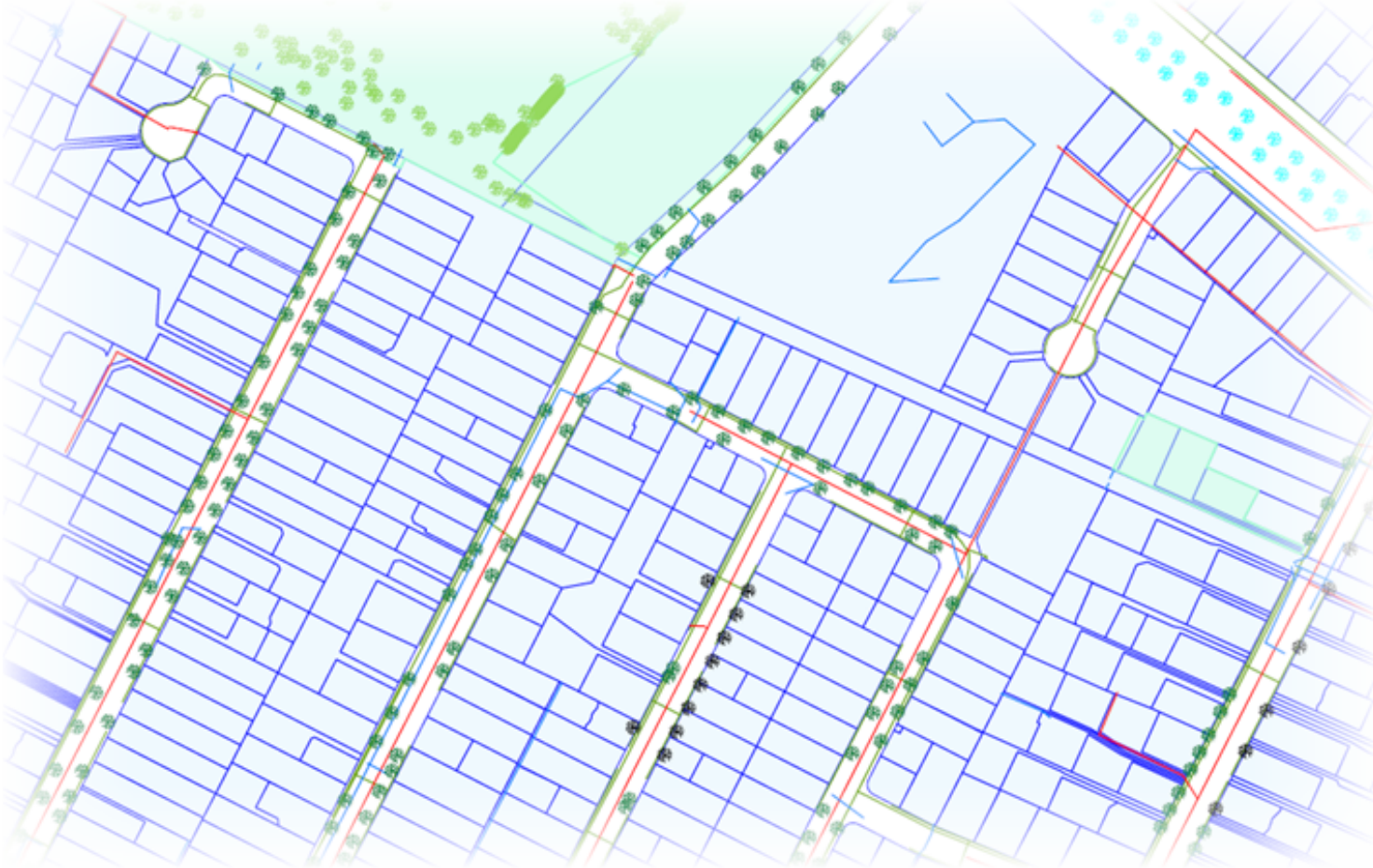
Christchurch City Council

Land Information Memorandum



Property address:
12 Cameo Grove

Christchurch City Council
53 Hereford Street, PO Box 73015
Christchurch 8154, New Zealand
Tel 64 3 941 8999
Fax 64 3 941 8984
www.ccc.govt.nz

LIM number: 70235897

Land Information Memorandum

Christchurch City Council

Application details

Please supply to	PROFESSIONALS CHRISTCHURCH 33 HALSWELL ROAD HORNBY CHRISTCHURCH 8025
Client reference	
Phone number	338 5924
Fax number	
Date issued	10 September 2020
Date received	9 September 2020

Property details

Property address	12 Cameo Grove
Valuation roll number	21852 70301
Valuation information	Capital Value: $6320000 Land Value: $6300000 Improvements Value: $20000 *Please note: these values are intended for Rating purposes*
Legal description	Lot 4 DP 420075 Lot 46 DP 431366
Existing owner	CDL Land New Zealand Limited PO Box 3248 Auckland 1140

Council references

Debtor number	4124228
Rate account ID	73163321
LIM number	70235897
Property ID	1163602

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Document information

This Land Information Memorandum (LIM) has been prepared for the purpose of section 44A of the Local Government Official Information and Meetings Act 1987 (LGOIMA). It is a summary of the information that we hold on the property. Each heading or "clause" in this LIM corresponds to a part of section 44A.

Sections 1 to 10 contain all of the information known to the Christchurch City Council that must be included under section 44A(2) LGOIMA. Any other information concerning the land as the Council considers, at its discretion, to be relevant is included at section 11 of this LIM (section 44A(3) LGOIMA). If there are no comments or information provided in these sections this means that the Council does not hold information on the property that corresponds to that part of section 44A.

The information included in this LIM is based on a search of Council records only and there may be other information relating to the land which is unknown to the Council. Please note that other agencies may also hold information relevant to the property, or administer legislation relevant to the use of the land, for example, the Regional Council (Ecan), Heritage New Zealand Pouhere Taonga, and Land Information New Zealand.

Council records may not show illegal or unauthorised building or works on the property. The applicant is solely responsible for ensuring that the land is suitable for a particular purpose.

A LIM is only valid at the date of issue as information is based only upon information the Council held at the time of that LIM request being made.

Property file service

This Land Information Memorandum does not contain all information held on a property file. Customers may request property files by phoning the Council's Customer Call Centre on (03) 941 8999, or visiting any of the Council Service Centres. For further information please visit www.ccc.govt.nz .

To enable the Council to measure the accuracy of this LIM document based on our current records, we would appreciate your response should you find any information contained therein which may be considered to be incorrect or omitted. Please telephone the Customer Call Centre on (03) 941 8999.

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A search of records held by the Council has revealed the following information:

1. Special features and characteristics of the land

Section 44A(2)(a) LGOIMA. This is information known to the Council but not apparent from the district scheme under the Town and Country Planning Act 1977 or a district plan under the Resource Management Act 1991. It identifies each (if any) special feature or characteristic of the land concerned, including but not limited to potential erosion, avulsion, falling debris, subsidence, slippage, alluvion, or inundation, or likely presence of hazardous contaminants.

(For enquiries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

- **Consultant Report Available**

  Land Information New Zealand (LINZ) engaged Tonkin and Taylor to provide a Geotechnical Report on Ground Movements that occurred as a result of the Canterbury Earthquake Sequence. The report indicates this property may have been effected by a degree of earthquake induced subsidence. The report obtained by LINZ can be accessed on their website at https://www.linz.govt.nz/land/surveying/earthquakes/canterbu ry-earthquakes/information-for-canterbury-surveyors

- **Coastal Hazard Inundation**

  The Council has a report, Coastal Hazard Assessment for Christchurch and Banks Peninsula (2017), that indicates this property or part of this property may be susceptible to coastal inundation (flooding by the sea). The 2017 report considers four sea level rise scenarios through to the year 2120. A copy of the 2017 report and other coastal hazard information can be found at www.ccc.govt.nz/coastalhazards.

- **Liquefaction Vulnerability**

  Christchurch City Council holds indicative information on liquefaction hazard for Christchurch. Information on liquefaction, including an interactive web tool, can be found on the Council website at ccc.govt.nz/liquefaction. Depending on the liquefaction potential of the area that the property is in, the Council may require site-specific investigations before granting future subdivision or building consent for the property.

- **Pool**

  PoolID Number: 4806. This property has a Private Above Ground Swimming Pool which is Empty.

Related information

- There is attached a soil investigation report for this property.

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2. Private and public stormwater and sewerage drains

Section 44A(2)(b) LGOIMA. This is information about private and public stormwater and sewerage drains as shown in the Council's records.

(For stormwater and sewerage enquiries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

Related information

- No up-to-date drainage plan is available for the development of this site. However, the installation of a water connection along with sewer and stormwater drains is checked by the Council prior to the issue of a Code Compliance Certificate.
- The Council's records show a public stormwater pipe passing through the site.
- The Council's records show a private sewer pipeline passing through the site.

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3. Drinking Water Supply

Section 44A(2)(ba) and (bb) LGOIMA. This is information notified to the Council about whether the land is supplied with drinking water, whether the supplier is the owner of the land or a networked supplier, any conditions that are applicable, and any information the Council has about the supply.

Please note the council does not guarantee a particular water quality to its customers. If you require information on current water quality at this property please contact the Three Waters & Waste Unit.

(For water supply queries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

Water Supply

Christchurch City Council is the networked supplier of water to this property. This property is connected to the Christchurch City Council Water Supply. The conditions of supply are set out in the Christchurch City Council Water Supply, Wastewater & Stormwater Bylaw (2014), refer to www.ccc.govt.nz.

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4. Rates

Section 44A(2)(c) LGOIMA. This is information on any rates owing in relation to the land.

(For rates enquiries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

(a) Annual rates

Annual rates to 30/06/2021: $ 35,704.71

	Instalment Amount	Date Due
Instalment 1	$ 8,926.12	31/08/2020
Instalment 2	$ 8,926.12	30/11/2020
Instalment 3	$ 8,926.12	28/02/2021
Instalment 4	$ 8,926.35	31/05/2021

Rates owing as at 10/09/2020: $ 0.00

(b) Excess water charges

$ 0.00

(For water charge enquiries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

(c) Final water meter reading required?

No Reading Required

(To arrange a final water meter reading, please phone (03) 941 8999 or visit www.ccc.govt.nz.

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5. Consents, certificates, notices, orders, or requisitions affecting the land and buildings

*Section 44A(2)(d) LGOIMA. This is information concerning any consent, certificate, notice, order, or requisition, affecting the land or any building on the land, previously issued by the Council.*The information in this section may also cover building consent and/or code compliance information issued by building certifiers under the Building Act 1991 and building consent authorities that are not the Council under the Building Act 2004.

You can check the property file to identify whether any consent or certificate was issued by a building certifier under the Building Act 1991.

Section 44A(2)(da) LGOIMA. The information required to be provided to a territorial authority under section 362T(2) of the Building Act 2004. There is currently no information required to be provided by a building contractor to a territorial authority under section 362T(2) of the Building Act 2004. The Building (Residential Consumer Rights and Remedies) Regulations 2014 only prescribed the information that must be given to the clients of a building contractor.

(For building enquiries, please phone (03) 941 8999, email EPADutyBCO@ccc.govt.nz or visit www.ccc.govt.nz.

(a) Consents

- BCN/2020/8241 Applied: 24/07/2020 Status: Completed
  14 Cameo Grove Burwood
  Exemption from building consent approved 28/07/2020
  Retaining wall - between 1.40m and 1.75m in height as part of the civil works for the underlying Prestons Park subdivision.

(b) Certificates

Note: Code Compliance Certificates were only issued by the Christchurch City Council since January 1993.

(c) Notices

- Placards issued under the Civil Defence Emergency Management Act 2002 as a result of the 4 September 2010 and 22 February 2011 earthquakes have now expired (by 12 July 2011 if not before). Some civil defence placards were replaced with dangerous building notices issued under section 124 Building Act 2004, and where this has happened the section 124 notice is separately recorded. Many other buildings, although not issued with a section 124 notice, may require structural work or other repairs before they can be occupied again. It is the building owners responsibility to make sure the building is safe for any occupier or visitor. Detailed structural engineering assessments may still be required to be carried out.
- CDB75010064 01/03/2011
  Building Evaluation : Building Inspected Under Civil Defence Emergency , Green Placard Issued (a deemed Building Act notice)
- CDB75010064 24/02/2011
  Building Evaluation : Building Inspected Under Civil Defence Emergency , Red Placard Issued (a deemed Building Act notice)

(d) Orders

(e) Requisitions

Related information

- Council holds no record of building permit/consent for dwelling at this address. No information is held by Council relating to the materials, construction or year the dwelling was built.

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6. Certificates issued by a building certifier

Section 44A(2)(e) LGOIMA. This is information notified to the Council concerning any certificate issued by a building certifier pursuant to the Building Act 1991 or the Building Act 2004.

(For building enquiries, please phone (03) 941 8999, email EPADutyBCO@ccc.govt.nz or visit www.ccc.govt.nz.

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7. Weathertightness

Section 44A(2)(ea) LGOIMA. This is information notified to the Council under section 124 of the Weathertight Homes Resolution Services Act 2006.

(For weathertight homes enquiries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

If there is no information below this means Council is unaware of any formal Weathertight Homes Resolution Services claim lodged against this property.

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8. Land use and conditions

Section 44A(2)(f) LGOIMA. This is information relating to the use to which the land may be put and conditions attached to that use. The planning information provided below is not exhaustive and reference to the Christchurch District Plan and any notified proposed changes to that plan is recommended: https://ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/plans/christchurch-district-plan/.

There maybe some provisions of the Christchurch City Plan or Banks Peninsula District Plan that affect this property that are still operative.

(For planning queries, please phone (03) 941 8999, email DutyPlanner@ccc.govt.nz or visit www.ccc.govt.nz.

- **Regional plan or bylaw**

There may be objectives, policies or rules in a regional plan or a regional bylaw that regulate land use and activities on this site. Please direct enquiries to Canterbury Regional Council (Environment Canterbury).

(a)(i)Christchurch City Plan & Banks Peninsula District Plan

(ii)Christchurch District Plan

- **Liquefaction Management Area (LMA)**

  Property or part of property within the Liquefaction Management Area (LMA) Overlay which is operative.

- **Outline Development Plan**

  Property or part of property is within an Outline Development Plan area which is affected by specific provisions that are operative.

- **Retirement Village Overlay**

  Property or part of property within the Christchurch District Plan (operative) Prestons Road Retirement Village Overlay

- **Flood Management Area**

  Property or part of property within the Flood Management Area (FMA) Overlay which is operative.

- **Fixed Minimum Floor Overlay**

  This property or parts of the property are located within the Fixed Minimum Floor Overlay level in the Christchurch District Plan. Under this plan pre-set minimum floor level requirements apply to new buildings and additions to existing buildings. The fixed minimum floor level can be searched at http://ccc.govt.nz/floorlevelmap. For more information please contact a CCC duty planner on 941 8999.

- **District Plan Zone**

  Property or part of property within the Residential New Neighbourhood Zone which is operative.

- **District Plan Zone**

  Property or part of property within the Residential Suburban Zone which is operative.

(b) Resource consents

If there are any land use resource consents issued for this property the Council recommends that you check those

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resource consents on the property file. There may be conditions attached to those resource consents for the property that are still required to be complied with.

- RMA/2016/2855 - Certification
  12 Cameo Grove Burwood
  Wastewater Capacity Certificate
  Status: Processing complete
  Applied 10/10/2016
  Certificate issued 03/11/2016

- RMA/2018/2576 - Land Use Consent
  12 Cameo Grove Burwood
  To undertake bulk earthworks and Variation of a Consent Notice protecting a subdivision tree
  Status: Processing complete
  Applied 24/10/2018
  Granted 07/03/2019
  Decision issued 08/03/2019

- RMA/2019/2745 - Subdivision Consent
  14 Cameo Grove Burwood
  Fee simple subdivision - 254 lots and a number of amalgamation and boundary adjustments to Stage 2 Prestons Park
  Status: Consent issued
  Applied 25/11/2019
  Granted 17/03/2020
  Decision issued 17/03/2020

- RMA/1993/2406 - Subdivision Consent
  Comp. Title SUBDIVISION - Historical Reference RMA6667
  Status: Processing complete
  Applied 05/10/1993

- RMA/1994/1874 - Subdivision Consent
  Fee Simple SUBDIVISION - Historical Reference RMA11118
  Status: Processing complete
  Applied 06/07/1994

- RMA/1995/4099 - Subdivision Consent
  Fee Simple SUBDIVISION - Historical Reference RMA2839
  Status: Processing complete
  Applied 16/11/1995

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- RMA/1997/3625 - Subdivision Consent
  Fee Simple SUBDIVISION - Historical Reference RMA13149
  Status: Processing complete
  Applied 06/05/1997

- RMA/1999/4735 - Subdivision Consent
  FEE-SIMPLE - Historical Reference RMA20000195
  Status: Processing complete
  Applied 08/12/1999
  Granted 02/06/2000
  Decision issued 02/06/2000

- RMA/2000/1122 - Subdivision Consent
  FEE SIMPLE SUBDIVISION - 31 LOTS STAGE 2 - Historical Reference RMA20001814
  Status: Processing complete
  Applied 01/05/2000
  Granted 17/08/2000
  Decision issued 17/08/2000

- RMA/2000/2088 - Subdivision Consent
  2 LOT FEE SIMPLE SUBDIVISION - Historical Reference RMA20002828
  Status: Lapsed
  Applied 18/08/2000
  Granted 28/09/2000
  Decision issued 28/09/2000

- RMA/2001/2700 - Subdivision Consent
  FEE SIMPLE SUBDIVISION - 26 LOTS Certified 28/8/02 223 STG2 02/12/02 224 requested 3/10/02 224 Issued 17/10/02 312984 - Historical Reference RMA20008621
  Status: Processing complete
  Applied 02/11/2001
  Granted 25/02/2002
  Decision issued 25/02/2002

- RMA/2001/3110 - Subdivision Consent
  FEE SIMPLE SUBDIVISION - 1 LOT 224 REQUESTED 26/07/02 224 ISSUED 08/08/02 311536 224 REQUESTED 21/05/03 RELEASED 19/09/03 DP 319376 - Historical Reference RMA20009043
  Status: Processing complete
  Applied 18/12/2001
  Granted 15/01/2002
  Decision issued 15/01/2002

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- RMA/2002/1082 - Subdivision Consent
  BOUNDARY ADJUSTMENT - Historical Reference RMA20010073
  Status: Cancelled
  Applied 10/05/2002

- RMA/2006/3056 - Subdivision Consent
  FEE SIMPLE SUBDIVISION - 46 LOTS - granted 22/04/08 (Land Use 92009659) 223 & 224 Issued 14/7/10 DP431366 - Historical Reference RMA92007183
  Status: Processing complete
  Applied 21/12/2006
  Granted 22/04/2008
  Decision issued 22/04/2008

- RMA/2008/1398 - Subdivision Consent
  FEE SIMPLE SUBDIVISION 223 & 224 issued 14/7/10 DP 431366 - Historical Reference RMA92012253
  Status: Processing complete
  Applied 30/06/2008
  Decision issued 25/09/2008
  Granted 19/09/2008

- RMA/2013/116 - Subdivision Consent
  AMENDMENT TO RMA92019798 AND CREATE 2 NEW LOTS Issued 21/05/2013: 223 + 224 Issued 27/05/2013 - Historical Reference RMA92021697
  Status: Processing complete
  Applied 29/01/2013
  Granted 23/05/2013
  Decision issued 23/05/2013

- RMA/2013/1562 - Subdivision Consent
  200 LOT FEE SIMPLE RESIDENTIAL SUBDIVISION Originally Part of RMA92019798. Split by Land ownership this appication issued origianlly 4 July 2012. - Historical Reference RMA92023244
  Status: Consent issued
  Applied 12/08/2013
  Decision issued 28/08/2013
  Granted 28/08/2013

- RMA/2015/278 - Subdivision Consent
  Fee Simple Subdivision - Sixty Nine Lots 224 Requested 30/5/2016 223 issued 30/5/2016 - Historical Reference RMA92028454
  Status: Consent issued
  Applied 03/02/2015
  Decision issued 01/05/2015
  Granted 01/05/2015

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Related information

- Council records show that there is a current/on hold monitoring job in our system. This monitoring is to ensure that the resource consent conditions have been met. For further information you can contact the Compliance & Investigation team A on 941 8999 or email: rcmon@ccc.govt.nz and reference to resource consent RMA/2018/2576.

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9. Other land and building classifications

Section 44A(2)(g) LGOIMA. This is information notified to the Council by any statutory organisation having the power to classify land or buildings for any purpose.

(For land and building enquiries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

Please refer to Section 1 for details

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10. Network utility information

Section 44A(2)(h) LGOIMA. This is information notified to the Council by any network utility operator pursuant to the Building Act 1991 or the Building Act 2004.

(For network enquiries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

None recorded for this property

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11. Other information

Section 44A(3) LGOIMA. This is information concerning the land that the Council has the discretion to include if it considers it to be relevant.

(For any enquiries, please phone (03) 941 8999 or visit www.ccc.govt.nz.

(a) Kerbside waste collection

- Your recycling is collected Fortnightly on the Week 2 collection cycle on a Wednesday. Please leave your recycling at the Kerbside by 6:00 a.m. Your nearest recycling depot is the Styx Mill EcoDrop.

- Your refuse is collected Fortnightly on the Week 2 collection cycle on a Wednesday. Please leave your rubbish at the Kerbside by 6:00 a.m. Your nearest rubbish depot is the Styx Mill EcoDrop.

- Your organics are collected Weekly on Wednesday. Please leave your organics at the Kerbside by 6:00 a.m.

(b) Other

- **Floor Levels Information**

  Christchurch City Council holds a variety of information relevant to building/property development across the city. This includes minimum finished floor levels that need to be set to meet the surface water requirements in clause E1.3.2 of the building code (where this applies), and the requirements of the Christchurch District Plan (where a property is in the Flood Management Area). Where this information has been processed for your site, it can be viewed at https://ccc.govt.nz/floorlevelmap/, otherwise site specific advice can be obtained by emailing floorlevels@ccc.govt.nz.

- **Community Board**

  Property located in Coastal-Burwood Community Board.

- **Guest Accommodation**

  Guest accommodation (including whole unit listings on Airbnb; BookaBach; etc.) generally requires a resource consent in this zone when the owner is not residing on the site. For more information, please refer to: https://ccc.govt.nz/providing-guest-accommodation/.

- **Tsunami Evacuation Zone**

  This property is not in a tsunami evacuation zone. It is not necessary to evacuate in a long or strong earthquake or during an official Civil Defence tsunami warning. Residents may wish to offer to open their home to family or friends who need to evacuate from a tsunami zone, and should plan with potential guests to do so in advance.More information can be found at https://ccc.govt.nz/services/civil-defence/hazards/tsunami-e vacuation-zones-and-routes/

- **Electoral Ward**

  Property located in Burwood Electoral Ward

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- **Listed Land Use Register**

  Hazardous activities and industries involve the use, storage or disposal of hazardous substances. These substances can sometimes contaminate the soil. Environment Canterbury identifies land that is used or has been used for hazardous activities and industries. This information is held on a publically available database called the Listed Land Use Register (LLUR). The Christchurch City Council may not hold information that is held on the LLUR Therefore, it is recommended that you check Environment Canterbury's online database at www.llur.ecan.govt.nz

- **Spatial Query Report**

  A copy of the spatial query report is attached at the end of this LIM. The spatial query report lists land use resource consents that have been granted within 100 metres of this property.

- Our records show that there is a residential pool on this site. The current status of the pool is unknown. Under the 2004 Building Act and New Zealand building code (F9 Restricting access to residential pools) it is the responsibility of a pool owner, pool operator, land owner or occupier of the property were the pool is situated to ensure that the pool has a physical barrier that restricts access to the pool by unsupervised children under the age of 5 years.
- If you have any queries or wish to arrange an inspection to determine whether the pool now complies with the Act or building code then please contact the Pool Inspectors in the Compliance and Investigation Team on (03) 941 8999 or email: FSPInspections@ccc.govt.nz. For further information about the New Zealand building code - F9 Restricting access to residential pools requirements click on the link https://www.building.govt.nz/building-code-compliance/f-safety-of-users/pool-safety/
- The Council has received a third party report/information relating to soil contamination on this property. It has been placed on the property file as a public record ONLY. The Council does not accept any liability for the contents, or representations, made within the report/information. The report is not included in the Land Information Memorandum (LIM) because the Council cannot verify the information in the report. If a copy is required you can request a property file by contacting Council on (03) 941 8999 or visiting a Council Service Centre.

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Law Block Subdivision

Resource Consent Geotechnical Report

CDL Land Ltd.

Reference: 235361

Revision: 0

14 June 2018

aurecon

Bringing ideas to life

Document control record

Document prepared by:

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Document control						
Report title		Resource Consent Geotechnical Report				
Document ID			**Project number**		235361	
File path		P:\235361\Geotech\Law Block\Law Block Subdivision Consent Report\04 Reporting\235361 Law Block Resource Consent Report Rev1.docx				
Client		CDL Land Ltd.				
Client contact		Jason Adams	**Client reference**			
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
0	6 June 2018	Internal review	MFSL	JSM		
1	4 July 2018	Initial Issue	KJF	JSM	IDM	IDM
Current revision		**0**				

Approval			
Author signature		Approver signature	
Name	Kieran Foote	Name	Ian McPherson
Title	Geotechnical Engineer	Title	Technical Director – Ground Engineering

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Liquefaction Assessment Results

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RMA Geotechnical Hazard Assessment

Tables

Executive Summary

CDL Land Ltd. are developing a large residential subdivision with associated commercial lots. The site is located on an area of land between Prestons Road and Mairehau Road on the north-east side of Christchurch. The subdivision is currently referred to as Prestons Park, although was previously referred to as Prestons South. The Prestons Park subdivision is part of the larger Prestons subdivision, which extends north to Lower Styx Road. The greater Prestons Subdivision is approximately 150ha, whilst Prestons Park is approximately 75ha. As part of the expansion of the Prestons Park subdivision, CDL Land Ltd. are proposing to develop an approximately 10ha area in the northeast region known as Law Block.

Aurecon NZ Ltd (Aurecon) has previously carried out a geotechnical investigation and assessment for the purpose of the earthworks and subdivision resource consents for the entire Prestons Subdivision. Previous reports for Prestons North and Preston Park identified the liquefaction and lateral spreading risk associated with the site and defined the technical classification of the subdivision area. To allow classification of the site and provision of development recommendations additional site investigations were completed for Law Block.

Our ground investigations for Law Block indicated relatively consistent and predictable ground conditions in line with our past experience in the Prestons Road area. Ground conditions comprise loose to medium dense sand to 3m depth underlain by medium dense to dense sand to depth. Groundwater level has been measured at 1m to 2m depth, which is consistent with previous work across the area.

A liquefaction assessment has been carried out using the CPT information. For the assessment we have reviewed the three levels of seismic shaking as recommended in Module 3 of the NZGS Guidelines. Based on the results of the liquefaction assessment, the liquefiable layers are predominantly in the upper 3m of the soil profile, although the assessment does indicate liquefiable layers below 5m depth. The liquefaction assessment identified that due to the potential for liquefiable soil layers in the upper 3m, there is a potential for lateral spreading of the soil adjacent to any new stormwater basins/channels and into the existing Snellings Drain.

Based on the liquefaction results, parts of the site can be classified as Technical Category 1 (TC1) while other parts can be classified as Technical Category 2 (TC2). The extent of the liquefaction induced ground damage and settlements in parts of the area classified as TC2 are at a level where we consider that the ground could be improved to a TC1 equivalent performance level.

In terms of lateral spreading, the MBIE guidelines indicate that lateral spreading should not occur for a site to be classified as TC1. The liquefiable layers are predominantly within the upper 3m of the soil profile and there is the potential for lateral spreading adjacent to the stormwater basins and channels if ground treatment is not undertaken. Hence, from a lateral spreading assessment perspective the site cannot be classified as TC1. However, as the depth of the liquefiable soil layers are limited to the upper soil profile, it is considered that there are suitable engineering options available that will minimise the potential for liquefaction induced lateral spreading.

Although the site is classified partly asTC1, and partly as TC2, the intention is to develop the Law Block into TC1 equivalent land.

The ground conditions and liquefaction potential at Law Block are similar to that of Prestons North and Prestons Park areas. The Prestons North and Preston Park earthworks have included the use of an impact compactor to densify the upper soil profile and hence minimise the liquefaction potential. In addition, gravel embankments have been constructed to mitigate the lateral spreading potential susceptibility adjacent to stormwater basins/channels. We recommend that these mitigation measures are used on the Law Block.

A trial of the impact compactor was carried out on Prestons Park and the results indicate that the liquefaction induced settlements can be reduced significantly with the use of the impact compactor. As part of the detailed design of the Law Block subdivision, further geotechnical analysis will be required to confirm the extent of the area requiring impact compaction. Quality assurance testing with CPTs will be required in conjunction with the impact compaction to confirm that the required level of ground densification is being achieved.

The impact compactor improves ground conditions and hence reduces the potential for lateral spreading. Although the potential for lateral spreading is reduced, there still remains a lateral spreading potential

adjacent to the stormwater basins that cannot be addressed with the impact compaction alone, particularly if TC1 land is required. Therefore, construction of a wide gravel embankment founded below the liquefiable layer is to be considered. If the gravel embankment method is found to be not feasible in suppressing the lateral spreading hazard, then alternative options such as stone columns or vibrofloatation can be considered. As part of the detailed design of the Law Block subdivision, geotechnical design will be required to confirm the gravel embankment design for each of the stormwater pond or, if required, alternative mitigation options identified and designed.

Suitable foundation types for the various technical categories have been defined in the MBIE Guidelines and for TC1 areas the MBIE Guidelines recommend Standard NZS3604:2011 type foundations with well reinforced slabs. In the unlikely case where residential sites cannot be improved to a TC1 classification then TC2 type enhanced foundations will be required.

In our opinion, and based on our assessment, we consider that under Section 106 of the RMA (2017) there are no geotechnical reasons preventing the development, provided the appropriate engineering measures as recommended in this report are carried out.

Our limitations are at the end of this report and this report shall be read as a whole.

1 Introduction

CDL Land Ltd. are developing a large residential subdivision with associated commercial lots on an area of land between Prestons Road and Mairehau Road on the north-east side of Christchurch. The subdivision is currently referred to as Prestons Park, although was previously referred to as Prestons South. The Prestons Park subdivision is part of the larger Prestons subdivision, which extends north to Lower Styx Road. The greater Prestons Subdivision is approximately 150ha, whilst Prestons Park is approximately 75ha. As part of the expansion of the Prestons Park subdivision, CDL Land Ltd. are proposing to develop an approximately 10ha area in the northeast region known as Law Block.

Aurecon NZ Ltd (Aurecon) has previously carried out a geotechnical investigation and assessment for the purpose of the earthworks and subdivision resource consents for the entire Prestons Subdivision. Previous reports for Prestons North and Preston Park identified the liquefaction and lateral spreading risk associated with the site and defined the technical classification of the subdivision area. To allow classification of the site, and provision of development recommendations, additional site investigations were completed for Law Block in May 2018.

The scope of work included the following:

- A review of existing geotechnical and geological information on the site.
- Cone Penetrometer Tests (CPT) across the site to provide information on the soil at depth and to obtain data to allow a liquefaction assessment to be undertaken.
- Machine borehole drilling to confirm the soil type, collect samples for laboratory testing, and to calibrate the CPT logs.
- Laboratory testing of soil samples.

The assessment of the geotechnical investigation results included:

- A liquefaction analysis using the latest MBIE and NZGS Guidelines to assess the liquefaction potential of the underlying natural soils and to confirm the technical categories across the site based on the results of the liquefaction assessment.
- Provide indicative engineering measures required to address liquefaction and lateral spreading potentials.
- Preparation of this geotechnical report to present the above information.

This geotechnical report presents the results of our geotechnical investigations and assessment, confirms the suitability of the land for residential development as well providing recommendations for development of the site.

Our limitations are attached as Section 6 of this report. This report shall be read as a whole.

2 Site Conditions

2.1 Site Descriptions

The Prestons subdivision is located on the north-eastern fringes of Christchurch City. The site is made up of a series of adjacent properties forming an irregular and elongated rectangle shape, orientated approximately north to south. The total area of the overall Prestons Subdivision site is approximately 150ha of which Prestons Park is approximately 75ha. Prestons Park extends from Prestons Road, through to Mairehau Road to the south, as shown in Figure 1 in Appendix A. The Law Block is in the northeast corner of the Prestons Park subdivision and is bounded by Prestons Park subdivision to the south and west, and existing developed land to the north and east.

The main features of Law Block are as follows:

- The Law Block is approximately 10ha in area with the topography ranging from flat through to gently undulating.
- The area is divided into a number of paddocks which have been used for various purposes over recent years and are divided into smaller fields by north-south and east-west trending treelines. There are several warehouse type structures and a hardstand area in the southeast corner of the site which are accessed off Cameo Grove.
- Snellings Drain runs along the eastern and northern boundary of the Law Block and drains in a southerly direction towards the Avon River.

2.2 Regional Geology

The geology of the site is described in the 1:25,000 scale geological map – 'Geology of the Christchurch Urban Area' published in 1992 by the Institute of Geological and Nuclear Sciences (GNS). This map has been referenced as it is at an appropriate scale and covers the entire site. The geological map indicates several different material types and indicates the following underlying geology:

- The Law Block area is predominantly underlain by drained peat swamps.
- Along the west side of the Law Block is sand of fixed and semi-fixed dunes and beaches.

The GNS Active Fault System database (GNS, 2012a) indicates that the site is located approximately:

- 27km north east of the eastern end of the Greendale Fault System. Movement on the Greendale Fault System was responsible for the Magnitude 7.1 Darfield (Canterbury) Earthquake on 4 September 2010.
- 14km north of the epicentre of the Magnitude 6.2 Christchurch Earthquake on 22 February 2011.
- 12km north west of the Magnitude 6.0 earthquake on 13 June 2011.
- 8km north west of the Magnitude 5.9 earthquake on 23 December 2012.

2.3 Previous Work

Aurecon has been involved in the geotechnical assessment for the Prestons Subdivision since 2005. Previous documentation which has been reviewed as part of this geotechnical assessment includes the following:

- "Prestons Park – Law Block Geotechnical Assessment", dated 26 July 2017.
- "Prestons South Subdivision, Resource Consent Geotechnical Report", dated 6 June 2013.
- "Prestons Road Subdivision, Detailed Geotechnical Design Report", dated 12 July 2012

- “Geotechnical Assessment Report for Resource Consent”, dated 5 March 2012, which included assessing technical categories across the site.
- “Geotechnical Assessment Report for Earthworks Consent”, dated 28 November 2011.
- “Supplementary Evidence (Post 22 February 2011)”, dated March 2011, provided as part of Plan Change 30.
- “Prestons Road Rezoning Liquefaction Reassessment”, dated October 2010, which reviewed the liquefaction risk to the site following the Darfield Earthquake.
- “Prestons Road Rezoning Geotechnical Investigation Report”, dated August 2008, which included logs from intrusive investigations and a geotechnical assessment on the suitability of the area for development.
- “Stage 1 Environmental Assessment Report, Prestons Road Development Area, Christchurch”, dated August 2008.
- Aerial photographs dating back to 1955, used as part of the environmental study.

3 Geotechnical Investigations

3.1 Introduction

The objective of the recent geotechnical investigation was to determine the nature and composition of the underlying ground conditions and to identify the relevant geotechnical issues. The investigation for Law Block was carried out as part of a wider investigation programme.

The recent geotechnical investigation for Law Block comprised the following:

- Undertake a site walkover to identify the geomorphological features of the site.
- Review previous investigation results.
- Carry out 14 CPT's across the site to confirm ground conditions at depth and to provide information for a liquefaction assessment.
- Drilling of two geotechnical boreholes to determine the nature of the soil profile, obtain soil samples for laboratory testing, and to calibrate the CPT logs.
- Laboratory testing including particle size distributions for the calibration of the CPT results.
- Review of investigations completed by Aurecon in 2017 which comprised 12 test pits and six CPTs.
- Review the New Zealand Geotechnical Database (NZGD) borehole logs and CPTs on or near the site, as at June 25 2018.

Our ground investigation indicated a relatively consistent and predictable geology in line with our past geotechnical investigation experience in the wider Prestons' development area.

A detailed description of the geotechnical investigations and the results are provided in the following sections.

3.2 Site Walk Over

Numerous site walkovers have been completed by an Aurecon Geotechnical Engineer between July 2017 and May 2018. The purpose of the site walkovers was to identify site features and any ground damage from previous seismic activity.

3.2.1 Site Features

The site is bounded by the Prestons Park subdivision to the west and south, and residential housing to the east and north. The site is predominantly flat with extensive areas of vegetation, the removal of which was being completed at the time of writing this report. A large tire dump was located in the south-western corner of the site, and some small sheds were located in the south-eastern corner. The northern and eastern boundary is adjacent to Snellings Drain, which comprises a box drain approximately 1m deep.

3.2.2 Ground Damage

Based on a number of site walkovers, we note the following:

- Evidence of liquefaction surface ejecta (i.e. sand boils) was not apparent during the site walkover carried out as part of this investigation. The site walkovers were carried out more than six years since the last large earthquake and it is possible that any evidence of liquefaction may have been removed or buried over time.
- No other evidence of ground damage such as ground cracking or lateral spreading adjacent to the drainage ditches was apparent on the site.

- A review of high resolution aerial photographs from the New Zealand Geotechnical Database did not identify any apparent surface manifestation of liquefaction on the site.

3.3 Cone Penetrometer Tests (CPTs)

Cone penetrometer tests (CPT) across the Preston Subdivision area have been carried out over a number of stages. CPTs completed for the Law Block area include:

- Six CPTs completed by Aurecon in 2017 up to 15m deep;
- 14 CPTs completed as part of Aurecon's 2018 investigations.

The additional 14 CPTs were undertaken across the Law Block area to provide further information on the ground conditions and to support the assessment of liquefaction hazard. The CPTs were undertaken on 2 and 3 May 2018 using a track-mounted rig owned and operated by LandTest and extended to 10m depth.

The CPTs measured tip resistance (q_c), friction (f_s) and dynamic pore pressure (u_2) at 10mm intervals.

Test locations are shown in the figures in Appendix A and CPT logs are presented in Appendices B and C.

3.4 Machine Boreholes (Aurecon 2018)

Two boreholes were machine drilled on 10 May 2018 using a sonic drill rig operate by Land Test and supervised by an Aurecon Geotechnical Engineer. The boreholes were positioned close to CPTs to allow calibration of the CPT logs and refinement of the fines correction factor used in the liquefaction assessment.

All core was placed in core boxes for storage and logged by an Aurecon Geotechnical Engineer in accordance with the New Zealand Geotechnical Society's "Guide for the Field Classification and Description of Soil and Rock for Engineering Purposes The test locations are shown in the figures in Appendix A and the borehole logs are presented in Appendix D together with an explanatory sheet outlining the terms and symbols used on the logs.

3.5 Test Pit Excavations (Aurecon 2017)

Test pits were excavated across the Law Block area on 13 July 2017, and are summarised in *"Prestons Park – Law Block Geotechnical Assessment*", dated 26 July 2017. Twelve test pits were excavated to 3m to 3.4m depth using a 20 Tonne excavator operated by KB Contractors Ltd. The purpose of the test pits was to provide information on the upper soil profile and groundwater levels.

The test pits were logged by a Geotechnical Engineer in accordance with the New Zealand Geotechnical Society's "Guide for the Field Classification and Description of Soil and Rock for Engineering Purposes". The test pits were backfilled with the excavated spoil.

The locations of the test pits are shown on the figures in Appendix A and the logs are attached in Appendix E.

3.6 Laboratory Testing

Laboratory testing was completed on select samples recovered from the boreholes at 6m, 7m, 8m and 9m depth. The samples were sent to Central Testing Services Limited (CTS) for wet sieve analysis (PSD) and water content testing. The report issued by CTS indicates that the testing was completed in accordance with the relevant New Zealand Standard.

The PSD results indicate that the soils tested are predominantly sand with a fines (<75µm) content between 3% and 7%. The laboratory test results are presented in Appendix F together with the laboratory testing certificate.

3.7 New Zealand Geotechnical Database (NZGD)

The Preston Subdivision area is well represented in the New Zealand Geotechnical Database (NZGD); but no testing was found to exist within the Law Block area. Given the level of testing completed n the Law Block area by Aurecon in 2017 and 2018, and the variability of the local geology, the NZGD data was reviewed but not included in the geotechnical assessment of Law Block.

3.8 Law Block Geological Model

3.8.1 General Conditions

The geological model has been developed based on the testing completed in the Law Block area, testing completed across the broader Preston Subdivision area, and local knowledge and experience. The test pitting, drilling and CPTs indicated a relatively consistent soil profile comprising a thin mantle of topsoil, overlying loose to dense sand to depth investigated. The CPT profiles indicate a gradual strength increase with depth with the upper 3m being loose to medium dense sand. Thin layers of peat were recorded in several test pits.

Table 1 below provides a summary of the ground conditions across the Law Block area.

Table 1 Geological Model – Law Block

Depth to Top of Unit (m)	Depth to Base of Unit (m)	Soil Unit	CPT Q_c Value (MPa)
0	0.3 to 0.6	Topsoil, silt/sand	-
0.3 to 0.6	3	Sand with minor Silt, loose to medium dense 50 to 100mm peat layers in TP02, 03 & 04.	0.5 to 10
3	12	Sand with minor Silt fraction, medium dense to dense	12 to 18
12	Not determined	Sand, dense to very dense	20+

3.8.2 Groundwater

Groundwater monitoring has not been undertaken across the Law Block area and groundwater levels have been assessed based on observations during test pitting and borehole drilling, and interpretation of pore pressure measurements taken during CPT. The groundwater table was observed, or inferred, to be between 1m and 2.5m below ground level. The groundwater level is expected to vary depending on the time of year, and after heavy rainfall or periods of drought conditions.

3.8.3 Peat

Peat has been commonly encountered across the Preston Subdivision area with layers up to 0.5m thick found within the surficial soils. The intrusive investigations completed across Law Block (test pits and boreholes) encountered only minor peat with a 50mm to 100mm layer encountered in Test Pits TP02, TP03 and TP04 between 1.8m and 2.1m depth in the south-west part of the site. However, peat can be localised and the presence of thicker peat layers across the area is possible.

4 Engineering Considerations

4.1 Introduction

CDL Land Ltd is proposing to develop the Law Block subdivision, located at the end of Cameo Grove, Christchurch. The site earthworks will involve placing up to 1m of fill across the majority of the site with cutting required to form the new stormwater retention basin located in the southeast corner of the site. Previous stages of the Prestons Park subdivision have been developed into Technical Category TC1, which has required ground improvement with an impact compactor and installation of gravel embankment to mitigate the effects of liquefaction and lateral spreading. At this stage it is understood that a similar approach will be taken, and the intention is to develop the land to TC1 equivalent ground performance.

Based on the ground conditions encountered during the geotechnical investigation we consider that the following geotechnical aspects need to be considered as part of the subdivision:

- Potential for seismically induced liquefaction.
- Recommendations for liquefaction mitigation measures.
- Implications for building foundations.
- Identify the presence of the peat and the affect it may have on the residential buildings or infrastructure.
- Provide recommendations with regard to site earthworks.
- Assessment against Resource Management Act (RMA) Section 106.

Each of these is discussed in the following sections along with recommendations for engineering mitigating measures.

4.2 Liquefaction Hazard

Under cyclic loading loose, non-plastic materials such as gravel, sand and silt tend to decrease in volume. If these soils are saturated and rapid loading occurs under un-drained conditions, the soil densification causes pore water pressure to increase. The increase in pore water pressure results in a loss of soil strength due to a decrease in effective stress, and eventually leads to liquefaction once effective stress drops to near zero. Liquefaction can lead to large displacements of foundations, flow failures of slopes, ground surface settlement, sand boils, and post-earthquake stability failures.

The four primary factors that contribute to liquefaction potential are:

- Geological age of the deposit (with the younger soils being more susceptible to liquefaction);
- Loose, non-plastic soils (i.e. sands and silty sands);
- Groundwater levels; and
- Sufficiently high, earthquake induced ground acceleration and sustained shaking (i.e. sufficient load cycles).

Each of these is considered below together with conclusions on the site liquefaction potential.

Geological Criteria

Liquefaction resistance increases with geological age and sediments of Holocene age (<10,000 years) are most susceptible. The soils mapped in the Law Block area are Holocene and are therefore expected to have a limited increase of resistance to liquefaction based on aging criteria.

Soil Character and Density

Liquefiable soils generally have a Coefficient of Uniformity of less than 5 and low proportion of soil finer than 75 microns in size (typically less than 5% to 10%, but up to 30%). Laboratory testing indicated the soils tested have a fines content of between 3% and 7%.

Values for the Cyclic Resistance Ratio (CRR) correlated to CPT resistance depend significantly on the fine content (FC) of the soil for two main reasons:

- The presence of fines affects the resistance of soil to cyclic loading; and
- The presence of fines also reduces the penetrations resistance measured during CPT.

The method of Boulanger and Idriss (2014) allows adjustments based on the fines content to increase the measured CPT resistance values (q_c) to give an 'equivalent' resistance value for clean sand.

The site-specific data has been used to calibrate the fines-content component of the liquefaction assessment using the following approach:

- General correlations between FC and the soil behaviour type index (I_c) determined from CPT data exhibit large scatter and site-specific calibrations are recommended to reduce the uncertainty.
- The two boreholes (BH101 and BH102) were coupled with CPTs (CPT109 and CPT103, respectively) to assist with calibrating the FC estimate from the CPT data. The samples tested were from 6m, 7m, 8m and 9m depth in each borehole and results indicated a fines content of less than 7%, and typically 3% to 4%.
- The method of Boulanger and Idriss (2014) was used to determine the curve fitting parameter C_{FC} with a positive C_{FC} corresponding to a larger FC estimate. Although a slight scatter was observed with the data, a C_{FC} of 0.1 for the Law Block appears reasonable and consistent with other Christchurch sites. A copy of the chart used to assess the fitting parameters is provided in Appendix G.

Groundwater

Groundwater levels within the Law Block area vary but are typically around 1m to 2m below the existing ground level. For the purpose of the liquefaction assessment soils are considered potentially liquefiable from depths greater than 1m below the existing ground level. Groundwater levels will vary depending on the time of year and recent weather conditions.

Earthquake Intensity

Module 3 of the New Zealand Geotechnical Society (NZGS) Earthquake Geotechnical Engineering Practice provides recommended ground accelerations (a_{MAX}) and effective earthquake magnitude, M_W, for Class D sites in the Canterbury earthquake region based on an Important Level 2 (IL2) and 50-year design life, which are presented in Table 2.

For the Serviceability Limit State (SLS) cases, both the SLS-a and SLS-b cases were analysed and the highest calculated settlement was adopted.

Table 2 Geotechnical Seismic Design Criteria

	SLS-a	SLS-b	ULS
Peak Ground Acceleration (a_{MAX})	0.13	0.19	0.35
Effective Magnitude (M_W)	7.5	6.0	7.5

4.2.1 Liquefaction Potential

A liquefaction assessment was undertaken using the CPT profiles from the Geoscience 2013 and Aurecon 2018 investigations using an in-house spreadsheet and the industry recognised software CLiq version 2.1. The ability of the subsoils to resist the ground shaking associated with the three design earthquakes has been assessed from the subsoil information obtained from the investigations.

The method prescribed by Module 3 of the New Zealand Geotechnical Society (NZGS) Earthquake Geotechnical Engineering Practice has been used for assessing the liquefaction potential and consequences. The method of Boulanger and Idriss (2014) was adopted for assessing the liquefaction potential from the CPT data. Boulanger and Idriss (2014) incorporates updates and calibration of the triggering method based on data collected following the Christchurch earthquake sequence. The method of Zhang (2002) was used to calculate post liquefaction reconsolidation settlements.

The following is a summary of key assumptions and results from the liquefaction assessment:

- A groundwater level of 1m below existing ground level was adopted for the assessment based on average groundwater levels.
- The effects of filling have not been considered during the analysis as it is considered that 1m of filling will have limited effect on the liquefaction assessment.
- A fines correct factor C_{FC} of 0.1 was applied for the assessment although it was determined that the effect of applying a C_{FC}=0.1 was minimal.
- The liquefaction assessment was carried out on the full CPT profile as well as the upper 10m of the soil profile, as the MBIE guidelines indicates that for technical classification of a site settlements over the upper 10m do not need to be assessed (Index Settlement).
- Table 3 and Table 4 present the results of the liquefaction assessment for the upper 10m and full soil profile, respectively.

Table 3 Summary of calculated settlements for upper 10m of soil profile (Index Settlements)

	SLS-a a_{MAX} = 0.13, M_W = 7.5	SLS-b a_{MAX} = 0.19, M_W = 6.0	ULS Case a_{MAX} = 0.35, M_W = 7.5
Maximum Settlement (mm)	5	15	50
Minimum Settlement (mm)	0	0	5
Average (mm)	<5	<5	20

Note: The settlements presented above are to the nearest 5mm.

Table 4 Summary of calculated settlements for full soil profile

	SLS-a a_{MAX} = 0.13, M_W = 7.5	SLS-b a_{MAX} = 0.19, M_W = 6.0	ULS Case a_{MAX} = 0.35, M_W = 7.5
Maximum Settlement (mm)	5	15	50
Minimum Settlement (mm)	0	0	5
Average (mm)	<5	<5	20

Note: The settlements presented above are to the nearest 5mm.

From our analysis we note the following:

- The liquefiable are predominantly within the upper 3m of the soil profile and below a depth of about 5m to 6m. Limited liquefaction is predicted between 3m and 5mbgl.
- Limited liquefaction is predicted during both SLS-a and SLS-b with similar liquefiable zones under both cases.

4.2.2 Ground Damage

Published information (Ishihara, 1985 and T&T, 2013) can be used to assess the potential for surface expression of liquefaction and hence the likelihood of ground induced damage. Our assessment of liquefaction induced ground damage is based on the liquefaction plots of the Boulanger and Idriss (2014) method. Table 5 summarises the calculated ranges of Liquefaction Severity Number (LSN) (T & T, 2013) for each event.

Table 5 Summary of Calculated LSN

	SLS-a a_{MAX} = 0.13, M_W = 7.5	SLS-b a_{MAX} = 0.19, M_W = 6.0	ULS Case a_{MAX} = 0.35, M_W = 7.5
Maximum LSN	2	8	21
Minimum LSN	0	0	2
Average LSN	<1	<1	9

Assessment of ground damage using the method of Ishihara and T&T indicates:

- Ishihara Method: Liquefaction induced ground damage is not predicted during SLS events. Liquefaction induced ground damage during a ULS event is predicted at 19 of 20 (or 95%) CPT locations.
- LSN Method: Little to no liquefaction induced ground damage is expected during a SLS event, while minor expression of liquefaction is expected during an ULS event.

4.2.3 Lateral Spread

Flow failures caused by seismically induced liquefaction can occur when the shear stress required for static equilibrium of a soil mass is greater than the shear strength of the soil in its liquefied state (Kramer, 1996). Lateral spreading can occur where there is a continuous liquefiable layer through to the free face, such as a stream or river back. Lateral spreading can also occur where the ground slopes at greater than 1:100.

Lateral spreading damage was not observed at the site during the Canterbury Earthquake sequence. We do note that the ground shaking the site has experienced from the recent earthquakes is likely to be between a SLS and a ULS design earthquake event. As the liquefiable layers appear to be predominantly within the upper 3m of the soil profile, there is the potential for lateral spreading adjacent to Snellings Drain and the proposed stormwater retention basins/channels if land is left untreated. The details of the proposed stormwater basin/channels are uncertain at this stage but the intention is to develop the block to a TC1 classification. Previous stages of Prestons Park have included the installation of gravel embankments to mitigate against lateral spreading and therefore a similar approach is likely to be used at the Law Block. Provided a similar approach is undertaken as for other parts of the subdivision we consider that lateral spreading will not be an issue at the Law Block. Further comments on the lateral spread hazard and mitigation options are provided in Section 4.6.

4.2.4 Land Classification Technical Categories

For the Christchurch Region, MBIE has released a classification system for residential ‘Green Zone’ land on the flat in regard to liquefaction susceptibility. The classification system is divided into three technical

categories (TC) that reflect both the liquefaction experienced to date and future land performance expectations. The categories and corresponding criteria are summarised as follows:

- **Technical Category 1 (TC1):** Liquefaction damage is unlikely in a future large earthquake.
- **Technical Category 2 (TC2):** Minor to moderate land damage is possible is a future large earthquake.
- **Technical Category 3 (TC3):** Moderate to significant land damage is possible is a future large earthquake.

The MBIE has indicated the following liquefaction deformation limits for house foundations as summarised in Table 6.

Table 6 Liquefaction Deformation Limits and House Foundation Requirements

Technical Categories	Vertical Limits		Lateral Spread Limits		Likely Implications for House Foundations
	SLS	ULS	SLS	ULS	
TC1	15mm	25mm	Nil	Nil	Standard NZS3604 foundations with tied slabs
TC2	50mm	100mm	50mm	100mm	MBIE enhanced foundation solutions
TC3	>50mm	>100mm	>50mm	>100mm	MBIE TC3 specific foundation

Based upon the results of the liquefaction assessment only, parts of the site can currently be classified as TC1 while other parts as TC2. Although parts of the site can be classified as TC2, the extent of the liquefaction induced ground damage and settlements are at a level where we consider that suitable engineering options are available to improve the ground to a TC1 level. These potential mitigation measures are identified in the following sections, and have been successfully used on the Prestons North and Prestons Park subdivision.

In terms of lateral spreading, the MBIE Guidelines indicate that no lateral spreading should occur for a site to be classified as TC1. The liquefiable layers appear to be predominantly within the upper 3m of the soil profile and therefore there is the potential for lateral spreading into the existing Snellings Drain and the proposed stormwater basins and channels if ground improvement is not undertaken. Hence, from a lateral spreading assessment perspective the areas near Snellings Drain and proposed the basin/channel cannot be classified as TC1. However, as the depth of the liquefiable soil layers are limited to the upper soil profile, it is considered that there are suitable engineering options available, such as the installation of gravel embankments, that will minimise the potential for liquefaction induced lateral spreading. These potential mitigation measures are discussed further in the following sections.

4.3 Compliance with the Definition of ‘Good Ground’

Based on the review of the results of the geotechnical site investigations, it is inferred based on considerations of soil strength, that the site is non-compliant with the definition of ‘Good Ground’ in terms of the New Zealand Standards “*Timber Framed Buildings*” (NZS3604:2011) and “*Concrete Masonry Buildings Not Requiring Specific Engineering Design”* (NZS4229:1999).

Therefore, irrespective of any potential liquefaction risk at the site, typical light weight timber framed or masonry houses (which would generally be designed using NZS3604:2011 or NZS4229:1999) would either require specific foundation design, or the land improved. The earthworks strategy for the Law Block area includes placing fill across the majority of the development area. Provided the fill placed is suitable and of sufficient thickness and strength the earthworks may render the site compliant with the definition of ‘Good Ground’. Site specific testing (such as Scala penetrometer) should be undertaken following bulk earthworks to better define the compliance with ‘Good Ground’.

4.4 Engineering Mitigation Measures

The liquefaction assessment indicates that based on the potential liquefaction induced vertical settlements the Law Block can be classified as TC1 and TC2, with a potential lateral spreading adjacent to the stormwater basins/channels. Liquefaction hazard mitigation measures are discussed in the following sections.

4.4.1 Liquefaction

Current MBIE Guidelines indicate that there are various foundation solutions available for constructing on TC1 and TC2 land. For TC1 land NZS3604:2011 type foundations are suitable provide the required bearing capacity can be achieved. For TC2 land enhanced raft foundations (gravel raft, thickened slab or generic grid and beam slab or waffle slab) or piles could be used construct resilient houses. At present no specific ground improvement is required as there are foundation solutions available for construction on TC1 and TC2 land. However, at this stage, the Client's preference is to develop the entire Law Block land into TC1 equivalent performance.

The liquefaction assessment indicates that the majority of the liquefaction is occurring in the upper 3m of the soil profile. Liquefaction could potentially occur at depths in the order of 5m to 6m but at this depth this is likely to be beyond the zone of influence for a residential building on shallow foundations. Similar ground conditions have been encountered in the developed (or developing) Prestons Park area to the west. As part of the earthworks for Prestons North and Prestons Park, ground improvement using an impact compactor, supplied by Landpac, has been carried out in TC2 areas. Based on our extensive construction monitoring, which has included numerous CPTs, the use of the Landpac compactor to improve ground from TC2 to TC1 has been successful.

As the ground conditions across Law Block are very similar to the wider Prestons Park area and the preference is to form TC1 land, we propose to use impact compaction on the TC2 area within Law Block. The proposed impact compactor technology to be used at the Law Block will be different to that adopted for Prestons North and previous areas of Prestons Park and therefore an impact compaction trial is scheduled to take place within Law Block to confirm its suitability.

4.4.2 Lateral Spreading

The lateral spreading assessment indicates that there is a potential for lateral spreading adjacent to the stormwater basins and channels, which would have an impact on the site technical classification and building foundations. We therefore recommend that as the lateral spreading risk is likely to govern the land classification and infrastructure resilience, mitigation measures are used to eliminate, or limit, the lateral spreading potential.

Similar lateral spreading potential and ground conditions have been encountered in Prestons North and the wider Prestons Park area. As part of the earthwork for Prestons North and Prestons Park, a geotechnical assessment of lateral spreading was carried out and gravel embankments were installed along the sides of the stormwater basins/channels embedded at a depth below any liquefiable layers. Lateral spreading occurs where there is a continuous liquefiable layer through to the free face, so by installing wide gravel embankments along any free edges the lateral spreading potential was eliminated. From our experience around Christchurch, observational and quantitative evidence indicates the presence of shallow gravel layers in the river banks has resulted in negligible lateral spreading adjacent to rivers.

As the lateral spreading potential and ground conditions are similar to that across Prestons Park, we propose to use gravel embankments adjacent to Snellings Drain and the stormwater basins and channels. If the gravel embankment method is not feasible then alternative options such as stone columns or vibrofloatation may need to be considered. The gravel embankment assessment is provided in Section 4.6 together with a discussion of alternative methods.

4.5 Impactor Compactor Trial Assessment

At the time of report preparation, the impact compaction trials had not been completed. It is anticipated that once completed the results of compaction testing will be incorporated into a revision of this report, or will be provided in a separate addendum report.

4.6 Lateral Spreading Mitigation Measures

The impact compactor assessment indicates that the magnitude of lateral spreading can be significantly reduced but not entirely eliminated by compaction. Therefore, to mitigate against lateral spreading other options need to be considered and based on our experience on Prestons North, the most appropriate method is likely to be gravel embankments. However, depending on the depth of the liquefiable layers, the use of stone columns or vibrofloatation may need to be considered.

4.6.1 Gravel Embankment Assessment

The gravel embankment would comprise of a block of well compacted sandy gravel founded below the liquefiable layers and wide enough to prevent lateral displacement towards the stormwater basin/channel. Lateral spreading occurs where there is a continuous liquefiable layer through to the free face, so by installing wide gravel embankments along any free edges the lateral spreading can be eliminated.

In determining the extent of the mitigation measures to minimise the lateral spreading, we need to consider where the liquefiable layers are present in the soil profile and how this relates to the depth of Snellings Drain and the proposed basin and channels.

At this stage, the details of the stormwater basin and associated channels are not known however the basin will be located in the southeast corner of Law Block. Snellings Drain runs along the northern and eastern boundary of Law Block and the likelihood of lateral spreading adjacent the existing open drain will need to be assessed.

For the proposed stormwater basin we have reviewed relevant CPT logs and the liquefaction analysis to confirm where liquefaction is occurring. The depth of the liquefiable layers has been determined for the most part to be less than 3m below existing ground level.

The extent and depth of liquefiable layers are similar to those identified in Prestons Park where gravel embankments have been designed and constructed to eliminate the lateral spreading potential. As the depth of the liquefiable layers is predominantly in the upper 3m with further liquefiable layers at depths of greater than 5m, we consider the use of gravel embankment adjacent to Snellings Drain and the stormwater basin/channel is a feasible mitigation option.

Where liquefiable layers are present at 3m to 4m depth, the predominant option is to excavate out the liquefiable soils and replace with compacted gravel. This method would require relatively deep excavations but such excavations have been completed successfully in Prestons North and Prestons Park.

An alternative is to excavate to 3m depth, place a layer of compacted gravel then use the impact compactor to densify the soil below the gravel, before building up the remainder of the gravel embankment. As this option involves ground densification, quality assurance testing with CPT will be required to confirm that the required ground improvement has been achieved. It may also be necessary to pre-drill through the compacted gravel before CPT testing can be carried out which will increase QA costs.

As part of the detailed design of the Law Block subdivision, further geotechnical assessment will be required to confirm the gravel embankment design for each of the stormwater features including the existing Snellings Drain.

Indicative recommendations for construction of the gravel embankment are as follows:

- Embankment fill material will consist of free draining, well graded sandy gravel fill.
- Fill is placed in a dry excavation to allow maximum compaction. As groundwater is anticipated at shallow levels dewatering will be required.

- The base of the should be inspected by a geotechnical engineer prior to fill placement to confirm that the base of excavation is clear of organics.
- If there is loose soil in the base of the excavation, then the soil will need to be compacted, or removed and replaced with gravel fill.
- Construction of the embankment will require gravel to be compacted to 95% of vibrating hammer compaction in accordance with NZS4402:1986, Test 4.1.3.

4.6.2 Stone Columns

If the detailed design of the embankment indicates that the depth of liquefaction is significant enough that excavation of the embankment is not feasible, then stone columns many need to be considered. Stone columns would densify the ground and reduce the potential for the ground to liquefy and hence reduce the potential for lateral spreading.

The installation of stone columns only becomes cost effective if the depth of densification exceeds 3m to 4m. Typically stone columns would be installed on a 6m deep grid over a zone ranging from 10m to 15m in width, depending on the basin configuration. The stone columns will need to be designed by a geotechnical engineer as part of the detailed subdivision design.

This method of compaction has the advantage that it can be undertaken below the water table in saturated soils. Therefore, no dewatering is required for the compaction process to be undertaken.

A stone column field trial is recommended, in order to determine the degree of ground improvement, to optimise the column spacing and to determine the viability of the proposed works. Stone columns are typically installed by a specialist contractor, whose input would be required in carrying out the detailed design.

4.6.3 Vibrofloatation

An alternative densification method to stone columns is to undertake vibrofloatation compaction adjacent to the basins/channels. This essentially involves using a crane mounted vibrating probe that is inserted into the ground. As the probe penetrates the soil skeleton around the probe collapses and densifies due to the high frequency vibration. The probe would be inserted on a triangular grid, at approximately 2.5m to 3.5m centres, across the site to the required depth of penetration.

The vibrofloatation method leaves hollows in the ground following treatment (due to the volumetric reduction in the soil volume caused by the soil densification) which will then need filling. If this method is used it is recommended that the surface is rolled with an impact compactor post filling as the vibrofloatation method can potentially loosen the upper 600mm of soils.

This method of compaction has the advantage that it can be undertaken below the water table in saturated soils. Therefore, no dewatering is required for the compaction process to be undertaken.

As part of the detailed subdivision design the vibrofloatation will need to be designed by a geotechnical engineer. A field trial is recommended, in order to determine the degree of ground improvement, to optimise the probe spacing, and to determine the viability of the proposed works. Vibrofloatation is typically carried out by a specialist contractor, whose input would be required in carrying out the detailed design.

4.7 Foundation Implications

4.7.1 TC1 Compliance

Suitable foundation types for the various technical categories have been defined in the MBIE Guidelines. For Technical Category 1 areas the MBIE Guidelines has recommended Standard NZS3604:2011 type foundations with tied slabs provided there is suitable bearing. As required under the MBIE Guidelines for detailed house design, a site specific geotechnical assessment shall be carried out by suitability qualified chartered engineer with experience in residential house development.

4.7.2 TC2 Compliance

Where residential sites cannot be improved to TC1 classification then TC2 type foundations will be required. For Technical Category 2 areas the MBIE Guidelines has recommended types of enhanced foundation systems. The appropriate foundation system will depend on the ultimate bearing capacity of the foundation soil. Schematics and typical cross sections of these foundation systems are presented in the guidelines. For detailed house design, a site specific geotechnical assessment shall be carried out by suitability qualified chartered engineer with experience in residential house development.

As part of the detailed foundation design, particular attention should be paid to detailing the connection joints of buried services (water and sewer pipes, power conduits, etc.) between the house foundation and the in situ ground. The design should allow sufficient movement and ductility to account for seismic shaking and liquefaction induced movement, and to allow for easy reinstatement if they were to be damaged during a future seismic event.

4.8 Organic Soil Layers

Peat has been commonly encountered across the Preston Subdivision area with layers up to 0.5m thick found within the upper surficial soils. The intrusive investigations completed across Law Block (test pits and boreholes) encountered only minor peat with a 50mm to 100mm thick layer encountered in Test Pits TP02, TP03 and TP04 at approximately 2m depth in the south-west quadrant of the site area. However, peat can be localised and the presence of thicker peat layers across the area is possible. The peat layers encountered were at depths of around 2m and are at a depth and of a thickness (≤100mm) that settlement is anticipated to be negligible under additional loading and/or dewatering effects. During earthworks design the presence of the peat will be further assessed, and if shallow peat layers are considered an issue for the development then these layers will be removed. In addition, during site earthworks if peat is encountered at shallow depths, then it will be removed prior to further earthworks being carried out.

4.9 Earthworks

4.9.1 Cut Excavations

It is proposed to form a series of stormwater basins and channels as part of the development which will require excavations into the existing ground surface. Based on the investigation results we make the following comments:

- Cuts are likely to encounter predominantly loose to medium dense sandy soil with possible interbedded peat and silt layers. We anticipate that the soils will be easy to excavate with conventional earth moving equipment.
- Cut slopes of 4H:1V or less are likely to maintain global stability for static and seismic cases. However, there is a potential for the cuts to be affected by lateral spreading. The lateral spreading risk has been discussed in Section 4.2.3 and mitigation measures will be required.
- Groundwater is present at relatively shallow depths across the site and is likely to be encountered during cut slope construction. Earthworks will need to be carried out so that the presence of the groundwater does not adversely affect the stability of the cuts. It is anticipated that groundwater seeps are initially likely to be present in the cut faces however the levels are likely to equalise in the long term.
- If significant groundwater inflows are encountered and left untreated, slumping of cuts could occur. Hence, site specific treatment should be adopted on an as required basis.
- Cut slopes will be vulnerable to erosion and therefore should be treated or otherwise protected as soon as practicable after excavation.

4.9.2 Earthfill

It is proposed to reuse the soils from the stormwater basin/channel excavations as fill across the site as well as using imported fill to meet the balance of the site fill requirements. The majority of the insitu soils consist of fine to medium grained sand with possible peat and silt in the upper layers. Based on the anticipated soil types we make the following comments:

- **Peat:** The peat is unsuitable for fill and would need to be cut to waste or retained as landscape fill.
- **Silt**: The silt is marginally suitable for fill, as it is moisture sensitive and can be difficult to compact. It would be preferable that the silt is used as landscaping fill, where achieving high levels of compaction are not essential. However, following a field trial this material may be considered as fill in appropriate locations.
- **Sand:** The sand is considered to be suitable as an earthfill material. However, previous compaction testing (across the existing Prestons Park development) indicate that the maximum dry density will be sensitive to moisture content and will be difficult to compact if the water content is above the optimum moisture content. The moisture content of the sand will need to be controlled during fill placement to ensure appropriate compaction is achieved. Alternatively, where the sand is too dry, wetting may be required.
- **Imported Fill:** In case of a shortfall of site won fill, imported fill will be required. When the fill source site has been identified, an inspection of the material by a geotechnical engineer and review of laboratory testing results by a geotechnical engineer should be carried out to confirm the fill suitability.

4.9.3 Earthwork Volumes

In considering earthworks volumes the following aspects need to be considered:

Impact Compactor Induced Settlements

Impact compactor trials completed across Prestons North and Prestons Park indicate that the compaction method will cause ground settlement. We recommend that an allowance is made for 100mm of additional fill to compensate for compaction induced settlement.

Impactor Compactor Working Surface

The impact compactor will need a working surface to allow for ease of movement and to improve its effectiveness. Previous impact compaction has been undertaken on the topsoil surface but if the topsoil is soft or wet, particularly during winter, then the topsoil and any other unsuitable soil will need to be removed and a working layer of 300mm gravel fill placed across the proposed ground improvement area. It may be possible to re-use parts or all of the gravel layer as bulk filling once ground improvement works are completed.

5 Assessment Against RMA

Section 106 of the Resource Management Act (RMA) (2017) states *inter alia*

Consent authority may refuse subdivision consent in certain circumstances

1) A consent authority may refuse to grant a subdivision consent, or may grant a subdivision consent subject to conditions, if it considers that—

- *a) there is a significant risk from natural hazards; or*
- *b) Repealed*
- *c) sufficient provision has not been made for legal and physical access to each allotment to be created by the subdivision.*

1A) For the purpose of subsection (1) (a), an assessment of the risk from natural hazards requires a combined assessment of—

- *a) the likelihood of natural hazards occurring (whether individually or in combination); and*
- *b) the material damage to land in respect of which the consent is sought, other land, or structures that would result from natural hazards; and*
- *c) any likely subsequent use of the land in respect of which the consent is sought that would accelerate, worsen, or result in material damage of the kind referred to in paragraph (b).*

2) Conditions under subsection (1) must be—

- *a) for the purposes of avoiding, remedying, or mitigating the effects referred to in subsection (1); and*
- b) *of a type that could be imposed under section 108.*

A risk assessment approach has been undertaken on the significant geotechnical hazards that may affect the site, which is presented in Appendix H.

The assessment identified liquefaction and lateral spread risk adjacent to the proposed retention basin and along the existing Snellings Drain. There may be a low risk of soil erosion due to the dispersive nature of the soil. However, provided that the geotechnical recommendations in this report are followed and the appropriate engineering measures are implemented, then we consider that the development is unlikely to be affected by significant geotechnical hazards nor will the development worsen, accelerate or result in material damage. Therefore, from a geotechnical perspective we consider that the Law Block Subdivision development can proceed.

6 Limitations

We have prepared this report in accordance with the brief as provided. The contents of the report are for the sole use of the Client and no responsibility or liability will be accepted to any third party. Data or opinions contained within the report may not be used in other contexts or for any other purposes without our prior review and agreement.

The recommendations in this report are based on data collected at specific locations and by using appropriate investigation methods with limited site coverage. Only a finite amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgment and it must be appreciated that actual conditions could vary from the assumed model.

Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay.

7 References

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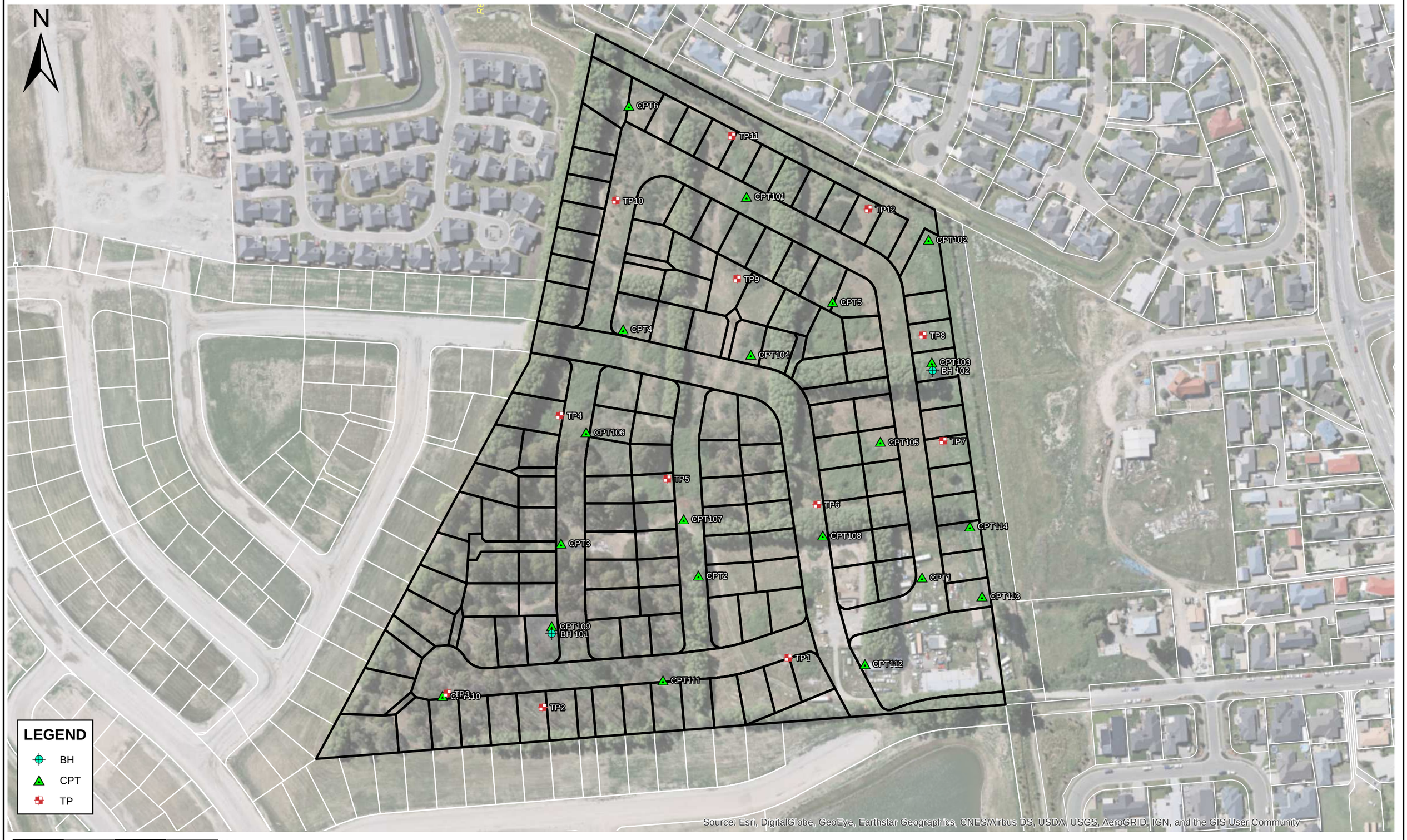
Appendices

Appendix A
Figures



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CLIENT
CDL LAND
NEW ZEALAND LIMITED

REV	DATE	REVISION DETAILS	APPROVED
A	07.18	ISSUE FOR INFORMATION	I. McPHERSON

DRAWN	DESIGNED
R DAWSON	M. LAZZARO

CHECKED: J. MUIRSON

APPROVED: I.McPHERSON — DATE: July 2018

PROJECT: PRESTONS PARK

TITLE: INVESTIGATION LOCATION PLAN
STAGE 4 - LAW BLOCK

PROJECT No.: 235361

SCALE: 1: 2000 | SIZE: A3

DRAWING No.: GIS 37 | REV: A

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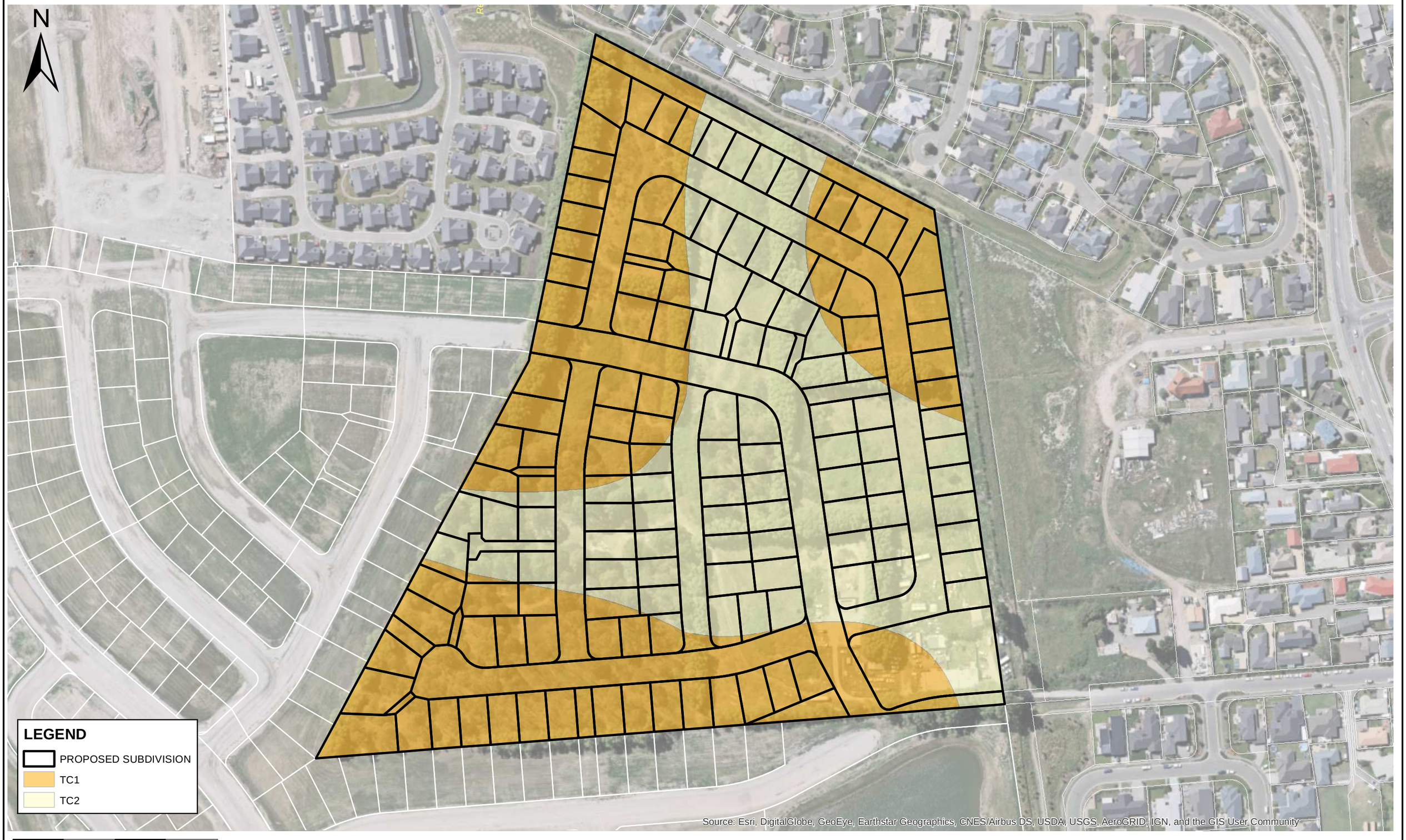

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R DAWSON	M. LAZZARO

CHECKED: J. MUIRSON

APPROVED: I. McPHERSON — DATE: July 2018

PROJECT: PRESTONS PARK

TITLE: TECHNICAL CATEGORY BOUNDARIES
STAGE 4 - LAW BLOCK

PROJECT No.: 235361

SCALE	SIZE
1: 2000	A3

DRAWING No.	REV
GIS 36	A

Path: P:\223488\GIS\MXD\235361-GIS 36 TCs STAGE 4.mxd

Appendix B
2017 CPT Logs

CONE PENETRATION TEST (CPT) REPORT

Client: Aurecon NZ Ltd

Location: Prestons Law Block
Cameo Grove, Christchurch

Printed: 17/07/2017

CONE PENETRATION TEST

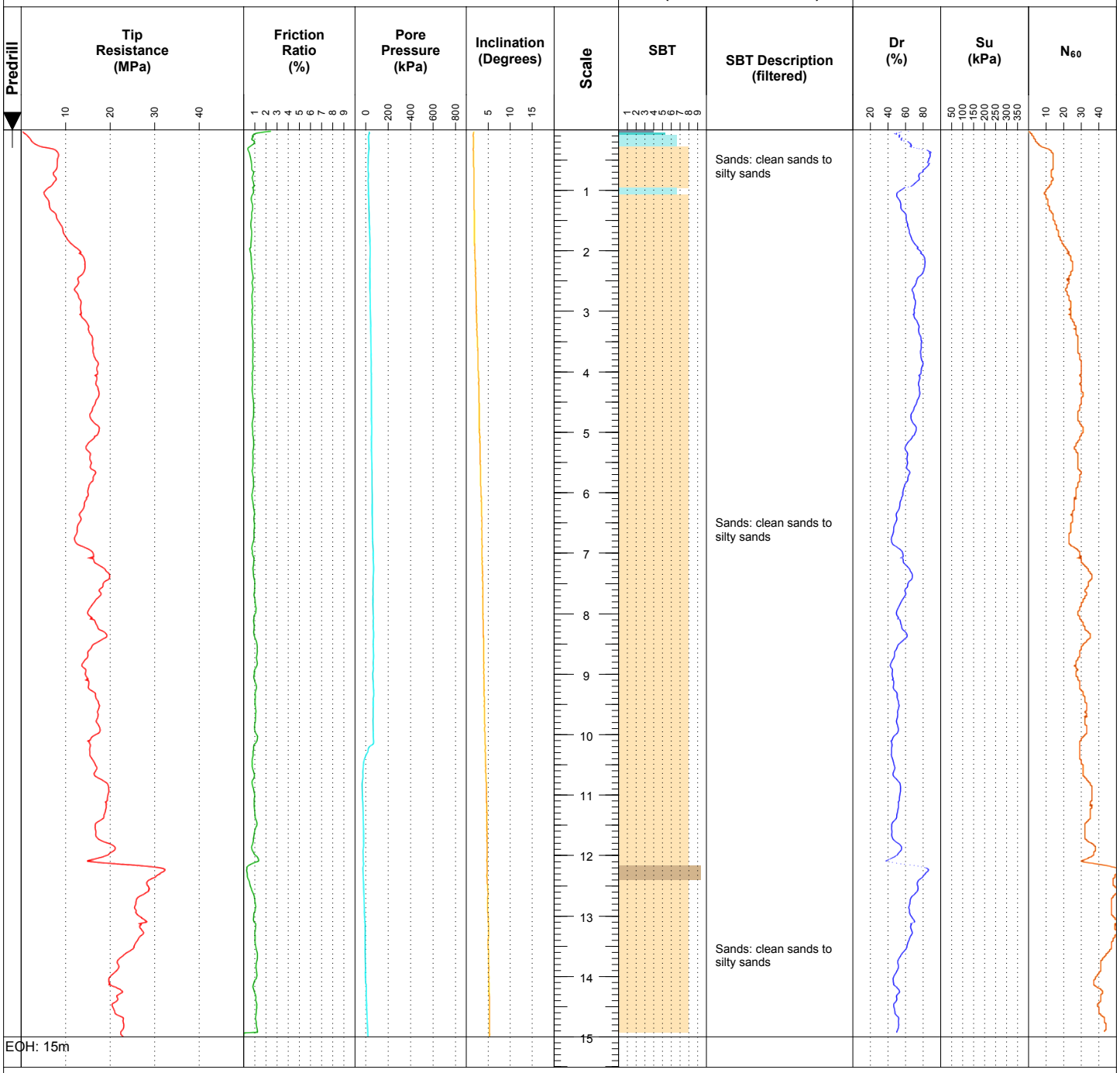
Job:	16970
CPT No.:	CPTu001

Name: Prestons Law Block
Client: Aurecon NZ Ltd
Location: Cameo Grove, Christchurch

Hole Depth (m): 15.00
Elevation (m): 0.00
Datum: Ground

North (m): 5185984.50
East (m): 1573845.69
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100 - track
Cone Reference: 160925
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: -0.9188
Local Friction (MPa) Initial: 0.0069
Pore Pressure (KPa) Initial: -0.0117

Date: 14/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.20
Final: -0.908
Final: 0.0007
Final: -0.0112

Effective Refusal
Tip:
Gauge:
Inclinometer:
Other:
Target Depth: ✓

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks
Target Depth

Hole Depth (m): 15.00

CONE PENETRATION TEST

McMILLAN Drilling

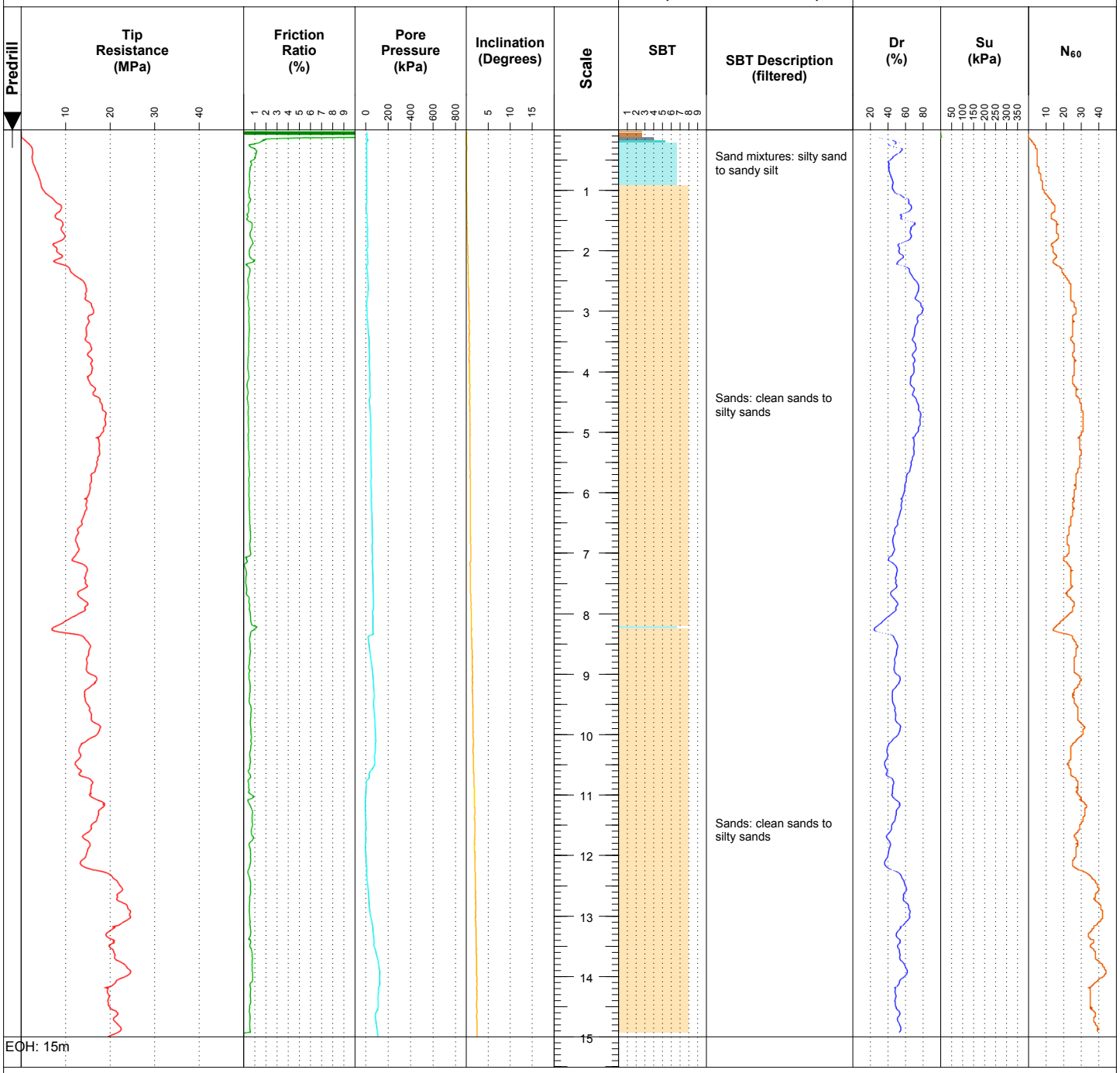
Job:	16970
CPT No.:	CPTu002

Name: Prestons Law Block
Client: Aurecon NZ Ltd
Location: Cameo Grove, Christchurch

Hole Depth (m): 15.00
Elevation (m): 0.00
Datum: Ground

North (m): 5185991.67
East (m): 1573719.32
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100 - track
Cone Reference: 100992
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10
Tip Resistance (MPa) Initial: 1.2635
Local Friction (MPa) Initial: 0.032
Pore Pressure (KPa) Initial: -0.0047

Date: 14/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.70
Final: 1.2695
Final: 0.0319
Final: -0.0069

Effective Refusal
Tip:
Gauge:
Inclinometer:
Other:
Target Depth: ✓

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks
Target Depth

Hole Depth (m): 15.00

CONE PENETRATION TEST

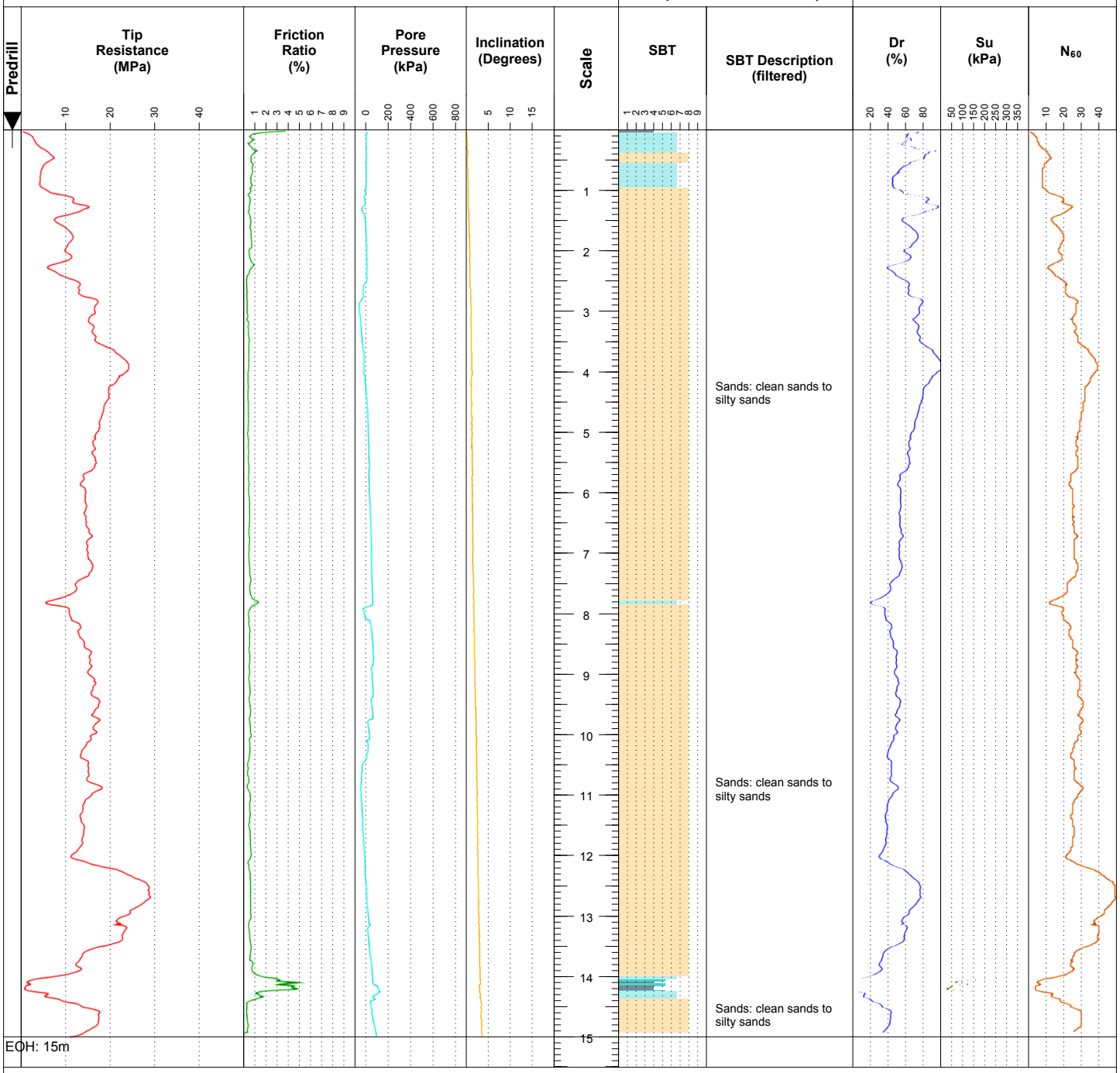
Job:	16970
CPT No.:	CPTu003

Name: Prestons Law Block
Client: Aurecon NZ Ltd
Location: Cameo Grove, Christchurch

Hole Depth (m): 15.00
Elevation (m): 0.00
Datum: Ground

North (m): 5186009.40
East (m): 1573623.11
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100 - track
Cone Reference: 100992
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10
Tip Resistance (MPa) Initial: 1.1853
Local Friction (MPa) Initial: 0.0306
Pore Pressure (KPa) Initial: 0.0086

Date: 13/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.90
Final: 1.2165
Final: 0.0311
Final: 0.004

Effective Refusal
Tip:
Gauge:
Inclinometer:
Other:
Target Depth: ✓

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks
Target Depth

Hole Depth (m): 15.00

McMILLAN Drilling

CONE PENETRATION TEST

Job: 16970

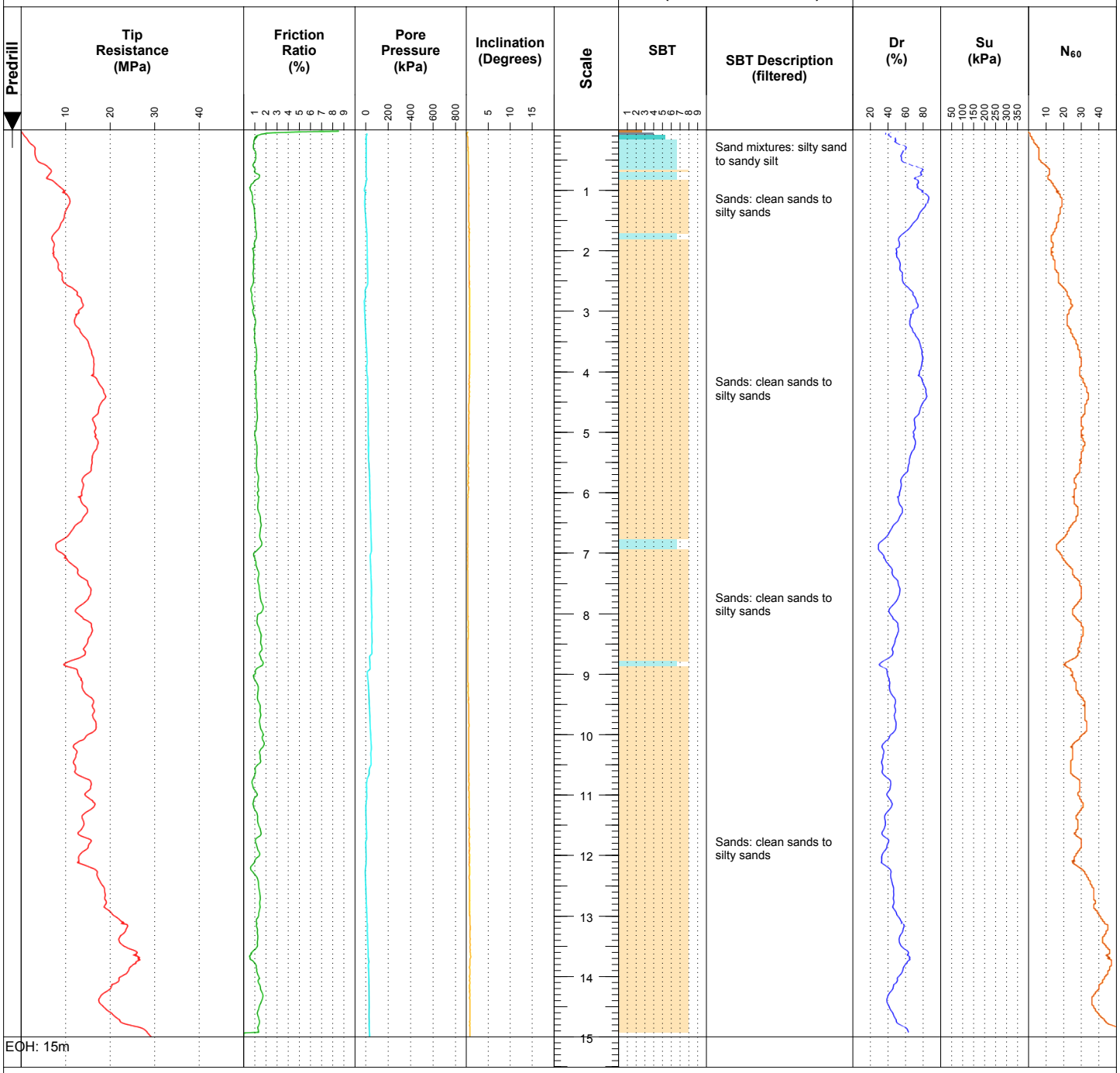
CPT No.: CPTu004

Name: Prestons Law Block
Client: Aurecon NZ Ltd
Location: Cameo Grove, Christchurch

Hole Depth (m): 15.00
Elevation (m): 0.00
Datum: Ground

North (m): 5186126.94
East (m): 1573671.82
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100 - track
Cone Reference: 170302
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: 1.0633
Local Friction (MPa) Initial: -0.0077
Pore Pressure (KPa) Initial: 0.0561

Date: 13/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.70
Final: 1.0792
Final: -0.0153
Final: 0.0483

Effective Refusal
Tip:
Gauge:
Inclinometer:
Other:
Target Depth: ✓

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks
Target Depth

Hole Depth (m): 15.00

McMILLAN Drilling

CONE PENETRATION TEST

Job: 16970

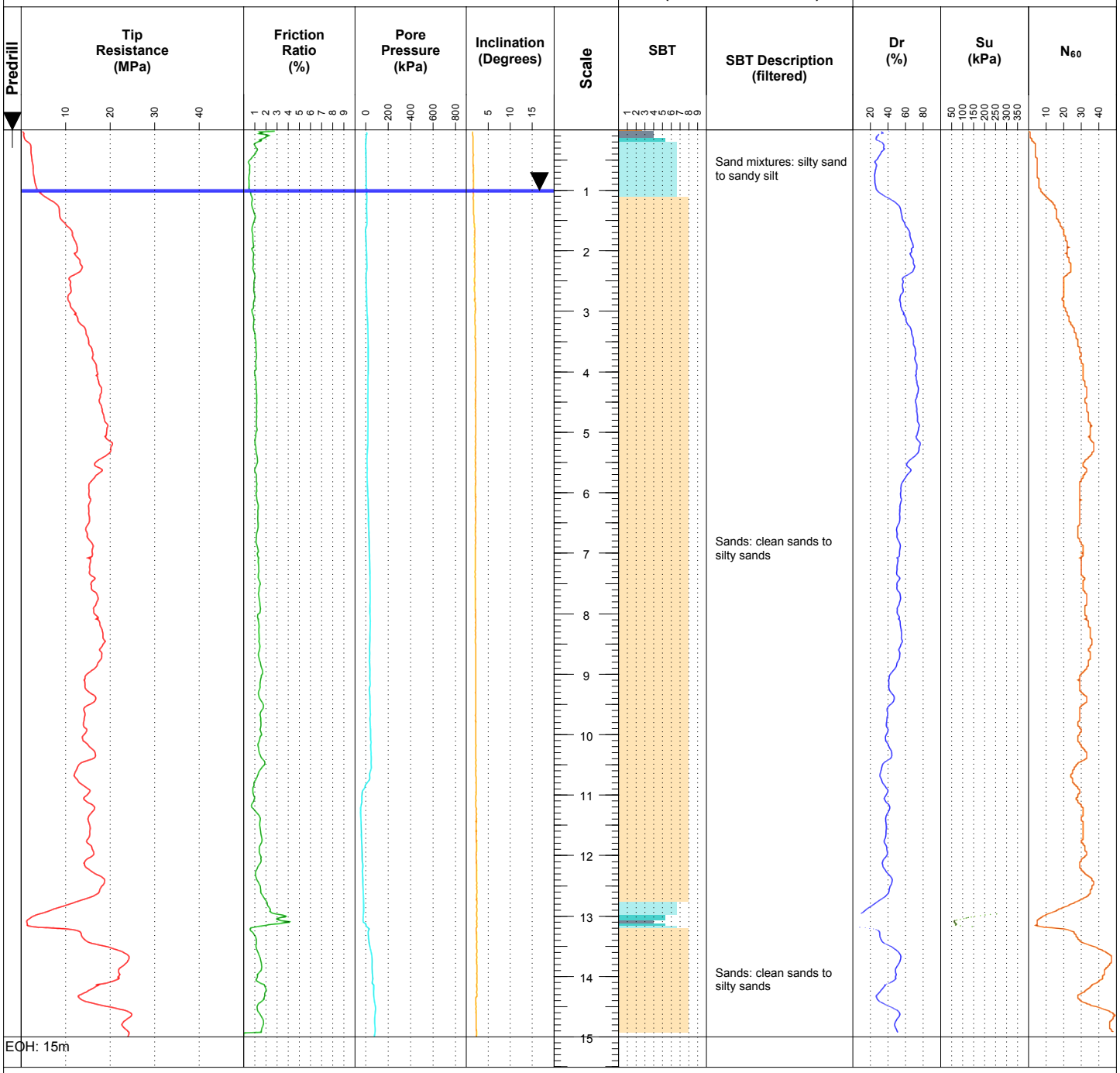
CPT No.: CPTu005

Name: Prestons Law Block
Client: Aurecon NZ Ltd
Location: Cameo Grove, Christchurch

Hole Depth (m): 15.00
Elevation (m): 0.00
Datum: Ground

North (m): 5186145.15
East (m): 1573788.94
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100 - track
Cone Reference: 170302
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: 1.0289
Local Friction (MPa) Initial: -0.0035
Pore Pressure (KPa) Initial: 0.0041

Date: 14/07/2017
Predrill: 0.00
Water Level: 1.00
Collapse: 1.10
Final: 1.0545
Final: -0.0059
Final: -0.0221

Effective Refusal
Tip:
Gauge:
Inclinometer:
Other:
Target Depth: ✓

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks
Target Depth

Hole Depth (m): 15.00

CONE PENETRATION TEST

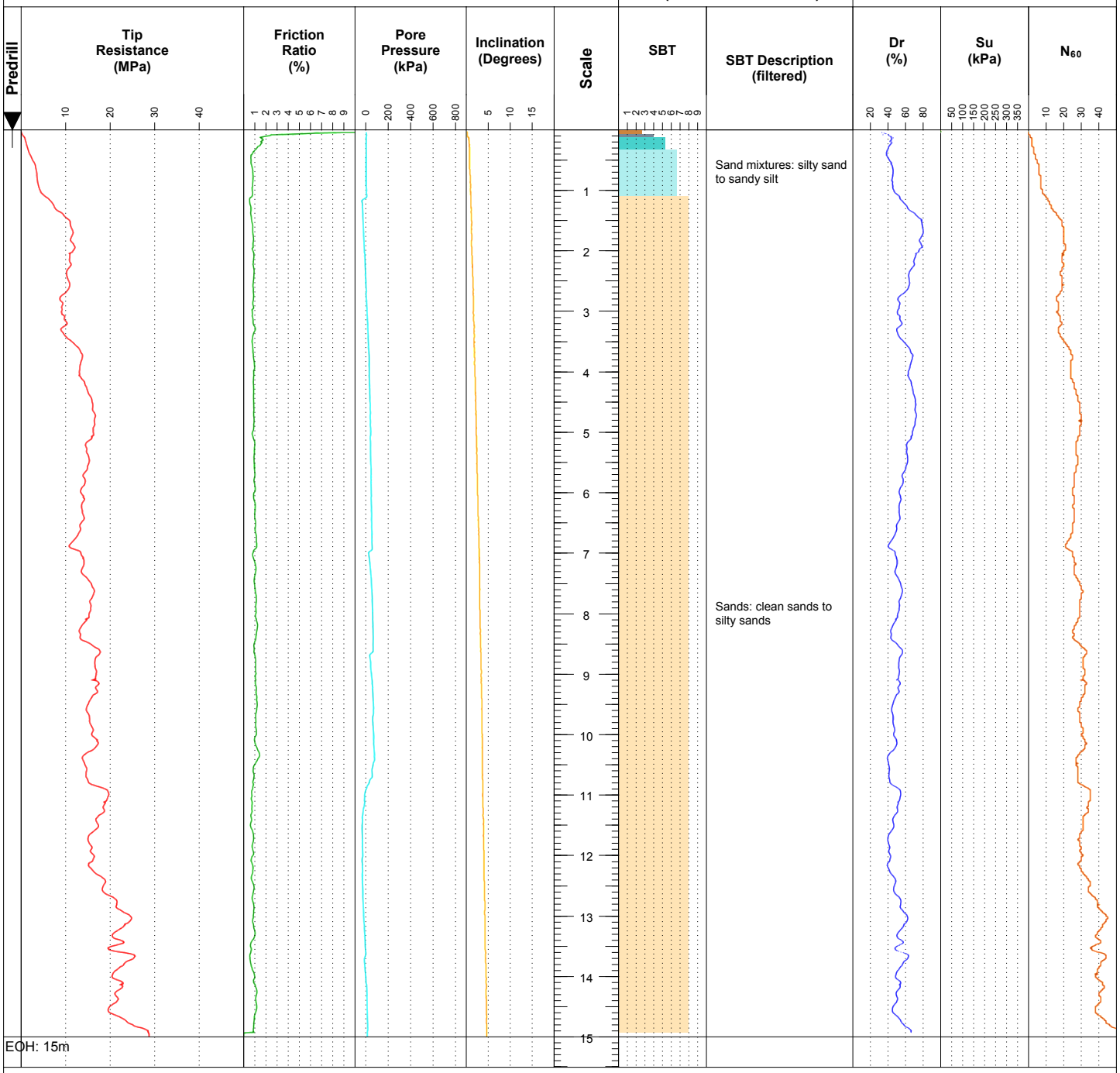
Job:	16970
CPT No.:	CPTu006

Name: Prestons Law Block
Client: Aurecon NZ Ltd
Location: Cameo Grove, Christchurch

Hole Depth (m): 15.00
Elevation (m): 0.00
Datum: Ground

North (m): 5186261.87
East (m): 1573663.35
Grid: NZTM

RAW DATA | **SOIL BEHAVIOUR TYPE (NON-NORMALISED)** | **ESTIMATED PARAMETERS**



Operator: R. Wyllie
Rig: Geomil Panther 100 - track
Cone Reference: 160925
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15
Tip Resistance (MPa) Initial: -0.9709
Local Friction (MPa) Initial: 0.0059
Pore Pressure (KPa) Initial: 0.0103

Date: 13/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.90
Final: -0.9588
Final: 0.0009
Final: -0.0013

Effective Refusal
Tip:
Gauge:
Inclinometer:
Other:
Target Depth: ✓

Soil Behaviour Type (SBT) - Robertson et al. 1986

0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Notes & Limitations

Data shown on this report has been assessed to provide a basic interpretation in terms of Soil Behaviour Type (SBT) and various geotechnical soil and design parameters using methods published in P. K. Robertson and K.L. Cabal (2010), Guide to Cone Penetration Testing for Geotechnical Engineering, 4th Edition. The interpretations are presented only as a guide for geotechnical use, and should be carefully reviewed by the user. Both McMillan Drilling Ltd & Geroc Solutions Ltd do not warranty the correctness or the applicability of any of the geotechnical soil and design parameters shown and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used to derive data shown in this report.

Remarks
Target Depth

Hole Depth (m): 15.00

TEST DETAIL

PointID: CPTu001

Sounding: 1

Operator: R. Wyllie
Cone Reference: 160925
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15

Date: 14/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.20

Effective Refusal Tip:
Gauge:
Inclinometer:
Other:

Tip Resistance (MPa) Initial: -0.9188 **Final:** -0.908
Local Friction (MPa) Initial: 0.0069 **Final:** 0.0007
Pore Pressure (kPa) Initial: -0.0117 **Final:** -0.0112

Target Depth: ✓

PointID: CPTu002

Sounding: 2

Operator: R. Wyllie
Cone Reference: 100992
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10

Date: 14/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.70

Effective Refusal Tip:
Gauge:
Inclinometer:
Other:

Tip Resistance (MPa) Initial: 1.2635 **Final:** 1.2695
Local Friction (MPa) Initial: 0.032 **Final:** 0.0319
Pore Pressure (kPa) Initial: -0.0047 **Final:** -0.0069

Target Depth: ✓

PointID: CPTu003

Sounding: 3

Operator: R. Wyllie
Cone Reference: 100992
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-10

Date: 13/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.90

Effective Refusal Tip:
Gauge:
Inclinometer:
Other:

Tip Resistance (MPa) Initial: 1.1853 **Final:** 1.2165
Local Friction (MPa) Initial: 0.0306 **Final:** 0.0311
Pore Pressure (kPa) Initial: 0.0086 **Final:** 0.004

Target Depth: ✓

PointID: CPTu004

Sounding: 4

Operator: R. Wyllie
Cone Reference: 170302
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15

Date: 13/07/2017
Predrill: 0.00
Water Level: -
Collapse: 0.70

Effective Refusal Tip:
Gauge:
Inclinometer:
Other:

Tip Resistance (MPa) Initial: 1.0633 **Final:** 1.0792
Local Friction (MPa) Initial: -0.0077 **Final:** -0.0153
Pore Pressure (kPa) Initial: 0.0561 **Final:** 0.0483

Target Depth: ✓

PointID: CPTu005

Sounding: 5

Operator: R. Wyllie
Cone Reference: 170302
Cone Area Ratio: 0.75
Cone Type: I-CFXYP20-15

Date: 14/07/2017
Predrill: 0.00
Water Level: 1.00
Collapse: 1.10

Effective Refusal Tip:
Gauge:
Inclinometer:
Other:

Tip Resistance (MPa) Initial: 1.0289 **Final:** 1.0545
Local Friction (MPa) Initial: -0.0035 **Final:** -0.0059
Pore Pressure (kPa) Initial: 0.0041 **Final:** -0.0221

Target Depth: ✓

TEST DETAIL

PointID: CPTu006

Sounding: 6

Operator:	R. Wyllie	**Date:**	13/07/2017	**Effective Refusal**	
Cone Reference:	160925	**Predrill:**	0.00	**Tip:**	
Cone Area Ratio:	0.75	**Water Level:**	-	**Gauge:**	
Cone Type:	I-CFXYP20-15	**Collapse:**	0.90	**Inclinometer:**	
				Other:	
Tip Resistance (MPa) Initial:	-0.9709	**Final:**	-0.9588		
Local Friction (MPa) Initial:	0.0059	**Final:**	0.0009		
Pore Pressure (kPa) Initial:	0.0103	**Final:**	-0.0013	**Target Depth:**	✓

McMILLAN Drilling GROUP

CPT CALIBRATION AND TECHNICAL NOTES

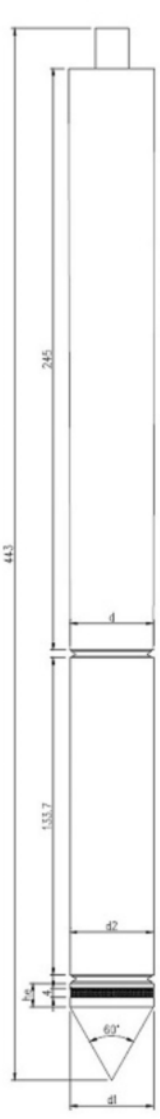
These notes describe the technical specifications and associated calibration references pertaining to the following cone types:

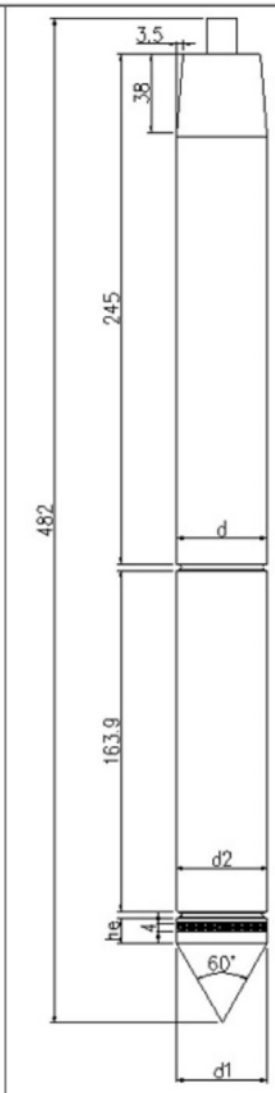
- I-CFXY-10 measuring cone resistance, sleeve friction and inclination (standard cone, 10cm²);
- I-CFXY-15 measuring cone resistance, sleeve friction and inclination (standard cone, 15cm²);
- I-CFXYP20-10 measuring cone resistance, sleeve friction, inclination and pore pressure (piezocone, 10cm²);
- I-CFXYP20-15 measuring cone resistance, sleeve friction, inclination and pore pressure (piezocone, 15cm²);
- I-C5F0p15XYP20-10 measuring sensitive cone resistance, sleeve friction, inclination and pore pressure (piezocone, 10cm²).

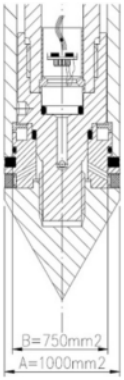
Dimensions

Dimensional specifications for all cone types are detailed below. All tolerances are routinely checked prior to testing and measurements taken are manually recorded on CPT field sheets. All field sheets are kept on file and available on request.

A.P. van den Berg Machinefabriek tel.: +31 (0)513-631355 info@apvandenberg.com	**DEVIATION of Straightness + MINIMUM Dimensions tip, friction jacket, cone adapter**	Standards: EN ISO 22476-1 APB-standard	
Type of cone:	Icone 10 cm²		Icone 15 cm²
ALLOWABLE SIZE VARIATION			
Diameter of tip:	$35,3 \leq d1 \leq 36,0$		$43,2 \leq d_1 \leq 44,1$
Diameter of centering ring CFP	$35,3 \leq d1 \leq 36,0$		$43,2 \leq d_1 \leq 44,1$
Diameter of friction jacket:	$d_1 \leq d_2 < d_1 + 0,35$		$d_1 \leq d_2 < d_1 + 0,43$
Height dimension of tip edge:	$7 \leq h_e \leq 10$		$9 \leq h_e \leq 12$
PRODUCTION DIMENSIONS			
Tip:	$d_1 = 35,7\ ^{+0,2}_{0}$		$d_1 = 43,8\ ^{+0,2}_{0}$
Jacket (C-cone):	$d_2 = 35,7\ ^{+0,2}_{0}$		$d_2 = 43,7\ ^{+0,2}_{0}$
Friction jacket (CF-cone):	$d_2 = 35,9\ ^{+0,1}_{0}$		$d_2 = 44,0\ ^{+0,1}_{0}$
Tip for used cone:	$d_1 = 35,5\ ^{+0,1}_{0}$		$d_1 = 43,5\ ^{+0,1}_{0}$
MINIMUM DIMENSIONS			
Minimum diameter jacket (C-cone):	$d_2 = 35,2$ (APB standard)		$d_2 = 43,0$ (APB standard)
Minimum diameter friction jacket (CF-cone):	$d_2 = 35,3$		$d_2 = 43,2$
Use "used cone"-tip when friction jacket diameter:	$d_2 \leq 35,65$		$d_2 \leq 43,7$
Minimum diameter of cone adaptor:	$d = 35,3$		$d = 43,8$
Maximum deviation of straightness:	1 mm on a length of 1000 mm (max. oscillation 1,0 mm.)		1 mm on a length of 1000 mm (max. oscillation: 2.0 mm)



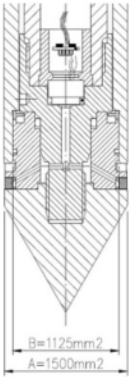




Cone area ratio

$\alpha = A / B = 0.75$

$\beta = 1 - A / B = 0.25$



McMILLAN Drilling GROUP

CPT CALIBRATION AND TECHNICAL NOTES (cont.)

Calibration

Each cone has a unique identification number that is electronically recorded and reported for each CPT test. The identification number enables the operator to compare 'zero-load offsets' to manufacturer calibrated zero-load offsets.

The recommended maximum zero-load offset for each sensor is determined as ± 5% of the nominal measuring range.

In addition to maximum zero-load offsets, McMillan Drilling also limits the difference in zero load offset before and after the test as ± 2% of the maximum measuring range. See table below:

	Tip (MPa)	Friction (MPa)	Pore Pressure (MPa)
Maximum Measuring Range:	150	1.50	3.00
Nominal Measuring Range:	75	1.00	2.00
Max. 'zero-load offset':	7.5	0.10	0.20
Max 'before and after test':	3	0.03	0.06

Note: The zero offsets are electronically recorded and reported for each test in the same units as that of each sensor.

TEST CERTIFICATE
Icone (all versions)

Supplier:	A.P. v.d. Berg Machinefabriek, Heerenveen The Netherlands
Production-order:	73868
Client:	Mc Millan
Cone-type:	I-CFXYP 20-10
Cone-number:	100992

To test / To check item	**Required value**	**Checked value**	
Check Quad-ring groove behind friction sleeve with check ring; **Sample testing: 1 of every 5 Icones is tested.**	Sleeve fixed	✓	
Isolation-resistance.	>0.5 GΩ	>0,5 GΩ	
Straightness: Icone 5, 10 and 15 cm^2 S < 2.2. mm. At Icone base: S < 0,2 mm	S<= 2,2 mm	0,2 mm	
"Classic calibration" NOT present! Check of calibration-file: "Classic calibration" removed.	O.K.	✓	
Check alarm-settings Icone. Alarm values are set. (Kill Shutdown).	O.K.	✓	
Software version - check at opening screen.	version:	2.0	
Calibration date of Icone; check cone data [F1]..[F1].	O.K.		
Initial zero-Value Tip after calibration – within 1.0 % of nominal load.	Value:	~~0,012~~ MPa	0.007
Initial zero-Value Local Friction after calibration – within 1.0% of nominal load.	Value:	~~0,0024~~ MPa	0.001
Initial zero-Value Pore Pressure after calibration – within 1.0% of nominal load.	Value:	~~-13,4~~ kPa	-13.2
Initial zero-Value Inclination X. -1°< X <+1° Initial zero-Value Inclination Y. -1° < Y <+1°	Value: Value:	-0,2 ° 0,0 °	
Measurements Tip resistance OK?	Tested range	0-75MPa	
Influence Tip load on **Local Friction and Pore Pressure:** Max. tip load: 5 cm^2: 65 MPa; 10 cm^2: 100 MPa; 15 cm^2: 75 MPa.	LF < 10 kPa PP <½% nom	4 kPa 1 kPa	
Measurements local friction OK?	Tested range:	0-1 MPa	
Local friction at max. load.	Tested value:	1,5 MPa	
Measurements Pore Pressure OK?	Tested range:	2000 kPa	
Measure Pore Pressure to 150%.	Tested value:	~~3000~~ kPa	
Measurements Inclination OK?	Tested range:	± 24°	
Cone recognition on disconnecting and connecting Icone again?	Yes	✓	

Remarks:

Calibrated by:	C. Ouwejan	Date: 05-01-2018	Sign.:
Final check:	E. v.d. Duim	Date: 05-01-2018	Sign.:

TEST CERTIFICATE
Icone (all versions)

Supplier:	A.P. v.d. Berg Machinefabriek, Heerenveen The Netherlands
Production-order:	72614
Client:	Mc Millan
Cone-type:	I-CFXYP20-15
Cone-number:	160925

To test / To check item	Required value	Checked value
Check Quad-ring groove behind friction sleeve with check ring; **Sample testing: 1 of every 5 Icones is tested.**	Sleeve fixed	/
Isolation-resistance.	>0.5 GΩ	1.1 GΩ
Straightness: Icone 5, 10 and 15 cm^2 S < 2.2. mm. At Icone base: S < 0,2 mm	S<= 2,2 mm	0.4 mm
"Classic calibration" NOT present! Check of calibration-file: "Classic calibration" removed.	O.K.	/
Check alarm-settings Icone. Alarm values are set. (Kill Shutdown).	O.K.	O.K.
Software version - check at opening screen.	version:	2.0
Calibration date of Icone; check cone data [F1]..[F1].	O.K.	O.K.
Initial zero-Value Tip after calibration – within 1.0 % of nominal load.	Value:	-0.003 MPa
Initial zero-Value Local Friction after calibration – within 1.0% of nominal load.	Value:	0,0001 MPa
Initial zero-Value Pore Pressure after calibration – within 1.0% of nominal load.	Value:	-1.4 kPa
Initial zero-Value Inclination X. -1°< X <+1°	Value:	-0.2 °
Initial zero-Value Inclination Y. -1° < Y <+1°	Value:	0.3 °
Measurements Tip resistance OK?	Tested range	0 - 75 MPa
Influence Tip load on **Local Friction and Pore Pressure:** Max. tip load: 5 cm^2: 65 MPa; 10 cm^2: 100 MPa; 15 cm^2: 75 MPa.	LF < 10 kPa PP <½% nom	4 kPa 0.1 kPa
Measurements local friction OK?	Tested range:	0 - 1 MPa
Local friction at max. load.	Tested value:	1.5 MPa
Measurements Pore Pressure OK?	Tested range:	0-2000 kPa
Measure Pore Pressure to 150%.	Tested value:	3000 kPa
Measurements Inclination OK?	Tested range:	24-0-+24
Cone recognition on disconnecting and connecting Icone again?	Yes	Yes
Remarks: /		

Calibrated by: W de Jong	Date: 28-09-16	Sign.:	
Final check: J.W van der Meer	Date: 28-09-16	Sign.:	

R:\E&D\Beproevingsprotocollen\Beproevingsprotocol Icone English version Mc Millan.doc.docx

McMILLAN Drilling GROUP

TEST CERTIFICATE
Icone (all versions)

Supplier:	A.P. v.d. Berg Machinefabriek, Heerenveen The Netherlands
Production-order:	74378
Client:	Mc Millan
Cone-type:	I-CFXYP20-15
Cone-number:	170302

To test / To check item	Required value	Checked value	
Check Quad-ring groove behind friction sleeve with check ring; **Sample testing: 1 of every 5 Icones is tested.**	Sleeve fixed	/	
Isolation-resistance.	>0.5 GΩ	5 GΩ	
Straightness: Icone 5, 10 and 15 cm^2 S < 2.2. mm. At Icone base: S < 0,2 mm	S<= 2,2 mm	0,35 mm	
"Classic calibration" NOT present! Check of calibration-file: "Classic calibration" removed.	O.K.	/	
Check alarm-settings Icone. Alarm values are set. (Kill Shutdown).	O.K.	OK	
Software version - check at opening screen.	version:	2.0	
Calibration date of Icone; check cone data [F1]..[F1].	O.K.	OK	
Initial zero-Value Tip after calibration – within 1.0 % of nominal load.	Value:	0,007 MPa	0,006 MPa
Initial zero-Value Local Friction after calibration – within 1.0% of nominal load.	Value:	-0,002 MPa	-0,001 MPa
Initial zero-Value Pore Pressure after calibration – within 1.0% of nominal load.	Value:	0,2 kPa	-5.5 KPa
Initial zero-Value Inclination X. -1°< X <+1° Initial zero-Value Inclination Y. -1° < Y <+1°	Value: Value:	0,2 ° 0,4 °	
Measurements Tip resistance OK?	Tested range	0-75 MPa	
Influence Tip load on **Local Friction and Pore Pressure:** Max. tip load: 5 cm^2: 65 MPa; 10 cm^2: 100 MPa; 15 cm^2: 75 MPa.	LF < 10 kPa PP <½% nom	0,8 KPa 2 KPa	
Measurements local friction OK?	Tested range:	0-1 MPa	
Local friction at max. load.	Tested value:	1,5 MPa	
Measurements Pore Pressure OK?	Tested range:	0-2000 KPa	
Measure Pore Pressure to 150%.	Tested value:	3000 KPa	
Measurements Inclination OK?	Tested range:	24-0-24	
Cone recognition on disconnecting and connecting Icone again?	Yes	OK	

Remarks:

Calibrated by: C.J. Ouwejan	Date: 02/03/2017	Sign.:
Final check: J.W. van der Meer	Date: 02/03/2017	Sign.:

McMILLAN Drilling GROUP