SINCLAIR KNIGHT MERZ
SKM

CHRISTCHURCH CITY COUNCIL
PRK_0895_BLDG_008 EQ2
Ruru Lawn Cemetery – Tool Shed & Lean-To
Raymond Road, Bromley

QUALITATIVE ASSESSMENT REPORT

FINAL

- Rev C
- 13 February 2013

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1. Executive Summary

1.1. Background

A Qualitative Assessment was carried out on building PRK_0895_BLDG_008 EQ2 located at Ruru Lawn Cemetery, Bromley. This building consists of tool shed which is constructed from unreinforced masonry walls and a timber framed roof. There is timber framed lean-to located on the southern side of the tool shed. An aerial photograph illustrating the location of this building is shown below in Figure 1. Detailed descriptions outlining the buildings age and construction type is given in Section 5 of this report.

- **Figure 1 Aerial Photograph of Building PRK_0895_BLDG_008 EQ2 Located at Ruru Lawn Cemetery**

The qualitative assessment broadly includes a summary of the building damage as well as an initial assessment of the current Seismic Capacity compared with current seismic code loads using the Initial Evaluation Procedure (IEP).

This Qualitative report for the building structure is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 and our visual inspections carried out on the 3 April 2012

1.2. Key Damage Observed

Key damage observed includes:-

- Major cracking and movement to the unreinforced masonry walls.

1.3. Critical Structural Weaknesses

The following potential critical structural weakness has been identified.

- Since the unreinforced masonry walls are part of the gravity resisting system and are unable to behave in a ductile manner they present a critical structural weakness to this building.

1.4. Indicative Building Strength (from IEP and CSW assessment)

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the original seismic capacity of the building has been assessed to be in the order of 18%NBS. Major structural damage to the masonry walls was observed during our site investigation. Due to this the post earthquake capacity will be less than 10%NBS. Note that temporary propping to the walls had been installed along the northern face to help support the building.

As noted above our analysis indicates that the current seismic capacity of the building will be less than 10% NBS and therefore is a potentially earthquake prone buildings. Due to the structural damage present and the size of the building it is not cost effective to carry out a quantitative assessment or strengthen the structure to current code requirements. We recommend that this structure is demolished and replaced with either a timber framed or reinforced concrete block building that meets current code requirements.

Please note that structural strengthening is required by law for buildings that are confirmed to have a seismic capacity of less than 34% NBS.

1.5. Recommendations

It is recommended that:

a) The current placard status of the building remain as Red 2.

b) Due to the presence of the temporary propping installed along the north wall we consider that barriers around the building are not necessary.

2. Introduction

Sinclair Knight Merz was engaged by the Christchurch City Council to prepare a qualitative assessment report for the building PRK_0895_BLDG_008 EQ2 located at Ruru Lawn Cemetery, Bromley following the magnitude 6.3 earthquake which occurred in the afternoon of the 22nd of February 2011 and the subsequent aftershocks.

The qualitative assessment uses the methodology recommended in the Engineering Advisory Group document "Guidance on Detailed Engineering Evaluation of Earthquake affected Non-residential Buildings in Canterbury". The qualitative assessment broadly includes a summary of the building damage as well as an initial assessment of the current Likely Seismic Capacity compared with current seismic requirements.

A qualitative assessment involves inspections of the building and a desktop review of existing structural and geotechnical information, including existing drawings and calculations, if available.

The purpose of the assessment is to determine the likely building performance and damage patterns, to identify any potential critical structural weaknesses or collapse hazards, and to make an initial assessment of the likely building strength in terms of percentage of new building standard (%NBS).

This report describes the structural damage observed during our inspection and indicates suggested remediation measures. The inspection was undertaken from floor levels and was a visual inspection only. Our report reflects the situation at the time of the inspection and does not take account of changes caused by any events following our inspection. A full description of the basis on which we have undertaken our visual inspection is set out in Section 7

The NZ Society for Earthquake Engineering (NZSEE) Initial Evaluation Procedure (IEP) was used to assess the likely performance of the building in a seismic event relative to the New Building Standard (NBS). 100% NBS is equivalent to the strength of a building that fully complies with current codes. This includes a recent increase of the Christchurch seismic hazard factor from 0.22 to 0.3[1].

At the time of this report, no detailed analysis, or modelling of the building structure had been carried out. No structural drawings were available for this structure therefore the building description outlined in Section 5 is based on our visual inspection only which was carried out on the 3 April 2012.

[1] http://www.dbh.govt.nz/seismicity-info

3. 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.

3.1. 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 carry out a full structural survey before the building is re-occupied.

We understand that CERA will 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). It is anticipated that CERA will adopt the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

The qualitative assessment is a desk-top and site inspection assessment. It is based on a thorough visual inspection of the building coupled with a review of available documentation such as drawings and specifications. The quantitative assessment involves analytical calculation of the buildings strength and may require non-destructive or destructive material testing, geotechnical testing and intrusive investigation.

It is anticipated that factors determining the extent of evaluation and strengthening level required will include:

- The importance level and occupancy of the building
- The placard status and amount of damage
- The age and structural type of the building
- Consideration of any critical structural weaknesses
- The extent of any earthquake damage

3.2. Building Act

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

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

3.2.2. Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) be satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'. Regarding seismic capacity 'as near as reasonably practicable' has previously been interpreted by CCC as achieving a minimum of 67%NBS however where practical achieving 100%NBS is desirable. The New Zealand Society for Earthquake Engineering (NZSEE) recommend a minimum of 67%NBS.

3.2.3. Section 121 – Dangerous Buildings

The definition of dangerous building in the Act was extended by the Canterbury Earthquake (Building Act) Order 2010, and it now defines a building as dangerous if:

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

3.2.4. Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone 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 ground shaking 33% of the shaking used to design an equivalent new building.

3.2.5. 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.

3.2.6. Section 131 – Earthquake Prone Building Policy

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

3.3. 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 of the 4th September 2010.

The 2010 amendment includes the following:

- A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- A strengthening target level of 67% of a new building for buildings that are Earthquake Prone. Council recognises that it may not be practicable for some repairs to meet that target. The council will work closely with building owners to achieve sensible, safe outcomes;
- A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- Repair works for buildings damaged by earthquakes will be required to comply with the above.

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

We anticipate that any building with a capacity of less than 34%NBS (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67%NBS of new building standard as recommended by the Policy.

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.

3.4. 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.

After the February Earthquake, on 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

a) Hazard Factor increased from 0.22 to 0.3 (36% increase in the basic seismic design load)
b) Serviceability Return Period Factor increased from 0.25 to 0.33 (80% increase in the serviceability design loads when combined with the Hazard Factor increase)

The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

4. 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 new building standard load requirements have been determined in accordance with the current earthquake loading standard (NZS 1170.5:2004 Structural design actions - Earthquake actions - New Zealand).

The likely capacity of this building has been derived in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' (AISPBE), 2006. These guidelines provide an Initial Evaluation Procedure that assesses a buildings capacity based on a comparison of loading codes from when the building was designed and currently. It is a quick high-level procedure that can be used when undertaking a Qualitative analysis of a building. The guidelines also provide guidance on calculating a modified Ultimate Limit State capacity of the building which is much more accurate and can be used when undertaking a Quantitative analysis.

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 2 below.

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

- **Figure 2: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines**

Table 1 below provides an indication of the risk of failure for an existing building with a given percentage NBS, relative to the risk of failure for a new building that has been designed to meet current Building Code criteria (the annual probability of exceedance specified by current earthquake design standards for a building of 'normal' importance is 1/500, or 0.2% in the next year, which is equivalent to 10% probability of exceedance in the next 50 years).

- **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

5. Building Details

5.1. Building description

Building PRK_0895_BLDG_008 EQ2 is a single storey building that is used as storage shed for the Ruru Lawn Cemetery. The building is constructed from unreinforced masonry walls and a timber framed roof. The cladding to roof is corrugated steel. There is a timber framed lean-to structure located on the south side of the main building. This is clad with corrugated steel to both the walls and the roof. The building is believed to be supported on concrete strip footings and a concrete slab on grade. Due to the architecture of this building we believe that it was constructed sometime in the 1960's.

5.2. Gravity Load Resisting System

Our evaluation was based on our visual investigation carried out on the 3 April 2012.

The roof structure consists of timber purlins which are supported on timber roof trusses. These trusses are supported on the unreinforced masonry walls.

5.3. Seismic Load Resisting System

Lateral loads acting across and along this building will be resisted by the masonry walls via shear.

Note that for this building the 'across direction' has been taken as north-south whereas the 'along direction' has been taken as east-west.

5.4. Geotechnical Conditions

A geotechnical desktop study was carried out for this site. The main conclusions from this report are:

- Liquefaction risk is low to moderate for this site, with localised liquefaction on site or the liquefaction of the roads more likely to occur.

Unless a change of use is intended for the site we do not believe that any further geotechnical investigations are required. Specific ground investigation should be undertaken if significant alterations or new structures are proposed. Our Desktop study is detailed in Appendix 4.

6. Damage Summary and Remediation

SKM undertook inspections on the 3 April 2012. The following areas of damage were observed during the time of inspection:

6.1. Damage Summary

External Damage

1) North Elevation:
    - Severe step cracking present along mortar joints. Bricks in NW corner have moved out of alignment. Temporary propping has been installed along the north wall to provide support to the damaged wall (PHOTO 4-8).
2) East Elevation:
    - Minor cracking to the mortar around the top brick in the south corner (PHOTO 9 & 10).
3) South Elevation:
    - Roof to the lean-to has been damaged mid-way along the south elevation. This damage appears to be existing and is not earthquake related (PHOTO 11).
    - Step cracking present along masonry mortar joints.
4) West Elevation:
    - Step cracking present along masonry mortar joints. Severe cracking present in the NW corner, bricks have moved out of alignment in this location (PHOTO 12 & 13).

Internal Damage

1) Due to the unstable condition of the building no internal inspection was carried out for safety reasons.

Photos of the above damage can be found in Appendix 1 – Photos.

7. Initial Seismic Evaluation

7.1. The Initial Evaluation Procedure Process

This section covers the initial seismic evaluation of the building as detailed in the NZSEE 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes'. The IEP grades buildings according to their likely performance in a seismic event. The procedure is not yet recognised by the NZ Building Code but is widely used and recognised by the Christchurch City Council as the preferred method for preliminary seismic investigations of buildings[2].

The IEP is a coarse screening process designed to identify buildings that are likely to be earthquake prone. The IEP process ranks buildings according to how well they are likely to perform relative to a new building designed to current earthquake standards, as shown in Table 2. The building grade is indicated by the percent of the required New Building Standard (%NBS) strength that the building is considered to have. Earthquake prone buildings are defined as having less than 33 %NBS strength which correlates to an increased risk of approximately 10 times that of 100% NBS (refer Table 1)[3]. Buildings in Christchurch City that are identified as being earthquake prone are required by law to be followed up with a detailed assessment and strengthening work within 30 years of the owner being notified that the building is potentially earthquake prone[4].

Table 2: IEP Risk classifications

Description	Grade	Risk	%NBS	Structural performance
Low risk building	A+	Low	> 100	Acceptable. Improvement may be desirable.
	A		100 to 80	
	B		80 to 67	
Moderate risk building	C	Moderate	67 to 33	Acceptable legally. Improvement recommended.
High risk building	D	High	33 to 20	Unacceptable. Improvement required.
	E		< 20	

The IEP is a simple desktop study that is useful for risk management. No detailed calculations are done and so it relies on an inspection of the building and its plans to identify the structural members and describe the likely performance of the building in a seismic event. A review of the

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[2] http://resources.ccc.govt.nz/files/EarthquakeProneDangerousAndInsanitaryBuildingsPolicy2010.pdf
[3] NZSEE 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*, p 2-2
[4] http://resources.ccc.govt.nz/files/EarthquakeProneDangerousAndInsanitaryBuildingsPolicy2010.pdf

plans is also likely to identify any critical structural weaknesses. The IEP assumes that the building was properly designed and built according to the relevant codes at the time of construction. The IEP method rates buildings based on the code used at the time of construction and some more subjective parameters associated with how the building is detailed and so it is possible that %NBS derived from different engineers may differ.

This assessment describes only the likely seismic Ultimate Limit State (ULS) performance of the building. The ULS is the level of earthquake that can be resisted by the building without catastrophic failure. The IEP does not attempt to estimate Serviceability Limit State (SLS) performance of the building, or the level of earthquake that would start to cause damage to the building[5]. This assessment concentrates on matters relating to life safety as damage to the building is a secondary consideration. SLS performance of the building can be estimated by scaling the current code levels if required.

The NZ Building Code describes that the relevant codes for NBS are primarily:

- AS/NZS 1170 Structural Design Actions
- NZS 3101:2006 Concrete Structures Standard
- NZS 3404:1997 Steel Structures Standard
- NZS4230:2004 Design of Reinforced Concrete Masonry Structures
- NZS 3603:1993 Timber Structures Standard
- NZS 3604:2011 Timber Framed Buildings

7.2. Available Information, Assumptions and Limitations

Following our inspection on the 6 march 2012, SKM carried out a preliminary structural review. The structural review was undertaken using the available information which was as follows:

- SKM site measurements and inspection findings of the building.
- No structural drawings were available for this building.

The assumptions made in undertaking the assessment include:

- The building was built according to good practices at the time.
- The soil on site is class D as described in AS/NZS1170.5:2004, Clause 3.1.3, Soft Soil.
- Standard design assumptions as described in AS/NZS1170.0:2002:
  - 50 year design life, which is the default NZ Building Code design life.
  - The soil on site is class D as described in AS/NZS1170.5:2004, Clause 3.1.3, Soft Soil.

[5] NZSEE 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*, p2-9

- Structure importance level 1 since the total floor area is <30m^2 and represents structures presenting a low degree of hazard to life and other property.

- Ductility level of 1, based on our assessment and code requirements at the time of design.
- Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011

This IEP was based on our visual inspection of the building and a review of the available structural drawings. Since it is not a full design and construction review, it has the following limitations:

- It is not likely to pick up on any original design or construction errors (if they exist)
- Other possible issues that could affect the performance of the building such as corrosion and modifications to the building will not be identified
- The IEP deals only with the structural aspects of the building. Other aspects such as building services are not covered.
- The IEP does not involve a detailed analysis or an element by element code compliance check.

7.3. Survey

There was no visible settlement of the structure, nor were there any significant ground movement issues around the building. The building is zoned TC2 on the CERA Technical Categories Map. The combination of these factors means that we do not recommend that any survey be undertaken at this stage of the assessment.

7.4. Critical Structural Weaknesses

The building has the following potential critical structural weakness:

- Since the unreinforced masonry walls are part of the gravity resisting system and are unable to behave in a ductile manner they present a critical structural weakness to this building.

This critical structural weakness has been incorporated into the qualitative results below. The effect of these will be a lower qualitative assessment result when compared to a building containing no critical structural weaknesses.

7.5. Qualitative Assessment Results

The building has had its capacity assessed using the Initial Evaluation Procedure based on the information available. The buildings capacity excluding any structural damage and the capacity of any identified structural damage are expressed as a percentage of new building standard (%NBS) and are in the order of that shown below in Table 3. These capacities are subject to confirmation by a quantitative analysis. However due to the structural damage present and the size of the building it building it is not cost effective to carry out a quantitative assessment or strengthen the structure to current code requirements.

Table 3: Qualitative Assessment Summary

Item	%NBS
Original Likely Seismic Capacity of Building	18
Likely Seismic Capacity of Building in Damaged State	<10

Our qualitative assessment found that the building is likely to be classed as a ‘High Risk Building’ (capacity less than 34% of NBS). The full IEP assessment form is detailed in Appendix 2 – IEP Reports.

The Council regulations state that if the %NBS of the building is less than 34%, this building is considered earthquake prone and is required to be strengthened.

The Engineering Advisory Group notes:

> *“For buildings with insignificant damage, but that have %NBS<33%, and buildings with significant damage, a quantitative assessment is required. Note that according to the extent of damage, it may be possible to complete a quantitative assessment for part only of the structure, with a qualitative analysis for the structure as a whole. This could be sufficient when there is highly localised severe damage but the building has otherwise suffered little or no damage.”*

8. Further Investigation

Due to the structural damage present and the size of the building it is not cost effective to carry out a quantitative assessment or strengthen the structure to current code requirements. We recommend that this structure is demolished and replaced with either a timber framed or reinforced concrete block building that meets current code requirements.

9. Conclusion

A qualitative assessment was carried out on building PRK_0895_BLDG_008 EQ2, located at Ruru Lawn Cemetery, Bromley. The building has sustained major damage to masonry walls. Taking this damage into consideration the building has been assessed to have a likely seismic capacity less than 10% NBS and is therefore potentially earthquake prone (capacity less than 34% of NBS).

Due to the structural damage present and the size of the building it is not cost effective to carry out a quantitative assessment or strengthen the structure to current code requirements.

It is recommended that:

a) The current placard status of the building remain as Red 2.
b) Due the presence of the temporary propping installed along the north wall we consider that barriers around the building are not necessary.

10. Limitation Statement

This report has been prepared on behalf of, and for the exclusive use of, SKM’s client, and is subject to, and issued in accordance with, the provisions of the contract between SKM and the Client. It is not possible to make a proper assessment of this report without a clear understanding of the terms of engagement under which it has been prepared, including the scope of the instructions and directions given to, and the assumptions made by, SKM. The report may not address issues which would need to be considered for another party if that party's particular circumstances, requirements and experience were known and, further, may make assumptions about matters of which a third party is not aware. No responsibility or liability to any third party is accepted for any loss or damage whatsoever arising out of the use of or reliance on this report by any third party.

Without limiting any of the above, in the event of any liability, SKM's liability, whether under the law of contract, tort, statute, equity or otherwise, is limited in as set out in the terms of the engagement with the Client.

It is not within SKM’s scope or responsibility to identify the presence of asbestos, nor the responsibility of SKM to identify possible sources of asbestos. Therefore for any property pre-dating 1989, the presence of asbestos materials should be considered when costing remedial measures or possible demolition.

There is a risk of further movement and increased cracking due to subsequent aftershocks or settlement.

Should there be any further significant earthquake event, of a magnitude 5 or greater, it will be necessary to conduct a follow-up investigation, as the observations, conclusions and recommendations of this report may no longer apply Earthquake of a lower magnitude may also cause damage, and SKM should be advised immediately if further damage is visible or suspected.

11. Appendix 1 – Photos

Photo 1: West Elevation of Building

Photo 2: Internal View of Tool Shed - Temporary Proping Installed along North Face

Photo 3: Lean-To Part of Building

Photo 4: North Elevation of Building

	
Photo 5: Major Cracking to Masonry in NW Corner	Photo 6: Major Cracking to Masonry in NW Corner
	
Photo 7: Step Cracking to Masonry on the North Face	Photo 8: Major Cracking to Masonry in NE Corner
	
Photo 9: East Elevation	Photo 10: Minor Cracking around top Brick in the SE Corner

Photo 11: Broken Lean-To Roof

Photo 12: Cracking to Masonry in NW Corner

Photo 13: Close up of Photo 12

12. Appendix 2 – IEP Reports

Table IEP-1 **Initial Evaluation Procedure – Step 1** Page 1

(Refer Table IEP - 2 for Step 2; Table IEP - 3 for Step 3, Table IEP - 4 for Steps 4, 5 and 6)

Building Name:	Ruru Lawn Cemetery - PRK_0895_BLDG_008 EQ2	Ref.	ZB01276.45
Location:	Raymond Road, Bromley, Christchurch	By	KW
		Date	4/04/2012

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketch of building plan

1.3 List relevant features

This building is constructed is a small single storey building that is constructed from unreinforced masonry walls and a timber framed roof. There is a timber framed lean-to structure located on the south side of the main building. Due to the architecture of this building we have believe that it was constructed sometime in the 1960's

1.4 Note information sources

	Tick as appropriate
Visual Inspection of Exterior	✓
Visual Inspection of Interior	☐
Drawings (note type)	☐
Specifications	☐
Geotechical Reports	☐
Other (list)	☐

Table IEP-2 **Initial Evaluation Procedure – Step 2**

Page 2

(Refer Table IEP - 1 for Step 1; Table IEP - 3 for Step 3, Table IEP - 4 for Steps 4, 5 and 6)

Building Name:	Ruru Lawn Cemetery - PRK_0895_BLDG_008 EQ2	Ref.	ZB01276.45
Location:	Raymond Road, Bromley, Christchurch	By	KW
Direction Considered:	**Longitudinal & Transverse**	Date	4/04/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Step 2 - Determination of (%NBS)b

2.1 Determine nominal (%NBS) = (%NBS)nom

Pre 1935			○	See also notes 1, 3
1935-1965			◉	
1965-1976	Seismic Zone;	A	○	
		B	○	
		C	○	See also note 2
1976-1992	Seismic Zone;	A	○	
		B	○	
		C	○	
1992-2004			○	

b) Soil Type

From NZS1170.5:2004, Cl 3.1.3

A or B Rock	○
C Shallow Soil	○
D Soft Soil	◉
E Very Soft Soil	○

From NZS4203:1992, Cl 4.6.2.2
(for 1992 to 2004 only and only if known)

a) Rigid	◉	N-A
b) Intermediate	○	

c) Estimate Period, T

building Ht = 3 meters

	Longitudinal	Transverse	
Ac =	4.6	3.2	m2

Can use following:

		Longitudinal	Transverse
$T = 0.09h_n^{0.75}$	for moment-resisting concrete frames	○ MRCF	○ MRCF
$T = 0.14h_n^{0.75}$	for moment-resisting steel frames	○ MRSF	○ MRSF
$T = 0.08h_n^{0.75}$	for eccentrically braced steel frames	○ EBSF	○ EBSF
$T = 0.06h_n^{0.75}$	for all other frame structures	○ Others	○ Others
$T = 0.09h_n^{0.75}/A_c^{0.5}$	for concrete shear walls	○ CSW	○ CSW
$T \le 0.4\text{sec}$	for masonry shear walls	◉ MSW	◉ MSW

Where hn = height in m from the base of the structure to the uppermost seismic weight or mass.
Ac = ΣAi(0.2 + Lwi/hn)2
Ai = cross-sectional shear area of shear wall i in the first storey of the building, in m2
lwi = length of shear wall i in the first storey in the direction parallel to the applied forces, in m
with the restriction that lwi/hn shall not exceed 0.9

Longitudinal	Transverse	
0.4	**0.4**	Seconds

d) (%NBS)nom determined from Figure 3.3

Longitudinal	2.8	$(\%NBS)_{nom}$
Transverse	2.8	$(\%NBS)_{nom}$

			Factor
Note 1:	For buildings designed prior to 1965 and known to be designed as public buildings in accordance with the code of the time, multiply (%NBS)nom by 1.25.	No	1
	For buildings designed 1965 - 1976 and known to be designed as public buildings in accordance with the code of the time, multiply (%NBS)nom by 1.33 - Zone A or 1.2 - Zone B	No	1
Note 2:	For reinforced concrete buildings designed between 1976 -1984 (%NBS)nom by 1.2	No	1
Note 3:	For buildings designed prior to 1935 multiply (%NBS)nom by 0.8 except for Wellington where the factor may be taken as 1.	No	1

Longitudinal	2.8	$(\%NBS)_{nom}$
Transverse	2.8	$(\%NBS)_{nom}$

Continued over page

Table IEP-2 Initial Evaluation Procedure – Step 2 continued

Page 3

Building Name:	Ruru Lawn Cemetery - PRK_0895_BLDG_008 EQ2	Ref.	ZB01276.45
Location:	Raymond Road, Bromley, Christchurch	By	KW
Direction Considered:	**Longitudinal & Transverse**	Date	4/04/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

2.2 Near Fault Scaling Factor, Factor A
If T < 1.5sec, Factor A = 1

a) **Near Fault Factor, N(T,D)** 1
(from NZS1170.5:2004, Cl 3.1.6)

b) **Near Fault Scaling Factor** = 1/N(T,D)

Factor A	1.00

2.3 Hazard Scaling Factor, Factor B

Select Location: Christchurch

a) **Hazard Factor, Z, for site**
(from NZS1170.5:2004, Table 3.3)

Z = 0.3
Z 1992 = 0.8

Auckland	0.6	Palm Nth	1.2
Wellington	1.2	Dunedin	0.6
Christchurch	0.8	Hamilton	0.67

b) **Hazard Scaling Factor**
For pre 1992 = 1/Z
\# For 1992 onwards = Z 1992/Z
(Where Z 1992 is the NZS4203:1992 Zone Factor from accompanying Figure 3.5(b))

Factor B	3.33

2.4 Return Period Scaling Factor, Factor C

a) **Building Importance Level** 1
(from NZS1170.0:2004, Table 3.1 and 3.2)

b) **Return Period Scaling Factor from accompanying Table 3.1**

Factor C	2.00

2.5 Ductility Scaling Factor, D

a) **Assessed Ductility of Existing Structure, μ**
(shall be less than maximum given in accompanying Table 3.2)

Longitudinal	1	μ Maximum = 2
Transverse	1	μ Maximum = 2

b) **Ductility Scaling Factor**
For pre 1976 = k_μ
For 1976 onwards = 1
(where k_μ is NZS1170.5:2005 Ductility Factor, from accompanying Table 3.3)

Longitudinal	**Factor D**	1.00
Transverse	**Factor D**	1.00

2.6 Structural Performance Scaling Factor, Factor E

Select Material of Lateral Load Resisting System
Longitudinal * Masonry Block
Transverse ** Masonry Block

a) **Structural Performance Factor, S_p**
from accompanying Figure 3.4

Longitudinal	Sp	1.00
Transverse	Sp	1.00

b) **Structural Performance Scaling Factor**

Longitudinal	$1/S_p$	**Factor E**	1.00
Transverse	$1/S_p$	**Factor E**	1.00

2.7 Baseline %NBS for Building, $(\%NBS)_b$
(equals $(\%NSB)_{nom}$ x A x B x C x D x E)

Longitudinal	18.7	(%NBS)b
Transverse	18.7	(%NBS)b

Table IEP-3 **Initial Evaluation Procedure – Step 3**

(Refer Table IEP - 1 for Step 1; Table IEP - 2 for Step 2, Table IEP - 4 for Steps 4, 5 and 6)

Building Name:	Ruru Lawn Cemetery - PRK_0895_BLDG_008 EQ2	Ref.	ZB01276.45
Location:	Raymond Road, Bromley, Christchurch	By	KW
Direction Considered:	**a) Longitudinal**	Date	4/04/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Step 3 - Assessment of Performance Achievement Ratio (PAR)
(Refer Appendix B - Section B3.2)

Critical Structural Weakness	**Effect on Structural Performance** (Choose a value - Do not interpolate)				**Building Score**
	Severe	Significant	Insignificant		
3.1 Plan Irregularity Effect on Structural Performance	○	○	(•)	**Factor A**	1
Comment					
3.2 Vertical Irregularity Effect on Structural Performance	○	○	(•)	**Factor B**	1
Comment					
3.3 Short Columns Effect on Structural Performance	○	○	(•)	**Factor C**	1
Comment					

3.4 Pounding Potential

(Estimate D1 and D2 and set D = the lower of the two, or =1.0 if no potential for pounding)

a) Factor D1: - Pounding Effect
Select appropriate value from Table

Note:
Values given assume the building has a frame structure. For stiff buildings (eg with shear walls), the effect of pounding may be reduced by taking the co-efficient to the right of the value applicable to frame buildings.

Factor D1 1

Table for Selection of Factor D1	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Alignment of Floors within 20% of Storey Height	○ 0.7	○ 0.8	(•) 1
Alignment of Floors not within 20% of Storey Height	○ 0.4	○ 0.7	○ 0.8

b) Factor D2: - Height Difference Effect
Select appropriate value from Table

Factor D2 1

Table for Selection of Factor D2	Severe	Significant	Insignificant
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

Factor D 1

(Set D = lesser of D1 and D2 or..
set D = 1.0 if no prospect of pounding)

3.5 Site Characteristics - (Stability, landslide threat, liquefaction etc)

	Severe	Significant	Insignificant		
Effect on Structural Performance	○ 0.5	○ 0.7	(•) 1	**Factor E**	1

3.6 Other Factors

For < 3 storeys - Maximum value 2.5,

otherwise - Maximum value 1.5. No minimum. **Factor F** 1

Record rationale for choice of Factor F:

3.7 Performance Achievement Ratio (PAR)
(equals A x B x C x D x E x F)

PAR 1

Table IEP-3 **Initial Evaluation Procedure – Step 3** Page 5

(Refer Table IEP - 1 for Step 1; Table IEP - 2 for Step 2, Table IEP - 4 for Steps 4, 5 and 6)

Building Name:	Ruru Lawn Cemetery - PRK_0895_BLDG_008 EQ2	Ref.	ZB01276.45
Location:	Raymond Road, Bromley, Christchurch	By	KW
Direction Considered:	**b) Transverse**	Date	4/04/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Step 3 - Assessment of Performance Achievement Ratio (PAR)
(Refer Appendix B - Section B3.2)

Critical Structural Weakness — **Effect on Structural Performance** (Choose a value - Do not interpolate) — **Building Score**

3.1 Plan Irregularity
Effect on Structural Performance: Severe ○ / Significant ○ / Insignificant ◉ — **Factor A** 1
Comment

3.2 Vertical Irregularity
Effect on Structural Performance: Severe ○ / Significant ○ / Insignificant ◉ — **Factor B** 1
Comment

3.3 Short Columns
Effect on Structural Performance: Severe ○ / Significant ○ / Insignificant ◉ — **Factor C** 1
Comment

3.4 Pounding Potential
(Estimate D1 and D2 and set D = the lower of the two, or =1.0 if no potential for pounding)

a) Factor D1: - Pounding Effect
Select appropriate value from Table

Note:
Values given assume the building has a frame structure. For stiff buildings (eg with shear walls), the effect of pounding may be reduced by taking the co-efficient to the right of the value applicable to frame buildings.

Factor D1 1

Table for Selection of Factor D1

Separation	Severe 0<Sep<.005H	Significant .005<Sep<.01H	Insignificant Sep>.01H
Alignment of Floors within 20% of Storey Height	○ 0.7	○ 0.8	◉ 1
Alignment of Floors not within 20% of Storey Height	○ 0.4	○ 0.7	○ 0.8

b) Factor D2: - Height Difference Effect
Select appropriate value from Table

Factor D2 1

Table for Selection of Factor D2

Separation	Severe 0<Sep<.005H	Significant .005<Sep<.01H	Insignificant 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

Factor D 1
(Set D = lesser of D1 and D2 or..
set D = 1.0 if no prospect of pounding)

3.5 Site Characteristics - (Stability, landslide threat, liquefaction etc)
Effect on Structural Performance: Severe ○ 0.5 / Significant ○ 0.7 / Insignificant ◉ 1 — **Factor E** 1

3.6 Other Factors
For < 3 storeys - Maximum value 2.5,
otherwise - Maximum value 1.5. No minimum. — **Factor F** 1

Record rationale for choice of Factor F:

3.7 Performance Achievement Ratio (PAR)
(equals A x B x C x D x E x F) — **PAR** 1

Table IEP-4 **Initial Evaluation Procedure – Steps 4, 5 and 6**

(Refer Table IEP - 1 for Step 1; Table IEP - 2 for Step 2, Table IEP - 3 for Step 3)

Page 6

Building Name:	Ruru Lawn Cemetery - PRK_0895_BLDG_008 EQ2	Ref.	ZB01276.45
Location:	Raymond Road, Bromley, Christchurch	By	KW
Direction Considered:	**Longitudinal & Transverse**	Date	4/04/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Step 4 - Percentage of New Building Standard (%NBS)

	Longitudinal	Transverse
4.1 Assessed Baseline $(\%NBS)_b$ (from Table IEP - 1)	18	18
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	1.00	1.00
4.3 PAR x Baseline $(\%NBS)_b$	18	18
4.4 Percentage New Building Standard (%NBS) (Use lower of two values from Step 4.3)		18

Step 5 - Potentially Earthquake Prone?
(Mark as appropriate)

%NBS ≤ 33 — YES

Step 6 - Potentially Earthquake Risk?

%NBS < 67 — YES

Step 7 - Provisional Grading for Seismic Risk based on IEP

Seismic Grade — E

Evaluation Confirmed by

Signature

NICK CALVERT Name

242062 CPEng. No

Relationship between Seismic Grade and % NBS :

Grade:	A+	A	B	C	D	E
%NBS:	> 100	100 to 80	80 to 67	67 to 33	33 to 20	< 20

13. Appendix 3 – CERA Standardised Report Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	PRK_0895_BLDG_008 EQ2	Reviewer:	K Wylie
	Unit / No: / Street	CPEng No:	1007058
Building Address:	Ruru Lawn Cemetery - Tool Shed / Raymond Road	Company:	SKM
Legal Description:		Company project number:	ZB01276.45
		Company phone number:	09 940 4900
	Degrees / Min / Sec		
GPS south:		Date of submission:	13-Feb
GPS east:		Inspection Date:	3/04/2012
		Revision:	C
Building Unique Identifier (CCC):		Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	
Soil type:		Soil Profile (if available):	refer to geotech desktop study attached in qualitative report
Site Class (to NZS1170.5):	D		
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):
Ground floor split?	no	Ground floor elevation above ground (m):	
Storeys below ground	0		
Foundation type:	strip footings	if Foundation type is other, describe:	
Building height (m):	3.00	height from ground to level of uppermost seismic mass (for IEP only) (m):	3.00
Floor footprint area (approx):	15		
Age of Building (years):	52	Date of design:	1935-1965
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	other (specify)	Brief strengthening description:	
Use (upper floors):			
Use notes (if required):	storage shed for Ruru Cemetery		
Importance level (to NZS1170.5):	IL1		

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber truss	truss depth, purlin type and cladding	truss is trianglar and is 1.0m high at the apex. Timber purlins supporting light weight corrugated cladding.
Floors:			
Beams:	timber	type	
Columns:			200 dp x 135 w (UB)
Walls:	load bearing brick	thickness (mm)	105

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	unreinforced masonry bearing wall - brick		note wall thickness and cavity	double brick, cavity unknown
Ductility assumed, μ:	1.00			
Period along:	0.40	0.40 from parameters in sheet	estimate or calculation?	estimated
Total deflection (ULS) (mm):	5		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):	0		estimate or calculation?	estimated
Lateral system across:	unreinforced masonry bearing wall - brick		note wall thickness and cavity	double brick, cavity unknown
Ductility assumed, μ:	1.00			
Period across:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):	5		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):	0		estimate or calculation?	estimated

Separations:

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

Non-structural elements

Stairs:			n/a
Wall cladding:	exposed structure	describe	brick walls form the wall cladding
Roof Cladding:	Metal	describe	Light weight corrugated steel cladding
Glazing:	timber frames		n/a
Ceilings:			
Services(list):	n/a		

Available documentation

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

Damage

Site: (refer DEE Table 4-2)

Site performance:	1	Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	red		
Along	Damage ratio:	44%	Describe how damage ratio arrived at:	Major structural damage has occurred to the brick walls making them unstable. If the walls fail then the entire structure will collapse.
	Describe (summary):			
Across	Damage ratio:	44%		
	Describe (summary):			

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

Diaphragms	Damage?:	yes	Describe:	major cracking and movement to brick walls present
CSWs:	Damage?:	yes	Describe:	unreinforced masonry
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

Recommendations

Level of repair/strengthening required:	demolition	Describe:	major cracking and movement to brick walls present
Building Consent required:	yes	Describe:	
Interim occupancy recommendations:	do not occupy	Describe:	

Along	Assessed %NBS before:	18%	%NBS	If IEP not used, please detail assessment methodology:	Qualitative Assessment carried out which includes the NZSEE IEP (refer to SKM report)
	Assessed %NBS after:	10%			
Across	Assessed %NBS before:	18%	%NBS		
	Assessed %NBS after:	10%			

14. Appendix 4 – Geotechnical Desktop Study

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Saint Albans
PO Box 21011, Edgeware
Christchurch, New Zealand

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Fax: +64 3 940 4901
Web: www.globalskm.com

1. Christchurch City Council - Structural Engineering Service

2. Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	043 to 048 inclusive
Address	Ruru Cemetery, 63 Ruru Rd
Report date	21 May 2012
Author	Ananth Balachandra / Ross Roberts
Reviewer	Leah Bateman
Approved for issue	Yes

3. Introduction

This report outlines the geotechnical information that Sinclair Knight Merz (SKM) has been able to source from our database and other sources in relation to the property listed above. We understand that this information will be used as part of an initial qualitative Detailed Engineering Evaluation (DEE) of whether the building can be economically repaired, and will be supplemented by more detailed information and investigations to allow detailed scoping of the repair or rebuild of the building.

4. Scope

This geotechnical desk top study incorporates information sourced from:

- Published geology
- Publically available borehole records
- Liquefaction records
- Aerial photography
- Council files
- A preliminary site walkover

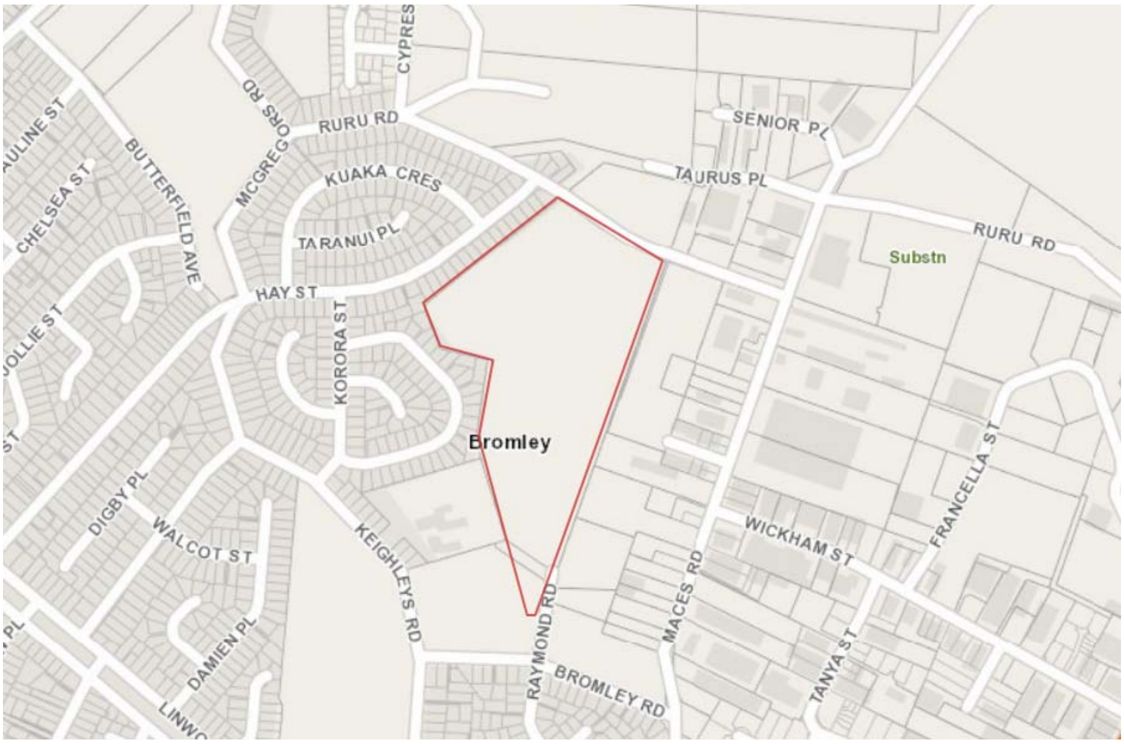
5. Limitations

This report was prepared to address geotechnical issues relating to the specific site in accordance with the scope of works as defined in the contract between SKM and our Client. This report has been prepared on behalf of, and for the exclusive use of, our Client, and is subject to, and issued in accordance with, the provisions of the contract between SKM and our Client. The findings presented in this report should not be applied to another site or another development within the same site without consulting SKM.

The assessment undertaken by SKM was limited to a desktop review of the data described in this report. SKM has not undertaken any subsurface investigations, measurement or testing of materials from the site. In preparing this report, SKM has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by our Client, and from other sources as described in the report. Except as otherwise stated in this report, SKM has not attempted to verify the accuracy or completeness of any such information.

This report should be read in full and no excerpts are to be taken as representative of the findings. It must not be copied in parts, have parts removed, redrawn or otherwise altered without the written consent of SKM.

6. Site location

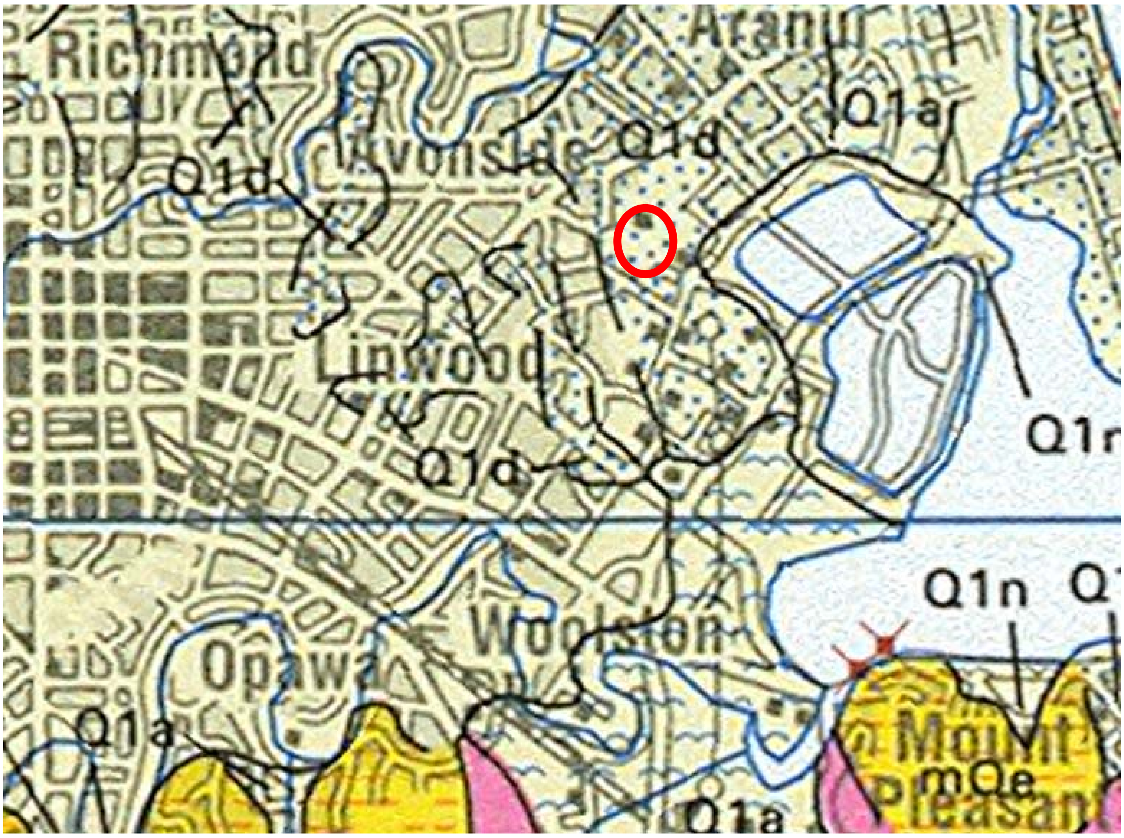


- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

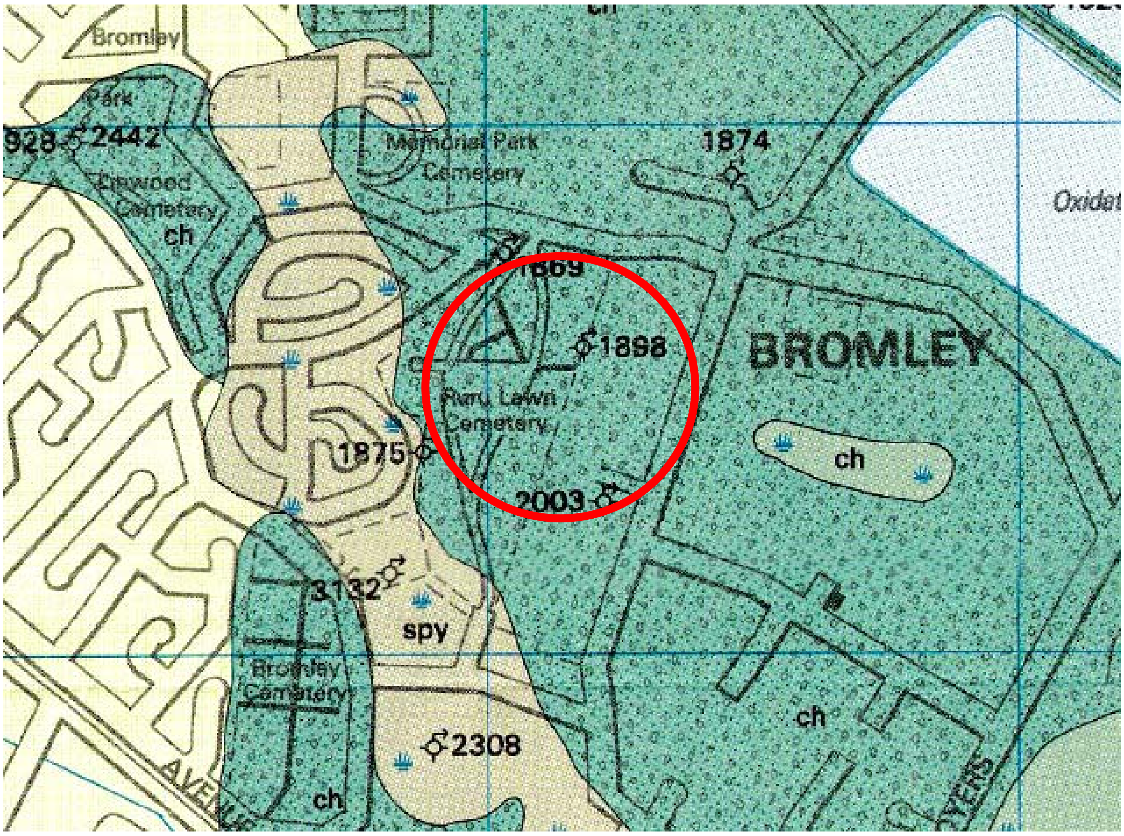
The site is located on 63 Ruru Road at grid reference 1574990 E, 5179890 N (NZTM).

7. Review of available information

7.1 Geological maps



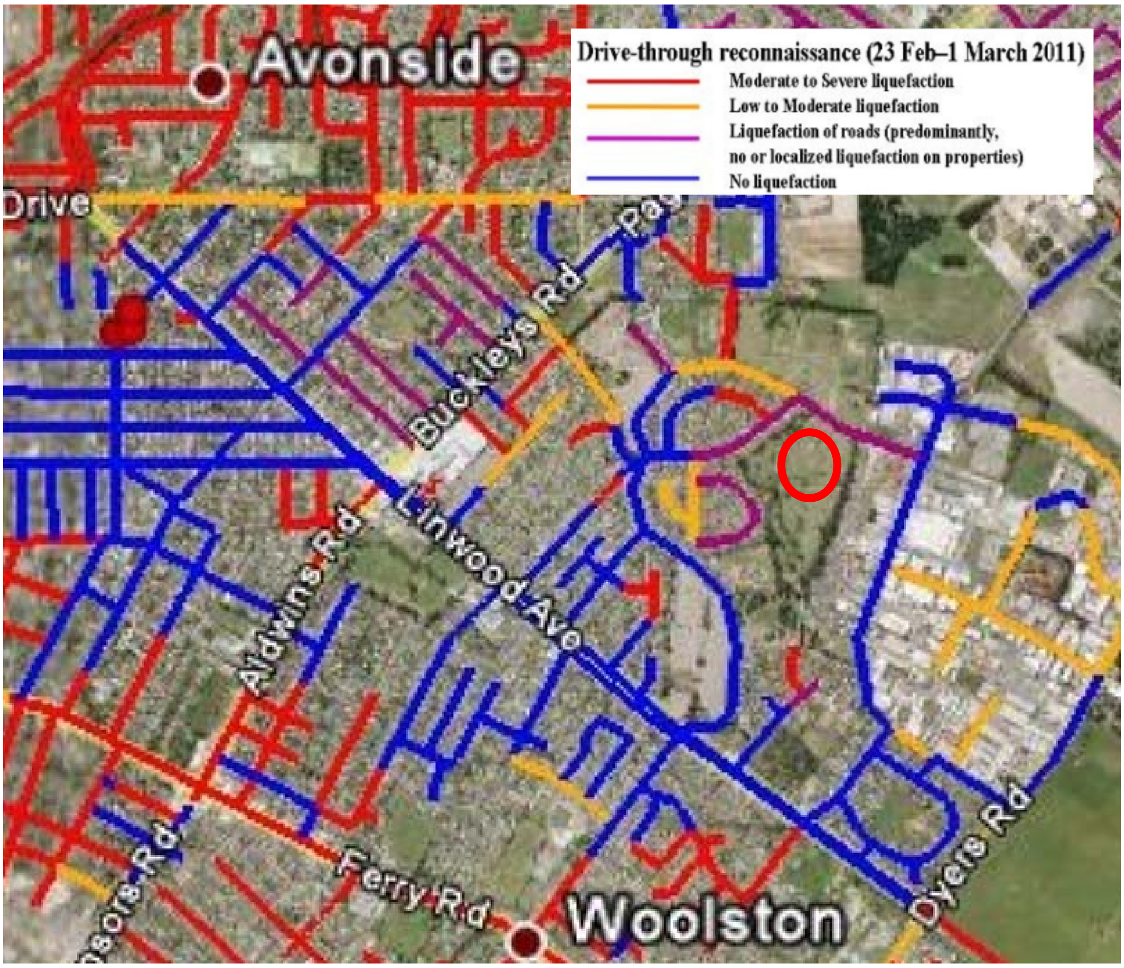
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



- **Figure 3 – Local geological map (Brown et al, 1992). Site marked in red.**

The site is shown to be underlain by Holocene deposits comprising predominantly sands of fixed and semi-fixed dunes and beaches from the Christchurch Formation. The area immediately to the west of the site is underlain by peat swamps, now drained, from the Springston Formation.

7.2 Liquefaction map



- **Figure 4 – Liquefaction map (Cubrinovski & Taylor, 2011). Site marked in red.**

Following the 22 February 2011 event drive through reconnaissance was undertaken from 23 February until 1 March by M Cubrinovsko and M Taylor of Canterbury University. Their findings show predominantly liquefaction of roads with no or localised liquefaction in the areas near the site. In parts of the area immediately west of the site low to moderate and moderate and severe liquefaction had been noted.

7.3 Aerial photography

- **Figure 5 Aerial photography from 24 Feb 2011 (http://viewers.geospatial.govt.nz/)**

- **Figure 6 – Aerial photography from 24 Feb 2011 (http://viewers.geospatial.govt.nz/)**

Significant amount of liquefied material can be seen on Ruru road, running down the northern section of the site, from the aerial photographs. Additionally, localised liquefaction and evidence of sand boils could be seen on adjacent properties.

7.4 CERA classification

A review of the LINZ website (http://viewers.geospatial.govt.nz/) shows that the site is:

- Zone: Green
- DBH Technical Category: N/A (Urban Non-residential) – with properties to the west categorised as TC2

7.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the site was recorded as marshland or swamp in 1856. Therefore, it is possible that soft or liquefiable soils would be present near the site.

7.6 Existing ground investigation data

- **Figure 7 – Local boreholes from Project Orbit and SKM files (https://canterburyrecovery.projectorbit.com/)**

Where available logs from these investigation locations are attached to this report (Appendix B), and the results are summarised in Appendix C.

7.7 Council property files

Council property files comprising drawings showing the conceptual layout of the cemetery, proposed drawings for the public toilet and consent document for landscaping the cemetery was available and reviewed for this desk study.

The drawings for the public toilet show that the structure was supported on reinforced concrete slab on grade foundation. The concrete floor slab was noted to be approximately 200mm in thickness supported on compacted hardfill. Thickened concrete slab measuring approximately 500mm in thickness, 300mm of which is embedded, was noted beneath the internal and external walls of the structure. Additionally, in the proposed drawing a septic tank was noted to be buried approximately 4m away from the toilet. Therefore, the area near the septic tank may be contaminated.

No other ground condition information or information regarding the foundation details of other structure on site was evident in the available council files.

7.8 Site walkover

An external site walkover was undertaken by a SKM engineer in the week commencing 19 March 2012.

There was no significant sign of land damage or evidence that liquefaction had occurred on site. There were two toilets on site; one was a concrete block structure with the other being a brick structure. Both had metal roofing. The pump house was a timber structure with a felt roof, and the toolshed was constructed using bricks and a metal roof. The office was a portacom.

The toolshed was the only building on the site with any noticeable structural damage. The main damage observed was the cracking of the bricks.

- **Figure 8 Visible damage to the tool shed**

- **Figure 9 No visible damage to land or the building**

- **Figure 10 No visible damage to the pump house**

8. Conclusions and recommendations

8.1 Site geology

An interpretation of the most relevant local investigation suggests that the site is underlain by:

Depth range (mBLG)	Soil type
0 – 1	Soft clayey silt and silt
1 – 6	Medium dense clean sand to silty sand
6 – 13	Dense clean sand to silty sand
13 - 25+	Very dense clean sand

8.2 Seismic site subsoil class

The site has been assessed as NZS1170.5 Class D (deep or soft soil) from adjacent borehole logs with sand and clay material inferred to present below a depth of 60m.

As described in NZS1170, the preferred site classification method is from site periods based on four times the shear wave travel time through material from the surface to the underlying rock. The next preferred methods are from borelogs including measurement of geotechnical properties or by evaluation of site periods from Nakamura ratios or from recorded earthquake motions. Lacking this information, classification may be based on boreholes with descriptors but no geotechnical measurements. The least preferred method is from surface geology and estimates of the depth to underlying rock.

In this case the second preferred method has been used to make the assessment.

8.3 Building Performance

Only foundation records for the public toilet were available. However, the performance of the structures to date would suggest that the existing foundations are adequate for their purpose. The only building with noted damage was the tool shed structure. However, there was little to no evidence from the site visit showing excessive settlement of the structure or damage to the foundations.

8.4 Ground performance and properties

Liquefaction risk is moderate for this site, with localised liquefaction on site or the liquefaction of the roads more likely to occur.

For the purposes of shallow foundation design, the following parameters are recommended for the shallow materials. It should be noted that the shallow soft clayey silt and silt layer would likely have been removed before the construction of the foundations. This could not be confirmed for all structures; however, the floor slab for the public toilet was noted to be constructed on compacted hardfill. Therefore, following parameters are recommended for the medium dense clean sand to silty sand layer in order to perform a quantitative DEE:

Parameter	Estimated value
Effective angle of friction	32 degrees
Effective Cohesion	0 kPa
Unit weight	18 kPa
Ultimate bearing capacity of a shallow square pad footing	300 kPa

NOTE: These parameters should not be relied upon for consent purposes or design work. Site specific investigations would be required in which case to confirm the recommended parameters.

8.5 Further investigations

Unless a change of use is intended for the site we do not believe that any further geotechnical investigations are required.

However, if consent is required or significant alterations to the site are proposed, additional investigations recommended are:

- Two CPTs near the structure to refusal

9. References

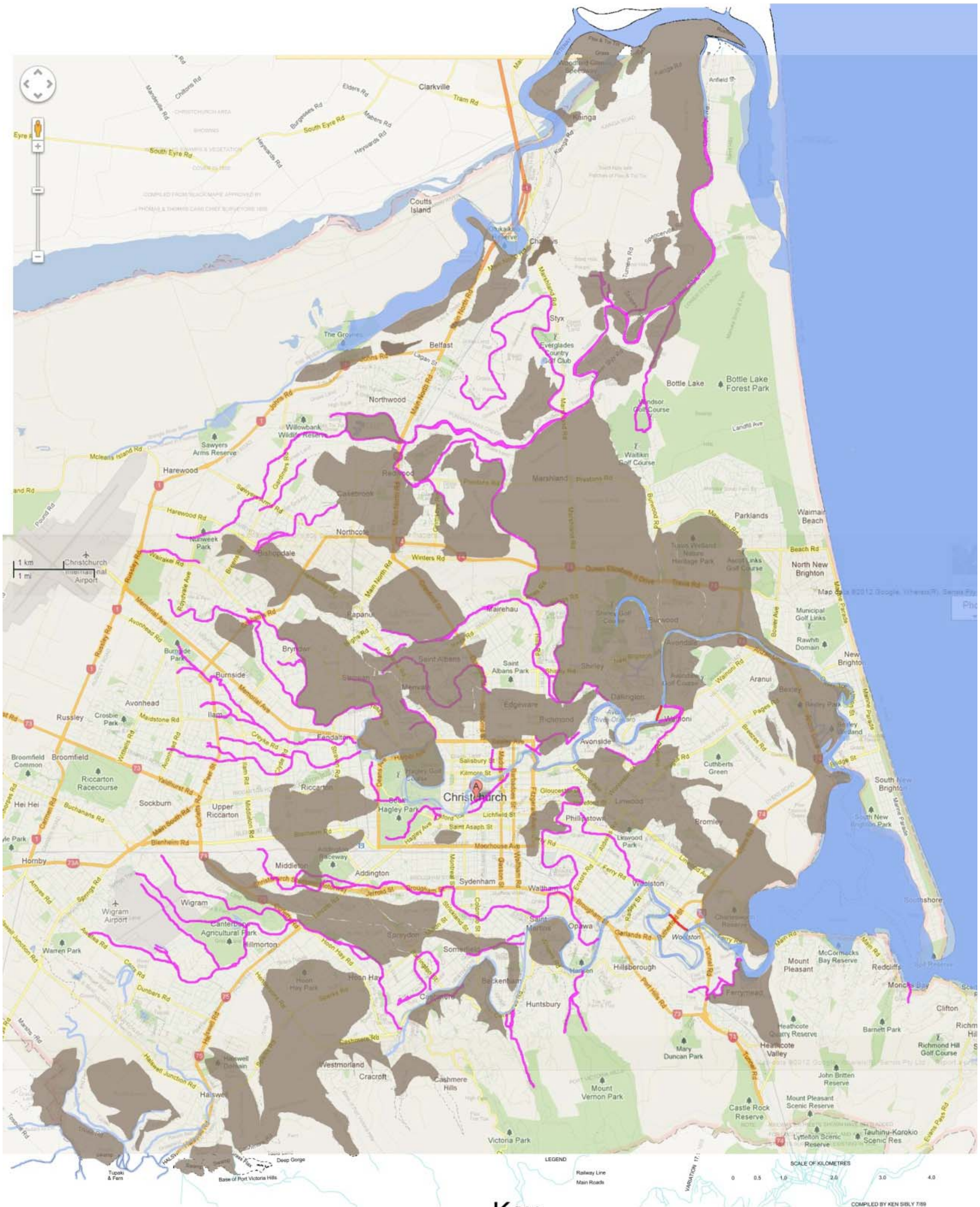
Brown LJ, Weeber JH, 1992. Geology of the Christchurch urban area. Scale 1:25,000. Institute of Geological & Nuclear Sciences geological map 1.

Forsyth PJ, Barrell DJA, Jongens R, 2008. Geology of the Christchurch area. Institute of Geological & Nuclear Sciences geological map 16.

Land Information New Zealand (LINZ) geospatial viewer (http://viewers.geospatial.govt.nz/)

EQC Project Orbit geotechnical viewer (https://canterburyrecovery.projectorbit.com/)

10. Appendix A – Christchurch 1856 land use



Key

- Previous creeks/rivers
- Existing creeks/rivers
- New creeks/rivers
- Swamp/Marshland

The swamps and previous creeks/rivers from 1856 have been overlayed onto a map of Christchurch in 2012

11. Appendix B – Existing ground investigation logs

Borelog for well M35/1898

Gridref: M35:851-416 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 6.4 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -90.5m Drill Date :

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
- 25.9m	Sand	ch
- 33.5m	Clay	ch
- 58.8m	Gravel, water level 0.3m	ri-br
- 60.9m	Clay	br
- 62.1m	Gravel	br
- 67.0m	Clay	br
- 74.3m	Gravel	li-1
- 76.2m	Peat	li-2
- 77.7m	Clay	li-2
- 85.0m	Gravel, water level 3.0m	li-2
- 88.3m	Clay	li-2
- 90.7m	Gravel, water level 3.6m	li-3

Borelog for well M35/1869

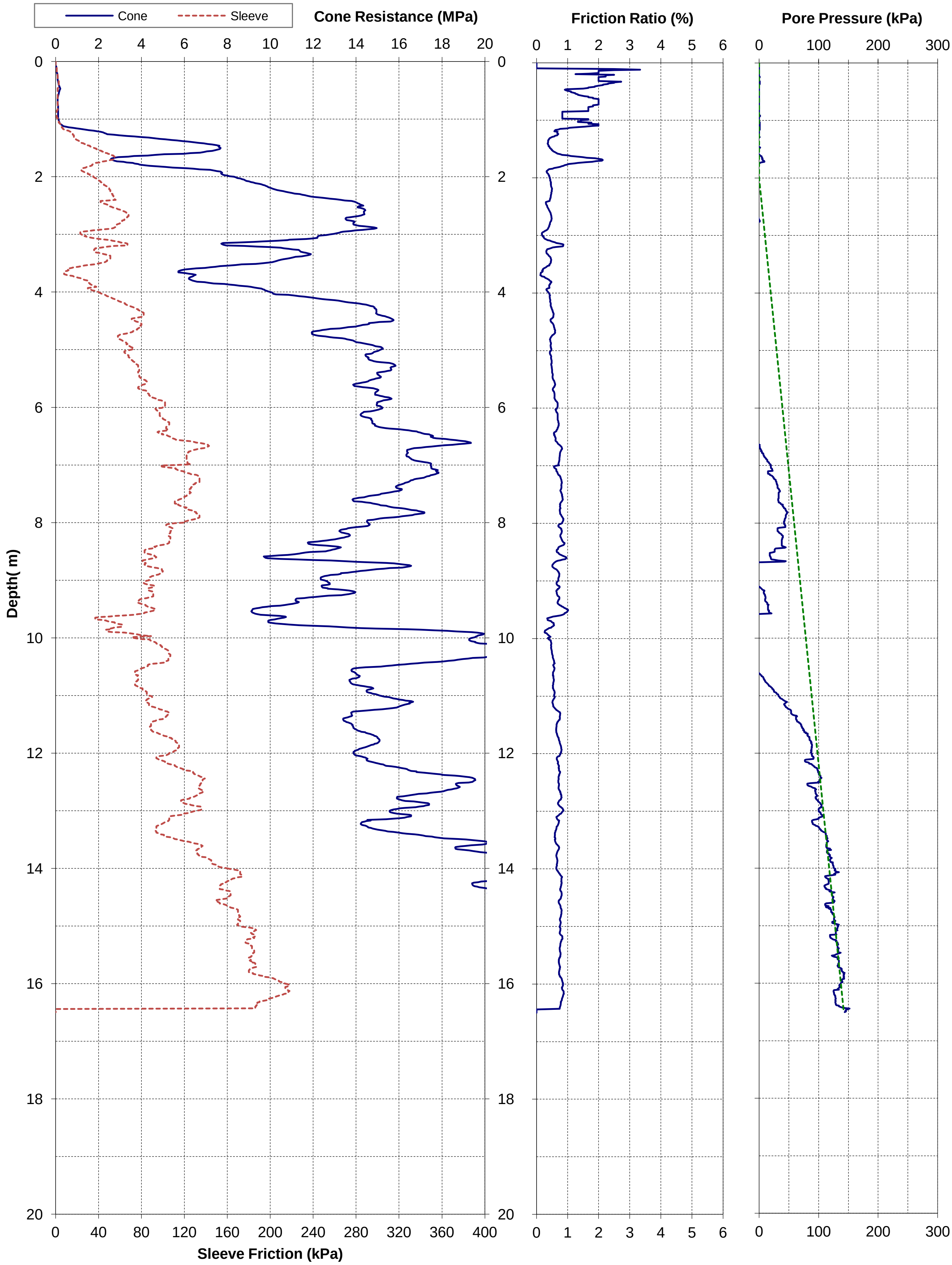
Gridref: M35:85053-41774 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.04 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -60.29m Drill Date :

Water Level: Artesian

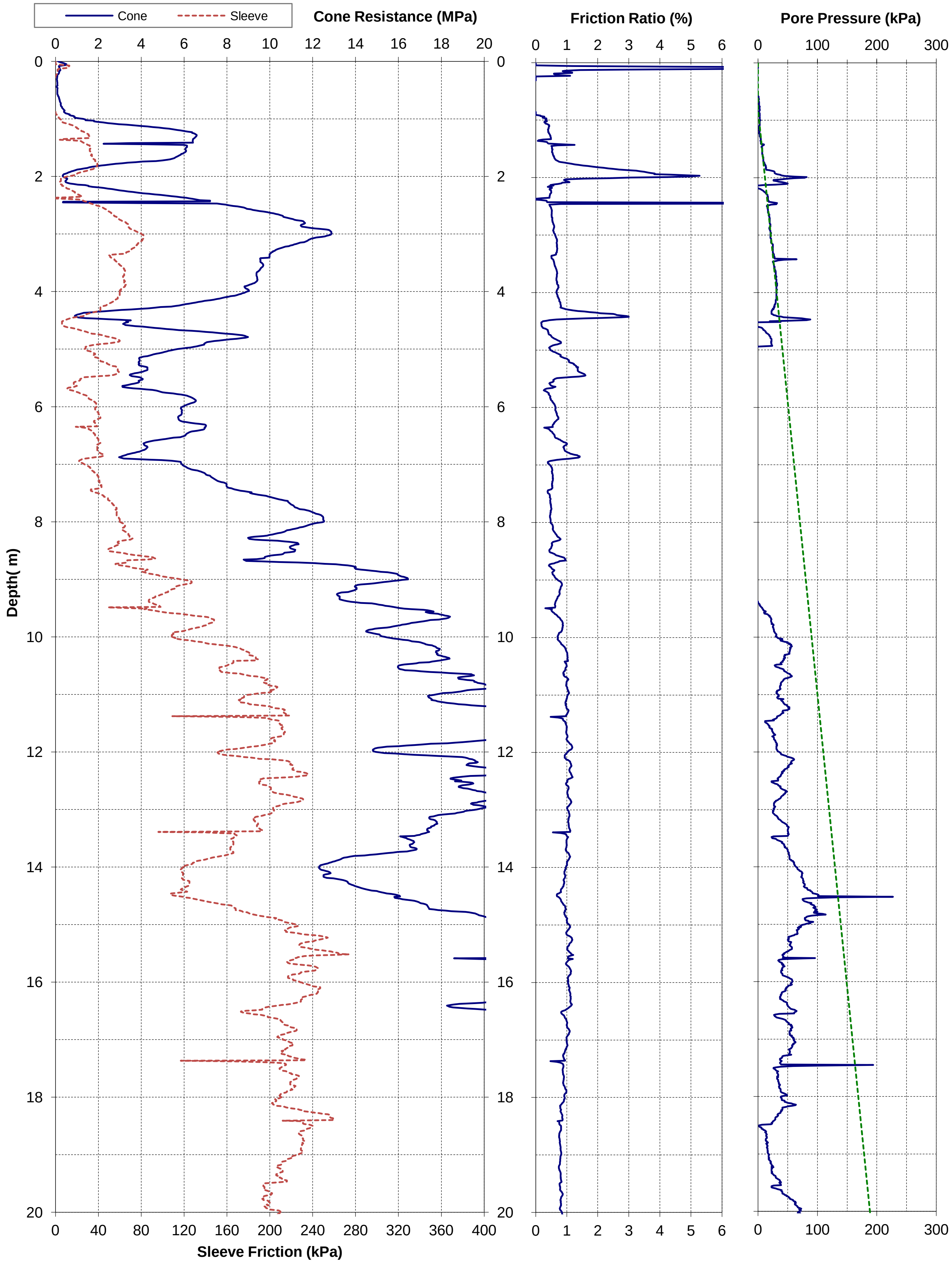
Depth(m)	Full Drillers Description	Formation Code
- 28.9m	Blue sand	ch
- 32.6m	Blue clay	ch
- 33.2m	Blue sand	ch
- 42.0m	Blue shingle water level 2.7m away	ri
- 49.6m	Brown shingle	ri
- 55.4m	Yellow sand	br
- 55.8m	Yellow sand & clay	br
- 60.3m	?????	br

Scale(m): -10, -20, -30, -40, -50, -60

Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	1 of 1	CPT-BRY-20
Test Date:	9-Aug-2011	Location:	Bromley	Operator:	Opus	
Pre-Drill:	1.2m	Assumed GWL:	2mBGL	Located By:	Survey GPS	
Position:	2484825.2mE	5741365.3mN	3.08mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page: 1 of 2	CPT-BRY-08
Test Date:	16-Jun-2011	Location:	Bromley	Operator: Perry	
Pre-Drill:	1.2m	Assumed GWL:	0.8mBGL	Located By: Survey GPS	
Position:	2485354.4mE	5741594.8mN	4.07mRL	Coord. System: NZMG & MSL	
Other Tests:				Comments:	



Borelog for well M35/1869

Gridref: M35:85053-41774 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.04 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -60.29m Drill Date :

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
- 28.9m	Blue sand	ch
- 32.6m	Blue clay	ch
- 33.2m	Blue sand	ch
- 42.0m	Blue shingle water level 2.7m away	ri
- 49.6m	Brown shingle	ri
- 55.4m	Yellow sand	br
- 55.8m	Yellow sand & clay	br
- 60.3m	?????	br

Scale(m): -10, -20, -30, -40, -50, -60

12. Appendix C – Geotechnical Investigation Summary

▪ Table 1 Summary of most relevant investigation data

ID		1	2	3	4	5
Type *		BH	CPT	CPT	CPT	BH
Ref		M35 - 1898	BRY - 20	BRY - 08	BRY - 21	M35 - 1869
Depth (m)		90.5	16.5	32	32	60.3
Distance from site (m)		0**	50	90	0**	20
Ground water level (mBGL)		Artesian	0.8	2	2	Artesian
Simplified recorded geological profile (depth below ground level to top of stratum, m)	0		VS	N/A	N/A	
	1		L	L	MD	
	2		MD	So MD	MD	
	3		MD	MD	MD	
	4		D	MD	MD	
	5		D	L MD	MD	
	6		D	MD	MD	
	7		D	MD	D	
	8		D	D	D	
	9		D	D	D	
	10		D	D	D	
	11		D	D		
	12		D	D		
	13		VD	D		
	14		VD	D		
	15		VD	VD		
	16		VD	VD		
	17			VD		
	18			VD		
	19			VD		
	20			VD		
	21			VD		
	22			VD		
	23			VD		
	24			VD		
	25			VD		
Greater depths						

*BH: Borehole, HA: Hand Auger, WW: Water Well, CPT: Cone Penetration Test

Sensitive or organic clay/silt | Clay to silty clay | Clayey silt to silt | Silty sand to silt

Clayey sand | Sand | Gravelly sand or gravel

VL = very loose, L = loose, MD = medium dense, D = dense, VD = very dense
VS = very soft, So = soft, F = firm, St = stiff, VS = very stiff, H = hard