

## Additional Waitemata Harbour Crossing



## Noise and Vibration Assessment





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## 1. Introduction

The Additional Waitemata Harbour Crossing (AWHC) Project (the Project) progresses the outcomes of previous studies undertaken which have examined the nature and form of an additional transport crossing of Auckland's Waitemata Harbour. These studies have been undertaken in recognition of the contribution of an additional crossing to improving the accessibility and resilience of Auckland's transport network in a manner that will facilitate the predicted future growth of the Auckland Region.

In order to develop a business case for an AWHC the Project has been split into three separate, concurrent workstreams. PriceWaterhouseCoopers (PWC) and the New Zealand Institute of Economic Research (NZIER) are contracted to deliver economic advisory services, develop funding options and develop the overall Business Case; Sinclair Knight Merz (SKM) and Flow Transportation Specialists (Flow) are undertaking transport and toll modelling; and Beca and AECOM are providing engineering and planning services.

The Engineering and Planning Services workstream involves a number of phases including:

- Phase 1: Confirming objectives, principles, constraints and requirements.
- Phase 2: Rapid narrowing of a long list of options to a short list of a bridge and tunnel options, defined for further detailed assessment.
- Phase 3: Targeted design and assessment of up to three options to consider the relative merits of each option in terms of consentability or consenting risk, constructability and operational functionality.
- Phase 4: Design and assessment of up to three options to understand the cost, effects, risks and benefits of each option as an input to the Business Case to recommend a preferred option.

This report has been prepared at the end of Phase 3 of the Engineering and Planning Services workstream. It provides an assessment of the relative merits of each shortlisted option in terms of noise and vibration and identifies areas of consenting risk. Ultimately, the work undertaken in this project will determine whether an additional harbour crossing should be "under the water" (tunnel), "over the water" (bridge) or a combination of both.

This report addresses the issue of noise and vibration for both the construction and operation of the two options under consideration.



## 2. Previous Studies

The existing studies that have informed this report are discussed below.

### 2.1 1988 Waitemata Harbour Crossing Study

This study, prepared by the Ministry of Works and Development, Maunsell and Parsons Brinkerhoff Joint Venture, considered a range of alternative options for an additional crossing of the Waitemata Harbour. It recommended that priority be given to increasing the capacity of the Auckland Harbour Bridge (AHB).

### 2.2 1997 Waitemata Harbour Crossing Study

This study, prepared by Opus International Consultants Limited, built on the 1988 study, identifying a range of road and public transport options for an additional crossing of the Waitemata Harbour. A crossing design in the vicinity of the existing AHB was recommended.

### 2.3 2002 Construction Feasibility Study

This study, prepared by Opus International Consultants Limited, in association with COWI (Denmark), ARUP (Hong Kong, Sydney and Melbourne) and Golder Associates (Christchurch, New Zealand), considered in detail eight alternative crossing alignments. A new bridge 500 metres west of AHB and an immersed tube tunnel across the harbour to Wynyard Wharf were identified as options for further investigation.

### 2.4 2007 Screening of Possible Options

This study prepared by Richard Paling Consulting Limited considered eight options identified by the 1997 and 2002 studies. A tunnel from Esmonde Road to the Western Reclamation was recommended as the preferred option.

### 2.5 2008 Additional Waitemata Harbour Crossing Study

This study, prepared by Sinclair Knight Merz, Connell Wagner and Zomac Planning, considered options for both rail and road crossings of the Waitemata Harbour in two phases. A long list of 159 crossing options was developed in Phase 1. Phase 2 involved a detailed investigation of three of the identified options. The study recommended a harbour crossing west of Wynyard Quarter, comprising two driven tunnels of three lanes each for road traffic, and two single track rail tunnels.



## 2.6 2010 Additional Waitemata Harbour Crossing Study

In 2010 NZTA and KiwiRail submitted a number of Notices of Requirement (NoR) to seek designations within both Auckland City and North Shore City District Plans for the protection of land to allow the construction of both a driven twin tunnel road crossing and a driven twin tunnel rail crossing. The documentation included an Assessment of Environmental Effects and a number of Specialist Technical Reports.

## 3. Existing Environment

The study area for the project extends from the State Highway (SH) 1 Esmonde Road interchange on the North Shore to the locality of the Cook St/ Wellington St interchanges on SH 1, and the SH 16 links in Auckland City (i.e. the Central Motorway Junction (CMJ)). The indicative extent of this study area is shown in Figure 3.1.

For the purpose of this Project the study area is divided into a Northern Sector, Central Sector and Southern Sector as follows:

**Northern Sector:** located on the North Shore, extending from the SH1 / Esmonde Road interchange in the north to Stokes Point / Northcote Point in the south;

**Central Sector:** encompasses the Waitemata Harbour, extending from the end of Northcote Point, on the North Shore to the coastal edge of Auckland City between Point Erin and Wynyard Quarter; and

**Southern Sector:** encompasses the areas above Mean High Water Springs (MHWS) extending from Westhaven Drive and Wynyard Quarter in the north to the locality of the CMJ in Auckland City.

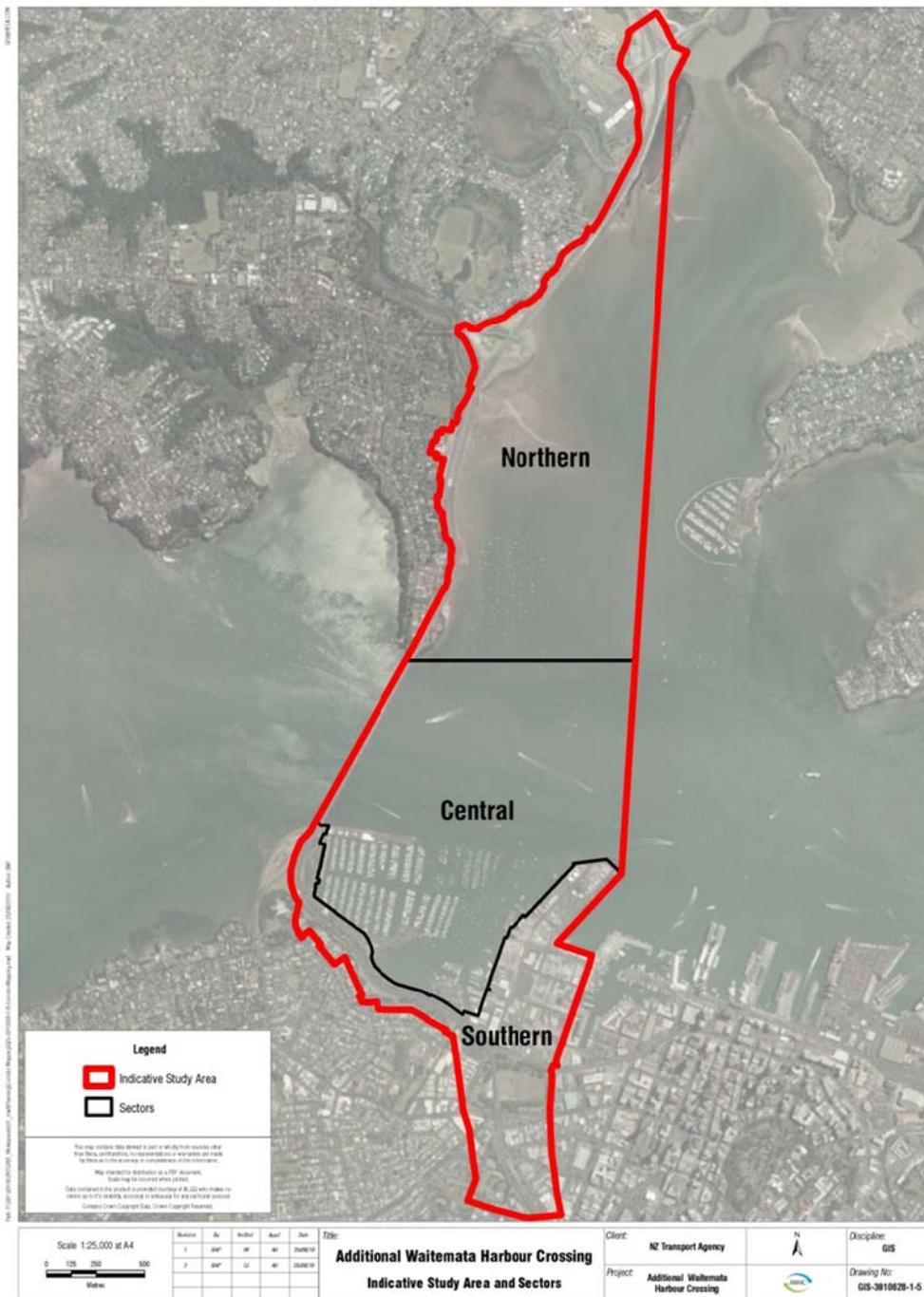


Figure 3.1: Indicative Extent of Study Area



### 3.1 Northern Sector

The connection point of the proposed Harbour Crossing into the existing Esmonde Road Interchange and Akoranga Busway Station is of varying use and zoning. The north-eastern quadrant immediately adjacent the Akoranga Busway Station is zoned Recreation and is predominantly open space with some unused marshland, and with commercial properties on the eastern edge. East and south-east is the Shoal Bay, consisting of tidal flats.

To the west of the Esmonde Road Interchange is a mixture of educational and business zoning. The Auckland University of Technology's Akoranga Campus lies between the SH1 motorway and Akoranga Drive, on the north side of the interchange; commercial properties are located adjacent to the motorway to the south of Akoranga Drive. Further to the west is a residential cluster on Akoranga Drive.

Existing ambient noise levels in this area are high, dominated by traffic noise from Akoranga Drive, the SH1 motorway (approximately 50,000 vehicles per day southbound, 48,000 northbound), and to a lesser extent (though still significant) from Esmonde Road (approximately 46,000 vehicles joining/leaving SH1).

Between Akoranga Drive and Stokes Point / Northcote Point, the area to the east of SH1 is open water (Shoal Bay). To the west of the motorway is predominantly residential, interspersed with some small pockets of reserve parkland. Existing ambient noise levels are again dominated by the existing motorway, which carries in the order of 135,000 vehicles per day along that section. Due to the local topography between the motorway and the residences, most residences adjacent this section of motorway will have direct line-of-sight to the motorway.

### 3.2 Central Sector

The AHB dominates the existing noise environment for the harbour crossing, carrying in the order of 158,000 vehicles per day. While there are no specific receivers under the bridge, the acoustic amenity of recreational users of Waitemata Harbour, and of local birdlife, may be considered.

Where the Harbour Bridge makes landfall on Point Erin, the land use is predominantly recreational – largely passive recreation on Point Erin, and a mix of commercial and active recreational uses to the east of the motorway, including the Westhaven Marina and the facilities which support and service the marina.

The marina and its coastal reserve extend along the north and north-east of the motorway, as it passes along the edge of St Mary's Bay. To the south and south east of this section of motorway is predominantly residential, with a strip of land at the base of the hill which is passive recreational parkland.

Existing ambient noise levels are again high and are dominated by the motorway, which carries in the order of 141,000 vehicles per day along that section, with the remainder leaving the motorway at Shelly Beach Road. Due to the local topography between the motorway and the residences, almost all residences adjacent this section of motorway will have direct line-of-sight to the motorway.



The “clanking” of lines on masts within Westhaven Marina also contributes to the background noise levels within the marina area itself.

### 3.3 Southern Sector

As the motorway turns south, away from the harbour, the existing nature and use of the adjoining properties to the Project change again. To the north of Fanshawe Street and Westhaven Drive, the largely commercial area of Wynyard Quarter extends back out into the harbour. Existing ambient noise at the properties on the western side of the Wynyard Quarter, facing St Mary’s Bay, is still dominated by the existing motorway, with the acoustically reflective surface of the water within the marina providing little mitigation of traffic noise from the motorway and the existing harbour bridge.

Those properties adjacent Fanshawe Street have an ambient noise environment influenced by both the motorway, which at that point is on an elevated viaduct structure veering away from the area, and the traffic on Fanshawe Street itself, which carries in the order of 36,000 vehicles per day.

The remainder of the Wynyard Quarter area has a different ambient noise character entirely. The noise from the motorway is generally still audible, but the acoustic shielding provided by the buildings on the western and southern edges of the area means that the street-level noise is considerably lower than for the areas directly adjacent to the existing motorway. The noise environment is controlled by local activities such as traffic on Beaumont, Gaunt, Halsey and Jellicoe Streets, and the general commercial activities going on in the area including the fish markets and the various retail outlets and marine-related commercial premises.

Victoria Park lies directly beneath, and extends to the east and west of, the existing motorway viaduct. Being surrounded by the busy city streets of Victoria, Beaumont, Fanshawe and Halsey Streets, noise levels at locations across the recreational area are largely controlled by vehicles on the nearest road, with the motorway audible and significant but not necessarily dominant.

The area west of Beaumont street is of mixed use – commercial, residential, and religious (Victory Christian Church). The existing noise environment at the church is dominated by the motorway, and is presently influenced by the construction of the Victoria Park Tunnel (VPT). The residential enclave accessed from Fisher Point Drive is still influenced by traffic noise from the motorway, however the enclave is relatively quiet due to the arrangement of the residential spaces about a central access and open living space.

South of Victoria Street West, the project area to the west of the motorway becomes increasingly residential in nature, and ambient noise levels fall and become more residential in character. This is partly due to the existing topography and large commercial buildings providing some shielding from the existing motorway. To the east of the motorway, the land use becomes increasing commercial in nature, and has higher density buildings, thereby reducing the influence of the traffic noise from the motorway. Residential uses are generally high density apartment blocks, and there is little open recreational space, with the result that local noise levels are generally controlled by traffic on the city roads.

## 4. Shortlisted Options Description

### 4.1 Tunnel Option

The shortlisted tunnel option is an all-tunnel option for road and rail. The alignment generally accords with the 2010 Notice of Requirement (NoR) Concept Design. The road tunnels connect to the existing motorway network in the vicinity of Onewa Road interchange in the north and the Central Motorway Junction (CMJ) in the south. The rail tunnels connect to Akoranga Busway Station in the north and the proposed Gaunt Street underground station in the south.

#### 4.1.1 Northern Sector

The tunnel option requires reclamation through Shoal Bay to accommodate road and rail. The road mainline is at grade through northern sector, descending into a trench and cut and cover tunnel before entering a bored tunnel in the vicinity of Northcote point. Rail will be elevated on bridge structure from Esmonde Road to the vicinity of the City of Cork beach, where it descends into a trench and cut and cover tunnel sections before entering a bored tunnel in the vicinity of Onewa Road interchange.

The road mainline accesses the North Shore via interchanges at Onewa and Esmonde Roads.

#### 4.1.2 Central Sector

The tunnel option consists of two bored tunnels for road (three lanes in each tunnel) and two bored tunnels for rail (one track in each tunnel) through the central sector. The outside diameter (OD) of the road tunnels is 15.5 metres and rail tunnels have an OD of 6.9 metres. Road and rail tunnels will be some 50 metres below sea level across the harbour.

The existing AHB will be retained and used for general traffic, pedestrians, cyclists and bus public transport.

#### 4.1.3 Southern Sector

The bored road tunnels emerge in Victoria Park and continue south in cut and cover tunnel and trench to the CMJ. Rail tunnels continue as a bored tunnel through Wynyard Quarter and are 30 metres below ground level at Gaunt Street train station.

The south connections are to SH16 / Ports and the motorway south of Cook Street. Cook Street off ramp from AHB is a three lane cut and cover tunnel over the top of the road mainline bored tunnels. Cook Street on ramp to AHB is a two lane cut and cover tunnel beneath the road mainline trenches and joins VPT.

Cook Street ramps also provide for bus public transport.



## 4.2 Bridge Option

The shortlisted bridge option is a road bridge to the west of the NoR alignment and rail tunnels generally on the NoR alignment. The road bridge is three lanes each way and connects to the existing motorway network in the vicinity of Onewa Road Interchange in the north and the CMJ in the south. Two rail tunnels are bored (one track in each tunnel) and connect to Akoranga Busway Station in the north and Gaunt Street (underground station) in the south.

### 4.2.1 Northern Sector

The bridge option requires reclamation through Shoal Bay to accommodate road and rail. The road mainline is at grade through the northern sector. Rail will be elevated on bridge structure from Esmonde Road to the vicinity of the City of Cork beach, where it descends into a trench and cut and cover tunnel sections before entering a bored tunnel in the vicinity of Onewa Road interchange.

The road mainline accesses the North Shore via interchanges at Onewa and Esmonde Roads.

### 4.2.2 Central Sector

The bridge spans 2.8 kilometres in length with a maximum vertical gradient 5%. A clearance of 41 metres will be maintained over the navigation channel within the harbour and a clearance of 30 metres will be provided over the Westhaven Marina entrance. The rail tunnels have an OD of 6.9 metres and will be some 50 metres below sea level across the harbour.

The existing AHB will be retained and used for general traffic, pedestrians, cyclists and bus public transport.

### 4.2.3 Southern Sector

The bridge south approach is located in the vicinity of Z-Pier. The south bound connection to CMJ will be a new cut and cover tunnel east of VPT. Rail tunnels continue as a bored tunnel through Wynyard Quarter and are 30 metres below ground level at Gaunt Street station.

The south connections are to SH16 / Ports and the motorway south of Cook Street. Fanshawe Street off and on ramps will pass under the bridge at grade. Cook Street off ramp from AHB is at grade under the bridge and enters a cut and cover tunnel to Cook Street. Cook Street on ramp to AHB is a cut and cover tunnel. Wellington Street is a north bound on ramp to the mainline tunnel.

Cook Street ramps provide for bus public transport.

## 5. Environmental Noise and Vibration Goals

### 5.1 Construction

The design goals for construction noise and vibration associated with the AWHC Project are based on local (city/district level), NZ national and international Standards and guidelines.

#### 5.1.1 Airborne Noise

NZS 6803 (1999 version current at the time of this report) provides guidance in relation to the control of all demolition and construction noise (except emergency situations) in New Zealand, and is therefore applicable to the AWHC project.

The environmental noise criteria recommended by NZS 6803:1999 for works conducted in the vicinity of residential and commercial/industrial areas are summarised in the tables below:

**Table 5.1: Construction noise limits recommended by NZS 6803 for residential areas**

Time of Week	Time Period	Noise Limit – Typical Duration (dB)		Noise Limit – Short Term Duration (dB)		Noise Limit – Long-term Duration (dB)	
		L <sub>Aeq</sub>	L <sub>AFmax</sub>	L <sub>Aeq</sub>	L <sub>AFmax</sub>	L <sub>Aeq</sub>	L <sub>AFmax</sub>
Weekdays	0630 – 0730	60	75	65	75	55	75
	0730 – 1800	75	90	80	95	70	85
	1800 – 2000	70	85	75	90	65	80
	2000 – 0630	45	75	45	75	45	75
Saturdays	0630 – 0730	45	75	45	75	45	75
	0730 – 1800	75	90	80	95	70	85
	1800 – 2000	45	75	45	75	45	75
	2000 – 0630	45	75	45	75	45	75
Sundays and Public Holidays	0630 – 0730	45	75	45	75	45	75
	0730 – 1800	55	85	55	85	55	85
	1800 – 2000	45	75	45	75	45	75
	2000 – 0630	45	75	45	75	45	75

Table 5.2: Construction noise limits recommended by NZS 6803 for commercial and industrial areas

Time of Week	Time Period	Noise Limit – Typical Duration (dB)	Noise Limit – Short Term Duration (dB)	Noise Limit – Long-term Duration (dB)
		L <sub>Aeq</sub>	L <sub>Aeq</sub>	L <sub>Aeq</sub>
All days	0730 – 1800	75	80	70
	1800 – 0730*	80	85	75

\* The night-time limits for residential areas shall apply where commercial or industrial areas include residential activities that may be subject to sleep disturbance, including hospitals, hotels, hostels, and other accommodation facilities.

**Note:**

- 1) “Typical Duration” is defined as construction work at any one location for more than 14 calendar days but less than 20 weeks.
  - 2) “Short Term” is defined as construction work at any one location for up to 14 days.
  - 3) “Long Term” is defined as construction work at any one location with a duration exceeding 20 weeks.
- It is anticipated that the majority of the works associated with the Project will exceed a 20-week duration at any one location. Accordingly, the “Long Term” criteria are likely to be applicable to this project.

### 5.1.2 Regenerated Noise

Ground-borne vibration generated by piling, compacting and drilling enters buildings via the ground and building foundations. This can cause the floors, walls and ceilings to vibrate and to radiate noise. This noise is commonly referred to as structure- or ground-borne noise or regenerated noise. Ground-borne noise is low frequency and if audible is perceived as a ‘rumble’.

In general, ground-borne noise level values are relevant only where they are higher than the airborne noise from the construction activities such as surface rockbreaking. In general, regenerated noise levels will be masked by air-borne noise associated with the construction activities. This is not the case for tunnel boring.

The criteria for regenerated noise cannot be stipulated separately from the specifications for airborne background noise levels. The maximum allowable regenerated noise levels must sensibly relate to the background noise levels, although the two are not directly linked.

The criteria for regenerated noise are defined in terms of L<sub>Amax</sub> levels measured with a slow response time-integration (i.e. duration of 1 second). Maximum allowable sound levels, L<sub>Amax</sub> are not to exceed the background L<sub>eq</sub> criterion + 5 dB in sensitive areas such as Protected Premises and Facilities as defined in NZS 6806:2010 (refer to Section 5.2.1.4) and the background L<sub>eq</sub> criterion + 10 dB in general areas. The adopted background noise level criteria are based on information provided in AS/NZS 2107:2000 *Acoustics - Recommended design sound levels and reverberation times for building interiors*.

Average continuous  $L_{Aeq}$  noise levels are also to be considered in terms of the WHO guideline values identified in Section 5.2.1.1; namely 30 dB  $L_{Aeq}$  for bedrooms and 35  $L_{Aeq}$  for living spaces.

### 5.1.3 Tactile Vibration

In general the human response to vibration is found to be a complex phenomenon. There are wide variations in vibration tolerance of humans and accordingly acceptable goals for human comfort are hard to define and quantify. Acceptable values of human exposure to vibration are primarily dependent on the activity taking place in the occupied space (e.g. workshop, office, or residence) and the character of vibration (e.g. continuous or intermittent). In addition, specific values are dependent upon social and cultural factors, psychological attitudes, expected interference with privacy, and ultimately the individual's perceptibility.

Also the level at which humans generally perceive vibration is much lower than the level necessary to cause any structural or cosmetic damage to buildings. However, residents can become concerned about building damage even when the levels are not likely to cause building damage.

There is no New Zealand Standard which specifically addresses vibration, however the NZTA Environmental Plan suggests some standards against which the impact of tactile vibration might be assessed. These are the superseded ISO Standard 2631-2, Australian Standard AS 2670-2:1990 'Evaluation of Human Exposure to Whole-body Vibration- Continuous and shock-induced vibration in buildings (1 to 80 Hz)' and Norwegian Standard NS 8176E:2005 'Vibration and Shock : Measurement of vibration in buildings from land based transport and guidance to evaluation of its effects on human beings'.

Recent technical discussions suggest that tactile vibration may also be assessed against BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings - Part 1: Vibration sources other than blasting". The criteria given in the British Standard are considered to be less stringent than the Norwegian, ISO or Australian Standards.

BS 6472-1:2008 assesses the probability of adverse comment from vibration (by means of Vibration Dose Values (VDVs)) rather than assessing against specific proscriptive criteria for such a subjective effect. The VDV is much more strongly influenced by vibration magnitude than by duration. A doubling (or halving) in the vibration magnitude results in a sixteen fold decrease (or increase) in the exposure duration for a VDV with the same magnitude.

The probability of adverse comment from occupants exposed to a particular level of vibration is given in

Table 5.3.

BS 6472-1:2008 acknowledges that there is widely-differing susceptibility to vibration in the community and accordingly, ranges rather than discrete values are provided.

**Table 5.3: Vibration dose value ranges which might result in various probabilities of adverse comment within residential buildings**

Place and time	Low probability of adverse comment (VDV, ms <sup>-1.75</sup> )	Adverse comment possible (VDV, ms <sup>-1.75</sup> )	Adverse comment probable (VDV, ms <sup>-1.75</sup> )
Residential buildings, 16hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings, 8hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Office buildings, 16hr day	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2
Workshops, 16 hr day	0.8 to 1.6	1.6 to 3.2	3.2 to 5.4

#### 5.1.4 Structural Damage

The German standard DIN 4150 “Structural Vibration Part 3: Effects of Vibration on Structures” is often used in New Zealand to assess structural damage due to construction vibration. In this standard damage is defined as “*any permanent effect of vibration that reduces the serviceability of a structure or of one of its components.*” In addition, serviceability is considered to have been reduced if :

- Cracks form in plastered surfaces of walls;
- Existing cracks in the building are enlarged; and
- Partitions become detached from load-bearing walls or floors.
- These effects are classified as minor damage.

DIN 4150:3 distinguishes between short-term and long-term exposure duration. Short-term vibration is vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated. Long-term vibration, in turn, covers all types of vibration which are not covered by the definition of short-term vibration.

Guideline vibration levels to assess short term and long term vibration on structures are listed in Table 5.4 and Table 5.5.

**Table 5.4: DIN4150:3 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on structures**

Type of structure	Guideline values for Peak Particle Velocity (PPV, mm/s)			
	Vibration at the foundation at a frequency of :			Vibration in the horizontal plane of highest floor, at all frequencies
	1 Hz to 10 Hz	10 Hz to 50Hz	50 Hz to 100Hz	
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 mm/s at 10Hz to 40 mm/s at 50 Hz	40 mm/s at 50Hz to 50 mm/s at 100Hz	40 mm/s
Dwellings and buildings of similar design and/or occupancy	5	5 mm/s at 10Hz to 15 mm/s at 50Hz	15 mm/s at 50Hz to 20 mm/s at 100Hz	15 mm/s
Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 mm/s at 10Hz to 8 mm/s at 50Hz	8 mm/s at 50Hz to 10 mm/s at 100Hz	8 mm/s

**Table 5.5: DIN4150:3 Guideline values for vibration velocity to be used when evaluating the effects of long-term vibration on structures**

Type of structure	Guideline values for Peak Particle Velocity (PPV, mm/s) in horizontal plane of highest floor, at all frequencies
Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	2.5
Dwellings and buildings of similar design and/or occupancy	5
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	10

DIN 4150:3 also states that:

*'Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible'.*

It also states that exceeding the values above does not necessarily lead to damage. Should these values be significantly exceeded, however, further investigations are necessary.

## 5.2 Operation

The operational noise and vibration goals are based on district, regional, national and international Standards and guidelines, and noise goals do not necessarily correlate to the construction noise goals identified in Section 5.1.

### 5.2.1 Air-borne Noise

#### 5.2.1.1 Operational Rail Noise

There are no noise standards currently applicable in New Zealand to operational noise from railway lines; therefore guidance is sought from a number of national and international documents. Ontrack is, however, in the process of developing rail noise criteria and reverse sensitivity guidelines. While these have not been released, and are currently in draft form, these have been presented at a recent acoustics conference and therefore are included here for completeness.

The Resource Management Act 1991 (RMA) sets out the governing rules with respect to environmental noise in New Zealand. Operational noise associated the rail component of the AWHC Project must comply with the requirements of the RMA. Specifically, Section 16 of the RMA requires that environmental noise emissions be avoided or mitigated by adopting the best practical approach to ensure that the emission of noise does not exceed a reasonable level.

Guidance in relation to “reasonable” operational noise and vibration levels is provided by reference to the following documents :

- Australian rail noise guidelines “Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects” (IGANRIP)
- World Health Organisation Guidelines for Community Noise (WHO Guidelines)
- North Shore City – District Plan– Operative 2002 – Section 10.5
- City of Auckland – District Plan Central Area Section – Operative 2004 – Part 7
- City of Auckland – District Plan Isthmus Section – Operative 1999 – Part 4a
- Auckland Regional Plan: Coastal – Operative 2004– Chapter 35
- New Zealand Standard 6802:2008 “Acoustics – Environmental Noise”

- Table 1: Assessment Criteria (Noise and Vibration) for New Developments Adjoining the Rail Corridor of Ontrack’s draft reverse sensitivity guidelines

It should be noted that all except the WHO and rail-specific noise guidelines are defined for steady state noise only, rather than the intermittent character of rail noise. As such, these documents are included here only as a reference to the normal ambient noise environment to which the affected receiver locations are likely to be exposed during the operation of the proposed AWHC rail lines.

**Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects (IGANRIP)**

The IGANRIP was released by the Department of Environment, Climate Change and Water (DECCW) in Australia. The guideline provides procedures for the assessment and approval process for rail infrastructure developments that have the potential for rail noise and vibration impacts. Rail noise triggers are given in Tables 1 and 2 of that document, and are provided below in Table 5.6 and Table 5.7. External noise levels are assessed at one metre in front of the most affected building façade.

**Table 5.6: Airborne rail traffic noise trigger levels for residential land uses.**

Type of Development	Noise Trigger Level		
	Day (7 am–10 pm)	Night (10 pm–7 am)	Comment
New rail line development	Development increases existing rail noise levels <i>and</i> resulting rail noise levels exceed:		These numbers represent external levels of noise that trigger the need for an assessment of the potential noise impacts from a rail infrastructure project.  An ‘increase’ in existing rail noise levels is taken to be an increase of 2 dB LAeq or more in any one hour or an increase of 3 dB LAFmax or more.
	60 dB LAeq(15h) 80 dB LAm <sub>ax</sub>	55 dB LAeq(9h) 80 dB LAm <sub>ax</sub>	
Redevelopment of existing rail line	Development increases existing rail noise levels <i>and</i> resulting rail noise levels exceed:		
	65 dB LAeq(15h) 85 dB LAm <sub>ax</sub>	60 dB LAeq(9h) 85 dB LAm <sub>ax</sub>	

**Table 5.7: Airborne rail traffic noise trigger levels for sensitive land uses other than residential.**

Noise-Sensitive Land Use	Noise Trigger Level	
	New rail line development	Redevelopment of existing rail line
	Development increases existing rail noise levels by 2 dB LAeq or more in any hour  <i>and</i> resulting rail noise levels exceed:	



Maximum Permitted Noise Levels by Zone				
Appendix 10E.				
As measured at any residential zone boundary located in the high background noise area identified in Appendix 10E.	55 dB LA10	50 dB LA10	45 dB LA10	45 dB LA10 75 dB LAmax
Business Zones 1, 2, 3, 4, 5, 6, 7, 8 and 11 and Mixed Use Overlay Area.	65 dB LA10	65 dB LA10	65 dB LA10	65 dB LA10

**City of Auckland – District Plan**

Noise criteria in the Auckland City Council District Plan which might be considered “reasonable” are:

- Noise from the Central Area to residential, special purpose or business areas in the adjoining Isthmus area :
  - Monday to Saturday 7am to 10pm; Sunday and Public Holidays 9am to 6pm : LAeq 55 dB
  - All other times : LA10 45 dB, LAmax 75 dB
- Noise from activities in the Isthmus area to residential and other sensitive areas within the Isthmus area :
  - Monday to Saturday 7am to 10pm; Sunday and Public Holidays 9am to 6pm : LAeq 50 dB
  - All other times : LA10 40 dB, LAmax 75 dB
- Noise from activities in the Isthmus area to business zones within the Isthmus area :
  - 7am to 10pm : ranging from LAeq 55 to 70 dB depending on the zoning
  - 10pm to 7am: ranging from LAeq 45 to 70 dB depending on the zoning

**Auckland Regional Plan: Coastal – Operative 2004– Chapter 35**

The overarching aim of the Auckland Regional Plan : Coastal is as given in Section 35.8.1, “That noise generated within the coastal marine area is at a level that maintains as far as practicable people’s health, wellbeing, and amenity values, and the health and wellbeing of coastal fauna.”

This is supported by the requirement of Section 35.4.3 that “Any structure or activity in the coastal marine area should be designed or undertaken in such a manner that the adverse effects of noise generated from it are avoided, remedied or mitigated as far as practicable.”

However, the noise rules set out in that document relate to noise from the Coastal Marine Area to land-based receivers, rather than to receivers within the Coastal Marine Area itself, and as such there are no specific noise rules within that document to guide the AWHC project as to acceptable noise levels for receivers within the marina itself.

**New Zealand Standard 6802:2008 “Acoustics – Environmental Noise”**

NZS 6802:2008 provides the following generic guideline environmental noise levels to be applied to residential receivers in the absence of any other territorial guidelines :

- Daytime 7am to 7pm : 55 dB  $L_{Aeq(15min)}$
- Evening 7pm to 10pm : 50 dB  $L_{Aeq(15min)}$
- Night 10pm to 7am : 45 dB  $L_{Aeq(15min)}$  and 75 dB  $L_{AFmax}$

**Ontrack Draft Reverse Sensitivity Guidelines**

Table 1 of the draft Reverse Sensitivity Guidelines are provided here for completeness; however, even if they were current, as Reverse Sensitivity guidelines they would not to be utilised as design guides for the assessment of impact of noise from new rail developments on existing sensitive receivers.

**Table 5.9 – North Shore City Council District Plan Permitted Noise Levels.**

Distance from nearest track edge	Assessment Criteria
Less than 40 metres <sup>1</sup>	<p><u>Noise:</u> Applicants will need to demonstrate they can meet the following noise levels:</p> <ul style="list-style-type: none"> <li>• Dwellings: 35 dB <math>L_{Aeq(1hr)}</math> inside bedrooms or 40 dB <math>L_{Aeq(1hr)}</math> inside other habitable spaces<sup>2</sup>.</li> <li>• All other developments: no greater than the recommended maximum design guidelines given in <i>AS/NZS 2107- 2000: Acoustics – recommended design sound level and reverberation times for building interiors</i><sup>2</sup>.</li> </ul> <p>Compliance with these limits shall be demonstrated by either a desktop exercise based on a design train noise level 3, or a detailed assessment based on actual train noise levels and recognised acoustic modelling.</p> <p><u>Vibration:</u> Applicants should be aware that vibration within this area may cause annoyance and possibly damage to buildings. Vibration is very site specific and applicants are advised to undertake a vibration assessment to determine whether it will be an issue for their particular development.</p>
40 to 80 metres	<p>Standard New Zealand building construction will be acceptable, provided that the total area of glass, other than in walls facing directly away from the rail line, does not exceed 30% of the total area of all external walls. All windows and external doors in bedrooms must be fitted with perimeter seals<sup>2</sup>.</p> <p>If Applicants consider the above treatment is not warranted, then advice should be sought from an acoustic consultant to justify an alternative approach.</p> <p>Applicants should note that vibration may be noticeable within this area, but will be less than international standards for damage to modern buildings.</p>

Notes:

1. In cases where there is no track but the land is designated for railway purposes the distance shall be measured from the boundary of railway land. The applicable distances will be 30 metres and 30 to 70 metres.

2. To comply with these guidelines, windows and external doors shall be closed. Therefore, applicants will need to ensure compliance with the minimum ventilation requirements of section G4 of the Building Code with doors and windows closed. This may require mechanical ventilation.
3. For the purposes of compliance with these limits, train noise shall be deemed to be 70 dB  $L_{Aeq(1hr)}$  at 12 metres from the closest rail track. This level shall be deemed to vary at a rate of 3 dB per doubling of distance up to 30 metres, and 6 dB per doubling beyond 30 metres.
4. When using measured noise levels, applicants shall add an allowance of 3 dB to the measurement results to allow for future growth in rail traffic.
5. A maximum noise limit ( $L_{max}$ ) is not included because the 1 hour  $L_{eq}$  has been found to adequately control noise from individual train passes.
6. These limits also apply to groundborne noise from underground lines.

#### 5.2.1.2 Environmental Noise – Railway Station Noise Sources

For steady-state noise emissions from the proposed stations at Akoranga and Gaunt Street, the noise rules as outlined in the relevant sections of the North Shore City and Auckland District Plans respectively, as given in Section 5.2.1 above, are not strictly applicable as the Stations are expected to be located within the rail designation area.

The noise rules in these District Plans may be considered in relation to determining reasonable noise criteria to be applied to the project, which will then be proposed to be incorporated into the Designation conditions. Such noise conditions would be applicable to such noise sources as station ventilation fans, mechanical services, hydraulics noise etc.

#### 5.2.1.3 Environmental Noise – Tunnel-related Noise Sources

Other steady and stationary noise sources associated with road and rail tunnels, such as ventilation stacks, substation / control buildings, tunnel services buildings etc also need to be considered for their impact on the existing noise environment in the vicinity of each of these.

As per Section 5.2.1.2, the noise rules as outlined in the relevant sections of the North Shore City and Auckland District Plans respectively are not strictly applicable where these sources are located within the rail designation area, but may be considered in relation to determining reasonable noise criteria to be applied to the project, which will then be proposed to be incorporated into the Designation conditions.

#### 5.2.1.4 Traffic Noise

The primary road traffic noise criteria are given by NZS 6806:2010 '*Acoustics – Road-traffic noise – New and altered roads*'. The assessment point for NZS 6806:2010 is the exterior wall of the noise-sensitive premises (Protected Premises and Facility (PPF)) most affected by noise from the road being assessed and is 1.2 to 1.5m above the floor level of interest. The extent of assessment is limited to a distance of 100m from the edge of the closest traffic lane in urban areas.

A PPF is defined as :

- (a) Buildings used for residential activities including
  - i. Boarding establishments
  - ii. Homes for elderly persons
  - iii. Retirement villages
  - iv. In-house aged-care facilities
  - v. Buildings used as temporary accommodation in residentially zoned areas, including hotels and motels but excluding camping grounds;
- (b) Marae;
- (c) Spaces in buildings used for overnight patient care; and
- (d) Teaching areas and sleeping rooms in buildings used as educational facilities including tertiary institutions and schools, and premises licensed under the Education (Early Childhood Services) Regulations, and playgrounds which are part of such facilities and located within 20m of buildings used for teaching purposes.

The assessment point is based on the sound incident on the building at this position and does not include reflections from the wall. The road noise criteria are shown below in Table 5.10.

**Table 5.10: NZS 6806:2010 Road Noise Criteria.**

Category		Altered Roads dB LAeq(24h)	New roads with a predicted traffic volumes >75 000 AADT at the design year dB LAeq(24h)	New roads with a predicted traffic volume of 2000 to 75 000 AADT at the design year dB LAeq(24h)
A	(primary free-field external noise criterion)	64	64	57
B	(secondary free-field external noise criterion)	67	67	64
C	(internal noise criterion)	40	40	40

The conditions under which a project is to be considered an “altered road” are presented below;

*‘An altered road means an existing road that is subject to alterations of the horizontal or vertical alignment where at an assessment position at any one or more Protected Premises and Facility (PPF):*

- a) *The do-minimum noise environment would be greater than or equal to 64 dB  $L_{Aeq(24h)}$  and, if no specific noise mitigation was undertaken, the alterations would increase road-traffic noise at that assessment position by 3 dB  $L_{Aeq(24h)}$  or more at the design year, when compared to the do-nothing noise environment; or*
- b) *The do-minimum noise environment is greater than or equal to 68 dB  $L_{Aeq(24h)}$  and, if no specific noise mitigation was undertaken, the alterations would increase road-traffic noise at that assessment position by 1 dB  $L_{Aeq(24h)}$  or more at the design year, when compared with the do-nothing noise environment.'*

If any PPF's in the project area meet the requirements stated above the entire project is considered an altered road and all PPF's are considered.

Where the AWHC project ties into the existing road network, some small sections of the Project may be considered to fall into the category of "Altered Road". However, the AWHC road component predominantly falls into the category of 'New Road', although it is important to note that the design targets for an "altered road" are the same as those for a "new road" carrying greater than 75,000 vehicles per day.

As most sections of the proposed road which are expected to carry greater than 75,000 vehicles per day, the higher of the "new road" criteria will need to be considered.

#### 5.2.1.5 Rail – Ground–borne Noise

Vibration generated in the rail–wheel interface enters the trackbed via the track support and continues to propagate through the ground to buildings' foundations and throughout buildings. This can cause the floors, walls and ceilings to vibrate and in turn radiate noise. This noise is commonly referred to as structure– or ground–borne noise or regenerated noise. Ground–borne noise is low frequency and, if audible, is perceived as a 'rumble'. Another effect of non–destructive vibration is that it can induce small objects to rattle such as ornaments on shelves.

New Zealand does not have defined limits specifically in terms of regenerated noise. However the Department of Environment, Climate Change and Waters (New South Wales, Australia) guideline *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* provides suitable noise limits for ground–borne noise. These levels are 5 dBA more stringent than the WHO guidelines. Additionally, the IGANRIP ground–borne noise trigger levels are also measured in  $L_{Amax}$  'slow' response, rather than 'fast' response like the WHO guidelines.

The ground–borne noise limits recommended by IGGANRIP are provided below:

**Table 5.11: Recommended ground–borne noise limits.**

Receiver	Time of Day	Noise Trigger Level
		Development increases existing rail noise levels by 3 dB(A) or more <i>and</i> Resulting rail noise levels exceed :

Receiver	Time of Day	Noise Trigger Level
Residential	Day (7 am – 10 pm)	40 dB L <sub>Amax(slow)</sub>
	Night (10pm – 7am)	35 dB L <sub>Amax(slow)</sub>
Schools, educational institutions, places of worship	When in use	40–45 dB L <sub>Amax(slow)</sub>

5.2.1.6 Railway Station Noise – Internal

The recommended internal design noise and reverberation time targets for the internal spaces within the railway stations associated with the AWHC Project are generally as outlined in AS/NZS 2107 and shown in Table 5.12.

**Table 5.12: Internal noise levels recommended by AS/NZS 2107:2000.**

Type of Occupancy / Activity	Recommended Design Sound Level (dB L <sub>Aeq</sub> )	
	Satisfactory	Maximum
Railway and Bus Terminals		
Staff office areas	40	45
Ticket sales areas	45	50
Waiting areas	45	55

Specific recommended reverberation times are not provided; rather, the design guidance given is to “minimise reverberation times as far as practicable for noise control”.

5.2.1.7 Railway Station – Occupational Safety and Health Noise

The noise-related health and safety of passengers and staff within the occupied station areas is considered here to address the issue of hearing loss and other health effects due to excessive noise exposure. This requirement does not consider the acoustic amenity of the areas as outlined in Section 5.2.1.6 above; rather, it is an Occupational Safety and Health (OSH) concern addressing the safe noise exposure of the occupants.

New Zealand has legislation in place for the protection of employees in the form of the *Health and Safety in Employment Act, 1992* and related documents including *Health and Safety in Employment Regulations, 1995* and a code of practice for the management of noise in the workplace.

The Act implements and enforces its objective through the Health and Safety in Employment Regulations, 1995 which contains a number of requirements relating specifically to management of noise. Section 11 of the Regulation states that:

*Every employer shall take all practicable steps to ensure, in relation to every place of work under the control of that employer, that no employee is exposed to noise above the following levels:*

*a noise exposure level,  $L_{Aeq,8h}$  of 85 dB*

*a peak noise level,  $L_{peak}$ , of 140 dB — whether or not the employee is wearing a personal hearing protection device.*

## 5.2.2 Operational Vibration

Structural damage and tactile vibration need not be assessed directly for the rail tunnels because if operational regenerated noise levels as identified in Section 5.1.2 are achieved, this typically ensures that structural damage and tactile vibration is adequately addressed.

Tactile and structural vibration limits for the operating road options are identical to those given in Sections 5.1.3 and 5.1.4.

# 6. General Discussion – Noise and Vibration Impacts

A brief discussion of general noise and vibration impacts is provided as a benchmark against which the Option Assessment can be undertaken.

## 6.1 Construction

### 6.1.1 Noise

#### **Noise Data**

Tunnel boring and other underground works, or works within contained / covered pits and enclosures, are unlikely to have any significant impact on properties in the vicinity of those works. However, significant impacts typical of construction activities can be expected from airborne noise during the construction of the Project.

Airborne noise is considered in accordance with the current (1999) version of NZS 6803, as identified in Section 5.1.1. A Construction Noise Management Plan will need to be prepared prior to the construction of the Project and will be required to address the matter of construction noise in accordance with the version of this Standard current at the time of the works occurring, or other Standard as appropriate.

Table 6.1 presents typical “Activity Noise Levels” for the types of construction activities that are likely to occur during the open-to-the-environment construction of the Project, including:

- General bulk earthworks and ground/road surface removal and replacement.
- Piling works associated with the installation of cut-and-cover construction shoring panels, underground station supports and bridge/overpass structures.
- Works associated with the installation of new rail track.
- Works associated with the construction of new road surfaces.

These noise levels are taken from NZS 6803, and are used in this assessment to predict typical setback distances to meet the noise criteria in Section 5.1.1.

**Table 6.1: Typical activity noise levels at 10m for works associated with construction.**

<b>Construction Activity</b>	<b>Typical L<sub>Aeq</sub> Activity Noise Level at 10 m, dB</b>
<b>Earthworks</b>	
Bulldozer spreading fill, levelling ground.	85 to 94
Grader levelling ground	83 to 86
Dump truck tipping fill	82
Tracked excavator operating	82 to 88
Tracked excavator idling	68
Vibratory roller compacting fill	74 to 78
<b>Piling</b>	
Impact bored/pile cast in place	76 to 84
<b>Road Surfacing</b>	
Asphalt Spreader	82
Road roller	77

Construction Activity	Typical L <sub>Aeq</sub> Activity Noise Level at 10 m, dB
<b>Earthworks</b>	
Truck idling	75 to 80
Crane Noise	81 to 86

The values in the above table reflect the typical noise levels from individual sources. A number of different construction activities could take place simultaneously within the same general area, potentially resulting in higher overall construction noise levels than the individual levels shown in the table above.

### Construction Noise Estimation

The data presented in Table 6.1 demonstrates that noise levels due to construction activities may vary widely. Based on the noise levels presented in Table 6.1, it is calculated that the distances shown in Table 6.2 and Table 6.3, are likely to be the minimum distances at which compliance with the construction noise criteria would be achieved for construction works of “Long Duration”. The noise levels at noise sensitive premises closer than these distances are likely to exceed the construction noise criteria.

**Table 6.2: Minimum residential distances from long-term duration construction activities for compliance without noise mitigation.**

Construction Activity	Distance to Achieve Compliance (m)			
	Weekdays 0730 – 1800 Saturdays 0730 – 1800  70 dB L <sub>Aeq</sub>	Weekdays 1800 – 2000  65 dB L <sub>Aeq</sub>	Weekdays 0630 – 0730 Sundays and Public Holidays 0730 – 1800 55 dB L <sub>Aeq</sub>	All Other Times  45 dB L <sub>Aeq</sub>
<b>Earthworks</b>				
Bulldozer spreading fill, levelling ground	60 to 80 m	≥ 100 m	> 200 m	> 200 m
Grader levelling ground	45 to 65 m	80 to 110 m	> 200 m	> 200 m
Dump truck tipping fill	40 m	70 m	> 200 m	> 200 m
Tracked excavator operating	40 to 80 m	70 to 140 m	> 200 m	> 200 m

Construction Activity	Distance to Achieve Compliance (m)			
	8 m	15 m	45 m	140 m
Tracked excavator idling	8 m	15 m	45 m	140 m
Vibratory roller compacting fill	16 to 25 m	30 to 45 m	90 to 140 m	> 200 m
<b>Piling</b>				
Precast concrete piles	40 to 120 m	70 to 200 m	> 200 m	> 200 m
<b>Road Surfacing</b>				
Asphalt Spreader	40 m	70 m	> 200 m	> 200 m
Road roller	22 m	40 m	130 m	> 200 m
Truck idling	20 to 35 m	32 to 60 m	90 to 180 m	> 200 m
Crane Noise	35 to 65 m	65 to 120 m	> 200 m	> 200 m

Table 6.3: Minimum commercial and industrial distances from long-term duration construction activities for compliance without noise mitigation.

Construction Activity	Distance to Achieve Compliance (m)	
	All Days 0730 - 1800	All Days 1800 - 0730
	70 dB LAeq	75 dB LAeq
<b>Earthworks</b>		
Bulldozer spreading fill, levelling ground	60 to 80 m	35 to 90 m
Grader levelling ground	45 to 65 m	25 to 35 m
Dump truck tipping fill	40 m	22 m
Tracked excavator operating	40 to 80 m	22 to 45 m
Tracked excavator idling	8 m	5 m
Vibratory roller compacting fill	16 to 25 m	15 m

<b>Piling</b>		
Precast concrete piles	40 to 120 m	25 to 65 m
<b>Road Surfacing</b>		
Asphalt Spreader	40 m	25 m
Road roller	25 m	15 m
Truck idling	20 to 35 m	10 to 20 m
Crane Noise	35 to 65 m	20 to 35 m

**Regenerated Noise**

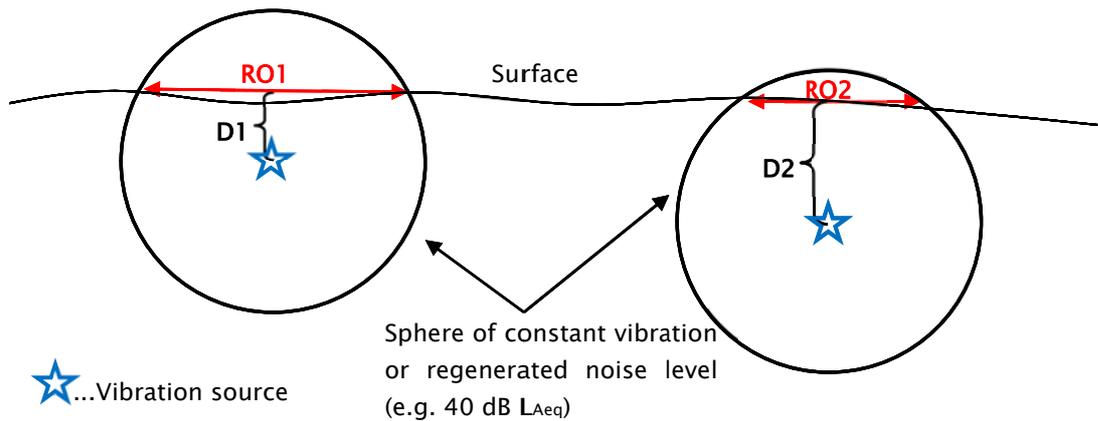
No relevant measured regenerated noise data for Auckland was readily available to the project team and the regenerated noise levels inside buildings have therefore been calculated based on measured data associated with tunnel boring in Hawkesbury sandstone (Sydney). Typically, regenerated noise inside buildings shows large variations and the presented set of data is based on the worst-cases as measured in Sydney.

These measurements indicate approximate regenerated noise levels within buildings directly above a tunnel boring machine as given in Table 6.4.

**Table 6.4: Regenerated Noise from Tunnel Boring Machine.**

Distance Below Ground (m)	Regenerated Noise (dB LAeq)
10	55
20	50
30	45
40	43

For equipment such as roadheaders or rockbreakers, minimum required offsets (ROs) reduce with increasing depth of the operation as indicated schematically in Figure 6.1. Consequently, required horizontal offsets must be viewed as a ‘dynamic’ quantity that changes as the vibration sources change depth.



**Figure 6.1 : Surface safe distances reduce with increasing depth of the vibration source**

Required horizontal offsets to achieve evening regenerated noise levels of 40 dB LAeq for different operation depths of roadheaders and rockbreakers are provided in the Table 6.5. The estimates are based on empirical formulas and are indicative only. The actual required horizontal offsets will depend on local soil properties, specifics of the equipment operated and the coupling loss between buildings and soil.

**Table 6.5: Indicative horizontal offset distances for regenerated noise – evening goal.**

Estimated required horizontal offset to achieve 40 dB LAeq regenerated noise				
Working Depth	Roadheader	Light Rockbreaker	Medium Rockbreaker	Heavy rockbreaker
0m	35m	55m	65m	75m
20m	28m	51m	61m	72m
40m	0m	32m	47m	60m

### 6.1.2 Vibration

During construction of the cut and cover tunnel sections the dominant vibration sources will be rockbreakers and piling activity.

Conservatively, a screening criterion of 2.5 mm/s is used to assess the risk of structural damage. This corresponds with the long-term limit of structures which have particular sensitivity to vibration such as heritage listed buildings (see Section 5.1.4). In practice even cosmetic damage such as the forming of cracks does not occur from typical construction activities below 15 mm/s.

As no construction vibration data specific to New Zealand conditions is available, reference was made to the Australian Transport Infrastructure Development Corporation’s (TIDC) publication entitled “Construction Noise Strategy (Rail Projects)” (CNS) and previous AECOM studies. From these reference documents, distances at

which vibration from general construction activities are expected to achieve the relevant structural and human comfort vibration criteria were determined, and are provided in Table 6.6.

**Table 6.6: Screening distances for structural damage and human comfort.**

Plant	Safe Working distance (m)	
	Structural Damage	Human Comfort / Tactile Vibration
Small hydraulic hammer	4	10
Medium hydraulic hammer	12	30
Large hydraulic hammer	40	90
Sheet piling	6	30
10T vibrating roller (high setting)	15	50

In addition to the estimated vibration levels associated with general construction activities, Table 6.7 shows the estimated Peak Particle Velocities (PPVs) associated specifically with tunnel boring.

**Table 6.7: Peak Particle Velocity Vibration Levels from Tunnel Boring Machine.**

Distance Below Ground (m)	Peak Particle Velocity (mm/s)
10	0.6
20	0.5
30	0.4
40	0.3

## 6.2 Operation

### 6.2.1 Noise

Traffic-noise adjacent the SH1 motorway in the vicinity of the project has not been measured for this Options Comparison phase of the AWHC Project. Traffic noise as a result of the Project will vary according to the section of road under consideration, as the likely levels are dependent on several factors :

- The distance of the receiver from the road carriageway edge
- The traffic volume on that section of road
- The percentage heavy vehicles on that section of road
- The speed of traffic on the road
- The gradient of the road
- The road surface type
- The angle of view to the road from any given receiver
- The degree of shielding provided by intervening structures or terrain

However, the impact of road noise generated at the potentially affected receivers adjacent the AWHC Project must also take into account not only the noise generated by traffic on the new roads constructed as part of the project, but also the change in noise generated by the existing road network as a whole as a result of the change to the network.

For example, noise generated by traffic using the new harbour crossing will not simply be added to existing noise from traffic on the existing harbour bridge. Not only will the traffic volumes on the existing harbour bridge change from the existing situation at the time of the Project's opening in (nominally 15 years' time) due to the predicted growth in commuter numbers, but also the availability of the new crossing will mean that the actual traffic volumes on the existing bridge may in fact reduce in the first instance as commuters opt to use the new harbour crossing.

Similarly, the impact of the Project on receivers in the vicinity of St Mary's Bay and Victoria Park will need to take into account the traffic noise levels resulting from the VPT project (which is currently under construction) which will have been in operation for some time by the time the AWHC project opens.

Therefore, the impact of the two road options will not strictly be made against the relevant NZS 6806:2010 traffic noise design targets, although this is addressed in general terms in the following sections, but rather against the relative change in received noise levels at premises in the vicinity of the Project between each Option and the situation which might exist in the absence of the Project.

### 6.2.2 Vibration

Traffic-induced vibration adjacent the SH1 motorway in the vicinity of the project has not been measured for this Options Comparison phase of the AWHC Project. Traffic vibration as a result of the Project will vary according to the section of road under consideration, as the likely vibration levels are dependent on several factors :

- The distance of the receiver from the road carriageway edge
- The traffic volume on that section of road
- The percentage heavy vehicles on that section of road
- The presence of surface irregularities such as manholes and drains
- The intervening ground type
- Elevated, ground level or underground roadway

Nevertheless, to enable the comparison of the two Road options, measured vibration levels (2010) in the vicinity of SH1 in Papakura are included to provide an indication of typical vibration levels adjacent a busy state highway. At the measurement location, the road was carrying in the order of 71,000 vehicles per day, with an average of between 7% and 7.7% heavy vehicles.

**Table 6.8: Measured Vibration Levels from SH1, Papakura.**

Distance From Nearside Lane Centre (m)	Measured Peak Particle Velocity (mm/s)
10	0.52
20	0.37
30	0.30
40	0.26

## 7. Option Assessment – Rail Options

The key sections of works, in relation to potential noise and vibration impact are as described as per the General Arrangement drawings 60157303-RD-060 to -064 and -070 to -072 (Rev B) for the Bridge option and 60157303-RD-020 to -024 and -030 to -032 (Rev B) for the Tunnel option.

There is no significant difference between the rail alignments proposed for the Bridge vs Tunnel options. Both extend from the existing Akoranga Bus Station in the north (which is proposed under both schemes to be upgraded to incorporate a railway station linked to the bus station to create a northern transit hub) to the proposed new below-ground railway station at Gaunt Street.

Therefore, in terms of the comparison of environmental noise and vibration effects relating to operational and construction noise and vibration, there is no significant benefit or disadvantage attributable to either the Bridge or the Tunnel option. Therefore, the remainder of this acoustic comparison document compares the two Road Traffic scenarios and excludes the Rail Traffic component.

This is not to say that the proposed rail alignment is without environmental impact on the adjoining areas, for construction or operational noise and vibration. A brief discussion of this is given below.

## 7.1 Northern Sector

### 7.1.1 Construction

At the connection point of the rail line into the Akoranga Busway Station, there are currently no buildings within approximately 200m of the railway line (approximately 300m to the nearest noise sensitive building at the AUT Campus), apart from the Busway Station itself. Therefore the likely impact of construction noise and vibration, as based on the definitions provided in Section 6.1, is small, and the relevant daytime criteria are unlikely to be breached. Consideration will need to be given to the structural impact of any significant vibration-generating construction activities on the Station as the works approach it; however, good work practices and adherence to a strong Construction Noise and Vibration Management Plan will minimise the likelihood of damage.

As the railway line continues southwards, it generally veers away from the coastal edge. The closest point to residential receivers is the section of open trench in the vicinity of residences on Heath Avenue, at which it is approximately 150m from the residential boundary. Again, the likely impact of construction noise and vibration, as based on the examples provided in Section 6.1, is small, and the relevant daytime criteria are unlikely to be breached.

At this point, the tunnel construction commences, and further issues of construction noise are negated, and vibration generated by the tunnel boring equipment is likely to be well below either tactile or structural criteria.

### 7.1.2 Operation

As per the consideration of construction noise and vibration, it is noted that the proposed railway comes no closer to potentially affected noise and vibration sensitive residential receivers than approximately 150m before it enters the tunnel beneath the harbour. At this distance, the noise from the operational rail may be audible at the residential locations, although the road traffic noise is likely to dominate. Noise levels from the railway line are expected to be within any applicable or reasonable noise guideline values.

The proposed railway station at Akoranga will also need to be assessed in terms of operational noise from fixed services such as building services and public address systems, however it is noted that the distance between the station and the nearest sensitive receivers means that standard mitigation measures are likely to be effective in achieving compliance with the relevant noise criteria.

## 7.2 Central Sector

### 7.2.1 Construction

The proposed rail line is in tunnel for all of the Central Sector, to a depth of up to 50m, and as such there are no significant construction noise or vibration effects anticipated in this area.

### 7.2.2 Operation

The proposed rail line is in a tunnel for all of the Central Sector, to a depth of up to 50m, and as such there are not likely to be any significant operational noise or vibration effects.

## 7.3 Southern Sector

### 7.3.1 Construction

The rail tunnel remains as a bored tunnel to its termination at the proposed Gaunt Street Station, at a depth of 30m. As such there are no significant construction noise or vibration effects anticipated. The regenerated noise from the boring may become audible for any buildings directly above the Gaunt Street Station; however, these are commercial buildings for which the possible regenerated noise levels are likely to be within normal office background internal noise levels and therefore unobtrusive.

### 7.3.2 Operation

The rail tunnel remains as a bored tunnel to its termination at the proposed Gaunt Street Station, at a depth of 30m. As such there are no significant operational noise or vibration effects anticipated. Noise emissions from tunnel or station ventilation can readily be mitigated by standard means (barriers, attenuators, equipment selection, duct lining etc) to achieve relevant District Plan noise limits.

## 8. Option Assessment – Road Options

The key sections of works, in relation to potential noise and vibration impact are as described as per the General Arrangement drawings 60157303-RD-060 to -064 and -070 to -072 (Rev B) for the Bridge option and 60157303-RD-020 to -024 and -030 to -032 (Rev B) for the Tunnel option.

## 8.1 Northern Sector

### 8.1.1 Construction

As per the rail assessment, the distance between the work site and the sensitive receivers at the northern end of the Project means that the likely impact of road construction noise and vibration, as based on the definitions provided in Section 6.1, is small, and the relevant daytime criteria are unlikely to be breached.

The Bridge option shows that the Esmonde Road overpass above the motorway requires a new structure; should this require piling to be undertaken, there may be some small impact from noise and vibration from this activity at the AUT campus; however, it is unlikely to be significant and would be controllable by good management processes including undertaking works at a time which least disrupts the campus activities.

The road section between Esmonde and Onewa Roads is also quite similar between the two road options. Reclamation of land from Shoal Bay is a feature of this section, and is therefore expected to entail significant earthworks. The work site is on the far (eastern) side of the existing motorway in relation to the nearest residential receivers, so any construction noise generated by the works is to be considered in light of the already elevated traffic noise levels associated with SH1.

The closest residences to the proposed works are located on Heath and Sylvan Avenues; a distance of approximately 100m to 120m. Based on the construction noise estimations given in Section 6.1, these works are expected to generally comply with the daytime construction noise criteria, but may exceed the recommended limits during the evening and night time periods.

In the event that evening or night works cannot be avoided, noise mitigation measures such as specification of equipment which is quieter (for example, operating at lower speeds) or localised equipment enclosures or barriers for noisier items of equipment should be considered. However, the existing ambient noise environment should be taken into account when the detailed Construction Noise Management assessment and plan are developed.

A “background-plus” approach, such as has been undertaken for recent significant Auckland road traffic projects such as the Victoria Park Tunnel, is likely to indicate that the criteria identified in the NZS 6803 are unreasonably low. Where construction noise criteria are increased to represent a reasonable level of amenity in the already-elevated ambient noise environment, it is likely that evening and night construction noise levels generally fall within reasonable tolerances, and that mitigation may only be required for specific or unusually noisy activities which are required to be undertaken at night.

Vibration from construction is also expected to be within the recommended levels for structural and tactile vibration.

For the section south of Onewa Road, the Bridge and Tunnel options of the proposed project begin their deviation; the Bridge option starting its ascent to the second Harbour Bridge and the Tunnel option starting its descent into the bored tunnel crossing of the harbour.



Both options indicate structural changes are required to the existing motorway; noise and vibration from these works are considered for the nearest residential properties on Waimana Avenue and Stafford Road. The new off-ramp to Onewa Road is in the order of 70m from the nearest Waimana Avenue residences; the Bridge option indicates the start of the ramp construction, while the Tunnel option commences the required trenching, at a similar distance from both the Waimana and Stafford residential properties.

In this respect, the Tunnel option is considered to have marginally less impact from a construction noise and vibration perspective. Although both options require significant earthworks, the Tunnel option has the benefit of the works becoming more shielded from the residences by the walls of the trench as it progresses, whereas the Bridge becomes more prominent as the works become elevated above the local natural landform.

In either event, the estimated construction noise levels from the earthworks falling within the region where the compliance with daytime construction noise limits is marginal; careful management and possible mitigation in terms of equipment selection or localised barriers will be required for both options. At these noise levels, the construction noise is expected to be close to the existing traffic noise levels on SH1, and therefore may become noticeable to residents. Evening and night time works, if required, are likely to require designation conditions to be established which specifically address management of construction noise, with an emphasis on close consultation with potentially affected parties.

Up to Northcote Point, both Bridge and Tunnel options indicate significant construction works. Earthworks for reclamation are required for both options, as is construction of additional structures over the existing motorway. However, the Tunnel option is expected to have a lesser impact on the nearby residential areas; the extent of trenching and cut-and-cover required is smaller than the earthbuilding requirements of the Bridge option, with the benefit of some degree of acoustic shielding from the trench walls and from when the cover is installed over the cut-and-cover sections whereas all of the Bridge construction is above ground, elevated and without any natural shielding.

For the Bridge option particularly, the construction of the proposed northbound busway is extensive and very close to the residential properties. Approximately 25 properties on Sulphur Beach Road and Princes Street are within 40m of the proposed works (of which approximately 18 are within 25m of the proposed works). For these residences, compliance with the daytime construction noise criteria is expected to be marginal for most of the earthworks operations, and will require significant community consultation and localised mitigation measures in terms of equipment barriers. Depending on the elevation of individual residences in relation to the works, semi-permanent property boundary barriers may be more effective.

Night time works, if required, will require designation conditions to be established which specifically address management of construction noise, with an emphasis on close consultation with potentially affected parties and consideration given to equipment, methodology and on-site mitigation measures such as local barriers or shields, as the nominal construction noise standards would be impractical to achieve with standard mitigation measures. Even elevated night time construction noise criteria based on a “background-plus” approach are likely to be exceeded for significant earthworks, and the construction management plan should preclude such works as far as possible. For these residences, temporary relocation during evening- or night-works earthworks may be the most effective means of mitigation.

### 8.1.2 Operation

The current NZS6806:2010 traffic noise standard states that an important factor to consider when assessing a road project is to consider the change in the existing noise environment as a result of the Project. While traffic noise from a New Road would generally not be comparable to the existing environmental noise, because there would be no existing road traffic noise, the AWHC project is different. The “existing” noise levels, in the situation where the project does not go ahead and traffic volumes increase by natural growth (the “do-nothing” scenario), will already be elevated, and the impact of both Options need to be compared against this scenario.

The theoretical predicted traffic noise levels for the three scenarios (“Do-Nothing”, Bridge and Tunnel Options) are presented in **Error! Reference source not found.** on the following page for the Northern Sector. The data on which these modelled traffic noise levels are based is included in Appendix A for reference.

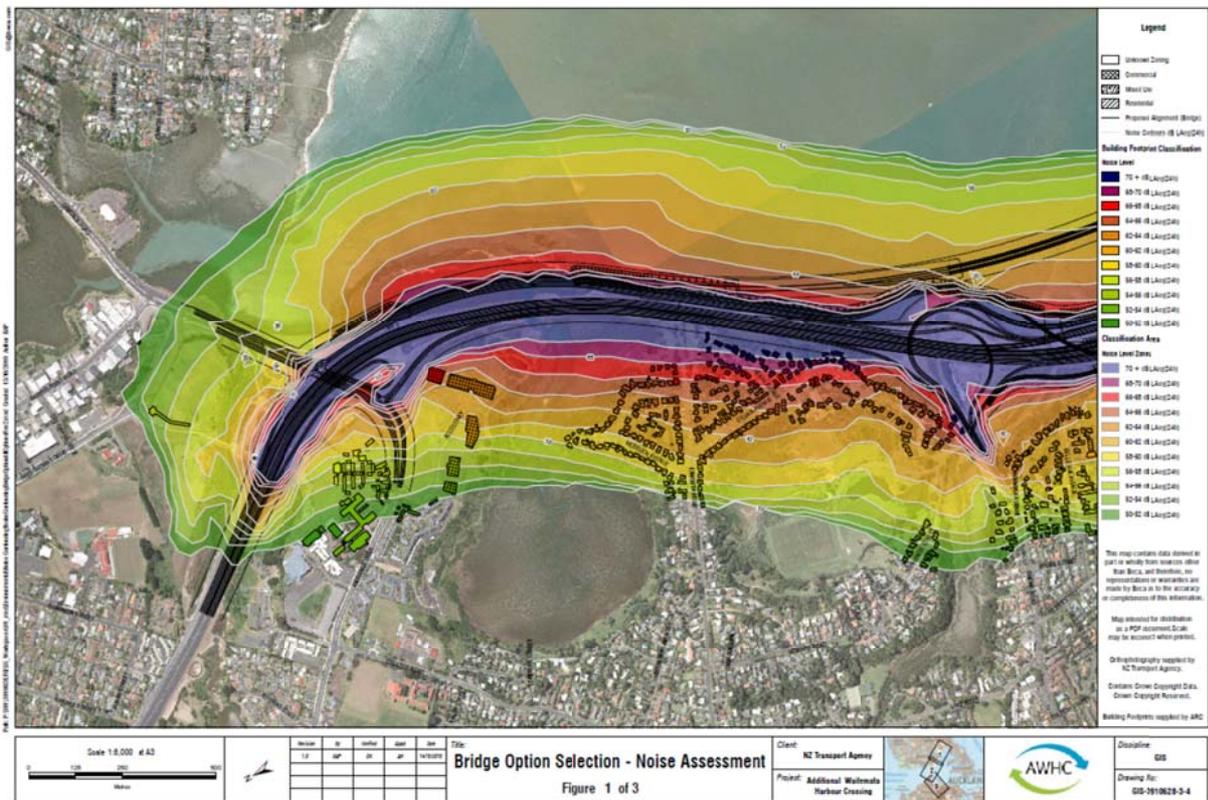
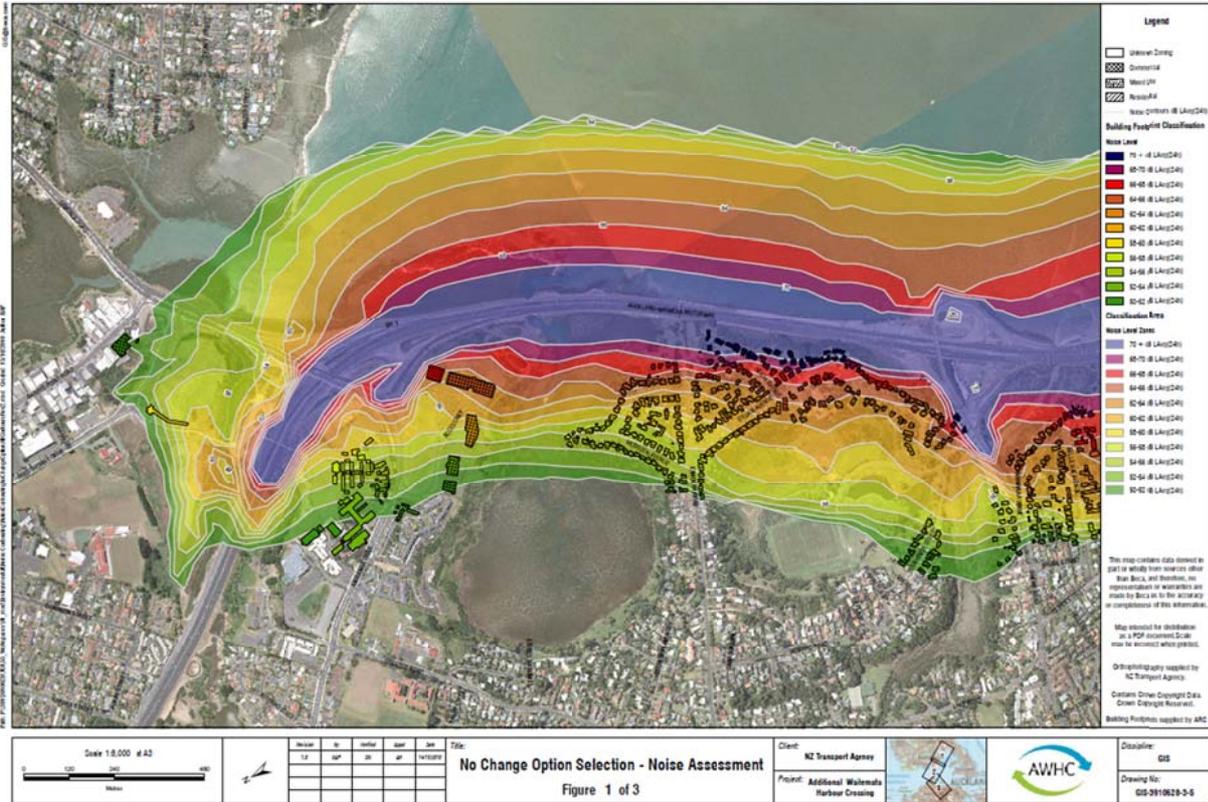
The immediate conclusion to be drawn is that both the new Bridge and the Tunnel options result in reductions in traffic noise levels at relevant residential receivers within 100m of the roadway. This is because that, although overall traffic volumes increase, the effect of relocating a percentage of that traffic to a road (the Project) further from the residential area than the existing motorway counters the expected increase in noise levels due to increased traffic flow.

NZS 6806:2010 (Clause 1.2.3 (c)) indicates that the Standard shall apply to relevant receivers near a new road where the noise from the new road increases the noise level at any affected receiver by 3 dB  $L_{Ae(24hr)}$ . Therefore, in accordance with the provisions of that Clause, the Standard would not apply to this section of the road.

Even if both Options were in some manner considered to be “altered” versions of the existing SH1, the rules under which the Standard is considered indicate that the Standard is not applicable to this section of the Project. Clause 1.5.2 indicates that where the traffic noise levels (at affected receivers) as a result of the upgrade (without mitigation) are greater than or equal to 68 dB  $L_{Aeq(24hr)}$ , as may be the case for the AWHC project, traffic noise levels as a result of the Project would need to increase by at least 1dB over the “do-nothing” traffic noise levels, which is not the case for either Option.

Therefore, no traffic noise mitigation is required for either option.

Nevertheless, to enable a comparison between the potential effects for the two Options, the predicted noise levels and number of affected residences in the vicinity of the Options are also considered.



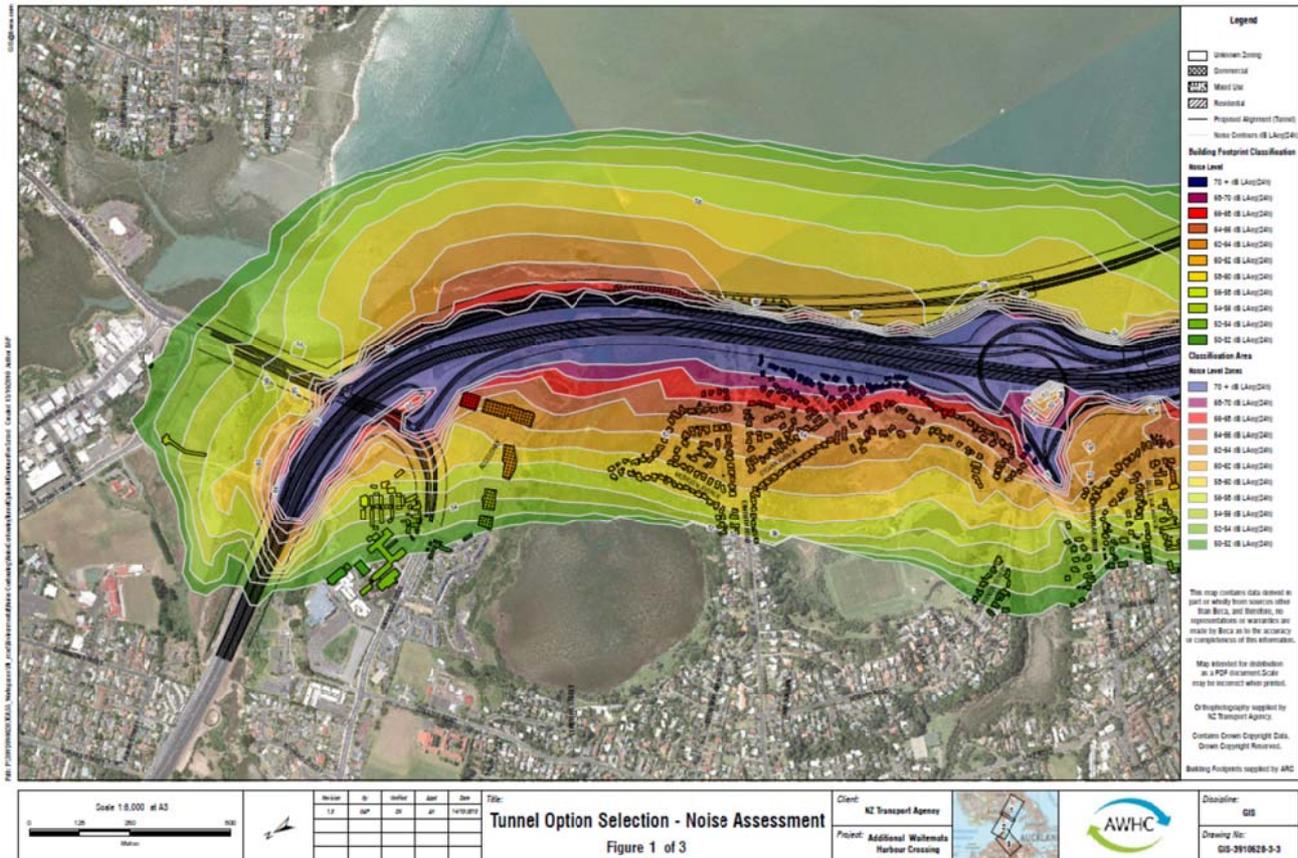


Figure 8.1: Northern Sector – Comparison of “Do-Nothing” vs Bridge and Tunnel Options

It should be noted that no attempt has been made at this stage to calibrate the acoustic modelling against existing traffic noise levels – this would be undertaken at the design phase. Nevertheless, within the limitations of the theoretical traffic noise modelling, the predicted traffic noise levels for the two Options are considered to be representative of the order of magnitude of impact of traffic noise on affected properties. Figure 8.2 to Figure 8.5 indicate the relationship of the two Options to the Category A (64 dB LAeq(24h)) and Category B (67 dB LAeq(24h)) design targets as indicated by NZS 6806:2010, regardless of the conclusions drawn above regarding the applicability of this Standard to this Project.

By means of comparison, the estimated number of residences falling into these Categories are as follows :

Table 8.1: Northern Sector – Bridge vs Tunnel – Number of Receivers in NZS 6806:2010 Categories.

AWHC Option	Protected Premises and Facilities Within 100m of Upgraded Road		
	Category A	Category B	Category C
Bridge	59	106	92

AWHC Option	Protected Premises and Facilities Within 100m of Upgraded Road		
	Category A	Category B	Category C
Bridge	59	106	92
Tunnel	44	67	86

Therefore, in terms of numbers of (potentially) affected residences alone, the Bridge option shows more affected properties than the Tunnel for the Northern Sector, particularly in the approach to the proposed new Bridge.

Although actual noise levels may not be significantly different, the increasingly elevated roadway of the new bridge, means that more residents have a direct line-of-sight to the road network; and the perception of affected residents could possibly change as a result.

We note that the terrain data available for the acoustic model in the vicinity of the existing bridge was fairly limited, and this has resulted in apparent noise levels in the vicinity of Northcote Point itself showing as below the 64 dB  $L_{Aeq(24h)}$  category threshold. While in reality this is unlikely to be the case, in that the noise levels in the vicinity of the existing harbour bridge are known to be high. However, despite this inaccuracy, the ranking of the options is not considered to be significantly affected by this.



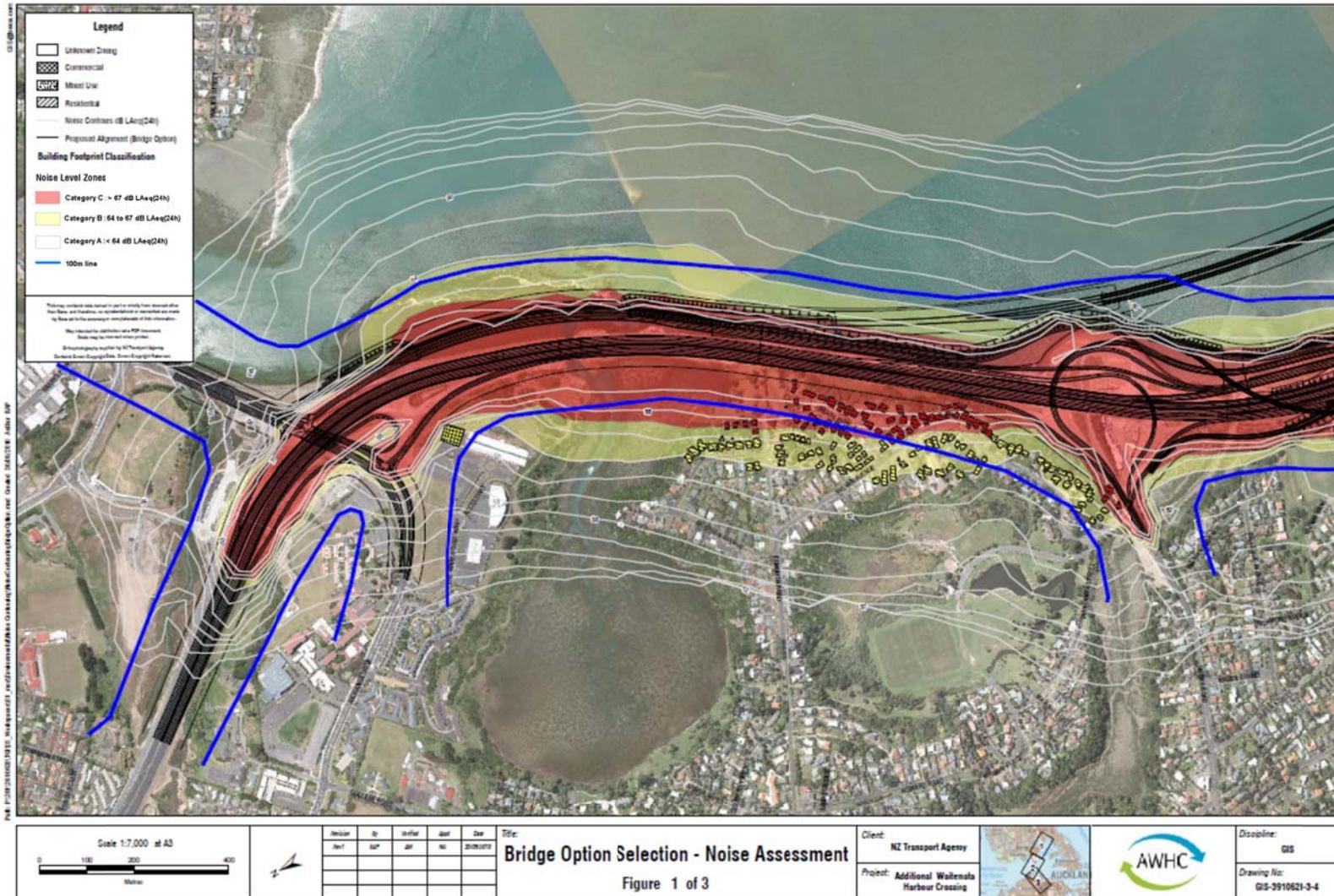


Figure 8.2: Northern Sector -Bridge Option (Esmonde to Onewa)

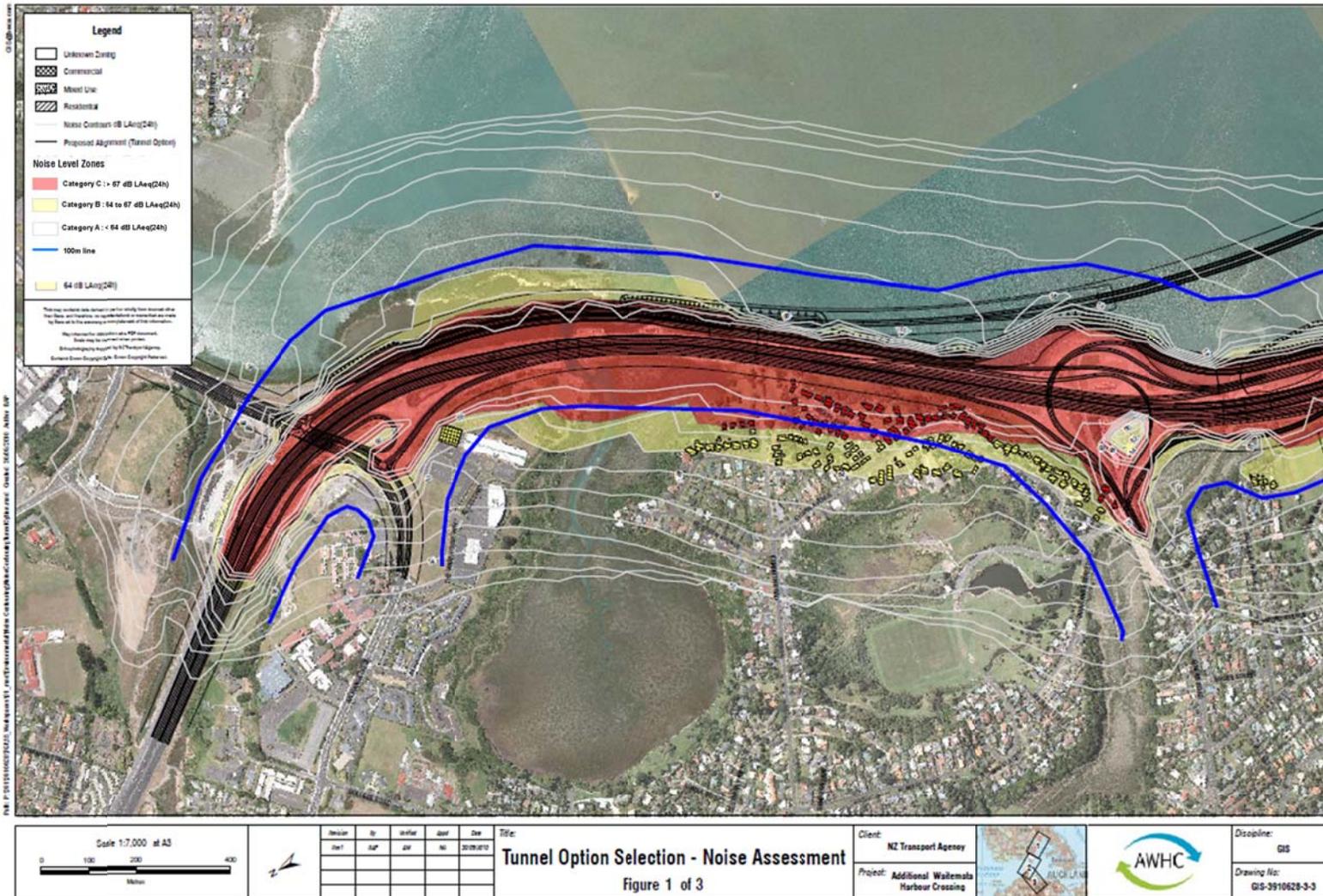


Figure 8.3: Northern Sector –Tunnel Option (Esmonde to Onewa)

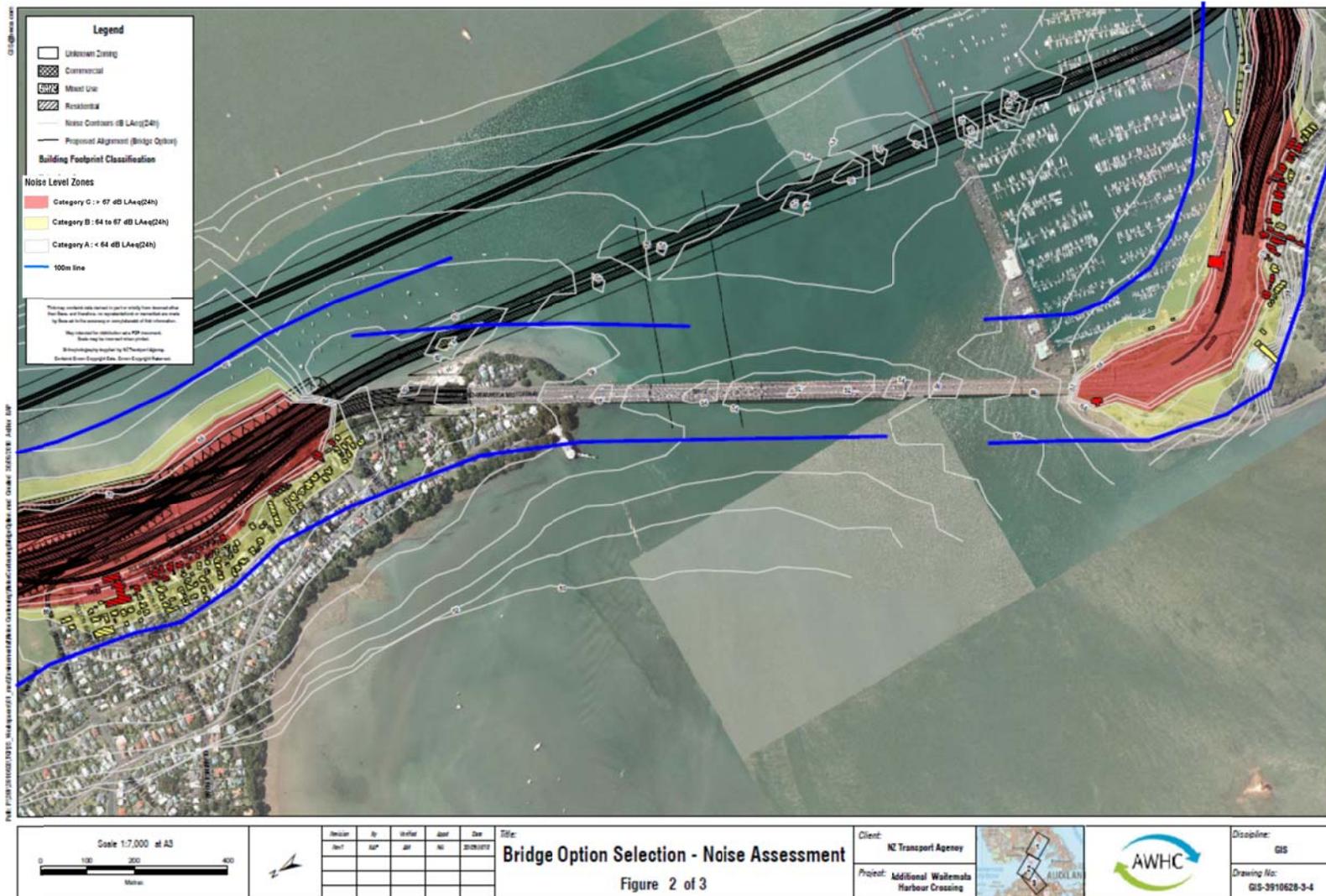


Figure 8.4: Northern Sector –Bridge Option (Onewa to Northcote Point)

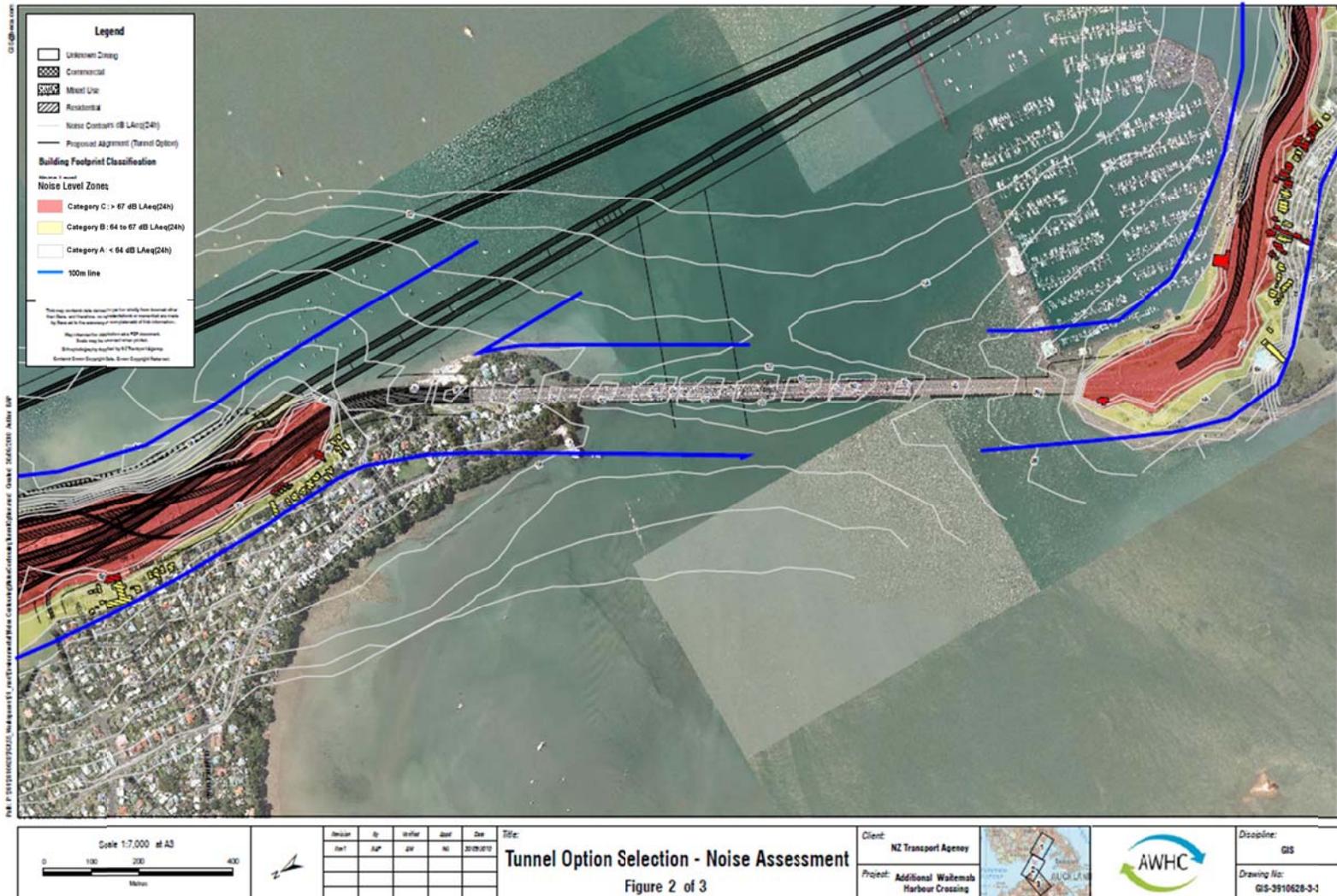


Figure 8.5: Northern Sector –Tunnel Option (Onewa to Northcote Point)

## 8.2 Central Sector

This is the sector of the project in which the Waitemata Harbour is crossed. This section is characterised by the option definition of Bridge vs Tunnel, and is where the greatest differences between the two road options is to be found.

### 8.2.1 Construction

The Bridge option will require, most prominently, significant piling for the support piers as it crosses the harbour. While this activity is undertaken at distances such that there are no properties immediately affected by construction noise and vibration, it is a highly visible activity and is likely to result in public opinion regarding (amongst other things) noise and vibration issues. While this is not a quantitative effect, it is considered to be a qualitative effect, and is to be considered in terms of public perception of noise rather than actual measurable noise effects.

Similarly, any and all activities related to structural steelworks, concrete pouring and the like for the structure once the piers are in place will be highly visible. Screening or other physical mitigation measures will be of limited effectiveness due to the distances between the source and receiver locations, the elevation of the bridge in relation to affected residents adjacent St Mary's Bay and Northcote Point, and the acoustically-reflective nature of the surface of the water in the harbour. This is not to say they are not manageable.

By comparison, the construction noise and vibration effects of the bored tunnel option on nearby sensitive receivers is negligible, as all noise is effectively contained within the tunnel as it progresses, and vibration levels at the indicated depths are expected to be well below the guideline criteria at the land-based receivers.

The section between the harbour itself and where the new motorway proper makes landfall or joins to the existing motorway is similarly visible for the Bridge option and requires careful handling of the construction process, while presenting no significant impacts for the Tunnel option. Construction noise is expected to be high at the Westhaven Marina itself.

Although the Wynyard Quarter is currently predominantly commercial in nature, it is acknowledged that the District Plan plan change in place will mean that both residential and commercial properties may be established within this area. Therefore, the impact of construction activities on any residential premises which are developed as part of the area's rejuvenation will need to be considered when construction commences.

The construction noise and vibration guidelines are not applicable directly to the watercraft berthed at the marina, and there is nothing in the however the impact of the construction in terms of the change to the acoustic environment is likely to exact public comment, particularly from those who use the marina for occasional recreational purposes.

Similarly, there are no rules or guidelines within the Auckland Regional Plan: Coastal which relate specifically to construction activities within the Coastal area which are not related to port, airport, navigational or fauna management.

Commercial buildings within the marina are, however, relevant to the application of the construction noise standard. The impact on the commercial buildings will require a more standard approach to mitigation; however, being commercial in nature, the applicable construction criteria are more lenient and will not require onerous measures to be taken. Night time works in particular will be more acceptable to these premises, as the construction noise criteria outside of normal working hours are higher than during the day.

Given the small distances between parts of the marina and the overhead Bridge construction activities alongside or overhead the watercraft, the daytime construction noise limits are likely to be exceeded for a portion of the works.

As the potentially affected watercraft are mobile, and the construction process is more difficult to change, the most likely mitigation option is to relocate the affected watercraft to another marina or berthing location (a minimum of 200m distant to allow for night time works) for the duration of the construction works affecting that craft's normal berthing arrangements. The actual duration of the activities is yet to be determined, and will be based on the final construction programme developed by the Construction Contractor prior to works commencing. However, as the construction relates to both piling and general bridge-building construction activities, it is expected that this time frame will run to years rather than months.

### 8.2.2 Operation

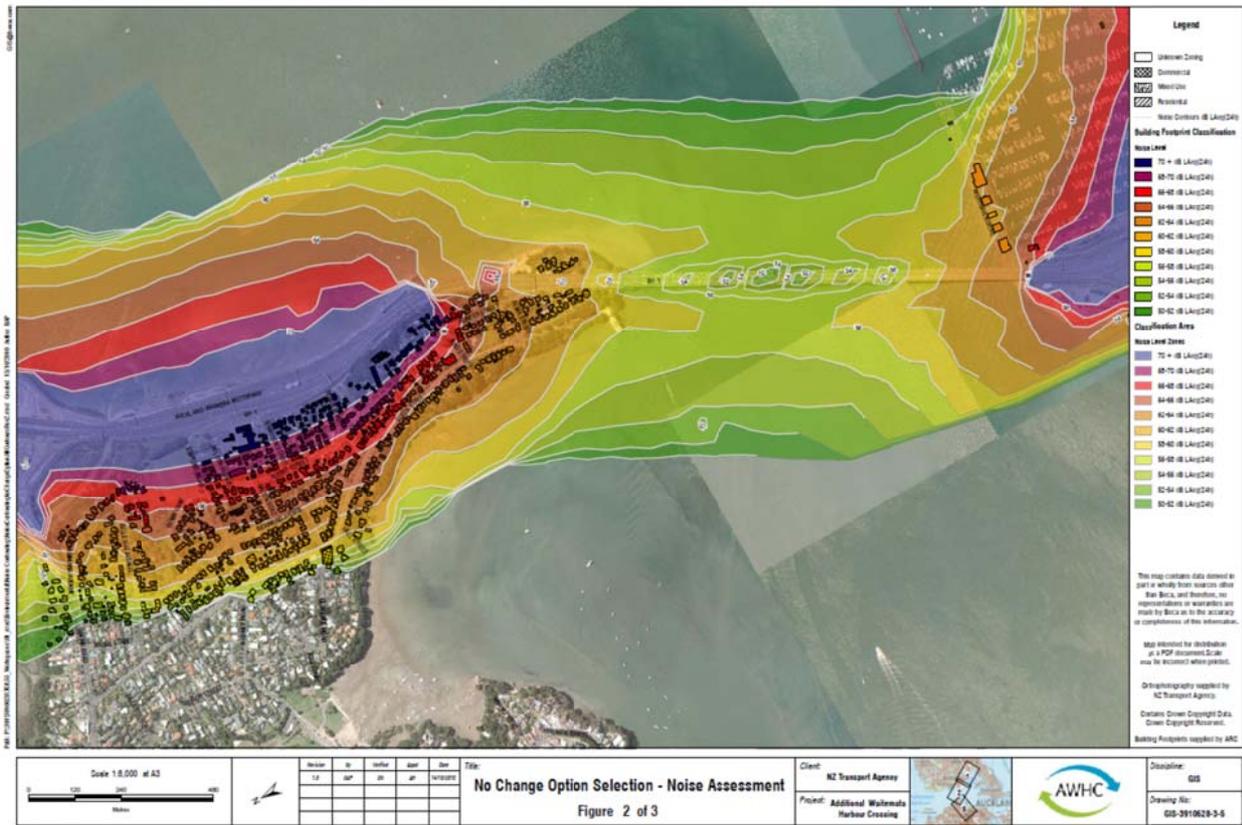
The theoretical predicted traffic noise levels for the three scenarios ("Do-Nothing", Bridge and Tunnel Options) are presented in **Error! Reference source not found.** on the following page for the Central Sector. The data on which these modelled traffic noise levels are based is included in Appendix A for reference.

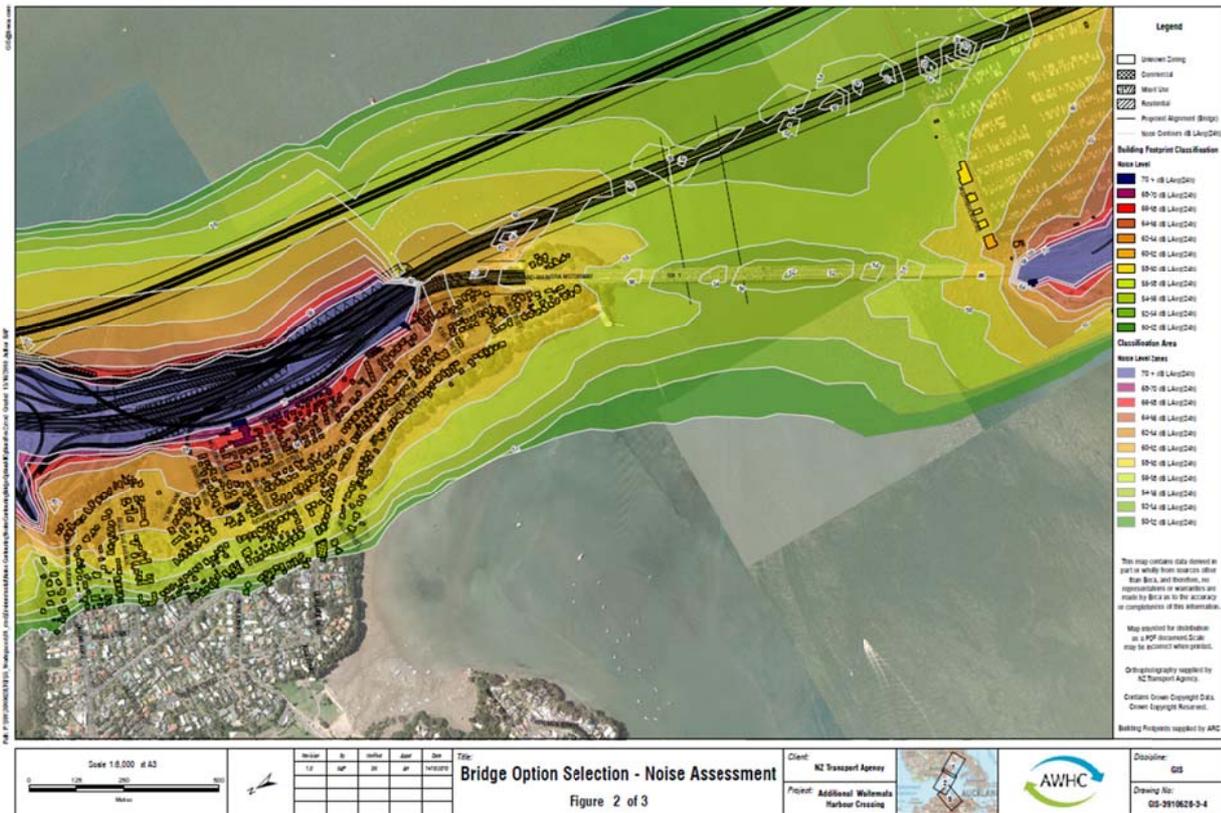
Both the new Bridge and the Tunnel options result in an increase in traffic noise levels at the water level of the harbour. For the Tunnel Option, this is due simply to the increased traffic volumes crossing the existing AHB with the traffic segregation of the Project; for the Bridge Option, this is compounded by the addition to the Harbour area of an additional environmental noise source across the Harbour (the Bridge itself).

There are no PPFs (residential or educational facilities) in the vicinity of the Harbour Crossing itself, therefore no comparison is made against either Category A or Category B of the NZS 6806:2010, as per Figure 8.2 to Figure 8.5.

Road traffic noise from the Bridge option is predicted to increase at the Westhaven Marina itself, by up to 14dB at locations close to the bridge at the point on its span furthest from the existing AHB, representing a clearly noticeable change over the existing noise levels, however is still within ambient noise levels at which comfortable conversation can be held without the need for raised voices.

Therefore, traffic noise mitigation measures are not considered to be warranted for the Central section of the Project for either the Bridge or the Tunnel Option.





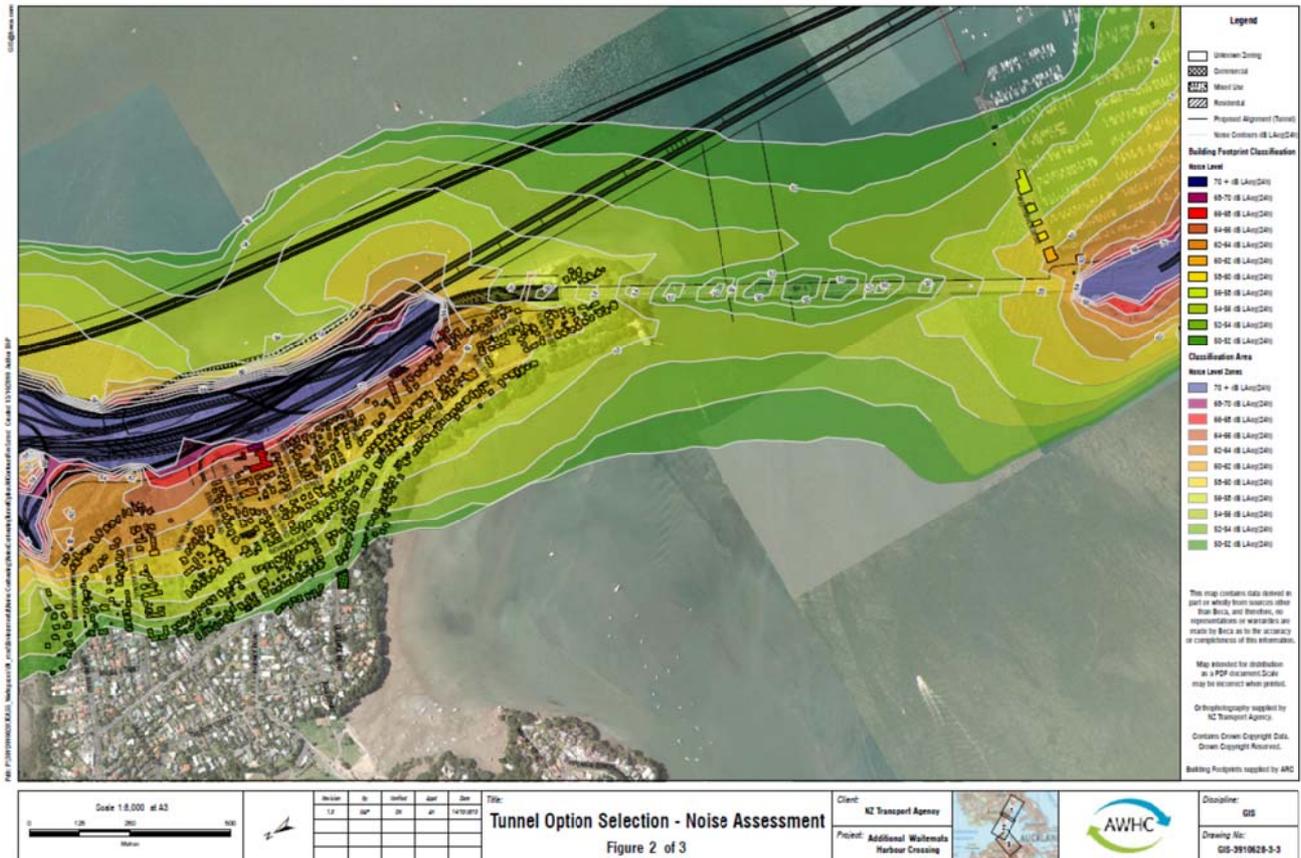


Figure 8.6: Central Sector – Comparison of “Do-Nothing” vs Bridge and Tunnel Options

## 8.3 Southern Sector

The Bridge and Tunnel options make their connections to the existing SH1 and major local roads within this section, via the VPT alignment or new cut-and-cover tunnels.

### 8.3.1 Construction

For the likely complex time frames and construction processes required for the two Options, it is not possible to quantify the construction noise and vibration effects for this section of works with any degree of accuracy. Until the final design is prepared, it will not be possible for any construction contractor to accurately define the equipment, processes or schedule for the construction works for this Project. Nevertheless, some estimations have been provided for guidance in relation to construction noise and vibration from both the Bridge and the Tunnel Option.

Both Bridge and Tunnel options require reclamation of land from the St Mary's Bay foreshore in the Westhaven Marina. The construction activities associated with these earthworks are significant, and it is likely that daytime construction noise limits will be exceeded for these works at residences on London and Harbour Streets. Evening and night time construction works are expected to significantly exceed the relevant noise limits during these periods, and it is recommended that daytime construction only is undertaken as far as is practicable for the project to minimise the need for additional mitigation.

The Bridge option again is expected to generate higher construction noise levels at affected receivers due to the more significant reclamation works required, and the more extensive trenching activities proposed on the St Mary's Bay waterfront. The sides of the trenches and cut-and-cover forms is less beneficial in terms of acoustic shielding than for the northern sector due to the particular topography in the area meaning that elevated residential receivers on the hillside generally have a clear line-of-sight into the working trenches and cut sections of the works.

Clear, frequent and timely consultation advice is recommended to minimise the concern to affected residents. This has been shown to be highly beneficial to the project team and residents alike for the current Victoria Park Tunnel project. Residents may be more accepting of construction noise if the construction team shows commitment to consultation, communication, management and mitigation.

It is strongly recommended that the communication plan and construction management process undertaken by the current Victoria Park Tunnel project be considered and implemented. Construction noise criteria related to the existing high background noise levels within the residential area of St Mary's Bay (in particular) have been successfully implemented, and the process of notification to both residents and Council for any night works or works expected to produce noise levels in excess of even these elevated criteria has resulted in satisfactory outcomes for all parties.

Both Bridge and Tunnel options propose to employ significant extents of cut-and-cover tunnel construction between Beaumont Street and the Cook Street connections. The Bridge option indicates a greater extent of cut-and-cover works through Victoria Park than the Tunnel option, and therefore the issue of construction noise during these earthworks and wall shoring will be greater for the Bridge option. At distances of approximately



80m to the nearest residence at Fisher Point Drive, the construction noise levels are likely to be generally within the daytime construction noise limits, but for evening and night works the construction noise is expected to exceed the criteria.

As the construction process progresses southwards away from the residential area, the likelihood of compliance with the construction noise limits increases at the Fisher Point Drive residences, but exceedance of the noise limits at the commercial / retail properties in the vicinity of the Cook Street connection point increases.

However even with good construction management practices in place, it is likely that the criteria may still be exceeded at times, and it is likely that application for exemptions for specific high-impact procedures may need to be sought from the relevant authority. Good communication with affected parties will be critical to the success of this stage of works for both options.

Vibration from these construction activities is expected to fall within the safe levels for structural damage and tactile (felt) vibration, although for the start of the cut-and-cover works there is a chance that the vibration may be felt for a short period of time until the workfront progresses away from the residences.

As the workfront progresses towards the Cook Street connection point, both options indicate the necessity to remove some commercial buildings to enable the cut-and-cover and trenching processes to proceed. However, despite these removals, there are still several buildings which are located within close proximity to the construction works. Both construction noise and vibration limits will be exceeded, and significant mitigation measures will need to be put in place to manage these locations.

A strong Construction Management Plan will need to be in place to control the use of measures such as low noise / low vibration equipment, local screens up to 1m higher than the relevant item of equipment, and clear and continuous consultation processes to keep affected parties well informed of any significant upcoming construction events which are estimated to cause the construction noise or vibration guideline criteria to be exceeded.

With respect to construction vibration, several sensitive receivers in the vicinity of the project are noted, including the Victoria Park Market, Campbell Free Kindergarten, residential buildings in the vicinity of the Cook Street off-ramp, and potentially even the Victoria Park Tunnel itself which will have been completed by the time the AWHC project commences.

The undertaking of building inspections prior to commencement of works within this section of works, particularly close to the Cook Street and Fanshawe Street works and the sensitive receivers noted above, is crucial to the Project in terms of ensuring certainty for all parties involved in relation to potential building damage arising from the construction works.

Additional to these vibration issues, the Tunnel option involves provision of a new structure to carry the Cook Street on-ramp from the western side of the VPT / AWHC tunnel. This is likely to involve piling for pier supports in the vicinity of the buildings identified above, reinforcing the need for the management procedures identified, in particular the pre-construction building inspections at potentially affected buildings within a prescribed distance of the construction works (e.g. 20m) depending on the equipment to be used.

For the Tunnel option, the tunnel boring machine will pass directly beneath some commercial and hospitality (Swashbucklers Restaurant and Bar) buildings on Westhaven Drive / Beaumont Street. As these are close to the point at which the tunnel emerges from underground and is connected into a cut-and-cover tunnel, it is expected that the distance of the tunnelling beneath the ground level (building ground floors) will decrease as the tunnel approaches the surface. Regenerated noise within those buildings is likely to reach audible levels within the occupied spaces (e.g. 50 dB  $L_{Aeq}$  for a boring depth of 20m). For general office areas, this may be acceptable for short periods of time, however may not be acceptable to patrons of Swashbucklers. In this instance, it may be appropriate to undertake the boring of these last tunnel sections outside of normal office and restaurant opening hours.

Vibration levels generated by the final stages of boring are still not expected to reach levels at which structural damage may occur, however it is likely that the vibration may be felt by staff and patrons. This serves to strengthen the argument for undertaking these works outside of normal operating hours to minimise anxiety and discomfort.

For all areas where vibration is expected to be felt, or where there is a risk of structural damage occurring, the management plan should incorporate a regime of building inspection / dilapidation reporting prior to works commencing. A plan for construction vibration monitoring should also be developed.

### 8.3.2 Operation

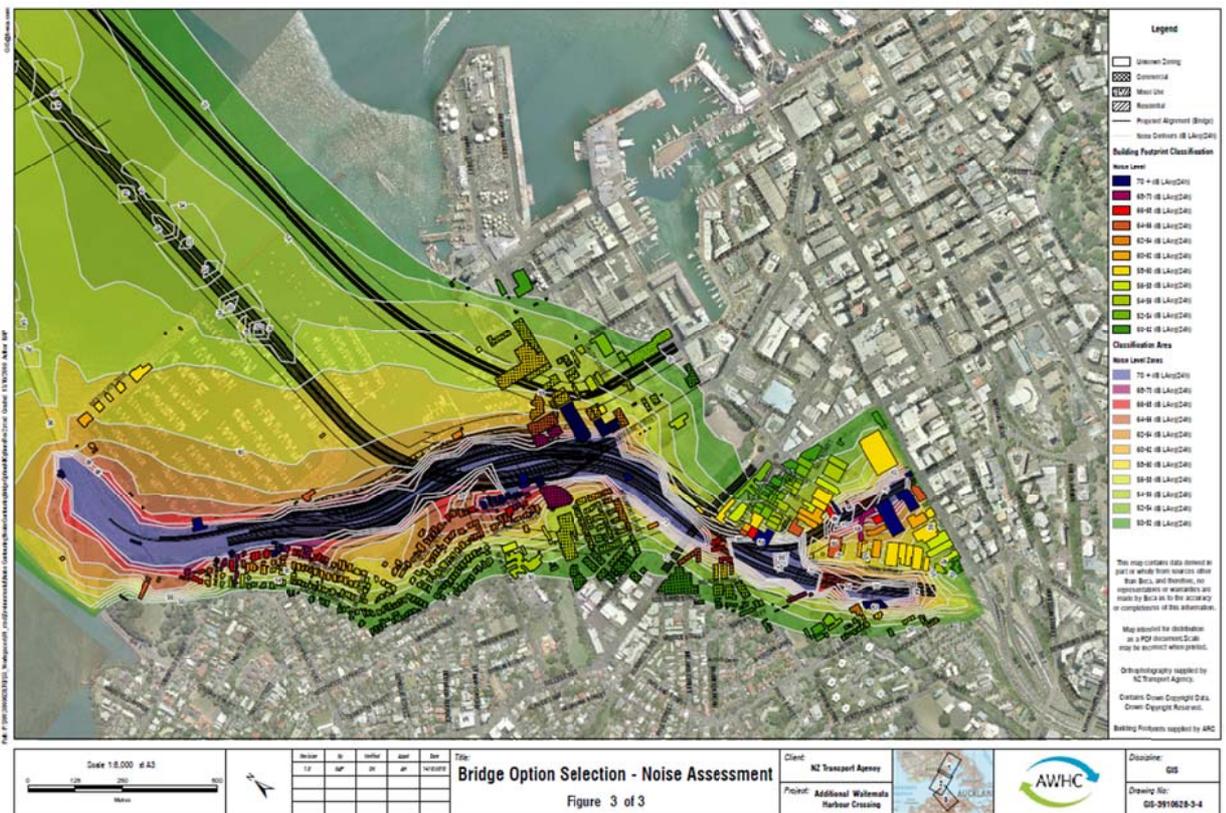
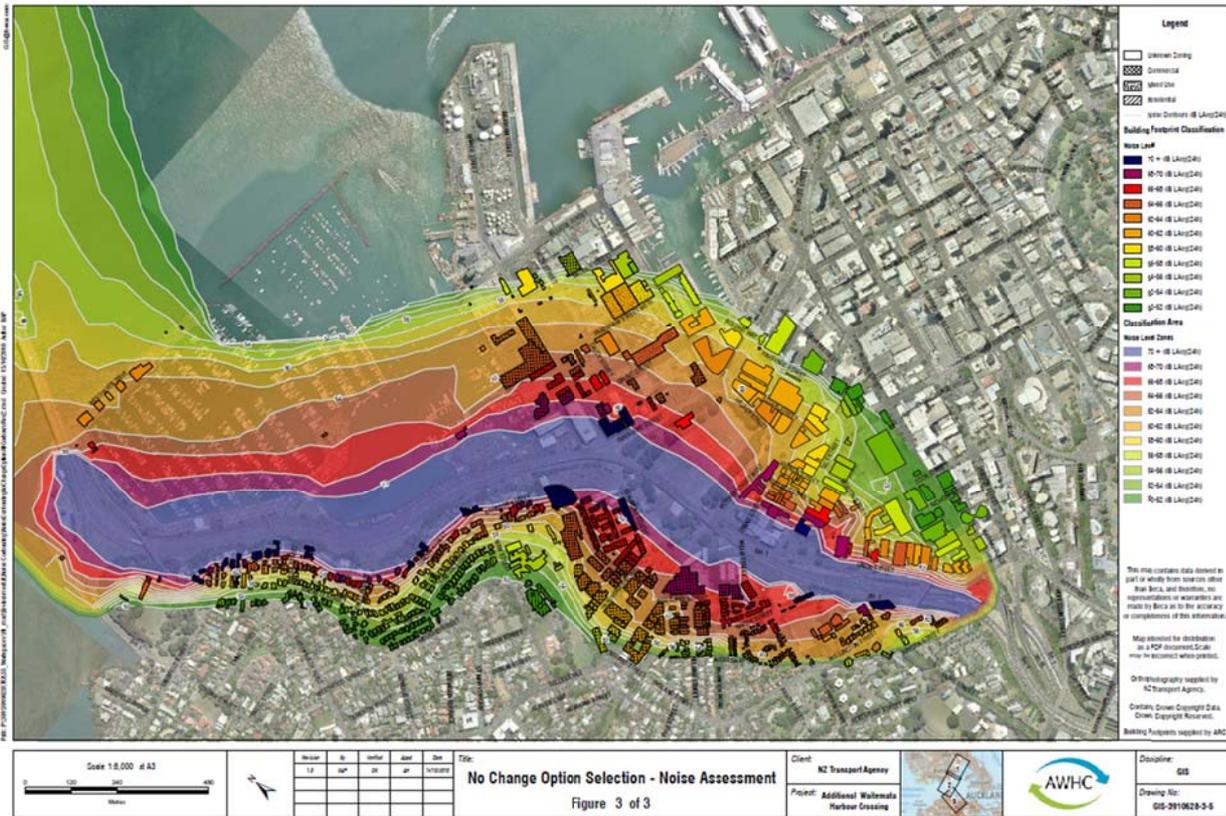
The theoretical predicted traffic noise levels for the three scenarios (“Do-Nothing”, Bridge and Tunnel Options) are presented in **Error! Reference source not found.** on the following page for the Southern Sector. The data on which these modelled traffic noise levels are based is included in Appendix A for reference.

The immediate conclusion to be drawn is that both the new Bridge and the Tunnel options result in reductions in traffic noise levels at relevant residential receivers within 100m of the roadway. This is because that, although overall traffic volumes increase, the effect of relocating a percentage of that traffic to a road (the Project) further from the residential area than the existing motorway counters the expected increase in noise levels due to increased traffic flow.

NZS 6806:2010 (Clause 1.2.3 (c)) indicates that the Standard shall apply to relevant receivers near a new road where the noise from the new road increases the noise level at any affected receiver by 3 dB  $L_{Aeq(24hr)}$ . Therefore, in accordance with the provisions of that Clause, the Standard would not apply to this section of the road.

Even if both Options were in some manner considered to be “altered” versions of the existing SH1, the rules under which the Standard is considered indicate that the Standard is not applicable to this section of the Project. Clause 1.5.2 indicates that where the traffic noise levels (at affected receivers) as a result of the upgrade (without mitigation) are greater than or equal to 68 dB  $L_{Aeq(24hr)}$ , as may be the case for the AWHC project, traffic noise levels as a result of the Project would need to increase by at least 1dB over the “do-nothing” traffic noise levels, which is not the case for either Option.

Therefore, no traffic noise mitigation is required for either option.



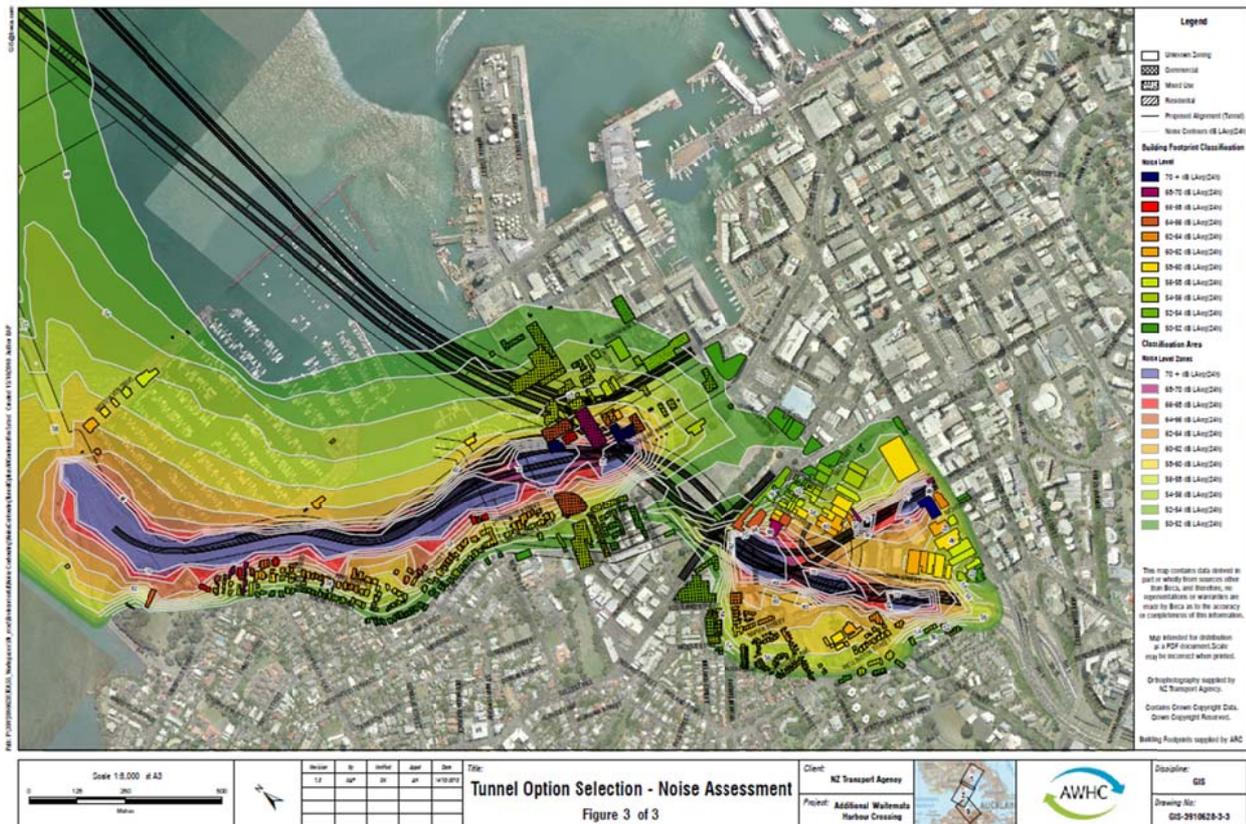


Figure 8.7: Southern Sector – Comparison of “Do–Nothing” vs Bridge and Tunnel Options

Nevertheless, to enable a comparison between the potential effects for the two Options, the predicted noise levels and number of affected residences in the vicinity of the Options are also considered.

It should be noted, as above, that no attempt has been made at this stage to calibrate the acoustic modelling against existing traffic noise levels – this would be undertaken at the design phase. Nevertheless, within the limitations of the theoretical traffic noise modelling, the predicted traffic noise levels for the two Options are considered to be representative of the order of magnitude of impact of traffic noise on affected properties.

Figure 8.8 and Figure 8.9 indicate the relationship of the two Options to the Category A (64 dB LAeq(24h)) and Category B (67 dB LAeq(24h)) design targets as indicated by NZS 6806:2010, regardless of the conclusions drawn above regarding the applicability of this Standard to this Project.

By means of comparison, the estimated number of residences falling into these Categories are as follows :

Table 8.2: Southern Sector – Bridge vs Tunnel – Number of Receivers in NZS 6806:2010 Categories.

AWHC Option	Protected Premises and Facilities Within 100m of Upgraded Road		
	Category A	Category B	Category C
Bridge	76	46	51
Tunnel	57	53	44

Therefore, in terms of numbers of (potentially) affected residences alone, the Bridge option shows more affected properties than the Tunnel for the Southern Sector, particularly along Ring Terrace and where the Bridge connects into SH1 near Waitemata Street.

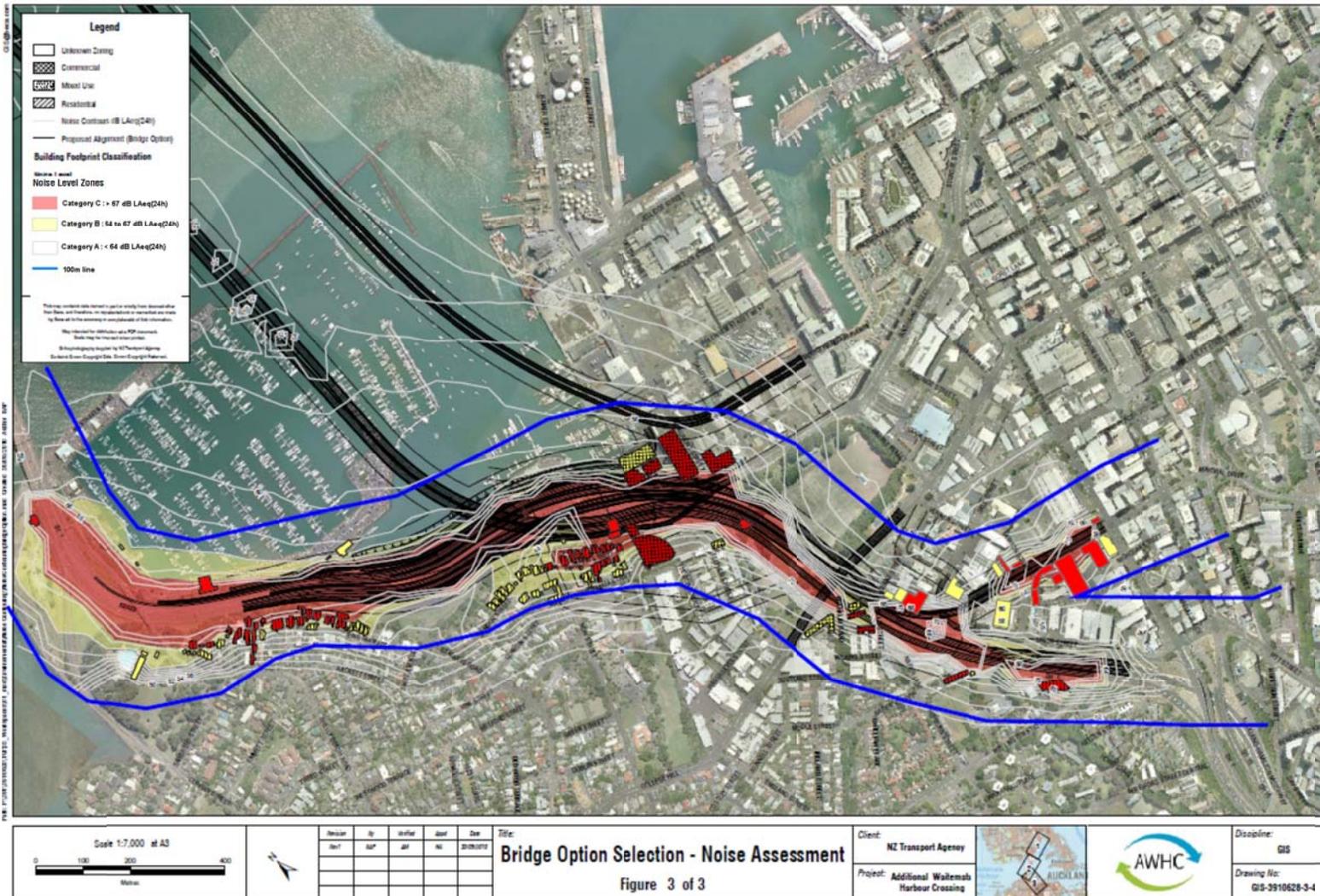


Figure 8.8: Southern Sector –Bridge Option

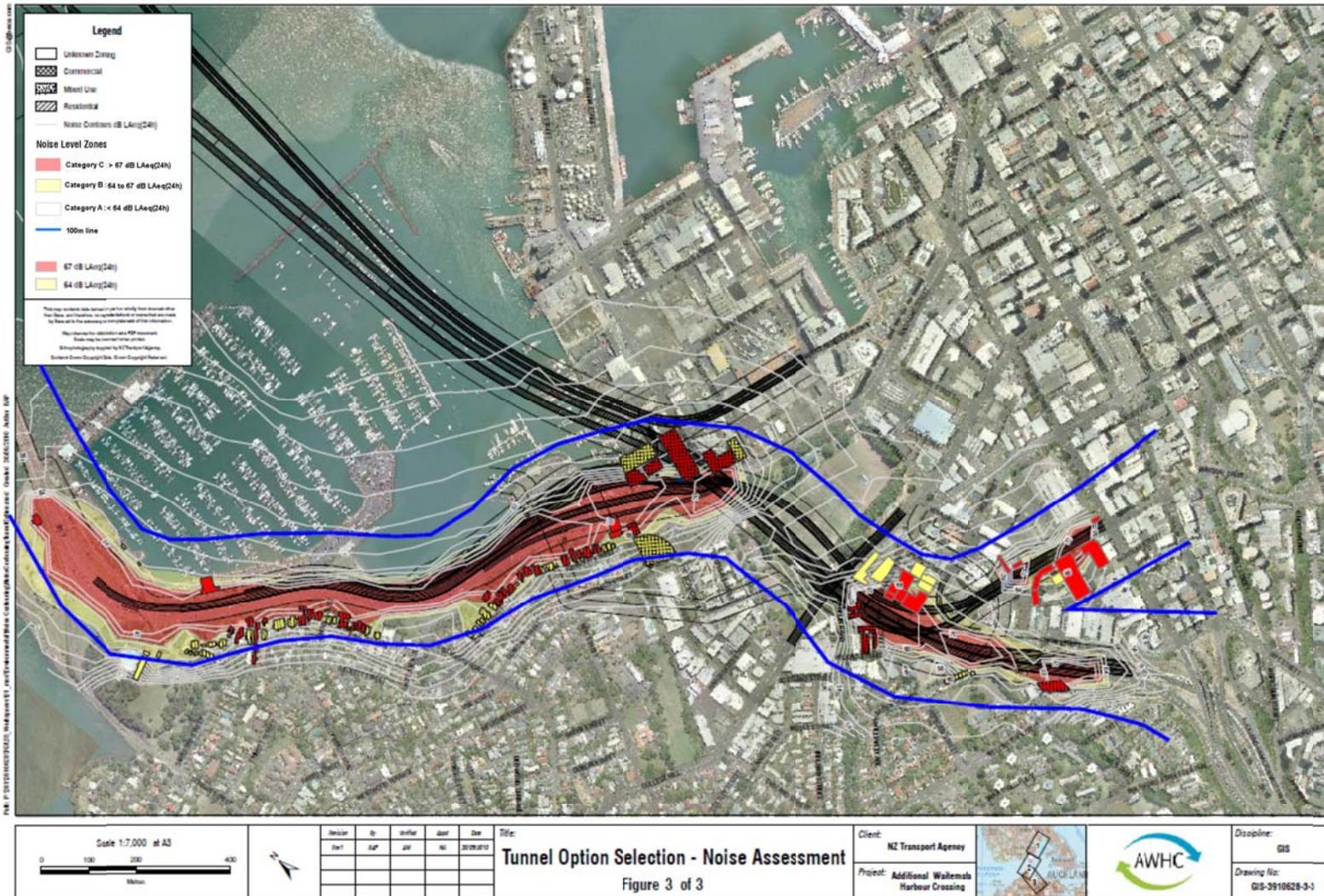


Figure 8.9: Southern Sector - Tunnel Option

For both options, the impact of the AWHC project on received road traffic noise levels at the Wynyard Quarter is small, well below the threshold criteria given in NZS 6806:2010 for residential areas adjacent new roads.

For both Bridge and Tunnel options, the southern end of the proposed works represents an area where operational traffic noise is predicted to be markedly reduced from the existing situation. The new roads associated with the AWHC project are predominantly below ground for this section – for the Bridge option, this is cut-and-cover tunnels from Wynyard Quarter up to the approach to the Cook Street trench and across Victoria Park; for the Tunnel option, the bored tunnels rise to the surface and continue as cut-and-cover tunnels to a similar extent to the Bridge option.

Traffic noise levels at the residences on Napier Street, which are located within approximately 25m of the motorway, would nominally increase with the increased capacity afforded by the AWHC project. However, the provision of a road trench in the vicinity of these residences means that this increase is somewhat counteracted by the partial acoustic shielding provided by the new road alignment; specifically shielding of road–tyre interface noise provided by the walls of the trench.

By comparison, the operational traffic noise effects of the Tunnel option on nearby sensitive land- or water-based receivers is negligible, as all noise is effectively contained within the tunnel as it progresses.

## 9. Conclusion

The construction and operation of the proposed road Tunnel option is anticipated to provide a solution which has generally less impact on potentially affected premises when compared to the road Bridge option, in terms of environmental effects relating to operational and construction noise and vibration. Although the construction noise and vibration effects of the Bridge option may be more significant than the Tunnel option, the operational effects of the Bridge option are still less than the ‘do nothing’ scenario.

For the northern sector of the works, there is little to distinguish between the two options for either construction or operational noise and vibration. However, for the central sector, the enclosure of construction equipment (tunnel boring machine) and operational traffic within the Tunnel option means that there is no emission of noise from either construction or operation to affected properties from the actual crossing of the harbour. For the southern sector, both options require significant earthworks in terms of providing the proposed cut-and-cover tunnels and trenches, and although the two options are similar, they both result in likely exceedances of construction noise and vibration criteria.

It is considered that there is no significant difference between the rail alignments proposed for the Bridge vs Tunnel options. Therefore, in terms of the comparison of environmental effects relating to operational and construction noise and vibration, there is no significant benefit or disadvantage attributable to either the Bridge or the Tunnel option.



## APPENDIX A

Data on which Derivation of  $L_{Aeq,24h}$  Traffic Noise Levels is based



<b>SB All Vehicles</b>	<b>2041 (AADT)</b>	<b>%HCV</b>	<b>Comments</b>
Esmonde on	26844	6%	
Onewa on	21552	7%	
Esmonde-Onewa (M'way)	77207	5%	
AHB, main	38944	9%	
AHB, Shelly beach	11976	2%	
WHC	73235	4%	
Fanshawe off	22795	9%	
Cook off	16149	8%	
<b>NB All Vehicles</b>			
Esmonde off	38665	6%	
Onewa off	17663	5%	
Onewa-Esmonde (M'way)	107231	5%	
AHB	54599	6%	
WHC	74755	5%	
Fanshawe on	20871	9%	
Cook on	16918	6%	
<b>Assumed Data</b>			
<b>SB All Vehicles</b>			
Esmonde off	0	0%	Not modelled
Esmonde on to WHC	13422	6%	Half Esmonde on traffic
Esmonde on to AHB	13422	6%	Half Esmonde on traffic
Onewa on to WHC	10776	7%	Half Onewa on traffic
Onewa on to AHB	10776	7%	Half Onewa on traffic
M'way to WHC	49037	3%	WHC less traffic coming from Esmonde and Onewa
M'way to AHB	26722	8%	AHB (main + Shelly beach) less traffic coming from Esmonde and Onewa
Onewa off	1448	17%	Esmonde-Onewa (Mway) less Mway to WHC and Mway to AHB
<b>NB All Vehicles</b>			
Onewa on	1448	17%	Same as Onewa off
WHC to Onewa off	13622	5%	Sum of AHB, WHC and Onewa on less Onewa-Esmonde (Mway) multiplied by %traffic on WHC
AHB to Onewa off	9949	5%	Sum of AHB, WHC and Onewa on less Onewa-Esmonde (Mway) multiplied by %traffic on AHB
WHC to Onewa-Esmonde (M'way)	61133	5%	WHC less WHC to Onewa off
AHB to Onewa-Esmonde (M'way)	44650	5%	AHB less AHB to Onewa off

Traffic speed = 80km/hr everywhere (all scenarios)

Road surface = dense graded asphalt (all scenarios)