Project Number: W-SL001.03

Queen Street Wastewater Diversion: Part 3 Works

20 July 2023

CONFIDENTIAL

Construction Noise and Vibration Impact Assessment

wsp

150 YEARS IN AOTEAROA

Contact Details

WSP
100 Beaumont Street
Auckland 1010
New Zealand
+64 9 355 9500
wsp.com/nz

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Prepared by
George van Hout

Reviewed by
Kezia Lloyd

Approved for release by
Kezia Lloyd

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Revision	Details
0	Issue to Client
1	Updated construction methodology
2	Updated basalt removal methodology and Greys Ave Support

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Abbreviation and Definitions

AC	Auckland Council
AEE	Assessment of Environmental Effects
AT	Auckland Transport
AUP	Auckland Unitary Plan
CNVMP	Construction Noise and Vibration Management Plan
CNVIA	Construction Noise and Vibration Impact Assessment
CRLL	City Rail Link Limited
DCS	Design and Construction Statement
mTBM	Micro Tunnel Boring Machine
NES	National Environmental Standard
NPS	National Policy Statement
NSR	Noise Sensitive Receptor(s)
TMPs	Traffic Management Plans
Watercare	Watercare Services Limited
WSP	WSP New Zealand Limited

Glossary

Glossary	
Term	Description
A-weighting, dBA	The unit of sound level, weighted according to the A-scale, which considers the increased sensitivity of the human ear at some frequencies at low levels.
Ambient noise	The all-encompassing sound, at a given place at a certain time, is usually a composite of sounds from many sources near and far.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s_1 and s_2 is given by $20 \log_{10} (s_1 / s_2)$. The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa.
Façade Level	A noise level measured/assessed at 1 metre in front of a sound reflecting object such as a building façade and including the contribution of the sound reflection.
Free-Field Level	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5 metres.
$L_{eq,T}$	A noise level index called the equivalent continuous noise level over time T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
$L_{10,T}$	A statistical analysis noise descriptor being a sound pressure level exceeded for 10% of the measurement period.
L_{max}	A noise level index is defined as the maximum noise level during the period T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L_{Peak}	The instantons peak pressure level was recorded during the measurement period.
Octave Band	A range of frequencies whose upper limit is twice the frequency of the lower limit.
PPV	Peak Particle Velocity: Measure of the greatest instantaneous velocity change in a specific spot during a measurement period.
Sound Power Level (SWL)	The logarithmic measure in decibels of the sound power (P) generated by a source.
Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (SPL)	The sound level is the sound pressure relative to a standard reference pressure of 20µPa (20×10^{-6} Pascals) on a decibel scale.

Executive Summary

WSP has been engaged by Watercare Services Limited to assess the noise and vibration impacts from Part 3 of the Queen Street Wastewater Diversion Project, in Auckland.

Noise and vibration criteria have been developed based on the Auckland Unitary Plan. Noise from construction works within the roading corridor is exempt from the construction noise limits, provided that a CNVMP is developed with the measures being implemented. While a CNVMP will be adopted by the contractor (and a framework CNVMP has been provided with the Resource Consent), we have assessed noise from within the roading corridor for completeness.

The construction methodology for the installation of the wastewater pipework has been provided by Fulton Hogan, McConnell Dowell (the proposed tunnelling contractors) and the WSP design team. This methodology has been used to develop the phases of construction and equipment used as part of the construction.

Physical mitigation is proposed by the contractor by using solid site hoardings around each construction area, apart from access gates. However, as many of the surrounding buildings are multi-story, the screens are unlikely to be effective above ground level.

Managerial mitigation measures such as controlling high-vibration equipment from operating near buildings within the Historic Heritage Overlay and using low-vibration rock fracking procedures will minimise the vibration generated during construction.

Based on the construction methodology, and managerial and physical mitigation measures, it is predicted that noise and vibration levels will be below the AUP construction noise and vibration standards.

Therefore, to ensure that the mitigation measures incorporated in this assessment are undertaken, a Construction Noise and Vibration Management Plan shall be adopted. This will require noise and vibration to be reduced as far as reasonably practicable by the use of physical and managerial mitigation measures to control the effects.

The implementation of a Construction Noise and Vibration Management Plan is expected to manage noise and vibration levels related to the construction of the Stage 3 works associated with the Queen Street Diversion Project effectively.

1 Introduction

Watercare Services Limited ("Watercare") is a lifeline utility providing water and wastewater services to a population of 1.7 million people in Auckland. Its services are vital for life, keep people safe and help communities to flourish. More specifically, Watercare is the council-controlled organisation of Auckland Council responsible for municipal water supply and wastewater treatment within Auckland, and the provider of bulk water and wastewater services to Pokeno and Tuakau in the Waikato District.

Watercare is proposing to upgrade the wastewater network within the upper catchment (southern) of Auckland City Centre. It has been established by Watercare that the existing network does not have sufficient capacity to meet future demands. WSP New Zealand (WSP) has been engaged by Watercare to design and consent a new wastewater mainline through Auckland city centre (the Project).

This report provides an assessment of construction noise and vibration for Part 3 of the Queen Street Wastewater Diversion Project only.

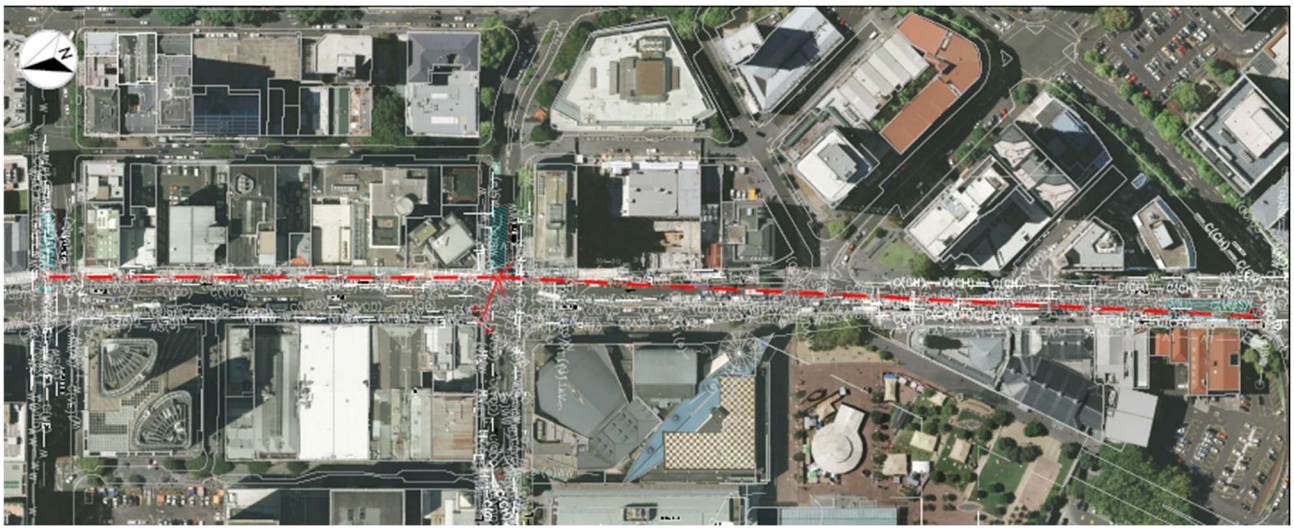


Figure 1 Aerial view of the Part 3 alignment along Queen Street

This project involves a new wastewater pipe being positioned under Queen Street, between the intersection at Mayoral Drive and the intersection at Victoria Street. Manholes for the new wastewater pipe will be provided at the Mayoral Drive intersection, Wellesley Street intersection and Victoria Street intersection. During construction, the manhole locations will be temporarily used as construction shafts.

This report is based on discussions with the design team along with the following information:

- Design and construction statement titled *Design and Construction Statement; Queen Street Wastewater Diversion Project – Part 3*, project number W-SL001.00, version V01.0, prepared by WSP and dated 17 July 2023.
- Wastewater pipe alignment drawings titled *Queen Street WW Diversion Proposed Pipe Alignment*, preliminary design stage, drawing numbers R0021853.007, R0021853.008, R0021853.009, R0021853.010, R0021853.011, R0021853.017, R0021853.018 and R0021853.019, prepared by Watercare Services Limited, and dated 21 April 2023.
- Greys Ave site compound drawings titled, *Queen Street Sewer Diversion Site Compound & Welfare Layout*, drawing number QSSD_FH_001, revision D, prepared by Fulton Hogan Ltd, and dated 20 June 2023.

2 Description of Existing Environment

2.1 Location

The project is located within Auckland City Centre, a dense urban environment with a mixture of commercial, civic and residential activities and uses. The built form is predominately made up of multi-level buildings that generally align with the street. The majority of buildings are provided with verandas, overhanging the footpath area of the roads. The built form along Queen Street is a mix of modern buildings as well as important heritage structures. At street levels, the majority of buildings provide retail stores/units.

The project area is linear along Queen Street, between Victoria Street and Mayoral Drive. During construction, the area subject to project works will extend onto sections of Victoria Street, Wellesley Street and the surface carpark at 329 Queen Street and 38 Greys Avenue.

Figure 2 shows the geographic area for the project in yellow, however, construction activity at surface level will be focused on the Queen Street intersections of Mayoral Drive, Wellesley Street and Victoria Street as shown in red.

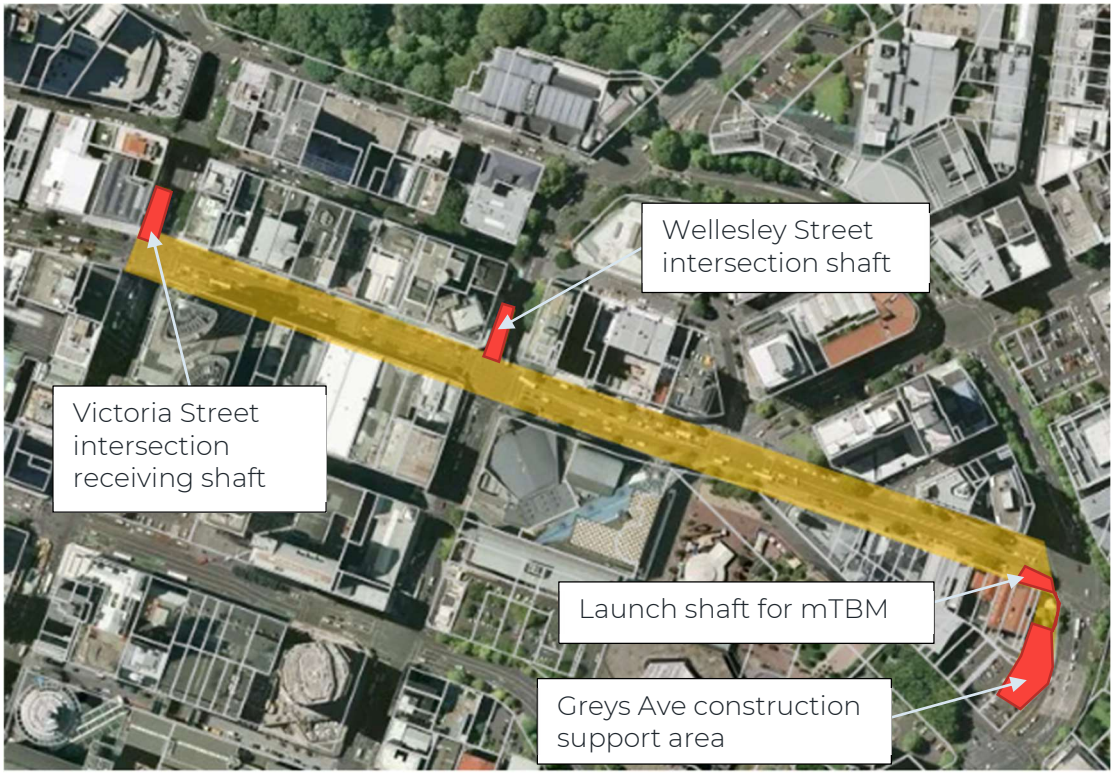


Figure 2 Project area and surface level areas used

2.2 Zoning and Overlays

All construction works occur within a road zone apart from the location of the Greys Ave construction support area, which is located within a Business – City Centre Zone, as outlined in the Auckland Unitary Plan (AUP).

The majority of sites directly adjacent to the works are also located within a Business – City Centre Zone. The exception is Myers Park (Open Space – Community Zone) and Aotea Square (Open Space – Civic Spaces Zone). Some adjacent buildings are also protected by a Historic Heritage and Special Character overlay under the AUP.

The zoning of the three sites and surrounding areas are shown in Figure 3.

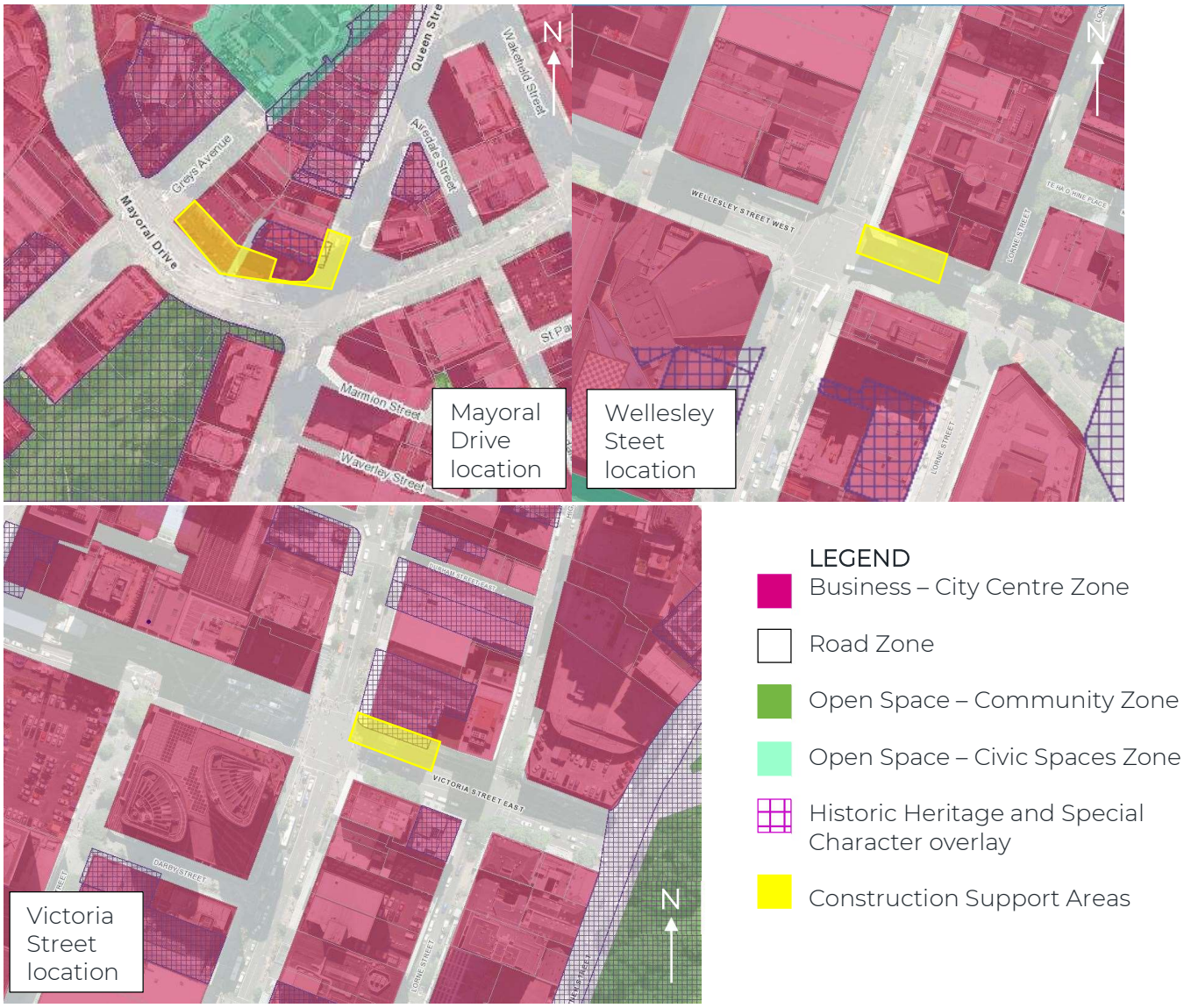


Figure 3 Sites (yellow) and surrounding zoning

2.3 Noise and Vibration Sensitive Receptors

Most buildings around the construction areas are commercial in nature. There are also hotels and apartments near the sites. Commercial properties (yellow), hotels (blue), and apartments (pink) near each of the construction sites (red) are provided in Figure 3.

Many of the properties directly adjacent to the construction sites are also located within the historic heritage overlay as outlined in the AUP. These properties are likely more sensitive to vibration and therefore specific management procedures will need to be adopted by the contractor to minimise the impact of vibration. These management procedures will be captured in a CNVMP.

Figure 4 Adjacent noise sensitive receptor building types – commercial (yellow), hotels (blue), apartments (pink)

3 Project Works

The Project works will see the construction of a new wastewater pipeline under Queen Street, running between Mayoral Drive and Victoria Street. Connections to the existing wastewater network will be provided at Mayoral Drive, Wellesley Street and Victoria Street.

To provide for the new pipe, three temporary shafts will be provided along Queen Street (located at Mayoral Drive, Wellesley Street and Victoria Street). Once the shafts are constructed, tunnelling works will commence from Mayoral Drive, heading north along Queen Street towards Victoria Street. The Micro-Tunnel Boring Machine (mTBM) will be extracted at Victoria Street. Once tunnelling works are completed, the three shafts will be backfilled and converted to manholes.

The following is a summary of the project works, with a more detailed description provided within the Design and Construction Statement (Appendix C of the resource consent application).

3.1 Construction Hours and Duration

The anticipated construction hours are noted in Table 1.

Table 1 Construction hours

Construction Hours	
Activity	Hours
Shaft construction	Monday to Saturday – 0700hrs to 1800hrs Sunday, Public Holiday and night works are not proposed. These will only be carried out if required by traffic management restrictions or Watercare operational requirements for tie-in connections to existing network
Tunnelling works	Monday to Saturday – 0700hrs to 1900hrs Sunday and Public Holidays – No construction works
Greys Avenue Construction Support Area	Monday to Saturday – 0700hrs to 2000hrs Sunday and Public Holidays – No construction works

In some exceptional circumstances, works may be required outside the hours noted above due to operational requirements.

The duration of construction works is yet to be confirmed; however, it is anticipated that physical works will commence in Q1 2024 and would finish around Q1 2025. Table 2 notes the likely construction duration.

Table 2 Construction duration

Construction Duration	
Site	Duration
Queen Street / Mayoral Drive Shaft	2 – 3 months to construct the shaft (Q2 to Q3 2024)
Queen Street/ Wellesley Street Shaft	2 – 3 months to construct the shaft (Q2 to Q3 2024)
Queen Street/ Victoria Street Shaft	3 – 4 months to construct the shaft (Q2 to Q3 2024)
Tunnelling Activity (including site establishment)	7 months including site establishment operation and take-down Q2 to Q4 2024).
Trenched tie-in works	Queen Street pipe work connections (x3) – 1 month (Q4 2024)

3.2 Temporary Construction Shafts

Three temporary shafts for trenchless construction are to be provided along the alignment. These will be constructed into manholes once the trenchless construction works have finished.

Queen Street/ Mayoral Drive Shaft

This shaft will be located on Queen Street, outside 323 Queen Street and once constructed will have a depth of around 13.79m and be 4.5 metres wide by 10 metres long. This shaft will be used as a launch shaft for tunnelling works. The shaft will be of post and panel construction and as such will require continuous dewatering whilst the shaft is in use.

Excavation of the shaft will result in a total of approximately 968 m^3 of spoil being removed.

Figure 5 shows the position of the shaft (red) and the surrounding construction area (yellow).

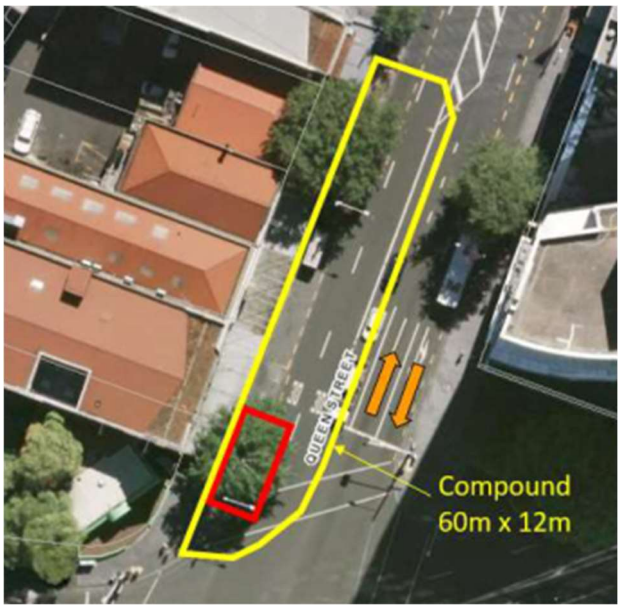


Figure 5 Mayoral Drive Shaft position and construction support area

Queen Street/ Wellesley Street Shaft

This shaft will be located on Wellesley Street, adjacent to 290 Queen Street and will have a total depth of around 7.21m. This shaft will be used for service connections as well as support for tunnelling works. This shaft will be sealed once constructed and as such ongoing dewatering will not be required.

The shaft is to have an internal diameter of 3.5 metres and results in 126 m^3 of spoil being removed due to excavation.

Figure 6 shows the position of the shaft (red) and the surrounding construction area on Wellesley Street (yellow).

Figure 6 Wellesley Street Shaft position and construction support area

Queen Street/ Victoria Street Shaft

This shaft will be located on Victoria Street, adjacent to 210 Queen Street and will have a total depth of around 6.87m. This shaft will be used to provide a connection to the Ōrākei Main Sewer (OMS) as well as for the recovery of the mTBM. The shaft will be of post and panel construction and as such will require continued dewatering whilst the shaft is in use.

The shaft is to be 3 metres wide by 7 metres long and will result in 240 m^3 of spoil being removed due to excavation.

Figure 7 shows the position of the shaft (red) and the surrounding construction support area on Victoria Street (yellow).

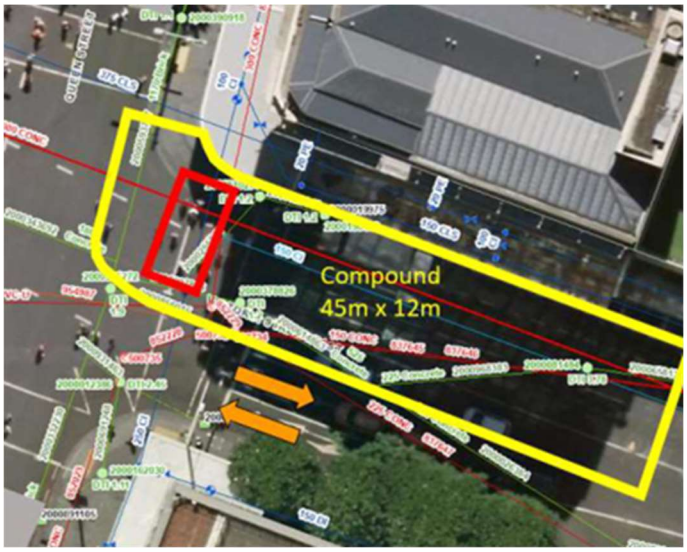


Figure 7 Victoria Street Shaft position and construction support area

3.3 Tunnelling Works

Tunnelling works will commence from the shaft at Mayoral Drive and end at the shaft at Victoria Street using a mTBM.

To support tunnelling works, a Construction Support Area (CSA) will be established on part of the public car park at 38 Greys Avenue that will contain ancillary equipment and functions for tunnelling. A construction area around the shaft will include equipment used for the operation of the mTBM. Figure 8 shows the proposed layout for the Greys Avenue CSA and how it relates to the construction shaft on Queen Street.

Approximately 576 metres of 1.2-metre diameter pipe will be installed between the Mayoral Drive site and Victoria Street site. A total of 970 m^3 of spoil is to be excavated during tunnelling activities.

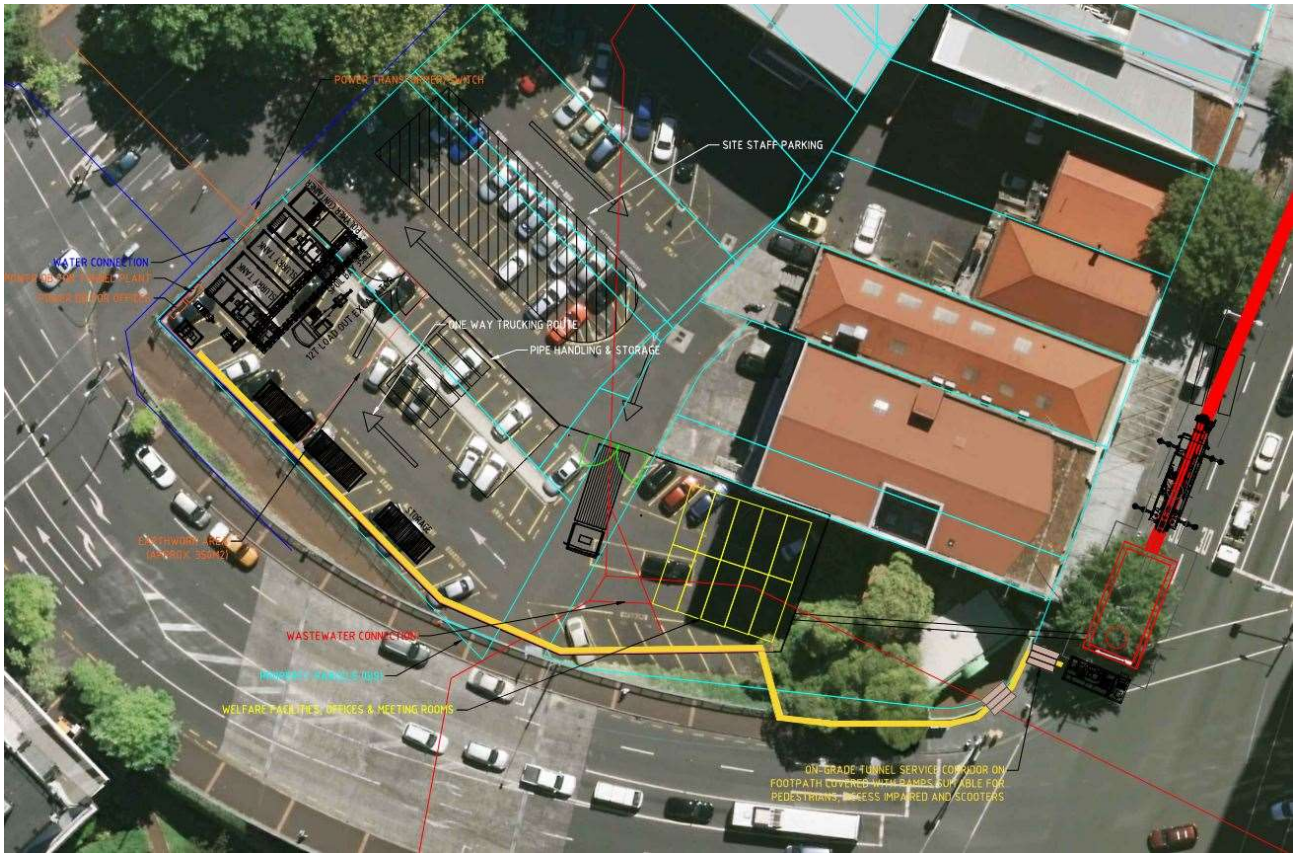


Figure 8 Greys Avenue CSA during tunnelling works

The equipment to be provided within the Greys Avenue CSA and the Mayoral Drive construction area during tunnelling is given in Table 3.

Table 3 Equipment located at Greys Avenue CSA and Mayoral Drive site

Construction Support Areas Equipment during Tunnelling works	
Greys Avenue CSA	Mayoral Drive CSA
• Project site office • Staff welfare facilities • 12t excavator (for removing spoil from the site, and loading onto trucks) • Separation plant • Slurry tanks • Electrical container • 800kW diesel generator (only required if connection to electrical mains cannot be established) • Pumps • Site laydown area/ material storage area • Pipe fit-out area	• Tunnelling control cabin • In-shaft jacking equipment • 50t mobile crane • Pipe laydown area

A 2m wide service corridor will connect the Greys Avenue CSA and Mayoral Drive CSA. The services will be laid on the ground and covered with a walkway to maintain pedestrian access between Queen Street and Mayoral Drive.

Once tunnelling commences, extracted material will be transported in a slurry medium to the separation plant at Greys Avenue CSA. Once the solids have been removed from the slurry, it will be loaded onto trucks and disposed of off-site, with the liquid returning to the closed-loop system.

As the mTBM progresses, 6m long sections of pipe will be installed. As the jacking rig is retracted, the next pipe section is lowered by a crane from the surface and placed into position. The cycle continues until the drive is complete.

Once tunnelling is completed, the mTBM will be recovered at the Victoria Street Shaft.

Further detail on the construction methodology and staging is provided in Section 5.1 below. This includes a breakdown of the equipment, expected durations, and processes undertaken.

3.4 Vehicle Movements

Vehicle movements will be occurring to and from CSAs during the project works. The following outlines the likely vehicle movements expected to occur.

Table 4 Vehicle movements

Proposed Vehicle Movements at Each Site		
Stage of Works	Likely vehicle movements (daily – average)	
Shaft Construction	Mayoral Drive site	• Light vehicles: 10 per day • Flatbed delivery trucks: 2 per day • Spoil/ aggregate trucks: 8 per day (peak)
	Wellesley Street site	• Light vehicles: 10 per day • Flatbed delivery trucks: 2 per day • Spoil/ aggregate trucks: 8 per day (peak)
	Victoria Street site	• Light vehicles: 10 per day • Flatbed delivery trucks: 2 per day • Spoil/ aggregate trucks: 8 per day (peak)
Tunnelling works	Light vehicles: 10 per day	
	Flatbed delivery trucks: 2 per day	

Please note that other vehicle movements will occur during site establishment and disestablishment activities.

4 Performance Standards

Section 16 of the Resource Management Act (RMA) requires occupiers of land 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.'*

Guidance as to what a reasonable level of noise and vibration when assessed at adjacent noise sensitive receptors is taken from Chapter E25 – Noise and Vibration of the AUP. This chapter sets out noise and vibration standards for permitted activities. Where the AUP noise and/or vibration standards are exceeded, then a resource consent is required as a restricted discretionary activity.

4.1 Construction Noise Criteria

This section outlines guidance as to what constitutes a reasonable level of noise.

4.1.1 Auckland Unitary Plan

The majority of the construction works occur within the road corridor and therefore section E25.6.29 of Chapter E25 (AUP) applies. The relevant sections of these noise standards are reproduced below. Where construction works occur outside of the road corridor, the noise standards outlined in section E25.6.27 apply.

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

(3) The noise levels specified in Standard E25.6.29(1) above do not apply to unplanned repair or maintenance works or planned works in the road corridor between the hours of 7am and 10pm where:

(b) because of the nature of the works and the proximity of receivers the noise generated cannot be practicably made to comply with the relevant noise levels of the following tables:

(i) Table E26.6.27.1 Construction noise limits for activities sensitive to noise in all zones except the Business - City Centre Zone and the Business – Metropolitan Centre Zone;

(ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or

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

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

(c) for planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council five days prior to work commencing; or

(d) for planned works where the works will take more than 8 hours to complete a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5) below

(4A) The vibration levels specified in E25.6.29(1A)(b) do not apply to works within the road where:

(b) a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29.(5) below.

(5) construction noise and vibration management plan must be prepared by a suitably qualified and experienced person and include the following:

(a) details of the community consultation to be undertaken to advise the occupiers of properties located within 100m of the proposed works of all of the following:

(i) the area affected by the work;

(ii) why the work is required to be undertaken at night (where relevant);

(iii) the times and days when the noise and vibration is likely to be generated;

(iv) a contact name and number of the works supervisor who can be contacted if any issues arise and

(v) how noise and vibration complaints will be managed and responded to;

(b) a description of the works and its duration, anticipated equipment to be used, the processes to be undertaken, and the predicted noise and vibration levels; and

(c) 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 levels of the following tables:

(i) Table E26.6.27.1 Construction noise limits for activities sensitive to noise in all zones except the Business - City Centre Zone and the Business – Metropolitan Centre Zone;

(6) For the purpose of Standards E25.6.29(1) to E25.6.29(4A) above:

(a) planned work means work that has been planned to take place at least seven days before the work commences;

(b) the measurement and assessment of all construction noise must be in accordance with New Zealand Standard NZS 6803:1999 Acoustics – Construction noise; and

(c) the measurement of all vibration must be in accordance with E25.6.30 Vibration.

The removal of noise limits for works in the road reserve, as per item 3(d), allows for potentially disruptive road corridor works to be completed efficiently to minimise road closures and subsequent disruptions.

However, under Section 16 of the RMA, there is still a requirement for construction noise (and vibration) to not exceed a reasonable level. There is also a requirement for the CNVMP to indicate the area impacted by the works. Therefore, we have predicted noise generated by the construction activities regardless of where the works occur.

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

(1) Construction activities in the Business – City Centre Zone and the Business –Metropolitan Centre Zone must comply with Standard E25.6.27(1) above for any receiver not in a Business – City Centre Zone or a Business –Metropolitan Centre Zone and must not exceed the levels in Table E25.6.28.1 Construction noise levels for construction less than 15

consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.28.2 Construction noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone when measured for any 30 minute period 1m from the façade of any building in the Business – City Centre Zone or the Business – Metropolitan Centre Zone that is occupied during the work.

Where external measurement of construction noise is impractical or inappropriate, the upper limits for the noise measured inside the building will be 20dB less than the relevant levels.

Whilst construction works are only proposed on Monday to Saturday, and therefore will always be less than 15 consecutive calendar days in duration, we have conservatively applied the noise limits in Table E25.6.28.2 (for works that occur for more than 15 consecutive days), which are reproduced below.

Table 5 AUP Construction noise limits in the Business – City Centre Zone

Construction Noise Assessment Criteria AUP Construction noise limits in the Business – Metropolitan Centre Zone, assessed 1m from the facade		
Time	$L_{Aeq,30\ min}$ (dB)	L_{AFmax} (dB)
Monday to Friday 6.30am – 10.30pm	75	90
Saturday 7am-11pm	80	90

The most stringent noise limit during this time is 75 dB $L_{Aeq(30min)}$ / 90 dB L_{AFmax} from construction activities. We have therefore assessed noise against these criteria.

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

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

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

Based on the proposed construction methodology, the construction works will occur for 6 – 8 months, as outlined in Table 2 .

This rule applies to all properties that are not zoned City Centre. Specifically for this project, the buildings within Aotea Square are outside of the City Centre zone, and therefore the construction noise limits in Rule E25.6.27 of the AUP apply. These levels (including the adjustment for works greater than 20 weeks) are provided in Table 6.

Table 6 Construction noise limits outside the city centre

Construction Noise Assessment Criteria AUP Construction noise limits for sites outside of the Business – Metropolitan Centre Zone or Business – Metropolitan Centre Zone, assessed 1m from the facade			
Day	Time	$L_{Aeq,30min}$ (dB)	L_{AFmax} (dB)
Monday to Friday	6:30am – 7:30am	55	70
	7:30am – 6pm	70	85
	6pm – 8pm	65	80
Saturdays	6:30am – 7:30am	40	70
	7:30am – 6pm	70	85
	6pm – 8pm	40	70
Sundays and public holidays	6:30am – 7:30am	40	70
	7:30am – 6pm	50	80
	6pm – 8pm	40	70
Night-time	8pm – 6:30am	40	70

Source: Auckland Unitary Plan – Table E25.6.27.1

The construction noise limits under the AUP apply 1 metre away from the façade of a residentially occupied building.

In line with other noise standards within the AUP, construction noise in this assessment has been undertaken over 30 minutes.

4.1.2 New Zealand Standard NZS 6803:1999

New Zealand Standard NZS 6803:1999 provides guidance for the prediction and measurement of noise from construction sites. Where no noise limits are provided in planning standards, NZS 6803:1999 provides guidance on noise limits. The AUP has specific noise limits for set zones, and therefore the AUP limits override the recommended limits in NZS 6803:1999.

Table 2 and Table 3 of NZS 6803:1999 outlines the recommended upper limits for construction noise for noise received at residential receptors and commercial or industrial receptors

The long-term duration construction noise limits (defined as *construction work at any one location with a duration exceeding 20* weeks) from NZS 6803:1999 are reproduced in Table 7, based on the timeframes where construction will occur.

Table 7 NZS 6803 Recommended upper limits for construction noise

Construction Noise Assessment Criteria New Zealand Standard NZS 6803:1999 recommended noise limits			
Day	Time	$L_{Aeq,30min}$ (dB)	L_{AFmax} (dB)
Residential receptors			
Weekdays	0630-0730	55	75
	0730-1800	70	85
	1800-2000	65	80
	2000-0630	45	75
Saturday	0630-0730	45	75
	0730-1800	70	85
	1800-2000	45	75
	2000-0630	45	75
Sundays and public holidays	0630-0730	45	75
	0730-1800	55	85
	1800-2000	45	75
	2000-0630	45	75
Commercial and Industrial receptors			
All days	0730-1800	70	-
	1800-0730	75	-

The levels provided in NZS 6803:1999 are the same or more lenient than those outlined in the AUP.

These noise limits apply 1 m from the wall most exposed to construction activity and 1.2 to 1.5 m above the relevant floor level.

NZS 6803:1999 notes that a measurement sample time should not exceed one hour, and 15 minutes will often be adequate.

4.2 Construction Vibration Criteria

This section outlines guidance as to what constitutes a reasonable level of vibration.

4.2.1 Auckland Unitary Plan

Section E25.6.30 of the AUP outlines the relevant vibration limits, which are reproduced below.

E25.6.30. Vibration

(1) Construction and demolition activities must be controlled to ensure any resulting vibration does not exceed:

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

b. *the limits in Table E25.6.30.1 vibration limits in buildings in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500 mm of ground level at the foundation of a single storey building.*

4.2.2 German Standard DIN 4150-3:1999

The German Standard DIN 4150:1999 'Structural Vibration – Part 3: Effects of Vibration on Structures' is an internationally recognised standard used to assess the effects of vibration on structures. The Standard is widely used throughout New Zealand and is referenced by many District Plans (or similar) including the AUP.

DIN 4150-3:1999 criteria to evaluate the effects of short-term vibration on structures (such as impact piling or blasting which occurs instantaneously) that does not induce resonance in a building structure, or long-term vibration (such as from vibratory piling or traffic).

The vibration limits in DIN 4150-3 relate to avoiding cosmetic damage to buildings (such as cracking in paint). This is framed as 'minor damage' in DIN 4150, meaning it can easily be repaired. DIN 4150 states:

> *'Experience has shown that if these values are complied with, damage will not occur. Exceeding the values in table 3 slightly does not necessarily lead to damage.'*

The vibration limits outlined in DIN 4150-3 are set such that there is a low probability of cosmetic damage. These apply at the plane of the highest floor of various types of building. 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.

The long-term vibration limits outlined in Table 3 of DIN 4150-3:1999 are outlined in Table 8.

Table 8 DIN 4150-3 long-term guideline vibration limits

Construction Vibration Criteria DIN 4150-3 Guideline vibration limits used to assess the effects of long term-vibration on structures		
Line	Type of Structure	Guideline values for velocity, i_i, in mm/s, of vibration in the horizontal plane of the highest floor, at all frequencies.
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	10
2	Dwellings and buildings of similar design and/or use.	5
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic values (e.g., buildings under a preservation order).	2.5

4.2.3 Auckland Unitary Plan Vibration Amenity Limits

The vibration amenity limits outlined in Table E25.6.30.1 of the AUP are reproduced below.

Table 9 AUP Amenity vibration limits

Construction Vibration Criteria Vibration limits in buildings from construction (E25.6.30.1)		
Receiver	Period	Maximum Peak Particle Velocity (PPV) Limit, mm/s
Occupied activity sensitive to noise	Night-time 10pm to 7am	0.3
	Daytime 7am to 10pm	2.0
Other occupied buildings	At all times	2.0

The vibration limits in Table 8 apply to any axis when measured in the corner of the floor of the storey of interest for a multi-storey building, or within 500mm of ground level at the foundation of a single storey building. An allowance for properties to receive up to 5 mm/s is provided for, only if prior notification was given, at least three days in advance, within 50m of the works.

The vibration limits in Table 9 are useful in considering whether an adjacent resident or occupant is likely to have their amenity reasonably affected by vibration, however they should not generally be used as an absolute threshold. Exceeding these limits is a call to action, that requires certain management measures to be set in place i.e., through a CNVMP.

4.2.4 British Standard BS 5228-2:2014

British Standard BS 5228-2:2014 *Code of Practice for noise and vibration control on construction and open sites – Part 2: Vibration* provides guidance on human perception of vibration. However, we note that 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.

Humans perceive vibration at much lower magnitudes than the levels of vibration that are likely to cause building damage. Occupants of buildings are therefore likely to complain about vibration significantly below the levels likely to result in cosmetic damage to buildings.

The guidance values in BS 5228-2 are provided in Table 10. These levels are provided as a means of acknowledging that humans perceive vibration well before vibration venerated from construction activities would impact the building structure. However, these levels can be used to provide guidance as to at what level certain management measures should be adopted.

Table 10 BS5228 vibration subjective impacts

Construction Perception Criteria BS 5228-2:2014 guidance on human perception of vibration	
Vibration Level (PPV)	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction . At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.

4.3 Noise Impact Terminology

We have used the following terminology when considering the impacts on adjacent properties

Table 11 Noise impact terminology

Noise Impact Terminology	
Noise impact wording	Description
Acceptable	The predicted noise or vibration level is at or below the AUP criteria
Reasonable	The predicted noise or vibration level is above the AUP criteria, but due to timing, assessment location, hours of operation, receiver, or other factor the level of noise or vibration impact on the receiver is low.
Obvious	The predicted noise or vibration level is above the AUP criteria and is likely to have a low or medium impact on adjacent receptors. Noise-sensitive activities are likely to be disturbing.
Unreasonable	The noise or vibration level is likely to have a high impact on adjacent receptors. All but least lest sensitive activities are likely to be disturbed.

5 Assessment Methodology

This section details the assessment methodology, the assumptions and limitations used within this assessment.

5.1 Construction Staging and Equipment

5.1.1 Construction Equipment

Appendix A provides a list of the expected equipment to be used during construction, the associated sound power of that equipment, and the percentage of time in use over a worst-case 30-minute period.

The equipment selection and associated sound power levels are based on BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites*, NZS 6803:1999 *Acoustics – Construction noise*, or previous measurements of similar equipment.

Appendix B also presents the vibration levels for specific high-vibration equipment taken from the NZTA *State highway construction and maintenance noise and vibration guide,* BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites*, or previous measurements of similar equipment.

Vibration measurements of pipejacking operations have been undertaken by the contractor on other projects. These have resulted in vibration levels of 0.3 mm/s PPV or less at adjacent buildings. However, without the specific ground conditions known, distance, or foundation type, we have used a conservative vibration generating assumption in our calculations.

WSP undertook vibration measurements of a plate compactor at the proposed Victoria Street / Queen Street shaft location. The plate compactor operated on a single spot, with the vibration measurements made at various distances away from the plate compactor including on the foundation (on ground level) and within the basement of 210 Queen Street. The measurements of the plate compactor operating and the specific foundation reduction for 210 Queen Street have been used in our analysis.

The evaluation and assessment have been conducted under the assumption that the equipment or plant will not exceed the levels outlined in Appendix A. It is the contractor's responsibility to ensure that all equipment and/or plant on site is equivalent to or less than the assumed sound power levels.

Light construction works (such as light handheld tools, manual digging, line painting etc.) are also expected to occur on site. These activities are not expected to produce excessive noise or vibration levels and have therefore not been included unless otherwise specified.

5.1.2 Physical Site Mitigation

The contractor is proposing to use temporary concrete barriers with plywood hoardings around the perimeter of each of the construction support areas, except where a gate is required for access. These include the launch and receiving shafts for the trenchless construction. The proposed site hoardings are shown in Figure 9.

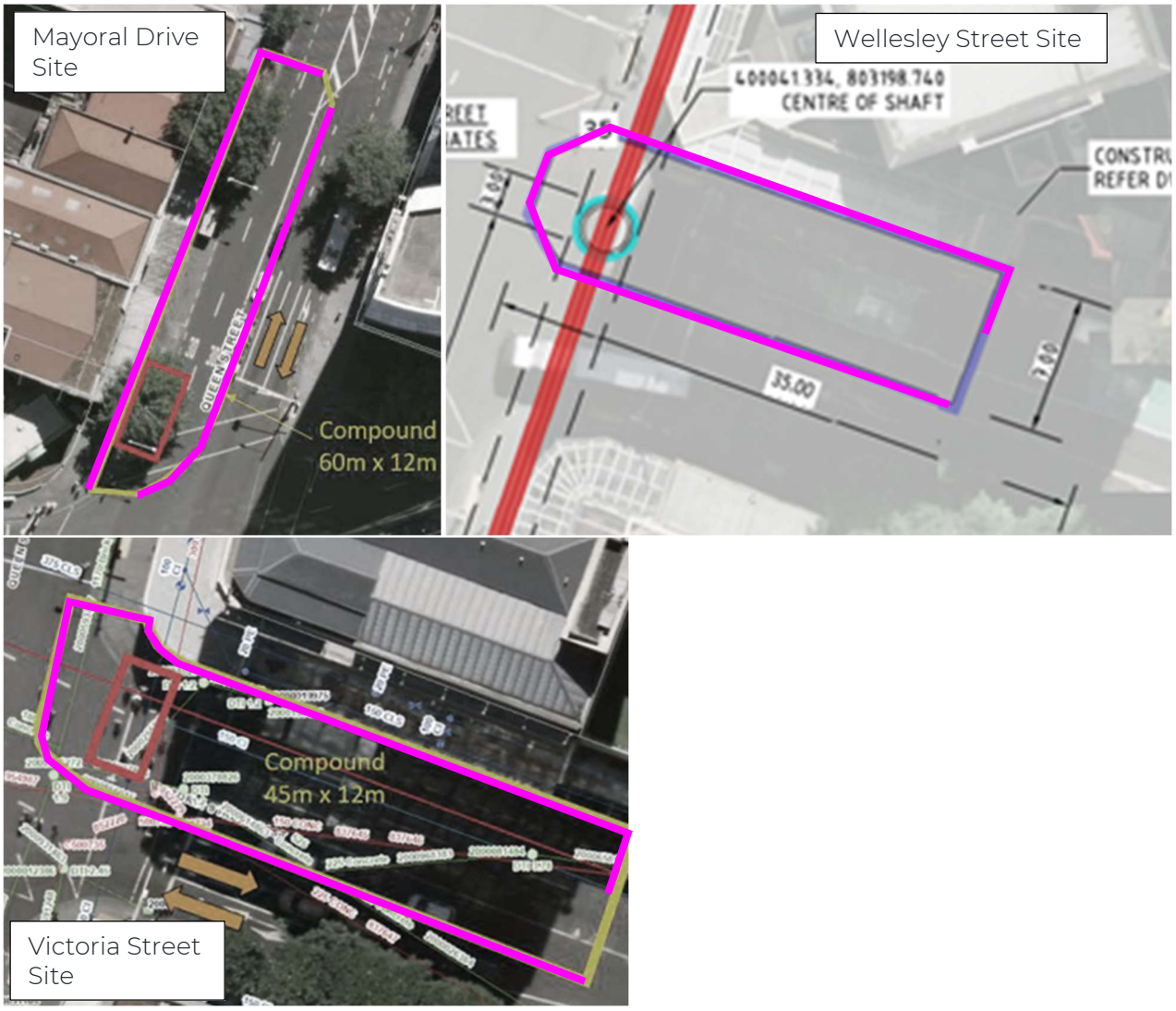
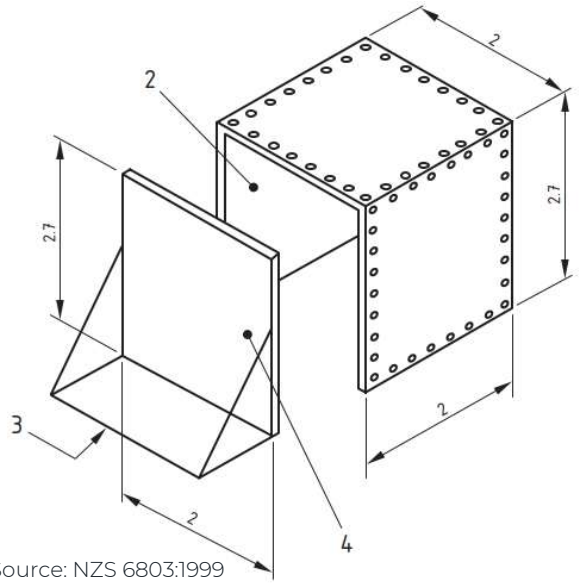


Figure 9 Proposed locations of site hoardings (pink)

The site hoardings are to be constructed to a height of no less than 2.0 metres with a surface mass of 10 kg/m^2 (such as 18 mm plywood) and have no gaps or cracks.

Temporary localised barriers or enclosures should be used over the opening of the shaft during any drilling of the basalt, and around generators and/or pumps used for dewatering during the night-time. An example of temporary enclosures that could be constructed over the shaft opening during rock fracking or compaction is shown in Figure 10.



Source: NZS 6803:1999

Source: https://blog.echobarrier.com/

Figure 10 Example of temporary acoustic enclosure

5.1.3 Managerial Mitigation

Managerial mitigation measures will be adopted by the contractor to further help reduce the noise and vibration and the impacts of any exceedances.

Further information on managerial mitigation measures are provided in Section 9.3.

A Construction Noise and Vibration Management Plan is recommended as a condition of consent such that these mitigation options are adopted by the contractor.

5.1.4 Construction Staging

The general construction staging for the overall construction works is provided in Table 12. It is unknown whether the shafts will be constructed concurrently or consecutively.

Table 12 Overall construction works staging

Overall Construction Staging		
Activity	Starting	Duration
Queen Street / Mayoral Drive shaft	Q2 2024	2 – 3 months to construct the shaft (Q2 to Q3 2024)
Queen Street/ Wellesley Street Shaft	Q2 2024	2 – 3 months to construct the shaft (Q2 to Q3 2024)
Queen Street/ Victoria Street Shaft	Q2 2024	3 – 4 months to construct the shaft (Q2 to Q3 2024)
Construction Support Area setup to support tunnelling operations	Q2 2024	7 months including site establishment operation and take-down Q2 to Q4 2024).
Trenchless pipe installation	Q3 2024	Queen Street pipe work connections (x3) – 1 month (Q4 2024)
Trenched tie-in works	Q3 2024	2 – 3 months to construct the shaft (Q2 to Q3 2024)

The construction staging for the Mayoral Drive, Wellesley Street, and Victoria Street shafts, trenchless pipe installation, and trenched pipe installation construction activities are outlined in Table 13 to Table 19 . Some phases do not include noise generating activities. These phases have not been assessed as they will generate noise levels lower than the remainder of the phases assessed.

Table 13 Shaft Construction - Queen Street / Mayoral Drive

Shaft Construction Queen Street/ Mayoral Drive		
Phase	Activity	Equipment/Materials assessed for noise and/or vibration impact.
1	Shaft extent will be saw cut and an 8t to 14t excavator used to remove pavement layers and other shallow level obstructions.	• Concreate cutter • Excavator
2	A GEAZ EX40/60 piling rig will be used to bore 400 to 600mm diameter holes to a depth of 2m below shaft base.	• Piling rig (GEAZ EX40/ 60)
3	Steel UC posts will be lowered into each bore using a 14t excavator and the bores backfilled with sand or pea gravel.	• Excavator
4	Shaft extent will be excavated using a 5 to 20t excavator and workers with compressor powered hand held air tools. A 25t crane and skip will be used to remove hand excavated materials when the excavator runs out of reach. Shaft spoil will be removed from site using a 6 or 8 wheeler truck with sealed bins.	• Excavator • Hand held power tools • Crane • Skip • 6 or 8 wheeler truck
5	Timber lagging will be cut to fit and installed between UC posts as the excavation progresses to retaining surrounding ground. Steel waler beams will be installed and welded together within the shaft to support the UC posts.	*This activity will occur concurrently with Phase 4. Therefore, noise generated in this phase has been assessed concurrently with Phase 4.*
6	Shaft will require 24/7 dewatering and a submersible pump will be used to pump water into clarifying tank(s) for treatment, before discharging into the local wastewater network. The pump will be powered by a diesel generator which will run continuously while the shaft is open (subject to water ingress rates). Please note that, if possible, connection to local power network would be used over a generator. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft.	*This activity will occur concurrently with Phase 4. Therefore, noise generated in this phase has been assessed concurrently with Phase 4.* • Submersible pump • Diesel generator • Ventilation fan
6	Following completion of tunnelling works, an in situ concrete manhole will be formed and poured within the shaft using a concrete skip and 25t crane at road level or with concrete pump. Precast concrete riser manhole sections will be installed using a 25t crane at road level. Shaft will be backfilled with compacted GAP65 or low strength concrete.	• Crane • Concrete skip • Concrete pump
7	Temporary works will be progressively removed using a 5t to 20t excavator as the shaft is backfilled.	• Excavator
8	Road pavement (GAP65 and AC) will be reinstated using a 5 to 20t excavator and vibratory roller.	• Excavator • Plate compactor

Table 14 Shaft Construction - Queen Street / Wellesley Street

Shaft Construction Queen Street/ Wellesley Street		
Phase	Activity	Equipment/Materials assessed for noise and/or vibration impact.
1	Shaft extent will be saw cut and a 5t to 20t excavator used to remove pavement layers and other shallow-level obstructions.	• Concrete cutter • Excavator
2	A concrete ring beam will be formed. If required by temporary work design, hydraulic jacks will be fixed to the top of the ring beam.	• Hydraulic jack • Concrete truck • Concrete pump
3	A combination of 8t excavator digging and jacks will be used to sink the precast shaft rings. As the depth increases workers will access the shaft and hand excavate the shaft into a skip lifted by 25t crane. Shaft spoil will be removed from the site using 6 or 8 wheeler trucks with sealed bins.	• Excavator • Hydraulic jacks • Handheld power tools • Skip • Crane • 6 or 8 wheeler trucks • Submersible pump • Diesel generator • Ventilation fan
4	In situ concrete foundation plug will be poured using a concrete boom pump or skip.	• Concrete pump (or skip) • Concrete truck
5	Following completion of tunnelling works, an in situ concrete manhole will be formed and poured within the shaft using a concrete skip and 25t crane at road level or with concrete pump. Precast concrete riser manhole sections will be installed using a 25t crane at road level. Shaft will be backfilled with compacted GAP65 or low strength concrete.	• Crane • Concrete skip • Concrete pump
6	Temporary works will be progressively removed using a 5t to 20t excavator as the shaft is backfilled.	• Excavator
7	Road pavement (GAP65 and AC) will be reinstated using a 5 to 20t excavator and vibratory roller.	• Excavator • Plate compactor

For this phase, dewatering will be required all day and night for up to 12 months. This is expected to be the only activity requiring night works.

Table 15 Shaft Construction - Queen Street / Victoria Street

Shaft Construction Queen Street/ Victoria Street		
Phase	Activity	Equipment/Materials assessed for noise and/or vibration impact.
1	Shaft extent will be saw cut and a 5 to 20t excavator used to remove pavement layers and other shallow-level obstructions.	• Concreate cutter • Excavator
2	GEAZ EX 40/60 piling rig will be used to bore 400 to 600mm diameter holes to the top of basalt level.	• Piling rig (GEAZ EX40/ 60)
3	Steel UC posts will be lowered into each bore using a 5 to 20t excavator and the bores backfilled with sand or pea gravel.	• Excavator • 6 or 8 wheeler truck
4	The shaft extents will be excavated using an 8 to 14t excavator and workers with compressor powered hand held air tools. A 25t crane and skip will be used to remove hand held excavated materials when the excavator runs out of reach. Shaft spoil will be removed from site using a 6 to 8 wheeler trucks with sealed bins.	• Excavator • Hand held power tools • Crane • Skip • 6 or 8 wheeler truck
5	Timber lagging will be cut to fit and installed between UC posts as the excavation progresses to retaining the surrounding ground. At least two steel waler beams will be installed and welded together within the shaft to support the UC posts.	*This activity will occur concurrently with Phase 4. Therefore, noise generated in this phase has been assessed concurrently with Phase 4* • Timber lagging • Steel waler beams
6	Solid basalt will be found within this shaft at approximately 5.5m below road level. The basalt layer will be fractured using a stitch core line of holes to the nominated lift depth in the basalt, adjacent and parallel to the existing sewer to provide a relief gap. Rows of holes will be drilled adjacent and parallel to the stitch cored row. Plug and feather wedges or expanding mortar methods will be used to fracture the basalt until the final excavation depth is achieved.	• Excavator • Rock diamond drill • Crane
7	Shaft will require 24/7 dewatering and a submersible pump will be used to pump water into clarifying tank(s) for treatment, before discharging into the local wastewater network. The pump will be powered by a diesel generator which will run continuously while the shaft is open (subject to water ingress rates). Please note that, if possible, connection to local power network would be used over a generator. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft.	*This activity will occur concurrently with Phase 4 and 6. Therefore, noise generated in this phase has been assessed concurrently with Phase 4 and 6.* • Submersible pump • Diesel generator • Ventilation fan
8	After mTBM extraction, an in situ concrete manhole will be formed and poured within the shaft using a concrete skip and 25t crane at road level or with concrete pump. Precast concrete riser manhole sections will be installed using a 25t crane at road level. Shaft will be backfilled with compacted GAP65 or low strength concrete.	• Concrete skip • Crane • Concrete pump • Concrete truck • Trucks • Excavator • Submersible pump • Diesel generator • Ventilation fan
9	Temporary works will be progressively removed using a 5t to 20t excavator as the shaft is backfilled.	• Excavator
10	Road pavement (GAP65 and AC) will be reinstated using a 5t to 20t excavator and vibratory roller.	• Excavator • Plate compactor

Table 16 Open Trench Pipe Installation

Open Cut Pipe Laying Queen Street/ Wellesley Street		
Phase	Activity	Equipment/Materials assessed for noise and/or vibration impact.
1*	Temporary traffic management set up in accordance with approved Traffic Management Plans (TMPs). TMPs will be staged, allowing only short sections of pipeline to be constructed at any one time.	• Traffic management equipment
2	Approximately 20 to 30m of trenching will be open at any one time. Open earthworks would be up to 300m^3. Depth of trenches are not known, however for any trench deeper than 1.5m, a trench shield will be used.	• Trench shield • Flatbed truck • Excavator • Submersible pump • Diesel generator
3	Pipe lengths and precast manholes will be delivered to site on flatbed trucks and unloaded within the site using HIAB or excavators.	*This activity will occur concurrently with Phases 2 - 5. Therefore, noise generated in this phase has been assessed concurrently with Phases 2 – 5.*
4	Excavator will be used to trench to the required depth and install trench shields as the excavations advance. Wider trench boxes will be provided at manhole locations. Excavated material will be cut to waste as clean, managed or contaminated fill subject on contamination testing results.	*This activity will occur concurrently with Phases 2 - 5. Therefore, noise generated in this phase has been assessed concurrently with Phases 2 – 5.*
5	If dewatering is required (subject to ground investigation outcome), a two-inch submersible pump and hole will be used to remove water from excavations. Water will be pumped into clarifying tanks/ containers for treatment before discharge. The pumps will be powered by a diesel generator which will run continuously while the trench is open, dependent on water ingress rates. Dewater is not anticipated to be required in a single location for more than three weeks.	*This activity will occur concurrently with Phases 2 - 5. Therefore, noise generated in this phase has been assessed concurrently with Phases 2 – 5.*
6	Pipe bedding material will be carted to the worksite directly from source in 6 or 8 wheeler trucks, spread into the trench using an excavator and compacted using 300kg plate compactors. Excavators will be used to lift 2.4m pipe lengths into the trench.	• 6 to 8 wheeler truck • Excavator • Plate compactor
7	Side haunch, overlay bedding and hard fill to pavement level will be constructed as per pipe bedding material (refer above). Pavement layer will be stepped out from trench excavation to provide key into the existing pavement layers. Pavement aggregates will be spread using excavators and compacted using drum rollers.	• Excavator • Drum roller

The location of the open-trench construction works are shown in Table 17.

Table 17 Location and Length of Three Wastewater Connections

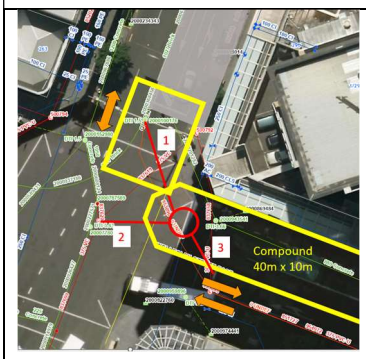
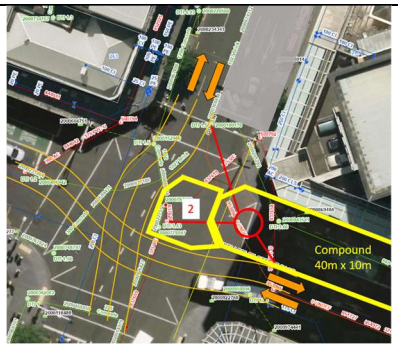
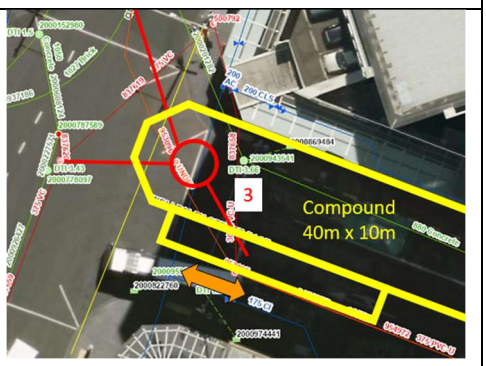
Connection 1	Connection 2	Connection 3
14.76m in length	10m in length	11.4m in length
Adjacent to the north approach on Queen Street	In the middle of the intersection	Adjacent to the east approach on Wellesley Street
		

Table 18 Trenchless Pipe Installation – shaft areas

Queen Street/Victoria Street and Queen Street/Mayoral Drive Trenchless Construction		
Stage	Activity	Equipment/Materials
1*	Insertion of mTBM into the shaft in multiple stages. A 25t crane at surface level will be used to drop mTBM into the shaft. Handheld power tools will be used to connect all parts and move to the required position. The shaft will require 24/7 dewatering and a submersible pump will be used to pump water into clarifying tank(s) for treatment, before discharging into the local wastewater network. The pump will be powered by a diesel generator which will run continuously while the shaft is open (subject to water ingress rates). Please note that, if possible, a connection the local power network would be used over a generator. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft.	• Submersible pump • Diesel generator • Ventilation fan • Crane • Handheld power tools
2*	Operation of the mTBM including noise from the operation, control cabin and 50t crane to insert new 6m lengths of pipe. It is predicted that up to 12 metres of pipe installation will occur each day requiring the use of the crane twice for insertion of new pipework. Pumps will be required at the surface level to remove the slurry from the bore face and bring water back, along with the pumping bentonite slurry around the drill head for lubrication for the pipes. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft. Dewatering of the shaft will be required 24/7 with a submersible pump with a clarifying tank, powered by a diesel generator.	• mTBM machine • Control cabin • Cane • Submersible pump • Diesel generator • Ventilation fan • 6-inch pumps
3^	Victoria Street intersection will receive the mTBM. Hand power tools will be used to dismantle the drill head to allow extraction from the shaft. A 30t mobile crane will be used to lift the mTBM parts from the shaft onto a truck and trailer unit. Each shaft will then be backfilled as per the tables above.	• Submersible pump • Diesel generator • Ventilation fan • Crane • Handheld power tools • Truck and trailer

*Noise generated at Wellesley Street shaft only
^Noise Generated at Victoria Street shaft only

Table 19 Noise from Construction Compound Area and haul road

Greys Avenue Construction Support Compound		
Stage	Activity	Equipment/Materials
1	The Greys Avenue Construction Support Area will be established around June 2024. This will require multiple hiabs delivering site office, staff welfare facilities, separation plant and slurry tanks, and generators. Trucks will deliver large machinery. Temporary traffic management and site hoardings will enclose the site.	• Hiabs, • Trucks • Excavator • Crane
2	During the mTBM operation, the separation plant and slurry tank will be operational. An excavator will be used to remove slurry from the tank into arriving and departing 6 wheeled trucks. Excavators will be used to move pipes from the compound to the Mayoral Drive shaft location via the service corridor (twice daily).	• Separation Plant • Generator • Pumps • Excavator • Trucks

5.2 Noise Prediction Methodology

Appendix B presents the noise levels for specific high noise-generating equipment from all stages. Noise propagation between the source equipment and 1m from the façade of all adjacent buildings have been undertaken in accordance with the method provided in BS 5228-1:2009.

SoundPLAN Version 8.2 3D computational noise modelling software has been used to develop a noise prediction model. A series of scenarios have been analysed with the calculations and presented to support the acoustic assessment.

The model prediction considers attenuation due to distance, terrain, absorption by the atmosphere and ground, and reflections from building facades (including a contribution of the receiver façade).

The assessment assumes worst-case theoretical downwind conditions in all directions from all sources, which provides a conservative approach for assessment.

Table 20 presents the noise modelling parameters adopted for this assessment.

Table 20 Noise modelling parameters

Parameters for computational noise modelling		
Property	Value	Source
Calculation method	ISO 9613	-
Terrain contours	0.25 m vertical heights	Auckland Council GeoMaps
Buildings	Outlines of Building footprints Heights set to 3.m for each story	Auckland Council GeoMaps, Heights via Google Street View.
Land parcels	Property land and road extent	Auckland Council GeoMaps
Ground Absorption Coefficient	0.1 – acoustically hard ground	Street View
Number of Reflections	3	-
Assessment location	1.0 metres from any façade	-

All equipment is assumed to operate at the closest point to any adjacent site for our analysis.

The L_{AFmax} was calculated using the maximum noise level generated by any piece during any phase when undertaken at the closest point from the site to the receptor building. This approach provides a worst-case assessment of noise levels.

5.3 Vibration Prediction Methodology

Appendix A presents the vibration levels for specific high-vibration equipment. Vibration propagation between the source equipment and receiving locations has been predicted based on the methodology outlined in the Waka Kotahi NZ Transport Agency's *State Highway Construction and Maintenance Noise Vibration Guide* (version 1.1, dated August 2019). This method assumes hard soil conditions (compacted clay, exposed rock), and slab-on-grade foundations type of all adjacent properties. This is a conservative assessment of the ground conditions and foundation types. Actual vibration levels are likely to be lower.

5.4 Assumptions and Limitations

The following assumptions and limitations apply to this construction noise and vibration assessment:

- Construction activity locations are based on the preliminary design and contractor documentation, including proposed methodology, construction plant and master schedule.
- An assessment period of 30-minutes has been applied.
- It is conservatively assumed that all equipment will operate within a worst-case 30-minute period for each construction stage.
- There is always a level of uncertainty in predicting noise from construction activities. Numerous variables including variations in the specific models of equipment, the exact location of each item on site, and how the operator uses the equipment, will affect the accuracy of the noise predicted.

6 Predicted Levels

This section outlines the predicted noise and vibration levels associated with the construction works.

6.1 Predicted Noise Levels

6.1.1 Average Noise Levels ($L_{Aeq,30min}$)

The predicted noise levels at each noise-sensitive receptor for each construction phase and stage are presented in Appendix B, assuming the physical mitigation measures described in Section 5.1.2 are provided, unless otherwise specified.

In Appendix B, properties that receive noise levels exceeding the 75 dB $L_{Aeq,30\ min}$ noise limit are highlighted in red, indicating a potential non-compliance with the noise limits set by the council. Furthermore, properties marked with a hash (#) indicate those affected by noise levels generated from activities within the road corridor designation only.

It is important to note that works associated with the shaft construction, open trenching, and trenchless construction are located within road reserve, and so, are exempt from the wider Auckland Unitary Plan (AUP) construction noise limits. This exemption is based on the understanding that construction activities within the road reserve are subject to separate noise regulations and considerations.

Greys Avenue Construction Support Area is the only area of the construction works which is located outside of the road reserve. Therefore, noise generated in this area must adhere to the broader AUP construction noise limits unless a Resource Consent is granted.

The construction works at Mayoral Drive/Queen Street intersection and at Greys Avenue Construction Support Area has been assessed when operating independently and concurrently. All other work has been assessed independently.

Assessing all stages independently and assessing the Mayoral Drive/Queen Street Intersection stage and Greys Avenue Construction Support Area stage concurrently, allows specific assessment of compliance at all construction operating scenarios. This is then compared to the compliance requirements related to the road reserve and non-road reserve areas, ensuring alignment with the Auckland Council's regulations and guidelines.

Through this assessment with consideration to the exemptions and applicable regulations, this allows the predicted construction noise levels to be compared against the applicable AUP noise standards and maintain a responsible approach to construction noise management.

The table below outlines the properties which exceed the AUP 75 dB $L_{Aeq,30\ min}$ noise limit irrespective of the noise source being within the road corridor or within any other zoned land.

Table 21 Properties predicted to exceed the construction noise limits

Properties Predicted to Exceed the AUP Construction Noise Limits										
Stage of Works	Properties exceeded at each phase									
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8	Phase 9	Phase 10
Shaft Construction: Queen Street/Mayoral Drive [#]	313 Queen St 317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St 380 Queen St 396 Queen St	313 Queen St 317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St	313 Queen St 317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St	313 Queen St 317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St 380 Queen St 396 Queen St			313 Queen St 317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St	313 Queen St 317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St 380 Queen St 396 Queen St	n/a	n/a
Shaft Construction: Queen Street/Wellesley Street [#]	290 Queen St 300 Queen St 10 Wellesley St	290 Queen St 300 Queen St 10 Wellesley St	290 Queen St 300 Queen St 10 Wellesley St	290 Queen St 10 Wellesley St	290 Queen St 300 Queen St 10 Wellesley St	290 Queen St 300 Queen St 10 Wellesley St	290 Queen St 300 Queen St 10 Wellesley St	n/a	n/a	n/a
Shaft Construction: Queen Street/Victoria Street [#]	59-67 High St 203 Queen St 214 Queen St 9 Victoria St E	59-67 High St 214 Queen St 9 Victoria St E	59-67 High St 214 Queen St 9 Victoria St E	59-67 High St 214 Queen St 9 Victoria St E	Phase undertaken concurrently with Phase 4	59-67 High St 2 Lorne St 186 Queen Street 203 Queen St 205-225 Queen St 214 Queen St 238 Queen St 9 Victoria St E	Phase undertaken concurrently with Phase 4 or Phase 6	59-67 High St 214 Queen St 9 Victoria St E	59-67 High St 214 Queen St 9 Victoria St E	59-67 High St 214 Queen St 9 Victoria St E
Open Trench Construction: Queen Street/Wellesley Street [#]	-	290 Queen St				290 Queen St 300 Queen St	290 Queen St 300 Queen St	n/a	n/a	n/a
Trenchless construction: Shaft locations only[#]	313 Queen St 317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St	313 Queen St 317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St 396 Queen St	59-67 High St 214 High St 9 Victoria St E	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Greys Ave CSA operating only.	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Greys Avenue CSA and Mayoral Drive operating concurrently.	313 Queen St[#] 317 Queen St[#] 319 Queen St[#] 321 Queen St[#] 323 Queen St[#] 329 Queen St[#]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[#]Noise generated within the roading corridor impacting properties only.

6.1.2 Maximum Noise Levels (L_{AFmax})

The predicted maximum noise levels have been undertaken for the loudest construction activities; including piling, excavation, rock drilling, and vibratory roller. All these activities are located within the road corridor.

The predicted maximum noise levels at each receptor based on the worst-case equipment without any noise mitigation are presented in Appendix B.

The following properties are predicted to exceed the maximum noise limit outlined in the AUP, with the exceedance decibel level provided in brackets:

- 301 Queen Street (4 dB)
- 313 Queen Street (10 dB)
- 317 Queen Street (18 dB)
- 319 Queen Street (18 dB)
- 321 Queen Street (18 dB)
- 323 Queen Street(20 dB)
- 329 Queen Street (19 dB)
- 380 Queen Street (7 dB)
- 396 Queen Street (9 dB)

Maximum noise levels from construction activities outside of the road corridor are predicted to comply with the maximum noise limits of the AUP.

6.2 Predicted Vibration Levels

The key vibration activities are from excavators breaking ground, piling or drilling of holes, operation of the mTBM, and compaction.

Table 22 outlines the stand-off distance of each piece of high vibration equipment used to achieve the various vibration limit. The stand-off distance is the distance from any vibration generating equipment at which the vibration limits are reached. Any building within the stand-off distance is predicted to exceed the vibration criteria.

Other equipment will also be used on site but generate lower levels of vibration or are installed on manufacturer's vibration isolation (such as the separation unit). Therefore, vibration levels will be lower than the equipment provided below.

Table 22 Vibration stand-off distances

Predicted vibration stand-off distances to achieve the relevant vibration criteria						
No.	Equipment	The vibration level of equipment (mm/s PPV @10m)	Stand-off distance to achieve vibration criteria (metres)			
			10 mm/s	5 mm/s	2.5 mm/s	2 mm/s*
1	Excavator breaking ground	1.5	1.5	3	6	8
2	CFA piling, auguring, small diameter drilling of holes in basalt or similar	0.5	1	2	3	4
3	Tunnel Boring	2.0	2	4	8	10
4	Vibratory Roller	3.6	4	8	15	18
5	Plate Compactor**	1	1	2	4	5

*AUP vibration amenity limit
**From WSP measurements at Victoria St site

The 10 mm/s criteria apply at any commercial building, or structure commercial in nature (high-rise concrete or steel residential buildings for instance). The 5 mm/s applies to single or two-storey residential dwellings.

Heritage properties are subject to more onerous vibration limits because of their structural sensitivity to vibration and their intrinsic value. We have considered that the 2.5 mm/s PPV limit applies to all buildings within the Historic Heritage overlay under the AUP.

Managerial mitigation measures have been adopted by the contractor to minimise the impacts of vibration. These include:

- Not operating vibratory rollers within 15 metres of any building within the Historic Heritage Overlay in the AUP. This requires that only plate compactors are used at the Mayoral Drive and Victoria Street CSA's
- Using low/no vibration rock fracturing methods to remove basalt from the Victoria Street CSA.
- Providing excavator operator training on specific measures to reduce vibration (such as slowly lowering the bucket onto the ground).
- Undertaking vibration measurements during the first operation of each piece of high-vibration equipment to quantify the level of vibration generated on site.

Based on the setback distances and mitigation measures adopted above, there are no properties predicted to exceed the DIN 4150-3 vibration criteria.

There are also no properties within the 2 mm/s AUP amenity limit setback distance from vibration generated outside of the road corridor.

7 Proposed Activity/s and Triggered Rules

The following section provides an indication of the AUP Chapter E25 rules which are predicted to be exceeded.

7.1 Noise

Noise generated from construction activity within the road corridor is exempt from achieving the AUP construction noise limits if a Construction Noise and Vibration Management Plan (CNVMP) is adopted, as outlined in Section E25.6.29 of the AUP.

A CNVMP is provided as part of this application. The adoption of a CNVMP by the contractor allows for specific exemptions or deviations from the standard AUP construction limits for works within the road corridor. These exemptions are based on the mitigation strategies outlined in the CNVMP, which are designed such that noise and vibration levels are managed within acceptable levels.

Noise generated from the Greys Avenue Construction Support Area is outside the road corridor and therefore is required to comply with the AUP noise limits outlined in Section E25.6.28. **There are no properties which are predicted to exceed the construction noise limits** from construction works outside of the road corridor.

7.2 Vibration

Vibration generated within the roading corridor is exempt from achieving the vibration limits outlined in Section E25.6.30(1)(b) where a CNVMP is adopted. A CNVMP is provided as part of this application.

A CNVMP is provided as part of this application. The adoption of a CNVMP by the contractor allows for specific exemptions or deviations from Section E25.6.30(1)(b) vibration limits for works within the road corridor. These exemptions are based on the mitigation strategies outlined in the CNVMP, which are designed such that noise and vibration levels are managed within acceptable levels.

The vibration limits outlined in Section E25.6.30(1)(a) are required to be achieved regardless of location and if a CNVMP is adopted.

Based on the setback distances and specific managerial mitigation measures outlined in Section 6.2, **no properties are predicted to exceed the AUP Section E25.6.30(1)(a) vibration limits**.

Vibration generated outside of the road corridor is also predicted to comply with the AUP Section E25.6.30(1)(b) vibration limits.

Based on the above, construction noise and vibration are assessed as a permitted activity under Activity Rule E25.4.1 (A1) of the AUP.

8 Effects Assessment

The following sections provide an assessment of the construction noise and vibration generated by the proposed activities.

8.1 Construction Noise Effects

Noise from construction works will likely dominate the surrounding areas at times. In addition, most adjacent buildings are multi-storey or elevated compared to the work sites. Whilst physical barriers will mitigate noise effects at street level, this will not sufficiently reduce noise for receptors above ground level due to the unobstructed line of sight.

We have the following comments regarding the effects of the noise associated with construction.

- Many of the construction activities which lead to non-compliance with the construction noise criteria occur within the roading corridor. These are however exempt from the noise limits if a CNVMP is adopted. Therefore, this level of noise could be generated as a permitted activity from any permitted works.
- Each shaft is predicted to take 2 – 3 months to construct. The high-level construction programme indicates the following timeframes for each activity:

Table 23 Timing for works

Predicted Detailed Construction Timing		
Phase	Activity	Duration
Mayoral Drive / Queen Street Shaft Construction		
1	Saw cut and breakout of pavement.	2 days
2 & 3	Piling, installation of Steel UC posts and backfilling holes,	6 days total
4	Excavation of shaft and install base slab	23 days
5	Installation of maintenance hole and pipe connections and backfill shaft.	25 days
6	Road pavement reinstatement and site compound removal	8 days
Wellesley Street / Queen Street Shaft Construction		
1	Saw cut and breakout of pavement	2 days
2	Construction of ring beam and set-up of hydraulic jacks	8 days
3	Excavation of shaft	10 days
4	Installation of the base slab	10 days
5 & 6	Installation of maintenance hole and backfill	5 days total
7	Road pavement reinstatement and site compound removal	8 days
Victoria Street / Queen Street Shaft Construction		
1	Saw cut and breakout of pavement	2 days
2 &3	Piling, installation of Steel UC posts and backfilling holes,	6 days total
4	Excavation of shaft and install base slab	20 days
5	Rock fracking to remove basalt	1 – 3 months
6& 7	Installation of maintenance hole and backfill	25 days total
8	Road pavement (GAP65 and AC) will be reinstated using an excavator and vibratory roller.	8 days

Trenchless Construction		
1	Establishment and commissioning of mTBM, installation and commissioning of separation plant ready for trenchless construction.	35 days
2	Tunnelling works	65 days
3	Equipment recovery from Victoria Street Equipment recovery from Mayoral Drive	10 days 22 days
Open Trench Construction		
1, 2, 3 &4	Open Trench works	40 days total

While the worst-case noise levels have been predicted, we have considered the dynamic nature of the construction activities and the varying equipment used. We anticipate fluctuations in noise levels at different stages of the project. We have taken this into account during the noise impact assessment and have adjusted our recommended mitigation measures accordingly.

- The predicted noise levels provided in Appendix B are for all equipment within each phase operating concurrently at surface level at the closest relevant location where the equipment could occur on site. This is unlikely to occur at all times on all days. Therefore, actual noise received at adjacent buildings is likely lower than that predicted for most of the time.
- The assessment assumes that all equipment within each phase operates within a worst-case 30-minute period. This is unlikely to occur for most of the construction period as equipment is not used or used less than assumed for the worst-case. Therefore, it is likely that for much of the construction period, noise received at adjacent properties are lower than those predicted.
- The above analysis assumes that all equipment is located at the surface. Where machinery is located below ground level, the equipment will benefit from acoustic screening from the pit itself (this could include a plate compactor working at the bottom of trenches, or hydraulic breakers breaking rock in shafts).
- During high noise activities within the shaft (such as when drilling the basalt), an acoustic enclosure shall be installed over the shaft opening, where practicable. This will further reduce noise from this activity (by approximately 8 – 10 dB).
- The predicted noise levels are assessed at 1 metre from the façade of the building at 1.5 metres above any floor level in the building. At levels above the ground that wouldn't be screened by the proposed site hoardings, a noise level 1 metre from the façade is not an appropriate location to assess the noise effects from construction works. Inside a building at levels above the ground is a more relevant location to assess the impacts of construction noise. Table 24 has been developed based on current guidance and our professional experience. This assumes a 25 dB reduction as windows in these buildings adjacent are likely to be closed.

Table 24 Construction noise subjective effects

Subjective Construction Noise Effects in Adjacent Buildings	
External noise level, 1m from the facade	Effects with windows closed
80 dB $L_{Aeq, T}$	Disruption is likely for quiet activities. Likely to require volume the on TV or radio to be turned up to be intelligible over background noise.
75 dB $L_{Aeq, T}$	Noise from construction is likely perceptible over background noise. May be disruptive for quiet activities such as reading. Not likely to disrupt fewer sensitive activities such as watching TV; however, these may require more concentration.
70 dB $L_{Aeq, T}$	Little disruption. Noise is likely to be perceptible over background noise during quiet activities (such as reading). Unlikely to disrupt less sensitive activities such as watching TV.
65 dB $L_{Aeq, T}$	Unlikely to disrupt activity. May be audible within the building if quiet activities are occurring

The sites which are directly impacted by noise are within the Business – City Centre Zone. More recent buildings (generally either constructed under the previous Auckland City Council's District Plan or the current AUP) are likely to have specific façade constructions to minimise reverse sensitivity issues. For these buildings, the façade is likely to reduce external noise by 30 – 35 dB. However, we assumed all facades reduce noise by 25 dB.

- No night works are required (unless specifically required due to non-acoustic requirements, such as the traffic management plan). Therefore, there is no concern that noise from these construction works would cause sleep disturbance.
- During dewatering works, a low-noise generator and pump will run 24 hours a day to keep water out of the shafts. For the Mayoral Drive and Victoria Street shafts, these will require constant dewatering until reconstructed as a manhole. The Wellesley Street shaft is secant piled and only requires dewatering during earthworks until the shaft base slab is constructed. To provide a worst-case estimate of effects, a sound power level of 97 dB L_{wA} has been assumed, operating at ground level without any additional hoardings or enclosures. Noise from this equipment operating at night is predicted to be no greater than 35 dB $L_{Aeq,30min}$ within any adjacent residential apartment, and therefore unlikely to cause sleep disturbance.
- Where practicable, all available physical mitigation measures shall be provided by the contractor to reduce the actual noise levels received by adjacent residents. Managerial mitigation measures shall also be adopted as part of a CNVMP to advise residents of the construction activities.

With the adoption of all practicable physical mitigation measures, the assessment of noise described above, and the implementation of a CNVMP, noise effects from construction are predicted to be **reasonable**.

8.2 Construction Vibration Effects

Vibration from the proposed construction activities are predicted to be below the vibration criteria outlined in Section E25.6.30 of the AUP both for works within the road corridor and outside of the road corridor.

Vibration at all other properties is predicted to be reasonable, as the levels are lower than that recommended under DIN 4150-3 and are allowed under the AUP as a permitted activity.

It should be noted that properties that are predicted to be within the 2 mm/s PPV setback distance may still experience vibration. Therefore, it is recommended that regardless of the location of the works as part of the CNVMP, these properties are notified a minimum of 10 working days prior to the commencement of the vibration activities outlined in Table 22.

9 Mitigation Measures

The construction noise and vibration assessment indicates that mitigation measures are required to reduce the noise and/or vibration impacts on adjacent properties.

This section provides details of the specific mitigation measures that shall be applied to the construction works.

Additionally, as noted in the Resource Management Act, mitigation measures should be adopted in any case to protect against unreasonable levels of noise and vibration where practically possible.

9.1 General Mitigation Measures

A Construction Noise and Vibration Management Plan (CNVMP) is recommended to be adopted as a condition of consent. This document shall be followed and updated by the contractor for the duration of the project. The CNVMP shall be developed in accordance with E25.6.29(5) of the AUP and Annex E2 of NZS 6803:1999.

Chiefly, the CNVMP shall include an outline of how communications will be undertaken between the consent holder (and its contractors) and the neighbouring properties, particularly those which are predicted to exceed the recommended noise and/or vibration limits. The CNVMP shall include:

- How communication by the consent holder will occur about certain construction works expected to exceed the noise levels in NZS 6803:1999, including scheduling/timing of works and the identification of potential temporary nuisance effects.
- How residents may communicate any enquiries or complaints about construction noise.
- Procedures for directly notifying neighbouring properties at least 10 working days in advance of programmed noise events which are predicted to exceed the noise limit for each property such as piling, including the duration that they will occur for, and times they will occur between.
- Procedures for notifying neighbouring properties within the 2 mm/s PPV setback distance at least 10 working days in advance of the equipment outlined in Table 22**Error! Reference source not found.** operating. This includes the duration that the equipment will operate and the times that it will operate between. Noting that vibration is unlikely to be at this level for the entire period.
- The contact details of the lead contractor/project manager and a representative of the consent holder.

A framework CNVMP is provided as part of this Resource Consent application (Appendix G2 of the resource consent package).

9.2 Physical Mitigation Measures

9.2.1 Acoustic Site Hoardings

Physical mitigation measures are only effective where they block the line of sight from the plant to the receptor. In many cases, the surrounding buildings are multi-story and therefore when assessing noise at 1 metre from the façade of the building, therefore physical mitigation will have a limited impact.

However, physical mitigation measures are recommended as they can effectively reduce the impact in receptors who traverse along the footpath adjacent to the construction sites.

Site hoardings are proposed to be installed around the construction sites, as outlined in Section 5.1.2. The acoustic site hoardings shall achieve the following minimum specification.

- Height: >2.0metres
- Surface mass: >10 kg/m^2
- The hoardings shall be constructed and maintained such that there are no gaps or cracks in the fence.
- Where timber is used, the paling shall be overlapped by a minimum of 25 mm, or a board and batten system implemented. A sleeper rail will be required to seal the bottom of the fence to the ground. If timber is used, this would be constructed of 25 mm pine (or equivalent) to resist warping.

Where practicable, localised movable acoustic screens/barriers/hoardings shall be used around high noise-generating equipment when in use, such as a concrete saw. The movable site hoardings shall achieve the minimum specifications listed above.

9.2.2 Selection of Equipment

Equipment is to be selected with the generated noise level in mind. This includes:

- Vehicles with audible reversing warning sirens will be fitted with broadband reversing beepers.
- Generators and/or water pumps are to be selected that have acoustic enclosures to reduce the noise radiated by these units. The reduction the acoustic enclosures provide over standard units depends on the manufacturer. Where generators are required, these shall be installed on site as far as practicable from sensitive receptors. Where possible, dedicated localised acoustic barriers will be constructed around any generators and water pumps.
- Use of electric equipment over petrol/diesel alternatives including saws, hand power tools, chainsaws, and the like.
- Selection of equipment that is an appropriate power for the use (i.e., not using more powerful equipment than needed.

9.3 Managerial Mitigation Measures

9.3.1 General

The following managerial mitigation measures are to be adopted by the contractor as far as reasonably practicable:

- Site-specific training shall be given to site personnel including management and workers involved in construction activities or equipment operators that have the potential to generate noise and vibration effects. This also includes training for personnel involved in monitoring noise and vibration.
- Equipment outlined in Appendix A (or other high noise generating equipment) is to be operated only between 0730 and 1800 hours Monday to Saturday, with no works occurring on Sundays or Public Holidays.
- All machinery to be used on site will be acoustically tested to determine the sound power level of the machinery and compared to the sound power levels in Appendix B of this Assessment. Where the tested sound power level is greater, either this machinery shall be fitted with acoustic noise reduction measures (mufflers), or additional noise modelling was undertaken to determine whether further mitigation is required to attenuate noise to adjacent properties to achieve desired noise levels.
- Preferential selection of sub-contractors that use a lower noise-generating demolition, piling, compaction, and construction methodologies.
- No unnecessary idling of equipment on site (such as trucks and excavators) when not in use.

9.3.2 Vibration Management

Specific vibration management will be required to control vibration generating plant, particularly near buildings within the Historic Heritage Overlay in the AUP. The vibration managerial mitigation measures outlined in Section 6.2 are to be adopted as part of the CNVMP to reduce the likelihood of high vibration levels impacting heritage buildings.

9.3.3 Monitoring

While managerial mitigation measures are adopted by the contractor to reduce the level of vibration received at buildings, it is recommended that vibration monitoring is undertaken during the first high-vibration equipment operating to confirm the setback distances.

Vibration monitoring will be undertaken during the first high-vibration equipment outlined in Table 22 at the following properties:

- 323-327 Queen Street
- 210 Queen Street

Where vibration levels are measured to be above 2.5mm/s, works on site will stop until the vibration source is identified and any/all mitigation measures are implemented to reduce the received vibration level within the buildings.

Vibration monitoring will also be undertaken during the first operation of pipe installation using trenchless construction. Vibration measurements are to be undertaken to confirm the vibration levels meet the required acoustic criteria. Where levels are measured to be above 2.5mm/s from the mTBM, continuous vibration monitoring will be undertaken.

10 Identification of Affected Parties

This section outlines the potentially affected parties.

10.1 Noise

There are no properties which exceed the construction noise limits when noise is generated outside of the road corridor. Therefore there are no parties affected by construction noise.

10.2 Vibration

With the managerial mitigation measures outlined in Section 6.2, there are no properties that are predicted to exceed the vibration limits outlined in the AUP, and therefore no parties affected by vibration.

11 RMA s104 Assessment

Section 104 of the RMA sets out the matters that the consent authority are to consider when considering an application for resource consent.

Based on the assessment provided within this report, construction noise and vibration has been assessed as a permitted activity under the provision of the AUP. As such, in accordance with s.104(2), a consent authority may disregard any adverse effects in relation to noise and vibration as they are provided for my the AUP.

Mitigation and management measures have been detailed within this report, with a framework CNVMP being prepared to meet the permitted activity provisions of the AUP.

12 Conclusion and Recommendations

WSP has been engaged by Watercare to assess the noise and vibration impacts from the construction of a new wastewater mainline through Auckland city centre for the Queen Street Wastewater Diversion Project. This report provides an assessment of the construction noise and vibration in relation to Part 3 of the Project.

Noise and vibration criteria have been developed based on the Auckland Unitary Plan. Noise from construction works within the roading corridor are exempt from the construction noise limits, provided that a CNVMP is developed. However, for completeness, noise from this activity has been predicted. Works within other zones have been assessed against the applicable noise standards.

The construction methodology for Part 3 of the Project has been provided by Fulton Hogan, the proposed contractor. This methodology has been used to develop the phases of construction and equipment used.

Based on the construction methodology and proposed mitigation, there are no properties that are predicted to exceed the noise and vibration levels within the AUP. As mitigation measures are required to achieve the limits, it is recommended that as a conditions of consent a CNVMP is adopted to ensure that noise and vibration impacts are mitigated as far as reasonably practicable.

With the adoption of the conditions of consent below, the effects associated with the construction of the shafts and installation of the wastewater pipes are predicted to be reasonable.

12.1 Recommendations

The following conditions of consent are recommended:

1 A CNVMP shall be implemented, in line with Section E25.6.29(5) of the AUP and Annex E2 of NZS 6803:1999. This is to include:

   (a) Construction methodology and proposed equipment by the contractor.

   (b) Updated noise predictions based on the final construction methodology.

   (c) Outline mandatory mitigation measures to reduce the effects of noise on adjacent noise sensitive receptors.

   (d) Outline practicable physical and managerial mitigation measures to reduce the effects of noise on adjacent noise-sensitive receptors, site mitigation to equipment on site, and community liaison methodology.

2 Where access is granted, attended vibration measurements are to be undertaken during the first high-vibration equipment operating close to the following properties:

   (a) 323-327 Queen Street
   (b) 210 Queen Street

   Where measured vibration levels from the mTBM exceed 2.5mm/s in 232-327 Queen Street building, continuous vibration monitoring must also be undertaken throughout the installation of the pipework within the same building.

Appendix A
Construction Equipment Schedule

Equipment List						
Site	Stage	Activity	Equipment	SWL (dB L_{Aeq})	SWL (dB L_{Amax})	% on time
Queen Street/Mayoral Drive Shaft Construction	1	Road surface breakout	Concrete Saw	113	-	50
			20T Excavator	105	120	100
			Truck	107	120	50
	2	Boring holes	Piling Rig (GEAZ EX40/60)	105	-	100
	3	Installing UC beams into holes	20T Excavator	105	120	100
			Truck	107	120	50
	4	Excavation of shaft	20T excavator	105	120	100
			Hand-held power tools	100	-	100
			50T crane	98	-	100
			Truck	107	120	50
			Welder and generator	101	-	50
			Submersible pump	96	-	100
			Diesel Generator	94	-	100
			Ventilation fan	100	-	100
	5	Installation of maintenance hole and backfilling	50T crane	98	-	100
			Concrete truck and pump	103	-	100
			Truck	107	120	50
			Ventilation fan	100	-	100
			20T excavator	105	120	100
	6	Reinstatement	20T Excavator	105	120	100
			Vibratory Roller	107	-	100
Queen Street/Wellesley Street Shaft Construction	1	Road surface breakout	Concrete Saw	113	-	50
			20T Excavator	105	120	100
			Truck	107	120	50
	2	Construction of concrete beam	Concrete truck and pump	103	-	100
			Trucks	107	120	50
			Hydraulic jack	85	-	100
	3	Excavation of shaft	20T excavator	105	120	100
			Hydraulic jack	85	-	100
			Hand-held power tools	100	-	100
			50T crane	98	-	100
			Trucks	107	120	50
	4	Construction of concrete foundation plug	Concrete truck and pump	103	-	100
			Plate compactor	108	-	100
	5		50T crane	98	-	100

		Installation of maintenance hole and backfilling	Concrete truck and pump	103	-	100
			Truck	107	120	50
			Ventilation fan	100	-	100
			20T excavator	105	120	100
	6	Reinstatement	20T Excavator	105	120	100
			Vibratory Roller	107	-	100
Queen Street/Victoria Street Shaft Construction	1	Road surface breakout	Concrete Saw	113	-	50
			20T Excavator	105	120	100
			Truck	107	120	50
	2	Boring holes	Piling Rig (GEAZ EX40/60)	105	-	100
	3	Installing UC beams into holes	20T Excavator	105	120	100
			Truck	107	120	50
	4	Excavation of shaft	20T excavator	105	120	100
			Hand-held power tools	100	-	100
			50T crane	98	-	100
			Truck	107	120	50
			Welder and generator	101	-	50
			Submersible pump	96	-	100
			Diesel Generator	94	-	100
			Ventilation fan	100	-	100
	5	Excavation of Basalt	20T excavator	105	120	100
			Rock drill (attachment or handheld)	114	120	100
			50T crane	98	-	100
			Submersible pump	96	-	100
			Diesel Generator	94	-	100
			Ventilation fan	100	-	100
	5	Installation of maintenance hole and backfilling	50T crane	98	-	100
			Concrete truck and pump	103	-	100
			Truck	107	120	50
			Ventilation fan	100	-	100
			20T excavator	105	120	100
	6	Reinstatement	20T Excavator	105	120	100
			Vibratory Roller	107	-	100
Open-cut pipe installation	1	Temporary traffic management setup	Truck	107	120	50
	2	Excavation of trench	Truck	107	120	50
			20T excavator	105	120	100
			Submersible pump	96	-	100
			Diesel Generator	94	-	100

	3	Installation of pipe	Truck	107	120	50
			20T excavator	105	120	100
			Plate compactor	108	-	100
	4	Backfilling and reinstatement	20T excavator	105	120	100
			Drum Roller			
			Truck	107	120	50
Trenchless pipe installation	1*	Insertion of mTBM into the shaft	50T crane	98	-	100
			Ventilation fan	100	-	100
			Hand-held power tools	100	-	100
			Diesel Generator	94	-	100
	2*	Operation of mTBM at Mayoral Drive Site	mTBM machine	103	-	100
			Control Cabin	86	-	100
			50T Crane	98	-	100
			Diesel Generator	94	-	100
			Ventilation Fan	100	-	100
	3^	Extraction of mTBM at Victoria Street site	50T Crane	98	-	100
			Diesel Generator	94	-	100
			Ventilation Fan	100	-	100
			Truck	107	120	50
			Hand-held power tools	100	-	100
Greys Avenue Construction Support Compound	1	Set-up	Hiab trucks	107	120	50
			20T excavator	105	120	100
			Truck	107	120	50
			50T crane	98	-	100
	2	Operation of mTBM	20T excavator	105	120	100
			Separating tanks, slurry tanks with generator	117	120	100
			Truck	107	120	50

Vibration Equipment List		
No.	Equipment	PPV (mm/s) @10m
1	Excavator breaking ground	1.5
2	CFA piling, auguring, drilling of holes, or similar	0.5
3	Tunnel Boring	2.0
4	Vibratory Roller	3.6
5	Plate compactor	1.0

Appendix B
Predicted Noise Levels

Queen Street/Mayoral Drive Shaft Construction						
Property	Phases					
	1	2	3	4, 5, 6	7	8
16 Wakefield Street	57	51	54	58	54	55
36 Wakefield Street	58	52	55	59	55	56
3 Airedale Street	69	63	66	70	66	67
8 Airedale Street	67	61	64	68	64	65
35 Airedale Street	54	48	51	55	51	52
3 Greys Avenue	55	49	52	56	52	53
48 Greys Avenue	64	58	61	65	61	62
68 Greys Avenue	61	55	58	62	58	59
78 Greys Avenue	57	51	54	58	54	55
80 Greys Avenue	55	49	52	56	52	53
95 Greys Avenue	59	53	56	60	56	57
100 Mayoral Drive	61	55	58	62	58	59
120 Mayoral Drive	69	63	66	70	66	67
269-297 Queen Street	57	51	54	58	54	55
280 Queen Street	50	44	47	51	47	48
290 Queen Street	51	45	48	52	48	49
299 Queen Street	56	50	53	57	53	54
300 Queen Street	52	46	49	53	49	50
301 Queen Street	74	68	71	75	71	72
304-308 Queen Street	55	49	52	56	52	53
313 Queen Street	81	75	78	82	78	79
317 Queen Street	89	83	86	90	86	87
319 Queen Street	89	83	86	90	86	87
321 Queen Street	89	83	86	90	86	87
323 Queen Street	91	85	88	92	88	89
329 Queen Street	87	81	84	88	84	85
330 Queen Street	57	51	54	58	54	55
350 Queen Street	60	54	57	61	57	58
360 Queen Street	58	52	55	59	55	56
361 Queen Street	69	63	66	70	66	67
363 Queen Street	62	56	59	63	59	60
368 Queen Street	68	62	65	69	65	66
369 Queen Street	56	50	53	57	53	54
371 Queen Street	60	54	57	61	57	58
380 Queen Street	78	72	75	79	75	76
396 Queen Street	78	72	75	79	75	76
438 Queen Street	68	62	65	69	65	66
450 Queen Street	62	56	59	63	59	60
456 Queen Street	58	52	55	59	55	56

Queen Street/Wellesley Street Shaft Construction							
Property	Phases						
	1	2	3	4	5	6	7
16 Wakefield Street	54	50	52	46	52	52	52
36 Wakefield Street	52	48	50	44	50	50	50
3 Airedale Street	36	32	34	28	34	34	34
8 Airedale Street	55	51	53	47	53	53	53
35 Airedale Street	36	32	34	28	34	34	34
98-102 Albert Street	45	41	43	37	43	43	43
99 Albert Street	45	41	43	37	43	43	43
135 Albert Street	58	54	56	50	56	56	56
1 Kitchener Street	66	62	64	58	64	64	64
44-48 Lorne Street	70	66	68	62	68	68	68
187-189 Queen Street	54	50	52	46	52	52	52
191 Queen Street	56	52	54	48	54	54	54
203 Queen Street	57	53	55	49	55	55	55
205-225 Queen Street	62	58	60	54	60	60	60
214 Queen Street	60	56	58	52	58	58	58
222 Queen Street	61	57	59	53	59	59	59
229 Queen Street	64	60	62	56	62	62	62
233-237 Queen Street	65	61	63	57	63	63	63
238 Queen Street	64	60	62	56	62	62	62
239 Queen Street	69	65	67	61	67	67	67
246 Queen Street	65	61	63	57	63	63	63
253-261 Queen Street	74	70	72	66	72	72	72
256 Queen Street	66	62	64	58	64	64	64
262 Queen Street	68	64	66	60	66	66	66
263 Queen Street	75	71	73	67	73	73	73
269-297 Queen Street	72	68	70	64	70	70	70
280 Queen Street	72	68	70	64	70	70	70
290 Queen Street	92	88	90	84	90	90	90
299 Queen Street	49	45	47	41	47	47	47
300 Queen Street	80	76	78	72	78	78	78
301 Queen Street	58	54	56	50	56	56	56
304-308 Queen Street	72	68	70	64	70	70	70
313 Queen Street	53	49	51	45	51	51	51
330 Queen Street	64	60	62	56	62	62	62
350 Queen Street	63	59	61	55	61	61	61
360 Queen Street	57	53	55	49	55	55	55
361 Queen Street	49	45	47	41	47	47	47
363 Queen Street	48	44	46	40	46	46	46
368 Queen Street	58	54	56	50	56	56	56
10 Wellesley Street	90	86	88	82	88	88	88
15-23 Wellesley Street	65	61	63	57	63	63	63
24 Wellesley Street	65	61	63	57	63	63	63

32-42 Wellesley Street	62	58	60	54	60	60	60
37 Wellesley Street	61	57	59	53	59	59	59
44-52 Wellesley Street	60	56	58	52	58	58	58
54-56 Wellesley Street	58	54	56	50	56	56	56
18-26 Wellesley Street East	73	69	71	65	71	71	71
28-36 Wellesley Street East	67	63	65	59	65	65	65
37-69 Wellesley Street East	56	52	54	48	54	54	54

Queen Street/Victoria Street

Shaft Construction

Property	Phases							
	1	2	3	4	5	6	7	8
98-102 Albert Street	60	54	57	59	67	58	54	58
99 Albert Street	60	54	57	59	67	58	54	58
135 Albert Street	44	38	41	43	51	42	38	42
22 Durham Street West	65	59	62	64	72	63	59	63
59-67 High Street	89	83	86	88	96	87	83	87
2 Lorne Street	73	67	70	72	80	71	67	71
4 Lorne Street	68	62	65	67	75	66	62	66
44-48 Lorne Street	44	38	41	43	51	42	38	42
152 Queen Street	61	55	58	60	68	59	55	59
154 Queen Street	61	55	58	60	68	59	55	59
155 Queen Street	60	54	57	59	67	58	54	58
158 Queen Street	62	56	59	61	69	60	56	60
162 Queen Street	63	57	60	62	70	61	57	61
163 Queen Street	61	55	58	60	68	59	55	59
164 Queen Street	63	57	60	62	70	61	57	61
166-174 Queen Street	65	59	62	64	72	63	59	63
167 Queen Street	64	58	61	63	71	62	58	62
175 Queen Street	66	60	63	65	73	64	60	64
176 Queen Street	66	60	63	65	73	64	60	64
182-184 Queen Street	67	61	64	66	74	65	61	65
186 Queen Street	72	66	69	71	79	70	66	70
187-189 Queen Street	68	62	65	67	75	66	62	66
191 Queen Street	73	67	70	72	80	71	67	71
203 Queen Street	76	70	73	75	83	74	70	74
205-225 Queen Street	73	67	70	72	80	71	67	71
214 Queen Street	82	76	79	81	89	80	76	80
222 Queen Street	74	68	71	73	81	72	68	72
229 Queen Street	66	60	63	65	73	64	60	64
233-237 Queen Street	64	58	61	63	71	62	58	62
238 Queen Street	71	65	68	70	78	69	65	69
239 Queen Street	63	57	60	62	70	61	57	61
246 Queen Street	67	61	64	66	74	65	61	65
253-261 Queen Street	61	55	58	60	68	59	55	59
256 Queen Street	64	58	61	63	71	62	58	62

262 Queen Street	64	58	61	63	71	62	58	62
263 Queen Street	58	52	55	57	65	56	52	56
269-297 Queen Street	54	48	51	53	61	52	48	52
280 Queen Street	61	55	58	60	68	59	55	59
290 Queen Street	59	53	56	58	66	57	53	57
3 Victoria Street East	67	61	64	66	74	65	61	65
9 Victoria Street East	82	76	79	81	89	80	76	80
27-31 Victoria Street East	68	62	65	67	75	66	62	66
19 Victoria Street West	67	61	64	66	74	65	61	65
27-35 Victoria Street West	64	58	61	63	71	62	58	62
37-39 Victoria Street West	63	57	60	62	70	61	57	61
43 Victoria Street West	61	55	58	60	68	59	55	59
55-59 Victoria Street West	58	52	55	57	65	56	52	56

Queen Street/Wellesley Street

Open Trench Construction

Property	Phases			
	1	2	3	4
135 Albert Street	51	55	57	56
1 Kitchener Street	56	60	62	61
44-48 Lorne Street	58	62	64	63
191 Queen Street	47	51	53	52
203 Queen Street	47	51	53	52
205-225 Queen Street	53	57	59	58
214 Queen Street	51	55	57	56
222 Queen Street	53	57	59	58
229 Queen Street	55	59	61	60
233-237 Queen Street	57	61	63	62
238 Queen Street	55	59	61	60
239 Queen Street	61	65	67	66
246 Queen Street	56	60	62	61
253-261 Queen Street	67	71	73	72
256 Queen Street	57	61	63	62
262 Queen Street	60	64	66	65
263 Queen Street	69	73	75	74
269-297 Queen Street	65	69	71	70
280 Queen Street	64	68	70	69
290 Queen Street	74	78	80	79
300 Queen Street	71	75	77	76
301 Queen Street	50	54	56	55
304-308 Queen Street	63	67	69	68
330 Queen Street	56	60	62	61
350 Queen Street	55	59	61	60
360 Queen Street	49	53	55	54
10 Wellesley Street	65	69	71	70
15-23 Wellesley Street	58	62	64	63

24 Wellesley Street	57	61	63	62
32-42 Wellesley Street	54	58	60	59
37 Wellesley Street	54	58	60	59
44-52 Wellesley Street	52	56	58	57
54-56 Wellesley Street	49	53	55	54
18-26 Wellesley Street East	60	64	66	65
28-36 Wellesley Street East	56	60	62	61

Queen Street/Victoria Street and Queen Street/Mayoral Drive Trenchless Construction			
Property	Phases		
	1*	2*	3^
16 Wakefield Street	51	54	39
36 Wakefield Street	52	55	39
3 Airedale Street	63	66	35
8 Airedale Street	61	64	37
35 Airedale Street	48	51	30
3 Greys Avenue	49	52	35
48 Greys Avenue	58	61	38
68 Greys Avenue	54	57	38
78 Greys Avenue	51	54	38
80 Greys Avenue	48	51	36
95 Greys Avenue	53	56	39
59-67 High Street	34	37	86
2 Lorne Street	35	38	70
4 Lorne Street	35	38	66
44-48 Lorne Street	46	49	41
100 Mayoral Drive	55	58	41
120 Mayoral Drive	63	66	38
152 Queen Street	38	41	58
154 Queen Street	39	42	58
155 Queen Street	35	38	57
158 Queen Street	39	42	59
162 Queen Street	39	42	60
163 Queen Street	33	36	58
164 Queen Street	38	41	60
166-174 Queen Street	39	42	62
167 Queen Street	35	38	61
175 Queen Street	35	38	63
176 Queen Street	39	42	63
182-184 Queen Street	39	42	64
186 Queen Street	40	43	69
187-189 Queen Street	34	37	65
191 Queen Street	36	39	70
203 Queen Street	36	39	73
205-225 Queen Street	42	45	71

214 Queen Street	41	44	80
222 Queen Street	41	44	71
229 Queen Street	43	46	63
233-237 Queen Street	43	46	61
238 Queen Street	43	46	68
239 Queen Street	44	47	60
246 Queen Street	43	46	64
253-261 Queen Street	45	48	58
256 Queen Street	43	46	61
262 Queen Street	44	47	61
263 Queen Street	44	47	55
269-297 Queen Street	51	54	51
280 Queen Street	44	47	58
290 Queen Street	44	47	56
299 Queen Street	49	52	37
300 Queen Street	45	48	54
301 Queen Street	69	72	49
304-308 Queen Street	49	52	53
313 Queen Street	75	78	47
317 Queen Street	83	86	46
319 Queen Street	83	86	45
321 Queen Street	83	86	45
323 Queen Street	85	88	45
329 Queen Street	81	84	38
330 Queen Street	50	53	50
350 Queen Street	53	56	50
360 Queen Street	52	55	45
361 Queen Street	63	66	45
363 Queen Street	56	59	44
368 Queen Street	62	65	47
369 Queen Street	50	53	39
371 Queen Street	54	57	43
380 Queen Street	72	75	47
396 Queen Street	74	77	45
438 Queen Street	62	65	44
450 Queen Street	56	59	43
456 Queen Street	52	55	43
3 Victoria Street East	31	34	64
9 Victoria Street East	34	37	79
27-31 Victoria Street East	33	36	65
19 Victoria Street West	35	38	65
27-35 Victoria Street West	32	35	61
37-39 Victoria Street West	31	34	60
43 Victoria Street West	32	35	58
55-59 Victoria Street West	34	37	55

Greys Avenue Construction Support Compound		
Property	Phases	
	1	2
3 Airedale Street	52	60
8 Airedale Street	42	50
35 Airedale Street	38	46
3 Greys Avenue	61	69
48 Greys Avenue	66	74
68 Greys Avenue	58	66
78 Greys Avenue	49	57
80 Greys Avenue	50	58
95 Greys Avenue	61	69
100 Mayoral Drive	65	73
120 Mayoral Drive	47	55
269-297 Queen Street	43	51
299 Queen Street	52	60
301 Queen Street	53	61
313 Queen Street	55	63
317 Queen Street	54	62
319 Queen Street	55	63
321 Queen Street	62	70
323 Queen Street	67	75
329 Queen Street	61	69
350 Queen Street	37	45
361 Queen Street	64	72
363 Queen Street	61	69
368 Queen Street	43	51
369 Queen Street	57	65
371 Queen Street	48	56
380 Queen Street	52	60
396 Queen Street	52	60
438 Queen Street	53	61
450 Queen Street	42	50
456 Queen Street	41	49
3 Victoria Street East	25	33

Greys Avenue, Mayoral Street/Queen Street Intersection All Trenchless Construction Concurrently	
Property	Operation
16 Wakefield Street	51
36 Wakefield Street	52

3 Airedale Street	63
8 Airedale Street	61
35 Airedale Street	50
3 Greys Avenue	67
48 Greys Avenue	72
68 Greys Avenue	66
78 Greys Avenue	63
80 Greys Avenue	60
95 Greys Avenue	68
100 Mayoral Drive	71
120 Mayoral Drive	63
269-297 Queen Street	56
299 Queen Street	66
301 Queen Street	69
313 Queen Street	75
317 Queen Street	83
319 Queen Street	83
321 Queen Street	83
323 Queen Street	85
329 Queen Street	81
330 Queen Street	50
350 Queen Street	53
360 Queen Street	52
361 Queen Street	75
363 Queen Street	67
368 Queen Street	62
369 Queen Street	65
371 Queen Street	54
380 Queen Street	72
396 Queen Street	74
438 Queen Street	71
450 Queen Street	65
456 Queen Street	52

Maximum Noise Levels from Any Construction Equipment	
Property	Maximum Noise Level L_{AFmax} (dB)
16 Wakefield Street	66
36 Wakefield Street	67
3 Airedale Street	78
8 Airedale Street	76
35 Airedale Street	63
98-102 Albert Street	47
99 Albert Street	50
135 Albert Street	55
22 Durham Street West	49

3 Greys Avenue	64
48 Greys Avenue	73
68 Greys Avenue	70
78 Greys Avenue	66
80 Greys Avenue	64
95 Greys Avenue	68
59-67 High Street	49
1 Kitchener Street	50
2 Lorne Street	50
4 Lorne Street	51
44-48 Lorne Street	61
100 Mayoral Drive	70
120 Mayoral Drive	78
152 Queen Street	54
154 Queen Street	54
155 Queen Street	50
158 Queen Street	54
162 Queen Street	54
163 Queen Street	48
164 Queen Street	54
166-174 Queen Street	54
167 Queen Street	50
175 Queen Street	50
176 Queen Street	54
182-184 Queen Street	54
186 Queen Street	55
187-189 Queen Street	49
191 Queen Street	51
203 Queen Street	51
205-225 Queen Street	57
214 Queen Street	56
222 Queen Street	57
229 Queen Street	58
233-237 Queen Street	58
238 Queen Street	58
239 Queen Street	59
246 Queen Street	58
253-261 Queen Street	60
256 Queen Street	58
262 Queen Street	59
263 Queen Street	60
269-297 Queen Street	66
280 Queen Street	59
290 Queen Street	60
299 Queen Street	65
300 Queen Street	61

301 Queen Street	84
304-308 Queen Street	64
313 Queen Street	90
317 Queen Street	98
319 Queen Street	98
321 Queen Street	98
323 Queen Street	100
329 Queen Street	96
330 Queen Street	66
350 Queen Street	69
360 Queen Street	67
361 Queen Street	78
363 Queen Street	71
368 Queen Street	77
369 Queen Street	65
371 Queen Street	69
380 Queen Street	87
396 Queen Street	89
438 Queen Street	77
450 Queen Street	71
456 Queen Street	67
3 Victoria Street East	46
9 Victoria Street East	49
27-31 Victoria Street East	49
19 Victoria Street West	50
27-35 Victoria Street West	48
37-39 Victoria Street West	46
43 Victoria Street West	47
55-59 Victoria Street West	49
10 Wellesley Street	56
15-23 Wellesley Street	51
24 Wellesley Street	56
32-42 Wellesley Street	54
37 Wellesley Street	54
44-52 Wellesley Street	55
54-56 Wellesley Street	55
18-26 Wellesley Street East	53
28-36 Wellesley Street East	51
37-69 Wellesley Street East	47

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