CHRISTCHURCH CITY COUNCIL
PRK_0657_BLDG_004 EQ2
Westminster Park – Community Building
272 Westminster Street, Mairehau

QUALITATIVE ASSESSMENT REPORT
FINAL

- Rev C
- 29 May 2013

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	Signature	Date	Name	Title
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1. Executive Summary

1.1. Background

A Qualitative Assessment was carried out on the building located at 272 Westminster Street, Mairehau. The building is single storey and currently unoccupied. It is constructed from unreinforced masonry walls and a timber-framed ceiling with a lightweight roof. An aerial photograph illustrating these areas 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 272 Westminster Street

The qualitative assessment 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 a visual inspection on 16 April 2012.

1.2. Key Damage Observed

Key damage observed includes:-

- Step cracking along mortar joints
- Cracking around door frame and architrave on the East wall.
- External concrete floor slab south of the building has pulled away from the masonry walls.

1.3. Critical Structural Weaknesses

The following potential critical structural weaknesses have been identified:

- Load-bearing unreinforced masonry walls on all sides of the building, due to their low out-of-plane bending capacity and long spans.

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

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the buildings original capacity has been assessed to be less than 10%NBS. The damage observed during the site investigation was not significant, therefore the post earthquake capacity will not change as a result of earthquake damage.

The building has been assessed to have a seismic capacity less than 34% NBS and is therefore potentially earthquake prone.

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) It is not likely to be cost-effective to carry out a quantitative assessment and strengthening, due to the complex strengthening solution required and the current state of disrepair.

b) We consider that barriers around the building are not necessary.

2. Introduction

Sinclair Knight Merz was engaged by Christchurch City Council to prepare a qualitative assessment report for the building located at 272 Westminster Street 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 draft document "Guidance on Detailed Engineering Evaluation of Earthquake affected Non-residential Buildings in Canterbury", issued 19 July 2011. The qualitative assessment includes a summary of the building damage as well as an initial assessment of the likely current Seismic Capacity compared with current seismic code 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 intrusive site investigation, detailed analysis, or modelling of the building structure had been carried out. The building description below is based on our visual inspections.

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[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 33%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)

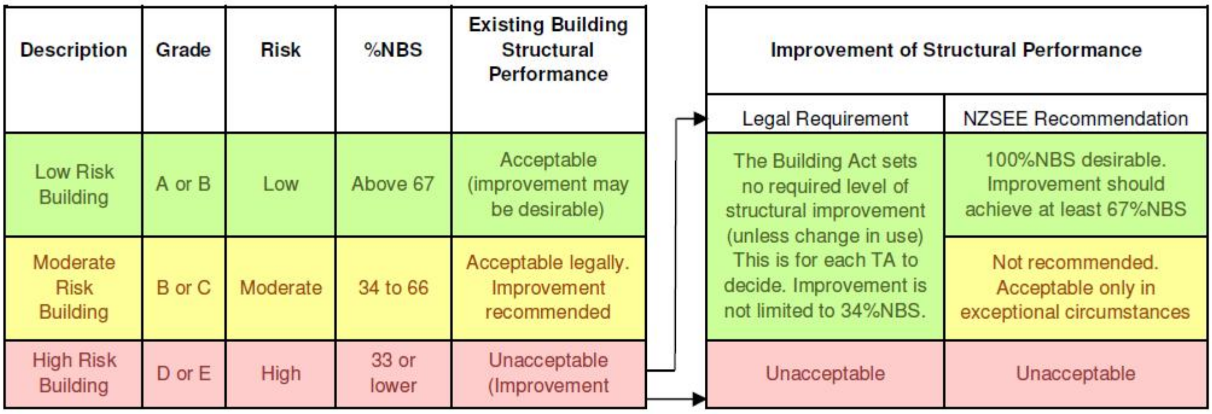
The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

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.

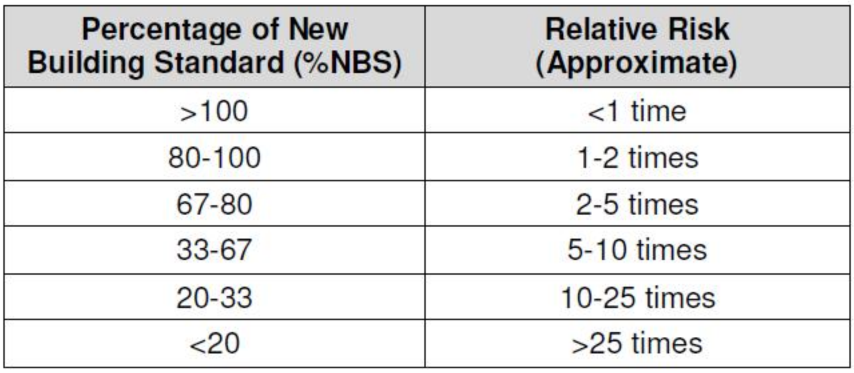


Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless 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

The building is located at 272 Westminster Street. There is only one building on this site. The building has one unoccupied storey. The building has previously primarily been used as recreational space for the sports field nearby. The building is constructed from unreinforced, unfilled masonry walls and a lightweight roof with timber framing. The ground floor appears to be supported on a concrete slab foundation. It is assumed the building was designed and constructed in the 1960s as the masonry is unfilled.

Our evaluation was based on the external visual inspection carried out on 16 April 2012 and a cover meter survey carried out on 26 April 2012. Internal inspection was not able to be carried out as the building was boarded up at the time of the visual inspection. Drawings were not available to verify the foundation system and the date of construction.

5.2. Gravity Load Resisting system

It appears that the gravity loads are taken by the masonry block walls, with direct transfer into the concrete slab foundation below.

5.3. Seismic Load Resisting system

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

Note that for this building the ‘across direction’ has been taken as east-west and the ‘along direction’ has been taken as north-south.

5.4. Geotechnical Conditions

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

- In accordance with NZS1170.5 the site is likely to be seismic subsoil Class D (deep or soft soil) ground performance and properties.
- Liquefaction risk is expected to be low to moderate for the site. However, additional investigations closer to the site are required to confirm this assessment. An estimation of the ground properties for the site has not been made in this desk study.

If a quantitative assessment is to be undertaken, additional investigations recommended are:

- Two boreholes to a minimum depth of 20m. One borehole to be located south east of the existing buildings.
- Three dynamic cone penetration tests to estimate likely properties of the soil near the surface.

6. Damage Summary

SKM undertook an inspection on 16 April 2012. The following areas of damage were observed during the time of inspection:

6.1. General

1) No visual evidence of settlement was noted at this site and this site is classified as TC2 land[2]. Therefore a level survey is not required at this stage of assessment.

6.2. External Damage

1) Step cracking along mortar joints throughout the walls of the building.
2) External concrete floor slab pulling away from the building on the southern side.
3) Cracking along the top lintel on the south wall.
4) Hairline cracks in the foundation.
5) Cracking around door frame and architrave on the east wall.
6) Damage to soffit lining on southern side of building was noted, but it does not appear to be a result of earthquake damage.

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

We note that the building is generally in a state of disrepair. The reinstatement of these areas are not covered in this report and only damage thought to be the cause of the earthquakes have been considered.

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[2] http://cera.govt.nz/maps/technical-categories

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[3].

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 rank 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 20 times that of 100% NBS[4]. Buildings that are identified to be 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[5].

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[3] http://resources.ccc.govt.nz/files/EarthquakeProneDangerousAndInsanitaryBuildingsPolicy2010.pdf

[4] NZSEE 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*, p 2-2

[5] http://resources.ccc.govt.nz/files/EarthquakeProneDangerousAndInsanitaryBuildingsPolicy2010.pdf

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 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 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[6]. 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

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

7.2. Available Information, Assumptions and Limitations

Following our inspection on 16 April 2012, SKM carried out a preliminary structural review. The structural review was undertaken using the available information which was as follows:

- SKM site measurements, cover meter survey and external inspection findings of the building. Please note no intrusive investigations were undertaken.
- There were no drawings available to carry out our review

The following assumptions and design criteria were used in this assessment:

- Standard design assumptions for typical office and factory buildings as described in AS/NZS1170.0:2002
  - 50 year design life, which is the default NZ Building Code design life.
  - Structure Importance Level 2. This level of importance is described as ‘normal’ with medium or considerable consequence of failure.
  - Ductility level of 1 in both directions, 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 external visual inspection of the building. 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.

7.3. Critical Structural Weaknesses

The following potential critical structural weaknesses have been identified:

- Load-bearing unreinforced masonry walls on all sides of the building, due to their low out-of-plane bending capacity and long spans.

7.4. Qualitative Assessment Results

The building has had its capacity assessed using the Initial Evaluation Procedure based on the information available. The buildings capacity is expressed as a percentage of new building standard (%NBS) and are in the order of that shown below in Table 3. This capacity is subject to confirmation by a quantitative analysis.

Table 3: Qualitative Assessment Summary

Item	%NBS
Likely Seismic Capacity of Building	9

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

Further investigation is required to confirm our initial findings and establish possible strengthening concepts.

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 lack of structural drawings and the likely seismic capacity of the building being less than 34% NBS a quantitative assessment will be required. However, given the state of disrepair of the building and the likely cost of strengthening and repairs, it may be more cost-effective to demolish the building instead of strengthening it, as a complex strengthening solution might be required.

If a quantitative assessment is carried out then intrusive investigations will be required to confirm the following structural details:

- Foundation layout and size of elements.
- Structural roof member sizes and layouts.
- Connections sizes and layouts.

A building consent will likely be required to strengthen the building. A building consent may not be required to demolish it.

9. Conclusion

A qualitative assessment was carried out on the building located at 272 Westminster Street, Mairehau. The building has sustained minor damage to the external masonry wall with step cracking along the masonry joints, cracking of the timber doorframe and hairline cracking to concrete elements. The building has been assessed to have a seismic capacity less than 10% NBS and is therefore potentially earthquake prone and is likely to be classified as a 'High Risk Building' (capacity less than 34% of NBS).

Further investigation is required to confirm our initial findings and to establish possible strengthening concepts. This investigation will require carrying out a quantitative assessment on the building to determine if there is enough capacity in the structural elements to resist the required earthquake demand.

However, strengthening of the masonry walls will be complex and it may be more cost effective to demolish the building and replace it with a new structure, if required, that meets current code requirements. If the building is to be strengthened, building consent will likely be required. Building consent may not be required for demolition of the building.

It is recommended that:

a) It is not likely to be cost-effective to carry out a quantitative assessment and strengthening, due to the complex strengthening solution required and the current state of disrepair.

b) 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: East elevation

Photo 2: South elevation

Photo 3: West elevation

Photo 4: North elevation

Photo 5: Existing damage to soffit lining

Photo 6: External ground slab pulling away from south wall

Photo 7: Looking inside the unreinforced block wall on the southern side of the building.

Photo 8: Internal view of building through hole in masonry showing timber-framed ceiling.

	
Photo 9: Hairline cracking in foundation under north wall.	Photo 10: Low-quality pointing between blocks on north wall.
	
Photo 11: Step cracking along mortar joints (typical on all walls).	Photo 12: Cracking in timber doorframe on north wall.

12. Appendix 2 – IEP Reports

Table IEP-1 Initial Evaluation Procedure – Step 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: Westminster Park - Community Building PRK_0657_BLDG_004 EQ2
Location: 272 Westminster Street, Mairehau, Christchurch

Ref. ZB01276.41
By WPK
Date 17/04/2012

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketch of building plan

1.3 List relevant features

Building 4 is a one storey building that is currently unoccupied, but appears to have been previously used as changing rooms for the nearby sports field. The building consists of concrete masonry block walls and a timber-framed roof. The main lateral load-resisting system appear to be the walls. These act as shear walls in the north-south and east-west direction. A cover meter survey of the building found that the masonry walls are unreinforced. The roof structure appears to consist of timber rafters that support a lightweight roof. Internal inspection was not able to be performed as the windows and doors were boarded up, however there was a small opening that allowed viewing of the timber rafters. The block walls appear to be founded on concrete strip footings.

1.4 Note information sources

Tick as appropriate

Visual Inspection of Exterior	☑
Visual Inspection of Interior	☐
Drawings (note type)	☐
Specifications	☐
Geotechical Reports	☑
Other (list)	☑

Cover meter survey

Table IEP-2 Initial Evaluation Procedure – Step 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:	Westminster Park - Community Building PRK_0657_BLDG_004 E	Ref.	ZB01276.41
Location:	272 Westminster Street, Mairehau, Christchurch	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	17/04/2012

(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	a) Rigid	○	N-A
(for 1992 to 2004 only and only if known)	b) Intermediate	○	

c) Estimate Period, T

building Ht = 2.8 meters

	Longitudinal	Transverse	
Ac =	38	25	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 <= 0.4sec	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

Building Name: Westminster Park - Community Building PRK_0657_BLDG_004 E
Location: 272 Westminster Street, Mairehau, Christchurch
Direction Considered: **Longitudinal & Transverse**
(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Ref. ZB01276.41
By WPK
Date 17/04/2012

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 2 ▼
(from NZS1170.0:2004, Table 3.1 and 3.2)

b) Return Period Scaling Factor from accompanying Table 3.1

Factor C	1.00

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	9.3	$(\%NBS)b$
Transverse	9.3	$(\%NBS)b$

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:	Westminster Park - Community Building PRK_0657_BLDG_004 EQ2	Ref.	ZB01276.41
Location:	272 Westminster Street, Mairehau, Christchurch	By	WPK
Direction Considered:	**a) Longitudinal**	Date	17/04/2012

(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

	Severe	Significant	Insignificant		
Effect on Structural Performance	○	○	●	**Factor A**	1
Comment					

3.2 Vertical Irregularity

	Severe	Significant	Insignificant		
Effect on Structural Performance	○	○	●	**Factor B**	1
Comment					

3.3 Short Columns

	Severe	Significant	Insignificant		
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**

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

Building Name:	Westminster Park - Community Building PRK_0657_BLDG_004	Ref.	ZB01276.41
Location:	272 Westminster Street, Mairehau, Christchurch	By	WPK
Direction Considered:	**b) Transverse**	Date	17/04/2012

(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

	Severe	Significant	Insignificant		
Effect on Structural Performance	○	○	●	**Factor A**	1
Comment					

3.2 Vertical Irregularity

	Severe	Significant	Insignificant		
Effect on Structural Performance	○	○	●	**Factor B**	1
Comment					

3.3 Short Columns

	Severe	Significant	Insignificant		
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-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)

Building Name:	Westminster Park - Community Building PRK_0657_BLDG_004 EQ2	Ref.	ZB01276.41
Location:	272 Westminster Street, Mairehau, Christchurch	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	17/04/2012

(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)	9	9
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	1.00	1.00
4.3 PAR x Baseline (%NBS)$_b$	9	9
4.4 Percentage New Building Standard (%NBS) (Use lower of two values from Step 4.3)		9

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

JAMES CARTER Name

1017618 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: Westminster Park - Community Building

Unit / No: / Street

Building Address: 272 Westminster Street

Legal Description:

Degrees / Min / Sec

GPS south:

GPS east:

Building Unique Identifier (CCC): PRK_0657_BLDG_004

Reviewer: **James Carter**

CPEng No: **1017618**

Company: SKM

Company project number: ZB01276.41

Company phone number: 09 928 5500

Date of submission: 30-May

Inspection Date: 16/04/2012

Revision: C

Is there a full report with this summary? yes

Site

Site slope: flat

Soil type:

Site Class (to NZS1170.5): D

Proximity to waterway (m, if <100m):

Proximity to clifftop (m, if < 100m):

Proximity to cliff base (m,if <100m):

Max retaining height (m):

Soil Profile (if available):

If Ground improvement on site, describe:

Approx site elevation (m):

Building

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

Ground floor split? no

Storeys below ground 0

Foundation type: strip footings

Building height (m): 2.80

Floor footprint area (approx): 130

Age of Building (years): 50

Ground floor elevation (Absolute) (m): 2.80

Ground floor elevation above ground (m): 2.80

if Foundation type is other, describe:

height from ground to level of uppermost seismic mass (for IEP only) (m):

Date of design: 1935-1965

Strengthening present? no

Use (ground floor): recreational

Use (upper floors):

Use notes (if required):

Importance level (to NZS1170.5): IL2

If so, when (year)?

And what load level (%g)?

Brief strengthening description:

Gravity Structure

Gravity System: load bearing walls

Roof: timber framed

Floors: timber

Beams: none

Columns: none

Walls: unreinforced concrete masonry

rafter type, purlin type and cladding: Timber rafters & purlins, assume lightweight steel cladding

joist depth and spacing (mm): Unknown

overall depth x width (mm x mm): None

typical dimensions (mm x mm): None

thickness (mm): 200

Lateral load resisting structure

Lateral system along: unreinforced masonry bearing wall - stone

Ductility assumed, μ: 1.00

Period along: 0.40 — 0.40 from parameters in sheet

Total deflection (ULS) (mm): 10

maximum interstorey deflection (ULS) (mm):

Note: Define along and across in detailed report!

note wall thickness and cavity: 200mm

estimate or calculation? estimated

estimate or calculation? estimated

estimate or calculation? estimated

Lateral system across: unreinforced masonry bearing wall - stone

Ductility assumed, μ: 1.00

Period across: 0.40 — 0.00

Total deflection (ULS) (mm): 10

maximum interstorey deflection (ULS) (mm):

note wall thickness and cavity: 200mm

estimate or calculation? estimated

estimate or calculation? estimated

estimate or calculation? estimated

Separations:

north (mm):

east (mm):

south (mm):

west (mm):

leave blank if not relevant

Non-structural elements

Stairs:

Wall cladding: exposed structure — describe: Masonry walls

Roof Cladding:

Glazing:

Ceilings:

Services(list): Unknown

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: partial — original designer name/date:

Damage

Site:
(refer DEE Table 4-2)

Site performance:

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: green

Along — Damage ratio: 0%

Describe (summary): Cracking along mortar joints

Describe how damage ratio arrived at: Current damage noted will not diminish the capacity of the building.

Across — Damage ratio: 0%

Describe (summary): Cracking along mortar joints

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

Diaphragms — Damage?: no — Describe:

CSWs: — Damage?: no — Describe:

Pounding: — Damage?: no — Describe:

Non-structural: — Damage?: yes — Describe: Minor cracking to masonry walls and timber doorframe.

Recommendations

Level of repair/strengthening required: significant strengthening — Describe: Or demolition. May not be cost-effective to perform quantitative analysis and carry out the significant strengthening required.

Building Consent required: yes — Describe: Building consent may not be required for demolition.

Interim occupancy recommendations: full occupancy — Describe: Not an immediate collapse hazard.

Along — Assessed %NBS before: 9% — %NBS from IEP below

Assessed %NBS after: 9%

If IEP not used, please detail assessment methodology: Qualitative Assessment carried out includes NZSEE IEP (refer to SKM report).

Across — Assessed %NBS before: 9% — %NBS from IEP below

Assessed %NBS after: 9%

14. Appendix 4 – Geotechnical Desktop Study

Sinclair Knight Merz
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Saint Albans
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Christchurch, New Zealand

Tel: +64 3 940 4900
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	041 to 042 inclusive
Address	264 Westminster St
Report date	03 April 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), 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:

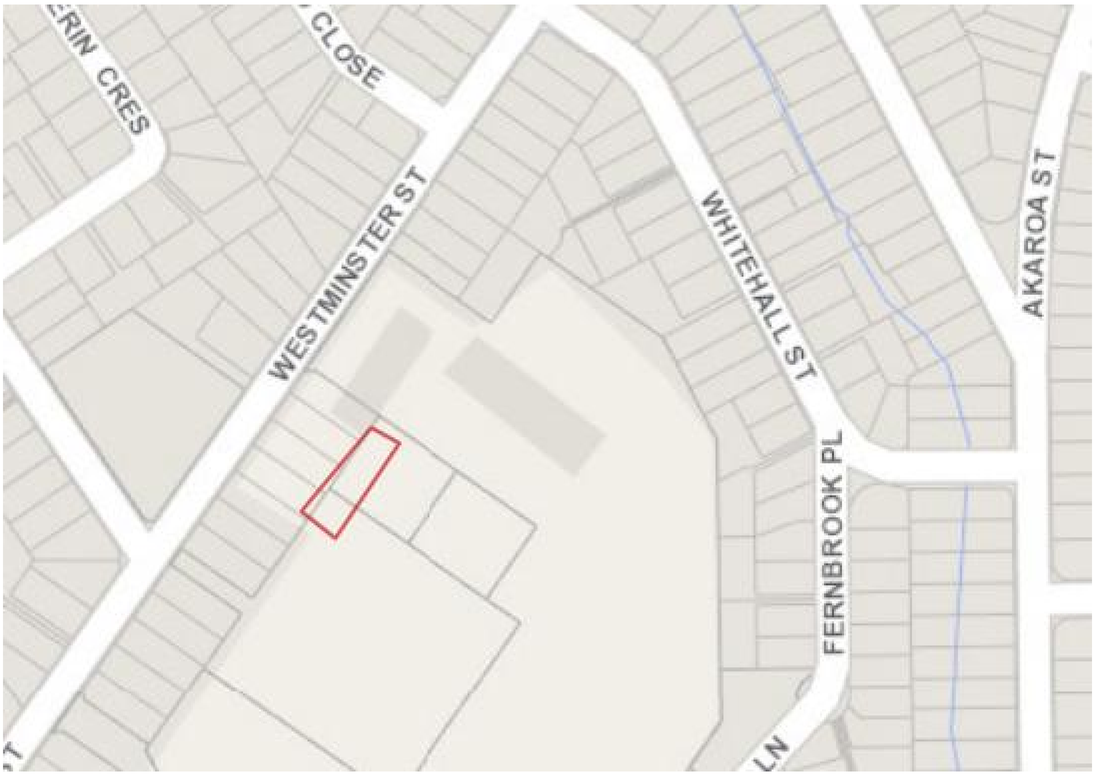
- Published geology
- Publically available borehole records
- Liquefaction records
- Aerial photography
- Council files
- A preliminary site walkover

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.

6. Site location



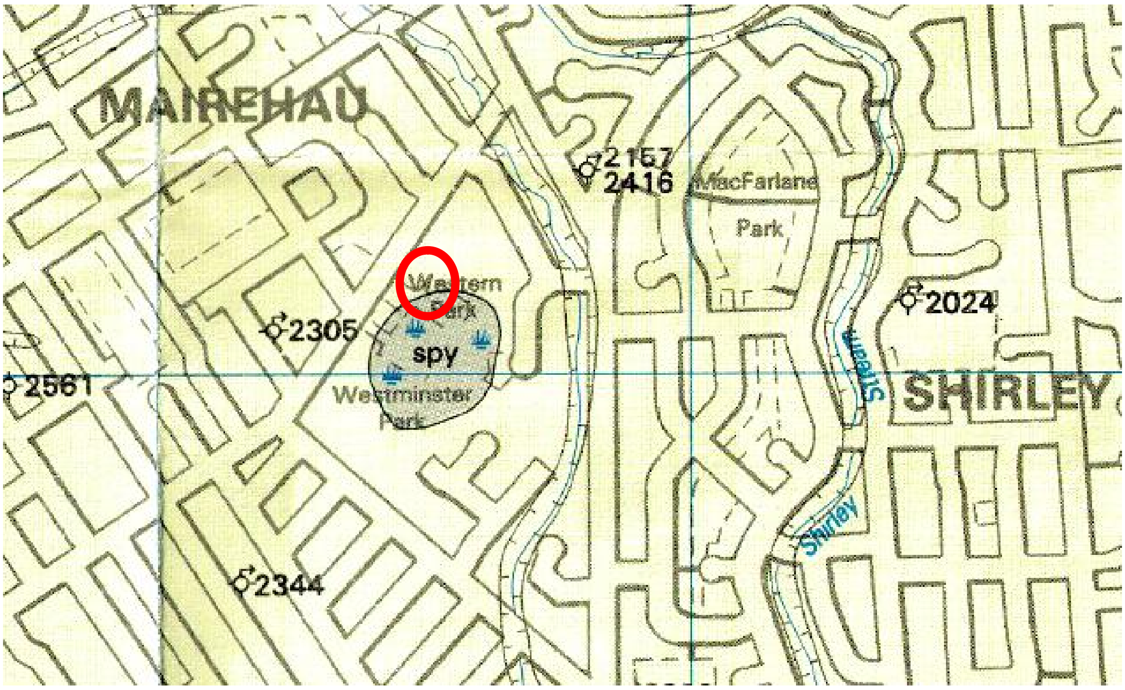
- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

The structures are located on 264 Westminster St at grid reference 1571472 E, 5183547 N (NZTM).

7. Review of available information

7.1 Geological maps

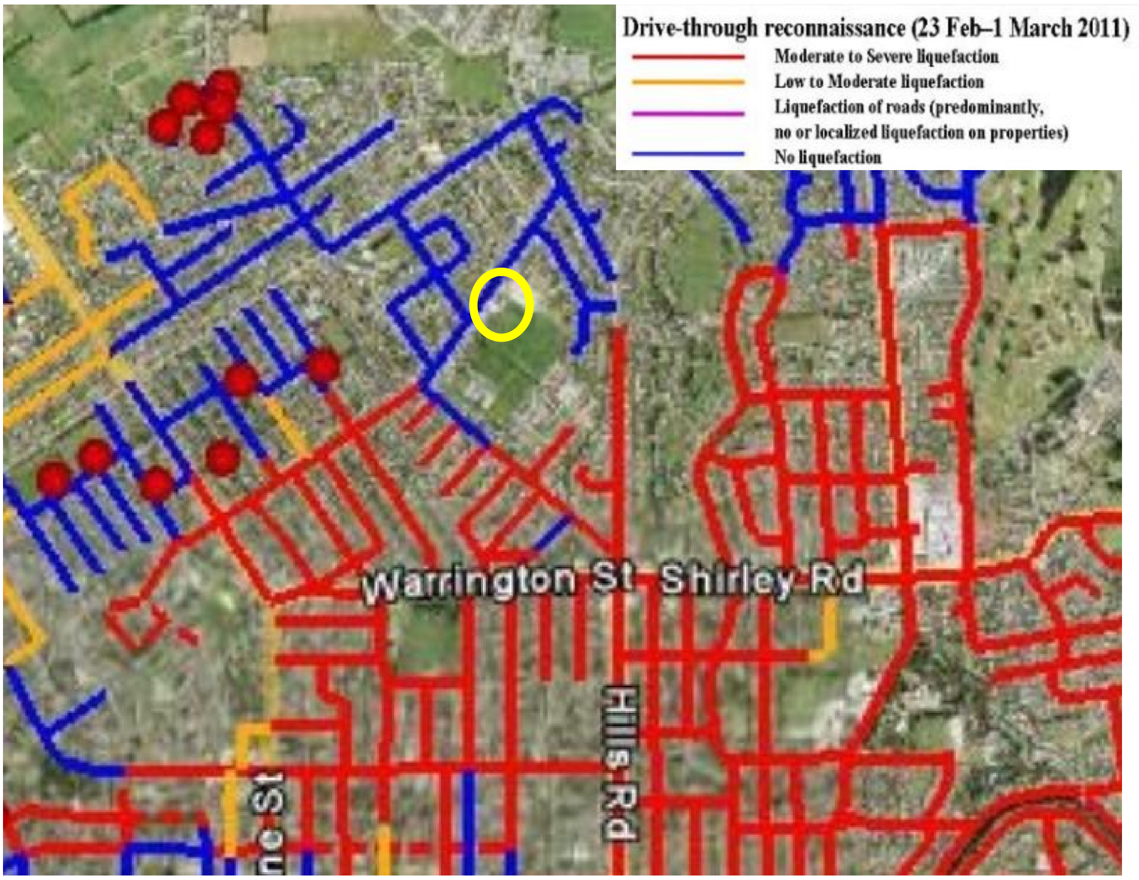
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



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

Most of the site is shown to be underlain by Holocene deposits comprising predominantly alluvial sand and silt over bank deposits of the Springston Formation. The ground immediately south east of the site is shown to be underlain by peat swamp deposits, now drained, of the Springston Formation.

7.2 Liquefaction map



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

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 no liquefaction at this site.

7.3 Aerial photography

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

The dark patches at the front of the property may be evidence of liquefied material and pore water being ejected to the surface. Similar dark patches were observed from aerial photographs taken after the September 2010, June 2011 and December 2011 earthquake events. As no liquefaction was observed in the mapping exercise the dark colouration may also be water from a broken water main or leaking hydrant.

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 surrounding the site classed as TC2

7.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the site was recorded as grassland in1856. However, as geological maps show some areas near the site to be underlain by swamp deposits, it is possible some of the site used to be swamp or marshland. These areas are likely to be underlain by soft deposits including potentially compressible peat deposits.

7.6 Existing ground investigation data

- **Figure 6 – 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

The available council property files pertain to the reworking of the Westminster drain. The work includes naturalising the drain by using an open channel with sloping side embankments replacing the existing pipe and timber supported open channel drain.

Council records show significant earthworks were proposed in constructing the new drain. However, no record on the material excavated was found in the available council records. Additionally, no information regarding the community building or underlying ground conditions was found during the review of council files.

The drawings for the proposed drain show the sides of the channel to slope at a grade of 1V:3H to 1V:2.5H. Additionally the drawings show up to 300mm of top soil on the slopes of the channel and AP40 compacted layer used at the base of the channel. An Amoco 4550 Geotextile is shown to be installed under the AP40 compacted layer.

7.8 Site walkover

An engineer from SKM undertook a site walkover in the week commencing 12 March 2012.

Both of the buildings on site were concrete and metal roof constructions. Some cracks in the walls of buildings were observed during the external inspection of the site. The windows on both of the building were boarded up but it is unknown if this is a result of earthquake damage. There were no signs that liquefaction occurred at the site. The site was asphalted to the NW, with large playing field to the SE of the building. There was no obvious land damage on site.

- **Figure 7 Observed cracks in the Westminster Street community building**

- **Figure 8 Overview of the Westminster community building**

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 – 3	Sensitive fine grained soils (clay or silt) and peat deposits.
3 – 5	Firm clays, silty clays and clayey silts.
5 -9	Medium dense sand and silty sand.
9 - 25+	Dense sand.

However, it should be noted that most of the available investigation data were located a significant distance away from the site. Additionally, a different underlying geology immediately south east of the site was inferred from the local geological maps. Therefore, additional investigations near the site would be needed to confirm the boundary of the swamp peat deposits present south east of the site.

8.2 Seismic site subsoil class

In accordance with NZS1170.5 the site is likely to be seismic subsoil Class D (deep or soft soil) from adjacent borehole logs. It should be noted the nearest borehole log is 90m from the site and therefore it is possible to site could be subsoil Class E.

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 however the distance to the nearest ground investigation information is 90m. It is therefore possible that site specific investigation could revise the site class.

8.3 Building Performance

Although detailed records of the existing foundations are not available, the performance to date suggests that they are adequate for their current purpose.

8.4 Ground performance and properties

Liquefaction risk is expected to be low to moderate for the site. However, additional investigations closer to the site are required to confirm this assessment. An estimation of the ground properties for the site has not been made in this desk study. Most of the available investigation data are located at a significant distance away from the site. Additionally, there are uncertainties regarding the underlying geology due to the presence of swamp deposits immediately south east of the site. Therefore, additional investigations are required in order to provide an estimate of the ground properties.

8.5 Further investigations

Additional investigations recommends are:

- Two boreholes to a minimum depth of 20m. One borehole to be located south east of the existing buildings
- Three dynamic cone penetration tests to estimate likely properties of the soil near the surface

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.

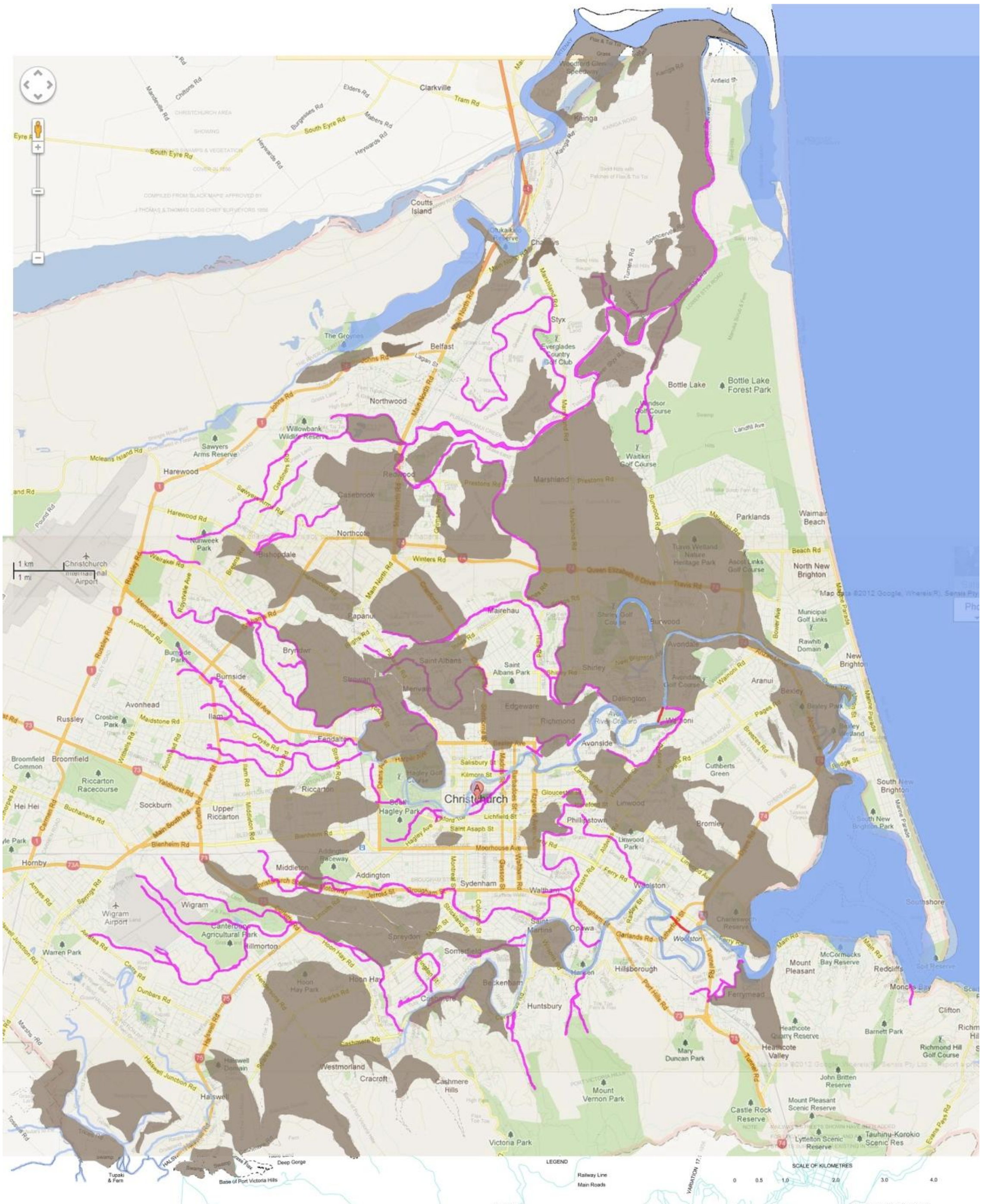
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

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



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

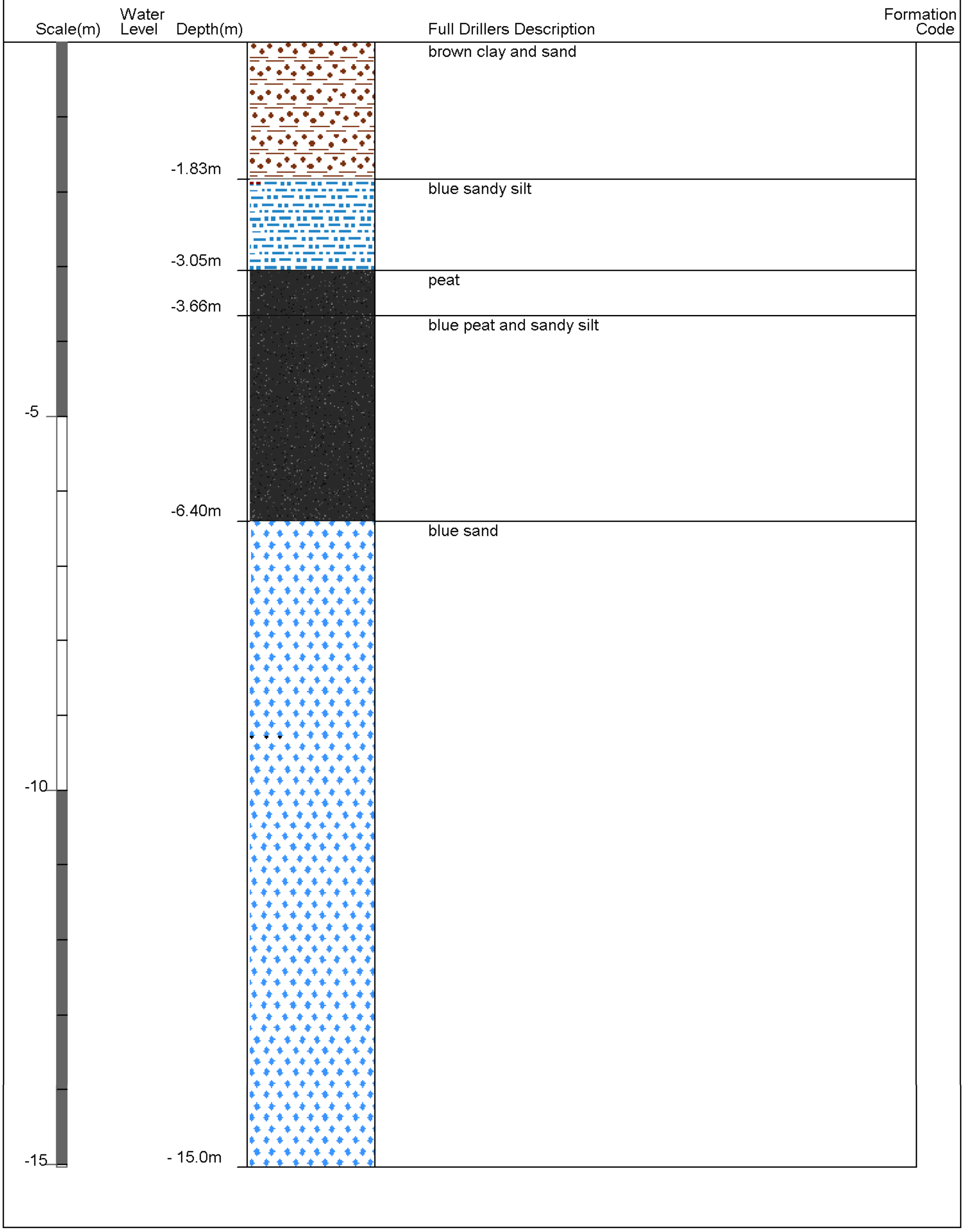
Key

🟪 Previous creeks/rivers
🟦 Existing creeks/rivers
🟥 New creeks/rivers
🟫 Swamp/Marshland

11. Appendix B – Existing ground investigation logs

Borelog for well M35/13177

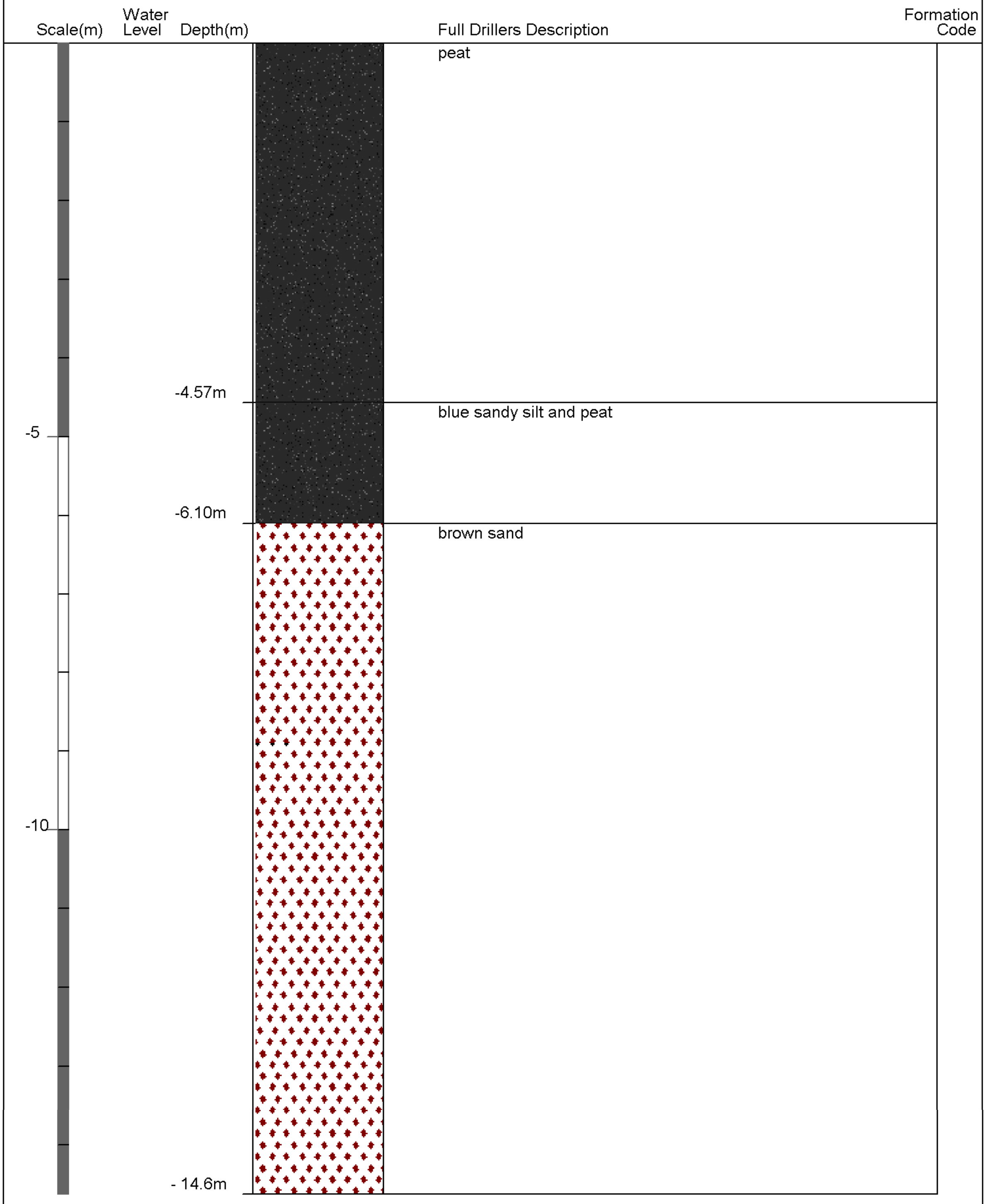
Gridref: M35:81232-45318 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.27 +MSD
Well name : CCC BorelogID 1444
Drill Method : Not Recorded
Drill Depth : -15.04m Drill Date : 1/01/1956



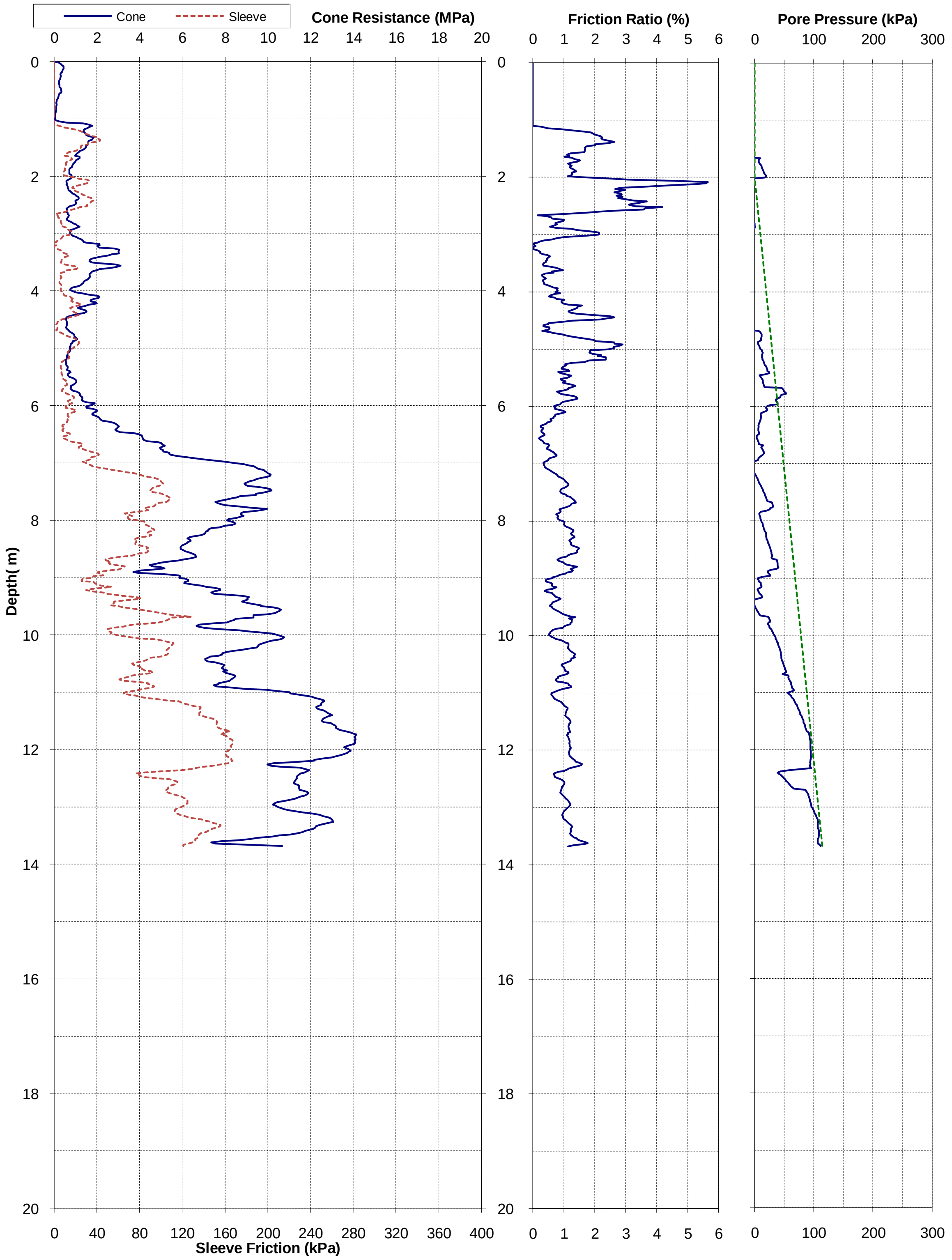
Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-1.83m	brown clay and sand	
		-3.05m	blue sandy silt	
		-3.66m	peat	
		-6.40m	blue peat and sandy silt	
		- 15.0m	blue sand	

Borelog for well M35/13184

Gridref: M35:81388-45149 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.12 +MSD
Well name : CCC BorelogID 1451
Drill Method : Not Recorded
Drill Depth : -14.63m Drill Date : 1/01/1956

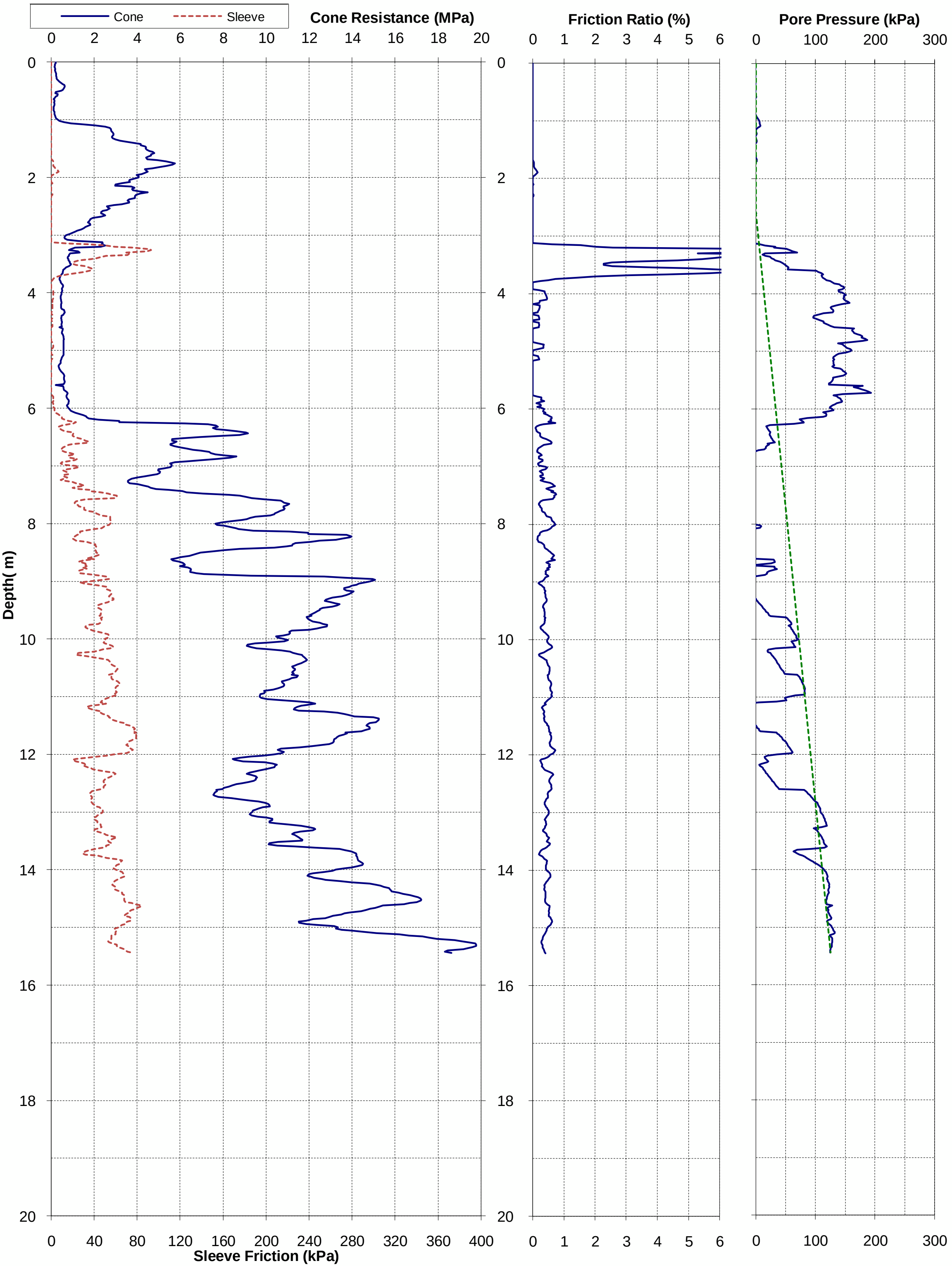


Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			**Page:** 1 of 1	**CPT-STA-57**
Test Date:	25-May-2011	**Location:**	St Albans	**Operator:**	Geotech
Pre-Drill:	1.2m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS
Position:	2481801.4mE	5744879.2mN	5.35mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	



T+T Ref: 52000.3000 Printed: 12/08/2011 11:07 a.m. Template: CPT Graph Template v0.41.xls

Project:	Christchurch 2011 Earthquake - EQC Ground Investigations	**Page:**	1 of 1	**CPT-SHY-21**	
Test Date:	20-Jun-2011	**Location:**	Shirley	**Operator:**	Geotech
Pre-Drill:	1.2m	**Assumed GWL:**	2.6mBGL	**Located By:**	Survey GPS
Position:	2481842.9mE	5745056.1mN	5.43mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	



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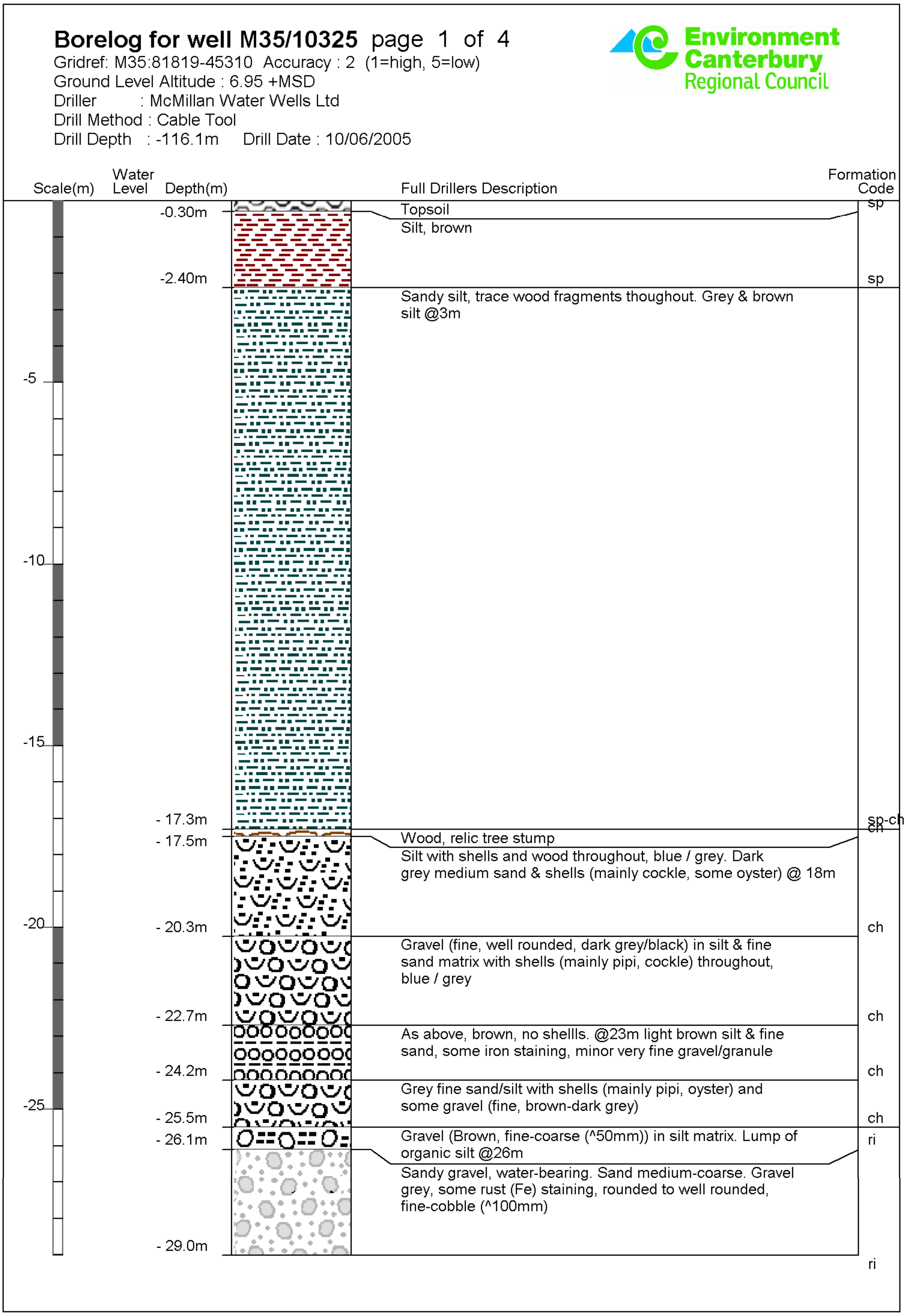


Borelog for well M35/10325 page 1 of 4

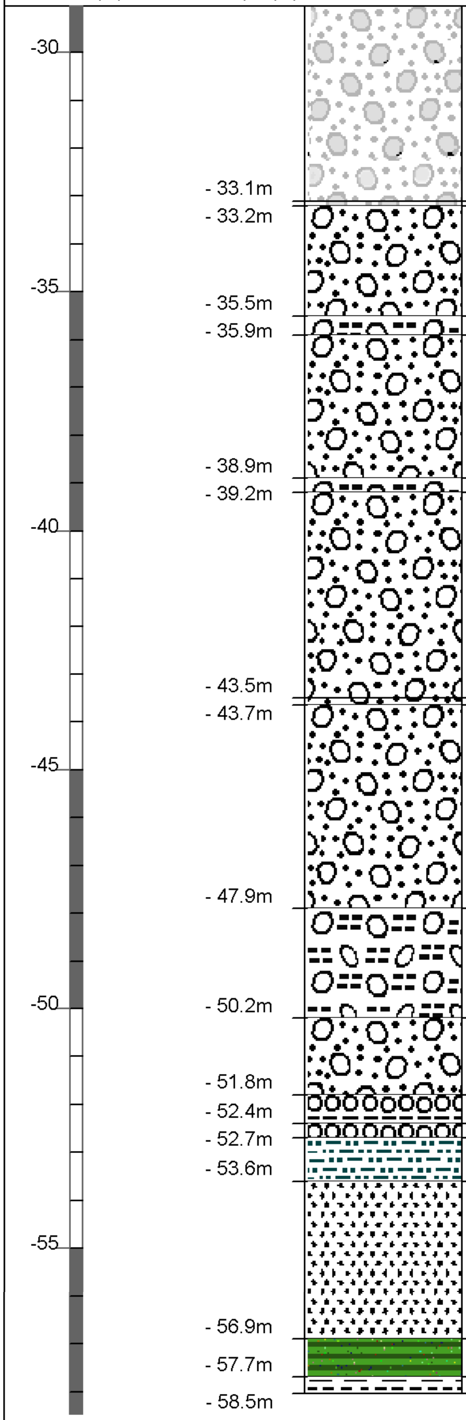
Gridref: M35:81819-45310 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.95 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -116.1m Drill Date : 10/06/2005

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.30m	Topsoil	sp
		-2.40m	Silt, brown	sp
-5 -10 -15		- 17.3m	Sandy silt, trace wood fragments thoughout. Grey & brown silt @3m	sp-ch
		- 17.5m	Wood, relic tree stump	ch
-20		- 20.3m	Silt with shells and wood throughout, blue / grey. Dark grey medium sand & shells (mainly cockle, some oyster) @ 18m	ch
		- 22.7m	Gravel (fine, well rounded, dark grey/black) in silt & fine sand matrix with shells (mainly pipi, cockle) throughout, blue / grey	ch
		- 24.2m	As above, brown, no shellls. @23m light brown silt & fine sand, some iron staining, minor very fine gravel/granule	ch
-25		- 25.5m	Grey fine sand/silt with shells (mainly pipi, oyster) and some gravel (fine, brown-dark grey)	ch
		- 26.1m	Gravel (Brown, fine-coarse (^50mm)) in silt matrix. Lump of organic silt @26m	ri
		- 29.0m	Sandy gravel, water-bearing. Sand medium-coarse. Gravel grey, some rust (Fe) staining, rounded to well rounded, fine-cobble (^100mm)	ri

Borelog for well M35/10325 page 2 of 4

Gridref: M35:81819-45310 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.95 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -116.1m Drill Date : 10/06/2005

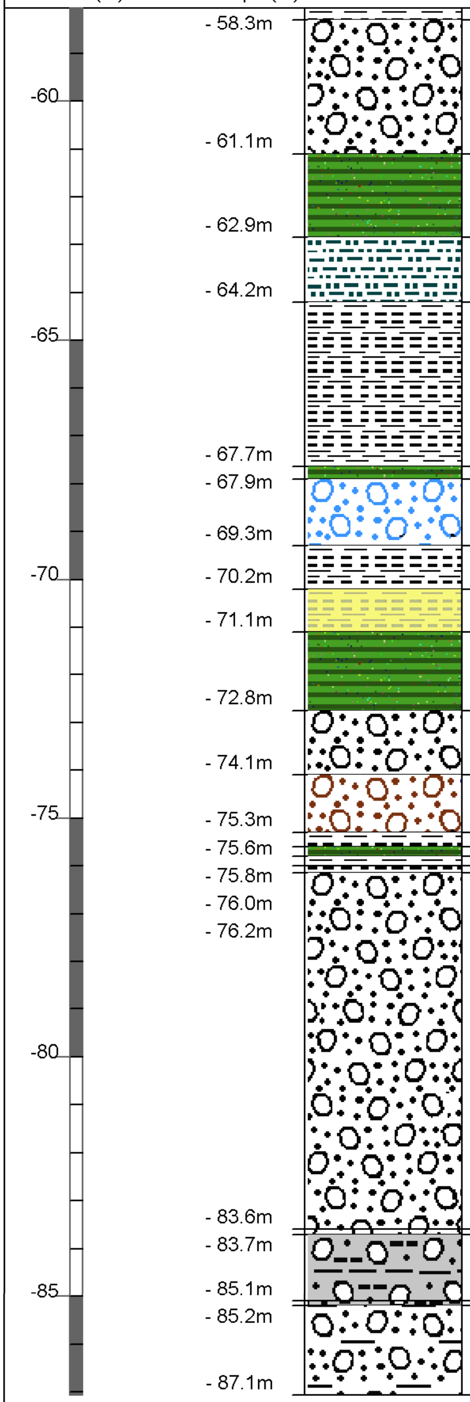
Environment Canterbury
Regional Council



Water Level	Depth(m)	Full Drillers Description	Formation Code
	- 33.1m	Sandy gravel, water-bearing. Sand medium-coarse. Gravel grey, some rust (Fe) staining, rounded to well rounded, fine-cobble (^100mm)	ri
	- 33.2m	Some gravel in yellow/brown silt matrix. Gravel brown, fine-cobble (^110mm), rounded	ri
	- 35.5m	Sandy gravel , water-bearing. Sand medium-very coarse. Gravel brownish-grey, fine-coarse (^50mm), rounded-well rounded	ri
	- 35.9m	Gravel in silt matrix, yellow	ri
	- 38.9m	Sandy gravel, water-bearing, grey, iron staining. @37.7m light brown-orange clay/silt layer. @38m Gravel brown, fine-cobble (^120mm), brown-black stained, rounded-well rounded.	ri
	- 39.2m	Gravel in light brown- orange silt/clay matrix. Gravel grey/brown, fine-coarse, rounded-well rounded	ri
	- 43.5m	Medium-coarse sandy fine-coarse grey gravel with much brown/black staining. Water-bearing.	ri
	- 43.7m	Gravel in yellow/brown silt & medium sand matrix. Gravel brown/grey, fine-coarse (^70mm).	ri
	- 47.9m	Sandy gravel, water-bearing, grey / brown. Gravel fine-cobble(>80mm), rounded-well rounded.	ri
	- 50.2m	Gravel in bright yellow silt matrix. Gravel fine-coarse, brown with some orange rust stain.	ri
	- 51.8m	Sandy gravel, water-bearing, grey / brown. Clay/silt trace. Sand fine-coarse. Gravel fine-coarse (^40mm), rounded-well rounded	ri?
	- 52.4m	Fine gravel in yellow/brown-orange silt matrix	br
	- 52.7m	Some fine grey/brown Gravel in grey very soft silt with some fine sand matrix.	br
	- 53.6m	Yellow & grey fine sand and some clay/silt	br
	- 56.9m	Fine Sand, brown	br
	- 57.7m	Silt/clay with organic material (peat), hard, blue/grey. @57.1m, peat + grey silt (some laminated). @57.5 light yellow/brown fine sandy silt/clay with trace organic material.	br
	- 58.5m		br

Borelog for well M35/10325 page 3 of 4

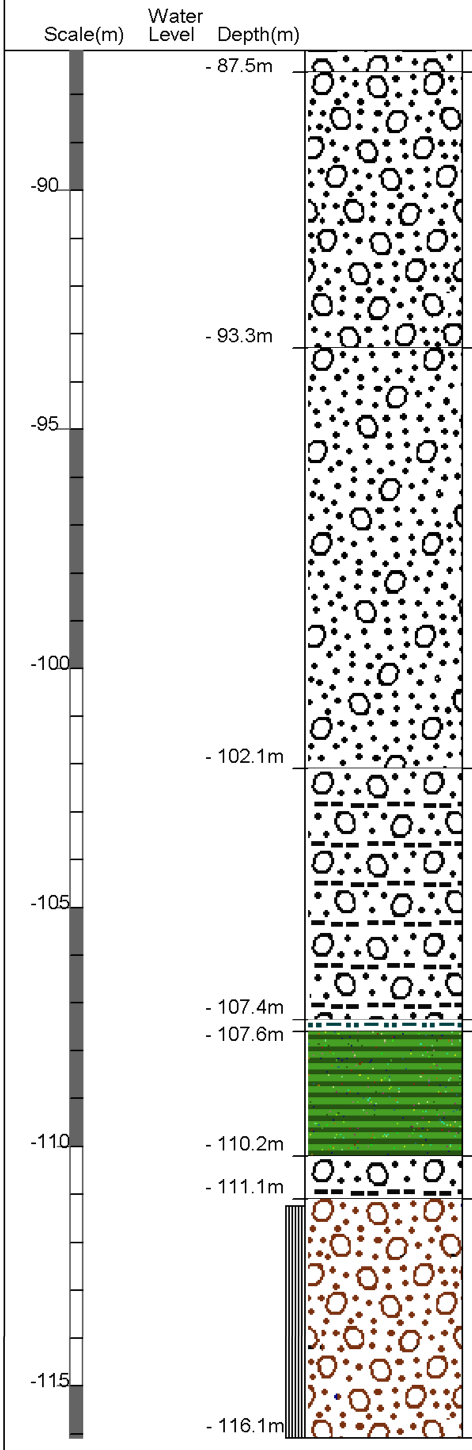
Gridref: M35:81819-45310 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.95 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -116.1m Drill Date : 10/06/2005



Depth(m)	Full Drillers Description	Formation Code
- 58.3m	Silt / clay, hard, white	br
- 61.1m	Sandy gravel, water-bearing, grey/brown with rust staining common. Sand medium-coarse. Gravel fine-coarse (^75mm), rounded-well rounded.	li-1
- 62.9m	Dark grey Silt / clay with grey/black organic material (peat), hard	li-2
- 64.2m	Silty sand, blue / grey	li-2
- 67.7m	Silt / clay, blue / grey, soft	li-2
- 67.9m	Grey-grey/brown Silt / clay with organic material (peat) (check for beetle remains???)	li-2
- 69.3m	Sandy gravel, blue, some iron staining, fine-cobble (^100mm) rounded-well rounded.	li-2
- 70.2m	Silt / clay, blue / grey, soft	li-2
- 71.1m	Silt / clay, yellow, soft-stiff	li-2
- 72.8m	Silt / clay with organic material (peat), grey/brown, soft-firm	li-2
- 74.1m	Fine-medium Sandy grey/brown fine-coarse gravel, rounded-well rounded	li-2
- 75.3m	Sandy gravel, water-bearing, brown	li-2
- 75.6m	Yellow/brown Silt / clay, firm-stiff	li-2
- 75.8m	Silt / clay with organic material (peat), grey, soft	li-3
- 76.0m	Yellow/brown fine-medium sand and silt.	li-3
- 76.2m	Silt / clay with organic material (peat), grey, stiff	li-2
- 83.6m	Gravel with sand, water-bearing, brown / grey. @77m gravel fine-cobble (^150mm), rounded-well rounded, Sand fine-coarse.	li-3
- 83.7m	@83.6m light yellow/brown + dark brown soft Silt/clay. @83.7m Dark brown (organic?) soft silt/clay	li-2
- 85.1m	Gravel and peat, blue	li-3
- 85.2m	Yellow + grey orange mottled fine sandy silt	li-2
- 87.1m	Fine-coarse iron stained brown Gravel with sand and traces of silt/clay. Gravel rounded-well rounded.	li-3

Borelog for well M35/10325 page 4 of 4

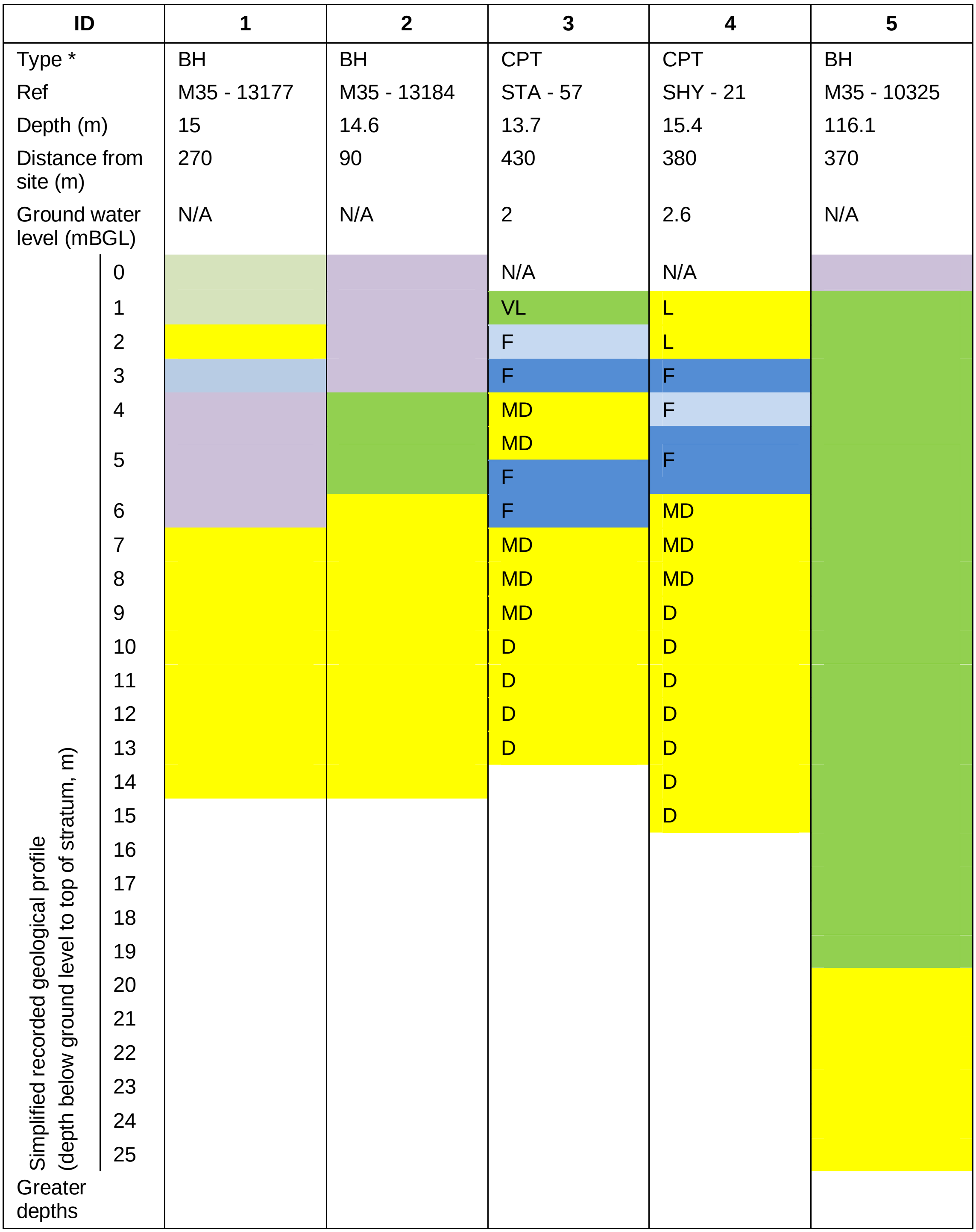
Gridref: M35:81819-45310 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.95 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -116.1m Drill Date : 10/06/2005



Depth(m)	Full Drillers Description	Formation Code
- 87.5m	Fine-coarse iron stained brown Gravel with sand and traces of silt/clay. Gravel rounded-well rounded.	li-3
	Gravel with sand , water-bearing, brown/grey . @ 87.75m Gravel brown/grey, fine-cobble (^110mm), rounded-well rounded. Sand fine-coarse. @89.9m gravel brown/grey, fine (some coarse up to 45mm), rounded-well rounded. Sand fine-coarse. Clay trace.	
- 93.3m	Sand with some gravel, brown. Sand fine @98m	li-3
- 102.1m	Gravel in silt and sand matrix, brown. @104m gravel brown, fine-cobble (^140mm), rounded-well rounded. Sand brown, fine-medium.	he
- 107.4m	Grey & yellow Silt/fine sand, some lamination, stiff. Trace organic material????	he
- 107.6m	As above , blue with peat fragments throughout. @107.7 grey silt, not laminated. @110m silt/clay grey + yellow/brown + dark orange/brown (+ organic matter?)	he
- 110.2m	Gravel in yellow to orange silty sand matrix. Gravel brown with brown staining, fine-coarse (<80mm), rounded-well rounded. Sand fine-medium	he
- 111.1m	Gravel with sand, water-bearing, brown	bu
- 116.1m		bu

12. Appendix C – Geotechnical Investigation Summary

- **Table 1 Summary of most relevant investigation data**



ID	1	2	3	4	5
Type *	BH	BH	CPT	CPT	BH
Ref	M35 - 13177	M35 - 13184	STA - 57	SHY - 21	M35 - 10325
Depth (m)	15	14.6	13.7	15.4	116.1
Distance from site (m)	270	90	430	380	370
Ground water level (mBGL)	N/A	N/A	2	2.6	N/A
Simplified recorded geological profile (depth below ground level to top of stratum, m) 0	▤	🟪	N/A	N/A	🟪
1	▤	🟪	🟩 VL	🟨 L	🟩
2	🟨	🟪	▥ F	🟨 L	🟩
3	▥	🟪	🟦 F	🟦 F	🟩
4	🟪	🟩	🟨 MD	▥ F	🟩
5	🟪	🟩	🟨 MD 🟦 F	🟦 F	🟩
6	🟪	🟨	🟦 F	🟨 MD	🟩
7	🟨	🟨	🟨 MD	🟨 MD	🟩
8	🟨	🟨	🟨 MD	🟨 MD	🟩
9	🟨	🟨	🟨 MD	🟨 D	🟩
10	🟨	🟨	🟨 D	🟨 D	🟩
11	🟨	🟨	🟨 D	🟨 D	🟩
12	🟨	🟨	🟨 D	🟨 D	🟩
13	🟨	🟨	🟨 D	🟨 D	🟩
14	🟨	🟨		🟨 D	🟩
15				🟨 D	🟩
16					🟩
17					🟩
18					🟩
19					🟩
20					🟨
21					🟨
22					🟨
23					🟨
24					🟨
25					🟨
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