Project Number: W-SL001.03

Queen Street Wastewater Diversion Programme (Part 3 – Part 4 Connector)

16 May 2024

Framework Construction Noise and Vibration Management Plan

wsp

150 YEARS IN AOTEAROA

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0	Framework CNVMP for Consenting
1	Revised Shaft Location

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Abbreviation and Definitions

AC	Auckland Council
AT	Auckland Transport
AUP	Auckland Unitary Plan
CNVMP	Construction Noise and Vibration Management Plan
CNVA	Construction Noise and Vibration Assessment
CSA	Construction Support Area
mTBM	Micro Tunnel Boring Machine
NSR	Noise Sensitive Receptor(s)
Watercare	Watercare Services Limited
WSP	WSP New Zealand Limited

Glossary

Glossary	
Term	Definition/Description
A-weighting, dBA	A frequency weighting designed to reflect the relative loudness perceived by the human ear. It de-emphasises frequencies in which the ear is less sensitive and is commonly used to measure environmental and industrial noise, ensuring readings are more representative of human auditory perception.
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	The decibel (dB) is a logarithmic scale that allows a wide range of sound pressures to be represented in a more comprehensible range, typically 0 dB to 120 dB. The decibel is ten times the logarithm of the ratio of sound energy (i.e., power squared, or pressure squared relative to a reference level squared). The reference level for sound pressure is typically 20 µPa which is the approximate threshold of human hearing.
Façade Level	A noise level measured/assessed at one 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.
Equivalent Continuous Sound Pressure Level, $L_{eq,T}$	Many sounds, such as road traffic noise or construction noise, vary repeatedly in level over a given time period. Leq,T is the equivalent continuous sound level over a given time period (T). It is often referred to as the 'average' level.
Maximum Sound Pressure Level, L_{max}	L_{max} is the absolute maximum sound level recorded over the measurement period.
Peak Particle Velocity, PPV	The peak speed in a particular direction a particle travels at the measurement location resulting from vibration.
Sound Power Level, L_W or SWL	A measure of the total acoustic energy emitted by a source. Expressed in decibels (dB), it represents the intrinsic acoustic output of a source and is independent of distance from the source or the specific conditions of the surrounding space.
Sound Pressure Level, L_p or SPL	The sound pressure level of a source, in dB, varies with distance from the noise source and with the environment in which it is located. Sound pressure simply put is a deviation over atmospheric/ambient pressure due to sound energy from a source or reflection propagating through a medium over time.

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.

The Queen Street Wastewater Diversion Project 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.

This Construction Noise and Vibration Management Plan (CNVMP) covers the service tunnel/pipe which will connect Part 3 and Part 4 of the Queen Street Wastewater Diversion Project (the Project). Specific CNVMPs will be provided for the other Parts of the wider Diversion works. The objective of this CNVMP is to:

1 Identify the Best Practicable Option (BPO) for the management and mitigation of construction noise and vibration effects.
2 Identify the noise and vibration limits for the Project, how they will be met, and set out methods for scheduling and undertaking works to avoid disruption.
3 Outline the engagement procedure with affected receptors and timely management of complaints.

This plan achieves the requirements outlined in the Auckland Unitary Plan (AUP). It also follows the guidance set out in NZS 6803:1999 *Acoustics – Construction noise* (NZS 6803).

General details of the Project are presented in Table 1.

Table 1 Project details

General Project Details	
Property	Description
Location	Shaft construction and much of the trenchless equipment are to be located in the Greys Avenue CSA (Construction Support Area). Some works are occurring in the construction compound on Mayoral Drive.
Contractor	Fulton Hogan and McConnell Dowell
Construction Period	A 6-week period commencing *TBC*
Construction Hours	<u>Greys Avenue Temporary Shaft Construction:</u> Monday to Saturday: 0700 – 1900 hours Sunday and Public Holidays – No construction works 24-hour works may be required for de-watering of shaft during construction for up to 2 days.
	<u>Trenchless Pipe Installation:</u> Monday to Saturday – 0700hrs to 1900hrs Sunday and Public Holidays – No construction works 24-hour works may be required for de-watering of tunnel during construction for up to 7 days.
	<u>Backfilling of Temporary Shaft:</u> Monday to Saturday – 0700hrs to 1900hrs Sunday and Public Holidays – No construction works
Contractor Contact	*TBC*
Noise and Vibration Contact	*TBC*

The Noise and Vibration Contact will be responsible for ensuring that this CNVMP is continuously updated and correctly implemented. They will review all documentation relating to construction noise before it is issued.

As part of site induction, all personnel will be made aware of the management and procedures to control noise and vibration outlined in this plan.

Items in *red italics* are important specific areas of the plan that need to be reviewed and updated as works progress.

This is a live document and will be continually updated if the construction methodology changes, when measurements have been undertaken on the specific machinery, and for specific management of impacted properties.

1.1 Contact Details

Table 2 should be completed by the relevant person before the commencement of any construction works. The table outlines key contacts associated with the Project.

Table 2 Key Contacts

Key contact people for The Project				
Role	Name	Organisation	Phone	Email
24 – Hour Public Contact	*TBC*			
Environmental Manager	*TBC*			
Project Manager	*TBC*			
Construction Manager	*TBC*			
Community Relations Manager	*TBC*			
Noise Liaison Officer	*TBC*			
Noise and Vibration Monitoring Manager	*TBC*			
Council – Noise Officer	*TBC*			
Compliance Monitoring Officers	*TBC*			
Authority Contact Details (Auckland Council).	*TBC*			

2 Project Overview

The Project is located within Auckland City Centre in the surface carpark at 329 Queen Street/34, 36-38 Greys Avenue(Greys Avenue CSA) and a portion of the road reserve (footpath) below ground on Queen Street. Adjacent to the construction works are a mix of modern buildings and important heritage structures. At street level, the buildings are retail, hospitality, and commercial premises.

The Project works will see the construction of a new wastewater pipe that ultimately connects the eastern length of the Mayoral Drive Alignment (Part 4) and the southern manhole in Part 3 (P3MH1) in the wider Queen Street Wastewater Diversion Programme of Works.

To provide for the new pipe, a temporary shaft will be created within the existing Greys Avenue Carpark, and another temporary shaft located at the intersection of Mayoral Drive and Queen Street (Mayoral Drive shaft). The construction of the temporary shaft at the Mayoral Drive/Queen Street intersection will be developed as part of the Part 3 Queen Street Diversion Works, which is covered by a separate CNVMP.

Once the temporary shaft is constructed, trenchless pipe installation works will commence. Once these works are completed, the new wastewater pipe will be used as an underground service lane for Part 3 of the Queen Street Diversion Works. The temporary shaft will be connected to Part 4 (works covered under a separate CNVMP), and then backfilled once the Queen Street Wastewater Diversion Programme of works is complete.

Figure 1 shows the wider environment in which the new wastewater pipe will be constructed along with the proposed temporary shaft and CSAs.

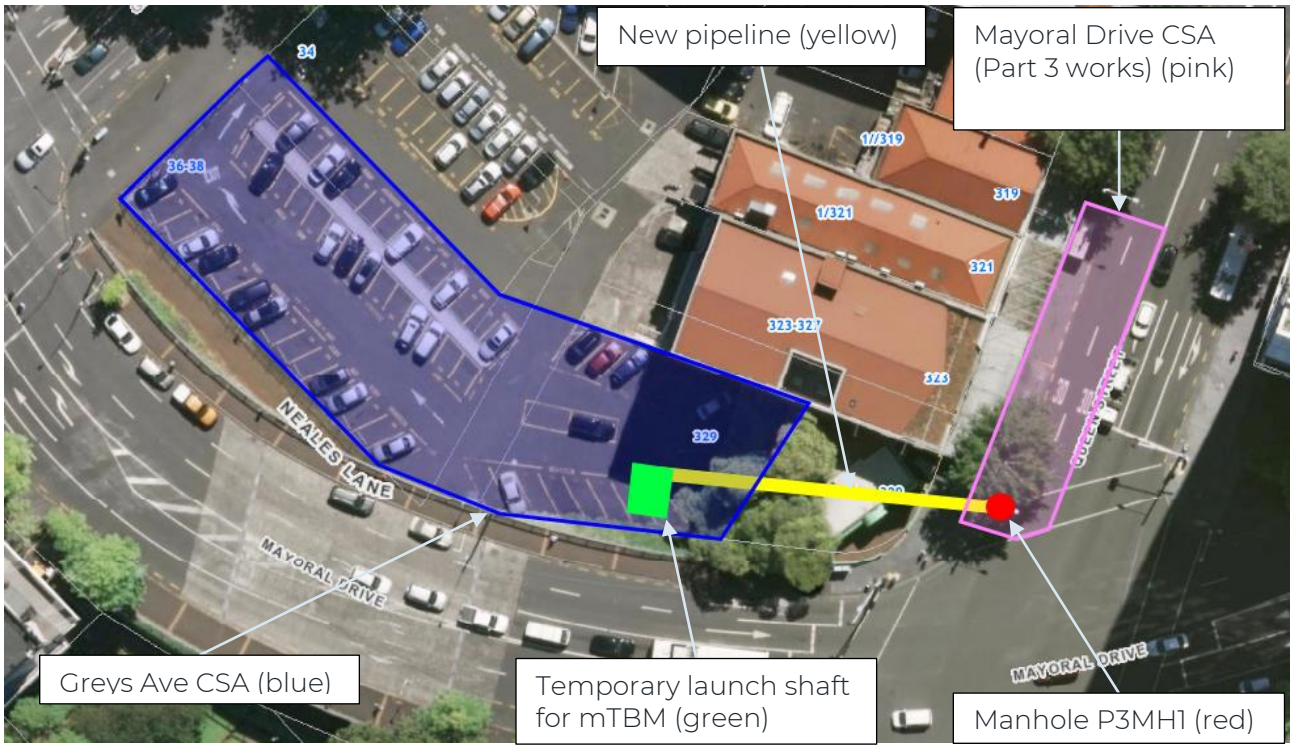

Figure 1 Project area and surface level areas used

2.1 Construction Hours and Duration

The anticipated construction hours are noted in Table 3.

Table 3 Construction hours

Construction hours	
Activity	Hours
Greys Avenue temporary shaft construction	Monday to Saturday – 0700 hours to 1900 hours
Trenchless pipe installation works	Monday to Saturday – 0700 hours to 1900 hours

Works outside of the hours listed above only include de-watering pumps, which may be required during the shaft construction and trenchless installation works.

The general construction staging for the overall construction works is provided in Table 4.

Table 4 Overall construction works staging

Overall construction staging		
Activity	Starting	Duration
Greys Avenue temporary shaft construction	*TBC*	15 days
Trenchless pipe installation works	*TBC*	6 days
Backfilling of temporary shaft	*TBC*	10 days
Total	*TBC*	*31 days (approximately six weeks)*

There will be a delay between “Trenchless pipe installation works” and “backfilling of temporary shaft”, during the connection works from the temporary shaft to the wider Part 4 Mayoral Drive Alignment works.

2.2 Temporary Shaft Construction

A temporary shaft will be provided to undertake the trenchless installation of a pipe between the Greys Ave CSA and Mayoral Drive shaft (within Park 3). While the management of noise/vibration from the construction of the Mayoral Drive shaft is covered by a separate CNVMP, the use of this shaft for the connection works is provided within this CNVMP.

Greys Avenue CSA Shaft

This shaft will be located within the Grey Avenue CSA. It will have a depth of approximately 5.5 metres. The construction of the shaft will take 15 days. This shaft will be used for service connections as well as support for the trenchless pipe installation works.

Figure 2 shows the approximate position of the shaft (green) and the Greys Avenue CSA (blue).

Figure 2 Wellesley Street Shaft position and CSA

The significant noise-generating plant provided by the contractor for this construction has been included in Table 5.

Table 5 Plant list for shaft construction works

Shaft construction works plant list	
Activity	Plant List
Drilling and installing steel posts	10-20t excavator and/or GEAX EK-40
Excavating Shaft	10-20t excavator
Spoil removal	6-wheeler or articulated truck
Concrete base	Plate compactor Concrete truck and pump

2.3 Trenchless Tunnel Construction

Trenchless construction works will occur between the Greys Ave CSA temporary shaft and the shaft at the Mayoral Drive intersection.

The Greys Avenue CSA, established as part of the Part 3 resource consent application, will be used as part of the works. This will contain ancillary equipment and functions for trenchless pipe installation.

Approximately 23 metres of 600 mm diameter pipe will be installed between the two sites. The trenchless construction works are proposed to take 6 working days to complete

The equipment to be provided within the Greys Avenue CSA and Mayoral Drive compound as part of this project is given in Table 6.

Table 6 Equipment at Greys Avenue CSA and Mayoral Drive CSA for trenchless construction

Greys Avenue and Mayoral Drive CSA trenchless tunnel construction equipment	
Greys Avenue CSA	Mayoral Drive CSA
• Crane • Power pack container • Pipe jack • Vacuum truck or 6-wheeler • Tool truck • Ventilation Fan	• Crane • Power Pack container • Pipe jack • Tool truck

2.4 Vehicle Movements

Based on the volume of the shaft and the volume of the proposed pipe, the following total truck movements will be required:

- 20 truck movements for removing spoil from shaft construction.
- 8 truck movements for removing spoil from pipe installation.

2.5 Noise and Vibration Sensitive Receptors

The land use around the Project is a mixture of retail, commercial, hospitality, civic, and residential, representing a highly developed urban environment. For the most part, retail activity is provided at street level with other uses provided above. 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 works are also located within the Historic Heritage overlay of the AUP. These properties are likely to be more sensitive to vibration. Specific management procedures have been developed for these receptors within this CNVMP.

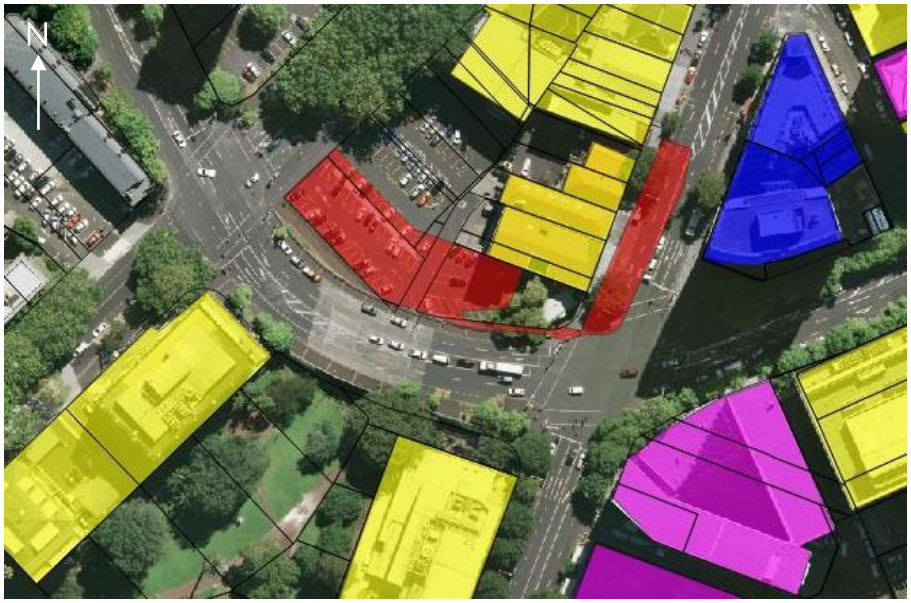

Figure 3 Adjacent noise sensitive receptor building types – commercial (yellow), hotels (blue), apartments (pink)

3 Construction Noise and Vibration Criteria

The construction noise and vibration criteria for the Project have been developed based on the following documents:

- Auckland Unitary Plan: Section E25.6.28 – Construction noise levels in the Business – City Centre Zone and the Business – Metropolitan Centre Zone.
- Auckland Unitary Plan: Section E25.6.29 – Construction noise and vibration levels for work within the road.
- Auckland Unitary Plan: Section E25.6.30 – Vibration.
- NZS 6803:1999 Acoustics – Construction Noise
- DIN 4150-3:1999 Vibrations in buildings – Part 3: Effects on structures.
- BS 5228-2:2014: Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration.

3.1 Construction Noise Criteria

Table 7 outlines the trigger levels for construction noise. Where predicted or measured noise levels are above the noise criteria in Table 7, the Best Practicable Option (BPO) of mitigation will need to be implemented.

Table 7 Construction noise criteria 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			
Day	Time	$L_{Aeq,30min}$ (dB)	L_{AFmax} (dB)
Monday to Friday	6.30am – 10.30pm	75	90
Saturday	7am-11pm	80	90

3.1.1 Regenerated Noise

There is no requirement in the AUP or New Zealand Standard which addresses regenerated noise. However, regenerated noise from ground borne vibration may impact adjacent receptors due to noise radiating from building elements (walls, floors), or from fittings and fixtures rattling (such as Venetian blinds).

The mTBM is only to operate during the daytime, and therefore, any sleep impacts are unlikely. Based on NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors* (NZS 2107), the following table presents relevant regenerated noise criteria.

Table 8 Recommended internal noise levels from regenerated noise from mTBM

Regenerated noise criteria	
Space	Recommended internal noise level for regenerated noise from mTBM activities
Office, retail or hospitality	45 dB $L_{Aeq,T}$
Residential sleeping or living areas in the inner city (including hotels)	35 dB $L_{Aeq,T}$

3.2 Construction Vibration Criteria

Construction vibration criteria to assess the effects of vibration on structures are provided in Table 9. Where predicted or measured vibration levels are at or above this vibration criteria the BPO of mitigation will be implemented.

Table 9 DIN 4150-3 long-term guideline vibration criteria

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 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

The vibration criteria in Table 9 apply in any horizontal 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.

3.2.1 Auckland Unitary Plan Vibration Amenity Limits

The vibration amenity limits outlined in Table E25.6.30.1 of the AUP are reproduced in Table 10 .

Table 10 AUP Amenity vibration limits (E25.6.30.1)

AUP amenity vibration limits		
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 10 apply to any axis when measured in the corner of the floor of the storey of interest for a multi-storey building, or within 500 mm 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 50 m of the works.

The vibration limits in Table 10 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, as detailed in Section 6.

4 Assessment Methodology

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

4.1 Construction Activities

The construction staging for the shafts and trenchless pipe installation are outlined in Table 11 and Table 12. 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. Phases marked with a hash (#) indicate those which occur outside of the road corridor (within the Greys Avenue CSA), and those marked with an asterisk (*) indicate phases which occur within the road corridor (and therefore exempt from the noise limits).

Table 11 Shaft Construction and Rehabilitation Stage – Greys Avenue CSA

Shaft Construction and Rehabilitation - Greys Avenue CSA		
Phase	Activity	Equipment/Materials
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 • 10-20t Excavator
2#	An Auger attachment on a 10 – 20t excavator or small piling rig (GEAZ EK-40) will be used to drill 300 to 400-diameter holes. Steel H-beams will be set into each with sand or concrete backfill	• Excavator or GEAX EK-40 piling rig
3#	The shaft will be excavated from the top using an excavator at surface level to a depth of approximately 1m below the pipe invert (5.5m deep shaft). Six-wheeler trucks will be used to remove spoil off site. Approx shaft spoil volume will be 100m^3 (20 return truck trips). Steel road plates or timber lagging will be installed between H-beams as the excavation advances	• Excavator • 6-wheeler trucks • Ventilation fan
4#	The shaft base will be lined out with 500mm of aggregate or blinding concrete to provide a solid and level working platform.	• Concrete pump • Concrete truck • Plate compactor • Ventilation fan
-	If de-watering is required, a 2-to-4-inch submersible pump will be used to remove water from the excavation. The water will be pumped into a clarifying tank for treatment before discharging. The pumps will be powered by a diesel generator or grid power. *This activity has been assumed as part of Phases 3 and 4.*	• Submersible pump • Diesel generator
5#	Temporary works will be progressively removed using a 5t to 20t excavator as the shaft is backfilled.	• 10-20t Excavator
6#	Road pavement (GAP65 and AC) will be reinstated using a 5 to 20t excavator and plate compactor.	• 10-20t Excavator • Plate compactor

For this stage, de-watering will be required all day and night for up to 2 days. This is expected to be the only activity required to be undertaken during the night.

Table 12 Trenchless Pipe Installation Stage - Greys Avenue CSA to Mayoral Drive CSA

Trenchless Pipe Installation Stage - Greys Avenue CSA to Mayoral Drive CSA		
Phase	Activity	Equipment/Materials
1#	Set up power pack, pump, and water tank on the surface adjacent to Greys Avenue shaft.	• Hiab/crane truck • Ventilation fans
2#	Lift pilot bore rig into pit and survey into position	• Hiab/crane truck • Ventilation fans
3#	Drill pilot hole to Mayoral Drive/Queen Street shaft using laser guided steering head	• Power pack container • Pipe jack • Vacuum truck • Tool truck • Ventilation fans
4*#	Install cutting reamer in the Mayoral Drive/Queen Street shaft and backreaming/cut back to the Greys Avenue Shaft. A vacuum truck will be used to remove spoil from the drive, and it will be disposed of offsite using 6 wheelers or vacuum trucks. Approx wet spoil volume will be 20m^3 (8 return truck trips).	• Hiab/crane truck • Power pack container • Pipe jack • Vacuum truck • Tool truck • Ventilation fans
5*#	Using pipe jacking methodology, install GRP pipes from the Greys Avenue shaft to the Mayoral Drive/Queen Street shaft.	• Hiab/crane truck • Power pack container • Pipe jack • Vacuum truck • Tool truck • Ventilation fans
6#	Clean up and flush the drill slurry out of the pipe with a vacuum truck. Inspect and test pipe	• Vacuum truck

For this stage, de-watering may be required all day and night for up to 7 days. This is expected to be the only activity required to be undertaken during the night.

Appendix A provides the sound power level and the percentage of time in use over a worst-case 30-minute period of the equipment listed in Table 11 and Table 12.

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* (BS 5228-1), NZS 6803, or WSP's previous measurements of similar equipment.

Appendix A 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, or previous measurements of similar equipment.

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 levels in Appendix A.

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.

4.2 Physical Site Mitigation

Temporary concrete barriers with plywood hoardings are to be installed around the perimeter of each of the CSA, except where a gate is required for access, as shown in Figure 4.

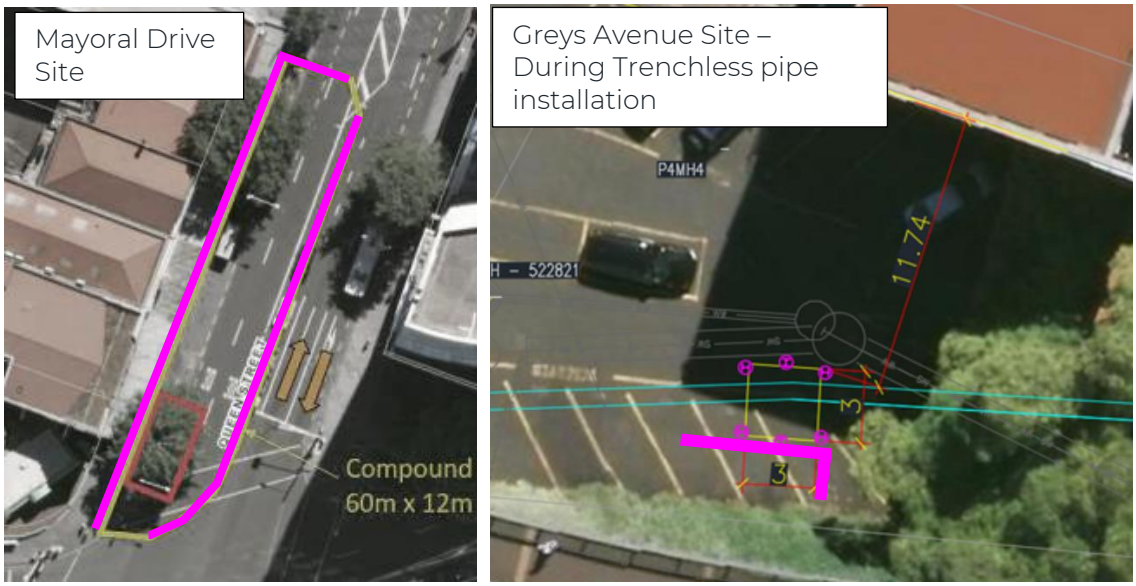

Figure 4 Proposed locations of site hoardings (pink)

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.

4.2.1 Managerial Mitigation

The following managerial mitigation measures will be undertaken to control noise at the closest properties:

- Equipment associated with the trenchless pipe equipment (such as power packs) in the Greys Avenue CSA is to be installed on the Mayoral Drive side of the shaft, as shown in blue in Figure 5.
- The excavator used for piling the Greys Avenue CSA temporary shaft will be set up on the side of the shaft adjacent to Mayoral Drive as shown in blue in Figure 5.
- During the excavation of the Greys Avenue shaft, the excavator will be set up in the area in blue or orange in Figure 5.

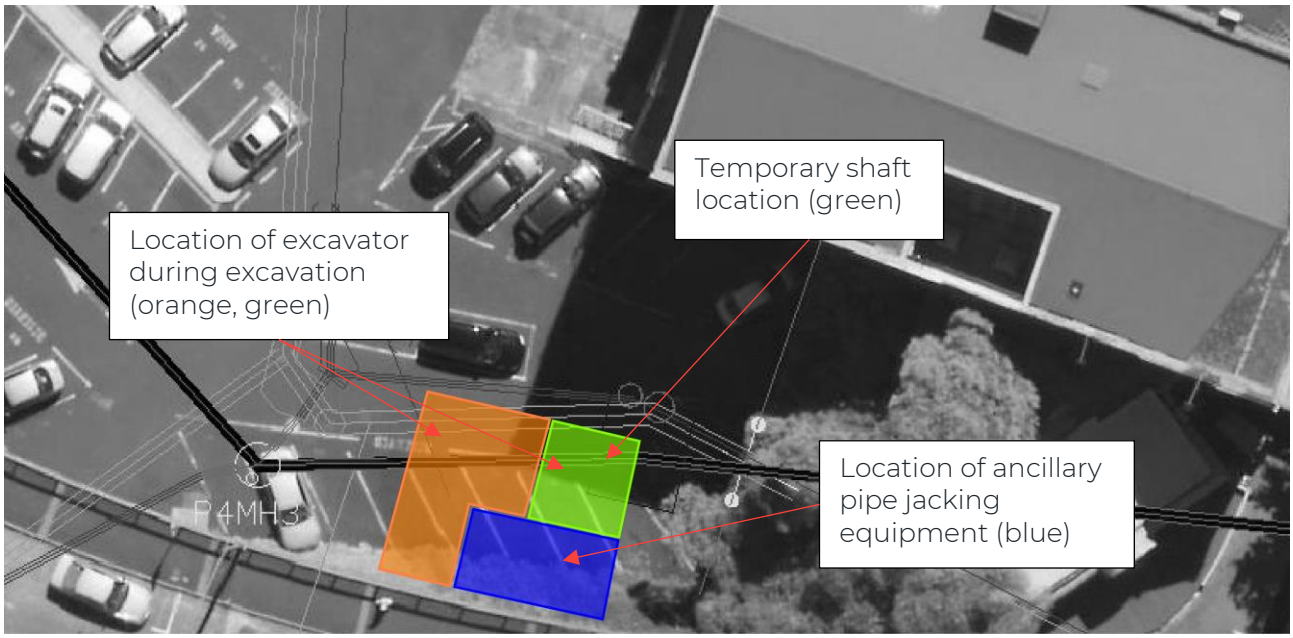

Figure 5 Location of equipment setup on site

The following managerial mitigation measures have been adopted by the contractor to reduce the impacts of vibration:

- Compaction activities are to be undertaken using plate compactors only (not vibratory rollers, etc.).
- 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.

Further information on managerial mitigation measures is provided in Section 6.

4.3 Noise Prediction Methodology

A noise prediction model has been prepared using SoundPLAN Version 8.2 3D computational noise modelling software. A series of scenarios have been analysed with supporting spreadsheet calculations.

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

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

Table 13 presents the noise modelling parameters adopted for this assessment.

Table 13 Noise modelling parameters

Parameters for computational noise modelling		
Property	Value	Source
Calculation method	NZS 6803 for construction noise ISO 9613-2 for propagation	-
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	Google Street View
Number of Reflections	3	-
Assessment location	1.0 metres from any façade	NZS 6803

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.

4.4 Regenerated Noise

Regenerated noise predictions from vibration generated by a mTBM received in adjacent buildings are based on the propagation model outlined in Amick[1] with building coupling losses and floor resonances provided in the Federal Transport Agency *Transit Noise and Vibration Impact Assessment Manual*. This method assumes competent soil conditions soil conditions (compacted clay, exposed rock), and slab-on-grade foundation types and masonry building of all adjacent properties.

4.5 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 competent soil conditions (sandy clays, silty clays, gravel, silts), and slab-on-grade foundation types of all adjacent properties.

[1] *A frequency-dependent soil propagation model* (Amick) PROC SPIE conference on current developments in vibration control for optomechanical systems, 1999.

5 Predicted Noise Levels

This section outlines the minimum distances from any building to comply with the noise criteria along with the predicted noise level from each construction stage.

5.1 Noise Stand-off Levels

A list of the key equipment used for these works and the operating sound power level is given in Table 14. Table 14 also provides the predicted noise level at various distances and the stand-off distance to achieve the 75 dB $L_{Aeq,T}$ daytime weekday noise limit without any noise limits.

Table 14 Proposed equipment sound power levels, the noise level at various distances and stand-off distances without mitigation

Stand-off distance of proposed equipment without mitigation						
Source	Sound Power Level (dB L_{wA})	Predicted noise level at distance (dB $L_{Aeq,T}$)				Stand-off distance in metres to achieve 75 dB $L_{Aeq,T}$
		5	10	15	20	
Concrete cutter	113	94	88	84	82	45
20t excavator	105	86	80	76	74	18
6-wheeler truck / tool truck	107	88	82	78	76	22
Piling rig (GEAX EK-40)	108	89	83	79	77	25
Ventilation fan	100	81	75	71	69	10
Concrete truck and pump	103	84	78	74	72	14
Plate compactor	108	89	83	79	77	25
Hiab	107	88	82	78	76	22
Power pack	103	84	78	74	72	14
Pipe jack	82	63	57	53	51	2
Vacuum truck	108	89	83	79	77	25
Submersible pump	90	71	65	61	59	3
Generator	95	76	70	66	64	6

In addition, Table 8 provides the stand-off distance which is the slope distance between the mTBM and adjacent buildings which is predicted to achieve the internal regenerated noise criteria. This assumes competent soil types, masonry buildings on spread footings, noise levels assessed at ground levels, typical residential (furnished room with carpet) or office/retail/hospitality environment (furnished room with carpet and ceiling tiles), and the current pipe installation alignment.

Table 15 Predicted stand-off distance for regenerated noise from mTBM

Regenerated noise stand-off distance	
Regenerated internal noise level criteria	Stand-off distance
45 dB $L_{Aeq,T}$	7 metres
35 dB $L_{Aeq,T}$	15 metres

When considering the slope distance (vertical and horizontal distance) from the mTBM to the adjacent buildings, the following properties may exceed the criteria:

- 329 Queen Street.

All other buildings are predicted to be outside the stand-off distance

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

The predicted noise levels at each noise-sensitive receptor for each construction phase and stage listed in Table 11 and Table 12 are presented in Appendix B, assuming the physical mitigation measures described in Section 6.2 are provided, unless otherwise specified. Noise level predictions during Trenchless Construction Phases 4 and 5 from works outside the road corridor are shown, with cumulative noise level predictions from works within, and outside the road corridor presented in brackets. In Appendix B, exceedances are highlighted based on the following:

- Green indicates properties where the predicted cumulative noise levels are greater than the 75 dB $L_{Aeq,30\ min}$ noise limit, and the predicted noise levels from works outside the road corridor (i.e. in Greys Ave CSA) are less than the 75 dB $L_{Aeq,30\ min}$ noise limit.
- Red indicates properties where the predicted noise levels from works outside the road corridor (i.e. in Greys Ave CSA) are greater than the 75 dB $L_{Aeq,30\ min}$ noise limit.
- Purple indicates properties where the predicted cumulative noise levels are greater than the 75 dB $L_{Aeq,30\ min}$ noise limit, and the predicted noise levels from works outside the road corridor (i.e. in Greys Ave CSA) are greater than the 75 dB $L_{Aeq,30\ min}$ noise limit.

Table 16 outlines the properties that are predicted to exceed the AUP 75 dB $L_{Aeq,30\ min}$ noise limit irrespective of the noise source being within or outside of the road corridor. Properties marked with a hash (#) indicate those which receive noise levels greater than the AUP construction noise standards from works located outside of the roading corridor (i.e. from construction within the Greys Avenue CSA). Properties marked with a star (*) indicate those which receive levels greater than the AUP construction noise standards from construction works located outside of the road corridor (such as from Mayoral Drive CSA).

Table 16 Properties predicted to exceed the construction noise limits

Properties predicted to exceed the construction noise limits						
Stage of Works	Properties subject to exceedances of noise standards at each phase					
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Shaft Construction: Greys Avenue CSA	323-327 Queen St# 329 Queen St#	323-327 Queen St#	323-327 Queen St# 329 Queen St#			
Trenchless Construction: Shaft locations only	329 Queen St#	329 Queen St#	323-327 Queen St# 329 Queen St#	319 Queen St* 321 Queen St* 323-327 Queen St*# 329 Queen St*# 396 Queen St*	319 Queen St* 323-327 Queen St*# 329 Queen St* 396 Queen St*	-

#Noise exceeds AUP noise standards from works outside the roading corridor.
*Cumulative noise exceeds AUP noise standards from works within, and outside the roading corridor

5.3 Maximum Noise Levels (L_{AFmax})

The maximum sound level (L_{AFmax}) is the highest noise level measured during a time-weighted period. It is generated by single events such as the dropping of spoil into an empty truck, the impact of an excavator bucket on asphalt to break it up, and the like.

The predicted maximum noise levels have been undertaken for the loudest construction activities that occur outside the road corridor (construction of the Greys Avenue Shaft).

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

Based on the predicted maximum noise events, no properties are predicted to exceed the maximum noise limit of 90 dB L_{AFmax} outlined in the AUP.

5.4 Predicted Vibration Levels

Table 17 outlines the stand-off distance of each piece of high vibration equipment used to achieve the various vibration limits. 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.

Table 17 Vibration stand-off distances to achieve the relevant acoustic criteria

Vibration stand-off distances						
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	1.9 at 10 m	0.5	1.8	6.5	10
2	CFA piling, auguring, or similar	0.5 at 10 m	0.1	0.2	0.5	1
3	Pipe jacking	1.5 at 10 m	0.3	1.1	4.5	7
5	Plate Compactor**	1.6 at 1.5 m	0.1	0.2	0.7	1

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

The 10 mm/s criteria apply at any commercial building, or structures that are commercial in nature (high-rise concrete or steel residential buildings for instance). The 5 mm/s applies to single, or two-storey detached or semi-detached 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 of the AUP.

Based on the stand-off distances and mitigation measures adopted above, there are **no properties** predicted to exceed the DIN 4150-3 vibration criteria at any stage of construction.

The following properties are predicted to be within the 2 mm/s AUP amenity limits stand-off distance from the operation of the pipe jack when it is operated outside of the road corridor for phases 4 and 5 of the trenchless construction only:

- 323-327 Queen Street
- 329 Queen Street

These properties shall be notified 10 working days before trenchless construction works to manage the potential vibration amenity impacts.

6 Mitigation and Management

This section describes the managerial and physical mitigation measures which should be implemented as far as reasonably practicable. This is to protect against unreasonable noise and reduce the effects of noise and vibration at receptors in line with the Resource Management Act (RMA). *This section shall be kept up to date by the contractor throughout the construction process.*

6.1 Principles of Mitigation

Proactive noise mitigation is the most effective method to control construction noise and vibration. Noise and vibration events that the community deem to be unnecessary are more likely to generate complaints.

Guiding Principles:

- The BPO shall be identified and implemented to manage and mitigate potential adverse effects of noise and vibration. The BPO of mitigation will need to be constantly reviewed during construction.
- Construction noise and vibration effects need to be managed, even when levels are within the limits, and management needs to be intensified if the limits are approached.
- Ongoing assessment of all construction activities and continual consideration of potential noise and vibration effects and appropriate mitigation shall be undertaken.
- Ongoing effective stakeholder engagement shall be provided, making available information on what, when and why construction works are happening.

6.1.1 Development of Best Practicable Options for Mitigation

A general hierarchy of mitigation measures to reduce the impact of noise and vibration is:

1 Scheduling construction activities to avoid sensitive times, particularly in the case of night works.
2 Use equipment and construction methods that minimise noise and vibration at the source, including the use of quieter machinery and tools.
3 Including physical mitigation measures to reduce the noise and vibration levels at receivers, such as noise barriers at the boundary of the Site and for specific items of plant.
4 Maintain open communication with the community and inform them about the schedule, duration, and potential noise impacts of the construction work. Respond promptly to any complaints and adjust the work plan as needed.
5 Deploying trained workers in noise management practices and encourage them to minimise noise by following best practices, such as avoiding unnecessary idling of equipment and using proper tools for the job. Hold regular toolbox talks and site inductions which discuss potential noise and vibration impacts.
6 Temporary relocation of potentially affected parties during high noise/vibration night works.

6.2 Physical Mitigation

Where practicable, physical mitigation shall be used to reduce the noise emissions from the construction works. In some instances, the use of physical mitigation may not be practicable (due to space requirements, or machinery utilised).

For this site, the key physical mitigation measures for noise and vibration are:

- Equipment selection, operation, and siting of equipment.
- Adoption of equipment specific enclosures, or other physical barriers.

Where new or improved physical mitigation measures are available, these will be considered by the team and added as a best practicable option to this section, if they can be utilised for this Project.

6.2.1 Equipment Selection and Siting

Equipment and plant for the Project will, as far as reasonably practicable:

- Prioritise quieter and newer technologies/models over noisier and older equipment/plant.
- Will have periodic inspections of equipment to ensure that they have been maintained correctly and are not generating excessive noise and/or vibration.
- Selection of equipment that is an appropriate power for the use (i.e., not using more powerful equipment than needed.
- Be fitted with the appropriate exhaust attenuators and broadband reversing alarms.
- Equipment that is used intermittently to be shut off when not in use.
- Limit and/or not use any compression/engine breaking on site as far as practicable; and
- Plan traffic flow, parking, and loading/unloading area to reduce reversing movements of trucks and equipment. Forward-in/forward-out movements are preferred.
- Where practicable, power shall be provided from mains power rather than generators.
- 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 away 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, and the like.

6.2.2 *Specific Physical Mitigation Measures*

To reduce noise predicted from the equipment and plant to adjacent receptors, the following physical noise reduction measures are to be incorporated as far as reasonably practicable:

- Temporary concrete barriers with plywood hoardings are to be installed around the perimeter of each of the CSA, except where a gate is required for access. Temporary acoustic barriers are also proposed at the Greys Avenue Site during trenchless construction. The proposed site hoardings are shown in Figure 6.

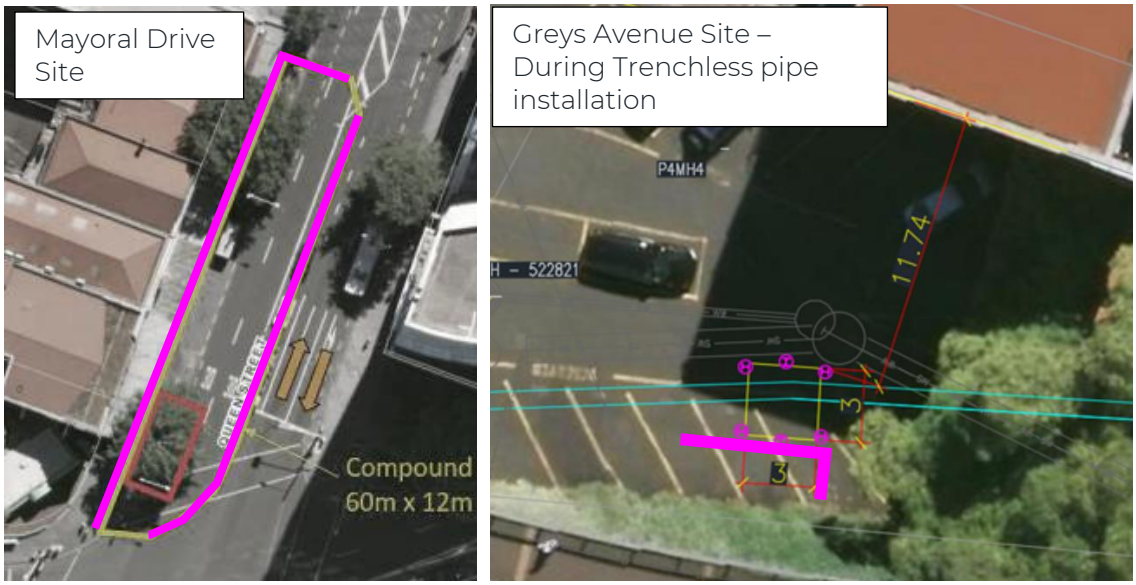

Figure 6 Proposed locations of site hoardings (pink)

- 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 palings 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.

The above provides the best practicable option for physical mitigation measures to control noise and/or vibration from the proposed construction works.

6.3 Managerial Mitigation Measures

This section describes the best practicable option for managerial mitigation measures which can be implemented to reduce the effects of noise and vibration at adjacent properties.

For this site, the key managerial mitigation for noise and vibration are:

- Noise and vibration monitoring and validation
- Training of staff
- Site conduct of staff on site

This section shall be kept up to date by the contractor throughout the construction process.

6.3.1 Validation and Monitoring

Acoustic validation measurements for specific parts of the works shall be undertaken to ensure acoustic predictions are accurate and in line with site noise levels. In particular:

- Noise and vibration monitoring of trenchless pipe installation activity are to be measured on-site during the first activity to confirm noise and vibration levels emitted.

6.3.2 Training

All staff who work or visit site are required to undertake induction training that includes a briefing on the relevant aspects of this CNVMP. This is to ensure all staff, contractors, and sub-contractors are aware of equipment and relevant mitigation measures to minimise noise and vibration effects as far as practicable.

The induction to the site will include the following:

- The roles and responsibilities of all site personnel in the management of noise and vibration effects.
- Identification of the sensitive receivers and activities that have the potential to cause noise and vibration effects.
- Procedures and operational considerations associated with those sensitive receivers and activities, to manage the noise and vibration effects. This may include:
    - Understanding of minimum noise and vibration stand-off distances,
    - Physical mitigation requirements,
    - Understanding of allowable hours of operation,
    - Appropriate use of equipment,
    - Procedure for receiving noise and/or vibration complaints.
- Contacts for site personnel to gain information related to noise and vibration, including the limits, equipment on site, mitigation measures, and management procedures.
- How plant equipment and methodologies may impact noise and vibration effects, and the relevant procedures to follow for the selection of appropriate plant and methodologies.
- How site behaviours and conduct may affect noise and vibration effects, and procedures to follow for appropriate site behaviours and conduct.
- Maintaining goodwill amongst the community.

Toolbox/tailgate meetings throughout the construction will also include consideration of noise and vibration effects, refreshing the training information given in the site induction and/or updating training information.

Site specific training must be provided to site personnel involved in monitoring noise and vibration and development of procedures for management and mitigation of noise and vibration effects, where required.

This includes where noise and/or vibration monitoring is required to investigate any complaint. Site induction for these personnel will include a briefing on relevant aspects of the CNVMP as above, plus procedures for recording monitoring results and where noise and vibration effects are identified to comply or not comply with the limits.

This includes where noise and/or vibration monitoring is required to investigate any complaint. Site induction for these personnel will include a briefing on relevant aspects of the CNVMP as above, plus procedures for recording monitoring results and where noise and vibration effects are identified to comply or not comply with the limits.

6.3.3 Scheduling of Works

The final scheduling of particularly loud activities shall be decided once consultation with the community has been undertaken.

Occupied buildings are sensitive to the timing of construction works.

All high-noise construction activities are proposed during the day, when adjacent residential/travellers accommodation are less sensitive to noise. While construction activities should be prioritised when buildings are not occupied (and less sensitive to noise), there will unlikely be a period where all buildings are unoccupied.

De-watering equipment is proposed to operate for up to 9 days, 24-hours a day, during the construction of the shaft and the trenchless construction. During the night, the key noise sensitive receptors will be any residential and/or travellers accommodation properties. With the appropriate selection of equipment and noise mitigation (acoustic barriers or enclosures), noise levels within any sleeping areas are not predicted to exceed 35 dB $L_{Aeq,T}$.

Cumulative noise emissions should always be considered by the contractor when scheduling the works. Noise emitting from multiple items of the plant will summate and cause a greater overall noise level. Only one item of particularly loud plant should be used at any one time on site, to reduce the cumulative noise and vibration from multiple items of equipment operating concurrently.

6.3.4 Behaviour and Conduct

Site personnel shall understand that their behaviours and conduct can affect noise and vibration effects. Conduct that is perceived as unnecessarily noisy can influence the community's perception of the overall noise generated by the Project.

During the site induction for contractor staff, the following management mitigation measures will be acknowledged and addressed where practicable and safe to do so:

- When arriving at work, please drive slowly on site and keep revs to a minimum. Keep stereos at a low volume (or off), and do not slam doors.
- No shouting on site. Either walk over and talk to somebody or use a radio/phone.
- Be careful with tools and equipment. Place them down, and do not drop them.
- Do not drag materials on the ground. Place them down when you arrive at the work area.
- Equipment and vehicles shall be switched off when not in use.
- When loading trucks do not drop material from a height.
- Noise enclosures should also have doors/hatches closed when the equipment is in use.

- All equipment is to be well maintained.
- If staff see anything/anyone making unnecessary noise, then stop it/them. If the source cannot be stopped, then report it to the Noise Liaison Officer.

It is essential that good relationships are maintained with the local community. Any queries from members of the public shall be responded to politely and referred to the Noise Liaison Officer / Stakeholder and Engagement Manager. Staff shall assist the public to contact this person. Staff shall not enter a debate or argue with members of the public.

6.3.5 Vibration Management

Rule E26.2.5.4(4) requires that a CNVMP is prepared if any buildings within 20 metres of the site are listed as primary features in Schedule 14.1 of the AUP. This provides a generic distance consideration for vibration sensitive buildings regardless of the construction works carried out. In this plan, specific vibration calculations and analysis has been undertaken. Therefore, the specific buildings analysed as being particularly susceptible and with vibration levels near the limit have been considered only.

In addition, general vibration management will be required to control vibration generating plant, particularly near buildings within the Historic Heritage Overlay in the AUP. The following vibration managerial mitigation measures are to be followed to reduce the likelihood of high vibration levels impacting heritage buildings:

- Not operating vibratory rollers within 15 metres of any building within the Historic Heritage Overlay in the AUP. This requires only plate compactors to be used at the Mayoral Drive and Victoria Street CSA's
- 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.

Specific vibration management will be required for 323-327 and 329 Queen Street, which are predicted to exceed the 2.0 mm/s PPV vibration amenity criteria from the pipe jack operation. To mitigate the amenity impacts from this activity, 323-327 and 329 Queen Street will be notified before the mTBM will operate. This notification will include that outlined in Section 7.2 below.

6.4 Receptor Specific Measures

Additional receptor specific noise and/or vibration mitigation measures may be required due to changes in the use of adjacent buildings, or complaints received. This section will be updated with a list of properties which specific management schedules are developed. All Receptor Specific Measures will be included as appendices to this CNVMP.

7 Community Engagement

A key component in minimising the impact of noise and vibration effects is early community engagement. Prior to the start of construction, a Community Relations Manager role (or equivalent) will be established. This representative for the Project will advise (in person or by writing) all properties within 100 metres of any construction site. This advice will include:

- Description of the wider construction works
- The activity that the occupants/landowners may be impacted by.
- Why the works are required to occur.
- Duration of these specific activities.
- Timing of when they will occur.
- Contact details (including telephone number and email) for the Noise Liaison Officer which the public can contact to find out information or lodge a complaint.
- How any noise and vibration complaints will be handled by the contractor.

Regular direct communication (in person or by writing) will be undertaken with the properties that potentially could receive noise levels greater than the noise limits outlined in this report at any point during the construction.

7.1 Consultation

The objective of consultation with neighbouring properties is to foster positive communication and relationships between the contractors, clients, and potentially affected parties. It also provides a platform for residents to learn about the Project.

Consultation will be undertaken with all properties that are potentially impacted by construction noise and/or vibration to determine:

- Hours that higher noise and/or vibration activities would have the lowest impact (such as times when all residential occupants are at work).
- Days/times when occupants are the most sensitive (during key religious events, at night if small children are going to bed, etc.).
- If there are any special needs relating to noise and/or vibration within the construction window (i.e., children birthday parties), that may require key management of construction noise and/or vibration.

Where practicable, high noise and/or vibration construction activities will occur at times when the adjacent occupants are least noise sensitive.

7.2 Notification Procedures

For buildings that are to receive noise or vibration levels greater than the required criteria, the following procedure to notify these properties is to be undertaken:

- Identification of properties that would receive levels greater than the AUP noise and vibration criteria for the specific equipment being used.
- A minimum of 10 working days prior to any noise or vibration equipment being used that would lead to potential exceedances, communication will be undertaken to adjacent receptor buildings to notify them of upcoming high noise and/or vibration works. This communication is to include:

    - Description of the specific activity being undertaken
    - Why the works are required to occur.
    - Duration of these specific activities.
    - Timing of when they will occur.
    - Contact details (including telephone number and email) for the Noise Liaison Officer which the public can contact to find out information or lodge a complaint.
    - How any noise and vibration complaints will be handled by the contractor.
    - If pre and post construction inspections will be undertaken (if not already) and when likely times these will occur.
- Noise and/or vibration monitoring is to be undertaken during activities where practicable to confirm the received levels and to determine future mitigation for the equipment.

8 Complaints Handling Protocol

The Contractor will adopt the following protocol for handling complaints. This protocol is intended to ensure that the issues are addressed, and that appropriate corrective actions are identified and implemented as necessary.

The Noise Liaison Officer will record all verbal and telephone complaints in writing within a Noise Complaint Register. Details to be recorded should include:

- Full details of the complaint (complainant's name and address)
- Time and date of the event.
- Location of the event.
- What was felt/heard (can they identify the plant or process).
- If it was felt/heard outside or inside.
- If inside, were windows/doors open.
- Impact of the event (e.g., woken from sleep, couldn't hear the TV, disturbed whilst reading etc.).
- Weather conditions at the time (if known) including cloud cover, temperature, wind strength and direction.
- Any specific requests.
- What activities were occurring at the time of the complaint, including the items of equipment operating and where they were operating.
- Any additional acoustic data, including any noise or vibration measurements that are relevant to the complaint.

An initial response will be made and recorded. Depending on the nature of the complaint, the initial response could be to immediately cease the activity pending investigation, to replace an item of equipment, or screen the activity. However, it might not be practicable to provide immediate relief in some cases. The complainant and Council will be informed of actions taken. Contact details for the Council are recorded above.

Where the initial response does not address the complaint, further investigation, corrective action, and follow-up monitoring shall be undertaken as appropriate within 5 working days. The complainant [and Council] will be informed of actions taken.

Complainants will be informed of the implementation of the corrective action that has been taken to mitigate the adverse effects.

All actions will be recorded on a Noise Complaint Register, and the complaint will then be closed. The Contractors' complaint response line will be always attended to during out of hours works. It will be kept up to date and made available to the Environmental Health Officer (or equivalent) of Auckland Council if requested.

9 Monitoring

It is recommended that acoustic monitoring is undertaken at key milestones to confirm that the actual noise emissions are no greater than those predicted, or to investigate any noise and/or vibration complaints.

9.1 Noise

Noise monitoring shall be conducted by one of the following staff in accordance with NZS 6801:2008 and NZS 6803:1999.

- Contractor to include appropriately qualified staff

Noise monitoring will be undertaken by a suitably qualified person using a Class 1 or 2 Sound Level Meter (SLM) and associated kit. The calibrator will be verified by an accredited laboratory annually, and the sound level meter and microphone biannually (every two years) during the construction programme.

The contractors may undertake noise monitoring with an SLM that does not have any class classification; however, it must be noted that this approach would not be in accordance with noise measurement guidance and standards. If this approach is adopted and measured noise levels exceed the predicted noise levels, noise monitoring by a suitably qualified person using a Class 1 or 2 SLM shall be undertaken.

Noise monitoring is recommended to be conducted:

- To confirm the sound level generated by the equipment on site.
- During the piling and shaft construction, particularly at 323-327 Queen Street to confirm the levels of exceedances and any specific mitigation measures.
- During the first night of works associated with each stage to confirm the noise emissions.
- To address any reasonable complaints.

Measurement sample time should not exceed one hour, and 15 minutes is likely to be adequate. Measurements will be used to validate or refine the noise level predictions and determine which receivers may be at risk of noise levels exceeding the criteria.

Following each noise survey, the results will be evaluated and reported on a noise survey report template. If noise monitoring indicates an exceedance of the noise criteria, then the noise management of the works will be reviewed and updated. This may include changing construction methodologies (to use lower noise equipment), additional noise mitigation (such as higher barriers), or reducing the operating time of equipment near buildings (such as limiting works close to one receptor to between 0900 – 1500 hours). Specific management will be dependent on the activity, duration, and sensitivity of the receptor.

All noise survey reports will be kept on file and available to the territorial authority on request.

9.2 Vibration

Monitoring of building vibration will be performed in accordance with *DIN 4150-3 Structural Vibration – Effects of vibration on structures*. The monitoring methodology to determine attended or unattended long-term monitoring is also provided below. Specific vibration predictions and analysis has been undertaken for the proposed activity, and as such, specific monitoring is recommended for identified buildings only. This work is to be undertaken by the following trained staff:

- Contractor to include appropriately qualified staff

Vibration monitoring will be conducted on the following occasions:

- At the start of piling or other high vibration generating activities outlined in Table 17 to validate predictions and confirm vibration levels near heritage buildings are acceptable.
- During the first pipe jacking operation to determine the vibration level from this activity and reassess any mitigation measures required to control vibration.
- To address reasonable complaints relative to construction vibration.

For all vibration measurements, vibration levels and frequencies will be recorded at a known distance from the plant item of interest using a vibration logger that satisfies the requirements of DIN 45669-11 and operated in accordance with DIN 45669-22. Vibration recordings will be made for each item of plant operating normally on its own, where practicable.

The methodology to determine when vibration monitoring is to be undertaken is as follows:

1 Measure the vibration level of the equipment used on site and compare with the levels provided in Table 17.
2 Calculate the vibration stand-off distance of the equipment based on the site specific measurements. Compare to the stand-off distances provided in Table 17.
3 Where buildings are within the stand-off distances, continuous vibration monitoring on the foundation of these buildings will be undertaken during construction works within the stand-off distances.
4 In addition to undertaking the monitoring listed above, vibration monitoring will also be conducted at the following occasions:

    - During the first pipe jacking operation to confirm the vibration level from this activity and reassess any mitigation measures required to control vibration.
    - When equipment is located at the closest point to 323-327 Queen Street and 329 Queen Street.

Where continuous vibration monitoring is required, as assessed in step 3 above, the selected continuous vibration monitoring system is to have an automatic warning system. A vibration threshold will be set, and immediate warnings to key personnel will be sent. If a warning is received., works are to stop while the source of the vibration is determined. If it is found that the exceedance was caused by construction activity, the building should be inspected by a suitably qualified and experienced person, and any damage should be documented via sketches and photographs. Mitigation measures (either physical or managerial) will be put in place such that exceedances are not predicted to be experienced in future.

If vibration monitoring indicates that criteria are being exceeded and that was not anticipated, then the management of the works will be reviewed.

All vibration survey reports will be kept on file and available to the territorial authority upon request.

Best practicable option mitigation that considers vibration is to be reviewed constantly by the Contractor, particularly for high-vibration methods (such as piling). This could include changing the piling methodology or using smaller items of plant.

9.3 Building Condition Survey

Currently, no buildings are predicted to exceed the DIN4105-3 vibration criteria, and therefore no requirement to undertake building condition surveys. Where vibration measurements are undertaken and are shown to be above the vibration criteria, all works on site will cease, and a building condition survey will be undertaken.

Qualified building surveyor staff who will conduct building condition surveys are:

- *TBC*
- *TBC*

A report will be prepared for each building surveyed including:

- A description of the building condition including construction materials and the present condition;
- Any existing cosmetic or structural damage, or other building-related defects;
- Sketched and photographs showing the location and extent of any existing damage such as cracks; and
- Verification of the report by the surveyor and building owner.

Following the works all building condition surveys will be repeated. The post-completion report will be prepared including:

- Sketches and new photographs of any new damage, and
- Verification of the report by the surveyor and building owner.

Pre- and post-construction building condition surveys will be held on record and provided to the building owner, Heritage New Zealand Pouhere Taonga, and/or relevant territorial authority if requested.

9.4 Seismic Building Assessments

An Initial Seismic Assessment (ISA) should be undertaken for the following buildings (that have previously been identified my heritage architectural consultants), where this has not been undertaken for other Parts of the Queen Street Wastewater Diversion Project. This is to determine the structural integrity of the building to confirm the likelihood of damage to the building from vibration due to construction equipment:

- Auckland Sunday School Building (323 – 327 Queen Street)
- Two-Storey Commercial Building (319 Queen Street)

Qualified staff who can undertake ISA's are:

- *TBC*
- *TBC*

The structural performance of each building given as percentage of New Building Standard (%NBS) shall be recorded and a conclusion will be developed around the likelihood of building damage (cosmetic or structural) with the developed vibration limits. Specific limits may need to be developed for buildings that have not been recently strengthened.

Appendix A
Construction Equipment Schedule

Equipment List						
Site	Phase	Activity	Equipment	SWL (dB L_{Aeq})	SWL (dB L_{Amax})	% on time
Greys Avenue Shaft Construction	1	Saw cut and removal pavement	Concrete Cutter	113	-	30
			20t Excavator	105	120	80
			6-wheeler truck	107	120	25
	2	Auguring and installing H-Beams	Excavator or GEAX EK-40 piling rig	108	-	80
	3	Excavation of shaft	20t Excavator	105	120	80
			6-wheeler truck	107	120	25
			Ventilation fans	100	-	100
			Submersible pump	90	-	100
			Generator	95	-	100
	4	Lining base of shaft with concrete	Concrete truck and pump	103	-	100
			Plate compactor	108	-	50
			Ventilation fans	100	-	100
			Submersible pump	90	-	100
			Generator	95	-	100
			6-wheeler truck	107	120	25
	5	Backfilling trench	20t Excavator	105	120	80
			6-wheeler truck	107	120	25
			Plate compactor	108	-	100
	6	Reinstatement of road pavement	20t Excavator	105	120	80
			Plate compactor	108	-	100
			6-wheeler truck	107	120	25
Trenchless pipe construction (Greys Avenue to Queen Street/Mayoral Drive)	1	Site setup	Hiab/crane truck	107	-	80
			Ventilation fans	100	-	100
	2	Lift boring rig into pit and survey	Hiab/crane truck	107	-	80
			Ventilation fans	100	-	100
	3	Drill pilot hole to Queen Street/Mayoral Drive shaft	Power pack container	103	-	100
			Pipe jack	82	-	100
			Vacuum truck	108	115	100
			Tool truck	107	120	25
			Ventilation fans	100	-	100
	4	Install reamer and cutback	Hiab/crane truck	107	-	80
			Power pack container	103	-	100
			Pipe jack	82	-	100
			Vacuum truck	108	115	100
			Tool truck	107	120	25
			Ventilation fans	100	-	100
	5	Install wastewater pipe	Hiab/crane truck	107	-	80
			Power pack container	103	-	100
			Pipe jack	82	-	100

			Vacuum truck	108	115	100
			Tool truck	107	120	25
			Ventilation fans	100	-	100
	6	Clean-up, inspection and testing	Vacuum truck	108	115	100

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	Pipe jacking	1.5
4	Plate compactor	0.6

Appendix B
Predicted Noise Levels

The following tables provide the predicted noise level at each construction location for each phase and stage. Hash (#) means noise level is received from works outside the road corridor (noise generated within Greys Avenue CSA). The star (*) means noise is received from works within the road corridor (Mayoral Drive/Queen Street shaft site).

Where works are located concurrently within and outside of the road corridor (Trenchless Construction Phases 4 and 5), noise level is provided is bracketed based on the following:

- Predicted noise levels from just the works within Greys Ave CSA are shown as the number outside of the brackets.
- Predicted cumulative noise from the Greys Ave CSA and works within the road corridor are shown as the number inside the brackets.

The noise exceedances are highlighted based on the following:

- Green indicates properties where the predicted cumulative noise levels are greater than the 75 dB $L_{Aeq,30\ min}$ noise limit, and the predicted noise levels from works outside the road corridor (i.e. in Greys Ave CSA) are less than the 75 dB $L_{Aeq,30\ min}$ noise limit.
- Red indicates properties where the predicted noise levels from works outside the road corridor (i.e. in Greys Ave CSA) are greater than the 75 dB $L_{Aeq,30\ min}$ noise limit.
- Purple indicates properties where the predicted cumulative noise levels are greater than the 75 dB $L_{Aeq,30\ min}$ noise limit, and the predicted noise levels from works outside the road corridor (i.e. in Greys Ave CSA) are greater than the 75 dB $L_{Aeq,30\ min}$ noise limit

Greys Avenue CSA Shaft Construction						
Property	Phases					
	1#	2#	3#	4#	5#	6#
3 Airedale Street	58	56	57	60	58	58
301 Queen Street	58	56	57	60	58	58
313 Queen Street	58	56	57	60	58	58
315 Queen Street	60	58	59	62	60	60
317 Queen Street	49	47	48	51	49	49
319 Queen Street	50	48	49	52	50	50
321 Queen Street	72	70	71	74	72	72
323-327 Queen Street	81	79	80	83	81	81
329 Queen Street	78	75	77	80	78	78
361 Queen Street	70	68	69	72	70	70
380 Queen Street	53	51	52	55	53	53
396 Queen Street	60	58	59	62	60	60

Queen Street/Mayoral Drive and Greys Avenue CSA Trenchless Construction						
Property	Phases					
	1#	2#	3#	4#^	5#^	6#
3 Airedale Street	56	56	54	54 (70)	52 (68)	55
301 Queen Street	53	53	58	58 (71)	56 (69)	52
313 Queen Street	46	46	51	51 (73)	49 (71)	45
315 Queen Street	49	49	52	52 (74)	50 (72)	48
317 Queen Street	48	48	48	47 (75)	45 (73)	47
319 Queen Street	49	49	49	49 (79)	47 (77)	48
321 Queen Street	63	63	71	71 (77)	69 (75)	62
323-327 Queen Street	75	75	78	78 (87)	76 (85)	74
329 Queen Street	76	76	77	77 (84)	75 (82)	75
361 Queen Street	71	71	70	70 (72)	68 (70)	70
380 Queen Street	51	51	51	51 (73)	49 (71)	50
396 Queen Street	59	59	57	57 (78)	55 (76)	58

Predicted Maximum Noise Levels from Any Construction Equipment	
Property	Predicted Maximum Noise Level L_{AFmax} (dB)
3 Airedale Street ^	78
301 Queen Street ^	76
313 Queen Street ^	78
315 Queen Street ^	82
317 Queen Street ^	85
319 Queen Street ^	87
321 Queen Street ^	84
323-327 Queen Street ^	90
329 Queen Street ^	88
361 Queen Street ^	80
380 Queen Street ^	82
396 Queen Street ^	86

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