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Lake Okareka Fire Station

Geotechnical Assessment Report

Contact Details

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Contents

1. Introduction

WSP Opus has been engaged by Fire and Emergency NZ to undertake a geotechnical assessment with foundation recommendations for a proposed portal frame fire station building on the corner of Acacia and Okareka Loop Roads, Rotorua. The proposed fire station will be an Importance Level 4 structure in accordance with the requirements of 1170.0:2005.

The purpose of this report is to provide an assessment of the geotechnical risks and issues with methods to mitigate any such risks and provide foundation recommendations for the foundations to be used for the building development. We understand this report will be used as part of the building consent application.

2. Scope

To provide a geotechnical assessment and foundation recommendations for the proposed fire station building. The following works were undertaken, as set out in the scope and fee proposal letter dated the 6th June 2018 (REF 4000.nz):

- A desktop study (review of the local site geology, aerial photos and the Rotorua Lakes Council (RLC) hazard maps;
- A site walkover to identify any site specific geotechnical constraints to the proposed development and finalise the proposed investigation scope;
- Two Cone Penetrometer Tests (CPTs) to a target depth of 20m within the building platform to confirm ground conditions and engineering properties;
- Six Hand Auger and accompanying Scala Penetrometer tests (HAS) to a target depth of 4.0m within the proposed building platform to confirm the ground conditions and engineering properties;
- Preparation and issue of a geotechnical assessment report providing geotechnical design parameters for building foundation recommendations and the result of the analysis and interpretation regarding geotechnical risk to the site.

3. Proposed Development

We understand the proposed structure will have a maximum building footprint of 400m^2. The building will be founded on steel columns with reinforced concrete column pads and strip footings.

4. Site Description

The proposed site is located on the corner of Acacia and Okareka Loop Roads, Rotorua as shown in Appendix A – Location. The site is approximately 45m from the edge of Lake Okareka in an area prone to flooding. The ground is topographically flat with no sloped ground near the development.

5. Regional Geology

5.1. Local Site Geology

The Rotorua Lakes Councils[1] Geyserview indicates the property is located in undifferentiated Holocene alluvium known as zone C. The New Zealand Geological map of the Rotorua Area[2] shows this area as part of the Pokopoko Formation, consisting of Rhyolite Ignimbrite dominated by lapilli- to block sized pumice clasts.

5.2. Fault Hazard

The site is in a region of frequent seismic activity and within the topographic margin of various caldera structures, which are geomorphic features of the wider Taupō Volcanic Zone (TVZ). There are numerous active faults in the Okareka area made up of the Crater Lake Fault cluster. The closest of these faults to the site is 400m to the south.

6. Geotechnical Investigations

The objectives of the geotechnical site investigation were to collect subsoil and groundwater information in order to provide recommendations for the proposed development the geotechnical investigation was planned and carried out by WSP Opus Hamilton and Rotorua Laboratories on the 11th and 12th of July 2018 and comprised of the following:

- Shallow investigations comprising of six hand auger boreholes with associated Scala penetrometer tests to a target depth of 4.0m below ground level;
- Deep investigations comprising of two Cone Penetrometer Tests (CPTs) up to 20.0m below ground level or refusal.

A test location plan is presented as part of Appendix A.

7. Ground Conditions

We have interpreted the results of the investigations and based on our knowledge of the soils in the area and beneath the proposed building area. The soils below the site consist of Loose to very dense sands, soft clay and potentially shallow rhyolitic ignimbrite as described by the New Zealand Geological map of the Rotorua Area

[1] http://geo.rdc.govt.nz/Spatial/?viewer=GeyserView
[2] Leaonard, G.S., Begg, J.G., Wilson, G.J.N. (compilers) 2010. Geology of Rotorua Area. Institute of Geological & Nuclear sciences 1:250 000 geological map 5. 1 sheet + 102p. Lower Hutt, New Zealand. GNS Science.

A summary of the soil parameters at the site:

Table 1: Summary of the soil parameters at the proposed Okareka Fire Station

Layer	Depth below ground to top of layer	Depth below ground to base of layer	Soil description	Consistency/ Density	Scala Blows/100 mm	Shear Vane (kPa)	CPT qc (Mpa)
1	0.0m	0.1m	Topsoil	Soft	1 - 3	N/A	N/A
2	0.1m	0.25m	Fine silty SAND	Medium dense	1 - 7	N/A	4 - 6
3	0.25m	1.0m	Sandy coarse pumice GRAVEL	Medium dense to dense	3-9	N/A	5 - 7
4	1.0m	3.5 - 4.5m	SAND	Loose to Dense	N/A	N/A	2 - 6
5	3.5 - 4.5m	5.0m	CLAY	Very soft	N/A	N/A	<1
6	5.0m	8.5 - 9.0m	Rhyolite Ignimbrite, weathered	Very Dense	N/A	N/A	10 - 40+
7	8.5 - 9.0m	-	Rhyolite Ignimbrite	Very Dense	N/A	N/A	40+

Ground water table was found in every geotechnical test location at depths ranging from 0.1m to 0.4m below ground level.

8. Engineering Considerations

8.1. Introduction

We have been asked by WSP Opus Hamilton structural engineers to consider multiple foundation options for the proposed Lake Okareka Firestation. We believe the most appropriate foundation for this development would be the use of steel columns with reinforced concrete column pads and strip footings. Our foundation assessments and recommendations have been undertaken in accordance with the New Zealand Building Code, appendix B1/VM4.

Based on our desktop study and the results of the recent site investigations, the key geotechnical aspects for design and construction of the proposed fire station building is as follows:

- Soil Design Parameters;
- Seismic Considerations;
- Site Clearance & Earthworks;
- Inundation by Flood Waters
- Building Foundations;
- Shallow Ground Improvement;
- Stormwater and Effluent Disposal.

8.2. Soil Design Parameters

The soil parameters have been selected based on our interpretation of the geotechnical testing information, and our experience within similar ground conditions. The soil parameters used for the bearing capacity analysis are presented in table 2 below.

Table 2: Soil Parameters for Design

Depth	Unit weight, γ, (kN/m3)	Angle of Internal Friction, φ, (°)	Drained Young's Modulus, E' MPa	Undrained Shear Strength, (Su) kPa	Effective Cohesion, (c), kPa
0.0 – 1.0m	16	32	20	-	0
1.0 – 4.0m	17	30	14	-	0
4.0 – 5.0m	16	28	2.5	15 - 35	3
5.0 – 9.0m	18	38	40	-	0

8.3. Seismic Consideration

8.3.1. Peak Ground Acceleration

The peak ground acceleration (PGA) for the site has been calculated in accordance with NZS 1170.0 (section 5 earthquake design for structures) and the recent Geotechnical Society's (Earthquake geotechnical engineering practise – 2016) guidelines. The assessed PGA, site subsoil class and importance level.

$$PGA = C_{0,1000} \times \frac{R_u}{1.3} \times f \times g$$

Where:

$C_{0,1000}$ = 1000 year return period PGA coefficient for a subsoil Class A or B rock site or Class C shallow soil site derived from figure 6.1(a), or for subsoil Class D deep or soft soil site or Class E very soft soil site from figure 6.1(b). Alternatively, for the locations listed, PGA coefficients may be taken from table 6A.1 contained in addendum 6A

R_u = return period factor derived from table 3.5 of NZS 1170.5 *Structural design actions* part 5 Earthquake actions – New Zealand[1] corresponding to the design return period determined from tables 2.2 or 2.3, as appropriate

f = Site subsoil class factor, where

$f = 1.0$ for a Class A, B, D and E soil sites

$f = 1.33$ for a Class C shallow soil site

- Design Life = 50 years;
- Importance Level = 4;
- Seismic subsoil class = D (Deep or Soft Soil);
- Annual probability of exceedance (SLS_1) = 1/25;
- Annual probability of exceedance (SLS_2) = 1/500
- Annual probability of exceedance (ULS) 1/2500

The PGAs for assessment are shown in Table 3 below.

Table 3: Summary of peak ground accelerations

Site Subsoil Class	Design Life	Importance Level	Unweighted Seismic Hazard Factor ($C_{0,1000}$)	Design Case		
				SLS_1	SLS_2	ULS
D	50 Years	4	0.39	0.08	0.3	0.54

8.3.2. Faulting

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

The fault rupture risk for this development is moderate with the multiple faults being located within 1.0km of the site. The closest identified fault is located approximately 400m south of the building site according to the New Zealand Active Faults Database (GNS Active Faults online database).

No evidence of any surficial features or lineaments were identified during the site appraisal that would suggest active fault movement closer than that implied by the database or maps, and therefore no specific investigations or design considerations are necessary for the proposed development.

8.3.3. Liquefaction Assessment

A quantitative assessment of liquefaction potential has been undertaken using proprietary liquefaction analyses software Cliq (V.1.7) by Geologismiki, which provides an assessment of liquefaction potential using the available CPT test data. The liquefaction assessment was undertaken using the Idriss and Boulanger (2014) calculation method. The Cliq outputs are presented within Appendix D.

The surficial Holocene alluvial granular subsoils encountered at the subject site typically comprise variable very loose to medium dense sands, that if saturated, maybe susceptible to liquefaction during an extreme seismic event, as shown in Table 4.

Table 4: Liquefaction Assessment Summary

Test Location	SLS_1 (0.08g)		SLS_2 (0.3g)		ULS (0.54g)	
	Depth of Potentially Liquefiable Stratum (mbgl)	Settlement (mm)	Depth of Potentially Liquefiable Stratum (mbgl)	Settlement (mm)	Depth of Potentially Liquefiable Stratum (mbgl)	Vertical Settlement (mm)
CPT01	None	<10	0.4m-3.8m	110	0.4m-3.8m	120
			4.7m-6.0m		4.7m-6.0m	
			7.0m-7.3m		7.0m-7.3m	
			8.0m-8.5m		8.0m-8.5m	
CPT02	None	20	0.1m-3.3m	115	0.1m-3.3m	120
			4.3m-5.6m		4.3m-5.6m	
			6.6m-7.0m		6.6m-7.0m	
			7.3m-7.6m		7.3m-7.6m	

8.3.4. *Lateral Spreading Assessment*

Flow failures caused by seismically induced liquefaction can occur when the shear stress required for static equilibrium of a soil mass is greater than the shear strength of the soil in its liquefied state. The proposed Fire Station area is located within 43m from the free edge of Lake Okareka and lateral spreading may occur in future earthquake events. Hence, we have considered lateral spreading of the ground surface across the warehouse building footprint.

An analysis using the CPT results has been completed to assess the lateral spreading potential. The semi-empirical method has been used which is based on estimated shear strain potentials. The slope profile has been determined based on our field observation and simplified as a 1.0m crest with a 43m setback between the edge of the development and Lake Okareka. It should be noted that there is currently no reliable way of calculating the exact magnitude of lateral spreading and so the results of our assessment should be considered indicative only. The results of our assessment are presented in Table 5 below and outputs from our calculations are included in Appendix D.

Table 5: Lateral Spreading analysis for SLS and ULS Seismic Events

CPT	Lateral Spreading (mm)		
	SLS_1	SLS_2	ULS
01	<10	100	110
02	<10	150	160

The results of the liquefaction and lateral spreading analysis are summarised as follows:

- The extent of total liquefaction induced settlement during an SLS_1 seismic event is expected to be less than 20mm across the site.
- The results of the liquefaction assessment indicate that the potential surface expression of liquefaction (sand boils) is unlikely to occur in the SLS_1.
- The extent of total liquefaction induced settlement during a SLS_2 and ULS seismic events is calculated to be less than 130mm across the site.
- The LPI and LSN numbers indicate that the site has a very high risk of liquefaction during a SLS_2 and ULS seismic event.
- The lateral spreading under a SLS_1 event is expected to be less than 10mm and under SLS_2 and ULS events, are expected to range between 100 to 160mm.
- Overall, our liquefaction analyses suggest that the site has a very high risk of liquefaction under ULS event up to 8m below the existing ground level. It is considered unlikely that major damage to the structure will be cause during both SLS and ULS earthquake events.

8.4. Site Clearance

All existing building foundations services, construction debris and any deleterious material within the zone of influence of future building platforms, should be completely removed prior to excavation for foundations. It is recommended that general site clearance should be carried out in accordance with NZS 4431:1989, Section 8.

8.5. Earthworks

The proposed building site is located on level ground, however some shallow excavation and ground improvement beneath the proposed column pads and strip footings will be required given the presence of very loose to loose surficial coarse-grained soils. This is explained further in Section 8.8.

Any earthworks fill placed and compacted within the boundaries of the proposed building platform shall be observed, tested and certified by a Chartered Professional Geotechnical Engineer. Fill shall be placed on ground cleared free from vegetation, topsoil, and any other deleterious material.

Excavations for building platforms may encounter very loose to loose surficial coarse-grained soils which may be susceptible to bearing, liquefaction or differential settlement issues. Where such materials are encountered during construction, shallow ground improvement will be required, as outlined in Section 8.8.

The Contractor shall ensure that all excavations are benched/battered to ensure that there are safe working conditions and adequate support to the excavation at all times.

Any earthworks cuts required adjacent to existing buildings or roading may require temporary support designed by a Chartered Professional Geotechnical Engineer, taking account soil design parameters, retained heights and building surcharge loads etc.

8.6. Inundation by Flood Waters

As the site is located adjacent to Lake Okareka, the Fire Station floor level will need to comply with the minimum finished floor levels (FFL) set by RLC and BOPRC to protect buildings from damage during flood events. The minimum FFLs are expected to prevent flood damage affecting the proposed development, and although there may be some temporary loss of amenity at the site during extreme flood events, these effects are not expected to be significant or different to that of the nearby dwellings on the lake shore.

RLC have confirmed this in their correspondence dated 26 July 2018 that the Lake Okareka 2%AEP flood level is RL355.5m Moturiki, inclusive of 300mm free-board allowance.

8.7. Building Foundations

8.7.1. Overview

As per our understanding, the proposed building foundations will comprise of either steel column concrete pad foundations with associated strip footings.

8.7.1. Structural Loads

WSP Opus Hamilton structural engineer advised following structural loads acting on a fire station building column foundation.

- Maximum column vertical load = 30kN
- Maximum column lateral load = 35kN
- Uplift Vertical force= 10kN
- Strip footing = 10kN/m

8.7.2. Foundation Bearing Capacities

The investigation indicates that there is a relatively dense sand crust about 2 to 3m thick across the site underlain by about 1m of soft clay having undrained shear strength ranging between 20 to 30 kPa. Due to this variability, we consider that a reasonably conservative design approach is warranted to minimise the risk of problems during construction.

BOPRC has advised that the minimum height of the building floor level should be RL355.5m. Therefore, the existing ground should be raised by at least 1m to fulfil the BOPRC inundation requirement by using compacted engineered hardfill fill materials. We anticipated that the building will be founded on this compacted engineered hardfill material. We propose that the compacted fill will achieve 300kPa Ultimate Bearing Capacity.

We have also assessed the ultimate bearing capacity for a range of foundation sizes is accordance with NZBC, appendix B1/VM4. Following shallow ground improvement, the ultimate bearing capacities presented in table 6 below may be assumed for the design of column pad foundations.

Our recommended soil ultimate bearing capacities are presented below:

Table 6: Ultimate Bearing Capacity for Column Pad foundations & Strip Footing

Foundation Size (m)	Ultimate Bearing Capacity (kPa)
2.0(W) x 2.0(L) x 0.5(D) - Column C2	450
1.5(W) x 1.5(L) x 0.5(D) - Column C1, C10 and P1	350
0.5(W) x 1.0(L) x 0.5(D) – Strip Footing	200

In accordance with the recommendations contained with the NZBC, appendix B1/VM4, the ultimate bearing capacity for shallow foundations should be used in conjunction with the following strength reduction factors.

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

Further, the Structural Engineer should consider provision for perimeter column pad foundation pads to be integrally tied together by interconnecting strip footings. This will help to provide a more uniform response during a large seismic event.

8.7.3. Floor Slab – Subgrade Modulus

An assessment on the subgrade modulus at the corner and centre of the concrete slab was carried out using the Timeshenko and Goodier (1951) method (as cited in Bowles, 1997), assuming 400mm of shallow ground improvement below the concrete floor slab. The proposed shallow ground improvement below the floor slab is outlined in Section 8.8.
The assessed subgrade modulus values for the design of reinforced concrete slab are as follows:

KCorner = 40.0 kPa/mm (Corner of the concrete slab)

KCentre = 10.0 kPa/mm (Centre of the concrete slab)

8.8. Shallow Ground Improvement

To improve the bearing characteristics of the surficial soils below the proposed structure, we recommend shallow ground improvement via undercutting the upper loose sandy subsoils and reinstating with engineer certified granular fill.

The shallow ground improvement shall comprise of the following:

To improve the bearing characteristics of surficial soils and to limit total and differential settlements under static conditions below the proposed structure, we recommend shallow ground improvement via undercutting the upper loose sandy subsoils and reinstating with engineer certified granular fill.

The shallow ground improvement shall comprise the following:

1. Excavate and remove all topsoil and loose fill material up to 0.5m below the existing ground level. The excavation shall extend a minimum length of 1.0m beyond the building platform areas.

2. Once the excavation is completed down to the correct level the Contractor shall inform the geotechnical engineer for an inspection of the excavation and subgrade testing. Scala

penetrometer testing shall be performed at the base of the excavation to a depth of 1.0m, achieving a minimum of 3 blows per 100mm of penetration.

3. Static proof rolling or hand compactor should be carried out at the base of the excavation. Any areas demonstrating high deflections (i.e. visual movement >10mm) or not meeting the criteria specified in Step 2 will be required to be undercut and reinstated with granular fill materials.

4. Bidim A19 geotextile shall be laid and placed prior to the placement of granular fill (e.g. GAP65 or AP65). The filter fabric shall be laid without folds, parallel to each other and with 100mm overlap, extending up the sides of the excavation a minimum depth of 500mm.

5. Placed one layer of triaxial geogrid (TX160 or equivalent) at the middle of the excavation depth.

6. Imported granular fill (e.g. GAP65 or AP65) shall be placed and compacted in lifts up to the invert level of the proposed foundation, not exceeding 150mm loose lift thickness which if necessary shall be decreased to achieve the required density. The fill shall be compacted to 95% of the maximum dry density as per NZS4402. In-situ nuclear densometer (NDM) testing in accordance with NZS 4407:1991 (at least 4 NDM tests every 300mm vertical layer) can be used to check compaction.

7. The fill and compaction should be continuing up to final inundation level RL355.5m.

8.9. Foundation Settlement

During the Cone Penetrometer testing a layer of potentially compressible Clay was found at approximately 4.0m deep and is approximately 1.0m thick. Due to the thickness of this material and the dense sand layers above and below and 1.5m thick compacted granular fill at top, the impact to the development due to settlement is considered to be negligible. However, We have calculated the static settlement based on the supplied serviceability column loads for each foundation type using the Steinbrenner settlement formula. We have assumed a Poisson's ratio of 0.3. A summary of our static settlement calculation results is presented in Table 7.

Table 7: Summary of settlement results

Foundation Type	Static Settlement (mm)	
	Centre	Corner
C1	<5	<5
C2	<5	<5
C10	<5	<5
P1	<5	<5
Strip	<5	<5

8.10. Stormwater and Effluent Disposal

Stormwater to be connected to the existing council system on Acacia Road. Effluent disposal to be connected to the existing council reticulated system.

9. Further Work

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

All fill material shall be tested and certified by the chartered professional geotechnical engineer.

WSP Opus will require a minimum of 24 hours' notice for construction observations and geotechnical testing prior to commencement of foundation excavations.

10. Conclusions and Recommendations

Based on our geotechnical analysis, we have made following conclusion and recommendations:

- Based on our site inspection and council topographical information, the site is located on a level ground. We anticipated that minor earthworks will be required to create a level building platform.
- Any earthworks filling within the boundaries of the proposed building platforms shall be observed, tested and certified by a Chartered Professional Geotechnical Engineer.
- A shallow ground improvement is recommended for the proposed fire station building foundation. See section 8.8 for details.
- As per BOPRC, the minimum floor level of the building should be RL355.5m Moturiki, inclusive of 300mm free-board allowance.
- The results of our investigation confirm that soils underlying the proposed fire station building is suitable on which to construct shallow building foundations (either strip or pad) after shallow ground improvement as recommended on Table 6.
- The differential settlement under the proposed building foundations are within acceptable limits, i.e. The maximum allowable differential settlement should be less than 25mm over a 6m horizontal distance.
- Due to the presence of shallow groundwater levels, free draining granular or volcanic derived subsoil materials, and the general elevation of the landform at the site, the effects of potential liquefaction induced vertical settlement are expected to be no greater than 120mm across the site.
- Based on the geotechnical testing results, the ultimate bearing capacities for the various size of steel column pad foundations and strip footings are presented on Table 6.
- Once the excavation is completed to the founding level, the contractor shall inform the geotechnical engineer for an inspection of the excavation and subgrade testing. Scala penetrometer testing shall be performed at the base of the excavation to a depth of 0.5m, achieving a minimum of 3 blows per 100mm of penetration.
- Any earthworks excavations required adjacent to existing site boundaries may require temporary support during construction. All temporary support (if required) should be designed by a Chartered Professional Geotechnical Engineer, taking account soil design parameters, retained heights and building surcharge loads etc.

11. Limitations

The interpretation of ground conditions presented in this report is based on the tests undertaken at discreet locations of the site. Ground conditions may change suddenly over short distances resulting in variations between test positions across the site.

Data or opinions in this document may not be relied upon or used out if context, by any other party or for any other purpose without further reference to the Tauranga Geotechnical Section of Opus International Consultants Ltd.
It is recognised that the passage of time affects the information and assessment provide in this Document. Opus's opinions are based upon information that existed at the time of the production of this Ground Conditions Report. It is understood that the services provided allowed Opus to form no more than an opinion on the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings or any laws or regulations.

Appendix A

Location

PROPOSED SITE PLAN

SCALE 1:250

- Hand Auger/Scala's
- CPT

SKETCH SCHEME 2

MIKE BOWMAN DESIGN LTD
A: PO Box 238, Dunedin
P: 03 470 1080
E: info@msdesign.co.nz
W: www.msdesign.co.nz

msd ARCHITECTURE

FIRE EMERGENCY NEW ZEALAND

PROPOSED VRFF STATION
LAKE OKAREKA FIRE STATION
ROTORUA

SCALE	1:250 @ A3
DATE	MAY 2018
JOB NUMBER	CN17-1733
PRINT DATE	16/05/2018

02

Appendix B

Shallow Investigations

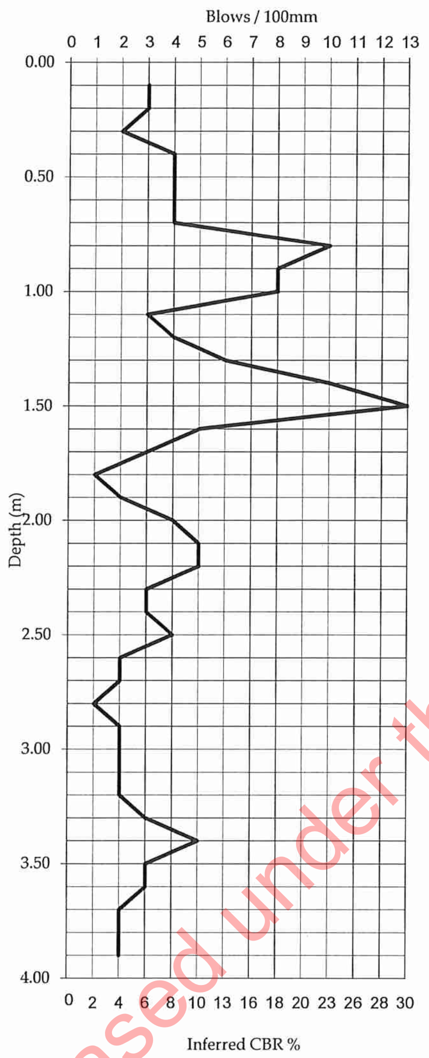
AUGER / SCALA PENETROMETER TEST REPORT

WSP | OPUS

Project :	**Lake Okareka Fire Station**
Location :	**Corner of Okareka Loop Road and Acacia Road**
Client :	**WSP Opus**
Contractor :	**Unknown**
Test number :	**1**
Shear vane number :	**N/A**
Shear vane correction :	**N/A**
Water level (m):	**0.3**
Reduced level (m):	**N/A**

Project No :	**4-52149.00**
Lab Ref No :	**RT1097**
Client Ref No :	**00GEO**

Scala Penetrometer



Test Results

Depth (m)	Shear Strength (kPa)	Soil Description
0.10		Topsoil.
0.20		Fine silty SAND, light brown, medium dense, wet.
0.30	▽	Sandy coarse pumice GRAVEL, light grey, medium dense to dense, wet.
0.90		End of hole, could not obtain further sample.

Test Methods	
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2	Field Descriptions of Soils and Rocks by
Shear Strength using a Hand Held Shear Vane: NZ Geotechnical Soc Inc 8/2001	NZ Geotechnical Society Dec 2005, Scala over 1.5m
Inferred CBR values taken from Austroads Pavement Design Manual 2004	and Inferred CBR values are not IANZ accredited

Date tested : 11/07/18
Date reported : 11/07/18

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Approved

Designation : *Laboratory Manager*
Date : 13/07/18

PF-LAB-061 (20/03/2018)

WSP Opus
Rotorua Laboratory
Quality Management Systems Certified to ISO 9001

20 Te Ngae Road
PO Box 1245, Rotorua 3040, New Zealand

Telephone +64 7 343 1440
Website

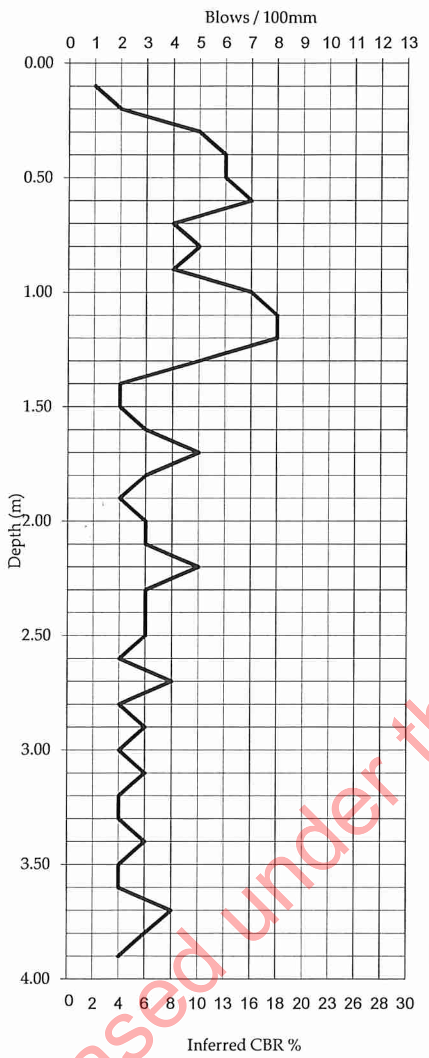
AUGER / SCALA PENETROMETER TEST REPORT

WSP | OPUS

Project :	**Lake Okareka Fire Station**
Location :	**Corner of Okareka Loop Road and Acacia Road**
Client :	**WSP Opus**
Contractor :	**Unknown**
Test number :	**2**
Shear vane number :	**N/A**
Shear vane correction :	**N/A**
Water level (m):	**0.3**
Reduced level (m):	**N/A**

Project No :	**4-52149.00**
Lab Ref No :	**RT1097**
Client Ref No :	**00GEO**

Scala Penetrometer



Test Results

Depth (m)	Shear Strength (kPa)	Soil Description
0.10		Topsoil.
0.20		Fine silty SAND, light brown, medium dense, wet.
0.30		Sandy coarse pumice GRAVEL, light grey, medium dense to dense, wet.
1.20		End of hole, could not obtain further sample.

Test Methods

Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2	Field Descriptions of Soils and Rocks by
Shear Strength using a Hand Held Shear Vane: NZ Geotechnical Soc Inc 8/2001	NZ Geotechnical Society Dec 2005, Scala over 1.5m
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Website

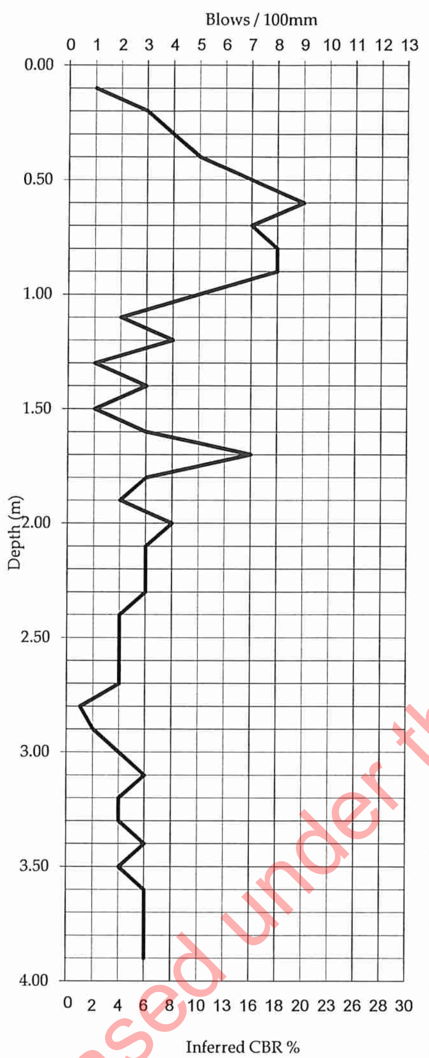
AUGER / SCALA PENETROMETER TEST REPORT

WSP | OPUS

Project :	**Lake Okareka Fire Station**
Location :	**Corner of Okareka Loop Road and Acacia Road**
Client :	**WSP Opus**
Contractor :	**Unknown**
Test number :	**3**
Shear vane number :	**N/A**
Shear vane correction :	**N/A**
Water level (m):	**0.15**
Reduced level (m):	**N/A**

Project No :	**4-52149.00**
Lab Ref No :	**RT1079**
Client Ref No :	**00GEO**

Scala Penetrometer



Test Results

Depth (m)	Shear Strength (kPa)	Soil Description
0.10		Topsoil.
0.15		SILT, grey, firm, wet
		Sandy coarse pumice GRAVEL, light grey, medium dense to dense, wet.
1.00		End of hole, could not obtain further sample.

Test Methods	
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2	Field Descriptions of Soils and Rocks by
Shear Strength using a Hand Held Shear Vane: NZ Geotechnical Soc Inc 8/2001	NZ Geotechnical Society Dec 2005, Scala over 1.5m
Inferred CBR values taken from Austroads Pavement Design Manual 2004	and Inferred CBR values are not IANZ accredited

Date tested : 11/07/18
Date reported : 11/07/18

This report may only be reproduced in full

Approved

Designation : *Laboratory Manager*
Date : 13/07/18

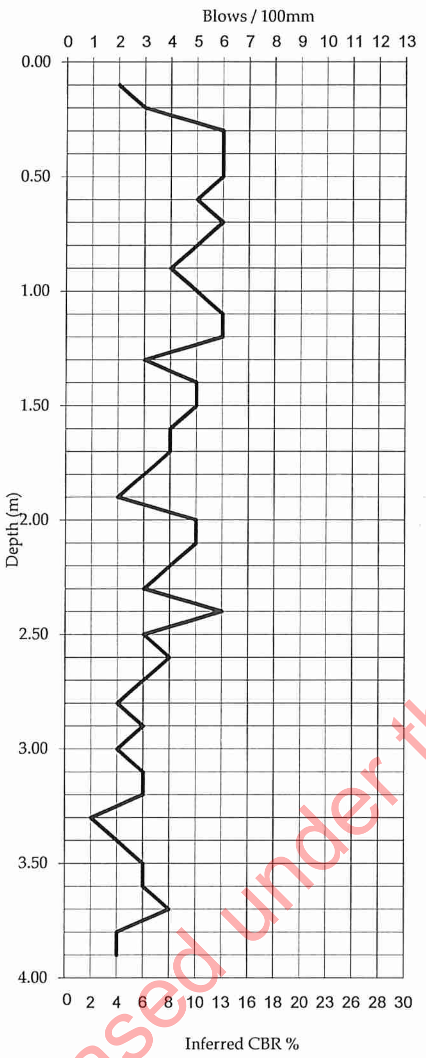
PF-LAB-061 (20/03/2018)

AUGER / SCALA PENETROMETER TEST REPORT

Project :	**Lake Okareka Fire Station**
Location :	**Corner of Okareka Loop Road and Acacia Road**
Client :	**WSP Opus**
Contractor :	**Unknown**
Test number :	**4**
Shear vane number :	**N/A**
Shear vane correction :	**N/A**
Water level (m):	**0.3**
Reduced level (m):	**N/A**

Project No :	**4-52149.00**
Lab Ref No :	**RT1079**
Client Ref No :	**00GEO**

Scala Penetrometer



Test Results

Depth (m)	Shear Strength (kPa)	Soil Description
0.10		Topsoil.
0.20		Fine silty SAND, light grey, firm, moist.
0.30	▽	Sandy coarse pumice GRAVEL, light grey, medium dense to dense, wet.
1.00		End of hole, could not obtain further sample.

Test Methods

Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2	Field Descriptions of Soils and Rocks by
Shear Strength using a Hand Held Shear Vane: NZ Geotechnical Soc Inc 8/2001	NZ Geotechnical Society Dec 2005, Scala over 1.5m
Inferred CBR values taken from Austroads Pavement Design Manual 2004	and Inferred CBR values are not IANZ accredited

Date tested : 11/07/18
Date reported : 11/07/18

This report may only be reproduced in full

Approved

Designation : *Laboratory Manager*
Date : 13/07/18

WSP Opus
Rotorua Laboratory
Quality Management Systems Certified to ISO 9001

20 Te Ngae Road
PO Box 1245, Rotorua 3040, New Zealand

Telephone +64 7 343 1440
Website

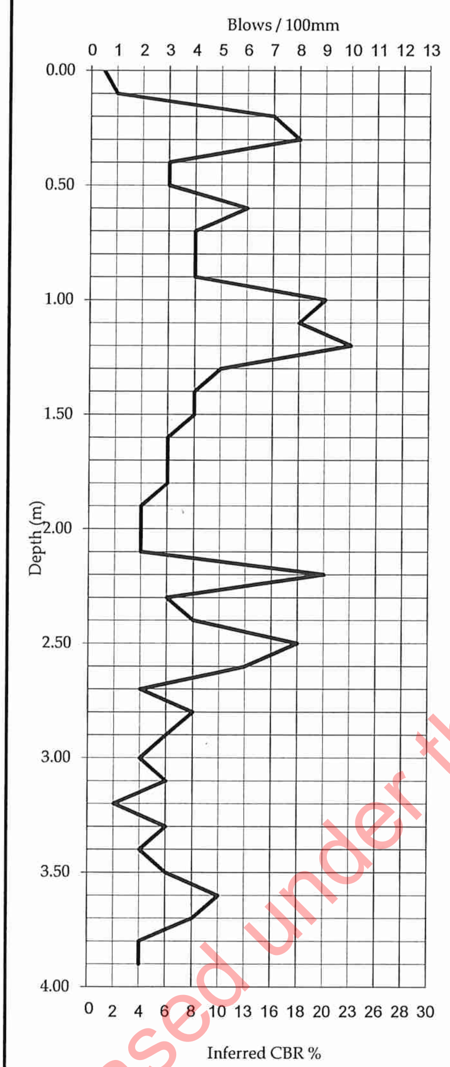
AUGER / SCALA PENETROMETER TEST REPORT

WSP | OPUS

Project :	**Lake Okareka Fire Station**
Location :	**Corner of Okareka Loop Road and Acacia Road**
Client :	**WSP Opus**
Contractor :	**Unknown**
Test number :	**5**
Shear vane number :	**N/A**
Shear vane correction :	**N/A**
Water level (m):	**0.4**
Reduced level (m):	**N/A**

Project No :	**4-52149.00**
Lab Ref No :	**RT1079**
Client Ref No :	**00GEO**

Scala Penetrometer



Test Results

Depth (m)	Shear Strength (kPa)	Soil Description
0.10		Topsoil.
0.25		Fine silty SAND, grey, medium dense, wet.
0.40		
0.60		Silty fine SAND and coarse pumice GRAVEL, grey, dense, wet.
0.80		Fine medium SAND, dark grey, medium dense, wet.
		Silty fine SAND and coarse pumice GRAVEL, grey, dense, wet.
1.20		End of hole, could not obtain further sample.
		Note: Gas bubbling out of hole after scala had been extruded. Stopped after 2 minutes.

Test Methods

Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2	Field Descriptions of Soils and Rocks by
Shear Strength using a Hand Held Shear Vane: NZ Geotechnical Soc Inc 8/2001	NZ Geotechnical Society Dec 2005, Scala over 1.5m
Inferred CBR values taken from Austroads Pavement Design Manual 2004	and Inferred CBR values are not IANZ accredited

Date tested : 11/07/18
Date reported : 11/07/18

This report may only be reproduced in full

Approved

Designation : *Laboratory Manager*
Date : 13/07/18

WSP Opus
Rotorua Laboratory
Quality Management Systems Certified to ISO 9001

20 Te Ngae Road
PO Box 1245, Rotorua 3040, New Zealand

Telephone +64 7 343 1440
Website

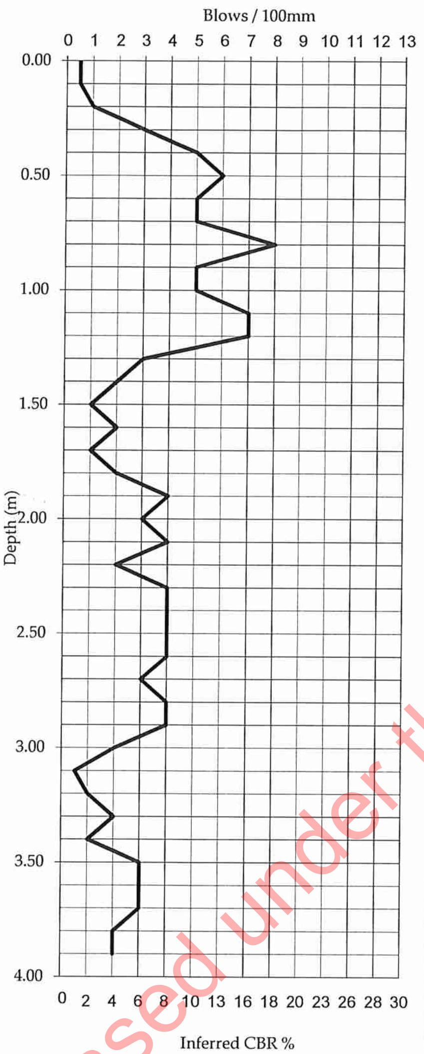
AUGER / SCALA PENETROMETER TEST REPORT

wsp | OPUS

Project :	**Lake Okareka Fire Station**
Location :	**Corner of Okareka Loop Road and Acacia Road**
Client :	**WSP Opus**
Contractor :	**Unknown**
Test number :	**1**
Shear vane number :	**N/A**
Shear vane correction :	**N/A**
Water level (m):	**0.35**
Reduced level (m):	**N/A**

Project No :	**4-52149.00**
Lab Ref No :	**RT**
Client Ref No :	**00GEO**

Scala Penetrometer



Test Results

Depth (m)	Shear Strength (kPa)	Soil Description
0.10		Topsoil.
0.25		Fine silty SAND, grey, medium dense, wet.
0.35	▽	Sandy coarse pumice GRAVEL, grey white, dense, wet.
1.00		End of hole, could not obtain further sample.
		Note: Gas bubbling out of hole after scala has been extruded. **Bubbling stoped after 2 min.**

Test Methods	
Determination of Penetration Resistance of a Soil, NZS 4402 : 1988, Test 6.5.2 Shear Strength using a Hand Held Shear Vane: NZ Geotechnical Soc Inc 8/2001 Inferred CBR values taken from Austroads Pavement Design Manual 2004	Field Descriptions of Soils and Rocks by NZ Geotechnical Society Dec 2005, Scala over 1.5m and Inferred CBR values are not IANZ accredited

Date tested : 11/07/18
Date reported : 11/07/18

This report may only be reproduced in full

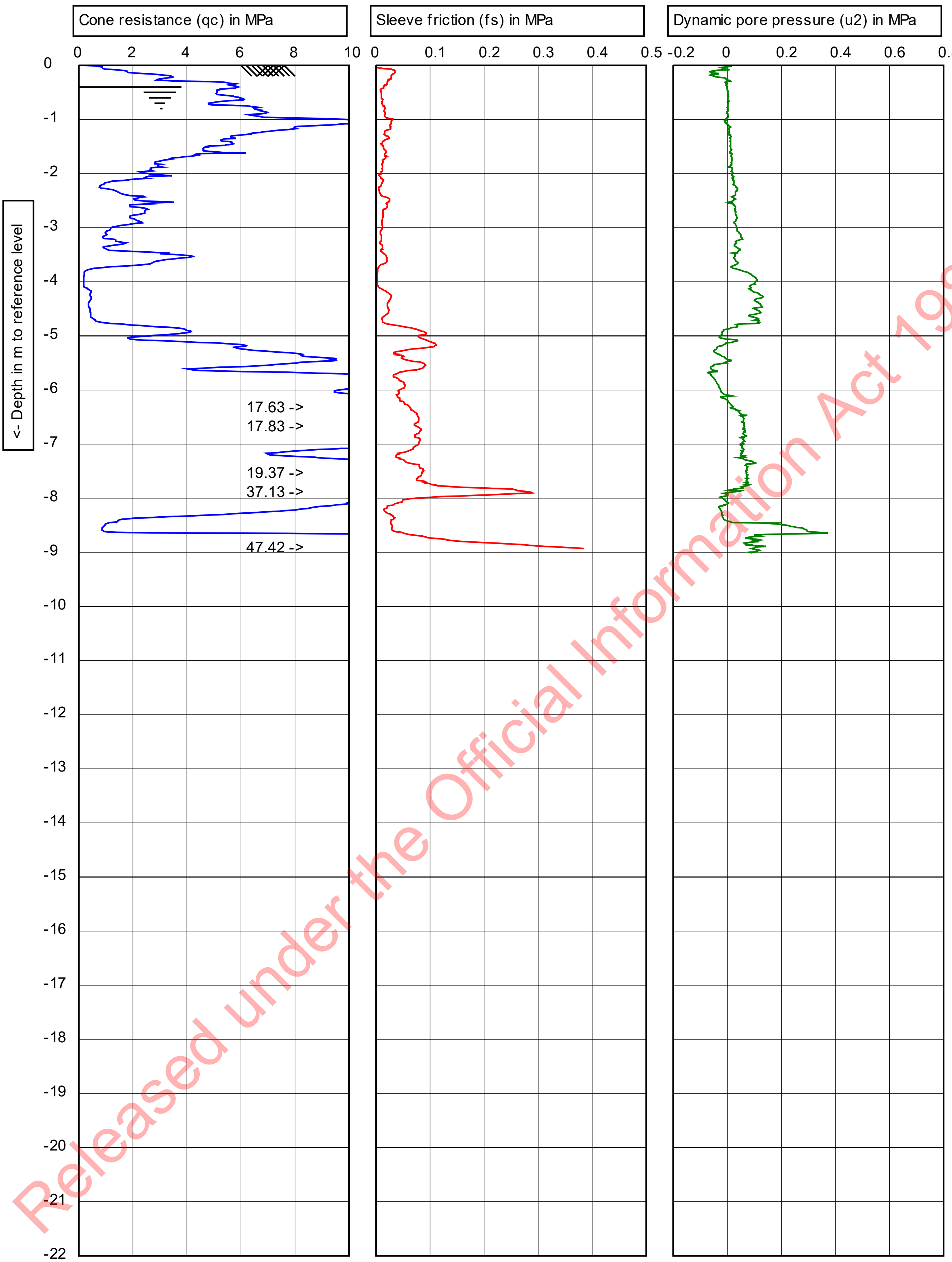
Approved

Designation : *Laboratory Manager*
Date : 13/07/18

WSP Opus
Rotorua Laboratory
Quality Management Systems Certified to ISO 9001
20 Te Ngae Road
PO Box 1245, Rotorua 3040, New Zealand
Telephone +64 7 343 1440
Website

Appendix C

Deep Investigations



Refusal (qc 40+ MPa)

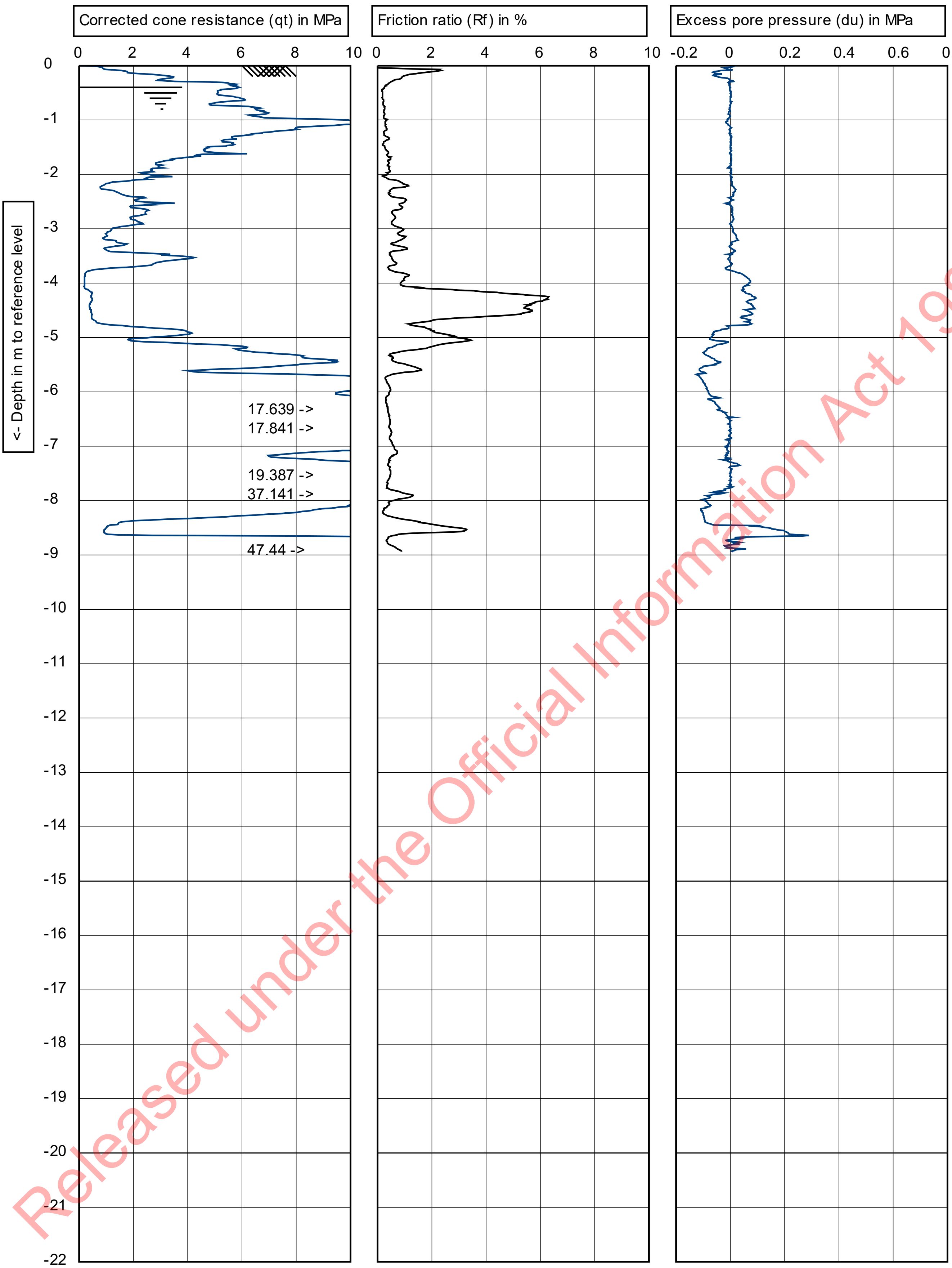
EOH - Dipped - GWL @ 0.4m

u2 150 cm² 10 cm²	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m MSL** W.L.: **-0.40 m**	Date:	**11/07/2018**
Project:	**Lake Okareka Firestation**	Cone no.:	**C10CFIIP.C15211**
Location:	**Okareka Loop Rd - Lake Okareka**	Project no.:	**4-52149.02_HA3040**
Position:	**1893208, 5769393 NZTM**	CPT no.:	**01** **1/6**

wsp OPUS

Graphs on this page are not IANZ accredited

1.44



Refusal (qc 40+ MPa)

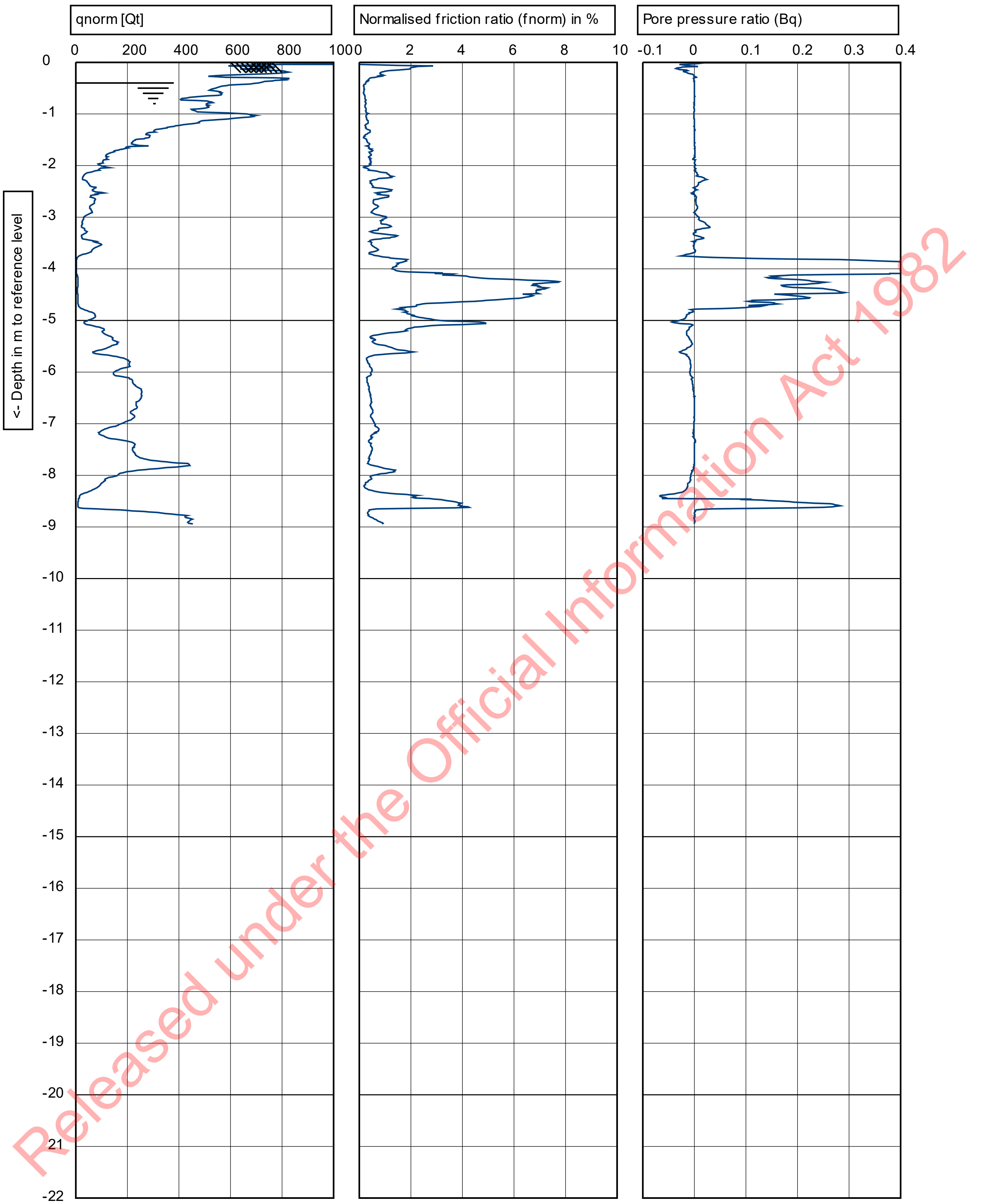
EOH - Dipped - GWL @ 0.4m

wsp | OPUS

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	**0.00 m Predrilled**
G.L.: **0.00 m MSL**	W.L.: **-0.40 m**	Date:	**11/07/2018**
Project: **Lake Okareka Firestation**		Cone no.:	**C10CFIIP.C15211**
Location: **Okareka Loop Rd - Lake Okareka**		Project no.:	**4-52149.02_HA3040**
Position: **1893208, 5769393 NZTM**		CPT no.:	**01** **2/6**



Refusal (qc 40+ MPa)

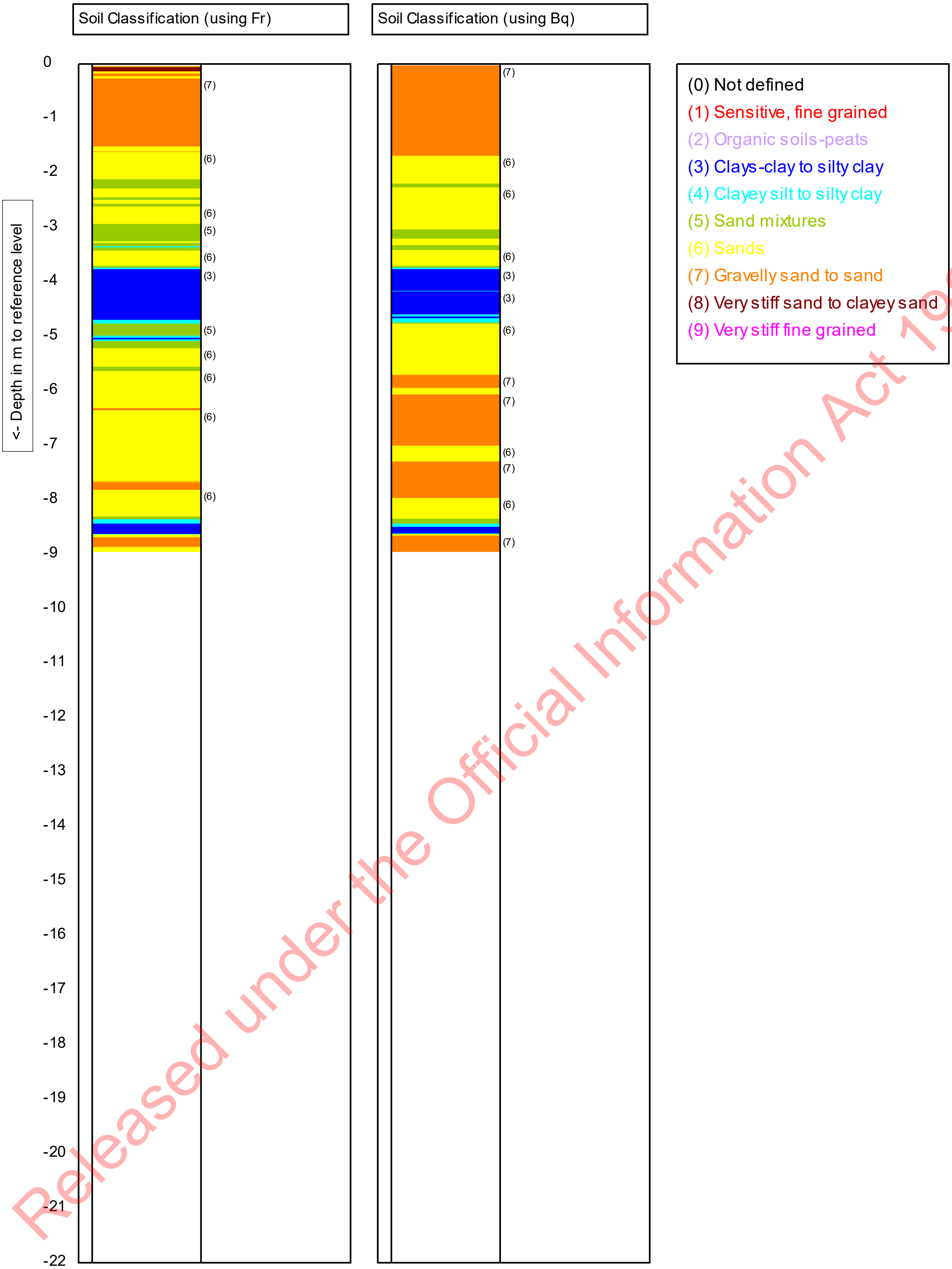
EOH - Dipped - GWL @ 0.4m

wsp | OPUS

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m MSL** W.L.: **-0.40 m**	Date:	**11/07/2018**
Project:	**Lake Okareka Firestation**	Cone no.:	**C10CFIIP.C15211**
Location:	**Okareka Loop Rd - Lake Okareka**	Project no.:	**4-52149.02_HA3040**
Position:	**1893208, 5769393 NZTM**	CPT no.:	**01** **3/6**

1.44

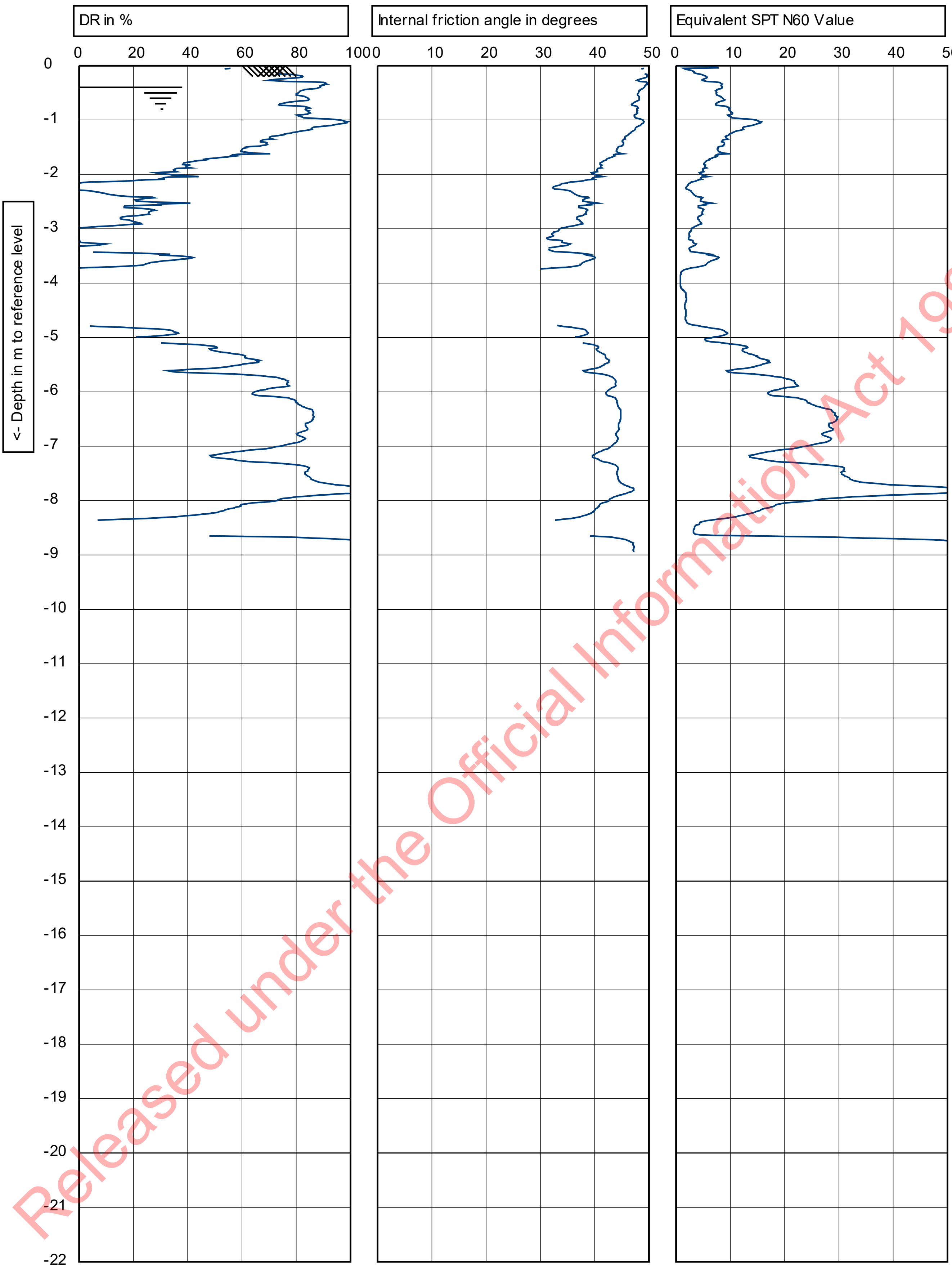


wsp | OPUS

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²	Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m MSL**	W.L.: **-0.40 m**	Date:	**11/07/2018**
Project:	**Lake Okareka Firestation**		Cone no.:	**C10CFIIP.C15211**
Location:	**Okareka Loop Rd - Lake Okareka**		Project no.:	**4-52149.02_HA3040**
Position:	**1893208, 5769393 NZTM**		CPT no.:	**01** **4/6**

1.44



Refusal (qc 40+ MPa)

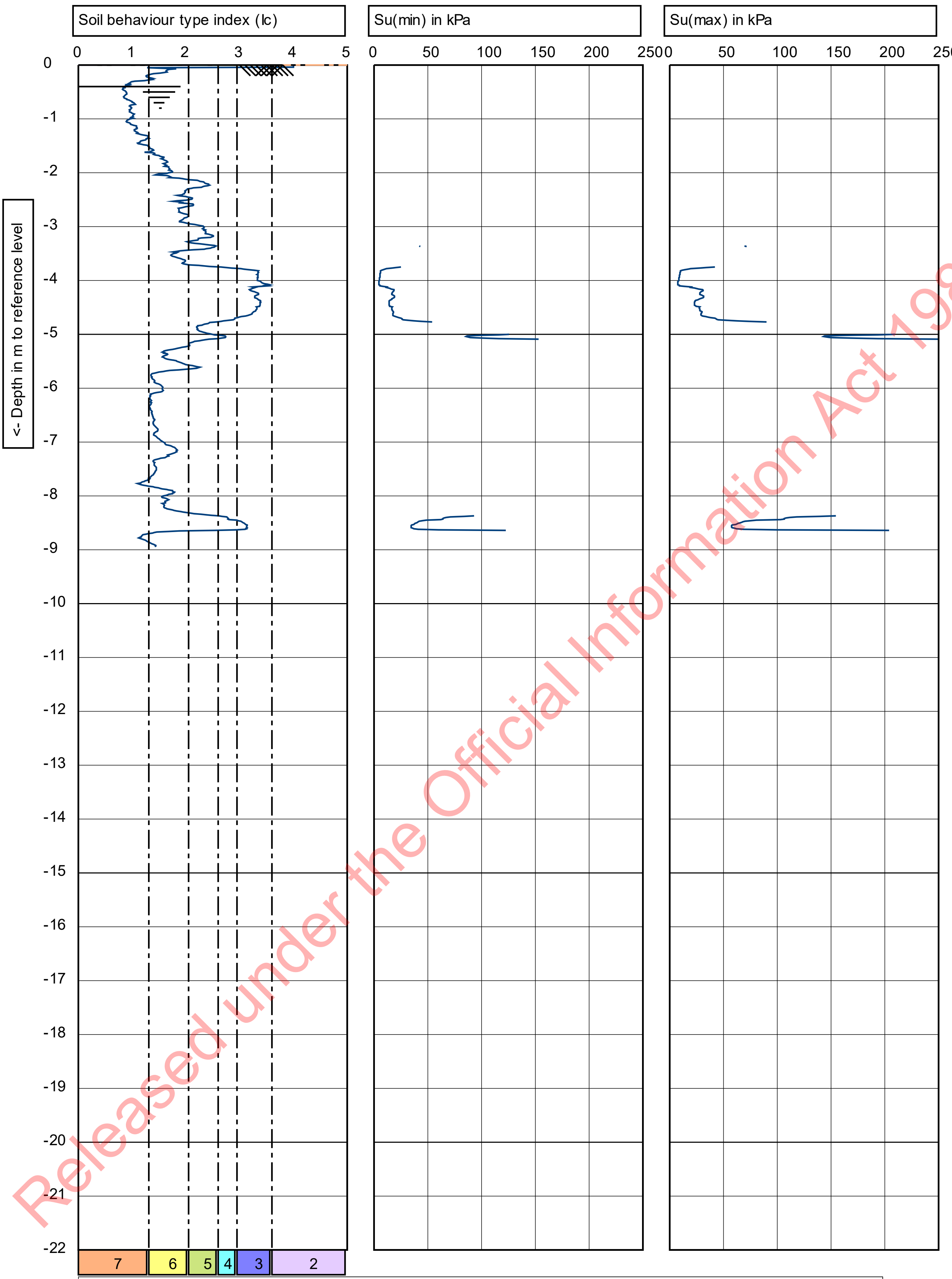
EOH - Dipped - GWL @ 0.4m

wsp | OPUS

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m MSL** W.L.: **-0.40 m**	Date:	**11/07/2018**
	Project: **Lake Okareka Firestation**	Cone no.:	**C10CFIIP.C15211**
	Location: **Okareka Loop Rd - Lake Okareka**	Project no.:	**4-52149.02_HA3040**
	Position: **1893208, 5769393 NZTM**	CPT no.:	**01** **5/6**

1.44



Refusal (qc 40+ MPa)

EOH - Dipped - GWL @ 0.4m

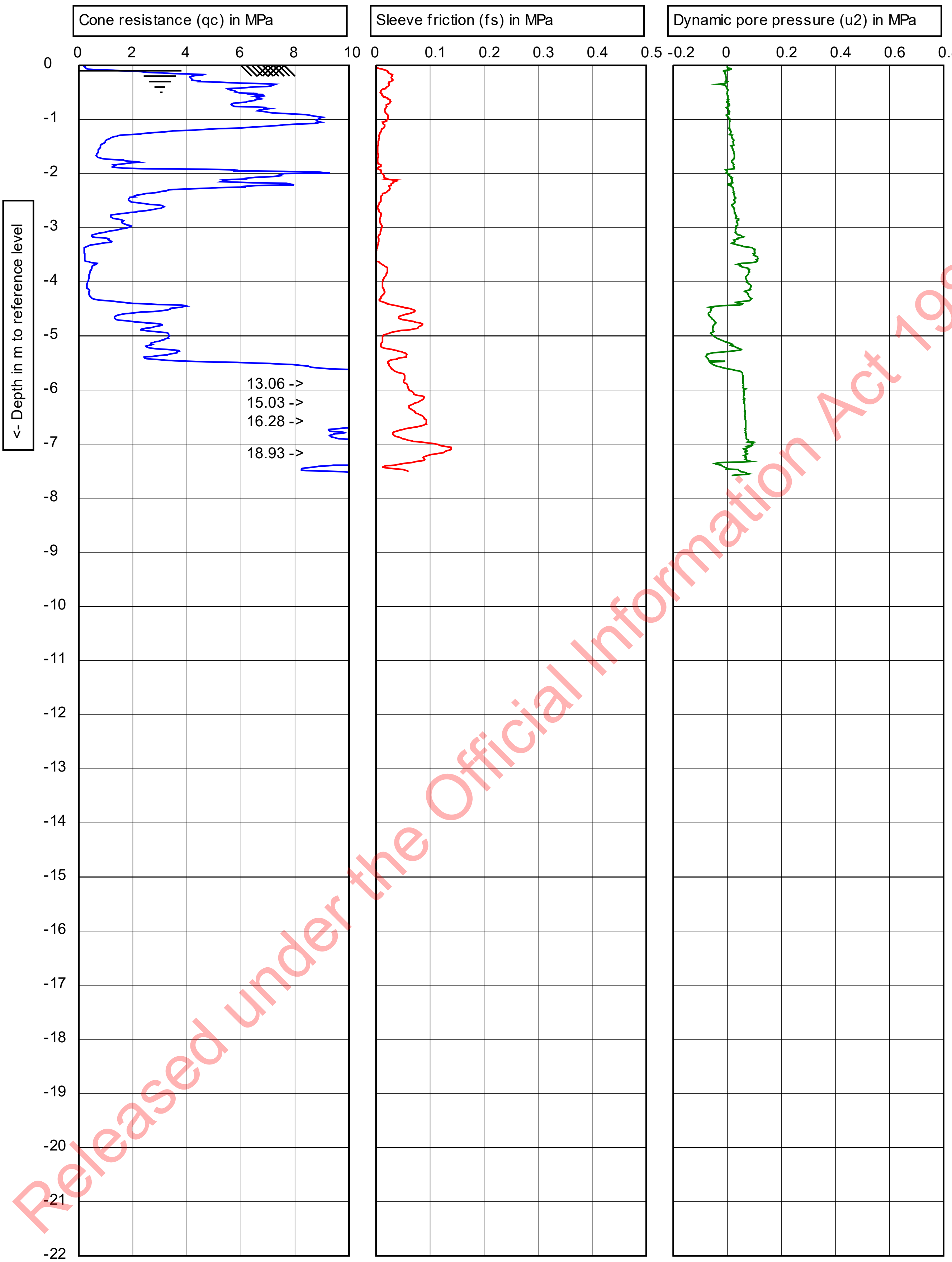
wsp | OPUS

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	**0.00 m Predrilled**
G.L.: **0.00 m MSL**	W.L.: **-0.40 m**	Date:	**11/07/2018**
Project:	**Lake Okareka Firestation**	Cone no.:	**C10CFIIP.C15211**
Location:	**Okareka Loop Rd - Lake Okareka**	Project no.:	**4-52149.02_HA3040**
Position:	**1893208, 5769393 NZTM**	CPT no.:	**01** **6/6**

1.44



Refusal (qc 40+ MPa)

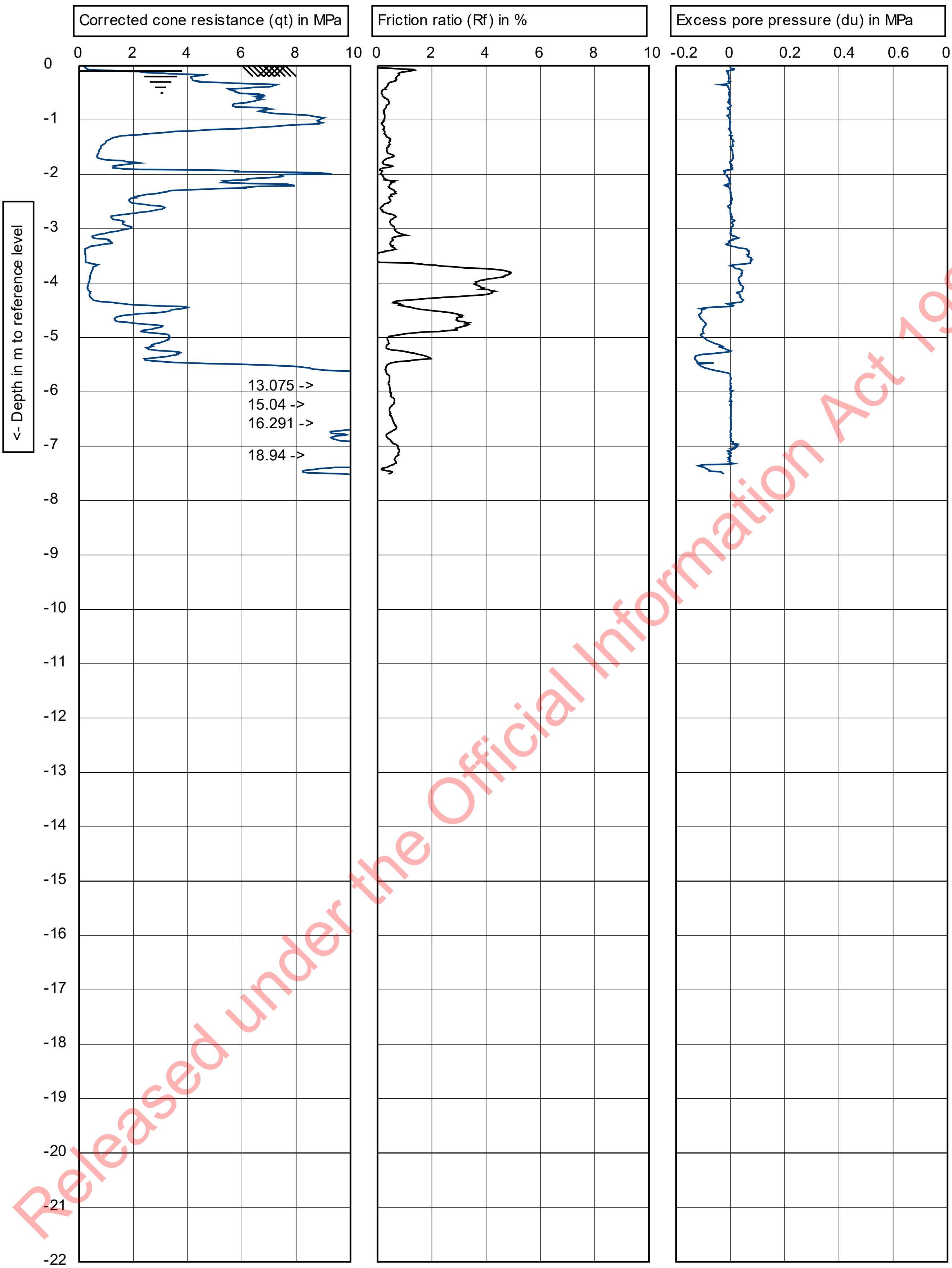
EOH - Dipped - GWL @ 0.1m

wsp | OPUS

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m MSL** W.L.: **-0.10 m**	Date:	**11/07/2018**
	Project: **Lake Okareka Firestation**	Cone no.:	**C10CFIIP.C15214**
	Location: **Okareka Loop Rd - Lake Okareka**	Project no.:	**4-52149.02_HA3040**
	Position: **1893210, 5769384 NZTM**	CPT no.:	**02** **1/6**

1.44



Refusal (qc 40+ MPa)

EOH - Dipped - GWL @ 0.1m

wsp OPUS

Graphs on this page are not IANZ accredited

1.44

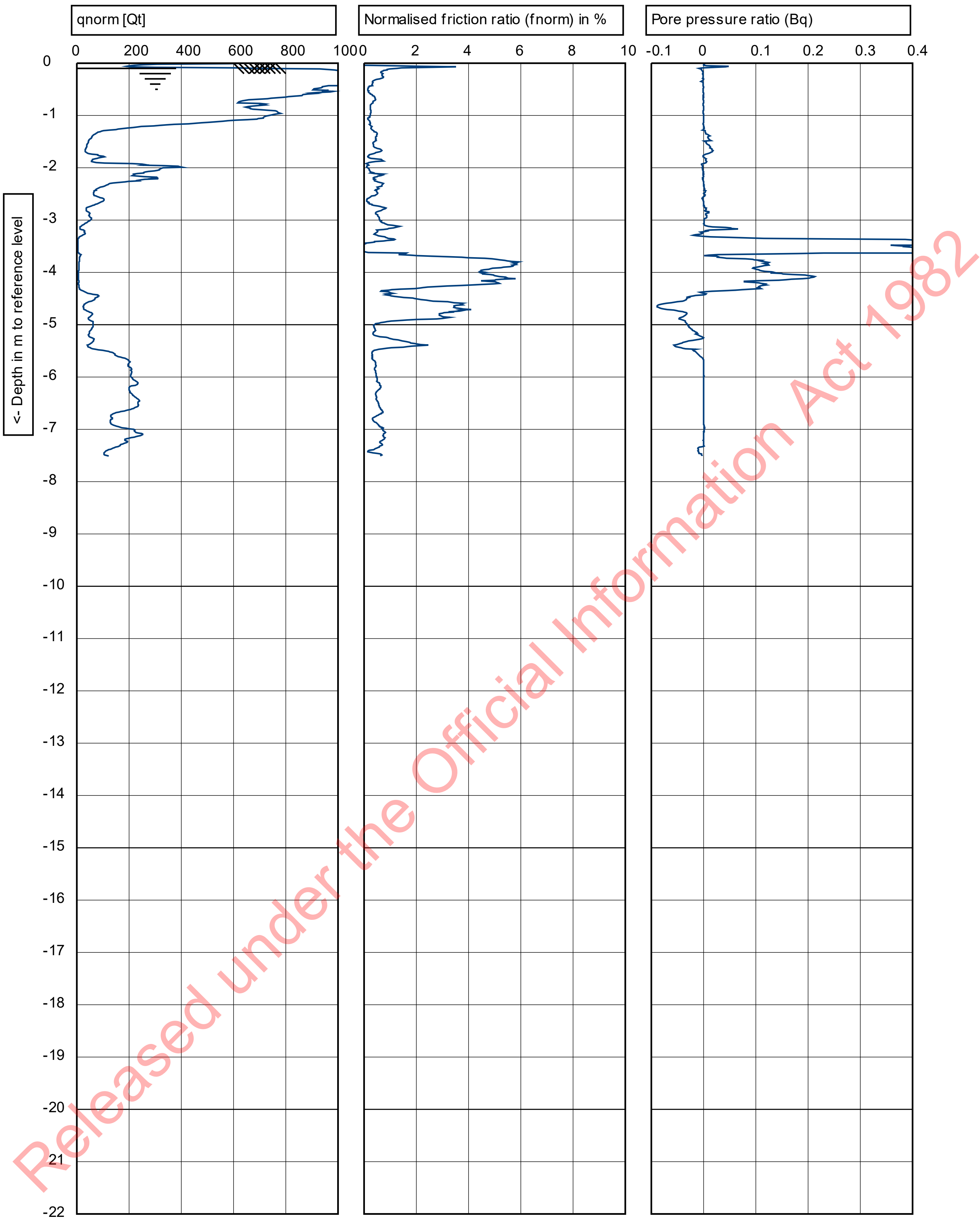
u2
150 cm²
10 cm²

Test according ASTM D5778-12 & ISO 22476-1:2012

G.L.: **0.00 m MSL** W.L.: **-0.10 m**

Project: **Lake Okareka Firestation**
Location: **Okareka Loop Rd - Lake Okareka**
Position: **1893210, 5769384 NZTM**

Predrill: **0.00 m Predrilled**
Date: **11/07/2018**
Cone no.: **C10CFIIP.C15214**
Project no.: **4-52149.02_HA3040**
CPT no.: **02** **2/6**

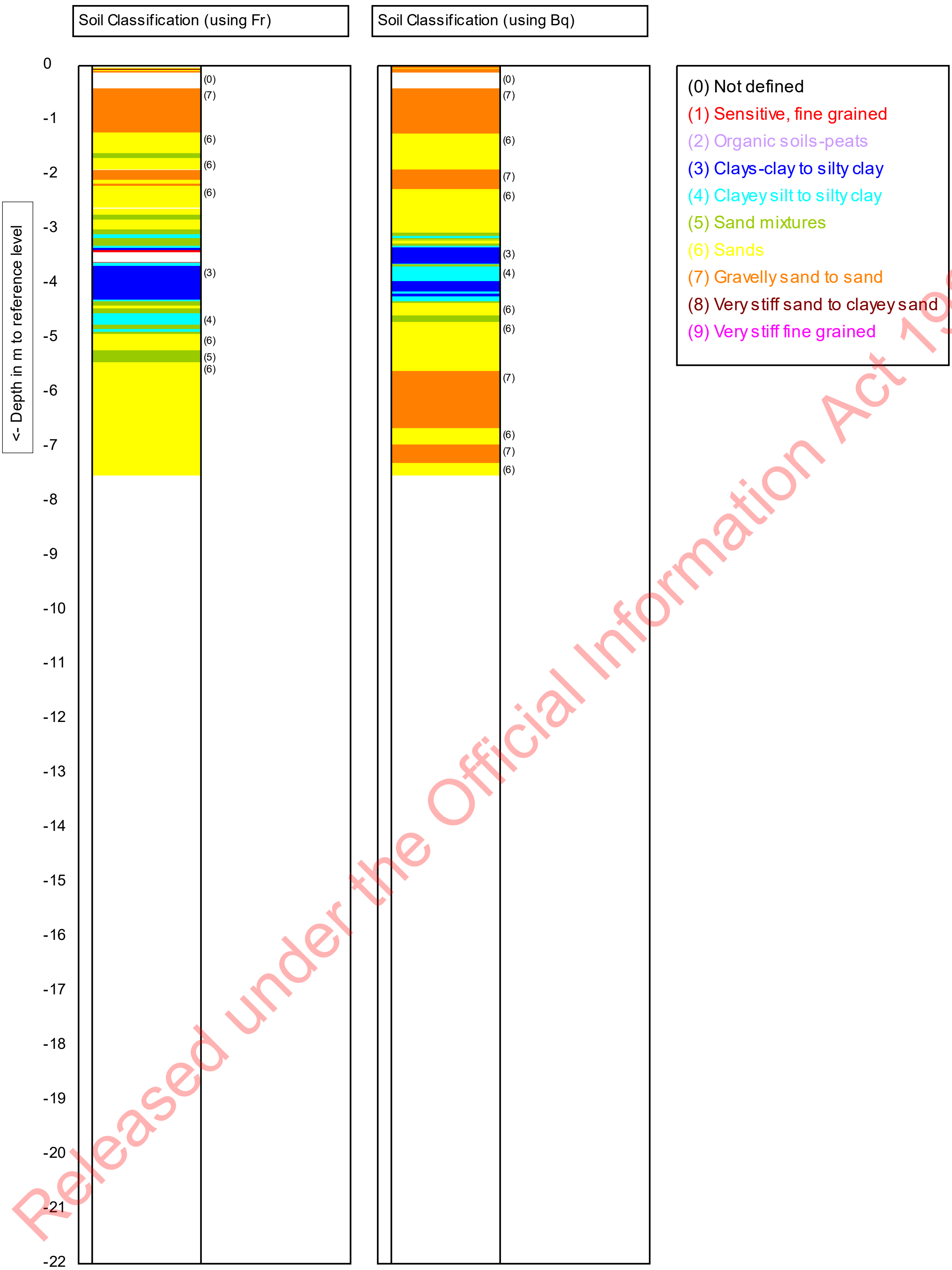


Refusal (qc 40+ MPa)

EOH - Dipped - GWL @ 0.1m

Graphs on this page are not IANZ accredited	u2 150 cm² 10 cm²	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill: **0.00 m Predrilled**
		G.L.: **0.00 m MSL** W.L.: **-0.10 m**	Date: **11/07/2018**
	Project:	**Lake Okareka Firestation**	Cone no.: **C10CFIIP.C15214**
	Location:	**Okareka Loop Rd - Lake Okareka**	Project no.: **4-52149.02_HA3040**
	Position:	**1893210, 5769384 NZTM**	CPT no.: **02** 3/6

1.44

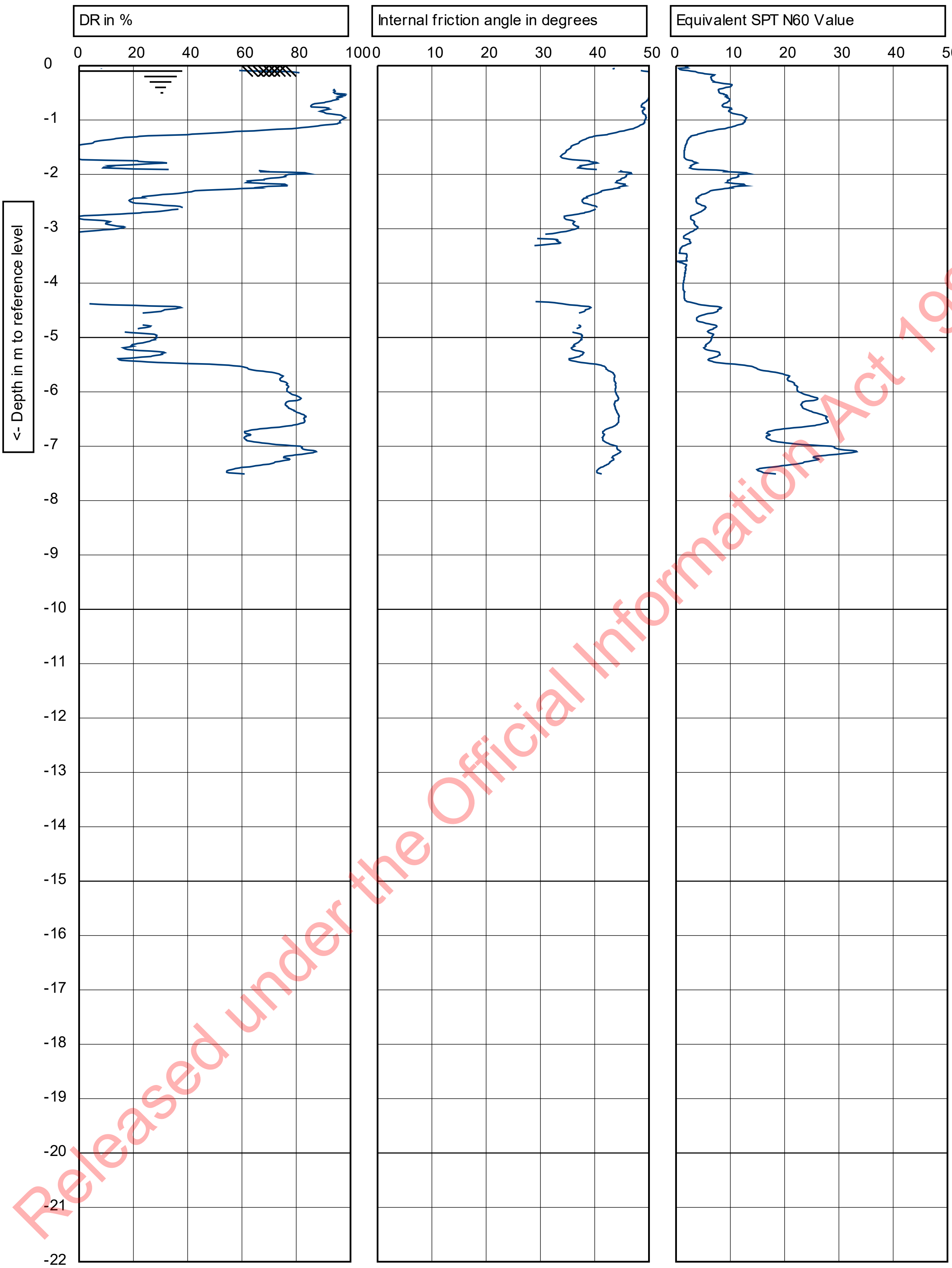


wsp | OPUS

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m MSL** W.L.: **-0.10 m**	Date:	**11/07/2018**
Project:	**Lake Okareka Firestation**	Cone no.:	**C10CFIIP.C15214**
Location:	**Okareka Loop Rd - Lake Okareka**	Project no.:	**4-52149.02_HA3040**
Position:	**1893210, 5769384 NZTM**	CPT no.:	**02** 4/6

1.44



Refusal (qc 40+ MPa)

EOH - Dipped - GWL @ 0.1m

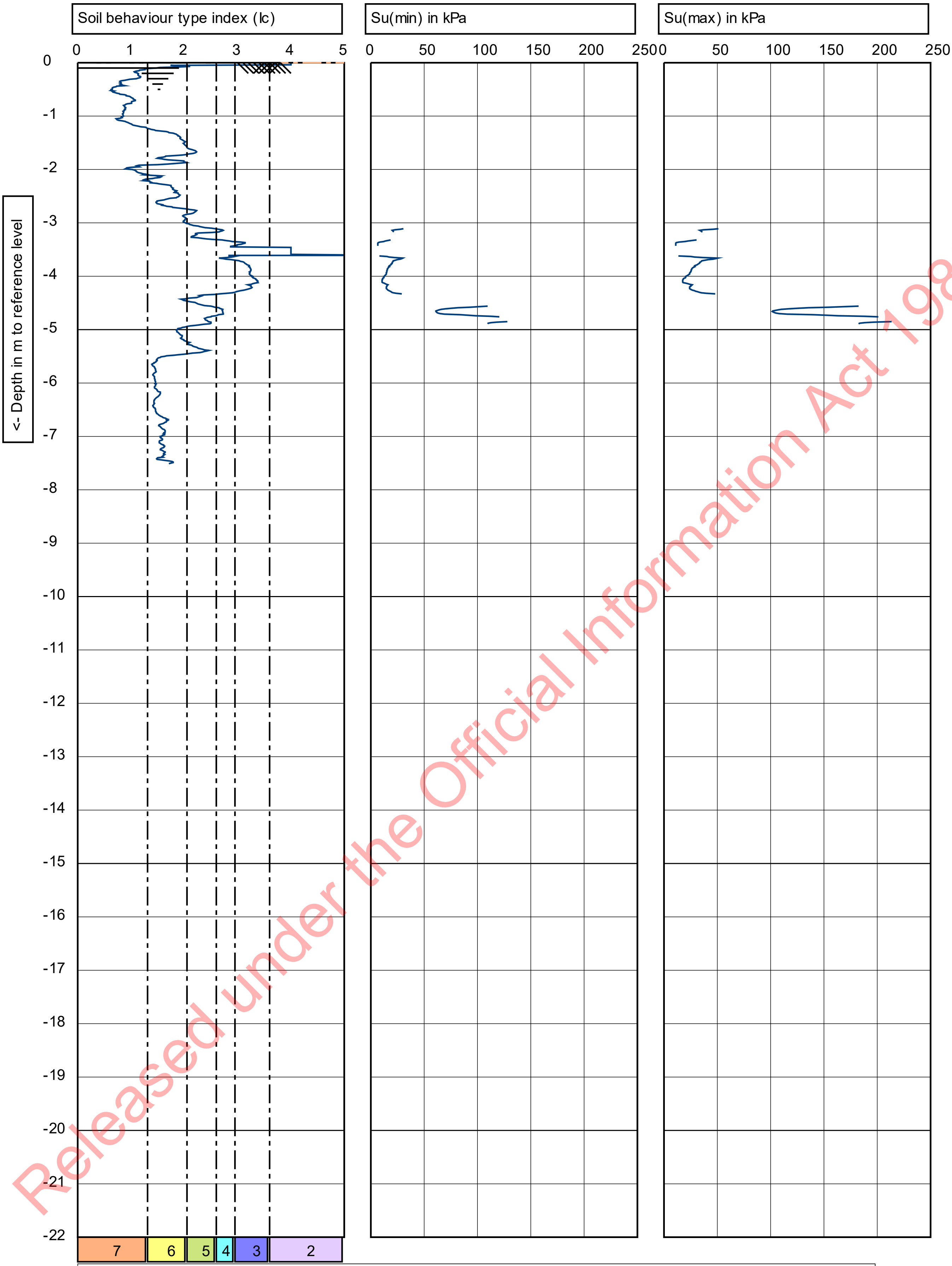
WSP | OPUS

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²

Test according ASTM D5778-12 & ISO 22476-1:2012		Predrill:	**0.00 m Predrilled**
G.L.: **0.00 m MSL**	W.L.: **-0.10 m**	Date:	**11/07/2018**
Project:	**Lake Okareka Firestation**	Cone no.:	**C10CFIIP.C15214**
Location:	**Okareka Loop Rd - Lake Okareka**	Project no.:	**4-52149.02_HA3040**
Position:	**1893210, 5769384 NZTM**	CPT no.:	**02** 5/6

1.44



Refusal (qc 40+ MPa)

EOH - Dipped - GWL @ 0.1m

Graphs on this page are not IANZ accredited

u2 150 cm² 10 cm²	Test according ASTM D5778-12 & ISO 22476-1:2012	Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m MSL** W.L.: **-0.10 m**	Date:	**11/07/2018**
	Project: **Lake Okareka Firestation**	Cone no.:	**C10CFIIP.C15214**
	Location: **Okareka Loop Rd - Lake Okareka**	Project no.:	**4-52149.02_HA3040**
	Position: **1893210, 5769384 NZTM**	CPT no.:	**02** **6/6**

1.44

Appendix D

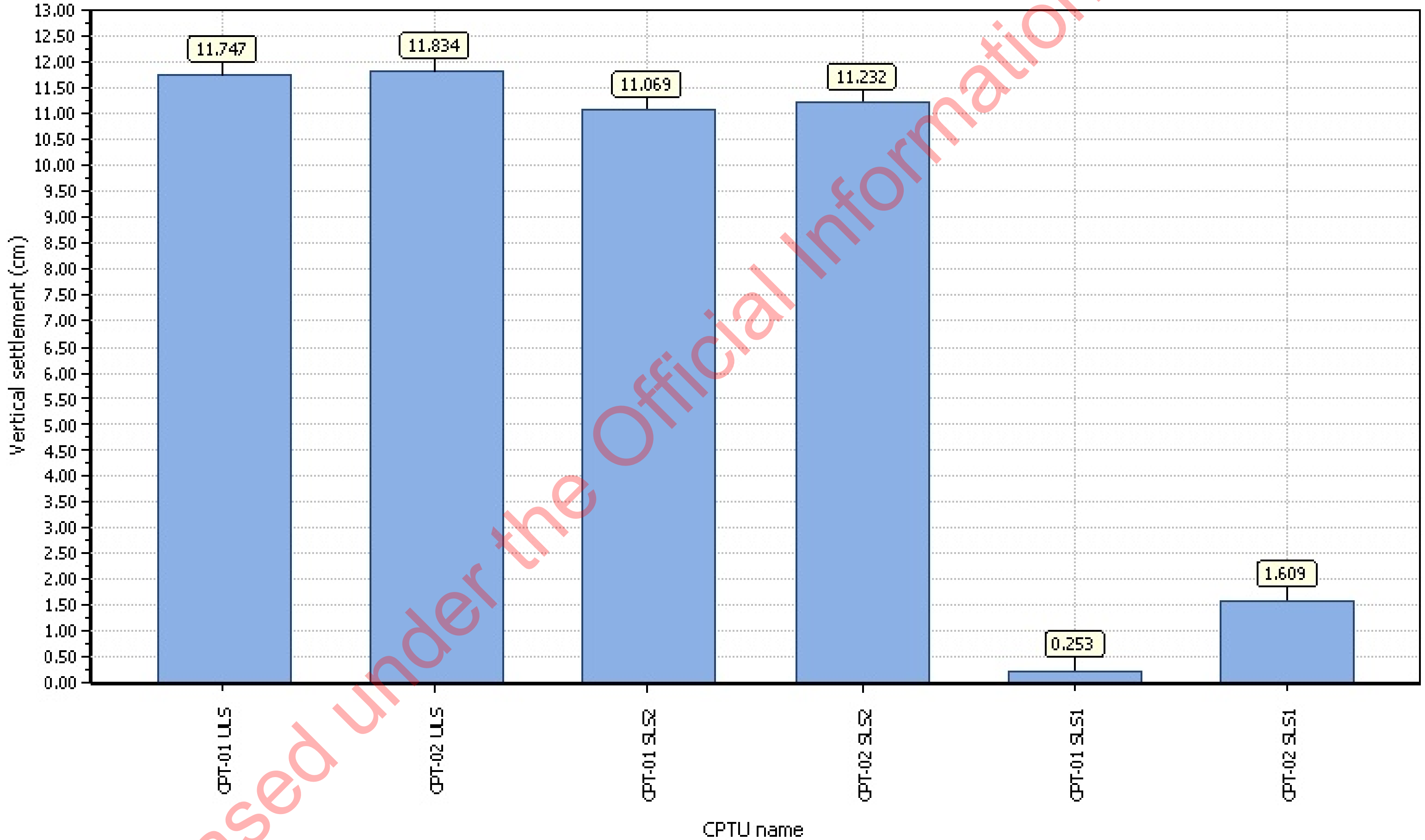
Liquefaction Results

WSP OPUS
Gartshore House, Level 3
116 Cameron Road
Tauranga 3110

Project title : Lake Okareka Fire Station

Location : Lake Okareka

Overall vertical settlements report

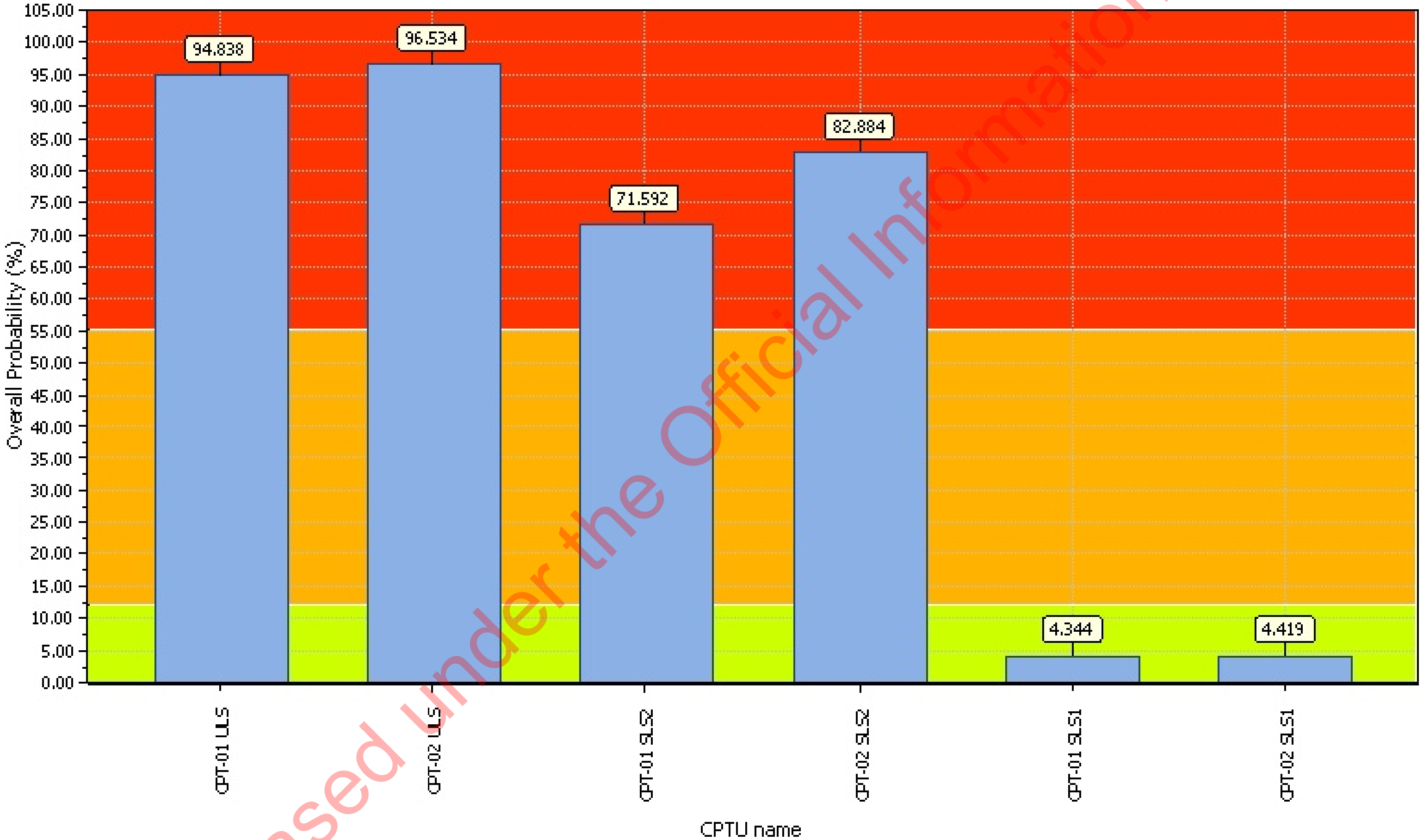


WSP OPUS
Gartshore House, Level 3
116 Cameron Road
Tauranga 3110

Project title : Lake Okareka Fire Station

Location : Lake Okareka

Overall Probability for Liquefaction report



Probability color scheme

- Very High Probability
- High Probability
- Low Probability

Basic statistics

Total CPT number: 6
33.33% low probability
0.00% high probability
66.67% very high probability

WSP OPUS
Gartshore House, Level 3
116 Cameron Road
Tauranga 3110

Project title : Lake Okareka Fire Station

Location : Lake Okareka

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: 6

33.33% little liquefaction

0.00% minnor liquefaction

0.00% moderate liquefaction

0.00% moderate to major liquefaction

0.00% major liquefaction

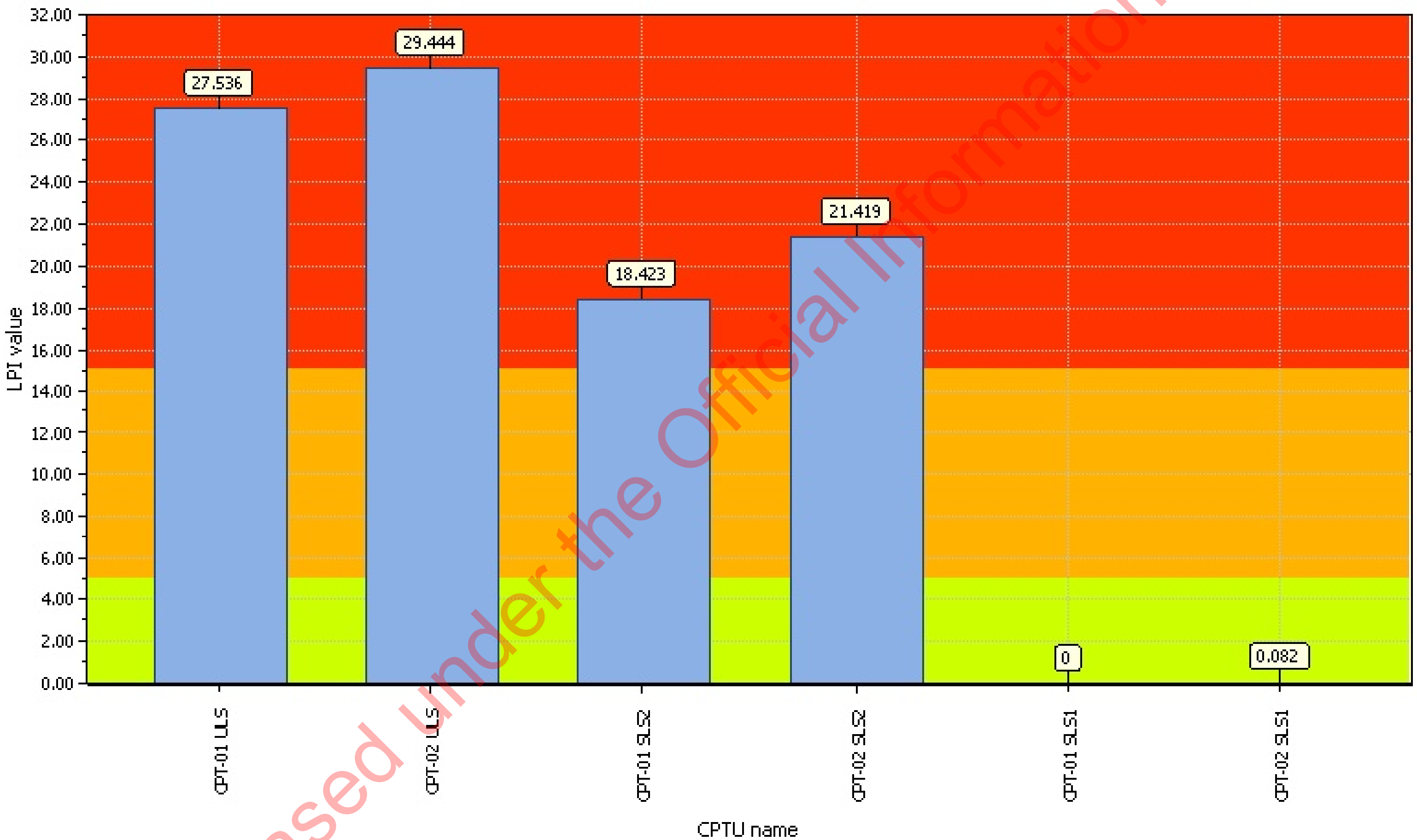
66.67% severe liquefaction

WSP OPUS
Gartshore House, Level 3
116 Cameron Road
Tauranga 3110

Project title : Lake Okareka Fire Station

Location : Lake Okareka

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

Basic statistics

Total CPT number: 6
33.33% low risk
0.00% high risk
66.67% very high risk

WSP OPUS
Gartshore House, Level 3
116 Cameron Road
Tauranga 3110

Project title : Lake Okareka Fire Station

Location : Lake Okareka

Overall lateral displacements report