REPORT

Tonkin+Taylor

Groundwater and Settlement Monitoring & Contingency Plan

Northern Interceptor Phase 2 (NI2) Project

Prepared for
Watercare Services Limited
Prepared by
Tonkin & Taylor Ltd
Date
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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 pile hole drilling operations.
Completion of dewatering	When all excavation/tunnelling is completed below the groundwater level, 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 pile hole drilling operations.
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 (WSL) has engaged Tonkin & Taylor Ltd (T+T) to undertake an Assessment of Effects (AoE) for Groundwater and Settlement for the Phase 2 of the Whenuapai Redhills Wastewaters Servicing Scheme.

As part of our services under the T+T order of service dated 29 April 2021[1], we have been asked to prepare a draft Groundwater and Settlement Monitoring and Contingency Plan (GSMCP) to support a Resource Consent application for the Northern Interceptor Phase 2 (NI2) Project. Monitoring plans are shown on Figure 1015506-F1 to Figure 1015506-F11 in Appendix A.

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

- Northern Interceptor Phase 2 (NI2) Project, Groundwater and Settlement Effects Assessment by T+T reference 1015506.v2.

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.

This report, the proposed monitoring locations, and monitoring trigger levels reflect the confirmed detailed design and construction methodologies that will be adopted during construction as presented to us at the time of authoring this report (refer to Section 2). We assess that the trigger levels set within this report are within the damage risk classification presented in our Groundwater and Settlement Effects Assessment[2]. If construction methods change, this report should be reviewed to ensure that appropriate monitoring measures are in place.

A final GSMCP shall be prepared and submitted to the Engineer and Council a minimum of one month prior to the commencement of baseline readings for approval. The final GSMCP shall include drawings prepared by the Contractor showing the location and type of all instruments to be installed for the purposes of monitoring, and include any requirements outlined in the Consent.

1.1 Project overview

The projected Northern Inceptor Phase 2 Project (**Error! Reference source not found.**, below) forms a section of a new wastewater pipeline that will be built in stages to redirect wastewater from the north-western parts of Auckland to the Rosedale Wastewater Treatment Plant. This plan covers Phase 2 of works and includes the construction of approximately 4 km of wastewater pipeline between a new Break Pressure Tank (BPT) at 32 Mamari Road, Whenuapai, and the existing Hobsonville Pump Station at 2A Buckley Avenue, Hobsonville.

Construction of the project is expected to be broken down into the following phases:

Phase	Description of Work
Phase 2	• **Massey Connector Gravity Pipeline** – construction is planned to start from 27 Trig Road, progressing north-west to the Break Pressure Tank (BPT) at 32 Mamari Road

[1] Tonkin + Taylor Ltd, Offer of Service, Northern Interceptor Phase 2, Assessment of Groundwater & Settlement Effects and Monitoring & Contingency Plan, Job No. 1015506, dated 29 April 2021

[2] Tonkin + Taylor Ltd, Groundwater and Settlement Effects Assessment, Job No. 1015506 v2, dated July 2023

	• **Northern Interceptor (Main) Gravity Tunnel** – construction is planned to start from Shaft 17 adjacent to Hobsonville Pump Station, progressing south-west to 27 Trig Road
	• **Pump Station Connection** – construction is planned to start from the Northern Interceptor tunnel and connect to the existing Hobsonville Pump Station

Nine circular shafts are proposed along the extent of the project, inclusive of the excavations for MH1 and MH2.

1.1.1 Massey Connector

As shown in Figure 1.1 below, the Massey Connector will comprise an approximately 1 km long new gravity pipeline from the Break Pressure Tank (BPT) and passing beneath SH18 to 27 Trig Road. Land use along the proposed alignment comprises residential lots along Spedding Road and grassed paddocks between Spedding Road and the northern SH18 berm.

The pipeline will comprise:

- A gravity pipeline 1 km long with an invert level between approximately 8 m and 30 m below ground level;
- 2100 mm inside pipe diameter.

The ground elevation along the Northwest section of the Massey Connector is gently inclined, with a relatively steady increase in gradient from 37 mRL at Mamari Road to 50 mRL at the junction between Spedding Road and Trig Road. The ground elevation undulates significantly south-east of Trig Road and declines to approximately 20 mRL at the east extent of the alignment.

1.1.2 Northern Interceptor (Main) Tunnel

A new gravity tunnel is proposed to be constructed from the eastern extent of the Massey Connector at 27 Trig Road, continuing north-east to the Hobsonville Pump Station. The alignment is bordered by SH18 to the north and residential, business, and light industrial zones and stormwater treatment ponds to the south.

The main tunnel will comprise:

- A gravity tunnel 2.8 km long with an invert level between approximately 8 and 30 m below ground level;
- 2100 mm inside pipe diameter.

1.1.3 Pump Station Connection

As shown in Figure 1.1 below, the Pump Station connection is proposed between the Northern Interceptor tunnel and the existing Hobsonville Pump Station comprising:

- A connection approximately 40 m in length with an invert level between approximately 6 and 5 m below ground level;
- 600 mm inside pipe diameter.

This connection includes excavations for two manholes, MH1 and MH2.

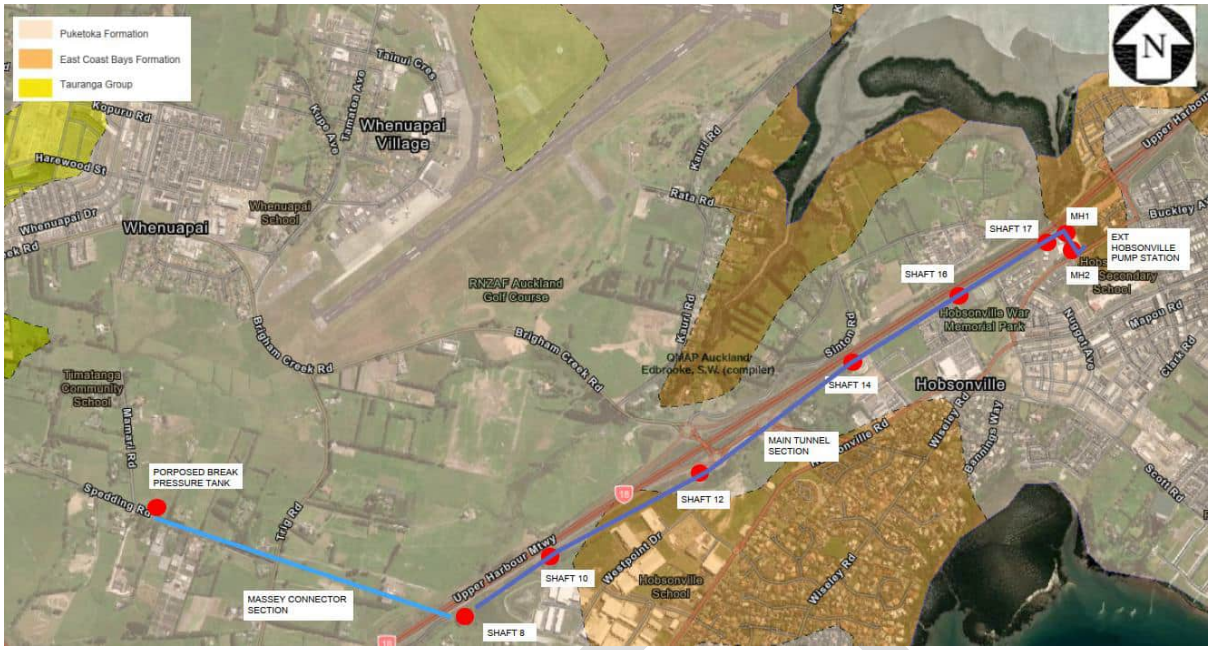

Figure 1.1. Proposed Whenuapai Redhills Wastewaters Servicing Scheme

2 Proposed construction methodologies

The proposed construction methodology has been summarised from the memorandum prepared by Brian Perry Civil Ltd, dated 25 March 2022[3].

The proposed underground structures for the Northern Interceptor that are part of this assessment includes the BPT shaft at the western extent of the alignment, the six shafts to be constructed along the southern side of SH18, and the two smaller shafts near the Hobsonville Pump Station to allow for the installation of MH1 and MH2. An Earth Pressure Balance (EPB) tunnel boring machine (TBM) is to be used for the excavation from the BPT through to shaft 17 (by the Hobsonville Pump Station). Trenchless construction methods such as Trenchless Horizontal Direction Drilling (HDD) are proposed from shaft 17 through to MH1 and MH2; and open trench excavation for the remaining alignment to connecting into the existing Pump Station.

The details of the shafts are summarised in

[3] Brian Perry Civil Ltd, Construction Methodology, Whenuapai Redhills Package 2 (WRP2) – Tunnel, Shafts, Structures, BPT (Break Pressure Tank) and Hobsonville Pump Station connection, Revision A1, dated 25 March 2022

Table 2.1 and the locations are shown on Figure 1.1. The proposed construction methodology for all shaft structures, except MH1 and MH2, comprises secant piles arranged in a circular arrangement extending through the overburden soils (Tauranga Group Alluvium and ECBF soils) and embedding into the ECBF rock. Lateral stiffening support may be provided by the use of ring beams if required by the designer.

The construction methodology for MH1 and MH2 is specified to comprise an excavation support system that provides seepage control. The details of the construction methodology have not yet been confirmed. For the purposes of assessing groundwater drawdown, secant piles with a 3 m embedment below the base of the excavation for MH1 and sheet piles with a 1.5 m embedment below the base of the excavation for MH2 have been assumed Further assessments are required to assess pile depths for stability purposes.

All shaft excavation supports have been specified to impede groundwater flow into the shafts during construction, and therefore limit groundwater drawdown. Groundwater modelling undertaken to support the consent application incorporates a low permeability liner through the soils at the site.

It is expected that construction of the secant pile supported shafts will take approximately 24 months in total (from site preparation works through to sealing and reinstatement) although potentially longer (up to 36 months maximum). MH1 and MH2 are expected to take up to 60 days.

Following construction, a permanent water-tight concrete lining will be installed around the shaft walls and base, forming a complete seal from groundwater intrusion.

Table 2.1: Shaft details

Shaft ID	Inner Shaft Diameter (m)	Approximate Shaft Depth (m)	Pipe Invert Level (m RL)	Depth of piles (m)	Secant Pile Configuration	Type	Launch / Reception of TBM
BPT	7.5	9.4	28.88	14.0	900 mm dia at 700 mm c/c	Permanent Access	Reception
Shaft 8 (LS8)	13.0	17.7	7.54/5.32 *	19.5	900 mm dia at 700 mm c/c	Permanent Access	Launch
Shaft 10 (RS10)	6.75	26.7	4.79	34.1	750 mm dia at 550 mm c/c	Temporary	Reception
Shaft 12 (LS12)	11.25	18.6	4.19	21.0	750 mm dia at 550 mm c/c	Temporary	Launch
Shaft 14 (RS14)	7.5	25.3	3.57	28.0	900 mm dia at 700 mm c/c	Permanent Access	Reception
Shaft 16 (LS16)	11.25	21.5	3.10	26.7	800 mm dia at 550 mm c/c	Temporary	Launch
Shaft 17 (RS17)	12.0	14.0	2.60	190	900 mm dia at 700 mm c/c	Permanent Access	Reception / Launch**
MH1	6.0	4.5	2.39	TBC	TBC	Permanent Access	Reception / Launch
MH2	2.5	5.1	1.86	TBC	TBC	Permanent Access	Reception

* Invert levels listed are for the pipeline connecting to the LS8 shaft from the BPT and RS10, respectively.
** RS17 is a reception shaft for the 2.1 m diameter tunnel boring machine and the launch shaft for the smaller TBM to install the 0.6 m diameter pipeline to MH1.

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.
- Excavation retention monitoring via Ground Monitoring Pins placed behind the ground retention walls.
- Groundwater level monitoring via standpipe piezometers.
- Critical underground services settlement monitoring via Ground Monitoring Pins located directly above the monitored service.

The monitoring locations and baseline readings shall be established prior to construction as outlined in this document. 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 (refer to Section 3.6.3 of this Plan). Should any Alert or Alarm levels be breached, the responses detailed in the sections below shall 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 Datums

A common datum shall be selected for all construction stage monitoring. Unless otherwise agreed in writing, the horizontal coordinates are to be taken in terms of New Zealand Transverse Mercator Projection based on NZGD2000 datum and vertical levels in terms of Auckland Height Datum 1946.

3.3 Operational life

All monitoring locations shall remain operational for a minimum of 3 months post completion of the proposed works. Where possible, monitoring points shall be located in such a manner that construction activities are unlikely to result in damage or inability to access the monitoring point during construction. If a monitoring point is damaged or becomes inoperable during construction, a replacement monitoring point shall be established in the same location as the damaged point within 1 monitoring round from being identified as damaged.

3.4 Data management

An electronic database of all monitoring locations and their results shall be created and maintained throughout the required monitoring period in Microsoft Excel or similar.

All monitoring locations shall also be surveyed (x, y, z coordinates) and presented on a plan that is made available electronically and is compatible with GIS or CAD software (Autodesk, ArcGIS, MicroStation or similar).

3.5 Data collection

A telemetry system should be used where practical to record near real-time data and centralise data collection. This system can be linked to automatic alerts via email and SMS if specified thresholds are

reached. Such systems have the advantage of improving Health and Safety on the project by reducing staff exposure to site risks, the carbon footprint associated with travel and risk by providing near live data to proactively respond to observed changes.

3.6 Building and ground settlement monitoring

3.6.1 General

Building and ground settlement monitoring marks shall be established at the approximate locations presented in the Ground Settlement Monitoring Plan (Figures 1015506-F1 to 1015506-F11) presented in Appendix A.

Building monitoring points shall be affixed to structural elements of the building where possible to monitoring actual building movement such as foundations and building columns. Placement of monitoring points on cladding or non-structural elements is likely to result is non-representative building movement.

Ground settlement monitoring points shall be installed into existing paving. Where paving is not present, the monitoring pins shall extend a minimum of 600 mm into the ground and be sleeved to minimise the effects of season shrink/swell on the pin.

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.

The potential for the onset of minor severity 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 3.6.3. 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 3.6.3. 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 Settlement Points denoted as B-XX have been assigned to any structure that lies within the envelope of potential settlement effects (greater than 5 mm settlement) adjacent to the tunnel alignment, pump station, and shafts. 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 unless otherwise agreed, as their purpose is to monitor that settlement of a magnitude sufficient to cause minor severity 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 Figures 1015506-F1 to 1015506-F11 (Appendix A).

Ground Monitoring Settlement Points denoted as G-XX are generally located at the road-side boundary of SH18 to check that Alert or Alarm level settlements, should they occur, are limited to the project site and general Watercare designation. They have also been placed as an array at approximately 400 m centres along the pipeline alignment. The array spacing is 0, 2, 5 and 10 m to either side of the pipeline centreline.

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.

3.6.2 Settlement monitoring intervals

Surveys shall be carried out by the Contractor or the contractor's 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.

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: • All monitoring markers within 50 m of TBM tunnel/trench excavations • All monitoring markers within 30 m of a TBM shaft or manhole excavation Fortnightly where: • All monitoring markers within 100 m of TBM tunnel/trench excavations • All monitoring markers within 50 m of a TBM shaft or manhole excavation Monthly where: • All monitoring markers within 100 m of a TBM shaft or manhole excavation
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.

3.6.3 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
B-X to B-XX	Building monitoring points	7	10	1 in 1000 between any two building	1 in 700 between any two building

Monitoring item	Description	Settlement Alert level (mm)	Settlement Alarm level (mm)	Differential settlement Alert level	Differential settlement Alarm level
				settlement survey markers	settlement survey markers
G-X to G-XX	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

3.7 Excavation retention deflection monitoring

3.7.1 General

All retention systems for shafts and manhole structures shall be monitored for lateral deflection. Each secant pile shaft shall have a minimum of 4 deflection monitoring points installed at the top of the retention system, and 1 inclinometer that shall be installed within one of the secant piles to the base of the pile.

Where sheet piles are used to enable excavations (potential at MH1 and MH2), the inclinometer can be omitted due to the smaller and shallower nature of these excavation. However, a minimum of 4 deflection monitoring points shall still be installed at the top of the sheet pile retention system.

The purpose of these monitoring points is to observe the horizontal and vertical movements of the retention system to predict deformations that may extend beyond the excavation. Survey markers shall be monitored for both vertical and horizontal movement.

Survey measurements of the retaining structure monitoring points shall be accurate to +/- 2 mm vertically and +/- 5 mm horizontally. The inclinometer probe should have an overall resolution of ±0.025 mm per 500 mm of casing and a system accuracy of ±6 mm per 30 m length of casing. The repeatability should be ±1 mm per 30 m length.

3.7.2 Excavation retention monitoring intervals

Surveys shall be carried out by the contractor or the contractor's approved surveyor at the intervals specified in Table 3-3.

Table 3-3: Excavation retention monitoring intervals

Phase	Monitoring frequency
Prior to excavation	A minimum of 2 baseline readings within 1 month prior to commencement.
During excavation/dewatering	Weekly
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 may be reduced if stable measurements are observed, and written confirmation is provided by AC.

3.7.3 Excavation retention deflection trigger levels

Trigger Levels for horizontal displacement are presented in Table 3-4. If the trigger levels are exceeded, the actions outlined in Section 7 shall be carried out.

Table 3-4: Excavation retention trigger levels

Monitoring item	Alert Trigger Level (mm)	Alarm Trigger level (mm)
R-X-R-XX (retaining wall monitoring pins)	5	7
INC-X-INC-XX (inclinometers)	5	7

3.8 Groundwater monitoring

3.8.1 General

Groundwater levels shall be monitored at the groundwater monitoring wells installed along the pipe alignment identified on Figures 1015506-F1 to 1015506-F11 (Appendix A). Additional monitoring wells may be required during the course of the project if the proposed works is likely to destroy groundwater monitoring wells. Where possible, the replacement monitoring wells should be installed a minimum of 1 month prior to decommission the existing well to establish correlated readings.

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.

3.8.2 Groundwater monitoring intervals

Groundwater monitoring shall be carried out by the Contractor prior to, during and post construction at the intervals specified in Table 3-5. Groundwater monitoring wells are required to be installed prior to commencement of dewatering to establish the baseline readings summarised in the table below.

Table 3-5: Groundwater monitoring interval summary

Phase	Monitoring frequency
Prior to construction	A minimum of 2 baseline readings within 1 month prior to commencement of dewatering.
During excavation/dewatering	Weekly for: • All monitoring wells within 50 m of TBM tunnel/trench excavations • All monitoring wells within 30 m of a TBM shaft or manhole excavations Fortnightly where: • All monitoring wells within 100 m of TBM tunnel/trench excavations • All monitoring wells within 50 m of a TBM shaft or manhole excavations Monthly where: • All monitoring wells within 100 m of a TBM shaft or manhole excavations

Phase	Monitoring frequency
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 approval is granted from AC to cease monitoring.

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

Monitoring frequency may be reduced if stable measurements are observed, and written confirmation is provided by AC.

3.8.3 Groundwater trigger levels

Monitoring data shall be compared with the design assumptions and baseline readings. The baseline reading shall be taken as the summer low groundwater level (GWL) where possible and recorded before the commencement of construction. Preliminary Alert and Alarm levels prior to establishing baseline readings are summarised in Table 3-6. If the Alert levels are reached, the actions outlined in Section 7 shall be carried out. An Alarm level has not been specified as exceedance of groundwater drawdown is not assessed to be sufficiently severe on its own to warrant the actions of an Alarm Level exceedance. Rather the review process required as part of an Alert Level exceedance is expected to identify any areas of concerns and provide opportunity to adjust monitoring and contingency measures as needed.

Table 3-6: Groundwater drawdown trigger levels

Groundwater Monitoring Well ID	Installation Type	Alert level 1 for drawdown below summer low GWL (m)	Alert level 2 for drawdown below summer low GWL (m)
WSL-21-BH103	VWP	0.7	1.0
WSL-21-BH104	SPP	0.7	1.0
WSL-21-BH109	VWP	0.7	1.0
WSL-21-BH115 D	SPP	0.7	1.0
WSL-21-BH115 S	SPP	0.5	0.8
WSL-21-BH117	VWP	0.5	0.8
WSL-21-BH118	SPP	0.5	0.8
WSL-21-BH122 D	SPP	0.5	0.8
WSL-21-BH122 S	SPP	0.5	0.8
WSL-21-BH125	SPP	0.5	0.8
WSL-21-BH126	VWP	0.5	0.8
WSL-21-BH127 D	SPP	0.5	0.8
WSL-21-BH127 S	SPP	0.5	0.8
WSL-21-BH128	VWP	0.5	0.8
WSL-21-BH129	SPP	0.5	0.8
WSL-21-BH130	VWP	0.5	0.8
WSL-21-BH132 D	SPP	0.5	0.8
WSL-21-BH132 S	SPP	0.5	0.8

Groundwater Monitoring Well ID	Installation Type	Alert level 1 for drawdown below summer low GWL (m)	Alert level 2 for drawdown below summer low GWL (m)
WSL-21-BH134	SPP	0.5	0.8
WSL-21-BH201	VWP	0.7	1.0
WSL-21-BH206	VWP	0.7	1.0

3.9 Underground services settlement monitoring

3.9.1 General

Proposed excavations (trenches, shafts and tunnels) are expected to be undertaken in proximity to various existing underground services including stormwater, wastewater, water supply, electricity, and telecommunications. 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 full list of services assessed is presented in the Groundwater and Settlement Effects Assessment[2].

Several critical services are present within a distance where settlement could occur, and as such more intensified monitoring should be carried out in these areas. The critical services are listed below:

- Shaft 17: Ex Vodafone asset running north to north-west approximately 6 m from the western edge of the shaft. No additional information is known to us about the asset. Location should be surveyed prior to undertaking earthworks in the area.
- Shaft 17: United Power Supply HV-EX line
- Auckland Council/Watercare Services Ltd wastewater/stormwater/water supply assets (pipeline and manhole) in proximity to shafts 12, 16, 17, MH1, and MH2.

As these are critical assets. Ground Monitoring Pins shall be placed over top of the asset, except where not required by the asset owner during consultation.

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 0 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
439 Hobsonville Road (electrical substation)	SEC 1 SO 450384	Commercial
1 Memorial Park Lane (bowling club)	PT ALLOT 523 SO 40181 WAIPAREIRA	Commercial
2 Buckley Avenue	LOT 50 DP 523085	Commercial (WSL Owned)
2A Buckley Avenue	Section 1 SO 419259	Commercial (WSL Owned)

The baseline survey report shall confirm the existing condition of these properties (including dwelling, garage and sheds if 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 baseline 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	Prior to commencement excavation	During excavation and dewatering	After completion of excavation and dewatering	After completion of construction
Building and Ground Settlement monitoring points	A minimum of 2 baseline readings, 1 month prior to construction	Weekly for: • All monitoring markers within 50 m of TBM tunnel/trench excavations • All monitoring markers within 30 m of a TBM shaft or manhole excavations Fortnightly where: • All monitoring markers within 100 m of TBM tunnel/trench excavations • All monitoring markers within 50 m of a TBM shaft or manhole excavations Monthly where: • All monitoring markers within 100 m of a TBM shaft or manhole excavations	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
Retaining structure monitoring points and inclinometers	A minimum of 2 baseline readings, 1 month prior to construction	Weekly for: During excavation and 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.	N/A

Monitoring System	Prior to commencement excavation	During excavation and dewatering	After completion of excavation and dewatering	After completion of construction
Groundwater Monitoring Well	Baseline readings to be undertaken prior to work commencing to establish seasonal fluctuation	Weekly for: • All monitoring markers within 50 m of TBM tunnel/trench excavations • All monitoring markers within 30 m of a TBM shaft or manhole excavations Fortnightly where: • All monitoring markers within 100 m of TBM tunnel/trench excavations • All monitoring markers within 50 m of a TBM shaft or manhole excavations Monthly where: All monitoring markers within 100 m of a TBM shaft or manhole excavations	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.	N/A

6 Reporting on monitoring records

6.1 Baseline readings

Baseline readings for ground and building deformation shall be established before the commencement of excavation, including retention excavation and dewatering activities. Excavation retention deflection monitoring marks shall be established prior to excavation commencing as specified in Section 3.7.

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 Data management

An electronic database of all monitoring locations and their results shall be created and maintained throughout the required monitoring period in Microsoft Excel of similar.

All monitoring locations shall also be surveyed (x, y, z) and presented on a plan that is made available electronically and is compatible with GIS or CAD software (Autodesk, ArcGIS, MicroStation or similar).

6.3 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 conformation 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 Excavation retention deflection contingency measures

In the event of excavation retention deflections exceeding the trigger levels, a review of the retaining design model shall be carried out to assess the increased load in the excavation retention and existing props. If required, the following actions may be taken:

1 Install additional props and/or anchors.

2 Install additional piles to isolate potentially effected structures from settlement effects.

3 Form grout curtains behind excavation retention.

4 If deflections are due to groundwater drawdown, groundwater injection through recharge wells to commence.

8.3 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.

8.4 Underground services 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.

We understand and agree that our client will submit this report as part of an application for resource consent and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
.....	.....
Eduard Mandru Geotechnical Engineer	Tim Coote Project Director

20-Jul-23
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Appendix A Monitoring Plans

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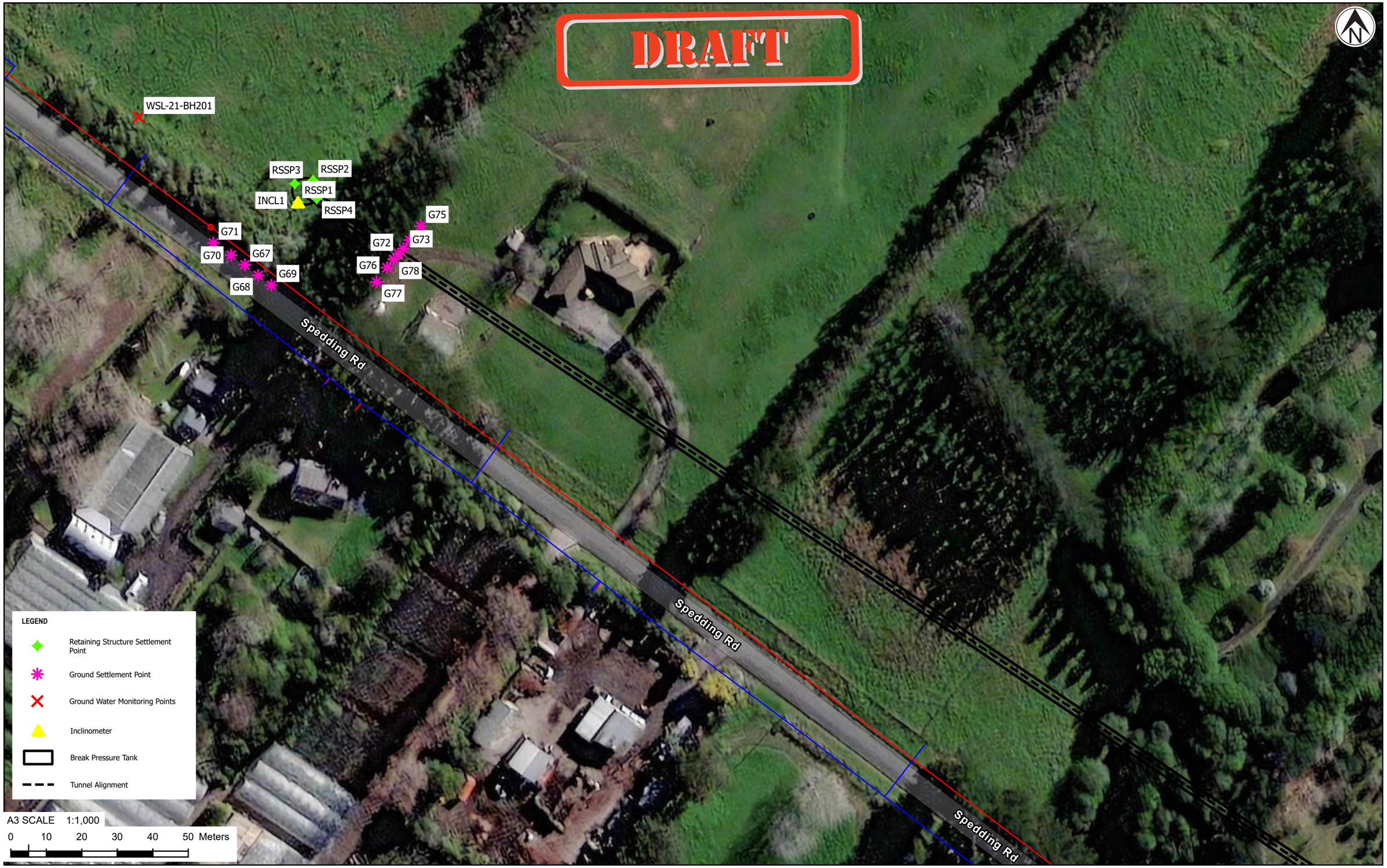

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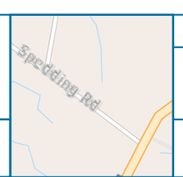

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CLIENT **WATERCARE SERVICES LIMITED**

PROJECT **NORTHERN INTERCEPTOR PHASE 2**

TITLE GROUND SETTLEMENT MONITORING PLAN
SHEET: 1 OF 11

SCALE (A3) 1:1000 FIG No. 1015506 - F1 REV 1

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TITLE GROUND SETTLEMENT MONITORING PLAN
SHEET: 2 OF 11

SCALE (A3) 1:1000 FIG No. 1015506 - F2 REV 1

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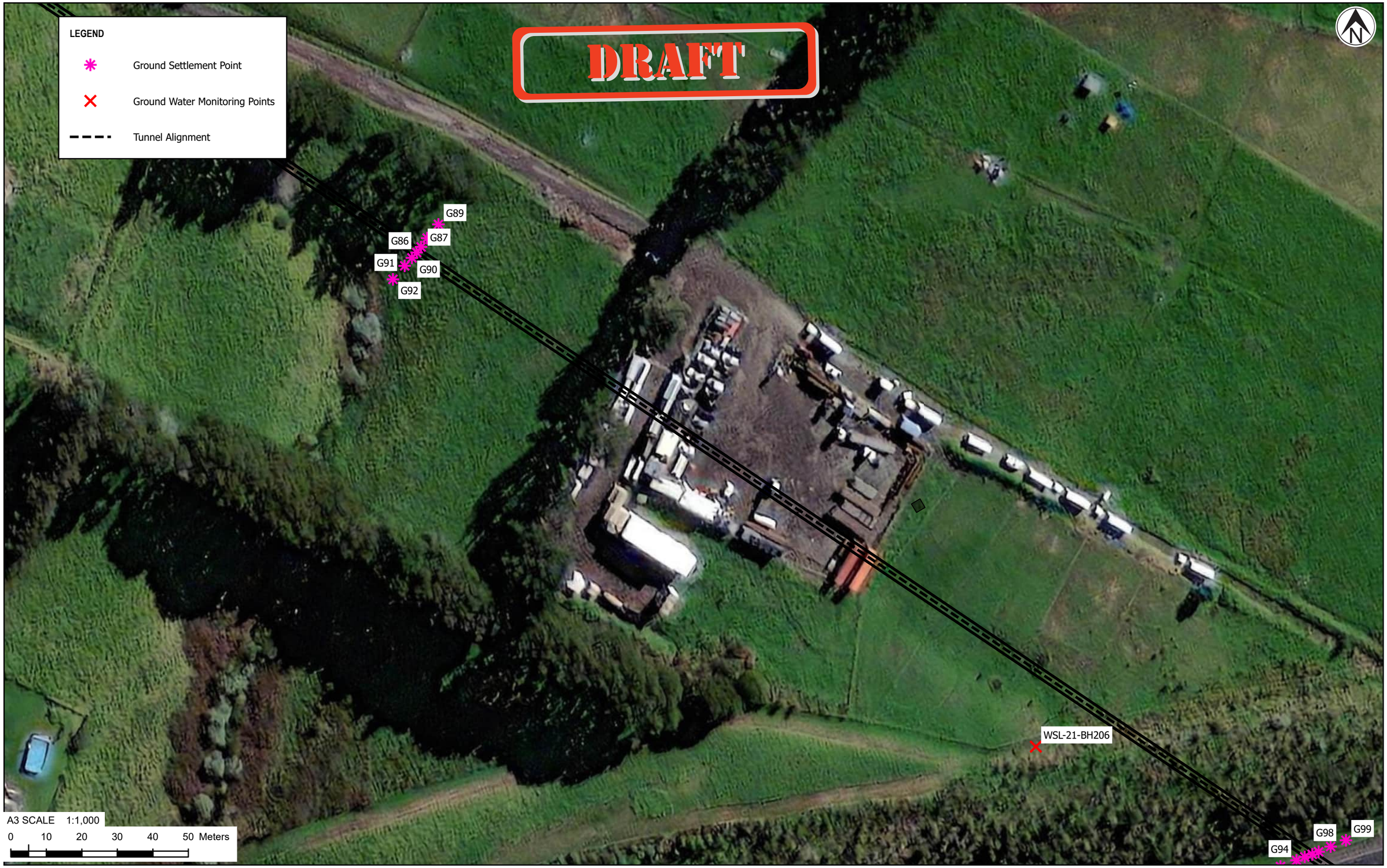

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PROJECT **NORTHERN INTERCEPTOR PHASE 2**

TITLE GROUND SETTLEMENT MONITORING PLAN
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SCALE (A3) 1:1000 FIG No. 1015506 - F3 REV 1

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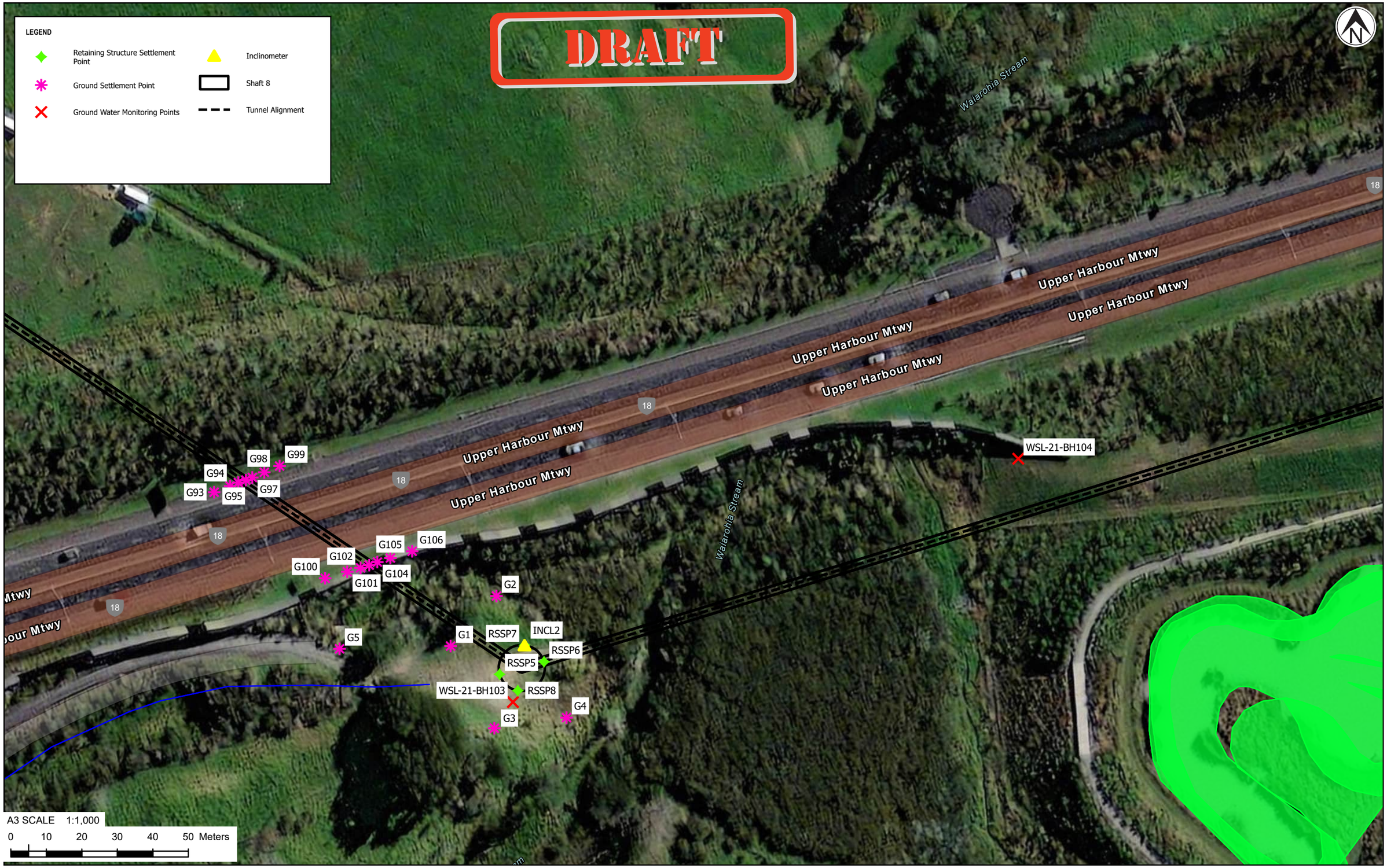

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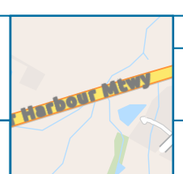

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TITLE GROUND SETTLEMENT MONITORING PLAN
SHEET: 4 OF 11

SCALE (A3) 1:1000 FIG No. 1015506 - F4 REV 1

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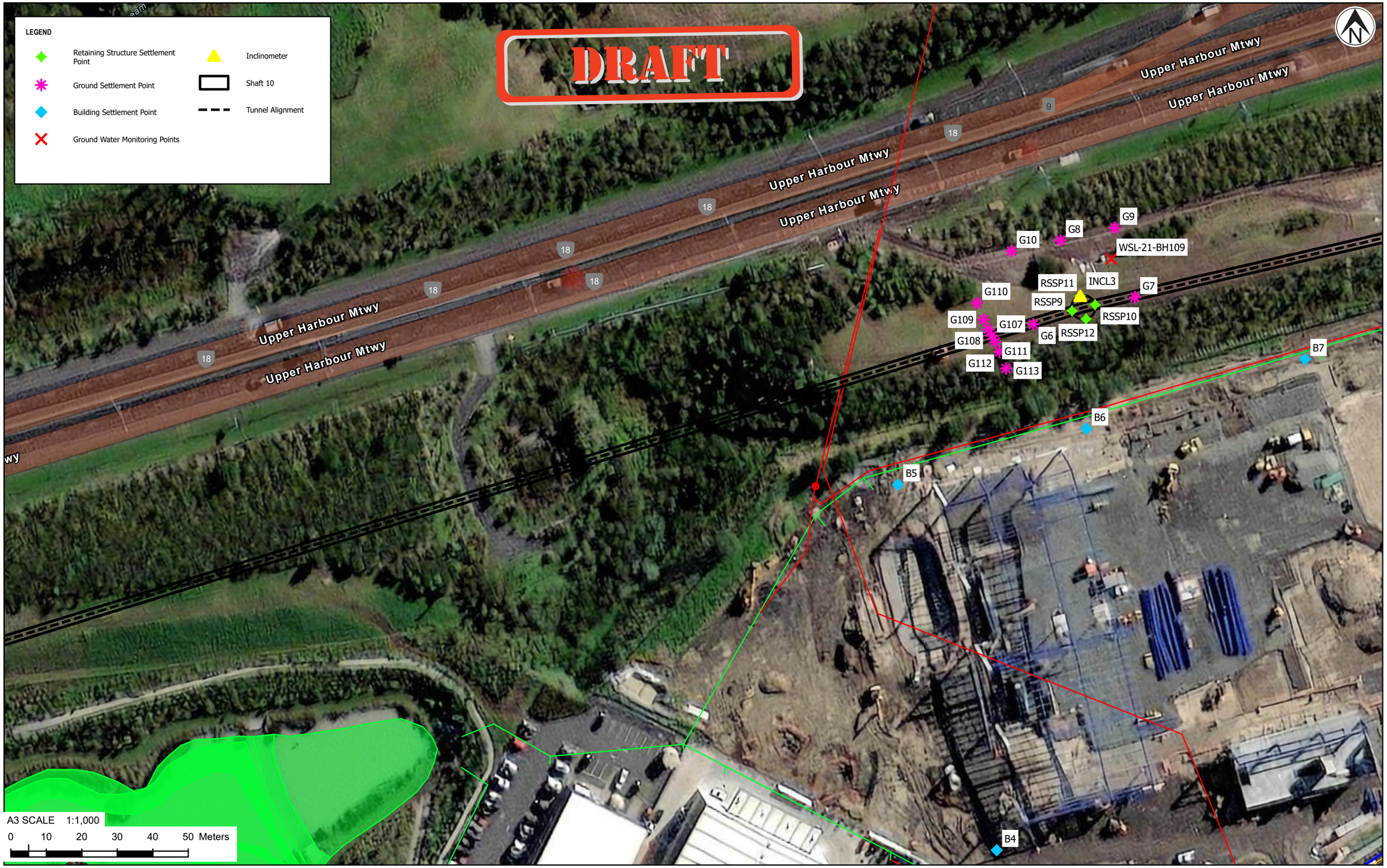

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TITLE GROUND SETTLEMENT MONITORING PLAN
SHEET: 5 OF 11

SCALE (A3) 1:1000 FIG No. 1015506 - F5 REV 1

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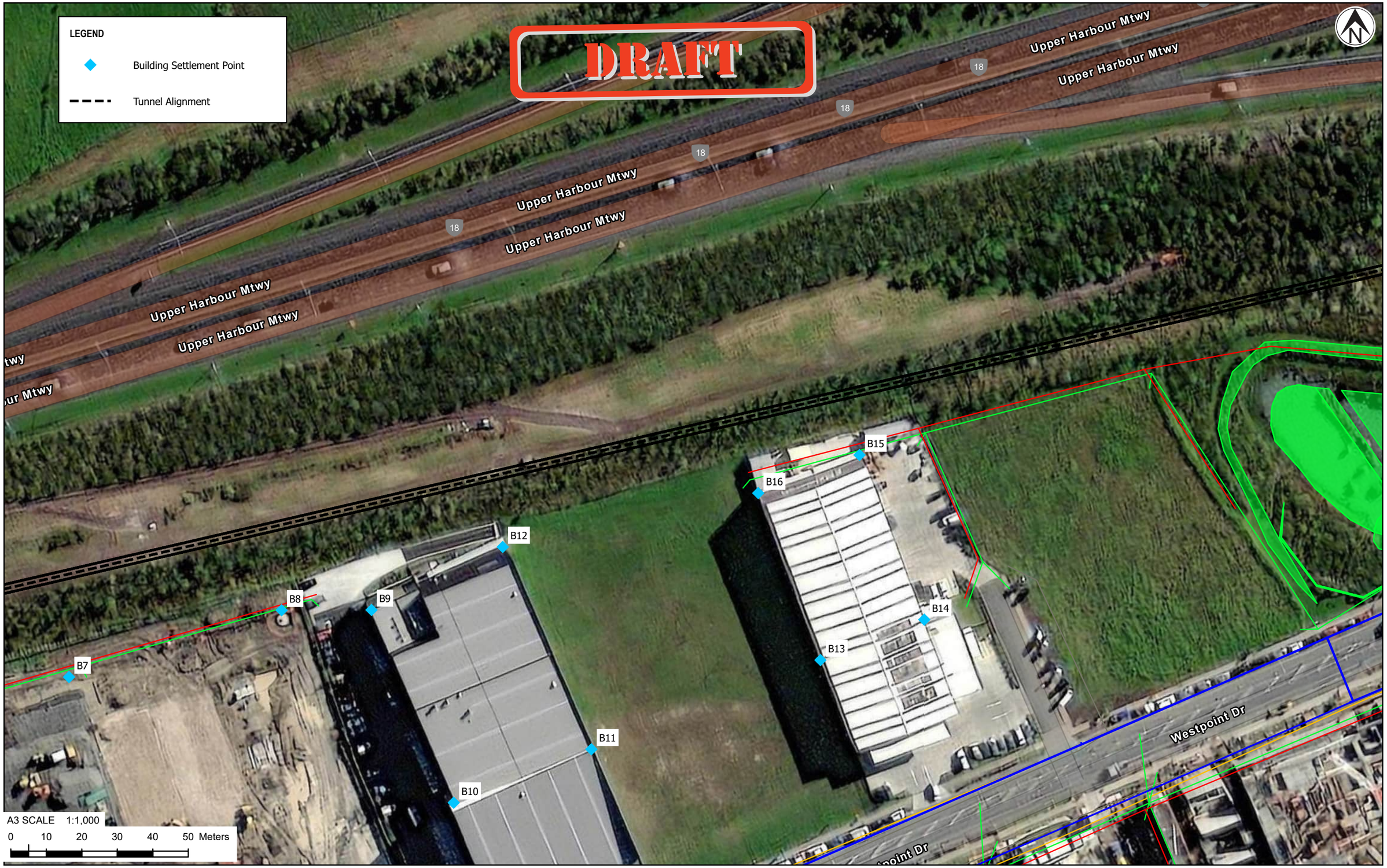

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TITLE	GROUND SETTLEMENT MONITORING PLAN SHEET: 6 OF 11
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FIG No.	1015506 - F6
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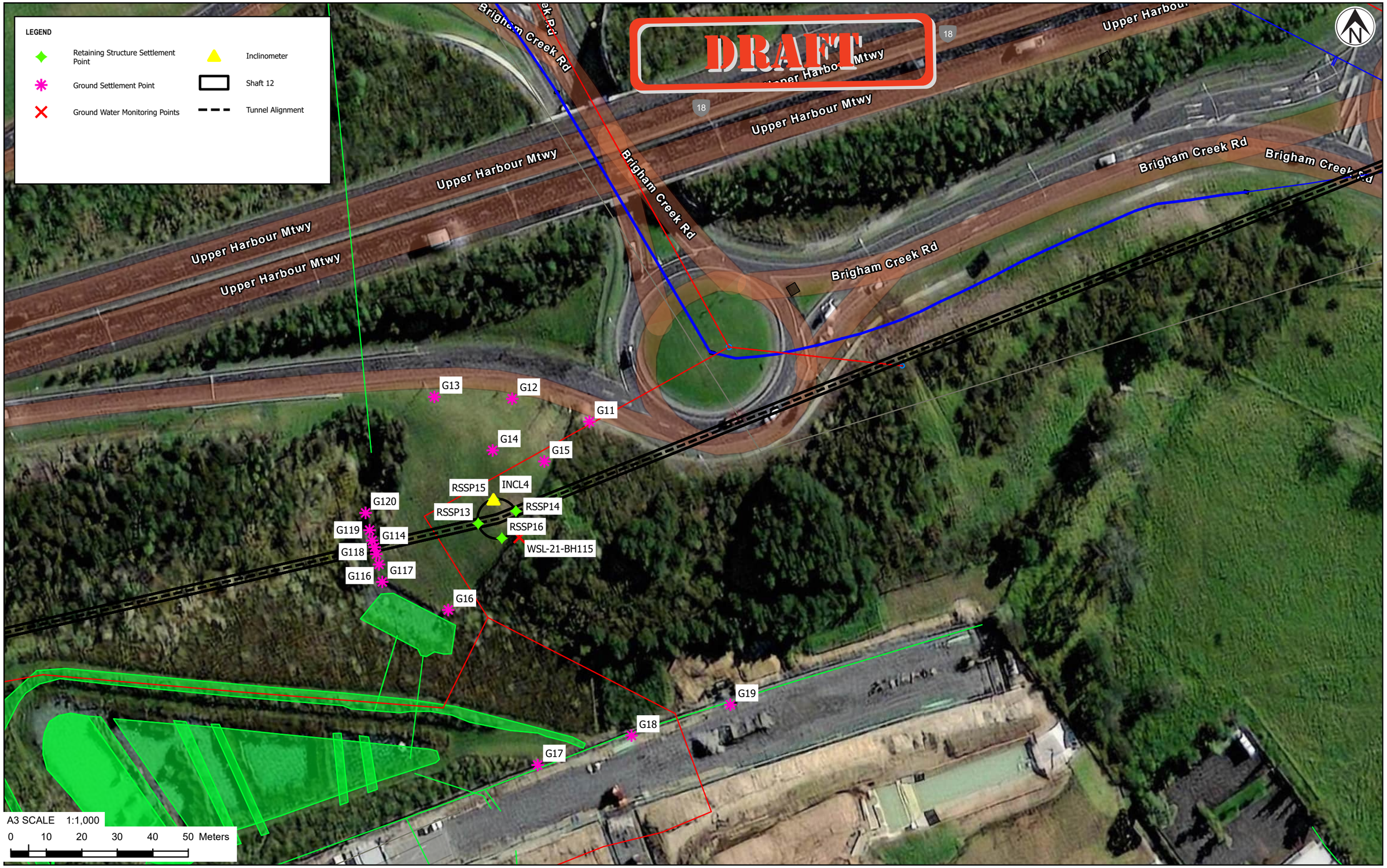

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TITLE GROUND SETTLEMENT MONITORING PLAN
SHEET: 7 OF 11

SCALE (A3) 1:1000 FIG No. 1015506 - F7 REV 1

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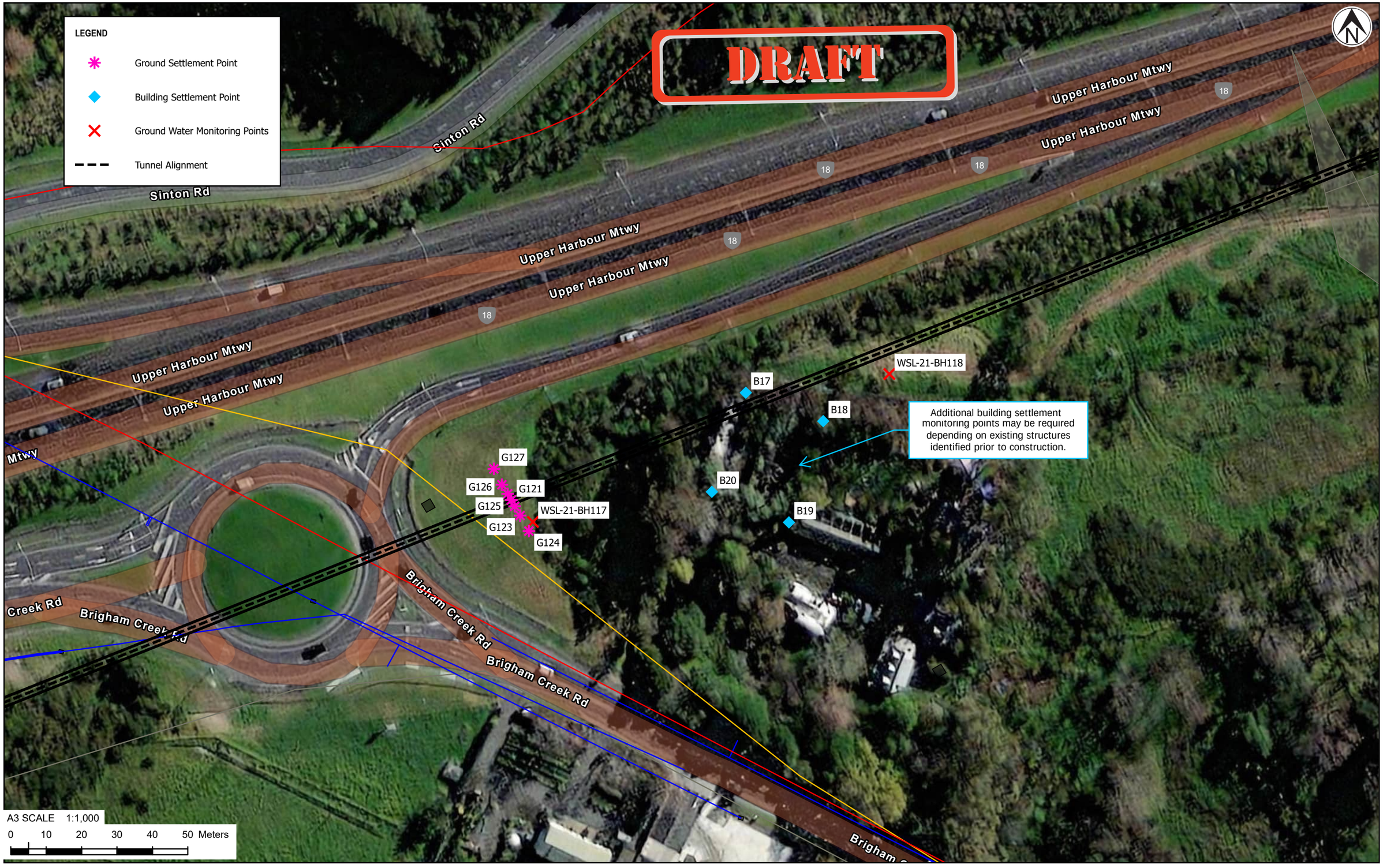

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TITLE GROUND SETTLEMENT MONITORING PLAN
SHEET: 8 OF 11

SCALE (A3) 1:1000 FIG No. 1015506 - F8 REV 1

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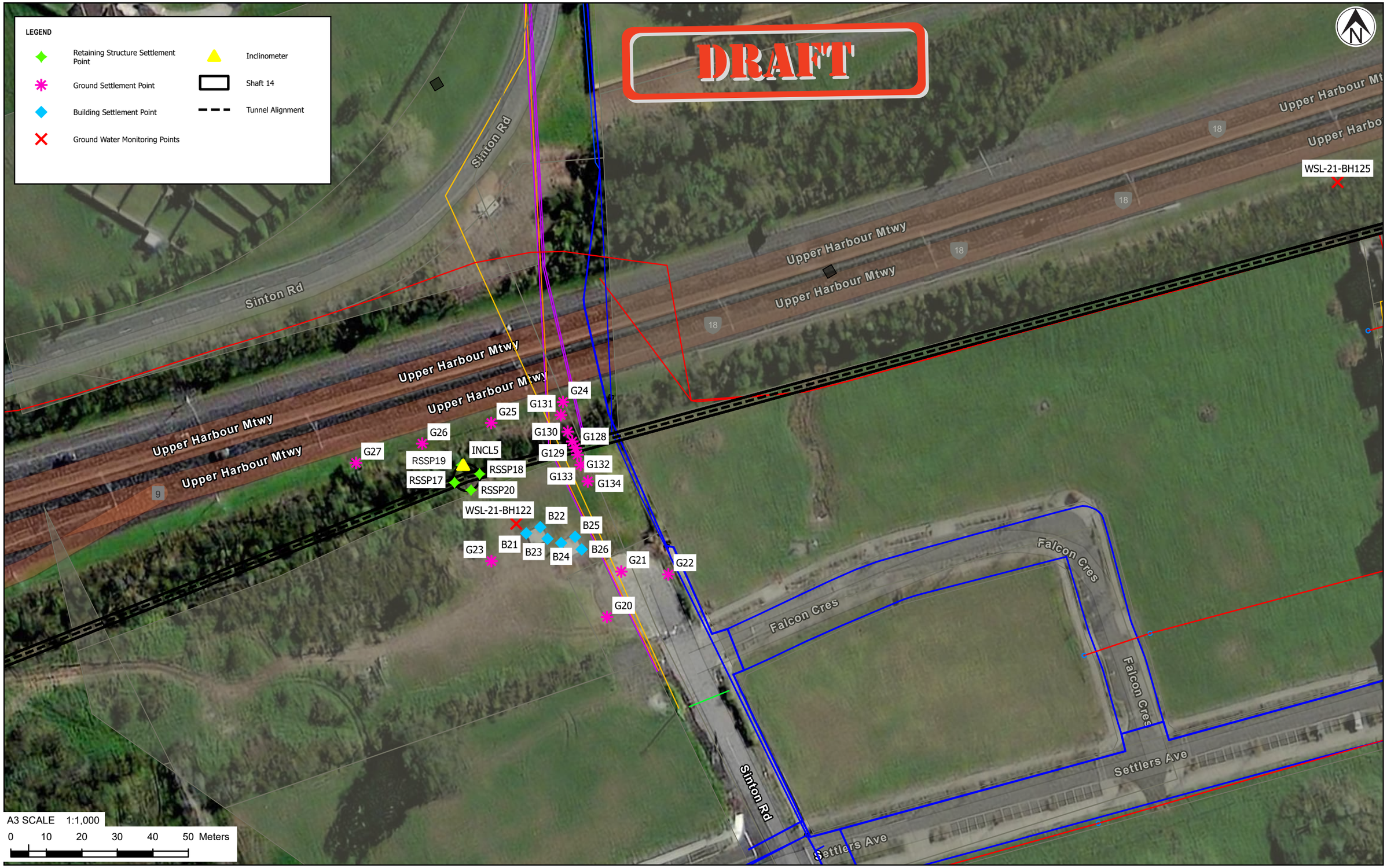

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PROJECT **NORTHERN INTERCEPTOR PHASE 2**

TITLE GROUND SETTLEMENT MONITORING PLAN
SHEET: 9 OF 11

SCALE (A3) 1:1000 FIG No. 1015506 - F9 REV 1

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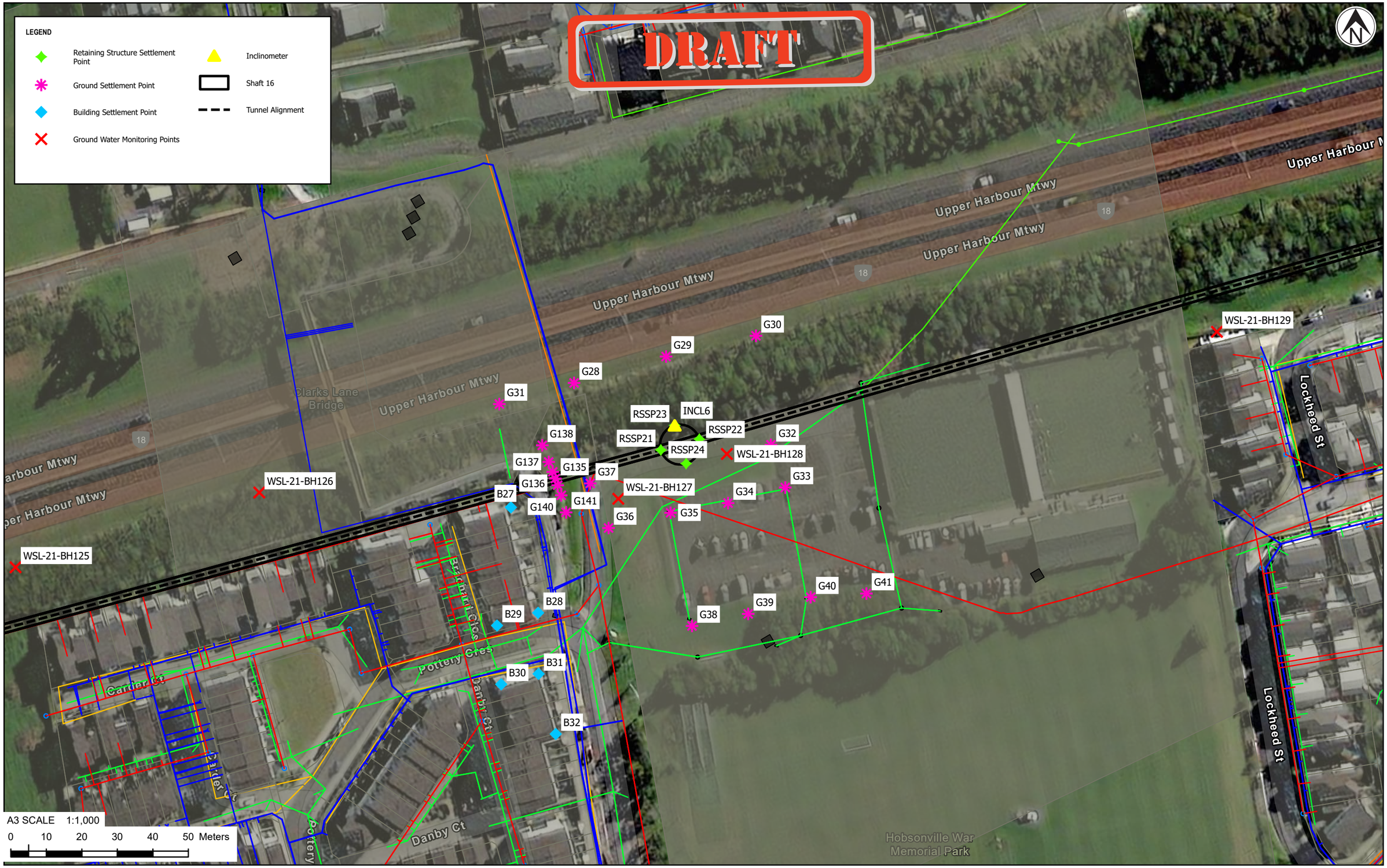

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PROJECT **NORTHERN INTERCEPTOR PHASE 2**

TITLE GROUND SETTLEMENT MONITORING PLAN
SHEET: 10 OF 11

SCALE (A3) 1:1000 FIG No. 1015506 - F10 REV 1

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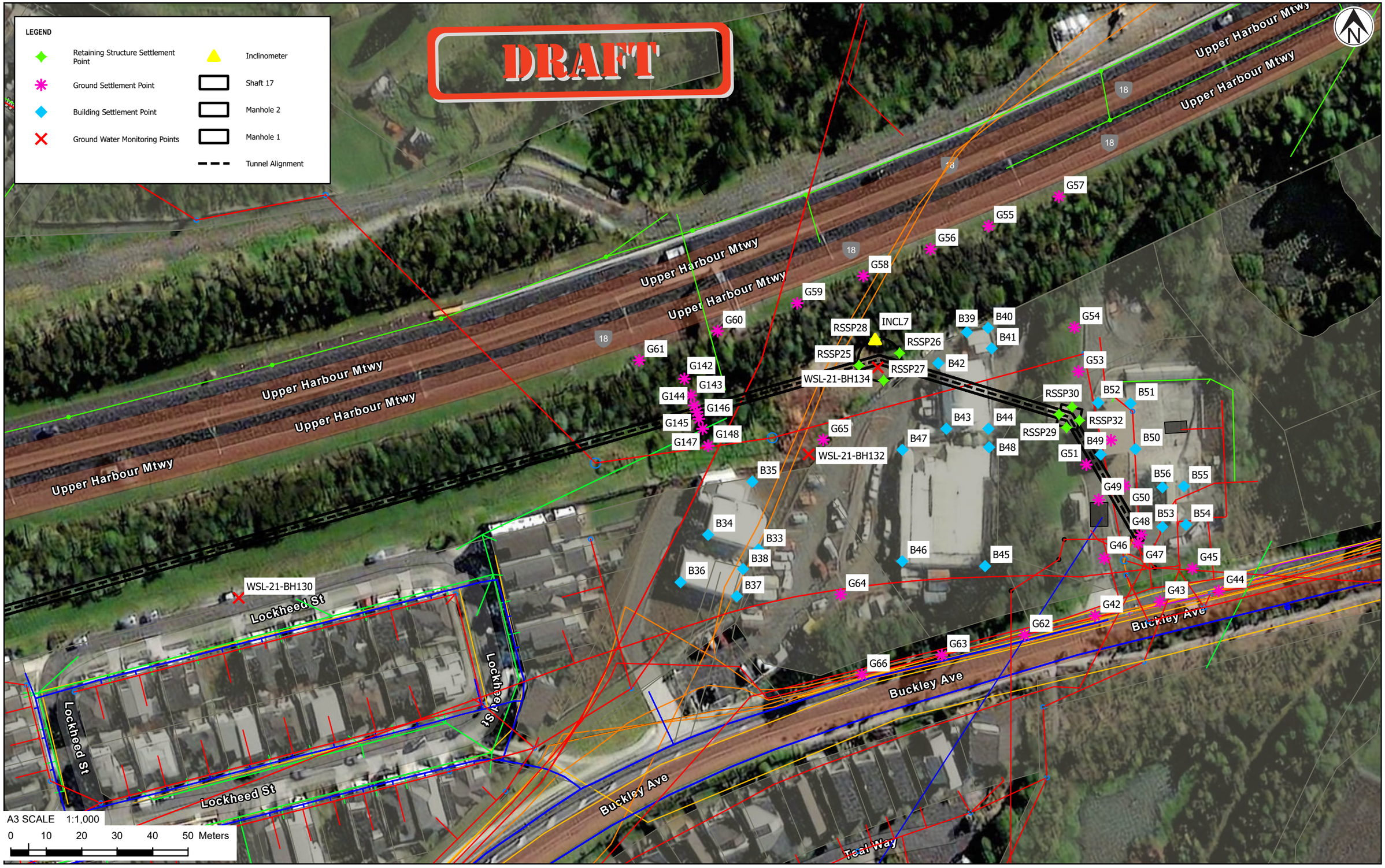

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TITLE GROUND SETTLEMENT MONITORING PLAN
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