NZ TRANSPORT AGENCY
WAKA KOTAHI

TE ARA HAUĀURU
NORTHWEST RAPID TRANSIT

ASSESSMENT OF GROUNDWATER AND SETTLEMENT EFFECTS

GREG SHEPPARD

15 DECEMBER 2025

New Zealand Government

Qualifications and experience of the author

My full name is Gregory Maitland Sheppard. I hold a Bachelor of Science degree in Geology (1993) and a Master of Science degree in Engineering Geology from University of Canterbury (1996). I work for Jacobs New Zealand Limited as a Principal Hydrogeologist. I have been in this position since August 2016. Prior to that I was employed as a Principal Hydrogeologist with RPS Aquaterra in both New Zealand and Australia, and prior to that I held several hydrogeological roles in Australia. I have a total of 29 years' experience as a hydrogeological consultant.

My experience relevant to this Application includes providing groundwater advice and completing groundwater assessments for numerous roading and linear infrastructure projects within New Zealand and Australia including:

- Lead hydrogeologist – M1 Pacific Motorway extension to Raymond Terrace, Transport for New South Wales. Groundwater Assessment in support of Environmental Impact Statement.
- Lead hydrogeologist – Penlink Tender Design, New Zealand Transport Agency Waka Kotahi. Groundwater input to tender design and resource consent investigations.
- Lead hydrogeologist – Quakers Hill to Prospect Reservoir purified recycled water pipeline, Sydney Water. Groundwater Assessment in support of Environmental Impact Statement.
- Lead hydrogeologist – Quakers Hill WRRF Advanced Treatment Upgrade Project and brine pipeline, Sydney Water. Groundwater Assessment in support of Review of Environmental Factors.
- Lead hydrogeologist – Khyber Pass Road Stormwater Upgrade, Auckland Council Healthy Waters. Groundwater Assessment of Effects in support of Assessment of Environmental Effects.
- Lead hydrogeologist – ANZAC Street Stormwater upgrade, Auckland Council Healthy Waters. Geotechnical and Groundwater Assessment of Effects in support of Assessment of Environmental Effects.

Although this matter is not before the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses as contained in section 9 of the Environment Court Practice Note 2023. I agree to comply with that Code. My qualifications as an expert are set out above. I am satisfied that the matters which I address in this report are within my area of expertise, except where I state that I am relying on information provided by another person or expert. I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Contents

Appendices

Tables

Figures

Acronyms, definitions and abbreviations

Term	Definition
AEE	Assessment of Environmental Effects
ANZG	Australian and New Zealand guidelines for fresh and marine water quality
AUP	Auckland Unitary Plan (Operative in Part)
AVF	Auckland Volcanic Field
BH	Borehole
DGV	Default guideline value
ECBF	East Coast Bays Formation
FTAA	Fast-Track Approvals Act 2024
GSMCP	Groundwater and settlement monitoring and contingency plan
Indicative Design	The indicative design of the Project within the Project Area as shown on the Indicative Design drawings in Part 6 that will be confirmed during detailed design
Invert	The lowest elevation of a pipe, culvert, or channel, acting as the "floor" for water or material flow. In the context of this assessment, invert is used to describe the lowest elevation of an excavation used for assessing groundwater seepage
Kh	Horizontal Hydraulic Conductivity
Kv	Vertical hydraulic conductivity
m/s	Metres per second
mbgl	Metres below ground level
mg/L	Milligrams per litre
ML	Megalitre
MPa	Mega Pascals
NPS-FM	National Policy Statement for Freshwater Management (as amended October 2024)
NZGD	New Zealand Geotechnical Database
NZVD	New Zealand Vertical datum 2016
Project	Te Ara Hauāuru Northwest Rapid Transit
Project Area	The Proposed Designation and the extent of the coastal occupation permits sought
Proposed Designation	The area defined by the Proposed Designation boundary as shown on the Proposed Designation Plans in Part 6
RMA	Resource Management Act 1991
µS/m	micro-Siemens per metre

1. Introduction

1.1 Purpose and scope of this report

This technical assessment has been prepared to inform a substantive application for the Northwest Rapid Transit Project (the Project) under the Fast-Track Approvals Act 2024 (FTAA). It forms part of a suite of specialist reports that collectively support the applications for statutory approvals.

The purpose of this report is to evaluate the actual and potential effects of the Project on the environment in relation to groundwater and settlement. This report addresses the following matters:

- The potential for significant excavations to intersect the groundwater table, including:
  - assessment of groundwater seepage to excavations;
  - assessment of groundwater drawdown; and
  - assessment of consolidation settlement.
- Potential effects of groundwater drawdown on:
  - other groundwater users;
  - surface water bodies and wetlands; and
  - potential for settlement outside of the Proposed Designation (the area defined by the Proposed Designation boundary as shown on the Proposed Designation Plans in Part 6) boundary.

This report should be read alongside the Substantive Application including the Assessment of Environmental Effects (AEE) in Part 4, which contains further details on the context of the Project. The Substantive Application also contains a description of works to be authorised and the typical construction methodologies that will be used to implement this work (refer to Part 2). I have reviewed this and have been considered as part of my assessment of effects. As such, they are not repeated here. Where a description of an activity is necessary to understand the potential effects, it has been included in this report for clarity.

2. Assessment methodology

This assessment addresses the actual and potential groundwater effects arising from the Indicative Design (the indicative design of the Project within the Project Area as shown on the Indicative Design drawings in Part 6 that will be confirmed during detailed design), as well as potential movement of the Indicative Design within the Proposed Designation (the area defined by the Proposed Designation boundary as shown on the Proposed Designation Plans in Part 6).

The assessment was informed by a desktop study, Project specific groundwater investigations, and analytic and numerical modelling.

2.1 Desktop study

The desktop study characterised existing groundwater conditions across the Project Area (the Proposed Designation and the extent of the coastal occupation permits sought). The study reviewed publicly available databases and mapping, available scientific literature, and other relevant reports and investigations that have been undertaken in the broader area that may have collected groundwater information (e.g. geotechnical and contamination investigations). Information relating to geological conditions, groundwater levels and quality, formation hydraulic conductivity, surface water interaction, and other groundwater users, was reviewed as available.

2.2 Site investigations

Eleven monitoring bores were drilled and installed along the Indicative Design in areas of substantial cuttings, generally associated with either stations or underpasses. The borehole locations are shown on Figure 2-1. The borehole monitoring details are summarised in Table 2-1 and borelogs are provided in

Appendix A. BH007 was initially proposed as part of a cluster of bores with BH005 and BH006, but was ultimately not required and removed from the programme.

The following investigations were conducted at each borehole:

- Permeability testing;
- Groundwater sampling and analysis; and
- Groundwater level monitoring.

Site investigation methodologies are provided in Sections 2.2.1, 2.2.2 and 2.2.3. The field investigations confirmed the existing groundwater conditions along the Indicative Design.

Table 2-1: Monitoring bore summary

ID	Screen from (mbgl)	Screen to (mbgl)	Screened lithology
BH001	1.0	11.9	Residual Soil, Weathered ECBF
BH002	1.0	11.9	Residual Soil, Weathered ECBF
BH003	2.0	10.9	Takanini Formation, Residual Soil, Weathered ECBF
BH004	2.0	12.9	Takanini Formation, Residual Soil, Weathered ECBF
BH005	2.0	13.0	Fill, Takanini Formation, Residual Soil, Weathered ECBF
BH006	2.0	14.5	Takanini Formation
BH007	Borehole removed from programme		
BH008	2.8	13.9	Takanini Formation, Residual Soil, Weathered ECBF
BH009	2.0	13.9	Takanini Formation, minor Residual Soil
BH010	2.0	13.0	Weathered ECBF
BH011	2.0	7.7	Takanini Formation, Residual Soil
BH012	1.0	12.7	Takanini Formation, Residual Soil, Weathered ECBF

2.2.1 Permeability testing

Permeability testing (rising and falling head testing) was undertaken at the monitoring bores using a solid "slug" to displace a known volume of water and monitoring the water level recovery response.

The tests were completed by measuring the rate of rise and fall of the water column within the piezometer following insertion and removal of the solid slug. One falling and one rising head test was completed for each piezometer. Tests were not terminated until the water level in the piezometer recovered to at least 90% of the measured maximum displacement. Note, at the time of this report, no slug testing was undertaken in piezometers BH010 or BH011 due to the bores being dry.

Groundwater level responses were recorded with a water level data logger and the resulting water level recovery curves were analysed using the Hvorslev (1951) method.

The results of the permeability testing and analysis are provided in Section 3.4.3 with analyses provided in Appendix B.

2.2.2 Groundwater sampling and analysis

Groundwater samples for laboratory analysis were collected from each piezometer following construction and development of the monitoring bore. The monitoring bores were sampled using a low-flow peristaltic pump with a dedicated LDPE sample hose.

In-situ water quality parameters were tested using a multi-parameter sensor probe. The testing was done by filling a PVC jar with pumped groundwater and analysing the required parameters. The sensor probe was calibrated prior to the measurements. In between each piezometer measurement, the testing jar was flushed with distilled water to avoid cross-contamination.

Groundwater samples were then collected in laboratory provided containers. The samples were kept cool and dark and were delivered to Hill Laboratories Limited within 24 hours.

The results of the groundwater analysis are discussed in Section 3.4.5.2 with laboratory analyses provided in Appendix C.

2.2.3 Groundwater level monitoring

Groundwater levels were measured manually at monitoring bores throughout the field investigations with up to seven rounds of monitoring at the earliest installed monitoring bores and four rounds of monitoring at the latest monitoring bores.

Groundwater level monitoring results are discussed in Section 3.4.4.3 and groundwater level observations are attached in Appendix D.

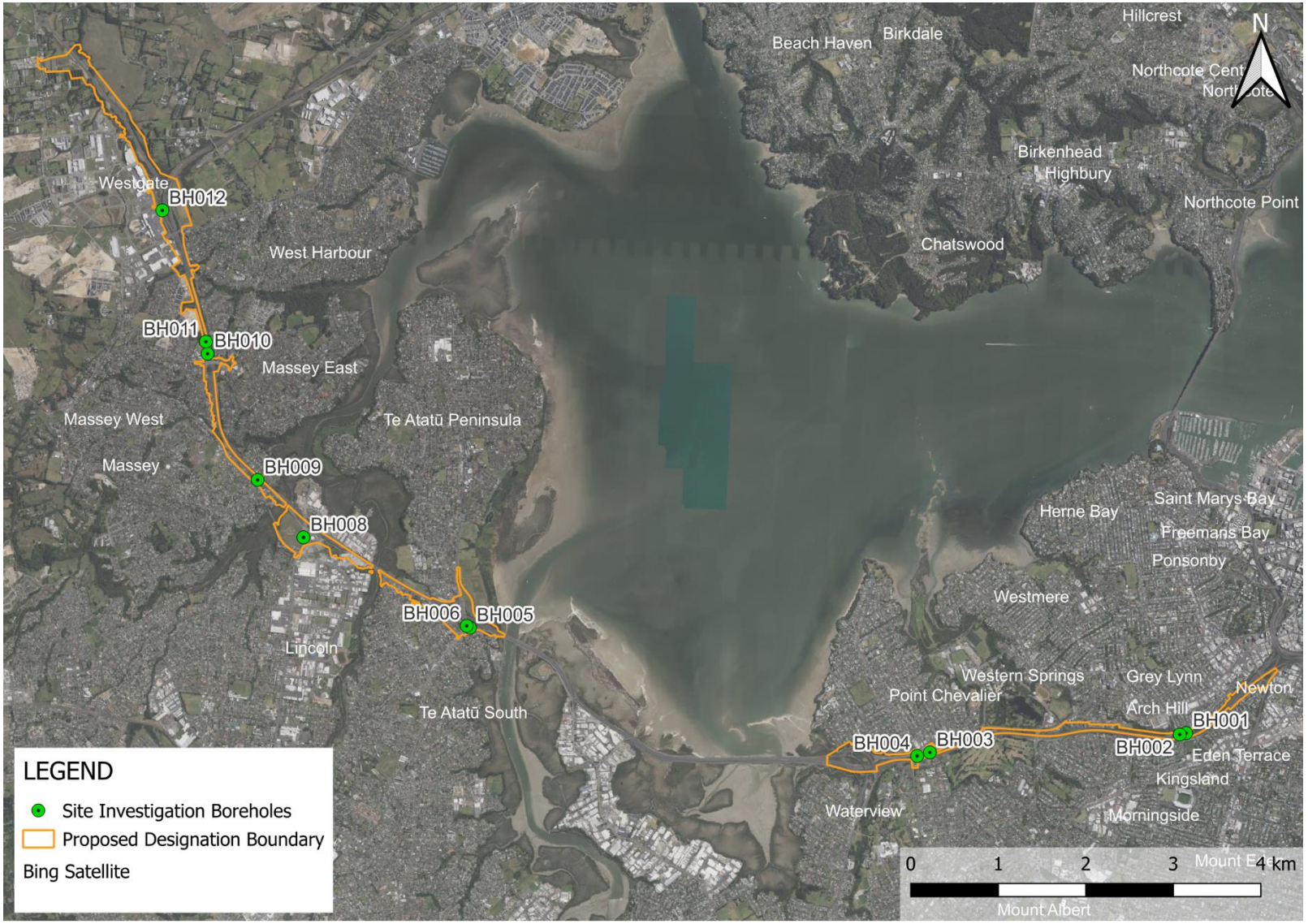

Figure 2-1: Site investigations

2.3 Modelling

Analytical modelling of groundwater seepage to cuttings and excavations was undertaken using the methods of Mansur and Kaufman (1962) for the assessment of linear flow to excavations in an unconfined aquifer, as presented in Neville (2017).

Groundwater response to excavations below the water table was modelled using GeoStudios' Seep/W (Geo-Slope, 2015). Seep/W is a finite element software component of GeoStudio, used for modelling two-dimensional groundwater flow in porous media, considering both saturated and unsaturated conditions.

Groundwater seepage to excavations and the resulting groundwater drawdown are discussed in Section 4.2 and Section 4.3 respectively. Calculations and model outputs are provided in Appendix E and Appendix F.

2.4 Ground settlement

Potential formation consolidation and ground settlement resulting from groundwater drawdown was assessed using one-dimensional consolidation theory after CIRIA (2017) and is discussed in Section 4.3.

2.5 Assessment of effects

I assessed potential groundwater effects by:

- Assessing the magnitude of potential groundwater drawdown and settlement resulting from cuttings below the water table at the Proposed Designation boundary.
- Assessing the magnitude of potential groundwater drawdown at nearby sensitive receptors, such as groundwater users and surface water bodies (if any).
- Assessing the magnitude of potential groundwater settlement at nearby buildings with comparison to building damage assessment criteria.

3. Receiving environment

3.1 Surface water

There are a number of surface water bodies within and nearby to the Project Area. Surface water bodies may rely on groundwater in whole or in part to sustain their aquatic ecosystems.

In the western Project Area, the Project crosses Oratia Stream, Huruhuru Creek, and Rarawaru Stream. North of Royal Road Mānutewhau station, the Project crosses Tihema Stream and Rush Creek, and north of Westgate Te Waiarohia station, the Project crosses Tōtara Creek and Pikau Stream.

In the eastern Project Area, Western Springs Lake / Te Wai Ōrea is the major surface water feature, with Motions Creek to the east and Meola Creek to the west. Western Springs Lake / Te Wai Ōrea receives groundwater discharge from the Western Springs-Three Kings volcanic aquifer.

3.2 Wetlands

The AEE in Part 4 has identified two exotic wetlands within the Project Area that are consistent with the Resource Management Act 1991 (RMA) and National Policy Statement for Freshwater Management (NPS-FM) definition of a wetland / natural inland wetland, including:

- Wetland 1, located at 74 Trig Road, Whenuapai; and
- Wetland 2, located at Eric Armishaw Park, Point Chevalier.

While both of these exotic induced wetlands are within the Project Area, neither will be directly impacted by the Indicative Design and are away from areas of potential excavation and dewatering.

3.3 Geology

Geology is the dominant control on the presence and movement of groundwater. The geology of the Project Area is mapped in the 1:250,000 scale geological map "Geology of the Auckland Area" (Edbrooke, 2001) and is shown in Figure 3-1. The Project Area is underlain by three main geological units as follows:

- Holocene to Late Pliocene Tauranga Group alluvial and estuarine sediments:
  - Holocene alluvial and estuarine deposits. Comprising sand, silt mud and clay with local gravel and peat beds.
  - Puketoka Formation Late Pliocene to Middle Pleistocene pumiceous river deposits. Comprising pumiceous mud, sand and gravel with muddy peat and lignite: rhyolite pumice, including non-welded ignimbrite, tephra and alluvial pumice deposits; massive micaceous sand.

    More recent work in revising the formal stratigraphic framework or late Pliocene to recent sedimentary rocks and sediments (Barrell, et al. 2021) has resulted in reclassification of alluvial materials that used to be broadly classified under Tauranga Group, including the Puketoka Formation. These are now classified as Takaanini Formation and are referred to as such within the report.
- Late Pleistocene basaltic deposits of the Auckland Volcanic Field (AVF):
  - Grey to very dark grey, dense, fine grained olivine basalt or basanite lava flows.
- Early Miocene East Coast Bays Formation of the Waitematā Group:
  - Alternating sandstone and mudstone with variable volcanic content and interbedded volcaniclastic grits.

The Puketoka Formation (Takaanini Formation) and East Coast Bays Formation (ECBF) underly the bulk of the Project Area with Auckland Volcanic Field basalts limited to the vicinity of Western Springs (approximate chainages 70,300 to 71,400) (Figure 3-1).

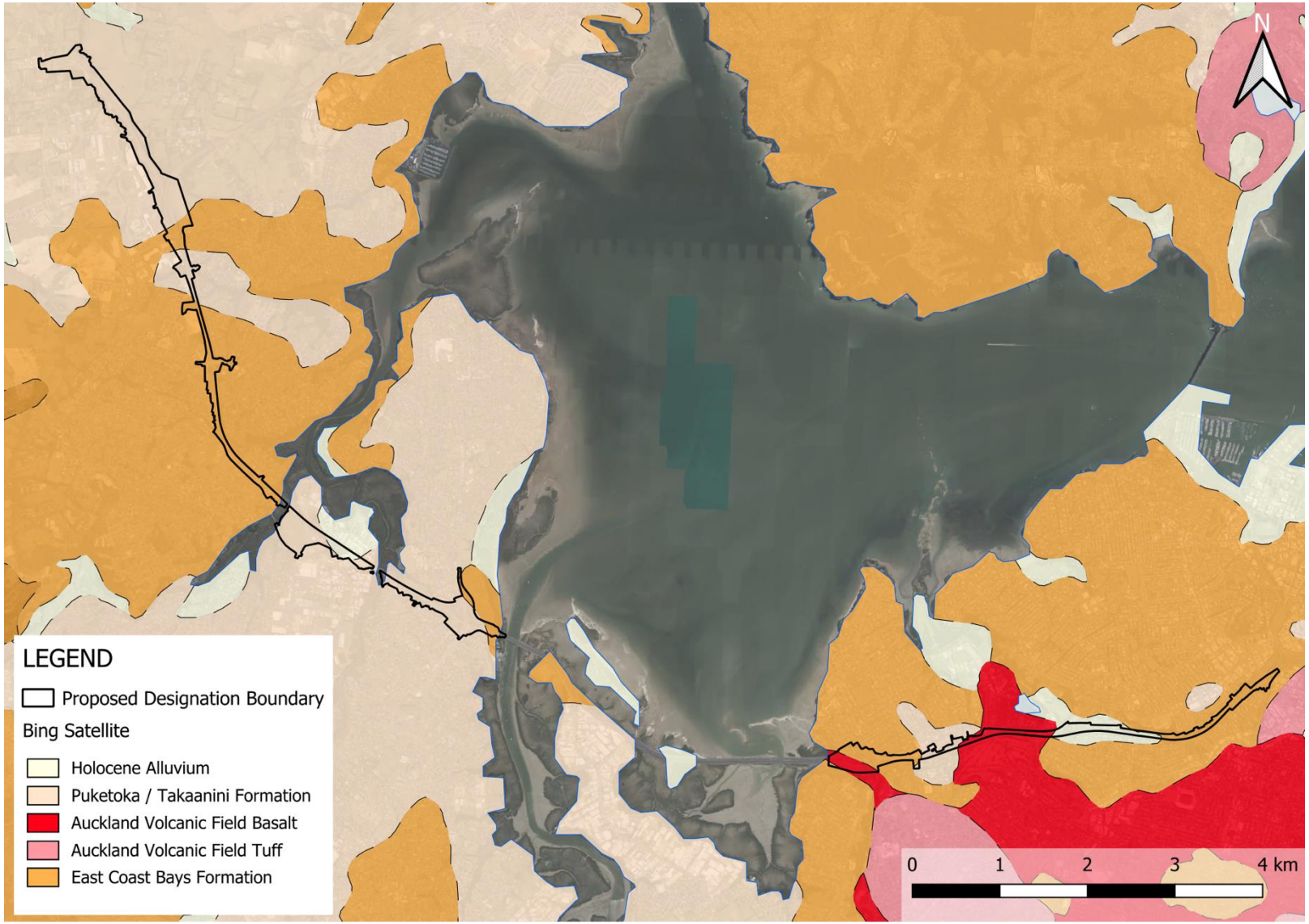

Figure 3-1: Project Area geology

3.4 Hydrogeology

The hydrogeological characteristics of the geological units along the Project Area are highly variable, ranging from relatively high yielding productive aquifers to low permeability aquitards.

3.4.1 Hydrostratigraphic units

Hydrostratigraphic units are geological units or groups of geological units with distinct groundwater flow characteristics, grouped based on their hydraulic properties such as permeability and porosity, and their ability to transmit or restrict groundwater flow. Key hydrostratigraphic units within the Project Area are summarised in the following sections.

3.4.1.1 Tauranga Group – Takaanini Formation

The undifferentiated Holocene alluvium and Takaanini Formation typically consist of low permeability and highly compressible sediments. The sediments can be highly heterogeneous ranging from sands and gravels thought to silt, clay and peat. In the Project Area, the Takaanini Formation has primarily been encountered as silts and clays.

3.4.1.2 Basalts

The basalt flows of the Auckland Volcanic Field form the major aquifers of the Auckland area, and the basalts that cross beneath the Project Area are part of the Western Springs - Three Kings Volcanic aquifer. The basalts are generally characterised by high transmissivity resulting from secondary porosity and fracturing. The basalt aquifers have high infiltration rates and throughflow, contributing to their important role in stormwater discharge via soakage (Auckland Council, 2021).

Recharge to the basalts is predominantly via rainfall infiltration in the unconfined areas of the aquifers, infiltration of stormwater from stormwater infiltration basins, and by vertical leakage and throughflow to the lower and confined aquifers (Auckland Council, 2021).

Groundwater flow in the Western Springs - Three Kings Volcanic aquifer is generally in a north-northwesterly direction, discharging to Waitematā Harbour at Meola Creek and Motions Creek. A component of groundwater from the Western Springs - Three Kings Volcanic aquifer also discharges to Western Springs Lake / Te Wai Ōrea. The lava flow is exposed along the edges of the lake displaying the columnar jointing through which the bulk of the groundwater moves (Auckland Council, 2020).

3.4.1.3 ECBF – Waitematā Group

The ECBF consists of relatively weak siltstones and sandstones that weather to firm to stiff residual silts and clays. Stratification in both residual soils and rock can lead to very low vertical hydraulic conductivity that can often result in a sequence of perched aquifers or multiple, vertically separated saturated horizons.

Residual soils of the ECBF generally have similar hydrogeological properties to the Holocene alluvium and Takaanini Formation.

While the siltstones and mudstones of the ECBF rock have very little in the way of effective primary porosity (and subsequent very low hydraulic conductivity), secondary porosity in the form of fracturing can result in moderate permeability in some areas. Although typically low yielding, in the greater Auckland area, the fractured Waitematā Group formations represent a significant regional aquifer.

3.4.2 Desktop study – permeability

Estimates of hydraulic conductivity for each formation from previous investigations (Beca, 2010; Tonkin and Taylor, 2012; Aurecon, 2025) are summarised in Table 3-1.

Table 3-1: Formation hydraulic conductivity

Geological Unit	Minimum Horizontal Hydraulic Conductivity (m/s)	Maximum Horizontal Hydraulic Conductivity (m/s)	Representative Horizontal Hydraulic Conductivity (m/s)
Tauranga Group Alluvium / Upper Puketoka Group	4E-09	2E-06	2E-07
Basalt	1E-06	1E-03	1E-04
Weathered ECBF	2E-08	2E-06	2E-07
ECBF Rock	2E-09	2E-06	2E-07
Fractured ECBF	6E-06	5E-04	1E-04

Vertical hydraulic conductivity can be significantly lower than horizontal hydraulic conductivity, particularly in highly stratified lithologies. The vertical anisotropy (vertical hydraulic conductivity divided by horizontal hydraulic conductivity; Kv/Kh) is typically in the order of 0.1 (one order of magnitude) but can be significant lower in highly stratified and unfractured ECBF rock (<0.01).

3.4.3 Site investigations – permeability

Hydraulic conductivity values derived from the rising and falling head tests are summarised in Table 3-2. Analyses are provided in Appendix B.

Table 3-2: Hydraulic testing summary

ID	Falling head hydraulic conductivity (m/s)	Rising head hydraulic conductivity (m/s)	Comment
BH001	4.5E-06	1.6E-06	
BH002	1.3E-05	-	Rising head test failed
BH003	4.4E-08	3.3E-08	
BH004	1.5E-05	1.3E-05	
BH005	5.8E-07	6.2E-07	
BH006	*Not tested at time of reporting*		
BH008	8.7E-08	-	Rising head test failed
BH009	1.0E-07	1.0E-07	
BH010	-	-	Dry
BH011	-	-	Dry
BH012	*Not tested at time of reporting*		

BH001, BH002 and BH004 display elevated permeability that I have attributed to fracturing within the weathered siltstone and sandstone. This fracturing is recorded below the following elevations (refer to Appendix A):

- 29m NZVD in BH001;
- 20m NZVD in BH002; and
- 15m NZVD in BH004.

The results from BH003, BH005, BH008 and BH009 are consistent with the anticipated low permeability.

The range of the recorded hydraulic conductivity values is generally consistent with those of previous investigations summarised in Section 3.4.2.

Excluding the elevated permeability attributed to fracturing within the ECBF, the average derived bulk hydraulic conductivity value for combined Takaanini Formation, residual soil and weathered ECBF is approximately 2.2E-07m/s and is very close to the indicative representative hydraulic conductivity from previous investigations of 2E-07m/s. A value of 2.2E-07m/s has therefore been adopted for the assessment of groundwater seepage to excavations and resulting groundwater drawdown.

3.4.4 Groundwater levels and flow

3.4.4.1 GNS Science national water table model

Figure 3-2 shows indicative groundwater level contours from the GNS Science national water table model (GNS, 2018). While not necessarily accurate at a local scale, the contours provide an indication of anticipated water table elevation and groundwater flow directions. The groundwater contours indicate the water table to generally follow topography. Groundwater flow direction is down-gradient perpendicular to the contour lines and is generally from areas of high topographic relief to areas of low topographic relief.

Groundwater recharge will occur as rainfall infiltration on open areas and as infiltration from surface water features and stormwater drains. Groundwater discharge will generally be to surface water features in lower lying areas and to the Waitematā Harbour.

3.4.4.2 NZGD water levels

Boreholes from the New Zealand Geotechnical Database[1] (NZGD) in the vicinity of the Project Area and with available water level data are shown in Figure 3-3 in green.

The recorded water levels indicate the range of water levels that might be expected within the Project Area, but may not be indicative of true, or current, groundwater levels because:

- The water level observations are often taken during drilling, at the beginning or end of shift, or at end of hole. As such, water levels may not have had time to equilibrate in low permeability formations.
- The date of water level observations is variable with earliest observations from 1999.

The recorded water levels range from 0 to 13.1 metres below ground level (mbgl), with an average recorded depth to water of 2.9mbgl and a median water level depth of 2.5mbgl.

[1] https://identity.beca.digital/cdn/beyon-nzgd/pdfs/About%20NZGD.pdf

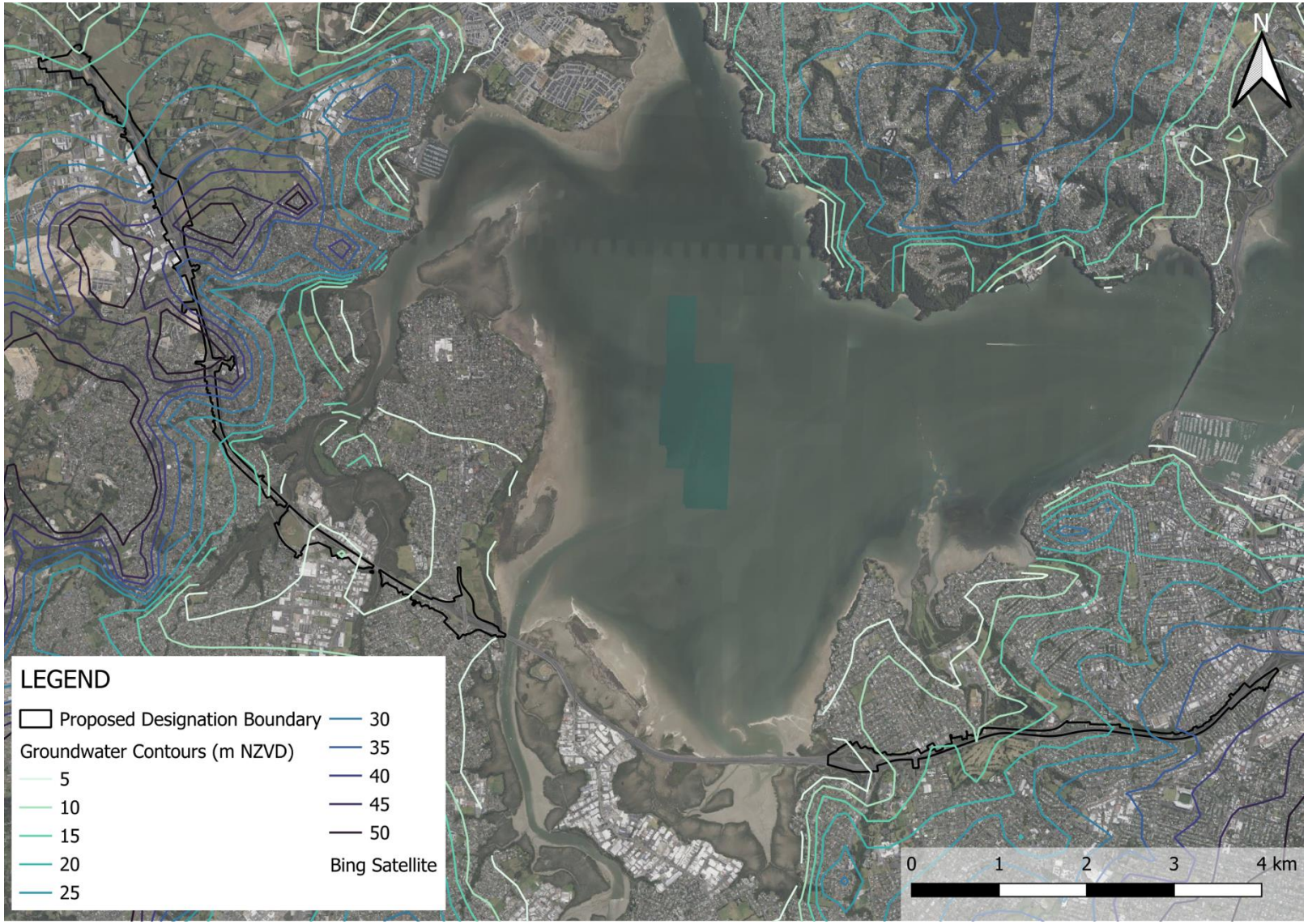

Figure 3-2: Indicative groundwater level contours

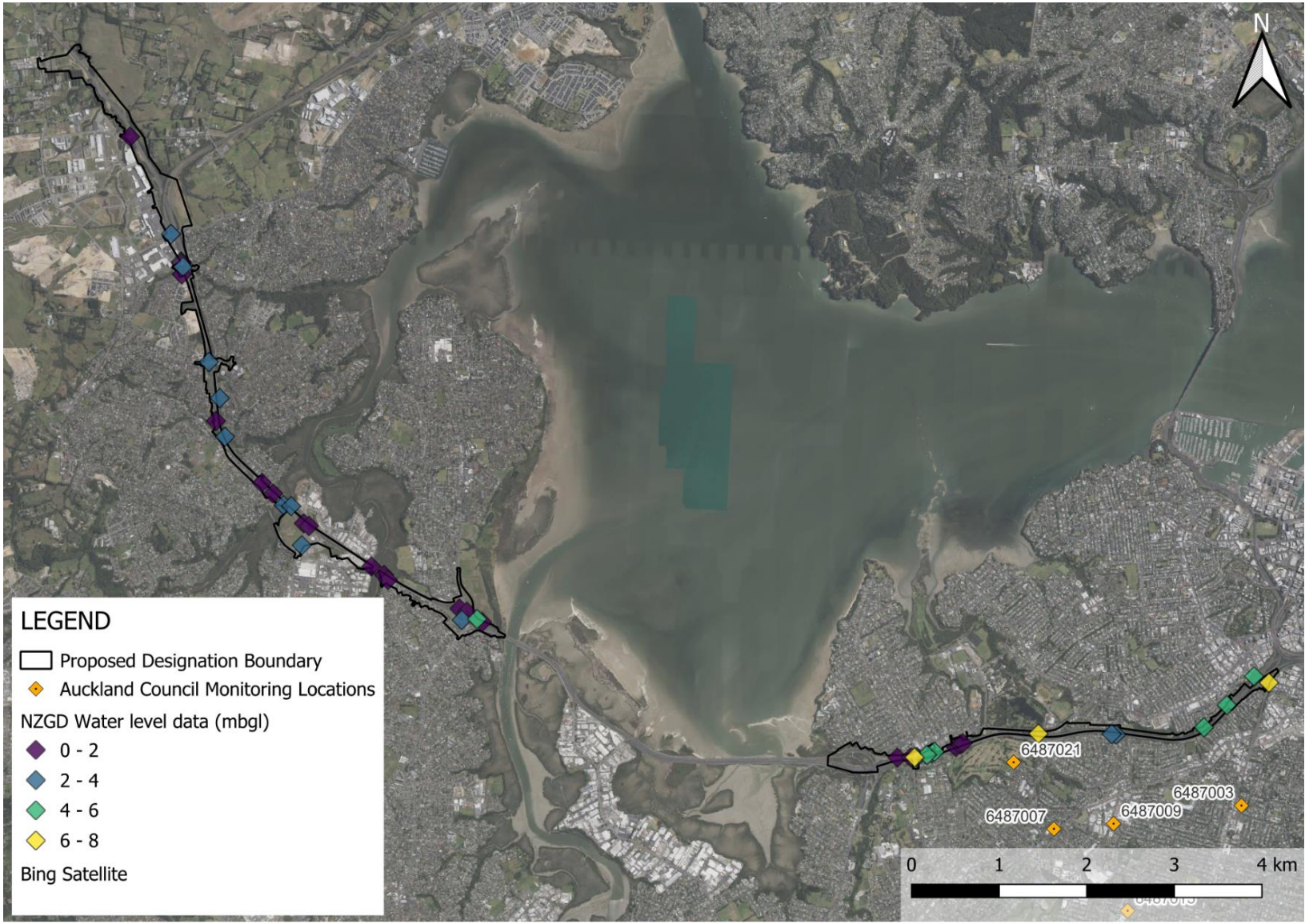

Figure 3-3: Groundwater level data

3.4.4.3 Site investigations – groundwater levels

Groundwater level observations from site investigations are shown on Figure 3-4 with data provided in Appendix C.

Groundwater levels are highly variable along the Project Area with observed depths to groundwater ranging from approximately 1.0 to 6.3mbgl, with an average observed depth to groundwater of approximately 3.85mbgl.

Two of the monitoring bores (BH010 and BH011) are recorded as being dry to depths of 13.0mbgl and 7.5mbgl respectively, while BH012 was not accessible for monitoring at time of writing.

BH001 and BH003 display an equilibration response following drilling, with water levels rising over a period of weeks before settling-in to what is considered to be a representative water level. BH004 displays an initial equilibration period of declining water levels.

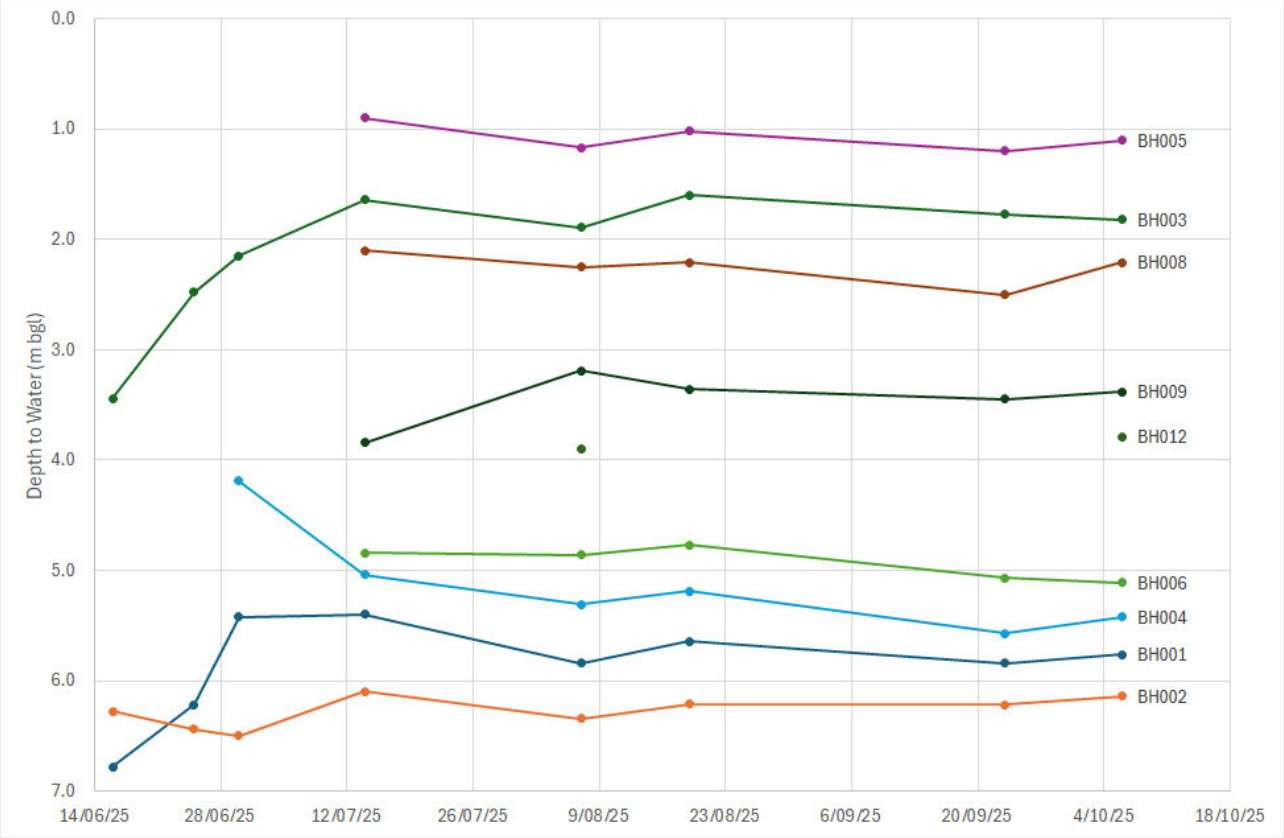

Figure 3-4: Project groundwater level observations

3.4.4.4 Seasonal groundwater fluctuations

Auckland Council manage a number of groundwater monitoring bores in the vicinity of the Project Area with data available through the Environmental Data Portal.[2] The nearest bores with complete data records are located approximately 1km south of the Indicative Design and are located in the Western Springs – Three Kings Volcanic aquifer. These bore locations are shown in Figure 3-3 in orange.

Average daily groundwater level hydrographs for the Selkirk Road Bore (ID 6487007) and the Leslie Road Bore (ID 6487009) over the past ten years are plotted in Figure 3-5 and Figure 3-6, respectively, along with median and 95th percentile (high) water levels. The bores are installed in the basalt aquifer and as such will have a “flashier” groundwater level response compared to groundwater levels in low permeability formations such as the Takaanini Formation and ECBF. A “flashier” groundwater level response means, in general, the

[2] https://environmentauckland.org.nz/Data/Map/Parameter/GW%20Level/Statistic/LASTRECORD/Interval/Latest - accessed July 2025.

water levels will display more rapid fluctuations with recharge and subsequent regression and are expected to have a greater seasonal variation in water levels compared to the less permeable formations. However, both bores display higher than average water levels during July 2025, indicating the water levels measured as part of the Project site investigations during July and August 2025 can be considered to be representative of seasonal high water levels for the purposes of assessing potential groundwater seepage to excavations.

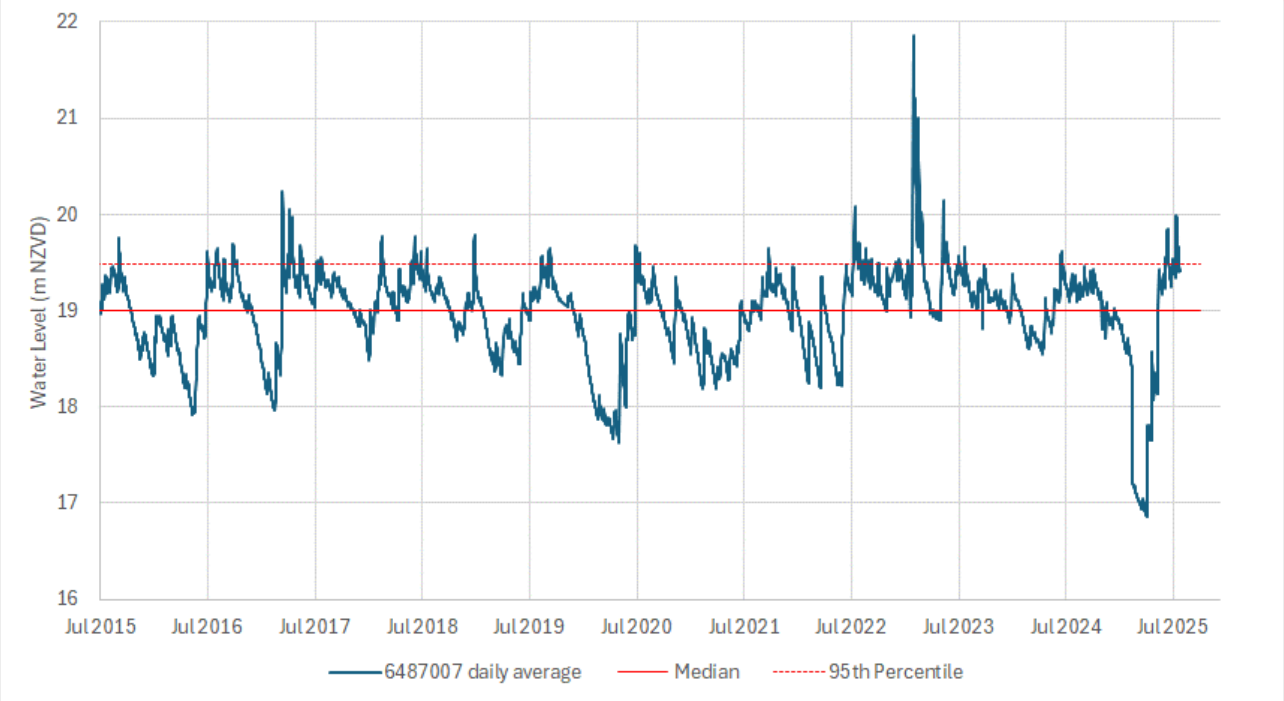

Figure 3-5: 6487007 - Selkirk Road Bore hydrograph

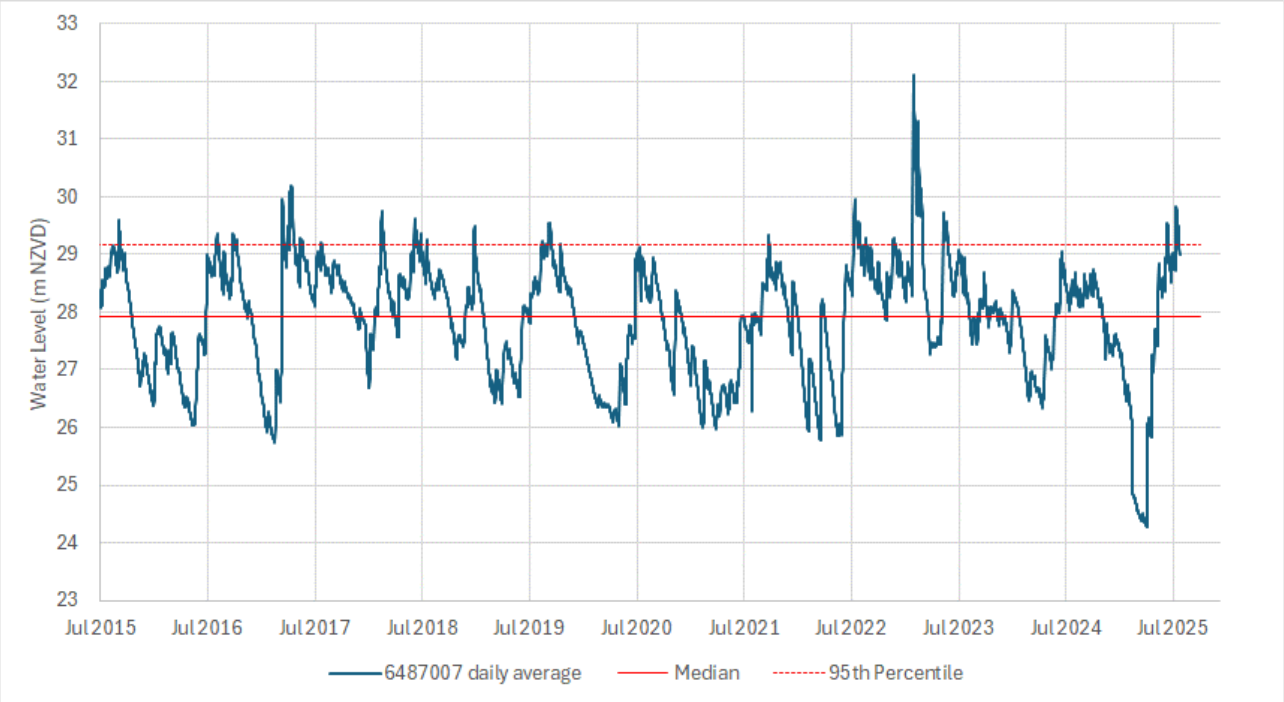

Figure 3-6: 6487009 - Leslie Road Bore hydrograph

3.4.5 Groundwater quality

3.4.5.1 Desktop study

Groundwater quality monitoring in the vicinity of the Project Area is limited to one site in the Western Springs – Three Kings Volcanic Aquifer, being the Watson Avenue groundwater quality site (ID 6487015).

Median water quality parameters for the Watson Avenue groundwater monitoring bore for the period 2015 to 2019 are summarised in Table 3-3. The water quality is fresh with close to neutral pH, although the pH level is outside of the ANZG (2018) default guideline value (DGV) range. Dissolved oxygen is also below the ANZG (2018) DGV range, however lower dissolved oxygen is to be expected in in groundwater, whereas the ANZG (2018) DGV are specifically for surface water.

Median concentrations of nitrate and dissolved reactive phosphorous are also above the relevant DGVs. Auckland Council (2021) attribute the dissolved reactive phosphorous to a natural process of the dissolution of volcanic glass within the aquifer and note that nitrate concentrations have been elevated for nearly 100 years so it was not clear if they are attributable to anthropogenic causes or are naturally elevated. However, the report concluded that, overall, results from the groundwater quality monitoring programme indicated that nitrate was the foremost contaminant of concern for shallow volcanic aquifers in the Auckland region, with high nitrate concentrations coinciding with both horticultural and urban land uses.

The only exceedance of a toxicant DGV is for zinc. Auckland Council (2021) noted an increasing trend for zinc. Elevated concentrations are potentially linked to the use of the aquifer for stormwater infiltration.

Table 3-3: Watson Avenue – median water quality parameters (2015 to 2019)

Parameter		ANZG (2018)*	Value
Ammonia N	**(mg/L)**	*[0.01]*	0.009
Nitrite N	**(mg/L)**		0.001
Nitrate N	**(mg/L)**	*[0.065]*	3.75
Dissolved reactive phosphorus (mg/L)		*[0.014]*	0.065
Soluble iron	**(mg/L)**		0.047
Soluble manganese	**(mg/L)**	*1.9*	0.01
Soluble sodium	**(mg/L)**		22
Soluble zinc	**(mg/L)**	*0.008*	0.012
Soluble copper	**(mg/L)**	*0.0014*	0.0008
pH		*[7.26 to 7.7]*	6.89
Alkalinity	**(mg/L)**		48
Dissolved oxygen	**(mg/L)**	*[9 -10.2]***	6.55
Electrical conductivity	**(µS/m)**	*[115]*	214
Chloride	**(mg/L)**		18
Total Hardness	**(mg/L)**		44
Total Dissolved Solids	**(mg/L)**		140
Soluble Sulphate	**(mg/L)**		12.85

Notes: * Default Guideline Value (DGV). [Value in parentheses] = DGV for physical and chemical stressors, Warm Wet Low-elevation, otherwise toxicant DGV for 95% aquatic ecosystem protection.
** - Approximate equivalent at 16°C. Actual DGV is for 92 to 103% dissolved oxygen.
- Yellow highlight – value exceeds DGV for physical and chemical stressors
- Orange highlight – value exceeds toxicant DGV.

3.4.5.2 Site investigations

The results of groundwater quality analyses from the monitoring bores are summarised in Table 3-4, with laboratory reports provided in Appendix C.

The groundwater is generally characterised as being relatively fresh, with total dissolved solids ranging from 88 to 460mg/L, and slightly acidic, with pH ranging from 5.1 to 6.8. pH and electrical conductivity exceed the ANZG (2018) physical and chemical stressor DGV for pH and electrical conductivity for freshwater ecosystems (warm wet low-elevation).

Total nitrogen and total phosphorous are also elevated and consistently exceed the relevant physical and chemical stressor DGV.

The ANZG 2018 toxicant DGV for nickel is exceeded at most monitoring bores and the DGV for zinc is exceeded at four of the eight monitoring bores tested. Due to the ubiquitous nature of the exceedances for nickel, elevated metals are likely due to the geological formations as opposed to anthropogenic influences.

Table 3-4: Project water quality parameters

Parameter		*ANZG 2018*	BH01	BH02	BH03	BH04	BH05	BH06	BH08	BH09
Physical Parameters										
pH	(pH units)	*[7.26 to 7.7]*	6.2	6.8	5.9	5.9	5.9	6.1	5.5	5.1
Total Alkalinity	(mg/L as CaCO3)	-	64	155	21	40	46	84	14.4	23
Free Carbon Dioxide	(mg/L)	-	75	46	52	102	113	125	96	340
Total Hardness	(mg/L as CaCO3)	-	102	200	23	28	31	62	10.9	128
Electrical Conductivity	(mS/m)	*[11.5]*	34.3	50.7	19.4	20.3	25.8	28.2	18.1	66.7
Total Dissolved Solids	(mg/L)	-	250	360	126	124	400	320	88	460
Major Ions										
Sodium	(mg/L)	-	26	28	27	29	40	34	26	54
Potassium	(mg/L)	-	2	2.4	1.15	1.44	0.8	2.1	1.65	3.6
Calcium	(mg/L)	-	27	59	6.4	5.9	9.1	18.2	1.74	24
Magnesium	(mg/L)	-	8.5	13.6	1.74	3.1	2	3.9	1.6	16.8
Chloride	(mg/L)	-	31	36	25	20	29	28	35	70
Sulphate	(mg/L)	-	47	47	21	19	30	12	7.9	185
Carbonate	(mg/L)	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate	(mg/L)	-	78	189	26	49	56	102	17.6	28
Nutrients										
Total Nitrogen	(mg/L)	*[0.292]*	1.16	0.3	1.27	0.25	1.31	1.31	2.6	3.4
Total Ammoniacal-N	(mg/L)	*[0.01]*	0.014	0.023	<0.010	<0.010	<0.010	0.052	1.37	0.57
Nitrite-N	(mg/L)	-	0.005	0.002	<0.002	<0.002	0.002	0.002	0.003	<0.002
Nitrate-N	(mg/L)	*[0.065]*	1.00	<0.002	1.06	0.049	0.079	0.008	<0.002	<0.002

Parameter		*ANZG 2018*	BH01	BH02	BH03	BH04	BH05	BH06	BH08	BH09
Nitrate-N + Nitrite-N	(mg/L)	-	1.01	0.003	1.06	0.049	0.081	0.011	0.005	<0.002
Total Kjeldahl Nitrogen	(mg/L)	-	0.16	0.3	0.21	0.2	1.23	1.3	2.6	3.4
Total Phosphorus	(mg/L)	*[0.024]*	0.155	0.014	0.064	0.032	0.45	0.43	0.37	8.5
Metals										
Aluminium	(mg/L)	-	<0.003	<0.003	0.041	0.042	0.04	0.029	0.057	0.35
Arsenic	(mg/L)	*0.013**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0029
Cadmium	(mg/L)	*0.0002*	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00013
Chromium	(mg/L)	*0.001***	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	(mg/L)	*0.0014*	<0.0005	<0.0005	<0.0005	0.0012	<0.0005	0.0006	0.0046	0.0005
Lead	(mg/L)	*0.0034*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00032
Iron	(mg/L)	-	<0.02	<0.02	<0.02	<0.02	0.06	<0.02	3.6	39
Magnesium	(mg/L)	-	8.5	13.6	1.74	3.1	2.0	3.9	1.6	16.8
Manganese	(mg/L)	*1.9*	0.31	0.3	0.08	0.065	0.135	0.26	0.192	0.66
Nickel	(mg/L)	*0.0011*	0.0032	<0.0005	0.0012	0.0021	0.0017	0.0023	0.0083	0.021
Zinc	(mg/L)	*0.008*	0.005	0.0019	0.0102	0.0058	0.0022	0.0082	0.0189	0.111
Notes:		ANZG 2018 – [Value in parentheses] – Physical and Chemical Stressor DGV for fresh water aquatic ecosystems, 'Warm Wet Low-elevation' river environment classification, otherwise Toxicant DGV for 95% protection of freshwater aquatic ecosystems.								
		* - value is for pentavalent arsenic (AsV)				** - value is for hexavalent chromium (CrVI)				
		Yellow highlight – exceeds Physical and Chemical Stressor DGV				Orange highlight – exceeds Toxicant DGV				

3.4.6 Groundwater users

Existing groundwater wells in the vicinity of the Proposed Designation area have been sourced from the Wells Aotearoa New Zealand database[3] and are shown in Figure 3-7. These represent all well records held by Auckland Council, regardless of consent status and age.

Wells in Figure 3-7 are categorised by use, with the majority of wells recorded as being of unknown use.

The closest wells to the Project Area recorded as being for abstractive use, such as for irrigation or water supply, are located in the Western Springs - Three Kings Volcanic aquifer, with the closest being approximately 180m south of the Proposed Designation boundary within the Chamberlain Park Golf Course.

A summary of consented and permitted activity wells installed for abstractive use within approximately 200m of the Indicative Design, provided by Auckland Council, is provided in Table 3-5.

Table 3-5: Bores installed for domestic, stock or irrigation uses

Bore ID	Consent number/ reference	Address	Total depth	Purpose	Approximate distance from Project Area / Comment
5653	15969	Hobsonville Road onramp to the Upper Harbour motorway	305m	Irrigation	Beneath alignment – unlikely still exists. Drilled 1997
-	LUC80313246	28 Carrington Road, Mount Albert	Unknown	Domestic supply	100m
-	LUC80312239	22-24 Point Chevalier Road, Point Chevalier	Unknown	Domestic supply	50 m New development on site – unlikely still exists
5205	14906	Western Springs Lakeside Park	17m	Domestic supply	60m
20657	-	805 Great North Road (Motat)	6.8m	Not provided	50m

[3] https://wellsnz.teurukahika.nz/ - accessed July 2025.

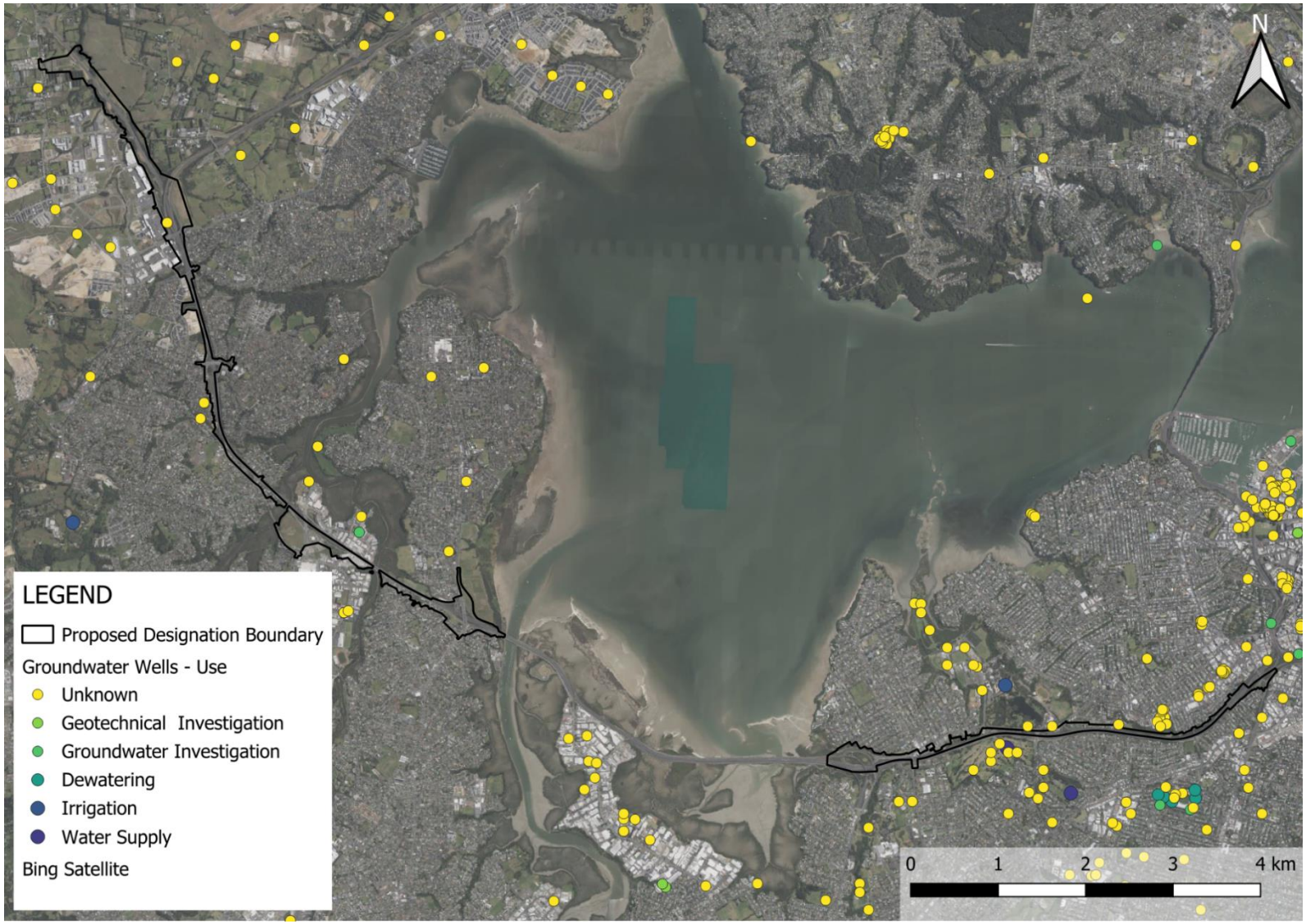

Figure 3-7: Groundwater wells

3.5 Potential for settlement

Ground settlement due to groundwater drawdown results from a reduction in pore water pressure caused by groundwater removal. This reduction in pore pressure increases the effective stress (total vertical load) acting on the soil particles, causing them to compact. Finer grained, porous, and low strength soils such as clays and peat are generally more susceptible to settlement.

Young's modulus (also known as the modulus of elasticity, elastic modulus, tensile modulus, and deformation modulus) is a mechanical property that represents a material's stiffness or resistance to deformation under stress (measured in Mega-Pascals, MPa).

Indicative values for Young's modulus for the formations likely to be encountered within the Project Area are provided in Table 3-6 (Tonkin and Taylor, 2012). Lower values, typically <15MPa, indicate greater potential for settlement.

Table 3-6: Indicative material stiffness – previous investigations

Geological Unit	Indicative values for Young's Modulus (MPa)		
	Minimum	Maximum	Representative
Tauranga Group Alluvium / Shallow Takaanini Formation	2.5	20	6
Deeper Takaanini Formation (below 12 m)	10	40	15
Basalt	Considered to be essentially non-compressible for the purposes of this assessment and the likely range of effective stress.		
Weathered ECBF	4	40	15
ECBF Rock	150	1000	500

Potential settlement has been assessed by applying representative values of Young's Modulus of 8MPa for the Takaanini Formation and Residual Soils, and 15MPa for the weathered ECBF as relevant.

4. Predicted Project interactions with groundwater

4.1 Project cuts anticipated to interact with groundwater

The major potential for interaction of Project elements with groundwater is through deep cuttings and excavations to accommodate the busway and stations. Areas of cut along the Indicative Design have been reviewed and the areas of indicative cut with potential to intercept groundwater are summarised on Table 4-1.

While the Project will also include other smaller excavations, such as for bridge foundations and pilings, these are not expected to have substantial interactions with groundwater or result in greater than minor effects.

The cuttings at Huruhuru Road underpass, Lincoln Road Wai o Pareira station, Te Atatū Ōrangihina station, and Point Chevalier station are anticipated to be below the water table with potential to result in groundwater seepage to excavations and propagation of groundwater drawdown. The cut for the Fred Taylor Drive underpass is one of the deepest cuts, however the cut is through an area of locally elevated ground surrounded by ground of similar or lower elevation than the proposed cut. The cut is unlikely to intersect the water table or result in any substantial propagation of drawdown.

It is noted that site investigations (BH010) indicate that the cutting at Royal Road station is above the water table, however previous investigation from the NZGD near Royal Road indicates potential for a higher water table, which has been adopted for this assessment on a conservative basis.

Most cuttings are anticipated to be within the Takaanini Formation or residual ECBF, or a combination of both.

Given the potential for movement of the Indicative Design within the Proposed Designation, deep cuttings and excavations may also occur in other locations across the Project Area and may be below the water table.

It is anticipated that the majority of the deeper areas of cut and underpasses will be retained through the application of pre-installed secant pile walls or diaphragm walls prior to excavation. Secant piles and diaphragm walls will act to restrict groundwater seepage to excavations, however as designs have yet to be finalised, all excavations have been treated as being free-draining. Accordingly, this assessment presents the ‘worst case scenario’ in terms of potential groundwater seepage and drawdown.

Table 4-1: Interaction of major cut areas with groundwater

Approximate Chainage from	Approximate Chainage to	Location	Indicative Design	Comment	Site investigations
20,500	20,600	Fred Taylor Drive underpass	▪ Retained cut and cut and cover tunnel up to approximately 9.7m depth.	▪ Proposed Designation boundary approaches within approximately 8.5m of retained cut. ▪ Areas of cut are within Takaanini Formation, and residual and weathered ECBF. ▪ Elevated ground is localised and the design elevation (invert) is above or similar to adjacent ground elevations. ▪ Potential for localised perched water table but with no potential for propagation of drawdown.	BH012 (approx. 260m north)
21,880	30,080	Royal Road station and Royal Road underpass	▪ Retained cut up to approximately 9m depth. ▪ Average invert approx. 55.6m NZVD.	▪ Location is constrained within Proposed Designation with limited scope for lateral movement. ▪ Proposed Designation boundary approaches within approximately 10m, with school buildings within approximately 14m of retained cut. ▪ BH010 was dry to 13.0mbgl (52m NZVD) during site investigations, however, NZGD has a nearby water level observation of 3.3mbgl (58.4m NZVD) ▪ Cutting has potential to be below water table within residual ECBF. ▪ Cut-back of existing slope with one sided groundwater seepage.	BH010
31,240	31,840	Huruhuru Road underpass	▪ Small local cuts and underpass up to 4-5m. ▪ Underpass invert approximately 16m NZVD.	▪ Location is constrained within Proposed Designation with limited scope for lateral movement. ▪ Proposed Designation boundary approximately 40m from cut, no buildings within 70m of deepest cut area. ▪ Depth to water at BH009 is approximately 3mbgl (21.5m NZVD) ▪ Cutting is expected to be below water table within Takaanini Formation. ▪ Cut-back of existing slope with one sided groundwater seepage.	BH009

Approximate Chainage from	Approximate Chainage to	Location	Indicative Design	Comment	Site investigations
32,180	40,180	Lincoln Road station and Lincoln Road underpass	▪ Retained cut up to approximately 8m depth. ▪ Some battered cut. ▪ Invert is approximately 9 to 11m NZVD.	▪ Proposed Designation boundary >170m from deepest cut area. ▪ Undeveloped area. ▪ Depth to water at BH008 is approximately 2.25mbgl (14.0m NZVD) ▪ Cutting is expected to be below water table, predominantly within Takaanini Formation and some residual ECBF. ▪ Slot-cut with groundwater seepage both sides.	BH008
42,080	50,180	Te Atatū station and Te Atatū Road underpass	▪ Retained cut up to approximately 9m depth. ▪ Invert is approximately 16 to 17m NZVD.	▪ Proposed Designation boundary >70m from deepest cut area. ▪ Depth to water at BH005 is approximately 1.0mbgl (19.7m NZVD) ▪ Cutting is expected to be below water table within Takaanini Formation. ▪ Slot-cut with limited relict ground between busway and motorway. Potential for short term seepage both sides and long-term one sided groundwater seepage.	BH005, BH006
59,700	70,100	Point Chevalier station and Carrington Road underpass	▪ Retained cut up to approximately 6.7m depth. ▪ Invert is approximately 19 to 21m NZVD.	▪ Location is constrained within Proposed Designation with limited scope for lateral movement. ▪ Proposed Designation boundary and buildings are very close to station (<10m) at 1210 Great North Road ▪ Depth to water at BH004 is approximately 5.0mbgl (22.7m NZVD) ▪ Cutting is expected to be below water table, predominantly within Takaanini Formation and some residual ECBF. ▪ Slot-cut with minor relict ground between Busway and motorway. One sided groundwater seepage.	BH003, BH004

4.2 Groundwater seepage to excavations

Groundwater seepage to excavations has been estimated for larger cuts that are anticipated to be below the water table as assessed in Table 4-1. The calculations are presented in Appendix E and summarised in Table 4-2.

4.2.1 Methodology and assumptions

Seepage rates have been calculated using the method of Mansur and Kaufman (1962) for the assessment of linear flow to an excavation in an unconfined aquifer, as presented in Neville (2017). The cuts are either cutting back of existing cuts, with potential for one-sided groundwater seepage, or are slot-cuts adjacent to existing cuts for the Northern Motorway, with potential for either one or two sided groundwater seepage depending on the remnant ground between the Northwestern Motorway and Project. Cuttings at Lincoln Road station and Te Atatū station have potential for groundwater seepage from both sides, while cuttings at Royal Road station, Huruhuru Road underpass, and Point Chevalier station are only likely to have groundwater seepage from one side (Table 4-1).

The seepage modelling is for a conservative scenario in which excavation shoring methods or retaining walls do not inhibit groundwater seepage to excavations.

Seepage calculations are based on the following simplifying assumptions:

- The Indicative Design has been divided into 50m long sections within each cut area to account for variable invert and groundwater levels along the alignment.
- Average invert and interpreted water level elevations are applied over each section. Groundwater levels are estimated based on available observations. Where only one groundwater level observation is available, then the observed depth to groundwater is adopted along the length of the cut.
- Invert depth, water table elevation and required groundwater drawdown are as presented in Appendix E.
- Allowance is included for an additional 0.5m excavation depth below invert elevation to account for foundation and drainage layers.
- Alluvium, residual soils and weathered ECBF have an average hydraulic conductivity of 2.0E-07m/s (0.017m/day) and a specific yield of 0.1.
- Aquifer depth contributing to groundwater flow to the excavation extends 5m below excavation floor level.
- Estimated seepage rates are for steady state, long term equilibrated conditions.
- Total head beneath the excavation is equal to the elevation of the excavation floor, therefore vertical flow to the excavation is negligible.
- Excavation shoring methods do not restrict groundwater ingress to excavations.
- The method requires the input of a distance to a fixed head boundary for the estimation of hydraulic gradient. In this case a distance of three times the required drawdown within the cut has been adopted. For example, if the excavation is assessed as being 4m below the water table, a distance to the fixed head boundary of 12m is applied. It is noted that a shorter distance to the fixed head boundary results in a steeper hydraulic gradient and higher rate of inflow and is therefore conservative.

It is noted that in some instances there will already be a component of groundwater seepage to drainage layers behind existing retaining walls and pavements. These pre-existing seepage rates have not been assessed.

4.2.2 Results

Potential seepage rates to cuttings are summarised in Table 4-2, with seepage calculations provided in Appendix E.

Table 4-2: Groundwater seepage to cuttings - unmitigated

Location	Average seepage rate (m^3/day/m)	Indicative seepage rate - whole of cutting (m^3/day)	Annual seepage volume (ML)
Royal Road station and underpass	0.042	12.51	4.56
Huruhuru Road underpass	0.030	4.54	1.66
Lincoln Road station	0.080	31.81	11.61
Te Atatū station	0.053	15.98	5.83
Point Chevalier station	0.032	13.52	4.94

4.3 Groundwater drawdown and settlement

4.3.1 Methodology and assumptions

Groundwater drawdown resulting from seepage to cuttings has been assessed using GeoStudio Seep/W (Geo-Slope, 2015). Seep/W is a two-dimensional finite element groundwater flow model that simulates groundwater flow and pressure along a vertical section or slice. Modelling has been completed considering steady state conditions.

To assess potential groundwater drawdown resulting from the Project, a difference modelling approach has been applied. Each section was initially modelled without the Project simulating the key existing features along the section (the 'base case')). Another model was then run incorporating the Project cuttings as included in the Indicative Design. The difference in the modelled water table between the two modelled scenarios is attributed as the drawdown resulting from the Project.

For each of the areas being assessed, a representative section has been adopted, typically located at deepest section of cut or where the cutting approaches the Proposed Designation boundary or buildings. The section locations are provided with model outputs in Appendix F.

The base case modelling is unmitigated with respect to groundwater inflows and assumes unrestricted groundwater seepage to excavations. Retaining structures such as secant piling and diaphragm walls are not simulated and groundwater is free to drain at the excavation face. As such, the assessment is conservative as the retaining structures would act to restrict, and in some cases prevent, groundwater seepage to excavations and the resulting groundwater drawdown.

Based on the modelled drawdown, potential groundwater settlement has also been assessed using one-dimensional consolidation theory after CIRIA (2017). As consolidation settlement can only occur when the groundwater level is drawn below historical low groundwater levels. It is noted that water levels adopted for assessment of groundwater seepage to excavations and drawdown are indicative of seasonal high water levels. One meter has therefore been subtracted from the modelled drawdown to account for historical seasonal variations for the assessment of consolidation settlement.

Mechanical settlement is typically limited to within close proximity to the excavation compared to consolidation settlement due to drawdown, and will generally be constrained within the Proposed Designation boundary. In areas where excavations are closer to the Proposed Designation boundary, such as at Point Chevalier station and Royal Road station, lateral deflection of secant pile or diaphragm retaining walls can be managed through design; by increasing wall stiffness (pile diameter or wall thickness), incorporating ground anchors, and the use of lateral bracing. These construction and design options are commonly used to manage mechanical settlement and avoid settlement beyond acceptable tolerances.

4.3.2 Results

Predicted drawdown and settlement at the Proposed Designation boundary and for any adjacent buildings where the Proposed Designation boundary is close to the cut, are summarised on Table 4-3.

Groundwater drawdown and settlement profiles for the sections that have been assessed are plotted on Figure 4-1 to Figure 4-5 where predicted drawdown is shown in blue on the primary vertical axis (Drawdown in metres), drawdown modified for historical low water levels is shown in blue dash, and the resulting

calculated settlement is shown in orange on the secondary vertical axis (Settlement in millimetres). The vertical axes orientations are reversed so that the drawdown and settlement curves do not over-plot.

Seep/W pore pressure profiles for the locations of the model sections are presented in Appendix F.

Groundwater drawdown itself is not considered to be an impact unless it directly effects a beneficial use of groundwater, such as groundwater discharge to surface water or groundwater abstraction for water supply. Ground settlement resulting from groundwater drawdown has the potential to impact buildings, structures and services. These potential effects are assessed in Section 5.

Table 4-3: Predicted groundwater drawdown and ground settlement - unmitigated

Location	Approximate distance to Proposed Designation boundary along section (m)	Modelled groundwater drawdown at Proposed Designation boundary (m)	Estimated settlement at Proposed Designation boundary (mm)	Estimated differential settlement at Proposed Designation boundary (%)	Estimated settlement at nearest building (mm)
Royal Road station	14	1.8	2.6	0.035	2.6
Huruhuru Road Underpass	40	0.5	0	0	0
Lincoln Road station	180	0	0	0	n/a
Te Atatū station	75	0.9	0	0.004	0
Point Chevalier station	6	2.0	6.5	0.060	6.5

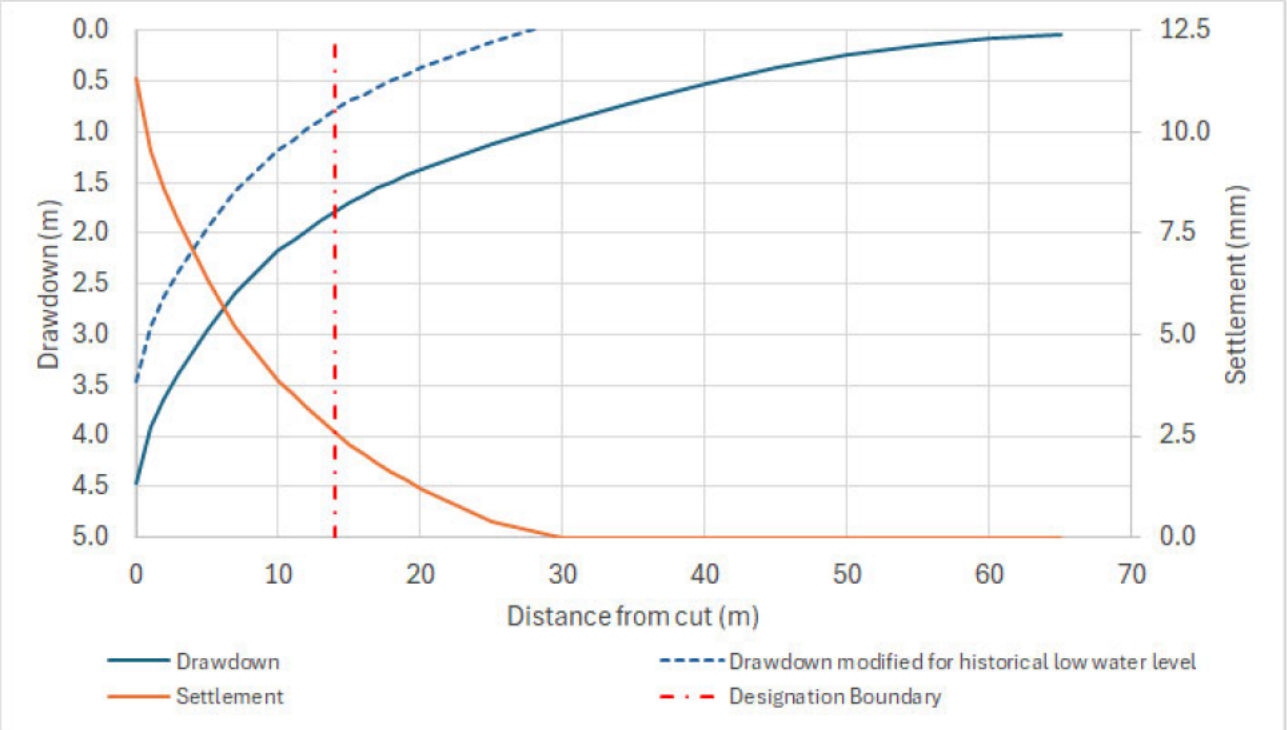

Figure 4-1: Royal Road station – Groundwater drawdown and settlement – unmitigated

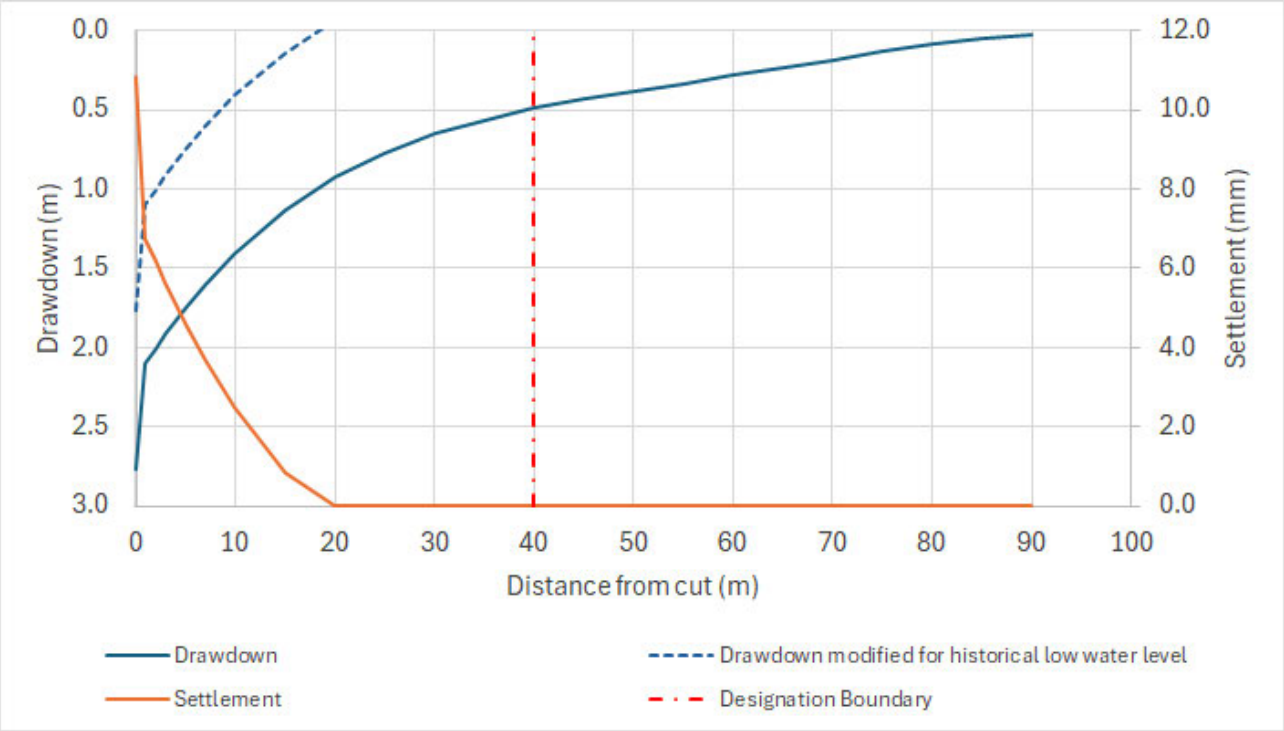

Figure 4-2: Huruhuru Road Underpass – Groundwater drawdown and settlement – unmitigated

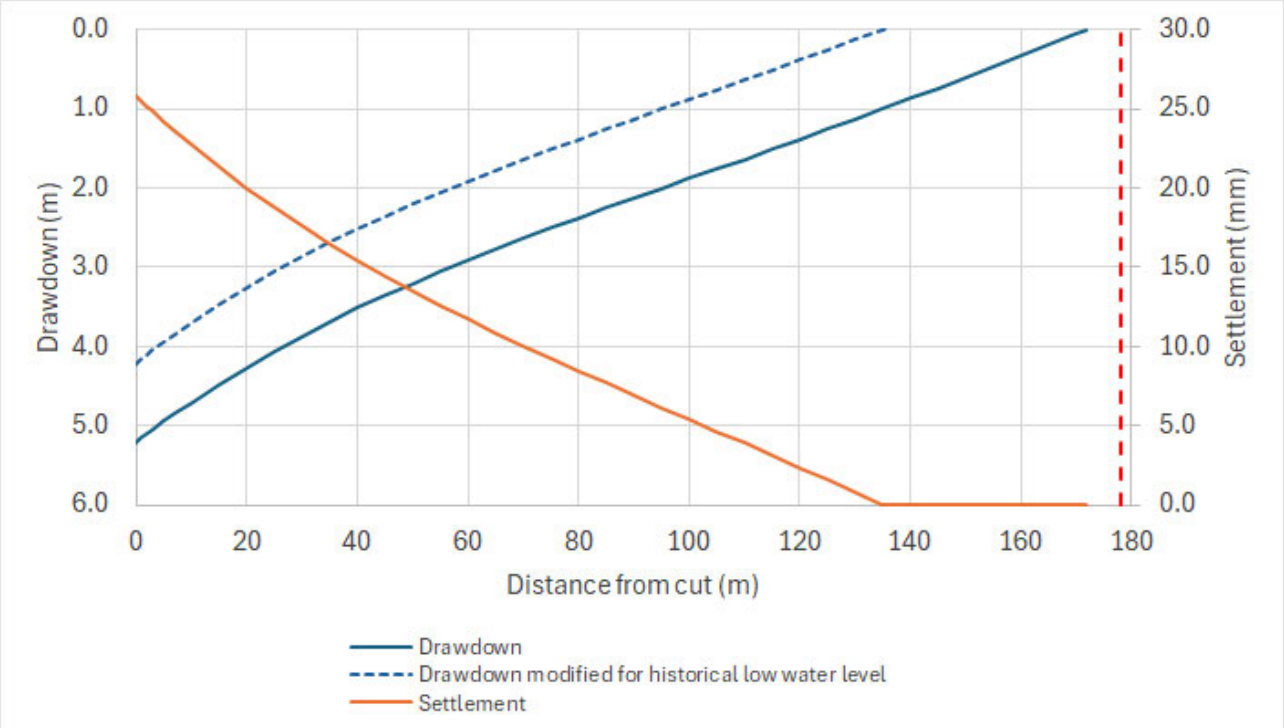

Figure 4-3: Lincoln Road station – Groundwater drawdown and settlement – unmitigated

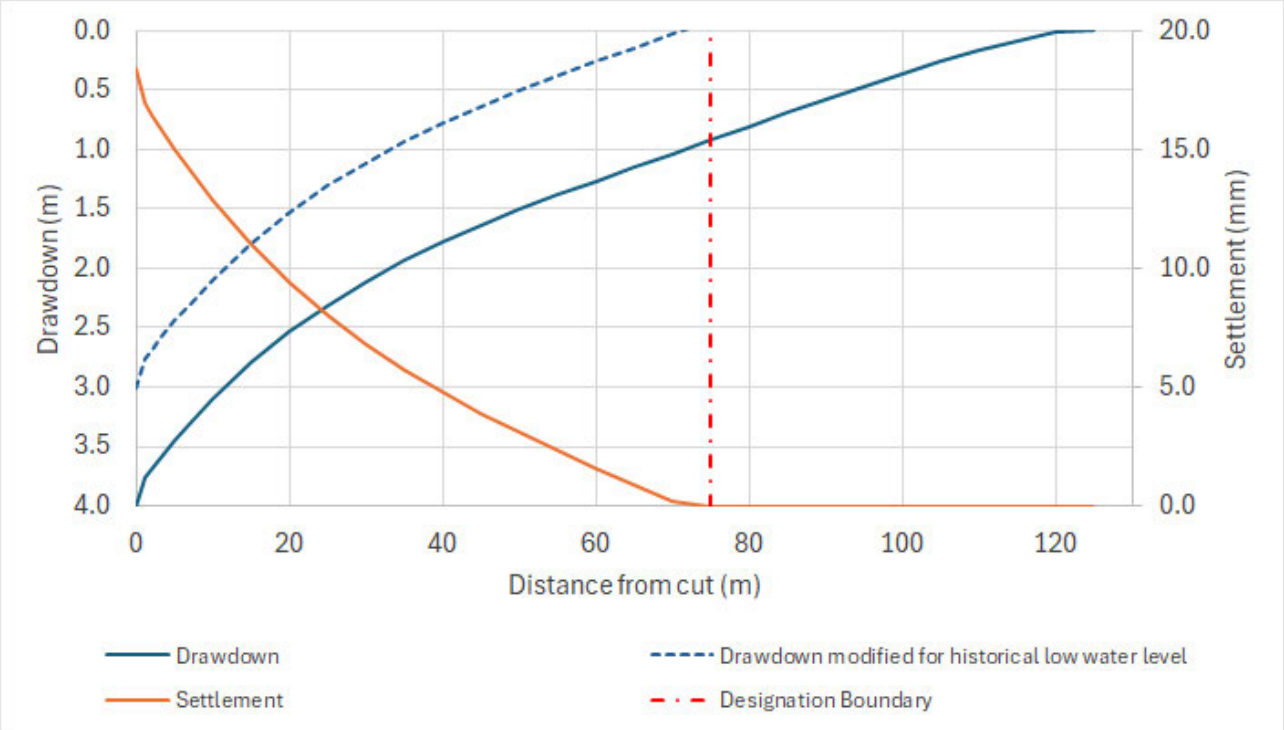

Figure 4-4: Te Atatū station – Groundwater drawdown and settlement – unmitigated

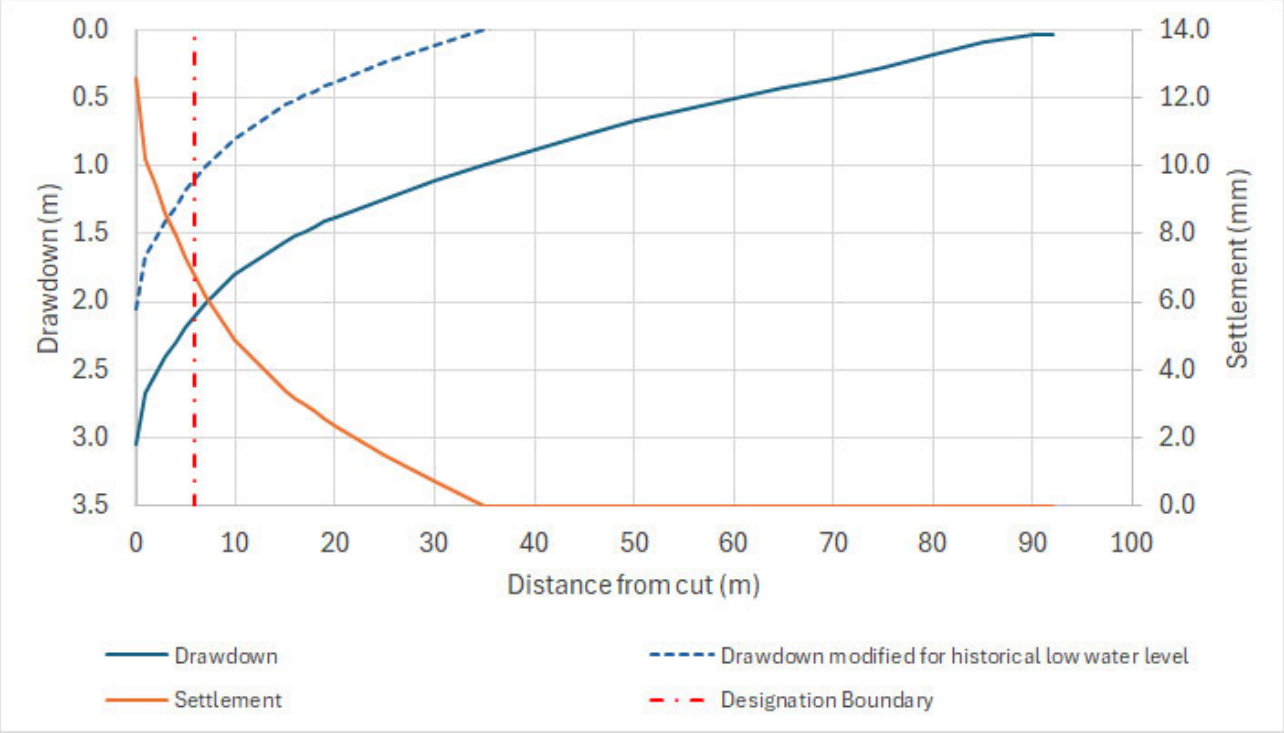

Figure 4-5: Point Chevalier station – Groundwater drawdown and settlement - unmitigated

4.4 Discussion of predicted changes to groundwater levels and groundwater diversion

The combination of low hydraulic conductivity values for the Takaanini Formation and residual ECBF results in limited propagation of groundwater drawdown away from areas of cuts below the water table, even with my conservative assessment that does not include the benefits of design features such as secant piling or diaphragm walls.

The maximum predicted drawdown at the boundary of the Proposed Designation is approximately 2.3m for Point Chevalier station.

The groundwater diversion volumes are presented in Table 4-2 with an estimated total annual seepage volume of the order of 28.6ML. In reality, due to the use of secant pilings and diaphragm walls as retaining structures, the actual volume of groundwater seepage and diversion is likely to be substantially lower.

5. Assessment of effects

5.1 Assessment of construction effects

5.1.1 Potential effects on other groundwater users

There is no recorded abstractive groundwater use within the areas of excavation and predicted drawdown. I consider there will be no impacts on groundwater users.

5.1.2 Potential effects on surface water bodies and wetlands

There are no surface water bodies or wetlands within close proximity to the areas of substantial excavation and predicted groundwater drawdown. The closest substantial excavation to a surface water body is the excavation of cuttings for Lincoln Road station, which come within approximately 60m of Huruhuru Creek. However, the cutting invert is approximately 10m higher than the level of the creek and therefore I consider the cutting will not have any groundwater related impacts.

In my opinion, there will be no impacts on surface water bodies or wetlands resulting from groundwater drawdown.

5.1.3 Potential settlement effects

Ground settlement has potential to result in damage to buildings and infrastructure.

5.1.3.1 Criteria

Potential for damage to buildings resulting from settlement is summarised in Table 5-1, after Burland (1997), Maire et al (1996), and Rankin (1988).

Table 5-1: Building damage assessment criteria

Building damage classification		Approximate equivalent ground settlement	
Risk Category	Description of degree of damage	Maximum differential settlement	Maximum settlement (mm)
0	Negligible	-	-
1	Very Slight	<1:500 (0.2%)	<10
2	Slight	1:500 to 1:200 (0.2 to 0.5%)	10 to 50
3	Moderate	1:200 to 1:50 (0.5 to 2%)	50 to 75
4	Severe	1:200 to 1:50 (0.5 to 2%)	>75
5	Very Severe	>1:50 (>2%)	>75

For potential damage to services, CIRIA PR30 (1996) provides recommended limiting values of settlement for buried pipes based on O'Rourke & Trautmann (1982). For rigid pipes with a diameter of greater than 200mm the maximum recommended differential settlement is 1:140 (0.71%) and for flexible pipes with a diameter less than 200mm the maximum recommended differential settlement is 1:80 to 1:40 (1.25 to 2.5%).

5.1.3.2 Assessment

The maximum predicted settlement due to drawdown at the Proposed Designation boundary is approximately 6.5mm at Point Chevalier station.

The maximum predicted settlement at a building is approximately 6.5mm with a differential settlement of approximately 0.06%. This occurs at Point Chevalier station and the building in question is the heritage listed Auckland Savings Bank building at 1210 Great North Road. Refer to the Assessment of Built Heritage Effects report for discussion regarding the building's heritage values.

It is noted that at Royal Road station, there are also buildings within approximately 14m of the proposed cut. However, the excavations at Royal Road station are within weathered ECBF as opposed to Takaanini Formation which has a greater strength and resistance to settlement, and the maximum predicted settlement at a building is only 2.6mm.

Based on this assessment, potential building damage due to settlement resulting from groundwater drawdown outside of the Proposed Designation boundary is in the negligible to very slight categories. Further, it is noted that the assessment of settlement due to groundwater drawdown assumes unrestricted groundwater seepage to excavations. In reality, the excavation will be retained by secant pilings or similar that will act to restrict groundwater seepage and drawdown resulting in settlement.

Accordingly, in my opinion, potential settlement effects resulting from groundwater drawdown will be less than minor to negligible.

5.2 Sensitivity testing of Indicative Design

I understand the Indicative Design may move within the Proposed Designation depending on the final design. The Proposed Designation allows for limited horizontal shifts of the Indicative Design and vertical shifts are also possible. Alternative designs could result in cuttings occurring in other locations across the Project Area or increases or decreases in existing proposed cut depths.

In my opinion, horizontal or vertical shifts to the Indicative Design within the Proposed Designation are unlikely to result in more than minor groundwater effects. This opinion is based on the low permeability of the formations and the limited propagation of drawdown resulting in settlement.

As noted earlier, my assessment is conservative, and in reality, I expect that the cuts will be retained by structural works such as secant piled or diaphragm wall retaining walls. In higher risk areas, where deep cuts are located closer to the Proposed Designation boundary and sensitive features such as buildings, those structural works will further act to limit groundwater seepage and drawdown propagation.

5.3 Assessment of operational effects

While there may be some ongoing groundwater seepage to drainage layers during Project operation, I consider there will be no further or additional effects, over and above those already assessed for the construction period.

5.4 Auckland Unitary Plan considerations

Section E7 of the Auckland Unitary Plan (Operative in Part) (AUP) requires an assessment of the proposed activity in relation to the taking, using, damming and diversion of groundwater in accordance with section 14(1) and section 14(3) of the Resource Management Act 1991.

An assessment of the proposed activity against the AUP groundwater provisions detailed in Sections E7.6.1.6 and E7.6.1.10 is presented in Table 5-2. Based on this assessment the project meets the criteria of a restricted discretionary activity and requires resource consent.

Table 5-2: Assessment of proposed activity against AUP groundwater provisions

Rule / Standard	Provision	Status
Standard E7.6.1.6	Dewatering or groundwater level control associated with a groundwater diversion permitted under Standard E7.6.1.10, all of the following must be met: 1. The water take must not be geothermal water; 2. The water take must not be for a period of more than 10 days where it occurs in peat soils, or 30 days in other types of soil or rock; and 3. The water take must only occur during construction.	Non-compliant (refer following dot points) 1. Meets provision 2. Seepage to excavations will take place for a period of greater than 30 days

Rule / Standard	Provision	Status
		3. Ongoing seepage may occur during operation
Standard E7.6.1.10(1)	Diversion of groundwater caused by any excavation, (including trench) or tunnel. All of the following activities are exempt from the Standards E7.6.1.10(2) – (6): a. pipes cables or tunnels including associated structures which are drilled or thrust and are up to 1.2m in external diameter; b. pipes including associated structures up to 1.5m in external diameter where a closed faced or earth pressure balanced machine is used; c. piles up to 1.5m in external diameter are exempt from these standards; d. diversions for no longer than 10 days; or e. diversions for network utilities and road network linear trenching activities that are progressively opened, closed and stabilised where the part of the trench that is open at any given time is no longer than 10 days.	The Project is not exempt therefore, a further assessment has been provided against Standards E7.6.1.10(2)-(6) below. a. N/A b. N/A c. N/A d. diversion will be greater than 10 days. e. N/A
Standard E7.6.1.10(2)	Any excavation that extends below natural groundwater level, must not exceed: a. 1ha in total area; and b. 6m depth below the natural ground level.	Does not fully meet standard. a. Meets standard b. Cuts will be greater than 6m depth.
Standard E7.6.1.10(3)	The natural groundwater level must not be reduced by more than 2m on the boundary of any adjoining site.	Meets standard. While the maximum estimated unmitigated drawdown at the Proposed Designation boundary is 2.3m at Point Chevalier Station, due to the use of retaining walls, as previously discussed, this magnitude of drawdown is unlikely to be realised.
Standard E7.6.1.10(4)	Any structure, excluding sheet piling that remains in place for no more than 30 days, that physically impedes the flow of groundwater through the site must not: a. impede the flow of groundwater over a length of more than 20m; and b. extend more than 2m below the natural groundwater level.	Does not meet standard. a. Retaining walls will impede the flow of groundwater over a length of more than 20m b. Retaining walls will extend more than 2m below the natural groundwater level.
Standard E7.6.1.10(5)	The distance to any existing building or structure (excluding timber fences and small structures on the boundary) on an adjoining site from the edge of any: a. trench or open excavation that extends below natural groundwater level must be at least equal to the depth of the excavation; b. tunnel or pipe with an external diameter of 0.2 - 1.5m that extends below natural groundwater level must be 2m or greater; or c. a tunnel or pipe with an external diameter of up to 0.2m that extends below natural groundwater level has no separation requirement.	Meets standard. a. Meets standard. b. N/A c. N/A
Standard E7.6.1.10(6)	The distance from the edge of any excavation that extends below natural groundwater level, must not be less than: a. 50m from the Wetland Management Areas Overlay; b. 10m from a scheduled Historic Heritage Overlay; or c. 10m from a lawful groundwater take.	Does not fully meet standard. a. Meets standard. b. Heritage building at 1210 Great North Road is <10m from retained excavation.

Rule / Standard	Provision	Status
		c. Meets standard.

6. Recommended measures to avoid, remedy or mitigate effects

6.1 Construction effects

I consider the effects associated with groundwater dewatering and associated ground settlement will be less than minor to negligible. As noted earlier, my assessment is conservative, and in reality I expect the design of the excavations will include the use of preinstalled secant piling or diaphragm wall retaining walls, which will act to limit groundwater seepage and drawdown, and further reduce potential for ground settlement resulting from dewatering.

7. Conclusion

I consider the actual and potential adverse effects of the Project on groundwater users, surface water bodies, and adjacent buildings resulting from ground settlement will be less than minor to negligible. I do not consider any mitigation to be required to manage the groundwater-related effects of the Project.

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Appendix A. Borelogs

Machine Borehole

BH001

Client:	NZTA Waka Kotahi	**Date started:**	02-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	03-06-2025
Project ID:	705100376-004	**Weather:**	Cloudy, rainy
Location:	Cooper Street, Grey Lynn, Auckland	**Logged by:**	RC
Feature:	2m west of parking space	**Checked by:**	NL
Elevation:	34.25 mRL **Datum:** NZVD2016 **Coordinates:** E 1755529.42 N 5918319.82 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			34.0	0.0	Hydro excavated								
			33.5	0.5									
			33.0	1.0									
			32.5	1.5									
HQ			32.0	2.0	Silty CLAY with trace sand, light grey. Very soft, moist, low plasticity. Contains carbonaceous/organic fragments at unit top [Residual Soil].								
			31.5	2.5	Completely weathered, grey, silty MUDSTONE. Extremely weak; soil behaviours including stiff to very stiff, moist, high plasticity [EAST COAST BAYS FORMATION].								
			31.0	3.0	Highly weathered, light brown, medium to coarse sandy SILTSTONE, very weak [EAST COAST BAYS FORMATION].			100	77	77			
SPT	HSV (P/R) SPT/C	UTP/ 8,6// 7, 13, 26, 4 N = 50	30.5	3.5									
HQ			30.0	4.0	Highly weathered, light brown, fine SANDSTONE; very weak. Contains carbonaceous fragments. [EAST COAST BAYS FORMATION].			100	91	83			
			29.5	4.5									
SPT	SPT/C	4,18// 38, 12 for 10mm N = >50	29.0	5.0	Moderately weathered, grey, clay-rich interbedded SILTSTONE and SANDSTONE; weak. Heterogeneous, rhythmically bedded sequence of alternating Sandstone and Siltstone. Widely spaced, steeply inclined discontinuities [EAST COAST BAYS FORMATION].								
HQ			28.5	5.5				96	51	40	5.55 m: 30° - 40° inclined to core axis (steeply inclined), moderately wide aperture, undulating rough open fracture, infilled with carbonaceous material.		
			28.0	6.0									
SPT	SPT/C	0,0// 11, 39 N = 50	27.5	6.5									
			27.0	7.0	*7.2 - 7.9m Thick bed of coarse SANDSTONE; turbidite base.*			100	63	61	6.90 m: 30° - 40° inclined (steeply inclined), moderately wide aperture, undulating rough open fracture.		
			26.5	7.5									
			26.0	8.0	*8 - 8.45m Thin beds of SILTSTONE transit to medium to fine SANDSTONE, grey.*								
			25.5	8.5	Slightly weathered, dark grey, interbedded SILTSONE and SANDSTONE; weak. Heterogeneous, rhythmically bedded sequence of alternating Sandstone and Siltstone. Siltstone and Sandstone are moderately thick bedded. Discontinuities are moderately widely spaced (>300mm), with varying inclination [EAST COAST BAYS FORMATION].			100	68	60	9.20 m: 81° - 83° inclined (Sub-vertical inclined), tight aperture, no open fracture.		
			25.0	9.0									
			24.5	9.5	*9.65 - 9.7m Thinly laminated, wavy, carbonaceous bands at top of fine sandstone bed.*								

03-06-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH001

Client:	NZTA Waka Kotahi	**Date started:**	02-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	03-06-2025
Project ID:	705100376-004	**Weather:**	Cloudy, rainy
Location:	Cooper Street, Grey Lynn, Auckland	**Logged by:**	RC
Feature:	2m west of parking space	**Checked by:**	NL
Elevation:	34.25 mRL **Datum:** NZVD2016 **Coordinates:** E 1755529.42 N 5918319.82 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			24.0	10.5	Slightly weathered, dark grey, interbedded SILTSONE and SANDSTONE; weak. Heterogeneous, rhythmically bedded sequence of alternating Sandstone and Siltstone. Siltstone and Sandstone are moderately thick bedded. Discontinuities are moderately widely spaced (>300mm), with varying inclination [EAST COAST BAYS FORMATION].			100	89	90			
			23.5	11.0							11.00 m: Joint is approximate 40cm in length, sub-vertical, 81° - 85°, undulating smooth open fracture, very narrow aperture.		
			23.0	11.5	*11.5 - 11.7m Convolute bedding on top of sub-horizontal to gently-inclined, laminated to thinly bedded, carbonaceous laminations. Flame structure.*			94	34	60	11.60 m: Joint is approximate 20cm in length, 82° inclined (sub-vertical), very narrow aperture, undulating smooth open fracture.		
			22.5	12.0	*12 - 12.3m Thick convolute bedding, carbonaceous laminations.*						11.86 m: Sub-vertical, very narrow aperture, undulating smooth open fracture.		
			22.0	12.5									
			21.5	13.0				100	63	68	12.90 m: Joint is approximate 20cm in length, sub-vertical inclined, very narrow aperture, undulating slickensided open fracture.		
			21.0	13.5									
			20.5	14.0									
			20.0	14.5				94	93	93			
			19.5	15.0									
			19.0	15.5									
			18.5	16.0				98	95	96	15.95 m: 5° - 10° inclined (Sub-horizontal), moderately narrow aperture, undulating rough open fracture.		
			18.0	16.5									
			17.5	17.0									
			17.0	17.5				100	85	80			
			16.5	18.0							18.04 m: 5°- 10° inclined (sub-horizontal), moderately narrow aperture, undulating smooth open fracture.		
			16.0	18.5									
			15.5	19.0									
			15.0	19.5				100	80	48			
			14.5		End of Machine Borehole at 20.00m								

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:	M726205.02
Survey accuracy:	+-5m

Machine Borehole

BH002

Client:	NZTA Waka Kotahi	**Date started:**	04-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	05-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	Arch Hill Reserve, Grey Lynn, Auckland	**Logged by:**	RC
Feature:	Slope along footpath	**Checked by:**	NL
Elevation:	28.00 mRL **Datum:** NZVD2016 **Coordinates:** E 1755456.12 N 5918303.70 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HA			27.5	0.5	Clayey SILT with trace organics; dark brown. Stiff, moist, low plasticity, contains rootlets. [Topsoil]								
					Silty CLAY; grey mixed light brown. Soft, moist, high plasticity [FILL].								
	SPT/SS	0,1// 1, 1, 1, 1 N = 4	27.0	1.0									
SPT			26.5	1.5									
			26.0	2.0				70					
HQ			25.5	2.5									
	HSV (P/R) SPT/SS	28/ 0,0// 0, 1, 1, 1 N = 3	25.0	3.0									
SPT			24.5	3.5				120					
HQ			24.0	4.0	Clayey SILT with trace gravel and sand; grey speckled dark brown. Soft, moist; low plasticity, contains iron-oxidised stained surfaces [Residual Soil].								
	HSV (P/R) SPT/SS	38/ 6,7// 14, 12, 26 for 5mm N = >50	23.5	4.5									
SPT			23.0	5.0				100					
HQ			22.5	5.5	Completely weathered, clayey SILTSTONE; grey. Extremely weak to very weak. Recovered as clayey SILT with some rock fabric preserved. Stiff to very stiff, moist, low plasticity [EAST COAST BAYS FORMATION]								
	SPT/C	9,17// 20, 30 N = 50	22.0	6.0									
SPT			21.5	6.5									
					Highly weathered, clayey interbedded SILTSTONE and fine SANDSTONE; grey. Very weak to weak, heterogeneous [EAST COAST BAYS FORMATION].			42	32	36			
HQ			21.0	7.0									
					Moderately weathered, clay-rich interbedded SILTSTONE and SANDSTONE; grey. Very weak. Heterogeneous, rhythmically bedded sequence of alternating Siltstone and Sandstone. Closely to moderately widely spaced, generally sub-horizontal discontinuities [EAST COAST BAYS FORMATION]. *7.5 - 7.65m: Core loss*								
	SPT/C	20 ,30 for 65mm// N = >50	20.5	7.5									
SPT													
			20.0	8.0				91	82	73	7.75 m: 2 joints are intercepted, both steeply inclined (31° - 45°), moderately wide aperture, stepped rough open fracture surface. 8.30 m: 2 joints are intercepted, joint 1 intersects joint 2 at approx. 45°, sits at top of joint 2. Joint 1: sub-horizontal inclined, moderately narrow aperture, undulating smooth open fracture surface. Joint 2: sub-vertical inclined, moderately narrow aperture, undulating smooth open fracture.		
			19.5	8.5									
			19.0	9.0									
			18.5	9.5				93	84	76			

05-07-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH002

Client:	NZTA Waka Kotahi	**Date started:**	04-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	05-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	Arch Hill Reserve, Grey Lynn, Auckland	**Logged by:**	RC
Feature:	Slope along footpath	**Checked by:**	NL
Elevation:	28.00 mRL **Datum:** NZVD2016 **Coordinates:** E 1755456.12 N 5918303.70 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			17.5	10.5	Moderately weathered, clay-rich interbedded SILTSTONE and SANDSTONE; grey. Very weak. Heterogeneous, rhythmically bedded sequence of alternating Siltstone and Sandstone. Closely to moderately widely spaced, generally sub-horizontal discontinuities [EAST COAST BAYS FORMATION].						10.21 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture.		
			17.0	11.0				100	83	83	10.94 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture. 11.03 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture.		
			16.5	11.5									
			16.0	12.0							11.86 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture.		
			15.5	12.5				93	72	51			
			15.0	13.0									
			14.5	13.5									
			14.0	14.0	*13.78 - 13.82m Carbonaceous thinly bedded laminations.*			95	82	86			
			13.5	14.5									
			13.0	15.0							15.12 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture.		
			12.5	15.5				84	72	55			
			12.0	16.0	*16.28 - 16.5m: Core loss*								
			11.5	16.5	*16.5 - 20.0m: Contains carbonaceous streaks*			96	85	85			
			11.0	17.0									
			10.5	17.5	*17.31 - 17.36m Thin carbonaceous bands, sub-horizontally inclined.* *17.55 - 17.6m Carbonaceous flecks.*								
			10.0	18.0				80	80	76			
			9.5	18.5									
			9.0	19.0	*19.2 - 19.5m: Core loss*								
			8.5	19.5				100	80	80			
					End of Machine Borehole at 20.00m								

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:	M726205.02
Survey accuracy:	+-5m

Machine Borehole

BH003

Client:	NZTA Waka Kotahi	**Date started:**	11-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	12-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	Parr Road North	**Logged by:**	RC
Feature:	Road end car park	**Checked by:**	NL
Elevation:	25.00 mRL **Datum:** NZVD2016 **Coordinates:** E 1752601.80 N 5918099.24 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 19.71 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			24.5	0.5	Hydro excavated.								
			24.0	1.0									
			23.5	1.5									
			23.0	2.0									
HQ			22.5	2.5	Silty CLAY, grey mixed orangish brown. Soft, iron oxidised staining, moist, high plasticity. Old alluvial deposits [TAKAANINI FORMATION]. *2-2.9m Core loss*			5					
SPT	SPT/SS	0,0// 1, 1, 1, 2 N = 5	22.0	3.0									
HQ			21.5	3.5				47					13-06-2025
			21.0	4.0									
SPT	SPT/SS	0,1// 1, 1, 1, 1 N = 4	20.5	4.5									
HQ			20.0	5.0				100					
			19.5	5.5									
SPT	SPT/SS	0,1// 1, 1, 1, 2 N = 5	19.0	6.0									
HQ			18.5	6.5	*6.45-6.85m Core loss*			77					
			18.0	7.0	Clayey SILT, trace sand, light grey, mottled brownish orange, stiff, moist, high plasticity [Residual soil].								
	HSV (P/R)	68/	17.5	7.5									
SPT	SPT/SS	0,0// 1, 1, 1, 1 N = 4											
HQ			17.0	8.0				83					
			16.5	8.5									
	HSV (P/R)	68/	16.0	9.0									
SPT	SPT/SS	0,1// 1, 1, 1, 1 N = 4											
			15.5	9.5				120					
	HSV (P/R)	64/			Completely weathered clay-rich SILTSTONE recovered as soil. Clayey SILT, dark grey, very soft to stiff, moist, high plasticity [EAST COAST BAYS FORMATION].								
HQ													

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH003

Client:	NZTA Waka Kotahi	**Date started:**	11-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	12-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	Parr Road North	**Logged by:**	RC
Feature:	Road end car park	**Checked by:**	NL
Elevation:	25.00 mRL **Datum:** NZVD2016 **Coordinates:** E 1752601.80 N 5918099.24 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 19.71 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
					Completely weathered clay-rich SILTSTONE recovered as soil. Clayey SILT, dark grey, very soft to stiff, moist, high plasticity [EAST COAST BAYS FORMATION]. *10.3m Large charcoal fragments.*								
SPT	SPT/C	1,2// 2, 2, 2, 3 N = 9	14.5	10.5	*10.5 - 11.2m Brownish grey/beige*								
HQ			14.0	11.0				100					
			13.5	11.5									
SPT	SPT/C	3,3// 3, 4, 4, 5 N = 16	13.0	12.0									
HQ			12.5	12.5				73					
			12.0	13.0	*13-13.2m Trace Gravels.*								
SPT	SPT/C	3,5// 6, 6, 8, 10 N = 30	11.5	13.5									
HQ			11.0	14.0				93					
			10.5	14.5									
SPT	SPT/C	3,6// 7, 9, 11, 13 N = 40	10.0	15.0	Highly weathered to moderately weathered caly-rich interbedded SILTSTONE and fine SANDSTONE, grey, very weak [EAST COAST BAYS FORMATION] *15-16.02m Clay-rich SILTSTONE, very weak.*			100	37	59			
HQ			9.5	15.5									
			9.0	16.0	*16.02-16.5m Interbedded SILTSTONE and fine SANDSTONE, weak.*								
SPT	SPT/C	5,20// 4, 3, 7, 50 for 20mm N = >50	8.5	16.5	Moderately weathered, interbedded SILTSTONE and fine to coarse SANDSTONE, grey, weak [EAST COAST BAYS FORMATION].			83	76	77			
HQ			8.0	17.0							17.45 m: Sub-horizontal, moderately wide aperture, undulating smooth open fracture.		
			7.5	17.5									
SPT	SPT/C	13,35// 50 for 25mm N = >50	7.0	18.0							17.87 m: Sub-horizontal, moderately wide aperture, undulating rough open fracture.		
HQ			6.5	18.5				100	75	70	17.93 m: Sub-horizontal, moderately wide aperture, undulating rough open fracture.		
			6.0	19.0									
SPT	SPT/C	23,27// 50 N = 50	5.5	19.5									
					End of Machine Borehole at 19.70m								

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH004

Client:	NZTA Waka Kotahi	**Date started:**	23-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	24-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	Carrington Road	**Logged by:**	RC
Feature:	Carrington Road and Great North Road interception	**Checked by:**	NL
Elevation:	27.75 mRL **Datum:** NZVD2016 **Coordinates:** E 1752455.88 N 5918058.52 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			27.5	0.5	Hydro excavated.								
SPT	SPT/SS	0,0// 1, 1, 1, 2 N = 5	27.0	1.0									
			26.5	1.5									
HQ			26.0	2.0				100					
			25.5	2.5									
			25.0	3.0	CLAY, grey mixed light brown. Soft, moist, high plasticity [FILL].								
			24.5	3.5									
			24.0	4.0				73					
			23.5	4.5	Silty CLAY, trace sand; orangish brown. Soft to very soft, moist, high plasticity. Minor iron oxidised mottling [TAKAANINI FORMATION].								
	HSV (P/R)	48/											
SPT	SPT/SS	0,1// 1, 1, 1, 1 N = 4	23.0	5.0									
			22.5	5.5	Clayey SILT, yellowish light brown. Very soft, moist, low plasticity [TAKAANINI FORMATION].			53					
HQ			22.0	6.0									
	HSV (P/R)	UTP/											
SPT	SPT/SS	1,2// 2, 2, 3, 3 N = 10	21.5	6.5	Clayey SILT, trace sand, dark grey. Soft, moist, low plasticity [Residual soil].								
			21.0	7.0				93					
HQ			20.5	7.5	Completely weathered clay-rich coarse SILTSTONE, dark grey, very weak to extremely weak. Recovered as soil, soil behaviours including very soft, low plasticity, moist [EAST COAST BAYS FORMATION].								
SPT	SPT/SS	2,2// 3, 4, 5, 6 N = 18	20.0	8.0				100	94	91			
			19.5	8.5	Highly weathered interbedded clay-rich SILTSTONE and fine SANDSTONE, dark grey, very weak. Rhythmically thickly bedded sequence of alternating Siltstone and Sandstone, bedding contacts are very indistinct due to extensive weathering and discolouration. Carbonaceous flecks are present at the top of the unit [EAST COAST BAYS FORMATION].								
HQ			19.0	9.0									
SPT	SPT/C	3,5// 6, 7, 7, 7 N = 27	18.5	9.5				100	78	72			
HQ			18.0										

25-06-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH004

Client:	NZTA Waka Kotahi	**Date started:**	23-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	24-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	Carrington Road	**Logged by:**	RC
Feature:	Carrington Road and Great North Road interception	**Checked by:**	NL
Elevation:	27.75 mRL **Datum:** NZVD2016 **Coordinates:** E 1752455.88 N 5918058.52 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			17.5	10.5	Highly weathered interbedded clay-rich SILTSTONE and fine SANDSTONE, dark grey, very weak. Rhythmically thickly bedded sequence of alternating Siltstone and Sandstone, bedding contacts are very indistinct due to extensive weathering and discolouration. Carbonaceous flecks are present at the top of the unit [EAST COAST BAYS FORMATION].						10.40 m: Sub-horizontal, very narrow aperture, undulating smooth open fracture.		
SPT	SPT/C	5,8// 9, 9, 8, 8 N = 34	17.0	11.0									
HQ			16.5	11.5				81	71	62	11.05 m: Sub-horizontal, moderately narrow aperture, undulating rough open fracture. 11.36 m: Sub-horizontal, moderately narrow aperture, undulating rough open fracture.		
			16.0	12.0									
SPT	SPT/C	3,11// 13, 12, 13, 11 N = 49	15.5	12.5	Moderately weathered interbedded clay-rich SILTSTONE and fine to coarse SANDSTONE, grey, yellowish brown sand infill, weak to very weak. Rhythmically thickly bedded sequence of alternating Siltstone and Sandstone. Discontinuities varies from sub-horizontal to steeply inclined, very closely spaced [EAST COAST BAYS FORMATION]						11.88 m: Moderately inclined, moderately wide aperture, undulating rough open fracture. 12.20 m: Gently inclined, moderately narrow aperture, undulating rough open fracture. Clay infill. 12.40 m: Gently inclined, moderately narrow aperture, undulating smooth open fracture. 12.70 m: Gently inclined, moderately narrow, undulating smooth. 13.05 m: Sub-horizontal, moderately wide, undulating smooth open fracture. 13.26 m: Steeply inclined, moderately wide aperture, undulating rough open fracture.		
HQ			15.0	13.0	*12.65-13.5m Fine to coarse SANDSTONE bed, with coarsening downwards sedimentary sequence (Sandstone are more coarse with increasing depth).*			100	82	80			
			14.5	13.5									
SPT	SPT/C	4,12// 19, 21, 10, 50 for 35mm N = >50	14.0	14.0	*13.9-15m Fine to coarse SANDSTONE bed, with coarsening downwards sedimentary sequence (Sandstone are more coarse with increasing depth).*								
HQ			13.5	14.5	*14.45m Carbonaceous flecks.* *14.56m Thick bedded carbonaceous laminations.*			100	91	89			
			13.0	15.0							14.80 m: Sub-horizontal, moderately narrow aperture, undulating smooth open fracture.		
SPT	SPT/C	4,10// 23, 22, 50 for 55mm N = >50	12.5	15.5	*15.45m Thick bedded carbonaceous laminations.*								
HQ			12.0	16.0				100	78	66	15.80 m: Sub-horizontal, moderately narrow aperture, undulating smooth open fracture.		
			11.5	16.5									
SPT	SPT/C	10,26// 50 for 15mm N = >50	11.0	17.0				93	77	71			
HQ			10.5	17.5									
			10.0	18.0									
			9.5	18.5				100	73	70			
			9.0	19.0									
			8.5	19.5									
			8.0		*19.6-19.8m Coarse SANDSTONE, turbidite base.*			100	84	60			
					End of Machine Borehole at 20.00m								

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:	M726205.02
Survey accuracy:	+-5m

Machine Borehole

BH005

Client:	NZTA Waka Kotahi	**Date started:**	27-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	28-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	SH16 - Te Atatu Road	**Logged by:**	RC
Feature:	Reserve cycleway side	**Checked by:**	NL
Elevation:	20.75 mRL **Datum:** NZVD2016 **Coordinates:** E 1747345.91 N 5919524.86 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 28.82 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			20.5	0.5	Hydro excavated.								
HQ			20.0	1.0	Silty sandy CLAY, grey mixed orangish brown. Organic-rich layer transits to very dense gravelly bottom. Stiff, moist, high plasticity [FILL].			120					
			19.5	1.5	*2.7 - 2.9m: Colour changes to black, suspected buried topsoil.*								
	HSV (P/R)	UTP/	19.0	2.0									
SPT	SPT/SS	2,5// 7, 15, 15, 13 N = 50	18.5	2.5	Silty CLAY, trace sand; light brown. Firm, moist, high plasticity, contains carbonaceous fragments; sand, fine [TAKAANINI FORMATION].								
HQ			18.0	3.0				27					
	HSV (P/R)	32/	17.5	3.5									
SPT	SPT/SS	1,1// 1, 1, 1, 1 N = 4	17.0	4.0	*4.5 - 5.2m: Becomes light brown, soft.*								
HQ			16.5	4.5				73					
			16.0	5.0	Organic, sandy CLAY; black. Very soft, wet, High plasticity; low energy alluvial depositional environment [TAKAANINI FORMATION].								
	HSV (P/R)	30/	15.5	5.5									
SPT	SPT/SS	1,1// 1, 1, 2, 1 N = 5	15.0	6.0	Silty CLAY; light brown with iron-oxidised staining. Firm, wet, high plasticity [TAKAANINI FROMATION].								
HQ			14.5	6.5				100					
			14.0	7.0									
	HSV (P/R)	40/	13.5	7.5									
SPT	SPT/SS	0,1// 1, 1, 1, 2 N = 5	13.0	8.0									
HQ			12.5	8.5				86					
			12.0	9.0									
	HSV (P/R)	28/	11.5	9.5									
SPT	SPT/SS	0,1// 1, 1, 2, 2 N = 6	11.0	10.0	Silty CLAY, trace sand; light brown. Firm, moist, high plasticity, contains carbonaceous fragments; sand, fine to medium [TAKAANINI FORMATION]. Organic-rich, silty CLAY; black. Very soft to soft, wet, high plasticity [TAKAANINI FORMATION].			70					
HQ													

02-07-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH005

Client:	NZTA Waka Kotahi	**Date started:**	27-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	28-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	SH16 - Te Atatu Road	**Logged by:**	RC
Feature:	Reserve cycleway side	**Checked by:**	NL
Elevation:	20.75 mRL **Datum:** NZVD2016 **Coordinates:** E 1747345.91 N 5919524.86 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 28.82 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
					Organic-rich, silty CLAY; black. Very soft to soft, wet, high plasticity [TAKAANINI FORMATION].								
	HSV (P/R)	26/		10.5									
SPT	SPT/SS	0,0// 0, 1, 1, 1 N = 3	10.0		Silty CLAY; greyish brown. Firm, wet, high plasticity, contains carbonaceous fragments [TAKAANINI FORMATION].								
				11.0									
			9.5					33					
HQ				11.5									
			9.0										
	HSV (P/R)	34/		12.0									
SPT	SPT/SS	0,1// 1, 1, 1, 2 N = 5	8.5		Organic-rich, silty CLAY, trace sand; dark brown. Soft, wet, high plasticity, contains carbonaceous fragments; sand, fine to medium [TAKAANINI FORMATION].								
				12.5									
			8.0					100					
HQ				13.0									
			7.5		*13.4 - 13.5m: reddish light brown, minor medium to coarse sand.*								
	HSV (P/R)	52/		13.5									
SPT	SPT/SS	0,1// 1, 1, 2, 2 N = 6	7.0		Silty CLAY, trace sand; light brown with iron-oxidised staining. Stiff, wet, high plasticity; sand, fine to medium [TAKAANINI FORMATION].								
				14.0	*13.4 - 13.5m: reddish light brown, minor medium to coarse sand.*								
			6.5					83					
HQ				14.5									
			6.0										
	HSV (P/R)	34/		15.0	*15 - 19.5m: Very soft to soft.*								
SPT	SPT/SS	1,1// 1, 1, 2, 2 N = 6	5.5		*15.2 - 16.5m: Colour changes to dark brownish grey.*								
				15.5									
			5.0					90					
HQ				16.0									
			4.5										
	HSV (P/R)	54/		16.5									
SPT	SPT/SS	0,0// 1, 1, 2, 2 N = 6	4.0										
				17.0									
			3.5					70					
HQ				17.5									
			3.0										
	HSV (P/R)	48/		18.0									
SPT	SPT/SS	0,1// 1, 1, 2, 2 N = 6	2.5										
				18.5									
			2.0					100					
HQ				19.0	*18.9 - 19.5m: Colour changes to brownish grey.*								
			1.5										
	HSV (P/R)	56/		19.5	Clayey SILT, trace sand; dark grey. Stiff, moist, high plasticity; sand, fine [Residual Soil].								
SPT	SPT/SS	0,2// 2, 2, 2, 2 N = 8	1.0										
				20.0									
			0.5					100					

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:	M726205.02
Survey accuracy:	+-5m

Machine Borehole

BH005

Client:	NZTA Waka Kotahi	**Date started:**	27-06-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	28-06-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	SH16 - Te Atatu Road	**Logged by:**	RC
Feature:	Reserve cycleway side	**Checked by:**	NL
Elevation:	20.75 mRL **Datum:** NZVD2016 **Coordinates:** **E** 1747345.91 **N** 5919524.86 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 28.82 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			0.0	20.5	Clayey SILT, trace sand; dark grey. Stiff, moist, high plasticity; sand, fine [Residual Soil].								
SPT	HSV (P/R) / SPT/SS	UTP/ 2,3// 4, 3, 3, 5 N = 15	-0.5	21.0	Completely weathered, brownish grey, fine SANDSTONE, extremely weak. Recovered as clayey SAND. Dense, moist, uniformly graded; sand, fine [EAST COAST BAYS FORMATION].								
HQ			-1.0	21.5	Highly weathered, brownish grey, clay-rich interbedded SILTSTONE and fine to medium SANDSTONE, very weak. Moderately widely to widely spaced discontinuities [EAST COAST BAYS FORMATION].			80	62	66			
			-1.5	22.0									
SPT	SPT/SS	3,3// 4, 4, 4, 6 N = 18	-2.0	22.5									
HQ			-2.5	23.0				90	74	69			
			-3.0	23.5									
SPT	SPT/C	5,5// 7, 7, 7, 8 N = 29	-3.5	24.0									
HQ			-4.0	24.5				100	63	46	24.20 m: Sub-horizontal, moderately wide aperture, undulating slickensided open fracture. 24.80 m: Gently inclined, moderately wide aperture, stepped rough open fracture.		
			-4.5	25.0									
SPT	SPT/C	6,6// 7, 10, 10, 13 N = 40	-5.0	25.5	Moderately weathered, brownish grey interbedded SILTSTONE and fine to medium SANDSTONE, very weak. Intact rock with breakages incurred by drilling [EAST COAST BAYS FORMATION].						25.40 m: Sub-horizontal, moderately narrow aperture, undulating slickensided open fracture.		
HQ			-5.5	26.0				60	36	36			
			-6.0	26.5									
SPT	SPT/C	8,8// 13, 14, 14, 9 for 55mm N = >50	-6.5	27.0									
HQ			-7.0	27.5				100	52	51			
			-7.5	28.0									
SPT	SPT/C	10,18// 22, 22, 6 for 15mm N = >50	-8.0	28.5	End of Machine Borehole at 28.82m								
			-8.5	29.0									
			-9.0	29.5									
			-9.5	30.0									
				30.5									

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:	M726205.02
Survey accuracy:	+-5m

Machine Borehole

BH006

Client:	NZTA Waka Kotahi	**Date started:**	04-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	05-07-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	SH16 - Te Atatu Road	**Logged by:**	RC
Feature:	Road side grass patch	**Checked by:**	NL
Elevation:	22.50 mRL **Datum:** NZVD2016 **Coordinates:** E 1747309.07 N 5919545.53 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 21.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			22.0	0.5	Hydro excavated.								
			21.5	1.0									
			21.0	1.5									
			20.5	2.0									
					Silty CLAY, dark grey to brown. Soft, moist, high plasticity. Contains carbonaceous fragments, rootlets present in top 150mm [TAKAANINI FORMATION].			100					
			20.0	2.5									
SPT	SPT/SS	4,4// 3, 3, 3, 3 N = 12	19.5	3.0	Gravelly CLAY; black, mottled dark reddish brown. Soft to firm, wet, low plasticity; gravel, fine to medium., angular to sub-angular, basalt, reworked [TAKAANINI FORMATION].								
HQ			19.0	3.5				47					
			18.5	4.0	*4.0 - 4.5m: reduces to minor gravel.*								
	HSV (P/R)	34/	18.0	4.5	Silty CLAY; yellowish light brown. Soft to firm, moist, high plasticity. Contains carbonaceous flecks [TAKAANINI FORMATION.								
SPT	SPT/SS	0,1// 1, 1, 1, 2 N = 5											
HQ			17.5	5.0				97					
			17.0	5.5									
	HSV (P/R)	62/	16.5	6.0									
SPT	SPT/SS	4,5// 3, 3, 3, 4 N = 13											
HQ			16.0	6.5				0					
			15.5	7.0									
	HSV (P/R)	43/	15.0	7.5									
SPT	SPT/SS	0,1// 1, 1, 2, 3 N = 7											
			14.5	8.0	Organic CLAY; dark brown to black. Very soft to soft, moist, high plasticity [TAKAANINI FORMATION.								
HQ			14.0	8.5				100					
	HSV (P/R)	29/	13.5	9.0	Silty CLAY; yellowish brown. Soft, moist, high plasticity. Contains carbonaceous flecks [TAKAANINI FORMATION.								

04-07-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:	M726205.02
Survey accuracy:	+-5m

Machine Borehole

BH006

Client:	NZTA Waka Kotahi	**Date started:**	04-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	05-07-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	SH16 - Te Atatu Road	**Logged by:**	RC
Feature:	Road side grass patch	**Checked by:**	NL
Elevation:	22.50 mRL **Datum:** NZVD2016 **Coordinates:** E 1747309.07 N 5919545.53 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 21.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing: Type	In-situ testing: Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
SPT	SPT/SS	0,1// 1, 1, 2, 2 N = 6			Silty CLAY; yellowish brown. Soft, moist, high plasticity. Contains carbonaceous flecks [TAKAANINI FORMATION.								
			13.0	9.5	Organic CLAY; black. Very soft, saturated, low plasticity [TAKAANINI FORMATION].								
HQ			12.5	10.0				60					
	HSV (P/R)	39/	12.0	10.5									
SPT	SPT/SS	0,1// 1, 1, 1, 2 N = 5											
			11.5	11.0	Silty CLAY; yellowish light brown. Soft to firm, moist to wet, high plasticity [TAKAANINI FORMATION].								
HQ			11.0	11.5				66					
	HSV (P/R)	42/	10.5	12.0									
SPT	SPT/SS	0,1// 1, 1, 2, 2 N = 6											
HQ			10.0	12.5				57					
			9.5	13.0									
	HSV (P/R)	52/	9.0	13.5									
SPT	SPT/SS	0,0// 1, 2, 1, 1 N = 5											
HQ			8.5	14.0				3					
			8.0	14.5									
	HSV (P/R)	49/	7.5	15.0	Organic CLAY; black. Very soft, wet, low plasticity [TAKAANINI FORMATION].								
SPT	SPT/SS	0,0// 1, 1, 2, 1 N = 5			Silty CLAY; yellowish brown. Very soft, wet, low plasticity [TAKAANINI FROMATION].								
			7.0	15.5				66					
HQ			6.5	16.0									
	HSV (P/R)	41/	6.0	16.5									
SPT	SPT/SS	0,0// 0, 1, 1, 1 N = 3											
			5.5	17.0				27					
HQ			5.0	17.5									
	HSV (P/R)	52/	4.5	18.0	*18.0 - 21.0: becomes firm, moist, high plasticity.*								
SPT	SPT/SS	0,2// 1, 2, 2, 2 N = 7											

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH006

Client:	NZTA Waka Kotahi	**Date started:**	04-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	05-07-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	SH16 - Te Atatu Road	**Logged by:**	RC
Feature:	Road side grass patch	**Checked by:**	NL
Elevation:	22.50 mRL **Datum:** NZVD2016 **Coordinates:** **E** 1747309.07 **N** 5919545.53 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 21.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			4.0	18.5	Silty CLAY; yellowish brown. Very soft, wet, low plasticity [TAKAANINI FROMATION].			13					
	HSV (P/R)	60/	3.5	19.0									
SPT	SPT/SS	0,1// 1, 2, 2, 2 N = 7	3.0	19.5									
HQ			2.5	20.0				87					
	HSV (P/R)	58/	2.0	20.5									
SPT	SPT/SS	2,1// 2, 1, 2, 1 N = 6	1.5	21.0	End of Machine Borehole at 21.00m								
			1.0	21.5									
			0.5	22.0									
			0.0	22.5									
			-0.5	23.0									
			-1.0	23.5									
			-1.5	24.0									
			-2.0	24.5									
			-2.5	25.0									
			-3.0	25.5									
			-3.5	26.0									
			-4.0	26.5									
			-4.5	27.0									
			-5.0	27.5									

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH008

Client:	NZTA Waka Kotahi	**Date started:**	08-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	09-07-2025
Project ID:	705100376-004	**Weather:**	Cloudy, dry
Location:	SH19	**Logged by:**	TZ
Feature:	Paved road west of on-ramp	**Checked by:**	NL
Elevation:	16.25 mRL **Datum:** NZVD2016 **Coordinates:** E 1745443.40 N 5920556.87 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** Truck mounted rig **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			16.0	0.5	Hydro-vacuum extracted.								
HQ			15.5	1.0	Silty SAND, trace clay; reddish light brown. Medium dense, moist, uniformly graded; sand, fine, sub-angular [TAKAANINI FORMATION].								
			15.0	1.5	SILT, some clay; light grey streaked light brown. Very stiff, moist, low plasticity [TAKAANINI FORMATION].								
			14.5	2.0	*2.95 - 3.15m: Some sand, soft, moist to wet; sand, fine to medium*			90					
	HSV (P/R)	48/	14.0	2.5	Sandy SILT; light grey streaked light brown. Soft to firm, wet, low plasticity; sand, fine, sub-angular [TAKAANINI FORMATION].								
SPT	SPT/SS	1,1// 2, 3, 2, 3 N = 10	13.5	3.0	*4.05 - 4.2m: Mottled light red.*								
HQ			13.0	3.5	Sandy SILT, minor clay; light brown speckled light grey. Soft, wet, non-plastic; sand, fine, sub-angular [TAKAANINI FORMATION].			86					
	HSV (P/R)	34/	12.5	4.0	*5.55 - 5.7m: Comprises silty SAND.; sand, fine to medium*								
SPT	SPT/SS	1,2// 2, 2, 3, 4 N = 11	12.0	4.5	Silty SAND; grey. Loose, moist, uniformly graded; sand, fine, sub-angular [Residual soil].			86					
HQ			11.5	5.0	Completely weathered, dark grey fine SANDSTONE, extremely weak. Silty Sand, dense to very dense, uniformly graded; sand, fine, sub-angular [EAST COAST BAYS FORMATION].								
	HSV (P/R)	64/	11.0	5.5	*7.05 - 7.20m: Recovered as silty sand, saturated.*			100	76	70			
SPT	SPT/SS	2,4// 4, 5, 7, 7 N = 23	10.5	6.0	*7.6 - 7.75m: Recovered as sandy silt, soft, saturated, low plasticity.*								
HQ			10.0	6.5	Highly weathered, grey interbedded fine SANDSTONE and clayey SILTSTONE, very weak. Rhythmically bedded sequence of alternating moderately thin to thick beds of Siltstone and Sandstone. Closely spaced to moderately widely spaced, very steeply inclined discontinuities with moderately narrow apertures and planar rough fractures [East Coast Bays Formation].						8.00 m: Sub-horizontal defect, narrow aperture, planar rough open fracture.		
	HSV (P/R)	UTP/	9.5	7.0	*8.5 - 8.75m: Extremely weak. Recovered as silty fine sand, moist, medium dense.*								
SPT	SPT/SS	5,7// 8, 13, 14, 15 N = 50	9.0	7.5	*8.9 - 9.05.: Moderately thin bed of extremely weak clayey SILTSTONE. Recovered as clayey silt, moist, very stiff, low plasticity.*			90	60	43	9.00 m: 2 intercepted discontinuities at an approximate angle of 45°. Joint 1, very steeply inclined, moderately narrow aperture, rough stepped fracture. Joint 2, sub-horizontal, narrow aperture, undulating rough fracture.		
HQ			8.5	8.0									
			8.0	8.5									
			7.5	9.0									
			7.0	9.5									
SPT	SPT/C	7,10// 12, 12, 16 for 70mm N = >50	6.5								9.10 m: Sub-horizontal defect, moderately narrow aperture, rough stepped fracture.		

09-07-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH008

Client:	NZTA Waka Kotahi	**Date started:**	08-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	09-07-2025
Project ID:	705100376-004	**Weather:**	Cloudy, dry
Location:	SH19	**Logged by:**	TZ
Feature:	Paved road west of on-ramp	**Checked by:**	NL
Elevation:	16.25 mRL **Datum:** NZVD2016 **Coordinates:** E 1745443.40 N 5920556.87 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** Truck mounted rig **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			6.0	10.5	Highly weathered, grey interbedded fine SANDSTONE and clayey SILTSTONE, very weak. Rhythmically bedded sequence of alternating moderately thin to thick beds of Siltstone and Sandstone. Closely spaced to moderately widely spaced, very steeply inclined discontinuities with moderately narrow apertures and planar rough fractures [East Coast Bays Formation].			88	39	33	9.70 m: Very steeply inclined defect, moderately narrow aperture, planar rough fracture. 9.85 m: Very steeply inclined defect, moderately narrow aperture, planar rough fracture. 10.30 m: Very steeply inclined to sub-vertical discontinuity, moderately narrow aperture, planar rough fracture.		
			5.5		*10.7 - 11.0m: Moderately thick bed of extremely weak, clayey Siltstone. Recovered as clayey silt, stiff, moist, low plasticity.*								
SPT	SPT/C	6,10// 13, 16, 5 for 25mm N = >50	5.0	11.0	*11.1 - 11.55m: Moderately thick bed of clayey Siltstone.*								
			4.5	11.5				43	17	17			
			4.0	12.0									
			3.5	12.5									
			3.0	13.0				90	75	63	13.20 m: Very steeply inclined, moderately narrow aperture, planar rough fracture. 13.40 m: Sub-horizontal discontinuity, narrow aperture, undulating rough fracture.		
			2.5	13.5									
			2.0	14.0							14.10 m: Very steeply inclined discontinuity, moderately narrow aperture, planar rough fracture.		
			1.5	14.5									
			1.0	15.0	*15.2 - 15.25m: Recovered as sandy silt, soft, saturated, low plasticity.*			83	59	64	14.70 m: Sub-vertical discontinuity, moderately narrow aperture, planar rough fracture. Discontinuity surface shows speckled light brown discoloration.		
			0.5	15.5									
HQ			0.0	16.0	Moderately weathered, grey interbedded fine SANDSTONE and clayey SILTSTONE, weak. Rhythmically bedded sequence of alternating thick beds of Siltstone and Sandstone. Closely spaced, sub-horizontal to sub-vertical discontinuities with narrow to moderately narrow apertures and planar smooth to planar rough fractures [East Coast Bays Formation].			97	97	93	16.40 m: Sub-horizontal discontinuity, narrow aperture, planar rough aperture.		
			-0.5	16.5	*16.5 - 18.0m: Thick be of clayey Siltstone.*								
			-1.0	17.0									
			-1.5	17.5				90	77	84	17.35 m: Sub-horizontal discontinuity, narrow aperture, planar smooth fracture. 17.45 m: Sub-horizontal fracture, moderately narrow aperture, planar rough fracture. 17.60 m: Sub-vertical discontinuity, narrow aperture, planar rough fracture. 18.10 m: Steeply inclined, narrow aperture, planar rough fracture. 18.20 m: Sub-horizontal discontinuity, very narrow aperture, planar smooth fracture.		
			-2.0	18.0									
			-2.5	18.5	*18.6 - 20.0m: Thick bed of clayey Siltstone (low core recovery, top of bed is unknown).*								
			-3.0	19.0				23	13	13			
			-3.5	19.5									
					End of Machine Borehole at 20.00m								

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:	M726205.02
Survey accuracy:	+-5m

Machine Borehole

BH009

Client:	NZTA Waka Kotahi	**Date started:**	10-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	11-07-2025
Project ID:	705100376-004	**Weather:**	Rainstorm
Location:	Triangle Rd / Huruhuru Rd	**Logged by:**	TZ
Feature:	North of roundabout	**Checked by:**	NL
Elevation:	24.50 mRL **Datum:** NZVD2016 **Coordinates:** E 1744919.93 N 5921213.79 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	MacMillan Drilling **Drilling Rig:** Truck mounted rig **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			24.0	0.5	Hydro-excavated.								
			23.5	1.0									
			23.0	1.5									
			22.5	2.0									
HQ			22.0	2.5	Sandy SILT, minor gravel; light grey, streaked light brown. Firm, wet, non-plastic; sand, fine, pumiceous, gravel, fine to medium [TAKAANINI FORMATION] Silty CLAY, minor sand; light brown, streaked black. Firm, moist, high plasticity, contains carbonaceous fragments; sand, medium [TAKAANINI FORMATION]. *2.8 - 2.9m: Dark brown.* *2.75 - 2.8m: Brownish grey.* *2.75 - 3.0m: Soft.*			113					
			21.5	3.0									
			21.0	3.5	Core loss, soil was dropped during recovery.								
SPT	SPT/SS	1,1// 1, 1, 1, 2 N = 5	20.5	4.0	Silty CLAY, trace sand; greyish light brown. Soft, moist, high plasticity; sand, fine to medium [TAKAANINI FORMATION].			100					
HQ			20.0	4.5	Organic, silty CLAY; brownish black. Very soft, wet, high plasticity, contains carbonaceous fragments [TAKAANINI FORMATION]. Silty CLAY, some sand; grey. Very soft, saturated, non-plastic, contains carbonaceous fragments; sand, fine [TAKAANINI FORMATION].								
	HSV (P/R)	38/	19.5	5.0	*5.0 - 5.5m: Firm.*								
SPT	SPT/SS	1,1// 2, 1, 1, 2 N = 6	19.0	5.5	Core loss due to soil being washed out.			0					
HQ			18.5	6.0									
			18.0	6.5	Silty SAND; grey. Very loose, saturated, uniformly graded; sand, fine [TAKAANINI FORMATION].								
SPT	SPT/SS	0,0// 0, 0, 0, 0 N = 0	17.5	7.0	Silty CLAY; dark grey. Very soft, saturated, non-plastic [TAKAANINI FORMATION]. *7.0 - 7.3m: Firm.*			100					
HQ			17.0	7.5	*7.5 - 7.75m: Firm.*								
	HSV (P/R)	52/	16.5	8.0	Organic silty CLAY; blackish brown. Firm, wet, low plasticity [TAKAANINI FORMATION]. *8.0 - 8.35m: Stiff.*								
SPT	SPT/SS	1,1// 1, 1, 1, 1 N = 4	16.0	8.5	Silty CLAY; greyish light brown. Firm, moist, high plasticity [TAKAANINI FORMATION].			73					
HQ			15.5	9.0									
	HSV (P/R)	48/	15.0	9.5									
SPT	SPT/SS	1,1// 1, 1, 1, 1 N = 4											

11-07-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:

Survey accuracy: +-5m

Machine Borehole

BH009

Client:	NZTA Waka Kotahi	**Date started:**	10-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	11-07-2025
Project ID:	705100376-004	**Weather:**	Rainstorm
Location:	Triangle Rd / Huruhuru Rd	**Logged by:**	TZ
Feature:	North of roundabout	**Checked by:**	NL
Elevation:	24.50 mRL **Datum:** NZVD2016 **Coordinates:** E 1744919.93 N 5921213.79 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	MacMillan Drilling **Drilling Rig:** Truck mounted rig **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			14.0	10.5	Silty CLAY, some sand; light brown, mottled grey. Firm to stiff, moist, low plasticity; sand, fine [TAKAANINI FORMATION].			90					
	HSV (P/R)	28/	13.5	11.0	Silty CLAY; light brown, mottled grey. Soft, moist, high plasticity [TAKAANINI FORMATION].								
SPT	SPT/SS	1,1// 1, 1, 1, 1 N = 4	13.0	11.5									
HQ			12.5	12.0	Sandy SILT, minor clay; light brown mottled grey. Firm, moist, low plasticity; sand, fine [TAKAANINI FORMATION].			40					
	HSV (P/R)	56/	12.0	12.5									
SPT	SPT/SS	1,1// 1, 1, 1, 1 N = 4	11.5	13.0	Silty SAND; light brown. Medium dense, moist, uniformly graded; sand, fine to medium [RESIDUAL SOIL].			73					
HQ			11.0	13.5	*13.5 - 13.9m: Silty sand becomes grey, loose, saturated.*								
SPT	SPT/C	2,2// 2, 2, 2, 3 N = 9	10.5	14.0	Completely weathered, grey, fine Sandstone, Very weak [EAST COAST BAYS FORMATION].								
HQ			10.0	14.5	Highly weathered, grey SILTSTONE, very weak [EAST COAST BAYS FORMATION].			63	45	30			
			9.5	15.0									
SPT	HSV (P/R) SPT/C	UTP/ 21 ,29 for 30mm// N = >50	9.0	15.5	Moderately weathered, dark grey, interbedded clay-rich SILTSTONE and fine SANDSTONE, weak. Rhythmically sequence of thin beds of Siltstone and Sandstone. Moderately widely spaced, sub-horizontal to steeply inclined discontinuities with narrow apertures and stepped to planar rough fractures [EAST COAST BAYS FORMATION].			90	86	73	15.85 m: Sub-horizontal discontinuity, narrow aperture, planar rough fracture. 16.10 m: Sub-horizontal discontinuity, very narrow aperture, planar rough fracture. 16.25 m: Sub-horizontal discontinuity, narrow aperture, planar rough fracture. 16.80 m: Sub-horizontal discontinuity, narrow aperture, rough stepped fracture.		
HQ			8.5	16.0									
			8.0	16.5	*16.8 - 17.0m: Completely weathered to soil. Recovered as silty Sand, loose, saturated; sand, fine.*								
SPT	SPT/C	20 ,30 for 13mm// N = >50	7.5	17.0				95	72	73	17.40 m: Sub-horizontal discontinuity, narrow aperture, planar rough fracture. 17.90-17.75 m: Two very steeply inclined discontinuities, moderately narrow apertures, undulating rough fractures. 17.95 m: Gently inclined discontinuity, moderately narrow aperture, rough stepped fracture.		
HQ			7.0	17.5									
			6.5	18.0	Slightly weathered, dark grey, interbedded clay-rich SILTSTONE and fine SANDSTONE, weak. Rhythmically sequenced thin to moderately thin beds of Siltstone and Sandstone. Moderately widely spaced, generally sub-horizontal discontinuities with narrow to moderately narrow apertures and planar rough fractures [EAST COAST BAYS FORMATION].								
SPT	SPT/C	22 ,28 for 10mm// N = >50	6.0	18.5				63	63	63			
HQ			5.5	19.0									
			5.0	19.5							19.40 m: Sub-horizontal discontinuity, narrow aperture, planar rough fracture. 19.60 m: Sub-horizontal discontinuity, narrow aperture, rough stepped fracture.		
					End of Machine Borehole at 20.00m								

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:

Survey accuracy: +-5m

Machine Borehole

BH010

Client:	NZTA Waka Kotahi	**Date started:**	09-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	10-07-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	Royal Road - SH16 cycle way	**Logged by:**	RC
Feature:	cycle way first section	**Checked by:**	NL
Elevation:	65.00 mRL **Datum:** NZVD2016 **Coordinates:** E 1744347.85 N 5922655.46 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			64.5	0.5	Hydro excavated.								
			64.0	1.0									
			63.5	1.5									
			63.0	2.0	Clayey SILT, trace sand; grey. Firm, moist, low plasticity; sand, fine [Residual soil].								
			62.5	2.5	Completely weathered clay-rich SILTSTONE, recovered as soil, partial rock fabric preserved. Soil behaviour includes clayey SILT, trace sand, grey, firm to soft, moist, low plasticity [EAST COAST BAYS FORMATION].			150					
	HSV (P/R)	75/20/	62.0	3.0									
SPT	SPT/SS	2,2// 3, 3, 4, 4 N = 14	61.5	3.5									
HQ			61.0	4.0	Highly weathered clay-rich SILTSTONE, very weak to extremely weak. Soil behaviour includes clayey SILT, trace sand, grey, firm, moist, low plasticity [EAST COAST BAYS FORMATION].			93					
	HSV (P/R)	UTP/	60.5	4.5									
SPT	SPT/SS	4,4// 6, 7, 8, 10 N = 31	60.0	5.0				77					
HQ			59.5	5.5									
SPT	SPT/C	8,8// 21, 23, 6 for 10mm N = >50	59.0	6.0									
HQ			58.5	6.5				100					
SPT	SPT/C	-,-// 11, 39, 11 N = >50	58.0	7.0									
			57.5	7.5	Moderately weathered, light brownish grey, interbedded SILTSTONE and fine to medium SANDSTONE, trace gravel, weak; gravel, fine, sub-angular. Rhythmically thickly bedded sequence of alternating Siltstone and SANDSTONE. Bedding contacts typically indistinguishable due to discolouration of weathering. Discontinuities vary from sub-horizontal to steeply inclined, closely spaced to very closely spaced [EAST COASTS BAYS FORMATION].								
HQ			57.0	8.0				60	40	23	8.25 m: Sub-horizontal, moderately narrow aperture, undulating smooth open fracture. 8.45 m: Sub-horizontal, moderately narrow aperture, undulating rough open fracture. 8.75 m: Gently inclined, moderately wide aperture, undulating rough open fracture.		
			56.5	8.5									
SPT	SPT/C	8 ,74 for 50mm// N = >50	56.0	9.0									
			55.5	9.5	*9.4 - 9.5m Thinly laminated, wavy, carbonaceous laminations.* *9.72m Thin carbonaceous laminae* *9.9m Thin carbonaceous laminae*			83	42	40	9.40 m: Gently inclined, moderately wide aperture, stepped smooth open fracture. Clay infill. 9.46 m: Sub-horizontal, moderately wide aperture, undulating rough open fracture. Clay infill.		

11-07-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH010

Client:	NZTA Waka Kotahi	**Date started:**	09-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	10-07-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	Royal Road - SH16 cycle way	**Logged by:**	RC
Feature:	cycle way first section	**Checked by:**	NL
Elevation:	65.00 mRL **Datum:** NZVD2016 **Coordinates:** E 1744347.85 N 5922655.46 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 20.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			54.5	10.5	Moderately weathered, light brownish grey, interbedded SILTSTONE and fine to medium SANDSTONE, trace gravel, weak; gravel, fine, sub-angular. Rhythmically thickly bedded sequence of alternating Siltstone and SANDSTONE. Bedding contacts typically indistinguishable due to discolouration of weathering. Discontinuities vary from sub-horizontal to steeply inclined, closely spaced to very closely spaced [EAST COASTS BAYS FORMATION]. *10m Thin carbonaceous laminae.* *10.76 Thin carbonaceous laminae*						9.95 m: Two joints are intercepted. Joint 1: gently inclined, narrow aperture, closed defect. Joint 2: Moderately inclined, narrow aperture, closed defect. 10.10 m: Gently inclined, moderately narrow aperture, undulating slickensided open fracture. 10.90 m: Multiple joints are intercepted. Joint 1: 3 - 5° inclined, narrow, closed defect. Joint 2: 45° inclined moderately narrow aperture, undulating smooth to rough open fracture. Joint 3: 80° - 83° inclined, moderately narrow aperture, undulating rough open fracture.		
			54.0	11.0	*11.2m Thin carbonaceous laminae*			100	59	55			
			53.5	11.5	*11.5m Carbonaceous flecks.*								
			53.0	12.0									
			52.5	12.5				100	52	48			
			52.0	13.0							12.90 m: Sub-vertical inclined, moderately wide aperture, undulating smooth open fracture.		
			51.5	13.5							13.60 m: Sub-horizontal discontinuity, narrow aperture, planar rough fracture. 13.70 m: Steeply inclined, moderately narrow aperture, undulating rough open fracture.		
			51.0	14.0				100	52	48			
			50.5	14.5									
			50.0	15.0							15.15 m: Steeply inclined, moderately narrow aperture, undulating rough open fracture. Clay infill. 15.38 m: Sub-horizontal, moderately narrow aperture, undulating smooth open fracture. 15.80 m: Sub-horizontal discontinuity, moderately narrow aperture, planar smooth fracture. 16.10 m: Sub-horizontal discontinuity, narrow aperture, planar smooth fracture.		
			49.5	15.5				100	82	74			
			49.0	16.0									
			48.5	16.5							16.65 m: Sub-horizontal discontinuity, narrow aperture, planar smooth fracture.		
			48.0	17.0							17.10 m: Sub-horizontal discontinuity, tight aperture, planar smooth fracture; intersected by sub-vertical discontinuity, tight aperture, rough stepped fracture.		
			47.5	17.5				100	53	36			
			47.0	18.0									
			46.5	18.5							18.60 m: Steeply inclined, moderately narrow aperture, undulating rough open fracture.		
			46.0	19.0				100	63	48	19.00 m: Steeply inclined, moderately narrow aperture, undulating rough open fracture. 19.10 m: Gently inclined, moderately narrow aperture, undulating smooth open fracture.		
			45.5	19.5									
								100	90	80			
					End of Machine Borehole at 20.00m								

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration:	M726205.02
Survey accuracy:	+-5m

Machine Borehole

BH011

Client:	NZTA Waka Kotahi	**Date started:**	10-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	14-07-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	West of SH16	**Logged by:**	RC
Feature:	On cycleway	**Checked by:**	NL
Elevation:	59.00 mRL **Datum:** NZVD2016 **Coordinates:** E 1744328.54 N 5922793.66 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	MacMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 27.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			58.5	0.5	Hydro excavated.								
			58.0	1.0									
			57.5	1.5									
			57.0	2.0									
HQ			56.5	2.5	Silty CLAY, trace gravels; yellowish light brown with iron-oxidised flecks. Firm to stiff, moist, low plasticity; gravel, fine to medium, sub-angular [TAKAANINI FORMATION].			60					
	HSV (P/R)	62/	56.0	3.0									
SPT	SPT/SS	0,1// 1, 1, 1, 2 N = 5											
HQ			55.5	3.5				23					
			55.0	4.0									
	HSV (P/R)	38/	54.5	4.5	Silty CLAY, trace sand; grey. Soft to firm, moist, high plasticity; sand, fine, sub-angular [Residual Soil].								
SPT	SPT/SS	0,1// 1, 1, 1, 1 N = 4											
HQ			54.0	5.0				60					
			53.5	5.5									
	HSV (P/R)	40/	53.0	6.0	Clayey SILT, trace sand; grey. Soft to firm, wet to moist, low plasticity; sand, fine, sub-angular [Residual Soil].								
SPT	SPT/SS	0,1// 1, 1, 2, 2 N = 6											
HQ			52.5	6.5				77					
			52.0	7.0									
	HSV (P/R)	20/	51.5	7.5									
SPT	SPT/SS	0,1// 1, 1, 1, 1 N = 4											
HQ			51.0	8.0				100					
			50.5	8.5									
	HSV (P/R)	38/	50.0	9.0									
SPT	SPT/SS	0,0// 0, 1, 1, 1 N = 3											
HQ			49.5	9.5				33					

17-07-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH011

Client:	NZTA Waka Kotahi	**Date started:**	10-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	14-07-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	West of SH16	**Logged by:**	RC
Feature:	On cycleway	**Checked by:**	NL
Elevation:	59.00 mRL **Datum:** NZVD2016 **Coordinates:** **E** 1744328.54 **N** 5922793.66 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	MacMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 27.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing: Type	In-situ testing: Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
					Clayey SILT, trace sand; grey. Soft to firm, wet to moist, low plasticity; sand, fine, sub-angular [Residual Soil].								
	HSV (P/R)	36/	48.5	10.5									
SPT	SPT/SS	0,0// 0, 1, 1, 2 N = 4											
HQ			48.0	11.0				97					
			47.5	11.5									
	HSV (P/R)	40/	47.0	12.0									
SPT	SPT/SS	0,0// 1, 1, 1, 2 N = 5											
HQ			46.5	12.5				100					
			46.0	13.0									
	HSV (P/R)	40/	45.5	13.5									
SPT	SPT/SS	0,0// 1, 1, 1, 2 N = 5											
HQ			45.0	14.0	Completely weathered interbedded SILTSTONE and fine to coarse SANDSTONE, very weak, to extremely weak. Retaining relict rock fabrics, whereas rock strengths completely lost, soil behaviours include clayey SILT, firm to soft, moist, low plasticity [EAST COAST BAYS FORMATION].			97					
			44.5	14.5									
	HSV (P/R)	46/	44.0	15.0									
SPT	SPT/SS	0,0// 1, 1, 2, 2 N = 6											
HQ			43.5	15.5				100					
			43.0	16.0									
	HSV (P/R)	98/	42.5	16.5									
SPT	SPT/SS	1,2// 2, 2, 2, 2 N = 8											
HQ			42.0	17.0				87					
			41.5	17.5									
	HSV (P/R)	50/	41.0	18.0	Highly weathered interbedded clay-rich SILTSTONE and fine to coarse SANDSTONE, grey, yellowish brown sand infill, weak to very weak. Rhythmically thickly bedded sequence of alternating Siltstone and Sandstone. Discontinuities varies from sub-horizontal to steeply inclined, very closely spaced [EAST COAST BAYS FORMATION].								
SPT	SPT/SS	2,3// 2, 3, 3, 3 N = 11											
HQ			40.5	18.5				66	33	53			
			40.0	19.0									
	HSV (P/R)	94/	39.5	19.5									
SPT	SPT/SS	2,2// 3, 3, 5, 5 N = 16			*19.95m Thin carbonaceous laminae.*								

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH011

Client:	NZTA Waka Kotahi	**Date started:**	10-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	14-07-2025
Project ID:	705100376-004	**Weather:**	Rainy
Location:	West of SH16	**Logged by:**	RC
Feature:	On cycleway	**Checked by:**	NL
Elevation:	59.00 mRL **Datum:** NZVD2016 **Coordinates:** **E** 1744328.54 **N** 5922793.66 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	MacMillan Drilling **Drilling Rig:** N118 **Termination:** Target depth at 27.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			38.5	20.5	Highly weathered interbedded clay-rich SILTSTONE and fine to coarse SANDSTONE, grey, yellowish brown sand infill, weak to very weak. Rhythmically thickly bedded sequence of alternating Siltstone and Sandstone. Discontinuities varies from sub-horizontal to steeply inclined, very closely spaced [EAST COAST BAYS FORMATION].			80	78	76			
SPT	HSV (P/R) SPT/SS	UTP/ 2,3// 4, 5, 6, 6 N = 21	38.0	21.0							20.80 m: Gently inclined discontinuity, moderately narrow aperture, undulating smooth fracture.		
HQ			37.5	21.5	Moderately weathered interbedded clay-rich SILTSTONE and fine to coarse SANDSTONE, grey, yellowish brown sand infill, weak to very weak. Rhythmically thickly bedded sequence of alternating Siltstone and Sandstone. Discontinuities varies from sub-horizontal to steeply inclined, very closely spaced [EAST COAST BAYS FORMATION].			66	53	40			
SPT	HSV (P/R) SPT/C	UTP/ 5,7// 8, 9, 13, 13 N = 43	36.5	22.5	*22.5-24.4m: Fine to medium sandstone, coarsening downwards, sedimentary structures.*						22.40 m: Sub-horizontal discontinuity, moderately narrow aperture, undulating smooth fracture.		
HQ			36.0	23.0				100	70	66			
SPT	SPT/C	9 ,41 for 70mm// N = >50	35.5	23.5									
HQ			35.0	24.0				100	93	90	24.85 m: Sub-horizontal discontinuity, moderately narrow aperture, undulating smooth fracture. 25.20 m: Sub-horizontal discontinuity, moderately narrow aperture, undulating smooth fracture.		
SPT	SPT/C	15 ,35 for 60mm// N = >50	34.5	24.5									
HQ			34.0	25.0				100	84	84	25.40 m: Gently inclined discontinuity, moderately narrow aperture, undulating smooth fracture. 25.90 m: Gently inclined discontinuity, narrow aperture, planar smooth fracture. 26.00 m: Sub-horizontal discontinuity, moderately wide aperture, undulating rough fracture.		
SPT	SPT/C	17 ,33 for 45mm// N = >50	33.5	25.5									
			33.0	26.0									
			32.5	26.5									
			32.0	27.0	End of Machine Borehole at 27.00m								
			31.5	27.5									
			31.0	28.0									
			30.5	28.5									
			30.0	29.0									
			29.5	29.5									

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH012

Client:	NZTA Waka Kotahi	**Date started:**	21-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	22-07-2025
Project ID:	705100376-004	**Weather:**	Sunny
Location:	Gunton Drive	**Logged by:**	RC
Feature:	SH16 entrance side	**Checked by:**	NL
Elevation:	39.30 mRL **Datum:** NZVD2016 **Coordinates:** E 1743831.11 N 5924294.24 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N101 **Termination:** Target depth at 21.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
			39.0	0.5	Hydro excavated.								
	SPT/SS	1,1// 1, 2, 2, 3 N = 8	38.5	1.0									
			38.0	1.5									
SPT			37.5	2.0	Gravelly CLAY; yellowish light brown. Firm, moist, high plasticity; gravel, fine, sub-angular [TAKAANINI FORMATION].								
HQ			37.0	2.5	Silty Sandy CLAY, yellowish light brown, iron-oxidised stains, Soft to firm, moist, high plasticity; sand. fine to medium, sub-angular [TAKAANINI FORMATION].			145					
	HSV (P/R)	40/	36.5	3.0	*3.0 - 5.5m: Light greyish brown.*								
SPT	SPT/SS	0,1// 2, 1, 1, 2 N = 6	36.0	3.5									
HQ			35.5	4.0				83					
	HSV (P/R)	42/	35.0	4.5									
SPT	SPT/SS	0,0// 1, 1, 2, 2 N = 6	34.5	5.0									
HQ			34.0	5.5				66					
			33.5	6.0	Clayey SILT, trace sand; dark grey. Firm, moist, low plasticity; sand, fine, sub-angular [Residual Soil].								
	HSV (P/R)	82/											
SPT	SPT/SS	1,1// 2, 2, 2, 2 N = 8	33.0	6.5	*6.5 - 6.9m: Brownish grey.*								
HQ			32.5	7.0				87					
			32.0	7.5	Completely weathered clay-rich SILTSTONE, light grey, extremely weak. Recovered as clayey SILT, firm to very soft, moist, low plasticity [EAST COAST BAYS FORMATION].								
	HSV (P/R)	130/			Highly weathered interbedded SILTSTONE and fine SANDSTONE, clay-rich, dark grey, very weak. Moderately thin to moderately thick beds. Partially recovered as clayey SILT and fine SAND. Clayey Silt, very stiff to hard, wet, low plasticity. Sand, dense, wet, uniformly graded; sand, fine, sub-rounded [EAST COAST BAYS FORMATION].								
SPT	SPT/SS	2,3// 3, 4, 5, 5 N = 17	31.5	8.0									
HQ			31.0	8.5				66	34	26			
	HSV (P/R)	100/	30.5	9.0									

23-07-2025

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH012

Client:	NZTA Waka Kotahi	**Date started:**	21-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	22-07-2025
Project ID:	705100376-004	**Weather:**	Sunny
Location:	Gunton Drive	**Logged by:**	RC
Feature:	SH16 entrance side	**Checked by:**	NL
Elevation:	39.30 mRL **Datum:** NZVD2016 **Coordinates:** E 1743831.11 N 5924294.24 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N101 **Termination:** Target depth at 21.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
SPT	SPT/SS	2,4// 4, 5, 5, 5 N = 19	30.0	9.5	Highly weathered interbedded SILTSTONE and fine SANDSTONE, clay-rich, dark grey, very weak. Moderately thin to moderately thick beds. Partially recovered as clayey SILT and fine SAND. Clayey Silt, very stiff to hard, wet, low plasticity. Sand, dense, wet, uniformly graded; sand, fine, sub-rounded [EAST COAST BAYS FORMATION].								
HQ			29.5	10.0				73	45	24			
					10.05m Stronger rock strength.								
	HSV (P/R)	UTP/	29.0	10.5	*10.4m Thinly laminated, gently inclined, wavy, carbonaceous laminations.*								
SPT	SPT/SS	4,5// 8, 8, 10, 12 N = 38	28.5	11.0	*10.7 - 15.0m: Brownish grey.*								
HQ					*11m Carbonaceous flecks.*			80	61	20			
			28.0	11.5									
SPT	SPT/C	4,4// 7, 10, 13, 16 N = 46	27.5	12.0									
HQ			27.0	12.5				53	12	0			
			26.5	13.0									
SPT	SPT/C	7,13// 22, 25, 14 for 50mm N = >50	26.0	13.5									
HQ			25.5	14.0				73	25	8			
			25.0	14.5									
SPT	SPT/C	7,15// 18, 18, 14 for 50mm N = >50	24.5	15.0	Highly weathered to moderately weathered interbedded SILTSTONE and fine SANDSTONE, brownish grey, very weak. Moderately thick bedding. Partially recovered as clayey SILT and fine SAND. Clayey Silt, very stiff to hard, wet, low plasticity. Sand, dense, wet, uniformly graded; sand, fine, sub-rounded [EAST COAST BAYS FORMATION].								
HQ			24.0	15.5				70	35	29	15.80 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture. 16.00 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture. 16.20 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture. 16.50 m: Steeply inclined joint, moderately wide aperture, undulating rough open fracture. Sand infilled.		
			23.5	16.0									
SPT	SPT/C	7,20// 29, 21 for 55mm N = >50	23.0	16.5	Moderately weathered interbedded SILTSTONE and fine to medium SANDSTONE, dark grey, weak. Rhythmically thickly bedded Siltstone and Sandstone. Bedding contacts are distinguishable due to weathering and discolouration. Discontinuities vary from sub-horizontal to moderately inclined, closely spaced [EAST COAST BAYS FORMATION].								
			22.5	17.0				90	78	76	17.20 m: Gently inclined defect, moderately narrow aperture, undulating slickensided open fracture. 17.38 m: Sub-horizontal defect, moderately wide aperture, undulating rough open fracture. 17.70 m: Gently inclined defect, moderately narrow aperture, undulating smooth open fracture.		
			22.0	17.5									
			21.5	18.0							18.10 m: Sub-horizontal defect, moderately narrow aperture, planar smooth open fracture.		
			21.0										

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

Machine Borehole

BH012

Client:	NZTA Waka Kotahi	**Date started:**	21-07-2025
Project:	Te Ara Hauauru - Northwest Rapid Transit	**Date completed:**	22-07-2025
Project ID:	705100376-004	**Weather:**	Sunny
Location:	Gunton Drive	**Logged by:**	RC
Feature:	SH16 entrance side	**Checked by:**	NL
Elevation:	39.30 mRL **Datum:** NZVD2016 **Coordinates:** **E** 1743831.11 **N** 5924294.24 **Grid:** NZTM2000	**Status:**	FINAL
Drilling company:	McMillan Drilling **Drilling Rig:** N101 **Termination:** Target depth at 21.00 mbgl	**Logging Standard:**	NZGD2005

Drilling method	In-situ testing Type	In-situ testing Results	R.L. (m)	Depth (m)	Material description	Unit	Legend	Recovery % TCR	Recovery % SCR	Recovery % RQD	Discontinuities	Backfill	Water strike
HQ			20.5 20.0 19.5 19.0 18.5 18.0 17.5 17.0 16.5 16.0 15.5 15.0 14.5 14.0 13.5 13.0 12.5 12.0	18.5 19.0 19.5 20.0 20.5 21.0 21.5 22.0 22.5 23.0 23.5 24.0 24.5 25.0 25.5 26.0 26.5 27.0 27.5	Moderately weathered interbedded SILTSTONE and fine to medium SANDSTONE, dark grey, weak. Rhythmically thickly bedded Siltstone and Sandstone. Bedding contacts are distinguishable due to weathering and discolouration. Discontinuities vary from sub-horizontal to moderately inclined, closely spaced [EAST COAST BAYS FORMATION]. End of Machine Borehole at 21.00m			100	61	55	18.50 m: Gently inclined defect, moderately narrow aperture, undulating slickensided open fracture. 18.83 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture. 18.88 m: Sub-horizontal defect, moderately narrow aperture, undulating smooth open fracture. 19.25 m: Multi joints. Joint 1: Sub-horizontal, narrow aperture, closed defect. Joint 2: Moderately inclined, moderately wide aperture, undulating rough open fracture. 19.40 m: Moderately inclined defect, moderately narrow aperture, planar smooth open fracture. 19.90 m: Sub-horizontal defect, narrow aperture, planar rough fracture. 20.00 m: Sub-horizontal defect, narrow aperture, planar rough fracture. 20.75 m: Gently inclined defect, moderately narrow aperture, planar smooth fracture. 20.85 m: Gently inclined defect, moderately narrow aperture, planar rough aperture.		

Manual groundwater measurement

Date	Water strike (mbgl)

Remarks

Shear vane calibration: M726205.02

Survey accuracy: +-5m

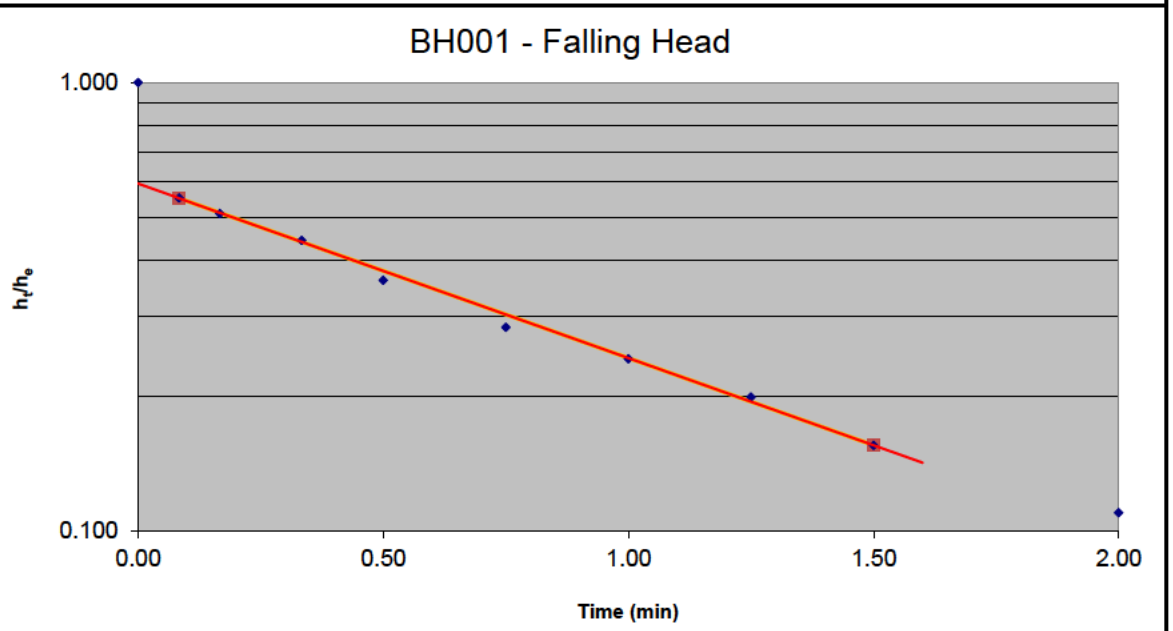
Appendix B. Permeability testing

Bore No:	BH001	Test No:	#1	Job No: NWRT	Date: 4/07/25	Logged by: TZ

Borehole co-ordinates:	Easting:	1755529.42	Northing: 5918319.8	Collar elevation (m):	
Depth to top of test section (m):		5.4		Length of test section, L (m):	7.25
Depth of static water level, H_w (m):		5.4		Radius of borehole, r (m):	0.05
Excess head, h_e (m):		0.71		Radius of standpipe or casing, r_c (m	0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	**0.000**	**4.693**	**0.707**	**1.000**	
5	0.083	5.009	0.391	0.552	45%
10	0.167	5.039	0.361	0.510	49%
20	0.333	5.086	0.314	0.444	56%
30	0.500	5.144	0.256	0.362	64%
45	0.750	5.199	0.201	0.284	72%
60	1.000	5.229	0.171	0.242	76%
75	1.250	5.260	0.140	0.199	80%
90	1.500	5.290	0.110	0.155	85%
120	2.000	5.323	0.078	0.110	89%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.552		
t_1	0.083		
h_2	0.155		
t_2	1.500		
S	3.9E-01		
k	**4.5E-06**	**3.9E-01**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)

where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

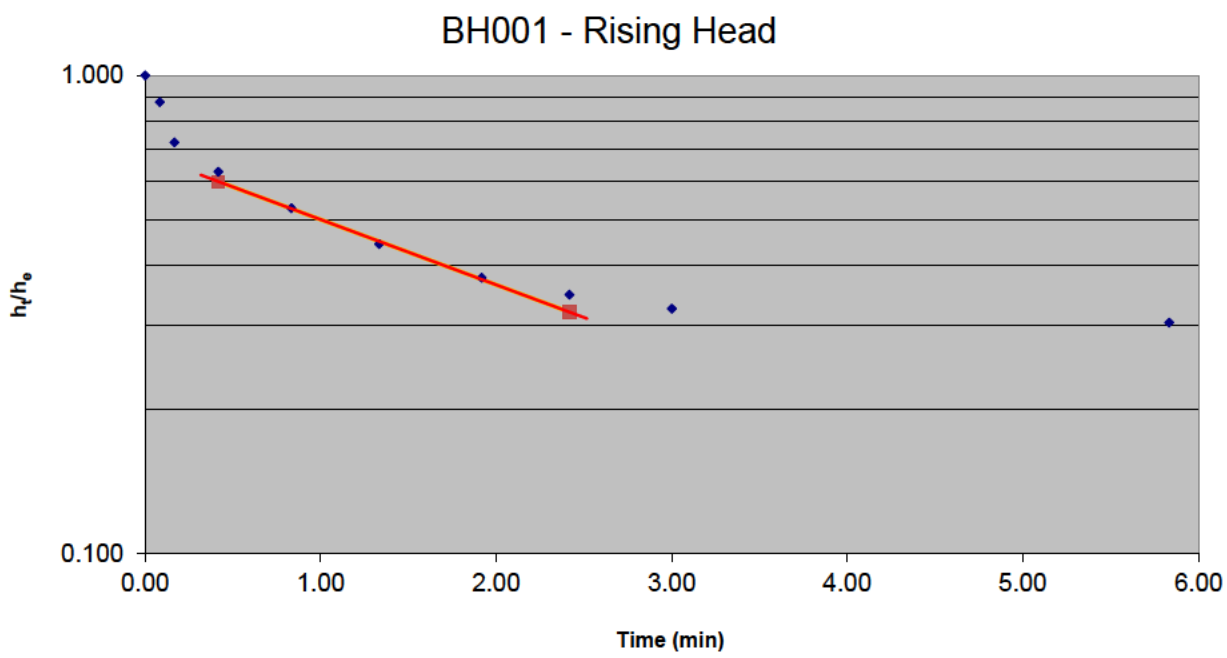
Notes:

Bore No:	BH001	Test No: #1	Job No: NWRT	Date: 4/07/25	Logged by: TZ

Borehole co-ordinates:	Easting: 1755529.42	Northing: 5918319.8	Collar elevation (m):
Depth to top of test section (m):	5.4		Length of test section, L (m): 7.25
Depth of static water level, H_w (m):	5.4		Radius of borehole, r (m): 0.05
Excess head, h_e (m):	-0.71		Radius of standpipe or casing, r_c (m) 0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.000	6.107	-0.707	1.000	
5	0.083	6.022	-0.622	0.880	12%
10	0.167	5.912	-0.512	0.724	28%
25	0.417	5.845	-0.445	0.629	37%
50	0.833	5.773	-0.373	0.528	47%
80	1.333	5.714	-0.314	0.444	56%
115	1.917	5.667	-0.267	0.378	62%
145	2.417	5.646	-0.246	0.348	65%
180	3.000	5.630	-0.230	0.325	67%
350	5.833	5.615	-0.215	0.304	70%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.600		
t_1	0.417		
h_2	0.320		
t_2	2.417		
S	1.4E-01		
k	**1.6E-06**	**1.4E-01**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)
where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

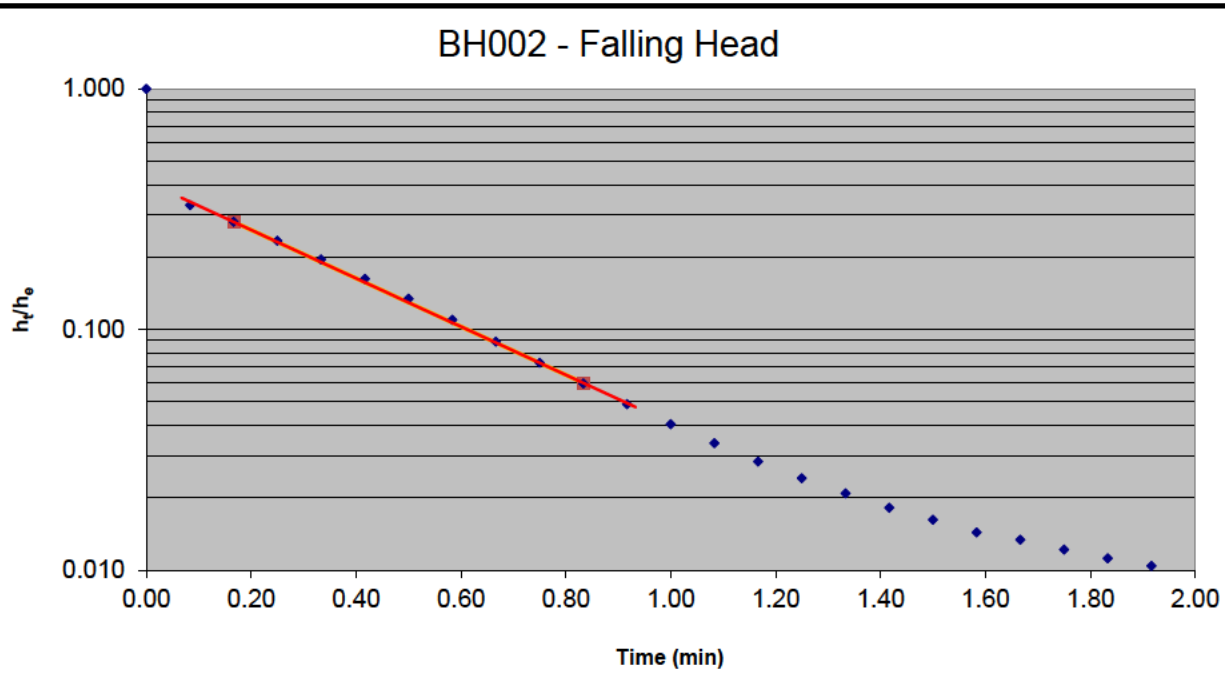
Notes:

Bore No:	BH002	Test No: #1	Job No: NWRT	Date: 4/07/25	Logged by: TZ

Borehole co-ordinates:	Easting:	1755456	Northing: 5918303	Collar elevation (m):	
Depth to top of test section (m):		6.1		Length of test section, L (m):	6.55
Depth of static water level, H_w (m):		6.1		Radius of borehole, r (m):	0.05
Excess head, h_e (m):		1.42		Radius of standpipe or casing, r_c (m)	0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.00	4.68	1.42	1.000	
5	0.08	5.63	0.47	0.328	67%
10	0.17	5.70	0.40	0.280	72%
15	0.25	5.77	0.33	0.234	77%
20	0.33	5.82	0.28	0.196	80%
25	0.42	5.87	0.23	0.162	84%
30	0.50	5.91	0.19	0.134	87%
35	0.58	5.94	0.16	0.110	89%
40	0.67	5.97	0.13	0.089	91%
45	0.75	6.00	0.10	0.073	93%
50	0.83	6.02	0.08	0.060	94%
55	0.92	6.03	0.07	0.049	95%
60	1.00	6.04	0.06	0.040	96%
65	1.08	6.05	0.05	0.034	97%
70	1.17	6.06	0.04	0.028	97%
75	1.25	6.07	0.03	0.024	98%
80	1.33	6.07	0.03	0.021	98%
85	1.42	6.07	0.03	0.018	98%
90	1.50	6.08	0.02	0.016	98%
95	1.58	6.08	0.02	0.014	99%
100	1.67	6.08	0.02	0.013	99%
105	1.75	6.08	0.02	0.012	99%
110	1.83	6.08	0.02	0.011	99%
115	1.92	6.09	0.01	0.010	99%
120	2.00	6.09	0.01	0.010	99%
125	2.08	6.09	0.01	0.009	99%
130	2.17	6.09	0.01	0.009	99%
135	2.25	6.09	0.01	0.009	99%
140	2.33	6.09	0.01	0.008	99%
145	2.42	6.09	0.01	0.008	99%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.280		
t_1	0.167		
h_2	0.060		
t_2	0.833		
S	1.0E+00		
k	1.3E-05	1.1E+00	

Permeability, $k = 0.133 \times S \times (rc^2/L)$ (m/sec)/(m/day)

where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

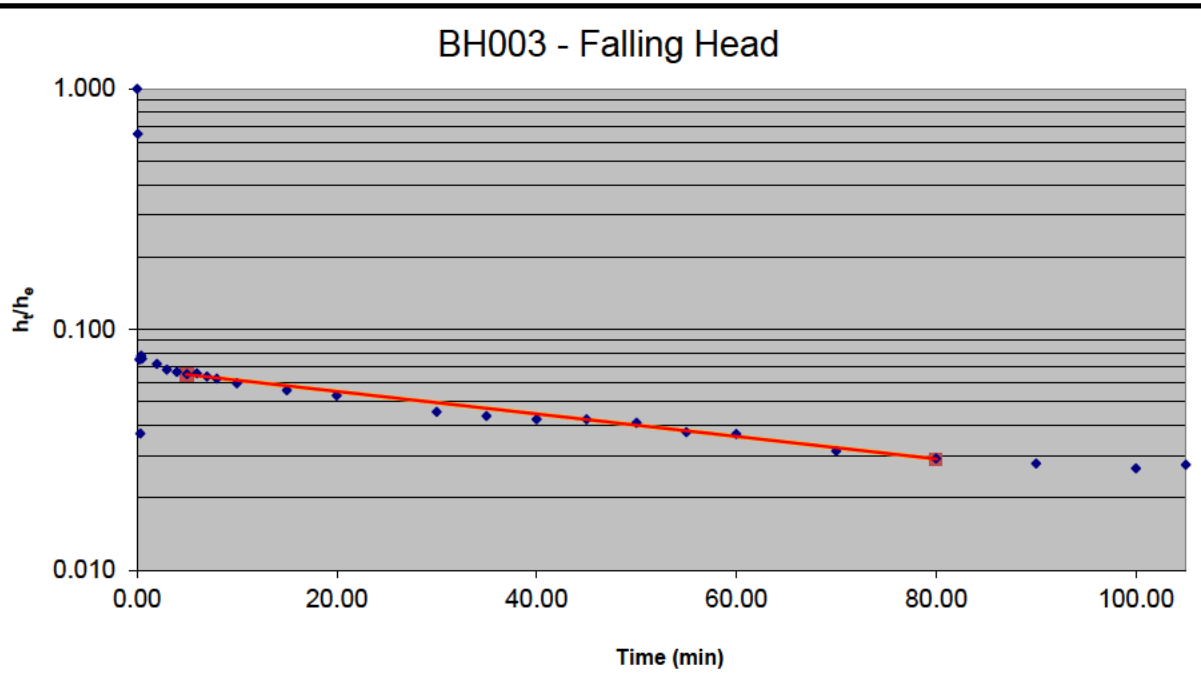
Notes:

Bore No:	BH003	Test No: #1	Job No: NWRT	Date: 1/07/25	Logged by: TZ

Borehole co-ordinates:	Easting:	1752601	Northing: 5918099	Collar elevation (m):	
Depth to top of test section (m):		2		Length of test section, L (m):	8.9
Depth of static water level, H_w (m):		2		Radius of borehole, r (m):	0.05
Excess head, h_e (m):		0.65		Radius of standpipe or casing, r_c (m)	0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.0	1.351	0.649	1.000	
5	0.1	1.578	0.422	0.651	35%
10	0.2	2.127	-0.127	-0.196	120%
15	0.3	1.951	0.049	0.075	92%
20	0.3	1.976	0.024	0.037	96%
25	0.4	1.950	0.051	0.078	92%
30	0.5	1.951	0.049	0.076	92%
60	1.0	2.002	-0.002	-0.002	100%
120	2.0	1.953	0.047	0.072	93%
180	3.0	1.956	0.044	0.068	93%
240	4.0	1.957	0.043	0.067	93%
300	5.0	1.958	0.042	0.065	93%
360	6.0	1.957	0.043	0.066	93%
420	7.0	1.959	0.041	0.064	94%
480	8.0	1.959	0.041	0.063	94%
600	10.0	1.961	0.039	0.060	94%
900	15.0	1.964	0.036	0.056	94%
1200	20.0	1.966	0.034	0.053	95%
1800	30.0	1.971	0.030	0.045	95%
2100	35.0	1.972	0.028	0.044	96%
2400	40.0	1.973	0.028	0.042	96%
2700	45.0	1.973	0.028	0.042	96%
3000	50.0	1.973	0.027	0.041	96%
3300	55.0	1.976	0.024	0.037	96%
3600	60.0	1.976	0.024	0.037	96%
4200	70.0	1.980	0.020	0.031	97%
4800	80.0	1.981	0.019	0.029	97%
5400	90.0	1.982	0.018	0.028	97%
6000	100.0	1.983	0.017	0.026	97%
6300	105.0	1.982	0.018	0.027	97%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.065		
t_1	5.000		
h_2	0.029		
t_2	80.000		
S	4.7E-03		
k	**4.4E-08**	**3.8E-03**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)

where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

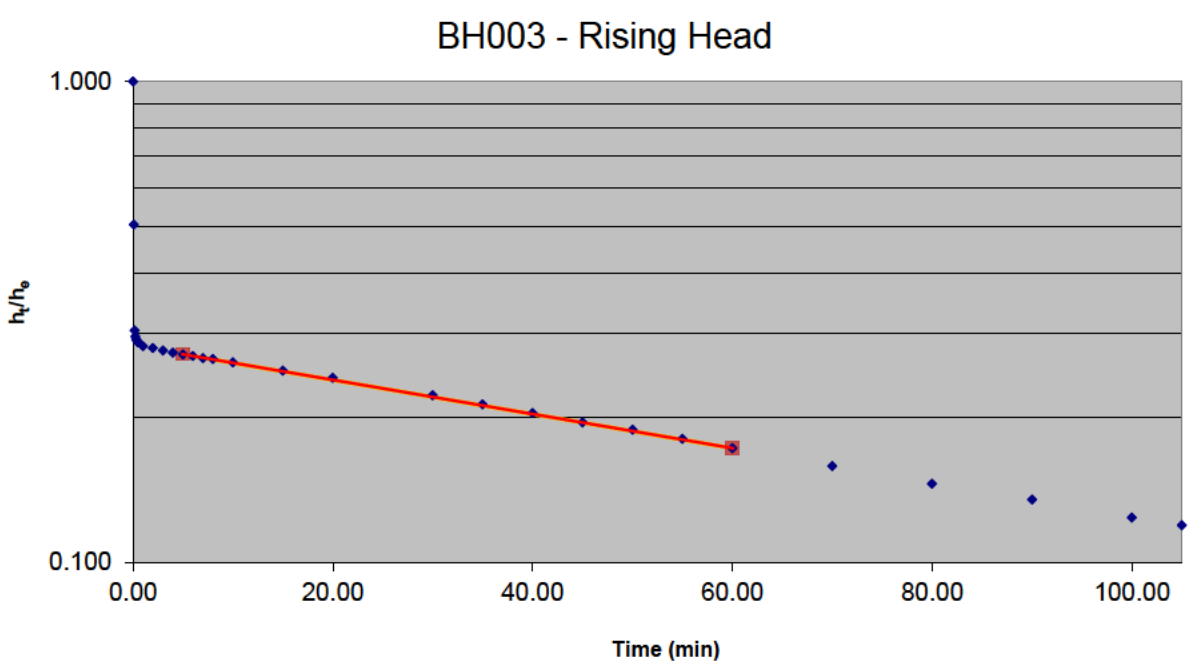
Notes:

Bore No:	BH003	Test No: #1	Job No: NWRT	Date: 1/07/25	Logged by: TZ

Borehole co-ordinates:	Easting:	1752601	Northing: 5918099	Collar elevation (m):	
Depth to top of test section (m):		2		Length of test section, **L** (m):	8.9
Depth of static water level, H_w (m):		2		Radius of borehole, **r** (m):	0.05
Excess head, h_e (m):		-1.12		Radius of standpipe or casing, r_c (m)	0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.0	3.125	-1.125	1.000	
5	0.1	2.567	-0.567	0.504	50%
10	0.2	2.342	-0.342	0.304	70%
15	0.3	2.332	-0.332	0.295	70%
20	0.3	2.328	-0.328	0.291	71%
25	0.4	2.325	-0.325	0.289	71%
30	0.5	2.323	-0.323	0.287	71%
60	1.0	2.317	-0.317	0.282	72%
120	2.0	2.314	-0.314	0.279	72%
180	3.0	2.310	-0.310	0.276	72%
240	4.0	2.307	-0.307	0.273	73%
300	5.0	2.304	-0.304	0.271	73%
360	6.0	2.302	-0.302	0.269	73%
420	7.0	2.299	-0.299	0.266	73%
480	8.0	2.298	-0.298	0.265	74%
600	10.0	2.294	-0.294	0.261	74%
900	15.0	2.282	-0.282	0.251	75%
1200	20.0	2.272	-0.272	0.242	76%
1800	30.0	2.251	-0.251	0.223	78%
2100	35.0	2.240	-0.240	0.213	79%
2400	40.0	2.230	-0.230	0.205	80%
2700	45.0	2.220	-0.220	0.196	80%
3000	50.0	2.213	-0.213	0.189	81%
3300	55.0	2.203	-0.203	0.181	82%
3600	60.0	2.194	-0.194	0.173	83%
4200	70.0	2.179	-0.179	0.159	84%
4800	80.0	2.164	-0.164	0.146	85%
5400	90.0	2.152	-0.152	0.135	86%
6000	100.0	2.140	-0.140	0.124	88%
6300	105.0	2.135	-0.135	0.120	88%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.271		
t_1	5.000		
h_2	0.173		
t_2	60.000		
S	3.5E-03		
k	**3.3E-08**	**2.9E-03**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)

where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

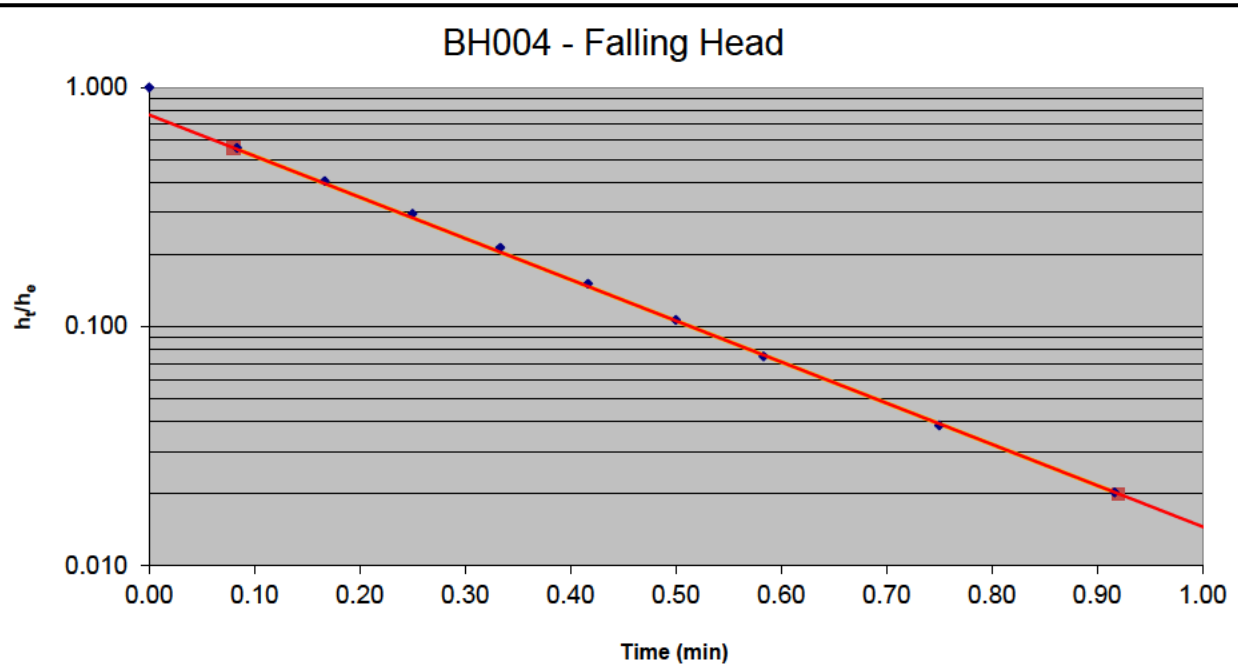
Notes:

Bore No:	BH004	Test No: #1	Job No: NWRT	Date: 9/07/25	Logged by: TZ

Borehole co-ordinates:	Easting: 1752456	Northing: 5918059	Collar elevation (m):
Depth to top of test section (m):	4.84		Length of test section, **L** (m): 8.1
Depth of static water level, H_w (m):	4.84		Radius of borehole, **r** (m): 0.05
Excess head, h_e (m):	0.68		Radius of standpipe or casing, r_c (m) 0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.0	4.163	0.677	1.000	
5	0.1	4.462	0.379	0.559	44%
10	0.2	4.565	0.275	0.406	59%
15	0.3	4.639	0.201	0.296	70%
20	0.3	4.695	0.145	0.214	79%
25	0.4	4.738	0.102	0.151	85%
30	0.5	4.768	0.072	0.107	89%
35	0.6	4.789	0.051	0.075	92%
45	0.8	4.814	0.026	0.039	96%
55	0.9	4.826	0.014	0.020	98%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.559		
t_1	0.080		
h_2	0.020		
t_2	0.920		
S	1.7E+00		
k	**1.8E-05**	**1.5E+00**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)
where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

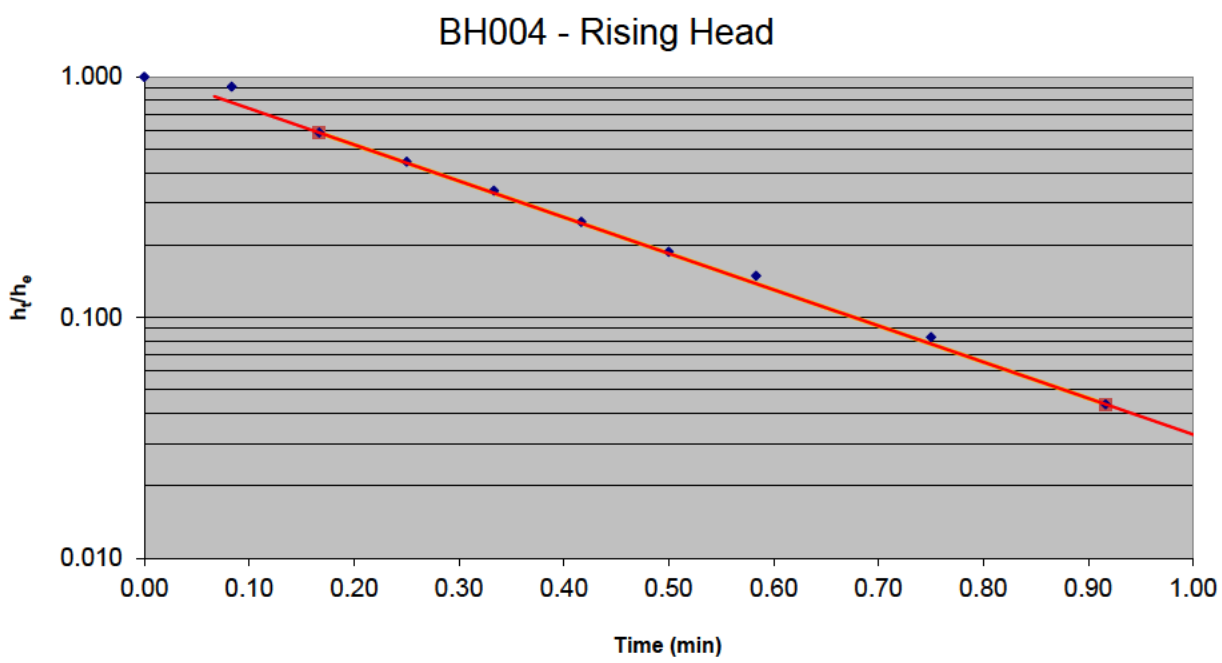
Notes:

Bore No:	BH004	Test No: #1	Job No: NWRT	Date: 9/07/25	Logged by: TZ

Borehole co-ordinates:	Easting: 1752456	Northing: 5918059	Collar elevation (m):
Depth to top of test section (m):	4.84		Length of test section, **L** (m): 8.1
Depth of static water level, H_w (m):	4.84		Radius of borehole, **r** (m): 0.05
Excess head, h_e (m):	-0.40		Radius of standpipe or casing, r_c (m) 0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	**0.0**	**5.242**	**-0.402**	**1.000**	
5	0.1	5.206	-0.366	0.911	9%
10	0.2	5.076	-0.236	0.587	41%
15	0.3	5.018	-0.178	0.444	56%
20	0.3	4.975	-0.135	0.336	66%
25	0.4	4.940	-0.100	0.250	75%
30	0.5	4.915	-0.075	0.188	81%
35	0.6	4.900	-0.060	0.149	85%
45	0.8	4.873	-0.033	0.083	92%
55	0.9	4.858	-0.018	0.044	96%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.587		
t_1	0.167		
h_2	0.044		
t_2	0.917		
S	1.5E+00		
k	**1.5E-05**	**1.3E+00**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)
where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

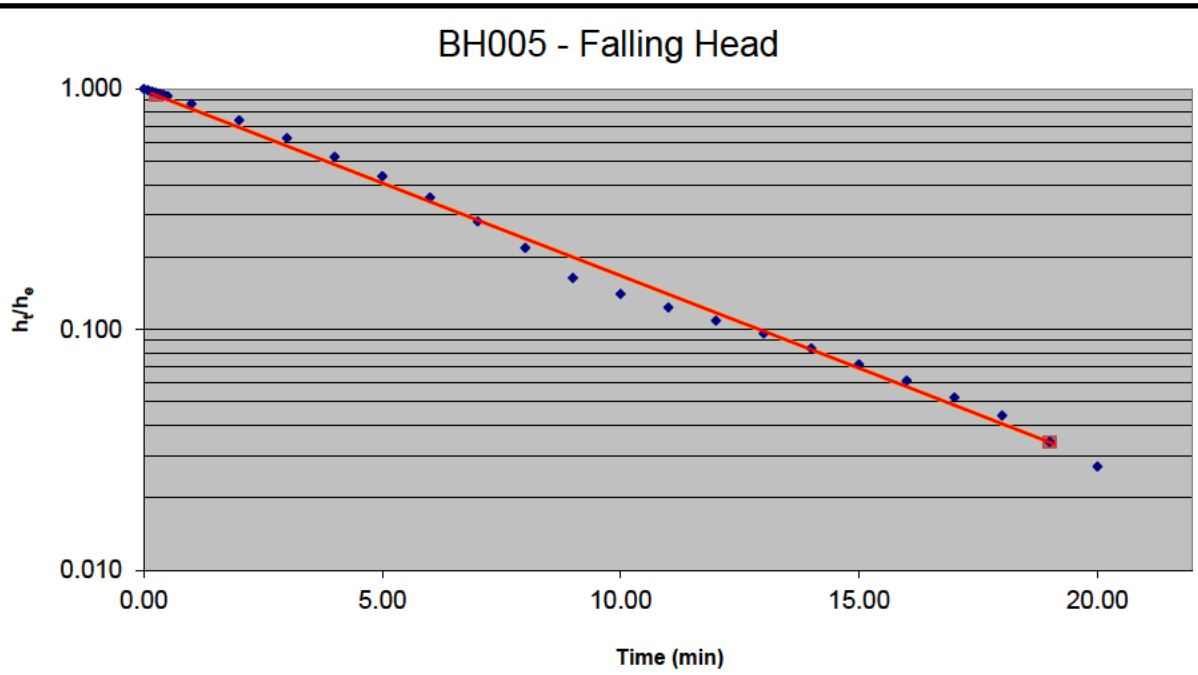
Notes:

Bore No:	BH005	Test No: #1	Job No: NWRT	Date: 16/07/25	Logged by: TZ

Borehole co-ordinates:	Easting: 1747345	Northing: 5919524	Collar elevation (m):
Depth to top of test section (m):	2		Length of test section, **L** (m): 11
Depth of static water level, H_w (m):	0.9		Radius of borehole, **r** (m): 0.05
Excess head, h_e (m):	0.38		Radius of standpipe or casing, r_c (m) 0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.0	0.522	0.378	1.000	
5	0.1	0.526	0.374	0.989	1%
10	0.2	0.531	0.369	0.976	2%
15	0.3	0.535	0.365	0.965	4%
20	0.3	0.540	0.360	0.953	5%
25	0.4	0.543	0.357	0.943	6%
30	0.5	0.547	0.353	0.933	7%
60	1.0	0.572	0.328	0.866	13%
120	2.0	0.620	0.280	0.741	26%
180	3.0	0.664	0.236	0.624	38%
240	4.0	0.703	0.197	0.522	48%
300	5.0	0.736	0.164	0.433	57%
360	6.0	0.766	0.134	0.354	65%
420	7.0	0.794	0.106	0.281	72%
480	8.0	0.817	0.083	0.219	78%
540	9.0	0.838	0.062	0.164	84%
600	10.0	0.847	0.053	0.141	86%
660	11.0	0.853	0.047	0.123	88%
720	12.0	0.859	0.041	0.109	89%
780	13.0	0.864	0.036	0.096	90%
840	14.0	0.868	0.032	0.084	92%
900	15.0	0.873	0.027	0.072	93%
960	16.0	0.877	0.023	0.061	94%
1020	17.0	0.880	0.020	0.052	95%
1080	18.0	0.883	0.017	0.044	96%
1140	19.0	0.887	0.013	0.034	97%
1200	20.0	0.890	0.010	0.027	97%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.943		
t_1	0.250		
h_2	0.034		
t_2	19.000		
S	7.7E-02		
k	**5.8E-07**	**5.0E-02**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)
where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

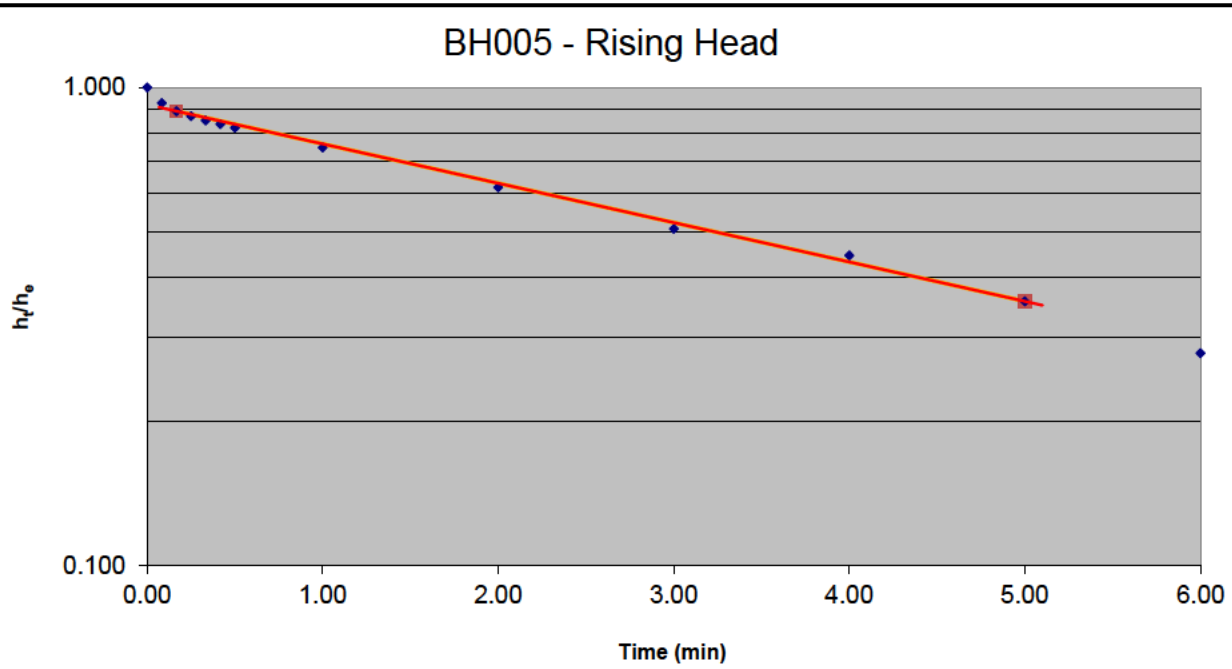
Notes:

Bore No:	BH005	Test No:	#1	Job No:	NWRT	Date:	4/07/25	Logged by:	TZ

Borehole co-ordinates:	Easting:	1747345	Northing:	5919524	Collar elevation (m):
Depth to top of test section (m):		2			Length of test section, **L** (m): 11
Depth of static water level, H_w (m):		0.9			Radius of borehole, **r** (m): 0.05
Excess head, h_e (m):		-0.33			Radius of standpipe or casing, r_c (m) 0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.0	1.230	-0.330	1.000	
5	0.1	1.206	-0.306	0.928	7%
10	0.2	1.194	-0.294	0.892	11%
15	0.3	1.187	-0.287	0.871	13%
20	0.3	1.182	-0.282	0.853	15%
25	0.4	1.177	-0.277	0.838	16%
30	0.5	1.172	-0.272	0.824	18%
60	1.0	1.147	-0.247	0.748	25%
120	2.0	1.104	-0.204	0.618	38%
180	3.0	1.067	-0.167	0.506	49%
240	4.0	1.047	-0.147	0.445	55%
300	5.0	1.018	-0.118	0.357	64%
360	6.0	0.992	-0.092	0.278	72%
420	7.0	0.968	-0.068	0.207	79%
480	8.0	0.948	-0.048	0.145	85%
540	9.0	0.930	-0.030	0.089	91%
600	10.0	0.913	-0.013	0.039	96%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.892		
t_1	0.167		
h_2	0.357		
t_2	5.000		
S	8.2E-02		
k	**6.2E-07**	**5.4E-02**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)
where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

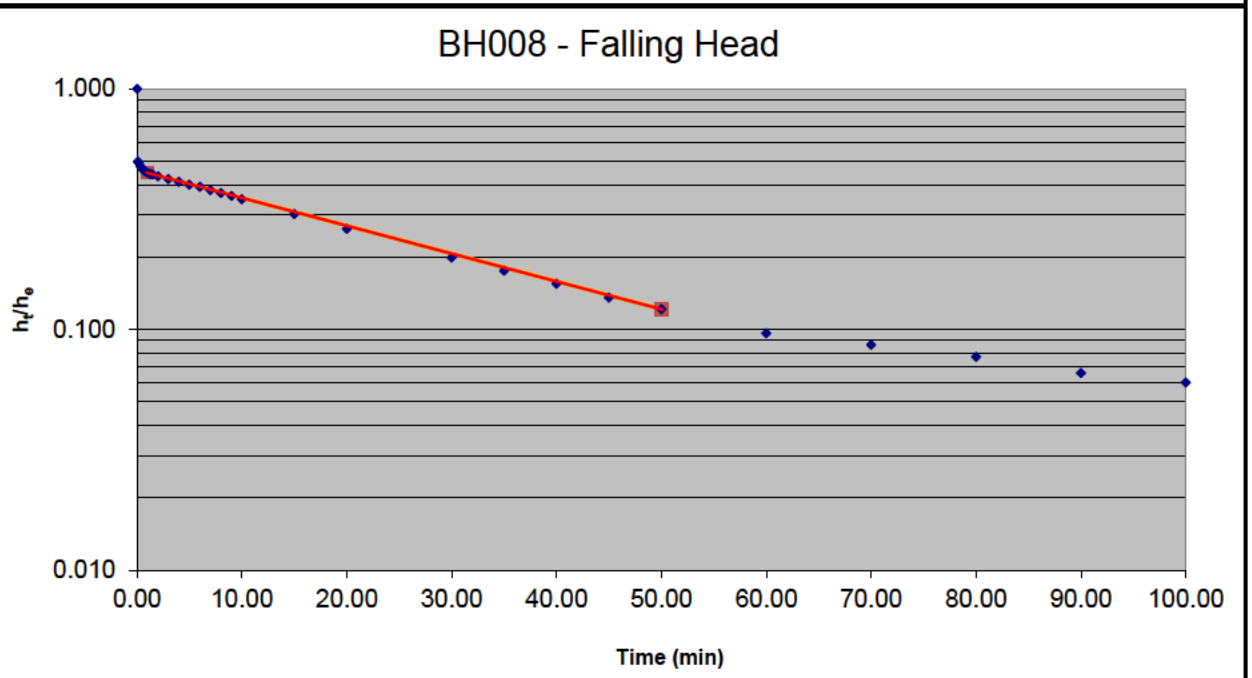
Notes:

Bore No:	BH008	Test No: #1	Job No: NWRT	Date: 7/08/25	Logged by: TZ

Borehole co-ordinates:	Easting:	1745443	Northing: 5920556	Collar elevation (m):	
Depth to top of test section (m):		2.8		Length of test section, L (m):	11.1
Depth of static water level, H_w (m):		2.25		Radius of borehole, r (m):	0.05
Excess head, h_e (m):		1.08		Radius of standpipe or casing, r_c (m)	0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.0	1.173	1.077	1.000	
5	0.1	1.713	0.538	0.499	50%
10	0.2	1.720	0.530	0.492	51%
20	0.3	1.737	0.513	0.477	52%
30	0.5	1.748	0.502	0.466	53%
45	0.8	1.760	0.490	0.455	55%
60	1.0	1.767	0.483	0.448	55%
75	1.3	1.773	0.477	0.443	56%
90	1.5	1.775	0.475	0.441	56%
120	2.0	1.783	0.467	0.433	57%
180	3.0	1.796	0.454	0.422	58%
240	4.0	1.808	0.442	0.411	59%
300	5.0	1.820	0.430	0.400	60%
360	6.0	1.828	0.422	0.392	61%
420	7.0	1.841	0.409	0.380	62%
480	8.0	1.853	0.397	0.369	63%
540	9.0	1.864	0.386	0.359	64%
600	10.0	1.875	0.375	0.348	65%
900	15.0	1.925	0.325	0.302	70%
1200	20.0	1.968	0.282	0.262	74%
1800	30.0	2.036	0.214	0.199	80%
2100	35.0	2.061	0.189	0.176	82%
2400	40.0	2.083	0.167	0.155	85%
2700	45.0	2.104	0.146	0.136	86%
3000	50.0	2.119	0.131	0.122	88%
3600	60.0	2.146	0.104	0.096	90%
4200	70.0	2.157	0.093	0.086	91%
4800	80.0	2.167	0.083	0.077	92%
5400	90.0	2.179	0.071	0.066	93%
6000	100.0	2.185	0.065	0.060	94%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.448			
t_1	1.000			
h_2	0.122			
t_2	50.000			
S	1.2E-02			
k	**8.7E-08**	**7.5E-03**		

Permeability, $k = 0.133 \times S \times (rc^2/L)$ (m/sec)/(m/day)

where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

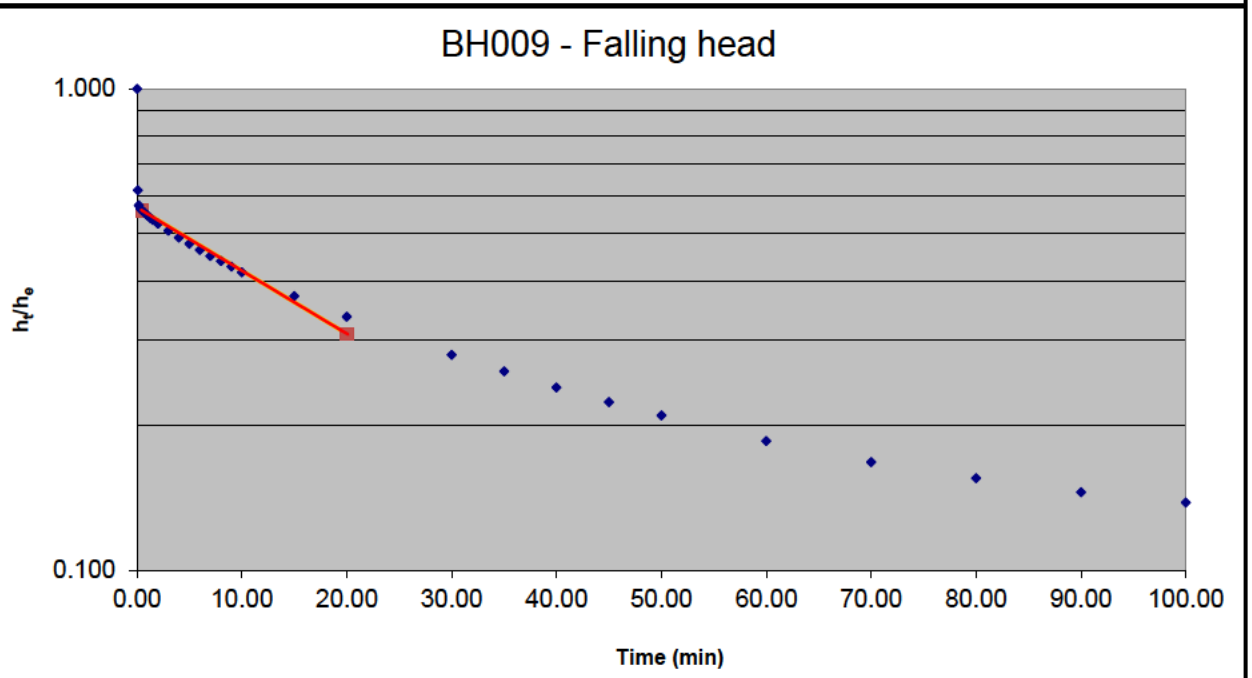
Notes:

Bore No:	BH009	Test No: #1	Job No: NWRT	Date: 7/08/25	Logged by: TZ

Borehole co-ordinates:	Easting:	1744919	Northing: 5921213	Collar elevation (m):	
Depth to top of test section (m):		3.19		Length of test section, L (m):	10.66
Depth of static water level, H_w (m):		3.19		Radius of borehole, r (m):	0.05
Excess head, h_e (m):		0.78		Radius of standpipe or casing, r_c (m)	0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	0.0	2.414	0.776	1.000	
5	0.1	2.712	0.478	0.616	38%
10	0.2	2.745	0.445	0.573	43%
20	0.3	2.752	0.438	0.564	44%
30	0.5	2.756	0.434	0.559	44%
45	0.8	2.762	0.429	0.552	45%
60	1.0	2.766	0.424	0.546	45%
75	1.3	2.771	0.419	0.540	46%
90	1.5	2.776	0.415	0.534	47%
120	2.0	2.783	0.407	0.525	48%
180	3.0	2.796	0.394	0.507	49%
240	4.0	2.809	0.381	0.491	51%
300	5.0	2.820	0.370	0.476	52%
360	6.0	2.831	0.359	0.463	54%
420	7.0	2.841	0.349	0.450	55%
480	8.0	2.849	0.341	0.439	56%
540	9.0	2.858	0.332	0.427	57%
600	10.0	2.867	0.323	0.416	58%
900	15.0	2.902	0.288	0.371	63%
1200	20.0	2.929	0.261	0.336	66%
1800	30.0	2.973	0.218	0.280	72%
2100	35.0	2.989	0.201	0.259	74%
2400	40.0	3.004	0.186	0.240	76%
2700	45.0	3.017	0.174	0.223	78%
3000	50.0	3.027	0.163	0.210	79%
3600	60.0	3.046	0.144	0.185	81%
4200	70.0	3.060	0.130	0.168	83%
4800	80.0	3.069	0.121	0.155	84%
5400	90.0	3.077	0.113	0.145	85%
6000	100.0	3.083	0.107	0.138	86%
6900	115.0	3.091	0.099	0.128	87%
7800	130.0	3.095	0.095	0.123	88%
8700	145.0	3.100	0.090	0.116	88%
9600	160.0	3.103	0.087	0.112	89%
10500	175.0	3.105	0.086	0.110	89%
11400	190.0	3.106	0.084	0.109	89%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.559		
t_1	0.500		
h_2	0.310		
t_2	20.000		
S	1.3E-02		
k	**1.0E-07**	**8.8E-03**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)

where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

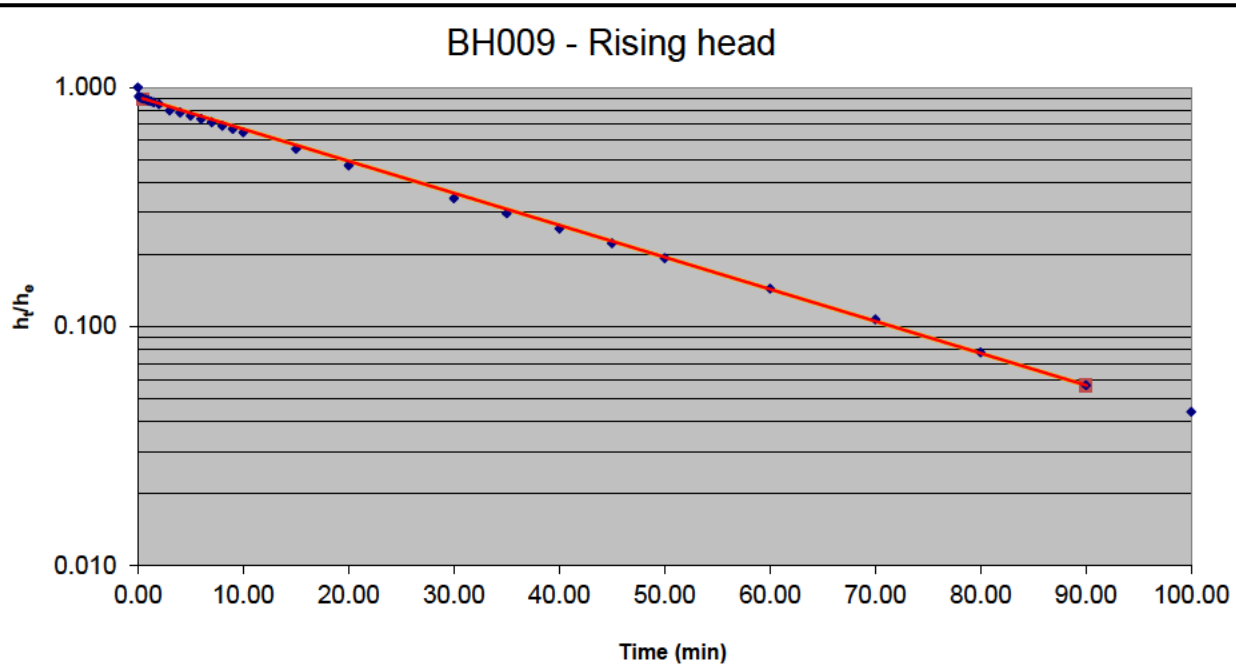
Notes:

Bore No:	BH009	Test No: #1	Job No: NWRT	Date: 7/08/25	Logged by: TZ

Borehole co-ordinates:	Easting: 1744919	Northing: 5921213	Collar elevation (m):
Depth to top of test section (m):	3.14		Length of test section, **L** (m): 10.66
Depth of static water level, H_w (m):	3.14		Radius of borehole, **r** (m): 0.05
Excess head, h_e (m):	-0.29		Radius of standpipe or casing, r_c (m) 0.025

Time (sec)	Time (min)	Depth to water, h_w (m)	Excess head, $h_t=H_w-h_w$ (m)	h_t/h_e	Recovery
0	**0.0**	**3.429**	**-0.289**	**1.000**	
5	0.1	3.405	-0.265	0.917	8%
10	0.2	3.402	-0.262	0.909	9%
20	0.3	3.401	-0.261	0.904	10%
30	0.5	3.399	-0.259	0.897	10%
45	0.8	3.397	-0.257	0.890	11%
60	1.0	3.395	-0.254	0.882	12%
75	1.3	3.392	-0.252	0.874	13%
90	1.5	3.390	-0.250	0.866	13%
120	2.0	3.386	-0.246	0.851	15%
180	3.0	3.371	-0.231	0.801	20%
240	4.0	3.367	-0.227	0.786	21%
300	5.0	3.360	-0.220	0.762	24%
360	6.0	3.353	-0.213	0.738	26%
420	7.0	3.346	-0.206	0.715	29%
480	8.0	3.340	-0.200	0.691	31%
540	9.0	3.334	-0.193	0.670	33%
600	10.0	3.327	-0.187	0.649	35%
900	15.0	3.300	-0.160	0.554	45%
1200	20.0	3.276	-0.136	0.472	53%
1800	30.0	3.239	-0.099	0.344	66%
2100	35.0	3.226	-0.086	0.298	70%
2400	40.0	3.214	-0.074	0.257	74%
2700	45.0	3.204	-0.064	0.223	78%
3000	50.0	3.196	-0.056	0.193	81%
3600	60.0	3.182	-0.042	0.144	86%
4200	70.0	3.171	-0.031	0.107	89%
4800	80.0	3.163	-0.022	0.078	92%
5400	90.0	3.156	-0.016	0.057	94%
6000	100.0	3.153	-0.013	0.044	96%

Head - time graph (slope of graph is S)



Calculations:

h_1	0.897		
t_1	0.500		
h_2	0.057		
t_2	90.000		
S	1.3E-02		
k	**1.0E-07**	**9.0E-03**	

Permeability, k = 0.133 x S x (rc^2/L) (m/sec)/(m/day)
where S = (log (h1/h2)/(t2 - t1), (ie slope of plot, t in mins)

Notes:

Appendix C. Groundwater quality

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

0508 HILL LAB (44 555 22)
+64 7 858 2000
mail@hill-labs.co.nz
www.hill-labs.co.nz

Certificate of Analysis

Client:	Mott MacDonald	**Lab No:**	3929344	SPv1
Contact:	Toby Zaege	**Date Received:**	02-Jul-2025	
	C/- Mott MacDonald	**Date Reported:**	08-Jul-2025	
	PO Box 37525	**Quote No:**	138803	
	Parnell	**Order No:**	70550122	
	Auckland 1151	**Client Reference:**		
		Submitted By:	Toby Zaege	

Sample Type: Aqueous

Sample Name:		NWRT - BH01 01-Jul-2025	NWRT - BH02 01-Jul-2025	NWRT - BH03 01-Jul-2025	NWRT - BH04 01-Jul-2025
Lab Number:		3929344.1	3929344.2	3929344.3	3929344.4
Individual Tests					
Sum of Anions	meq/L	3.2	5.1	1.64	1.77
Sum of Cations	meq/L	3.2	5.4	1.69	1.84
pH	pH Units	6.2	6.8	5.9	5.9
Total Alkalinity	g/m³ as $CaCO_3$	64	155	21	40
Carbonate	g/m³ at 25°C	< 1.0	< 1.0	< 1.0	< 1.0
Bicarbonate	g/m³ at 25°C	78	189	26	49
Free Carbon Dioxide	g/m³ at 25°C	75	46	52	102
Total Hardness	g/m³ as $CaCO_3$	102	200	23	28
Electrical Conductivity (EC)	mS/m	34.3	50.7	19.4	20.3
Total Dissolved Solids (TDS)	g/m³	250	360	126	124
Dissolved Aluminium	g/m³	< 0.003	< 0.003	0.041	0.042
Dissolved Calcium	g/m³	27	59	6.4	5.9
Dissolved Iron	g/m³	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved Magnesium	g/m³	8.5	13.6	1.74	3.1
Dissolved Manganese	g/m³	0.31	0.30	0.080	0.065
Dissolved Potassium	g/m³	2.0	2.4	1.15	1.44
Dissolved Sodium	g/m³	26	28	27	29
Chloride	g/m³	31	36	25	20
Total Nitrogen	g/m³	1.16	0.30	1.27	0.25
Total Ammoniacal-N	g/m³	0.014	0.023	< 0.010	< 0.010
Nitrite-N	g/m³	0.005	0.002	< 0.002	< 0.002
Nitrate-N	g/m³	1.00	< 0.002	1.06	0.049
Nitrate-N + Nitrite-N	g/m³	1.01	0.003	1.06	0.049
Total Kjeldahl Nitrogen (TKN)	g/m³	0.16	0.30	0.21	0.20
Total Phosphorus	g/m³	0.155	0.014	0.064	0.032
Sulphate	g/m³	47	47	21	19.0
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Dissolved Cadmium	g/m³	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Copper	g/m³	< 0.0005	< 0.0005	< 0.0005	0.0012
Dissolved Lead	g/m³	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Dissolved Nickel	g/m³	0.0032	< 0.0005	0.0012	0.0021
Dissolved Zinc	g/m³	0.0050	0.0019	0.0102	0.0058

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00005 - 0.0010 g/m^3	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E : Online Edition.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E : Online Edition.	0.05 meq/L	1-4
pH	pH meter. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-4
Carbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Free Carbon Dioxide	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B : Online Edition.	0.1 mS/m	1-4
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) : Online Edition.	10 g/m^3	1-4
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B : Online Edition.	-	1-4
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.003 g/m^3	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m^3	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-4
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3. In-house calculation.	0.05 g/m^3	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m^3	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m^3	1-4
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, automated phenol/hypochlorite colorimetry. APHA 4500-N_{org} D (modified): Online Edition.	0.10 g/m^3	1-4
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) : Online Edition.	0.002 g/m^3	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 03-Jul-2025 and 07-Jul-2025. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Kim Harrison MSc
Client Services Manager - Environmental

Appendix D. Groundwater level observations

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Hamilton 3240 New Zealand

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www.hill-labs.co.nz

Certificate of Analysis

Client:	Mott MacDonald	**Lab No:**	3929344	SPv1
Contact:	Toby Zaege	**Date Received:**	02-Jul-2025	
	C/- Mott MacDonald	**Date Reported:**	08-Jul-2025	
	PO Box 37525	**Quote No:**	138803	
	Parnell	**Order No:**	70550122	
	Auckland 1151	**Client Reference:**		
		Submitted By:	Toby Zaege	

Sample Type: Aqueous

Sample Name:		NWRT - BH01 01-Jul-2025	NWRT - BH02 01-Jul-2025	NWRT - BH03 01-Jul-2025	NWRT - BH04 01-Jul-2025
Lab Number:		3929344.1	3929344.2	3929344.3	3929344.4
Individual Tests					
Sum of Anions	meq/L	3.2	5.1	1.64	1.77
Sum of Cations	meq/L	3.2	5.4	1.69	1.84
pH	pH Units	6.2	6.8	5.9	5.9
Total Alkalinity	g/m³ as $CaCO_3$	64	155	21	40
Carbonate	g/m³ at 25°C	< 1.0	< 1.0	< 1.0	< 1.0
Bicarbonate	g/m³ at 25°C	78	189	26	49
Free Carbon Dioxide	g/m³ at 25°C	75	46	52	102
Total Hardness	g/m³ as $CaCO_3$	102	200	23	28
Electrical Conductivity (EC)	mS/m	34.3	50.7	19.4	20.3
Total Dissolved Solids (TDS)	g/m³	250	360	126	124
Dissolved Aluminium	g/m³	< 0.003	< 0.003	0.041	0.042
Dissolved Calcium	g/m³	27	59	6.4	5.9
Dissolved Iron	g/m³	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved Magnesium	g/m³	8.5	13.6	1.74	3.1
Dissolved Manganese	g/m³	0.31	0.30	0.080	0.065
Dissolved Potassium	g/m³	2.0	2.4	1.15	1.44
Dissolved Sodium	g/m³	26	28	27	29
Chloride	g/m³	31	36	25	20
Total Nitrogen	g/m³	1.16	0.30	1.27	0.25
Total Ammoniacal-N	g/m³	0.014	0.023	< 0.010	< 0.010
Nitrite-N	g/m³	0.005	0.002	< 0.002	< 0.002
Nitrate-N	g/m³	1.00	< 0.002	1.06	0.049
Nitrate-N + Nitrite-N	g/m³	1.01	0.003	1.06	0.049
Total Kjeldahl Nitrogen (TKN)	g/m³	0.16	0.30	0.21	0.20
Total Phosphorus	g/m³	0.155	0.014	0.064	0.032
Sulphate	g/m³	47	47	21	19.0
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Dissolved Cadmium	g/m³	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Copper	g/m³	< 0.0005	< 0.0005	< 0.0005	0.0012
Dissolved Lead	g/m³	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Dissolved Nickel	g/m³	0.0032	< 0.0005	0.0012	0.0021
Dissolved Zinc	g/m³	0.0050	0.0019	0.0102	0.0058

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00005 - 0.0010 g/m^3	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E : Online Edition.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E : Online Edition.	0.05 meq/L	1-4
pH	pH meter. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-4
Carbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Free Carbon Dioxide	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B : Online Edition.	0.1 mS/m	1-4
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) : Online Edition.	10 g/m^3	1-4
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B : Online Edition.	-	1-4
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.003 g/m^3	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m^3	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-4
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3. In-house calculation.	0.05 g/m^3	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m^3	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m^3	1-4
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, automated phenol/hypochlorite colorimetry. APHA 4500-N_{org} D (modified): Online Edition.	0.10 g/m^3	1-4
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) : Online Edition.	0.002 g/m^3	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 03-Jul-2025 and 07-Jul-2025. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Kim Harrison MSc
Client Services Manager - Environmental

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Hamilton 3240 New Zealand

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www.hill-labs.co.nz

Certificate of Analysis

Client:	Mott MacDonald	**Lab No:**	3943192	SPv1
Contact:	Toby Zaege	**Date Received:**	22-Jul-2025	
	C/- Mott MacDonald	**Date Reported:**	05-Aug-2025	
	PO Box 37525	**Quote No:**	138803	
	Parnell	**Order No:**		
	Auckland 1151	**Client Reference:**		
		Submitted By:	Toby Zaege	

Sample Type: Aqueous

		Sample Name:	BH05 21-Jul-2025 8:00 am	BH06 21-Jul-2025 8:30 am	BH08 21-Jul-2025 9:00 am	BH09 21-Jul-2025 9:30 am
		Lab Number:	3943192.1	3943192.2	3943192.3	3943192.4
Individual Tests						
Sum of Anions	meq/L		2.4	2.7	1.44	6.3
Sum of Cations	meq/L		2.4	2.8	1.65	6.5
pH	pH Units		5.9	6.1	5.5	5.1
Total Alkalinity	g/m³ as $CaCO_3$		46	84	14.4	23
Carbonate	g/m³ at 25°C		< 1.0	< 1.0	< 1.0	< 1.0
Bicarbonate	g/m³ at 25°C		56	102	17.6	28
Free Carbon Dioxide	g/m³ at 25°C		113	125	96	340
Total Hardness	g/m³ as $CaCO_3$		31	62	10.9	128
Electrical Conductivity (EC)	mS/m		25.8	28.2	18.1	66.7
Total Dissolved Solids (TDS)	g/m³		400	320	88	460
Dissolved Aluminium	g/m³		0.040	0.029	0.057	0.35
Dissolved Calcium	g/m³		9.1	18.2	1.74	24
Dissolved Iron	g/m³		0.06	< 0.02	3.6	39
Dissolved Magnesium	g/m³		2.0	3.9	1.60	16.8
Dissolved Manganese	g/m³		0.135	0.26	0.192	0.66
Dissolved Potassium	g/m³		0.80	2.1	1.65	3.6
Dissolved Sodium	g/m³		40	34	26	54
Chloride	g/m³		29	28	35	70
Total Nitrogen	g/m³		1.31	1.31	2.6	3.4
Total Ammoniacal-N	g/m³		< 0.010	0.052	1.37	0.57
Nitrite-N	g/m³		0.002	0.002	0.003	< 0.002
Nitrate-N	g/m³		0.079	0.008	< 0.002	< 0.002
Nitrate-N + Nitrite-N	g/m³		0.081	0.011	0.005	< 0.002
Total Kjeldahl Nitrogen (TKN)	g/m³		1.23	1.30	2.6	3.4
Total Phosphorus	g/m³		0.45	0.43	0.37	8.5
Sulphate	g/m³		30	12.0	7.9	185
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³		< 0.0010	< 0.0010	< 0.0010	0.0029
Dissolved Cadmium	g/m³		< 0.00005	< 0.00005	< 0.00005	0.00013
Dissolved Chromium	g/m³		< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Copper	g/m³		< 0.0005	0.0006	0.0046	0.0005
Dissolved Lead	g/m³		< 0.00010	< 0.00010	< 0.00010	0.00032
Dissolved Nickel	g/m³		0.0017	0.0023	0.0083	0.021
Dissolved Zinc	g/m³		0.0022	0.0082	0.0189	0.111

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00005 - 0.0010 g/m^3	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E : Online Edition.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E : Online Edition.	0.05 meq/L	1-4
pH	pH meter. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-4
Carbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Free Carbon Dioxide	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B : Online Edition.	0.1 mS/m	1-4
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) : Online Edition.	10 g/m^3	1-4
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B : Online Edition.	-	1-4
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.003 g/m^3	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m^3	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-4
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-4
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3. In-house calculation.	0.05 g/m^3	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m³	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m³	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	1-4
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, automated phenol/hypochlorite colorimetry. APHA 4500-N_{org} D (modified): Online Edition.	0.10 g/m³	1-4
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) : Online Edition.	0.002 g/m³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m³	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 23-Jul-2025 and 05-Aug-2025. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Kim Harrison MSc
Client Services Manager - Environmental

ID	Collar (m NZVD)	Reference	16/06/2025	25/06/2025	30/06/2025	14/07/2025	07/08/2025	19/08/2025	23/09/2025	6/10/2025
BH001	34.25	m bgl	6.78	6.22	5.42	5.40	5.84	5.64	5.84	5.76
		m NZVD	27.47	28.03	28.83	28.85	28.41	28.61	28.41	28.49
BH002	28	m bgl	6.28	6.44	6.50	6.10	6.34	6.21	6.22	6.14
		m NZVD	21.72	21.56	21.50	21.90	21.66	21.79	21.78	21.86
BH003	25	m bgl	3.44	2.48	2.15	1.64	1.89	1.60	1.77	1.82
		m NZVD	21.56	22.52	22.85	23.36	23.11	23.40	23.23	23.18
BH004	27.75	m bgl	-	-	4.19	5.04	5.31	5.19	5.57	5.42
		m NZVD	-	-	23.56	22.71	22.44	22.56	22.18	22.33
BH005	20.75	m bgl	-	-	-	0.90	1.17	1.02	1.20	1.10
		m NZVD	-	-	-	19.85	19.58	19.73	19.55	19.65
BH006	22.5	m bgl	-	-	-	4.84	4.86	4.77	5.07	5.11
		m NZVD	-	-	-	17.66	17.64	17.73	17.43	17.39
BH008	16.25	m bgl	-	-	-	2.10	2.25	2.21	2.50	2.21
		m NZVD	-	-	-	14.15	14.00	14.04	13.75	14.04
BH009	24.5	m bgl	-	-	-	3.84	3.19	3.36	3.45	3.38
		m NZVD	-	-	-	20.66	21.31	21.14	21.05	21.12
BH010	65	m bgl	-	-	-	-	dry	dry	dry	dry
		m NZVD	-	-	-	-	-	-	-	-
BH011	59	m bgl	-	-	-	dry	dry	dry	dry	dry
		m NZVD	-	-	-	-	-	-	-	-
BH012	39.3	m bgl	-	-	-	-	3.90	-	-	3.79
		m NZVD	-	-	-	-	35.40	-	-	35.51

Appendix E. Seepage calculations

Royal Station and Underpass

Linear unconfined flow into a trench (flow one side)

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
Chainage Start (m)	21800	21850	21900	21950	30000	30050
Average Invert elevation (m AHD)	56.2	56.8	56.6	55.7	54.5	54.3
Average WL elevation (m AHD)	57.2	60.5	62.9	63.2	61.6	58.7
Excavation below WT?	Yes	Yes	Yes	Yes	Yes	Yes
Inflow						
Hydraulic conductivity, K (m/s)	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07
Elevation of base of aquifer, z_{bot} (m AHD)	51.2	51.8	51.6	50.7	49.5	49.3
Distance to constant-head boundary, A (m)	4.67	12.36	20.50	23.82	22.68	14.50
Width of aquifer transverse to groundwater flow, L (m)	50.0	50.0	50.0	50.0	50.0	50.0
Head at the constant-head boundary, H (m AHD)	57.2	60.5	62.9	63.2	61.6	58.7
Head in the excavation, h_d (m AHD)	55.7	56.3	56.1	55.2	54.0	53.8
Specific Yield	0.1	0.1	0.1	0.1	0.1	0.1
K (m/d)	0.017	0.02	0.02	0.02	0.02	0.02
Required dd (m)	1.56	4.12	6.83	7.94	7.56	4.83
Radius of influence (m)	3.43	4.09	4.69	4.92	4.84	4.26
Results						
Calculated inflow, Q, (m3/s)	0.00002	0.00002	0.00003	0.00003	0.00003	0.00002
Calculated inflow, Q, (m3/d)	1.52	1.89	2.28	2.44	2.38	1.99
Total inflow (m3/day)	N/A	N/A	N/A	N/A	N/A	N/A
Cumulative inflow (m3)	N/A	0.00	0.00	0.00	0.00	0.00

C.Head Boundary factor

3 x required dd

0.042 m3/day/m

12.51 m3/day

4,565 m3/year

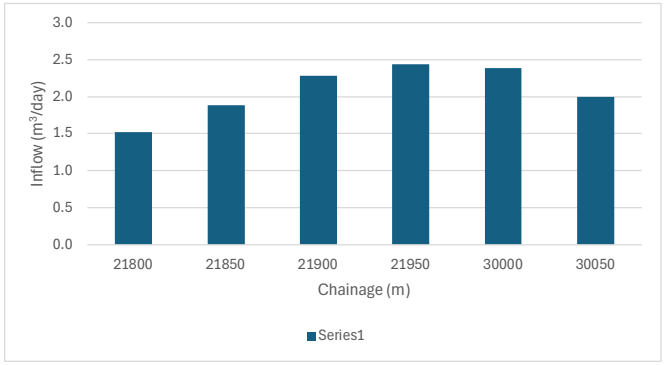
4.56 ML

Max inflow 2.4 m3/day

Average inflow 2.1 m3/day

Max R0 4.9 m

Average R0 4.4 m



Huruhuru Road Underpass

Linear unconfined flow into a trench (flow one side)

	Section 1	Section 2	Section 3
Chainage Start (m)	31550	31600	31650
Average Invert elevation (m AHD)	18.1	16.5	14.1
Average WL elevation (m AHD)	19.0	19.1	13.7
Excavation below WT?	Yes	Yes	Yes
Inflow			
Hydraulic conductivity, K (m/s)	2.00E-07	2.00E-07	2.00E-07
Elevation of base of aquifer, z_{bot} (m AHD)	13.1	11.5	9.1
Distance to constant-head boundary, A (m)	4.17	9.24	0.18
Width of aquifer transverse to groundwater flow, L (m)	50.0	50.0	50.0
Head at the constant-head boundary, H (m AHD)	19.0	19.1	13.7
Head in the excavation, h_d (m AHD)	17.6	16.0	13.6
Specific Yield	0.1	0.1	0.1
K (m/d)	0.017	0.02	0.02
Required dd (m)	1.39	3.08	0.06
Radius of influence (m)	3.38	3.84	2.98
Results			
Calculated inflow, Q, (m3/s)	0.00002	0.00002	0.00002
Calculated inflow, Q, (m3/d)	1.50	1.74	1.30
Total inflow (m3/day)	N/A	N/A	N/A
Cumulative inflow (m3)	N/A	0.00	0.00

C.Head Boundary factor

3 x required dd

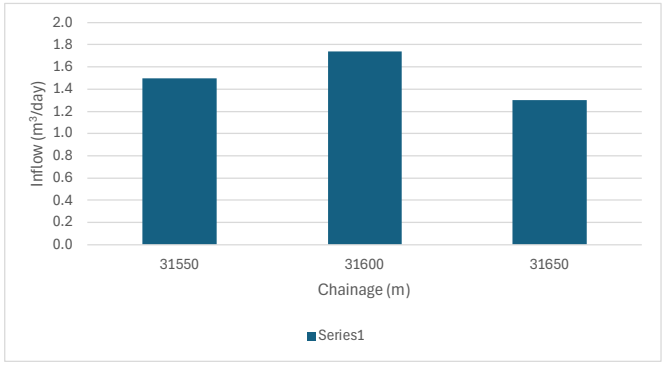
0.030 m3/day/m

4.54 m3/day

1,657 m3/year

1.66 ML

Max inflow	4.5	m3/day
Average inflow	2.3	m3/day
Max R0	3.8	m
Average R0	3.4	m



Lincoln Road Station

Linear unconfined flow into a trench (flow two sides)

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8
Chainage Start (m)	32150	32200	32250	32300	32350	32400	32450	32500
Average Invert elevation (m AHD)	10.7	11.1	10.7	9.5	9.0	8.7	8.7	9.0
Average WL elevation (m AHD)	12.7	14.5	14.5	14.8	15.1	14.5	13.9	11.8
Excavation below WT?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Inflow								
Hydraulic conductivity, K (m/s)	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07
Elevation of base of aquifer, z_{bot} (m AHD)	5.7	6.1	5.7	4.5	4.0	3.7	3.7	4.0
Distance to constant-head boundary, A (m)	7.32	11.67	12.94	17.65	19.89	19.10	17.05	9.73
Width of aquifer transverse to groundwater flow, L (m)	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Head at the constant-head boundary, H (m AHD)	12.7	14.5	14.5	14.8	15.1	14.5	13.9	11.8
Head in the excavation, h_d (m AHD)	10.2	10.6	10.2	9.0	8.5	8.2	8.2	8.5
Specific Yield	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
K (m/d)	0.017	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Required dd (m)	2.44	3.89	4.31	5.88	6.63	6.37	5.68	3.24
Radius of influence (m)	3.67	4.04	4.14	4.49	4.65	4.60	4.45	3.88
Results								
Calculated inflow, Q, (m3/s)	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00004
Calculated inflow, Q, (m3/d)	3.29	3.71	3.83	4.29	4.50	4.43	4.23	3.53
Total inflow (m3/day)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cumulative inflow (m3)	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00

C.Head Boundary factor

3 x required dd

0.080 m3/day/m

31.81 m3/day

11,610 m3/year

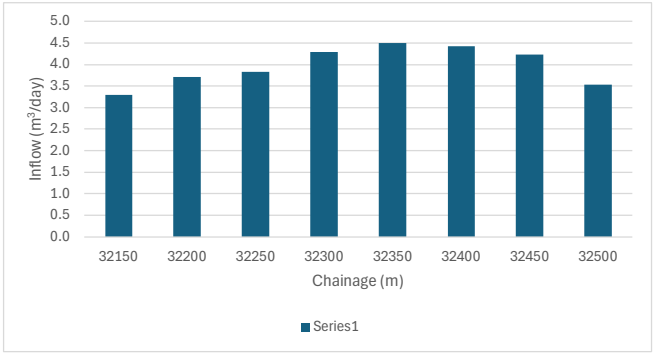
11.61 ML

Max inflow 4.5 m3/day

Average inflow 4.0 m3/day

Max R0 4.7 m

Average R0 4.3 m



Te Atatū Station

Linear unconfined flow into a trench (full flow one side, half flow one side)

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
Chainage Start (m)	42050	42100	42150	42200	42250	42300
Average Invert elevation (m AHD)	16.1	16.3	16.5	16.8	17.0	17.2
Average WL elevation (m AHD)	16.5	20.1	21.4	21.6	20.2	17.2
Excavation below WT?	Yes	Yes	Yes	Yes	Yes	Yes
Inflow						
Hydraulic conductivity, K (m/s)	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07
Elevation of base of aquifer, z_{bot} (m AHD)	11.1	11.3	11.5	11.8	12.0	12.2
Distance to constant-head boundary, A (m)	2.85	12.80	16.07	15.81	10.91	1.46
Width of aquifer transverse to groundwater flow, L (m)	50.0	50.0	50.0	50.0	50.0	50.0
Head at the constant-head boundary, H (m AHD)	16.5	20.1	21.4	21.6	20.2	17.2
Head in the excavation, h_d (m AHD)	15.6	15.8	16.0	16.3	16.5	16.7
Specific Yield	0.1	0.1	0.1	0.1	0.1	0.1
K (m/d)	0.017	0.02	0.02	0.02	0.02	0.02
Required dd (m)	0.95	4.27	5.36	5.27	3.64	0.48
Radius of influence (m)	3.25	4.13	4.38	4.36	3.98	3.11
Results						
Calculated inflow, Q, (m3/s)	0.00002	0.00003	0.00004	0.00004	0.00003	0.00002
Calculated inflow, Q, (m3/d)	2.15	2.87	3.10	3.08	2.73	2.05
Total inflow (m3/day)	N/A	N/A	N/A	N/A	N/A	N/A
Cumulative inflow (m3)	N/A	0.00	0.00	0.00	0.00	0.00

C.Head Boundary factor

3 x required dd

0.053 m3/day/m

15.98 m3/day

5,831 m3/year

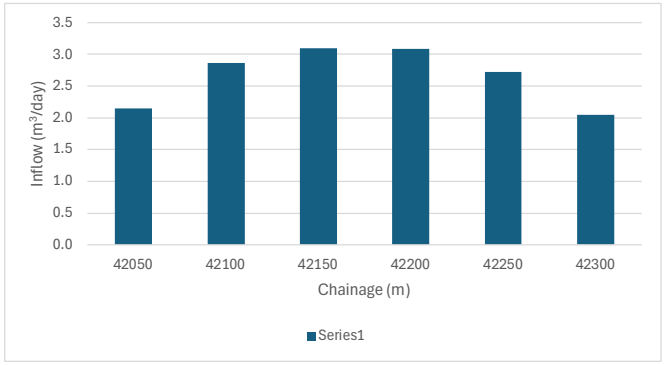
5.83 ML

Max inflow 3.1 m3/day

Average inflow 2.7 m3/day

Max R0 4.4 m

Average R0 3.9 m



Point Chevalier Station

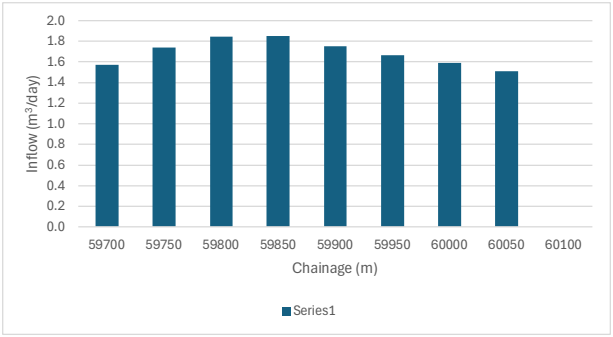
Linear unconfined flow into a trench (flow one side)

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9
Chainage Start (m)	59700	59750	59800	59850	59900	59950	60000	60050	60100
Average Invert elevation (m AHD)	21.2	21.4	21.6	21.6	21.2	20.8	20.2	19.8	19.2
Average WL elevation (m AHD)	22.6	23.9	24.9	25.0	23.9	22.9	21.8	20.8	18.6
Excavation below WT?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Inflow									
Hydraulic conductivity, K (m/s)	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07	2.00E-07
Elevation of base of aquifer, z_{bot} (m AHD)	16.2	16.4	16.6	16.6	16.2	15.8	15.2	14.8	14.2
Distance to constant-head boundary, A (m)	5.77	9.21	11.41	11.58	9.55	7.68	6.09	4.40	N/A
Width of aquifer transverse to groundwater flow, L (m)	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	20.0
Head at the constant-head boundary, H (m AHD)	22.6	23.9	24.9	25.0	23.9	22.9	21.8	20.8	18.6
Head in the excavation, h_d (m AHD)	20.7	20.9	21.1	21.1	20.7	20.3	19.7	19.3	18.7
Specific Yield	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
K (m/d)	0.017	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Required dd (m)	1.92	3.07	3.80	3.86	3.18	2.56	2.03	1.47	N/A
Radius of influence (m)	3.53	3.84	4.02	4.03	3.86	3.70	3.56	3.41	N/A
Results									
Calculated inflow, Q, (m3/s)	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	N/A
Calculated inflow, Q, (m3/d)	1.57	1.74	1.84	1.85	1.75	1.66	1.59	1.51	N/A
Total inflow (m3/day)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cumulative inflow (m3)	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

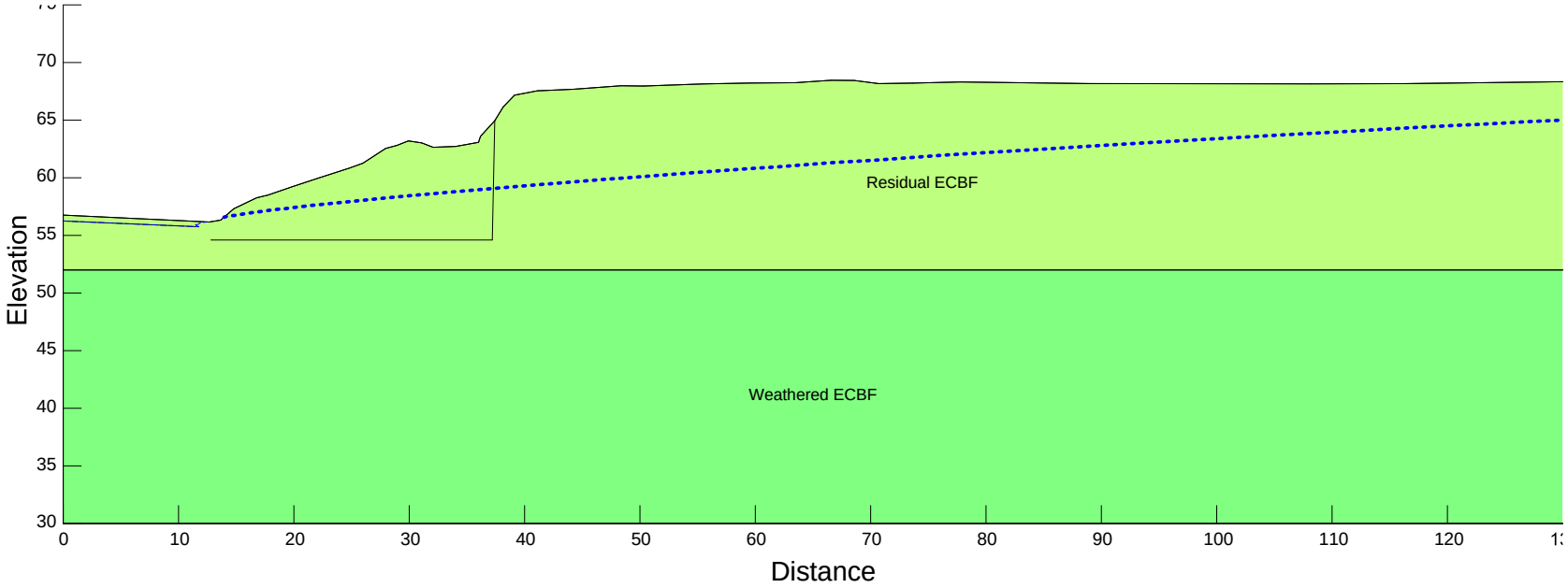
C.Head Boundary factor
3 x required dd

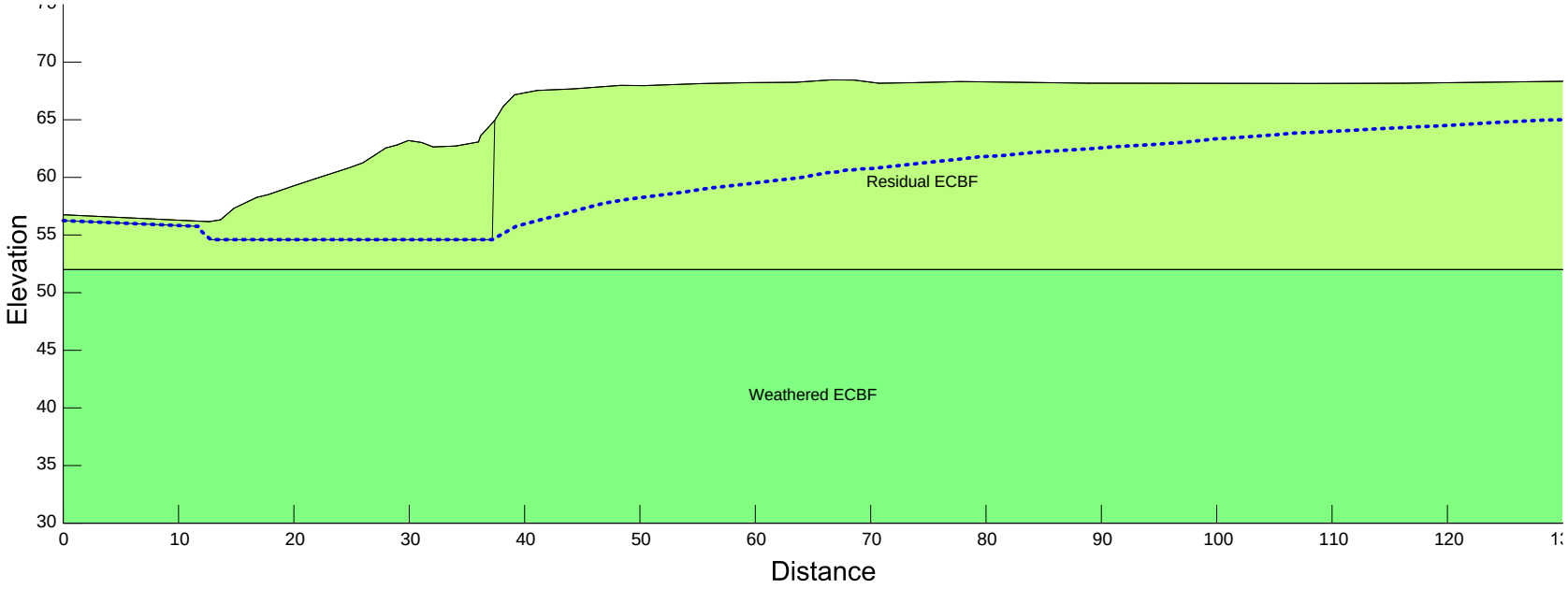
0.032 m3/day/m
13.52 m3/day
4,935 m3/year
4.94 ML

Max inflow	1.9	m3/day
Average inflow	1.7	m3/day
Max R0	4.0	m
Average R0	3.8	m

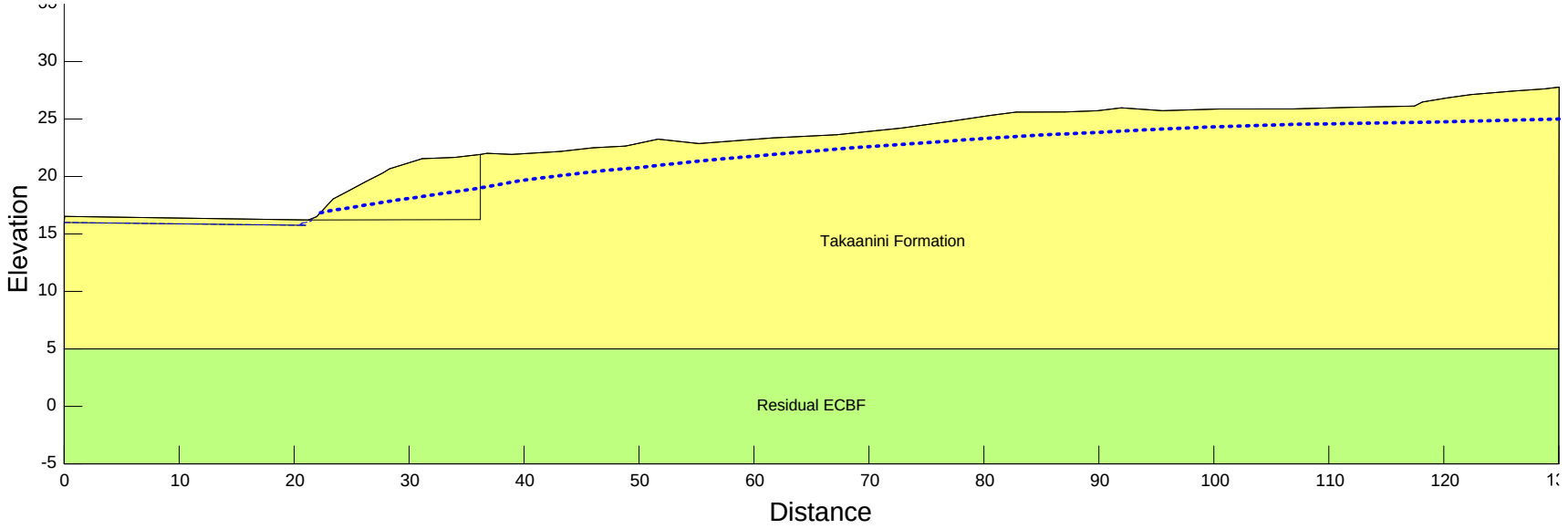


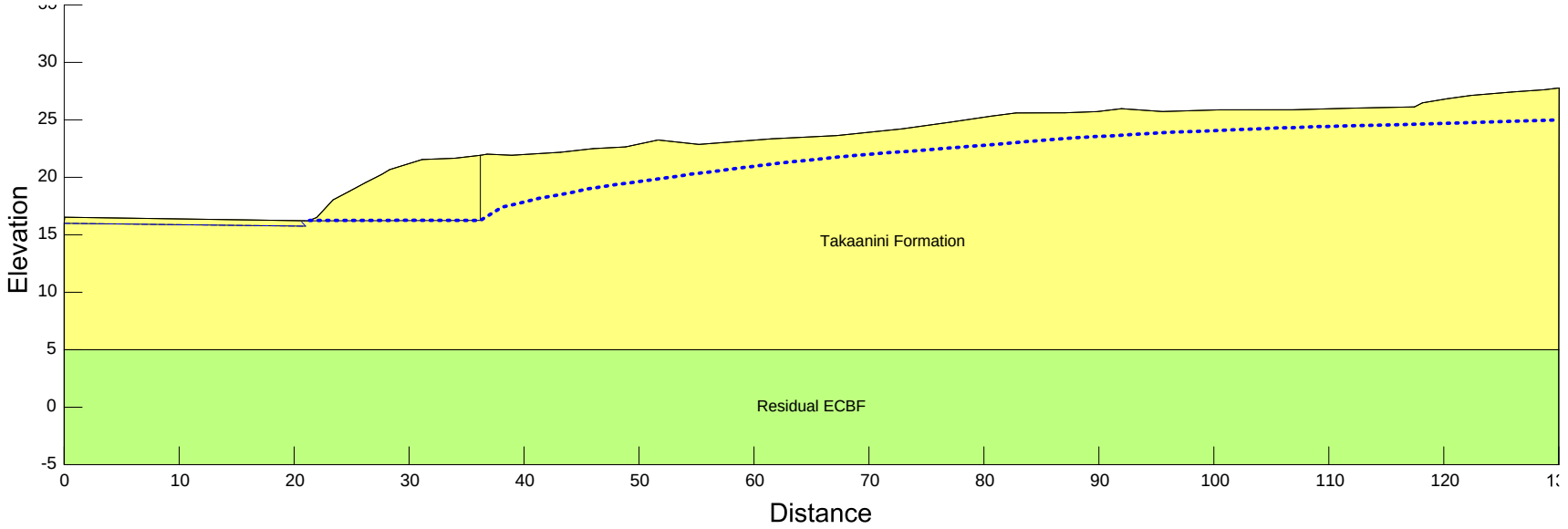
Appendix F. Seep/W Pore Pressure Profiles



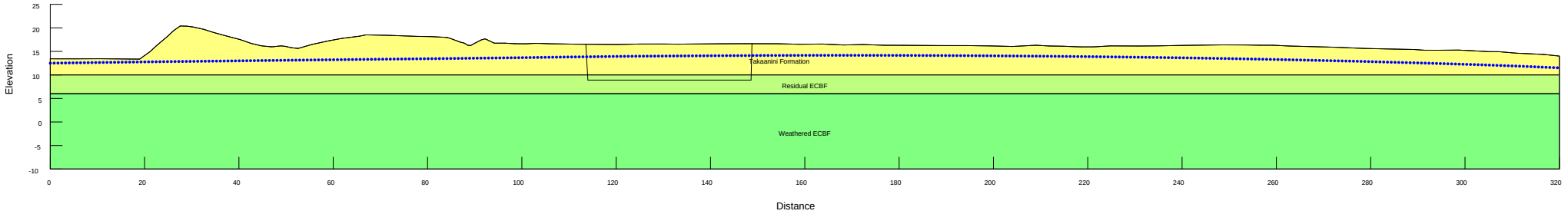


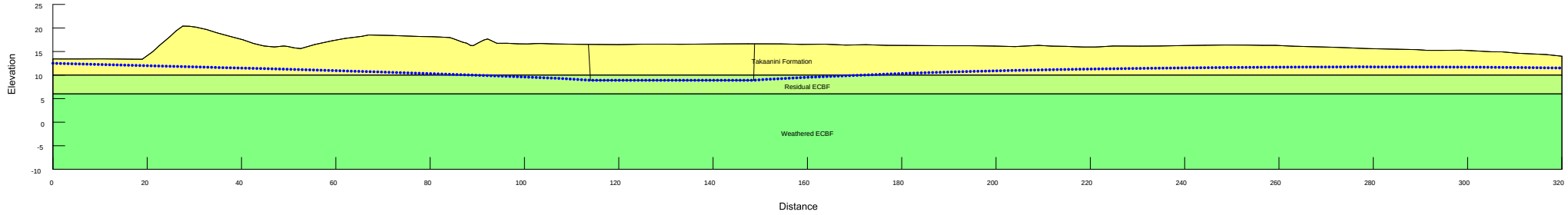
Royal Road Station - Chainage 21960



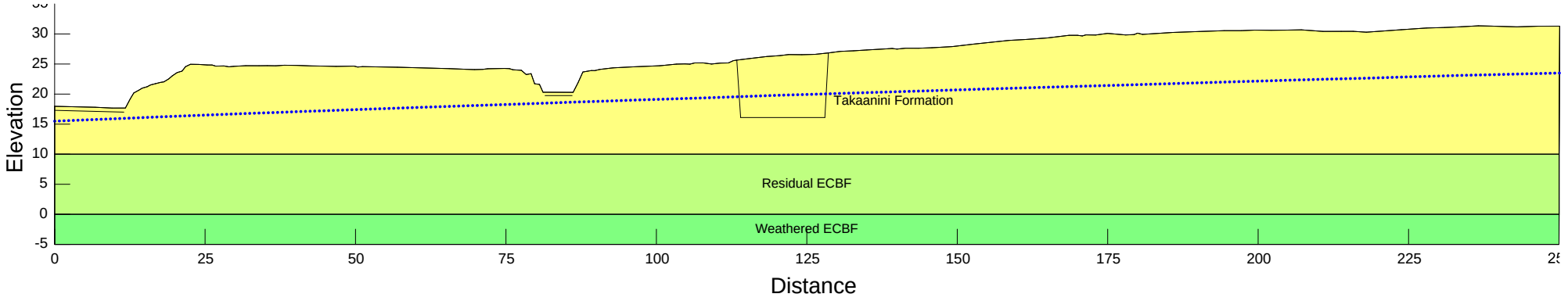


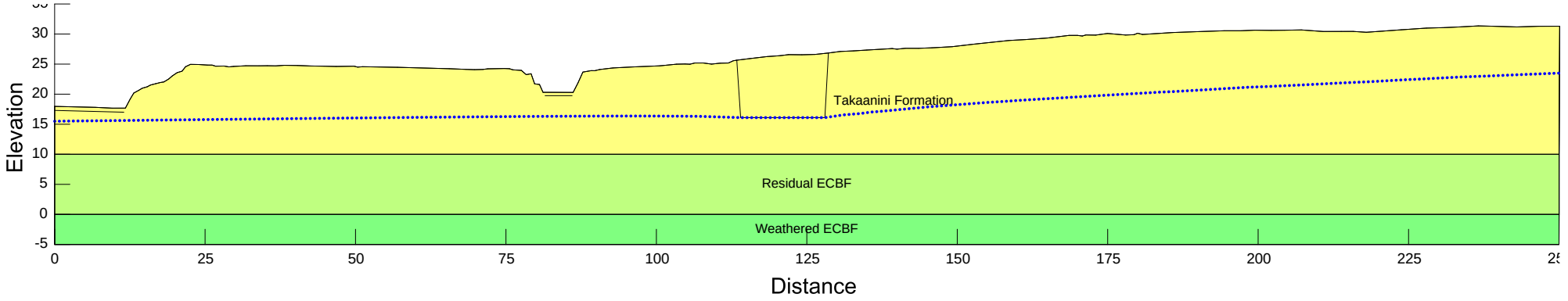
Huruhuru Road - Chainage 31600



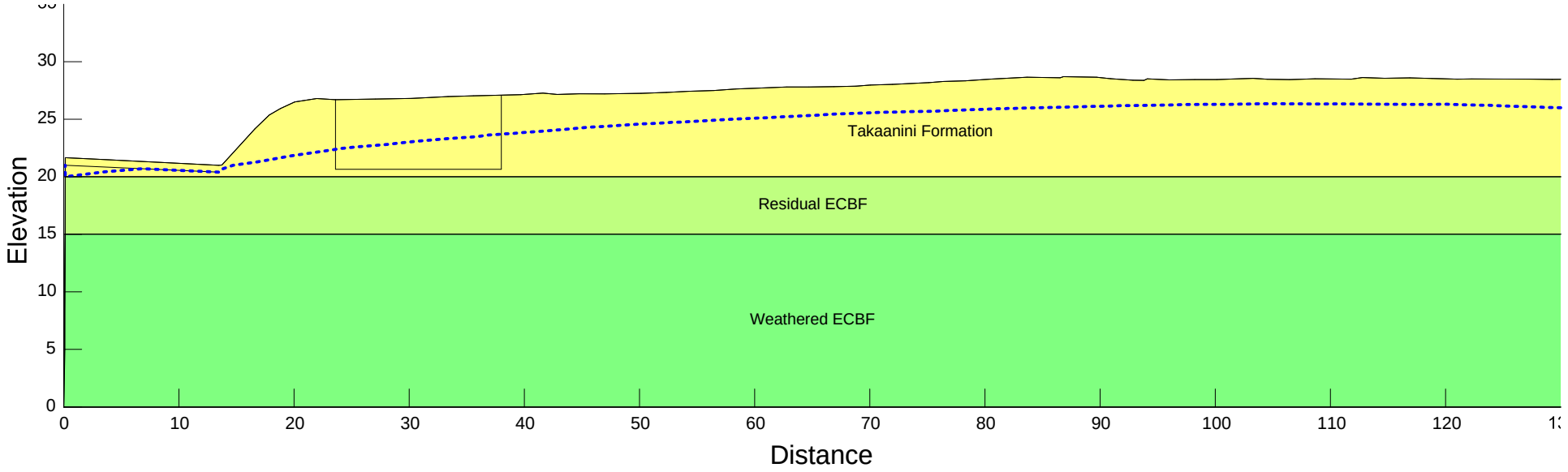


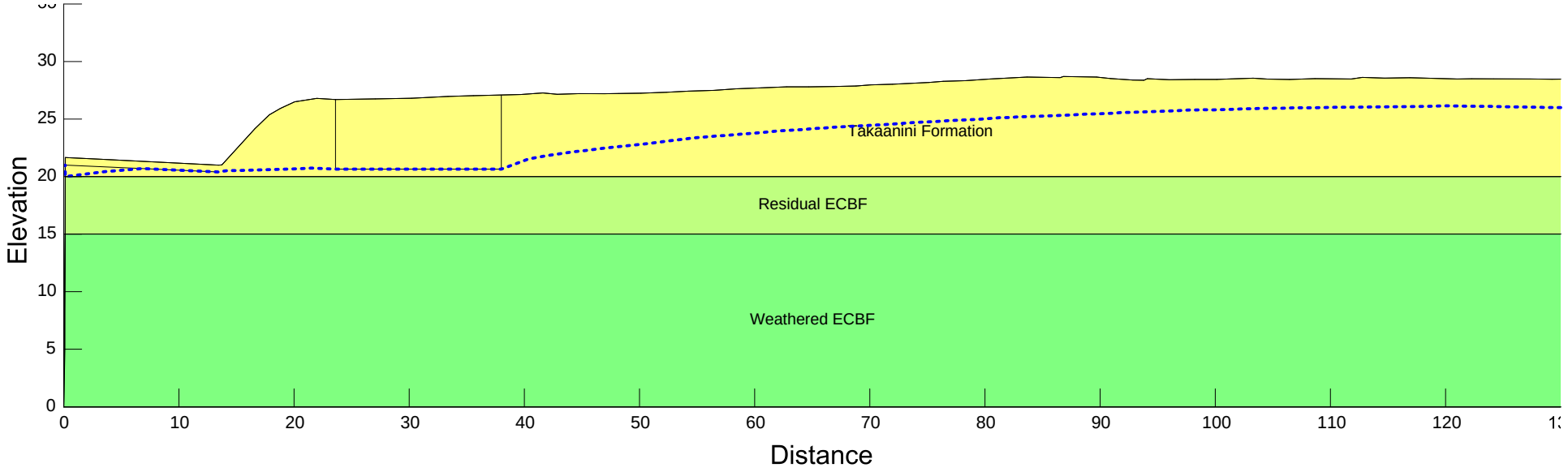
Lincoln Road Station - Chainage 32300





Te Atatū Station - Chainage 50100





Point Chevalier Station - Chainage 59940