

**CHRISTCHURCH SOUTHERN MOTORWAY STAGE 2 &
MAIN SOUTH ROAD 4 LANING**

Assessment of Construction Noise & Vibration

Rp009 R01 2010286C

November 2012



Project: **CHRISTCHURCH SOUTHERN MOTORWAY STAGE 2 & MAIN
SOUTH ROAD FOUR LANING**

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Report No.: **Rp009 R01 2010286C**

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This Technical Report has been produced in support of the Assessment of Environmental Effects (AEE) for the Main South Road Four Laning and Christchurch Southern Motorway Stage 2 Project. It is one of 20 Technical Reports produced (listed below), which form Volume 3 of the lodgement document. Technical information contained in the AEE is drawn from these Technical Reports, and cross-references to the relevant reports are provided in the AEE where appropriate.

A Construction Environmental Management Plan (CEMP) has been prepared to provide the framework, methods and tools for avoiding, remedying or mitigating environmental effects of the construction phase of the Project. The CEMP is supported by Specialised Environmental Management Plans (SEMPs), which are attached as appendices to the CEMP. These SEMPs are listed against the relevant Technical Reports in the table below. This Technical Report is highlighted in grey in the table below. For a complete understanding of the project all Technical Reports need to be read in full along with the AEE itself; however where certain other Technical Reports are closely linked with this one they are shown in bold.

Schedule of Technical Reports for the AEE

No.	Technical Report Title	Primary AEE Chapter Reference	SEMPs
1	Design philosophy statement	4	
2	Traffic and transportation effects report	11	Construction Traffic Management Plan
3	Assessment of stormwater disposal and water quality	19	Erosion and Sediment Control Plan, Accidental Aquifer Interception Management Plan
4	Landscape and visual effects	15	Landscape Management Plan
5	Assessment of effects - urban design	14	Landscape Management Plan
6	Urban and landscape design framework	14, 15	Landscape Management Plan
7	Landscape context report	15	Landscape Management Plan
8	Assessment of operational noise effects	17	
9	Assessment of construction noise & vibration	17	Construction Noise and Vibration Management Plan
10	Assessment of air quality effects	18	Air Quality Management Plan
11	Geotechnical engineering and geo-hazards assessment	3, 21	
12	Assessment of archaeological effects	24	
13	Social impact assessment	26	
14	Economic impact assessment	25	
15	Cultural impact assessment	23	
16	Contaminated land assessment	22	
17	Aquatic ecology assessment	20	
18	Terrestrial ecology assessment	20	
19	Lighting assessment	16	
20	Statutory provisions report	6, 28	
-	Construction Environmental Management Plan	5	

For further information on the structure of the lodgement documentation, refer to the 'Guide to the lodgement documentation' document issued with the AEE in Volume 1.

EXECUTIVE SUMMARY

This report provides an assessment of construction noise and vibration effects associated with the NZTA's Christchurch Southern Motorway Stage 2 and Main South Road four-laning project.

It contains a discussion of appropriate criteria and assessment methodologies and details of predicted noise levels and potential areas of risk. Construction noise criteria are based on those contained in NZS 6803: 1999 "*Acoustics - Construction Noise*", with the aim of achieving compliance with these criteria where practicable. The Standard acknowledges the requirement of Section 16 of the Resource Management Act that the best practicable option be adopted to ensure that noise emissions from any site do not exceed a reasonable level. The methodology used for this assessment takes account of, and discusses, the practicability of mitigation options.

A review of the construction methodology information available has allowed for an assessment of the Project's potential noise effects. Construction noise has been predicted using information contained in NZS6803:1999 and BS5228-1:2009 *Code of practice for noise and vibration control on construction and open sites - Noise*. Tables are provided that show potential noise emissions from the construction activities proposed. These predictions are based on assumptions provided by the Project team. Actual construction methodology and construction equipment will not be known in detail until a Contractor has been appointed to the Project.

Where there is a large scope for different construction methods to be used (such as different techniques for piling or ground improvement works), information is provided that will be considered during the tendering and detailed design process.

General noise management and mitigation measures have been recommended that should be implemented throughout the Project construction as a best practice provision, e.g. the maintenance of equipment to a high level and the avoidance of unnecessary noise such as the use of horns. In addition, where there is a risk that the construction noise standards would be exceeded, recommendations for specific noise mitigation and management methodologies are provided. These recommendations are site specific and involve additional measures such as the installation of temporary construction noise barriers or the timing of construction activities to avoid effects on receivers.

Overall, the construction of the Project is predicted to result in noise levels that are generally within the construction noise criteria in accordance with the NZS6803:1999, with some exceptions. While construction noise levels are higher than ongoing operational noise levels, it is commonly accepted that for any construction to occur, construction noise criteria must be less stringent than operational noise criteria, with the understanding that construction is a temporary activity with a finite duration.

Construction vibration effects have been assessed through on-site measurement of identified machinery, as well as the review of data from relevant standards and previous measurements. This data has been analysed and processed to establish setback distances for building vibration risk assessments.

Predictions of construction vibration levels indicate there is a degree of risk that the Project criteria may be exceeded at dwellings within 20m of the Main South Road Four-Laning alignment. The information provided in this report will assist in the tendering process and the development of a more detailed construction methodology.

The most effective method to control construction noise and vibration is through proactive management and we recommend that this is achieved through the implementation of the Construction Noise and Vibration Management Plan (CNVMP) which will be formulated and updated as appropriate to reflect the actual activities occurring. A draft CNVMP has been provided as Appendix D.

It is considered that the Christchurch Southern Motorway and Main South Road four-laning Project can be constructed within reasonable noise and vibration criteria, provided that the best practicable option of mitigation is implemented throughout and contractors are committed to managing construction noise and vibration on an ongoing basis.

TABLE OF CONTENTS

1.0	INTRODUCTION	9
2.0	EXISTING NOISE ENVIRONMENT.....	9
3.0	PROJECT OVERVIEW.....	9
3.1	Project Description (provided by GHD)	9
3.2	MSRFL.....	9
3.3	CSM2	10
3.4	Key Design Features.....	10
3.5	Construction Programme	11
3.6	Project Assessment Sectors.....	14
4.0	ASSESSMENT METHODOLOGY.....	14
5.0	CONSTRUCTION NOISE PERFORMANCE STANDARDS.....	15
5.1	New Zealand Construction Noise Standard NZS 6803:1999.....	15
5.2	NZTA Environmental Plan (June 2008)	16
5.3	District Plans	16
5.4	Resource Management Act.....	17
6.0	PROJECT CONSTRUCTION NOISE CRITERIA.....	17
7.0	ASSESSMENT OF CONSTRUCTION NOISE EFFECTS.....	18
7.1	Construction Scenarios	19
7.2	Typical Construction Noise Levels.....	20
7.3	Predicted Noise Levels for Construction Scenarios	21
7.4	MSRFL - South of Weedons (Sector 12).....	21
7.5	Weedons Road Interchange (Sector 11).....	24
7.6	MSRFL - Robinsons to Weedons (Sector 10).....	26
7.7	MSRFL - Robinsons to Berketts (Sector 9)	28
7.8	Robinsons Road (Sector 8).....	30
7.9	Waterholes Road (Sector 7)	33
7.10	CSM2 - Trents to Waterholes (Sector 6).....	36
7.11	CSM2 - Shands to Trents (Sector 4 and 5)	38
7.12	Shands Road (Sector 3)	41
7.13	Halswell Junction/Springs Road (Sector 1 and 2).....	43
7.14	Night-time Construction Activities.....	46
7.15	Ground Improvements and Piling Techniques.....	47

7.16	Summary of Noise Mitigation Required	48
8.0	VIBRATION PERFORMANCE STANDARDS.....	49
8.1	Review of vibration standards.....	49
8.2	Draft NZTA “State highway construction and maintenance noise and vibration guide” .	49
8.3	Resource Management Act	50
8.4	District Plans	51
8.5	NZTA Environmental Plan (June 2008)	51
8.6	National Environmental Standards.....	51
9.0	PROJECT CONSTRUCTION VIBRATION CRITERIA	52
10.0	ASSESSMENT OF CONSTRUCTION VIBRATION EFFECTS	53
10.1	Typical Vibration Levels	53
10.2	Risk of Construction Vibration Effects	54
10.3	Assessment of Construction Vibration Effects	55
11.0	CONSTRUCTION NOISE MITIGATION AND MANAGEMENT.....	56
12.0	DESIGNATION CONDITIONS	57
13.0	SUMMARY AND CONCLUSIONS.....	58
APPENDIX A	GLOSSARY OF TERMINOLOGY.....	59
APPENDIX B	ASSESSMENT SECTORS	60
APPENDIX C	VIBRATION STANDARDS.....	62
	DIN 4150-3:1999	62
	BS 6472-1:2008	63
	BS 7385-2:1993	63
	BS 5228-2:2009	64
APPENDIX D	DRAFT CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN.....	66

1.0 INTRODUCTION

The purpose of this report is to provide an assessment of the potential noise and vibration effects associated with the construction of the proposed New Zealand Transport Agency's (NZTA's) Christchurch Southern Motorway Stage 2 (CSM2) and the associated four-laning of Main South Road (MSRFL) [the Project].

This report predicts noise and vibration levels from construction activities associated with the construction of the Project. Proposed construction noise and vibration criteria for the Project are outlined.

A glossary of acoustics terminology used in this report is provided in **Appendix A**.

2.0 EXISTING NOISE ENVIRONMENT

As part of the Project's operational noise assessment, a series of noise measurements were conducted along the extent of the proposed scheme. Traffic tends to dominant the existing noise environment and noise levels are relatively high at dwellings along Main South Road (SH1), Springs and Shands Roads. Measured noise levels are lower at dwellings adjacent to less busy roads and, the further a dwelling is located from a road, the greater the influence of other environmental sounds such as birdsong and rustling leaves. Measured noise levels are in the range 47 to 74 dB $L_{Aeq(24h)}$. Noise levels at night are typically lower than during the day with 30 to 35 dB $L_{Aeq(15min)}$ being typical away from busy roads.

3.0 PROJECT OVERVIEW

3.1 Project Description (provided by GHD)

The NZ Transport Agency (NZTA) seeks to improve access for people and freight to and from the south of Christchurch via State highway 1 (SH1) to the Christchurch City centre and Lyttelton Port by constructing, operating and maintaining the Christchurch Southern Corridor. The Government has identified the Christchurch motorway projects, including the Christchurch Southern Corridor, as a road of national significance (RoNS).

The proposal forms part of the Christchurch Southern Corridor and is made up of two sections: Main South Road Four Laning (MSRFL) involves the widening and upgrading of Main South Road (MSR), also referred to as SH1, to provide for a four-lane median separated expressway; and the construction of the Christchurch Southern Motorway Stage 2 (CSM2) as a four-lane median separated motorway. The proposed construction, operation and maintenance of MSRFL and CSM2, together with ancillary local road improvements, are referred to hereafter as 'the Project'.

3.2 MSRFL

Main South Road will be increased in width to four lanes from its intersection with Park Lane north of Rolleston, for approximately 4.5 km to the connection with CSM2 at Robinsons Road. MSRFL will be an expressway consisting of two lanes in each direction, a median with

barrier separating oncoming traffic, and sealed shoulders. An interchange at Weedons Road will provide full access on and off the expressway. MSRFL will connect with CSM2 via an interchange near Robinsons Road, and SH1 will continue on its current alignment towards Templeton.

Rear access for properties fronting the western side of MSRFL will be provided via a new road running parallel to the immediate east of the Main Trunk rail corridor from Weedons Ross Road to just north of Curraghs Road. For properties fronting the eastern side of MSRFL, rear access is to be provided via an extension of Berketts Drive and private rights of way.

The full length of MSRFL is located within the Selwyn District.

3.3 CSM2

CSM2 will extend from its link with SH1 / MSRFL at Robinsons Road for approximately 8.4 km to link with Christchurch Southern Motorway Stage 1 (CSM1, currently under construction) at Halswell Junction Road. The road will be constructed to a motorway standard comprising four lanes, with two lanes in each direction, with a median and barrier to separate oncoming traffic and provide for safety.¹ Access to CSM2 will be limited to an interchange at Shands Road, and a half-interchange with eastward facing ramps at Halswell Junction Road. At four places along the motorway, underpasses (local road over the motorway) will be used to enable connectivity for local roads, and at Robinsons / Curraghs Roads, an overpass (local road under the motorway) will be provided. CSM2 will largely be constructed at grade, with a number of underpasses where elevated structures provide for intersecting roads to pass above the proposed alignment.

CSM2 crosses the Selwyn District and Christchurch City Council boundary at Marshs Road, with approximately 6 km of the CSM2 section within the Selwyn District and the remaining 2.4 km within the Christchurch City limits.

3.4 Key Design Features

The key design features and changes to the existing road network (from south to north) proposed are:

- a new full grade separated partial cloverleaf interchange at Weedons Road;
- a new roundabout at Weedons Ross / Jones Road;
- a realignment and intersection upgrade at Weedons / Levi Road;
- a new local road running to the immediate east of the rail corridor, to the west of Main South Road, between Weedons Ross Road and Curraghs Road;
- alterations and partial closure of Larcombs Road intersection with Main South Road to left in only;

¹ CSM2 will not become a motorway until the Governor-General declares it to be a motorway upon request from the NZTA under section 71 of the Government Rooding Powers Act 1989 (GRPA). However, for the purposes of this report, the term "motorway" may be used to describe the CSM2 section of the Project.

- alterations to Berketts Road intersection with Main South Road to left in and left out only;
- a new accessway running to the east of Main South Road, between Berketts Road and Robinsons Road;
- an overpass at Robinsons and Curraghs Roads (the local roads will link under the motorway);
- construction of a grade separated y-junction (interchange) with Main South Road near Robinsons Road;
- a link road connecting SH1 with Robinsons Road;
- a short new access road north of Curraghs Road, adjacent to the rail line;
- a new roundabout at SH1 / Dawsons Road / Waterholes Road;
- an underpass at Waterholes Road (the local road will pass over the motorway);
- an underpass at Trents Road (the local road will pass over the motorway);
- the closure of Blakes Road and conversion to two cul-de-sacs where it is severed by CSM2;
- a new full grade separated diamond interchange at Shands Road;
- an underpass at Marshs Road (the local road will pass over the motorway);
- providing a new walking and cycling path linking the Little River Rail Trail at Marshs Road to the shared use path being constructed as part of CSM1;
- an underpass at Springs Road (the local road will pass over the motorway);
- a new grade separated half interchange at Halswell Junction Road with east facing on and off ramps linking Halswell Junction Road to CSM1; and
- closure of John Paterson Drive at Springs Road and eastern extension of John Paterson Drive to connect with the CSM1 off-ramp via Halswell Junction Road roundabout (east of CSM2).

The proposed alignment is illustrated in Figure 1 and encompasses the MSRFL and CSM2 alignments between Rolleston and Halswell Junction Road.

3.5 Construction Programme

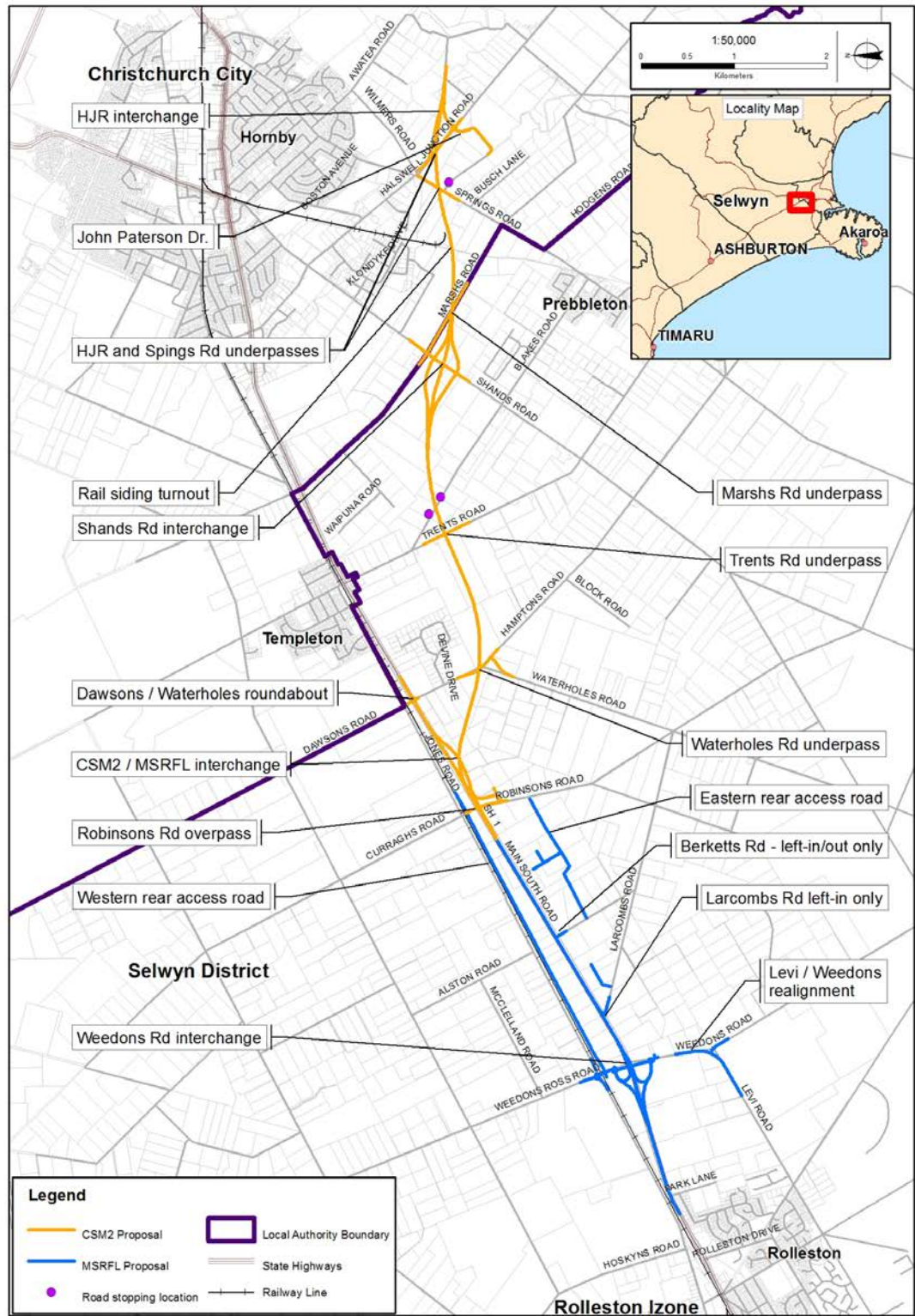
The current programme assumes that the construction of the Project will take up to approximately three years.

At this stage, the outline construction methodology includes:

- Enabling works including connecting utilities, erecting construction compounds and fencing;
- Relocation of overhead transmission lines and other network utilities;

- Ground improvements at main structure locations which may involve piling and installation of stone columns;
- Transportation of fill to form approaches to bridge structures;
- Construction of bridge structures;
- Construction of interchanges;
- Excavation of swales and stormwater treatment ponds with surplus material used to form noise bunds;
- Work on surrounding roads;
- Road construction involving the stripping of topsoil and bringing the road to formation level; and
- Installation of road pavement and street furniture (barriers, signs etc).

Figure 1: Location Map of MSRFL and CSM2 Project



3.6 Project Assessment Sectors

The CSM2/MSRFL alignment has been broken up into 12 Sectors for assessment. These Sectors are described in Table 1 below, and shown in Appendix B.

Table 1: Assessment Sectors

Assessment Sector	Description
12 MSRFL - South of Weedons	MSRFL from Weedons Road to existing four-laning at Rolleston
11 Weedons Road	MSRFL/Weedons Road Interchange
10 MSRFL - Robinsons to Weedons	Main MSRFL alignment between Berketts Road and Weedons Road/Weedons Ross Road
9 MSRFL - Robinsons to Berketts	Main MSRFL alignment between Robinsons Road and Berketts Road
8 Robinsons Road	CSM2/MSRFL Interchange at Robinsons Road
7 Waterholes Road	Waterholes Road overbridge and realignment
6 CSM2 - Trents to Waterholes	Main CSM2 alignment between Trents Road and Waterholes Road
5 Trents Road	Trents Road overbridge
4 CSM2 - Marshs to Trents	Main CSM2 alignment between Marshs Road and Trents Road
3 Shands Road	CSM2/Shands Road Interchange and Marshs Road overbridge
2 CSM2 - Springs to Shands	Main CSM2 alignment between Springs Road and Shands Road
1 Halswell Junction/Springs Road	Halswell Junction Road/Springs Road Interchange and Springs Road overbridge

4.0 ASSESSMENT METHODOLOGY

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

- A review of the preferred alignment has been undertaken and nearby sensitive receivers identified.
- A review of noise and vibration emission data for each construction task / process has been undertaken. Data from appropriate standards and published guidance has informed this process. In addition, data previously obtained by Marshall Day Acoustics has also been considered, where relevant.

- A review of relevant noise and vibration assessment criteria has been undertaken: these criteria are set out in this report and Project noise and vibration limits have been recommended.
- Predictions of noise and vibration levels from key construction process have been undertaken and dwellings that are likely to receive levels above the Project criteria identified.
- Where activities with the potential to generate noise levels in excess of the criteria are identified, the best practicable option (BPO) for reducing adverse noise and / or vibration effects has been proposed. This will be included in the draft Construction Noise and Vibration Management Plan (CNVMP) which is attached as **Appendix D**. Any modified construction methodology would need to be taken into consideration and included in, and by regular updating of, the CNVMP.

5.0 CONSTRUCTION NOISE PERFORMANCE STANDARDS

5.1 New Zealand Construction Noise Standard NZS 6803:1999

The Construction Noise Standard NZS 6803 “Acoustics - Construction Noise” contains recommended noise criteria that are appropriate and applicable to noise from construction operations, excluding blasting.

5.1.1 Noise from Construction

The recommended construction noise criteria of NZS 6803:1999 are contained in Tables 2 and 3 of the Standard, and are reproduced in Table 2 and Table 3 below.

Table 2: Recommended upper limits for construction noise received in residential zones and dwellings in rural areas (Table 2 from NZS 6803:1999)

Time of week	Time period	Duration of work					
		Typical duration (dBA)		Short-term duration (dBA)		Long-term duration (dBA)	
		L _{eq}	L _{max}	L _{eq}	L _{max}	L _{eq}	L _{max}
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	0630-0730	45	75	45	75	45	75

and public holidays	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 3: Recommended upper limits for construction noise received in industrial or commercial areas for all days of the year (Table 3 from NZS 6803:1999)

Time period	Duration of work		
	Typical duration (dBA)	Short-term duration (dBA)	Long-term duration(dBA)
	L_{eq}	L_{eq}	L_{eq}
0730-1800	75	80	70
1800-0730	80	85	75

The Standard provides for higher noise levels during normal working hours for construction noise received in residential areas in order to enable normal construction activity to take place. For commercial and industrial areas, higher noise criteria are allowed 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.

5.1.2 Night-Time and Sunday Work

The Standard provides more stringent noise limits during the night-time and on Sundays for residential areas and dwellings in rural zones.

It is envisaged that during critical periods, occasional night-time and Sunday construction work may be required for the Project to avoid disruption to the roading network, and this will be the time where potential noise disturbance is greatest. Where night-time noise limits cannot be met, alternative strategies should be described in the CNVMP to address the effects of noise on neighbours.

5.2 NZTA Environmental Plan (June 2008)

Section 2.1 of the Transit (NZTA) Environmental Plan (June 2008) refers to “managing and minimising potentially unreasonable noise effect during construction, so far as is practicable, in accordance with NZS 6803:1999 ‘Acoustics - Construction Noise.’” The Plan does not detail the specific methods of noise mitigation that might be used.

5.3 District Plans

The Project lies within the areas administered by both Christchurch City Council and the Selwyn District Councils.

5.3.1 Christchurch City Plan

Whilst the Christchurch City Plan provides noise rules for activities within a range of land use zones, noise from construction activities are specifically exempt.

5.3.2 Selwyn District Plan

The Selwyn District Plan references NZS 6802:1991 as the standard for assessment of environmental sound. Section 1.2 of NZS 6802:1991 specifically excludes noise from construction from being assessed using the Standard, except for when the sound from the construction activity is part of the overall sound emission from a land use activity, or is part of the background sound for a specific site. Furthermore, in Rural zones, Rule 9.16.6.1 states that the plan noise limits do not apply to:

“Noise from any motor vehicle or any mobile machinery (including farm machinery and stationary equipment not fixed to the ground).”

5.4 Resource Management Act

Under the provisions of the Resource Management Act (RMA) there is a duty to adopt the best practicable option to ensure that the noise from any development does not exceed a reasonable level. Note that the definition of noise in Section 2 of the RMA includes vibration.

Specifically, sections 16 and 17 of the RMA reference ‘noise’ effects as follows.

Section 16 states that *“every occupier of land (including any coastal marine area), and every person carrying out an activity, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level”*.

Section 17 states that *“every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity, whether or not the activity is in accordance with a rule in a plan, a resource consent or relevant sections of the RMA”*.

6.0 PROJECT CONSTRUCTION NOISE CRITERIA

On the basis of our review of available performance standards, we consider NZS6803 to be the most appropriate means of assessing and managing construction noise effects. Given the proposed construction period of **three** years, the “long term duration” noise limits are applicable in this instance. The Project construction noise limits in Table 4 and Table 5 are taken from NZS 6803:1999. The noise assessment period should not exceed one hour, and 15 minutes will often be adequate.

Table 4: Project noise limits for construction noise received in residential zones

Time of week	Time period	“Long-term” duration construction (dB)	
		L _{Aeq}	L _{AFmax}
Weekdays	0630-0730	55	75
	0730-1800	70	85
	1800-2000	65	80
	2000-0630	45	75
Saturdays	0630-0730	45	75
	0730-1800	70	85
	1800-2000	45	75
	2000-0630	45	75
Sundays and public holidays	0630-0730	45	75
	0730-1800	55	85
	1800-2000	45	75
	2000-0630	45	75

Table 5: Project noise limits for construction noise received in industrial or commercial areas

Time period	“Long-term” duration construction
All days of the year	dB L _{Aeq}
0730-1800	70
1800-0730	75

For this report, where a specific level is not defined (i.e. 70 dB L_{Aeq}) “daytime noise criteria” refers generally to those noise criteria that apply between the hours of 0630 - 2000 Monday to Friday, and 0730 - 1800 Saturday and Sunday. “Night-time noise criteria” refers generally to those noise criteria that apply between the hours of 2000 - 0630 Monday to Friday, and 1800 - 0730 Saturday and Sunday.

7.0 ASSESSMENT OF CONSTRUCTION NOISE EFFECTS

Construction of the Project will require the use of large mobile mechanical equipment and processes that are likely to generate elevated levels of noise at the nearest residences. As such, there are likely to be some temporary noise impacts over the construction phase of the Project.

Construction noise impacts can be minimised through appropriate management and planning. For example, the erection of traffic noise barriers during the early phases of construction would also serve to reduce noise from road construction work.

7.1 Construction Scenarios

For ease of assessment, the construction activities are grouped into a number of typical scenarios. For each scenario the significant noise generating activities are identified.

Table 6: Construction scenarios

Construction Scenario	Significant noise and/or vibration generating activities that may occur
Enabling Works	Heavy earthmoving machinery during initial site compound erection.
Topsoil Stripping	Motor-scraper, excavator and trucks.
General Earthworks	Large excavators, spreaders, rollers/compactors and truck movements.
Ground Improvements	Vibratory construction activities (stone column construction, vibratory compaction), rollers/compactors, bored concrete piles, driven steel piles, excavators, truck movements.
Bridge Construction	Mobile cranes, truck movements, concrete pumping, steel sheet piling, excavators, rollers/compactors.
Pavement Construction	Spreader machine, grader, paving roller, vibratory roller, truck movements.
Electricity Network Utilities	Mobile cranes and jointing methods (N.B. controlled by Transpower).

Note that all of the activities listed may not occur at the same time. In some scenarios there are multiple construction methods available (such as bored concrete piling or impact steel piling) and in these instances, we have assessed the potential effects for each construction method.

Not all of these scenarios occur at all locations along the CSM2/MSRFL alignment. Table 7 outlines the Sectors where each of these construction scenarios may occur.

Table 7: Sectors where construction activities may occur

Construction Scenario	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8	Sector 9	Sector 10	Sector 11	Sector 12
Enabling Works	*	*	✓	*	*	*	*	*	*	*	*	*
Topsoil Stripping	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
General Earthworks	✓	✓		✓		✓			✓	✓		✓
Ground Improvements**	✓		✓		✓		✓	✓				
Bridge Construction	✓		✓		✓		✓	✓			✓	
Pavement Construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Electricity Network Utilities***	-	-	-	-	-	-	-	-	-	-	-	-

Construction Scenario	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8	Sector 9	Sector 10	Sector 11	Sector 12
<p>* The main compound is likely to be situated to the east of the CSM2/Robinsons Road. The civil/earthworks compound is likely to be situated on the SE corner of the Marshs/Shands intersection, in the space between the intersection and the proposed on ramp. There will be other smaller compounds along the length of the site dependent on the Contractor's requirements.</p> <p>** Ground improvements will be required at the bridge abutments. At this stage there are no other dynamic ground improvement works planned. A general assessment of effects from this activity has been conducted to inform any future works.</p> <p>*** There are a number of existing electricity network utilities within the Project area that will require protection and/or relocation, in particular the relocation of Transpower's overhead lines at Shands Road Interchange. Construction relating to the relocation of the overhead power lines is controlled by Transpower.</p>												

7.2 Typical Construction Noise Levels

Table 8 contains typical construction noise sources and activities associated with road construction along with noise levels from BS 5228-1:2009. BS 5228 is referenced in NZS 6803.

Table 8: BS5228-1:2009 Typical construction noise levels

Source/Activity	Sound Pressure Level at 10m (dB L _{Aeq})	
	Range	Average
Asphalt Paver	75 - 84	78
Auger piling	75 - 81	78
Bulldozers (up to 350kW/50t)	74 - 86	79
Concrete Mixer Trucks	75 - 80	77
Diesel Generator less than 20kW	65 - 66	65
Diesel Water Pumps	68 - 81	73
Diesel Scissor Lift	70 - 78	74
Concrete/Rock Drilling	85 - 92	89
Dumping Rubble	80 - 80	80
Excavators	65 - 91	77
Hydraulic Breaking	83 - 93	90
Loaders	61 - 91	80
Mobile Crane	67 - 82	73

Source/Activity	Sound Pressure Level at 10m (dB L _{Aeq})	
	Range	Average
Pneumatic Breaker (Hand-Held)	82 - 95	87
Excavator-mounted Pulveriser	72 - 80	76
Concrete Pumping	75 - 82	77
Road Planer	68 - 82	75
Rock breaking (30t Excavator)	85 - 95	91
Road Roller (20t)	73 - 80	77
Rotary Bored Piling	75 - 83	79
Steel Sheet Piling - Hydraulic Jacking	59 - 68	63
Steel Sheet Piling - Vibratory	88	88
Tubular Steel Piling - Drop Hammer	69 - 88	80
Vibratory Compaction	67 - 84	77

7.3 Predicted Noise Levels for Construction Scenarios

Table 9 below contains predicted noise levels at a nominal distance of 100m from the construction scenarios outlined in Table 6 above.

Table 9: Construction scenarios

Construction Scenario	Predicted Noise Level at 100m (dB L _{Aeq})
Enabling Works	45 - 71
Topsoil Stripping	75
General Earthworks*	57 - 64
Ground Improvements**	57 - 83
Bridge Construction	64 - 83
Pavement Construction*	55 - 63
Electricity Network Utilities***	53

* Upper value assumes multiple items of large plant operating

** Noise emissions highly dependent on construction method and equipment used

*** Mobile crane only

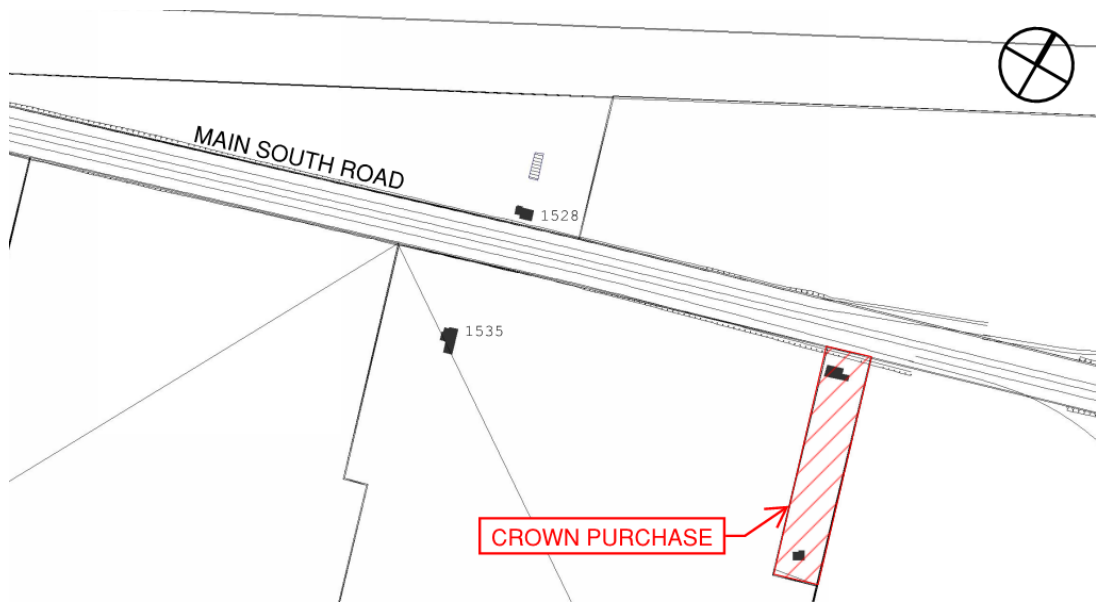
7.4 MSRFL - South of Weedons (Sector 12)

This Sector is shown in Figure 2 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Pavement Construction.

There may also be some enabling works noise generation associated with small staging areas as required by the contractors. The major construction activities in this Sector relate to the four-laning of Main South Road.

Figure 2: Sector 12 - MSRFL South of Weedons Road



7.4.1 Potential noise levels

The closest dwelling in this Sector is located at 1528 Main South Road to the North of the main alignment and is around 10m from the edge of the construction area. This dwelling will have a noise barrier erected as part of the mitigation of traffic noise. (Refer to **Appendix C-7** in the Assessment of Operational Noise Report).

The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the following table.

Table 10: Sector 12 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L _{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L _{Aeq} noise criteria.
	General site establishment	Potential to exceed 45dB L _{Aeq} night-time criteria for short periods of time.

Scenario	Activity	Potential to exceed criteria
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L _{Aeq} daytime noise criterion when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L _{Aeq} night-time criterion.
General Earthworks	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L _{Aeq} night-time noise criterion.
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L _{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 1528 and 1535 Main South Road have the potential for the Project construction noise criteria to be exceeded.

7.4.2 Mitigation required

In order to reduce the effect of noise levels that exceed the Project noise criteria, the following mitigation is proposed:

Table 11: Noise mitigation for construction activities in Sector 12

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Ground Improvements	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques.
Bridge Construction	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques and Section 7.14 for a discussion on noise mitigation and management for night-time works.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

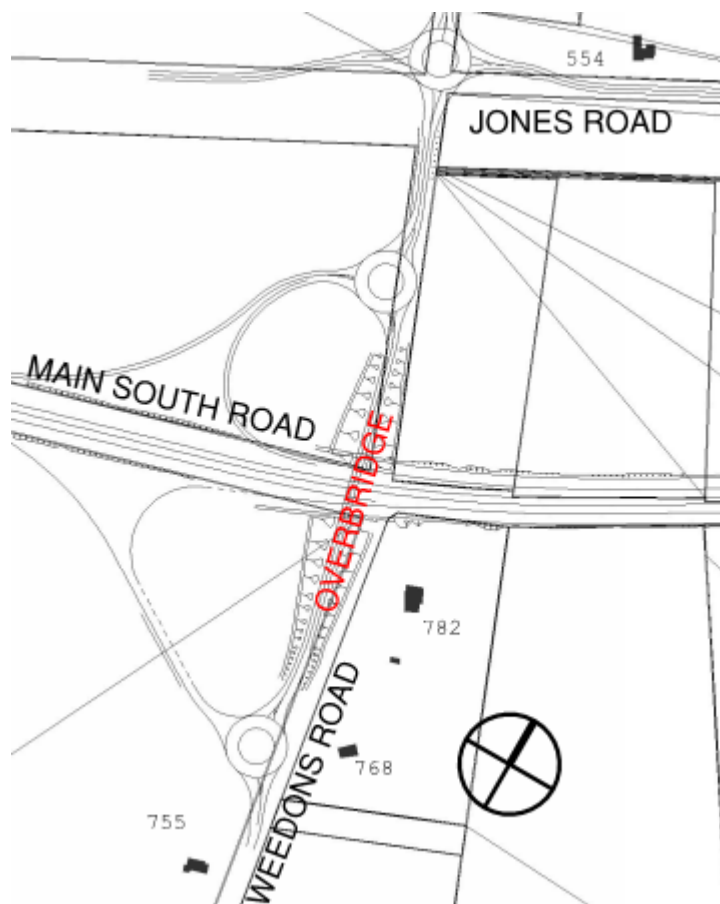
7.5 Weedons Road Interchange (Sector 11)

This Sector is shown in Figure 3 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Ground Improvements.
- Bridge Construction.
- Pavement Construction.

There may also be some enabling works noise generation associated with small staging areas as required by the contractors. The major construction activities in this Sector relate to the construction of the Weedons Road interchange.

Figure 3: Sector 11 - Weedons Road Interchange



7.5.1 Potential noise levels

There are a number of commercial and residential buildings in this Sector. The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the following table.

Table 12: Sector 11 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site establishment	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.
General Earthworks (Main Alignment)	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
General Earthworks (Bridges)	Heavy machinery e.g. excavators, compactors, spreaders.	Unlikely to exceed daytime noise criteria except where works occur within 50m of occupied dwellings. Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
Ground Improvements	Vibratory construction techniques and most piling activities	Likely to exceed 70 dB L_{Aeq} daytime noise criterion.
	Rollers/compactors, bored concrete piles.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
Bridge Construction	Abutment preparation - driven steel piles	Likely to exceed daytime noise criteria during construction of Weedons Road overbridge.
	Abutment preparation - auger piles	Unlikely to exceed daytime noise criteria, except when occurring within 50m of occupied residential dwellings. Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
	Installation of precast bridge structures	Likely to exceed 45 dB L_{Aeq} night-time noise criterion when occurring within 250m of occupied residential dwellings.

Scenario	Activity	Potential to exceed criteria
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L _{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 755, 768 and 782 Weedons Road and 554 Jones Road have the potential for the Project construction noise criteria to be exceeded.

7.5.2 Mitigation required

In order to reduce the effect of noise levels that exceed the Project noise criteria, the following mitigation is proposed:

Table 13: Noise mitigation for construction activities in Sector 11

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Ground Improvements	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques.
Bridge Construction	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques and Section 7.14 for a discussion on noise mitigation and management for night-time works.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

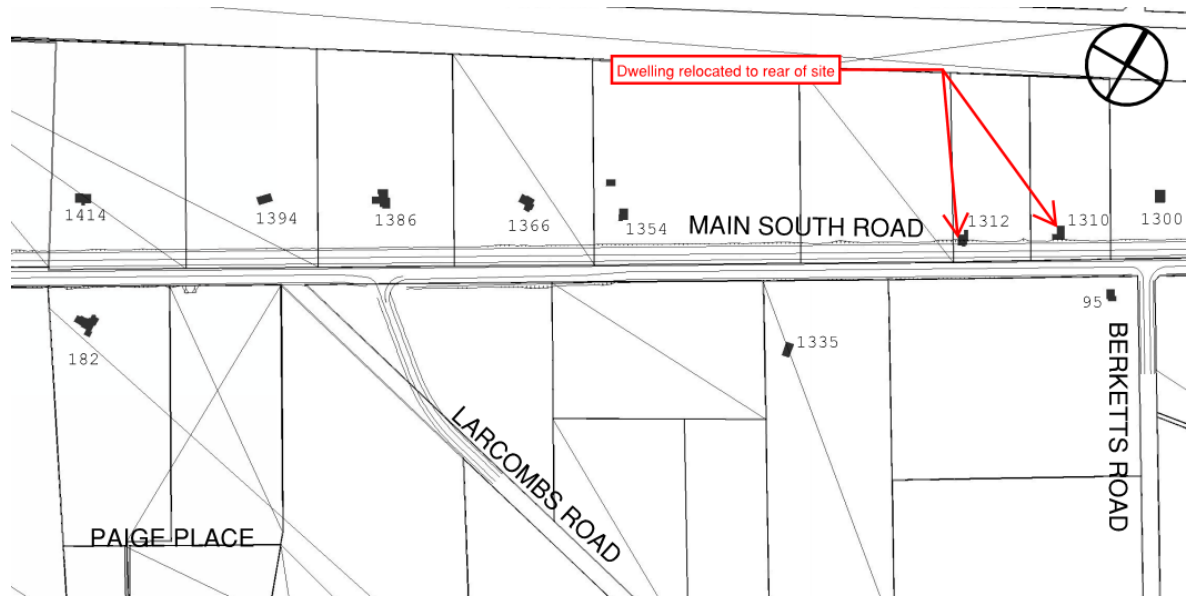
7.6 MSRFL - Robinsons to Weedons (Sector 10)

This Sector is shown in Figure 4 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Pavement Construction.

There may also be some enabling works noise generation associated with small staging areas as required by the contractors. The major construction activities in this Sector relate to the four-laning of Main South Road.

Figure 4: Sector 10 - MSRFL between Berketts Road and Weedons Road



7.6.1 Potential noise levels

The closest dwelling in this sector is around 20m from the edge of the construction area. The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the following table.

Table 14: Sector 10 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site establishment.	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper.	Likely to exceed 70 dB L_{Aeq} daytime noise criterion when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.
General Earthworks	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.

Scenario	Activity	Potential to exceed criteria
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L _{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 1414, 1394, 1386, 1366, 1354, 1335, 1312, 1310 and 1300 Main South Road, 182 Paige Place and 95 Berketts Road have the potential for the Project construction noise criteria to be exceeded.

7.6.2 Mitigation required

In order to reduce the effect of noise levels that exceed the Project noise criteria, the following mitigation is proposed:

Table 15: Noise mitigation for construction activities in Sector 10

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

One dwelling at 95 Berketts Road will have a noise control fence erected as part of the traffic noise mitigation (refer **Appendix C-6** in the Assessment of Operational Noise Report). This will be installed prior to commencing construction works as far as practicable and will serve to reduce the construction noise levels at this dwelling, reducing any noise effects.

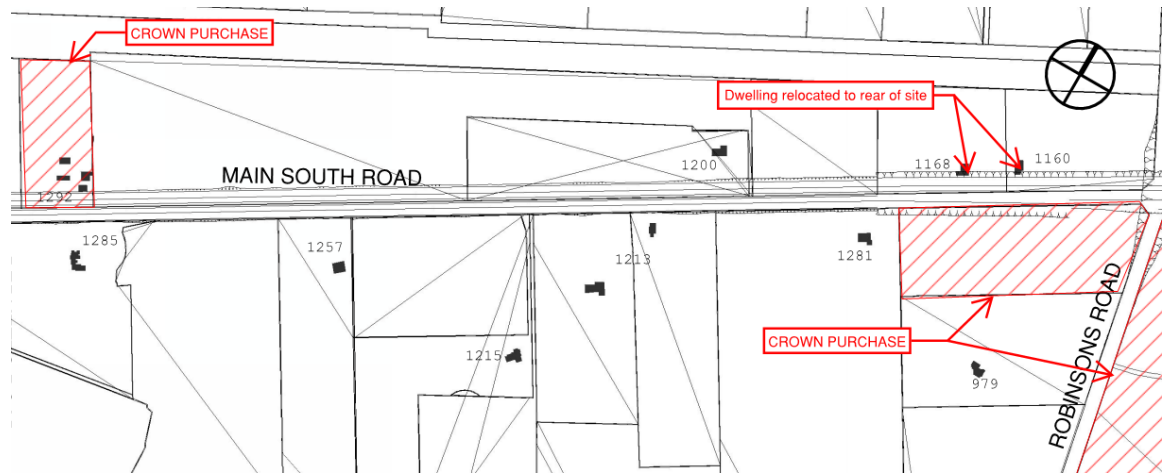
7.7 MSRFL - Robinsons to Berketts (Sector 9)

This Sector is shown in Figure 5 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Pavement Construction.

There may also be some enabling works noise generation associated with small staging areas as required by the contractors. The major construction activities in this Sector relate to the four-laning of Main South Road.

Figure 5: Sector 9 - MSRFL between Robinsons Road and Berketts Road



7.7.1 Potential noise levels

The closest dwelling in this sector is approximately 20m from the edge of the construction area.

The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the following table.

Table 16: Sector 9 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site establishment	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L_{Aeq} daytime noise criterion when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.
General Earthworks	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.

Scenario	Activity	Potential to exceed criteria
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L _{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 1285, 1257, 1215, 1213, 1200, 1281, 1168 and 1160 Main South Road and 979 Robinsons Road have the potential for the Project construction noise criteria to be exceeded.

7.7.2 Mitigation required

In order to reduce the effect of noise levels that exceed the Project noise criteria, the following mitigation is proposed:

Table 17: Noise mitigation for construction activities in Sector 9

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

One dwelling at 1213 Main South Road will have a noise control fence erected as part of the traffic noise mitigation (refer **Appendix C-5** in the Assessment of Operational Noise Report). This fence will be installed prior to commencing construction works as far as practicable and will serve to reduce the construction noise levels at this dwelling, reducing any noise effects.

7.8 Robinsons Road (Sector 8)

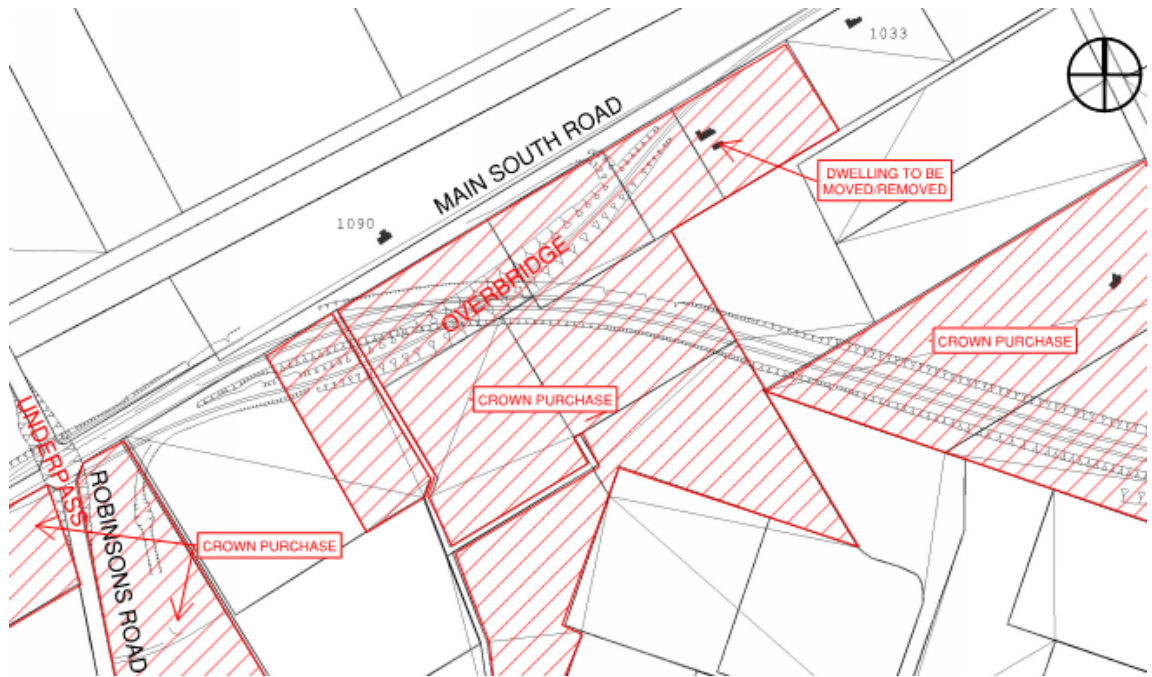
This Sector is shown in Figure 6 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Ground Improvements.
- Bridge Construction.

- Pavement Construction.

The major construction activities in this Sector relate to the construction of the MSRFL/CSM2 interchange (including overbridge) and the Robinsons Road underpass. The main site compound is also located in this Sector adjacent to Robinsons Road.

Figure 6: Sector 8 - CSM2 / MSRFL interchange and Robinsons Road underpass



7.8.1 Potential noise levels

There are a number of commercial and residential buildings in this Sector and the predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria as indicated in the following table.

Table 18: Sector 8 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works (Main Compound)	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site establishment	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.

Scenario	Activity	Potential to exceed criteria
General Earthworks (Main Alignment)	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
General Earthworks (Bridges)	Heavy machinery e.g. excavators, compactors, spreaders.	Unlikely to exceed daytime noise criteria except where works occur within 50m of occupied dwellings (at Northern end of MSRFL overbridge). Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
Ground Improvements	Vibratory construction techniques and most piling activities	Likely to exceed 70 dB L_{Aeq} daytime noise criterion.
	Rollers/compactors, bored concrete piles.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
Bridge Construction	Abutment preparation - driven steel piles	Likely to exceed daytime noise criteria during construction of MSRFL overbridge.
	Abutment preparation - auger piles	Unlikely to exceed daytime noise criteria, except when occurring within 50m of occupied residential dwellings. Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
	Installation of precast bridge structures	Likely to exceed 45 dB L_{Aeq} night-time noise criterion when occurring within 250m of occupied residential dwellings.
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L_{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L_{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 1090 and 1033 Main South Road and 979 Robinsons Road have the potential for the Project construction noise criteria to be exceeded.

7.8.2 Mitigation required

In order to reduce the effect of noise levels that exceed the Project noise criteria, the mitigation shown in Table 19 is proposed:

Table 19: Noise mitigation for construction activities in Sector 8

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Ground Improvements	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques.
Bridge Construction	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques and Section 7.14 for a discussion on noise mitigation and management for night-time works.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

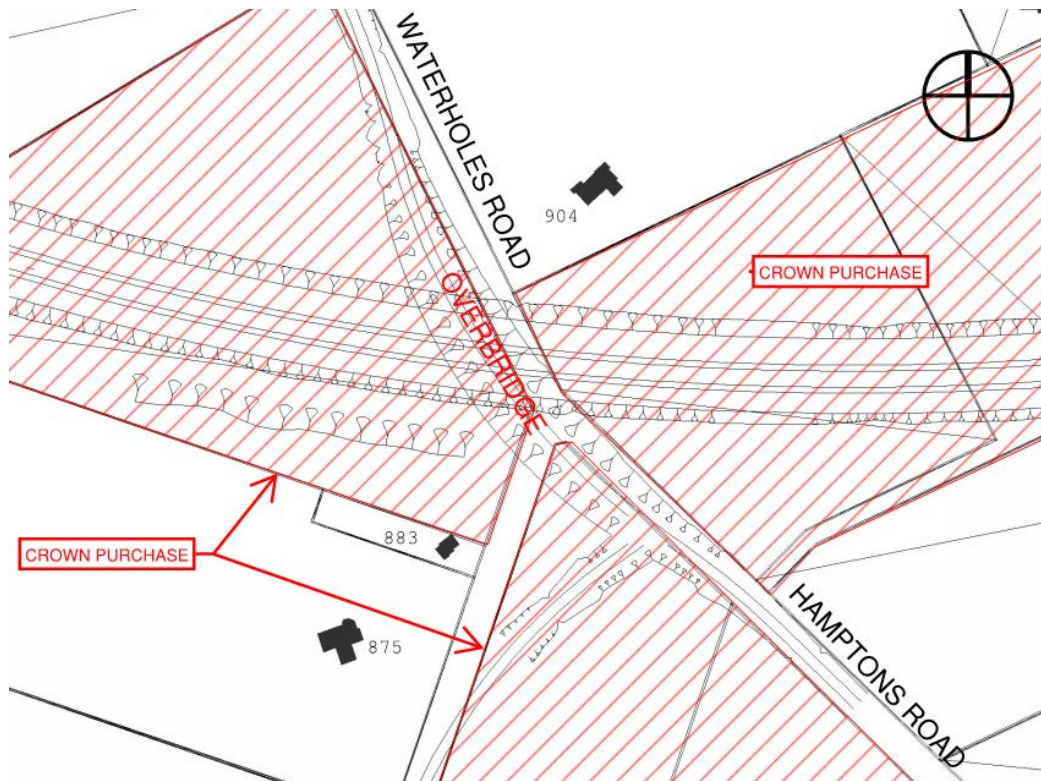
7.9 Waterholes Road (Sector 7)

This Sector is shown in Figure 7 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Ground Improvements.
- Bridge Construction.
- Pavement Construction.

There may also be some enabling works noise generation associated with small staging areas as required by the contractors. The major construction activities in this Sector relate to the construction of the Waterholes Road overbridge.

Figure 7: Sector 7 - Waterholes Road



7.9.1 Potential noise levels

The closest dwelling to overbridge construction area is located close to the Northern end of the overbridge. There are two dwellings located to the South of the main alignment, on the Eastern side of Waterholes Road. The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the following table.

Table 20: Sector 7 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site erection	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.

Scenario	Activity	Potential to exceed criteria
General Earthworks (Main Alignment)	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L _{Aeq} night-time noise criterion.
General Earthworks (Bridges)	Heavy machinery e.g. excavators, compactors, spreaders.	Unlikely to exceed daytime noise criteria except where works occur within 50m of occupied dwellings. Likely to exceed 45 dB L _{Aeq} night-time noise criterion.
Ground Improvements	Vibratory construction techniques and most piling activities	Likely to exceed 70 dB L _{Aeq} daytime noise criterion.
	Rollers/compactors, bored concrete piles.	Likely to exceed 45 dB L _{Aeq} night-time noise criterion.
Bridge Construction	Abutment preparation - driven steel piles	Likely to exceed daytime noise criteria during construction of Waterholes Road overbridge.
	Abutment preparation - auger piles	Unlikely to exceed daytime noise criteria, except when occurring within 50m of occupied residential dwellings. Likely to exceed 45 dB L _{Aeq} night-time noise criterion.
	Installation of precast bridge structures	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 250m of occupied residential dwellings.
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L _{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 875, 883 and 904 Waterholes Road have the potential for the Project construction noise criteria to be exceeded.

7.9.2 Mitigation required

In order to reduce the effect of noise levels that exceed the Project noise criteria, the mitigation shown in Table 21 is proposed:

Table 21: Noise mitigation for construction activities in Sector 7

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Ground Improvements	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques.
Bridge Construction	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques and Section 7.14 for a discussion on noise mitigation and management for night-time works.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

7.10 CSM2 - Trents to Waterholes (Sector 6)

This Sector is shown in Figure 8 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Pavement Construction.

There may also be some enabling works noise generation associated with small staging areas as required by the contractors. The major construction activities in this Sector relate to the formation of the main CSM2 alignment.

Figure 8: Sector 6 - CSM2 between Trents Road and Waterholes Road / Hamptons Road



7.10.1 Potential noise levels

There are a significant number of dwellings at the subdivision to the North, the closest being in the order of 170m from the edge of the construction area.

The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the following table.

Table 22: Sector 6 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site erection	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.
General Earthworks	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.

Scenario	Activity	Potential to exceed criteria
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L _{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Several dwellings located on Devine Drive, including Nos. 14 to 30, have the potential for the Project construction noise criteria to be exceeded.

7.10.2 Mitigation required

In order to reduce the effect of noise levels that exceed the Project noise criteria, the following mitigation is proposed:

Table 23: Noise mitigation for construction activities in Sector 6

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

7.11 CSM2 - Shands to Trents (Sector 4 and 5)

These Sectors are shown in Figure 9 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Ground Improvements.
- Bridge Construction.
- Pavement Construction.

There may also be some enabling works noise generation associated with small staging areas as required by the contractors. The major construction activities in this Sector relate to the construction of the Trents Road overbridge. (We note that earlier versions of this report addressed each of these sectors individually).

Figure 9: Sector 4 and 5 – Shands to Trents Road



7.11.1 Potential noise levels

There are five dwellings in this Sector that are intended to be purchased by the Crown. It is assumed that these dwellings will be removed prior to commencing construction or that affected party approval will be provided. The dwelling at 104 Trents Road is the closest to the overbridge construction area.

The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the following table.

Table 24: Sector 5 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site erection	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.
General Earthworks (Main Alignment)	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
General Earthworks (Bridges)	Heavy machinery e.g. excavators, compactors, spreaders.	Unlikely to exceed daytime noise criteria except where works occur within 50m of occupied dwellings (at Northern end of Trents Road overbridge). Likely to exceed 45 dB L_{Aeq} night-time noise criterion.

Scenario	Activity	Potential to exceed criteria
Ground Improvements	Vibratory construction techniques and most piling activities	Likely to exceed 70 dB L _{Aeq} daytime noise criterion.
	Rollers/compactors, bored concrete piles.	Likely to exceed 45 dB L _{Aeq} night-time noise criterion.
Bridge Construction	Abutment preparation - driven steel piles	Likely to exceed daytime noise criteria during construction of Trents Road overbridge.
	Abutment preparation - auger piles	Unlikely to exceed daytime noise criteria, except when occurring within 50m of occupied residential dwellings. Likely to exceed 45 dB L _{Aeq} night-time noise criterion.
	Installation of precast bridge structures	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 250m of occupied residential dwellings.
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L _{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 106 Trents Road and 273, 260 and 240 Blakes Road have the potential for the Project construction noise criteria to be exceeded.

7.11.2 Mitigation required

In order to reduce the effect of noise levels that exceed the Project noise criteria, the following mitigation is proposed:

Table 25: Noise mitigation for construction activities in Sector 5

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Ground Improvements	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques.

Scenario	Mitigation
Bridge Construction	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques and Section 7.14 for a discussion on noise mitigation and management for night-time works.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

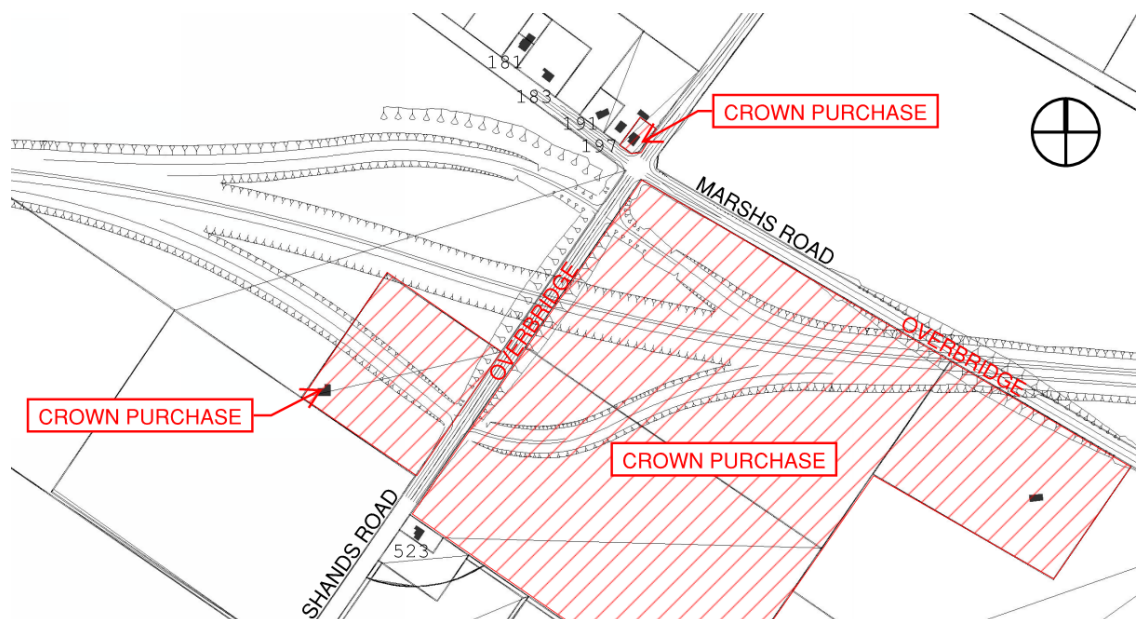
7.12 Shands Road (Sector 3)

This Sector is shown in Figure 10 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.
- Ground Improvements.
- Bridge Construction.
- Pavement Construction.
- Enabling Works.

The major construction activities in this Sector relate to the construction of the Shands Road Interchange and the Shands Road and Marshs Road overbridges. The civil/earthworks compound is likely to be situated in this Sector on the South-East corner of the Marshs Road/Shands Road intersection, in the space between the intersection and the proposed on ramp.

Figure 10: Sector 3 - Shands Road



7.12.1 Potential Noise Levels

There are three dwellings in this Sector that are intended to be purchased by the Crown in this Sector.

The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the following table.

Table 26: Sector 3 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site erection	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.
General Earthworks (Main Alignment)	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
General Earthworks (Bridges)	Heavy machinery e.g. excavators, compactors, spreaders.	Unlikely to exceed daytime noise criteria except where works occur within 50m of occupied dwellings (at Northern end of Shands Road overbridge). Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
Ground Improvements	Vibratory construction techniques and most piling activities	Likely to exceed 70 dB L_{Aeq} daytime noise criterion.
	Rollers/compactors, bored concrete piles.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
Bridge Construction	Abutment preparation - driven steel piles	Likely to exceed daytime noise criteria during construction of Shands Road and Marshs Road overbridge.
	Abutment preparation - auger piles	Unlikely to exceed daytime noise criteria, except when occurring within 50m of occupied residential dwellings. Likely to exceed 45 dB L_{Aeq} night-time noise criterion.

Scenario	Activity	Potential to exceed criteria
	Installation of precast bridge structures	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 250m of occupied residential dwellings.
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L _{Aeq} night-time noise.
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 523 Shands Road and 181, 183, 191 and 197 Marshs Road have the potential for the Project construction noise criteria to be exceeded.

7.12.2 Mitigation required

In order to reduce the effect of noise levels in that exceed the Project noise criteria, the following mitigation is proposed:

Table 27: Noise mitigation for construction activities in Sector 3

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Ground Improvements	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques.
Bridge Construction	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques and Section 7.14 for a discussion on noise mitigation and management for night-time works.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

7.13 Halswell Junction/Springs Road (Sector 1 and 2)

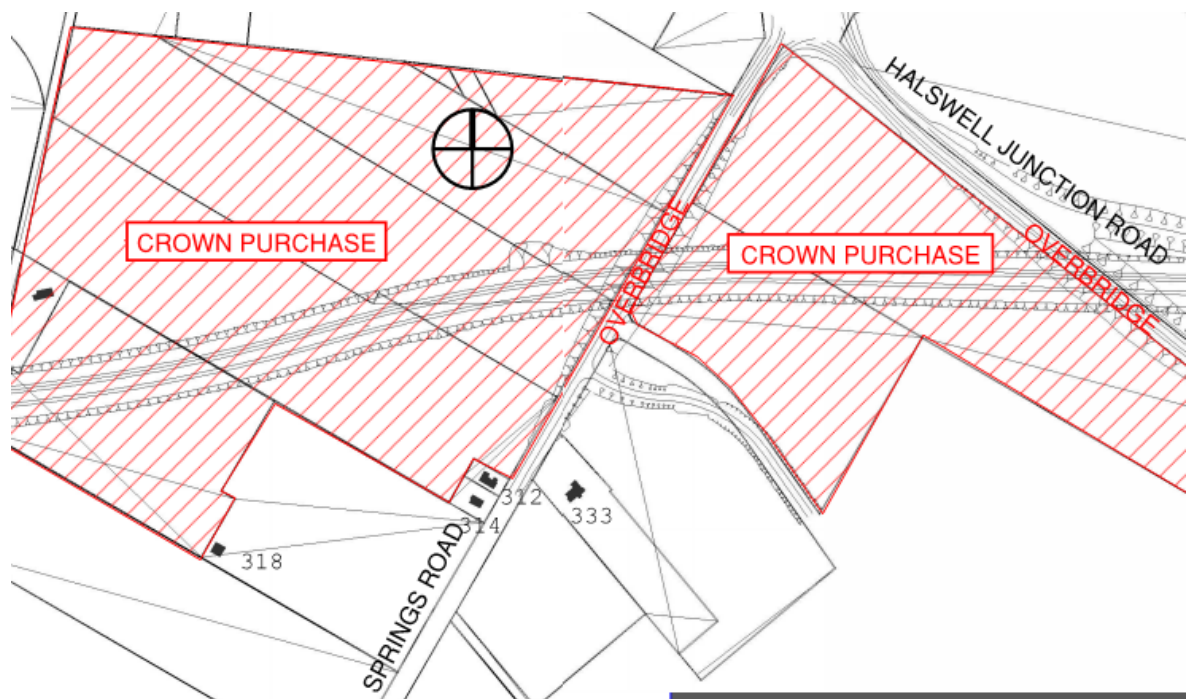
These Sectors are shown in Figure 11 and the following construction activities will occur:

- Topsoil Stripping.
- General Earthworks.

- Ground Improvements.
- Bridge Construction.
- Pavement Construction.

There may also be some enabling works noise generation associated with small staging areas as required by the contractors. The major construction activities in this Sector relate to the construction of the Halswell Junction Road overbridge and the Springs Road overbridge. One of the main stormwater pond systems will also be constructed in this Sector. (We note that earlier versions of this report addressed each of these sectors individually).

Figure 11: Sector 1 and 2 - Halswell Junction/Springs Road



7.13.1 Predicted Noise Levels

There are less than five dwellings close to the construction zone in this Sector. The critical dwellings are those located on Springs Road to the South of the main CSM2 alignment, as they are close to the overbridge construction area.

The predicted noise levels in Table 9 indicate that some construction activities may exceed the Project noise criteria in this Sector as indicated in the Table 28.

Table 28: Sector 1 construction activities and potential to exceed the Project noise criteria

Scenario	Activity	Potential to exceed criteria
Enabling Works	Heavy machinery e.g. excavators, compactors, rollers.	Potential to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time. Likely to exceed night-time 45 dB L_{Aeq} noise criteria.
	General site erection	Potential to exceed 45dB L_{Aeq} night-time criteria for short periods of time.
Topsoil Stripping	Motor scraper	Likely to exceed 70 dB L_{Aeq} daytime noise criterion for short periods of time when within 180m of occupied residential dwellings. Will significantly exceed 45 dB L_{Aeq} night-time criterion.
General Earthworks (Main Alignment)	Heavy machinery e.g. excavators, compactors, spreaders.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
General Earthworks (Bridges)	Heavy machinery e.g. excavators, compactors, spreaders.	Unlikely to exceed daytime noise criteria except where works occur within 50m of occupied dwellings (at Southern end of Springs Road overbridge). Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
Ground Improvements	Vibratory construction techniques and most piling activities	Likely to exceed 70 dB L_{Aeq} daytime noise criterion.
	Rollers/compactors, bored concrete piles.	Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
Bridge Construction	Abutment preparation - driven steel piles	Likely to exceed daytime noise criteria during construction of Springs Road overbridge.
	Abutment preparation - auger piles	Unlikely to exceed daytime noise criteria, except when occurring within 50m of occupied residential dwellings. Likely to exceed 45 dB L_{Aeq} night-time noise criterion.
	Installation of precast bridge structures	Likely to exceed 45 dB L_{Aeq} night-time noise criterion when occurring within 250m of occupied residential dwellings.
Pavement Construction	Multiple items operating simultaneously.	Likely to exceed 45 dB L_{Aeq} night-time noise.

Scenario	Activity	Potential to exceed criteria
	Single item of plant operating	Likely to exceed 45 dB L _{Aeq} night-time noise criterion when occurring within 300m of occupied residential dwellings.

Dwellings located at 312, 314, 318 and 333 Springs Road have the potential for the Project construction noise criteria to be exceeded.

7.13.2 Noise Mitigation

In order to reduce the effect of noise levels that exceed the Project noise criteria, the following mitigation is proposed:

Table 29: Noise mitigation for construction activities in Sector 1

Scenario	Mitigation
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.
Ground Improvements	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques.
Bridge Construction	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques and Section 7.14 for a discussion on noise mitigation and management for night-time works.
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.

The dwelling on the Western side of Springs Road (312 Springs Road), closest to the overbridge will have a noise control fences erected on the property boundary with Springs Rd as part of the traffic noise mitigation (refer **Appendix C-1** in the Assessment of Operational Noise Report). This fence will be installed prior to commencing construction works as far as practicable and will serve to reduce the construction noise levels at this dwelling, reducing any noise effects.

7.14 Night-time Construction Activities

In general construction activities will be limited to daytime hours. However some activities may occur during the night-time for logistical and traffic management reasons. At this stage, no detailed planning of these activities has been prepared. However, these activities might include:

- Installation of pre-cast bridge deck beams.
- Traffic management activities .
- Pavement construction and marking (especially at local road tie-ins).

Before confirming that night works are required, it should be evaluated:

- What options are available to avoid working at night?
- If there are options, are these technically and economically feasible?

Robust consideration of these questions is required to justify night works. Once detailed plans for night-time construction work have been developed, appropriate management and noise mitigation can be designed. It will be critical that dialogue with potentially affected residents is conducted to deliver the most appropriate outcomes.

7.15 Ground Improvements and Piling Techniques

There are a number of different piling and dynamic ground improvement construction methods available, all with varying levels of noise emissions. The exact method that will be used for this Project has not yet been selected. As the selection of a “quieter” method can result in significantly reduced adverse noise effects, the following information should be considered during the tendering process and at the detailed design stage.

- Construction methods involving large impacts should not be used where alternative methods are available. This includes using an impact hammer for steel sheet pile-driving.
- Noise emissions from construction methods where a vibrating “head” or “tip” is suspended on a mobile crane or similar rig (such as vibro-compaction, vibro-replacement or stone column construction) are highly variable. Noise level measurements should be conducted of the actual equipment in the early stages of construction to accurately determine the noise emissions from the equipment.
- Should additional dynamic ground improvement be required, a detailed assessment of effects should be conducted prior to commencing works.

7.16 Summary of Noise Mitigation Required

Table 30: Noise mitigation summary

Scenario	Mitigation	Sector
Enabling Works	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday.	ALL
Topsoil Stripping	Restrict motor scraper use to 0730 - 1800 Monday to Saturday.	ALL
General Earthworks	Restrict use of heavy machinery to 0730 - 2000 Monday to Friday and 1730 - 1800 on Saturday, or ensure minimum setback distance of 900m to any occupied residential dwelling and 50m from any occupied commercial building.	ALL
Ground Improvements	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques.	1, 3, 5, 7, 8, 11
Bridge Construction	See Section 7.15 for a discussion on Ground Improvements and Piling Techniques and Section 7.14 for a discussion on noise mitigation and management for night-time works.	1, 3, 5, 7, 8, 11
Pavement Construction	Restrict use of loud construction machinery to 0730 - 2000 Monday to Saturday.	ALL

8.0 VIBRATION PERFORMANCE STANDARDS

For any significant construction project, two aspects of vibration effects are normally considered: the potential for damage to buildings, and the human response to vibration.

Whilst vibration levels produced by construction will be higher than for the operation of the completed road, the construction phase has a finite timeframe and with effective management (through the implementation of management plans etc), the effects can be avoided and/or mitigated. In addition to this, the most common concern of receivers during construction is damage to their buildings which is addressed by the building damage criteria.

8.1 Review of vibration standards

There are no current New Zealand standards specifically relating to construction or traffic vibration. There is, however, a precedent for adopting selected international vibration standards which are either referenced by statutory or policy documents (i.e. district plans, NZTA policy) or have been successfully implemented in other large projects. These Standards are:

- DIN 4150-3:1999
- BS 7385-2:1993
- BS 5228-2:2009
- BS 6472-1:2008

The above vibration Standards are referenced in the following sections and are outlined in detail in **Appendix C**.

8.2 Draft NZTA “State highway construction and maintenance noise and vibration guide”

The NZTA, with the assistance of several consultants including Marshall Day Acoustics, has published a draft guide to provide information on prediction, management, mitigation and documentation of construction noise and vibration. Whilst the construction noise aspects of the guide are broadly the same as those set out in the earlier sections of this report, a relatively new approach to construction vibration is promoted.

The progressive criteria approach from the road noise standard NZS 6806:2010 “Acoustics – Road-traffic noise – New and Altered Roads” has been adopted for the draft guide, insofar as there are two distinct categories which are applied in sequence, depending on the situation.

This draft guide is a work in progress and its proposed criteria are included below:

Construction should be managed to comply with the Category A criteria in Table A. If measured or predicted vibration and airblast levels exceed the Category A criteria then a suitably qualified expert should be engaged to assess and manage

construction vibration and airblast to comply with the Category A criteria as far as practicable.

If the construction vibration exceeds the Category B criteria then construction activity shall only proceed if there is continuous monitoring of vibration levels and effects on those buildings at risk of exceeding the Category B criteria, by suitably qualified experts.

Measurements of construction vibration and airblast shall be in accordance with:

- a) ISO 4866:2010 “Mechanical vibration and shock - Vibration of fixed structures - Guidelines for the measurement of vibrations and evaluation of their effects on structures”; and
- b) AS 2187-2:2006 “Explosives – Storage and use – Part 2: Use of explosives”.

Table A Construction vibration and airblast criteria

Receiver	Details	Category A	Category B
Occupied dwellings	Night-time 2000h - 0630h (transient vibration)	0.3 mm/s PPV	1 mm/s PPV
	Daytime 0630h - 2000h	1 mm/s PPV	5 mm/s PPV
Other occupied buildings	Daytime 0630h - 2000h	2 mm/s PPV	5 mm/s PPV
All occupied buildings	Daytime blasting - vibration	5 mm/s PPV	10 mm/s PPV
	- airblast	120 dB L _{ZPeak} ^{*2}	-
All other buildings	Vibration – transient (including blasting)	5 mm/s PPV	BS 5228-2 ^{*2} Table B.2
	Vibration – continuous		BS 5228-2 ^{*1} 50% of Table B.2 values
	Airblast	-	133 dB L _{ZPeak} ^{*2}

^{*1} BS 5228-2:2009 “Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration”

^{*2} ‘dB L_{ZPeak}’ is the current terminology for peak decibels Linear or ‘dBL’. The reference sound pressure is 20 µPa.

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

8.3 Resource Management Act

Under the provisions of the Resource Management Act (RMA) there is a duty to adopt the best practicable option to ensure that the noise from any development does not exceed a reasonable level. Note that the definition of noise in Section 2 of the RMA includes vibration.

Specifically, Sections 16 and 17 reference 'noise' effects as follows.

Section 16 states that *“every occupier of land (including any coastal marine area), and every person carrying out an activity, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level”*.

Section 17 states that *“every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity, whether or not the activity is in accordance with a rule in a plan, a resource consent or relevant sections of the RMA”*.

8.4 District Plans

The Christchurch City Plan and the Selwyn District Plan contain no criteria, nor reference to standards relating to construction vibration.

8.5 NZTA Environmental Plan (June 2008)

Section 2.12 of the NZTA Environmental Plan (June 2008) addresses noise and vibration effects of State Highways, and the construction and maintenance thereof.

The Environmental Plan (June 2008) references a number of vibration standards, however, the most appropriate to the construction noise vibration is DIN4150 which is referred to in Section 8.2. The Plan also states: *“Manage and minimise potentially unreasonable noise effects during construction, so far as is practicable, in accordance with NZS 6803:1999 ‘Acoustics – Construction Noise”*. This Standard has been previously discussed in Section 8.1.

8.6 National Environmental Standards

Whilst there is no National Environmental Standard (NES) to control noise and vibration from construction works or traffic operation, it is noted that the NES for Electricity Transmission Activities contains reference to DIN 4150-3:1999 in clause 37.3, in relation to vibration control of construction activities relating to existing transmission lines.

9.0 PROJECT CONSTRUCTION VIBRATION CRITERIA

Based on the above discussion, we propose that the draft NZTA vibration guide (refer Section 8.2) form the basis for the Project construction vibration criteria. The draft guide adopts criteria from DIN 4150-3:1999 and BS 5228-2:2009 (refer **Appendix C**) in a management-based framework designed to address both human response and building damage effects. The draft guide applies to both construction vibration and airblast from blasting, so has been reduced and revised as appropriate to form the Project construction criteria, as follows:

Category A: adopts criteria from British Standard BS 5228-2:2009 and is designed to practically address the **human response effects** in dwellings during the daytime and night-time periods, and offices during the daytime. For other building types, and offices during the night-time (i.e. unoccupied), the policy reverts to the residential building damage criterion from German Standard DIN 4150-3:1999.

If measured or predicted vibration levels exceed the Category A criteria then a suitably qualified expert shall be engaged to assess and manage construction vibration and to comply with the Category A criteria. If the Category A criteria cannot be practicably achieved, the Category B criteria shall be applied.

Category B: is generally **designed to protect buildings against damage** and adopts criteria from DIN 4150-3:1999 and BS 5228-2:2009, but retains a higher degree of **night-time protection for occupied dwellings at night** using human response criteria of BS 5228-2:2009.

If measured or predicted vibration levels exceed the Category B criteria then construction activity shall only proceed if there is continuous monitoring of vibration levels and effects on those buildings at risk of exceeding the Category B criteria by suitably qualified experts.

Table 31 is a reduced version of Table A from the draft policy (refer Section 8.2), with aspects not relevant to the Project removed, and some clarification of terms added.

Table 31: Project construction vibration criteria

Receiver	Details	Category A	Category B
Occupied dwellings*	Night-time 2000h - 0630h	0.3 mm/s PPV	1 mm/s PPV
	Daytime 0630h - 2000h	1 mm/s PPV	5 mm/s PPV
Other occupied buildings**	Daytime 0630h - 2000h	2 mm/s PPV	5 mm/s PPV
All other buildings	Vibration – transient	5 mm/s PPV	BS 5228-2:2009, Table B.2

Receiver	Details	Category A	Category B
	Vibration – continuous		BS 5228-2:2009, 50% of Table B.2
<p>* Schools, hospitals, rest homes etc. would fall under the occupied dwellings category. ** ‘Other occupied buildings’ is intended to include daytime workplaces such as offices, community centres etc., not industrial buildings. .</p>			

10.0 ASSESSMENT OF CONSTRUCTION VIBRATION EFFECTS

The Project’s construction phase will involve the use of heavy machinery operating for periods in relatively close proximity to some sensitive buildings such as residences. Night-time construction may be required in some areas. Throughout the construction phase, vibration effects must be carefully managed.

The sources that have been identified as the highest risk for building damage from construction vibration are vibratory rollers and piling. Other construction machinery and activities such as trucks, excavators, etc. will produce ground vibration also. Prior experience has shown that these activities can give rise to adverse effects (particularly adverse human response).

It is noted that the use of excavators for standard cut and fill operations is not typically associated with high vibration levels.

In Section 10.1 we have predicted typical vibration levels for the Project, however, these results are provisional and must be refined and supported by site-specific measurements and predictions once construction planning commences.

For crucial activities, such as vibratory compacting and piling where large vibration energy is typically produced, test measurements of the initial works are recommended. As the number of on-site measurements increases, the models can be refined to allow more accurate prediction of the subsequent construction stages and improved controls can be achieved.

10.1 Typical Vibration Levels

The effects of construction vibration involve large variables, predominantly with regard to different construction methods, vibration source energies, variable ground type and the behaviour of vibration waves through an inhomogeneous medium. Additional variables include, but are not limited to, machine type (and consequently the energy delivered into the ground), operating mode, operator skill, and the presence of submerged solid objects (e.g. boulders).

In Table 32 we have provided a range of typical vibration levels based on Marshall Day Acoustics’ historical measurements and published data.

Table 32: Measured vibration levels

Typical construction sources	Measured vibration level (PPV)	Distance
Vibratory sheet piling	0.62mm/s	19m
Impact piling	2.7mm/s	28m
	1 mm/s	35m
Vibratory compactors/rollers	1.5 - 2.4 mm/s	20m

10.2 Risk of Construction Vibration Effects

The following section outlines the identified high-vibration machinery to be used in each Project Sector with a list of ‘risk contours’, which indicate the distance at which each vibration source is expected to comply with the risk assessment criterion of 5 mm/s PPV (refer Section 9.0).

In order to categorise the closest receivers to each vibration source as high or medium risk of exceeding the criterion, detailed plans showing the extent of the works are required.

As these are not yet available, we have provided the following information to assist with the detailed assessment at a later date:

10.2.1 Risk classifications

The following definitions should be used when classifying the vibration risk of buildings:

- High Risk – Dwellings where vibration levels are likely to exceed the risk assessment criteria. This does not necessarily imply damage to the building structure, but these are the receivers subject to the highest vibration levels.
- Medium Risk – These dwellings are close to the risk contour and some construction activities may produce vibration levels close to the risk assessment criteria, with potential to intermittently exceed the criteria
- Others – No significant risk.

These risk levels should also inform the community liaison process in the CNVMP.

10.2.2 Risk Contours

Table 33 gives the risk contours distances that should be used to classify the dwellings as defined in Section 10.2.1. Dwellings that are within the contour distance are classified as High Risk.

Table 33: Risk Contour Distances for Construction Activities

Activity	Risk contour distance
Piling: Vibro-hammer or cast-in-place methods only	19m
Vibratory Rollers	16m
Excavators (digging and tracking)	8m
Wheeled loaders	
Motor scrapers	
Off-road trucks	

10.3 Assessment of Construction Vibration Effects

The effects of construction vibration involve large variables, predominantly with regard to different construction methods, vibration source energies, variable ground types, the behaviour of vibration waves through this inhomogeneous medium, and the foundation type of a receiver.

The significant vibration sources have been identified, and conservative calculations of risk contour distances have been undertaken.

These results are provisional however, and must be refined and supported by site-specific measurements once construction begins, as recommended in the CNVMP. For crucial activities such as excavating, vibratory compacting and pile driving, measurements of the initial works are recommended.

As the repository of on-site measurements increases, the risk categories can be refined and improved controls can be achieved.

The initial predictions will be considered during the tendering and detailed design process to identify dwellings which have a high level of vibration risk.

The results indicate that it is unlikely for there to be any buildings along the CSM2 alignment with a High vibration risk. Detailed consideration of dwellings along the MSRFL alignment should be given, and all dwellings within 20m should be marked.

Note that construction vibration may be felt at locations further from the Project than listed in Table 33. These effects can be managed by the Category A Project criteria through the CNVMP.

11.0 CONSTRUCTION NOISE MITIGATION AND MANAGEMENT

The most effective way of managing construction noise and vibration on a day-to-day basis is through the implementation of a Construction Noise and Vibration Management Plan (CNVMP). A Draft CNVMP has been produced for the Project and is contained in **Appendix D**.

A CNVMP should outline consultant and contractor obligations during construction and should generally include:

- The construction noise and vibration project criteria;
- Hours of operation, including times and days when high-vibration machinery would be used;
- Description of the works and a list of machinery to be used;
- Requirements for vibration measurements of relevant machinery prior to construction or during their first operation, to confirm risk contours;
- Requirements for building condition surveys of critical dwellings prior to and after completion of construction works, and during the works if required;
- Requirements for identifying any existing infrastructure assets (services, roads etc) which may be at risk of vibration induced damage during construction;
- Staff training/awareness programme;
- Construction noise and vibration monitoring and reporting requirements;
- Monitoring and reporting requirements;
- Methods for receiving and handling complaints about construction noise and vibration.

In addition, the CNVMP may contain specific details relating to a particularly sensitive location or activity. These details should be described in a schedule and should include:

- Activity location, start and finish date;
- The nearest neighbours to the activity;
- A location plan;
- Predictions and mitigation for the activity;
- Communication with neighbours;
- Location, times and type of monitoring.

12.0 DESIGNATION CONDITIONS

We recommend that conditions are placed on the designation that requires the following:

- Implementation of a Construction Noise and Vibration Management Plan (CNVMP) (as described in **Appendix D**) throughout the entire construction period of the Project;
- Implementation of those Structural Mitigation measures for operational noise which will also mitigate construction noise prior to commencing major construction works in the vicinity of each of those mitigation measures;
- Compliance with the Project construction noise criteria specified in Table 4 and Table 5 of this report, when measured and assessed in accordance with NZS 6803:1999; and
- Compliance with the Project construction vibration criteria specified in Table 31 of this report, when measured and assessed in accordance with the relevant standards.

13.0 SUMMARY AND CONCLUSIONS

An assessment of construction noise and vibration effects associated with the NZTA's Christchurch Southern Motorway Stage 2 and Main South Road four-laning has been conducted.

Appropriate criteria and assessment methodologies, and details of predicted noise levels and potential areas of risk have been identified. Construction noise and vibration criteria are provided based on those contained in NZS6803:1999 and relevant international vibration standards. The Project vibration criteria for the construction phase address both building damage and human response, and are based on the draft policy of an NZTA working group.

The aim for this Project is to achieve compliance with these criteria where practicable, in accordance with the requirement of Section 16 of the Resource Management Act that the best practicable option be adopted to ensure that noise and vibration emissions do not exceed a reasonable level.

Noise from all proposed construction activities has been considered and noise levels have been predicted at surrounding dwellings. Several construction activities are likely to generate noise levels in excess of the 70 dB L_{Aeq} daytime Project construction noise criterion. Construction activities occurring at night, if required, are likely to be confined to bridge beam placement and intersection works; these activities are predicted to generate noise levels in excess of the night-time Project construction noise criterion (45 dB L_{Aeq}).

For the above activities, active noise management and mitigation measures are recommended to be undertaken to reduce, avoid and mitigate noise emissions as far as practicable. These measures are detailed in the draft Construction Noise and Vibration Management Plan (CNVMP).

The assessment of vibration effects draws on data obtained through on-site measurements of existing vibration environments, construction activities and heavy vehicle movements with supplementary information obtained through the review and implementation of historical vibration measurements and the use of empirical prediction models.

It is anticipated that the Project's most significant vibration effects are likely to come from the use of vibrating rollers along MSRFL, and piling activities at the various overbridge sites. Ground improvement works at the bridge abutments may also result in adverse vibration effects.

Where there is a large scope for different construction methods to be used (such as piling and ground improvement works), information is provided that will be considered during the tendering and detailed design process.

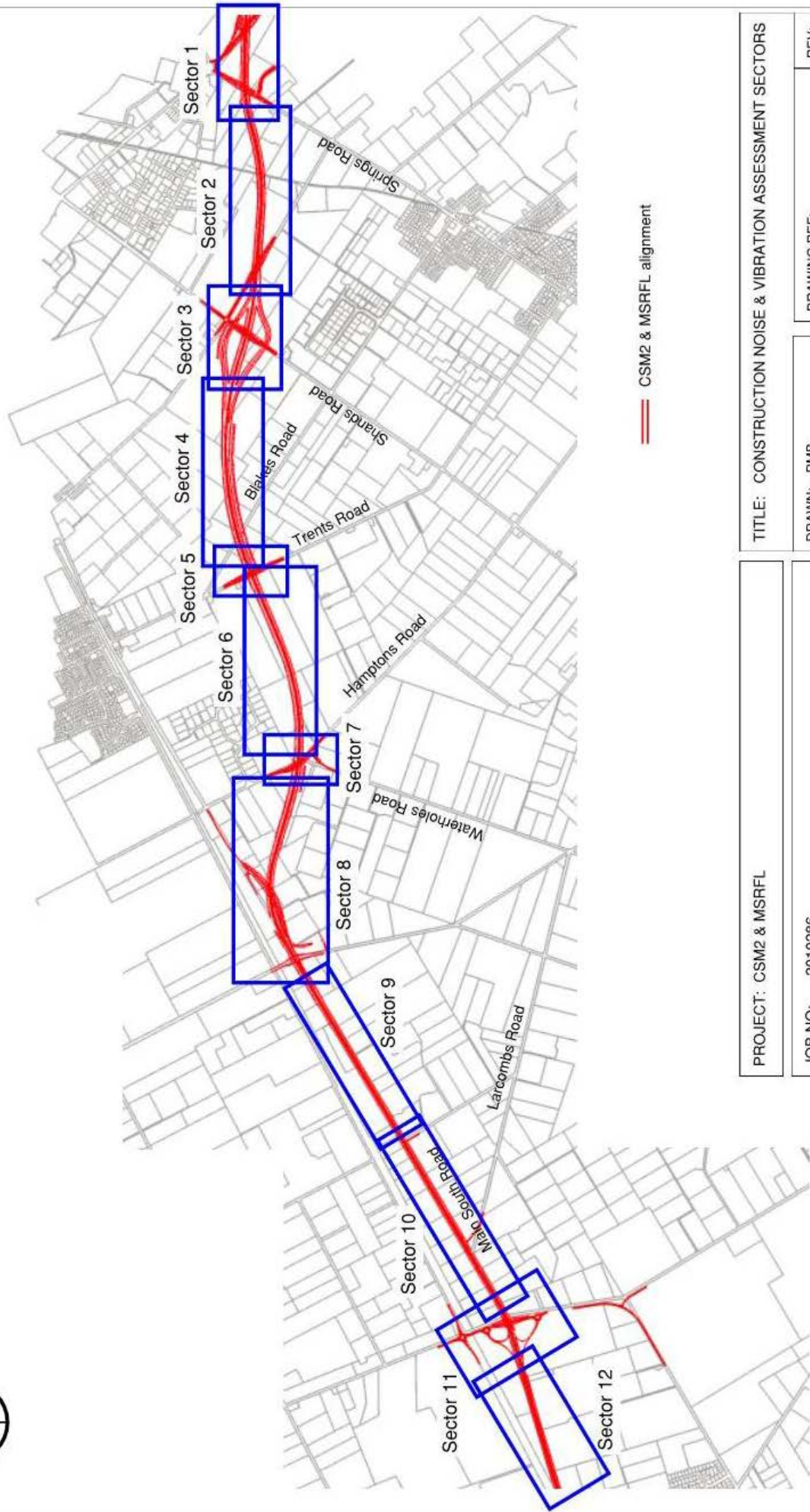
Overall, it is considered that the Christchurch Southern Motorway Stage 2 and Main South Road Four-Laning Project can be constructed such that adverse noise and vibration effects can generally be avoided, remedied or mitigated using best practicable options to achieve compliance with the Project criteria.

APPENDIX A GLOSSARY OF TERMINOLOGY

Frequency	The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).
Hertz (Hz)	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).
SPL or L_p	<u>Sound Pressure Level</u> A logarithmic ratio of a sound pressure measured at distance, relative to the threshold of hearing (20 μ Pa RMS) and expressed in decibels.
dB	<u>Decibel</u> The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of $P_r=20 \mu\text{Pa}$ i.e. $\text{dB} = 20 \times \log(P/P_r)$
dBA	The unit 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.
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
$L_{Aeq}(t)$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
NZS 6801:2008	New Zealand Standard NZS 6801:2008 "Acoustics – Measurement of environmental sound"
NZS 6802:2008	New Zealand Standard NZS 6802:2008 "Acoustics – Environmental Noise"
NZS 6803:1999	New Zealand Standard NZS 6803: 1999 "Acoustics - Construction Noise"
NZS 6806:2010	New Zealand Standard NZS 6806:2010 "Acoustics - Road-traffic noise - New and altered roads"

APPENDIX B ASSESSMENT SECTORS

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APPENDIX C VIBRATION STANDARDS

DIN 4150-3:1999

The use of German Standard DIN 4150-3:1999 “*Structural vibration – Part 3: Effects of vibration on structures*” is widespread in New Zealand and it has a history of successful implementation in projects involving construction activities.

The Standard adopts the Peak Particle Velocity (PPV) metric and gives guideline values which, “when complied with, will not result in damage that will have an adverse effect on the structure’s serviceability.”

The guideline values are different depending on the vibration source, and are separated on the basis of short-term and long-term vibration. The standard defines short-term vibration as “vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated”. Long-term vibration is defined as all other types of vibration not covered by the definition of short-term vibration.

Pragmatically, the short-term vibration definition applies to activities which follow the form of a single shock followed by a period of rest such as blasting, drop hammer pile-driving (i.e. non-vibratory), dynamic consolidation etc. All other construction activities (including the majority of those proposed for this Project) would be categorised as long-term.

Traffic may be categorised as either, depending on the nature of the vibration i.e. vibration from consistent (but rough) road surface may be long-term, whereas a road with a bump in the pavement may generate a short-term vibration event.

The criteria for short-term and long-term vibration activities, as received by different building types, are summarised in Table C.1 below which is a combination of Tables 1 and 3 of the Standard:

Table C.1: Summary of Building Damage criteria in DIN 4150-3:1999

Type of structure	Short-term vibration			Long-term vibration	
	PPV at the foundation at a frequency of			PPV at horizontal plane of highest floor (mm/s)	PPV at horizontal plane of highest floor (mm/s)
	1 - 10Hz (mm/s)	10 - 50 Hz (mm/s)	50 - 100 Hz (mm/s)		
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

The standard also contains criteria for buried pipework of different materials and the effects of vibration on floor serviceability, as well as guidelines for measurement of vibration in buildings i.e. placement and orientation of the transducers.

It should be noted that these criteria are designed to avoid *all* damage to buildings i.e. even superficial damage like cracking in plaster. Significantly greater limits would be applied for damage to structural foundations.

BS 6472-1:2008

The British Standard BS 6472-1:2008 *“Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting”* is not widely adopted in New Zealand, but has advantages in the assessment of operational vibration effects due to its dose-response metric Vibration Dose Value (VDV).

VDV is calculated from the frequency-weighted vibration acceleration (weighted according to the W_b or W_d curves for vertical and horizontal acceleration respectively), which is integrated over the day or night time period. Table 1 of the Standard contains VDV ranges which may result in adverse comment in residential buildings, and is copied in Table C.2 below:

Table C.2 Vibration dose value ranges which might result in various probabilities of adverse comment within residential buildings

Place and time	Low probability of adverse comment $ms^{-1.75}$	Adverse comment possible $ms^{-1.75}$	Adverse comment probable $ms^{-1.75}$
Residential buildings 16 h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

NOTE For offices and workshops, multiplying factors of 2 and 4 respectively should be applied to the above vibration dose value ranges for a 16 h day.”

There is however some controversy surrounding the use and usability of VDV. Its calculation method is complex and results in values with the rather cumbersome units of $ms^{-1.75}$. Additionally, for continuous vibration (such as motorway traffic), the “estimated VDV” metric eVDV is recommended in place of VDV. The correlation between VDV and eVDV for the same data set is variable, and relies heavily on the event period used in the calculation.

The Institute of Acoustics (UK) has undertaken comparison studies of the two parameters, and concludes that eVDV is generally a reliable estimate of VDV provided the crest factors for transient signals are calculated correctly, and that the constant 1.4 in the eVDV equation is not necessarily correct and should be derived for a given signal (e.g. a value of 1.11 should be used for a sinusoidal signal) (Greer et al, 2005).

BS 7385-2:1993

The second part of the British Standard BS 7385 series – BS 7385-2:1993 *“Evaluation and measurement for vibration in buildings – Part 2. Guide to damage levels from ground borne vibration”* sets vibration limits for building structures based on an extensive review of international case histories. The introduction states that despite the large number of UK case studies involved in the review, “very few cases of vibration-induced damage were found”.

The criteria, also in PPV, are contained in Table 1 of the Standard, which is copied in Table C.3 below:

Table C.3 – Transient vibration guide values for cosmetic damage in BS 7385-2:1993

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

NOTE 1. Values referred to are at the base of the building (see 6.3)

NOTE 2. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

These criteria relate predominantly to transient vibration, and the standard suggests that the criteria “may need to be reduced by up to 50%”, especially at low frequencies. Notwithstanding this, the criteria are 3 to 10 times higher (i.e. less stringent) than those in DIN 4150-3:1999.

Note that there is no consideration for historic or sensitive structures in the above table. This is addressed in Section 7.5.2 which states:

“7.5.2 Important buildings

Important buildings which are difficult to repair may require special consideration on a case-by-case basis. A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.”

Note that ‘peak component particle velocity’ refers to the maximum PPV of the three orthogonal axes (longitudinal, transverse or vertical), also known as peak vector sum (PVS).

This approach to historic structures is quite different to that of the DIN 4150-3:1999 Standard which is less definitive with its definition of such buildings and more stringent in its criteria.

BS 5228-2:2009

The British Standard BS 5228-2:2009 “Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration” is a comprehensive standard covering many aspects of prediction, measurement, assessment and control of vibration from construction works.

In terms of vibration criteria, this Standard contains references to, and reiterates the criteria from BS 6472 (human response) and BS 7385 (building damage).

However Annex B of the Standard addresses human response to construction vibration and suggests that BS 6472 may not be appropriate. It states:

“BS 6472, as stated, provides guidance on human response to vibration in buildings. Whilst the assessment of the response to vibration in BS 6472 is based on the VDV and weighted acceleration, for construction it is considered more appropriate to provide guidance in terms of the PPV, since this parameter is likely to be more routinely measured based on the more usual concern over potential building damage. Furthermore, since many of the empirical vibration predictors yield a result in terms of PPV, it is necessary to understand what the consequences might be of any predicted levels in terms of human perception and disturbance.”

Some guidance is given in Table B.2 of the Standard, reproduced in Table C.4 below:

Table C.4 Guidance on the effects of vibration levels in BS 5228-2:2009

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.

The use of PPV is a pragmatic approach to construction vibration assessment and the criteria in Table C.1 are considered suitable for assessment of human response to construction vibration effects. Furthermore, the criteria have a reasonable correlation with DIN 4150-3:1999 in terms of the level of concern expected with regard to building damage.

It is noted that the primary issue relating to construction vibration is damage to buildings and although people may become concerned at levels above 1 mm/s PPV, in the context of a project, this effect can be managed through communication with concerned residents and other mitigation strategies outlined in project specific construction management plans.

APPENDIX D DRAFT CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN

Refer to SEMP003 contained within Volume 4 - Management Plan