


TECHNICAL REPORT 8

CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

NOVEMBER 2016

Quality Assurance Statement	
Prepared by	Peter Ibbotson (Marshall Day Acoustics)
	Shaun King (Marshall Day Acoustics)
	Siiri Wilkening (Marshall Day Acoustics)
	Craig Fitzgerald (Marshall Day Acoustics)
Reviewed by	Siiri Wilkening (Marshall Day Acoustics)
Approved for release	 Patrick Kelly (EWL Alliance Manager)

Revision schedule					
Rev. N°	Date	Description	Prepared by	Reviewed by	Approved by
0	November 2016	Final for Lodgement	Peter Ibbotson Shaun King Siiri Wilkening Craig Fitzgerald (Marshall Day Acoustics)	Siiri Wilkening	Patrick Kelly

Disclaimer

This report has been prepared by Marshall Day Acoustics on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Marshall Day Acoustics has not given its prior written consent, is at that person's own risk.

EXECUTIVE SUMMARY

1. Marshall Day Acoustics has undertaken an assessment of the noise and vibration effects associated with the construction of the proposed East West Link project (EWL or the Project).
2. Recommended construction noise and vibration criteria for the Project are provided. These have been based on:
 - NZS 6803:1999 (with correction to night time levels for high background noise), and
 - Vibration criteria of the NZ Transport Agency Guide (refer Appendix C).
3. A risk assessment of construction vibration and noise effects has been performed for the Project. This has shown that there is a medium to high level of risk that vibration guidelines will be exceeded for some buildings adjacent to the Project. This is because buildings are located within 20m from the site works and in some instances within 10m of earthworks and retaining walls. At such distances, vibration levels from some activities may be above 5mm/s, which is the Project criterion to avoid building damage. In addition to this, vibration is likely to result in human discomfort at a greater number of dwellings.
4. Due to the close proximity of dwellings and businesses to the works, there are many locations where there is potential for daytime and night time noise limits to be exceeded. Due to the practical and safety constraints of the Project, night time construction will be required in some locations. Where practicable, night time works will be minimised in areas where residential dwellings are in close proximity, such as on State highway 1. Where these night works cannot be avoided, site specific noise management will be required for night time construction activities.
5. As noise and vibration from construction activities has the potential to exceed the recommended limits, a thorough regime of noise management will be required to ensure that noise and vibration effects are mitigated as far as practicable. This will be anchored in the Construction Noise and Vibration Management Plan (CNVMP). Management will include noise and vibration monitoring along the route, clear communication with the public, condition surveys of dwellings likely to receive high levels of vibration and strategies for mitigation such as resident relocation where necessary.
6. Noise and vibration management procedures will be detailed in the CNVMP. Where there is a risk of exceedance of the relevant criteria, noise and/or vibration management schedules will be produced which set out how effects from specific activities or in specific areas will be managed and potentially affected parties communicated with. The schedule will contain communication, management and mitigation specific to a certain task or area and be attached to the CNVMP, providing additional information that would sit alongside the general management and mitigation options within the CNVMP.
7. Communication with affected parties is the most important and effective management measure. Frequent information and updates to neighbouring communities will allow dialogue between the construction contractor and residents and businesses potentially affected by the works.
8. Noise and vibration monitoring is an essential part of ensuring construction activities comply with the noise and vibration limits. Successful management of noise and vibration effects from construction activities will rely heavily on good procedures and awareness of the noise and vibration effects of different construction machinery.
9. On and off site management and mitigation will need to be implemented, including solid site hoardings and acoustic barriers, choice of low noise equipment and methodologies, minimising night works as far as practicable in the vicinity of residences and avoidance of unnecessary noise on site.

10. Overall, while the Project construction will likely result in temporary disturbance to nearby residents and businesses, the Project can be constructed in such a way that any adverse construction noise and vibration effects are either mitigated or specifically managed to reduce effects as far as practicable.

Table of Contents

EXECUTIVE SUMMARY	ii
1 Introduction.....	1
1.1 Purpose and scope of this report.....	1
1.2 Project description	1
2 Experience	2
2.1 Peter Ibbotson	2
2.2 Shaun King	2
2.3 Craig Fitzgerald	2
2.4 Siiri Wilkening	2
3 Assessment Methodology.....	3
3.1 Assumptions	3
3.2 Assessment methodology.....	3
3.3 Construction noise	3
3.4 Construction vibration	4
3.5 Mitigation and management	4
4 Noise and Vibration Criteria	5
4.1 Resource Management Act 1991	5
4.2 Noise.....	5
4.3 Vibration and overpressure	9
4.4 Underwater noise.....	10
5 Existing Environment	11
5.1 Noise.....	11
5.2 Vibration.....	12
6 Assessment of Construction Noise Effects	13
6.1 Main construction activities.....	13
6.2 Night works	14
6.3 Equipment.....	15
6.4 Noise level predictions.....	15
6.5 Construction noise risk assessment.....	16
6.6 Dredging	21
6.7 Exceedance of criteria	21
7 Assessment of Construction Vibration.....	23
7.1 Equipment vibration levels.....	23
7.2 Vibration risk assessment.....	23
8 Underwater Noise Assessment.....	25
8.1 PAUP requirements	25

8.2 Impact piling (Policy (1))	25
8.3 Dredging (Policy (3)(b))	28
9 Construction Noise and Vibration Management.....	29
9.1 Noise management methodology.....	29
9.2 General mitigation measures.....	29
9.3 Vibration management and mitigation	30
10 Conclusion	31

Appendices

Appendix A: Sound Power Level of East West Link Construction Activities
Appendix B: Regional Coastal Plan and Proposed Auckland Unitary Plan Rules – Excerpts
Appendix C: The NZ Transport Agency Guide Vibration Criteria
Appendix D: Noise Level Survey Results – Diurnal Variation
Appendix E: Construction Noise Contour Maps
Appendix F: Construction Vibration Risk Zone Maps

List of Tables

Table 4-1: Recommended upper limits for long duration construction noise received in residential zones and dwellings in rural areas	6
Table 4-2: Recommended upper limits for long duration construction noise received in industrial or commercial areas for all days of the year	7
Table 4-3: Recommended Project construction noise criteria for dwellings	8
Table 4-4: Recommended Project construction noise criteria for industrial or commercial premises for all days of the year	9
Table 5-1: Noise level survey results	11
Table 6-1: Construction activities per sector	13
Table 6-2: Activity sound power levels and compliance distance	15
Table 6-3: Approximate number of commercial buildings likely to receive noise levels in excess of the Project criteria	17
Table 6-4: Addresses of commercial buildings likely to receive noise levels in excess of the Project criteria	17
Table 6-5: Number of dwellings likely to receive noise levels in excess of the Project criteria	19
Table 6-6: Addresses of residential buildings likely to receive noise levels in excess of the Project criteria	19
Table 7-1: Activity and risk zones	23
Table 8-1: Pile Driving Noise Levels	26
Table 8-2: Zones of Influence	26

Glossary of Technical Terms/Abbreviations

Abbreviation	Term
AADT	Average annual daily traffic
AEE	Assessment of Effects on the Environment
ALW Plan	Auckland Council Regional Plan: Air, Land and Water
Bol	Board of Inquiry
CMA	Coastal Marine Area
dB	Decibel
PPV	Peak particle velocity
SH(x)	State highway (number)
ARP:C	Auckland Council Regional Plan: Coastal
BCR	Benefit Cost Ratio
EWL	East West Link
EWLA	East West Link Alliance
NoR	Notice of Requirement
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"
NZ Transport Agency,	New Zealand Transport Agency
Project	Means the EWL Project as described in Part C of the AEE
PAUP	Proposed Auckland Unitary Plan ¹
PPF	Protected premises and facilities in accordance with NZS 6806:2010
RMA	Resource Management Act 1991
RoNS	Road of National Significance
Noise	A sound that is unwanted by, or distracting to, the receiver.
Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 µPa i.e. $dB = 20 \times \log(P/Pr)$
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
(t)	The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of eight hours, (15 min) would represent

¹ Subject to legal status of district and regional plans at the time of lodgement.

Abbreviation	Term
	a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L _{Aeq} (t)	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.
L _{A90} (t) OR L _{A95} (t)	The A-weighted noise level equalled or exceeded for 90% or 95% of the measurement period. This is commonly referred to as the background noise level.
L _{A10} (t)	The A-weighted noise level equalled or exceeded for 10% of the measurement period. This is commonly referred to as the average maximum noise level.
L _{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
Vibration	<p>When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity.</p> <p>Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into the vertical direction (up and down vibration), the horizontal transverse direction (side to side) and the horizontal longitudinal direction (front to back).</p>

1 Introduction

1.1 Purpose and scope of this report

This report describes the assessment of construction noise and vibration effects of the Project. The assessment is based on the current New Zealand and international standards and guidelines which are widely used and accepted and have been applied to all recent large scale road construction projects.

The purpose of this report is to assess the noise and vibration effects associated with construction of the Project and to recommend mitigation and management measures to minimise adverse effects.

The scope of work involved the following:

- Reviewing relevant construction noise and vibration standards and determining appropriate criteria;
- Determining potential construction activities and equipment, and associated noise levels;
- Calculating construction noise levels and determining potentially affected dwellings;
- Determining construction vibration distances outside which the risk of building damage is medium or high; and
- Recommending mitigation where required to achieve appropriate outcomes.

This report deals with construction noise and vibration only. Operational noise is addressed in *Volume 3: Technical Report 7 - Traffic Noise and Vibration*.

1.2 Project description

The Project involves the construction, operation and maintenance of a new four lane arterial road from State highway 20 (SH20) at the Neilson Street Interchange in Onehunga, connecting to State highway 1 (SH1) at Mt Wellington as well as an upgrade to SH1 between the Mt Wellington Interchange and the Princes Street Interchange at Ōtāhuhu. New local road connections are provided at Galway Street, Captain Springs Road, the port link road and Hugo Johnston Drive. Cycle and pedestrian facilities are provided along the alignment.

The primary objective of the Project is to address the current traffic congestion problems in and across the Onehunga, Penrose and Mt Wellington commercial areas which will improve freight efficiency and travel reliability for all road users. Improvements to public transport, cycling and walking facilities are also proposed.

A full description of the Project including its design, construction and operation is provided in Part C: Description of the Project in the Assessment of Effects on the Environment Report contained in *Volume 1: AEE* and shown on the Drawings in *Volume 2: Drawing Set*.

A full description of the construction aspects of the Project are shown in Chapter 10.

2 Experience

2.1 Peter Ibbotson

Peter has 15 years of experience in acoustic consulting work throughout Australasia and the Pacific. Peter graduated from the University of Auckland with a Bachelor of Mechanical Engineering (Hons) and worked in Mining and Process Engineering prior to specialising in acoustics.

Peter joined Marshall Day Acoustics in 2006. Peter has a range of experience within acoustics, including building and room acoustics, mechanical services noise control, industrial noise control and environmental acoustics. Peter has an interest in large infrastructure projects and has been directly involved in the construction noise assessment of several large road projects, such as Pūhoi to Warkworth, MacKays to Peka Peka Expressway, Southern Corridor Improvements, and others. Peter has presented evidence at many Council hearings and has presented evidence in several Environment Court Mediations and Supreme Court cases overseas.

2.2 Shaun King

Shaun King is a Consultant with eight years' experience, based in the Auckland office. He specialises in vibration, environmental and building acoustics. He graduated with a degree in Mechanical Engineering from the University of Auckland in 2008. Before joining Marshall Day in 2012, Shaun worked with the AECOM acoustics team in Auckland.

Shaun has experience in vibration, environmental and building acoustics. This work includes traffic noise and vibration assessments, industrial and construction noise and vibration, mechanical services noise control, room acoustics design and sound insulation.

2.3 Craig Fitzgerald

Craig Fitzgerald is a Consultant with seven years' experience, based in the Auckland office. He has specialised in environmental noise and vibration assessments, building acoustics and underwater acoustics. Craig graduated with a Bachelor of Engineering (Mechanical) from the University of Auckland in 2003. He joined the Wellington office in 2007, following several years working as a mechanical engineer. Before joining the Auckland office in 2011, Craig spent two years at Capita Symonds (UK) where he gained Chartered Engineer status with the Engineering Council (UK).

Craig has experience in environmental acoustics for large infrastructure projects and has presented as the noise expert at Council hearings and Environment Court mediation. His underwater acoustic experience was gained on projects such as the Kennedy Point Marina, Ports of Auckland, Marlborough, Napier and Otago, the Rena Salvage Operation and the Old Māngere Bridge replacement. In particular, the latest project provided valuable information for the Project as it is located in the same body of water.

2.4 Siiri Wilkening

Siiri Wilkening has nearly 20 years' experience in acoustic consulting work, both in Germany and New Zealand. She graduated with a Masters degree in Engineering (Landscaping and Environmental Protection) from the University of Rostock in Germany and worked in Germany for two years in the acoustics section of the TÜV Nord Umweltschutz GmbH. There, she was mainly involved with city noise mapping using the computer program LIMA. Siiri joined Marshall Day in 1998 and has since worked predominantly in environmental acoustics, specialising in the measurement and assessment of environmental noise, computer noise modelling, traffic, industrial and construction noise assessment, management and mitigation.

Siiri has been the lead acoustic consultant for a number of significant infrastructure projects, including the RoNS MacKays to Peka Peka Expressway, Pūhoi to Warkworth, Southern and Northern Corridor Improvements (SH1 Auckland), Waterview Connection, Newmarket Viaduct Improvement, Vic Park Tunnel and Waikato Expressway. She has presented expert evidence at many Council hearings, Boards of Inquiry, Environment Court, Environment Court Mediation and the Arbitration Court.

3 Assessment Methodology

3.1 Assumptions

Assessment of construction noise and vibration effects is based on assumptions of construction activities and equipment referred to in Chapter 8 of the AEE and based on Marshall Day Acoustics' experience with previous large scale infrastructure projects of a similar kind. As a contractor has not been appointed for each stage of the works, the methodology for works is not confirmed.

This assessment is based on similar construction projects Marshall Day Acoustics has worked on, including the Southern Corridor Improvements, Waterview Connection, MacKays to Peka Peka and Pūhoi to Warkworth motorway projects. Although contractors have not been appointed, it is considered that the methodology set out in Chapter 8 is representative of activity that has occurred in these previous projects and is accurate for the purposes of assessment at this stage of the Project.

3.2 Assessment methodology

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

- A review of noise and vibration emission data for each construction task / process has been performed. Data previously obtained by Marshall Day Acoustics has informed this process. In addition, data from appropriate noise and vibration standards has also been considered, where relevant;
- A review of relevant criteria has been performed. These criteria are set out in this report and Project limits have been recommended;
- Noise measurements along the route have been performed as part of the operational noise assessment. This information has also been considered in determining a reasonable night time noise limit for the construction activity;
- Predictions of noise and vibration levels from each construction task / process have been performed and setback distances determined to determine whether the Project criteria can be achieved. These setback distances have been plotted as mark-ups of the drawings and are shown in Appendix E for noise and Appendix F for vibration;
- Where the Project cannot meet the noise or vibration criterion, mitigation is considered.

3.3 Construction noise

Noise level predictions for construction projects consider the sound power levels of each item of equipment, and model the noise propagation characteristics over distance, including the effects of ground and air absorption. Indicative noise levels were calculated in accordance with International Standard ISO 9613-2:1996 "*Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation*" for all relevant construction scenarios, assuming multiple items of equipment operating simultaneously. This approach is deliberately conservative in order to represent the reasonable worst-case noise levels that may infrequently occur. The results are shown in Appendix A.

Other than the variations in noise level due to the factors discussed above, there are numerous additional factors that affect construction noise generation. Some of these factors are variations among individual items of equipment, the state of equipment repair, exact locations of each item and operator idiosyncrasies. Generally, these factors cannot be accounted for as they cannot be reasonably quantified. However, the conservative approach outlined above is considered to generally provide for these variables.

3.4 Construction vibration

Construction vibration is a separate issue from construction noise and is addressed separately in this report. Construction equipment that produces high noise levels do not necessarily also produce high vibration levels.

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

As a result, safe distances have been based on vibration measurements² previously performed for high vibration sources such as vibropiling and vibrating rollers, and based on vibration prediction tools as contained in Hassan (2006)³. These have been cross-checked against empirically derived relationships as contained in BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites* Part 2: Vibration.

The results from these measurements and predictions have been used to determine risk radii within which buildings are at medium or high risk of building damage. The risk radii also consider human annoyance effects. Refer to section 4.3.2 and section 7 for further details of how the Project criteria are implemented with regard to annoyance and building damage.

3.5 Mitigation and management

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

In order to set out all appropriate mitigation and management, a Construction Noise and Vibration Management Plan (CNVMP) is generally used. Construction noise management plan examples and guidance are contained in the Transport Agency guidance online.⁴

² Measurements performed at State highway 18 and as used in the Waterview Project.

³ Hassan, O., "Train Induced Groundborne Vibration and Noise in Buildings", Multi-Science Publishing Co Ltd, ISBN 0906522 439, 2006.

⁴ <https://acoustics.nzta.govt.nz/management-plans> and <http://nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/noise-and-vibration/construction-and-maintenance-noise/>

4 Noise and Vibration Criteria

Statutory requirements under the RMA are set out in this section of the report. Relevant guidance within the regional plan and the Proposed Auckland Unitary Plan (PAUP) are also discussed.

4.1 Resource Management Act 1991

The relevant RMA requirements relating to noise area set out in Sections 16 and 17 as follows:

Section 16: Duty to avoid unreasonable noise

1. *Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level.*
2. *A national environmental standard, plan, or resource consent made or granted for the purposes of any of sections 9, 12, 13, 14, 15, 15A, and 15B may prescribe noise emission standards, and is not limited in its ability to do so by subsection (1).*

Section 17: Duty to avoid, remedy, or mitigate adverse effects

1. *Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of that person, whether or not the activity is in accordance with a rule in a plan, a resource consent, a designation, section 10, section 10A, or section 20A.*

4.2 Noise

4.2.1 Auckland Council Regional Plan: Coastal

The Project is located within the Auckland Council area. Some of the regional coastal policies of the PAUP are under appeal and the regional coastal plan component of the PAUP has yet to receive Ministerial approval; therefore, the ACRP:C remains operative in the interim.

Chapter 35.5.5(b) and (c) contain noise criteria for construction noise for a duration of 15 days or more. The rules reference NZS6803P:1984 “The measurement and assessment of noise from construction, maintenance, and demolition work”. This provisional standard has been superseded since 1999 by the full standard NZS 6803:1999 discussed in Section 4.2.3.

Criteria of the ACRP:C are less stringent than those of NZS6803:1999, and it is recommended that all construction works on the Project are governed by one set of criteria, which are discussed below.

4.2.2 Unitary Plan

The Council’s decisions version of the PAUP was released on 19 August 2016. The PAUP references NZS 6803:1999 in regards to construction noise. While general compliance with the noise criteria of NZS 6803 is required, the PAUP provides for an exemption of compliance with the noise criteria if works are of limited duration (e.g. between three nights and 20 days). Since this Project will require works in excess of these timeframes, they have not been further discussed.

In addition, the regional coastal plan part of the PAUP contains objectives and policies in relation to underwater noise from construction. However, no criteria are provided, but rather there is a general direction to assess construction noise levels as they may affect the health and wellbeing of marine

fauna, and the health of users of the coastal marine area. Relevant excerpts from the Plans are included in Appendix B.

4.2.3 Construction noise standard NZS 6803:1999

The most appropriate document for the assessment of construction noise is NZS 6803:1999 (the Standard), which integrates with the relevant noise survey and assessment standards (NZS 6801 and 6802) and has been used for all major infrastructure projects in recent years. This is the criteria referenced in the PAUP and the *NZTA State Highway Construction and Maintenance Noise and Vibration Guide*.

It is considered that only one construction noise standard should apply to the entirety of the Project, as otherwise there will be issues with compliance testing (e.g. when a truck passes from the coastal marine area (CMA) into the Auckland Isthmus and different rules would apply to the same equipment and activity).

A summary of the key elements of the Standard are described below. The recommended noise criteria of the Standard are summarised in Table 4-1 and Table 4-2.

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

Table 4-1: Recommended upper limits for long duration construction noise received in residential zones and dwellings in rural areas

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

Table 4-2: Recommended upper limits for long duration construction noise received in industrial or commercial areas for all days of the year

Time period	dB L _{Aeq}
0730 – 1800	70
1800 – 0730	75

Notwithstanding the above criteria, the Standard states in Section 7.2.6:

“One major factor which should be considered is whether there is a relatively high background sound level (L_{A90}) due to noise from sources other than construction work at the location under investigation. In such cases limits should be based on a determination of the existing level of noise in the area (a “background plus” approach).”

For this Project, the ambient noise environment adjacent to State highway 20 and State highway 1 is significantly impacted by traffic noise. Therefore, higher night time noise criteria are appropriate for the residential areas along State highway 1 (Sector 5). There are specific areas identified in Sector 5 as requiring night works; these are the Ōtāhuhu Creek bridge works and the construction and demolition of Panama Bridge and Princes Street Bridge. In the event that night time construction is required to widen the State highway at times, these criteria would apply to these activities also.

If night time widening works are required on State highway 1 and State highway 20, traffic and safety considerations would typically mean that site works will not occur on Friday and Saturday nights. While the Standard provides for lower noise levels on Saturday and Sunday evening and morning shoulder periods, it is considered that for this Project, the “quiet nights” should be Friday and Saturday nights, rather than Saturday and Sunday as provided for in the Standard. It is noted that only specific bridge construction activities have been earmarked for night works at this stage. On this basis night time noise at levels that breach the Standard would likely only occur for a limited duration.

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

The Standard does not anticipate that full compliance with the construction noise criteria of Table 4-1 and Table 4-2 will necessarily be achieved at all times and at all receivers. It focuses on the implementation of the best practicable option (BPO) for construction noise management and mitigation rather than requiring that the criteria must be achieved. Management measures are further discussed in Section 9 of this report.

4.2.4 Night time noise levels

As discussed above, the Standard makes provision for higher night time noise criteria where these are appropriate, i.e. where existing ambient noise levels are already elevated. This is the case in the vicinity of State highway 1 and State highway 20.

Based on the diurnal variation of the long duration noise level surveys (refer section 5.1), average night time noise levels close to State highway 1 between 10 pm and 6 am have been shown to range from 41 to 68 dB L_{A90}, with night time background noise levels rarely dropping below 50 dB L_{A90} weeknights. Adjacent to State highway 20, night time noise levels range from 42 to 66 dB L_{A90}, with an average background noise level of 54 dB. Applying the “background plus” rule, a night time noise limit of around 60 dB L_{Aeq} would be appropriate.

This is also in line with other recent projects involving works on the Auckland motorway system, with night time noise criteria consented as follows:

- Vic Park Tunnel – 60 dB L_{Aeq} ;
- Newmarket Viaduct Improvement Project – 65 dB L_{Aeq} ;
- Waterview Connection – 60 dB L_{Aeq} ;
- Southern Corridor Improvements – 60 dB L_{Aeq} .

The average L_{Aeq} night time noise levels across the Project between 10pm and 6am are generally above 60 dB L_{Aeq} , with noise levels of up to 71 dB L_{Aeq} . However, note that in some of the Māngere Bridge area, night time noise levels are likely to be lower as not all of this area receives high levels of road traffic noise on State highway 20. Within this area, it would be reasonable to apply a noise limit of 45 dB L_{Aeq} during the night period, i.e. the night time noise limit recommended by NZS 6803:1999.

It is also understood that night time works will not occur on Fridays and Saturdays in the interest of driver and worker safety. For that reason, those two nights are generally the “quiet” nights. For all other nights of the week, no such issues are present, and night works can be undertaken safely.

4.2.5 Recommended Project construction noise criteria

Based on the review of the relevant documents, experience with similar projects in the Auckland region and the high ambient noise levels as determined by the ambient noise surveys, the following construction noise criteria are recommended for the entirety of the Project:

Table 4-3: Recommended Project construction noise criteria for dwellings

Time of week	Time period	dB L_{Aeq}	dB L_{AFmax}
Sundays to Thursdays	0630-0730	55	75
	0730-1800	70	85
	1800-2000	65	80
	2000-0630	60	75
Fridays	0630-0730	60	75
	0730-1800	70	85
	1800-2000	45	75
	2000-0630	45	75
Saturdays and Public Holidays	0630-0730	45	75
	0730-1800	55	85
	1800-2000	45	75
	2000-0630	45	75

Table 4-4: Recommended Project construction noise criteria for industrial or commercial premises for all days of the year

Time period	dB L _{Aeq}
0730 – 1800	70
1800 – 0730	75

4.3 Vibration and overpressure

4.3.1 Regional and Unitary Plans

There are limited relevant references to construction vibration criteria in the Auckland District Plan – Isthmus Section, Regional Plan and PAUP. The PAUP references German Standard DIN 4150-3:1999 “Structural Vibration – Part 3 – Effects of vibration on structures” which is considered appropriate for the control of building damage from construction vibration. In addition, the PAUP contains amenity vibration criteria that may be exceeded for up to three days if it is not practicable to meet these criteria.

Excerpts from the Plans are contained in Appendix B.

4.3.2 NZ Transport Agency guide

The NZ Transport Agency (the Transport Agency) has issued a “State highway construction and maintenance noise and vibration guide (August 2013)”, (the NZ Transport Agency Guide) which Marshall Day Acoustics helped to develop. The NZ Transport Agency Guide adopts the German and British standards noted in the list above, and applies them in a progressive manner that addresses both annoyance and building damage effects. Prior to the development of this Guide annoyance criteria were not usually applied to construction works, so the Guide adds this additional level of protection for receivers.

The NZ Transport Agency Guide is available at: <http://www.nzta.govt.nz/assets/resources/sh-construction-maintenance-noise/docs/construction-maintenance-noise-vibration-guide.pdf>. An excerpt from the document, which contains the vibration and overpressure criteria, is shown in Appendix C.

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

The DIN 4150-3:1999 Standard, which the 5mm/s Category B criteria are taken from, is a conservative standard designed to avoid all damage to buildings, i.e. even superficial damage like cracking in plaster. Significantly higher limits would be applied if damage to structural foundations was the only consideration.

The NZ Transport Agency Guide contains an airblast overpressure criterion of 120 dB L_{Zpeak}. This is consistent with most construction guidelines and the criteria contained within the PAUP (Decisions version) (refer Appendix B: E25.6.31. Noise Levels from Blasting).

4.3.3 Recommended Project construction vibration and airblast overpressure criteria

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

4.4 Underwater noise

The PAUP (Decisions version) contains no noise limits, however blasting, impact and vibratory piling, and marine seismic surveys are listed as restricted discretionary activities that require an acoustic assessment addressing the following matters:

- The health and wellbeing of marine fauna (including threatened and at-risk species) and people from the noise associated with the proposal;
- The practicability of being able to control the noise effects;
- The social and economic benefits to the community of the proposal; and
- The extent to which the adverse effects of the noise will be mitigated.

5 Existing Environment

5.1 Noise

Both long and short duration noise level surveys were undertaken in the vicinity of the Project area in May 2016.

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

Short duration attended surveys were located in the vicinity of the Project area, including in areas away from the road that may be affected, e.g. in Māngere Bridge. Generally, noise levels were controlled by traffic on State highway 1 and State highway 20, with some contribution from local roads and businesses. As traffic distribution over the day is known, the short duration survey results can be used to derive a 24-hour traffic noise level.

All noise level survey results are shown in Table 5-1. For each long duration noise level survey, the diurnal variation in level is also shown in Appendix D. Measured and derived noise levels ranged from 45 dB $L_{Aeq(24h)}$ at Norana Park in Māngere Bridge (away from any major roads or other noise generating activities) to 72 dB $L_{Aeq(24h)}$ adjacent to Onehunga Harbour Road and beside State highway 20.

Table 5-1: Noise level survey results

Location	Measured noise level	Derived noise level
Long duration surveys	dB $L_{Aeq(24h)}$	dB $L_{Aeq(24h)}$
13 Kotahi Road, Mt Wellington	65	n/a
24 Frank Grey Place, Ōtāhuhu (AMA yard)	66	n/a
14 Onehunga Harbour Road, Onehunga (The Landing)	66	n/a
88 Panama Road, Mt Wellington	75	n/a
Short duration surveys	dB $L_{Aeq(15min)}$	dB $L_{Aeq(24h)}$
13 Frank Grey Place, Ōtāhuhu	67	65
1 Deas Place, Ōtāhuhu	70	68
36 Mataroa Place, Mt Wellington	68	66
102 Hillside Road, Mt Wellington	69	67
96 Captain Springs Road, Onehunga	65	63
Waikaraka Cemetery (water end)	54	53
31 Onehunga Harbour Road, Onehunga	74	72
16 Mona Avenue, Māngere Bridge	51	49
31 Norana Avenue, Māngere Bridge	49	48
Norana Park, Māngere Bridge	46	45

5.2 Vibration

The Auckland Motorway Alliance (AMA) is responsible for the maintenance of the Auckland State highway network and receives any complaints in regards to these roads. The AMA has advised that no vibration complaints have been received on State highway 1 between Tip Top Corner and Princes Street. No recorded vibration complaints have been found for State highway 20.

As no complaints have been received regarding operational vibration, ambient vibration levels have not been performed as part of this assessment. It is expected that operational vibration levels from motorways and local roads will not typically be significant.

6 Assessment of Construction Noise Effects

6.1 Main construction activities

The main construction activities required on each Sector are set out as follows:

Table 6-1: Construction activities per sector

Construction Sector	Main construction activities
Sector 1: Neilson Street Interchange	<ul style="list-style-type: none"> • Earthwork cut and fill at several locations as well as earthwork preparation of new road alignments; • Construction of retaining walls at multiple points around interchange; • Piling for overbridge / interchange foundations and placement or launching of beams, girders and caps (night); • Construction of traffic noise barriers; • Precast overbridge/interchange construction (night); • Pavement preparation and surfacing for new and realigned roads.
Sector 2: Foreshore Works and Dredging	<ul style="list-style-type: none"> • Large scale earthworks / reclamation to establish road platform embankment and external bund (night, some locations); • Pavement preparation and surfacing (night, some locations); • Piling and construction of foreshore walkway; • Dredging using a barge mounted excavator(s); • Loadout and haulage of dredging as required including pugmill preparation of mudcrete.
Sector 3: Anns Creek	<ul style="list-style-type: none"> • Piling, concrete foundations and structures; • Precast Bridge construction and lifting; • Earthwork fills around Hugo Johnston Drive Intersection; • Pavement preparation and surfacing.
Sector 4: Great South Road to State highway 1	<ul style="list-style-type: none"> • Road surface removal, earthworks and sealing around Great South Road Intersection including driven piles (night); • Earthworks, pavement preparation and surfacing on Sylvia Park Road including construction of new roads and new intersections beneath of and on-ramps; • Piling for State highway 1 connection off/on-ramp foundations, precast bridge constructions, lifting, etc (night); • Widening of lanes on State highway 1 (night).
Sector 5: State highway 1	<ul style="list-style-type: none"> • Fill haulage and general earthmoving; • Drilling at certain locations for anchor retaining walls along motorway; • Construction of traffic noise barriers; • Sealing and road finishing in many locations; • Earthworks and piling for Panama Bridge and the Princes Street Interchange (night); • Precast bridge lifting and construction (night); • General earthworks, piling and concreting around the Ōtāhuhu Creek culvert installation (night).
Sector 6: Local Works	<ul style="list-style-type: none"> • Earthworks for MetroPort Link; • Pavement preparation and surfacing along Captain Springs Road and MetroPort Link.

6.2 Night works

Night time works will be required along the route. These night works are often required where daytime activity is not possible due to safety or traffic considerations. An example of such activity would include piling near motorway overbridges.

The following areas of night works have been identified in the AEE report:

Sector 1 – Neilson Street Interchange

- Piling and installation of Neilson Street overbridge;
- Northbound off-ramp tie in;
- Gloucester Park Road to State highway 20 tie in;
- Southbound on-ramp tie in;
- Northbound off-ramp temporary pavement.

Sector 2 – Foreshore Works

- Works in front of properties along Captain Springs Road;
- Works in front of properties along the port link road;
- Dredging within the CMA is also required. Dredging material will be used in the new containment contaminant bund. Material will be dredged using a barge mounted excavator, transported to the site on a loading barge and then mixed with stabilizer and then placed to establish the embankment. A pugmill will be required to mix the mud with concrete.

Sector 3 – Anns Creek

- Construction of Great South Road / Sylvia Park intersection

Sector 4 – Great South Road to State highway 1

- Piling and pier construction for the southbound on-ramp on State highway 1;
- Piling and pier construction for the northbound off-ramp on State highway 1;
- Piling and pier construction for the southbound on-ramp on Mt Wellington Highway;
- Piling and pier construction for the northbound off-ramp on Mt Wellington Highway;
- Widening of the northbound lane on State highway 1;
- Widening of the southbound lane on State highway 1;
- Piling and pier construction of Panama Bridge and Princes Street Bridge over State highway 1;
- Deconstruction of the existing Panama Bridge and Princes Street Bridge.

Sector 5 – State highway 1

- Ōtāhuhu Creek structures;
- Construction and demolition of Panama Bridge and Princes Street Bridge.

Sector 6 – Local Works

- No night works anticipated.

Other

- Vegetation clearing near state highways. Vegetation works above major roads can be required to be performed at night where there is a risk to vehicle safety if the task was to be performed during the daytime.

In order to allow for night works at any location, our assessment has considered the effects that would arise from any activity occurring during the night period. In commercial and industrial areas (i.e. from the Neilson Street Interchange to State highway 1 after Tip Top corner) the NZS 6803:1999 noise rules are generally more permissive during the night period and daytime works would be subject to greater noise restrictions than night time works. In many cases, night works in these areas may result in reduced noise effects when compared with daytime activity.

As discussed above, in the residential areas beside State highway 1, only piling and construction of the Ōtāhuhu Creek Bridge, Panama Bridge and Princes Street Bridges (and demolition of existing structures) has been marked for night works. However, Marshall Day Acoustics' experience with previous Southern Corridor Widening works suggested that general night-work activity along the shoulder would be required at times. Our assessment has allowed for these activities at this stage of the works; if the contractor does not require such works to occur this can be reflected in the site specific noise management plans.

6.3 Equipment

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

6.4 Noise level predictions

Based on the sound power levels in the table in Appendix A, combined “activity sound power levels” have been predicted (refer Table 6-2). From the activity sound power levels, the distance at which the 70 dB L_{Aeq} day-time noise criterion can be complied with, without mitigation by noise barriers, has been determined. The distances at which the construction night time noise criterion (75 dB L_{Aeq}) and residential night time criterion (60 dB L_{Aeq}) are complied with have also been determined.

Table 6-2: Activity sound power levels and compliance distance

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

Activity	Activity Sound Power Level	Distance beyond which compliance with day-time limit (70 dB L_{Aeq}) is achieved without noise barriers
	dB L_{WA}	metres
Staging area/construction yard	100	10
Dredging	99	12

Many buildings are located within close proximity to the works. In the area between State highway 20 and State highway 1, these are generally commercial or industrial buildings, many of which will be quite insensitive to noise.

Residential areas are located alongside State highway 1 and many dwellings are within close proximity to the works. Some of these dwellings receive acoustic screening from cutting escarpments or noise barriers, however much of this residential area is relatively unprotected from construction activity that could occur on the motorway.

As part of the assessment of operational noise, new noise barriers have been proposed along the route to the south of Panama Road. These noise barriers should be constructed at the earliest instance in the construction period to provide effective mitigation of construction noise. The traffic noise barriers are generally of notable heights (up to 3m) and would therefore provide significant mitigation beyond that achieved by standard site hoardings.

However, for the purposes of this assessment, in most situations, limited screening from potential noise barriers or earthwork cuttings has been assumed.

Based on the likely level of noise emission from various stages of construction, effects envelopes have been developed to demonstrate distances beyond which compliance with the daytime and/or night time noise criteria can be achieved with existing and proposed noise barriers in place. These distances have been plotted onto aerial photographs to show those areas where mitigation would need to be considered and implemented (refer Appendix E and Tables in section 6.5).

It is recommended that similar figures be included in any construction noise and vibration management schedule, once they have been revised as necessary to ensure they reflect the final alignment and construction methodology.

6.5 Construction noise risk assessment

6.5.1 Sectors 1 to 4: Commercial Area (State highway 20 to State highway 1 Panama Bridge)

Sectors 1 to 4 contain mainly commercial and industrial buildings. In these sectors, the zoning of properties is generally Business 4, 6 or Open Space in the operative District Plan. Areas of Mixed Use also occur to the north of the Onehunga Interchange. The PAUP also zones these areas predominantly for “business” activities. Therefore, Project criteria for commercial and industrial areas apply in this area.

Many buildings are likely to be exposed to noise levels in excess of 70 dB L_{Aeq} during the daytime. Night time works within those sectors also risk breaching the 75 dB L_{Aeq} noise criterion at times. The individual properties where breaches of the noise criterion are likely are shown in Appendix E.

The effects of noise on commercial activities will vary significantly. Insensitive activities such as electricity generation, stevedoring and industrial fabrication or manufacturing are unlikely to be appreciably affected by noise levels of above 75 dB L_{Aeq} , irrespective of whether this occurs during the daytime or night time.

Activity such as retail, sales, office administration or tourist services may be affected to a greater extent where noise levels are in excess of 70 dB L_{Aeq} during the daytime. The primary effect is likely to be an interference with communication as well as general annoyance where concentration is interrupted.

In general, night time construction within the commercial or industrial area will result in low risk of annoyance. However, the specific effects of construction noise occurring in these commercial areas should be considered on a case-by-case basis prior to these works, through site specific construction and noise vibration management plans (refer to section 9). It is noted that where the effects of night time construction could be significant such as at hotels (e.g. 8 Onehunga Harbour Road), specific noise mitigation measures may be required, such as temporary hiring of the most affected rooms of the hotel.

Table 6-3 summarises the number and approximate location of commercial buildings that are likely to receive noise levels in excess of the Project criteria.

Table 6-3: Approximate number of commercial buildings likely to receive noise levels in excess of the Project criteria

Location	Approx. number of commercial buildings where the “Daytime” noise limit (70 dB L_{Aeq}) is likely to be exceeded	Approx. number of commercial buildings where the “Night time” noise limit (75 dB L_{Aeq}) ⁵ is likely to be exceeded (if night time works occur)
Sector 1	73	53
Sector 2	8	4
Sector 3	15	13
Sector 4	16	5
Sector 5	15	14
Sector 6	36	29

Table 6-4 summarises the addresses where these effects are likely to occur.

Table 6-4: Addresses of commercial buildings likely to receive noise levels in excess of the Project criteria

Addresses of commercial buildings likely to receive noise levels exceeding the “Daytime” noise limit (70 dB L_{Aeq})	Addresses of commercial buildings likely to receive noise levels exceeding the “Night time” noise limit (75 dB L_{Aeq}) ⁶ (if night time works occur)
1 Princes Street	1,3 Wharangi Street
5-7,9 Wharangi Street	2-4 Hill Street

⁵ Note that night time activity is not proposed at all locations and noise levels would not breach 75 dB L_{Aeq} at all 53 buildings

⁶ Note that night time activity is not proposed at all locations and noise levels would not breach 75 dB L_{Aeq} at all buildings

Addresses of commercial buildings likely to receive noise levels exceeding the “Daytime” noise limit (70 dB L _{Aeq})	Addresses of commercial buildings likely to receive noise levels exceeding the “Night time” noise limit (75 dB L _{Aeq}) ⁶ (if night time works occur)
6,8 Hill Street	1,3,5,8 Gloucester Park Road
1-2/3,3-5 Hill Street	27-31 Princes Street
39-39A, 41 Neilson Street	31-33,37 Neilson Street
11A-D Selwyn Street	31-31A,33-33A,35,35A,37A-M,1-20/39,41,45-47 Onehunga Mall
6-10 Selwyn Street	40,42,44,44A,46-48,48,50,51-55,54,56,58,60 Onehunga Mall Road
10,18,20 Gloucester Park Road	55 Onehunga Harbour Road
4-6 Alfred Street	1-25/2, 8 Onehunga Road
1048-1050 Great South Road	57,59,61,63,65,67,69,71-73,72,75-89, 76,80,82,84,84,94,96,98, 100,91-105,101-103 Onehunga Road
10,12-14 Lockhart Place	10A,19,34 Galway Street
30A-30L,32,40,42,44 Vestey Drive	100 Neilson Street
8A-8E Sylvia Park Road	2 Alfred Street
1A, 9 Pacific Rise	69 Captain Springs Road
7 Clemow Drive	35,59 Miami Parade
28 Pukemiro Street	108-136,120,124,164-220 Hugo Johnston Drive
29-33 Miami Parade	741-779, 781,1012,1016A-F Great South Road
	20A-Q Sylvia Park Road
	8 Lockhart Place
	34,36,38 Vestey Drive
	3 Clemow Drive
	99A,113 Carbine Road
	4,5, 6,7-8 Monahan Road
	7,8 Hotunui Drive
	7 Carmont Place
	4 Te Apunga Place
	14 George Burke Road
	175-243 Neilson Street
	226, 230, 232A, 232,234,236,238,249,264 Neilson Street
	79,83-91,102,105 Captain Springs Road
	23 Pukemiro Street
	57,63 Angle Street
	3 Edinburgh Street

It is considered that the effects of noise on industrial and commercial receivers should be considered on a case-by-case basis where an activity is likely to receive noise levels in excess of the Project noise criterion. Site specific noise management should be implemented to ensure that noise effects are avoided, remedied or mitigated wherever practicable. Such management should be documented in schedules attached to the CNVMP.

6.5.2 Sector 5: Residential Area (State highway 1 Panama Bridge to Extent of Works)

Within Sector 5, nearby receivers are predominantly residential in nature. With the exception of one Business zoned property adjacent to the Ōtāhuhu Creek, land is generally zoned Residential from just north of Panama Bridge to the southern extent of the Project. The predominant nature of this area is one of “residential activity”. As such, the Project criteria with respect to residential areas apply.

In this sector, a significant number of dwellings will be exposed to construction noise levels in excess of 70 dB L_{Aeq} during the daytime (the Project “daytime” criterion). Where night time works occur, a larger number of dwellings will be exposed to noise levels of greater than 60 dB L_{Aeq} (the Project “night time” criterion). In general, the first row of dwellings adjacent to the works will receive noise levels in excess of 70 dB L_{Aeq} during daytime, with the second row of dwellings normally receiving noise levels of lower than 70 dB L_{Aeq}.

Night time noise levels of above 60 dB L_{Aeq} may be received by dwellings three to four rows back from the works. This is general guidance only; for specific information refer to the contours in Appendix E.

Table 6-5 summarises the number and approximate location of dwellings that are likely to receive noise levels in excess of the Project criteria.

Table 6-5: Number of dwellings likely to receive noise levels in excess of the Project criteria

Location	Chainage	Approx. number of dwellings where the “Daytime” noise limit (70 dB L _{Aeq}) may be exceeded	Approx. number of dwellings where the “Night time” noise limit (60 dB L _{Aeq}) may be exceeded
Sector 5: Panama Road Bridge to Ōtāhuhu Creek Bridge	7100-8000	78	164
Sector 5: Ōtāhuhu Creek Bridge to Princes Street Bridge	8050-8650	50	85
Sector 5: Princes Street Bridge to limit of works	8650-9100	33	80

Table 6-6 summarises the addresses where these effects are likely to occur.

Table 6-6: Addresses of residential buildings likely to receive noise levels in excess of the Project criteria

Addresses of dwellings likely to receive noise levels exceeding the “Daytime” noise limit (70 dB L _{Aeq})	Addresses of dwellings likely to receive noise levels exceeding the “Night time” noise limit (60 dB L _{Aeq}) ⁷ (if night time works occur)
72,76,84,84A-C,86,86A Panama Road	2,5,6,7,8,9,10,11,12,13,14,15,16 Sophia Close
1-2/130,136,1-3/138.1-3/144.1-3/146,1-3/152,154,156A,158A,160,1-3/166,158A,160 Panama Road	58,60,62,62A,76A,76B,82A,1-4/82A Panama Rd

⁷ Note that night time activity is not proposed at all locations and noise levels would not breach 75 dB L_{Aeq} at all 53 buildings

Addresses of dwellings likely to receive noise levels exceeding the “Daytime” noise limit (70 dB L _{Aeq})	Addresses of dwellings likely to receive noise levels exceeding the “Night time” noise limit (60 dB L _{Aeq}) ⁷ (if night time works occur)
1,3,3A,1-3/4,5,5A,5B,7,13,15,17,19,21,23,25 McLennan Road	3-5/130,134,134A-D,1-4/140,1-4/140,1-4/148, 2/150,156B,156C,158B,156C,1-6/164,1-3/168, 170A-E Panama Road
69,77,85,1-7/93 Panama Road	77,1-7/91,1-6/97 Panama Road
369,1-2/371,448,450,452,446A Panama Street	6A-C,8,10,26 McLennan Road
102,104,106,110,112 Hillside Road	43,64-66,68,70,72,74,74A,86,88,90, 90A,92,94,96 Hillside Road
55,57,59,61,63,65,67 Hillside Road	9,10,17,18,19,20 Kotahi Road
53 Hillside Road	9,10,11,13,23,24 Coppins Road
1-8 Deborah Hatton Lane	442,444,446 Panama Road
11,12,13,14,15,16,17 Kotahi Road	4,8,10,16,18,22,24,33,35,37,37A,37B,39 Mataroa Road
14,14A,16A,17,18,19,20,22,21,21A Coppins Road	9,11,13,15,17,19,20,21,22,23,26 Luke Street East
446,454 Panama Street	1-5/82,1/82A,2/84 Luke Street East
14,28,30,34,41,43,45,47,49,51,53,55,57, 61C Mataroa Road	2-5/81, 81A,83 Luke Street
1,2,5,7,6,8,10,16,18 Deas Place	79A-C Avalon Street
1,3,3A,5,5A,7,9,11,15,29 Frank Grey Place	28-36 Avalon Court
142,1/144,146 Princes Street	101,101A,103,103A,105,105A Luke Street East
2,4,6,8,10,1-2/12,1-2/14 Fencible Place	16,18,20 Fencible Place
85,85A Luke Street	129,133,135,152 Princes Street
1-12/14 Avalon Street	2A,4,4A,6,6A,8,8A,10,12,14,16,18,20,22,24,26,28 Todd Place
19-27 Avalon Court	102,105,105A,105B Avenue Road
10-18 Avalon Street	34 Water Street
120,1-2/131 Princes Street	3,8,10 Trenwith Street
89,91 Princes Street	49,59A,150C,150B Avenue Road East
51,53,55,57 Frank Grey Place	136A,138,140 Avenue Road East
54,56,58 Frank Grey Street	80,82 Frank Grey Street
60,1-4/62, 64,66,68,70, 72, 72A, 72B, 74, 76, 84 Frank Grey Place	
3/113,132,136 Avenue Road	
107A Avenue Road	
12,14 Trenwith Street	
1 to 24/48 Water Street	

While not shown in Table 6-6, many more dwellings are likely to receive noise levels of above 45 dB L_{Aeq} during construction works on the motorway. Noise emissions from activities such as earthmoving or retaining wall construction would likely be above 45 dB L_{Aeq} within around 200m to 300m of the construction operation, even where noise barriers are in place. The recommended Project noise criterion is 45 dB L_{Aeq} only on Friday and Saturday nights. During these times, construction activity could not occur without significantly breaching the Project noise criteria.

Construction activity occurring at the Neilson Street Interchange and on the embankment is considered to represent a negligible risk of breaching the Project night time noise criteria at the residential areas to the south of the Māngere Inlet. For further details of this effects envelope, refer to the figures in Appendix E.

6.6 Dredging

Dredging may occur 24 hours per day as required due to tidal constraints. Dredging is predicted to readily comply with the 70 dB L_{Aeq} daytime noise limit at all relevant receiver locations. However, a setback distance only around 250m is predicted to enable compliance with the 45 dB L_{Aeq} night time construction noise criterion at residential receivers in Māngere⁸. It is considered unlikely that dredging could occur within this distance from dwellings at Māngere and there is therefore a negligible risk that the Project noise criterion will be exceeded by dredging.

6.7 Exceedance of criteria

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

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

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

In the event that night time works occur for one or two nights, this may be acceptable provided that residents have been informed and a clear time frame has been provided. However, if night time works are expected to be ongoing for several consecutive nights, and at a noise level that affects residents’ ability to sleep, then alternative strategies should be implemented, such as offering temporary relocation for those affected residents.

The following activities have the potential to result in exceedances of the Project noise criteria. Note that of these activities, only activities associated with bridge and culvert construction have been identified as requiring night works in residential areas at present.

- Piling, construction and demolition of bridges may generate high noise levels at nearby dwellings due to the proximity of these works to dwellings and the likely direct line-of-sight between dwellings and machinery. In addition, the construction of retaining walls and noise barriers would generate relatively high levels of noise at dwellings, however the construction of noise barriers early in the Project will reduce overall construction noise levels received at dwellings;
- Bulk earthworks would generate noise levels of above 60 dB L_{Aeq} within 175m of operations where direct line-of-sight occurs between dwellings and earthworks. Typically, however, noise levels would

⁸ Setback distances of 350m would be required to achieve the noise limit set out in the PAUP

be much lower than this at such distances due to acoustic screening provided by intervening dwellings or by noise barriers or topography. Because of this, bulk earthworks will typically generate noise levels of above 60 dB L_{Aeq} within the first few rows of dwellings in built-up areas; and

- Construction of structures and pavements is potentially less noisy than bulk earthworks, notwithstanding that these activities still have the potential to generate noise levels of above 60 dB L_{Aeq} within 40m to 80m of the works depending on acoustic screening.

Night time works in Sector 5 could affect a large number of residents. To mitigate this, night works in residential areas should, if practicable, only be undertaken for safety critical bridge and culvert construction and demolition. Where practicable all other road construction works in this area should be confined to the daytime period.

Schedules of specific noise management should be developed prior to any construction activities proposed to occur at night in residential areas and within noise sensitive commercial areas as required. These schedules will be attached to the CNVMP. These schedules will identify the noise and/or vibration risks and establish the management procedures that will be used in each area. These may involve the use of temporary noise mitigation (barriers or bunds), reduction of operating equipment or rescheduling activity to occur during the day period. Noise management plans are further discussed in section 9.

7 Assessment of Construction Vibration

7.1 Equipment vibration levels

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

7.2 Vibration risk assessment

There is a risk that the Project criteria will be exceeded at dwellings within Sector 5 of the Project bounding the State highway 1 corridor. Vibration generating construction activities along this section of the alignment are understood to generally be limited to vibrating roller compactors. Vibropiling or impact piling has not been specifically referenced along the route, however it is possible that these activities may be required in some locations and risk distances have been calculated on this basis. It is understood that areas of rock on the abutments at the Panama Street and Princes Street bridges may require removal using explosives.

The risk categories in Table 7-1 relate to the risk of exceeding the Project criteria at various distances from the vibration inducing works. The all other buildings zone has been calculated under the worst case assumption that all of these buildings are light weight structures. The risk categories are defined as follows:

High Risk Predicted to exceed Category A and B Project criteria

Medium Risk Predicted to exceed Category A criteria, but comply with the Category B criteria

Low Risk Predicted to comply with Category A and B Project criteria

Table 7-1: Activity and risk zones

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

Drawings showing the approximate risk zones for the identified equipment along the Project extents are included in Appendix F.

Residential buildings are typically around 15m to 20m from the closest extent of the works. However, in some instances dwellings are located very close to the works, i.e. less than 10m of retaining wall or potential earthworks operation.

The area surrounding Sector 5 is generally densely developed in general and there are therefore likely to be a significant number of dwellings located within the high and medium risk zones. In general, only the closest of dwellings would be located within the high risk zone and the majority of the first and second row of dwellings adjacent State highway 1 would be within the medium risk zone.

The Project criteria are significantly more stringent at dwellings during the night and have the potential to be exceeded at distances greater than 200m from the Project area. On this basis, vibration intensive activities adjacent residential areas should be generally scheduled for the daytime wherever practicable.

Commercial buildings vary in their proximity to works, with the majority of commercial buildings located along Sectors 1 to 4 and in Sector 6. In the commercial areas near the Neilson Street Interchange and State highway 1 on and off-ramps, some commercial and industrial activities are located close to the proposed works, i.e. within around 10m of the works. These commercial buildings will receive perceptible vibration when compaction is being undertaken, however it is unlikely that the unoccupied Category B Project criteria (building damage) would be breached at this distance.

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

Blasting is not provided for in the above table as it is subject to specific criteria. Blasting vibration is required to comply with a criterion of 5mm/s or the ground borne vibration limits as set out in BS5228-2. Compliance with these criteria can often be achieved at relatively short distances from construction blasting. Noise and vibration effects from blasting are directly dependent on the charge mass and the ground conditions affecting the propagation of vibration. Typically, blasting will be designed around the noise and vibration limits within consent conditions.

For construction activities within the High and Medium Risk zone of a building it is recommended that low vibration methods of construction be investigated and implemented wherever practicable with the aim of achieving Category A compliance. This may include using screw piling methods, non-vibrating rollers, pre-drilling piles or chemical splitting of rock. If low vibration methodologies are not deemed practicable, for dwellings in the High Risk zone it is recommended that the following process be implemented before construction commences;

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

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

Other vibration management measures will also be required and these are discussed in Section 9.3.

8 Underwater Noise Assessment

8.1 PAUP requirements

The PAUP (Decisions Version) contains no criteria relating to underwater noise or vibration generation. However, it contains an objective and relevant policies as follows:

F2.18.2.Objective [rpc]

- (1) *Underwater noise from identified activities is managed to maintain the health and well-being of marine fauna and users of the coastal environment.*

F2.18.3.Policies [rcp]

- (1) *Require underwater blasting, impact and vibratory piling, and marine seismic surveys in the coastal marine area to adopt the best practicable option to manage noise so that it does not exceed a reasonable level.*
- (2) *Assess the following matters for underwater blasting, impact and vibratory piling, and marine seismic surveys:*
 - (a) *The health and well-being of marine fauna (including threatened and at-risk species) and people from the noise associated with the proposal;*
 - (b) *The practicability of being able to control the noise effects;*
 - (c) *The social and economic benefits to the community of the proposal; and*
 - (d) *The extent to which the adverse effects of the noise will be mitigated.*
- (3) *Enable the generation of underwater noise where that noise is associated with the following activities:*
 - (a) *The operational requirements of vessels;*
 - (b) *Construction or operation of marine and port activities, marine and port facilities, marina activities, marine and port accessory structures and services, maritime passenger facilities and dredging, that do not involve underwater blasting, impact and vibratory piling, or marine seismic surveys; and*
 - (c) *Sonar not including marine seismic surveys.*

Of interest are objective (1) and policies (1), (2) (a), (b) and (d) and (3)(b). Other parts of these policies are not relevant in the context of this acoustic assessment.

8.2 Impact piling (Policy (1))

Impact piling is predicted to produce the highest levels of underwater construction noise. Impact piling is proposed for a bridge at the eastern end of the Māngere Inlet. The 900mm diameter steel piles for this bridge will be located approximately 600m from the low tide line of the main harbour. Piling is also required as part of the establishment of the coastal boardwalk along Sector 2 in the Māngere Inlet. This will require a significant number of 300mm diameter piles to be driven in this sector at a typical distance of 20-40m from the toe of the proposed embankment.

An assessment of underwater noise effects is required for impact piling activities in accordance with the decision version of the PAUP.

Impact piling can generate peak noise levels of between 180 and 250 dB re 1µPa peak at 1m from the source depending on the pile type (e.g. timber pile, steel H pile, sheet pile), size of pile and piling rig, and the piling method and mitigation employed. Comparable reference measurements⁹ for a single strike of a 900mm diameter steel pile is summarised as follows:

Table 8-1: Pile Driving Noise Levels

900mm diameter steel pile	300mm diameter wood pile	300mm diameter concrete or steel pile	300mm steel H type
210 dB re 1µPa peak	172 dB re 1µPa peak	182 dB re 1µPa peak	190 dB re 1µPa peak
183 dB re 1µPa rms	147 dB re 1µPa rms	157 dB re 1µPa rms	156 dB re 1µPa rms
193 dB re 1µPa SEL	157 dB re 1µPa SEL	167 dB re 1µPa SEL	168 dB re 1µPa SEL

* All values are given at a reference distance of 10 metres from the source

For 'land-based' piles (in the mudflats or intertidal zone), the Caltrans¹⁰ pile driving screening tool has been used to predict conservative 'zones of influence'. Assuming up to five piles per day and 600 strikes per pile,¹¹ the zones of influence are predicted to be:

Table 8-2: Zones of Influence

Effect	900mm diameter steel pile	300mm diameter timber pile	300mm diameter concrete or steel pile	300mm steel H type
Potential PTS onset from a single strike (230 dB re 1 µPa peak);	Within 10m	Within 10m	Within 10m	Within 10m
Potential PTS onset from cumulative piling exposure (187 dB re 1 µPa ² /s SEL _{cum})	Within 210m	Within 21 m	Within 97m	Within 113m
Effective quiet (154 dB re 1 µPa ² /s SEL).	Beyond 350m	Beyond 29 m	Beyond 136 m	Beyond 158m

⁹ California Department of Transportation Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish (Nov 2015), Table VI-1

¹⁰ California Department of Transportation Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish (Nov 2015), Table VI-3

¹¹ California Department of Transportation Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish (Nov 2015), Table 2-3

As discussed above, impact piling is proposed approximately 600m from the low tide line at the eastern end of Māngere Inlet. All zones of influence associated with this bridge are within the intertidal zone. The intertidal zone consists of shallow mudflats with low risk of noise effects.

Piling required to establish the coastal boardwalk along Sector 2 may result in a risk of potential permanent threshold shift in mid-frequency (MF) cetaceans (dolphins and whales) in the event that these animals are located within a distance of 21 to 113 metres of piling activity (distance will vary depending on the final pile type used by the contractor).

8.2.1 Policy (2)(a)

There is no New Zealand guidance on underwater noise effects. However, the US Department of Commerce National Oceanic and Atmospheric Administration (NOAA) provides guidance for assessing the effects of anthropogenic (human-made) sound on marine mammals. It identifies the received levels above which individual marine mammals are predicted to experience changes in hearing sensitivity, either temporary or permanent. Permanent Threshold Shift (PTS) is the permanent loss of hearing caused by some kind of acoustic or trauma. NOAA provides dual PTS onset thresholds for mid-frequency (MF) cetaceans using 'peak' and 'SEL_{cum}' assessment descriptors. The unweighted peak instantaneous pressure level is recorded during the measurement period, whereas SEL_{cum} is the M-weighted sound exposure level over a 24-hour period.

Dr Sharon De Luca is the Project ecologist from Boffa Miskell. Ms De Luca has been consulted on the relevant 'species of interest' in the area. In summary:

- The Manukau Harbour is occasionally frequented by common dolphins and orca. However, they are unlikely to venture east of the Onehunga Wharf into the Māngere Inlet. The Māngere Inlet is not a notable feeding, breeding or rearing site for marine mammals, and not a migration path;
- The Māngere Inlet is not a dedicated habitat for a specific fish species of interest.

The identified species of potential interest in the unlikely event that they venture into the Māngere Inlet are common dolphins and orca. These are both classified as MF cetaceans for the purposes of underwater noise sensitivity, with a functional hearing range of 150 Hz to 160 kHz. The NOAA PTS onset thresholds for MF cetaceans are summarised as follows:

- Impulsive sources (e.g. impact piling): 230 dB re 1 µPa peak, and 187 dB re 1 µPa²/s SEL_{cum};
- Non-impulsive sources (e.g. vibro piling): 230 dB re 1 µPa peak, and 199 dB re 1 µPa²/s SEL_{cum}.

The term 'effective quiet' has been defined in the NOAA guidelines as the "maximum sound pressure level that will fail to produce any significant threshold shift in hearing despite duration of exposure and amount of accumulation". It is essentially a 'safe exposure level' in terms of hearing loss. NOAA has not defined a single level for 'effective quiet', but indicates it might be around 154 dB re 1 µPa µPa²/s SEL for marine mammals.

In summary, the following performance standards are recommended:

- PTS onset threshold: 230 dB re 1 µPa peak and 187 dB re 1 µPa²/s SEL_{cum};
- Effective quiet: 154 dB re 1 µPa²/s SEL.

Overall, the presence of marine fauna of interest is unlikely in the area of piling.

8.2.2 Policies (2)(b) and (d)

Given that the Māngere Inlet is not a notable feeding, breeding or rearing site for cetaceans, the underwater noise effects from piling activities are considered unlikely to occur and any risk of effects to be manageable. Specific measures that may be included in the CNVMP to reduce or control the effects of underwater noise include soft starts (gradually increasing the intensity of impact piling) and minimising duty cycle.

Implementing mitigation procedures, such as visual or passive acoustic monitoring of marine mammals and low power or shut down procedures may be required where there is a known risk that MF cetaceans are within the zones of influence for the specific piling type as set out in Table 8-2: Zones of Influence. Such measures should be prepared as part of a site specific noise management schedule.

8.3 Dredging (Policy (3)(b))

Dredging is required to be conducted as part of the Project. The proposed dredging works do not include blasting, impact piling, vibratory piling and/or marine seismic surveys. Therefore, this work is considered consistent with the objectives and policies of the PAUP and further assessment is not required. It is noted that all forms of dredging would be similar to the noise level from the barge operating without the dredging activities.

9 Construction Noise and Vibration Management

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

9.1 Noise management methodology

The most effective way to control construction noise is through good on-site management and communication between managers and other staff. Specific noise or vibration management schedules are a useful tool in determining how the noise effects from each stage of the works will be managed and potentially affected parties communicated with. Construction noise management plan examples and guidance are contained in <https://acoustics.nzta.govt.nz/management-plans>. These draft management plans will generally include information set out in NZS 6803:1999 in Section 8 and Annex E.2 such as:

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

It is recommended that a CNVMP be prepared and implemented for the overall Project. The construction methodology has not been finalised at this stage, therefore, a CNVMP would be prepared once a contractor has been appointed and the construction methodology and equipment is known. For noise management which is specific to a site or activity, schedules will be attached to the CNVMP that discuss specific actions to avoid, remedy or mitigate noise or vibration levels. The schedules would be prepared prior to works that may result in exceedance of the acoustic criteria, and will be appended to the CNVMP in addition of the general management and mitigation within the main CNVMP.

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

9.2 General mitigation measures

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

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

More discussion regarding the management of construction noise is published at: <http://nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/noise-and-vibration/construction-and-maintenance-noise/>

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

- Training of personnel with regard to quiet and low vibration operating procedures shall be given;

- Maintenance of equipment to ensure noise and vibration levels remain as low as practicable;
- Noise barriers, temporary or otherwise, are considered where necessary. Where operational noise barriers are proposed, these should be implemented at the start of the construction period to reduce construction noise effects as far as practicable;
- Enclosures of noisy stationary equipment should be implemented if necessary and where practicable;
- Low noise and vibration plant should be selected wherever practicable. Noisy plant shall have noise mitigation measures (such as silencers or enclosures) fitted. Where practicable, plant that generates low levels of vibration will be used in preference to vibration intensive plant (e.g. using auger piling methods rather than vibropiling where ground conditions permit);
- Selection of a blast design that ensures that Project overpressure and ground-borne vibration criteria are complied with;
- Management of piling noise within the foreshore zone with regard to potential effects on marine mammals / cetaceans.
- Night time operation should only occur when Project criteria can be complied with or where all practicable measures have been implemented to reduce noise emissions as per the CNVMP;
- Tonal reversing alarms shall be deactivated or replaced with a suitable alternative such as a visual or broadband alarm if required for night time works. This approach has been successfully implemented on a number of Transport Agency projects;
- Temporary resident relocation where all practicable noise mitigation measures have been implemented and noise levels are predicted to exceed the Project criteria. Such a measure shall be considered generally as a last resort;
- Public liaison and communication to ensure potentially affected dwellings are reasonably informed. A contractor environmental manager or appointed representative shall be available for residents to contact. Guidance contained in <http://nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/noise-and-vibration/construction-and-maintenance-noise/> will be referred to where relevant; and
- Noise barrier screening and appropriate management of temporary construction yard compounds.

9.3 Vibration management and mitigation

Typical measures for mitigating and managing construction vibration effects include:

- Liaison with affected parties;
- Monitoring of building condition prior to and after construction and in response to complaints;
- Fixing any damage to buildings that occurred due to construction works;
- Monitoring of vibration levels received by buildings during the first use of high-vibration activities in their vicinity and in response to complaints; and
- Using low-vibration techniques and managing the timing of activities where practicable to avoid disturbance.

Detailed management and mitigation options for Project construction vibration will be contained in the CNVMP. Additional vibration monitoring and follow-up building condition surveys should be undertaken in response to complaints, to ensure the Project construction activities comply with the Category B criteria and that no building damage has occurred. If any construction-induced damage were shown to have occurred as a result of Project construction activities, this will be required to be remedied in full.

10 Conclusion

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

A risk assessment of construction vibration and noise effects has been performed for the Project. This has shown that there is a medium to high level of risk that vibration guidelines will be exceeded for buildings adjacent to the Project. This is because buildings are located within 20m from the site works and in some instances within 10m of earthworks and retaining walls. At such distances, vibration levels from some activities may be above 5mm/s (which is the Project criterion to avoid building damage). In addition to this, vibration is likely to result in human discomfort at a still greater number of dwellings.

Due to the close proximity of dwellings and businesses to the works, there are many locations where there is potential for daytime and night time Project noise criteria to be exceeded. Due to the practical and safety constraints of the Project, night time construction will be required in some locations. Where possible, night time works will be minimised in areas where residential dwellings are in close proximity such as on State highway 1. Where these night works cannot be avoided, site specific noise management will be required for night time construction activities.

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

Noise and vibration management procedures will be detailed in the CNVMP for the Project, and the noise and/or vibration management schedules with specific responses where noise and vibration criteria are likely to be approached or exceeded. Noise and vibration monitoring is an essential part of ensuring construction activities comply with the Project criteria. Successful management of noise and vibration effects from construction activities will rely heavily on good procedures and awareness of the noise and vibration effects of different construction machinery

Overall, while the Project construction will likely result in temporary disturbance to nearby residents and businesses, it can be constructed in such a way that any adverse construction noise and vibration effects are either mitigated or specifically managed to reduce effects as far as practicable.

Appendix A

Sound Power Level of East West Link Construction Activities

TECHNICAL REPORT 8 – CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

Activity	Plant type	Sound power level (dB L _{WA})
Earthworks, cuts and fills	Dump truck	106
	Hydraulic excavator	113
	Bulldozer	114
	Compactor	112
	Grader	110
	Water truck	105
Bridge foundations (piling)	Rotary bored piling rig	111
	Concrete trucks	107
Concrete foundations and structures	Crane	106
	Concrete pump	100
	Vibratory pokers	114
	Concrete trucks	107
Precast bridge construction, lifting, etc	Straddle Carrier	102
	Low Loader	107
	Launching Gantry	85
	Crane	106
	Hydraulics	107
	Concrete pump	102
	Concrete vibrators	115
	Segment carrier	100
	On road trucks	100
	Concrete trucks	107
Retaining Wall Construction (MSA and L-shaped walls)	Concrete trucks	107
	Crane	106
	On road trucks	100
Retaining Wall Construction (Drilled rock anchor walls)	Drilling rig	120
	Concrete trucks	107
	Crane	106
	On road trucks	100
Rammed Pile Walls or Vibropiled Walls	Vibration piling rig	120
	Rammed pile rig	120
	Rotary Piling Rig	111
	Concrete trucks	107
	Crane	106
	On road trucks	100
Pavement preparation	Grader	110
	Dozer	114
	Vibratory roller	108
	Water trucks	105
Surfacing	Paver	113
	Road rollers	106
	Asphalt delivery trucks	108
Yard activities	Vehicle movements	102
	Material handling	105
	Administration area	50
	Workshop	80

Appendix B

**Regional Coastal Plan and Proposed Auckland
Unitary Plan Rules – Excerpts**

Coastal Marine Area (Auckland Regional Coastal Plan)

Rule 35.5.5

- a. Construction noise of less than 15 days duration shall not exceed the following levels when measured 1 metre from the façade of any occupied or inhabited adjacent building, for any 30 minute period in accordance with Section 3.2.1 of NZS 6803P: 1984:

	L ₁₀	L _{max}
Monday to Friday 6:30am to 10:30pm	80 dBA	90 dBA
Saturday 7.00am to 11.00pm	85 dBA	90 dBA
Sunday 9.00am to 7.00pm	80 dBA	90 dBA
At all other times (night time)	60 dBA	75 dBA
At all other times (night time in any area where an operative District Plan provides for residential activity as the principal activity)	55 dBA	75 dBA

- b. Construction noise of 15 days or more in duration shall not exceed the following levels when measured 1 metre from the façade of any occupied or inhabited adjacent building, for any 30 minute period in accordance with Section 3.2.1 of NZS 6803P: 1984:

	L ₁₀	L _{max}
Monday to Friday 6:30am to 10:30pm	75 dBA	90 dBA
Saturday 7.00am to 11.00pm	80 dBA	90 dBA
Sunday 9.00am to 7.00pm	65 dBA	85 dBA
At all other times (night time)	60 dBA	75 dBA
At all other times (night time in any area where an operative District Plan provides for residential activity as the principal activity)	55 dBA	75 dBA

- c. In situations where measurements cannot be made outside affected buildings, measurements shall be taken inside the affected building in accordance with Section 3.2.2 of NZS 6803P: 1984 either in the affected habitable space (as defined by the NZ Building Code) or in the principal place of work. Noise levels measured within the building shall be 10 dBA or more below those in tables in Rule 35.5.5a and 35.5.5b above.

Proposed Auckland Unitary Plan – Decisions Version 19 August 2016

E25 Noise and Vibration

E25.6.1 General Standards

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

Construction noise

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

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

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

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

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

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

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

- (3) For a project involving a total duration of construction work that is less than 15 calendar days, the noise levels in Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.27.2 Construction noise levels for noise affecting any other activity above may be increased by 5dB in all cases.
- (4) For a project involving a total duration of construction work that is more than 20 weeks the noise limits in Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.27.2 Construction noise levels for noise affecting any other activity above may be decreased by 5dB in all cases.

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

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

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

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

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

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

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

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

- (1) Noise from any construction, maintenance and demolition activities in the road must meet the relevant noise levels in the following relevant table:
 - (a) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

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

At any one receiver is 3 nights or less; and
 - (b) The works cannot practicably be carried out during the day or because the road controlling authority requires this work to be done at night time; or
 - (c) Because of the nature of the works the noise produced cannot be practicably be made to comply with the relevant noise levels of the following tables:
 - (i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or
 - (iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (d) For planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council five days prior to work commencing; or Auckland Unitary Plan Independent Hearings Panel Recommendation Version 22 July 2016 26 E25 Noise and vibration;

- (e) For minor planned works a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5) below.
- (3) The noise levels specified in Standard E25.6.29(1) above do not apply to unplanned repair or maintenance works or planned works in the road between the hours of 7am and 10pm where:
- (a) The number of days where the noise generated by the works exceeds the relevant noise levels in the following tables:
 - (i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or
 - (iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; at any one receiver is 10 or less; or
 - (b) Because of the nature of the works and the proximity of receivers the noise generated cannot practicably made to comply with the relevant noise levels of the following tables:
 - (i) Table E25.6.27.1 Construction noise limits for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (ii) Table E25.6.27.2 Construction noise limits for noise affecting any other activity; or
 - (iii) Table E25.6.28.1 Construction noise limits for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (iv) Table E25.6.28.2 Construction noise limits for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (c) For planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council five days prior to work commencing; or
 - (d) For planned works where the works will take more than 8 hours to complete a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5) below.
- (4) The noise levels specified in Standard E25.6.29(1) do not apply to road rehabilitation works that comprise the substantial removal and replacement of the road structural base and pavement in the road where:
- (a) The number of nights where the noise generated by the works exceeds the relevant noise levels in the following tables:

- (i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
- (ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or
- (iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
- (iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone;

At any one receiver is 20 days or less; and

- (b) Milling, concrete cutting, percussive demolition are completed by 10.30pm; and
 - (c) The works cannot practicably be carried out during the day or because the road controlling authority requires this work to be done at night time; and
 - (d) Because of the nature of the works the noise produced cannot be practicably be made to comply with the relevant noise levels of the following tables:
 - (i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or
 - (iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; and
 - (e) A copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council five days prior to work commencing; and
 - (f) A construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5) below.
- (5) A construction noise and vibration management plan must be prepared by a suitably qualified and experienced person and include the following:
- (a) Details of the community consultation to be undertaken to advise the occupiers of properties located within 100m of the proposed works of all of the following:
 - (i) The area affected by the work;
 - (ii) Why the work is required to be undertaken at night (where relevant);
 - (iii) The times and days when the noise and vibration is likely to be generated;

- (iv) A contact name and number of the works supervisor who can be contacted if any issues arise; and
- (v) How noise and vibration complaints will be managed and responded to;
- (b) A description of the works and its duration, anticipated equipment to be used and the processes to be undertaken; and
- (c) Identification of the best practicable options that will be undertaken to mitigate and minimise any noise being produced that is likely to exceed the relevant levels of the following tables:
 - (i) Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or
 - (iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or
 - (iv) Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone.
- (6) For the purpose of Standards E25.6.29(1) to E25.6.29(4) above:
 - (a) Planned work means work that has been planned to take place at least seven days before the work commences; and
 - (b) The measurement and assessment of all construction noise must be in accordance with New Zealand Standard NZS 6803:1999 Acoustics – Construction noise.

Vibration

E25.6.30. Vibration

- (1) Construction and demolition activities must be controlled to ensure any resulting vibration does not exceed:
 - (a) The limits set out in German Industrial Standard DIN 4150-3 (1999): Structural vibration – Part 3 Effects of vibration on structures when measured in accordance with that Standard on any structure not on the same site; and
 - (b) The limits in Table E25.6.30.1 Vibration limits in buildings in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500mm of ground level at the foundation of a single storey building.

Table E25.6.30.1 Vibration limits in buildings

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

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

- (i) All occupied buildings within 50m of the extent of the works generating vibration are advised in writing no less than three days prior to the vibration-generating works commencing; and
 - (ii) The written advice must include details of the location of the works, the duration of the works, a phone number for complaints and the name of the site manager.
- (2) Permanently installed stationary vibrating, reciprocating and rotating machinery and all piping, ducting and other equipment attached to such machinery must be installed and maintained so that any resulting vibration does not exceed the limits of Table E25.6.30.2 Vibration levels for stationary machinery when measured in any occupied room of any building on another site or in any occupied unit under different ownership from the source of the vibration. Vibration must be measured in accordance with ISO 2631-2:2003 Mechanical vibration and shock – Evaluation of human exposure to whole body vibration – Part 2: Vibration in buildings (1Hz to 80Hz):

Table E25.6.30.2 Vibration levels for stationary machinery

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

Blasting

E25.6.31. Noise levels for blasting

- (1) The noise created by the use of explosives for any blasting activity measured at the boundary of the site on which the explosives are used must not exceed a peak sound pressure of 120 dB (Lzpeak).
- (2) The noise created by the use of explosives for construction activities must not exceed a peak sound pressure level of 120dBC measured 1m from the façade of any occupied building.

Appendix C

The NZ Transport Agency Guide Vibration Criteria

Criteria

On the basis of the standards discussed above, the criteria in table 2.3 can be used to manage the effects of construction vibration and airblast²³. These are structured as part of a process whereby construction should be managed to comply with the Category A criteria. If measured or predicted vibration and airblast levels exceed the Category A criteria then a suitably qualified expert should be engaged to assess and manage construction vibration and airblast to comply with the Category A criteria as far as practicable (see figure 2.5). If the construction vibration exceeds the Category B criteria then construction activity shall only proceed if there is appropriate monitoring of vibration levels and effects on those buildings at risk of exceeding the Category B criteria, by suitably qualified experts.

TABLE 2.3 | Construction vibration criteria

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

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

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

Additional criteria should be used in the case of historic, vibration-sensitive or multi-storey buildings. Advice on such buildings is given in BS 5228-2⁰⁷ and DIN 4150-3¹⁸. Similarly, if there is history of foundation settlement, then expert geotechnical advice should be sought regarding specific vibration criteria.

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

Appendix D

Noise Level Survey Results – Diurnal Variation

Logger Measurements



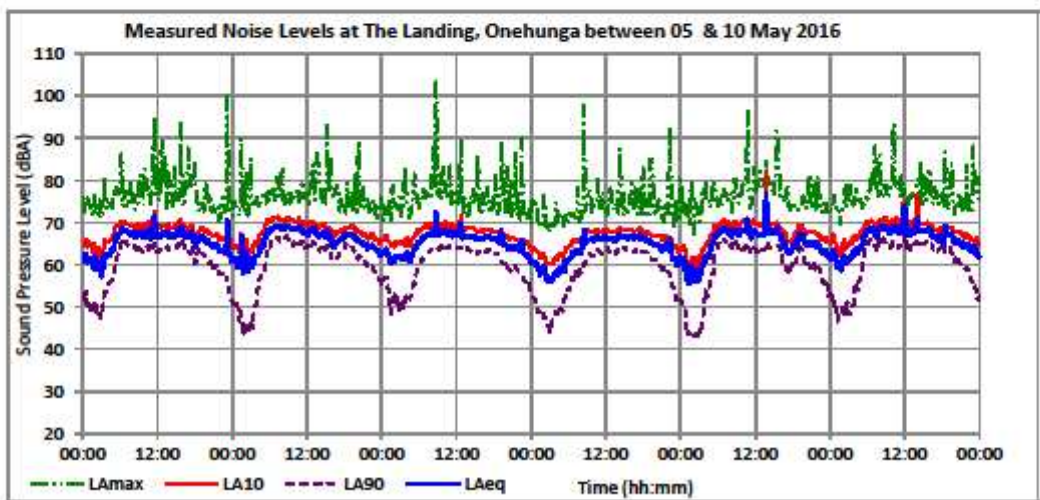
Date: Thursday, 26 May 2016
 File name: J:\JOBS\2016\2016010A\03 Survey Data & Measurements\[EWL - Onehunga Harbour Road Landing.xlsx]Logger_Summary
 Job number: 2016010A
 Job name: East West Link
 Initials: SW
 Measurement Dates: Thursday, 05 May 2016 to Tuesday, 10 May 2016
 Weather during: No adjustment due to adverse weather was necessary
 Measurement:
 Notes: The Landing, Onehunga

OVERVIEW SUMMARY SHEET

Noise Level, dB		L _{Aeq}	L _{A10}	L _{A90}	L _{Amax}
Day (0700-1800)	Lowest	63	65	56	70
	Average	68	70	64	78
	Highest	77	82	69	103
Evening (1800-2200)	Lowest	64	66	58	70
	Average	66	68	61	76
	Highest	69	70	65	89
Night (2200-0700)	Lowest	56	58	42	67
	Average	63	66	54	75
	Highest	71	71	66	100



L_{Aeq} 24-hr 66 dB



Logger Measurements

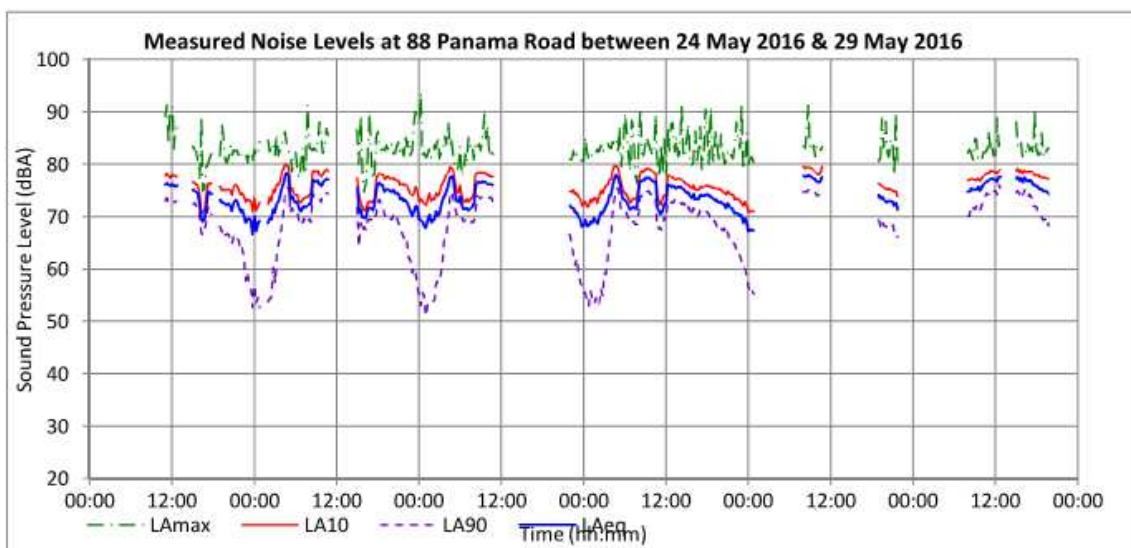
Date: Friday, 24 June, 2016
 File name: J:\JOBS\2016\2016010A\03 Survey Data & Measurements\[EWL - 88 Panama Road 24-29 May 2016
 Logger Summary.xlsx]Logger_Summary
 Job number: 2016010A
 Job name: East West Link
 Initials: BL
 Measurement Dates: Tuesday, 24 May 2016 to Sunday, 29 May 2016
 Weather during: Adjustment for adverse weather condition - relevant survey periods excluded
 Measurement:
 Notes: Measurements effected by Wind (≥ 5 m/s) and Rain (≥ 6 mm/h) have been excluded

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A95}	
Day (0700-1800)	Lowest	69	70	64	75
	Average	76	77	72	84
	Highest	78	80	76	91
Evening (1800-2200)	Lowest	71	74	65	78
	Average	74	76	68	69
	Highest	77	78	73	91
Night (2200-0700)	Lowest	67	71	51	77
	Average	72	74	62	55
	Highest	78	80	76	94



L_{Aeq} 24-hr 75 dB



Logger Measurements

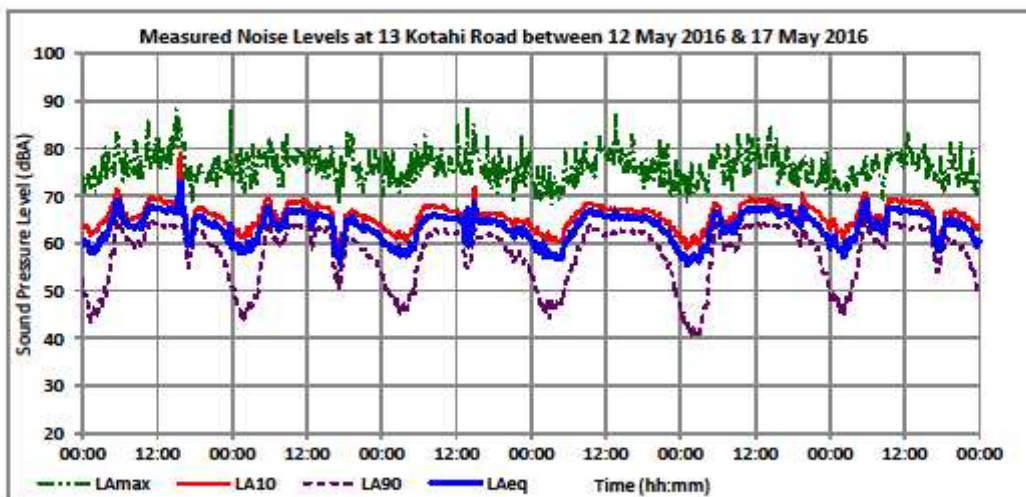
Date: Thursday, 26 May 2016
 File name: J:\JOBS\2016\2016010A\03 Survey Data & Measurements\{EWL - 13 Kotahi Road Logger Summary.xlsx\Logger_Summary
 Job number: 2016010A
 Job name: East West Link
 Initials: SW
 Measurement Dates: Thursday, 12 May 2016 to Tuesday, 17 May 2016
 Weather during: No adjustment due to adverse weather was necessary
 Measurement:
 Notes: 13 Kotahi Road, Mt Wellington

OVERVIEW SUMMARY SHEET

Noise Level, dB		L _{Aeq}	L _{A10}	L _{A90}	L _{Amax}
Day (0700-1800)	Lowest	56	59	50	68
	Average	66	68	62	77
	Highest	73	79	65	89
Evening (1800-2200)	Lowest	61	62	56	69
	Average	64	66	60	75
	Highest	68	71	63	84
Night (2200-0700)	Lowest	55	59	41	68
	Average	62	65	52	75
	Highest	69	71	66	88



L_{Aeq 24-hr} 65 dB



Logger Measurements

Date: Thursday, 19 May 2016
 File name: J:\JOBS\2016\2016010A\03 Survey Data & Measurements\[Sp 002 2016010A BL EWL - 24 Frank Grey Place (AMA Yard).xlsx]Logger_Summary
 Job number: 2016010A
 Job name: East West Link
 Initials: BL
 Measurement Dates: Friday, 13 May 2016 to Tuesday, 17 May 2016
 Weather during: No adjustment due to adverse weather was necessary
 Measurement:
 Notes: 24 Frank Grey Place

OVERVIEW SUMMARY SHEET

Noise Level, dB		L _{Aeq}	L _{A10}	L _{A95}	L _{Amax}
Day (0700-1800)	Lowest	61	64	54	72
	Average	68	70	63	79
	Highest	72	74	68	93
Evening (1800-2200)	Lowest	62	65	55	70
	Average	66	68	59	76
	Highest	70	72	65	85
Night (2200-0700)	Lowest	57	61	44	69
	Average	64	66	52	76
	Highest	71	74	67	86



L_{Aeq} 24-hr 66 dB

