Project Number: W-SL001.03

Assessment of Dewatering Effects

Queen Street Wastewater Diversion Project (Part 3-Part 4 Connector tunnel)

10 November 2023

CONFIDENTIAL

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150 YEARS IN AOTEAROA

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Executive Summary

Watercare Services Limited (Watercare) are proposing to upgrade the wastewater network within the Auckland City Centre. This report provides an assessment of dewatering effects in relation to the construction of the service tunnel which will connect Parts 3 and 4 of the Queen Street Wastewater Diversion Project, only. The construction for this Part 3-Part 4 Connector tunnel comprises:

- Construction of the shaft in Greys Avenue Carpark (Greys shaft)
- Tunnelling between the Greys and Mayoral shafts
- Construction of the manhole (P4MH4) at Greys shaft and shaft reinstatement

The Mayoral shaft itself forms part of the Part 3 alignment of the Queen Street Wastewater Diversion programme. Resource consent for Parts 3 and 4 of the wider programme of works has been sought separately from these connecting works. Information for the Mayoral shaft is included for reference, where relevant, but the dewatering for the Mayoral shaft is only assessed in terms of additional drawdown that may occur as a result of the dewatering from the Greys shaft.

The Greys shaft is proposed to be post and panel and will require dewatering for the duration of the construction works, which is 60 days maximum. The Mayoral shaft is also proposed to be post and panel and will require dewatering for 12 months. The tunnelling works will not be dewatered, apart from the access shafts (Greys and Mayoral shafts) as mentioned, and the dewatering depths will be reduced as the manhole (P4MH4) construction progresses and will cease when the manhole is completed.

The shaft excavations for the Greys and Mayoral shafts are assessed as a restricted discretionary activity and detailed assessment is required as part of the consent application process. These activities are thus classified in terms of Table E7.4.1 Activity Table (Auckland Unitary Plan) as:

- (A20) – Dewatering or groundwater level control associated with a groundwater diversion authorised as a restricted discretionary activity under the Unitary Plan, not meeting permitted activity standards or is not otherwise listed.
- (A28) - The diversion of groundwater caused by any excavation, (including trench) or tunnel that does not meet the permitted activity standards or not otherwise listed.

The site-specific investigations indicated a perched aquifer associated with the residual soil East Coast Bay Formation (ECBF) and fill comprising clayey silt and silty clay with a slightly higher conductivity, underlain by a deeper regional aquifer comprised of the ECBF mudstone and sandstone with a low hydraulic conductivity. The groundwater model was set up to represent the most conservative dewatering scenarios with shallow groundwater level and representative model layers to mimic site conditions.

The assessment of environmental effects indicated effects on neighbouring bores, nearby environmental features (streams and other surface water bodies) and saline intrusion will be negligible.

The dewatering is highly unlikely to result in consolidation settlement in addition to the limited settlement estimated for the Part 3 works at the Mayoral shaft. The drawdown effects for the Mayoral shaft do not change. However, a groundwater and settlement monitoring and contingency plan has been recommended for this shaft as a precautionary approach

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Abbreviation and Definitions

AC	Auckland Council
AEE	Assessment of Environmental Effects
AUP	Auckland Unitary Plan
BH	Borehole
CIRIA	Construction Industry Research and Information Association
CRLL	City Rail Link Limited
CSA	Construction Support Area
ECBF	East Cost Bays Formation
EWS	Electronic Weather Station
GNS	Geological and Nuclear Sciences
GRP	Glass Reinforced Plastics
GSMCP	Groundwater and Settlement Management and Compliance Plan
K	Hydraulic conductivity
NES	National Environmental Standard
NPS	National Policy Statement
NZGD	New Zealand Geotechnical Database
PDP	Pattle Delamore Partners
PZ	Piezometer
RL	Reduced Level (to Sea Level)
RMA	Resource Management Act
T+T	Tonkin & Taylor
UC	Universal Column
Watercare	Watercare Services Limited
WSP	WSP New Zealand Limited

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

The Queen Street Wastewater Diversion programme is comprised of the following parts (indicated in Figure 1-1) and likely to be constructed in this sequence:

- Part 3 alignment along Queen Street between Mayoral Drive and Victoria Street East (the resource consent for this alignment has been submitted)
- The Mayoral alignment (consisting of Parts 1, 4 and 5 of the programme) along Mayoral Drive from Queen Street to Vincent Street (resource consent to follow next)
- Part 6 alignment from Mayoral Drive along Marmion Drive (not shown in Figure 1-1 because the alignment has not been finalised yet – resource consent to follow at a later date)

This project involves the early construction of a section of pipeline of the Part 4 alignment (shown as P3-P4 connector tunnel on the map in Figure 1-1) to enable the tunnelling works required for the Part 3 alignment of the wastewater pipeline. These works will consist of constructing one additional shaft (in the Greys Avenue carpark and hereinafter referred to as Greys shaft and the location of manhole P4MH4), and a 43 m length of tunnel from this shaft to the Part 3 launch shaft (on the corner of Mayoral Drive and Queen Street and hereinafter referred to as Mayoral shaft).

The temporary purpose of this tunnel is to service the Tunnel Boring Machine (TBM) which will be used to construct the Part 3 alignment of pipeline from the Mayoral shaft down Queen Street.

Figure 1-1: Queen Street Wastewater Diversion: Part 3-Part 4 connector tunnel, Part 3 and Part 4

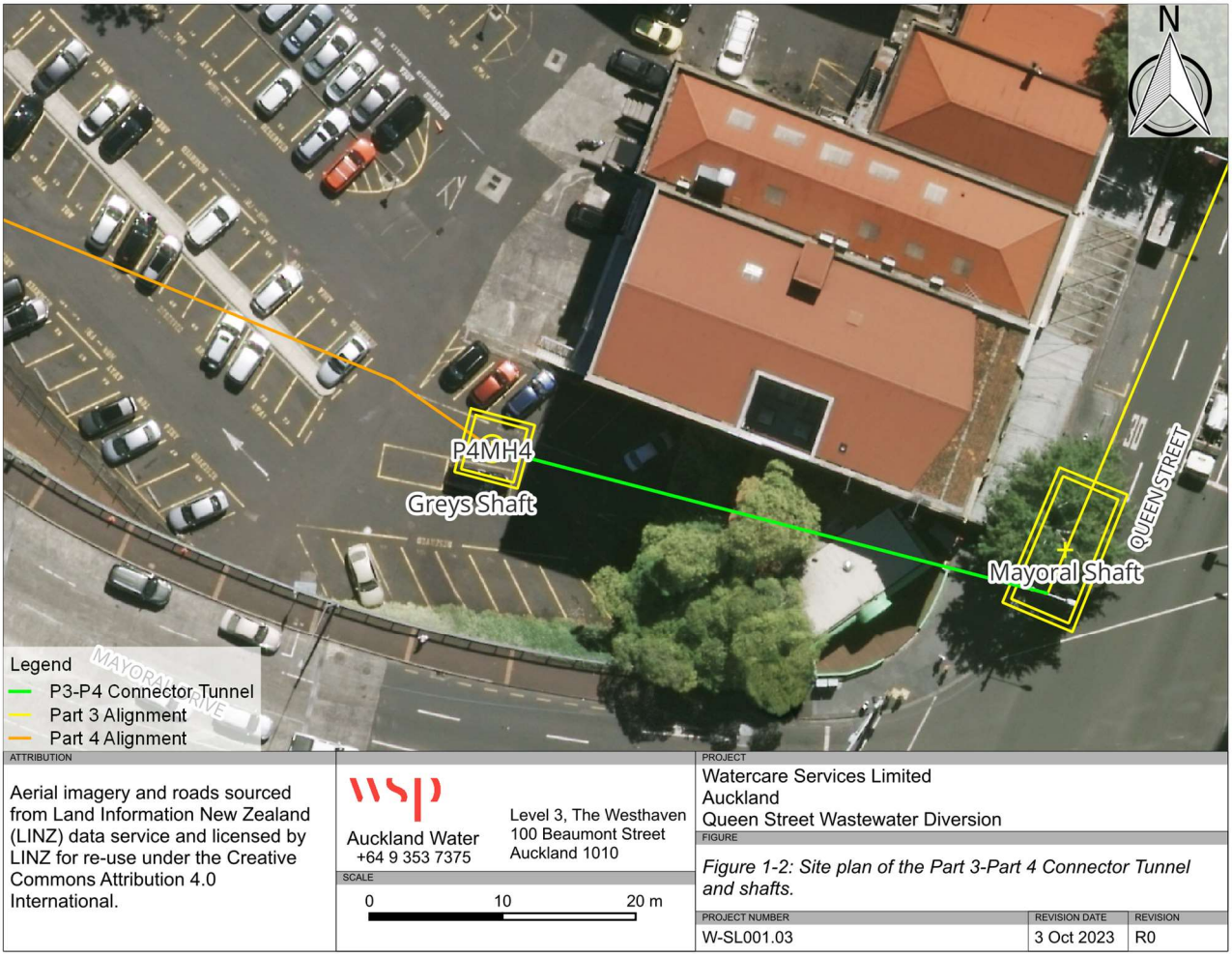

Figure 1-2: Site plan of the Part 3-Part 4 connector tunnel and shafts

This report provides an assessment of dewatering effects in relation to the construction of the Part 3 – Part 4 connector tunnel project of the Queen Street Wastewater Diversion Programme. Resource consent for Parts 3 and 4 of the wider programme of works has been and are being sought separately from these connecting works.

2 Description of Existing Environment

This section 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 in the carpark at 34 and 36-38 Greys Avenue, the carpark adjacent to 329 Queen Street (6 m below Queen Street road level) and a portion of the road reserve on Queen Street. The tunnel will be constructed to connect to the Construction Support Area (CSA) in the carpark at Greys Avenue (Figure 1-2).

The land use around the intersection of Mayoral Drive and Queen Street is a mixture of retail, commercial, hospitality, civic, and residential functions. It represents a highly developed urban environment. For the most part, retail activity is provided at street level with other uses provided above. The buildings along Queen Street are multi-levelled with a mixture of heritage structures and more modern high-rises.

2.2 Regional Geology

The published geological map information (GNS, 1992) indicates that Part 3-Part 4 connector tunnel towards the southwestern extent of the Part 3 alignment of the Queen Street Wastewater Diversion is underlain by the East Coast Bays Formation (ECBF), Waitematā Group (Mwe), comprising alternating sandstone and mudstone with variable volcanic content and interbedded volcaniclastic grits (Figure 2-1). The ECBF is typically considered the basement rock in the area.

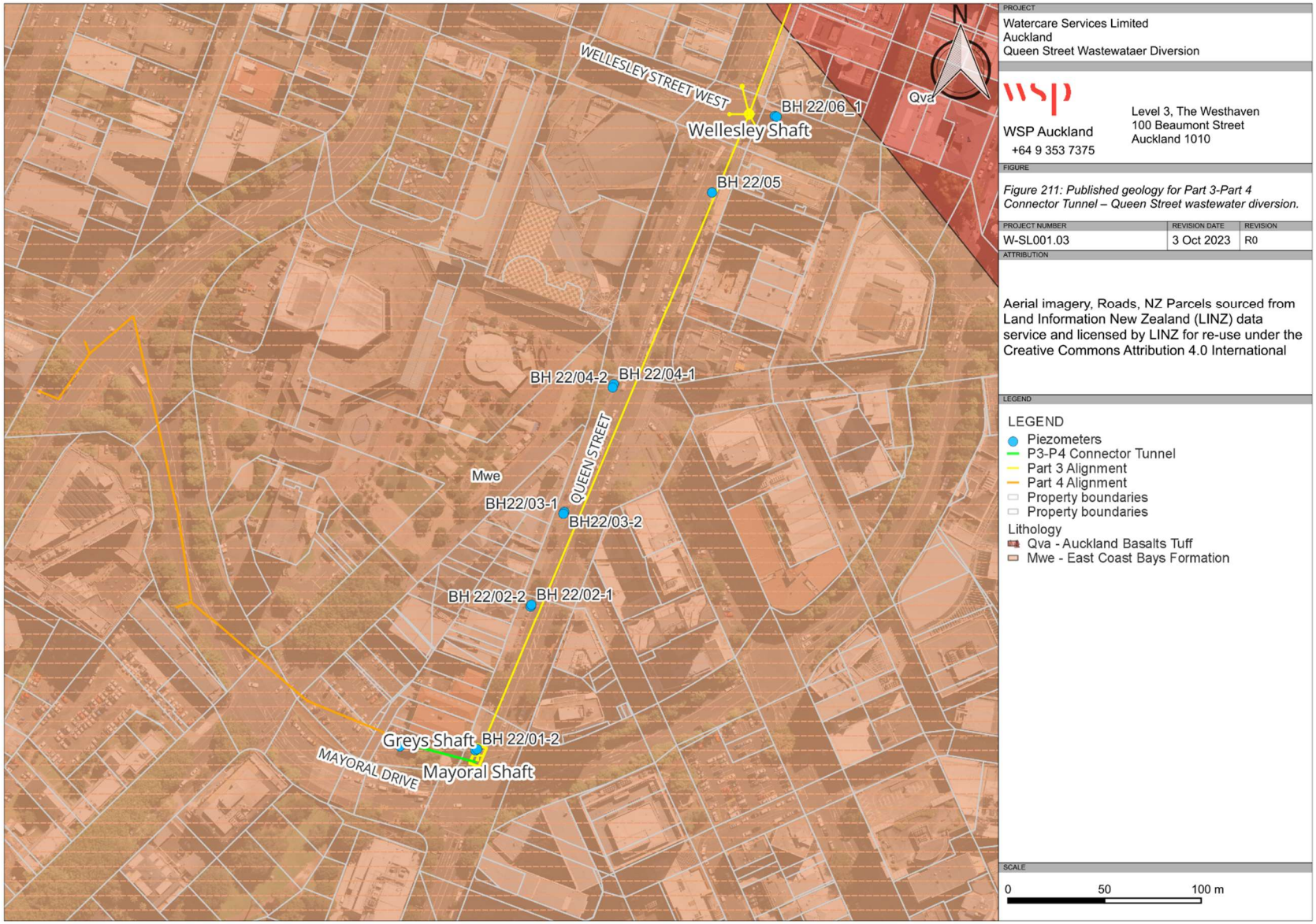

Figure 2-1: Published geology for Part 3-Part 4 Connector Tunnel – Queen Street wastewater diversion.

2.3 Local Geology

Lithological logs were obtained from the New Zealand Geotechnical Database (NZGD) for existing bores within the area. A site-specific bore (BH23/02) was also drilled as part of the geotechnical investigations, specifically to obtain site-specific hydraulic conductivity information of the geology for the Part 3-Part 4 connector tunnel location. A piezometer was constructed in the geotechnical bores to allow for monitoring of groundwater levels. The location of the NZGD site and the site-specific bore information used for interpretation of lithology on site are shown on the geology map in Figure 2-1.

The existing geological log confirmed that the area is underlain by ECBF residual soils grading into competent and fractured ECBF.

Geotechnical investigations were undertaken between 14 and 21 July 2023. Two bores were drilled within the Greys Avenue Carpark area (BH23/01 and BH23/02), and a single piezometer (PZE2) was installed in bore BH23/02 (Figure 2-1). Bore BH23/01 was backfilled. The information from the piezometers constructed at the Mayoral shaft location, PZ01_S and PZ01_D is also used in the assessment. The hydrogeological information obtained from the drilling logs and subsequent hydraulic testing for the Part 3 alignment was documented in the hydrogeological factual and interpretive report (WSP, 2023b). Geotechnical logs for the two newly drilled bores are attached in Appendix A.

The geotechnical logs for the site-specific bores confirm the published regional geological mapping, which indicates that the bedrock formation along the formation towards the south is typically ECBF mudstone and sandstone, with a thin cover (4 m) of residual ECBF soils.

Construction fill (debris, concrete, brick, rubble and reinforced steel bar) is observed in bore BH23/01 above a concrete basement slab. This construction fill is underlain by ECBF residual soils grading into highly weathered ECBF mudstone and sandstone.

Thick fill is observed at site PZ01, which was screened to enable hydraulic conductivity testing of fill materials and obtain groundwater level information for the shaft at Mayoral Drive.

2.4 Hydrogeology

It is generally considered that a dual groundwater system occurs in the City Centre, with a shallow perched, or near surface, aquifer system in the residual soils and a deeper, regional groundwater system within the basement ECBF (T+T, 2017; PDP, 2016, Link Alliance, 2021). This has been noted in several of the geotechnical studies conducted for various construction projects, including the City Rail Link Limited (CRLL) project (PDP, 2016). The shallow perched aquifer system is considered laterally discontinuous and is typically perched on low permeability sediments. The ECBF comprises interbedded sandstone and mudstone and groundwater flow is associated with secondary porosity as a result of jointing and fracturing.

2.4.1 Groundwater levels

Groundwater level information is needed to assess possible inflows of groundwater to the shafts during construction and to determine the extent of drawdown required to dewater each shaft. Groundwater level loggers (i.e., automatic pressure transducers) were deployed in PZ01-S and PZ01-D as part of the monitoring for the Part 3 alignment and this data with the measured water level for PZE2 has been used for the assessment of the Part 3-Part 4 connector tunnel.

The groundwater levels for PZ01-S and PZ01-D for the period February to August 2023 are graphed in Figure 2-2. Rainfall records were taken from the MOTAT EWS (agent #41351), located approximately 4 km southwest from the site.

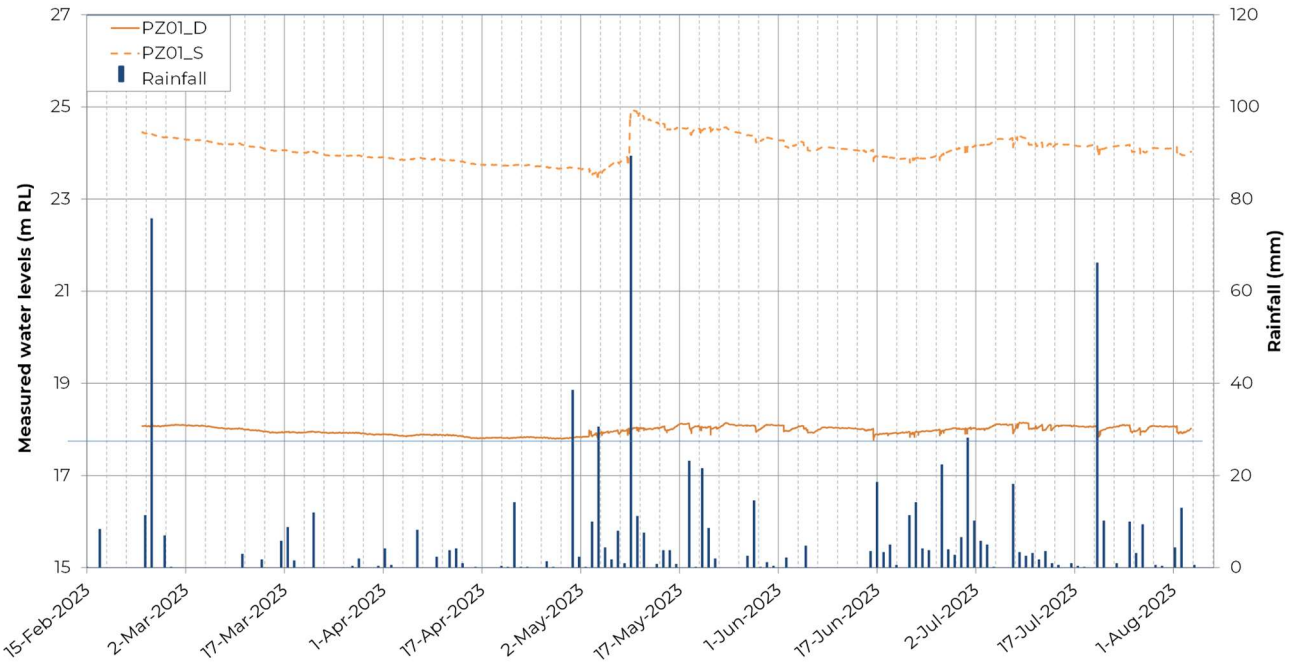

Figure 2-2: Groundwater levels for piezometers along the Part 3-Part 4 connector tunnel alignment

The groundwater levels show some variation for the perched aquifer as measured in the shallow piezometer (PZ01-S), in particular a significant increase in groundwater level after a big rainfall event on 10 May. The groundwater levels in deep piezometer (PZ01-D) in the ECBF shows very little variation. The high-water level from these were used for the Assessment of Effects for Part 3 (WSP, 2023c). Piezometer PZE2 was constructed in the ECBF and the water level was measured on 12 August, towards the end of the winter rainfall season when water levels are expected to be high. The rainfall over the 2022/2023 summer season was higher than usual with frequent storms. The longer term groundwater level monitoring from PZ07 (Part 3, WSP, 2023c), shows groundwater level highs equivalent to the winter levels. It is thus considered that the measured groundwater level is an exceptionally high level and will be used for a highly conservative analysis.

These high groundwater levels will be used to estimate maximum drawdown levels for the assessment of groundwater inflows to the shafts.

The high groundwater levels are as follows at the two shaft sites:

- Groundwater level at Mayoral shaft: 24.80 m RL
- Groundwater level at the Greys shaft: 17.14 m RL

2.4.2 Hydraulic Conductivity Data

Slug tests (i.e., falling and rising head tests) were undertaken on PZ01-S and PZ01-D (as part of the site investigation for the Part 3 AEE (WSP, 2023c)), and for PZE2 after construction of the piezometer. A conventional, cylindrical steel slug was sunk below the groundwater level in the monitoring wells to induce a near-instantaneous change in hydraulic head, following which, the rate of groundwater level recovery back to the static groundwater level (prior to testing) (falling head test) was measured. The slug was removed after groundwater level recovery to near static level. The recovery back to static groundwater level was measured for the rising head test. The groundwater level during each test was recorded automatically using a Solinst Levelogger set at 2 second intervals.

The testing was undertaken on 22 and 23 February (site PZ01), and 12 and 13 August 2023 (PZE2). The test data were analysed using AQTESOLV® from HydroSOLVE Inc. version 4.50 (2017), which is an industry standard groundwater parameter analysis package. Hydraulic

conductivity values were derived from the slug test data using the Bouwer-Rice (1976) and Hvorslev (1951) analysis methods, with the mean result taken as the best estimate. The recovery curves and analyses are presented in Appendix B.

The results of the hydraulic testing and analysis are presented in Table 2-1. There is a clear hydrogeological difference between the shallow (fill) and deep (ECBF) unit. The shallow unit is predominantly silts and clays, where the deeper unit is predominantly weathered and fractured sandstone and mudstone. This is reflected in a distinct increase in hydraulic conductivity of more than one order of magnitude in the deep unit in comparison to the shallow unit.

Table 2-1: Summary of hydraulic conductivity testing and analysis.

Piezometer ID	Screen interval (m)	Geology of screened interval	Static groundwater level (m bgl)	Estimated hydraulic conductivity (K) (m/day)	Average hydraulic conductivity (K) (m/day) per geology unit	Comment
PZ01-S	3-6	FILL – Gravelly Sand and silt, clayey silt	3.42	0.005	0.005	The hydraulic conductivity of fill can vary widely depending on the composition of the fill (PDP, 2016).
PZ01-D	12.4-15.4	ECBF Sandstone interbedded with siltstone	9.95	0.022	0.02	The typical range for weathered and fractured ECBF is 0.0004 to 0.5 m/day (PDP, 2016).
PZE2	5-8.5	Interlayered Sandstone and Mudstone (ECBF)	3.12	0.067	0.067	The typical range for weathered and fractured ECBF is 0.0004 to 0.5 m/day (PDP, 2016).

3 Project Works

The following is a summary of the project works, relevant to the dewatering AEE. The Project works allows for an early section of the Part 4 works to be constructed to enable the Part 3 tunnelling works. The works will consist of:

- Construction of the shaft in Greys Avenue Carpark (Greys shaft) at the location of manhole P4MH4
- Tunnelling between the Greys and Mayoral shafts
- Construction of the manhole (P4MH4) at Greys shaft and shaft reinstatement

The construction of the tunnel and manhole will be used as a service tunnel for temporary works for the Part 3 construction. After that it will to be used as permanent works (wastewater pipeline) for Part 4.

The current Part 3-Part 4 Connector Tunnel Methodology (Appendix D of the resource consent application) indicates that the service tunnel will be constructed using trenchless pipe jacking construction. The tunnelling will require two, deep temporary shafts at either end for access for the tunnelling equipment and pipes for the service tunnel, as indicated in Figure 1-2. The shafts are defined as follows:

- Mayoral shaft – at the intersection of Queen Street and Mayoral Drive, near PZ01-S and PZ01-D. The construction of this shaft has been described as part of the Part 3 consent application.
- Greys shaft – in the Greys Avenue Carpark.

Once tunnelling works are completed, the Greys shaft will be converted to a manhole (P4MH4).

3.1 Construction Hours and Duration

The Greys shaft construction is expected to take 15 days. Tunnelling operations will last for 20 days, followed by construction of the permanent manhole which will take 10 days. A total construction and dewatering time of 60 days have been allowed as a conservative measure to accommodate any unplanned delays.

3.2 Temporary Shafts Construction

The Greys and Mayoral shafts will be used for access during construction works. Relevant shaft construction and dewatering information and assumptions are outlined below, based on the construction and hydrogeological information discussed in Sections 2 and 3. The information for Mayoral shaft is replicated from the Part 3 AEE (WSP, 2023c), and any effects from the construction of this shaft are assessed in this application.

Greys Shaft

- A square footprint of 4×4 m (external dimension) with the shaft walls being supported with post and panel construction.
- Excavation depth: 14.75 m RL (5.5 m bgl).
- An auger attachment on a 10-20 t excavator or small piling rig will be used to drill 300-400 mm diameter holes. Steel H beams will be set into each hole and then backfilled with sand or concrete.
- The shafts will be excavated from the top using an excavator at surface level.
- Steel road plates or timber lagging will be installed between the H beams as the excavation progresses.
- The post and panel shaft wall supports will be unsealed and will require 24/7 dewatering.

- The manhole will be constructed as per the Part 3-Part 4 construction methodology (Appendix D of the resource consent application).
- Dewatering period is indicated as 60 days.

Mayoral Shaft

- A rectangular footprint of 4.5×10 m (internal dimension) with shaft walls being supported by post and panel construction.
- Excavation depth: 12.5 m RL (15.55 m bgl).
- A piling rig will be used to drill 400-600 mm diameter bores to 2 m below the pipe invert. Steel UC posts will be lowered into each bore and then backfilled.
- The shafts will be excavated using an excavator and hand-held air tools.
- Timber panels will be installed between the UC posts as the excavation progresses.
- Steel whaler beams will be used as support between the UC posts.
- The post and panel shaft wall supports will be unsealed and will require 24/7 dewatering.
- Dewatering period indicated as 12 months (365 days).

3.3 Tunnelling Works

A Trenchless pipe jacking construction methodology will be used for the tunnelling works between the Greys and Mayoral shafts. This has been described in more detail in the construction methodology (Appendix D of the resource consent application).

4 Assessment Methodology

4.1 Dewatering Modelling

4.1.1 Hydrostratigraphy

The interpretation of the hydrostratigraphy for Greys shaft is based on the Geotechnical Interpretive Report (WSP, 2023a) and the Hydrogeology Factual and Interpretive Report (WSP, 2023b), as well as the additional site investigations for the Greys shaft specifically. key hydrostratigraphic units identified within proximity to the Mayoral and Greys shafts area are as follows:

- Fill material: gravelly sand and silt
- East Coast Bay Formation (ECBF) derived residual soils: silty clay
- Weathered ECBF: weathered sandstone interbedded with mudstone
- ECBF: competent ('fresh') sandstone interbedded with siltstone

The hydraulic test data from the hydraulic tests (i.e., falling and rising head tests) on the site-specific monitoring wells and from various other literature sources was also reviewed to derive representative hydraulic parameters of the various hydrostratigraphic units. The adopted hydraulic properties for the cross-sectional model as well as the literature references this is based on, are listed in Table 4-1 below.

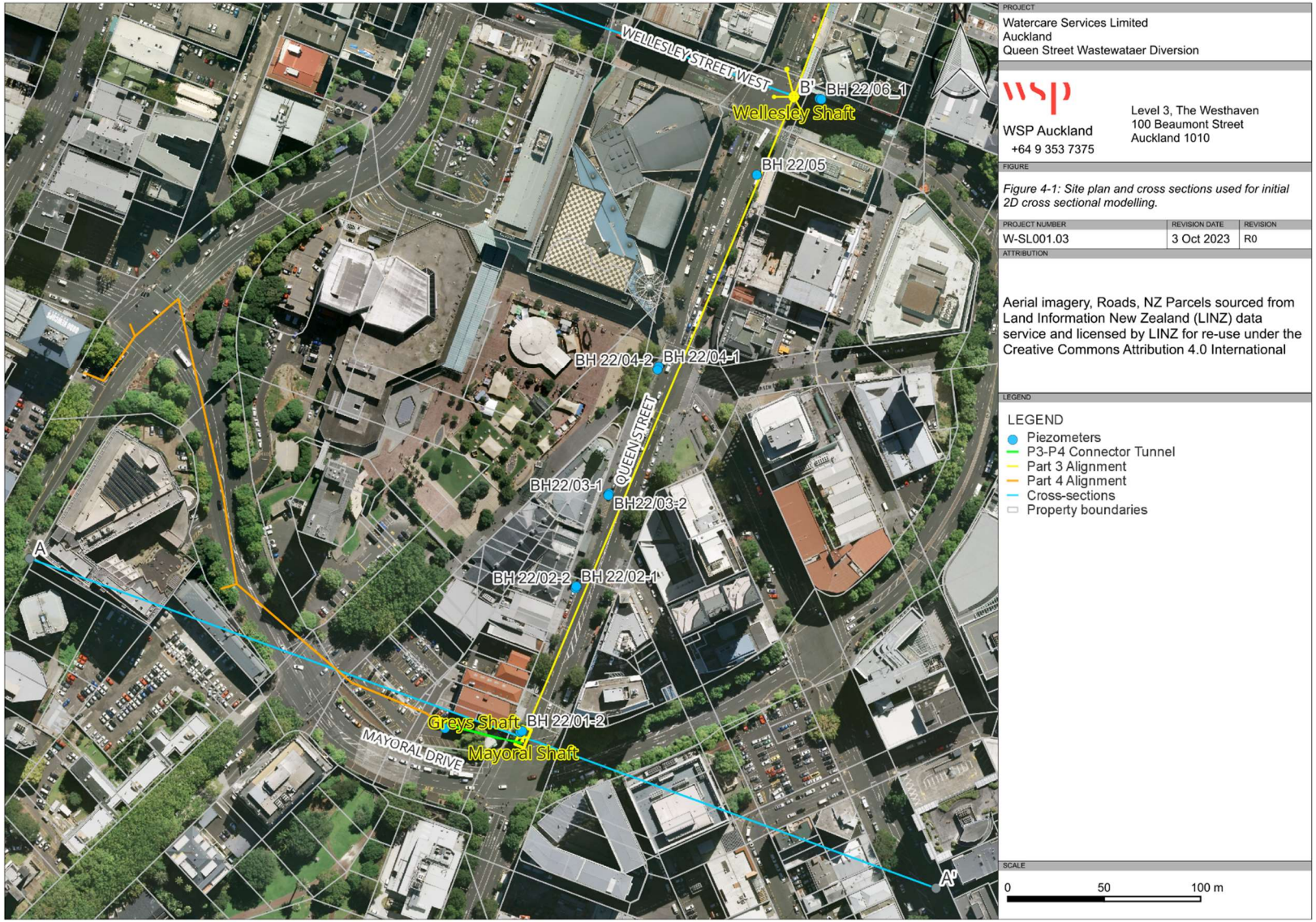

Figure 4-1: Site plan and cross sections used for initial 2D cross sectional modelling.

Table 4-1: Assumed hydraulic parameters for initial 2D cross sectional modelling.

Geology	Hydraulic Conductivity (m/day)		Kv:Kh ratio		Volumetric Water Content (-)		Compressibility (/kPa)
	Range	*Best Estimate*	*Range*	*Best Estimate*	*Range*	*Best Estimate*	*Best Estimate*
Fill (gravelly sand and silt)	0.001 to 0.1 [2)]	0.005	0.1-1	1	0.30-0.58 [1)]	0.4	1.0×10^{-5} [4)]
Residual soils ECBF	0.002 to 0.2 [2)]	0.018	0.1-1	1	0.35-0.58 [1)]	0.4	5.0×10^{-6} [4)]
Weathered ECBF	0.0078 to 0.016 [3)]	0.010	0.1-1	0.1	0.35-0.58 [1)]	0.4	1.0×10^{-6} [4)]
ECBF	0.0004 to 0.5 [3)]	0.022	0.1-1	1	0.06-0.18 [2)]	0.08	1.0×10^{-6} [4)]

Notes:

[1)] WSP (2023) Plasticity Index for Soils Test Reports - Queen Street Wastewater Diversion Project

[2)] Jacobs and Aecom (2017a; 2017b) and Tonkin & Taylor (2012)

[3)] Hydrogeology Factual and Interpretive Report (WSP, 2023b)

[4)] Freeze & Cherry (1979)

4.1.2 Modelling Approach and Setup

The cross-sectional numerical groundwater model for the Mayoral shaft (Part 3 AEE (WSP, 2023c)) was adapted to include the Greys shaft. By doing so, the cumulative drawdown effects of the dewatering for both shafts are simulated. Any additional drawdown effects on the Mayoral shaft will also be addressed. Relevant information for the Mayoral shaft from the Part 3 assessment is replicated here for reference.

The cross-sectional numerical model was developed using SEEP/W to assess dewatering induced groundwater drawdown effects during construction of the Part 3-Part 4 connector tunnel (Figure 4-1). SEEP/W is a finite element numerical modelling software for groundwater flow in porous media, developed by Seequent (2021). SEEP/W can model simple saturated steady-state problems or sophisticated transient analyses accounting for saturated and unsaturated groundwater flow.

The boundary conditions and assumed geological configuration is shown in the cross section in Figure 4-2. The numerical grid cells have a size of 2 m x 2 m at the outer extent of the model and are gradually refined to 0.5 m x 0.5 m in proximity of the shafts.

The model includes a steady state model that simulates the current hydrogeological state prior to construction, followed by a transient model that calculates the groundwater drawdown effect over the duration of the dewatering as listed in Section 3.1. The timesteps in the transient calculation increase exponentially because the drawdown effect will be greatest in the initial stages of dewatering.

Water total head boundaries (i.e., constant head boundaries) representing high groundwater levels at each shaft were applied to the sides of each model (Figure 5-1). At the Mayoral shaft, there is a significant change in elevation between the Mayoral shaft and the Greys shaft because of a cut west of Queen St, down to the Greys Avenue carpark (shown on the cross-sectional model in Figure 4-2). It is likely that a drainage feature (likely subsurface drainage) lowers the groundwater level to below ground surface around the Greys shaft. Therefore, the water total head boundaries in the model were raised to estimate the recorded representative high groundwater table at the Mayoral shaft site, and an additional seepage face was added to lower the water level at the Greys shaft. The effect of dewatering to dry out the excavations was simulated by applying a seepage face boundary. This boundary will remove any groundwater that would seep out on the surface or into an excavation.

The update to the cross-sectional model for the Greys and Mayoral shafts is summarised as follows:

- The addition of the Greys shaft, 37 m west of Mayoral shaft to a depth of 5.5 m bgl (14.75 m RL), with an associated dewatering level of 0.3 m below that of 5.8 m bgl (14.45 m RL).
- An additional seepage face boundary was included to reduce the modelled groundwater level to the measured groundwater level. The estimated natural groundwater level from the Mayoral shaft modelling (Part 3 AEE, (WSP, 2023c)) was indicated as near surface around the Greys shaft. It is considered likely that there is some additional drainage of groundwater occurring in this area, for e.g., dewatering of basements, subsurface drainage (likely along service networks), lowering the natural groundwater table.
- The Greys and Mayoral shafts are dewatered concurrently for the first 60 days, during the construction of the Greys shaft and manhole construction, thereafter the dewatering at Greys shaft is stopped, while dewatering at the Mayoral shaft continues for another 305 days.

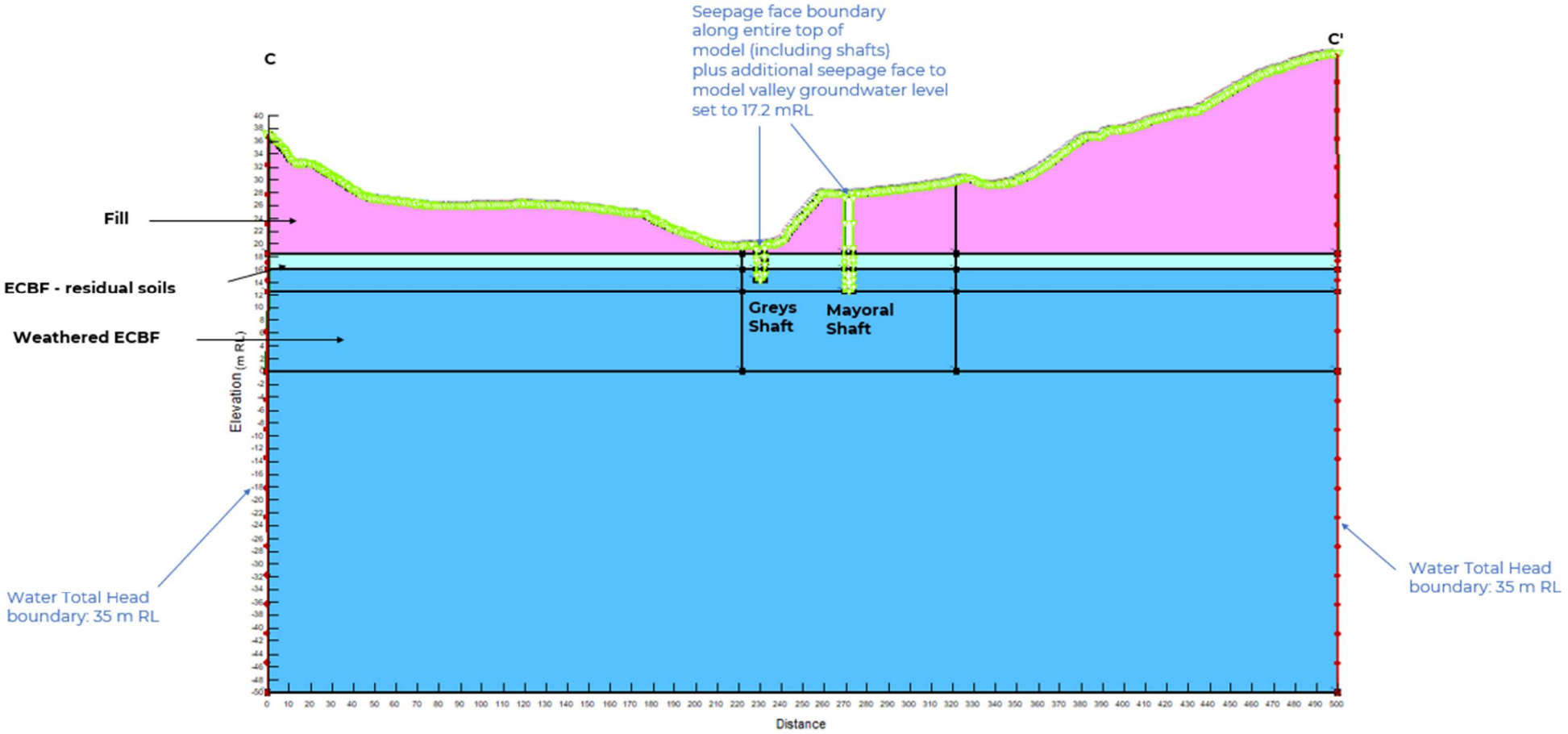

Figure 4-2: 2D Cross sectional model setup for Mayoral Section.

4.1.3 Sensitivity Analysis

A sensitivity analysis was undertaken to assess uncertainties in adopted hydraulic parameters and the lateral extent of the geological profile. The following cases were investigated for each of the three shafts:

- Best estimate case represents the horizontal hydraulic conductivity values (Kh) listed under 'best estimate' in Table 4-1. This is considered the most likely case.
- High-K case: represents the highest estimated horizontal hydraulic conductivity (Kh) listed in the hydraulic conductivity range in Table 4-1.
- Low-K case: represents the lowest estimated horizontal hydraulic conductivity (Kh) listed in the hydraulic conductivity range Table 4-1.

The three cases listed above will result in three different groundwater level drawdowns, representing a range of possible groundwater drawdown gradients to be considered in the land settlement assessments.

4.2 Land Settlement Modelling

Land subsidence can occur from dewatering activities and groundwater level drawdown, as a result of reduced pore water pressure and subsequent increase in effective stresses in the soil. Nearby structures or services could be affected, particularly if differential settlement exceeds a certain threshold. Groundwater level drawdowns create a cone shape during abstraction, so any land subsidence resulting from dewatering is likely to be differential.

Settlement generated by drawdown in the vicinity of the shaft was calculated using the drawdown results generated for upper bound and low bound assumptions for the hydraulic conductivity of the soil, characterised as 'high' and 'low', respectively.

To assess the potential maximum settlement, the analyses used the maximum predicted drawdown at the locations of the Greys and Mayoral shafts, calculated for the assumption of 'high' hydraulic conductivity. The assessment of maximum gradient of differential settlement, the analyses used the drawdown data corresponding to 'low' hydraulic conductivity which yield the steepest cone of depression. All analyses were undertaken at distances of 5 m, 10 m and 20 m away from the walls of the shaft for the drawdown values provided after 60 days of dewatering, which is when dewatering at Greys shaft ceases. This methodology is presented in Table 4-2 below.

Table 4-2: Methodology for Assessment of Settlement

	High-K	Low-K	Justification
Assessment of maximum settlement	√		Maximum drawdown → Maximum settlement
Assessment of maximum differential settlement		√	Steeper cone of depression → Maximum differential settlement

As shown on Figure 4-3 the distance of the corner of the adjoining heritage building from the edge of the shaft is approximately 5 m.

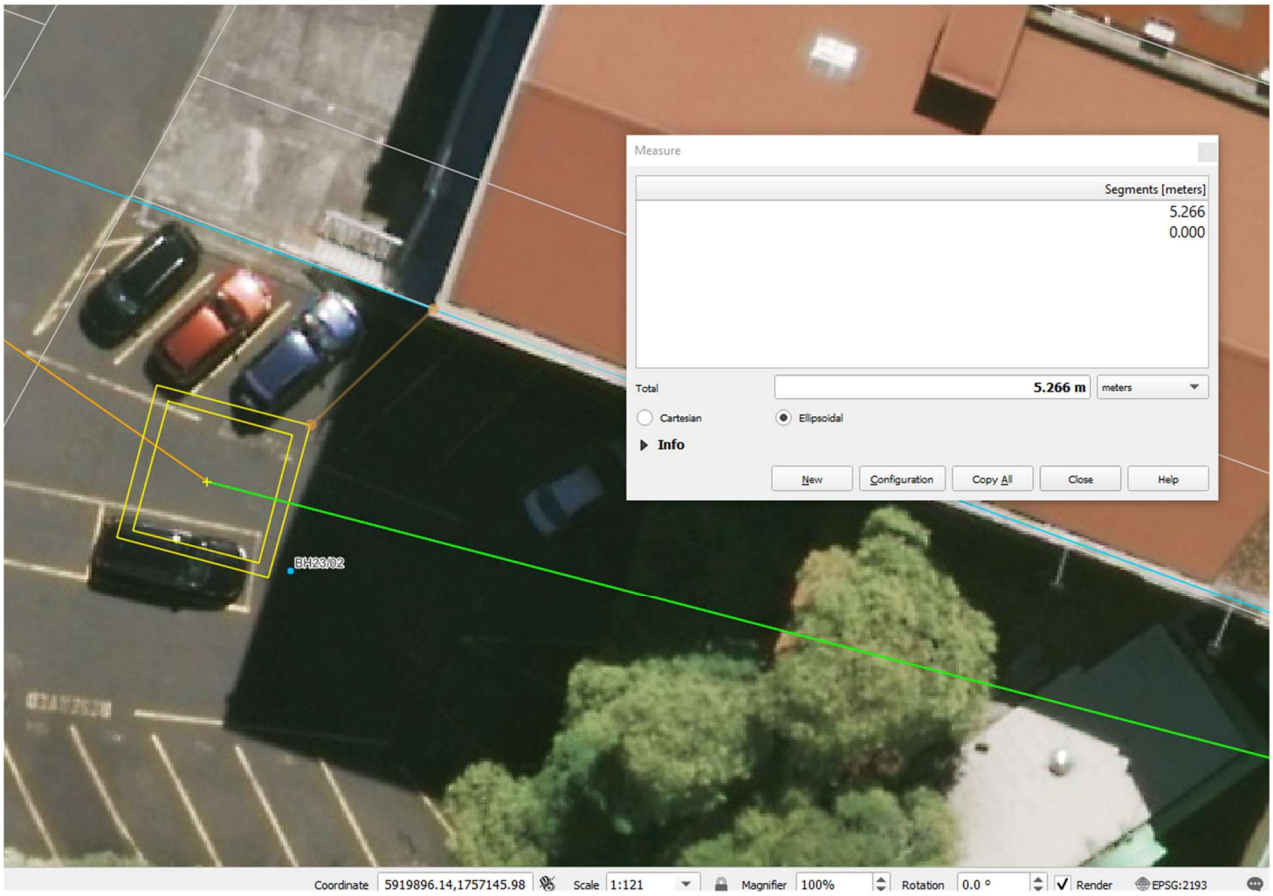

Figure 4-3: Distance of Heritage Building at 325 Queen Str from Greys Shaft.

Settlement was calculated assuming a linear elastic soil behaviour. The compressibility parameters were based on consistency descriptors on the borehole logs, testing and experience. The analyses were undertaken using the software *Settle3*. The groundwater drawdown was modelled by introducing a uniform stress at the depth of the groundwater table before drawdown. The specific assumptions and the results are presented in Section 5.2.

5 Technical Analysis (Specialists)

5.1 Dewatering Analysis

The estimated groundwater level drawdowns at the Greys and Mayoral shafts are presented in Table 5-1 and Figure 5-1. Key matters to note for either shaft is listed. The results have been passed on to geotechnical experts for further land settlement assessments.

5.1.1 Greys Shaft

Key matters to note in relation to dewatering and groundwater level drawdown at the Greys shaft are as follows:

- In the best estimate case, the dewatering rate for the Greys shaft is estimated to be 0.8 m^3/day at the start but will gradually reduce to 0.65 m^3/day after 7 days, and further reduce to 0.3 m^3/day at the end of the dewatering period. This dewatering rate is much lower than the dewatering rate at Mayoral shaft (2.6-1.5 m^3/day), because the required dewatering depth is substantially less than that of the Mayoral shaft.
- The relative drawdown midway between the Greys and Mayoral shafts (southeast side of Greys shaft, at approximately 20 m) is similar to the drawdown estimated from the dewatering of Mayoral shaft alone (estimated to be 2.97 m for Mayoral shaft alone and 3.4 m for Greys and Mayoral shafts for the best estimate scenario), after 365 days. This is because the starting groundwater level at Greys shaft is deeper (3.12 m bgl) than the starting water level for Mayoral shaft, which was assumed to be near surface.
- On the southeast side of the shaft (towards Mayoral shaft), for the high-K case, the 2 m groundwater level drawdown contour is likely to be exceeded (maximum of 3.4 m drawdown as mentioned above) between the Greys and Mayoral shafts. In the best estimate case, drawdowns decrease towards the Greys shaft, when the dewatering stops after 60 days as the combined influence of dewatering decreases (see Figure 5-1).
- Note that the 3.4 m drawdown is only relevant between the Greys and Mayoral shafts and drawdown towards the northwest will be notably less because it is only influenced by the drawdown from Greys shaft.
- On the northwest side of the shaft (away from Mayoral shaft), for the low-K case, the 2 m groundwater level drawdown contour is estimated as less than 1 m from the edge of the shaft at the end of the 60 days of dewatering. In the best estimate case, this distance is less than 2 m from the shaft.
- Expected groundwater level drawdowns for the best estimate, low hydraulic conductivity and high hydraulic conductivity cases are presented in Table 5-1 below.
- Best estimate groundwater level drawdowns are shown in the cross-sectional diagram in Figure 5-1.

Table 5-1: Groundwater level drawdown from dewatering at Greys shaft (with concurrent dewatering at Mayoral shaft).

Northwest Side						
Distance from shaft (m)	Best estimate case		High-K case		Low-K case	
	Drawdown (m) 1 week after start of dewatering	Drawdown (m) after 60 days - end of dewatering, Greys shaft	Drawdown (m) 1 week after start of dewatering	Drawdown (m) after 60 days - end of dewatering, Greys shaft	Drawdown (m) 1 week after start of dewatering	Drawdown (m) after 60 days - end of dewatering, Greys shaft
3	0.8	1.26	0.7	1.2	1.0	1.9
5	0.6	1.3	0.6	1.0	0.9	1.6

Southeast Side (between Greys and Mayoral shafts)									
Distance from shaft (m)	Best estimate case			High-K case			Low-K case		
	Drawdown (m) 1 week after start of dewatering	Drawdown (m) after 60 days - end of dewatering, Greys shaft	Drawdown (m) after 365 days; end of dewatering, Mayoral shaft	Drawdown (m) 1 week after start of dewatering	Drawdown (m) after 60 days - end of dewatering, Greys shaft	Drawdown (m) after 365 days; end of dewatering, Mayoral shaft	Drawdown (m) 1 week after start of dewatering	Drawdown (m) after 60 days - end of dewatering, Greys shaft	Drawdown (m) after 365 days; end of dewatering, Mayoral shaft
5	0.3	0.7	0.8	0.3	1.0	0.6	0.6	1.4	0.8
10	0.5	1.4	1.8	0.5	1.1	1.2	0.3	1.1	1.3
20	0.6	1.8	3.4	1.1	1.8	2.3	0.4	1.5	3.1
37 m (Mayoral shaft)	6.4	7.1	7.8	5.2	5.2	5.2	3.2	5.1	7.1

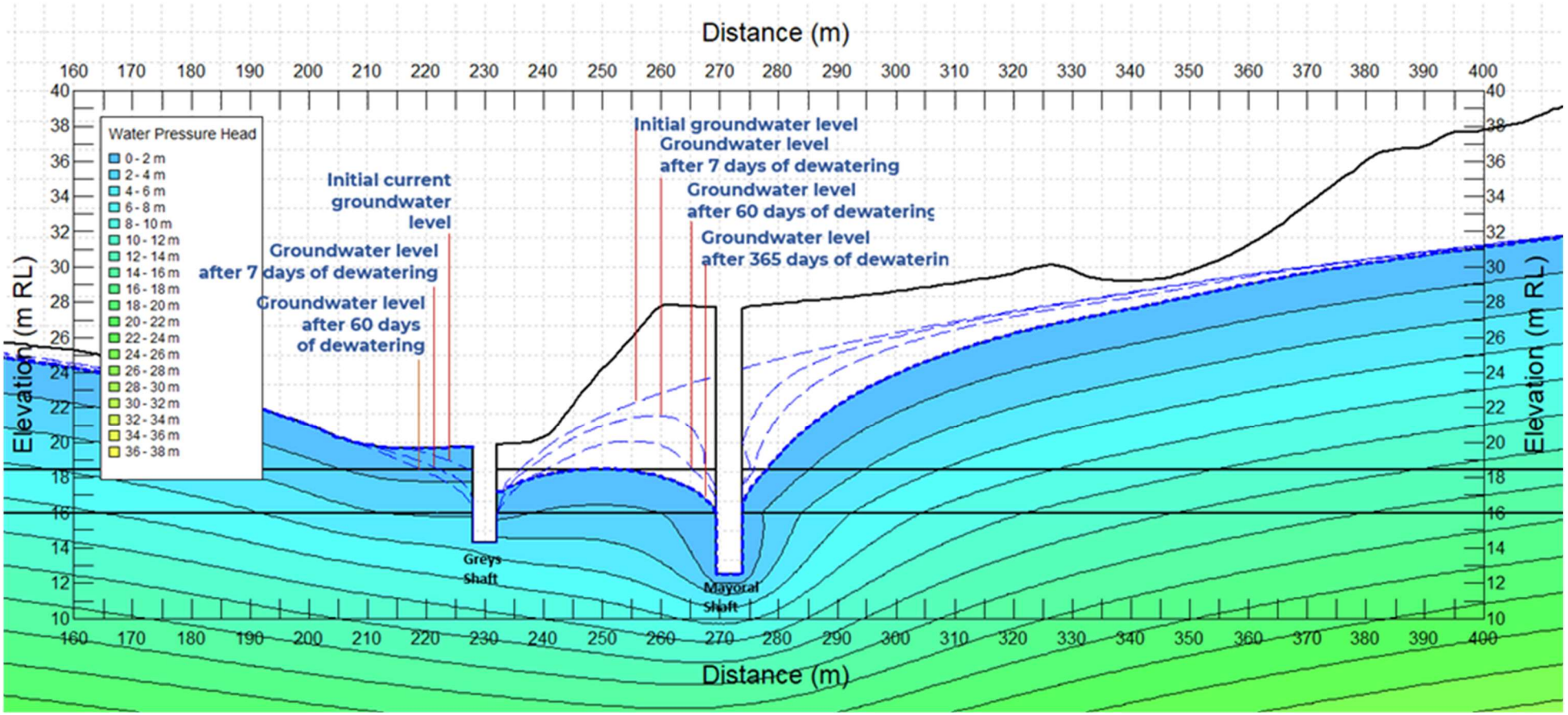

Figure 5-1: Best estimate case groundwater level cross section at Greys and Mayoral shafts.

5.1.2 *Mayoral Shaft*

The additional drawdown from the 60 days of dewatering at Greys shaft, i.e., in addition to the 365 days of dewatering at Mayoral shaft, does not extend past Mayoral shaft. The groundwater level changes southeast of the Mayoral shaft along the cross-section line is the same as for the Part 3 Assessment.

5.2 Settlement Analysis

The ground model was developed using the findings of the recent machine borehole BH23/02 undertaken by WSP and the historic investigations by T&T available in NZGD: BH_160746 (T+T BH01), HA_160747, HA_160748 and HA_160749. Their locations are shown on Figure 5-2.

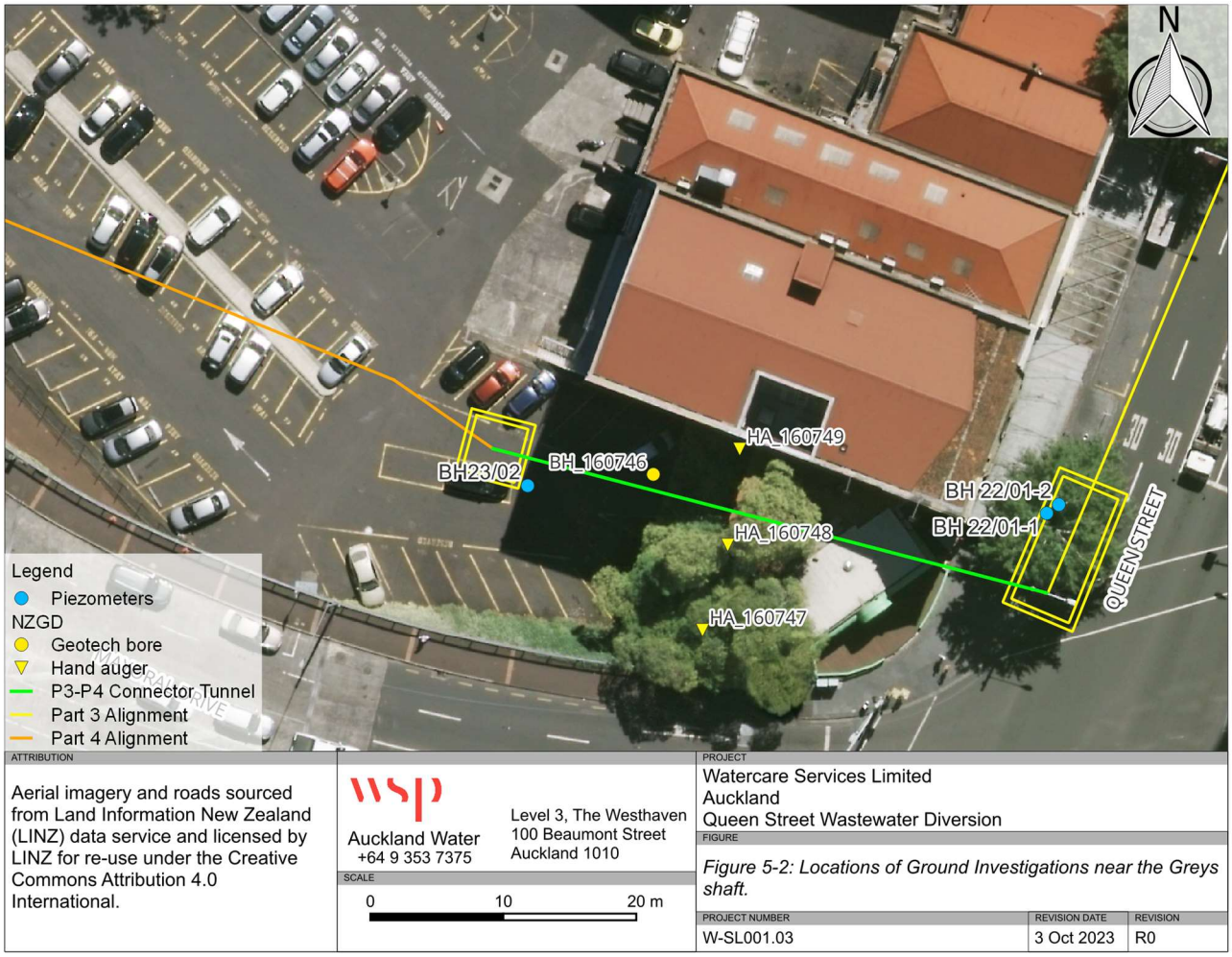

Figure 5-2: Locations of Ground Investigations Near the Greys shaft.

In BH23/02, extremely weathered ECBF bedrock was encountered at 4 m depth and moderately weathered with SPT-N=50+ at 7.5 m. The findings in BH01 (NZGD id#: BH_160746) are similar. In all investigations, the materials at the surface down to 4 m depth are predominantly described as silt or clayey silt, very stiff to stiff. The undrained shear strength is generally between 70 kPa and 130 kPa. Based on these findings, the ground model adopted in the analyses is shown on Table 5-2.

Table 5-2: Ground Model for Settlement Analyses

Layer	Depth (m)	Unit Weight (kn/m3)	Es (MPa)
Silt / Clayey Silt	0 – 4	17	20
Extremely Weathered ECBF	4 – 7.5	18	50
Moderately Weathered ECBF	>7.5	20	100

The uniform stress corresponding to the increase in effective stress because of the drawdown was assumed to apply at 3.1 m depth, the same as the groundwater level in the dewatering calculations. The estimated settlement is summarised in Table 5-3.

Table 5-3: Estimated settlement – Greys shaft

Settlement (mm) after 60 days – end of dewatering, Greys shaft		
Distance from shaft (m)	High-K case	Low-K case
5	2	3
10	2	2
20	4	3

Based on the above the differential settlement of 1 mm across 5 m is estimated to be negligible (in the order of 1:5000).

Under a worst-case scenario that the groundwater table at the time of dewatering is shallower, at a depth of 1.5 m, the above settlement estimated increase by approximately 1 mm for each case. The differential settlement remains negligible.

For the settlement effects classification according to Burland, please refer to Section 7.5.

6 Proposed Activity/s and Triggered Rules

6.1 Introduction

Table E7.4 1 of the Auckland Unitary Plan (AUP) specifies the activity status in relation to taking, using, damming and diversion of surface water and groundwater in accordance with section 14(1) and 14(3) of the Resource Management Act 1991 (RMA). The activities summarised in Table 6-1 are considered relevant for the construction of Part 3 of the Queen Street wastewater diversion pipeline.

Table 6-1: Relevant Activity Status

Activity	Activity status		
	All Zones	High-Use Stream Management Areas Overlay	Wetland Management Areas Overlay
Take and use of groundwater			
(A17) Dewatering or groundwater level control associated with a groundwater diversion permitted under the Unitary Plan	Permitted	Permitted – N/A – Activity not in a high-use stream management area overlay	Restricted Discretionary – N/A – Activity not in a wetland management area overlay
(A20) Dewatering or groundwater level control associated with a groundwater diversion authorised as a restricted discretionary activity under the Unitary Plan, not meeting permitted activity standards or is not otherwise listed	Restricted Discretionary	Restricted Discretionary – N/A	Restricted Discretionary – N/A
Diversion of groundwater			
(A27) Diversion of groundwater caused by any excavation (including trench) or tunnel	Permitted	Permitted – N/A – Activity not in a high-use stream management area overlay	Restricted Discretionary – N/A – Activity not in a high-use stream management area overlay
(A28) The diversion of groundwater caused by any excavation, (including trench) or tunnel that does not meet the permitted activity standards or not otherwise listed	Restricted Discretionary	Restricted Discretionary – N/A	Restricted Discretionary – N/A

The following Auckland Unitary Plan standards have been assessed to classify the proposed dewatering activity for the construction activities.

> Standard E7.6.1.6 – permitted activity standard to divert water for groundwater level control.
> Standard E7.6.1.10 – permitted activity standard to divert groundwater due to excavation.

Matters of discretion for assessment of the restricted discretionary resource consent application are stipulated under E7.8.1 Matters of discretion ***(4) for take and use of groundwater for dewatering or groundwater level control associated with groundwater diversion*** , which refers to ***(6) diversion of groundwater***.

6.2 Assessment of Activity Against the Auckland Unitary Plan Provisions.

Table 6-2 details the assessment of the activity against Standard E7.6.1.6, which is the standard for dewatering or groundwater level control associated with a groundwater diversion permitted under Standard E7.6.1.10. "Yes" indicates the PA standard condition is met, "No" indicates the standard condition is not met, and a comment for clarification is provided. The standard specifies that for the dewatering or groundwater level control to be assessed as permitted, all the conditions must be met.

Table 6-2: Assessment Standard E7.6.1.6 – Dewatering or groundwater level control.

Condition	Complies - Comment
(1) The water take must not be geothermal water;	Yes
(2) The water take must not be for a period of more than 10 days where it occurs in peat soils, or 30 days in other types of soil or rock; and	No – Greys and Mayoral shafts: no peat, but will be open for more than 30 days.
(3) The water take must only occur during construction.	Yes

Table 6-3 details the assessment of the activity against permitted activity Standard E7.6.1.10, which is the standard for diversion of groundwater caused by any excavation (including trench) or tunnel. "Yes" indicates the activity complies with the standard's condition and "No" indicates the activity does not comply with the standard's condition. The standard specifies that for the dewatering or groundwater level control to be assessed as permitted, all the conditions must be met.

Table 6-3: Assessment: Standard E7.6.1.10 – Groundwater diversion.

Condition	Complies – Comment
(1) All of the following activities are exempt from the Standards E7.6.1.10(2) – (6):	
(a) pipes, cables or tunnels including associated structures which are drilled or thrust and are up to 1.2 m in external diameter;	Yes – Proposed pipe diameter of DN450.
(b) pipes including associated structures up to 1. 5m in external diameter where a closed faced or earth pressure balanced machine is used;	NA
(c) piles up to 1.5 m in external diameter are exempt from these standards;	NA
(d) diversions for no longer than 10 days; or	No – Both shafts will be open for longer than 10 days.
(e) diversions for network utilities and road network linear trenching activities that are progressively opened, closed and stabilised where the part of the trench that is open at any given time is no longer than 10 days.	NA
(2) Any excavation that extends below natural groundwater level, must not exceed:	
(a) 1 ha in total area; and	Yes – the biggest excavation will be the Mayoral shaft, which is 4.5×10 m inside diameter and will account for a maximum area of 45 m^2 (0.0045 ha).
(b) 6 m depth below the natural ground level.	No – Mayoral shaft is below natural groundwater level and more than 6 m below natural ground level. Yes – Greys shaft is below the groundwater level but is 5.5 m bgl.
(3) The natural groundwater level must not be reduced by more than 2 m on the boundary of any adjoining site.	No – The nearest property boundary is 3.3 m from the edge of Greys shaft. The 2.5 m drawdown extends to midway between the Greys and Mayoral shafts (approximately 20 m from the edge of Greys shaft) along the cross-sectional line. The estimated drawdown perpendicular to the cross-sectional line from Greys shaft will be less, but as a conservative measure 2.5 m is assumed up to 90 ° from the cross-sectional line.

Condition	Complies – Comment
(4) Any structure, excluding sheet piling that remains in place for no more than 30 days, that physically impedes the flow of groundwater through the site must not:	
(a) impede the flow of groundwater over a length of more than 20 m; and	Yes – both shaft installations are less than 10 m long.
(b) extend more than 2 m below the natural groundwater level.	No – both shafts extend more than 2 m below the natural groundwater level.
(5) The distance to any existing building or structure (excluding timber fences and small structures on the boundary) on an adjoining site from the edge of any:	
(a) trench or open excavation that extends below natural groundwater level must be at least equal to the depth of the excavation;	No – both shafts are below natural groundwater level and within close proximity to buildings and structures.
(b) tunnel or pipe with an external diameter of 0.2 - 1.5 m that extends below natural groundwater level must be 2 m or greater; or	Yes – the depth of pipeline install is greater than 2 m – based on the latest design drawings in Appendix D of the main resource consent application.
(c) a tunnel or pipe with an external diameter of up to 0.2 m that extends below natural groundwater level has no separation requirement.	N/A
(6) The distance from the edge of any excavation that extends below natural groundwater level, must not be less than:	
(a) 50 m from the Wetland Management Areas Overlay;	Yes – there are no wetlands mapped in the area.
(b) 10 m from a scheduled Historic Heritage Overlay; or	No – The Mayoral shaft is directly adjacent to the Auckland Sunday School Union Building (325 Queen Street) and the Greys shaft is approximately 5 m from the Auckland Sunday School Union Building (325 Queen Street).
(c) 10 m from a lawful groundwater take.	Yes – based on the groundwater take information obtained from Auckland Council, the nearest groundwater take is ~ 110 m from the Mayoral shaft – see Section7.2.

Based on the Auckland Unitary Plan, the dewatering and diversion of groundwater caused by any excavation (including trench) or tunnel that does not meet the permitted activity standards is a restricted discretionary activity:

- The shaft excavations for the trenchless installation of the pipeline do not meet the permitted activity standards, as above, hence a resource consent will need to be obtained.
- The matters of discretion for assessment of the restricted discretionary activity are summarised in Table 6-4. See attached AUP maps obtained from the AC Geomaps website[1] in Appendix C.

*Table 6-4: E7.8.1 Assessment – Restricted discretionary activities. Matters of discretion for **(6) diversion of groundwater**:*

Matters of Discretion	Comment
(a) how the proposal will avoid, remedy or mitigate adverse effects:	
(i) on the base flow of rivers and springs;	N/A – No rivers of springs occur in proximity to the works.
(ii) on levels and flows in wetlands;	N/A – No wetlands have been identified in proximity to the works.
(iii) on lake levels;	N/A – No lakes have been identified in proximity to the works.
(iv) on existing lawful groundwater takes and diversions;	To be assessed
(v) on groundwater pressures, levels or flow paths and saline intrusion;	To be assessed
(vi) from ground settlement on existing buildings, structures and services including roads, pavements, power, gas, electricity, water mains, sewers and fibre optic cables;	To be assessed
(vii) arising from surface flooding including any increase in frequency or magnitude of flood events;	To be assessed

[1] https://unitaryplanmaps.aucklandcouncil.govt.nz/upviewer/

Matters of Discretion	Comment
(viii) from cumulative effects that may arise from the scale, location and/or number of groundwater diversions in the same general area;	To be assessed
(ix) from the discharge of groundwater containing sediment or other contaminants;	Managed via consent condition through on-site treatment (settlement tanks) prior to discharge of water.
(x) on any scheduled historic heritage place; and	N/A – All historic heritage places are buildings, and these are assessed for settlement effects.
(xi) on terrestrial and freshwater ecosystems and habitats.	N/A – no terrestrial or freshwater ecosystems and habitats located nearby.
(b) the need for mineral extraction within a Special Purpose - Quarry Zone to carry out dewatering or groundwater level control and diversion and taking of groundwater in the context of mineral extraction activity.	Not applicable – site is not a quarry operation
(c) monitoring and reporting requirements incorporating, but not limited to:	
(i) the measurement and recording of water levels and pressures;	Proposed GSMCP
(ii) the measurement and recording of the settlement of the ground, buildings, structures and services	Proposed GSMCP
iii) the measurement and recording of the movement of any retaining walls constructed as part of the excavation or trench; and	Proposed GSMCP
(iv) requiring the repair, as soon as practicable and at the cost of the consent holder, of any distress to buildings, structures or services caused by the groundwater diversion.	Proposed GSMCP
(d) the duration of the consent and the timing and nature of reviews of consent conditions;	Proposed consent conditions
(e) the requirement for and conditions of a financial contribution and/or bond; and	N/A
(f) the requirement for a monitoring and contingency plan or contingency and remedial action plan.	Proposed GSMCP

7 Effects Assessment

7.1 Introduction

Part 3-Part 4 Connector tunnel will comprise the construction of one shaft, Greys shaft, in addition to the Mayoral shaft of the Queen St Part 3 alignment, installation of 43 m of GRP pipe with an internal diameter of 450 mm, at various depths. This effects assessment is based on the alignment as presented in the design drawings included in the construction methodology (Appendix D of the resource consent application) and specifications listed in Section 4.

Based on the planning assessment in Section 6.2, the dewatering activity for the shafts will require resource consent.

The abstraction of groundwater for dewatering will cause a depression cone in the groundwater table. Groundwater levels will generally decrease around the excavation and the area of the groundwater depression cone will extend outwards over time until dewatering ceases. Therefore, it needs to be considered that drawdowns may propagate outwards over time.

Both Greys and Mayoral Drive shafts will comprise post and panel construction and will require continuous dewatering during the construction period of the shaft, trenchless drilling and manhole construction. The maximum dewatering period for Greys shaft is estimated at 60 days and the maximum dewatering period for Mayoral shaft is estimated at 12 months.

Based on the planning assessment completed in Section 6.2, groundwater drawdown effects will only be estimated for Greys shaft because the drawdown for Mayoral shaft is the same as that estimated for the Part 3 AEE. The drawdown effects will be estimated for:

- Effects on neighbouring bores
- Stream depletion effects
- Saltwater intrusion effects
- Settlement effects on neighbouring properties and utilities due to dewatering
- Surface flooding and water quality effects that may arise from the abstracted groundwater being diverted.

7.2 Effects on Neighbouring Bores

Effects on neighbouring bores are estimated based on the level of groundwater drawdown from the dewatering at the location of the existing bore. The location of existing bores and groundwater take locations was obtained from regulatory support at Auckland Council. Groundwater level drawdown of 0.1 m is considered the estimated maximum lateral extent of the drawdown cone where effects on other groundwater users and groundwater dependent ecosystems should be assessed, which is the level change that would be measurable above natural variation. The groundwater level drawdown estimation from the best estimate case at the end of the dewatering period of 60 days of the Greys shaft is used for the assessment of effects.

7.2.1 Greys Shaft

The lateral extent of the drawdown cone for the Greys shaft is limited to a maximum of 17 m from the shaft location, based on the drawdown on the north-western side, which is outside of the Mayoral shaft extent on the south-eastern side. The maximum drawdown extent is shown in Figure 7-1.

Water take consent WAT60315306 is 110 m from the edge of the Greys shaft excavation, which is outside of the drawdown extent and no additional drawdown will occur at the take location. It is thus considered that the dewatering activity at Greys shaft will have no effect on the existing water take consent WAT60315306.

Figure 7-1: Lateral extent of drawdown cones and neighbouring bore consents (Auckland Council).

7.3 Stream Depletion Effects

There are no surface water bodies or streams in close proximity (within the zone of drawdown influence - See AC planning maps in Appendix C) to the pipe alignment, hence the groundwater drawdown will have no stream depletion effects on surface water bodies on stream and other terrestrial and freshwater ecosystems were not conducted.

7.4 Saltwater intrusion

Based on the assessment for the Part 3 alignment along Queen Street, the likelihood of saltwater intrusion is considered negligible because the water level will not be reduced below sea level during dewatering; additional drawdown resulting from the Greys shaft dewatering is limited in lateral extent (17 m) and short duration (60 days maximum).

7.5 Settlement effects

The Burland Building Damage Assessment Classification is typically adopted to categorise buildings based on the effects from settlement. The damage classification in Table 7-1 provides a category of damage that would be associated with the approximate vertical ground settlement.

Table 7-1: Building damage assessment criteria.

Building Damage Classification after Burland (1997) and Mair et al., (1996).			Approximate Equivalent Ground Settlement and Slopes (CIRIA, 1996)	
Category of Damage	Description of Degree of Damage	Limiting Tensile Strain (%)	Max Slope of the Ground	Maximum Settlement of the Building (mm)
0	Negligible	<0.05		
1	Very slight	0.05-0.075	<1/500	<10
2	Slight	0.075-0.15	1/500 – 1/200	10-50
3	Moderate	0.15-0.3	1/200 – 1/50	50-75
4	Severe	>0.3	1/200 – 1/50	>75
5	Very Severe		>1/50	>75

The settlement analysis conducted suggests that the category of damage will be 0 and negligible damage is likely to incur to the adjoining building at 325 Queen Street.

A services and utilities location process will be implemented and in collaboration with the utilities' owners/authorities, a programme of relocations/diversions, protection and monitoring will be undertaken to protect the services and utilities, from risk of damage, with the proposed works.

7.6 Surface Flooding and Water Quality Effects

The dewatering water will be treated in clarifying tanks to required standards before discharge to the local stormwater network. The abstraction rates from the different shafts are very low:

- Greys shaft – the dewatering rate is initially estimated to be 0.8 m^3/day reducing to 0.3 m^3/day towards the end of the dewatering period.
- The difference between the dewatering assessed for the Part 3 works and this Part3-Part4 connector tunnel works (combined discharge from Mayoral and Greys shaft) is minimal. The

total discharge from the combined dewatering of the Mayoral and Greys shafts increases by approximately 20%.

The discharge rate for Greys shaft is low and thus it is considered that flooding as a result of dewatering is unlikely.

8 Mitigation Measures

A groundwater and settlement monitoring and contingency plan (GSMCP) has already been requested by Auckland Council for the Mayoral Drive shaft dewatering as a conservative measure for the Part 3 alignment resource consent[2] and this includes a recommendation for groundwater level monitoring, ground settlement monitoring and deformation monitoring of the heritage building (Auckland Sunday School Union Building, 325 Queen Street) on Mayoral Drive. Any monitoring and mitigation required based on the settlement assessment of this Part3-Part 4 connection tunnel will thus be covered by the GSMCP for the Part 3 alignment.

The purpose of a GSMCP is to, so far as reasonably practical:

- Present indicative monitoring requirements for the proposed construction works
- Prevent damage related to the dewatering activity that may affect the serviceability of structures and services, and
- Provide appropriate measures to remediate or mitigate any adverse effects (including cumulative effects) as a result of the dewatering and excavation activities involved in the early works.

The likely settlement from the additional dewatering at Greys Avenue shaft is considered negligible. Hence the proposed GSMCP for works to construct Mayoral shaft is considered sufficient.

9 Identification of affected parties

No affected parties were identified within the likely settlement zones for the dewatering of the Mayoral shaft (WSP, 2023c). However, it was recommended that the Auckland Sunday School Union Building on Mayoral Drive be included in the proposed GSMCP and this recommendation stands.

10 RMA s104 Assessment

The matters of discretion for assessment of the restricted discretionary activity table in Section 6.2 have been updated in Table 10-1.

Table 10-1: E7.8.1 Assessment – Restricted discretionary activities. Matters of discretion for (6) diversion of groundwater – Updated outcomes

Matters of Discretion	Comment
(a) how the proposal will avoid, remedy or mitigate adverse effects:	
(i) on the base flow of rivers and springs;	N/A – No rivers of springs occur in proximity to the works.
(ii) on levels and flows in wetlands;	N/A – No wetlands have been identified in proximity to the works.
(iii) on lake levels;	N/A – No lakes have been identified in proximity to the works.
(iv) on existing lawful groundwater takes and diversions;	Section 7.2 – less than minor effect
(v) on groundwater pressures, levels or flow paths and saline intrusion;	Section 7.3 – less than minor effect

[2] BUN60422974 s92 request, dated 28 September 2023

Matters of Discretion	Comment
(vi) from ground settlement on existing buildings, structures and services including roads, pavements, power, gas, electricity, water mains, sewers and fibre optic cables;	Section 7.5 – less than minor effect
(vii) arising from surface flooding including any increase in frequency or magnitude of flood events;	Section 0 – less than minor effect
(viii) from cumulative effects that may arise from the scale, location and/or number of groundwater diversions in the same general area;	Section 0 – less than minor effect
(ix) from the discharge of groundwater containing sediment or other contaminants;	Managed via consent condition through on-site treatment (settlement tanks) prior to discharge of water.
(x) on any scheduled historic heritage place; and	N/A – All historic heritage places are buildings, and these are assessed for settlement effects, so already addressed under Section 7.5.
(xi) on terrestrial and freshwater ecosystems and habitats.	N/A – no terrestrial or freshwater ecosystems and habitats located nearby.
(b) the need for mineral extraction within a Special Purpose - Quarry Zone to carry out dewatering or groundwater level control and diversion and taking of groundwater in the context of mineral extraction activity.	Not applicable – site is not a quarry operation
(c) monitoring and reporting requirements incorporating, but not limited to:	
(i) the measurement and recording of water levels and pressures;	Proposed GSMCP for Part 3
(ii) the measurement and recording of the settlement of the ground, buildings, structures and services	Proposed GSMCP for Part 3
iii) the measurement and recording of the movement of any retaining walls constructed as part of the excavation or trench; and	Proposed GSMCP for Part 3
(iv) requiring the repair, as soon as practicable and at the cost of the consent holder, of any distress to buildings, structures or services caused by the groundwater diversion.	Proposed GSMCP for Part 3
(d) the duration of the consent and the timing and nature of reviews of consent conditions;	Proposed consent conditions
(e) the requirement for and conditions of a financial contribution and/or bond; and	N/A
(f) the requirement for a monitoring and contingency plan or contingency and remedial action plan.	Proposed GSMCP for Part 3

11 Conclusion and Recommendations

Watercare Services Limited (Watercare) are proposing to upgrade the wastewater network within the City Centre of Auckland, due to insufficient capacity to meet future demand. An assessment of dewatering effects in relation to only Part 3-Part4 connector tunnel of the Queen Street Wastewater Diversion is presented in this report.

The environmental effects on neighbouring bores, nearby environmental features (streams and other surface water bodies) and saline intrusion have been assessed to be negligible.

The assessment of settlement effects indicated that settlement associated with the dewatering of the Greys shaft will be less than 8 mm within 2 m of the edge of the shaft. This is less than the settlement estimated for the Mayoral shaft for the Part 3 AEE (WSP 2023c). It is unlikely that the dewatering activity will result in damage from land settlement effects on any of the heritage sites in proximity to the shafts. However, utilities and services in 10 m proximity to the proposed works may require specific investigation and management.

It was proposed in the Part 3 AEE that groundwater level monitoring and ground settlement monitoring should be undertaken adjacent to the Mayoral and Victoria shafts as a conservative

measure. Relevant mitigation measures will be included in the GSMCP. These measures will also benefit the Greys shaft dewatering project and are considered sufficient to address any risk from the dewatering of the Greys shaft.

12 References

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Appendix A
Geotechnical Logs – Greys Shaft

Appendix B
Hydraulic Test Analyses – PZE2

Appendix C
AUP Management Layers (from Geomaps)

wsp.com/nz