Watercare Services Limited

CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

QUEEN STREET WASTEWATER DIVERSION PROGRAMME: PART 3 - PART 6 LINK PROJECT

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ABBREVIATIONS AND DEFINITIONS

AC	Auckland Council
AUP	Auckland Unitary Plan (Operative in Part)
BPO	Best Practicable Option
CNVMP	Construction Noise and Vibration Management Plan
CSA	Construction Support Area
NSR	Noise and Vibration Sensitive Receptor
RMA	Resource Management Act 1991
The Project	The Part 3 – Part 6 Link Project, being the construction of a wastewater pipeline from the Part 3 Mayoral Shaft to the new Part 3 – Part 6 Marmion Shaft at the intersection of Queen Street and Marmion Street.
TMPs	Traffic Management Plans
Watercare	Watercare Services Limited
WSP	WSP New Zealand Limited

GLOSSARY

Term	Definition/Description
A-weighting, dBA	A frequency weighting designed to reflect the relative loudness perceived by the human ear. It de-emphasizes 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.
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. $L_{eq,T}$ 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.

EXECUTIVE SUMMARY

WSP has been engaged by Watercare Services Limited to assess the construction noise and vibration impacts from Part 3 – Part 6 Link Project (the Project) of the Queen Street Wastewater Diversion Programme, in Auckland. The Project involves the construction of a wastewater pipeline from the Part 3 Mayoral Shaft to a new shaft at the intersection of Queen Street and Marmion Street

Construction noise and vibration criteria have been developed based on the Auckland Unitary Plan (AUP). The Project is located entirely within the road corridor. Therefore, the AUP noise and vibration (amenity) limits for construction works do not apply, provided that a Construction Noise and Vibration Management Plan (CNVMP) is developed and followed. While a CNVMP is required to be adopted by the contractor (and a framework CNVMP has been provided with the Resource Consent), we have assessed noise and vibration effects from works occurring within the road corridor for completeness.

The construction methodology for the Project has been provided by Fulton Hogan, the proposed main contractor. This methodology has been used to define the stages of construction, and to develop a construction equipment list for each phase / activity.

The key proposed physical and administrative mitigation measures are:

- Acoustic site hoardings around the construction compound on Marmion Street, apart from gates.
- Where practicable, localised movable acoustic barriers around high noise-generating equipment during operation, such as the concrete saw and the handheld concrete breaker.
- Appropriate selection and placement of equipment such as generators and water pumps for dewatering, and
- Work outside the construction hours and concrete breaking activities will be scheduled to minimise the impact on noise and vibration sensitive receptors where these activities are required.

Based on the proposed construction methodology, the implementation of a CNVMP including all proposed and practicable mitigation measures, and the AUP construction noise and vibration rules for works within the road corridor; the construction noise and vibration effects are predicted to be acceptable to reasonable and can be undertaken as a permitted activity as per AUP Rule E25.4.1 (A1).

1 INTRODUCTION

1.1 OVERVIEW

Watercare Services Limited ('Watercare') is a lifeline utility providing water and wastewater services to a population of 1.7 million people in Auckland and Northern Waikato. 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 are proposing to upgrade the existing wastewater network of the upper (southern) catchment of Auckland City Centre. The current network has insufficient capacity to meet the future needs based on increased development in the area. The wider programme of works has been split into separate parts for the purpose of design, consenting and construction; the consenting and construction packages of the Queen Street programme are shown below in Figure 1-1.

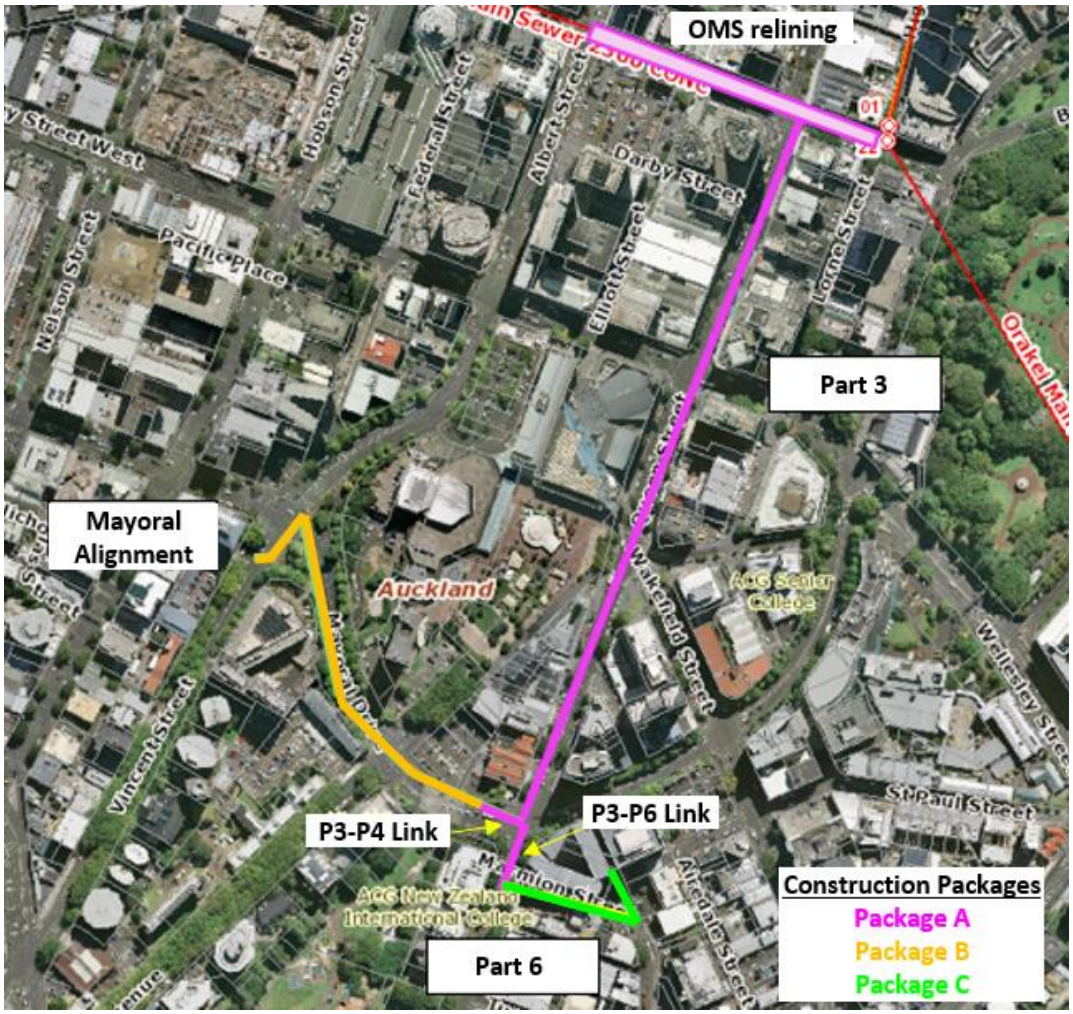

Figure 1-1: Queen Street Wastewater Diversion Programme

The Part 3 – Part 6 Link Project involves the construction of a wastewater pipeline from the Part 3 Mayoral Shaft to a new shaft at the intersection of Queen Street and Marmion Street (known as the 'Marmion Shaft').

1.2 CONSENTING BACKGROUND

Resource consent for two sections of the wider Queen Street Programme have already been approved by Auckland Council, being:

1) Part 3 Alignment/Resource Consent No. BUN60422974:

A 650 m long, 1200 mm diameter wastewater pipeline within Queen Street between the intersections of Mayoral Drive and Victoria Street, with connections to the local network at Wellesley Street and the Orakei Main Sewer at Victoria Street. This consent was approved on the 4th of July 2024 and was amended via s127 of the RMA by BUN60422974-A on the 5th of September 2024.

2) Part 3 – Part 4 Connector Tunnel/Resource Consent No. BUN60425924:

A 43 m-long, 700 mm diameter tunnel between the Mayoral Drive shaft established under Part 3 and a new shaft within the Construction Support Area ('CSA') within 329 Queen Street. The tunnel will initially be utilised to provide services to the micro-TBM for Part 3 construction, and will be utilised as a permanent wastewater pipeline once Part 3 construction has been completed. This consent was approved on the 9th of July 2024.

The resource consent application for the following project is currently being prepared and is expected to be lodged with Council in April 2025:

3) Mayoral Drive Alignment (Yet to be lodged)

The Mayoral Drive alignment involves the construction of a new wastewater pipe within or adjacent to the road reserve of Mayoral Drive, between the intersection with Queen Street and Vincent Street. The works include a 375 - 700mm diameter wastewater pipeline between the Part 3-Part 4 Connector Tunnel and a new manhole within Vincent Street.

1.3 PURPOSE OF THIS REPORT

The purpose of this report is to provide an assessment of construction noise and vibration in relation to the Part 3 – Part 6 Link Project.

It is noted that noise and vibration produced during the construction of the Mayoral shaft and its associated activities (such as tunnelling operations) is not expressly included within this assessment, as this element is captured within the existing consent for the Part 3 Alignment (BUN60422974) and the Part 3 – Part 4 Connector Tunnel (BUN60425924) projects.

2 DESCRIPTION OF EXISTING ENVIRONMENT

The following provides a description of the existing environment applicable to the application.

2.1 LOCATION AND PHYSICAL ENVIRONMENT

The Project is located within Auckland City Centre, to the immediate north and south of the intersection of Queen Street and Mayoral Drive. The project alignment extends from the 'Mayoral Shaft', established under the Part 3 consent, to a new shaft opposite the intersection of Queen Street and Marmion Street, as shown below in Figure 2-1.

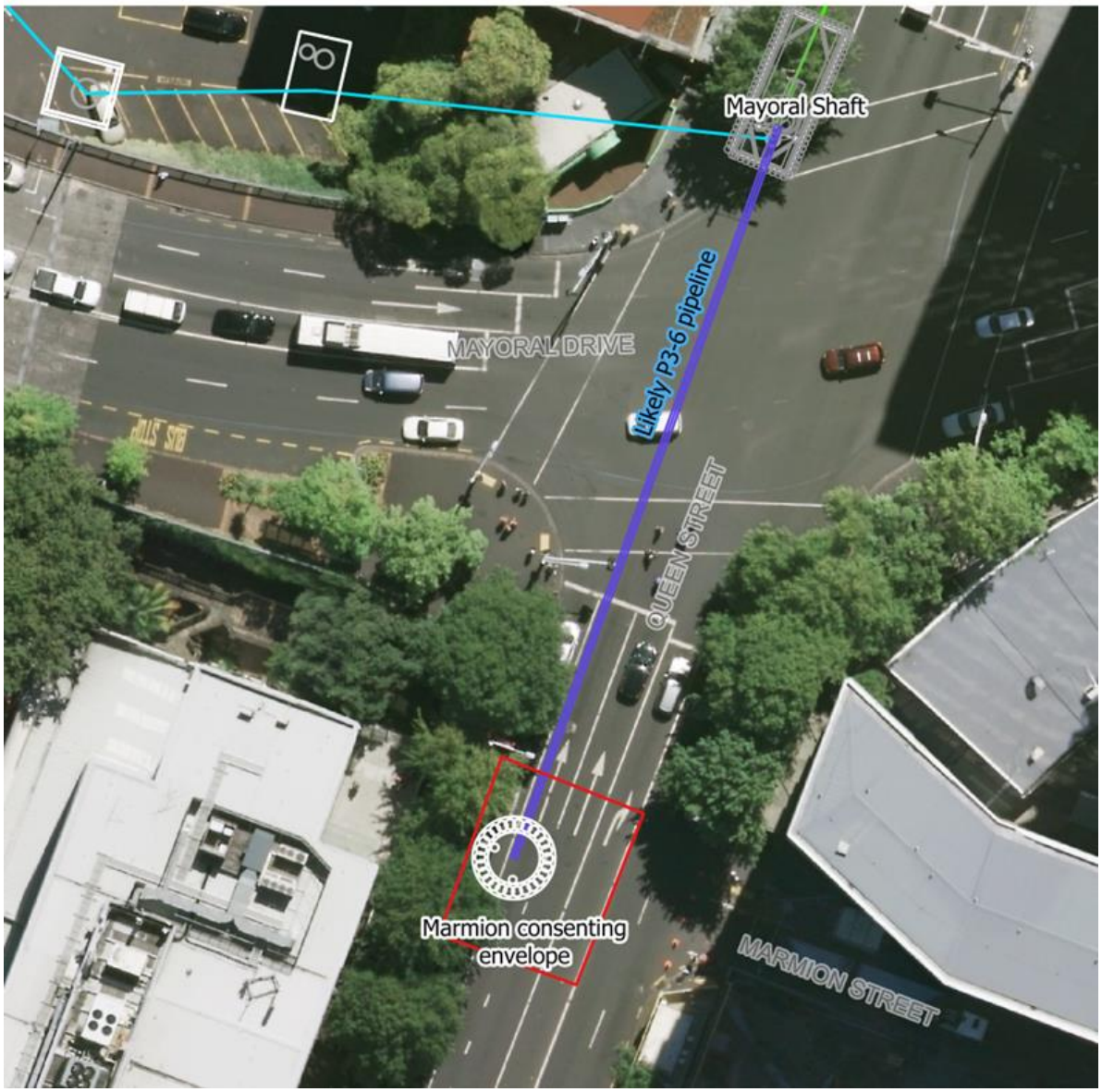

Figure 2-1: Project area

Queen Street is generally two lanes in width (following the pedestrian upgrades undertaken in 2021), with some vehicle access restrictions between Wakefield and Wellesley Street to enable priority for bus movements. Mayoral Drive is an arterial road linking Wellesley Street, Cook Street and Queen Street and is generally five lanes in width with a painted central median. Marmion Street is a one-way laneway-style street that primarily provides access to adjacent residential apartment buildings.

The land use surrounding the project area is typified by medium and high-density developments containing apartments, offices, accommodation, education facilities and entertainment, with retail predominantly occupying the ground level of most buildings. The area contains a combination of heritage and special character buildings (such as the Auckland Sunday School Union Building at 323-327 Queen Street) and modern buildings. The Auckland Civic Precinct is located a short distance to the north-west and contains a range of landmarks including Auckland Town Hall, Aotea Square, Aotea Centre and the former Civic Administration building, which has been recently renovated and converted into apartments.

2.2 NOISE AND VIBRATION SENSITIVE RECEPTORS AND ZONING

The adjacent noise and vibration sensitive receptors (NSR) are within the Business – City Centre Zone. These NSR have been categorised into commercial properties (yellow), hotels (blue), and apartments (pink) and are presented with the Marmion Shaft consenting envelope (red) in Figure 2-2. The Marmion Shaft consenting envelope allows for flexibility where the Marmion Shaft may be located anywhere within the envelope.

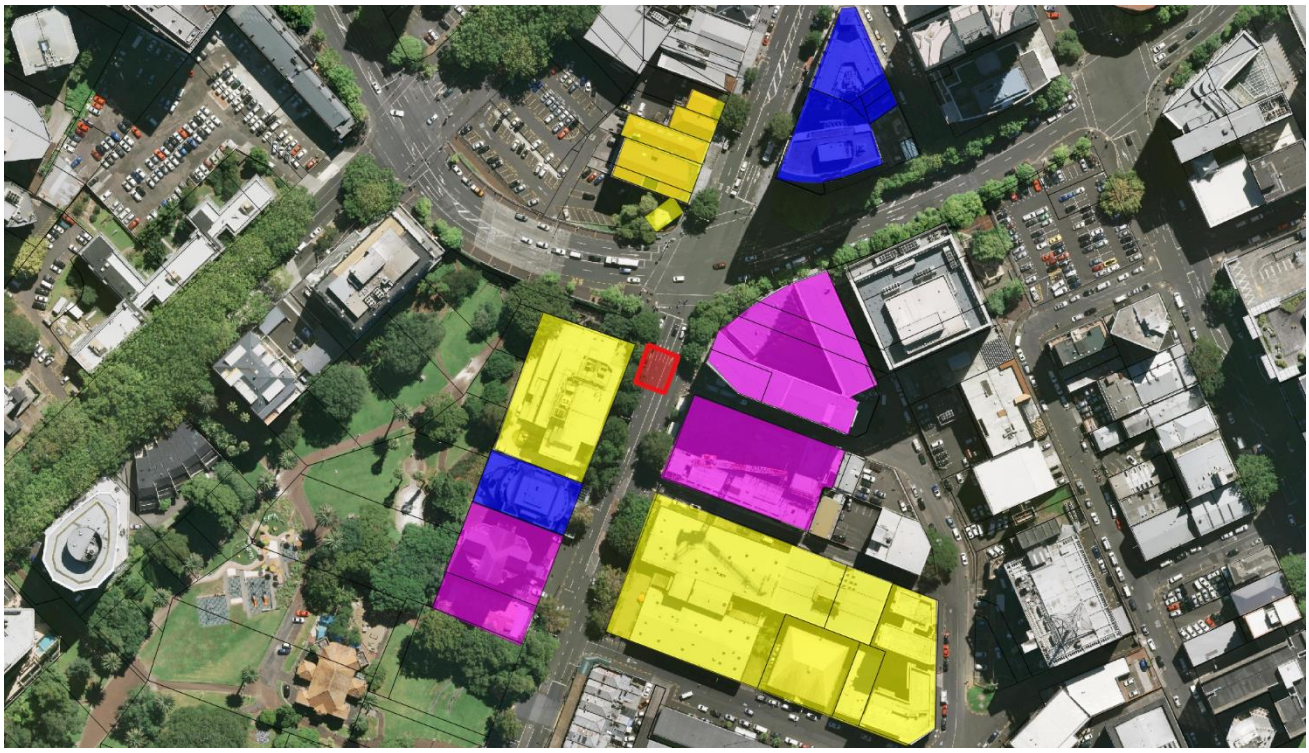

Figure 2-2: NSR adjacent to the Marmion Shaft consenting envelope (red) – commercial (yellow), hotels (blue), and apartments (pink)

3 NATURE OF WORK (ACTIVITIES) SUBJECT TO ASSESSMENT

3.1 OVERVIEW

Watercare are proposing a programme of works to upgrade the wastewater network in the upper section of Auckland City Centre to accommodate the substantial and sustained urban growth from residential, municipal and commercial development. This Project relates to the construction of a new wastewater sewer line from the existing Mayoral Shaft to a new shaft opposite the intersection of Queen Street and Marmion Street.

The Project will be constructed using a combination of trenchless pilot bore to construct the wastewater pipeline tunnel, and secant piling to construct the temporary shaft. An overview of the proposed construction activities is shown below as Figure 3-1.

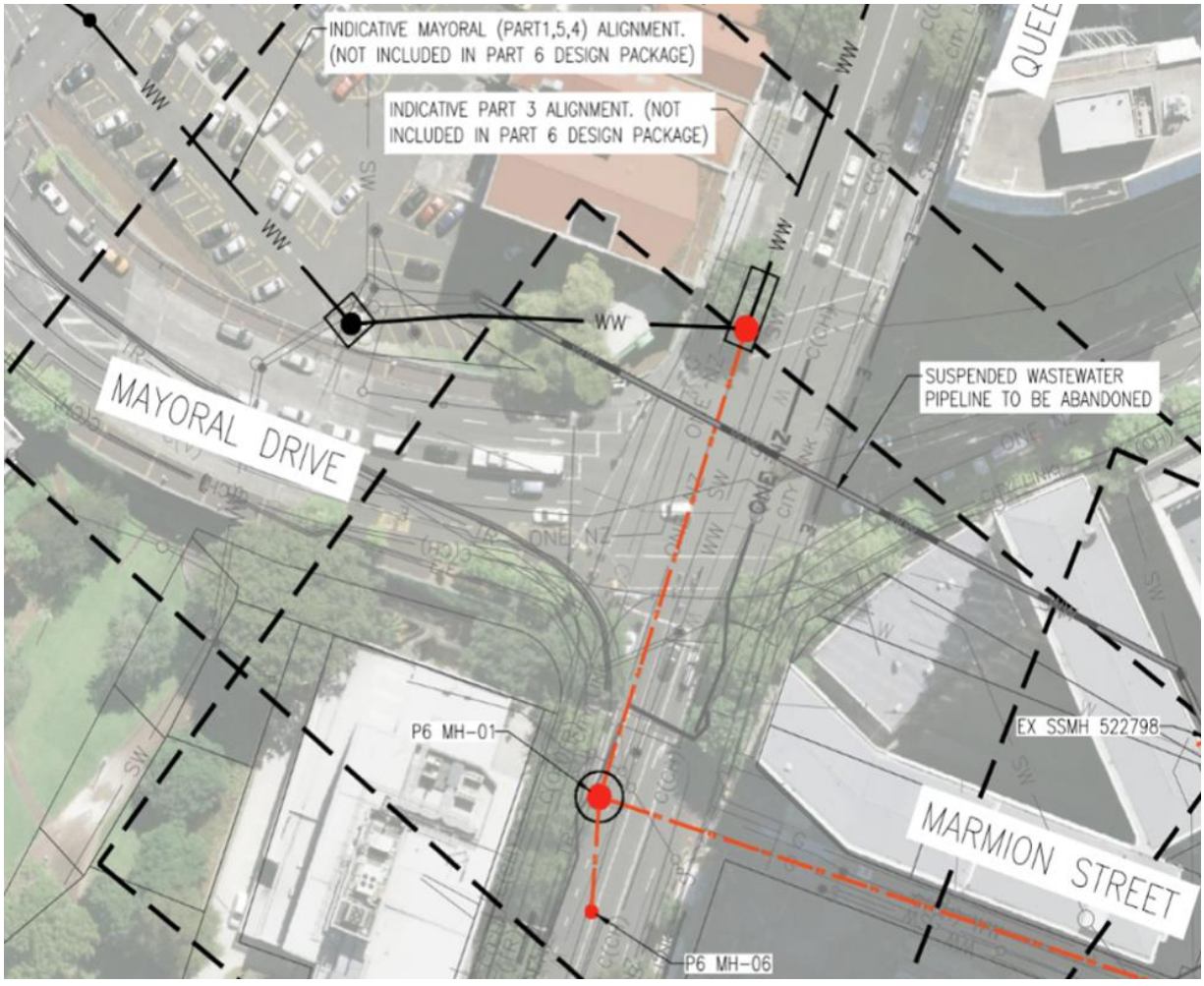

Figure 3-1: Overview of construction works

3.2 CONSTRUCTION HOURS AND DURATION

The anticipated construction hours are noted in Table 3-1 below.

Table 3-1: Construction hours

Works	Construction Hours
Shaft Construction	Monday to Saturday – 0700hrs to 1800hrs *Sunday and night work will only be caried out if required by traffic management restrictions or Watercare operational requirements for tie ins / connections to existing network.*
Tunnelling works	Monday to Saturday – 0700hrs to 1900hrs

3.3 TEMPORARY CONSTRUCTION SHAFT

The temporary shaft opposite Marmion Street will be used as a reception pit for the Pilot Guided Boring Machine. The shaft's outside diameter will be 6.4 m constructed using 600 – 900 mm piles, 200 mm in-situ shotcrete lining, 4 m internal diameter and will be up to 17 m deep.

The shaft will be constructed as follows:

1. A concrete guide wall is excavated and formed at ground level to guide the drill rig.
2. Soft piles are drilled in a hit and miss fashion to avoid damaging the adjacent pile while they are curing.
3. The missed soft piles are then constructed.
4. Hard piles are then drilled through the soft piles creating a continuous retaining wall
5. Steps 2 to 4 are repeated until all piles are constructed and there is a continuous retaining wall.

Once the shaft has been excavated to approximately 1 m below the invert, a 300-500 mm thick concrete plug will be poured to form the base. This plug creates a level working platform while also retaining the groundwater from below. Once the plug has been constructed the dewatering requirements will significantly reduce or stop.

The shaft will be lined using shotcrete in 2 m lifts to the depth of the shaft. The shaft lining and secant piles will remain in place and form part of the permanent works.

3.4 TRENCHLESS TUNNELLING WORKS

The proposed wastewater pipeline will be installed using a Pilot Guided Boring Machine. This method drills a smaller diameter pilot bore from the launch pit to the reception pit; a reamer is then connected in the reception pit and guided back to the launch pit. A soft pile window will be constructed on the pipe alignment at each shaft to allow the boring machine to breakthrough. A summary of the key steps of the boring machine is as follows:

3.4.1 PILOT BORE

1. Set up the Guidance System in the Launch Pit
2. Place drill rig in launching pit and align rack

3. Place Drill Head on Drill Rack
4. Connect all supporting items including vacuum to carry the slurry
5. Commence pilot bore

3.4.2 REAMER AND PIPE INSTALLATION

1. Install pusher unit at reception pit
2. Attach the reamer to the pilot
3. Place pipe on pusher and install vacuum system through the pipe
4. Start the reamer and push pipe into bore
5. Place next pipe disconnect vacuum system and install through second pipe
6. Repeat steps 3-5 until all the pipes have reached the launch pit

3.5 CONSTRUCTION EQUIPMENT

The following equipment is required to construct the Project:

Table 3-2: Construction equipment required for the Project

Secant shaft construction	Trenchless construction
CFA piling - SR-45 or SR-65	35-90T All Terrain / mobile crane
3-35T excavators	HIAB truck
6-8-wheeler trucks	Power pack container
400 kg plate compactor	Tool truck
Concrete pump	Vacuum truck
Concrete trucks	Axis / Pilot bore micro-tunnelling machine
Silenced generator	Bentonite mixing system (if required)
7T vibrating drum construction roller	
90T Crane	

3.6 MANHOLE CONSTRUCTION AND ROAD REINSTATEMENT

A manhole will be installed in the shaft and the road surface reinstated upon completion of the shaft and tunnelling construction works.

3.7 NETWORK UTILITY RELOCATIONS

The existing network utilities within the carriageway of Queen Street will need to be relocated to enable construction of the Marmion Shaft. As a flexible 'consenting envelope' is being sought, the exact utilities to be diverted are yet to be confirmed, but will likely include potable water, electricity, wastewater, stormwater and communications.

Open-cut progressive trenching will be utilised to relocate any utilities that are required to be relocated. The trenches are expected to typically be between 0.4 m and 2 m in width and between 0.3 m and 4 m deep, depending on the location of the utility, and will be constructed in 3 to 10 m-

long sections per day (depending on depth of trench). Once the new ducts and pipes are installed, the trenches shall be backfilled with the footpath and / or road reinstated.

Where trench works are required within the road corridor, this will involve a combination of reduced traffic lanes and full closure of traffic lanes to enable utility relocation works to be completed.

The following high-level methodology will apply to network utility relocations:

Table 3-3: High-level network utility relocation methodology

Stage	Construction Activities	Equipment and Materials
Site set out	Set up traffic management and fencing. Identify and mark-out position of trenches along the affected roadway and footpath areas.	Truck, handheld service locator, spray paint
Pavement removal	Saw cut and remove existing pavement.	Concrete saw, handheld concrete breaker (only where necessary), 8T excavator, truck.
Trench construction	Expose, identify, and support existing utilities up to a 4 m depth. Trenches will be constructed to a width of approximately between 0.4 m and 2 m. All spoil will be loaded onto trucks and disposed of off-site.	Hydro vac, normal excavator, truck, trench shields, air actuated compaction equipment, compressor and mobile generator.
Utilities installation	Once trench is at required depth, bedding will be placed in the trench, with the new utility assets installed.	Trench shield, 4-8 wheeled truck, excavators, plate compactor, concrete trucks, asphalt paver, double drum roller, small water cart or water blaster
Reinstatement	Once installed, the trench will be backfilled and compacted in layers as specified. Surface is then reinstated with asphalt. Backfill material will be imported. Fill will be a mixture of cut to fill aggregate from site and imported fill. Backfill may be stockpiled on site for a short period.	

The network utilities within the Marmion Shaft's consenting envelope which may need to be relocated or protected are outlined in Table 3-4 below.

Table 3-4: Summary of potentially affected network utilities

Asset ID	Type	Owner	Action
N/A	Electricity – 11 kV	Vector	Relocate
N/A	Electricity - HV	Vector	Avoid
Cable ID HOB-PEN-A-CBL	Electricity – LV	Transpower	Relocate
Manholes – IDs 2000465764, 2000308548, 2000017189	Stormwater	Healthy Waters	Protect
Pipes – IDs 2000110404, 2000937040, 2000486432	Stormwater	Healthy Waters	Protect
Pipes – IDs 2000277930, 2000679895	Stormwater	Healthy Waters	Relocate

Asset ID	Type	Owner	Action
Pipe ID 852334	Wastewater	Watercare	Relocate
Manhole ID 522814	Wastewater	Watercare	Protect
Pipe ID 1650257	Potable Water	Watercare	Relocate
N/A	Communications	Vector	Relocate
N/A	Communications	One NZ	Relocate
N/A	Communications	City Link	Relocate

Due to the proximity of these services to each other, a wider trench may be necessary to divert the services in a common service trench which would be either benched or shored. This may increase the earthworks volumes described in Table 3-5 below.

3.8 EARTHWORKS

The following table provides an estimate of the earthworks requirements for the Project:

Table 3-5: Earthworks summary for the Project

Activity	Area	Volume
Network utility relocations	260 m^2	507.5 m^3
Crane & piling platform	216 m^2	152 m^3
Shaft construction	32 m^2	544 m^3
Trenchless (pilot bore)	46 m^2	25 m^3
Total	554 m^2	1,228.5 m^3

The spoil material will be drilled out using an SR-45 or SR-65 and loaded using a 20T excavator into 6-8-wheeler trucks to be carted offsite over a period of 1-2 weeks.

3.9 CONSTRUCTION PROGRAMME

Construction works are anticipated to commence in September 2025 and take approximately 8 – 11 months. The estimated construction timeframe for each key activity is detailed below in Table 3-6.

Table 3-6: Estimated construction activity durations

Activity	Timeframe
Compound / traffic management set up	13 days
Network utility relocations	3 – 6 months
Shaft construction	70 days, of which dewatering is required for 50 days
Tunnel construction	15 days
Manhole construction[1]	30 days
Road reinstatement	10 days

[1] Manhole construction may be completed at a later date.

3.10 CONSTRUCTION SUPPORT AREA AND COMPOUND

To support the proposed construction activities, a construction support area (CSA) within the public carpark at 34-38 Greys Avenue and 329 Queen Street will be required. This CSA has been initially established to support the Part 3 Alignment and Part 3 – Part 4 Connector Tunnel projects.

The CSA contains site offices and welfare facilities, along with some limited site laydown and materials storage areas. Note however that most excavated materials will be immediately removed from site, while construction materials (such as pipes and aggregates) will be delivered to site on a 'just in time' basis.

The site layout for the Greys Avenue CSA (as approved in the Part 3 consent) is shown below in Figure 3-2.

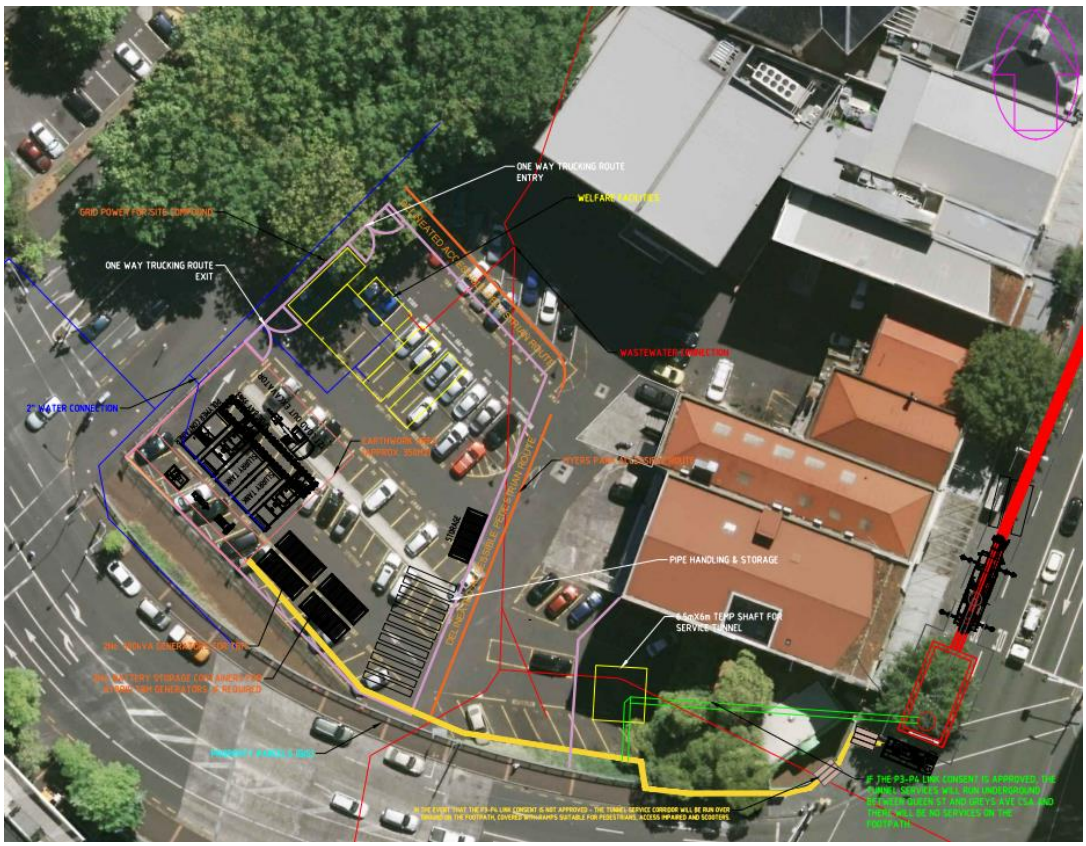

Figure 3-2: Greys Avenue CSA Layout

A 45 m long by 11 m wide compound will be set up around the Marmion Shaft to allow for the construction of the shaft and the tunnelling operations. The compound will make use of temporary concrete or steel barriers with hoardings around the perimeter of each, with access gates one or both ends.

Figure 3-3 below shows the consenting envelope for the proposed Marmion Shaft (red box). The construction compound for the shaft, defined by the pink lines for the hoarding and traffic barrier, will move with the shaft as drawn below, and will be finalised in the Construction Management Plan to be prepared by Fulton Hogan.

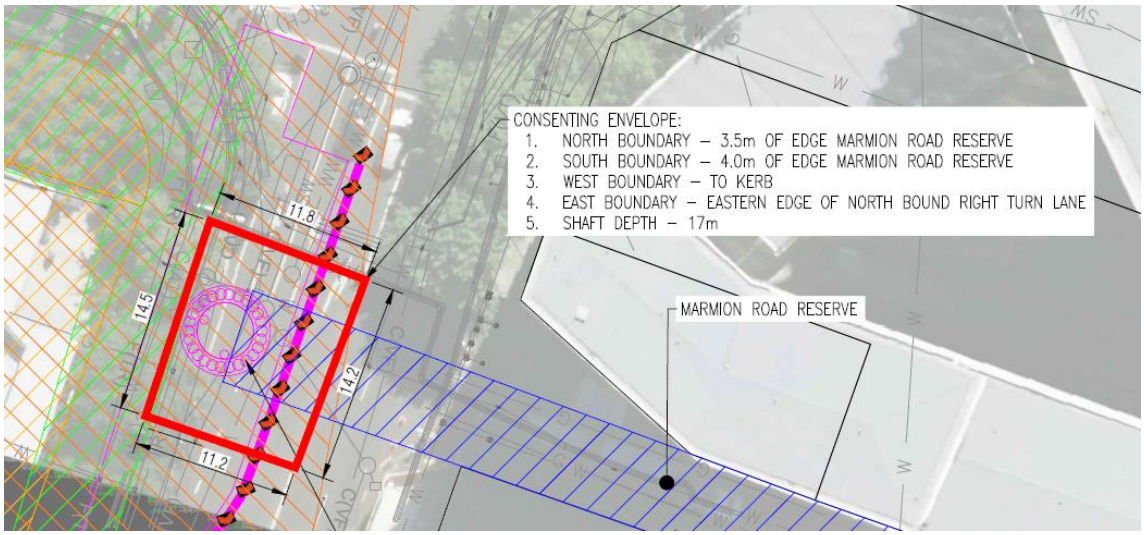

Figure 3-3: Shaft footprint and indicative compound

4 ASSESSMENT METHODOLOGY

This section presents the Performance Standards and the Technical Analysis Methodology for the Project.

4.1 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 Auckland Unitary Plan (AUP). This chapter sets out noise and vibration standards for permitted activities. Where the AUP noise and/or vibration standards are exceeded, then resource consent is required as a restricted discretionary activity.

4.1.1 AUCKLAND UNITARY PLAN – CONSTRUCTION NOISE RULES

As the Project is located within the road corridor, Section E25.6.29 of the (AUP) applies. The relevant subsections are reproduced below.

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:

(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.

(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.*

Exemption from compliance with noise limits for works in the road reserve as per item 3 allows for 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 to not exceed a reasonable level. There is also a requirement for the Construction Noise and Vibration Management Plan (CNVMP) to indicate the area impacted by the works (refer to Section 4.1.3). Therefore, we have predicted noise generated by construction activities regardless of where the works occur.

For reference, the noise limits from *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* of Standard E25.6.29(1) are reproduced as Table 4-1 below.

Table 4-1 AUP construction noise limits in the Business - City Centre Zone

Time	$L_{Aeq,30\ min}$ (dB)	L_{AFmax} (dB)
Monday to Friday 6.30am – 10.30pm	75	90
Saturday 7am-11pm	80	90
All other times (night time)	60	75
All other times in the City Centre Residential Precinct and the Learning Precinct	55	75

4.1.2 AUCKLAND UNITARY PLAN – CONSTRUCTION VIBRATION RULES

As the Project is located within the road corridor, Section E25.6.29 and E25.6.30 of the (AUP) applies. The relevant subsections are reproduced below.

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

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

(a) 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; and

(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.

(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.*

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 by 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.*

Exemption from compliance with vibration limits in buildings for works in the road reserve as per item 4(A) allows for road corridor works to be completed efficiently.

There is also a requirement for the CNVMP to indicate the area impacted by the works (refer to Section 4.1.3). Therefore, we have predicted vibration generated by the construction activities regardless of where the works occur.

For reference, the vibration amenity limits in Table E25.6.30.1 of the AUP are reproduced in Table 4-2.

Table 4-2 AUP Amenity vibration limits (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 4-2 are useful in determining/assessing 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.

4.1.2.1 GERMAN STANDARD DIN 4150-3:1999

The German Standard DIN 4150:1999 *Structural Vibration – Part 3: Effects of Vibration on Structures* (DIN 4150-3) 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 provides criteria to evaluate the effects of short-term vibration on structures (such as impact piling or blasting which occurs instantaneously) that do 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 4150-3, meaning it can easily be repaired. DIN 4150-3 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 buildings. Structural damage is considered unlikely in residential and commercial buildings at vibration levels below 50 mm/s PPV. Similarly, in-ground structures and infrastructure services are unlikely to sustain damage at vibration levels below 100 mm/s PPV.

The long-term vibration limits outlined in Table 3 of DIN 4150-3 are outlined in Table 4-3.

Table 4-3: DIN 4150-3 long-term guideline vibration limits

Line	Type of Structure	Guideline values for velocity, v_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

The vibration criteria in Table 4-3 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 500 mm of ground level at the foundation of a single storey building.

4.1.2.2 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* (BS 5228-2) 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 experiencing vibration magnitudes significantly below the levels likely to result in cosmetic damage to buildings. The guidance values in BS 5228-2 acknowledge this fact and are provided in Table 4-4. The BS 5228-2 levels can be used as thresholds to trigger certain management measures.

Table 4-4: BS 5228-2 vibration 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.

4.1.3 AUCKLAND UNITARY PLAN – CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN REQUIREMENTS

As the Project is located within the road corridor and Standard E25.6.29 of the AUP applies, a CNVMP is required. The following reproduced subsections detail the CNVMP specifications.

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

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

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

(i) the area affected by the work;

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

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

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

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

(b) a description of the works and its duration, anticipated equipment to be used, 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:

(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

(v) Table E25.6.30.1 Vibration limits in buildings

4.1.4 REGENERATED NOISE

Regenerated noise from a trenchless boring machine is typically assessed only when it operates during the night-time period, as this is when receptors are generally more sensitive, the background levels are lower, and sleep disturbance can cause health impacts.

For this Project, the trenchless boring machine will only operate between 0700 to 1900 hours, Monday to Saturday i.e. during daytime hours only.

New Zealand Standard NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors* (NZS 2107) presents recommended internal noise levels with the aim of providing *a healthy, comfortable and productive environment for the occupants and users,* which apply to spaces which are unoccupied but ready for occupancy. It is noted that the occupied noise levels are typically higher than the recommended limits in NZS 2107 when considering the operation/activity within spaces.

Based on the recommended internal noise levels in NZS 2107, the proposed criteria for regenerated noise are presented in Table 4-5 below based on the surrounding noise-sensitive spaces.

Table 4-5: Recommended internal noise levels from regenerated noise from trenchless boring

Space	Recommended internal noise limit for regenerated noise from trenchless boring activities
Office, retail, or hospitality	45 dB $L_{Aeq,T}$
Residential sleeping or living area in the inner city (including hotels)	35 dB $L_{Aeq,T}$

4.2 TECHNICAL ANALYSIS METHODOLOGY

This assessment has been based on the proposed works, equipment, methodology, and timing within the construction methodology document developed by Fulton Hogan.

A summary of the construction methodology is provided in Section 3.

The methodology has been rationalised into two construction stages, each with its associated phases and corresponding equipment. Only equipment capable of generating significant levels of noise have been considered per phase. Other activities such as the use of light hand tools are expected to readily comply criteria. The two stages are:

1. Utility relocation and protection presented within Table 4-6.
2. Main works including shaft construction, trenchless tunnelling, and road reinstatement, presented within Table 4-7.

Table 4-6: Utility relocation and protection activities

Phase	Activity	Equipment
1	Saw cut and remove existing pavement including concrete breaking if required.	— Concrete saw — 8T excavator — Handheld concrete breaker — Mobile generator
2	Expose, identify, and support existing utilities up to a depth of 4 metres. All spoil loaded onto trucks and disposed of off-site.	— 8T excavator — 6-wheeler truck — Vacuum truck
3	Trench bedding, backfill and compaction Or Place concrete protection slabs or similar around the utility to be protected.	— Plate compactor# — 8T excavator — 6-wheeler truck or Hiab
4*	Install new pit(s) over new ducts (if required)	— 8T excavator — 6-wheeler truck or Hiab
5	Reinstate with Asphalt.	— 6-wheeler truck or Hiab — Concrete truck and pump — Bitumen Truck
6*	Carry out pressure and bacteria tests where required for potable water relocation.	— 6-wheeler truck — Hiab
7*	Complete connections to existing watermain where required for potable water relocation.	— 8T excavator — Hiab — Concrete truck and pump
8*	Backfill and reinstate connection points where required for potable water relocation.	— 8T excavator — 6-wheeler truck — Concrete truck and pump — Plate compactor#
#	Typically, air actuated/pneumatic equipment are quieter than petrol alternatives. Therefore, in lieu of specific noise data we have assumed that the combined noise levels of the air actuated compaction equipment, associated compressor, and mobile generator do not exceed those of petrol plate compactors referenced in NZS 6803.	
*	Phase to occur if required.	

Table 4-7: Main works activities (shaft construction, tunnelling, and road reinstatement)

Phase	Activity	Equipment
1	Shaft extent will be saw cut and a 35T excavator used to remove pavement layers.	— Concrete saw — 35T Excavator — 6-wheeler truck
2	Form concrete guiding wall to assist with managing pile placement and verticality. A SR-45 or SR-65 drill rig will be used to undertake secant piling of the shaft perimeter to a depth of approximately 17 metres.	— Concrete truck and pump — SR-45 drill rig* — 35T Excavator — 6-wheeler truck
3	Excavate shaft using the SR-45 or SR-65 drill rig to drill out spoil and a 35T excavator to load the material onto a 6-wheeler truck to be carted offsite. Once the shaft has been excavated to approximately 1 m below the invert, a 300-500 mm thick concrete plug will be poured to form the base. This plug creates a level working platform while also retaining the groundwater from below. With the formation of the plug dewatering requirements will be significantly reduced. The shaft will be lined using shotcrete in multiple 2 m lifts to the depth of the shaft.	— SR-45 drill rig* — 35T Excavator — Handheld power tools — Concrete truck and pump — 6-wheeler truck — Submersible pump — Diesel generator — 90T Crane — Ventilation fan — Shotcrete machine
3A	Dewatering outside of construction hours (if required).	— Submersible pump — Diesel generator
4	Following the pilot bore from the launch pit, a pusher unit will be installed, and the reamer attached to the pilot bore. A section of pipe is installed on the pusher with a vacuum system from a vacuum truck installed through the pipe. The reamer is started back toward the launch pit, and the pipe pushed into the subsequent bore. The above pipe process is repeated until the launch pit is reached.	— 90T Crane — Power pack container — Pipe jack — Vacuum truck — Tool truck — Ventilation fan
5	Following tunnelling works, the reception shaft will be cleaned up with a vacuum truck and the equipment within the shaft removed by the 90T crane. Then a precast lid with 1-2No. 600 mm manhole openings will be installed for future entry. The shaft lining and secant piles will remain in place and form part of the permanent works.	— 90T Crane — Vacuum truck — 6-wheeler truck — Handheld power tools — Ventilation fan
6	Road pavements (GAP65 and AC) will be reinstated using a 35T excavator, plate compactor and 7T vibratory construction roller.	— 35T Excavator — Plate compactor — 7T Vibratory roller — 6-wheeler truck
*	The SR-45 generates higher noise levels than the SR-65.	

Appendix A provides the equipment sound power levels, and the percentage of time in use over a worst-case 30-minute period for each construction stage and phase.

The equipment selection and associated sound power levels are based on BS 5228-1[2], NZS 6803, or previous measurements undertaken by WSP 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 the noise generated by any 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.

4.2.1 PHYSICAL SITE MITIGATION

Physical site mitigation in the form of acoustic site hoardings is proposed. The Marmion Shaft compound will be enclosed by site hoardings and access gates one or both ends.

Figure 4-1 presents the site hoarding location (green) and the Marmion Shaft noise source area (red). Note that the site hoarding location and noise source area presented in Figure 4-1 are approximate and may change due to site requirements/restrictions.

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 shall be installed to have no gaps or cracks between panels. Further specifications of these barriers are found in Section 8.2.1.

Figure 4-1: Proposed site hoarding location (green) and Marmion Shaft noise source area (red)

[2] BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites*

4.2.2 NOISE PREDICTION METHODOLOGY

Noise propagation from the source equipment to a point one metre from the façades of NSR buildings has been assessed in accordance with the method provided in NZS 6803 and ISO 9613-2[3]

SoundPLAN Version 8.2 3D computational noise modelling software has been used to develop a noise prediction model All phases of construction have been analysed with the model to predict noise levels at NSR. 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 assessment assumes worst-case theoretical downwind conditions in all directions from all sources, which provides a conservative approach for assessment.

Table 4-8 presents the noise modelling parameters adopted for this assessment.

Table 4-8: Noise modelling parameters

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 storey	Auckland Council GeoMaps, Heights: 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 metre from any façade	NZS 6803

The L_{AFmax} at each receiver was calculated based on the noise levels that would occur if the loudest piece of equipment for each stage operated at the closest point on the site boundary to that receiver. This approach provides a worst-case assessment of noise levels.

4.2.3 REGENERATED NOISE

Regenerated noise predictions from vibration generated by a trenchless boring machine received in adjacent buildings are based on the propagation model outlined in Amick[4] with building coupling losses and floor resonances provided in the Federal Transport Agency *Transit Noise and Vibration Impact Assessment Manual*. The following has been assumed:

- Competent soil conditions (compacted clay, exposed rock).
- 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).

[3] *ISO 9613-2:1996 Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation* (ISO 9613-2).

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

4.2.4 VIBRATION PREDICTION METHODOLOGY

Table 5-6 presents the vibration levels for equipment emitting notable vibration relative to the vibration criteria. 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). We have assumed competent soil conditions (sandy clays, silty clays, gravel, silts), and spread footing foundation types of all adjacent properties.

4.3 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 and construction plant.
- An assessment period of 30-minutes has been applied.
- It is conservatively assumed that all equipment will be operated within a worst-case 30-minute period for each construction phase.
- 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 prediction.

4.4 ACOUSTIC IMPACT TERMINOLOGY

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

Table 4-9: Noise impact terminology

Noise and/or vibration 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 factors 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 disturbed.
Unreasonable	The noise or vibration level is likely to have a high impact on adjacent receptors. All but the least sensitive activities are likely to be disturbed.

5 TECHNICAL ANALYSIS

This section presents:

- The minimum distances between equipment and any NSR, to comply with the noise criteria.
- The predicted average and maximum noise levels from each construction stage.
- The minimum distances from equipment and any NSR to comply with the regenerated noise criteria, including identification of any NSR within these distances.
- The minimum distances from equipment and any NSR structure, to comply with the vibration criteria, including identification of NSR structures that are predicted to receive vibration levels in excess of the criteria.

5.1 PREDICTED NOISE LEVELS

Table 5-1 presents a list of equipment used for the project, its associated sound power level, and the predicted noise level at increasing distances from the equipment operation. Additionally, the setback distance is provided at which the 75 dB $L_{Aeq,30min}$ weekday noise limit (between 06:30 am - 10:30 pm) may be achieved without any noise mitigation. The predicted noise levels assume each individual piece of equipment is operating separately.

Table 5-1: Equipment sound power levels, and setback distances without mitigation

Equipment	Sound Power Level (dB L_{wA})	Predicted freefield noise level at distance (dB $L_{Aeq,T}$)				Setback distance in metres to achieve 75 dB $L_{Aeq,T}$
		5 m	10 m	15 m	20 m	
35T Excavator	107	88	82	78	76	22
6-wheeler truck / Hiab	107	88	82	78	76	22
90T Crane	105	86	80	76	74	18
Bitumen truck	95	76	70	66	64	6
Concrete saw	113	94	88	84	82	45
Concrete truck and pump	103	84	78	74	72	14
Diesel Generator	94	75	69	65	63	5
Handheld concrete breaker	121	102	96	92	90	107
Handheld tools	100	81	75	71	69	10
Mobile generator	103	84	78	74	72	14
Pipejack	82	63	57	53	51	2
Plate compactor	108	89	83	79	77	25
Power pack	103	84	78	74	72	14
Shotcrete machine	108	89	83	79	77	25
8T excavator	102	83	77	73	71	12
SR-45 drill rig	108	89	83	79	77	25
Submersible pump	96	77	71	67	65	6
Vacuum truck	108	89	83	79	77	25
Ventilation fan	100	81	75	71	69	10

Table 5-2 lists NSR which will be exposed to appreciable levels of noise relative to the weekday noise limit for each phase of utility relocation and protection works.

Table 5-2 Predicted noise levels for network utility relocation and protection works

Property	Predicted façade noise level (dB $L_{Aeq,30min}$) during phase						
	1	2	3	4	5	6	7
361 Queen Street	91	85	85	81	81	82	82
430 Queen Street	88	82	82	78	78	78	79
438 Queen Street	88	82	81	77	78	78	79
329 Queen Street	81	75	74	70	71	71	72
363 Queen Street	81	74	74	70	71	71	72
450 Queen Street	80	74	74	70	71	71	72
323-327 Queen Street	79	73	73	69	69	70	70
396 Queen Street	75	69	68	64	65	65	66
369 Queen Street	75	68	68	64	65	65	66
371 Queen Street	75	68	68	64	65	65	66
321 Queen Street	74	68	68	64	65	65	66
3 Airedale Street	72	66	66	62	62	63	64
315 Queen Street	72	66	66	62	62	62	63
456 Queen Street	72	66	65	61	62	62	63
319 Queen Street	72	66	65	61	62	62	63
9 Marmion Street	72	66	65	61	62	62	63
317 Queen Street	72	65	65	61	62	62	63
48 Greys Avenue	71	65	65	61	61	62	62
380 Queen Street	71	64	64	60	61	61	62
301 Queen Street	69	63	63	59	60	60	61
100 Mayoral Drive	69	63	63	59	59	60	61
313 Queen Street	69	63	63	59	59	60	61
71 Greys Avenue	68	62	62	58	58	59	59
120 Mayoral Drive	67	61	60	56	57	57	58
3 Greys Avenue	67	61	60	56	57	57	58

Table 5-3 lists NSR which will be exposed to appreciable levels of noise relative to the weekday noise limit for each phase of the main works.

Table 5-3 Predicted noise levels for main works (shaft construction, tunnelling, and road reinstatement)

Property	Predicted façade noise level (dB $L_{Aeq,30min}$) during phase						
	1	2	3	3A*	4	5	6
361 Queen Street	87	86	89	73	86	86	86
430 Queen Street	84	83	86	70	83	83	83
438 Queen Street	84	83	85	69	82	82	83
329 Queen Street	77	76	78	62	75	75	76
363 Queen Street	77	76	78	62	75	75	76
450 Queen Street	76	76	78	62	75	75	76
323-327 Queen Street	75	74	77	61	74	74	75
396 Queen Street	71	70	72	56	69	69	70
369 Queen Street	71	70	72	56	69	69	70
371 Queen Street	71	70	72	56	69	69	70
321 Queen Street	70	70	72	56	69	69	70
3 Airedale Street	68	67	70	54	67	67	68
315 Queen Street	68	67	70	54	67	67	67
456 Queen Street	68	67	69	53	66	66	67
319 Queen Street	68	67	69	53	66	66	67
9 Marmion Street	68	67	69	53	66	66	67
317 Queen Street	68	67	69	53	66	66	67
48 Greys Avenue	67	66	69	53	66	66	67
380 Queen Street	67	66	68	52	65	65	66
301 Queen Street	65	65	67	51	64	64	65
100 Mayoral Drive	65	64	67	51	64	64	65
313 Queen Street	65	64	67	51	64	64	65
71 Greys Avenue	64	63	66	50	63	63	64
120 Mayoral Drive	64	63	65	49	62	62	63
3 Greys Avenue	63	62	64	48	61	61	62

* If required, dewatering outside of construction hours.

5.1.1 MAXIMUM NOISE LEVELS (L_{Afmax})

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

Table 5-4 lists NSR which will be exposed to appreciable maximum noise levels relative to the criteria.

Table 5-4 Predicted maximum noise levels at NSR

Property	Predicted façade maximum noise level (dB L_{Afmax})	
	6-wheeler truck and/or any Excavator	Vacuum Truck
361 Queen Street	95	90
430 Queen Street	91	86
438 Queen Street	91	86
329 Queen Street	84	79
363 Queen Street	84	79
450 Queen Street	84	79
323-327 Queen Street	83	78

5.1.2 REGENERATED NOISE

Table 5-5 provides the setback distance, which is the slope distance between the tunnel boring machine and adjacent buildings, at which the regenerated noise criteria is achieved.

Table 5-5 Predicted setback distance for regenerated noise from trenchless tunnel boring

Regenerated noise criteria	Setback 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 trenchless tunnel boring machine to the adjacent buildings, there are no properties within the setback distance from works outside of the road corridor. Therefore, regenerated noise is not predicted to cause adverse effects.

5.2 PREDICTED VIBRATION LEVELS

Table 5-6 presents the notable vibratory equipment and the setback distance for each piece of equipment to achieve the vibration criteria. The setback distance is the distance from the equipment at which the vibration limits are reached. Any structure within the setback 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 the manufacturer's vibration isolation. Therefore, vibration levels at any structure are expected to be lower than those of the equipment provided below.

Table 5-6: Vibration stand-off distances to achieve the relevant acoustic criteria

Equipment	Vibration level of equipment (mm/s PPV)	Setback distance to achieve vibration criteria (metres)	
		10 mm/s	2 mm/s*
Excavator breaking ground	1.9 at 10 m	0.5	10
Plate compactor**	1.6 at 1.5 m	0.1	1
7T Vibratory compaction roller	2.9 at 10 m	1	18
Pipe jacking	1.5 at 10 m	0.3	7
CFA piling, auguring, or similar	0.5 at 10 m	0.1	1
Handheld concrete breaker	1.1 at 10m	0.2	3.5

* AUP vibration amenity limit.

** Based on WSP measurements at the Victoria St site

The surrounding buildings are a mix of commercial and residential. Their sensitivity to vibration is based on the building type, which is assumed to be a concrete and masonry structure.

The 10 mm/s PPV criterion applies at any commercial building or structures that are commercial in nature (high-rise concrete or steel residential buildings for instance).

Based on the setback distances there are no properties predicted to exceed the DIN 4150-3 10 mm/s PPV vibration criterion at any stage of construction.

Following Table 5-6 above, Table 5-7 below presents the NSR predicted to be within the 2 mm/s PPV AUP amenity limit setback distance and the activity/equipment causing the exceedance.

Table 5-7: NSR predicted within AUP vibration amenity limit setback distance

NSR	Exceedance(s) at all applicable phases by:
345-361 Queen Street	— Excavator breaking ground. — Vibratory compaction roller.
430 Queen Street	— Excavator breaking ground. — Vibratory compaction roller.
438 Queen Street	— Pipe jacking. — Excavator breaking ground. — Vibratory compaction roller.

6 CONSENT RULES TRIGGERED

The section assessed if any relevant rules within AUP Chapter E25 are triggered.

6.1 NOISE

Noise generated from construction activity within the road corridor is exempt from achieving the AUP construction noise limits between 7am – 10pm if a CNVMP is adopted, as outlined in Section E25.6.29 of the AUP.

As the Project is located entirely within the road corridor, a framework CNVMP has been provided as part of this resource consent application. The CNVMP will be reviewed and finalised by the contractor (including any changes to the methodology etc.) prior to the works commencing and provided to Auckland Council for certification before works commence. 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 adoption of the mitigation strategies outlined in the CNVMP, which are designed such that noise levels are managed to remain within reasonable levels.

The construction works can be undertaken as a permitted activity within under Rule E25.4.1 (A1).

6.2 VIBRATION

Vibration generated within the roading corridor is exempt from achieving the amenity vibration limits outlined in Section E25.6.30(1)(b) where a CNVMP is adopted. As described above, the exemptions are based on the adoption of the mitigation strategies outlined in the CNVMP.

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

Based on the setback distances outlined in Section 5.2, no properties are predicted to experience vibration levels exceeding the AUP Section E25.6.30(1)(a) vibration limits. As such, the consent rules are not predicted to be triggered.

7 EFFECTS ASSESSMENT

The following sections provide an effects assessment of the construction noise and vibration generated by the Project.

7.1 CONSTRUCTION NOISE EFFECTS

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

We have the following comments regarding the noise impacts from the Project:

- All noise is generated within the road corridor. A CNVMP will be implemented by the contractor to outline the procedures for the best practicable option (BPO) of mitigation to control the noise and vibration effects.
- While the worst-case noise levels have been predicted, we have considered the dynamic nature of the construction activities and the varying equipment used. It is anticipated noise levels will fluctuate at different stages of the Project. The noise impact assessment takes this into account and recommended mitigation measures are adjusted accordingly.
- The predicted noise levels provided in Section 6.1 are considered a worst-case, and include all equipment within each phase operating at their specified percentage on times within the assessment period at surface level at the closest location to each NSR on site. This is unlikely to occur at all times on all days. Therefore, actual noise received at NSR is likely to be lower than that predicted for most of the time.
    - For example, the predicted noise levels of Phase 1 of the Utility protection and relocation works is close to 90 dBA at the nearest NSRs. However, the phase's combined sound power level is dominated by the handheld concrete breaker. Both the concrete saw and the handheld concrete breaker have been accounted for in the phase. It is unlikely this equipment will be used at the same time, therefore where the concrete saw is instead of the handheld concrete breaker predicted noise levels are expected to be 6 dB lower.
- 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 where equipment is not used or is used less than assumed. Therefore, it is likely that for much of the construction period, noise levels received at adjacent NSR will be 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.
- The NSR 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 City 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 as opposed to a 20-25 dB façade due to low-frequency reduction requirements in the AUP. Therefore, these NSR are likely better equipped to reduce the effect of construction noise on indoor amenity.

- Works outside the construction hours will not be undertaken unless specifically required, such as to comply with the traffic management plan or to facilitate dewatering if required. Where these works are required specific mitigation measures as outlined in Section 8.3.2 will be adopted to mitigate the risk of sleep disturbance.
- Concerning dewatering activities outside of the construction hours:
  - The predicted noise levels assume that the submersible pump and diesel generator are placed at the worst-case location within the works area. However, in reality, the submersible pump is expected to be at the bottom of the excavation, which will provide some screening and should reduce the noise levels.
  - The submersible pump and generator selected for the assessment represent a worst-case scenario with no specific mitigation and conservative source noise levels adopted. With the inclusion of an enclosure for the generator (as required in Section 8.3.2) or the use of mains power, the actual noise level is expected to be lower than predicted.
- Where the handheld concrete breaker is required specific mitigation measures as outlined in Section 8.3.3 will be adopted to minimise the impact of NSR.
- 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 and the predictions within this assessment.

Considering the assessment of noise described above, the implementation of a CNVMP including all proposed and practicable mitigation measures, and the AUP construction noise rules for works within the road corridor; the noise effects from the Project are predicted to be acceptable to reasonable.

7.2 CONSTRUCTION VIBRATION EFFECTS

Construction vibration emissions from the Project at NSR structures are predicted to be below the vibration criteria outlined in AUP E25.6.30(1)(a).

As all works of the Project are within the road corridor, the Project is exempt from the AUP vibration amenity limits of E25.6.30(1)(b). However, it should be noted that occupants of NSR structures that are predicted to be within the 2 mm/s PPV setback distance may still perceive vibration. Therefore, it is recommended as a part of the CNVMP these properties are notified prior to the commencement of the vibration activities outlined in Table 5-7.

Considering the assessment of vibration described above, the implementation of a CNVMP including all proposed and practicable mitigation measures, and the AUP construction vibration rules for works within the road corridor; the vibration effects from the Project are predicted to be acceptable to reasonable.

8 MITIGATION MEASURES

The construction noise and vibration assessment indicate that mitigation measures are required to reduce the noise and/or vibration impacts on NSRs. This section provides details of the specific mitigation measures that shall be applied to the Project. 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.

8.1 GENERAL MITIGATION MEASURES

As the Project is located within the road corridor and Standard E25.6.29 of the AUP applies, a CNVMP is required. The CNVMP shall be developed in accordance with E25.6.29(5) of the AUP and shall be followed and updated by the contractor for the duration of the project.

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 that are predicted to exceed the AUP construction noise and/or vibration limits. The CNVMP shall include:

- How communication by the consent holder will occur about certain construction works expected to exceed AUP construction noise and/or vibration limits, including scheduling/timing of works and the identification of potential temporary nuisance effects.
- How residents may communicate any enquiries or complaints about construction noise.
- The contact details of the lead contractor/project manager and a representative of the consent holder.

8.2 PHYSICAL MITIGATION MEASURES

The following subsections present specific physical mitigation measures that shall be applied to the Project.

8.2.1 ACOUSTIC SITE HOARDINGS

Acoustic site hoardings 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 overlook the Project.

Whilst acoustic site hoardings will have a limited impact for overlooking buildings, there will be an effective reduction in noise impact for ground level receptors including pedestrians and local businesses.

Acoustic site hoardings are proposed to be installed around the Marmion Shaft compound boundary, as outlined in Section 4.2.1. The acoustic site hoardings shall achieve the following minimum specification:

- Height: >2.0 m
- 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 barriers shall be used around high noise-generating equipment when in use, such as a concrete saw and the handheld concrete breaker. The movable site hoardings shall achieve the minimum specifications listed above but may be 2 m in height.

8.2.2 SELECTION OF EQUIPMENT

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

- Vehicles with audible reversing warning sirens shall 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 NSR. Where possible, dedicated localised acoustic barriers will be constructed as close as practical around any generators and water pumps.
- Use of electric equipment over petrol/diesel alternatives including saws, hand power tools, and the like.
- Selection of equipment that is an appropriate power for the use, i.e. not using more powerful equipment than needed.

8.3 MANAGERIAL MITIGATION MEASURES

The following subsections present the managerial mitigation measures that shall be applied to the Project.

8.3.1 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.
- If any equipment item generates noise levels significantly higher than the sound power levels in Appendix A of this assessment, the equipment item shall either be fitted with acoustic noise reduction measures such as mufflers, replaced with lower noise generating equipment or additional noise modelling shall be 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.

8.3.2 WORK OUTSIDE THE CONSTRUCTION HOURS

If equipment generating notable noise relative to the noise criteria within Table 4-1 is required for connection or tie-in works outside the construction hours (such as concrete cutting or breaking, metallic grinding/cutting, or use of an air/hydro-vac or excavator), this shall occur prior to 10:30 pm as far as reasonably practicable to minimise sleep disturbance for the adjacent accommodation/residential buildings.

8.3.3 SCHEDULING OF CONCRETE BREAKING

As the extent of concrete breaking is unknown at this stage the BPO will be a balance between managing the noise exposure time and mitigating noise emissions from this activity. The following procedure or similar shall be undertaken to determine the BPO of mitigation for this activity:

- Excavate and uncover the area where concrete impacts the works.
- Determine the number of hours likely required for concrete breaking.
- Where:
  - Concrete breaking is required for 8 hours or less, undertake this over a single day where practicable.
  - Concrete breaking required between 8 and 18 hours will be undertaken over 2 days limited to between 9 am to 6 pm.
  - Concrete breaking required over 18 hours will be undertaken between 9 am and 6 pm on weekdays and the contractor shall determine the applicability of further best practicable mitigation such as dedicated movable screening as per Section 8.2.1.
  - If concrete breaking is required to be undertaken after 6 pm, and it is not considered practicable to schedule the activity between 9 am – 6 pm, then all concrete breaking shall occur prior to 10:30 pm. The contractor shall also determine the applicability of further best practicable mitigation such as dedicated movable screening as per Section 8.2.1.
- Communication shall be maintained with NSR about the scheduling of concrete breaking in line with the communication protocols of the CNVMP.

9 IDENTIFICATION OF AFFECTED PARTIES

There are no parties that have been identified as being adversely affected by construction noise or vibration effects from the Project.

10 RMA SECTION 104 ASSESSMENT

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

Based on the assessment provided within this report, construction noise and vibration is a permitted activity under 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 by the AUP.

Mitigation and management measures are detailed within this report, with a framework CNVMP provided to meet the permitted activity provisions of the AUP.

11 CONCLUSION

WSP has been engaged by Watercare to assess the construction noise and vibration impacts from the Part 3 – Part 6 Link Project of the Queen Street Wastewater Diversion Programme, in Auckland. The Project involves the construction of a wastewater pipeline from the Part 3 Mayoral Shaft to a new shaft at the intersection of Queen Street and Marmion Street (Marmion Shaft).

Construction noise and vibration criteria have been assessed based on the standards of Chapter E25 of the AUP. The Project is located within the road corridor; therefore, the AUP noise and vibration (amenity) limits for construction works do not apply, provided that a CNVMP is developed and followed. However, for completeness construction noise and vibration generated in the road corridor from the Project has been predicted within this assessment.

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

Considering the assessment of noise described above, the implementation of a CNVMP including all proposed and practicable mitigation measures, and the AUP construction noise and vibration rules for works within the road corridor; the construction noise and vibration effects are predicted to be acceptable to reasonable and can be undertaken as a permitted activity as per AUP Rule E25.4.1 (A1).

12 LIMITATIONS

This report ('Report') has been prepared by WSP New Zealand Limited ('WSP') exclusively for Watercare Services Limited ('Client') in relation to the assessment of noise and vibration effects for the Part 3 – Part 6 Link Project of the Queen Street Wastewater Diversion Programme ('Purpose') and in accordance with the Master Services Agreement between the Client and Consultant ('Agreement'). The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any use or reliance on this Report, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Report by any third party.

In preparing this Report, WSP has relied upon data, surveys, analyses, designs, plans and other information ('Client Data') provided by or on behalf of the Client. Except as otherwise stated in this Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable for any incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

APPENDIX A: EQUIPMENT SCHEDULE

Table A-1 Construction equipment schedule, sound power levels, and percent on-time: Utility relocation and protection works

Phase	Equipment	SWL (dB L_{wA})	SWL (dB L_{wAmax})	% On time
1	Concrete saw	113		50
	Handheld concrete breaker	121		25
	8T excavator	102	120	100
	Mobile generator	103		100
2	8T excavator	102	120	100
	6-wheeler truck	107	120	50
	Vacuum Truck	108	115	100
3	8T excavator	102	120	100
	Plate compactor	108		100
	6-wheeler truck/Hiab	107	120	50
4	8T excavator	102	120	100
	6-wheeler truck/Hiab	107	120	50
5	6-wheeler truck/Hiab	107	120	50
	Concrete truck and pump	103		100
	Bitumen truck	95		50
6	6-wheeler truck	107	120	50
	Hiab	107	120	50
7	8T excavator	102	120	100
	Hiab	107	120	50
	Concrete truck and pump	103		100
8	8T excavator	102	120	100
	6-wheeler truck	107	120	50
	Concrete truck and pump	103		100
	Plate compactor	108		100

Table A-2 Construction equipment schedule, sound power levels, and percent on-time: Main works including shaft construction, trenchless tunnelling, and road reinstatement

Phase	Equipment	SWL (dB L_{wA})	SWL (dB L_{wAmax})	% On time
1	Concrete saw	113		50
	35T excavator	107	120	100
	6-wheeler truck	107	120	50
2	SR-45 drill rig	107		100
	35T excavator	105	120	100
	6-wheeler truck	107	120	50
	Concrete truck and pump	103		100
3	35T excavator	107	120	100
	SR-45 drill rig	107		100
	Handheld power tools	100		100
	Concrete truck and pump	103		100
	6-wheeler truck	107	120	50
	Ventilation fan	100		100
	Shotcrete machine	108		100
	Submersible dewatering pump	96		100
	Silenced Generator for dewatering	94		100
	90T Crane	105		80
3A	Submersible dewatering pump	96		100
	Silenced Generator for dewatering	94		100
4	Power pack	103		100
	Pipejack	82		100
	Ventilation fan	100		100
	Vacuum truck	108	115	100
	Tool truck	107	120	25
	90T Crane	105		80
5	90T Crane	105		75
	Vacuum truck	108	115	100
	6-wheeler truck	107	120	50
	Handheld power tools	100		100
	Ventilation fan	100		100
6	35T excavator	107	120	100
	Plate compactor	108		100
	7T vibratory roller	103		100
	6-wheeler truck	107	120	50