Christchurch City Council

Halswell Courts Housing Complex
PRO 1630

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Halswell Courts Housing Complex

Quantitative Assessment Report

Halswell, Christchurch

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Summary

Halswell Courts Housing Complex
PRO 1630

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background

This is a summary of the quantitative report for the Halswell Courts 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 three residential unit blocks (all with five units per block) and the two three-car garages.

Key Damage Observed

No damage was observed to have been sustained by the garages.

The residential unit blocks suffered minor amounts of damage to non-structural elements. This included cracking of brick veneers and cracking to wall and ceiling linings.

Structural damage to the residential unit blocks was generally minor and was limited to cracking of wall and ceiling linings. There is significant cracking of concrete ground slabs, rotation of firewalls and differential foundation settlements in block B.

Critical Structural Weaknesses

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

Indicative Building Strength

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

Table A: Summary of Building Performance

Block	NBS%	Floor Levels	Nail Spacings
PRO 1630 B001 (Block A)	58%	Pass	Pass
PRO 1630 B003 (Block B)	58%	Partial Fail	Pass
PRO 1630 B004 (Block C)	58%	Partial Fail	Pass
PRO 1630 B002 (Storage Garage)	87%	N/A	Pass
PRO 1630 B005 (Storage Garage)	87%	N/A	Pass

The storage garages have been assessed to have capacities of 87% NBS. They are limited by the in-plane shear capacity of the sheet-lined, timber-framed shear walls on the front and rear elevations. The garages are classified as low risk buildings in accordance with NZSEE guidelines.

The residential unit blocks have been assessed to have capacities of 58% NBS. They are limited by the in-plane shear capacity of the sheet-lined, timber-framed shear walls on the front elevation. The units are classified as moderate risk buildings in accordance with NZSEE guidelines.

Recommendations

It is recommended that the residential unit blocks be strengthened to at least 67% NBS and the damaged walls, slabs and foundations are addressed.

A site-specific geotechnical investigation should be undertaken to determine the liquefaction susceptibility of the site and to assist in the development of foundation repair and re-levelling strategies.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council to undertake a Detailed Engineering Evaluation (DEE) of the Halswell Courts Housing Complex; located at 38 Kennedys Bush Road, Halswell, Christchurch. A DEE is required following the Canterbury Earthquake sequence since September, 2010. The purpose of this DEE is to determine if the buildings in the village are classed as being Earthquake Prone in accordance with the Building Act 2004. The site was visited by Opus International Consultants on 12 June 2013.

The assessment and reporting have been undertaken based on the qualitative and quantitative procedures detailed in the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Engineering Society (SESOC)[1].

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[1]. 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:

- The importance level and occupancy of the building.
- The placard status and amount of damage.

- The age and structural type of the building.
- Consideration of any critical structural weaknesses.

Christchurch City Council[2] 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%.

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)[3].

Section 121 – Dangerous Buildings

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

- 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
- 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
- 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
- There is a risk that other property could collapse or otherwise cause injury or death; or
- 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[2] following the Darfield Earthquake on 4 September 2010.

- The policy includes the following:
- A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
- A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- 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[4].

A generally accepted classification of earthquake risk for existing buildings, in terms of %NBS, has been proposed by the NZSEE (2006)[3] and is presented in Figure 1.

Description	Grade	Risk	%NBS	Existing Building Structural Performance
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)

Improvement of Structural Performance	
Legal Requirement	NZSEE Recommendation
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
	Not recommended. Acceptable only in exceptional circumstances
Unacceptable	Unacceptable

Figure 1: NZSEE risk classifications extracted from table 2.2 of the NZSEE 2006 AISPBE guidelines.

Table 1 compares the % NBS to the relative risk of a 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 Ministry of Business, Innovation and Employment (MBIE) guidance[5], 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[3] 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.

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[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

Figure 2 shows the location of the site relative to Christchurch City. The site contains 15 residential units (date of drawings, 1978) in three identical, five-unit blocks, and two identical three-car garages (date of drawings, 1997). A site plan showing the locations of the units and garages is shown in Figure 3.

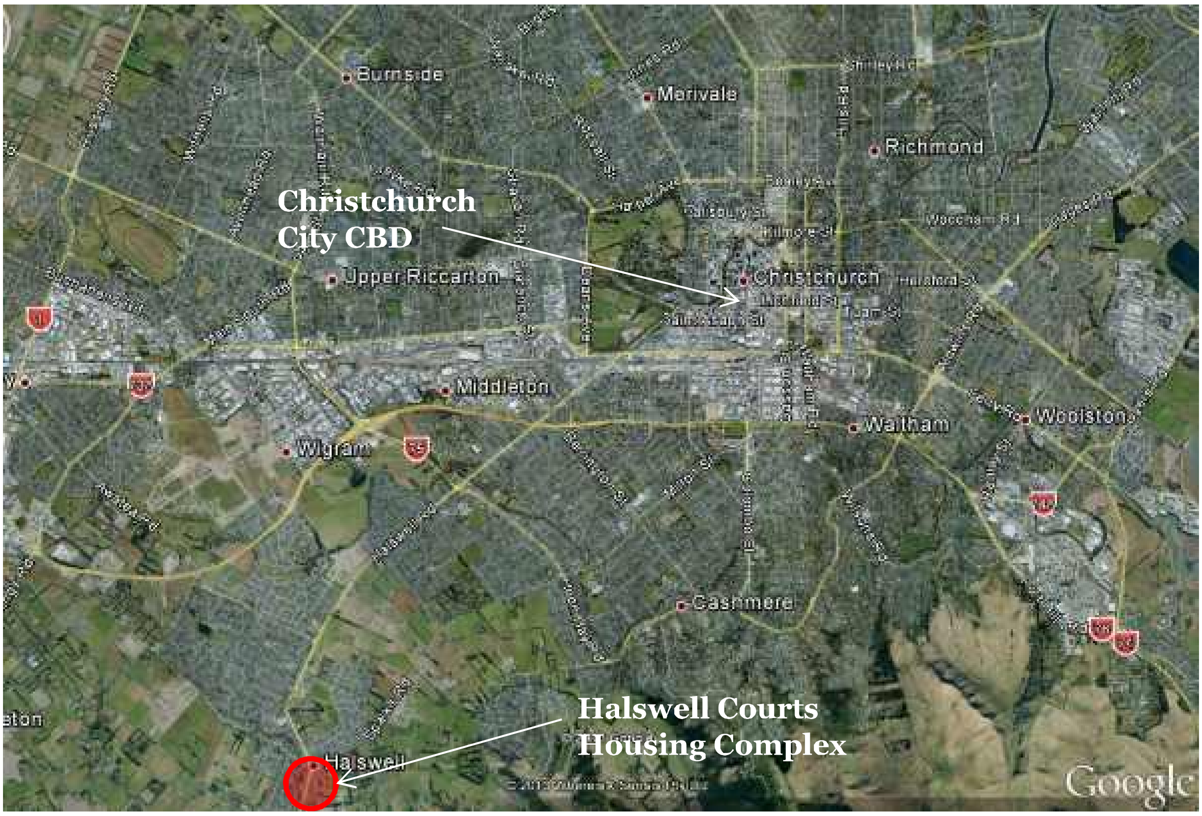


Figure 2: Location of site relative to Christchurch City CBD (from Google Maps).

Figure 3: Site plan of Halswell Courts housing complex.

4.1.1 Unit Blocks

Each block of units contains five units separated by 200mm thick block masonry fire walls. Based on information available from similar blocks of the same era, and the lack of cracking to the walls observed during site inspections, it is anticipated that these block walls are fully grouted.

Roof gravity loads are supported by 30° pitched, timber truss roofs with 50mm x 100mm purlins supporting concrete roof tiles (drawings show plywood sarking with corrugated iron sheeting; concrete tiles were confirmed from site visits). The roofs are supported on timber-framed walls which are internally lined with 9.5mm GIB and clad with 'La Strada' masonry veneer (approximately 90mm thick).

Building lateral loads are resisted by the GIB-lined, timber-framed walls, and the block masonry walls separating the units.

The unit blocks are founded on 100mm thick concrete slabs supported on hard fill and 200mm x 300mm perimeter beams. The perimeter beams are not tied into the slab and also support the masonry veneer. Figure 4 shows the floor plan and elevations of the unit blocks. Figure 5 shows a typical floor plan and section of an individual unit.

Figure 4: Floor plan and elevation of the unit blocks.

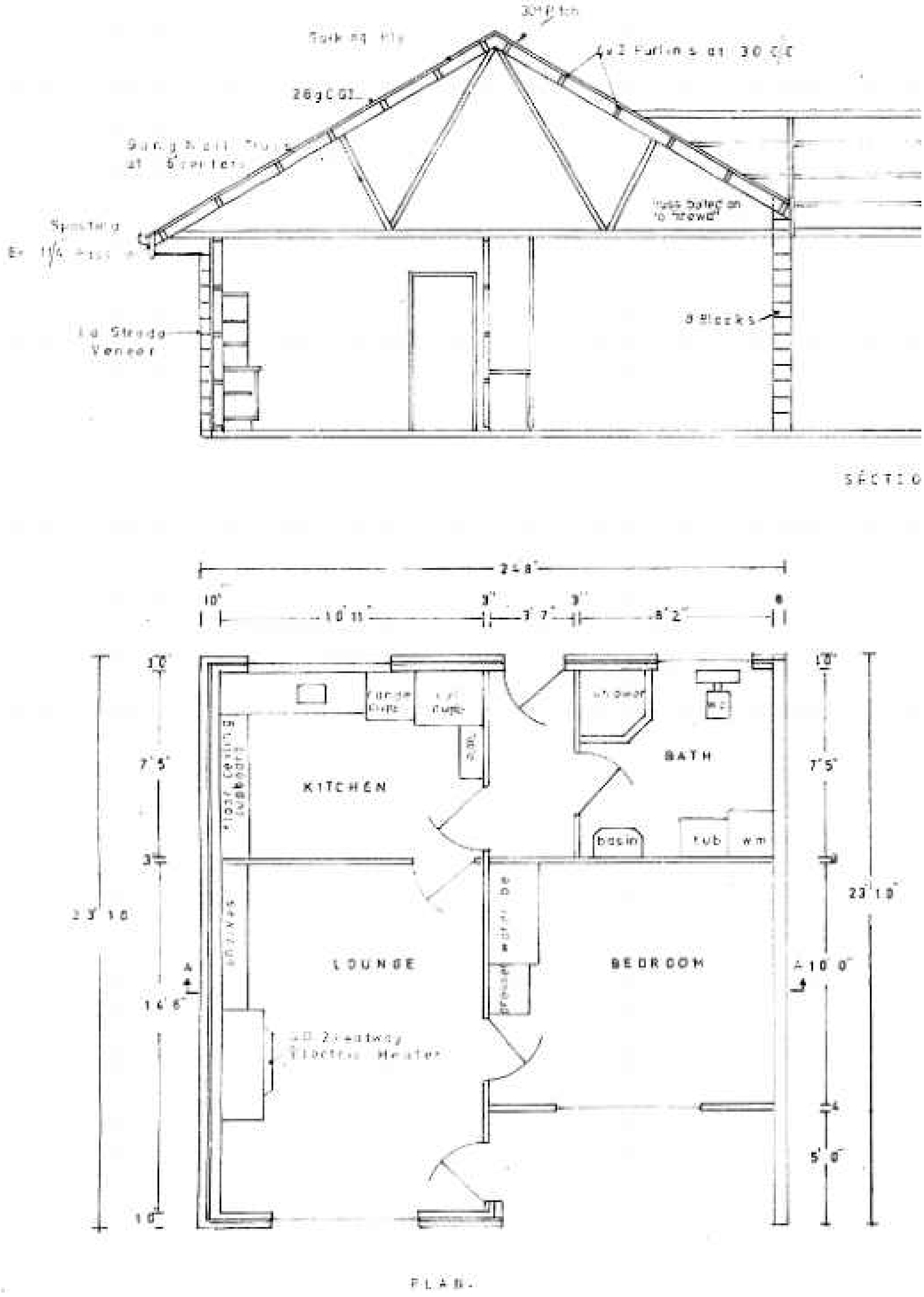


Figure 5: Typical floor plan and typical section of an individual unit.

4.1.2 Garages

Roof gravity loads in the garages are supported by a 10° sloping, timber-framed roof clad with colour steel corrugated roofing. The roof is supported by external timber-framed walls. The walls are clad with 90mm block veneer and internally lined with 9mm construction plywood. Drawings indicate that this plywood covers all internal walls. However, inspection on site showed that the walls are only partially lined, with a large portion of the rear wall unlined (as indicated in Figure 6).

Lateral loads are resisted by the plywood-lined walls. Loads are distributed to these walls through dragon ties and steel strap bracing.

The garages are founded on a 100mm thick slab-on-grade tied into 300mm x 220mm perimeter beams. The perimeter beams also support the masonry veneer. Figure 6 shows the floor plan and elevations of the garages and Figure 7 shows a typical section through the garages.

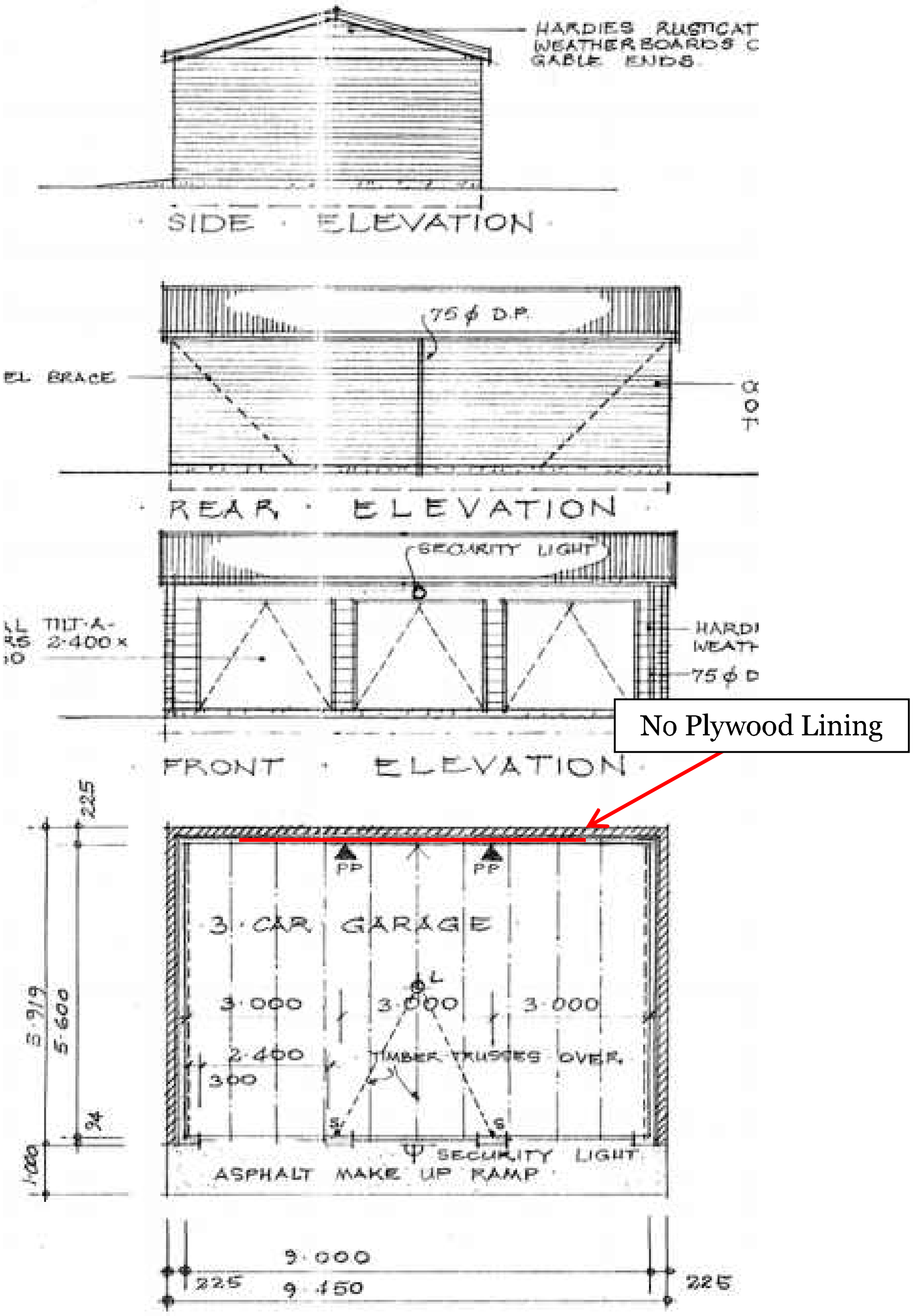


Figure 6: Plan and elevations of the three-car garages.

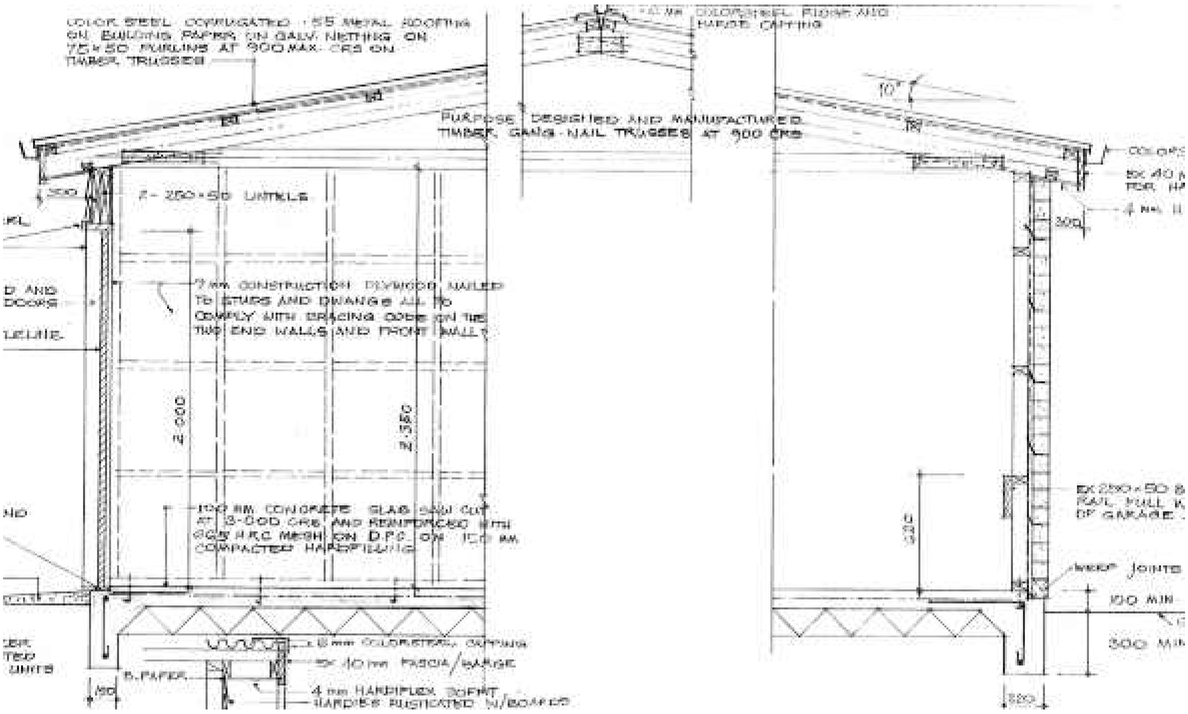


Figure 7: Typical section through the three-car garages.

4.2 Survey

4.2.1 Structural Inspection

Structural (Level 2) assessments of the site were undertaken by an Opus Engineer on 28 September 2010 with subsequent visits on 19 June 2013 and 27 September 2013. The purpose of the inspections was to document obvious visible damage to structural and non-structural elements, and to confirm the structural layout and materials of the buildings. The inspections did not include any intrusive investigations and were not intended to completely document all damage sustained by the buildings.

4.2.2 Level Survey

A level survey of the unit blocks was undertaken in June 2013. The results of the survey are shown in Table 2. Discussion of the results is presented in Section 8.

4.2.3 Fire Wall Verticality

The verticality of the block fire walls in the group of units containing units 7-10 were up to 30mm out of vertical alignment.

4.2.4 Nail Spacing

Nail spacing was checked in a number of units and was consistently 250mm.

Table 2: Summary of level survey results

Unit	Level Difference (mm)	Difference Distance (m)	Slope (mm/m)
1	32	6	5
2	14	4	4
3	20	4	5
4	28	10.5	3
5	20	7	3
6	48	6	8
7	25	7	4
8	30	7	4
9	16	10.5	2
10	26	6	4
11	28	6	5
12	12	6	2
13	12	4	3
14	12	6	2
15	40	4.7	9

4.2.5 Geotechnical Survey/Appraisal

A geotechnical site walkover was conducted in June 2013 to supplement a geotechnical desktop study. A summary of the geotechnical findings is given in section 8.

4.3 Original Documentation

Copies of the following construction drawings were provided by CCC:

- a partial site plan;
- unit blocks: elevations and partial floor plan;
- unit blocks: typical unit floor plan and partial typical cross-section;
- unit blocks: partial typical unit joinery and fitting details;
- garages: full plan, elevations and typical section.

The drawings have been used to confirm the structural systems, investigate potential critical structural weaknesses (CSW) and identify details which required particular attention.

Copies of the design calculations were not available.

5 Structural 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 noticeable during visual inspection only. Appendix A shows site photos exemplifying typical types of damage to the unit blocks.

5.1 Residual Displacements

Section 4.2.2 provides a summary of the level survey results. Discussion of these results is presented in Section 8.

5.2 Foundations

Damage to the foundations of the units included extensional cracking (up to 10mm wide) in the concrete slab of Unit 8 and minor external cracking to the ground slabs of Unit 3, Unit 6, Unit 7 and Unit 13.

5.3 Primary Gravity Structure

The primary gravity structure of the units blocks was not able to be inspected due to being hidden behind wall linings, etc. However, no effects (sagging of beams, etc) resulting from damage to gravity structure elements were noticed during inspections. The firewalls between 6 and 7 and the one between 8 and 9 are 30mm out of plumb by 30mm.

5.4 Primary Lateral-Resistance Structure

Cracking of wall and ceiling linings was distributed around the unit blocks. No damage was noticed to the lateral load resisting system of the garages.

5.5 Non Structural Elements

The unit blocks have suffered cracking and stepping to the brick masonry veneers and cracking to wall and ceiling linings. No damage was noticed to the non-structural elements of the garages.

6 General Observations

The buildings appeared to have performed as reasonably expected during the earthquakes. They have suffered distributed amounts of damage. The level of damage is consistent with the heavy nature of the roof and cladding and the age of the buildings.

7 Detailed Seismic Assessment

The detailed seismic assessment has been based on the NZSEE[3], Engineering Advisory Group[1], MBIE[5] and SESOC[6] guidelines.

7.1 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 critical structural weaknesses were identified in the buildings.

7.2 Quantitative Assessment Methodology

The assessment methodology has 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 distributed to walls by tributary area and relative rigidity. The capacities of the walls were calculated and used to estimate the %NBS.

7.3 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, but are not limited to:

- 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.
- The structures were designed and constructed in accordance with relevant codes of the time.
- The structures were built according to the drawings that were available at the time of the assessment, subject to variations noticed during site visits.

7.4 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. Figure 8 shows the location of the critical walls for determining the %NBS of the unit blocks.

Table 3: Summary of seismic performance.

Building	**Loading Direction**	**Failure Mode, or description of limiting criteria based on displacement capacity of critical element.**	**% NBS based on calculated capacity.**
Unit Blocks	Longitudinal	Bracing capacity of shear walls in the longitudinal direction.	58%
	Transverse	Bracing capacity of shear walls in the transverse direction.	>100%
	N/A	Out-of-plane failure of block masonry fire walls.	>100%
Garages	Longitudinal	Bracing capacity of shear walls in the longitudinal direction.	87%
	Transverse	Bracing capacity of shear walls in the transverse direction.	>100%

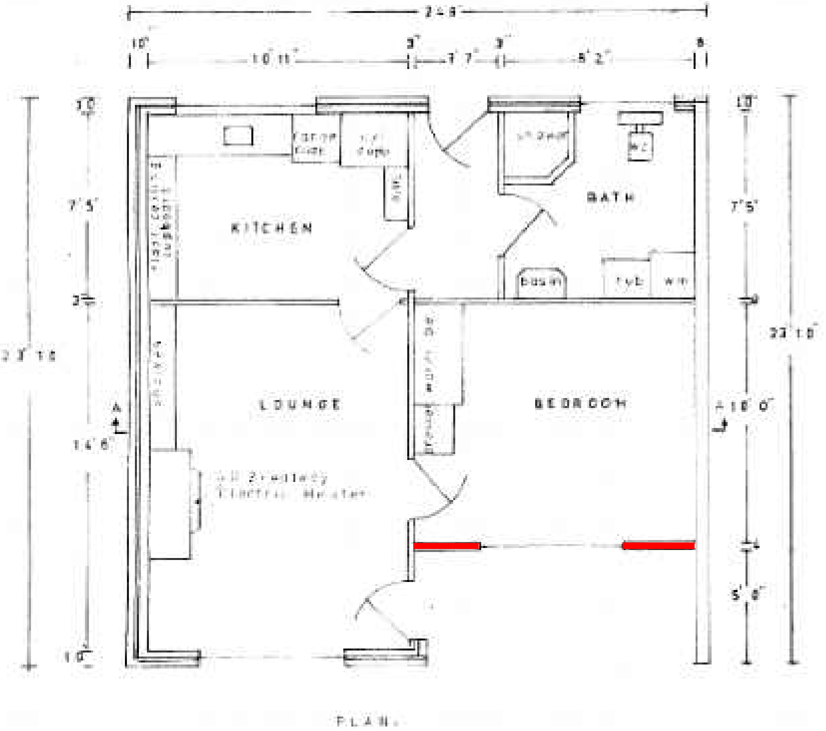


Figure 8: Location of critical walls (in red) governing the %NBS rating of the unit blocks.

8 Summary of Geotechnical Appraisal

This section summarises the information relevant to the structures on site presented in the Geotechnical Desktop Study prepared by Opus. The full report is provided in Appendix C. This was deemed necessary as the site is located adjacent to a TC3 site, as showing in Figure 9.

Figure 9: TC category for Halswell Courts (location starred).

8.1 Site Conditions

Data for the inference of ground conditions on site were obtained from two mains sources; Borehole Logs and Cone Penetrometer Tests (CPTs) and a Geotechnical Investigation Report for the development of the adjacent Halswell School (prepared by Tonkin and Taylor Ltd (T&T)). Borehole Logs and CPTs have not been undertaken on site. The Earthquake Commission, CERA, Environment Canterbury (ECan) and T&T have all conducted Boreholes and/or CPTs in the vicinity of the site. Of this information, 14 CPTs, two machine boreholes and two hand auger boreholes were within 60m of the site.

Published geological mapping of the area indicates that the site is underlain by near-surface Holocene river alluvium of the Springston Formation. This overlays Riccarton Formation gravels and undifferentiated Quaternary deposits.

From the information above, the inferred ground profile for the site is as presented in Table 4. The site investigation logs from immediately east of the site differed from those immediately south. Layer 2 was encountered at approximately 3.5m-4.0m to the east and at approximately 1.5m-2.5m to the south.

Table 4: Inferred ground conditions.

Layer No.	Stratigraphy	Thickness (m)	Depth Encountered (m)
1	Sandy SILT and SILT (Soft to Firm) interbedded with some Silty SAND (Loose), SAND (Loose) and minor Organic SILT (Soft to Firm)	1.5-3.0	0.0-3.0
2	Sandy medium GRAVEL (Medium Dense to Dense)	4.0-6.0	1.5-8.0
3	Fine SAND with trace of silt (Medium Dense)	3.0-4.0	6.0-10.5
4	Organic SILT and STIL (Very Soft to Firm) with some PEAT lenses (Stiff to Very Stiff)	2.5-3.0	10.5-13.5
5	Interbedded Sandy SILT and Silty SAND (Soft; Loose to Medium Dense)	2.0	13.0-15.0
6	Sandy fine to medium GRAVEL (Dense to Very Dense)	-	15.0+

Groundwater depths have been interpreted from the site investigation logs as approximately 1.0m below ground surface to the east and approximately 2.0m below ground level to the west. Whilst the site is outside its study area, maps available within Project Orbit and within the GNS Science Median Groundwater Surface Elevation Report indicate that the median depth to the groundwater surface at the site is likely 1.0m to 3.0m.

8.2 Liquefaction Potential

A liquefaction hazard study was conducted by ECan in 2004 to identify areas of Christchurch that are susceptible to liquefaction during an earthquake. The study indicated the site has “no liquefaction predicted” or that “a low liquefaction potential may be expected” for both high and low groundwater scenarios. The study also classified the ground damage potentials of areas around Christchurch. The site was identified as having a “no liquefaction ground damage potential” for the low groundwater scenario.

T&T have interpreted data from high resolution aerial photos of the September 2010, February 2011, June 2011 and December 2011 events to prepare maps for the EQC showing where areas of liquefaction occurred. No data was available for the site with respect to these maps. Observations made at adjacent roads and properties indicate:

- ‘little’ to ‘moderate’ quantities of ejected liquefied material at the site after the September 2010 event;
- ‘moderate’ quantities of ejected liquefied material near the site after the February 2011 event;
- ‘minor’ to ‘moderate’ quantities of ejected liquefied material observed near the site after the June 2011 event;

- no data was available for the December 2011 event.

The T&T report for Halswell School and GNS liquefaction observation maps available through Project Orbit indicate that widespread surface expressions of liquefaction were observed immediately south of the site after both the September 2010 and the February 2011 events.

CERA have zoned land in the greater Christchurch area according to its expected ground performance in future large earthquakes. The site is indicated as being in the 'Green' zone. MBIE have further subdivided green zone properties into 'Technical Categories'[8] to classify the expected land performance during 1 in 25 year (serviceability limit state (SLS)) and 1 in 500 year (ultimate limit state (ULS)) events. The site has been classed as "N/A-Urban Non-residential" by MBIE. However, adjacent residential properties have been classed as 'Technical Category 2' (TC2) or 'Technical Category 3' (TC3).

Given the available information, an SLS event is expected to result in 0mm-175mm of liquefaction-induced global vertical settlement when the ground water depth is between 1.0m-2.2m. This is expected to be accompanied by 'little' to 'moderate' surface expression of liquefaction (e.g: sand boils). A ULS event is expected to result in 50mm-250mm of liquefaction-induced global vertical settlement when the ground water depth is between 1.0m-2.2m. This is expected to be accompanied by 'some' to 'severe' surface expression of liquefaction. The varying thicknesses of the liquefiable layers mean the liquefaction-induced differential settlements in the order of 20mm-200mm can be expected from a ULS event. These settlement magnitudes would likely lead to the site being classified as TC3 under the MBIE guidelines.

8.3 Level Survey Analysis

The level survey results are presented in Appendix B and summarised in Table 2. The summarised results contain an adjustment for the heights of the different floor coverings, which are not indicated in Appendix B.

8.4 Discussion and Summary

Minor to moderate levels of liquefaction occurred at Halswell Courts during the earthquakes. This has resulted in changes to the ground on site which has caused some damage to the residential units. This damage has included cracking to foundations, wall and ceiling linings, veneers and differential settlement. Differential settlements have been measured up to 9mm/m (in Unit 15).

MBIE have published guidelines relating to the remediation of residential foundations that have suffered damage from earthquakes[8]. Though these guidelines were not developed for multi-unit residential buildings, they provide a useful indication of re-levelling limits and strategies. Within these guidelines is a classification system for different foundation types. The unit blocks have reinforced concrete slabs supported on independent perimeter beams, which are classified as 'Type C2' according to the guidelines. The guidelines indicate that Type C2 buildings with settlements greater than 5mm/m would require re-levelling. This would indicate that units 6 and 15 may require re-levelling when considering the results in Table 2. Liquefaction-induced differential settlements in the order of 20mm-200mm can be expected during a ULS event.

8.5 Further Work

A site-specific geotechnical investigation is recommended to determine foundation repair options for Halswell Courts. This will enable a site-specific liquefaction assessment to be undertaken, which will help to determine repair and re-levelling options. The investigation should consist of:

- A series of CPTs to a depth of 20m.
- Several hand auger boreholes and DCP tests; to depths of 3m, or refusal.
- Assessment and reporting.

9 Conclusions

Various assumptions have been made about the buildings due to an incomplete set of structural information being available for the assessment. The conclusions herein are subject to these assumptions, which are listed in section 7.3 and Appendix D. The conclusions for this assessment are:

- The garages have a rating of 87% NBS and are not considered earthquake prone. The garages are classified as low risk buildings in accordance with NZSEE guidelines.
- The unit blocks have a rating of 58% NBS and are not considered earthquake prone. The units are classified as moderate risk buildings in accordance with NZSEE guidelines.
- The site is likely to have ground performance in future earthquakes equivalent to TC3 ground.
- MBIE guidelines developed for single-unit residential buildings classify the unit blocks as having foundation Type C2.
- MBIE guidelines indicate differential settlements greater than 5mm/m in Type C2 foundations require re-levelling.
- Most units have residual differential settlements of less than 5mm/m. Unit 6 and Unit 15 have residual differential settlements of 8mm/m and 9mm/m respectively.
- Unit 8 has a significant floor crack which propagates through the foundations. A repair strategy for this area is required.
- The firewalls between 6 and 7 and the one between 8 and 9 need to be straightened or rebuilt.
- Liquefaction-induced differential settlements in the order of 20mm-200mm can be expected in a ULS earthquake event.

10 Recommendations

- A strengthening works scheme be developed to increase the seismic capacity of the residential unit blocks to at least 67% NBS and the damaged walls, slabs and foundations are addressed.
- A site-specific geotechnical investigation be undertaken to better determine the liquefaction susceptibility of the site, and to assist in the development of foundation repair and re-levelling strategies, where necessary.

11 Limitations

This report is based on information from inspections of the buildings and limited available drawings. Where damage is discussed, it is focused on the structural damage resulting from the September 2010 Darfield Earthquake and its subsequent aftershocks only. 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 Halswell Courts Housing complex. It is not intended for any other party or purpose.

12 References

[1] Engineering Advisory Group (2011), *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.

[2] Christchurch City Council (2010), *Earthquake-Prone, Dangerous and Insanity Buildings Policy*.

[3] New Zealand Society of Earthquake Engineering (2006), *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*.

[4] Standards New Zealand (2004) *Structural design actions, Part 5: Earthquake actions – New Zealand*. Wellington: Technical Committee BD-006-04-11.

[5] Department of Building and Housing (2012), *Guidance for engineers assessing the seismic performance of non-residential and multi-unit residential buildings in greater Christchurch*. Wellington.

[6] SESOC (2011), *Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes*. Version 4, 21 December 2011.

[7] Standards New Zealand (1990) *Code of Practice For Light Timber Frame Buildings Not Requiring Specific Design*. Wellington.

[8] Ministry of Business, Innovation and Employment (2012) *Repairing and Rebuilding Houses Affected by the Canterbury Earthquakes*. Version 3, December 2012. Wellington.

Appendix A

Photographs

Halswell Courts Housing Complex		
No.	**Item description**	**Photo**
Unit Blocks		
1	Front elevation, typical.	
2	Partial rear elevation, typical.	
3	Side elevation, typical.	

4	Site photo, typical.	
5	Typical cracking of wall linings from corners of doors.	
6	Typical cracking of wall linings from corners of windows.	

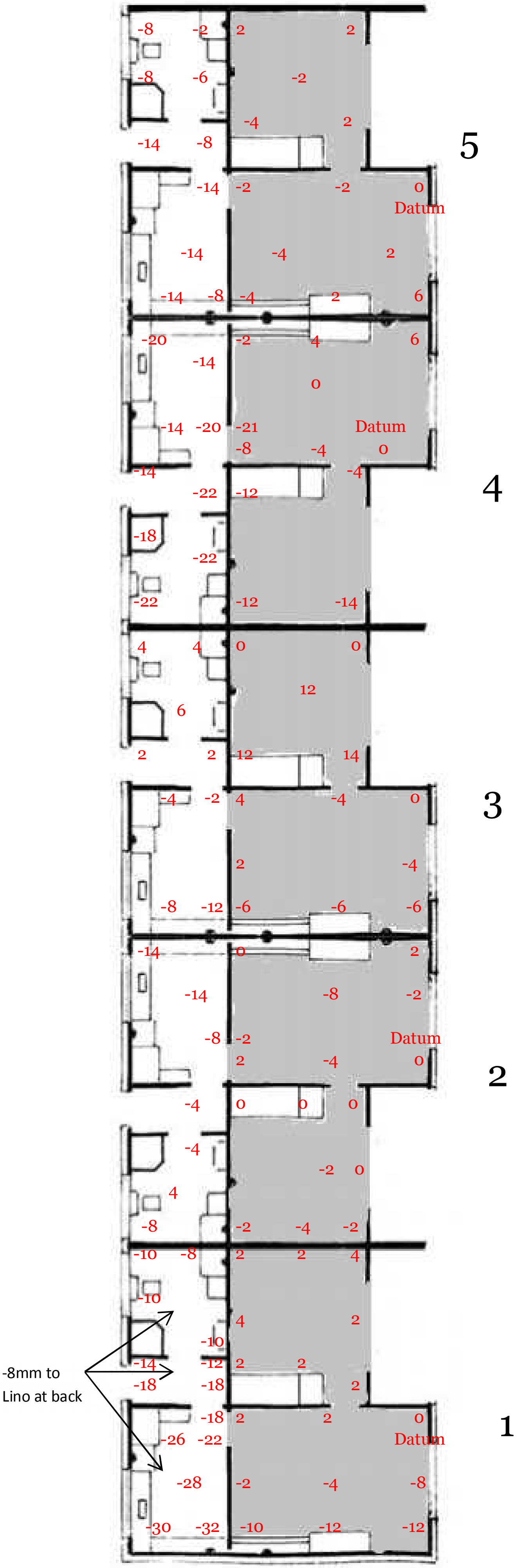
7	Typical separation/cracking of timber walls and ceilings from block masonry firewalls.	
8	Typical cracking/stepping of brick masonry veneers.	

9	Typical cracking to external surface of concrete foundations.	
10	Extension crack to slab of Unit 8.	

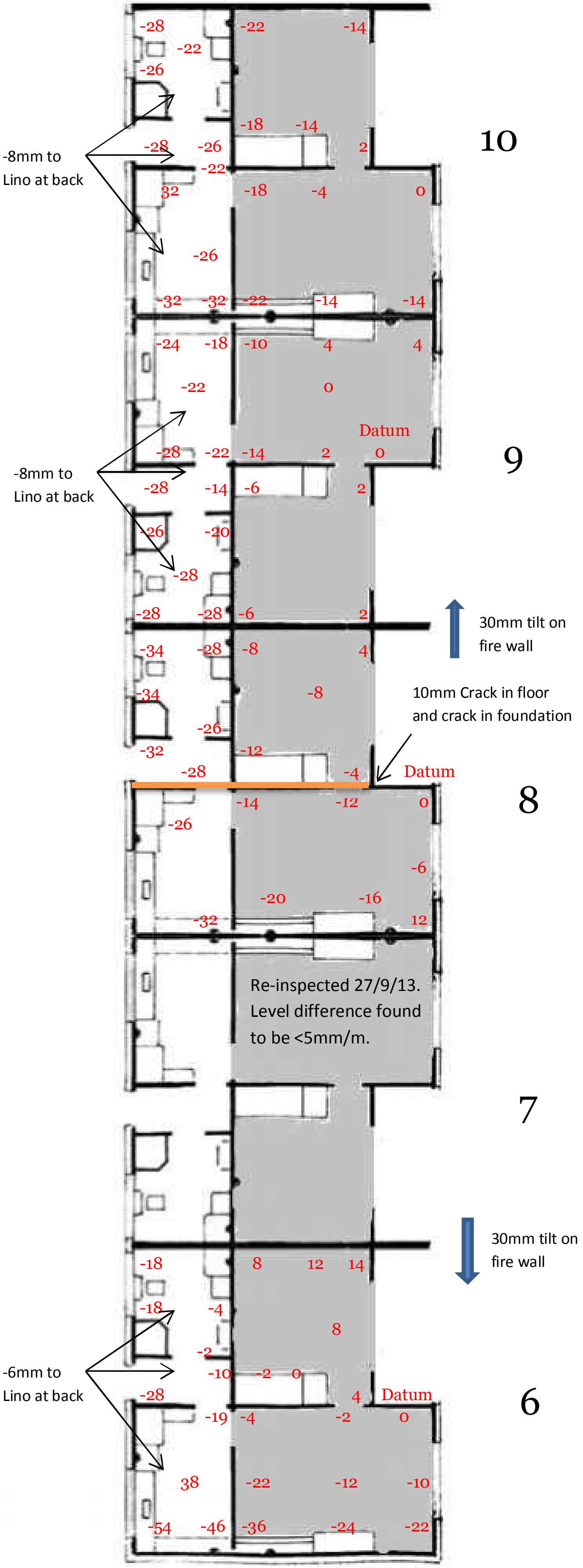
Garages		
11	Front and side elevation, typical.	
12	Front elevation, typical.	
13	Internal view showing dragon tie, roof strap bracing and rear wall with partial plywood coverage.	

Appendix B

Level Survey Results



-8mm to Lino at back



-8mm to Lino at back

-8mm to Lino at back

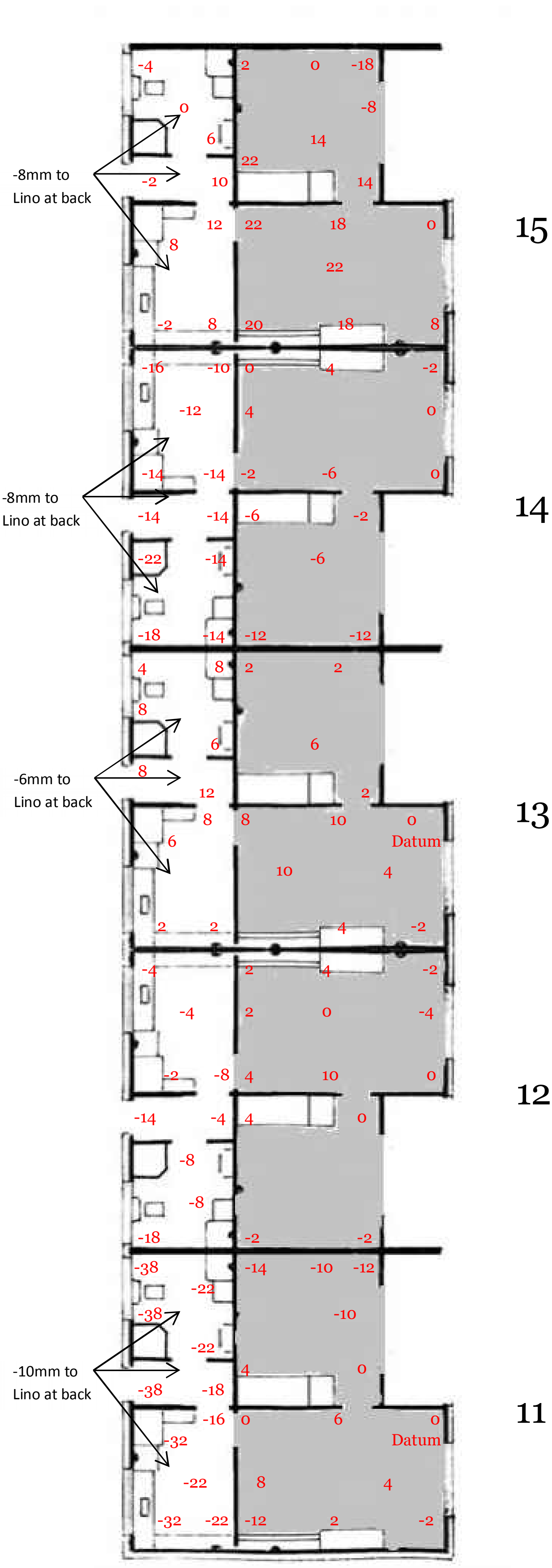
30mm tilt on fire wall

10mm Crack in floor and crack in foundation

Re-inspected 27/9/13. Level difference found to be <5mm/m.

30mm tilt on fire wall

-6mm to Lino at back



-8mm to
Lino at back

-8mm to
Lino at back

-6mm to
Lino at back

-10mm to
Lino at back

Appendix C

Geotechnical Appraisal

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23 October 2013

Christchurch City Council
c/- Opus International Consultants Ltd
Attention: Geoff Bawden
PO Box 1482
Christchurch 8140

6-QC355.00

Dear Geoff

Geotechnical Desk Study - Halswell Courts

1 Introduction

Christchurch City Council (CCC) has commissioned Opus International Consultants (Opus) to undertake a Geotechnical Desk Study and site walkover inspection of the CCC Halswell Courts housing complex at 38 Kennedys Bush Road, Halswell, Christchurch. Refer to Figure 01 for the Site Locality Map. The purposes of this study are to collate the existing subsoil information, prepare an interpretive geotechnical ground model, undertake an appraisal of the potential geotechnical hazards at this site and determine whether further investigations are required.

This Geotechnical Desk Study has been prepared in accordance with Part 2 of the "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury"[1] publication. Whilst not specifically prepared to provide guidance on the preparation of Detailed Engineering Evaluations of residential buildings, this publication provides guidance that is considered generally applicable to this study.

This Geotechnical Desk Study has been undertaken without the benefit of any site specific investigations and is, therefore, preliminary in nature.

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[1] Engineering Advisory Group, "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury", Part 2, Evaluation Procedure, Reference ENG.EAG.0001.2, Draft Revision 5, 19 July 2011.

2 Desktop Study

2.1 Site Location

The CCC Halswell Courts housing complex is at 38 Kennedys Bush Road, Halswell. The complex is bounded by residential areas to the north, Kennedys Bush Road to the east, Halswell Primary School to the south and Halswell Road to the west. The site is located approximately 30 m east of an open channel stream, which is located along the western side of Halswell Road. Refer to Figure 02 for the Site Vicinity Map for the location of the site.

2.2 Site Description

2.2.1 Structures

The Halswell Courts housing complex was built circa 1972 and comprises 15 residential units within three buildings (i.e. "Blocks"). Six associated detached garages (comprising two structures, three garages per structure) at the site were later constructed circa 1997. Refer to Figure 03 for the Site Walkover Plan and to Appendix A for copies of the Construction Drawings.

Each residential building has a simple rectangular floor plan and comprises a single-storey timber-framed structure with structural masonry party walls between each unit. The building exteriors comprise "La Strada" masonry veneer and timber cladding. The building roofs comprise tiles over plywood supported on timber trusses. The buildings are supported by approximately 16-inch (400 mm) deep reinforced concrete perimeter footings, with the floor comprising a separately-poured 4-inch (100 mm) thick reinforced concrete slab over hardfill. Based on construction drawings there are no tied connections between the footing and the floor slab. The foundations are considered to be equivalent to "Type C2" in accordance with the "Repairing and rebuilding houses affected by the Canterbury Earthquakes"[2] publication. Refer to Photos 1 through 7 in Appendix B for typical elevation views of the residential buildings.

The detached single-storey timber-framed garages are rectangular in shape and are supported by 220 mm wide concrete perimeter footings embedded 300 mm below adjacent ground level (the front footings are 150 mm wide). The garage floors comprise 100 mm thick reinforced slab on 150 mm compacted hardfill, and the garage roofs comprise Colorsteel corrugated metal roofing supported on timber purlins and trusses. These foundations would be equivalent to "Type C2" in accordance with the "Repairing and rebuilding houses affected by the Canterbury Earthquakes"[3] publication. Refer to Photo 5 in Appendix B for a typical elevation view of the garages.

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[2] Ministry of Business, Innovation and Employment (MBIE), "Repairing and rebuilding houses affected by the Canterbury Earthquakes", Version 3, December 2012.

[3] Ministry of Business, Innovation and Employment (MBIE), "Repairing and rebuilding houses affected by the Canterbury Earthquakes", Version 3, December 2012.

2.2.2 Grounds

The ground profile is relatively low lying and gently sloping (e.g. approximately 1%) down to the east. The ground surface in the east side of the site is approximately 1.0 to 1.2 m lower than the ground surface in the west. Halswell Road and Kennedys Bush are both elevated approximately 300 to 500 mm relative to the site and the surrounding properties, while the invert of the stream channel adjacent to Halswell Road is approximately 2000 to 2500 mm lower than the site. Refer to Photos 8 and 9 in Appendix B for views of the stream channel. A shallow depression is located in the vicinity of Flats 1, 2 and 3 as indicated on Figure 03. The ground surrounding the buildings is predominantly grassed surfaces. Refer to Photos 1-3, 7 and 18-20 for views of the grounds surrounding Halswell Courts; Photos 18 and 19 show the shallow depression in front of Flats 1, 2 and 3.

2.3 Regional Geology

Published geological mapping[4] of the area indicates that the site is underlain by near-surface Holocene river alluvium of the Springston Formation overlying Riccarton Formation gravels and undifferentiated Quaternary deposits. At depths of approximately 200 to 400 m, Section B-B' of Forsyth, Barrell and Jongens (2008) indicates that these near-surface deposits may be underlain by Pliocene age Kowhai Formation greywacke conglomerate underlain by various older sedimentary rocks and volcanic rocks.

2.4 Expected Ground Conditions

Logs of Boreholes and Cone Penetrometer Tests (CPTs) undertaken/compiled by the Earthquake Commission (EQC) and/or by Canterbury Earthquake Recovery Authority (CERA) as well as Environment Canterbury (ECan) well logs have been reviewed as part of this study. A Geotechnical Investigation and Assessment Report[5] by Tonkin and Taylor Ltd (T&T) in 2013 for Halswell School immediately to the south of the site was also reviewed.

The T&T report included nine CPTs, two machine boreholes, two hand auger boreholes and one test pit within approximately 50 m of the site. The reviewed EQC investigation data included an additional five CPTs within approximately 60 m of the site. Of the 14 reviewed CPTs, 11 refused or terminated in Sandy GRAVEL. The remaining three CPTs terminated at approximately 14.5 to 15.5 m below ground surface in the very dense Sandy fine to medium GRAVEL of the Riccarton Formation. Two boreholes SH1 and BH103 completed at Halswell School, south of the site, identified a shallow sandy gravel layer of approximately 4.0mm to 5.5mm thickness. CPT19226 and 1922 north east of the site did not identify the presence of shallow gravel layer.

Refer to Figure 02 and 04 for a presentation of the surrounding site investigation locations. Copies of the referenced site investigation logs, as well as reports of relevant laboratory testing completed on samples obtained from these boreholes and test pits, are also included in Appendix C.

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[4] Forsyth, Barrell and Jongens, "Geology of the Christchurch area", Scale 1:250 000, Institute of Geological & Nuclear Sciences, geological map 16, 2008.

[5] Tonkin and Taylor Ltd, "Halswell School, Geotechnical Investigation and Assessment Report", T&T Ref: 53062.004, Prepared for Ministry of Education, February 2013.

Using the available referenced geotechnical data, a sub-surface interpretive ground model was prepared for the site. The inferred ground conditions comprise sub-surface soil stratigraphy interpreted from the available data and from experience with comparable soils in similar geological settings. The inferred ground conditions are presented in Table 1.

Table 1: Inferred Ground Conditions

Layer No.	Layer Description: Stratigraphy (Consistency)	Approximate Thickness (m)	Depths Encountered (m)
1	Sandy SILT and SILT (Soft to Firm) interbedded with some Silty SAND (Loose), SAND (Loose) and minor Organic SILT (Soft to Firm)	1.5 to 3.0	Surface to 3.0
2	Sandy medium GRAVEL (Medium Dense to Dense)	4.0 to 6.0	1.5 to 8.0
3	Fine SAND with trace of silt (Medium Dense)	3.0 to 4.0	6.0 to 10.5
4	Organic SILT and SILT (Very Soft to Firm) with some PEAT lenses (Stiff to Very Stiff)	2.5 to 3.0	10.5 to 13.5
5	Interbedded Sandy SILT and Silty SAND (Soft; Loose to Medium Dense)	2.0	13.0 to 15.0
6	Sandy fine to medium GRAVEL (Dense to Very Dense)	-	15.0+

It is noted that the site investigation logs from immediately north east of the site differ from those immediately south of the site. The presence and extent of the shallow gravel layer needs to be verified.

Groundwater depths of approximately 1.0 m below ground surface in the east, and approximately 2.0 m below ground level in the west have been interpreted from the referenced site investigation logs. Whilst the site is outside its study area, maps available within Project Orbit[6] and within the GNS Science Median Groundwater Surface Elevation[7] report indicate that the median depth to the groundwater surface at the site is likely 1.0 to 3.0 m.

2.5 Liquefaction Hazard

2.5.1 Existing Studies

A liquefaction hazard study was conducted by the ECan in 2004 to identify areas of Christchurch that are susceptible to liquefaction during an earthquake. Maps prepared through this study identify the site as having either a “no liquefaction predicted” or “a low liquefaction potential may be expected” for both the high and low groundwater scenarios. The same ECan study classified the ground damage potentials of Christchurch areas, and the study identified the site as having a “no liquefaction ground damage potential” for the low groundwater scenario.

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[6] Project Orbit, Canterbury Geotechnical Database, Interagency/organisation collaboration portal for Christchurch recovery effort, https://canterburygeotechnicaldatabase.projectorbit.com/, accessed July 2013.

[6] GNS Science, “Median water table elevation in Christchurch and surrounding area after the 4 September 2010 Darfield Earthquake”, GNS Science Report 2013/01, 66p and 8 Appendices, March 2013.

Working for the EQC, T&T 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. No data was available for the site with respect to these maps. However, observations made at the surrounding roads and properties indicate

- Generally no liquefaction to moderate quantities of ejected liquefied material at the site after the September 2010 seismic event;
- Moderate quantities of ejected liquefied material observed on roads around the site after the February 2011 seismic event;
- Minor to moderate quantities of ejected liquefied material observed on roads around the site after the June 2011 seismic events; and
- No data available for on or around the site after the December 2011 seismic event.

In addition to the mapping described above, the referenced T&T report for Halswell School, as well as GNS Science liquefaction observation maps indicate that widespread surface expression of liquefaction was observed immediately south of the site after both the September 2010 and the February 2011 seismic events.

EQC maps showing ground cracks observed after the Canterbury Earthquake Sequence indicate that ground cracking occurred to the west of the site near the open channel stream adjacent to Halswell Road. More ground cracking was observed farther to the north and northeast of the site. These cracks generally ranged from less than 50 mm in width to up to 200 mm in width. These EQC maps are included in Appendix D. This suggests that there is a potential risk of lateral ground movement at the site, particularly in the western portion of the site that is nearer to the open channel stream adjacent to Halswell Road, as a result of a future seismic event.

Based on our liquefaction assessment, land situated within 50m of the open channel stream is considered to be susceptible to lateral spread in a future ULS event. Movement of the order of 100 to 200mm is possible. The risk of lateral spreading in an SLS event is considered to be low.

2.5.2 Technical Category

Following the recent strong earthquakes in Canterbury, CERA zoned land in the Greater Christchurch area according to its expected ground performance in future large earthquakes. The site was listed in the “Green” residential recovery zone.

MBIE further classified the CERA “Green” zone on the flat in Christchurch into technical categories (TCs). The three TCs are summarised in Table 2, which has been adapted from the referenced Guidance document (MBIE, 2012).

MBIE classified the Halswell Place housing complex as “N/A-Urban Non-residential”. However, the neighbouring residential properties have been generally zoned TC2, with the properties along the open water channel stream adjacent to Halswell Road zoned TC3. This indicates that minor to moderate land deformations are expected in future small to medium sized earthquakes and that moderate to significant land deformations in a future moderate to large earthquake.

Table 2: Technical Categories based on Expected Land Performance

Foundation Technical Category	Future land performance expected from liquefaction	Expected SLS land settlement	Expected ULS land settlement
TC 1	Negligible land deformations expected in a future small to medium sized earthquake and up to minor land deformations in a future moderate to large earthquake.	0-15 mm	0-25 mm
TC 2	Minor land deformations possible in a future small to medium sized earthquake and up to moderate land deformations in a future moderate to large earthquake.	0-50 mm	0-100 mm
TC 3	Moderate land deformations possible in a future small to medium sized earthquake and significant land deformations in a future moderate to large earthquake.	>50 mm	>100 mm

2.5.3 CPT Liquefaction Assessment

2.5.3.1 Analyses

A preliminary liquefaction assessment has been completed using the computer software CLiq[8]. A preliminary liquefaction assessment was conducted using data from six CPTs located within approximately 50 m of the site boundary. Only the results from six deep CPTs have been presented. CPT locations are identified in Figure 02 and in Figure 04. Note that of the available CPT data, only three CPTs penetrated through Layer No. 2, as presented in Table 1.

In accordance with Technical Specification 01, “Liquefaction Evaluation of CPT Investigations” (GCD, 2013)[9], the method presented by Idriss & Boulanger (2008)[10] with settlements calculated using the method presented by Zhang et al. (2002)[11] were utilised. A Magnitude 7.5 earthquake and Peak Ground Accelerations of 0.13 g and 0.35 g for the SLS1 and ULS design events have been applied. Observed groundwater levels as discussed in the referenced T&T report for Halswell School have been utilised in this preliminary liquefaction assessment: specifically, the groundwater elevation is assumed to be relatively uniform across the site, but with the depth to the groundwater table varying from approximately 2.0 m in the west to approximately 1.0 m in the east congruent with the variation in the ground surface elevation.

In addition to the Idriss & Boulanger (2008) method, the 1998 NCEER[12] method was applied together with the Zhang et al. (2002) method to estimate the free field

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[8] GeoLogismiki, *CLiq*, version 1.7.1.6. Computer software, 2006.

[9] Canterbury Geotechnical Database, “Liquefaction Evaluation of CPT Investigations”, Technical Specification 01, 21 May 2013.

[10] Idriss and Boulanger, *Soil Liquefaction During Earthquakes*, MNO-12, Earthquake Engineering Research Institute, 242p, 2008.

[11] Zhang, G., Robertson, P.K. and Brachman, R.W.I., “Estimating Liquefaction induced Ground Settlements From CPT for Level Ground”, *Canadian Geotechnical Journal*, 39(5): 1168-1180. 2002.

[12] Youd et al. (20 co-authors) (2001), “Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils”, *ASCE Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 127, No 4. pp 297-313. 2001.

liquefaction-induced vertical subsidence at the site. The free field liquefaction-induced vertical subsidences were estimated over the complete CPT depth (up 15.87 m for CPT_19226) as well as in the top 10 m of the soil profile. These estimates are presented in Table 3 for the six deep CPT's. The CLiq output for all the reviewed CPT's are presented in Appendix D.

Table 4 presents the Liquefaction Potential Index (LPI), which is calculated using the existing CPT data within CLiq, and the Liquefaction Severity Number (LSN), which was calculated utilising the CLiq output at each CPT location. The LPI is an indicator originally developed by Iwasaki et al. (1978, 1981 and 1982)[13,14,15] that aims to predict the performance of a soil column and the consequence of liquefaction at the ground surface. LPI is correlated to the depth of a liquefiable layer and its factor of safety against liquefaction. Table 5, which is adapted from information provided with CLiq, summarises the relationship between LPI and the risk of liquefaction occurring at a site.

The LSN is an indicator that was developed to compare test data with the observed liquefaction-induced ground damage attributes caused by the Canterbury Earthquake Sequence[16]. T&T correlated LSN to the predominant observed land performance and damage attributes. Table 13.1 within the referenced Liquefaction Vulnerability Study presents the results of this correlation, and this table is reproduced in Table 6 herein.

2.5.3.2 Results

Review of the liquefaction assessment results indicates that the site is likely have a high to very high risk of liquefaction and is likely to be affected by liquefaction-induced vertical ground settlements during a ULS design earthquake.

During a ULS design event, liquefaction-induced free field vertical subsidence of the order of 50 to 250 mm, are typically estimated for areas near the site. Due to the variable thicknesses of the encountered liquefiable layers, liquefaction-induced differential settlements would be expected to occur during the design ULS event. Magnitudes of these differential settlements are anticipated to be of the order of 50 to 200 mm for a ULS seismic event.

Based on the liquefaction-induced free field vertical subsidence's predicted to occur within the top 10 m, the site would likely correspond to a TC3 classification. Liquefaction induced subsidence greater than 50mm in an SLS event and greater than 100mm in a ULS event is anticipated.

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[13] Iwasaki, Tatsuoka, Tokida and Yasuda, "A practical method for assessing soil liquefaction potential based on case studies at various sites in Japan", *Proc. 2nd Int. Conf. on Microzonation*, San Francisco, pp. 885-896, 1978.

[14] Iwasaki, Tokida and Tatsuoka, "Soil liquefaction potential evaluation with use of the simplified procedure", *Intl. Conf. on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics*, St. Louis, pp. 209-214, 1981.

[15] Iwasaki, Arakawa and Tokida, "Simplified procedures for assessing soil liquefaction during earthquakes", *Proc. Conf. on Soil Dynamics and Earthquake Engineering*, Southampton, UK, pp. 925-939, 1982.

[16] Tonkin & Taylor Ltd, "Liquefaction Vulnerability Study", Prepared for the Earthquake Commission, T&T reference 52020.0200/v1.0, February 2013.

Table 3: Estimated Free Field Liquefaction-Induced Vertical Subsidence

Project Orbit CPT No. (Test Depth)	Event	Mag / PGA	Depth to Groundwater (m)	Estimated Free Field Liquefaction-Induced Vertical Subsidence (mm*)			
				Complete CPT Depth		Top 10 m of Soil Profile	
				NCEER$	I&B^	NCEER$	I&B^
CPT_19227 (15.46 m)	ULS	M7.5 / 0.35g	1.00	160	240	135	210
	SLS1	M7.5 / 0.13g	1.00	60	175	45	150
CPT_19226 (15.87 m)	ULS	M7.5 / 0.35g	1.00	100	160	60	110
	SLS1	M7.5 / 0.13g	1.00	20	85	15	55
CPT105% (6.28 m)**	ULS	M7.5 / 0.35g	2.00	20	35	N/A	N/A
	SLS1	M7.5 / 0.13g	2.00	N	15	N/A	N/A
CPT111% (14.57 m)**	ULS	M7.5 / 0.35g	2.20	140	210	90	145
	SLS1	M7.5 / 0.13g	2.20	65	130	45	95
CPT108% (7.92 m)**	ULS	M7.5 / 0.35g	1.20	15	35	N/A	N/A
	SLS1	M7.5 / 0.13g	1.20	N	15	N/A	N/A
CPT113% (5.45 m)**	ULS	M7.5 / 0.35g	2.00	20	25	N/A	N/A
	SLS1	M7.5 / 0.13g	2.00	N	N	N/A	N/A

* Rounded up to nearest 5 mm
^ Subsidence estimated utilising Idriss & Boulanger (2008) method
$ Subsidence estimated utilising NCEER (1998) method
N = Negligible (e.g. <10 mm)
** Note the shallow refusal of this CPT
% From referenced T&T report for Halswell School

Table 4: Calculated LPI and LSN for Design Seismic Event

Project Orbit CPT No.	Event	Mag / PGA	Depth to Groundwater (m)	Liquefaction Potential Index*		Liquefaction Severity Number*
				NCEER[$]	I&B^	NCEER[$]
CPT_19227 (15.46 m)	ULS	M7.5 / 0.35g	1.00	23	>20	38
	SLS1	M7.5 / 0.13g	1.00	1	4	14
CPT_19226 (15.87 m)	ULS	M7.5 / 0.35g	1.00	12	18	24
	SLS1	M7.5 / 0.13g	1.00	1	1	4
CPT105[%] (6.28 m)**	ULS	M7.5 / 0.35g	2.00	3	3	8
	SLS1	M7.5 / 0.13g	2.00	0	1	0
CPT111[%] (14.57 m)**	ULS	M7.5 / 0.35g	2.20	16	19	20
	SLS1	M7.5 / 0.13g	2.20	1	3	7
CPT108[%] (7.92 m)**	ULS	M7.5 / 0.35g	1.20	2	4	6
	SLS1	M7.5 / 0.13g	1.20	0	0	2
CPT113[%] (5.45 m)**	ULS	M7.5 / 0.35g	2.00	2	3	7
	SLS1	M7.5 / 0.13g	2.00	0	0	1

* Rounded up to nearest whole number

^ Estimated utilising Idriss & Boulanger (2008) method

[$] Estimated utilising NCEER (1998) method

** Note the shallow refusal of this CPT

[%] From referenced T&T report for Halswell School

Table 5: Correlation between LPI and Liquefaction Risk

LPI Range	Liquefaction Risk
LPI = 0	Very Low
0 < LPI ≤ 5	Low
5 < LPI ≤ 15	High
15 < LPI	Very High

Table 6: LSN Ranges and Observed Land Effects

LSN Range	Predominant Performance	Photographs in T&T (2013) Appendix N
0-10	Little to no expression of liquefaction, minor effects	Figure N7a-y
10-20	Minor expression of liquefaction, some sand boils	Figure N8a-y
20-30	Moderate expression of liquefaction, with sand boils and some structural damage	Figure N9a-t
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage	Figure N10a-v
40-50	Major expression of liquefaction, undulations and damage to ground surface; severe total and differential settlement of structures	Figure N11a-p
>50	Severe damage, extensive evidence of liquefaction at surface, severe total and differential settlements affecting structures; damage to services	Figure N12a-x

Note: Table from Tonkin & Taylor Ltd (2013); LSN derived from Canterbury Earthquake Sequence observations

3 Site Walkover Inspection

A site walkover inspection of the Halswell Courts housing complex was carried out by Opus Geotechnical Engineers on 12 June 2013 and on 11 July 2013. Photographs of significant observations were taken during the site walkover inspection with selected photographs presented in Appendix B and their locations and directions of view approximated on Figure 03. The following observations were made during the site walkover:

- Cracking of the southern fence foundations and extension/deformation of the fence panels (typified by Photos 10 through 12 in Appendix B)
- Minor to moderate stepping cracks within the brick veneer of Flats 6, 7, and 15 (typified by Photos 21 through 23 in Appendix B)
- Moderate extensional cracking within the concrete slab floor of Flat 8 associated with moderate cracking of the foundations (typified by Photos 26 through 28 in Appendix B)
- Cracking of concrete footpath between Flats 1 and 8 and at front of Flat 15 (typified by Photos 29 through 31 in Appendix B)
- Differential movement of concrete footpaths behind Flats 6-8 and in front of Flat 8 (typified by Photos 25 and 32 in Appendix B)
- Grey SILT/SAND ejecta behind Flats 6 and 15 (typified by Photos 13, 16 and 17 in Appendix B)
- Ground settlement in behind Flats 6 and 15 (typified by Photos 14 and 15 in Appendix B)
- Shallow ground depression in front of Flats 1-3 (refer to Photos 18 and 19 in Appendix B)

- Tilting light post in front of Flat 3. However, the cause for this tilting may be due to the location of the light post relative to nearby trees (refer to Photo 20 in Appendix B)

Due to the amount of time since the Canterbury Earthquake Sequence events, signs of land damage, which may have existed immediately after the earthquakes, may have been cleared or become less apparent by the time the Opus site walkover inspections were conducted.

4 Level Survey

A summary of the level survey undertaken by Opus Christchurch Surveyors on 12 June 2013 at the Halswell Courts housing complex is given in Table 7.

Table 7: Summary of Level Survey Results

Block	Unit No.	Elevation Difference (mm)	Distance (m)	Slope (mm/m)
A	1	32	6	5
	2	14	4	4
	3	20	4	5
	4	28	10.5	3
	5	20	7	3
B	6	48	6	8
	7	25	7	4
	8	30	7	4
	9	16	10.5	2
	10	26	6	4
C	11	28	6	5
	12	12	6	2
	13	12	4	3
	14	12	6	2
	15	40	4.7	9

5 Discussion

All the flats at the Halswell Courts housing complex are supported on reinforced concrete perimeter footings with reinforced concrete slab floors. These buildings are considered to be equivalent to “Type C2” in accordance with the MBIE (2012) guidance.

Minor to moderate liquefaction damage occurred at the Halswell Courts housing complex as a result of the 2010 and 2011 earthquake sequence. At the time of the 11 July 2013 inspection, evidence of ejected material and ground settlement was observed. Some of the damage to the concrete footpaths appears to be a result of liquefaction-induced settlement. Some minor to moderate cracking within the building footings and walls was observed.

The level survey results have been assessed and indicated large floor level variations (i.e. maximum falls greater than 5 mm/m) in flats 6 and 15 at the Halswell Courts housing complex. In accordance with Table 2.3 the MBIE (2012) guidance, the units with maximum falls greater than 5 mm/m foundation relevel is indicated. For the remaining units no relevel is considered necessary.

Machine boreholes, CPTs and hand auger boreholes indicate that the residential complex is likely to be founded on soft to firm Sandy SILT and SILT interbedded with some loose Silty SAND and SAND, overlying a variable thickness of medium dense to dense Sandy GRAVEL and SAND, overlying very soft to firm Organic SILT and SILT, overlying interbedded soft Sandy SILT and loose to medium dense Silty SAND; overlying Riccarton Formation. Groundwater layers are expected to be of approximately 1.0 to 2.2 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 utilising data from nearby CPTs identified liquefiable layers throughout the majority of the sub-surface profile. The sub-surface 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 to very high risk of liquefaction and that further ground subsidence and differential settlements are likely during a future design seismic event.

GNS Science and the EQC indicate on GeoNet[17] that there is an elevated risk of seismic activity in the Canterbury region as a result of the earthquake sequence following the September 2010 earthquake. Recent advice on 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. Depending on the epicentre location, such an event could cause liquefaction-induced land damage at the site similar to what was experienced in 2010 and 2011.

Based on our liquefaction assessment the site is considered to be equivalent to a TC3 site and that portions of the site within 50m of the open channel may spread laterally during in a ULS event.

6 Recommendations

In order to determine foundation repair options at the Halswell Courts housing complex, it is recommended that a site specific investigation is undertaken at the site comprising CPTs, hand auger boreholes and Dynamic Cone Penetrometer (DCP) tests (i.e. “Scalas”). An integrated CPT rig is recommended to allow for predrilling of shallow gravel levels if encountered. The site investigation will enable a site specific liquefaction assessment to

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[17] GNS Science and the Earthquake Commission, “Canterbury region long-term probabilities” in “Aftershocks” on “GeoNet”, available online at http://info.geonet.org.nz/display/home/Aftershocks, accessed 22 July 2013.

and re-levelling options. The recommended scope of the proposed site specific geotechnical investigations comprises the following:

- A series of integrated CPTs with allowance for predrilling of shallow gravel if encountered;
- Several hand auger boreholes and DCP tests carried out to depths of 3 m or refusal;
- Assessment and reporting.

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 and/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 the assessments 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.

For and on behalf of Opus International Consultants Ltd,

Prepared By:	Reviewed By:
Riley Gerbrandt	Graham Brown
Geotechnical Engineer	Senior Geotechnical Engineer

Figures:

Figure 01	Site Locality Map
Figure 02	Site Vicinity Map
Figure 03	Site Walkover Plan
Figure 04	T&T Site Investigation Plan

Appendices:

Appendix A	Construction Drawings
Appendix B	Selected Site Walkover Photographs
Appendix C	Surrounding Site Investigation Data
Appendix D	EQC Map Output

Appendix E CLiq Liquefaction Analysis Output

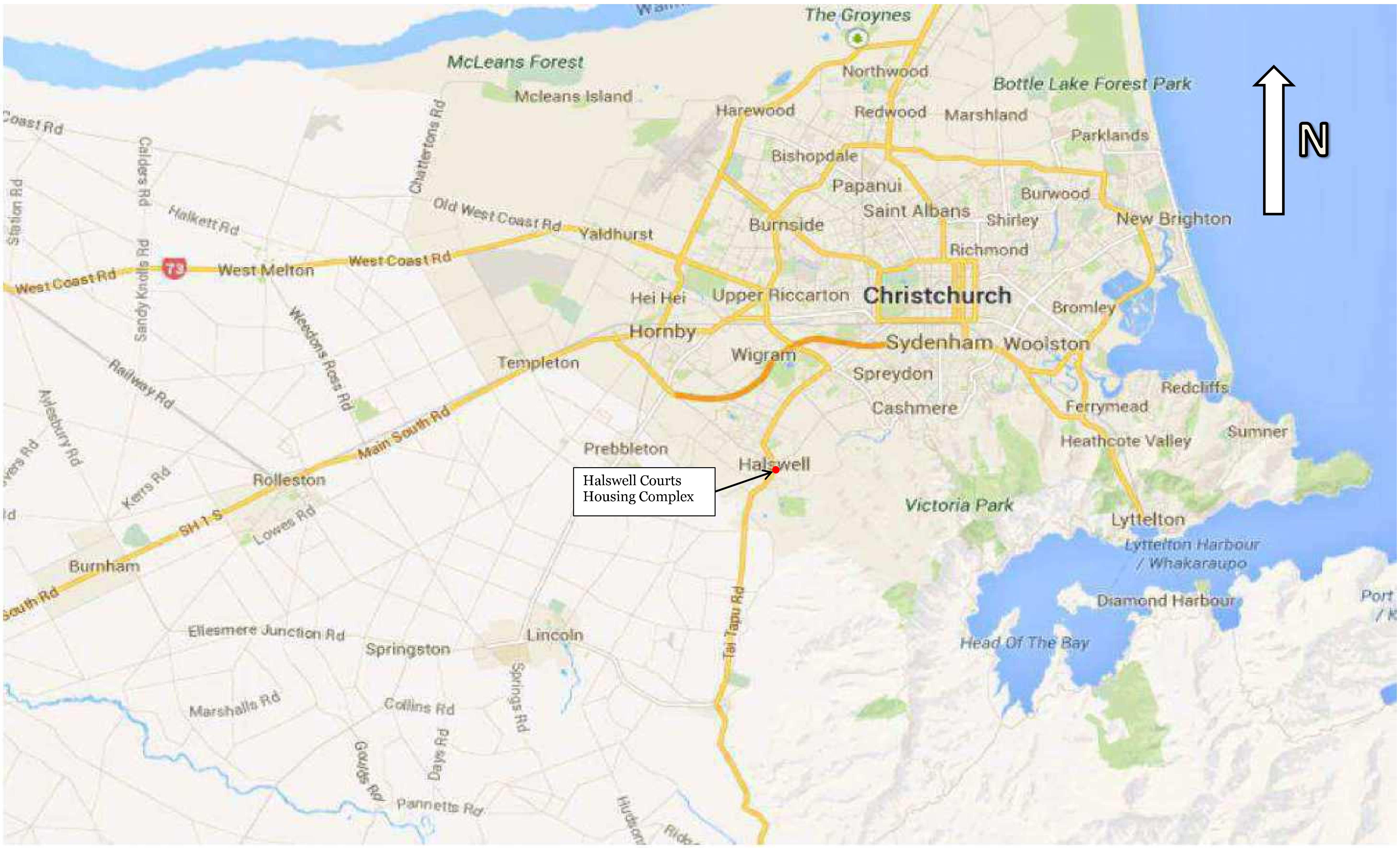
Appendix E.1 CLiq NCEER (1998) SLS1 Liquefaction Analysis Output

Appendix E.2 CLiq Idriss and Boulanger (2008) SLS1 Liquefaction Analysis Output

Appendix E.3 CLiq NCEER (1998) ULS Liquefaction Analysis Output

Appendix E.4 CLiq Idriss and Boulanger (2008) ULS Liquefaction Analysis Output

Figures



SOURCE: Google Maps (Accessed on 22/7/2013)

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

Project: Halswell Courts, 38 Kennedys Bush Road, Halswell
Project No.: 6-QC355.00
Client: Christchurch City Council

Figure 01: Site Locality Map

Drawn: Opus Geotechnical Engineer
Scale: Not to Scale
Date: 22-Jul-13

SOURCE: https://canterburygeotechnicaldatabase.projectorbit.com/ (Accessed on 15/7/2013)

OPUS

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Project: Halswell Courts, 38 Kennedys Bush Road, Halswell
Project No.: 6-QC355.00
Client: Christchurch City Council

Figure 02: Site Vicinity Map

Drawn: Opus Geotechnical Engineer
Scale: Not to Scale
Date: 22-Jul-13

SOURCE: Google Maps (Accessed on 22/7/2013)

OPUS
Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Ave
PO Box 1482
Christchurch, New Zealand
Tel: +64 3 363 5400   Fax: +64 3 365 7857

Project:	Halswell Courts, 38 Kennedys Bush Road, Halswell
Project No.:	6-QC355.00
Client:	Christchurch City Council

Figure 03: Site Walkover Plan

Drawn:	Opus Geotechnical Engineer
Scale:	Not to Scale
Date:	22-Jul-13

Legend:

CPTs assessed for liquefaction potential

SOURCE: Tonkin and Taylor Ltd, "Halswell School, Geotechnical Investigation and Assessment Report", T&T Ref: 53062.004, Prepared for Ministry of Education, February 2013

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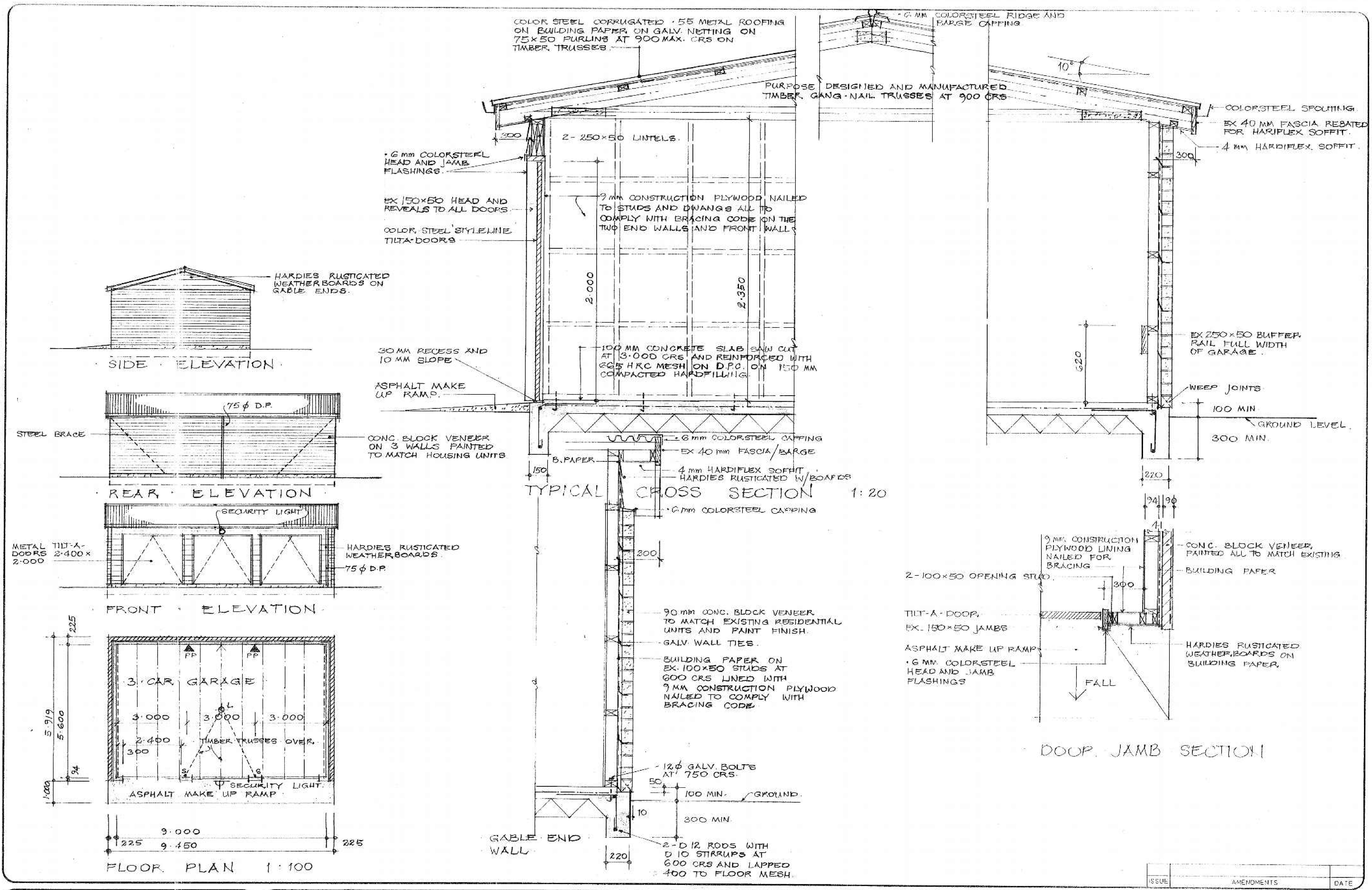
Project: Halswell Courts, 38 Kennedys Bush Road, Halswell
Project No.: 6-QC355.00
Client: Christchurch City Council

Figure 04: T&T Site Investigation Plan

Drawn: Opus Geotechnical Engineer
Scale: Not to Scale
Date: 22-Jul-13

Appendix A

Construction Drawings



ISSUE	AMENDMENTS	DATE

CITY DESIGN

CHRISTCHURCH
THE GARDEN CITY
The city that shines

	INITIALS	DATE		
DESIGNED			DATUM	
DRAWN	G.F.H.	14.7.97	BENCH MK.	
TRACED			SURVEY FB	
DRW. CHK.			SURVEY LB	
DES. CHK.			CONSTN. EB	
INDEXED			CONSTN. LB	

APPROVED
17/7/97
DATE
CITY DESIGN MANAGER

DRAWING TITLE FLOOR PLAN · ELEVATIONS · SECTIONS

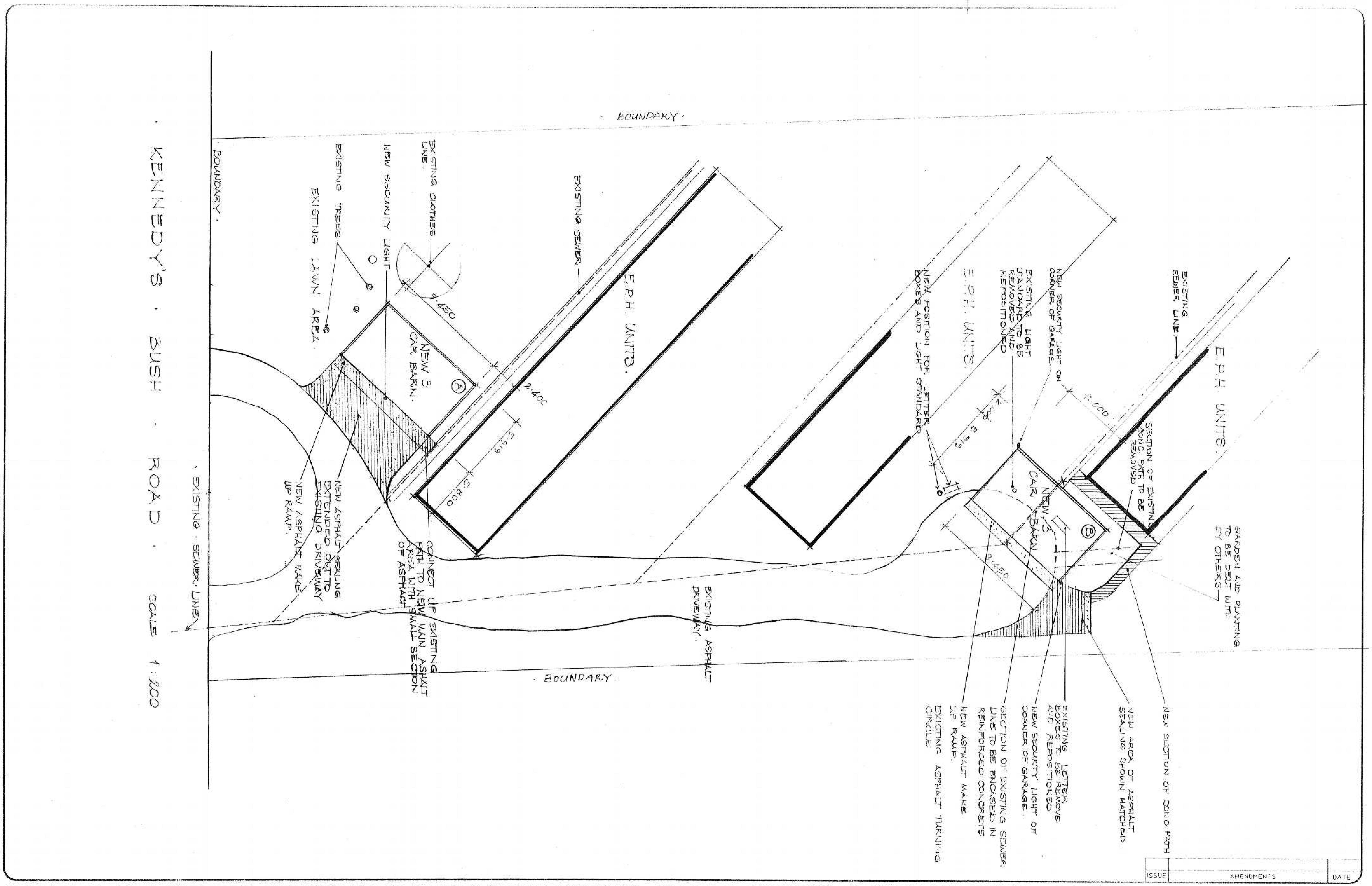
KENNEDY'S BUSH ROAD E.P.H.
6 NEW GARAGES.

SCALES
1:100
1:20

C.N. 97 98 37

509·86

SHEET 1 OF 2



CITY DESIGN

CHRISTCHURCH
THE GARDEN CITY
The city that shines

	INITIALS	DATE			APPROVED
DESIGNED			DATUM		17/7/97
DRAWN	G.F.H.	14.7.97	BENCH MK		DATE
TRACED			SURVEY FB		
DRW. CHK.			SURVEY LB		
DES. CHK.			CONSTN. FB		
INDEXED			CONSTN. LB		CITY DESIGN MANAGER

DRAWING TITLE · SITE · PLAN ·

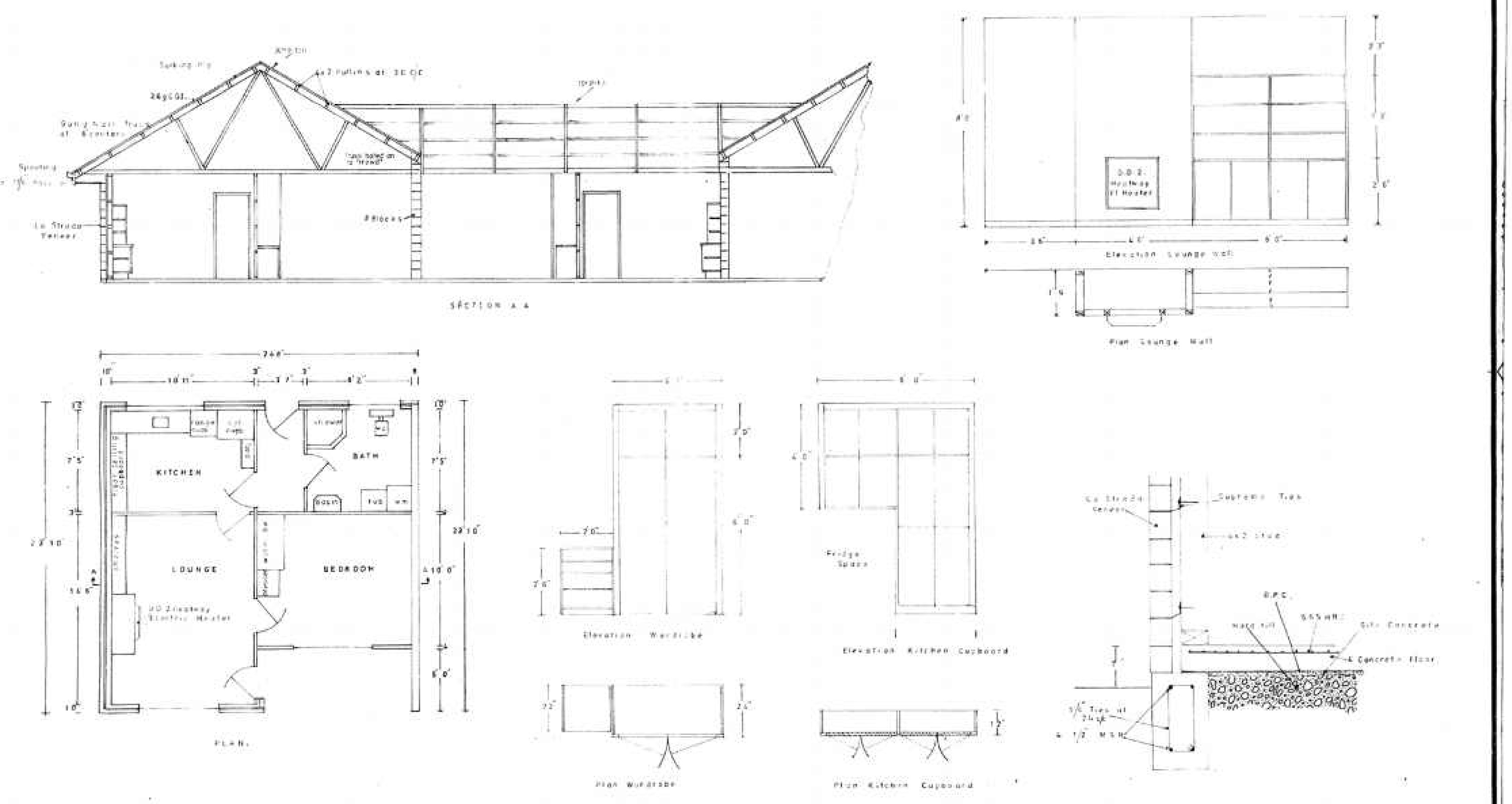
KENNEDY'S BUSH ROAD E.P.H.
& NEW GARAGES.

SCALES
1:200

C.N. 97/98-37

509·86

SHEET 2 OF 2



D5288

Amendments	Initial	Date		Initial	Date
			Surveyed		
			Drawn	T.J.B.	1 Sept 72
			Designed	-	-
			Traced	-	-
			Checked	-	-
			Filed		

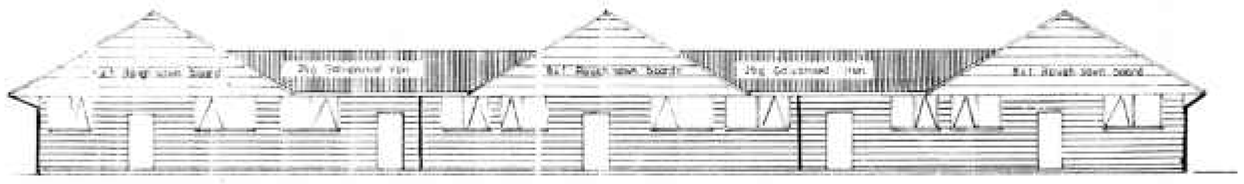
PAPARUA COUNTY COUNCIL

HALSWELL COURTS

APPROVED
M. Ashby M.N.Z.I.E. County Engineer

Datum				
	Book	Page	Initial	Date
Survey				
Levels				

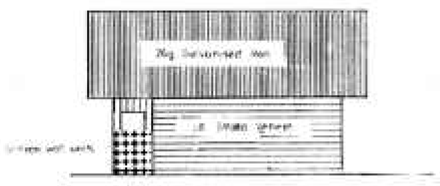
SCALE 1/2" = 1ft
Issue
DWG Nº B 600/2
Sheet Nº of sheets
A1



SOUTH EAST ELEVATION

NORTH EAST ELEVATION

NORTH WEST ELEVATION



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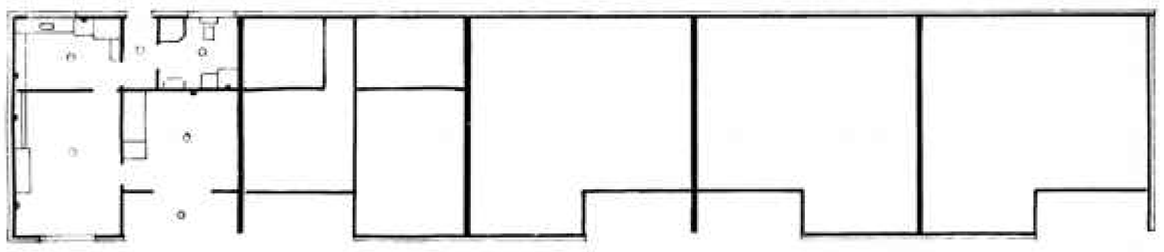


PLAN

lights

● points

Amendments	Initial	Date		Initial	Date
			Surveyed		
			Drawn	T.J.B.	Sept 72
			Designed		
			Traced		
			Checked		
			Filed		

PAPARUA COUNTY COUNCIL

HALSWELL COURTS

APPROVED

M.N.Z.I.E. County Engineer

Datum				
	Book	Page	Initial	Date
Survey Levels				

SCALE

DWG Nº B 600/3

Sheet Nº of sheets

A1

D 238

Appendix B

Selected Site Walkover Photographs


Photo 1: View Behind Flats 3-5, Looking Southeast


Photo 2: View Behind Flats 1-5, Looking East


Photo 3: View Behind Flats 13-15, Looking West


Photo 4: View of Driveway, Flat 11 and Garages, Looking West

OPUS	Christchurch City Council		**Site Walkover Photographs**
	22/07/2013	**6-QC355.00**	**Geotechnical Desktop Study** **Halswell Courts, Halswell, Christchurch**


Photo 5: View behind Flat 11, Looking West (Garages in Foreground)


Photo 6: View of Front of Flats 11-15, Looking South


Photo 7: View Behind Flats 6-14, Looking South


Photo 8: View of Stream alongside Halswell Road, Looking South-Southwest

OPUS	Christchurch City Council		**Site Walkover Photographs**
	22/07/2013	**6-QC355.00**	**Geotechnical Desktop Study** **Halswell Courts, Halswell, Christchurch**

Photo 9: View of Stream alongside Halswell Road, Looking Southwest

Photo 10: View Cracked Southern Fence Foundation, Looking Southwest

Photo 11: View of Southern Fence Distortion, Looking West

Photo 12: View of Extension within Southern Fence, Looking South

OPUS	Christchurch City Council		**Site Walkover Photographs**
	22/07/2013	**6-QC355.00**	**Geotechnical Desktop Study** **Halswell Courts, Halswell, Christchurch**


Photo 13: Ejecta along Southern Fence Behind Flat 15, Looking South


Photo 14: View of Ground Settlement behind Flat 15, Looking Southwest


Photo 15: View of Ground Settlement behind Flat 15, Looking Southeast


Photo 16: Ejecta behind Flat 6, Looking Northwest

OPUS	Christchurch City Council		Site Walkover Photographs
	22/07/2013	6-QC355.00	Geotechnical Desktop Study Halswell Courts, Halswell, Christchurch


Photo 17: Ejecta behind Flat 6, Looking Northwest


Photo 18: Shallow Depression in Front of Flat 1, Looking East


Photo 19: Shallow Depression in Front of Flats 1-3, Looking Northeast


Photo 20: Leaning Light Post in Front of Flat 3, Looking Southeast

OPUS	Christchurch City Council		**Site Walkover Photographs**
	22/07/2013	**6-QC355.00**	**Geotechnical Desktop Study** **Halswell Courts, Halswell, Christchurch**


Photo 21: Minor Stepping Crack at Back of Flat 6, Looking Northwest


Photo 22: Moderate Stepping Crack at Back of Flat 7, Looking Northwest


Photo 23: Moderate Stepping Crack at Back of Flat 7, Looking Northwest


Photo 24: Displacement in Concrete Footpath at Front of Flat 15, Looking Northeast

OPUS	Christchurch City Council		**Site Walkover Photographs**
	22/07/2013	**6-QC355.00**	**Geotechnical Desktop Study** **Halswell Courts, Halswell, Christchurch**

Photo 25: Displacement in Concrete Footpath at Front of Flat 15, Looking South

Photo 26: Foundation Cracking at Front of Flat 8, Looking Southeast

Photo 27: Cracking of Concrete Slab Floor in Flat 8

Photo 28: Cracking of Concrete Slab Floor in Flat 8

OPUS	Christchurch City Council		**Site Walkover Photographs**
	22/07/2013	**6-QC355.00**	**Geotechnical Desktop Study** **Halswell Courts, Halswell, Christchurch**

Photo 29: Cracking of Concrete Footpath Behind Flat 6, Looking Northwest

Photo 30: Cracking of Concrete Footpath behind Flat 1, Looking North

Photo 31: Cracking of Concrete Footpath behind Flat 1, Looking Northeast

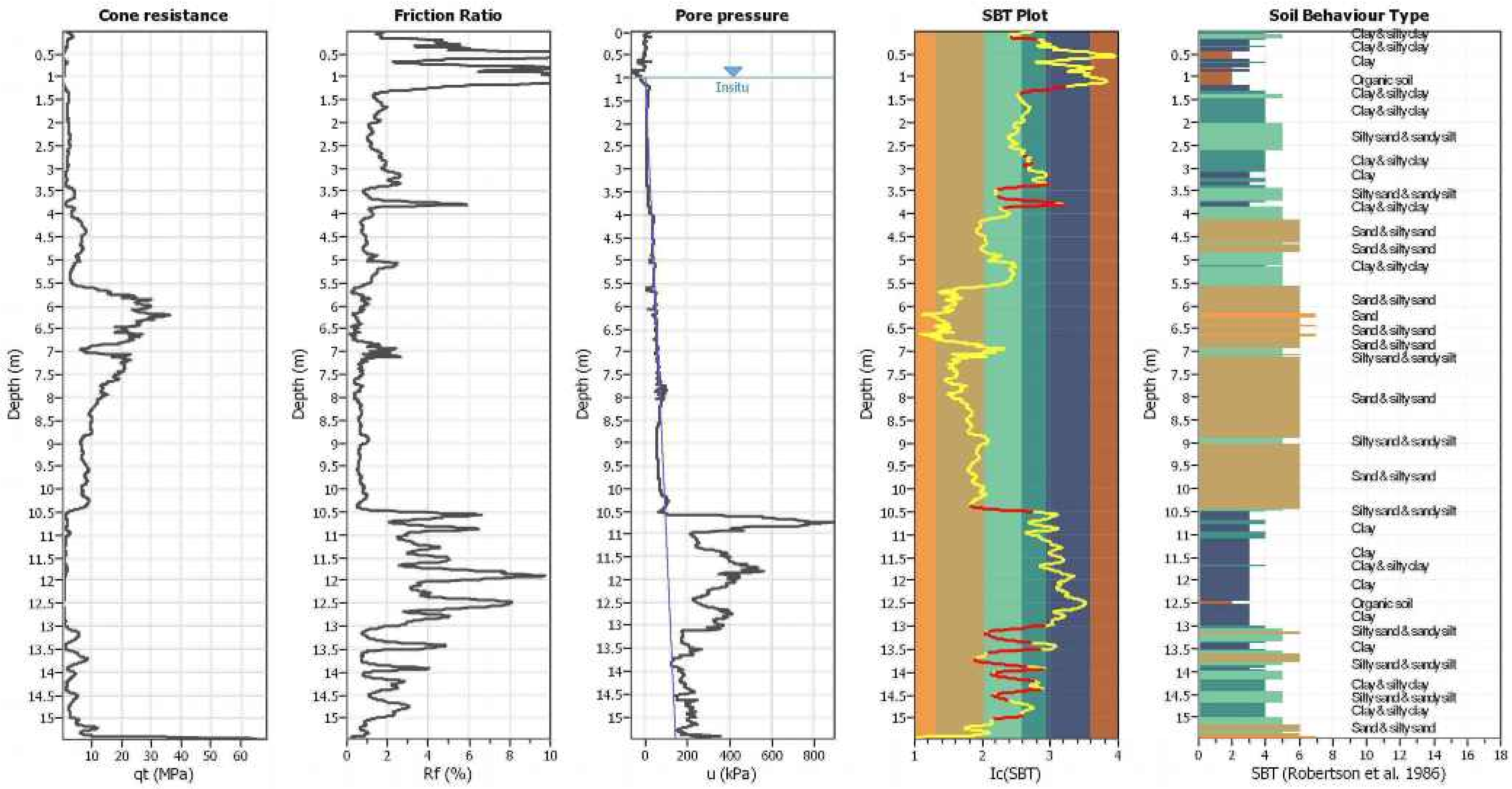
Photo 32: Subsidence Tilting of Concrete Footpath behind Flats 6-8, Looking Southwest

OPUS	Christchurch City Council		**Site Walkover Photographs**
	22/07/2013	**6-QC355.00**	**Geotechnical Desktop Study** **Halswell Courts, Halswell, Christchurch**

Appendix C

Surrounding Site Investigation Data

CPT basic interpretation plots



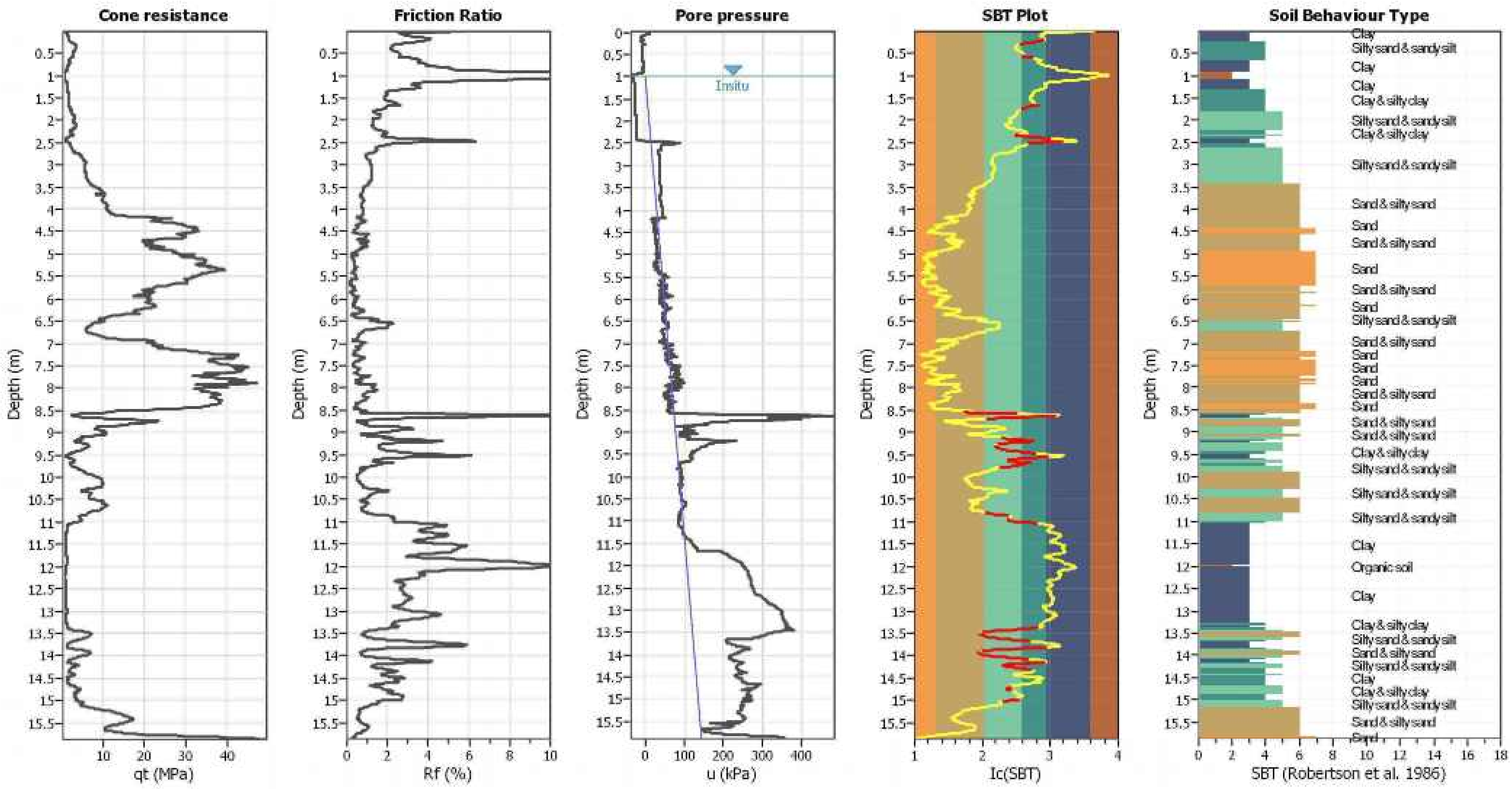
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to
⬜ 9. Very stiff fine grained

CPT basic interpretation plots



Input parameters and analysis data

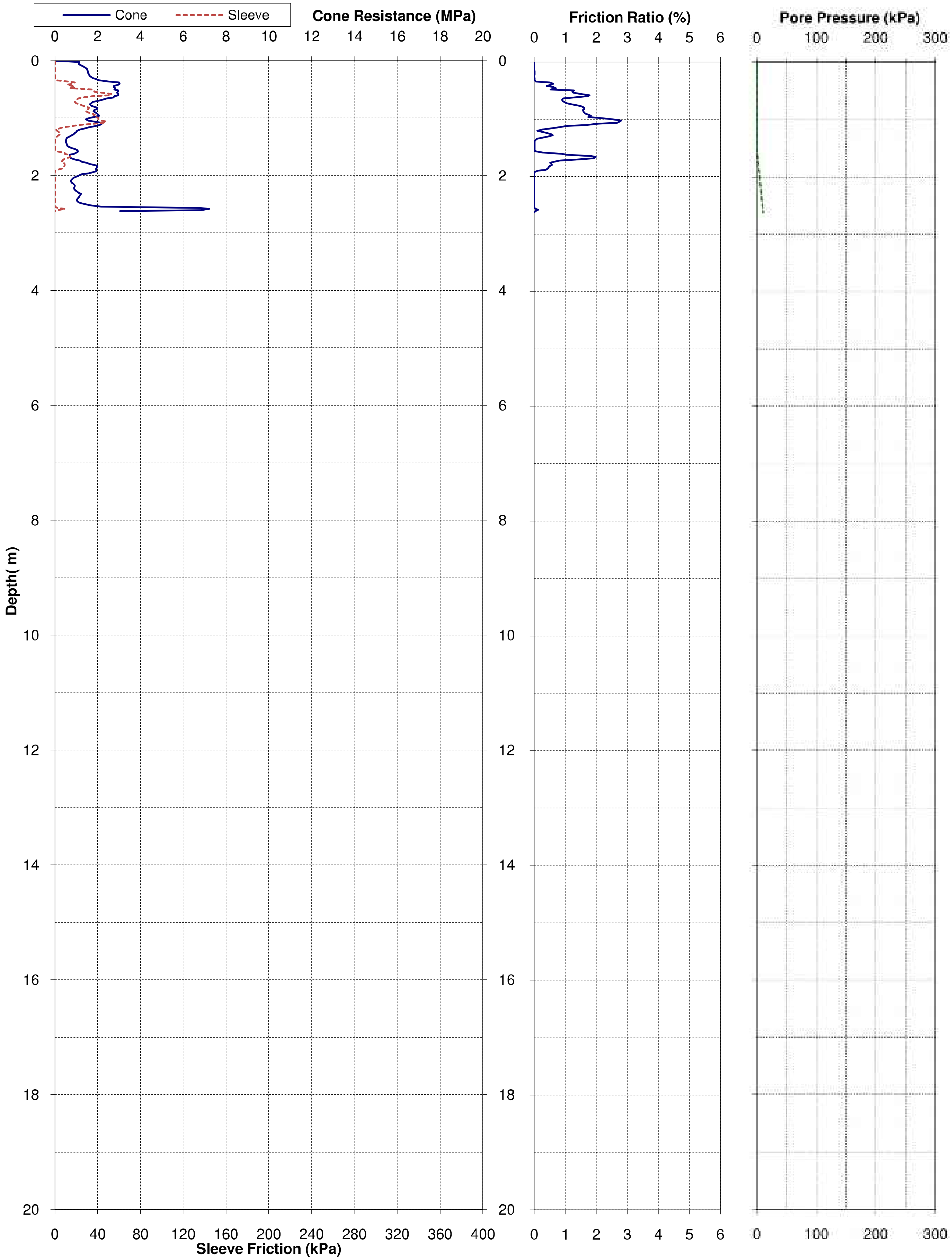
Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟨 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

Project:	Darfield 2010 Earthquake - EQC Ground Investigations			**Page:**	1 of 1
Test Date:	5-Oct-2010	**Location:**	Halswell	**Operator:**	Geotech
Pre-Drill:	0m	**Assumed GWL:**	1.5mBGL	**Located By:**	Survey GPS
Position:	2475359.6mE	5735244.7mN	13.307mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	

CPT-HAL-07



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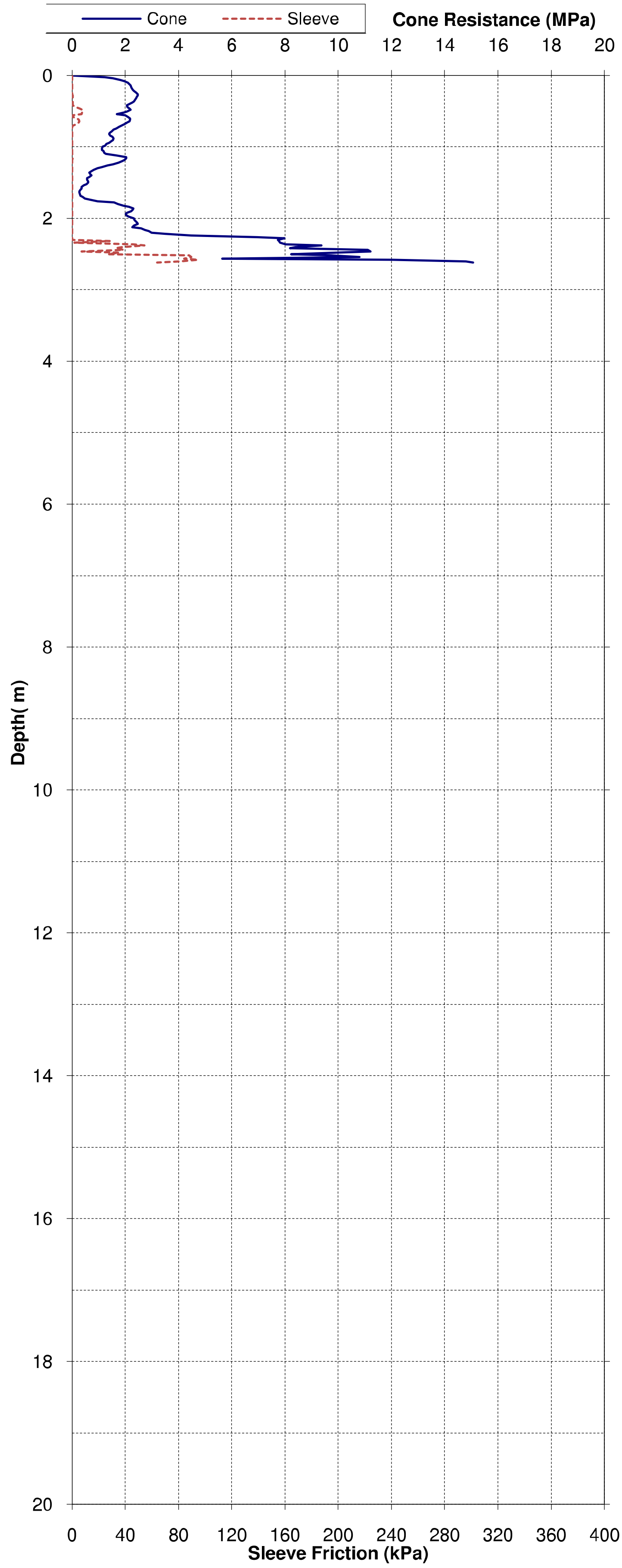
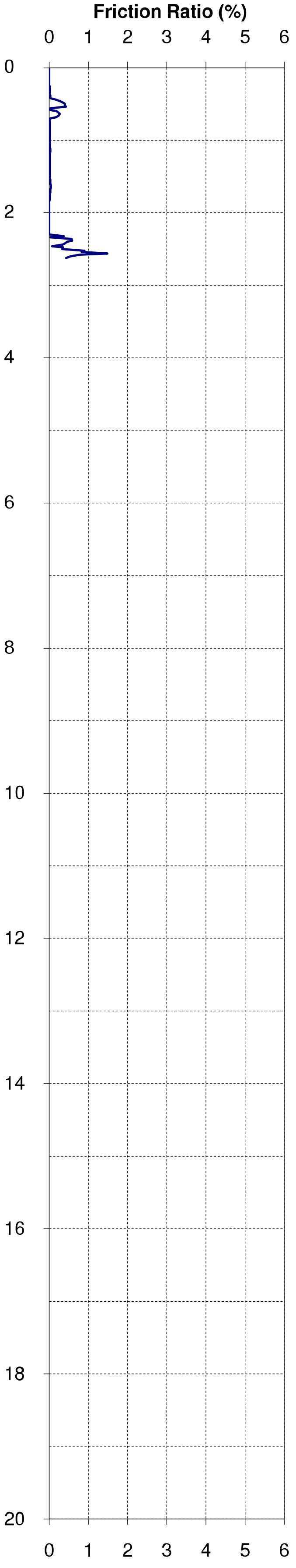
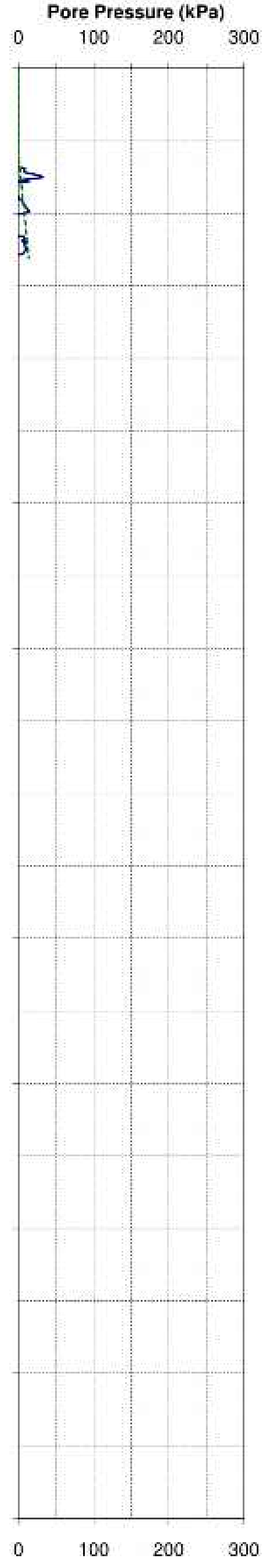
Project:	Darfield 2010 Earthquake - EQC Ground Investigations			**Page:**	1 of 1
CPT-HAL-04					
Test Date:	4-Oct-2010	**Location:**	Halswell	**Operator:**	Geotech
Pre-Drill:	0m	**Assumed GWL:**	1.2mBGL	**Located By:**	Survey GPS
Position:	2475264.5mE	5735209.4mN	14.117mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	







Project:	Darfield 2010 Earthquake - EQC Ground Investigations			**Page:**	1 of 1
Test Date:	4-Oct-2010	**Location:**	Halswell	**Operator:**	Geotech
Pre-Drill:	0m	**Assumed GWL:**	1.5mBGL	**Located By:**	Survey GPS
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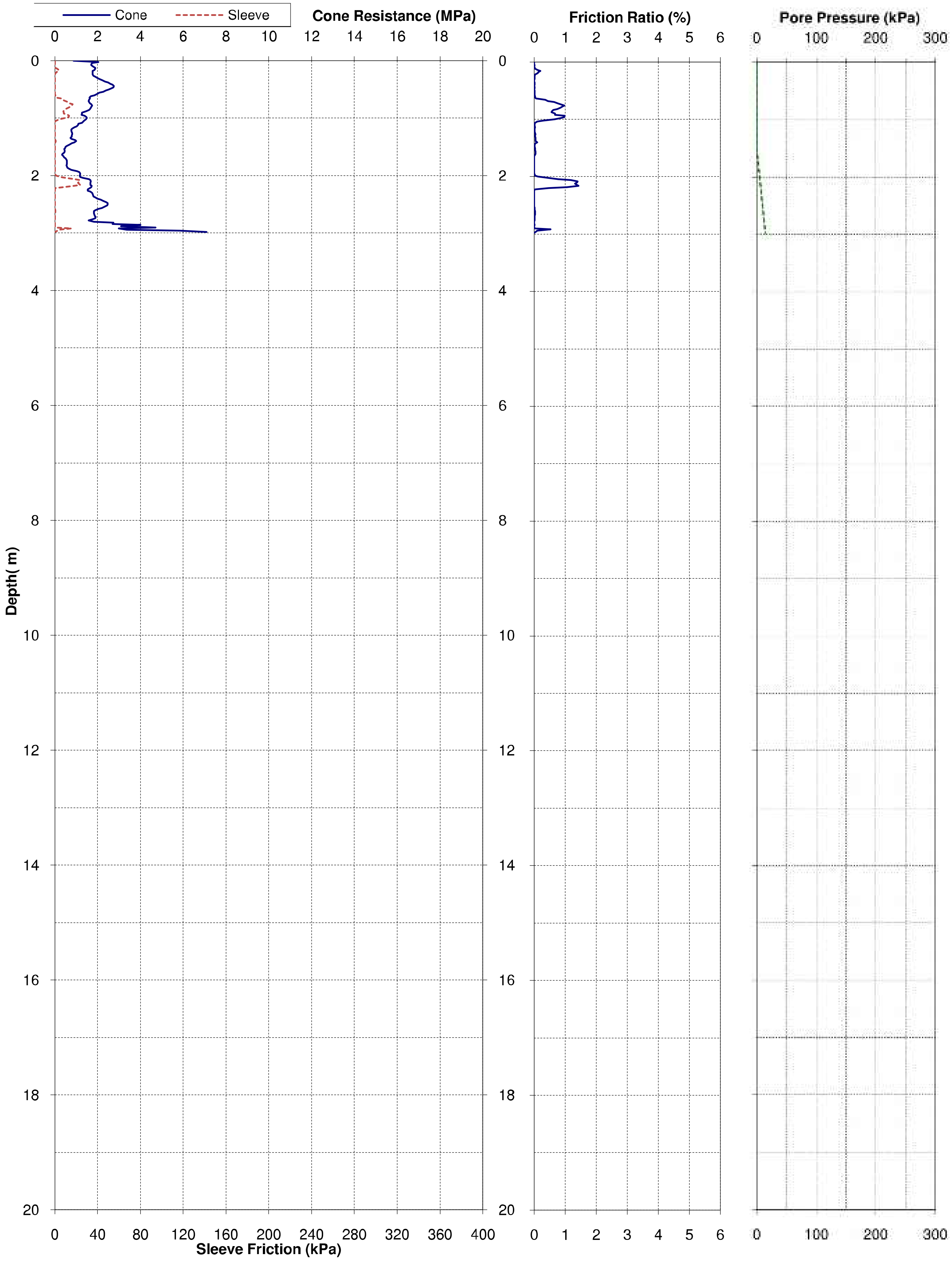
Other Tests:				**Comments:**	

CPT-HAL-05



LEGEND

HA 105	Hand Auger Locations (2012)
TP 104	Test Pit Locations (2012)
CPT 10	Cone Penetration Test Locations (2010)
CPT 111	Cone Penetration Test Locations (2012)
CPT 111	Proposed Cone Penetration Test Locations
BH2	Borehole Test Locations (2010)
BH 101	Borehole Test Locations (2012)

A3 SCALE 1: 1000

0 5 10 15 20 30 40 50 (m)

NOTES:
1. Aerial photo sourced from Land Information New Zealand data (Crown Copyright Reserved).
2. Base concept drawing supplied by Brewer Davidson Achitecture & Urban Design

Tonkin & Taylor
Environmental and Engineering Consultants
33 Parkhouse Road, Wigram, Christchurch
www.tonkin.co.nz

DRAWN	NSW	Jan. 13
DRAFTING CHECKED		
APPROVED		

CADFILE :
CADFILE

SCALES (AT A3 SIZE)
1: 1000

PROJECT No.
53062.004

MINISTRY OF EDUCATION

HALSWELL PRIMARY SCHOOL
437 HALSWELL ROAD, HALSWELL

Investigation Location Plan

FIG. No. 53062.004–F1

REV. 0

P:\53062\53062.0040\WorkingMaterial\CAD\53062.004-F1.dwg, F1, 24/01/2013 4:58:10 p.m., nsw

Engineering Log Terminology

GENERAL

Soil and rock descriptions follow the “Guidelines for the field classification and description of soil and rock for engineering purposes” by the New Zealand Geotechnical Society (2005). Refer to this document for methods of field determination.

Water

Water level on date shown	▼
Water inflow	▶
Water outflow	◀

Core recovery

Expressed as percentage of the length of the core run recovered.

Drilling method/casing

Shows drilling method and depth of casing.

Common types:

OB	Open barrel
W	Wash
HQ3	HQ triple tube
PQ3	PQ triple tube coring
HSA	Hollow Stem Auger
WS	Window Sampler

Graphic logs

The graphic log shows soil and rock types. The defect log indicates the location, orientation and abundance of defects of all types.

Typical material symbols:

▨	Organic material	▨	Igneous rock
▨	Clay	▨	Mudstone
▨	Silt	▨	Siltstone
▨	Sand	▨	Sandstone
▨	Gravel or Conglomerate	▨	Metamorphic Rock

Tests

- **N=22:**SPT uncorrected blow count for 300 mm
- **75/12:**Undrained shear strength (peak /residual as measured by field vane.

Laboratory test(s) carried out:

PMT	Pressuremeter test
LT	Lugeon test
LV	Laboratory vane
AL	Atterburg limits
UU	Undrained triaxial
PSD	Particle size
c’ Ø’	Effective stress
CONS	Consolidation
DS	Direct shear
COMP	Compaction
UCS	Unconfined compression
IS	Point load

Installation type

◫	Standpipe	▥	Slotted standpipe
◆	VWP	■	Bentonite seal
▨	Filter pack		

Sample type

▤	Spt	◩	Other
◧	Thin-wall tube	☒	Core or Sample loss
◫	Bulk sample		

SOIL DESCRIPTION

Moisture content

D	Dry, looks and feels dry
M	Moist, no free water on hand when remoulding
W	Wet, free water on hand when remoulding
S	Saturated, free water present on sample

Consistency/undrained shear strength

		S_u **(kPa)**
VS	Very soft	< 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very stiff	100 to 200
H	Hard	> 200

Density index

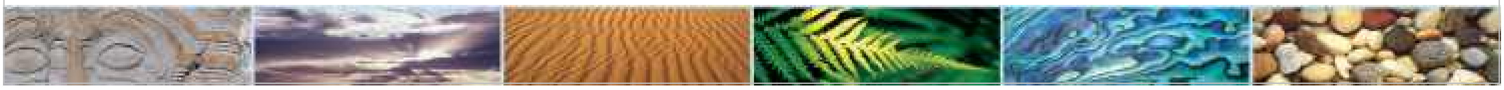
		SPT(N) - uncorrected
VL	Very loose	0 to 4
L	Loose	4 to 10
MD	Medium dense	10 to 30
D	Dense	30 to 50
VD	Very dense	> 50

Proportional terms definition (Coarse soils)

Fraction	**Term**	**% of soil mass**	**Example**
Major	(UPPER CASE)	Major constituent	Gravel
Subordinate	(lower case)	> 20	Sandy
Minor	with some... with minor...	12 - 20 5 - 12	with some sand with minor sand
	with trace of... (or slightly)...	< 5	with trace of sand (slighly sandy)

Grain size criteria

Type	**Coarse**								**Fine**	
	Boulders	Cobbles	Gravel			Sand			Silt	Clay
			Coarse	Medium	Fine	Coarse	Medium	Fine		
Size range (mm)	200	60	20	6	2	0.6	0.2	0.06	0.002	



TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BH1
Hole Location: Playing Field

SHEET 1 OF 1

PROJECT: Geotechnical Investigation
LOCATION: Halswell Primary School
JOB No: 51751

CO-ORDINATES 5173589mN
1565319mE
R.L. m
DATUM

DRILL TYPE: Mobile Truck
DRILL METHOD: Hollow Flyght Auger
DRILL FLUID: N/A

HOLE STARTED: 4/10/10
HOLE FINISHED: 4/10/10
DRILLED BY: Geotech Drilling
LOGGED BY: BMcD
CHECKED: PMM

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	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.
SPRINGSTON FORMATION YALDHURST MEMBER ALLUVIAL SAND AND OVERBANK SILT		04/10/10 ▼		HOLLOW FLYGHT AUGER					0	SW						SAND and SILTY SAND, fine to medium, grey brown layers.
									2.6	SW/GW						Gravelly SAND and Sandy Gravel and sand, fine to medium, grey, layers 0.1m - 0.3m, trace to some coarse gravel.
						5 6 7 N=13	1		3							
						13 16 >20 N>50	2		4.5							
						25 25 - N>50	3		6							
						18 26 25 N>50	4		7.5							
									8	ML/SW						SILT and SILTY SAND, fine, low plasticity to non plastic, layers 0.1m - 0.2m.
						5 14 17 N=32	5		9							
									9.45							END OF BOREHOLE AT 9.45m

T+T DATATEMPLATE.GDT mm

BORELOG 51751.GPJ 19/10/10

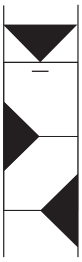
Tonkin & Taylor

Engineering Log Terminology

GENERAL

Soil and rock descriptions follow the "Guidelines for the field classification and description of soil and rock for engineering purposes" by the New Zealand Geotechnical Society (2005). Refer to this document for methods of field determination.

Water



Water level on date shown

Water inflow

Water outflow

Core recovery

Expressed as percentage of the length of the core run recovered.

Drilling method/casing

Shows drilling method and depth of casing.

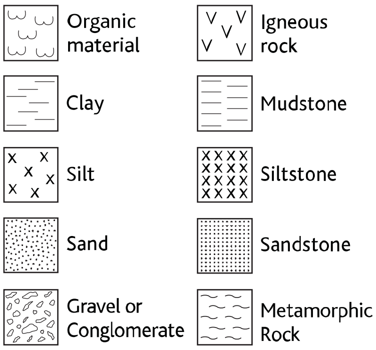
Common types:

OB	Open barrel
W	Wash
HQ3	HQ triple tube
PQ3	PQ triple tube coring
HSA	Hollow Stem Auger
WS	Window Sampler

Graphic logs

The graphic log shows soil and rock types. The defect log indicates the location, orientation and abundance of defects of all types.

Typical material symbols:



Organic material

Igneous rock

Clay

Mudstone

Silt

Siltstone

Sand

Sandstone

Gravel or Conglomerate

Metamorphic Rock

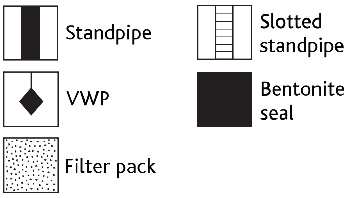
Tests

- **N=22:**SPT uncorrected blow count for 300 mm
- **75/12:**Undrained shear strength (peak /residual as measured by field vane.

Laboratory test(s) carried out:

PMT	Pressuremeter test
LT	Lugeon test
LV	Laboratory vane
AL	Atterburg limits
UU	Undrained triaxial
PSD	Particle size
c' Ø'	Effective stress
CONS	Consolidation
DS	Direct shear
COMP	Compaction
UCS	Unconfined compression
IS	Point load

Installation type



Standpipe

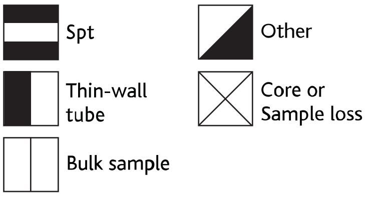
Slotted standpipe

VWP

Bentonite seal

Filter pack

Sample type



Spt

Other

Thin-wall tube

Core or Sample loss

Bulk sample

SOIL DESCRIPTION

Moisture content

D	Dry, looks and feels dry
M	Moist, no free water on hand when remoulding
W	Wet, free water on hand when remoulding
S	Saturated, free water present on sample

Consistency/undrained shear strength

		S_u (kPa)
VS	Very soft	< 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very stiff	100 to 200
H	Hard	> 200

Density index

		SPT(N) - uncorrected
VL	Very loose	0 to 4
L	Loose	4 to 10
MD	Medium dense	10 to 30
D	Dense	30 to 50
VD	Very dense	> 50

Proportional terms definition (Coarse soils)

Fraction	**Term**	**% of soil mass**	**Example**
Major	(UPPER CASE)	Major constituent	Gravel
Subordinate	(lower case)	> 20	Sandy
Minor	with some... with minor...	12 - 20 5 - 12	with some sand with minor sand
	with trace of... (or slightly)...	< 5	with trace of sand (slighly sandy)

Grain size criteria

Type	**Coarse**								**Fine**	
	Boulders	Cobbles	Gravel			Sand			Silt	Clay
			Coarse	Medium	Fine	Coarse	Medium	Fine		

Size range (mm) 200 60 20 6 2 0.6 0.2 0.06 0.002

ENVIRONMENTAL AND ENGINEERING CONSULTANTS www.tonkin.co.nz

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH103
Hole Location: NE corner of playing fields
SHEET 1 OF 4

PROJECT: Halswell School
LOCATION: 437 Halswell Rd, Christchurch
JOB No: 53062.004

CO-ORDINATES: 5735243 mN
2475384 mE
R.L.: 12.95 m
DATUM: LIDAR (Canterbury Geotechnical Database)

DRILL TYPE: Mobile 1000
DRILL METHOD: Rotary-sonic
DRILL FLUID: Water/Polymer

HOLE STARTED: 26/11/12
HOLE FINISHED: 26/11/12
DRILLED BY: Pro Drill (Ray)
LOGGED BY: SAFF
CHECKED: RAP

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	CORE RECOVERY (%)	METHOD	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
Topsoil/Fill		100	SONIC					OL	D	L	SILT, trace rootlets, brown.
						12.5		GM			GRAVEL, silty, angular to sub-angular, medium to coarse, brown.
Yaldhurst Member of Springston Formation		78	SPT	1 1 1 1 1 1 N=4		12.0	0.5	ML	M	F	SILT, trace organics, greyish brown. Low plasticity, very slow dilatancy. 0.85-0.95m: No recovery.
	▼ Approximate GWL observed during drilling (26/11/2012)	100	SONIC				1.0	OL	W	S-F	Organic SILT, minor wood fragments, dark brown. Low plasticity, very slow dilatancy.
		67	SPT	**PI WC** 1 1	*	11.5	1.5	ML		F-St	SILT, trace organics, grey. Low to moderate plasticity, very slow dilantancy. **WC = 33%, LL = 35%, PI = 11** - below 1.4m: trace fine sand - below 1.5m: sandy
				2 2 **FC** 3 3 N=10	*	11.0	2.0	SM		MD	SAND, fine, silty, grey. **28% passing 75µm seive** **23% passing 63µm seive** 1.8-1.95m: No recovery. - trace gravel.
		100	SONIC			10.5 10.0	2.5 3.0	GW			GRAVEL, medium to coarse, sub-rounded, some fine to medium sand, trace silt, grey.
		44	SPT	5 6 5 6 5 5 N=21		9.5					3.2-3.45m: No recovery.
		100	SONIC			9.0 8.5	3.5 4.0 4.5				- Below 3.5m: gravel is fine to coarse (predominantly fine); trace cobbles.
		67	SPT	2 8 10 8 6 5 N=29		8.0	5				- Below 4.6m: sandy (fine to medium). 4.85-5.0m: No recovery.

Log Scale 1:25

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH103
Hole Location: NE corner of playing fields
SHEET 2 OF 4

PROJECT: Halswell School
LOCATION: 437 Halswell Rd, Christchurch
JOB No: 53062.004

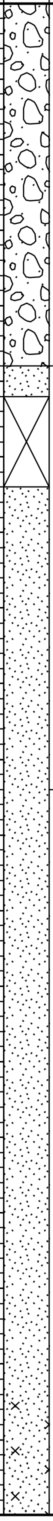
CO-ORDINATES: 5735243 mN
2475384 mE
R.L.: 12.95 m
DATUM: LIDAR (Canterbury Geotechnical Database)

DRILL TYPE: Mobile 1000
DRILL METHOD: Rotary-sonic
DRILL FLUID: Water/Polymer

HOLE STARTED: 26/11/12
HOLE FINISHED: 26/11/12
DRILLED BY: Pro Drill (Ray)
LOGGED BY: SAFF
CHECKED: RAP

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) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	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.
Yaldhurst Member of Springston Formation			100	SONIC							GW	W	MD				GRAVEL, fine to coarse, sub-rounded, some fine to coarse sand, trace silt and cobbles, grey.
			44	SPT		3 4 5 5 4 7 N=21					SP						SAND, fine, trace silt, grey. 6.3-6.6m: No recovery.
			100	SONIC													- Below 6.9m: sand is predominantly fine, some medium. - 7.3-7.6m: trace organics; silt lenses up to 5mm thick.
			100	SPT		2 2 3 **FC** 4 5 7 N=19	*				SW						- Below 7.6m: sand is fine to medium. **5% passing 75µm seive** **4% passing 63µm seive**
			100	SONIC													
			100	SPT		1 2 3 **FC** 4 5 7 N=19	*										**5% passing 75µm seive** **4% passing 63µm seive**
			100	SONIC													- Below 9.6m: minor silt.

R.L. (m)	DEPTH (m)
7.5	5.5
7.0	6.0
6.5	6.5
6.0	7.0
5.5	7.5
5.0	8.0
4.5	8.5
4.0	9.0
3.5	9.5
3.0	10



TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH103
Hole Location: NE corner of playing fields
SHEET 3 OF 4

PROJECT: Halswell School
LOCATION: 437 Halswell Rd, Christchurch
JOB No: 53062.004

CO-ORDINATES: 5735243 mN
2475384 mE
R.L.: 12.95 m
DATUM: LIDAR (Canterbury Geotechnical Database)

DRILL TYPE: Mobile 1000
DRILL METHOD: Rotary-sonic
DRILL FLUID: Water/Polymer

HOLE STARTED: 26/11/12
HOLE FINISHED: 26/11/12
DRILLED BY: Pro Drill (Ray)
LOGGED BY: SAFF
CHECKED: RAP

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

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.

SHEAR STRENGTH (kPa): 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250
DEFECT SPACING (mm): 50 250 1000 2000

R.L. (m)	DEPTH (m)
2.5	10.5
2.0	11.0
1.5	11.5
1.0	12.0
0.5	12.5
0.0	13.0
-0.5	13.5
-1.0	14.0
-1.5	14.5
-2.0	15

CORE RECOVERY (%)	METHOD	TESTS
100	SONIC	
100	SPT	3 5 2 2 3 9 N=16
100	SONIC	
100	SPT	1 0 1 1 2 2 N=6
100	SONIC	
100	SPT	1 1 0 2 6 8 N=16
100	SONIC	

GEOLOGICAL UNIT	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
Yaldhurst Member of Springston Formation	SW	W	MD	Gravelly SAND, grey. Gravel is medium to coarse, sub-rounded. Sand is predominantly fine to medium, some coarse.
	OL		St	Organic SILT, brownish grey. Low plasticity, very slow dilantancy.
	Pt		St-VSt	- 150mm PEAT, amorphous, dark brown.
	OL		St	
	Pt		St-VSt	- 150mm PEAT, amorphous, dark brown.
	ML		F	SILT, minor organics, grey. Low plasticity, very slow dilatancy. - 50mm PEAT lens - 12.9-13.2m: some fine sand; slow dilatancy. - 13.1m: wood fragments.
Riccarton Gravels	GW		MD	Sandy GRAVEL, grey. Gravel is fine to coarse, sub-rounded. Sand is fine to coarse, predominantly medium.

T+T DATATEMPLATE.GDT rxf

Log Scale 1:25

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH103
Hole Location: NE corner of playing fields
SHEET 4 OF 4

PROJECT: Halswell School
LOCATION: 437 Halswell Rd, Christchurch
JOB No: 53062.004

CO-ORDINATES: 5735243 mN
2475384 mE
R.L.: 12.95 m
DATUM: LIDAR (Canterbury Geotechnical Database)

DRILL TYPE: Mobile 1000
DRILL METHOD: Rotary-sonic
DRILL FLUID: Water/Polymer

HOLE STARTED: 26/11/12
HOLE FINISHED: 26/11/12
DRILLED BY: Pro Drill (Ray)
LOGGED BY: SAFF
CHECKED: RAP

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) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	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.
Riccarton Gravels											GW	W	MD				Sandy GRAVEL, brown. Gravel is fine to coarse, sub-rounded. Sand is fine to coarse, predominantly medium.
			44	SPT		7 8 8 7 7 8 N=30		-2.5	15.5				D				15.4-15.65m: No recovery.
																	END OF BOREHOLE @15.65m bgl No piezometer installed.
								-3.0	16.0								
								-3.5	16.5								
								-4.0	17.0								
								-4.5	17.5								
								-5.0	18.0								
								-5.5	18.5								
								-6.0	19.0								
								-6.5	19.5								
								-7.0	20								

T+T DATATEMPLATE.GDT rxf

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA-103
Hole Location: See location map

SHEET 1 OF 1

PROJECT: Geotechnical investigation and assessment
LOCATION: Halswell School
JOB No: 53062.0040

CO-ORDINATES: 5735204 mN
2475261 mE
R.L.:
DATUM:

DRILL TYPE: Hand Auger
DRILL METHOD: Hand Auger
DRILL FLUID: NONE

HOLE STARTED: 20/11/12
HOLE FINISHED: 20/11/12
DRILLED BY: SAFF
LOGGED BY: SAFF
CHECKED: RXF

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) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	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.
Topsoil		levels recorded between 20/11/12 and 20/12/12	100	HAND AUGER							OL	D					Silty TOPSOIL, trace rootlets, dark brown
Yaldhurst Member of Springston Formation									0.5 1.0		ML	M	L				Sandy SILT, brown. Non-plastic. Sand is fine -0.9m: Becomes brown-mottled orange, trace iron staining
									1.5		ML		S-F				SILT, trace fine sand, brownish grey-mottled orange. Low plasticity, slow dilatancy
											SM		L				Silty fine SAND, grey
									2.0		ML		S				SILT with trace fine sand and organics, grey-mottled orange. Low plasticity, very slow dilatancy
											ML	W	F-St				SILT, minor fine sand, blueish grey. Low plasticity, slow dilatancy
									2.5		SM		L				Silty fine SAND, grey
									3								**E.O.H at 2.9m due to refusal** Piezoemeter installed

T+T DATATEMPLATE GDT rxf

Log Scale 1:15

BORELOG 2013-01-14.SAFF.HAS 101-105.GPJ 25-Feb-2013

TONKIN & TAYLOR LTD

EXCAVATION LOG

EXCAVATION No: TP-101
Hole Location: See location plan.

SHEET 1 OF 1

PROJECT: Geotechnical investigation and assessment
LOCATION: Halswell School
JOB No: 53062.0040

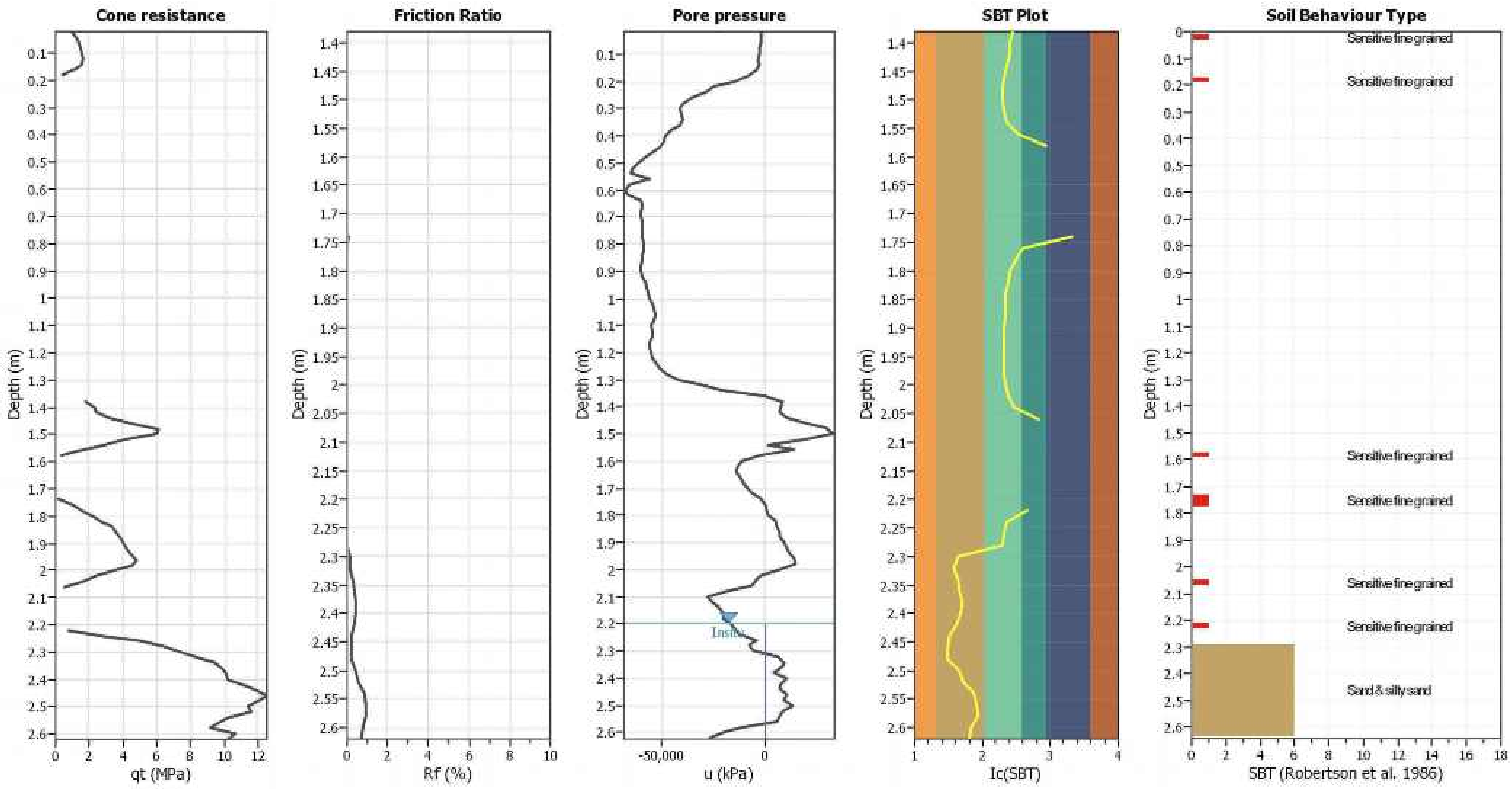
CO-ORDINATES:	5735244 mN 2475380 mE	EXPOSURE TYPE:	Test-Pit
		EQUIPMENT:	Yuchai YC 135-8
R.L.		OPERATOR:	Shearing's
DATUM		DIMENSIONS:	1.8x3x2.5m

EXCAV. STARTED: 20/12/12
EXCAV FINISHED: 20/12/12
LOGGED BY: SAFF
CHECKED BY: RXF

EXCAVATION TESTS — ENGINEERING DESCRIPTION — GEOLOGICAL

PENETRATION 1 2 3	SUPPORT	WATER	SAMPLES, TESTS	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION / WEATHERING	STRENGTH / DENSITY CLASSIFICATION	ESTIMATED SHEAR STRENGTH (kPa) 10 25 50 100 200	ORIGIN TYPE MINERAL COMPOSITION DEFECTS, STRUCTURE	UNIT
							OL	FILL: Silty TOPSOIL, trace rootlets, dark brown.	D			Fill	
							ML	FILL: SILT, minor organics, trace brick fragments, brown. Low plasticity, slow dilatancy.	M	F			
					0.5		ML	SILT, minor tree roots, brown. Low plasticity, slow dilatancy.				Yaldhurst Member o Springston Formation	
		Major in low	0.9m Bulk sample		1.0								
								@1.3m: Becomes grey.					
					1.5				W				
			1.6m Bulk sample				SW /GW	Sandy GRAVEL/Gravelly SAND, grey. Gravel is medium to coarse, sub-rounded. Sand is fine to medium.		-			
			2.0m Bulk sample		2.0								
							GW	GRAVEL, grey. Medium to coarse, sub-rounded.					
					2.5			**END OF TEST PIT @2.5m bgl**					
					3.0								
					3.5								
					4.0								
					4.5								

CPT basic interpretation plots



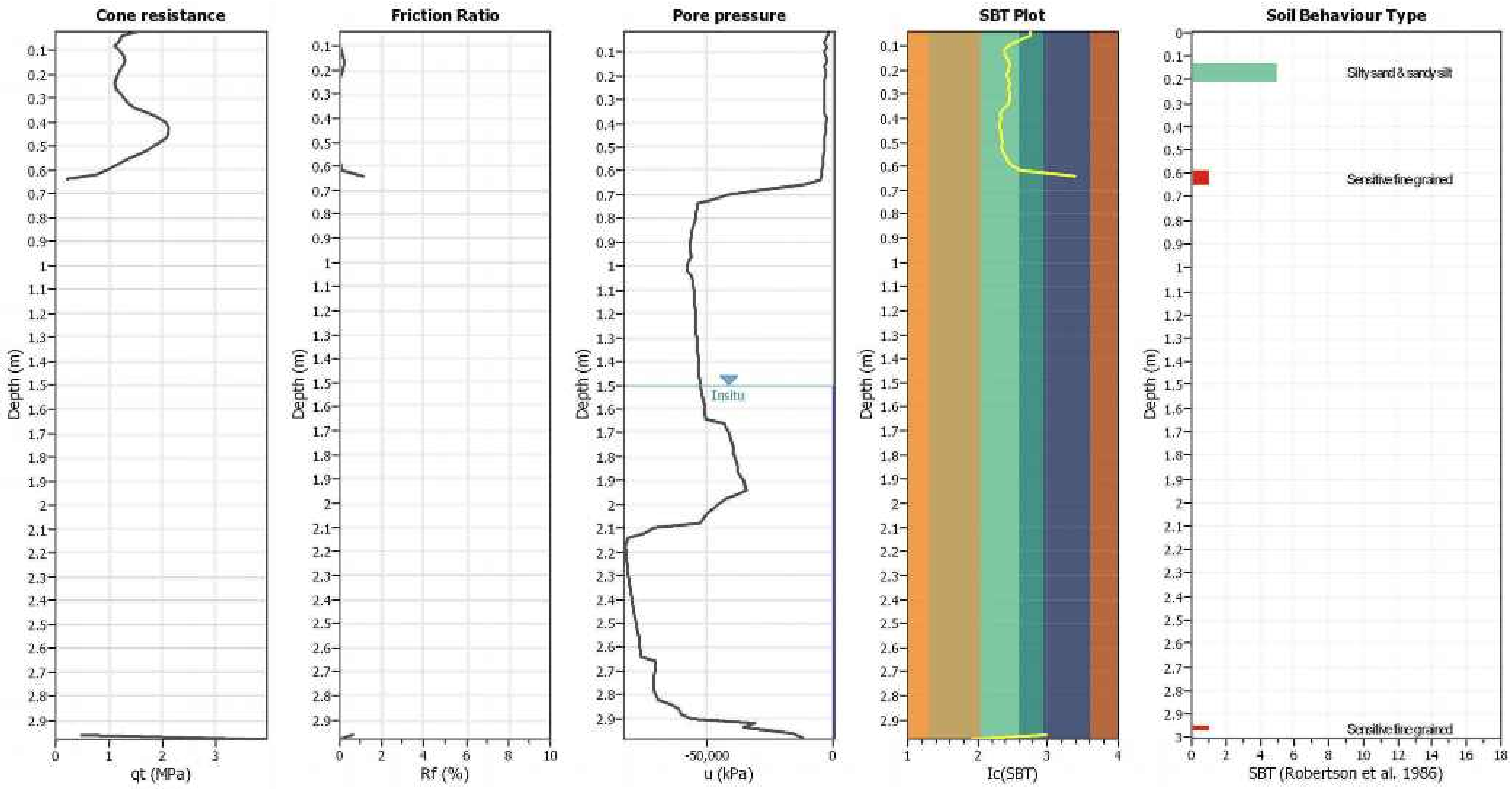
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.20 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬜ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟫 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

CPT basic interpretation plots



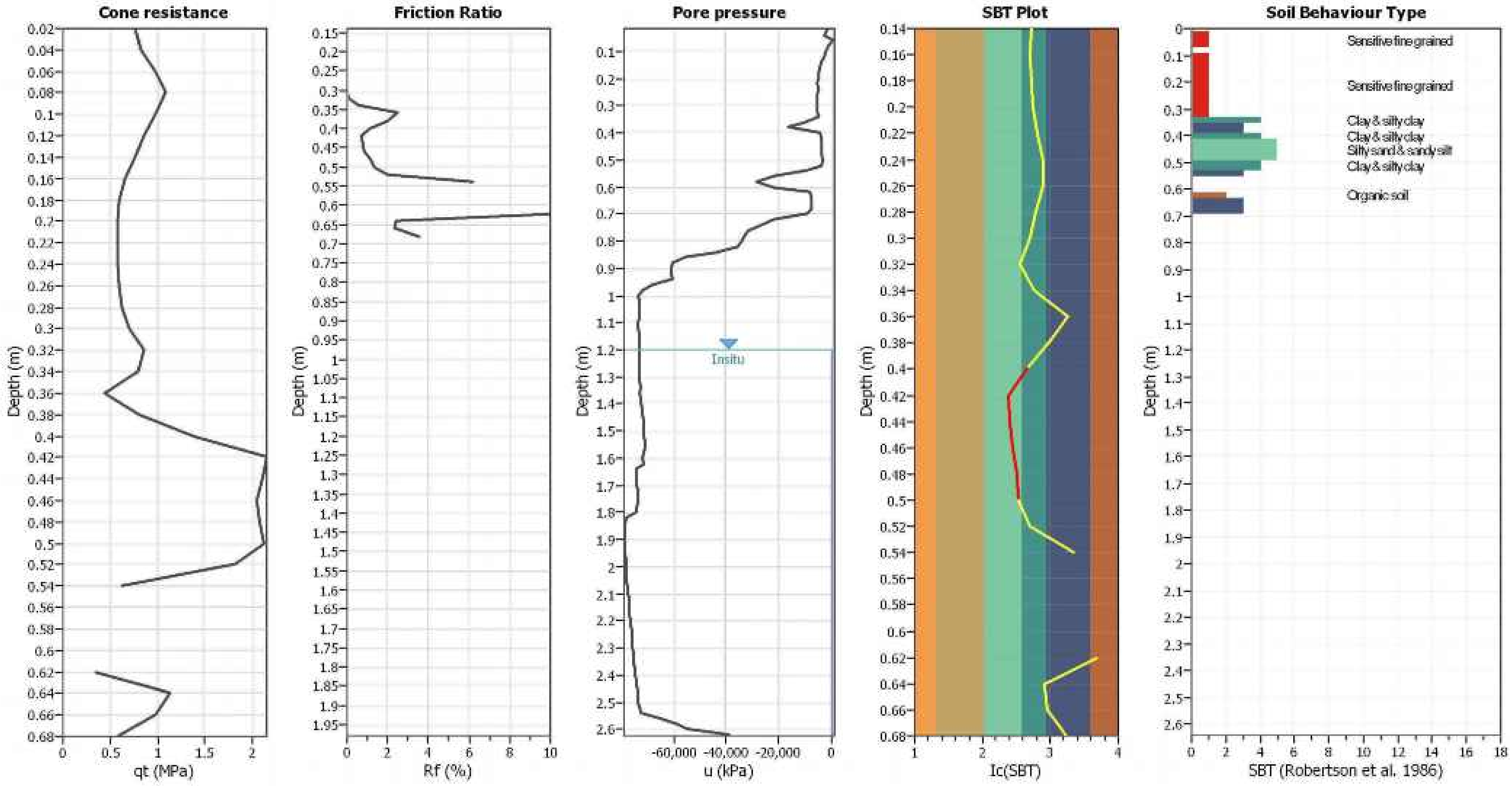
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬜ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots



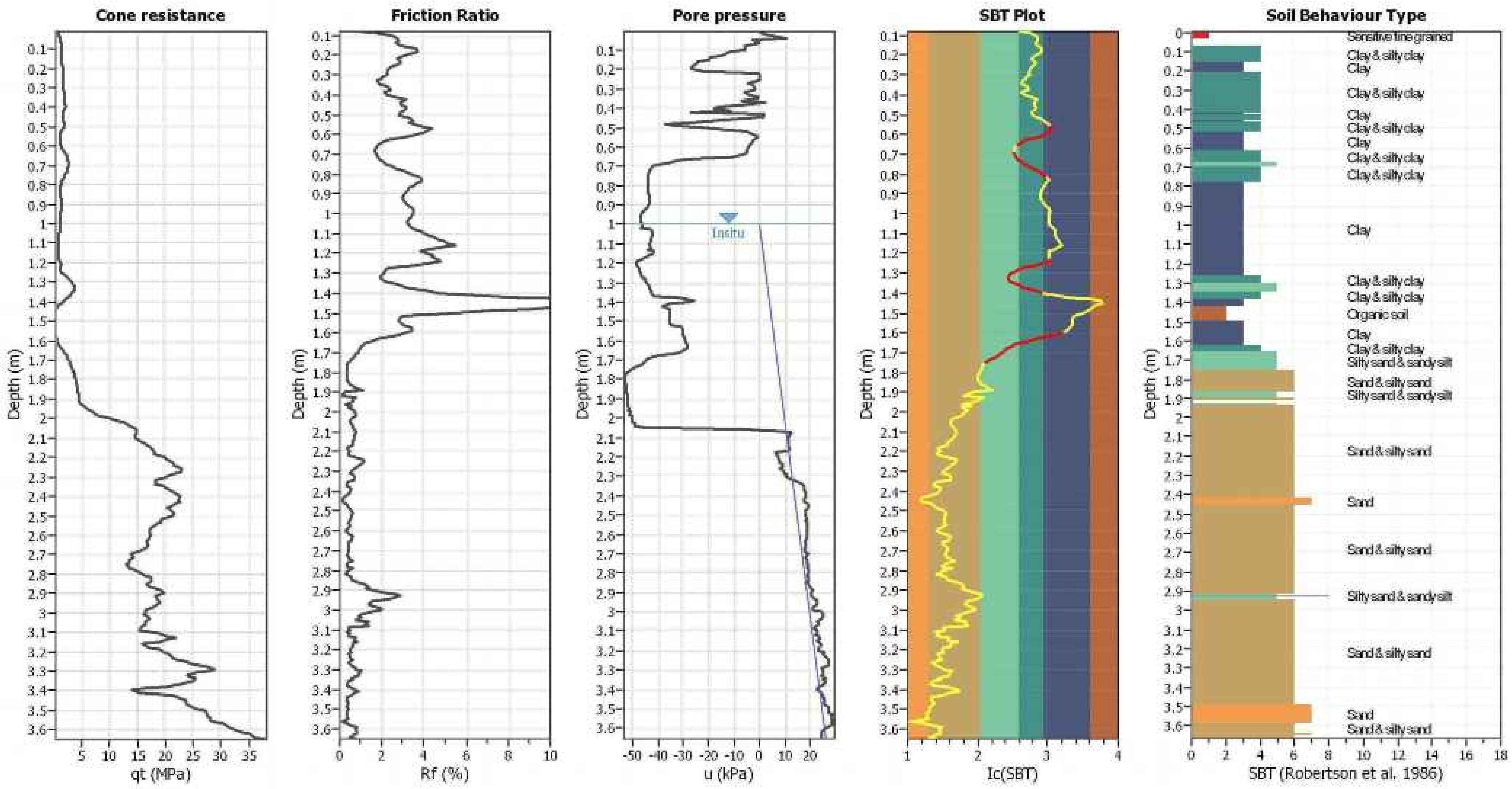
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.20 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬜ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟫 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

CPT basic interpretation plots



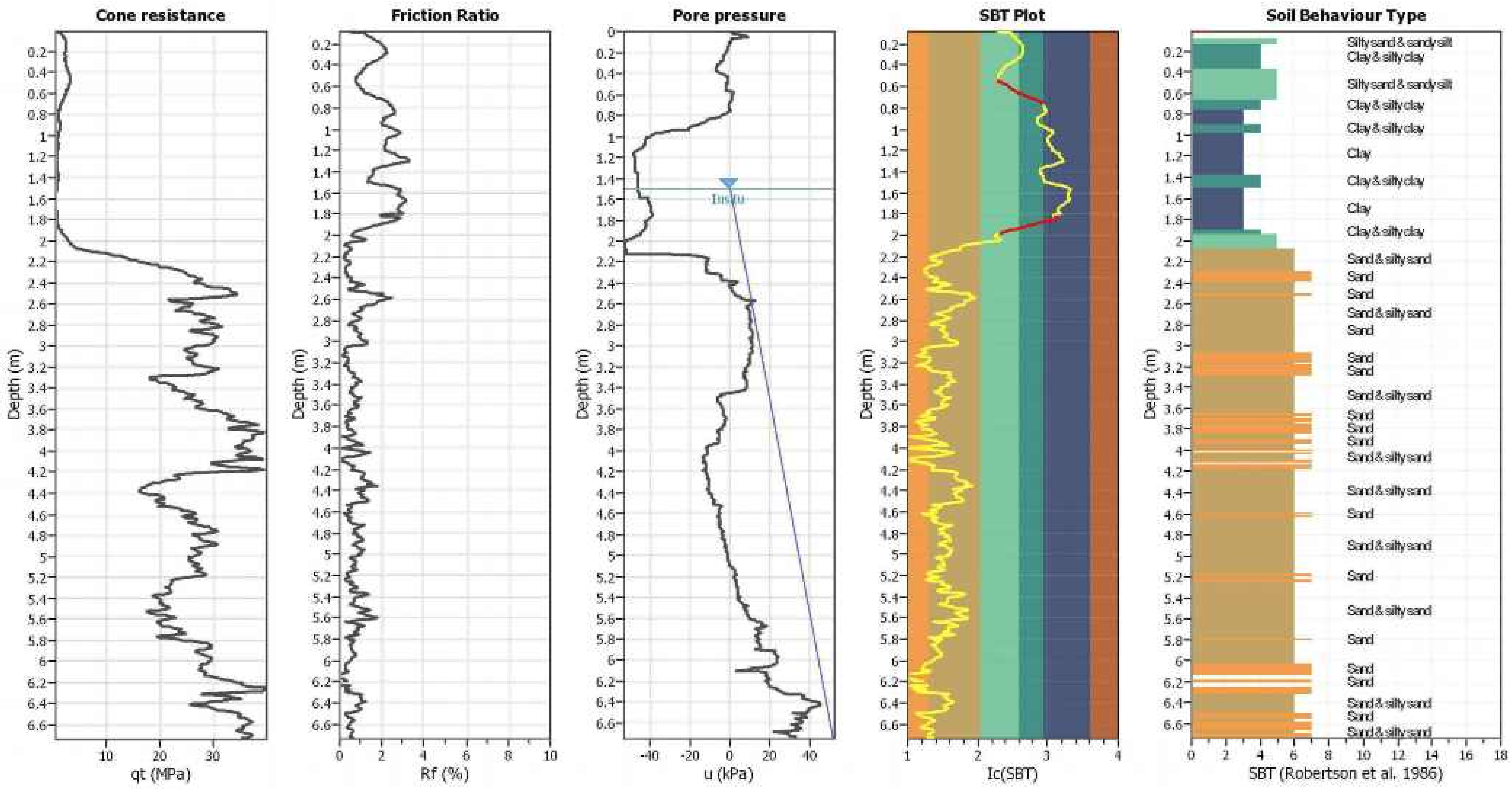
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟨 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

CPT basic interpretation plots



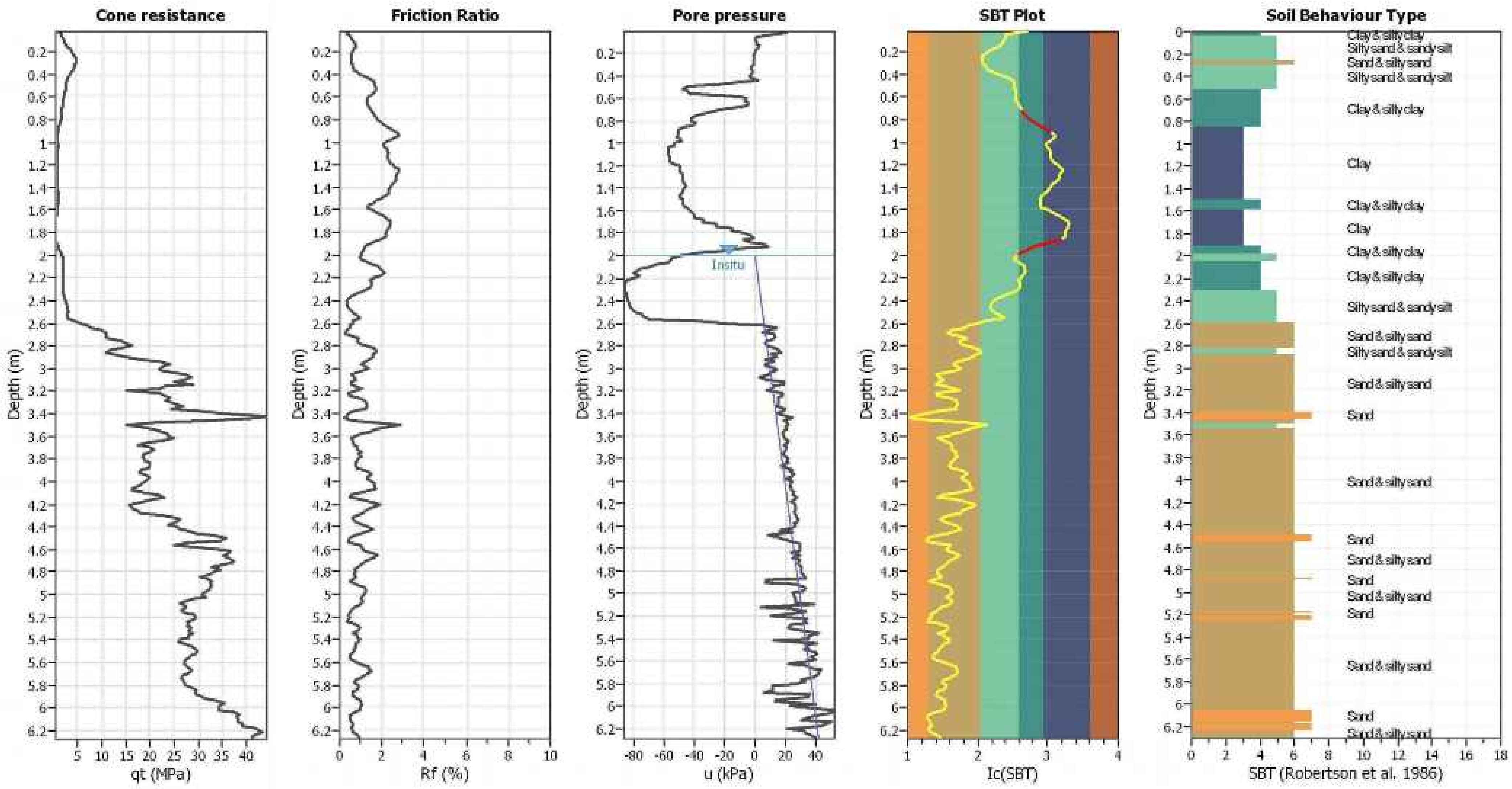
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥	1. Sensitive fine grained	🟩	4. Clayey silt to silty	🟧	7. Gravely sand to sand
🟫	2. Organic material	🟩	5. Silty sand to sandy silt	⬛	8. Very stiff sand to
🟦	3. Clay to silty clay	🟫	6. Clean sand to silty sand	⬜	9. Very stiff fine grained

CPT basic interpretation plots



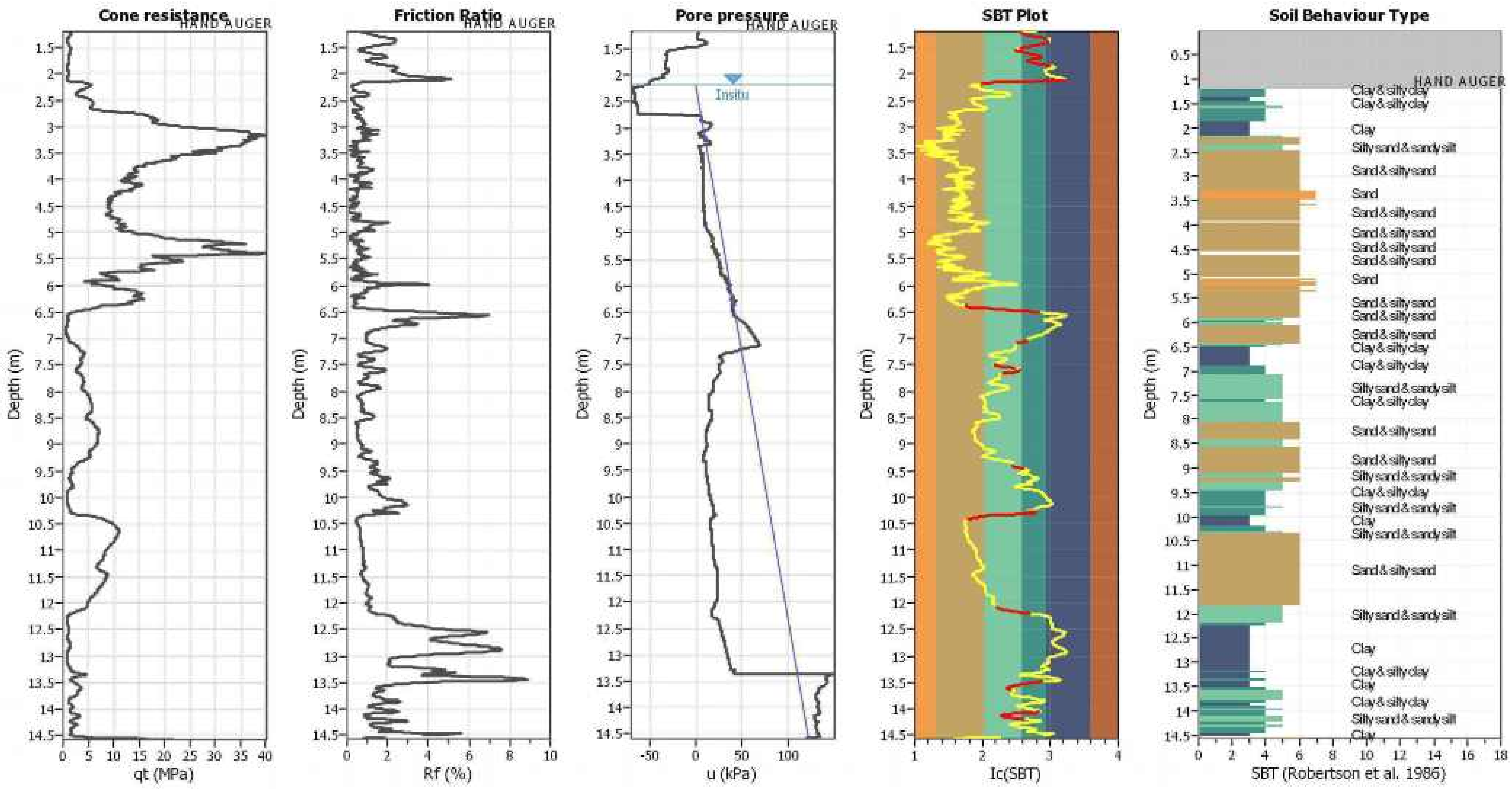
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬜ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots



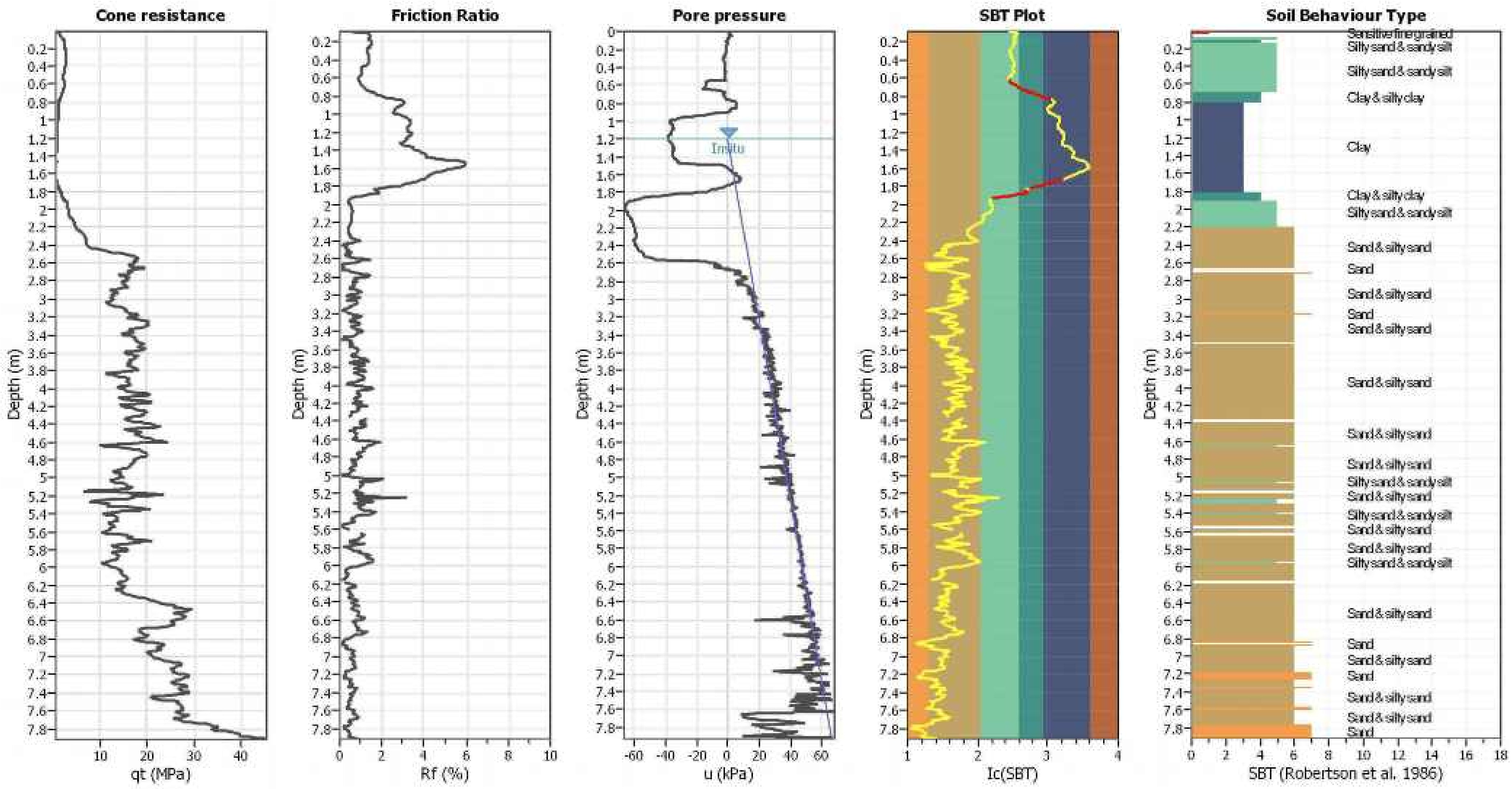
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.20 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟨 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

CPT basic interpretation plots



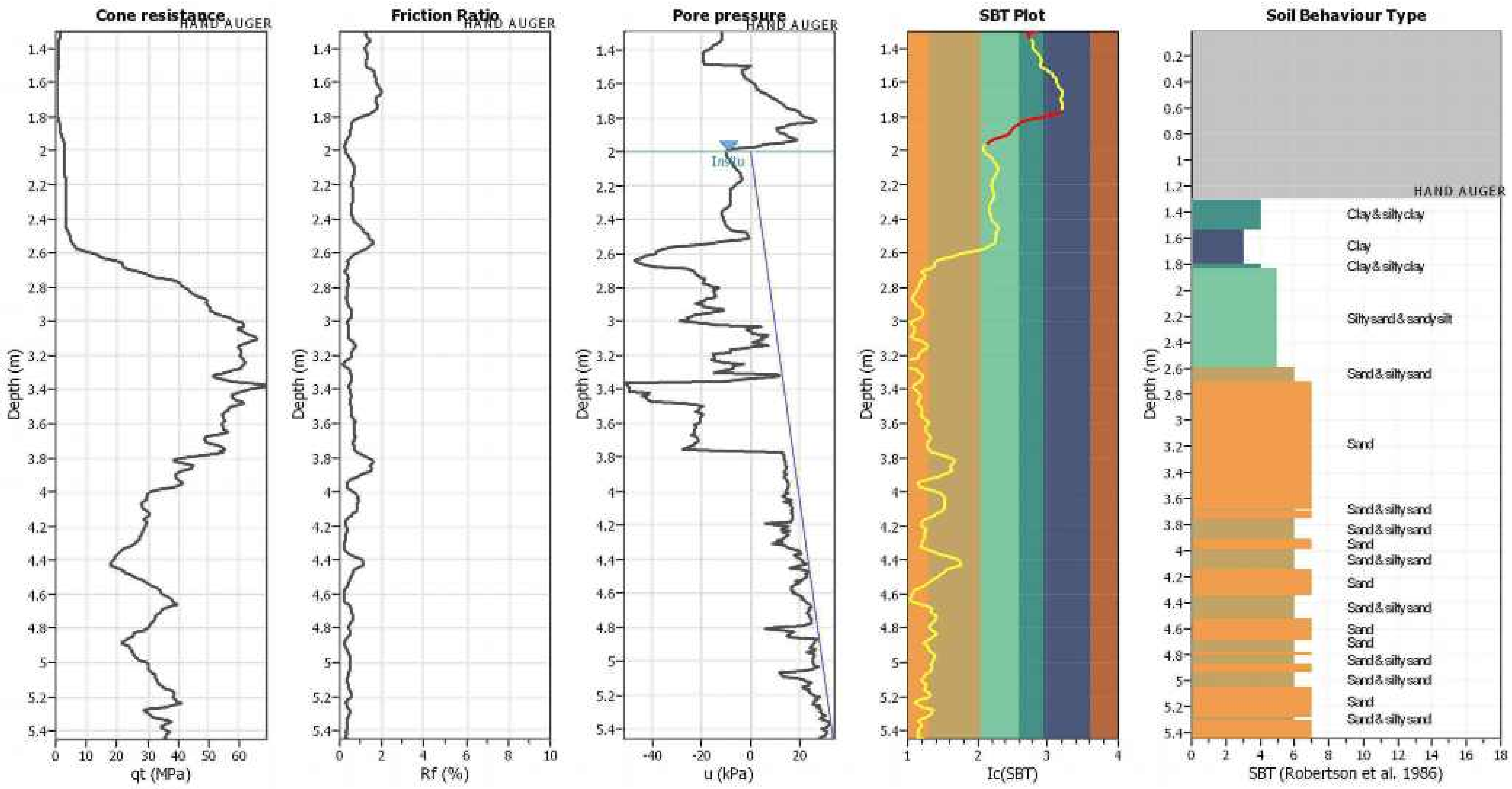
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	1.20 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟫 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

CPT basic interpretation plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟨 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

Central Testing Services
18 Ngapara Street, P.O. Box 397, ALEXANDRA, Central Otago, NZ
Telephone (03) 448 7644, Fax (03) 448 7401, Email alan.julius@xtra.co.nz

Page 1 of 2 Pages

Reference No: 12/1807

Date: 3 December 2012

TEST REPORT – HALSWELL SCHOOL INVESTIGATIONS

Client Details:	**Tonkin & Taylor Ltd, P.O. Box 13055, Christchurch**	**Attention:**	**S. Forster**
Job Description:	**Halswell School Investigations – Job No. 53062.004**		
Sampled By:	**S. Forster**	**Sample Method:**	**Borehole**
Date & Time Sampled:	**26-Nov-12**	**Date Received:**	**29-Nov-12**

Sample ID	Depth	Sample Description	% Passing 75µm Sieve	% Passing 63µm Sieve	PI Fraction Tested	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Water Content (%)
BH101	SPT @ 1.5m	Brown Sandy SILT	70	61	-	-	-	-	-
	SPT @ 4.6m	Grey SAND with minor gravel, minor silt. Wood fragments / organic matter	8	6	-	-	-	-	-
	9.8m	Grey SILT with minor sand	-	-	Whole Soil	Not Applicable *	22	Not Applicable	34.2
	SPT @ 10.7m	Grey Silty SAND	40	35	-	-	-	-	-
	SPT @ 12.2m	Grey SILT with some sand	87	82	-	-	-	-	-
BH102	1.4m	Brown SILT with minor / some clay	-	-	-425µm	39	27	12	40.4
	SPT @ 1.5m	Grey SILT with trace of sand & trace of organic matter	98	97	-	-	-	-	-
	SPT @ 7.6m	Grey Gravelly SAND with minor silt	7	6	-	-	-	-	-
	9.4m	Grey SILT with minor sand, minor clay & trace of fine gravel	-	-	-425µm	34	23	11	36.2
	SPT @ 10.7m	Grey SAND with some silt	22	18	-	-	-	-	-
BH103	1.4m	Grey SILT with trace of / minor clay and trace of organics	-	-	Whole Soil	35	24	11	33.0
	SPT @ 1.5m	Grey Silty SAND	28	23	-	-	-	-	-
	SPT @ 7.6m	Grey SAND with trace of gravel and trace of silt	5	4	-	-	-	-	-
	SPT @ 9.1m	Grey SAND with trace of silt	5	4	-	-	-	-	-

Notes:
- The % passing the finest sieve was obtained by difference.
- The water content test was carried out on the sample as received.
- * Unable to cut groove in the LL test. Sample sliding in the bowl.

Test Methods:
- Particle Size Analysis - NZS 4402:1986, Test 2.8.1
- Plasticity Index - NZS 4402:1986 Test 2.2. 2.3 & 2.4
- Water Content - NZS 4402:1986, Test 2.1

General Notes:
- Information contained in this report which is Not IANZ Accredited relates to the sample description.
- IANZ endorsement of this report applies to the samples as received.
- This report may not be reproduced except in full.

Tested By: A.P. Julius & N.P. Danischewski **Date: 30-Nov-12 to 2-Dec-12**

Transcriptions Checked By:

Tests indicated Not IANZ Accredited are outside the laboratory's scope of accreditation

434
new zealand accredited laboratory

CALIFORNIA BEARING RATIO (REMOULDED)
TEST REPORT

OPUS

Project:	**Material Investigation**	Date sampled:	**20 December 2012**
Location:	**Halswell School**	Sampling method:	**Not Advised**
Client:	**Hiway Geotechnical**	Sample condition:	**Damp as Received**
Contractor:	**Hiway Geotechnical**	Sample description:	**Silt**
Sampled by:	**Not Advised**	Date sample/s received:	**21 December 2012**

Project No:	**6-JHIGE.12/006LC**
Lab Ref No:	**8917**
Client Ref No:	**HG 2059**

Test Results

	Sample condition at test	Curing time (Days)	Soaking time (Days)	Passing 19mm (%)	Surcharge mass (kg)	Lime additive (%)	Cement additive (%)	Swell (%)	Penetration (mm)	Water content as received (%)	Water content as compacted (%)	Water content after testing (%)	Dry density (t/m³)	CBR value (%)
Lab Ref No. 8917	Location	Halswell School, Testpit no.1 (0.9m)						Sample description		SILT with 3% cement				
	Wet,Dense	2	5	100	4	0	3	0	5		29.6	27.7	1.48	**12**
Lab Ref No. 8917	Location	Halswell School, Testpit no.1 (0.9m)						Sample description		SILT with 4% cement				
	Wet,Dense	2	5	100	4	0	4	0	5		29.6	26.5	1.50	**18**

Test Methods	
CBR	NZS : 4402 : 1986 : 6.1.1
Water Content	NZS : 4402 : 1986 : 2.1
Compaction	NZS : 4402 : 1986 : 4.1.1 (Standard)

Notes	
Material Used:	Passing 19mm sieve
Rate of penetration :	1mm/min

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

IANZ Approved Signatory

Date tested:	14 January 2013	Designation :	*Assistant Laboratory Manager*
Date reported:	14 January 2013	Date :	15 January 2013

laboratory

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

PF-LAB-021 (9/12)

CALIFORNIA BEARING RATIO (REMOULDED)
TEST REPORT

OPUS

Project:	**Material Investigation**	Date sampled:	**20 December 2012**
Location:	**Halswell School**	Sampling method:	**Not Advised**
Client:	**Hiway Geotechnical**	Sample condition:	**Damp as Received**
Contractor:	**Hiway Geotechnical**	Sample description:	**Gravelly SAND**
Sampled by:	**Not Advised**	Date sample/s received:	**21 December 2012**

Project No:	**6-JHIGE.12/006LC**
Lab Ref No:	**8918**
Client Ref No:	**HG 2059**

Test Results

	Sample condition at test	Curing time (Days)	Soaking time (Days)	Passing 19mm (%)	Surcharge mass (kg)	Lime additive (%)	Cement additive (%)	Swell (%)	Penetration (mm)	Water content as received (%)	Water content as compacted (%)	Water content after testing (%)	Dry density (t/m^3)	CBR value (%)
Lab Ref No.	Location	Halswell School, Testpit no.1 (2.0m)						Sample description	Gravelly SAND with 5% cement					
8918	Wet,Dense	2	5	100	4	0	5	0	5		21.4	13.8	1.72	**100**
Lab Ref No.	Location	Halswell School, Testpit no.1 (2.0m)						Sample description	Gravelly SAND with 7% cement					
8918	Wet,Dense	2	5	100	4	0	7	0	5		21.4	13.5	1.68	**155**

Test Methods		**Notes**	
CBR	NZS : 4402 : 1986 : 6.1.1	Material Used:	Passing 19mm sieve
Water Content	NZS : 4402 : 1986 : 2.1	Rate of penetration :	1mm/min
Compaction	NZS : 4402 : 1986 : 4.1.1 (Standard)		

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

IANZ Approved Signatory

Date tested:	15 January 2013	Designation :	*Assistant Laboratory Manager*
Date reported:	15 January 2013	Date :	16 January 2013

laboratory

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

PF-LAB-021 (9/12)

Appendix D

EQC Map Output

Important notice

This map and data was prepared and/or compiled for the Earthquake Commission (EQC) to assist in assessing insurance claims made under the Earthquake Commission Act 1993 and/or for the Canterbury Geotechnical Database on behalf of the Canterbury Earthquake Recovery Authority (CERA). It was not intended for any other purpose. EQC, CERA, their data suppliers and their engineers, Tonkin & Taylor, have no liability to any user of this map and data or for the consequences of any person relying on them in any way. Each Canterbury Geotechnical Database (https://canterburygeotechnicaldatabase.projectorbit.com/) map and data is made available solely on the basis that:

- Any Database user has read and agrees to the terms of use for the Database;
- Any Database user has read any explanatory text accompanying this map; and
- The "Important notice" accompanying the map and data must be reproduced wherever the map or data are reproduced.

SOURCE: https://canterburygeotechnicaldatabase.projectorbit.com/ (Accessed on 15/7/2013)

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

Project: Halswell Courts, 38 Kennedys Bush Road, Halswell
Project No.: 6-QC355.00
Client: Christchurch City Council

EQC Observed Ground Cracking
4 September 2010 to 22 February 2011

Drawn: Opus Geotechnical Engineer

Date: 22-Jul-13

Important notice

This map and data was prepared and/or compiled for the Earthquake Commission (EQC) to assist in assessing insurance claims made under the Earthquake Commission Act 1993 and/or for the Canterbury Geotechnical Database on behalf of the Canterbury Earthquake Recovery Authority (CERA). It was not intended for any other purpose. EQC, CERA, their data suppliers and their engineers, Tonkin & Taylor, have no liability to any user of this map and data or for the consequences of any person relying on them in any way. Each Canterbury Geotechnical Database (https://canterburygeotechnicaldatabase.projectorbit.com/) map and data is made available solely on the basis that:

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OPUS

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

Project: Halswell Courts, 38 Kennedys Bush Road, Halswell
Project No.: 6-QC355.00
Client: Christchurch City Council

EQC Observed Ground Cracking
Post 22 February 2011

Drawn: Opus Geotechnical Engineer

Date: 22-Jul-13

Appendix E

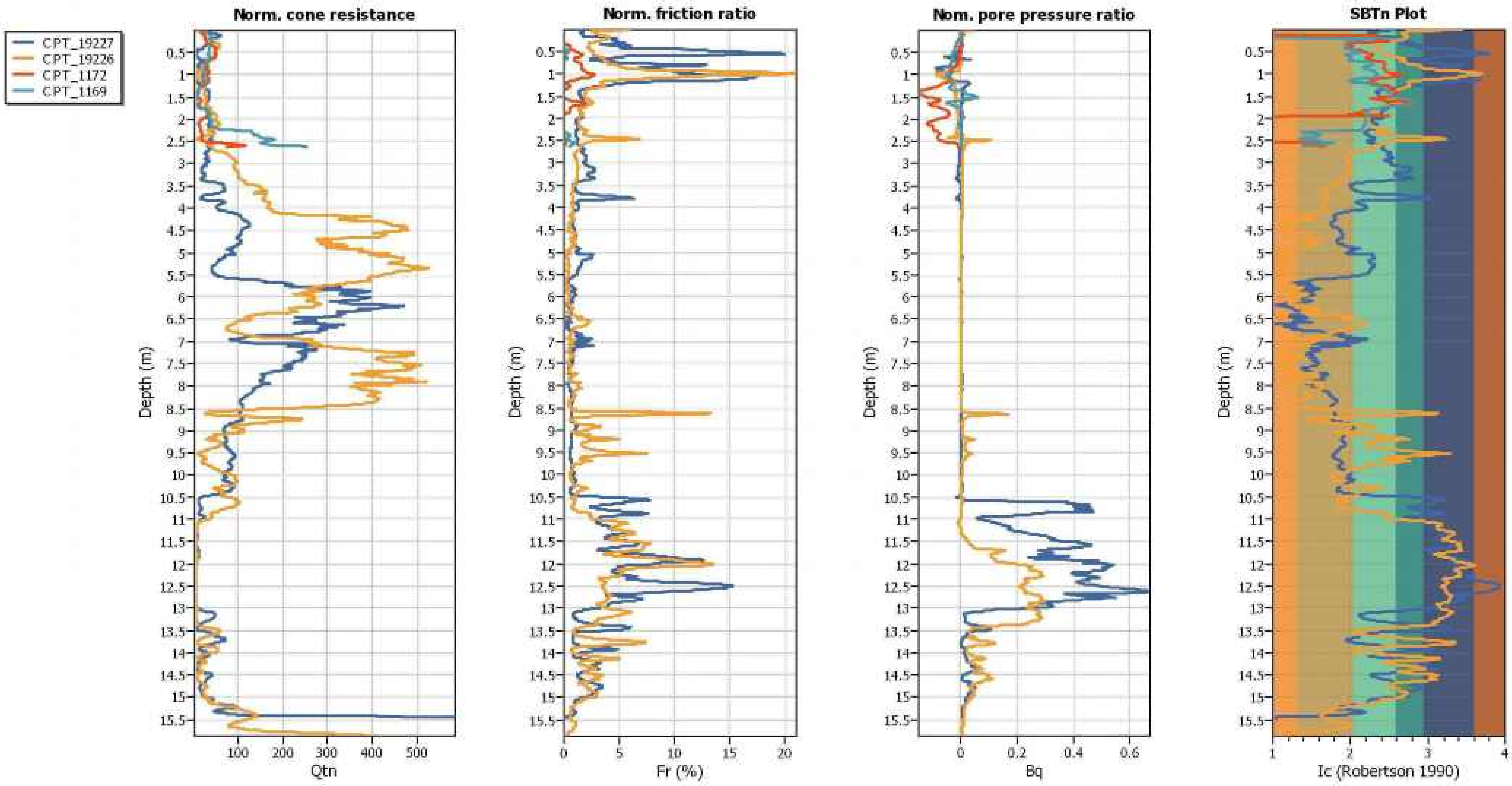
CLiq Liquefaction Analysis Output

Appendix E.1

CLiq NCEER (1998) SLS1 Liquefaction Analysis Output

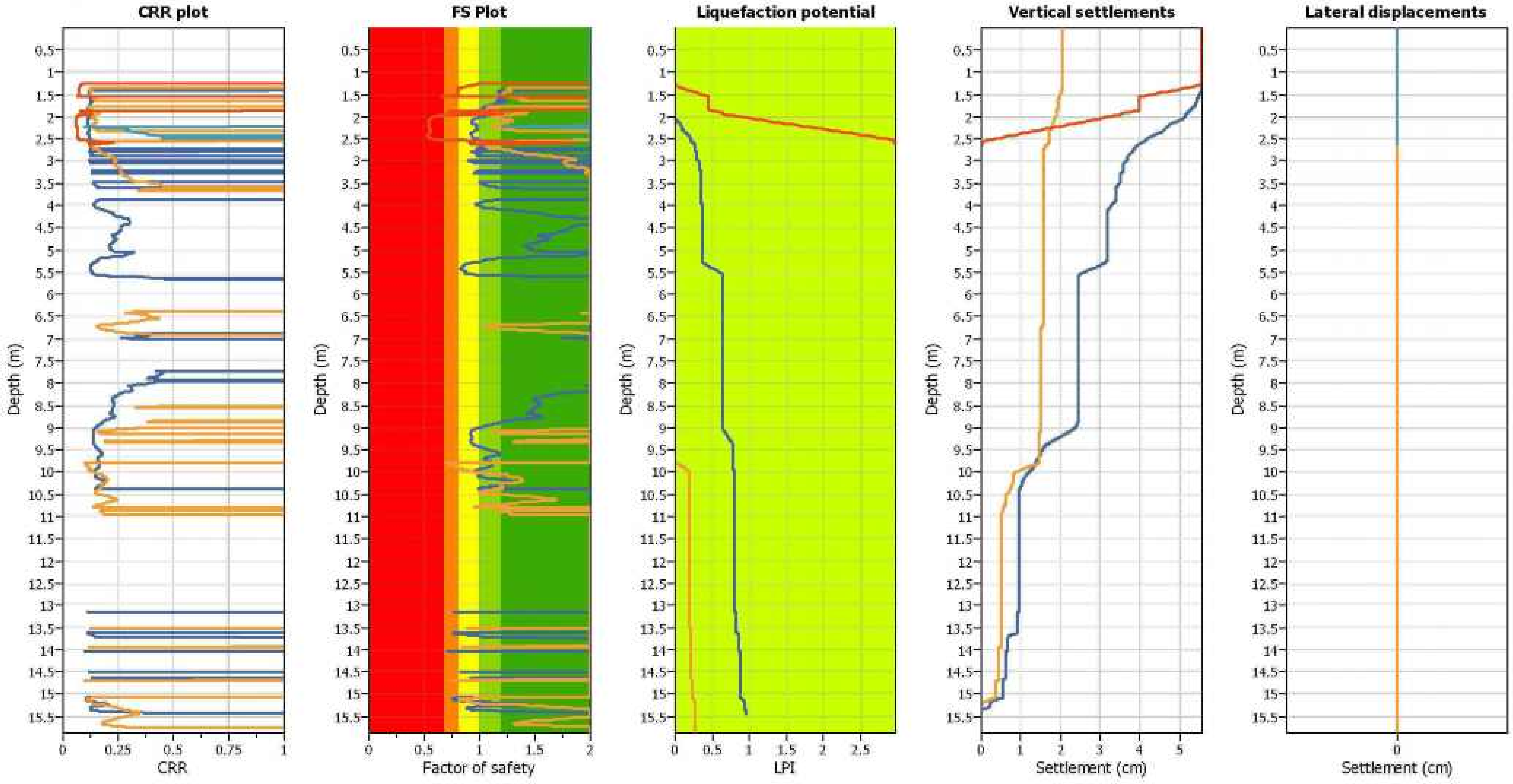
Project: Halswell Courts

Overlay Normalized Plots



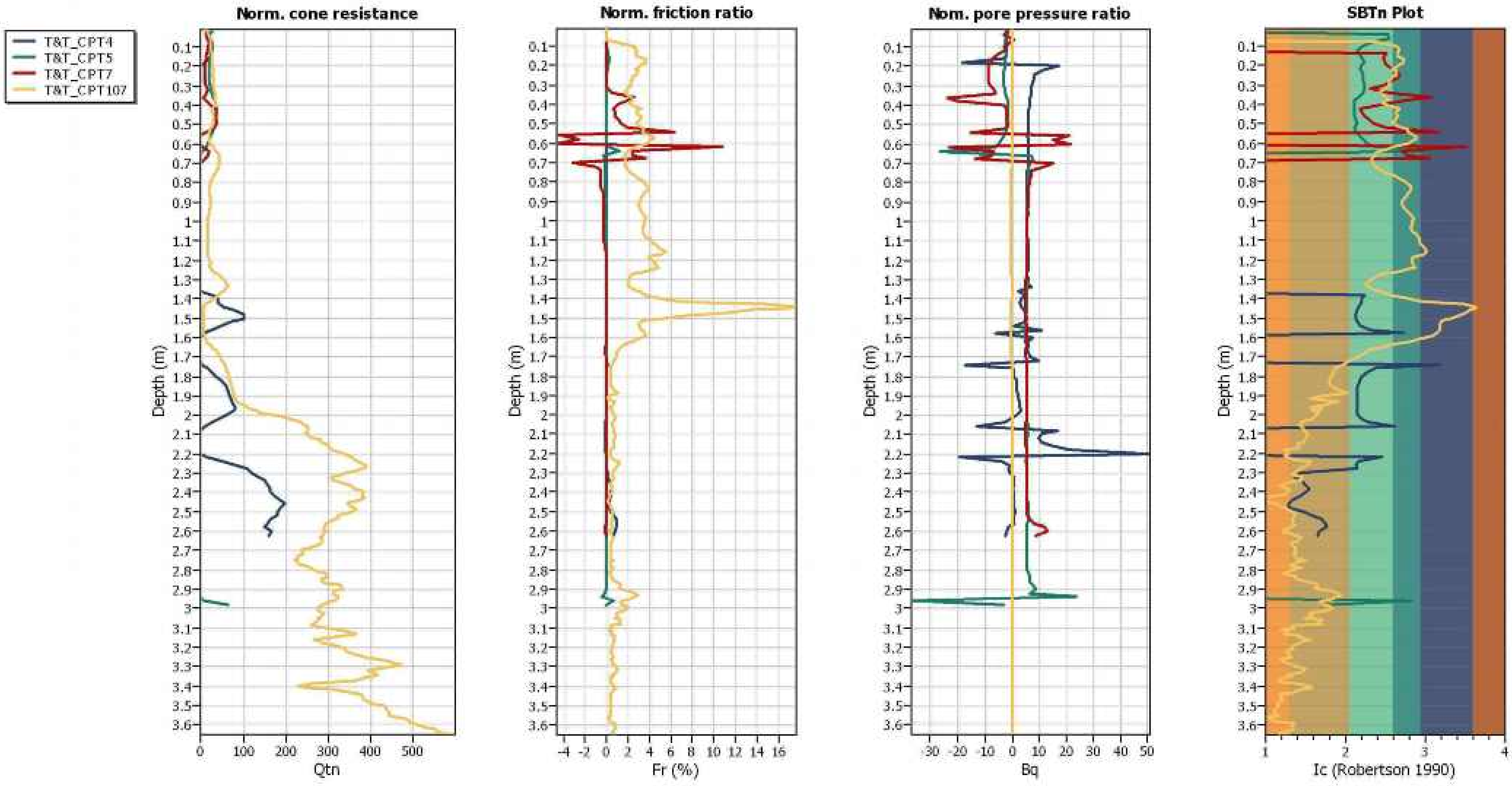
Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



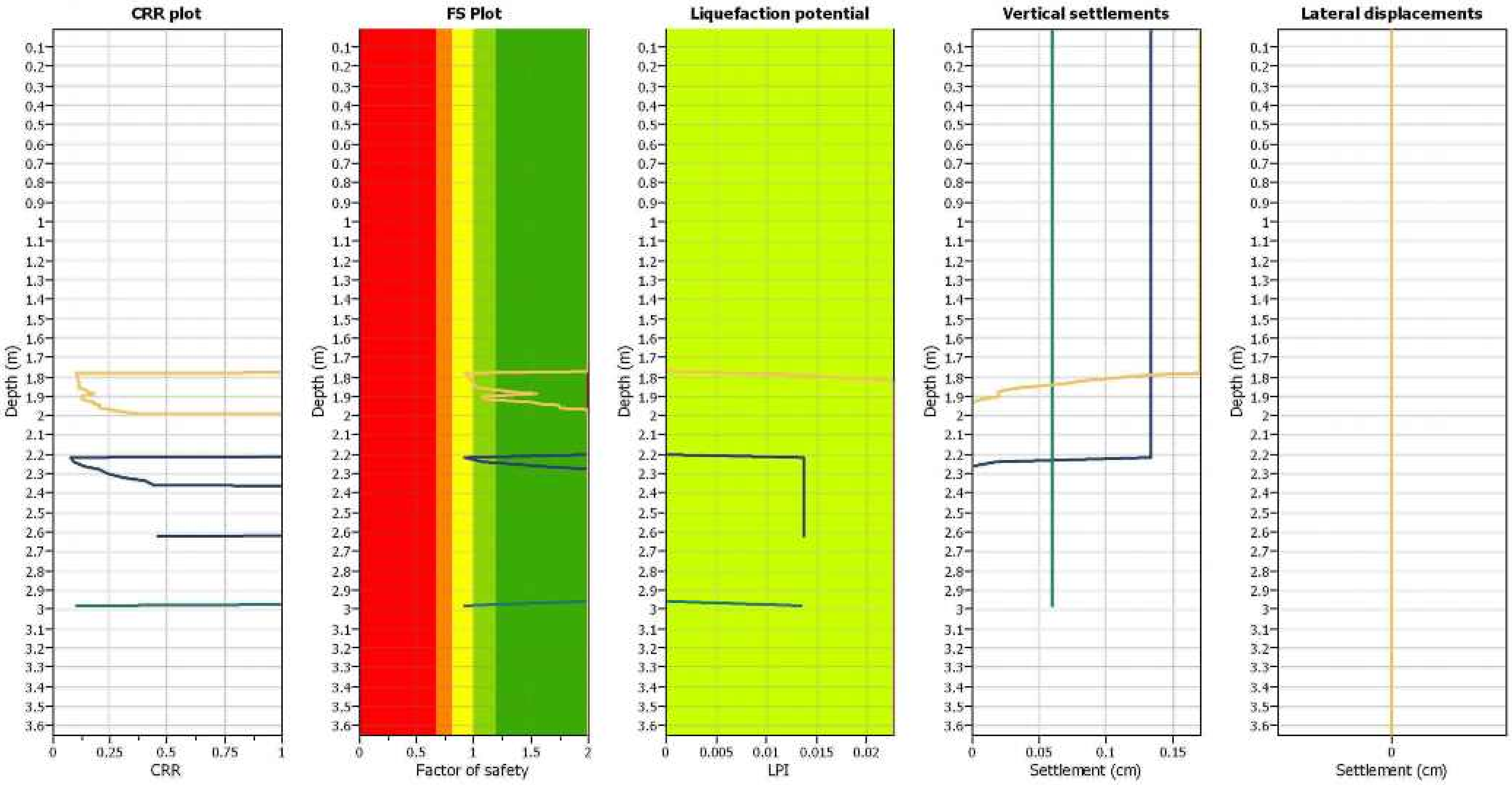
Project: Halswell Courts

Overlay Normalized Plots



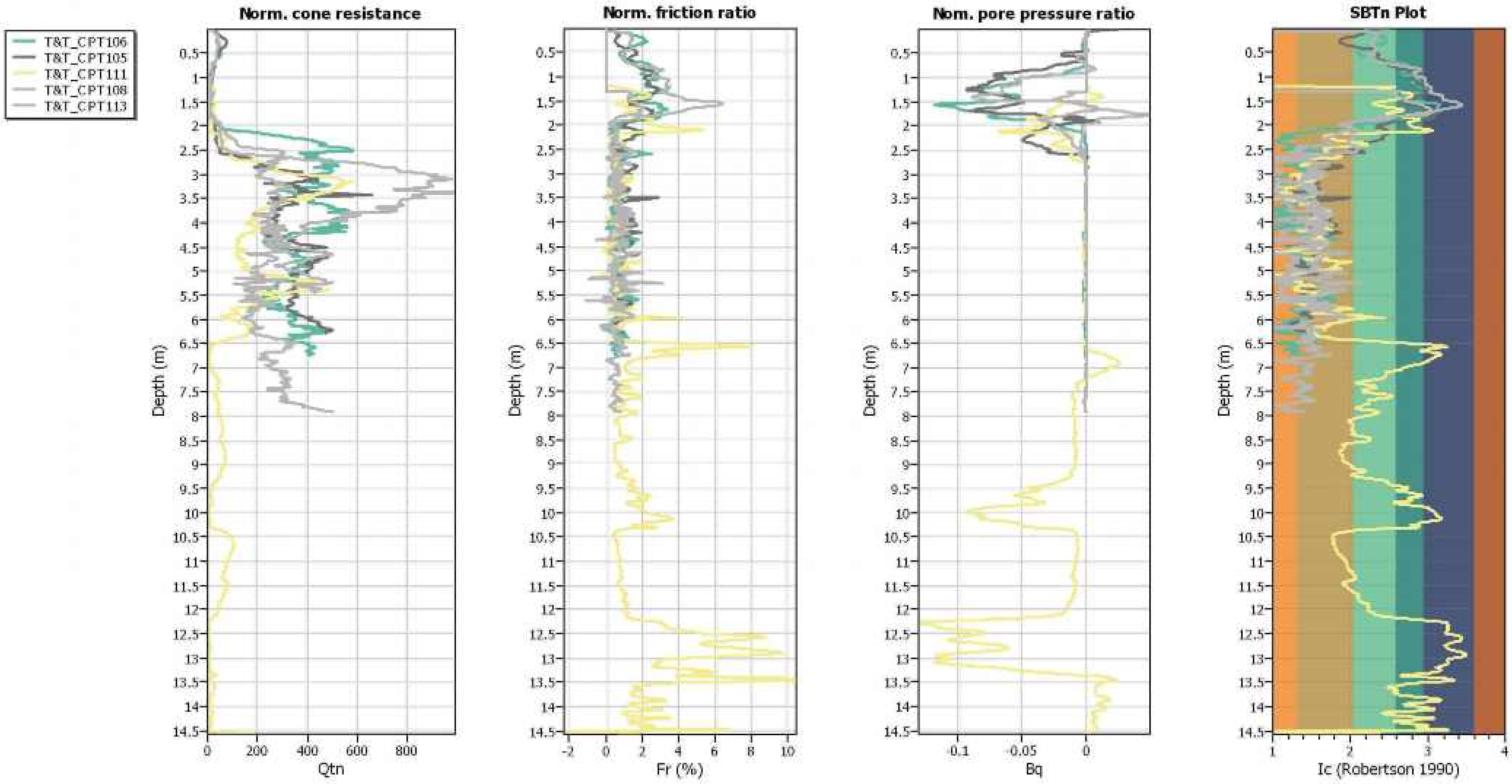
Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



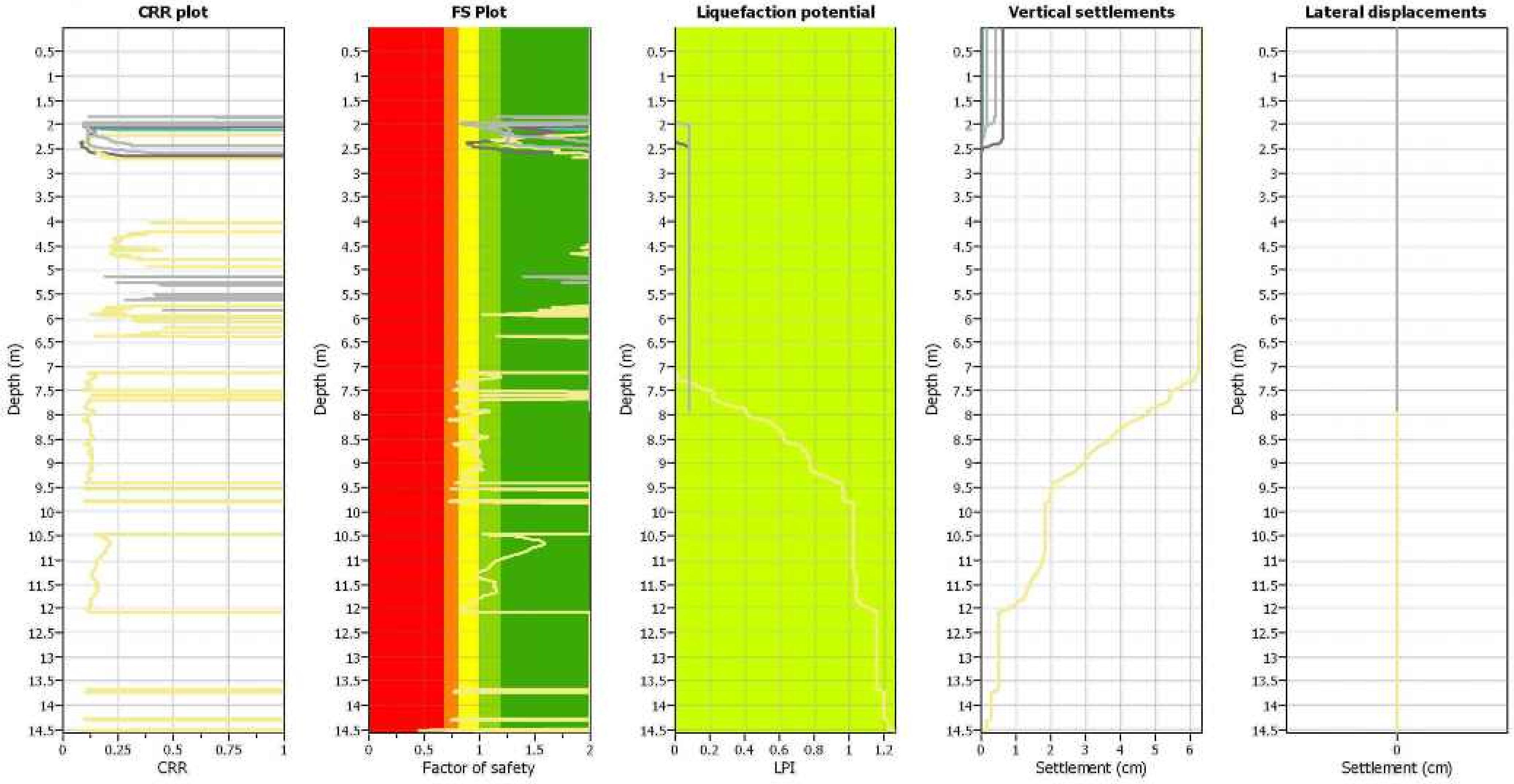
Project: Halswell Courts

Overlay Normalized Plots



Project: Halswell Courts

Overlay Cyclic Liquefaction Plots

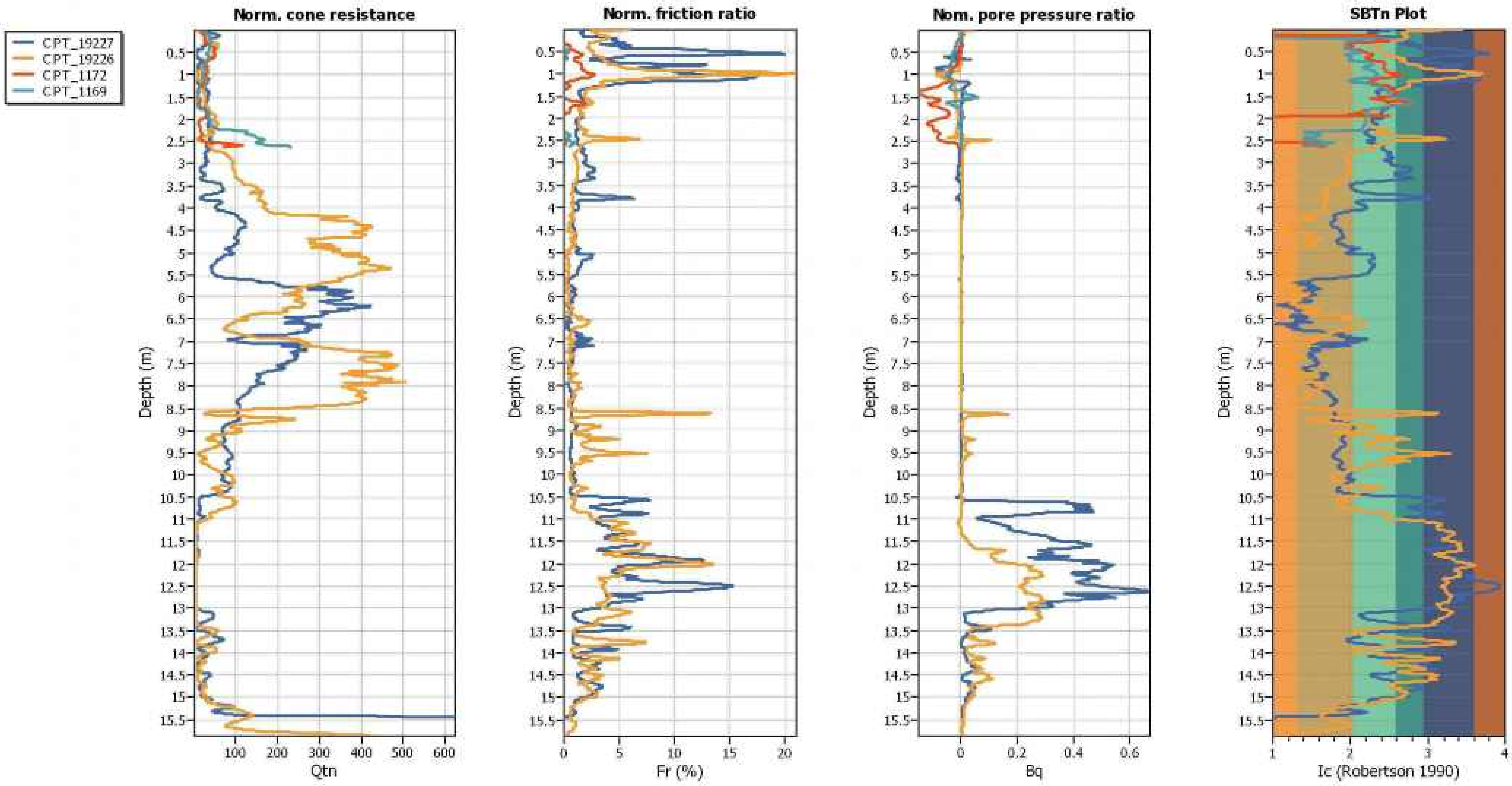


Appendix E.2

CLiq Idriss and Boulanger (2008) SLS1 Liquefaction Analysis Output

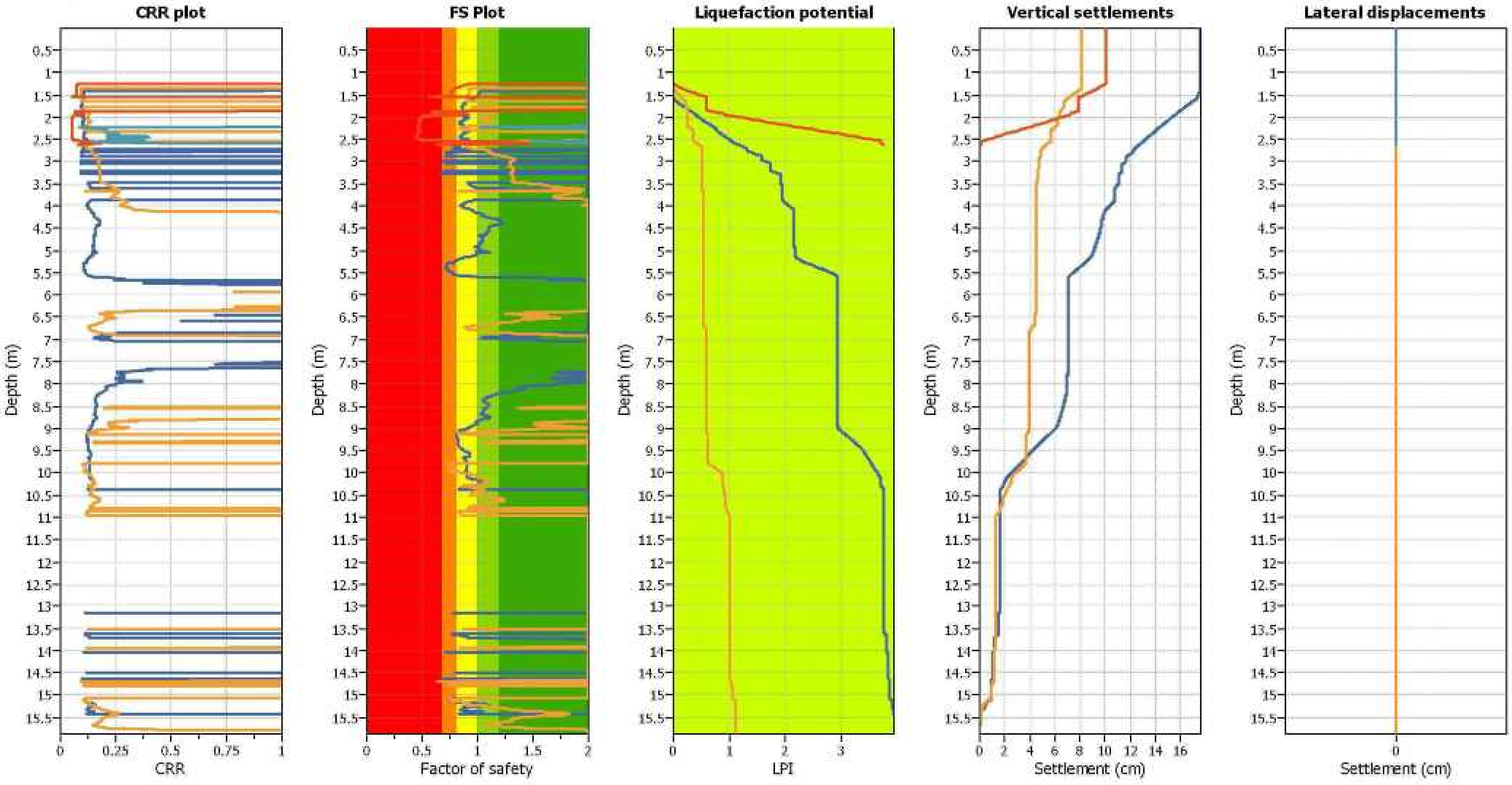
Project: Halswell Courts

Overlay Normalized Plots



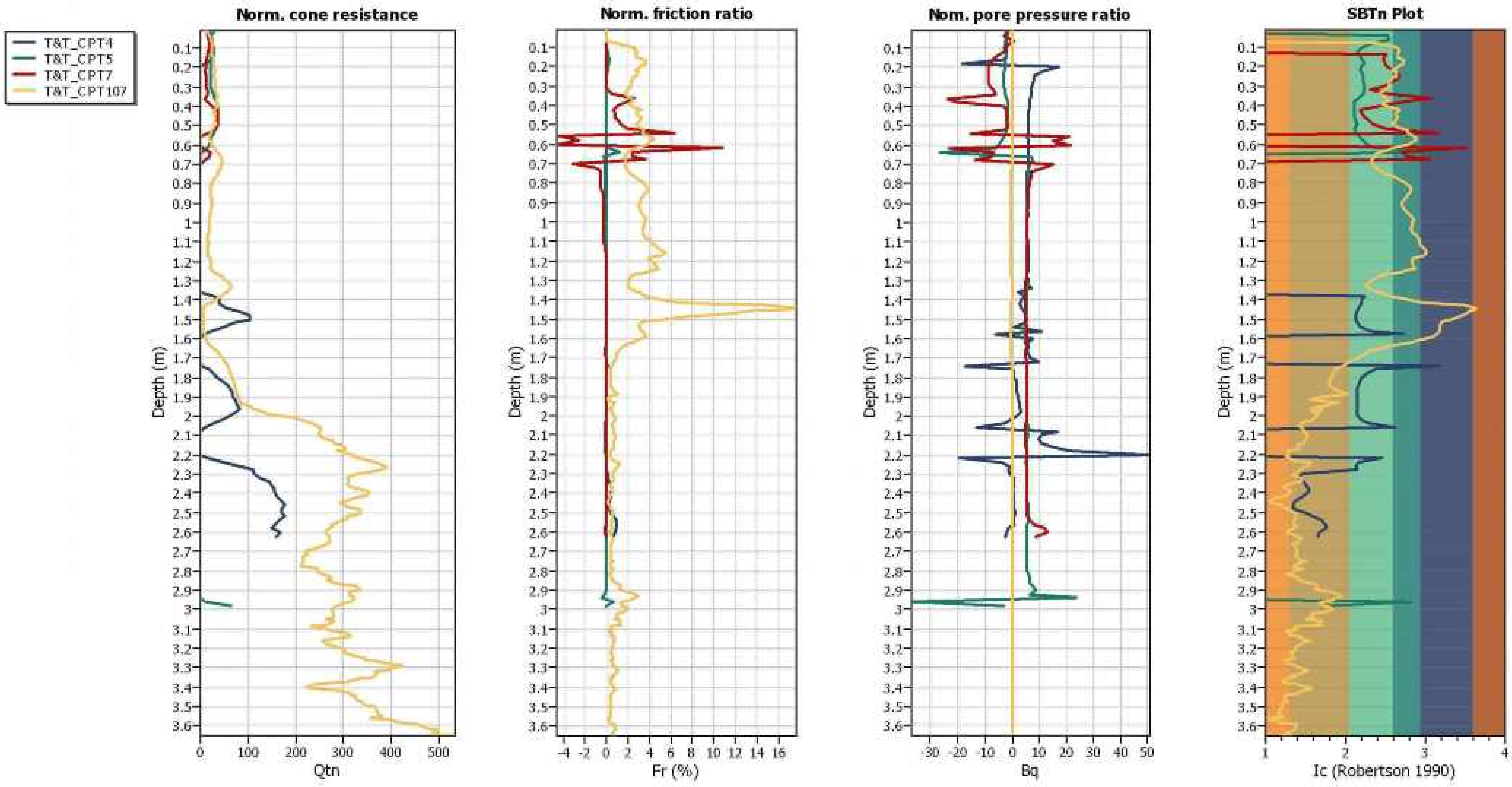
Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



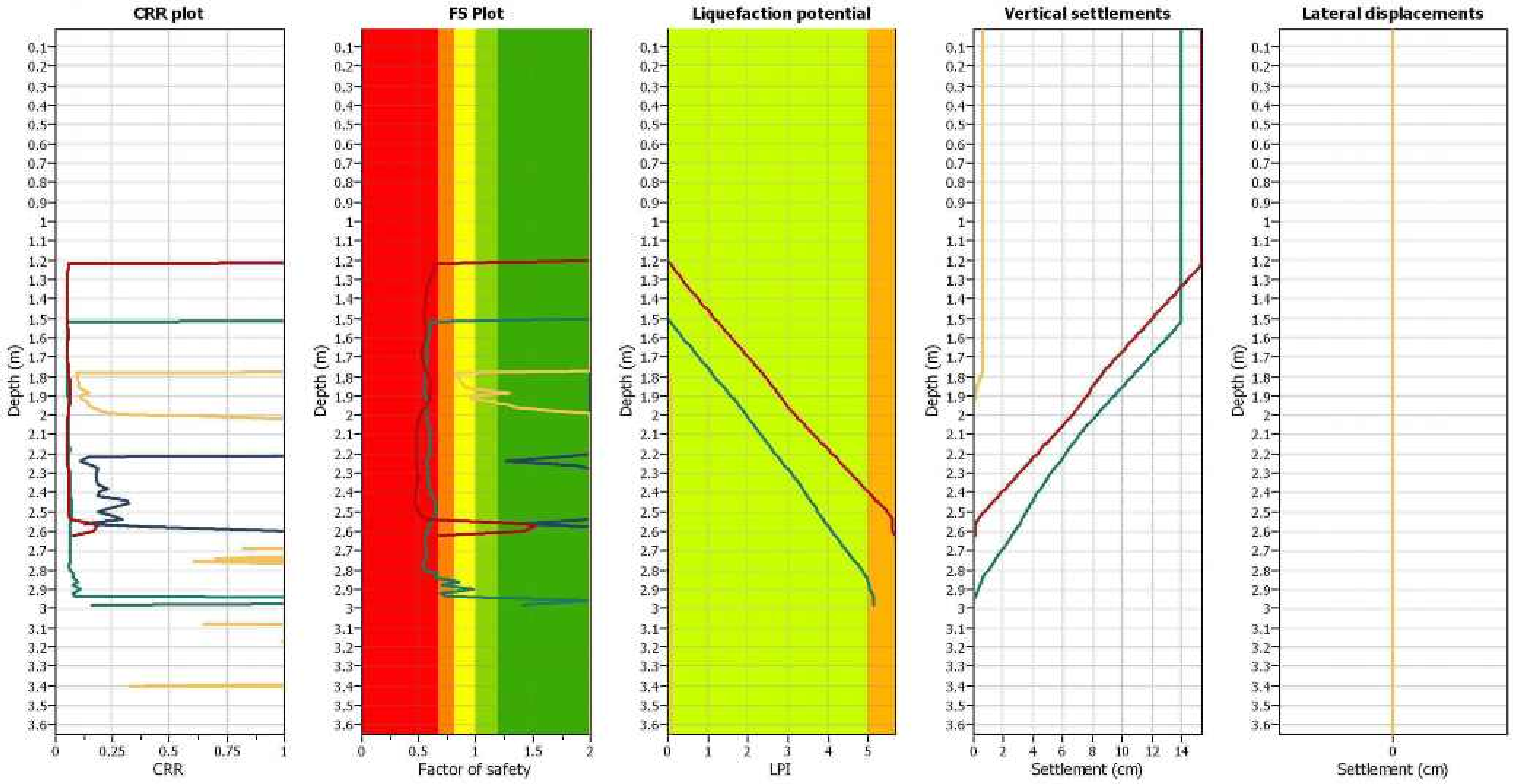
Project: Halswell Courts

Overlay Normalized Plots



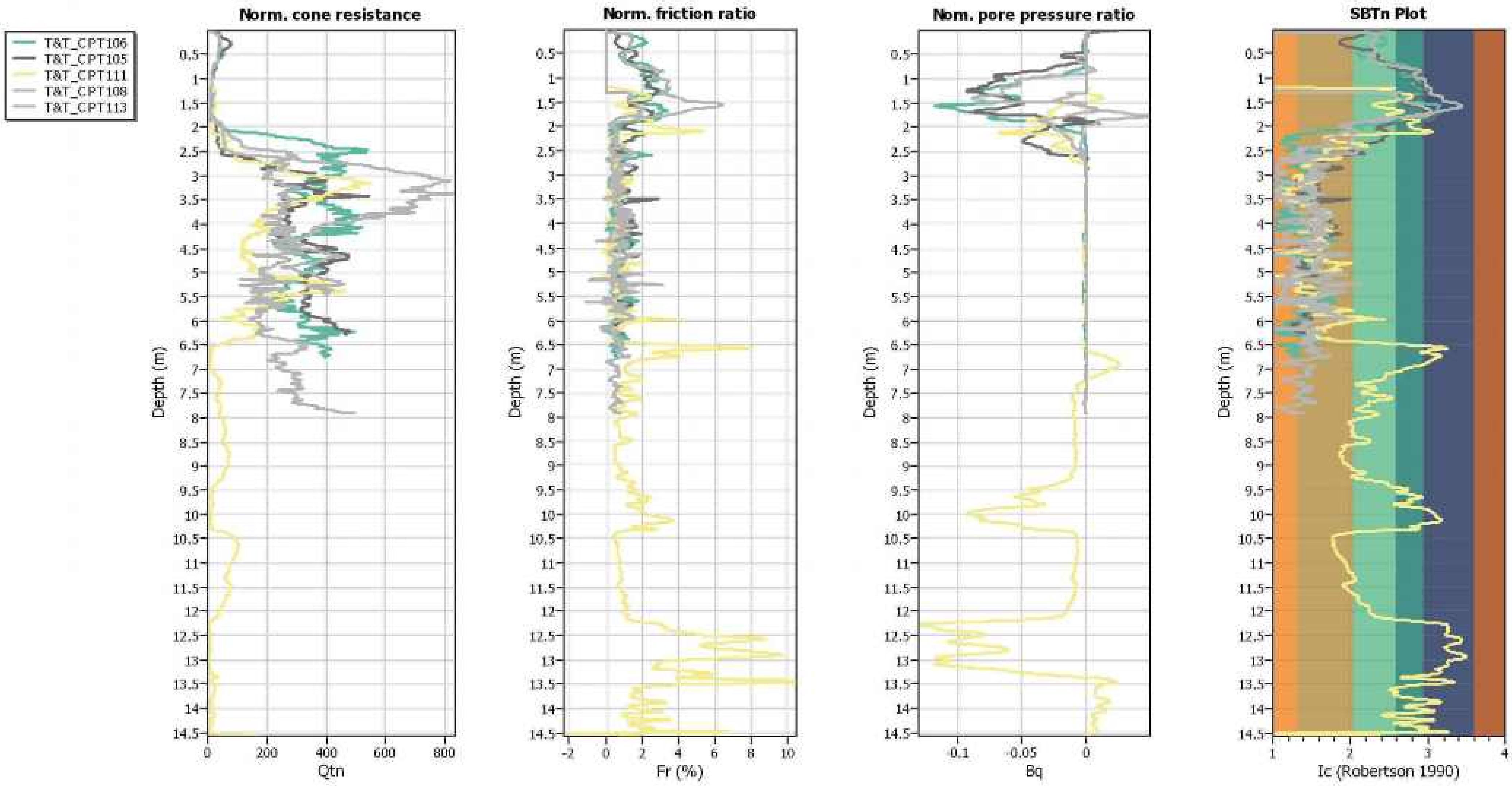
Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



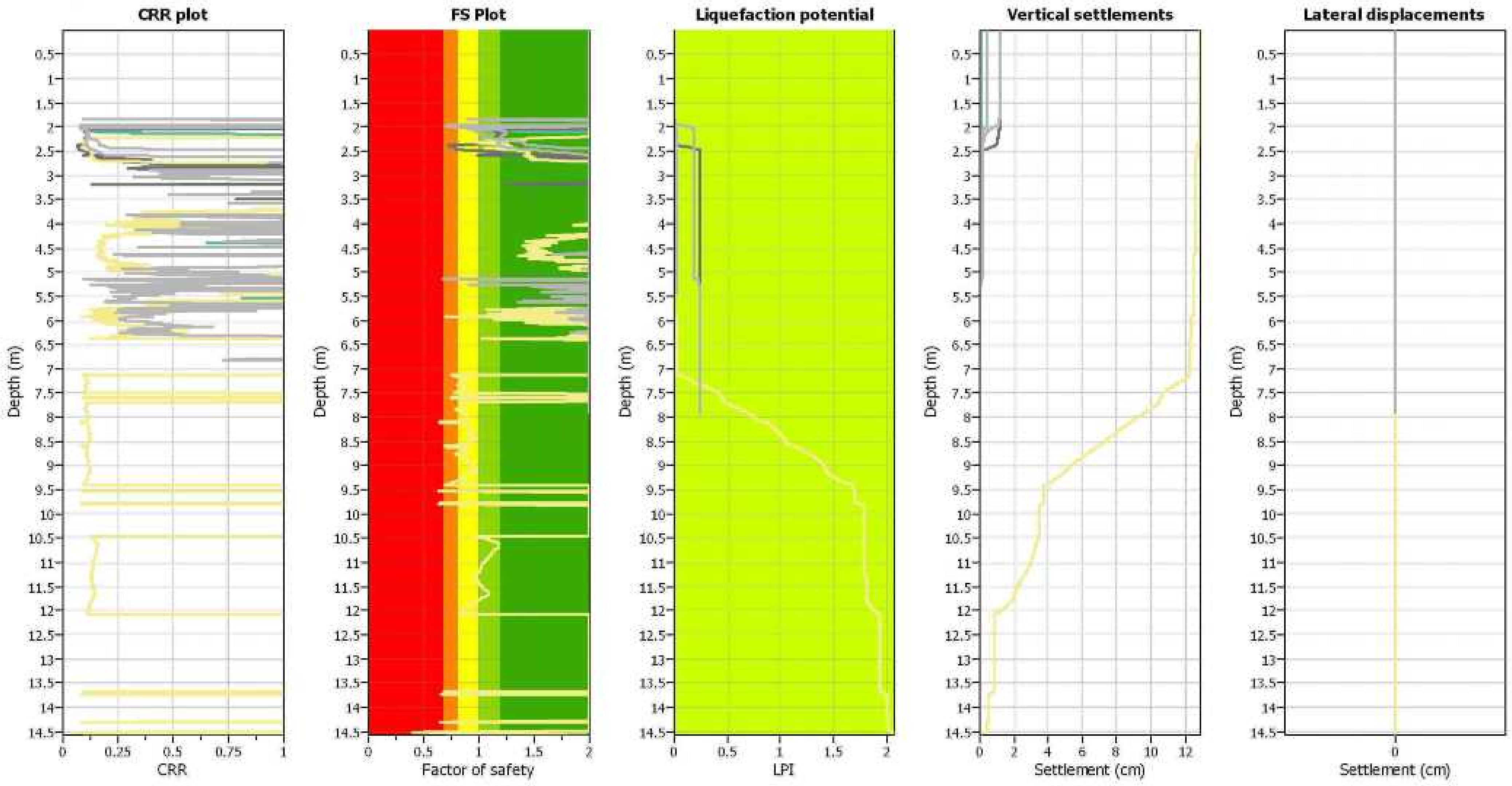
Project: Halswell Courts

Overlay Normalized Plots



Project: Halswell Courts

Overlay Cyclic Liquefaction Plots

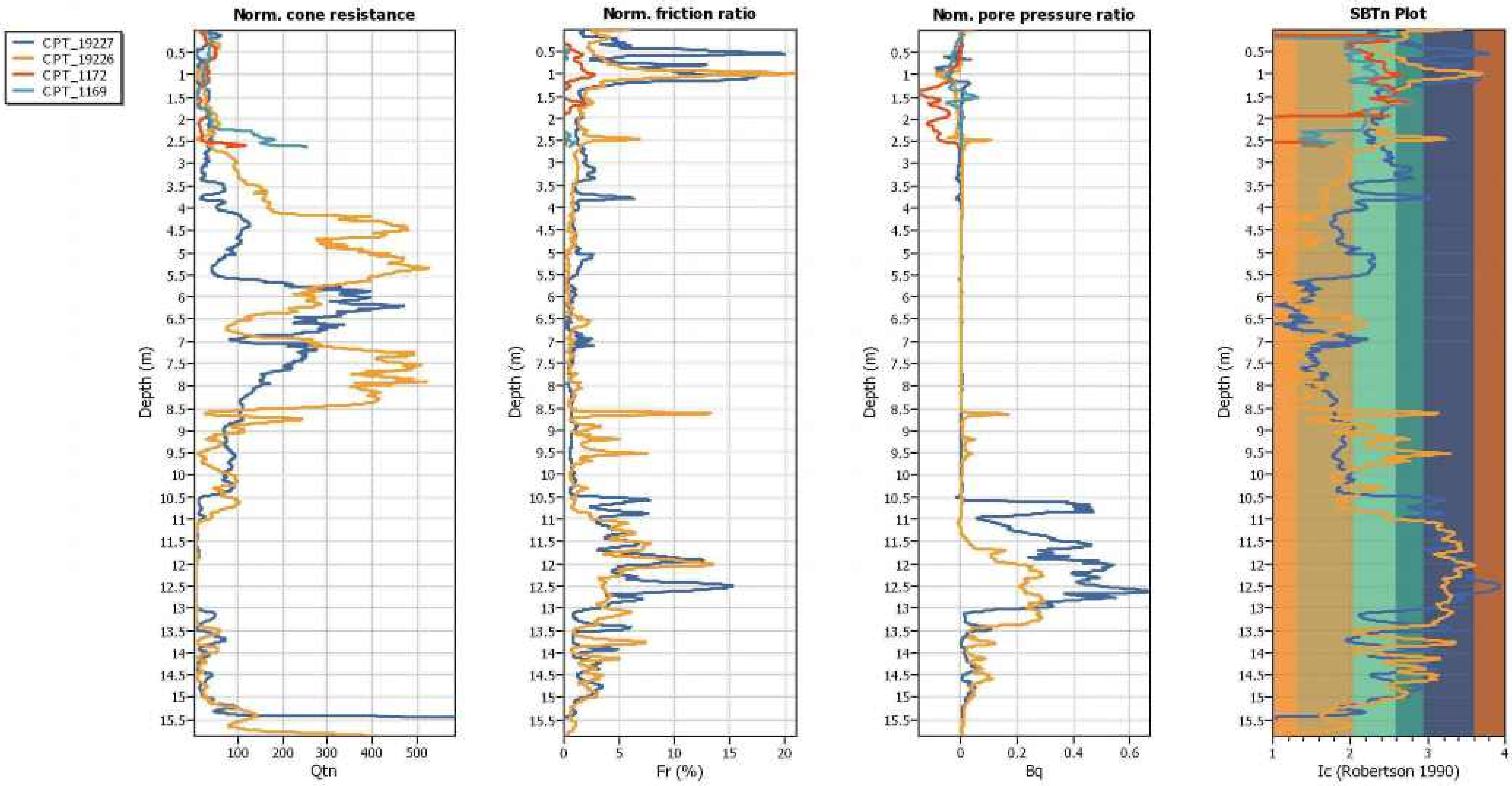


Appendix E.3

CLiq NCEER (1998) ULS Liquefaction Analysis Output

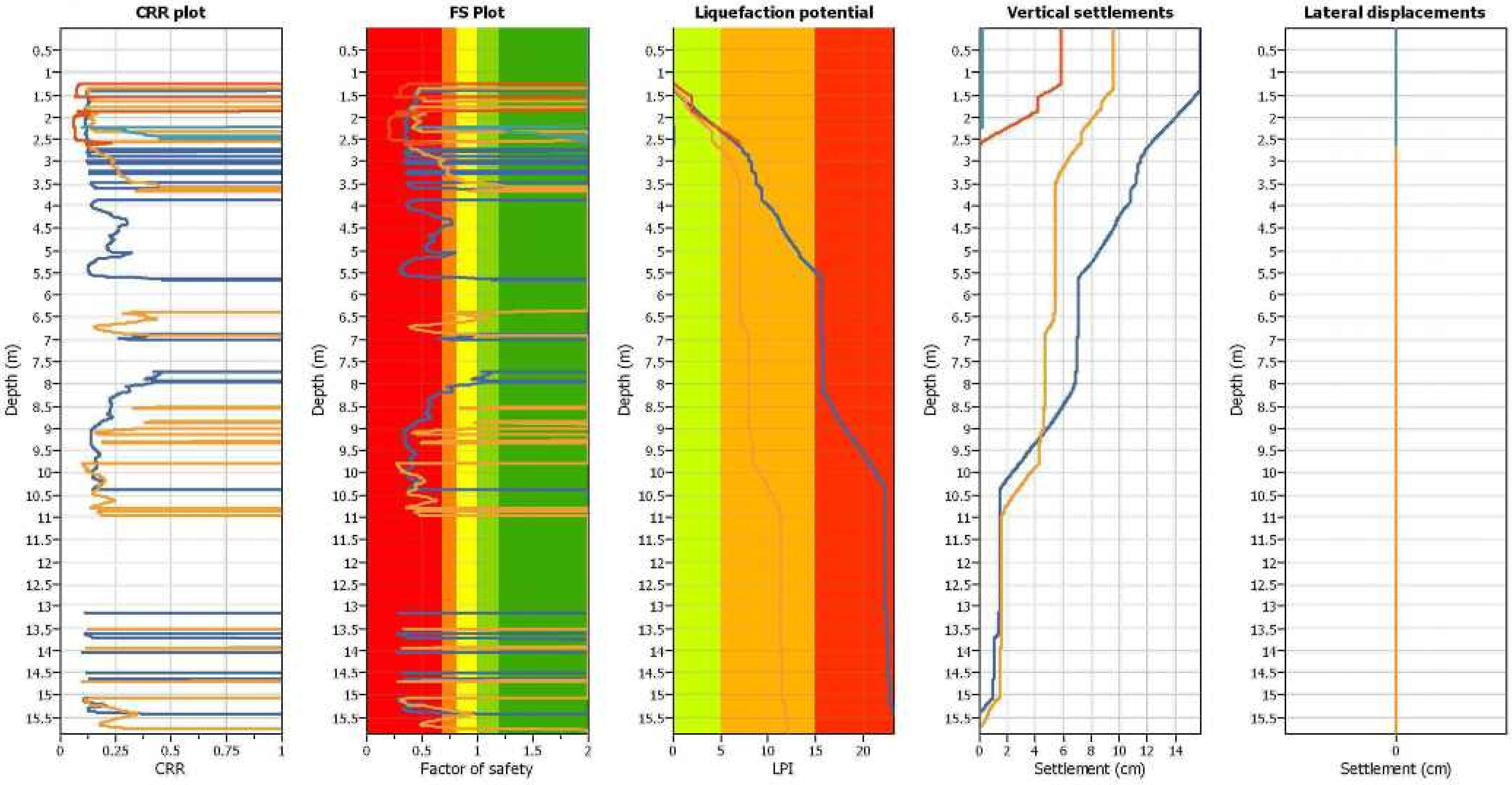
Project: Halswell Courts

Overlay Normalized Plots



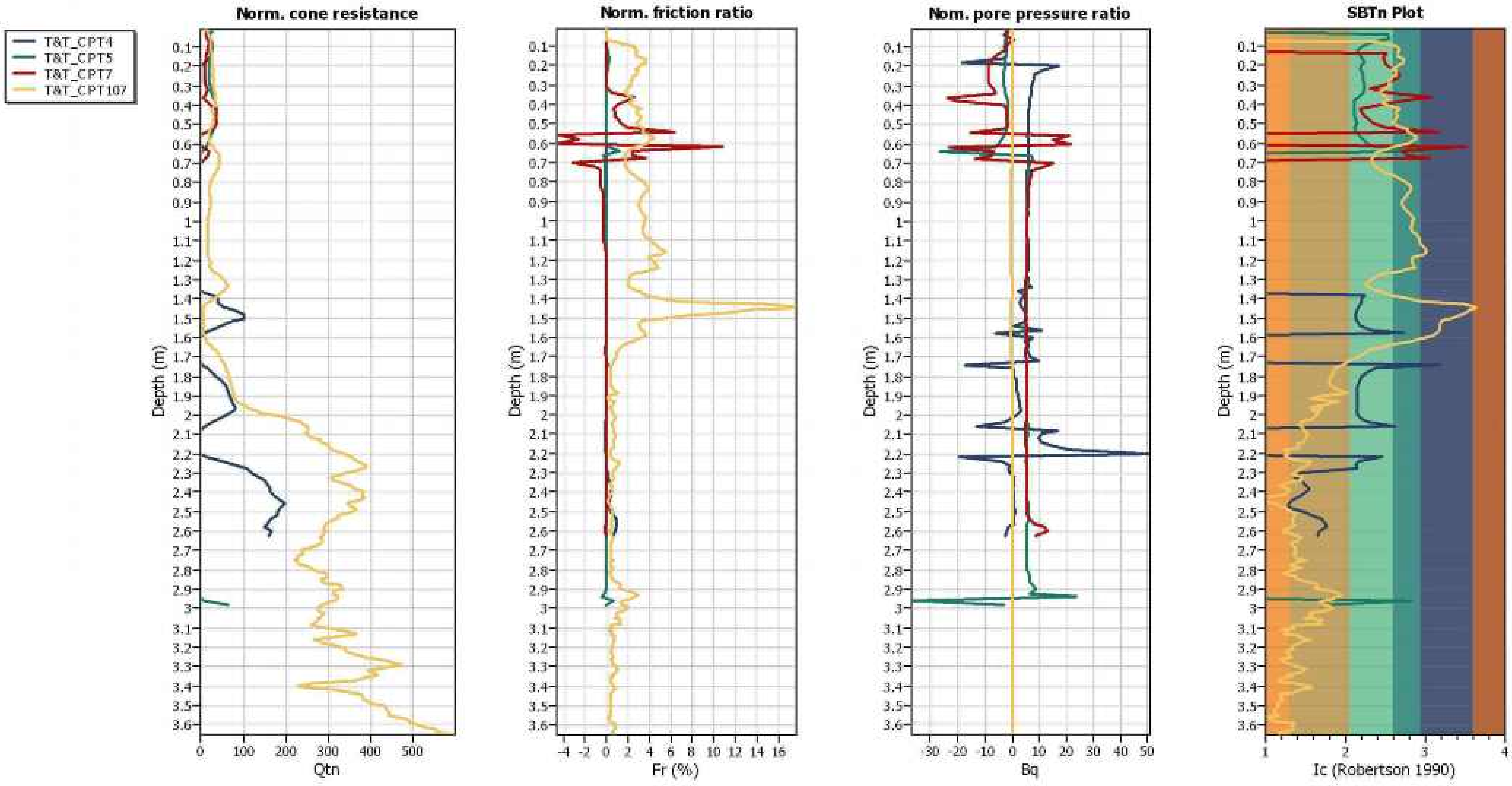
Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



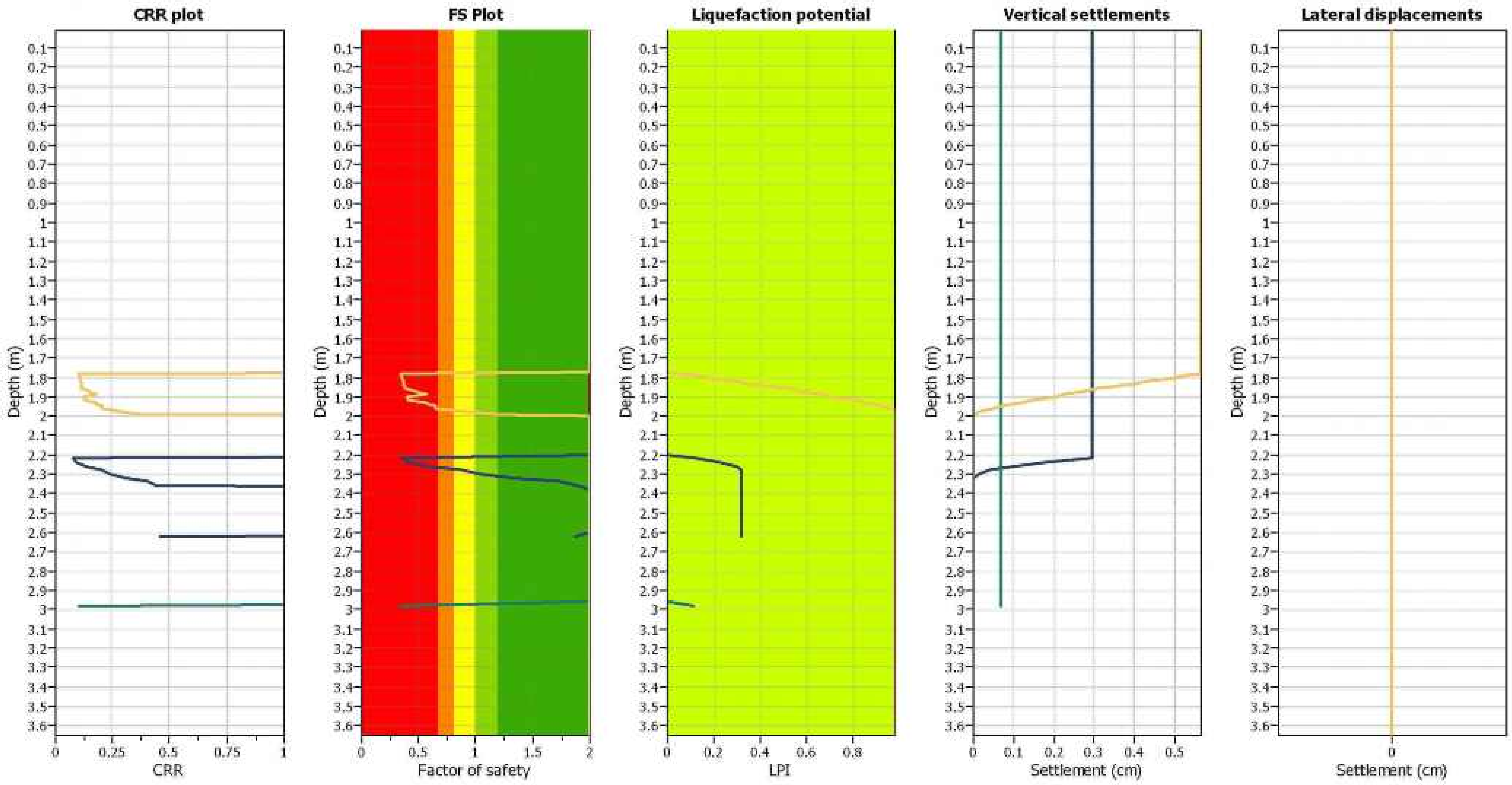
Project: Halswell Courts

Overlay Normalized Plots



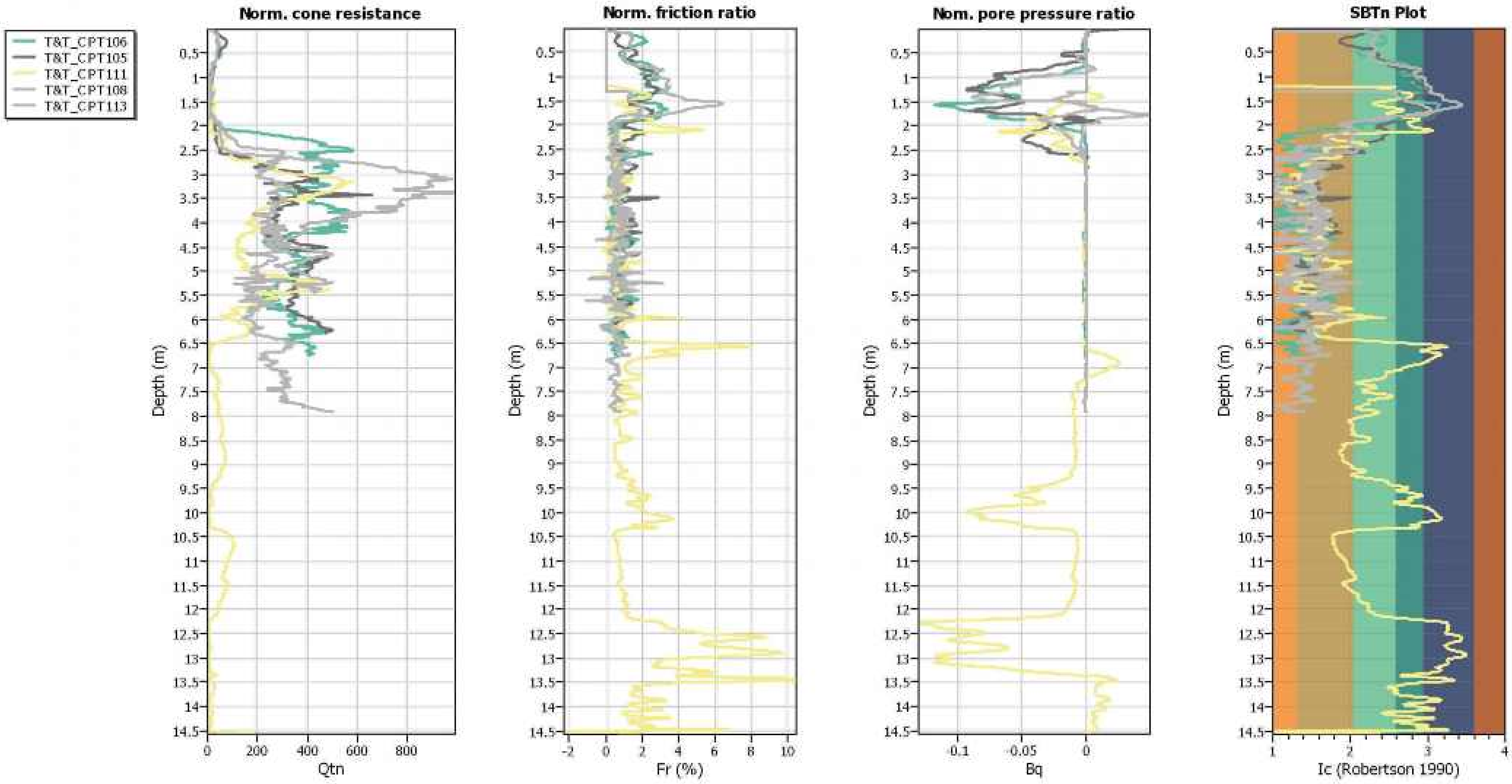
Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



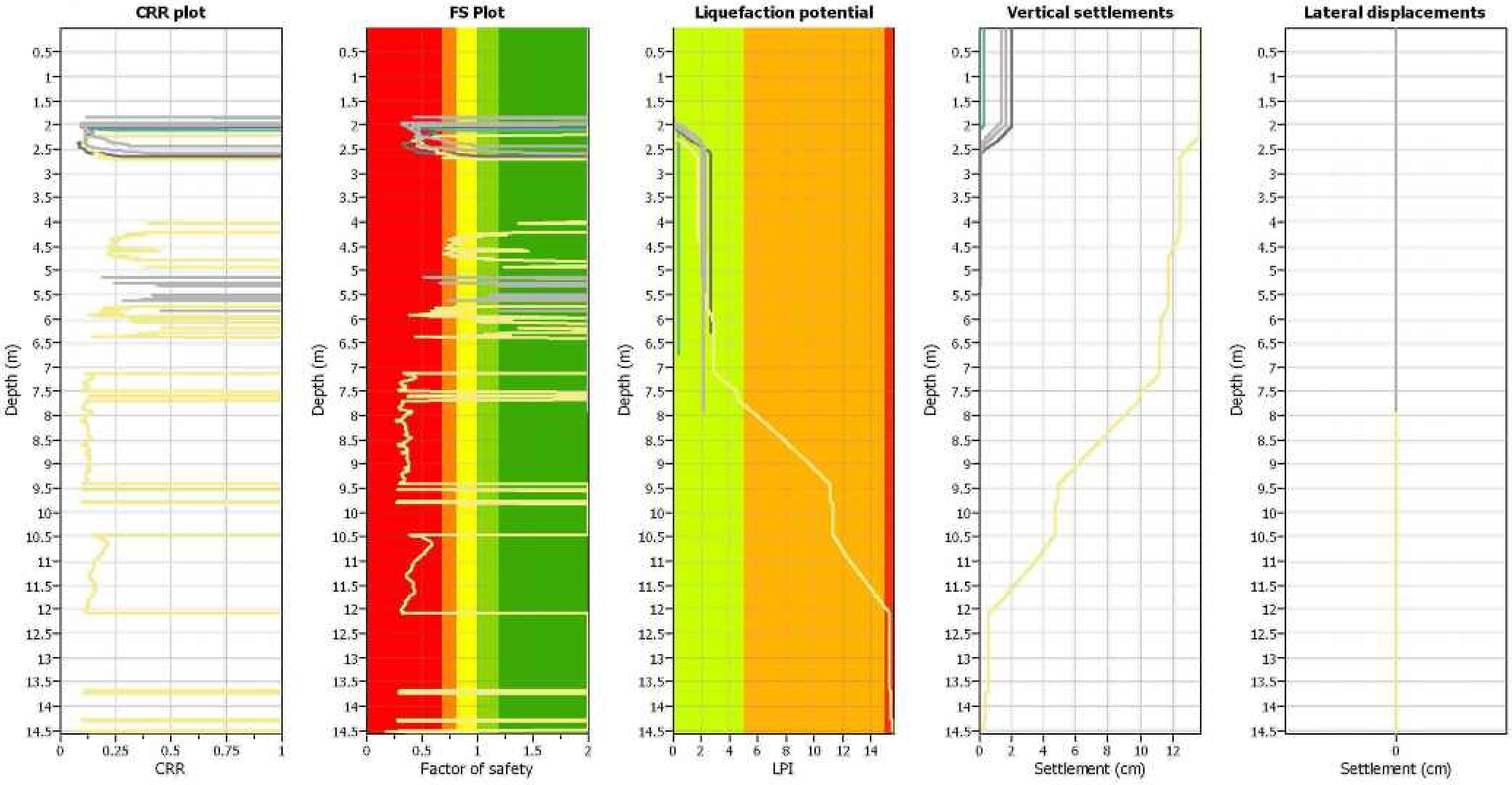
Project: Halswell Courts

Overlay Normalized Plots



Project: Halswell Courts

Overlay Cyclic Liquefaction Plots

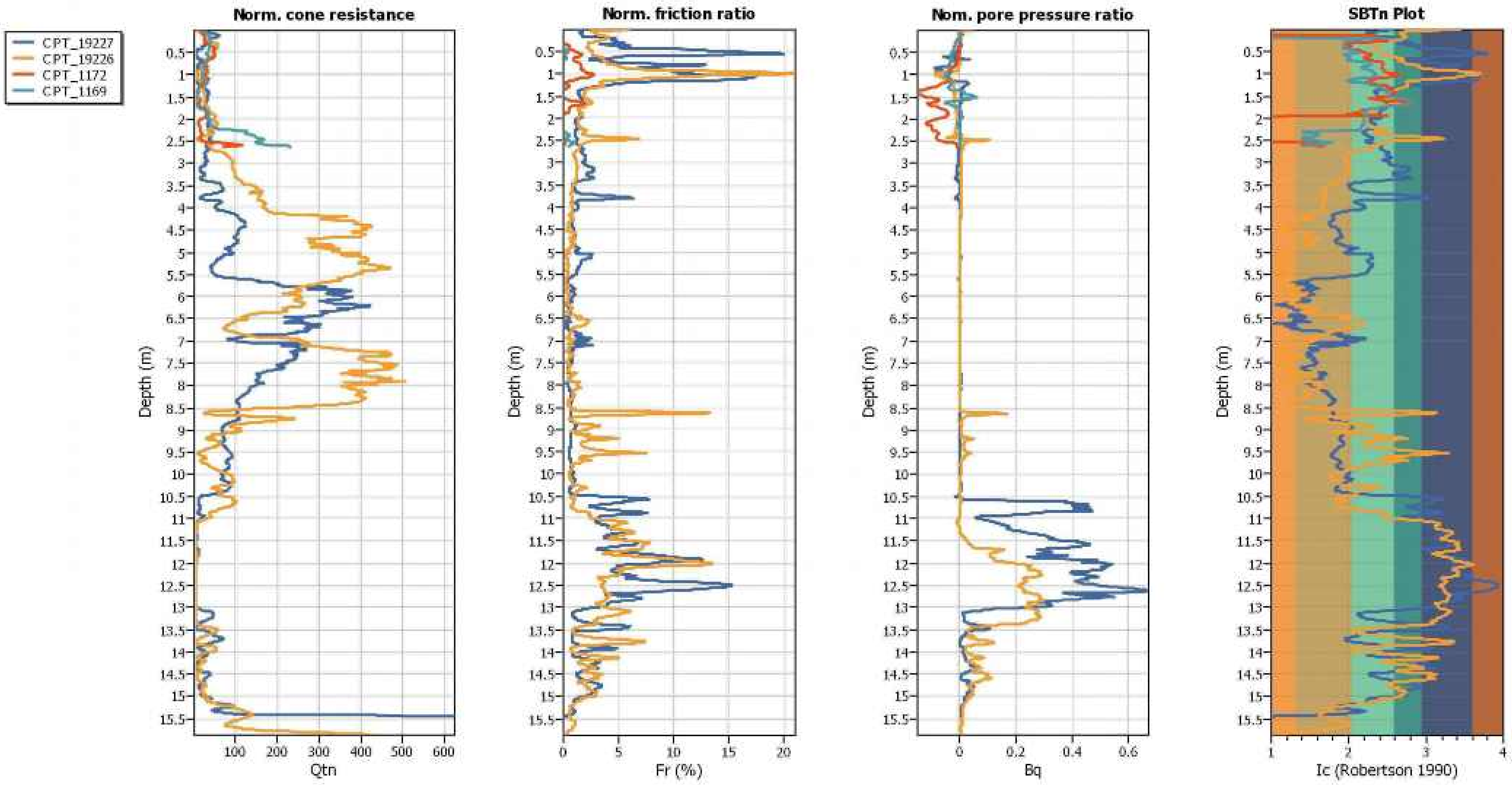


Appendix E.4

CLiq Idriss and Boulanger (2008) ULS Liquefaction Analysis Output

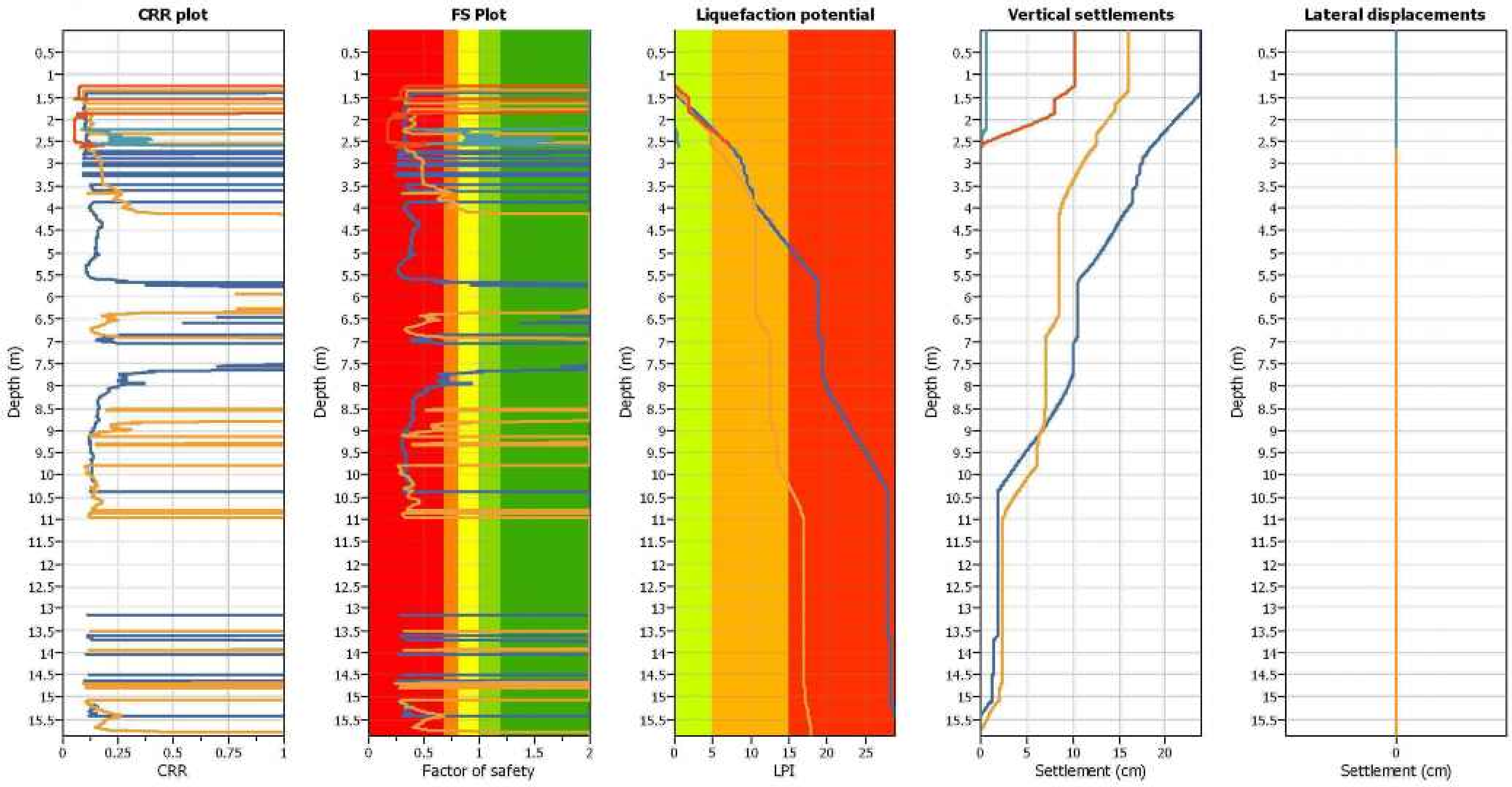
Project: Halswell Courts

Overlay Normalized Plots



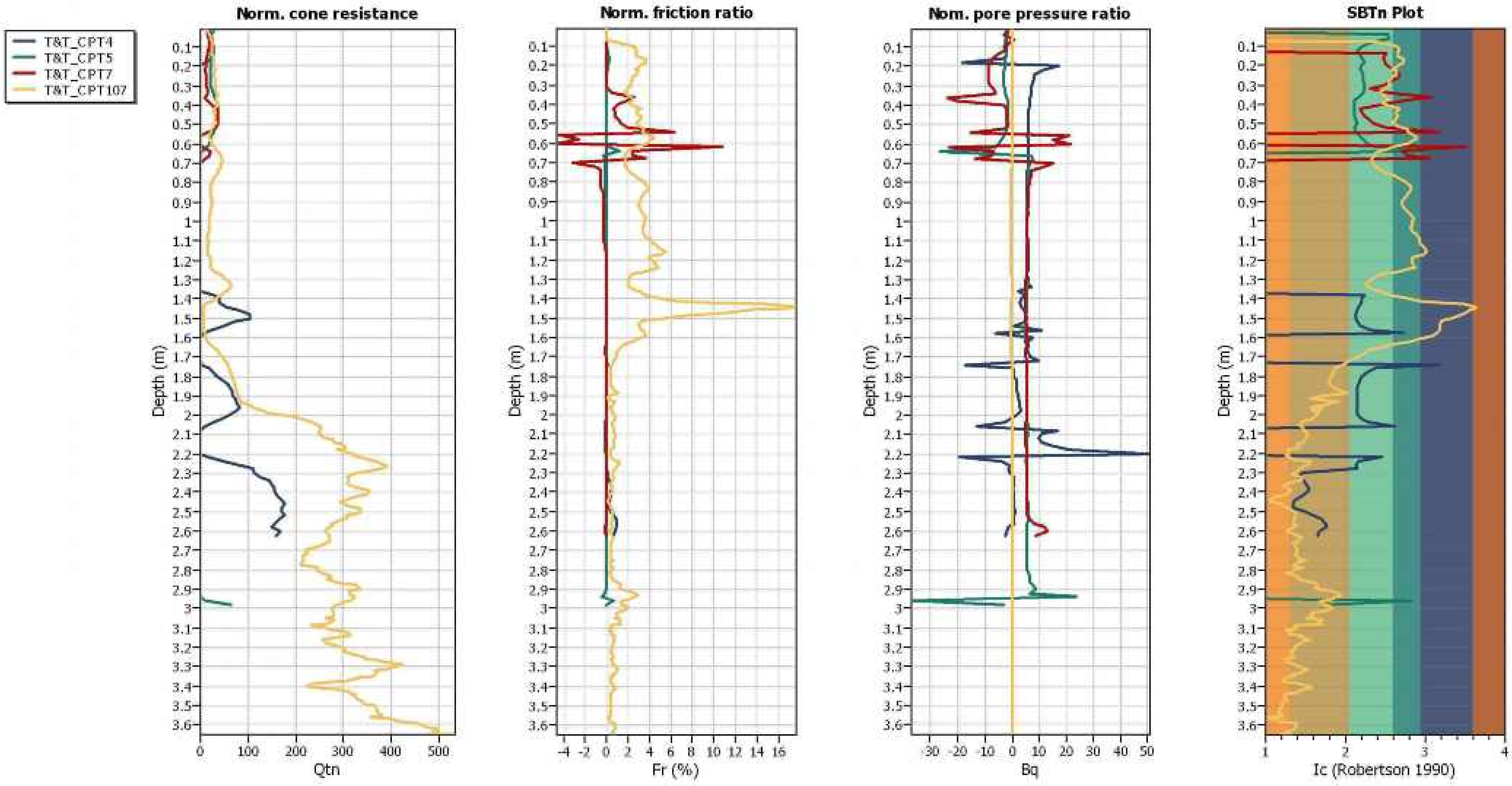
Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



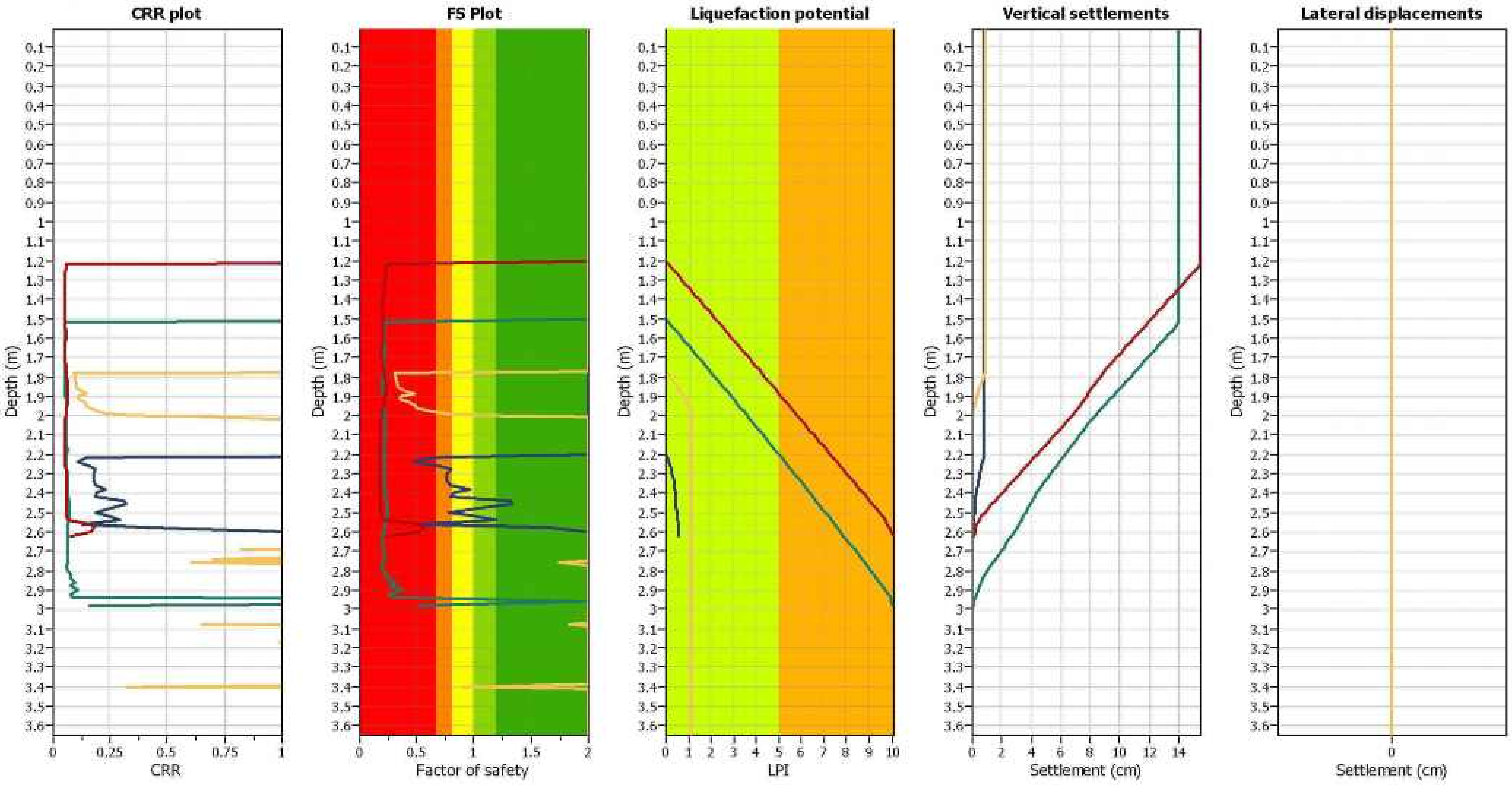
Project: Halswell Courts

Overlay Normalized Plots



Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



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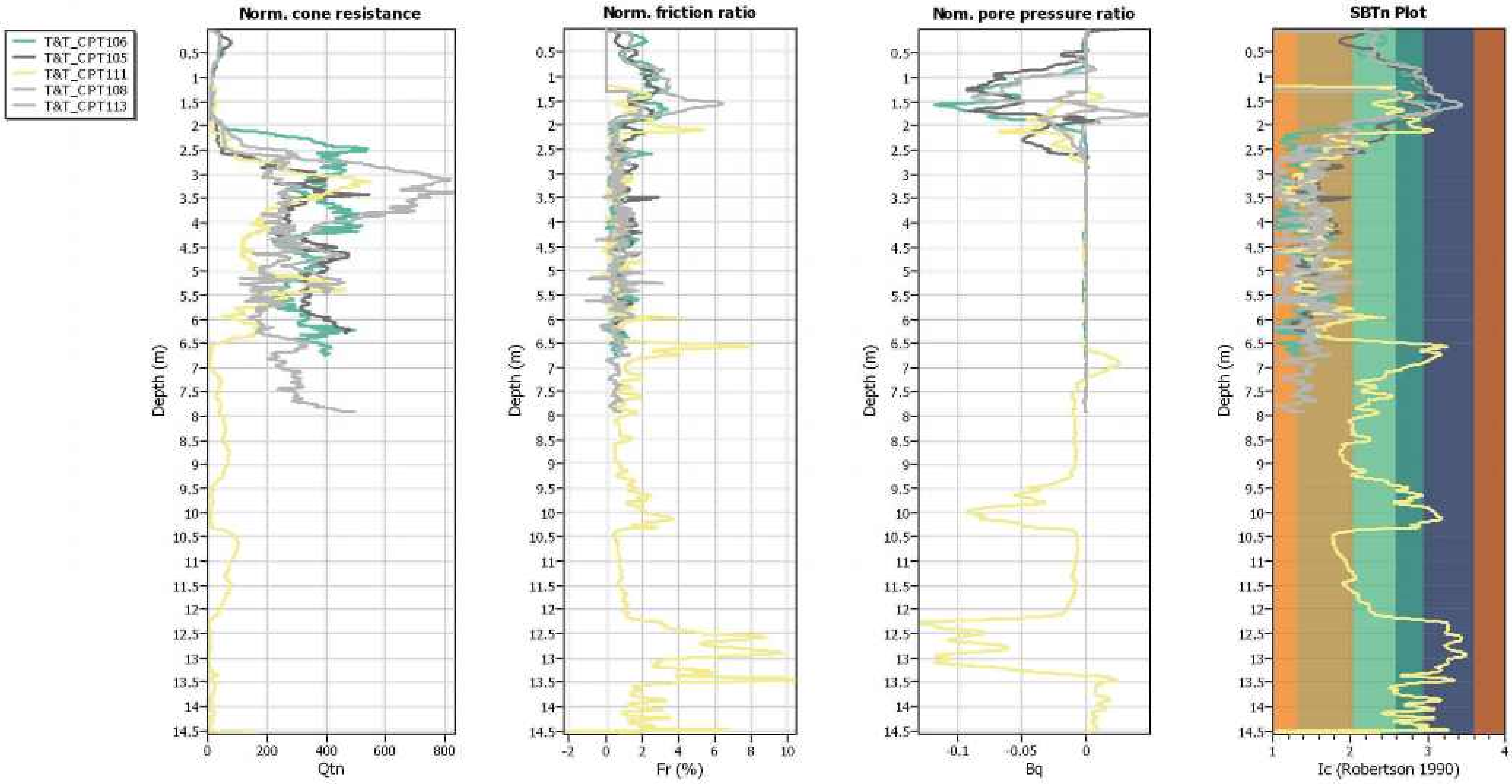
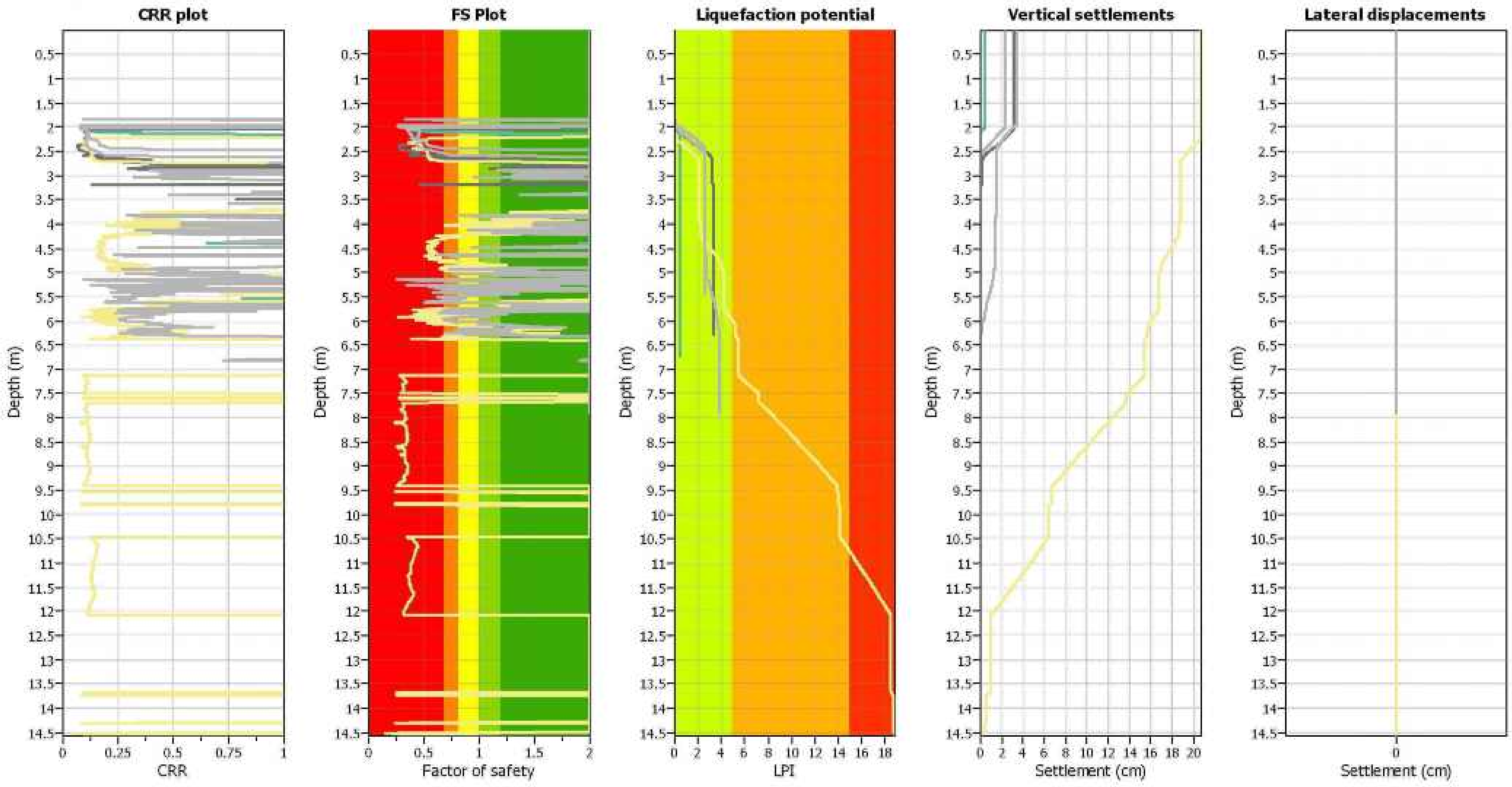
Project: Halswell Courts

Overlay Normalized Plots



Project: Halswell Courts

Overlay Cyclic Liquefaction Plots



Appendix D

Methodology and Assumptions

Analysis Procedure

Earthquake loads were calculated using NZS 1170.5. In the unit blocks, these loads were distributed to bracing walls on a tributary basis, as a flexible diaphragm was assumed. The garages were assumed to have small enough dimensions and sufficient members (dragon ties and strap bracing) to allow a global distribution to be considered.

Due to the unknown nature of the walls in the unit blocks, the bracing capacity of the timber walls was conservatively taken as 60 BU/m. The bracing capacity for the plywood-lined walls of the garages was taken as 83 BU/m. %NBS values were then found through the ratio of bracing demand to bracing capacity for each bracing element; with the worst %NBS for each block in each direction of loading being reported.

An out-of-plane check was completed on the block masonry fire walls in the unit blocks. This considered loading from Section 8 of NZS 1170.5 (parts and portions). The walls were assumed to simply span between the ground and the diaphragm.

Seismic Parameters

As per NZS 1170.5:

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

Due to the timber-framed construction, but with a lack of information about the detailing, a μ of 2.0 was assumed for the unit blocks.

Due to the more modern construction and the plywood walls, a μ of 3.0 was assumed for the garages.

Assumptions

Further to those indicated in section 7.3, the following assumptions were used in the assessment:

- Sheet linings and their connections on all walls of the residential units are such that they are able to develop a strength of at least 3kN/m (60BU/m).
- Sheet linings and their connections on all walls of the garages are installed to NZS 3604:1990[7] and as such, the bracing capacity of these walls can be taken from this standard.
- Block masonry fire walls between units are fully grouted and reinforced with D12 bars at 600mm centres both ways.
- Connections between structural elements are strong enough to transmit all seismic loads. This includes all nailed connections between diaphragms and wall linings and their respective timber framing.
- Flexible diaphragms are able to adequately transfer seismic loads to bracing walls without failing.

Appendix E

CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name: Halswell Courts units

	Unit	No:	Street
Building Address:		38	Kennedys Bush Road

Legal Description:

	Degrees	Min	Sec
GPS south:	43	35	21.49
GPS east:	172	34	12.71

Building Unique Identifier (CCC): PRO1630

Reviewer: Mary Ann Halliday
CPEng No: 67073
Company: OPUS International Consultants Ltd
Company project number: 6-QC355.00
Company phone number: 6433635400

Date of submission: Nov-13
Inspection Date: 12-Jun-13
Revision: Final
Is there a full report with this summary? yes

Site

Site slope: flat
Soil type:
Site Class (to NZS1170.5): D
Proximity to waterway (m, if <100m):
Proximity to clifftop (m, if < 100m):
Proximity to cliff base (m,if <100m):

Max retaining height (m):
Soil Profile (if available):

If Ground improvement on site, describe:

Approx site elevation (m):

Building

No. of storeys above ground: 1 single storey = 1
Ground floor split? no
Storeys below ground 0
Foundation type: mat slab
Building height (m): 3.00
Floor footprint area (approx): 350
Age of Building (years): 35

Ground floor elevation (Absolute) (m):
Ground floor elevation above ground (m):

if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m):

Date of design: 1976-1992

Strengthening present? no

If so, when (year)?
And what load level (%g)?
Brief strengthening description:

Use (ground floor): multi-unit residential
Use (upper floors):
Use notes (if required):
Importance level (to NZS1170.5): IL2

Gravity Structure

Gravity System: frame system
Roof: timber framed
Floors: concrete flat slab
Beams:
Columns:
Walls: non-load bearing

rafter type, purlin type and cladding
slab thickness (mm)

0

Lateral load resisting structure

Lateral system along: lightweight timber framed walls
Ductility assumed, μ: 2.00
Period along: 0.10 0.00
Total deflection (ULS) (mm):
maximum interstorey deflection (ULS) (mm):

Note: Define along and across in detailed report!

note typical wall length (m)
estimate or calculation? estimated
estimate or calculation?
estimate or calculation?

Lateral system across: lightweight timber framed walls
Ductility assumed, μ: 2.00
Period across: 0.10 0.00
Total deflection (ULS) (mm):
maximum interstorey deflection (ULS) (mm):

note typical wall length (m)
estimate or calculation? estimated
estimate or calculation?
estimate or calculation?

Separations:

north (mm):
east (mm):
south (mm):
west (mm):

leave blank if not relevant

Non-structural elements

Stairs:
Wall cladding: brick or tile
Roof Cladding: Metal
Glazing: aluminium frames
Ceilings: fibrous plaster, fixed
Services(list):

describe (note cavity if exists)
describe

Available documentation

Architectural partial
Structural partial
Mechanical none
Electrical none
Geotech report full

original designer name/date
original designer name/date
original designer name/date
original designer name/date
original designer name/date

Damage

Site:
(refer DEE Table 4-2)

Site performance:

Describe damage:

Settlement: 0-25mm
Differential settlement: 0-1:350
Liquefaction: none apparent
Lateral Spread: 0-50mm
Differential lateral spread: none apparent
Ground cracks: none apparent
Damage to area: moderate to substantial (1 in 5)

notes (if applicable):
notes (if applicable):
notes (if applicable):
notes (if applicable):
notes (if applicable):
notes (if applicable):
notes (if applicable):

Building:

Current Placard Status: green

Along Damage ratio: 0%
Describe (summary):

Describe how damage ratio arrived at:

Across Damage ratio: 0%
Describe (summary):

$$Damage\_Ratio = \frac{(\% NBS\,(before) - \% NBS\,(after))}{\% NBS\,(before)}$$

Diaphragms Damage?: no Describe:

CSWs: Damage?: no Describe:

Pounding: Damage?: no Describe:

Non-structural: Damage?: yes Describe:

Recommendations

Level of repair/strengthening required: significant structural
Building Consent required: no
Interim occupancy recommendations: full occupancy

Describe:
Describe:
Describe:

Along Assessed %NBS before e'quakes: 58% ##### %NBS from IEP below
Assessed %NBS after e'quakes: 58%

If IEP not used, please detail assessment methodology: Equivalent Static

Across Assessed %NBS before e'quakes: 100% ##### %NBS from IEP below
Assessed %NBS after e'quakes: 100%

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