

7 – 15 Church Street (Ashburton)

Geotechnical Design Report

Prepared for Kāinga Ora Prepared by Beca Limited

7 August 2023



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Revision History

Revision N ^o	Prepared By	Description	Date
01	Oliver Rees	For Building and Subdivision Consent.	26/07/2023
02	Oliver Rees	Updated Finished Floor Levels	07/08/2023

Document Acceptance

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Approved by	Paul Horrey	Blow	07/08/2023
on behalf of	Beca Limited		1

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Executive Summary

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Ground Conditions

This site investigation revealed a soil profile consisting of silty sands/sandy silts in the

upper 2 m overlying medium dense to dense sand/gravel.

Site Classification						
NZS1170.5 Site Subsoil class		Soil class D				
Liquefaction Hazard						
The equivalent MBIE residential at this site is:	Foundation Technical Category	TC1				
Predicted maximum SLS free field	Predicted maximum SLS free field settlements					
Predicted maximum ULS free field	Predicted maximum ULS free field settlements					
Lateral Movement Hazard						
Distance to the nearest free face	e/ watercourse	400 m				
Height of the free face	Height of the free face					
Risk of lateral movement-induce	Risk of lateral movement-induced ground damage					
Design Depths	Design Depths					
Measured depth to groundwate	Measured depth to groundwater at time of investigation					
Average depth to groundwater (Canterbury Maps	5 m bgl				
Worst case topsoil thickness/ma	aximum elevation	0.30 m / 89.41 m RL				
Anticipated maximum depth to a capacity	achieve 200 kPa ultimate bearing	1.10 m bgl / 88.90 m RL				
Anticipated maximum depth to a capacity (accounting for topsoil	achieve 100 kPa ultimate bearing removal)	0.30 m bgl / 89.41 m RL				
Foundation Solution						
Controlling factor for foundation solution	Finished floor level, ultimate bear	ing capacity				
Recommended foundation type	TC1 Waffle slab designed for 100 bearing capacity) kPa geotechnical ultimate				
Long term static settlement (50 settlement)	years, excluding liquefaction	<5 mm				
Modulus of subgrade reaction for	or foundation	4 MPa				
Driveway CBR		2 %				

Preliminary Foundation Depths (m RL)								
House Typology / Position	Base Elevation Topsoil ¹	FFL (m RL ²) (top of stiffened waffle slab)	TC1 waffle slab thickness (mm)	Base of TC1 waffle slab (m RL ²)	Base of gravel pad / excavation level (m RL ²)	Thickness of gravel pad (mm)		
House 9	89.41	90.05	400	89.65	89.40	250		
House 6	89.41	90.10	400	89.70	89.40	300		
Houses 3 & 4	89.41	90.15	400	89.75	89.40	350		
Houses 7, 10 & 11	89.41	90.20	400	89.80	89.40	400		
Houses 1, 12 & 13	89.41	90.25	400	89.85	89.40	450		
Houses 2, 5, 8	89.41	90.30	400	89.90	89.40	500		

Notes:

¹ Based on worst case maximum elevation of topsoil.
 ² Based on preliminary slab finished floor level (m RL, Lyttelton 1937) as stated. If this changes during detailed design, the finished ground level and base of raft will need to be updated on final construction drawings.
 ³ Excavation and replace to approximately 2.4 m bgl may be required where houses are positioned over infiltration test pit locations.

1 Introduction

Kāinga Ora is redeveloping the site at Church Street in Hampstead, Ashburton. Beca Limited (Beca) has been commissioned to undertake a geotechnical investigation and provide analysis and recommendations to support the development of the site. This report outlines the findings from the geotechnical investigations, desktop assessment, geotechnical design, and recommendations.

2 Site Description

The house development site is located in Hampstead on 5 - 15 Church Street to the southeast of the Ashburton CBD. The site is being uplifted from five houses to 15 on a plot covering an area of 4038 m² and has predominantly flat topography. The site is 0.4 km from the nearest waterway which is unnamed and heavily modified to the east. The site is 0.9 km northeast of the Ashburton River. The site location and basic details of the proposed development are presented in Figure 2-1.



Figure 2-1:Site Location Plan.



3 Geology

The published geology map (Cox and Barrell, 2007) shows the site to be underlain by Late Pleistocene (Q2a) aged river gravel, sand and silt forming a modern floodplain or low-level terrace.

The Mt Hutt-Mt Peel fault zone (also called the Canterbury Range Front Faults and Geraldine-Mt Hutt Fault System) is the nearest mapped active fault system located approximately 30 km northwest of the site. Active faults within this fault zone include the Peel Forest Fault and the Montalto Fault (GNS, 2020). A study of this fault system by Pettinga et al. (2001) indicates that the average earthquake recurrence interval on this fault system is approximately every 5,000 to 10,000 years. This fault system has the potential to produce earthquakes up to magnitude 7.3 Mw (Pettinga et al., 2001). No other active faults are known to exist within a 30 km radius from the site.

The Canterbury Plains typically have a shallow unconfined aquifer with a water table at less than 20 m deep below the ground surface. Deeper confined aquifers are generally found at 30 to 80 m and 130 to 160 m depth (Cox and Barrell, 2007).

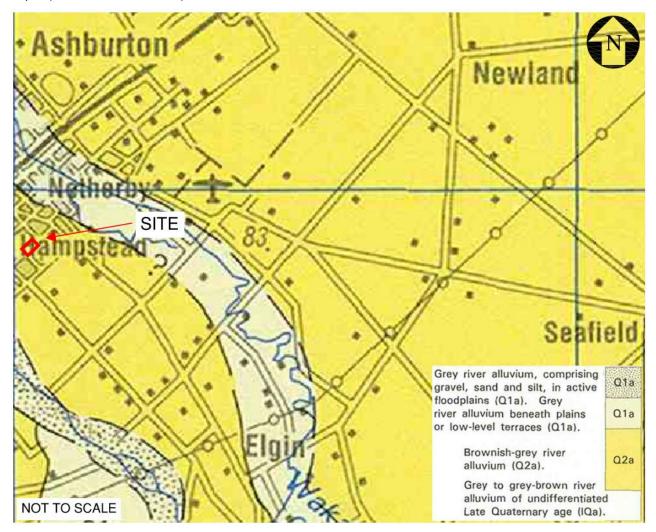


Figure 3-1: Geology at the site (GNS Science, 2022).



4 Desktop Information

A geotechnical desktop assessment was undertaken to understand the published information of the site. The following resources were reviewed:

- New Zealand Geotechnical Database (NZGD)
- Beca Reports Database
- Canterbury Maps
- Ashburton District Planning Maps
- Retrolens historical aerial photographs

4.1 Desktop Review Summary

The findings of the assessment are as follows:

- There is no existing geotechnical data within 200 m of the site.
- Previous housing development system (HDS) developments within proximity of the site include 27-33
 Willow Street, 300 m to the northwest. The site revealed ground profiles consist of silty gravels/sandy silts
 underlain by dense sandy gravels and was classified as equivalent TC1 following site-specific
 investigations.
- The desktop information indicates that the depth to ground water is approximately 0 to 5 m bgl. This is based on groundwater maps created for the Ashburton District Council.
- The site is approximately 400 m from the nearest waterway, the unnamed to the east with a free face height of approximately 1 m. The Ashburton River is 900 m to the northeast with a free face height of 3 - 5 m.
- A review of historic aerial imagery shows that the land was used as agricultural land prior to being developed in the 1940's.
- The site is not in a tsunami evacuation zone.
- The site is not in a flood management zone.
- The site subsoil class is likely to be classified as class D according to AS/NZS1170.5:2002.
- The site is classified as having low liquefaction potential (Yetton & McCahon, 2002).
- The MBIE Residential Foundation Technical Category (TC) system is not applicable for the Ashburton area, however, it can be used to compare the equivalent risk and it is expected the liquefaction risk at this site would result in an equivalent TC1 or TC2.

5 Geotechnical Investigation

The geotechnical investigation commenced on 12/07/2023 and was completed on the same day. The investigation locations have been surveyed post construction in terms of New Zealand Transverse Mercator Projection (NZTM2000). Elevations have been surveyed in Lyttelton 1937. Locations are presented on a site plan in Appendix A. The site investigations were observed and logged full time by a Beca Engineering Geologist, and the logs have been verified by a Beca Senior Geotechnical Engineer.

5.1 Standards and Calibration

The investigation was undertaken in general accordance with the New Zealand Ground Investigation Specification (2017), and a list of standards used during the site investigation is shown in Table 5-1.

Table 5-1: Summary of Standards used in this Investigation

Field Procedure	Standard Used
Soil and Rock Logging	In general accordance with New Zealand Geotechnical Society Guidelines (NZGS, 2005).
Scala (Dynamic Cone) Penetrometer Testing	NZS 4402.6.5.2 (1988)
Cone Penetration Testing	ASTM D5778-20 ⁽¹⁾
Notes:	

(1) Standard widely adopted by contractors in NZ with the requirement of a maximum of half the allowable zero drift limit

Up to date calibration certificates for the testing equipment used in the investigations are attached in Appendix B.

5.2 Hand Auger Hole

Hand augers were drilled and logged on site by Beca staff. The hand auger logs and photographs are shown in Appendix C. Hand auger test locations can be referred to within Appendix A and are summarised in Table 5-2.

In-situ testing comprised:

Scala penetrometer testing was undertaken between the ground surface and to 900 mm below the base
of the hole, blows recorded at 50 mm centres. The hole was augered between tests, with a maximum of
one rod length per test.

Table 5-2: Hand Auger Summary

Hand Auger ID	Location	Easting	Northing	Ground Level (m RL)	Total Depth (m bgl)
AR109524-GE-HA-001	Rear of No# 7	1500154.7	5136979.1	90.07	1.95
AR109524-GE-HA-002	Front of No# 9	1500167.2	5136980.1	89.99	2.20
AR109524-GE-HA-003	Front of No# 13	1500165.0	5137009.1	89.88	1.95
AR109524-GE-HA-004	Rear of No# 11	1500197.5	5136994.4	89.80	1.80
AR109524-GE-HA-005	Front of No# 15	1500212.6	5137005.4	89.71	2.00
AR109524-GE-HA-006	Rear of No# 15	1500178.7	5137034.6	89.80	1.40
Notoo:					

Notes:

RL (Relative Level) (Lyttelton 1937)

Survey coordinates are given in NZTM2000

m bgl (metres below ground level)



5.3 Scala (Dynamic Cone) Penetrometer Testing

Scala penetrometer tests were carried out at the ground surface at eight locations. Tests were carried out in general accordance with the methods described in NZS 4402 Test 6.5.2. Scala test locations are summarised in Table 5-3 and are presented in Appendix A. Test records are included in Appendix D.

Scala ID	Location	Easting	Northing	Ground Level (m RL)	Total Depth (m bgl)
AR109524-GE-DCP-001	Front yard of No 7	1500162.2	5136961.2	89.98	1.95
AR109524-GE-DCP-002	Rear yard of No# 7	1500138.9	5136982.8	90.07	1.95
AR109524-GE-DCP-003	Front yard of No# 9	1500174.9	5136970.8	89.87	1.95
AR109524-GE-DCP-004	Rear yard of No# 9	1500158.9	5136989.3	90.01	1.95
AR109524-GE-DCP-005	Front yard of No# 11	1500182.6	5136991.8	90.03	1.95
AR109524-GE-DCP-006	Rear of No# 13	1500169.2	5137022.0	90.15	1.95
AR109524-GE-DCP-007	Front of No# 9	1500196.0	5137006.6	89.89	1.95
AR109524-GE-DCP-008	Rear of No# 15	1500193.2	5137029.7	89.72	1.75

Table 5-3: Scala Summary

Notes:

RL (Relative Level) (Lyttelton 1937)

Survey coordinates are given in NZTM2000

m bgl (metres below ground level)

5.4 **Cone Penetration Testing (CPT)**

Static CPTs were conducted by Geotechnics Ltd using a Ingenjörsfirman Geotech AB 220 CPT fitted with a 46 mm to measure cone resistance, sleeve friction and water pressure. CPT test locations are summarised in Table 5-4 and are presented in Appendix A.

Test records for cone resistance, sleeve friction and friction ratio, zero drift and pore pressure are included in Appendix E.

Table 5-4: CPT Summary

CPT ID	Location	Easting	Northing	Ground Level (m RL)	Total Depth (m bgl)	Type of Test
AR109524-GE-CPT-001	Front of No# 7	1500163	5136960	89.98	2.68	Static
AR109524-GE-CPT-002	Rear of No# 9	1500151	5136997	90.03	1.96	Static
AR109524-GE-CPT-003	Front of No# 11	1500188	5136991	89.77	2.70	Static
AR109524-GE-CPT-004	Rear of No# 15	1500182	5137031	90.08	1.74	Static
Notes:						

Notes:

RL (Relative Level) (Lyttelton 1937) Survey coordinates are given in NZTM2000

m bgl (metres below ground level)



5.5 Groundwater

The depth to groundwater within the CPTs and hand augers was checked with dip meters following completion of the activity. Groundwater was not encountered or observed in any of the site-specific investigations conducted for this project.

Figure 5-1 indicated the site location in reference the average (median) depth to groundwater contours map available via Canterbury Maps (2018). The map was developed by the Environment Canterbury Regional Council (ECan) following the analysis of available groundwater data from a large network of piezometers.

The map shows that the closest groundwater contour to the 7-15 Church Street site is 5 m bgl (Figure 5-1).



Figure 5-1: Groundwater contour map sourced from Canterbury maps (2018)

6 Infiltration Rates

6.1 Infiltration Testing

Infiltration testing was carried out in accordance with the Ministry of Business, Innovation and Employment (MBIE) Acceptable Solutions and Verification Methods E1/VM1 (Surface Water), Section 9.0.2 (2017).

A memorandum containing the results and recommendations produced by a BECA Hydrogeologist and is presented in Appendix K.



7 Geotechnical Parameters

7.1 Generalised Soil Profile

This site investigation revealed a soil profile consisting of silty sands/sandy silts in the upper 2 m overlying medium dense to dense sand/gravel. A generalised soil profile was generated from the ground investigations conducted in March 2023 and is summarised within Table 7-1.

Soil Unit	Description	Depth to Top of Layer (m bgl)	Layer Thickness (m)	Average Cone Resistance q₀ (MPa)			
1	Very loose fine gravelly SILT, some sand, some organics [Topsoil]	0.00	0.20 – 0.30	1 - 2			
1a [*]	Very loose, gravelly SILT [Fill]	0.00	0.30	-			
2	Loose to medium dense, sandy SILT/silty SAND	0.20 – 0.30	1.20 – 1.90	1 - 5			
3	Medium dense to dense GRAVEL, some sand, some silt	1.40 – 2.20	>0.50	10 - 40			
Notes:							
1a [*] only p	1a [°] only present in HA-003						
m bgl (me	tres below ground level)						

Table 7-1: Generalised Soil Profile

Based on borehole data from BH_193212 (New Zealand Geotechnical Database (NZGD), 2023), approximately 900 m from site, the gravel extends beyond 20 m depth. A groundwater well bore log, L37/0031 (New Zealand Government, 2023) 1200 m from site, indicates that alluvial gravel deposits extend to over 70 m depth.

7.2 Design Soil Parameters

The soil strength parameters adopted for the geotechnical assessment and design are set out in Table 7-2. Listed soil units correspond with those described in Table 7-1.

Table 7-2: Soil Strength Parameters

Soil Unit	Description	Unit Weight (kN/m ³)	Friction Angle, Φ (degree)	Effective Cohesion, c' (kPa)	Young's Modulus (MPa)
2	Loose to medium dense, sandy SILT/silty SAND	18	32	0	20
3	Medium dense to dense, GRAVEL, some sand, some silt	20	35	0	70

8 Seismic Design Requirements

8.1 Design Life and Importance Level

The proposed structure is being designed as Importance Level of 2 (IL2) structure with a design life of 50 years, in accordance with AS/NZS 1170.0:2002 and as agreed upon with Kāinga Ora.

8.2 Site Subsoil Class

The site subsoil class in accordance with NZS 1170.5:2004 depends on the depth of the underlying soils or rock with each site being classified as either Site Class A, B, C, D or E. Class A refers to sites founded directly on very strong rock material, while Site Class B refers to slightly less competent rock. Class E refers to sites with more than 10 m of soils with SPT N values of less than 6 (i.e., soft soils). These classes are not applicable to the site as shown by the investigative data.

Class C refers to shallow soil sites, with a limit concerning the maximum depth of soils depending on the geology and density. The maximum depth of a Class C site, considering unit 4 (dense sand) is 55 m.

The geological map of the Aoraki area (Cox, Barrell, et.al, 2007) indicates that alluvial materials are likely to continue to depth beyond 55 m depth. A review of Beca data and publicly available information also shows the alluvial deposits extending beyond 100 m. As such, a Site Subsoil Class of D (deep soil site) has been adopted for this assessment.

8.3 Seismic Loads

Seismic (earthquake) loads were computed for the site according to the methodology outlined within the MBIE Earthquake Geotechnical Engineering Practice (Module 1, Section 5.1) for the Canterbury Earthquake Region (CER). This module states recommended values for earthquake peak ground acceleration (PGA) and effective magnitude (Mw) for the CER, to be compared with values calculated according to the methodology outlined in the New Zealand Transport Agency Bridge Manual (Version 3.3) as recommended by the MBIE Guidance for the Assessment of Liquefaction Hazards (NZGS, 2021). The greater of the resulting PGA/Mw combinations are to be adopted for design purposes and are presented herein as SLS1_a and SLS1_b.

Two limit state load cases were analysed: Serviceability Limit State (SLS) and Ultimate Limit State (ULS) design earthquakes:

- For a SLS design earthquake: The structure is "intended to be used without the need for repair".
- For a ULS design earthquake: The structure is required to maintain life safety of the building's occupants and ensure the structural integrity of the building is not lost following the event.

Following analysis, the recommended values within the Earthquake Geotechnical Engineering Practice guide (MBIE, 2021) represent the conservative scenario and has been adopted for design purposes. Recommended PGAs and Mw for liquefaction analyses are summarized in Table 8-1.

Limit State Load	Annual Probability of Exceedance (yr)	Effective Magnitude (Mw)	Peak Ground Acceleration (PGA)
SLS1a	1/25	6.1	0.06
ULS	1/500	6.1	0.26

Table 8-1: Peak Ground Acceleration and Effective Magnitude for Liquefaction Analysis



9 Liquefaction Assessment

Liquefaction may occur in loosely consolidated and saturated deposits as earthquake-induced cyclic shearing causes pore-water pressures to increase and exceed the static confining pressures, resulting in significant loss of stiffness and strength. Surface effects of liquefaction typically include surface cracking and permanent ground deformations such as vertical settlements and lateral displacements.

Fine grained cohesive soils that have 'clay-like' behaviour may be susceptible to cyclic softening under intense earthquake shaking. Cyclic softening induces a loss in shear strength to its residual/remoulded capacity as a result of monotonic and cyclic loading.

An assessment of the likelihood of liquefaction is required for deposits identified as being potentially susceptible to liquefaction, as set out in Earthquake Geotechnical Engineering Practice Module 3 (NZGS, 2021). The likelihood of liquefaction at the site under the design earthquakes listed in Table 9-1 was assessed from the CPT data using the methodology outlined by Boulanger and Idriss (2014) and an assumed design groundwater depth of 2 m bgl (conservative).

Results from the liquefaction assessment are summarised within Table 8-1, and full results are available within Appendix F.

СРТ	Depth	Liquefaction Induced Free Field Settlement mm (Liquefaction Potential Index [LPI]) <i>'risk'</i>				
		SLS1	ULS			
AR109524-GE-CPT-001	2.68	<5 [0] ' <i>mild</i> '	<5 [0] 'mild'			
AR109524-GE-CPT-002	1.96	<5 [0] ' <i>mild</i> '	<5 [0] <i>'mild'</i>			
AR109524-GE-CPT-003	2.70	<5 [0] ' <i>mild</i> '	<15[1] 'moderate'			
AR109524-GE-CPT-004	1.74	<5 [0] 'mild'	<5 [0] 'mild'			

Table 9-1: Liquefaction Triggering Potential Summary

For determination of the MBIE technical category assignment to the site, the liquefaction induced free field settlement over the top 10 m is summarised below:

- SLS = <5 mm
- ULS = <15 mm

Based on the estimated free field settlement calculated above and nearby deeper borehole information outlined in section 7.1 confirming the thickness of the gravel layer, the site is considered TC1 in line with the repairing and rebuilding houses affected by the Canterbury earthquakes guidance document (Ministry of Business, Innovation and Employment (MBIE), 2012) While the MBIE guidance is not applicable outside of the Canterbury area. The risk of liquefaction in the Ashburton Area is similar to Christchurch, therefore we recommend that it is used for classification and foundation recommendation requirements at this site.

9.1.1 Estimated Differential Settlement

Literature indicates that differential settlements across a structure can be considered to be between 50% and 100% of the total estimated free-field settlements depending on lithology and length of the structure. CPTs were undertaken across the site and provide an indication of the anticipated differential settlements. We recommend that the full total estimated free field settlement be considered as differential settlement equating to <5 mm for SLS, and <15 mm across the raft for ULS events.

Note that in addition to free field settlement, settlement can potentially result from loss of soil associated with liquefaction ejecta or lateral ground movement.



9.1.2 Lateral Spreading

Lateral spreading occurs as liquefied soils lose shear strength and flows towards an unconfined free face exposure (i.e. towards a river bank) resulting in horizontal displacements of the ground surface. Surface effects typically include cracking and ejection of liquefied deposits.

Based on available information the site is considered to have a low risk of lateral spreading due to the lack of topographic variability across the site and no nearby water courses.

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10 Foundation Design Recommendations

10.1 Bearing Capacity

The ultimate bearing capacity was assessed from dynamic cone penetrometer (DCP) testing. Testing was conducted at the proposed house locations on site, and a depth to competent bearing was determined. Table 10-1 shows the depth to a competent bearing at each test location. Full bearing capacity results can be referred to in Appendix G.

Test ID Location		Depth to 300kl Bearing Capa		Ultimat	to 200kPa e Bearing ty (Static)	Depth to 100kPa Ultimate Bearing Capacity (Static)	
		m bgl	(m RL)	m bgl	(m RL)	m bgl	(m RL)
AR109524-GE- HA-001	Rear of No# 7	0.90	89.20	0.20	89.90	0.00	90.10
AR109524-GE- HA-002 [*]	Front of No# 9	2.10	87.90	1.10	88.90	0.80 (0.10)	89.20 (89.90)
AR109524-GE- HA-003	Front of No# 13	1.00	88.90	0.20	89.70	0.00	89.90
AR109524-GE- HA-004	Rear of No# 11	0.80	89.00	0.60	89.20	0.10	89.70
AR109524-GE- HA-005 [*]	Front of No# 15	1.00	88.70	1.00 (0.40)	88.70 (89.30)	0.10	89.60
AR109524-GE- HA-006	Rear of No# 15	0.50	89.30	0.40	89.40	0.00	89.80
AR109524-GE- DCP-001	Front of No# 7	>2.00	<88.00	0.00	90.00	0.00	90.00
AR109524-GE- DCP-002 [*]	Rear of No# 7	1.40 (0.20)	88.70 (89.90)	0.10	90.00	0.00	90.10
AR109524-GE- DCP-003 [*]	Front of No# 9	1.10	88.80	0.90	89.00	0.50 (0.10)	89.40 (89.80)
AR109524-GE- DCP-004 [*]	Rear of No# 9	>2.0	<88.00	1.10	88.90	0.80 (0.10)	89.20 (89.90)
AR109524-GE- DCP-005	Front of No# 11	>2.0	<88.00	0.30	89.70	0.10	89.90
AR109524-GE- DCP-006	Rear of No# 13	>2.0	<88.20	0.20	90.00	0.20	90.00
AR109524-GE- DCP-007*	Front of No# 9	>2.0	<87.90	1.20 (0.70)	88.70 (89.20)	0.10	89.60
AR109524-GE- DCP-008*	Rear of No# 15	1.30	88.40	1.00 (0.50)	88.70 (89.20)	0.10	89.60
Notes:							

Table 10-1: Depth to variable bearing capacity layers

* Results show soft pockets of 100 kPa (0 - 1 blows / 100 mm). The depth excluding isolated soft lenses is included in the brackets.

Given the depth to 300 and 200 kPa ground across the site, we recommend that a specific engineer designed shallow foundation solution is designed for a lower 100 kPa geotechnical ultimate bearing capacity which is present from 0.1 m bgl.

10.2 Static Settlement

The site investigations show that the site is not underlain by organic soils and the risk of long-term static settlement is considered to be low. Static settlement was assessed based on the CPT results using the settlement analysis tool in CPeT-IT (version 3.0, published by GeoLogismiki). The assumed ultimate limit state (ULS) dead load for the structure is 730 kN (100% weatherboard cladding), for a plan area of 85 m² as provided by the structural engineer for a typical TC2 raft slab foundation. The raft foundation is assumed to



act as a large rigid footing and the dead loads are assumed to be evenly spread over the foundation. Dead and live loads were factored by 1.2 and 1.5 respectively and converted to surcharge loads (approx. 15 kPa, considering plan area) for the purposes of the settlement assessment.

Settlements were estimated at this site are outlined below in Table 10-2.

Table 10-2: Static Settlement Analysis for 50 Year Design Life Results.

CPT Test	Settlement (mm) (12 months)	Settlement (mm) (50 years)
AR109524-GE-CPT-001	<5	<5
AR109524-GE-CPT-002	<5	<5
AR109524-GE-CPT-003	<5	<5
AR109524-GE-CPT-003	<5	<5

The settlement analysis results estimate that the construction loads proposed will likely result in less than 5 mm of long-term static settlement over the 50-year design life of the structures.

10.3 Soil Modulus of Subgrade Reaction

Soil springs were determined on site based on an ultimate bearing capacity of 100 kPa for a maximum deformation of 25 mm based on recommendations in Foundation Analysis and Design, (Bowles, 1997). Due to the potential variation in soil stiffness under a slab we recommend a range of modulus of subgrade reaction is modelled from -50% to +200% of the estimated value. The estimated modulus of subgrade reaction is 4 MPa and the recommended range for design is 2 to 8 MPa.

10.4 Foundation Solution

MBIE Residential Foundation Technical Category (TC) maps do not exist for the Ashburton area. However, foundation recommendations are provided in accordance with the 'repairing and rebuilding houses affected by the Canterbury earthquakes' guidance (2012) to account for the site-specific risks which are similar to the conditions encountered in Christchurch. While the site is technically equivalent to TC1, the ground does not consistently meet the NZS3604 definition of "good ground" (or 300 kPa) prior to approximately 2.1 m bgl (deepest layer of liquefiable soil/softer ground) and would require significant excavate and replace of the soft ground with compacted gravel hardfill for NZS3604 shallow foundation solutions.

Kainga Ora's preferred option is a TC1 stiffened waffle slab, with specific engineering design for 100 kPa ultimate geotechnical bearing capacity.

House Number / Position	Base Elevation Topsoil/depth to competent subgrade ¹ (m RL)	Finished Floor Level Requirement (m RL²) (top of stiffened waffle slab)	Base of stiffened waffle slab (m RL ²)	Base of gravel pad / excavation level (m RL ²)	Thickness of gravel pad (mm)
9	89.41	90.05	89.65	89.40	250
6	89.41	90.10	89.70	89.40	300
3 & 4	89.41	90.15	89.75	89.40	350
7, 10, &11	89.41	90.20	89.80	89.40	400
1, 12 & 13	89.41	90.25	89.85	89.40	450
2, 5 ³ & 8	89.41	90.30	89.90	89.40	500

Table 10-3: Summary of preliminary foundation levels

Notes:

¹ Based on worst case maximum elevation of topsoil.

² Based on preliminary slab finished floor level (m RL, Lyttelton 1937) as stated. If this changes during detailed design, the finished ground level and base of raft will need to be updated on final construction drawings.

³ Excavation and replace to approximately 2.4 m bgl may be required where houses are positioned over infiltration test pit locations.

The slab is to be constructed on a layer of non-woven geotextile at the bottom of the excavation and should be compacted in maximum 200 mm thick layers to 95% of maximum dry density. The waffle slab is to be constructed on top of the gravel raft. Please refer to the Beca Kainga Ora Project Velocity Specification for construction information, material details and testing requirements.

Topsoil removal considers the worst case base elevation of topsoil encountered at site, being 89.41 m RL in HA-005 (maximum 300 mm thick).

An alternative solution is the NZS 3604 timber pile foundation. This solution meets the TC1 requirements in accordance with the "Repairing and rebuilding houses affected by the Canterbury earthquakes" guidance (2012). Timber piles are to be founded on the dense gravels present from approximately 2.1 m bgl, 87.9 m RL on 300 kPa ground as per section 9.1 above.

If this option is to be pursued, foundation (auger) diameter, concrete encasement, and timber pile dimensions are to be determined as per the requirements of NZS 3604 section 6.4.5, based on the span of bearers and joists as per Table 6.1. The piles shall be augured and concreted in place or driven in accordance with the requirements of NZS 3604.

The PS1 producer statement for the geotechnical foundation design is included in Appendix I.

11 Pavement Design Recommendations

The California Bearing Ratio (CBR) for pavement design was assessed from the DCP testing conducted across the site, with an average penetration depth (mm) per blow (e) was derived from the results of each test. Values within the upper 300 mm soil deposits were disregarded as they are considered unreliable due to insufficient lateral resistance on the rod tip and will likely be removed during initial site stripping. CBR percentages are calculated in accordance with Austroads – Guide to Pavement Technology Part 2 and are listed in Table 10-1. The insitu CBR is determined from a weighted average of the CBR below the cut level (70% weighting in top 300mm and 30% weighting for 900mm below this level). A recommended CBR of up to 2% is proposed for pavement design. The CBR results are included in Appendix H.

Test ID	DCP Depth Considered (m bgl)	Insitu CBR (%)
AR109524-GE-HA-001	0.3 – 1.5	5
AR109524-GE-HA-002	0.3 – 1.5	3
AR109524-GE-HA-003	0.3 – 1.5	4
AR109524-GE-HA-004	0.3 – 1.5	3
AR109524-GE-HA-005	0.3 – 1.5	3
AR109524-GE-HA-006	0.3 – 1.5	5
AR109524-GE-DCP-001	0.3 – 1.5	6
AR109524-GE-DCP-002	0.3 – 1.5	6
AR109524-GE-DCP-003	0.3 – 1.5	2
AR109524-GE-DCP-004	0.3 – 1.5	2
AR109524-GE-DCP-005	0.3 – 1.5	5
AR109524-GE-DCP-006	0.3 – 1.5	5
AR109524-GE-DCP-007	0.3 – 1.5	3
AR109524-GE-DCP-008	0.3 – 1.5	7

Table 11-1: CBR Summary

¹ Austroads – Guide to Pavement Technology Part 2: Pavement Structural Design, Section 5.2, Figure 5.3.

These CBR results are based on insitu testing representing the soil conditions and moisture content at the time of testing and may not reflect the worst case (e.g., saturated conditions).

12 Natural Hazard Assessment

The risk of natural hazards at the site has been assessed in accordance with section 106 of the Resource Management Act (RMA) and appropriate Ashburton district Council (ADC) and MBIE documents to support the subdivision consent application for the property. The statement of professional opinion for the development of the land is included in Appendix J. A summary of the section 106 hazards at the site is included in Table 12-1 below.

Table 12-1: RMA	s106 Hazard	Assessment	Summarv	Table

Natural Hazard	Current Risk (as per s106(1)(a))	Effects from Development (as per s106(1)(a))					
Flood Inundation	Low Risk the ADC District plan indicated the property is not in a flood zone.	Low Risk Stormwater management is being designed in accordance with ADC standards.					
Slips	Low Risk the property is not locate	d near a slope or channel.					
Subsidence and Settlement (Static)	Low Risk CPTs and hand augers have indicated there are no peat or soft cohesive soils within the ground profile.	Low Risk Assessments have estimated loading of the site may induce up to 5 mm of static consolidation settlement over the design life.					
Subsidence and Settlement (Seismic)	Following site investigations, the sit	e has been classified as TC1 equivalent. duced settlement under ULS events. ordance with MBIE guidance.					
Lateral Spreading	Low Risk the site is not situated near any free faces or watercourses that may cause lateral spreading in an earthquake.						
Erosion	Low Risk no surface water flow source of erosion has been identified near the site.						
Falling Debris	Low Risk no source of falling debris has been identified near the site.						

13 Geotechnical Risks

The investigation is based upon isolated investigation data over the site and there is a residual risk with geotechnical investigations and design that conditions may differ from those assumed or deteriorate on site during construction. A summary of the risks and proposed mitigation measures is included in Table 13-1 below.

Table 13-1: Development risks and recommended mitigation measures

Risk	Likelihood	Effects on development	Proposed mitigation measures
Isolated soft zones in subgrade cut (<100kPa ultimate bearing capacity)	Possible	Additional over-excavation required, minor delays	Test subgrade cut surface during construction and recommend additional excavation and replacement with AP65 in affected areas
Heavy rain during subgrade cut or backfilling works	Likely	Foundation softens and requires additional over excavation. Fill becomes contaminated with fines and cannot be compacted to target density, fill removed and replaced, significant delays	Aim to complete foundation excavation works only during fine weather. Install geotextile between cut subgrade and fill to reduce risk of fines migration into fill during rain events. Backfill the excavation promptly. Adjust the compaction methodology to match the subgrade and aggregate moisture content.
Long term static foundation settlement (organic/soft soils)	Rare	Tilting and settlement of house. Separation between house and adjacent access structures. Damage to services connections at edge of house.	Assess long term settlement risk for property. Where settlement is anticipated, add additional control measures such as flexible services connections or additional reinforcement in slab foundation. The foundations are able to be relevelled if required.
Encountering groundwater during foundation excavations	Rare	Dewatering may be required for foundation excavations.	Plan for dewatering if deep foundation excavations below groundwater level are required.
Soakage pits clog up and no longer soak stormwater into ground	Likely	Localised flooding around soakage pit areas during extreme storm events.	Allow for regular maintenance of soakage pits in design of stormwater system. Secondary flow paths have been designed to move water to the accessways and onto the road.

14 Applicability Statement

This report has been prepared by Beca Ltd (Beca) on the specific instructions of Kāinga Ora (Client). It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

In preparing this report Beca has relied on key information including the following:

- Site survey information supplied by Kāinga Ora Project Velocity Survey on July 2023.
- Site investigation data (boreholes, CPTs, etc) and CES data from the New Zealand Geotechnical Database, accessed July 2023.
- Site investigation CPTs supplied by Geotechnics Ltd on July 2023.
- Preliminary foundation floor levels supplied by Kāinga Ora Project Velocity Civil Engineer on July 2023.

Unless specifically stated otherwise in this report, Beca has relied on the accuracy, completeness, currency and sufficiency of all information provided to it by, or on behalf of, the Client, including the information listed above, and has not sought independently to verify the information provided.

This report should be read in full, having regard to all stated assumptions, limitations and disclaimers. No part of this report shall be taken out of context and, to the maximum extent permitted by law, no responsibility is accepted by Beca for the use of any part of this report in any context, or for any purpose, other than that stated herein.

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Appendix A – Site Investigation Plan



DO NOT SCAL

IF IN DOUBT AS



Appendix B – Calibration Certificates

Göteborg:2023-03-29

CALIBRATION CERTIFICATE FOR CPT PROBE 4600

Probe No Date of Calibration Calibrated by Run No Test Class:	4600 2023-03-29 Alexander I 2704 ISO 1		l-	m
Point Resistance	Tip Area 1	0cm ²		
Maximum Load	50	MPa		
Range	50	MPa		
Scaling Factor	1329			
Resolution	0,5741	kPa		
Area factor (a)	0,844			
Zero	7,048 MPa			
ERRORS				
Max. Temperature effect when n	ot loaded	14,343	kPa	
Temperature range 5 –40 deg. Ce		1,0.0		
Local Friction	Sleeve Are		1 ²	
Maximum Load	0,5	MPa		
Range	0,5	MPa		
Scaling Factor	3701			
Resolution	0,0103	kPa		
Area factor (b)	0			
Zero	127,82 kPa			
<u>ERRORS</u> Max. Temperature effect when n Temperature range 5 –40 deg. Ce		0,391	kPa	
Pore Pressure				
	2	MPa		
Maximum Load	2 2	MPa		
Range Scaling Factor	3405	IVII a		
Resolution	0,0224	kPa		
Zero	272,7 kPa	KI d		
2010	272,7 KI u			
ERRORS				
Max. Temperature effect when n	ot loaded	0,716	kPa	
Temperature range 5 -40 deg. Ce				
Tilt Angle				
Scaling Factor	0,93	-		
Range	0 - 40	Deg.		
Backup memory				
Conductivity probe				Entered By: CHES 29/06/2023 Checked By: JEBR 29/06/2023
conductivity probe				KTP Approved By: JEBR 29/06/2023

Ingenjörsfirman Geotech AB +46 (0)31-28 99 20 <u>www.geotech.se</u> Datavägen 53 +46 (0)31-68 16 39 VAT No.

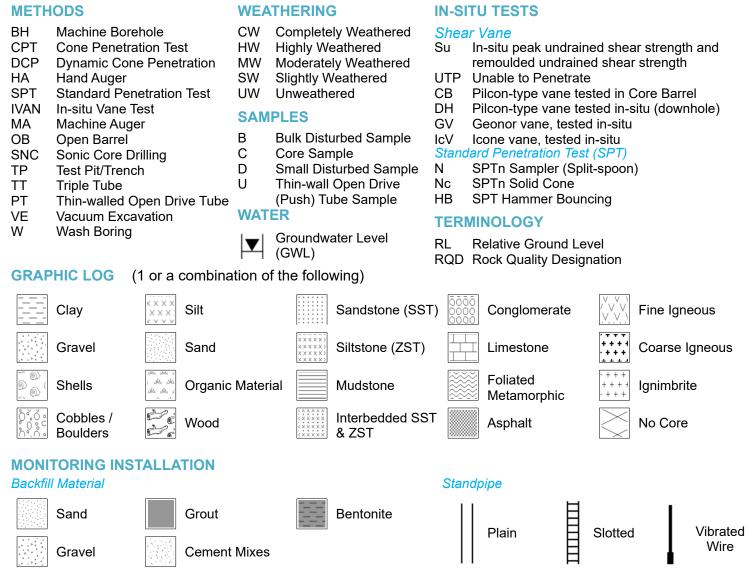
Specialists in Geotechnical Field Equipment



Appendix C – Hand Auger Logs and Photographs

SOIL AND ROCK DESCRIPTIONS

Soil and Rock Descriptions are in general accordance with the NZ Geotechnical Society (NZGS), 2005. Hand-held Vane Shear Strength measurements are in general accordance with the NZGS, 2001.



ORGANIC SOILS

Von Post Degree of Humification

- H1 Completely unconverted and mud-free peat, when pressed gives clear water and plant structure is visible.
- H2 Partially unconverted and mud-free peat, when pressed gives almost clear water and plant structure is visible.
- H3 Very slightly decomposed or very slightly muddy peat, when pressed gives marked muddy water, no peat substance passes through the fingers and plant structure is less visible.
- H4 Slightly decomposed or slightly muddy peat, when pressed gives muddy water and plant structure is less visible.
- H5 Moderately decomposed or very muddy peat with growth structure evident but slightly obliterated.
- H6 Moderately decomposed or very muddy peat with indistinct growth structure.
- H7 Fairly well decomposed or very muddy peat but the growth structure can just be seen.
- H8 Well decomposed or very muddy peat with very indistinct growth structure.
- H9 Practically decomposed or mud-like peat in which almost no growth structure is evident.
- H10 Completely decomposed or mud peat where no growth structure can be seen, entire substance passes through the fingers when pressed.

							Ha	nd Auger	Log	Hand Auger ID: AR109524-GE Sheet 2	^{Е-на-00⁻ 1 of 1}
Project						et (Ashb	urton)		Project Number:	3160491/AR109524	
Site Location: 7-15 Church Street (Ashburton) Location: Rear yard of 7 Church Street. In Situ Tests In Situ Tests					-			Coordinate Syster Northing: Easting:	Client: m: NZTM2000 5136979.1 1500154.7	Kainga Ora Vertical Datum: Lyttelton 1937 Ground level (mRL): 90.07 Location Method: Survey	
E	In Situ	Tests				_				· ·	-
Groundwater (m)	Su (kPa)	Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log			Soil/ Rock Descript	lion	Geological
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Location:	Rear yard of 7 Church Street.	Coordinate system: NZTM2000 Northing: 5136979.1 Easting: 1500154.7	Vertical datum: Lyttelton 1937 Ground level (mRL): 90.07 Location method: Survey
	Project: HDS- Geotechnical D: HA-00 ² Date D: HA-00 ² Date D	7-15 CHURCH ST Job No: 3160491 12 7123 Box No: 1 Depth: 0 m 20 m 00 m 00 m 00 m	

Box 1 - 0.00mbgl to 1.95mbgl

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Groundwater (m)	Su (kPa)	Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log			Soil/ Rock Descrip	otion	Geological
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				- - 4.5 —	 - 85.5 -	-					
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谓 Be	ca	Photo Log	9	Location I	D: AR109524-GE-HA- Sheet 1 of
Project:	HDS - 7-15 Church Street (Ashburton)		Project number:	3160491/AR109524	
Site location:	7-15 Church Street (Ashburton)		Client Name:	Kainga Ora	
_ocation:	Front yard of 9 Church Street.	Coordinate system:		Vertical datum:	Lyttelton 1937
		Northing:	5136980.1	Ground level (mRL):	
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Box 1 - 0.00mbgl to 2.20mbgl

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Project: HDS - 7-15 Church Street (Ashburton) Site Location: 7-15 Church Street (Ashburton)						burton)	Client:	Kainga Ora		
Location: Front yard of 13 Church Street.					Church	Street.	Coordinate Sy Northing: Easting:	System: NZTM2000 5137009.1 1500165.0	Vertical Datum:Lyttelton 1937Ground level (mRL):89.88Location Method:Survey	
ater	In Situ	Tests F				Ď				al
Groundwater (m)	Su (kPa)	Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log		Soil/ Rock Descrip	tion	Geological
		1 0 0 1 1		-	-			plastic, insensitive. Gravel: r	organics, trace brick fragments; ounded slightly weathered;	
		1 1 2 1 1 1 1 1		- 0.5 – -	- 89.5 - -		Loose, SILT, some fine s	sand; brownish orange; dry,	non plastic, insensitive.	
		1 1 1 1 2 1 2 2		- - 1.0 — -	- _ 89.0 -		1.00m: medium dense			Ouatemary Alluvium
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Project:	HDS - 7-15 Church Street (Ashburton)		Project number:	3160491/AR109524			
Site location:	7-15 Church Street (Ashburton)		Client Name:	Kainga Ora			
ocation:	Front yard of 13 Church Street.	Coordinate system: Northing: Easting:	NZTM2000 5137009.1 1500165.0	Vertical datum:Lyttelton 1937Ground level (mRL):89.88Location method:Survey			
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Box 1 - 0.00mbgl to 1.95mbgl

Projec	+ .	шг	NS 7	15 Churo	ch Straa	t (Achhi	urton)		Project Number:	Sheet 1 3160491/AR109524	01		
	t: ocation:			rch Stre			inton)		Client: Kainga Ora				
.ocati	on:	Re	ar yaro	d of 11 C	Church S	street.		Coordinate System: Northing: Easting:	NZTM2000 5136994.4 1500197.5	Vertical Datum: Lyttelton 1937 Ground level (mRL): 89.80 Location Method: Survey			
Iter	In Situ	Tests				D					al		
Groundwater (m)	Su (kPa)	Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log			Soil/ Rock Descript	ion	Geological		
		0 0 0 1 1						e, fine to medium sanc e. Organics: roots and		cs; dark brown; moist, nom plastic,			
		1 0 1 1 1		- - 0.5 -	89.5 -		Loose, fin	e sandy SILT; dark bro	own; moist, non plast	ic, insensitive.			
		0 1 1 1 1 2		-							Alluvium		
		1 1 2 2 2 2		 1.0			Medium d insensitive		to medium sand; ora	ange brown; moist, non plastic,	Ollatemary Alluvium		
		2 3 4 3 3 2		- - 1.5	88.5 -		1.40 - 1.80	0m: brown					
		2 3 5 4 4 4		-									
		7 10		 2.0			∖ <u>1.80m - E</u>	nd of hand auger					
				-		-							
				2.5 — — —		-							
				3.0	87.0 —								
				-	86.5 -								
				3.5 — 	 								
				 4.0	86.0								
				-	 - 85.5 -								
				4.5 — -		•							
				-	- 85.0 — 								
ogge	Started ed By: eter:	J	2/07/2 H 0mm	023	Vane I Vane V Vane 1	Nidth:	N/A N/A N/A	Comme Termina encount	ted on suspected gra	avel at 1.8 m bgl. No groundwater			

谓 Bee	ca	Photo Log	3	Location ID: AR109524-GE- Sheet 1				
Project:	HDS - 7-15 Church Street (Ashburton)		Project number:	3160491/AR109524				
Site location:	7-15 Church Street (Ashburton)		Client Name:	Kainga Ora				
Location:	Rear yard of 11 Church Street.	Coordinate system:	NZTM2000	Vertical datum:	Lyttelton 1937			
		Northing:	5136994.4	Ground level (mRL):	89.80			
		Easting:	1500197.5	Location method:	Survey			
	Becca Project Rotech Leicon - 7 Geotechnical ID: HA-ott-Date: 12/of Internet Internet Interne	AS GWAS STREET Job No: SI HOW OUT TO DEPIN: O NO: 1 Depth: O NO: 1 OF TO DEPIN: O NO: 1 OF TO DEPIN: O						

Box 1 - 0.00mbgl to 1.80mbgl

rojec ito L	:t: ocation			15 Churo rch Stre		t (Ashbu	ırton)		Project Number: Client:	3160491/AR109524 Kainga Ora	
ocati				d of 15 (-	-		Coordinate System: Northing: Easting:		Vertical Datum: Lyttelton 1937 Ground level (mRL): 89.71 Location Method: Survey	
(m)	Su (kPa)	Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log			Soil/ Rock Descript	ion	Geological
		0 0 1 1 1 1	0	-	89.5 –		insensitiv	e. Organics: roots and	rootlets. [TOPSOIL]	cs; dark brown; moist, non plastic, moist, non plastic, insensitive.	
		1 0 1 1 1 1 2 2 2 2 2			- - 89.0 — -			ty fine to medium SAN			Allusia and
		0 1 2 1 2 1 2 1 2 1 2 1 2 1		1.0 — - - 1.5 —	- - 88.5 — -						
		2 2 2 3 3 5 8 13			- 88.0 — - -		insensitiv	lense, SILT, minor fine	to medium sand; ora	ange brown; moist, non plastic,	
				- - - 2.5 -	 87.5 - -						
					 87.0 	-					
				_ _ 3.5	86.5 — - - -						
				- - 4.0	86.0 - - -						
				 4.5	85.5 — - - -						
	Started		2/07/2		85.0 — - - Vane I		N/A	Comme			
	ed By: eter:		H 0mm		Vane V Vane 1	Nidth:	N/A N/A	Terminat	ed at target depth. N	No groundwater encountered.	

調Be	ca	Photo Log	3	Location	ID: AR109524-GE-HA-0 Sheet 1 of
Project: Site location:	HDS - 7-15 Church Street (Ashburton) 7-15 Church Street (Ashburton)		Project number: Client Name:	3160491/AR109524 Kainga Ora	
Location:	Front yard of 15 Church Street.	Coordinate system: Northing: Easting:	NZTM2000 5137005.4 1500212.6	Vertical datum: Ground level (mRL) Location method:	Lyttelton 1937): 89.71 Survey
		Easting:	1500212.8		Sulvey
			1 6 55 6 79 88 55 55 18 18 28 49 66 79 88 88		
	Beca Project: Royer Veraling 7-	5 Church Street Job No: 1316040	A REAL PROPERTY AND A REAL		Carl and a second s
	Geotechnical ID: HA-OUS Date: 12/09	2013 Box No: 1 Depth: 0 mt	to <u>2 m</u> source source		
		MS CAPE AL	and an all		
					1 SPH
		et and the			(A)×
		WEB TY	A CA		
		and the second	and the second	-72	
			Park A	i store	
			and the second		
	The second se				
		CARCINE		- Merica	

Box 1 - 0.00mbgl to 2.00mbgl

							Hai	nd Aug	er Log	Hand Auger ID: AR109524-G	1 of 1	
Projec						et (Ashbu	urton)		Project Number:	3160491/AR109524		
ocati	ocation: on:				et (Ashl Church S			Coordinate Sy Northing: Easting:	Client: vstem: NZTM2000 5137034.6 1500178.7	M2000 Vertical Datum: Lyttelton 1937 7034.6 Ground level (mRL): 89.80		
iter	In Situ	Tests E				D					a	
Groundwater (m)	Su (kPa)	Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log			Soil/ Rock Descrip	otion	Geological	
		1 0 1 1 1 0		-			plastic, in rootlets. [sensitive. Grave TOPSOIL]	ILT, some fine sand, trace I: rounded slightly weathe n SAND; brown; moist, no	e organics; dark brown; moist, non red; greywacke. Organics: roots and on plastic, insensitive.	_	
		0 1 1 2 2 1		- 0.5 — -			0.60m: m	edium dense			Quaternary Alluvium	
2 - 89.0 - Wedium dense, SILT, some fine sand; brownish orange; moist, non plastic, insensitive. 1 - - - - 1 - - - - 2 - - - - 3 - - - -							Quaterna					
					88.5 -) 1.40m - E	nd of hand auge	9r			
		12		-	88.0	-						
				2.0		-						
				- 2.5 — -		-						
				- - 3.0	87.0	-						
				-	- 86.5 – 	-						
				3.5 — - -	 86.0	-						
				- 4.0 — -		-						
				- - 4.5 -	85.5	-						
				-	- 85.0	-						
	Started ed By: eter:	0	2/07/20 R)mm	023	Vane I Vane V Vane 1	Width:	N/A N/A N/A	Те	omments: erminated on suspected gr acountered.	ravel at 1.4 m bgl. No groundwater		

調Be	ca	Photo Log	3	Location	D: AR109524-GE-HA-00 Sheet 1 of 1
Project:	HDS - 7-15 Church Street (Ashburton)		Project number:	3160491/AR109524	
Site location:	7-15 Church Street (Ashburton)		Client Name:	Kainga Ora	
Location:	Rear yard of 15 Church Street.	Coordinate system:	NZTM2000	Vertical datum:	Lyttelton 1937
		Northing:	5137034.6	Ground level (mRL):	89.80
		Easting:	1500178.7	Location method:	Survey
	Project: HDS- 7-IS CH Geotechnical ID: MA-000 Date: 12 / 7] 12 Date: 12 / 7] 12 /	WRCH ST Job No: 31604 Box No: 1 Depth O 20 mm a and and and and and and and and and a	91		
	X - Card	A Standard			

Box 1 - 0.00mbgl to 1.40mbgl

					roject: HDS - 7-15 Church Street (Ashbu						Test Pit ID:			
Projec							on)				3160491/AR109524			
Site Io _ocati	cation: on:				reet (Ash Church S		N	oordinate sy orthing: asting:	Clier stem: NZTM 51369 15001	Kainga OraVertical datum:Lyttelton 1937Ground level (mRL):90.12Location method:Survey				
e	In Situ	Tests						asting.	10001	50.0	Location method.	Guivey		
Groundwater (m)	Su (kPa)	Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log			Soil/ Ro	ock Descriptic	on		Geological	
		<u>a</u>		-	90.0			sensitive. Gra			ace organics; dark brow d, slightly weathered, g			
						× × × × × × × × × × × × × × × × × × × ×	/ledium dense	e, SILT, trace	fine to mediur	n sand; browı	n; moist, non plastic, ir	nsensitive.		
				-	-).90 - 1.20m: g	greyish browr	n mottled brow	vnish red.			8	
				1.0 — - -		× ×	.20 - 1.50m: d	1.50m: dark brown.						
				- 1.5 — -	- 88.5 —	×××× ×××× ×××× ×××× ×××× ××××	.50 - 1.80m: t	trace amorph	ous organics,	blackish brov	vn.		Ousternary Allunium	
					- - 88.0	× × × >			se sandy fine nded, slightly v		AVEL, trace silt brown eywacke.	; moist, well	_	
				- - 2.5 -			2.50m - End o	f tost pit						
				-	87.5 — _ _									
				3.0	- - 87.0 — -									
				3.5 —	- - 86.5 -									
				4.0										
				-	86.0 — - -									
				4.5 — — —	- 85.5 — -									
				-	-									
/ane /ane /ane	type: width:		12/07 N/A N/A N/A	/2023	Con	ipment:	GT Miles Constructi 5T Excavator		omments: erminated at ta	rget depth.				

調Be	ca	Photo Log	3	Location ID: AR109524-GE-ITP Sheet 1 of
Project:	HDS - 7-15 Church Street (Ashburton)		Project number:	3160491/AR109524
Site location:	7-15 Church Street (Ashburton)		Client Name:	Kainga Ora
ocation:	Rear yard of 7 Church Street.	Coordinate system:	NZTM2000	Vertical datum: Lyttelton 1937
		Northing:	5136989.3	Ground level (mRL): 90.12
		Easting:	1500136.6	Location method: Survey
		0.00mbgl to 2.5	interest of the second se	

								est Pi	t Log		Test Pit ID:	AR1095 T Sheet 1	TP-00
Projec	et: cation:				urch Stre reet (Ash	et (Ashbu	urton)			Project number: Client:	3160491/AR109524 Kainga Ora		
ocati					Church S			Coordinate Northing: Easting:	system:	Vertical datum: Lyttelton 1937 Ground level (mRL): 89.87 Location method: Survey			
ē	In Situ					-		J		1500154.4		<u>y</u>	_
Groundwater (m)	Su (kPa)	Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log		T trace fine a		Soil/ Rock Descriptio		aiat nan	Geological
				-				ensitive. Orga			ganics; dark brown; m	dist, non	
				-	89.5 —		Loose, fine	to coarse SA	ND, trace	silt; brown; moist, n	on plastic, insensitive.		
				0.5 -									
	well gra					well graded	l. Gravel: sub	-angular t	o sub-rounded, sligh	RAVEL, trace silt; brow tly weathered, greywa	cke.	_	
				-		× × × × × × × × × × × × × × × × × × ×	non plastic,	nse, SILI, tra , insensitive. (Ce fine to Organics:	medium sand, trace amorphous.	organics; greyish brov	vn; moist,	
				- 1.5 —	88.5 —	× × × × × × × × × × × × × × × × × × × ×							č
				2.0	88.0	× × × >					AVEL, trace cobbles, t d, slightly weathered, g		
				-	87.5 —		2.20m - En	d of test pit					
				2.5 -									
				-	87.0								
				3.0									
				-									
				3.5 -	86.5 —								
				-									
				4.0 —	86.0 —								
				-									
				- 4.5 —	85.5 —								
				-									
		•		-	85.0 —				-				
)ate : /ane	starteo ID:	3:	12/07 N/A	/2023	-	ged by: tractor:		ruction	Commer Terminat	n ts: ed at target depth.			
	type:		N/A				5T Excavato		lonnindu	ca at larget depuit.			
Vane	width:		N/A		Met								
	orient				d 1 hhr-	viotiona	See Key S	hoot					

調Be	ca	Photo Log	2	Location	ID: AR109524-GE-ITP-00 Sheet 1 of 1
Project:	HDS - 7-15 Church Street (Ashburton)		Project number:	3160491/AR109524	Sheet 1 01
Site location:	7-15 Church Street (Ashburton)		Client Name:	Kainga Ora	
Location:	Rear yard of 9 Church Street.	Coordinate system:		Vertical datum:	Lyttelton 1937
	Real yard of a charon chock.	Northing:	5137003.6	Ground level (mRL)	
		Easting:	1500154.4	Location method:	Survey
		0.00mbgl to 2.2	ombgl		

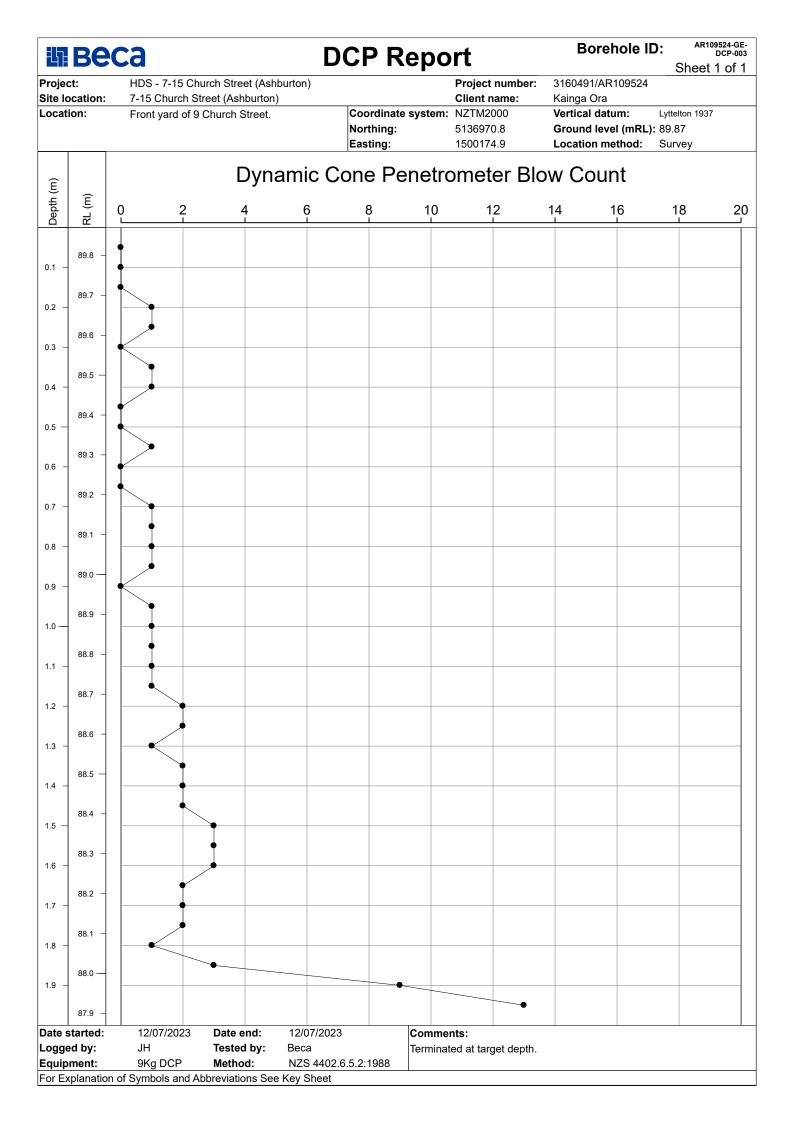
Sensitivity: General



Appendix D – Scala Results

Ľ١	iii Beca						Rep	ort		Borel	hole ID:	AR109524-GE- DCP-001 Sheet 1 of 1	
	cation		HDS - 7-15 Church 7-15 Church Street	(Ashburton			-	Project n Client na	me:	3160491/AR Kainga Ora			
Locat	ion:		Front yard of 7 Chu	urch Street.		Coord Northi Eastin		n: NZTM200 5136961.2 1500162.2	2	Vertical datu Ground leve Location me	el (mRL): 8	Lyttelton 1937 89.98 Survey	
(L				Dyna	amic C	one	Peneti	romete	r Blo	w Cour	nt		
Depth (m)	RL (m)	0	2	4	6	8	10	12		14	16	18	20
	89.9 –		•										
0.1 –	89.8 -		•										
0.2 -													
0.3 -	89.7 -		•										
0.4 -	89.6 -		•										
0.5 —	89.5 —												
0.6 -	89.4 -												
0.7 -	89.3 -		•										
0.8 -	89.2 -		•										
0.9 -	89.1 -		•										
1.0 —	89.0 —		•										
1.1 -	88.9 -												
1.2 -	88.8 -												
1.3 -	88.7 -		•										
	88.6 -												
1.4 –	88.5 —												
1.5 —	88.4 -		•										
1.6 -	88.3 -		•										
1.7 –			•										
1.8 -	88.2 -		•										
1.9 –	88.1 -												
	88.0 —		40/07/2025		40/07/202								
Date s	started:			ate end: ested by:	12/07/202 Beca	3	Comm		t donth				
Equip				ested by: lethod:	веса NZS 4402	6.5 2.10		ated at targe	i uepiñ.				
		on of	Symbols and Abbre										

	Be	eca		DCP R	epo	rt	Borehole	AR109524-GE- DCP-002 Sheet 1 of 1
Projec Site Ic	ct: ocation:	HDS - 7-15 Church S 7-15 Church Street (Street (Ashburton)			Project number: Client name:	3160491/AR10952 Kainga Ora	
Locat	ion:	Rear yard of 7 Churc	ch Street.	Coordinate Northing: Easting:		NZTM2000 5136982.8 1500138.9	Vertical datum: Ground level (mF Location method	
я ш			Dynamic	Cone Pe	netro	meter Blo	w Count	
Depth (m)	RL (m)	0 2	4 6	8	10	12	14 16	18 20
	90.0 —	•						
0.1 –	89.9 –							
0.2 –	89.8 -							
0.3 –	89.7 –							
0.4 -	89.6 -							
0.5 —	89.5 —	•						
0.6 -	89.4 -							
0.7 -	89.3 –							
0.8 -	89.2 -	•						
0.9 -	89.1 –							
1.0 —	89.0 —							
1.1 –	88.9 —							
1.2 –	88.8 -							
1.3 -	88.7 -	•						
1.4 –	88.6 -							
1.5 —	88.5 —							
1.6 -	88.4 -	•						
1.7 -	88.3 -							
1.8 -	88.2 -							
1.9 –	88.1 -							
Date s Logge	started:		te end: 12/07/20 sted by: Beca		Commen Terminate	i ts: ed at target depth.		
Equip	ment:		thod: NZS 44	02.6.5.2:1988				

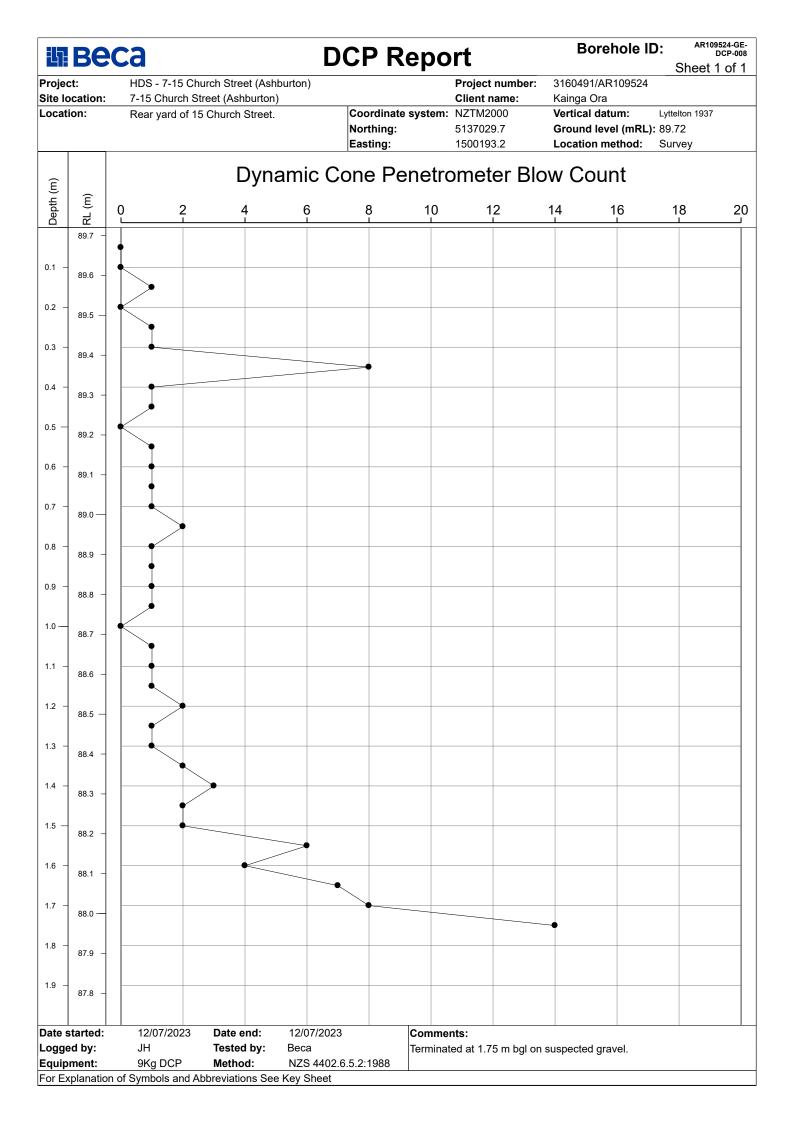


Ľ١.	Be) (:a				DCI	P Re	еро	rt		Boreho		AR109524-GE DCP-004 Sheet 1 of 1	4
Projec			HDS - 7-15 (7-15 Church							Project nun Client name		60491/AR109 iinga Ora			<u> </u>
Locat	ion:	1	Rear yard of	9 Church	Street.		Nor	ordinate thing: sting:	system:	NZTM2000 5136989.3 1500158.9	Gi	rtical datum ound level (ocation meth	mRL): 90.0		
(m)					Dyna	amic	Con	e Pe	netro	ometer	Blow	Count			
Depth (m)	RL (m)	0	2		4	6		8	10	12	14	16	1	8 20	С
	_														
0.1 –	89.9 -														
0.2 -	89.8 -	-													
0.3 -	89.7 -														
0.4 -	89.6 -	┤╺													
0.5 —	89.5 –														
0.6 -	89.4 -														
0.7 -	89.3 -														
0.8 -	89.2 -														
0.9 -	89.1 -														
1.0															
1.1 -	88.9 -														
1.2 -	88.8 -	_													
	88.8 -		•												
1.3 –	88.7 -		•												
1.4 –	88.6 -		•	>											
1.5 —	88.5 -		•	/											
1.6 -	88.4 -		•												
1.7 -	88.3 -														
1.8 -	88.2 -		•												
1.9 -	88.1 -														
			•				1000-								
Date s	started: ed by:		12/07/2023 JH		end: ed by:	12/07/ Beca	2023		Comme Terminat	nts: ed at target c	lepth.				
Equip	ment:		9Kg DCP	Meth	nod:	NZS 4	402.6.5.2:				· · ·				
For Ex	planati	on of	f Symbols and	Abbrevia	tions See	Key Sh	eet								

Ψ	Be	ca		D	СР	Repo	ort	Shee			9524-GE- DCP-005 1 Of 1
Proje Site lo	ct: ocation:	HDS - 7-15 Chu 7-15 Church Stre					Project number Client name:	316049 Kainga	01/AR109524 Ora		
Locat	ion:	Front yard of 11	Church Street.		Coord Northi Eastin	ng:	: NZTM2000 5136991.8 1500182.6	Ground	d level (mRL): 9	_yttelton 1937 90.03 Survey	
(u			Dyna	amic C	one	Penetr	ometer Bl	ow Co	ount		
Depth (m)	RL (m)	0 2	4	6	8	10	12	14	16	18	20
	90.0 —	•									
0.1 –	89.9 –	•									
0.2 -	89.8 –										
0.3 -	00.7										
0.4 -	89.7 –										
0.5 —	89.6 –										
0.5 —	89.5 —	•									
0.6 -	89.4 –	•									
0.7 -	89.3 –	•									
0.8 -	89.2 –										
0.9 -	89.1 -										
1.0	89.0 —	•									
1.1 -		•									
1.2 -	88.9 –										
1.3 -	88.8 -	•									
	88.7 –	•									
1.4 –	88.6 –										
1.5 —	88.5 —		-								
1.6 -	88.4 –		•								
1.7 –	88.3 -										
1.8 -	88.2 –		•								
1.9 –			•								
	88.1 –										
Date s Logge	started:	12/07/2023 JH	Date end: Tested by:	12/07/2023 Beca	3	Comme					
Equip		9Kg DCP	Method:	веса NZS 4402.	6.5.2:198		ated at target depth				
		n of Symbols and Ab				I					

Цŋ	Be	ca			[DCP	Rep	ort		Bore	hole ID:	AR10 Sheet	9524-GE- DCP-006 1 of 1
	ocation:		15 Church \$ rch Street (Clie	ject number: nt name:	3160491/AF Kainga Ora			
Locat	ion:	Rear yard	d of 13 Chu	rch Street.		Coord North Eastir		513	M2000 7022.0 0169.2	Vertical dat Ground lev Location m	el (mRL): 9	yttelton 1937 0.15 Survey	
(ب				Dyna	amic (Cone	Pene	trom	eter Blo	w Cou	nt		
Depth (m)	RL (m)	0	2	4	6	8	1	0	12	14	16	18	20
	90.1 -												
0.1 -	90.0												
0.2 -													
0.3 -	89.9 –												
0.4 -	89.8 –		>										
	89.7 –	•											
0.5 —	89.6 –		>										
0.6 -	89.5 —												
0.7 -			>										
0.8 -	89.4 –												
0.9 -	89.3 –												
	89.2 –	•											
1.0 —	89.1 –		•										
1.1 -	89.0 —		\										
1.2 -	88.9 -												
1.3 -			•										
1.4 -	88.8 —		•										
1.5 —	88.7 –		•										
1.6 -	88.6 -												
1.6 -	88.5 —		•										
1.7 -	88.4 –		•										
1.8 -	88.3 -		•										
1.9 –			•										
Data	88.2 -	12/07/2	022	to and:	40/07/00	22							
Logge		OR	Te	te end: sted by: ethod:	12/07/20 Beca	23 2.6.5.2:19	Term	nments: ninated at	target depth.				
	o ment: kplanatic	9Kg DC on of Symbols					00						

Ľ٦	Be	C	a		D	CP R	lepo	rt	Borehole ID: AR109524 DCP Sheet 1 c		
Projec Site Ic	ct: ocation		HDS - 7-15 Churcl 7-15 Church Stree					Project number: Client name:	3160491/AR1095 Kainga Ora		
Locat	ion:	1	Front yard of 9 Ch	urch Street.		Coordinate Northing: Easting:		NZTM2000 5137006.6 1500196.0	Vertical datum: Ground level (m Location method		
(m)				Dyna	amic C	one Pe	enetro	meter Blo	w Count		
Depth (m)	RL (m)	0	2	4	6	8	10	12	14 16	18 20	
	89.8 -										
0.1 –	09.0		•								
0.2 -	89.7 -		•								
0.3 -	89.6 -										
0.4 -	89.5 -										
0.5 —	89.4 -		•								
0.6 -	89.3 -		•								
0.7 –	89.2 -		•								
0.8 -	89.1 -		•								
0.9 -	89.0 —		•								
1.0	88.9 -		•								
	88.8 -		•								
1.1 –											
1.2 –	88.7 -		•								
1.3 –	88.6 -		•								
1.4 –	88.5 –		-<								
1.5 —	88.4 -										
1.6 -	88.3 -		_								
1.7 -	88.2 -		• •								
1.8 -	88.1 -										
1.9 -	88.0 —	$\left \right _{-}$									
			•								
Date s	started:			Date end: Fested by:	12/07/2023 Beca	i	Commen	ed at target depth.			
Equip				Nethod:	NZS 4402.0	6.5.2:1988		o ar larger ueptri.			
		on of S	Symbols and Abbr				1				



Sensitivity: General



Appendix E – Raw CPT Data



12 July 2023 Our Ref: 1020961.0072.0.0/Rep01 Customer Ref: 6232030

Kāinga Ora – Homes and Communities 107 Carlton Gore Road Newmarket Auckland 1023

Attention: David Dobson

Dear David

7 - 15 Church Street, Ashburton

Site Report – Piezocone Penetration Testing

Customer's Instructions

We were instructed to complete:

Four Piezocone 50 MPa penetration tests CPT01, CPT02, CPT03 and CPT04 to a target depth of 20 m or refusal.

Specifications

None issued.

Date of Procedures

12th July 2023

Locations

Test locations were determined by the customer.

The attached plan(s) provides indicative locations only and is not to scale. All other information we provide regarding location should be referenced to the asset owner.

Coordinates are provided in the CPT plots.

- a Method used to determine locations: GIS\Web map viewer
- b Method used to determine RL: GIS\Web map viewer
- c Expected accuracy for location: 10 m
- d Expected accuracy for elevation: 10 m

Geotechnics Ltd

45A Parkhouse Road, Wigram, Christchurch, 8042 | PO Box 13055, Armagh, Christchurch, 8141 +64-3-361 0300 | christchurch@geotechnics.co.nz | www.geotechnics.co.nz

Method

ISO 22476-1: 2012(E) - Geotechnical investigation and testing – Field testing – Part 1: Electrical cone and piezocone penetration test

Results

The following is attached:

- CPT plots.
- Probe calibration certificate.

Raw CPTu data files have been supplied via email.

Test Remarks

Test IDs	СРТ01, СРТ02, СРТ03, СРТ04
Operator	CHES
Machine	Ingenjörsfirman Geotech AB 220, capacity 200 kN
Cara	Probe No 4600
Cone	Porewater Pressure Location u ₂ , Glycerine Saturated
Friction Reducer	Ring type, Outer diameter 46mm, Amount 1, Located at 0.50m behind the base of the cone

CPT01 -	Target Depth:	20m						
	Predrill Depth:	0m						
	Penetration Length:	2.68m 2.68m						
	Actual Depth:							
	Operation Date:	12/07/2023						
	Coordinates:	NZTM - N 5 ²	136960 E 150	0163				
		89m (amsl)						
	Ground Water Level:	N/A						
	Test Notes:	Test refusal	at 2.68m > 35	5 MPa, ancho	r failure			
	Other Tests:	None						
		qc (MPa)	fs (kPa)	u2 (kPa)				
	BaselineInital	7.03	127.40	270.40				
	Baseline(Initial - Final)	-0.01	0.00	0.30				
	% of MSO(Initial - Final)	-0.02	0.00	0.21				
	Max Measure value	38.33	358.50	140.70				
	Meets ISO 22476-1-2012 - An	nlication class 3	•	•				

Meets ISO 22476-1:2012 - Application class 3

CPT02 -	Target Depth:20mPredrill Depth:0mPenetration Length:1.96mActual Depth:1.96mOperation Date:12/07/2023Coordinates:NZTM - N 5136997 E 1500151 89m (amsl)Ground WaterN/A							
	Level: Test Notes: Other Tests:	Test refusal at 1.96m > 30 MPa, danger of breaking equipment due to tilt None						
		qc (MPa)	fs (kPa)	u2 (kPa)				
	BaselineInital	7.08	126.90	270.10				
	Baseline(Initial - Final)	-0.05	0.40	-0.20				
	% of MSO(Initial - Final)	-0.17	0.23	-0.60				
	Max Measure value	30.90	171.20	33.30				
	Mooto ISO 22476 1.2012	Application class 2						

Meets ISO 22476-1:2012 - Application class 3

CPT03 -	Target Depth:	20m							
	Predrill Depth:	0m							
	Penetration Length:	2.7m							
	Actual Depth:	2.7m							
	Operation Date:	12/07/2023							
	Coordinates:	NZTM - N 51	136991 E 150	0188					
		89m (amsl)							
	Ground Water Level:	N/A							
	Test Notes:	Test refusal at 2.70m > 40 MPa, anchor failure							
	Other Tests:	None							
		qc (MPa)	fs (kPa)	u2 (kPa)					
	BaselineInital	7.04	127.10	270.20					
	Baseline(Initial - Final)	0.02	-0.10	0.00					
	% of MSO(Initial - Final)	0.04	-0.02	0.00					
	Max Measure value	42.66	479.50	20.40					

CPT04 -	Target Depth:	20m					
	Predrill Depth:	0m					
	Penetration Length:	1.74m					
	Actual Depth:	1.74m					
	Operation Date:	12/07/2023					
	Coordinates:	NZTM - N 5137031 E 1500182					
		89m (amsl)					
	Ground Water Level:	N/A					
		Test refusal at 1.74m > 40 MPa, anchor failure					
	Test Notes:	Test refusal	at 1.74m > 40) MPa, ancho	r failure		
	Test Notes: Other Tests:	Test refusal None	at 1.74m > 40) MPa, ancho	r failure		
			at 1.74m > 40 fs (kPa)) MPa, ancho u2 (kPa)	r failure		
		None			r failure		
	Other Tests:	None qc (MPa)	fs (kPa)	u2 (kPa)	r failure		
	Other Tests: Baseline _{Inital}	None qc (MPa) 7.07	fs (kPa) 127.10	u2 (kPa) 270.60	r failure		
	Other Tests: Baseline _{Inital} Baseline _(Initial - Final)	None qc (MPa) 7.07 -0.03	fs (kPa) 127.10 0.20	u2 (kPa) 270.60 -0.80	r failure		

Raw Data: The data presented in this report is factual and based on the results of CPTu testing undertaken with reasonable diligence. Any interpretation of the data is the sole responsibility of the user.

Measured Water Levels: Where water level measurements are reported, the depth was determined immediately after the test with an electronic water level meter. Where water level measurement was not successful, a hydrostatic line of best fit was added to the CPTu plot and is noted in the report as 'assumed'.

Penetration Speed: Adding 1 m length rods requires a pause in penetration and the testing is therefore non-continuous. Where materials may damage equipment, penetration speed is reduced to protect equipment and limit inclination deviation. Penetration speed is recorded in the tab data and when reduced to <20 mm/second is not in accordance with the test method.

Tip Resistance (q_c): The CPTu plots show tip resistance as q_c.

The static pore water pressure line shown is assumed to be hydrostatic from the phreatic surface. The validity of this assumption must be checked by the user.

Pore Pressure (u_2) : The test method for taking pore pressure readings may not be suitable for the type of material being tested. Therefore, the corrected or calculated parameters bases on u_2 values are not included in this report.

Friction Ratio (Rf): There is no offset between tip resistance and sleeve friction used for friction ratio determination.

General Remarks

This report has been prepared for the benefit of Kāinga Ora – Homes and Communities, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

The inherent uncertainties of site investigation work, mean the nature and continuity of subsoil away from the test location could vary from the data logged.

Material descriptions are not covered under the IANZ endorsement of this report.

As agreed, we have forwarded a copy of our unlocked spreadsheets. We take no responsibility for alteration or loss of data in the electronic transfer/transmittal, or manipulation of the data after it has been transmitted.

Please reproduce this report in full when transmitting to others or including in internal reports.

If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of the letterhead page.

GEOTECHNICS LTD

Report approved by:

Jeremy Brokenshire Project Manager Key Technical Person

Authorised for Geotechnics by:

Alan Benton Project Director



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

12-Jul-23

 $t: \ to 7 - 15 \ church \ street \ working material \ 20230712. jebr. 1020961.0072. 0.0. rep 01.7$

- 15 church street, ashburton.docx



LOCATION PLAN

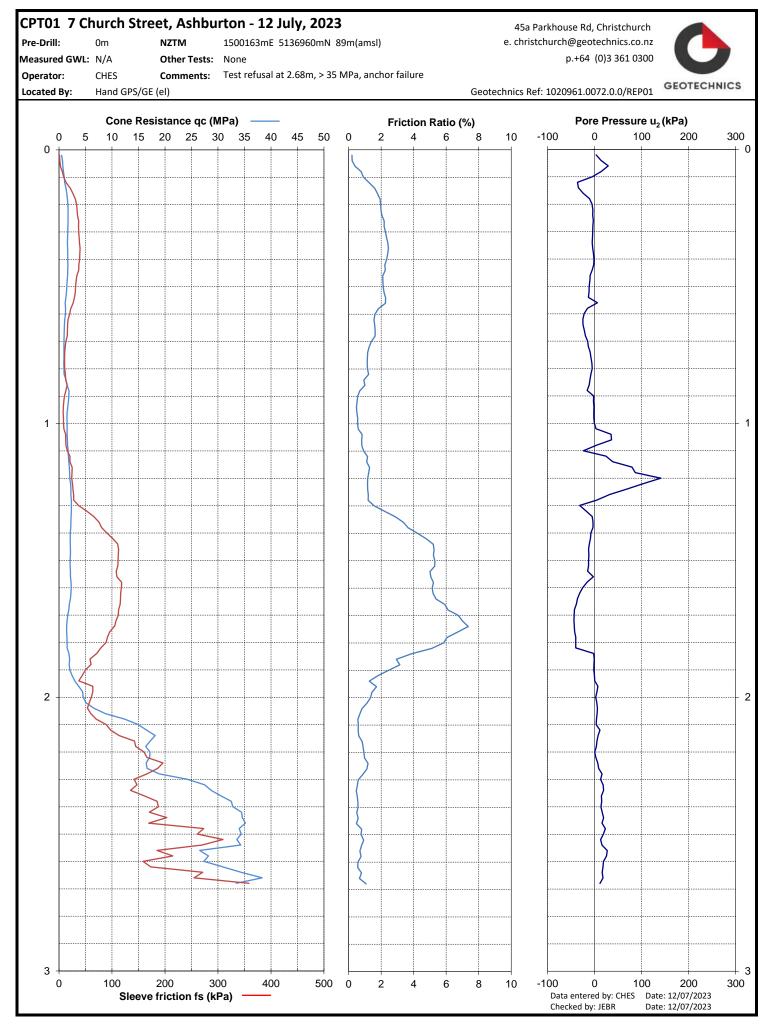
Piezocone Penetration Testing – 7 – 15 Church Street, Ashburton – 12th July 2023

Locations are indicative only

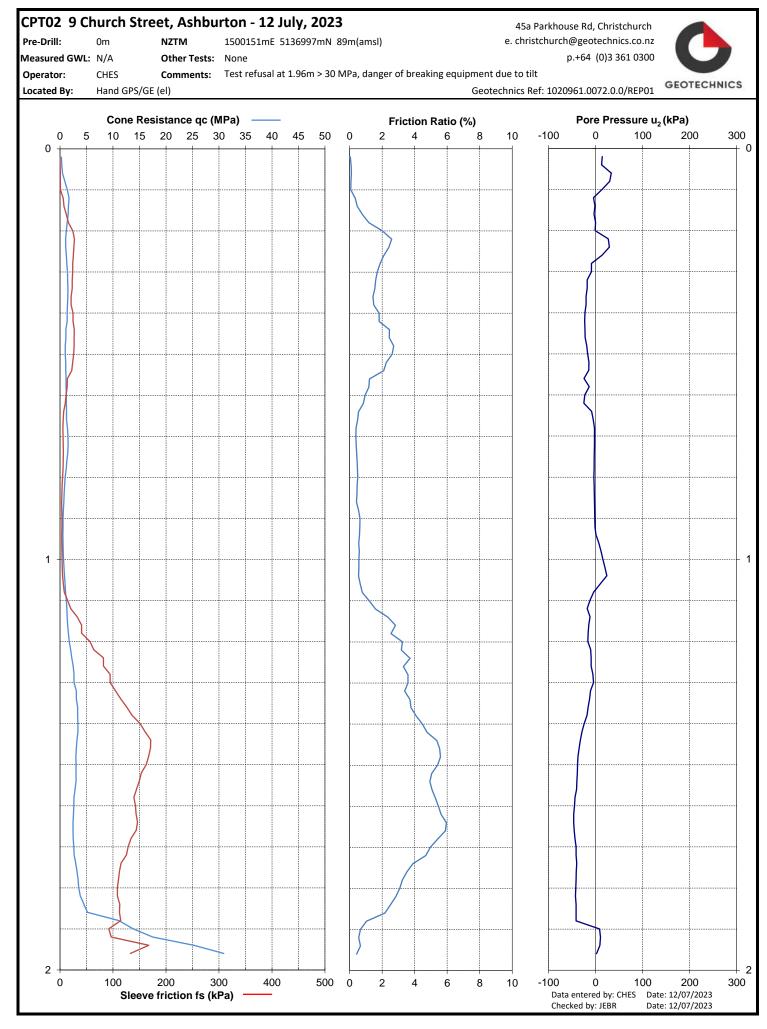
		Site	7 – 15 Church Street	Our Ref	1020961.0072.0.0/Rep01	Drawn By	JEBR	Date	12/07/23	NI	
	45A Parkhouse Road Wigram	Location	Ashburton	Customer Ref	6232030	Checked By	CXPG	Date	13/07/23	N	
GEOTECHNICS	Christchurch	Project	G CH KO 7 – 15 Church Street	Lab Ref	N/A	Scale		Not to Sca	le		

Aerial photograph(s) sourced from Google Earth (Copyright 2023).

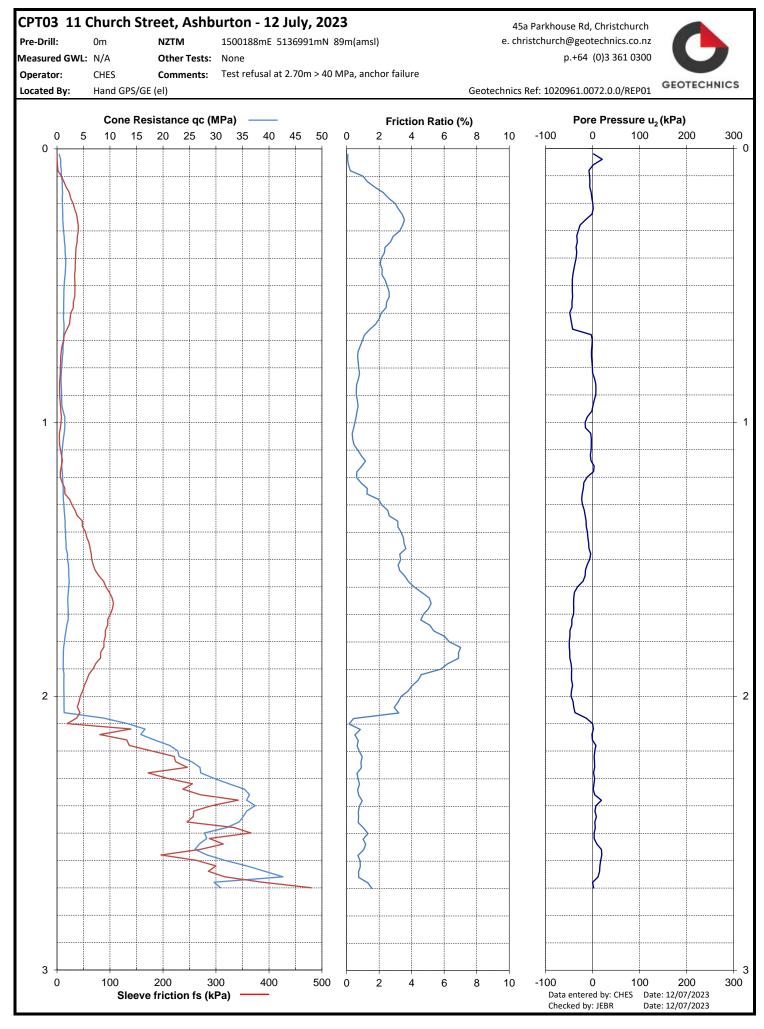
Page 7 of 11



Page 8 of 11

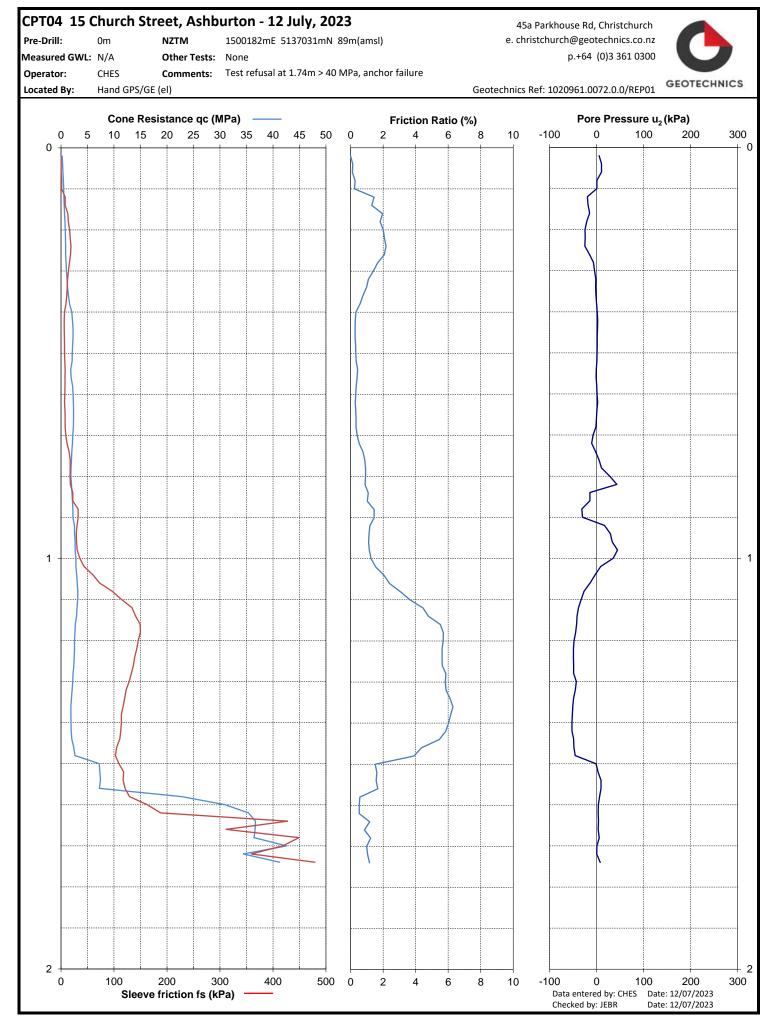


Page 9 of 11



Geotechnick: Getechnick: Getec

Page 10 of 11



Geotechnick: Getechnick: Getec

Göteborg:2023-03-29

CALIBRATION CERTIFICATE FOR CPT PROBE 4600

Probe No Date of Calibration Calibrated by Run No Test Class:	4600 2023-03-29 Alexander I 2704 ISO 1		l-	m
Point Resistance	Tip Area 1	0cm ²		
Maximum Load	50	MPa		
Range	50	MPa		
Scaling Factor	1329			
Resolution	0,5741	kPa		
Area factor (a)	0,844			
Zero	7,048 MPa			
ERRORS				
Max. Temperature effect when n	ot loaded	14,343	kPa	
Temperature range 5 –40 deg. Ce		1,0.0		
Local Friction	Sleeve Are		1 ²	
Maximum Load	0,5	MPa		
Range	0,5	MPa		
Scaling Factor	3701			
Resolution	0,0103	kPa		
Area factor (b)	0			
Zero	127,82 kPa			
<u>ERRORS</u> Max. Temperature effect when n Temperature range 5 –40 deg. Ce		0,391	kPa	
Pore Pressure				
	2	MPa		
Maximum Load	2 2	MPa		
Range Scaling Factor	3405	IVII a		
Resolution	0,0224	kPa		
Zero	272,7 kPa	KI d		
2010	272,7 KI u			
ERRORS				
Max. Temperature effect when n	ot loaded	0,716	kPa	
Temperature range 5 -40 deg. Ce				
Tilt Angle				
Scaling Factor	0,93	-		
Range	0 - 40	Deg.		
Backup memory				
Conductivity probe				Entered By: CHES 29/06/2023 Checked By: JEBR 29/06/2023
conductivity probe				KTP Approved By: JEBR 29/06/2023

Ingenjörsfirman Geotech AB +46 (0)31-28 99 20 <u>www.geotech.se</u> Datavägen 53 +46 (0)31-68 16 39 VAT No.

Specialists in Geotechnical Field Equipment



Appendix F – Liquefaction Assessment Results

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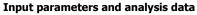
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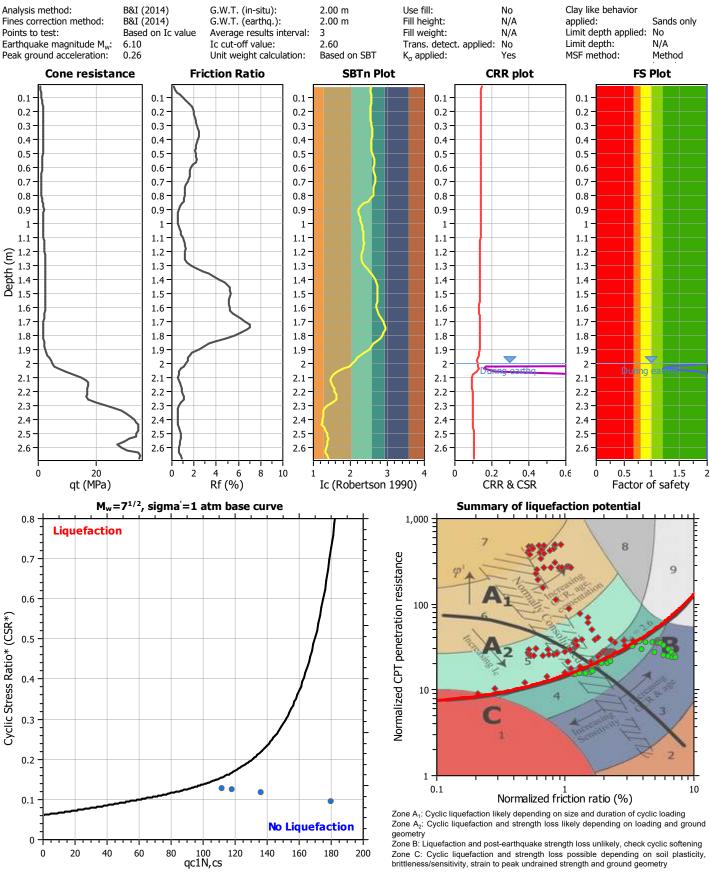
LIQUEFACTION ANALYSIS REPORT

Project title : Kainga Ora - HDS

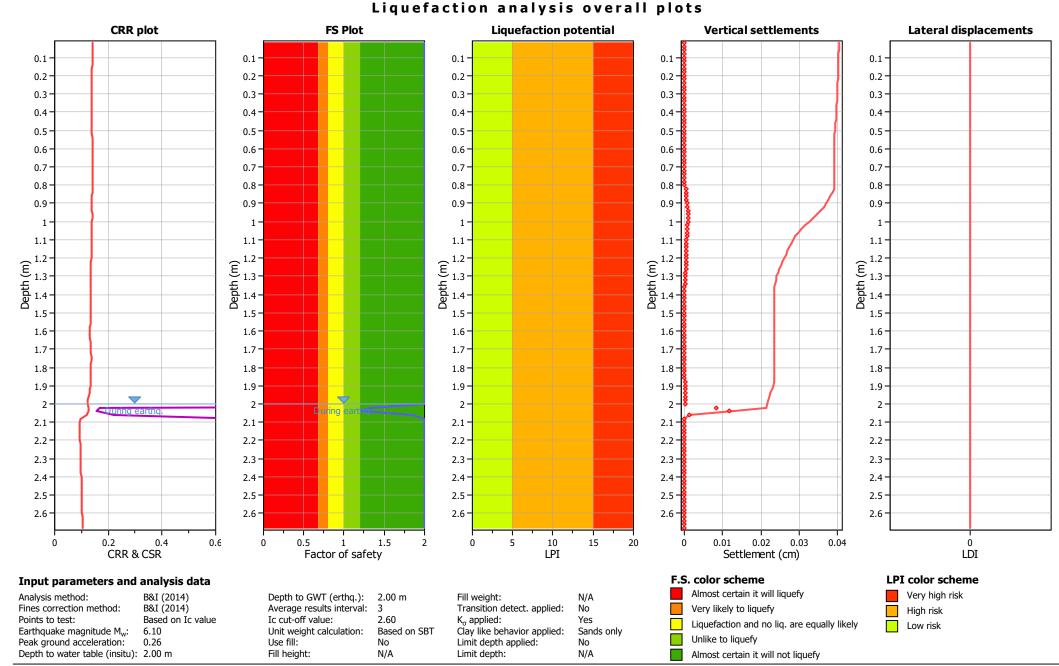
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CPT file : CPT01-ULS-6.1-0.26g





CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:19:59 pm 1 Project file: C:\Users\or680\Beca\3160491 - Project Velocity - Chch Pilot - Documents\Technical - Working Files\Technical Geotechnical\03 Working Files\Church Street (Ashburton), 7



CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:19:59 pm

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2

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LIQUEFACTION ANALYSIS REPORT

Project title : Kainga Ora - HDS

0.1

0

0

20

40

60

80

Location : 7 - 15 Church Street

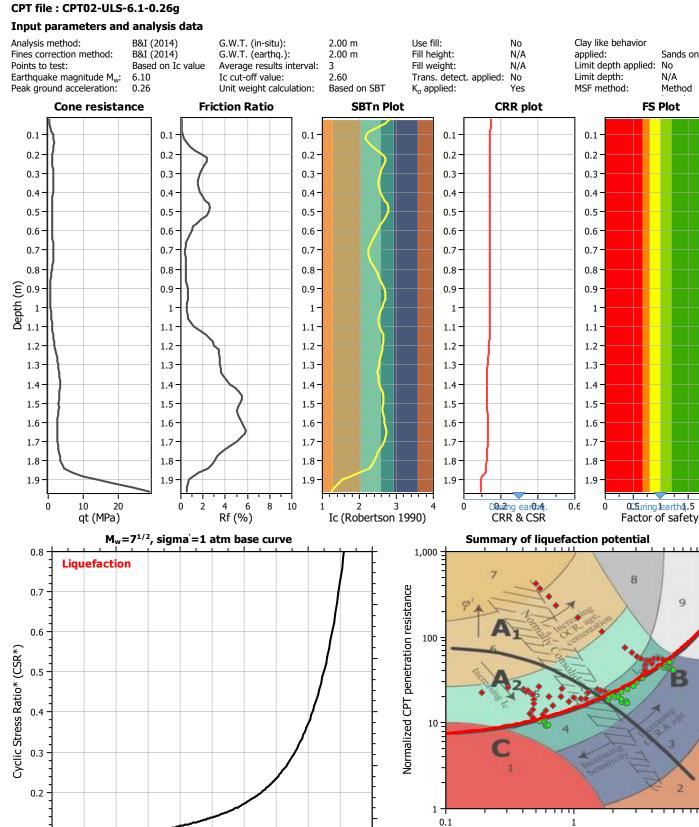
Sands only

N/A

Method

2

9



10 Normalized friction ratio (%) Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading Zone A₂: Cyclic liquefaction and strength loss likely depending on loading and ground geometry

Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity. brittleness/sensitivity, strain to peak undrained strength and ground geometry

200

No Liquefaction

180

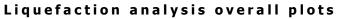
160

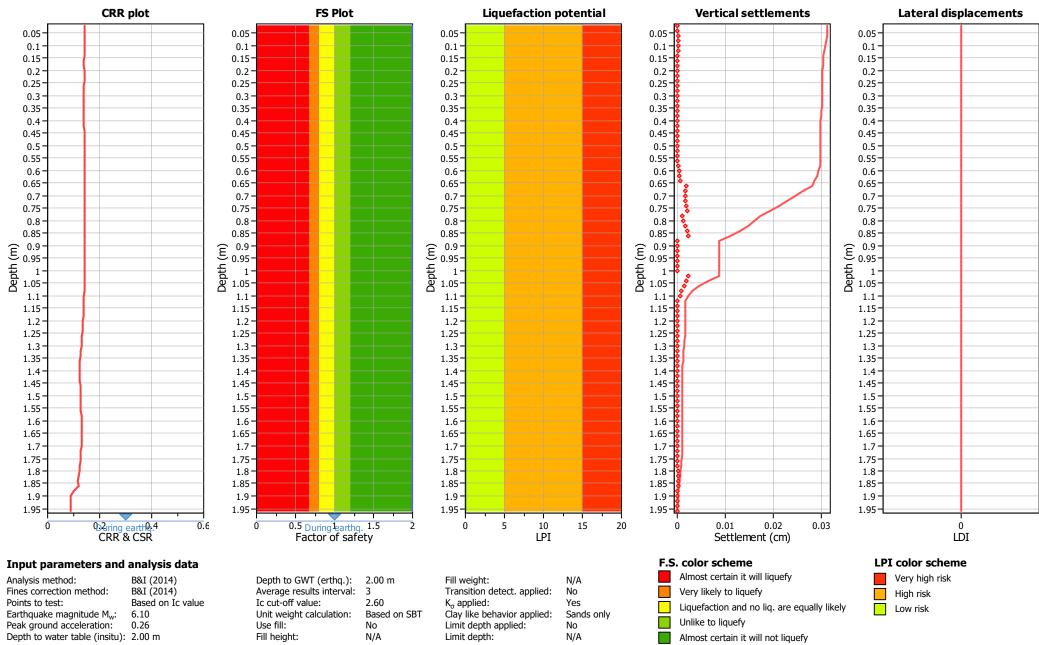
100 qc1N,cs

120

140

Δ





CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:19:59 pm

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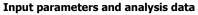
Beca Limited Level 2 ANZ Center 267 High Street, Christchurch https://www.beca.com/

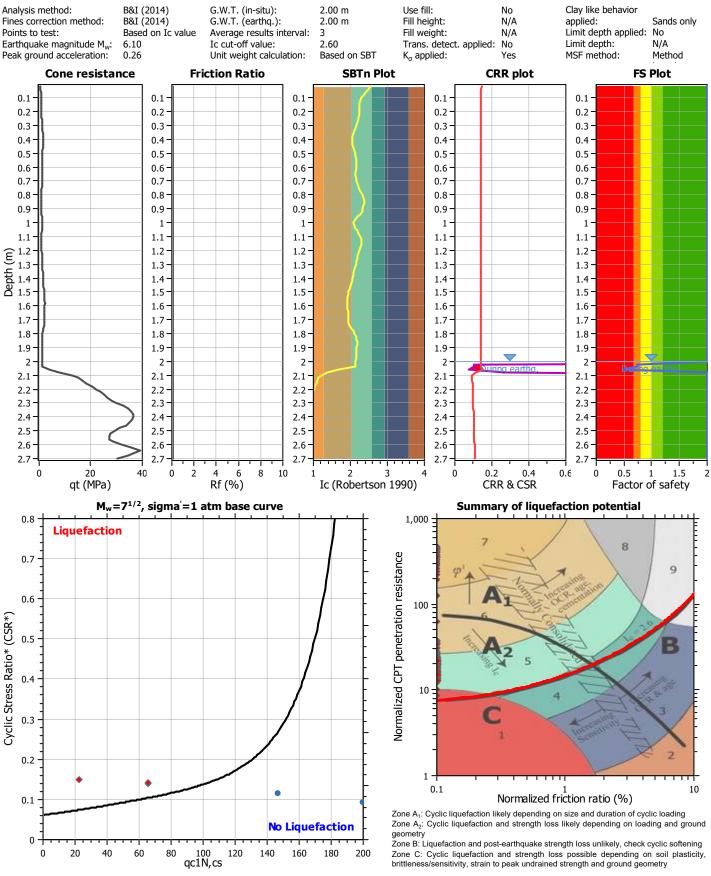
LIQUEFACTION ANALYSIS REPORT

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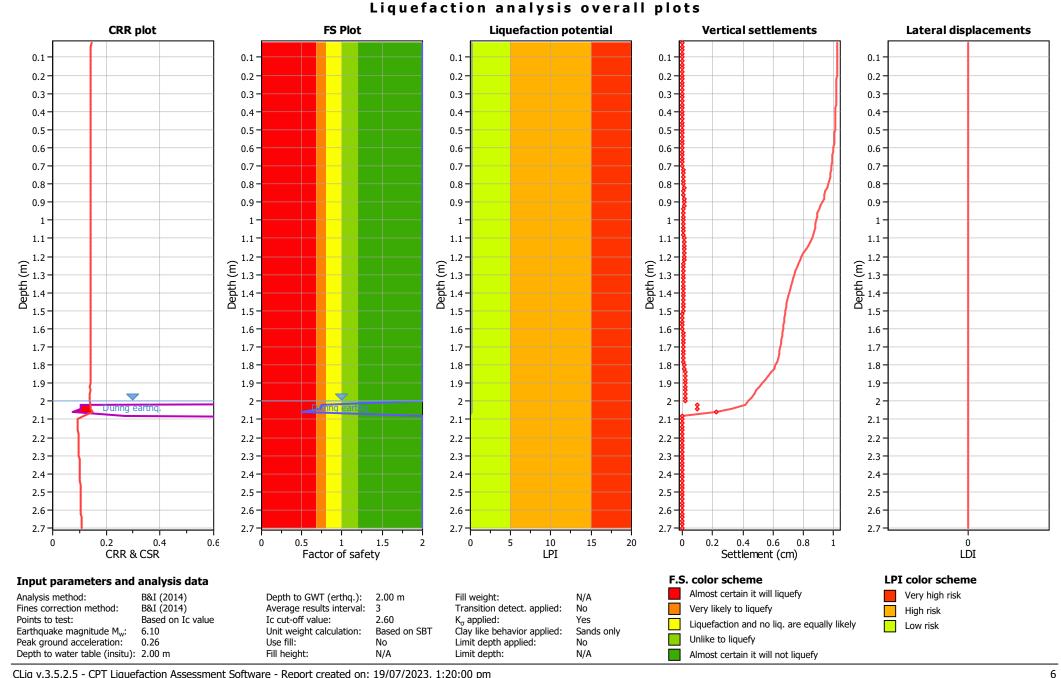
Location : 7 - 15 Church Street

CPT file : CPT03-ULS-6.1-0.26g





CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:20:00 pm 5 Project file: C:\Users\or680\Beca\3160491 - Project Velocity - Chch Pilot - Documents\Technical - Working Files\Technical Geotechnical\03 Working Files\Church Street (Ashburton), 7



CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:20:00 pm

Project file: C:\Users\or680\Beca\3160491 - Project Velocity - Chch Pilot - Documents\Technical - Working Files\Technical Geotechnical\03 Working Files\Church Street (Ashburton), 7 - 15\03 Design\Liquefaction Analysis\7-15 Church St Liquefaction Analysis.cg

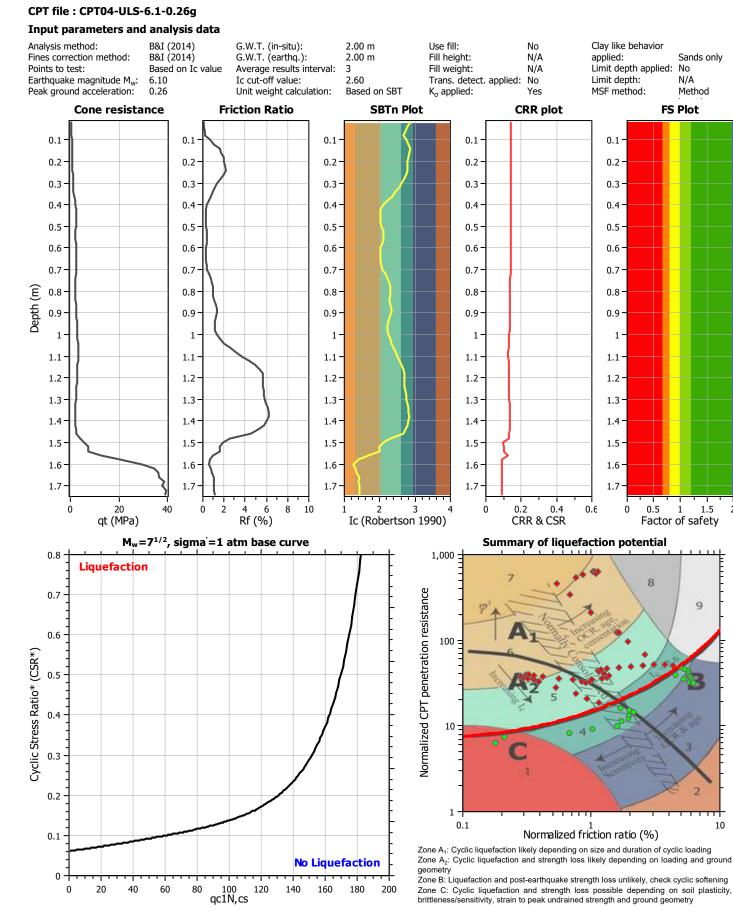
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LIQUEFACTION ANALYSIS REPORT

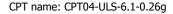
Project title : Kainga Ora - HDS

Location : 7 - 15 Church Street



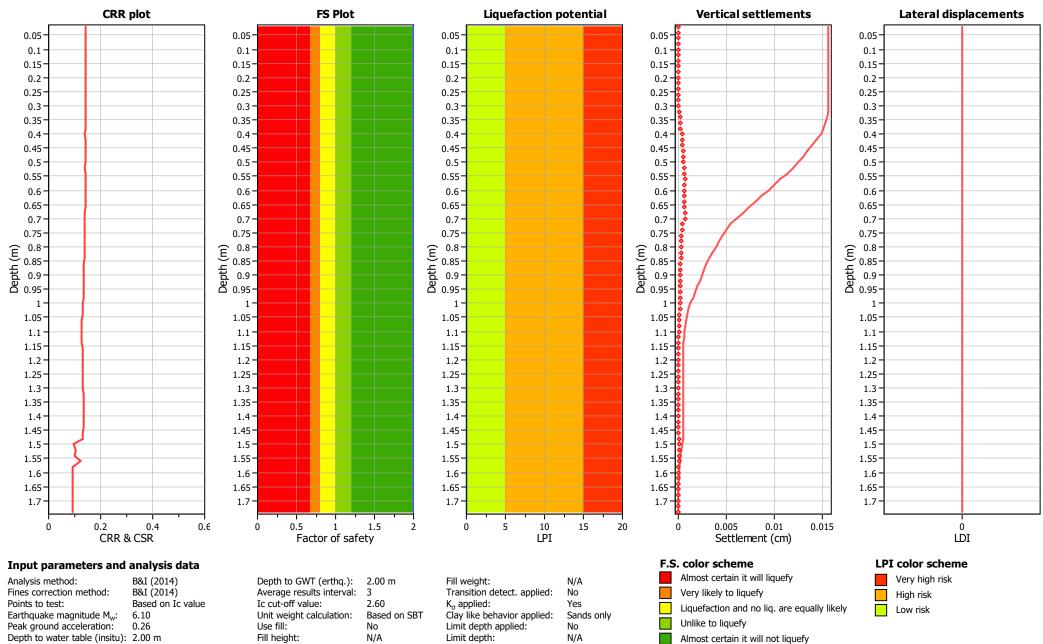
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7 CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:20:00 pm Project file: C:\Users\or680\Beca\3160491 - Project Velocity - Chch Pilot - Documents\Technical - Working Files\Technical Geotechnical\03 Working Files\Church Street (Ashburton), 7



8





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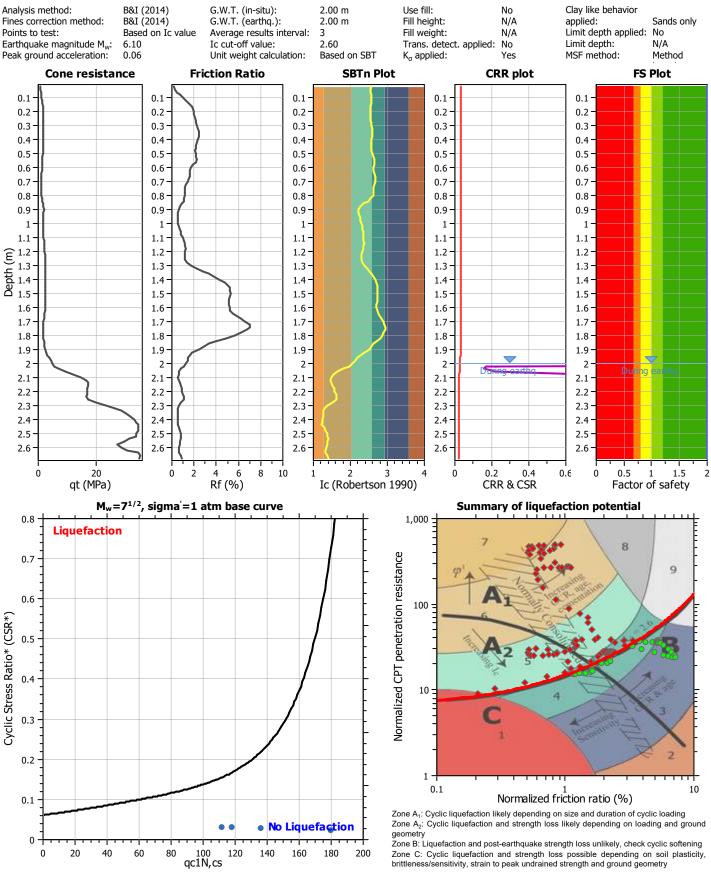
LIQUEFACTION ANALYSIS REPORT

Project title : Kainga Ora - HDS

Location : 7 - 15 Church Street

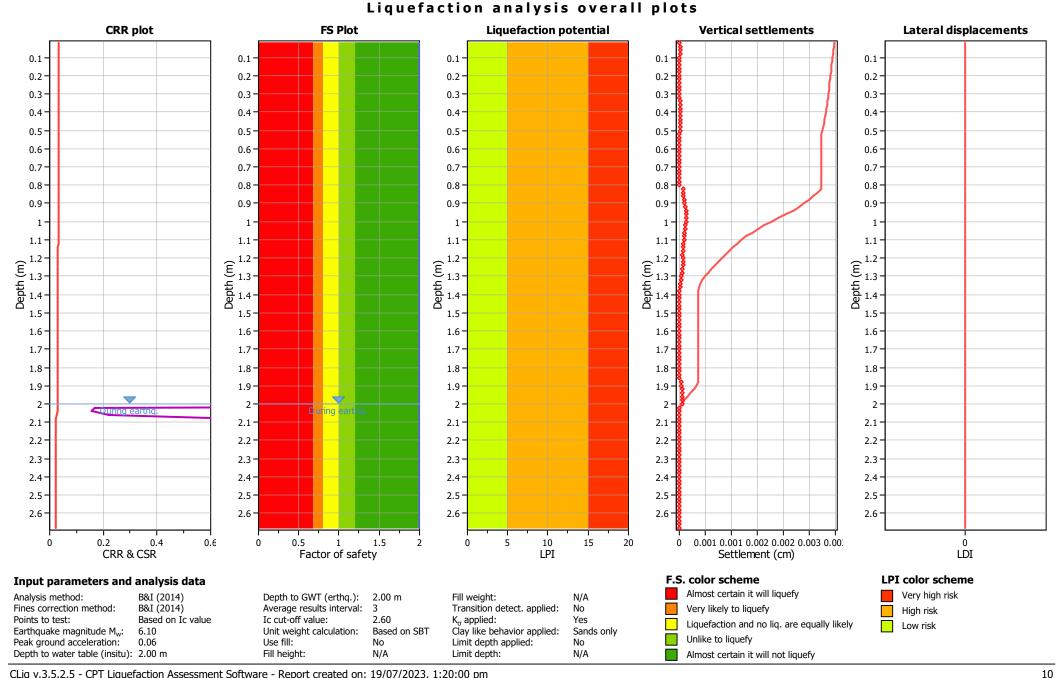
CPT file : CPT01-SLS-6.1-0.06g

Input parameters and analysis data



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CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:20:00 pm

Project file: C:\Users\or680\Beca\3160491 - Project Velocity - Chch Pilot - Documents\Technical - Working Files\Technical Geotechnical\03 Working Files\Church Street (Ashburton), 7 - 15\03 Design\Liquefaction Analysis\7-15 Church St Liquefaction Analysis.cg

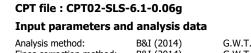
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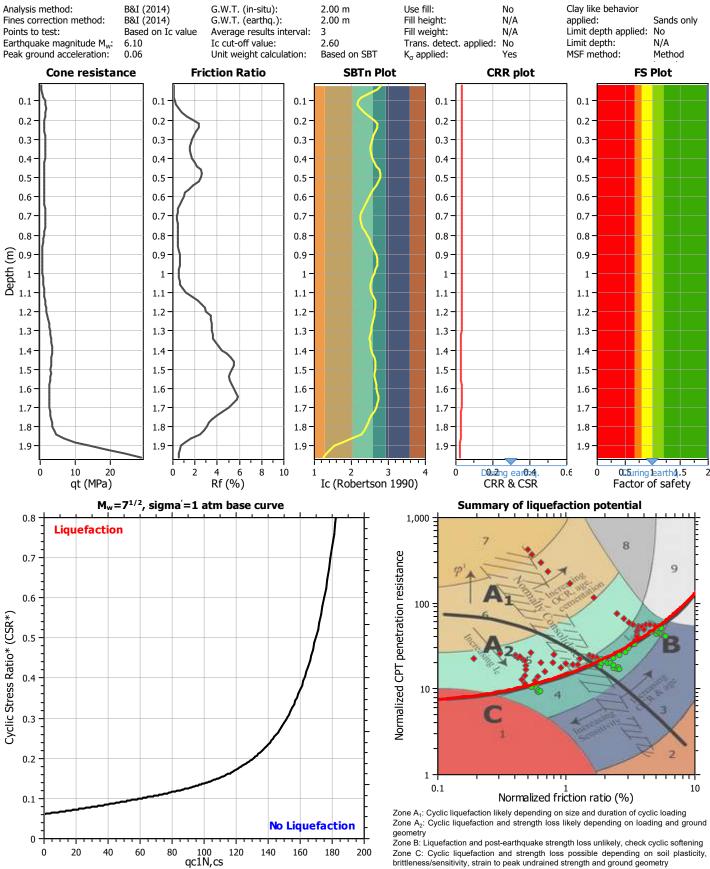
Beca Limited Level 2 ANZ Center 267 High Street, Christchurch https://www.beca.com/

LIQUEFACTION ANALYSIS REPORT

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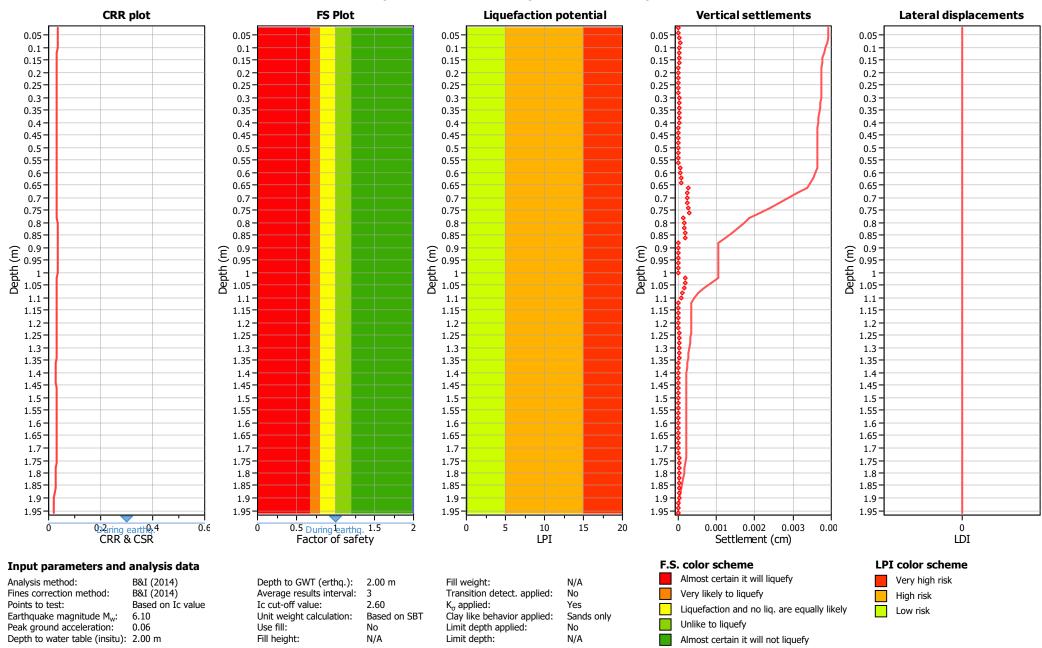
Location : 7 - 15 Church Street





12





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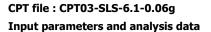
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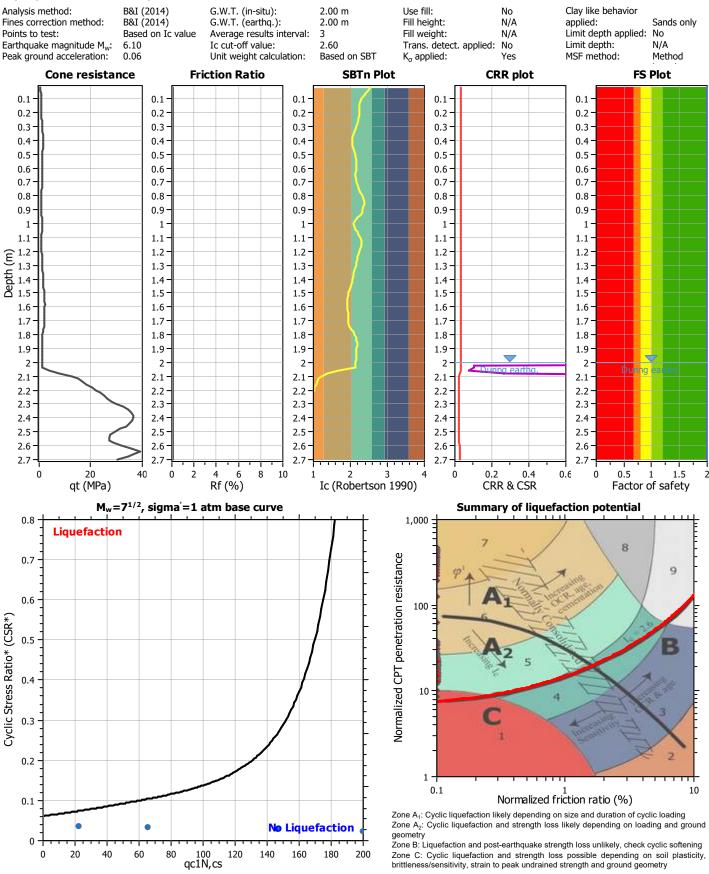
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LIQUEFACTION ANALYSIS REPORT

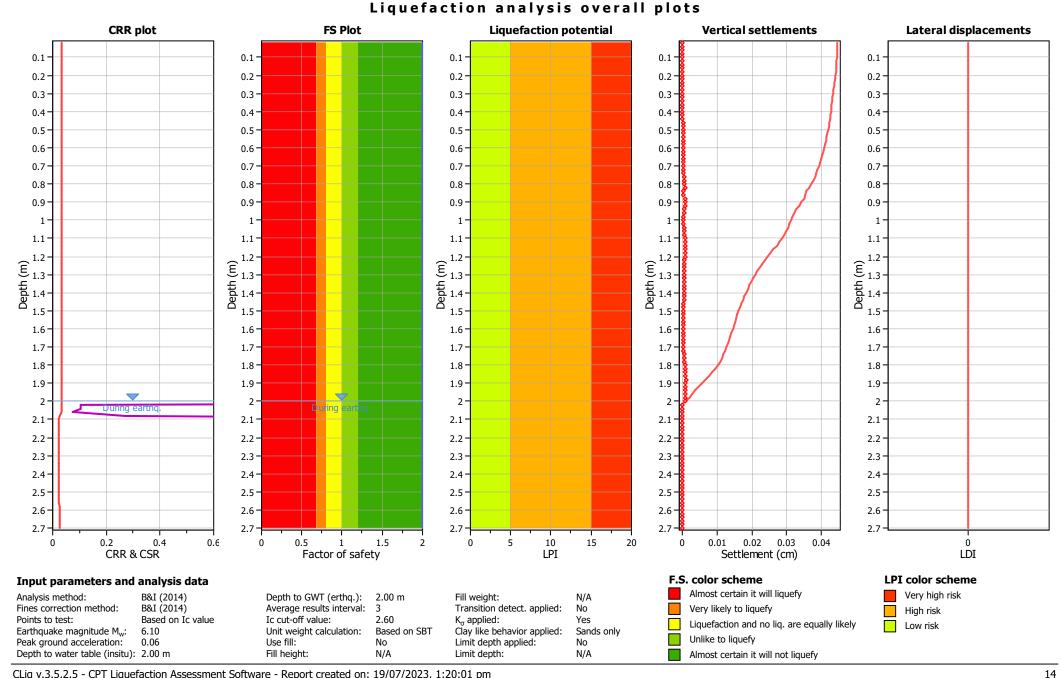
Project title : Kainga Ora - HDS

Location : 7 - 15 Church Street





CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:20:01 pm 13 Project file: C:\Users\or680\Beca\3160491 - Project Velocity - Chch Pilot - Documents\Technical - Working Files\Technical Geotechnical\03 Working Files\Church Street (Ashburton), 7



CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:20:01 pm

Project file: C:\Users\or680\Beca\3160491 - Project Velocity - Chch Pilot - Documents\Technical - Working Files\Technical Geotechnical\03 Working Files\Church Street (Ashburton), 7 - 15\03 Design\Liquefaction Analysis\7-15 Church St Liquefaction Analysis.cg

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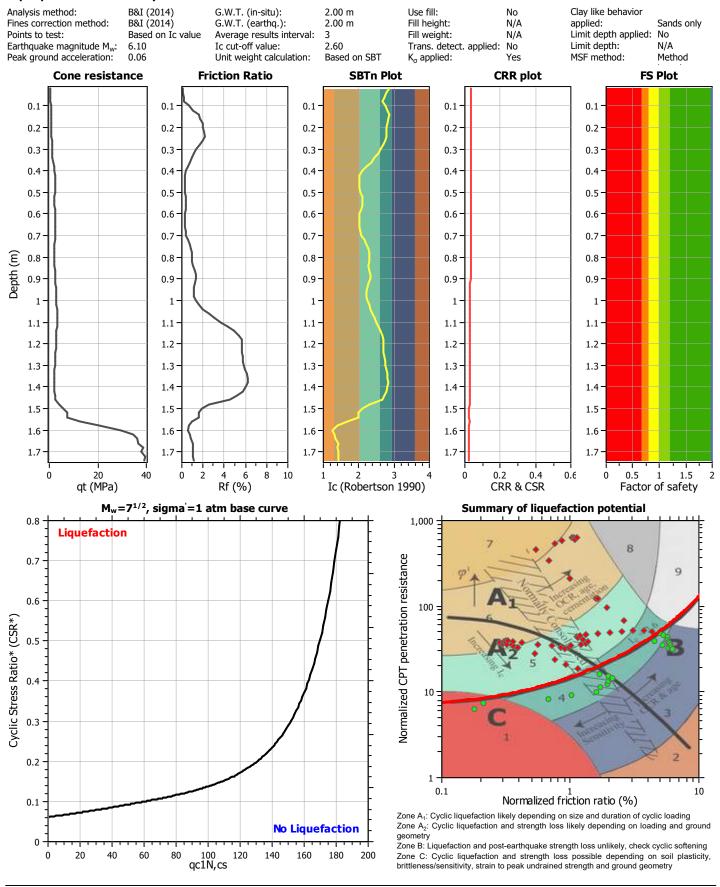
Beca Limited Level 2 ANZ Center 267 High Street, Christchurch https://www.beca.com/

LIQUEFACTION ANALYSIS REPORT

Location : 7 - 15 Church Street

Project title : Kainga Ora - HDS CPT file : CPT04-SLS-6.1-0.06g

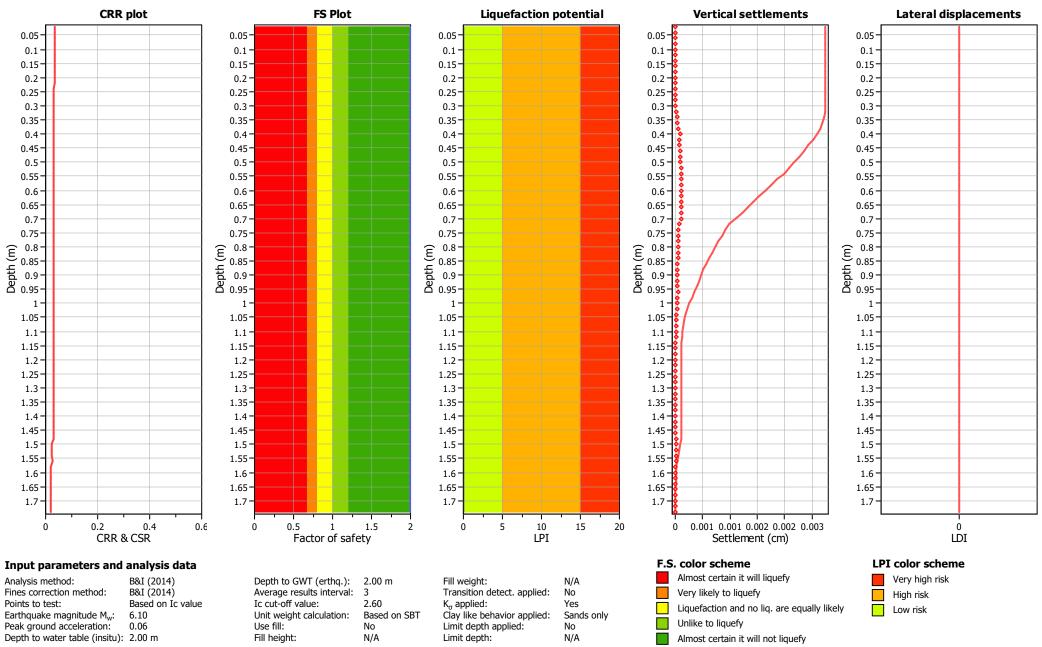
Input parameters and analysis data



CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:20:01 pm 15 Project file: C:\Users\or680\Beca\3160491 - Project Velocity - Chch Pilot - Documents\Technical - Working Files\Technical Geotechnical\03 Working Files\Church Street (Ashburton), 7

16





CLiq v.3.5.2.5 - CPT Liquefaction Assessment Software - Report created on: 19/07/2023, 1:20:01 pm

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Appendix G – Bearing Capacity Calculation Sheets



Kainga Ora - HDS316049117 July 2023Site AddressEngineer7-15 Church Street (Ashburton)OR

Job Number

Date

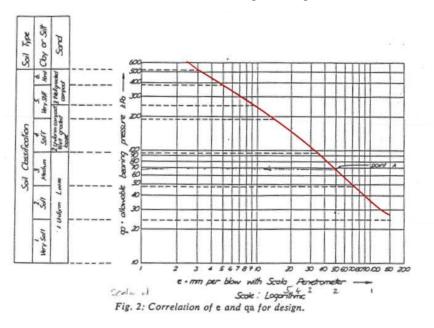
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GE - Determination of Bearing Pressures and California Bearing Ratios

Job Name

AR109524-GE-HA-003 Page 1

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



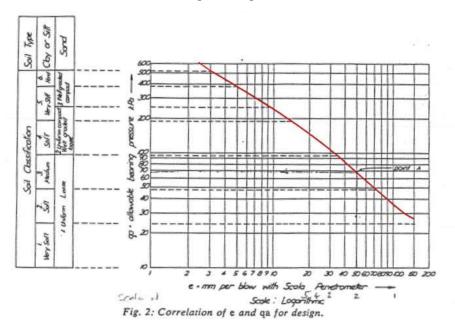
Gound Level (mRL)			89.90				
D	Depth (mm)		m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.80	1	100.0	33	100
100	-	200	89.70	1	100.0	33	100
200	-	300	89.60	2	50.0	67	200
300	-	400	89.50	2	50.0	67	200
400	-	500	89.40	3	33.3	100	300
500	-	600	89.30	2	50.0	67	200
600	-	700	89.20	2	50.0	67	200
700	-	800	89.10	2	50.0	67	200
800	-	900	89.00	2	50.0	67	200
900	-	1000	88.90	2	50.0	67	200
1000	-	1100	88.80	3	33.3	100	300
1100	-	1200	88.70	4	25.0	116	348
1200	-	1300	88.60	4	25.0	116	348
1300	-	1400	88.50	5	20.0	135	405
1400	-	1500	88.40	4	25.0	116	348
1500	-	1600	88.30	4	25.0	116	348
1600	-	1700	88.20	4	25.0	116	348
1700	-	1800	88.10	4	25.0	116	348
1800	-	1900	88.00	4	25.0	116	348
1900	-	2000	87.90	12	8.3	260	780



GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-DCP-001

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



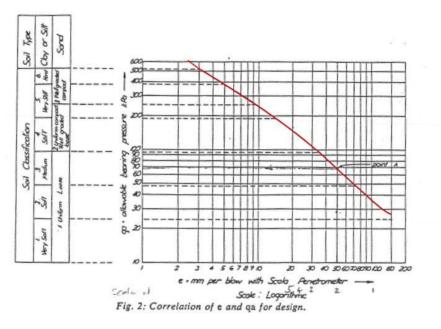
Gound Level (mRL)			90.00				
De	Depth (mm)		m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.90	2	50.0	67	200
100	-	200	89.80	3	33.3	100	300
200	-	300	89.70	3	33.3	100	300
300	-	400	89.60	4	25.0	116	348
400	-	500	89.50	3	33.3	100	300
500	-	600	89.40	3	33.3	100	300
600	-	700	89.30	2	50.0	67	200
700	-	800	89.20	2	50.0	67	200
800	-	900	89.10	2	50.0	67	200
900	-	1000	89.00	2	50.0	67	200
1000	-	1100	88.90	4	25.0	116	348
1100	-	1200	88.80	5	20.0	135	405
1200	-	1300	88.70	4	25.0	116	348
1300	-	1400	88.60	5	20.0	135	405
1400	-	1500	88.50	5	20.0	135	405
1500	-	1600	88.40	4	25.0	116	348
1600	-	1700	88.30	4	25.0	116	348
1700	-	1800	88.20	4	25.0	116	348
1800	-	1900	88.10	5	20.0	135	405
1900	-	2000	88.00	2	50.0	67	200



GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-DCP-002

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gound Level (mRL)			90.10				
De	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	90.00	1	100.0	33	100
100	-	200	89.90	2	50.0	67	200
200	-	300	89.80	3	33.3	100	300
300	-	400	89.70	3	33.3	100	300
400	-	500	89.60	3	33.3	100	300
500	-	600	89.50	4	25.0	116	348
600	-	700	89.40	3	33.3	100	300
700	-	800	89.30	4	25.0	116	348
800	-	900	89.20	4	25.0	116	348
900	-	1000	89.10	3	33.3	100	300
1000	-	1100	89.00	5	20.0	135	405
1100	-	1200	88.90	4	25.0	116	348
1200	-	1300	88.80	5	20.0	135	405
1300	-	1400	88.70	2	50.0	67	200
1400	-	1500	88.60	4	25.0	116	348
1500	-	1600	88.50	5	20.0	135	405
1600	-	1700	88.40	4	25.0	116	348
1700	-	1800	88.30	4	25.0	116	348
1800	-	1900	88.20	5	20.0	135	405
1900	-	2000	88.10	3	33.3	100	300

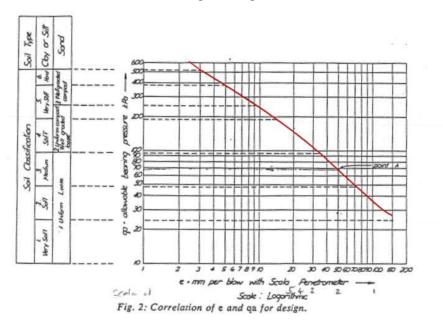


Job Name	Job Number	Date
Kainga Ora - HDS	3160491	17 July 2023
Site Address		Engineer
7-15 Church Street (Ashbur	ton)	OR

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-DCP-003

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gound Level (mRL)			89.90				
De	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.80	0			
100	-	200	89.70	1	100.0	33	100
200	-	300	89.60	1	100.0	33	100
300	-	400	89.50	2	50.0	67	200
400	-	500	89.40	0			
500	-	600	89.30	1	100.0	33	100
600	-	700	89.20	1	100.0	33	100
700	-	800	89.10	2	50.0	67	200
800	-	900	89.00	1	100.0	33	100
900	-	1000	88.90	2	50.0	67	200
1000	-	1100	88.80	2	50.0	67	200
1100	-	1200	88.70	3	33.3	100	300
1200	-	1300	88.60	3	33.3	100	300
1300	-	1400	88.50	4	25.0	116	348
1400	-	1500	88.40	5	20.0	135	405
1500	-	1600	88.30	6	16.7	150	450
1600	-	1700	88.20	4	25.0	116	348
1700	-	1800	88.10	3	33.3	100	300
1800	-	1900	88.00	12	8.3	260	780
1900	-	2000	87.90	12	8.3	260	780

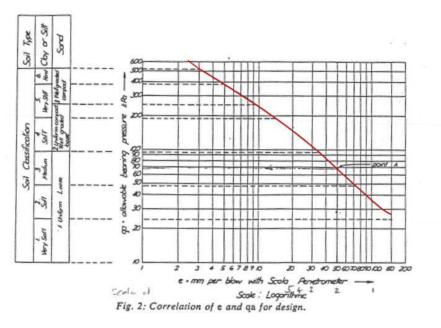


Job Name	Job Number	Date
Kainga Ora - HDS	3160491	17 July 2023
Site Address		Engineer
7-15 Church Street (Ashburto	n)	OR

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-DCP-004

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gound Level (mRL)			90.00				
De	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.90	0			
100	-	200	89.80	3	33.3	100	300
200	-	300	89.70	2	50.0	67	200
300	-	400	89.60	1	100.0	33	100
400	-	500	89.50	1	100.0	33	100
500	-	600	89.40	1	100.0	33	100
600	-	700	89.30	2	50.0	67	200
700	-	800	89.20	0			
800	-	900	89.10	2	50.0	67	200
900	-	1000	89.00	1	100.0	33	100
1000	-	1100	88.90	1	100.0	33	100
1100	-	1200	88.80	4	25.0	116	348
1200	-	1300	88.70	4	25.0	116	348
1300	-	1400	88.60	4	25.0	116	348
1400	-	1500	88.50	5	20.0	135	405
1500	-	1600	88.40	4	25.0	116	348
1600	-	1700	88.30	4	25.0	116	348
1700	-	1800	88.20	4	25.0	116	348
1800	-	1900	88.10	4	25.0	116	348
1900	-	2000	88.00	2	50.0	67	200

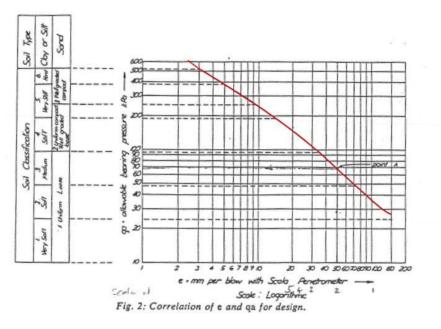


Job Name	Job Number	Date
Kainga Ora - HDS	3160491	17 July 2023
Site Address		Engineer
7-15 Church Street (Ashburto	n)	OR

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-DCP-005

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



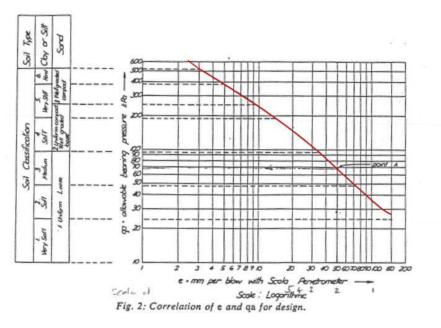
Goun	d Level	(mRL)	90.00				
De	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.90	0			
100	-	200	89.80	1	100.0	33	100
200	-	300	89.70	1	100.0	33	100
300	-	400	89.60	2	50.0	67	200
400	-	500	89.50	4	25.0	116	348
500	-	600	89.40	2	50.0	67	200
600	-	700	89.30	2	50.0	67	200
700	-	800	89.20	2	50.0	67	200
800	-	900	89.10	2	50.0	67	200
900	-	1000	89.00	2	50.0	67	200
1000	-	1100	88.90	2	50.0	67	200
1100	-	1200	88.80	3	33.3	100	300
1200	-	1300	88.70	4	25.0	116	348
1300	-	1400	88.60	4	25.0	116	348
1400	-	1500	88.50	6	16.7	150	450
1500	-	1600	88.40	6	16.7	150	450
1600	-	1700	88.30	6	16.7	150	450
1700	-	1800	88.20	6	16.7	150	450
1800	-	1900	88.10	6	16.7	150	450
1900	-	2000	88.00	2	50.0	67	200



GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524GE-DCP-006

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gound Level (mRL)			90.20				
De	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	90.10	1	100.0	33	100
100	-	200	90.00	0			
200	-	300	89.90	2	50.0	67	200
300	-	400	89.80	3	33.3	100	300
400	-	500	89.70	2	50.0	67	200
500	-	600	89.60	3	33.3	100	300
600	-	700	89.50	3	33.3	100	300
700	-	800	89.40	2	50.0	67	200
800	-	900	89.30	2	50.0	67	200
900	-	1000	89.20	2	50.0	67	200
1000	-	1100	89.10	4	25.0	116	348
1100	-	1200	89.00	5	20.0	135	405
1200	-	1300	88.90	4	25.0	116	348
1300	-	1400	88.80	4	25.0	116	348
1400	-	1500	88.70	4	25.0	116	348
1500	-	1600	88.60	4	25.0	116	348
1600	-	1700	88.50	4	25.0	116	348
1700	-	1800	88.40	4	25.0	116	348
1800	-	1900	88.30	4	25.0	116	348
1900	-	2000	88.20	2	50.0	67	200

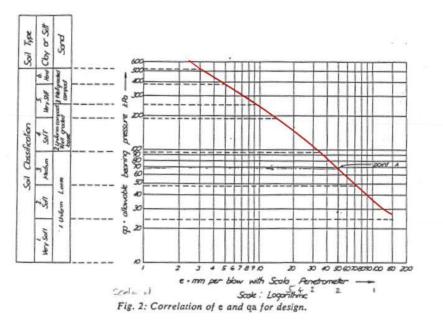


Job Name	Job Number	Date
Kainga Ora - HDS	3160491	17 July 2023
Site Address		Engineer
7-15 Church Street (Ashburto	n)	OR

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524GE-DCP-007

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gound Level (mRL)			89.90				
De	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.80	0			
100	-	200	89.70	2	50.0	67	200
200	-	300	89.60	3	33.3	100	300
300	-	400	89.50	3	33.3	100	300
400	-	500	89.40	1	100.0	33	100
500	-	600	89.30	1	100.0	33	100
600	-	700	89.20	1	100.0	33	100
700	-	800	89.10	2	50.0	67	200
800	-	900	89.00	2	50.0	67	200
900	-	1000	88.90	2	50.0	67	200
1000	-	1100	88.80	2	50.0	67	200
1100	-	1200	88.70	1	100.0	33	100
1200	-	1300	88.60	2	50.0	67	200
1300	-	1400	88.50	3	33.3	100	300
1400	-	1500	88.40	4	25.0	116	348
1500	-	1600	88.30	4	25.0	116	348
1600	-	1700	88.20	4	25.0	116	348
1700	-	1800	88.10	5	20.0	135	405
1800	-	1900	88.00	3	33.3	100	300
1900	-	2000	87.90	2	50.0	67	200

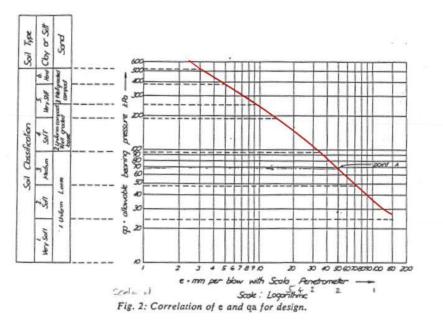


Job Name	Job Number	Date				
Kainga Ora - HDS	3160491	17 July 2023				
Site Address	Site Address					
7-15 Church Street (Ashburto	n)	OR				

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524GE-DCP-008

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gound	d Level	(mRL)	89.70				
De	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.60	0			
100	-	200	89.50	1	100.0	33	100
200	-	300	89.40	2	50.0	67	200
300	-	400	89.30	9	11.1	200	600
400	-	500	89.20	1	100.0	33	100
500	-	600	89.10	2	50.0	67	200
600	-	700	89.00	2	50.0	67	200
700	-	800	88.90	3	33.3	100	300
800	-	900	88.80	2	50.0	67	200
900	-	1000	88.70	1	100.0	33	100
1000	-	1100	88.60	2	50.0	67	200
1100	-	1200	88.50	3	33.3	100	300
1200	-	1300	88.40	2	50.0	67	200
1300	-	1400	88.30	5	20.0	135	405
1400	-	1500	88.20	4	25.0	116	348
1500	-	1600	88.10	10	10.0	220	660
1600	-	1700	88.00	12	8.3	260	780
1700	-	1800	87.90	12	8.3	260	780
1800	-	1900	87.80				
1900	-	2000	87.70				



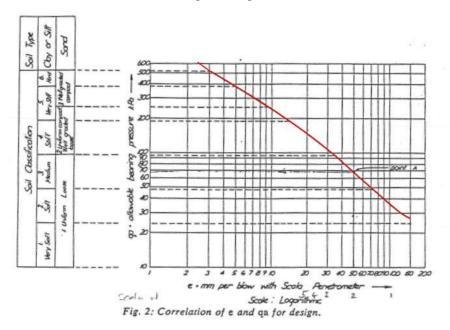
Job NameJob NumberDateKainga Ora - HDS316049117 July 2023Site AddressEngineer7-15 Church Street (Ashburton)OR

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GE - Determination of Bearing Pressures and California Bearing Ratios

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M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Goun	d Level	(mRL)	90.10				
D	Depth (mm)		m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	90.00	1	100.0	33	100
100	-	200	89.90	1	100.0	33	100
200	-	300	89.80	2	50.0	67	200
300	-	400	89.70	2	50.0	67	200
400	-	500	89.60	2	50.0	67	200
500	-	600	89.50	2	50.0	67	200
600	-	700	89.40	2	50.0	67	200
700	-	800	89.30	2	50.0	67	200
800	-	900	89.20	2	50.0	67	200
900	-	1000	89.10	3	33.3	100	300
1000	-	1100	89.00	5	20.0	135	405
1100	-	1200	88.90	4	25.0	116	348
1200	-	1300	88.80	5	20.0	135	405
1300	-	1400	88.70	10	10.0	220	660
1400	-	1500	88.60	8	12.5	195	585
1500	-	1600	88.50	10	10.0	220	660
1600	-	1700	88.40	12	8.3	260	780
1700	-	1800	88.30	10	10.0	220	660
1800	-	1900	88.20	12	8.3	260	780
1900	-	2000	88.10	12	8.3	260	780

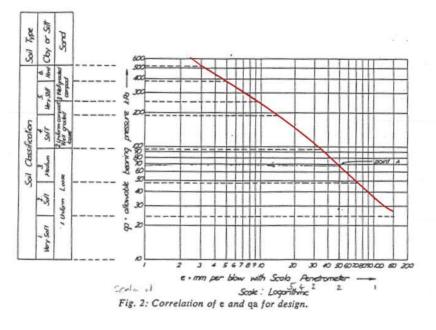


Job Name	Job Number	Date				
Kainga Ora - Project Velocity	3160491	17 July 2023				
Site Address	Site Address					
7-15 Church Street (Ashburto	on)	OR				

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-001 Page 2

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



I	Depth (mr	n)	m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
2000	-	2100	88.00	12	8.3	260	780
2100	-	2200	87.90				
2200	-	2300	87.80				
2300	-	2400	87.70				
2400	-	2500	87.60				
2500	-	2600	87.50				
2600	-	2700	87.40				
2700	-	2800	87.30				
2800	-	2900	87.20				
2900	-	3000	87.10				
3000	-	3100	87.00				
3100	-	3200	86.90				
3200	-	3300	86.80				
3300	-	3400	86.70				
3400	-	3500	86.60				
3500	-	3600	86.50				
3600	-	3700	86.40				
3700	-	3800	86.30				
3800	-	3900	86.20				



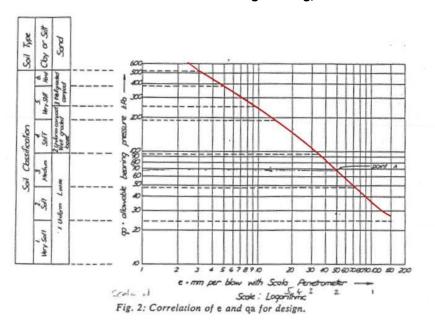
Job NameJob NumberDateKainga Ora - HDS316049117 July 2023Site AddressEngineer7-15 Church Street (Ashburton)OR

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GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-002 Page 1

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gour	d Level	(mRL)	90.00				
D	Depth (mm)		m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.90	0			
100	-	200	89.80	2	50.0	67	200
200	-	300	89.70	2	50.0	67	200
300	-	400	89.60	1	100.0	33	100
400	-	500	89.50	2	50.0	67	200
500	-	600	89.40	2	50.0	67	200
600	-	700	89.30	1	100.0	33	100
700	-	800	89.20	0			
800	-	900	89.10	2	50.0	67	200
900	-	1000	89.00	1	100.0	33	100
1000	-	1100	88.90	1	100.0	33	100
1100	-	1200	88.80	2	50.0	67	200
1200	-	1300	88.70	2	50.0	67	200
1300	-	1400	88.60	3	33.3	100	300
1400	-	1500	88.50	4	25.0	116	348
1500	-	1600	88.40	4	25.0	116	348
1600	-	1700	88.30	3	33.3	100	300
1700	-	1800	88.20	2	50.0	67	200
1800	-	1900	88.10	3	33.3	100	300
1900	-	2000	88.00	1	100.0	33	100

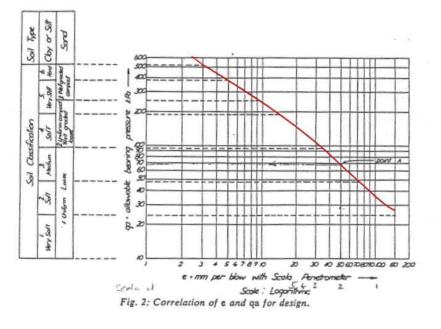


Job Name	Job Number	Date			
Kainga Ora - Project Velocity	3160491	17 July 2023			
Site Address	Site Address				
7-15 Church Street (Ashburt	ton)	OR			

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-002 Page 2

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



D	epth (m	n)	m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
2000	-	2100	87.90	2	50.0	67	200
2100	-	2200	87.80	8	12.5	195	585
2200	-	2300	87.70	12	8.3	260	780
2300	-	2400	87.60				
2400	-	2500	87.50				
2500	-	2600	87.40				
2600	-	2700	87.30				
2700	-	2800	87.20				
2800	-	2900	87.10				
2900	-	3000	87.00				
3000	-	3100	86.90				
3100	-	3200	86.80				
3200	-	3300	86.70				
3300	-	3400	86.60				
3400	-	3500	86.50				
3500	-	3600	86.40				
3600	-	3700	86.30				
3700	-	3800	86.20				
3800	-	3900	86.10				

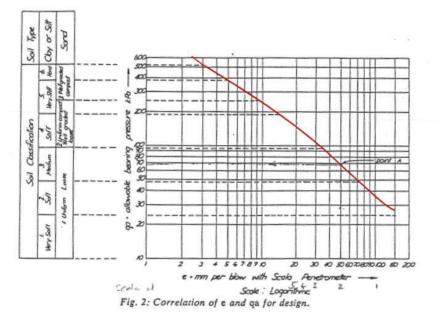


Job Name	Job Number	Date			
Kainga Ora - Project Velocity	3160491	17 July 2023			
Site Address	Site Address				
7-15 Church Street (Ashburt	ton)	OR			

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-003 Page 2

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



C	Depth (mr	n)	m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
2000	-	2100	87.80				
2100	-	2200	87.70				
2200	-	2300	87.60				
2300	-	2400	87.50				
2400	-	2500	87.40				
2500	-	2600	87.30				
2600	-	2700	87.20				
2700	-	2800	87.10				
2800	-	2900	87.00				
2900	-	3000	86.90				
3000	-	3100	86.80				
3100	-	3200	86.70				
3200	-	3300	86.60				
3300	-	3400	86.50				
3400	-	3500	86.40				
3500	-	3600	86.30				
3600	-	3700	86.20				
3700	-	3800	86.10				
3800	-	3900	86.00				



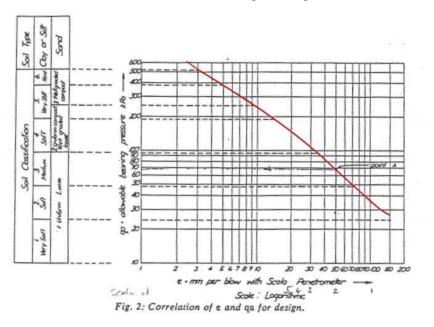
Job NameJob NumberDateKainga Ora - HDS316049117 July 2023Site AddressEngineer7-15 Church Street (Ashburton)OR

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GE - Determination of Bearing Pressures and California Bearing Ratios

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M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Goun	d Level	(mRL)	89.80				
D	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.70	0			
100	-	200	89.60	1	100.0	33	100
200	-	300	89.50	2	50.0	67	200
300	-	400	89.40	1	100.0	33	100
400	-	500	89.30	2	50.0	67	200
500	-	600	89.20	1	100.0	33	100
600	-	700	89.10	2	50.0	67	200
700	-	800	89.00	2	50.0	67	200
800	-	900	88.90	3	33.3	100	300
900	-	1000	88.80	3	33.3	100	300
1000	-	1100	88.70	4	25.0	116	348
1100	-	1200	88.60	4	25.0	116	348
1200	-	1300	88.50	5	20.0	135	405
1300	-	1400	88.40	8	12.5	195	585
1400	-	1500	88.30	5	20.0	135	405
1500	-	1600	88.20	6	16.7	150	450
1600	-	1700	88.10	9	11.1	200	600
1700	-	1800	88.00	8	12.5	195	585
1800	-	1900	87.90	12	8.3	260	780
1900	-	2000	87.80				

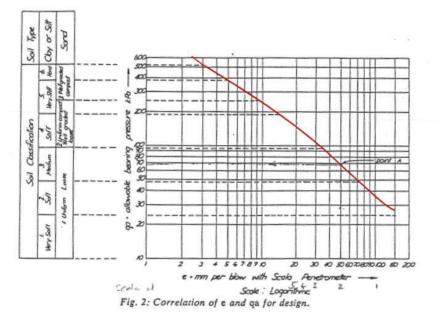


Job Name	Job Number	Date			
Kainga Ora - Project Velocity	3160491	17 July 2023			
Site Address	Site Address				
7-15 Church Street (Ashburt	ton)	OR			

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-004 Page 2

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



D	Depth (mm)		m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
2000	-	2100	87.70				
2100	-	2200	87.60				
2200	-	2300	87.50				
2300	-	2400	87.40				
2400	-	2500	87.30				
2500	-	2600	87.20				
2600	-	2700	87.10				
2700	-	2800	87.00				
2800	-	2900	86.90				
2900	-	3000	86.80				
3000	-	3100	86.70				
3100	-	3200	86.60				
3200	-	3300	86.50				
3300	-	3400	86.40				
3400	-	3500	86.30				
3500	-	3600	86.20				
3600	-	3700	86.10				
3700	-	3800	86.00				
3800	-	3900	85.90				



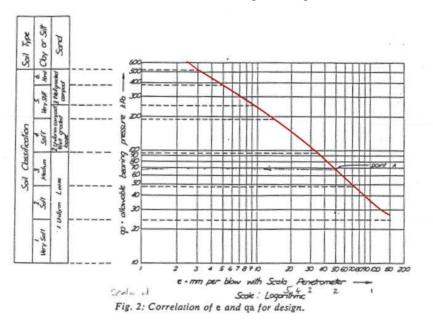
Job NameJob NumberDateKainga Ora - HDS316049117 July 2023Site AddressEngineer7-15 Church Street (Ashburton)OR

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GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-005 Page 1

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gound Level (mRL)		89.70					
C	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.60	0			
100	-	200	89.50	2	50.0	67	200
200	-	300	89.40	2	50.0	67	200
300	-	400	89.30	1	100.0	33	100
400	-	500	89.20	2	50.0	67	200
500	-	600	89.10	2	50.0	67	200
600	-	700	89.00	2	50.0	67	200
700	-	800	88.90	4	25.0	116	348
800	-	900	88.80	4	25.0	116	348
900	-	1000	88.70	1	100.0	33	100
1000	-	1100	88.60	3	33.3	100	300
1100	-	1200	88.50	4	25.0	116	348
1200	-	1300	88.40	3	33.3	100	300
1300	-	1400	88.30	3	33.3	100	300
1400	-	1500	88.20	3	33.3	100	300
1500	-	1600	88.10	4	25.0	116	348
1600	-	1700	88.00	4	25.0	116	348
1700	-	1800	87.90	6	16.7	150	450
1800	-	1900	87.80	12	8.3	260	780
1900	-	2000	87.70	12	8.3	260	780

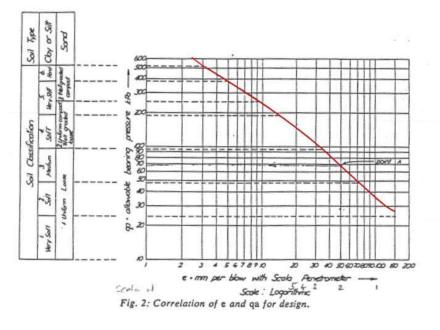


Job Name	Job Number	Date		
Kainga Ora - Project Velocity	3160491	17 July 2023		
Site Address	Site Address			
7-15 Church Street (Ashburt	OR			

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-005 Page 2

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



D	Depth (mm)		m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
2000	-	2100	87.60				
2100	-	2200	87.50				
2200	-	2300	87.40				
2300	-	2400	87.30				
2400	-	2500	87.20				
2500	-	2600	87.10				
2600	-	2700	87.00				
2700	-	2800	86.90				
2800	-	2900	86.80				
2900	-	3000	86.70				
3000	-	3100	86.60				
3100	-	3200	86.50				
3200	-	3300	86.40				
3300	-	3400	86.30				
3400	-	3500	86.20				
3500	-	3600	86.10				
3600	-	3700	86.00				
3700	-	3800	85.90				
3800	-	3900	85.80				

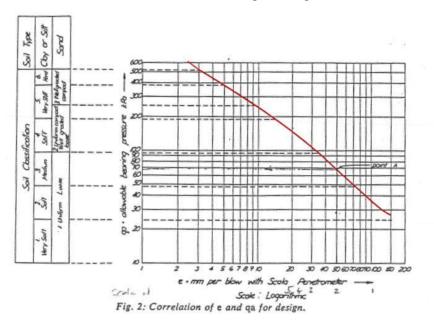


Job Name	Job Number	Date
Kainga Ora - HDS	3160491	17 July 2023
Site Address	Engineer	
7-15 Church Street (Ashburte	OR	

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-006 Page 1

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



Gound Level (mRL)		89.80					
C	Depth (mm)			Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
0	-	100	89.70	1	100.0	33	100
100	-	200	89.60	1	100.0	33	100
200	-	300	89.50	1	100.0	33	100
300	-	400	89.40	1	100.0	33	100
400	-	500	89.30	2	50.0	67	200
500	-	600	89.20	3	33.3	100	300
600	-	700	89.10	3	33.3	100	300
700	-	800	89.00	4	25.0	116	348
800	-	900	88.90	3	33.3	100	300
900	-	1000	88.80	3	33.3	100	300
1000	-	1100	88.70	4	25.0	116	348
1100	-	1200	88.60	6	16.7	150	450
1200	-	1300	88.50	5	20.0	135	405
1300	-	1400	88.40	6	16.7	150	450
1400	-	1500	88.30	4	25.0	116	348
1500	-	1600	88.20	12	8.3	260	780
1600	-	1700	88.10				
1700	-	1800	88.00				
1800	-	1900	87.90				
1900	-	2000	87.80				

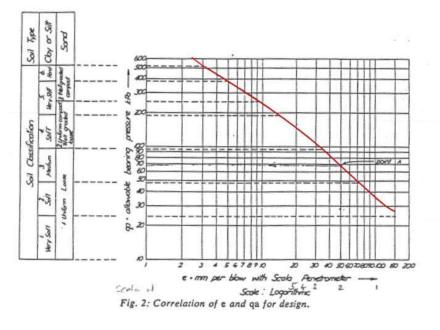


Job Name	Job Number	Date		
Kainga Ora - Project Velocity	3160491	17 July 2023		
Site Address	Site Address			
7-15 Church Street (Ashburt	OR			

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-006 Page 2

M.J. STOCKWELL DETERMINATION OF ALLOWABLE PRESSURE UNDER SMALL STRUCTURES CALIFORNIA BEARING RATIO



D	Depth (mm)		m RL	Measured No. Blows / 100mm	e mm/blow	Stockwell - qa kPa	Stockwell - qu kPa
2000	-	2100	87.70				
2100	-	2200	87.60				
2200	-	2300	87.50				
2300	-	2400	87.40				
2400	-	2500	87.30				
2500	-	2600	87.20				
2600	-	2700	87.10				
2700	-	2800	87.00				
2800	-	2900	86.90				
2900	-	3000	86.80				
3000	-	3100	86.70				
3100	-	3200	86.60				
3200	-	3300	86.50				
3300	-	3400	86.40				
3400	-	3500	86.30				
3500	-	3600	86.20				
3600	-	3700	86.10				
3700	-	3800	86.00				
3800	-	3900	85.90				



Appendix H – CBR Calculation Sheets

調 Beca

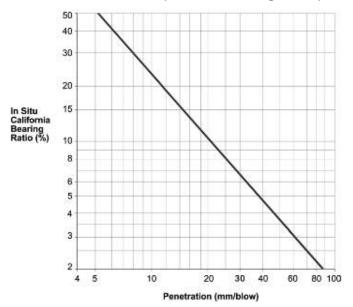
Sensitivity: General	Job Name Job Number		Date
調 Beca	Kainga Ora - HDS	3160491	17 July 2023
ili dalla	Site Address	Engineer	
	7-15 Church Street (Ashburton)	OR	

GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-DCP-001

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	90.00			
C	Depth (mm)		m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.90	2	50.0	3.5
100	-	200	89.80	3	33.3	6.0
200	-	300	89.70	3	33.3	6.0
300	-	400	89.60	4	25.0	8.0
400	-	500	89.50	3	33.3	6.0
500	-	600	89.40	3	33.3	6.0
600	-	700	89.30	2	50.0	3.5
700	-	800	89.20	2	50.0	3.5
800	-	900	89.10	2	50.0	3.5
900	-	1000	89.00	2	50.0	3.5
1000	-	1100	88.90	4	25.0	8.0
1100	-	1200	88.80	5	20.0	10.0
1200	-	1300	88.70	4	25.0	8.0
1300	-	1400	88.60	5	20.0	10.0
1400	-	1500	88.50	5	20.0	10.0

Weighted Average

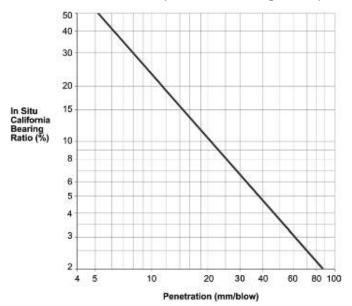
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Sensitivity: General	Job Name	Job Number	Date	
調 Beca	Kainga Ora - HDS 3160491		17 July 2023	
	Site Address	Engineer		
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AR109524-GE-DCP-002

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	l Level (ml	RL, CDD)	90.10			
	Depth (mr	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	90.00	1	100.0	1.5
100	-	200	89.90	2	50.0	3.5
200	-	300	89.80	3	33.3	6.0
300	-	400	89.70	3	33.3	6.0
400	-	500	89.60	3	33.3	6.0
500	-	600	89.50	4	25.0	8.0
600	-	700	89.40	3	33.3	6.0
700	-	800	89.30	4	25.0	8.0
800	-	900	89.20	4	25.0	8.0
900	-	1000	89.10	3	33.3	6.0
1000	-	1100	89.00	5	20.0	10.0
1100	-	1200	88.90	4	25.0	8.0
1200	-	1300	88.80	5	20.0	10.0
1300	-	1400	88.70	2	50.0	3.5
1400	-	1500	88.60	4	25.0	8.0

Weighted Average

Sensitivity: General	Job Name	Job Number	Date
	Kainga Ora - HDS	3160491	17 July 2023
ili dela	Site Address		Engineer
	7-15 Church Street (Ashburton)		OR

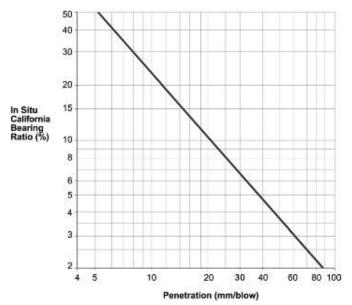
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GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-DCP-003

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	89.90			
C	Depth (mi	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.80	0		
100	-	200	89.70	1	100.0	1.5
200	-	300	89.60	1	100.0	1.5
300	-	400	89.50	2	50.0	3.5
400	-	500	89.40	0		
500	-	600	89.30	1	100.0	1.5
600	-	700	89.20	1	100.0	1.5
700	-	800	89.10	2	50.0	3.5
800	-	900	89.00	1	100.0	1.5
900	-	1000	88.90	2	50.0	3.5
1000	-	1100	88.80	2	50.0	3.5
1100	-	1200	88.70	3	33.3	6.0
1200	-	1300	88.60	3	33.3	6.0
1300	-	1400	88.50	4	25.0	8.0
1400	-	1500	88.40	5	20.0	10.0

Weighted Average

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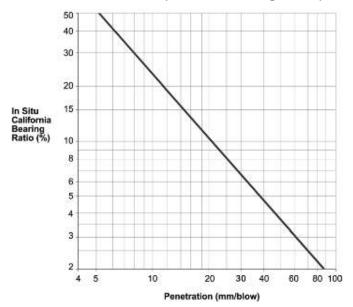
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GE - Determination of Bearing Pressures and California Bearing Ratios

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AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	90.00			
[Depth (mi	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.90	0		
100	-	200	89.80	3	33.3	6.0
200	-	300	89.70	2	50.0	3.5
300	-	400	89.60	1	100.0	1.5
400	-	500	89.50	1	100.0	1.5
500	-	600	89.40	1	100.0	1.5
600	-	700	89.30	2	50.0	3.5
700	-	800	89.20	0		
800	-	900	89.10	2	50.0	3.5
900	-	1000	89.00	1	100.0	1.5
1000	-	1100	88.90	1	100.0	1.5
1100	-	1200	88.80	4	25.0	8.0
1200	-	1300	88.70	4	25.0	8.0
1300	-	1400	88.60	4	25.0	8.0
1400	-	1500	88.50	5	20.0	10.0

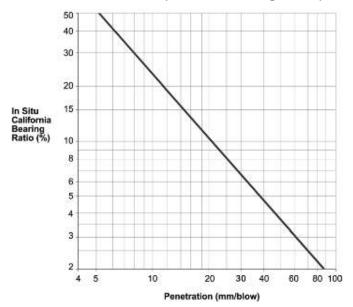
Weighted Average

Sensitivity: General	Job Name	Job Number	Date
調 Beca	Kainga Ora - HDS 3160491		17 July 2023
	Site Address	Engineer	
	7-15 Church Street (Ashburton)	OR	
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AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	90.00			
C	Depth (mr	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.90	0		
100	-	200	89.80	1	100.0	1.5
200	-	300	89.70	1	100.0	1.5
300	-	400	89.60	2	50.0	3.5
400	-	500	89.50	4	25.0	8.0
500	-	600	89.40	2	50.0	3.5
600	-	700	89.30	2	50.0	3.5
700	-	800	89.20	2	50.0	3.5
800	-	900	89.10	2	50.0	3.5
900	-	1000	89.00	2	50.0	3.5
1000	-	1100	88.90	2	50.0	3.5
1100	-	1200	88.80	3	33.3	6.0
1200	-	1300	88.70	4	25.0	8.0
1300	-	1400	88.60	4	25.0	8.0
1400	-	1500	88.50	6	16.7	12.0

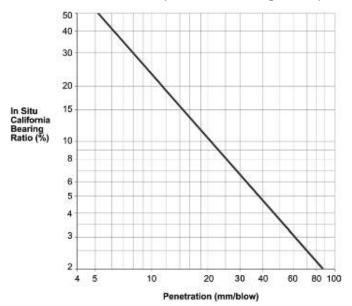
Weighted Average

Sensitivity: General	Job Name	Job Number	Date
調 Beca	Kainga Ora - HDS 3160491		17 July 2023
	Site Address	Engineer	
	7-15 Church Street (Ashburton)	OR	
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AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	90.20			
C	Depth (m	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	90.10	1	100.0	1.5
100	-	200	90.00	0		
200	-	300	89.90	2	50.0	3.5
300	-	400	89.80	3	33.3	6.0
400	-	500	89.70	2	50.0	3.5
500	-	600	89.60	3	33.3	6.0
600	-	700	89.50	3	33.3	6.0
700	-	800	89.40	2	50.0	3.5
800	-	900	89.30	2	50.0	3.5
900	-	1000	89.20	2	50.0	3.5
1000	-	1100	89.10	4	25.0	8.0
1100	-	1200	89.00	5	20.0	10.0
1200	-	1300	88.90	4	25.0	8.0
1300	-	1400	88.80	4	25.0	8.0
1400	-	1500	88.70	4	25.0	8.0

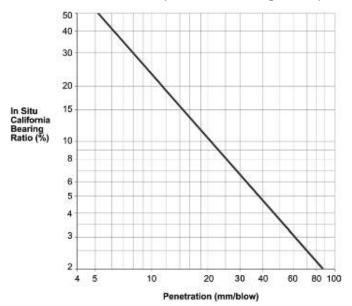
Weighted Average

Sensitivity: General	Job Name	Job Number	Date
調 Beca	Kainga Ora - HDS 3160491		17 July 2023
	Site Address	Engineer	
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AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (ml	RL, CDD)	89.90			
[Depth (mr	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.80	0		
100	-	200	89.70	2	50.0	3.5
200	-	300	89.60	3	33.3	6.0
300	-	400	89.50	3	33.3	6.0
400	-	500	89.40	1	100.0	1.5
500	-	600	89.30	1	100.0	1.5
600	-	700	89.20	1	100.0	1.5
700	-	800	89.10	2	50.0	3.5
800	-	900	89.00	2	50.0	3.5
900	-	1000	88.90	2	50.0	3.5
1000	-	1100	88.80	2	50.0	3.5
1100	-	1200	88.70	1	100.0	1.5
1200	-	1300	88.60	2	50.0	3.5
1300	-	1400	88.50	3	33.3	6.0
1400	-	1500	88.40	4	25.0	8.0

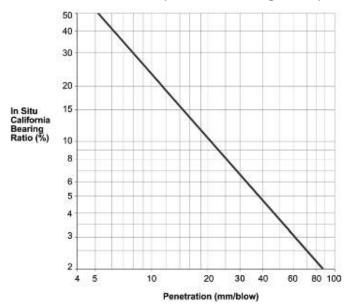
Weighted Average

Sensitivity: General	Job Name	Job Number	Date
調 Beca	Kainga Ora - HDS	17 July 2023	
	Site Address	Engineer	
	7-15 Church Street (Ashburton)	OR	
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AR109524-GE-DCP-008

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	89.70			
C	epth (mi	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.60	0		
100	-	200	89.50	1	100.0	1.5
200	-	300	89.40	2	50.0	3.5
300	-	400	89.30	9	11.1	20.0
400	-	500	89.20	1	100.0	1.5
500	-	600	89.10	2	50.0	3.5
600	-	700	89.00	2	50.0	3.5
700	-	800	88.90	3	33.3	6.0
800	-	900	88.80	2	50.0	3.5
900	-	1000	88.70	1	100.0	1.5
1000	-	1100	88.60	2	50.0	3.5
1100	-	1200	88.50	3	33.3	6.0
1200	-	1300	88.40	2	50.0	3.5
1300	-	1400	88.30	5	20.0	10.0
1400	-	1500	88.20	4	25.0	8.0

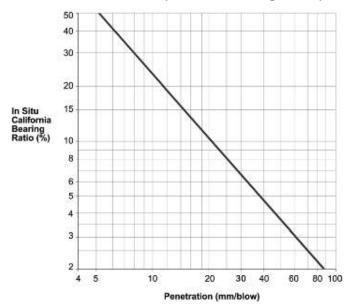
Weighted Average

Sensitivity: General	Job Name	Job Number	Date
調 Beca	Kainga Ora - HDS	17 July 2023	
	Site Address	Engineer	
	7-15 Church Street (Ashburton)	OR	
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AR109524-GE-HA-001

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	90.10			
C	Depth (m	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	90.00	1	100.0	1.5
100	-	200	89.90	1	100.0	1.5
200	-	300	89.80	2	50.0	3.5
300	-	400	89.70	2	50.0	3.5
400	-	500	89.60	2	50.0	3.5
500	-	600	89.50	2	50.0	3.5
600	-	700	89.40	2	50.0	3.5
700	-	800	89.30	2	50.0	3.5
800	-	900	89.20	2	50.0	3.5
900	-	1000	89.10	3	33.3	6.0
1000	-	1100	89.00	5	20.0	10.0
1100	-	1200	88.90	4	25.0	8.0
1200	-	1300	88.80	5	20.0	10.0
1300	-	1400	88.70	10	10.0	20.0
1400	-	1500	88.60	8	12.5	17.0

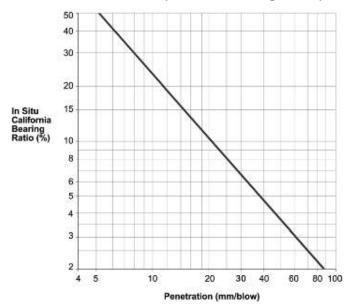
Weighted Average

Sensitivity: General	Job Name	Job Number	Date
	Kainga Ora - HDS 3160491		17 July 2023
調 Beca	Site Address	Engineer	
	7-15 Church Street (Ashburton)	OR	
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AR109524-GE-HA-002

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (ml	RL, CDD)	90.00			
[Depth (mr	n)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.90	0		
100	-	200	89.80	2	50.0	3.5
200	-	300	89.70	2	50.0	3.5
300	-	400	89.60	1	100.0	1.5
400	-	500	89.50	2	50.0	3.5
500	-	600	89.40	2	50.0	3.5
600	-	700	89.30	1	100.0	1.5
700	-	800	89.20	0		
800	-	900	89.10	2	50.0	3.5
900	-	1000	89.00	1	100.0	1.5
1000	-	1100	88.90	1	100.0	1.5
1100	-	1200	88.80	2	50.0	3.5
1200	-	1300	88.70	2	50.0	3.5
1300	-	1400	88.60	3	33.3	6.0
1400	-	1500	88.50	4	25.0	8.0

Weighted Average

Sensitivity: General	Job Name Job Nu		Date
調 Beca	Kainga Ora - HDS	3160491	17 July 2023
	Site Address		Engineer
	7-15 Church Street (Ashburton)		OR

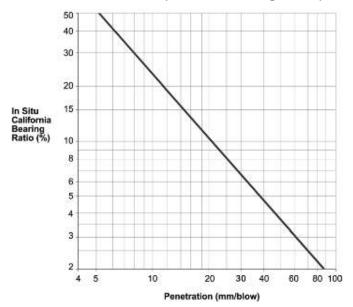
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GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-003

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	89.90			
C	Depth (mi	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.80	1	100.0	1.5
100	-	200	89.70	1	100.0	1.5
200	-	300	89.60	2	50.0	3.5
300	-	400	89.50	2	50.0	3.50
400	-	500	89.40	3	33.3	6.00
500	-	600	89.30	2	50.0	3.50
600	-	700	89.20	2	50.0	3.50
700	-	800	89.10	2	50.0	3.50
800	-	900	89.00	2	50.0	3.50
900	-	1000	88.90	2	50.0	3.50
1000	-	1100	88.80	3	33.3	6.00
1100	-	1200	88.70	4	25.0	8.00
1200	-	1300	88.60	4	25.0	8.00
1300	-	1400	88.50	5	20.0	10.00
1400	-	1500	88.40	4	25.0	8.00

Weighted Average

Sensitivity: General	Job Name Job Nu		Date
調 Beca	Kainga Ora - HDS	3160491	17 July 2023
	Site Address		Engineer
	7-15 Church Street (Ashburton)		OR

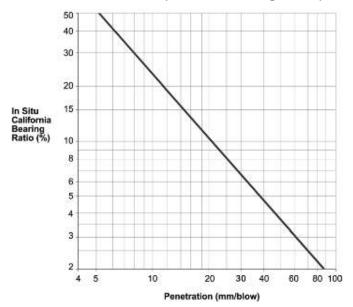
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GE - Determination of Bearing Pressures and California Bearing Ratios

AR109524-GE-HA-004

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	89.80			
C	Depth (mr	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.70	0		
100	-	200	89.60	1	100.0	1.5
200	-	300	89.50	2	50.0	3.5
300	-	400	89.40	1	100.0	1.5
400	-	500	89.30	2	50.0	3.5
500	-	600	89.20	1	100.0	1.5
600	-	700	89.10	2	50.0	3.5
700	-	800	89.00	2	50.0	3.5
800	-	900	88.90	3	33.3	6.0
900	-	1000	88.80	3	33.3	6.0
1000	-	1100	88.70	4	25.0	8.0
1100	-	1200	88.60	4	25.0	8.0
1200	-	1300	88.50	5	20.0	10.0
1300	-	1400	88.40	8	12.5	17.0
1400	-	1500	88.30	5	20.0	10.0

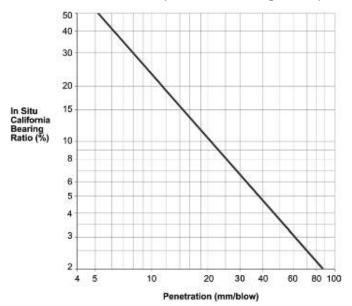
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Sensitivity: General	Job Name	Job Number	Date
調 Beca	Kainga Ora - HDS	17 July 2023	
	Site Address	Engineer	
	7-15 Church Street (Ashburton)	OR	
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AR109524-GE-HA-005

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	89.70			
C	Depth (m	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.60	0		
100	-	200	89.50	2	50.0	3.5
200	-	300	89.40	2	50.0	3.5
300	-	400	89.30	1	100.0	1.5
400	-	500	89.20	2	50.0	3.5
500	-	600	89.10	2	50.0	3.5
600	-	700	89.00	2	50.0	3.5
700	-	800	88.90	4	25.0	8.0
800	-	900	88.80	4	25.0	8.0
900	-	1000	88.70	1	100.0	1.5
1000	-	1100	88.60	3	33.3	6.0
1100	-	1200	88.50	4	25.0	8.0
1200	-	1300	88.40	3	33.3	6.0
1300	-	1400	88.30	3	33.3	6.0
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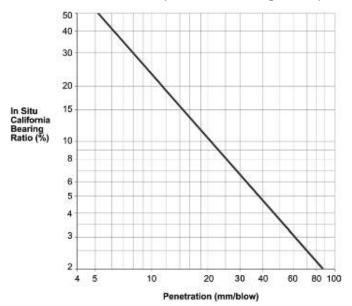
Weighted Average

Sensitivity: General	Job Name	Job Number	Date
調 Beca	Kainga Ora - HDS	3160491	17 July 2023
ili dela	Site Address		Engineer
	7-15 Church Street (Ashburton)		OR
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AR109524-GE-HA-006

AUSTROADS Part 2: Pavement Structural Design CALIFORNIA BEARING RATIO

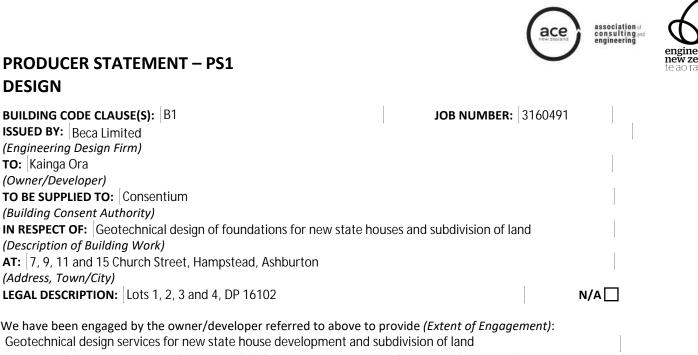
Reference: Austroads Ltd. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Sydney: Austroads Ltd. (Section 5.5.2, Figure 5.3)



Ground	Level (m	RL, CDD)	89.80			
C	Depth (m	m)	m RL	Measured No. Blows / 100mm	e mm/blow	Austroads - Correlated CBR (%)
0	-	100	89.70	1	100.0	1.5
100	-	200	89.60	1	100.0	1.5
200	-	300	89.50	1	100.0	1.5
300	-	400	89.40	1	100.0	1.5
400	-	500	89.30	2	50.0	3.5
500	-	600	89.20	3	33.3	6.0
600	-	700	89.10	3	33.3	6.0
700	-	800	89.00	4	25.0	8.0
800	-	900	88.90	3	33.3	6.0
900	-	1000	88.80	3	33.3	6.0
1000	-	1100	88.70	4	25.0	8.0
1100	-	1200	88.60	6	16.7	12.0
1200	-	1300	88.50	5	20.0	10.0
1300	-	1400	88.40	6	16.7	12.0
1400	-	1500	88.30	4	25.0	8.0

Weighted Average

Appendix I – Geotechnical PS1 Producer Statement



in respect of the requirements of the Clause(s) of the Building Code specified above for Part only , as specified in the Schedule, of the proposed building work.

The design carried out by us has been prepared in accordance with:

- Compliance documents issued by the Ministry of Business, Innovation & Employment (Verification method/acceptable solution) and/or;
- Alternative solution as per the attached Schedule.

The proposed building work covered by this producer statement is described on the drawings specified in the Schedule, together with the specification, and other documents set out in the Schedule.

On behalf of the Engineering Design Firm, and subject to:

- Site verification of the following design assumptions: Depth to 100kPa geotechnical ultimate bearing capacity.
- All proprietary products meeting their performance specification requirements;

I believe on reasonable grounds that:

- the building, if constructed in accordance with the drawings, specifications, and other documents provided or listed in the Schedule, will comply with the relevant provisions of the Building Code and that;
- the persons who have undertaken the design have the necessary competency to do so.

I recommend the CM2 level of construction monitoring.

I, (Name of Engineering Design Professional) Samuel Glue

• CPEng number 248637

and hold the following qualifications BE Hons (Civil)

The Engineering Design Firm holds a current policy of Professional Indemnity Insurance no less than \$200,000 The Engineering Design Firm is a member of ACE New Zealand.

SIGNED BY (Name of Engineering Design Professional): Samuel Glue

(Signature below):

due

ON BEHALF OF (Engineering Design Firm): Beca Limited

Note: This statement has been prepared solely for the Building Consent Authority named above and shall not be relied upon by any other person or entity. Any liability in relation to this statement accrues to the Engineering Design Firm only. As a condition of reliance on this statement, the Building Consent Authority accepts that the total maximum amount of liability of any kind arising from this statement and all other statements provided to the Building Consent Authority in relation to this building work, whether in tort or otherwise, is limited to the sum of \$200,000.

This form is to accompany Form 2 of the Building (Forms) Regulations 2004 for the application of a Building Consent.



Date: 26/07/2023

SCHEDULE to PS1

Please include an itemised list of all referenced documents, drawings, or other supporting materials in relation to this producer statement below:

7 - 15 Church Street (Ashburton). Geotechnical Design Report

GUIDANCE ON USE OF PRODUCER STATEMENTS

Information on the use of Producer Statements and Construction Monitoring Guidelines can be found on the Engineering New Zealand website

https://www.engineeringnz.org/engineer-tools/engineering-documents/producer-statements/

Producer statements were first introduced with the Building Act 1991. The producer statements were developed by a combined task committee consisting of members of the New Zealand Institute of Architects (NZIA), Institution of Professional Engineers New Zealand (now Engineering New Zealand), Association of Consulting and Engineering New Zealand (ACE NZ) in consultation with the Building Officials Institute of New Zealand (BOINZ). The original suite of producer statements has been revised at the date of this form to ensure standard use within the industry.

The producer statement system is intended to provide Building Consent Authorities (BCAs) with part of the reasonable grounds necessary for the issue of a Building Consent or a Code Compliance Certificate, without necessarily having to duplicate review of design or construction monitoring undertaken by others.

PS1 DESIGN Intended for use by a suitably qualified independent engineering design professional in circumstances where the BCA accepts a producer statement for establishing reasonable grounds to issue a Building Consent;

PS2 DESIGN REVIEW Intended for use by a suitably qualified independent engineering design review professional where the BCA accepts an independent design professional's review as the basis for establishing reasonable grounds to issue a Building Consent;

PS3 CONSTRUCTION Forms commonly used as a certificate of completion of building work are Schedule 6 of NZS 3910:2013 or Schedules E1/E2 of NZIA's SCC 2011²

PS4 CONSTRUCTION REVIEW Intended for use by a suitably qualified independent engineering construction monitoring professional who either undertakes or supervises construction monitoring of the building works where the BCA requests a producer statement prior to issuing a Code Compliance Certificate.

This must be accompanied by a statement of completion of building work (Schedule 6).

The following guidelines are provided by ACE New Zealand and Engineering New Zealand to interpret the Producer Statement.

Competence of Engineering Professional

This statement is made by an engineering firm that has undertaken a contract of services for the services named, and is signed by a person authorised by that firm to verify the processes within the firm and competence of its personnel.

The person signing the Producer Statement on behalf of the engineering firm will have a professional qualification and proven current competence through registration on a national competence-based register such as a Chartered Professional Engineer (CPEng).

Membership of a professional body, such as Engineering New Zealand provides additional assurance of the designer's standing within the profession. If the engineering firm is a member of ACE New Zealand, this provides additional assurance about the standing of the firm.

Persons or firms meeting these criteria satisfy the term "suitably qualified independent engineering professional".

Professional Indemnity Insurance

As part of membership requirements, ACE New Zealand requires all member firms to hold Professional Indemnity Insurance to a minimum level.

The PI Insurance minimum stated on the front of this form reflects standard practice for the relationship between the BCA and the engineering firm.

Professional Services during Construction Phase

There are several levels of service that an engineering firm may provide during the construction phase of a project (CM1-CM5 for engineers³). The building Consent Authority is encouraged to require that the service to be provided by the engineering firm is appropriate for the project concerned.

Requirement to provide Producer Statement PS4

Building Consent Authorities should ensure that the applicant is aware of any requirement for producer statements for the construction phase of building work at the time the building consent is issued as no design professional should be expected to provide a producer statement unless such a requirement forms part of the Design Firm's engagement.

Refer Also:

- ¹ Conditions of Contract for Building & Civil Engineering Construction NZS 3910: 2013
- ² NZIA Standard Conditions of Contract SCC 2011
- ³ Guideline on the Briefing & Engagement for Consulting Engineering Services (ACE New Zealand/Engineering New Zealand 2004)
- ⁴ PN01 Guidelines on Producer Statements

www.acenz.org.nz www.engineeringnz.org

Appendix J – Statement of Professional Opinion

Statement of Professional Opinion on the Suitability of Land for Subdivision

(Appendix I to the Infrastructure Design Standard)

Issu	ued by: Beca Limited (Geotechnical engineering firm or suitably qualified engineer)
To:	Kainga Ora
10.	(Owner/Developer)
Tob	be supplied to: Ashburton District Council
	(Territorial authority)
In re	espect of: State housing development and land subdivision (Description of proposed infrastructure/land development)
At:	7, 9, 11 and 15 Church Street, Hampstead, Christchurch (Address)
۱.S	Samuel Birdling Glue on behalf of <i>Beca Limited</i> (Geotechnical engineer) (Geotechnical engineering firm)
here	eby confirm:
1.	I am a suitably qualified and experienced geotechnical engineer and was retained by the owner/developer as the geotechnical engineer on the above proposed development.
2.	My/the geotechnical assessment report, datedJuly 2023 has been carried out in accordance with the Department of Building and Housing <i>Guidelines for geotechnical investigation and assessment of subdivisions</i> and includes:
	 (i) Details of and the results of my/the site investigations. (ii) A liquefaction assessment. (iii) An assessment of rockfall and slippage, including hazards resulting from seismic activity.
	(iv) An assessment of the slope stability and ground bearing capacity confirming the location and appropriateness of building sites.
	 (v) Recommendations proposing measures to avoid, remedy or mitigate any potential hazards on the land subject to the application, in accordance with the provisions of Section 106 of the Resource Management Act 1991.
3.	In my professional opinion, I consider that Council is justified in granting consent incorporating the following conditions:
	Foundations to be TC1 waffle slab foundation on a 200 to 500mm thick gravel raft and designed for
	100kPa geotechnical ultimate bearing capacity.
4.	This professional opinion is furnished to the territorial authority and the owner/developer for their purposes alone, on the express condition that it will not be relied upon by any other person and does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any building.

- 5. This certificate shall be read in conjunction with my/the geotechnical report referred to in Clause 2 above, and shall not be copied or reproduced except in conjunction with the full geotechnical completion report.
- 6. The geotechnical engineering firm issuing this statement holds a current policy of professional indemnity

due

(Signature of Engineer)

Date: 26/07/2023

Qualifications and experience:

BE Civil (Hons), CPEng, CMEngNZ, 16 years experience in Geotechnical Engineering design.



Memorandum

To:	Caio Bridi	Date:	28 July 2023
From:	David Dobson	Our Ref:	3160491-1666321878-31924
Copy:	Sam Glue; Paul Horrey; Mike Thorley; Chris	Hyslop	

Subject: CHU7-15-AR109524-GEO-MEM-Infiltration

This memorandum presents infiltration testing data from testing conducted at 7-15 Church Street (AR109524, Ashburton) on 12th July 2023.

It is a request by Ashburton District Council, that the proposed structures provide stormwater discharge via ground soakage. The testing was completed to support civil design of proposed soakage pits for the site as part of a Kāinga Ora Housing Delivery System residential development at the site.

Infiltration testing was conducted prior to the proposed soak pit construction location being known (refer site testing plan, Attachment 1) via excavation of a test pit to at least 0.5 m within the target unit (dense gravel encountered from approximately 1.8m bgl).

Ashburton District Council have communicated infiltration to ground is preferred to stormwater attenuation (storage) options.

1.1 Infiltration_Testing

Infiltration testing was carried out in accordance with the Ministry of Business, Innovation and Employment (MBIE) Acceptable Solutions and Verification Methods E1/VM1 (Surface Water), Section 9.0.2 (2017).

Testing was conducted at a depth of 2.2m and 2.5m bgl within dense gravel using the falling head test method. The excavated test pit was filled with potable water to within 300 mm of the ground surface, with this level maintained for at least 40 to 60 minutes to pre-soak the ground (determined by limited availability of 10,000l of water, test commenced following full staged application to maintain maximum levels).

Infiltration testing was conducted with the results summarised in Table 1-1, and detailed infiltration testing results are presented in Attachment 2. The infiltration rates presented are based on the range of field measurements observed without a design factor applied.

Test Pit ID	Test Date	Measurement Intervals (min)	Test Depth (m bgl)	Water Level at Start (m above base)	Minimum Measured Infiltration Rate (mm/hr)
AR109524-ITP-01	12/07/2023	0.5 – 5.0	2.50	2.14	600
AR109524-ITP-02	12/07/2023	0.5 – 5.0	2.20	1.91	300

Table 1-1: Infiltration Testing Summary

1.2 Recommended Infiltration Rates

The observed infiltration rates are based on the field measurements without a design factor applied. Infiltration testing within the test pits included a component of horizontal infiltration in addition to vertical infiltration (i.e., the measured overall rate is higher than the vertical infiltration rate alone). The minimum stabilised infiltration results, which typically occur towards the end of the soakage test and are largely



Memorandum

reflecting vertical flow with minimal hydraulic gradient effects, are recommended to be used for infiltration basin design purposes.

The assessment of appropriate design rate is based on the minimum stabilised measured rate during the testing.

A mounding assessment was not considered to be required due to the measured depth to groundwater exceeding 4 m bgl during the site testing (July 2023) considering publicly available data (refer Kāinga Ora report ref: CHU7-15-AR109524-GEO-RP-Geotechnical Design Report). Site investigations (July 2023) did not encounter groundwater to a depth of 2.5 m bgl (terminated on dense ground) and were undertaken during winter when groundwater levels are anticipated to be higher.

For soakage pit design purposes, we recommend a design factor of safety be applied to the minimum measured infiltration rate as recommended in the Stormwater Soakage and Groundwater Recharge in the Auckland Region (Auckland Council, 2021). We recommend the following factors as per the guidance (refer Attachment 3 for an extract of the guidance regarding consequence and testing):

- Consequence of Failure FoS (F_c): A consequence level 2 is recommended, meaning that 'the secondary flow path complies with the Stormwater Code of Practice and one of the following will apply; 1) pre-treatment will be present, 2) access for maintenance will be easy, frequency of maintenance will be high, and a maintenance plan will be implemented.'
- Testing Quality FoS (F_u): a quality level 4 is recommended, as the test was conducted on site, but not in the approximate location of the civil proposed soakage pit location (unknown at time of testing).

The above factors are based on discussion with Kāinga Ora civil engineers, confirming that the following measures are to be incorporated into the stormwater and soakage pit design;

- Overflow of the system will backup and discharge at the sump as the lowest point, with secondary flow path via the accessway to the road (in accordance with the Stormwater Code of Practice).
- (Pre-treatment) Litter traps and leaf separators on the downpipes as anti-clogging measures
- (Pre-treatment) Type 2 sump in the accessway with submerged outlet and silt trap
- (Maintenance) A manhole will be incorporated into the soak pit for maintenance access, also accessing the silt trap
- Recommend maintenance to the client for the silt traps and measures on down pipes

Considering the tested rates and factor of safety, the recommended maximum infiltration rate for each soakage structure can be referred to in Table 1-2.

Test Pit ID	Minimum Observed Infiltration Rate (mm/hr)	Consequence of Failure FoS (F _c) ¹	Testing Quality FoS (F _u) ¹	Recommended FoS ¹ (Fc x Fu)	Recommended Design Infiltration Rate (mm/hr)
AR109524- ITP-01	600	1.5	2.4	3.6	167
AR109524- ITP-02	300	1.5	2.4	3.6	83

Table 1-2: Maximum Recommended Design Infiltration Rates

Note: (1) Stormwater Soakage and Groundwater Recharge in the Auckland Region (Auckland Council, 2021)



1.3 Construction Recommendations

The following general construction recommendations are based on the site investigation, testing, and analysis, as well as our experience with similar construction:

- Soak pits must terminate at least 0.5m within the dense sandy gravel. We recommend a minimum soak pit depth of 2.5 m bgl considering the depth observations during site testing. Should the surficial silt extend beyond 2.0 m bgl during construction, the proposed depth may require extension to ensure at least 0.5 m into the target infiltration unit is attained.
- The pre-treatment options confirmed by Kāinga Ora civil engineers (refer section 1.2) must be incorporated into the stormwater design to use the factored infiltration rates provided.
- A maintenance plan should be communicated to Kāinga Ora as per agreement with the Kāinga Ora civil engineer. Failure to maintain the system may result in compromised performance.
- Groundwater soakage pit bases should typically be above the groundwater table, as the depth to groundwater will affect infiltration performance.
- Seasonal groundwater variations and groundwater mounding may reduce infiltration performance depending on the depth to groundwater and duration of the discharge.
- We recommend that suitably graded filter material be applied around the proposed infiltration system. Grading of the filter materials should meet Section 2.3 of the TNZ F/2 (2000) Notes on Pipe Subsoil Drain Construction Specification
- We do not recommend the use of filter cloth around the infiltration system or subsoil drains as they may clog over time and will be difficult to maintain
- Subsoil drainage materials should be reviewed by the project Geotechnical Engineer or Hydrogeologist
- Infiltration testing of the constructed soakage pit(s) is/are recommended to determine an as constructed site-specific infiltration rate

A minimum setback distance of 3 m is recommended for buildings and property boundaries according to the Stormwater Soakage and Groundwater Recharge in the Auckland Region (Auckland Council, 2021).

David Dobson

Senior Geotechnical Engineer

Phone Number: +64 (3) 366 3521 Email: David.Dobson@beca.com

Mike Thorley

Technical Director - Hydrogeology

Phone Number: +64 (3) 366 3521 Email: Mike.Thorley@beca.com



Memorandum

Attachment 1: Testing Location Plan



Beca | 28/07/2023 |3160491-1666321878-31479 | Page 4



DO NOT SCAL

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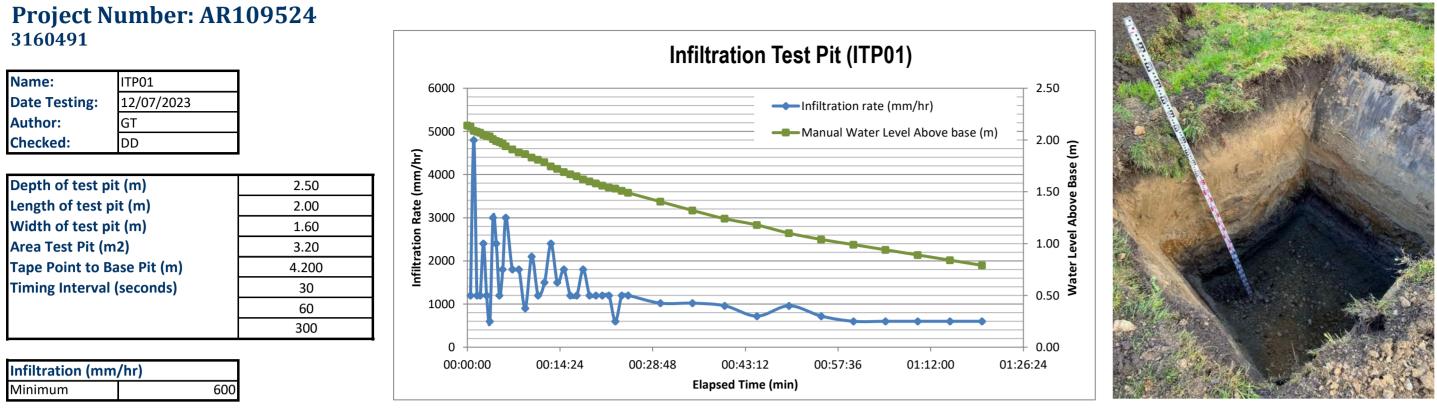
Memorandum

Attachment 2: Infiltration Testing Results



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Location ID: ITP01 Project Number: AR109524 3160491



Date	Test Time Interval Man mea	ual Test surement (m)	Manual Water Level Above base (m)	Auto Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)) Change level (mm)	Change time (hr)	Infiltration rate (mm/hr)	Cumulative infiltration (mm)	Comment
12/07/2023	00:00:00	2.06	2.140	N/A	N/A	0.360	0.00		0.00	1		
12/07/2023	00:00:30	2.07	2.130	N/A	N/A	0.370	0.50) 10	0.0083	1200.0	10)
12/07/2023	00:01:00	2.11	2.090	N/A	N/A	0.410	1.00) 40	0.0083	4800.0	50)
12/07/2023	00:01:30	2.12	2.080	N/A	N/A	0.420	1.50) 10	0.0083	1200.0	60)
12/07/2023	00:02:00	2.13	2.070	N/A	N/A	0.430	2.00) 10	0.0083	1200.0	70)
12/07/2023	00:02:30	2.15	2.050	N/A	N/A	0.450	2.50) 20	0.0083	2400.0	90)
12/07/2023	00:03:00	2.16	2.040	N/A	N/A	0.460	3.00) 10	0.0083	1200.0	100)
12/07/2023	00:03:30	2.165	2.035	N/A	N/A	0.465	3.50) 5	5 0.0083	600.0	105	5
12/07/2023	00:04:00	2.19	2.010	N/A	N/A	0.490	4.00) 25	5 0.0083	3000.0	130)
12/07/2023	00:04:30	2.21	1.990	N/A	N/A	0.510	4.50) 20	0.0083	2400.0	150)
12/07/2023	00:05:00	2.22	1.980	N/A	N/A	0.520	5.00) 10	0.0083	1200.0	160)
12/07/2023	00:05:30	2.235	1.965	N/A	N/A	0.535	5.50) 15	5 0.0083	1800.0	175	5
12/07/2023	00:06:00	2.26	1.940	N/A	N/A	0.560	6.00) 25	5 0.0083	3000.0	200)
12/07/2023	00:07:00	2.29	1.910	N/A	N/A	0.590	7.00) 30	0.0167	1800.0	230)
12/07/2023	00:08:00	2.32	1.880	N/A	N/A	0.620	8.00) 30	0.0167	1800.0	260)
12/07/2023	00:09:00	2.335	1.865	N/A	N/A	0.635	9.00) 15	5 0.0167	900.0	275	5
12/07/2023	00:10:00	2.37	1.830	N/A	N/A	0.670	10.00) 35	5 0.0167	2100.0	310)
12/07/2023	00:11:00	2.39	1.810	N/A	N/A	0.690	11.00) 20	0.0167	1200.0	330)
12/07/2023	00:12:00	2.415	1.785	N/A	N/A	0.715	12.00) 25	5 0.0167	1500.0	355	5
12/07/2023	00:13:00	2.455	1.745	N/A	N/A	0.755	13.00) 4(0.0167	2400.0	395	5
12/07/2023	00:14:00	2.48	1.720	N/A	N/A	0.780	14.00) 25	5 0.0167	1500.0	420)
12/07/2023	00:15:00	2.51	1.690	N/A	N/A	0.810	15.00) 30	0.0167	1800.0	450)
12/07/2023	00:16:00	2.53	1.670	N/A	N/A	0.830	16.00) 20	0.0167	1200.0	470)
12/07/2023	00:17:00	2.55	1.650	N/A	N/A	0.850	17.00) 20	0.0167	1200.0	490)
12/07/2023	00:18:00	2.58	1.620	N/A	N/A	0.880	18.00) 30	0.0167	1800.0	520)
12/07/2023	00:19:00	2.6	1.600	N/A	N/A	0.900	19.00) 20	0.0167	1200.0	540)
12/07/2023	00:20:00	2.62	1.580	N/A	N/A	0.920	20.00) 20	0.0167	1200.0	560)
12/07/2023	00:21:00	2.64	1.560	N/A	N/A	0.940	21.00) 20	0.0167	1200.0	580)
12/07/2023	00:22:00	2.66	1.540	N/A	N/A	0.960	22.00) 20	0.0167	1200.0	600)
12/07/2023	00:23:00	2.67	1.530	N/A	N/A	0.970	23.00) 10	0.0167	600.0	610)
12/07/2023	00:24:00	2.69	1.510	N/A	N/A	0.990	24.00) 20	0.0167	1200.0	630)
12/07/2023	00:25:00	2.71			N/A	1.010	25.00) 20	0.0167	1200.0		
12/07/2023	00:30:00	2.795			N/A	1.095	30.00) 85	5 0.0833	1020.0		
12/07/2023	00:35:00	2.88			N/A	1.180	35.00) 85	5 0.0833	1020.0		
12/07/2023	00:40:00	2.96	1.240	N/A	N/A	1.260	40.00) 80	0.0833	960.0	900)
12/07/2023	00:45:00	3.02			N/A	1.320	45.00					
12/07/2023	00:50:00	3.1			N/A	1.400	50.00) 80	0.0833	960.0	1040)
12/07/2023	00:55:00	3.16			N/A	1.460	55.00	60	0.0833	720.0		
12/07/2023	01:00:00	3.21			N/A	1.510	60.00					
12/07/2023	01:05:00	3.26		-	N/A	1.560	65.00					
12/07/2023	01:10:00	3.31			N/A	1.610	70.00					
12/07/2023	01:15:00	3.36		-	N/A	1.660	75.00					
12/07/2023	01:20:00	3.41	0.790	N/A	N/A	1.710	80.00) 50	0.0833	600.0	1350	0 Terminated

Testing Notes:

40min pre-soak conducted, level maintained 2.14m above base,

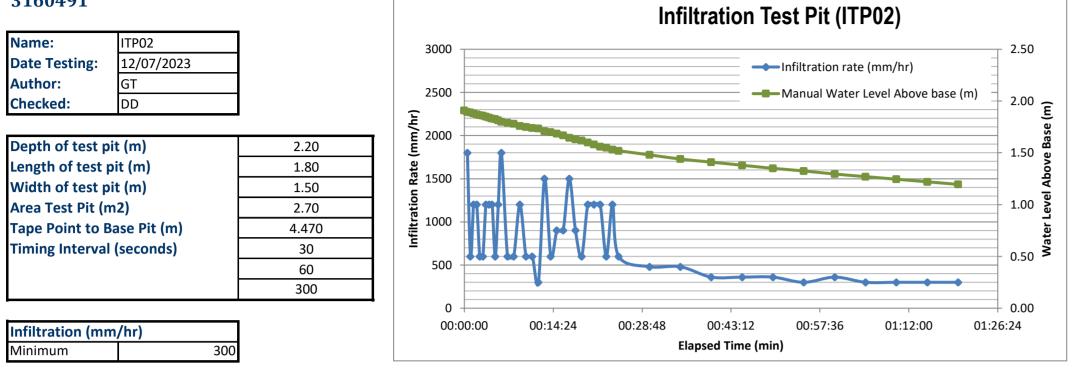
- pre-soak terminated on reach of target time

Soakage test readings at 30 seconds, 1min and 5min intervals

Data sampled manually onsite using a fixed dip meter

Groundwater not encountered

Location ID: ITP02 Project Number: AR109524 3160491



Date	Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)		Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	-	Infiltration rate (mm/hr)	Cumulative infiltration (mm)	Comment
12/07/2023	00:00:00	2.56	1.910	N/A	N/A	0.290	0.00	0	0.00)	、	
12/07/2023	00:00:30	2.575	1.895	N/A	N/A	0.305	0.50	15	0.0083	1800.0		15
12/07/2023	00:01:00	2.58	1.890	N/A	N/A	0.310	1.00	5	0.0083	600.0		20
12/07/2023	00:01:30	2.59	1.880	N/A	N/A	0.320	1.50	10	0.0083	1200.0		30
12/07/2023	00:02:00	2.6	1.870	N/A	N/A	0.330	2.00	10	0.0083	1200.0		40
12/07/2023	00:02:30	2.605	1.865	N/A	N/A	0.335	2.50	5	0.0083	600.0		45
12/07/2023	00:03:00	2.61	1.860	N/A	N/A	0.340	3.00	5	0.0083	600.0		50
12/07/2023	00:03:30	2.62	1.850	N/A	N/A	0.350	3.50	10	0.0083	1200.0		60
12/07/2023	00:04:00	2.63	1.840	N/A	N/A	0.360	4.00	10	0.0083	1200.0		70
12/07/2023	00:04:30	2.64	1.830	N/A	N/A	0.370	4.50	10	0.0083	1200.0		80
12/07/2023	00:05:00	2.645	1.825	N/A	N/A	0.375	5.00	5	0.0083	600.0		85
12/07/2023	00:05:30	2.655	1.815	N/A	N/A	0.385	5.50	10	0.0083	1200.0		95
12/07/2023	00:06:00	2.67	1.800	N/A	N/A	0.400	6.00	15	0.0083	1800.0	1	10
12/07/2023	00:07:00	2.68	1.790	N/A	N/A	0.410	7.00	10	0.0167	600.0	1	20
12/07/2023	00:08:00	2.69	1.780	N/A	N/A	0.420	8.00	10	0.0167	600.0	1	30
12/07/2023	00:09:00	2.71	1.760	N/A	N/A	0.440	9.00	20	0.0167	1200.0	1	50
12/07/2023	00:10:00	2.72	1.750	N/A	N/A	0.450	10.00	10	0.0167	600.0	1	60
12/07/2023	00:11:00	2.73	1.740	N/A	N/A	0.460	11.00	10	0.0167	600.0	1	70
12/07/2023	00:12:00	2.735	1.735	N/A	N/A	0.465	12.00	5	0.0167	300.0	1	75
12/07/2023	00:13:00	2.76	1.710	N/A	N/A	0.490	13.00	25	0.0167	1500.0	2	00
12/07/2023	00:14:00	2.77	1.700	N/A	N/A	0.500	14.00	10	0.0167	600.0	2	10
12/07/2023	00:15:00	2.785	1.685	N/A	N/A	0.515	15.00	15	0.0167	900.0	2	25
12/07/2023	00:16:00	2.8	1.670	N/A	N/A	0.530	16.00	15	0.0167	900.0	2	40
12/07/2023	00:17:00	2.825	1.645	N/A	N/A	0.555	17.00	25	0.0167	1500.0	2	65
12/07/2023	00:18:00	2.84	1.630	N/A	N/A	0.570	18.00	15	0.0167	900.0	2	80
12/07/2023	00:19:00	2.85	1.620	N/A	N/A	0.580	19.00	10	0.0167	600.0	2	90
12/07/2023	00:20:00	2.87	1.600	N/A	N/A	0.600	20.00	20	0.0167	1200.0	3	10
12/07/2023	00:21:00	2.89	1.580	N/A	N/A	0.620	21.00	20	0.0167	1200.0	3	30
12/07/2023	00:22:00	2.91	1.560	N/A	N/A	0.640	22.00	20	0.0167	1200.0	3	50
12/07/2023	00:23:00	2.92	1.550	N/A	N/A	0.650	23.00	10	0.0167	600.0	3	60
12/07/2023	00:24:00	2.94	1.530	N/A	N/A	0.670	24.00	20	0.0167	1200.0	3	80
12/07/2023	00:25:00	2.95	1.520	N/A	N/A	0.680	25.00	10	0.0167	600.0	3	90
12/07/2023	00:30:00	2.99	1.480	N/A	N/A	0.720	30.00	40	0.0833	480.0	4	30
12/07/2023	00:35:00	3.03	1.440	N/A	N/A	0.760	35.00	40	0.0833	480.0	4	70
12/07/2023	00:40:00	3.06	1.410	N/A	N/A	0.790	40.00	30	0.0833	360.0	5	00
12/07/2023	00:45:00	3.09	1.380	N/A	N/A	0.820	45.00	30	0.0833	360.0	5	30
12/07/2023	00:50:00	3.12	1.350	N/A	N/A	0.850	50.00	30	0.0833	360.0	5	60
12/07/2023	00:55:00	3.145	1.325	N/A	N/A	0.875	55.00	25	0.0833	300.0	5	85
12/07/2023	01:00:00	3.175	1.295	N/A	N/A	0.905	60.00	30	0.0833	360.0	6	15
12/07/2023	01:05:00	3.2	1.270	N/A	N/A	0.930	65.00	25	0.0833	300.0	6	40
12/07/2023	01:10:00	3.225	1.245	N/A	N/A	0.955	70.00	25	0.0833	300.0	6	65
12/07/2023	01:15:00	3.25	1.220	N/A	N/A	0.980	75.00	25	0.0833	300.0	6	90
12/07/2023	01:20:00	3.275	1.195	N/A	N/A	1.005	80.00	25	0.0833	300.0	7	15 Terminated

Testing notes:

60min pre-soak conducted, level maintained 1.91m above base,

pre-soak terminated on on reach of target time

Soakage test readings at 30 seconds, 1min and 5min intervals

Data sampled manually onsite using a fixed dip meter

Groundwater not encountered



nge time	Infiltration rate (mm/hr)	Cumulative infiltration (mm)	Comment
0.00		()	
0.0083	1800.0	15	
0.0083	600.0	20	
0.0083	1200.0	30	
0.0083	1200.0	40	
0.0083	600.0	45	
0.0083	600.0	50	
0.0083	1200.0	60	
0.0083	1200.0	70	
0.0083	1200.0	80	
0.0083	600.0	85	
0.0083	1200.0	95	
0.0083	1800.0	110	
0.0167	600.0	120	
0.0167	600.0	130	
0.0167	1200.0	150	
0.0167	600.0	160	
0.0167	600.0	170	
0.0167	300.0	175	
0.0167	1500.0	200	
0.0167	600.0	210	
0.0167	900.0	225	
0.0167	900.0	240	
0.0167	1500.0	265	
0.0167	900.0	280	
0.0167	600.0	290	
0.0167	1200.0	310	
0.0167	1200.0	330	
0.0167	1200.0	350	
0.0167	600.0	360	
0.0167	1200.0	380	
0.0167	600.0	390	
0.0833	480.0	430	
0.0833	480.0	470	
0.0833	360.0	500	
0.0833	360.0	530	
0.0833	360.0	560	
0.0833	300.0	585	
0.0833	360.0	615	
0.0833	300.0	640	
0.0833	300.0	665	
0.0833	300.0	690	
0.0833	300.0	715	Terminated

Attachment 3: Extract of Stormwater Soakage and Groundwater Recharge in the Auckland Region (Auckland Council, 2021);

Consequence of Failure FoS (Fc) 2 Testing Quality FoS (Fu) 4



B.4.0 Factors of safety for soakage device sizing

There are many uncertainties in the design process, not least the assumed soakage rate. Soakage rates may change significantly over time and can vary by orders of magnitude. In addition, failure consequences vary depending upon the device's design and location. To account for these issues a factor of safety that reduces observed soakage rates needs to be introduced into the design process. When choosing an appropriate factor of safety, engineering judgement, depending upon the consequences of failure and subsequent design uncertainties, is needed. Key risks that are addressed with the factor of safety are:

- Insufficient confidence in input data, e.g., soakage testing
- Insufficient pre-treatment of stormwater inflow into the device
- Difficult access to the proposed device for maintenance •
- Frequency of maintenance of proposed device is likely to be low. •

The observed soakage rate used in the design process should be divided by the safety factor. The safety factor is generated by multiplying together two partial factors. These are:

- A factor for the consequences of failure, and
- A factor to account for uncertainty in input data. •

			$F_{(total)} = F_{(c)} \times F_{(u)}$	Equation 1
Where:	F _(total)	-	Total combined Factor of Safety to be applied	
	F _(c)	-	Factor of Safety representing the consequences of fai	lure from Table 5
	F _(u)	-	Factor of Safety representing testing uncertainty from	Table 6

Equation 1 should be used to calculate the required Factor of Safety (F(total)):

Table 5, which has been adapted and modified from the CIRIA SuDS Manual C753 (Woods Ballard, et al., 2015), shows suggested safety factors for the consequences of failure. Note that the figures are not based on actual observation of performance loss. Table 6 shows suggested safety factors for the uncertainty in input data.

Table 5: Suggested partial factor of safety	(F _(c)) for consequences of failure
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Device	Consequences of failure (see table notes for definitions of Consequence Levels)					
	Consequence Level 1	Consequence Level 2	Consequence Level 3	Consequence Level 4		
Soakpit	1	1.5	2.5	5		
Groundwater recharge pit	1	1	Not acceptable	Not acceptable		
Rockbore	1	1.5	2.5	5		

- **Consequence Level 1**: The secondary flow path complies with the Stormwater Code of Practice and all of the following apply:
 - o Pre-treatment will be present
 - Access for maintenance will be easy, frequency of maintenance will be high, and a maintenance plan will be implemented.
- Consequence Level 2: The secondary flow path complies with the Stormwater Code of Practice and one <u>or</u> more of the following applies:
 - Pre-treatment will be present
 - Access for maintenance will be easy, frequency of maintenance will be high, and a maintenance plan will be implemented.
- **Consequence Level 3**: The secondary flow path does not meet the Stormwater Code of Practice but will only cause minor damage to external areas, or non-habitable floor flooding (e.g., surface water on car parking), and one or more of the below points applies:
 - Pre-treatment will be present
 - Access for maintenance will be easy, frequency of maintenance will be high, and a maintenance plan will be implemented.
- **Consequence Level 4:** Any other scenario, including all situations where the secondary flow path is likely to cause damage to buildings or structures, or major flooding of roads.

Table 6: Suggested partial factor of safety (F_(u)) for uncertainty in input data

Testing situation	Testing quality (see table notes for definitions of Quality Levels)			
	Quality Level 1	Quality Level 2	Quality Level 3	Quality Level 4
Falling head test in soil	1.2	1.4	1.8	2.4
Constant head test in soil	1.0	1.2	1.5	2.0
Rockbore test	1.0	1.2	1.5	2.0

- Quality Level 1: All of the following apply:
 - Test undertaken at the location and depth of the proposed device
 - Test undertaken at a time when groundwater is at an annual high. For rock bores, this must be after heavy rain at a time when the rainfall-induced groundwater level peak is likely to be present
 - Groundwater monitoring with a duration of over 12 months and measurements taken in winter and summer is available within 100 m of the proposed device. For rockbore tests, this must include monitoring at short intervals (1 hour or less) to identify short-term response to heavy rainfall.

- **Quality Level 2:** All of the following apply:
 - o Test undertaken at the location and depth of the proposed device
 - Test undertaken at a time when groundwater is likely to be at an annual high. For rock bores, this must be after heavy rain at a time when the rainfall-induced groundwater level peak is likely to be present.
- **Quality Level 3:** One of the following apply:
 - Test undertaken at the location and depth of the proposed device, but at a time of year when the groundwater may be lower than the seasonal high
 - Test undertaken at a time when groundwater is likely to be at an annual high, but not at the exact device location. For this to apply, the test must be in a location where the geological and hydrogeological conditions are expected to be the same as the actual proposed device location, and no more than 10 m (horizontally) and 1 m (vertically) from the actual proposed device location.
- **Quality Level 4:** Any other scenario. The designer will still have to demonstrate that the testing is representative of the proposed device location.