



Herne Bay Connector Project

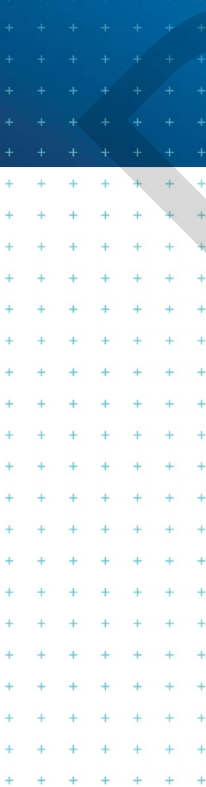
Groundwater and Settlement Monitoring & Contingency Plan

Prepared for
Watercare Services Limited

Prepared by
Tonkin & Taylor Ltd

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Glossary

This glossary defines the specific meaning of certain words and phrases used in this report. Note that some words and phrases used in this report have different definitions and meanings in other literature.

Council	Auckland Council (AC).
Commencement of dewatering	Excavation/tunnelling below groundwater level and/or commencing taking any groundwater. Excludes piling operations.
Completion of dewatering	When excavation/tunnelling below groundwater level is completed, and ground openings are backfilled above the groundwater level.
Commencement of excavation	Excavations deeper than 1.5m and greater than 1 m ³ in volume. Excludes excavation of shaft retention piles.
Completion of excavation	When all tunnelling and excavations have been completed, tunnel liner has been installed, and ground openings have been backfilled.
Completion of construction	Means when the Certificate of Completion is issued by AC.
Minor severity	Damage and defects that are typically localised in nature and their effects are typically of low significance and readily repairable (e.g. hairline cracks).
Moderate severity	Damage and defects that are typically spread over a larger area and/or may be of greater significance and impact upon serviceability (e.g. sticking doors and cracked window panes).
Severe	Damage and defects that are typically widespread in nature and/or their effects are typically of high significance (e.g. visible deformation and crack in structural elements).
Damage	Includes aesthetic, serviceability and severe damage.
Aesthetic damage	Superficial damage and defects that do not affect the use, integrity or serviceability of the item. In certain situations, aesthetic damage may develop into serviceability and/or structural damage. Aesthetic damage may include fine cracks easily treated during normal redecoration, cracks in exterior visible upon close inspection, etc.

Serviceability damage	Damage and defects that may impact the use, integrity or serviceability of the item but have not led to (nor are expected to immediately develop in) structural damage. Serviceability damage may include cracked window panes, uneven pavements, bowing and/or cupping decking boards, sticking windows and doors etc. Over time, serviceability damage may develop into structural damage.
Structural damage	Damage and defects that affect structural components of an item and have the potential to cause structural failure of the item. This may include bulging concrete block walls, detached structural members, decay in structural timber members, differential settlement in foundations resulting in reduced stability etc.
Alert Level	Monitoring reaches a level close to where damage may occur unless movement continues unchecked, and requires review of available monitoring information (plus other information) to assess the future trend.
Alarm Level	Monitoring reaches a level where damage may occur, and requires immediate action including the cessation of ground dewatering and other construction activities that may have an effect on ground deformation.
The Council	Auckland Council (Team Leader, Water Allocation, NRSI) or nominated AC staff acting on The Team Leader's behalf.
NRSI	Natural Resources and Specialist Input, Auckland Council.
RL	Reduced Level.
Services	Includes for example fibre optic cables, sanitary drainage, gas and water mains, power and telephone, road infrastructure assets such as footpaths, kerbs, catch-pits, pavements and street furniture.

1 Introduction

Watercare Services Limited (Watercare) has commissioned Tonkin & Taylor Ltd (T+T) to provide a Draft Groundwater and Settlement Monitoring & Contingency Plan (GSMCP) to support a Resource Consent application for the proposed Herne Bay Connector Project (the Project)¹. The proposed wastewater pipeline will run from Marine Parade at its south-western end to the proposed Central Interceptor drop shaft in Point Erin Park at its north-eastern end.

The GSMCP is based on the following reports prepared for the project:

- Herne Bay Connector Project – Groundwater and Settlement Assessment Report by T+T reference 1090120.v3, dated June 2023.

This GSMCP serves to establish a set of project controls to measure groundwater drawdown and ground settlements, and to address potential geotechnical effects related to the project works. The GSMCP also provides contingency and mitigation measures that may be applied should monitoring results indicate ground settlement and groundwater drawdown to be approaching or likely to exceed established alert and alarm limits. Monitoring plans are shown on Figure 1090120-F1 to 1090120-F7 in Appendix A.

This GSMCP has been prepared for approval by Auckland Council. This report, the proposed monitoring locations, and monitoring trigger levels have been established to reflect the design and construction methodologies proposed at the time of writing. We assess that the trigger levels set within this report are within the damage risk classification presented in our Groundwater and Settlement Assessment Report².

1.1 Project overview

Watercare is working jointly with Auckland Council to deliver the Western Isthmus Water Quality Improvement Programme (WIWQIP), which will reduce wastewater overflows and improve water quality at local beaches. As part of the WIWQIP, this Project will upgrade the existing Branch 5 Sewer in the Herne Bay area by constructing a new wastewater trunk sewer. Upon completion, the new Herne Bay trunk sewer line will connect to the Central Interceptor (CI) wastewater conveyance and storage tunnel (which is to be extended from Tawariki Street in Grey Lynn to a new drop shaft in Point Erin Park).

1.1.1 Project scope

The proposed alignment will comprise:

- Installation of approximately 1.5 km of 2.1 m internal diameter trunk sewer line between Shaft 1 (at Point Erin Park) and Shaft 7 (on Marine Parade), constructed via a tunnel-boring machine (TBM);
- Installation of approximately 150 m of 600 mm diameter trunk sewer within Marine Parade (between Shaft 7 and 8), constructed via open-cut trenching;
- Construction of 8 No. primary tunnel shafts, ranging in diameter from 3.5 m to 13.5 m, along with 4 No. 3.5 m diameter intercepting shafts;
- Installation of 4 interception pipes and 11 connections to existing engineered overflow points (EOPs);

¹ Tonkin & Taylor Ltd, May 2023. *Variation Order, Change Request for Herne Bay Technical Assessment Reporting*. T+T Ref. 1090120.1000

² Tonkin & Taylor Ltd, June 2023. *Herne Bay Connector Project – Groundwater and Settlement Assessment Report*. T+T Ref. 1090120.v3

- Relocation and reinstatement of utilities as required.

The primary purpose of the Project is to reduce engineered overflow spill frequencies resulting from the aging combined sewer network in the area and to comply with Watercare's Network Discharge Consent (NDC) conditions. This is expected to lead to improvements in bathing water quality conditions at the beaches, reduction of odour from stormwater catchpits and improved overall amenity.

1.1.2 Project Alignment

Figure 1.1 and Figure 1.2 below show the proposed alignment and key features of the Project.



Figure 1.1: Eastern portion of the Project

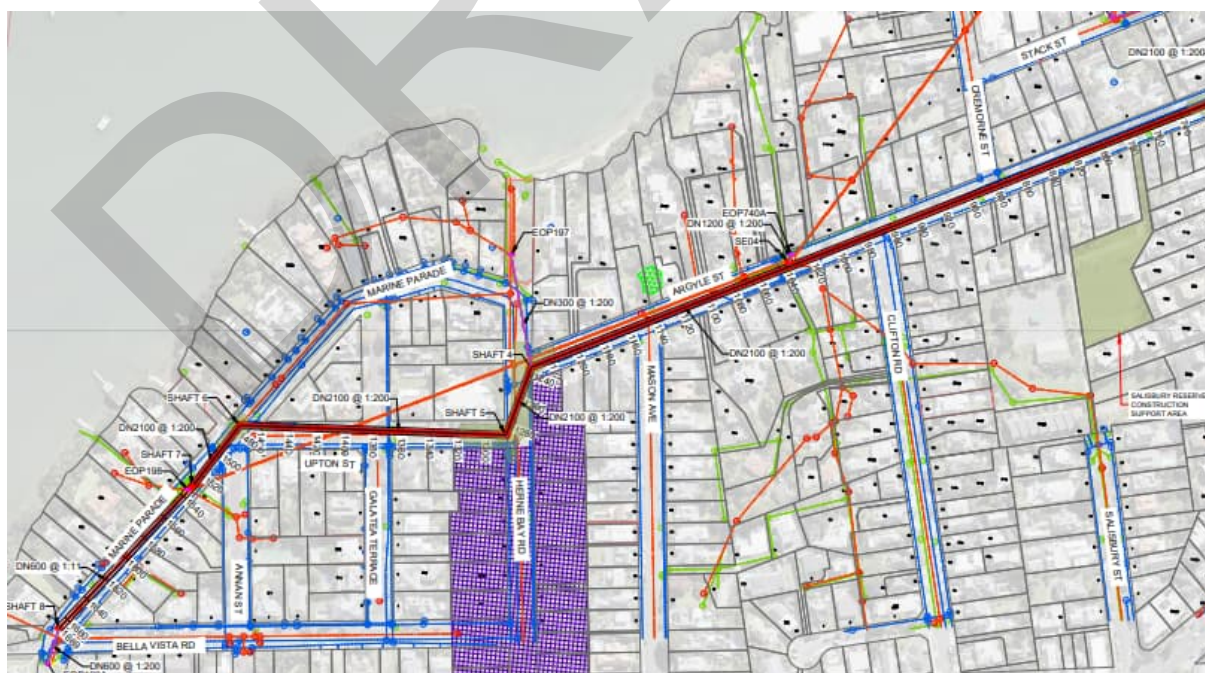


Figure 1.2: Western portion of the Project

1.1.3 Outside of scope – Point Erin Park

The eastern terminus of the Project is at Point Erin Park, where it will connect to the CI extension via a drop chamber, which will be constructed as part of the CI extension project.

The following works within Point Erin Park are covered by the CI extension resource consent application and do not form part of the 'application area' for the Herne Bay Project:

- The construction of the CI tunnel terminal shaft, control chamber, and stub connection to facilitate a potential future connection to the proposed Herne Bay Trunk Sewer tunnel;
- The construction of a plant room to house equipment to control the gates;
- Connections between the terminal shaft, control chamber, vent and plant room; and
- Tree works (pruning, works in the root zone, removal, relocation), and park reinstatement and landscaping following completion of construction works.

1.2 Assessment overview

WSP concept drawings of the scheme³ include two design options being considered for the final tunnel depth along the main alignment.

The final tunnel elevation is to be determined as part of detailed design, and therefore both potential tunnel depths have been considered in this GSMCP and the T+T Groundwater and Settlement Assessment Report (GSAR). While it is anticipated that some details may change as the Project moves through the detailed design process and as construction methodology is confirmed, this GSMCP assumes that the geotechnical and groundwater effects remain within the envelope outlined in the GSAR. All figures and dimensions provided are approximate and will be confirmed during the detailed design stage.

2 Proposed construction methodology

2.1 Main pipeline

2.1.1 Tunnel boring machine

The excavation of the main tunnel alignment between Shaft 1 (at Point Erin Park) and Shaft 7 (on Marine Parade) will be undertaken with an Earth Pressure Balance (EPB) Tunnel Boring Machine (TBM). The TBM will be launched from the thrust shafts and retrieved from the reception shafts, with the concrete liner sections to be placed in behind the TBM as it progresses. Invert levels of the bored tunnel sections are to range between 6.28 m bgl (Option 2 at Shaft 7) and up to 25.24 m bgl (Option 1 at Shaft 5)³.

The TBM is expected to predominantly operate in closed mode (with hydrostatic pressures balanced) for the bored portion of the alignment. It may be necessary to operate the TBM in open mode over short sections of the tunnel alignment, where hydrostatic pressures will not be (or only partially) pressure balanced. Where open mode is used, some groundwater inflow into the tunnel is expected resulting in some depressurisation of the hydrostratigraphic unit / aquifer immediately outside the tunnel. It is anticipated that tunnelling in open mode would only be used where drilling within very weak East Coast Bays Formation (ECBF) rock.

³ WSP (16 February 2023). *Herne Bay Trunk Sewer Upgrade, Marine Parade to Pt Erin*. DWG No. W-SL007.001 – W-SL007.008. Ref No. W-SL007.01.

2.1.2 Open trenching

Between Shaft 7 and Shaft 8, the construction methodology is proposed to comprise open trenching temporarily supported using a slide rail shoring system. The proposed depth of trenching will vary between approximately 2.4 m (Shaft 8) to 5.9 m (Shaft 7) below existing ground levels (bgl).

Where trenches extend below groundwater levels, pumping may be required during construction to limit groundwater inflows into the excavation. The Contractor may choose a different temporary support mechanism from that presented above as the design is developed, provided that the chosen support method can be demonstrated to limit the total ground deformations to the values presented in this GSMCP.

2.2 Primary tunnel shafts (thrust/receiving)

The thrust and receiving shafts are located where the direction of the alignment changes to follow the road alignment and allows for the deployment and retrieval of the TBM. The shafts generally have an external diameter of 9 m and 13.5 m for the receiving and launch shafts, respectively, with a finished shaft invert between 2.42 m deep (Shaft 8) and 25.24 m deep (Shaft 5).

Secant piles will form the shaft walls and will be constructed with a bored piling rig and support crane. The secant piles are proposed to extend to full depth of the shafts. The piled shaft will then be excavated, and a capping ring beam installed. The shaft is expected to be excavated by conventional mechanical equipment (e.g. 23 t excavator with 2 t excavator within the shaft) through overburden soils and East Coast Bay Formation (ECBF) soil and rock.

On completion of the shaft and tunnel excavations, a permanent manhole will be installed within the shaft, the space between the shaft walls and manhole will be backfilled with hardfill, and holes will be cut into the shaft walls to reduce groundwater impedance by the secant piles and allow for groundwater flow around the manhole in the long term.

Given the depth of the proposed shaft excavations, control groundwater inflow will be required to maintain groundwater levels at or below the base of each shaft during the construction period, by way of:

- Exclusion (secant piling extending to or below the base of the shaft will act as a hydraulic barrier impeding groundwater inflow); and
- Temporary dewatering/pumping to maintain groundwater levels below the base of each shaft during the construction period.

2.3 Interceptor Shafts (SE)

Four intercept shafts (SE01 – SE04) will be constructed following the completion of the main tunnel by drilling vertical shafts beside the main tunnel. The interceptor shaft invert levels are proposed to be a minimum of -3.27 m RL (23.89 m bgl) at SE01 and a maximum of 0.89 m RL (12.86 m bgl) at SE04.

A trench box or casing will be installed for the stability of surficial soils prior to drilling of the shaft. This is to extend into competent ground that would maintain stability during excavation. If required, the casing can be extended deeper by welding additional segments as drilling progresses, to maintain stability of the surrounding soils.

The shaft would then be drilled to depth with a 75 t piling rig with a 3.5 m diameter auger following which a temporary steel casing would be installed to full depth. A window will then be cut into the base of the casing and a lateral passage excavated/mined to connect to the main tunnel. Once the lateral passage is lined, the permanent concrete manhole structure will be installed into the shaft

and the temporary casing removed. Grout will then be poured or tremmied into the annulus between the permanent manhole and ground.

Due to the depth of excavation, groundwater inflow control will be required to maintain groundwater levels at or below the base of each shaft during the construction period. Inflow rates are anticipated to be low, and pumping/dewatering would only occur when construction is taking place in the base of the shaft. In practice that would mean that groundwater could refill within the shaft overnight, and it is expected that pumping would mainly be required each morning to provide a reasonably dry work environment for constructability and safety purposes.

If required during construction, contingency options to minimise water inflows during construction may be considered such as concrete seal at the base of the bored shaft.

2.4 Interception pipes

The proposed construction methodology for the interception pipes will generally be undertaken using temporary excavations shored with trench boxes (for shallower excavations where possible) or adopting a similar methodology to that of the intercept shafts at deeper locations. The invert levels of the EOPs are between 1.1 m bgl (9.39 m RL) at EOP202 and 14.56 m bgl (10.48 m RL) at EOP197.

The pipe connections between the EOPs and the main tunnel shafts / intercept shafts are expected to be either trenched or directionally drilled. Open trenching will be undertaken for shallower connections using "traditional construction" with 23 t excavators and slide rail shoring systems with multi-level props to support the sides of the excavation. Directional drilling will comprise excavation of drilling and receiving pits which will be shored with trench shields. A directional drill rig will then be mobilised to site and a bore drilled using a recirculating bentonite slurry. A polyethylene pipe (PE) will be pulled through and the grouted into place.

2.5 Service relocation

The pipeline alignment and shaft locations are to be formed within the road corridor. It is expected that some services may be located within construction zones that therefore may need to be relocated or otherwise protected.

3 Monitoring

3.1 General

Ground settlement and groundwater drawdown monitoring during the construction works will be undertaken to assess if the response of the surrounding structures is within design tolerances. This process allows for the geotechnical effects to be monitored and can act as an indication for mitigation or remedial measures to be implemented if required.

Monitoring and surveying of the following shall be undertaken during construction:

- Building and Ground Settlement Monitoring Points via survey markers.
- Groundwater level monitoring via standpipe piezometers.

The monitoring results will be collected by the contractor prior to and during construction, and collated by the Geotechnical Engineer for comparison with the specified Alert and Alarm trigger levels. Should any Alert or Alarm levels be breached, the responses detailed in the sections below must be implemented.

Monitoring records will be included in summary reports prepared by the Geotechnical Engineer and issued to AC every two months during the implementation of this GSMCP.

3.2 Building and ground settlement monitoring

3.2.1 General

Building and ground settlement monitoring marks shall be established at the approximate locations presented in the Ground settlement monitoring plan (Figure 1090120-F1 to 1090120-F7) presented in Appendix A.

The philosophy of the monitoring programme is to monitor that actual settlements are less than the values that can be expected to result in the onset of minor severity damage to structures under worst-case assumptions.

The potential for the onset of minor damage under worst-case assumptions equates to the Alarm Trigger Level. This corresponds to the point at which remedial actions to prevent further settlement are enacted. Alarm Trigger Levels are presented in Section 3.2.3. Required actions are presented in Section 7.

Each monitoring point has an Alert Trigger Level which represents a settlement at 70% of the Alarm Trigger Level. These are defined in Section 3.2.3. The purpose of the Alert Trigger Level is to provide sufficient notice for additional monitoring and assessment of construction operations to be undertaken prior to the Alarm Trigger Level being reached. The Alert Trigger Level checks that adjacent structures will not suffer damage from either excavation or groundwater drawdown effects.

Building Monitoring Points have been assigned to any structure that lies within the envelope of potential settlement effects adjacent to the TBM thrust / reception shaft or interception shaft excavations. Buildings that are outside the calculated settlement envelope will not be directly monitored. Ground Monitoring Points will be utilised to assess ground movements within and immediately outside the calculated settlement envelope.

The Alert and Alarm settlement levels are uniform for all Building Monitoring Points, as their purpose is to monitor that settlement of a magnitude sufficient to cause minor damage will not occur. A minimum of three monitoring points arranged in a triangular orientation are proposed on each property dwelling to monitor differential settlements as shown on Figure 1090120-F1 to 1090120-F7) (Appendix A).

Ground Monitoring Points have generally been positioned as per the following:

- A minimum of two monitoring points have been placed at the road-side boundary of private properties located adjacent to the main thrust / reception shafts or interception shafts. These monitoring points are intended to check that Alert or Alarm level settlements, should they occur, are limited to the road corridor and provide comparison to building settlement points established on these structures.
- Along the tunnel alignment, monitoring points have been established at the road kerbs alternating either side of the road (and tunnel alignment) at the following spacings:
 - 50m spacings where the tunnel depth is less than 15m below road level.
 - 100m spacings where tunnel depth is greater than 15m below road level.
- Where critical services are located near the proposed works, a ground settlement monitoring point has been located in close proximity to the service.

Vertical survey measurements shall be accurate to +/- 2 mm vertically. It is noted that the settlement markers will be subject to landowner approval when placed on private property, and may require re-locating.

3.2.2 Settlement monitoring intervals

Surveys shall be carried out by the Contractor or their approved surveyor at the intervals outlined in Table 3-1. Although no settlement effects can reasonably be expected to occur beyond 100 m from the work site, those points located at this distance or greater are to be surveyed once a month as a means of assessing the magnitude of natural ground surface elevation fluctuations (i.e. not as a result of the proposed works).

Table 3-1: Settlement monitoring interval summary

Phase	Monitoring frequency
Prior to construction	A minimum 2 baseline readings within 1 month prior to commencement of dewatering
During excavation/dewatering	Weekly for: <ul style="list-style-type: none"> All monitoring markers within 50 m of TBM tunnel/trench excavations All monitoring markers within 20 m of a TBM shaft Fortnightly where: <ul style="list-style-type: none"> All monitoring markers within 100 m of TBM tunnel/trench excavations All monitoring markers within 50 m of a TBM shaft Monthly where: All monitoring markers following establishment of baseline readings (to monitor seasonal fluctuations)
After completion of excavation/dewatering	Monthly for three months or until such time following the completion of excavation and dewatering that stable measurements are demonstrated, and written confirmation is provided from AC to cease monitoring.

Monitoring frequency to be increased as advised by the Geotechnical Engineer at any monitoring point where the measured rate of settlement indicates that the alert or alarm level trigger may be approached prior to the next normally scheduled monitoring round.

3.2.3 Settlement trigger levels

Alert and Alarm Trigger Levels are summarised in Table 3-2. Monitoring data shall be compared with the trigger levels within 24 hours of recording. If an Alert or Alarm Trigger Level is breached, the actions identified in Section 7 of this GSMCP shall be undertaken.

Table 3-2: Ground (G) and Building (B) settlement trigger levels

Monitoring item	Description	Settlement Alert level (mm)	Settlement Alarm level (mm)	Differential settlement Alert level	Differential settlement Alarm level
BS1 to B161	Building monitoring point	7	10	1 in 1000 between any two building settlement survey markers	1 in 700 between any two building settlement survey markers
GS1 to GS106	Ground monitoring points	7	10	1 in 700 between any two ground settlement survey markers	1 in 500 between any two ground settlement survey markers

3.3 Groundwater monitoring

3.3.1 General

Groundwater levels shall be monitored during construction with groundwater monitoring wells installed along the pipe alignment. T+T are currently undertaking ground investigations for the proposed development, which includes installation of 25 No. multi-point Vibrating Wire Piezometers (VWPs). It is intended that these would be utilised to undertake groundwater monitoring during construction of the tunnel and shafts.

The proposed locations of these monitoring positions are shown on Figure 1090120-F1 to 1090120-F7 in Appendix A. The final positions will be confirmed by survey following completion of the investigations, with these location plans updated as required.

Additional monitoring wells may be required during the course of the project if the proposed works is likely to destroy the groundwater monitoring well or if excavations change from the proposed locations.

Should any of the monitoring bores be damaged and become in-operable during construction works, then AC is to be informed and a new monitoring bore is to be drilled at an appropriate nearby location.

3.3.2 Groundwater monitoring intervals

The monitoring installations are to be installed within telemetry instrumentation which allows for near-continuous monitoring to be undertaken at 15-minute intervals.

A groundwater monitoring viewing portal is to be established to view real-time monitoring data across all installations prior to and during construction.

3.3.3 Groundwater trigger levels

Following completion of the ground investigations, long-term groundwater monitoring is to be undertaken in order to establish the baseline groundwater levels across the site. The baseline reading shall be taken as the summer low groundwater level (GWL) where possible and recorded before the commencement of construction.

Following development of the groundwater baseline levels, Alert and Alarm levels will be established with respect to the design assumptions and final tunnel elevation adopted.

Preliminary Alert and Alarm levels prior to establishing baseline readings are summarised in Table 3-3. If the Alert or Alarm levels are reached, the actions outlined in Section 7 shall be carried out.

Table 3-3: Groundwater drawdown trigger levels

Monitoring Well*	Description	Alert level for drawdown below typical summer low GWL (m)	Alarm level for drawdown below typical summer low GWL (m)
<i>To be confirmed following completion of GI</i>	VWP installations monitoring shallow superficial soils (i.e. Alluvium / Residual soils) which may be more prone to drawdown-induced settlement	0.7	1.0
<i>To be confirmed following completion of GI</i>	VWP installations monitoring bedrock geology (i.e. N>30 ECBF / ECBF rock) which are considered at low risk of drawdown-induced settlement	<i>To be confirmed following completion of GI and final tunnel / elevations</i>	

3.4 Underground services settlement monitoring

3.4.1 General

Proposed excavations (trenches, shafts and tunnels), are expected to be undertaken in proximity to various existing underground services including wastewater, stormwater, water, electricity, telecommunications, and gas. These services are constructed of different materials to various standards, and as such may have varying tolerances to deformation.

Settlement trigger level criteria shall be based on the condition of the current asset and its tolerance to deformation. The asset owners shall be consulted to establish deformation tolerances of the given assets, and the associated monitoring requirements.

A number of services are present within a distance where settlement could occur, and as such settlement monitoring at the ground surface will be carried out for these assets where they intersect the estimated settlement area of the proposed works. The critical services are listed below and are presented in Appendix A:

- Wastewater Transmission Line (229VC to 375VC)
- Water Transmission Line (700CLS to 810CLS)
- Stormwater Network (225CONC to 1050CONC) – monitoring to be undertaken for services in excess of 300mm diameter.

Prior to construction a pre-condition survey shall be undertaken on assets that are able to be accessed. The survey may comprise a CCTV condition assessment carried out by adequately qualified personnel, and shall include the following but not limited to:

- 1 Existing levels of aesthetic damage.
- 2 Existing levels of serviceability damage.
- 3 Existing levels of structural damage.
- 4 Existing top of pipe RL (GPS).
- 5 Photographic/video evidence of (1), (2), and (3) above.

If the total or differential Alarm limits are reached during construction in close proximity of the pipe (less than 20 m), a post-construction survey will be done within six months of completion of construction activity covering the items detailed above.

A copy of the pre- and post-construction survey report shall be forwarded to AC within 15 working days of completing the reports along with a certificate from the Chartered Surveyor or Chartered Professional Engineer who has certified that the survey has been completed in a professional manner and is an accurate assessment of the condition of the structure concerned.

The monitoring programme and the vertical Alert and Alarm Trigger Levels for the Ground Monitoring Pins for monitoring underground services is the same as the Ground Monitoring Points presented in Section 3.3.2 unless otherwise agreed upon with the asset owner. If the trigger levels are exceeded, the actions outlined in Section 7 shall be carried out.

4 Pre and post construction condition survey

A pre-construction condition survey of the properties listed in Table 4-1 shall be carried out a maximum of 3 months prior to the commencement of construction and/or dewatering (whichever occurs first). An external survey should be undertaken as a minimum.

Table 4-1: Summary of properties to be surveyed

Building Address	Legal Title	Building Type
28 Sarsfield Street	LOT 1 DP 335655	Residential
30 Sarsfield Street	PART ALLOTMENT 9-10 SECTION 8 SUBURBS OF AUCKLAND	Residential
32 Sarsfield Street	PART ALLOTMENT 9 SECTION 8 SUBURBS OF AUCKLAND	Residential
37 Sarsfield Street	LOT 5 DP 499	Residential
59 Hamilton Road	PART ALLOTMENT 8-9 SECTION 8 SUBURBS OF AUCKLAND	Residential
54 Sarsfield Street	LOT 1 DP 509905	Residential
61 Sarsfield Street	LOT 1 DP 1228	Residential
UNIT 1-6, 65 Sarsfield Street	UNIT 1A AND ACCESSORY UNIT 2 DP 120066	Residential
80 Sarsfield Street	LOT 1 DP 176793	Residential
81 Sarsfield Street*	LOT 1 DP 375454	Residential
56 Sentinel Road	LOT 1 DP 6560	Residential
83B Sarsfield Street	LOT 2 DP 470317	Residential
85 Sarsfield Street	LOT 1 DP 470317	Residential
86 Sarsfield Street	LOT 1 DP 498806	Residential
88 Sarsfield Street	LOT 11 DP 11193	Residential
91 Sarsfield Street	LOT 5 DP 441	Residential
99 Sarsfield Street	LOT 1 DP 202223	Residential
UNIT 1-3, 105 Sarsfield Street	UNIT 1A AND ACCESSORY UNIT 1 DP 107274	Residential
92 Sarsfield Street	FLAT 1 DP 87128, PT LOT 3 DP 7639	Residential

Building Address	Legal Title	Building Type
94 Sarsfield Street	FLAT 2 DP 87128, PT LOT 3 DP 7639	Residential
96 Sarsfield Street	FLAT 3 DP 99775, PT LOT 3 DP 7639	Residential
98 Sarsfield Street	FLAT 4 DP 87128, PT LOT 3 DP 7639	Residential
51 Wallace Street	FLAT 5 DP 87128, PT LOT 3 DP 7639	Residential
2 Stack Street	LOT 1 DP 338779	Residential
58 Wallace Street	PART LOT 2-3 ALLOTMENT 5 OF SECTION 8 SUBURBS OF AUCKLAND	Residential
43 Wallace Street	LOT 2 DP 7639	Residential
41 Wallace Street	PART LOT 1 DP 7639	Residential
39 Wallace Street	LOT 1 DP 454071	Residential
48 Wallace Street	PART ALLOTMENT 5 SECTION 8 SUBURBS OF AUCKLAND AND DP 21470	Residential
50A Wallace Street	PART ALLOTMENT 5 SECTION 8 SUBURBS OF AUCKLAND AND DP 3212	Residential
46 Argyle Street	LOT 1 DP 147	Residential
50A & 50B Argyle Street	LOT 4 DP 31540, LEASEHOLD, FLAT 1 DP 89770	Residential
49A Argyle Street	LOT 1 DP 42614	Residential
45 Argyle Street	LOT 1 DP 448279	Residential
79 Argyle Street	LOT 1 DP 350150	Residential
42 Herne Bay Road	PT LOT 3 ALLOTMENT 1 SECTION 2&8 SUBURBS OF AUCKLAND	Residential
36 Herne Bay Road	DP 11631	Residential
34 Herne Bay Road	PART ALLOTMENT 1 SECTION 8 SUBURBS OF AUCKLAND	Residential
32 Herne Bay Road	Lot 1 DP 145282	Residential
27 Herne Bay Road	Lot 37 DP 2477	Residential
72 Argyle Street	LOT 1 DP 308160	Residential
31 Herne Bay Road	LOT 2 DP 308160	Residential
29 Herne Bay Road	LOT 2 DP 327185	Residential
20 Marine Parade	LOT 1 DP 76835	Residential
16 Upton Street	LOT 1 DP 1214	Residential
31 Marine Parade	LOT 1 DP 510896	Residential
33A Marine Parade	LOT 1 DP 149545, LEASEHOLD, FLAT 1 DP 149545	Residential
35 Marine Parade	LOT 1 DP 29583	Residential
37 Marine Parade	LOT 2 DP 29583	Residential

Building Address	Legal Title	Building Type
39 Marine Parade	LOT 3 DP 29583	Residential
22 Marine Parade	PART ALLOTMENT 1 SECTION 8 SUBURBS OF AUCKLAND	Residential
24 Marine Parade	Lot 1 DP 46328	Residential
51-53 Marine Parade	ALLOTMENT 77 SUBURBS OF AUCKLAND AND LOT 2 DP 90153	Residential
32 Marine Parade & 13 & 17 Bella Vista Road	LOT 3 DP 182886	Residential

* Set out of Building monitoring pins to be co-ordinated as building is currently under construction.

The survey report shall confirm the existing condition of these properties (including dwelling, garage and sheds where applicable). Major features of the buildings and site developments shall be recorded including location, type of construction, age and present conditions including defects.

The survey shall include, but not limited to the following:

- 1 Type of foundations (where observable or otherwise inferred).
- 2 Condition of existing asset including existing level of damage.
- 3 Susceptibility of structure to further movement and damage.
- 4 Review of proposed Alert and Alarm levels to confirm they are appropriately set based on the building type and condition.
- 5 Photographic evidence of (1), (2), and (3) above.

During construction, visual observations of the structure and surrounding ground of the assets identified in the pre-construction property survey shall be performed on a fortnightly basis where properties are within 25 m of active works. Additional observations may be required if requested by the building or asset owner.

Within six months of completion of construction, a post-construction survey covering the items detailed above shall be completed for any building that had a pre-construction survey carried out. The survey report shall include a determination of the cause of damage identified (if any) since the pre-construction or previous survey and steps to repair it.

A copy of the pre and post-construction survey reports shall be forwarded to AC within 15 working days of completing the reports. Reports should be reviewed and signed by a Chartered Professional Engineer who has certified that the survey has been completed in a professional manner and is an accurate assessment of the condition of the buildings concerned.

5 Summary of monitoring frequency

The monitoring frequency requirements detailed in the previous sections are summarised in Table 5-1 below.

Table 5-1: Summary of monitoring frequency requirements

Monitoring system	Monitoring Locations	Prior to commencement excavation	During excavation and dewatering	After completion of excavation and dewatering	After completion of construction
Settlement monitoring points	BS1 – BS161 GS1 – GS106	A minimum of 2 baseline readings, 1 month prior to construction	Weekly for: <ul style="list-style-type: none"> All monitoring points within 50 m of TBM tunnel/trench excavations All monitoring points within 20 m of a TBM shaft Fortnightly where: <ul style="list-style-type: none"> All monitoring points within 100 m of TBM tunnel/trench excavations All monitoring points within 50 m of a TBM shaft Monthly where: <ul style="list-style-type: none"> All monitoring points within 100 m of a TBM shaft 	Monthly for three months or until such time following the completion of excavation and dewatering that stable measurements are demonstrated and written confirmation is provided from AC to cease monitoring.	Post-construction condition survey of dwellings
Vibrating-wire piezometer	TBC	Baseline readings to be undertaken prior to work commencing to establish seasonal fluctuation	'Continuous' monitoring at 15-minute intervals to be undertaken using telemetry instrumentation. Monitoring records to be available via online monitoring portal. Automatic warning system to be established for Alert / Alarm trigger levels.	Monitoring portal to be available for three months or until such time following the completion of excavation and dewatering that stable measurements are demonstrated and written confirmation is provided from AC to cease monitoring.	N/A

6 Reporting of monitoring records

6.1 Baseline readings

Baseline readings for ground and building deformation shall be established before the commencement of excavation, including piling works.

These baseline readings shall be compiled and submitted to AC's representative for approval prior to commencement of dewatering.

Groundwater monitoring shall be undertaken throughout the summer period when possible. The lowest recorded groundwater level during monitoring will season will be taken as the baseline level.

All monitoring results shall be submitted to AC and written confirmation provided prior to beginning works.

6.2 Reporting intervals and requirements

All monitoring records as detailed in this report shall be compiled and submitted to AC's representative at 2-month intervals from the commencement of excavation until three months after the completion of excavation and dewatering (or at such time following the completion of excavation that stable measurements are demonstrated and written confirmation is provided from AC).

Each report shall include the following:

- 1 Monitoring records presented in a tabulated format as well as on a timeline plot with rainfall data.
- 2 Comparison of monitoring data with trigger levels.
- 3 Previous results set out with an explanation of any trends.
- 4 A construction progress summary.
- 5 Results of fortnightly visual observations of the structure and surrounding ground of the assets identified in the relevant pre-construction property survey.
- 6 Any other information relevant to the reporting period (i.e. exceedance of trigger levels and contingency measures being undertaken).

7 Alert and Alarm trigger level response procedures

7.1 Response procedure if the Alert trigger levels are exceeded

If any of the monitoring Alert trigger levels are reached, then one or more of the contingency options described in Section 8 of this plan shall be carried out together with the following:

- 1 Notify the Project Manager.
- 2 Notify AC, in writing within one working day of the trigger level being exceeded, with details of any actions being undertaken.
- 3 Survey all survey monitoring marks within 25 m of the affected monitoring marks to confirm the extent of deformation and exceedance of the Alert trigger.
- 4 Review the monitoring data, as-built details and geology, and compare against the assumptions made in the design analyses.
- 5 Submit a written report by a Chartered Professional Engineer to AC for approval, within one week of trigger level exceedance, which provides analyses of all monitoring data, including excavation retention deflection monitoring, relating to the exceedance of any of the trigger

levels and any recommendations for remedial actions and time frames for implementing these actions.

- 6 If considered necessary:
 - Increase monitoring frequency.
 - Develop a detailed contingency plan and submit to AC.

7.2 Response procedure if the Alarm trigger levels are exceeded

If the monitoring Alarm trigger levels are reached for any ground, building, excavation retention, or service deformation, then the following shall be carried out for the different works in addition to the actions outlined in Section 7.1:

- 1 Cease further excavation (including tunnelling) or any other activity such as dewatering which has the potential to cause further deformations. Dewatering will not cease where this may result in the potential loss of the TBM or cause instability in an excavation.
- 2 Submit a written report by a Chartered Professional Engineer to AC for approval, within one week of Alarm trigger level exceedance, which provides analyses of all monitoring data and any recommendations for remedial action.
- 3 Once approved by AC the recommendations shall be implemented.

Dewatering and/or construction may be resumed once AC's representative provides written notice to the Contractor that AC's representative is satisfied that damage to buildings, structures and services is unlikely with or without any approved additional mitigation measures to be undertaken and that AC is satisfied that owners of potentially affected buildings, structures and services have given written approval for construction to continue.

8 Contingency options

8.1 General

If any of the monitoring trigger levels are exceeded the general response will be as detailed in Section 7. Specific actions will be selected depending on the exact nature of the problem. Possible contingency actions are detailed in the following sections.

8.2 Ground and building deformation contingency measures

In the event of ground or building deformation exceeding the monitoring trigger levels, one or more of the following actions shall be taken:

- 1 Review pre-construction condition surveys of the affected building, followed up by discussions on the situation with the property/service owner that may be affected.
- 2 If deformations are due to groundwater drawdown, groundwater injection to commence.
- 3 Monitor the rate of settlement (assuming that other steps have been undertaken to address the cause).
- 4 Check public safety is maintained.

8.3 Underground service settlement contingency measures

Contingency measures for the settlement of underground services shall be established with the asset owner.

9 Monitoring and contingency plan review

The GSCMP shall be reviewed as required during construction to reflect on any changes that relate to implementation of the GSCMP. Reviews shall take into consideration the following:

- Changes in ground conditions and or site conditions.
- Changes in existing structures.
- Changes in analysis, design or construction methods.
- Changes in legal requirements, consent conditions, guidance notes, industry best practices standards, etc.
- Unresolved comments and/or complaints and responses to the complaints and remedial action (if taken) to the address.

10 Applicability

This report has been prepared for the exclusive use of our client Watercare Services Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:

Authorised for Tonkin & Taylor Ltd by:

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Kishan Ranchhod
Geotechnical Engineer

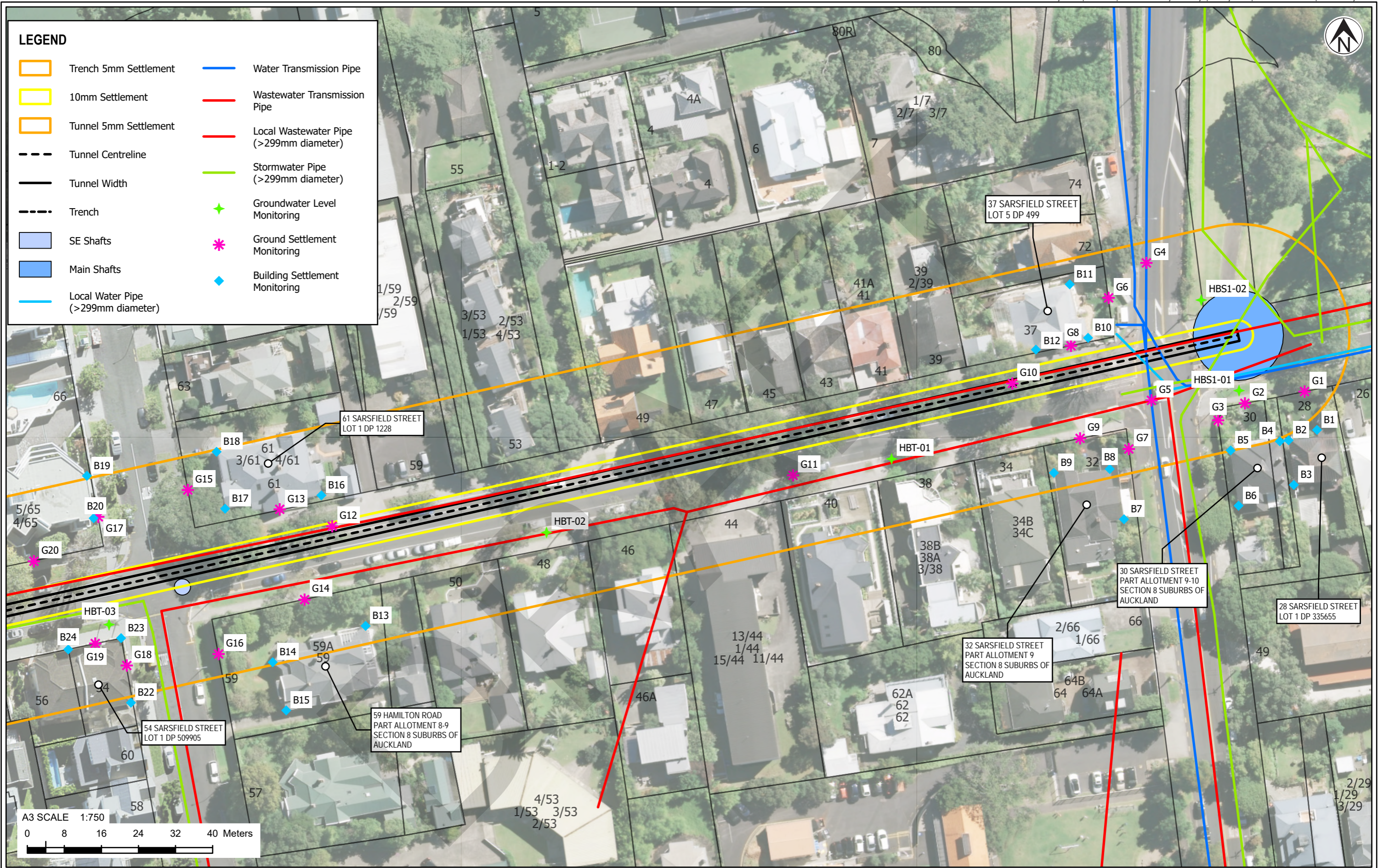
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Shannon Richardson
Project Director

Report has been reviewed by Mark Thomas, Senior Geotechnical Engineer

9-Jun-23

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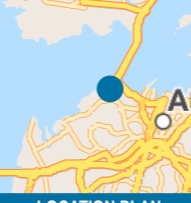
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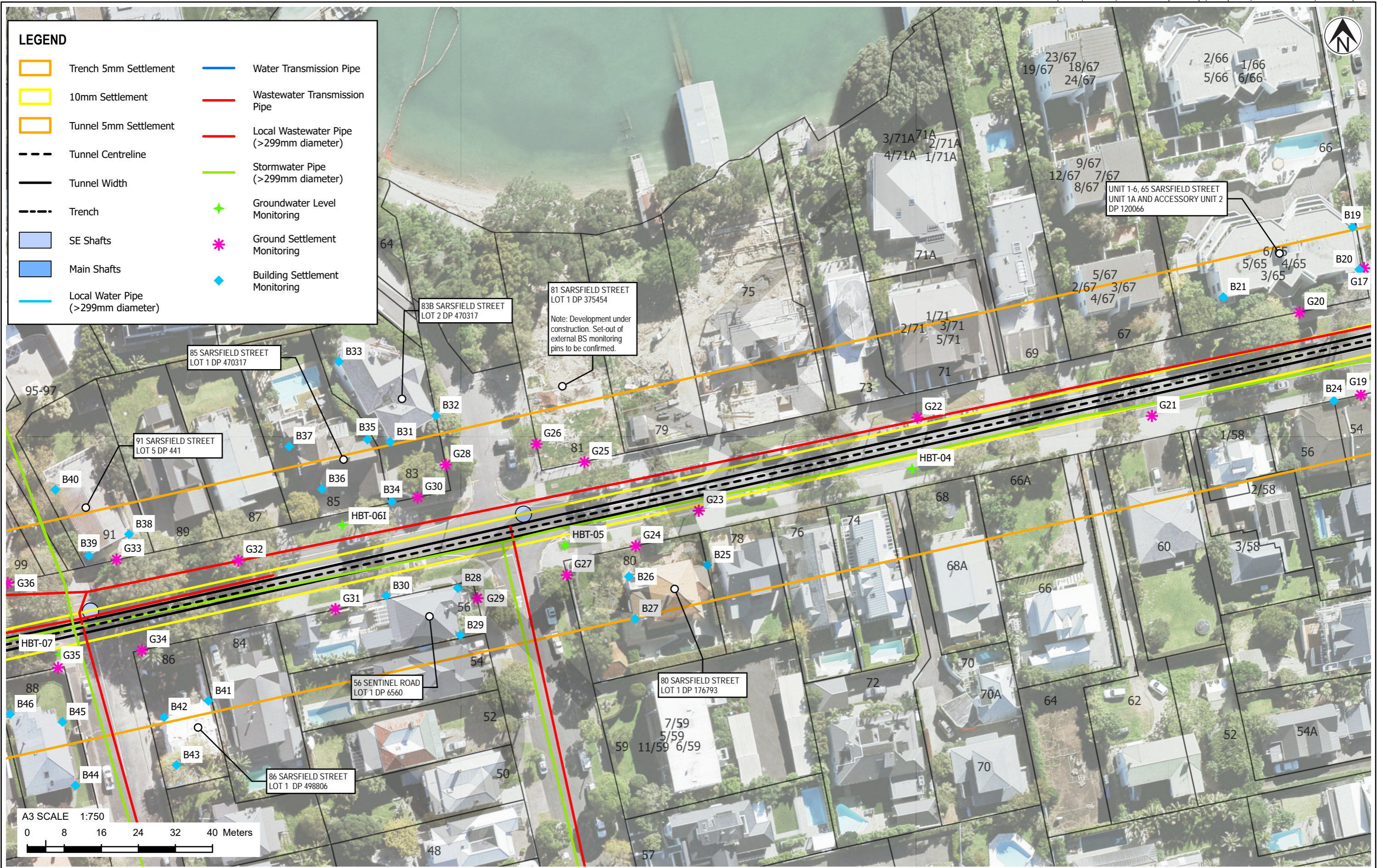
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REV	DESCRIPTION	GIS	CHK	DATE



PROJECT No.	1090120	
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DRAWN	KIRA	JUN.23
CHECKED	RSXW	JUN.23
APPROVED	DATE	

CLIENT	WATERCARE SERVICES LIMITED	
PROJECT	HERNE BAY CONNECTOR	
TITLE	GROUND SETTLEMENT MONITORING PLAN - SHEET 1 OF 7	
SCALE (A3)	1:750	FIG No. 1090120-F1
		REV 0

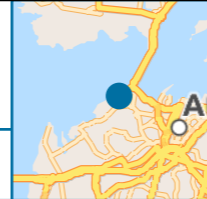


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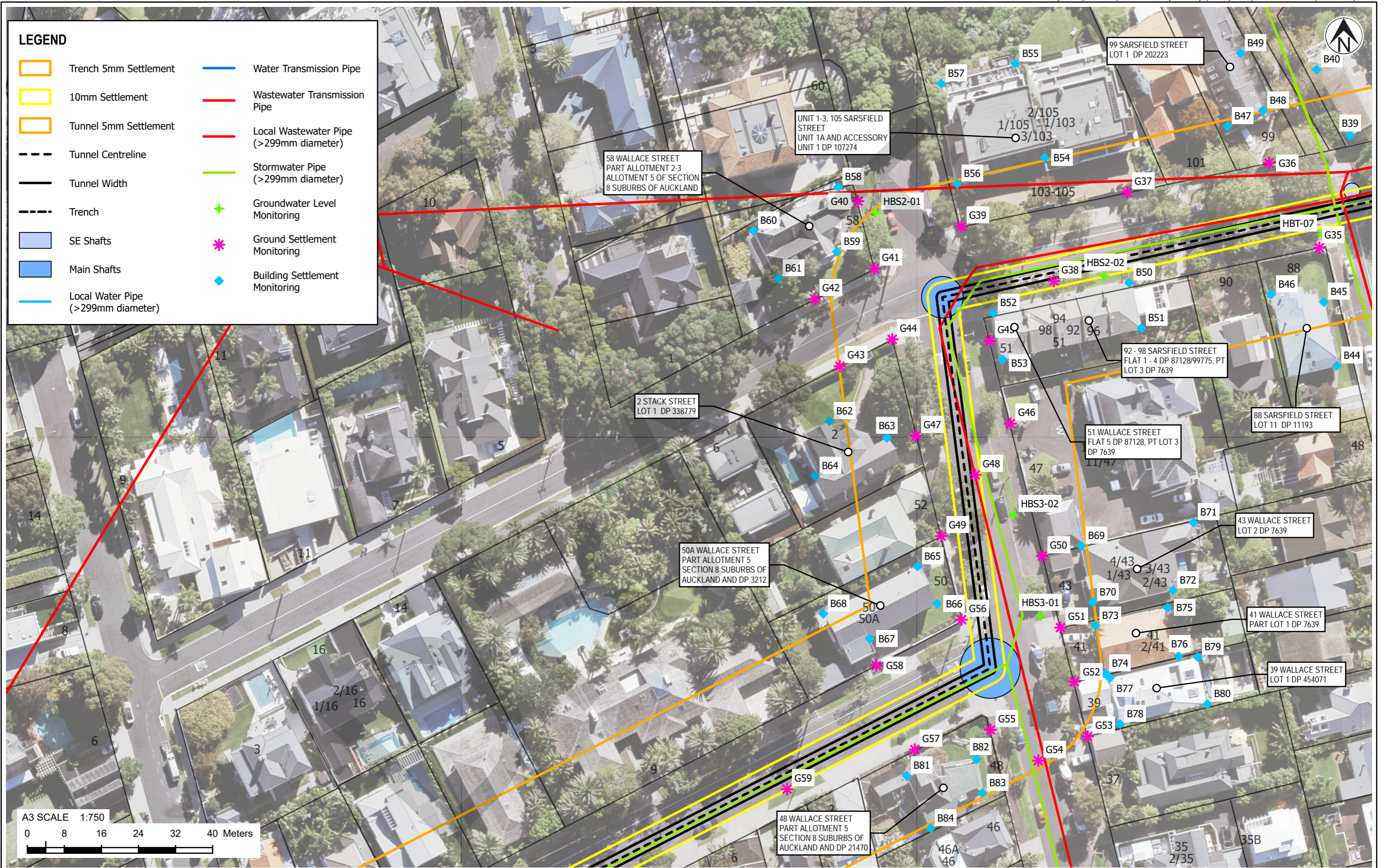
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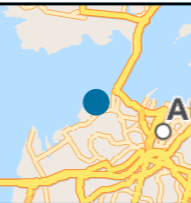
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PROJECT	HERNE BAY CONNECTOR
TITLE	GROUND SETTLEMENT MONITORING PLAN - SHEET 2 OF 7
SCALE (A3)	1:750
FIG No.	1090120-F2
REV	0



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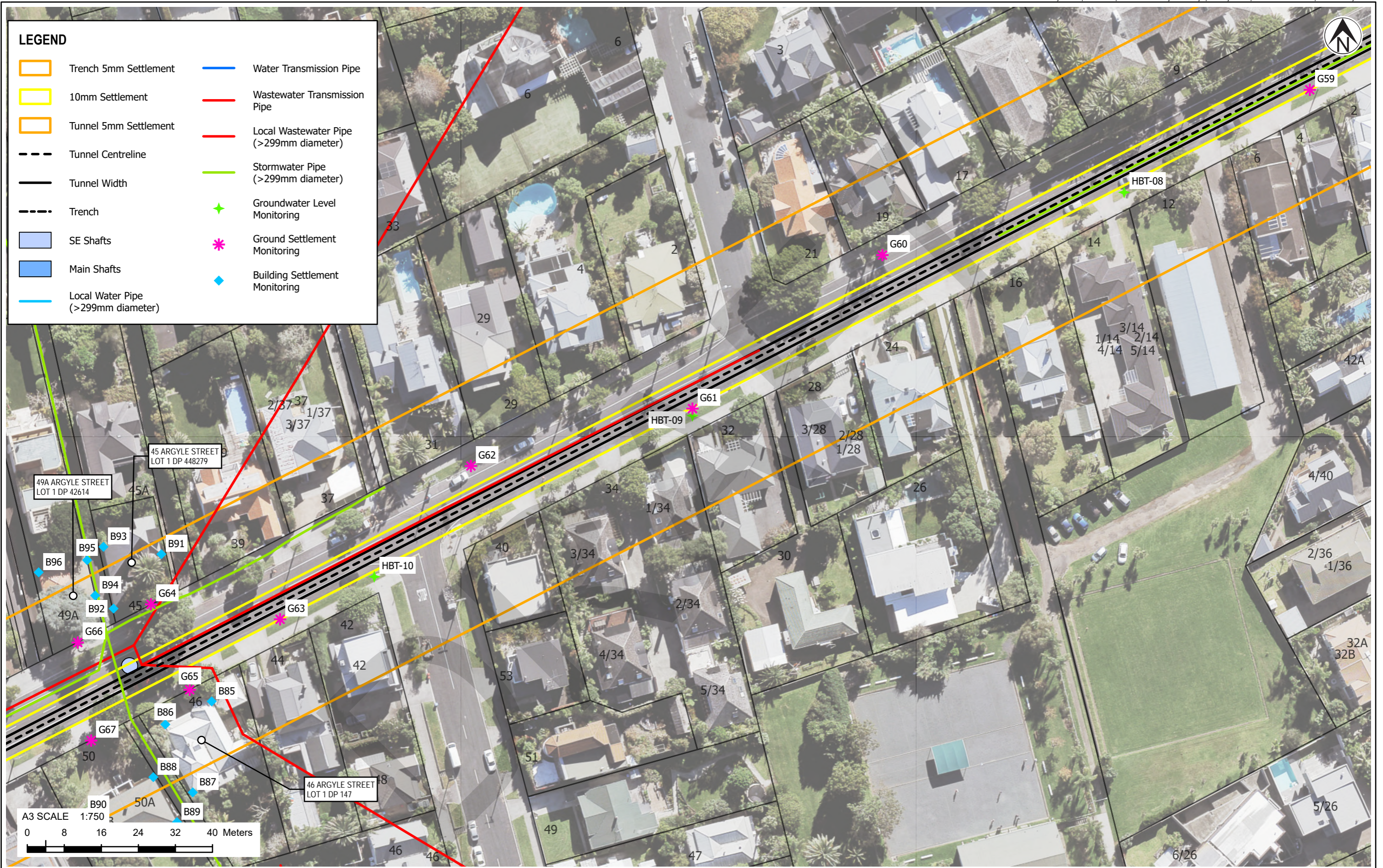
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CLIENT	WATERCARE SERVICES LIMITED
PROJECT	HERNE BAY CONNECTOR
TITLE	GROUND SETTLEMENT MONITORING PLAN - SHEET 3 OF 7
SCALE (A3)	1:750
FIG No.	1090120-F3
REV	0

REV	DESCRIPTION	GIS	CHK	DATE	APPROVED	DATE

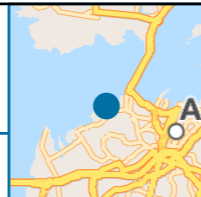


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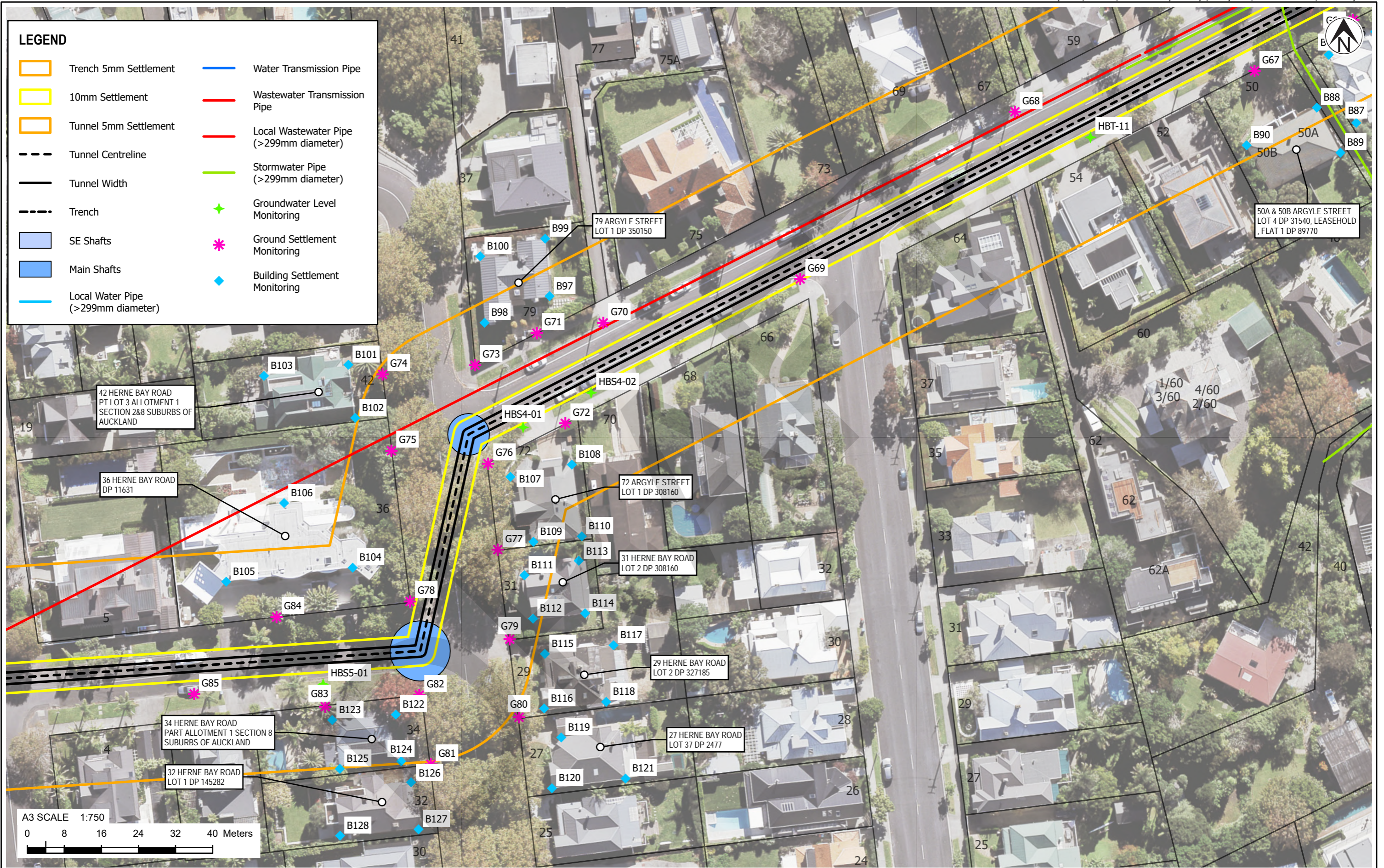
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CLIENT **WATERCARE SERVICES LIMITED**
 PROJECT **HERNE BAY CONNECTOR**

TITLE **GROUND SETTLEMENT MONITORING PLAN - SHEET 4 OF 7**

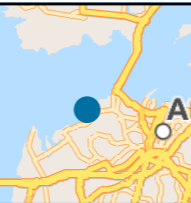
SCALE (A3) 1:750 FIG No. 1090120-F4 REV 0



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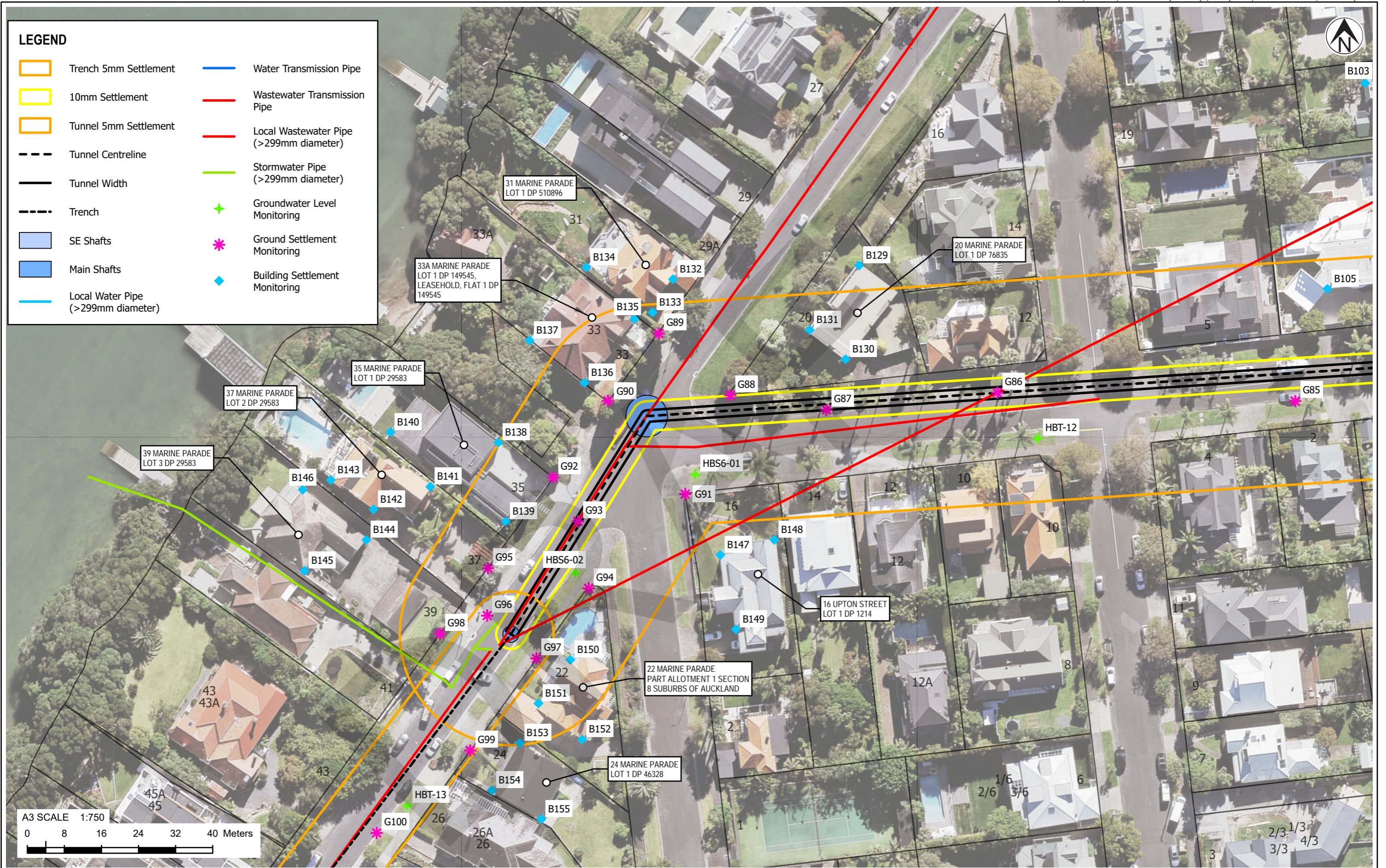
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PROJECT	HERNE BAY CONNECTOR
TITLE	GROUND SETTLEMENT MONITORING PLAN - SHEET 5 OF 7
SCALE (A3)	1:750
FIG No.	1090120-F5
REV	0

REV	DESCRIPTION	GIS	CHK	DATE	APPROVED	DATE
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TITLE **GROUND SETTLEMENT MONITORING PLAN - SHEET 6 OF 7**

SCALE (A3) 1:750 FIG No. 1090120-F6 REV 0

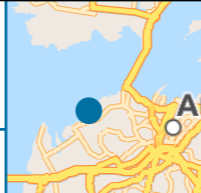


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TITLE **GROUND SETTLEMENT MONITORING PLAN - SHEET 7 OF 7**

SCALE (A3) 1:750 FIG No. 1090120-F7 REV 0

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