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APPROVED BUILDING CONSENT
BC82325
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Rotorua Lakes Council

GT Homes Ltd
76 Pererika Street

Geotechnical Assessment Report

March 2021

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1. Introduction

Stratum Consultants Ltd (Stratum) has been engaged by GT Homes Limited to carry out a geotechnical investigation and assessment of the proposed five townhouses at 76 Pererika Street (Lot 12 DPS 3016) Rotorua (the site).

The purpose of this report is to assess the geotechnical hazards (e.g. liquefaction, slope stability, settlement, bearing capacity, etc.) associated with this site and provide recommendations for the foundations to be used for the residential building development. We understand that this report will be used as part of the building and resource consent application.

2. Proposed Development

We understand the development of the site will include subdivision into five lots and construction of one building comprising five double-storey lightweight timber framed townhouses. The proposed subdivision and building layout plan are presented in **Appendix A**.

3. Scope

In order to provide a geotechnical assessment of the development area and to assist in providing recommendations for foundation design and construction, the following works were undertaken, as set out in our scope and fee proposal letter dated 18th December 2020, (233257-R-P-C001).

- A desktop study (review of the local site geology, aerial photos, and Rotorua Lakes Council hazard maps);
- Twelve hand auger boreholes and accompanying Scala penetrometer testing;
- Two cone penetration tests (CPT) up to a depth of 16.2m to confirm the ground conditions, potential groundwater level, temperature profile, engineering properties, and to provide information for the liquefaction assessment;
- Preparation of a geotechnical report detailing the foundation assessment, the key geotechnical findings, and recommendations for a new building foundation design.

4. Site Description

The proposed house site is located at 76 Pererika Street as outlined in Appendix A – Site Location Plan and is legally described as Lot 12 DPS 3016. The site is bordered by residential properties to the east, west and south, and Pererika Street to the north.

The total area of the land is approximately 1012 m². The site is relatively flat, at street level. Currently, there is a residential dwelling sitting nearly at the middle of the section. We understand that the existing dwelling will be demolished and removed from the site prior to the construction of the five new residential units. The site is approximately 1700 m south-west of Lake Rotorua.

5. Geological Setting

The Rotorua Lakes Council's Geyserview¹ indicates the property is located within unconsolidated Holocene alluvial deposits, called zone D, and is generally expected to have poor founding conditions with the potential for liquefaction. These findings are consistent with The New Zealand Geological map for the Rotorua area² that indicates

¹ http://geo.rdc.govt.nz/GSLV_Ext/viewer.html?Viewer=geyserview4

² Leaward, G.S., Begg, J.G., Wilson, G.J.N. (compilers) 2010. Geology of Rotorua Area.

the site is underlain by Holocene aged Tauranga group lake sediments comprising mixed alluvial gravel, sand, silts, mud and clay with local peat zones.

The site is located in a region of frequent seismic activity and within the topographic margin of the Rotorua Caldera, a geomorphic and volcanological feature of the wider Taupo Volcanic Zone.

The closest active fault identified by the New Zealand Active Fault Database is the Horohoro Fault, located approximately 8.5km south of the site.

The property is situated inside the Rotorua Geothermal Field Area ,however no evidence of geothermal activity was observed during our site visits.

6. Site Investigation

Stratum conducted geotechnical site investigations on 21 January 2021 and between 11th February to 14th February 2021, which included:

- A site walkover to identify any features that may have an impact on the development of the site.
- Shallow investigation comprising twelve hand auger boreholes (HA/SP01 to HA/SP12) with accompanying Scala penetrometer testing (DCP) to a target depth of 3.0m to 5.0m below ground level.
- Deep investigations comprising three cone penetrometer tests (CPT1 to CPT3) to a target depth of 20m below ground level.

Groundwater was encountered at 4.3m bgl during the hand auger investigation. The dipped ground water was encountered at approximately 4.2m bgl during CPT testing. The water table may slightly rise during winter time, so we will use a groundwater level of 3.8m bgl for the geotechnical assessment.

Materials recovered from the boreholes were logged in the field following the methods and procedures in the NZ Geotechnical Society Guidelines³ and NZS3604:2011.

A site investigation location plan and geotechnical testing results are presented in **Appendix B**.

7. Subsurface Conditions

The ground conditions have been interpreted based on the subsurface conditions encountered during the geotechnical investigations, review of available geotechnical information, and our knowledge and experience of the local geology. A generalised ground model of the soil stratigraphy underlying the site is presented in Table 1 below.

Table 1: Generalised ground model.

Soil Description	Depth (m)		Average cone resistance (qc), MPa	Scala reading (blows/100mm)
	From	To		
SILT minor fine to medium sand, dark brown, dry to moist, low plasticity (TOP SOIL)	0.0	0.3	2	1-2

Institute of Geological & Nuclear sciences 1:250 000 geological map 5. 1 sheet + 102p. Lower Hutt, New Zealand. GNS Science.

³ Field Description of Soil and Rock, Guideline for the field Classification and Description of Soil and Rock for Engineering Purposes, 2005.

SAND , fine to coarse trace silt, light yellowish brown, loose to very loose, moist, poorly graded.	0.3	1.0	1.5	1-2
Pumiceous GRAVEL , trace sand, yellowish brown, loose to medium dense, moist to wet, poorly graded.	1.0	3.5	3.0	3-5
SILT minor fine to medium sand, light brown, very stiff, saturated	3.5	4.5	1.0	3-4
Sand mixture	4.5	7.0	2.5	-
Silty CLAY	7.0	7.8	1.0	-
SAND /Sand mixture	7.8	13.5	6.5	-
CLAY to silty clay	13.5	16.0	1.0	-
SAND	16.0	19.0	15	-
CLAY to silty clay	19	20	1.9	-

8. Engineering Considerations

8.1 Introduction

It is our understanding that the proposed development will be two-storey timber-framed townhouses, with no heavy, concentrated or unusual loads.

Based on our site walkover, desktop study and the results of the geotechnical site investigations, the key geotechnical aspects for this development are as follows:

- Seismic Setting;
- Faulting;
- Liquefaction potential;
- Slope stability;
- Inundation risk (flooding);
- Geothermal activity;
- Soil bearing capacity;
- Settlement potential;
- Storm water and effluent disposal.

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8.2 Seismic Setting

In accordance with NZS1170.5, clause 3.1.3 the results of the investigation suggest subsoil flexibility is likely characterised by classification 'D' (Deep or soft soil sites).

8.3 Faulting

The Ministry of the Environment document, *planning for Development of Land on or Close to Active Faults*⁴, defines a Fault Avoidance Zone for buildings. This zone is a distance of 20m on either side of the fault rupture zone.

The fault rupture risk for this development is considered to be low with the closest identified fault, the Horohoro fault, being located approximately 8km to the south east

⁴ Kerr, J et al. 2003. Planning for Development of Land on or Close to Active Faults. A guideline to assist resource management planners in New Zealand. Ministry for the Environment, Wellington, New Zealand.

of the building site according to the New Zealand Active Faults Database (GNS Active Faults online database) and the RLC Planning Maps. No evidence of any surficial features or lineaments were identified during the site appraisal that would suggest active fault movement near the site, and therefore no specific investigations or design considerations are considered to be necessary for the proposed development.

8.4 Liquefaction Assessment

According to the Rotorua Lakes Council Plan Maps and the findings from the geotechnical site investigation, the site is located within zone D – Unconsolidated Holocene alluvial deposits. Within Zone D, materials generally have potential to liquefy and are not likely to meet the requirements of ‘good ground’ as defined in NZS3604:2011 (Dellow, 2010).

A quantitative assessment of liquefaction potential has been performed using proprietary liquefaction analysis software CLiq V3.0.2.4, which provides an assessment of liquefaction potential using the CPT data. CLiq software was used to assess the Liquefaction Potential Index (LPI) and other indices in order to assess the effects of liquefaction at the site as described in NZSG Module 3 (NZGS, 2016).

The liquefaction assessment was undertaken using the Idriss and Boulanger 2014 method as recommended by the NZGS Guidelines, Module 3 (NZGS, 2016). The soil character index (I_c) values have been estimated based on Robertson and Wride methods (Robertson, 1998). Soils have been assumed to be non-liquefiable when the I_c value is greater than 2.6.

8.4.1 Peak Ground Acceleration

For the liquefaction analysis we have calculated seismic peak ground acceleration coefficients (PGA) in accordance with the Earthquake Engineering Practice, 2016 published by the Ministry of Business Innovation and Employment (MBIE) and New Zealand Geotechnical Society, for the site subsoil class of “Deep or Soft Soil Sites - Class D”. We have considered two different earthquakes return periods. These are Serviceability Limit State (SLS) and Ultimate Limit State (ULS) to assess the liquefaction potential for different seismic events. We have assumed 50 years structural design life of the structure. The results are shown in Table 2.

Table 2: Summary of Parameters for Seismic Assessment

Structural Design Life	Importance Level	Annual Probability of Exceedance	Peak Ground Acceleration (PGA)
50 Years	2	1/25 (SLS)	0.074
50 Years	2	1/500 (ULS)	0.30

8.4.2 Liquefaction Induced Settlement

The liquefaction analysis indicates that the ground is potentially liquefiable within the loose to medium dense sands deposits beneath the water table between 4.5m to 16m bgl. A liquefaction analyses summary is presented in Table 3 and 4, and the CLiq outputs are presented in **Appendix C**.

Table 3: Liquefaction Analyses Summary (SLS)

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CPT Location	LPI	LSN	Seismic Induced Vertical Settlement (cm)	Effects of Liquefaction (NZGS Module 3)
CPT01	0	<10	<1	Insignificant
CPT02	0	<10	<1	Insignificant

Table 4: Liquefaction Analyses Summary (ULS)

CPT Location	LPI	LSN	Seismic Induced Vertical Settlement (cm)	Effects of Liquefaction (NZGS Module 3)
CPT01	20	20	26	High to Severe
CPT02	16	18	20	High to Severe

The LPI indices are used to quantify liquefaction induced damage in accordance with the NZGS Module 3 (NZGS, 2016) are as follows:

- LPI between 0 to 5 – Insignificant to moderate liquefaction effects;
- LPI between 5 to 15 - High liquefaction effects;
- LPI greater than 15 – Severe liquefaction effects.

Based on the criteria set out by the NZGS Guidelines Module 3 (NZGS, 2016) and the LPI indices above, the site is considered to be a performance level of L3 to L4 (high to severe). The foundation recommendations outlined in Section 9 account for this risk in the design. The water table is at least 4.2m below the base of the foundation, so there is a 4.2m non-liquifiable crust layer present on site so we anticipated that the impact of liquefaction on shallow foundations will be low.

8.5 Slope Stability

The proposed building platform is situated on a flat topographical area with no slopes located around the building area. It is therefore considered that the risk to the site from slope stability issues is minimal and no further action will be required to mitigate the risk.

8.6 Inundation Risk

According to Rotorua District Council's Geyserview¹ the proposed development is outside the inundation risk area. The nearest large body of water, Lake Rotorua, is located 1700m to the north-east.

Based on these findings and site observations, risk to the development from inundation is considered minimal.

8.7 Geothermal Activity

The site is located inside the Rotorua Geothermal Area, although there was no evidence of geothermal activity at the ground surface within the site or nearby areas during the site inspection.

The temperature measurements within the CPT tests varied between 17.5°C to 24°C

and was reasonably consistent over the depth of the CPTs.

Based on these findings, our site inspection and our investigation we consider this site to be at low risk of geothermal activity and that no mitigation measures are necessary in the design of the proposed building.

8.8 Bearing Capacity Calculation

Our foundation assessment is based on the Scala test results and has been conducted in accordance with the NZS 3604:2011. We interpret that in order for the site to have 'good ground' (Geotechnical Ultimate Bearing Capacity (UBC) >300kPa), the Scala readings per 100mm depth must exceed five blows between 300mm and 900mm below ground level, and three blows below 900mm depth. These depths are based on a typical NZS 3604:2011 shallow footing no more than 300mm wide and founded 300mm below ground level. Our assessment is presented in Table 6 below:

Table 6: Bearing Capacity Assessment

Test No.	House Unit	Geotechnical ULS bearing > 300kPa
HA/SP01	Unit 1	Yes (Below 0.9m)
HA/SP02	Unit 1	Yes (Below 1.1m)
HA/SP03	Unit 2	Yes (Below 0.9m)
HA/SP04	Unit 3	Yes (Below 0.9m)
HA/SP05	Unit 2	Yes (Below 0.9m)
HA/SP06	Unit 3	Yes (Below 0.9m)
HA/SP07	Unit 3	Yes (Below 0.9m)
HA/SP08	Unit 4	Yes (Below 0.9m)
HA/SP09	Unit 4	Yes (Below 0.9m)
HA/SP10	Unit 5	Yes (Below 1.7m)
HA/SP11	Unit 5	Yes (Below 0.9m)
HA/SP12	Unit 5	Yes (Below 0.9m)

The Scala test results indicate that the founding soils are generally not compliant with the NZS 3604:2011 definition of 'good ground' (i.e. ULS bearing capacity of >300kPa). The foundation recommendation based on these results is described in Section 9 below.

8.9 Settlement Calculation

A settlement analyses was undertaken for the proposed foundations under SLS loading in order to provide an estimate of settlement within the subsoils underlying the proposed building footprint. The assessment was undertaken using both immediate and consolidation settlement calculation methods utilising the available CPT data.

Based on our analysis and the loads expected we anticipate that there will be less than 25mm of settlement across the building platform. The proposed building foundations shall be designed to tolerate differential settlements of 25mm over a horizontal distance of 6.0m under SLS conditions, as per the recommendations contained within

the NZBC Clause B1 Structure, Appendix B1/VM4, Section B1.0.2.

It is important we are given the opportunity to perform in-situ testing at the base of the foundations in order to confirm our design assumptions, given the previous structure has surcharged the underlying subsoils where a portion of the proposed building is to be located. In addition, the original testing was undertaken outside of the existing building platform, and demolition of the previous structure may have disturbed the underlying soils.

8.10 Effluent Disposal

We understand that effluent disposal shall be via reticulated sewerage council system.

8.11 Stormwater Disposal

Stormwater from roof and hard surfaces should be collected and piped to a suitable disposal location. The onsite soakage system should be designed in accordance with the New Zealand Building Code prior to the building consent application.

A soakage test was conducted on 11 January 2021 in accordance with Department of Building and Housing (2000) "Acceptable Solutions and Verification Methods for New Zealand Building Code Clause E1 – Surface Water" Section 9.0.2 and in accordance with guidelines outlined in RCEIS8. The soakage test indicates that the soakage rate is around 5.63 litres/m²/min. Soakage test location and soakage test results are presented in **Appendix D**.

9 Foundation Recommendation

Based on our geotechnical hazard assessment, it is recommended that a rib raft or NZS3604:2011 shallow foundation can be constructed after ground improvement.

Ground Improvement:

We recommend a geogrid gravel raft for ground improvement to create a stable building platform.

The geogrid gravel raft foundation is considered to be the best solution based on the following:

- Eliminates the effects of long-term differential settlement due to the pre-consolidation history of the site and ability to distribute loads over a larger area;
- Mitigates the effect of immediate settlements incurred by the elastic response of the soil to loading;
- Provides increased resistance to liquefaction induced settlements in a ULS level seismic event; and
- Mitigates the effect of cyclic softening within sensitive cohesive strata in a seismic event.

For construction of a gravel raft, we recommend the following:

- Excavate to 1.0 m below the existing ground level. The excavation should extend 1m beyond the footprint, where practicable, to allow an even spread of

the load and limit the creation of voids beneath the foundation in a ULS earthquake;

- The trimmed subgrade should be proof rolled in the presence of a geotechnical engineer before any filling of the site commences to identify any soft spots and to decide their treatment and any undercutting;
- A layer of Bidim A29 or similarly approved geotextile should be placed in the excavation base;
- The geogrid reinforced raft should be 1.0m thick and constructed in 300mm thick lifts compacted to 98% of maximum dry density (95% for the first lift) at $\pm 2\%$ of optimum water content.
- A single layer of StrataGrid High Strength PET Geogrid (SG500 or equivalent) should be placed at 300mm above the excavation base.
- All fill material should be Light weight Pumice or equivalent.

Ultimate Bearing Capacity:

We can assume ultimate bearing capacity of soil 300kPa after ground improvement. In accordance with the recommendations contained with the NZBC, Appendix B1/VM4, the design bearing capacity includes the following strength reduction factors:

- Load combinations involving earthquake overstrength: 0.8
- All other load combinations: 0.5

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Geothermal Gas Prevention:

As described in Section 8.7, the site is located inside the Rotorua Geothermal Area. While no signs of elevated temperatures of gases were encountered, geothermal gases can be corrosive, which could be taken into account when specifying concrete mix types and steel reinforcement for building structures.

It is recommended that a gas proof DPM is used. If additional mitigation is required, all concrete members for structural elements in the development can use Concrete Grade XA1 concrete (NZS 3101:2006, Table 3.3).

10 Further work

We recommend that a geotechnical review of the final building plans is carried out to ensure the requirements and recommendations given in this report have been interpreted as intended.

During excavation for foundations, it is prudent we are given the opportunity to undertake site observations and perform any necessary additional in-situ testing as required. If ground conditions vary from those assumed within design, we would also be on hand to recommend the most appropriate design or construction modifications.

Any earthworks comprising cutting and filling operations within the zone of influence of the proposed building structure shall be completed once the appropriate resource or building consent has been obtained, and be observed, tested and certified by a Chartered Professional Geotechnical Engineer as per NZS4431.

Upon completion of the foundation construction works and site observations, we would then be in a position to issue a Producer Statement – Construction Review (PS4) to Council. Stratum will require a minimum of 24 hours' notice for construction observations, prior to commencement of foundation excavations.

11 Limitations

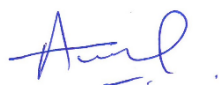
The assessment given in this report is based on limited site data from discrete test locations. Variations in ground conditions could exist across the site. The nature and continuity of subsoil conditions away from the test sites are inferred and it must be appreciated that actual conditions could vary from the assumed model.

This report has been prepared for the sole benefit of GT Homes Limited, their professional advisors and the relevant territorial authorities for the proposed townhouse building at 76 Pererika Street, Rotorua. It is not to be relied upon or used out of context by any other person without reference to Stratum Consultants Ltd. The reliance by other parties on the information or opinions contained in this report shall, without prior review and agreement in writing, be at such party's sole risk.

STRATUM CONSULTANTS LTD

Report Prepared By:

Reviewed By:



Atma Khanal (CPEng, TCC Cat 1)
Senior Geotechnical Engineer



Elles Pearse-Danker (TCC Cat 1)
Senior Geotechnical Engineer

Date: 11 March 2021

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Appendix A

Site Location and Building Location Plan

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Project: 76 Pererika Street, Rotorua

Project No.: 233257

Client: GT Homes Ltd

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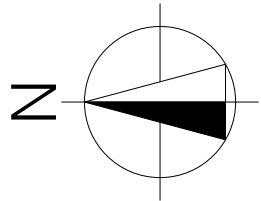
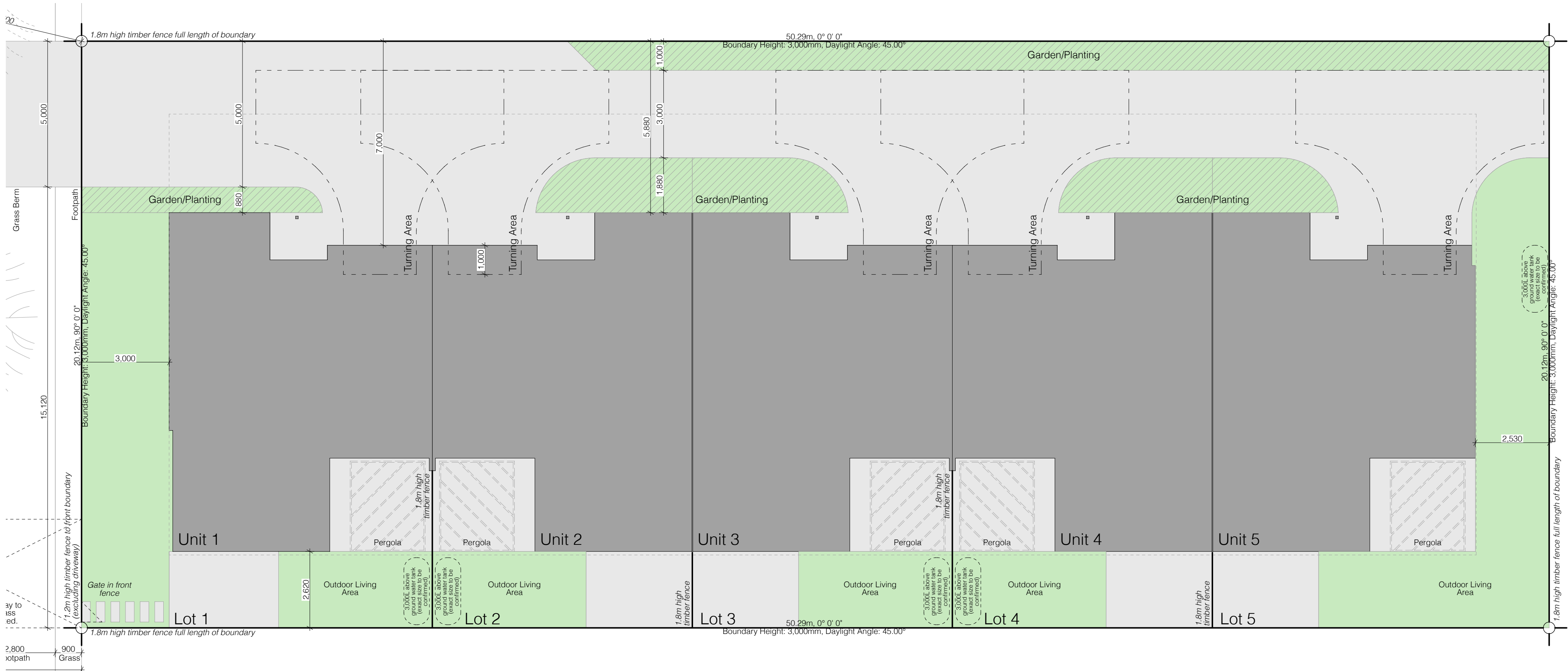
SITE LOCATION PLAN

Drawn: AK

Scale: N.T.S

Date: 8/03/2021

Sheet: 1



76 Pererika Street
ROTORUA

Lot 12 DP3016
Site Area 1012sqm

Wind Zone Low
Earthquake Zone 2
Exposure Zone B
Climate Zone 2
Rainfall Range 90-100
Rotorua District Council Zone Residential 2

Site Coverage Calculation:
Site Area 1012.00sqm
Total Building Footprint 441.45sqm

(441.45/1012) x 100 = **43.6% site coverage**

Unit Floor Areas:
Ground Floor Area (over frame) 83.95sqm
Ground Floor Area (over cladding) 86.14sqm

First Floor Area (over frame) 73.31sqm
First Floor Area (over cladding) 74.45sqm

TOTAL Floor Area (over frame) 157.26sqm
TOTAL Floor Area (over cladding) 160.59sqm

Outdoor Living Areas
(10% of site required to be outdoor living area)
Lot 1
Total Outdoor Living 84.13sqm
Excluding setbacks 15.64sqm
Lot 2
Total Outdoor Living 43.75sqm
Excluding setbacks 20.41sqm
Lot 3
Total Outdoor Living 43.75sqm
Excluding setbacks 20.41sqm
Lot 4
Total Outdoor Living 43.75sqm
Excluding setbacks 20.41sqm
Lot 5
Total Outdoor Living 82.77sqm
Excluding setbacks 18.84sqm

Total Outdoor Living Area 298.15sqm
(298.15/1012) x 100 = **29.46% achieved**

Total Outdoor Living Area 95.71sqm
(95.71/1012) x 100 = **9.45% achieved**

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REVISION	GT Homes Townhouse Development 76 Pererika Street Rotorua	SHEET 101	SHEET TITLE: Site Plan SCALE: 1:100 @ A2 ISSUED: 2/03/21 PROJECT: 235-2020	LAND USE CONSENT ISSUE (02/03/21) melissa@alterarchitecture.co.nz PO Box 1448 Waikato Mail Centre PHONE: 021 337 340	
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Appendix B

Site Investigation Data and Location Plans

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Project Title: Geotechnical Assessment

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No of Pages: 16

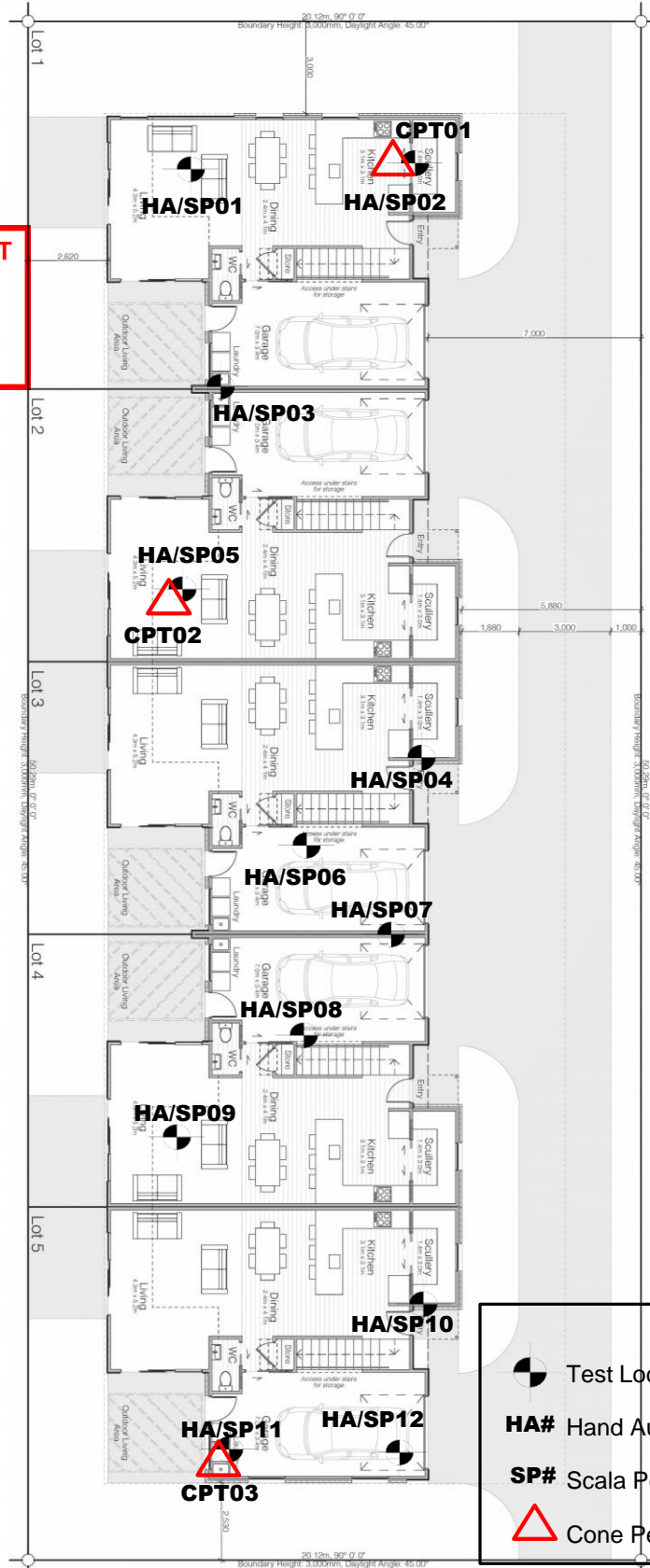
Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S001

Date Started: 11/01/2021
Date Finished: 14/01/2021
Logged By: SG





Test Location Sketch

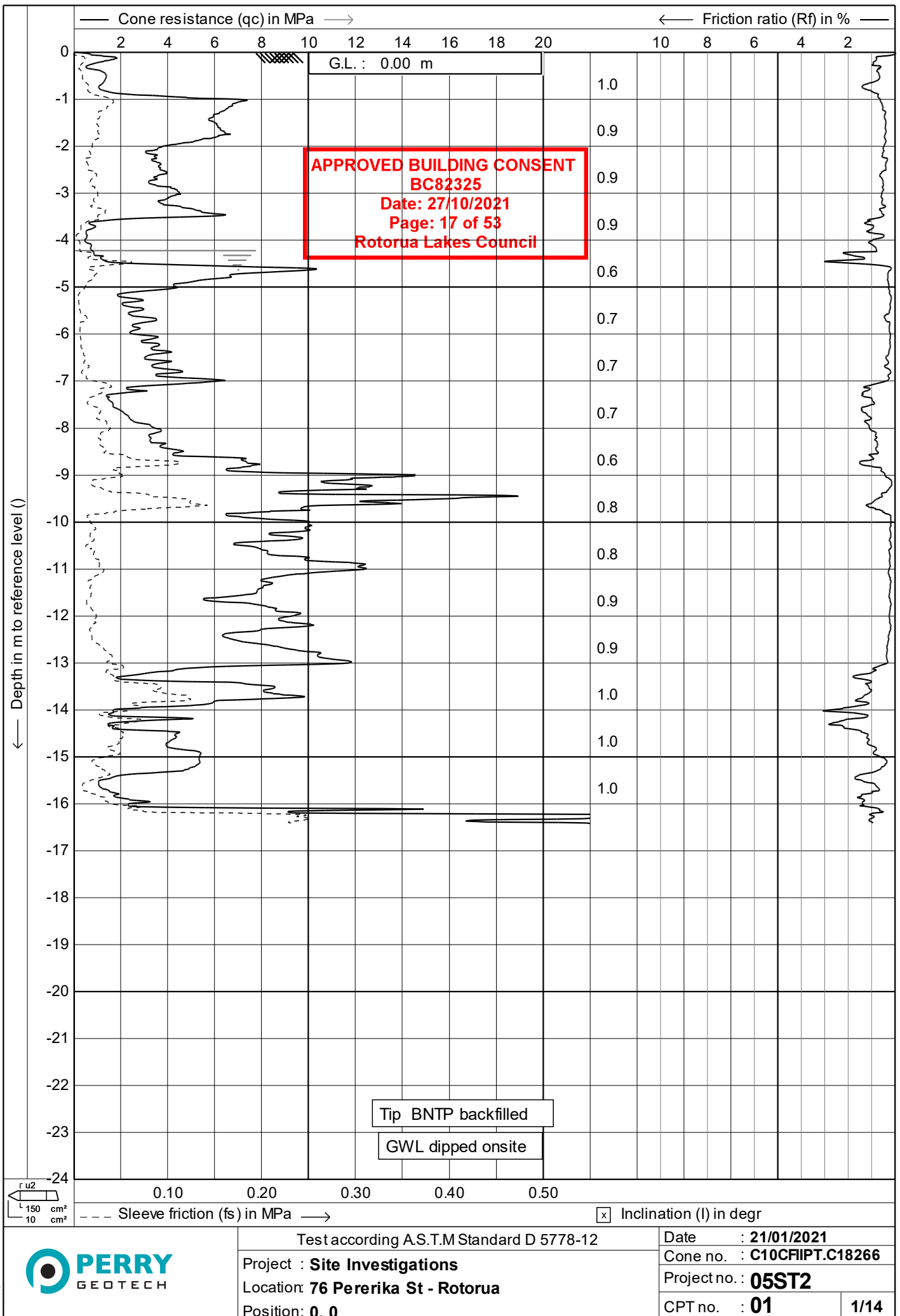
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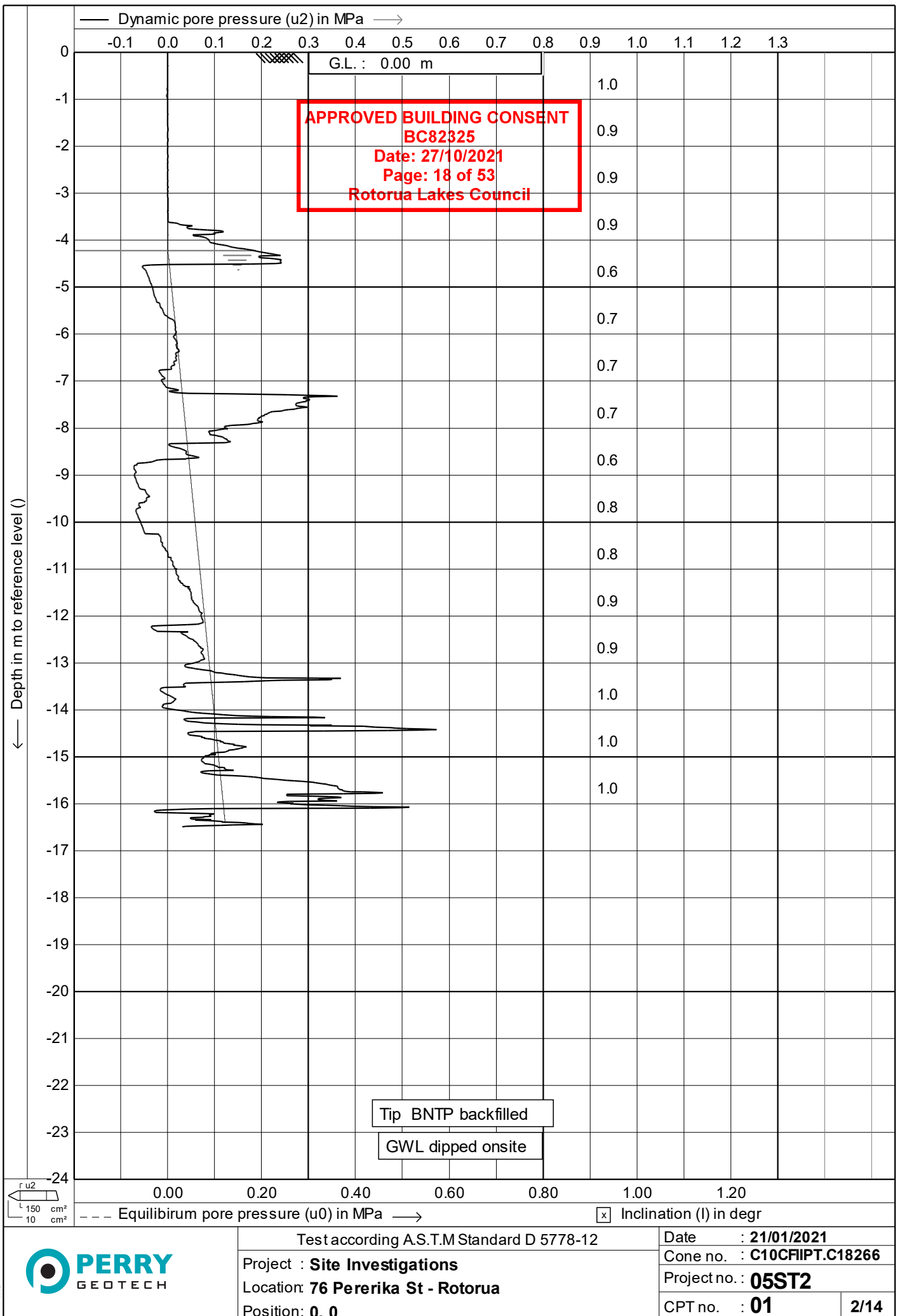


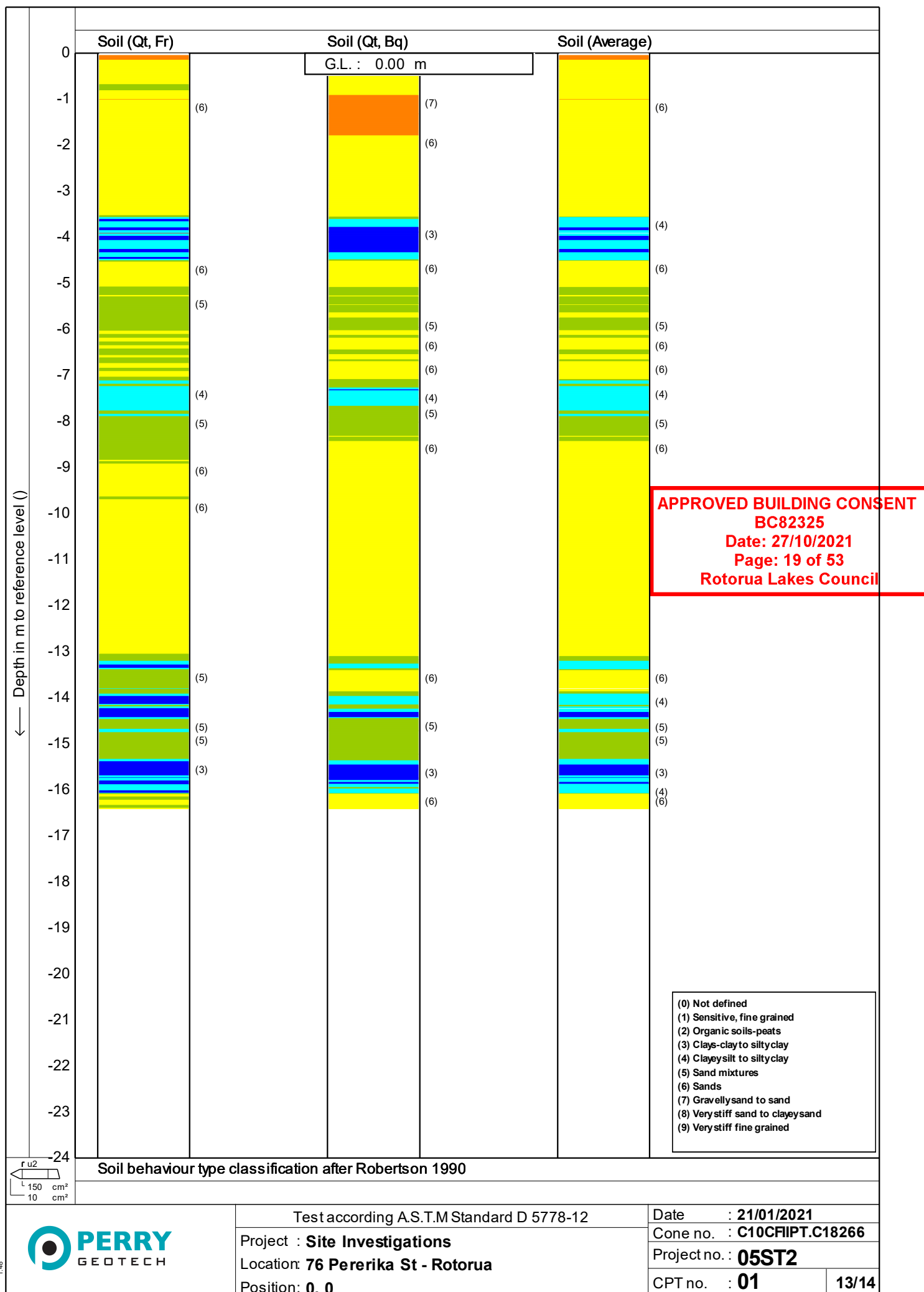
not gonna lie

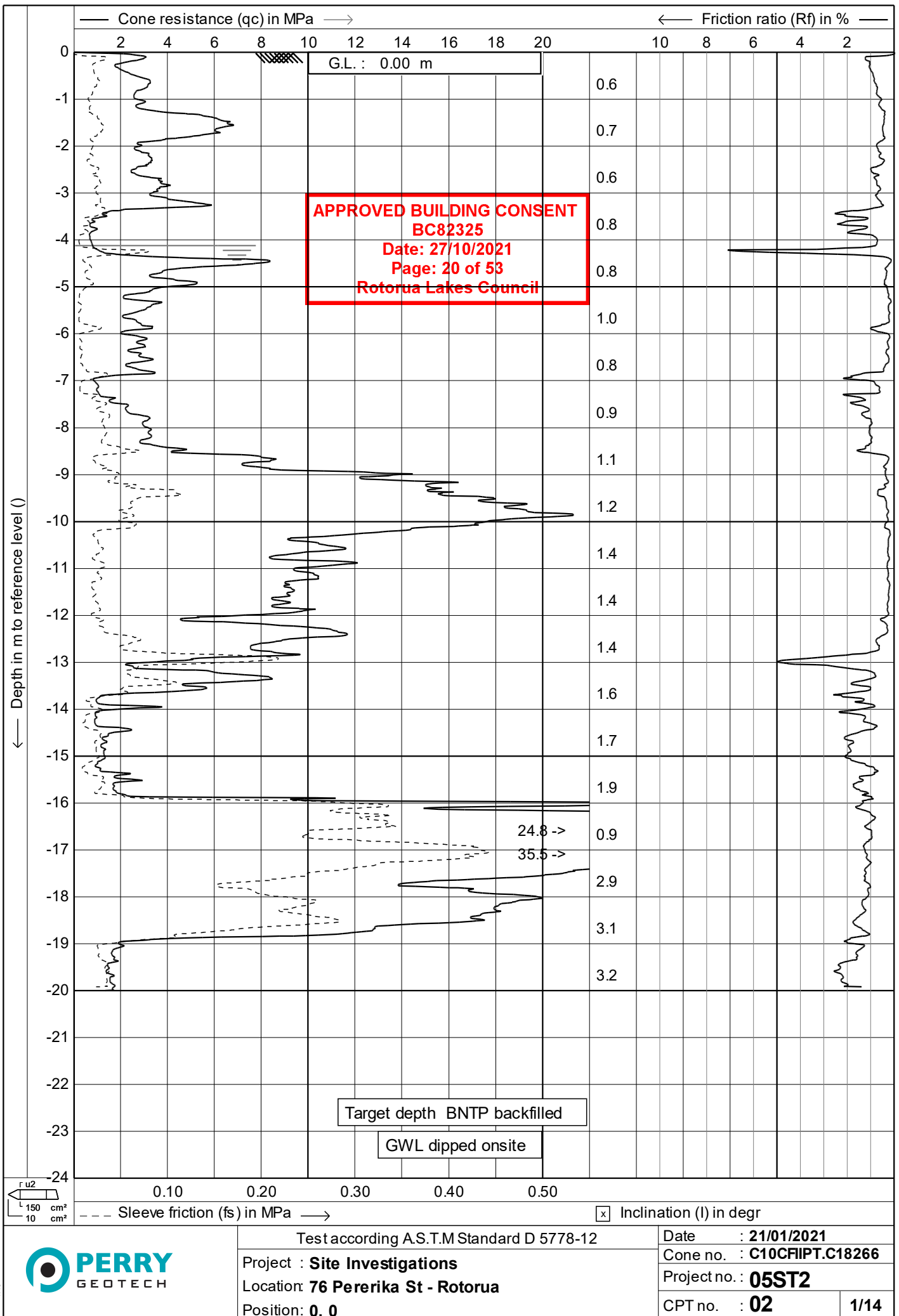
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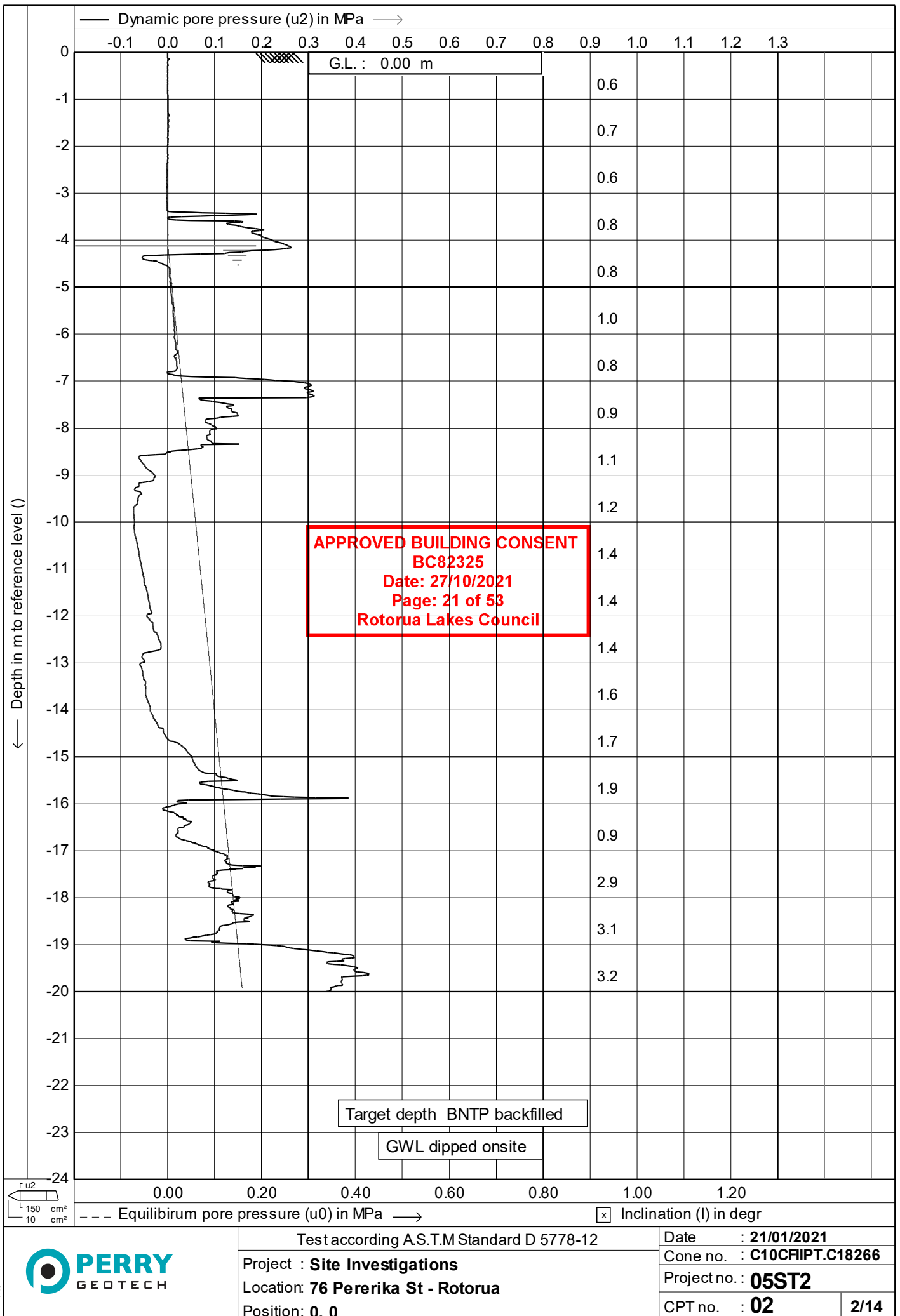
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- HA#** Hand Augered Borehole
- SP#** Scala Penetrometer
-  Cone Penetration Test (CPT)

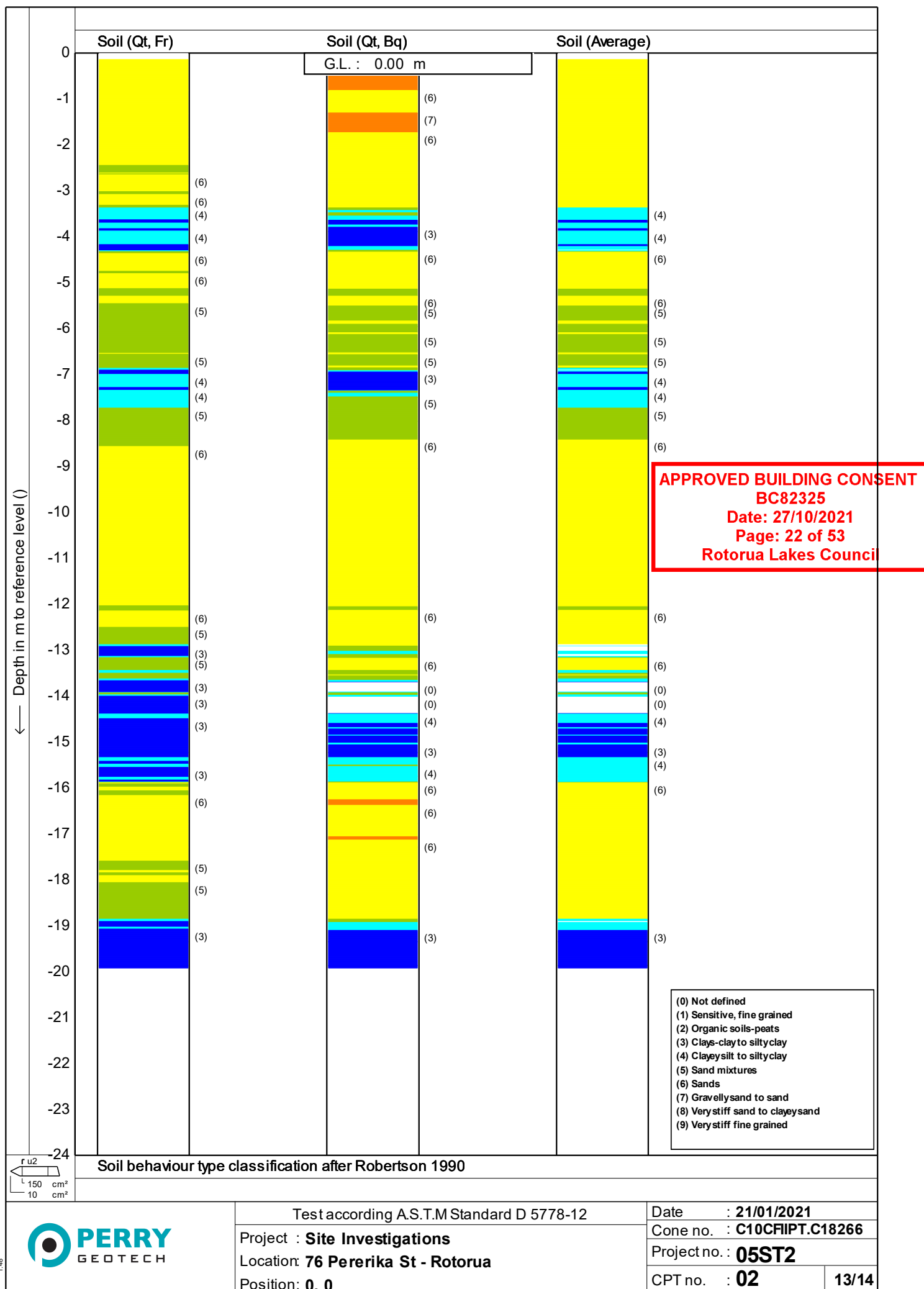


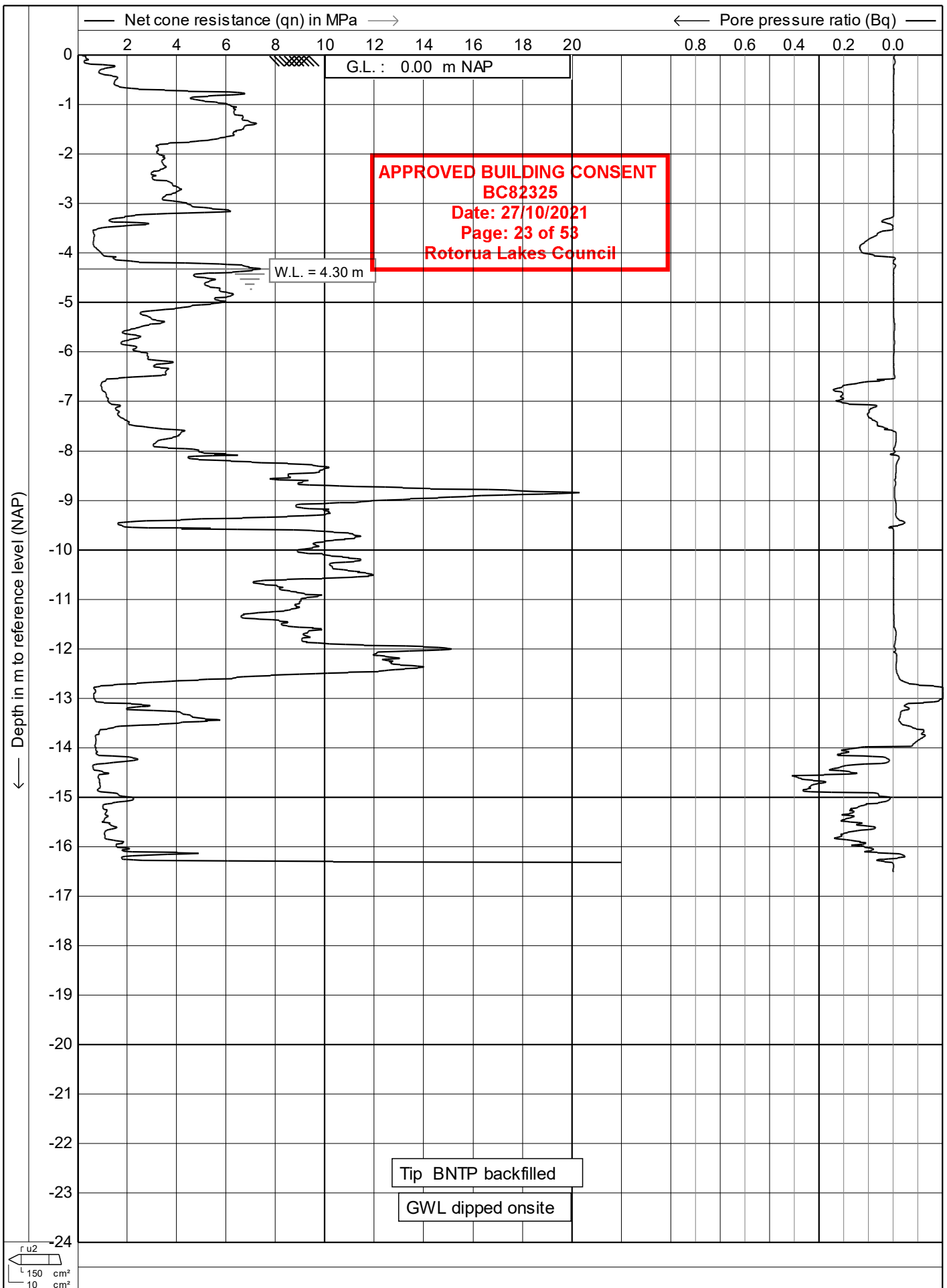












Test According A.S.T.M Standard D5778-12

Project : Site Investigations

Location: 76 Pererika St - Rototua

Position: 0, 0 RD

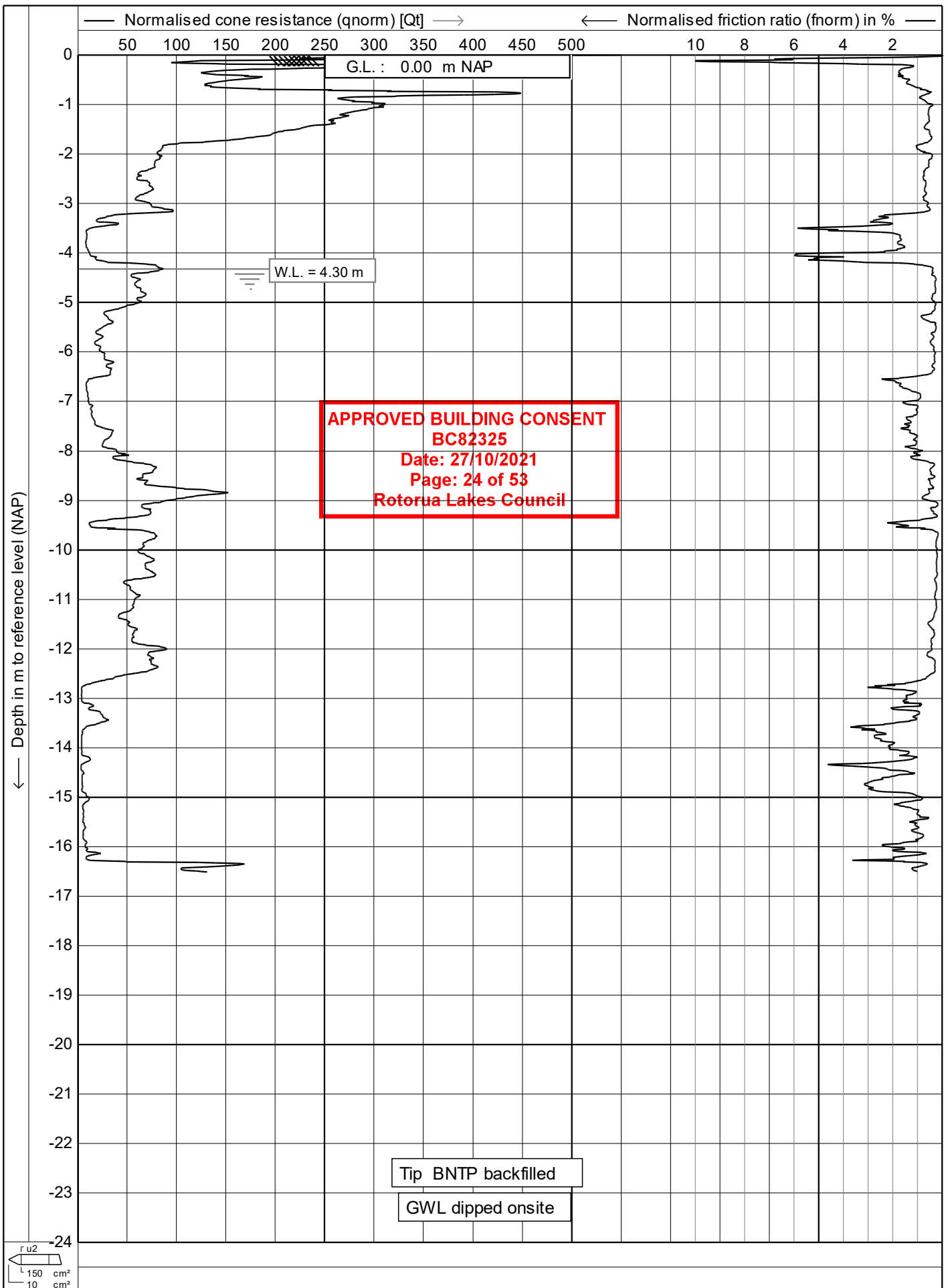
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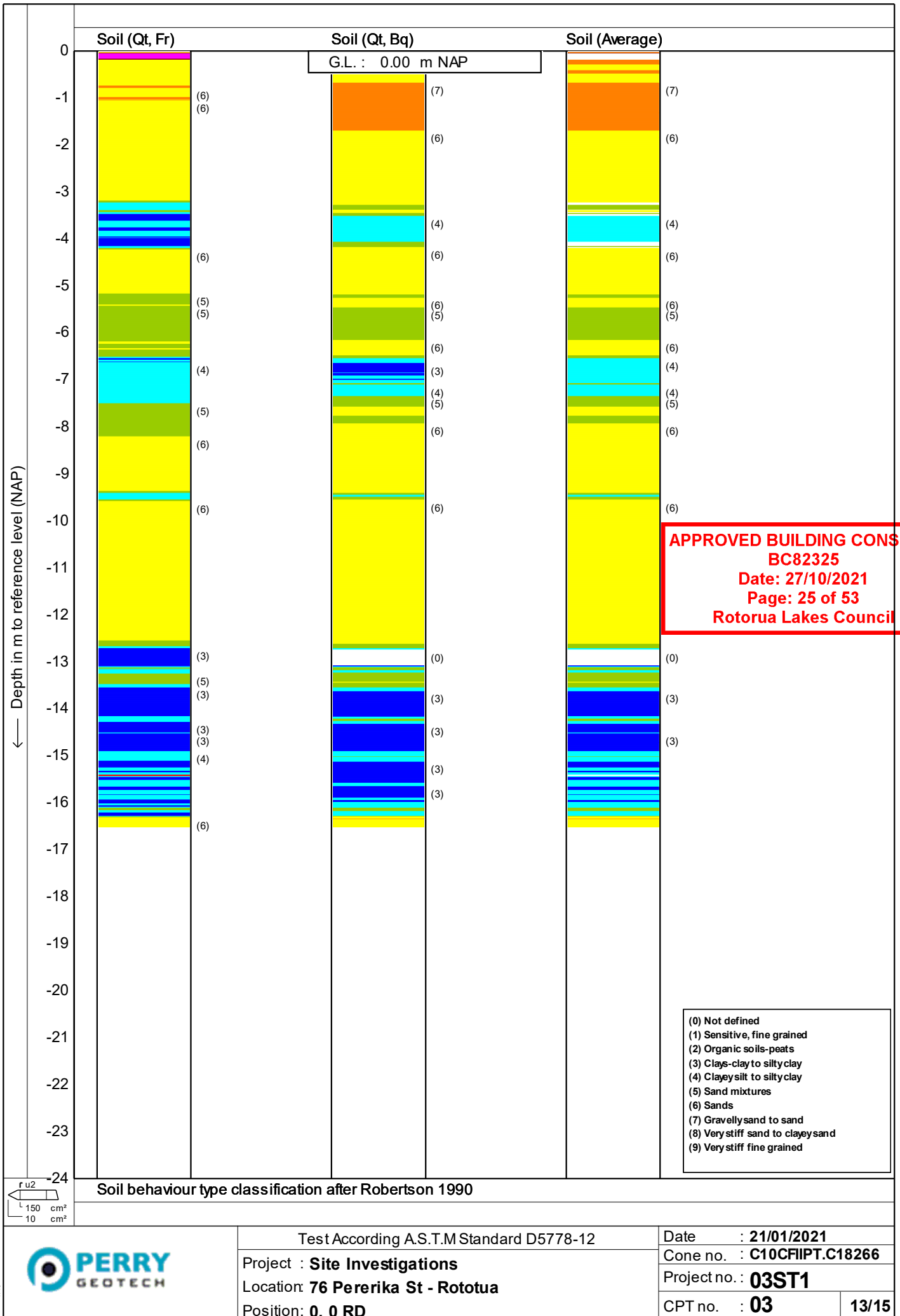
Project no. : 03ST1

CPT no. : 03

7/15



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	Location: 76 Pererika St - Rototua		Project no. : 03ST1	
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			8/15	



Client: GT Homes Ltd
Project Title: Geotechnical Assessment

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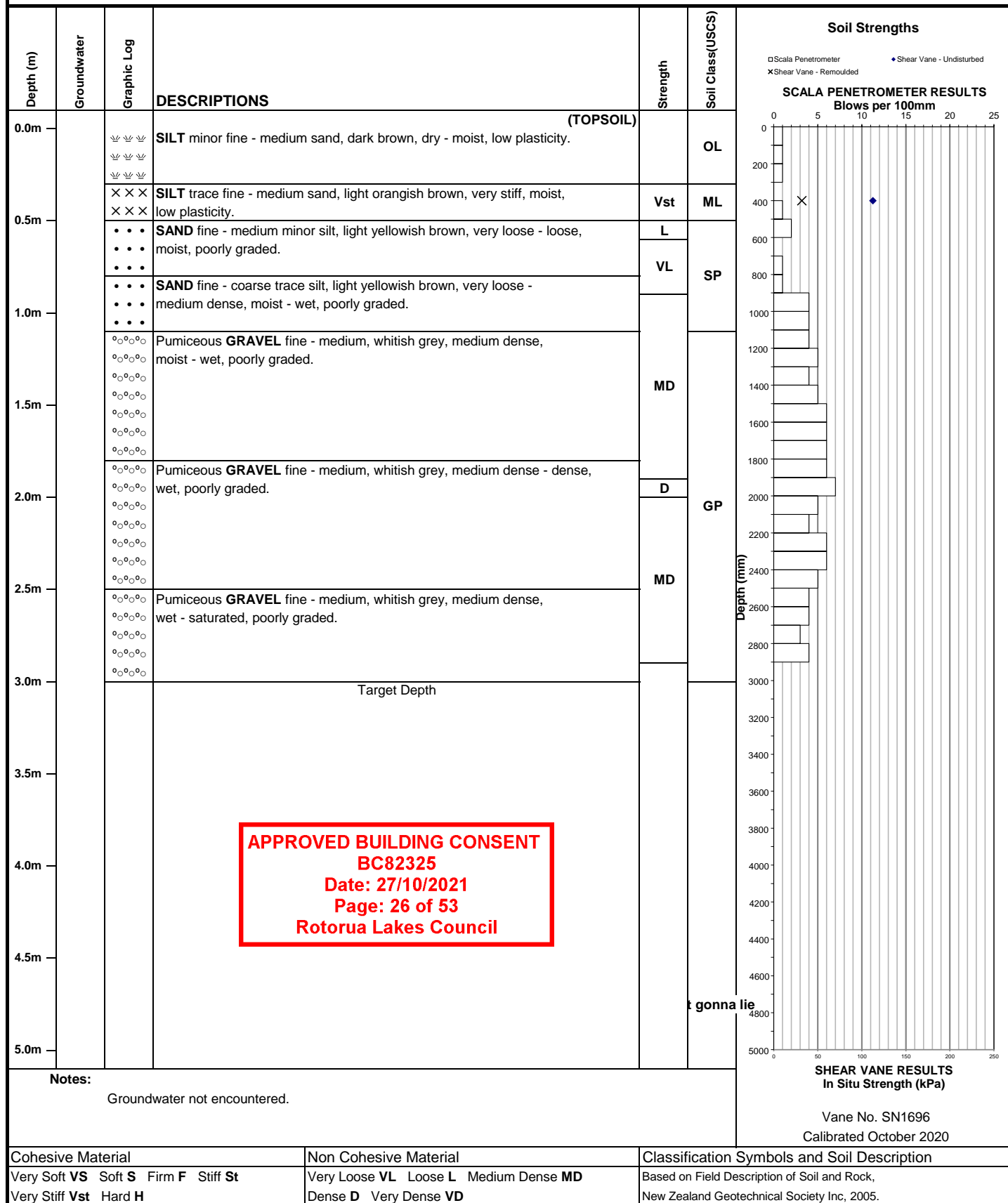
Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S001

Date: 14/01/2021
Logged By: SG
Checked: JNF

Hand Augered Borehole

Borehole No : HA01

Associated Penetrometer No : SP01



Notes:
 Groundwater not encountered.

Cohesive Material	Non Cohesive Material	Classification Symbols and Soil Description
Very Soft VS Soft S Firm F Stiff St	Very Loose VL Loose L Medium Dense MD	Based on Field Description of Soil and Rock,
Very Stiff Vst Hard H	Dense D Very Dense VD	New Zealand Geotechnical Society Inc, 2005.

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Logged By: SG
Checked: JNF



Associated Penetrometer No : SP02

Depth (m)	Groundwater	Graphic Log	DESCRIPTIONS	Strength	Soil Class(USCS)	Soil Strengths
0.0m			(TOPSOIL) SILT minor fine - medium sand, dark brown, dry - moist, low plasticity.		OL	<div>Soil Strengths</div> <div>□ Scala Penetrometer ◆ Shear Vane - Undisturbed ✕ Shear Vane - Remoulded</div> <div>SCALA PENETROMETER RESULTS</div> <div>Blows per 100mm</div>
0.5m			Fine SAND minor silt, light orangish brown, very loose, moist, poorly graded.	VL	SP	
			SAND fine - coarse trace silt, light yellowish brown, very loose, moist, poorly graded.			
1.0m			Fine pumiceous GRAVEL trace sand fine - coarse, light yellowish brown, loose - medium dense, moist - wet, poorly graded.	L	GP	
			Pumiceous GRAVEL fine - medium, whitish grey, medium dense - dense, moist - wet, poorly graded.	MD		
1.5m				D		
2.0m			Pumiceous GRAVEL fine - medium, whitish grey, medium dense - dense, wet, poorly graded.	MD		
2.5m						
3.0m			Pumiceous GRAVEL fine - medium, whitish grey, very loose - medium dense, wet - saturated, poorly graded.			
3.5m			<div>APPROVED BUILDING CONSENT BC82325 Date: 27/10/2021 Page: 27 of 53 Rotorua Lakes Council</div>			
4.0m						
4.5m						
5.0m						
			Target Depth			
Notes: Groundwater encountered at 4.3m						<div>SHEAR VANE RESULTS</div> <div>In Situ Strength (kPa)</div> <div>Vane No. SN1696</div> <div>Calibrated October 2020</div>
Cohesive Material			Non Cohesive Material		Classification Symbols and Soil Description	
Very Soft VS Soft S Firm F Stiff St			Very Loose VL Loose L Medium Dense MD		Based on Field Description of Soil and Rock,	
Very Stiff Vst Hard H			Dense D Very Dense VD		New Zealand Geotechnical Society Inc, 2005.	

Client: GT Homes Ltd
Project Title: Geotechnical Assessment

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Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S001

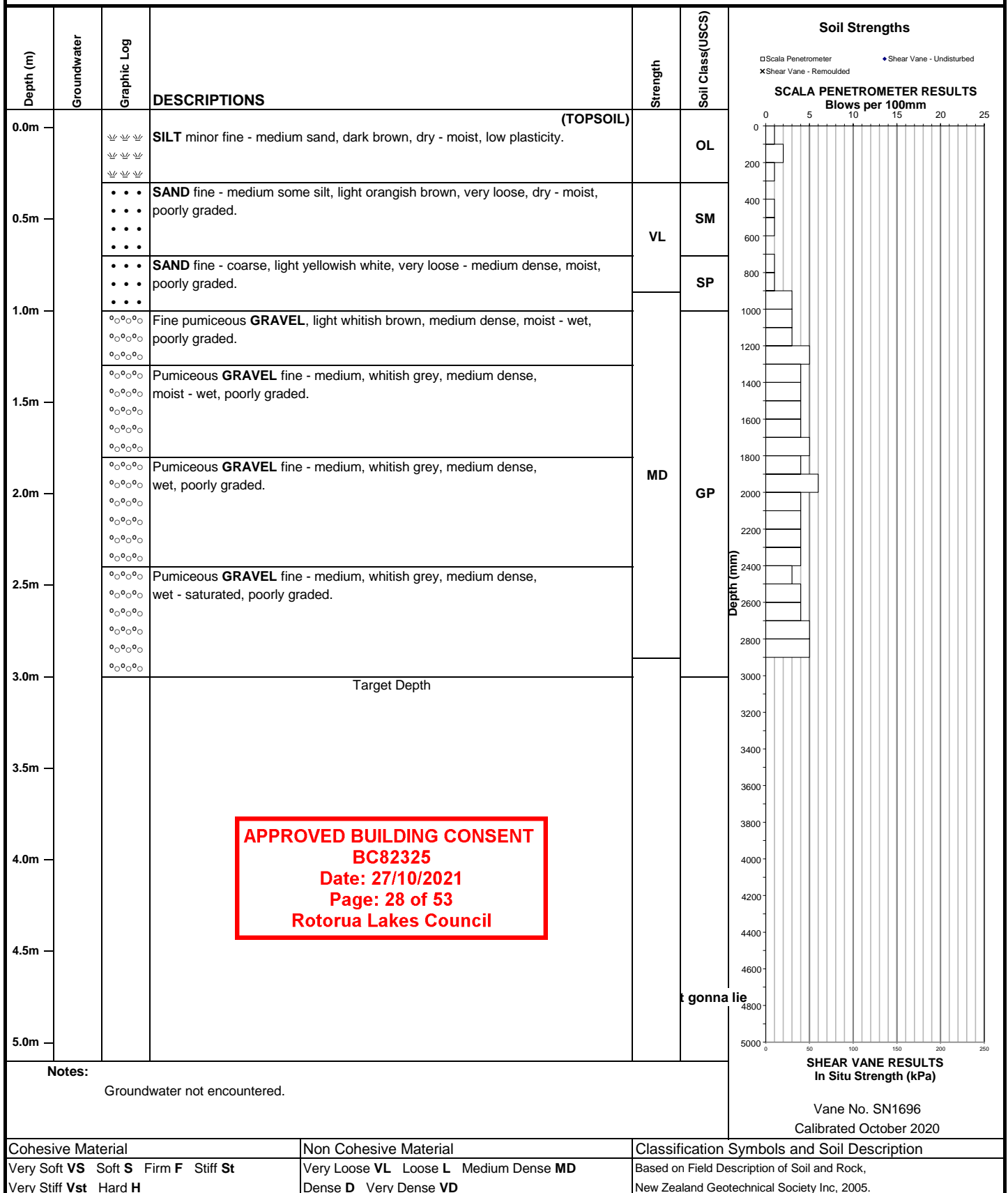
Date: 14/01/2021
Logged By: SG
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Hand Augered Borehole

Borehole No : HA03

Associated Penetrometer No : SP03



Notes:
 Groundwater not encountered.

Cohesive Material	Non Cohesive Material	Classification Symbols and Soil Description
Very Soft VS Soft S Firm F Stiff St	Very Loose VL Loose L Medium Dense MD	Based on Field Description of Soil and Rock,
Very Stiff Vst Hard H	Dense D Very Dense VD	New Zealand Geotechnical Society Inc, 2005.

Client: GT Homes Ltd
Project Title: Geotechnical Assessment
Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S001

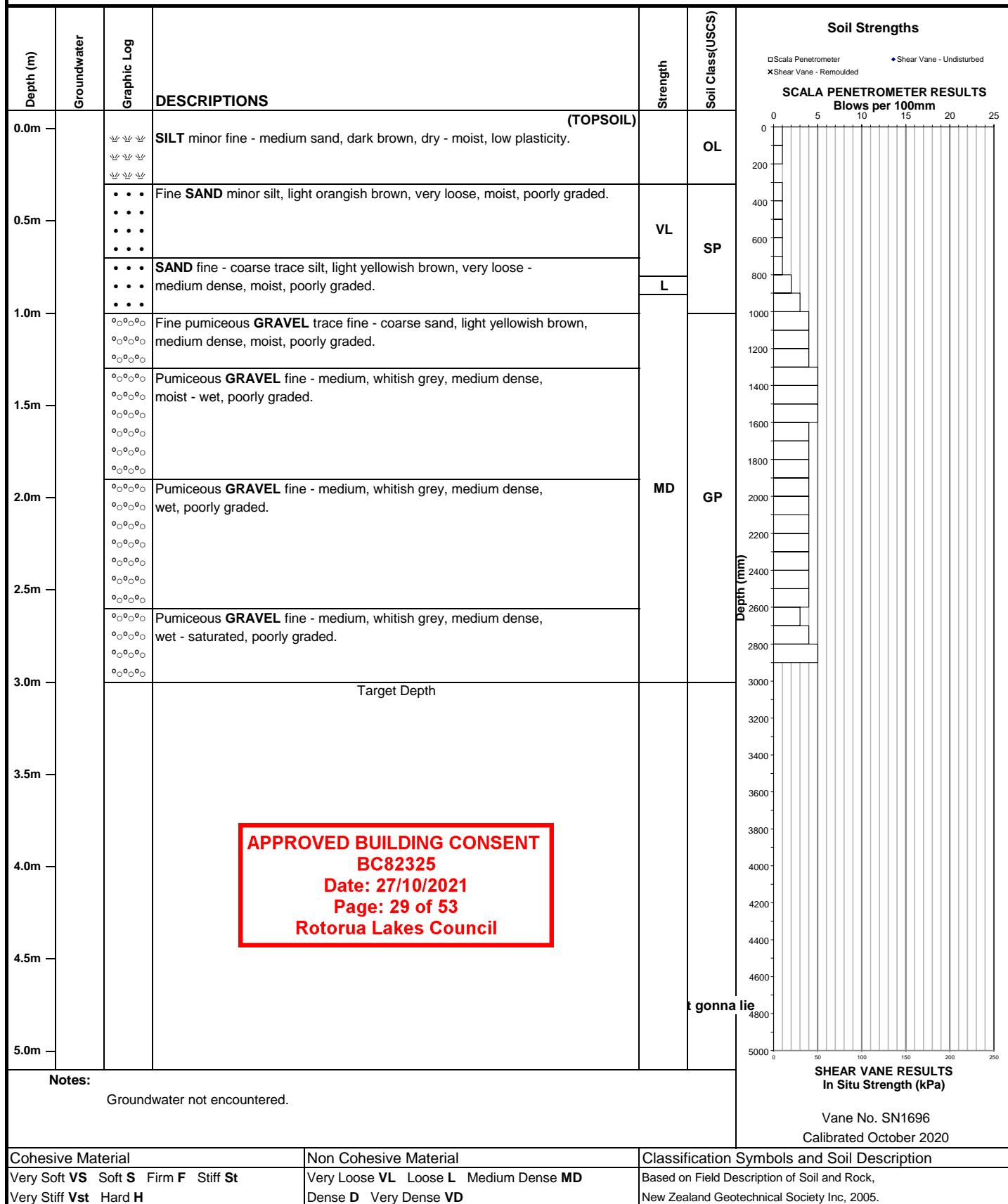
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Date: 14/01/2021
Logged By: SG
Checked: JNF



Hand Augered Borehole

Borehole No : HA04

Associated Penetrometer No : SP04



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Project Title: Geotechnical Assessment

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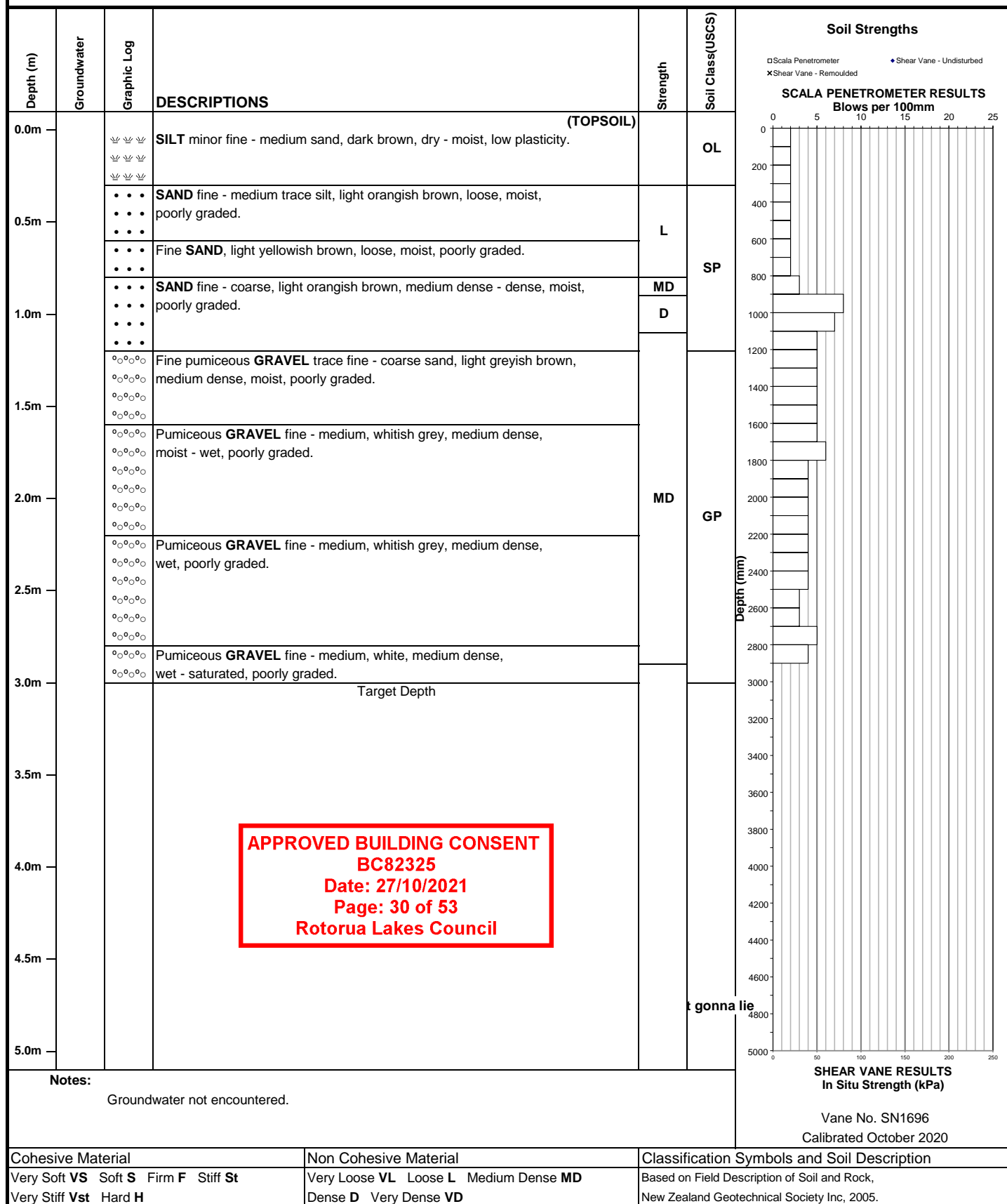
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City: Rotorua
File Number: 233257-R-E-S001

Date: 14/01/2021
Logged By: SG
Checked: JNF

Hand Augered Borehole

Borehole No : HA05

Associated Penetrometer No : SP05



Notes:
 Groundwater not encountered.

Cohesive Material	Non Cohesive Material	Classification Symbols and Soil Description
Very Soft VS Soft S Firm F Stiff St	Very Loose VL Loose L Medium Dense MD	Based on Field Description of Soil and Rock,
Very Stiff Vst Hard H	Dense D Very Dense VD	New Zealand Geotechnical Society Inc, 2005.

Client: GT Homes Ltd
Project Title: Geotechnical Assessment
Site Address: 76 Pererika Street
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Date: 14/01/2021
Logged By: SG
Checked: JNF



Hand Augered Borehole

Borehole No : HA06

Associated Penetrometer No : SP06

Depth (m)	Groundwater	Graphic Log	DESCRIPTIONS	Strength	Soil Class(USCS)	<div>Soil Strengths</div> <div>□ Scala Penetrometer ◆ Shear Vane - Undisturbed ✕ Shear Vane - Remoulded</div> <div>SCALA PENETROMETER RESULTS</div> <div>Blows per 100mm</div> <div></div> <div>SHEAR VANE RESULTS</div> <div>In Situ Strength (kPa)</div> <div></div> <div>Vane No. SN1696</div> <div>Calibrated October 2020</div>	
0.0m		≡ ≡ ≡ ≡ ≡ ≡ ≡ ≡ ≡	(TOPSOIL) SILT minor fine - medium sand, dark brown, dry - moist, low plasticity.		OL		
0.5m		• • • • • • • • • • • •	SAND fine - medium minor silt, light orangish brown, very loose - loose, moist, poorly graded.	VL	SP		
				L			
		• • • • • • • • • • • •	Fine SAND, light greyish brown, very loose - medium dense, moist, poorly graded.	VL			
				L			
1.0m		• • • • • • • • • • • •	SAND fine - coarse, light orangish brown, medium dense, moist, poorly graded.	MD	GP		
1.5m		○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	Fine pumiceous GRAVEL trace fine - coarse sand, light whitish brown, medium dense - dense, moist, poorly graded.	D			
2.0m		○ ○	Pumiceous GRAVEL fine - medium, whitish grey, medium dense, moist - wet, poorly graded.	MD			
2.5m		○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	Pumiceous GRAVEL fine - medium, white, medium dense, wet, poorly graded.	MD			
3.0m		○ ○	Pumiceous GRAVEL fine - medium, greyish white, medium dense - dense, wet - saturated, poorly graded.				D MD
3.5m		○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	Pumiceous GRAVEL fine - medium trace silt, white, very loose - loose, wet - saturated, poorly graded.	VL			not gonna lie
4.0m				L			
				VL			
				L			
				MD			
4.5m			Could not retrieve sample due to collapsing.				
			<div>APPROVED BUILDING CONSENT BC82325 Date: 27/10/2021 Page: 31 of 53 Rotorua Lakes Council</div>				
5.0m							
Notes: Groundwater not encountered.							
Cohesive Material			Non Cohesive Material		Classification Symbols and Soil Description		
Very Soft VS Soft S Firm F Stiff St			Very Loose VL Loose L Medium Dense MD		Based on Field Description of Soil and Rock, New Zealand Geotechnical Society Inc, 2005.		
Very Stiff Vst Hard H			Dense D Very Dense VD				

Notes:

Groundwater not encountered.

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Cohesive Material	Non Cohesive Material	Classification Symbols and Soil Description
Very Soft VS Soft S Firm F Stiff St	Very Loose VL Loose L Medium Dense MD	Based on Field Description of Soil and Rock,
Very Stiff Vst Hard H	Dense D Very Dense VD	New Zealand Geotechnical Society Inc, 2005.

Client: GT Homes Ltd
Project Title: Geotechnical Assessment

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Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S001

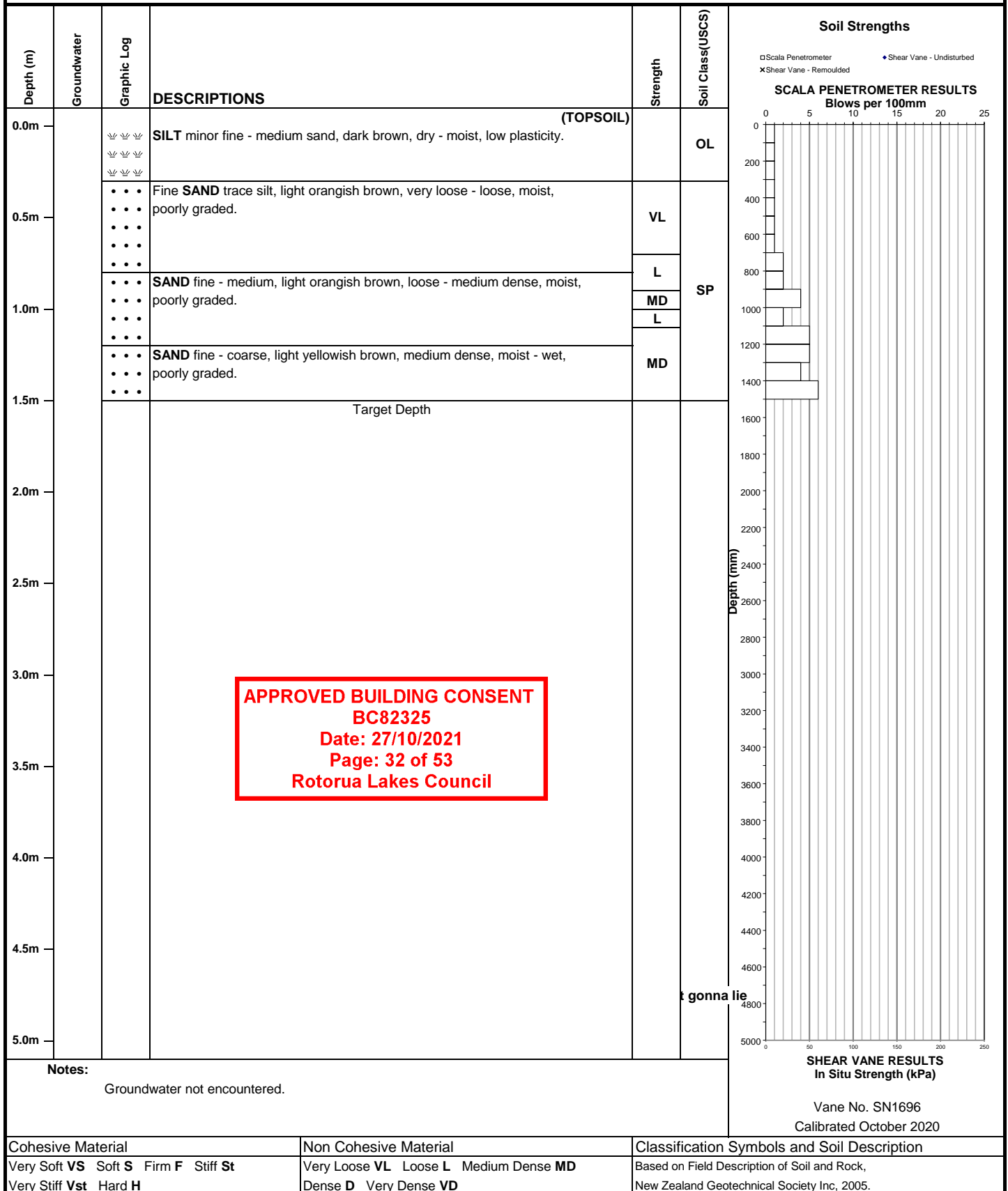
Date: 14/01/2021
Logged By: SG
Checked: JNF



Hand Augered Borehole

Borehole No : HA07

Associated Penetrometer No : SP07



Notes:
 Groundwater not encountered.

Cohesive Material	Non Cohesive Material	Classification Symbols and Soil Description
Very Soft VS Soft S Firm F Stiff St	Very Loose VL Loose L Medium Dense MD	Based on Field Description of Soil and Rock,
Very Stiff Vst Hard H	Dense D Very Dense VD	New Zealand Geotechnical Society Inc, 2005.

Client: GT Homes Ltd
Project Title: Geotechnical Assessment
Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S001

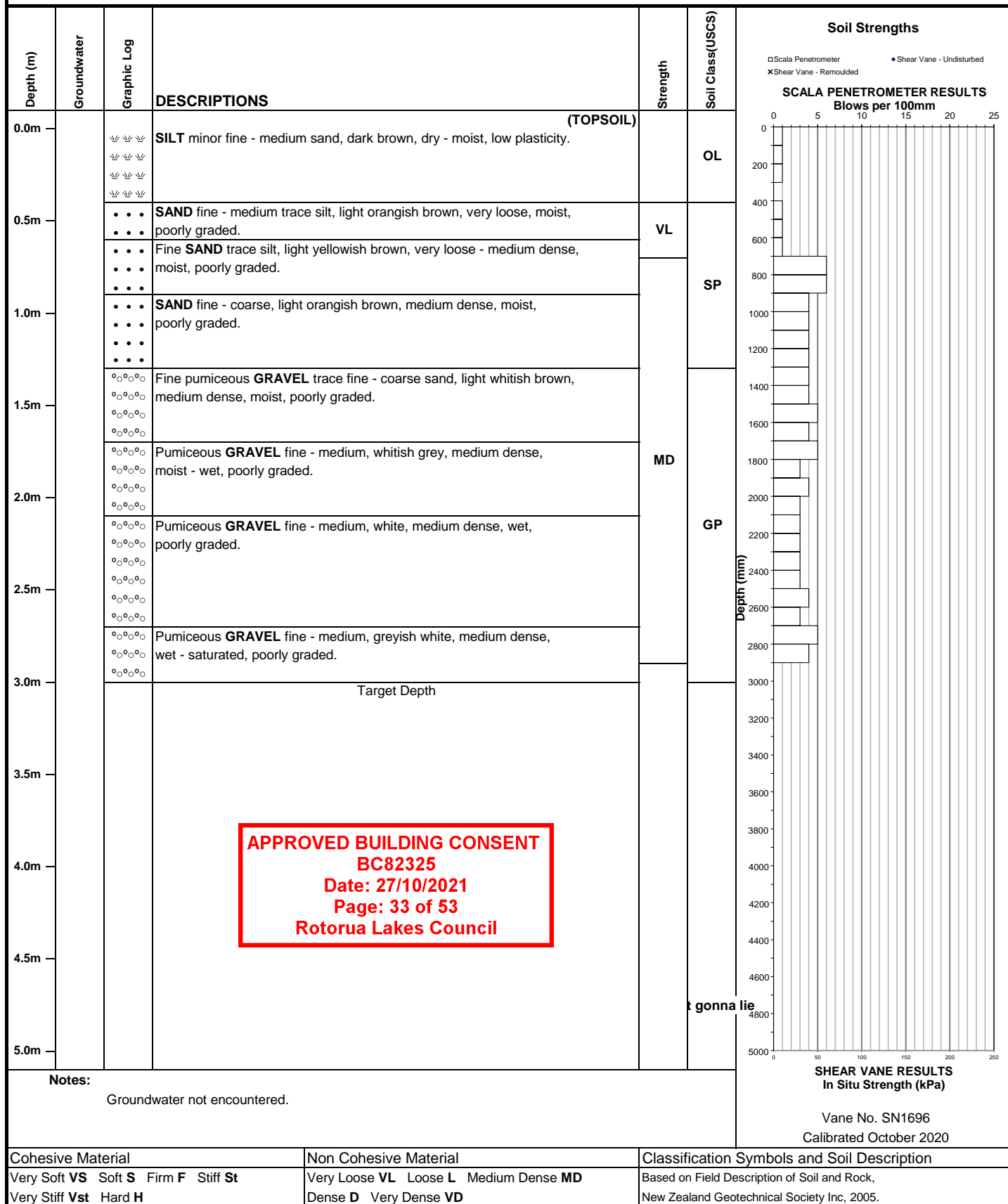
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Logged By: SG
Checked: JNF



Hand Augered Borehole

Borehole No : HA08

Associated Penetrometer No : SP08



Notes:
 Groundwater not encountered.

Cohesive Material	Non Cohesive Material	Classification Symbols and Soil Description
Very Soft VS Soft S Firm F Stiff St	Very Loose VL Loose L Medium Dense MD	Based on Field Description of Soil and Rock,
Very Stiff Vst Hard H	Dense D Very Dense VD	New Zealand Geotechnical Society Inc, 2005.

Client: GT Homes Ltd
Project Title: Geotechnical Assessment

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Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S001

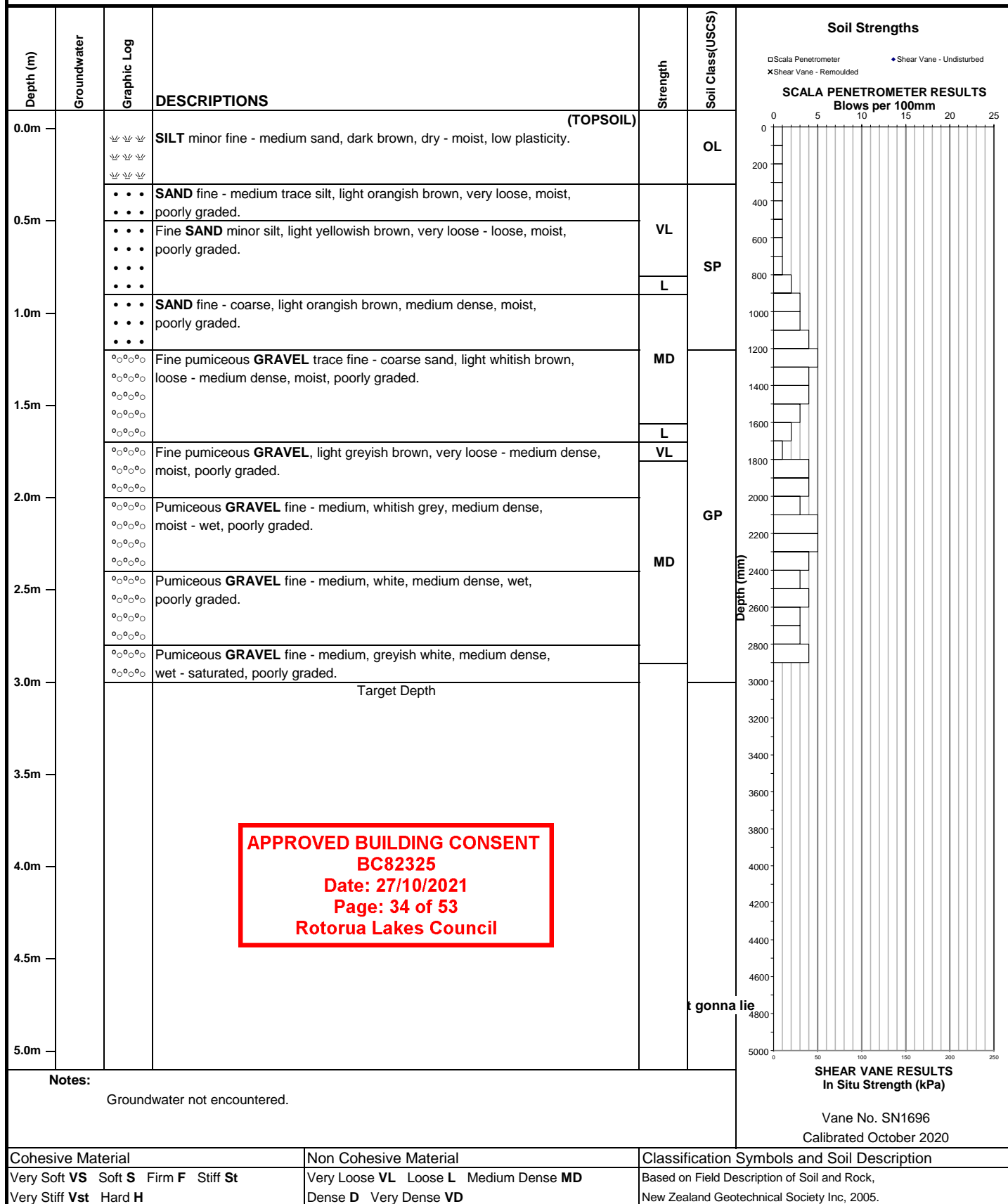
Date: 14/01/2021
Logged By: SG
Checked: JNF



Hand Augered Borehole

Borehole No : HA09

Associated Penetrometer No : SP09



Notes:
 Groundwater not encountered.

Cohesive Material	Non Cohesive Material	Classification Symbols and Soil Description
Very Soft VS Soft S Firm F Stiff St	Very Loose VL Loose L Medium Dense MD	Based on Field Description of Soil and Rock,
Very Stiff Vst Hard H	Dense D Very Dense VD	New Zealand Geotechnical Society Inc, 2005.

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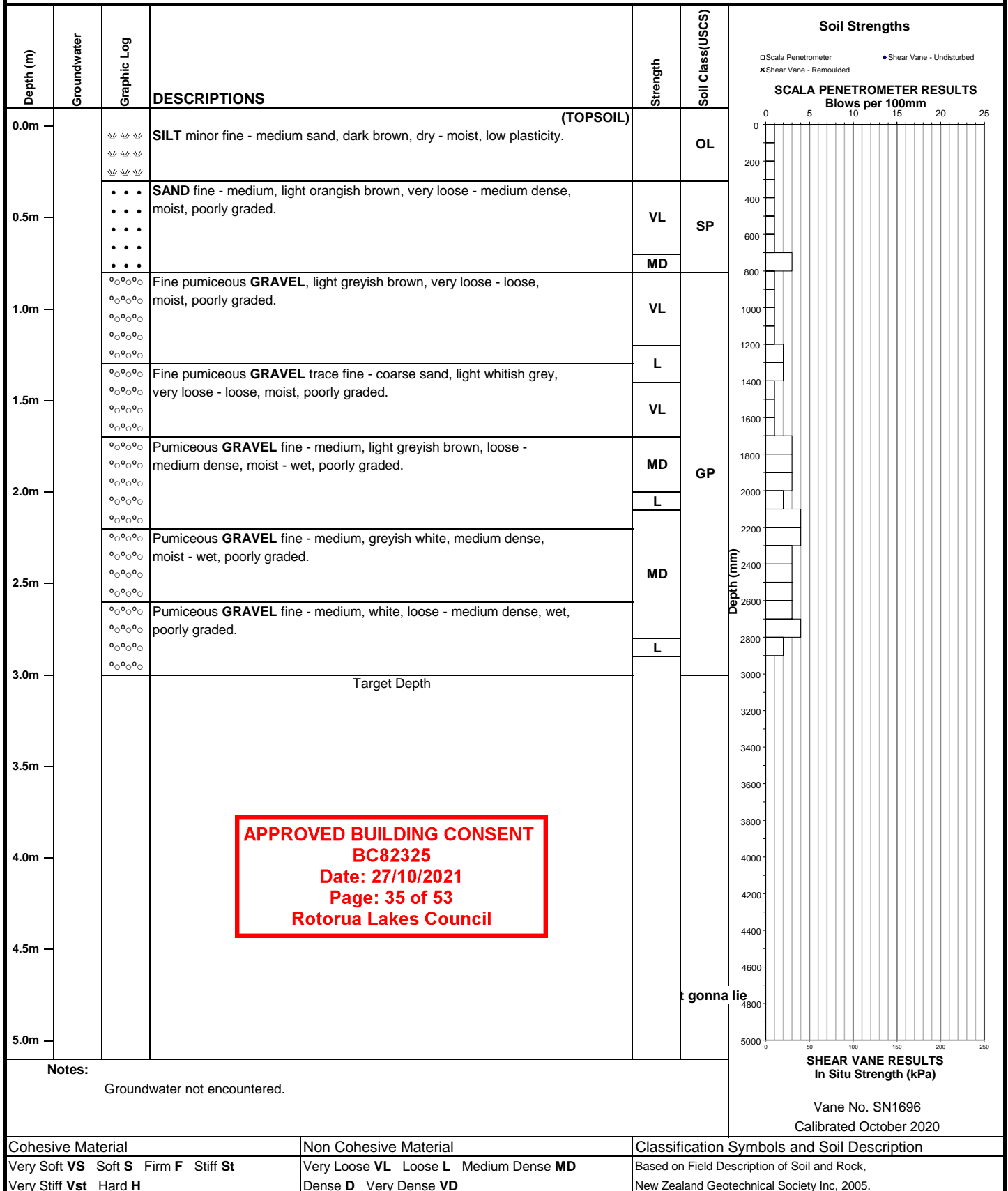
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Hand Augered Borehole

Borehole No : HA10

Associated Penetrometer No : SP10



Site Address: 76 Pererika Street

Date: 14/01/2021

City: Rotorua

Logged By: SG

File Number: 233257-R-E-S001

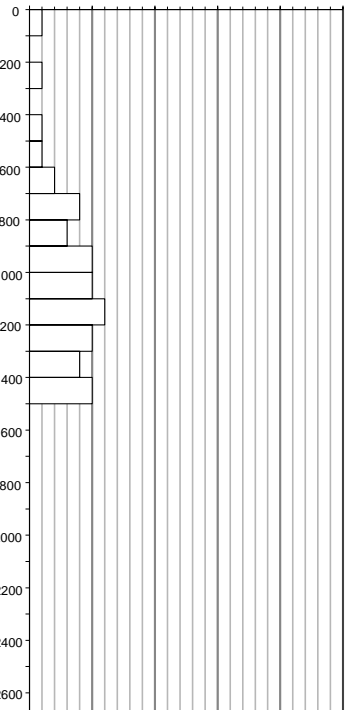
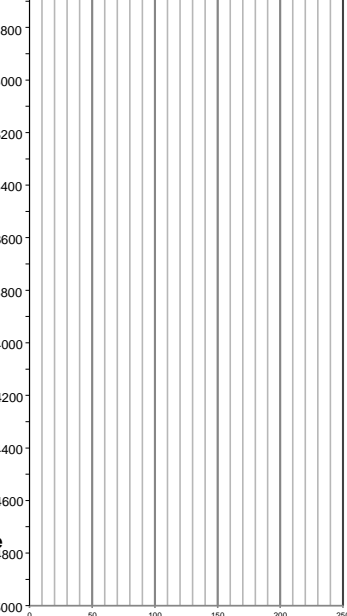
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Hand Augered Borehole

Borehole No : HA11

Associated Penetrometer No : SP11

Depth (m)	Groundwater	Graphic Log	DESCRIPTIONS	Strength	Soil Class(USCS)	Soil Strengths
0.0m		<div>⚡⚡⚡</div> <div>⚡⚡⚡</div> <div>⚡⚡⚡</div>	(TOPSOIL) SILT minor fine - medium sand, dark brown, dry - moist, low plasticity.		OL	<div>Soil Strengths</div> <div>□ Scala Penetrometer ◆ Shear Vane - Undisturbed ✕ Shear Vane - Remoulded</div> <div>SCALA PENETROMETER RESULTS</div> <div>Blows per 100mm</div> <div></div> <div>SHEAR VANE RESULTS</div> <div>In Situ Strength (kPa)</div> <div></div> <div>Vane No. SN1696</div> <div>Calibrated October 2020</div>
0.5m		<div>•••</div> <div>•••</div> <div>•••</div> <div>•••</div>	Fine SAND , light orangish brown, very loose - loose, moist, poorly graded.	VL	SP	
				L		
1.0m		<div>•••</div> <div>•••</div> <div>•••</div> <div>•••</div>	SAND fine - medium, light yellowish brown, medium dense, moist, poorly graded.	MD	GP	
		<div>○°○°○°</div> <div>○°○°○°</div> <div>○°○°○°</div> <div>○°○°○°</div>	Fine pumiceous GRAVEL , light greyish brown, medium dense, moist, poorly graded.			
1.5m		Target Depth				
2.0m						
2.5m						
3.0m						
3.5m						
4.0m						
4.5m						
5.0m						
Notes: Groundwater not encountered.						
Cohesive Material			Non Cohesive Material		Classification Symbols and Soil Description	
Very Soft VS Soft S Firm F Stiff St			Very Loose VL Loose L Medium Dense MD		Based on Field Description of Soil and Rock,	
Very Stiff Vst Hard H			Dense D Very Dense VD		New Zealand Geotechnical Society Inc, 2005.	

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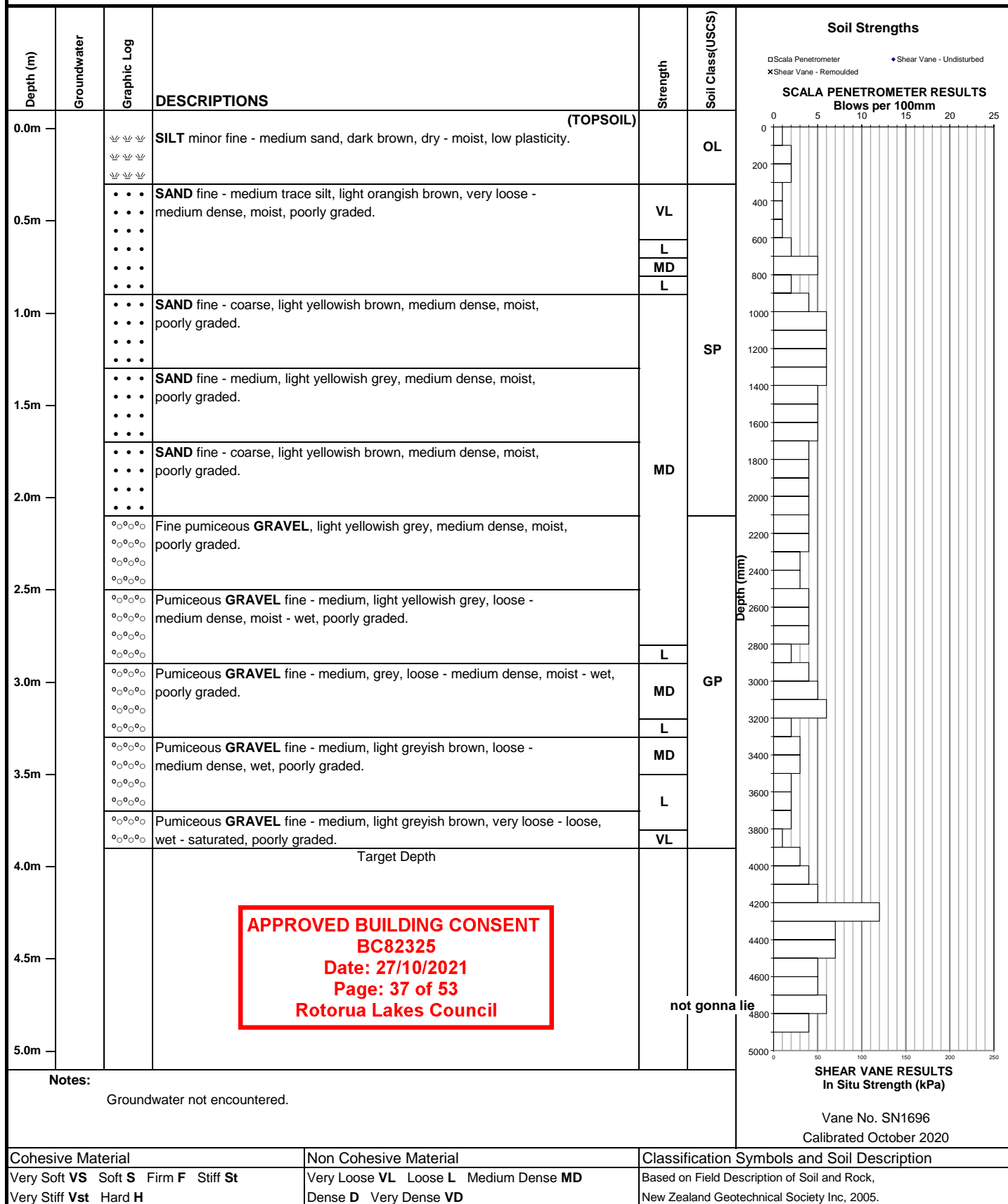
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Hand Augered Borehole

Borehole No : HA12

Associated Penetrometer No : SP12



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Site Address: 76 Pererika Street

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File Number: 233257-R-E-S001

Date Started: 11/01/2021

Date Finished: 14/01/2021

Logged By: SG



Shear Vane Test Results

Notes: UTP: Unable to penetrate.

Shear Vane readings are used to designate soil strength for cohesive soils only unless otherwise specified.

Shear Vane SN1696

Calibrated Oct-20

Constant 1.443

HA01				S/V No.		SN1696
Depth (mm)	Undisturbed			Remoulded		Sensitivity
	Reading	kPa	Strength	Reading	kPa	
400	78	113	Vst	22	32	3.5

HA02				S/V No.		SN1696
Depth (mm)	Undisturbed			Remoulded		Sensitivity
	Reading	kPa	Strength	Reading	kPa	
4100	73	105	Vst	22	32	3.3
4300	130	188	Vst	32	46	4.1
4500	140	202	H	40	58	3.5

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not gonna lie

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Date Started: 11/01/2021

Date Finished: 14/01/2021

Logged By: SG



Scala Penetrometer Results

Probe description: 9kg hammer falling 500mm striking a steel anvil driving a 16mm diameter rod fitted with a 20mm diameter cone

Depth of penetration begins at the existing ground level. Scala Penetrometer readings are used to designate soil strength for non-cohesive soils only unless otherwise specified.

Depth of Penetration	SP01	SP02	SP03	SP04	SP05	SP06	SP07	SP08
GL Start (mm)	Blows Per 100mm	Blows Per 100mm	Blows Per 100mm	Blows Per 100mm	Blows Per 100mm	Blows Per 100mm	Blows Per 100mm	Blows Per 100mm
0								
100	1	1	1	1	2	3	1	1
200	1	2	2	1	2	1	1	1
300	1	1	1	0	2	2	1	1
400	0	1	0	1	2	1	1	0
500	1	1	1	1	2	1	1	1
600	2	1	1	1	2	2	1	1
700	0	1	0	1	2	2	1	1
800	1	1	1	1	2	1	2	6
900	1	1	1	2	3	2	2	6
1000	4	2	3	3	8	3	4	4
1100	4	2	3	4	7	5	2	4
1200	4	5	3	4	5	6	5	4
1300	5	5	5	4	5	5	5	4
1400	4	7	4	5	5	5	4	4
1500	5	5	4	5	5	7	6	4
1600	6	5	4	5	5	5		5
1700	6	5	4	4	5	6		4
1800	6	5	5	4	6	5		5
1900	6	6	4	4	4	5		3
2000	7	5	6	4	4	5		4
2100	5	5	4	4	4	4		3
2200	4	4	4	4	4	4		3
2300	6	4	4	4	4	4		3
2400	6	4	4	4	4	4		3
2500	5	3	3	4	4	4		3
2600	4	3	4	4	3	4		4
2700	4	3	4	3	3	4		3
2800	3	3	5	4	5	4		5
2900	4	4	5	5	4	4		4
3000		4				4		
3100		4				4		
3200		4				5		
3300		4				4		
3400		4				7		
3500		4				4		
3600		6				1		
3700		4				2		
3800		1				2		
3900		1				1		
4000		1				2		
4100		2				2		
4200		2				3		
4300		3				3		
4400		2				4		
4500		3				4		
4600		2				5		
4700		3				7		
4800		4				4		
4900		2				5		
5000								

Notes:

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Date Started: 11/01/2021

Date Finished: 14/01/2021

Logged By: SG



Scala Penetrometer Results

Probe description: 9kg hammer falling 500mm striking a steel anvil driving a 16mm diameter rod fitted with a 20mm diameter cone

Depth of penetration begins at the existing ground level. Scala Penetrometer readings are used to designate soil strength for non-cohesive soils only unless otherwise specified.

Depth of Penetration	SP09	SP10	SP11	SP12				
GL Start (mm)	Blows Per 100mm	Blows Per 100mm	Blows Per 100mm	Blows Per 100mm				
0								
100	1	1	1	1				
200	1	1	0	2				
300	1	1	1	2				
400	1	1	0	1				
500	1	1	1	1				
600	1	1	1	1				
700	1	1	2	2				
800	1	3	4	5				
900	2	1	3	2				
1000	3	1	5	4				
1100	3	1	5	6				
1200	4	1	6	6				
1300	5	2	5	6				
1400	4	2	4	6				
1500	4	1	5	5				
1600	3	1		5				
1700	2	1		5				
1800	1	3		4				
1900	4	3		4				
2000	4	3		4				
2100	3	2		4				
2200	5	4		4				
2300	5	4		4				
2400	4	3		3				
2500	3	3		3				
2600	4	3		4				
2700	3	3		4				
2800	3	4		4				
2900	4	2		2				
3000				4				
3100				5				
3200				6				
3300				2				
3400				3				
3500				3				
3600				2				
3700				2				
3800				2				
3900				1				
4000				3				
4100				4				
4200				5				
4300				12				
4400				7				
4500				7				
4600				5				
4700				5				
4800				6				
4900				4				
5000								

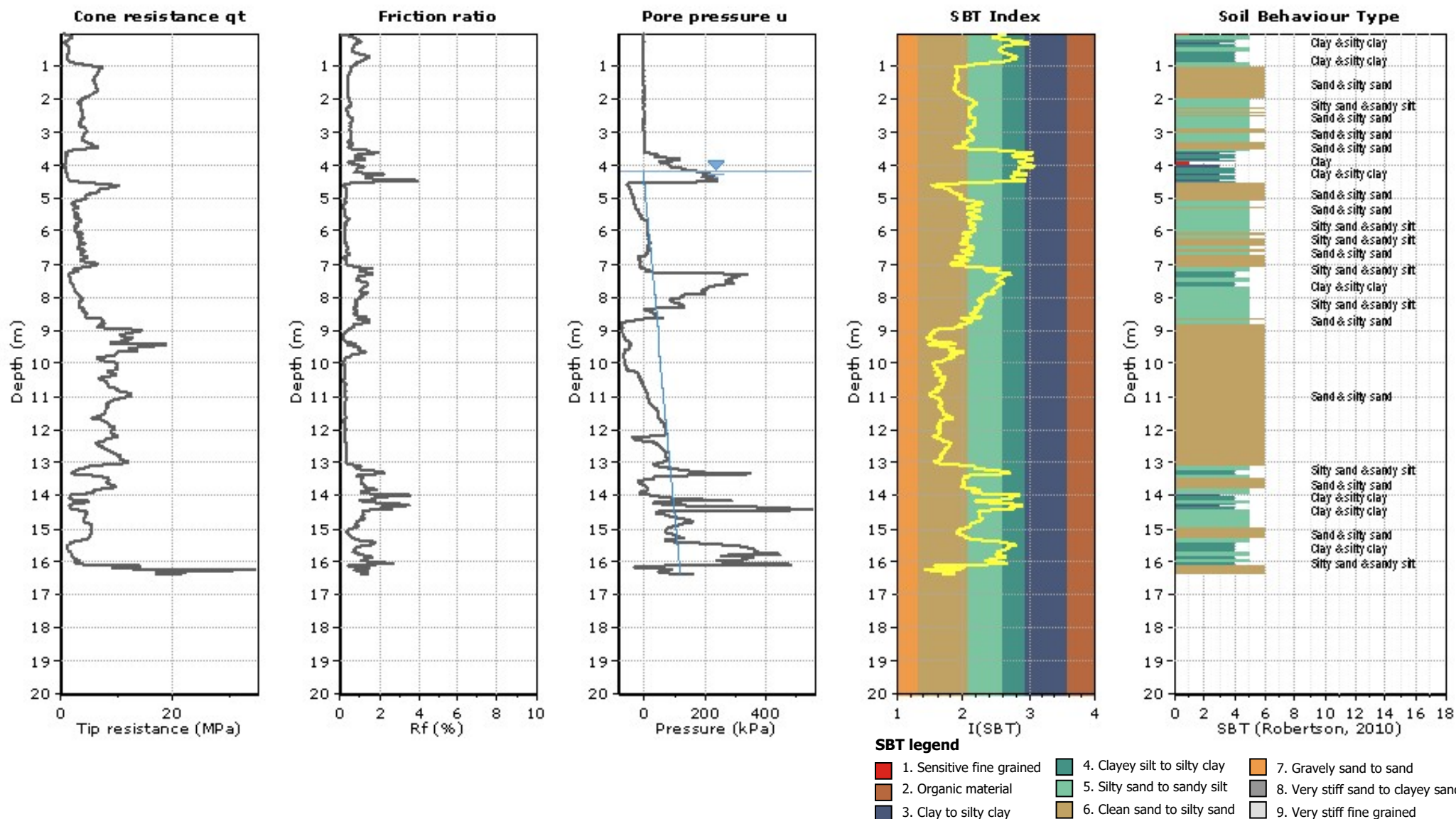
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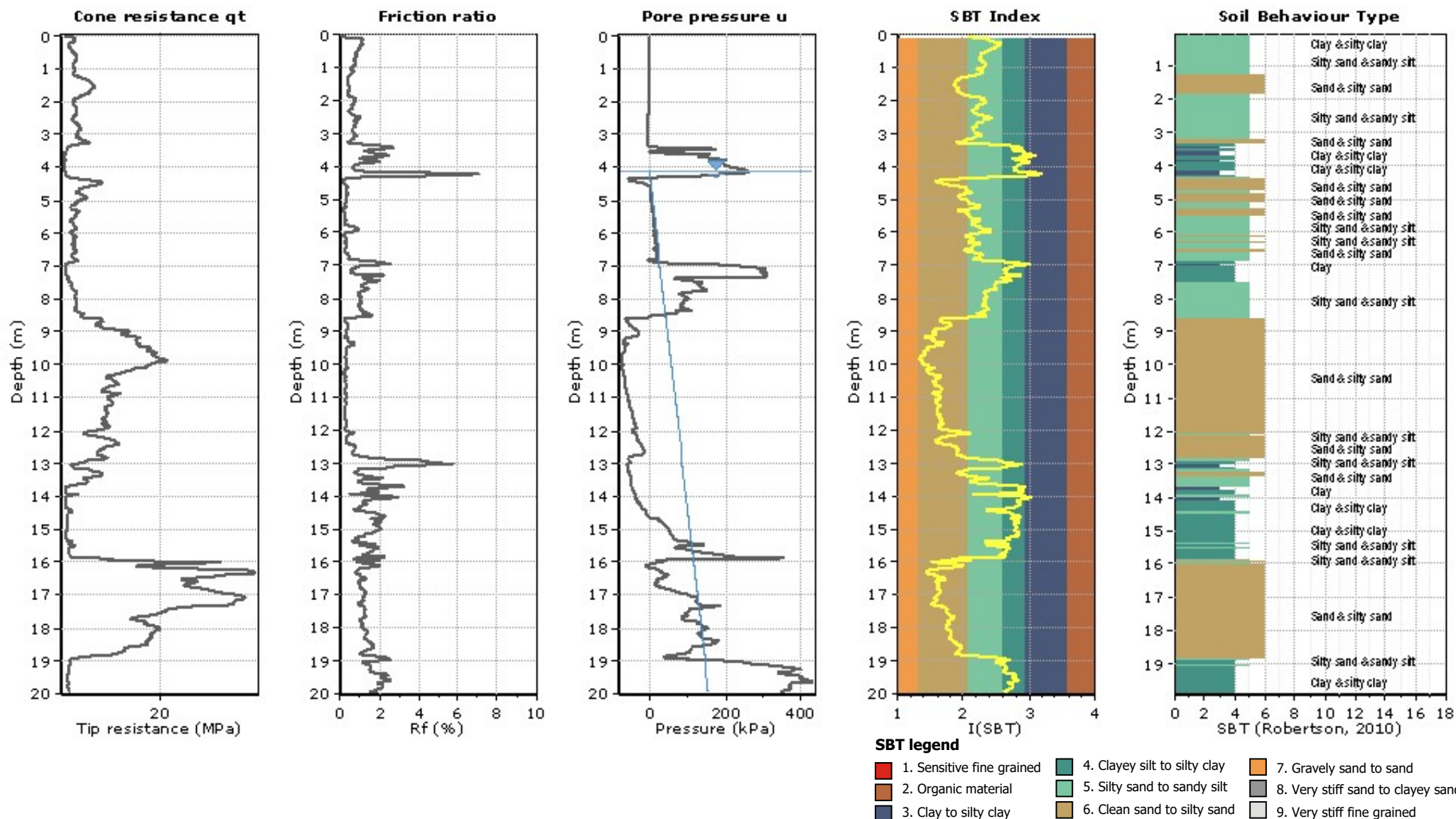
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Appendix C

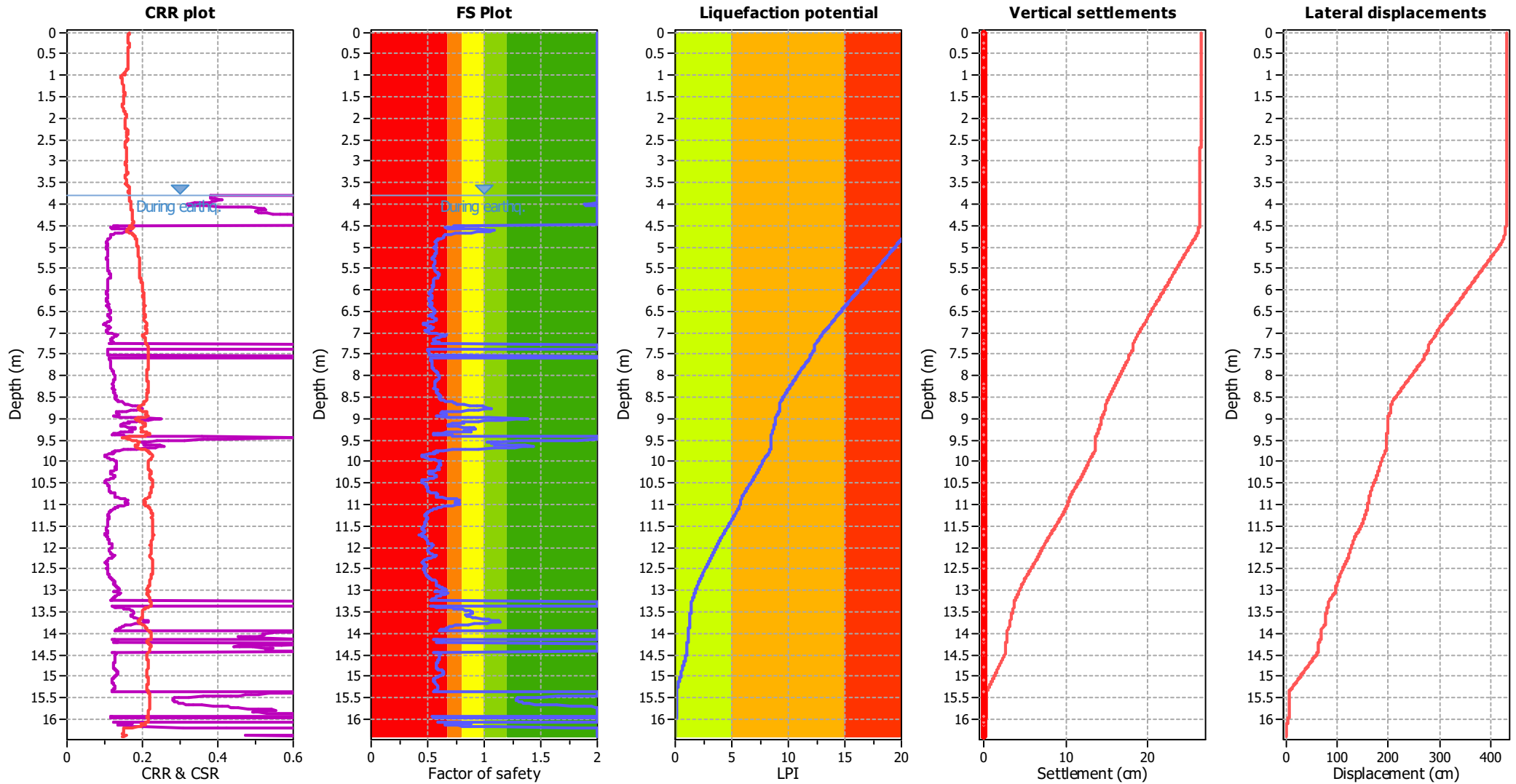
Liquefaction Analysis Results

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Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
 Fines correction method: B&I (2014)
 Points to test: Based on I_c value
 Earthquake magnitude M_w : 6.00
 Peak ground acceleration: 0.30
 Depth to water table (insitu): 4.20 m

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Fill weight: N/A
 Transition detect. applied: No
 K_0 applied: Yes
 Clay like behavior applied: Sand & Clay
 Limit depth applied: No
 Limit depth: N/A

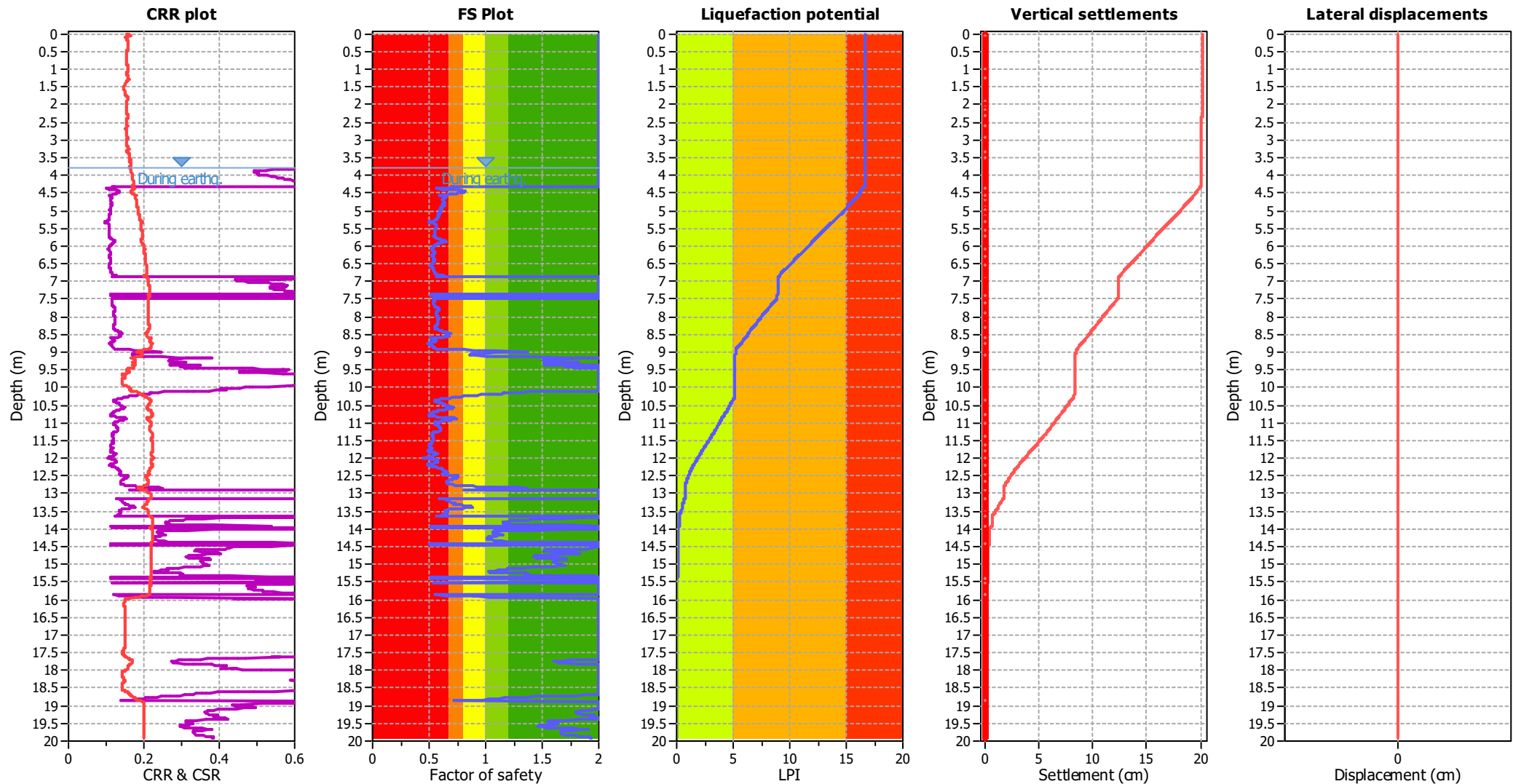
F.S. color scheme

Almost certain it will liquefy
 Very likely to liquefy
 Liquefaction and no liq. are equally likely
 Unlike to liquefy
 Almost certain it will not liquefy

LPI color scheme

Very high risk
 High risk
 Low risk

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
 Fines correction method: B&I (2014)
 Points to test: Based on Ic value
 Earthquake magnitude M_w : 6.00
 Peak ground acceleration: 0.30
 Depth to water table (insitu): 4.10 m

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Fill weight: N/A
 Transition detect. applied: No
 K_s applied: Yes
 Clay like behavior applied: Sand & Clay
 Limit depth applied: No
 Limit depth: N/A

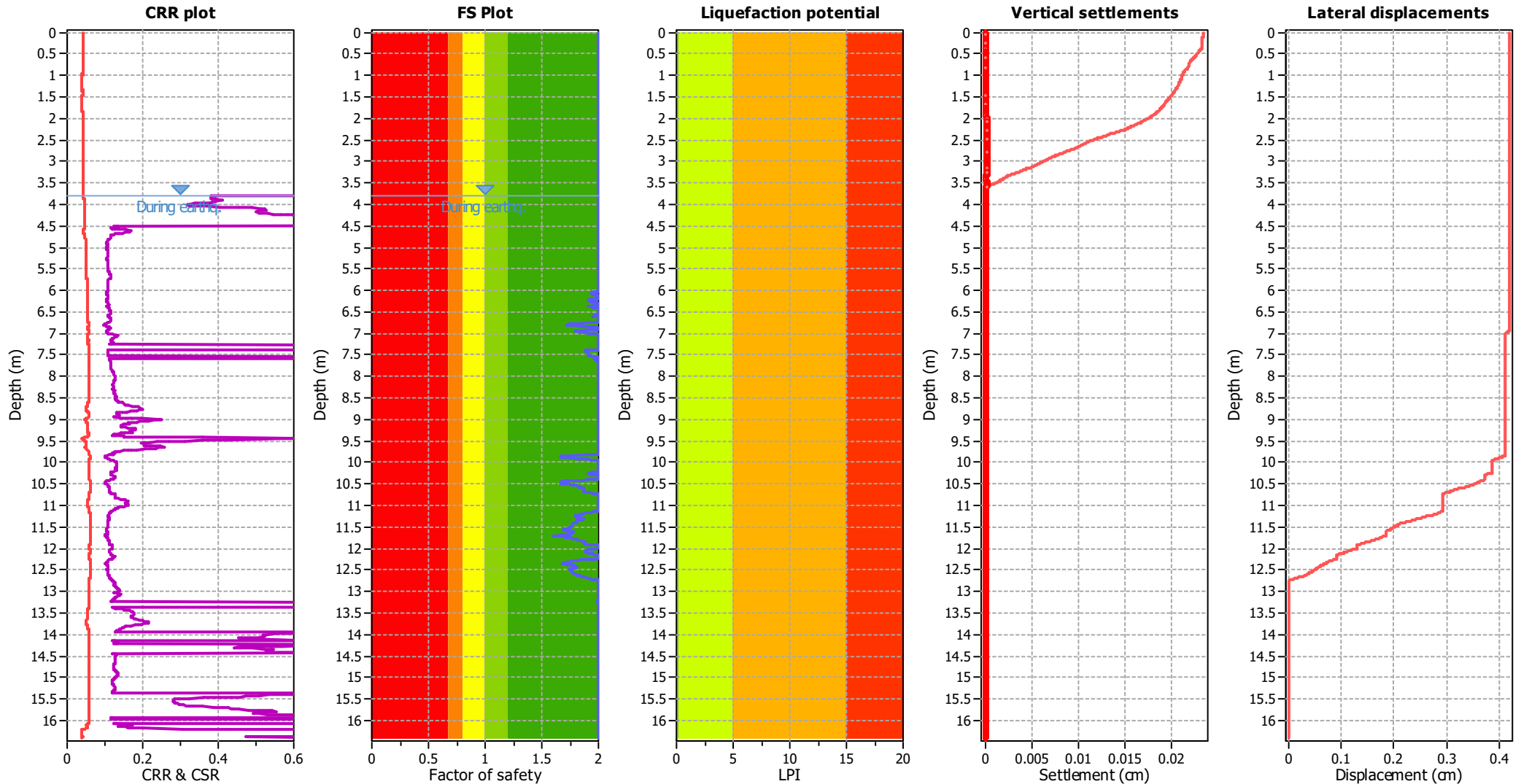
F.S. color scheme

Almost certain it will liquefy
 Very likely to liquefy
 Liquefaction and no liq. are equally likely
 Unlike to liquefy
 Almost certain it will not liquefy

LPI color scheme

Very high risk
 High risk
 Low risk

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
 Fines correction method: B&I (2014)
 Points to test: Based on Ic value
 Earthquake magnitude M_w : 6.00
 Peak ground acceleration: 0.08
 Depth to water table (insitu): 4.20 m

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Fill weight: N/A
 Transition detect. applied: No
 K_0 applied: Yes
 Clay like behavior applied: Sand & Clay
 Limit depth applied: No
 Limit depth: N/A

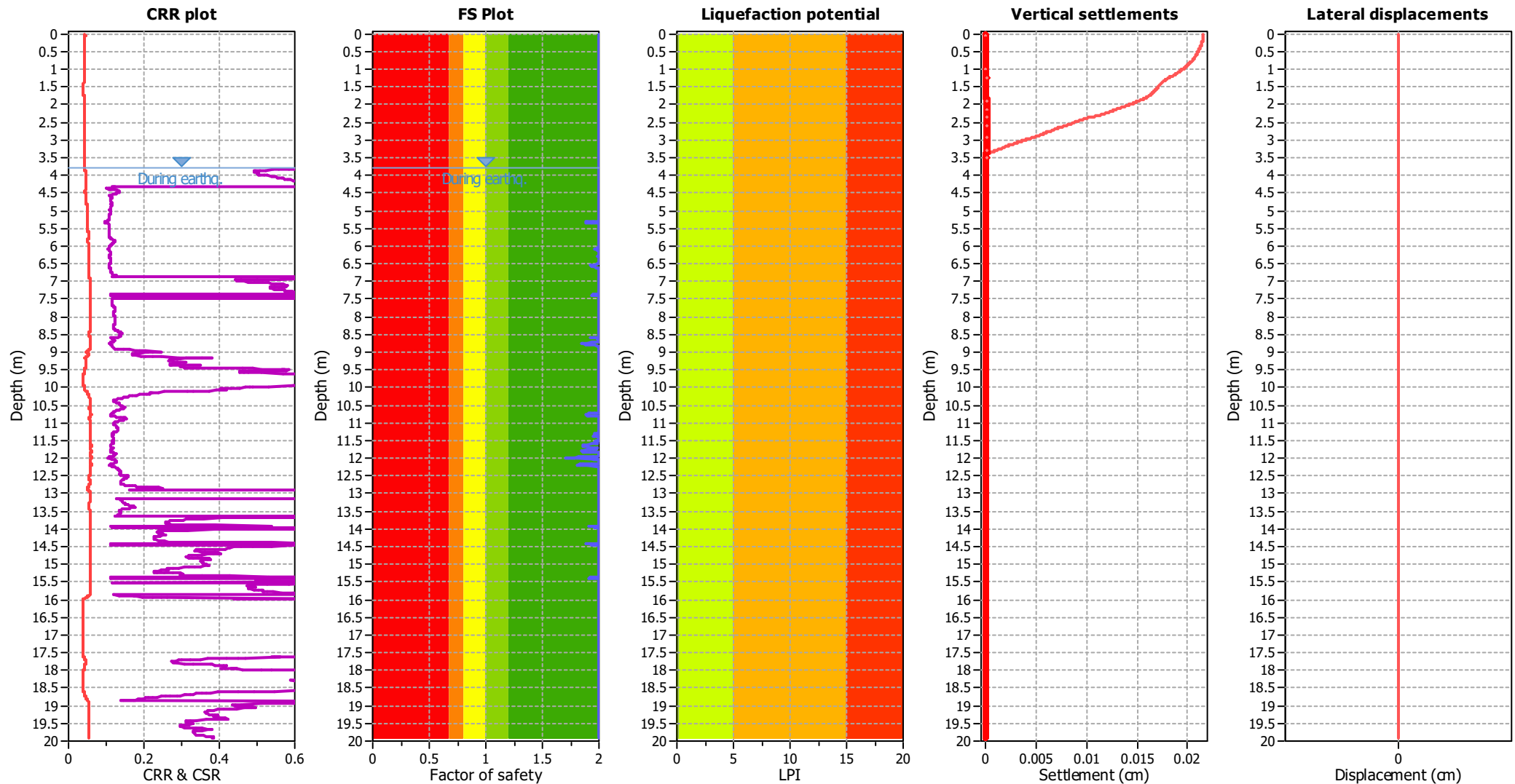
F.S. color scheme

Almost certain it will liquefy
 Very likely to liquefy
 Liquefaction and no liq. are equally likely
 Unlike to liquefy
 Almost certain it will not liquefy

LPI color scheme

Very high risk
 High risk
 Low risk

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
 Fines correction method: B&I (2014)
 Points to test: Based on Ic value
 Earthquake magnitude M_w : 6.00
 Peak ground acceleration: 0.08
 Depth to water table (insitu): 4.10 m

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Fill weight: N/A
 Transition detect. applied: No
 K_s applied: Yes
 Clay like behavior applied: Sand & Clay
 Limit depth applied: No
 Limit depth: N/A

F.S. color scheme

Almost certain it will liquefy
 Very likely to liquefy
 Liquefaction and no liq. are equally likely
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 Almost certain it will not liquefy

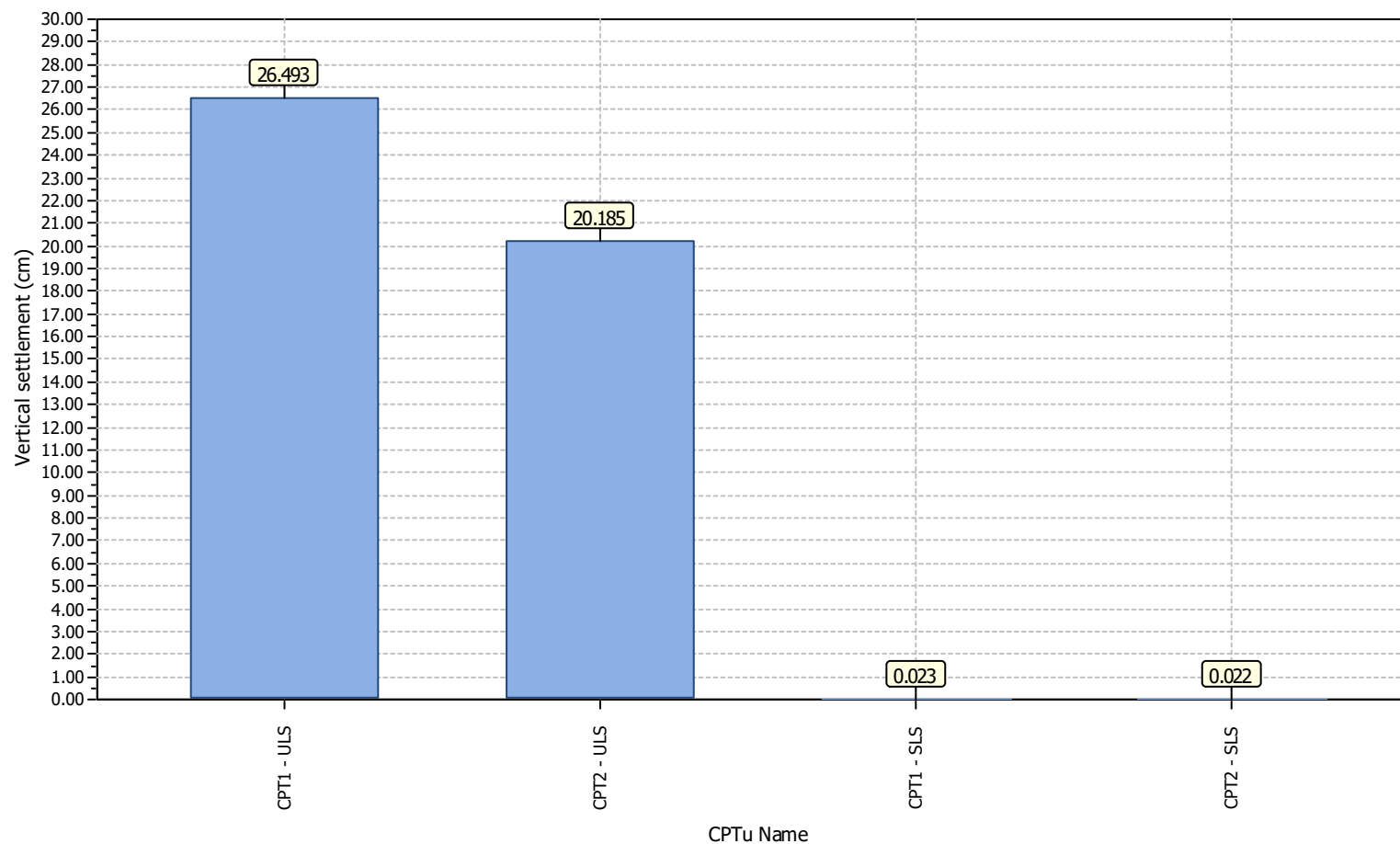
LPI color scheme

Very high risk
 High risk
 Low risk

Project title : Geotechnical Assessment

Location : 76 Pererika Street, Rotorua

Overall vertical settlements report





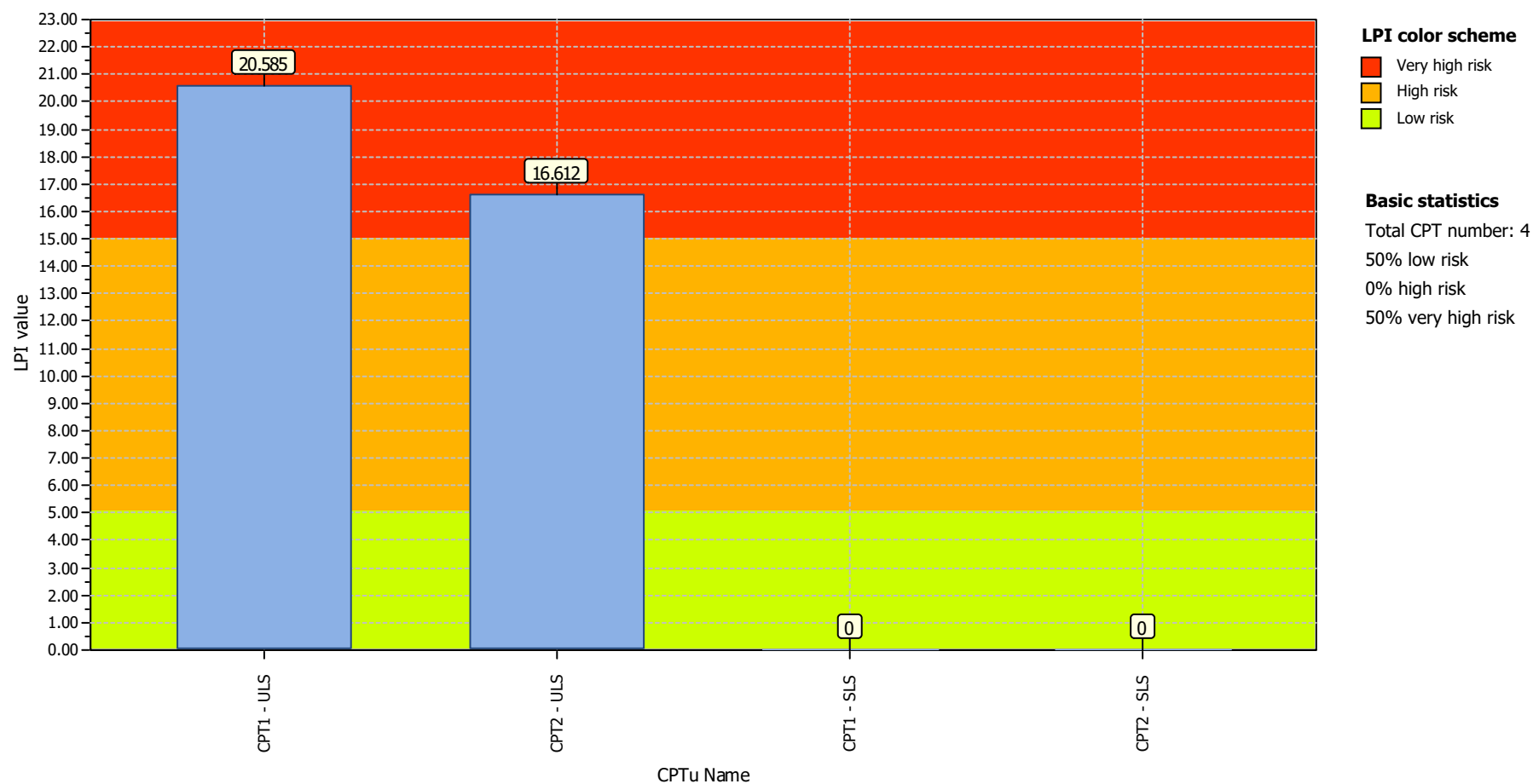
Stratum Consultants
Level 1, 29 Grey Street
Tauranga
www.stratum.nz

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Project title : Geotechnical Assessment

Location : 76 Pererika Street, Rotorua

Overall Liquefaction Potential Index report

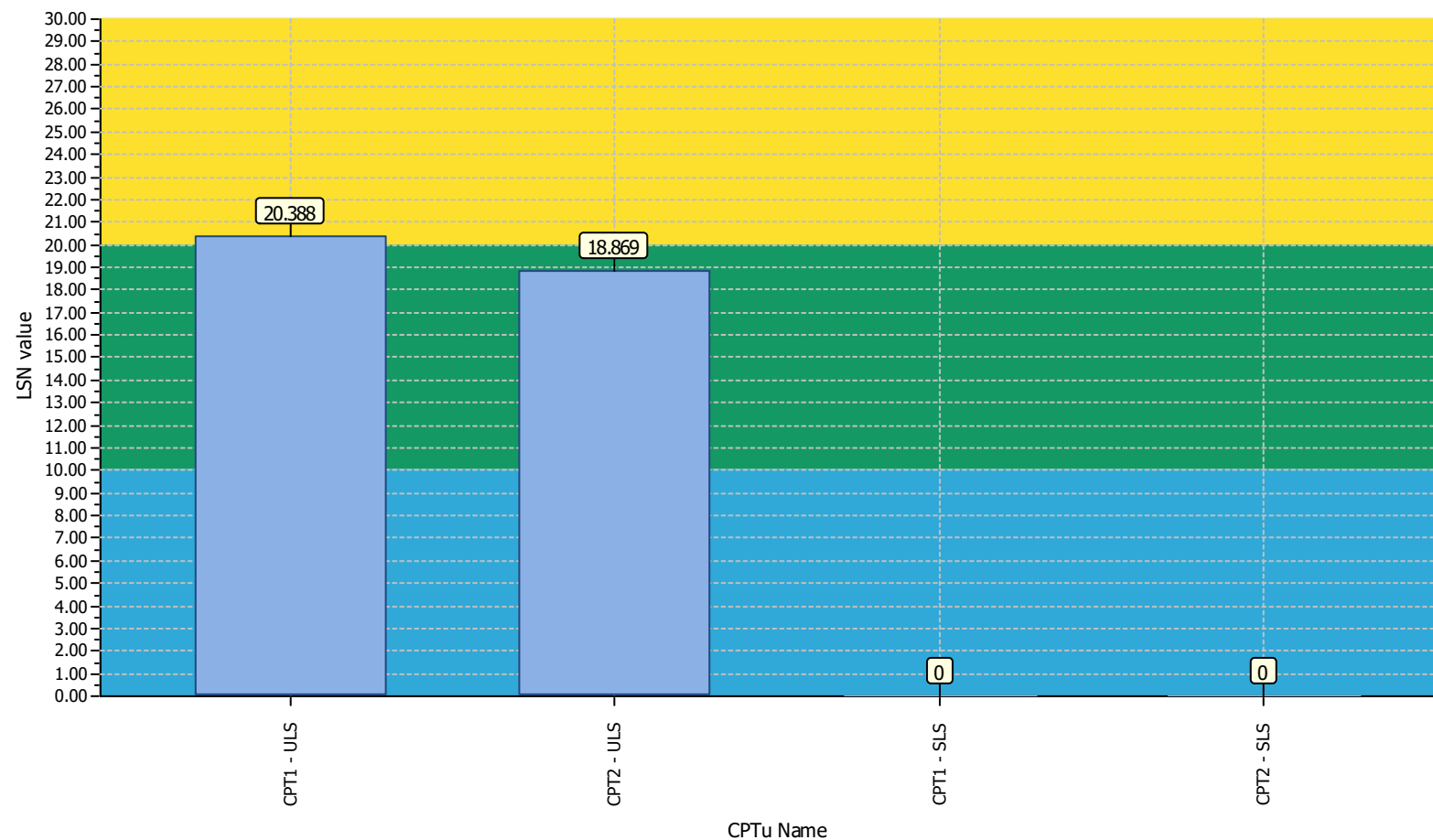




Project title : Geotechnical Assessment

Location : 76 Pererika Street, Rotorua

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 4
50% little liquefaction
25% minor liquefaction
25% moderate liquefaction
0% moderate to major liquefaction
0% major liquefaction
0% severe liquefaction

Appendix D

Soakage Test Results

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Client: GT Homes Ltd
Project Title: Soakage Assessment

Page: 1
No of Pages: 2

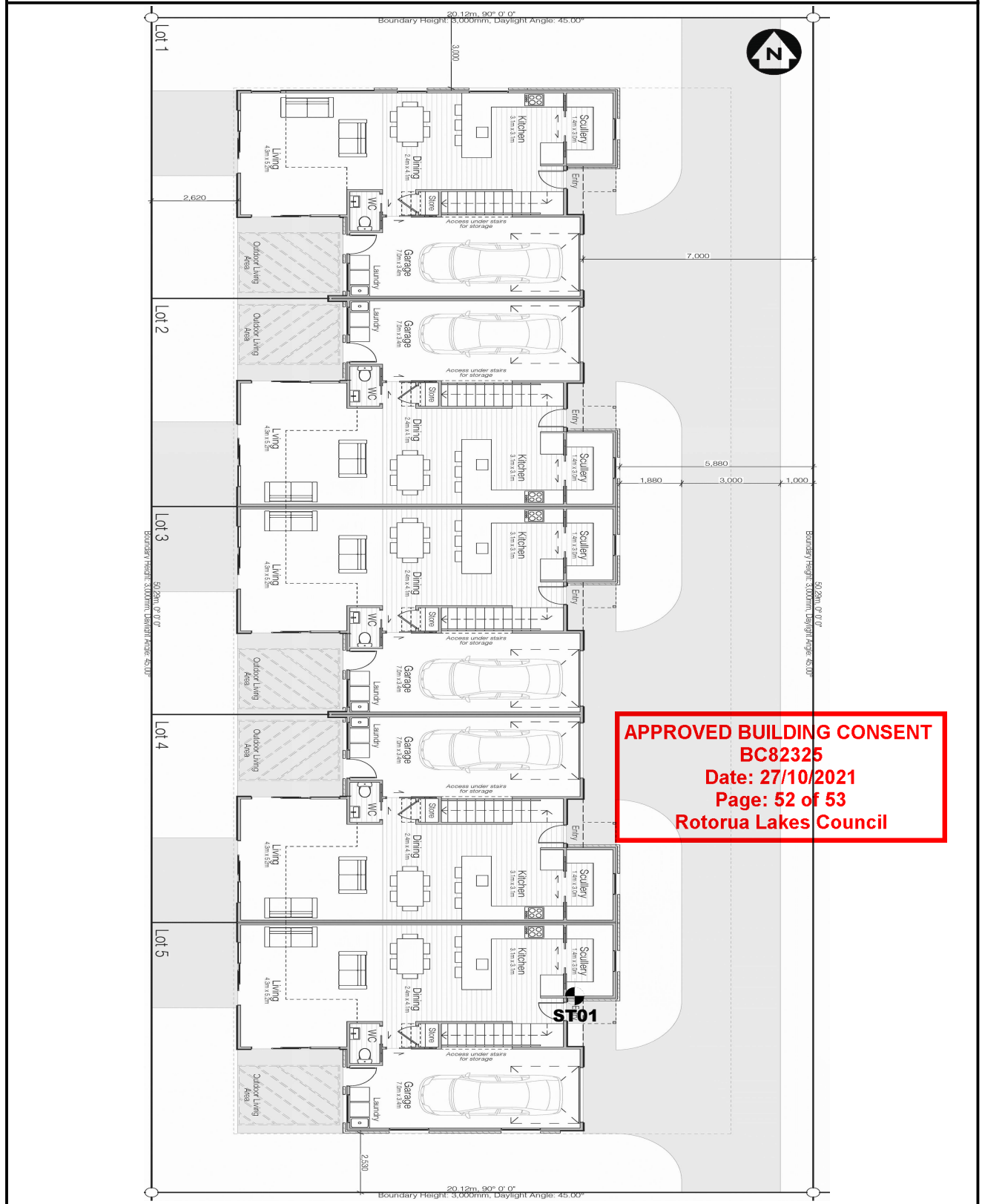
Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S002

Date Started: 11/1/2021
Date Finished: 11/1/2021
Logged By: SG



Test Location Sketch

Notes: Sketch of approximate locations only - not to scale



Client: GT Homes Ltd
Project Title: Soakage Assessment

Page: 2
No of Pages: 2

Site Address: 76 Pererika Street
City: Rotorua
File Number: 233257-R-E-S002

Date: 11/1/2021
Logged By: SG
Checked:



Stormwater Disposal - Percolation Test Results

Borehole No : 1

Test: 1

Depth (m)	Groundwater	Graphic Log	DESCRIPTIONS	Water level versus time			
0.0m			(TOPSOIL)				
0.5m							
1.0m				Time (minutes)	Level Drop (mm)	Cumulative Level Drop (mm)	
1.5m				0.0	0	0	Augered Hole depth (1): 3000 mm
2.0m				0.3	89.70	89.70	Presoak hole depth (2): 2700 mm
2.5m				0.6	451.60	541.30	End test hole depth (3): 2690 mm
3.0m				0.9	0.00	541.30	Auger Diameter: 100 mm
3.5m				1.3	-37.80	503.50	Water level drop: 2613 mm
4.0m				1.6	338.00	841.50	Av test depth (2+3)/2: 2695 mm
4.5m				1.9	0.00	841.50	Depth of topsoil: 300 mm
5.0m				2.2	1060.50	1902.00	Permeable Depth (av - topsoil): 2395 mm
				2.5	236.90	2138.90	modified Hole Diameter: 106 mm
				2.8	0.00	2138.90	Water Volume Lost: 22.8 litres
				3.1	115.00	2253.90	Hole Surface Area: 0.41 m ²
				3.4	0.00	2253.90	Total time of test: 10 min
				3.8	93.70	2347.60	
				4.1	77.70	2425.30	
				4.4	0.00	2425.30	
				4.7	63.60	2488.90	
				5.0	46.20	2535.10	
				5.3	0.00	2535.10	
				5.6	30.30	2565.40	
				5.9	0.00	2565.40	
				6.3	24.70	2590.10	
				6.6	11.80	2601.90	
				6.9	0.00	2601.90	
				7.2	4.00	2605.90	
				7.5	2.00	2607.90	
				7.8	0.00	2607.90	
				8.1	1.40	2609.30	
				8.4	0.00	2609.30	
				8.8	1.10	2610.40	
				9.1	0.30	2610.70	
				9.4	0.00	2610.70	
				9.7	0.70	2611.40	
				10.0	1.10	2612.50	
				Water source flow rate: 15 litres/min			
				Water level after presoak: 1.50m			
Notes: Borehole Collapsed 300mm during 30 minute pre-soak. Groundwater not encountered.				when time	0	to	10 min
				permeable depth is	2395	to	0 mm
				surface area is			0.41 m ²
Tests carried out in accordance with Section E1 of the NZ Building Code				Soakage rate 5.63 litres/m ² /min			

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