Brougham Village Blocks G and H
Detailed Engineering Evaluation
Quantitative Report

Christchurch City Council

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Detailed Engineering Evaluation Quantitative Report

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Brougham Village Blocks G and H
BU 1072-008 EQ2 and BU 1072-009 EQ2

Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Version 3 - FINAL

95 and 97 Hastings Street, Sydenham, Christchurch

Background

This report is a quantitative report for the Brougham Village Blocks G and H buildings. It is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, visual inspections conducted by Opus engineers on 13 June 2012 and available drawings and calculations.

Key Damage Observed

Minimal structural damage was observed throughout the buildings.

Critical Structural Weaknesses

The building seismic performance is governed by structural elements that resist significant torsional effects induced by non-symmetric wall configuration. Detailed Engineering Evaluations term this a Critical Structural Weakness called “Plan Irregularity”.

Indicative Building Strength

Based on the information available, the building capacities have been assessed to be 19% NBS in the east-west direction limited by the in-plane capacity of the east-west oriented shear walls in the second storey. The buildings have been assessed to be 100% NBS in the north-south direction.

The site in general is susceptible to future liquefaction and lateral spreading. Future liquefaction of foundations would cause further structural and non-structural damage. Due to the unpredictable effects of liquefaction, the reported building strength does not include a reduction factor for differential settlement induced forces.

The buildings have been assessed to have a seismic capacity of less than 34% NBS and are therefore classified as Earthquake Prone Buildings as defined by legislation.

Recommendations

It is recommended that:

(a) A cordon be placed around Blocks G and H. This cordon should extend 5m to the south of the buildings and 8m to the east of Block H. We also recommend this cordon extend 8m to the west of Block G. As this cordon will encroach on to a private right of way to the west of Block G, we recommend that discussions are held between CERA, the Christchurch City Council, Opus and the occupier of 91B Hastings St about the relative risks represented by the structure at 95 Hastings St and the extent of any cordon in this area.

(b) Cordoning or temporary propping of the courtyard walls on the north side of Blocks G and H be put in place until their lateral stability in the presence of possible liquefaction can be properly assessed.

(c) Further investigations be carried out to confirm the structural composition of the floor diaphragms.

(d) Geotechnical investigations be undertaken to quantify the liquefaction potential of the site and to conclusively determine the soil shallow bearing strength of the existing foundations in order to complete the assessment of the footings.

(e) A strengthening scheme be developed to increase the overall strength of the buildings to at least 67% NBS.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Brougham Village Blocks G and H, located at 95-97 Hastings St, Sydenham, following the M6.3 Christchurch earthquake on 22 February 2011.

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

The seismic assessment and reporting have been undertaken based on the qualitative and quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011.

2 Compliance

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

2.1 Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

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

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

1. The importance level and occupancy of the building.

2. The placard status and amount of damage.
3. The age and structural type of the building.
4. Consideration of any critical structural weaknesses.

Any building with a capacity of less than 34% of new building standard (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% as required by the CCC Earthquake Prone Building Policy.

2.2 Building Act

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

Section 112 - Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to the alteration.

This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) 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 CCC as being 67% of the strength of an equivalent new building. This is also the minimum level recommended by the New Zealand Society for Earthquake Engineering (NZSEE).

Section 121 – Dangerous Buildings

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

1. In the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
2. In the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
3. There is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a 'moderate earthquake' (refer to Section 122 below); or
4. There is a risk that other property could collapse or otherwise cause injury or death; or

5. A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

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

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

Section 124 – Powers of Territorial Authorities

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

Section 131 – Earthquake Prone Building Policy

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

2.3 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in 2006. This policy was amended immediately following the Darfield Earthquake on 4 September 2010.

The 2010 amendment includes the following:

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

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

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

- The accessibility requirements of the Building Code.

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

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:

- 36% increase in the basic seismic design load for Christchurch (Z factor increased from 0.22 to 0.3);
- Increased serviceability requirements.

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

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

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

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

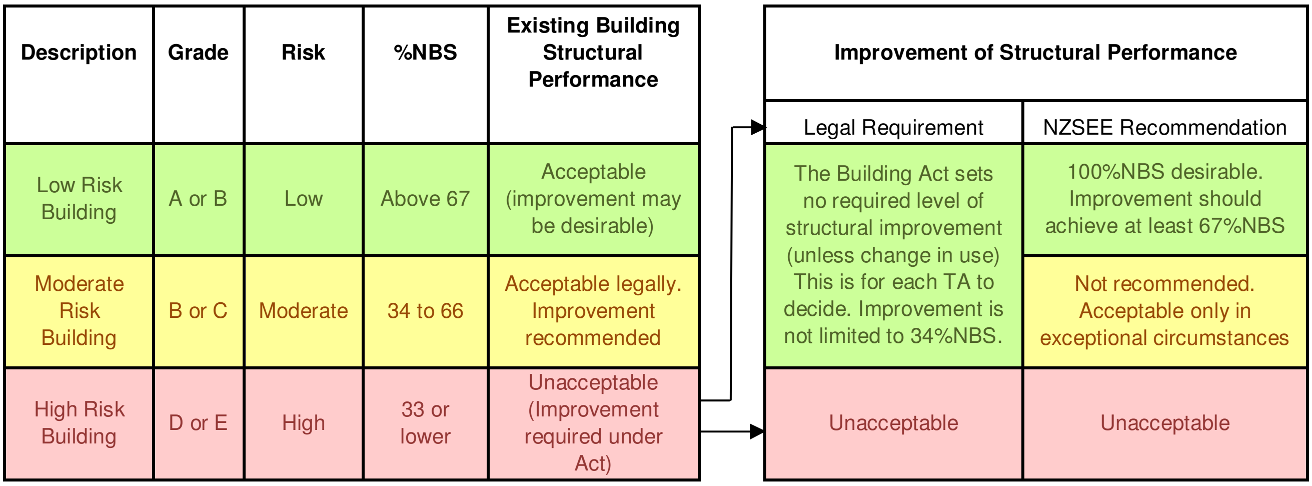
1.2 Ensuring that responsible steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.

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

3 Earthquake Resistance Standards

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

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



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

Figure 1: NZSEE Risk Classifications Extracted from Table 2.2 of the NZSEE 2006 AISPBE Guidelines

Table 1 below compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year). It is noted that the current seismic risk in Christchurch results in a 6% risk of exceedance 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

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

they are made aware of our assessment. Based on information received from CERA to date, 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/Christchurch City Council guidelines.

3.1.3 Strengthening

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

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

3.1.4 Our Ethical Obligation

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

4 Building Description

4.1.1 General

The Brougham Village Blocks G and H are two identical buildings, at 95 and 97 Hastings Street respectively, located at the south west corner of the Brougham Village complex. The buildings are three storeys with reinforced concrete masonry construction. The roofs are timber-framed. The floors are suspended concrete proprietary floors and the foundations are reinforced thickenings within the slabs. Ceilings are GIB-lined throughout and internal partition walls are timber-framed and GIB-lined.

The buildings are constructed on level ground. They are approximately 22m long in the east-west direction and 20m wide in the north-south direction. The buildings consist of 12 flats each (4 at each level) approximately 12m by 4m in plan dimensions. The apex of the roofs is approximately 8m high and the inter-storey heights are 2.55m. A site plan is given in Figure 2.

The buildings were designed in 1976.

Figure 2: Location of Blocks G and H on the Brougham Village site.

4.1.2 Gravity Load Resisting System

The roofs are timber-framed and are clad with lightweight metal sheeting, with GIB-lined ceilings. The roof structure is supported on the north-south oriented masonry walls.

The floors are suspended slabs supported on the north-south oriented masonry walls.

The walls are full-height reinforced concrete masonry with inter-storey height of 2.55m throughout.

The foundations consist of reinforced concrete floor slabs with reinforced foundation beams under the masonry walls.

4.1.3 Seismic Force Resisting System

Seismic forces in both principal directions are resisted by the reinforced concrete masonry walls. The walls in the north-south direction extend the length of the buildings and are spaced transversely at approximately 4m intervals. Walls in the east-west direction do not continue to the third (top) storey so lateral load resistance is provided by out-of-plane cantilever action of the north-south walls. In the first and second storeys, there are approximately 32m and 18m of east-west wall respectively. Appendix B shows the floor plans, including wall layouts, for the buildings.

The floors comprise mesh reinforced concrete and are assumed to provide diaphragm action to distribute the lateral forces to the wall bracing elements.

5 Survey

Copies of the following drawings were referred to as part of the assessment:

- A set of architectural and structural drawings by Cowey Mills & Co. Ltd. Registered Architects, titled “Brougham Street Urban Renewal 1. Stage 2”.

No copies of the design calculations have been obtained for the buildings.

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

6 Damage Assessment

Blocks G and H have minimal visible damage as a result of the recent earthquakes. Minor vertical cracking was observed on the exterior walls at the locations of downpipes adjacent to the stairs. Some cracking of structural masonry walls was observed in areas expected to have experienced stress concentrations.

Some of the patio walls at ground level have some vertical cracking due to differential settlement caused by liquefaction, but these do not affect the overall strength of the buildings.

7 General Observations

Overall the buildings have performed well during the recent earthquakes. An initial visual inspection of the buildings prior to a detailed assessment showed that they have sustained minimal visible damage.

8 Detailed Seismic Assessment

8.1 Critical Structural Weaknesses

As outlined in the Critical Structural Weakness and Collapse Hazards draft briefing document, issued by the Structural Engineering Society (SESOC) on 7 May 2011, 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 the building.

The following critical structural weaknesses have been identified:

- Plan irregularity.

8.2 Potential Structural Hazards

The following are potential hazards which have been identified in the structure. The nature of a structural hazard is to cause localised failure and damage but not influence the structure beyond the immediate area.

- Inadequate Foundations – The foundations to the walls are narrow strip footings typically 200mm-500mm wide. The effect of such narrow foundations is to dramatically increase the possibility of shear failure of the soils local to the foundations, resulting in excessive settlements and the introduction of forces to the frame for which it was not designed.

8.3 Seismic Coefficient Parameters

The seismic design parameters based on current design requirements from NZS1170.5:2004 and the NZBC clause B1 for these buildings are:

- Site soil class D, clause 3.1.3 NZS 1170.5:2004.
- Site hazard factor, Z=0.3, B1/VM1 clause 2.2.14B.
- Return period factor R_u = 1.0 from Table 3.5, NZS 1170.5:2004, for an Importance Level 2 structure with a 50 year design life.
- Structural ductility, μ = 2. Limited ductility.

8.4 Detailed Seismic Assessment Results

A summary of the structural performance of the buildings is shown in Table 2. Note that the values given represent the most critical and the worst performing elements in the buildings, as these effectively define the buildings’ capacity. Other elements within the buildings may have significantly greater capacity (but may still be below 100% NBS) when compared with the governing elements.

Table 2: Summary of Seismic Performance

Structural Element/System	**Failure mode and description of limiting criteria**	**% NBS based on calculated capacity**
Reinforced masonry walls in the east-west direction.	In-plane shear in the walls above the ground floor.	25%
	In-plane moment in the walls above the ground floor.	28%
	In-plane shear in the walls above the first suspended floor.	19%
	In-plane moment in the walls above the first suspended floor.	23%
Reinforced masonry walls in the north-south direction.	In-plane shear in all walls.	>100%
	In-plane moment in all walls.	>100%
	Out-of-plane moment in the walls above the second suspended floor.	27%
Shear transfer between diaphragm and shear walls.	Shear friction at first suspended floor.	41%

8.5 Discussion of Results

The buildings have a calculated seismic capacity of 19% NBS that is limited by in-plane shear resistance of the east-west oriented walls above the first suspended floor. For resistance to north-south seismic forces, the buildings have a capacity of 100% NBS. Accurate geotechnical information is not available to do a detailed assessment of the foundations, which could potentially have a lower %NBS than the walls.

The walls to the entrance courtyards at the ground level were assessed for their out-of-plane capacity as there is no slab above to restrain them. The strength of the block work was found to be at 100% NBS. However, an assessment of the capacity of the foundations of the walls to provided lateral stability could not be undertaken as soil shear strength parameters were not available. Of particular concern is the stability of these walls if liquefaction were to occur under them. Cordoning for these walls should be put in place until the lateral stability of the walls can be properly assessed.

Little information was available with regards to the detailing of the floor diaphragms and so calculations to assess their capacities could not be prepared. Based on the dimensions of the diaphragms, it is assumed that the capacities would be greater than 67% NBS and thus would not be the limiting feature of the structure in determining its capacity to resist seismic loads. The properties of the diaphragm will need to be confirmed prior to undertaking a detailed strengthening scheme.

8.6 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 during assessments that could cause the capacity of the buildings to be reduced; therefore the current capacity of the buildings may be lower than that stated.

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

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

9 Geotechnical Assessment

9.1 Introduction

This section summarises the findings of a Geotechnical Desk Study for the entire Brougham Village site and site walkovers completed on 10 May 2011 and 26 July 2012. The purpose of this desk study is to provide an initial appraisal of the suitability of the land and the future bearing capacity, in accordance with a CCC email request on 18 April 2011.

9.2 Ground Conditions

A desk study of geotechnical investigations in the area from Environment Canterbury and EQC identified four logs and five CPT tests within 200m of the site, refer to the Location Plan in Appendix D. Drill Hole M36/0964, drilled in 1899, was performed adjacent to Unit 402 Brougham Street.

A geological cross-section completed by EQC has been identified adjacent to the site along Brougham Street.

The borehole records, CPT test results and the geological cross-section are included in Appendix D.

The geological cross-section summarises the ground conditions in the area, which are Silty SAND from surface to a depth of 5m below ground level (BGL); SAND and GRAVEL to 7.5m BGL; Sandy GRAVEL to a depth of 11m BGL; Sandy SILT to a depth of 12m BGL; Gravelly SAND to a depth of 23.5m BGL and Sandy GRAVEL to a depth of 27.5m BGL.

The sloping ground, as indicated by the as built drawings is man-made. A specification for the hardfill material that comprises the sloping ground indicates that well graded, face-cut pitrun with a maximum grain size of 75mm has been used in conjunction with a crushed, “no fines” fill with a size range of 25mm and 40mm.

9.3 Ground Damage and Ground Induced Building Damage

As built drawings have been provided and indicate that the foundation system for the Brougham Village is strip footings to varying depths between 250mm and 700mm BGL. The floor slab is unreinforced concrete, varying in thickness between 100mm and 250mm.

An inspection of an open excavation adjacent to Unit 396 identified that the hardfill is not face-cut, and is sub-rounded to rounded in nature with a maximum size of 100mm, refer to photographs in Appendix D.

No signs of foundation subsidence were observed. A maximum of 50mm to 100mm of horizontal and vertical displacement was observed in the tiled areas around units 356 to 400 Brougham Street, refer to photographs in Appendix D. The land movement has generally been downslope towards Brougham Street.

A number of nearby units located at 356 – 400 Brougham Street have suffered significant structural damage, particularly the section of structure supporting their third storey. In contrast, there appears to be no structural damage to Blocks G and H. There has been significant damage to the buried services throughout the site.

There is evidence of moderate liquefaction throughout the site. Surface disruption and ground heave up to 100mm vertically was recorded at two locations on the asphalt driveway and also a service trench to the north of Unit 402.

It was recommended in May 2011 that the ground floor slabs within all the garages are checked for subsidence and liquefaction. Also the foundations for the 4 units at 131 Hastings Street East should be inspected as unit 2 has been affected by severe liquefaction. These proposed ground investigations have not yet been undertaken.

9.4 Liquefaction Hazard

The 2003 ECAN Liquefaction study[2] indicates Brougham Village as having a moderate to high liquefaction potential under high groundwater conditions. Based on a low groundwater table, ground damage is expected to be moderate, subsidence likely to be between 100mm and 300mm.

No liquefaction was reported following the Darfield Earthquake of 4 September 2010.

Liquefaction was identified on site following both the 22 February 2011 and 13 June 2011 earthquake events, by both road observations and interpretation of aerial photos by Tonkin & Taylor[3]. The liquefaction identified was stated as moderate to severe.

Brougham Village is bounded by residential properties to the east, south and west that are located in the CERA “green” zone. The “green” zone has been further categorised into technical categories by the Department of Building and Housing (DBH). This site is bounded by both “Technical Category 2” (TC2) and “Technical Category 3” (TC3) sites. The

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[2] ECan, The Solid Facts on Christchurch Liquefaction

[3] Project Orbit, 2011, Interagency/Organisation Collaboration Portal for Christchurch Recovery Effort, http://canterburyrecovery.projectorbit.com/sitepages/home/aspx

DBH technical categories are guidelines for residential foundations, however are likely to be used as a guideline by the Christchurch City Council for building consent. TC2 identifies the area may be subject to minor to moderate land damage from liquefaction in future large earthquakes, whilst TC3 identifies the area may be subject to moderate to significant land damage from liquefaction in future large earthquakes.

9.5 Appraisal

In summary, minimal damage to building foundations has occurred as a result of liquefaction following the 22 February 2011 earthquake. The slab on grade and shallow foundations appear to have performed adequately with only minor damage being reported.

The site comprises of imported fill material that slopes gently towards Brougham Street. The sloped ground profile has caused lateral spreading of the fill material on top of a liquefied soil layer. This is evident from cracks in the ground between buildings at the north-eastern corner of the site and indicates approximately 50mm of lateral movement. There are no streams or open watercourses within close proximity of the site that enhance the risk of lateral spreading.

GNS Science[4] indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice (Geonet) indicates there is a 14% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. It is expected that the probability of occurrence is likely to decrease with time, following periods of reduced seismic activity. However, similar ground damage to that experienced in February 2011 could re-occur if a future earthquake generated similar or greater intensity ground shaking at this site.

This report has identified a significant risk that liquefaction will occur again in the life of the buildings. This risk could be quantified with additional analysis to provide a risk based assessment of the expected future performance of the land.

9.6 Proposed Geotechnical Investigations

It is recommended that as a minimum, the following geotechnical inspections are undertaken for the repair of the buildings:

1. Excavate and inspect foundations in key areas to confirm there has been no damage or ground disruption.
2. Undertake a level survey of the buildings.

To determine the liquefaction potential of the site in future earthquakes and to identify the Technical Category of the site, the following site investigations (across the entire Brougham Village site) are recommended:

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[4] GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury- quakes/aftershocks/ updated on 9 July 2012.

1. 12 static Cone Penetration Tests (CPT) to confirm liquefaction potential.
2. 2 boreholes to a depth of about 25 m, with Standard Penetration Tests at 1.5 m depth intervals, and install piezometer to monitor groundwater level.
3. Assessment and reporting.

10 Remedial Options

Remedial options for strengthening the buildings would involve strengthening the lateral capacity of the building in the east-west direction and a more detailed investigation into the capacities of the foundations. This could involve strengthening or replacement of all east-west oriented walls in the first two storeys of the buildings or the possible addition of walls to the interior or exterior of the buildings.

11 Conclusions

The buildings have a seismic capacity of 19% NBS that is limited by the in-plane shear capacity of the second storey shear walls; the buildings are therefore Earthquake Prone Buildings as defined by legislation.

The buildings are classified as 'Grade D' (refer to Figure 1) and are at least 10-25 times more likely to fail during a design earthquake event when compared to buildings constructed according to the current building design standards.

There is a significant risk that liquefaction will occur again in the life of the buildings.

12 Recommendations

(a) A cordon be placed around Blocks G and H. This cordon should extend 5m to the south of the buildings and 8m to the east of Block H. We also recommend this cordon extend 8m to the west of Block G. As this cordon will encroach on to a private right of way to the west of Block G, we recommend that discussions are held between CERA, the Christchurch City Council, Opus and the occupier of 91B Hastings St about the relative risks represented by the structure at 95 Hastings St and the extent of any cordon in this area.

(b) Cordoning or temporary propping of the courtyard walls on the north side of Blocks G and H be put in place until their lateral stability in the presence of possible liquefaction can be properly assessed.

(c) Further investigations be carried out to confirm the structural composition of the floor diaphragms.

(d) Geotechnical investigations be undertaken to quantify the liquefaction potential of the site and to conclusively determine the soil shallow bearing strength of the existing foundations in order to complete the assessment of the footings.

(e) A strengthening scheme be developed to increase the overall strength of the buildings to at least 67% NBS.

13 Limitations

(a) This report is based on an inspection of the structures with a focus on the damage sustained from the 22 February 2011 Canterbury Earthquake and aftershocks only. Some non-structural damage is mentioned but this is not intended to be a comprehensive list of non-structural items.

(b) 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 the time.

(c) This report is prepared for the CCC to assist with assessing remedial works required for council buildings and facilities. It is not intended for any other party or purpose.

14 References

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

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

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

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

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

Appendix A – Photographs

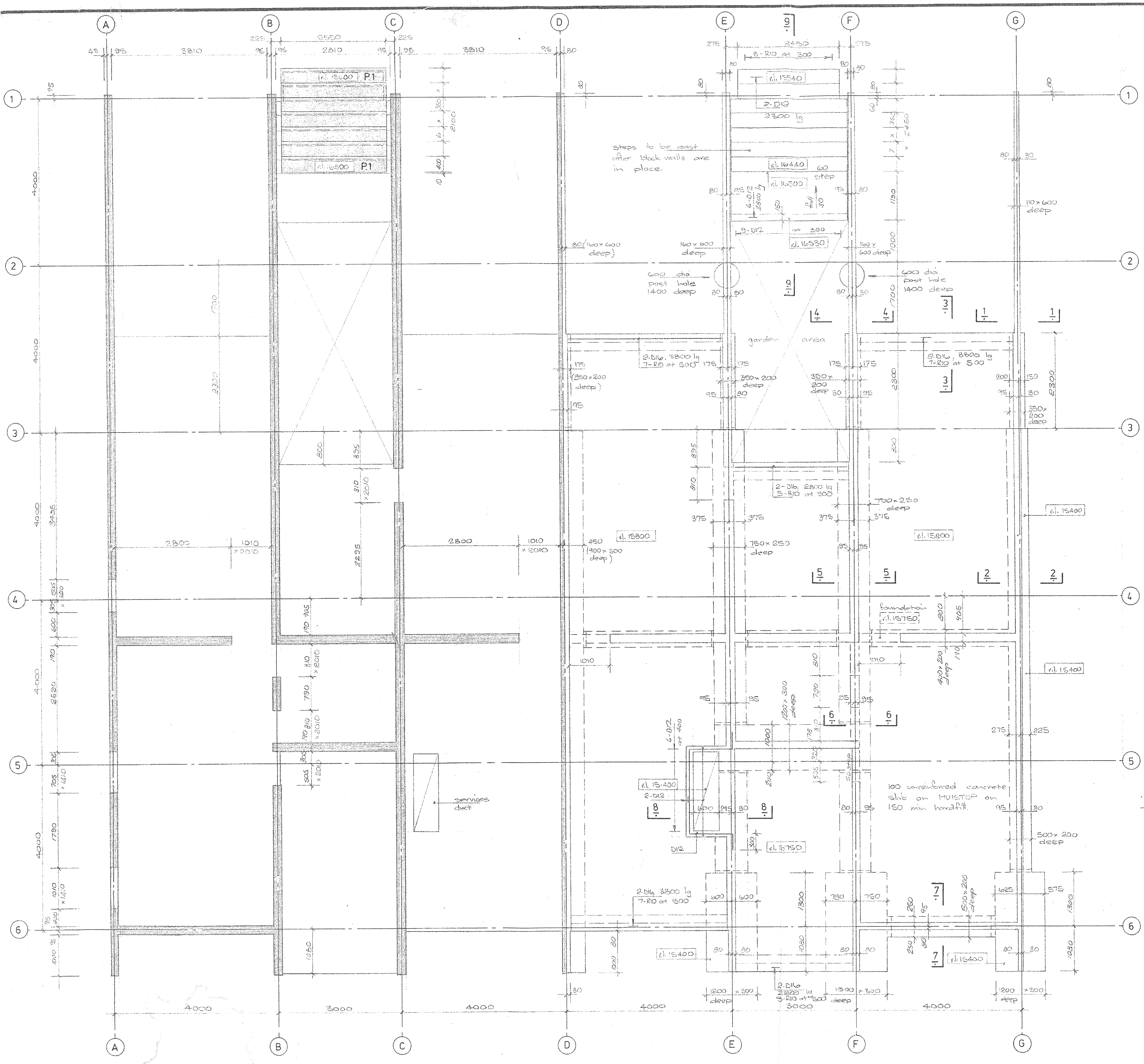
North elevation of Block H

East elevation of Block H

South elevation of Block G

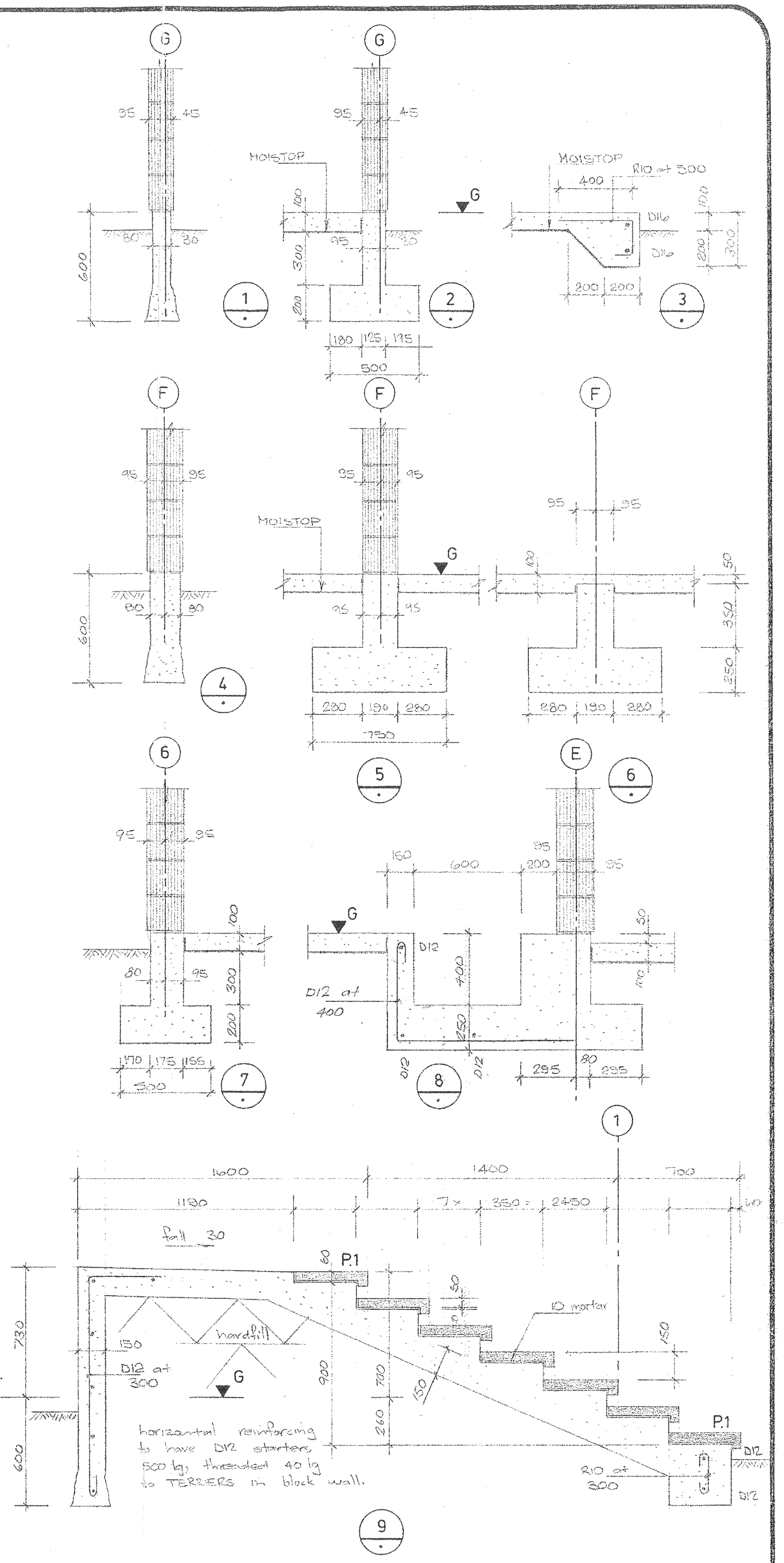
View of the interior of one unit

Appendix B – Floor Plan



blockwall setout symmetrical about line D

concrete foundation symmetrical about line D



note : · slab drawings detailed for ground floor at r.l. 15·800.
· adjust all levels by -100 for housing unit with ground floor at r.l. 15·700.

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Registered Architects
Christchurch

Holmes Wood Poole & Johnstone Ltd
Consulting Civil & Structural Engineers
Christchurch Wellington & Auckland

BROUGHAM STREET URBAN RENEWAL
STAGE 2

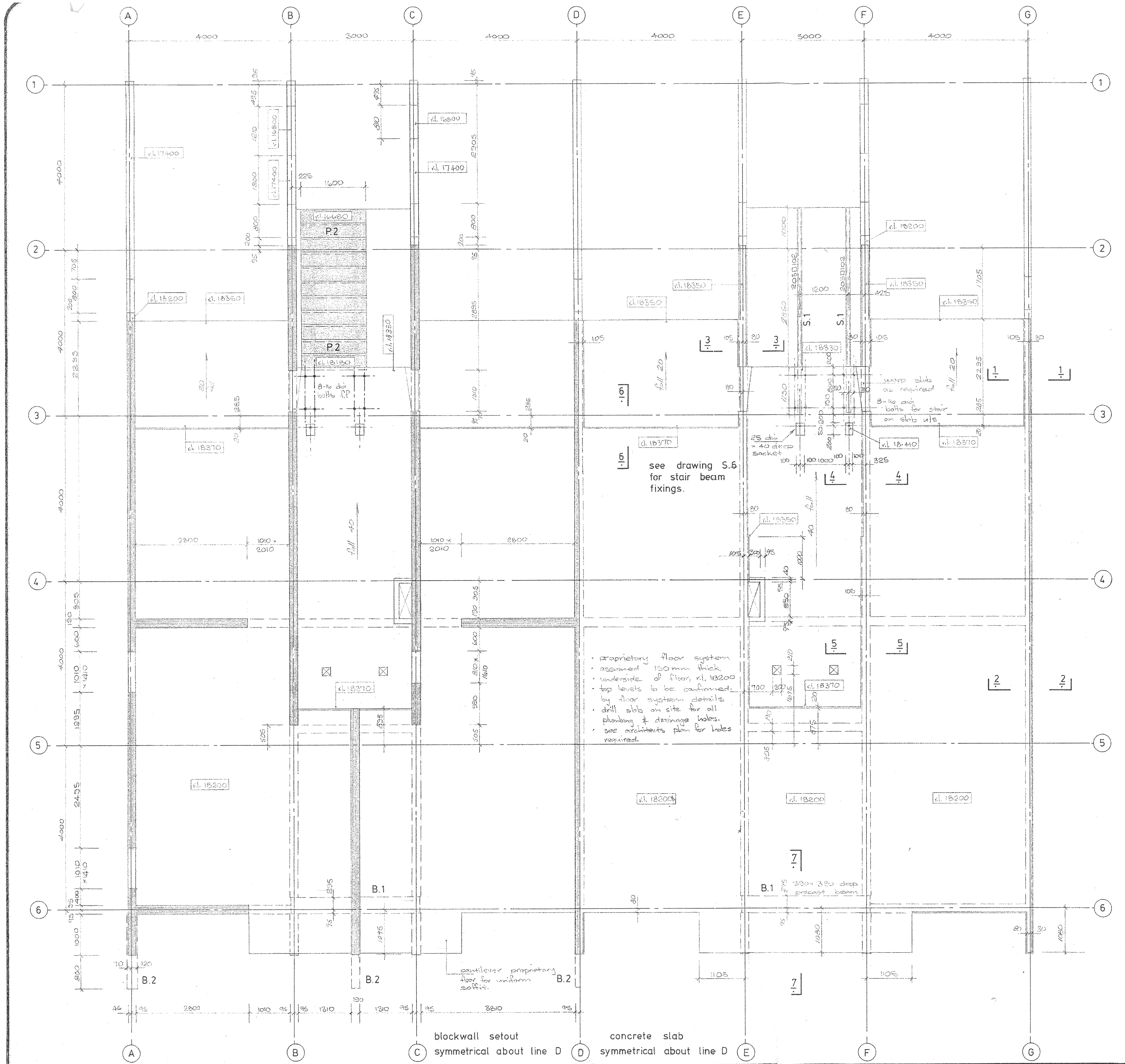
CARCASS
FOUNDATION & GROUND FLOOR

Scale 1 : 50
1 : 20
Drawn S. J. K.
Traced
Approved

D
C
B
A 28 . 2 . 83 Window openings
17. 11. 82 Contract

629-5/S1
A

The Contractor shall verify all dimensions prior to commencing work



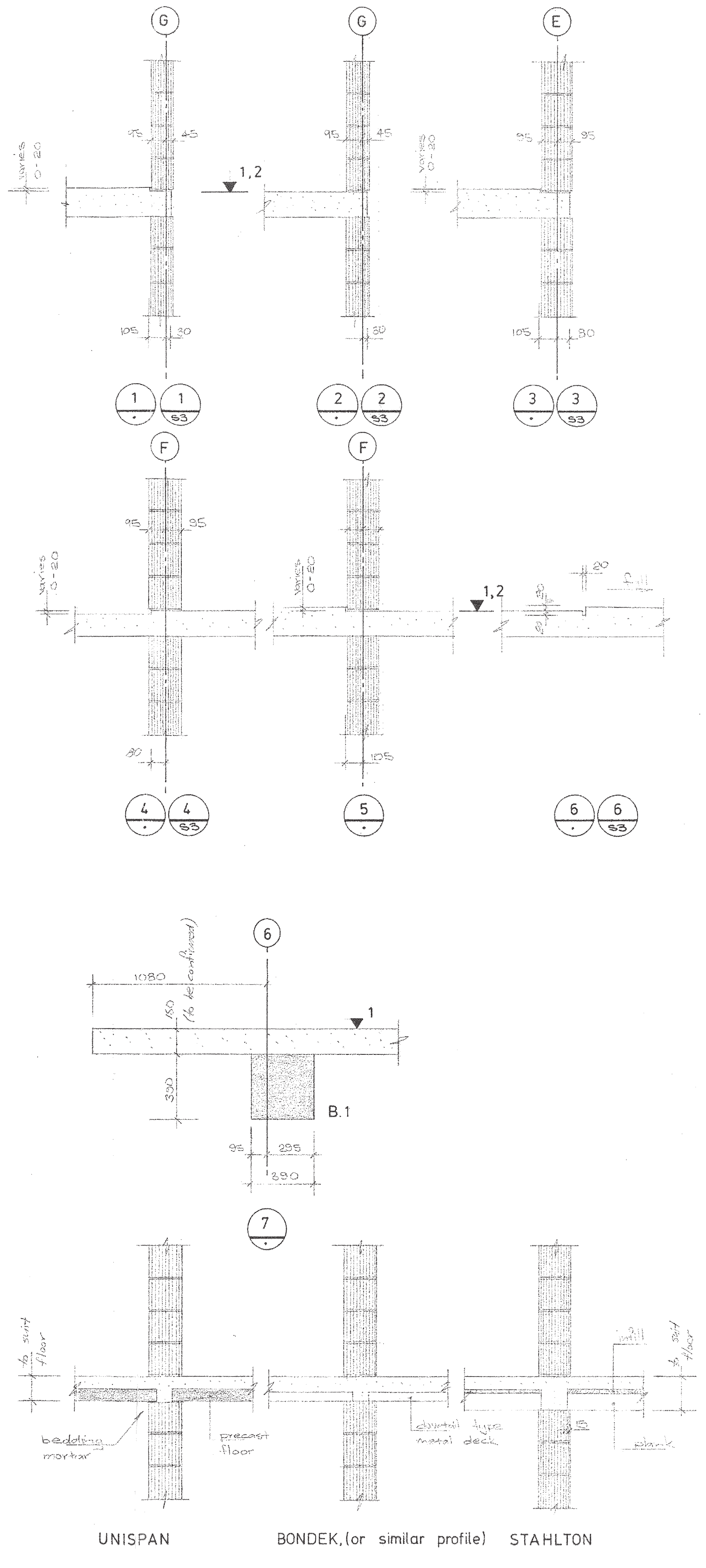
see drawing S.6 for stair beam fixings.

- proprietary floor system
- assumed 150mm thick
- underside of floor, r.l. 18200
- top levels to be confirmed by floor system details
- drill slab on site for all plumbing & drainage holes.
- see architects plan for holes required.

cantilever proprietary floor for uniform soffit.

blockwall setout symmetrical about line D

concrete slab symmetrical about line D



typical proprietary floor details

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Christchurch Wellington & Auckland

BROUGHAM STREET URBAN RENEWAL
STAGE 2

CARCASS
FIRST FLOOR

Scale 1 : 50
1 : 20
Drawn S. J. K.
Traced
Approved

D
C
B
A 28.2.83 Window / duct openings
17.11.82 Contract

629-5/S2
A

The Contractor shall verify all dimensions prior to commencing work

- proprietary floor system
- assumed 150mm thick
- underside of floor to be at r.l. 20.750 (to be confirmed)
- top floor levels to be confirmed by floor system details
- drill slab on site for all holes for plumbing and drainage.
- see architects plan for holes required.

see drawing S.6 for stair beam fixing.

8-16 dia bolts for stair in slab u/s.

blockwall setout symmetrical about line D

concrete wall symmetrical about line D

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Christchurch

Holmes Wood Poole & Johnstone Ltd
Consulting Civil & Structural Engineers
Christchurch Wellington & Auckland

BROUGHAM STREET URBAN RENEWAL
STAGE 2

CARCASS
SECOND FLOOR

Scale 1 : 50
1 : 20
Drawn
Traced S. J. K.
Approved

D
C
B
A 28 . 2 . 83 Window openings
17. 11. 82 Contract

629-5/S3
A

The Contractor shall verify all dimensions prior to commencing work

Appendix C – DEE Spreadsheet

Detailed Engineering Evaluation Summary Data

V1.11

Location

Building Name: Brougham Village Block G & Block H

Unit No: Street

Building Address: Block G & Block H 95-97 Hastings St.

Legal Description:

Degrees Min Sec

GPS south:

GPS east:

Building Unique Identifier (CCC):

Reviewer: John Newall

CPEng No: 1018146

Company: Opus International Consultants

Company project number: 6-QUCCC.92

Company phone number:

Date of submission: 4-Oct-12

Inspection Date: 13/06/2012

Revision: Final V3

Is there a full report with this summary? yes

Site

Site slope: flat

Soil type: mixed

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): 0

Soil Profile (if available):

If Ground improvement on site, describe:

Approx site elevation (m): 0.00

Building

No. of storeys above ground: 3 single storey = 1

Ground floor split? no

Storeys below ground 0

Foundation type: strip footings

Building height (m): 7.80

Floor footprint area (approx): 220

Age of Building (years): 36

Ground floor elevation (Absolute) (m): 0.00

Ground floor elevation above ground (m): 0.00

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): multi-unit residential

Use notes (if required):

Importance level (to NZS1170.5): IL2

Gravity Structure

Gravity System: load bearing walls

Roof: timber framed

Floors: precast concrete toppingless

Beams: cast-insitu concrete

Columns: load bearing walls

Walls: fully filled concrete masonry

rafter type, purlin type and cladding Unknown

unit type and depth (mm), diaphragm 150mm

overall depth x width (mm x mm) 350 x 350

typical dimensions (mm x mm)

#N/A

Lateral load resisting structure

Lateral system along: fully filled CMU

Ductility assumed, μ: 2.00

Period along: 0.40 ##### enter height above at H31

Total deflection (ULS) (mm):

maximum interstorey deflection (ULS) (mm):

Note: Define along and across in detailed report!

note total length of wall at ground (m):

wall thickness (m):

estimate or calculation? estimated

estimate or calculation?

estimate or calculation?

Lateral system across: fully filled CMU

Ductility assumed, μ: 2.00

Period across: 0.40 ##### enter height above at H31

Total deflection (ULS) (mm):

maximum interstorey deflection (ULS) (mm):

note total length of wall at ground (m):

wall thickness (m):

estimate or calculation? estimated

estimate or calculation?

estimate or calculation?

Separations:

north (mm): leave blank if not relevant

east (mm):

south (mm):

west (mm):

Non-structural elements

Stairs: precast, full flight

Wall cladding: other light

Roof Cladding: Metal

Glazing: timber frames

Ceilings: fibrous plaster, fixed

Services(list):

describe supports

describe

describe

Available documentation

Architectural partial

Structural partial

Mechanical none

Electrical none

Geotech report none

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: 0-2 $m^2/100m^3$

Lateral Spread: 0-50mm

Differential lateral spread: 0-1:400

Ground cracks: 0-20mm/20m

Damage to area: slight

notes (if applicable): Estimate (geotech report not available)

notes (if applicable): Estimate (geotech report not available)

notes (if applicable): Estimate (geotech report not available)

notes (if applicable): Estimate (geotech report not available)

notes (if applicable): Estimate (geotech report not available)

notes (if applicable): Estimate (geotech report not available)

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 and strengthening

Building Consent required: yes

Interim occupancy recommendations: do not occupy

Describe:

Describe:

Describe:

Along Assessed %NBS before: 19% ##### %NBS from IEP below

Assessed %NBS after: 19%

If IEP not used, please detail assessment methodology:

Across Assessed %NBS before: 100% ##### %NBS from IEP below

Assessed %NBS after: 100%

IEP

Use of this method is not mandatory - more detailed analysis may give a different answer, which would take precedence. Do not fill in fields if not using IEP.

Period of design of building (from above): 1976-1992

h_n from above: m

Seismic Zone, if designed between 1965 and 1992:

not required for this age of building

not required for this age of building

along across

Period (from above):	0.4	0.4
(%NBS)nom from Fig 3.3:		

Note:1 for specifically design public buildings, to the code of the day: pre-1965 = 1.25; 1965-1976, Zone A =1.33; 1965-1976, Zone B = 1.2; all else 1.0	1.00
Note 2: for RC buildings designed between 1976-1984, use 1.2	1.0
Note 3: for buildngs designed prior to 1935 use 0.8, except in Wellington (1.0)	1.0

	along	across
Final $(\%NBS)_{nom}$:	**0%**	**0%**

2.2 Near Fault Scaling Factor

Near Fault scaling factor, from NZS1170.5, cl 3.1.6:		1.00
	along	across
Near Fault scaling factor (1/N(T,D), **Factor A**:	1	1

2.3 Hazard Scaling Factor

Hazard factor Z for site from AS1170.5, Table 3.3:	
Z_{1992}, from NZS4203:1992	
Hazard scaling factor, **Factor B:**	#DIV/0!

2.4 Return Period Scaling Factor

Building Importance level (from above):	2
Return Period Scaling factor from Table 3.1, **Factor C**:	

2.5 Ductility Scaling Factor

	along	across
Assessed ductility (less than max in Table 3.2)	1.00	1.00
Ductility scaling factor: =1 from 1976 onwards; or =kμ, if pre-1976, fromTable 3.3:		
Ductiity Scaling Factor, **Factor D**:	1.00	1.00

2.6 Structural Performance Scaling Factor:

Sp:	1.000	1.000
Structural Performance Scaling Factor **Factor E**:	1	1

2.7 Baseline %NBS, $(NBS\%)_b = (\%NBS)_{nom} \times A \times B \times C \times D \times E$

$\%NBS_b$:	**#DIV/0!**	**#DIV/0!**

Global Critical Structural Weaknesses: (refer to NZSEE IEP Table 3.4)

3.1. Plan Irregularity, factor A:		1
3.2. Vertical irregularity, Factor B:		1
3.3. Short columns, Factor C:		1
3.4. Pounding potential	Pounding effect D1, from Table to right	1.0
	Height Difference effect D2, from Table to right	1.0
	Therefore, Factor D:	1
3.5. Site Characteristics		1

Table for selection of D1	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Alignment of floors within 20% of H	**0.7**	**0.8**	**1**
Alignment of floors not within 20% of H	**0.4**	**0.7**	**0.8**

Table for Selection of D2	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Height difference > 4 storeys	0.4	0.7	1
Height difference 2 to 4 storeys	0.7	0.9	1
Height difference < 2 storeys	1	1	1

3.6. Other factors, Factor F

	Along	Across
For ≤ 3 storeys, max value =2.5, otherwise max valule =1.5, no minimum		
Rationale for choice of F factor, if not 1		

Detail Critical Structural Weaknesses: (refer to DEE Procedure section 6)
List any: Refer also section 6.3.1 of DEE for discussion of F factor modification for other critical structural weaknesses

3.7. Overall Performance Achievement ratio (PAR)	**0.00**	**0.00**

4.3 PAR x (%NBS)b: PAR x Baselline %NBS:	**#DIV/0!**	**#DIV/0!**
4.4 Percentage New Building Standard (%NBS), (before)		**#DIV/0!**

Appendix D – Geotechnical Desk Study

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TO	Lindsay Fleming
COPY	Greg Saul, Sheryl Keenan
FROM	Graham Brown/Danielle Belcher
DATE	27 July 2012
FILE	6-QUCCC.92/105SC
SUBJECT	Brougham Village - Geotechnical Desk Study Revised

1. Introduction

This memo summarises the findings of a Geotechnical Desk Study and Site Walkovers completed on 10 May 2011 and 26 July 2012. The purpose of this desk study is to provide an initial appraisal of the suitability of the land and the future bearing capacity, in accordance with CCC email request of 18 April 2011.

This is the first geotechnical inspection undertaken at this site, following previous Structural Assessments completed by Opus.

2. Description of Facility

The Brougham Village comprises the following units,

- Units 356 – 400 Brougham Street, up to 3 storeys.
- Units at 402 Brougham Street, single storey.
- Units 95 and 97 Hastings Street East, up to 3 storeys.
- Units 131 Hastings Street East, single storey.

Refer to the annotated Site Plan Appendix B.

The site is relatively flat and low lying and is bounded to the north by Brougham Street and to the south by Hastings Street East. The ground profile slopes gently down towards Brougham Street and the ground floor units are approximately 0.5m to 0.75m above footpath level. The buildings range from one storey to three story structures and are formed of masonry block. The structures are estimated to have been built in the 1960's or 70's.

The site between the buildings is covered extensively with asphalt and paving stones. There are some grassed areas along the Brougham Street frontage and to the west of the units at 131 Hastings Street.

3. *Desk Study Results*

3.1 Ground Conditions

A desk study of geotechnical investigations in the area from Environment Canterbury and EQC identified four logs and five CPT tests within 200m of the site, refer to Location Plan Appendix A. Drill Hole M36/0964, drilled in 1899, was performed adjacent to Unit 402 Brougham Street.

A geological cross-section completed by EQC has been identified adjacent to the site along Brougham Street.

The borehole records, CPT test results and the geological cross-section are included in Appendix A.

The geological cross-section summarises the ground conditions in the area, which are Silty SAND from surface to a depth of 5m below ground level (bgl); SAND and GRAVEL to 7.5m bgl; Sandy GRAVEL to a depth of 11m bgl; Sandy SILT to a depth of 12m bgl; Gravelly SAND to a depth of 23.5m bgl and Sandy GRAVEL to a depth of 27.5m bgl.

The sloping ground, as indicated by the as built drawings is man-made. A specification for the hardfill material that comprises the sloping ground indicates that well graded, face-cut pitrun with a maximum grain size of 75mm has been used in conjunction with a crushed, “no fines” fill with a size range of 25mm and 40mm.

3.2 Ground and Building Damage

As built drawings have been provided and indicate that the foundation system for the Brougham Village is strip footings to varying depths between 250mm and 700mm bgl. The floor slab is unreinforced concrete, varying in thickness between 100mm and 250mm.

An inspection of an open excavation adjacent to Unit 396 identified that the hardfill is not face-cut, and is sub-rounded to rounded in nature with a maximum size of 100mm, refer to photographs.

No signs of foundation subsidence were observed. A maximum of 50mm to 100mm of horizontal and vertical displacement was observed in the tiled areas around units 356 to 400 Brougham Street, refer to photographs. The land movement has generally been downslope towards Brougham Street.

A number of units located at 356 – 400 Brougham Street have suffered significant structural damage, particularly the section of structure supporting the third storey. In contrast, there appears to be no structural damage to units 95 and 97 Hastings Street East. There has been significant damage to the buried services throughout the site.

There is evidence of moderate liquefaction throughout the site. Surface disruption and ground heave up to 100mm vertically was recorded at two locations on the asphalt driveway and also a service trench to the north of Unit 402.

It was recommended in May 2011 that the ground floor slabs within all the garages are checked for subsidence and liquefaction. Also the foundations for the 4 units at 131

Hastings Street East should be inspected as unit 2 was yellow stickered due to severe liquefaction. To date this has not been done.

3.3 Liquefaction Hazard

The 2003 ECAN Liquefaction study[1] indicates Brougham Village as having a moderate to high liquefaction potential under high groundwater conditions. Based on a low groundwater table, ground damage is expected to be moderate, subsidence likely to be between 100mm and 300mm.

No liquefaction was reported following the Darfield Earthquake of 4 September 2010.

Liquefaction was identified on site following both the 22 February 2011 and 13 June 2011 earthquake events, by both road observations and interpretation of aerial photos by Tonkin & Taylor[2]. The liquefaction identified was stated as moderate to severe.

Brougham Village is bounded by residential properties to the east, south and west that are located in the CERA “green” zone. The “green” zone has been further categorised into technical categories by the Department of Building and Housing (DBH). This site is bounded by both “Technical Category 2” (TC2) and “Technical Category 3” (TC3) sites. The DBH technical categories are guidelines for residential foundations, however are likely to be used as a guideline by the Christchurch City Council for building consent. TC2 identifies the area may be subject to minor to moderate land damage from liquefaction in future large earthquakes, whilst TC3 identifies the area may be subject to moderate to significant land damage from liquefaction in future large earthquakes.

4 Appraisal

In summary, minimal damage to building foundations has occurred as a result of liquefaction following the 22 February 2011 earthquake. The slab on grade and shallow foundations appear to have performed adequately with only minor damage being reported.

There are no streams or open watercourses within close proximity of the site, this minimises the potential for lateral spreading. However the site falls gently to Brougham Street as the units have been built on a man-made rise. This rise may provide a potential for lateral spreading which has resulted in the cracks between buildings at the north-eastern corner of the facility which indicates approximately 50mm of lateral movement.

GNS Science[3] indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice (Geonet) indicates there is a 14% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. It is expected that the probability of occurrence is likely to decrease with time, following periods of reduced seismic activity. However, we would expect that similar

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[1] ECan, The Solid Facts on Christchurch Liquefaction

[2] Project Orbit, 2011, Interagency/Organisation Collaboration Portal for Christchurch Recovery Effort, http://canterburyrecovery.projectorbit.com/sitepages/home/aspx

[3] GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury- quakes/aftershocks/ updated on 9 July 2012.

ground damage to that experienced could re-occur in a future earthquake, dependent on the location of the epicentre.

This report has identified a significant risk that liquefaction will occur again in the life of the buildings. We consider that this risk could be evaluated to inform CCC of the expected future performance of the land.

5 Proposed Geotechnical Investigations

It is recommended that as a minimum, the following geotechnical inspections are undertaken for the repair of the buildings.

1. Inspect the ground floor slabs within all the Garages for units 356 to 400, to check for subsidence and liquefaction damage.

2. Excavate and inspect foundations in key areas to confirm there has been no damage or ground disruption.

3. Undertake a Level Survey of the buildings.

To determine the liquefaction potential of the site in future earthquakes and to indentify the Technical Category of the site, the following site investigations are recommended:

1. Static Cone Penetration Tests (CPT) 12 No to confirm liquefaction potential.

2. Borehole 2 No – to a depth of about 25 m, with Standard Penetration Tests at 1.5 m depth intervals, and install piezometer to monitor groundwater level.

3. Assessment and reporting

Attachments:

Appendix A – Location Plan, BH and CPT Records

Appendix B – Annotated Site Plan

Photos showing liquefaction and site damage, Units 356 to 372 Brougham Street

South Elevation of Units 356 – 372

North Elevation of Units 356 – 372 from Brougham Street

View East, damage to Asphalt

General View

Structural Damage to 2nd and 3rd Storey at Unit 364

Ground Heave at footing adjacent to Unit 364

10mm crack, movement towards Brougham Street at Unit 368

Another example

Units 372 to 400 Brougham Street

South Elevation including

Heave and damage to driveway.

Garage 33 near Unit 388 crack in floor slab and liquefaction

Typical Structural Damage

10mm settlement of patio tiles

Typical damage to buried services

Open excavation showing rounded pit run.

Units 402 Brougham Street

General View 402 Brougham

Ground Heave above service trench

Units 131 Hastings Street East

No visible damage, unit 2 yellow stickered due to severe liquefaction

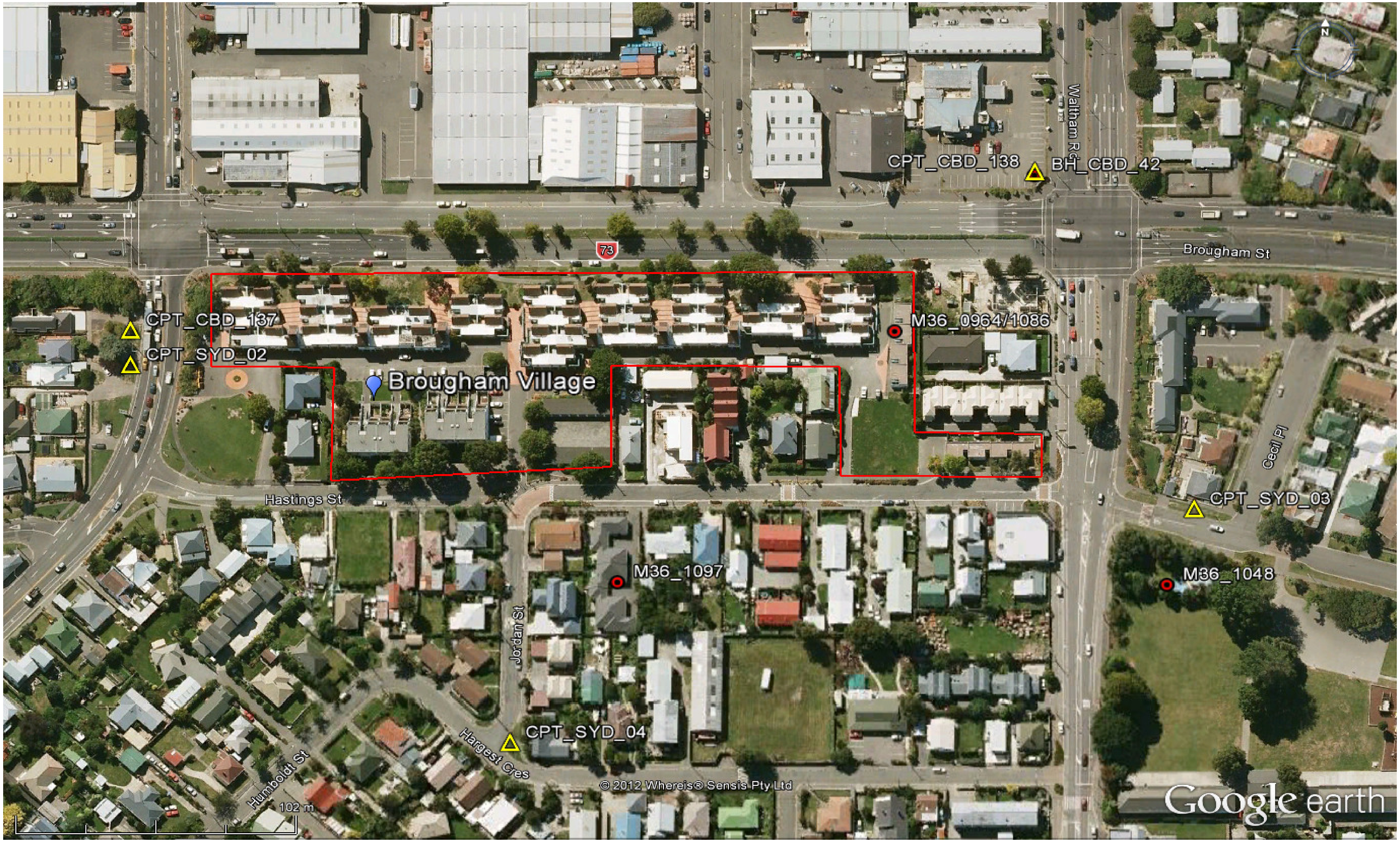
Units 95 and 97 Hastings Street East


Southern Elevation


Western limit, no damage visible


Northern elevation unit 95


Eastern Elevation



Key: Red Line: Outline of Brougham Village
Red Circle: Boreholes from ECan and EQC
Yellow Triangle: CPT

OPUS

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

Project: Brougham Village
Geotechnical Desktop Study

Project No.:

Client: Christchurch City Council

Previous Investigations Plan

Drawn: Engineering Geologist

Date: 26-Jul-12

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds
SHEET 1 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5739961.63 mN
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DCN
LOGGED BY: TH
CHECKED: GSH

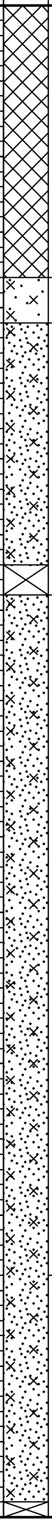
GEOLOGICAL
ENGINEERING DESCRIPTION

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.



R.L. (m): 5.5, 5.0, 4.5, 4.0, 3.5, 3.0, 2.5, 2.0, 1.5, 1.0

DEPTH (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5

GEOLOGICAL UNIT	CORE RECOVERY (%)	METHOD	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
HAND DIG FILL. (Potholed for services check and backfilled.)	0	HAND DUG					FILL: Borehole drilled through pre-dug and backfilled pothole.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)	100	SV		ML	M	F	SILT with some sand, orange mottled brown. Firm, moist, low plasticity. Sand is fine.
				SP	M	L	Silty, fine SAND with trace rootlets,orange mottled brown Loose, moist.
		SPT	2/2/2 N=4				
	50	SV					1.85 to 1.95m no recovery
	100	SONIC VIBRATION		ML	M	F	SILT with trace sand, bluish grey. Firm, moist, low plasticity. Sand is fine.
							- with minor interbedded sand. Interbedding is extremely closely spaced.
		SPT	1/3/3 N=6				
	100	SONIC VIBRATION					- fine to medium sand bed 50mm thick
			✱FC				
				SW	M	F	Fine to medium SAND with some silt, bluish grey. Firm, moist.
		SPT	2/3/5 N=8				- with some fine to coarse gravel. Gravel is subrounded to subangular

T+T DATATEMPLATE.GDT eek

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds
SHEET 2 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES	5739961.63 mN 2481450.24 mE	DRILL TYPE: Direct Push	HOLE STARTED: 1/8/11
		DRILL METHOD: Sonic Vibration	HOLE FINISHED: 2/8/11
R.L.	5.58 m		DRILLED BY: DCN
DATUM	NZMG	DRILL FLUID: N/A	LOGGED BY: TH CHECKED: GSH

GEOLOGICAL — ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	TESTS	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	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 THE SPRINGSTON FORMATION (ALLUVIAL)				-0.5					4.95m to 5.1m no recovery
						GW	M	D	Sandy fine to coarse GRAVEL, bluish grey. Dense, moist. Gravel is rounded to sub-rounded. Sand is fine to coarse.
	86	SONIC VIBRATION			5.5				
				-0.0					
			✱FC			SP	M	MD	Fine SAND with some silt and trace organic fragments, grey. Medium dense, moist.
					6.0				- sand becoming fine to coarse
		SPT	5/9/12 N=21	-0.5					
					6.5				
	100	SONIC VIBRATION	✱FC	-1.0					
					7.0	GW	M	D	Sandy, fine to coarse GRAVEL with rare cobbles, bluish grey. Dense, moist. Gravel is subrounded. Sand is fine to coarse.
				-1.5					
					7.5				
		SPT	9/16/24 N=40	-2.0					7.85 to 7.95m no recovery
					8.0				
				-2.5					
	100	SONIC VIBRATION	✱FC			ML	M	F	Sandy SILT interbedded with sand lamina, grey. Firm, moist, low plasticity. Sand is fine to medium. Sand interbedding is extremely closely spaced.
					8.5				
				-3.0					
					9.0	SW	M	MD	Fine to coarse SAND with trace silt, bluish grey. Medium dense, moist.
		SPT	3/7/12 N=19	-3.5					9.35 to 9.45m no recovery
					9.5				
	100	SONIC VIBR.	✱FC	-4.0					- becoming gravelly SAND. Gravel is fine to coarse, rounded to subrounded.
					10				

Other column headings: FLUID LOSS, WATER, CASING, SAMPLES, GRAPHIC LOG, SHEAR STRENGTH (kPa) 10 25 50 100 200, COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250, DEFECT SPACING (mm) 50 250 1000 2000

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds

SHEET 3 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5739961.63 mN
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DCN
LOGGED BY: TH
CHECKED: GSH

GEOLOGICAL 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) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	ENGINEERING DESCRIPTION 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 THE SPRINGSTON FORMATION (ALLUVIAL)								-4.5		GW	M	MD				Sandy, fine to coarse GRAVEL, bluish grey. Medium dense, moist. Gravel is subrounded. Sand is fine to coarse.
				SPT		4/9/8 N=17	■	-5.0	10.5							- contains minor gravels
							■									10.85 to 10.95m no recovery
								-5.5	11.0							
			100	SONIC VIBRATION				-6.0	11.5							
				SPT		3/6/15 N=21	■ ■	-6.5	12.0							- contains trace fine gravels - sand becoming fine to medium
								-7.0	12.5	SW	M	MD				Fine to medium SAND, grey. Medium dense, moist.
			100	SONIC VIBRATION				-7.5	13.0							
				SPT		3/4/9 N=13	■ ■	-8.0	13.5							
								-8.5	14.0							
			100	SONIC VIBRATION		✱FC		-9.0	14.5							
									15	GW						

T+T DATATEMPLATE.GDT eek

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds
SHEET 4 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE	LOCATION: CENTRAL CITY	JOB No: 52000.3400
CO-ORDINATES 5739961.63 mN 2481450.24 mE	DRILL TYPE: Direct Push	HOLE STARTED: 1/8/11
	DRILL METHOD: Sonic Vibration	HOLE FINISHED: 2/8/11
R.L. 5.58 m		DRILLED BY: DCN
DATUM NZMG	DRILL FLUID: N/A	LOGGED BY: TH CHECKED: GSH

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 THE SPRINGSTON FORMATION (ALLUVIAL)				SPT		3/5/8 N=13		-9.5			GW	M	MD				Sandy, fine to coarse GRAVEL, grey. Medium dense, moist. Gravel is subrounded. Sand is fine to coarse. 15.15 to 15.6m no recovery
									15.5								15.5
								-10.0									
			86	SONIC VIBRATION					16.0								16.0
								-10.5									
									16.5								16.5
								-11.0									
				SPT		8/11/23 N=34											16.65 to 16.95m no recovery
CHRISTCHURCH FORMATION (MARINE & ESTUARINE)									17.0		SW	M	MD				Fine to medium SAND with trace gravel, bluish grey. Medium dense, moist. Gravel is fine to medium, rounded. 17.0
								-11.5									
			100	SONIC VIBRATION					17.5								17.5
								-12.0									
						✱FC											
									18.0								18.0
								-12.5									
				SPT		4/7/18 N=25											
									18.5								18.5
								-13.0									
			100	SONIC VIBRATION					19.0								19.0
								-13.5									
																	- contains some fine to coarse gravel, subrounded.
									19.5		ML	M	St				Sandy SILT, bluish grey. Stiff, moist, low plasticity. Sand is fine. 19.5
								-14.0									
				SPT		4/5/7 N=12											
									20								

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds

SHEET 5 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5739961.63 mN
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DCN
LOGGED BY: TH
CHECKED: GSH

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	TESTS	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION / ROCK DESCRIPTION
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)	100	SONIC VIBRATION		-14.5 -15.0	20.5	ML	M	St	Sandy SILT, bluish grey. Stiff, moist, low plasticity. Sand is fine.
		SPT	1/1/3 N=4	-15.5	21.0			F	- becoming firm
	100	SONIC VIBRATION		-16.0 -16.5	21.5 22.0				
						OL	M	St	Organic SILT, brownish grey. Stiff, moist, low plasticity.
		SPT	2/4/5 N=9	-17.0	22.5				
	100	SONIC VIBRATION		-17.5 -18.0	23.0 23.5				
						PT	M	F	PEAT, dark brown. Firm, moist, fibrous.
RICCARTON GRAVELS		SPT	4/11/19 N=21	-18.5	24.0	GW	M	MD	Sandy, fine to coarse GRAVEL with trace rootlets, bluish grey. Medium dense. Gravel is subrounded. Sand is fine to coarse.
	86	SONIC VIBR.		-19.0	24.5 25				- contains trace cobbles

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds
SHEET 6 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE	LOCATION: CENTRAL CITY	JOB No: 52000.3400
CO-ORDINATES 5739961.63 mN 2481450.24 mE	DRILL TYPE: Direct Push	HOLE STARTED: 1/8/11
	DRILL METHOD: Sonic Vibration	HOLE FINISHED: 2/8/11
R.L. 5.58 m		DRILLED BY: DCN
DATUM NZMG	DRILL FLUID: N/A	LOGGED BY: TH CHECKED: GSH

GEOLOGICAL — GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION — 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.

GEOLOGICAL UNIT	CORE RECOVERY (%)	METHOD	TESTS	DEPTH (m)	R.L. (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
RICCARTON GRAVELS				to 25.5	-19.5	GW	M	D	Sandy, fine to coarse GRAVEL with trace rootlets, bluish grey. Dense. Gravel is subrounded. Sand is fine to coarse.
		SPT	15/19/28 N=47	25.5	-20.0				25.5 to 25.95m no recovery
	76	SONIC VIBRATION	✱FC	26.0	-20.5	SW	M	D	Fine to coarse SAND with trace silt, brown. Dense, moist.
				26.5	-21.0	GW	M	D	Sandy, fine to coarse GRAVEL, brown. Dense, moist. Gravel is subrounded. Sand is fine to coarse. 26.75 to 30.07m no recovery.
		SPT	24/25/27 N=52	27.0	-21.5			VD	- becoming very dense
	0	SONIC VIBRATION		27.5	-22.0				
				28.0	-22.5				
		SPT	50 for 90mm N>50	28.5	-23.0				
	0	SONIC VIBRATION		29.0	-23.5				
				29.5	-24.0				
				30					

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds

SHEET 7 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE	LOCATION: CENTRAL CITY	JOB No: 52000.3400

CO-ORDINATES 5739961.63 mN
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DCN
LOGGED BY: TH CHECKED: GSH

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.
				SPT		50/70mm N>50		-24.5									**End of borehole at 30.07mbgl.** Open standpipe piezometer installed. Please see attached diagram in Appendix F.
								-25.0	30.5								30.5
								-25.5	31.0								31.0
								-26.0	31.5								31.5
								-26.5	32.0								32.0
								-27.0	32.5								32.5
								-27.5	33.0								33.0
								-28.0	33.5								33.5
								-28.5	34.0								34.0
								-29.0	34.5								34.5
									35								

Borelog for well M36/0964 page 1 of 2

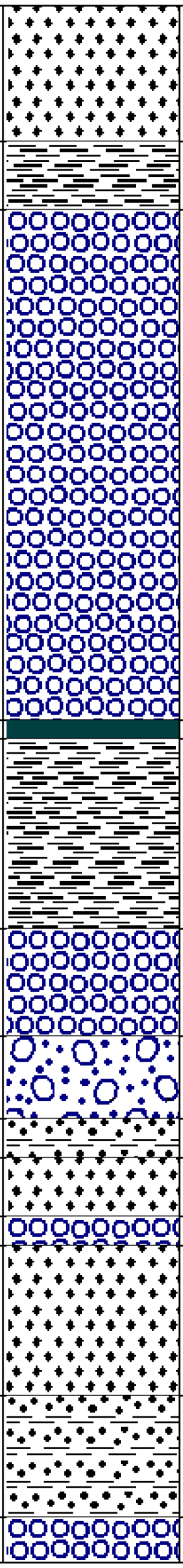
Gridref: M36:814-399 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.2 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -95.3m Drill Date : 6/05/1899

Scale(m): -5 -10 -15 -20 -25 -30 -35 -40 -45

Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	-2.09m	Soil	sp
	-6.09m	Clay	sp
	- 21.6m	Gravel (Bl)	sp
	- 24.4m	Blue sand & clay	ch
	- 25.3m	Blue clay & peat	ch
	- 36.9m	Gravel (Br) wl +0.3m	ri
	- 38.3m	Peat	br
	- 39.3m	Clay (Bl)	br
	- 42.0m	Gravel (Br) wl +0.6	br
	- 51.8m	Sand br	br

Borelog for well M36/0964 page 2 of 2

Gridref: M36:814-399 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.2 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -95.3m Drill Date : 6/05/1899



Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
-50	Artesian	- 51.8m	Sand br	br
		- 53.9m	Clay y	br
-55 -60 -65		- 69.5m	Gravel Brown wl +1.2m	li
-70		- 70.1m	Peat	li-2
-75		- 75.9m	Clay (Bl)	li-2
		- 79.2m	Gravel (Br) wl +2.1m	li-3
-80		- 81.7m	Yellow sandy gravel	li-3
		- 82.9m	Clay sandy y	he
		- 84.7m	Sand y	he
-85		- 85.6m	Gravel br	he
-90		- 90.2m	Yellow sand	he
		- 93.9m	Sand & clay y	he
-95		- 95.3m	Gravel Brown wl +7.9m	bu

Borelog for well M36/1048 page 1 of 2

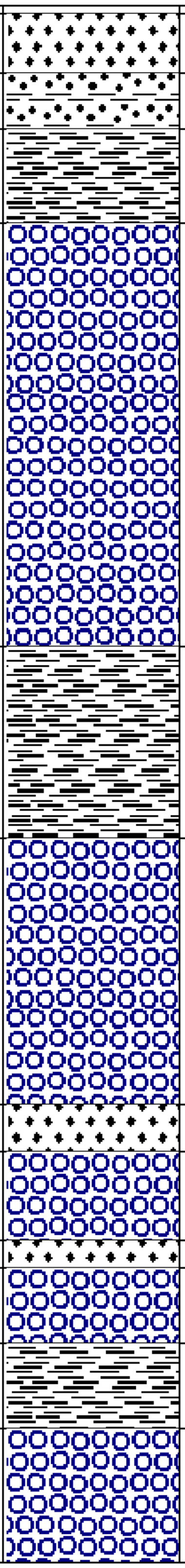
Gridref: M36:815-398 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.3 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -99.3m Drill Date :

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
	Artesian	-1.20m	Surface soil & sand	sp
-5		-6.00m	Blue shingle	sp
		-7.59m	Blue clay	sp
-10 -15		- 15.2m	Blue sand	ch
-20		- 21.3m	Blue shingle	sp
-25		- 27.4m	Blue clay	ch
-30 -35		- 39.6m	Brown shingle	ri
-40		- 40.8m	Blue clay & peat	br
		- 42.0m	Brown shingle	br
-45		- 49.9m	Brown sand	br

Borelog for well M36/1048 page 2 of 2

Gridref: M36:815-398 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.3 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -99.3m Drill Date :

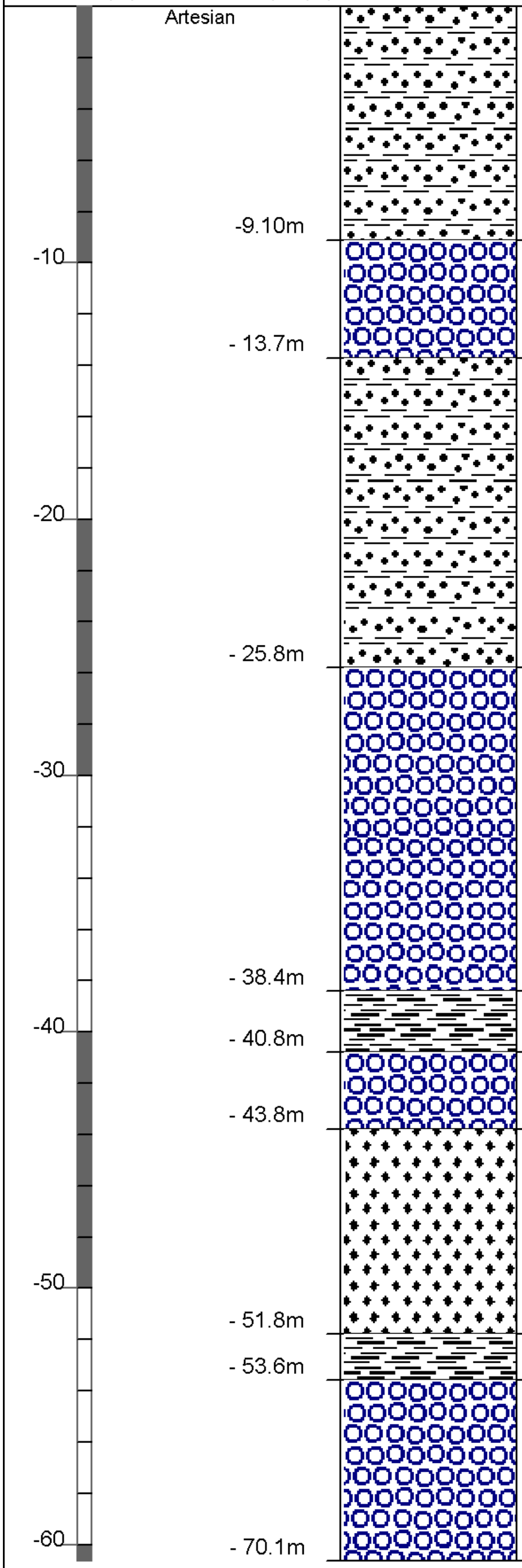
Scale(m): -50, -55, -60, -65, -70, -75, -80, -85, -90, -95



Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	49.9m	Brown sand	br
	- 51.8m	Blue sand	br
	- 53.6m	Blue sand & clay	br
	- 56.6m	Blue clay	br
	- 70.1m	Brown shingle	li
	- 76.2m	Blue clay	li-2
	- 84.7m	Brown shingle	li-3
	- 86.2m	Brown sand	he
	- 89.0m	Brown shingle	he
	- 89.9m	Brown sand	he
	- 92.3m	Brown shingle water rises 1.8m	he
	- 95.0m	Yellow clay	he
	- 99.3m	Brown shingle water rises 6.0m	bu

Borelog for well M36/1086 page 1 of 2

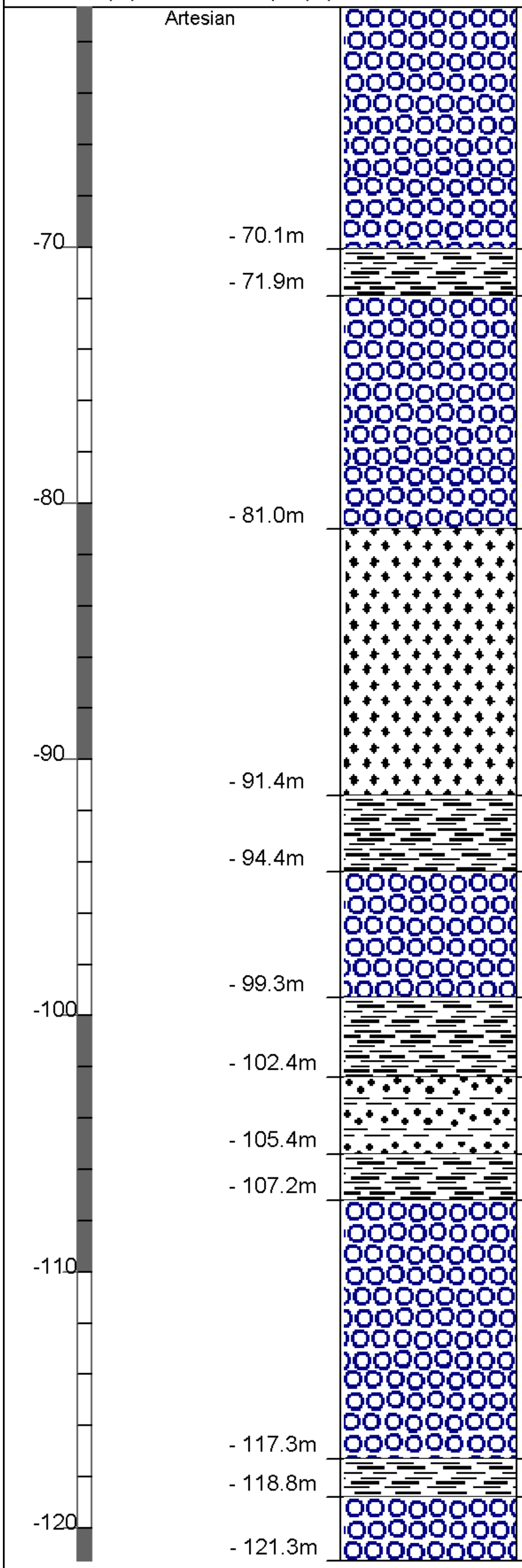
Gridref: M36:814-399 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.2 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -121.3m Drill Date :



Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	-9.10m	Clay & sand	sp
	- 13.7m	Blue shingle	sp
	- 25.8m	Clay & sand	ch
	- 38.4m	Brown shingle, water rises to surface	ri
	- 40.8m	Blue clay	br
	- 43.8m	Brown shingle, water rises to surface	br
	- 51.8m	Brown sand	br
	- 53.6m	Yellow clay	br
	- 70.1m	Brown shingle, water rises to 0.6m at 68.5m	li

Borelog for well M36/1086 page 2 of 2

Gridref: M36:814-399 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.2 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -121.3m Drill Date :

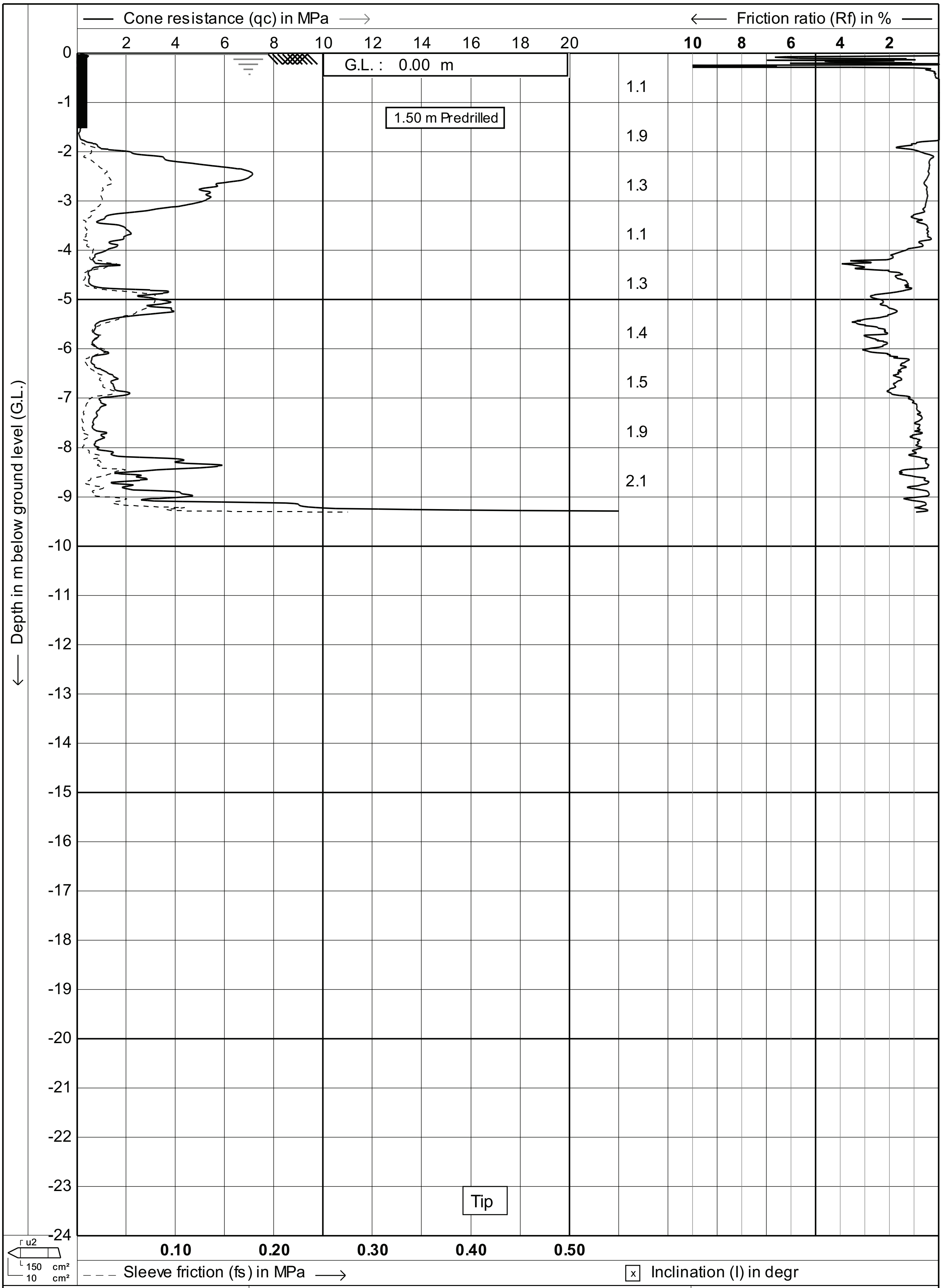


Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	- 70.1m	Brown shingle, water rises to 0.6m at 68.5m	li
	- 71.9m	Yellow clay	li-2
	- 81.0m	Brown shingle, water rises 1.2m at 73.1m	li-3
	- 91.4m	Brown sand	he
	- 94.4m	Yellow clay	he
	- 99.3m	Brown shingle, flow at 97.5m water rises 4.2m	bu
	- 102.4m	Yellow clay	sh
	- 105.4m	Blue clay & sand	sh
	- 107.2m	Yellow clay	sh
	- 117.3m	Brown shingle, flows at 109.7m & 112.7m, rises 5.1m	sh
	- 118.8m	Yellow clay	sh
	- 121.3m	Brown shingle flows at 262.0m3/d at the surface & rises 7.6m	wa

Borelog for well M36/1097

Gridref: M36:813-398 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.6 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -99m Drill Date : 12/02/1913

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
-10 -20	Artesian	- 24.3m	Clay & sand	sp-ch
-30		- 38.4m	Brown shingle	ri
-40		- 42.6m	Blue clay & sand	br
		- 48.7m	Blue sand	br
-50		- 51.2m	Brown sand	br
		- 52.4m	Blue shingle	li-1
		- 57.3m	Blue sand	li-1
-60		- 63.3m	Brown shingle	li-2
		- 68.2m	Blue clay & sand	li-2
-70		- 70.1m	Blue shingle	li-2
		- 76.2m	Blue shingle	li-3
		- 79.2m	Brown shingle, water rises 1.8m	li-3
-80 -90		- 93.2m	Brown sand & shingle	he
		- 97.8m	Yellow & Blue clay	he
		- 99.0m	Brown shingle, water flows 196.5m3/d & rises 6.7m	bu



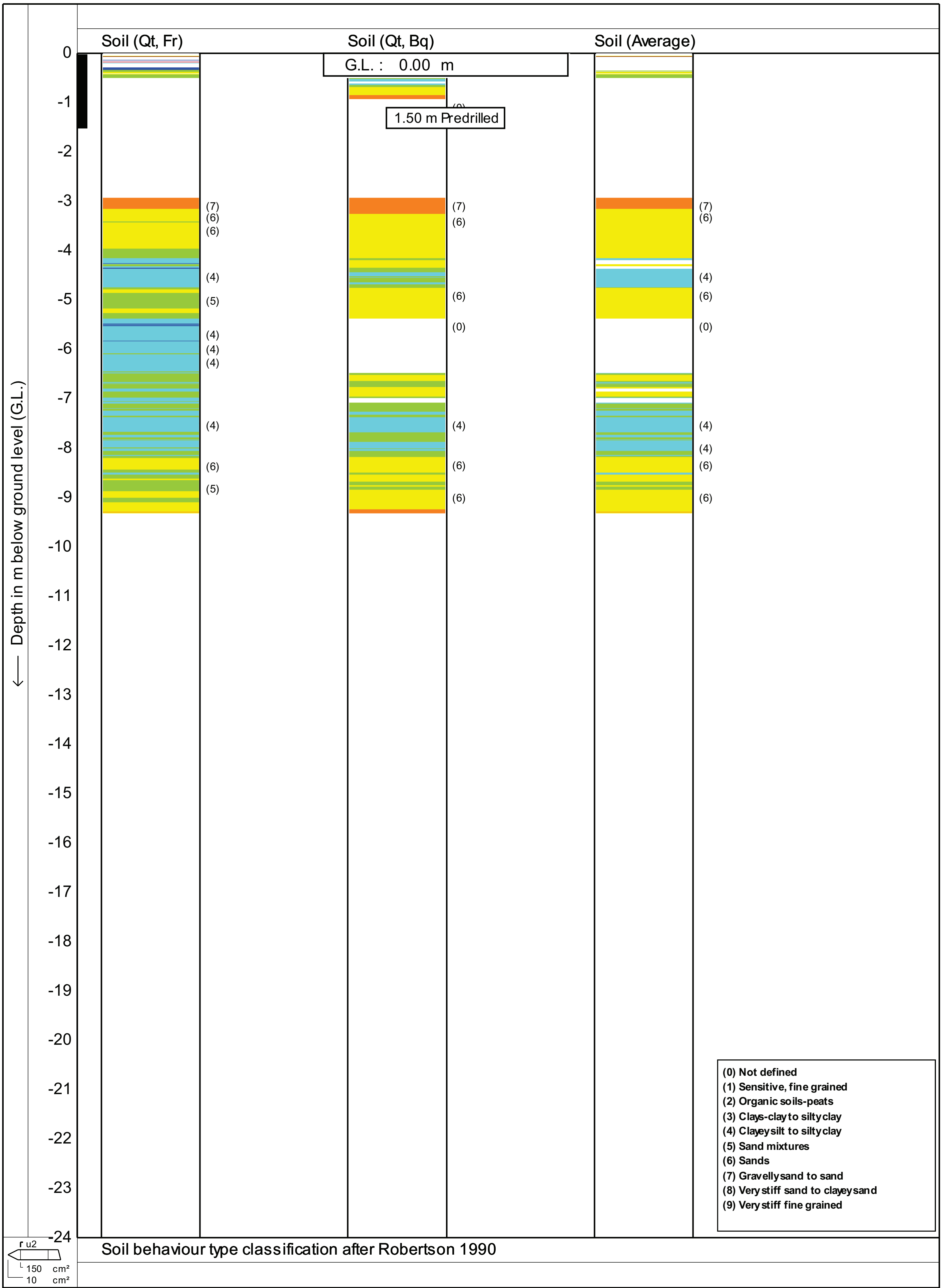
Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **CBD - Christchurch City**

Date : **30-8-2011**
Cone no. : **C10CFIIP.F56**
Project no. : **01TT26**
CPT no. : **CBD-137** **1/14**

CPTask V1.25

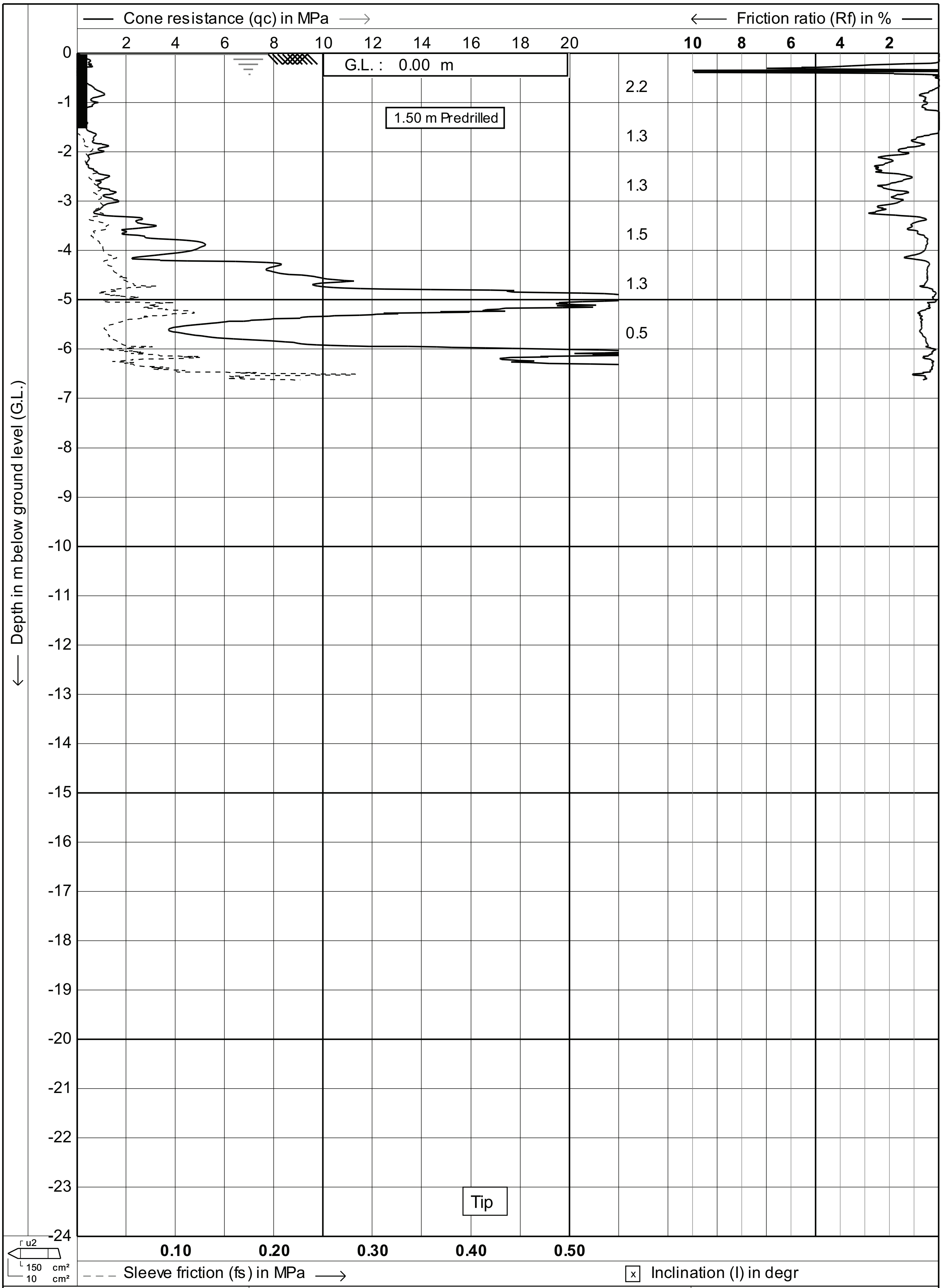


Soil behaviour type classification after Robertson 1990

Test according A.S.T.M. Standard D 5778-07

Project :	**Site Investigations**
Location:	**CBD - Christchurch City**

Date	: **30-8-2011**
Cone no.	: **C10CFIIP.F56**
Project no. :	**01TT26**
CPT no.	: **CBD-137**



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CPTask V1.25

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

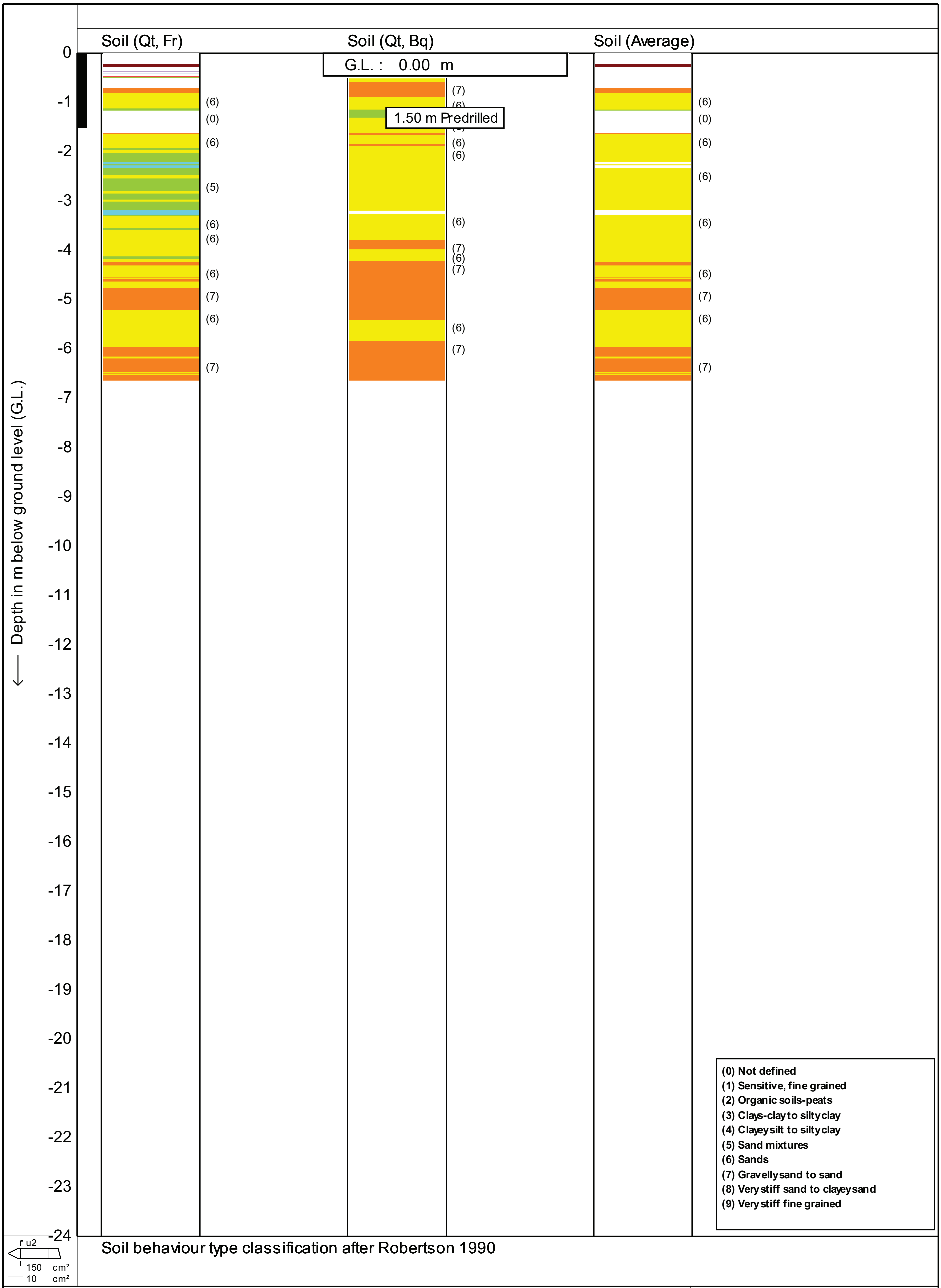
Location: **CBD - Christchurch City**

Date : **30-8-2011**

Cone no. : **C10CFIIP.F56**

Project no. : **01TT26**

CPT no. : **CBD-138** **1/14**



Soil behaviour type classification after Robertson 1990

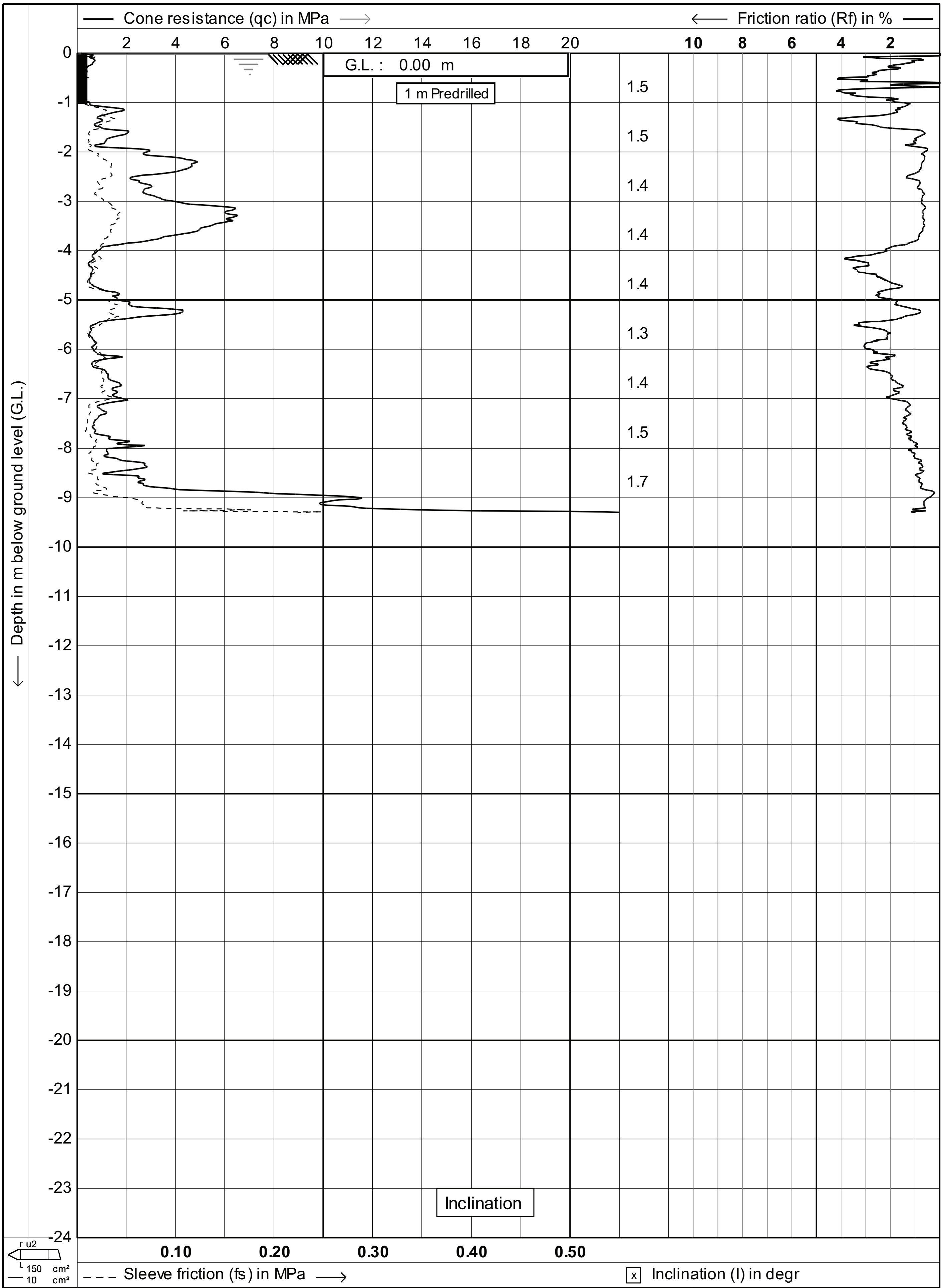
CPTask V1.25

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **CBD - Christchurch City**

Date	: **30-8-2011**
Cone no.	: **C10CFIIP.F56**
Project no.	: **01TT26**
CPT no.	: **CBD-138**



Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Sydenham - Christchurch City**

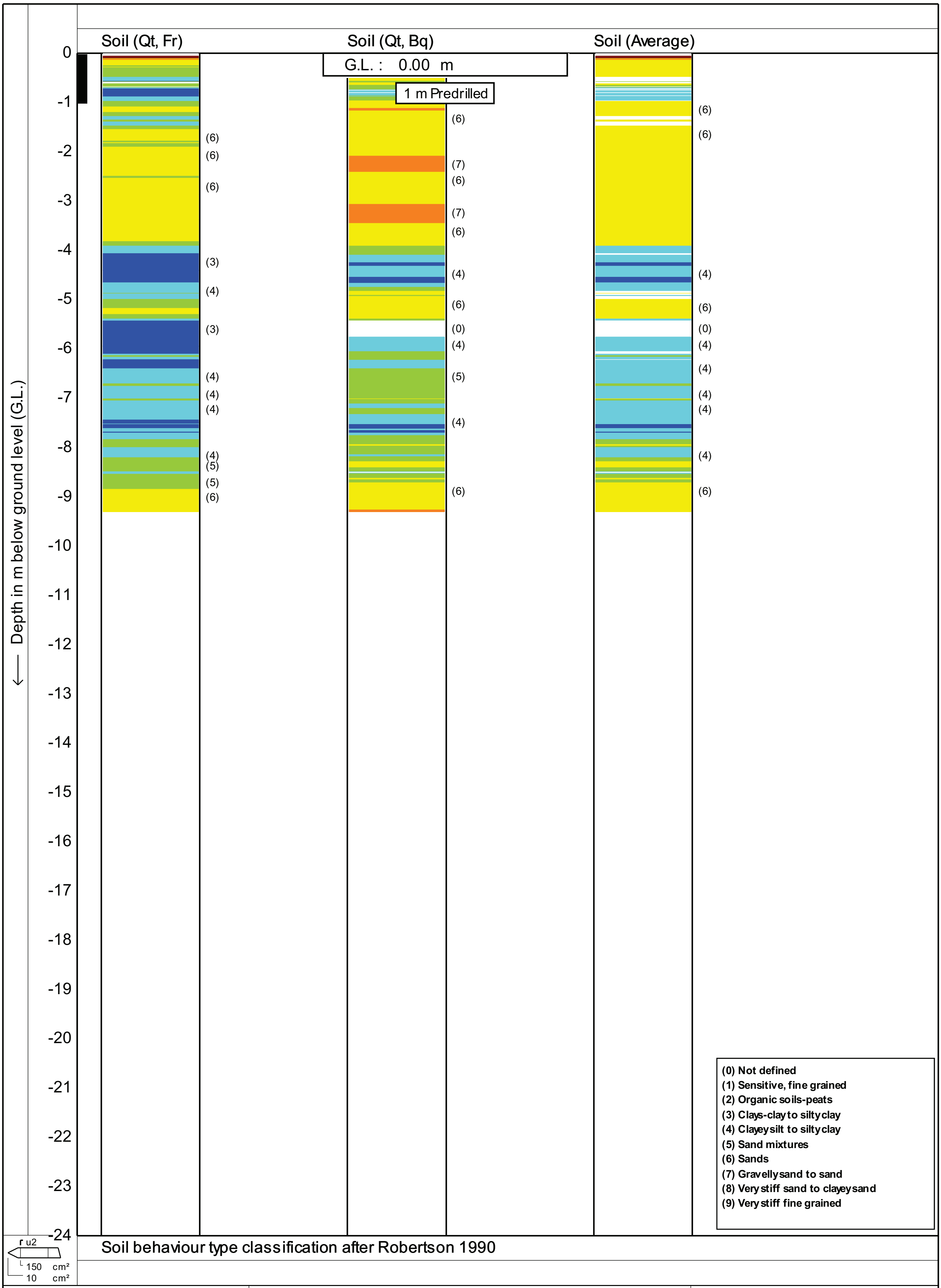
Date : **6-5-2011**

Cone no. : **C10CFIIP.F14**

Project no. : **01TT10**

CPT no. : **SYD-02** **1/14**

CPTask V1.25



Soil behaviour type classification after Robertson 1990

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CPTask V1.25

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

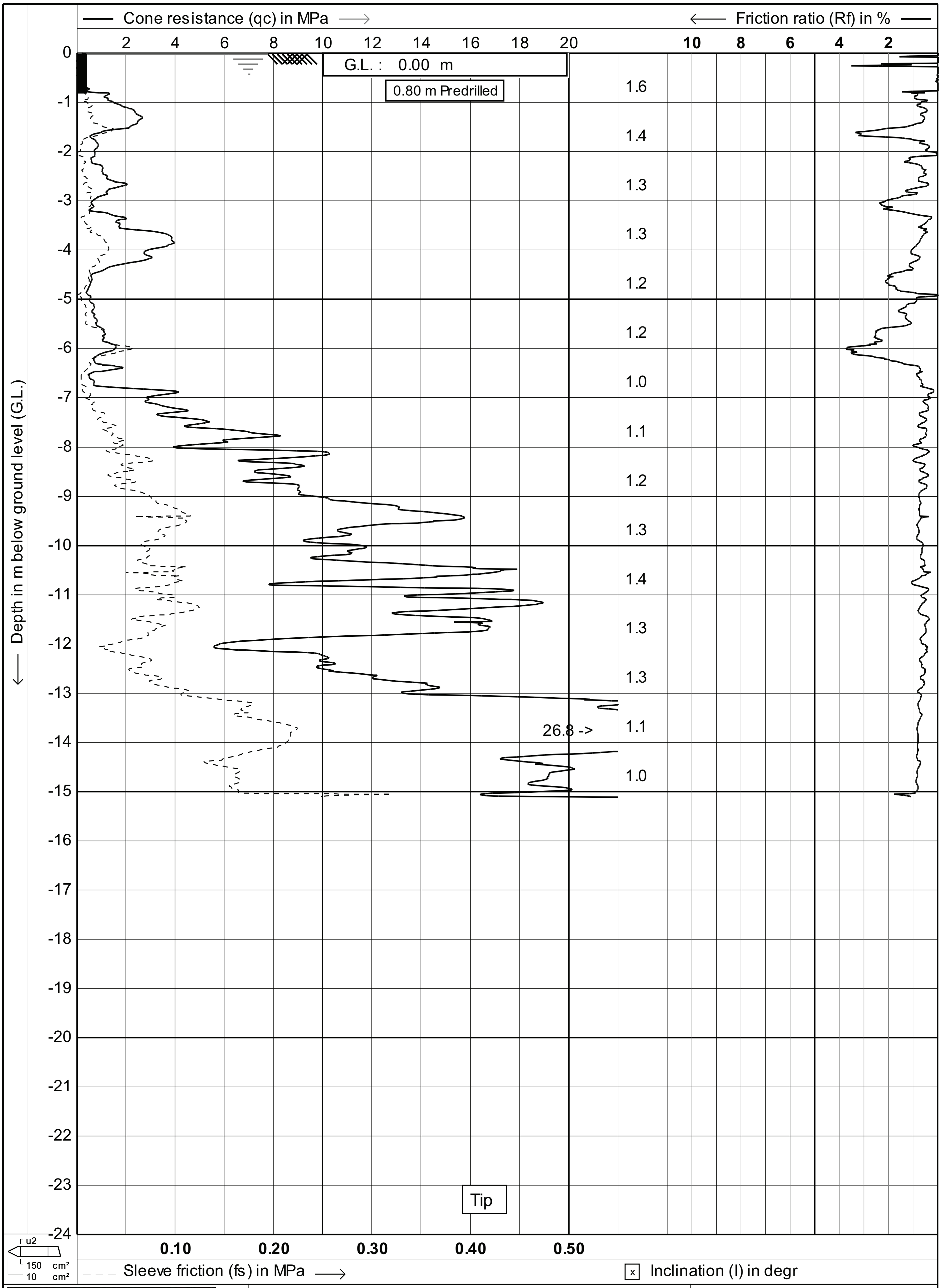
Location: **Sydenham - Christchurch City**

Date : **6-5-2011**

Cone no. : **C10CFIIP.F14**

Project no. : **01TT10**

CPT no. : **SYD-02**



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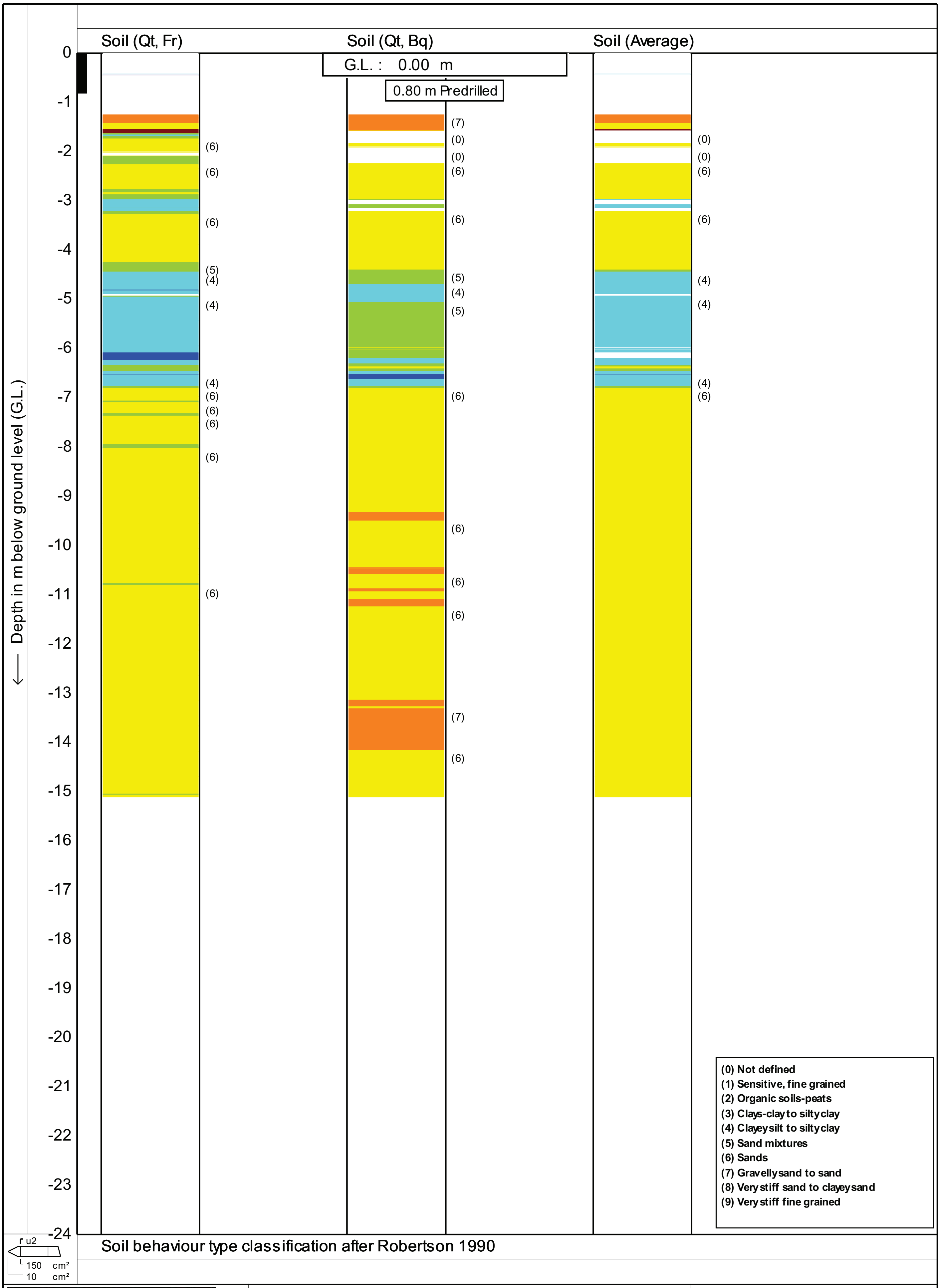
Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Sydenham - Christchurch City**

Date	: **6-5-2011**
Cone no.	: **C10CFIIP.F14**
Project no.	: **01TT10**
CPT no.	: **SYD-03** **1/14**

CPTask V1.25



Soil behaviour type classification after Robertson 1990

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

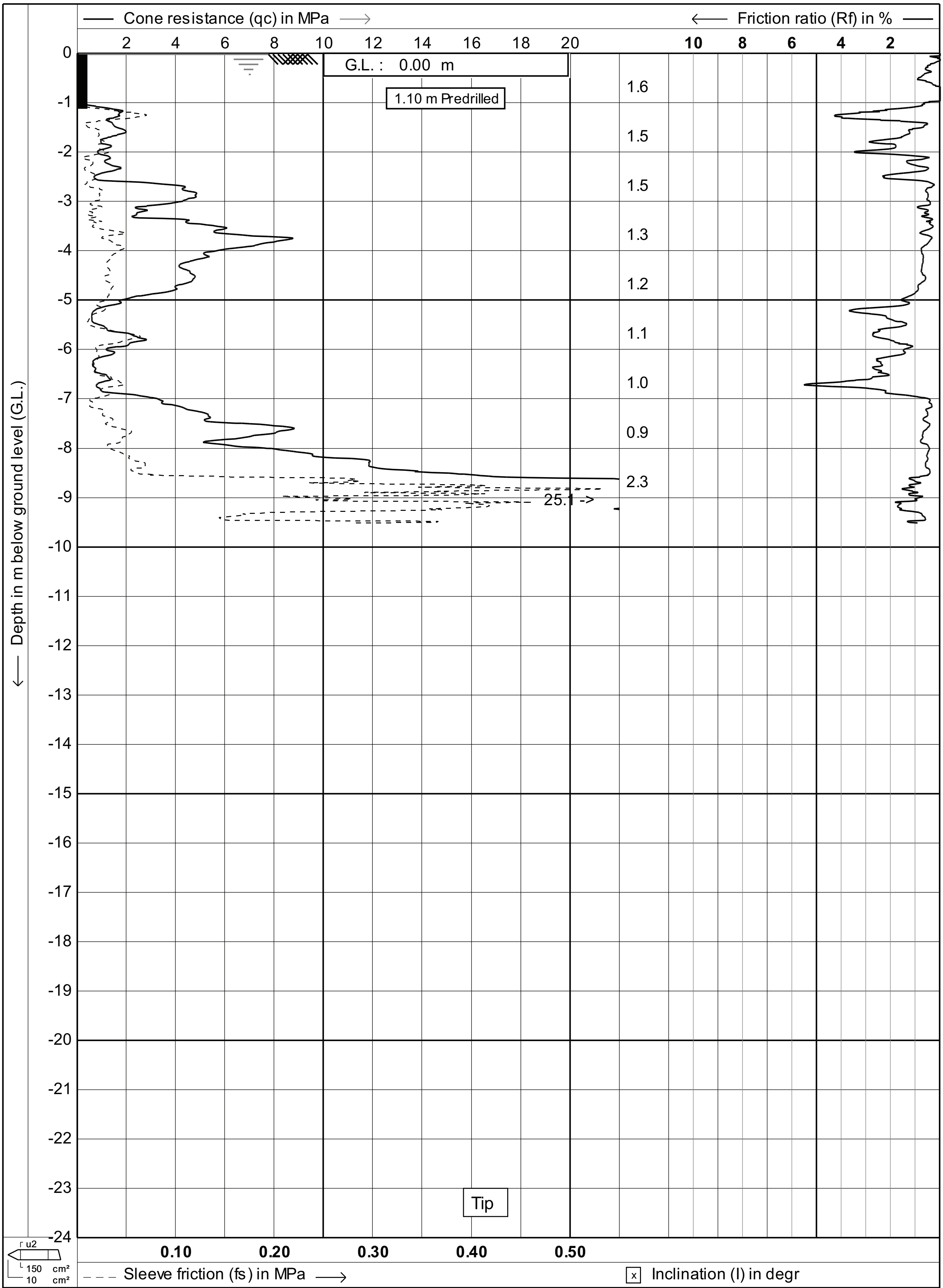
Location: **Sydenham - Christchurch City**

Date : **6-5-2011**

Cone no. : **C10CFIIP.F14**

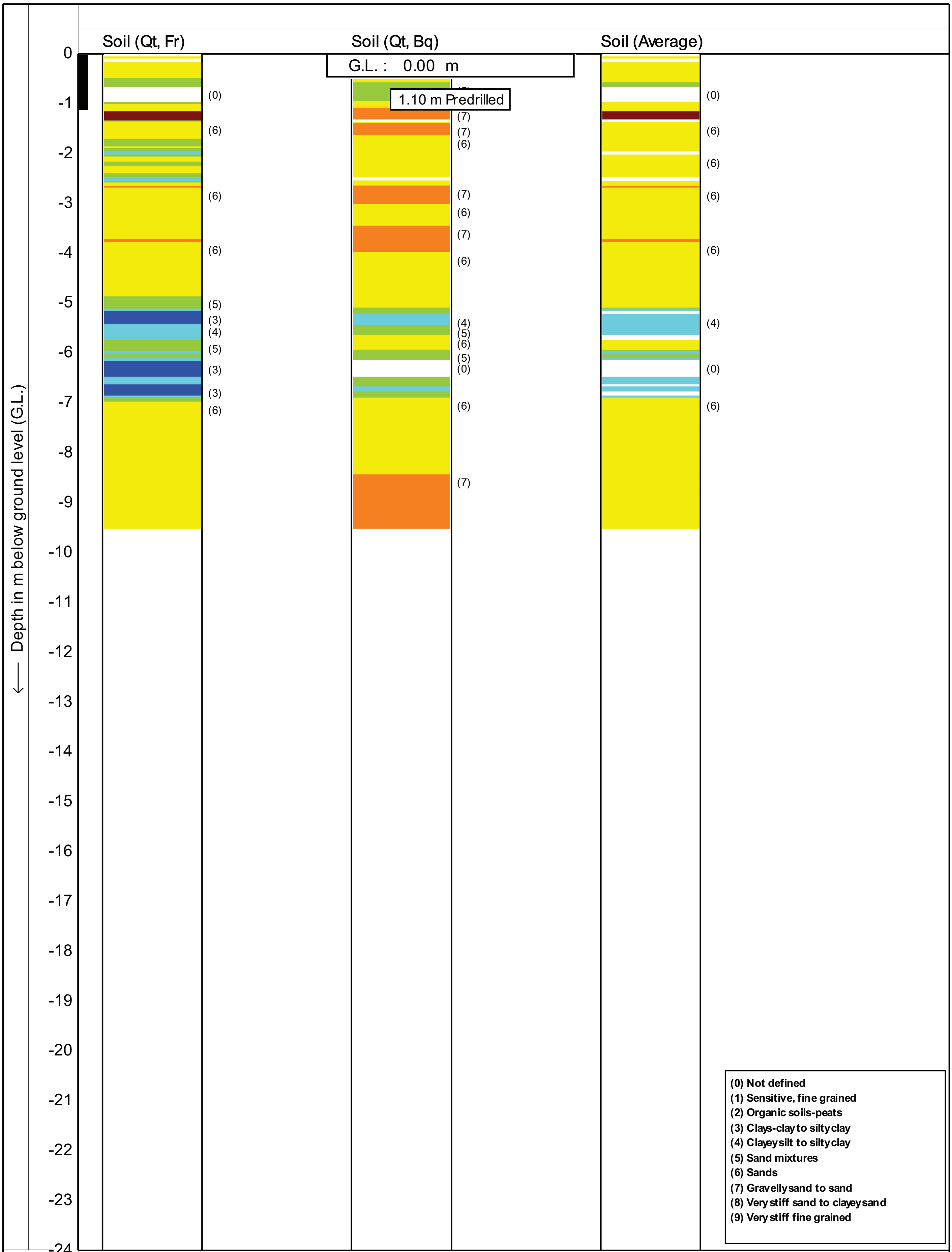
Project no. : **01TT10**

CPT no. : **SYD-03**



Perry Drilling GEO PROBE Ground Drilling and Environmental Specialists	Test according A.S.T.M. Standard D 5778-07	Date : **6-5-2011**
		Cone no. : **C10CFIIP.F14**
	Project : **Site Investigations**	Project no. : **01TT10**
	Location: **Sydenham - Christchurch City**	CPT no. : **SYD-04** 1/14

CPTask V1.25



(0) Not defined
(1) Sensitive, fine grained
(2) Organic soils-peats
(3) Clays-clay to silty clay
(4) Clayey silt to silty clay
(5) Sand mixtures
(6) Sands
(7) Gravelly sand to sand
(8) Very stiff sand to clayey sand
(9) Very stiff fine grained

Soil behaviour type classification after Robertson 1990

u2
150 cm²
10 cm²

CPTask V1.25

Ground Drilling and Environmental Specialists

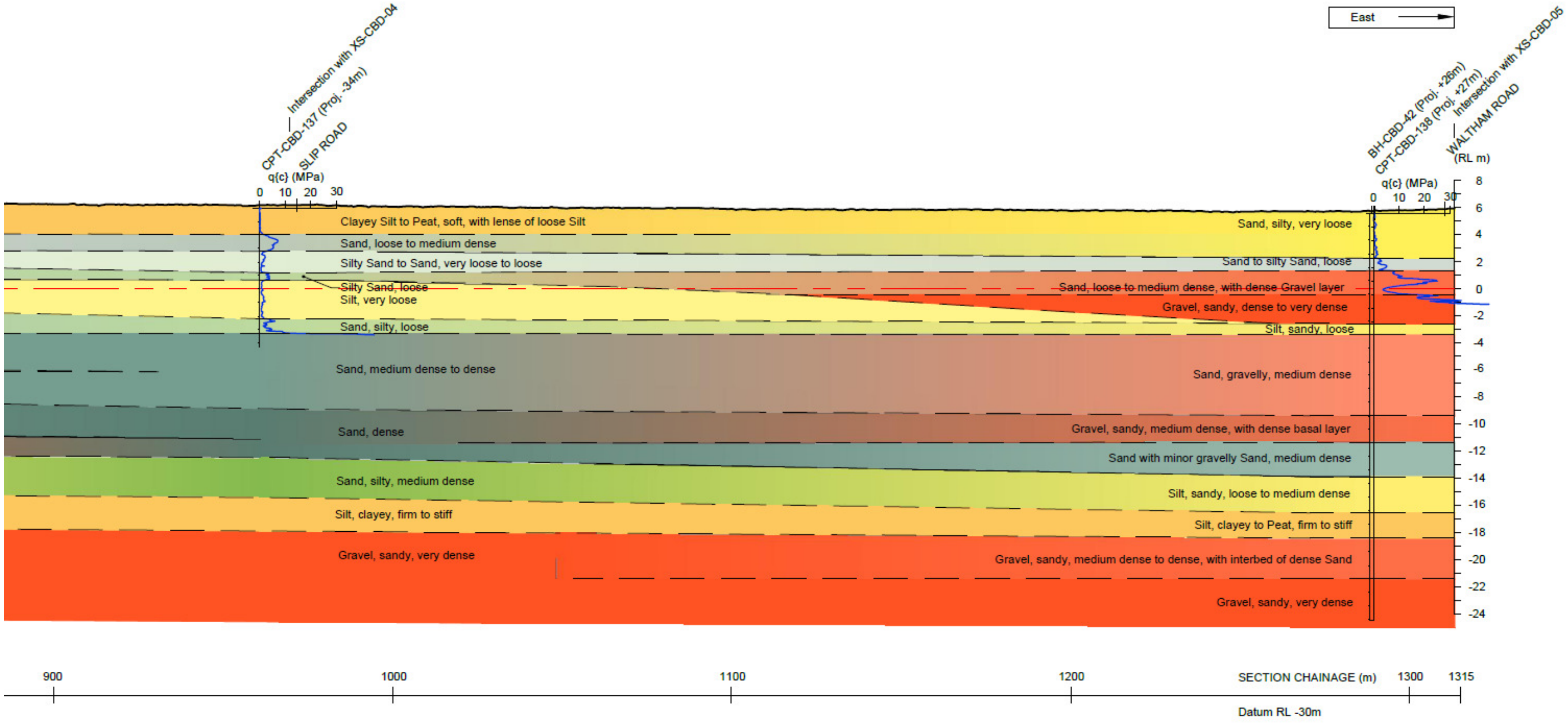
Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Sydenham - Christchurch City**

Date : **6-5-2011**
Cone no. : **C10CFIIP.F14**
Project no. : **01TT10**
CPT no. : **SYD-04**

13/14



Notes:

1. Subsurface conditions are inferred from borehole logs and correlations from CPT data. The nature and continuity of the subsoils away from the the investigation locations are inferred and it must be appreciated that actual ground conditions could vary from the assumed model.
2. Strength and density descriptions follow NZ Geotechnical Society "Guidelines for the Field Classification and Description of Soil & Rock for Engineering Purposes" (December, 2005).
3. No data available in top 1.2m due to services pre-drill.
4. Ground surface profile inferred from LIDAR data (flown by NZ Aerial Mapping 8-10 March 2011) where available.
5. CPT and borehole elevations are relative to Lyttelton Datum (mean sea level).
6. Soil material type, density and strength have been inferred from CPT data using methodologies published in Lunne, Robertson & Powell (1997).

Christchurch
City Council

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

COMPILED & DRAWN	LDE	12/11
REVIEWED	T&T	12/11
DRAFTING CHECKED	T&T	12/11

GXS-CBD-18 Final.dwg

SCALES (AT A3 SIZE)
1:2000 Horizontal
1:500 Vertical

Sheet 1 of 1

CHRISTCHURCH CITY COUNCIL
GEOLOGICAL INTERPRETATIVE REPORT
CHRISTCHURCH CENTRAL CITY
GXS-CBD-18 (Brougham Street)

FIG. No. C 23

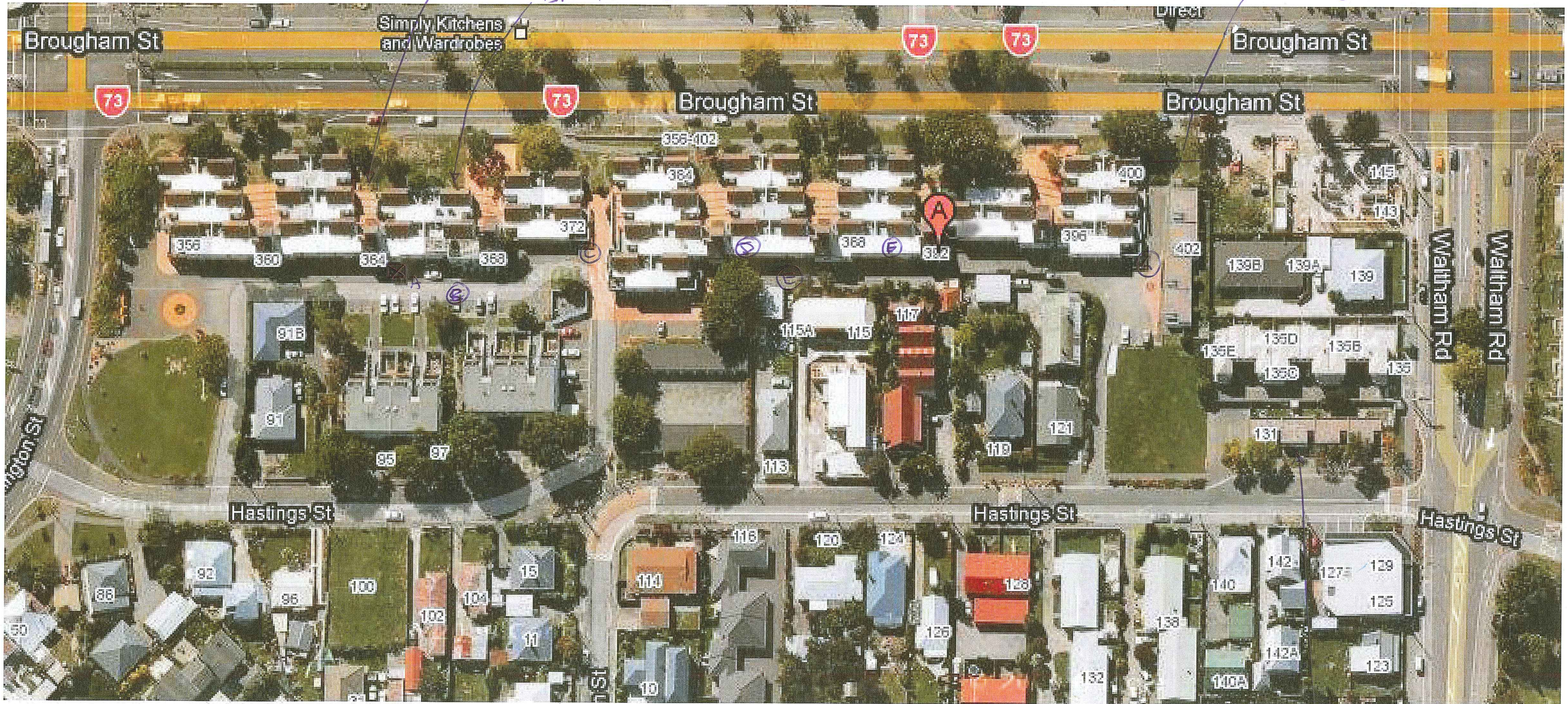
REV. 1

APPENDIX B - SITE PLAN Walkover notes 10/05/11 Graham Brown.

20mm gap in tiles

15mm gap in tiles

100mm of ground heave.



Unit 2 Yellow sticker
severe liquefaction

Record of Damage
- Ⓐ Ground heave 80mm
- Ⓑ Damage to carpark Area
- Ⓒ Damage to buried services
- Ⓓ Severe cracking in 1st Floor Slab.
- Ⓔ Heave in driveway 100mm
- Ⓕ Garage 33 cracking in ground floor Slab.
- Ⓖ Damaged services.

OPUS