including base course construction and sealing as well as replacement/new bridges over the Interchange. Night-time works will potentially be required on the bridge to minimise disruption to traffic. During this time, cranes and trucks will be operating to remove and replace the bridge deck.

Piling will be required as part of the works to extend the existing pier of the southbound bridge. This will require four new piles, which will be bored piles, requiring some vibratory piling techniques. It is understood that this work will take place during normal daytime operating hours.

8.1.2 Noise Barrier Construction

These barriers are proposed on the south-east, south-west and north-east sides of the interchange. The noise barriers are proposed to be up to 3.5 metres high in places and extend for a considerable distance. Barriers are proposed to be constructed from precast concrete panels, which will be manufactured off-site and craned into place. Piling is likely to be required to support these barriers. This will occur in close proximity to dwellings for a brief period of time. The proposed construction method will ensure fast completion and therefore noise effects of limited duration for adjacent residents. If these noise barriers can be constructed at the start of the Project, construction noise effects for dwellings shielded by the barriers will be reduced.

8.1.3 Pedestrian Facilities

The proposed pedestrian underpass below the existing eastbound off- and on-ramps on the northern side of the motorway will require the removal of the existing underpass and cut-and-cover tunnelling. Some of this work may occur during night-time in order to avoid disturbance of traffic on SH16.

8.1.4 Stormwater Wetland Pond

A stormwater wetland pond will be constructed within Jack Colvin Park. This will require excavation, which will occur during the daytime period and is expected to have little noise impact.

8.1.5 SH16 Vertical and Horizontal Realignment

The realignment of SH16 in this Sector will involve retaining walls to allow for the motorway widening. These will be required near Jack Colvin Park north and south of the motorway. The motorway will also be lowered east of the Interchange, which will generally occur during night-time to avoid traffic disturbance. New pavement will be constructed.

8.1.6 Construction Yard

One construction yard (Construction Yard 1 – Harbour View – Orangihina Park) is proposed in Sector 1. Construction Yard 1 will be located to the east of Te Atatu Road in an existing equestrian area.

Activities occurring in the construction yard relate to the bridge building and road alteration and will include machinery storage, offices, storage, waste management and refuelling. Further details of activities within the construction yards are contained in Chapter 5 of the AEE.

The nearest receivers to the construction yard are dwellings located to the west on Tatau Way.

8.1.7 Calculated Noise Emissions

The following tables contain summary noise levels for construction activities to be undertaken in Sector 1.

All noise predictions are for a circumstance where specific or general noise mitigation has not been implemented on site. Therefore, noise levels from the activity would generally be lower than shown in the tables once noise mitigation measures such as barriers and enclosures are implemented; the predicted noise levels in the tables represent the highest noise level likely to be received from the construction site without any mitigation.

Table 8-1: Sector 1 Motorway Widening Vertical and Horizontal Realignment

Activity	Est. Duration (36 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Retaining walls and filling for widening	~12 months	Day	Trench cutter On-road trucks Hydraulic excavator Concrete trucks Concrete pumps Concrete vibrator Group L_{AW}	108- 110 95 - 105 109 - 115 106 102 112 - 116 110	Patton Ave (~20m), Marewa St (~20m), Titoki St (~25m).	76	70
Road Milling	~12 months	Day/night	Road Milling Machine	115	Milich Tce (~25m) and McCormack Rd (~25m)	71	62
Road Construction and surfacing	~12 months	Day/night	Asphalt paver Rollers (vib.& non-vib.) Off road trucks On road trucks Water cart Kerbing machine Concrete trucks Concrete pumps Concrete vibrator Group L_{AW}	110 - 114 102 - 105 98 - 110 95 - 105 105 - 110 99 - 104 100 - 106 102 112 - 116 113	Milich Tce (~25m) and McCormack Rd (~25m)	81	61

Table 8-2: Sector 1 Noise Barrier Construction

Activity	Est. Durat. (< 1 month total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Noise Barriers	< 1 month	Day	Vibration piling rig Auger drilling rig Concrete trucks Boom cranes On road trucks Group L_{AW}	120 113 106 106 - 112 95 - 105 114	Milich Tce, Patton Ave (~10m).	86	67

Table 8-3: Sector 1 Overbridge Construction

Activity	Est. Durat. (42 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Bore piling	~12 months	Day	Vibration piling rig Auger drilling rig Concrete trucks Boom cranes Drilling rig On road trucks Group L_{AW}	120 113 106 106 - 112 112 - 123 95 - 105 114	Receivers on Titoki St (~130m), Alwyn Ave (~120m), and Royal View Rd (~120m).	65	65
Precast segment delivery, craning of segments into place, installation and tensioning of segments	~18 months	Night	Crane Hydraulic Pumps Hydraulic winches Generator Hydraulic jacks Concrete pump Concrete vibrators Grinder Segment carrier On road trucks Concrete trucks Group L_{AW}	106 - 112 106 - 108 100 - 110 100 - 110 100 - 120 102 112 - 116 120 - 122 95 - 105 95 - 105 106 110	Receivers on Titoki St (~130m), Alwyn Ave (~120m), and Royal View Rd (~120m).	59	58
Span finishing and barrier installation (if required, refer traffic noise assessment)	~6 months (Task)	Night	Cherry Picker Air compressor Jack hammer Generator Grinder Skillsaw Hiab truck Group L_{AW}	104 - 110 75 - 85 110 - 122 100 - 110 120 - 122 102 - 112 100 - 110 110	Receivers on Titoki St (~130m), Alwyn Ave (~120m), and Royal View Rd (~120m).	59	58
Surfacing	~6 months (Task)	Night	Trucks Asphalt spreader Drum roller Group L_{AW}	98 - 110 110 - 114 96 - 105 108	Receivers on Titoki St (~130m), Alwyn Ave (~120m), and Royal View Rd (~120m).	57	56

Table 8-4: Sector 1 Pedestrian/Cycle Underpass

Activity	Est. Durat. (42 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Cut-and-cover Construction	~12 months	Day	Vibration piling rig Auger drilling rig Excavator Concrete trucks Boom cranes On road trucks Group L_{AW}	120 113 109 - 115 106 106 - 112 95 - 105 114	Receivers on Titoki St (~40m)	74	69

Table 8-5: Sector 1 Construction Yard

Construction Yard	Est. Durat. (42 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
1 – Harbour View – Orangihina Park	Up to 5 years	Day	Vehicle movements Material Handling Group L_{AW}	95 – 105 100 – 115 100	Tatau Way (40m)	58	42

Table 8-6: Sector 1 Stormwater Wetland Pond

Activity	Est. Durat. (42 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Excavation and finishing of stormwater wetland pond	3 Months (Task)	Day	Hydraulic excavator On Road Trucks Group L_{AW}	109 - 115 95 - 105 105	Marewa St (50m)	63	60

8.1.8 Discussion

In Sector 1, typical average construction noise levels without mitigation are predicted to comply with the Project daytime noise criteria; however, when for specific operations (permanent noise barrier construction and road resurfacing) in close proximity to dwellings, noise levels may potentially exceed the Project daytime criteria. As noted, the noise barrier construction will be undertaken over a brief period (less than 1 month), after which noise to dwellings shielded by the barrier will be reduced considerably. This means that noise from resurfacing, amongst other activities, would be effectively mitigated by installing the barrier.

As construction will occur beside a busy motorway, noise effects are considered to be reasonable if noise levels can be managed to be below the night-time Project criterion of 60 dB $L_{Aeq(T)}$ (Refer Section 5.6). The construction of the northbound and southbound overbridge, localised sections of the on- and off-ramps and the vertical realignment, and resealing of the motorway are the only works proposed to occur during night-time in Sector 1. It is predicted that some noise from these activities will just exceed the 60 dB $L_{Aeq(T)}$ Project night-time criterion if mitigation is not implemented.

In order to achieve compliance with the Project noise criteria, the following specific noise mitigation measures are required to be implemented in addition to the general noise mitigation measures discussed in Section 7 and in the draft CNVMP.

Table 8-7: Sector 1 Specific Noise Mitigation

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Road Milling Road Construction and Surfacing 	Night-time restriction of noisy activities	Noisy activities should be programmed to occur during the daytime, with night-time activities restricted to quieter activities. Where these construction activities must occur during both the day and night-period, works should be scheduled to ensure that operation nearest to dwellings occurs during the day period with night-time operation occurring as far from dwellings as possible.
<ul style="list-style-type: none"> Road Construction and Surfacing 	Noise barriers	As substantial traffic noise barriers are required in this Sector, the installation of these noise barriers should be programmed for construction early in the construction period, if practicable. If this is not practicable, localised screening around noisy equipment or screening at property boundaries will be required. Temporary barriers should be used either at the source of the noise (around the construction site) or near the receiver (the nearby residential boundary)
<ul style="list-style-type: none"> Pedestrian cycle underpass 	Cover cut early on	Cut-and-cover tunnelling in this area should be performed underneath the cover from as early on in the construction period as possible. Excavation should be performed from underneath the capping, if practicable.

Subject to the above measures and the general mitigation measures in Section 7, noise from the majority of construction activities in Sector 1 is predicted to comply with the Project criteria. However, as the potential for exceedances exists, strict adherence to the CNVMP (Appendix C), frequent noise monitoring and liaison with residents will be required to adequately manage noise effects.

8.2 Sector 2 – Whau River

8.2.1 Construction Activity Overview

Sector 2 includes the enlargement of the existing Whau River Bridge to accommodate additional westbound and eastbound lanes. A separate dedicated cycle/pedestrian bridge will be constructed alongside the enlarged Whau River Bridge. Reclamation works are required on the east and west banks of the Whau River.

Construction noise from the bridge enlargement is likely to affect receivers in Alwyn Ave (the closest dwellings) if night-time construction were required. The Project team has advised that the bridge will be constructed during the daytime only.

As part of the addition of lanes to the motorway, the Whau River Bridge will need to be widened. This will involve driven piles (54 piles in total), cranes to lift cast concrete structures into place, road truck deliveries and other miscellaneous equipment such as hand tools, generators, etc. The new pedestrian/cycle bridge, which will be separate from the existing State highway bridge, will also require piling. Reclamation of the river banks will require delivery of fill material from the tunnel excavation or quarry.

8.2.2 Calculated Noise Emissions

The following tables provide a summary of activities and predicted noise levels for construction in Sector 2. All noise predictions are for a circumstance where specific or general noise mitigation has not been implemented on site. Therefore, noise levels from the activity would generally be lower than shown in the tables once noise mitigation measures such as barriers and enclosures are implemented; the predicted noise levels in the tables represent the highest noise level likely to be received from the construction site without any mitigation.

Table 8-8: Sector 2 Reclamation near Bridge Abutments

Activity	Est. Durat. (4 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Reclamation	4 Months (Task)	Day	On road trucks Hydraulic Excavators Concrete trucks Concrete pumps Group L_{AW}	95 – 105 109 – 115 106 102 100	Bridge Ave/Alwyn Ave (~80m)	54	51

Table 8-9: Sector 2 Reclamation near Bridge Abutments

Activity	Est. Durat. (28 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Driven Piling Operation (Pedestrian and Road Bridge)	~6 months (task)	Day	Rammed Piles Crane On Road Trucks Group L_{AW}	120 100 - 115 95 - 105 114	Alwyn Ave (~100m)	66	62
Pad footing construction or pier construction (Pedestrian and Road Bridge)	~8 months (task)	Day	Excavator Trucks Concrete Truck Concrete Vibrator Skillsaw Generator Air compressor Crane Concrete Pump Group L_{AW}	109 - 115 98 - 110 96 - 106 112 - 116 108 - 112 100 - 110 75 - 85 100 - 115 106 - 108 112	Alwyn Ave (~100m)	64	60
Precast segment delivery, craning of segments into place, installation and tensioning of segments (Pedestrian and Road Bridge)	~6 months (task)	Day	Crane Hydraulic Pumps Hydraulic winches Generator Hydraulic jacks Concrete pump Concrete vibrators Grinder Segment carrier On road trucks Concrete trucks Group L_{AW}	106 - 112 106 - 108 100 - 110 100 - 110 100 - 120 102 112 - 116 120 - 122 95 - 105 95 - 105 106 110	Alwyn Ave (~100m)	62	58
Driven Piling Operation (Pedestrian and Road Bridge)	~6 months (task)	Day	Rammed Piles Crane On Road Trucks Group L_{AW}	120 100 - 115 95 - 105 114	Alwyn Ave (~100m)	66	62
Pad footing construction or pier construction (Pedestrian and Road Bridge)	~8 months (task)	Day	Excavator Trucks Concrete Truck Concrete Vibrator Skillsaw Generator Air compressor Crane Concrete Pump Group L_{AW}	109 - 115 98 - 110 96 - 106 112 - 116 108 - 112 100 - 110 75 - 85 100 - 115 106 - 108 112	Alwyn Ave (~100m)	64	60

8.2.3 Discussion

In Sector 2, noise levels are expected to comply with the Project daytime noise criteria at receivers. Night-time work is not proposed in this Sector. On this basis, no specific noise mitigation measures are required.

8.3 Sector 3 – Rosebank – Terrestrial

Sector 3 of the Project involves the re-configuration of the existing on- and off-ramps at the Rosebank Interchange. Between the Rosebank Interchange and the Te Atatu Interchange additional lanes will be added to provide four lanes eastbound and westbound, and an additional bus shoulder in both directions. This will require the construction of additional retaining walls and the construction of a new access road to Rosebank Road. A new cycle bridge is also proposed.

Motorway construction will occur during the daytime alongside the existing motorway. The cycle bridge will be constructed offsite and craned into place. This will occur during night-time, however, it is expected to be completed over a short time frame.

In Sector 3, the land use is industrial, which is not generally sensitive to noise and often unoccupied at night, therefore, night-time construction works would be more appropriate in this Sector.

One construction yard is proposed in Sector 3 (Construction Yard 2 – Patiki Road) which will be located west of SH16 near the Rosebank Industrial Area. Activities occurring in the construction yards will relate to the bridge building and the yard will, in essence, be a yard for storage of machinery and building materials/waste.

8.3.1 Calculated Noise Emissions

The following tables provide a summary of activities and predicted noise levels for construction in Sector 3 without mitigation.

Table 8-10: Sector 3 Rosebank Road Off-Ramps and Road Widening

Activity	Est. Durat. (24 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Pad footing construction or pier construction	~6 months	Day and night	Drill Rig Excavator Trucks Concrete Truck Concrete Vibrator Skillsaw Generator Air compressor Crane Concrete Pump Group L_{AW}	111 - 125 109 - 115 98 - 110 96 - 106 112 - 116 108 - 112 100 - 110 75 - 85 100 - 115 106 - 108 112	Rosebank Industrial estate (~15m)	80	67
Precast segment delivery, launching or craning of segments into place, installation and tensioning of segments	~6 months	Day and night	Straddle Carrier Low Loader Launching Gantry Crane Hydraulic Pumps Hydraulic winches Generator Hydraulic jacks Concrete pump Concrete vibrators Grinder Segment carrier On road trucks Concrete trucks Group L_{AW}	100 - 105 101 - 112 81 - 91 106 - 112 106 - 108 100 - 110 100 - 110 100 - 120 102 112 - 116 120 - 122 95 - 105 95 - 105 106 110	Rosebank Industrial estate (~15m)	75	65
Span finishing and barrier installation (if required, refer traffic noise assessment)	~6 months	Day and night	Cherry Picker Air compressor Jack hammer Generator Grinder Skillsaw Hiab truck Group L_{AW}	104 - 110 75 - 85 110 - 122 100 - 110 120 - 122 102 - 112 100 - 110 110	Rosebank Industrial estate (~15m)	75	65
Surfacing	~6 months	Day and Night	Trucks Asphalt spreader Drum roller Group L_{AW}	98 - 110 110 - 114 96 - 105 108	Rosebank Industrial estate (~15m)	73	63

Table 8-11: Sector 3 Patiki Road Cycle Bridge

Activity	Est. Durat. (7 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Earthworks or retaining wall construction	~4 months	Day / Night	Vibration piling rig Auger drilling rig Hydraulic Excavator Concrete trucks Boom cranes Drilling rig On road trucks Group L_{AW}	120 113 109- 115 106 106 - 112 112 - 123 95 - 105 114	Rosebank Industrial estate (~140m)	63	63
Craning of Sections into place	~3 months	Night	Crane Hydraulic Pumps Hydraulic winches Generator Hydraulic jacks Concrete pump Concrete vibrators Grinder Segment carrier On road trucks Concrete trucks Group L_{AW}	106 - 112 106 - 108 100 - 110 100 - 110 100 - 120 102 112 - 116 120 - 122 95 - 105 95 - 105 106 110	Rosebank Industrial estate (~140m)	59	59

Table 8-12: 3 Rosebank Park Domain Access Road

Activity	Est. Durat. (6 months total)	Day/ Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
General Earthworks and Temporary Road Construction	~ 6 months	Day	Excavator Trucks Concrete Truck Concrete pump Grader Group L_{AW}	109 - 115 98 - 110 96 - 106 102 110 110	Rosebank Industrial estate (~140m)	58	52

Table 8-13: Sector 3 Construction Yards

Activity	Est. Durat.	Day/ Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Construction Yard 2 – Patiki Road	Until completion of Sector – approx 24 months	Day and night	Road Trucks Hydraulic excavators Group L_{AW}	95 - 105 109-115 95	Rosebank Industrial Area (~50m)	54	43

8.3.2 Discussion

Construction noise levels in Sector 3 will affect industrial receivers only, which are generally less noise sensitive. Average noise levels from construction will generally comply with the Project construction noise criteria for business and industrial buildings, however, where construction occurs close to receivers, these noise levels may be marginally exceeded.

Night-time construction is preferred in this area, as activities within the Rosebank Industrial area that are more sensitive to noise (such as administration areas) are less likely to be in operation during night-time. It is therefore recommended that construction activities located adjacent to industrial receivers are undertaken at night, where practicable.

Only the pad footing preparation is predicted to marginally exceed the Project noise criteria, and only where this activity occurs close to receivers; the average level of noise is predicted to comply with the relevant criteria. Temporary noise barriers should be used to screen pad footing construction works where these occur close to industrial receivers. Liaison with potentially affected industrial receivers should occur, as it is possible that they are not sensitive to noise during certain periods (e.g. night-time).

8.4 Sector 4 – Reclamation

8.4.1 Construction Activity Overview

Sector 4 involves the provision of two additional westbound lanes from the Great North Road Interchange to the Rosebank Road Interchange to create a total of five westbound lanes plus a dedicated bus shoulder. An additional lane will be added from the Rosebank Interchange to the Great North Road Interchange to create a total of four eastbound lanes in this section.

Construction in this Sector will occur over the entire 5 year construction period as spoil sourced from the tunnel or a quarry will be used for the elevation of the causeway. Construction will progressively move along the alignment and will occur in proximity to different noise sensitive receivers at different times. While most construction will be undertaken during daytime only, some of the bridge piling and reclamation, which is required to be undertaken at or below the water line, will need to occur during low tide, i.e. any time throughout the 24 hour period.

While the majority of the reclamation area is not in proximity to noise sensitive activities, the most eastern extent of Sector 4 is a moderate distance from receivers in the Waterview and Pt Chevalier coastal areas (approximately 350 m).

The main construction noise sources for Sector 4 will include carting and dumping of fill and rip-rap by road trucks and hydraulic excavators. Other noise sources will include concreting and road construction/sealing, dredging and piling for causeway bridges.

8.4.2 Calculated Noise Emissions

The following table provide a summary of activities and predicted noise levels for construction in Sector 4. All noise predictions are for a circumstance where specific or general noise mitigation has not been implemented on site. Therefore, noise levels from the activity would generally be lower than shown in the tables once noise mitigation measures such as barriers and enclosures are implemented; the predicted noise levels in the tables represent the highest noise level likely to be received from the construction site without any mitigation.

Table 8-14: Sector 4 Reclamation

Activity	Est. Durat. (24 months total)	Day/ Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Bridge Piling	~22 months (task)	Day/night	Rammed Piles On road trucks Group L_{AW}	120 95 - 105 120	Hemington St (~350m)	60	60
Dredging/ Channel Realignment	~8 months (task)	Day	Dredging	109	Hemington St (~400m)	48	42
Reclamation	~54 months (task)	Day/night	On road trucks Hydraulic Excavators Concrete trucks Concrete pumps Group L_{AW}	95 - 105 109 - 115 106 102 100	Hemington St (~170m)	47	35
Road Construction and surfacing	~12 months (task)	Day	Asphalt paver Rollers (vib.& non-vib.) Off road trucks On road trucks Water cart Kerbing machine Concrete trucks Concrete pumps Concrete vibrator Group L_{AW}	110 - 114 102 - 105 95 - 105 95 - 105 105 - 110 99 - 104 100 - 106 102 112 - 116 113	Hemington St (~140m)	62	48

8.4.3 Discussion

Construction of the causeway is predicted to result in typical average noise levels below 50 dB $L_{Aeq(T)}$, except during piling, which will increase noise levels to about 60 dB $L_{Aeq(T)}$ for a short period. Noise levels are predicted to comply with the Project noise criteria. Although construction will pass close to industrial buildings near the Rosebank Interchange, compliance with the relevant Project noise criteria can be achieved at all times.

8.5 Sector 5 – Great North Road Interchange

8.5.1 Construction Activity Overview

Sector 5 of the Project includes the ramps and alignment associated with the connection of SH20 to SH16 (the Great North Road Interchange) and the Waterview Park area. Key elements are as follows:

- A new two lane westbound ramp from the tunnel (SH20) towards Waitakere (SH16)
- A new two lane southbound ramp from Waitakere (SH16) to SH20 towards Maoro Street, the Airport and SH1
- A new two lane eastbound ramp from the tunnel (SH20) to SH16 towards the city in the vicinity of the Carrington Road Bridge
- A single lane southbound ramp from the city (SH16) to SH20 towards Maoro, the Airport and SH1 and
- Re-alignment of the existing SH16 eastbound on- and off-ramps

The proposed works will require the removal of a number of dwellings on Herdman Street, Cowley Street, and Great North Road.

Retaining walls will be required where the at-grade road approaches the northern tunnel portal. However, as the greater length of these retaining walls is located in Sector 7, the noise effects of the construction of these retaining walls, along with the tunnel ventilation building, are discussed in Sector 7 (Section 8.7 below).

Due to the close proximity of construction works to residences, there is the potential for intermittent elevated construction noise levels for short periods. Longer term general construction noise will be experienced by receivers in the vicinity, however, since construction will be at a greater distance it will be less noticeable.

Construction is likely to occur in Sector 5 over an extended time period, thus potentially increasing the construction noise effects. Some night-time works will be required in the vicinity of Great North Road and SH16 in order to avoid disruption to traffic on these major transport corridors.

The closest potentially affected receivers are the dwellings on Waterview Crescent south-west of the Interchange and Montrose Street north-east of the Interchange. These receivers are located close to the westbound ramp from SH20 to SH16 (approximately 70 metres) and the eastbound ramp from SH20 to SH16 (approximately 45 metres) respectively, but are more distant from the other ramps.

There are two schools located in Sector 5; St Francis School on Montrose Street and Waterview Primary School, with Waterview Kindergarten, on Oakley Avenue. The school classrooms for these buildings are at least 250 metres from the ramp structures of Sector 5, but closer to the at-grade lanes.

8.5.2 Interchange Ramps

The method of construction for the interchange ramps will involve piers on in-situ poured concrete footings with precast sections between them. Piers are likely to be constructed on large diameter bored concrete piled foundations in East Coast Bays Formation (ECBF) sandstone, however some foundations may be spread footings which will require sheet piling.

Lifting the precast span sections will involve the use of large lifting machinery such as cranes or launching gantries. Concrete trucks and on-road trucks will be required for delivery and construction of the sections.

8.5.3 Noise Barrier Construction

Safety edge barriers (TL5) of 1.1 metre in height are proposed on the elevated ramp structures and a short extent on the southern side of the motorway interchange where the road is at grade. (refer Technical Assessment Report No. G12) The barrier will be located some distance from the nearest dwellings and, given the low height, will provide only a limited reduction in construction noise.

8.5.4 Construction Yards

There will be three construction yards in Sector 5 (Construction Yards 3, 4, and 6). Activities in the construction yards will include: storage and parking of machinery; stockpiling of material; concrete batching operations (including truck deliveries and load out), administration offices and other activities of a similar nature. Further details of each activity are contained in Chapter 5 of the AEE. Specific activities proposed in each area are as follows:

- **Construction Yard 3 (GNR Interchange):** Generally used by the causeway contractor. Activities will include: Laboratory, workshop, administration offices, waste storage, storage and parking of machinery.
- **Construction Yard 4 (GNR interchange):** Generally will be used by the Great North Road contractor and for stockpiling spoil and will include: Pugmill, conveyed spoil stockpile, storage and parking of machinery, spoil screens, lime mixing and spoil drying.
- **Construction Yard 6 (Waterview Park):** Generally used by the tunnel contractor, but may also be used by the Great North Road interchange contractor. Activities are likely to include: workshops, storage and parking of machinery, vent building construction, bentonite plant, concrete batch plant, steel fixing, refuelling plant, administration offices and other activities of a similar nature.

Whilst all Contractor Yards will be accessible during night-time, it is likely that night-time operation will be limited to the load out of concrete from the concrete batch plant and stockpiling of spoil in a covered building, specifically in Construction Yard 6.

8.5.5 Calculated Noise Emissions

The following tables provide a summary of activities and predicted noise levels for construction in Sector 5. All noise predictions are for a circumstance where specific or general noise mitigation has not been implemented on site. Therefore, noise levels from the activity would generally be lower than shown in the tables once noise mitigation measures such as barriers and enclosures are implemented; the predicted noise levels in the tables represent the highest noise level likely to be received from the construction site without any mitigation.

Table 8-15: Sector 5 Great North Road Interchange

Activity	Est. Durat. (24 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Contiguous bored piling	~8 months	Day/night	Vibration piling rig Auger drilling rig Concrete trucks Boom cranes Drilling rig On road trucks Group L_{AW}	120 113 106 106 - 112 112 - 123 95 - 105 114	Waterbank Cres (Ramp 2 ~ 60m) Montrose St (Ramp 4 ~ 60m)	70	64
Pad footing construction or pier construction	~16 months	Day/night	Drill Rig Excavator Trucks Concrete Truck Concrete Vibrator Skillsaw Generator Air compressor Crane Concrete Pump Rock Breaking Group L_{AW}	111 - 125 109 - 115 98 - 110 96 - 106 112 - 116 108 - 112 100 - 110 75 - 85 100 - 115 106 - 108 120 - 125 118	Waterbank Cres (Ramp 2 ~ 60m) Montrose St (Ramp 4 ~ 60m)	74	68
Precast segment delivery, launching or craning of segments into place, installation and tensioning of segments	~16 months	Day/night	Straddle Carrier Low Loader Launching Gantry Crane Hydraulic Pumps Hydraulic winches Generator Hydraulic jacks Concrete pump Concrete vibrators Grinder Segment carrier On road trucks Concrete trucks Group L_{AW}	100 - 105 101 - 112 81 - 91 106 - 112 106 - 108 100 - 110 100 - 110 100 - 120 102 112 - 116 120 - 122 95 - 105 95 - 105 106 110	Waterbank Cres (Ramp 2 ~ 60m) Montrose St (Ramp 4 ~ 60m)	66	60
Span finishing	~8 months	Day/night	Cherry Picker Air compressor Jack hammer Generator Grinder Skillsaw Hiab truck Group L_{AW}	104 - 110 75 - 85 110 - 122 100 - 110 120 - 122 102 - 112 100 - 110 110	Waterbank Cres (Ramp 2 ~ 60m) Montrose St (Ramp 4 ~ 60m)	66	49*

Activity	Est. Durat. (24 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Surfacing	~8 months	Day/night	Trucks Asphalt spreader Drum roller Group L_{AW}	98 - 110 110 - 114 96 - 105 108	Waterbank Cres (Ramp 2 ~ 60m) Montrose St (Ramp 4 ~60m)	64	47*

Table 8-16: Sector 5 Noise Barrier Construction

Activity	Est. Durat. (1 month total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Noise Barriers	< 1 month	Day	Auger drilling rig Concrete trucks Boom cranes On road trucks Group L_{AW}	113 106 106 - 112 95 - 105 110	Waterbank Cres (~100m)	62	62

Table 8-17: Sector 5 Construction yards

Activity	Est. Durat.	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Yard 3 - GNR Interchange Causeway Construction Yard	5 years	Day	Laboratory Workshop Administration areas Hydraulic excavator On road trucks Concrete trucks Group L_{AW}	<90 50 - 100 50 109 - 115 95 - 105 106 100	Maryland St (~100m)	53	50
Yard 4 - Great North Road interchange. Great North Road Contractor	5 years	Day	Pugmill Screens Administration areas Hydraulic excavator Off road trucks On road trucks Group L_{AW}	95 - 105 106 50 109 - 115 98 - 110 95 - 105 100	Berridge St (~70m)	56	50
Yard 6 - Waterview Park. Tunnel Contractor	5 years	Day/night	Bentonite plant Refuelling plant Administration areas Hydraulic excavator Off road trucks On road trucks Concrete trucks Concrete Batch Plant Group L_{AW}	108 60 - 80 50 109 - 115 98 - 110 95 - 105 106 110 - 115 110	Waterbank Cres (~50m)	68	62

8.5.6 Discussion

The calculation results in the tables above show that most ramp construction activities have the potential to exceed the daytime and night-time Project noise criteria, without the implementation of noise mitigation. In order to ensure noise emissions are reasonable, general (refer Section 7) and specific (refer Section 8.5.8 below) noise mitigation measures will be required.

Activities that will generate high noise levels are those that occur at or near ground level, such as the pad footing construction and piling. These activities should be screened from nearby receivers through provision of temporary noise barriers around noisy equipment. Given that some ramps are a considerable distance from residential areas, it is recommended that work on ramp structures that are located close to noise sensitive areas be scheduled for daytime only, where practicable. Specific noise mitigation for activities in this Sector are summarised in Section 8.5.8 below.

Construction Yards are generally located some distance from residential areas, and compliance with the Project noise criteria can generally be achieved.

The concrete batch plant in Construction Yard 6 is required to operate 24 hours per day, 7 days per week. In order to ensure night-time noise emissions from the batch plant are managed, noise mitigation measures such as solid enclosures should be included around the batch plant. This will ensure that noise emissions can be reduced significantly.

Noise mitigation for this plant will include, but may not be limited to, the items listed in Table 8-18 in Section 8.5.8 below. Well treated batch plants can achieve noise levels of around 49 dB $L_{Aeq(T)}$ at distances of 150 metres, which is the anticipated distance between the batch plant and the closest receiver positions. This noise level is compliant with the Project night-time noise criterion of 60 dB $L_{Aeq(T)}$ for this Sector.

The above works are essential to the successful construction of the Project. It will therefore be important that the general mitigation measures contained in the CNVMP (Appendix C) are implemented on site and the best practicable options are chosen to control noise. Strict adherence to the CNVMP, frequent noise monitoring and liaison with residents will be required.

8.5.7 Waterview Primary School and Kindergarten

Waterview Primary School and Kindergarten are located in close proximity (approximately 150 metres) to Construction Yard 6 and approximately 100 metres from construction in Sector 7 in the vicinity of Great North Road. As the Construction Yard will be established and operated over the entire 5 year construction period, construction noise effects on the school and kindergarten are discussed in this section of the report.

Noise level predictions for the closest dwellings approximately 50 metres from Construction Yard 6 (refer Table 8-17 above) show that noise levels up to 68 dB $L_{Aeq(T)}$ are predicted. Waterview Primary School is approximately 150 metres from the yard, therefore, noise levels from the Construction Yard as received by the school are predicted to be at least 7 decibels lower due to increased distance.

In order to reduce noise effects and provide acoustic and visual shielding for the school, it is recommended that an acoustic fence be installed along the Herdman Street boundary. This would mean that the existing pool fence would need to be upgraded to a solid barrier, which can be undertaken by means of ply sheeting or similar, as discussed in Section 7.3 of this assessment. The resultant noise level reduction for classrooms will be in the order of 6 decibels, thus reducing the noise level at the facade of the closest classrooms to 55 dB $L_{Aeq(T)}$.

With windows open for ventilation, the internal noise level in these rooms is predicted to be 45 $L_{Aeq(T)}$ or less. This has been considered an acceptable internal noise level for classrooms in accordance with AS/NZ 2107:2000 "Acoustics – Recommended design sound levels and reverberation times for building interiors", and has been recommended by the Ministry of Education for another infrastructure project in the Auckland Region⁷.

During construction of the cut-and-cover part of the tunnel and the temporary realignment of Great North Road proposed for Sector 7, Waterview Primary School will be within 100 metres of the construction site, though partially shielded by intervening dwellings. When these dwellings are removed as part of the Project, alternative mitigation in the form of a substantial temporary acoustic barrier of approximately four metres in height could be installed along the southern school property boundary to provide an alternative for the shielding lost from the dwellings.

Nevertheless, for some construction activities that are required to be undertaken at grade (i.e. not below ground level in the cut) noise levels are predicted to be up to 60 dBA at the closest school buildings. However, these noise levels would occur only during limited times. It is recommended that these activities should be scheduled during school holidays, where practicable.

Where these measures will not be able to be implemented fully, there will be some times when external doors and windows will need to be kept shut in order to reduce internal noise levels to a reasonable level. If this is required for an extended period, alternative mitigation, such as mechanical ventilation, should be considered for the most affected classrooms to enable windows to remain shut.

Overall, with suitable mitigation, the noise effects on the school can be managed. Ongoing consultation and communication with the school will be important and required throughout the construction period.

Kindergartens are required to provide sleeping facilities for the children attending and internal noise criteria for sleeping areas (for houses near major roads) are 30 dB $L_{Aeq(T)}$ (satisfactory) and 40 dB $L_{Aeq(T)}$ (maximum). Construction noise in the vicinity of the Waterview Kindergarten is likely to exceed the internal noise criteria for sleeping areas at times, even with the implementation of the general mitigation measures noted above. Specific mitigation measures including the installation of mechanical ventilation in sleeping areas and barriers will be required. Nevertheless, at times, the recommended noise criteria may be exceeded. Relocation of the kindergarten may be considered as an alternative mitigation measure if other measures are not practicable.

⁷ Northern Busway

8.5.8 Specific Mitigation Measures

In addition to the general noise mitigation measures noted above and contained in the draft CNVMP (Appendix C), the following site specific noise mitigation measures will be required:

Table 8-18: Sector 5 Specific Mitigation Measures

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Contiguous bored piling Pad footing construction or pier construction Precast segment delivery, etc. Span finishing Sealing works 	Noise Barriers	<p>Where equipment is operating during the night-period and can be screened using temporary noise barriers, these should be located around noisy plant such as drilling, jack hammering, noisy hand tools, concrete slumping areas, cranes, concrete pumping plant, etc. to interrupt line-of-sight.</p> <p>Once the ramps are constructed, noise sensitive areas should be screened from sealing and finishing works using temporary noise barriers on the outside balustrade of the ramps.</p> <p>Operation restriction (as discussed below) may result in temporary noise barriers not being required for certain activities.</p>
	Night-time restriction of noisy activities	<p>There are four ramps in this area, which are all various distances from the nearest residential areas. Where practicable, noisy operation should be scheduled for daytime where operational areas are close to receivers or noise sensitive activities. Night time construction should be scheduled for ramp structures that are located further from residential areas. In general this will be Ramp 1, 3 and some parts of 4. The following provides recommended distances between dwellings and activities for night-time construction operation:</p> <p>Contiguous bored piling – 200m</p> <p>Pad footing construction or pier construction – 300m</p> <p>Precast segment delivery, etc. – 120m</p> <p>Span finishing – 120m</p> <p>Sealing works – 100m</p>
	Temporary resident relocation	<p>Where night construction must occur in close proximity to dwellings and no other mitigation measure is found to be practicable, affected residents may need to be temporarily relocated where noise levels are found to exceed the Table 5-5 criterion.</p> <p>This should be considered on a case-by-case basis for dwellings. The advice of a recognised acoustical consultant should be sought before the implementation of this measure.</p>

Activity	Mitigation Measures	Detail
Batch plant operation	Enclosure/operation	<p>Night-time operation of the batch plant within Construction Yard 6 will require the following noise mitigation measures to comply with the construction noise limits in NZS 6803:</p> <ul style="list-style-type: none"> • Batch plants located as far as possible from sensitive receivers; • Enclosure of mixing vessels or dry mixing hoppers; • Enclosure of conveyors; • Enclosure or screening of truck load-out area. • Truck slumping not at ground level where practicable; • Daytime operation of equipment such as loaders. Conveying of material to be used in preference to driven loaders; • Noise barriers located around concrete batch plant. • Batch plant designed and located such that reversing of trucks is not required; • Enclosure and treatment of other noisy equipment where identified; • Good driver and operator education regarding noise mitigation.
Construction Yard	Temporary Barriers	<p>In order to provide mitigation for the school to achieve suitable internal noise levels in classrooms, a 2.5 m high temporary barrier should be installed along the Herdman St boundary on top of the existing retaining wall. A 4 to 5 metre high barrier along the southern school boundary in the vicinity of teaching areas should be installed following the removal of the dwellings in Great North Road.</p>

Subject to the above mitigation measures, noise emissions from construction within Sector 5 can generally be managed to a reasonable level. If all practicable mitigation measures have been implemented and a reasonable external noise level cannot be achieved, alternative mitigation measures, such as the installation of mechanical ventilation (if windows are required to remain shut for extended periods to reduce internal noise levels) and temporary relocation of residents, should be considered on a case-by-case basis.

8.6 Sector 6 – SH16 to St Lukes

Construction in Sector 6 of the Project will include the widening of both sides of the existing SH16 to accommodate a bus lane. On the eastbound carriageway, widening will occur underneath the existing Carrington Road bridge, with retaining walls required to be demolished and re-established on both sides of the motorway.

Sector 6 runs adjacent to Chamberlain Park golf course and business/industrial land. Neither of these land uses is considered sensitive to noise. A limited number of dwellings are located on the southern (Sutherland Street and Parr Road South) and the northern (Great North Road and Parr Road North) side of SH16.

Permanent traffic noise barriers and bunds are proposed on the northern and southern side of the motorway to control noise from the motorway, with proposed heights up to 6 metres in some places.

8.6.1 Retaining Wall Construction

Existing retaining walls will be removed and reconstructed near the Carrington Road bridge. It is likely that the retaining walls along this section of motorway will consist of a soil nail reinforced wall (eastbound) and a bored pile wall (westbound).

Construction of the westbound retaining wall will occur adjacent to receivers on the south bank of the motorway, although these will be partially or fully screened from work by the edge of the cutting. On the eastbound side of the motorway, construction of the retaining wall will occur adjacent to commercial receivers.

The retaining wall works will require some rock breaking as well as piling. The bored pile wall on the westbound lane is closest to residential and commercial receivers.

A fill embankment is also proposed between chainage 1630 and 1810 (refer Plan No. 110 and 111).

8.6.2 Road Construction and Sealing

Road construction and sealing within Sector 6 will involve typical road construction machinery creating a base course and providing a seal.

8.6.3 Traffic Noise Barrier and Bund Construction

Traffic noise barriers and bunds will be constructed on both sides of the motorway to a height of up to 6 metres. Bunds will be utilised where the total height of the barrier is greater than 5.5 metres.

It is likely that noise barrier construction will require piling in close proximity to dwellings for a brief period. Noise barriers will be constructed from precast panels, which will be manufactured off-site and craned in to place. This construction method is relatively fast and will therefore reduce noise impact on residents in the vicinity. If it is practicable that the noise barriers can be constructed early in the programme, they will provide a good level of acoustic screening from construction noise.

8.6.4 Construction Yards

There will be a one construction yard within Sector 6 (Construction Yard 5 – Meola Creek). Activities occurring in the construction yard will include: storage and parking of machinery, administration offices and similar

activities. Lime drying of soils may also be undertaken at this construction yard, which will involve the spreading of soil and the addition of lime powder.

8.6.5 Calculated Noise Emissions

The following tables provide a summary of activities and predicted noise levels for construction in Sector 6. All noise predictions are for a circumstance where specific or general noise mitigation has not been implemented on site. Therefore, noise levels from the activity would generally be lower than shown in the tables once noise mitigation measures such as barriers and enclosures are implemented; the predicted noise levels in the tables represent the highest noise level likely to be received from the construction site without any mitigation.

Table 8-19: Sector 6 Road Construction

Activity	Est. Durat. (12 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Retaining Wall Structure (west bound)	~8 months	Day	Vibration piling rig Auger drilling rig Concrete trucks Boom cranes Drilling rig On road trucks Group L_{AW}	120 113 106 106 - 112 112 - 117 95 - 105 114	Sutherland Road (25m)	78	58
Construction of additional lanes	~4 months	Day/night	Asphalt paver Rollers (vib.& non-vib.) Off road trucks On road trucks Water cart Kerbing machine Concrete trucks Concrete pumps Concrete vibrator Rock Breakers/Picks Group L_{AW}	110 - 114 102 - 105 95 - 105 95 - 105 105 - 110 99 - 104 100 - 106 102 112 - 116 120 - 125 113	Sutherland Road (25m)	77	57

Table 8-20: Sector 6 Noise Barrier Construction

Activity	Est. Durat. (12 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Noise Barriers	<1 month (task)	Day	Auger drilling rig Concrete trucks Boom cranes On road trucks Group L_{AW}	113 106 106 - 112 95 - 105 110	Sutherland Road (~10m)	82	63

Table 8-21: Sector 6 Construction Yards

Activity	Est. Durat.	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
5- Meola Creek Road Builder Yard	Until completion of Sector – approx. 12 months	Day/Night	Laboratory Vehicle movements Material handling Lime drying Group L_{AW}	<90 95 – 105 100 – 115 100 – 107 100	Great North Road (~20m)	66	58

8.6.6 Discussion

Noise levels from wall construction, piling and road construction have the potential to exceed the daytime and night-time Project noise criteria where construction is occurring close to dwellings and no noise barriers (or other mitigation) are in place. However the average level of noise at any receiver is predicted to comply with the daytime Project noise criteria, and when average distances and acoustic screening is taken into account, compliance with the night-time Project criteria can also be achieved.

Recommended noise mitigation includes the early construction of operational (traffic) noise barriers if practicable. As an alternative, temporary noise barriers should also be considered around noisy operations. Subject to the recommended mitigation above, and the implementation of specific mitigation measures below, construction noise levels can be reduced significantly at dwellings and are predicted to comply with the Project noise criteria of Section 5.6 above.

Where these measures are not practicable, and night-time construction cannot be avoided, activities should be scheduled to ensure that noisy activities do not occur immediately adjacent to residents. Where all practicable mitigation measures have been considered and noise levels remain above the Project night-time noise criteria, alternative mitigation measures, such as temporary relocation of residents, may need to be considered on a case-by-case basis.

8.6.7 Specific Mitigation Measures

In addition to the general noise mitigation measures contained in Section 7 of this document and the draft CNVMP (Appendix C), the following site specific noise mitigation measures are recommended for Sector 6:

Table 8-22: Sector 6 Specific Mitigation Measures

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Retaining Wall Construction Construction of additional lanes 	Noise barriers	<p>As substantial traffic noise barriers are required in this Sector, the installation of these noise barriers should be programmed for construction early in the construction period if practicable. If this is not practicable, localised screening around noisy equipment or screening at property boundaries will be required. Temporary barriers should be used either at the source of the noise (around the construction site) or near the receiver (the nearby residential boundary).</p> <p>This measure should be sufficient to achieve compliance with construction criteria. If this measure is not practicable, other measures should be considered.</p>
	Night-time restriction of noisy activities	Noisy activities should be programmed to occur during the daytime, with night-time activities restricted to quieter activities. Where these construction activities must occur during the night-period, works should be scheduled to ensure that operation nearest to dwellings occurs during daytime, with night-time operation located as far from dwellings as possible.
	Temporary resident relocation	<p>Where night construction must occur in close proximity to dwellings and no other mitigation measure is found to be practicable, affected residents may need to be temporarily relocated where noise levels are found to exceed the Table 5-5 criterion and where the duration of the relocation is reasonable.</p> <p>This should be considered on a case-by-case basis for dwellings. The advice of a recognised acoustical consultant should be sought</p>
<ul style="list-style-type: none"> Construction Yard 	Site hoarding	<p>Surround site with solid hoarding where this will provide line of sight screening to nearby receivers. This would be required only on the western and northern sides of the yard.</p> <p>Restrict equipment movement to daytime hours where practicable. Limit operation of material handling and lime drying on site during the night time period.</p>

Subject to the implementation of the above mitigation measures, noise emissions are predicted to comply with the relevant Project noise criteria set out in Section 5.6 of this report. If the recommended mitigation measures are not practicable, and a reasonable external noise level cannot be achieved, alternative mitigation measures, such as mechanical ventilation (to enable windows to remain shut for extended periods) and temporary relocation of residents, should be considered on a case-by-case basis.

8.7 Sector 7 – Great North Road Underpass

Sector 7 involves the construction of two cut-and-cover tunnels beneath Great North Road from Great North Road Interchange to connect to the deep tunnels in Sector 8.

It is anticipated that construction in this Sector will be of reasonably long duration and involve significant construction activity. Works will be required to occur during night-time due to constraints on traffic diversion on Great North Road. A large extent of earthworks is likely to be required.

Construction will occur close to dwellings within the Waterview suburb. Dwellings on Oakley Avenue, and Alford Street will be located in close proximity to the construction. Waterview Primary is also located close to the construction that will occur in and around the cut-and-cover tunnel and the ventilation building.

8.7.1 Cut-and-Cover Tunnelling / Great North Road Underpass

Cut-and-cover tunnelling involves the cutting of a “trench” which is subsequently roofed. A strong overhead support system is required to carry the load of the covering material, roads or other transportation systems. For the Project, the tunnel roof will support Great North Road, and hence the structure will be substantial.

The method that will be used to construct the cut-and-cover tunnel is currently expected to consist of a combination of top-down and bottom-up construction. This would involve the construction of side support walls and capping beams through diaphragm wall construction methods. The tunnel will be partially excavated and the tunnel roof will then be constructed from concrete structures (precast or insitu poured concrete). This method will allow Great North Road to be diverted and the remainder of the tunnel completed without closure of Great North Road. Excavation machinery will then excavate under the tunnel roof to complete the tunnel.

A vent building will also be constructed in Sector 7, which will involve piling around the perimeter of the building and then excavating from within as the building will be partially below ground. The building will then be constructed in this excavated area using precast sections craned into place.

8.7.2 Construction Yards

There will be a construction yard in Sector 7 (Construction Yard 7 – Oakley Creek Reserve). Activities occurring in the construction yard will primarily relate to the driven tunnel operation (Sector 8) and include the following activities: storage and parking of machinery, administration offices and other activities of a similar nature.

8.7.3 Calculated Noise Emissions

The following tables provide a summary of activities and predicted noise levels for construction in Sector 7. All noise predictions are for a circumstance where specific or general noise mitigation has not been implemented on site. Therefore, noise levels from the activity would generally be lower than shown in the tables once noise mitigation measures such as barriers and enclosures are implemented; the predicted noise levels in the tables represent the highest noise level likely to be received from the construction site without any mitigation.

Table 8-23: Sector 7 Great North Road Underpass

Activity	Est. Durat. (24 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Great North Road Realignment	~4 months	Day /night	Asphalt paver Rollers (vib.& non-vib.) Off road trucks On road trucks Water cart Kerbing machine Concrete trucks Concrete pumps Concrete vibrator Rock Breakers/Picks Group L_{AW}	110 - 114 102 - 105 95 - 105 95 - 105 105 - 110 99 - 104 100 - 106 102 112 - 116 120 - 125 113	Oakley Ave (~10m) Alford St (~10m)	85	75
Retaining wall Structure	~16 months	Day/ night	Trench cutter Concrete trucks Boom cranes Drilling rig On road trucks Group L_{AW}	108-110 106 106 - 112 112 - 117 95 - 105 112	Oakley Ave (~30m) Alford St (~30m)	74	54
Excavation	~8 months	Day /night	Excavator Off road trucks Group L_{AW}	109 - 115 95 - 105 110	Oakley Ave (~30m) Alford St (~30m)	72	52
Tunnel Roof Construction	~8 months	Day/night	Boom Crane On road trucks Concrete trucks Group L_{AW}	106 - 112 95 - 105 106 107	Oakley Ave (~20m) Alford St (~20m)	73	53
Road Construction and surfacing (underground)	~4 months	Day/night	Asphalt paver Rollers (vib.& non-vib.) Off road trucks On road trucks Water cart Kerbing machine Concrete trucks Concrete pumps Concrete vibrator Group L_{AW}	110 - 114 102 - 105 95 - 105 95 - 105 105 - 110 99 - 104 100 - 106 102 112 - 116 113	Excavation occurs under capping	<40	<40
Vent Building	~12 months	Day/night	Soldier piling Crane On road trucks Hand held tools Group L_{AW}	120 106 - 112 95 - 105 101 - 110 114	Oakley Ave (~20m)	80	68

Table 8-24: Sector 7 Construction yard

Activity	Est. Durat.	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
7 - Oakley Creek Reserve Tunnel Construction	5 years	Day/Night	Vehicle Movements Material handling Vent bldg operations Group L_{AW}	95 - 105 100 - 115 100 - 110 105	Alford Street (~50m)	65	59

8.7.4 Discussion

In Sector 7, noisy activities will occur close to noise sensitive receivers at some locations. The above tables show that noise sources, without the implementation of mitigation, have the potential to exceed the daytime and night-time Project construction noise criteria.

For above ground construction, daytime operation is recommended wherever possible, as night-time operation adjacent to receivers would cause excessive noise levels at nearby dwelling facades. Temporary noise barriers will be required for noisy operation.

Whilst high noise levels can be mitigated to a certain extent, through the strict implementation of the general and specific mitigation measures for this Sector, achieving the Project night-time noise criterion of 60 dB $L_{Aeq(T)}$ will nonetheless be difficult.

Potential alternative noise mitigation measures involve constructing the cut-and-cover tunnel predominantly using the top-down methodology. This will allow for noisy excavation activities to be conducted predominantly below ground. Once the tunnel roofing is constructed, excavation below ground will be well shielded and result in reduced noise levels at nearby receivers which will be readily compliant with the daytime and night-time Project noise criteria.

Specific activities that will generate high noise levels are:

- Realignment of Great North Road;
- Vibropiling/rammed piling;
- Rock excavation (if necessary);
- Road construction near receivers;
- Ventilation building construction.

All of the above have the potential to generate noise levels that would exceed the daytime and night-time Project noise criteria if sufficient mitigation is not implemented. The following section details specific noise mitigation measures recommended to reduce noise levels as far as practicable.

8.7.5 Specific Mitigation Measures

In addition to the general noise mitigation measures contained in Section 7 of this report and the draft CNVMP (Appendix C), the following site specific noise mitigation measures should be implemented:

Table 8-25: Sector 7 Specific Mitigation Measures

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Cut and cover tunnelling 	Top-down construction	If practicable, using a top-down construction (where the tunnel capping is constructed early in the programme) will result in subsequent below ground night-time operation generally complying with the Project criteria.
<ul style="list-style-type: none"> Great North Road realignment Retaining wall construction Ventilation building construction Construction Yard 7 	Night-time restriction of noisy activities	All noisy above ground activity (i.e. pre- tunnel capping) should be performed during the day-period where practicable. Above ground night-time operation should be avoided. If above ground night-time operation is required, other noise mitigation measures such as noise barriers and/or resident relocation will be necessary.
	Noise Barriers	For noisy operation occurring at ground level during the day-time and night-time periods, provide temporary noise barriers between noisy sources and nearby receivers. This should involve the construction of a solid hoarding around above ground activity. These barriers can be constructed from plywood where such a measure will provide line-of-sight screening between source and receiver.
<ul style="list-style-type: none"> Great North Road realignment Retaining Wall Structure 	Temporary resident relocation	<p>Where noisy construction techniques are critical and must occur during night time, and noise effects are shown to be significant (i.e. noise levels above the Table 5-5 criteria), residents in the vicinity may need to be temporarily relocated to quiet accommodation. This should be considered on a case-by-case basis.</p> <p>Such measures should only be considered after all other practicable noise control options have been considered.</p>

Subject to the above measures, it is considered that noise effects from construction activities in Sector 7 can be mitigated, either through the implementation of adequate noise reduction measures or through the temporary relocation of affected residents. The effects and possible mitigation measures relating to Waterview Primary School are discussed in Section 8.5 above.

8.8 Sector 8 – Avondale Heights Tunnel

8.8.1 Construction Activity Overview

The Sector 8 alignment is in two ‘deep tunnels’ (one three-lane tunnel in each direction), connecting the cut-and-cover tunnel beneath Great North Road (Sector 7) with Alan Wood Reserve (Sector 9), passing beneath Avondale Heights/ Springleigh, the North Auckland Rail Line and New North Road.

The closest receivers in this Sector will be those located directly above the tunnel construction. These are mainly residential dwellings located to the east of Blockhouse Bay Road and Great North Road.

The construction methodology for the tunnelling is expected to involve one or a combination of the following:

- **Road header tunnelling:** This involves the use of a road header to provide the initial excavation. A road header is essentially a cutting head on a hydraulic arm which progressively removes material by sweeping back and forth across the face. Excavated material can be removed by truck or conveyor. It is likely that a road header would be used at both ends of each tunnel, requiring four in total.
- **Conventional excavator/face shovel:** This involves the use of conventional excavation machinery such as hydraulic excavators and trucks.

For both methodologies, fill is removed by conveyor to construction yards at both the north and south end.

As the exact construction methodology is not yet known, the effects of both potential tunnel methodologies have been assessed. Regardless of the construction methodology used, it is likely that the construction will proceed from both ends of the tunnel and meet in the middle. The tunnels will be constructed either sequentially or simultaneously at slightly staggered positions.

As the tunnelling occurs below ground, airborne noise will be readily attenuated by the intervening rock and earth layers. Noise arising from tunnelling operation within receiver buildings is generally due to re-radiated noise from vibrating structures, which is in turn dependent on the specific ground conditions between the tunnel machinery and the receivers and the cover thickness of ground above the construction. As discussed in Section 5.2.2, it is recommended that the re-radiated noise be assessed using the WHO internal noise guidelines of 30 dB $L_{Aeq(8hr)}$ inside at night and 35 dB $L_{Aeq(16hr)}$ inside during the day.

Above ground noise due to underground drilling activity is sometimes noticeable both through re-radiated noise through the building structure and vibration induced noise (e.g. rattling of cabinetry in the building). The effects of vibration are discussed in a separate report (Technical Report G19 ‘Assessment of Vibration Effects’).

Re-radiated noise levels due to vibration have been predicted based on the expected levels of vibration contained in Technical Report G19 ‘Assessment of Vibration Effects’. However, the level of re-radiated noise is dependent on ground conditions and the radiation efficiency of building elements, which is difficult to determine with certainty. Predictions have been based on road header tunnelling vibration measurements at St Mathews Church in Auckland City during the Vector tunnelling project. These measurements showed that the

vibration level for a road header at 46 metres below ground was no greater than 0.2mm/s PPV. Actual vibration levels due to construction may have been well below this level, with the measured vibration actually being caused by activities such as passing traffic and similar everyday activities. Based on these levels it is calculated that noise levels in Sector 8 due to re-radiated noise from road header tunnelling will be around 30 to 40 dB $L_{Aeq(T)}$ assuming a radiation efficiency of building elements of 0.4 – 0.5.

Measurements of tunnelling operation using excavators are not available as source data. However, the Technical Report G19 'Assessment of Vibration Effects' includes reference to data contained in BS 5228-2:2009 which have been used to predict vibration levels. This suggests that the vibration effects from tunnelling using excavation machinery will result in lower vibration levels – and hence lower re-radiated noise levels – than road header tunnelling.

Other noise sources within the tunnel will include shotcrete spraying of the walls to provide temporary structural support and concreting of each section of tunnel once excavated. It is expected that each tunnel section will be concreted using in-situ concrete pours in 12 metre long sections. Ventilation will also be required in the tunnel. The ventilation plant will be located at the tunnel face and ducted to the tunnel opening.

A conveyor is required for the transport of excavated material outside on a 24 hour, 7 days per week basis, however, this can be enclosed to achieve compliance with the night-time noise criteria.

Noise received by residential areas near the tunnel portals will reduce as equipment progresses further into the tunnel, due to air and tunnel wall absorption, distance attenuation and directivity effects.

The construction of the emergency ventilation building and stack will potentially require delivery of some materials by helicopter to an area in the vicinity of Cradock Street. As closest dwellings are within 50 metres of the site, and shielding of helicopters is not practicable, deliveries will be notified in writing to residents within 200 metres of the site.

8.8.2 Calculated Noise Emissions

The following table provide a summary of activities and predicted noise levels for construction in Sector 8. All noise predictions are for a circumstance where specific or general noise mitigation has not been implemented on site. Therefore, noise levels from the activity would generally be lower than shown in the tables once noise mitigation measures such as barriers and enclosures are implemented; the predicted noise levels in the tables represent the highest noise level likely to be received from the construction site without any mitigation.

Table 8-26: Sector 8 - Tunnelling

Activity	Est. Durat.	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Above tunnel boring	Tunnel portal (Hendon Avenue)
Tunnel Boring	4.5 years (task)	Day/night	Road Header	110 dB (operator position)	All receivers directly above tunnel boring route (Harlston, Powell, Cradock, Ennismore, New North Roads, depths 7 to 40 m below ground level) Receivers near mouth of tunnel (Hendon Ave)	30 – 40	50 At receiver facades
			Excavator/Face Shovel	109 - 115 dB L_{Aw} (free field)			
			Road Trucks	98 - 110 dB L_{Aw} (free field)			

Table 8-27: Sector 7 Construction yard

Activity	Est. Durat.	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Helicopter Delivery	< 1 week	Day	Helicopter	125 – 135 dB L_{Aw}	Dwellings within 200 metres of landing area	95	95

8.8.3 Discussion

Based on the above assessment, noise levels are predicted to comply with the Project daytime construction noise criterion of 70 dB $L_{Aeq(T)}$ for operations occurring at the tunnel portal. Noise from tunnelling operation near the tunnel face has the potential to exceed the night-time noise criteria for Sectors 8 and 9, however, as tunnelling deepens, noise emissions are predicted to reduce to below the noise limits.

Re-radiated noise levels may exceed the WHO guidelines for internal noise during the night-period (30 dB $L_{Aeq(8hr)}$). During the daytime, noise levels may just exceed the WHO Guideline (35 dB $L_{Aeq(16hr)}$).

As the predictions are very sensitive to ground conditions and the radiation efficiency of dwellings, the actual level of re-radiated noise and vibration may vary somewhat along the alignment and from dwelling to dwelling. It is therefore important that noise and vibration monitoring is performed at the start of the tunnelling to determine if internal noise and/or vibration limits can be complied with. If the limits are exceeded, temporary

relocation of residents may need to be considered during times when the tunnelling equipment operates in close proximity, particularly for night time construction.

Helicopter deliveries are predicted to exceed the daytime noise criteria. Noise mitigation of helicopter flight is not practicable in an urban environment with a large number of dwellings, therefore, management should be undertaken through scheduling and timing. Advance notification of residents will be required, similarly to blasting.

8.8.4 Specific Mitigation Measures

In addition to the general noise mitigation measures contained in Section 7 and in the draft CNVMP (Appendix C), the following site specific noise mitigation measures are recommended.

Table 8-28: Sector 8 Specific Mitigation Measures

Activity	Mitigation Measures	Detail
Tunnelling	Choice of methodology	It is not known if road headers or conventional excavators/trucks will be used for the excavation of the tunnelling. It is likely that conventional excavator/trucks will result in lower levels of reradiated noise due to vibration. This should be considered in the selection of an appropriate methodology.
	Daytime operation	At the start of the operation, noise levels from tunnelling are expected to be above the Project night-time noise criteria. Where the tunnelling has not yet progressed deep inside the tunnel, a restriction to daytime operation may be required until sufficient depth is obtained to mitigate noise to below the Project criteria.
	Tunnel breakout noise control	At the start of the operation, noise levels from tunnelling are expected to be above the Project night-time noise criteria. If night-time operation is required, noise emissions may be reduced through the provision of baffles or acoustic screens at the tunnel portal. (Continued overleaf)

Activity	Mitigation Measures	Detail
Tunnelling (Continued)	Resident relocation	If internal noise levels are unreasonable due to re-radiated noise inside receivers, provide temporary relocation of residents. It is expected that this relocation may be required for up to 7 days at the most affected locations. Unreasonable levels of noise shall be determined through evaluation of noise level (refer to Section 5.2.2 and evaluation of vibration levels and criteria).
	Monitoring	Levels of noise should be monitored at receivers from the beginning of the tunnelling operation and as needed throughout. Data obtained should be used to update the required noise mitigation measures.
Above ground activity	Conveyors	Conveyors between the construction face and the construction yards should be selected to be as quiet as possible as these will operate 24 hours per day. Conveyors may require enclosure.
Helicopter Delivery	Scheduling	Helicopter delivery of materials shall occur for no more than 10 times in any month. Residents within 200 metres shall be notified in advance of the helicopter delivery schedule, and a tight timeframe maintained for deliveries.

Subject to the above it is predicted that noise emissions can be managed and mitigated to comply with the relevant Project criteria. If the implementation of the recommended mitigation measures is not practicable, noise effects should be mitigated through alternative measures, such as temporary relocation of residents during times when the tunnelling occurs immediately below.

8.9 Sector 9 – Alan Wood Reserve

Sector 9 of the Project involves the construction of a surface road between the southern portal of the tunnel and the interchange with the existing Mt Roskill section of SH20 at Maoro Street. Activities within this Sector occur mainly during the daytime. Activities likely to involve noisy construction include:

- Construction of the southern tunnel portal, including the ventilation building
- Richardson Road underpass and bridge
- Roding construction along the route

- Construction of the Hendon Avenue pedestrian bridge
- Construction yards including crushing and concrete batching

The alignment between the Avondale Heights Tunnel (Sector 8) and the Maoro Street Interchange is 'at-grade', overlapping the existing land set aside for rail (the Avondale Southdown Line Designation), for a length of around 900m. Richardson Road will be bridged across the State highway and north-facing ramps will be built at the Maoro Street Interchange to provide local traffic access to SH20 northbound.

This section will largely be constructed in existing parkland and open space associated with the existing rail designation. Dwellings on Hendon Avenue, Methuen Road, Valonia Street and Ernie Pinches Street will all be located close to construction, and some dwellings will be removed for construction purposes.

8.9.1 Southern Tunnel Portal

The construction of the southern tunnel portal essentially involves excavating a large ramp down to the southern tunnel portal. This will require the existing basalt rock layer to be excavated and removed, either by drilling and splitting of the rock layer or through blasting. The basalt layer will then be strengthened through retaining measures such as ground anchors and shotcrete. Once the basalt overburden is removed, a continuous reinforced concrete retaining wall will be constructed to retain the soft ground below. This is likely to involve vibropiling methods. These piles will be tied back into the ground behind through the use of ground anchors and then faced with precast concrete panels.

Prior to the above construction, a grout curtain will be constructed within the basalt layer. This will involve the rotary percussive drilling of holes and the backfilling of these holes using grout under high pressure. Subsequent to the completion of the portal, a vent building will be constructed above the tunnel entrance using precast concrete sections and normal building construction methodologies.

8.9.2 Maoro Street / Richardson Road Underpass and Retaining Walls

Sector 9 will involve the construction of an underpass beneath the existing Richardson Road by means of a bored pile retaining structure and the subsequent excavation of earth. This structure will be capped and tied into the ground behind using ground anchors. The retaining wall will be covered in shotcrete and faced with precast panels. A bridge will then be constructed over the underpass to complete the works.

8.9.3 Traffic Noise Barrier Construction

Permanent traffic noise barriers will be constructed on the north and south sides of the motorway to acoustically screen some receivers on Hendon Avenue, Methuen Road, Richardson Road and other nearby roads. Noise barriers of up to 5 metres in height are proposed.

Noise barriers will be constructed from precast panels, which will be manufactured off-site and craned into place. The construction method will ensure a fast completion of the works thus reducing potential noise

impacts on residents. If it is practicable, the noise barriers should be constructed early in the construction programme as they will provide a good level of acoustic screening from construction of parts of the surface road.

8.9.4 Construction Yards

There will be five construction yards in Sector 9. Activities occurring in the construction yards include: storage and parking of machinery; stockpiling of material; concrete batching operations (including truck deliveries and load out), administration offices and other activities of a similar nature. Specific activities proposed in each area are as follows:

- **Construction Yard 8 (Alan Wood Park) – Mechanical Plant Storage and Staging:** mechanical plant parking/mobilisation area, storage and laydown areas, waste management, etc.
- **Construction Yard 9 (Alan Wood Park) – Driven Tunnel Operation:** offices and ablutions, storage, stockpiles and storage of waste and spoil.
- **Construction Yard 10 (Alan Wood Park) – Driven Tunnel Operation:** offices and ablutions, laboratory, concrete batching plant, and general storage.
- **Construction Yard 11 (Hendon Park) - Piling Operation Yard:** offices, a small laboratory and general storage/Construction yard.
- **Construction Yard 12 (Valonia Street) - Builders Yard:** offices and general storage/general Construction yard.

Of the above activities, the concrete batch plant located in Construction Yard 10 will require the most significant noise mitigation and management as this plant will be required to operate as necessary both day and night.

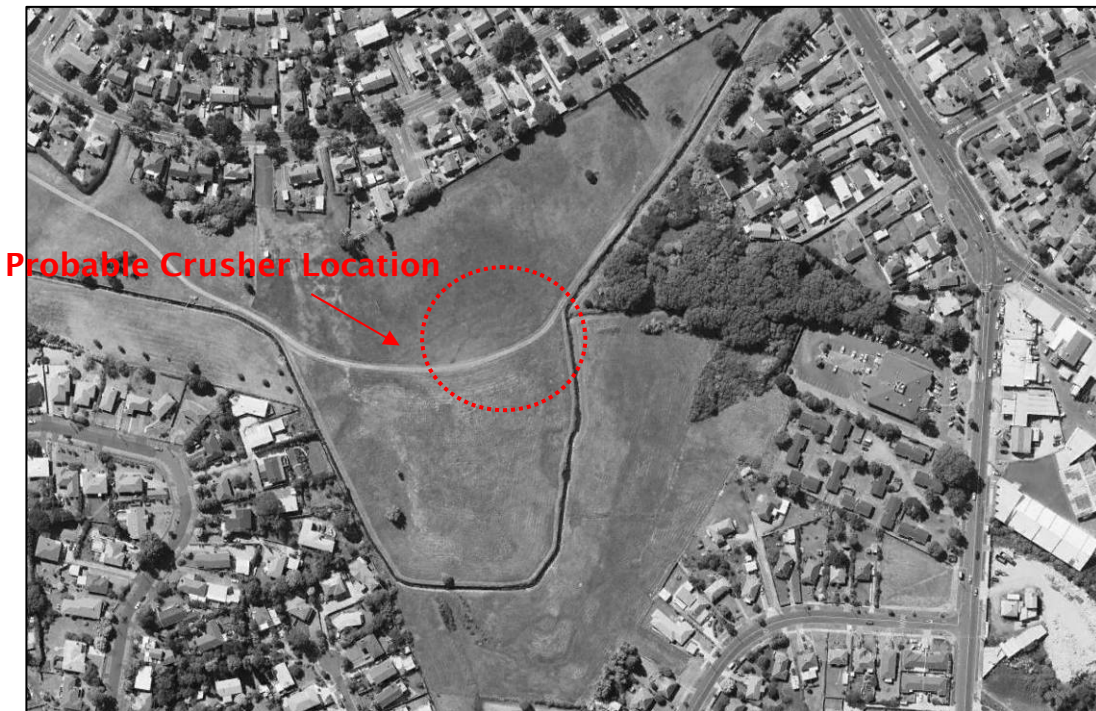
It is also proposed to crush basalt to enable it to be carted offsite. The rock crusher will be located in Hendon Reserve and will generate high noise levels at closest residences; however, crushing will occur during the daytime only.

The following figures show the proposed location of these activities:

Figure 1: Construction Yard 10 Batch Plant Location



Figure 2: Probable Crusher Location



8.9.5 Hendon Avenue Pedestrian Bridge

The foundations of Hendon Avenue bridge will be constructed from precast superstructure on concrete piers. The bridge itself will be constructed from steelwork and will comprise a 4-leg arch structure with a suspended steel deck. The bridge will be supported on a combination of spread footings onto basalt and bored concrete piles into the East Coast Bays rock formation (ECBF). The piles will be constructed by driving a casing through the overlying materials and the soil will be extracted by auger. The spread footings will be constructed by excavating to the top of the basalt and casting the footings insitu. The steel superstructure will be erected by crane located adjacent to the spans. The approach spans will comprise precast concrete deck spans which will be erected by crane

8.9.6 General Road Construction

Construction of the surface road will occur along the length of Sector 9 and will involve typical road construction equipment including: road (and potentially off road) trucks, compactors, rollers (vibratory, multi tyred and steel), concrete trucks, kerbing machines, asphalt paving plant, water trucks, graders and other ancillary plant such as generators, compressors, hand tools and miscellaneous other plant.

8.9.7 Calculated Noise Emissions

The following tables provide a summary of activities and predicted noise levels for construction in Sector 9. All noise predictions are for a circumstance where specific or general noise mitigation has not been implemented on site. Therefore, noise levels from the activity would generally be lower than shown in the tables once noise mitigation measures such as barriers and enclosures are implemented; the predicted noise levels in the tables represent the highest noise level likely to be received from the construction site without any mitigation.

Table 8-29: Sector 9 - Southern Tunnel Portal

Activity	Est. Durat. (18 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Topsoil removal/site preparation	~1 month	Day	Excavators/face shovel Off road trucks On road trucks Group L_{AW}	109 - 115 98 - 110 95 - 105 110	Receivers south of Hendon Ave (~20m)	76	68
Basalt Rock Breaking	~6 months	Day	Drilling rigs Explosive charges Rock breakers/picks Excavators/Face shovel Off road trucks Crushing plant Groundwater pumps Group L_{AW}	112 - 123 ref. elsewhere 120 - 125 109 - 115 95 - 105 100 - 117 90 - 100 118	Receivers south of Hendon Ave (~40m)	78	68* - 73**
Grout Curtain	~1 month	Day	Pneumatic percussion drilling Grout pumps Group L_{AW}	115 - 125 106 118	Receivers south of Hendon Ave (~20m)	84	77
Retaining Wall Structure	~12 months	Day	Vibration piling rig Auger drilling rig Concrete trucks Boom cranes Drilling rig On road trucks Group L_{AW}	120 113 106 106 - 112 112 - 123 95 - 105 114	Receivers south of Hendon Ave (~40m)	64*	59*
Vent Building	~12 months	Day	Boom Crane On road trucks Hand held tools Group L_{AW}	106 - 112 95 - 105 101 - 110 105	Receivers south of Hendon Ave (~50m)	60**	50*
Ground excavation / Drainage	~12 months	Day	Excavators/face shovel Trucks Off road trucks Group L_{AW}	109 - 115 98 - 110 95 - 105 110	Receivers south of Hendon Ave (~50m)	58*	53*
Road Construction and surfacing	~4 months	Day	Asphalt paver Rollers (vib.& non-vib.) Off road trucks On road trucks Water cart Kerbing machine Concrete trucks Concrete pumps Concrete vibrator Group L_{AW}	110 - 114 102 - 105 95 - 105 95 - 105 105 - 110 99 - 104 100 - 106 102 112 - 116 113	Receivers south of Hendon Ave (~50m)	61*	56*

* assumes full line-of-sight screening

** assumes partial line-of-sight screening

Table 8-30: Sector 9 - Richardson Road Underpass and Maioro Road Retaining Walls

Activity	Est. Durat. (12 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Topsoil removal/site preparation	~1 month	Day	Excavators/face shovel Off road trucks On road trucks Group L_{AW}	109 - 115 98 - 110 95 - 105 110	Receivers on Valonia and Ernie Pinches St (~70m)	65	62
Retaining Wall Structure	~8 months	Day	Auger pile drilling rig Concrete trucks Boom cranes Drilling rig On road trucks Drilling rig Group L_{AW}	113 106 106 - 112 112 - 117 95 - 105 112 - 123 110	Receivers on Valonia and Ernie Pinches St (~70m)	65	52*
Ground excavation / Drainage	~3 months	Day	Excavators/face shovel Trucks Off road trucks Group L_{AW}	109 - 115 98 - 110 95 - 105 110	Receivers on Valonia and Ernie Pinches St (~70m)	55*	47*
Road Construction and surfacing	~4 months	Day	Asphalt paver Rollers (vib.& non-vib.) Off road trucks On road trucks Water cart Kerbing machine Concrete trucks Concrete pumps Batch plant Concrete vibrator Group L_{AW}	110 - 114 102 - 105 98 - 110 95 - 105 105 - 110 99 - 104 100 - 106 102 110-115 112 - 116 113	Receivers on Valonia and Ernie Pinches St (~70m)	58*	50*

* assumes full line-of-sight screening

Table 8-31: Sector 9 - Richardson Road Bridge

Activity	Est. Durat. (12 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Bridge pad spread footing construction or pier construction	~4 months	Day/night	Drill Rig Excavator Trucks Concrete Truck Concrete Vibrator Skillsaw Generator Air compressor Crane Concrete Pump Rock Breaking Group L_{AW}	111 - 125 109 - 115 98 - 110 96 - 106 112 - 116 108 - 112 100 - 110 75 - 85 100 - 115 106 - 108 120 - 125 118	Richardson Rd and Valonia St (~80m)	62*	60*
Precast segment delivery, craning of segments into place, installation and tensioning of segments	~4 months	Day / night	Straddle Carrier Low Loader Launching Gantry Crane Hydraulic Pumps Hydraulic winches Generator Hydraulic jacks Concrete pump Concrete vibrators Grinder Segment carrier On road trucks Concrete trucks Group L_{AW}	100 - 105 101 - 112 81 - 91 106 - 112 106 - 108 100 - 110 100 - 110 100 - 120 102 112 - 116 120 - 122 95 - 105 95 - 105 106 110	Richardson Rd and Valonia St (~80m)	64	62
Span finishing and barrier installation (if required, refer traffic noise assessment)	~4 months	Day/ night	Cherry Picker Air compressor Jack hammer Generator Grinder Skillsaw Hiab truck Group L_{AW}	104 - 110 75 - 85 110 - 122 100 - 110 120 - 122 102 - 112 100 - 110 110	Richardson Rd and Valonia St (~80m)	64	62
Surfacing	~1 month	Day /Night	Trucks Asphalt spreader Drum roller Group L_{AW}	98 - 110 110 - 114 96 - 105 108	Richardson Rd and Valonia St (~80m)	62	60

* assumes full line-of-sight screening

Table 8-32: Sector 9 Noise Barrier Construction

Activity	Est. Durat.	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Noise Barriers	<1 month	Day	Auger drilling rig Concrete trucks Boom cranes On road trucks Group L_{AW}	113 106 106 - 112 95 - 105 110	Methuen Rd (~50m)	68	62

Table 8-33: Sector 9 – Construction Yards

Construction Yard	Est. Durat.	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
8 – Alan Wood Park Mechanical Plant Staging	5 Years	Day	Vehicle movements Material Handling Group L_{AW}	95 – 105 100 – 115 100	Hendon Ave (~20m) and Bollard Ave (~20m)	66	58
9 – Alan Wood Park Driven Tunnel Operation	5 Years	Day/Night	Vehicle Movements Material handling Vent building ops. Group L_{AW}	95 – 105 100 – 115 100 – 110 105	Hendon Ave (~20m) and Bollard Ave (~20m)	66	58
10 – Driven Tunnel Operation Alan Wood Park	5 Years	Day/Night	Concrete batch plant Concrete trucks Laboratory Vehicle movements Material handling Group L_{AW}	110 – 115 106 <90 95 – 105 100 – 115 115	Methuen Rd (~50m)	71	58 concrete batch plant not operating
11- Hendon Park Piling operation yard	5 years	Day	Laboratory Vehicle movements Material handling Group L_{AW}	<90 95 – 105 100 – 115 90	Hendon Avenue (~10m)	62	46
12 – Valonia Street Builders yard	5 years	Day	Vehicle movements Material handling Group L_{AW}	95 – 105 100 – 115 90	Richardson Rd (~40m)	50	44
Hendon Reserve Crushing Area	6 months to 1 year	Day	Crusher	125	Hendon Ave (~100m) Methuen Rd (~100m)	77	75

Table 8-34: Sector 9 – Roading Construction

Activity	Est. Durat.	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Topsoil removal/site preparation	~1 month	Day	Excavators/face shovel Off road trucks On road trucks Group L_{AW}	109 – 115 98 – 110 95 – 105 110	Varies along route. Typically 30 - 60 m	73	60
Road Construction and surfacing	~12 months	Day	Asphalt paver Rollers (vib.& non-vib.) Off road trucks On road trucks Water cart Kerbing machine Concrete trucks Concrete pumps Batch plant Concrete vibrator Group L_{AW}	110 – 114 102 - 105 98 - 110 95 - 105 105 - 110 99 - 104 100 - 106 102 110-115 112 – 116 113	Varies along route. Typically 30 - 60 m	75	62

Table 8-35: Sector 9 – Hendon Avenue Pedestrian Bridge

Activity	Est. Durat. (12 months total)	Day/Night	Equipment (add. equipment may be used)	Avg. Sound Power Level per unit (dB)	Closest receivers & min. est. distance from works	Noise level at closest receiver w/o mitigation $L_{Aeq(T)}$ dB	
						Max Avg.	Typ. Avg.
Foundation construction and support structure	~6 months	Day	Driven Piling Drill Rig Excavator Trucks Concrete Truck Concrete Vibrator Skillsaw Generator Air compressor Crane Concrete Pump Rock Breaking Group L_{AW}	120 111- 125 109 – 115 98 – 110 96 – 106 112 – 116 108 – 112 100 – 110 75 – 85 100 – 115 106 – 108 120 - 125 118	Hendon Ave (~100m) and Methuen Rd (~100m)	70	67
Bridge panel craning and other bridge finishing	~6 months	Day	Crane Hydraulic Pumps Hydraulic winches Generator Hydraulic jacks Concrete pump Concrete vibrators Grinder Segment carrier On road trucks Concrete trucks Group L_{AW}	106 – 112 106 – 108 100 – 110 100 – 110 100 – 120 102 112 – 116 120 – 122 95 – 105 95 – 105 106 110	Hendon Ave (~100m) and Methuen Rd (~100m)	62	59

8.9.8 Blasting

Blasting is likely to be required in Sector 9. Controlled blasting, though generally generating higher noise and vibration levels than other construction techniques, offers a less intrusive impact to surrounding premises due to the significantly shorter duration of works compared with alternative techniques, such as rock-breaking. Noise limits have been specified in Section 5.6 for controlled blasting and should be referenced when considering minimum safe distances. Detailed calculation of peak noise levels will be required before any blasting occurs to determine if and which receivers will be affected. These calculations shall be performed in accordance with AS 2187.2 Appendix J or an equivalent recognised method.

Blasting will be undertaken during daytime only, and noise management measures will be required in order to manage potential disturbance to residents. This will include notification of affected residents prior to any blasting, undertaking blasting at predictable/pre-determined times and notification of residents in the event of any deviation from the schedule. Where blasting is required in close proximity to receivers, personal communication is recommended before scheduled blasting commences.

A strict monitoring regime will accompany any controlled blasting operations including noise monitoring of all blasts. These issues should be noted in the designation conditions and included in the final CNVMP.

8.9.9 Discussion

Based on the assessments in the tables above, noise levels will generally comply with the Project daytime construction noise criterion of 70 dB $L_{Aeq(T)}$. However, certain activities may potentially exceed the Project daytime criteria without implementation of adequate noise mitigation, especially where noisy activities are carried out at ground level.

Night-time operation in Sector 9 is confined to the construction of the Richardson Road bridge and the operation of Construction Yards 9 and 10.

The concrete batch plant in Construction Yard 10 will be required to potentially operate at any time 24 hours per day. As the availability of concrete is critical to the safety of workers in the tunnel, the operation of the batch plant cannot be confined to daytime only.

Noise mitigation measures are required to be fitted to the batch plant to reduce noise levels as far as practicable. These include enclosures around the batch plant, the positioning of the plant such that openings are located away from residents and that the requirement for reversing of trucks is minimised. With these measures in place, the batch plant noise level can be reduced significantly. However, whether compliance with the Project noise criteria can be achieved will depend on the final extent of mitigation measures used and the choice of batch plant.

The basalt crusher is also likely to generate high noise levels, though during daytime only. Without mitigation, levels of around 75 dB $L_{Aeq(T)}$ are predicted at the facades of the most exposed receivers, which exceeds the Project daytime noise criterion. The basalt crushing is critical to the tunnelling operation. It is understood that the crusher cannot be located in the cut due to space and safety issues, but instead will operate at ground

level. Additional noise mitigation measures will be required for the basalt crushing, as set out in Section 8.9.10 below.

Management of the batch and crushing plants for the Project involves a number of issues. Therefore, a Concrete Batching and Crushing Plant Management Plan (CBCPMP) has been developed and is recommended to be implemented throughout the construction period. The draft CBCPMP is contained in Appendix E of this assessment.

8.9.10 Specific Mitigation Measures

In addition to the general noise mitigation measures contained in Section 7 of this document and the draft CNVMP (Appendix C), the following site specific noise mitigation measures will be required to be implemented:

Table 8-36: Sector 9 Specific Mitigation Measures

Activity	Mitigation Measures	Detail
Operation occurring at ground level for: <ul style="list-style-type: none"> Southern portal construction Roading construction Richardson Road bridge Contractor Yards 9 and 10 	Noise Barriers	For noisy operation occurring at ground level, provide noise barriers between noisy sources and nearby receivers. Operational noise barriers should be constructed early in the programme to provide acoustic screening of dwellings. For dwellings that are not protected by noise barriers, provide temporary noise barriers for the duration of above ground construction. Contractor yards should be surrounded with solid hoarding where this provides line-of-sight screening between noise sources and dwellings.
<ul style="list-style-type: none"> Richardson Road bridge construction 	Daytime Operation	The Richardson Road bridge construction has the potential to exceed the Table 5-5 night-time criterion. Noisy activities should be programmed to occur during the daytime, with night-time activities restricted to quieter activities. Where night-time operation is critical, temporary noise barriers (as discussed) above should be implemented around noisy sources.

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Batch plant operation 	Location, enclosures and alternatives	<p>Batch plants required for 24 hour use will require noise control measures to be applied. In this Sector, the batch plant should be located on the edge of the cut and designed such that the batch plant can load out to trucks below. The design of the batch plant in this manner will ensure that trucks do not need to be loaded out and slump at ground level.</p> <p>Further to this measure, noisy areas of the batch plant will need to be enclosed or screened from surrounding receivers. The contractor must therefore ensure that all practicable noise mitigation measures are included around the batch plant. This may include but shall not be limited to:</p> <ul style="list-style-type: none"> Batch plant located as far from receivers as possible; Enclosure of mixing vessels or dry mixing hoppers; Enclosure of conveyors; Enclosure of truck loadout area. Alternatively the batch plant may be able to be constructed such that trucks remain inside the tunnel cutting and are loaded out from above; Truck slumping to occur in the tunnel cutting and not at ground level where practicable; Daytime operation of equipment such as loaders. Conveying of material to be used in preference to driven loaders; Noise barriers located around concrete batch plant yard; Batch plant designed and located such that reversing of trucks is not required; Enclosure and treatment of other noisy equipment where identified; and Good driver and operator education regarding noise mitigation. <p>Even with the above measures in place, it is possible that dwellings within 150 metres of the batch plant will experience noise levels of above 45 dB $L_{Aeq(T)}$ during the night period, although the number of dwellings affected will depend on the successfulness of each of the above measures. If noise levels from the batch plant exceed this criterion, mechanical ventilation/air conditioning may need to be provided to allow these residents to sleep with their windows closed. The affected area is shown in Appendix D.</p> <p>(Continued overleaf)</p>

Activity	Mitigation Measures	Detail
Batch Plant (Continued)	Location, enclosures and alternatives	<p>Notwithstanding the above mitigation measures, the following alternative locations should also be considered for the batch plant:</p> <ul style="list-style-type: none"> Locating the batch plant at the bottom of the cut near the southern portal. This will result in the batch plant and truck movements being further from residents and very well screened by the edges of the cut; Locate the batch plant in the industrial area to the east of the operation (Stoddard Road Area), or in an industrial area. The Stoddard Road industrial area is located further from dwellings than Construction Yard 10 and, with a combination of noise enclosure and screening, the noise criteria could be achieved. Truck movements to and from the tunnel will be well screened by cuttings, however temporary noise barriers may be required at some locations. <p>NOTE: The draft CBCPMP contains more detail.</p>
Crushing	Management and location	<p>Crushing plant should be enclosed where practicable. Such an enclosure would consist of a well sealed enclosure with lined feed and output conveyor chutes. Crushing should only occur during the daytime, ideally between set times. The contractor must therefore ensure that all practicable noise mitigation measures are included around the crusher to ensure the noise level is below 70 dB $L_{Aeq(t)}$ when crushing is occurring. This may include, but shall not be limited to:</p> <ul style="list-style-type: none"> Locating the crusher within a well sealed enclosure. Feed and output conveyors would need to be tightly enclosed and lined with absorbent material. A large sheet steel enclosure lined internally with a heavier panel such as fibre cement may be the best solution; Operating the crusher only during the daytime. Operating the plant for periods that are as short as possible, generally around midday. Choosing quiet plant for operation in and around the crusher, such as quiet loaders. <p>If possible, rock should be transported off site for crushing.</p> <p>NOTE: The draft CBCPMP contains more detail.</p>

Activity	Mitigation Measures	Detail
Blasting	Notification	<p>Blasting should occur only during the daytime between the hours of 9 am and 5 pm, Monday to Saturday, but ideally around noon. Predictions of blast overpressure should be performed before any blasting and charge sizes selected to ensure that the Project criteria in Section 5.6 are complied with.</p> <p>Good communication with residents is essential and residents should be notified prior to blasting. Noise and vibration monitoring for blasting is recommended to ensure noise and vibration limits are in compliance with criteria.</p>
All operation	Resident relocation/ facade improvements	<p>Where noisy construction techniques are critical and must occur regardless of the exceedance of the Project noise criteria contained in Section 5.6, affected residents should be temporarily located to quiet accommodation.</p> <p>Where residents are unwilling to relocate or the construction period is sufficiently long as to make relocation not practicable, the improvement of the sound insulation of dwelling façades should be considered as an alternative. This would generally also require the provision of mechanical ventilation.</p> <p>This should be considered on a case-by-case basis. Such a measure should only be considered after all other practicable noise control options have been considered.</p>

The above noise mitigation measures will result in general compliance with the relevant Project noise criteria being achieved.

The contractor shall take all practicable steps to ensure compliance with the 45 dB $L_{Aeq(T)}$ night-time noise criterion at affected dwellings. Should compliance with the night-time noise criterion not be able to be achieved at surrounding dwellings with the implementation of general and specific mitigation measures set out above, mechanical ventilation may need to be considered for affected residents in order to enable windows to remain shut while achieving sufficient ventilation. If none of the above mitigation measures are practicable or effective, temporary relocation of residents should be considered on a case-by-case basis.

8.10 Construction Traffic

Construction traffic contributes to the overall construction noise. However, construction truck movements will occur on local roads and State highways and hence will generally be inseparable from general traffic on existing roads. Roads in the vicinity of the Project, such as Great North Road and the existing State highway system, already carry a very high number of vehicles.

Trucks removing spoil from the northern construction site are anticipated to exit the site towards and onto SH16. This would be supported with the potential to provide an on-ramp to SH16 prior to other Great North Road Interchange works to allow for easy truck access from the construction site to the motorway. From the southern construction site, trucks will travel towards the completed Mt Roskill section of SH20.

A preliminary assessment of truck movement numbers has been provided to Marshall Day Acoustics by the traffic modelling team of Beca. This assessment shows that even during busy construction periods, truck movements will typically be below 30 movements per hour during the daytime and less than 10 movements per hour during night-time. On major roads, such as the motorway and Great North Road, this number of truck movements would result in an imperceptible increase in traffic noise and noise effects would be less than minor.

However, it is recommended that the contractor consider the number of night-time truck movements on local roads and seek advice when significant numbers are required to use roads other than major roads.

9. Conclusions

Marshall Day Acoustics has undertaken an assessment of noise effects for the construction required for the Waterview Connection Project.

The recommended Project construction noise criteria in Section 5.6 of this assessment represent levels that construction activity should comply with as far as practicable. Project noise criteria are provided for external noise levels for residential and business/industrial buildings, internal noise levels for residential buildings and airblast noise levels. It is recommended that the Project construction noise criteria are set out in Designation conditions.

The most effective way to control construction noise is through good management. A draft Construction Noise and Vibration Management Plan has been prepared (Appendix C). The implementation of this CNVMP is an essential part of construction management for this Project.

In addition to the general noise mitigation measures contained in this assessment, specific noise mitigation has been recommended throughout this report. Examples of the specific mitigation measures proposed are: the location of batch plants to avoid reversing of trucks, the timing of blasts during daytime only and the enclosure of high noise generating equipment.

In Sectors 1, 5, 6 and 9, permanent traffic noise barriers will be required to reduce operational noise from the completed motorway. These traffic noise barriers will also be useful in controlling construction noise, and it is recommended that these barriers are constructed early in the construction programme, if practicable.

Enclosure of specifically noisy items of plant such as basalt crushing and concrete batching will be required. Further management measures for the crusher and batch plants are set out in the Concrete Batching and Crushing Plant Management Plan (Appendix E).

In addition, other general noise mitigation measures such as judicious location of noisy plant with respect to nearby receivers, noise barriers and other mitigation are contained in this document. Other mitigation such as resident relocation will need to be considered on a case-by-case basis.

The following table summarises the assessment of each Sector:

Table 9-1: Summary of Assessment

Sector	Discussion	Noise mitigation required
1	Typical average noise levels are generally expected to comply with the daytime noise criteria; however, when plant is operating close to receivers, noise levels from some activities have the potential to exceed the limits without mitigation.	Restriction of location of night-time activities, temporary and permanent noise barriers, cover cut-and-cover tunnel as soon as practicable
2	Noise levels are expected to comply with the daytime noise criteria at all receivers.	None required
3	Noise levels within this Sector will affect industrial receivers only. Average noise levels from construction will generally comply with the noise criteria, however, where construction occurs close to receivers and without implementation of mitigation, construction operations have the potential to exceed the noise criteria.	Bridge pad footing construction conducted during the night, or at least sensitive time as determined through consultation with industrial receivers. Temporary noise barriers where appropriate.
4	Noise levels from construction of the causeway are expected to result in typical average noise levels that are below daytime noise criteria	None required
5	Noise levels will typically be below daytime noise criteria, however, where construction is occurring in close proximity to receivers without implementation of mitigation, construction activities have the potential to be above the daytime and night-time noise criteria.	Noise barriers, restriction of location of night-time activities, enclosure of noise sources and, potentially, temporary resident relocation.
6	Noise levels from wall construction, piling and road construction will potentially exceed the noise criteria where no mitigation is implemented and construction is occurring close to dwellings.	Noise barriers, restriction of location of night-time activities, and, potentially, temporary resident relocation.
7	Where construction is occurring close to dwellings in this Sector, the daytime and night-time noise criteria will potentially be exceeded.	Top-down construction of cut-and-cover tunnel, temporary noise barriers, restriction of location of night-time activities and, potentially, temporary resident relocation.
8	Re-radiated noise from tunnelling may exceed the WHO night-time internal noise criteria; however, there is some uncertainty. During daytime, internal noise levels will either just comply or just exceed the criteria. Tunnelling at the start of the tunnel, where there is less cover above the activity, has the potential to exceed the night-time noise criterion	Daytime operation only at the start of tunnelling, tunnelling methodology, acoustic barriers/baffles at the tunnel exit, selection of conventional earthmoving equipment for tunnelling.

Sector	Discussion	Noise mitigation required
9	Noise levels will typically comply with the daytime noise criteria. However, for certain activities this criterion may be exceeded where noise barriers cannot be used. The construction of Richardson Road bridge will generate noise levels which would be above the night-time construction noise criteria	Noise barriers, restriction of location of night-time activities, enclosure of noise sources, batch plant treatment and, potentially, temporary resident relocation/provision of mechanical ventilation.

Subsequent to the implementation of best practicable noise management measures, it is expected that the Project construction noise criteria can generally be achieved.

However, certain high noise generating activities are essential to the successful construction of the Project and night-time construction is critical in some Sectors. Some of these works have the potential to exceed the noise criteria even with noise mitigation in place.

In most construction projects, occasional exceedances of the construction noise criteria are expected and would not necessarily be unreasonable. However, where exceedances are predictable and/or will occur for an extended duration, it will be important that the best practicable noise control and mitigation options are implemented on site or alternative measures are implemented such as temporary relocation of residents or provision of mechanical ventilation to affected properties.

The Waterview Connection Project is of national significance and will be one of the largest roading projects ever undertaken in New Zealand. There are considerable constraints on the Project construction and, given the established environment around the proposed route, elevated construction noise levels at nearby receivers are inevitable at times.

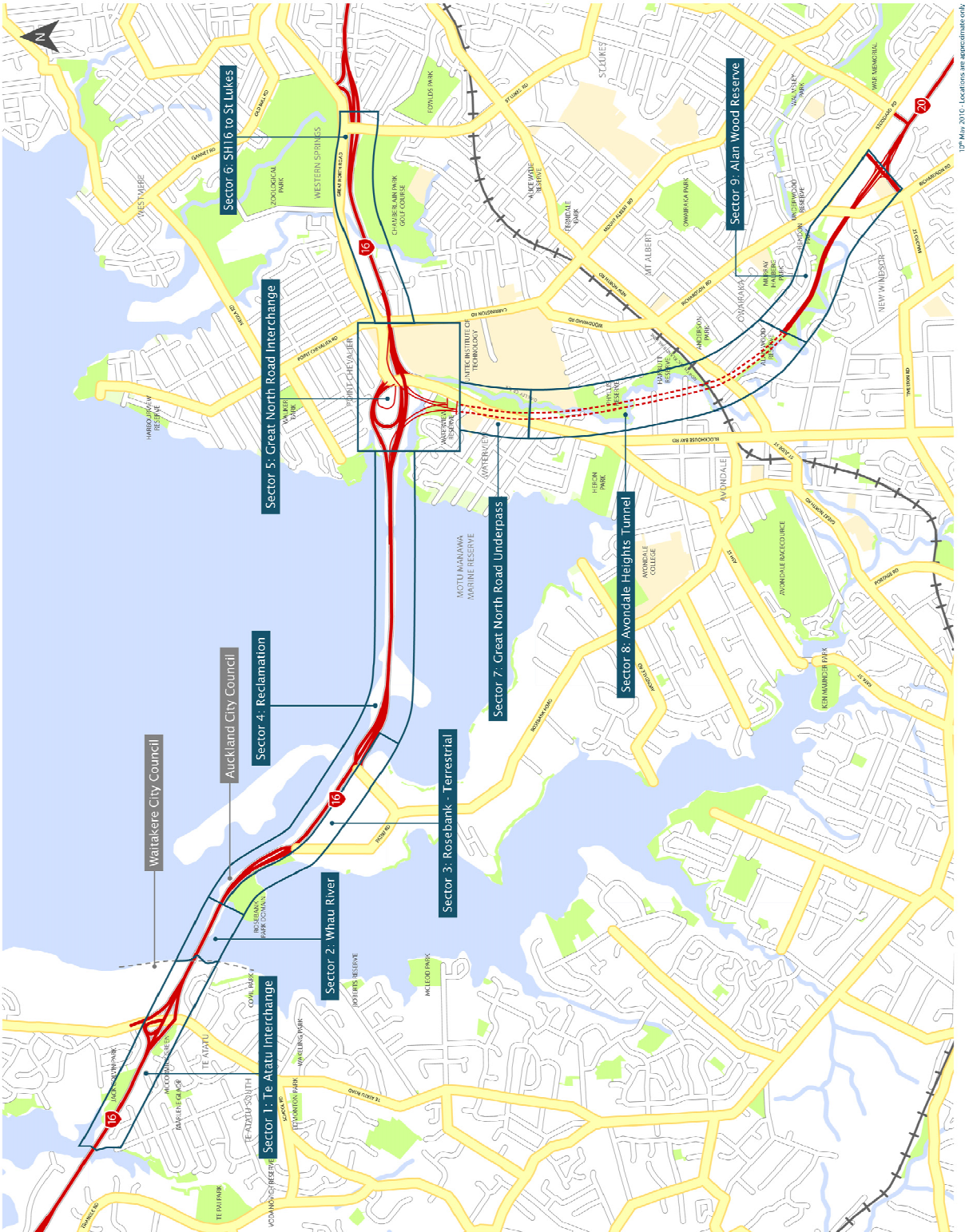
It is considered that the best practicable option for this Project is to ensure that construction noise effects are managed with the aim of meeting the Project construction noise criteria set out in Section 5.6 of this report and any exceedances are addressed through noise management.

APPENDIX A

Sector Map

Sector Diagram

Western Ring Route: Waterview Connection (SH16-20) - Sector Diagram



APPENDIX B

Glossary of Technical Terminology

Glossary of Technical Terms

dB	A measurement of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
$L_{Aeq}(T)$	The A-weighted, time averaged sound level (on a logarithmic/energy basis) over the measurement period.
$L_{A90}(T)$	The sound level which is equalled or exceeded for 90% of the measurement period. L_{A90} is an indicator of the mean minimum noise level and is used in New Zealand as the descriptor for background noise (normally A-weighted).
$L_{A10}(T)$	The sound level which is equalled or exceeded for 10% of the measurement period.
L_{AFmax}	The maximum sound level recorded during the measurement period (normally A-weighted).
L_{Zpeak}	The peak instantaneous pressure level recorded during the measurement period (flat weighted (Z)).
Noise	A sound that is unwanted by, or distracting to, the receiver.
NZS 6801:2008	New Zealand Standard NZS 6801:2008 "Acoustics - Measurement of 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".
AS 2187.2:2006	Australian Standard AS 2187.2:2006 "Explosives - Storage and use - Part 2: Use of explosives"
AS/NZS 2107:2000	Australian/New Zealand Standard AS/NZ 2107:2000 "Acoustics - Recommended design sound levels and reverberation times for building interiors"
Ambient Noise	Ambient Noise is the all-encompassing noise associated with any given environment and is usually a composite of sounds from many sources near and far.

APPENDIX C

Construction Noise and Vibration Management Plan (Overleaf)



Western Ring Route – Waterview Connection



Construction Noise and Vibration Management Plan



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Appendices

Appendix A – Glossary of Technical Terminology

Appendix B – Sector Diagram

Appendix C – Response Plans for Construction Vibration Issues

Appendix D – Response Plan for Construction Noise Complaints

Appendix E – Dwellings potentially requiring Mechanical Ventilation due to Batching Plant (Sector 9)

Appendix F – Schedules of at-risk buildings and high-vibration generating equipment

1. Introduction

This Construction Noise and Vibration Management Plan (CNVMP) (the Plan) forms part of a comprehensive suite of environmental controls within the Construction Environmental Management Plan (CEMP) for the construction phase of:

- State Highway: 16 and 20
- Project: The Western Ring Route - Waterview Connection project ("the Project")
- Construction location: Sectors 1 – 9 (SH20 connection to Te Atatu Interchange & St Lukes Interchange)
- Construction start date: **[Contractor to complete]**
- Construction finish date: **[Contractor to complete]**
- Designation number: **[Contractor to complete]**
- NZTA CSVue permit #: **[Contractor to complete]**

This CNVMP identifies the minimum standards that must be complied with as well as best practicable options for noise and vibration management for the Project. It is intended as a framework for the development of particular noise control practices and procedures to minimise affects on health and safety and to reduce the impact on the environment.

The CNVMP will be updated, with the necessary approval, throughout the course of the Project to reflect material changes associated with any changes to the construction methodologies or techniques or the natural environment. Approval from the [Auckland City] will be required for any relevant revisions of a material nature for the TSMP. The document shall be reviewed yearly to reflect any changes.

The Project is divided into 9 Sectors. A diagram showing the location and the extent of each Sector is attached in Appendix B.

This CNVMP will be implemented in alignment with information, management tools and standards as specified on the NZTA website for the management of transport noise located at <http://acoustics.nzta.govt.nz/construction-noise-management>.

2. Noise Performance Standards

2.1 Construction Noise excluding Blasting

Table 2.1: Project Construction Noise Criteria: Residential Receivers

Time of week	Time period	Project Construction Noise Criteria (Long Term Construction) dB		
		Sectors 1 to 7	Sectors 8 and 9	All Sectors
		$L_{Aeq(10-60 \text{ min})}$	$L_{Aeq(10-60 \text{ min})}$	L_{AFmax}
Monday - Saturday	0630-0730	60	45	75
	0730-1800	70	70	85
	1800-2000	65	65	80
	2000-0630	60	45	75
Sundays and Public Holidays	0630-0730	45	45	75
	0730-1800	60	45	85
	1800-2000	45	45	75
	2000-0630	45	45	75

Table 2.2: Project Construction Noise Criteria: Commercial and Industrial Receivers

Time period	Project Construction Noise Criteria (Long Term Construction) dB
	$L_{Aeq(10-60 \text{ min})}$
0730 - 1800	70
1800 - 0730	75

Table 2.3: Project Construction Noise Criteria: Internal for Residential Receivers

Time period	Project Construction Noise Criteria (Inside)	Habitable Rooms
0730 - 1800	35 dB $L_{Aeq(16h)}$	All habitable rooms
1800 - 0730	30 dB $L_{Aeq(8h)}$	Bedrooms

The following activities require specific mitigation in order to achieve compliance with the Project construction noise criteria above.

Daytime

- Retaining wall construction, road milling, road construction and surfacing, cycle underpass construction (Sector 1)

- Bridge pad footing construction, precast segment delivery/craning, span finishing, bridge surfacing (Sector 3 – industrial receivers only)
- Most activities associated with the Great North Road interchange (Sector 5)
- Retaining wall construction, construction of additional lanes (Sector 6)
- Most activities associated with the construction of the northern portal (Sector 7)
- Emergency smoke stack installation by helicopter (Sector 8)
- Preliminary portal works with equipment at ground level, grout curtain, road construction and finishing, basalt crushing (Sector 9)

Night Time

- Road construction and surfacing (Sector 1)
- Bridge pad footing construction (Sector 3)
- Most activities associated with the Great North Road interchange (Sector 5)
- Construction of additional motorway lanes (Sector 6)
- Most activities associated with the construction of the northern portal (Sector 7)
- Richardson Road overbridge segment launching and finishing (Sector 9)
- Contractor Yard operation (Sector 9)

2.2 Noise from Blasting

Noise from blasting shall be predicted, measured and managed in accordance with *AS 2187.2:2006 Explosives - Storage, transport and Use. Part 2: Use of Explosives*.

Table 2.4: Project Construction Noise Criteria: Airblast

Category	Type of Blasting Operations	Peak Sound Pressure Level (L_{Zpeak} dB)
Human Comfort Limits		
Sensitive Site	Operations lasting longer than 12 months or more than 20 Blasts	115 dB for 95% blasts per year. 120 dB maximum unless agreement is reached with occupier that a higher limit may apply
Sensitive Site	Operations lasting less than 12 months or less than 20 Blasts	120 dB for 95% blasts per year. 125 dB maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites such as factories and commercial premises	All blasting	125 dB maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications of levels that can be shown to adversely affect the equipment operation
Damage Control Limits		
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All Blasting	133 dB unless agreement is reached with owner that a higher limit may apply.
Service structures such as pipelines, powerlines and cables located above ground	All Blasting	Limit to be determined by structural design methodology

3. Vibration Performance Standards

Two construction vibration standards have been adopted for use in this Project:

- DIN 4150-3:1999 for building damage risk and
- BS 5228:2009 for human response

3.1 Building Damage Risk: DIN 4150-3:1999

Table 3.1: Summary of Building Damage criteria

Type of structure	Short-term vibration			Long-term vibration	
	PPV at the foundation at a frequency of			PPV at horizontal plane of highest floor	PPV at horizontal plane of highest floor
	1 - 10Hz	1 - 50 Hz	50 - 100 Hz		
Commercial/Industrial	20	20 – 40	40 – 50	40	10
Residential/School	5	5 – 15	15 – 20	15	5
Historic or sensitive structures	3	3 – 8	8 – 10	8	2.5

A statistical method may be applied to the assessment of blasting activities (which are categorised as short term activities in Table 3.1 above). This methodology requires that vibration from each and every blast is measured. Survey results are used to ensure that activities are conducted so that 95 % of the 20 most recent events, measured on the foundation of any building, produce peak particle velocities not exceeding the criteria specified for short-term activities in Table 3.1 above, and 100 % of the measured events do not exceed twice these criteria.

3.2 Human Response: BS 5228:2009 Appendix B

The criteria in British Standard BS 5228:2009 (Appendix B.2) shall be used for the management of complaints relating to construction vibration. Compliance with the criteria set out in Table 3.2 below are not mandatory, but provide contextual information on people's expected response to vibration.

Table 3.2: Human Response to Vibration

Vibration level (PPV)	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 has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

4. Key Construction Noise and Vibration Effects

The Project construction involves significant numbers of machinery operating in close proximity to noise and/or vibration sensitive receivers. Night-time construction is required in certain areas.

The primary effects of construction noise relate to annoyance and disturbance of people.

The primary effects of construction vibration relate to building damage. Secondary vibration effects relate to annoyance and disturbance of people. Responding to and mitigating the primary (building damage) effects often alleviates the secondary (annoyance) effects.

A list of the predominant noise and vibration generating activities in each Sector are outlined in Table 4.1 below:

Table 4.1: Key Construction Noise and Vibration Activities

Sector	Noise generating activities	Vibration generating activities
1	Base course and sealing of SH16 and Te Atatu Interchange Noise barrier construction	Vibratory rollers for base course and sealing of SH16 and Te Atatu Interchange
2	Piling for bridge construction Road milling and sealing	Piling for bridge construction
3	Bridge construction and surfacing Road widening and sealing	Vibratory rollers for base course and sealing of SH16
4	Causeway fill delivery for construction/ reclamation Piling Road sealing	Vibratory rollers for base course and sealing of SH16, and piling for bridge abutments
5	Interchange ramp footing and segment construction Piling Concrete batching	Vibratory rollers for base course and sealing of on-grade ramps
6	Piling, blasting and rockbreaking for widening works and retaining walls	Piling, blasting and rockbreaking for widening works and retaining walls Vibratory rollers for base course and sealing of on-grade ramps
7	Piling for diaphragm wall Excavation Road realignment and resurfacing	Piling for diaphragm wall Excavation plant Vibratory rollers for road realignment and resurfacing

Sector	Noise generating activities	Vibration generating activities
8	Tunnelling (road header or excavators) Construction of emergency smoke extract vent and services building Helicopter delivery of materials	Tunnelling (road header or excavators)
9	Blasting for portal construction Drilling for portal construction and grout curtain Rock breaking for portal construction Piling for portal construction Road basecourse and sealing Crushing of basalt Batch plant operation House demolition Noise barrier construction	Blasting for portal construction Drilling for portal construction and grout curtain Rock breaking for portal construction Piling for portal construction Vibratory rollers for road construction

Other construction machinery and activities, not specified in the above table, will produce noise and ground vibration also, but generally to a lesser degree.

5. Timeframe

The overall construction timeframe for the entire Project is expected to be five and a half years. This will comprise of the following activities:

- Tunnel construction: 4 years
- Te Atatu Interchange: 4 years
- Causeway and the Whau River bridge construction: 5 years
- Great North Road interchange: 2 years
- Widening works on SH16: 1 year
- SH20 from tunnel to Maoro Interchange: 1 year

6. Hours of Operation

Hours of operation are generally:

- Sectors 1, 2, 3, 5, 6, 7 and 9: Generally daytime operation, 6 days per week. Some night-time operation for specific areas.
- Sector 4: Causeway construction will occur at varying times throughout any 24 hour period at low tide.
- Sector 8: Tunnelling: 24 hours per day, 7 day per week

Blasting activities shall occur between 9 am and 5 pm, Monday to Saturday, only.

7. Roles and Responsibilities

Section 3.1 of the CEMP details roles and responsibilities associated with managing environmental effects from construction on the Project. The contractor will appoint a Contractor Environmental Manager who has the overall responsibility for the implementation of this CNVMP, including all required noise and vibration monitoring, and leading the review of results with appropriate communication to Local Authorities and the NZTA.

The following is a schedule of contact details for key personnel connected to the Construction Phase of the Project: **[The following schedule of contact details shall be completed by the contractor prior to commencement of the Project]**

Table 7.1 Schedule of Contact Details

Role	Name	Organisation	Phone	Email
Contractor Environmental Manager				
Client		NZTA		
Engineer				
Project Acoustic and Vibration Consultants				
Contractor				
Contractor's acoustics advisor				
Council – Noise/ Environmental Health				
Public complaint contact number				

[Contractor to insert name and company of appropriate person] will be responsible for ensuring that this CNVMP is correctly implemented. He/she will review all documentation relating to construction noise and vibration before it is issued.

All site personnel will be required to read this CNVMP and sign appropriate induction forms and any relevant schedules. All personnel working on the Project, including Contractor employees and subcontractors, are responsible for following the requirements of this CNVMP.

8. Training

Environmental training for all staff will be undertaken as part of the site induction programme as described in section 3.2 of the CEMP. Training for all site personnel shall be undertaken as part of the site induction programme. This requires all new staff to participate in an induction training session when they commence work, and regular (annual as a minimum) refresher courses.

Environmental Induction will include information on the following aspects of this CNVMP:

- Roles and responsibilities for management of Project noise and vibration issues
- Designation requirements/conditions
- Information about noise and vibration sources on site, and locations of critical receiver positions
- Noise and vibration management procedures
- Complaints management procedures

If required, training of site personnel in matters relating to construction noise and vibration will be provided by a suitably qualified person.

9. Monitoring

9.1 Noise

Construction noise levels shall be monitored and assessed:

- generally in accordance with the requirements of NZS 6801:2008 “Acoustics - Measurement of Environmental Sound”, NZS 6802:2008 “Acoustics - Assessment of Noise” and NZS 6803:1999 “Acoustics - Construction Noise”
- at monthly intervals throughout construction, but not at pre-arranged times
- as and when required, during critical phases of construction, i.e. when possible exceedance of the Project noise criteria is anticipated
- in response to reasonable noise complaints being received
- at locations representative of sensitive receivers in the vicinity
- at 1 metre from the most affected façade, or, if this position is not accessible, at an equivalent position where practicable. If this is not possible, measured noise levels shall be adjusted for distance and façade reflections if necessary.
- to reflect representative construction activities, and shall be no less than 10 minutes and longer than 60 minutes duration. The measured noise level shall be stated with the measurement duration: $L_{Aeq(T)}$
- by a suitably qualified acoustic specialist
- for any and all blasting activities (this would typically be undertaken by the blasting contractor)

General monitoring locations may include, but are not limited to:

- Sector 1: Residential areas near Te Atatu Interchange
- Sector 2: Residential areas overlooking bridge widening
- Sector 5: Residential areas located near retaining structures
- Sector 6: Adjacent to Ramp 2 and Ramp 4
- Sector 7: Adjacent to the tunnel portal

- Sector 8: Dwellings located above the tunnelling operation
- Sector 9: Adjacent to the tunnel portal, Richardson Road underpass and Contractor's Yard 10

9.2 Vibration

Prior to construction, trial measurements of high-vibration activities (including blasting) shall be undertaken to establish Project specific ground attenuation characteristics and safe distances to inform the risk categories for the vibration schedules (refer Section 12 below).

During construction, vibration levels shall be monitored and assessed:

- generally in accordance with the requirements of DIN 4150-3:1999
- at monthly intervals throughout construction at high risk receivers as set out in the vibration schedules
- as and when required, during critical phases of construction, i.e. when possible exceedance of the Project vibration criteria is anticipated
- in response to reasonable vibration complaints being received
- to reflect representative construction activities, and shall comprise measurements of peak particle velocity (PPV) at one second intervals
- by a suitably qualified and experienced specialist

The monitoring and complaints management procedure for vibration sources other than blasting is outlined in the second flowchart (for continuous vibration sources) attached in Appendix C.

For blasting activities:

- each and every blast shall be monitored by the blasting contractor at the high-risk receiver(s) in the vicinity (or equivalent location if access to the building structure is not granted)
- the criteria in DIN 4150-3:1999 apply, however the statistical method outlined in Section 3.1 above shall be applied such that 95% of all measurements must comply with the DIN criteria, and 100% of all measurements must comply with twice these criteria.

The monitoring and complaints management procedure for blasting is outlined in the first flowchart (for impulsive vibration sources) attached in Appendix C.

9.3 Contingency Measures

In the event that a measurement shows non-compliance with the Project criteria, the following procedures shall be implemented:

- For vibration, a building condition survey shall be undertaken and a report prepared by a suitably qualified person, including photographs, detailing the state of repair of the existing structure, and an opinion as to whether any damage may be due to construction activity.
- For noise, further measurements shall be undertaken where necessary, to determine the extent of non-compliance.
- A report shall be prepared, outlining the non-compliance and, if required, potential mitigation and management measures.
- Upon implementation of any additional mitigation measures, further measurements shall be undertaken to confirm the effectiveness of those mitigation measures.
- The Contractor Environmental Manager shall liaise with affected receivers throughout this process.

9.4 Reporting

Any noise, vibration or building condition surveys shall be summarised in a report, to be submitted to the Contractor Environmental Manager within one week of the assessment. Monitoring records shall be kept at the site office and made available upon request.

10. Procedures for Handling Noise and Vibration Complaints

Complaints procedures are detailed in section 3.6.1 of the CEMP. As part of the liaison process, affected parties shall be informed to direct noise and/or vibration complaints to the Contractor Environmental Manager. A flowchart outlining the process for noise complaints is contained in Appendix D.

The following complaint procedures shall be followed:

- The Contractor shall maintain a 24 hour hotline and this number shall be displayed in all consultation material and other publications
- Upon receiving a complaint, the complainant's name, contact details and the nature of their complaint will be noted and immediately forwarded to a designated Contractor staff member
- The Contractor staff member shall contact the complainant within one hour during the day and 15 minutes at night (10:00 pm to 7:00 am), or as soon as practicable thereafter, to address their concerns
- If practicable and appropriate, construction workers shall be instructed to modify the activity of concern and the complainant shall be informed
- If the complaint is in regards to building damage from construction vibration, the activity of concern shall cease and a building condition survey shall be undertaken. Flowcharts outlining the processes for blasting and other vibration sources are contained in Appendix C.

For on-going complaints, the Project Manager shall request additional measurements by a suitably qualified and experienced acoustic specialist targeting the specific noise or vibration source. The investigation of an ongoing noise or vibration complaint may include the following:

- Identification of noise or vibration inducing activities at the time of complaint, and measurement and assessment of noise or vibration levels from these activities
- Determination of the best practicable mitigation options in conjunction with the Contractor Environmental Manager
- Measurement of noise or vibration levels following implementation of mitigation action(s)
- Communication with complainant
- Reporting of findings and actions to the Contractor Environmental Manager

In addition, a complaints file will be maintained at the Project office, and available for inspection during normal office hours by affected parties and the relevant local authority.

11. General Management Procedures and Mitigation Measures

The following sections outline noise and vibration management and mitigation measures that shall be implemented throughout construction of the Project.

Sector specific mitigation measures are provided in Section 12 of this CNVMP and shall be implemented in addition to the general measures outlined below.

11.1 Consultation

Consultation with affected parties shall be carried out prior to commencement of construction activities as follows:

- Receivers within **100 metres** of the construction area: Written notification and a Project description shall be provided to raise awareness of the Project, its expected activities and duration in the vicinity.

For blasting activities, written notification shall be provided for all receivers within **200 metres**.

Where noisy activities are to be conducted during the night-period, it should be suggested to residents that they keep their windows shut when sleeping.

- Receivers within **50 metres** of the construction area: Individual notification shall be provided and opportunity made available for discussions on a case-by-case basis, if required by the occupants/owners.
- Receivers within **20 metres** of the construction area: Individual discussions shall be held and, if required, suitable alternatives and/or mitigation options explored that are acceptable to both parties. Ongoing consultation shall be carried out throughout the duration of construction.

For vibration, the distances specified above represent a suitable basis for standard consultation practice.

Further detail on identifying at-risk receivers in each Sector in relation to construction noise and vibration effects are contained in Schedules [xx] in Appendix F. **[Schedules xx of at-risk buildings and high-vibration equipment shall be completed by the contractor prior to commencement of the Project]**

11.2 Training of Personnel

All personnel on site shall be made aware of the importance of operating in the least disruptive manner. All personnel working on the Project, including Contractor employees and subcontractors, shall be familiar with, and be responsible for, implementing this CNVMP.

11.3 Selection of Low Noise and Vibration Plant

Low noise and vibration plant shall be selected and used wherever practicable. Where plant is identified as being particularly noisy and/or vibration inducing, action shall be taken to reduce emissions. This may involve the fitting of mitigation measures, such as silencers, enclosures or isolation pads. Plant shall be maintained to ensure that noise and vibration emissions remain as low as practicable.

11.4 Night-Time Operation

In close proximity to residences, high-noise and/or vibration activities shall be scheduled for the daytime where practicable, and avoided during the night-time.

In close proximity to schools and commercial buildings, high-noise and/or vibration activities shall be scheduled during the evening and night-time period where this is practicable.

For contractors yards located adjacent to noise sensitive receivers, noisy vehicles shall enter and leave the site during daytime hours, where practicable. Where this is not practicable, truck routes shall be chosen so as to minimise disruption to sensitive receiver positions.

11.5 Blasting

If blasting is required, this shall be notified at least 24 hours in advance to all receivers within 200 metres of the blast site. Blasts shall be performed at set times during the daytime between 9:00am and 5:00pm Monday to Saturday only.

Blasting activities will generate the highest noise and vibration levels of all construction activities. Prior to blasting works commencing, the blasting contractor shall undertake trial blasts to assess the potential for noise and vibration effects on critical receivers, and design the blasting programme.

In areas close to sensitive receivers alternative rock excavation methods shall be implemented, such as hand-drilling for small MICs, or PCF (gas).

Noise and vibration monitoring shall be undertaken for every blast to assess compliance and effects on critical buildings and building occupants. Blasting records shall be kept at the site office with weekly reports submitted to the Contractor Environmental Manager.

11.6 Noise Barriers and Enclosures

In areas where the Project noise criteria may be exceeded, noise barriers shall be used where they provide effective mitigation (i.e. break acoustic line-of-sight and are close to either the source (preferable) or the receiver).

Where practicable, permanent (traffic) noise barriers required for operational noise mitigation following completion of the Project shall be erected early during construction. This is relevant for Sectors 1, 6 and 9 specifically where substantial traffic noise barriers are required. Permanent noise barriers can be constructed in their final form and utilising the proposed final materials. Alternatively, permanent framing of barriers can be used in conjunction with temporary barrier materials such as plywood which, after completion of construction, can then be replaced with permanent materials. This may be practicable where permanent materials may be damaged by construction activities.

Temporary noise barriers shall be utilised for those areas where no permanent noise barriers are required or where these cannot be practicably implemented early during construction. Temporary barriers are typically constructed from plywood, shall contain no gaps and be of sufficient height to screen line-of-sight between the receiver and the source. Alternative barrier constructions may include fibre cement, shipping containers or mass-loaded vinyl etc

Where a noise barrier is not sufficient to achieve compliance with the Project noise criteria, an enclosure may be used where practicable, i.e. stationary plant such as conveyors or crushers. The enclosure shall be designed by a suitably qualified and experienced acoustic specialist.

11.7 Reversing Alarms

All equipment operating on any of the Project construction sites during night-time shall be fitted with alternatives to tonal reversing alarms. Such alternatives may include, but not be limited to, broadband auditory devices, visual signals, etc.

11.8 Concrete Batching and Crushing Plant Management

The concrete batching plants required in Sectors 5 and 9 will operate 24 hours per day, 7 days per week. The basalt crushing plant will operate in Sector 9 during daytime only.

The contractor must therefore ensure that all practicable noise mitigation measures are implemented at all plants.

Specific management and mitigation measures for the concrete batching plants and crushing plant are set out in the Concrete Batching and Crushing Plant Management Plan (CBCPMP).

11.9 Building Condition Surveys

Prior to the commencement of Project construction operations, a detailed pre-construction building condition survey of identified at-risk buildings, services and structures shall be conducted by a suitably qualified engineer. The survey shall include, but not be limited to, the following:

- Existing condition of buildings, services or structures, including existing levels of any aesthetic damage or structural damage
- Record (including photographs) of the major features of the buildings, services and structures including location, type, construction, age and present condition, including defects
- Foundation type of the building, service or structure
- Preparation of a report recording the findings of the survey. A copy of each report shall be forwarded to the Contractor Environmental Manager and kept at the site office
- Resurvey of buildings, services and structure, which are the subject of complaints or if the vibration criteria have been exceeded and there is potential for damage to have occurred
- Within six months of completion of the Project, a detailed post-construction condition survey of the same buildings, services and structures shall be conducted and a report prepared

11.10 Vibration Barriers

Vibration barriers can provide limited attenuation for ground-borne vibration. Accordingly, the practicability of implementing vibration barriers shall be assessed on a case-by-case basis by a suitably qualified and experienced specialist.

Vibration barrier options include, but are not limited to; open trenches, backfilled trenches, concrete-filled trenches, sheet pile walls, concrete pile walls, grout curtains etc.

The required depth of the barrier is based on the frequency characteristics of the vibration source.

11.11 Mechanical Ventilation of Dwellings

Where external windows of a residence must be closed in order to achieve compliance with the internal night-time Project noise criteria, the installation of mechanical ventilation shall be considered for that residence. This shall be investigated only after all other general noise management and mitigation have been deemed impracticable.

11.12 Temporary Resident Relocation

Where all practicable noise and vibration management and mitigation measures have been implemented, but compliance with the Project criteria is still not achievable, relocation of affected receivers may need to be considered.

Relocation shall be considered in exceptional cases only, and expert advice from a suitably qualified and experienced acoustics specialist shall be sought.

12. Sector-specific Noise and Vibration Management and Mitigation Measures

12.1 Noise Mitigation

Sections 12.3 to 12.11 below outline site specific noise mitigation measures that are required in each of the Project Sectors in addition to the general measures noted in Section 11 above.

Noise mitigation and management shall be implemented throughout the Project.

12.2 Vibration Risk

The primary management measure for vibration is to identify and develop awareness of vibration risk, i.e. which construction sources impose a risk of exceeding the Project criteria. The tables in the following sections specify key vibration sources and their 'design safe distances'.

The design safe distances are based on theoretical models, and should be updated to become 'safe distances' (i.e. no longer for design purposes only) as site-specific measurement data becomes available.

The 'safe distances' shall be used to identify at-risk receivers.

Risk is categorised as Low, Medium or High and each risk category requires specific actions to be undertaken when working in those areas, as follows:

High Risk: Receivers that are located within the 'design safe distance'

- Individual discussion with building owners and ongoing consultation
- Building condition survey prior to construction
- Site-specific vibration measurements to assess damage risk

Med Risk: Receivers that are close to the 'design safe distance' (safe distance + 20%)

- Notification of building owners and opportunity for discussion if requested
- Site-specific vibration measurements to assess damage risk if requested

Low Risk: Receivers that are further than the 'design safe distance' + 20%

- Notification of building owners

12.3 Sector 1 – Te Atatu Interchange

Table 12.1: Sector 1 Specific Noise Mitigation

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Road Milling Road Construction and Surfacing 	Night-time restriction of noisy activities	<ul style="list-style-type: none"> noisy activities to be programmed for daytime restrict night-time works to quieter activities for construction activities during both daytime and night-time, works should be scheduled to ensure that operation nearest to dwellings occurs during the day period with night-time operation occurring as far from dwellings as possible.
<ul style="list-style-type: none"> Road Construction and Surfacing 	Noise barriers	<ul style="list-style-type: none"> installation of traffic noise barriers shall be programmed for construction early in the construction period, if practicable. if not practicable, localised screening around noisy equipment or screening at property boundaries
<ul style="list-style-type: none"> Pedestrian cycle underpass 	Cover cut early on	<ul style="list-style-type: none"> construction should be performed underneath the cover as early on in the construction period as possible excavation should be performed from underneath the capping, if practicable.

Retaining wall construction, road milling, road construction and surfacing and cycle underpass construction are all likely to exceed the Project noise criteria.

Estimated design safe distances for vibration including activities in Sector 1 are shown in Table 12.2 below.

Table 12.2: Estimated design safe distances for vibration from construction activities in Sector 1

Source	Design safe distance
Vibratory rollers for road construction	15 m
Excavators	3 m

12.4 Sector 2 – Whau River

No specific noise mitigation measures are required for Sector 2.

Estimated design safe distances for vibration inducing activities in Sector 2 are shown in Table 12.3 below.

Table 12.3: Estimated design safe distances for vibration from construction activities in Sector 2

Source	Design safe distance
Vibratory rollers for road construction	15 m
Piling for bridge abutments	18m

12.5 Sector 3 – Rosebank Terrestrial

Bridge pad footing construction, precast segment delivery/craning, span finishing and bridge surfacing are all activities that are likely to exceed the Project noise criteria. For these activities, the general noise mitigation measures outlined in Section 11 shall be implemented and are considered the best practicable mitigation options.

Estimated design safe distances for vibration inducing activities in Sector 3 are shown in table 12.4 below.

Table 12.4: Estimated design safe distances for vibration from construction activities in Sector 3

Source	Design safe distance
Vibratory rollers for road construction	8 m

12.6 Sector 4 – Reclamation

Compliance with the Project noise and vibration criteria is anticipated for Sector 4.

12.7 Sector 5 – Great North Road Interchange

Table 12.5: Sector 5 Specific Noise Mitigation Measures

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Contiguous bored piling Pad footing construction or pier construction Precast segment delivery, etc. Span finishing Sealing works 	Noise Barriers	<ul style="list-style-type: none"> temporary noise barriers to be erected around noisy activities such as drilling, jack hammering, noisy hand tools, concrete slumping areas, cranes, concrete pumping plant, etc temporary noise barriers not required for certain activities if the activities are restricted to daytime hours or to distances greater than set out below
	Night-time restriction of noisy activities	<ul style="list-style-type: none"> where practicable, noisy operations on the ramps shall be scheduled for daytime where operational areas are close to receivers or noise sensitive activities night-time construction shall be scheduled for ramp structures that are located further from residential areas (Ramp 1, 3 and some parts of 4) recommended minimum distances between dwellings and activities for night-time construction operation are: <ul style="list-style-type: none"> Contiguous bored piling – 200m Pad footing construction or pier construction – 300m Precast segment delivery, etc. – 120m Span finishing – 120m Sealing works – 100m
	Resident relocation	<ul style="list-style-type: none"> where night construction must occur in close proximity to dwellings and no other mitigation measure is found to be practicable, affected residents may need to be temporarily relocated where noise levels would exceed the Project criteria relocation should be considered on a case-by-case basis. Before the implementation of this measure, advice shall be sought from an acoustic specialist

Activity	Mitigation Measures	Detail
Batch plant operation	Enclosure/operation	<p>night-time operation of the batch plant in Construction Yard 6 will require the following noise mitigation measures:</p> <ul style="list-style-type: none"> • Batch plant located as far as possible from sensitive receivers • Enclosure of mixing vessels or dry mixing hoppers • Enclosure of conveyors • Enclosure or screening of truck load-out area • Truck slumping below ground level where practicable • Daytime operation of equipment such as loaders. Conveying of material to be used in preference to driven loaders • Noise barriers located around concrete batch plant • Batch plant designed and located such that reversing of trucks is not required • Enclosure and treatment of other noisy equipment where identified • Driver and operator education regarding noise mitigation

Estimated design safe distances for vibration inducing activities in Sector 5 are shown in Table 12.6 below.

Table 12.6: Estimated design safe distances for vibration from construction activities in Sector 5

Source	Design safe distance
Vibratory rollers for road construction	30m
Piling	25m

12.8 Sector 6 – SH16 to St Lukes

Table 12.7: Sector 6 Specific Noise Mitigation Measures

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Retaining Wall Construction Construction of additional lanes 	Noise barriers	<ul style="list-style-type: none"> installation of permanent traffic noise barriers shall be programmed early in the construction programme if practicable otherwise, localised screening around noisy equipment or screening at property boundaries will be required
	Night-time restriction of noisy activities	<ul style="list-style-type: none"> noisy activities shall be programmed to occur during the daytime, with night-time activities restricted to quieter activities
	Resident relocation	<ul style="list-style-type: none"> where night construction must occur in close proximity to dwellings and no other mitigation measure is found to be practicable, affected residents may need to be temporarily relocated where noise levels would exceed the Project criteria relocation should be considered on a case-by-case basis. Before the implementation of this measure, advice shall be sought from an acoustic specialist
<ul style="list-style-type: none"> Construction Yard 	Noise barriers	<ul style="list-style-type: none"> temporary noise barriers on the western and northern sides of the yard limit operation of material handling and lime drying on site during the night time period

Estimated design safe distances for vibration inducing activities in Sector 6 are shown in Table 12.8 below.

Table 12.8: Estimated design safe distances for vibration from construction activities in Sector 6

Source	Design safe distance
Vibratory rollers for road construction	30m
Piling for Carrington Road Bridge	25m

12.9 Sector 7 – Great North Road Underpass

Table 12.9: Sector 7 Specific Mitigation Measures

Activity	Mitigation Measures	Detail
<ul style="list-style-type: none"> Cut and cover tunnelling 	Top down construction	<ul style="list-style-type: none"> top down construction is the preferred methodology from a noise perspective
<ul style="list-style-type: none"> Great North Road realignment Retaining wall construction Vent building construction Construction Yard 7 	Night-time restriction of noisy activities Noise Barriers	<ul style="list-style-type: none"> all noisy surface activity (i.e. pre-tunnel capping) shall be performed during the day-period where practicable noise barriers may be required if surface night-time operation is undertaken
<ul style="list-style-type: none"> Great North Road realignment Retaining Wall Structure 	Resident relocation	<ul style="list-style-type: none"> where night construction must occur in close proximity to dwellings and no other mitigation measure is found to be practicable, affected residents may need to be temporarily relocated where noise levels would exceed the Project criteria relocation should be considered on a case-by-case basis. Before the implementation of this measure, advice shall be sought from an acoustic specialist

Estimated design safe distances for vibration inducing activities in Sector 7 are shown in table 12.10 below.

Table 12.10: Estimated design safe distances for vibration from construction activities in Sector 7

Source	Design safe distance
Vibratory rollers for road construction	30m
Piling for secant pile and diaphragm walls	25m

12.10 Sector 8 – Avondale Heights Tunnel

Table 12.11: Sector 8 Specific Mitigation Measures

Activity	Mitigation Measures	Detail
Tunnelling (Continued overleaf)	Choice of methodology	<ul style="list-style-type: none"> conventional excavator/trucks should be considered in the selection of an appropriate methodology as they result in lower re-radiated noise
	Daytime operation	<ul style="list-style-type: none"> at commencement of construction, noise levels from tunnelling are expected to be above the Project night-time noise criteria where the tunnelling has not yet progressed deep inside the tunnel, a restriction to daytime operation may be required until sufficient depth is obtained to mitigate noise
	Tunnel breakout noise control	<ul style="list-style-type: none"> at commencement of construction, noise levels from tunnelling are expected to be above the Project night-time noise criteria if night-time operation is required, noise emissions may be reduced through the provision of baffles or acoustic screens at the outlet of the tunnel.

Activity	Mitigation Measures	Detail
Tunnelling (Continued)	Resident relocation	<ul style="list-style-type: none"> if internal noise levels are unreasonable due to re-radiated noise, temporary relocation of residents may be required relocation may be required for around 7 days at the worst affected locations
	Monitoring	<ul style="list-style-type: none"> noise levels should be monitored at receivers from the beginning of the tunnel construction, and as needed throughout data obtained should be used to update the noise mitigation measures required
Above ground activity	Conveyors	<ul style="list-style-type: none"> conveyors between the construction face and the construction yards should be selected to be as quiet as possible conveyors may require enclosure
Helicopter delivery	Scheduling	<ul style="list-style-type: none"> helicopter delivery of materials shall occur for no more than 10 times in any month residents within 200 metres shall be notified in advance of the helicopter delivery schedule a tight timeframe shall be maintained

Estimated Design safe distances for vibration inducing activities in Sector 8 are shown in table 12.12 below.

Table 12.12: Estimated design safe distances for construction activities in Sector 8

Source	Design safe distance
Tunnelling: Road header	6m
Tunnelling: Excavator – Bucket only	2m
Tunnelling: Excavator mounted rockbreaker	4m

12.11 Sector 9 – Alan Wood Reserve

Table 12.13: Sector 9 Specific Mitigation Measures

Activity	Mitigation Measures	Detail
Operation occurring at ground level for: <ul style="list-style-type: none"> • Southern portal construction • Roding construction • Richardson Road overbridge • Contractor Yards 9 and 10 	Noise Barriers	<ul style="list-style-type: none"> • for noisy operation occurring at ground level, provide noise barriers between noisy sources and nearby receivers • permanent traffic noise barriers should be constructed early in the programme to provide acoustic screening of dwellings • for dwellings that are not protected by noise barriers, provide temporary noise barriers for the duration of above-ground construction. • contractor yards should be surrounded with solid hoarding where this provides line-of-sight screening between noise sources and dwellings
Richardson Road Overbridge construction	Daytime Operation	<ul style="list-style-type: none"> • Richardson Road overbridge construction has the potential to exceed the Project night-time criterion • noisy activities should be programmed to occur during the daytime, with night-time activities restricted to quieter activities • where night-time operation is critical, temporary noise barriers should be implemented around noisy sources
Batch plant (Continued overleaf)	Location, enclosures and alternatives	<ul style="list-style-type: none"> • batch plants required for 24 hour use will require noise control measures to be applied. • the batch plant should be located on the edge of the cut and designed such that the batch plant can load out to trucks below • design of the batch plant in this manner will ensure that trucks do not need to be loaded out and slump at ground level.

Activity	Mitigation Measures	Detail
Batch Plant (Continued)	Location, enclosures and alternatives	<p>Noisy areas of the batch plant will need to be enclosed or screened from surrounding receivers.</p> <p>Mitigation may include but shall not be limited to:</p> <ul style="list-style-type: none"> • Batch plant located as far from receivers as possible; • Enclosure of mixing vessels or dry mixing hoppers; • Enclosure of conveyors; • Enclosure of truck loadout area. Alternatively the batch plant may be able to be constructed such that trucks remain inside the tunnel cutting and are loaded out from above; • Truck slumping to occur in the tunnel cutting and not at ground level where practicable; • Daytime operation of equipment such as loaders. Conveying of material to be used in preference to driven loaders; • Noise barriers located around concrete batch plant yard; • Batch plant designed and located such that reversing of trucks is not required; • Enclosure and treatment of other noisy equipment where identified; and • Good driver and operator education regarding noise mitigation. <p>Dwellings within 150 metres of the batch plant may still experience noise levels of above 45 dB $L_{Aeq}(t)$ during night-time. If noise levels from the batch plant exceed the Project criteria, mechanical ventilation/air conditioning may need to be provided where external windows need to remain shut. The affected area is shown in Appendix E.</p> <p>The following alternative locations should also be considered for the batch plant:</p> <ul style="list-style-type: none"> • at the bottom of the cut near the southern portal (this will result in noise sources being further from residents and very well screened by the edges of the cut) • in the industrial area to the east of the operation (Stoddard Road Area), or in an industrial area further afield, together with a combination of noise enclosure and screening (truck movements to and from the tunnel would be well screened by cuttings, however temporary noise barriers may be required at some locations)

Activity	Mitigation Measures	Detail
Crushing	Management and location	<ul style="list-style-type: none"> crushing plant shall be enclosed, where practicable, with a well sealed enclosure with lined feed and output conveyor chutes a large sheet steel enclosure lined internally with a heavier panel such as fibre cement may be the best solution crushing shall occur during the daytime only choose quiet plant for operation in and around the crusher, such as quiet loaders.
Blasting	Notification	<ul style="list-style-type: none"> blasting shall occur between the hours of 9am and 5pm, Monday to Saturday only predictions of blast overpressure shall be performed prior to any blasting and charge sizes selected to ensure that the Project noise criteria are complied with residents within 200 metres of the blast shall be notified prior to blasting
All operation	Resident relocation / façade improvements	<ul style="list-style-type: none"> where noisy construction techniques are critical and must occur regardless of the exceedance of the Project noise criteria, temporary relocating of affected residents shall be considered on a case-by-case basis where residents are unwilling to relocate or the construction period is sufficiently long as to make relocation not practicable, the improvement of the sound insulation of dwelling façades should be considered as an alternative, on a case-by-case basis and only after all other practicable noise control options have been considered.

Preliminary portal works with equipment at ground level, grout curtain, road construction and finishing, basalt crushing, Richardson Road overbridge segment launching and finishing and contractor yard operation may all exceed the Project noise criteria. Within this sector, careful implementation of the general and specific noise mitigation measures is necessary and all practicable steps should be taken to reduce noise emissions.

Estimated design safe distances for vibration including activities in Sector 9 are shown in Table 12.14 below.

Table 12-14: Estimated design safe distances for construction activities in Sector 9

Source	Design safe distance
Vibratory rollers for road construction	30m
Drilling for grout curtain and secant piles	15m
Piling	25m
Rockbreakers	15m
Blasting	Depends on Charge Weight

13. Construction Noise and Vibration Management Schedule

Once the contractor has defined the construction methodology and all proposed plant and equipment, management schedules for construction noise and vibration shall be prepared for each Sector.

The vibration schedules (Schedules [xx] in Appendix F) shall detail high-vibration equipment, their safe distances and all sensitive receivers within the high and medium risk categories (refer Section 12.2).

The noise schedules (Schedules [xx] in Appendix F) shall detail high-noise equipment and all sensitive receivers as follows:

- for daytime work: within the 20 metre and 50 metre categories and
- for night-time work: within the 20 metre, 50 metre and 100 metre categories (refer Section 11.1)

The schedules shall be completed prior to commencement of construction works in each Sector. An example schedule can be found at <http://acoustics.nzta.govt.nz/file/construction-noise-management-schedule-template>.

14. CNVMP Review

This CNVMP, including environmental controls and procedures, shall be reviewed to ensure that it remains applicable to the activities being carried out.

The CNVMP will be reviewed by the contractor after confirmation of the resource consent and designation conditions and will be revised in accordance with these conditions. The CNVMP will be updated, with the necessary approval, throughout the course of the Project to reflect material changes associated with changes to construction techniques or the natural environment. Approval from the [Auckland Council] will be required for any relevant revisions of a material nature for the CNVMP

A management review of the CNVMP will be undertaken at least annually by the Project Management team and the NZTA Environmental Representative. The management review will be organised by the Environmental Manager, and the Project team will be informed of any changes to this plan through the regular project communications processes.

The review will take into consideration:

- Significant changes that affect the noise and/or vibration generation
- Key changes to roles and responsibilities within the Project
- Changes in industry best practice standards
- Changes in methodology or management in response to noise and/or vibration monitoring showing non-compliance
- Changes in legal or other requirements (social and environmental legal requirements, consent conditions, NZTA objectives and relevant policies, plans, standards, specifications and guidelines)
- Public complaints

Reasons for making changes to the CNVMP will be documented. A copy of the original CNVMP document and subsequent versions will be kept for the Project records, and marked as obsolete. Each new/updated version of the CNVMP documentation will be issued with a version number and date to eliminate obsolete CNVMP documentation being used.

APPENDIX A

Glossary of Terminology

Parameter	Description
dB	A measurement of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
$L_{Aeq}(60 \text{ min})$	The A-weighted, time averaged sound level (on a logarithmic/energy basis) over the measurement period.
L_{A95}	The sound level which is equalled or exceed for 95% of the measurement period.
L_{A90}	The sound level which is equalled or exceed for 90% of the measurement period. L_{A90} is an indicator of the mean minimum noise level and is used in New Zealand as the descriptor for background noise (normally A-weighted).
L_{A10}	The sound level which is equalled or exceeded for 10% of the measurement period.
L_{AFmax}	The maximum sound level recorded during the measurement period (normally A-weighted).
L_{Zpeak}	The peak instantaneous pressure level recorded during the measurement period (flat weighted (Z)).
Noise	A sound that is unwanted by, or distracting to, the receiver.
NZS 6801:2008	New Zealand Standard NZS 6801:2008 " <i>Acoustics - Measurement of Sound</i> "
NZS 6802:2008	New Zealand Standard NZS 6802:2008 " <i>Acoustics - Environmental Noise</i> ".
NZS 6803:1999	New Zealand Standard NZS 6803:1999 " <i>Acoustics – Construction Noise</i> ".
Ambient Noise	Ambient Noise is the all-encompassing noise associated with any given environment and is usually a composite of sounds from many sources near and far.

Vibration

PPV	Peak Particle Velocity, measured in mm/s. This is the standard metric for assessing construction vibration levels.
DIN 4150-3:1999	German Standard DIN 4150-3:1999 "Structural Vibration – Part 3: Effects of vibration on structures". This standard generally adopted in NZ to assess building damage.
BS 5228-2:2009	British Standard BS 5228-2:2009 "Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration". This is the standard adopted for this Project to assess human response to construction.
MIC	Maximum Instantaneous Charge Weight. In blasting, this is the weight of explosive (in kg) used.

General

CNVMP	Construction Noise and Vibration Management Plan. This document
AEE	Assessment of Environmental Effects. A document relating to, and assessing the effects of a specific element of the Project e.g. Noise, Air Quality, Traffic, Vibration

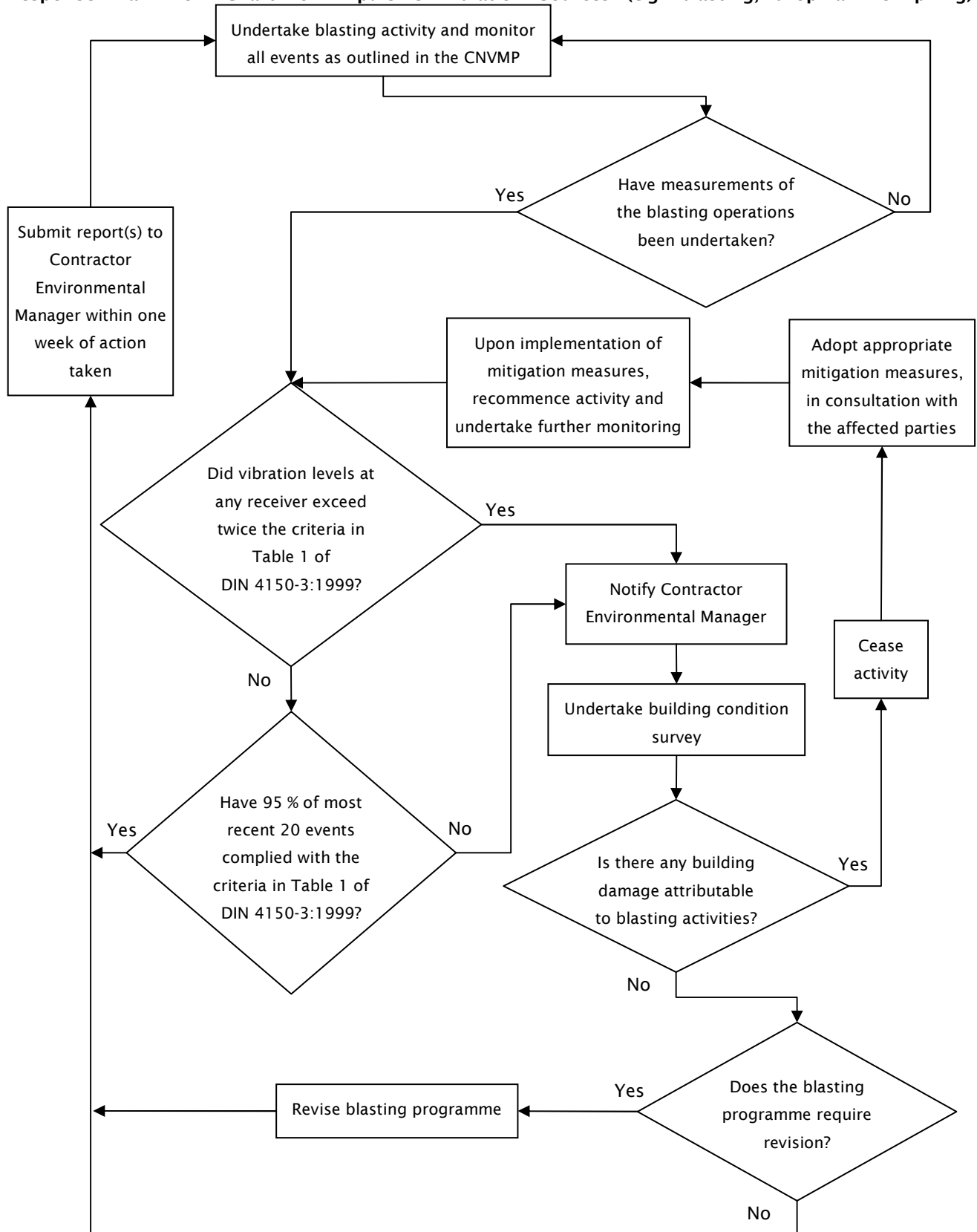
APPENDIX B

Project Sector Diagram

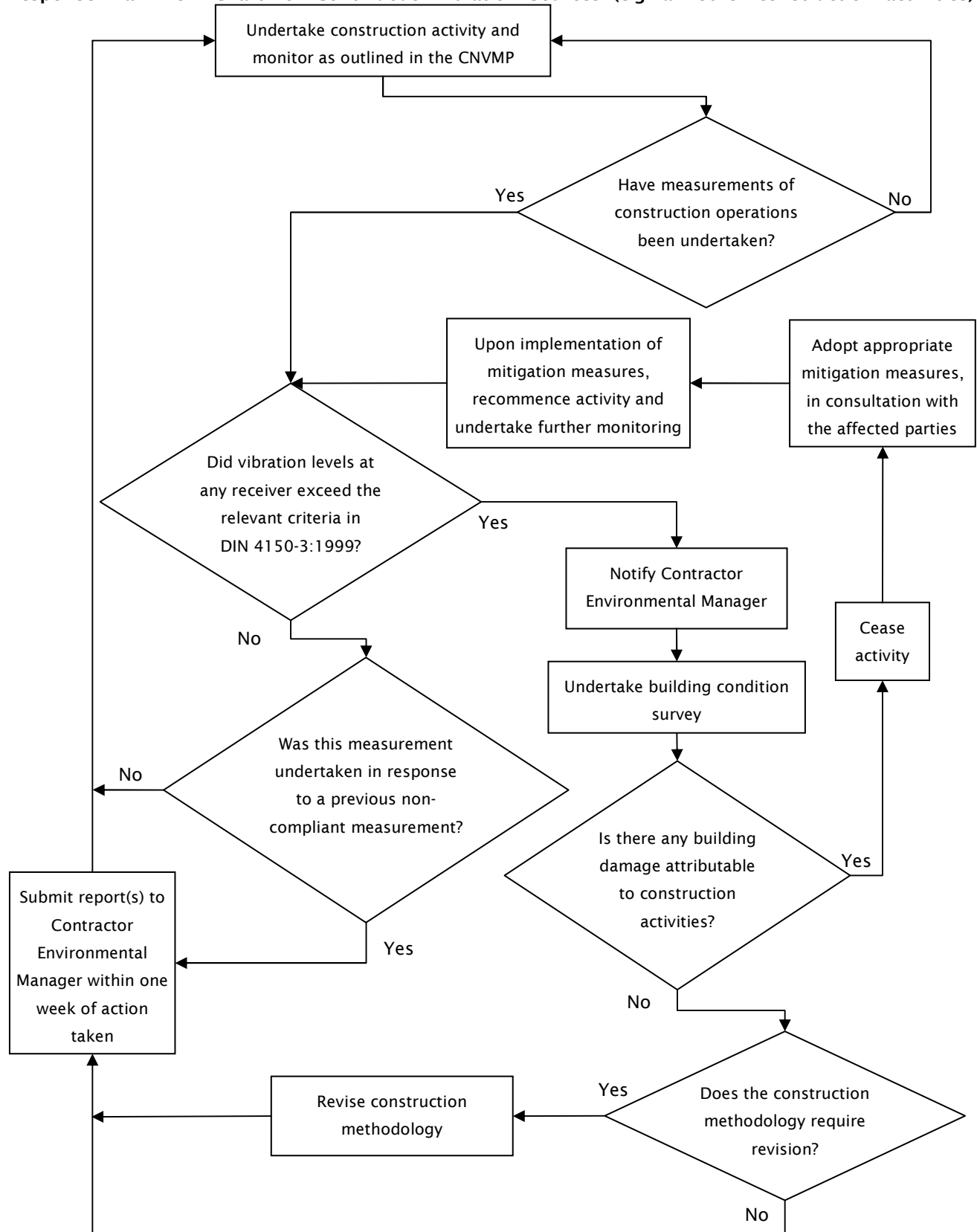
APPENDIX C

Response Plans for Construction Vibration Issues

Response Plan Flow Chart for Impulsive Vibration Sources (e.g. blasting, drop-hammer piling)



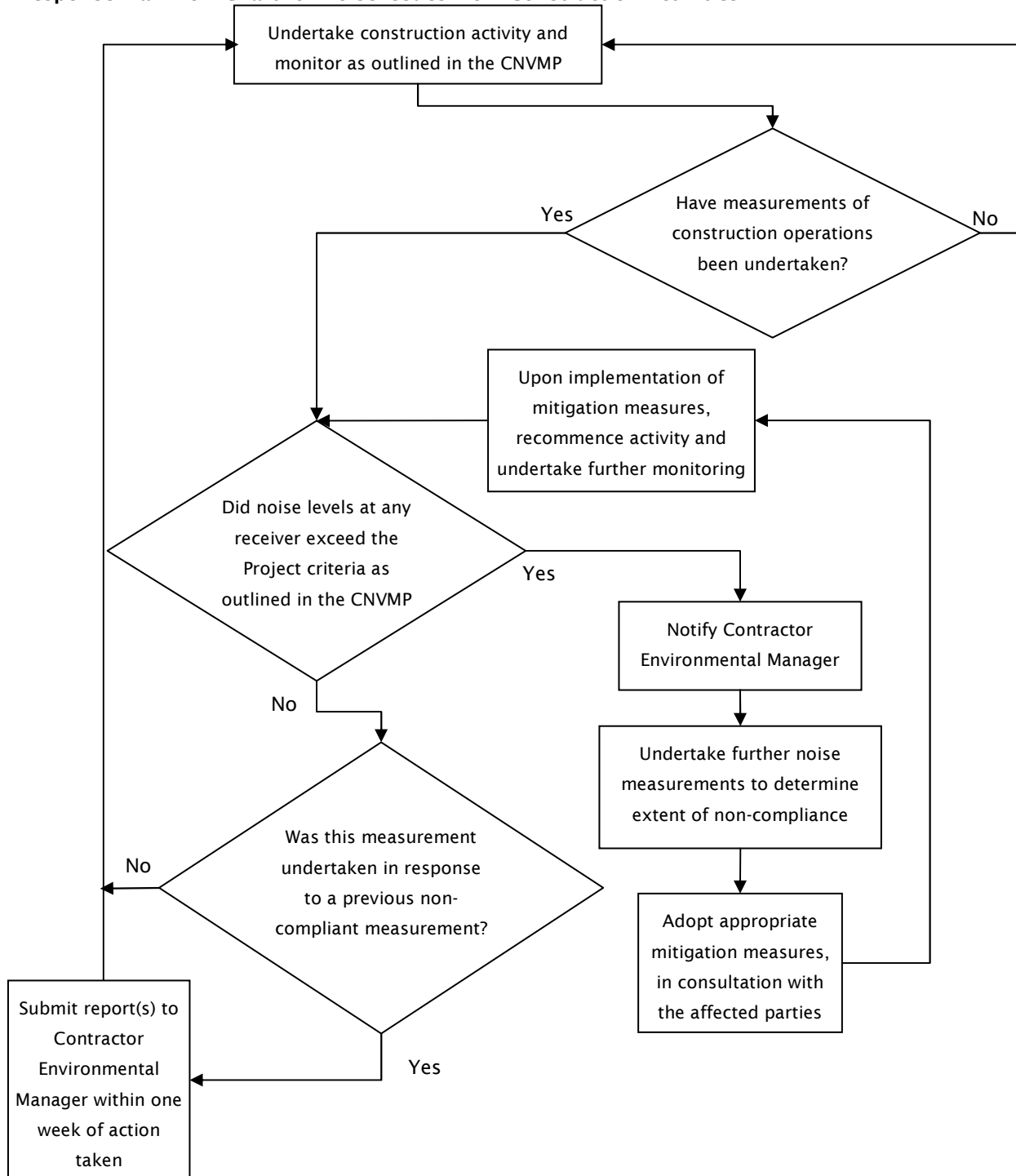
Response Plan Flow Chart for Continuous Vibration Sources (e.g. all other construction activities)



APPENDIX D

Response Plan for Construction Noise Issues

Response Plan Flow Chart for Noise Issues from Construction Activities



APPENDIX E

Dwellings potentially requiring mechanical Ventilation due to Batching Plan (Sector 9)

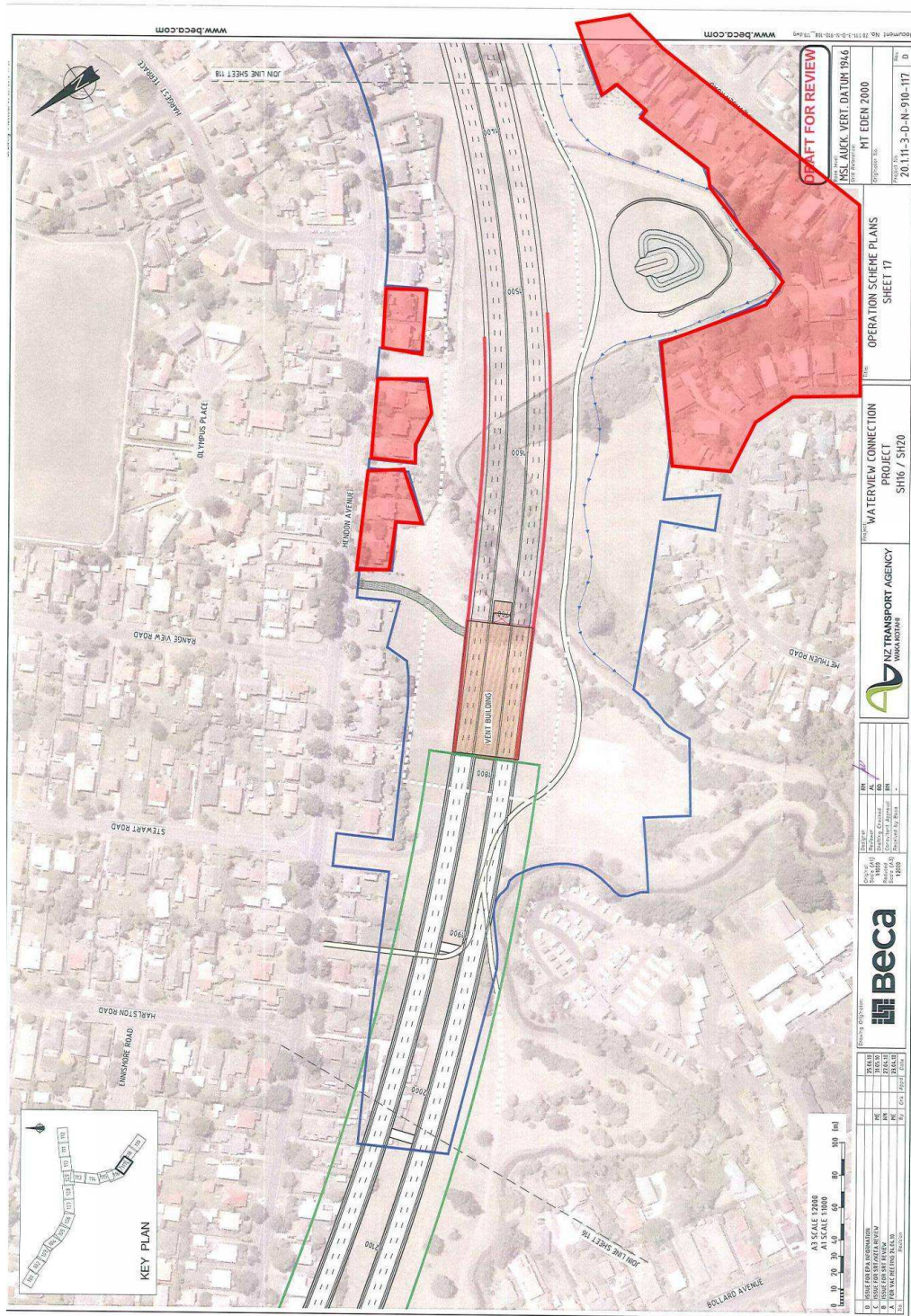
APPENDIX F

Schedules of at-risk buildings and high-vibration generating equipment

[Schedules of at-risk buildings and high-vibration equipment shall be completed by the contractor prior to commencement of the Project]

APPENDIX D

Dwellings potentially requiring mechanical Ventilation due to Batching Plan (Sector 9)



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APPENDIX E

Concrete Batching and Crushing Plan Management Plan (Overleaf)