Christchurch City Council

Gowerton Place Housing Complex PRO 0678

Detailed Engineering Evaluation

Quantitative Assessment Report

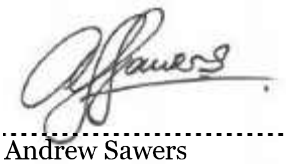
Christchurch City Council

Gowerton Place Housing Complex

Quantitative Assessment Report

Gowerton Place, Richmond, Christchurch 8013

Prepared By



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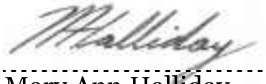

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Summary

Gowerton Place Housing Complex
PRO 0678

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background

This is a summary of the quantitative report for the Gowerton Place Housing Complex, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This assessment covers the 30 residential units on the site.

Key Damage Observed

The residential units have suffered moderate to severe damage to non-structural elements. This included cracking of the brick veneer cladding due to settlement of the perimeter wall and shear cracking. There is also severe cracking to the concrete foundation perimeter footing in some residential unit blocks. There is moderate damage to the roofline of some units due to the double brick fire wall being subject to differential settlement and movement during the earthquakes. This damage was deemed low enough to not affect the capacities of the buildings.

Level Survey

All floor slopes assessed in a full level survey. More than half of the floor slopes were greater than the 5mm/m limitation set out in the MBIE guidelines [6], as shown below.

Table A: Summary of Level Survey by Units

Unit No.	Comment	Unit No.	Comment
1	Pass	17	Fail
2	Pass	18	Fail
3	Pass	19	Fail
4	Fail	20	Fail
5	Pass	21	Fail
6	Pass	22	Fail
7	Pass	23	Pass
8	Pass	24	Pass
9	Pass	25	Fail
10	Pass	26	Fail
11	Fail	27	Fail
12	Fail	28	Fail
14	Fail	29	Fail
15	Fail	30	Pass
16	Fail	31	Pass

Critical Structural Weaknesses

No critical structural weaknesses were found in any of the buildings.

Indicative Building Strength

Table B: Summary of Seismic Performance by Blocks

Block	NBS%
PRO 0678 B001 (Block A)	72%
PRO 0678 B002 (Block B)	72%
PRO 0678 B003 (Block C)	72%
PRO 0678 B004 (Block D)	72%
PRO 0678 B005 (Block E)	72%
PRO 0678 B006 (Block F)	72%
PRO 0678 B007 (Block G)	72%
PRO 0678 B008 (Block H)	72%

No buildings on the site are considered to be earthquake prone.

The residential units have a capacity of 72% NBS as limited by the in-plane shear capacity of the timber-framed shear walls in the longitudinal direction.

Increasing the number of nails in the plasterboard will not significantly improve the strength of the buildings.

Recommendations

It is recommended that;

- Veneer at height (gable ends) have the veneer ties checked.
- The concrete perimeter footings be repaired on blocks where severe cracking occurs.
- The veneer and cracks be repaired so that the load path no longer travels through the veneer ties. This will ensure continued damage does not occur.
- A site specific geotechnical site investigation be carried out to determine the liquefaction potential of the site and the shallow bearing capacities of the soils if this information is required for future construction on the site.
- Cosmetic repairs be undertaken as required.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council to undertake a detailed seismic assessment of the Gowerton Place Housing Complex, located at Gowerton Place, Richmond, Christchurch, following the Canterbury earthquake sequence since September 2010. The site was visited by Opus International Consultants on 13 June 2013.

The purpose of the assessment is to determine if the buildings in the village are classed as being earthquake prone in accordance with the Building Act 2004.

The seismic assessment and reporting have been undertaken based on the qualitative and quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) [2] [3] [4] [5].

2 Compliance

This section contains a brief summary of the requirements of the various statutes and authorities that control activities in relation to buildings in Christchurch at present.

2.1 Canterbury Earthquake Recovery Authority (CERA)

CERA was established on 28 March 2011 to take control of the recovery of Christchurch using powers established by the Canterbury Earthquake Recovery Act enacted on 18 April 2011. This act gives the Chief Executive Officer of CERA wide powers in relation to building safety, demolition and repair. Two relevant sections are:

Section 38 – Works

This section outlines a process in which the chief executive can give notice that a building is to be demolished and if the owner does not carry out the demolition, the chief executive can commission the demolition and recover the costs from the owner or by placing a charge on the owners' land.

Section 51 – Requiring Structural Survey

This section enables the chief executive to require a building owner, insurer or mortgagee to carry out a full structural survey before the building is re-occupied.

We understand that CERA require a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). CERA have adopted the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011. This document sets out a methodology for both initial qualitative and detailed quantitative assessments.

It is anticipated that a number of factors, including the following, will determine the extent of evaluation and strengthening level required:

1. The importance level and occupancy of the building.

2. The placard status and amount of damage.

3. The age and structural type of the building.

4. Consideration of any critical structural weaknesses.

Christchurch City Council requires any building with a capacity of less than 34% of New Building Standard (including consideration of critical structural weaknesses) to be strengthened to a target of 67% as required under the CCC Earthquake Prone Building Policy.

2.2 Building Act

Several sections of the Building Act are relevant when considering structural requirements:

Section 112 - Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to the alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

The Earthquake Prone Building policy for the territorial authority shall apply as outlined in Section 2.3 of this report.

Section 115 – Change of Use

This section requires that the territorial authority is satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'.

This is typically interpreted by territorial authorities as being 67% of the strength of an equivalent new building or as near as practicable. This is also the minimum level recommended by the New Zealand Society for Earthquake Engineering (NZSEE).

Section 121 – Dangerous Buildings

This section was extended by the Canterbury Earthquake (Building Act) Order 2010, and defines a building as dangerous if:

1. In the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
2. In the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
3. There is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a 'moderate earthquake' (refer to Section 122 below); or
4. There is a risk that other property could collapse or otherwise cause injury or death; or
5. A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone (EPB) if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to other property.

A moderate earthquake is defined by the building regulations as one that would generate loads 33% of those used to design an equivalent new building.

Section 124 – Powers of Territorial Authorities

This section gives the territorial authority the power to require strengthening work within specified timeframes or to close and prevent occupancy to any building defined as dangerous or earthquake prone.

Section 131 – Earthquake Prone Building Policy

This section requires the territorial authority to adopt a specific policy for earthquake prone, dangerous and insanitary buildings.

2.3 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in October 2011 following the Darfield Earthquake on 4 September 2010.

The policy includes the following:

1. A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
2. A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
3. A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
4. Repair works for buildings damaged by earthquakes will be required to comply with the above.

The council has stated their willingness to consider retrofit proposals on a case by case basis, considering the economic impact of such a retrofit.

If strengthening works are undertaken, a building consent will be required. A requirement of the consent will require upgrade of the building to comply 'as near as is reasonably practicable' with:

- The accessibility requirements of the Building Code.
- The fire requirements of the Building Code. This is likely to require a fire report to be submitted with the building consent application.

Where an application for a change of use of a building is made to Council, the building will be required to be strengthened to 67% of New Building Standard or as near as is reasonably practicable.

2.4 Building Code

The Building Code outlines performance standards for buildings and the Building Act requires that all new buildings comply with this code. Compliance Documents published by The Department of Building and Housing can be used to demonstrate compliance with the Building Code.

On 19 May 2011, Compliance Document B1: Structure, was amended to include increased seismic design requirements for Canterbury as follows:

- Increase in the basic seismic design load for the Canterbury earthquake region (Z factor increased to 0.3 equating to an increase of 36 – 47% depending on location within the region);
- Increased serviceability requirements.

2.5 Institution of Professional Engineers New Zealand (IPENZ) Code of Ethics

One of the core ethical values of professional engineers in New Zealand is the protection of life and safeguarding of people. The IPENZ Code of Ethics requires that:

Members shall recognise the need to protect life and to safeguard people, and in their engineering activities shall act to address this need.

1.1 Giving Priority to the safety and well-being of the community and having regard to this principle in assessing obligations to clients, employers and colleagues.

1.2 Ensuring that responsible steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.

All recommendations on building occupancy and access must be made with these fundamental obligations in mind.

3 Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The loadings are in accordance with the current earthquake loading standard NZS1170.5 [1].

A generally accepted classification of earthquake risk for existing buildings in terms of %NBS that has been proposed by the NZSEE 2006 [2] is presented in Figure 1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)	Unacceptable	Unacceptable

Figure 1: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines [2]

Table 1 below compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year).

Table 1: %NBS compared to relative risk of failure

Percentage of New Building Standard (%NBS)	Relative Risk (Approximate)
>100	<1 time
80-100	1-2 times
67-80	2-5 times
33-67	5-10 times
20-33	10-25 times
<20	>25 times

3.1 Minimum and Recommended Standards

Based on governing policy and recent observations, Opus makes the following general recommendations:

3.1.1 Occupancy

The Canterbury Earthquake Order[1] in Council 16 September 2010, modified the meaning of "dangerous building" to include buildings that were identified as being EPB's. As a result of this, we would expect such a building would be issued with a Section 124 notice, by the Territorial Authority, or CERA acting on their behalf, once they are made aware of our assessment. Based on information received from CERA to date and from the MBIE guidance document dated December 2012 [6], this notice is likely to prohibit occupancy of the building (or parts thereof), until its seismic capacity is improved to the point that it is no longer considered an EPB.

3.1.2 Cordoning

Where there is an overhead falling hazard, or potential collapse hazard of the building, the areas of concern should be cordoned off in accordance with current CERA/territorial authority guidelines.

3.1.3 Strengthening

Industry guidelines (NZSEE 2006 [2]) strongly recommend that every effort be made to achieve improvement to at least 67%NBS. A strengthening solution to anything less than 67%NBS would not provide an adequate reduction to the level of risk.

It should be noted that full compliance with the current building code requires building strength of 100%NBS.

3.1.4 Our Ethical Obligation

In accordance with the IPENZ code of ethics, we have a duty of care to the public. This obligation requires us to identify and inform CERA of potentially dangerous buildings; this would include earthquake prone buildings.

[1] This Order only applies to buildings within the Christchurch City, Selwyn District and Waimakariri District Councils authority.

4 Background Information

4.1 Building Descriptions

The site contains 30 residential units which were constructed in 1960. A site plan showing the location of the units, numbered 1 to 31 (excluding number 13), is shown in Figure 2. Figure 3 shows the location of the site in Christchurch City. The units are grouped together to form blocks of either three or four units.

Figure 2: Site plan of Gowerton Place Housing Complex.

Figure 3: Location of site relative to Christchurch City CBD (Source: Google Earth).

The residential units are timber-framed buildings with timber roof framing supporting light-weight metal roofs. The ceiling follows the pitch of the roof leaving only a very small (1.4m wide), inaccessible ceiling space. Walls and ceilings are lined with plasterboard. Cladding above and below windows is light-weight Harditex-type cladding with the remaining wall areas clad with brick veneer. Foundations consist of a concrete perimeter wall with concrete piles, timber bearers, joists and tongue and groove floor boards.

Figure 4 shows a typical floor plan of a residential unit produced from site measurements by Opus. Figure 5 shows a comparable cross section used in calculations, from Poulson Courts.

The units in each block are separated by a 200mm thick double brick fire wall as shown in photo 5. We note that the walls are likely to be 2 wythes of veneer tied together.

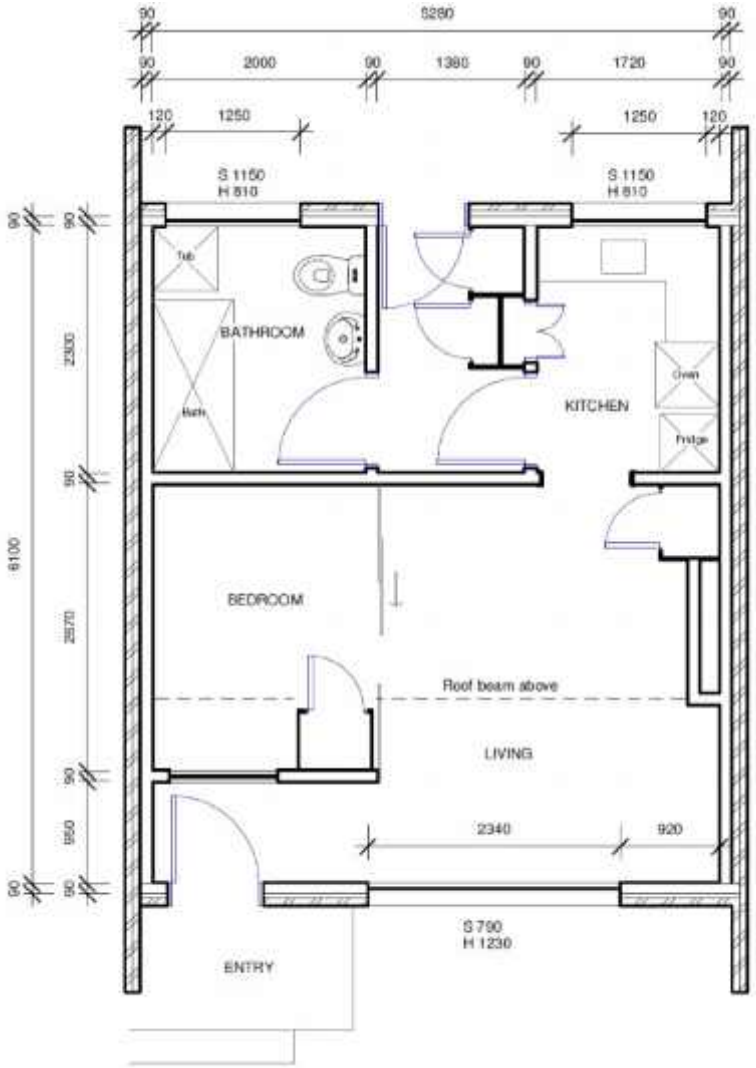


Figure 4: Typical partial floor plan of residential unit blocks.

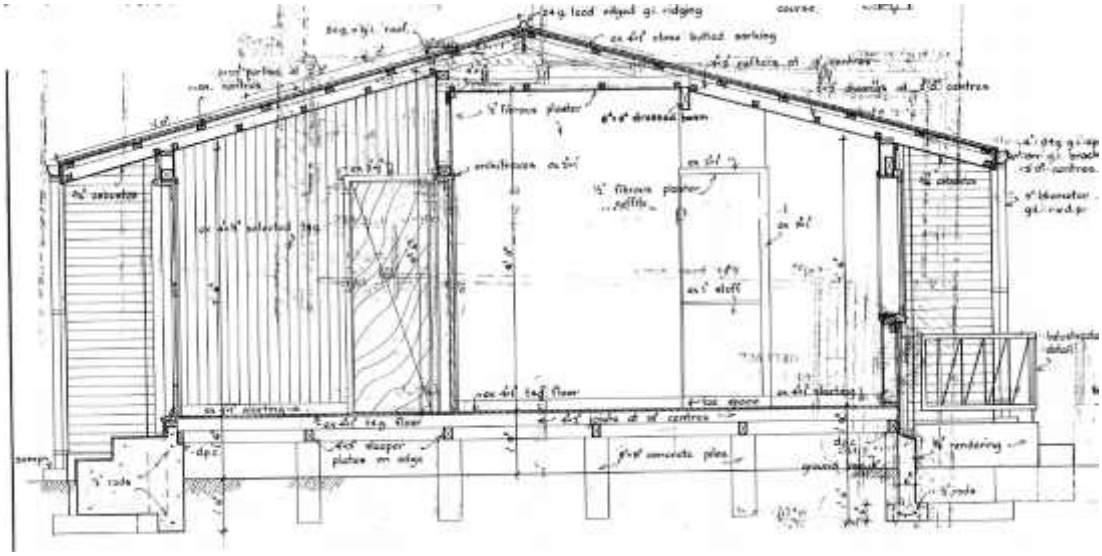


Figure 5: Comparable cross section (from Poulson Courts).

4.2 Survey

4.2.1 Post 22 February 2011 Rapid Assessment

A structural (Level 2) assessment of the buildings/property was undertaken on 8 March 2011 by Opus International Consultants.

4.2.2 Level Survey

A full level survey was deemed to be necessary at Gowerton Place Housing Complex as it is located in a TC3 zone (Figure 10). Properties in TC3 zones suffered moderate to significant amounts of damage due to liquefaction and/or settlement. A full level survey was completed in all units. The values from this level survey could then be used to determine the floor slope of the entire unit. Results for this level survey are summarised in Table 2 and Figure 6. For this site, the floor slopes in 17 of the 30 units on site were greater than the 5mm/m limitation imposed by the MBIE guidelines [6].

Table 2: Summary of the level survey

Block	Unit No.	Comment	Maximum Fall
A	1	Pass	-
	2	Pass	-
	3	Pass	-
B	4	Fail	7.1mm/m
	5	Pass	-
	6	Pass	-
C	7	Pass	-
	8	Pass	-
	9	Pass	-
	10	Pass	-
D	11	Fail	7.6mm/m
	12	Fail	8.1mm/m
	14	Fail	8.8mm/m
	15	Fail	11.2mm/m
E	16	Fail	8.9mm/m
	17	Fail	6.0mm/m
	18	Fail	6.2mm/m
	19	Fail	10mm/m
F	20	Fail	5.7mm/m
	21	Fail	9.2mm/m
	22	Fail	6.0mm/m
	23	Pass	-
G	24	Pass	-
	25	Fail	5.6mm/m
	26	Fail	5.8mm/m
	27	Fail	8.3mm/m
H	28	Fail	13.6mm/m
	29	Fail	6.8mm/m
	30	Pass	-
	31	Pass	-

4.3 Original Documentation

Copies of construction drawings and design calculations were not available for the site assessment. A typical floor plan of a residential unit has been produced by Opus from site measurements to help investigate potential critical structural weaknesses (CSWs) and identify details which required particular attention.

5 Damage

This section outlines the damage to the buildings that was observed during site visits. It is not intended to be a complete summary of the damage sustained by the buildings due to the earthquakes. Some forms of damage may not be able to be identified with a visual inspection only.

It is noticeable that some residential unit blocks, and individual units, have suffered more damage than others. Overall, Units 11-31 appear to have suffered the highest levels of damage.

Note: Any photo referenced in this section can be found in Appendix A.

5.1 Residual Displacements

The results of the level survey indicate the possibility of ground settlement due to the earthquakes. This is particularly evident in units 4, 11-15, 16-19, 20-22, and 25-27 and 28-29, coloured red in Figure 6, where the floor slopes were measured to be beyond the 5mm/m limitation imposed by MBIE guidelines.

Figure 6: Units which have floor slopes exceeding 5mm/m (coloured red).

Laser level measurements taken on-site indicates that fire walls separating Units 11-15, 16-19, 24-27 and 28-31 are up to 20mm out of vertical alignment at the top of the wall.

5.2 Foundations

A major cause of damage in these units was due to settlement of the perimeter wall, upon which the brick cladding is supported. Settlement of these footings relative to the concrete piles within the footing has caused the load path to shift as the veneers become supported by the wire veneer ties, as shown in Figure 7. This has caused splitting in the mortar joints up to 20mm wide. This change in load path increases the load on the timber framing and has already resulted in increased damage; this was observed to have worsened between the visits by Opus engineers in 2011 and 2013. It is expected that this will cause continued damage to the units unless repaired.

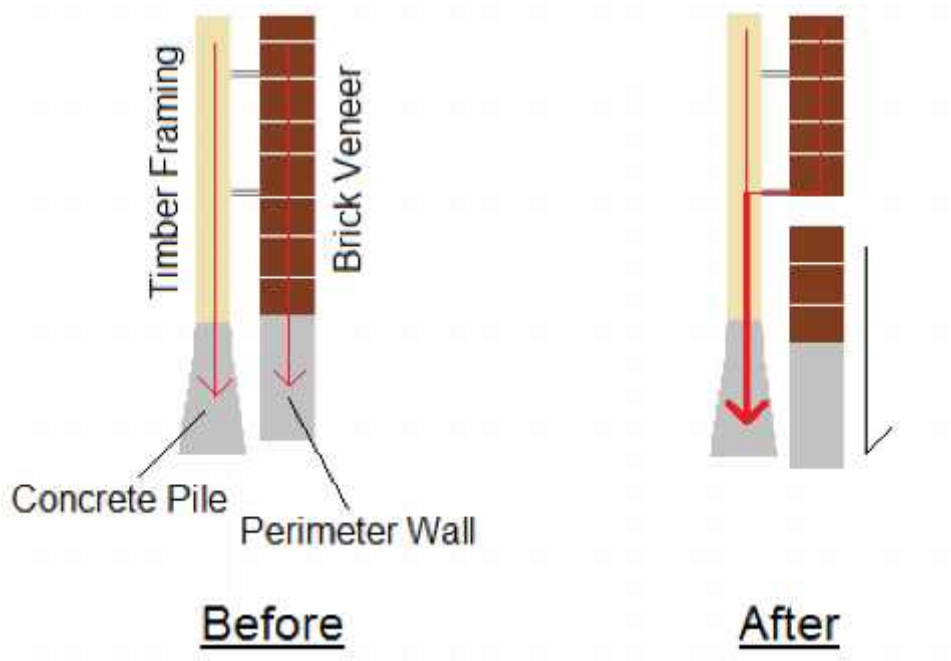


Figure 7: Example of damage due to relative settlement of the perimeter wall.

Many of the residential blocks have areas along their length where 0.1-1 mm wide cracks can be observed on the concrete perimeter foundation wall. In some locations cracking exceeds 40mm and are observed as being severe in nature (photos 14-17). Access to view the timber subfloor framing was limited to a visual assessment through a floor access hatch in unit 9.

5.3 Primary Gravity Structure

The roofline has been damaged where fire walls have been subject to differential settlement and movement of the wall during earthquake actions (photo 18).

5.4 Primary Lateral-Resistance Structure

Some cracking of GIB ceiling diaphragms and wall linings was observed in many of the units, typically at the joint between two panels (photos 19-21). This was consistent throughout all the units visited.

5.5 Non Structural Elements

Stepped cracking of the mortar joints and through the brick veneer exterior cladding was observed on most units (photos 6-13). Units 24-27 and 28-31 appear to have suffered the most cracking to their brick veneer cladding. This damage is due to shear failure, differential settlement and the foundation damage explained in section 5.2.

5.6 General Observations

The buildings have suffered distributed amounts of moderate to severe damage, which is consistent with the heavy nature of the cladding and the age of the buildings.

6 Detailed Seismic Assessment

The detailed seismic assessment has been based on the NZSEE 2006 [2] guidelines for the "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" together with the "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure" [3] draft document prepared by the Engineering Advisory Group on 19 July 2011, and the SESOC guidelines "Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes" [5] issued on 21 December 2011.

As the residential units have the same floor plan, the analysis was simplified by conducting the analysis of one multi-unit block with brick cladding and using this for all multi-unit blocks.

6.1 Critical Structural Weaknesses

The term Critical Structural Weakness (CSW) refers to a component of a building that could contribute to increased levels of damage or cause premature collapse of a building.

No CSWs were identified in the buildings.

6.2 Quantitative Assessment Methodology

The assessment assumptions and methodology have been included in Appendix D. A brief summary follows:

Hand calculations were performed to determine seismic forces from the current building codes. These forces were applied globally to the structure and the capacities of the walls were calculated and used to estimate the %NBS. The walls, highlighted in Figure 8 and Figure 9, were used for bracing in their respective directions.

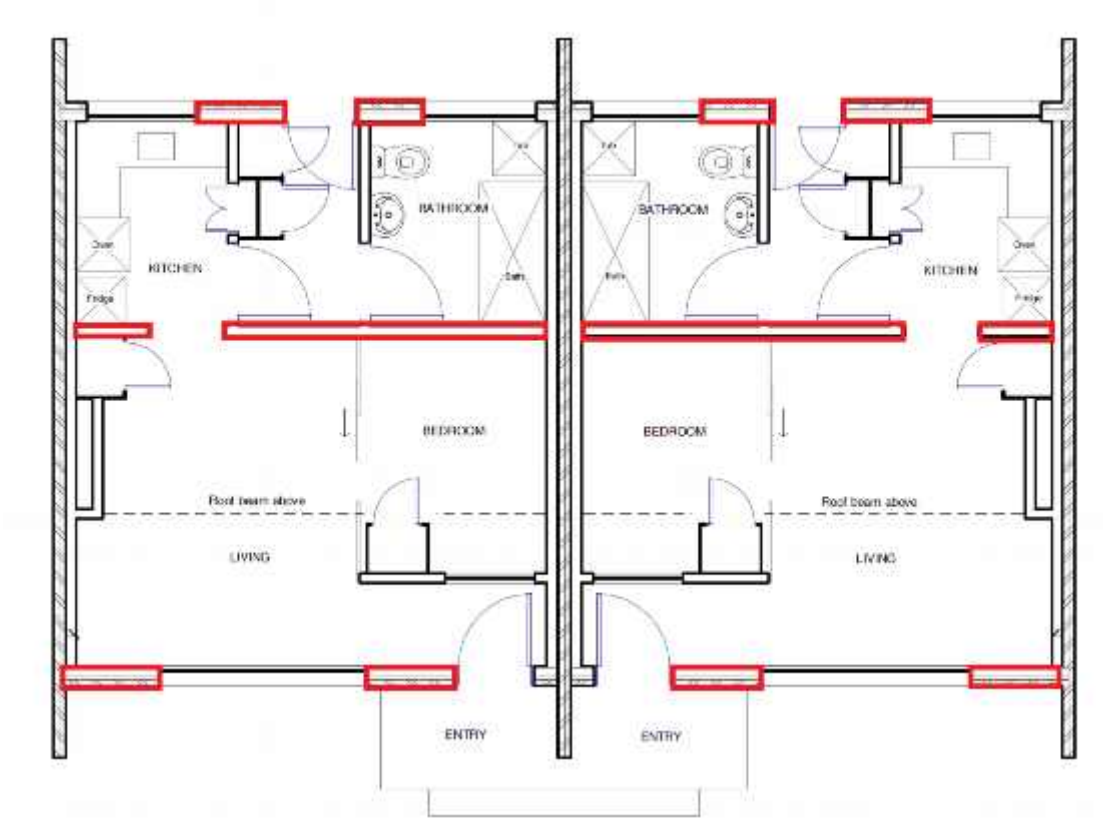


Figure 8: Walls used for bracing in the longitudinal direction.

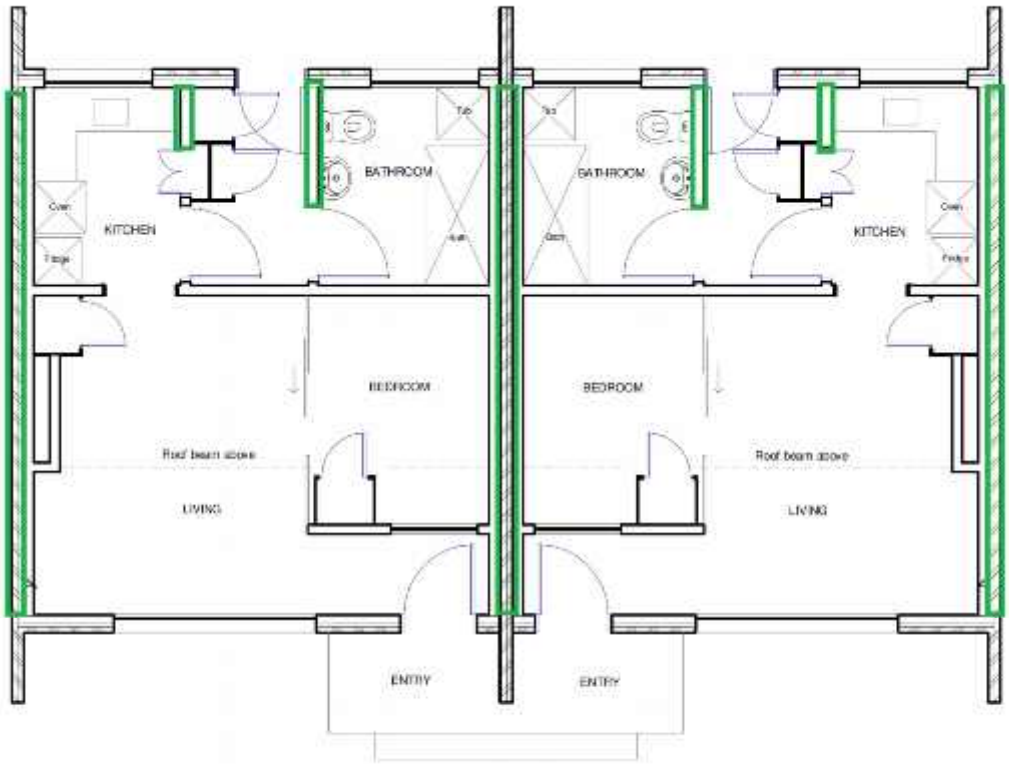


Figure 9: Walls used for bracing in the transverse direction.

6.3 Limitations and Assumptions in Results

The observed level of damage suffered by the buildings was deemed low enough to not affect their capacity. Therefore the analysis and assessment of the buildings was based on them being in an undamaged state. There may have been damage to the buildings that was unable to be observed that could cause the capacity of the buildings to be reduced; therefore the current capacity of the buildings may be lower than that stated.

The results have been reported as a %NBS and the stated value is that obtained from our analysis and assessment. Despite the use of best national and international practice in this analysis and assessment, this value contains uncertainty due to the many assumptions and simplifications which are made during the assessment. These include:

- Simplifications made in the analysis, including boundary conditions such as foundation fixity.
- Assessments of material strengths based on limited drawings, specifications and site inspections.
- The normal variation in material properties which change from batch to batch.
- Approximations made in the assessment of the capacity of each element, especially when considering the post-yield behaviour.
- Construction is consistent with normal practise of the era in which constructed.

6.4 Assessment

A summary of the structural performance of the buildings is shown in Table 3. Note that the values given represent the worst performing elements in the building, where these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing elements.

Table 3: Summary of Seismic Performance

Building Description	Critical element	% NBS based on calculated capacity in longitudinal direction	% NBS based on calculated capacity in transverse direction.
All Multi-Unit Blocks	Bracing capacity of structural walls.	72%	100%

Increasing the number of nails in the plasterboard will not significantly improve the strength of the buildings.

7 Geotechnical Summary

The following is a summary of the geotechnical desktop study undertaken by Opus. A full copy of the report can be found in Appendix C.

7.1 General

CERA indicates that Gowerton Courts Housing Complex is located in a TC3 zone (as shown in Figure 10). This classification suggests future significant earthquakes will cause moderate to significant land damage due to liquefaction and settlement. Due to this risk, a separate geotechnical desktop study was undertaken by Opus.

Figure 10: CERA Technical Categories map (loc. starred)

7.2 Liquefaction Potential

The liquefaction assessment suggested significant liquefaction risk in the western half of the site with expected liquefaction induced differential settlements of up to 150 mm in a future ULS earthquake event. The subsurface ground profile together with the ground damage reported at the site during the recent earthquakes of 2010 and 2011, confirms that the site has a high risk of liquefaction.

7.3 Summary

Significant liquefaction damage has occurred at Gowerton Place as a result of the 2010 and 2011 earthquake sequence. The level survey results have been assessed and indicated large floor variations (recorded maximum falls of up to 13.6 mm/m) in floor level in Units 4, 11-22 and 25-29 in the Gowerton Place complex. Lateral stretch in the order of 200 to 500 mm may occur across the footprint of units 1, 2 and 3 in a future large earthquake.

7.4 Further Work

It is recommended that in order to determine foundation repair options at Gowerton Place, a site specific investigation is undertaken including CPTs, Hand Augers and Scalas. The site investigation will enable a site specific liquefaction assessment to be undertaken to identify the liquefiable layers to help determine conceptual repair and relevelling options.

The scope of the proposed site specific geotechnical investigations will be:

- 5 Cone Penetration Tests to a target depth of 20 m or refusal.
- Approximately 6 Hand Auger and Scala tests should then be carried out to 3 m depth or refusal.
- Assessment and reporting.

The locations of the investigations are to be agreed in conjunction with the Structural Engineer.

8 Conclusions

- None of the buildings on site are considered to be Earthquake Prone.
- The residential units have a capacity of 72% NBS, as limited by the in-plane capacity of the bracing walls. They are deemed to be a 'low risk' in a design seismic event according to NZSEE guidelines. Their level of risk is 2-5 times that of a 100% NBS building (Figure 1).
- Based on the geotechnical appraisal, differential settlement as a result of liquefaction could result in further damage, similar in nature to that which has occurred in the recent earthquake sequence. However, based on the nature of construction, this is unlikely to result in the collapse of concrete ground beams beneath the masonry walls.

9 Recommendations

It is recommended that;

- Veneer at height (gable ends) have the veneer ties checked.
- The concrete perimeter footings be repaired on blocks where severe cracking occurs.
- The veneer and cracks be repaired so that the load path no longer travels through the veneer ties. This will ensure continued damage does not occur.
- A site specific geotechnical site investigation be carried out to determine the liquefaction potential of the site and the shallow bearing capacities of the soils if this information is required for future construction on the site.
- Cosmetic repairs be undertaken as required.

10 Limitations

- This report is based on an inspection of the buildings and focuses on the structural damage resulting from the Canterbury Earthquake sequence since September 2010. Some non-structural damage may be described but this is not intended to be a complete list of damage to non-structural items.
- Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time.
- This report is prepared for the Christchurch City Council to assist in the assessment of any remedial works required for the Gowerton Place Housing Complex. It is not intended for any other party or purpose.

11 References

[1] NZS 1170.5: 2004, Structural design actions, Part 5 Earthquake actions, Standards New Zealand.

[2] NZSEE (2006), Assessment and improvement of the structural performance of buildings in earthquakes, New Zealand Society for Earthquake Engineering.

[3] Engineering Advisory Group, Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure, Draft Prepared by the Engineering Advisory Group, Revision 5, 19 July 2011.

[4] Engineering Advisory Group, *Guidance on Detailed Engineering Evaluation of Non-residential buildings, Part 3 Technical Guidance*, Draft Prepared by the Engineering Advisory Group, 13 December 2011.

[5] SESOC (2011), Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes, Structural Engineering Society of New Zealand, 21 December 2011.

[6] MBIE (2012), Repairing and rebuilding houses affected by the Canterbury earthquakes, Ministry of Building, Innovation and Employment, December 2012.

Appendix A - Photographs

Gowerton Place Housing Complex		
No.	Item description	Photo
Residential Units		
1	Typical exterior elevation (back)	
2	Typical exterior elevation (front)	

3	Typical exterior elevation (front)	
4	Double brick fire wall between Units 17 and 18 is off vertical alignment	
5	Typical fire wall junction at foundation level within the subfloor cavity	

6	Typical cracking of brick veneer cladding along mortar joints and brick mass itself (Unit 17)	
7	Typical cracking of brick veneer mortar joints	
8	Typical stepped cracking of brick veneer	

9	Typical stepped cracking of brick veneer	
10	Typical stepped cracking of brick veneer	
11	Typical stepped cracking of brick veneer	

12	Typical cracking of brick veneer	
13	Typical stepped cracking of brick veneer	
14	Severe cracking of concrete perimeter foundation wall	

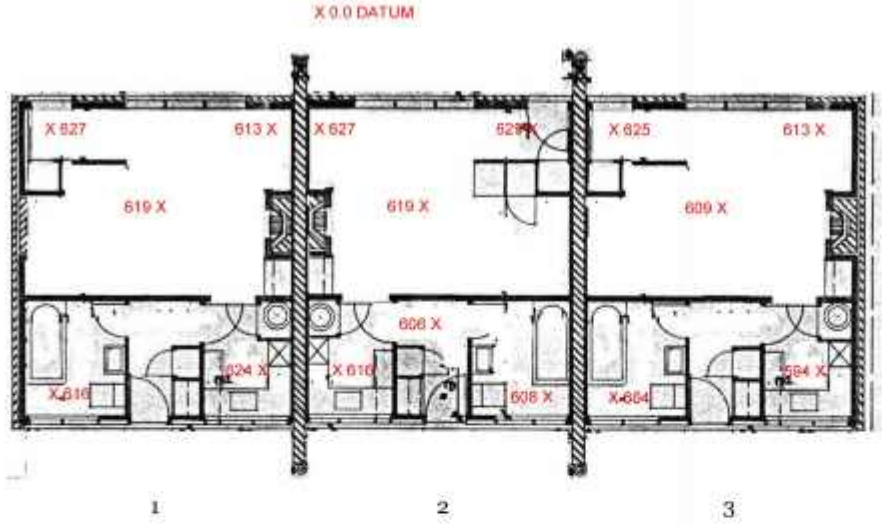
15	Cracking of concrete perimeter foundation wall	
16	Cracking of concrete perimeter foundation wall	
17	Severe cracking of concrete perimeter foundation wall	

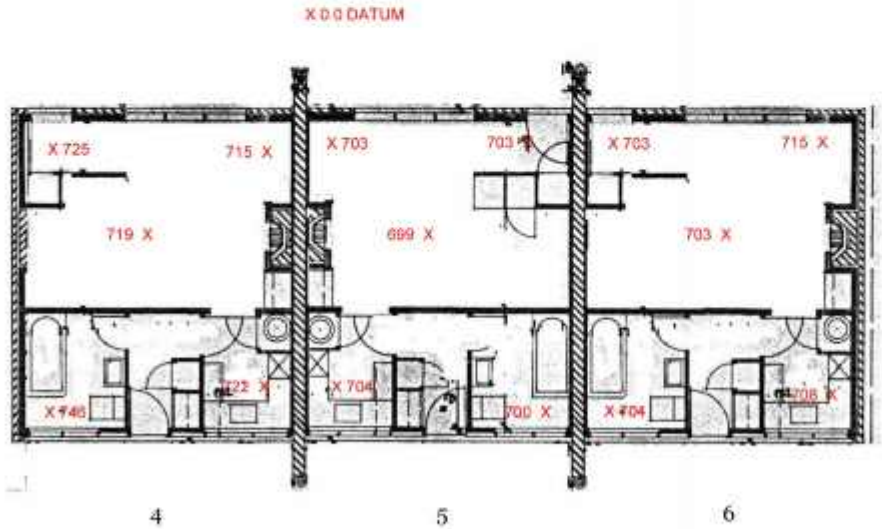
18	Ridge capping damaged due to differential settlement and movement of the fire wall	
19	Typical cracking of GIB wall lining	
20	Typical cracking of GIB wall lining above door opening	

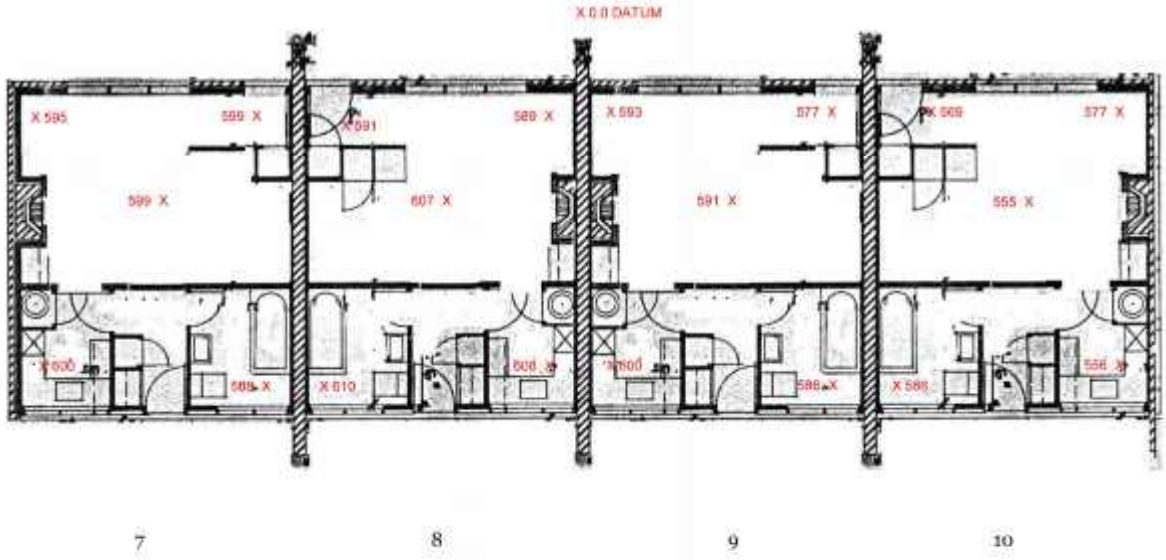
21	Typical cracking of GIB ceiling and wall lining	

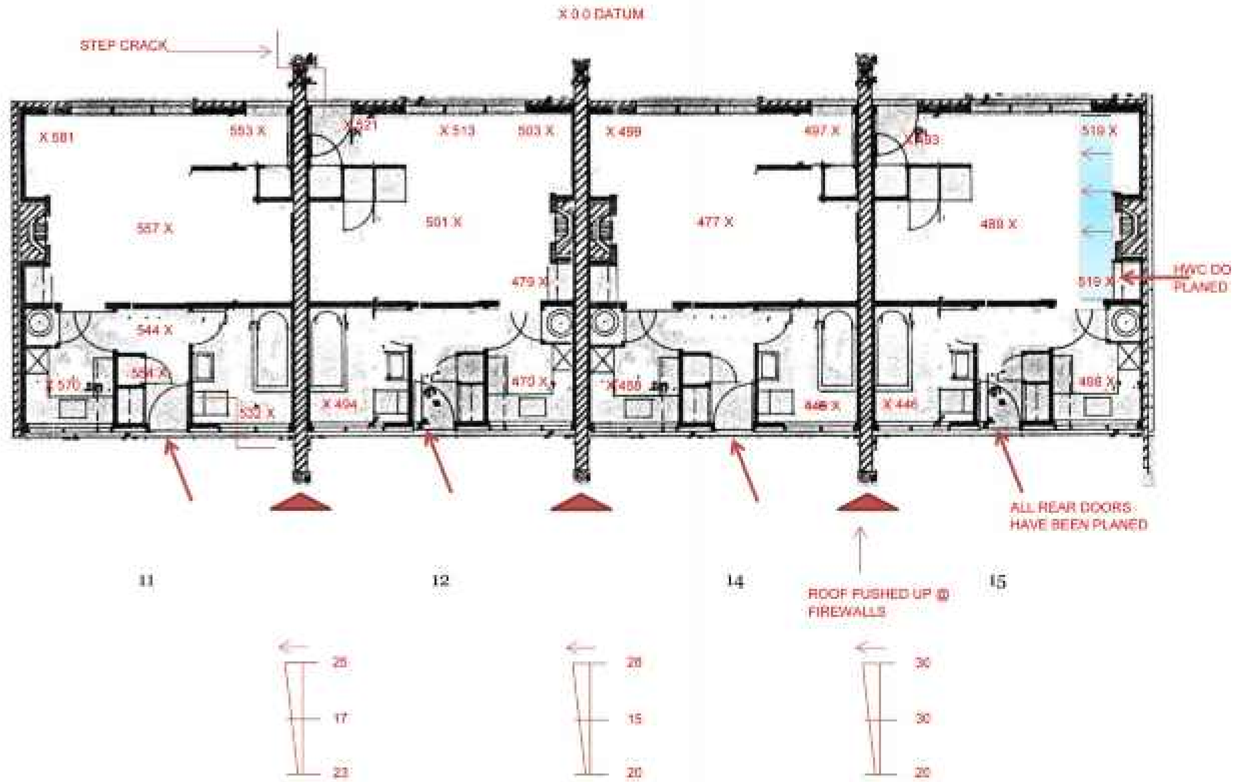
Appendix B – Level Survey

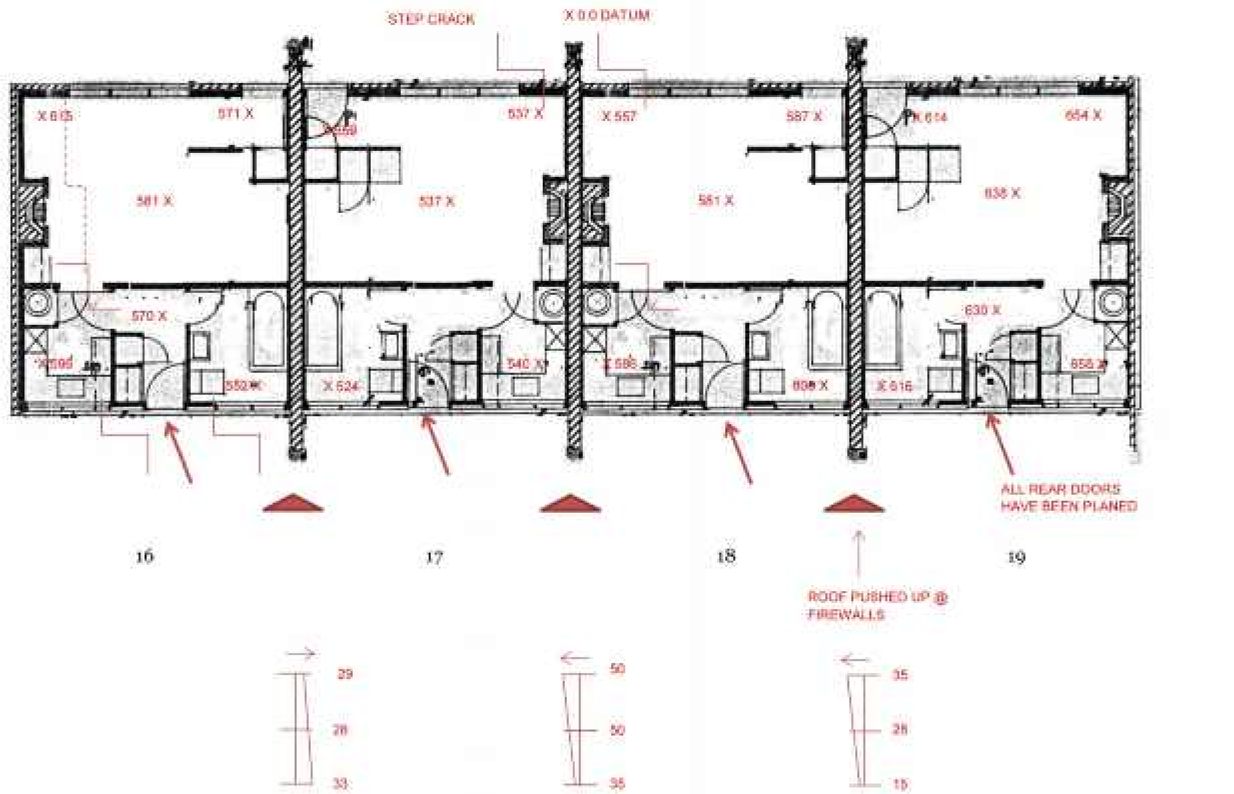
GOWERTON UNITS

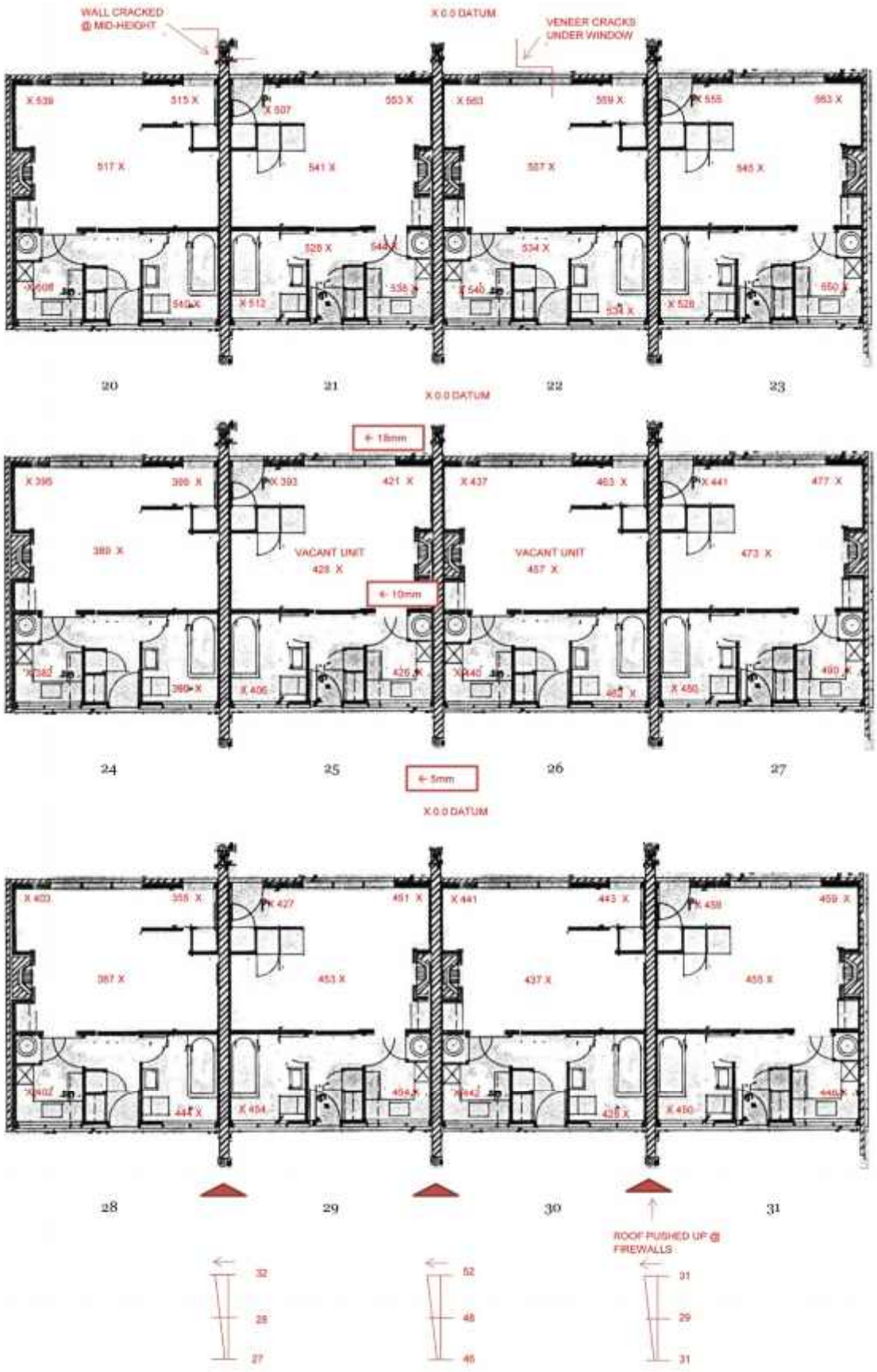







X 0.0 DATUM
STEP CRACK
ALL REAR DOORS HAVE BEEN PLANED
ROOF PUSHED UP @ FIREWALLS
11
12
14
15


STEP CRACK
X 0.0 DATUM
ALL REAR DOORS HAVE BEEN PLANED
ROOF PUSHED UP @ FIREWALLS
16
17
18
19


WALL CRACKED @ MID-HEIGHT
X 0.0 DATUM
VENEER CRACKS UNDER WINDOW
20
21
22
23
X 0.0 DATUM
← 18mm
VACANT UNIT
428 X
VACANT UNIT
457 X
← 10mm
24
25
26
27
← 5mm
X 0.0 DATUM
28
29
30
31
ROOF PUSHED UP @ FIREWALLS
32
28
27
52
48
46
31
29
31

Appendix C – Geotechnical Appraisal

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28 August 2013

Christchurch City Council
C/- Opus International Consultants Ltd
PO Box 1482
Christchurch 8140
Attention: Glenn Steetskamp

6-QC347.00

Geotechnical Desk Study – Gowerton Place

1 Introduction

Christchurch City Council has commissioned Opus International Consultants (Opus) to undertake a Geotechnical Desk Study and site walkover of the Gowerton Place housing complex in Richmond. The purpose of this study is to: collate existing subsoil information, undertake an appraisal of the potential geotechnical hazards at this site and determine whether further investigations are required. The site walkover was completed by Opus International Consultants on 13 June 2013.

This Geotechnical Desk Study has been prepared in accordance with the Engineering Advisory Group's Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Revision 5, 19 July 2011.

This geotechnical desk study has been undertaken without the benefit of any site specific investigations and is therefore preliminary in nature.

2 Desktop Study

2.1 Site Description

Gowerton Place is located in the suburb of Richmond, 2.3km northeast of the centre of Christchurch; refer to Site Location Plan in Appendix B. The complex is bounded by residential areas to the north, south, east and west.

The Gowerton Place complex was built in 1960 and consists of 30 residential units; refer to Walkover Inspection Plan in Appendix C. The complex consists of blocks of 3 and 4 units with double brick veneer party walls between the units. Each unit has a simple rectangular floor plan and all are single storey timber framed structures with brick veneer and timber roof framing supporting light-weight metal roofs. The foundations consist of 200 mm by 200 mm concrete piles founded at a depth of approximately 350

mm below ground level, with timber bearers supporting the floor boards and an inverted T-shaped concrete perimeter footing, approximately 350 mm wide by 150 mm thick, founded at a depth of 450 mm below ground level (refer to Construction Drawings in Appendix I). This is equivalent to Type B2 foundations in accordance with the Ministry of Business, Innovation and Employment (MBIE, 2012) guidance. A Site Plan dated August 1958 (refer to Construction Drawings in Appendix I) indicates that Units 4-6 and 11-12 were constructed on demolition sites. The Plan also indicates that a stream used to run through the southern end of the site in the vicinity of Units 1-6.

The ground profile is gently sloping with Units 4-10 founded approximately 0.5-1.0 m above Gowerton Place driveway and the remaining units founded up to 0.5 m above the driveway. The ground surrounding the buildings is predominantly grassed surfaces with the concrete driveway located west of Units 1-23.

2.2 Regional Geology

The published geological map of the area (Geology of the Christchurch Urban Area 1:25,000, Brown and Weeber, 1992), indicates the northern half of the site (Units 16-31) is the Yaldhurst member of the Springston Formation with dominantly alluvial sand and silt overbank deposits and the southern half of the site (Units 1-15) is of the Christchurch Formation with dominantly sand of fixed and semi-fixed dunes and beaches.

2.3 Expected Ground Conditions

The locations of Boreholes and Cone Penetrometer Tests (CPT) undertaken by the Earthquake Commission (EQC) have been reviewed. There have been four Boreholes and twenty CPTs conducted within approximately 100 m of the site boundary. Six existing CPT's undertaken by Opus at the adjacent Whakahoa Village complex have been used in this assessment. Refer to Site Location Plan in Appendix B and Surrounding Site Investigations in Appendix D.

Material logs available from the above sources have been used to infer the ground conditions at the site, as shown in Table 1 below.

Stratigraphy	Thickness (m)	Depth Encountered (m)
Sandy SILT (soft to stiff) and Silty SAND (loose to very loose)	3.6 – 6.5	Surface
SAND, very loose to dense	1.5 – 3.0	3.6 – 6.5
Sandy GRAVEL, medium dense	3.0 - 3.5	6.7 – 9.5
SAND, medium-dense to very dense	9.5	9.5 – 12.6
Sandy SILT, firm	2.0 – 2.5	22.0 – 22.5
Sandy GRAVEL, dense	-	22.0 – 24.0

Table 1: Inferred Ground Conditions

Groundwater depths of approximately 0.8 to 3.1 m below ground level have been interpreted from the EQC Borehole Logs. GNS Science indicates that the median depth to the groundwater surface at the site ranges from 2.0 to 3.0 m (Project Orbit, 2013).

2.4 Liquefaction Hazard

A liquefaction hazard study was conducted by the Canterbury Regional Council (ECan) in 2004 to identify areas of Christchurch susceptible to liquefaction during an earthquake. Gowerton Place is located on an area identified as having 'high liquefaction potential', for a low groundwater scenario.

Tonkin and Taylor Ltd (T&T Ltd), the Earthquake Commission's (EQC) geotechnical consultants, have prepared maps showing areas of liquefaction interpreted from high resolution aerial photos for the September 2010 earthquake and the aftershocks of February 2011, June 2011 and December 2011. The maps indicate evidence of moderate to severe observed liquefaction on the site, or in the vicinity, after the February 2011 and June 2011 seismic events and minor observed liquefaction after the December 2011 seismic event. No evidence of surface expression of liquefaction was observed after the September 2010 earthquake.

The risk of lateral spreading at this site is considered to be minor to moderate as the Avon River is located approximately 130 m southeast of the southern boundary of Gowerton Place. EQC maps showing observed crack locations (refer to EQC Map Output in Appendix E) after the February 2011 seismic event, indicate that ground cracking (typically up to 200 mm wide) occurred between Gowerton Place and the Avon River.

Table 12.3 of the MBIE guidance indicates that land within 150 m of the Avon River may be assumed to be in the major global lateral movement category with the potential to be susceptible to between 200 and 500 mm lateral stretch across the building footprint in future large earthquakes. Units 1, 2 and 3, Gowerton Place are located within 150 m of the Avon River and are therefore in the major global lateral movement category. The remaining units are located at a greater distance from the Avon River and would be expected to undergo minor to moderate lateral stretch of up to 200 mm in future large earthquakes.

Following the recent strong earthquakes in Canterbury, the Canterbury Earthquake Recovery Authority (CERA, 2012) has zoned land in the Greater Christchurch area according to its expected ground performance in future large earthquakes.

The adjacent residential properties to the immediate south east of the site are zoned "Red" which is evaluated as not being practical to rebuild, repair or reoccupy. Refer to the Land Recovery Zone Map in Appendix F.

The MBIE has sub-divided the CERA "Green" residential recovery zone land on the flat in Christchurch into technical categories. The three technical categories are summarised in Table 2 which has been adapted from the MBIE guidance document (MBIE, 2012).

Gowerton Place has been zoned as N/A-Urban Non-residential. However, the adjacent residential properties to the north, west and east have been zoned as Green-TC3. This

indicates that liquefaction damage is possible in future large earthquakes with Ultimate Limit State (ULS) settlements expected to be in excess of 100 mm.

Foundation Technical Category	Future land performance expected from liquefaction	Expected SLS land settlement	Expected ULS land settlement
TC 1	Liquefaction damage is unlikely in a future large earthquake.	0-15 mm	0-25 mm
TC 2	Liquefaction damage is possible in a future large earthquake.	0-50 mm	0-100 mm
TC 3	Liquefaction damage is possible in a future large earthquake.	>50 mm	>100 mm

Table 2: Technical Categories based on Expected Land Performance

A preliminary liquefaction assessment of selected CPT's has been completed using CLiq Software (Version 1.7, 2012) adopting the Idriss & Boulanger Method (2008) with settlements calculated using Zhang et al. (2002). Cone Penetrometer Tests (CPTs) form the basis for the prediction of liquefaction potential, with a Magnitude 7.5 earthquake considered, and earthquake groundwater depth of 1.5 m below ground level. The CLiq analysis was undertaken using four CPTs located within approximately 50 m of the site boundary, as specified in Table 3 (refer to Site Location Plan in Appendix B).

Both the Serviceability and Ultimate Limit States have been assessed for an Importance Level 2 Structure (with Peak Ground Accelerations (PGAs) as specified in Table 3). The free field liquefaction induced subsidence estimates have been calculated over the complete test depth (typically 20 m) and are presented in Table 3 (refer Appendix G for CLiq output). For comparison with MBIE (2012) guidelines, the estimated settlement in the top 10 m of the soil profile has also been presented.

CPT	Event	Mag / PGA	Depth to Groundwater (m)	Estimated Settlement (mm)	Estimated Settlement in top 10 m of soil profile (mm)
CPT 11215 (RCH-POD02-CPT74)	ULS	M7.5 / 0.35g	1.5	110	40
	SLS	M7.5 / 0.13g	1.5	10	0
CPT2915 (RCH-POD02-CPT66)	ULS	M7.5 / 0.35g	1.5	210	150
	SLS	M7.5 / 0.13g	1.5	60	55
CPT 4586 (RCH-POD01-CPT04)	ULS	M7.5 / 0.35g	1.5	165	60
	SLS	M7.5 / 0.13g	1.5	40	20
CPT 18719	ULS	M7.5 / 0.35g	1.5	40	40
	SLS	M7.5 / 0.13g	1.5	5	5

Table 3: Estimated Liquefaction Induced Settlements

Total liquefaction induced free field subsidence of up to 210 mm has been predicted in a future ULS earthquake event, for a ground water depth of 2.0 m. The total subsidence predicted to occur in the top 10 m is greater than 100 mm for CPT 2915, which would indicate that the land in the northwestern half of the site is comparable to MBIE Technical Category Three (TC3). Differential settlement is expected to occur due to variable thicknesses of liquefiable layers with expected differential settlements of up to 150 mm, for a ULS earthquake event.

The Liquefaction Potential Index (LPI) is another tool used to identify the soil's susceptibility to liquefaction. This index weights the potential impact of the predicted liquefaction with the depth. Results obtained from liquefaction analyses of CPT2915 and CPT4586 indicate LPI's of 25 and 16 respectively in a ULS seismic event. This categorises the western half of the site as a significant liquefaction risk.

3 Observations

A walkover site inspection of Gowerton Place was carried out by an Opus Geotechnical Engineer on 13 June 2013. Due to the amount of time since the 2010 and 2011 earthquakes, it is likely that the signs of land damage which may have existed have since been cleared or become less apparent by the time of the Opus site walkover. The following observations were made (refer to Walkover Inspection Plan in Appendix C):

- Cracking (typically up to 4 mm wide and 250 mm long) observed in the footings of several units (Photograph 3, Appendix A). The location of the footing cracks are marked 'x' in the Walkover Inspection Plan in Appendix C. Large cracking (up to 25 mm wide and 300 long) observed in footings of Units 21, 22, 25 and 27 (Photograph 4, Appendix A).
- Stepped cracking observed in brickwork of Unit 22 (approximately 40 mm wide and 1.5 m long) and Unit 18 (approximately 10 mm wide and 1.5 m long), which indicates settlement of footings (Photograph 5, Appendix A). Similar but less severe cracking observed in Units 9, 14, 15, 16, 23, 25 and 27. The location of the cracking is marked 'z' in the Walkover Inspection Plan in Appendix C.
- Cracks observed in the party walls (up to 4 mm wide and 500 mm long) between Units 11 & 12, 17 & 18 and 21 & 22 (Photograph 6, Appendix A)..
- Large cracks up to 3 mm wide and 750 mm long were observed in the front porch slabs of Units 5, 6, 9, 10, 11 and 12 (Photograph 7, Appendix A).
- Exposed concrete observed around drains where the ground may have settled (up to 60 mm) at the southern side of Units 9, 11 and 15 (Photograph 8, Appendix A).
- Moderate quantities of ejected liquefied material observed in the flower beds surrounding the residential units (Photograph 9).
- Large cracks up to 40 mm wide across entire widths of many footpath slabs (Photograph 10) indicating differential settlement.
- Evidence of liquefaction observed beneath floor in Unit 20 (Photograph 11).

4 Level Survey

A summary of the level survey undertaken by Opus Surveyors on 13 June 2013 at Gowerton Place is given in Table 4. The level survey results are included in Appendix H.

Block	Unit no.	Maximum Fall	MBIE (2012) Recomendation
A	1	-	Acceptable
	2	-	Acceptable
	3	-	Acceptable
B	4	7.1 mm/m	Re-level
	5	-	Acceptable
	6	-	Acceptable
C	7	-	Acceptable
	8	-	Acceptable
	9	-	Acceptable
	10	-	Acceptable
D	11	7.6 mm/m	Re-level
	12	8.1 mm/m	Re-level
	14	8.8 mm/m	Re-level
	15	11.2 mm/m	Re-level
E	16	8.9 mm/m	Re-level
	17	6.0 mm/m	Re-level
	18	6.2 mm/m	Re-level
	19	10 mm/m	Re-level
F	20	5.7 mm/m	Re-level
	21	9.2 mm/m	Re-level*
	22	6.0 mm/m	Re-level*
	23	-	Acceptable
G	24	-	Acceptable
	25	5.6 mm/m	Re-level
	26	5.8 mm/m	Re-level
	27	8.3 mm/m	Re-level
H	28	13.6 mm/m	Re-level
	29	6.8 mm/m	Re-level
	30	-	Acceptable
	31	-	Acceptable

Table 4: Level Survey Results (* Crack widths of approximately 25 mm were observed in footings on both sides of the structure. Full or partial rebuild is likely).

5 Discussion

All Units are constructed on 200 mm by 200 mm concrete piles founded at a depth of approximately 350 mm below ground level, with timber bearers supporting the floor boards and a concrete perimeter footing approximately 350 mm wide by 150 mm thick, founded at a depth of 450 mm below ground level. This is equivalent to Type B2 foundations in accordance with the MBIE (2012) guidance.

Significant liquefaction damage has occurred at Gowerton Place as a result of the 2010 and 2011 earthquake sequence. At the time of the 13 June 2013 inspection, evidence of ejected material and ground settlement was observed. The damage to pavements appears to be a result of differential settlement and uplift due to liquefaction heave.

Significant cracks with widths in excess of 5 mm were observed within the perimeter footings of Units 21, 22, 25 and 27. In accordance with MBIE guidance, cracks of width greater than 5 mm in the perimeter footing require Structural Repair. In Units 21 and 22, crack widths of approximately 25 mm were observed in the footings on both sides of the structure. This indicates that lateral stretch of the floor and foundations is likely to have occurred and in accordance with MBIE guidance, either full or partial foundation rebuild will be required.

The stepped cracking observed in the brick veneer suggests that settlement of footings has occurred. It was observed that settlement of these footings relative to the concrete piles may have caused a redistribution of load as the brick veneer became supported by the wire veneer ties. This change in load path may have increased the load on the timber framing and piles and resulted in increased damage; the cracking was observed to have worsened between site visits by Opus Structural Engineers. This will cause continued damage to the units unless repaired.

The level survey results have been assessed and indicated large floor variations (recorded maximum falls of up to 13.6 mm/m) in floor level in Units 4, 11-22 and 25-29 in the Gowerton Place complex. In accordance with the MBIE guidance (December 2012) subject to Structural Engineer confirmation, these units will require a foundation re-level. Except for Units 21 and 22, foundation rebuild is not required because the variation in floor level did not exceed 100 mm in any of the units.

Boreholes and CPTs undertaken for EQC indicate the residential complex is likely to be founded on layers of Silt, Sand and Gravel overlying dense Sandy Gravel from approximately 22.0-24.0 m depth, with groundwater depths of approximately 0.8-3.1 m below ground level. Liquefaction typically occurs in recent (i.e. less than 10,000 years old), normally consolidated silts and sands beneath groundwater and is dependent on material density, grain size and soil composition. The liquefaction assessment suggested significant liquefaction risk in the western half of the site with expected liquefaction induced differential settlements of up to 150 mm in a future ULS earthquake event. The subsurface ground profile together with the ground damage reported at the site during the recent earthquakes of 2010 and 2011, confirms that the site has a high risk of liquefaction.

GNS Science indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the September 2010 earthquake. Recent advice (Geonet) indicates there is currently an 11% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. Such an event may cause liquefaction induced land damage similar to that experienced, dependent on the location of the earthquake's epicentre. This confirms that there is currently a risk of liquefaction and further differential settlement at Gowerton Place.

Lateral stretch in the order of 200 to 500 mm may occur across the footprint of Units 1, 2 and 3 in a future large earthquake. The foundation solution should have the capacity to prevent tearing of the structure, provide a low probability of collapse and ideally offer resilience and ease of repair

6 Recommendations

It is recommended that in order to determine foundation repair options at Gowerton Place, a site specific investigation is undertaken including CPTs, Hand Augers and Scalas. The site investigation will enable a site specific liquefaction assessment to be undertaken to identify the liquefiable layers to help determine conceptual repair and relevelling options.

The scope of the proposed site specific geotechnical investigations will be:

- 5 Cone Penetration Tests to a target depth of 20 m or refusal.
- Approximately 6 Hand Auger and Scala tests should then be carried out to 3 m depth or refusal.
- Assessment and reporting.

The locations of the investigations are to be agreed in conjunction with the Structural Engineer (refer to Proposed Site Investigation Locations in Appendix J).

7 Limitation

This report has been prepared solely for the benefit of the Christchurch City Council as our client with respect to the particular brief given to us. Data or opinions in this desk study may not be used in other contexts, by any other party or for any other purpose.

It is recognised that the passage of time affects the information and assessment provided in this Document. Opus's opinions are based upon information that existed at the time of the production of this Desk Study. 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.

8 References

Brown, LJ; Webber, JH 1992: Geology of the Christchurch Urban Area. Scale 1:25,000. Institute of Geological and Nuclear Sciences geological map, 1 sheet + 104p.

Environment Canterbury, Canterbury Regional Council (ECan) website:

> ECan 2004: The Soild Facts on Christchurch Liquefaction. Canterbury Regional Council, Christchurch, 1 sheet.

Project Orbit, 2011: Interagency/organisation collaboration portal for Christchurch recovery effort.
https://canterburygeotechnicaldatabase.projectorbit.com/

GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury-quakes/aftershocks/ updated on 8 August 2013.

'Repairing and rebuilding houses affected by the Canterbury earthquakes': Ministry of Business, Innovation and Employment (December 2012).

Appendices

Appendix A: Site Inspection Photographs
Appendix B: Site Location Plan
Appendix C: Walkover Inspection Plan
Appendix D: Surrounding Site Investigations
Appendix E: EQC Map Output
Appendix F: Land Recovery Zone Map
Appendix G: CLiq Liquefaction Analysis
Appendix H: Level Survey
Appendix I: Construction Drawings
Appendix J: Proposed Site Investigation Locations

Appendix A

Site Inspection Photographs

Photograph 1: Front Elevation of Units 1 -3, Gowerton Place.

Photograph 2: Rear Elevation of Units 28 -31, Gowerton Place.

Photograph 3: Observed crack (approximately 4 mm wide) in footing, south-eastern side of Unit 18.

Photograph 4: Large crack (approximately 30 mm wide) observed in footing, north-western side of Unit 21.

Photograph 5: View of stepped cracking (approximately 40 mm wide and 2 m long) observed in the brick veneer in the southeast corner of Unit 22.

Photograph 6: View of cracking in the party walls (approximately 4 mm wide and 500 mm long) between Units 21 and 22.

Photograph 7: View of crack (approximately 3 mm wide and 750 mm long) observed in the front porch slab of Units 11 and 12.

Photograph 8: View of exposed concrete observed around drain where the ground may have settled (up to 60 mm) at the southern corner of Unit 11.

Photograph 9: View of ejected liquefied material (approximately 2 00 mm high) observed in the flower bed at southern corner of Unit 16.

Photograph 10: View of crack (approximately 40 mm wide) across entire width of footpath slab indicating differential settlement.

Photograph 11: View of liquefaction observed beneath floor in Unit 20.

Appendix B

Site Location Plan

Approximate CPT locations at Whakahoa Village

CPTs assessed for liquefaction potential.

0 200m

Approximate Scale:1 to 2000 at A3

SOURCE: canterburyrecovery.projectorbit.com (Accessed on 3/7/2013)

OPUS

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PO Box 1482
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Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Gowerton Place, Richmond
Project No.: 6-QC347.00
Client: Christchurch City Council

Site Location Plan

Drawn: Opus Geotechnical Engineer

Date: 14-Aug-13

Appendix C

Walkover Inspection Plan

1-31: Residential Unit Numbers
x: Large cracks up to 25 mm wide and 300 mm long in the perimeter footings.
z: Stepped cracking observed in brickwork (up to 40 mm wide and 1.5 m long).
– – – Cracking up to 40 mm wide across entire widths of footpath slabs.

0 50m

Approximate Scale:1 to 500 at A3.

SOURCE: canterburyrecovery.projectorbit.com (Accessed on 3/7/2013)

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Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Gowerton Place, Richmond
Project No.: 6-QC347.00
Client: Christchurch City Council

Walkover Inspection Plan

Drawn: Opus Geotechnical Engineer

Date: 3-Jul-13

Appendix D

Surrounding Site Investigations

Stronger Christchurch Infrastructure Rebuild Team
1 Magdala Place, Middleton, Christchurch, 8024

Job Number 10579
BOREHOLE LOG
10579-BH-01

PROJECT	: Pump Station PS5	GROUND LEVEL (RL)	: 12.31 m CDD Jan 2012	SHEET	: 1 OF 3
SITE	: Vogel Street	EASTING	: 395035.9 m	SCALE	: 1:63
START DATE	: 21/07/2012	NORTHING	: 809217.6 m	DEPTH	: 27 m
END DATE	: 21/07/2012	COORD. SYS.	: MPP Jan 2012		

RL (m CDD Jan 2012)	DEPTH (m)	SOIL / ROCK DESCRIPTIO	SAMPLE TYPE GRAPHIC	SAMPLE O. A D TYPE	DEPTH (m) FROM-TO	TEST TYPE AND VALUE	TCR (%)	MOISTURE CO DITIO	CO SISTE CY / RELATIVE DE SITY
		0.0 - 1.5m vacuum excavated. Not logged.					0		
10.81	1.50	SILT with trace very fine sand and minor clay; grey with brown mottling. Firm, wet, moderately plastic. Large wood fragment at 2.0m.		D1	1.50-1.95	S = 5	100	W	F
10.31	2.00	Silty fine SAND; brown. Saturated, non plastic. Contains occasional rootlets and wood fragments.		C2	1.95-3.00		100		
9.31	3.00	Silty very fine SAND; grey. Wet, non plastic. Occasional rootlets.		D3	3.00-3.45	S = 3	100		VL
				C4	3.45-4.50		100		
				D5	4.50-4.95	S = 7	100		L
7.31	5.00	SILT with some very fine sand and trace clay; grey. Firm, wet, non plastic. Occasional rootlets.		C6	4.95-6.00		100		F
6.61	5.70	Sandy SILT; grey. Firm, wet, non plastic. Sand is fine grained.							
6.31	6.00	Medium to fine SAND; grey. Wet.		D7	6.00-6.45	S = 30	90		D
				C8	6.45-7.50		100	W	
4.81	7.50	Sandy fine to coarse GRAVEL with trace silt; grey. Wet. Sand is fine to coarse. Gravels are rounded.		D9	7.50-7.95	S = 18	65		MD
				C10	7.95-9.00		100		
				D11	9.00-9.45	S = 14	65		MD
2.61	9.70			C12	9.45-10.50		100		

WATER LEVEL: 31/07/2012

01 PIEZOMETER DETAILES: Bentonite; Concrete; Gravel

WATER STRIKE							PIEZOMETER	
ID	DATE	STRIKE (m)	CASING DEPTH (m)	TIME TO RISE (min)	ROSE TO (m)	REMARKS	DATE	READING (m bgl)
							31/07/2012	1.83

GENERAL COMMENTS
Method:
0.00 to 1.50 'pot-holed' with vacuum excavator prior to drilling
1.50m to 27.00m: Drilled with rotary sonic rig.
Backfilled with bentonite from 27.00m to 7.50m.
Piezometer installed from 7.50m to 1.00m and hole backfilled with
sand.
Backfilled with bentonite from 1.00m to 0.20m.
Sealed with concrete from 0.20m to ground surface.

LOGGED BY: M Simpson CHECKED BY: CHECKED DATE:

Stronger Christchurch Infrastructure Rebuild Team
1 Magdala Place, Middleton, Christchurch, 8024

Job Number 10579
BOREHOLE LOG
10579-BH-01

PROJECT	: Pump Station PS5	GROUND LEVEL (RL)	: 12.31 m CDD Jan 2012	SHEET	: 2 OF 3
SITE	: Vogel Street	EASTING	: 395035.9 m	SCALE	: 1:63
START DATE	: 21/07/2012	NORTHING	: 809217.6 m	DEPTH	: 27 m
END DATE	: 21/07/2012	COORD. SYS.	: MPP Jan 2012		

RL (m CDD Jan 2012)	DEPTH (m)	SOIL / ROCK DESCRIPTIO	SAMPLE TYPE GRAPHIC	SAMPLE O. A D TYPE	DEPTH (m) FROM-TO	CASI G DEPTH (m)	TEST TYPE AND VALUE	TCR (%)	SCR (%)	RQD (%)	DEFECT SPACI G MAX/AVG/MI (mm)	MOISTURE CO DITIO	CO SISTE CY / RELATIVE DE SITY	WATER LEVEL	PIEZOMETER DETAILES
		Fine to coarse GRAVEL with some fine to coarse sand and trace silt; grey. Wet. *(continued)*						100							
1.81	10.50	Medium to fine SAND with trace silt; grey. Wet.		D13	10.50-10.95		S = 9	60					L		
				C14	10.95-12.00			100							
0.11	12.20	Fine SAND with minor silt; brownish grey. Wet.		D15	12.00-12.45		S = 33	100					D		
				C16	12.45-13.50			100							
-0.80	13.10	Orange/brown staining from 13.1m to 13.2m.													
-1.20	13.50	Fine SAND with minor silt; brownish grey. Wet.		D17	13.50-13.95		S = 19	100					MD		
				C18	13.95-15.00			100							
				D19	15.00-15.45		S = 28	100				W	MD		
				C20	15.45-16.50			100							
				D21	16.50-16.95		S = 30	100					D		
				C22	16.95-18.00			100							
				D23	18.00-18.45		S = 35	100					D		
				C24	18.45-19.50			100							
				D25	19.50-19.95		S = 27	100					MD		

Bentonite

WATER STRIKE

ID	DATE	STRIKE (m)	CASING DEPTH (m)	TIME TO RISE (min)	ROSE TO (m)	REMARKS

PIEZOMETER

DATE	READING (m bgl)
31/07/2012	1.83

GENERAL COMMENTS

Method:
0.00 to 1.50 'pot-holed' with vacuum excavator prior to drilling
1.50m to 27.00m: Drilled with rotary sonic rig.
Backfilled with bentonite from 27.00m to 7.50m.
Piezometer installed from 7.50m to 1.00m and hole backfilled with
sand.
Backfilled with bentonite from 1.00m to 0.20m.
Sealed with concrete from 0.20m to ground surface.

LOGGED BY: M Simpson CHECKED BY: CHECKED DATE:

Stronger Christchurch Infrastructure Rebuild Team
1 Magdala Place, Middleton, Christchurch, 8024

Job Number 10579
BOREHOLE LOG
10579-BH-01

PROJECT	: Pump Station PS5	GROUND LEVEL (RL)	: 12.31 m CDD Jan 2012	SHEET	: 3 OF 3
SITE	: Vogel Street	EASTING	: 395035.9 m	SCALE	: 1:63
START DATE	: 21/07/2012	NORTHING	: 809217.6 m	DEPTH	: 27 m
END DATE	: 21/07/2012	COORD. SYS.	: MPP Jan 2012		

HOLE PROGRESS DATE TIME WATER DEPTH	GRAPHIC LOG	RL (m CDD Jan 2012)	DEPTH (m)	SOIL / ROCK DESCRIPTION	SAMPLE TYPE GRAPHIC	SAMPLE ID TYPE	DEPTH (m) FROM-TO	CASING DEPTH (m)	TEST TYPE AND VALUE	TCR (%)	SCR (%)	RQD (%)	DEFECT SPACING MAX/AVG/MIN (mm)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	WATER LEVEL	PIEZOMETER DETAILS
		-7.70	20.00	Variable sandy SILT to silty fine SAND with fine shell fragments; grey.		C26	19.95-21.00			100							
		-8.20	20.50	SILT with trace fine sand and trace shell fragments; grey. Firm, wet.													
		-8.40	20.70	Fine SAND with some silt; grey. Wet.		D27	21.00-21.45		S = 35	100					D		
		-9.20	21.50	Sandy SILT; grey. Firm, wet. Sand is fine grained.		C28	21.45-22.50			100							
		-9.80	22.10	Large piece of wood at 22.1m.													
		-9.90	22.20	Sandy fine to coarse GRAVEL with minor silt; brown. Wet.		D29	22.50-22.95		S = 38	100					D		
						C30	22.95-24.00			100				W			
		-11.70	24.00	Fine to medium SAND; brown.		C31	24.00-25.50		C = 48	87					D		
		-12.00	24.30	Sandy fine to coarse GRAVEL with trace silt. Wet. Sand is fine to medium.												▼1	
		-13.20	25.50	Sandy fine to coarse GRAVEL with trace silt. Wet. Sand becomes medium to coarse.		C32	25.50-27.00		C = 45	87					D		
				Hole Terminated at 27.00 m Method: 0.00 to 1.50 'pot-holed' with vacuum excavator prior to drilling 1.50m to 27.00m: Drilled with rotary sonic rig. Backfilled with bentonite from 27.00m to 7.50m. Piezometer installed from 7.50m to 1.00m and hole backfilled with sand. Backfilled with bentonite from 1.00m to 0.20m. Sealed with concrete from 0.20m to ground surface.					C = 33						D		

WATER STRIKE

ID	DATE	STRIKE (m)	CASING DEPTH (m)	TIME TO RISE (min)	ROSE TO (m)	REMARKS
1	21/07/2012	25.50	25.50			Artesian groundwater below 25.50

PIEZOMETER

DATE	READING (m bgl)
25/07/2012	1.83

GENERAL COMMENTS

Method:
0.00 to 1.50 'pot-holed' with vacuum excavator prior to drilling
1.50m to 27.00m: Drilled with rotary sonic rig.
Backfilled with bentonite from 27.00m to 7.50m.
Piezometer installed from 7.50m to 1.00m and hole backfilled with
sand.
Backfilled with bentonite from 1.00m to 0.20m.
Sealed with concrete from 0.20m to ground surface.

LOGGED BY: M Simpson CHECKED BY: CHECKED DATE:

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BH-05
Hole Location:
RCH-POD01-BH05
(30 Warwick Street)
SHEET 1 OF 2

PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS | LOCATION: RICHMOND | JOB No: 52003.000

CO-ORDINATES 5742895.49 mN 2482380.29 mE
R.L. 3.68 m
DATUM NZMG, MSL (CCC 20/01/12 Datum -9.043m)

DRILL TYPE: Roto-Sonic
DRILL METHOD: PQDT/Auto SPT
DRILL FLUID: LP2000

HOLE STARTED: 23/7/12
HOLE FINISHED: 23/7/12
DRILLED BY: Pro-Drill
LOGGED BY: GLDS-KJ CHECKED: BMcD

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASIN | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | RAPHIC LO | CLASSIFICATION SYMBOL | WEATHERIN / MOISTURE CONDITION | STREN TH/DENSITY CLASSIFICATION | SHEAR STREN TH (kPa) | COMPRESSIVE STREN TH (MPa) | DEFECT SPACIN (mm)

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

Depth	Geological unit	Core recovery (%)	Method	Tests / samples	Classification symbol	Moisture condition	Strength / density	Description
0	ASPHALT							ASPHALT.
0	CHRISTCHURCH FORMATION (MARINE/ ESTUARINE)				ML	M		SILT with trace sand, brown, moist, low plasticity. Sand is fine to medium.
1		100	PQDT					Sandy SILT, grey, moist, low plasticity. Sand is fine to medium.
1						W		0.9m- wet.
2				*FC2.0 B				
3		100	SPT	0/0//0/1/1/1 N = 3			S	
3								3.0m- soft.
4		100	PQDT	*PSD3.5 B	SP		VL	Fine to medium SAND with some silt, grey, very loose, wet, poorly graded.
4								4.2m trace silt.
5		100	SPT	2/2//4/4/5/6 N = 19			MD	4.5m- medium dense.
5		100	PQDT	*FC5.5 B				
6		100	SPT	2/1//2/2/3/4 N = 11				
7		100	PQDT		SW			Sandy fine to coarse GRAVEL with trace silt, grey, medium dense, wet, well graded. Sand is fine to coarse.
7								7.5m- no SPT.
8		71	PQDT					
9		0	SPT	6/7//3/4/4/4 N = 15				8.7 to 9.45m - no recovery
10		100	PQDT		SM		St	Sandy SILT, grey, stiff, wet, low plasticity. Sand is fine to medium.

T+T DATATEMPLATE.GDT RCB

Log Scale 1:50

BORELOG-TC3 720016 RCH-POD01.GPJ 25/10/12

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BH-05
Hole Location:
RCH-POD01-BH05
(30 Warwick Street)
SHEET 2 OF 2

PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS | LOCATION: RICHMOND | JOB No: 52003.000

CO-ORDINATES 5742895.49 mN 2482380.29 mE
DRILL TYPE: Roto-Sonic
HOLE STARTED: 23/7/12
HOLE FINISHED: 23/7/12
R.L. 3.68 m
DRILL METHOD: PQDT/Auto SPT
DRILLED BY: Pro-Drill
DATUM NZMG, MSL (CCC 20/01/12 Datum -9.043m)
DRILL FLUID: LP2000
LOGGED BY: GLDS-KJ CHECKED: BMcD

GEOLOGICAL									ENGINEERING DESCRIPTION							
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASIN	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	RAPHIC LO	CLASSIFICATION SYMBOL	WEATHERIN / MOISTURE CONDITION	STREN TH/DENSITY CLASSIFICATION	SHEAR STREN TH (kPa)	COMPRESSIVE STREN TH (MPa)	DEFECT SPACIN (mm)	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
CHRISTCHURCH FORMATION (MARINE/ ESTUARINE)			100	PQDT							SM	W	St				Sandy SILT, grey, stiff, wet, low plasticity. Sand is fine to medium.
			100	SPT		1/2//3/4/4/8 N = 19		-7	11		SP		MD				Fine to medium SAND with trace broken shells, trace silt, trace gravel, grey, medium dense, wet, poorly graded. Gravel is fine, rounded.
			100	PQDT				-8									Fine to medium SAND with trace silt, grey, medium dense, wet, poorly graded.
			100	SPT		2/2//2/4/5/7 N = 18			12								
			100	PQDT		*FC13.0	B	-9	13								
			100	SPT		2/2// 4/7/8/10 N = 29		-10									13.45 to 13.5m - trace fibrous organics.
			100	PQDT				-11	14								
			100	SPT		2/1//2/4/6/9 N = 21			15								
			100	PQDT				-12	16								
			100	SPT		2/2//2/4/7/9 N = 22		-13									
			100	PQDT				-14	17								
			100	SPT		2/4// 6/7/8/15 N = 36			18				D				18.0m- dense.
			100	PQDT		*FC18.5	B	-15	19								
			100	SPT		3/5// 7/10/13/15 N = 45		-16	20								End of borehole at 19.95mbgl (target depth)

T+T DATATEMPLATE.GDT RCB

Log Scale 1:50

BORELOG-TC3 720016 RCH-POD01.GPJ 25/10/12

TONKIN & TAYLOR LTD

BOREHOLE LOG

BH No: RCH-POD02-BH005
Hole Location: 19 Forth Street

PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS		LOCATION: RICHMOND	JOB No: 52003.000
CO-ORDINATES:	5743088.34 mN 2482326.93 mE	DRILL TYPE: Roto-Sonic	HOLE STARTED: 6/12/12 HOLE FINISHED: 6/12/12
R.L.:	4.36 m	DRILL METHOD: PQDT/Auto SPT	DRILLED BY: ACL
DATUM:	NZMG, MSL (CCC 20/01/12 Datum -9.043m)	DRILL FLUID: LP2000	LOGGED BY: T&T-HU CHECKED: CMS

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	TESTS	DEPTH (m)	R.L. (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION / ROCK DESCRIPTION
TOPSOIL			4		SM	D		Silty fine to medium SAND with trace organics, dark brown, dry, poorly graded. Organics are fibrous rootlets.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)	FC@1.52m 1/1//2/2/1/2 N=7	1	3		ML	M		Sandy SILT, light brown mottled grey, moist, low plasticity. Sand is fine to medium.
		2	2		SM	W	L	Silty fine to medium SAND, brownish grey, loose, wet, poorly graded.
	FC@3.05m 2/3//3/2/2/3 N=10	3	1					2.05m- trace amorphous organics.
	1/1//1/1/1/1 N=4	4	0					
		5	-1		ML		F	Sandy SILT, grey, firm, wet, low plasticity. Sand is fine to medium.
	PL@6.1m FC@6.1m 1/0//1/0/1/0 N=2	6	-2				S	SILT with trace sand, grey, soft, wet, low plasticity. Sand is fine to medium.
		7	-3		SP		VL	Fine to medium SAND with minor silt, grey, very loose, wet, poorly graded. 6.55 to 6.7m- some fibrous organics, wood.
	3/2//2/3/2/3 N=10	8	-4		SW			Gravelly fine to coarse SAND with trace silt and trace rootlets, grey, very loose, wet, well graded. Gravel is fine to medium, rounded to subrounded.
					GW		L	Sandy fine to medium GRAVEL with trace silt, grey, rounded, very loose, wet, well graded. Sand is fine to medium. 7.62m- loose.
					SM			Silty fine to medium SAND with some gravel, grey, loose, wet, well graded. Gravel is fine to coarse, subrounded.
	5/5//6/5/5/6 N=22	9	-5		SW		MD	Gravelly fine to coarse SAND with trace silt, dark grey, loose, wet, well graded. Gravel is fine to medium, subrounded. 9.14m- medium dense.
		10			GW			Sandy fine to medium GRAVEL with trace silt, grey, subrounded, medium dense, wet, well graded. Sand is fine to coarse.

T+T DATATEMPLATE-SPT.GDT rcb

TONKIN & TAYLOR LTD

BOREHOLE LOG

BH No: RCH-POD02-BH005
Hole Location: 19 Forth Street

PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS | LOCATION: RICHMOND | JOB No: 52003.000

CO-ORDINATES: 5743088.34 mN, 2482326.93 mE
R.L.: 4.36 m
DATUM: NZMG, MSL (CCC 20/01/12 Datum -9.043m)

DRILL TYPE: Roto-Sonic
DRILL METHOD: PQDT/Auto SPT
DRILL FLUID: LP2000

HOLE STARTED: 6/12/12
HOLE FINISHED: 6/12/12
DRILLED BY: ACL
LOGGED BY: T&T-HU CHECKED: CMS

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	TESTS	CORE RECOVERY (%)	METHOD	CASING	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION / ROCK DESCRIPTION
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)	3/2//3/3/4/3 N=13	100	PQDT			-6	11	GW	W	MD	Sandy fine to medium GRAVEL with trace silt, grey, subrounded, medium dense, wet, well graded. Sand is fine to coarse.
		100	SPT			-7					
		100	PQDT			-8	12				
	4/4//5/6/5/7 N=23	100	SPT								
CHRISTCHURCH FORMATION (MARINE/ ESTUARINE)		81	PQDT			-9	13	SP			Fine to medium SAND with trace silt, grey, medium dense, wet, poorly graded.
	3/3//3/4/4/5 N=16	100	SPT								13.52 to 13.72m- no recovery.
		81	PQDT			-10	14				
	*FC@15.24m 1/2//2/5/5/8 N=20	100	SPT		B	-11	15				14.7m- greyish brown. 15.04 to 15.24m- no recovery.
		100	PQDT			-12	16				
	4/6//5/5/6/8 N=24	100	SPT			-13	17				
		100	PQDT			-14	18			D	18.29m- dense.
	4/6//7/10/9/12 N=38	100	SPT			-15	19				
		100	PQDT				20			VD	19.81m- very dense.

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.
ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

T+T DATATEMPLATE-SPT.GDT rcb

TONKIN & TAYLOR LTD

BOREHOLE LOG

BH No: RCH-POD02-BH005
Hole Location: 19 Forth Street

PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS | LOCATION: RICHMOND | JOB No: 52003.000

CO-ORDINATES: 5743088.34 mN, 2482326.93 mE
R.L.: 4.36 m
DATUM: NZMG, MSL (CCC 20/01/12 Datum -9.043m)

DRILL TYPE: Roto-Sonic
DRILL METHOD: PQDT/Auto SPT
DRILL FLUID: LP2000

HOLE STARTED: 6/12/12
HOLE FINISHED: 6/12/12
DRILLED BY: ACL
LOGGED BY: T&T-HU CHECKED: CMS

GEOLOGICAL									ENGINEERING DESCRIPTION							
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
CHRISTCHURCH FORMATION (MARINE/ ESTUARINE)			100	SPT		6/10//13/13/15/9 for 42mm N>50		-16		SP	W	VD				Fine to medium SAND with trace silt, grey, very dense, wet, poorly graded.
																End of borehole at 20.26mbgl (target depth)

T+T DATATEMPLATE-SPT.GDT rcb

Log Scale 1:50

TONKIN & TAYLOR LTD

BOREHOLE LOG

BH No: RCH-POD02-BH007
Hole Location: 65 Vogel Street

PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS | LOCATION: RICHMOND | JOB No: 52003.000

CO-ORDINATES: 5742974.92 mN, 2482448.39 mE
R.L.: 4.44 m
DATUM: NZMG, MSL (CCC 20/01/12 Datum -9.043m)

DRILL TYPE: Rotary
DRILL METHOD: HQTT/Std SPT
DRILL FLUID: LP2000

HOLE STARTED: 1/11/12
HOLE FINISHED: 1/11/12
DRILLED BY: Pro-Drill
LOGGED BY: T&T-EA CHECKED: BMcD

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FL ID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOIST CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	ENGINEERING DESCRIPTION
CONCRETE																	CONCRETE.
TOPSOIL											ML	M					SILT with some sand, minor gravel, trace organics and trace rootlets, dark brown, moist, low plasticity. Sand is fine to medium. Gravel is fine to medium, angular. Organics are amorphous.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)		▼	80	OB				4	0			W					0.48m- gravel absent. 1
									1								0.6m- rootlets and organics absent, brownish grey.
			100	SPT		*FC@1.5m 1/1//2/2/1/1 N=6	B	3	2				F				Sandy SILT, light brownish grey, wet, non plastic to low plasticity. Sand is fine to medium. 1.2 to 1.5m- no recovery. 1.5m- firm. 2
			100	OB				2	3								
			100	SPT		*FC@3.0m 3/3//3/4/3/4 N=14	B	1					St				3.0m- stiff. 3
			100	OB				0	4		SM		MD				Silty fine to medium SAND, grey, medium dense, wet, poorly graded. 4
			100	SPT		5/3//3/3/3/5 N=14		-1	5								5
			76	OB													5.55 to 5.8m- no recovery.
			100	HQTT				-2	6		SP						Fine to medium SAND with some gravel and minor silt, grey, medium dense, wet, poorly graded. Gravel is medium to coarse, subrounded. 6
			22	SPT		6/7//7/6/9/9 N=31							D				6.5m- dense. 6.6 to 8.25m- no recovery.
			0	HQTT				-3	7								7
			44	SPT		2/1/2/2/2/2// 2/2/2/2/2/2/ 2/2/3/2/2/4 N=27		-4	8				MD				8.0m- 0.1m heave observed prior to SPT. 8.0m- medium dense.
CHRISTCHURCH FORMATION (MARINE/ ESTUARINE)																	Fine to medium SAND with minor gravel, grey, medium dense, wet, poorly graded. Gravel is fine to coarse, subrounded.
			100	HQTT					9								Fine to medium SAND with trace gravel and trace silt, grey, medium dense, wet, poorly graded. Gravel is fine to medium, rounded. 9.1m- gravel absent. 9
			100	HQTT		*FC@9.4m	B	-5	10								9.5m- 0.4m heave observed prior to SPT. No SPT. 9.7 to 9.8m- trace fine gravel, rounded.

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.
ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

TONKIN & TAYLOR LTD

BOREHOLE LOG

BH No: RCH-POD02-BH007
Hole Location: 65 Vogel Street

PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS | LOCATION: RICHMOND | JOB No: 52003.000

CO-ORDINATES: 5742974.92 mN, 2482448.39 mE
R.L.: 4.44 m
DATUM: NZMG, MSL (CCC 20/01/12 Datum -9.043m)

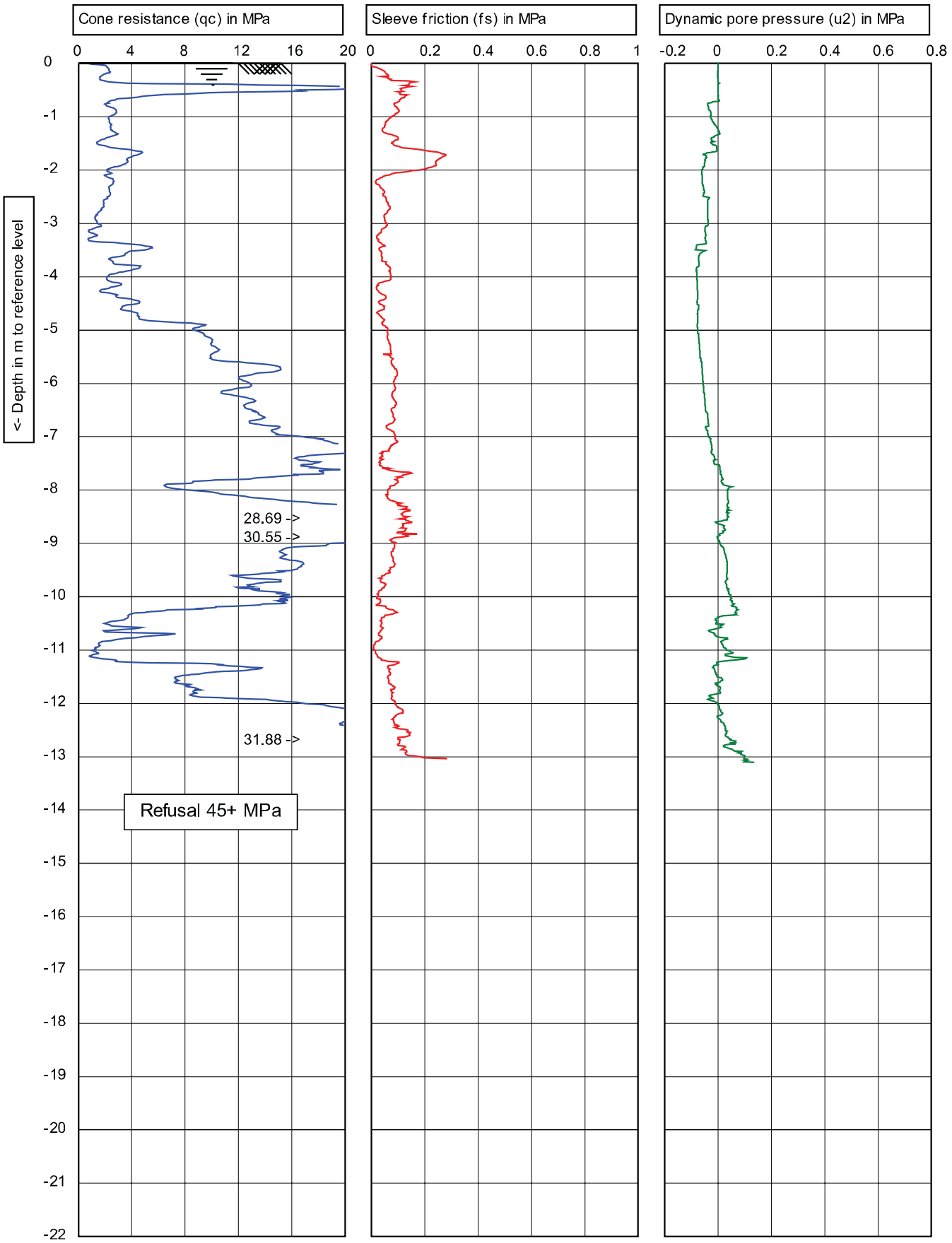
DRILL TYPE: Rotary
DRILL METHOD: HQTT/Std SPT
DRILL FLUID: LP2000

HOLE STARTED: 1/11/12
HOLE FINISHED: 1/11/12
DRILLED BY: Pro-Drill
LOGGED BY: T&T-EA CHECKED: BMcD

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FL ID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOIST RE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION / ROCK DESCRIPTION
CHRISTCHURCH FORMATION (MARINE/ ESTUARINE)			100	HQTT				-6	11		SP	W	MD				Fine to medium SAND with trace silt, grey, medium dense, wet, poorly graded.
			100	SPT		5/5//6/5/4/5 N=20											
			100	HQTT				-7	12								11.2 to 11.24m- trace fine gravel, rounded.
			100	SPT		*FC@12.5m 5/7//8/6/10/12 N=36	B	-8					D				12.5m- minor silt, dense.
			100	HQTT				-9	13								12.75 to 12.85m- amorphous organic layer.
			100	SPT		8/9//11/12/14/13 for 65mm N>50			14				VD				13.23 to 13.35m- trace organics (fibrous)
			81	HQTT				-10									14.0m- very dense.
			78	SPT		*FC@15.5m 8/10//11/13/16/10 for 40mm N>50	B	-11	15								14.45 to 14.65m- no recovery.
			86	HQTT				-12	16								15.5 to 15.6m- no recovery.
			100	SPT		7/8//9/10/13/16 N=48		-13					D				15.95 to 16.10m- no recovery.
			100	HQTT					17								17.0m- dense.
			100	SPT		5/8//8/8/12/14 N=42		-14	18								
			100	HQTT				-15	19								20.0m- 0.25m heave observed prior to SPT. No SPT. End of borehole at 20.0mbgl (target depth)
									20								

SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour.
ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.



OPUS
HAMILTON LABORATORY

u2
150 cm²
10 cm²

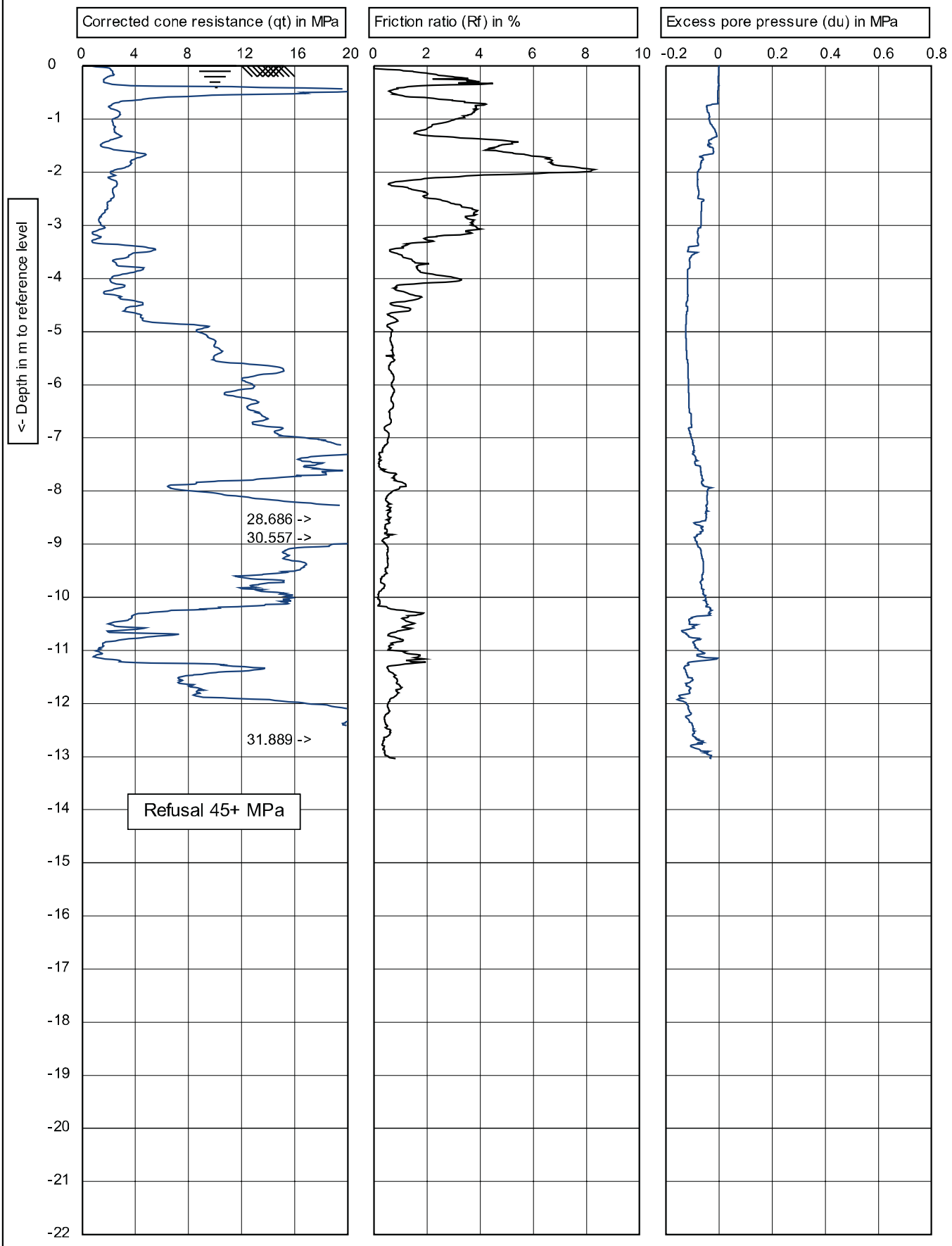
Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

Project: **Whakahoa Village- Richmond**
Location: **GPS:E1572335 N5181338**
Position:

Predrill : **0**
Date: **26/11/2012**
Cone no.: **C10CFIIP.C11284**
Project no.: **6-QUCCC.93**
CPT no.: **CPT01** **1/6**

CPTlask V1.20



OPUS
HAMILTON LABORATORY

u2
150 cm²
10 cm²

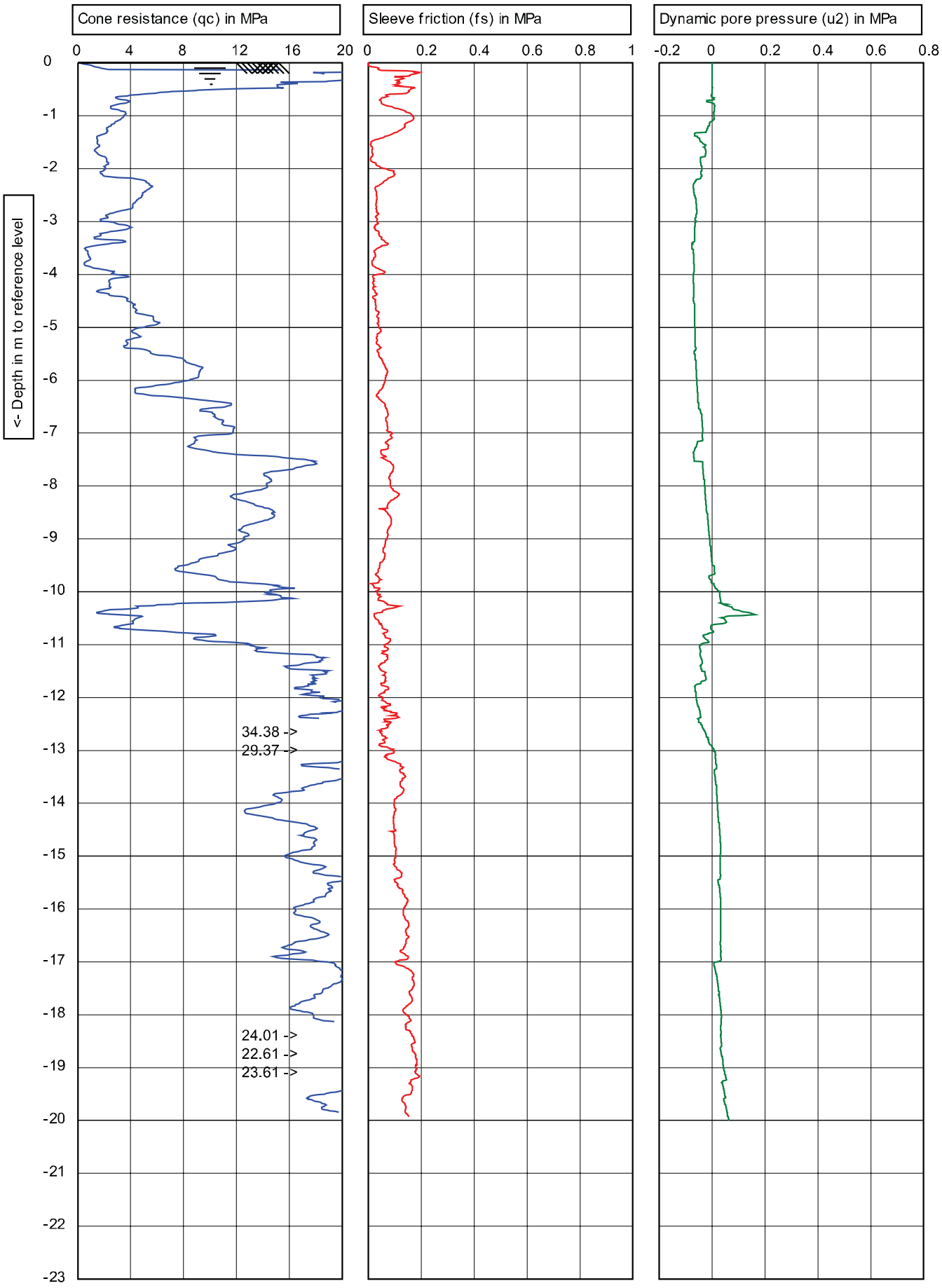
Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

Project: **Whakahoa Village- Richmond**
Location: **GPS:E1572335 N5181338**
Position:

Predrill : **0**
Date: **26/11/2012**
Cone no.: **C10CFIIP.C11284**
Project no.: **6-QUCCC.93**
CPT no.: **CPT01** **2/6**

CPTlask V1.20



OPUS
HAMILTON LABORATORY

Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

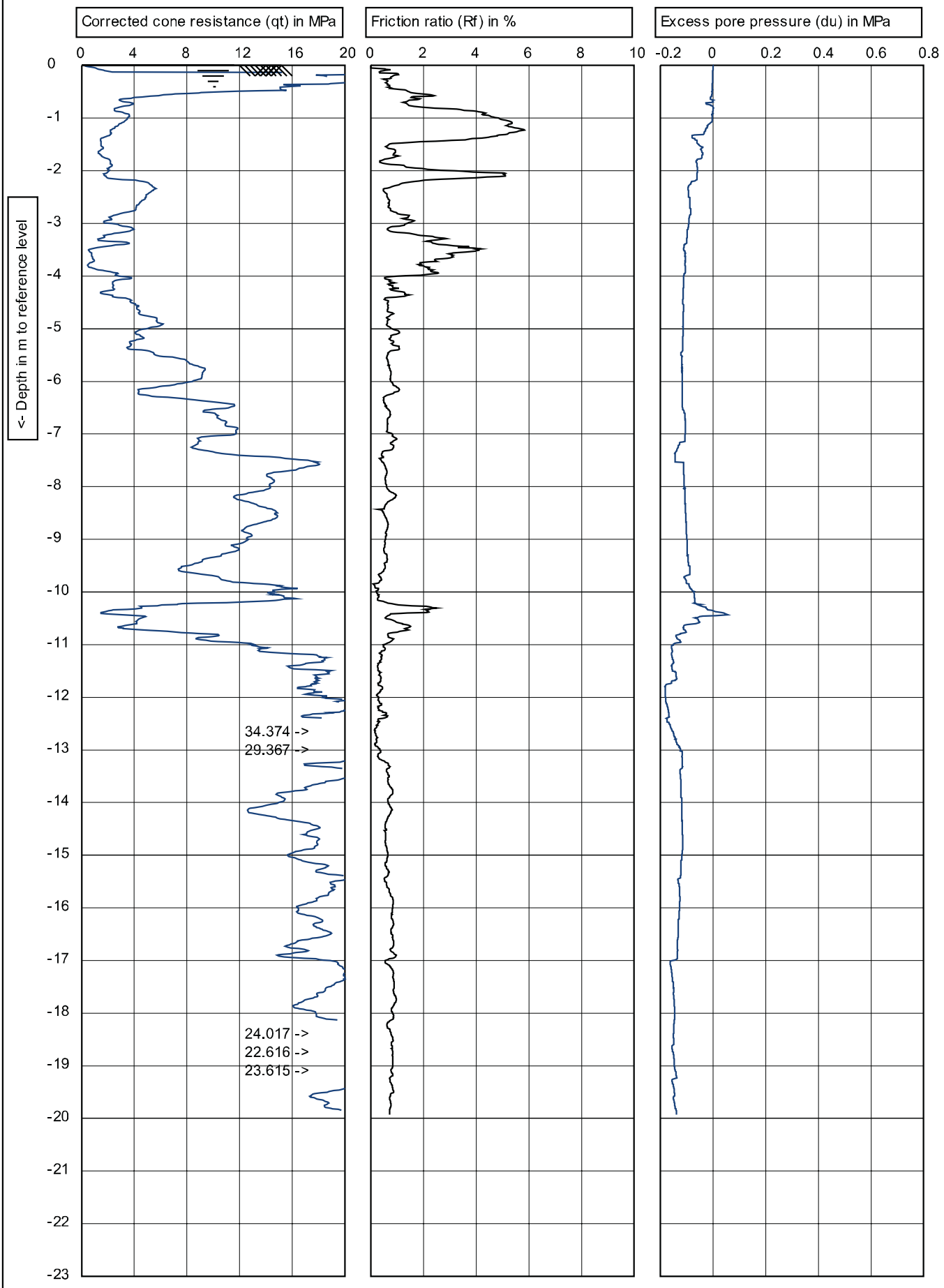
Project: **Whakahoa Village- Richmond**

Location: **GPS:E1572322 N5181379**

Position:

Predrill :	**0**
Date:	**26/11/2012**
Cone no.:	**C10CFIIP.C11284**
Project no.:	**6-QUCCC.93**
CPT no.:	**CPT02** 1/6

CPTask V1.20



OPUS
HAMILTON LABORATORY

u2
150 cm²
10 cm²

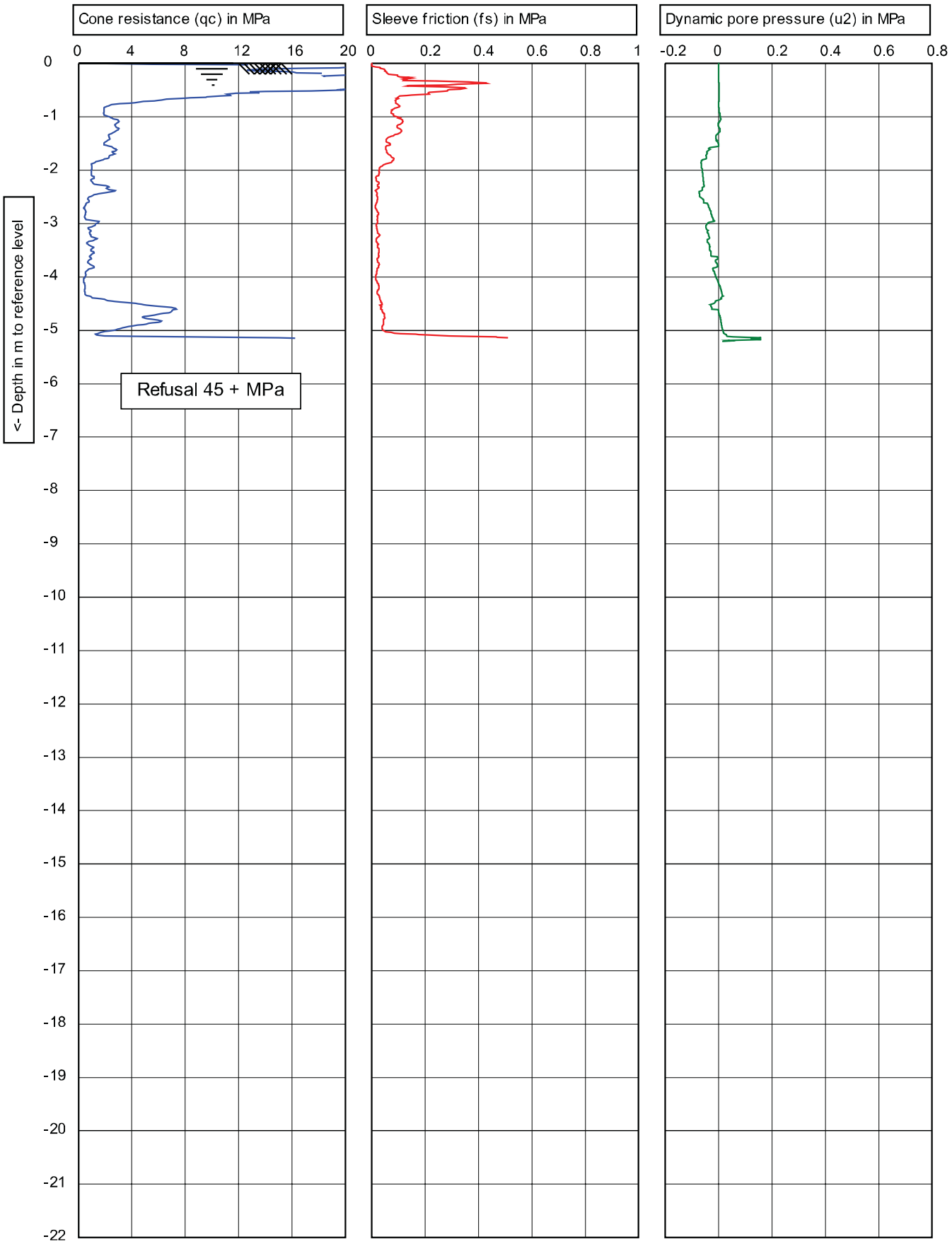
Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

Project: **Whakahoa Village- Richmond**
Location: **GPS:E1572322 N5181379**
Position:

Predrill :	**0**
Date:	**26/11/2012**
Cone no.:	**C10CFIIP.C11284**
Project no.:	**6-QUCCC.93**
CPT no.:	**CPT02** 2/6

CPTlask V1.20



OPUS
HAMILTON LABORATORY

u2
150 cm²
10 cm²

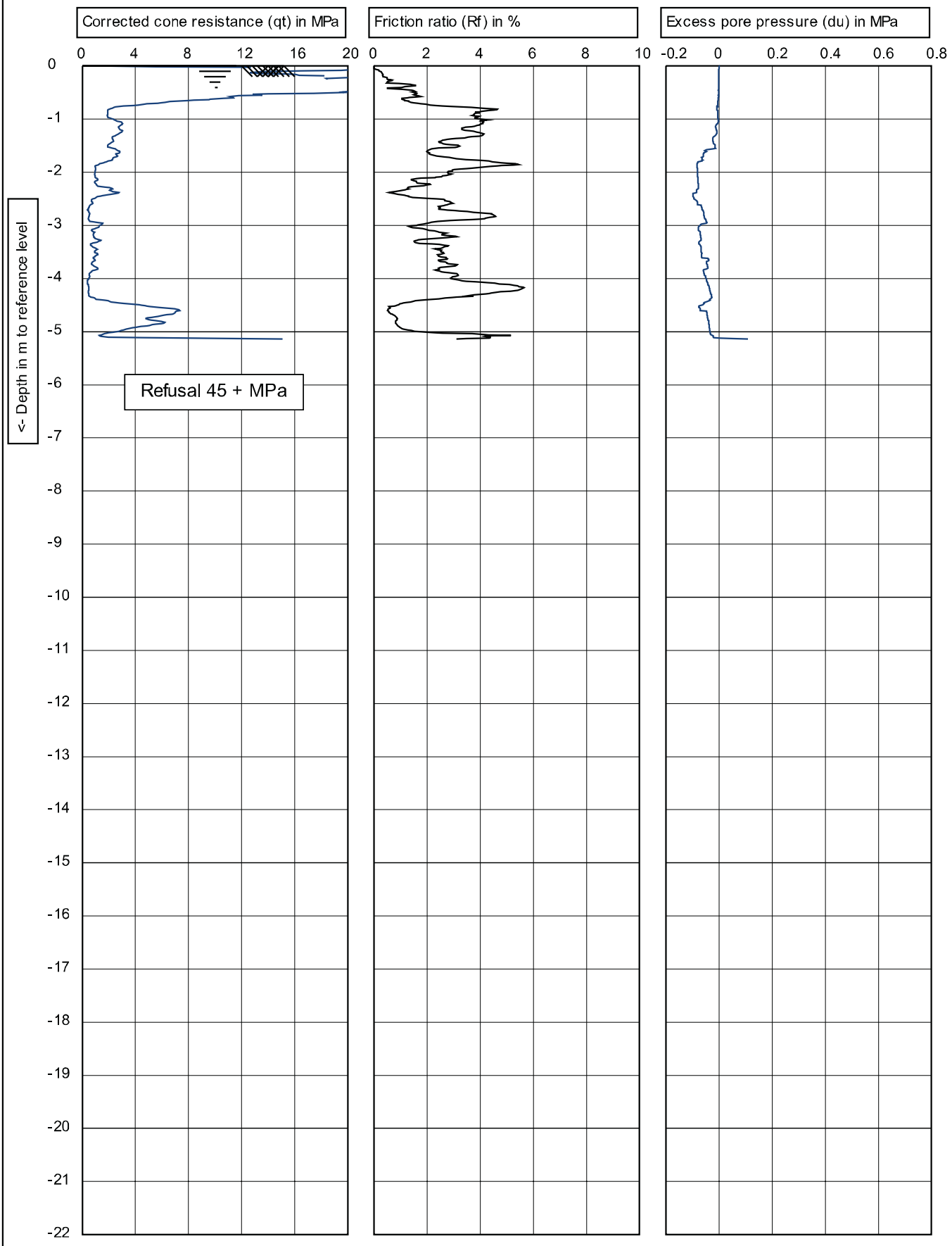
Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

Project: **Whakahoa Village- Richmond**
Location: **GPS:E1572306 N5181404**
Position:

Predrill :	**0**
Date:	**26/11/2012**
Cone no.:	**C10CFIIP.C11284**
Project no.:	**6-QUCCC.93**
CPT no.:	**CPT03** 1/6

CPTask V1.20



OPUS
HAMILTON LABORATORY

u2
150 cm²
10 cm²

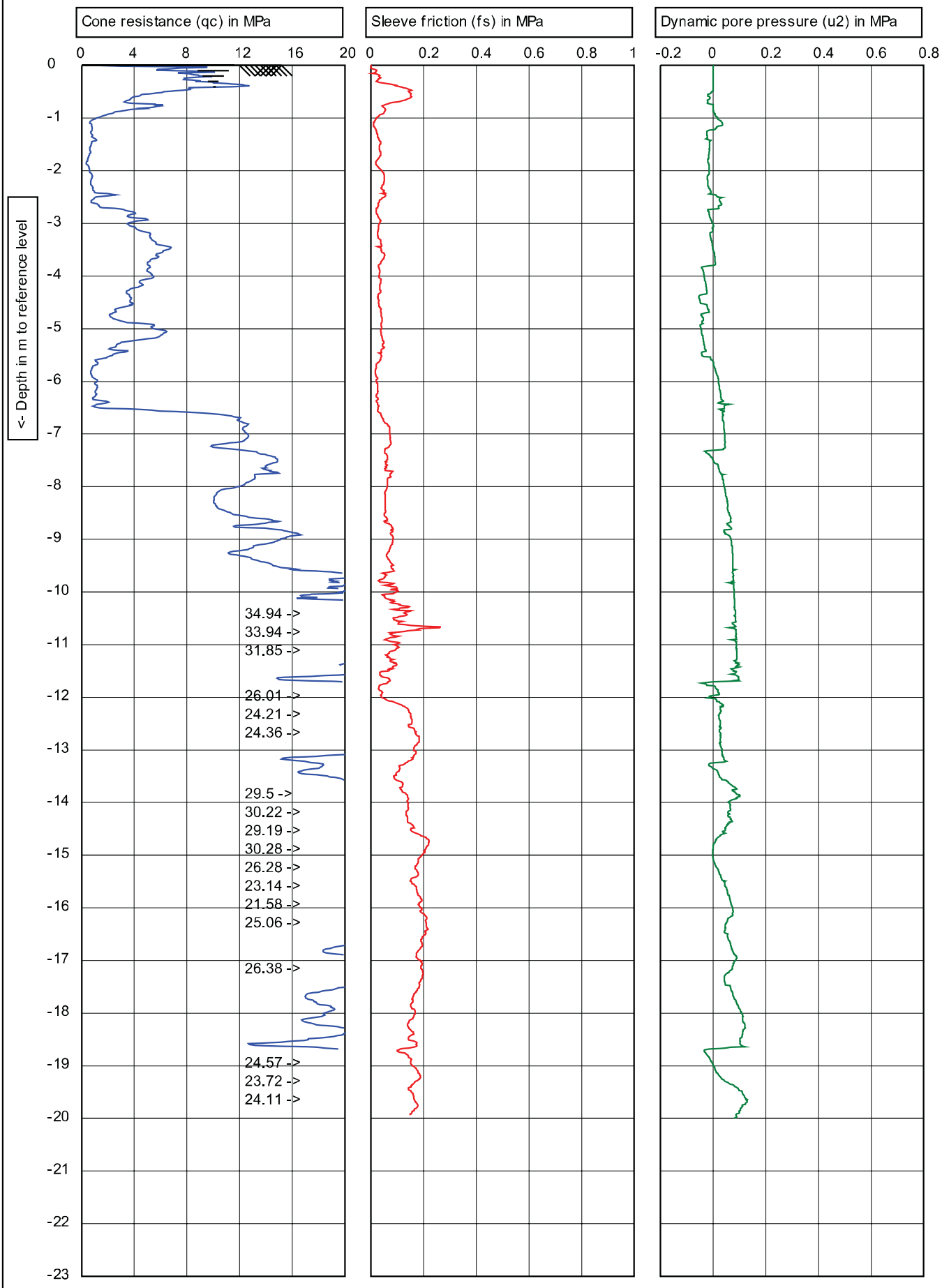
Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

Project: **Whakahoa Village- Richmond**
Location: **GPS:E1572306 N5181404**
Position:

Predrill :	**0**
Date:	**26/11/2012**
Cone no.:	**C10CFIIP.C11284**
Project no.:	**6-QUCCC.93**
CPT no.:	**CPT03** **2/6**

CPTask V1.20



OPUS
HAMILTON LABORATORY

Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

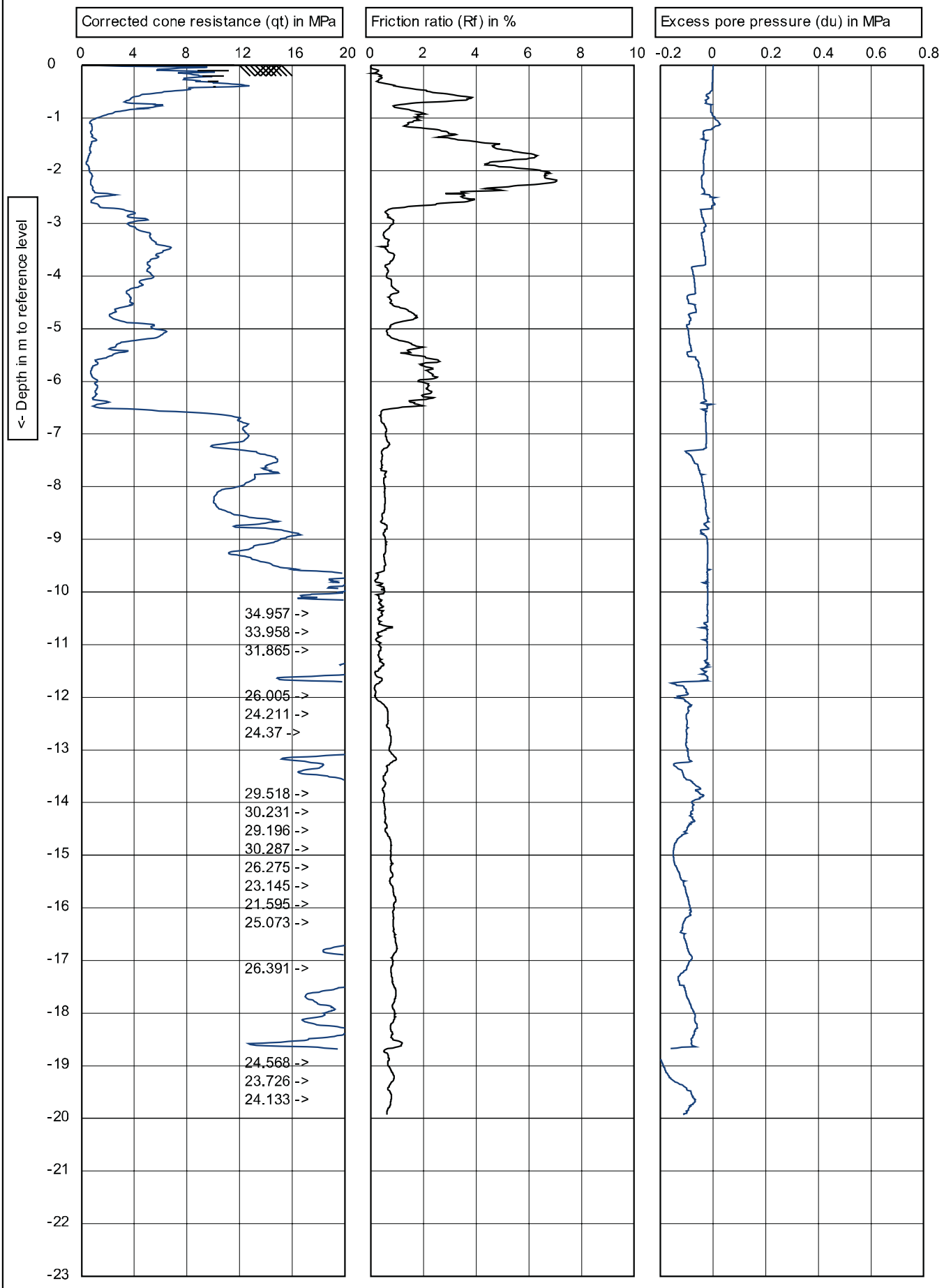
Project: **Whakahoa Village- Richmond**

Location: **GPS:E1572355 N5181401**

Position:

Predrill :	**0**
Date:	**26/11/2012**
Cone no.:	**C10CFIIP.C11284**
Project no.:	**6-QUCCC.93**
CPT no.:	**CPT04** 1/6

CPTask V1.20



OPUS
HAMILTON LABORATORY

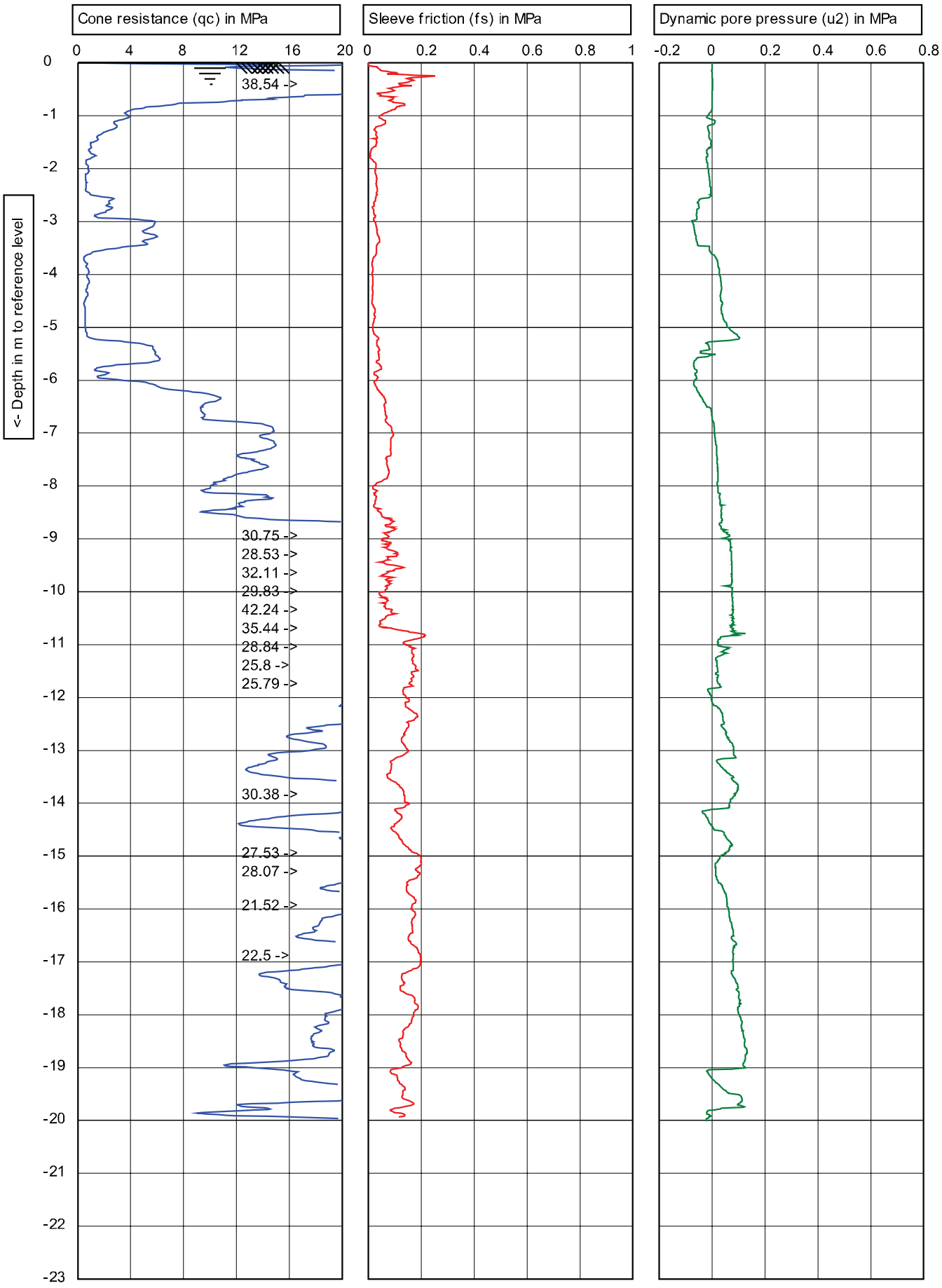
Test according to A.S.T.M standard D-5778-12

G.L. 0 | W.L.: 0

Project: Whakahoa Village- Richmond
Location: GPS:E1572355 N5181401
Position:

Predrill :	0
Date:	26/11/2012
Cone no.:	C10CFIIP.C11284
Project no.:	6-QUCCC.93
CPT no.:	CPT04 2/6

CPTask V1.20



OPUS
HAMILTON LABORATORY

u2
150 cm²
10 cm²

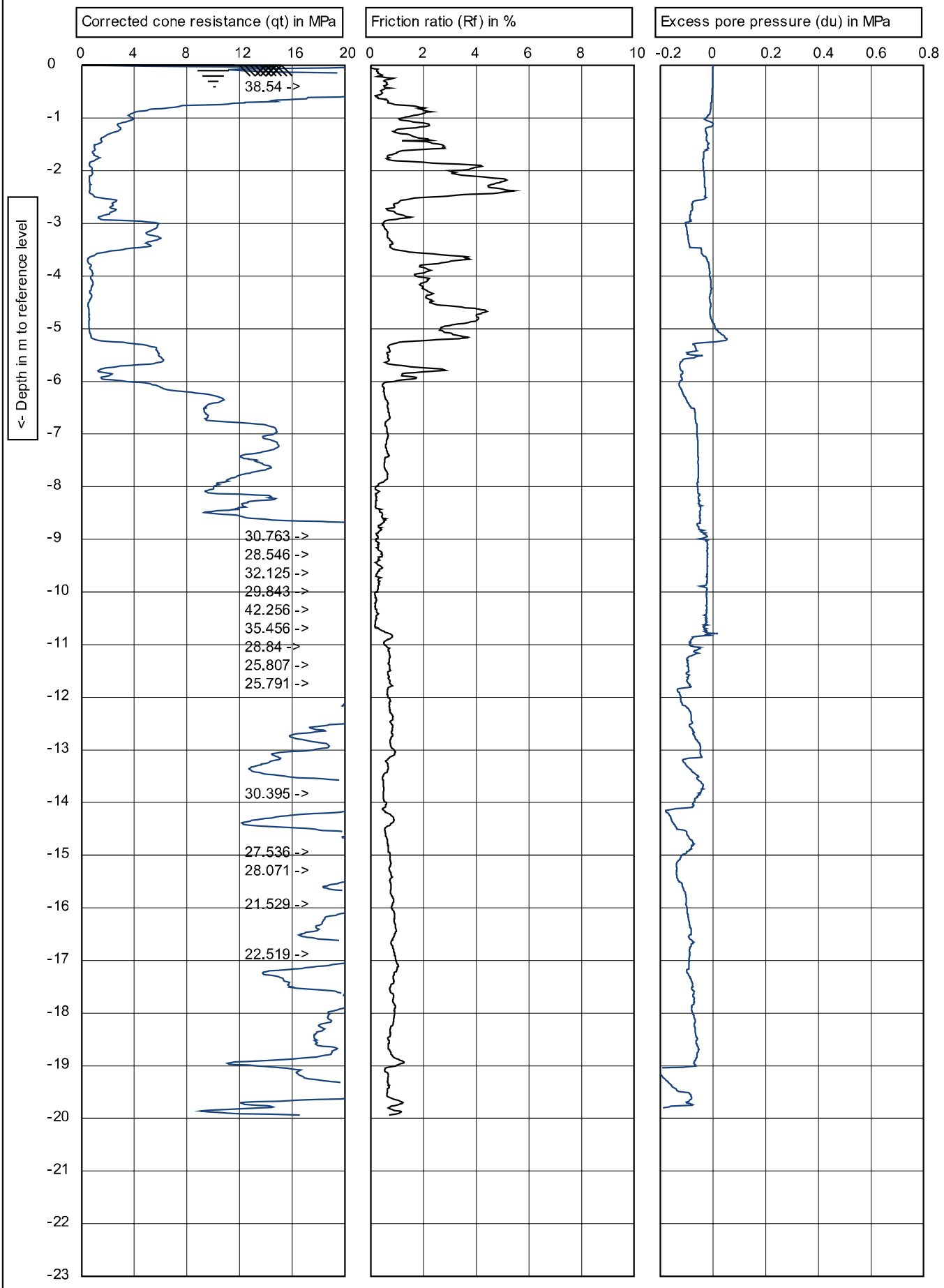
Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

Project: **Whakahoa Village- Richmond**
Location: **GPS:E1572372 N5181389**
Position:

Predrill :	**0**
Date:	**26/11/2012**
Cone no.:	**C10CFIIP.C11284**
Project no.:	**6-QUCCC.93**
CPT no.:	**CPT05** 1/6

CPTask V1.20



OPUS
HAMILTON LABORATORY

u2
150 cm²
10 cm²

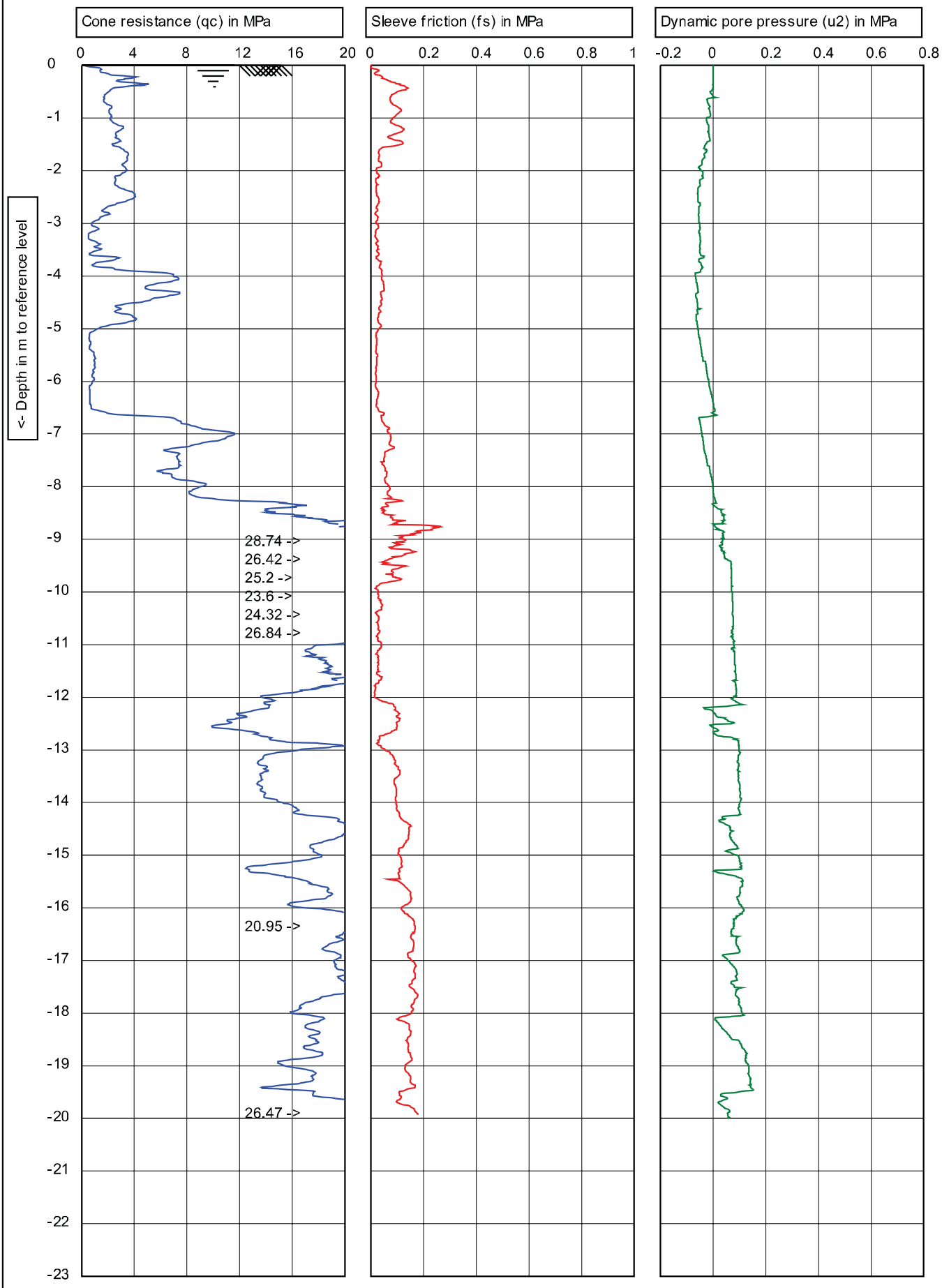
Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

Project: **Whakahoa Village- Richmond**
Location: **GPS:E1572372 N5181389**
Position:

Predrill : **0**
Date: **26/11/2012**
Cone no.: **C10CFIIP.C11284**
Project no.: **6-QUCCC.93**
CPT no.: **CPT05** **2/6**

CPTlask V1.20



OPUS
HAMILTON LABORATORY

Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

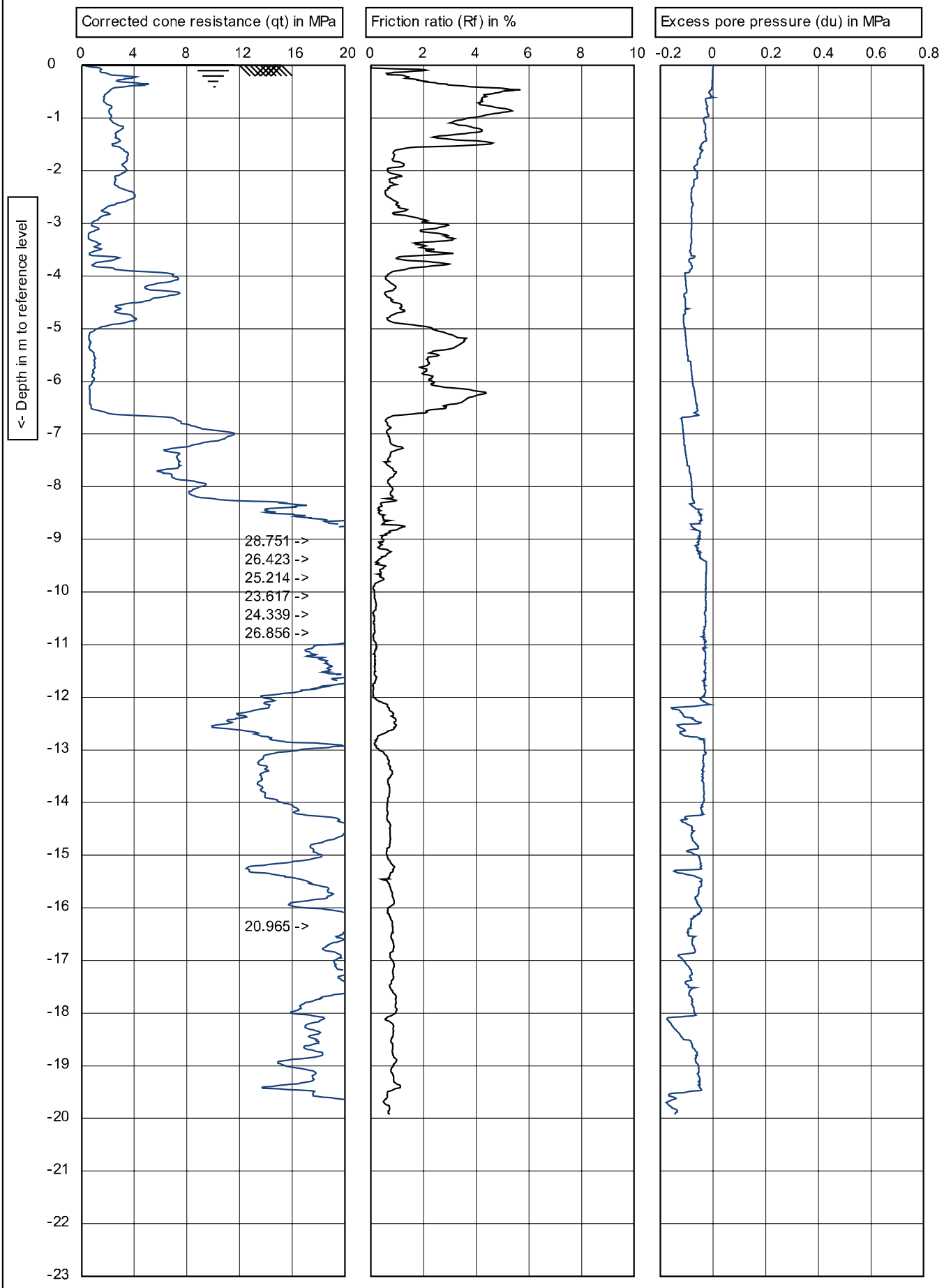
Project: **Whakahoa Village- Richmond**

Location: **GPS:E1572370 N5181341**

Position:

Predrill :	**0**
Date:	**26/11/2012**
Cone no.:	**C10CFIIP.C11284**
Project no.:	**6-QUCCC.93**
CPT no.:	**CPT06** 1/6

CPTask V1.20



OPUS
HAMILTON LABORATORY

u2
150 cm²
10 cm²

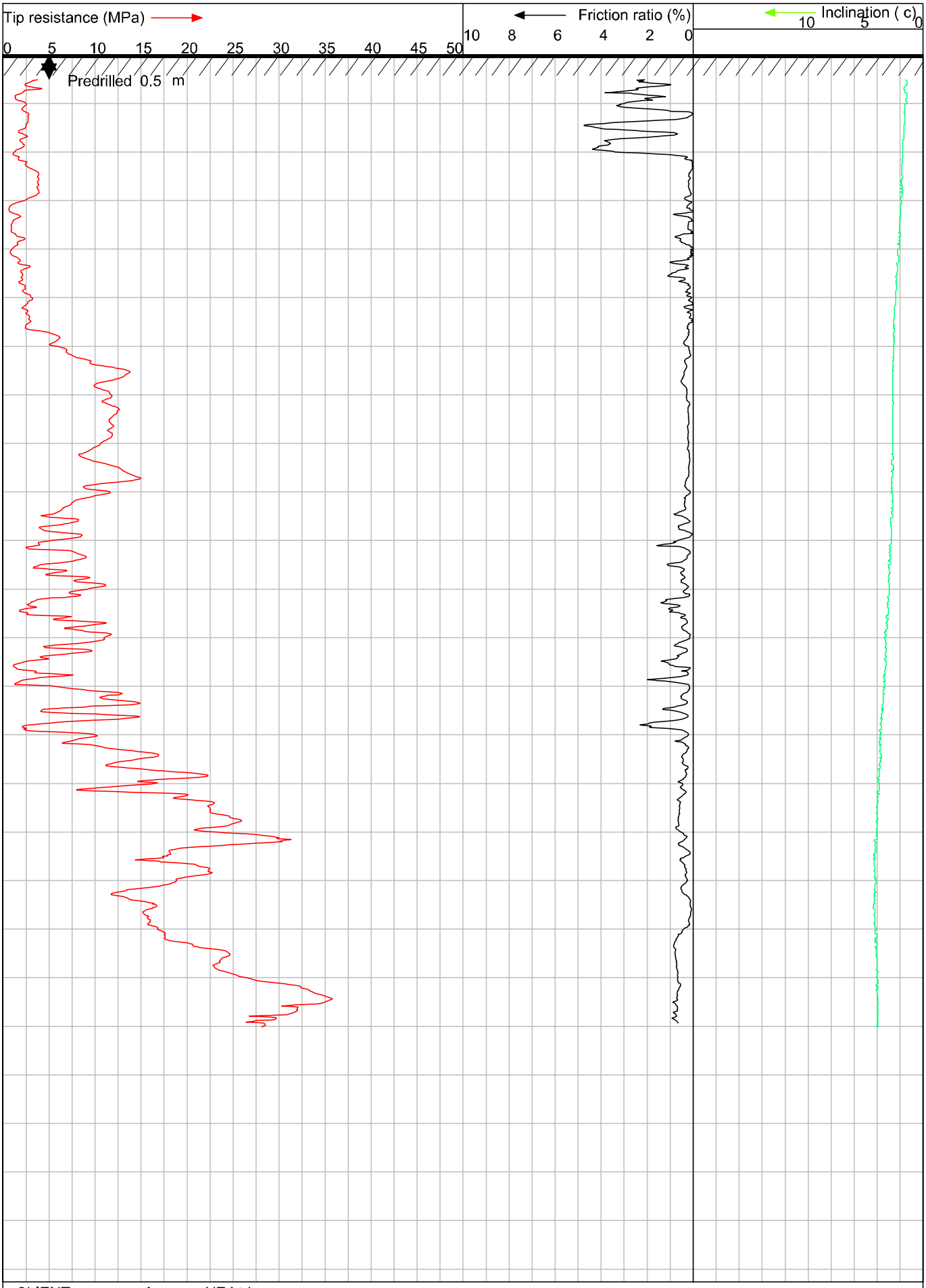
Test according to A.S.T.M standard D-5778-12

G.L. **0** W.L.: **0**

Project: **Whakahoa Village- Richmond**
Location: **GPS:E1572370 N5181341**
Position:

Predrill : **0**
Date: **26/11/2012**
Cone no.: **C10CFIIP.C11284**
Project no.: **6-QUCCC.93**
CPT no.: **CPT06** **2/6**

CPTask V1.20

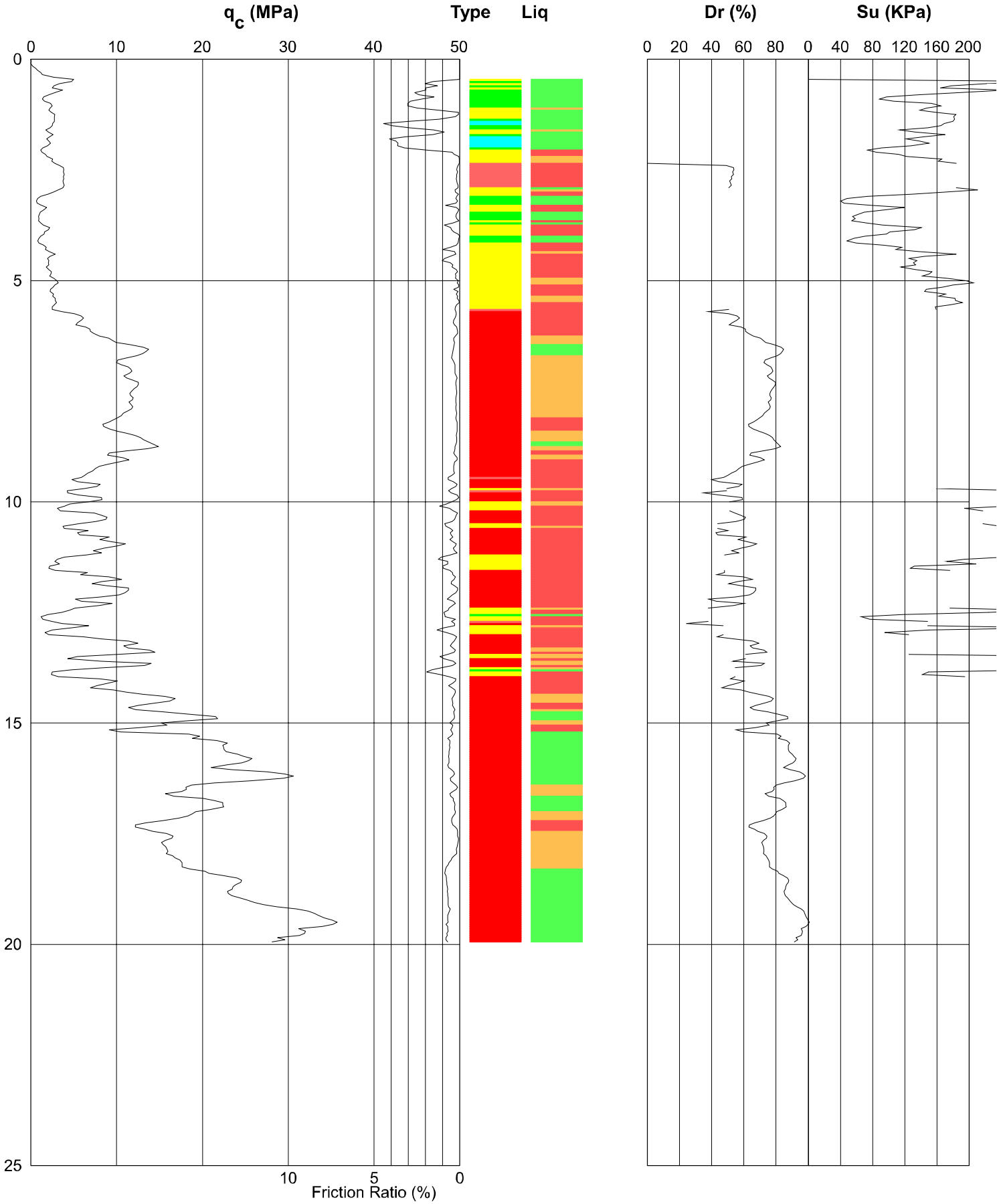


CLIENT : Aurecon NZ Ltd
LOCATION : 300 Stanmore Road, Christchurch (New World)
DATE : 29-11-2012
OPERATOR : S.Cardona
REMARK 1 : CPT001
REMARK 2 : Effective Refusal

JOB # : 11340
TEST #: 1
CONE TYPE/SERIAL #: I-CFXY-10 / 080238T

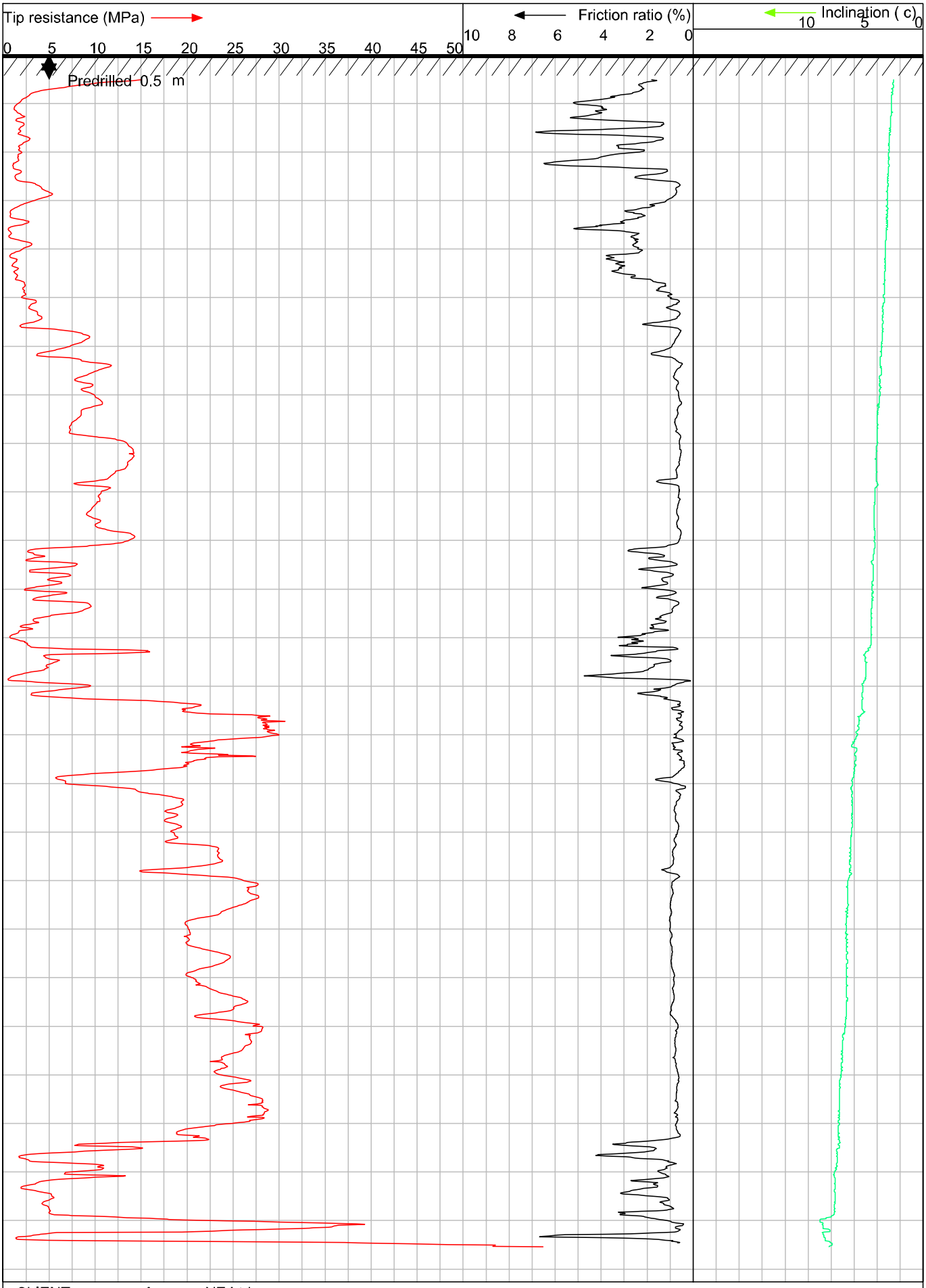
McMILLAN DRILLING SERVICES
120 High St Southbridge CANTERBURY NZ
Ph +64 3 324 2571 Fax +64 3 324 2431
www.drilling.co.nz

PIEZOCONE PENETROMETER TEST (CPTU) INTERPRETIVE REPORT



Job No:	11340	Date:	29-11-2012
CPT No:	CPT001	Operator:	S.Cardona
Project:	Aurecon NZ Ltd	Remark:	Effective Refusal
Location:	300 Stanmore Road, Christchurch (New World)		

McMILLAN DRILLING SERVICES



CLIENT : Aurecon NZ Ltd
LOCATION : 300 Stanmore Road, Christchurch (New World)
DATE : 23-11-2012
OPERATOR : S.Cardona
REMARK 1 : CPT002
REMARK 2 : Effective Refusal

JOB # : 11340
TEST #: 2
CONE TYPE/SERIAL #: I-CFXY-10 / 110542T

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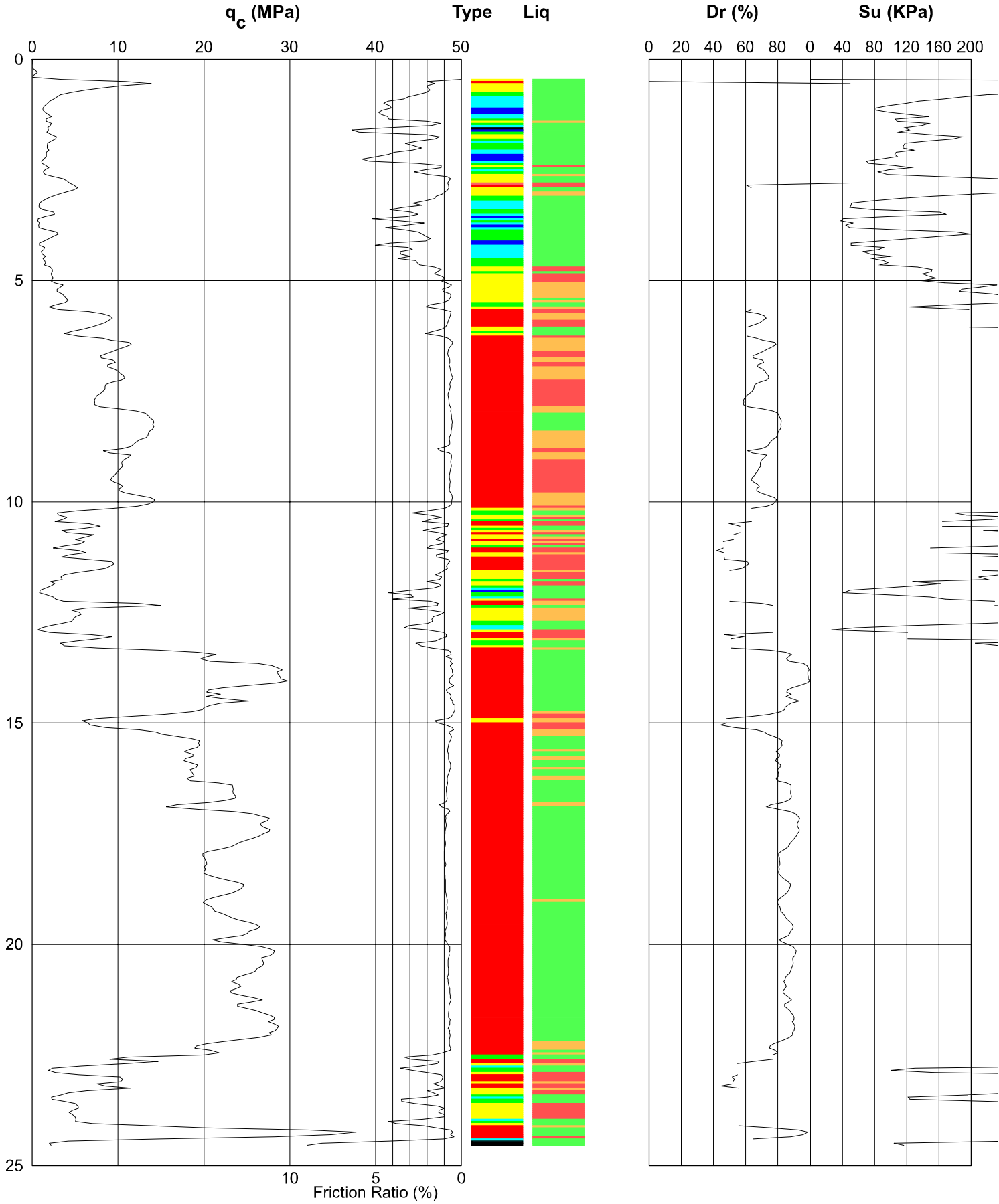
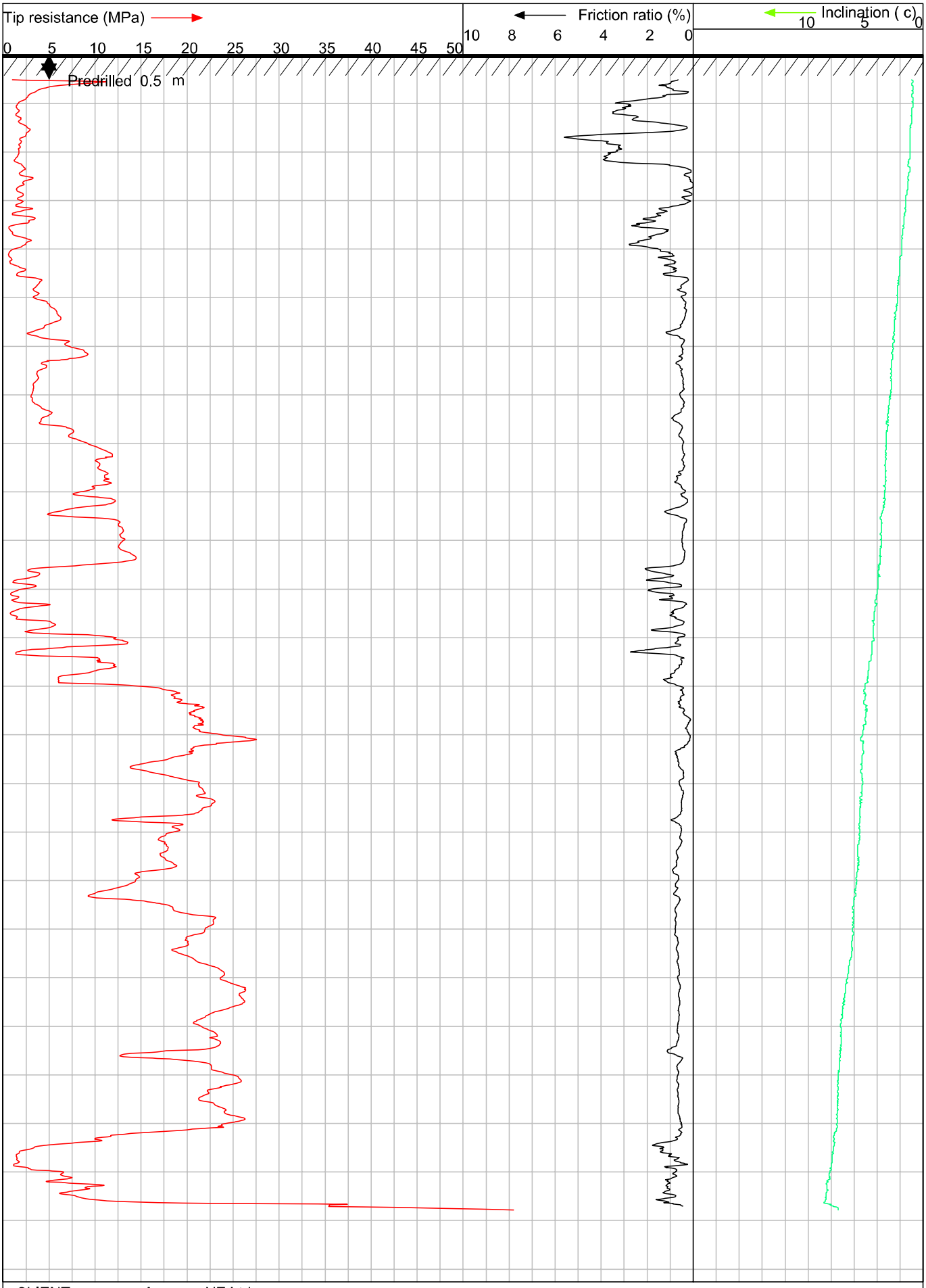
120 High St Southbridge CANTERBURY NZ
Ph +64 3 324 2571 Fax +64 3 324 2431
www.drilling.co.nz

PIEZOCONE PENETROMETER TEST (CPTU) INTERPRETIVE REPORT



Job No:	11340	Date:	23-11-2012
CPT No:	CPT002	Operator:	S.Cardona
Project:	Aurecon NZ Ltd	Remark:	Effective Refusal
Location:	300 Stanmore Road, Christchurch (New World)		

McMILLAN DRILLING SERVICES

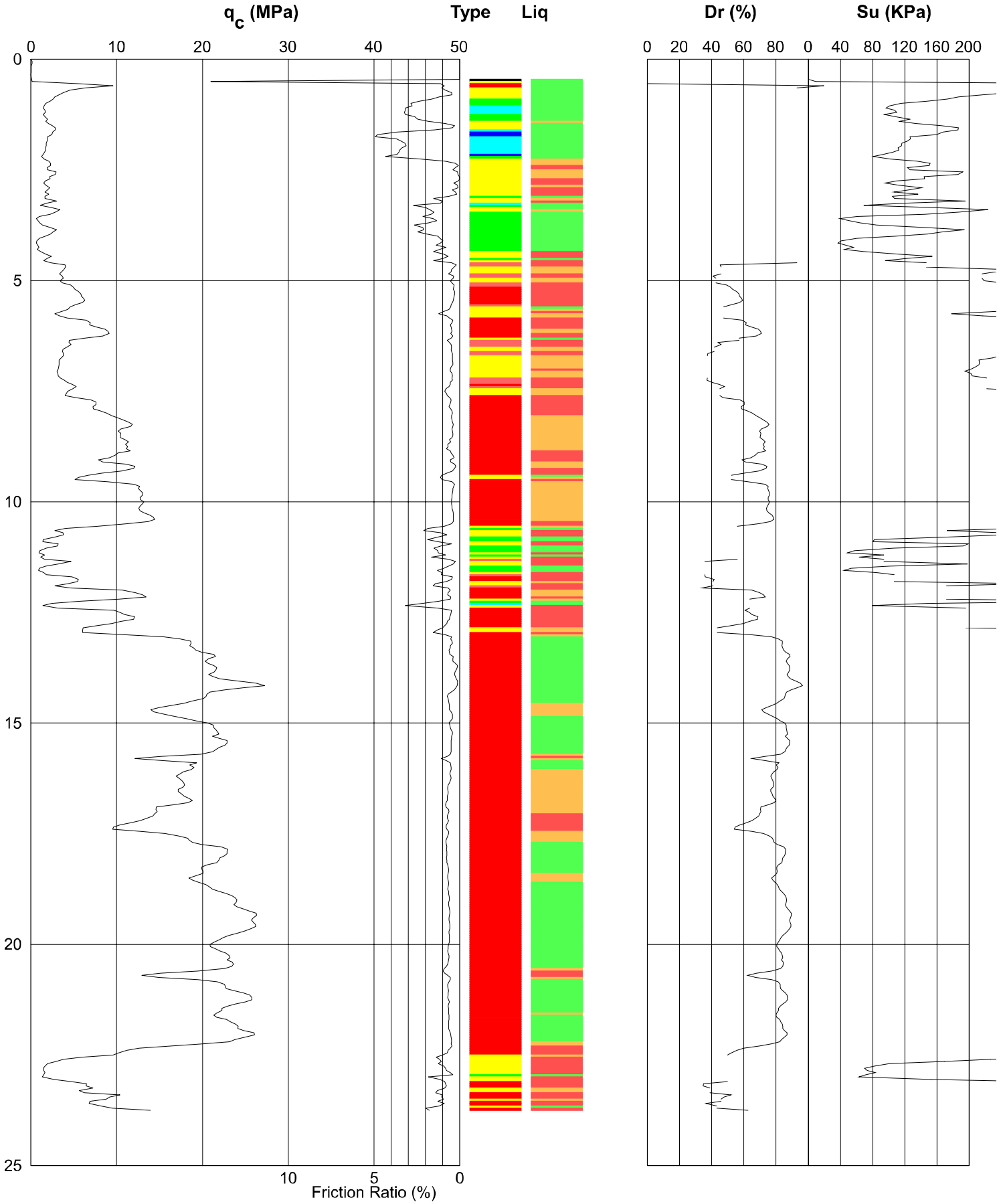


CLIENT : Aurecon NZ Ltd
LOCATION : 300 Stanmore Road, Christchurch (New World)
DATE : 27-11-2012
OPERATOR : S.Cardona
REMARK 1 : CPT003
REMARK 2 : Effective Refusal

JOB # : 11340
TEST #: 3
CONE TYPE/SERIAL #: I-CFXYP20-10/ 120523T

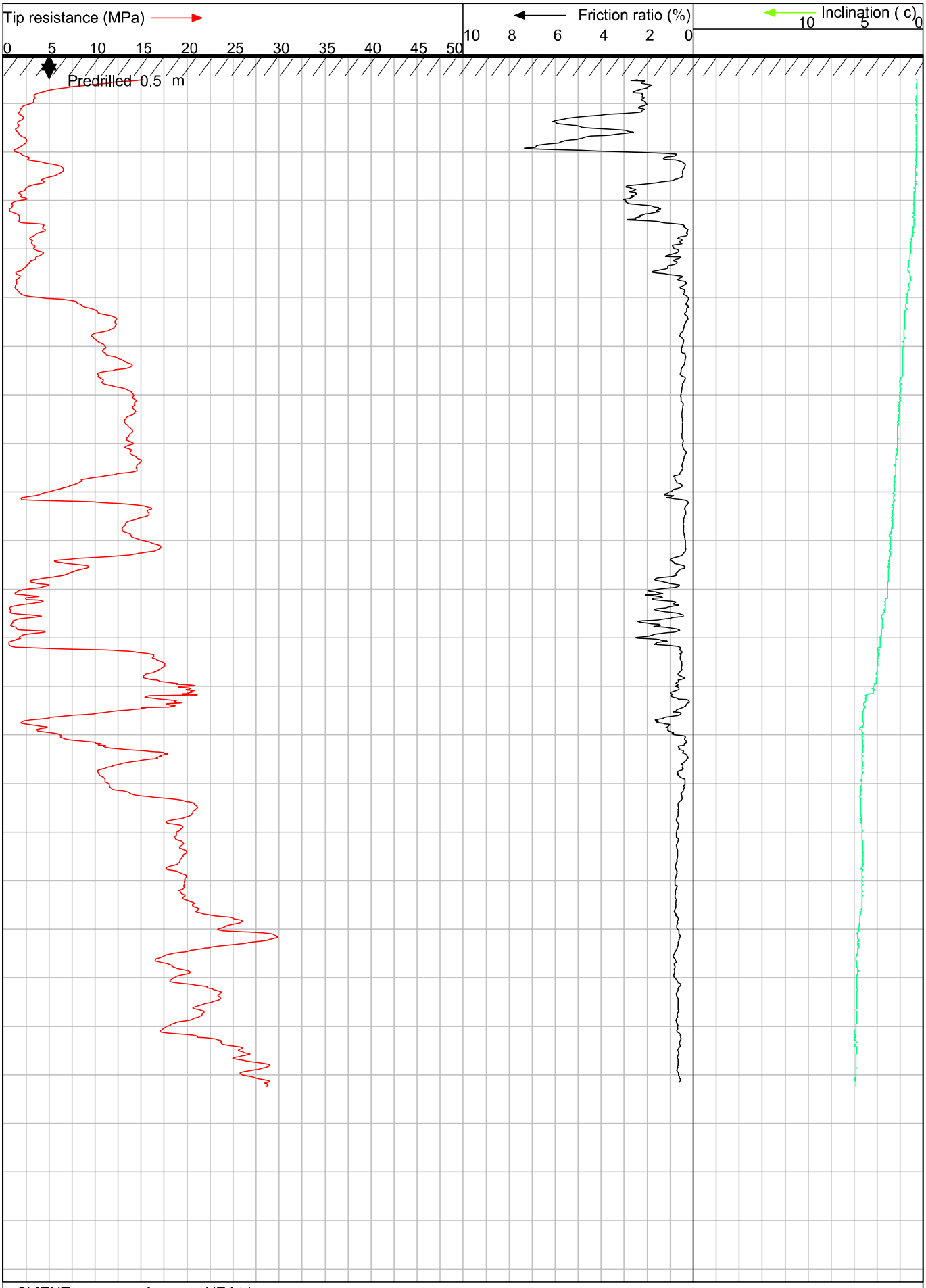
McMILLAN DRILLING SERVICES
120 High St Southbridge CANTERBURY NZ
Ph +64 3 324 2571 Fax +64 3 324 2431
www.drilling.co.nz

PIEZOCONE PENETROMETER TEST (CPTU) INTERPRETIVE REPORT



Job No:	11340	Date:	27-11-2012
CPT No:	CPT003	Operator:	S.Cardona
Project:	Aurecon NZ Ltd	Remark:	Effective Refusal
Location:	300 Stanmore Road, Christchurch (New World)		

McMILLAN DRILLING SERVICES

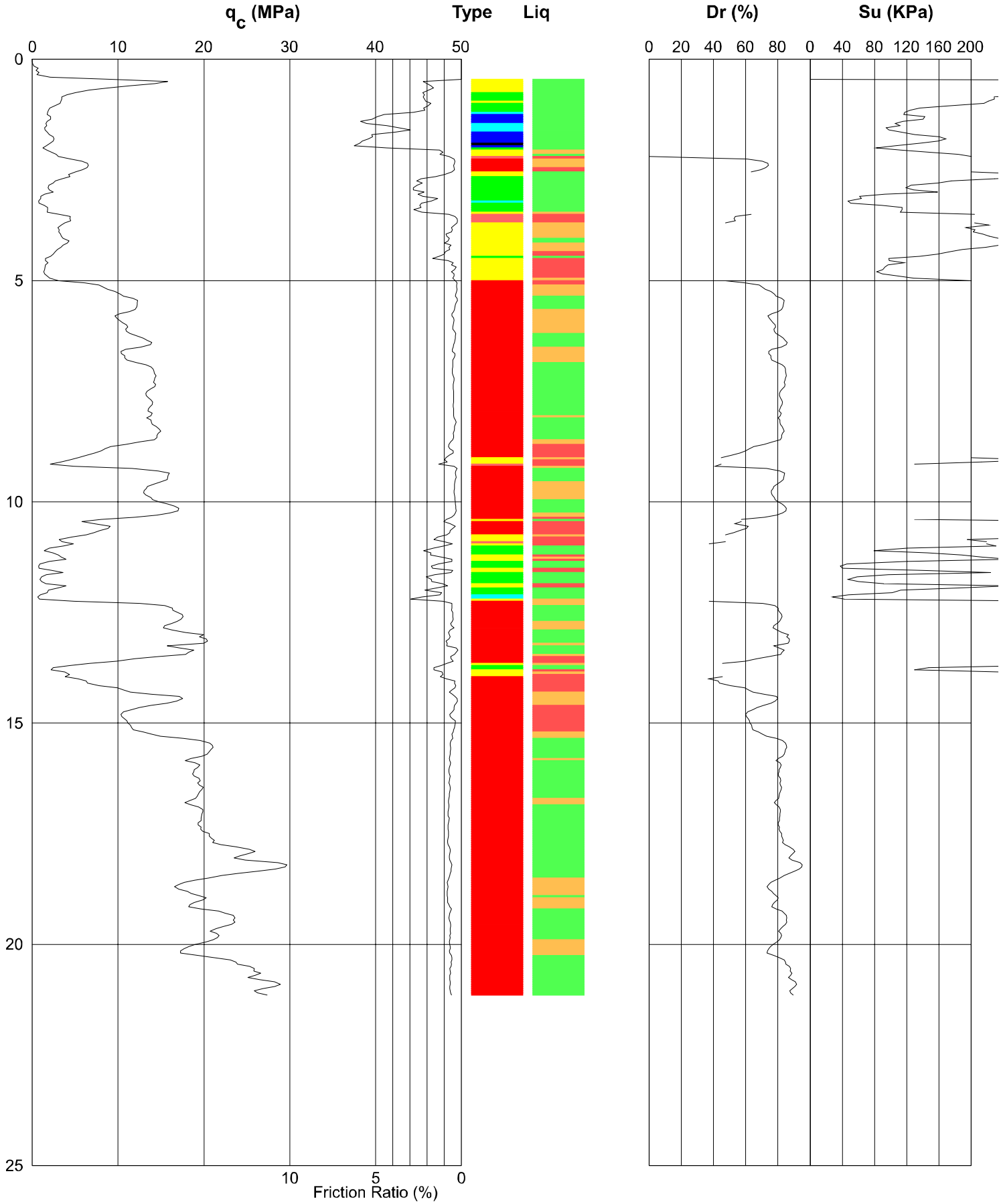


CLIENT : Aurecon NZ Ltd
LOCATION : 300 Stanmore Road, Christchurch (New World)
DATE : 27-11-2012
OPERATOR : S.Cardona
REMARK 1 : CPT004
REMARK 2 : Effective Refusal

JOB # : 11340
TEST #: 4
CONE TYPE/SERIAL #: I-CFXYP20-10/ 120523T

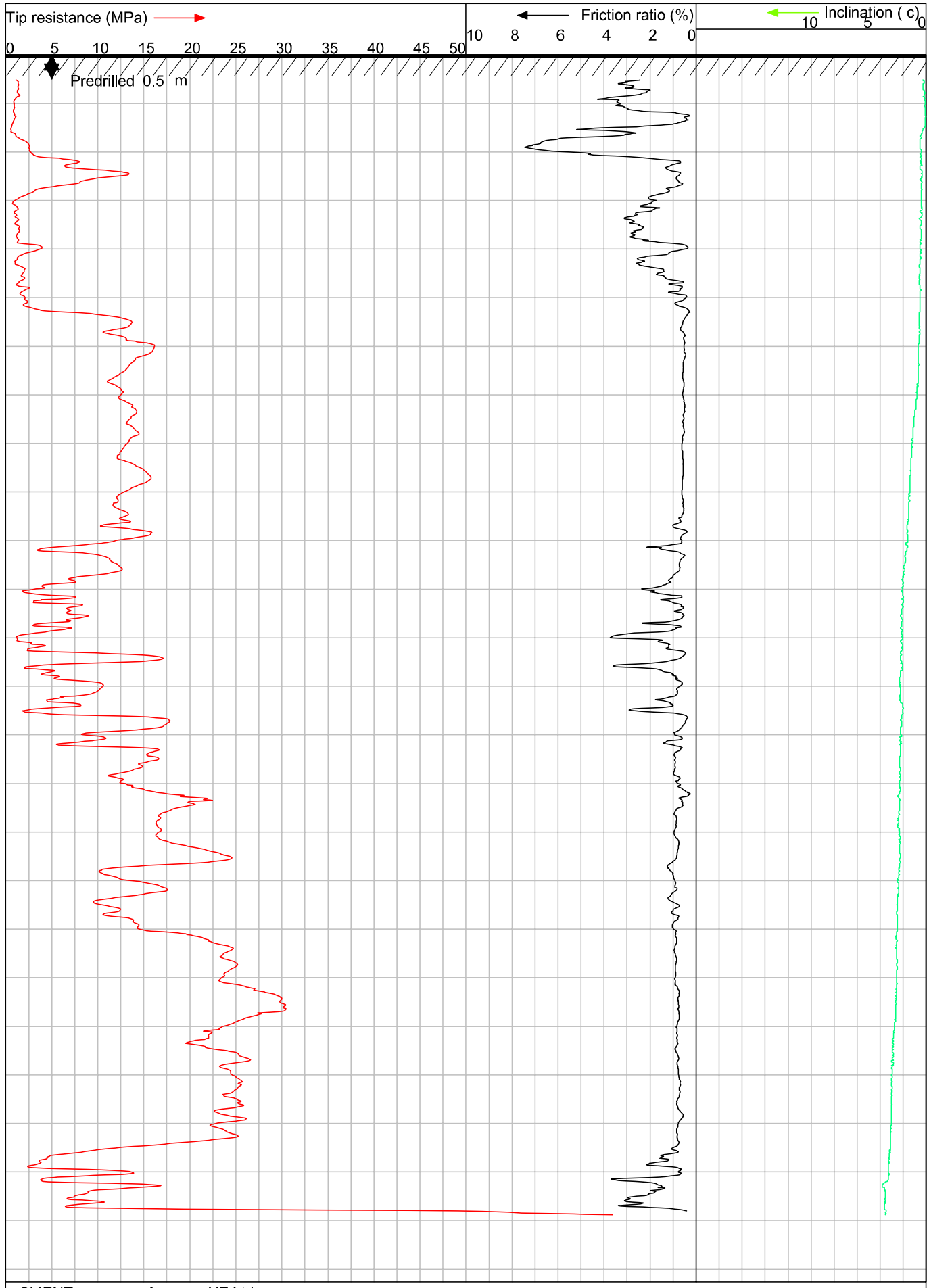
McMILLAN DRILLING SERVICES
120 High St Southbridge CANTERBURY NZ
Ph +64 3 324 2571 Fax +64 3 324 2431
www.drilling.co.nz

PIEZOCONE PENETROMETER TEST (CPTU) INTERPRETIVE REPORT



Job No:	11340	Date:	27-11-2012
CPT No:	CPT004	Operator:	S.Cardona
Project:	Aurecon NZ Ltd	Remark:	Effective Refusal
Location:	300 Stanmore Road, Christchurch (New World)		

McMILLAN DRILLING SERVICES

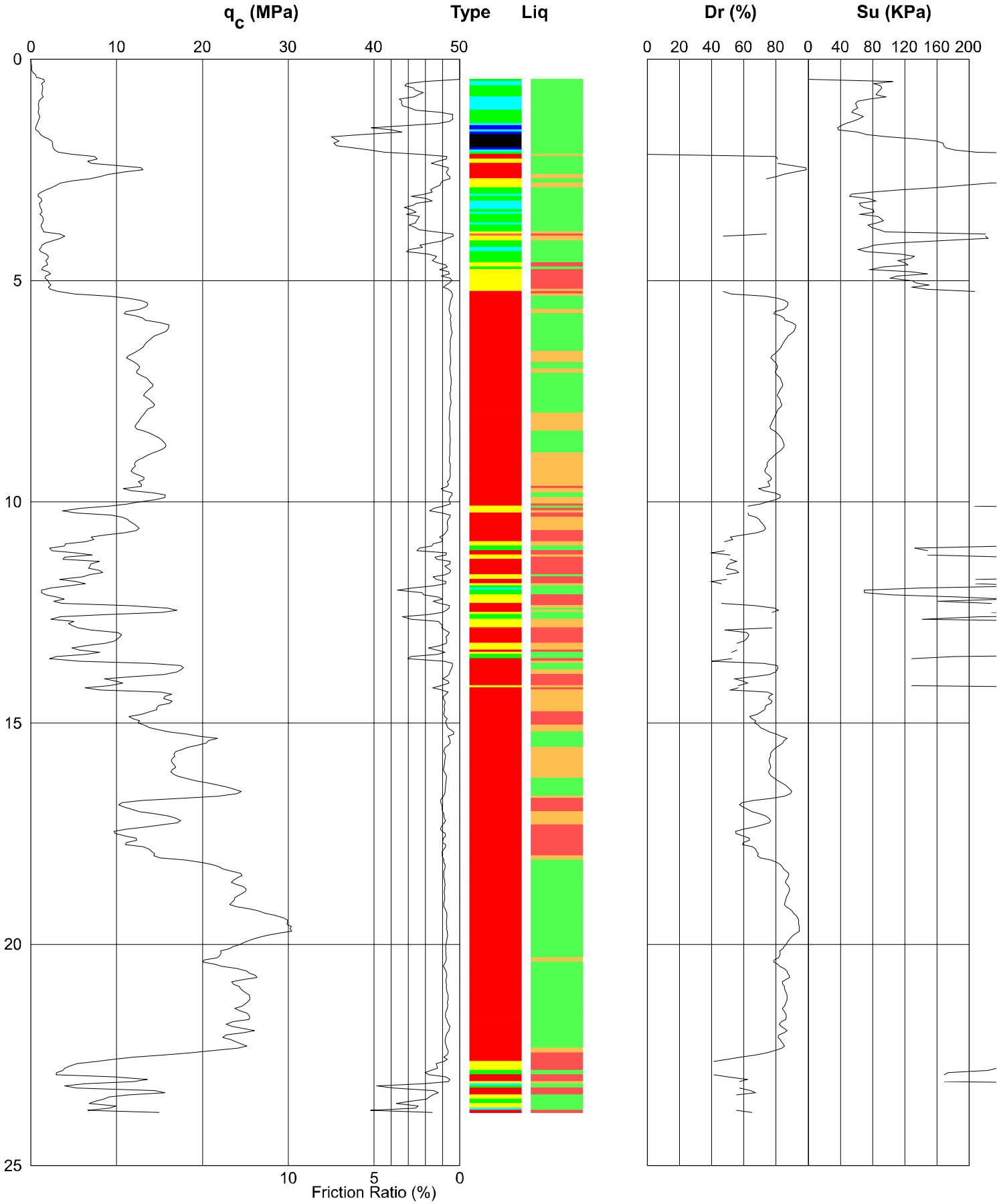


CLIENT : Aurecon NZ Ltd
LOCATION : 300 Stanmore Road, Christchurch (New World)
DATE : 23-11-2012
OPERATOR : S.Cardona
REMARK 1 : CPT005
REMARK 2 : Effective Refusal

JOB # : 11340
TEST #: 5
CONE TYPE/SERIAL #: I-CFXY-10 / 110542T

McMILLAN DRILLING SERVICES
120 High St Southbridge CANTERBURY NZ
Ph +64 3 324 2571 Fax +64 3 324 2431
www.drilling.co.nz

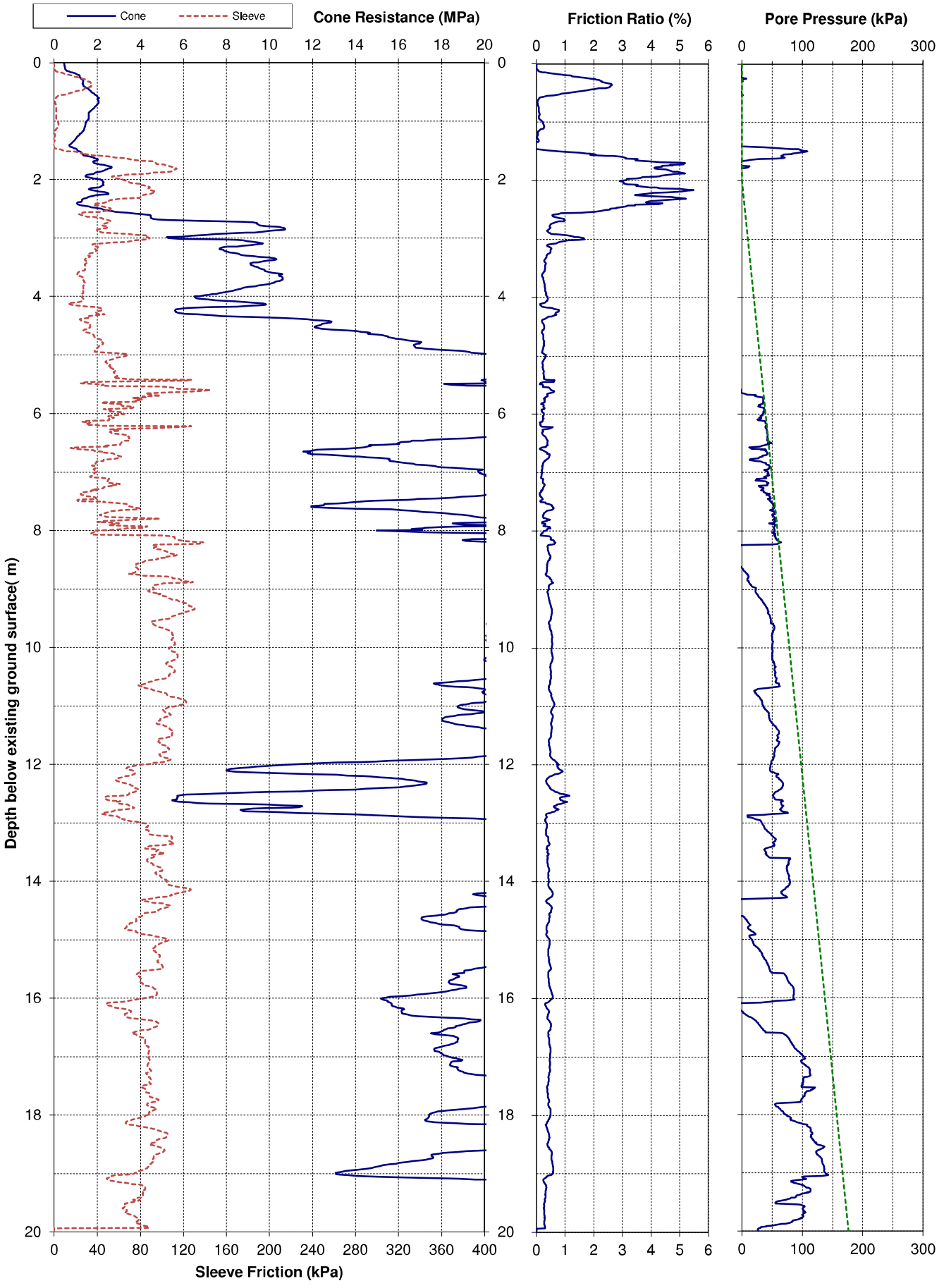
PIEZOCONE PENETROMETER TEST (CPTU) INTERPRETIVE REPORT



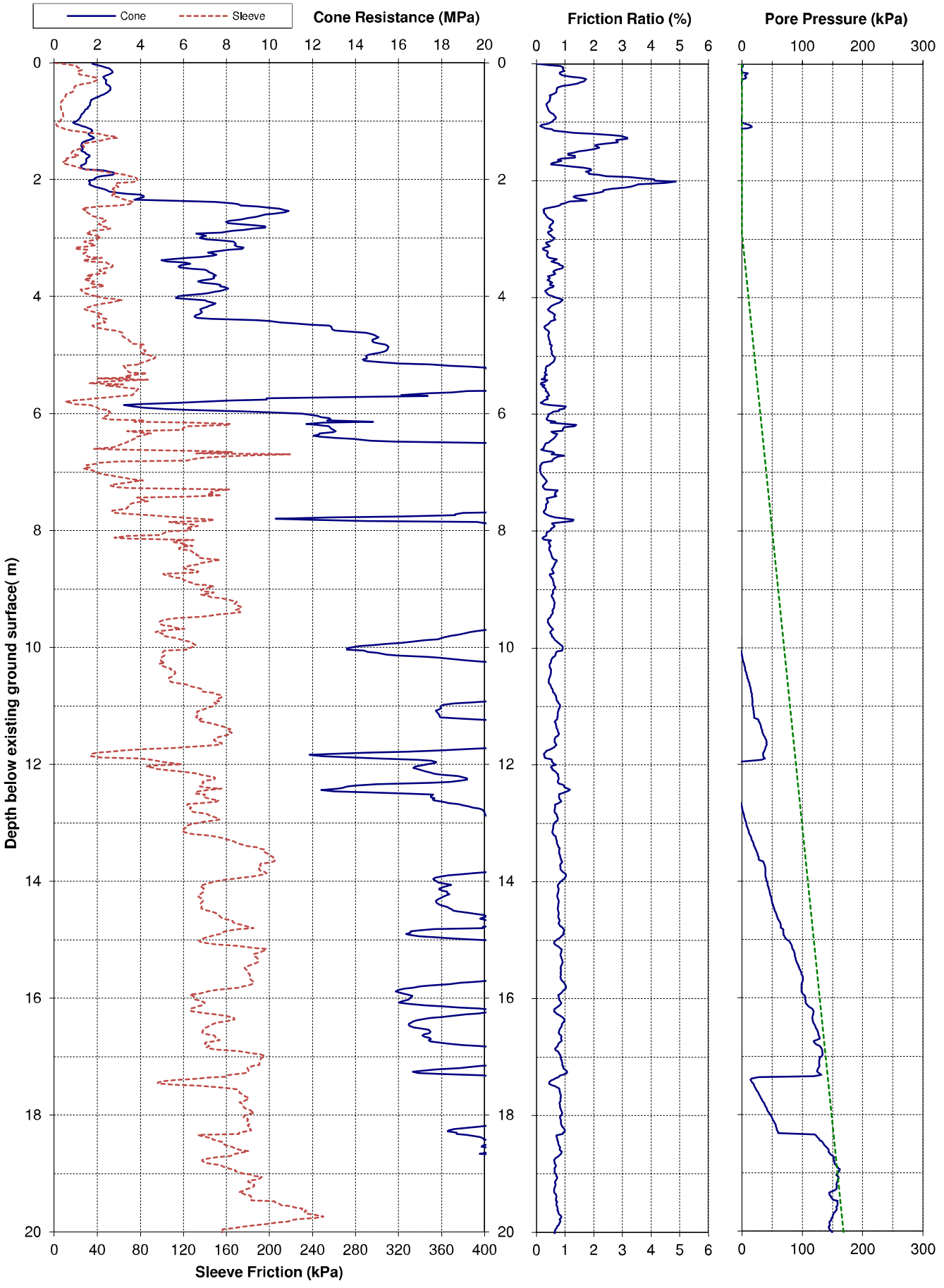
Job No:	11340	Date:	23-11-2012
CPT No:	CPT005	Operator:	S.Cardona
Project:	Aurecon NZ Ltd	Remark:	Effective Refusal
Location:	300 Stanmore Road, Christchurch (New World)		

McMILLAN DRILLING SERVICES

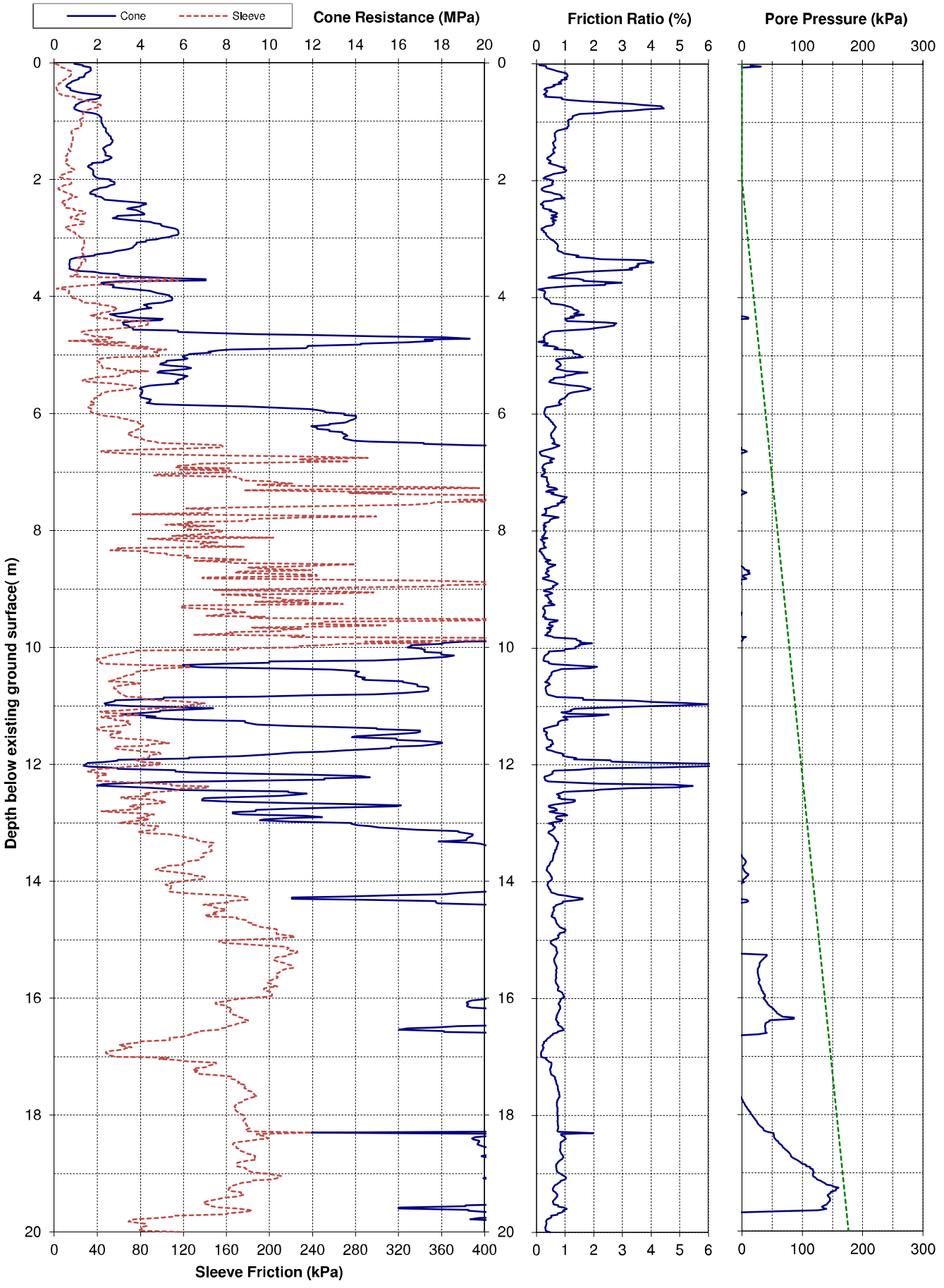
Project:	Christchurch TC3 Geotechnical Investigations				**Page:**	1 of 1	**RCH-POD02-CPT74**
Test Date:	25-Sep-2012	**Suburb:**	Richmond	**Operator:**	Geocivil		
Pre-Drill:	0m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS		
Position:	2482435.45mE	5743038.16mN	4.41mRL	**Coord. System:**	NZMG		
Address:	81 Vogel St			**Datum Reference:**	MSL (CCC 20/01/12 Datum -9.043)		



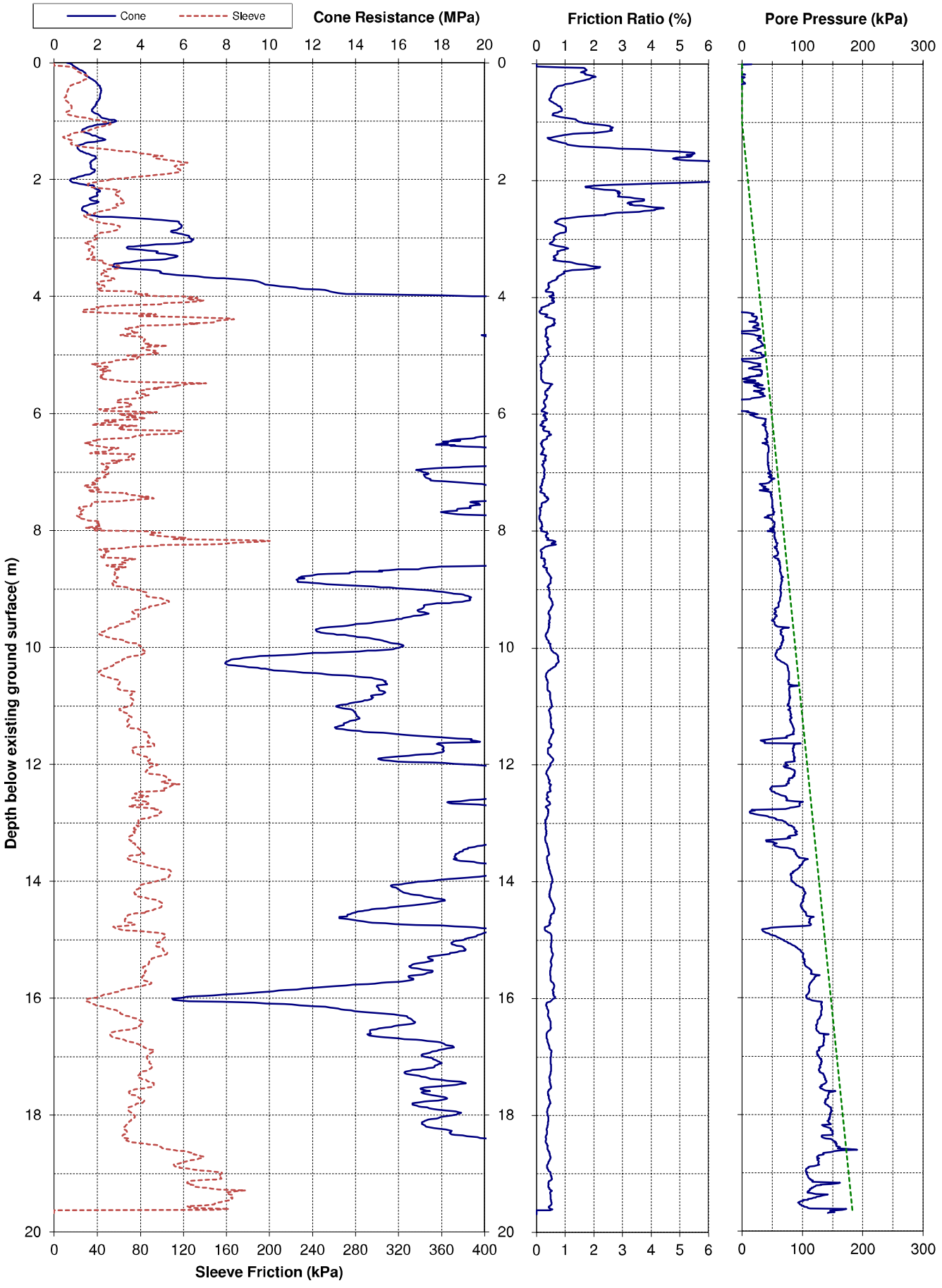
Project:	Christchurch TC3 Geotechnical Investigations				**Page:**	1 of 2	**RCH-POD02-CPT75**
Test Date:	23-Oct-2012	**Suburb:**	Richmond	**Operator:**	RDCL		
Pre-Drill:	0m	**Assumed GWL:**	2.9mBGL	**Located By:**	Survey GPS		
Position:	2482454.4mE	5743028.86mN	4.32mRL	**Coord. System:**	NZMG		
Address:	79 Vogel St			**Datum Reference:**	MSL (CCC 20/01/12 Datum -9.043)		



Project:	Christchurch TC3 Geotechnical Investigations			Page: 1 of 1	RCH-POD01-CPT93
Test Date:	24-Sep-2012	Suburb:	Richmond	Operator:	Geotechics
Pre-Drill:	0m	Assumed GWL:	2mBGL	Located By:	Survey GPS
Position:	2482343.63mE	5742794.26mN	3.72mRL	Coord. System:	NZMG
Address:	24 Vogel St			Datum Reference:	MSL (CCC 20/01/12 Datum -9.043)



Project:	Christchurch TC3 Geotechnical Investigations				**Page:**	1 of 1	**RCH-POD02-CPT56**
Test Date:	26-Sep-2012	**Suburb:**	Richmond	**Operator:**	Geocivil		
Pre-Drill:	0m	**Assumed GWL:**	1mBGL	**Located By:**	Survey GPS		
Position:	2482418.98mE	5743112.63mN	4.18mRL	**Coord. System:**	NZMG		
Address:	2 Tweed St			**Datum Reference:**	MSL (CCC 20/01/12 Datum -9.043)		

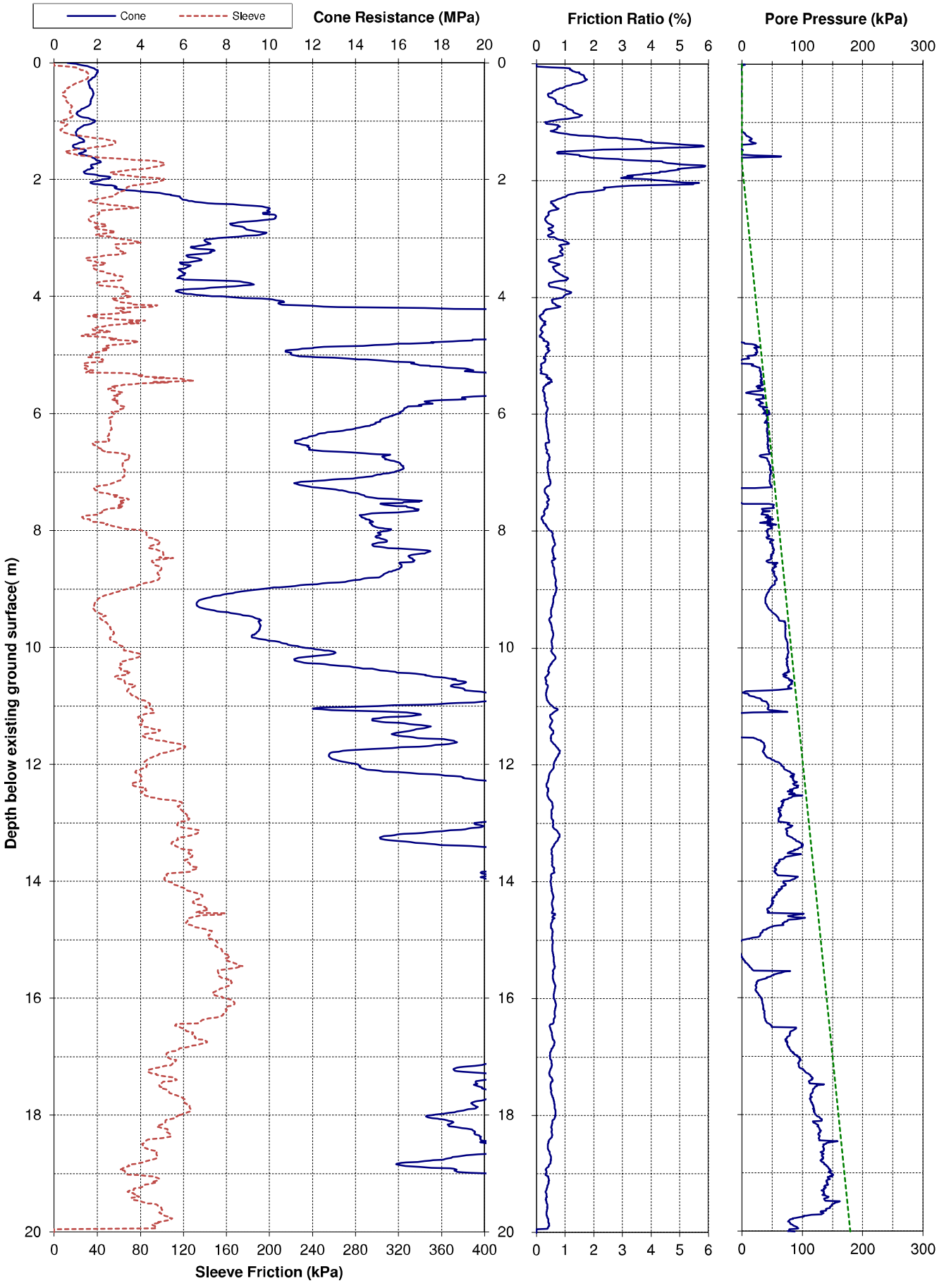


T+T Ref: 52003.2000

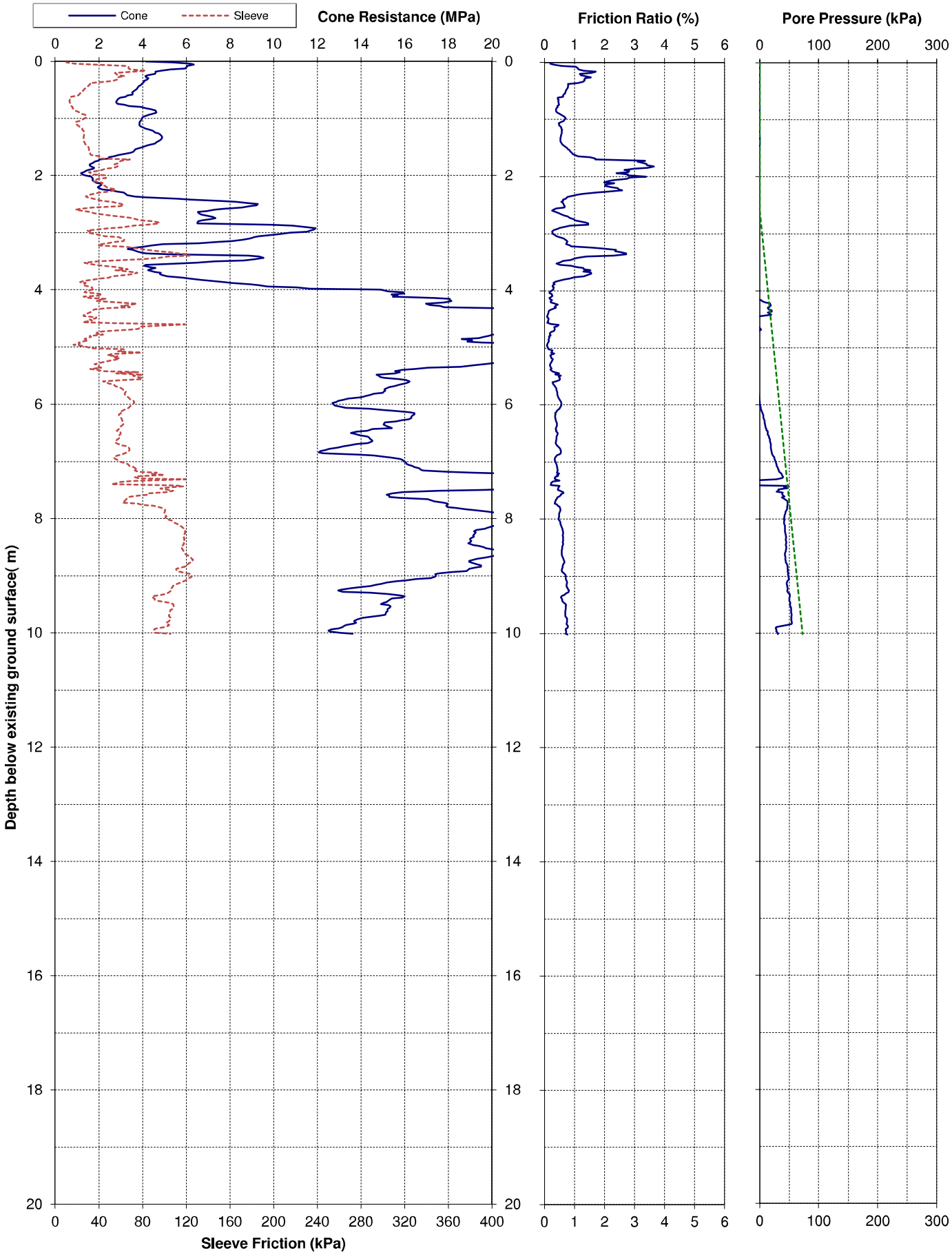
Printed: 15/01/2013 8:43 a.m.

Template: CPT Graph Template TC3 (2).xls

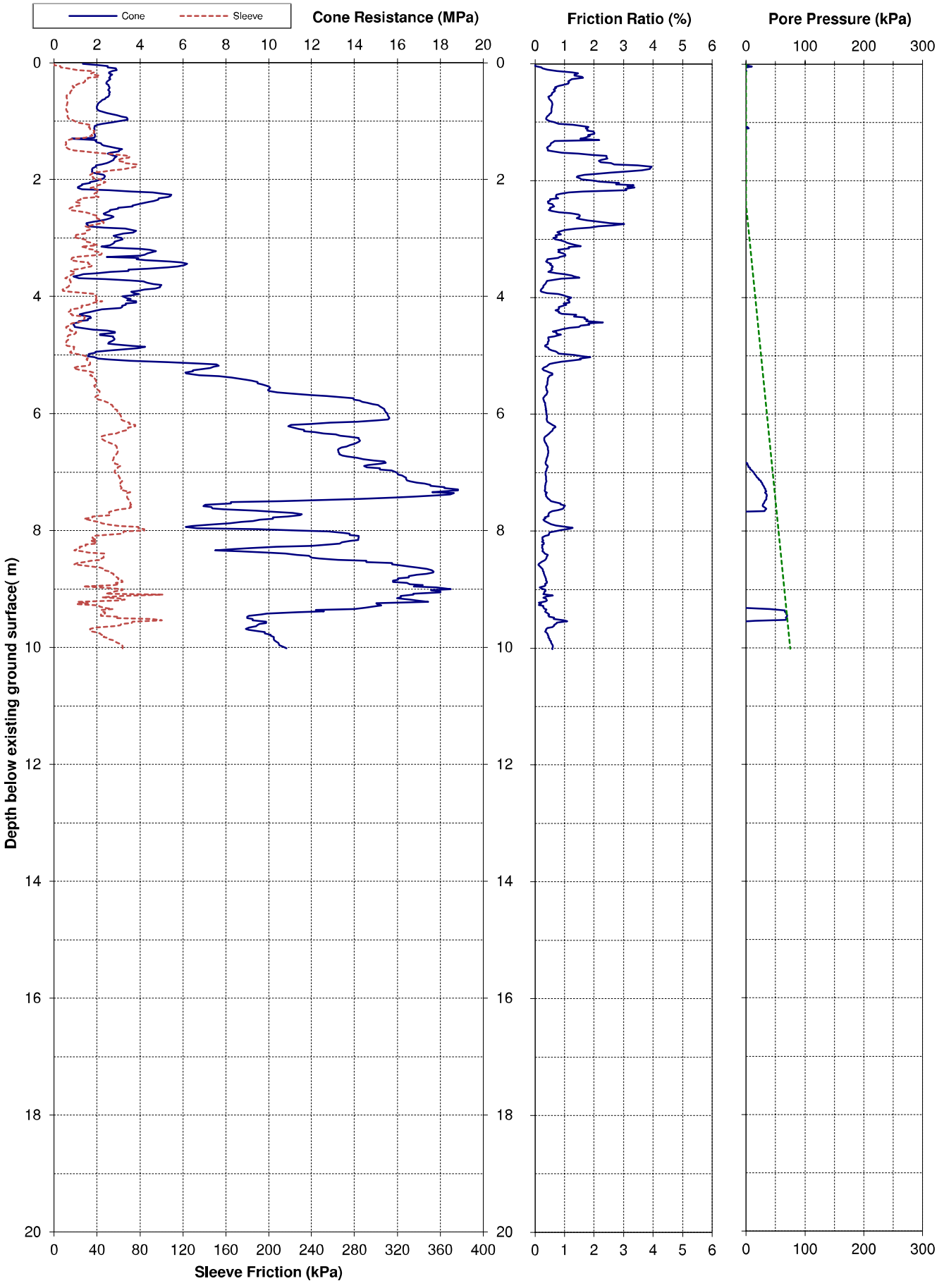
Project:	Christchurch TC3 Geotechnical Investigations				**Page:**	1 of 2	**RCH-POD02-CPT80**
Test Date:	23-Oct-2012	**Suburb:**	Richmond	**Operator:**	Geocivil		
Pre-Drill:	0m	**Assumed GWL:**	1.7mBGL	**Located By:**	Survey GPS		
Position:	2482474.93mE	5743062.58mN	4.06mRL	**Coord. System:**	NZMG		
Address:	94 Vogel St			**Datum Reference:**	MSL (CCC 20/01/12 Datum -9.043)		



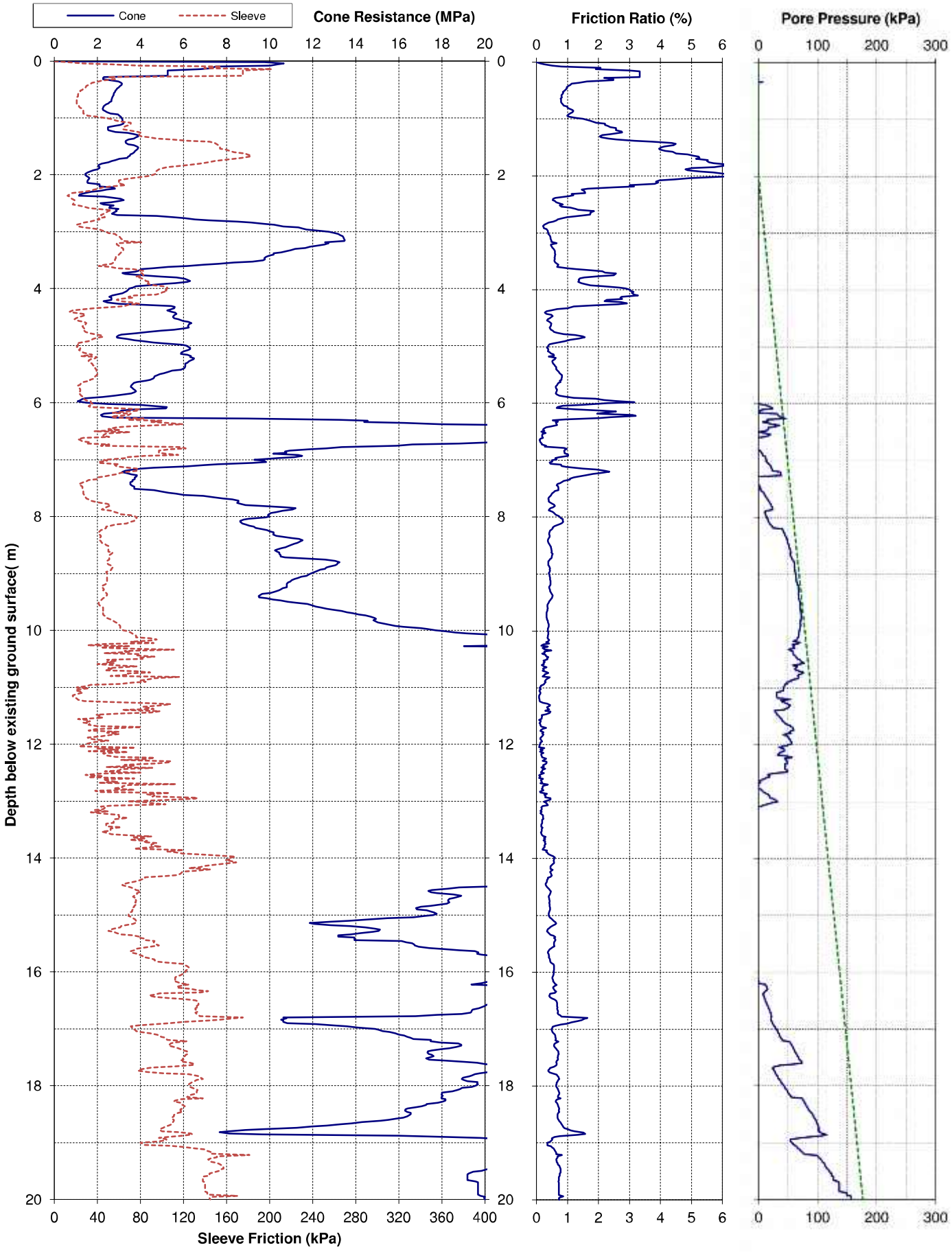
Project:	Christchurch TC3 Geotechnical Investigations			Page: 1 of 1	RCH-POD02-CPT98
Test Date:	29-Jan-2013	Suburb:	Richmond	Operator:	RDCL
Pre-Drill:	0m	Assumed GWL:	2.6mBGL	Located By:	Survey GPS
Position:	2482514.69mE	5743014.02mN	4.15mRL	Coord. System:	NZMG
Address:	5/80 Vogel St			Datum Reference:	MSL (CCC 20/01/12 Datum -9.043)



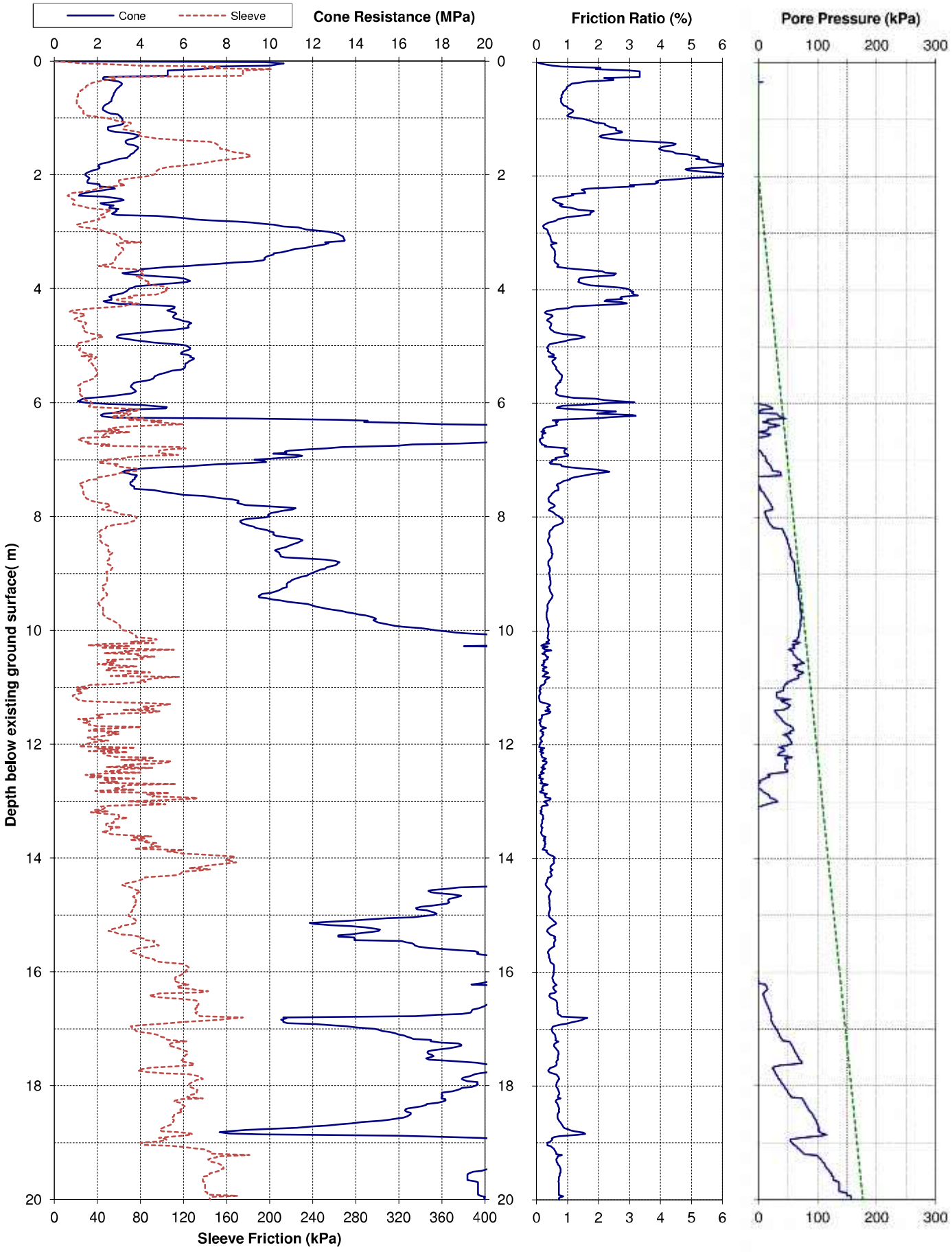
Project:	Christchurch TC3 Geotechnical Investigations			Page: 1 of 1	RCH-POD02-CPT90
Test Date:	4-Dec-2012	Suburb:	Richmond	Operator:	Geotechnics
Pre-Drill:	0m	Assumed GWL:	2.4mBGL	Located By:	Survey GPS
Position:	2482346.6mE	5743094.29mN	4.35mRL	Coord. System:	NZMG
Address:	Road verge, 21 Forth St			Datum Reference:	MSL (CCC 20/01/12 Datum -9.043)



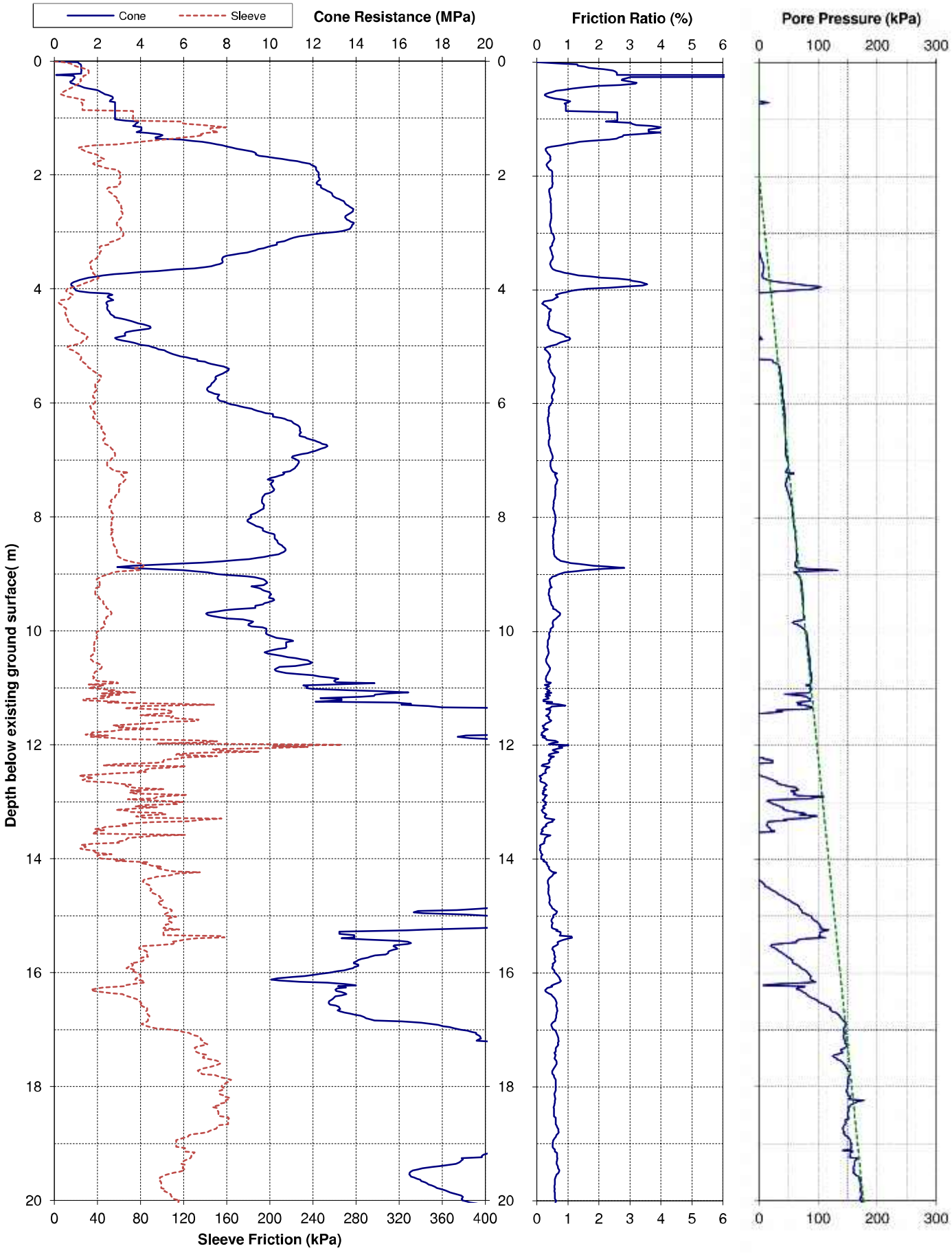
Project:	Christchurch TC3 Geotechnical Investigations				**Page:** 1 of 1	**RCH-POD02-CPT66**
Test Date:	12-Jul-2012	**Suburb:**	Richmond	**Operator:**	Geotech	
Pre-Drill:	0m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS	
Position:	2482314.76mE	5743050.09mN	4.85mRL	**Coord. System:**	NZMG	
Address:	3/14 Forth St			**Datum Reference:**	MSL (CCC 20/01/12 Datum -9.043)	



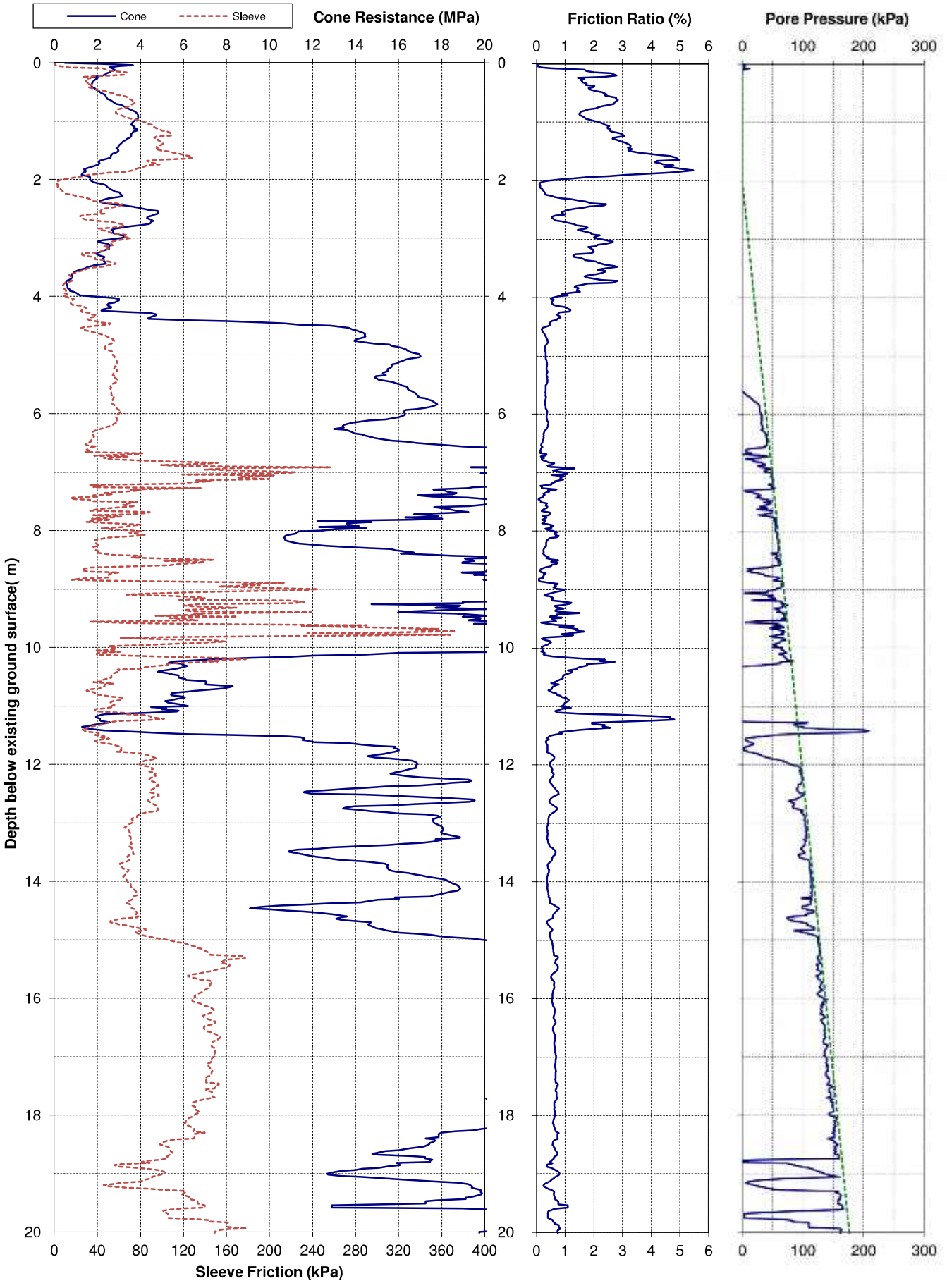
Project:	Christchurch TC3 Geotechnical Investigations				**Page:** 1 of 1	**RCH-POD02-CPT66**
Test Date:	12-Jul-2012	**Suburb:**	Richmond	**Operator:**	Geotech	
Pre-Drill:	0m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS	
Position:	2482314.76mE	5743050.09mN	4.85mRL	**Coord. System:**	NZMG	
Address:	3/14 Forth St			**Datum Reference:**	MSL (CCC 20/01/12 Datum -9.043)	



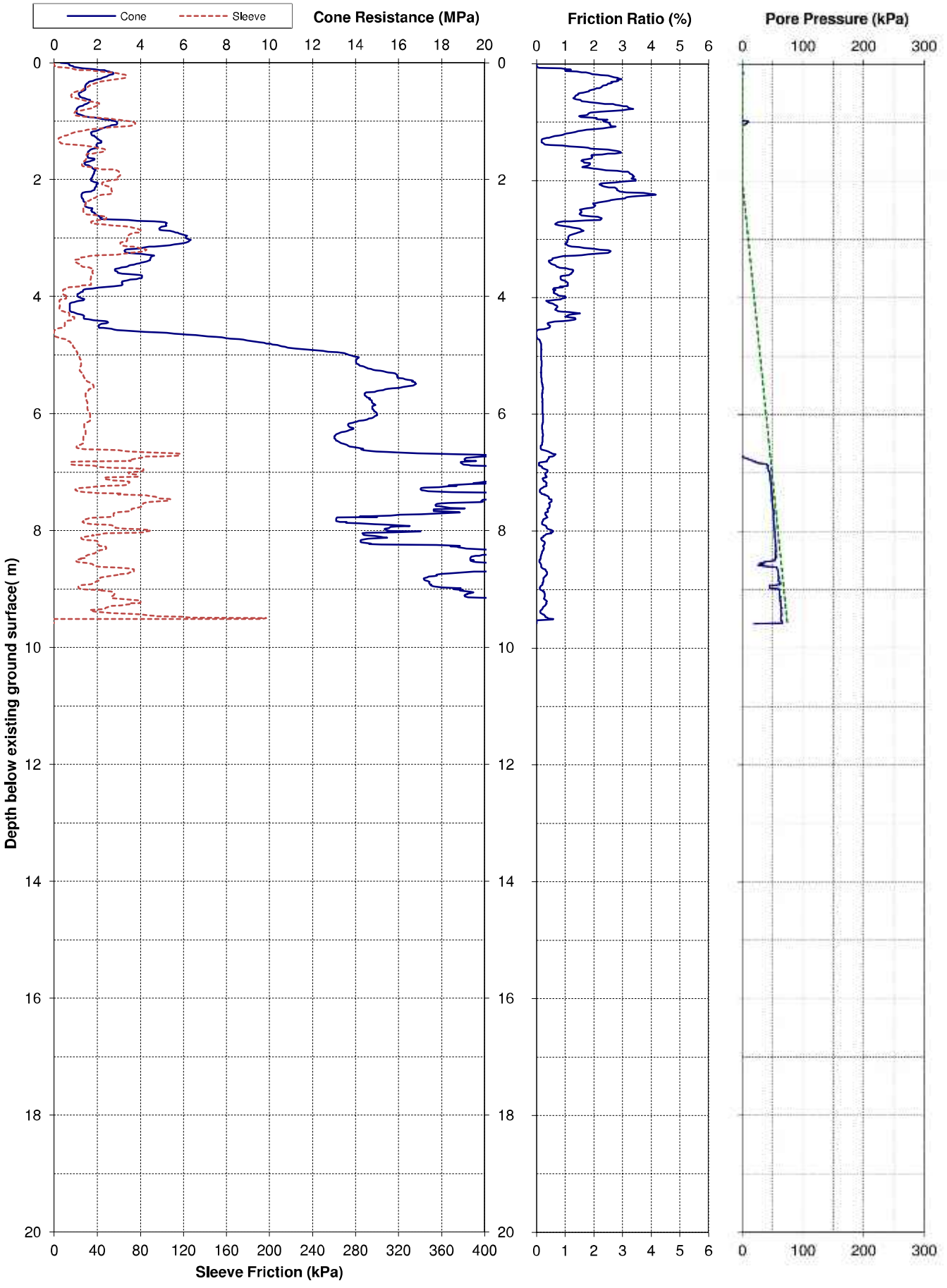
Project:	Christchurch TC3 Geotechnical Investigations			Page: 1 of 2	RCH-POD02-CPT37
Test Date:	12-Jul-2012	Suburb:	Richmond	Operator:	Geotech
Pre-Drill:	0m	Assumed GWL:	2mBGL	Located By:	Survey GPS
Position:	2482290.28mE	5743092.98mN	4.52mRL	Coord. System:	NZMG
Address:	11 Forth St			Datum Reference:	MSL (CCC 20/01/12 Datum -9.043)



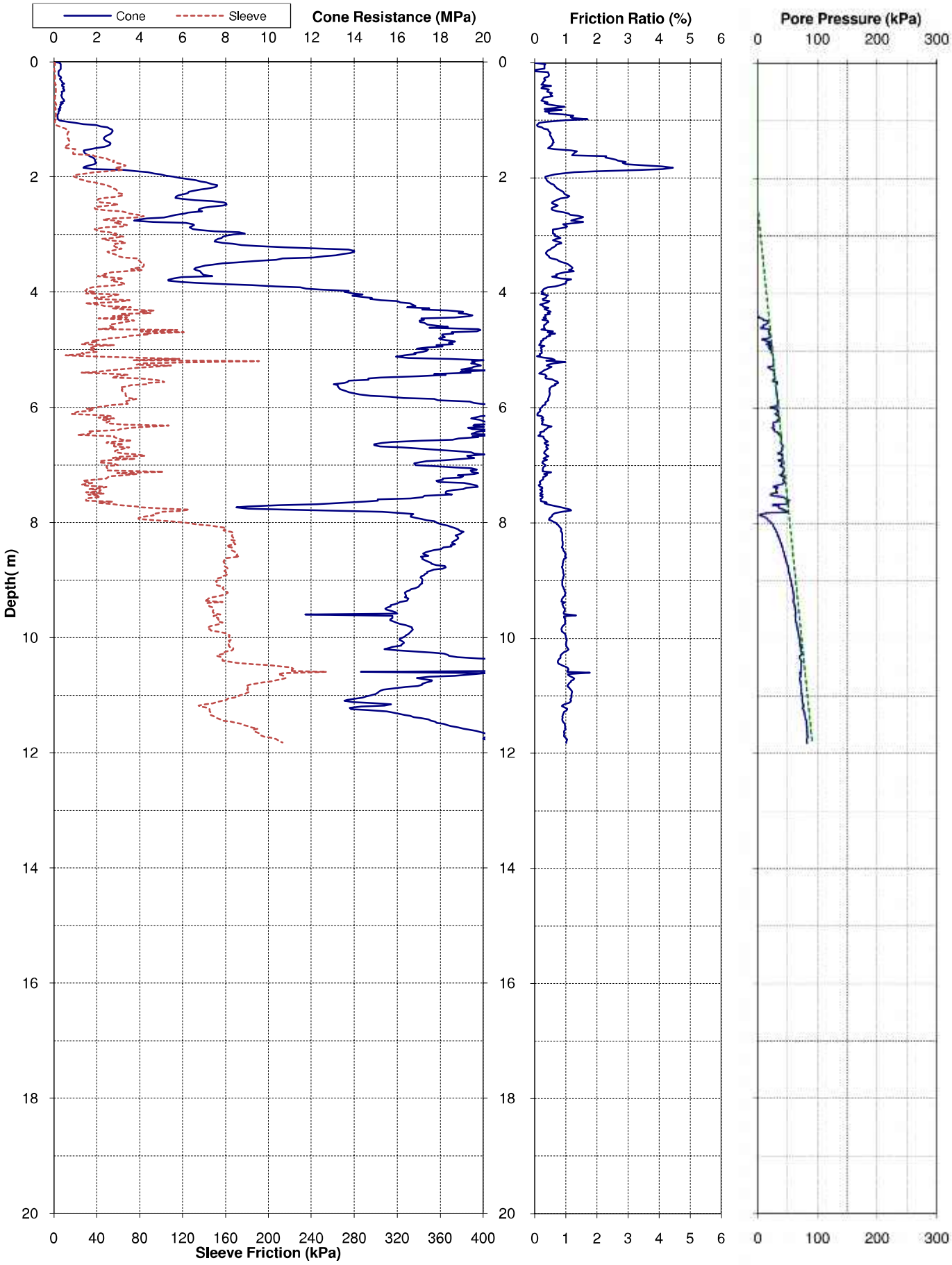
Project:	Christchurch TC3 Geotechnical Investigations			Page: 1 of 2	RCH-POD01-CPT04
Test Date:	18-Jul-2012	Suburb:	Richmond	Operator:	Geotech
Pre-Drill:	0m	Assumed GWL:	2mBGL	Located By:	Survey GPS
Position:	2482389.22mE	5742867.91mN	3.84mRL	Coord. System:	NZMG
Address:	40 Warwick St			Datum Reference:	MSL (CCC 20/01/12 Datum -9.043)



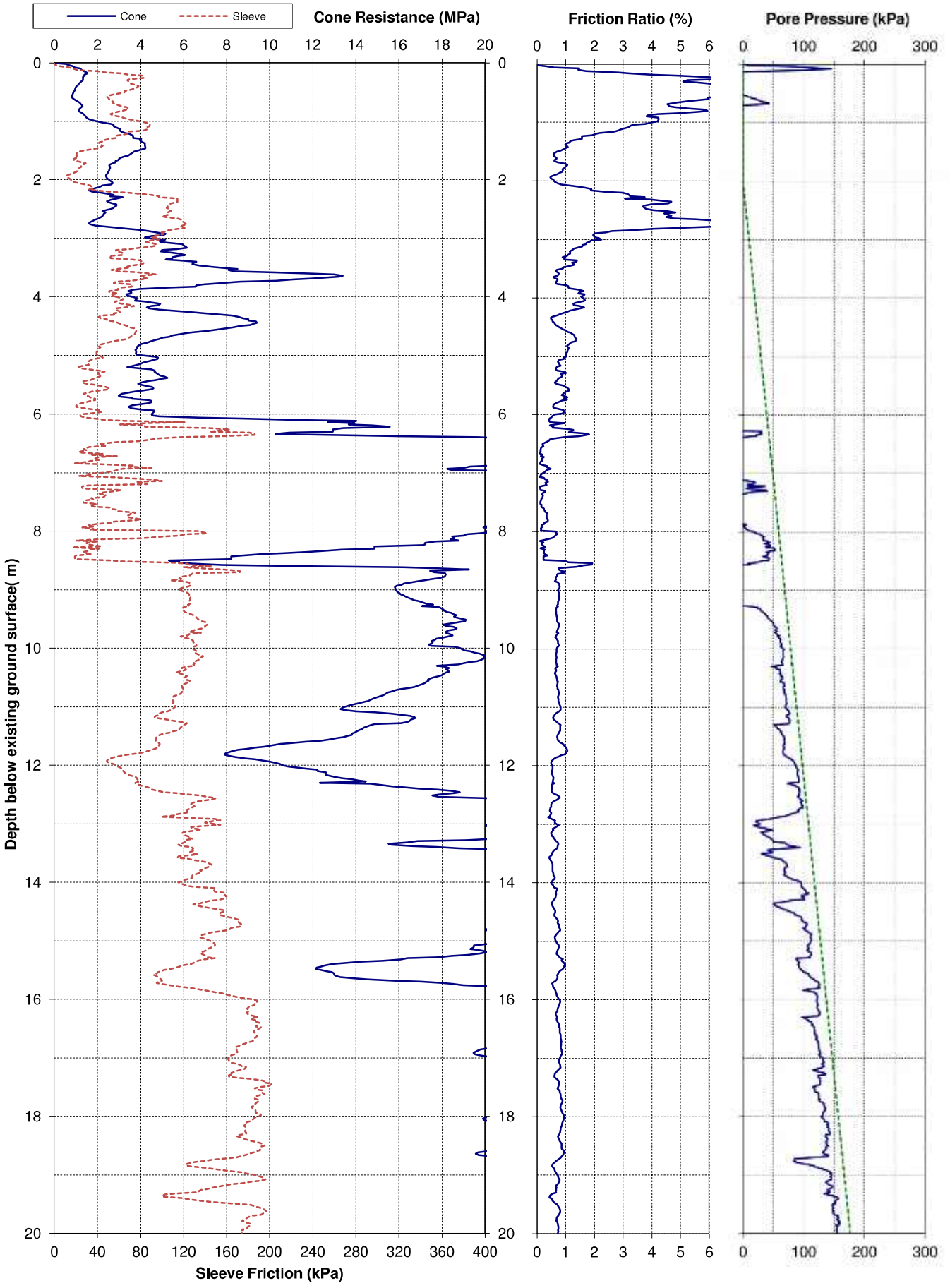
Project:	Christchurch TC3 Geotechnical Investigations				**Page:**	1 of 1	**RCH-POD01-CPT127**
Test Date:	1-Aug-2012	**Suburb:**	Richmond	**Operator:**	NSMTL		
Pre-Drill:	0m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS		
Position:	2482387.56mE	5742877.48mN	3.88mRL	**Coord. System:**	NZMG		
Address:	32 Warwick St			**Datum Reference:**	MSL (CCC 20/01/12 Datum -9.043)		



Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page: 1 of 1		CPT-RCH-37
Test Date:	30-May-2011	Location:	Richmond	Operator:	Geotech	
Pre-Drill:	1.2m	Assumed GWL:	2.5mBGL	Located By:	Survey GPS	
Position:	2482472.1mE	5742941.2mN	3.87mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		

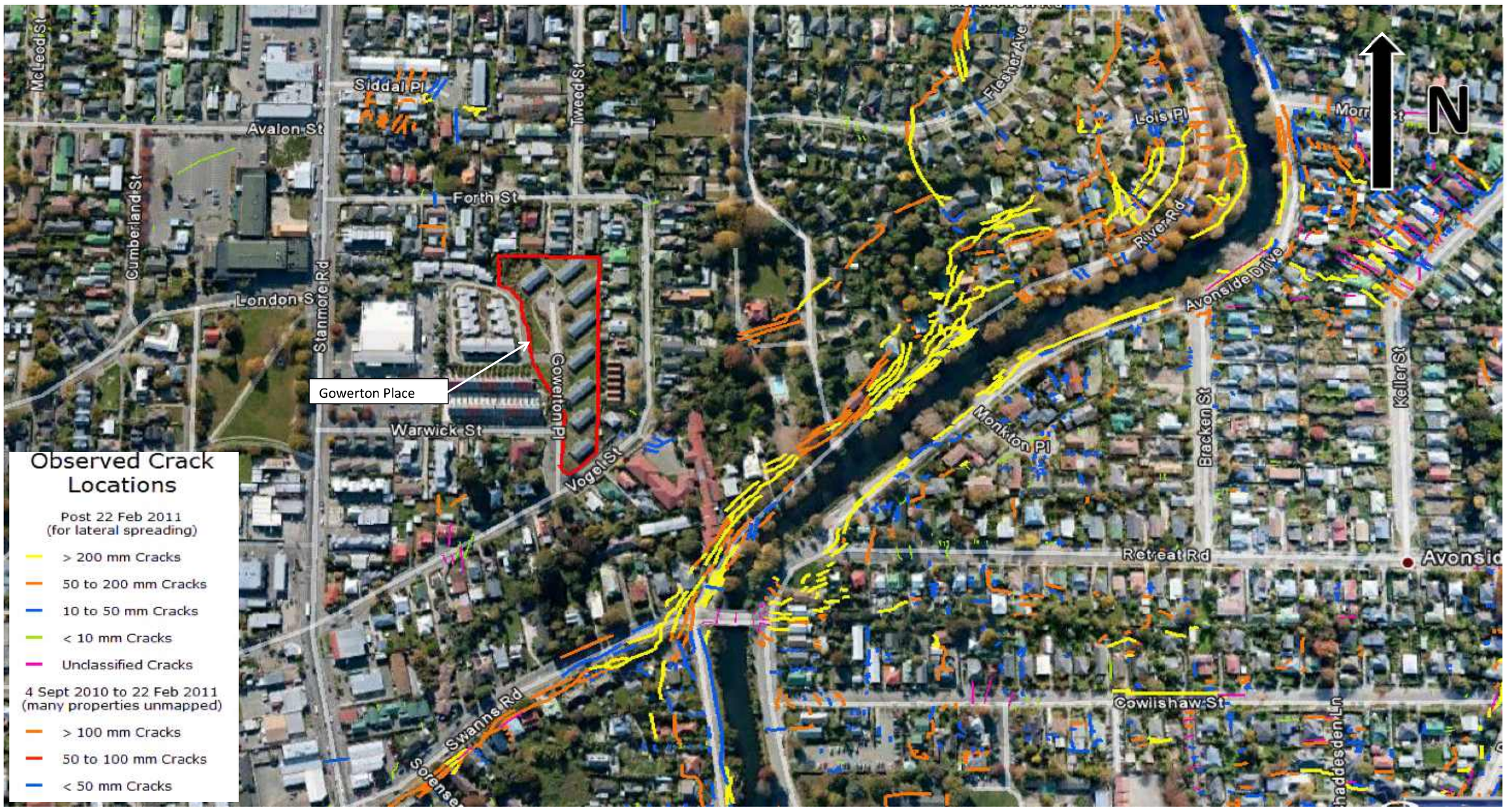


Project:	Christchurch TC3 Geotechnical Investigations			Page: 1 of 1	RCH-POD02-CPT77
Test Date:	24-Sep-2012	Suburb:	Richmond	Operator:	Geotech
Pre-Drill:	0m	Assumed GWL:	2mBGL	Located By:	Survey GPS
Position:	2482450.65mE	5742976.59mN	4.36mRL	Coord. System:	NZMG
Address:	65 Vogel St			Datum Reference:	MSL (CCC 20/01/12 Datum -9.043)



Appendix E

EQC Map Output



0 200m

Approximate Scale: 1 to 3000 at A3.

SOURCE:canterburyrecovery.projectorbit.com (Accessed on 2/7/2013)

OPUS

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20 Moorhouse Ave
PO Box 1482
Christchurch, New Zealand
Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Gowerton Place, Richmond
Project No.: 6-QC347.00
Client: Christchurch City Council

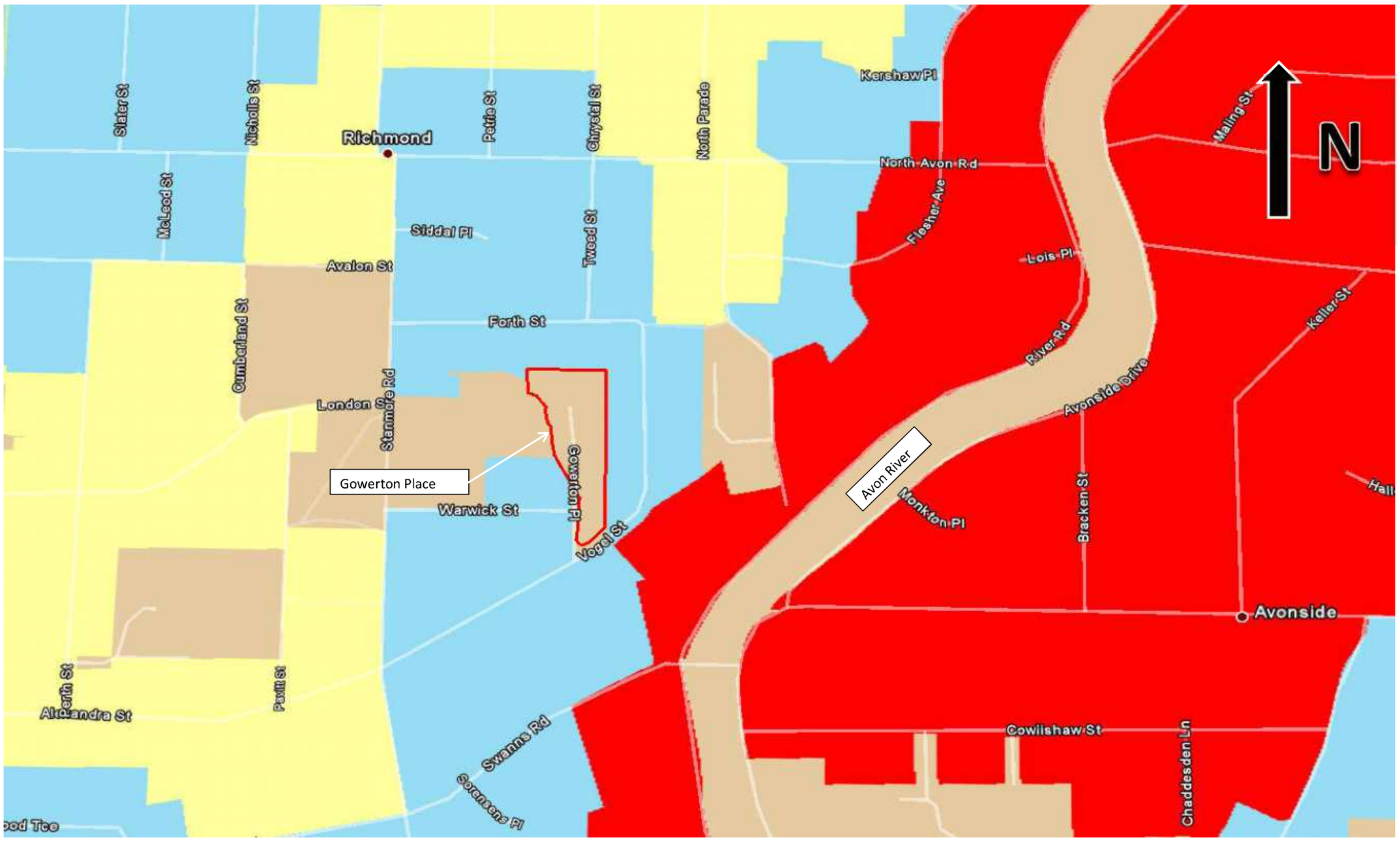
EQC Observed Ground Cracking

Drawn: Opus Geotechnical Engineer

Date: 2-Jul-13

Appendix F

Land Recovery Zone Map



Approximate Scale: 1 to 3600 at A3.

SOURCE:canterburyrecovery.projectorbit.com (Accessed on 2/7/2013)

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Project: Gowerton Place, Richmond
Project No.: 6-QC347.00
Client: Christchurch City Council

Land Recovery Zones

Drawn: Opus Geotechnical Engineer

Date: 2-Jul-13

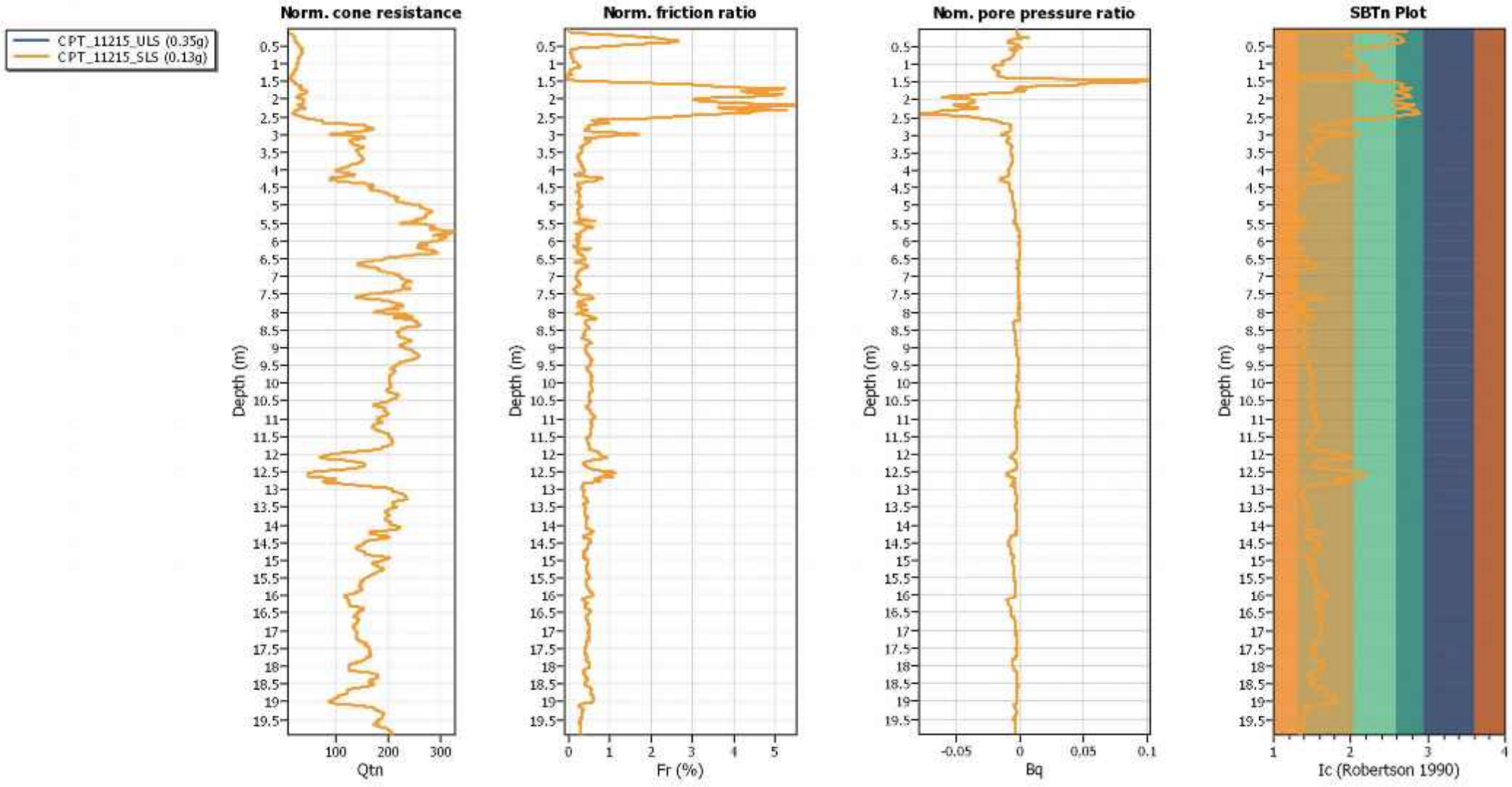
Appendix G

CLiq Liquefaction Analysis

Opus International Consultants
20 Moorhouse Avenue
Christchurch

Project:

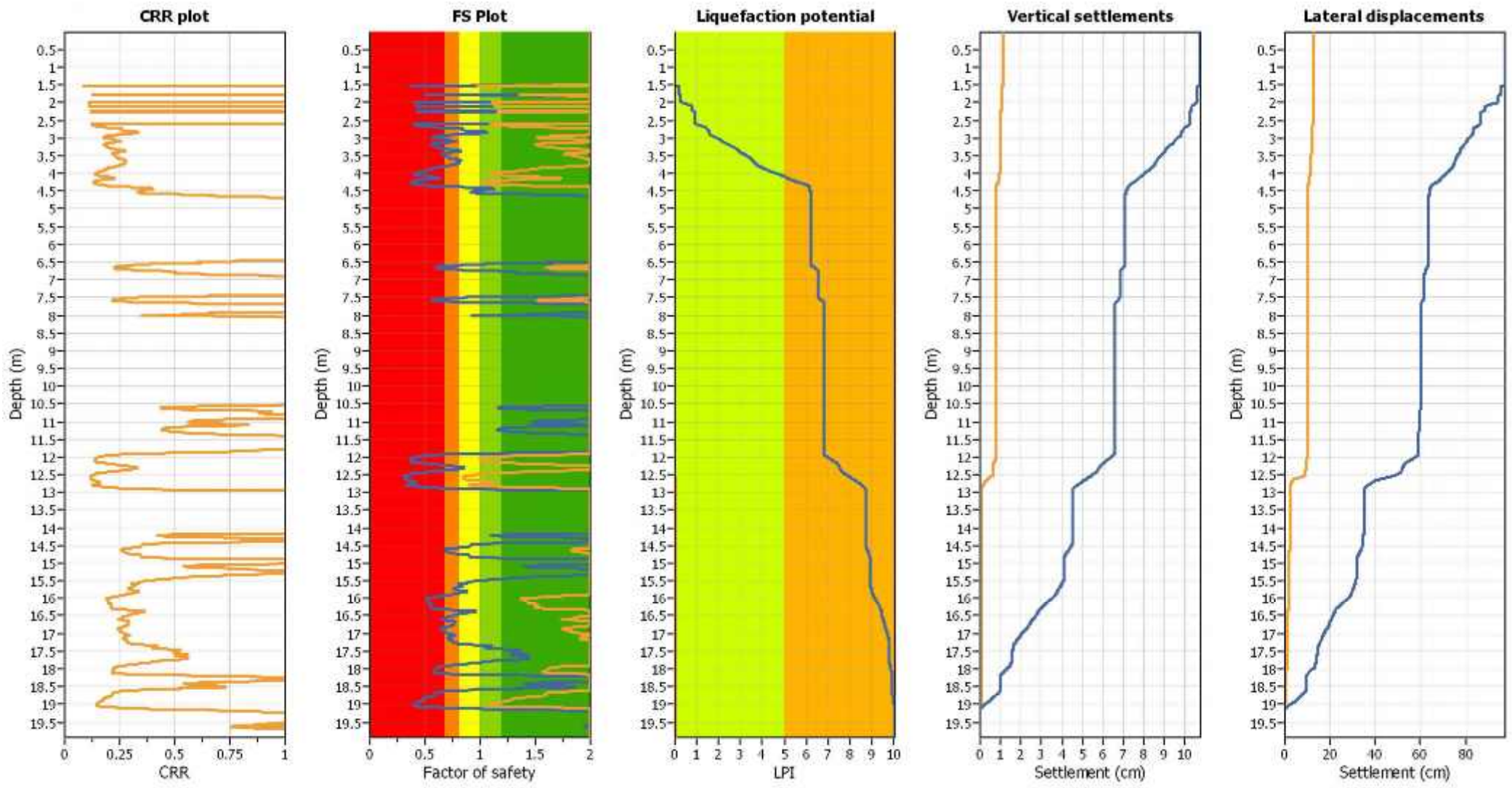
Overlay Normalized Plots



Opus International Consultants
20 Moorhouse Avenue
Christchurch

Project:

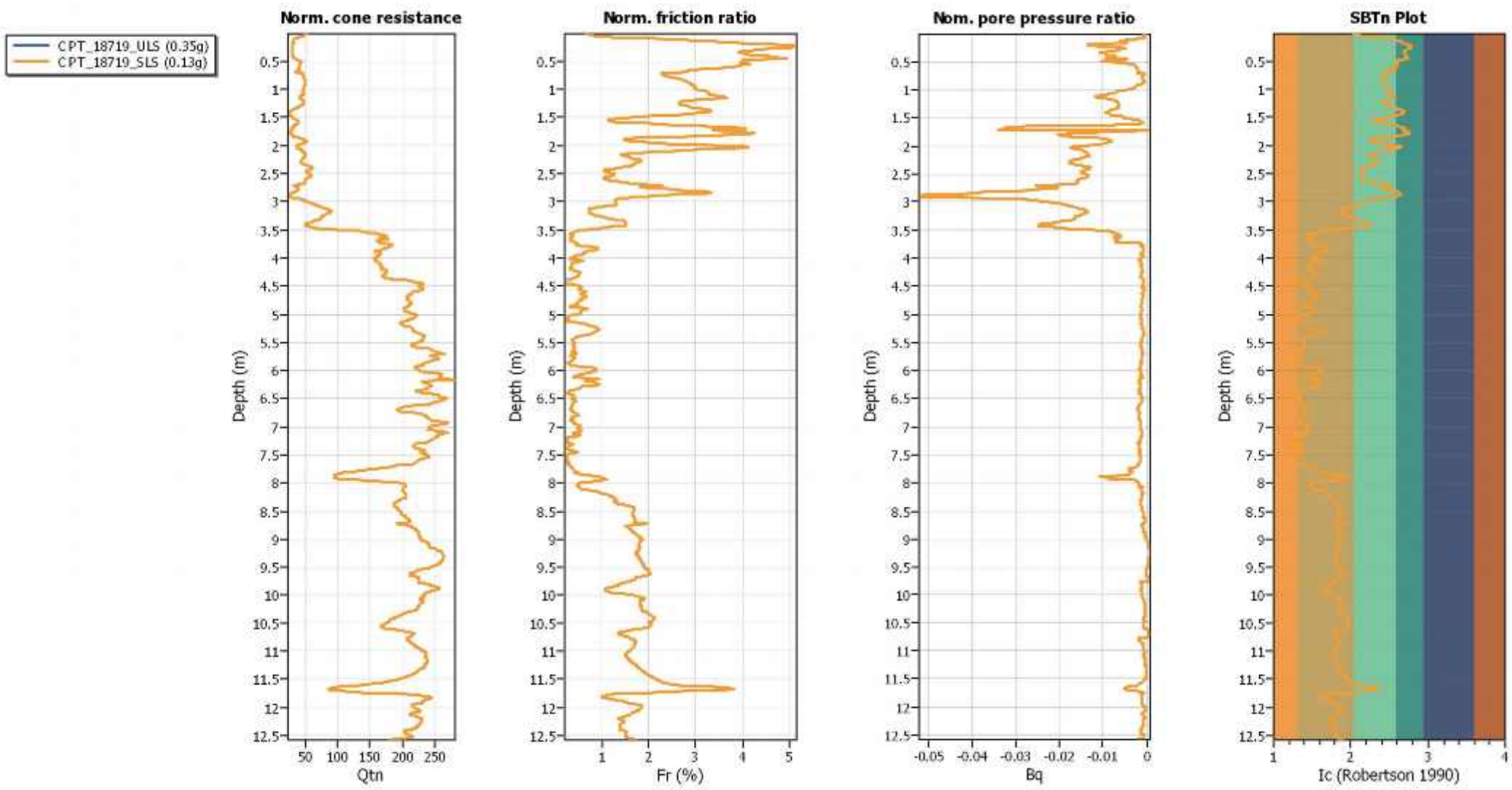
Overlay Cyclic Liquefaction Plots



Opus International Consultants
20 Moorhouse Avenue
Christchurch

Project:

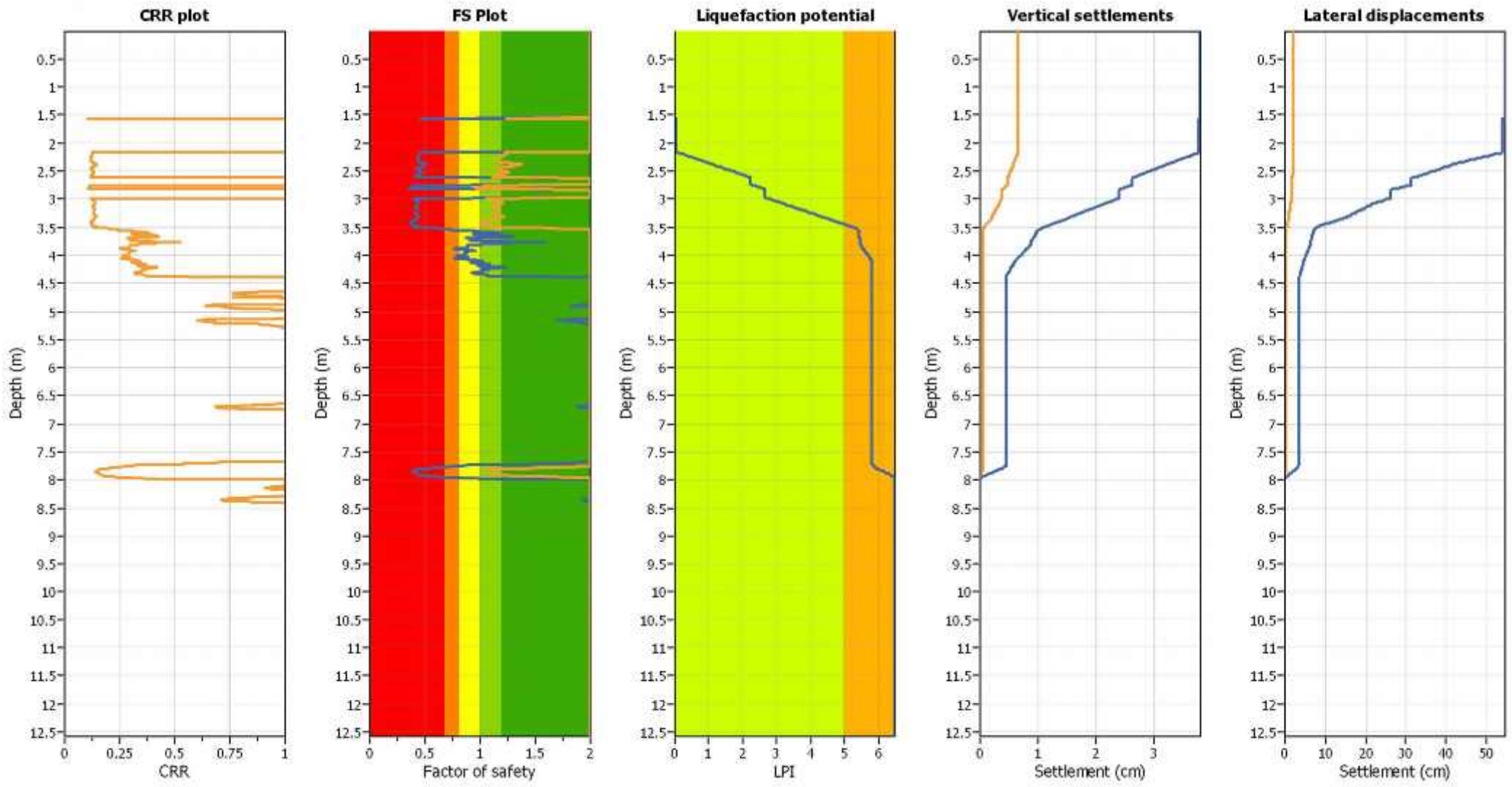
Overlay Normalized Plots



Opus International Consultants
20 Moorhouse Avenue
Christchurch

Project:

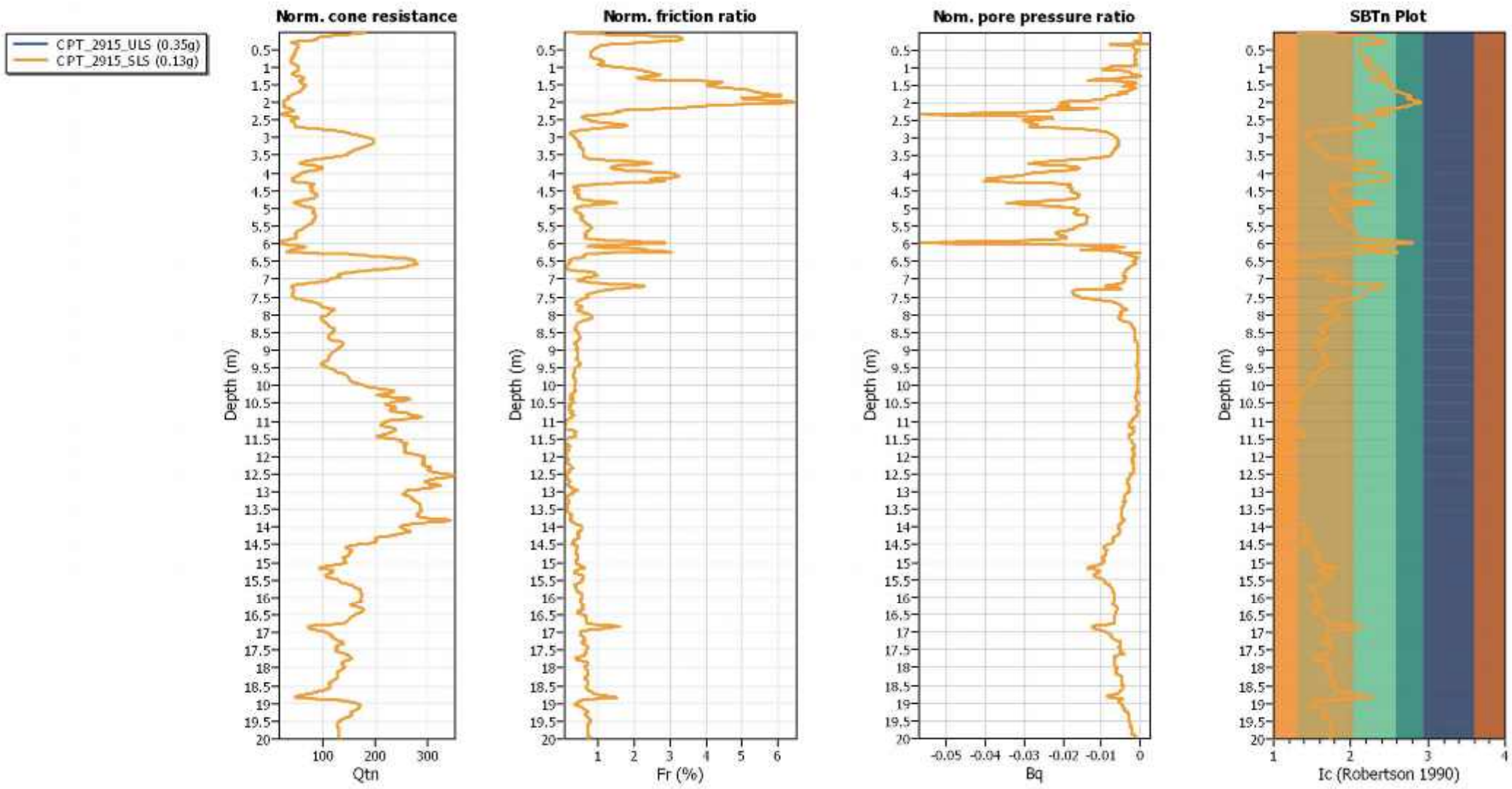
Overlay Cyclic Liquefaction Plots



Opus International Consultants
20 Moorhouse Avenue
Christchurch

Project:

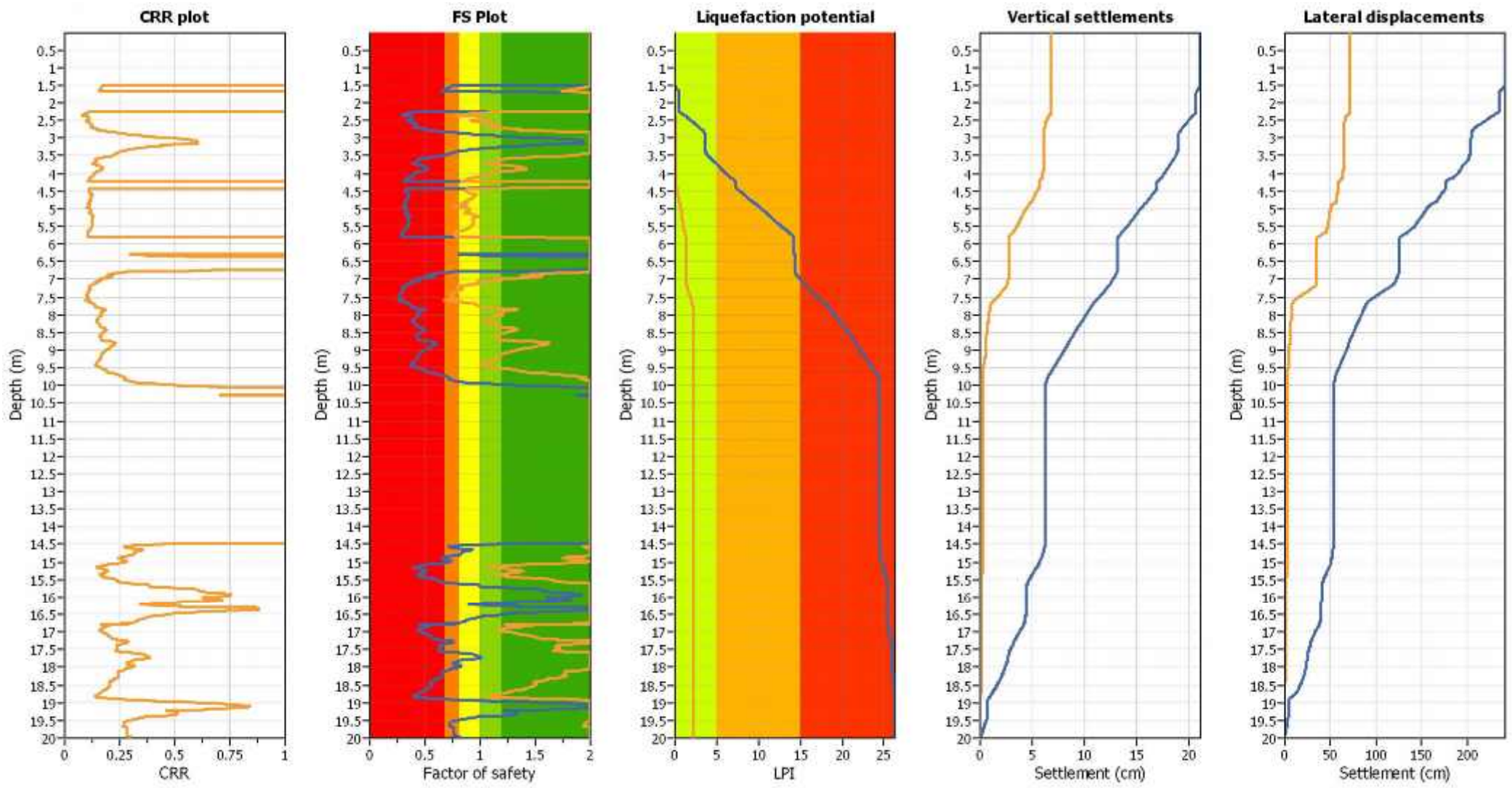
Overlay Normalized Plots



Opus International Consultants
20 Moorhouse Avenue
Christchurch

Project:

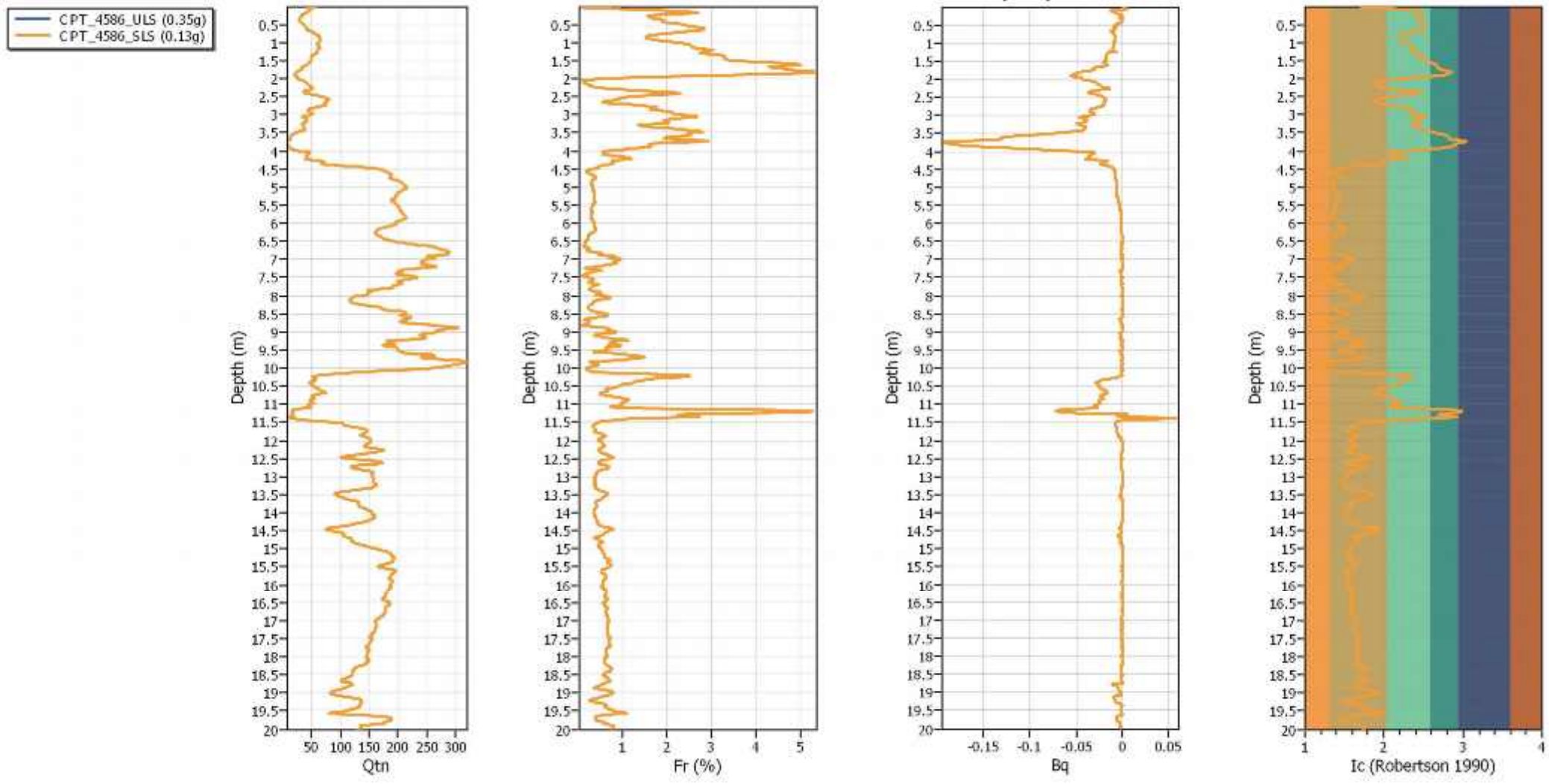
Overlay Cyclic Liquefaction Plots



Opus International Consultants
20 Moorhouse Avenue
Christchurch

Project:

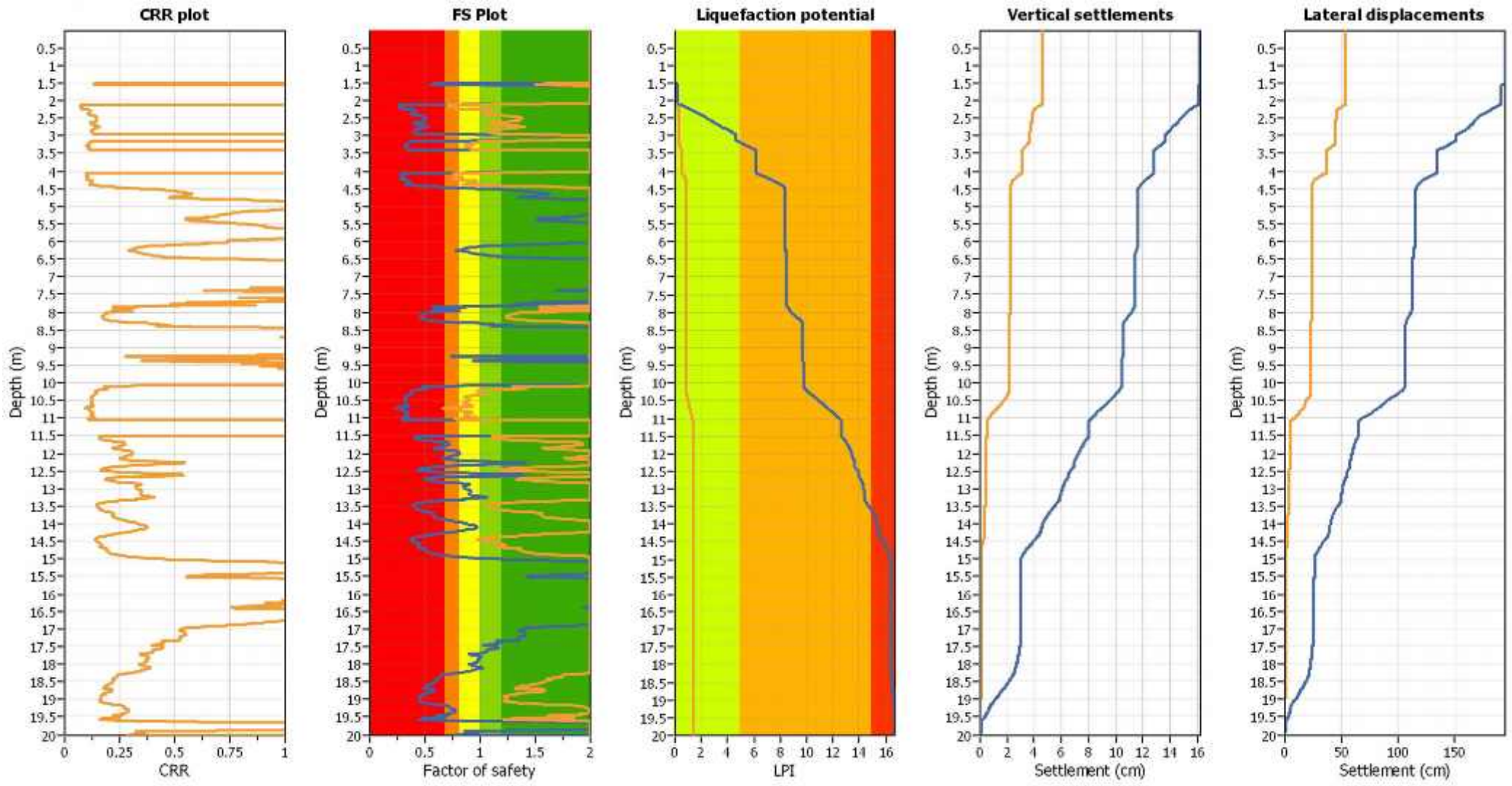
Overlay Normalized Plots



Opus International Consultants
20 Moorhouse Avenue
Christchurch

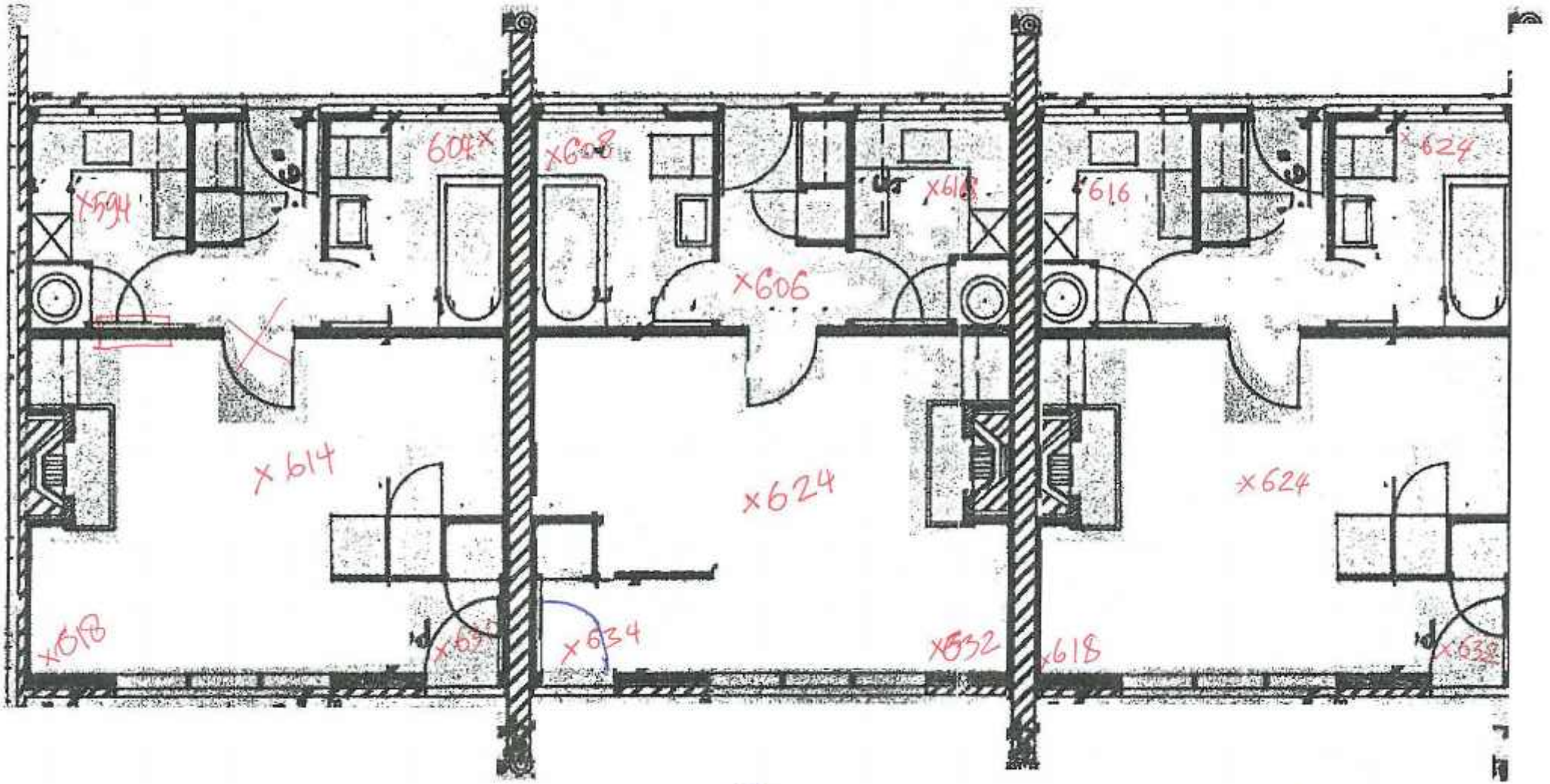
Project:

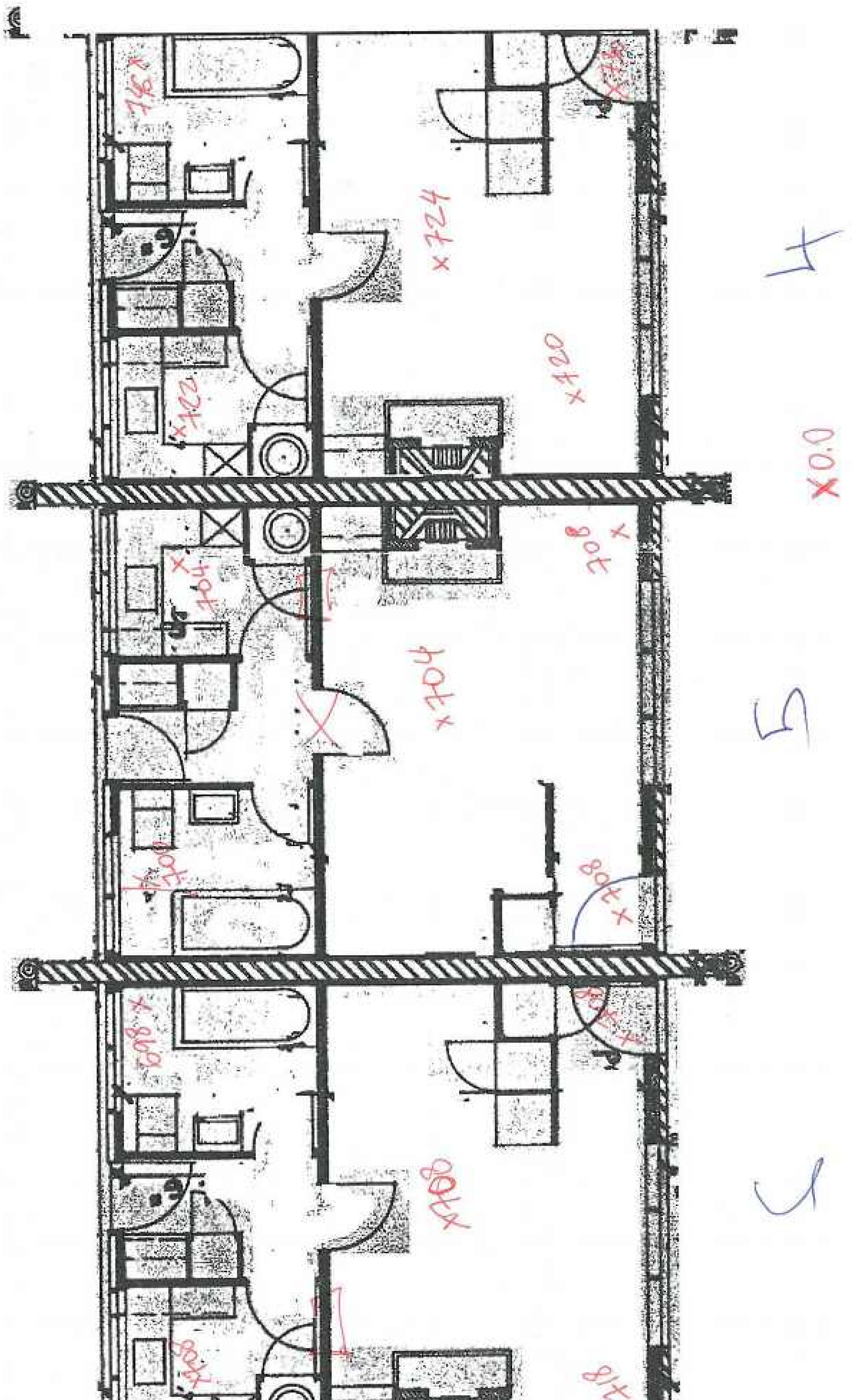
Overlay Cyclic Liquefaction Plots



Appendix H

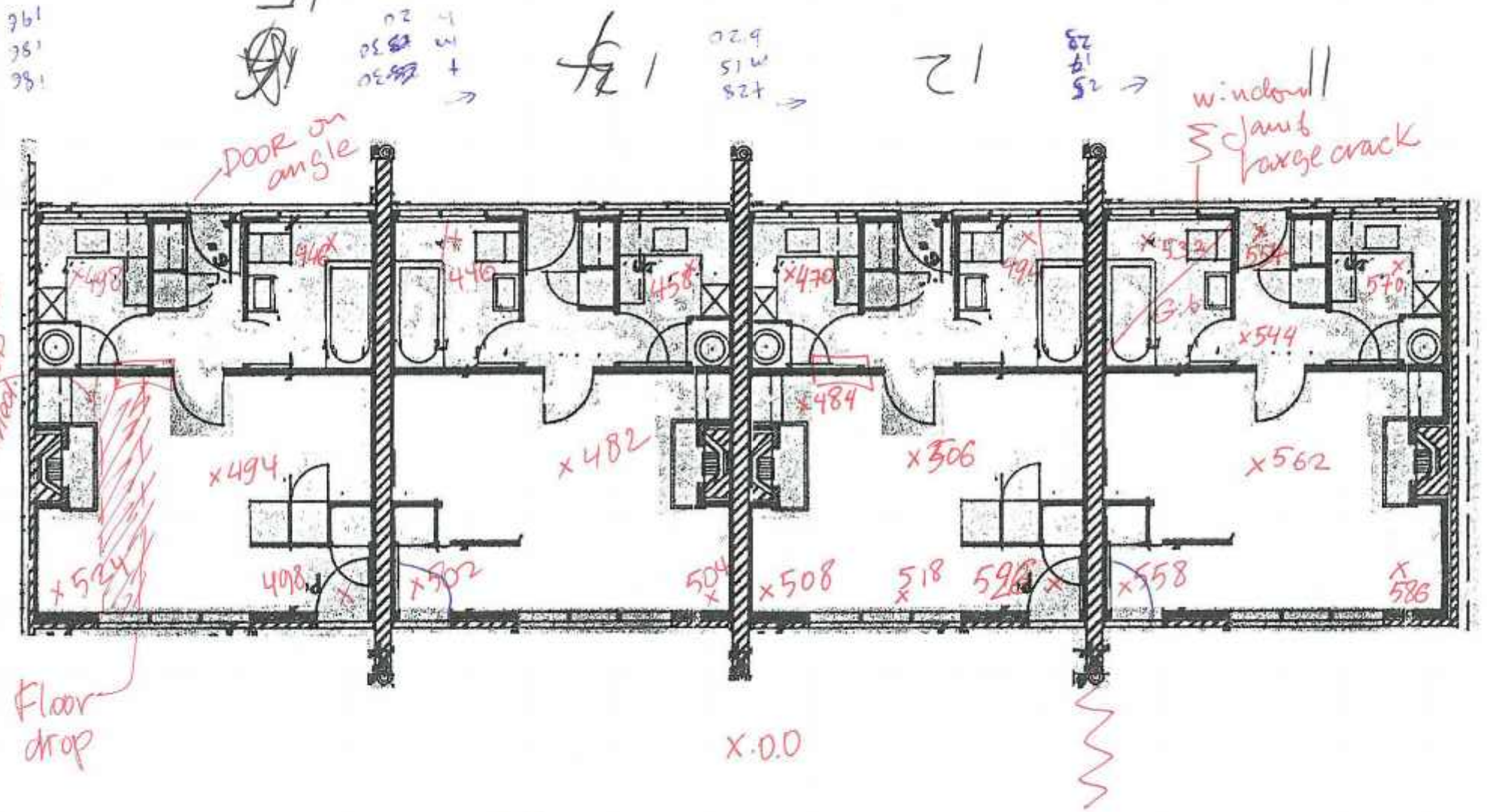
Level Survey

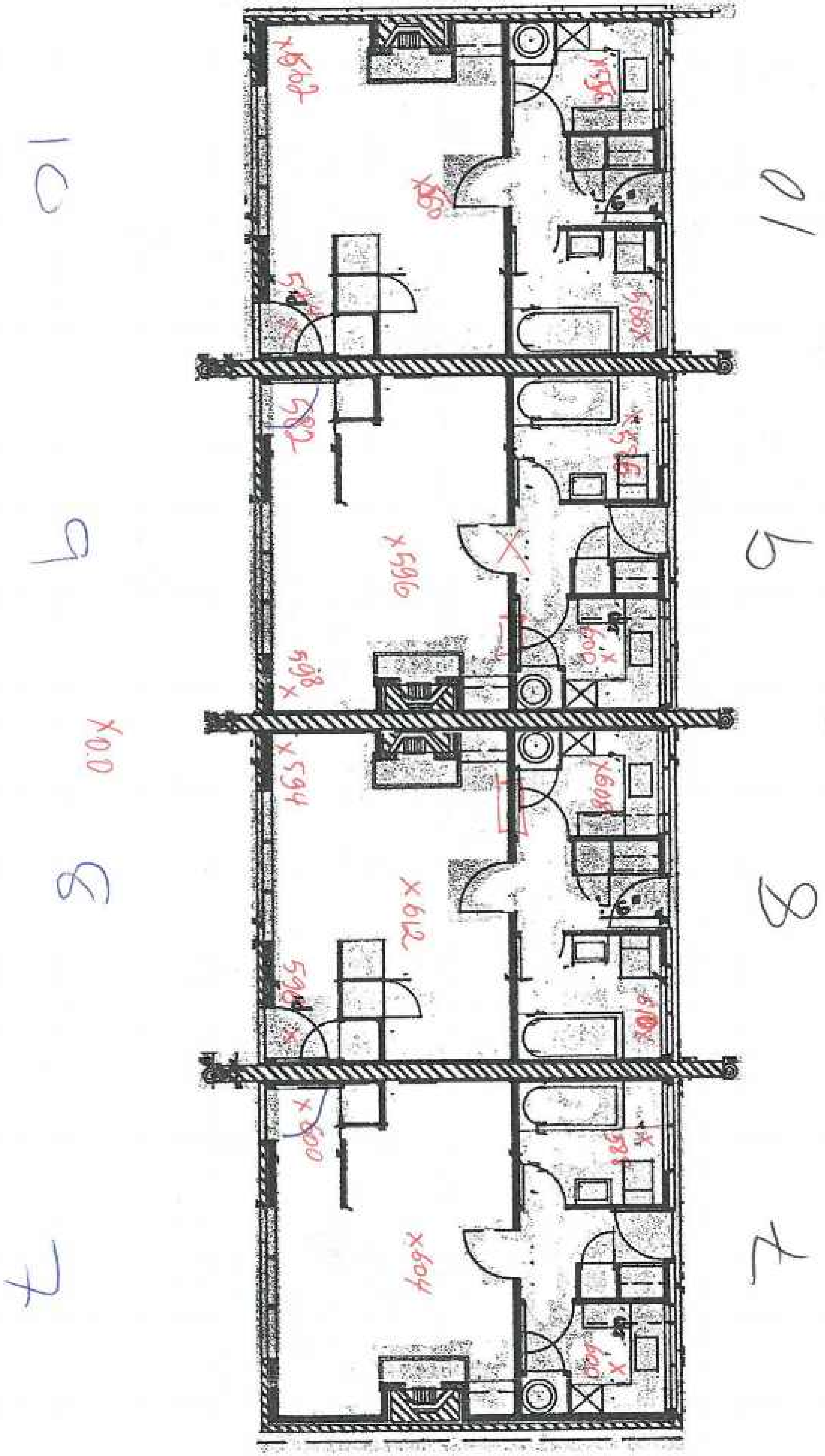

604
608
616
624
606
614
624
624
618
632
618
632
3
2
1
0.0



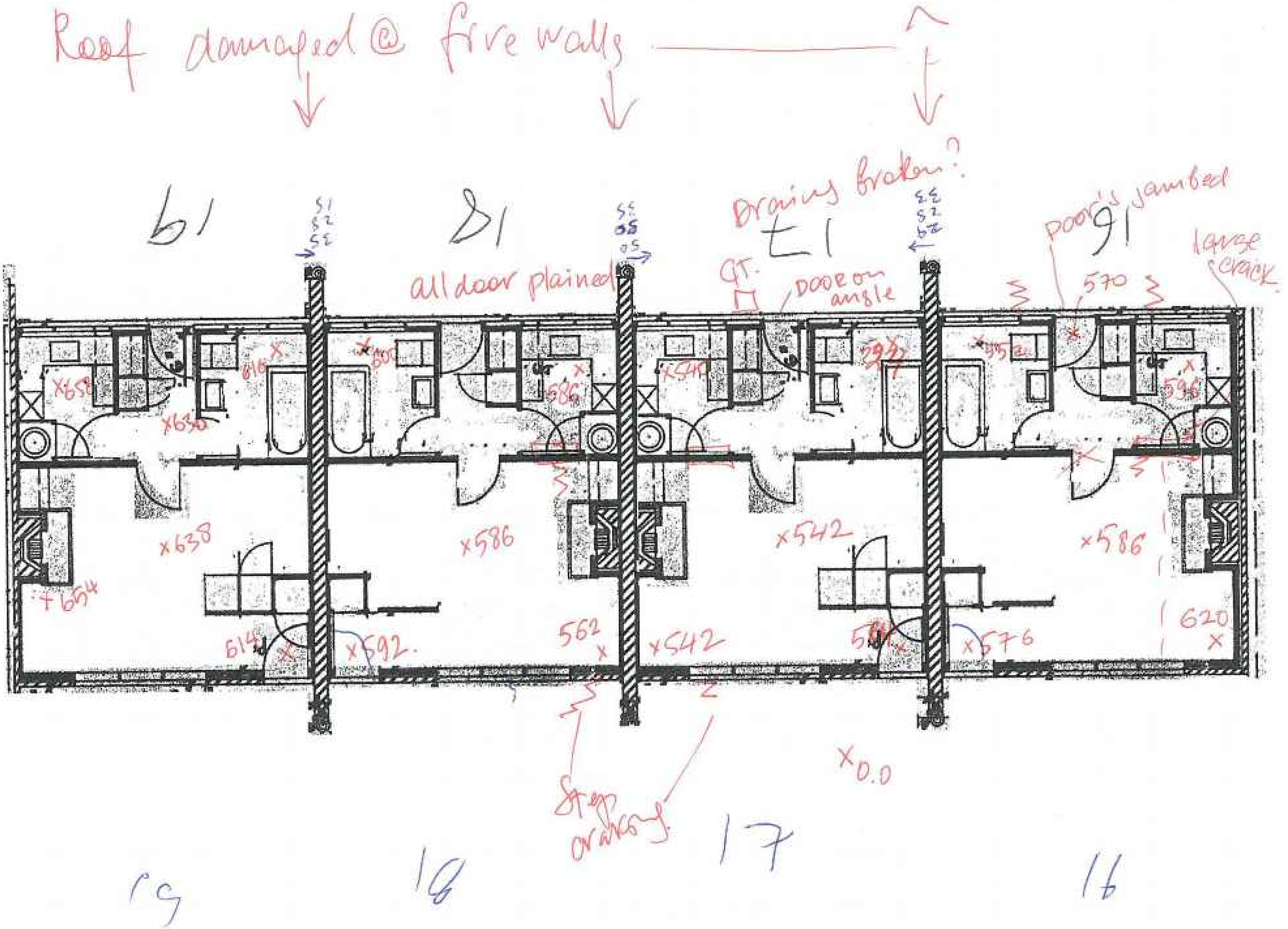
x724
x720
x704
x718
x0.0

Roof damage @ partition/fire walls.



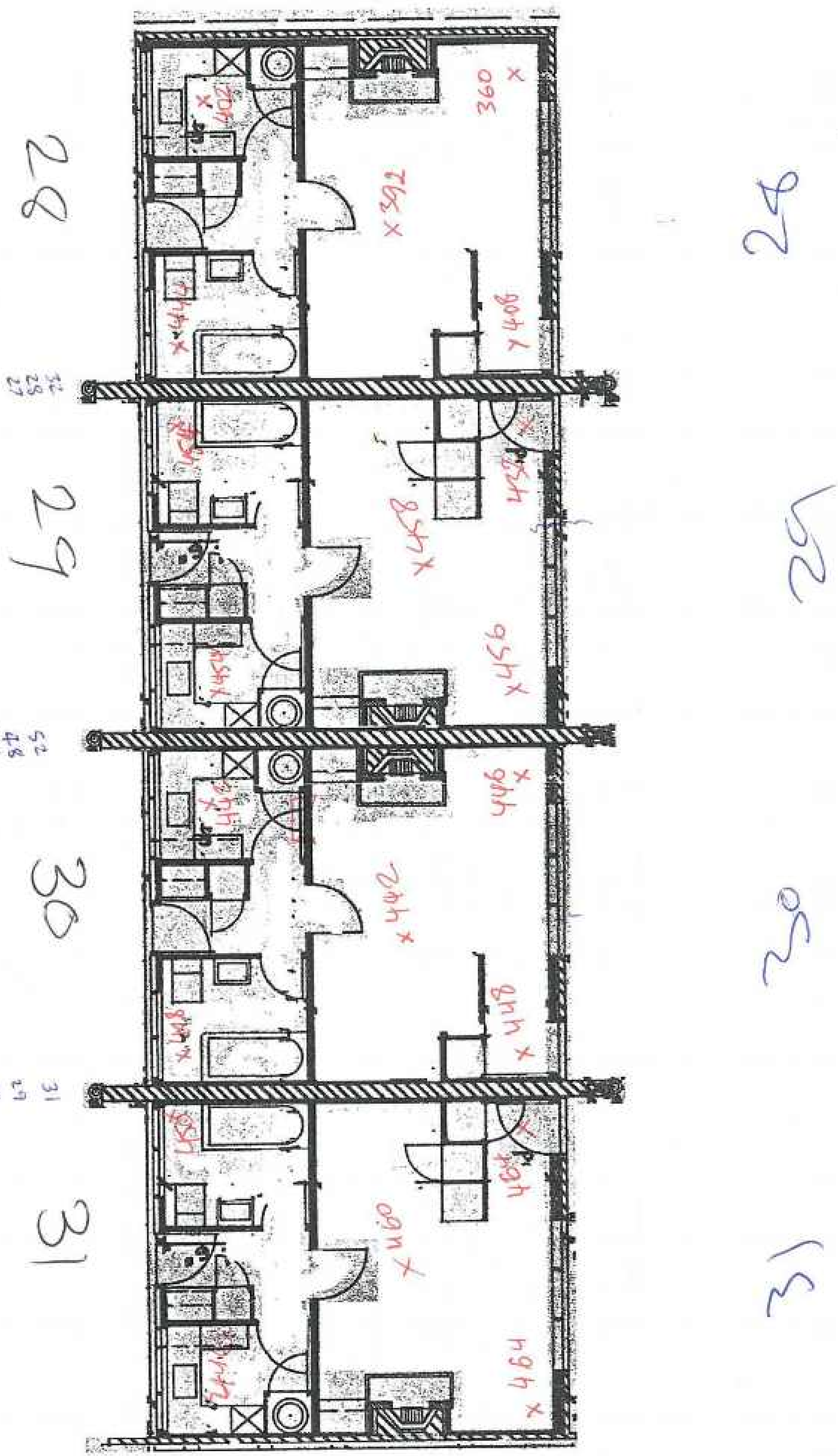

10
9
8
7

23
22
21
20
23
22
21
20



Roof damaged @ fire walls
all door plained
Drains broken?
GT.
DOOR on angle
Door's jambed
large crack.
570
Step cracking
x0.0
x638
x654
x586
x542
x592.
562
x576
620
19
18
17
16

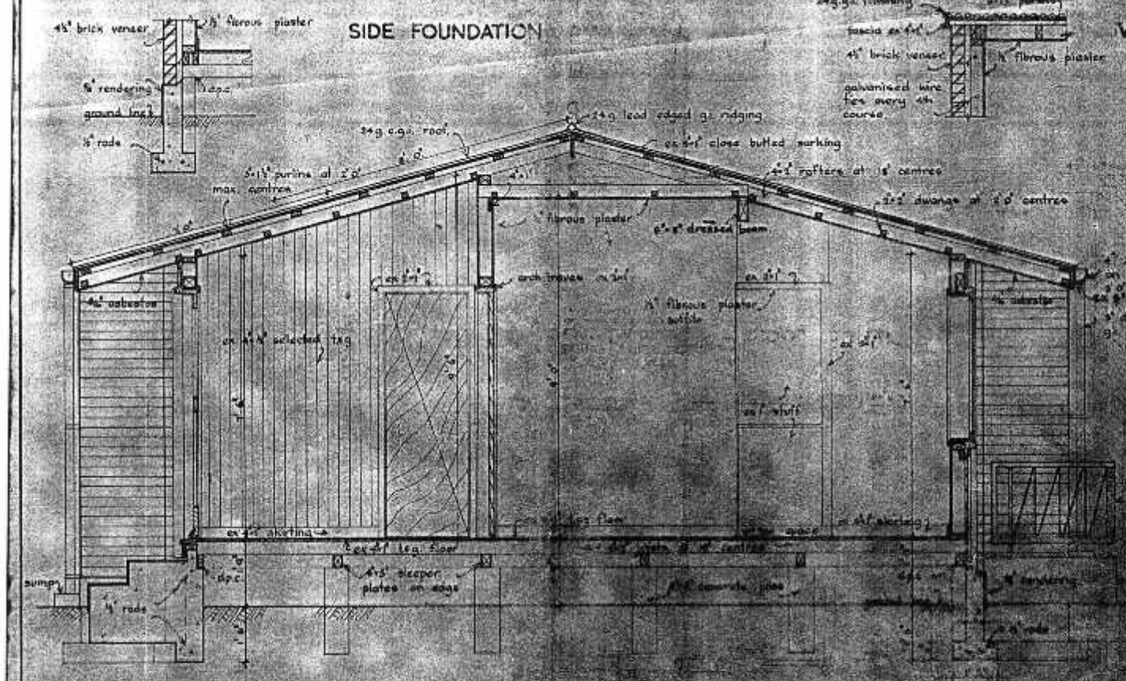
24
25
26
27
empty
empty
6mm
6mm
18mm
0.0
24
25
26
27


28
29
30
31

Appendix I

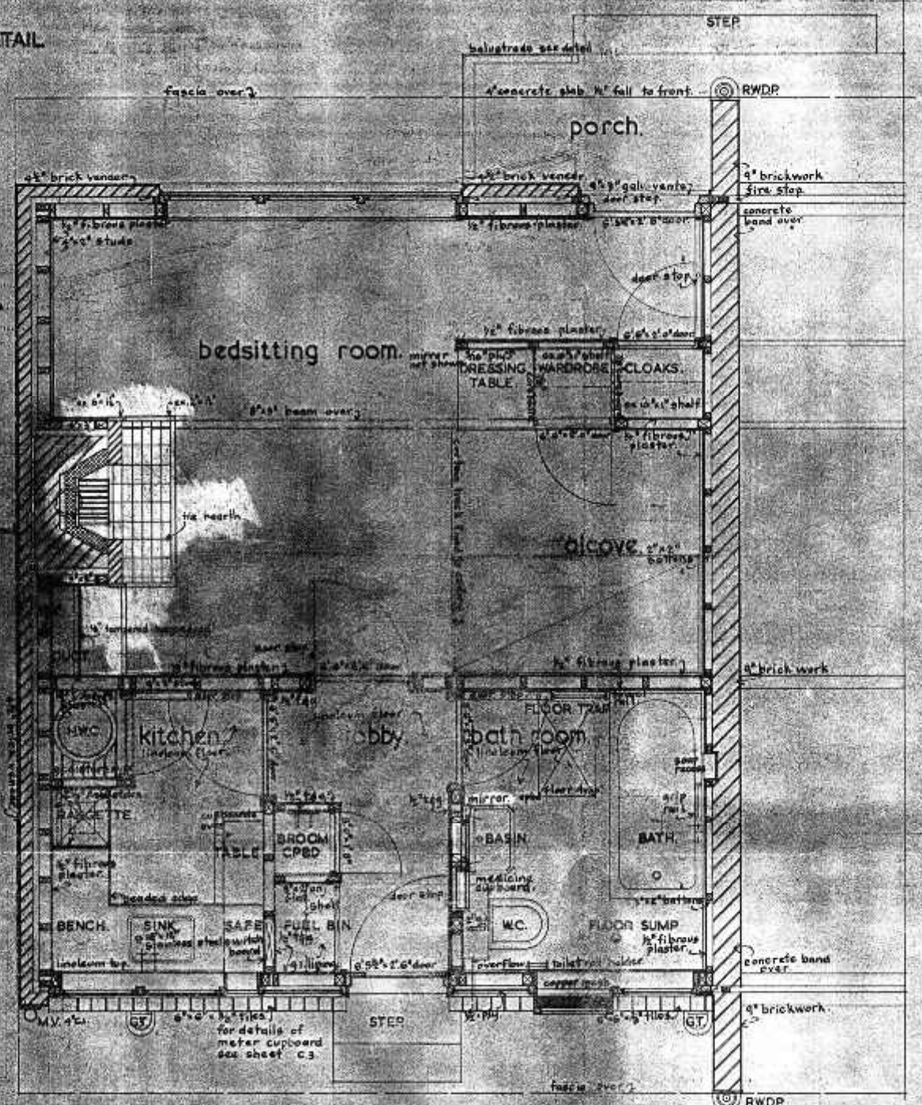
Construction Drawings

SIDE FOUNDATION

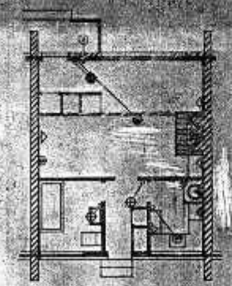


SECTION AA

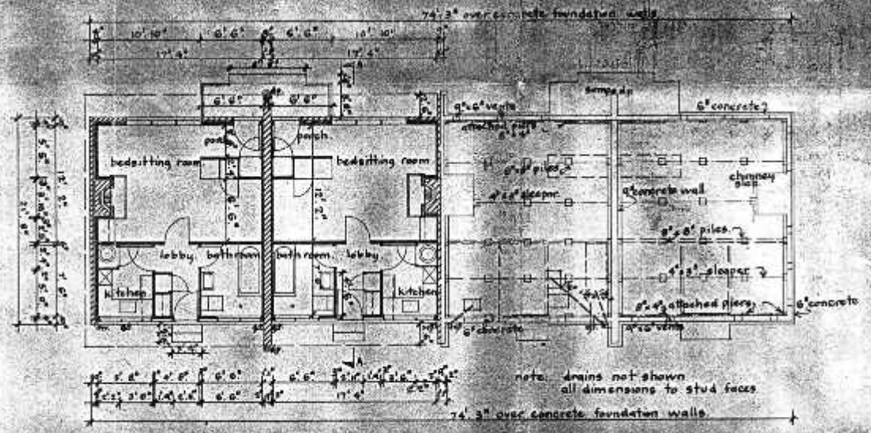
VERGE DETAIL



electrical installation

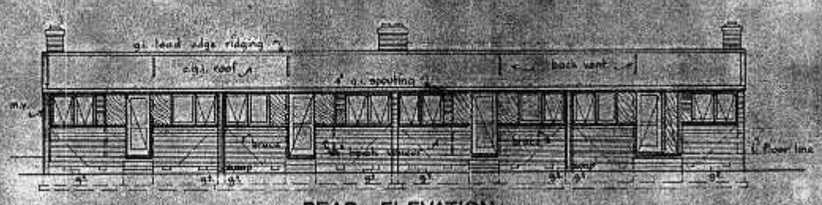


Switchboard
Light switch
Light pendant
Special light pendant
External soffite light
Bracket light & switch
Power point & switch
Hot water cylinder & switch
Electric Rangette & switch



FLOOR PLAN ⅛"=1'0"

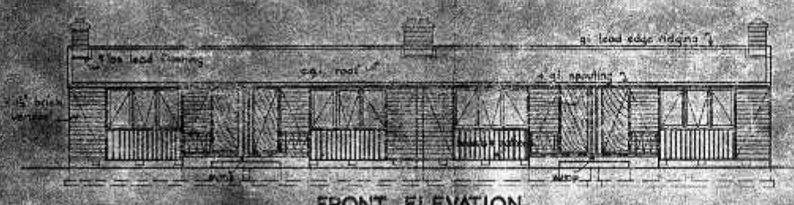
FOUNDATION PLAN



REAR ELEVATION

END ELEVATION

FLOOR PLAN OF END UNIT

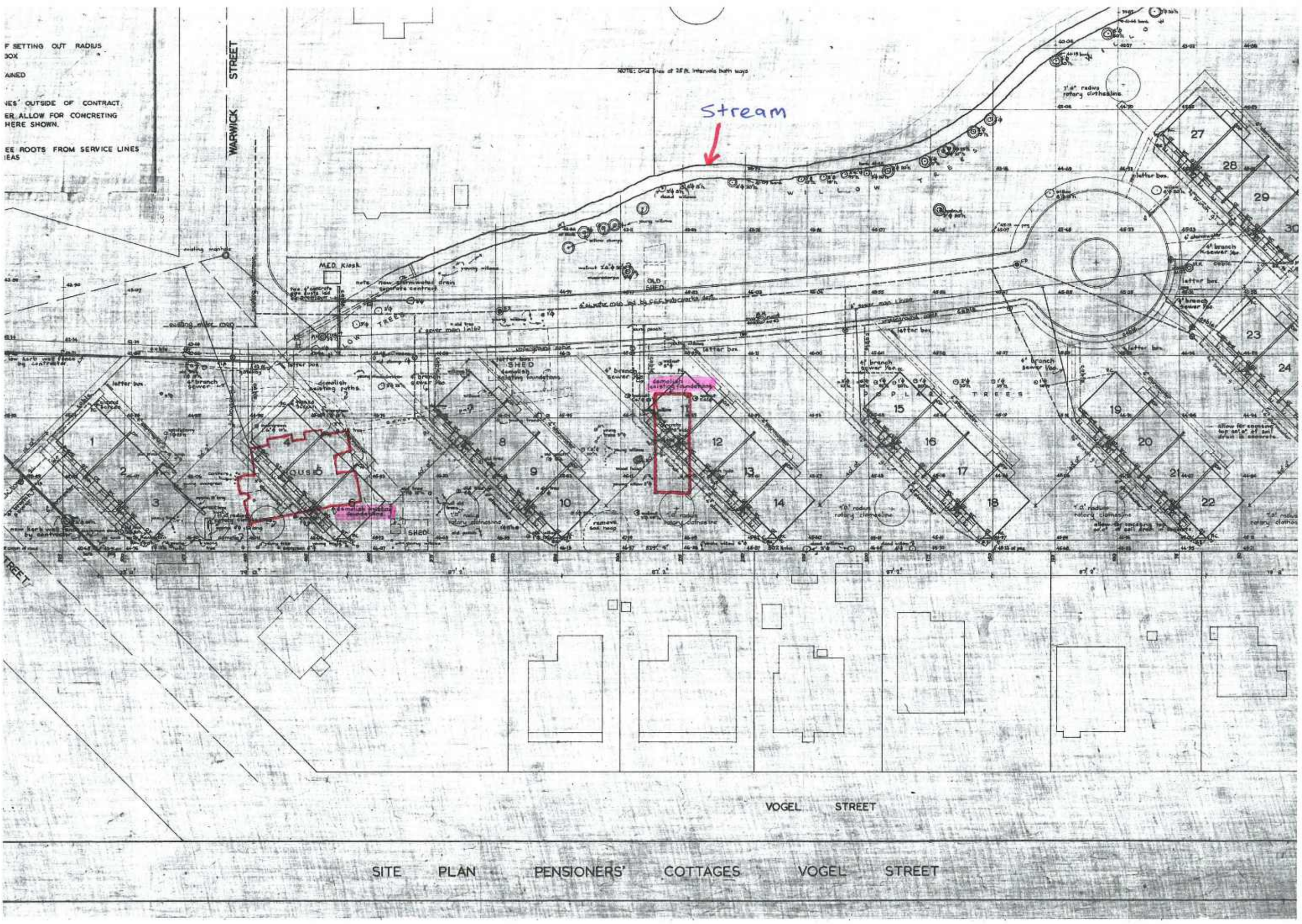


FRONT ELEVATION

CHRISTCHURCH CITY COUNCIL
CITY ENGINEER'S DEPARTMENT
Architect's Section

PENSIONER'S COTTAGES VOGEL [redacted] STREET

Dwg. No. A-1095
Scale ½" = 1'0"
⅛" = 1'0"
Date JANUARY 1959


F SETTING OUT RADIUS
BOX
AINED
IES' OUTSIDE OF CONTRACT.
ER ALLOW FOR CONCRETING
HERE SHOWN.
EE ROOTS FROM SERVICE LINES
IEAS
WARWICK STREET
NOTE: Grid lines at 25 ft. intervals both ways
Stream
MED. Kiosk
OLD SHED
SHED
demolish existing paths
demolish existing foundations
remove soil heap
existing manhole
existing water main
existing sewer main
low kerb wall fence by contractor
new kerb wall fence by contractor
letter box
4" branch sewer
4" branch sewer Yoo
cable
gateway
7'0" radius rotary clothesline
allow for concreting top 40'0" of soil drain in concrete
WILLOW TREES
POPLAR TREES
VOGEL STREET
SITE PLAN PENSIONERS' COTTAGES VOGEL STREET

Appendix J

Proposed Site Investigation Locations

Proposed Hand Auger and Scala Penetrometer test locations

Proposed CPT locations

0 50m

Approximate Scale:1 to 500 at A3.

SOURCE: canterburyrecovery.projectorbit.com (Accessed on 3/7/2013)

OPUS

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20 Moorhouse Ave
PO Box 1482
Christchurch, New Zealand
Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Gowerton Place, Richmond
Project No.: 6-QC347.00
Client: Christchurch City Council

Proposed Site Investigation Plan

Drawn: Opus Geotechnical Engineer

Date: 31-Jul-13

Appendix D - Methodology and Assumptions

Seismic Parameters

As per NZS 1170.5:

- T < 0.4s (assumed)
- Soil: Category D
- Z = 0.3
- R = 1.0 (IL2, 50 year)
- N(T,D) = 1.0

For the analyses, a μ of 2 was assumed for the residential units.

Analysis Procedure

As the units are small and have a number of closely spaced walls in both directions, the fibrous plaster board ceilings are assumed to be capable of transferring loads to all walls. It was therefore assumed that a global method could be used to carry the forces down to ground level in each direction. Bracing capacities were found by assuming a certain kN/m rating for the walls along each line. Due to the relatively unknown nature of the walls, the kN/m rating was taken as 3 kN/m for all timber walls with an aspect ratio (height: length) of less than 2:1. This was scaled down to zero kN/m at an aspect ratio of 3.5:1 as per NZSEE guidelines. %NBS values were then found through the ratio of bracing demand to bracing capacity for all walls in each direction.

Additional Assumptions

Further assumptions about the seismic performance of the buildings were:

- Foundations and foundation connections had adequate capacity to resist and transfer earthquake loads.
- Connections between all elements of the lateral load resisting systems are detailed to adequately transfer their loads sufficiently and are strong enough so as to not fail before the lateral load resisting elements.

Appendix E – CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Gowerton Place Housing Complex				Reviewer:	Mary Ann Halliday	
	Unit	No:	Street		CPEng No:	67073	
Building Address:	Units 1-31		Gowerton Place		Company:	OPUS International Consultants Ltd	
Legal Description:	Residential Units				Company project number:	6-QC347.00	
					Company phone number:	6433635400	
	Degrees	Min	Sec				
GPS south:	-43.52024812				Date of submission:	Sep-13	
GPS east:	172.6585369				Inspection Date:	13-Jun-13	
					Revision:	Final	
Building Unique Identifier (CCC):	PRO 0678				Is there a full report with this summary?	yes	

Site

Site slope:	slope < 1in 10	Max retaining height (m):	
Soil type:		Soil Profile (if available):	
Site Class (to NZS1170.5):			
Proximity to waterway (m, if <100m):		If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	4.00

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	
Ground floor split?	no		Ground floor elevation above ground (m):	
Storeys below ground	0			
Foundation type:	isolated pads, no tie beams		if Foundation type is other, describe:	
Building height (m):			height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):				
Age of Building (years):	53		Date of design:	1935-1965
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	multi-unit residential		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):				
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	frame system		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:	timber	joist depth and spacing (mm)	
Beams:	timber	type	
Columns:			
Walls:			

Lateral load resisting structure

Lateral system along:	lightweight timber framed walls	**Note: Define along and across in detailed report!**		
Ductility assumed, μ:	2.00		note typical wall length (m)	
Period along:	0.10	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	lightweight timber framed walls			
Ductility assumed, μ:	2.00		note typical wall length (m)	
Period across:	0.10	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

north (mm):		leave blank if not relevant
east (mm):		
south (mm):		
west (mm):		

Non-structural elements

Stairs:			
Wall cladding:	brick or tile	describe (note cavity if exists)	
Roof Cladding:	Metal	describe	light weight
Glazing:	aluminium frames		
Ceilings:	strapped or direct fixed		
Services(list):			

Available documentation

Architectural	none	original designer name/date	
Structural	none	original designer name/date	
Mechanical	none	original designer name/date	
Electrical	none	original designer name/date	
Geotech report	full	original designer name/date	2013

Damage

Site: (refer DEE Table 4-2)

Site performance:	Poor	Describe damage:	
Settlement:	25-100m	notes (if applicable):	
Differential settlement:	1:350-1:250	notes (if applicable):	
Liquefaction:	2-5 m³/100m²	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	0-20mm/20m	notes (if applicable):	
Damage to area:	moderate to substantial (1 in 5)	notes (if applicable):	

Building:

Current Placard Status: green

Along	Damage ratio:	0%	Describe how damage ratio arrived at:
	Describe (summary):		
Across	Damage ratio:	0%	$Damage\_Ratio = \frac{(\%NBS(before) - \%NBS(after))}{\%NBS(before)}$
	Describe (summary):		
Diaphragms	Damage?:	no	Describe:
CSWs:	Damage?:	no	Describe:
Pounding:	Damage?:	no	Describe:
Non-structural:	Damage?:	yes	Describe: minor GIB cracking

Recommendations

	Level of repair/strengthening required:			Describe:	
	Building Consent required:			Describe:	
	Interim occupancy recommendations:			Describe:	
Along	Assessed %NBS before e'quakes:	72%	##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	Equivalent Static
	Assessed %NBS after e'quakes:	72%			
Across	Assessed %NBS before e'quakes:	100%	##### %NBS from IEP below		
	Assessed %NBS after e'quakes:	100%			

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