# Whakahoa Village Units Block E

BU 2680-005 EQ2

# Detailed Engineering Evaluation

# Quantitative Report

Christchurch City Council

*Christchurch City Council*

# Whakahoa Village Block E

# Detailed Engineering Evaluation Quantitative Report

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Whakahoa Village Block E
BU 2680-005 EQ2

Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Final

Gowerton Place, Richmond

## Background

This is a summary of the quantitative report for the Whakahoa Village Block E building, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, visual inspections on 21 and 25 March 2012, available drawings and calculations.

## Key Damage Observed

There is only minor wall and ceiling cracking in the two units. The patio slab on ground to Unit 59 has settled. There were also obvious indications of ground movement around the building evidenced by ejected silt associated with liquefaction.

## Critical Structural Weaknesses

No critical structural weaknesses were identified.

## Indicative Building Strength

When subject to the current new building standard (NBS) seismic design forces, the reinforced masonry walls have a capacity greater than 100% NBS in both orthogonal directions.

Likewise, the timber walls have a capacity greater than 100% NBS in both orthogonal directions.

The building in its current damaged state has been assessed to have a post-earthquake seismic capacity of more than 100% NBS and is therefore not classed as earthquake prone.

## Recommendations

It is recommended that:

a) The building damage relating to cracking of wall or ceiling linings, and out-of-plumb windows and doors should be repaired.
b) Remove carpets and investigate ground floor slab for cracking. Assess and undertake crack repairs where necessary.
c) Six (6) Cone Penetrometer Tests to a depth of 25m be undertaken to enable a site wide liquefaction assessment.
d) If the site is assessed to be equivalent to the DBH Technical Category 3, in accordance with the interim guidance, a foundation re-level is likely for the affected units at Whakahoa Village. CCC will need to accept that more damage to the existing concrete slab foundations is likely in future seismic events. Further investigations will be required if re-levelling and subsequent structural design is required.

# Contents

# 1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Whakahoa Village Block E, located at Gowerton Place, Richmond, following the M6.3 Christchurch earthquake on 22 February 2011.

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

The seismic assessment and reporting have been undertaken based on the quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011 [3].

# 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 [3]. 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) [2].

### 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.*

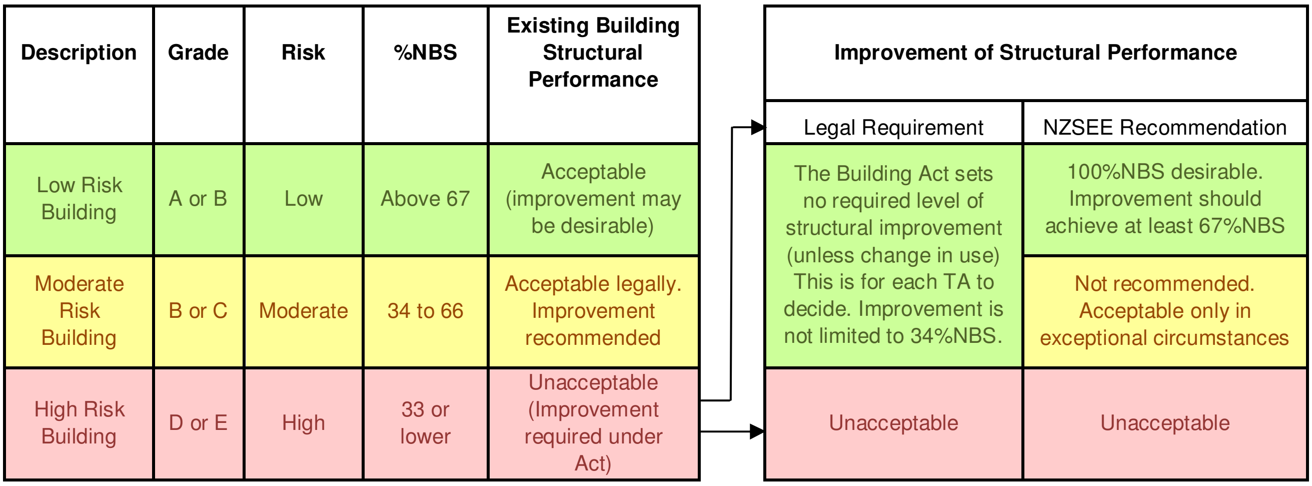
*1.2 Ensuring that responsible steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.*

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 |
|---|---|---|---|---|
| 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 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 General

The Whakahoa Village Block E building is a single storey reinforced masonry building with a pitched timber framed roof and fixed plasterboard ceiling. The building is founded on reinforced concrete strip footings.

**Figure 2 – Location of Block E on site**

The building comprises two residential apartments and is 18.0m long in the east-west direction and 16.0m wide in the north-south direction. The roof height is 2.45m to the ceiling from the ground slab.

The building construction was completed in 2007.

## 4.2 Gravity Load Resisting System

The ground floor construction is a 100mm thick in-situ concrete ground bearing slab.

The roof is a timber framed roof clad in lightweight profiled metal roof sheeting, with a plasterboard ceiling, supported on a combination of reinforced concrete masonry walls and timber framed walls.

## 4.3 Seismic Load Resisting System

Seismic loads are resisted in both orthogonal directions by a combination of Gib plasterboard lined timber bracing walls and reinforced concrete masonry walls. Seismic loads in the north-south direction are primarily resisted by masonry walls, and in the east-west direction primarily resisted by timber bracing walls. The timber and plasterboard ceiling provides an adequate diaphragm to distribute the lateral loads to the walls.

# 5 Survey

The building currently has a green placard, indicating that the units are safe for occupancy.

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

- Structural drawings by Powell Fenwick Consultants Limited titled "Gowerton Place Social Housing" (drawing numbers S1.1 – S1.7)
- Architectural drawings by City Solutions titles "Gowerton Place Social Housing" (drawing numbers WD01-01 – WD07-06)

No copies of the design calculations have been obtained for this building.

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

# 6 Damage Assessment

The building has performed well under seismic conditions with only minor localised wall lining damage due to movements of the building from either liquefaction and/or earthquake loading. The most noticeable damage in Unit 59 is the crack over the bathroom door. Cracking in Unit 58 is barely noticeable.

External to the building, obvious indications of ground movement exist, such as ejected silt associated with liquefaction, and settlement of the patio slab-on-ground to Unit 59. Liquefaction may have caused cracking to internal floor slabs, as seen in nearby units, but this was not observed here in the garages, or elsewhere due to the carpeted floors.

For the geotechnical assessment and recommendations of the site, refer to the Geotechnical Desk Study prepared by Opus in Appendix 2.

# 7 Detailed Seismic Assessment

## 7.1 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.

No critical structural weaknesses have been identified.

## 7.2 Seismic Coefficient Parameters

The seismic design parameters based on current design requirements from NZS1170.5:2004 and the NZBC clause B1 for this building 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;
- $\mu$ = 3 and $S_p$ = 0.7 (ductile) for the Gib plasterboard bracing walls
- $\mu$ = 1.25 and $S_p$ = 0.9 (nominally ductile) for the reinforced concrete masonry walls

## 7.3 Detailed Seismic Assessment Results

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

**Table 2: Summary of Seismic Performance**

| Structural Element/System | Failure mode and description of limiting criteria | % NBS based on calculated capacity |
|---|---|---|
| Masonry walls in the east-west direction i.e. across the building | In-plane bending and shear capacity of the reinforced concrete masonry bracing walls | >100% |
| Masonry walls in the north-south direction i.e. along the building | In-plane bending and shear capacity of the reinforced concrete masonry bracing walls | >100% |
| Timber framed walls in the east-west direction i.e. across the building | In-plane bracing capacity of the timber and Gib lined bracing walls | >100% |
| Timber framed walls in the north-south direction i.e. along the building | In-plane bracing capacity of the timber and Gib lined bracing walls | >100% |

## 7.4 Discussion of Results

The building has a calculated seismic capacity of more than 100% NBS. This capacity is based upon an assumption of nominally ductile reinforced concrete masonry walls, with assistance from plasterboard lined timber walls. The structural assessment would indicate that seismic damage to the wall and ceiling linings is likely to be the result of liquefaction rather than seismic loading.

Although not specifically detailed in the plans, the plasterboard ceilings could be expected to act satisfactorily as diaphragms due to the relatively small spans and appropriate aspect ratios to aid load distribution to stiffer masonry walls.

## 7.5 Limitations and Assumptions in Results

This report is based on an assessment of the building in its undamaged state.

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 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.

# 8 Geotechnical Assessment

The full geotechnical assessment completed by Opus is included in this report as Appendix 2. A summary of the geotechnical report is as follows:

## 8.1 General

The Whakahoa Village Residential Housing Units are situated approximately 2km north-east of Christchurch City in the suburb of Richmond. It is a relatively flat site, approximately 220m north-west of the Avon River.

The purpose of the geotechnical study is to assess the current ground conditions, the potential geotechnical hazards that may be present at the site, and determine whether further subsurface geotechnical investigations are necessary.

This Geotechnical Desk Study has been prepared in accordance with the Engineering Advisory Group’s Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Revision 5, 19 July 2011. This Geotechnical Desk Study forms parts of a Detailed Engineering Evaluation prepared by Opus, and has been undertaken without the benefit of any site specific investigations and is therefore preliminary in nature.

## 8.2 Expected Ground Conditions

A review of the Environmental Canterbury (ECan) Wells database [6] showed three wells located within approximately 100m of the property boundary. Material logs available from these wells in addition to EQC CPT tests have been used to infer the ground conditions at the site, as shown in the table below.

| Stratigraphy | Thickness (m) | Depth Encountered from (m) below ground |
|---|---|---|
| TOPSOIL | 0.2-0.5 | 0 |
| SAND (not present in M35/16568) | 0-0.75 | 0.2-0.5 |
| SILT | 1.2-1.5 | 0.5-1.0 |
| SAND | 20.3-21.0 | 1.8-2.5 |
| Clayey SILT | 1.5 | 22.8 |
| GRAVELS (Riccarton) | - | 24.3 |

The groundwater level was recorded as 1.2m-2.5m bgl in the borehole records.

## 8.3 Liquefaction Hazard

Examination of post-earthquake aerial photos taken by New Zealand Aerial Mapping (refer Project Orbit [7]) identified evidence of significant quantities of liquefied soils ejected at the ground surface of the site after the 22 February 2011 and 13 June 2011 events but not after the 4 September 2010 or 23 December 2011 events.

A preliminary CLiq analysis has been performed using the CPT-RCH-37 and CPT-RCH-50 data sets located 100m south east and 170m west of the site, respectively. A summary of the results of the analysis are presented in the table below.

| CPT | Distance from site boundary (m) | Direction | Event | Inferred Liquefiable Layers (bgl) | Total Liquefaction Induced Subsidence (mm) |
|---|---|---|---|---|---|
| CPT-RCH-37 | 100 | South East | ULS (0.35g) | -Ground Water Level to 4m<br>-Thin lenses at 7m and 11m | 60 |
| CPT-RCH-50 | 170 | West | ULS (0.35g) | -Ground Water level to 7m<br>-8.5m to 13.5m | 190 |

## 8.4 Site Walkover Inspection

A walkover inspection of the exterior of the buildings of Block A to E and surrounding land was carried out by an Opus Geotechnical Engineer on 14 May 2012. The following observations were made:

- Significant heave in the pavement up to 300mm is evident around the Whakahoa Village buildings.
- Liquefaction ejected soil is located in several gardens around the Whakahoa Village complex.

- A door frame in unit 54 (Block C) appears to be skewed by 10mm, likely due to differential settlement of foundations.
- The concrete driveways of unit 43 (west end of Block A) and unit 54 (south end of Block C) have cracked and have been offset vertically by up to 20mm (relative to the driveway) and laterally by 10mm directly outside of the garage doors.
- Cracking and settlement has occurred at several locations in the paved footpath in-between Blocks A, B and C.
- Gaps of up to 50mm wide have formed on the north and south sides of Block A.
- The footpath along the east side of Block B has settled by approximately 20mm.
- The units located on the west side of the stairs in Block A appear to have differentially settled compared to the units on the east side.
- No evidence of differential settlement or cracking was observed around Blocks D and E.

### 8.5 Level Survey

A summary of the level survey undertaken by Opus Surveyors on 14 May 2012 are given in the table below. Refer to the level survey results in the geotechnical report.

| Block | Unit | Differential Settlement [1,2] |
|---|---|---|
| A | 40,41 | 50mm (centre) |
| A | 42,43 | 120mm (west) |

*Notes: (1) Floor slab levels rounded to the nearest 10mm*
*(2) Direction of fall indicated in brackets*

### 8.6 Discussion

Due to the ground motion during the seismic events, the lateral movement that Block A has undergone may have caused the soils to consolidate resulting in the gaps observed on both the north and south sides of Block A.

Due to the reinforced masonry block construction of the units, the structural form is not directly recognised in the DBH guidance document [8]. Therefore, appropriate remedial solutions will be dependent on the integrity of the superstructure and liaison with the Structural Engineer.

No evidence of cracking in the floor slabs and perimeter footing were observed. Areas able to be inspected were limited due to the carpeted flooring and shrubbery.

The level survey results are consistent with the observations of differential settlement of the western units of Block A. Observations include pavement cracking of the driveway outside the western most unit (unit 43) separating from the stair well.

There is an open swale 10m east of Block A and B retained by a timber pole retaining wall. The depth of the swale invert relative to Whakahoa Village is approximately 1.5m. This open face represents a potential hazard for lateral spreading. The Avon River is located 150m south east of the Whakahoa Village. There has been no evidence of cracking on the site associated with lateral spreading.

The CLiq analysis based on the CPTs 170m west and 100m south east of the building indicated that there is possible total settlement of up to 190mm during an Ultimate Limit State seismic event. Liquefiable layers have been identified from the ground water level up to 13.0m bgl. The CPT results correlate with the observed differential settlement observed on site.

The differential settlement that appears to have occurred to Block A relative to the footpath may be attributed to a temporary loss of bearing capacity during the seismic shaking. Shallow investigations including hand augers and scalas should be undertaken to confirm the bearing capacity of the underlying material.

If the existing units are to be retained, a building consent will be necessary for remedial works. Remedial works will include re-levelling of Block A. Site specific investigations comprising of approximately 6 Cone Penetrometer Tests (CPT's) to a depth of 20m are recommended to be undertaken to enable a site wide liquefaction assessment and combined with shallow investigations to identify potential revelling/remedial solutions.

## 9 Remedial Options

No strengthening remedial work is required to Block E. Repairs should be carried out throughout the two units to cracked internal wall and ceiling linings. Floor slabs should be fully investigated for cracking and repaired where necessary.

## 10 Conclusions

(a) The building in its post-earthquake state has a seismic capacity of greater than 100% NBS and is therefore not classed as earthquake prone.

(b) Remedial repair work to cracked wall and ceiling linings and slabs is required.

(c) Further geotechnical investigations are required to assess liquefaction potential and ground bearing.

## 11 Recommendations

(a) The building damage relating to cracking of wall or ceiling linings should be repaired.

(b) Remove carpets and investigate ground floor slab for cracking and assess and undertake crack repairs where necessary.

The following geotechnical recommendation was also made in the report for the other four Blocks and is repeated herein. It is not additional to the recommendations in those reports.

(c) Six (6) Cone Penetrometer Tests to a depth of 25m be undertaken to enable a site wide liquefaction assessment.

## 12 Limitations

(a) This report is based on an inspection of the structure 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.

(d) The geotechnical assessment has been prepared solely for the benefit of CCC as our client with respect to the particular brief given to us. Data or opinions in this report may not be used in other contexts by any other party or for any other purpose.

(e) It is recognised that the passage of time affects the information and assessment provided in this document. Opus's opinions are based upon information that existed at the time of the production of this report. It is understood that the Services provided allowed Opus to form no more than an opinion on the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings or any laws or regulations.

## 13 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 1 – Photographs

**Photo 1: Crack in wall above bathroom door**

# Appendix 2 – Geotechnical Report

21 June 2012

Michael Sheffield
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6-QUCCC.93

Dear Michael

**Whakahoa Village - Geotechnical Desk Study**

## 1. Introduction

The Christchurch City Council (CCC) has requested Opus International Consultants (Opus) provide a geotechnical desktop study and walkover inspection of the Whakahoa Village (Gowerton Place) Residential Housing Units following the Canterbury Earthquake Sequence initiated by the 4 September 2010 earthquake.

The purpose of the geotechnical study is to assess the current ground conditions, the potential geotechnical hazards that may be present at the site, and determine whether further subsurface geotechnical investigations are necessary.

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

This Geotechnical Desk Study forms parts of a Detailed Engineering Evaluation prepared by Opus, and has been undertaken without the benefit of any site specific investigations and is therefore preliminary in nature.

## 2. Desktop Study

### *2.1 Site Description*

The Whakahoa Village Residential Housing Units are situated approximately 2km north-east of Christchurch City in the suburb of Richmond. It is a relatively flat site, approximately 220m north-west of the Avon River.

The housing development was constructed in 2007 and comprises 10 units of a single storey configuration and 8 units in a two storey configuration. The units are predominantly constructed of reinforced concrete masonry blocks with timber veneer being used in some areas.

### *2.2 Available Building Drawings*

Design drawings prepared by Powell Fenwick for Whakahoa Village were sourced from the CCC property file (refer to extract contained in Appendix C).

The drawings indicate the buildings foundations are reinforced concrete perimeter strip footings founded 525mm to 725mm below the finished floor slab level, with a 100mm thick reinforced concrete floor slab laid on compacted tailings or hard fill.

### *2.3 Regional Geology*

The published geological map of the area, (Geology of the Christchurch Urban Area 1:25,000, Brown and Weeber, Map 1, 1992) indicates the site is at the boundary between two surficial geological units; that being sand of fixed and semi-fixed dunes and beaches belonging to the Christchurch Formation and alluvial gravel sand and silt overbank deposits belonging to the Yaldhurst member of the Springston Formation.

A groundwater table depth of approximately 1m has been shown on the published map by Brown and Weeber (1992).

### *2.4 Earthquake Commission Subsurface Investigations*

Three Cone Penetrometer Tests (CPT's) have been completed within 170m of the site on behalf of the Earthquake Commission (EQC). The CPT's indicate the soils comprise silty SAND/sandy SILT layers to 1.6m depth, underlain by clayey SILT to 1.9m, before transitioning into clean and/or silty SAND to the end of the test holes at approximately 12m depth (Refer Appendix D). Note that CPT-RCH-38 refused on a possible shallow dense sand, gravel layer or obstruction at approximately 4.0m below ground level (bgl), which was not encountered in the remaining CPT's

In addition to the CPT's, two boreholes were completed on behalf of the Earthquake Commission within approximately 280m from the site. Due to their location and distance from the site, these EQC boreholes have not been used to infer the underlying geology.

### *2.5 Expected Ground Conditions*

A review of the Environmental Canterbury (ECan) Wells database showed three wells located within approximately 100m of the property boundary (refer to Appendix D). Material logs available from these wells in addition to the EQC CPT tests have been used to infer the ground conditions at the site, as shown in table 1 below.

**Table 1: Inferred Ground Conditions**

| Stratigraphy | Thickness (m) | Depth Encountered from (m) below ground |
|---|---|---|
| TOPSOIL | 0.2-0.5 | 0 |
| SAND (not present in M35/16568) | 0-0.75 | 0.2-0.5 |
| SILT | 1.2-1.5 | 0.5-1.0 |
| SAND | 20.3-21.0 | 1.8-2.5 |
| clayey SILT | 1.5 | 22.8 |
| GRAVELS (Riccarton) | - | 24.3 |

The groundwater level was recorded as 1.2m-2.5m bgl in the borehole records.

### *2.6 Liquefaction Hazard*

The 2004 Environment Canterbury Solid Facts Liquefaction Study indicates the site is in an area designated as having 'moderate liquefaction ground damage potential'. According to this study, based on a low groundwater table, ground damage from liquefaction is expected to be moderate and may be affected by 100mm to 300mm of ground subsidence.

Examination of post-earthquake aerial photos taken by New Zealand Aerial Mapping (refer Project Orbit) identified evidence of significant quantities of liquefied soils ejected at the ground surface of the site after the 22 February 2011 and 13 June 2011 events but not after the 4 September 2010 or 23 December 2011 events.

The Tonkin and Taylor Reconnaissance indicated evidence of liquefaction was observed at the site after the 22 February 2011 and 13 June 2011 events.

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

The residential properties from Vogel Street to the Avon River, 120m south east of the Whakahoa Village complex, are zoned “Red” which is evaluated as not being practical to rebuild, repair or reoccupy. Refer to the Land Recovery Zone Map in Appendix B.

The Department of Building and Housing has sub-divided the CERA “Green” residential land on the flat in Christchurch into technical categories. The three technical categories are summarised in Table 2 which has been adapted from the Department of Building and Housing guidance document (DBH, 2011).

**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 to large earthquake. | 0-15mm | 0-25mm |
| 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. | 0-50mm | 0-100mm |
| TC 3 | Moderate land deformations possible in a future small to medium sized earthquake and significant land deformations in future moderate to large earthquake. | >50mm | >100mm |

Whakahoa Village has been zoned as N/A-Urban Non-residential, as it is council owned land. The neighbouring residential properties have been zoned as Green-TC3 “blue zone”, which is determined to have a moderate to significant risk of land damage due to liquefaction in future significant earthquakes.

A preliminary CLiq analysis has been performed using the CPT-RCH-37 and CPT-RCH-50 data sets located 100m south east and 170m west of the site, respectively. A summary of the results of the analysis are presented in Table 3 below.

**Table 3: Results from a brief CLiq analysis**

| CPT | Distance from site boundary (m) | Direction | Event | Inferred Liquefiable Layers (bgl) | Total Liquefaction Induced Subsidence (mm) |
|---|---|---|---|---|---|
| CPT-RCH-37 | 100 | South East | ULS (0.35g) | -Ground Water Level to 4m<br>-Thin lenses at 7m and 11m | 60 |
| CPT-RCH-50 | 170 | West | ULS (0.35g) | -Ground Water level to 7m<br>-8.5m to 13.5m | 190 |

## 3. Site Walkover Inspection

A walkover inspection of the exterior of the buildings of Block A to E and surrounding land was carried out by an Opus Geotechnical Engineer on 14 May 2012. The following observations were made (refer to the Site Walkover Plan and Site Photographs attached to this report):

- Significant heave in the pavement up to 300mm is evident around the Whakahoa Village buildings (Figures 5, 6 and 10).
- Liquefaction ejected soil is located in several gardens around the Whakahoa Village complex (Figure 8).
- A door frame in unit 54 (Block C) appears to be skewed by 10mm, likely due to differential settlement of foundations (Figure 7).
- The concrete driveways of unit 43 (west end of Block A) and unit 54 (south end of Block C) have cracked and have been offset vertically by up to 20mm (relative to the driveway) and laterally by 10mm directly outside of the garage doors (Figure 3).
- Cracking and settlement has occurred at several locations in the paved footpath in-between Blocks A, B and C (Figure 11).
- Gaps of up to 50mm wide have formed on the north and south sides of Block A (Figures 4, 11 and 12).
- The footpath along the east side of Block B has settled by approximately 20mm (Figure 9).
- The units located on the west side of the stairs in Block A appear to have differentially settled compared to the units on the east side (Figure 14).
- No evidence of differential settlement or cracking was observed around Blocks D and E.

## 4. Level Survey

A summary of the level survey undertaken by Opus Surveyors on 14th May 2012 are given in Table 4. Refer to Level Survey results in Appendix F.

**Table 4: Results from the Level Survey**

| Block | Unit | Differential Settlement [1,2] |
|---|---|---|
| A | 40,41 | 50mm (centre) |
| A | 42,43 | 120mm (west) |
| *Notes: (1) Floor slab levels rounded to the nearest 10mm<br>(2) Direction of fall indicated in brackets* | | |

## 5. Discussion

As a result of the 4th September 2010 Canterbury Earthquake and the following aftershocks; cracking, heaving and settlement has occurred in Whakahoa Village.

Liquefaction has occurred in the Whakahoa Village complex and the wider vicinity in both the February 2011 and June 2011 earthquakes. This is evident due to the large amounts of ground heave in paved areas, liquefaction induced settlement, and liquefaction observed from aerial photographs.

The apparent settlement of the footpath along the east side of Block B appears to be due to liquefaction subsidence of the underlying soils. Up to 300mm of ground heave has occurred around the village, which is inferred to result from ejected soils accumulating under an impermeable surface, such as asphalt.

Due to the ground motion during the seismic events, the lateral movement that Block A has undergone may have caused the soils to consolidate resulting in the gaps observed on both the north and south sides of Block A.

It is unknown whether up to 10mm of vertical skew of the door in Unit 54 (Block C) is attributed to settlement or structural damage due to the shaking. A level survey is recommended of Block C to determine whether differential settlement has occurred.

A level survey has been undertaken on the ground floor and first floor of Block A, as it had sustained the majority of the damage. The results have been assessed by separating Block A into two areas divided by the staircase in the centre of the building. The results from the eastern units (40 and 41) showed differential settlement to up to 50mm, with a low point in the centre of Unit 40. Whereas, the units on the western side (42 and 43) showed differential settlement of up to 120mm, with the direction of fall towards the west.

The buildings at the site are two storey reinforced concrete masonry block. The Department of Building and Housing New Zealand guidance documents for repairing and rebuilding foundations in Technical Category 3 (DBH, 2012) is likely to be applicable for the buildings at this site. The guidance indicates that for concrete floor slab on grade (type C2) which is out of level between 50mm to 150mm, with cracks in the floor slab less than 3mm width; a foundation re-level is required.

Due to the reinforced masonry block construction of the units, the structural form is not directly recognised in the DBH guidance document. Therefore, appropriate remedial solutions will be dependent on the integrity of the super structure and liaison with the Structural Engineer.

No evidence of cracking in the floor slabs and perimeter footing were observed. Areas able to be inspected were limited due to the carpeted flooring and shrubbery.

The level survey results are consistent with the observations of differential settlement of the western units of Block A. Observations include pavement cracking of the driveway outside the western most unit (unit 43) separating from the stair well.

There is an open swale 10m east of Black A and B retained by a timber pole retaining wall. The depth of the swale invert relative to Whakahoa Village is approximately 1.5m. This open face represents a potential hazard for lateral spreading. The Avon River is located 150m south east of the Whakahoa Village. There has been no evidence of cracking on the site associated with lateral spreading.

The CLiq analysis based on the CPTs 170m west and 100m south east of the building indicated that there is possible total settlement of up to 190mm during an Ultimate Limit State seismic event. Liquefiable layers have been identified from the ground water level up to 13.0m bgl. The CPT results correlate with the observed differential settlement observed on site.

The peak ground accelerations (PGA) applied for the Ultimate Limit State (ULS) and Serviceability Limit State (SLS) seismic events at the site are based upon extensive probabilistic modelling by GNS Science and observations of land and building damage caused during the Canterbury Earthquake Sequence. The values used are recommended in Appendix C of the Department of Building and Housing guidance document (DBH, April 2012). The PGA are based on a Class D soil type (deep or soft soils), importance level 2 (IL2), and a design life of 50 years for the structure.

GNS Science 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 currently a 14% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. Ground damage similar to what has been observed is anticipated in such an event, dependent on the location of the epicentre. It is expected that the probability of occurrence is likely to decrease with time, following periods of reduced seismic activity.

The differential settlement that appears to have occurred to Block A relative to the footpath may be attributed to a temporary loss of bearing capacity during the seismic shaking. Shallow investigations including Hand Augers and Scalas should be undertaken to confirm the bearing capacity of the underlying material.

If the existing units are to be retained, a building consent will be necessary for remedial works. Remedial works will include re-levelling of Block A Site specific investigations comprising of approximately 6 Cone Penetrometer Tests (CPT's) to a depth of 20m are recommended to be undertaken to enable a site wide liquefaction assessment (refer to Appendix G) and combined with shallow investigations to identify potential revelling/remedial solutions.

## 6. Recommendations

It is recommended that:

- A level survey should be undertaken in Block C to confirm whether differential settlement has occurred.
- Two hand auger/scalas are undertaken surrounding the west side of Block A to assess the bearing capacity of the underlying material.
- Six (6) Cone Penetrometer Tests to a depth of 25m be undertaken to enable a site wide liquefaction assessment.
- If the site is assessed to be equivalent to the DBH Technical Category 3, in accordance with the interim guidance, a foundation re-level is likely for the affected units at Whakahoa Village. CCC will need to accept that more damage to the existing concrete slab foundations is likely in future seismic events. Further investigations will be required for detailed design.

## 7. Limitation

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

It is recognised that the passage of time affects the information and assessment provided in this document. Opus's opinions are based upon information that existed at the time of the production of this Desk Study. It is understood that the Services provided allowed Opus to form no more than an opinion on the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings or any laws or regulations.

## 8. Reference

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

Environment Canterbury, Canterbury Regional Council (ECan) website:

ECan Well Card
http://ecan.govt.nz/services/online-services/tools-calculators/Pages/well-card.aspx

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

Project Orbit, 2011: Interagency/organisation collaboration portal for Christchurch recovery effort. https://canterburyrecovery.projectorbit.com/SitePages/Home.aspx

GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury-quakes/aftershocks/ updated on 28 May 2012.

‘Interim recommendations for PGA values for geotechnical design in Canterbury’: Department of Building and Housing New Zealand (2012) *Appendix C: Interim guidance for repairing and rebuilding foundations in Technical Category 3.*

<u>Appendices:</u>

Appendix A: Site Photographs
Appendix B: Land Recovery Zones, Site Location and Walkover Plans
Appendix C: Available Structural Drawings
Appendix D: Earthquake Commission Subsurface Investigations
Appendix E: Environment Canterbury Borehole Logs
Appendix F: Level Survey
Appendix G: Site Investigation Location Plan

# Appendix A:
# Site Photographs

Figure 1: South elevation of Block A.

Figure 2: East elevation of Block B, C and D.

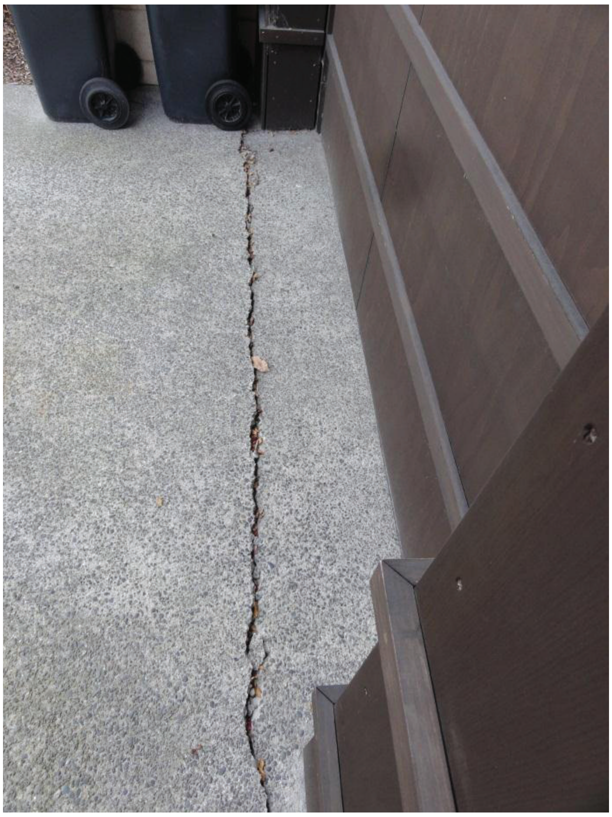


Figure 3: Up to 10mm lateral and 20mm of vertical movement.

Figure 4: Up to 30mm of lateral movement.

Figure 5: Up to 200m of heave in pavement south west of Block A.

Figure 6: Up to 300mm of heave in the pavement along the western boundary.

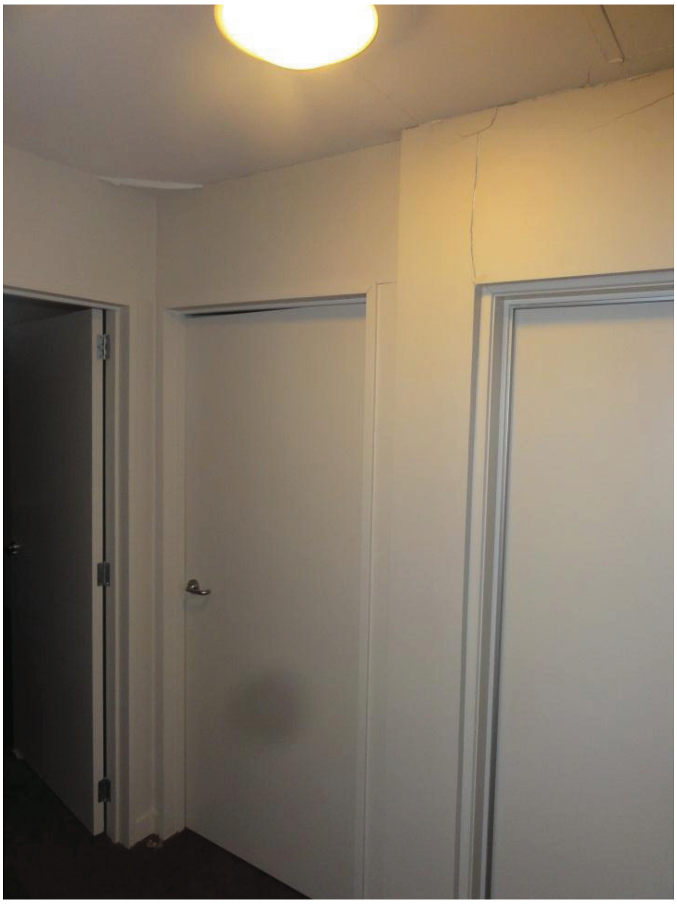


Figure 7: The bedroom door has skewed by up to 10mm.

Figure 8: Liquefaction ejected material is evident in gardens around the site.

Figure 9: Approximately 20mm of vertical settlement in footpath outside Block B.

Figure 10: Heave in the pavement along the western boundary.

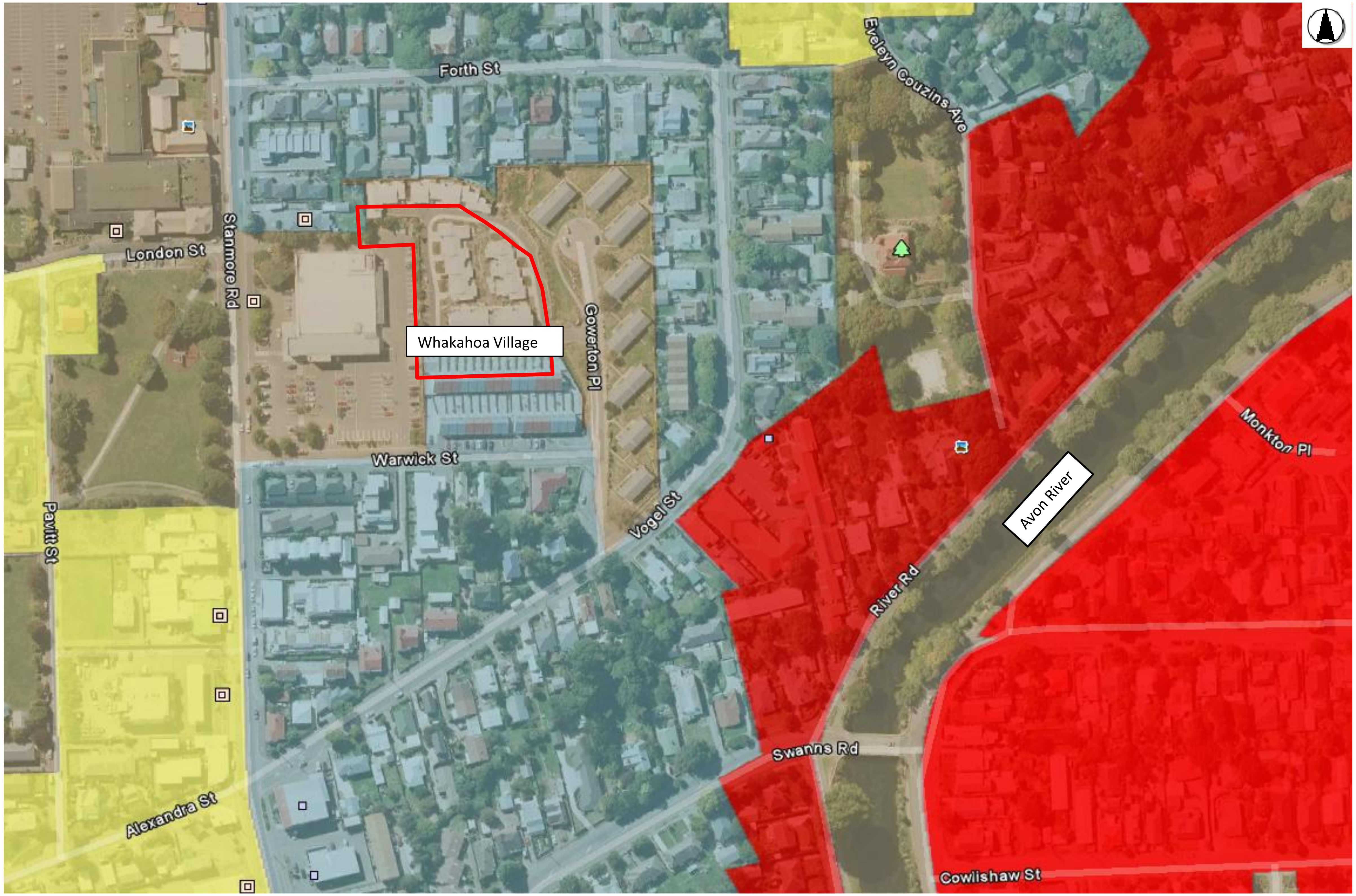
Figure 11: A gap up to 50mm is evident between the asphalt and concrete patio north of Block A.

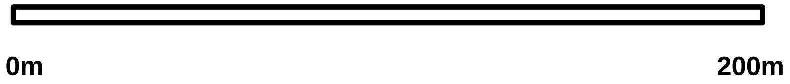
Figure 12: A gap up to 50mm is evident between a garden and concrete patio north of Block A.

Figure 13: Liquefaction induced settlement of the park benches east of the site.

Figure 14: Separation between west side of Block A and the stair well.

# Appendix B:
# Land Recovery Zones, Site Location and Walkover plans





Approximate Scale: 1:2350 (A3)

SOURCE: canterburyrecovery.projectorbit.com (Accessed on 5/06/12)

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**Project:** Whakahoa Village
Geotechnical Desktop Study

**Project No.:** 6-QUCCC.93

**Client:** Christchurch City Council

# Land Recovery Zones

**Drawn:** Opus Geotechnical Engineer

**Date:** 5/06/2012

0 100m

Approximate Scale: 1:1850 (A3)

Key:

▲ EQC CPT

● EQC Borehole

● Ecan Borehole

| BH | ECan Ref |
|---|---|
| 1 | M35/16806 |
| 2 | M35/16805 |
| 3 | M35/16568 |
| 4 | M35/1893 |

| BH/CPT | EQC Ref |
|---|---|
| 5 | CPT-RCH-37 |
| 6 | CPT-RCH-38 |
| 7 | BH-RCH-09 |
| 8 | BH-AVS-01 |
| 9 | CPT-RCH-50 |

SOURCE: 1) canterburyrecovery.projectorbit.com (Accessed on 19/04/12)
2) http://arcims.ecan.govt.nz/ecanmapping/ (Accessed on 19/04/12)

OPUS

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**Project:** Whakahoa Village
Geotechnical Desktop Study

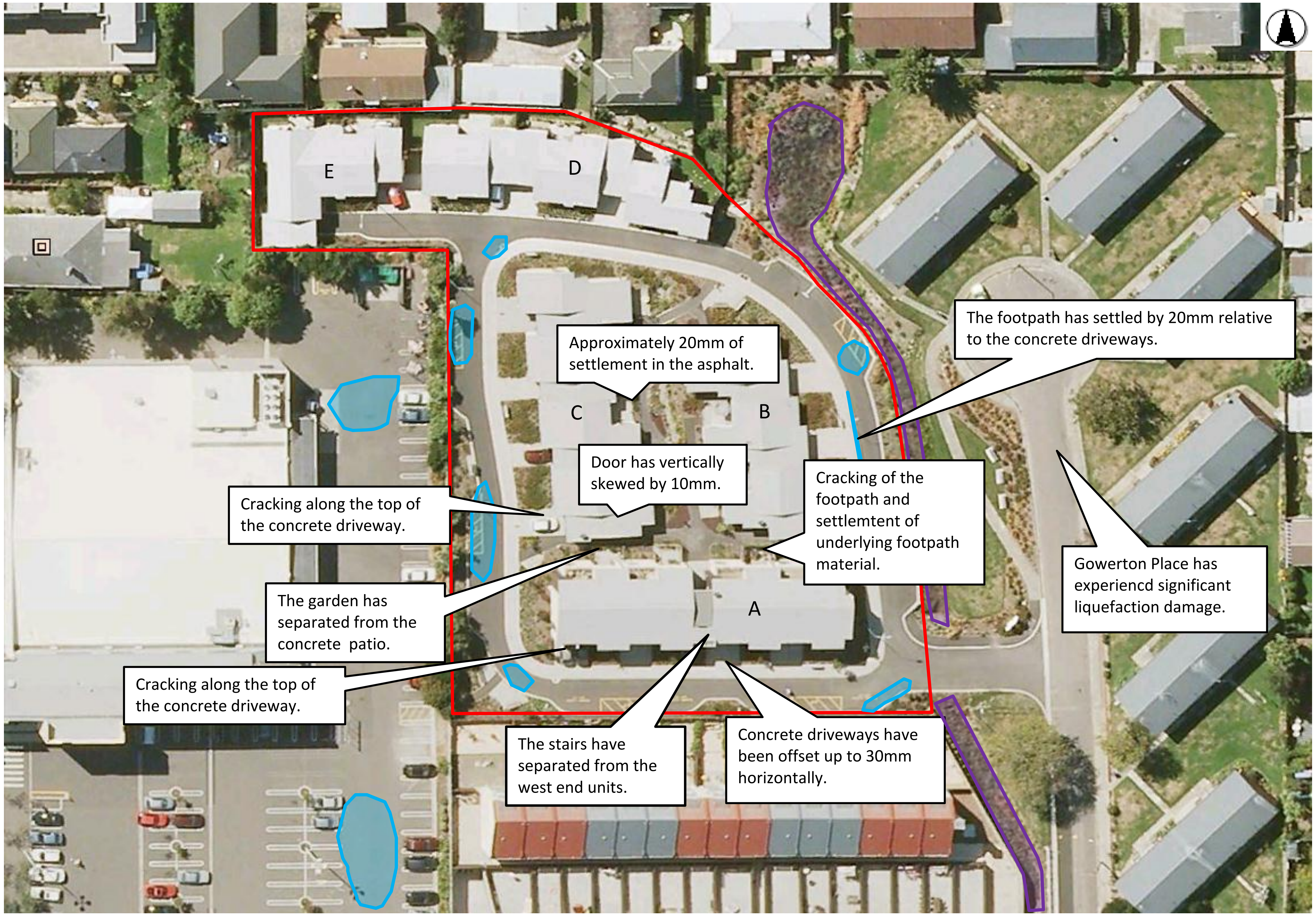
**Project No:** 6-QUCCC.93

**Client:** Christchurch City Council

# Site Location Plan

**Drawn:** Opus Geotechnical Engineer

**Date:** 27/04/2012



Approximately 20mm of settlement in the asphalt.

The footpath has settled by 20mm relative to the concrete driveways.

Door has vertically skewed by 10mm.

Cracking along the top of the concrete driveway.

Cracking of the footpath and settlemtent of underlying footpath material.

Gowerton Place has experiencd significant liquefaction damage.

The garden has separated from the concrete patio.

Cracking along the top of the concrete driveway.

The stairs have separated from the west end units.

Concrete driveways have been offset up to 30mm horizontally.

| | |
|---|---|
| 🟦 | Observed Ground Heave |
| 🟪 | Swale |

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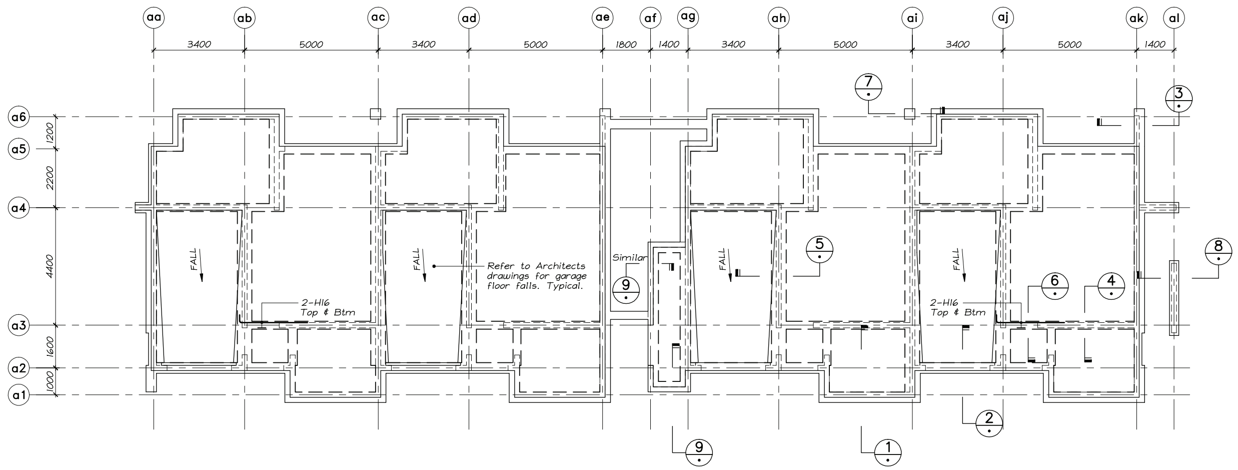
Geotechnical Desktop Study
**Project No:** 6-QUCCC.93
**Client:** Christchurch City Council

# Site Walkover Plan

**Drawn:** Opus Geotechnical Engineer

**Date:** 14/05/2012

# Appendix C:
# Available Structural Drawings



## FOUNDATION PLAN - GROUP A

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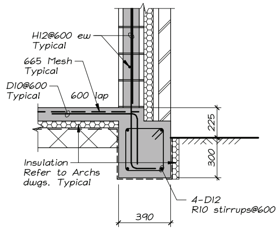

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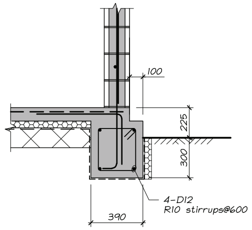

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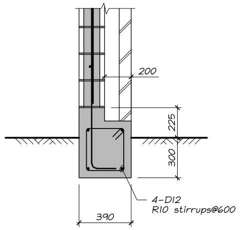

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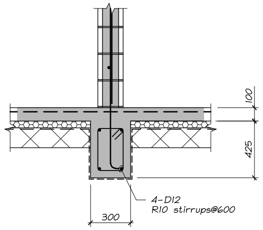

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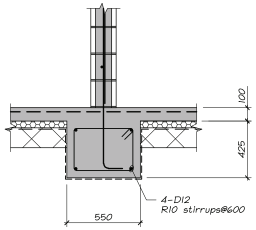

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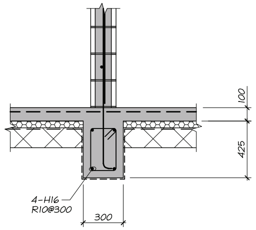

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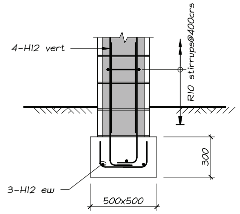

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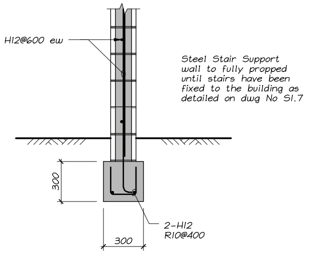
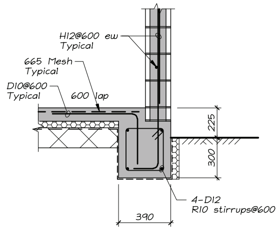


Steel Stair Support
wall to fully propped
until stairs have been
fixed to the building as
detailed on dwg No S1.7

8 1:20



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| ISSUE | DATE | AMENDMENT | CHECKED |
|---|---|---|---|
| A | 01.12.06 | Construction Issue | |
| 2 | 15.09.06 | Tender Issue | |
| 1 | 28.06.06 | Consent Issue | |

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# GOWERTON PLACE SOCIAL HOUSING

35 Warwick Street, Christchurch

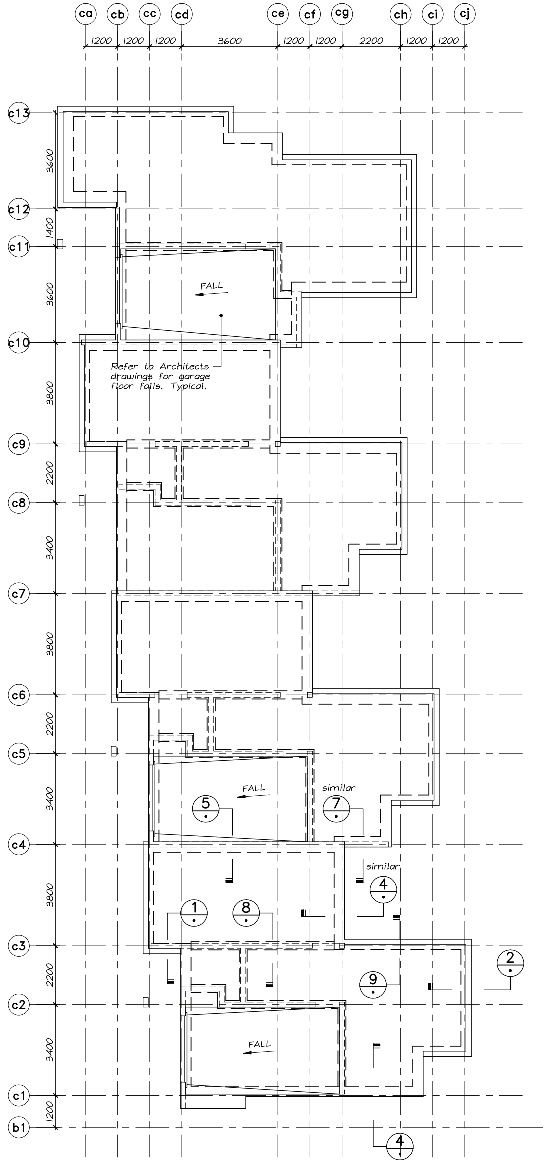
## FOUNDATION PLAN & DETAILS
## GROUP A

CONTRACTOR MUST VERIFY ALL DIMENSIONS ON SITE

| SCALES: | | | |
|---|---|---|---|
| 1:100 1:20 | DESIGNED | JK | 06/06 |
| | DRAWN | BLS | 06/06 |
| | CHECKED | | |

| SET | JOB NO. | SHEET NO. | ISSUE |
|---|---|---|---|
| | 051363 | S1.2<br>OF - SHEETS | A |

DATE PRINTED:



## FOUNDATION PLAN - GROUP C

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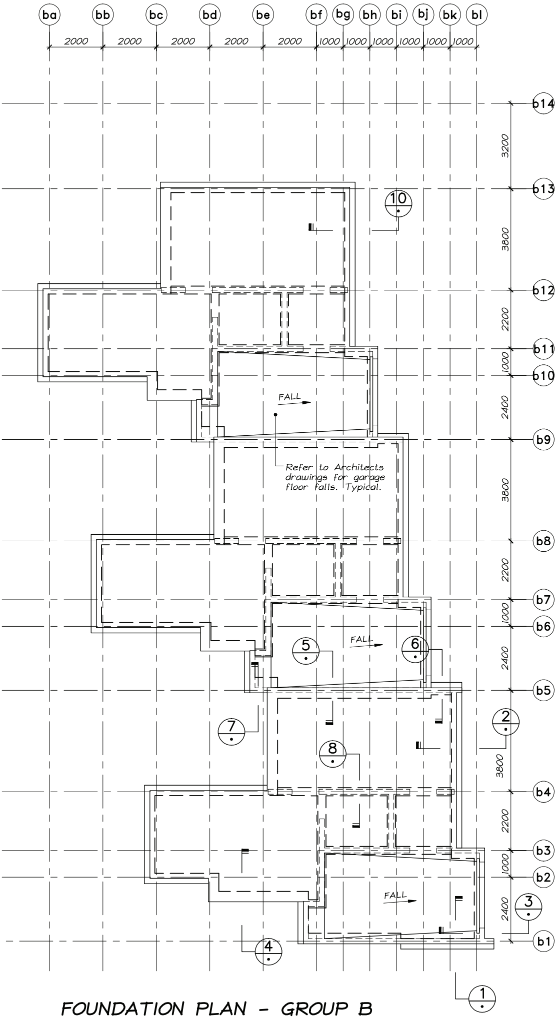

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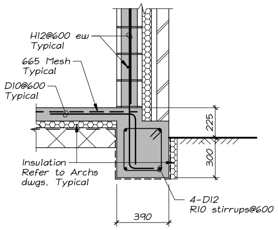

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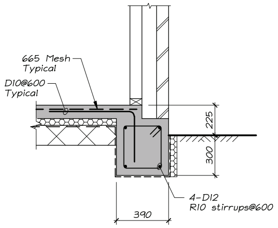

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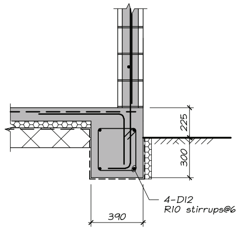

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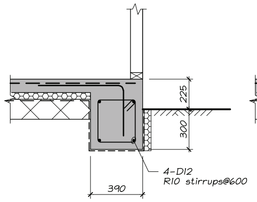

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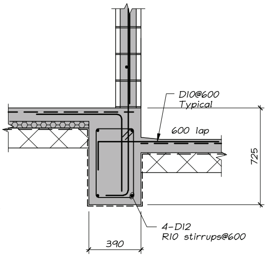

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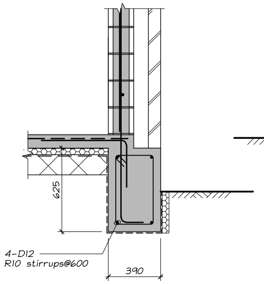

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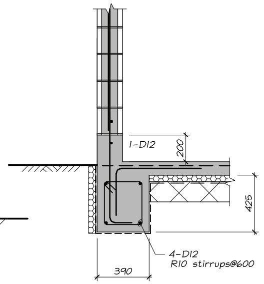

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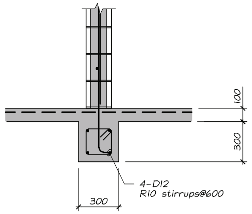

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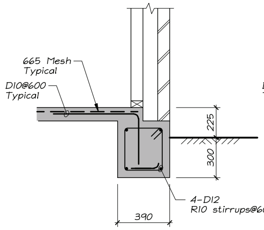
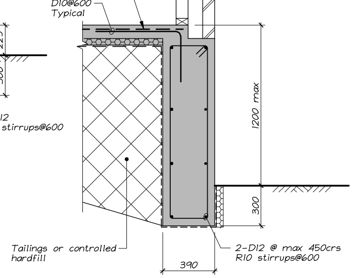


9 1:20

NOTE : The ground level falls away to a max of 1200mm below FFL in this corner of Unit B Step foundation as required to match perimeter ground level.



10 1:20

| ISSUE | DATE | AMENDMENT | CHECKED |
|---|---|---|---|
| A | 01.12.06 | Construction Issue | |
| 2 | 15.09.06 | Tender Issue | |
| 1 | 28.06.06 | Consent Issue | |

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# GOWERTON PLACE SOCIAL HOUSING

35 Warwick Street, Christchurch

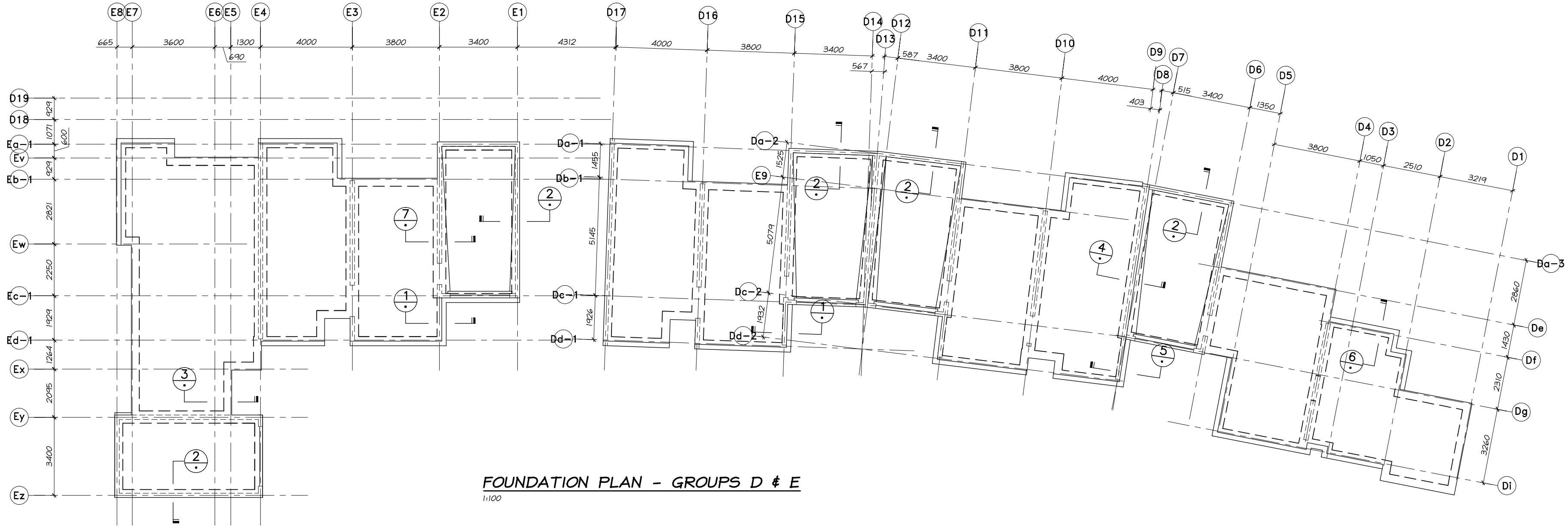
## FOUNDATION PLAN & DETAILS
## GROUP B & C

CONTRACTOR MUST VERIFY ALL DIMENSIONS ON SITE

| SCALES: | | |
|---|---|---|
| 1:20 | DESIGNED | JK | 06/06 |
| | DRAWN | BLS | 06/06 |
| | CHECKED | | |

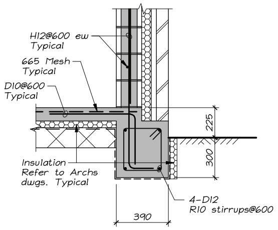
| SET | JOB NO. | SHEET NO. | ISSUE |
|---|---|---|---|
| | 051363 | S1.3<br>OF - SHEETS | A |

DATE PRINTED:

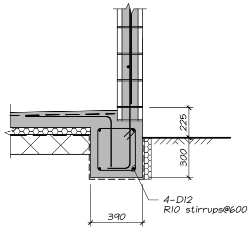


## FOUNDATION PLAN – GROUPS D & E

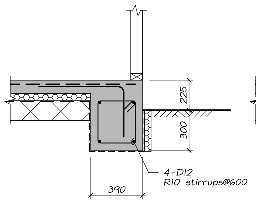
1:100



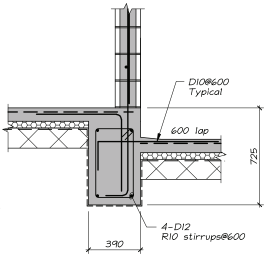
1 1:20



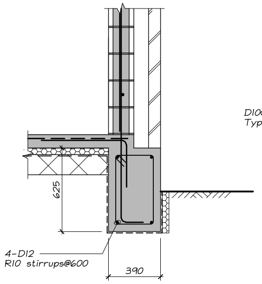
2 1:20



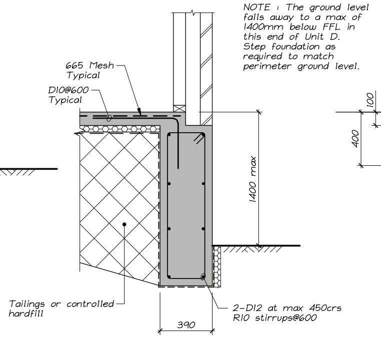
3 1:20



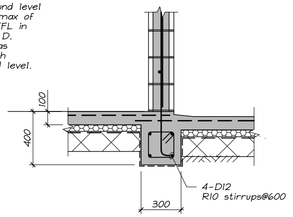
4 1:20



5 1:20


NOTE : The ground level falls away to a max of 1400mm below FFL in this end of Unit D. Step foundation as required to match perimeter ground level.

6 1:20



7 1:20

| ISSUE | DATE | AMENDMENT | CHECKED |
|---|---|---|---|
| A | 01.12.06 | Construction Issue | |
| 2 | 15.09.06 | Tender Issue | |
| 1 | 28.06.06 | Consent Issue | |

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# GOWERTON PLACE SOCIAL HOUSING
35 Warwick Street, Christchurch

FOUNDATION PLANS
GROUPS D&E

CONTRACTOR MUST VERIFY ALL DIMENSIONS ON SITE

| SCALES: | | | |
|---|---|---|---|
| 1:100, 1:20 | DESIGNED | JK | 06/06 |
| | DRAWN | BLS | 06/06 |
| | CHECKED | | |

| SET | JOB NO. | SHEET NO. | ISSUE |
|---|---|---|---|
| | 051363 | S1.4<br>OF – SHEETS | A |

DATE PRINTED:

# Appendix D:
# Earthquake Commissions Subsurface Investigations

# TONKIN & TAYLOR LTD

# BOREHOLE LOG

BOREHOLE No: RCH 09
Hole Location: On reserve opposite 33 Pavit St
SHEET 1 OF 4

PROJECT: CHRISTCHURCH 2011 EARTHQUAKE
LOCATION: RICHMOND
JOB No: 52000.3200

CO-ORDINATES 5742886.62 mN
2482155.38 mE
R.L. 4.46 m
DATUM NZMG

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

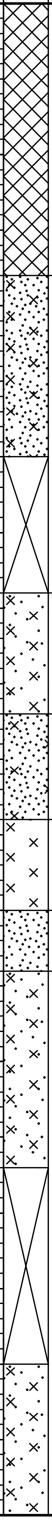
HOLE STARTED: 23/9/11
HOLE FINISHED: 24/9/11
DRILLED BY: DCN
LOGGED BY: TH
CHECKED: BMcD

GEOLOGICAL / ENGINEERING DESCRIPTION

| GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | 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. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HAND DIG FILL. (Pothole for services check and backfilled.) | | | 0 | PRE-DUG | | | | | | | FILL: Borehole drilled through pre-dug and backfilled pothole. |
| YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL) | | | 100 | SONIC VIBR. | | | | SP | M | MD | Silty, fine SAND with trace rootlets, grey mottled orange brown. Medium dense, moist. |
| | | | | SPT | | 2/4/6<br>N=10 | | | | | 1.5 to 1.95m no recovery |
| | | | 100 | SONIC VIBRATION | | | | ML | M | St | SILT with trace sand, brownish grey mottled dark brown. Stiff, wet, low plasticity. Sand is fine. |
| | | | | | | | | SW | W | L | Fine to medium SAND with some silt, grey. Loose, wet.<br>- becoming silty, fine sand<br>- contains trace silt. Sand becoming fine to medium. |
| | | | | | | | | ML | W | F | SILT, grey. Firm, wet, low plasticity. |
| | | | | SPT | | 1/1/2<br>N=3 | | SW | W | VL | Fine to medium SAND, dark grey. Very loose, wet. |
| | | | | | | | | ML | W | S | SILT with some sand, grey. Soft, wet, low plasticity. Sand is fine. |
| | | | 86 | SONIC VIBRATION | | ✱FC | B | | | | 4.85 to 4.5m no recovery |
| | | | | | | | | | | St | - becoming stiff |
| | | | | SPT | | 3/6/5<br>N=11 | | | | | |

| R.L. (m) | DEPTH (m) |
|---|---|
| 4.0 | 0.5 |
| 3.5 | 1.0 |
| 3.0 | 1.5 |
| 2.5 | 2.0 |
| 2.0 | 2.5 |
| 1.5 | 3.0 |
| 1.0 | 3.5 |
| 0.5 | 4.0 |
| 0.0 | 4.5 |
| -0.5 | 5 |

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: RCH 09
Hole Location: On reserve opposite 33 Pavit St
SHEET 2 OF 4

PROJECT: CHRISTCHURCH 2011 EARTHQUAKE
LOCATION: RICHMOND
JOB No: 52000.3200

CO-ORDINATES 5742886.62 mN
2482155.38 mE
R.L. 4.46 m
DATUM NZMG

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

HOLE STARTED: 23/9/11
HOLE FINISHED: 24/9/11
DRILLED BY: DCN
LOGGED BY: TH
CHECKED: BMcD

## GEOLOGICAL

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)

| CORE RECOVERY (%) | METHOD | TESTS | SAMPLES |
|---|---|---|---|
| 100 | SONIC VIBRATION | ✱FC | B |
|  | SPT | 6/12/20<br>N=22 |  |
| 100 | SONIC VIBRATION | ✱FC | B |
|  | SPT | 6/12/15<br>N=27 |  |
| 100 | SONIC VIBRATION |  |  |
|  | SPT | 5/6/7<br>N=13 |  |
| 100 | SONIC VIBR. |  |  |

| R.L. (m) | DEPTH (m) |
|---|---|
| -1.0 | 5.5 |
| -1.5 | 6.0 |
| -2.0 | 6.5 |
| -2.5 | 7.0 |
| -3.0 | 7.5 |
| -3.5 | 8.0 |
| -4.0 | 8.5 |
| -4.5 | 9.0 |
| -5.0 | 9.5 |
| -5.5 | 10 |

## ENGINEERING DESCRIPTION

| CLASSIFICATION SYMBOL | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SOIL DESCRIPTION |
|---|---|---|---|
| ML | W | St |  |
| SW | W | MD | Fine to medium SAND, dark grey. Medium dense, wet.<br>- thin lense of non-plastic silt<br>- sand becoming fine to coarse |
| ML | W | VSt | SILT with some sand, grey. Very stiff, wet, non plastic. Sand is fine. |
| SW | W | MD | Fine to medium SAND, dark grey. Medium dense, wet. |
| SW | W | MD | Gravelly, fine to medium SAND, dark grey. Medium dense, wet. Gravel is fine to coarse, rounded to subrounded. |

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.

PROJECT: CHRISTCHURCH 2011 EARTHQUAKE
LOCATION: RICHMOND
JOB No: 52000.3200

CO-ORDINATES 5742886.62 mN
2482155.38 mE
R.L. 4.46 m
DATUM NZMG

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

HOLE STARTED: 23/9/11
HOLE FINISHED: 24/9/11
DRILLED BY: DCN
LOGGED BY: TH
CHECKED: BMcD

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.

| DEPTH (m) | R.L. (m) | GEOLOGICAL UNIT | CORE RECOVERY (%) | METHOD | TESTS | SAMPLES | CLASSIFICATION SYMBOL | MOISTURE CONDITION | STRENGTH/DENSITY CLASSIFICATION | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|
| | | YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL) | | | ✱PSD WS | B | SW | W | MD | Gravelly, fine to medium SAND, dark grey. Medium dense, wet. Gravel is fine to coarse, rounded to subrounded. |
| 10.5 | -6.0 | | | SPT | 4/6/17<br>N=28 | | | | | |
| 11.0 | -6.5 | | 100 | SONIC VIBRATION | | | | | | |
| 11.5 | -7.0 | | | | | | | | | |
| 12.0 | -7.5 | | | SPT | 5/3/4<br>N=7 | | | | | 12.0 to 12.45m no recovery |
| 12.5 | -8.0 | CHRISTCHURCH FORMATION (MARINE & ESTUARINE) | 100 | SONIC VIBRATION | | | SW | W | L | Fine to coarse SAND, grey. Loose, wet. |
| 13.0 | -8.5 | | | | | | | | | |
| 13.5 | -9.0 | | | SPT | 4/4/10<br>N=14 | | ML | S | St | SILT with some gravel, sand and shells, grey. Stiff, saturated, low plasticity. Gravel is fine, subrounded. Sand is fine to coarse.<br>13.8 to 13.95m no recovery |
| 14.0 | -9.5 | | 100 | SONIC VIBRATION | | | SW | W | MD | Fine to coarse SAND with trace shells, dark grey. Medium dense, wet. |
| 14.5 | -10.0 | | | | | | | | | 14.5 to 14.65m contains some very closely spaced silt lenses |
| 15 | -10.5 | | | | | | | | | |

# TONKIN & TAYLOR LTD

# BOREHOLE LOG

BOREHOLE No: RCH 09
Hole Location: On reserve opposite 33 Pavit St
SHEET 4 OF 4

PROJECT: CHRISTCHURCH 2011 EARTHQUAKE
LOCATION: RICHMOND
JOB No: 52000.3200

CO-ORDINATES 5742886.62 mN
2482155.38 mE
R.L. 4.46 m
DATUM NZMG

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

HOLE STARTED: 23/9/11
HOLE FINISHED: 24/9/11
DRILLED BY: DCN
LOGGED BY: TH
CHECKED: BMcD

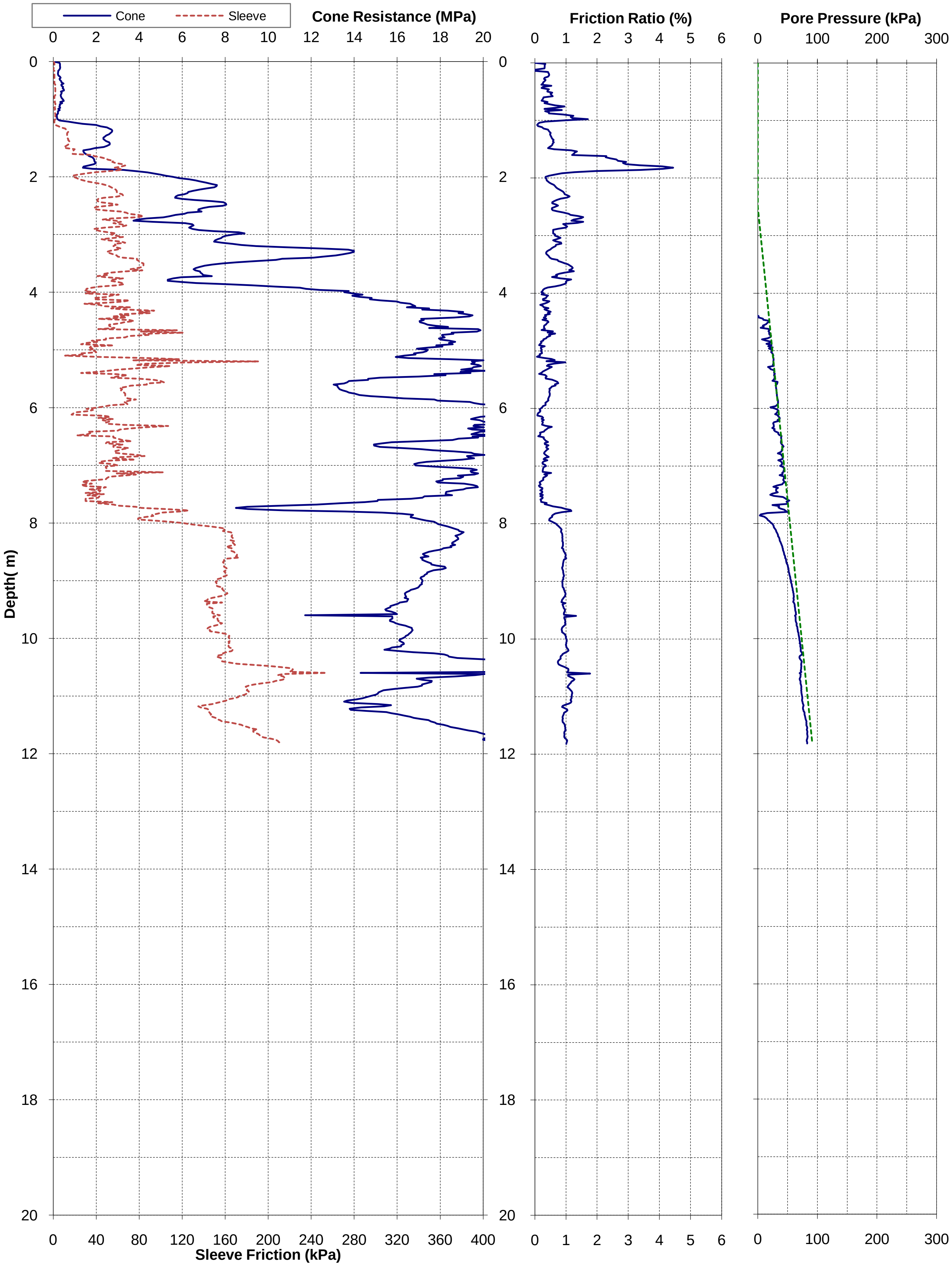
GEOLOGICAL: GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

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.

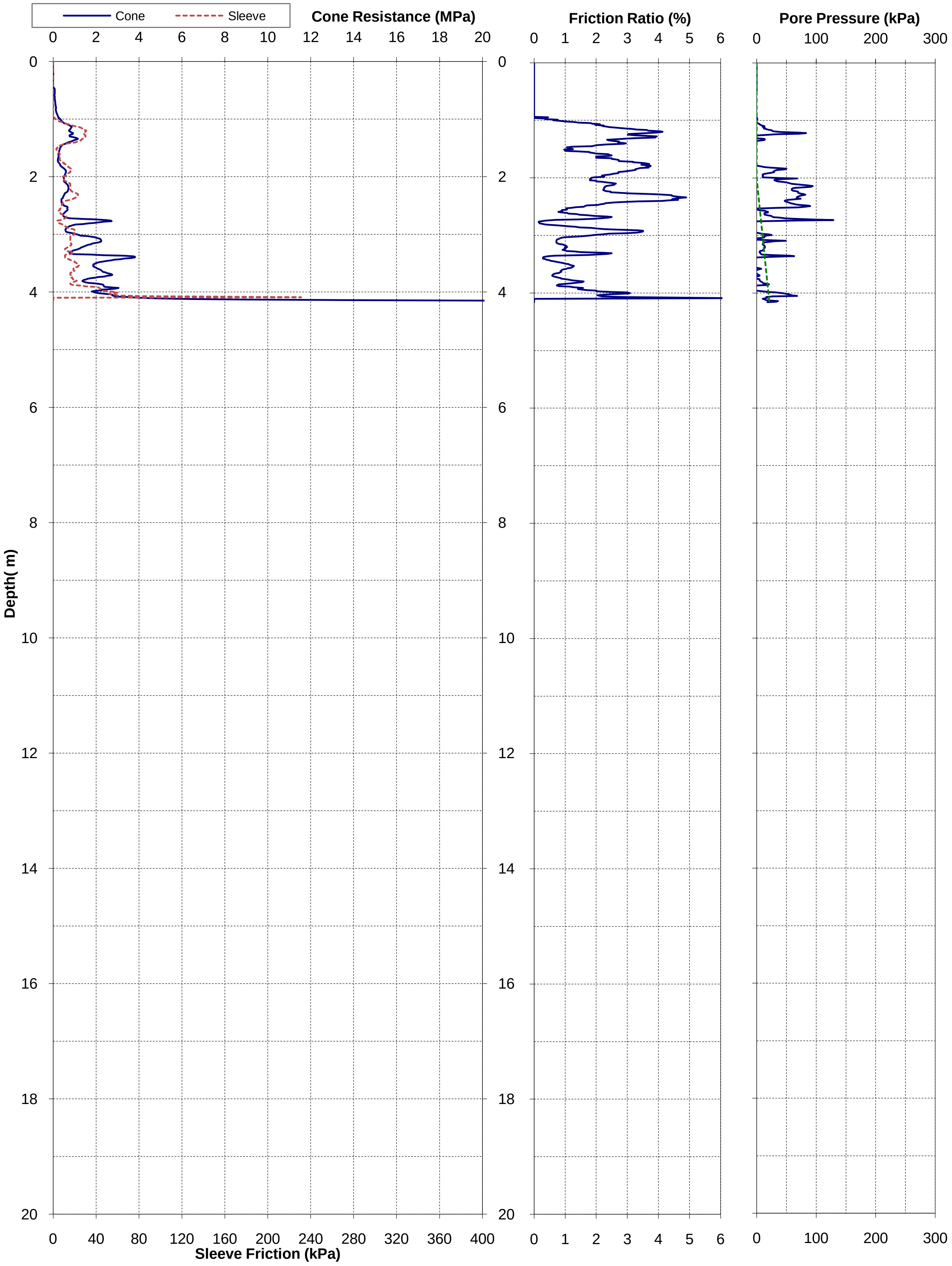
SHEAR STRENGTH (kPa): 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250
DEFECT SPACING (mm): 50 250 1000 2000

| DEPTH (m) | R.L. (m) | GEOLOGICAL UNIT | CORE RECOVERY (%) | METHOD | TESTS | SAMPLES | CLASSIFICATION SYMBOL | MOISTURE CONDITION | STRENGTH/DENSITY CLASSIFICATION | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|
| | | CHRISTCHURCH FORMATION (MARINE & ESTUARINE) | | SPT | 8/17/28<br>N=45 | | SW | W | D | 14.9 to 15.0m contains some very closely spaced silt laminae<br>- becoming dense |
| 15.5 | -11.0 | | 100 | SONIC VIBRATION | | | | | | - thin bed of shells and gravel. Gravel is fine, subrounded. |
| 16.0 | -11.5 | | | | | | | | | |
| 16.5 | -12.0 | | | SPT | 12/16/18<br>N=34 | | | | | |
| 17.0 | -12.5 | | 100 | SONIC VIBRATION | | | | | | |
| 17.5 | -13.0 | | | | | | | | | |
| 18.0 | -13.5 | | | SPT | 9/27/23<br>for 95mm<br>N>50 | | | | VD | - becoming very dense |
| 18.5 | -14.0 | | 87 | SONIC VIBRATION | | | | | | |
| 19.0 | -14.5 | | | | ✱FC | B | | | | 19.35 to 19.5m no recovery |
| 19.5 | -15.0 | | | SPT | 13/20/30/<br>for 135mm<br>N>50 | | | | | **End of borehole at 19.9mbgl.** Open standpipe piezometer installed. Please see attached diagram in Appendix C. |
| 20 | -15.5 | | | | | | | | | |

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

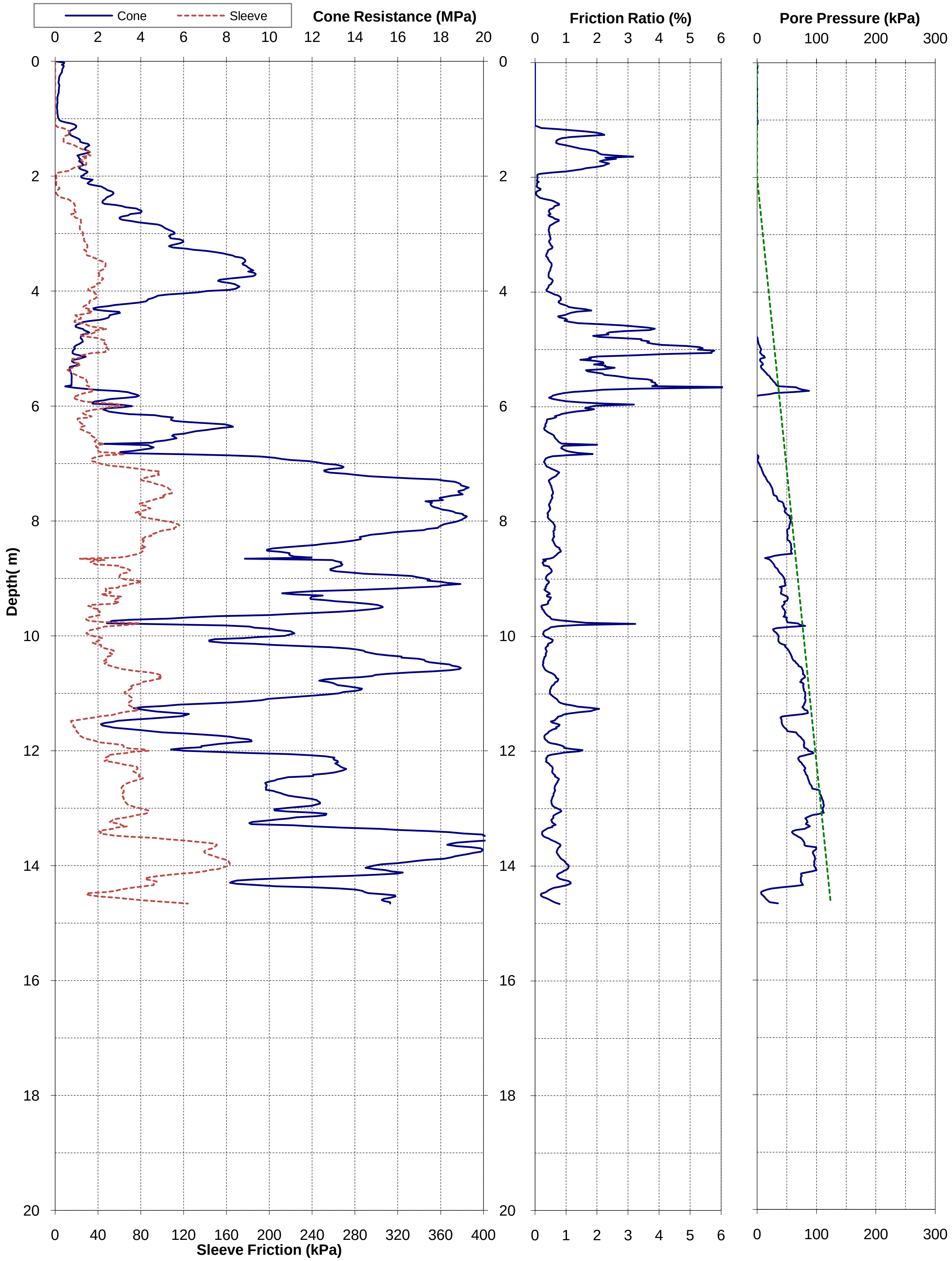


| | | | | | |
|---|---|---|---|---|---|
| **Project:** | Christchurch 2011 Earthquake - EQC Ground Investigations | | **Page:** 1 of 1 | | **CPT-RCH-38** |
| **Test Date:** | 31-May-2011 | **Location:** | Richmond | **Operator:** | Opus |
| **Pre-Drill:** | 1.2m | **Assumed GWL:** | 2mBGL | **Located By:** | Survey GPS |
| **Position:** | 2482415.4mE | 5742846.8mN | 3.24mRL | **Coord. System:** | NZMG & MSL |
| **Other Tests:** | Seismic downhole | | | **Comments:** | |



| | | | | | |
|---|---|---|---|---|---|
| **Project:** | Christchurch 2011 Earthquake - EQC Ground Investigations | | | **Page:** | 1 of 1 |
| **Test Date:** | 31-May-2011 | **Location:** | Richmond | **Operator:** | Geotech |
| **Pre-Drill:** | 1.2m | **Assumed GWL:** | 2mBGL | **Located By:** | Survey GPS |
| **Position:** | 2482150.1mE | 5743002.7mN | 4.44mRL | **Coord. System:** | NZMG & MSL |
| **Other Tests:** | | | | **Comments:** | |

## CPT-RCH-50



# Appendix E:
# Environment Canterbury Borehole Logs

**Unknown No:** M35/16568
**Well Name:** CCC BorelogID 6129
**Owner:** CCC borelog

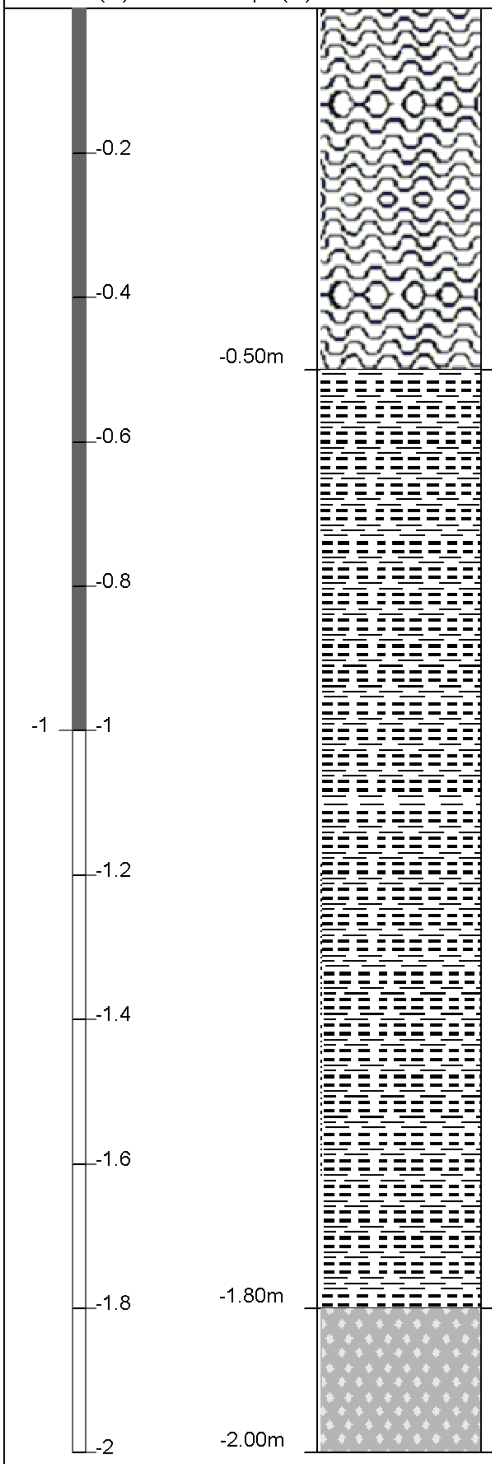
**Street of Well:** Warwick Street
**File No:**
**Locality:** Richmond
**Allocation Zone:** Christchurch/West Melton
**NZGM Grid Reference:** M35:82292-42865 QAR 3
**NZGM X-Y:** 2482292 - 5742865
**Location Description:**
**Uses:** Foundation/Investigation Bore
**ECan Monitoring:**
**Well Status:** Filled in

**Drill Date:** 17 Jul 2006
**Water Level Count:** 0
**Well Depth:** 2.00m -GL
**Strata Layers:** 3
**Initial Water Depth:** -1.20m -MP
**Aquifer Tests:** 0
**Diameter:**
**Isotope Data:** 0
**Yield/Drawdown Tests:** 0

**Measuring Point Alt:** 7.43m MSD QAR 4
**Highest GW Level:**
**GL Around Well:** 0.00m -MP
**Lowest GW Level:**
**MP Description:**
**First Reading:**
**Last Reading:**
**Driller:**
**Calc. Min. GWL:**
**Drilling Method:**
**Last Updated:** 05 Dec 2008
**Casing Material:**
**Last Field Check:**
**Pump Type:** None Installed
**Yield:**
**Screens:**
**Drawdown:**
**Screen Type:**
**Specific Capacity:**
**Top GL:**
**Bottom GL:**
**Aquifer Type:** Water Table
**Aquifer Name:** Christchurch Formation

# Borelog for well M35/16568

Gridref: M35:82292-42865  Accuracy : 3  (1=high, 5=low)
Ground Level Altitude : 7.43 +MSD
Well name  : CCC BorelogID 6129
Drill Method : Not Recorded
Drill Depth  : -2m  Drill Date : 17/07/2006



| Water Level | Depth(m) | Full Drillers Description | Formation Code |
|---|---|---|---|
|  | -0.50m | topsoil |  |
|  | -1.80m | grey / brown silty clay |  |
|  | -2.00m | grey sand |  |

**Unknown No:** M35/16805

**Well Name:** CCC BorelogID 6486

**Owner:** CCC borelog

Environment Canterbury
Your regional council

**Street of Well:** Stanmore Road

**File No:**

**Locality:** Richmond

**Allocation Zone:** Christchurch/West Melton

**NZGM Grid Reference:** M35:82276-43042 QAR 3

**NZGM X-Y:** 2482276 - 5743042

**Location Description:**

**Uses:** Foundation/Investigation Bore

**ECan Monitoring:**

**Well Status:** Filled in

**Drill Date:** 15 Nov 2006

**Water Level Count:** 0

**Well Depth:** 3.10m -GL

**Strata Layers:** 7

**Initial Water Depth:** -2.50m -MP

**Aquifer Tests:** 0

**Diameter:**

**Isotope Data:** 0

**Yield/Drawdown Tests:** 0

**Measuring Point Ait:** 7.47m MSD QAR 4

**Highest GW Level:**

**GL Around Well:** 0.00m -MP

**Lowest GW Level:**

**MP Description:**

**First Reading:**

**Last Reading:**

**Driller:**

**Calc. Min. GWL:**

**Drilling Method:**

**Last Updated:** 01 Sep 2009

**Casing Material:**

**Last Field Check:**

**Pump Type:**

**Yield:**

**Screens:**

**Drawdown:**

**Screen Type:**

**Specific Capacity:**

**Top GL:**

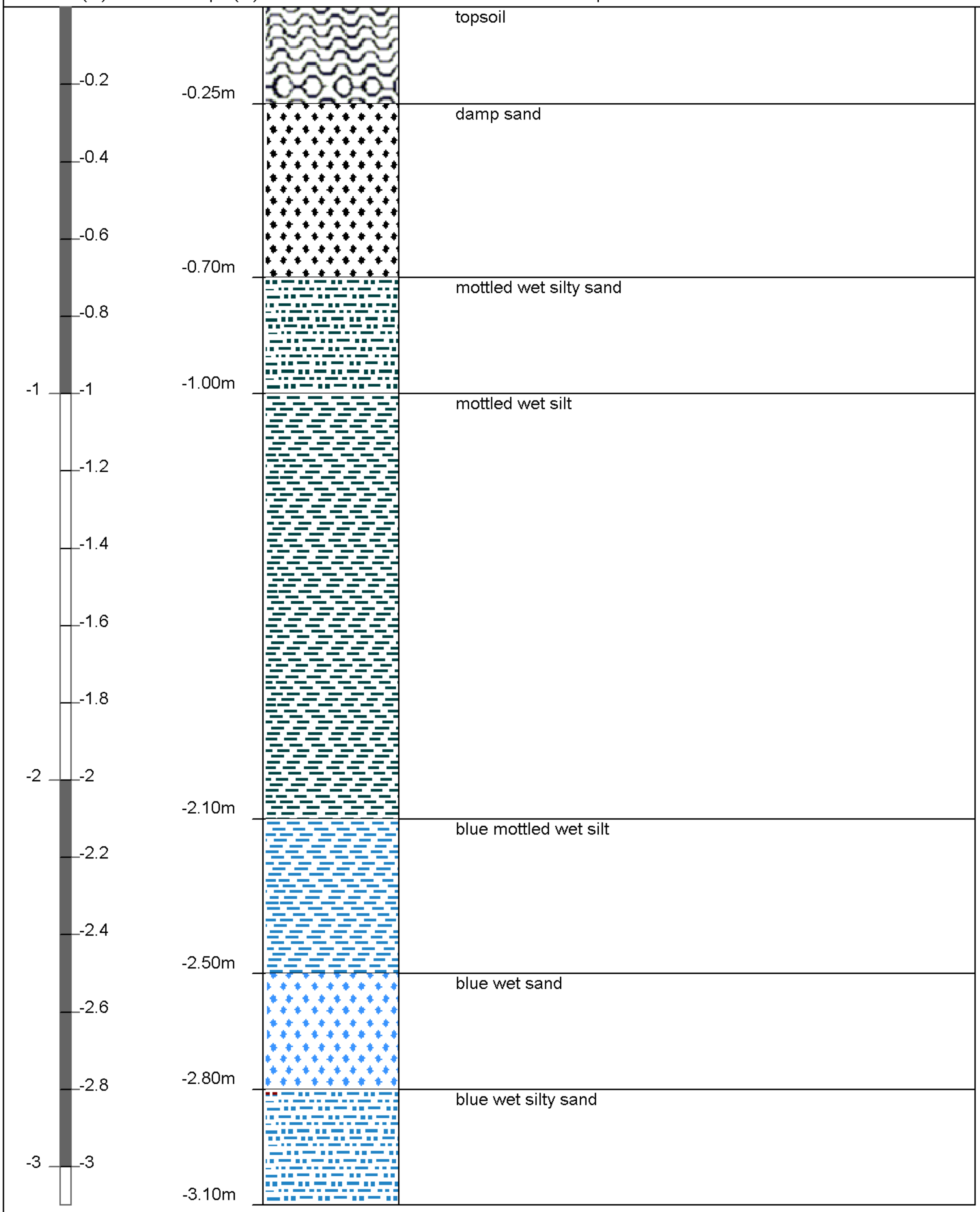
**Bottom GL:**

**Aquifer Type:** Water Table

**Aquifer Name:** Christchurch Formation

# Borelog for well M35/16805

Gridref: M35:82276-43042 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.47 +MSD
Well name : CCC BorelogID 6486
Drill Method : Not Recorded
Drill Depth : -3.1m Drill Date : 15/11/2006



| Depth(m) | Full Drillers Description | Formation Code |
|---|---|---|
| -0.25m | topsoil | |
| -0.70m | damp sand | |
| -1.00m | mottled wet silty sand | |
| -2.10m | mottled wet silt | |
| -2.50m | blue mottled wet silt | |
| -2.80m | blue wet sand | |
| -3.10m | blue wet silty sand | |

**Unknown No:** M35/16806
**Well Name:** CCC BorelogID 6487
**Owner:** CCC borelog

**Street of Well:** Stanmore Road
**Locality:** Richmond
**NZGM Grid Reference:** M35:82262-43060 QAR 3
**NZGM X-Y:** 2482262 - 5743060
**Location Description:**
**ECan Monitoring:**
**Well Status:** Filled in

**File No:**
**Allocation Zone:** Christchurch/West Melton
**Uses:** Foundation/Investigation Bore

**Drill Date:** 15 Nov 2006
**Well Depth:** 3.15m -GL
**Initial Water Depth:** -1.70m -MP
**Diameter:**

**Measuring Point Ait:** 7.48m MSD QAR 4
**GL Around Well:** 0.00m -MP
**MP Description:**

**Driller:**
**Drilling Method:**
**Casing Material:**
**Pump Type:**
**Yield:**
**Drawdown:**
**Specific Capacity:**

**Aquifer Type:** Water Table
**Aquifer Name:** Christchurch Formation

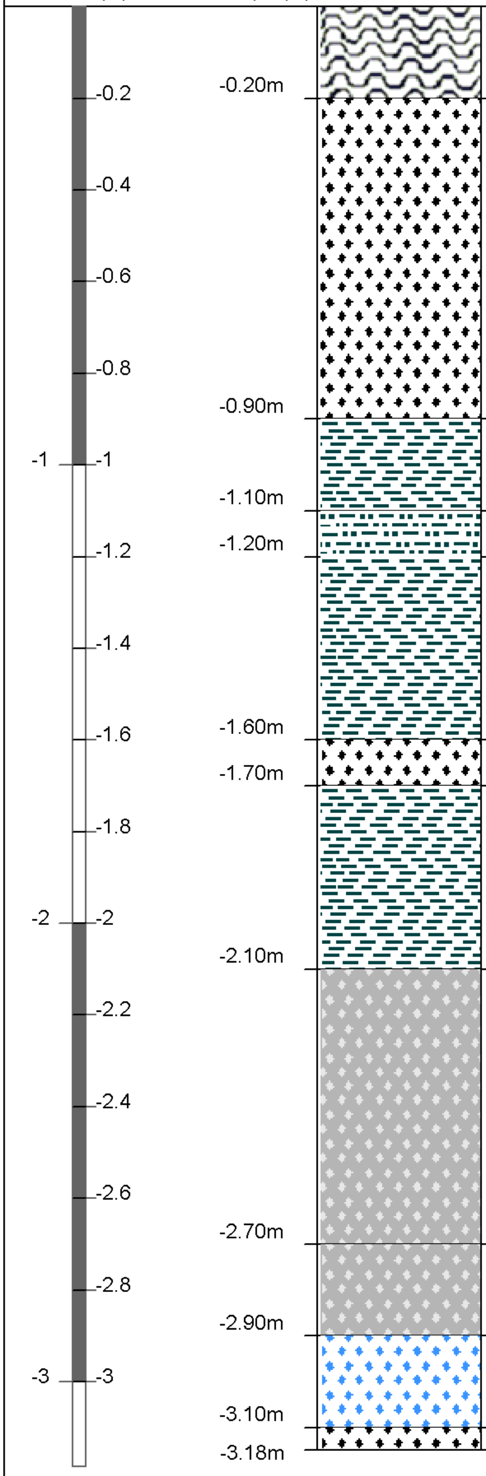
**Water Level Count:** 0
**Strata Layers:** 11
**Aquifer Tests:** 0
**Isotope Data:** 0
**Yield/Drawdown Tests:** 0

**Highest GW Level:**
**Lowest GW Level:**
**First Reading:**
**Last Reading:**
**Calc. Min. GWL:**
**Last Updated:** 01 Sep 2009
**Last Field Check:**

**Screens:**
**Screen Type:**
**Top GL:**
**Bottom GL:**

# Borelog for well M35/16806

Gridref: M35:82262-43060 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.48 +MSD
Well name : CCC BorelogID 6487
Drill Method : Not Recorded
Drill Depth : -3.15m Drill Date : 15/11/2006



| Depth(m) | Full Drillers Description | Formation Code |
|---|---|---|
| -0.20m | topsoil | |
| -0.90m | mottled damp sand | |
| -1.10m | mottled damp silt | |
| -1.20m | mottled wet sand and silt | |
| -1.60m | mottled damp silt | |
| -1.70m | mottled wet sand | |
| -2.10m | mottled wet silt | |
| -2.70m | grey wet sand | |
| -2.90m | dark grey wet sand | |
| -3.10m | blue wet sand | |
| -3.18m | running sand | |

**Bore or Well No:** M35/1893

**Well Name:**

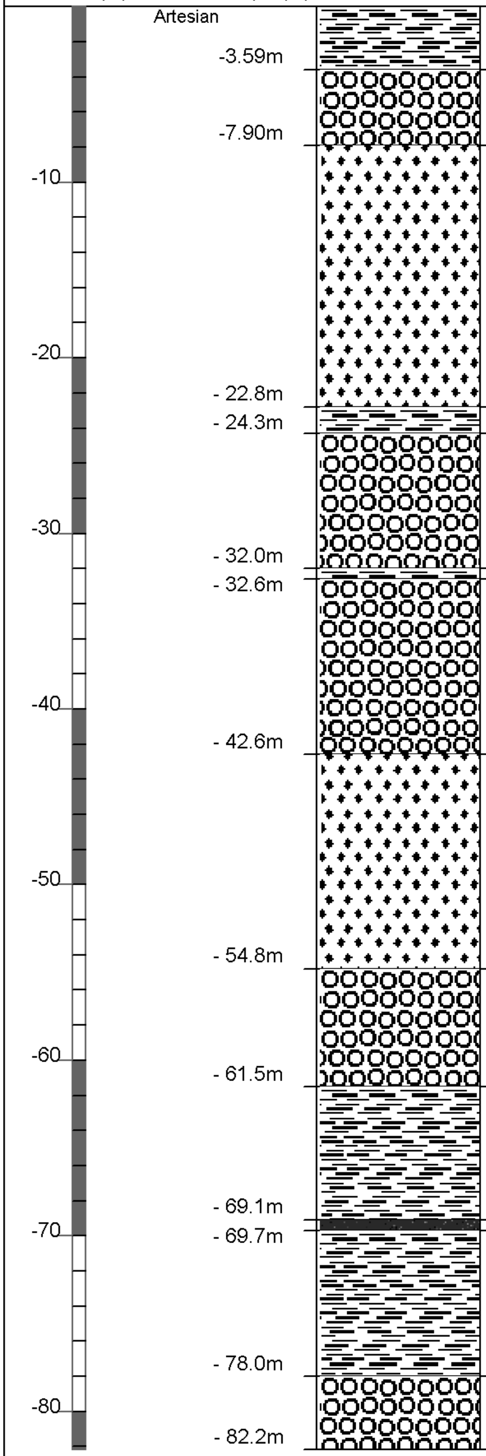
**Owner:** RICHMOND SCHOOL

|  |  |  |  |
|---|---|---|---|
| **Street of Well:** | STANMORE ROAD | **File No:** |  |
| **Locality:** | RICHMOND | **Allocation Zone:** | Christchurch/West Melton |
| **NZGM Grid Reference:** | M35:822-429 QAR 4 |  |  |
| **NZGM X-Y:** | 2482200 - 5742900 |  |  |
| **Location Description:** | OLD SCHOOL SITE,RECREATION RESERVE | **Uses:** |  |
| **ECan Monitoring:** |  |  |  |
| **Well Status:** | Not Used |  |  |

|  |  |  |  |
|---|---|---|---|
| **Drill Date:** | 30 Jan 1993 | **Water Level Count:** | 0 |
| **Well Depth:** | 82.20m -GL | **Strata Layers:** | 13 |
| **Initial Water Depth:** | 6.70m -MP | **Aquifer Tests:** | 0 |
| **Diameter:** | 76mm | **Isotope Data:** | 0 |
|  |  | **Yield/Drawdown Tests:** | 0 |
| **Measuring Point Ait:** | 4.60m MSD QAR 3 | **Highest GW Level:** |  |
| **GL Around Well:** | 0.00m -MP | **Lowest GW Level:** |  |
| **MP Description:** |  | **First Reading:** |  |
|  |  | **Last Reading:** |  |
| **Driller:** | Job Osborne (& Co/Ltd) | **Calc. Min. GWL:** | 3.10m -MP |
| **Drilling Method:** | Hydraulic/Percussion | **Last Updated:** | 21 Sep 2006 |
| **Casing Material:** |  | **Last Field Check:** |  |
| **Pump Type:** | Unknown |  |  |
| **Yield:** | 0 l/s | **Screens:** |  |
| **Drawdown:** | 0 m | **Screen Type:** |  |
| **Specific Capacity:** |  | **Top GL:** |  |
|  |  | **Bottom GL:** |  |
| **Aquifer Type:** | Flowing Artesian |  |  |
| **Aquifer Name:** | Linwood Gravel |  |  |

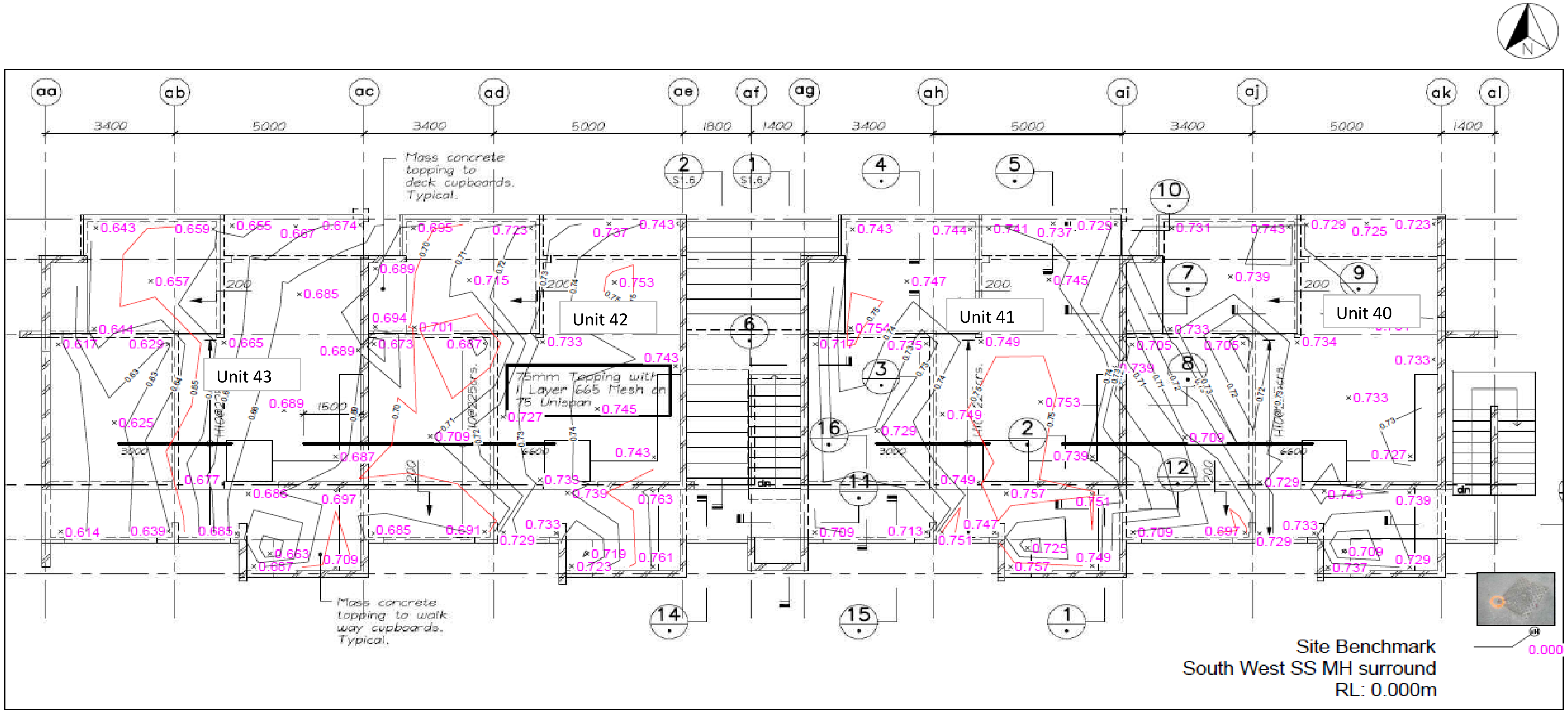
# Borelog for well M35/1893

Gridref: M35:822-429 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 4.6 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -82.19m Drill Date : 30/01/1993



| Water Level | Depth(m) | Full Drillers Description | Formation Code |
|---|---|---|---|
| Artesian | -3.59m | Clay | sp? |
| | -7.90m | Gravel | sp? |
| | - 22.8m | Sand | ch |
| | - 24.3m | Clay | ch |
| | - 32.0m | Gravel | ri |
| | - 32.6m | Clay | ri |
| | - 42.6m | Gravel | ri |
| | - 54.8m | Sand | br |
| | - 61.5m | Gravel | li-1 |
| | - 69.1m | Clay | li-2 |
| | - 69.7m | Peat | li-2 |
| | - 78.0m | Clay | li-2 |
| | - 82.2m | Gravel, water level +6.7m | li-3 |

# Appendix F:
# Level Survey



Site Benchmark
South West SS MH surround
RL: 0.000m

## Ground Floor Block A

Vertical Datum: Assumed
Site Benchmark: South West Corner MH Surround (Gowerton Place)
RL: 0.000m

OPUS
Christchurch Office
P O Box 1482
Christchurch 8143, New Zealand
+64 3 363 5400

Project: Whakahoa Village
Ground Floor Level Survey

| Drawn | Designed | Approved | Revision Date |
|---|---|---|---|
| J. Monroe | | S. Becker | |

| Project No. | Scale | Drawing No. | Sheet No. | Revision |
|---|---|---|---|---|
| 6OUCCC.93/05SC | Not to Scale | 6/1366/252/2604/R0 | 1/2 | R0 |

# Appendix G:
# Site Investigation Location Plan

★ Cone Penetrometer Test

● Hand Auger/Scala

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:** Whakahoa Village
Geotechnical Desktop Study
**Project No:** 6-QUCCC.93
**Client:** Christchurch City Council

# Site Investigation Plan

**Drawn:** Opus Geotechnical Engineer

**Date:** 14/05/2012

# Appendix 3 – CERA DEE Data Sheet

## Detailed Engineering Evaluation Summary Data

V1.11

### Location

Building Name: Whakahoa Village Block E
Reviewer: Michael Gibbs

Unit No: Street
CPEng No: 232386

Building Address: Block B | Gowerton Place, Richmond
Company: Opus International Consultants

Legal Description:
Company project number: 6-QUCCC.93
Company phone number: 03 363 5400

| | Degrees | Min | Sec |
|---|---|---|---|
| GPS south: | 43 | 31 | 10.90 |
| GPS east: | 172 | 39 | 26.30 |

Date of submission: 10/09/2012
Inspection Date: 20/03/2012
Revision: Final

Building Unique Identifier (CCC): BU 2680-005 EQ2
Is there a full report with this summary? yes

### Site

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

### Building

No. of storeys above ground: 1 single storey = 1
Ground floor elevation (Absolute) (m): 14.20
Ground floor split? no
Ground floor elevation above ground (m): 0.00
Storeys below ground 0
Foundation type: strip footings
if Foundation type is other, describe:
Building height (m): 2.45
height from ground to level of uppermost seismic mass (for IEP only) (m):
Floor footprint area (approx):
Age of Building (years): 5
Date of design: 2004-

Strengthening present? no
If so, when (year)?
And what load level (%g)?
Use (ground floor): multi-unit residential
Brief strengthening description:
Use (upper floors):
Use notes (if required):
Importance level (to NZS1170.5): IL2

Gravity Structure

Gravity System: load bearing walls
Roof: timber framed
rafter type, purlin type and cladding: 140x45 H3.1 Rafters @ 1200 centres, 70x45 Purlins @ 1000 centres
Floors:
Beams: timber
type
Columns:
Walls: fully filled concrete masonry
#N/A

Lateral load resisting structure

Lateral system along: fully filled CMU
**Note: Define along and across in detailed report!**
Ductility assumed, μ: 1.25
note total length of wall at ground (m):
Period along: 0.25 ##### enter height above at H31
estimate or calculation? estimated
Total deflection (ULS) (mm): 1
estimate or calculation? estimated
maximum interstorey deflection (ULS) (mm):
estimate or calculation? estimated

Lateral system across: lightweight timber framed walls
Ductility assumed, μ: 3.00
note typical wall length (m)
Period across: 0.25 0.00
estimate or calculation? estimated
Total deflection (ULS) (mm): 1
estimate or calculation? estimated
maximum interstorey deflection (ULS) (mm):
estimate or calculation? estimated

Separations:

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

Non-structural elements

Stairs:
Wall cladding: brick or tile
describe (note cavity if exists) 10 Series block veneer
Roof Cladding: Metal
describe Profiled metal roofing
Glazing: aluminium frames
Ceilings: plaster, fixed
Services(list):

### Available documentation

Architectural full
original designer name/date City Solutions, 24/11/2006
Structural full
original designer name/date Powell Fenwick Consultants Ltd, 01/12/2006
Mechanical none
original designer name/date
Electrical none
original designer name/date
Geotech report none
original designer name/date

### Damage

Site:
(refer DEE Table 4-2)
Site performance:
Describe damage:

Settlement:
notes (if applicable):
Differential settlement:
notes (if applicable):
Liquefaction:
notes (if applicable):
Lateral Spread:
notes (if applicable):
Differential lateral spread:
notes (if applicable):
Ground cracks:
notes (if applicable):
Damage to area:
notes (if applicable):

Building:

Current Placard Status: green

Along Damage ratio: 0%
Describe how damage ratio arrived at:
Describe (summary):

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?: no
Describe:

### Recommendations

Level of repair/strengthening required: minor non-structural
Describe: wall & ceiling lining repairs
Building Consent required: no
Describe:
Interim occupancy recommendations: full occupancy
Describe:

Along Assessed %NBS before e'quakes: 100% ##### %NBS from IEP below
If IEP not used, please detail assessment methodology: quantitative
Assessed %NBS after e'quakes: 100%

Across Assessed %NBS before e'quakes: 100% ##### %NBS from IEP below
Assessed %NBS after e'quakes: 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): 2004-
$h_n$ from above: m

Seismic Zone, if designed between 1965 and 1992:
Design Soil type from NZS1170.5:2004, cl 3.1.3:
not required for this age of building

| | along | across |
|---|---|---|
| Period (from above): | 0.249 | 0.249 |
| (%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**

| | along | across |
|---|---|---|
| Near Fault scaling factor, from NZS1170.5, cl 3.1.6: | | 1.00 |
| 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)$_{nom}$ x A x B x C x D x 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

| **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 |

| | | |
|---|---|---|
| **3.5. Site Characteristics** | | 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!** |

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