Watercare Services Limited

Motions Catchment Improvement

Construction Noise and Vibration Assessment

July 2025

Tonkin+Taylor

Watercare


Ki te ora te wai, Ka ora te whenua, Ka ora te tangata

Document Control

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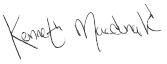
1	Approved by	Ken Macdonald	Project Director	23.07.25	
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Executive Summary

An assessment of noise and vibration has been undertaken for the construction of the proposed Motions Catchment Improvement Project, focusing on compliance with Auckland Unitary Plan (AUP) standards and identifying potential management and mitigation measures. Two tunnelling methods, pipe jacking and tunnel boring machine (TBM), have been considered, accounting for differences in shaft locations and alignment. The assessment has adopted a "worst-case scenario" approach to evaluate potential effects across eight main and eight interception shafts, using an indicative construction methodology.

The analysis predicts noise and vibration levels for key construction activities, including shaft construction (piling), open trenching, and tunnelling. Predictions used SoundPlan v9.1 modelling software, considering terrain, building heights, and standard mitigation, such as 2 m perimeter barriers around construction areas. However, multi-storey buildings near certain shaft locations, such as around Basque Park, present additional challenges for noise mitigation, particularly for upper floors.

Key findings from the assessment include:

- **Noise Levels**: During piling, 67 out of 186 receivers may experience noise above the AUP daytime limit of 70 dB L_{Aeq}, with nine receivers expected to exceed 80 dB L_{Aeq}. Open trenching near some properties may generate similarly elevated levels (up to 86 dB L_{Aeq}[1]), especially when rock breakers are used.
- **Vibration Levels**: 51 receivers are predicted to exceed the AUP amenity vibration limit of 2 mm/s PPV, with five residential properties predicted to exceed the cosmetic damage threshold of 5 mm/s PPV. Certain heritage properties on Cooper Street may experience vibration levels of 3–4 mm/s PPV during rock breaking or vibro piling, requiring tailored mitigation strategies.
- **Tunnelling Noise and Vibration**: Pipe jacking will operate during daytime hours, while TBM may operate 24/7, with both methods compliant with AUP standards for noise and vibration. Night-time TBM operations can meet stricter regenerative noise and vibration criteria.

While elevated noise levels are anticipated during intensive works like piling and rock breaking, such effects are typical of large-scale infrastructure projects in Auckland and have been successfully managed in similar cases, such as the Central Interceptor and City Rail Link. Mitigation measures including barriers, alternative construction methods, and consultation with affected communities will be critical to ensuring effects are minimised. A draft Construction Noise and Vibration Management Plan (CNVMP) outlines these measures to ensure compliance with best practicable options (BPO) and to manage effects effectively.

Overall, with appropriate mitigation and proactive communication, noise and vibration impacts are considered manageable and within acceptable limits for a project of this scale.

[1] Affected party approval is being sought for one property predicted to exceed 100 dB L_{Aeq}

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1 Introduction

1.1 About Watercare

Watercare Services Limited (Watercare) is a lifeline utility responsible for the planning, maintenance, and operation of wastewater services to communities in Auckland. Its activities and programmes are funded through user charges and borrowings. Watercare is required by the local authority by the Local Government (Auckland Council) Act 2009 to be a minimum-cost, cost-efficient service provider.

Watercare collects wastewater from 1.7 million people's homes including trade waste from industry, through approximately 8,700 km of pipelines, pumps through 534 pump stations, treats approximately 410 million litres of wastewater daily through 18 treatment plants and disposes in environmentally responsible ways to protect the public health, the local environment and coasts and harbours.

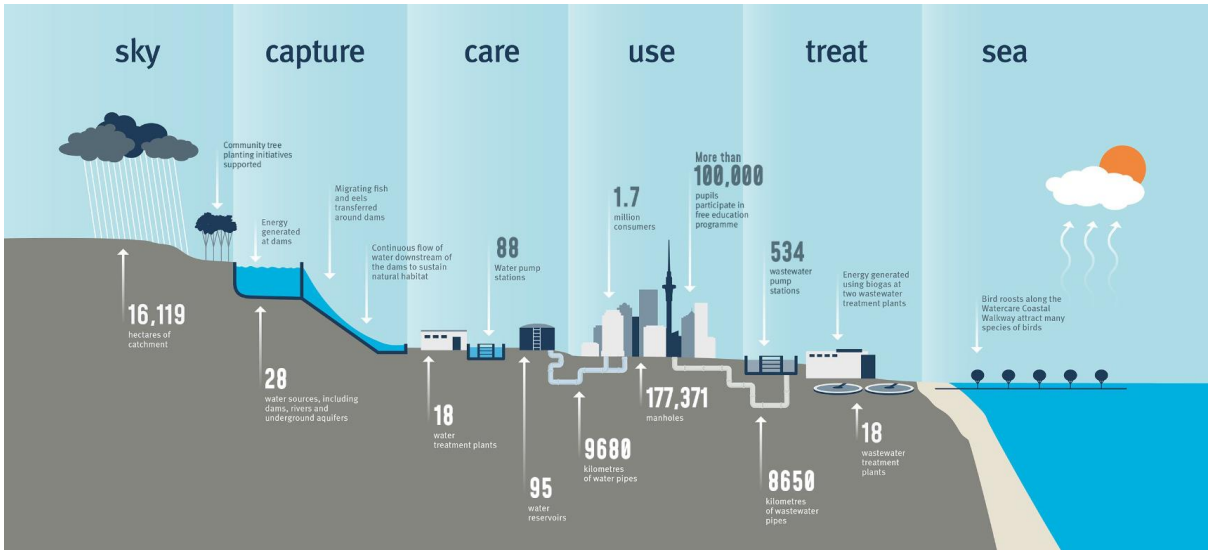


Figure 1: Overview of our assets and operations.

Watercare's activities are intrinsically linked to the health of people and the natural environment. Auckland's wastewater sources must be of sufficient volume and reliability to improve the quality of beaches and waterways.

Watercare carries out significant work to upgrade and build infrastructure, to maintain levels of service and provide capacity for a fast-growing population. Watercare ensures Auckland and its people continue to enjoy dependable services by upgrading its assets, planning, building, and delivering new infrastructure in cost-efficient ways.

1.2 Project background and description

The Western Isthmus Water Quality Improvement Programme (WIWQIP) Motions Catchment Improvements Project (the Project) involves the construction of a new collector sewer approximately 3.2 kilometres in length from Canada Street in Auckland's Central Business District (CBD) to Western Springs Park in Western Springs. The collector sewer is proposed to be a diameter ranging from 2.4 m up to 4.5 m and will have three branch connections. Two branch

connections will go under State Highway 16 connecting the Newton Catchment to Suffolk Reserve and connecting Arch Hill Scenic Reserve and southern parts of Grey Lynn to Nixon Park. The third branch connection will connect Suffolk Reserve to Basque Park. There will also be 16 Engineered Overflow Points (EOPs) and 16 local network connections. The Project will tie into the Central Interceptor at Western Springs Park.

The Project is part of the WIWQIP which aims to significantly reduce wastewater overflows into the Waitematā Harbour in order to improve stream and beach water quality across the City's Central Western Isthmus. The aim of the Project is to build a new pipeline to collect combined wastewater and stormwater flows from the Motions Catchment and convey these to the Central Interceptor at Point Erin Park, where they can then be safely conveyed to the Māngere Wastewater Treatment Plant. The WIWQIP is a joint initiative between Watercare and Auckland Council's Healthy Waters that was established in 2017 and has been identified in Watercare's Asset Management Plan 2021 – 2041 as a key programme to further protect the environment and provide clean harbours and waterways.[2] At a high level, the three main goals of the WIWQIP are:

- To reduce risks to public health by alleviating uncontrolled discharges into local catchments;
- To remove the permanent health warning status of both Meola Reef and Cox's Bay; and
- To reduce intermittent beach closures in the area over the next 10 years.

The Project is a critical component of the wider WIWQIP which will enable Watercare to bring about considerable environmental benefits, reduce risks to public health and improve the amenity of the Motions catchment. For further detail regarding the proposed works and the Project's objectives, please refer to Section 4 of the Assessment of Effects on the Environment.

1.3 Purpose of this report

This report has been prepared by Tonkin & Taylor Ltd (T+T) to support a resource consent application by Watercare for the Project. The following reasons for consent pertaining to noise and vibration have been identified:

- Rule E25.4.1 (A2): Construction noise and vibration levels will not comply with Standards E25.6.27 and E25.6.30. The construction activities will likely last more than 20 weeks. The 70 dB L_{Aeq} noise limit will be exceeded at 67 properties during shaft construction and at 34 properties for open trenching. Four receivers in the Cooper Street heritage area (SH13) are predicted to be subject to an exceedance of the 3 mm/s PPV threshold for sensitive heritage listed buildings, with levels of 3–4 mm/s PPV during rock breaking and vibro piling. 51 receivers may experience vibration above the AUP amenity limit of 2 mm/s PPV. Five properties will experience an exceedance of the 5 mm/s PPV cosmetic damage threshold. This requires a **restricted discretionary activity** resource consent.

For all resource consent triggers, please refer to the Assessment of Environmental Effects (AEE) for further details.

[2] Evidence of Stephen Webster for the Herne Bay Tunnel at [1.4].

This report provides an assessment of the noise and vibration effects associated with the construction of the Project. In particular, this report:

- Establishes the relevant noise and vibration limits for the construction sites set out in the Auckland Unitary Plan (AUP);
- Identifies the construction activities that will generate noise and vibration;
- Identifies noise sensitive receivers/potentially affected parties;
- Identifies potential night works and associated effects;
- Predicts the construction noise and vibration levels at identified receivers and determines compliance with relevant noise and vibration limits;
- Discusses potential noise and vibration effects;
- Discusses the reasonableness of those effects; and
- Provides recommendations to avoid, remedy, or mitigate those effects.

A glossary of terms is included at the end of this report (Appendix A).

This report has been prepared in accordance with T+T's proposal dated 17 April 2025[3].

[3] T+T, 17 April 2025, Letter of Engagement, Specialist technical reporting to support a resource consent application for the 'Motions' Project (ref job no. 0030552.5024).

2 Proposed works

2.1 Project alignment

Figure 2 and Figure 3 below shows the proposed alignment for the pipe jacking option and the tunnel boring machine (TBM) option. The key difference between the two options in terms of alignment is the location of Shaft 07a and the corresponding alignment as identified by the blue box in the figures below.

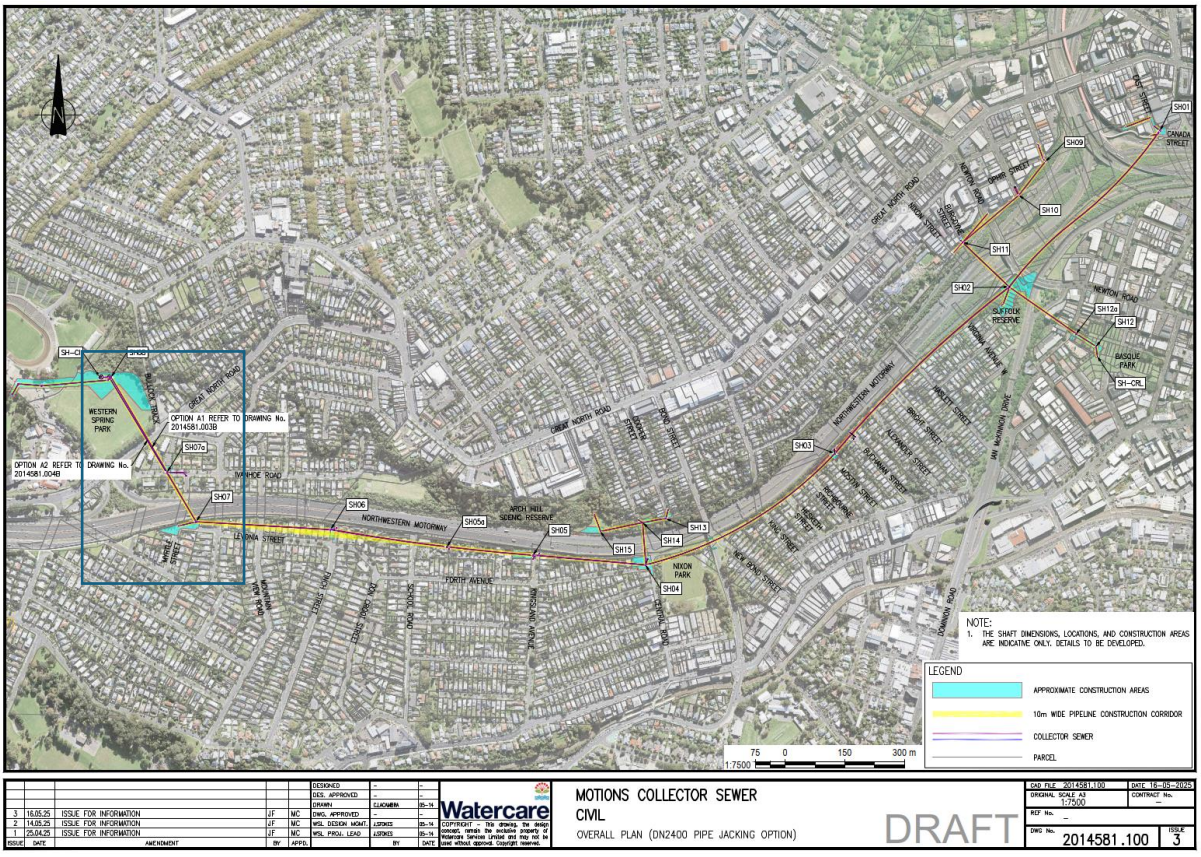


Figure 2: Overall plan for pipe jacking option

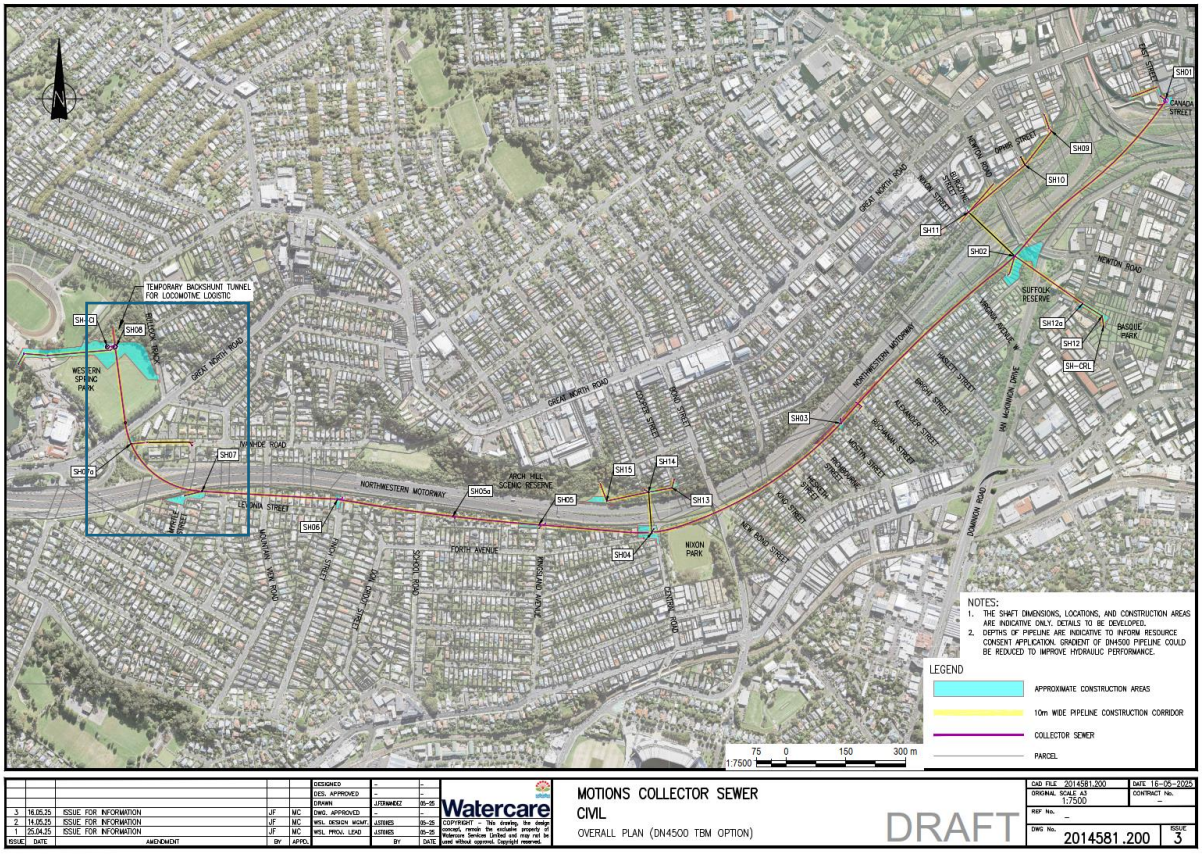


Figure 3: Overall plan for TBM option

2.2 Construction activities

A preliminary construction methodology[4] for the Project has been provided for review by Watercare and the proposed construction activities required are outlined in Table 2.1. The methodology is consistent with other Watercare tunnelling projects such as the Herne Bay Tunnel.

The pipeline will be constructed using a series of shafts, from which a micro-tunnelling machine (also known as pipe jacking machine) or TBM is launched (via thrust shafts) and retrieved (via receiving shafts). As the tunnelling machine (pipe jacking or TBM) advances, pipe sections are installed in the thrust shaft and jacked in behind the machine in the case of pipe jacking, or segmental linings are installed immediately behind the machine in the case of TBM tunnelling. The TBM will run in one continuous run.

Interception shafts are required along the alignment to provide connections from the local network to the Main Collector Sewer and the connections to the Engineered Overflow Points (EOP)s either drilled with trenchless technology or laid in open trenches as feasible.

[4] Construction statement memorandum – Aurecon – Ref 521290-064, Dated 14-05-2025

Table 2.1: Construction and staging activities

Construction Elements	Activities
Establishment	Main site established – (at Western Springs): • Central construction support compound set up • Worker welfare facilities established • Temporary traffic management set out
Enabling	Enabling works at each shaft location: • Pothole services throughout the route • Service diversions
Satellite site establishment	• Traffic and fencing management • Environmental controls • Hardfill • Plant delivery
Shaft piling	Piling shaft construction: • Temporary excavation support – either casing shaft or secant piling • Removal of spoil
Shaft construction	• Concrete breaking back • Excavation • De-water shafts • Concrete construction
Interception shafts construction	• Construct drilling platform • Drill casing • Cut into main sewer • Install manhole
Tunnelling	• Tunnelling using a TBM or Pipe jacking method • Set up tunnelling rig/equipment – supporting crane and excavator • Spoil removal • Install pipes
Manhole construction	• Install manholes within shafts • Progress backfilling of shaft around manhole • Removal of sheet piling or casing shaft as required • Break down concrete of secant shaft 1 m below ground • Reinstatement of surrounding roadway
Directional drilling	• Excavate drill pits with trench shields • Drill bore • Pull through drainage line
Open trenching	Open trench construction (limited section as needed): • Temporary excavation support – trench shields • Removal of spoil – to be loaded onto truck and removed from site • Install bedding and then new pipe, manhole backfill • Reinstatement works • Activities will be undertaken during daytime hours

Construction Elements	Activities
Reinstatement	Road reconstruction: • Concrete break out and excavation • Kerbing • Traffic Islands and footpaths • Asphalt • Line marking

2.2.1 Tunnelling

For the TBM option, there will be one launch shaft and one reception shaft at either Shaft 8 Western Springs Park (SH08) or Shaft 1 Canada Street (SH01) with tunnelling completed in one continuous run. SH08 is the preferred location for launching. The number of shafts is the same for both pipe jacking and TBM options to cater to the designed hydraulic connection points to the Main Collector Sewer.

The following pipe jacking sequence is proposed:

Table 2.2: Mainline tunnelling sequence

Tunnelling sequence	Launch shaft to reception shaft
Drive 1	Shaft 7 to Shaft 8
Drive 2	Shaft 7 to Shaft 6
Drive 3	Shaft 4 to Shaft 6
Drive 4	Shaft 4 to Shaft 3
Drive 5	Shaft 2 to Shaft 3
Drive 6	Shaft 2 to Shaft 1

Branch pipelines off the mainline will be pipe jacked for smaller pipelines (micro-tunnelling) with the following sequence:

Table 2.3: Branch pipeline tunnelling sequence

Micro tunnel sequence	Launch shaft to reception shaft
Drive 1	Shaft 4 to Shaft 14
Drive 2	Shaft 14 to Shaft 15
Drive 3	Shaft 14 to Shaft 13
Drive 4	Shaft 12a to Shaft 12
Drive 5	Shaft 11 to Shaft 10
Drive 6	Shaft 9 to Shaft 10
Drive 7	Shaft 2 to Shaft 12a
Drive 8	Shaft 2 to Shaft 11

2.2.2 Satellite construction sites

At each shaft location, a satellite construction site (CS) may be established where space permits, with its footprint minimised by utilising the central compound for material and plant storage. These satellite CSs will be set up progressively as the Project advances and will be disestablished as soon as they are no longer required, in order to minimise the number of active CSs at any one time.

There are also two locations that have been identified that will allow more room to support the CSs and enable additional storage space for materials and plant when required. The two locations for larger construction hubs are:

- Western Springs Park
- Suffolk Reserve

The CS working areas (CWAs) encompass all temporary and permanent facilities required throughout the construction phase. The CWAs will typically include:

- Zones for actual construction activities, such as excavation, foundation works, and structural installation;
- Space for temporary works, including scaffolding, formwork, and construction access roads;
- Operational areas for equipment and machinery;
- Storage zones for materials, plant, and construction site offices;
- Facilities for workers, including amenities and designated safety zones;
- Laydown areas for tunnel lining segments or ring components, particularly where TBMs are used;
- Dedicated zones for slurry treatment, ventilation plant, spoil (muck) handling and disposal and ancillary systems (tunnelling support at launch sites); and
- Construction programme and durations.

The indicative construction activities described in Table 2.1 are expected to be undertaken within two years of commencement.

2.2.3 Indicative construction durations

Whilst the construction methodology has not been finalised, an indicative programme has been provided to consider the overall envelope of effects. A detailed construction programme and methodology will be finalised by the contractor prior to the commencement of the works.

Indicative durations at each shaft locations are provided in Table 2.4 based on a pipe jacking method. These are subject to change which can be due to a variety of factors such as weather, ground conditions etc.

Table 2.4: Indicative construction durations at shaft site locations

Location	Approximate total time at location	Approximate shaft construction timeframes
SH08 – Western Springs	170 days	50 days

Location	Approximate total time at location	Approximate shaft construction timeframes
SH07 – Myrtle Street	230 days	35 days
SH06 – Finch Street	240 days	30 days
SH05 – Kingsland Avenue	270 days	40 days
SH04 – Nixon Park Carpark	260 days	40 – 60 days
SH03 – Mostyn St	280 days	35 days
SH02 – Suffolk Reserve	320 days	70 – 95 days
SH01 – Canada St	95 days	40 days
SH13, SH14, SH15 - Arch Hill	110 days	30 days (per shaft)
SH12a, SH12 - Basque Park	105 days	30-40 days (per shaft)
SH9, SH10, SH11 - Newton Road	120 days	30 days (per shaft)

2.2.4 Working hours

Noise generating activities and truck movements will typically occur during standard construction hours, which are as follows:

- Monday to Friday: 7 am to 6 pm (site mobilisation and pack down works are proposed to occur 30 mins before and after these time windows);
- Saturdays: 8 am to 6 pm;
- Sundays or public holidays: no works; and
- Tunnelling activities using the pipe jacking method will occur during the standard daytime construction hours only. The TBM method will occur 24 hours, 7 days a week.

Due to the nature of construction, it is likely that some activities will be undertaken outside these usual hours, for example, site meetings, setup, pack up, large plant (such as TBM) delivery early in the morning or later in the evening to avoid peak traffic volumes. Closed Circuit Television Video inspections, and service relocations and their connections will be carried out at night to reduce service disruptions. Work outside of standard hours will be limited as far as is practicable to reduce disruption as outlined above.

These activities undertaken outside work hours have been assessed as low risk, meaning that these activities are likely to be within permitted noise levels and will be carried out to meet AUP requirements. The works outside of standard construction hours will be detailed in the Project's draft CNVMP and/or an Activity Specific Construction Noise and Vibration Management Plan (ASCNVP), with specific sections identifying management and mitigation measures (i.e. adopting the best practicable option (BPO) to minimise potential adverse effects) such as communication with surrounding properties, the use of acoustic barriers and other practicable controls.

3 Performance standards

3.1 Introduction

The AUP sets out noise and vibration standards[5] for permitted activities. If noise and/or vibration above the applicable AUP limits is generated, then a resource consent is required.

In addition to this, there is a general duty under section 16 of the RMA to avoid unreasonable noise.

> *'Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level.'*

This section identifies the relevant performance standards applicable for the Project and as accepted on other Auckland projects such as Herne Bay Tunnel.

3.2 Construction noise

Standard E25.6.1(3) of the AUP states that "*The noise from any construction work activity must be measured and assessed in accordance with the requirements of New Zealand Standard NZS 6803:1999 Acoustics – Construction noise*".

Standards E25.6.27(1) and E25.6.27(2) respectively contain construction noise limits for activities sensitive to noise (residential receivers) and for any other activity (commercial receivers).

In accordance with E25.6.27(4), projects with a construction duration of more than 20 weeks are to include a 5 dB reduction to the noise limits in Table E25.6.27.1 and Table E25.6.27.2. The applicable construction noise limits with the required 5 dB reduction applied (in accordance with NZS 6803:1999) are detailed in Table 3.1 for residential receivers and Table 3.2 for non-residential receivers. The limits apply at 1 m from the façade of any building that contains an activity sensitive to noise that is occupied during the works.

Table 3.1: Construction noise limits for residential dwellings

Time of week	Time period	Noise limit dB	
		L_{Aeq}	L_{Amax}
Weekdays	6:30 am – 7:30 am	55	70
	7:30 am – 6:00 pm	70	85
	6:00 pm – 8:00 pm	65	80
	8:00 pm – 6:30 am	45	75
Saturdays	6:30 am – 7:30 am	45	75
	7:30 am – 6:00 pm	70	85
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75

[5] AUP, Chapter E Auckland-Wide Built Environment - E25 Noise and Vibration

Time of week	Time period	Noise limit dB	
		L_{Aeq}	L_{Amax}
Sundays and Public Holidays	6:30 am – 7:30 am	45	75
	7:30 am – 6:00 pm	55	80
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75

Table 3.2: Construction noise limits for noise affecting non-residential activities sensitive to noise

Time Period	Maximum noise levels (L_{Aeq} dB)
7:30 am – 6:00 pm	70
6:00 pm – 7:30am	75

3.2.1 Works in the road reserve

Mainline SH01 (Canada Street), near SH05 along Fourth Avenue, branch line SH09, SH10, and SH11[6] are located solely within the road reserve

Planned works within the road reserve between 7 am and 10 pm are not required to meet the above construction noise limits where, because of the nature of the works and the proximity of receivers, the noise generated cannot practicably be made to comply with Table 3.1 and Table 3.2 (E25.6.29(3)(b)), provided that a CNVMP is submitted to the Council no less than five days prior to the works commencing (E25.6.29(3)(d)). The requirements for the CNVMP are listed in Standard E25.6.29(5) and include:

- Details of the community consultation to be undertaken to advise the occupiers of properties located within 100 m of the proposed works of relevant details of the works;
- A description of the works and duration, anticipated equipment to be used, the processes to be undertaken and the predicted noise and vibration levels; and
- Identification of the best practicable options that will be undertaken to mitigate and minimise any noise and vibration being produced that is likely to exceed the relevant construction noise and vibration limits.

The removal of noise limits for works in the road reserve allows for potentially disruptive works to be completed efficiently to minimise road closures and subsequent disruption. As stated, this does not remove the requirement to manage noise levels.

3.3 Vibration from construction activities

The AUP contains standards relating to construction vibration that cover both building damage and amenity limits[7]. Standard E25.6.30 states that construction activities must be controlled to ensure any resulting vibration does not exceed:

[6] Receivers that are subjected to noise and or vibration effects from SH01, SH05, SH09, SH10 and SH11 have been identified in *italics* throughout the report.
[7] There are no sources of potential vibration post-construction.

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

b The limits set out in Table E25.6.30.1 [see Table 3.4] in buildings in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500 mm of ground level at the foundation of a single storey building.

3.3.1 Structural vibration

DIN 4150-3:1999 is an internationally recognised standard used to assess the effects of vibration on structures. The Standard is commonly used across New Zealand and, as set out above, is adopted by the AUP. The DIN 4150-3:1999 criteria to evaluate the effects of short-term vibration on structures are shown in Table 3.3 and summarised in Figure 3.1. Short-term vibration is vibration that does not induce resonance in a building structure.

Table 3.3 below and Figure 3.1 show the recommended vibration limits in terms of Peak Particle Velocity (PPV) for potential for damage to structures. They are lowest in the frequency range of 1-10 Hz, which is the normal range of natural frequency of most structures. The limits increase at higher frequencies where the potential harmonic effects are reduced. The guideline values for PPV are at the foundation and in the plane of the highest floor of various types of building.

Table 3.3: DIN 4150-3 :1999 guidelines for evaluating the effects of short-term vibration on structures

Line	Type of structure	Vibration at the foundation at a frequency of			Vibration at horizontal plane of the highest floor
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20 mm/s	20 to 40 mm/s	40 to 50 mm/s	40 mm/s
2	Dwellings and buildings of similar design and/or occupancy	5 mm/s	5 to 15 mm/s	15 to 20 mm/s	15 mm/s
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value	3 mm/s	3 to 8 mm/s	8 to 10 mm/s	8 mm/s

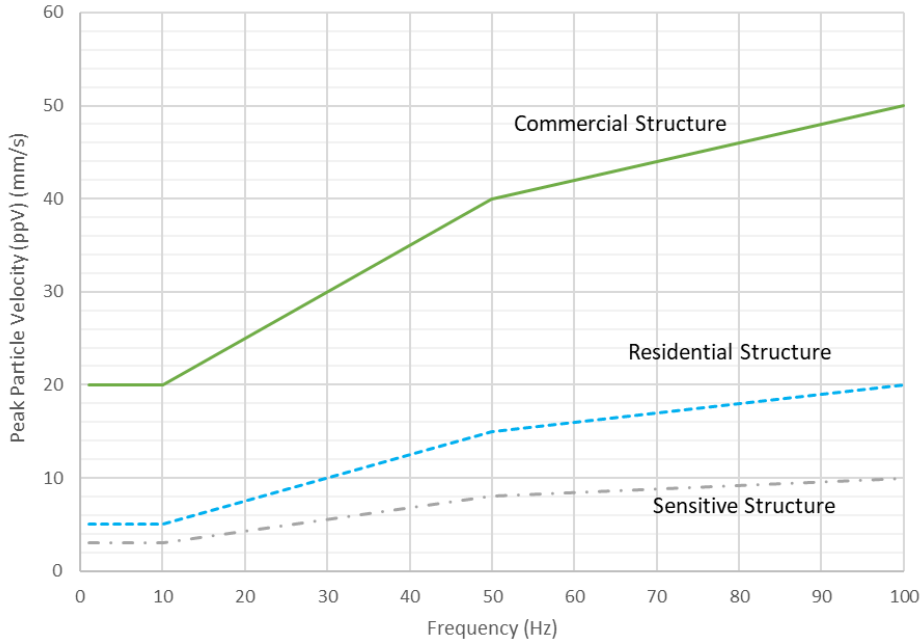


Figure 3.1: DIN 4150-3 Short-term standard baseline curves.

DIN:4150-3 gives further context to the guideline values:

> *"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. Exceeding the values in table 1 does not necessarily lead to damage; should they be significantly exceeded; however, further investigations are necessary."*

For the structures listed in lines 2 and 3 of Table 3.3, the 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 loadbearing walls or floors.

These effects are deemed 'minor damage'.

The limits recommended in DIN 4150-3 provide a low probability of cosmetic damage. In reality, structural damage is unlikely to occur in both residential and commercial structures at less than 50 mm/s, and for in-ground structures and infrastructure services at less than 100 mm/s.

Vibration is not the only potential cause of cosmetic damage to buildings. Natural seasonal fluctuations in groundwater and associated ground settlement, as well as expansion and contraction of timber frames buildings, may also contribute to minor cosmetic damage.

3.3.1.1 AUP amenity vibration limits

The AUP amenity limits are set out in Table 3.4 below.

Table 3.4: AUP Table E25.6.30.1 Vibration limits in buildings (amenity values)

Receiver	Period	Peak Particle Velocity (PPV) mm/s
Occupied activity sensitive to noise	Night-time 10 pm to 7 am	0.3
	Daytime 7 am to 10 pm	2.0
Other occupied buildings	At all times	2.0

Standard E25.6.30 includes an allowance for up to 5 mm/s PPV being received between 7 am and 6 pm for no more than three days (for the project duration) provided that building occupants within 50 m are advised at least three days prior to works commencing.

3.3.2 Works within the road reserve

Standard E25.6.29(4A) notes that the vibration levels specified in Standard E25.6.29(1A)(b) (vibration limits in buildings) do not apply where (a) for planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency [now Waka Kotahi New Zealand Transport Agency 'Waka Kotahi'] is provided to the Council five days prior to work commencing, and (b) a CNVMP is provided to the Council no less than five days prior to the works commencing. The requirements for the CNVMP are provided in Standard E25.6.29(5). Standard E25.6.29(1A)(a) applies to all works in the road (limits contained in DIN4150-3:1999).

3.4 Regenerated noise

Operation of the TBM and pipe jacking will generate vibration within the ground, which may cause regenerated noise within a building structure. Regenerated noise is typically assessed when the operation of the tunnelling equipment operates 24 hours, 7 days a week, as regenerated noise during the night-time period within dwelling may be audible, causing sleep disturbance, depending upon the proximity of the TBM to the dwelling and ground conditions.

For this Project, only the TBM option may operate 24 hours, 7 days a week. We have assessed regenerated noise to understand the effects of regenerated noise during the daytime and night-time.

Whilst there are no applicable standards available for regenerated noise within New Zealand[8], it is important to understand the conditions affecting the internal acoustic environment for the users' comfort and useability.

For dwellings in suburban areas or near minor roads, a night-time internal level of 30 to 35 dB L_{Aeq} is recommended. Similarly, the World Health Organisation[9] recommends a maximum

[8] For internally regenerated ground-borne noise, the noise limits as specified in NZS 6803 are not applicable as construction noise levels are determined at a distance of 1 m from an external facade. Australian/New Zealand Standard 2107:2016 (Acoustics – Recommended design sound levels and reverberation times for building interiors) provides recommended design criteria for conditions affecting the acoustic environment within occupied spaces for new or altered buildings but specifies not to be used for assessment or prescription of acceptable recommended noise levels from variable noises outside the building (such as construction).

[9] World Health Organisation (WHO), Guidelines for community noise, 1999

internal level for dwellings of 30 dB L_{Aeq} to avoid sleep disturbance and 35 dB L_{Aeq} for moderate indoor annoyance.

It is considered that a regenerated noise criterion of 35 dB $L_{Aeq(15min)}$, as adopted for other similar infrastructure projects such as Central Interceptor[10] and Herne Bay[11], is accepted as standard practice, and thus appropriate for the Project.

[10] Appendix L, Grey Lynn Tunnel Assessment of noise effects, Marshall Day Acoustics, Rp 002 20180726, 13 Feb 2019

[11] Herne Bay Tunnel – Construction noise and vibration technical assessment, Tonkin & Taylor Ltd, 1090120.3000v1, 03.08.23

4 Existing environment

4.1 Overview

The Project is located along State Highway 16 (SH16) with the alignment running from Canada Street in Auckland Central's Business City Centre Zone to the Central Interceptor connection point in Western Springs Park (Special Purpose Zone).

The shafts are located in a mix of Business City Centre with predominantly commercial businesses, residential single housing, residential mixed housing urban, residential mixed housing suburban and open space zones. The AUP zoning map in relation to the Project is provided in Appendix B.

The existing noise environment along the tunnel alignment is primarily influenced by road traffic noise from SH16, with levels ranging between 65–75 dB $L_{Aeq(24h)}$ in adjacent areas, except at Basque Park, where buildings provide shielding. These levels, consistent with the NZTA national noise model[12] , are representative of daytime ambient conditions, as confirmed during a site visit to SH04 at Nixon Park Carpark on 21 May 2025.

4.2 Sensitive receivers

Residential receivers are situated around most CWAs. Commercial and industrial receivers are located around Gundry Street and East Street (Karangahape Road area). The majority of receivers are two storey high buildings, with numerous apartment blocks around Basque Park. A map of nearby properties that may potentially be affected by noise and/or vibration from the construction works have been identified in Appendix C and listed in Appendix D. The table identifies receivers located within 80 m radius of each shaft location[13] and their nearest surface construction area.

4.2.1 Heritage buildings

There are two historic heritage areas within the vicinity of the construction sites at Cooper Street and Canada Street/Karangahape Road.

The AUP notes[14] that for this area, it is considered the buildings are normal residential buildings with historical features and not listed buildings (and are not particularly sensitive to vibration[15]). As such they would normally be assessed under DIN (Line 2) limits for residential buildings but to be protective of historical features, consideration under DIN (Line 3) for sensitive structures is undertaken for this assessment.

[12] https://nzta.maps.arcgis.com/home/item.html?id=7fd0c57ebe274e579b05c27c66e2a4fa#overview
[13] No predicted exceedances of the AUP construction noise limits beyond 80 m from any construction works.
[14] AUP Schedule 14.2.3 Cooper Street, AUP Schedule 14.2.12 Karangahape Road
[15] The structural elements of the buildings are similar to other residential buildings in the local area.

5 Noise and vibration assessment

5.1 Assessment approach

A preliminary assessment of construction noise and vibration has been based on an indicative construction methodology and durations informed by Watercare.

Whilst the construction methodology has not been finalised, an effects envelope has been developed for this assessment to account for potential changes to the activities and programme. As such, minor changes to the final construction methodology and programme are unlikely to change the overall envelope of effects as presented in this report. A detailed construction programme and methodology will be finalised by the contractor prior to the commencement of the works.

This noise and vibration assessment is informed by other Watercare projects such as that undertaken for the current Central Interceptor works due to comparable experience in relation to the type of works (tunnel and shaft) and proximity to dwellings. This provides a solid 'real-world' basis for understanding the nature of activities, the actual and potential noise and vibration effects of those activities, and how the effects are best managed and mitigated to cause the least disruption to surrounding residents and to minimise environmental effects. As such, physical mitigation such as 2 m barriers around shaft sites (typical Watercare practice) have been applied to this Project where required to reduce noise levels. The barriers have been included within the modelling and a 5dB partial reduction has been assumed for open trenching.

The assessment has been split into two distinct parts:

- Surface construction works (shaft construction and open trenching); and
- Tunnelling from TBM or pipe jacking option.

All figures and dimensions provided are approximate and will be confirmed during the detailed design stage.

Where works are solely within the road reserve between 7 am – 10 pm such as SH01, SH05 and SH09-11, AUP noise and amenity vibration levels do not apply (provided that a CNVMP is submitted). Works at these locations have therefore been assessed under the Project's criteria for information purpose only, as works are a permitted activity. The receivers identified as potentially affected from these shaft locations have been identified in *italics* for information only, and effects will be managed via the CNVMP.

All mainline shaft locations are significantly distanced from each other, such that no cumulative noise effects will be experienced at sensitive receivers.

No operational noise is proposed for this Project and this assessment only considers construction noise and vibration effects. Due to the depth of the tunnel, there will be no operational noise experienced at any receiver.

5.2 Source information

Sound power levels are provided in Table 5.1 below for the likely significant construction noise sources on site. Façade sound pressure levels at different set back distances, calculated using

NZS 6803 principles, are also provided to give an indication of likely noise levels for short term activities.

Sound power levels are taken from NZS 6803:1999 (reproduced from BS 5228-1) or from T+T's library of measured levels. No form of mitigation, such as acoustic barriers or enclosures, has been included within these noise levels and they therefore represent a 'worst-case' scenario. This is to represent noise levels at above ground level for nearby properties that are two storeys or higher.

Not all items of construction plant associated with the Project will operate simultaneously or within the same area. Hand tools have the potential to produce relatively high noise levels, however, these are typically used for short durations and are normally straightforward to screen effectively.

Table 5.1: Equipment list – Source data and set back distance to achieve compliance (without mitigation)

Source	Sound Power Level (dB L_{WA})	Approx set back distance to achieve 70 dB (m)
Auger Pile rig (Secant pile)	112	60
Vibro pile rig (for casing)^	114	70
23t Excavator with breaker attachment	112	60
15t Excavator	102	20
300t Crane	104	30
100t Mobile Crane	101	20
Hiab	98	15
Concrete pump	106	35
Concrete saw	115	75
Road paver	104	30
8t Roller	105	30
500kg compactor (4t)	109	45
Hydrovac	101	20
3 axle- Trucks	100	20
Dewatering pump	97	15
Generator	83	5
Tunnel ventilation	97	15
Water tank	98	15
Slurry Treatment Plant	107	35
Horizontal Directional Drill (HDD)	106	35
6-wheeler trucks	105	30

^ For manhole construction only

The following table shows key equipment likely to generate vibration for the Project. Where available, measurements / estimates of vibration from that equipment have been included.

Table 5.2: Construction equipment generating vibration

Equipment	PPV at 10 m
Excavator with breaker	3 – 4 mm/s
Compactor	2 – 3 mm/s
15-20t excavator	1 – 2 mm/s
Secant piles	1 – 2 mm/s
Vibro casing	3 – 4 mm/s

5.3 Assessment methodology

Due to the nature and extent of the proposed works there will be a variety of construction plant used. Table 5.1 lists the expected significant items of plant. It is not feasible to provide an assessment of noise effects from all construction plant that will operate across these works.

To provide a reasonable assessment of noise exposure for individual receivers, this assessment has taken the approach of assessing the impact from the most significant noise generating item of construction plant used in each activity. The main noise source for each activity has been identified in Table 5.3.

Table 5.3: Main significant noise source for each activity

Activity	Main noise source, LWA
Enabling works	20t excavator, 102 dB
Shaft construction	Secant piling, 112 dB
Tunnelling support (for pipe jacking) / general operation at shaft sites	Slurry treatment plant ,107 dB
Manhole construction	Vibro piling, 114 dB
Open trenching	Concrete saw, 112 dB
Trenchless excavation	Directional drill, 106 dB
Road reinstatement	Road paver, 104 dB

A duty correction[16] has been applied to equipment within each activity to account for usage of equipment over the 15-minute assessment period. (For example, secant piling & vibro pile - 100% on-time, concrete saw - 50% on-time). The presented sound power levels are indicative only, as the construction methodology has not yet been finalised. The sound power levels presented are similar to other major infrastructure projects in Auckland.

[16] Sound levels are adjusted based on the amount of time equipment is in use

Based on the set back distances shown in Table 5.1, receivers located over 80 m from the nearest construction area have not been included as they are unlikely to experience noise above the relevant AUP noise limits.

The two construction activities of shaft construction and open trenching have been used to assess a realistic worst case scenario. Whilst manhole construction has a higher sound power level than shaft construction, vibro piling of the casing is anticipated to take place within the footprint of the shafts. The noise levels predicted for the worst case locations for shaft construction (i.e. along the perimeter of the shaft) using secant piling are considered representative of the louder vibro piling (which will be located more central within the larger shaft) when accounting for the difference in distance from receivers. As such, manhole construction has not been assessed separately.

Similarly, tunnelling support at launch sites (such as the slurry treatment plant, truck movements for spoil removal, generators and cranes etc) is significantly quieter than piling works. As the layout of the sites are currently unknown but will be restricted to the proposed site areas, it is considered tunnelling support noise effects will be captured by the worst case predictions from shaft constructions. The layout of the site can be planned to reduce noise levels at nearby receivers by locating noisy plant away from receivers and/or placing welfare cabins between the receiver and nosier equipment etc. Tunnelling support can be effectively managed via the CNVMP and not assessed further.

Trenchless excavation and road reinstatement will generate lower noise levels than the open trenching source assesses. Since all three activities will occur along the same alignment, open trenching will capture the greatest potential impacts for works along the EOP connections.

5.3.1.1 Noise model

A SoundPLAN computer model (version 9.1) implementing ISO 9613-2:2024-01 *"Acoustics – Attenuation of sound outdoors – Part 2: engineering method for the prediction of sound pressure levels outdoors"* prediction algorithm has been used to predict noise levels from activities associated with the construction of the Project. The noise model takes into account ground contours, ground absorption, terrain, buildings and the location of works. The building footprints have been obtained from the LINZ database and adjusted for the number of floors (assuming 2.8 m height per floor with an average height of 7 m for double storey, 10 m for three storey and 16.8 m for five storey buildings).

For each receiver, the worst-case noise level has been calculated, which is typically when equipment is operating at the closest location. A 2 m noise barrier around the perimeter of each shaft's construction support area has been included in line with general Watercare practices.

The following scenarios have been modelled for the activities closest to receivers for surface works, with the construction plant operating at the edge of the construction location (i.e. worst case assessment):

- Shaft construction: source height of 1.8 m; and
- Open Trenching: source height 1 m.

5.4 Surface construction works

5.4.1 Predicted construction noise levels

Façade noise maps for each modelled scenario have been calculated for nearby sensitive receivers. The full graphical façade noise maps are presented in Appendix E. The façade noise maps show the highest sound level experienced at each building, i.e. the closest, highest floor and most exposed façade to the source. Colour coding has been used to highlight the range of construction noise levels.

Grid noise maps are modelled at 1.5 m above ground level to enable direct comparison for noise survey measurements that are undertaken in accordance with NZS 6801:2008. As buildings in and around the Project area are typically more than one storey high, predicted façade levels may be greater than those shown on the grid noise contours. Due to the height of surrounding residential buildings and the restricted distance from construction works, effective screening is often difficult to provide against construction noise. A 2 m perimeter noise barrier may not provide effective screening for receivers above ground floor level, but partial screening may still be experienced. A partial screening reduction has also been applied for open trenching.

Appendix D summarises the predicted worst-case noise levels for receivers (where SH07a for pipe jacking results in higher predicted noise levels, these have been presented). The number of properties experiencing noise greater than 70 dB L_{Aeq} (in 5 dB bands) is provided in Table 5.4. Noise level effects are discussed in Section 6.

A total of 258 properties are identified within 80 m of a shaft of which 72 are located in proximity to road reserve works near SH01, SH05, SH09, SH10 and SH11 and has not been counted in the summary table below. A total of 67 properties are predicted to exceed the AUP daytime noise limit of 70 dB L_{Aeq} due to shaft construction and 34 properties due to open trenching.

Table 5.4: Summary table of predicted noise exceedances

Construction Activity	Highest predicted levels (L_{Aeq},15min)	Number of properties exceeding AUP noise limit				
		≥85dB	80-85 dB	75-80 dB	70-75 dB	< 70dB
Shaft Construction	89 dB	3	6	24	34	119
Open trenching	86 dB	2	3	9	20	152

5.4.1 Construction traffic movements

Whilst the AUP does not require noise from construction truck movements to be assessed[17], it is noted due to the size constraints of the satellite support sites, stockpiling material on sites will be limited and regular haulage may be required. Truck movements to and from satellite support sites along public roads, whilst outside the scope of this assessment, will likely be noticeable to residents along the local road routes.

[17] The AUP excludes traffic noise – see AUP E25.1. Background.

5.4.1 Predicted construction vibration levels

The generation of vibration is dependent on the local site geology, the equipment being used, the nature of the works and the operator. To account for this, the likely worst-case vibration has been calculated based on the equipment from excavator with breaker attachment and hard ground geology to provide predicted vibration levels at the closest receivers.

The use of an excavator with a breaker attachment is expected across all activities (to break road surface) and is predicted to generate the highest level of vibrations in comparison to other equipment. Dwellings within 27 m from rock breaking around the shafts and open trenching locations may experience vibration levels of up to 2 mm/s PPV. For properties between 27 m and 5 m from works, vibration levels are likely to be greater than 2 mm/s PPV but expected to be below the DIN 4150-3 limit for cosmetic damage building of 5 mm/s PPV for residential buildings. Properties located further away are predicted to experience vibration levels of less than 2 mm/s.

Five properties within 5 m of open trench works are predicted to potentially exceed the DIN 4150-3 residential threshold. Four properties located within the heritage area along Cooper Street are predicted to exceed the DIN 4150-3 sensitive structure threshold, see Table 5.5. To mitigate vibration levels to permitted AUP levels, the use of a concrete saw or non-vibratory breaking method will be used within 5 m of any receiver. This can be managed accordingly via the CNVMP. Vibration effects are discussed in Section 6.1.3.

Table 5.5: Properties predicted to exceed Project vibration criteria using rock breaker

Address	Building Classification	Predicted vibration level, PPV
52 Kingsland Avenue	Residential	7 – 8 mm/s
28 Buchanan Street	Residential	6 - 7 mm/s
30 Buchanan Street	Residential	6 - 7 mm/s
41 Kingsland Avenue	Residential	5 - 6 mm/s
69 Finch Street	Residential	5 - 6 mm/s
41 Cooper Street	Heritage area	3 - 4 mm/s
43 Cooper Street	Heritage area	3 - 4 mm/s
48 Cooper Street	Heritage area	3 - 4 mm/s
50 Cooper Street	Heritage area	3 - 4 mm/s

5.4.1.1 Underground services

Underground services include high voltage power lines and water pipes. High voltage power lines are typically in a 150 mm PVC duct and the cable itself is typically of a more flexible material and not generally impacted by vibration. The condition and type of water pipes present is currently unknown, but plastic or masonry pipes of good condition will be more resistant to potential vibration induced damage.

DIN 4150-3 includes guideline vibration limits for utility protection, see Table 5.6. According to DIN 4150-3, rigid plastic/masonry pipes have a vibration tolerance of 50 mm/s PPV.

Table 5.6: DIN 4150-3 - Guidelines for allowable vibration level for utility protection

Pipe Material	Guideline values for allowable vibration levels (velocity measured on the pipe)
Steel (including welded pipes)	100 mm/s
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80 mm/s
Masonry, plastic	50 mm/s

Based on the use of an excavator with breaker, vibration levels of less than 10 mm/s are predicted at 1 m away from any services, indicating a low risk for vibration damage to underground services.

To further reduce the risk, any services shall be exposed using hydro-excavation during enabling works prior to any high vibration activities taking place. Piling and other works near the services should be carried out in consultation with the asset owner's agreement and at any agreed set back distances. Stand over from the asset owners may also be necessary and managed accordingly within the CNVMP.

5.5 Tunnelling

This section assesses the regenerated noise and vibrations levels generated by the TBM and pipe jacking excavation.

Tunnelling using the TBM or pipe jacking is proposed between shafts as described in Section 2.2. During pipe jacking drives, soil spoils will be extracted and removed from the respective 'launch' shaft (SH02, 04, 07, 09, 011,12a and 14). Surface works assessments due to the tunnelling have been considered within the construction activity 'shaft construction'.

There is a lack of information regarding the tunnelling progression rate but based on experience from similar projects, tunnelling can typically operate at a rate of around 7-10 m per day depending on optimal ground conditions with continuous tunnelling through the daytime construction hours only. Pipe jacking is not expected to operate at night for this Project, but the TBM will be operating continuously once launched and will be operated similar to other Central Interceptor projects.

5.5.1 Predicted vibration levels

The two tunnelling options proposed have a similar vertical tunnel depth along the main alignment, with the shallowest design (representing a worst case from a vibration effects perspective) proposed at vertical depths between 21 m and 44 m below surface ground level[18] transversing beneath residential properties, State Highway 16 and other infrastructure. This is representative of the worst-case scenario.

The tunnel alignment predominately transverses through East Coast Bays Formation (ECBF)[19].

[18] Measured between surface ground level and top of tunnel.
[19] WIWQIP Motions Catchment Improvements – Geotechnical Interpretative Report, Aurecon, 521290-W000064-REP-GG-0003 Rev A, 2025-04-24

Vibration assessment and testing of ground conditions carried out by T+T[20] for Watercare Central Interceptor locations across Auckland identified a best fit ground attenuation for vibration along the alignment in the form of $PPV = 9.26(d)^{-1.44}$ where d is distance from the source to the receiver. The attenuation exponent (-1.44) is reflective of the properties of soft soils overlying rock.

It is considered appropriate to adopt the same ground attenuation relationship as the proposed Central Interceptor extension project due to the similar geology makeup across the Project area and wider Auckland area.

Vibration data from other Auckland infrastructure projects (such as City Rail Link) using a larger TBM at shallow depths have not resulted in any significant vibration issues with management practices in place. This provides assurance that vibration effects from operation of the TBM are low risk and levels are generally in line with the adopted ground attenuation relationship. The TBM and pipejacking will generate similar vibration levels.

A vibration level of 0.1 mm/s is predicted at the minimum distance of 21 m. For TBM operations, a minimum set back distance of 11 m is predicted to result in a vibration level of 0.3 mm/s.

It is acknowledged that foundation piles within the Project area may extend into the ground reducing the vertical distance between the tunnel alignment and the receiver. As a setback distance of less than 3 m is required between the tunnelling machine and the receiver foundations to meet a vibration level of 2 mm/s PPV for daytime works, there is a negligible risk of an exceedance.

The closest known foundation at the apartment buildings around Basque Park is around 5 m from the pipe jacking alignment which is outside the setback distance for amenity level (2 mm/s PPV). Similarly, a slanted distance of approximately 8 m is calculated from the pipe jacking alignment near the heritage area buildings at Cooper Street, and vibration levels can readily achieve compliance with the DIN 4150-3:1999 for sensitive structures of 3 mm/s PPV.

All receivers are predicted to comply with the daytime amenity limit of 2 mm/s PPV and DIN 4150-3:1999 limits for all commercial (20 mm/s), residential buildings (5 mm/s) and sensitive structures (3 mm/s). The continuous operation of the TBM can also meet the night-time amenity limit of 0.3 mm/s PPV.

5.5.2 Tunnelling regenerated noise (night-time)

Based on experience from the existing Central Interceptor tunnelling works, a minimum slant distance of 18 m from buildings with bedrooms on the ground floor to the TBM will achieve compliance with a regenerated noise criterion of 35 dB L_{Aeq}.

The shallowest slant distance between the tunnel and ground surface level is around 21 m. TBM works along the alignment can meet compliance with the recommended 35 dB L_{Aeq} regenerated noise criteria during night-time hours.

[20] Central Interceptor – Vibration Assessment for Main Tunnels and Link Sewers, Tonkin + Taylor Ltd, July 2012, Ref 27993

6 Assessment of effects

6.1 Surface construction

6.1.1 Potential noise effects

The degree of the Project's noise effects will depend upon the magnitude, frequency of occurrence and duration of the noise exposure. An indication of the potential effects is provided in Table 6.1. Depending on the construction of the building, residential facades may provide around 20 dB reduction, 25 dB reduction for new builds with sealed windows and 25 to 30 dB for commercial buildings. Therefore, the assumptions and effects provided below are based on a conservative approach.

Receivers adjacent to SH16 experience elevated ambient noise levels of around 75 dB $L_{Aeq(24h)}$ [21], already exceeding AUP limits. While construction noise will be noticeable due to its closer proximity and different characteristics, its impact is expected to result in less annoyance for the limited duration of high-noise activities, especially during peak commuting hours.

Table 6.1: Subjective response to environmental noise (daytime) – residential building occupiers

External sound level (L_{Aeq})	Potential daytime effects outdoors	Corresponding internal sound level (L_{Aeq})	Potential daytime effects indoors
Up to 65 dB	Conversation becomes strained, particularly over longer distances.	Up to 45 dB	Noise levels would be noticeable but unlikely to interfere with residential activities.
65 to 70 dB	People would not want to spend any length of time outside.	45 to 50 dB	Concentration would start to be affected. TV and telephone conversations would begin to be affected.
70 to 75 dB	Outdoor users would experience considerable disruption.	50 to 55 dB	Phone conversations would become difficult. Personal conversations would need slightly raised voices. For residential activity, TV and radio sound levels would need to be raised.
75 to 80 dB	Some people may choose hearing protection for long periods of exposure. Conversation would be very difficult, even with raised voices.	55 to 60 dB	People would actively seek respite when exposed for a long duration.
80 to 90 dB	Hearing protection would be required for prolonged exposure (8 hours at 85 dB) to prevent hearing loss.	>60 dB	Untenable for residential environments. Unlikely to be tolerated for any extent of time.

Note: The adjustment factor between the external noise level and the internal noise level is based on a 20-decibel reduction as allowed for in NZS 6803. The table does not correct for façade effects – to simplify the presentation of internal noise levels.

[21] Traffic noise levels are average out over a 24 hour period, peak hours could generate higher noise levels than 75 dB L_{Aeq}(15min) and night-time traffic will be at lower levels. During standard daytime construction hours, noise levels from traffic is likely to average between the 70 - 80 dB L_{Aeq}(15min) range due to the high speeds and high volume flows.

This table relates to noise experienced during non-sleeping hours.

Estimated noise levels based on facade reduction, as replicated from the Association of Australasian Acoustical Consultants Guideline[22], have been include in Table 6.2. which correspond to the internal noise level effects in Table 6.1 above.

Table 6.2: Estimated internal noise levels based on glazing types (reproduced from Table 2 of AAAC guideline)

Incident noise level (dB L_{Aeq})	Estimated internal noise level (dB L_{Aeq})			
	Sealed windows (apartment/office)	Closed windows (modern building)	Closed windows (older building)	Partially open window (all buildings)
90 – 95	60 – 65	65 – 70	70 – 75	75 – 80
85 – 90	55 – 60	60 – 65	65 – 70	70 – 75
80 – 85	50 – 55	55 – 60	60 – 65	65 – 70
75 – 80	45 – 50	50 – 55	55 – 60	60 – 65
70 – 75	40 – 45	45 – 50	50 – 55	55 – 60

6.1.2 Construction noise effects

6.1.2.1 Shaft construction

Shaft construction with secant piling is the main source of noise at each shaft location. Of the 186 assessed receivers, 67 are predicted to experience noise levels exceeding the AUP daytime limit of 70 dB L_{Aeq}, with nine receiving levels above 80 dB L_{Aeq}. The highest predicted level is at 52 Kingsland Avenue with over 100 dB L_{Aeq} but affected party approval is being obtained for this property and therefore, effects can be disregarded on approval. However, if approval is not obtained, relocation of the occupants will be required for the duration of the shaft construction works.

The next highest predicted level is 89 dB L_{Aeq} at 30 Warwick Street (SH07). These remaining eight receivers located within 15 m of the shaft works are primarily multi-storey buildings, where standard 2 m noise barriers are only effective at ground level. Taller barriers (5–6 m) would theoretically reduce noise at upper floors but are impractical to implement.

Piling noise will not be continuous throughout the construction period, with predicted maximum noise levels likely only occurring for a few hours per day, intermittently over the planned construction period (35 days for SH07). Once piling is complete, noise levels from other activities will significantly decrease.

For 30 Warwick Street (6 m from the shaft), an external level of 89 dB L_{Aeq} corresponds to an internal level of 69 dB L_{Aeq} - tolerable only for short durations with advance notice. Mitigation such as work scheduling, enclosures, or ensuring sensitive rooms overlooking the works are unoccupied may be considered (if property is unoccupied then noise limits do not apply).

[22] Association of Australasian Acoustical Consultants – Guideline for interpreting and applying NZS 6803:1999 v1.0, ASBN 31 678 114 997

If noise impacts remain at high intolerable levels and are unavoidable despite all reasonable and practicable measures, temporary relocation will be considered. Advance notification, consultant and regular updates of noisy works is key to managing the expectations and effects for all potentially affected receivers.

High noise levels during piling are typical of infrastructure projects near residential areas and can be successfully managed, as demonstrated on the Central Interceptor project. The CNVMP will adopt best practicable options, including selecting suitable equipment, avoiding unnecessary noise, and maintaining clear communication with affected receivers.

For the majority of receivers, piling noise effects are deemed reasonable due to the intermittent nature and limited duration of the activity. With the CNVMP in place, construction noise levels are expected to remain within an acceptable range (75–80 dB L_{Aeq}) across most locations.

6.1.2.2 Open trenching

Open trenching is proposed both within and outside the road reserve between the mainline shafts and the local EOP connection points. Only a small part of the Project involves open trenching where EOP connections are made with the exception of Kingsland Avenue and Fourth Avenue around SH05. 34 out of 186 receivers have been predicted to experience noise levels of over 70 dB L_{Aeq}. Four receivers[23] are located less than 6 m from the nearest trench alignment and are predicted to experience noise of over 80 dB L_{Aeq} with the maximum predicted noise level of 86 dB L_{Aeq} at 69 Finch Street (SH06). These receivers with the exception of 41 Kingsland Avenue are two storey high residential dwellings.

A maximum internal noise level of approximately 66 dB L_{Aeq} is predicted and is likely to be tolerable for a short period of time with prior notice. With works typically progressing at 8-10 m per day, maximum noise levels may only occur over a relatively short period of 2-3 days and intermittently within the total duration of the works during the use of the rock breaker or concrete saw for breaking up road surface which is considered acceptable.

Noise levels can be further mitigated with a three sided barrier around the immediate area of works during concrete cutting and/or rock breaking. Where feasible trenchless excavation methods such as horizontal directional drilling (HDD) could reduce noise levels by up to 6 dB, with the highest predicted noise level dropping to 80 dB L_{Aeq}.

With physical mitigation, advance notification and regular communication with receivers, noise from open trenching can be effectively managed to reduce noise effects via a CNVMP.

6.1.2.3 Other activities

The layout of the satellite support site has not been finalised but can be established to minimise noise at the detailed design stage. Once the site has been established, general support work can be effectively managed such that noise levels would unlikely exceed the 70 dB L_{Aeq} daytime noise limit with activities undertaken away from receivers with site offices and breakout areas providing additional shielding. Noise monitoring of sites to check for compliance, regular communication and updates to neighbouring receivers will be required and has been successfully managed on other similar sites around Auckland.

[23] 69 Finch Street (SH06), 28 Buchanan Street (SH03), 30 Buchanan Street (SH03) and 41 Kingsland Avenue (SH05).

6.1.3 Potential vibration effects

6.1.3.1 Human vibration

Human perception and response to vibration varies depending upon the sensitivity of the individual, the tasks being performed, the magnitude, frequency and duration of the vibration, whether the vibration is expected, and whether there is concern that structural damage may occur.

Low levels of vibration can cause fixtures and fittings, such as doors and windows, to rattle and the noise that is sometimes generated by the 'rattling' can draw an individual's attention to the original source of the vibration. Humans perceive vibration at much lower magnitudes than the levels of vibration that are likely to cause building damage and as such homeowners are likely to complain about vibration significantly below the levels likely to result in cosmetic damage of buildings.

Within New Zealand there are no national vibration standards for the effects on human exposure within buildings. However, it is accepted practice to apply the guidance from British Standard BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration* (BS 5228-2)[24].

6.1.3.2 BS 5228-2

BS 5228-2[25] discusses vibration levels at which adverse comment is likely from building occupants. The guidance values of Table B.1 of BS 5228-2 are provided in Table 6.3.

Table 6.3: Guidance on effects of vibration levels - BS 5228-2:2009

Vibration level (PPV)	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction[26]. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.

The assessment shows that 51 receivers are predicted to experience vibrations above the 2 mm/s PPV AUP amenity level but under 5 mm/s PPV for DIN 4150-3:1999 threshold for cosmetic damage.

Five properties are predicted to exceed 5 mm/s PPV for residential buildings. Four receivers[27] within the Cooper Street heritage area (SH13) may exceed the 3 mm/s PPV sensitive building

[24] The previous version of this standard is referenced extensively throughout NZS 6803 as a method for predicting the noise levels from specific construction activities. The current version is considered appropriate.

[25] BS 5228-2:2009+A1:2014, Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration

[26] Below 50Hz

[27] 41, 43, 48 and 50 Cooper Street (SH13)

threshold, with vibration levels of 3–4 mm/s PPV during rock breaking or vibro piling within 15 m. Mitigation options include using a concrete saw instead of a rock breaker or bore piling with trench shields instead of vibro piling.

If these methods are not practicable on site, then a pre and post building condition survey (as provided in Section 7.1.6) is required and will be managed via the CNVMP along with monitoring requirements. There are no other known vibration sensitive receivers within the assessment Project areas.

Vibration levels of 2 mm/s may be perceivable by occupants, and they may be disturbed by such occurrences, but based on experience with other construction projects, vibrations at this level will generally be acceptable to receivers provided they have received prior warning (this is so that the receivers are not surprised or startled when the vibrations occur). Effects will be managed via the CNVMP through the use of monitoring and appropriate construction practices to minimize vibration levels.

6.2 Tunnelling

6.2.1 Potential vibration effects

For the TBM tunnelling where continuous operation is required throughout both daytime and night-time hours, a minimum set back distance of 11 m is required to achieve the night-time vibration level of 0.3 mm/s. Tunnelling is proposed at vertical depths between 21 m and 44 m along the main pipe alignment and even acknowledging some foundation piles within the Project area may extend into the ground reducing vertical distance between the tunnel alignment and the receiver, the risk of exceeding the night time limit is considered negligible.

For daytime tunnelling works, the nearest known apartment building foundation at Basque Park is around 5 m from the pipe jacking alignment between SH12a and SH02, which is outside the minimum set back distance of 3 m and can achieve the daytime amenity vibration level of 2 mm/s PPV. Similarly, a slanted distance of approximately 8 m is calculated from the pipe jacking alignment near the heritage area buildings at Cooper Street, and vibration levels can readily achieve compliance with the DIN 4150-3:1999 for sensitive structures of 3 mm/s PPV.

Whilst daytime vibration limits can be readily achieved, it may still be perceptible by occupants of Basque Park apartment (37 Fleet Street) which is five storeys high. Advance notification and clear communication on perception of vibration whilst tunnelling occurs below 37 Fleet Street should be undertaken as part of the CNVMP.

Overall, the effects of vibration on receivers along the tunnel alignment from the TBM are expected to be negligible to less than minor.

6.2.2 Regenerated tunnelling noise

Daytime indoor noise at 35 dB L_{Aeq} is unlikely to be noticeable from normal indoor activities and well below the AUP daytime limits.

7 Noise and vibration management

Construction Noise and Vibration Management Plan

It is standard practice for infrastructure projects to implement a CNVMP as part of the construction management plan. Implementing noise management and mitigation measures via a CNVMP is the most effective (and best practice) way to control construction noise and vibration impacts. The objective of the CNVMP should be to provide a framework for the development and implementation of best practicable options to avoid, remedy or mitigate the adverse effects on receivers of noise and vibration resulting from construction.

Works shall adopt BPO to ensure that noise and vibration levels do not exceed a reasonable level. BPO is to identify the best method for preventing or minimising the adverse effects on the environment, having regard, among other things, to:

- The nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects, and;
- The financial implications, and the effects on the environment, of that option when compared with other options, and;
- The current state of technical knowledge and the likelihood that the option can be successfully applied.

To determine BPO, the duration of works is important to consider. It is generally more acceptable to receivers if the work is carried out efficiently for a shorter period of time at higher noise levels, than working slowly over a much longer time period with lower noise levels. What may be reasonable for one property may not suit another due to lifestyle factors such as working shifts etc. Good relationship with the neighbouring communities and regular communication is a key management measure.

A draft CNVMP identifying the minimum level of information as set out in AUP Standard E25.6.29(5) for the works has been prepared in support of the resource consent.

A CNVMP will be implemented for the work site with specific sections on activities that are predicted to exceed the Project's adopted noise and vibration limits. The draft CNVMP will be updated to reflect detailed design before commencement of work and kept up to date regarding actual timing/equipment used and methodologies.

The following Project specific mitigation and management measures to be included within the CNVMP are provided in this section.

7.1.1 Communication and consultation

The key element of noise and vibration management is ensuring that appropriate communication occurs with affected neighbours. Such measures include:

- Prior notification of the works via a letterbox drops or emails and supplemented by other means (news article, website etc) to affected residents along the Project alignment. The letterbox drop or emails will provide contact details and will detail the overall nature and expected duration of the works; and

- Prior to any particularly noisy process being identified, the most affected residents as identified in red and yellow within Appendix D will be contacted individually. Residents will be informed of the proposed timing of specific works, the anticipated noise and/or vibration levels and the mitigation to be used. Ongoing consultation and communication with residents less than 50 m from any shaft works, or tunnelling works should be undertaken.

7.1.2 Scheduling

The time of day and the duration of the construction activities will be adjusted after consultation, where possible, to avoid particularly sensitive times for affected receivers.

7.1.3 Noise barriers

Where practicable, panels will be positioned as close as possible to the construction activity to block line-of-sight between the activity and noise sensitive receivers. Additional local barriers could be required near the activity to ensure effective mitigation for sensitive receivers on upper floor levels. The panels should be a minimum height of 2 m with a surface mass of > 7 kg/m^2, and higher if practicable to block line-of-sight[28]. The panels must be abutted or overlapped to provide a continuous screen without gaps at the bottom or sides of the panels.

Alternatively temporary noise barriers include the following proprietary 'noise curtains' can be used:

- Echo Barrier Temporary Acoustic Noise Barrier (http://www.supplyforce.co.nz/);
- Duraflex 'Noise Control Barrier – Performance Series' (www.duraflex.co.nz);
- Soundex 'Acoustic Curtain – Performance Series' (NZ); and
- Flexshield 'Sonic Curtain with 4 kg/m^2 mass loaded vinyl backing' (NZ).

These generally have a lower surface mass (of 4 kg/m^2) and will either need doubling up or will provide a lower sound reduction than barriers which achieve the minimum requirements above.

7.1.4 Construction support area mitigation

- A 2 m high barrier as specified in Section 7.1.3 should placed around the perimeter of the support area site.
- The layout of the support areas will be planned to minimise noise effects, such as placing staff areas and static temporary structures along the perimeter of the site to provide shielding.
- Noisy equipment should operate away from the perimeter of the site adjacent to neighbouring residents and localised screening shall be used (minimum of three sides).
- An enclosure may be required if noise monitoring shows regular exceedances of the noise limits at nearby residents and alternative best practices are still resulting in complaints.

7.1.5 Vibration mitigation

A hierarchy of vibration mitigation measures should be adopted through the CNVMP as follows:

[28] Temporary barriers greater than 3-4 m are generally impracticable to construct due to wind loading constraints.

- Managing times of activities to avoid night works and other sensitive times where practicable (communicated through community liaison);
- Liaising and consultation with neighbours prior to commencing works for vibration generating activities;
- Selecting equipment and methodologies to minimise vibration – such as the use of rock breaker and vibro piling should be avoided within 15 m of Cooper Street historical heritage properties; and
- Monitoring of vibration during activities predicted to exceed the 2 mm/s amenity limit and at heritage area buildings.

Mitigation will therefore focus on effective communication with neighbours, and selection of appropriate equipment and methods.

7.1.6 Building condition surveys

A pre-construction building condition survey will be undertaken at the four properties located within Cooper Street historical heritage area predicted to exceed 3 mm/s PPV (41, 43, 48 and 50 Cooper Street) before the construction works begins at SH13 if a rock breaker and/or vibro piling is anticipated to be used.

The building condition surveys will generally be undertaken as follows:

- The building surveys will be undertaken by a suitably qualified and experienced practitioner;
- Seek permission from the owner of a building, structure or service for a suitably qualified and experienced practitioner to prepare a report that:
  - describes any information about the type of foundations;
  - the existing levels of damage (cosmetic, superficial, affecting levels of serviceability);
  - any observed damage is associated with structural damage;
  - identifies the potential for further damage to occur and describes actions that will be taken to avoid further damage; and
  - photographic evidence.
- The Project team will provide the building condition survey report to the property owner; and
- A post condition survey will be undertaken after construction works has been completed, unless the landowner agrees otherwise, or if monitoring determines the post condition survey is unnecessary (i.e. below the DIN 4150-3 threshold).

During construction if complaints are made about vibration or if monitoring determines it necessary, further building condition surveys may be undertaken. Where further surveys identify damage has been encountered, relevant suitably qualified specialists will be engaged to investigate the cause. This may include the vibration specialist, building inspector and building condition author. The outcome of the investigation will be shared with the complainant/affected receiver. If it is determined that the Project is responsible for the damage, a plan will be made to rectify it at Watercare's cost.

8 Conclusions

An assessment of noise and vibration effects has been completed for the proposed Motions Catchment Improvement Project, assessed against relevant Auckland Unitary Plan (AUP) standards and adopting a "worst-case scenario" methodology for two possible tunnelling options. While some works occurring solely within the road reserve (e.g. SH01, SH09, SH10, and SH11) are permitted activities,detailed predictions have been provided for transparency and to identify potential mitigations.

8.1 Noise

Piling and open trenching activities represent the dominant noise sources during construction. Predicted exceedances of the AUP daytime noise limit of 70 dB L_{Aeq} include:

- **Piling Works**: 67 out of 186 receivers may exceed 70 dB L_{Aeq}, including nine receivers[29] exceeding 80 dB L_{Aeq}, where the highest noise level of 89 dB L_{Aeq} is predicted at 30 Warwick Street (SH07) and 101 dB LAeq at 52 Kingsland Avenue[30].
- **Open Trenching**: 34 receivers may exceed 70 dB L_{Aeq}, with four receivers[31] (located within 6 m of trench alignments) predicted to experience noise levels above 80 dB L_{Aeq}, peaking at 86 dB L_{Aeq} using a rock breaker. Use of trenchless excavation (e.g. HDD) where practicable, could reduce noise levels by up to 6 dB.

Other activities may also result in exceedances of 70 dB L_{Aeq} but at noticeably lower noise levels and can be effectively managed via the CNVMP.

Although construction noise will be perceptible, elevated ambient noise levels near SH16 contribute to a lessened impact compared to quieter suburban environments. High-noise activities such as piling and rock breaking are typical for large infrastructure works and have been successfully managed on similar Auckland projects (e.g. Central Interceptor, City Rail Link) with mitigation methods specified in the CNVMP. A noise limit of 85 dB L_{Aeq} has typically been acceptable to manage the shorter duration high noise activity for piling. Practical measures, including advance notification, regular updates, and managing expectations, will be key to limiting noise impacts to acceptable levels. Importantly, noise effects are intermittent and limited in duration, with no cumulative effects anticipated between mainline shaft locations.

8.2 Vibration

Vibration effects are expected to remain within acceptable thresholds:

- **Predicted Levels**: 51 receivers may experience vibration above the AUP amenity limit of 2 mm/s PPV, with five predicted to exceed the 5 mm/s PPV cosmetic damage threshold for residential buildings.

[29] 25 Mostyn Street (SH03), 24 Central Road (SH04), 50B Kingsland Avenue (SH05), 67 Finch Street (SH06), 30 Warwick Street (SH07), 1/14 Fleet Street (SH12a), 41 Cooper Street (SH13) and 43 Cooper Street (SH13).
[30] Written approval to be obtained
[31] 69 Finch Street (SH06), 28 Buchanan Street (SH03), 30 Buchanan Street (SH03) and 41 Kingsland Avenue (SH05).

- **Heritage Properties**: Four receivers[32] in the Cooper Street heritage area (SH13) are predicted to exceed the 3 mm/s PPV threshold for sensitive buildings, with levels of 3–4 mm/s PPV during rock breaking and vibro piling. Mitigation options include alternative construction methods, such as concrete saws or bore piling with trench shields, as well as pre- and post-construction building surveys and monitoring, managed through the CNVMP.

Vibrations of up to 2 mm/s PPV may be perceptible but are generally tolerable with prior warning. All vibration effects will be managed using monitoring and best practicable construction methods as outlined in the CNVMP.

8.3 Tunnelling

Both tunnelling options (pipe jacking and TBM) comply with AUP vibration amenity limits:

Daytime: Both methods meet the daytime limit of 2 mm/s PPV.

Night-Time: TBM operations outside daytime hours meet stricter night-time standards of 0.3 mm/s PPV and 35 dB L_{Aeq} for regenerative noise.

No exceedances are anticipated for either tunnelling method under these criteria.

8.4 Summary

Noise and vibration effects are considered to fall within acceptable limits for major infrastructure works, particularly in areas near sensitive multi-storey receivers. With appropriate management via the CNVMP, impacts will be mitigated using BPO, ensuring construction effects remain minor. Similar approaches have been successfully implemented for large-scale Auckland projects, such as the Central Interceptor and Central Rail Link, demonstrating the effectiveness of these measures.

[32] 41, 43, 48 and 50 Cooper Street (SH13)

Appendix A – Glossary

Term	Definition
dB	A unit of measurement on a logarithmic scale which describes the magnitude of sound pressure with respect to a reference value (20 µPa).
$L_{Aeq(t)}$	The A-weighted time-average sound level over a period of time (t), measured in units of decibels (dB).
L_{WA}	Sound power level.
PPV	Peak particle velocity. This is the instantaneous maximum velocity reached by the vibrating surface as it oscillates about its normal position.
Noise	Unwanted sound.

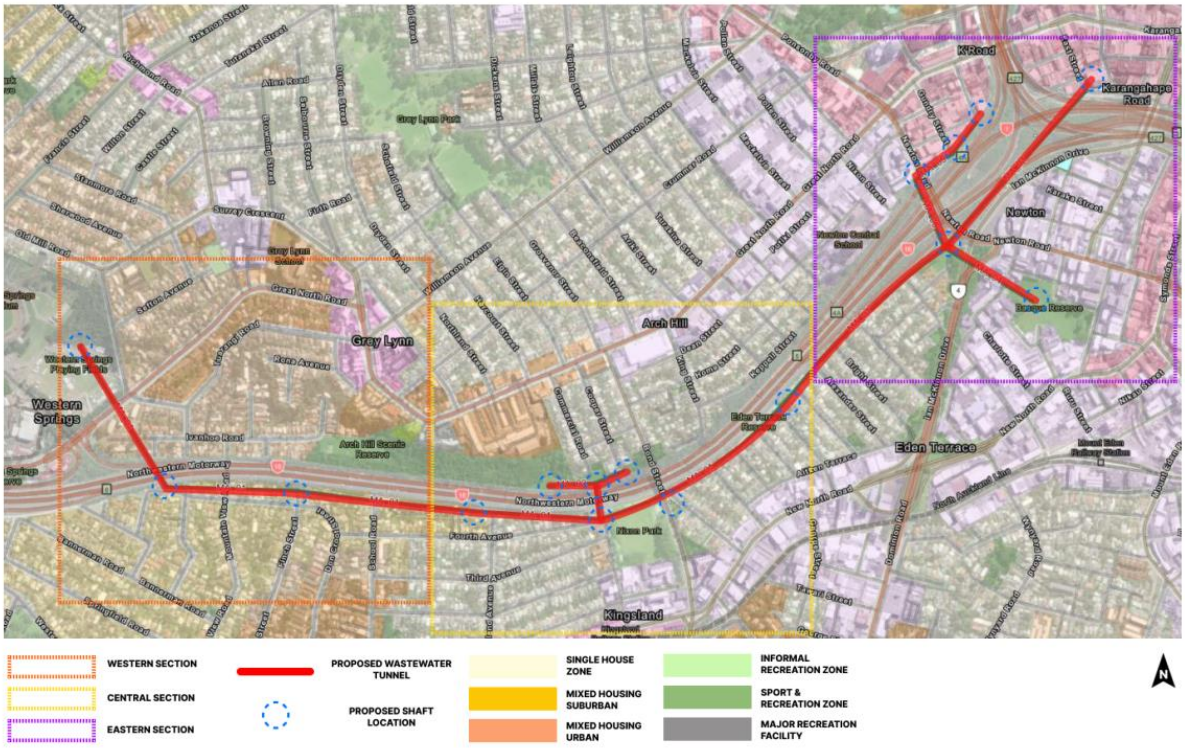
Every 10 dB increase in sound level doubles the perceived noise level. A sound of 70 dB is twice as loud as a sound level of 60 dB and a sound level of 80 dB is four times louder than a sound level of 60 dB. An increase or decrease in sound level of 3 dB or more is perceptible. A change in sound level of less than 3 dB is not usually discernible.

As sound level is measured on a logarithmic scale, the following chart provides examples of typical sources of noise.

Decibel (dB)	Example
0	Hearing threshold.
20	Still night-time.
30	Library.
40	Typical office room with no talking.
50	Heat pump running in living room.
60	Conversational speech.
70	10 m from edge of busy urban road.
80	10 m from large diesel truck.
90	Lawn mower – petrol.
100	Riding a motorcycle at 80 kph.
110	Rock band at a concert.
120	Emergency vehicle siren.
140	Threshold of permanent hearing damage.

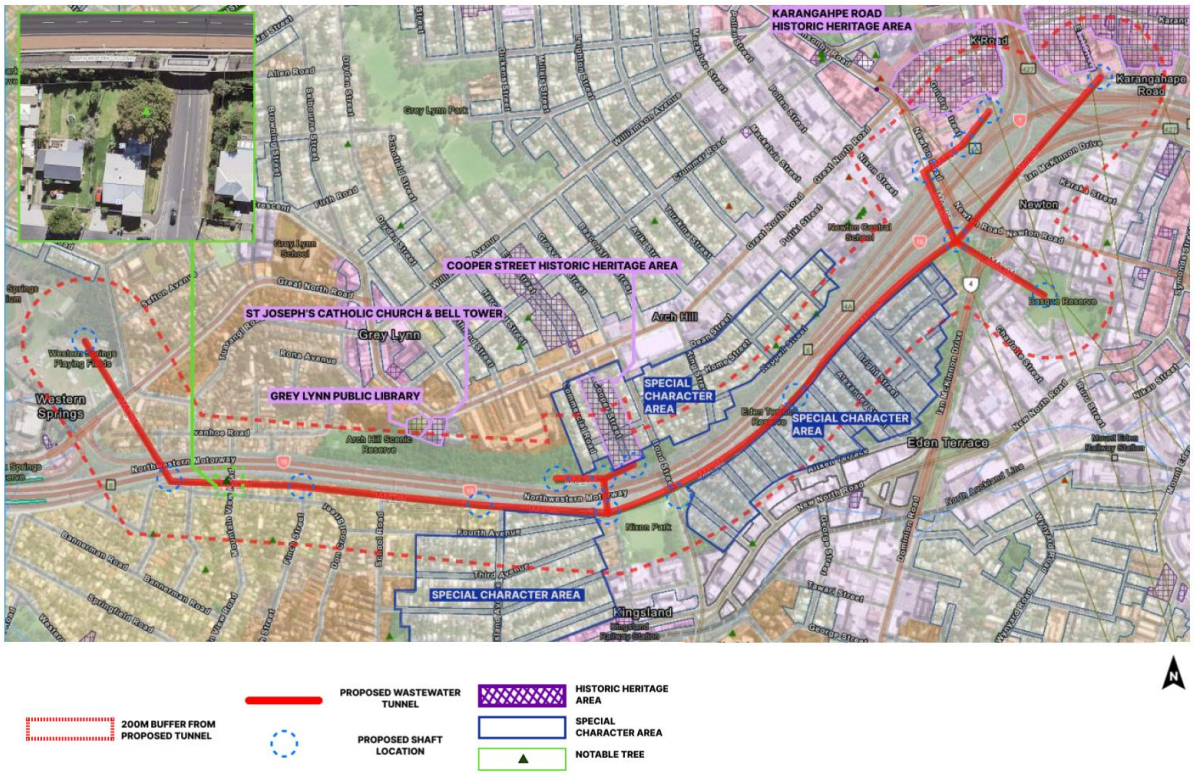
Appendix B – AUP Maps

Source: Specialist brief package for Noise and Vibration - Appendix A – Planning Maps



MAP 2 - AUP(OP) ZONING MAP

aurecon



MAP 3 - AUP(OP) OVERLAYS MAP