

Project Number: 3-WW019.11

Waterloo WTP Ground Improvement Geotechnical Site Investigations Factual Report

17 May 2021

3-WW019.11



Contact Details

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[Redacted]

Document Details:

Date: April 2021

Reference: 2020/60 3-WW019.11

Status: Issue 1

Prepared by

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Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
1	28/04/2021	s7(2)(a)			Issue 1

Revision Details

Revision	Details
1	Factual Report – Rev 1.



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1 Introduction

Wellington Water have commissioned WSP to implement a ground improvement programme (design and construction), involving the use of resin injection for the Waterloo Water Treatment Plant (WTP).

To obtain information about the ground conditions, a series of intrusive and nonintrusive investigations have been undertaken at the plant. The scope of investigations includes; geophysical survey, boreholes, cone penetration tests (CPT's) and laboratory testing. These were completed to identify the geological and hydrogeological units underlying the site and to obtain soil parameters to inform design.

2 Site Description

The site is located at 44D Oxford Terrace, Lower Hutt (Figure 1). The surrounding topography is flat and lies at an elevation of approximately 6 m above mean sea level. The site is adjacent to Waterloo Railway Station to the south west and railway line to the south east.



Figure 1: Waterloo Water Treatment Plant site.

The main buildings that accommodate the reservoirs and aerators are 2 storeys, reinforced concrete structures, constructed in 1978. The ancillary structures, including the lime hopper building and mobile generator enclosure, are steel portal frames structures, which were constructed in 1986 and 2003 respectively. The ground surface of the outdoor area of the site is asphalt.

3 Regional geology

The site location is situated upon a roughly horizontal alluvial terrace. The site is about 6m above the level of the Hutt River, which flows past the site approximately 1.5 km to the north-west.

According to the 1:250,000 geological map 10 of the Wellington area (Begg & Johnston, 2000), the site is underlain by Holocene River Deposits and well sorted floodplain gravels (Q1a) (Figure 2). These gravels are made up of Taita Alluvium, Petone Marine Beds and Waiwhetu Artesian Gravel, Wilford Shell Bed, Waimea Glacial & Karoro Interglacial, Moera Basal Gravel, Nemona Glacial Gravels and older deposits. The total thickness of these units is expected to be in the order of 400 m (Boon et. al, 2011), varying throughout the Hutt Valley. The underlying basement rock is Wellington Greywacke.



Figure 2: Geological Map (GNS, 2020)

The Waterloo Water Treatment Plant is within the Lower Hutt Groundwater Zone (LHGZ) and within the aquifer which is used for the public water supply.

The Wellington region lies near the Hikurangi Trough, an area characterised by a high level of seismicity. The region has several major, active faults associated with the active plate boundary between the Pacific and Australian plates (Begg and Johnson, 2000). These structures can generate large earthquakes of magnitude 7.0+, and together represent earthquake sources that contribute significantly to the seismic hazard in the Wellington region. The active faults are summarised in Table 1: Summary of faults in the Wellington Region.

Table 1: Summary of faults in the Wellington Region.

Fault Name	Distance from Site (km)	Direction from site	Expected Magnitude	Recurrence Interval (years)
Wellington Fault	1.5	NW	7.5	840
Moonshine Fault	8	W	7.1	2,000
Wairarapa Fault	12	E	8.2	1,200
Ohariu Fault	12	W	7.5	2,500

4 Site Investigations

Site investigation plans showing test locations are presented in Appendix A.

4.1 Geophysical Survey

Geophysical survey using the Multi-Channel Analysis of Surface Waves (MASW) technique was carried out by Southern Geophysical Limited on 13th November 2019. Shear wave velocity profiles were measured to over 30m depth across the site for a total of 215m surveyed line length, along 5No. of MASW survey lines (Table 2)

The report presenting results of the geophysical survey is included in Appendix B.

Table 2: Summary of MASW lines

Line	Length	Location
01	94m	South west to north east transect across the carpark at the Oxford Tce side of the plant
02	7m	South east to north west transect in the north eastern area of the carpark.
03	18m	South east to north west from the north eastern footprint of the building to the carpark entrance
04	81m	South west to north east transect on the train track side of the plant
05	12m	South west to north east transect across the north eastern area of the carpark.

4.2 Investigation Boreholes

Griffiths Drilling Ltd were commissioned to undertake borehole investigations across the site. A Fraste XL Duo Sonic drilling rig was provided, which is capable of sonic core drilling and standard penetration tests. The rig was mobilised onto the site to complete BH103 & 104 on 3 September 2020 and demobilised on 9 September. It was mobilised a second time to complete BH101 & 102 on the 30 September 2020 and demobilised on 2nd October. All drilling was supervised, and the cored soil samples logged by a WSP engineering geologist.

The objectives of the drilling were to:

- Evaluate the nature and thickness of soils;
- Carry out Standard Penetration Tests at 1.0 m intervals through soil materials;
- Determine aquitard characteristics;
- Install standpipe piezometers in 3No. selected holes to measure static groundwater levels.

Piezometer installations are discussed in section 4.7.

Full borehole logs are presented in Appendix C and a summary of borehole data is presented in Table 3.

Table 3: Summary of boreholes undertaken in the 2020 site investigations.

BH ID	Total Depth (m)	Vacuum Excavation (m)	Surface RL (m) (Wellington 1953)	Taita Alluvium Depth Interval (m bgl)	Petone Marine Beds Depth Interval	Waiwhetu Gravel Depth Interval
BH101	13.0	1.5	6.69	2.65 – 8.65	8.65 – 11.0	11.0 - EOH
BH102	15.0	1.5	6.68	1.5 – 6.3	6.3 – 14.3	14.3 - EOH
BH103	20.0	1.5	6.71	1.5 – 7.8	7.8 – 12.95	12.95 - EOH
BH104	21.3	2.5	6.55	3.0 – 8.2	8.2 – 10.4	10.4 - EOH

4.3 Previous Borehole Data from Investigations

Previous geotechnical investigations were carried out on the site in 2016 and 1977 respectively. These include:

- 3No. of boreholes undertaken by Griffiths Drilling Ltd. under the direction of Opus.
- 8No. of boreholes undertaken by Morrison, Cooper & Partners in 1977

All historical boreholes are summarised in Table 4 and presented in Appendix C (Sourced from Opus, 2016).

Table 4: Summary of historical boreholes undertaken at the site.

BH ID	Total Depth (m)	Consultant	Contractor
Boring 1	11.0	Morrison, Cooper & Partners	Unknown
Boring 2	15.0	Morrison, Cooper & Partners	
Boring 3	11.0	Morrison, Cooper & Partners	
Boring 4	13.0	Morrison, Cooper & Partners	
Boring 5	5.0	Morrison, Cooper & Partners	
Boring 6	5.0	Morrison, Cooper & Partners	
Boring 7	5.0	Morrison, Cooper & Partners	
Boring 8	5.0	Morrison, Cooper & Partners	
BH1	11.95	Opus	Griffiths
BH2	7.95	Opus	Griffiths
BH3	12.45	Opus	Griffiths

4.4 Cone Penetration Tests (CPT's)

Griffiths Drilling Ltd were contracted to undertake 8No. CPT investigations at the site. Two of these investigations were subcontracted to Ground Investigation as they were located inside the water treatment plant. All CPT's, except the two interior CPT's were vacuum excavated to 1.5m.

All CPT holes were backfilled with gravel. The rigs were mobilised to site on 14 September 2020 and carried out 8No. tests, with all work completed on 6 October.

CPT results are presented in Appendix D and summary data are presented in Table 5.

Table 5: Summary of CPT's undertaken in the 2020 investigations.

CPT ID	Total Depth (m)	Surface RL (m)	Contractor	Reason for termination
CPT101	8.41	6.57	Griffiths	Target depth reached
CPT102	7.54	6.59	Griffiths	Refusal
CPT103	8.99	6.69	Griffiths	Refusal
CPT104	7.69	6.68	Griffiths	Refusal
CPT105	9.86	6.7	Griffiths	Refusal
CPT106	9.84	6.67	Griffiths	Refusal
CPT107	8.1	6.97	Ground Investigation	Refusal
CPT109	5.09	4.3	Ground Investigation	Refusal

4.5 Previous CPT's

CPT's were carried out by Griffiths Drilling under the direction of Opus.

- 5No. of CPT's undertaken by Opus International Consultants in 2016 using Griffiths Drilling Ltd.

These CPT results are summarised in Table 6 and presented in Appendix D (Opus, 2016).

Table 6: Summary of historical CPT's undertaken at the site.

CPT ID	Total Depth (m)	Consultant	Contractor
CPT4	7.08	Opus	Griffiths
CPT5	11.98		
CPT6	12.12		
CPT7	7.96		
CPT9	7.26		

4.6 Laboratory Testing

Cored soil samples have been taken from BH101, 103 and 104 for Atterberg Limit Tests and Particle Size Analysis.

At BH101 & 102 undisturbed samples were retrieved using the Dames & Moore (D&M) method for cyclic triaxial testing. Cyclic triaxial testing is done to assess the liquefaction susceptibility of a silt/clay layer, which are present at approx. 3m – 6m bgl.

Twelve tubes of samples were collected and transported to University of Auckland for testing. Three cyclic triaxial tests were conducted on three specimens, from sample tubes 101_3-3.45 and 101_3.65-4.1. Sample tubes 102_3.05-3.5 and 102_3.7-4.15 were used for monotonic triaxial, direct shear and shear vane tests at WSP Hamilton laboratory.

Following all of the cyclic triaxial tests a monotonic undrained triaxial compression test without reconsolidation was undertaken.

The cyclic triaxial tests were conducted until one of the following conditions is met:

- Excess pore water pressure becomes equal to confining pressure (i.e. $R_u = 1.0$); or
- Double amplitude axial strain of 5% is achieved; or
- 100 load cycles.

Except the fourth cyclic triaxial test which was loaded for 20 cycles before the undrained monotonic triaxial test without reconsolidation was conducted. This was done to understand residual strength following dynamic loading but without triggering cyclic softening. The water content of the tested samples was measured.

A summary of samples and laboratory testing is given in Table 7. Results are presented in Appendix E.

Table 7: Summary of samples and laboratory testing undertaken in the 2020 investigations.

Sample ID	BH	Depth of sample retrieved	Sample Type	Type of test
101_3-3.45	BH101	3-3.45m	D&M push tube	Cyclic triaxial, 2x Atterberg PI, 2x PSD with hydrometer
101_3.65-4.1	BH101	3.65-4.1m	D&M push tube	Cyclic triaxial, 2x Atterberg PI, 2x PSD with hydrometer
101_4.3-4.75	BH101	4.3-4.75m	D&M push tube	No planned testing
101_4.95-5.4	BH101	4.95-5.4m	D&M push tube	No planned testing
101_5.6-6.05	BH101	5.6-6.05m	D&M push tube	No planned testing
101_6.25-6.7	BH101	6.25-6.7m	D&M push tube	No planned testing
102_2.4-2.85	BH102	2.4-2.85m	D&M push tube	No planned testing
102_3.05-3.5	BH102	3.05-3.5m	D&M push tube	Triaxial consolidated undrained 3 stage, Atterberg PI, PSD with hydrometer, direct shear (3 stage)
102_3.7-4.15	BH102	3.7-4.15m	D&M push tube	Handheld shear vane in tube
102_4.35-4.8	BH102	4.35-4.8m	D&M push tube	No planned testing
102_5-5.45	BH102	5-5.45m	D&M push tube	No planned testing
102_5.65-6.1	BH102	5.65-6.1m	D&M push tube	No planned testing
101_7.5-8	BH101	7.5-8m	Sonic core	PSD
103_4.5-5	BH103	4.5m-5m	Sonic core	Atterberg PI, PSD
103_8.6-9	BH103	8.6m-9m	Sonic core	PSD
104_3.5-4	BH104	3.5m-4m	Sonic core	PSD
104_5.5-6	BH104	5.5m-6m	Sonic core	PSD
104_8.5-9	BH104	8.5m-9m	Sonic core	PSD

4.7 Groundwater Levels

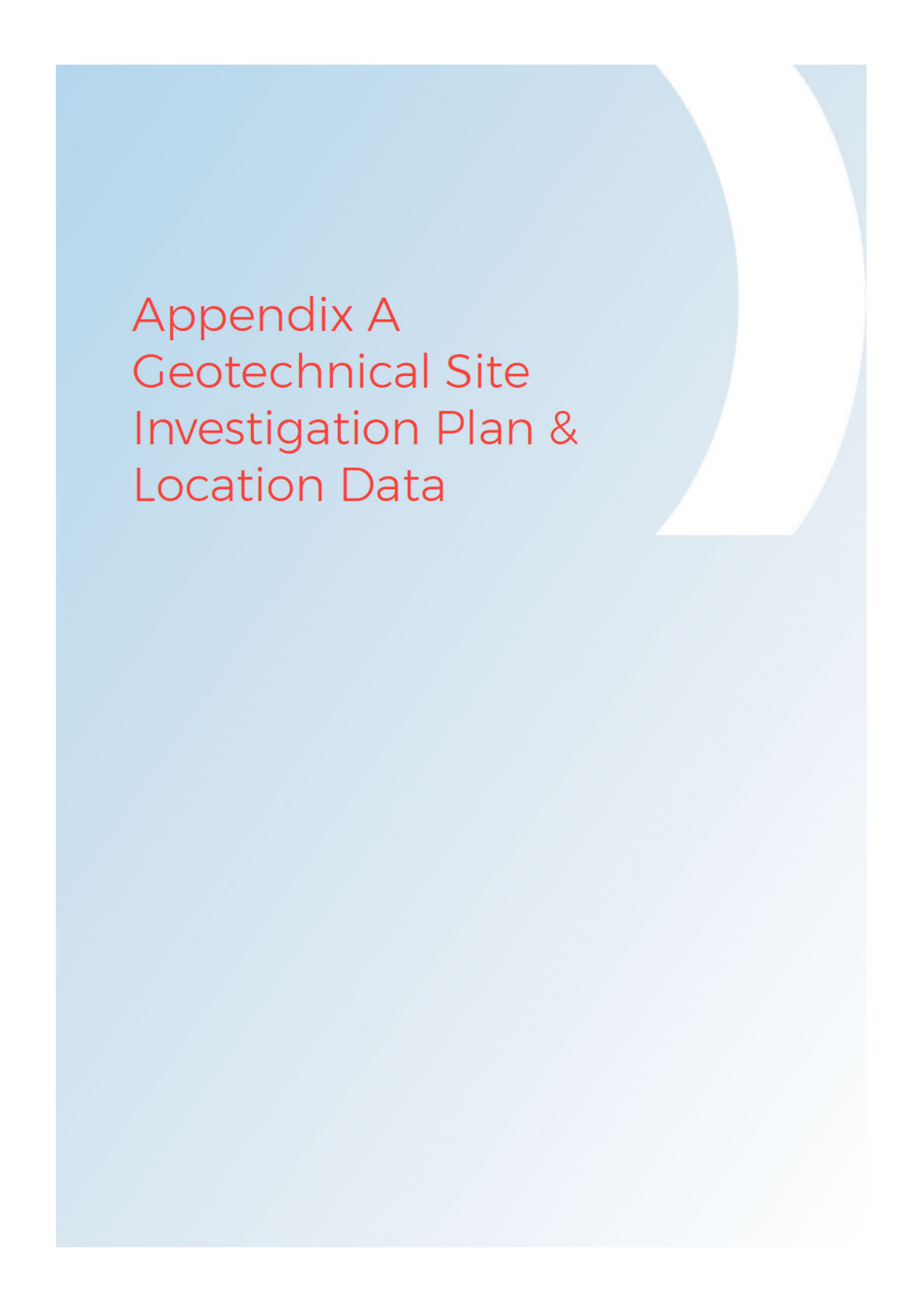
Piezometers were installed in BH101, 102 and 104, while a piezometer was installed in BH3 in 2016 investigations by Opus. Groundwater table readings were measured between September 2020 and March 2021. The measured groundwater levels and piezometer details are summarised in Table 8.

Table 8: Summary of piezometers at the site.

BH ID	Total Depth (m)	Screened Depth RL (m)	Water level reading RL (m)	Date of Water Level Reading
BH101	13.0	-5.81 to -4.81	4.74	9/10/2020
			3.64	23/02/2021
BH102	15.0	1.68 to 4.68	5.38	9/10/2020
			4.98	23/02/2021
			4.98	15/03/2021
BH104	21.3	-1.45 to 2.55	4.45	9/09/2020
			4.62	16/09/2020
			4.95	30/09/2020
			4.73	9/10/2020
			3.75	23/02/2021
			3.85	15/03/2021
BH3 (Historical)	12.45	-5.30 to -1.30	4.10	4/09/2020
			4.40	9/09/2020
			4.50	16/09/2020
			5.00	30/09/2020
			4.73	9/10/2020
			3.55	23/02/2021
			0.50	15/03/2021

5 References

- Begg, J.G., Johnston, M.R. (compilers) 2000: Geology of the Wellington area. Institute of geological & Nuclear Sciences 1:250,000 geological map. 1 sheet + 64p. Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences Limited.
- Boon, David & Perrin, N & Dellow, G.D. & Dissen, R & Lukovic, B. (2011). Site Subsoil Classification of Lower Hutt, New Zealand.
- Morrison, Cooper & Partners. (1977). Waterloo Pumping Station Site Survey (57073/A3).
- Opus (2016). Waterloo water Treatment Plant Geotechnical Investigations. Prepared for Wellington Water by Opus.



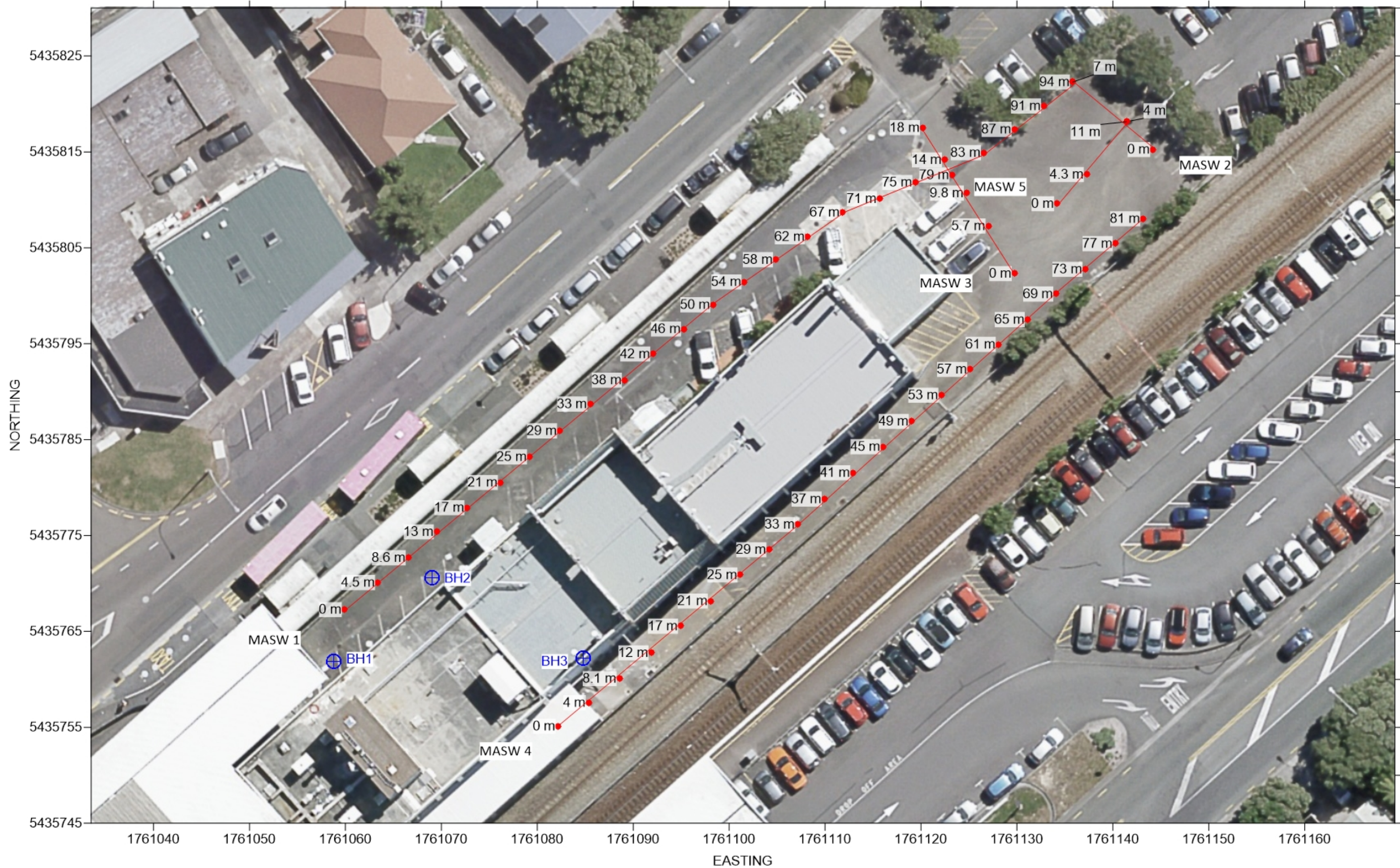
Appendix A Geotechnical Site Investigation Plan & Location Data



Although this information has been prepared with care and in good faith, this map is designed to be illustrative only. The Council cannot guarantee the accuracy or completeness of the graphical information and accepts no liability for any loss suffered as a result of reliance on the information. Cadastral information sourced from LINZ. CROWN COPYRIGHT RESERVED. Aerial photography was flown between January and March 2017 by AAM NZ Limited for Hutt City Council and GWRC and provided under the Creative Commons Attribution 3.0 New Zealand Licence (<https://creativecommons.org/licenses/by/3.0/nz/>).

Projection: NZGD_2000_New_Zealand_Transverse_Mercator

SCALE
1: 282



DRAWING-

Figure 1: Geophysical Site Investigation

LOCATION-

Waterloo WTP

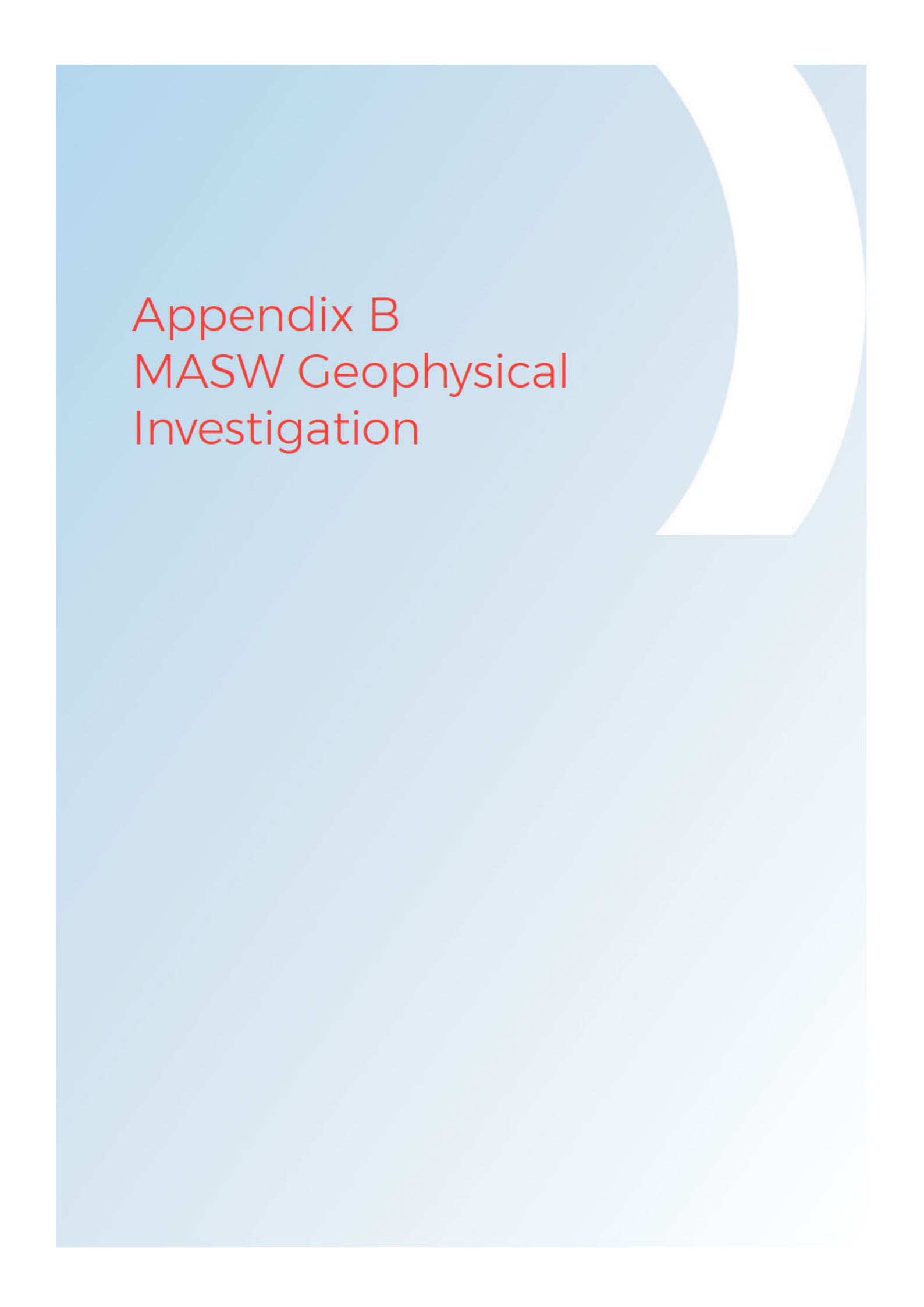
NOTES-

Coordinates NZ2000 TM Grid.
Aerial photograph sourced from LINZ, Crown Copyright ©



A3

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Appendix B MASW Geophysical Investigation

December 2019

GEOPHYSICAL

Geophysical Site Investigation: Waterloo Water Treatment Plant

Report prepared for WSP



Southern
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Figure 2: MASW profiles	5
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Summary:

A series of Multi-channel Analysis of Surface Waves (MASW) surveys were undertaken at the Wastewater Treatment Plant (WTP) in Waterloo, Upper Hutt on November 13, 2019 (Figure 1). In total, five MASW lines were undertaken. Overall the quality of the MASW data was good, with shear-wave velocities modelled to over 20 m depth across most of the site. Shear-wave velocities are around 150 m/s in the surface soils, increasing to over 500 m/s at 25 m depth.

Methodology:

MASW

MASW is a geophysical technique that uses the dispersive nature of surface waves to model shear-wave velocity versus depth.

A MASW survey is undertaken as a series of lines or points across the surface of a site. The MASW lines in this survey were collected using a 24-channel towed seismic array, with 4.5 Hz geophones. The geophone spacing was 1 m and the source offset was 10 m for most points, with a shorter array (0.5 m geophone spacing and 10 m source offset) used at the ends of some lines. The active source was an 8 lb sledgehammer impacting an aluminium plate. Recording parameters for the MASW survey were set with a 0.125 ms sample interval, 1.5 s record length, high gains, and an electric trigger system. Shot records were collected at 4 m spacing along the lines.

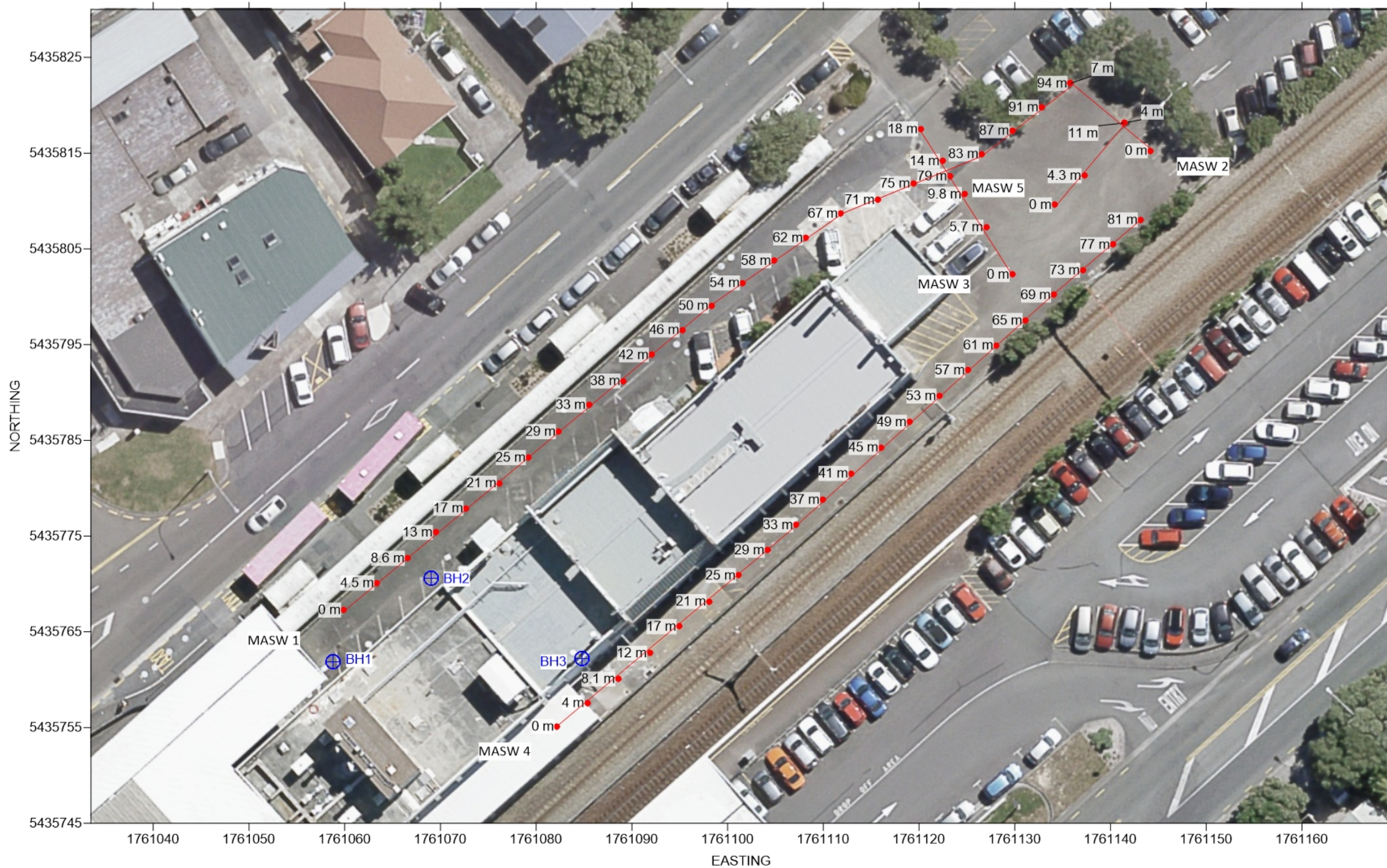
The field records were processed using the Kansas Geological Survey software package SurfSeis5 ©. The geometry was set according to the survey parameters and the dispersion curves were generated and edited. The inversions were run using a 10 layer variable depth model. The velocity data was interpolated into 2D V_s profiles for the MASW lines (Figure 2). The output shear-wave velocity data is included as a series of data files (CSV format), supplementary to this report.

The midpoint of the MASW seismic array at each shot record was recorded with a Trimble GeoXH GPS system. The GPS points were differentially corrected and output using the New Zealand Geodetic Datum (NZGD) 2000, with NZTM 2000 coordinates. The site did not have significant changes in elevation, so the profiles have not been corrected for topography.

Results:

Five MASW lines were collected with a total surveyed line length of ~215 m (Figure 1). The site had low levels of cultural noise due to traffic on some MASW lines, this was mitigated by real time monitoring of seismic noise and increasing the number of stacked shot records to improve the signal to noise ratio.

The MASW surveys imaged the subsurface to over 30 m depth (Figure 2). Areas where the survey did not penetrate to 30 m have been greyed out on the 2D MASW profiles. Confirmation of the site geology would require correlation of the shear-wave velocities with intrusive tests.



DRAWING-

Figure 1: Geophysical Site Investigation

LOCATION-

Waterloo WTP

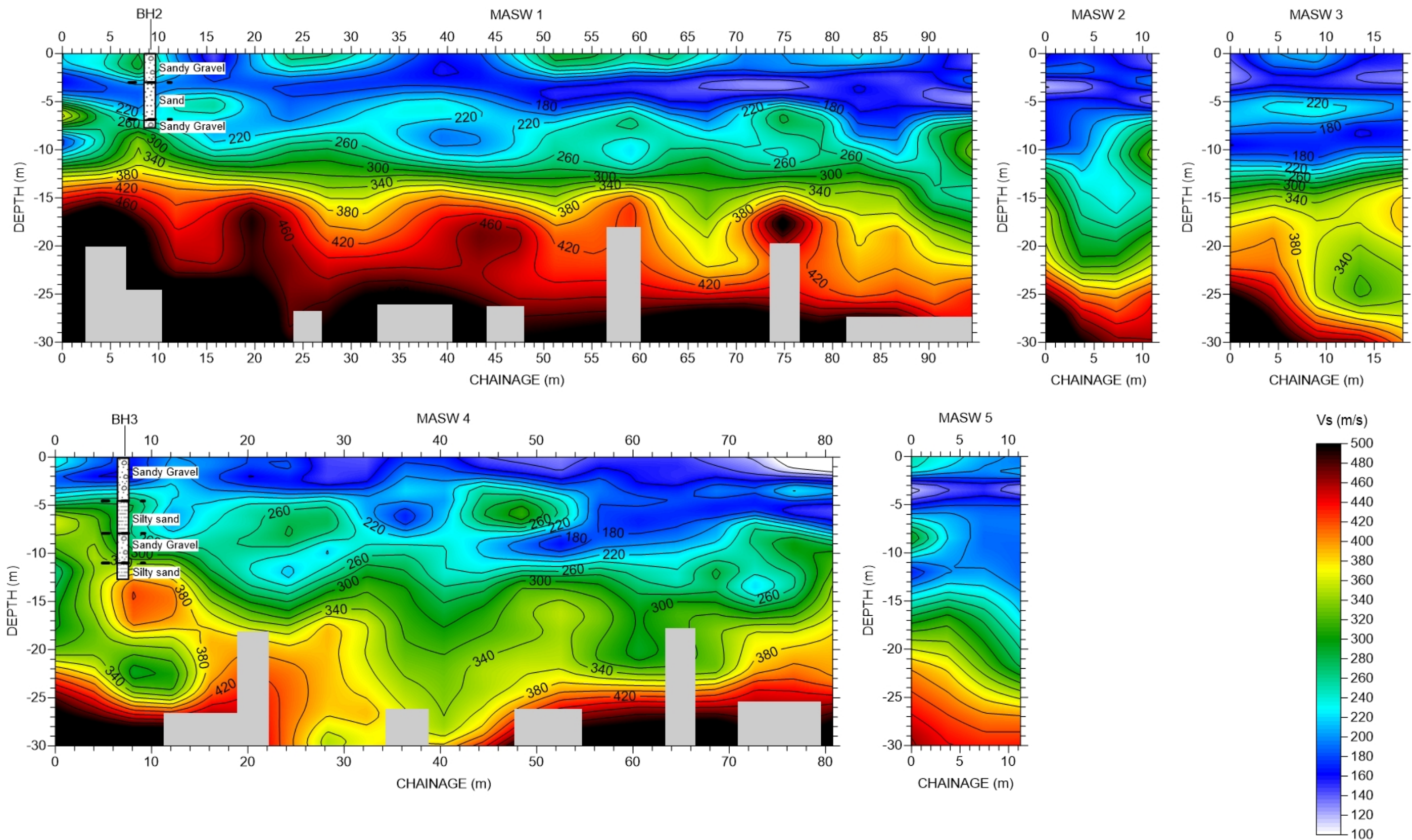
NOTES-

Coordinates NZ2000 TM Grid.
Aerial photograph sourced from LINZ, Crown Copyright ©



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Light grey zones are areas where 30 m depth penetration was not achieved.

DRAWING- **Figure 2: MASW 2D Vs Profiles**

LOCATION- **Waterloo WTP**

NOTES MASW Vs profile has contour intervals of 20 m/s (Vs).

See site map for location of points.

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Disclaimer:

This document has been provided by Southern Geophysical Ltd subject to the following:

Non-invasive geophysical testing has limitations and is not a complete source of testing. Often there is a need to couple non-invasive methods with invasive testing methods, such as drilling, especially in cases where the non-invasive testing indicates anomalies.

This document has been prepared for the particular purpose outlined in the project proposal and no responsibility is accepted for the use of this document, in whole or in part, in other contexts or for any other purpose. Southern Geophysical Ltd did not perform a complete assessment of all possible conditions or circumstances that may exist at the site. Conditions may exist which were undetectable given the limited nature of the enquiry Southern Geophysical Ltd was retained to undertake with respect to the site. Variations in conditions often occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account. Accordingly, additional studies and actions may be required by the client.

We collected our data and based our report on information which was collected at a specific point in time. The passage of time affects the information and assessment provided by Southern Geophysical Ltd. It is understood that the services provided allowed Southern Geophysical Ltd to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes for whatever reason. Where data is supplied by the client or other sources, including where previous site investigation data have been used, it has been assumed that the information is correct. No responsibility is accepted by Southern Geophysical Ltd for incomplete or inaccurate data supplied by others. This document is provided for sole use by the client and is confidential to that client and its professional advisers. No responsibility whatsoever for the contents of this document will be accepted to any person other than the client. Any use which a third party makes of this document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Southern Geophysical Ltd accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

Appendix C

Borehole Logs

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761083 E 5435782 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.69 m
 Datum: Wellington 1953
 Depth: 13 m
 Inclination: Vertical

GEOLOGY	CPT103 END RESISTANCE (MPa)	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
						SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Fill		Vacuum excavation, no core recovery.		6				VE					
		Sandy GRAVEL with some silt, orange, loose, wet.		1		8	1// 1/3/2/2	SPT	100				
Taita Alluvium		Lost core.		2		6	4// 2/1/2/1	SPT	33				
		D&M, disturbed sample not observed.		4				Sonic	30				
		Clayey SILT, grey, moist, very soft, high plasticity.		3				D&M	98				
		Brown streaks.		4				Sonic	100				
		With trace gravel from backfill used for vacuum excavation.		2				D&M	98				
				4				Sonic	100				
				5				D&M	99				
				6				Sonic	100				
				7				D&M	98				
				8				Sonic	100				
Petone Marine Beds		With trace gravel, blue brownish grey.		0				D&M	100				
		D&M, disturbed sample not observed.		7		3	3// 1/0/1/1	SPT	100				
		Silty SAND, dark grey, very loose, moist, wood fragments.		8		6	1// 1/2/2/1	SPT	100				
		Sandy SILT, greyish brown, moist, stiff, nonplastic, organics.		9		37	7// 9/10/9/9	SPT	75				
		Silty SAND, greyish brown, moist, loose, organics.		9									
		Sandy GRAVEL, bluish grey, medium dense to dense, moist.		9									
				9									
				9									
				9									
				9									

Notes:

- SPT hammer energy ratio 87%
- SPT hammer standard deviation 2.9%
- GWRC Consent No. WGN200182
- GWRC Borehole No. BQ32/0481
- D&M: Dames and Moore Sampling
- Adjacent to CPT103. CPT undertaken by Griffiths.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 1/10/2020 Finished: 2/10/2020
 Drilling Co.: Griffiths Drilling Ltd. Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a) Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761083 E 5435782 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.69 m
 Datum: Wellington 1953
 Depth: 13 m
 Inclination: Vertical

GEOLOGY	CPT103 END RESISTANCE (MPa)	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
						SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Waioheta Gravels		Sandy GRAVEL, bluish grey, medium dense to dense, moist. (continued)		4		25	4// 6/5/7/7	SPT	85	Sonic core drilling			
		Sandy GRAVEL, brown, very dense, wet.		11		50+	6// 6/13/17/14 for 30mm	SPT	100				
		END OF BOREHOLE AT 13m - Target Depth Reached		13				Sonic 100					
				14									
				15									
				16									
				17									
				18									
				19									

Notes:

- SPT hammer energy ratio 87%
- SPT hammer standard deviation 2.9%
- GWRC Consent No. WGN200182
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Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 1/10/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Logged by: s7(2)(a)
 Finished: 2/10/2020
 Drilling Rig: Fraste XL Duo Sonic
 Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761083 E 5435782 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.69 m
 Datum: Wellington 1953
 Depth: 13 m
 Inclination: Vertical

PHOTOGRAPHS



Photo BH101.1
Box 1



Photo BH101.2
Box 2

Notes:

1. SPT hammer energy ratio 87%
2. SPT hammer standard deviation 2.9%
3. GWRC Consent No. WGN200182
4. GWRC Borehole No. BQ32/0481
5. D&M: Dames and Moore Sampling
6. Adjacent to CPT103. CPT undertaken by Griffiths.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 1/10/2020
 Finished: 2/10/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a)
 Checked by: s7(2)(a)

Project: Waterloo WTP
Client: Wellington Water Ltd.
Project No.: 3-WW019.11
Location: Lower Hutt, New Zealand

Coordinates: 1761083 E 5435782 N
Ref. Grid: NZTM
R.L.: Approx. 6.69 m
Datum: Wellington 1953
Depth: 13 m
Inclination: Vertical

PHOTOGRAPHS



Photo BH101.3
Box 3

Notes:

1. SPT hammer energy ratio 87%
2. SPT hammer standard deviation 2.9%
3. GWRC Consent No. WGN200182
4. GWRC Borehole No. BQ32/0481
5. D&M: Dames and Moore Sampling
6. Adjacent to CPT103. CPT undertaken by Griffiths.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 1/10/2020
Finished: 2/10/2020
Drilling Co.: Griffiths Drilling Ltd.
Drilling Rig: Fraste XL Duo Sonic
Logged by: s7(2)(a)
Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761104 E 5435798 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.68 m
 Datum: Wellington 1953
 Depth: 15 m
 Inclination: Vertical

GEOLOGY	CPT104 END RESISTANCE (MPa)	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS	
						SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		BASE OF HOLE & WATER LEVEL	
Taita Alluvium	0	Vacuum excavation, no core recovery.		6				VE	0					
	10	Gravelly SILT with some sand and clay, brownish grey, very soft to soft, wet, low plasticity.		1		2	1// 0/0/0/2	SPT	100			1.50-1.95m - Gravel is medium, moderately weathered, angular.		
	20	SAND, brown, loose, moist.		2				Sonic	100					
	30	SILT with some sand, brownish grey, very soft to soft, moist, low plasticity.		3				D&M	100			2.40-2.85m - D&M sample, 8.5bar maximum pressure.		
		D&M Sample		4				Sonic	100			3.05-3.50m - D&M sample, 14bar maximum pressure.		
		Disturbed sample retrieved as clayey SILT, grey with some brown streaks, very soft, wet to saturated, moderate plasticity.		3				D&M	100			3.70-4.15m - D&M sample, 9bar maximum pressure.		
		Silty CLAY with traces of gravel, brownish grey, very soft, moist, high plasticity.		4				Sonic	100			4.35-4.80m - D&M sample, 10bar maximum pressure.		
				5				D&M	100			5.00-5.45m - D&M sample, 7bar maximum pressure.		
				6				Sonic	100			5.65-6.10m - D&M sample, 9bar maximum pressure.		
				7				D&M	100			6.10-6.30m - Gravel is medium, moderately to highly weathered, angular.		
Petone Marine Beds		Clayey GRAVEL with some silt, grey with some brown streaks, loose to medium dense, wet, high plasticity matrix.		0				Sonic	100					
		SAND with some silt, bluish grey, moist to wet, loose, wood fragments.		7		4	3// 0/0/1/3	SPT	100					
		Silty SAND, bluish grey with brown mottles, loose, moist, organic material.		8		50+	11// 2/3/5/10 for 50mm	SPT	70					
		Sandy GRAVEL with some silt, bluish grey, very dense, wet.		9		22	6// 4/7/16/5	SPT	45			7.40-9.30m - Gravel is fine to coarse, moderately weathered, subrounded to subangular.		
		Silty SAND with interbedded peaty SILT layers, brownish grey, moist to wet, loose to medium dense, organic material.						Sonic	100					

Notes:

- SPT hammer energy ratio 87%
- SPT hammer standard deviation 2.9%
- GWRC Consent No. WGN200182
- GWRC Borehole No. BQ32/0482
- D&M: Dames and Moore Sampling
- Adjacent to CPT104. CPT undertaken by Griffiths.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 30/09/2020 Finished: 1/10/2020
 Drilling Co.: Griffiths Drilling Ltd. Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a) Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761104 E 5435798 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.68 m
 Datum: Wellington 1953
 Depth: 15 m
 Inclination: Vertical

GEOLOGY	CPT104 END RESISTANCE (MPa)	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
						SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Petone Marine Beds		Silty SAND with interbedded peaty SILT layers, brownish grey, moist to wet, loose to medium dense, organic material. (continued)				5	0// 0/1/2/2	SPT	85				
		SAND with some silt, bluish grey, very loose to loose, moist to wet, shell fragments.		4				Sonic	100				
		Sandy SILT with some clay, brownish grey, firm, moist, low plasticity, shell fragments, organic material.		11		6	1// 1/0/2/4	SPT	100				
		SAND with some silt, bluish grey, very loose to medium dense, moist to wet, shell fragments.		12				Sonic	100				
Waiwhetu Gravels		Wood.		-6		2	2// 0/1/0/1	SPT	100				
		Silty SAND, greyish brown, moist to wet, medium dense to very dense, organic material.		13				Sonic	100				
		Sandy GRAVEL with some silt, brown with some grey streaks, very dense, wet to saturated.		14		14	3// 2/1/3/8	SPT	100				
		END OF BOREHOLE AT 15m - Target Depth Reached		15		50+	5// 9/26/15 for 40mm	SPT	100				
				-8				Sonic	100			14.30-15.00m - Gravel is medium to coarse, highly weathered, subangular.	
				16									
				-10									
				17									
				-12									
				19									

Notes:

- SPT hammer energy ratio 87%
- SPT hammer standard deviation 2.9%
- GWRC Consent No. WGN200182
- GWRC Borehole No. BQ32/0482
- D&M: Dames and Moore Sampling
- Adjacent to CPT104. CPT undertaken by Griffiths.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 30/09/2020 Finished: 1/10/2020
 Drilling Co.: Griffiths Drilling Ltd. Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a) Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761104 E 5435798 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.68 m
 Datum: Wellington 1953
 Depth: 15 m
 Inclination: Vertical

PHOTOGRAPHS



Photo BH102.1
Box 1

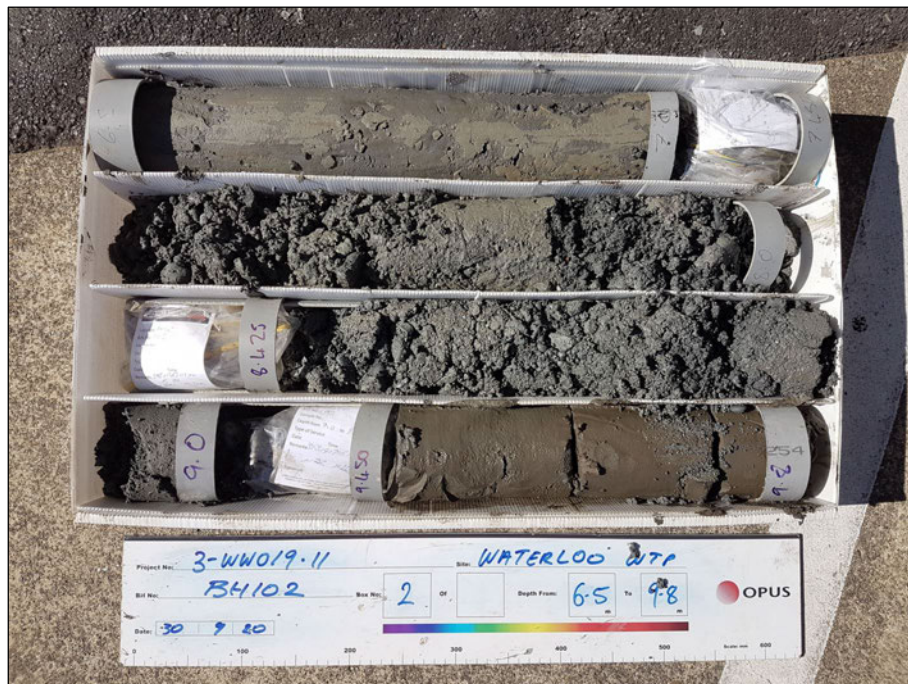


Photo BH102.2
Box 2

Notes:

1. SPT hammer energy ratio 87%
2. SPT hammer standard deviation 2.9%
3. GWRC Consent No. WGN200182
4. GWRC Borehole No. BQ32/0482
5. D&M: Dames and Moore Sampling
6. Adjacent to CPT104. CPT undertaken by Griffiths.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 30/09/2020
 Finished: 1/10/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a)
 Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761104 E 5435798 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.68 m
 Datum: Wellington 1953
 Depth: 15 m
 Inclination: Vertical

PHOTOGRAPHS



Photo BH102.3
Box 3



Photo BH102.4
Box 4

Notes:

1. SPT hammer energy ratio 87%
2. SPT hammer standard deviation 2.9%
3. GWRC Consent No. WGN200182
4. GWRC Borehole No. BQ32/0482
5. D&M: Dames and Moore Sampling
6. Adjacent to CPT104. CPT undertaken by Griffiths.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 30/09/2020
 Finished: 1/10/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a)
 Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761125 E 5435803 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.71 m
 Datum: Wellington 1953
 Depth: 20 m
 Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
					SPT N° VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Taita Alluvium	Vacuum excavation, no core recovery.						VE	0				Asphalt
	Sandy GRAVEL, greyish brown, wet, loose.						SPT	100			1.50-1.95m - Gravel is coarse, angular, slightly weathered. Sand is coarse.	
	SAND with some silt, brownish grey, medium dense, moist.						SPT	50				
	SILT with some sand and clay with minor gravel, grey becoming brown, loose, moist, low plasticity.						Sonic	100			2.40-2.70m - Sand is fine to coarse.	
	Silty GRAVEL, brown, loose, moist.						SPT	100				
	SILT with some sand and clay with minor gravel, grey becoming brown, firm to stiff, moist, low plasticity.						Sonic	100				
	Clayey SILT with some clay, grey, firm, moist, low plasticity.						SPT	100				
	Wet						Sonic	100				
	With some gravel.						SPT	100				
	Silty CLAY with some organics, brownish grey with black mottles, very soft to stiff, moderate plasticity.						Sonic	100			5.00m - Gravel is fine, angular, moderately to highly weathered.	
Petone Marine Beds	SAND, bluish grey, moist, medium dense.						SPT	100			6.20-9.80m - Sand is medium.	
							Sonic	100				
	Sandy SILT, bluish grey, stiff, moist.						SPT	100				
	SILT with some clay, bluish grey, stiff, moist.						Sonic	100				
	SAND with some silt, bluish grey, medium dense, moist, shell fragments.						SPT	100				
							Sonic	100				
	Sandy SILT with traces of clay, grey, stiff, moist, low plasticity.										9.80-10.20m - Sand is fine.	

Notes:

- SPT hammer energy ratio 87%
- SPT hammer standard deviation 2.9%
- GWRC Consent No. WGN200182
- GWRC Borehole No. BQ32/0483
- Coordinates and elevation are approximate.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 8/09/2020 Finished: 9/09/2020
 Drilling Co.: Griffiths Drilling Ltd. Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a) Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761125 E 5435803 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.71 m
 Datum: Wellington 1953
 Depth: 20 m
 Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS			
					SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING			BASE OF HOLE & WATER LEVEL		
Petone Marine Beds	Sandy SILT with traces of clay, grey, stiff, moist, low plasticity. <i>(continued)</i>				18	6// 3/5/4/6	SPT	100		Double Casing - Outer: 8" to 12.0m / Inner 5" to 20.0m		10.20-12.45m - Sand is fine to coarse.			
	Silty SAND, bluish grey, medium to very dense, moist, wood fragments.	-4					Sonic	100							
		-11			7	3// 2/1/2/2	SPT	100							
		With some clay, moderate plasticity.	-12			20	5// 4/6/5/5	SPT						100	
	SAND with some silt, brown with grey patches, medium dense, moist.	-6					Sonic	100				12.45-12.95m - Sand is coarse.			
Waiwhetu Gravels	Sandy GRAVEL with some silt, brown, wet to saturated, medium to very dense.	-13			50+	25// 50 for 70mm	SPT	100	Sonic core drilling			12.95-20.00m - Gravel is fine to coarse, subangular to angular, moderately to highly weathered. Sand is fine to coarse.			
							Sonic	100							
		-14			50+	26// 12/38/1	SPT	73							
		-8					Sonic	100							
		-15			33	9// 8/7/10/8	SPT	83							
							Sonic	100							
		-16			50+	20// 50	SPT	75							
		-10					Sonic	100							
		-17			50+	50	SPT	100							
							Sonic	100							
		-18			50+	50 for initial 125mm	SPT	100							
							Sonic	100							
		-12													
		-19			50+	50 for initial 115mm	SPT	100							
							Sonic	100							
										19.12-19.40m - Loss of fines.					

Notes: END OF BOREHOLE AT 20m - Target Depth Reached

1. SPT hammer energy ratio 87%
2. SPT hammer standard deviation 2.9%
3. GWRC Consent No. WGN200182
4. GWRC Borehole No. BQ32/0483
5. Coordinates and elevation are approximate.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 8/09/2020
 Finished: 9/09/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a)
 Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761125 E 5435803 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.71 m
 Datum: Wellington 1953
 Depth: 20 m
 Inclination: Vertical

PHOTOGRAPHS



Photo BH103.1
Box 1

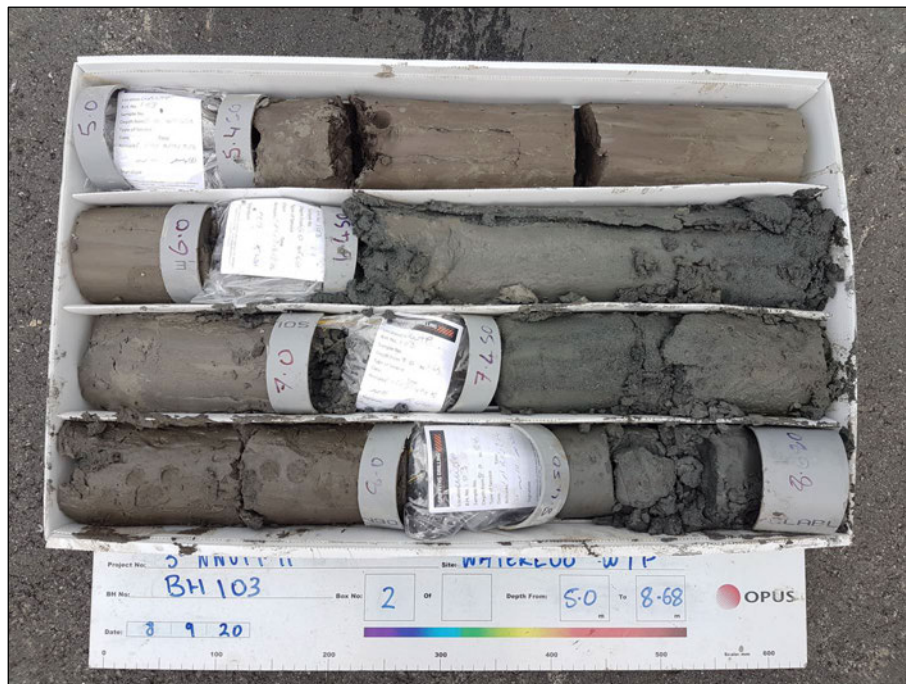


Photo BH103.2
Box 2

Notes:

1. SPT hammer energy ratio 87%
2. SPT hammer standard deviation 2.9%
3. GWRC Consent No. WGN200182
4. GWRC Borehole No. BQ32/0483
5. Coordinates and elevation are approximate.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 8/09/2020
 Finished: 9/09/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Drilling Rig: Fraste XL Duo Sonic
 Logged by: S7(2)(a)
 Checked by: S7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761125 E 5435803 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.71 m
 Datum: Wellington 1953
 Depth: 20 m
 Inclination: Vertical

PHOTOGRAPHS

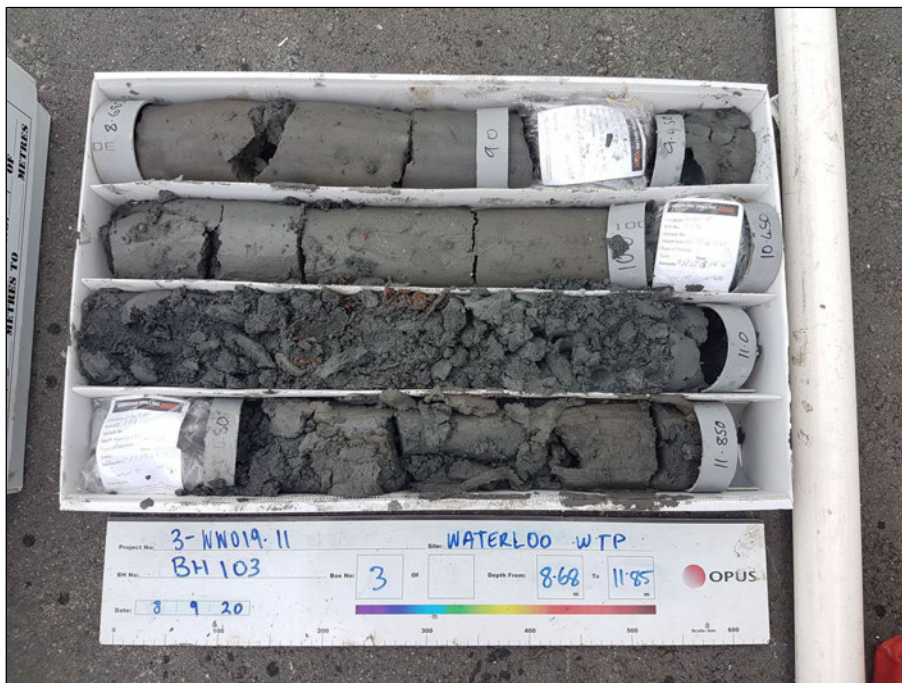


Photo BH103.3
Box 3



Photo BH103.4
Box 4

Notes:

1. SPT hammer energy ratio 87%
2. SPT hammer standard deviation 2.9%
3. GWRC Consent No. WGN200182
4. GWRC Borehole No. BQ32/0483
5. Coordinates and elevation are approximate.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 8/09/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Logged by: S7(2)(a)
 Finished: 9/09/2020
 Drilling Rig: Fraste XL Duo Sonic
 Checked by: S7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761125 E 5435803 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.71 m
 Datum: Wellington 1953
 Depth: 20 m
 Inclination: Vertical

PHOTOGRAPHS



Photo BH103.5
Box 5

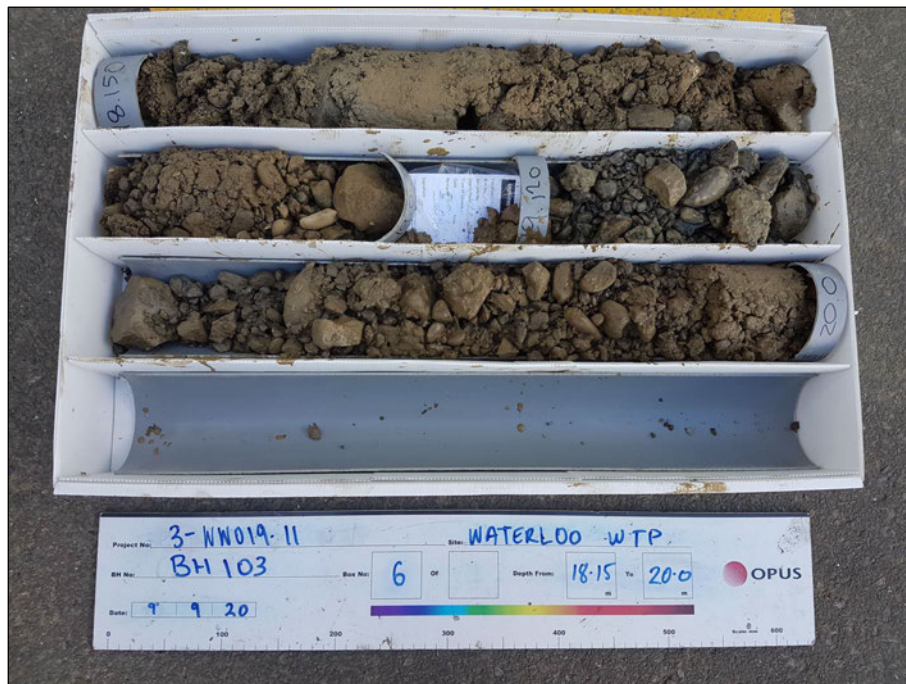


Photo BH103.6
Box 6

Notes:

1. SPT hammer energy ratio 87%
2. SPT hammer standard deviation 2.9%
3. GWRC Consent No. WGN200182
4. GWRC Borehole No. BQ32/0483
5. Coordinates and elevation are approximate.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 8/09/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Logged by: s7(2)(a)
 Finished: 9/09/2020
 Drilling Rig: Fraste XL Duo Sonic
 Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761064 E 5435769 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.55 m
 Datum: Wellington 1953
 Depth: 21.3 m
 Inclination: Vertical

GEOLOGY	CPT101 END RESISTANCE (MPa)	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
						SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Taia Alluvium	0	Vacuum Excavation.	6	1				VE	0				Flush toby.
	10		1	2									50mm PVC.
	20	Core loss.	4	3				Sonic	0				Bentonite seal.
	30	SAND with some silt, dark grey, loose to medium dense, moist to wet, wood fragments.	3	4		9	3// 1/3/2/3	SPT	100				
		No silt.		5				Sonic	100				
		Gravelly SAND, dark grey, moist, loose to medium dense, wood fragments.	2	6		21	4// 4/5/7/5	SPT	100				
				7				Sonic	100				
		SAND, dark grey, loose, moist, wood fragments.	0	8		9	5// 3/2/2/2	SPT	100				
		Clayey SILT, brownish grey, stiff, moist, moderate plasticity, wood fragments and organic material.	7	9				Sonic	100				
		Sandy GRAVEL, dark grey, medium dense, wet.		10		21	7// 5/6/5/5	SPT	100				
Petone Marine Beds				11				Sonic	100				
		Silty SAND, dark grey, medium dense, wet to saturated, wood fragments.	-2	12		12	5// 3/3/2/4	SPT	100				
				13				Sonic	100				
				14		14	1// 1/3/4/6	SPT	85				

Notes:

- Vacuum excavation to 2.5m due to proximity of services.
- SPT hammer energy ratio 87%
- SPT hammer standard deviation 2.9%
- GWRC Consent No. WGN200182
- GWRC Borehole No. BQ32/0484
- Coordinates and elevation are approximate.
- Adjacent to CPT101.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 3/09/2020 Finished: 7/09/2020
 Drilling Co.: Griffiths Drilling Ltd. Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a) Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761064 E 5435769 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.55 m
 Datum: Wellington 1953
 Depth: 21.3 m
 Inclination: Vertical

GEOLOGY	CPT101 END RESISTANCE (MPa)	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
						SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Waioheta Gravels	0	Silty SAND, dark grey, medium dense, wet to saturated, wood fragments. (continued)				19	10// 4/2/4/9	SPT	100	Sonic core drilling		SWL 2.50m 4/09 SWL 0.00m 3/09	
	10	Sandy GRAVEL with traces of silt, brown with some grey streaks, medium to very dense, wet.	-4				Sonic	100	10.40-17.50m - Gravel is coarse, subrounded to subangular, highly weathered,				
	20		11		50+	17// 15/10/12/13	SPT	80					
	30			12		50+	12// 13/12/14/11	SPT					
		With some orange streaks.	-6				Sonic	100	15.36-15.50m - Loss of fines.				
			13		50+	50	SPT	100					
				14		50+	19// 13/13/14/10	SPT					
		With some cobbles.	-8				Sonic	100	17.50-18.20m - Gravel is fine, subrounded to subangular, moderately to highly weathered.				
			15		50+	13// 16/12/22	SPT	100					
				16		50+	50	SPT					
		SAND with some gravel, brown, moist to wet, loose to very dense.	-10				Sonic	100	18.20-18.80m - Sand is fine to medium.				
			17		50+	12// 22/28	SPT	77					
				18		4	2// 1/1/1/1	SPT					
		Silty SAND with some clay, brown, loose, moist, non plastic.	-12				Sonic	100	18.80-21.30m - Sand is coarse.				
		Sandy GRAVEL with traces of silt, brown with some grey streaks, medium dense, wet.	19			50+	35// 35/15	SPT					
		Wet to saturated.					Sonic	100					

Notes:

- Vacuum excavation to 2.5m due to proximity of services.
- SPT hammer energy ratio 87%
- SPT hammer standard deviation 2.9%
- GWRC Consent No. WGN200182
- GWRC Borehole No. BQ32/0484
- Coordinates and elevation are approximate.
- Adjacent to CPT101.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 3/09/2020 Finished: 7/09/2020
 Drilling Co.: Griffiths Drilling Ltd. Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a) Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761064 E 5435769 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.55 m
 Datum: Wellington 1953
 Depth: 21.3 m
 Inclination: Vertical

GEOLOGY	CPT101 END RESISTANCE (MPa)	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
					SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Waioheta Gravels	0	Sandy GRAVEL with traces of silt, brown with some grey streaks, medium dense, wet. (continued) With some silt and clay.	-14		50+	27// 14/15/14/7	SPT	100	Sonic core drilling			
	10		21				Sonic	100				
	20						SPT	100				
	30	END OF BOREHOLE AT 21.3m - Target Depth Reached									SWL 2.30m 7/09	
			22									
			-16									
			23									
			24									
			-18									
			25									
			26									
			-20									
			27									
			28									
			-22									
			29									

Notes:

- Vacuum excavation to 2.5m due to proximity of services.
- SPT hammer energy ratio 87%
- SPT hammer standard deviation 2.9%
- GWRC Consent No. WGN200182
- GWRC Borehole No. BQ32/0484
- Coordinates and elevation are approximate.
- Adjacent to CPT101.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 3/09/2020 Finished: 7/09/2020
 Drilling Co.: Griffiths Drilling Ltd. Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a) Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761064 E 5435769 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.55 m
 Datum: Wellington 1953
 Depth: 21.3 m
 Inclination: Vertical

PHOTOGRAPHS



Photo BH104.1
Box 1



Photo BH104.2
Box 2

Notes:

1. Vacuum excavation to 2.5m due to proximity of services.
2. SPT hammer energy ratio 87%
3. SPT hammer standard deviation 2.9%
4. GWRC Consent No. WGN200182
5. GWRC Borehole No. BQ32/0484
6. Coordinates and elevation are approximate.
7. Adjacent to CPT101.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 3/09/2020
 Finished: 7/09/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a)
 Checked by: s7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761064 E 5435769 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.55 m
 Datum: Wellington 1953
 Depth: 21.3 m
 Inclination: Vertical

PHOTOGRAPHS



Photo BH104.3
Box 3



Photo BH104.4
Box 4

Notes:

1. Vacuum excavation to 2.5m due to proximity of services.
2. SPT hammer energy ratio 87%
3. SPT hammer standard deviation 2.9%
4. GWRC Consent No. WGN200182
5. GWRC Borehole No. BQ32/0484
6. Coordinates and elevation are approximate.
7. Adjacent to CPT101.

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 3/09/2020
 Finished: 7/09/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Drilling Rig: Fraste XL Duo Sonic
 Logged by: S7(2)(a)
 Checked by: S7(2)(a)

Project: Waterloo WTP
 Client: Wellington Water Ltd.
 Project No.: 3-WW019.11
 Location: Lower Hutt, New Zealand

Coordinates: 1761064 E 5435769 N
 Ref. Grid: NZTM
 R.L.: Approx. 6.55 m
 Datum: Wellington 1953
 Depth: 21.3 m
 Inclination: Vertical

PHOTOGRAPHS



Photo BH104.5
Box 5



Photo BH104.6
Box 6

Notes:

1. Vacuum excavation to 2.5m due to proximity of services.
2. SPT hammer energy ratio 87%
3. SPT hammer standard deviation 2.9%
4. GWRC Consent No. WGN200182
5. GWRC Borehole No. BQ32/0484
6. Coordinates and elevation are approximate.
7. Adjacent to CPT101.

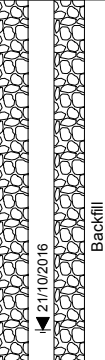
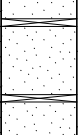
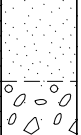
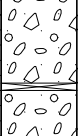
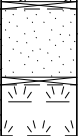
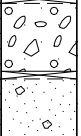
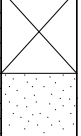
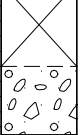
Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Started: 3/09/2020
 Finished: 7/09/2020
 Drilling Co.: Griffiths Drilling Ltd.
 Drilling Rig: Fraste XL Duo Sonic
 Logged by: s7(2)(a)
 Checked by: s7(2)(a)

Project: Waterloo Water Treatment Plant
Client: Wellington Water
Project No.: 3-WW016.00
Location: SW corner, near train station entrance
 Waterloo, Lower Hutt, Wellington

Coordinates: 1761046 E 5435759 N
Ref. Grid: NZTM
R.L.: 6 m
Datum: MSL (NZ Geoid 2009)
Depth: 11.95 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING			NOTES / OTHER TESTS	INSTALLATION DETAILS
					SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING	BASE OF HOLE & WATER LEVEL		
Fill	Vacuum excavation. FILL comprised of sandy GRAVEL, tightly packed.		1				VE	0					
			2										
Marine and Alluvial Deposits	SAND; dark grey, loose, moist.		3		4	2// 0/1/1/2	SPT	56				2.50m - Corase sand, minor white grains.	
			4		7	1// 1/2/2/2	SPT	82				3.00m - Large wood fragments.	
	Becomes medium dense.		5		12	3// 3/2/3/4	SPT	78				3.50m - No wood fragments. Lab: PSD	
			6		19	3// 2/3/6/8	SPT	84				4.00m - Some wood fragments.	
	Approximate contact. Sandy GRAVEL; dark grey, medium dense to dense, moist.		7		30	10// 9/6/8/7	SPT	67				4.50m - Gravel is subrounded, fine to 4 cm. Wood fragments.	
	Becomes more sandy, medium dense. Possible sand heave in sample.		8		20	4// 3/4/5/8	SPT	100				5.00m - Subrounded gravel fragment, 4 cm.	
	Possible sand heave in sample.		9		17	4// 5/5/4/3	SPT	67				5.50m - Well rounded gravel, minor wood fragments. Lab: PSD	
	Upper 0.14 m of SPT sample is fine gravel wash. Lower 0.15 m: SAND with minor gravel; dark grey, loose, moist. Minor zones of brown, organic peat.		10		4	6// 2/0/1/1	SPT	56				6.00m - Coarse sand. Abundant wood fragments. Fine gravel, subangular to subrounded, mostly <0.5 cm.	
	Sandy SILT with some clay; dark brown, very soft, high plasticity. Interbedded with lesser beds (5 cm) of SAND with minor gravel; dark grey.		11		3	3// 0/1/0/2	SPT					6.50m - Sand is coarse. Very fine gravel.	
	Sandy GRAVEL with minor silt; dark grey, medium dense, moist.		12		31	8// 8/8/8/7	SPT					7.00m - Gravel is mostly fine, up to 2 cm, rounded.	
	Becomes gravelly SAND; dark grey, medium dense, moist, interbedded with SAND.		13		14	10// 4/3/3/4	SPT	62				7.50m - Coarse sand, gravel is mostly fine, <0.5 cm, up to 3 cm, subrounded to aubangular. Lab: PSD	
			14				WD	0					
	Becomes sand with minor gravel and trace silt; dark grey, medium dense, moist.		15		16	6// 4/4/4/4	SPT	74				8.50m - Coarse sand. Gravel is fine to 1 cm, subrounded.	
			16				WD	0					
	Sandy GRAVEL; dark grey-brown, dense, moist. Minor iron staining throughout.		17		37	18// 10/9/9/9	SPT	67				9.50m - Gravel is brown, highly weathered, fine to 3 cm. Subrounded, some subangular fragments. Coarse sand.	

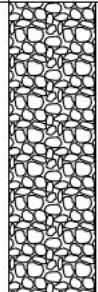
Notes:

Started: 19/10/2016
Drilling Co.: Griffiths Drilling
Logged by: S7(2)(a)

Finished: 20/10/2016
Drilling Rig: PLG Fraste
Checked by: S7(2)(a)

Project: Waterloo Water Treatment Plant
Client: Wellington Water
Project No.: 3-WW016.00
Location: SW corner, near train station entrance
 Waterloo, Lower Hutt, Wellington

Coordinates: 1761046 E 5435759 N
Ref. Grid: NZTM **Depth:** 11.95 m
R.L.: 6 m **Inclination:** Vertical
Datum: MSL (NZ Geoid 2009)

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING			NOTES / OTHER TESTS	INSTALLATION DETAILS
				SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING	BASE OF HOLE & WATER LEVEL		
Marine Deposits	Sandy GRAVEL; dark grey-brown, dense, moist. Minor iron staining throughout.	11		41	14// 11/8/10/12	WD	0	Wash boring			10.50m - Gravel is mostly fine, angular fragments. Well rounded, up to 2 cm.	
						SPT	67					
						WD	0					
				43	16// 9/11/11/12	SPT	67					
	END OF BOREHOLE AT 11.95m	-6 12										
		13										
		-8 14										
		15										
		-10 16										
		17										
		-12 18										
		19										
		-14										

Notes:

Started: 19/10/2016
Drilling Co.: Griffiths Drilling
Logged by: s7(2)(a)

Finished: 20/10/2016
Drilling Rig: PLG Fraste
Checked by: s7(2)(a)

Project: Waterloo Water Treatment Plant
Client: Wellington Water
Project No.: 3-WW016.00
Location: W side, centre of building
 Waterloo, Lower Hutt, Wellington

Coordinates: 1761072 E 5435780 N
Ref. Grid: NZTM
R.L.: 6 m
Datum: MSL (NZ Geoid 2009)
Depth: 7.95 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
					SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Fill	Vacuum excavation. FILL comprised of sandy GRAVEL, tightly packed.		1				VE	0				
	Sandy GRAVEL; brown, loose, moist. Low SPT value likely due to disturbance from vacuum excavation and wash drilling.		2		9	3// 3/2/1/3	SPT	22				
Marine and Alluvial Deposits	Approximate contact. SAND with minor gravel; dark grey, medium dense, moist.		3		12	4// 2/2/4/4	SPT	82	WD	0		
	SAND with minor to trace gravel, loose.		4		8	8// 2/1/3/2	SPT	73	WD	0		
	Becomes SAND; dark grey, loose, moist.		5		8	4// 2/2/2/2	SPT	69	WD	0		
	Minor gravel throughout.		6		13	6// 3/4/3/3	SPT	71	WD	0		
	Some gravel throughout.		7		15	3// 3/4/4/4	SPT	60	WD	0		
	Becomes SAND; dark grey, loose, moist interbedded with SILT; dark brown, soft.		8		8	3// 1/1/3/3	SPT	60	WD	0		
	Becomes SAND; dark grey, loose, moist.		9		3	4// 1/0/1/1	SPT	87	WD	0		
	SILT; dark brown, very soft, moist, high plasticity.		10		24	10// 6/5/5/8	SPT	80	WD	0		
	Sandy GRAVEL; grey, medium dense, moist, minor silty zones; light grey-brown, no plasticity.		11		31	9// 5/5/9/12	SPT	71	WD	0		
	Becomes dark grey, dense.		12									
	END OF BOREHOLE AT 7.95m		13									
			14									
			15									

Notes:

Started: 21/10/2016

Finished: 21/10/2016

Drilling Co.: Griffiths Drilling

Drilling Rig: PLG Fraste

Logged by: s7(2)(a)

Checked by: s7(2)(a)

Project: Waterloo Water Treatment Plant
Client: Wellington Water
Project No.: 3-WW016.00
Location: SE corner
 Waterloo, Lower Hutt, Wellington

Coordinates: 1761085 E 5435761 N
Ref. Grid: NZTM **Depth:** 12.45 m
R.L.: 6 m **Inclination:** Vertical
Datum: MSL (NZ Geoid 2009)

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
					SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Fill	Vacuum excavation. FILL comprised of sandy GRAVEL, tightly packed.		0				VE	0				
	Sandy GRAVEL; grey, medium dense, moist.		3				HQ	10			3.00m - Coarse sand. Gravel is >3 cm, subangular to subrounded.	
Marine and Alluvial Deposits	Clayey SILT with minor gravel; blue-grey, very soft, high plasticity.		5				HQ	27	HWT HQ Size, Triple Tube, Wireline Rotary Coring			
	Silty CLAY with minor gravels; dark brown, firm, moist, high plasticity. Mottled blue-grey silty zones.		6				HQ	90			6.00m - Very sticky. Gravel is fine, angular to subangular.	
	Silty SAND; blue grey and brown, loose to medium dense, moist.		7				HQ	0			6.80m - Minor organic/wood fragments.	
	Clayey GRAVEL; blue grey, loose to medium dense, moist to wet, low plasticity. Material too wet to roll.		8				HQ	0			7.50m - Gravel is fine to 2 cm, subangular to rounded.	
	Sandy SILT with minor gravel; dark grey and brown, soft to firm, moist.		9				SPT	89			8.00m - Gravel is medium, well rounded.	
	Sandy GRAVEL; grey, medium dense to dense.		10				HQ	0			9.00m - Fine gravel.	
	Becomes loose.		11		7	2// 1/1/2/3	SPT	100				
			12		30	7// 4/8/10/8	SPT	89				

Notes:
 Borehole drilled over CPT hole to ~ 8 m.

Started: 25/10/2016
Drilling Co.: Griffiths Drilling
Logged by: s7(2)(a)

Finished: 25/10/2016
Drilling Rig: PLG Fraste
Checked by: s7(2)(a)

Project: Waterloo Water Treatment Plant
Client: Wellington Water
Project No.: 3-WW016.00
Location: SE corner
 Waterloo, Lower Hutt, Wellington

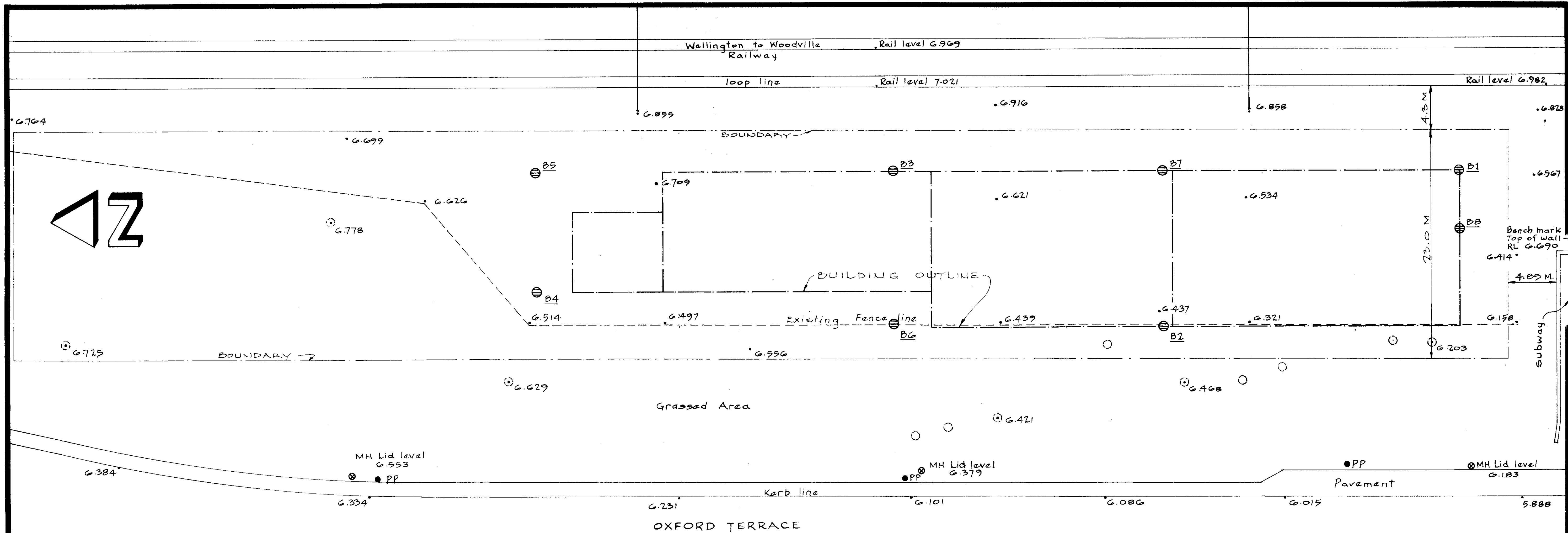
Coordinates: 1761085 E 5435761 N
Ref. Grid: NZTM **Depth:** 12.45 m
R.L.: 6 m **Inclination:** Vertical
Datum: MSL (NZ Geoid 2009)

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) DEPTH (m)	GRAPHIC LOG	TESTS		CORE		DRILLING		NOTES / OTHER TESTS	INSTALLATION DETAILS
				SPT 'N' VALUE	SPT BLOW COUNTS OR SHEAR VALUE	CORE TYPE	TOTAL CORE RECOVERY (%)	DRILLING METHOD	CASING		
Marine and Alluvial Deposits	Becomes medium dense.			26	5// 5/9/5/7	SPT	75	HQ Size, Triple Tube, Wireline Rotary Coring			11.00m - Gravel becomes more coarse, subangular. Wood fragments throughout. Medium sand. 12.00m - Gravel is coarse, angular to subangular.
						HQ	0				
	Silty SAND with some gravel; grey, dense to very dense.	11		49	38// 15/12/10/12	SPT	89				
						HQ	0				
	Silty CLAY with some gravel; grey, stiff to very stiff.	-6		30	6// 7/6/8/9	SPT	89				
	END OF BOREHOLE AT 12.45m									SWL 2.50m 26/10	
		13									
		-8									
		14									
		15									
		-10									
		16									
		17									
		-12									
		18									
		19									
		-14									

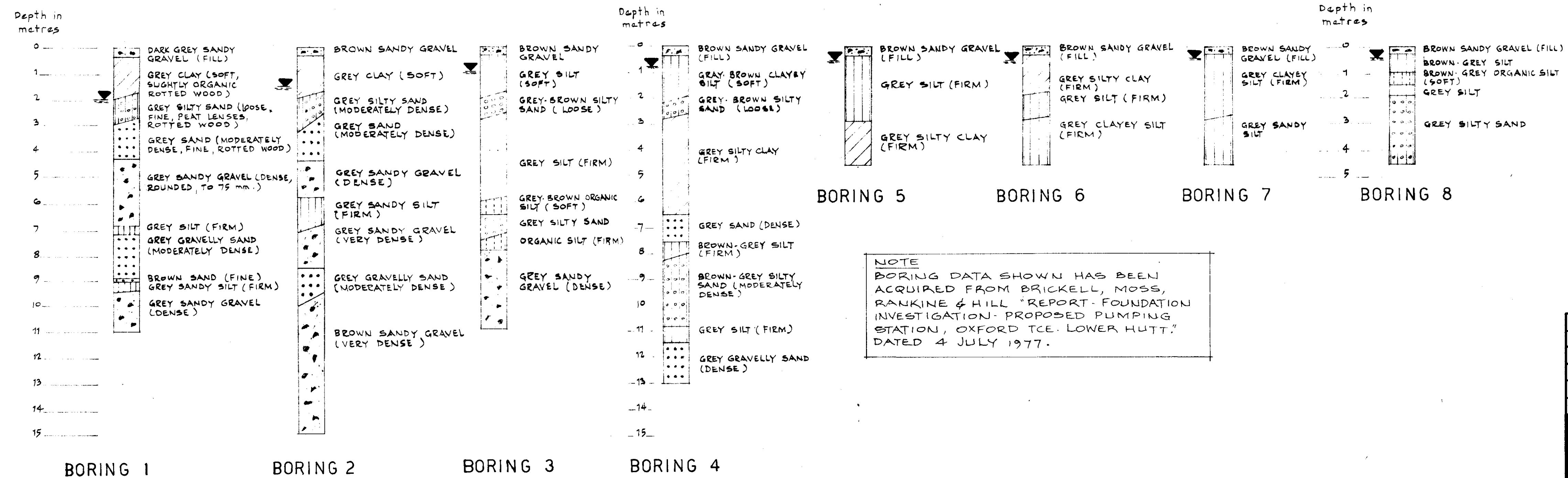
Notes:
 Borehole drilled over CPT hole to ~ 8 m.

Started: 25/10/2016
Drilling Co.: Griffiths Drilling
Logged by: s7(2)(a)

Finished: 25/10/2016
Drilling Rig: PLG Fraste
Checked by: s7(2)(a)



- ### Legend
- ⊗ MH - Manhole
 - PP - Power Pole
 - - Shrub
 - 0.460 - Reduced level (RL) metres Related to LHCC datum
 - ⊕ B7 - Boring holes
 - ⚡ - Ground water level



NOTE
BORING DATA SHOWN HAS BEEN
ACQUIRED FROM BRICKELL, MOSS,
RANKINE & HILL "REPORT- FOUNDATION
INVESTIGATION- PROPOSED PUMPING
STATION, OXFORD TCE. LOWER HUTT."
DATED 4 JULY 1977.



WELLINGTON REGIONAL
WATER BOARD

R. G. BISHOP
CHIEF ENGINEER

NO	BY	VO	AMENDMENT	DATE

WELLINGTON REGIONAL WATER BOARD
WATERLOO PUMPING STATION

SITE SURVEY

**MORRISON, COOPER
& PARTNERS**

**Consulting Engineers and Architects
Wellington-Invercargill**

SCALES : 200, 1:100	DRAWN RAL
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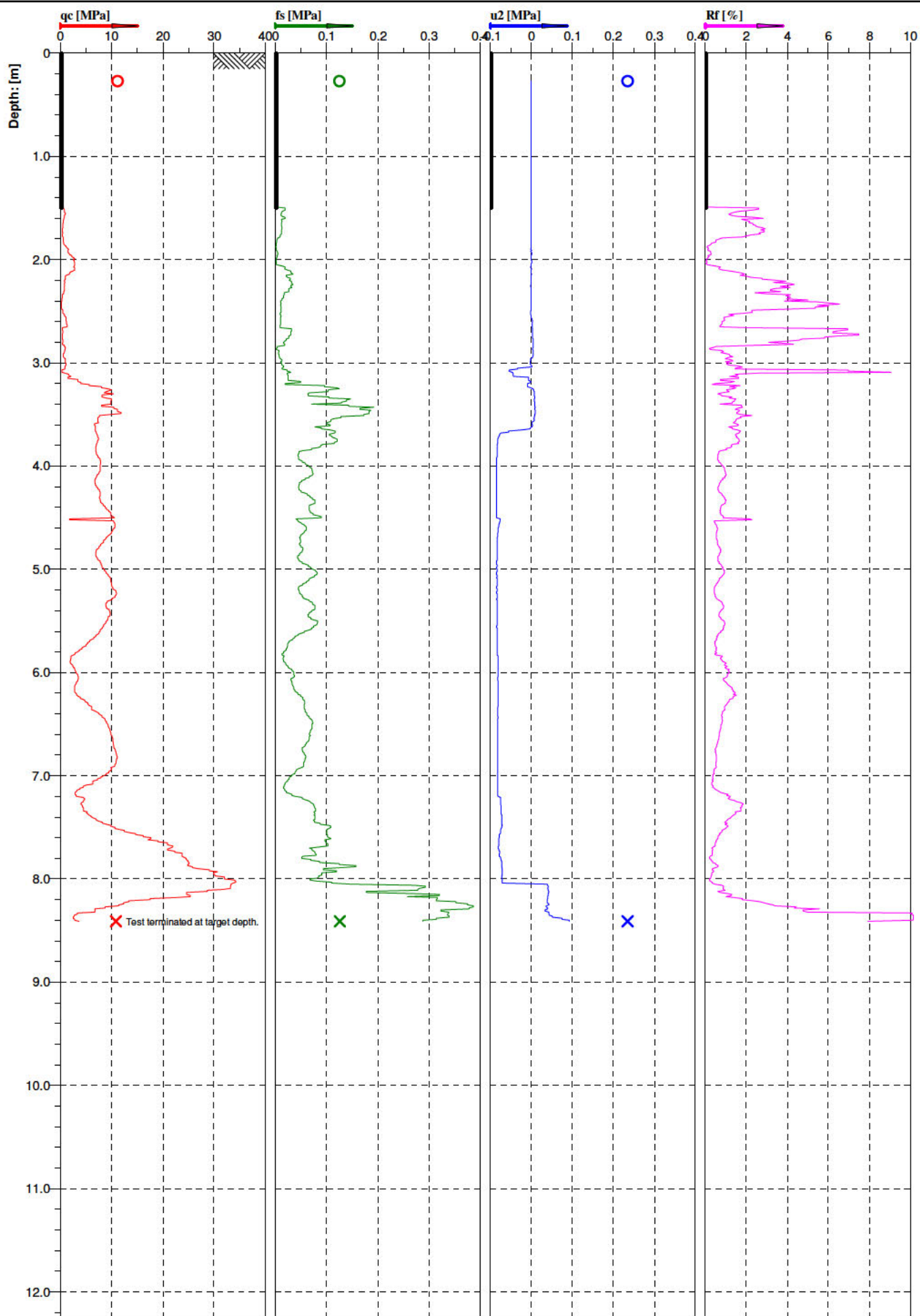
DATE FEB. 1978	APPROVED <i>[Signature]</i>
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DRAWING NUMBER	AMENDMENT
67073/A3	

BS 77/3

Appendix D

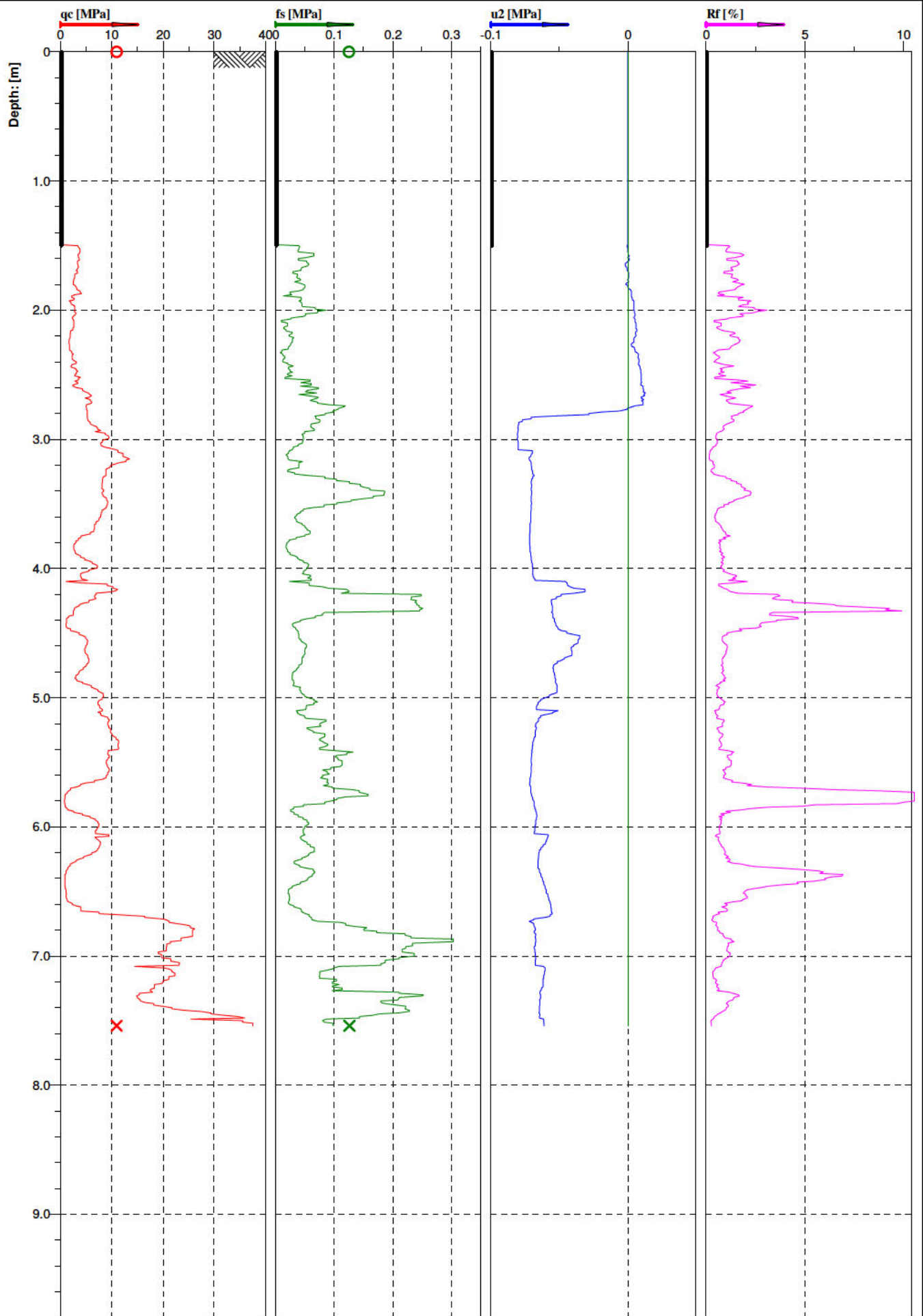
Cone Penetration Test Results



Griffiths Drilling

Cone No: 5336
Tip area [cm²]: 10
Sleeve area [cm²]: 150

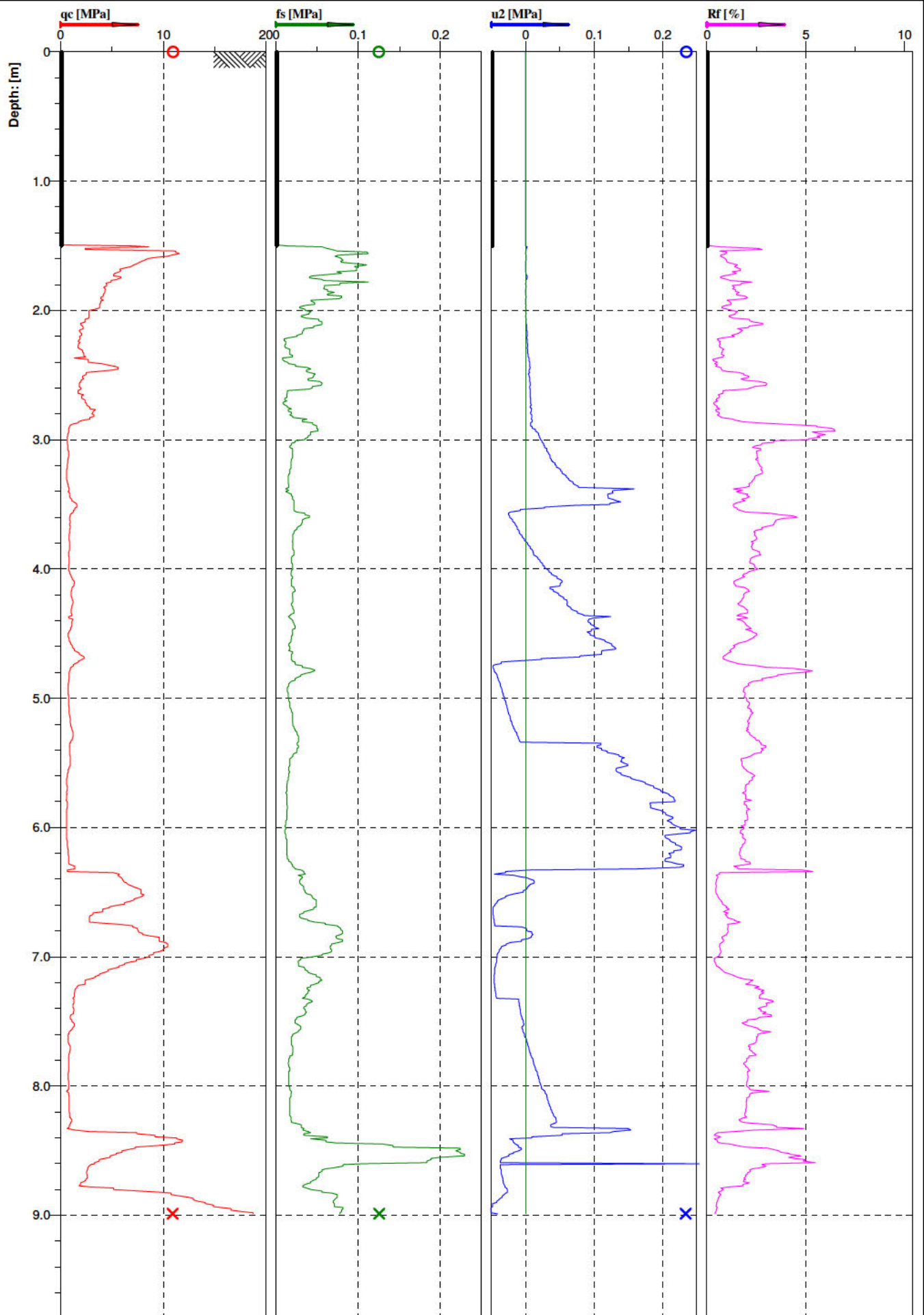
Location: 44D Oxford Terrace, Lower Hutt	Position:	Ground level: 0.00	Test No.: 1
Project ID: CPT101	Client: WSP	Date: 6/10/2020	Scale: 1 : 50
Project: Waterloo WTP		Page: 1/1	Fig.:
~1.5m Hydrovaccd, ~1.25m Backfilled. NB: fs graph max-value (0.4 MPa) increased compared to other Waterloo CTP graphs (0.35 MPa).		File: Waterloo CPT101.1.cpd	



Cone No: 5336
Tip area [cm²]: 10
Sleeve area [cm²]: 150

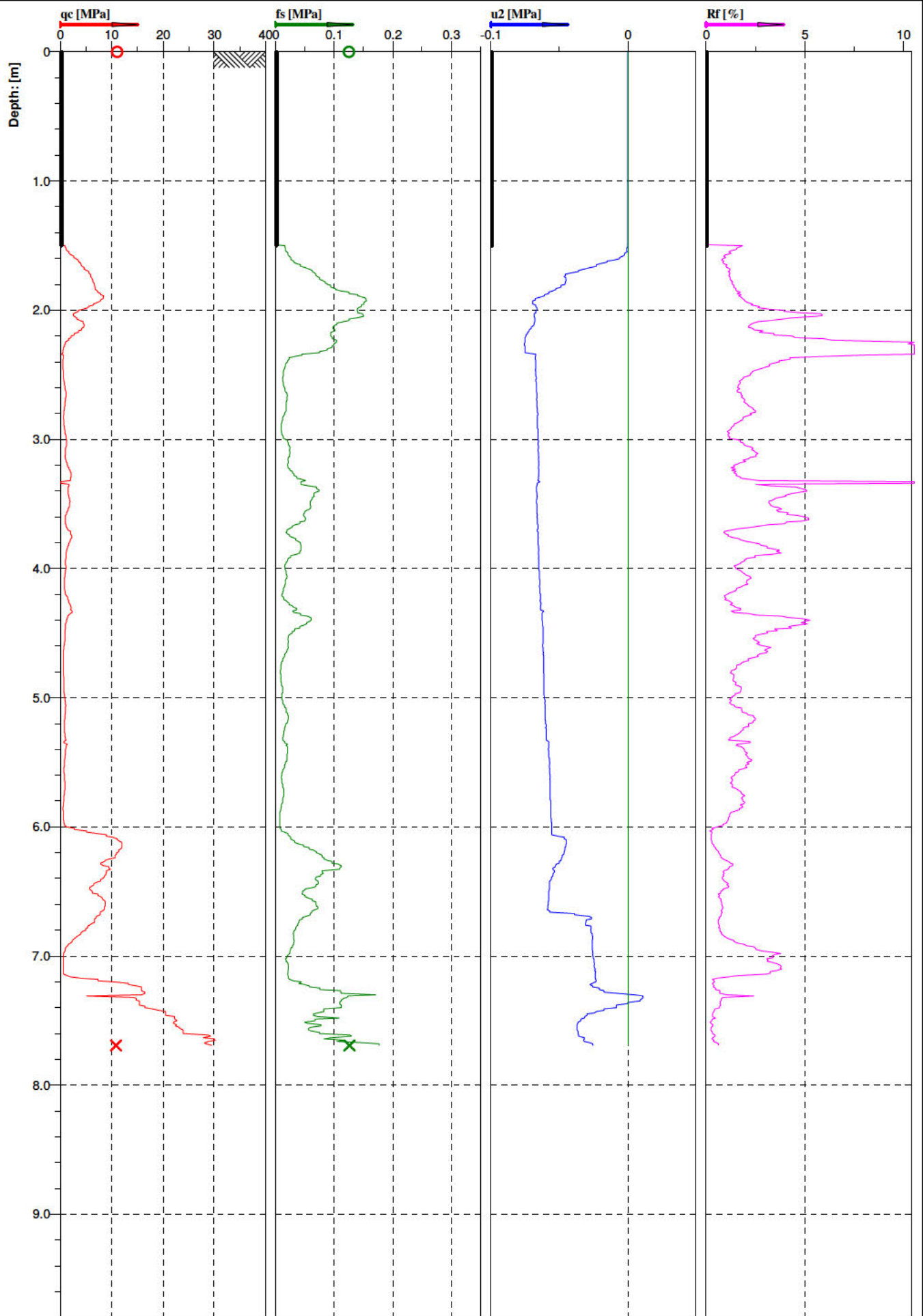


Location: 44D Oxford Terrace, Lower Hutt	Position:	Ground level: 0.00	Test No.: 1
Project ID: CPT102	Client: WSP	Date: 14/09/2020	Scale: 1 : 40
Project: Waterloo WTP		Page: 1/1	Fig.:
~1.5m Hydrovacted, ~1.25m Backfilled		File: WTP CPT3.1(102).cpd	



Cone No: 5336
Tip area [cm²]: 10
Sleeve area [cm²]: 150

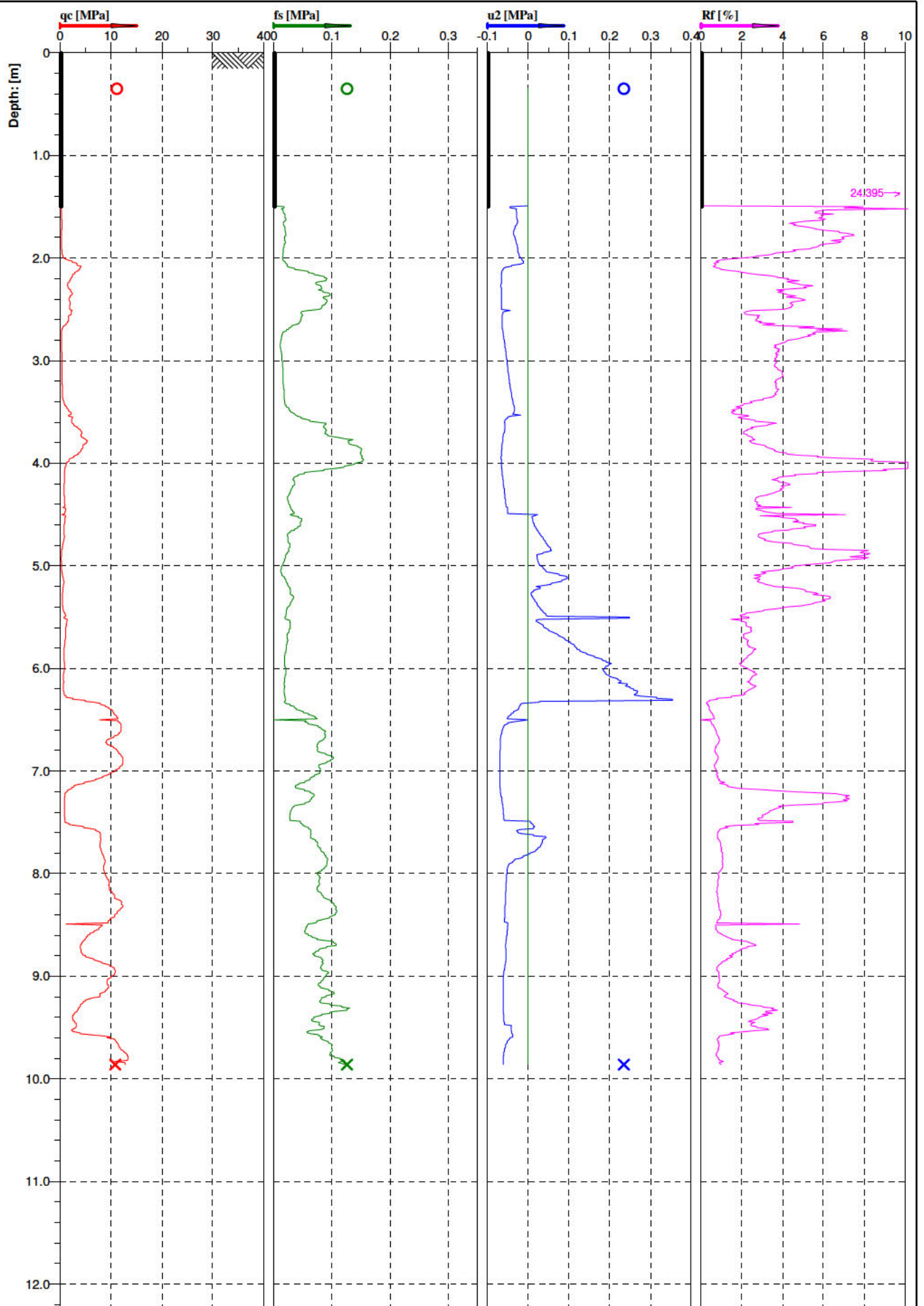
Location: 44D Oxford Terrace, Lower Hutt	Position:	Ground level: 0.00	Test No.: 1
Project ID: CPT103	Client: WSP	Date: 14/09/2020	Scale: 1 : 40
Project: Waterloo WTP		Page: 1/1	Fig.:
~1.5m Hydrovaccated & Backfilled		File: WTP CPT2.1(103).cpd	



Griffiths Drilling

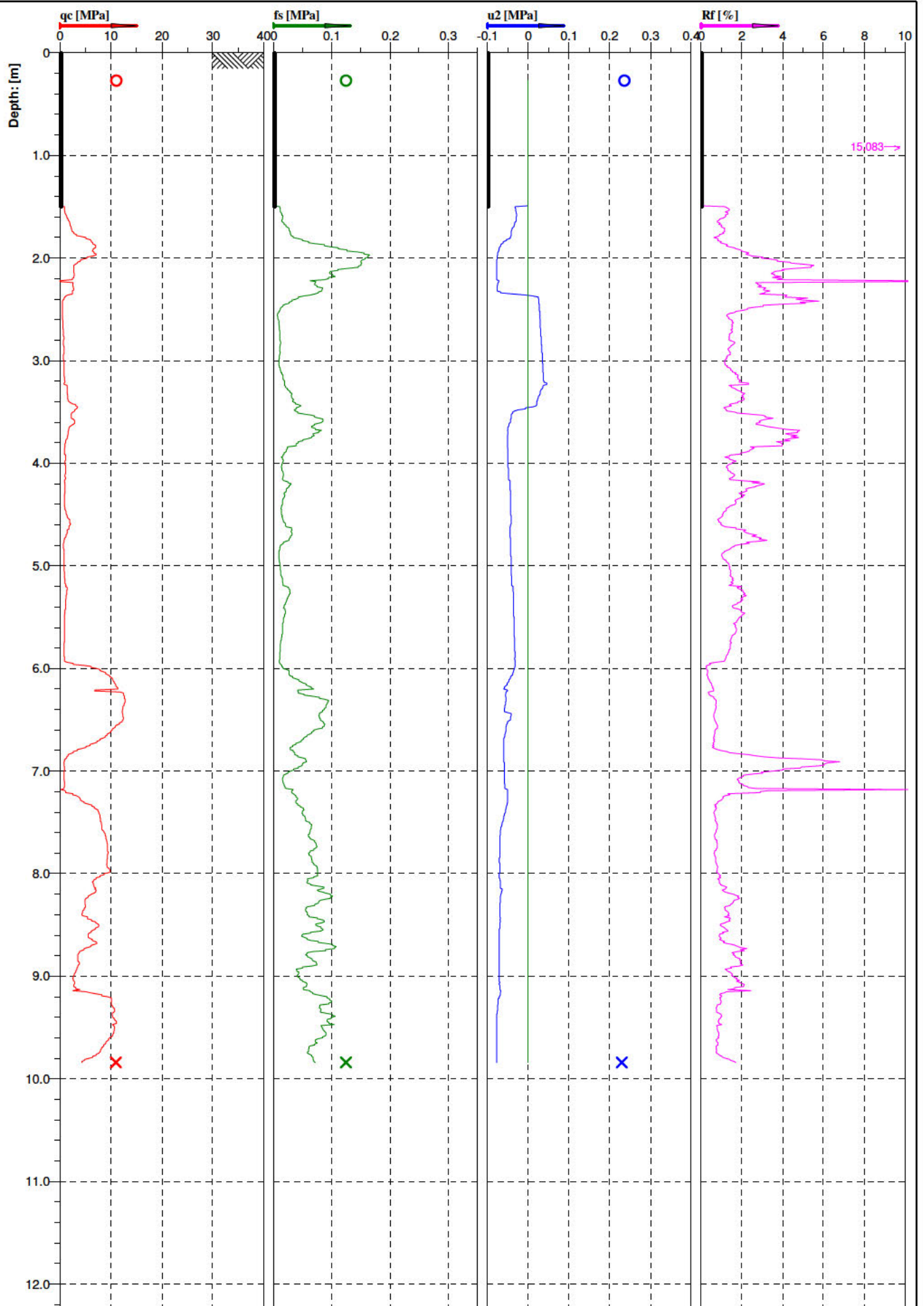
Cone No: 5336
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: 44D Oxford Terrace, Lower Hut	Position:	Ground level: 0.00	Test No.: 1
Project ID: CPT104	Client: WSP	Date: 14/09/2020	Scale: 1 : 40
Project: Waterloo WTP		Page: 1/1	Fig.:
~1.5m Hydrovaccated & Backfilled		File: WTP CPT1.1(104).cpd	



Cone No: 5336
Tip area [cm²]: 10
Sleeve area [cm²]: 150

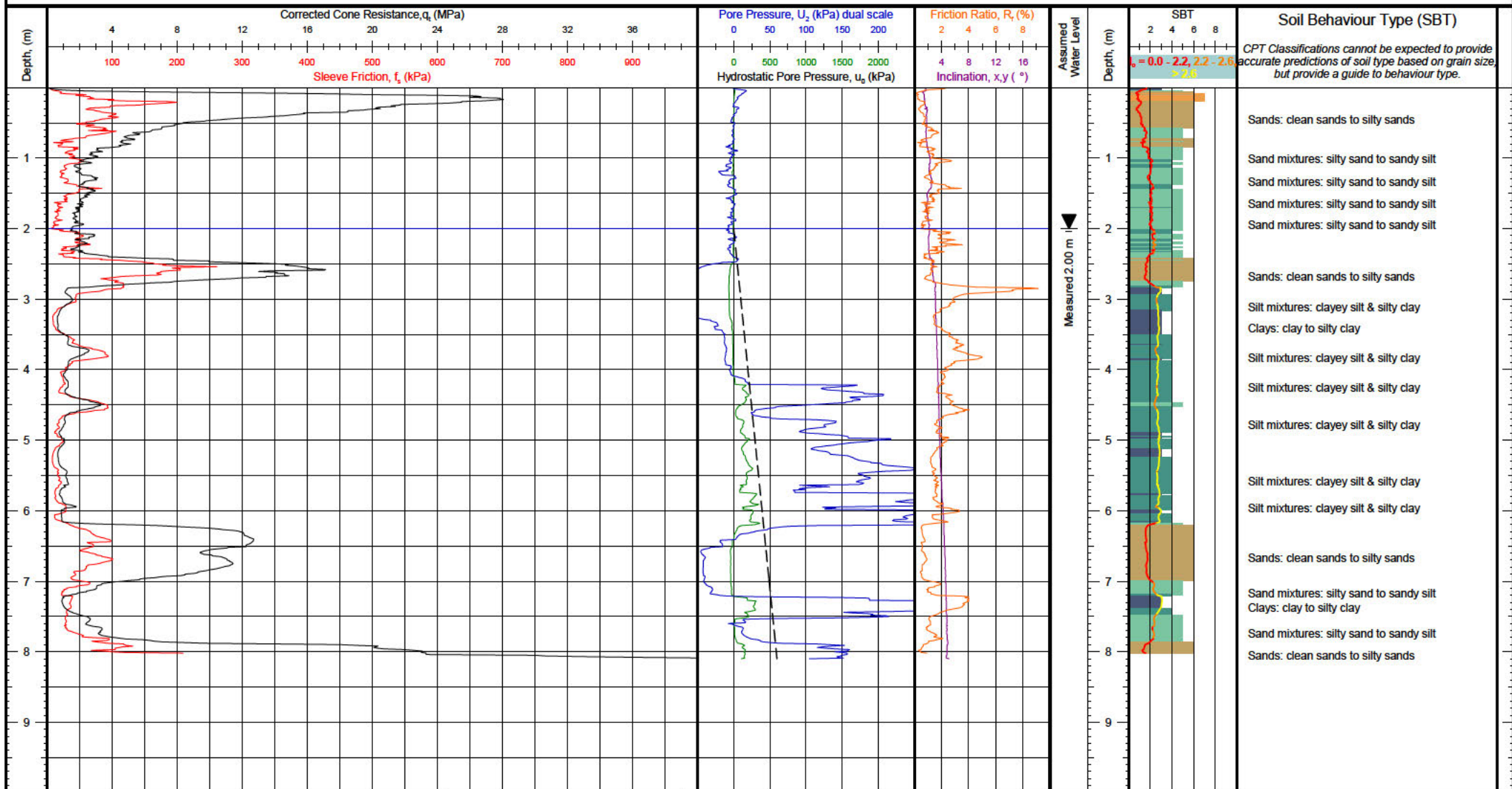
Location: 44D Oxford Terrace, Lower Hut	Position:	Ground level: 0.00	Test No.: 2
Project ID: CPT105	Client: WSP	Date: 16/09/2020	Scale: 1 : 50
Project: Waterloo WTP		Page: 1/1	Fig.:
~1.5m Hydrovacted, backfilled, inactive cone penetrated 0.35m, POOH, cleaned & reset		File: WaterlooCPT105.2.cpd	



Cone No: 5336
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: 44D Oxford Terrace, Lower Hutt	Position:	Ground level: 0.00	Test No.: 1
Project ID: CPT106	Client: WSP	Date: 16/09/2020	Scale: 1 : 50
Project: Waterloo WTP		Page: 1/1	Fig.:
~1.5m Hydrovacted, backfilled, inactive cone penetrated 0.27m, POOH, cleaned & reset		File: WaterlooCPT106.cpd	

CONE PENETRATION TEST (CPT) LOG



Client: Griffiths Drilling
Project: Waterloo Water Treatment Plant
Location: 44D Oxford Terrace, Lower Hutt, Wellington
Engineer: S7(2)(a)
Contractor: Ground Investigation Ltd.

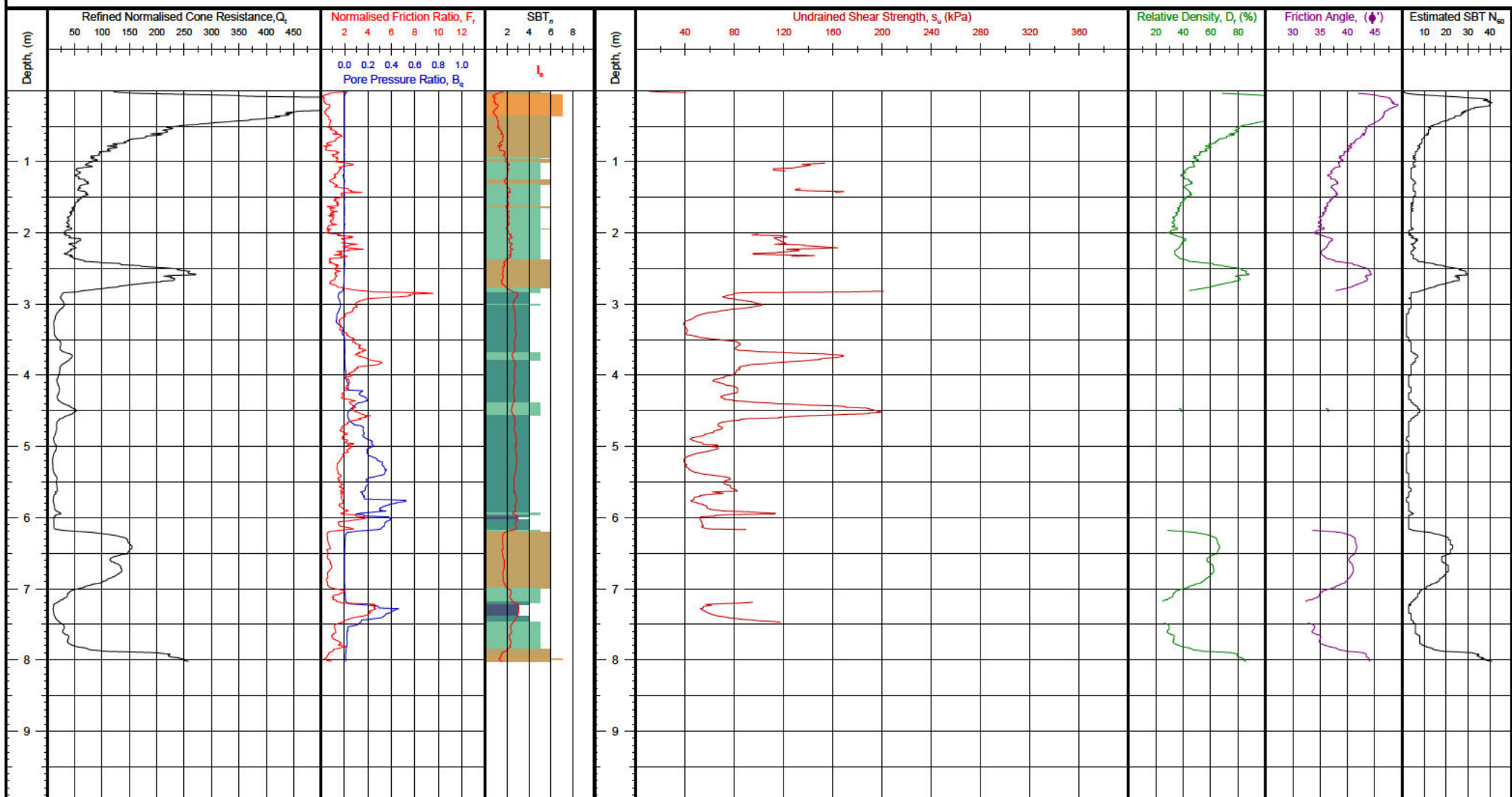
Operator: S7(2)(a)
Cone Ref: MKJ540
Cone Type: 10cm² Compression
Area Ratio: 0.8
Filter Type: u₂

NZTM 2000 N, E (m): 5435791.96, 1761117.52
WGS84 (deg): -41.213223, 174.921909
Location Method: Handheld GPS
Surveyor:
Termination Reason: Limit of reaction force

Elevation (m): Unknown
Date of Test: 15/09/2020
Depth (m): 8.10
Pre Drill (m): N/A

Client Job Ref:
Test Number: CPT-107
G.I. Job Ref: 200454

Comments:



Client: Griffiths Drilling
Project: Waterloo Water Treatment Plant
Location: 44D Oxford Terrace, Lower Hutt, Wellington
Engineer: S7(2)(a)
Contractor: Ground Investigation Ltd.

Soil Behaviour Type SBT_n - Robertson et al. 1990

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine grained	6	Sands: clean sands to silty sands
2	Organic: Organic clay/silt, peat	7	Dense sand to gravelly sand
3	Clay: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff silt/clay

Notes and Limitations:

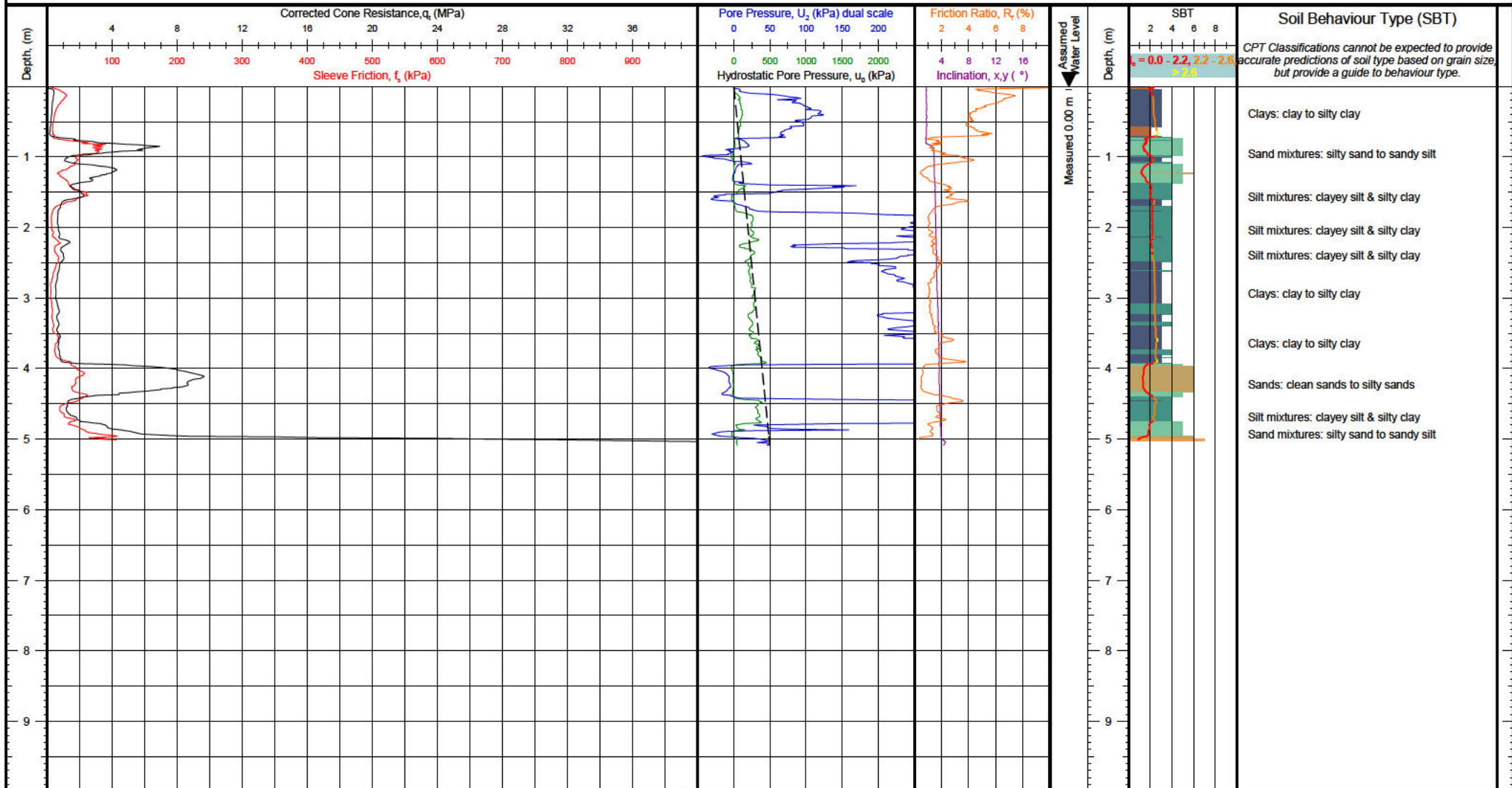
Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P.K. Robertson and K.L. Cabel (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed by the user. Ground Investigation Ltd. does not warrant the correctness or applicability of any of the geotechnical soil and design parameter shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Client Job Ref:

Test Number: CPT-107

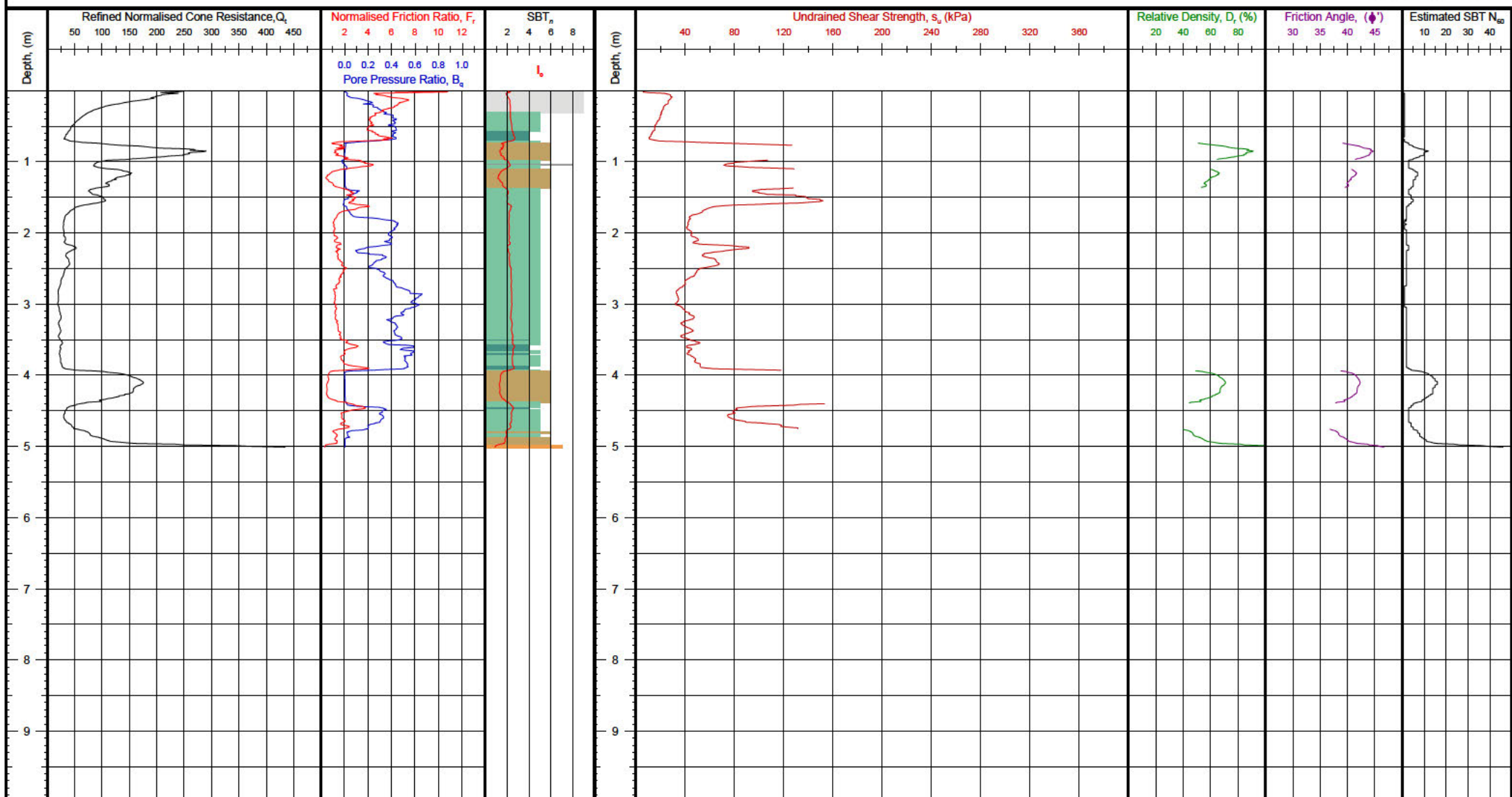
G.I. Job Ref: 200454

CONE PENETRATION TEST (CPT) LOG



Client: Griffiths Drilling	Operator: S7(2)(a)	NZTM 2000 N, E (m): 5435789.85, 1761097.68	Elevation (m): Unknown	Client Job Ref:
Project: Waterloo Water Treatment Plant	Cone Ref: MKJ540	WGS84 (deg): -41.213246, 174.921673	Date of Test: 15/09/2020	
Location: 44D Oxford Terrace, Lower Hutt, Wellington	Cone Type: 10cm ² Compression	Location Method: Handheld GPS	Depth (m): 5.09	Test Number: CPT-109
Engineer: S7(2)(a)	Area Ratio: 0.8	Surveyor:	Pre Drill (m): N/A	
Contractor: Ground Investigation Ltd.	Filter Type: u ₂	Termination Reason: Limit of reaction force		G.I. Job Ref: 200454

Comments:



Client: Griffiths Drilling
Project: Waterloo Water Treatment Plant
Location: 44D Oxford Terrace, Lower Hutt, Wellington
Engineer: S7(2)(a)
Contractor: Ground Investigation Ltd.

Soil Behaviour Type SBT_n - Robertson et al. 1990

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine grained	6	Sands: clean sands to silty sands
2	Organic: Organic clay/silt, peat	7	Dense sand to gravelly sand
3	Clay: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff silt/clay

Notes and Limitations:

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P.K. Robertson and K.L. Cabel (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed by the user. Ground Investigation Ltd. does not warrant the correctness or applicability of any of the geotechnical soil and design parameter shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

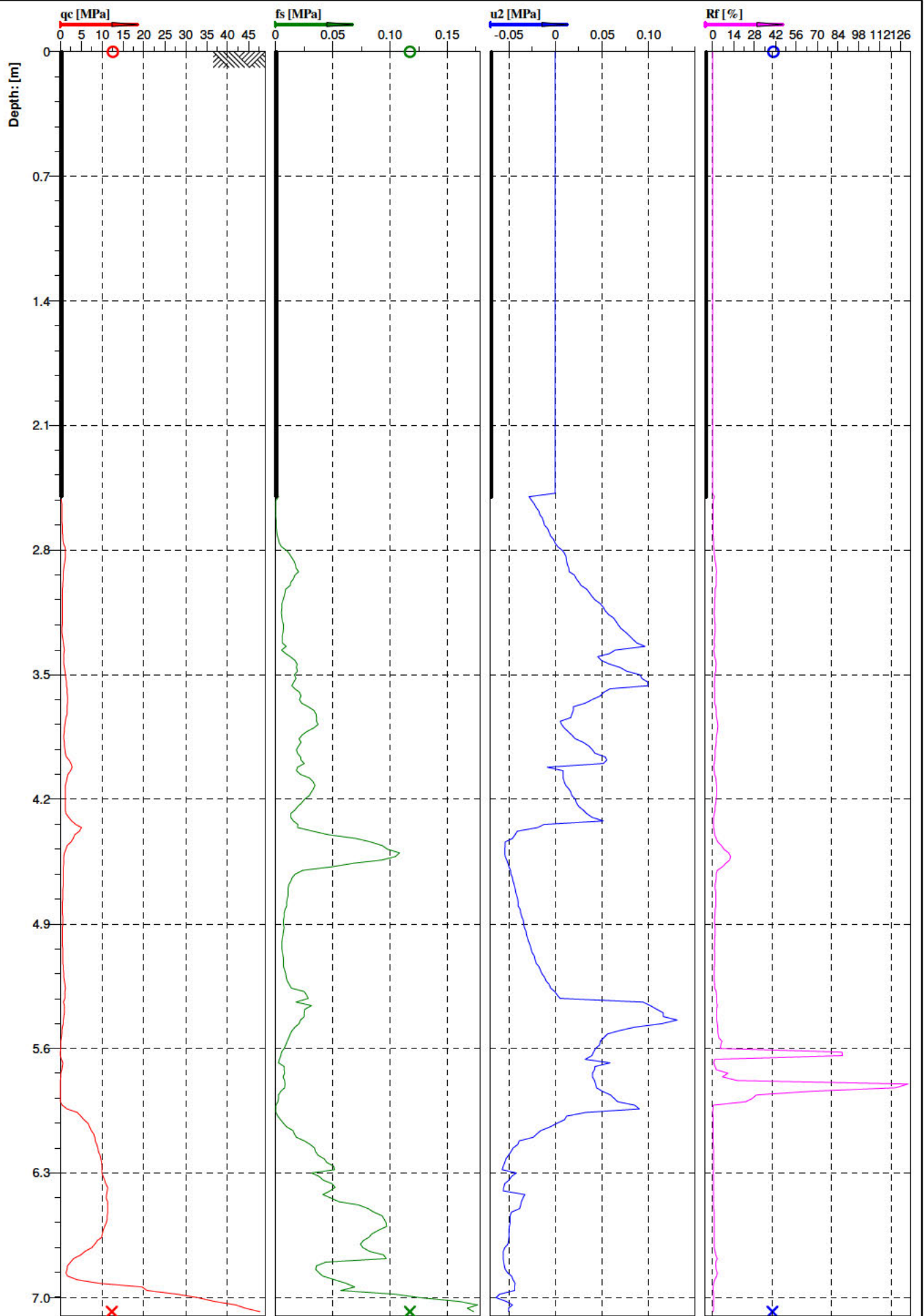
Client Job Ref:

Test Number: CPT-109

G.I. Job Ref: 200454

200454

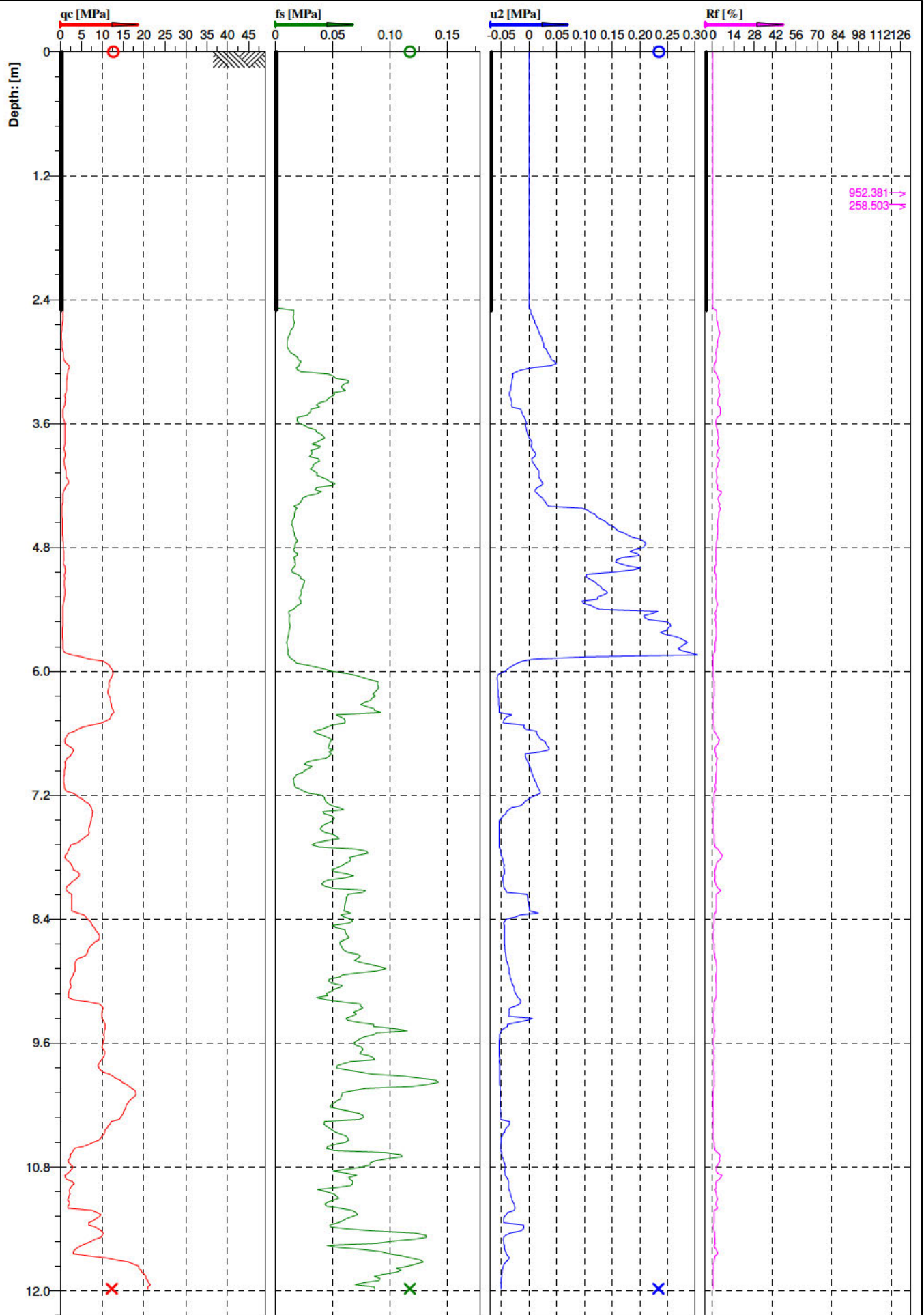
Cone Reference	CPT Name	Push Number	Tip Resistance			Local Friction			Pore Pressure		
			Initial (MPa)	Final (MPa)	Difference (kPa)	Initial (MPa)	Final (MPa)	Difference (kPa)	Initial (MPa)	Final (MPa)	Difference (kPa)
MKJ540	CPT-107	1	20.970	20.920	-50.0	0.2640	0.2613	-2.7	2.8470	2.8657	18.7
MKJ540	CPT-109	1	20.980	20.960	-20.0	0.2640	0.2612	-2.8	2.8388	2.8701	31.3



Cone No: 4616
Tip area [cm²]: 10
Sleeve area [cm²]: 150



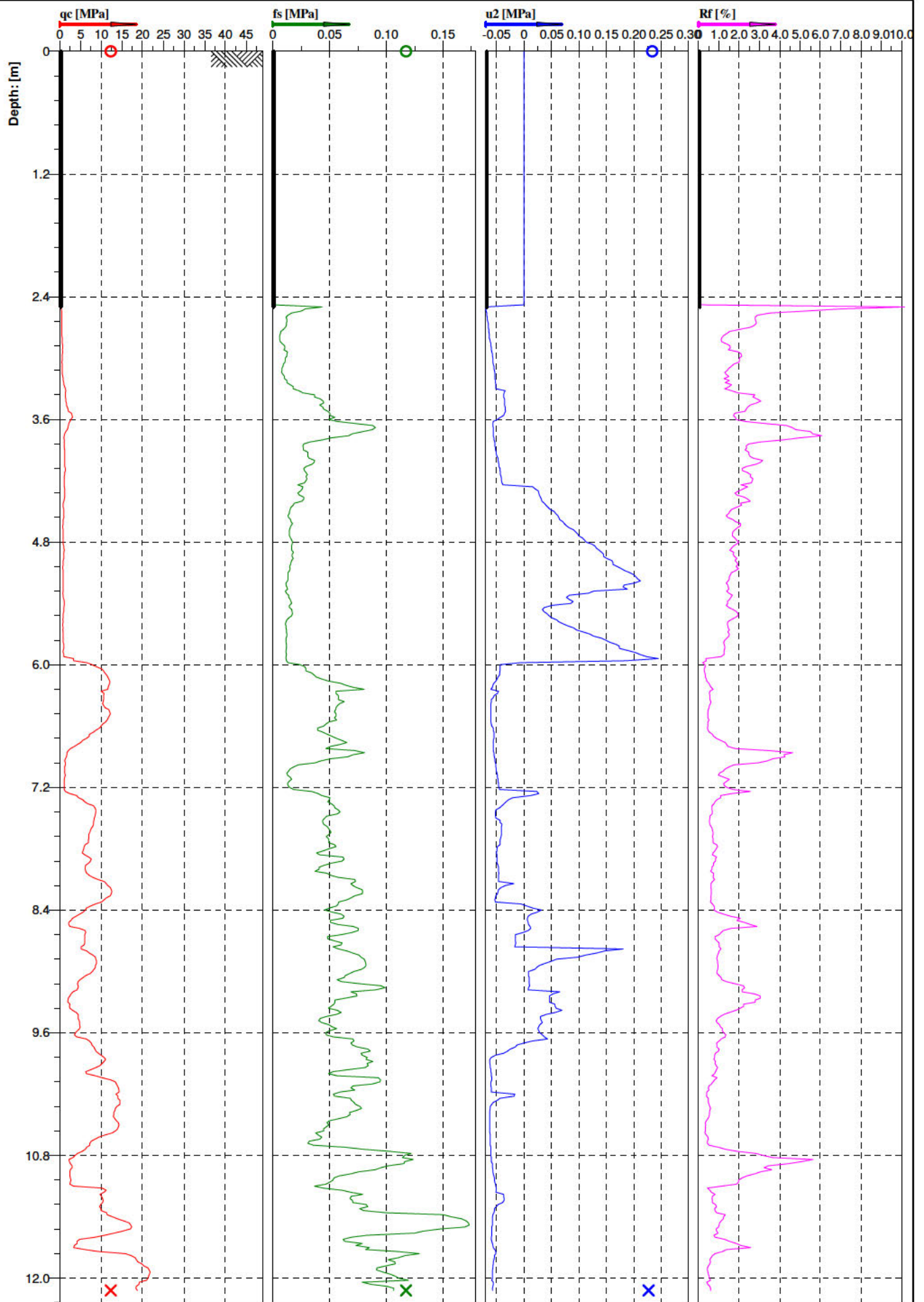
Location: Waterloo WTP, Lower Hutt	Position: S41°12.789', E174°53.300'	Ground level: 0.00	Test No.: CPT4
Project ID: 4	Client: Opus	Date: 10/10/2016	Scale: 1 : 29
Project: Waterloo Water Treatment Plant		Page: 1/1	Fig.:
Qc Refusal		File: cpt4.cpt	



Cone No: 4616
Tip area [cm²]: 10
Sleeve area [cm²]: 150

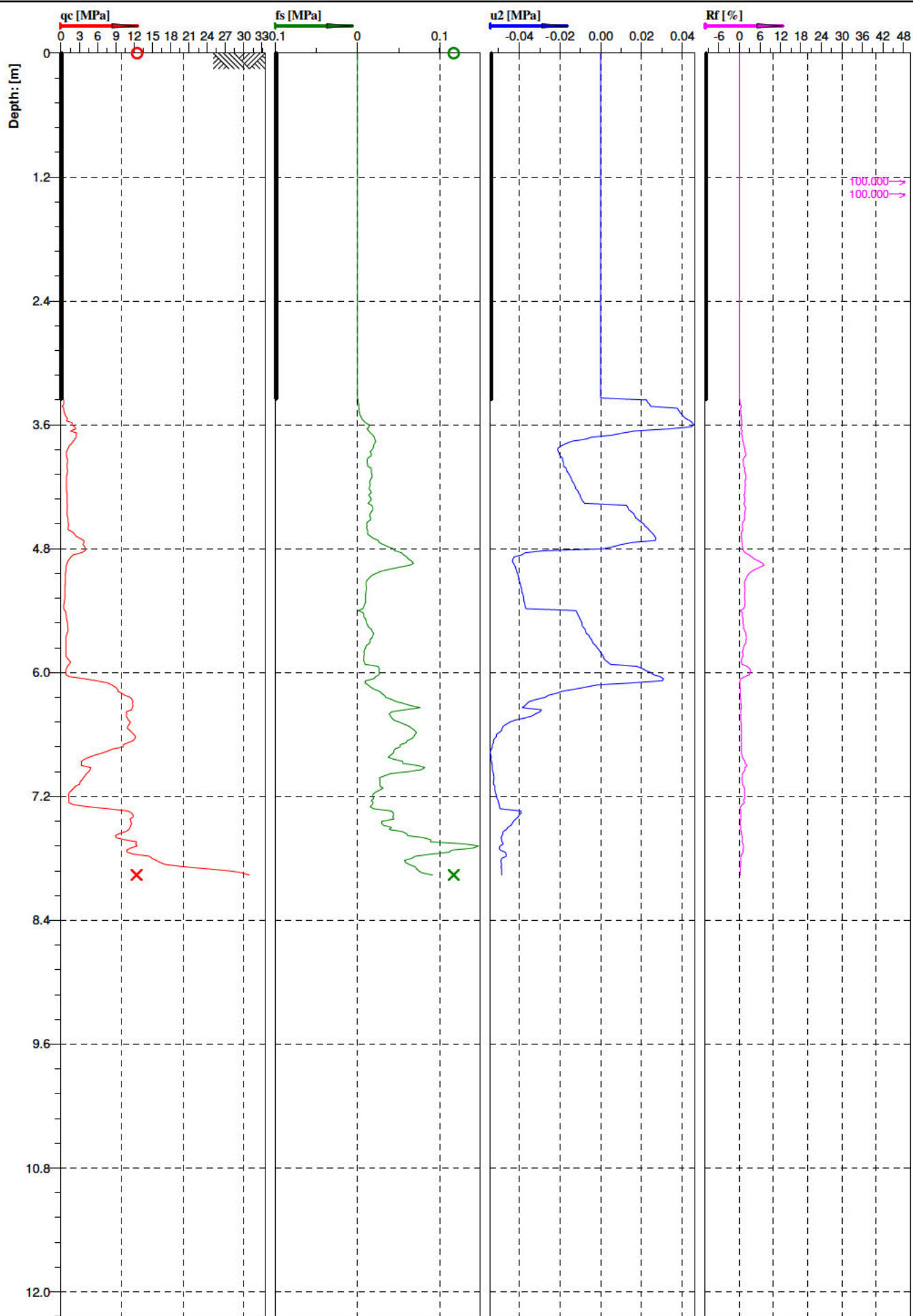


Location: Waterloo WTP, Lower Hutt	Position: S41°12.784', E174°55.314'	Ground level: 0.00	Test No.: CPT5
Project ID: 5	Client: Opus	Date: 10/10/2016	Scale: 1 : 50
Project: Waterloo Water Treatment Plant		Page: 1/1	Fig.:
		File: cpt5.cpt	



Cone No: 4616
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: Waterloo WTP, Lower Hutt	Position: S41°12.801', E174°55.320'	Ground level: 0.00	Test No.: CPT6
Project ID: 6	Client: Opus	Date: 10/10/2016	Scale: 1 : 50
Project: Waterloo Water Treatment Plant		Page: 1/1	Fig.:
		File: cpt6.cpt	

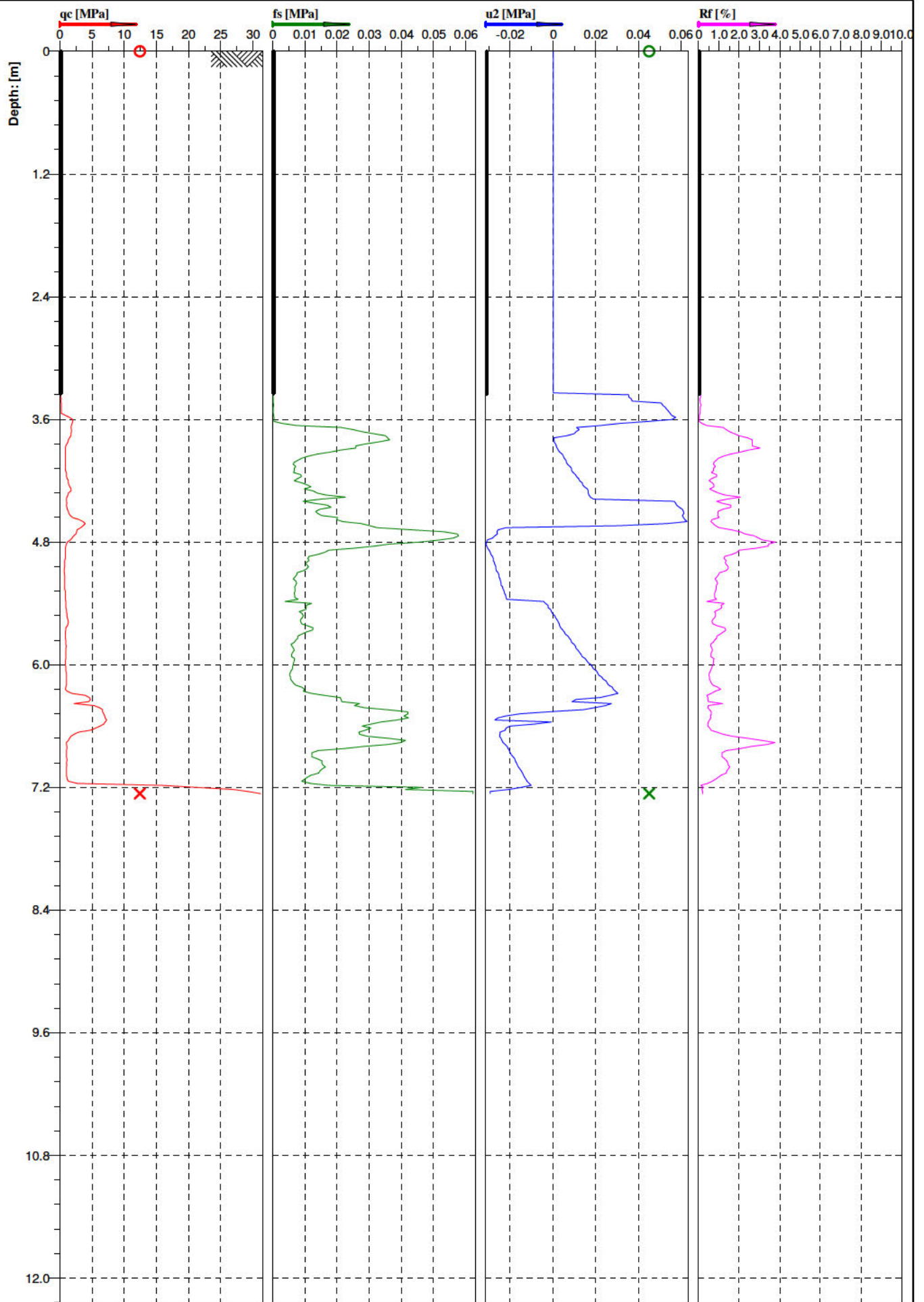


GRIFFITHS DRILLING



Cone No: 4616
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location:	Waterloo WTP	Position:	S41°12.798', E174°55.313'	Ground level:	0.00	Test No.:	CPT7
Project ID:	7	Client:	Opus	Date:	19/10/2016	Scale:	1 : 50
Project:	WATERLOO			Page:	1/1	Fig.:	
Qc Refusal				File:	cpt7.cpt		



Cone No: 4616
Tip area [cm²]: 10
Sleeve area [cm²]: 150



Location:	Waterloo WTP	Position:	S41°12.810', E174°55.295'	Ground level:	0.00	Test No.:	CPT9
Project ID:	9	Client:	Opus	Date:	19/10/2016	Scale:	1 : 50
Project:	WATERLOO			Page:	1/1	Fig.:	
Qc Refusal				File:	cpt9.cpt		

Appendix E

Laboratory Testing Results

Cyclic triaxial test for WSP OPUS**(Waterloo WTP Project)****Test 1 (BH-101, 3.0 - 3.45 m)**

Auckland UniServices Limited

70 Symonds St, Auckland 1142

Sample: BH-101, 3.0 - 3.45m	Depth (m): 3.0 – 3.45m	Formation: -
Test start: 19 August 2019	Test end: 22 August 2019	Initial mass (gr): 729.2
Initial length (mm): 126	Initial diameter (mm): 61.4	Initial unit weight (kN/m ³): 19.1
Effective consolidation pressure (kPa): 50		Consolidation volume change (ml): 7.5
Initial water content (%): 27.5		Final water content (%): 26.8
Target CSR: 0.67		Cyclic axial stress at CSR (kPa): 67
Number of cycles to 5% DA axial strain: 2		Number of cycles to $U_{cyc} / \sigma'_{30} = 0.95$: NA
Test performed by: s7(2)(a)		Apparatus: Geomechanics lab MTS810
Comments: After saturation and consolidation stages, the specimen was subjected to stress-controlled cyclic loading with frequency of 0.1 Hz. After liquefaction was observed ($\epsilon_{DA} = 5\%$), the specimen was subjected to strain-controlled monotonic load to about 5% axial strain at rate of 0.01 mm/sec. <u>Minor Incident:</u> During the consolidation stage, the data acquisition system did not save the data for unknown reasons; hence, in this report, a snapshot of the volume change versus time plot is taken from the data acquisition software (as illustrated in Figure 4).		

Photos:

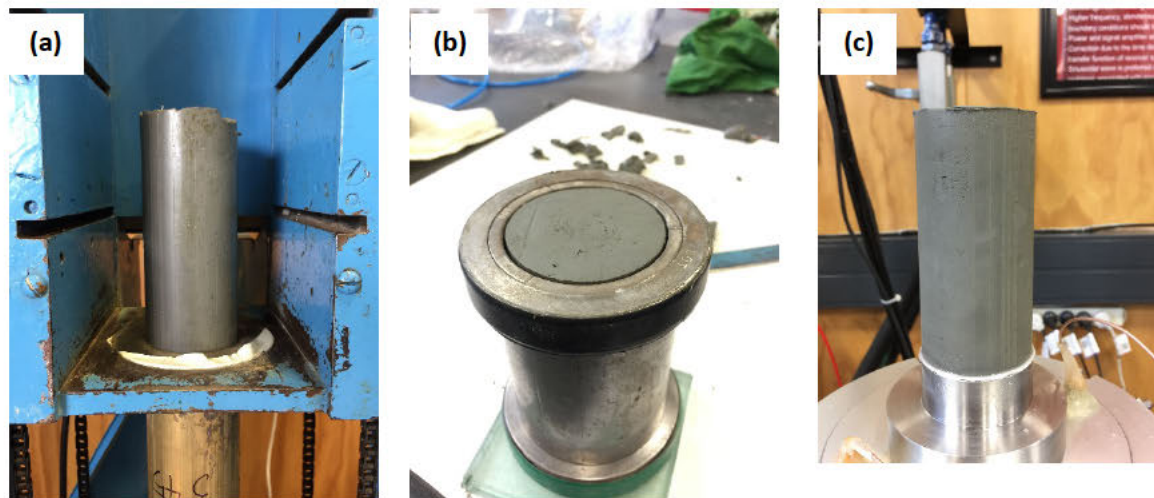


Figure 1: Specimen preparation for the triaxial test: (a) extruding the soil sample using a hydraulic jack; (b) trimming the specimen end inside the mould; (c) set up of specimen in the triaxial cell.

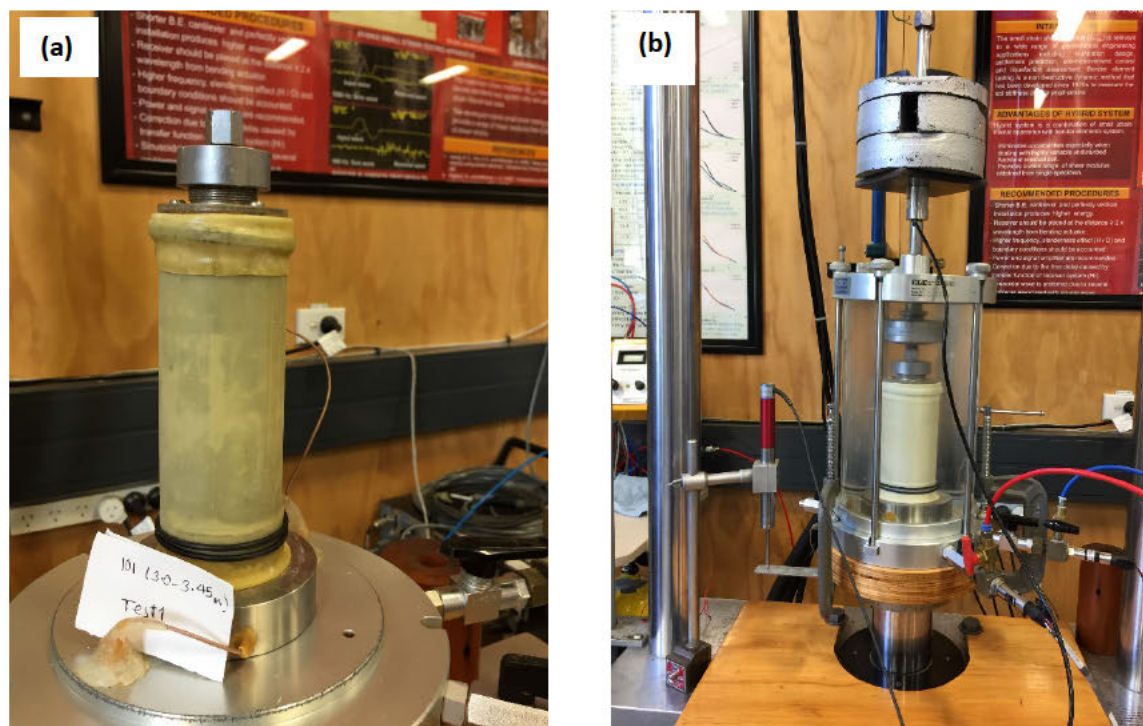


Figure 2: (a) Specimen enclosed with rubber membrane secured to the top cap and pedestal with O-rings; (b) filling the triaxial cell with water.



Figure 3: Condition of the specimen: (a) after undrained cyclic loading and before post-monotonic loading; (b) after post-monotonic loading; (c) after post-monotonic loading without the membrane.

Consolidation stage:

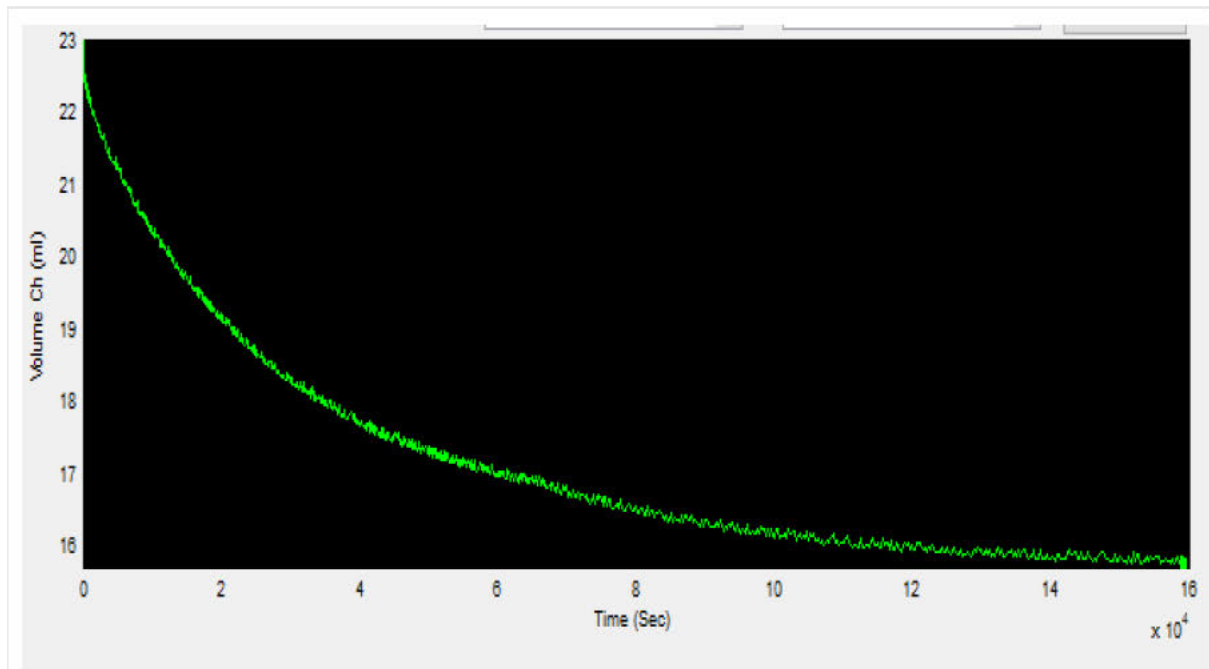


Figure 4: Consolidation volume change vs time.

Cyclic shear stage:

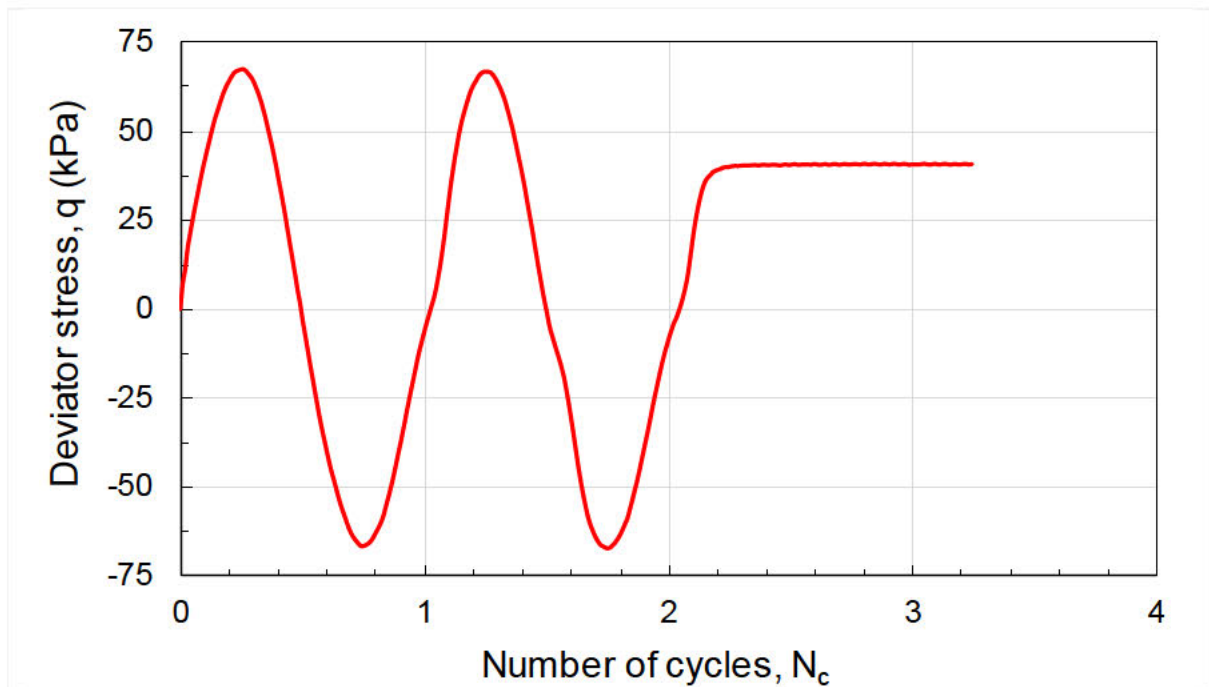


Figure 5: Deviator stress vs number of cycles

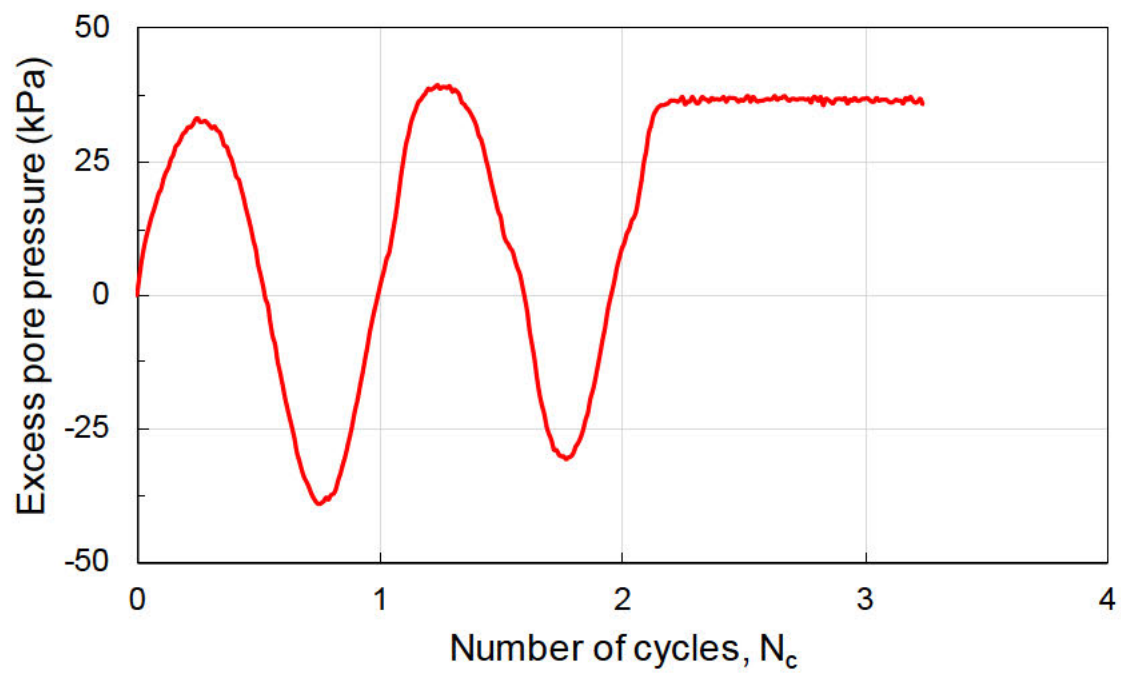


Figure 6: Excess pore water pressure vs number of cycles

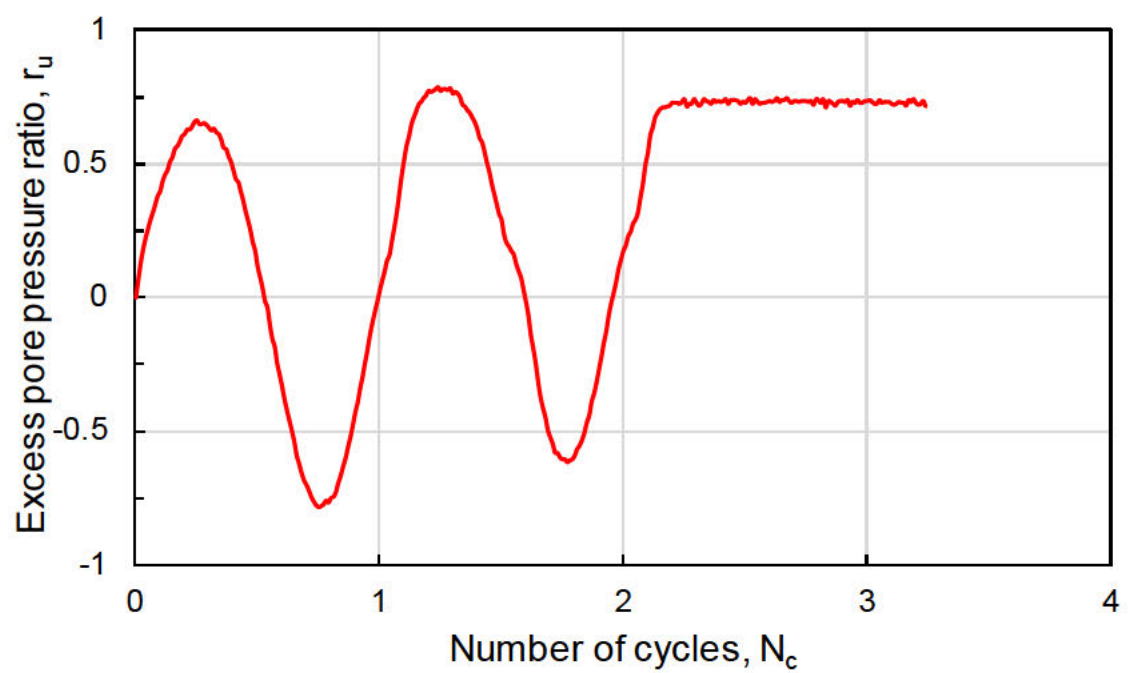


Figure 7: Excess pore water pressure ratio vs number of cycles

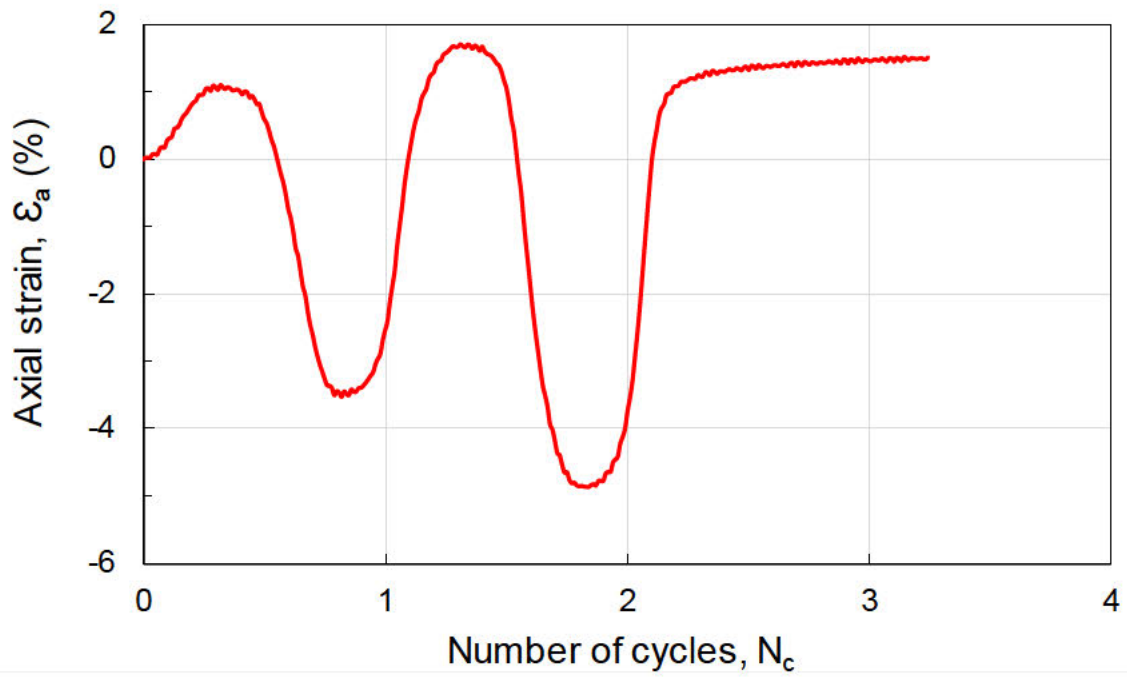


Figure 8: Axial strain vs number of cycles

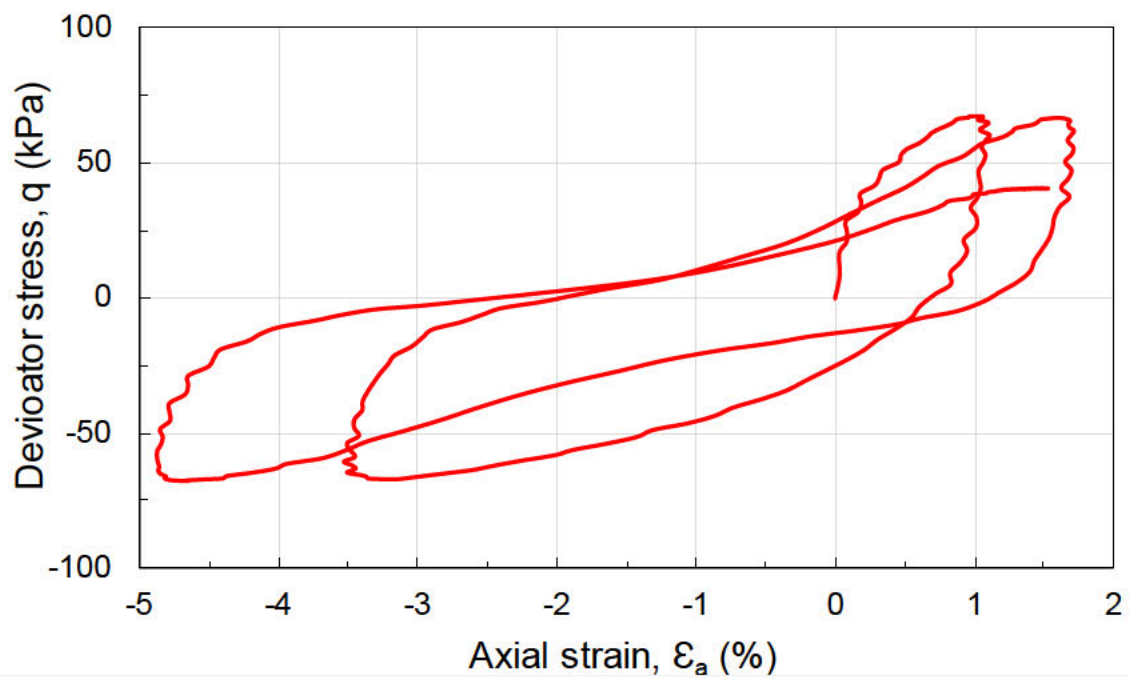


Figure 9: Deviator stress vs axial strain

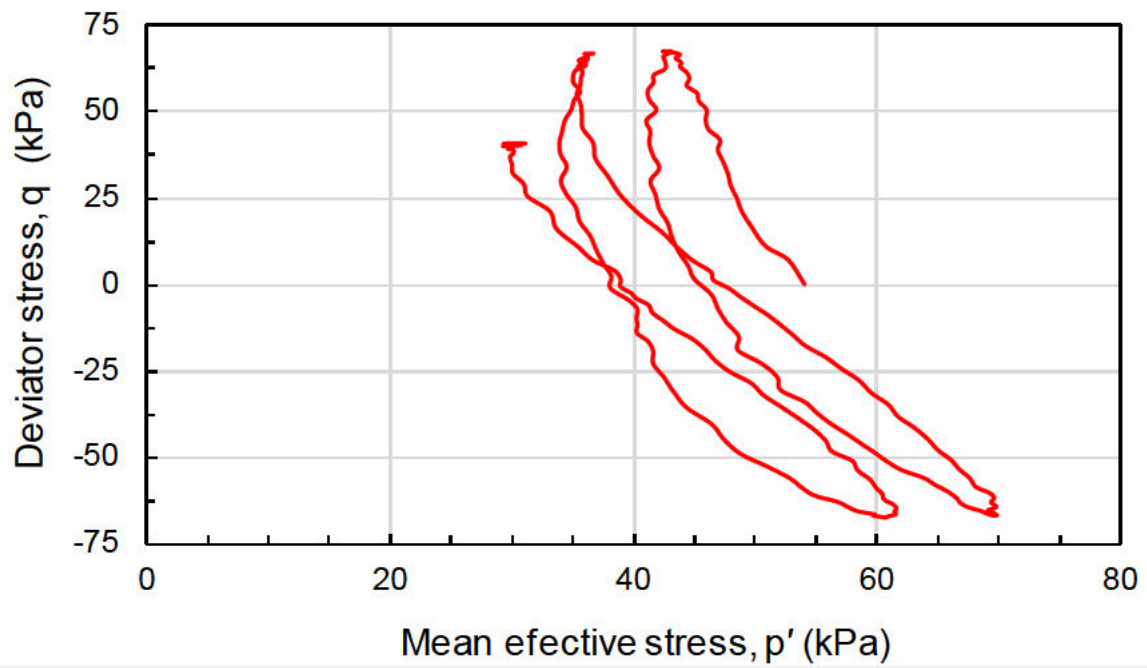


Figure 10: Deviator stress vs mean effective stress

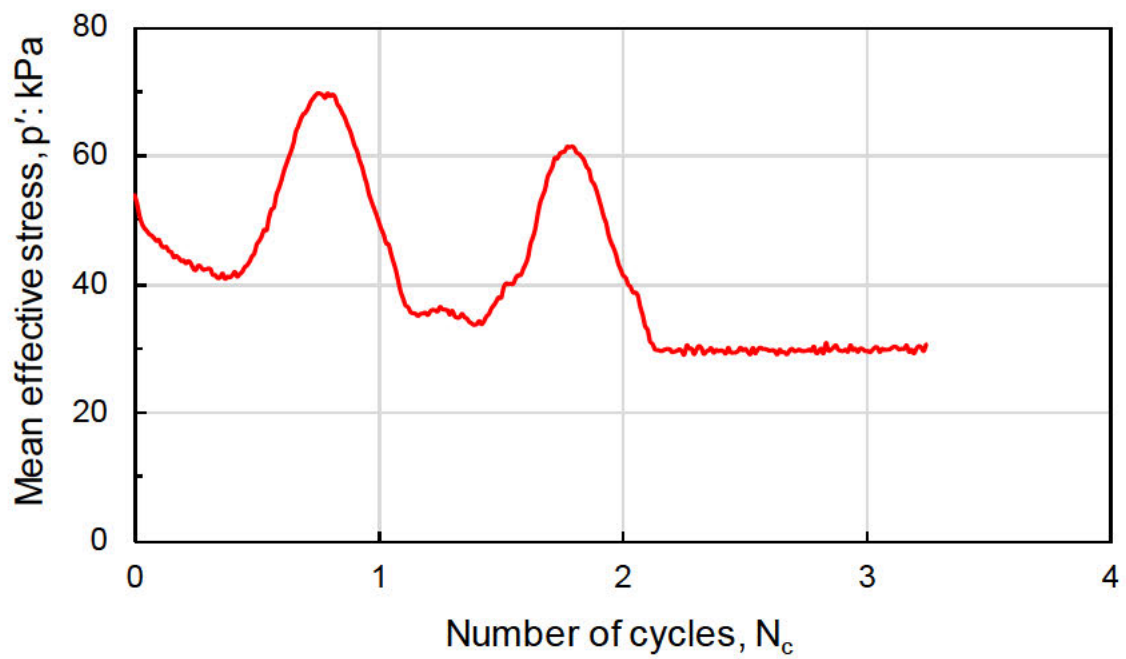


Figure 11: Mean effective stress vs number of cycles.

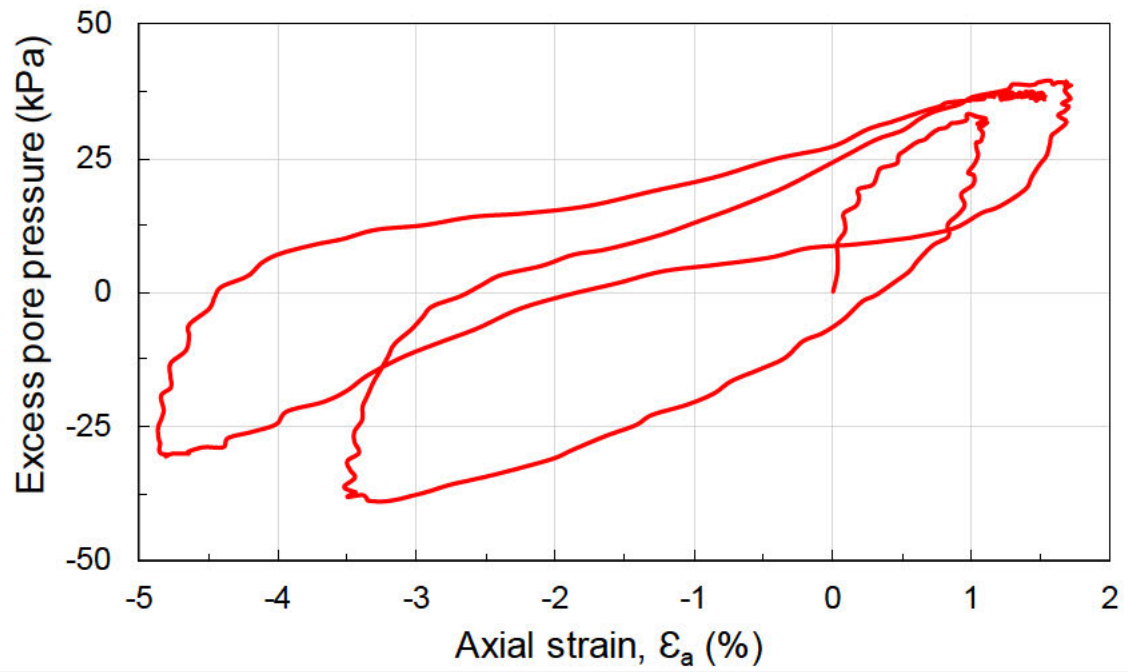


Figure 12: Excess pore water pressure vs axial strain

Post-cyclic monotonic shear stage:

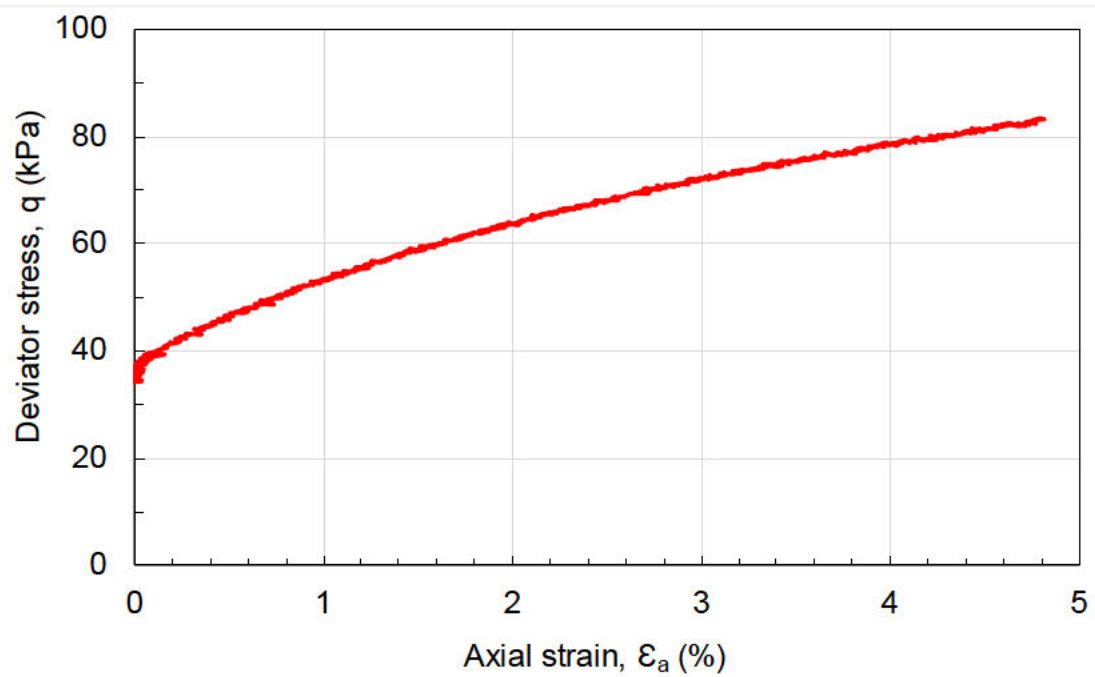


Figure 13: Deviator stress vs axial strain

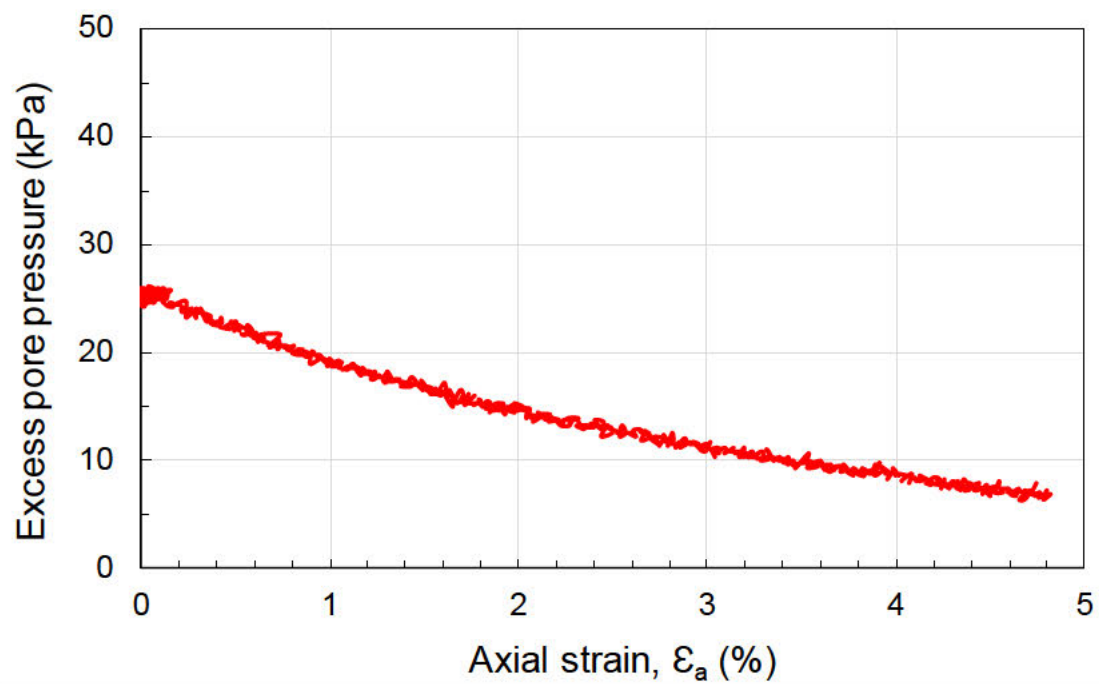


Figure 14: Excess pore water pressure vs axial strain

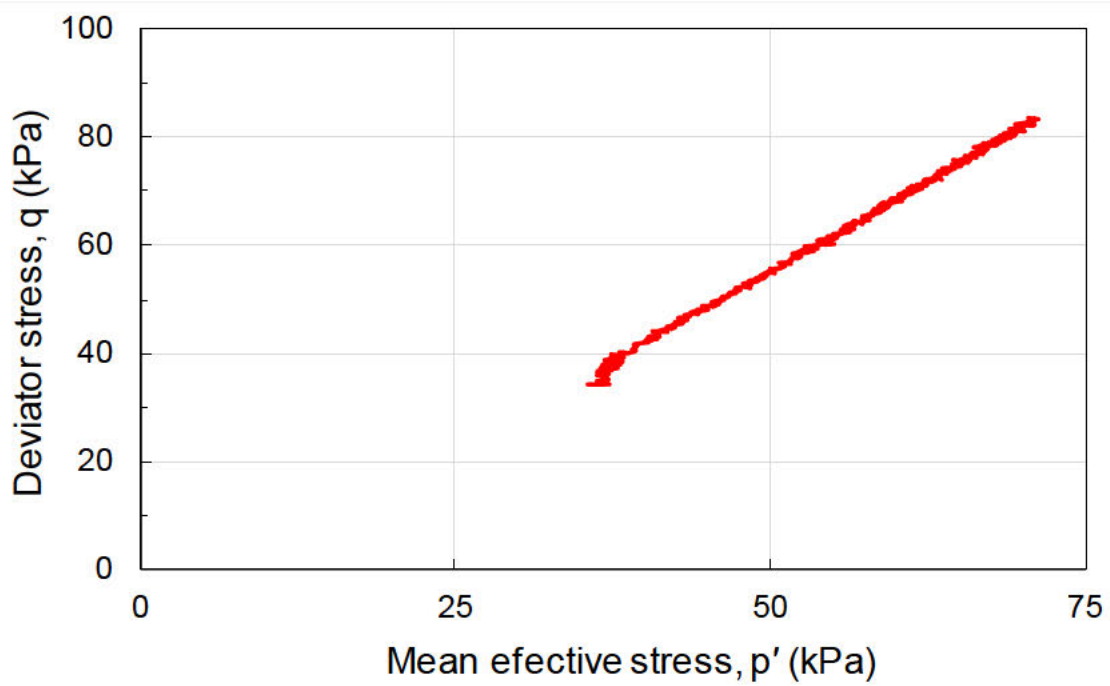


Figure 15: Post-cyclic stress path

Cyclic triaxial test for WSP OPUS**(Waterloo WTP Project)****Test 2 (BH-101, 3.0 - 3.45 m)**

Auckland UniServices Limited

70 Symonds St, Auckland 1142

Sample: BH-101, 3.0 - 3.45m	Depth (m): 3.0 - 3.45m	Formation: -
Test start: 22 October 2020	Test end: 27 October 2020	Initial mass (gr): 729.14
Initial length (mm): 126	Initial diameter (mm): 61.5	Initial unit weight (kN/m ³): 19.2
Effective consolidation pressure (kPa): 50		Consolidation volume change (ml): 7.3
Initial water content (%): 25.2		Final water content (%): 23.9
Target CSR: 0.37		Cyclic axial stress at CSR (kPa): 37
Number of cycles to 5% DA axial strain: 20		Number of cycles to $U_{cyc} / \sigma'_{30} = 0.95$: NA
Test performed by: s7(2)(a)		Apparatus: Geomechanics lab MTS810
Comments: After saturation and consolidation stages, the specimen was subjected to stress-controlled cyclic loading with frequency of 0.1 Hz. The specimen reached 5% double amplitude axial stain after 20 cycles of loading. The cyclic test was terminated after 30 cycles of loading. After cyclic test, the specimen was subjected to strain-controlled monotonic load to failure (i.e. large deformation) at rate of 0.01 mm/sec.		

Photos:

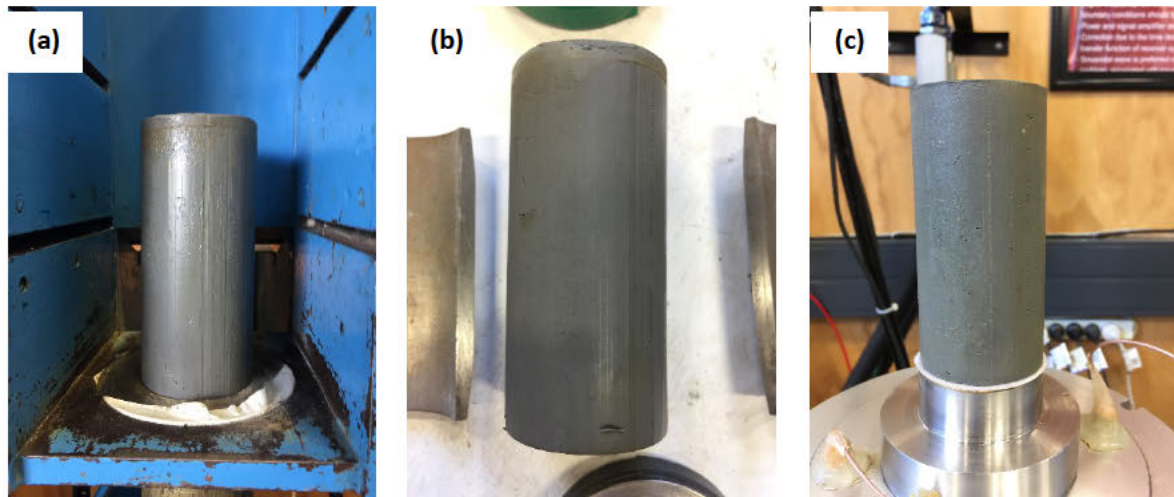


Figure 1: Specimen preparation for the triaxial test: (a) extruding the soil sample using a hydraulic jack; (b) trimming the specimen end inside the mould; (c) set up of specimen in the triaxial cell

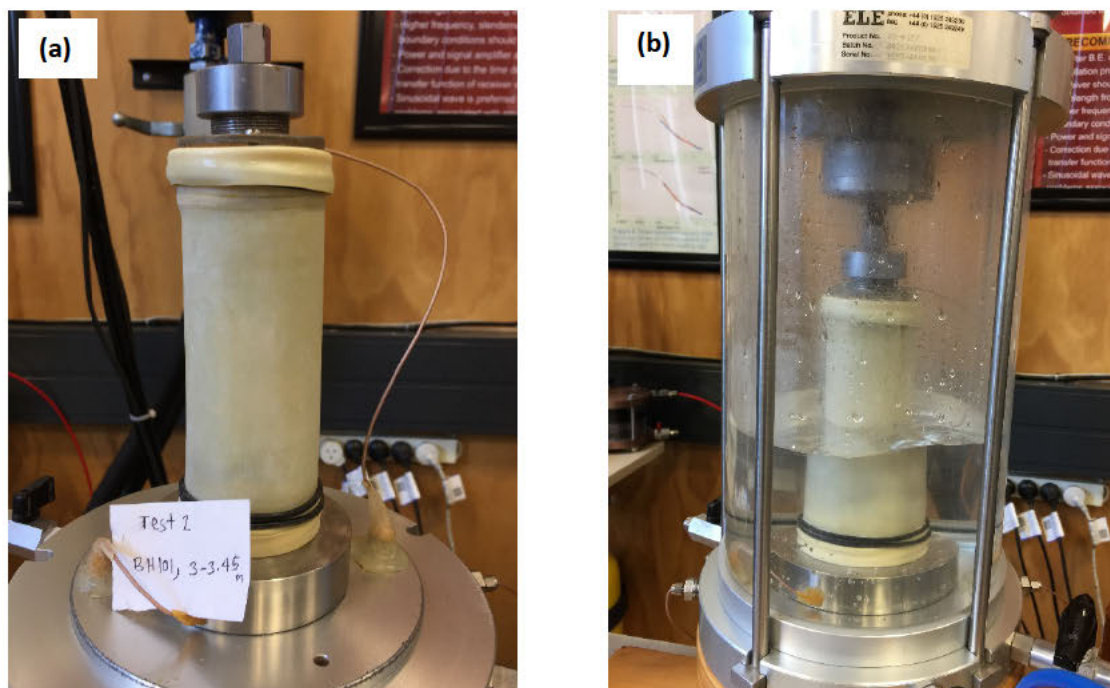


Figure 2: (a) Specimen enclosed with rubber membrane secured to the top cap and pedestal with O-rings; (b) filling the triaxial cell with water.



Figure 3: Condition of the specimen (a) after undrained cyclic loading and before post-monotonic loading; (b) after post-monotonic loading; (c) after post-monotonic loading without the membrane.

Consolidation stage:

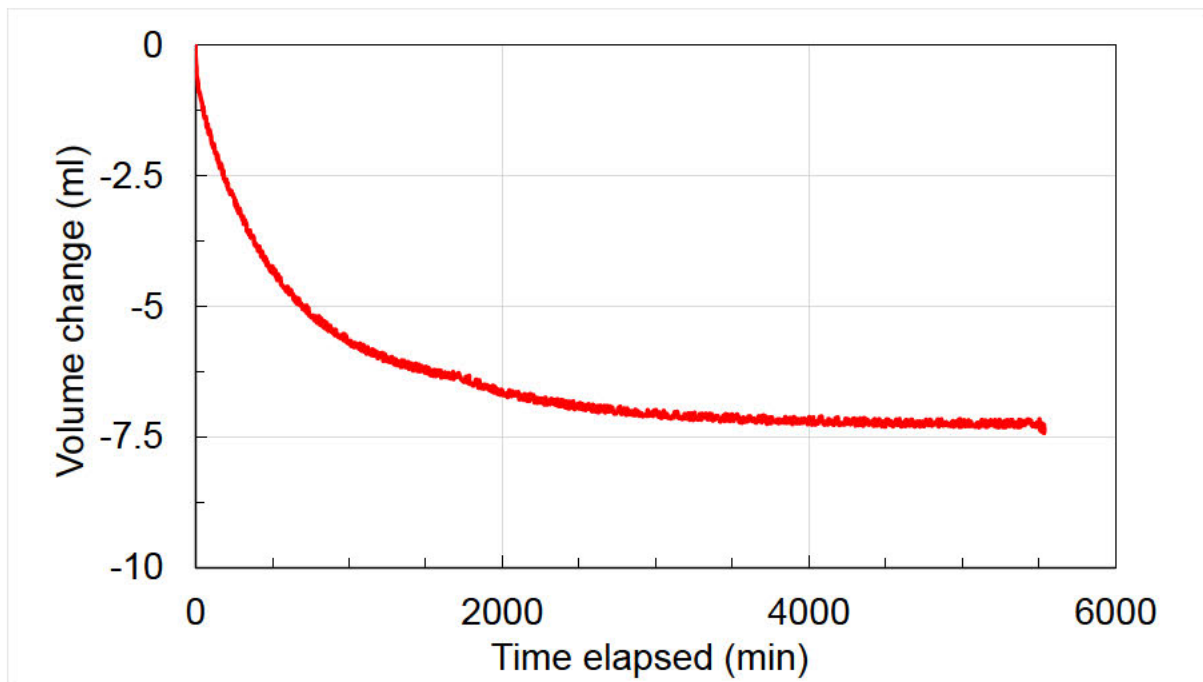


Figure 4: Consolidation volume change vs time.

Cyclic shear stage:

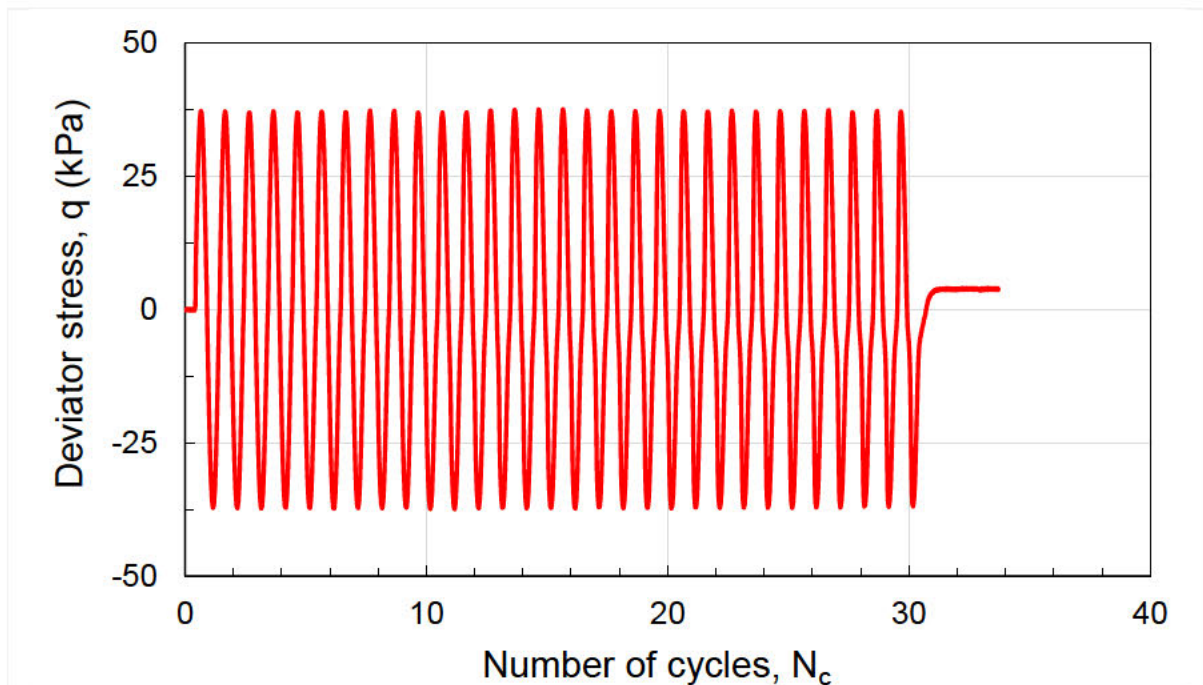


Figure 5: Deviator stress vs number of cycles

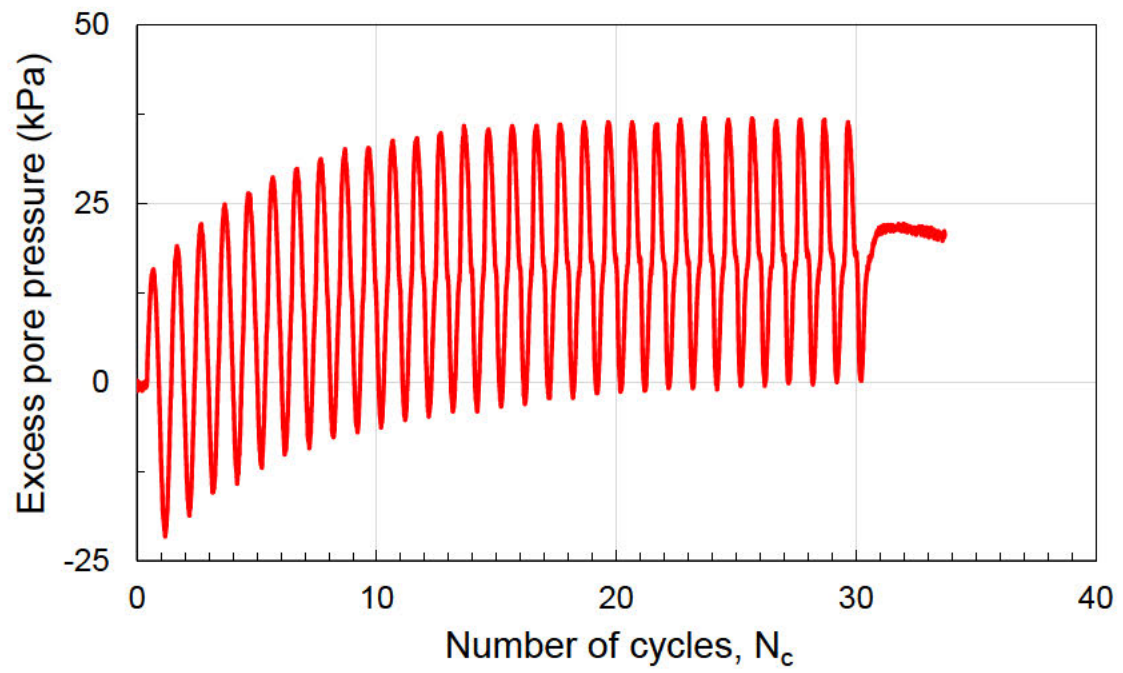


Figure 6: Excess pore water pressure vs number of cycles

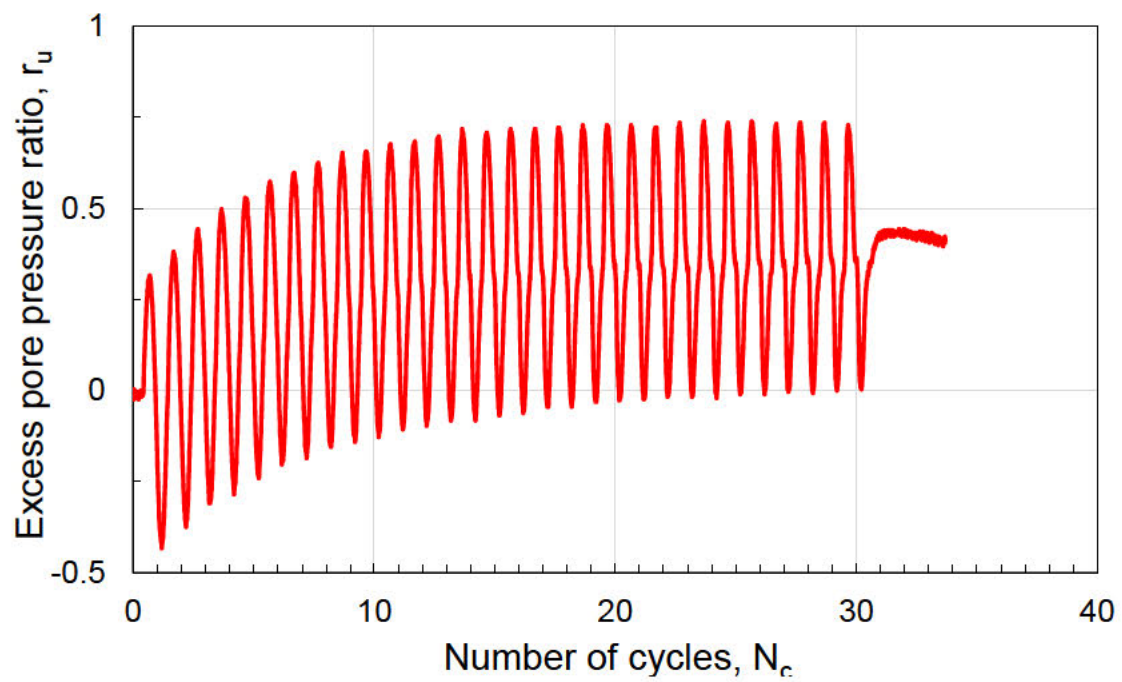


Figure 7: Excess pore water pressure ratio vs number of cycles

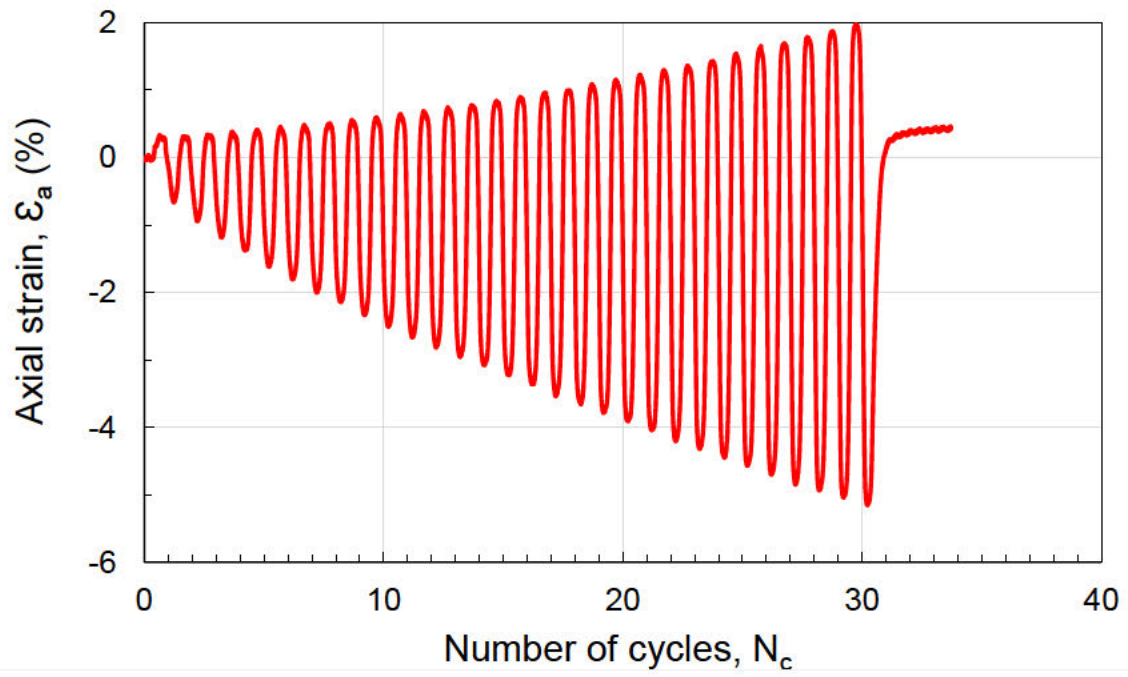


Figure 8: Axial strain vs number of cycles

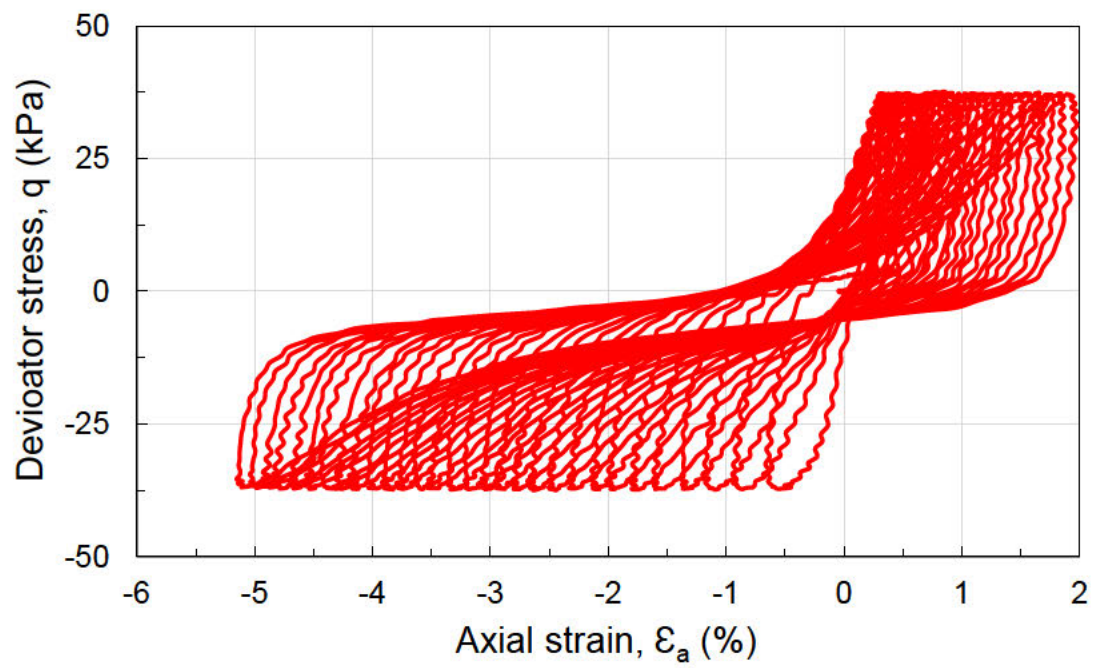


Figure 9: Deviator stress vs axial strain

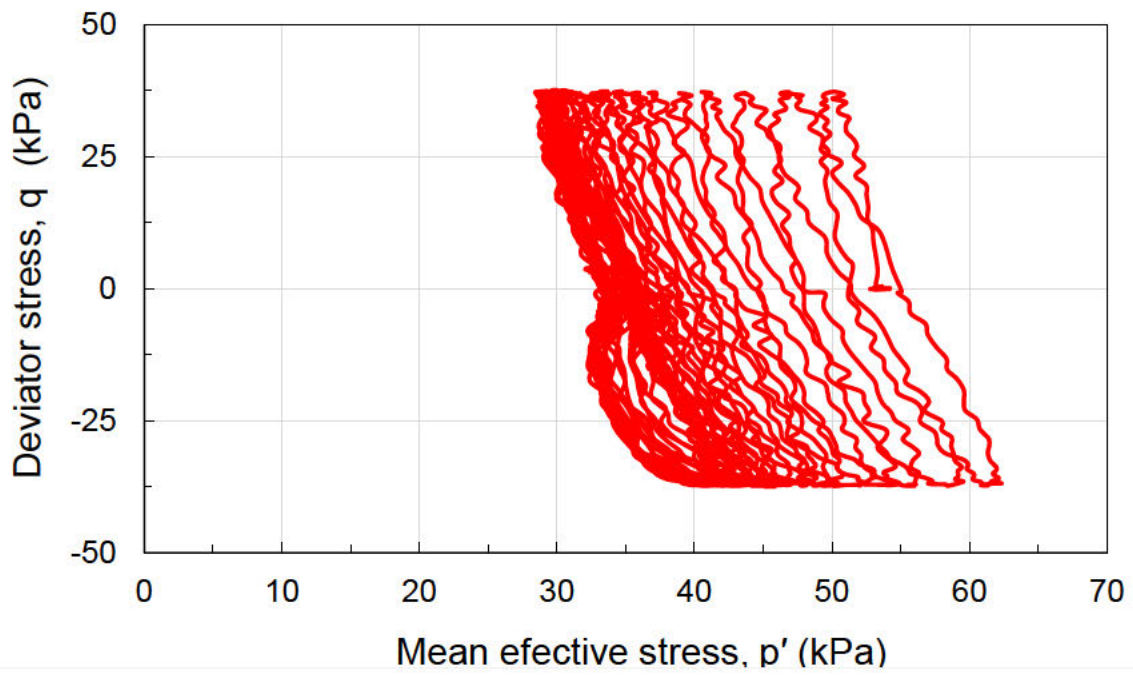


Figure 10: Deviator stress vs mean effective stress

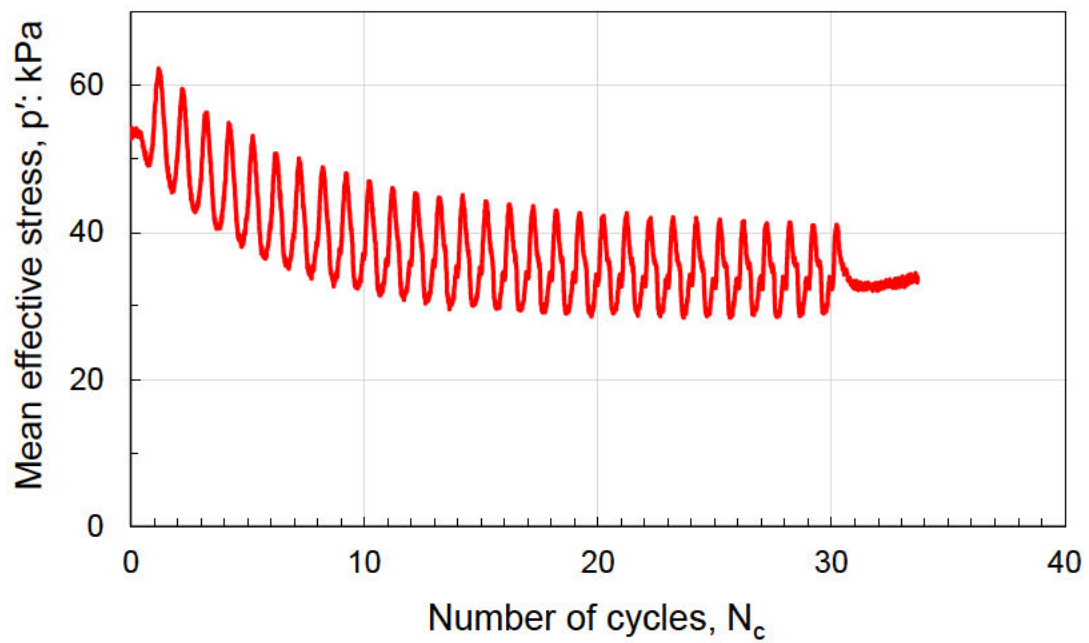


Figure 11: Mean effective stress vs number of cycles.

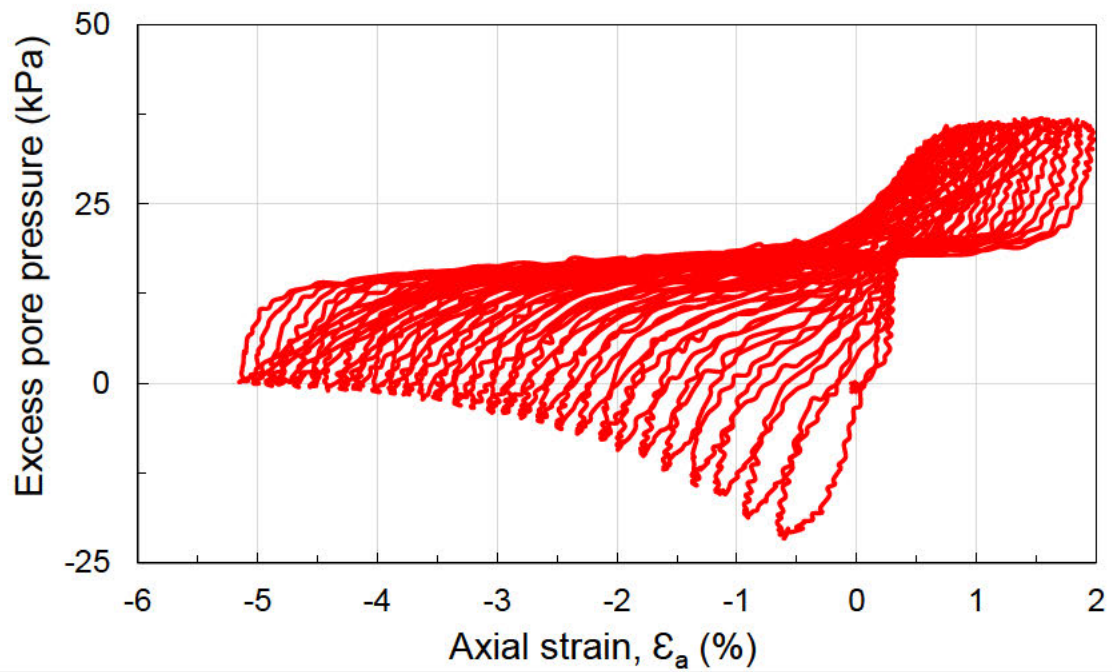


Figure 12: Excess pore water pressure vs axial strain

Post-cyclic monotonic shear stage:

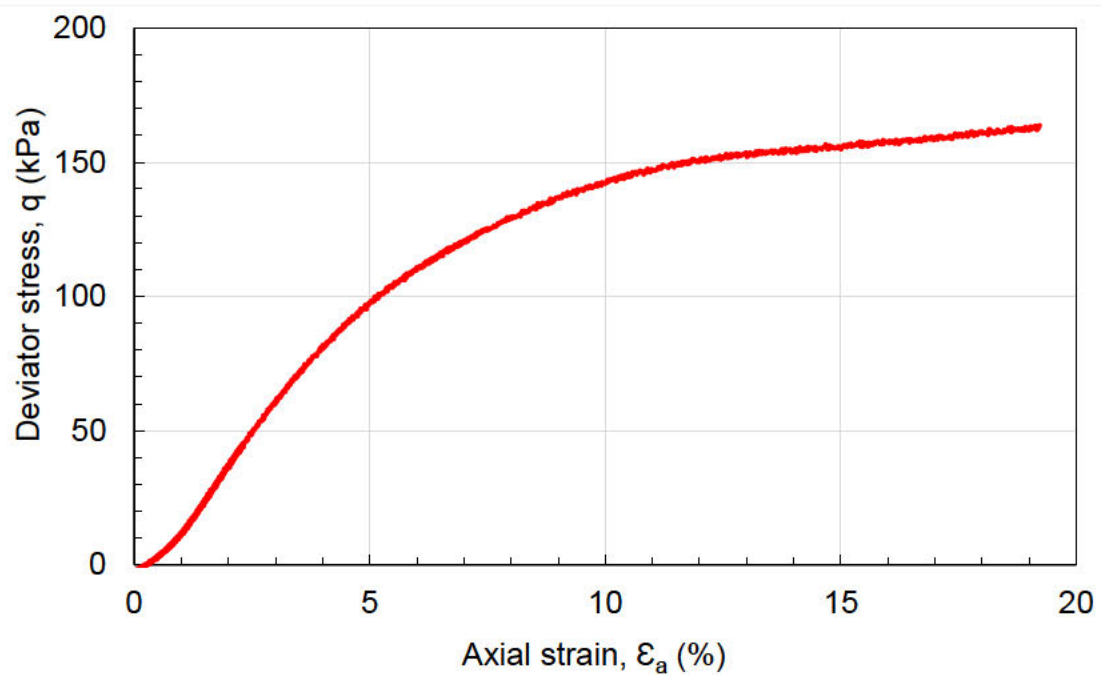


Figure 13: Deviator stress vs axial strain

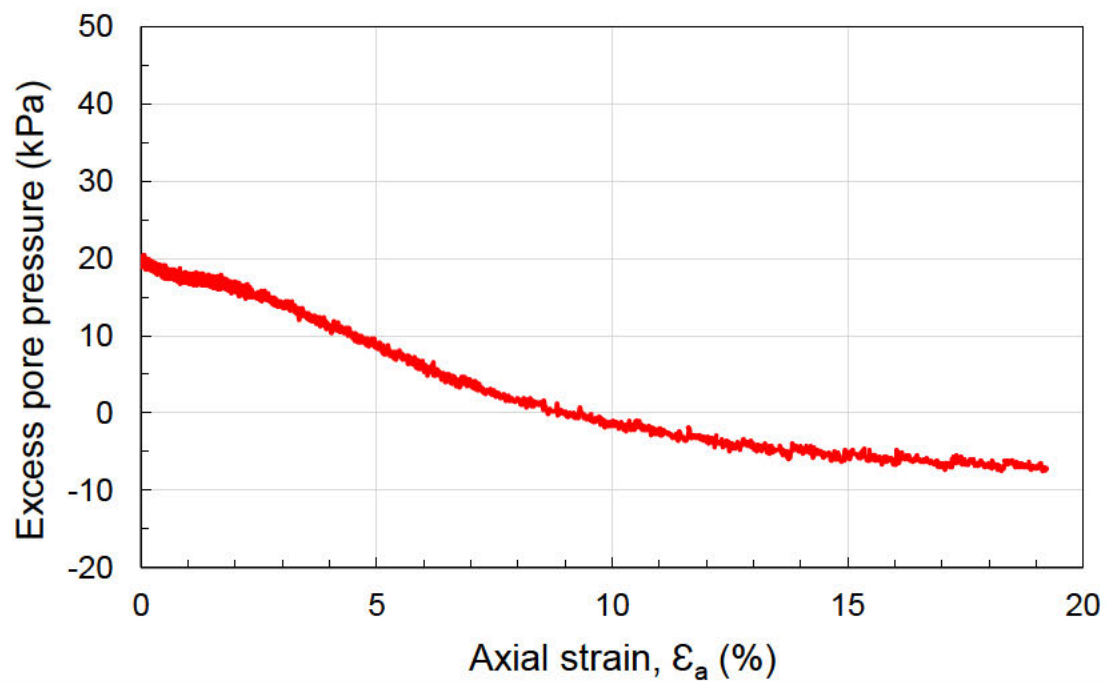


Figure 14: Excess pore water pressure vs axial strain

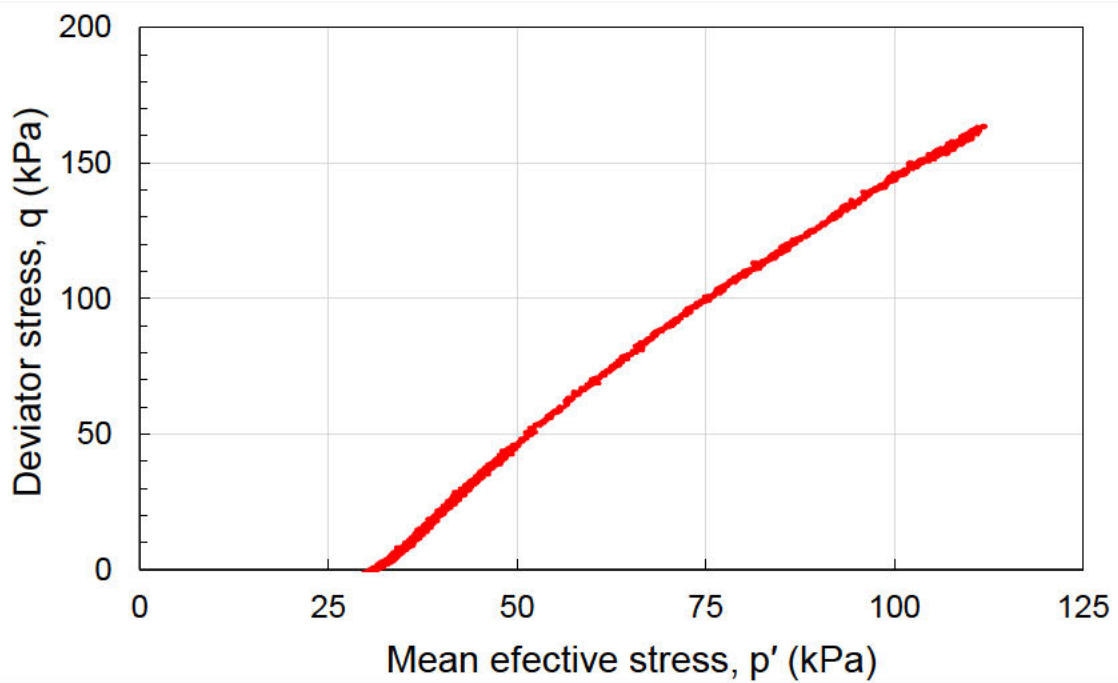


Figure 15: Post-cyclic stress path

Cyclic triaxial test for WSP OPUS**(Waterloo WTP Project)****Test 3 (BH-101, 3.65 - 4.1 m)**

Auckland UniServices Limited

70 Symonds St, Auckland 1142

Sample: BH-101, 3.65 - 4.1m	Depth (m): 3.65 - 4.1m	Formation: -
Test start: 27 October 2020	Test end: 30 October 2020	Initial mass (gr): 749.3
Initial length (mm): 126	Initial diameter (mm): 61.5	Initial unit weight (kN/m ³): 19.7
Effective consolidation pressure (kPa): 55		Consolidation volume change (ml): 2.4
Initial water content (%): 23		Final water content (%): 22.8
Target CSR: 0.47		Cyclic axial stress at CSR (kPa): 51.7
Number of cycles to 5% DA axial strain: 9		Number of cycles to $U_{cyc} / \sigma'_{30} = 0.95$: 6
Test performed by: s7(2)(a)		Apparatus: Geomechanics lab MTS810
Comments: After saturation and consolidation stages, the specimen was subjected to stress-controlled cyclic loading with a frequency of 0.1 Hz. The specimen reached 5% double amplitude axial stain after 9 cycles of loading. The cyclic test was terminated after about 12 cycles of loading. After the cyclic test, the specimen was subjected to strain-controlled monotonic load to failure (i.e., large deformation) at a rate of 0.01 mm/sec. In order to overcome the problem of different starting points for post-cyclic monotonic loading, the initial height of the specimen before cyclic loading was considered as the basis for calculating the axial strain for data processing; i.e., zero (0%) axial strain correlated with the initial height of the specimen before cyclic loading; a negative axial strain as a starting point had the post-cyclic monotonic loading start when the specimen was in extension condition.		

Photos:

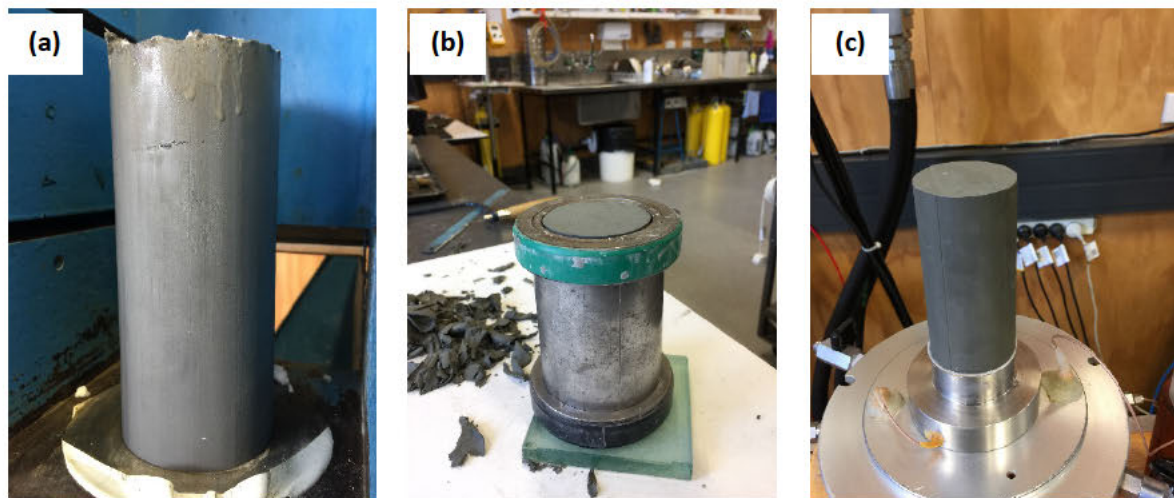


Figure 1: Specimen preparation for the triaxial test: (a) extruding the soil sample using a hydraulic jack; (b) trimming the specimen end inside the mould; (c) set up of specimen in the triaxial cell

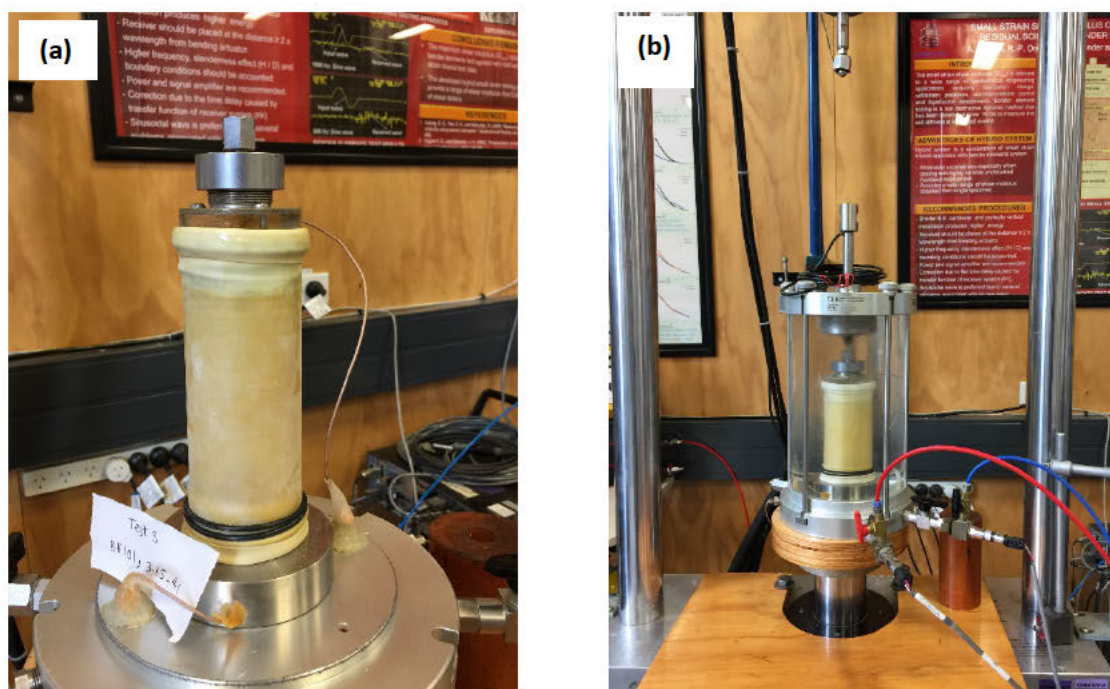


Figure 2: (a) Specimen enclosed with a rubber membrane secured to the top cap and pedestal with O-rings; (b) filling the triaxial cell with water.



Figure 3: Condition of the specimen: (a) after undrained cyclic loading and before post-monotonic loading; (b) after post-monotonic loading; (c) after post-monotonic loading without the membrane.

Consolidation stage:

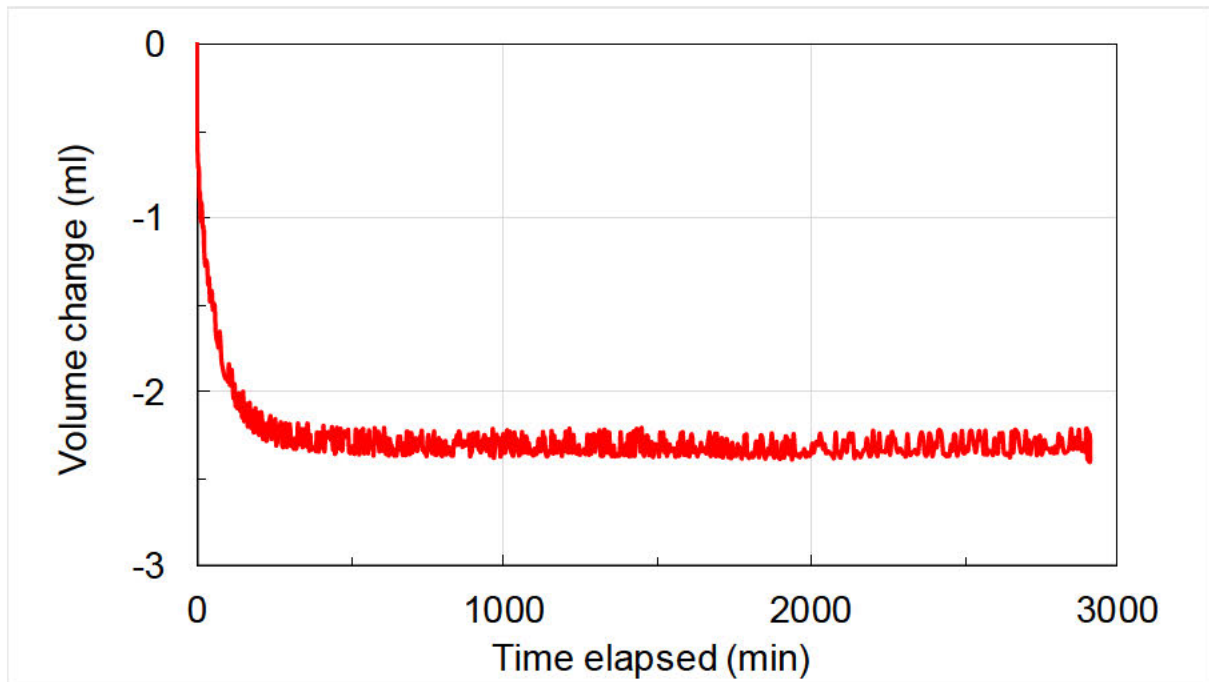


Figure 4: Consolidation volume change vs time.

Cyclic shear stage:

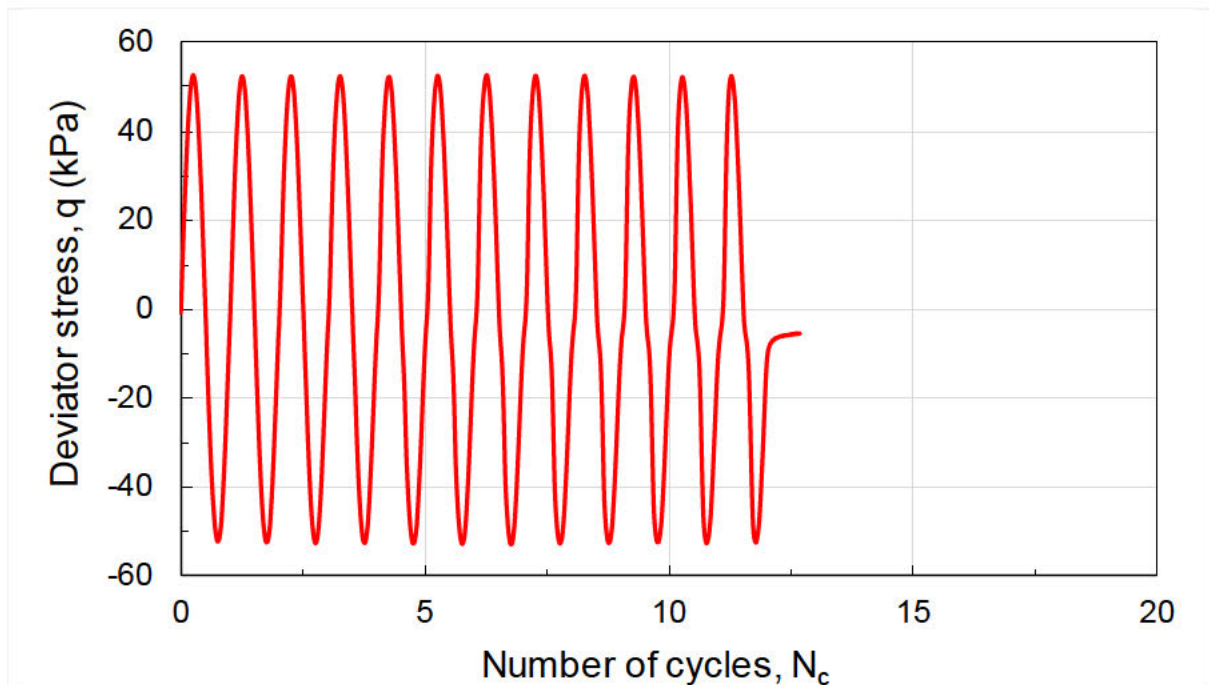


Figure 5: Deviator stress vs number of cycles

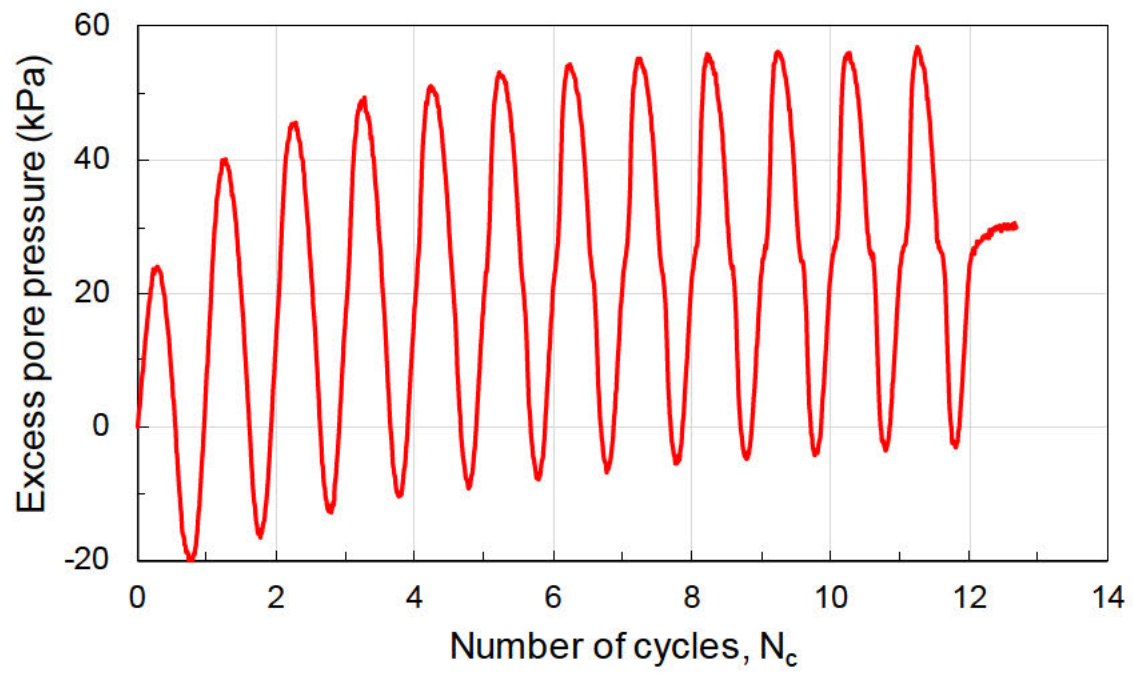


Figure 6: Excess pore water pressure vs number of cycles

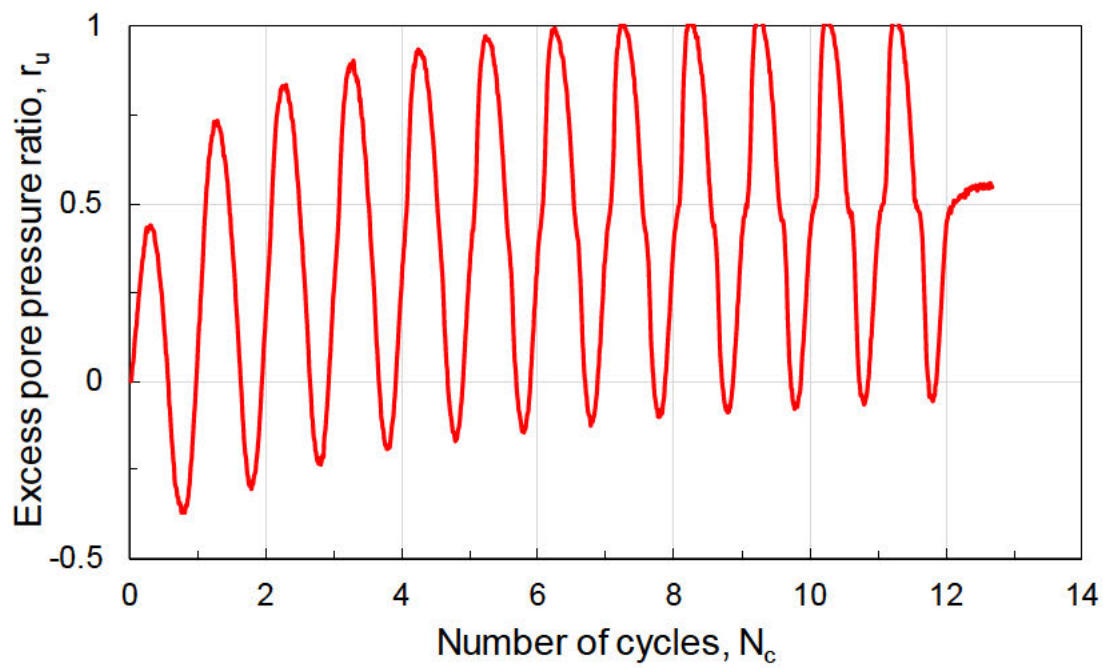


Figure 7: Excess pore water pressure ratio vs number of cycles

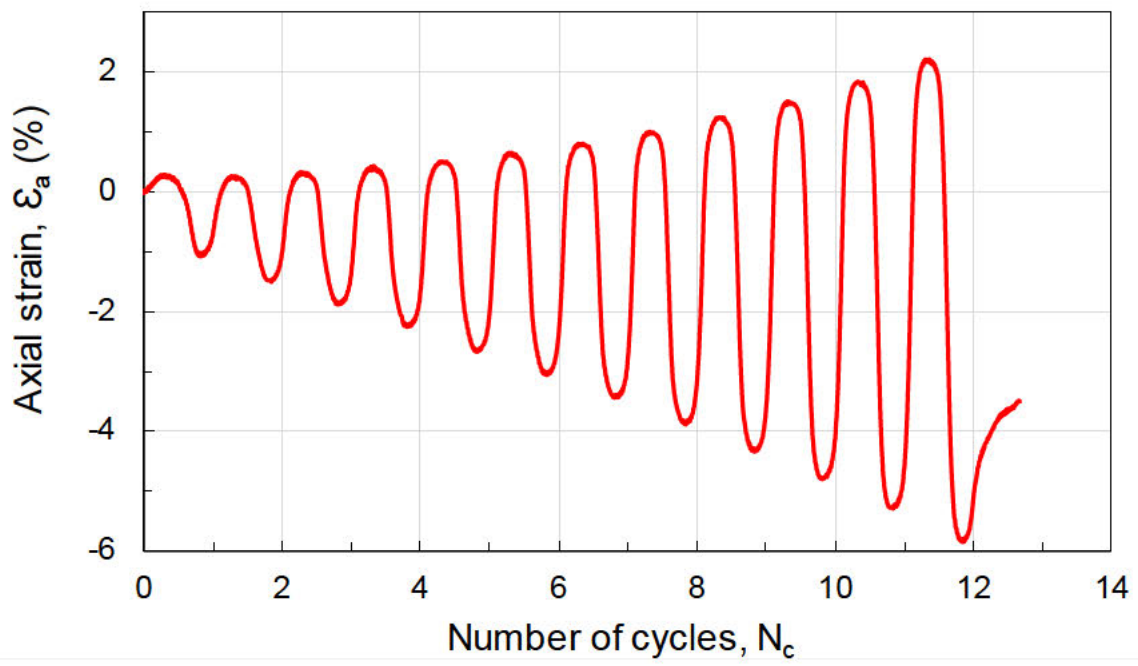


Figure 8: Axial strain vs number of cycles

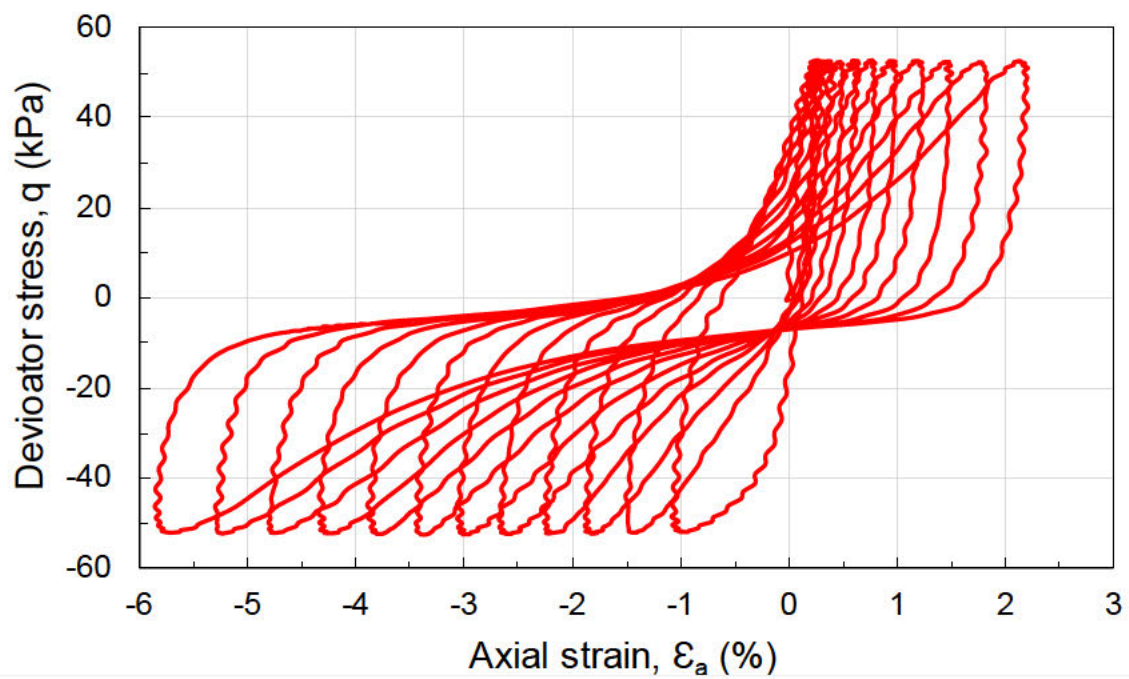


Figure 9: Deviator stress vs axial strain

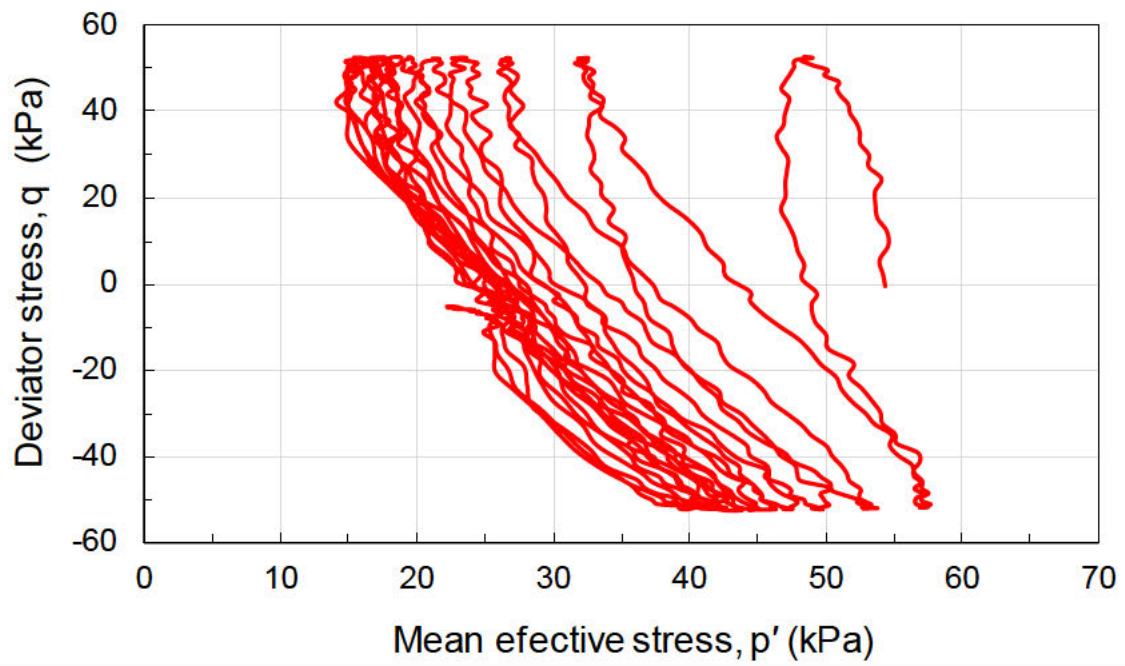


Figure 10: Deviator stress vs mean effective stress

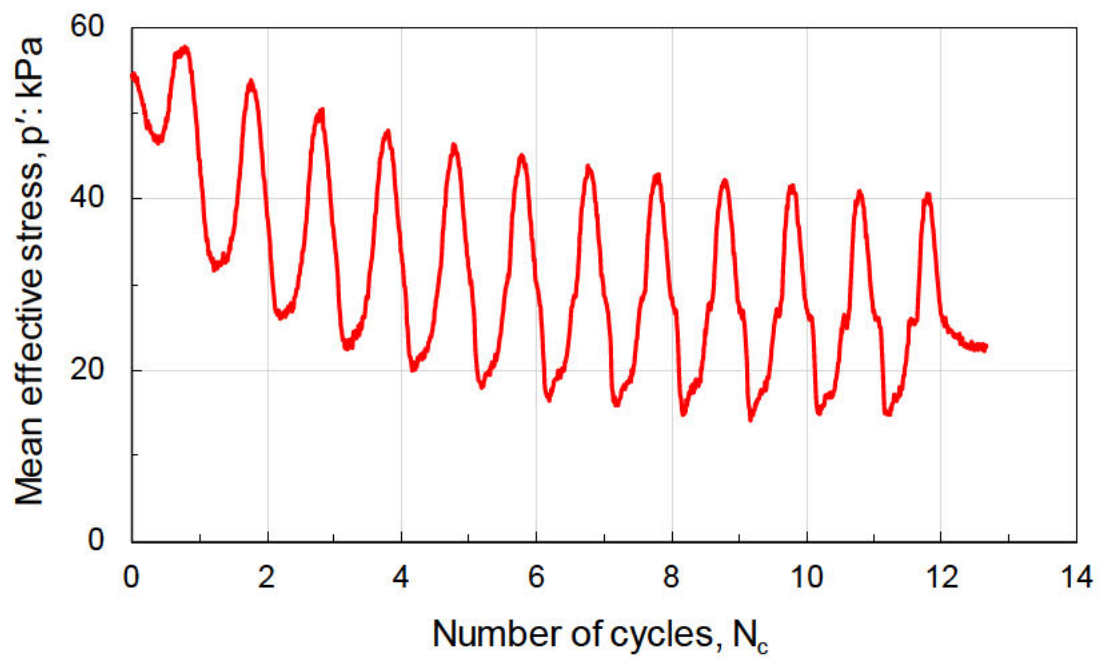


Figure 11: Mean effective stress vs number of cycles.

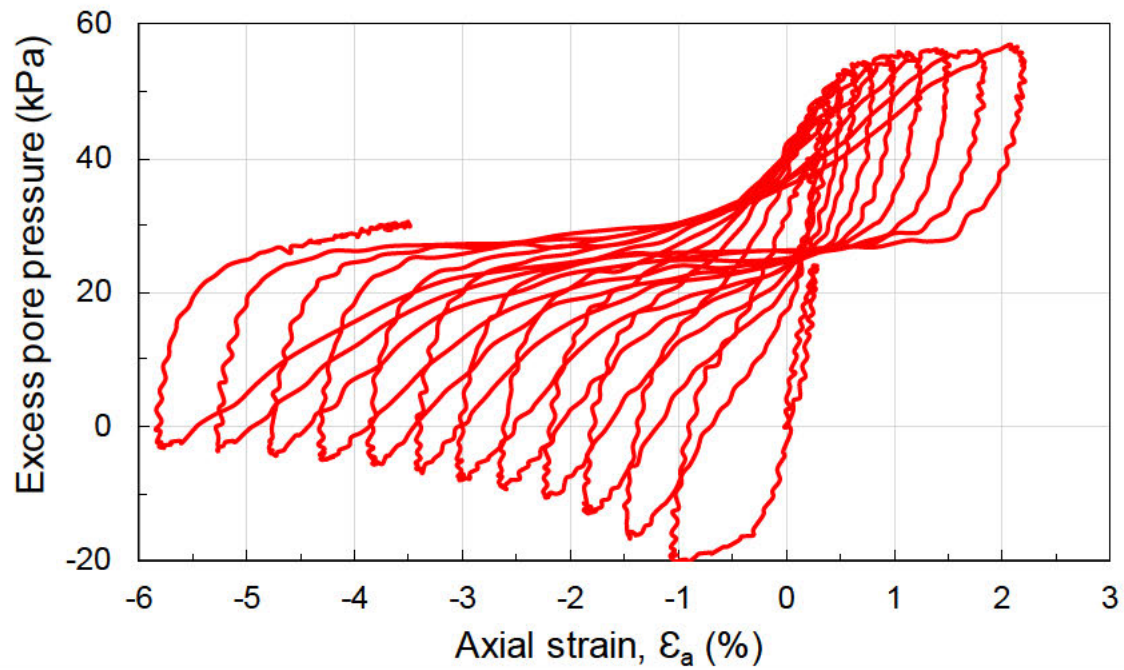


Figure 12: Excess pore water pressure vs axial strain

Post-cyclic monotonic shear stage:

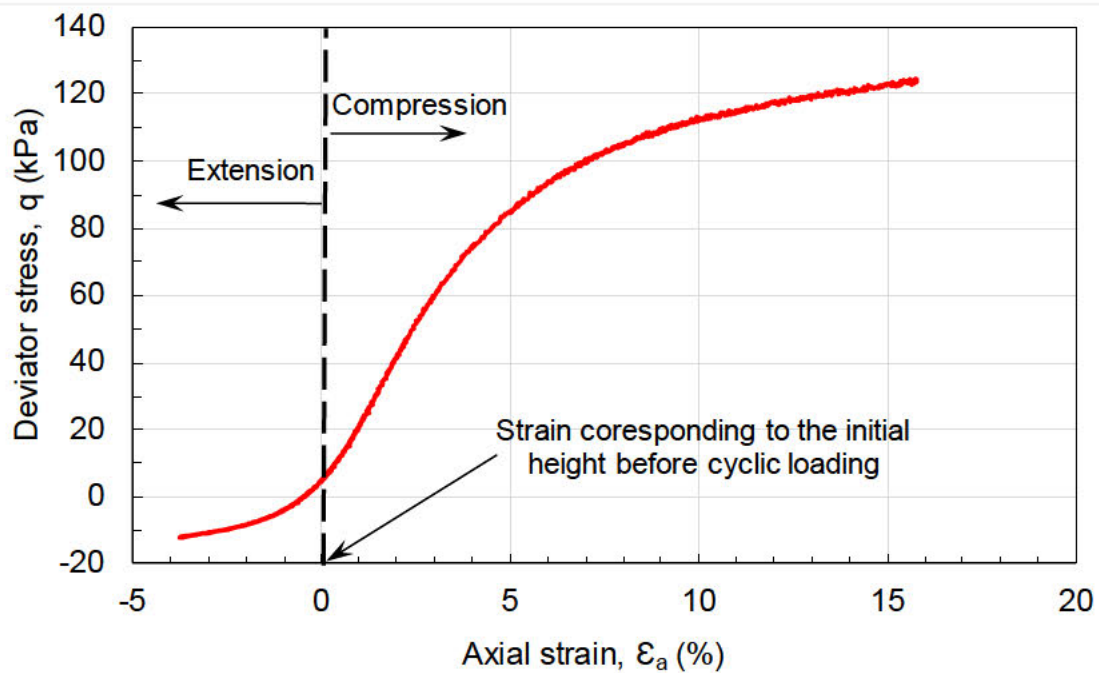


Figure 13: Deviator stress vs axial strain

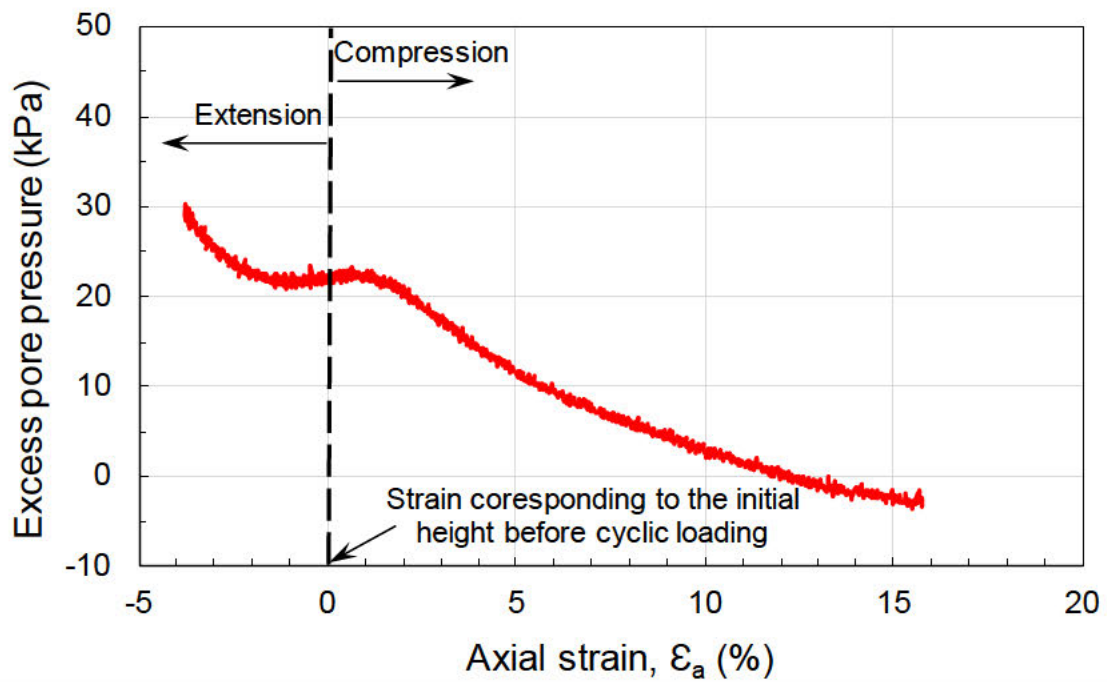


Figure 14: Excess pore water pressure vs axial strain

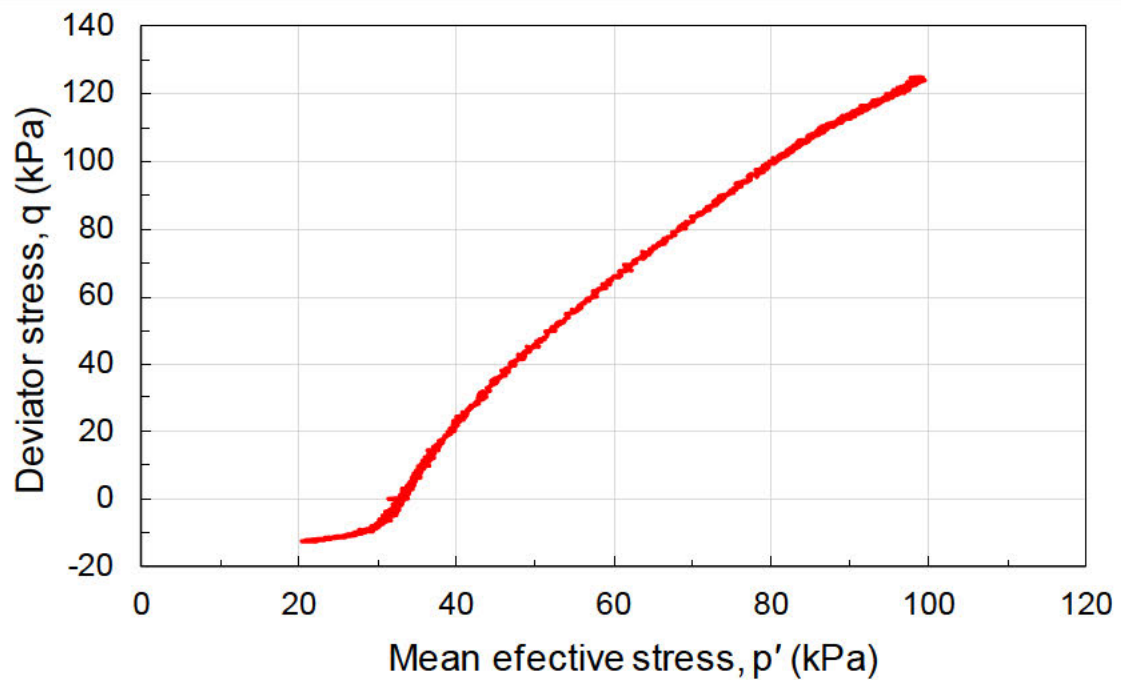


Figure 15: Post-cyclic stress path

Cyclic triaxial test for WSP OPUS**(Waterloo WTP Project)****Test 4 (BH-101, 3.65 - 4.1 m)**

Auckland UniServices Limited

70 Symonds St, Auckland 1142

Sample: BH-101, 3.65 - 4.1m	Depth (m): 3.65 - 4.1m	Formation: -
Test start: 11 November 2020	Test end: 13 November 2020	Initial mass (gr): 749
Initial length (mm): 126	Initial diameter (mm): 61.5	Initial unit weight (kN/m ³): 19.7
Effective consolidation pressure (kPa): 55		Consolidation volume change (ml): 3
Initial water content (%): 24.3		Final water content (%): 23.4
Target CSR: 0.26		Cyclic axial stress at CSR (kPa): 28.6
Number of cycles to 5% DA axial strain: NA		Number of cycles to $U_{cyc} / \sigma'_{30} = 0.95$: NA
Test performed by: s7(2)(a)		Apparatus: Geomechanics lab MTS810
Comments: After saturation and consolidation stages, the specimen was subjected to stress-controlled cyclic loading with a frequency of 0.1 Hz. The cyclic test was performed for about 21 cycles. After the cyclic test, the specimen was subjected to strain-controlled monotonic load to failure (i.e., large deformation) at a rate of 0.01 mm/sec.		

Photos:

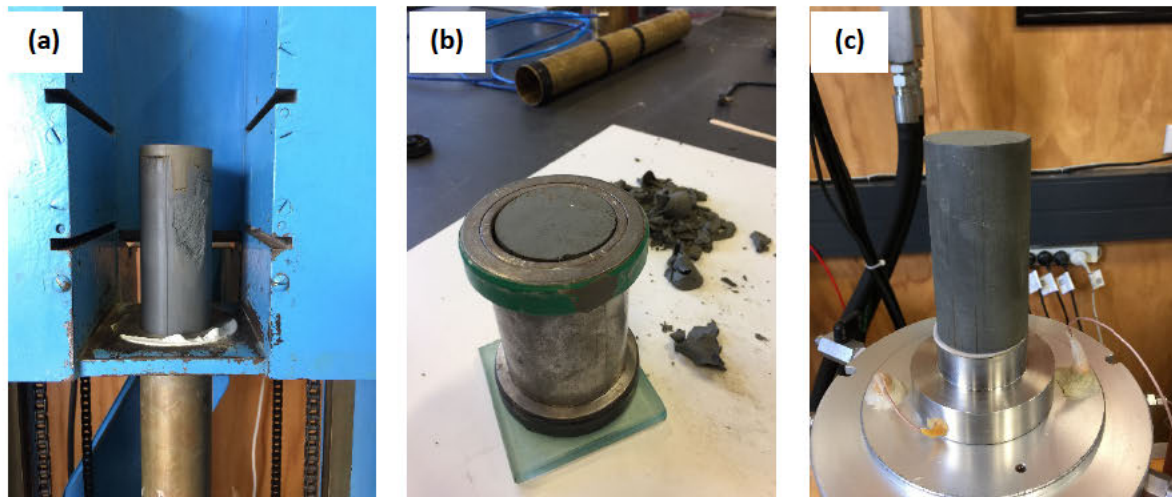


Figure 1: Specimen preparation for the triaxial test: (a) extruding the soil sample using a hydraulic jack; (b) trimming the specimen end inside the mould; (c) set up of specimen in the triaxial cell

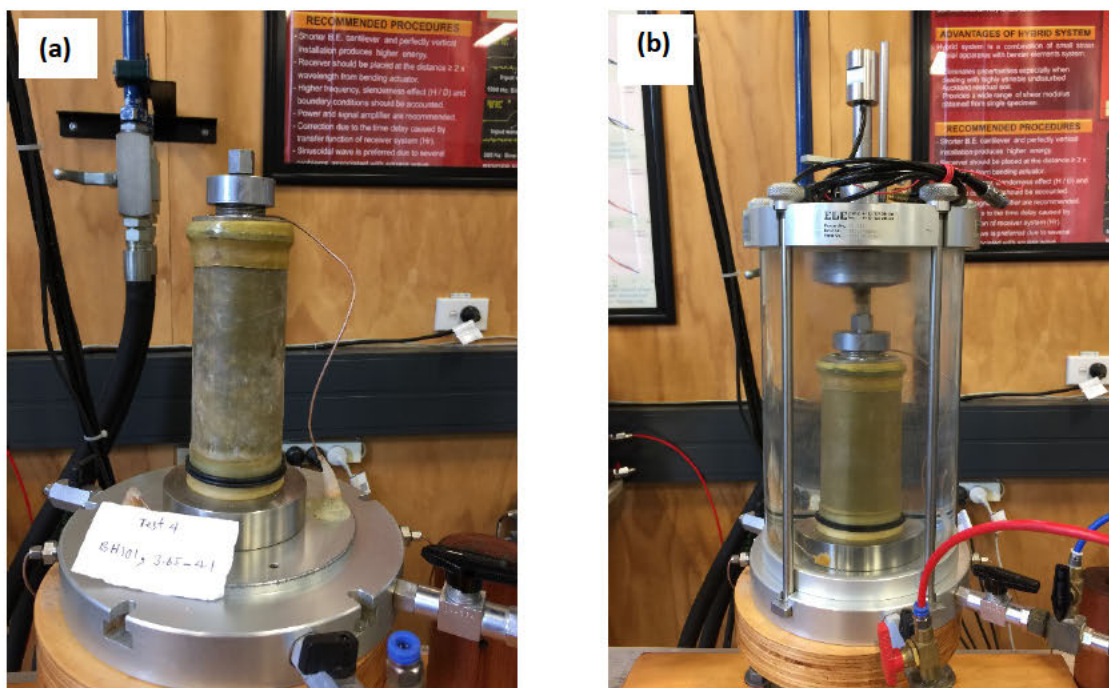


Figure 2: (a) Specimen enclosed with rubber membrane secured to the top cap and pedestal with O-rings; (b) filling the triaxial cell with water.



Figure 3: Condition of the specimen (a) after undrained cyclic loading and before post-monotonic loading; (b) after post-monotonic loading; (c) after post-monotonic loading without the membrane.

Consolidation stage:

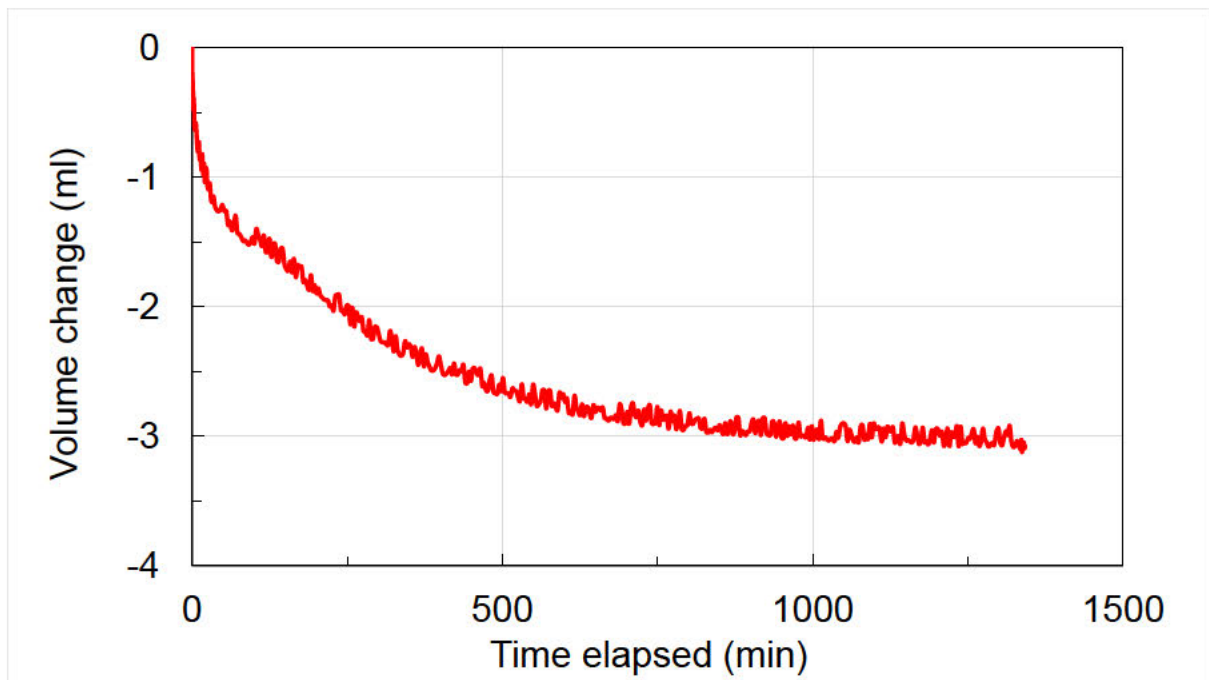


Figure 4: Consolidation volume change vs time.

Cyclic shear stage:

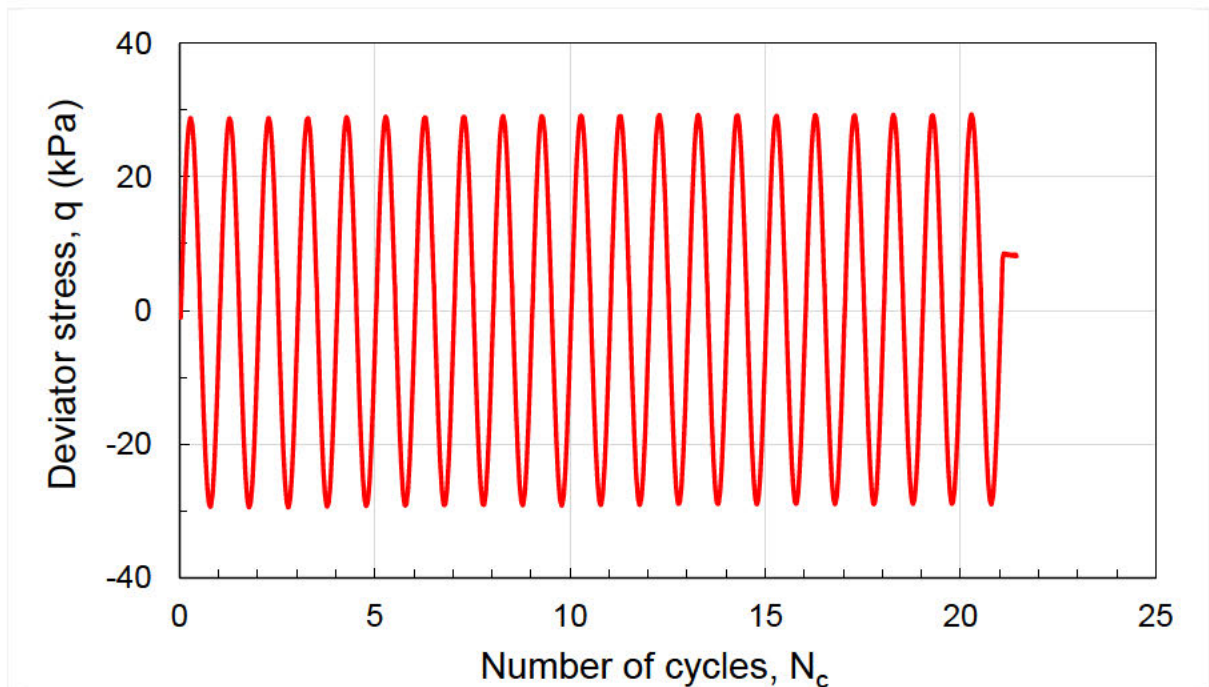


Figure 5: Deviator stress vs number of cycles

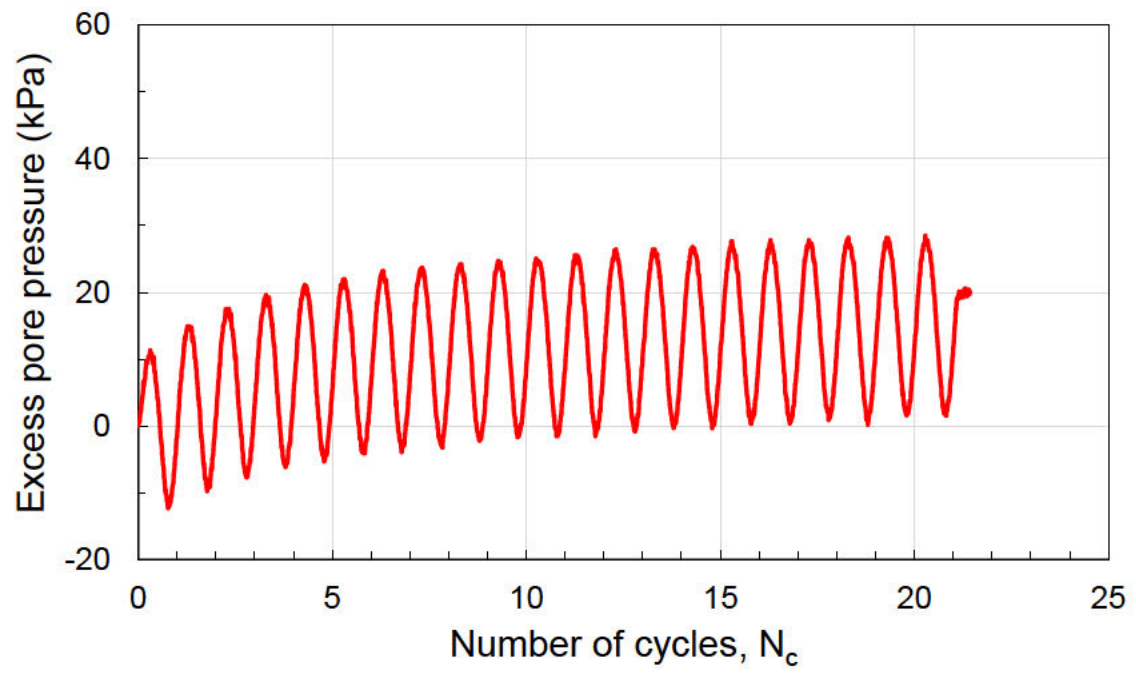


Figure 6: Excess pore water pressure vs number of cycles

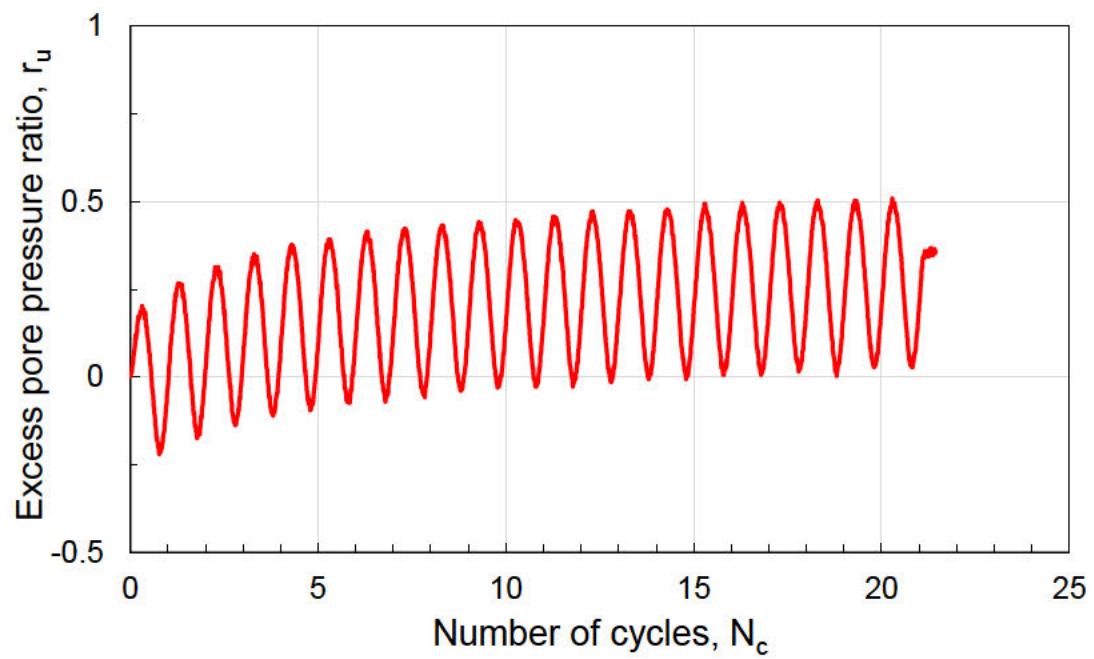


Figure 7: Excess pore water pressure ratio vs number of cycles

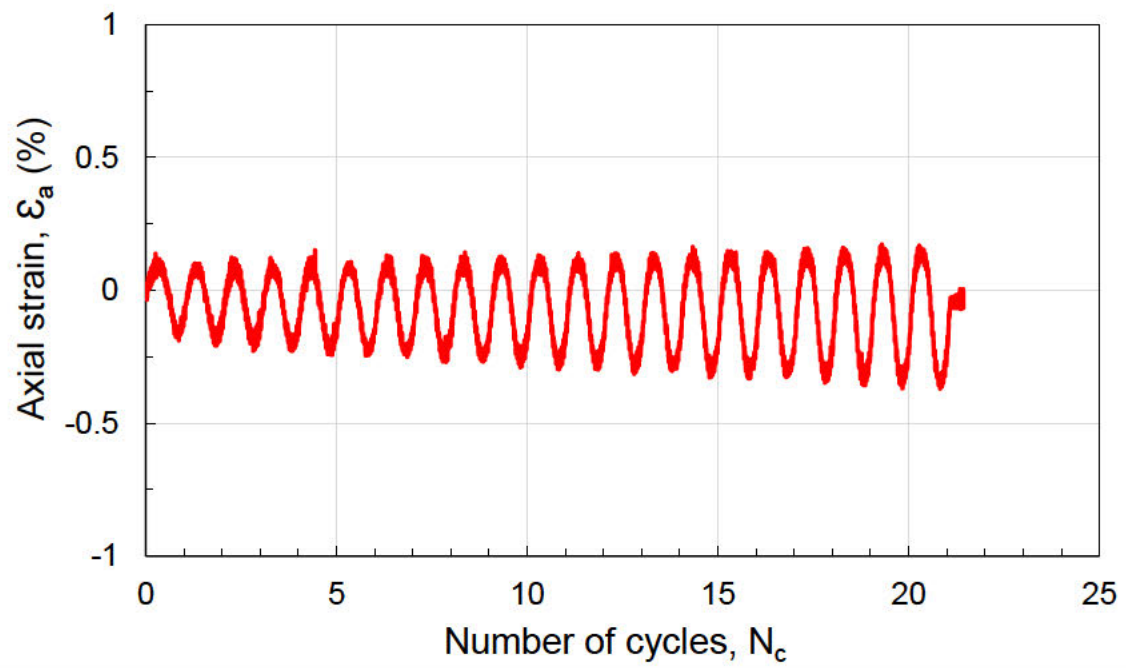


Figure 8: Axial strain vs number of cycles

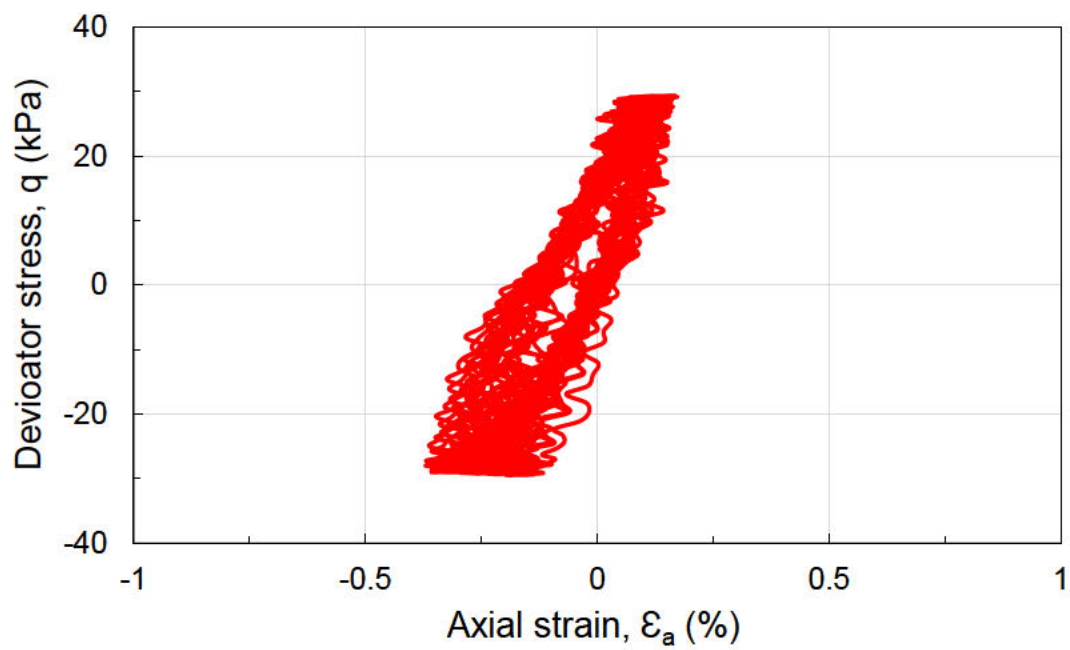


Figure 9: Deviator stress vs axial strain

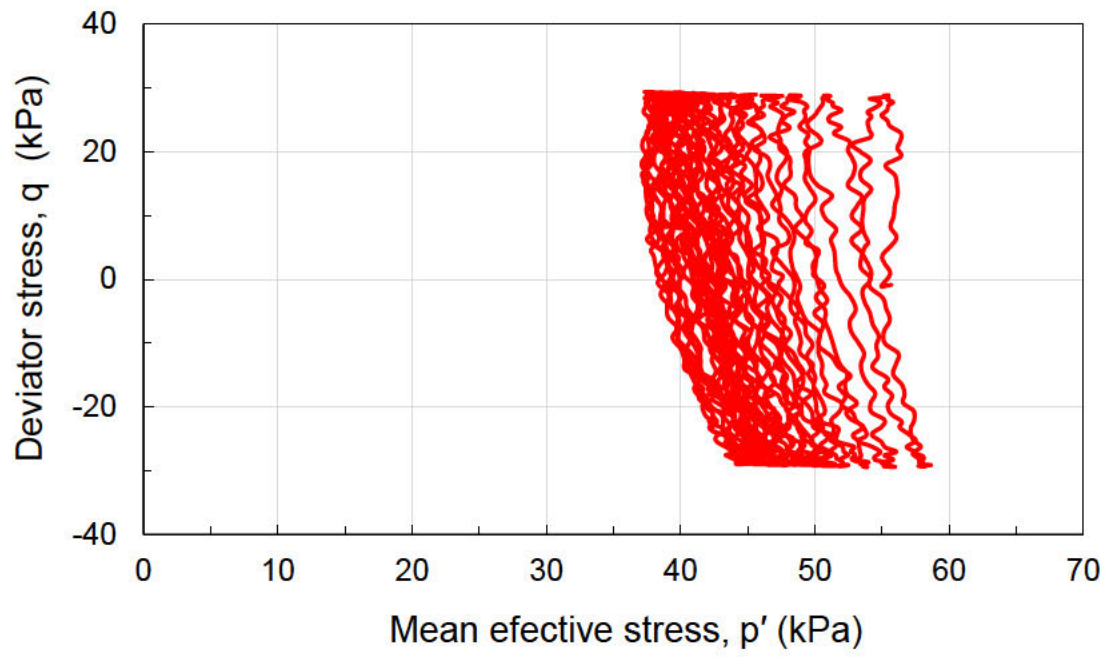


Figure 10: Deviator stress vs mean effective stress

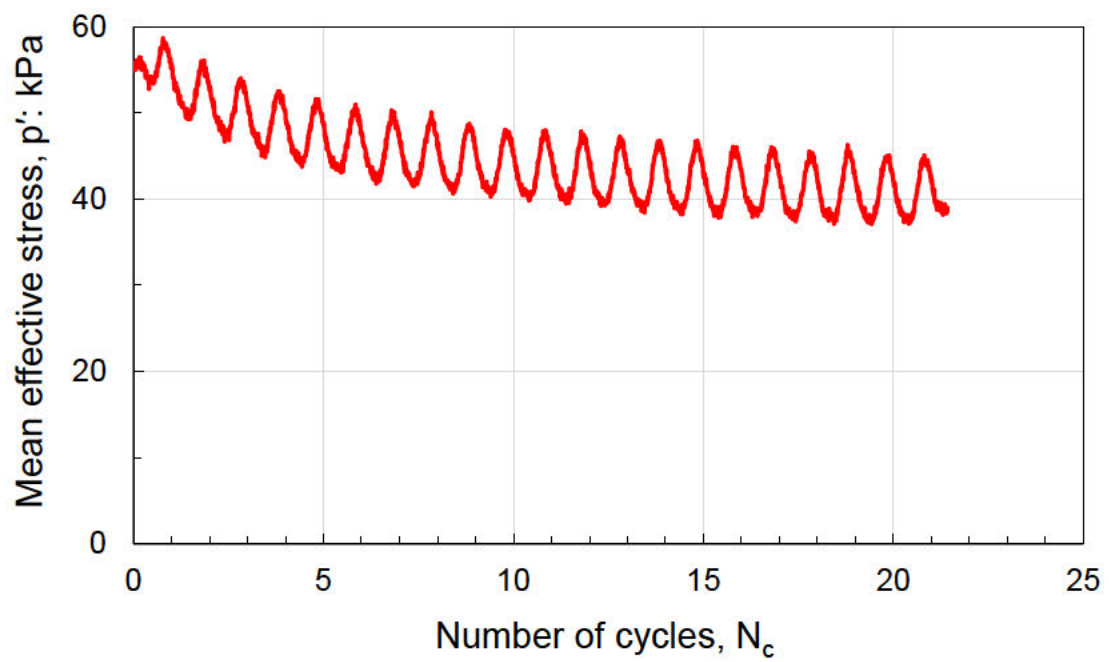


Figure 11: Mean effective stress vs number of cycles.

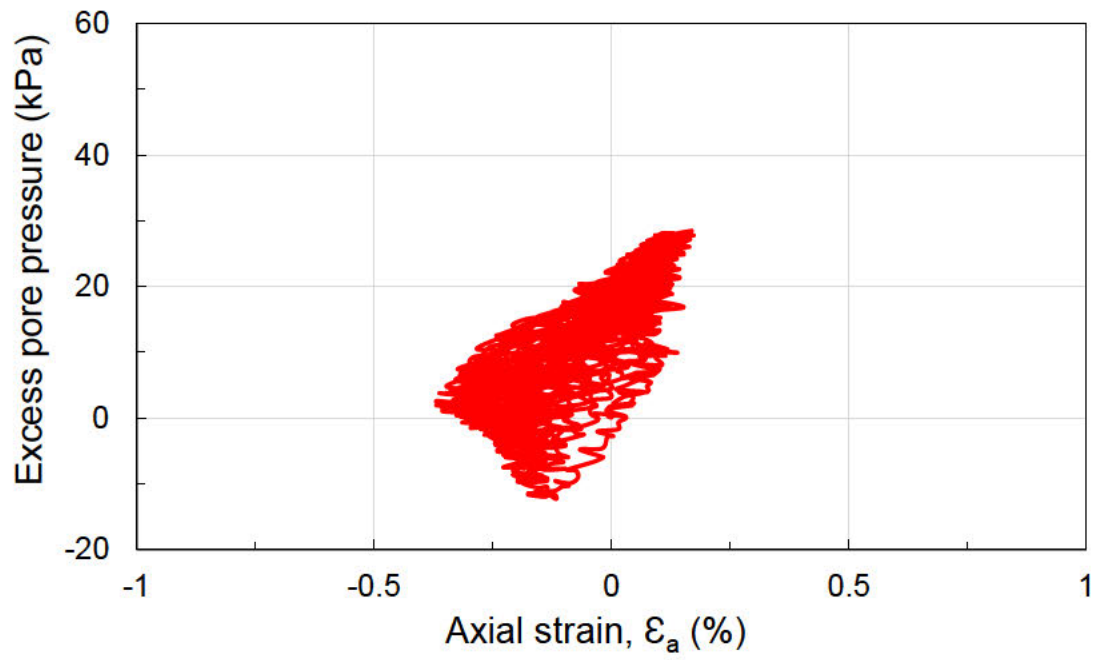


Figure 12: Excess pore water pressure vs axial strain

Post-cyclic monotonic shear stage:

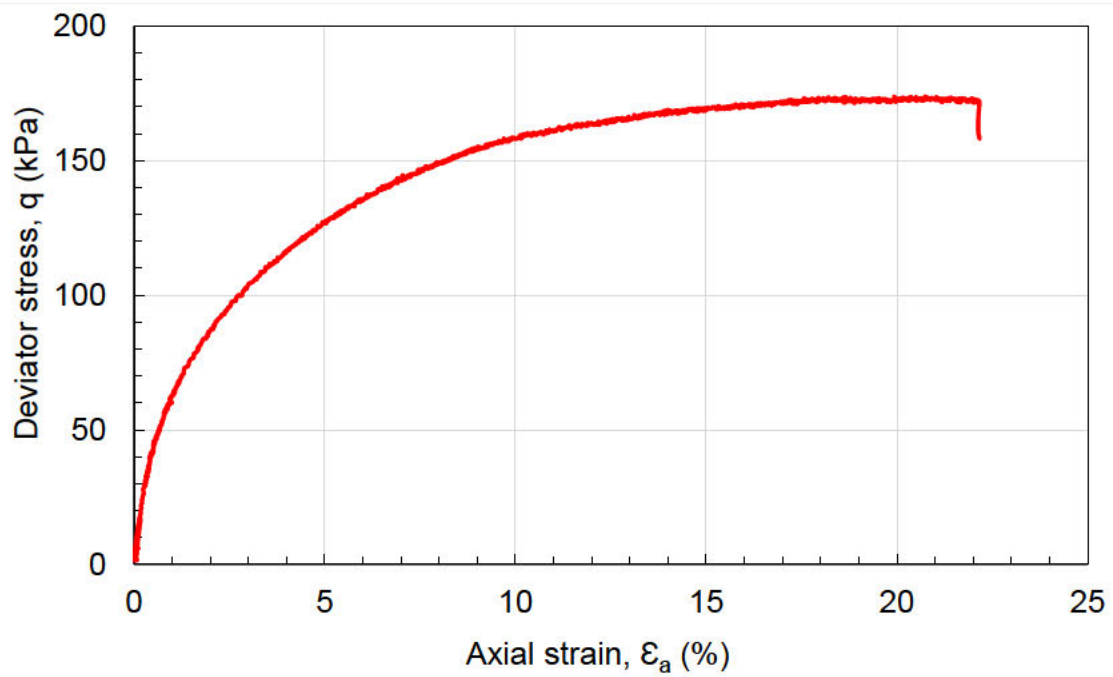


Figure 13: Deviator stress vs axial strain

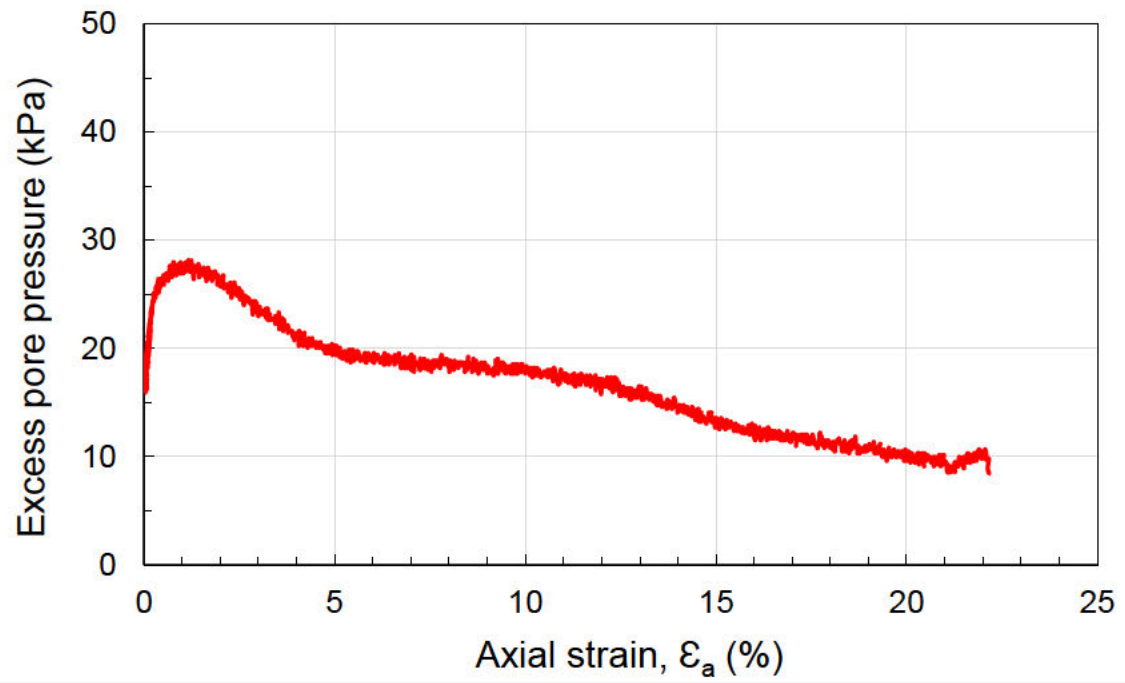


Figure 14: Excess pore water pressure vs axial strain

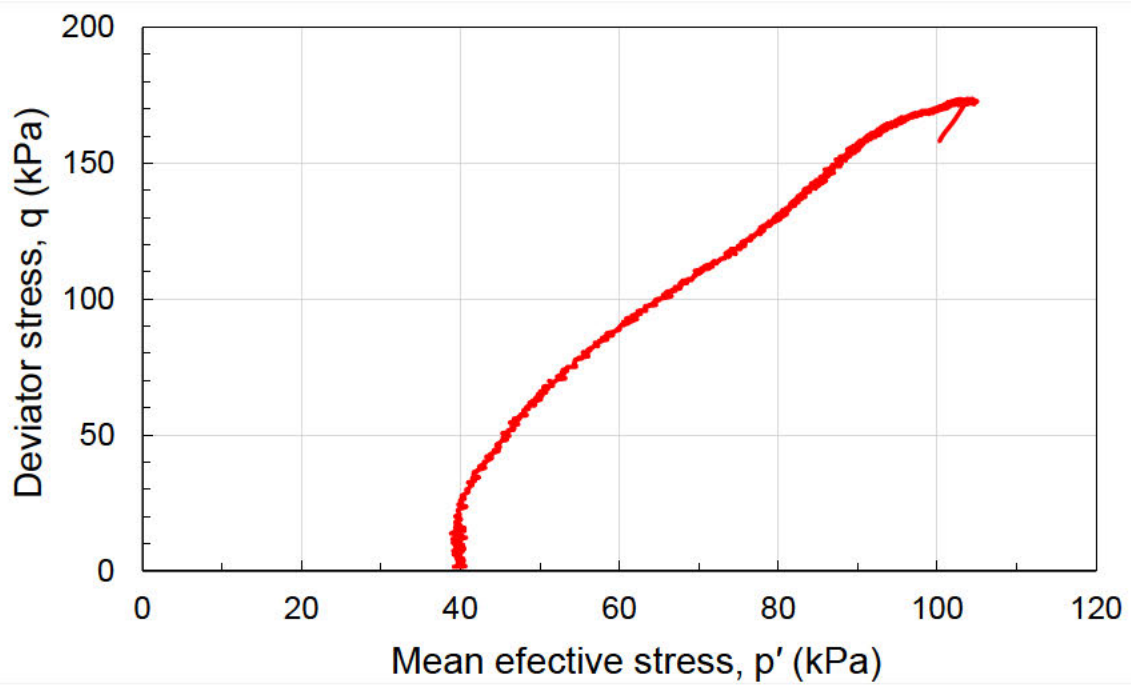


Figure 15: Post-cyclic stress path

PARTICLE SIZE ANALYSIS TEST REPORT

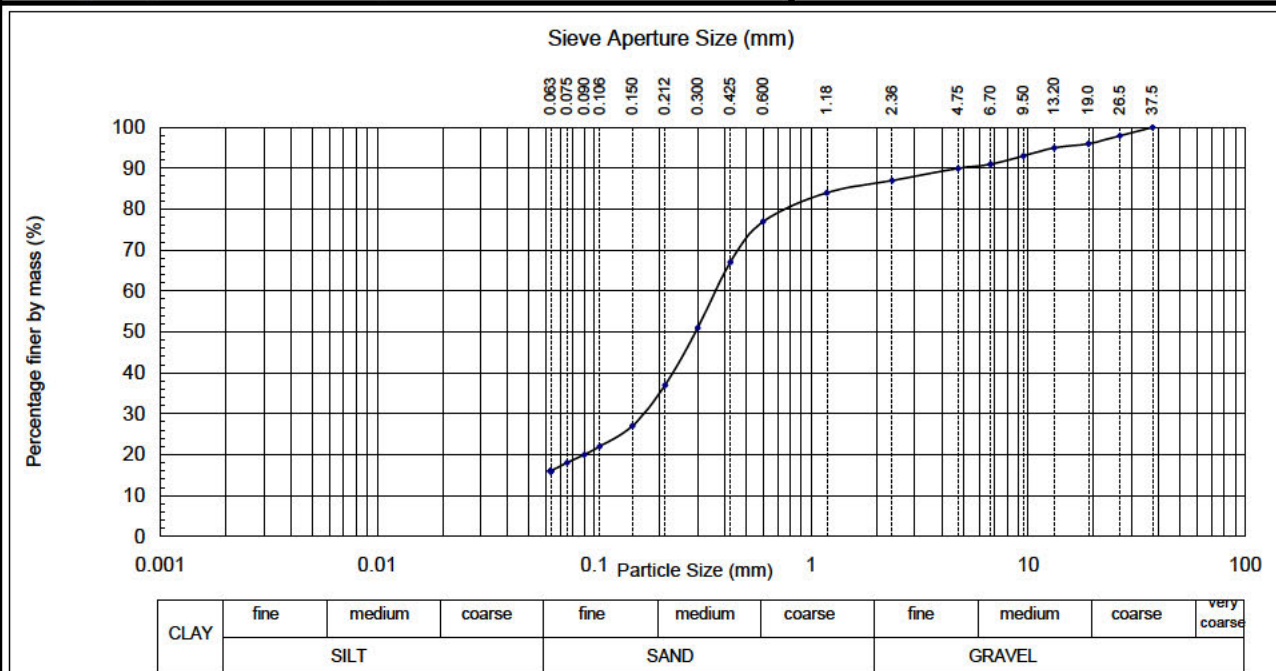


Project: **Waterloo WTP Ground Improvement 3-WW019.11**
 Location: **Waterloo Water Treatment Plant, Oxford Tce, LH**
 Client: **Wellington Water**
 Contractor: **Griffiths Drilling Limited**
 Sampled by: **s7(2)(a)**
 Date sampled: **3.9.20**
 Sampling method: **Sonic core drilling**
 Sample source: **BH104 8.5-9.0m**
 Sample description: **SAND:**
 Sample condition: **As received**
 Solid density (fines) **n/a** t/m³ **Assumed**
 Water content as rec'd **23.5** % **whole**

Report No: **522900/1406**
 Sample No: **2-20/299**
 Client Ref: **3-WW019.11**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
37.5	100	4.75	90	0.212	37				
26.5	98	2.36	87	0.150	27				
19.0	96	1.18	84	0.106	22				
13.20	95	0.600	77	0.090	20				
9.50	93	0.425	67	0.075	18				
6.70	91	0.300	51	0.063	16				

Percent passing finest sieve obtained by difference



Test Methods (where used)	Notes
Particle Size Analysis: NZS 4402 1986 Test 2.8.1 (Wet Sieve)	History: Air dried
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	Uncalibrated sieve sizes 0.212, 0.106, 0.090mm
	Project / sample details supplied by client

Date Tested: **10-23.11.20**
 Date Reported: **24.11.20**

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s7(2)(a)

Date: **24.11.20**



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 accordance with the
 laboratory's scope of
 accreditation

PLASTICITY INDEX FOR SOILS TEST REPORT



Project: **Waterloo WTP Ground Improvement 3-WW019.11**
 Location: **Waterloo Water Treatment Plant, Oxford Tce, LH**
 Client: **Wellington Water**
 Contractor: **Griffiths Drilling Limited**
 Sampled by: **s7(2)(a)**
 Date sampled: **8.9.20**
 Sampling method: **Sonic core drilling**
 Sample condition: **As received**

Report No: **522900/1406**
 Sample No: **2-20/295**
 Project No: **3-WW019.11**

Test Results						
OR Sample no:	2-20/295					
Sample source:	BH103 4.5-5.0m					
Sample description	SILT:					
Liquid Limit (LL):	23 ± 1					
Cone Pen. Limit (CPL):	-					
Plastic Limit (PL):	17 ± 1					
Plasticity Index (PI):	6 ± 2					
Natural Water Content (%): Whole soil	23.6					
Fraction tested	-0.425mm					
Number of LL or CPL points	5					

Test Methods	Notes
Liquid Limit	Alternative 0.01g accuracy balance used. NZS 4402:1986 requires the reporting of a range of values. History - natural Project / sample details supplied by client
Plastic Limit	
Plasticity Index	
Cone Penetration Limit	

Date tested : 9.11.20
 Date reported : 24.11.20

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s7(2)(a)

Date : 24.11.20



All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

PF-LAB-101 (30/05/2013)

**CONSOLIDATED DRAINED DIRECT SHEAR
TEST REPORT**



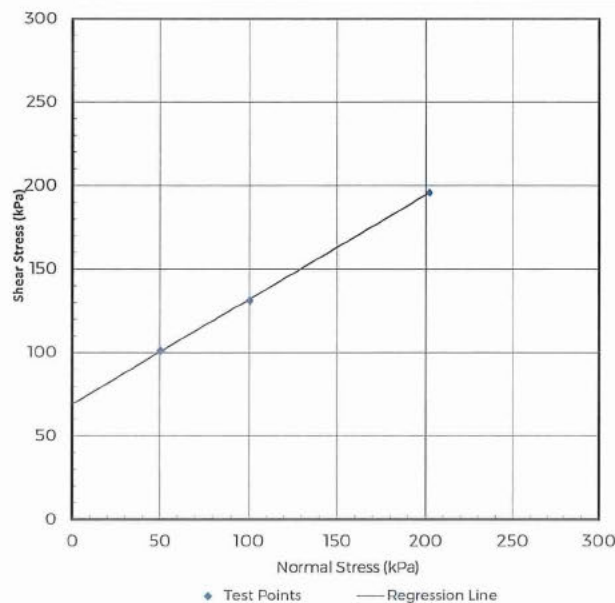
Project: Waterloo WTP Ground Improvement
 Location: Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client: Wellington Water c/o WSP
 Source: BH102(3.05-3.5) Depth: 3.20-3.35
 Sampled By: s7(2)(a) Date sampled: 30/09/20
 Description: Clayey SILT with minor sand
 Sample Condition: Undisturbed / As received water content

Sample type: Pushtube

Comments	
Consolidated Drained Test	
Initial Sample Dimensions:	Diameter=49.68 (mm), Ht=25.26 (mm).
Sheared at a constant rate of strain (mm/min)=	0.1691
Test Material Passing 2.36mm sieve (%) =	N/A

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_DS
 Client Ref:

Initial Sample Properties							Consolidated	
Sample No	Normal Stress (kPa)	Water Content (%)	Wet Density (t/m ³)	Dry Density (t/m ³)	Void Ratio (e ₀)	Deg Saturation (%)	Solid Density (t/m ³)	Void Ratio (e _p)
1	50	22.7	1.99	1.62	0.63	95	2.65 Assumed	0.60
2	100	22.7	1.99	1.62	0.63	95		0.61
3	202	22.7	1.97	1.60	0.65	92		0.58
Final Sample Properties			Maximum Stresses			Shear Rate: (Time to Failure (t _f)) (mins)		
Water Content (%)	Wet Density (t/m ³)	Dry Density (t/m ³)	Normal Stress (kPa)	Max Shear Stress (kPa)	Displacement (mm)	Sample No	Calculated t _f	t _f @ Shr Rate (mm/min)
						1		60min @ 0.1691
22.6	2.03	1.66	50	101.2	5.88	2		60min @ 0.1691
22.7	2.02	1.65	100	131.1	5.75	3	60.00	0.1691
22.2	2.05	1.67	202	195.9	5.27			
						Shear Strength Parameters @ Max Shear Stress		
Consolidated Drained Direct Shear Test Plot - Shear Stress (kPa) vs Normal Stress (kPa) Result at MAXIMUM SHEAR STRESS						φ _{hi} (°)	32	Degrees
						Cohesion (c)	69	kPa
						Correl Coeff	0.9998	r ²



Test Method	Notes
ASTM D 3080-11 : Direct Shear Test of Soils Under Consolidated Drained Conditions	W/C= Water Content. OWC=Optimum Water Content DD= Dry Density

Date Tested : 29/01-04/02/21

Date Reported : 5/02/2021

s7(2)(a)

Date : 5/02/2021

LHF 2511 (11/20)



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Page 1 of 4

**CONSOLIDATED DRAINED DIRECT SHEAR
TEST REPORT**



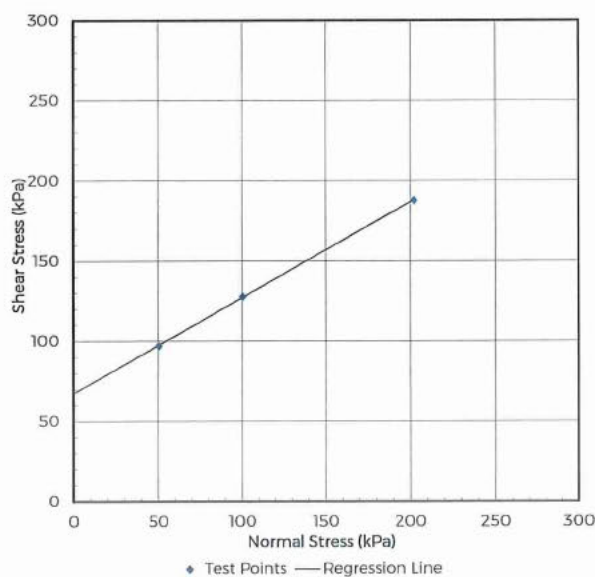
Project: Waterloo WTP Ground Improvement
 Location: Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client: Wellington Water c/o WSP
 Source: BH102(3.05-3.5) Depth: 3.20-3.35 Sample type: Pushtube
 Sampled By: **s7(2)(a)** 30/09/20
 Description: Clayey SILT with minor sand
 Sample Condition: Undisturbed / As received water content

Comments
 Consolidated Drained Test
 Initial Sample Dimensions: Diameter=49.68 (mm), Ht=25.26 (mm).
 Sheared at a constant rate of strain (mm/min)= 0.1691
 Test Material Passing 2.36mm sieve (%) = NA

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_DS
 Client Ref:

Test Values			Sample Properties at test			Result at RESIDUAL SHEAR STRESS		
Sample No	Normal Stress (kPa)	Shear Stress (kPa)	Water Content at Test (%)	Wet Density (t/m ³)	Dry Density (t/m ³)	Phi' (°)	31	Degrees
1	50	97.1	22.7	1.99	1.62	Cohesion (c)	68	kPa
2	100	127.9	22.7	1.99	1.62	Correl Coeff	0.9999	r ²
3	202	187.8	22.7	1.97	1.60			

Consolidated Drained Direct Shear Test Result at RESIDUAL SHEAR STRESS
 Normal Stress vs Shear Stress Plot
 Result at RESIDUAL SHEAR STRESS



Test Method	Notes
ASTM D 3080-11 : Direct Shear Test of Soils Under Consolidated Drained Conditions	

Date Tested: 29/01-04/02/21

Date Reported: 5/02/2021

s7(2)(a)



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Date: 5/02/2021
 LHF 2511 (11/20)

WSP
 Hamilton Laboratory
 Quality Management Systems Certified to ISO 9001

4 Fox Street
 Private Bag 3057
 Hamilton, New Zealand

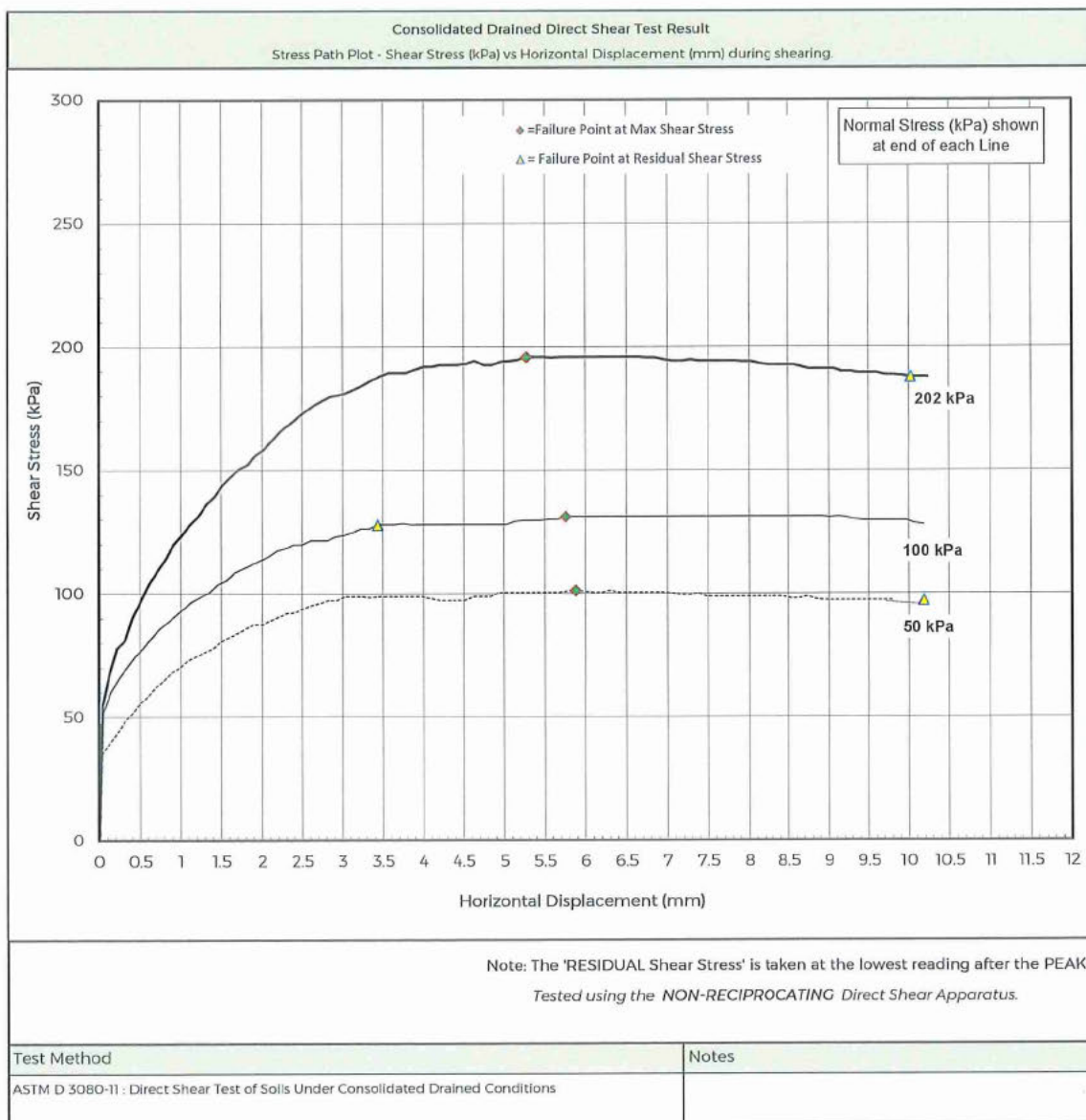
Telephone +64 7 856 2870
 Website www.wsp.com/nz

CONSOLIDATED DRAINED DIRECT SHEAR
Stress Path Plot TEST REPORT



Project: Waterloo WTP Ground Improvement
Location: Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
Client: Wellington Water c/o WSP
Source: BH102(3.05-3.5) Depth: 3.20-3.35 Sample type: Pushtube
Sampled By: s7(2)(a) 30/09/20
Description: Clayey SILT with minor sand
Sample Condition: Undisturbed / As received water content
Consolidated Drained Test

Project No: 3-WW019.11
Lab Ref No: HA6768_1_DS
Client Ref:



Date Tested : 29/01-04/02/21

Date Reported : 5/02/2021

s7(2)(a)

Date : 5/02/2021

LHF 2511 (1/20)



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CONSOLIDATED DRAINED DIRECT SHEAR
Stress Path Plot TEST REPORT

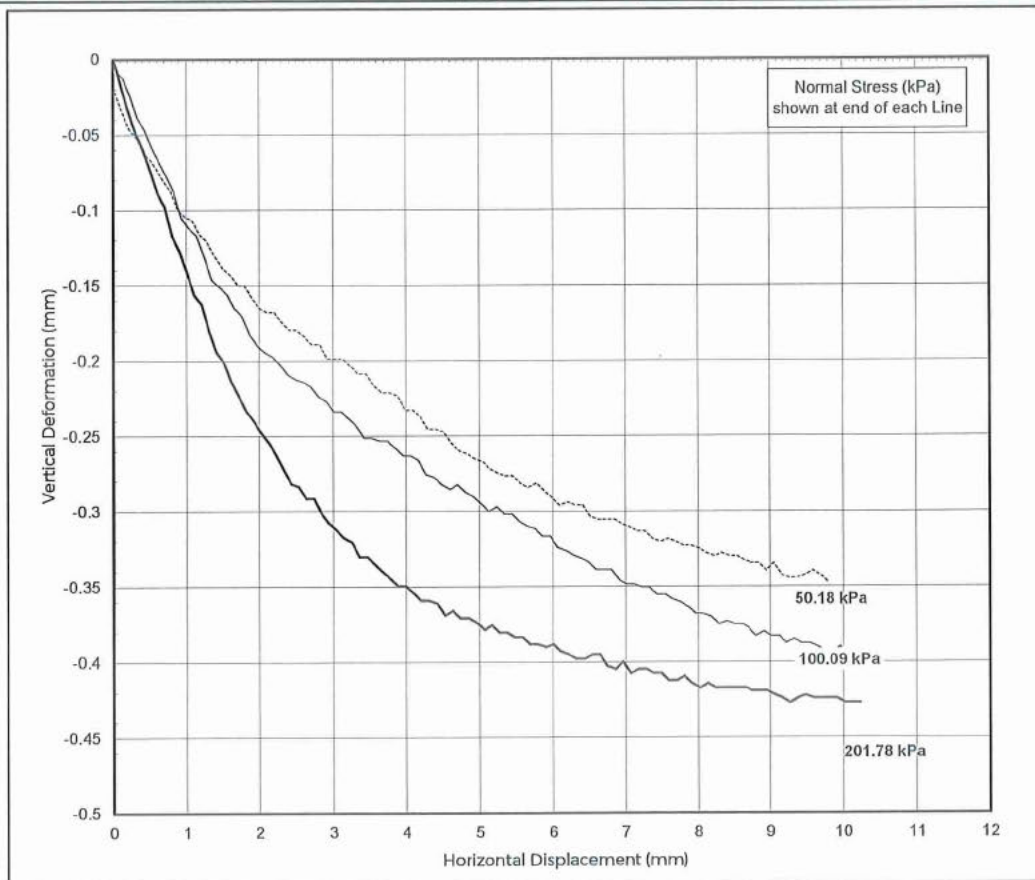


Project: Waterloo WTP Ground Improvement
Location: Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
Client: Wellington Water c/o WSP
Source: BH102(3.05-3.5) Depth: 3.20-3.35 Sample type: Pushtube
Sampled By: s7(2)(a) Date sampled: 30/09/20
Description: Clayey SILT with minor sand
Sample Condition: Undisturbed / As received water content

Project No: 3-WW019.11
Lab Ref No: HA6768_1_DS
Client Ref:

Consolidated Drained Direct Shear Test Result

Stress Path Plot - Vertical Deformation (mm) against Horizontal Displacement (mm) during shearing.



Note: The 'RESIDUAL Shear Stress' is taken at the lowest reading after the PEAK.
Tested using the NON-RECIPROCATING Direct Shear Apparatus.

Test Method	Notes
ASTM D 3080-11: Direct Shear Test of Soils Under Consolidated Drained Conditions	

Date Tested : 29/01-04/02/21

Date Reported : 5/02/2021

s7(2)(a)

Date : 5/02/2021

LHF 2511 (11/20)



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PLASTICITY INDEX FOR SOILS
TEST REPORT



Project : Waterloo WTP Ground Improvement
Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
Client : Wellington Water c/o WSP
Contractor : Griffiths Drilling
Sampled by : s7(2)(a)
Date sampled : 30/09/2020
Date received : 25/01/2021
Sampling method : Pushtube
Sample condition : As received

Project No : 3-WW019.11
Lab Ref No : HA6768_1_PI
Client Ref No :

Test Results				
Sample Lab Ref No :	HA6768_1_PI			
Sample Location ID :	BH102			
Sample Depth (m) :	3.05-3.5			
Soil Fraction Tested :	-425µm			
Natural Water Content (%) :	22.7			
Liquid Limit :	26			
Plastic Limit :	20			
Plasticity Index :	6			
Sample Description :	HA6768_1_PI Clayey SILT with minor sand			
Test Methods		Notes		
Water Content	NZS 4402 : 1986, Test 2.1	Soil fraction tested as shown.		
Liquid Limit	NZS 4402 : 1986, Test 2.2			
Plastic Limit	NZS 4402 : 1986, Test 2.3			
Plasticity Index	NZS 4402 : 1986, Test 2.4			

Date tested : 04/02/21
Date reported : 05/02/21

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s7(2)(a)

Date : 05/02/21



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PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

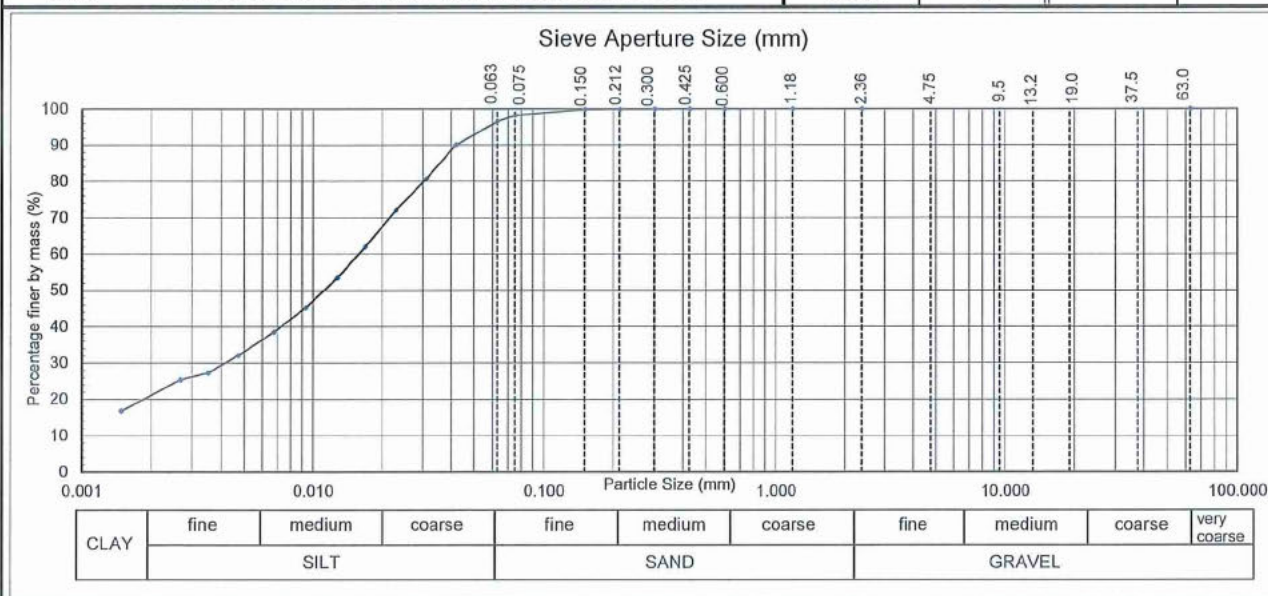
TEST REPORT



Project : Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water Limite c/o WSP
 Client/Sample Ref : BH102(3.05-3.5)
 Contractor : Griffiths Drilling
 Borehole No: BH102 Depth: 3.05-3.5 metres
 Sampled by : **s7(2)(a)**
 Date received : 25/01/21
 Sampling method : Pushtube
 Sample condition : As received
 Sample description : Clayey SILT with minor sand
 Solid Particle Density (t/m^3): 2.65 Assumed
 Water Content (as received): 22.7 %

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_PSD Hydro
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	100	0.0418	90	0.0067	38
37.5	--	2.36	100	0.212	100	0.0310	81	0.0047	32
19.0	--	1.18	100	0.150	100	0.0223	72	0.0035	27
13.2	--	0.600	100	0.075	98	0.0168	62	0.0027	25
9.5	--	0.425	100	0.063	97	0.0127	53	0.0015	17
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0093	45		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 8.0 (Whatmans Full Range pH Indicator paper) All information supplied by Client

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Date Tested: 04/02/21 This report may only be reproduced in full

Date Reported: 05/02/21

s7(2)(a)

Date : 05/02/21



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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Result Summary



Project: Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water c/o WSP
 Sample Location ID: BH102(3.05-3.5) Depth (m): 3.35-3.50
 Sampled by: **s7(2)(a)** Date sampled: 30/09/20
 Sampling Method: Pushtube
 Sample Description: Grey clayey SILT with minor sand. Firm, moist, low plasticity.

Comments: Multistage Test.

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_TxI
 Client Ref: -

Initial Sample properties

Length (mm) = 120.58
 Diameter (mm) = 60.42

Membrane Correction has been applied

Saturation achieved using a minimum Back Pressure of 300 kPa

Specimen Stage	Effective Confining Pressure (kPa)	INITIAL PROPERTIES			Solid Particle Density (t/m ³)	FINAL PROPERTIES		
		Densities (t/m ³)		Water Content (%)		Densities (t/m ³)		Water Content (%)
		Wet (t/m ³)	Dry (t/m ³)			Wet (t/m ³)	Dry (t/m ³)	
No								
1	50	2.11	1.71	23.0				
2	100				2.65			
3	200				(assumed)	2.11	1.78	18.9

Specimen Stage No	Effective Confining Pressure (kPa)	Void Ratio (e)	Deg of Saturation (Sr)		Deviator Stress $\sigma_1 - \sigma_3$ (kPa)	Pore Pressure μ (kPa)	Cumulative Strain (%)	Failure Criteria at Maximum Values
			Sr before Consolid. (%)	Sr after Consolid. (%)				
1	50	0.55	100	100	90.1	20	1.57	Stress Ratio
2	100				217.0	27	5.11	Stress Ratio
3	200				340.7	80	5.95	Stress Ratio

Specimen Stage No	Effective Confining Pressure (kPa)	Coefficient of Consolidation Cv (m ² /year)	Volume Compressibility Mv (m ² /MN)	Coefficient of Permeability k (m/s)	B at the start of test	Due to the use of side filter drains, IANZ endorsement does not include the Cv, Mv and k values reported herein. <u>Mv, Cv & k calculated for the following conditions:-</u> L/D=2, RADIAL+ONE END Drainage Side Filter Drains Used (L/D= Sample Length/Diameter.)
1	50	0.057	0.17	3.0 x 10 ⁻¹²	0.98	
2	100	0.36	0.19	2.1 x 10 ⁻¹¹		
3	200	0.063	0.17	3.3 x 10 ⁻¹²		

TOTAL STRESS RESULT		
Intercept d	6.83	(kPa)
Beta β	24.24	(deg)
Cohesion c	8	(kPa)
Phi ϕ	27	(deg)
Correl coeff.	0.9883	(r ²)

EFFECTIVE STRESS RESULT		
Intercept d'	2.19	(kPa)
Beta β'	30.12	(deg)
Cohesion c'	3	(kPa)
Phi ϕ'	35	(deg)
Correl ccoeff.	0.9998	(r ²)

Test Method	Notes
Triaxial Test : Consolidated undrained triaxial test : BS EN ISO 17892-9:2018 Water Content : NZS4402 : 1986 Test 2.1	Cv and Mv have been rounded to 2 significant figures. L/D= Sample Length/Diameter.

Date tested: 22/01-05/02/21
 Date reported: 9/02/21

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s7(2)(a)

Date: 9/02/21



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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Test Report - Mohr Coulomb Envelope Plot



Project: Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water c/o WSP
 Sample Location ID: BH102(3.05-3.5) Depth (m): 3.35-3.50
 Sampled by: s7(2)(a) Date sampled: 30/09/20
 Sampling Method: Pushtube
 Sample Description: Grey clayey SILT with minor sand. Firm, moist, low plasticity.

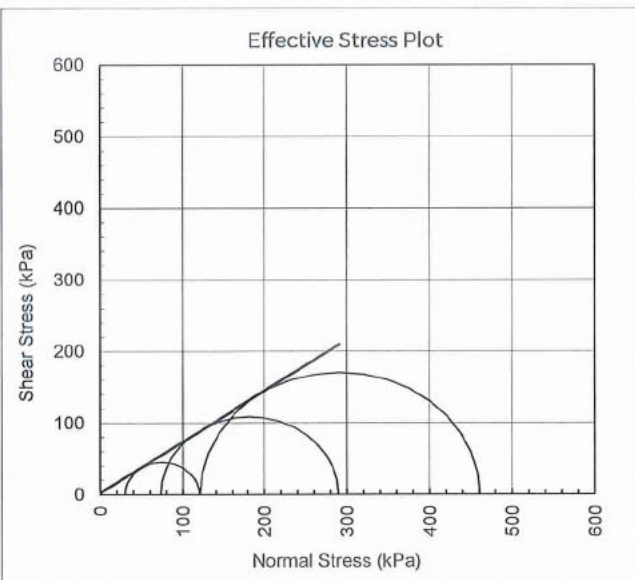
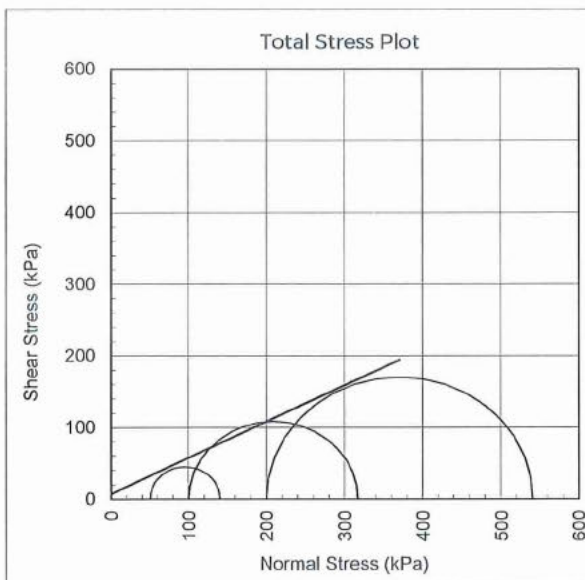
Comments: Multistage Test.

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_TxI
 Client Ref: -

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT

Mohr-Coulomb envelope plots - Result at Maximum Stress

Back Pressure Saturated at 300 kPa



TOTAL STRESS RESULT			
Intercept d	6.83	(kPa)	
Beta β	24.24	(deg)	
Cohesion c	8	(kPa)	
Phi ϕ	27	(deg)	
Correl coeff.	0.9883	(r^2)	

EFFECTIVE STRESS RESULT			
Intercept d'	2.19	(kPa)	
Beta β'	30.12	(deg)	
Cohesion c'	3	(kPa)	
Phi ϕ'	35	(deg)	
Correl coeff.	0.9998	(r^2)	

Test Method

Triaxial Test : Consolidated undrained triaxial test : BS EN ISO 17892-9:2018
 Water Content : NZS4402 : 1986 Test 2.1

Notes

Stage 1 : Stress Ratio
 Failure Criteria: Stage 2 : Stress Ratio
 (at Max. Values) Stage 3 : Stress Ratio

Date tested: 22/01-05/02/21

Date reported: 9/02/21

s7(2)(a)

Date: 9/02/21

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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All information supplied by Client



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Test Report - P vs Q Total Stress Plot



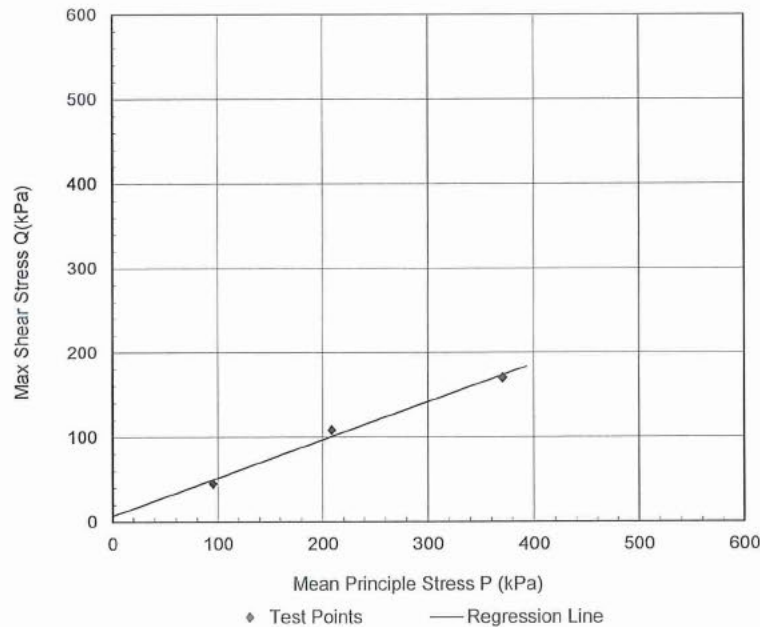
Project: Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water c/o WSP
 Sample Location ID: BH102(3.05-3.5) Depth (m): 3.35-3.50
 Sampled by: s7(2)(a) Date sampled: 30/09/20
 Sampling Method: Pushtube
 Sample Description: Grey clayey SILT with minor sand. Firm, moist, low plasticity.

Comments: Multistage Test.

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_TxI
 Client Ref: -

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT

P vs Q Total Stress Plot - Back Pressure saturated at 300 kPa



TOTAL STRESS RESULT			Correl coeff	0.9883	(r ²)
Intercept d	6.83	(kPa)	Cohesion c	8	(kPa)
Beta β	24.24	(deg)	Phi φ	27	(deg)

Test Method

Triaxial Test : Consolidated undrained triaxial test : BS EN ISO 17892-9:2018
 Water Content : NZS4402 : 1986 Test 2.1

Notes

Stage 1 : Stress Ratio
 Failure Criteria: Stage 2 : Stress Ratio
 (at Max. Values) Stage 3 : Stress Ratio

Date tested: 22/01-05/02/21
 Date reported: 9/02/21

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
 This report may only be reproduced in full
 All information supplied by Client

Date: 9/02/21



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Test Report - P' vs Q' Effective Stress Plot



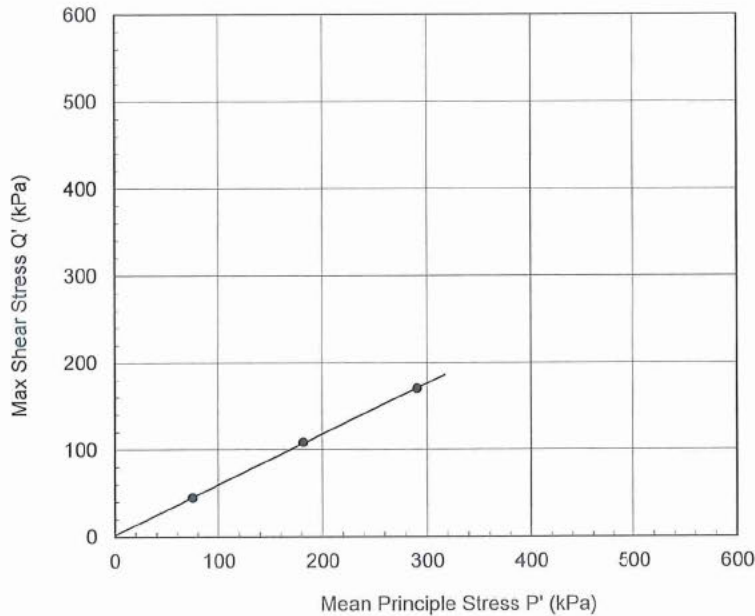
Project: Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water c/o WSP
 Sample Location ID: BH102(3.05-3.5) Depth (m): 3.35-3.50
 Sampled by: s7(2)(a) Date sampled: 30/09/20
 Sampling Method: Pushtube
 Sample Description: Grey clayey SILT with minor sand. Firm, moist, low plasticity.

Comments: Multistage Test.

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_TxI
 Client Ref: -

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT

P' vs Q' Effective Stress Plot - Back Pressure saturated at 300 kPa



● Test Points — Regression Line

EFFECTIVE STRESS RESULT				Correl coeff	0.9998	(r ²)
Intercept d'	2.19	(kPa)		Cohesion c'	3	(kPa)
Beta β'	30.12	(deg)		Phi Ø'	35	(deg)

Test Method

Triaxial Test : Consolidated undrained triaxial test : BS EN ISO 17892-9:2018
 Water Content : NZS4402 : 1986 Test 2.1

Notes

Stage 1 : Stress Ratio
 Failure Criteria: Stage 2 : Stress Ratio
 (at Max. Values) Stage 3 : Stress Ratio

Date tested: 22/01-05/02/21

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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All information supplied by Client

Date: 9/02/21

s7(2)(a)



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

LHF 2517 (09/20)

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Test Report - PvsQ Stress Path Plot



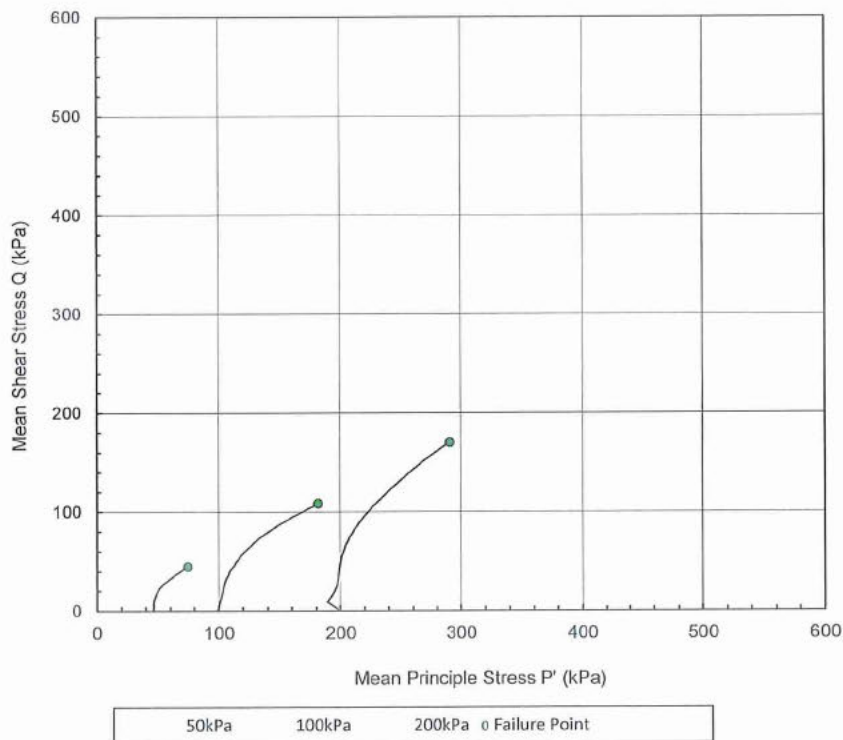
Project: Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water c/o WSP
 Sample Location ID: BH102(3.05-3.5) Depth (m): 3.35-3.50
 Sampled by: s7(2)(a) Date sampled: 30/09/20
 Sampling Method: Pushtube
 Sample Description: Grey clayey SILT with minor sand. Firm, moist, low plasticity.

Comments: Multistage Test.

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_TxI
 Client Ref: -

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT

P' vs Q Stress Path (Effective Stress Plot) - Back Pressure saturated at 300 kPa



Test Method	Notes
Triaxial Test : Consolidated undrained triaxial test : BS EN ISO 17892-9:2018	Stage 1 : Stress Ratio
Water Content : NZS4402 : 1986 Test 2.1	Failure Criteria: Stage 2 : Stress Ratio
	(at Max. Values) Stage 3 : Stress Ratio

Date tested: 22/01-05/02/21

s7(2)(a)

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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 All information supplied by Client

Date: 9/02/21



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Test Report - Strain vs Deviator Stress Plot



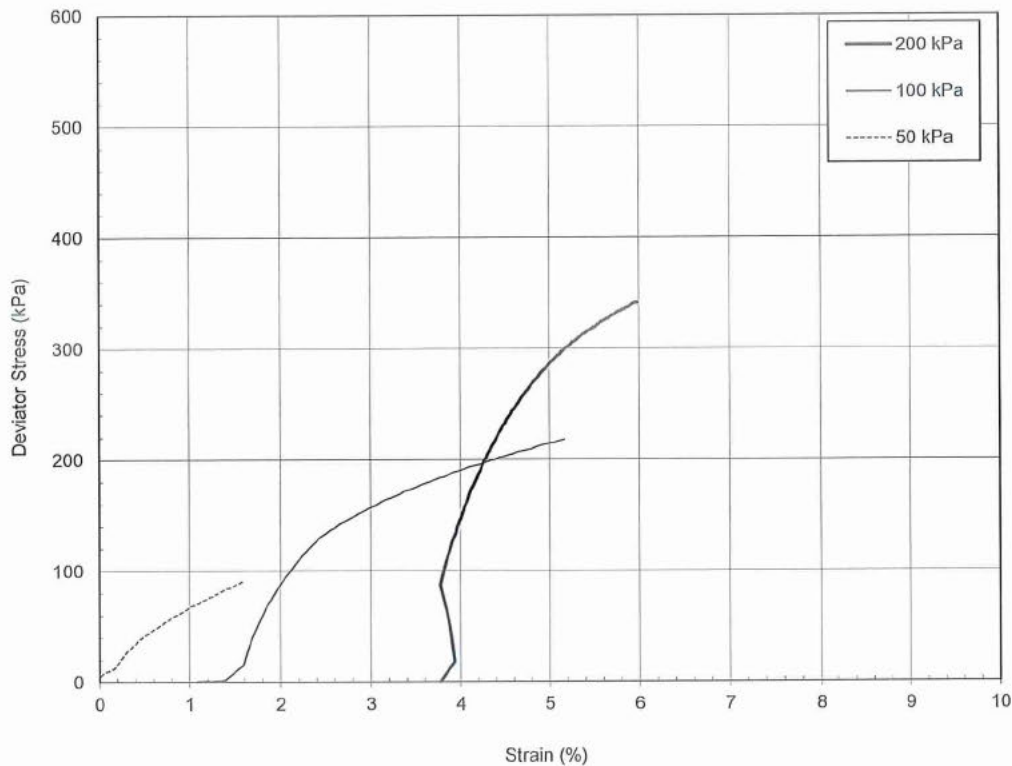
Project: Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water c/o WSP
 Sample Location ID: BH102(3.05-3.5) Depth (m): 3.35-3.50
 Sampled by: s7(2)(a) Date sampled: 30/09/20
 Sampling Method: Pushtube
 Sample Description: Grey clayey SILT with minor sand. Firm, moist, low plasticity.

Comments: Multistage Test.

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_TxI
 Client Ref: -

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT

Strain vs Deviator Stress Plot - Back Pressure saturated at 300 kPa



Test Method	Notes
Triaxial Test : Consolidated undrained triaxial test : BS EN ISO 17892-9:2018 Water Content : NZS4402 : 1986 Test 2.1	

Date tested: 22/01-05/02/21
 Date reported: 9/02/21

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
 This report may only be reproduced in full
 All information supplied by Client

s7(2)(a)

Date: 9/02/21



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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

Test Report - Strain vs Pore Pressure Plot



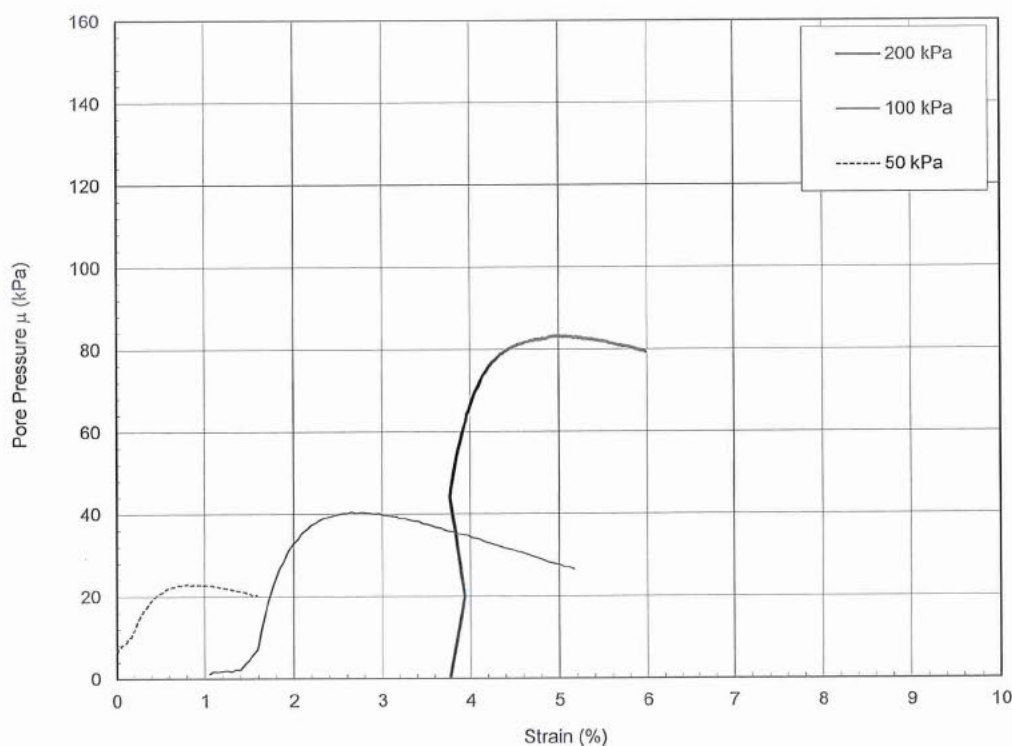
Project: Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water c/o WSP
 Sample Location ID: BH102(3.05-3.5) Depth (m): 3.35-3.50
 Sampled by: s7(2)(a) Date sampled: 30/09/20
 Sampling Method: Pushtube
 Sample Description: Grey clayey SILT with minor sand. Firm, moist, low plasticity.

Comments: Multistage Test.

Project No: 3-WW019.11
 Lab Ref No: HA6768_1_Txl
 Client Ref: -

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT

Strain vs Pore Pressure Plot - Back Pressure saturated at 300 kPa



Test Method

Triaxial Test : Consolidated undrained triaxial test : BS EN ISO 17892-9:2018
 Water Content : NZS4402 : 1986 Test 2.1

Notes

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
 This report may only be reproduced in full
 All information supplied by Client

Date tested: 22/01-05/02/21
 Date reported: 9/02/21

s7(2)(a)

Date: 9/02/21



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Displacement vs $\sqrt{t}$ Plot (Consolidation stage)

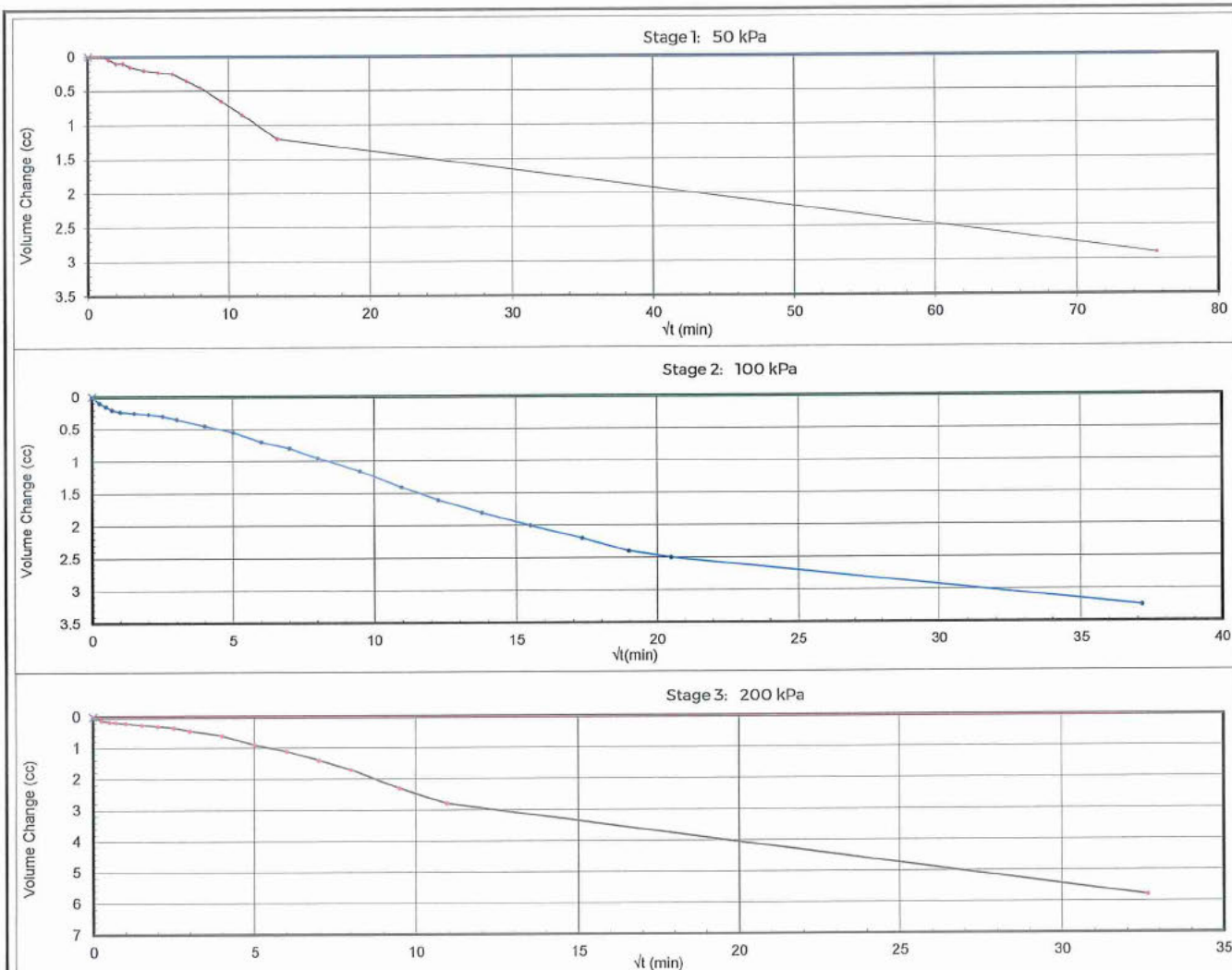


Project: Waterloo WTP Ground Improvement
Location: Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
Client: Wellington Water c/o WSP
Sample Location ID: BH102(3.05-3.5)
Sampled by: s7(2)(a)
Sampling Method: Pushtube
Sample Description: Grey clayey SILT with minor sand. Firm, moist, low plasticity.

Depth (m): 3.35-3.50
Date sampled: 30/09/20

Comments: Multistage Test.

Project No: 3-WW019.11
Lab Ref No: HA6768_1_Txl
Client Ref: -



Test Method	Test Results			
Triaxial Test : Consolidated undrained triaxial test : BS EN ISO 17892-9:2018	Confining Pressure (kPa)=	50 kPa	100 kPa	200 kPa
Water Content : NZS4402 : 1986 Test 2.1	C_v (m^2/yr)=	0.06	0.36	0.06
	M_v (m^2/VN)=	0.17	0.19	0.17
	k (m/s)=	2.96E-12	2.13E-11	3.31E-12
	$\sqrt{t_c}$ =	36.391	14.432	34.722
	t_{100} =	1324.305	208.283	1205.617

Date tested : 22/01-05/02/21
Date reported : 9/02/21

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
This report may only be reproduced in full

All information supplied by Client
Date: 9/02/21



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

s7(2)(a)

LHF 2517 (09/20)

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PLASTICITY INDEX FOR SOILS
TEST REPORT



Project : Waterloo Water Treatment Plant - Ground Improvement
Location : Lower Hutt, Wellington
Client : Wellington Water Limited c/o WSP
Contractor : -
Sampled by : WSP
Date sampled : October 2020
Date received : 6/11/2020
Sampling method : Bag Sample
Sample condition : As received

Project No : 3-WW019.11
Lab Ref No : HA6768/1-4_PI
Client Ref No :

Test Results

Sample Lab Ref No :	HA6768_1_PI	HA6768_2_PI	HA6768_3_PI	HA6768_4_PI
Sample Location ID :	BH101	BH101	BH101	BH101
Sample Depth (m) :	3.0-3.45(A)	3.0-3.45(B)	3.65-4.1(A)	3.65-4.1(B)
Soil Fraction Tested :	-425µm	-425µm	-425µm	-425µm
Liquid Limit :	29	24	24	26
Plastic Limit :	19	18	18	20
Plasticity Index :	10	6	6	6

Sample Description : HA6768_1_PI Clayey SILT, minor sand
HA6768_2_PI Clayey SILT, minor sand
HA6768_3_PI Clayey SILT, trace sand
HA6768_4_PI Clayey SILT, minor sand

Test Methods	Notes
Water Content NZS 4402 : 1986, Test 2.1	Soil fraction tested as shown.
Liquid Limit NZS 4402 : 1986, Test 2.2	1. Testing not accredited due to samples being oven dried prior to testing
Plastic Limit NZS 4402 : 1986, Test 2.3	2. W/C not included in report due to rewetting of samples
Plasticity Index NZS 4402 : 1986, Test 2.4	

Date tested : 18/01/21
Date reported : 04/02/21

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All information supplied by Client

s7(2)(a)

Date : 04/02/21

PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

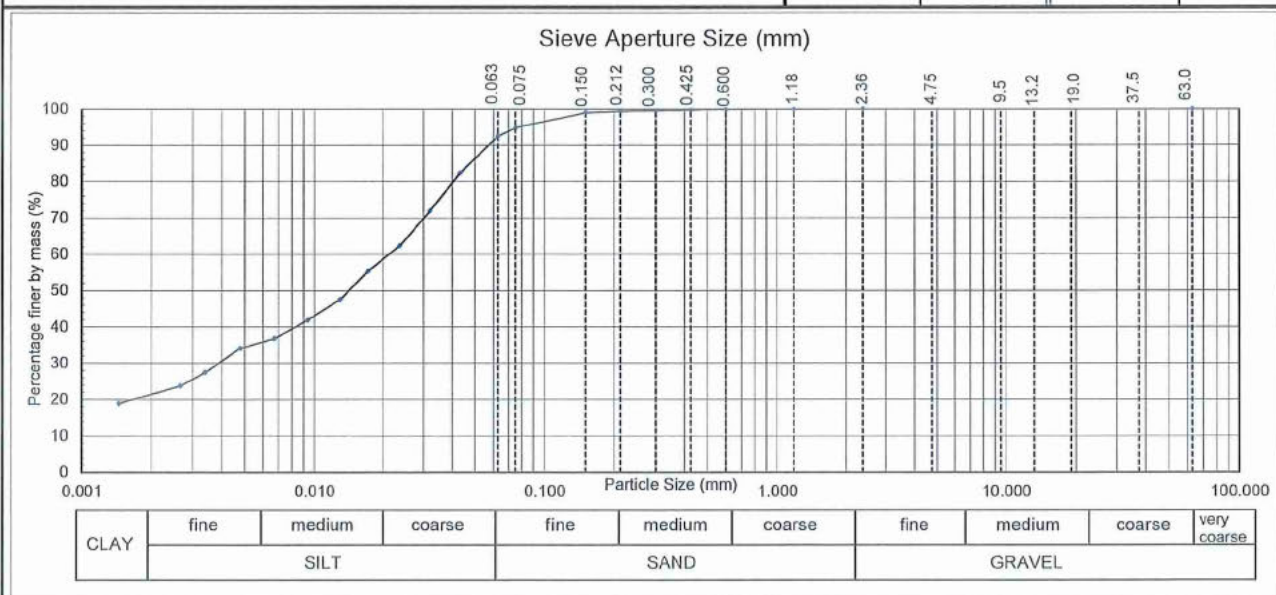
TEST REPORT



Project : Waterloo WTP Ground Improvements
 Location : Lower Hutt, Wellington
 Client : Wellington Water Limited c/o WSP
 Client/Sample Ref : 101_3-3.45A
 Contractor : -
 Borehole No: BH101 Depth: 3.0-3.45 metres
 Sampled by : WSP
 Date received : 06/11/20
 Sampling method : Bag Sample
 Sample condition : As received
 Sample description : Clayey SILT with minor sand
 Solid Particle Density (t/m³): 2.70 Assumed
 Water Content (as received): 23.9 %

Project No: 3-VVW019.11
 Lab Ref No: HA6768/1_Hydro
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	99	0.0431	82	0.0067	37
37.5	--	2.36	100	0.212	99	0.0320	72	0.0048	34
19.0	--	1.18	100	0.150	99	0.0235	62	0.0034	27
13.2	--	0.600	100	0.075	95	0.0172	55	0.0026	24
9.5	--	0.425	100	0.063	93	0.0129	48	0.0014	19
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0093	42		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 8.0 (Whatmans Full Range pH Indicator paper) All information supplied by Client Re wet sample. Sample cannot be IANZ accredited

Date Tested: 19/01/21 This report may only be reproduced in full

Date Reported: 04/02/21

s7(2)(a)

Approved
 Designation : Senior Civil Engineering Technician
 Date : 04/02/21

PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

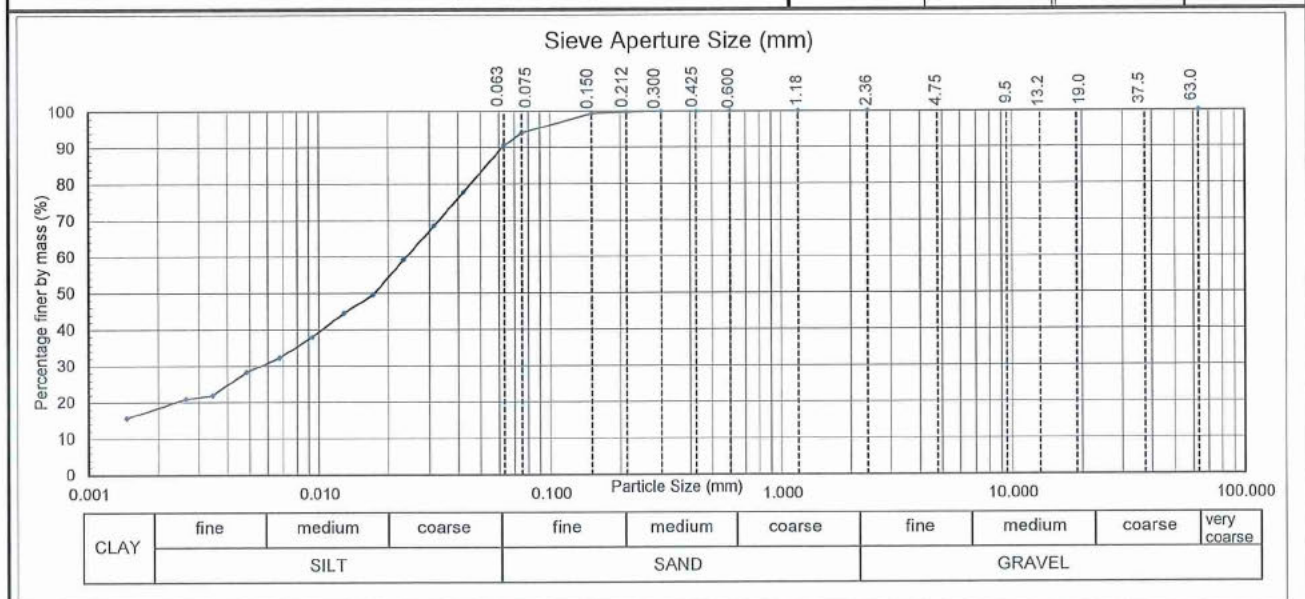
TEST REPORT



Project : Waterloo WTP Ground Improvements
 Location : Lower Hutt, Wellington
 Client : Wellington Water Limited c/o WSP
 Client/Sample Ref : 101_3-3.45B
 Contractor : -
 Borehole No: BH101 Depth: 3.0-3.45 metres
 Sampled by : WSP
 Date received : 06/11/20
 Sampling method : Bag Sample
 Sample condition : As received
 Sample description : Clayey SILT with minor sand
 Solid Particle Density (t/m^3): 2.70 Assumed
 Water Content (as received): 19.9 %

Project No: 3-WW019.11
 Lab Ref No: HA6768/2_Hydro
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	100	0.0422	78	0.0067	32
37.5	--	2.36	100	0.212	100	0.0314	68	0.0048	28
19.0	--	1.18	100	0.150	99	0.0232	59	0.0034	22
13.2	--	0.600	100	0.075	94	0.0172	50	0.0026	21
9.5	--	0.425	100	0.063	91	0.0128	45	0.0015	16
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0093	38		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986; Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 8.0 (Whatmans Full Range pH Indicator paper) All information supplied by Client Re wet sample. Sample cannot be IANZ accredited

Date Tested: 19/01/21 This report may only be reproduced in full

Date Reported: 04/02/21 **s7(2)(a)**

Approved
 Designation : Senior Civil Engineering Technician
 Date : 04/02/21

PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

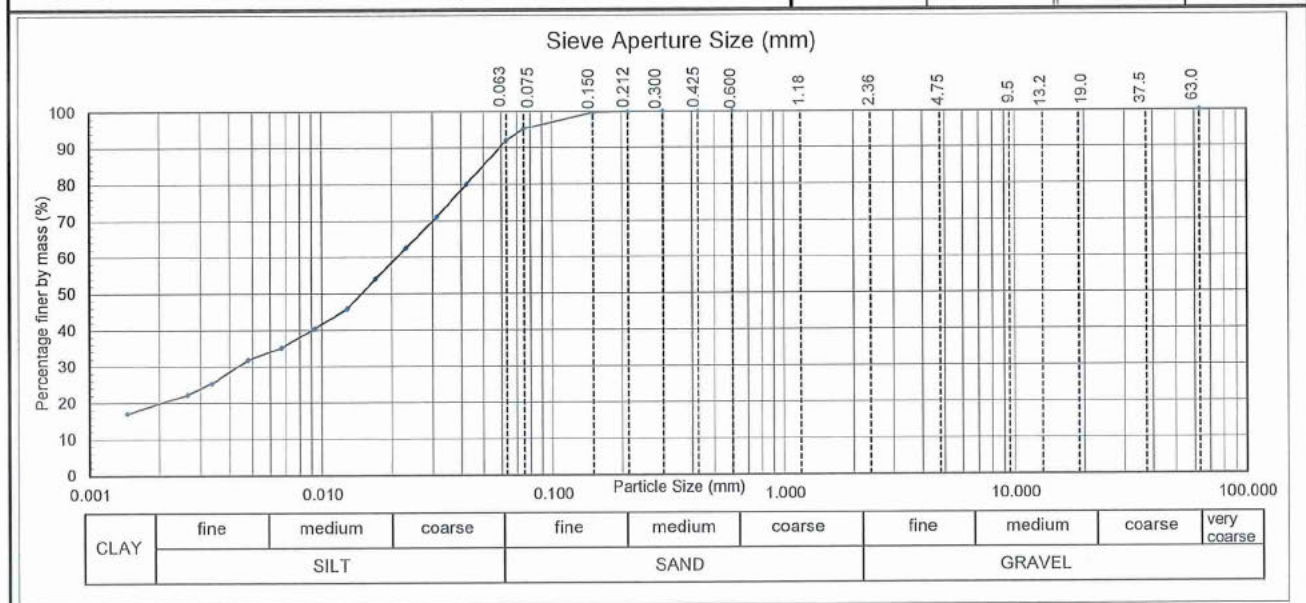
TEST REPORT



Project : Waterloo WTP Ground Improvements
 Location : Lower Hutt, Wellington
 Client : Wellington Water Limited c/o WSP
 Client/Sample Ref : 101_3.65-4.1A
 Contractor : -
 Borehole No: BH101 Depth: 3.65-4.1 metres
 Sampled by : WSP
 Date received : 06/11/20
 Sampling method : Bag Sample
 Sample condition : As received
 Sample description : Clayey SILT with trace sand
 Solid Particle Density (t/m^3): 2.70 Assumed
 Water Content (as received): 20.3 %

Project No: 3-WW019.11
 Lab Ref No: HA6768/3_Hydro
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	100	0.0421	80	0.0067	35
37.5	--	2.36	--	0.212	100	0.0312	71	0.0048	32
19.0	--	1.18	--	0.150	100	0.0230	63	0.0033	25
13.2	--	0.600	100	0.075	95	0.0169	54	0.0026	22
9.5	--	0.425	100	0.063	92	0.0128	46	0.0014	17
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0092	40		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 8.0 (Whatmans Full Range pH Indicator paper) All information supplied by Client Re wet sample. Sample cannot be IANZ accredited.

Date Tested: 19/01/21 This report may only be reproduced in full

Date Reported: 04/02/21 **s7(2)(a)**

Approved
 Designation : Senior Civil Engineering Technician
 Date : 04/02/21

PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

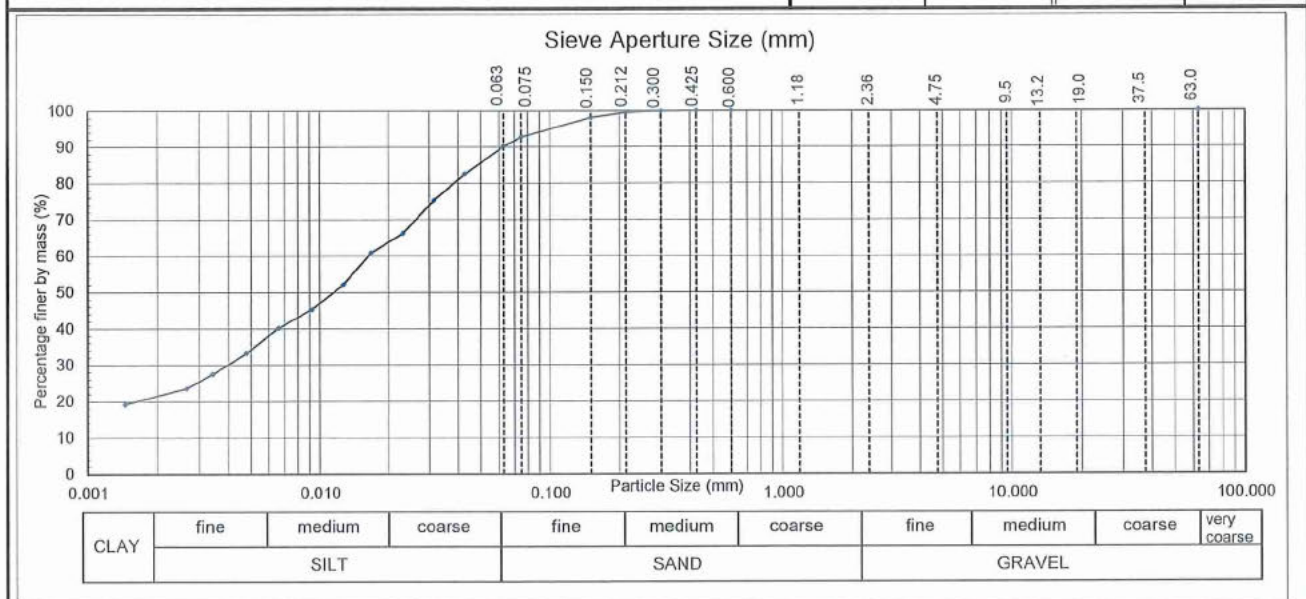
TEST REPORT



Project : Waterloo WTP Ground Improvements
 Location : Lower Hutt, Wellington
 Client : Wellington Water Limited c/o WSP
 Client/Sample Ref : 101_3.65-4.1B
 Contractor : -
 Borehole No: BH101 Depth: 3.65-4.1 metres
 Sampled by : WSP
 Date received : 06/11/20
 Sampling method : Bag Sample
 Sample condition : As received
 Sample description : Clayey SILT with minor sand
 Solid Particle Density (t/m^3): 2.70 Assumed
 Water Content (as Tested): 22.6 %

Project No: 3-WW019.11
 Lab Ref No: HA6768/4_Hydro
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	100	0.0427	83	0.0066	40
37.5	--	2.36	--	0.212	99	0.0313	75	0.0048	33
19.0	--	1.18	--	0.150	98	0.0231	66	0.0034	28
13.2	--	0.600	100	0.075	93	0.0167	61	0.0026	24
9.5	--	0.425	100	0.063	90	0.0125	52	0.0014	19
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0092	45		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 8.0 (Whatmans Full Range pH Indicator paper) All information supplied by Client Re Wet sample. Sample cannot be IANZ accredited

Date Tested: 19/01/21 This report may only be reproduced in full

Date Reported: 04/02/21 **s7(2)(a)**

Approved
 Designation : Senior Civil Engineering Technician
 Date : 04/02/21

TEST REPORT



Project : Waterloo WTP Ground Improvement
 Location : Waterloo Water Treatment Plant, Oxford Tce, Lower Hutt
 Client : Wellington Water c/o WSP
 Contractor : Griffiths Drilling
 Sampled by : s7(2)(a)
 Date sampled : 30/09/20
 Sampling method : Pushtube
 Sample ID : BH102(3.7-4.14) Depth (m): 4.14
 Sample description : Clayey SILT with minor sand
 Sample condition : As received

Project No : 3-WW019.11
 Lab Ref No : HA6768_SV
 Client Ref No :

Test Results

Peak shear strength	kPa	81
Remoulded shear strength	kPa	24

Test Methods

Shear Strength using a Hand Held Shear Vane, NZ Geotechnical Soc Inc 8/2001

Notes

Date tested : 05/02/21
 Date reported : 05/02/21

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
 This report may only be reproduced in full
 Information supplied by Client

IANZ Approved Signatory

s7(2)(a)

Designation : Senior Civil Engineering Technician
 Date : 05/02/21



Test results indicated as not
 accredited are outside the
 scope of the laboratory's
 accreditation

PARTICLE SIZE ANALYSIS TEST REPORT

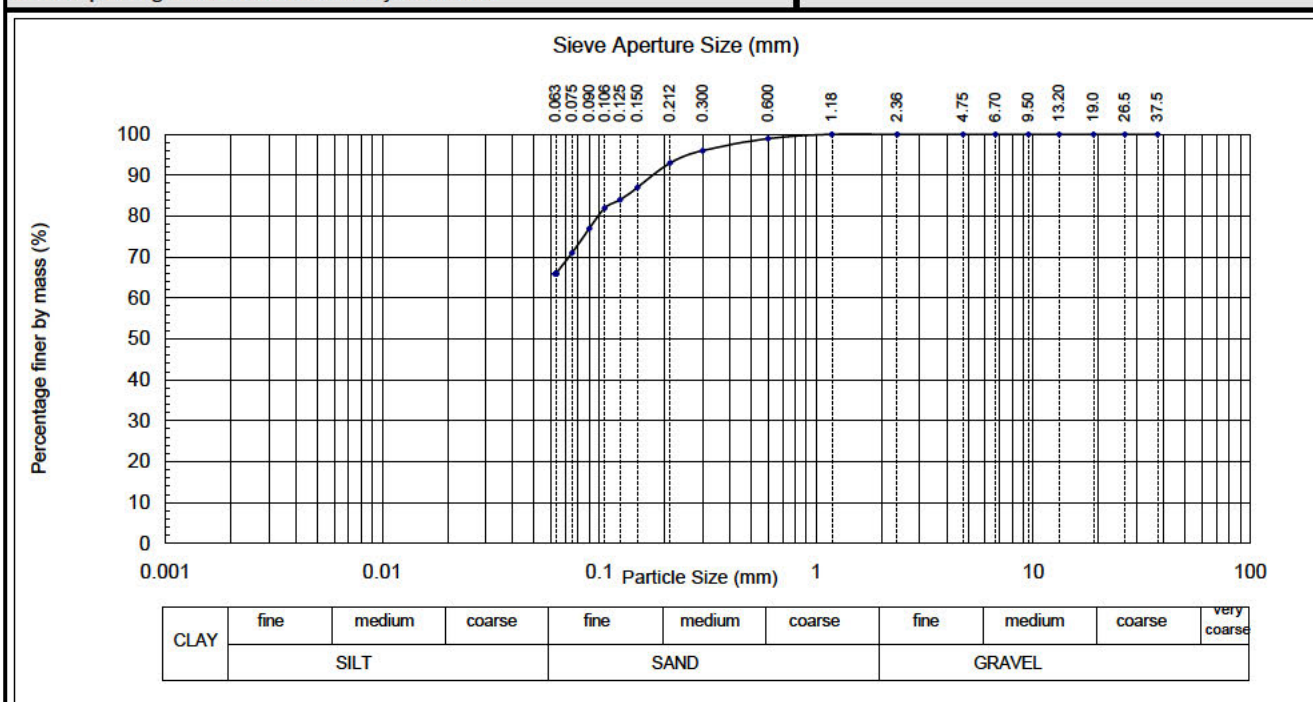


Project: **Waterloo WTP Ground Improvement 3-WW019.11**
 Location: **Waterloo Water Treatment Plant, Oxford Tce, LH**
 Client: **Wellington Water**
 Contractor: **Griffiths Drilling Limited**
 Sampled by: **s7(2)(a)**
 Date sampled: **2.10.20**
 Sampling method: **Sonic core drilling**
 Sample source: **BH101 7.5-8.0m**
 Sample description: **Sandy SILT:**
 Sample condition: **As received**
 Solid density (fines) **n/a** t/m³ **Assumed**
 Water content as rec'd **38.0** % **whole**

Report No: **522900/1406**
 Sample No: **2-20/294**
 Client Ref: **3-WW019.11**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
37.5	100	4.75	100	0.150	87				
26.5	100	2.36	100	0.125	84				
19.0	100	1.18	100	0.106	82				
13.20	100	0.600	99	0.090	77				
9.50	100	0.300	96	0.075	71				
6.70	100	0.212	93	0.063	66				

Percent passing finest sieve obtained by difference



Test Methods (where used)	Notes
Particle Size Analysis: NZS 4402 1986 Test 2.8.1 (Wet Sieve)	History: Air dried
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	Uncalibrated sieve sizes 0.212, 0.125, 0.106, 0.090mm
	Project / sample details supplied by client

Date Tested: **10-23.11.20**
 Date Reported: **24.11.20**

Testing only is covered by IANZ Accreditation
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IANZ Approved Signatory
 Designation *Technical Office*
 Date:

s7(2)(a)
24.11.20



All tests reported herein
 have been performed in
 accordance with the
 laboratory's scope of
 accreditation

PARTICLE SIZE ANALYSIS TEST REPORT

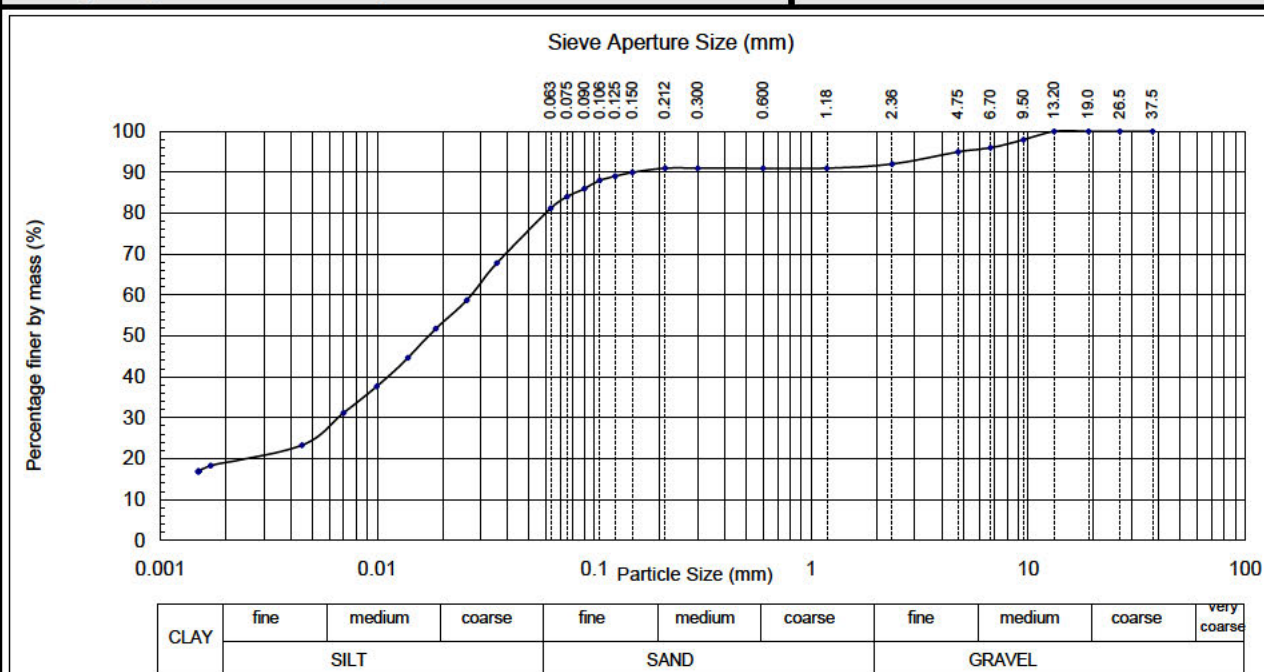


Project: **Waterloo WTP Ground Improvement 3-WW019.11**
 Location: **Waterloo Water Treatment Plant, Oxford Tce, LH**
 Client: **Wellington Water**
 Contractor: **Griffiths Drilling Limited**
 Sampled by: **s7(2)(a)**
 Date sampled: **8.9.20**
 Sampling method: **Sonic core drilling**
 Sample source: **BH103 4.5-5.0m**
 Sample description: **SILT:**
 Sample condition: **As received**
 Solid density (fines) **2.70 t/m³** Assumed
 Water content as rec'd **23.6 %** whole

Report No: **522900/1406**
 Sample No: **2-20/295**
 Client Ref: **3-WW019.11**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
37.5	100	4.75	95	0.150	90	0.0357	68	0.0045	23
26.5	100	2.36	92	0.125	89	0.0259	59	0.0017	18
19.0	100	1.18	91	0.106	88	0.0186	52	0.0015	17
13.20	100	0.600	91	0.090	86	0.0139	45		
9.50	98	0.300	91	0.075	84	0.0100	38		
6.70	96	0.212	91	0.063	81	0.0070	31		

Percent passing finest sieve obtained by difference



Test Methods (where used)	Notes
Particle Size Analysis: NZS 4402 1986 Test 2.8.1 (Wet Sieve)	History: Air dried
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	Uncalibrated sieve sizes 0.212, 0.125, 0.106, 0.090mm
	Project / sample details supplied by client

Date Tested: **10-23.11.20**
 Date Reported: **24.11.20**

Testing only is covered by IANZ Accreditation
 This report may only be reproduced in full

IANZ Approved Signatory
 Designation *Technical Officer*
 Date: **24.11.20**

s7(2)(a)



All tests reported herein
 have been performed in
 accordance with the
 laboratory's scope of
 accreditation

PARTICLE SIZE ANALYSIS TEST REPORT

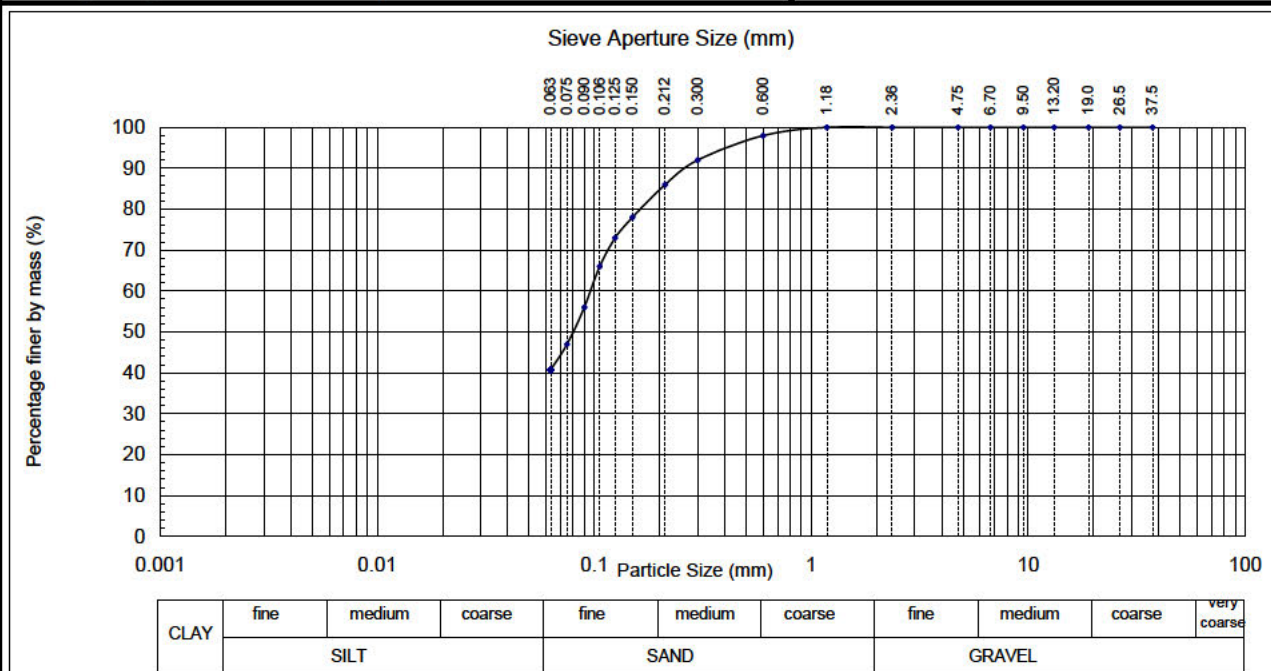


Project: **Waterloo WTP Ground Improvement 3-WW019.11**
 Location: **Waterloo Water Treatment Plant, Oxford Tce, LH**
 Client: **Wellington Water**
 Contractor: **Griffiths Drilling Limited**
 Sampled by: **s7(2)(a)**
 Date sampled: **8.9.20**
 Sampling method: **Sonic core drilling**
 Sample source: **BH103 8.6-9.0m**
 Sample description: **Silty SAND:**
 Sample condition: **As received**
 Solid density (fines) **n/a** t/m³ **Assumed**
 Water content as rec'd **27.8** % **whole**

Report No: **522900/1406**
 Sample No: **2-20/296**
 Client Ref: **3-WW019.11**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
37.5	100	4.75	100	0.150	78				
26.5	100	2.36	100	0.125	73				
19.0	100	1.18	100	0.106	66				
13.20	100	0.600	98	0.090	56				
9.50	100	0.300	92	0.075	47				
6.70	100	0.212	86	0.063	41				

Percent passing finest sieve obtained by difference



Test Methods (where used)	Notes
Particle Size Analysis: NZS 4402 1986 Test 2.8.1 (Wet Sieve)	History: Air dried
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	Uncalibrated sieve sizes 0.212, 0.125, 0.106, 0.090mm
	Project / sample details supplied by client

Date Tested: **10-23.11.20**
 Date Reported: **24.11.20**

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IANZ Approved Signatory
 Designation *Technical Officer*
 Date:

s7(2)(a)
24.11.20



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PARTICLE SIZE ANALYSIS TEST REPORT

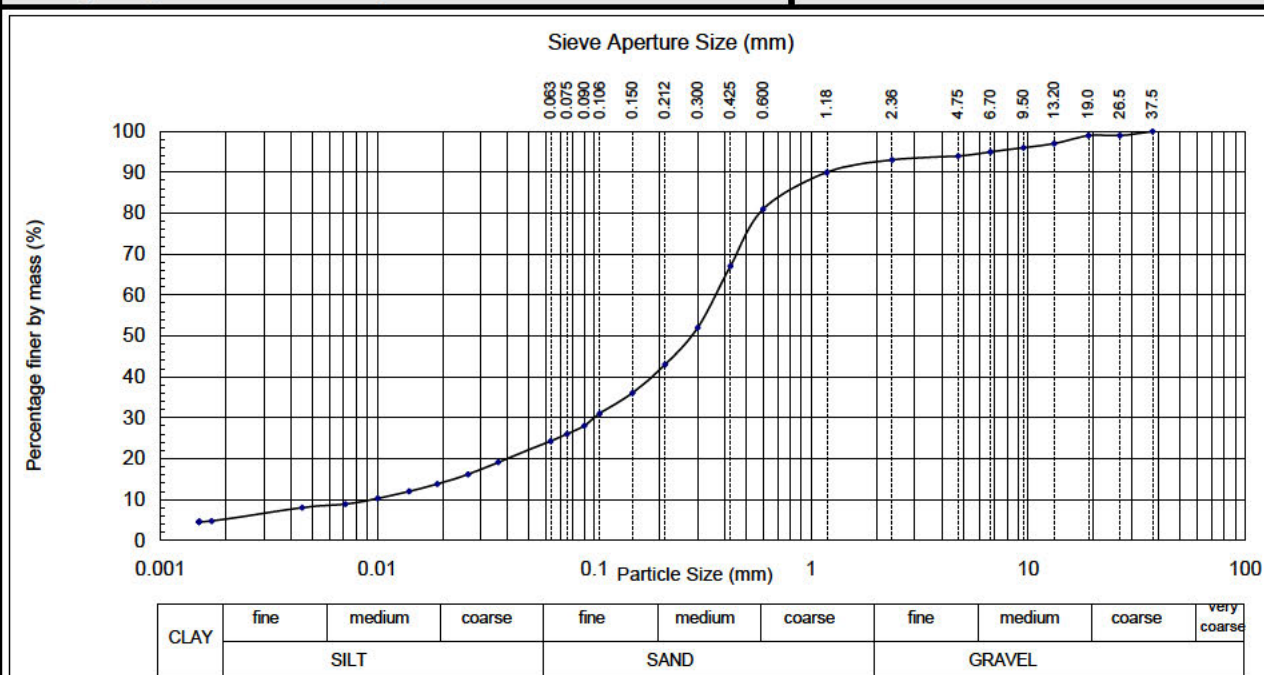


Project: **Waterloo WTP Ground Improvement 3-WW019.11**
 Location: **Waterloo Water Treatment Plant, Oxford Tce, LH**
 Client: **Wellington Water**
 Contractor: **Griffiths Drilling Limited**
 Sampled by: **s7(2)(a)**
 Date sampled: **3.9.20**
 Sampling method: **Sonic core drilling**
 Sample source: **BH104 3.5-4.0m**
 Sample description: **Silty SAND:**
 Sample condition: **As received**
 Solid density (fines) **2.70 t/m³** Assumed
 Water content as rec'd **17.8 %** whole

Report No: **522900/1406**
 Sample No: **2-20/297**
 Client Ref: **3-WW019.11**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
37.5	100	4.75	94	0.212	43	0.0361	19	0.0045	8
26.5	99	2.36	93	0.150	36	0.0262	16	0.0017	5
19.0	99	1.18	90	0.106	31	0.0189	14	0.0015	5
13.20	97	0.600	81	0.090	28	0.0140	12		
9.50	96	0.425	67	0.075	26	0.0101	10		
6.70	95	0.300	52	0.063	24	0.0071	9		

Percent passing finest sieve obtained by difference



Test Methods (where used)	Notes
Particle Size Analysis: NZS 4402 1986 Test 2.8.1 (Wet Sieve)	History: Air dried
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	Uncalibrated sieve sizes 0.212, 0.106, 0.090mm
	Project / sample details supplied by client

Date Tested: **10-23.11.20**
 Date Reported: **24.11.20**

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IANZ Approved Signatory
 Designation *Technical Officer*
 Date: **24.11.20**

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PARTICLE SIZE ANALYSIS TEST REPORT

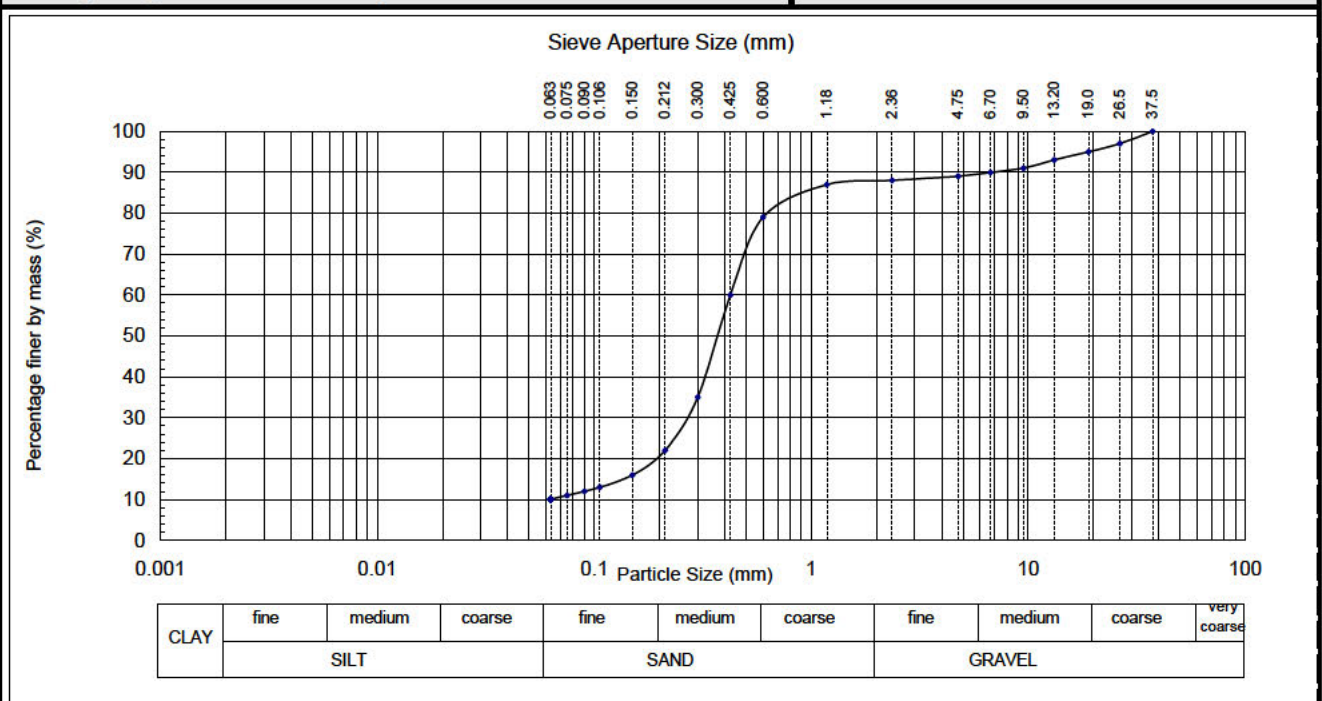


Project: **Waterloo WTP Ground Improvement 3-WW019.11**
 Location: **Waterloo Water Treatment Plant, Oxford Tce, LH**
 Client: **Wellington Water**
 Contractor: **Griffiths Drilling Limited**
 Sampled by: **s7(2)(a)**
 Date sampled: **3.9.20**
 Sampling method: **Sonic core drilling**
 Sample source: **BH104 5.5-6.0m**
 Sample description: **SAND:**
 Sample condition: **As received**
 Solid density (fines) **n/a** t/m³ Assumed
 Water content as rec'd **28.7** % whole

Report No: **522900/1406**
 Sample No: **2-20/298**
 Client Ref: **3-WW019.11**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
37.5	100	4.75	89	0.212	22				
26.5	97	2.36	88	0.150	16				
19.0	95	1.18	87	0.106	13				
13.20	93	0.600	79	0.090	12				
9.50	91	0.425	60	0.075	11				
6.70	90	0.300	35	0.063	10				

Percent passing finest sieve obtained by difference



Test Methods (where used)	Notes
Particle Size Analysis: NZS 4402 1986 Test 2.8.1 (Wet Sieve)	History: Air dried
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	Uncalibrated sieve sizes 0.212, 0.106, 0.090mm
	Project / sample details supplied by client

Date Tested: **10-23.11.20**
 Date Reported: **24.11.20**

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 Designation *Technical Officer*
 Date:

s7(2)(a)
 24.11.20



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