Before the Independent Hearing Panel
Appointed by the Christchurch District Council

Under	the Resource Management Act 1991
In the matter of	a hearing of submissions on Plan Change 14 (Housing and Business Choice) to the Christchurch District Plan
	Cashmere Park Limited, Hartward Investment Trust and Robert Brown
	Submitter ID: 593

Evidence of Nicholas John Traylen

20 September 2023

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Introduction

1 My name is Nicholas John Traylen.

2 I am a director and principal engineer at Geotech Consulting Limited. I have been in that position since August 1998.

3 I hold a Bachelor of Engineering (Civil) (Hons) from the University of Canterbury. I have over 35 years' experience as a geotechnical engineer.

4 I was made a Fellow of Engineering New Zealand (FEngNZ) in March 2016; prior to that I was a Chartered Member of Engineering New Zealand (CMEngNZ), and a corporate Member of IPENZ (MIPENZ) since March 1992.

5 I have been a member of the Institute of Civil Engineers (MICE) (UK) and a Chartered Engineer (CEng) (UK) since May 1994.

6 I am a member of the New Zealand Geotechnical Society (NZGS) and also the New Zealand Society for Earthquake Engineering (NZSEE).

7 Since the Canterbury Earthquake Sequence (CES), I have been a member of the Canterbury Engineering Advisory Group to MBIE, and have held various advisory roles with MBIE, CERA, CCC, ECan and the CEIT. I have undertaken numerous post-earthquake liquefaction assessments and geotechnical investigations.

8 I have carried out a subsurface site investigation and have prepared a geotechnical assessment supporting the submission of Cashmere Park Ltd, Hartward Investment Trust and Robert Brown, seeking to rezone the below sites (the **Site**) from Residential New Neighbourhood (**RNN**) and Rural Urban Fringe (**RUUF**) zones to Medium Density Residential Zone (**MDRZ**):

(a) 126 Sparks Road (Lot 1 DP 412488)

(b) 17 Northaw Street (Lot 2 DP 412488)

(c) 36 Leistrella Road (Lot 3 DP 412488)

(d) 240 Cashmere Road (Lot 23 DP 3217)

(e) 236 Cashmere Road (RS 41613)

(f) 200 Cashmere Road (Lot 1 DP 547021)

9 I have visited the site on numerous occasions since 2011.

10 My full geotechnical report, dated 6 September 2023, is attached as Appendix A. This evidence summarises the key points for the Site.

Code of Conduct for Expert Witnesses

11 While this is not a hearing before the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2023 and that I have complied with it when preparing my evidence. Other than when I state I am relying on the advice of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

12 I have prepared evidence in relation to the geotechnical suitability of the land for rezoning and eventual subdivision into residential lots.

13 I anticipate that at subdivision stage further investigations will be carried out to refine the assessment of liquefaction on the Site.

14 There are no issues relevant for the Site arising in the section 42A reports requiring further comment.

Executive summary

15 It is my opinion that the land is geotechnically suitable for rezoning for residential subdivision, and the eventual construction of residential housing.

Investigation undertaken

16 My site investigation has consisted of thirty-four cone penetrometer tests (CPT) to depths of 7 to 21 metres below ground level; sixteen hand auger boreholes (with associated scala penetrometer testing) to depths of 2 to 2.8 metres below ground level; two machine boreholes to 7 to 10 metres depth; a seismic dilatometer test to 10 metres depth; geophysical testing to a depth of 7 metres; and soils laboratory testing.

17 The testing regime complies with the Ministry for the Environment (MfE) document "Planning and Engineering Guidance for Potentially Liquefaction-Prone Land" (2017) as a 'Level C' assessment, being approximately 1 test per hectare, which falls within the required range of 0.1 to 4 per hectare for a 'Level C' investigation. (For a Plan Change on land where liquefaction is possible, a 'Level B' assessment or better is required. A 'Level C' assessment is better than a 'Level B' assessment). It also satisfies the investigation density requirements for a Plan Change outlined in the MBIE 'Module 2' document 'Geotechnical Investigations for Earthquake Engineering' (2021).

18 This testing has allowed me to assess the soil types across the Site; the strength of these soils; the water table depth; the liquefaction and lateral spread potential for the site; and the likely required foundations for future buildings on the site.

Subsoil characteristics

19 Ground conditions across the Site consist of interbedded loose to very loose liquefiable silts and sandy silts/silty sands, with some bands of medium dense clean sands, and also significant bands of non-liquefiable clayey materials. Most of the CPT probes terminated just past a lower sand or silt layer, refusing suddenly on a dense gravel layer some 9 to 12m below ground level. Below this are interbedded sands, gravels, and silts to 16-19m depth, then dense gravels to at least 21m depth.

Water Table

20 The water table (where full saturation of the soils occur) was found to be at between 1.3 and 1.8 metres below ground level.

Calculated liquefaction deformations

21 During the Canterbury Earthquake Sequence (**CES**, 2010 – 2011) Lidar measured ground deformations across the Site were quite modest, generally nil to 100mm, with some limited areas up to 200mm as shown in Figure 1 below.

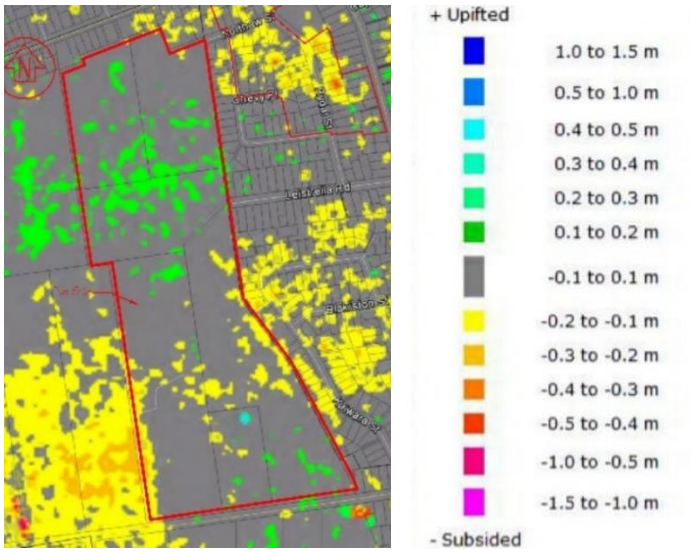


Figure 1 Lidar ground deformations, September 2010 to June 2011 Events

22 My own observations on the Site following the February 2011 earthquake event showed only minor surface manifestation of liquefaction, affecting less than 5% of the land.

23 All the land to the immediate east of the site is classified as MBIE Technical category 2 (**TC2**), as shown in Figure 2 below. The Lidar cumulative ground deformations to the immediate east of the Site are similar, if not slightly more intense, than this Site.

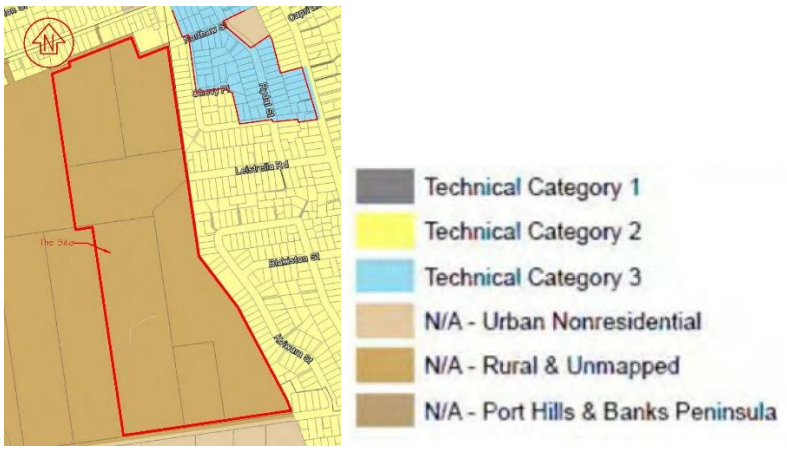


Figure 2 MBIE Technical Categorisation of Surrounding Land

24 A liquefaction assessment of all of the CPT data shows that in a large (500 year return period) earthquake (referred to as the Ultimate Limit State, or ULS earthquake for normal buildings) between 50mm and 260mm total settlement (averaging 95mm) might occur. It is noted that these theoretical

values significantly exceed what actually occurred on the site in the CES, showing the theoretical assessment to be likely quite conservative. Of that, between 50mm and 140mm occurs in the upper 10 metres of the soil profile (averaging 80mm over the site). The deformations in the upper 10 metres is an important metric as this is the part of the soil column that can contribute to potentially damaging deformations at the ground surface, as deformations deep in the soil profile only contribute to general, uniform settlement at the ground surface. (Deformations very close to the soil surface can also lead to surface rupture and soil ejecta.)

25 For a moderate (100-year return period) earthquake the total settlements are 40-180mm (averaging 70mm), with 35 -100mm (averaging 60mm) in the upper 10 metres of the soil profile.

26 For a smaller (25-year return period) earthquake (referred to as the Serviceability Limit State, or SLS, earthquake for normal buildings) the total settlements are 10-50mm (averaging 25mm), with 10-40mm (averaging 20mm) in the upper 10 metres of the soil profile.

Lateral spread

27 There are no significant waterways on or immediately adjacent to the Site that would give rise to a lateral spread hazard, although if there was a requirement to construct a stormwater detention basin then a localised lateral spread issue may be created. This can be relatively easily dealt with, by localised ground improvement to mitigate the new lateral spread hazard. This has been done recently near the southeastern area of the site with a series of shallow stone columns. I have also been involved on other similar projects where we used driven timber piles for this purpose, and where the hazard is due to a very shallow liquefiable layer, with excavation and replacement of the weaker soils with compacted hardfill.

28 In terms of the MfE categorisation, this land can be regarded as ‘Liquefaction Damage is Possible - Medium Liquefaction Vulnerability’.

29 The MfE guidelines indicates that this means:

- Minor to Moderate quantities of ejected liquefied material at the ground surface (e.g. less than 25 percent of a typical residential site covered); and/or

- Moderate differential settlement of the ground surface (e.g. undulations 25–100 mm in height).

- No significant lateral spreading ground movement (e.g. ground cracks less than 50 mm wide may be present, but pattern of cracking suggests the cause is primarily ground oscillation or settlement rather than lateral spreading).

- Liquefaction causes moderate but typically repairable damage to buildings and infrastructure. Damage may be substantially less where liquefaction was addressed during design (e.g. enhanced foundations).

30 The assessed deformations and liquefaction hazard are generally consistent with an MBIE TC2 site, with some areas possibly being suited to a hybrid TC2 / TC3 foundation system.

31 Static bearing capacities (also taking into account static settlements) for foundations are in the order of 200 kPa, so suitable for standard TC2 foundation types.

32 I summarise the position for other natural hazards that might be geotechnical in nature below:

(a) The Site is not subject to erosion, there being no major waterways on or near it;

(b) The Site is flat lying and not adjacent to sloping ground and therefore there are no hazards from falling debris or slope instability;

(c) The Site is not in a Tsunami zone; and

(d) Volcanic and geothermal activity are not known hazards in the Canterbury Region.

33 Flooding is outside my area of expertise and I defer to the evidence of Stephany Pandrea.

34 I acknowledge that experts must identify any knowledge gap that they are aware of and its potential implications in evidence.[1] Geotechnical engineering is a relatively young and continually evolving science. There are epistemic uncertainties in all aspects of geotechnical analysis, calculation and assessment. There are also aleatory uncertainties introduced by the necessarily low density of soil sampling that is carried out, in any geotechnical investigation. However, a comparison of my analyses to actual site performance has demonstrated that my calculated liquefaction outcomes are conservative (i.e. the site has performed better than theoretical calculations might suggest). Also, when comparing observed performance of the Site to that of adjacent TC2 land to the east (in Figure 1), it is quite apparent that on the whole the Site has performed better than that land to the east. Therefore I am very confident that the inherent uncertainties in geotechnical engineering do not undermine or detract from my conclusion, that the Site is suitable for rezoning as Medium Density Residential Zone.

Conclusion

35 The geotechnical investigation and assessment has demonstrated that the land is of only medium liquefaction vulnerability, and in general it is not subject to significant geotechnical hazards.

36 Therefore, from a geotechnical perspective it is my professional opinion that the Site is suitable for rezoning as Medium Density Residential Zone.

Nicholas John Traylen

20 September 2023

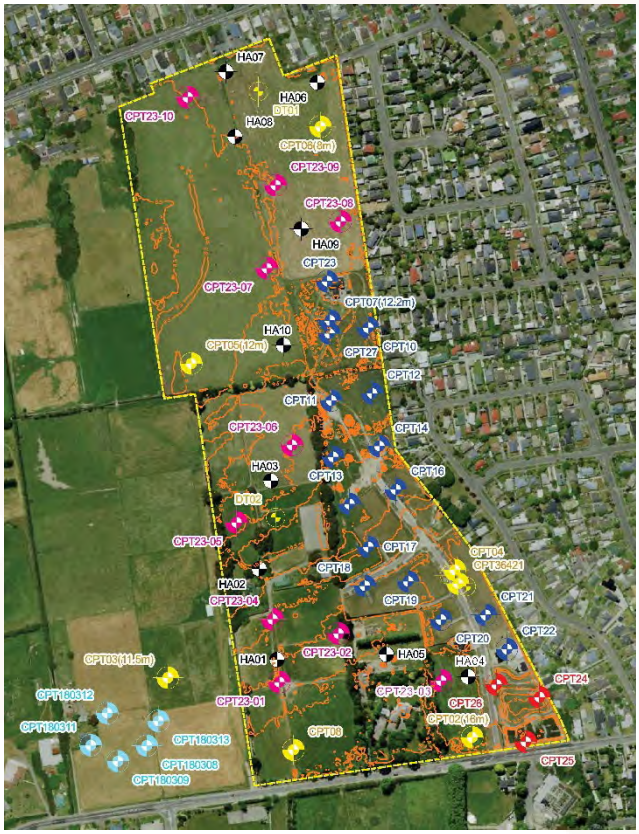
[1] Environment Court Practice Note 2023 at 9(f).

GEOTECH
consulting ltd

CASHMERE FIELDS

REZONING

GEOTECHNICAL REPORT



Reference Number: 3933

Date: 6 September 2023

CONTENTS

OVERVIEW SUMMARY

<table>
<tr><td>Project Type:</td><td colspan="4">Land Development</td></tr>
<tr><td>Nature of Project:</td><td colspan="4">Plan Change</td></tr>
<tr><td>Investigation undertaken:</td><td colspan="4">34 CPTs to 9 - 15m depth, 4 boreholes to 7 – 21m, 16 hand augers and scala penetrometer tests to 2-2.8m depth, seismic dilatometer testing to 10m depth, geophysical testing to 7m depth.</td></tr>
<tr><td>Subsoil Characteristics:</td><td colspan="4">Interbedded loose to very loose silts and sandy silts/silty sands, with some bands of medium dense clean sands, and also significant bands of non-liquefiable clayey materials. Most of the CPT probes terminated in a lower sand or silt layer prior to refusing suddenly on a dense gravel layer some 9 to 12m below ground level. Below this in the boreholes are interbedded sands, gravels and silts to 16-19m depth, then dense gravels to at least 21m depth.</td></tr>
<tr><td>Water table depth:</td><td colspan="4">1.3m -1.75m (full saturation) depth.</td></tr>
<tr><td rowspan="3">Calculated Settlements:</td><td colspan="2">SLS</td><td colspan="2">ULS</td></tr>
<tr><td>Total</td><td>Upper 10m</td><td>Total</td><td>Upper 10m</td></tr>
<tr><td>10-50mm (25mm avg)</td><td>10 - 40mm (20mm avg)</td><td>50 - 260mm (95mm avg)</td><td>50 - 140mm (80mm avg)</td></tr>
<tr><td>Lateral Spread:</td><td colspan="4">Currently not a likely hazard but the imposition of requirements for stormwater detention basins and the like will likely create a lateral spread risk that will require mitigation.</td></tr>
<tr><td>MBIE/MfE guidelines:</td><td colspan="4">‘Liquefaction is Possible - Medium Liquefaction Vulnerability’</td></tr>
<tr><td>Technical Category:</td><td colspan="4">Land assessed as TC2-like or Hybrid TC2/TC3 behavior for the purposes of foundation design.</td></tr>
<tr><td>Foundation options:</td><td colspan="4">Shallow TC2-type or TC2/TC3 Hybrid foundations will likely be suitable.</td></tr>
<tr><td>Suitability for Rezoning:</td><td colspan="4">Suitable for rezoning for residential subdivision.</td></tr>
</table>

GEOTECHNICAL REPORT

Cashmere Fields Rezoning

1.0 INTRODUCTION

It is proposed to rezone a block of land that lies to the immediate west of the existing residential suburb of Hoon Hay. The (currently rural) block, consisting mainly of relatively flat farmland, is bounded by a strip of residential land along Sparks Road to the north, runs south (in a width of 300 – 600m) to Cashmere Road. To the west is further rural land; to the east are the suburban houses of Hoon Hay.

A series of geotechnical investigations have been carried out at the site as part of the assessment of the land for the proposed plan change (as well as for an existing subdivision on the land), and a detailed liquefaction assessment has been undertaken. This report outlines that assessment and the conclusions that can be drawn from it.

It is envisaged that at subdivision stage further investigations will be carried out to refine the assessment of liquefaction on the site, and to provide design parameters for any future subdivision.

2.0 DAMAGE OBSERVATIONS

Lidar data shows very little to only moderate cumulative ground deformations at the site from the events spanning from September 2010 to June 2011. Appendix 1 (figure SK2) shows the results of these damage observations.

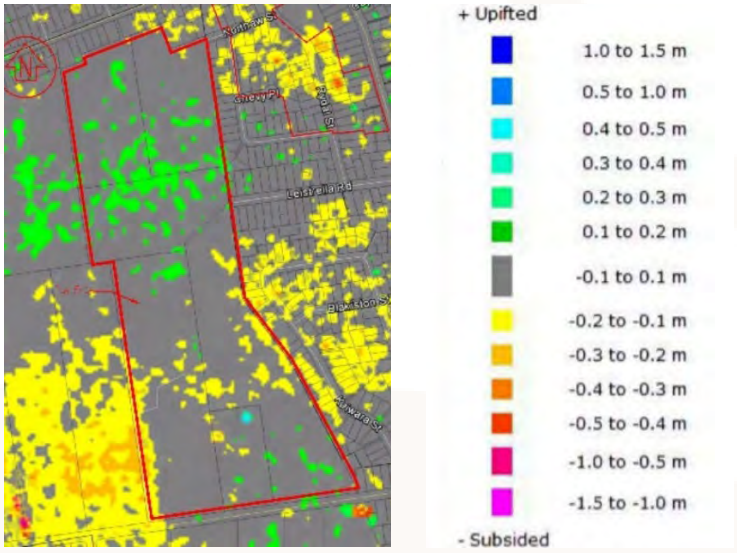


Figure 1 Lidar ground deformations, September 2010 to June 2011 Events

All the land to the immediate east of the site is classified as MBIE Technical category 2 ("TC2"); the Lidar cumulative ground deformations there (i.e. to the immediate east) are similar, if not slightly more intense, than those on this site. Our own observations on the site following the February 2011 earthquake event showed only minor surface manifestation of liquefaction, affecting less than 5% of the land.

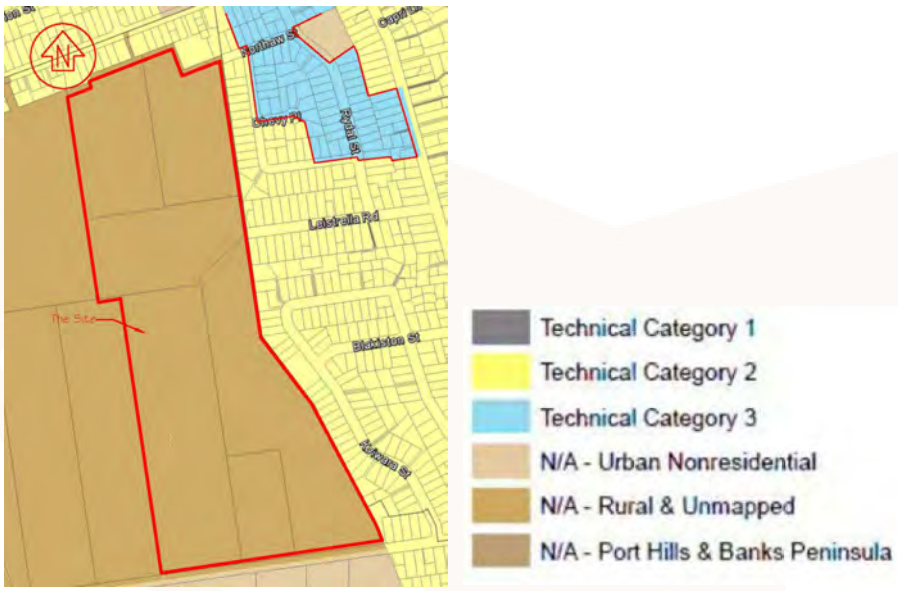


Figure 2 MBIE Technical Categorisation of Surrounding Land

Appendix 1 contains summary information from the NZGD (drawing sheets 2 & 3).

3.0 THE SITE INVESTIGATION

3.1 Objectives

This site investigation data has been analysed to provide information about the composition, spatial relationships and geotechnical properties of the materials that underlie the site.

In particular the following information was sought:

- Definition of the quality and variability of the soils underlying the site.
- Water table depth.
- Liquefaction potential.
- Permissible likely foundation types.
- Site subsoil category.

3.2 Methodology

Thirty-four cone penetrometer tests ("CPT") have been carried out at the site between 2011 and 2023. The combined data for the CPTs range in depth from 9 metres to 15 metres below ground level (all refusing on dense gravels). Two dual tube boreholes have been drilled at the site, one in the west of the site and one in the north of the site, to a depth of 21 metres in each case. A seismic dilatometer test has been carried out to 10 metres in the central part of the site, as well as two boreholes to 7 - 10 metres depth. Some geophysical testing (i.e. shear wave velocity) has also been carried out to 7 metres depth at the site as part of a University research project. Sixteen hand augers with associated scala penetrometer tests to 2 – 2.8 metres depth have been drilled at the site as well.

The Ministry for the Environment (MfE) document "Planning and Engineering Guidance for Potentially Liquefaction-Prone Land" (2017) requires a 'Level B' assessment or better for a Plan Change on land where liquefaction is possible. The data acquisition for this report meets the requirements for a 'Level C' assessment (which is better than a 'level B' assessment), being approximately 1 test per hectare, falling within the required range of 0.1 to 4 per hectare for a 'Level C' investigation. This investigation also satisfies the density requirements for a Plan Change outlined in the MBIE document 'Geotechnical Investigations for Earthquake Engineering' (2021).

Further information regarding groundwater levels, ground deformations, levels of shaking, and observed ground damage during the Canterbury Earthquake Sequence was also retrieved from the New Zealand Geotechnical Database.

Appendix 1 (drawing sheet 1) has a plan showing the locations of the investigations that have been carried out to date.

3.3 Subsurface Conditions

The geological map for Christchurch indicates that the site is underlain by predominantly sand and silt overbank deposits (Springston Formation), of Holocene age.

The interpreted CPT probes show variable subsurface conditions. Generally, the soils consist of interbedded loose to very loose silts and sandy silts/silty sands, with some bands of medium dense clean sands (often about 1-2 metres thick, somewhere between 3 and 6 metres below ground level) and also significant bands of non-liquefiable clayey materials. Most of the CPT probes terminated in a lower

sand or silt layer prior to refusing suddenly on what is likely to be a dense gravel layer 9-12m below ground. Below this are interbedded sands, gravels, and silts to 16-19m depth, then dense gravels to at least 21m depth.

CPT traces and borelogs are included in Appendix 2.

3.4 Groundwater

Groundwater was observed during the hand auger investigations at 1.0 – 1.9m. Piezometer records from the site indicate that groundwater levels can fluctuate from 2m depth to ground level. The GNS Science Median Groundwater Surface Elevations from the Canterbury Geotechnical Database for this site indicate that the long-term median water table is 1.3m below ground surface.

While these levels are a useful guide to expected conditions during construction, another aspect that can be considered for liquefaction analysis purposes is the degree of saturation of the soils that lie below the apparent water table. If a soil is not 100% saturated then it is unable to liquefy.

Typically, it is assumed that any soil below the water table is 100% saturated. However, in a number of separate liquefaction research projects in Christchurch and also overseas where cross-hole geophysical testing has been undertaken, the measured P-wave velocity ("V_P") profiles have shown that in fact it is not uncommon for soils below the water table to be unsaturated. V_P testing was undertaken at Cashmere Fields on two separate occasions. Testing in December 2013 showed that the soils were not saturated in the upper 2.7m of the soil profile. Testing in the same location in late March 2017 showed the depth to complete saturation to be over 8 metres. Therefore, adopting a design depth of 1.3m if used for liquefaction analyses would be conservative.

We have examined core photos from the borehole drilled at BH 38197. This shows a brown colouration to the soils to a depth of 1.75m, below which all of the soils are grey in colour. The grey soils are from the same geological origin as the brown ones, but the grey colouration indicates that they have not been exposed to oxygen in the long term. In other words, the position of the change in colour indicates the long term average (saturated) groundwater table.

Therefore, for liquefaction analysis purposes we have set a design median groundwater level at 1.75m depth.

3.5 Environmental Issues

Environmental engineering is beyond the scope of our expertise, however we have checked the Environment Canterbury 'Listed Land Use Register' (LLUR) (http://llur.ecan.govt.nz/) and found that (on the day accessed, 15 June 2023) it advises for this site (excluding the already developed area in the eastern side) the following:

"The Listed Land Use Register does not currently have any information about a Hazardous Activities and Industries List site on this land parcel"

For the area of land within this parcel that has already been (recently) developed as a subdivision (and therefore already dealt with), the LLUR reports the following:

HAIL activities:		
CT232572	I - Any other land	
Sites:		
SIT238095	Below guideline values – Residential	Farm Pit and dwelling areas
Investigations: (200 Cashmere Road, Hoon Hay, Christchurch)		
INV232671	Site Remedial Action Plan Remedial Action Plan (RMA 2018 1921)	25 Mar 2019
INV235799	Site Validation Report (SVR) RMA/2018/1921	24 May 2019
INV214835	Detailed Site Investigation Ground Contamination Assessment; Preliminary and Detailed Site Investigation.	3 Aug 2018

3.6 Flood Levels

The Christchurch City Council flood hazard maps at: https://www.ccc.govt.nz/services/stormwater-and-drainage/flooding/floorlevelmap were accessed on 15 June 2023. The CCC system shows that much of the site, with the exception of some higher ground in the central portion of the land, is within the modelled 50-year and 200-year flood extents, and is within the Flood Management Area ("FMA"). The City Council should be referred to for further information.

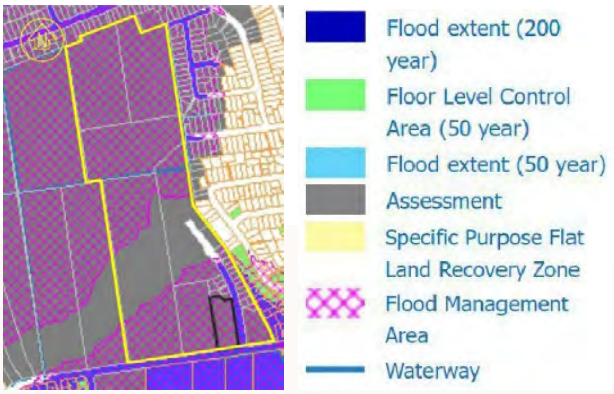


Figure 3 CCC Flood Map

4.0 INTERPRETATION

The gathered data (as described in the previous section) has been analysed for dynamic and static conditions as follows:

4.1 Fines Content Analysis

For routine liquefaction analysis it is common to use soil fines contents ('FC') that are inferred from the CPT data, rather than actual FC data from laboratory testing. This can affect the outcome of the analysis to varying degrees. The more robust way to carry out an analysis is to use detailed laboratory-measured fines contents from actual soil samples. However, the cost of doing this can be relatively high, and often not warranted on small projects. The CPT data-derived fines content formulation uses a 'best fit' line from a regression of historical FC and Ic data (Ic is a parameter derived from CPT data) – see Figure 4 below.

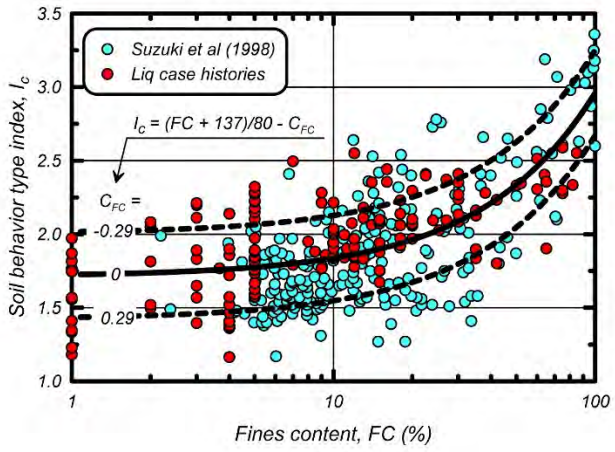


Figure 4 - Figure 2.11 from Boulanger & Idriss (2014)

The data is however quite scattered, and a particular site might not necessarily be best represented by the 'best fit' line (C_{FC} =0 in Figure 2). In Christchurch it is not uncommon for site data to fall well below the best fit line, for example. Other correlations can be used by employing an appropriate site-specific 'fines correction factor' ("C_{FC}"). It is often found in Christchurch that a C_{FC} of 0.2 – 0.3 can be appropriate.

Four samples were retrieved from the liquefiable soils at the Cashmere Fields site and tested for fines content, as part of a silty soils research project in 2013. The fines content tests when regressed against the CPT-derived Ic parameter, showed that a C_{FC} parameter of 0.23 is appropriate. (When additional data is added from adjacent properties, the average C_{FC} is even higher.)

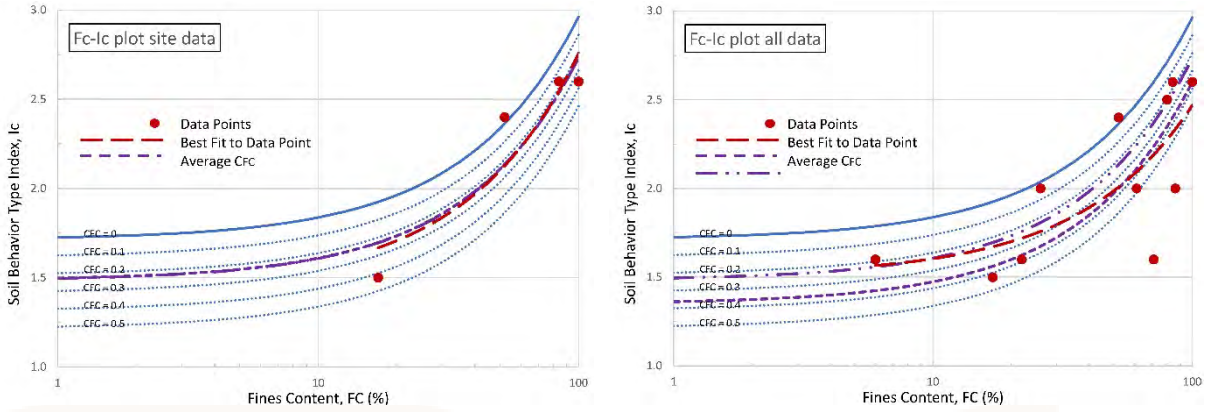


Figure 5 – C_{FC} Plots

(a) site specific data only. **(b) additional data from neighbouring sites**

4.2 Liquefaction Potential

The saturated silty and sandy materials below the water table have some potential for liquefaction in a large earthquake. The CPT profiles have been analysed using the method of Boulanger & Idriss (2014); and free field settlements assessed using the method of Zhang et al (2002). A 'fines correction' coefficient (C_{FC}) of 0.23 was adopted for the analysis, as described in the previous section. Additionally, given the good performance of the site in the Canterbury Earthquake Sequence as discussed in Section 2, a probability of liquefaction threshold, P_L, of 50% was adopted.

For the design input ground motion accelerations, we have adopted the PGAs (peak ground accelerations) recommended by MBIE, which is an SLS event (at M7.5) of 0.13g, a further SLS event (at M6) of 0.19g, and at ULS 0.35g (M7.5) for an IL2 (importance level 2) building. The SLS event at 0.19g/M6 was found (as is almost always the case) to be the dominant SLS event.

From the CPT data analyses we calculate Ultimate Limit State ('U.L.S.') theoretical post liquefaction free-field ground settlements at the site of up to 140mm in the upper 10m of the soil profile, averaging 80mm, and 260mm for the full depth of CPTs (but less than 120mm for all but one CPT location). We have also calculated liquefaction potential and ground settlements from the smaller Serviceability Limit State ('S.L.S.') – this indicates ground settlements of up to 40mm in the upper 10m of the soil profile and 50mm for the full depth profiles.

Additionally, we have assessed the 'Liquefaction Severity Number' (LSN) for each of the liquefaction cases.

Table 1 – **Assessed Liquefaction Induced Settlements (+/-50%) and LSN**

CPT I.D.	500 years (ULS) 0.35g/M7.5			100 years 0.3g / M6			25 years (SLS) 0.13g / M7.5, 0.19g / M6		
	Ground Settlement (mm)		LSN	Ground Settlement (mm)		LSN	Ground Settlement (mm)		LSN
	Total	Upper 10m		Total	Upper 10m		Total	Upper 10m	
CPT 02	257	137	35	182	102	26	51	27	7
CPT 03	109	107	22	87	86	17	29	29	5
CPT 04	96	75	14	106	83	16	23	17	3
CPT 05	93	74	16	87	73	15	42	37	7
CPT 06	52	52	14	47	47	12	11	11	3
CPT 07	53	50	12	48	47	11	15	15	3
CPT 08	104	104	23	75	75	16	22	22	4
CPT 36421	54	52	11	42	41	8	19	19	4
CPT 10	98	90	17	88	84	15	36	35	6
CPT 11	99	78	16	78	60	13	31	22	3
CPT 12	79	62	14	63	48	11	29	22	4
CPT 13	81	64	18	58	42	11	21	14	3
CPT 14	120	75	20	78	52	14	48	36	9
CPT 15	99	99	27	60	60	16	10	10	3
CPT 16	106	86	22	80	69	17	23	20	5
CPT 18	81	81	16	57	57	12	16	16	3
CPT 19	86	85	15	48	48	9	12	12	2
CPT 20	101	101	20	80	80	15	32	32	6
CPT 21	92	88	21	77	73	17	37	34	6
CPT 22	78	70	15	56	50	11	26	23	4
CPT 24	114	47	11	77	36	8	23	13	2
CPT 25	101	98	20	55	54	12	11	11	2
CPT 26	66	66	14	47	47	10	16	16	3
CPT 27	80	75	15	68	65	13	20	19	4
CPT 23-01	107	96	17	72	65	11	23	21	3
CPT 23-02	73	73	11	60	60	10	22	22	4
CPT 23-03	164	101	25	94	66	16	24	19	4
CPT 23-04	102	100	23	79	78	18	34	30	7
CPT 23-05	81	49	13	47	36	9	13	11	2
CPT 23-06	51	51	13	46	46	12	18	18	4
CPT 23-07	100	100	22	87	87	20	26	26	5
CPT 23-08	52	52	17	39	39	8	8	8	2
CPT 23-09	94	94	22	77	77	17	20	20	4
CPT 23-10	48	48	16	40	40	13	11	11	3

Table 2 – **Results Summary**

Design Event	Design Ground Acceleration	Ground Settlement		LSN
		Total	Upper 10m	
500 years (U.L.S.)	0.35g / M7.5	50 - 260mm (95mm)	50 - 140mm (80mm)	11-35 (18)
100 years	0.3g / M6	40 - 180mm (70mm)	35 - 100mm (60mm)	8-26 (14)
25 years (S.L.S.)	0.13g / M7.5, 0.19g / M6	10-50mm (25mm)	10 - 40mm (20mm)	2-9 (4)

(values in brackets are averages)

The LSN values are a rough guide to the degree of ground surface damage that might be expected. The general descriptors are as follows in Table 3 (taken from the NZGS Module 3 document, 'Investigation, Assessment and Mitigation of Liquefaction Hazards'):

Table 3 – General Performance levels for Liquefied Deposits

Performance Level	Effects	Characteristics and Consequences	Characteristic LSN
L0	Insignificant	No significant excess pore water pressures (no liquefaction).	<10
L1	Mild	Limited excess pore water pressures; negligible deformation of the ground, and small settlements.	5-15
L2	Moderate	Liquefaction occurs in layers of limited thickness (small proportion of the deposit, say 10 percent or less) and lateral extent; ground deformation results in relatively small differential settlements.	10 - 25
L3	High	Liquefaction occurs in significant portion of the deposit (say 30 percent to 50 percent) resulting in transient lateral displacements, moderate differential movements, and settlement of the ground in the order of 100mm to 200mm.	15 - 35
L4	Severe	Complete liquefaction develops in most of the deposit resulting in large lateral displacements of the ground, excessive differential settlements and total settlement of over 200mm.	>30
L5	Very Severe	Liquefaction resulting in lateral spreading (flow), large permanent lateral ground displacements and/or significant ground distortion (lateral strains/stretch, vertical offsets and angular distortion).	

The LSN values assessed at ULS levels of shaking indicate 'moderate' to 'high' effects. For the SLS case the assessed effects are 'insignificant' to 'mild'.

Work by Bradley & Hughes (2012) indicates that in the M6.2 February 2011 event, this site was subject to a median PGA of 0.46g, which scales to an equivalent 0.32g from a 'standard' M7.5 event (i.e. close to a ULS event) and is well in excess of a 100 year 'ILS' event. If the 10-percentile ground motion is considered, this ground motion scales to an equivalent 0.20g from an M7.5 event (i.e. equivalent to a 100-year ILS design event). Similarly, the September 2010 event (0.25g from M7.1) 10-percentile motion scales to an equivalent 0.14g from an M7.5 event (i.e. in excess of an SLS event).

From this we can conclude that the site has been 'well tested' at SLS levels of shaking and ILS shaking.

4.3 Lateral Spread

Lateral spread is the post-liquefaction movement of either level liquefied ground towards a free edge or of sloping liquefied ground downhill. It often occurs along riverbanks and shorelines, and ground deformation is often expressed as extensional fissures. No instances of lateral spread were observed as a result of the Canterbury Earthquake Sequence and in its current state we do not anticipate a lateral spread hazard for this land. However, any requirements imposed on future subdivisions on this land for stormwater detention basins or the like will likely result in the creation of a localised lateral spread risk that will need to be mitigated at the time of construction.

4.4 Static Bearing Capacities

In the limited number of hand augers carried out to date, below the topsoil layer, scala penetrometer testing averages in the order of 50mm per blow (with some variation across the site), which indicates an ultimate bearing capacity of 200 kPa. More extensive testing will be required at subdivision and building consent stages to confirm this.

5.0 RMA NATURAL HAZARDS

5.5.1 Erosion

There are no major waterways adjacent to this subdivision. If a swale is constructed, the flow quantities and velocities are likely to be small and will not cause erosion issues.

5.5.2 Falling Debris

The site is flat and not adjacent to any sloping ground; therefore danger from falling debris is not an issue at this site.

5.5.3 Subsidence

The land is regarded as TC2-like or in some areas 'TC2-3 Hybrid' in its performance with regard to foundation design (see section 6.2). Penetrometer testing has largely shown reasonable bearing capacities for shallow foundations, and investigations have not detected any areas of uncontrolled fill or significant organic deposits. If suitable foundations are constructed, then structures will meet the requirements of the building code.

5.5.4 Flooding

This aspect is discussed in section 3.6 of the report. Suitable floor levels will be set in consultation with the Christchurch City Council.

5.5.5 Instability

The site is flat lying and therefore slope instability is not an issue for the subdivision under static conditions.

5.5.6 Volcanic and Geothermal Activity

These are not recognised risks at this site as there are no known active volcanic or geothermal areas in or near Canterbury.

5.5.7 Fire

This is beyond the scope of our expertise, however we note that the site is serviced by the Spreydon Fire Station, located approximately 3.8 km away by road.

5.5.8 Wind

This is beyond the scope of our expertise, however we note that NZS 3604 would suggest that this site is subject to 'high' wind loads.

5.5.9 Tsunami

The site is well outside any designated Tsunami evacuation zones.

6.0 RECOMMENDATIONS

Based on the information contained in section 3, and the data interpretations of section 4, we make the following recommendations for this site:

6.1 MBIE/MfE guidelines

In terms of the 2017 MBIE/MfE guidelines (Planning and Engineering Guidance for Potentially Liquefaction-Prone Land) we have carried out the equivalent of a 'Level C' (i.e. a detailed area-wide) assessment, and this land is classified as 'Liquefaction is Possible - Medium Liquefaction Vulnerability'.

6.2 Likely Technical Category

In considering the likely future land performance at this site we have considered the following aspects:

- Low levels of damage were observed after the September and February earthquakes.

- As concluded in section 4.2, the site has been 'well tested' at SLS levels of shaking and ILS shaking, and possibly near to ULS levels of shaking. Ground damage in a future SLS or ILS event is therefore unlikely to significantly exceed what is already evident on the site (which is relatively minor).

- Research into the over-prediction of liquefaction deformations (which utilised data from the Cashmere Fields site) shows that soil profiles that consist of highly interbedded deposits with few layers of clean sands, and having liquefiable layers that are predominantly silty sands that lack vertical connectivity between liquefiable layers, will likely perform better than the standard analysis methods would predict (Cubrinovski et al, 2017). The soil profiles at Cashmere Fields are of this nature.

- The adjacent suburb is all TC2, but Lidar settlements there from the Canterbury Earthquake Sequence are, on the whole, a little worse than at Cashmere Fields.

Therefore, based on the CPT-based assessment the land, and backed up by its performance in the Canterbury Earthquake Sequence, we advise that the Cashmere Fields land in its current state can be characterised by Technical Category 2 ("TC2") performance. A limited number of CPTs did show slightly worse theoretical performance under ULS conditions, and additional investigations at subdivision stage may also find some areas that indicate potentially worse performance – but

given that SLS performance is uniformly good across the entire site, the worst outcome is likely to be some areas designated as TC2/TC3 Hybrid in terms of foundation design – in other words, 'TC2', once a modest gravel raft has been constructed for a TC2 slab on grade foundation.

6.3 Likely Foundation Construction

For residential buildings, TC2-type foundation construction likely will be suitable for much of the land here. This typically consists of a TC2 waffle slab or monolithic foundation mat for concrete floors, however other options are available (refer to the MBIE Guidelines for residential construction). For timber floors, shallow piles as per NZS 3604 are permissible (for a 'Type A' dwelling), or a well reinforced ring foundation (as per figure 4a in the MBIE guidelines), with internal shallow piles ('Type B' dwelling).

Where areas of TC/TC3 Hybrid performance are found, these TC2 waffle slabs will need to be underlain with a 600mm thick layer of reinforced compacted gravels.

6.4 Seismic Category

The consistency and depth of the alluvial formations underlying this site makes it a 'Class D' site in terms of the seismic design requirements of NZS1170.5:2004.

7.0 SUMMARY & CONCLUSIONS

Ground conditions consist of interbedded loose to very loose silts and sandy silts/silty sands, with some bands of medium dense clean sands, and also significant bands of non-liquefiable clayey materials. Most of the CPT probes terminated in a lower sand or silt layer prior to refusing suddenly on a dense gravel layer some 9 to 12m below ground level. Below this are interbedded sands, gravels, and silts to 16-19m depth, then dense gravels to at least 21m depth.

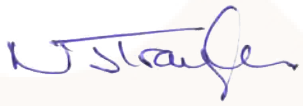
Liquefaction assessments and site performance in the 2010-2011 Canterbury Earthquake Series indicate minor land deformations at SLS and ILS levels of shaking, and moderate deformations at ULS. The land is assessed as likely having TC2-like performance, with some areas that may be akin to TC2/TC3 hybrid performance.

In terms of the 2017 MBIE/MfE guidelines (2017) this land is classified as 'Liquefaction is Possible - Medium Liquefaction Vulnerability'

It is my opinion that the land is geotechnically suitable for rezoning for residential subdivision and the construction of housing. Further ground investigations will be needed at subdivision consent stage as well as building consent stage.

Yours faithfully,

Geotech Consulting Ltd per:



Nick Traylen BE(Civil) (Hons) FEngNZ CPEng MICE CEng

CPEng 119170

8.0 LIMITATIONS

This report has been prepared solely for the benefit of, and under specific instruction from Cashmere Park Ltd as our client with respect to the brief, for use for this specific project. The reliance by other parties on the information or opinions contained in the report shall be at such parties' sole risk.

Recommendations and opinions (not to be construed as guarantees) in this report are based on data from boreholes and probings, including data provided by others. The borelogs are an engineering interpretation of the subsurface conditions. The nature and continuity of subsoil conditions away from the test locations are inferred and it must be appreciated that actual conditions could vary from the assumed model.

Environmental engineering is not within our area of expertise and therefore others will need to be consulted on such matters as contaminated ground issues.

During excavation and construction, the site should be examined by an Engineer or Engineering Geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation, and the modification of any design work that may have been based on this report.

It is important that Geotech Consulting Ltd is contacted if there is any variation in subsoil conditions from those described, as well as any variation in the property damage discussed in this report, as it may affect opinions expressed and any design parameters recommended in this report.

Regulatory and insurance issues may arise from some of the recommendations in this report; the client should seek independent advice on these aspects. This opinion is not intended to be advice that is covered by the Financial Advisers Act 2010.

9.0 REFERENCES

Boulanger, R.W., Idriss, I.M. (2014) "CPT and SPT based Liquefaction Triggering Procedures" *UCD Report UCD/CGM-14/01*

Bradley, B., Hughes, M. (2012) "Conditional Peak Ground Accelerations in the Canterbury Earthquakes for Conventional Liquefaction Assessment" *Technical Report for Department of Building and Housing*

Cubrinovski, M., Rhodes, A., Ntritsos, N., Van Ballegooy, S. (2017) "System Response of Liquefiable Deposits" *Proc. 3rd International Conference on Performance-based Design in Earthquake Geotechnical Engineering (PBD-III)*

Ishihara, K. (1985) "Stability of Natural Deposits During Earthquakes", *Proc. 11th International Conference on Soil Mechanics and Foundation Engineering, pp 321-376*

Ministry of Business Innovation and Employment (2012): "Repairing and Rebuilding Houses Affected by the Canterbury Earthquake Sequence" *dated December 2012*

Ministry of Business Innovation and Employment and Ministry for the Environment (2017) "Planning and Engineering Guidance for Potentially Liquefaction-Prone Land" *dated December 2012*

Zhang,,G., Robertson. P.K., Brachman, R.W.I. (2002) "Estimating Liquefaction-Induced Ground Settlements from CPT for Level Ground", Can. Geotech. J. (39), 1168-1180.

Appendix 1

Site Plan & Land Damage Records

New Zealand Aerial Imagery
Source: LINZ (2021-2022) NZTM2000 EPSG: 2193

0.5m Contour Lines
Source: LINZ (2020-2021) 1m DEM EPSG:2193

Inferred Site Boundary

100 0 100 200 300 400 500 m

GEOTECH

PROJECT:

CASHMERE FIELDS REZONING

DRAWING:

SITE INVESTIGATION PLAN

ISSUE | DATE | AMENDMENT DETAILS

SCALE.
1:5,000@A3

DRAWN: SAS
DATE: 31/05/2023
CHECKED: RBW

PROJECT No.	SHEET No.	ISSUE
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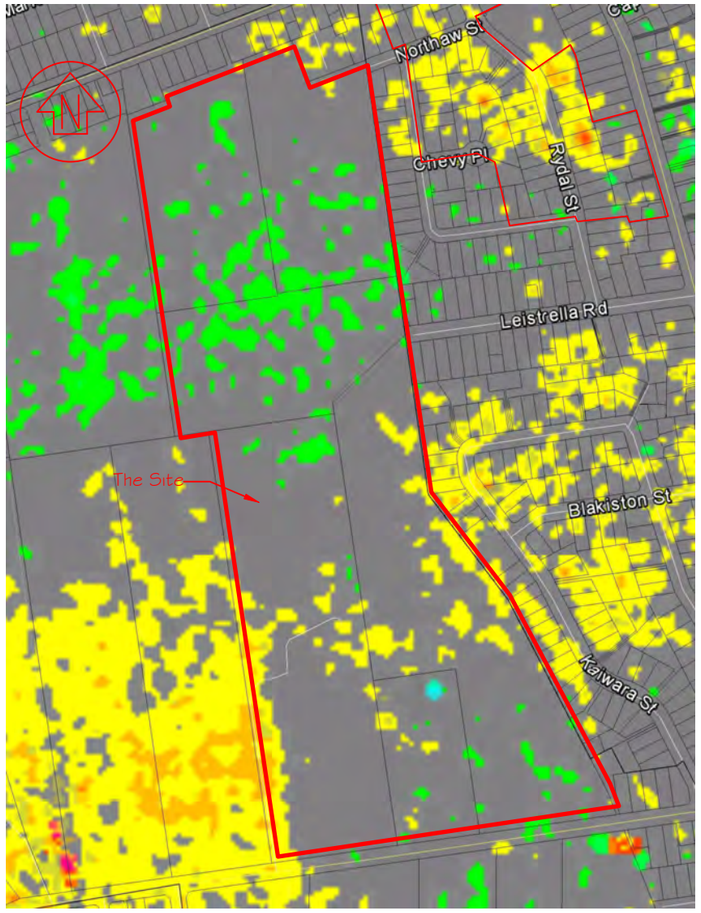

+ Upifted
1.0 to 1.5 m
0.5 to 1.0 m
0.4 to 0.5 m
0.3 to 0.4 m
0.2 to 0.3 m
0.1 to 0.2 m
-0.1 to 0.1 m
-0.2 to -0.1 m
-0.3 to -0.2 m
-0.4 to -0.3 m
-0.5 to -0.4 m
-1.0 to -0.5 m
-1.5 to -1.0 m
- Subsided

LIDAR LAND SETTLMENT SEPT 2010 - JUNE 2011
1:7500

LIQUEFACTION PROPERTY OBSERVATIONS SEPT 2010
1:7500

No observed ground cracking or ejected liquefied material
Minor ground cracking but no observed ejected liquefied material
No lateral spreading but minor to moderate quantities of ejected material
Moderate to major lateral spreading or large quantities of ejected material
Severe lateral spreading; ejected material often observed
No observations (uncoloured)

LIQUEFACTION PROPERTY OBSERVATIONS FEB 2011
1:7500

GEOTECH consulting ltd

PROJECT: CASHMERE FIELDS REZONING

DRAWING: DAMAGE OBSERVATIONS

ISSUE	DATE	AMENDMENT DETAILS	CHKD

SCALES:			
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	DRAWN	NJT	11/22
	CHECKED		

PROJECT No.	SHEET No.	ISSUE
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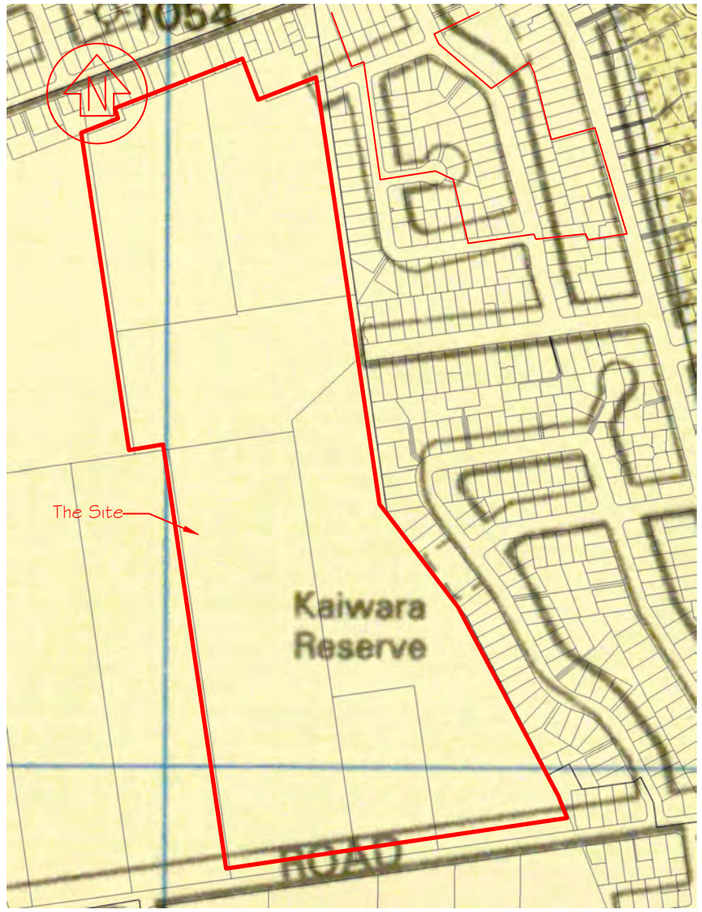

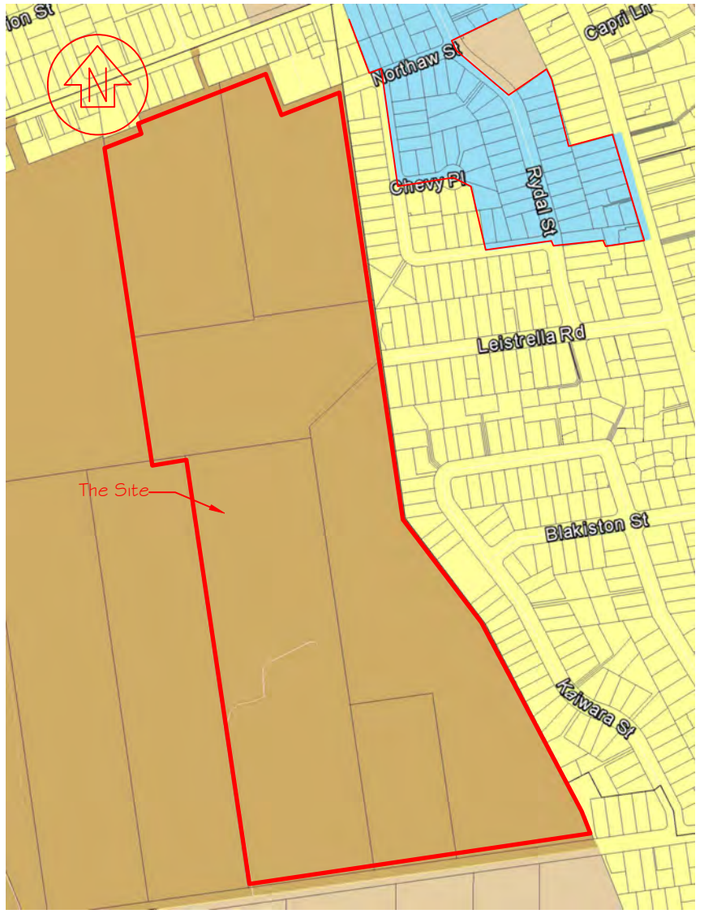

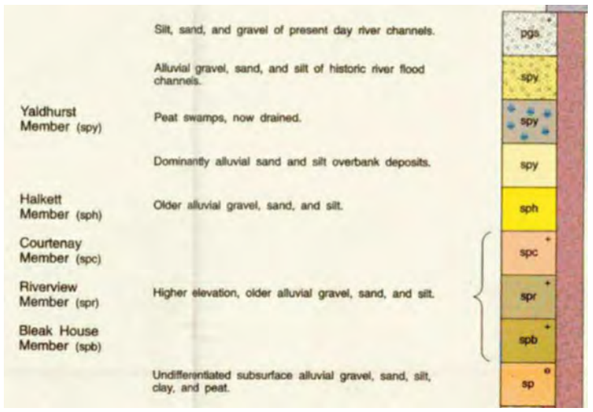

GEOLOGY
1:7500

MBIE TECHNICAL CATEGORIES
1:7500

GEOTECH
consulting ltd

PROJECT:
CASHMERE FIELDS REZONING

DRAWING:
GEOLOGY AND TECHNICAL CATEGORIES

ISSUE	DATE	AMENDMENT DETAILS	CHKD

SCALES:	DESIGNED	NJT	11/22
1:7500 @ A3	DRAWN	NJT	11/22
	CHECKED		

PROJECT No.	SHEET No.	ISSUE
3933	3	A

Appendix 2

CPT Profiles & Borelogs

GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
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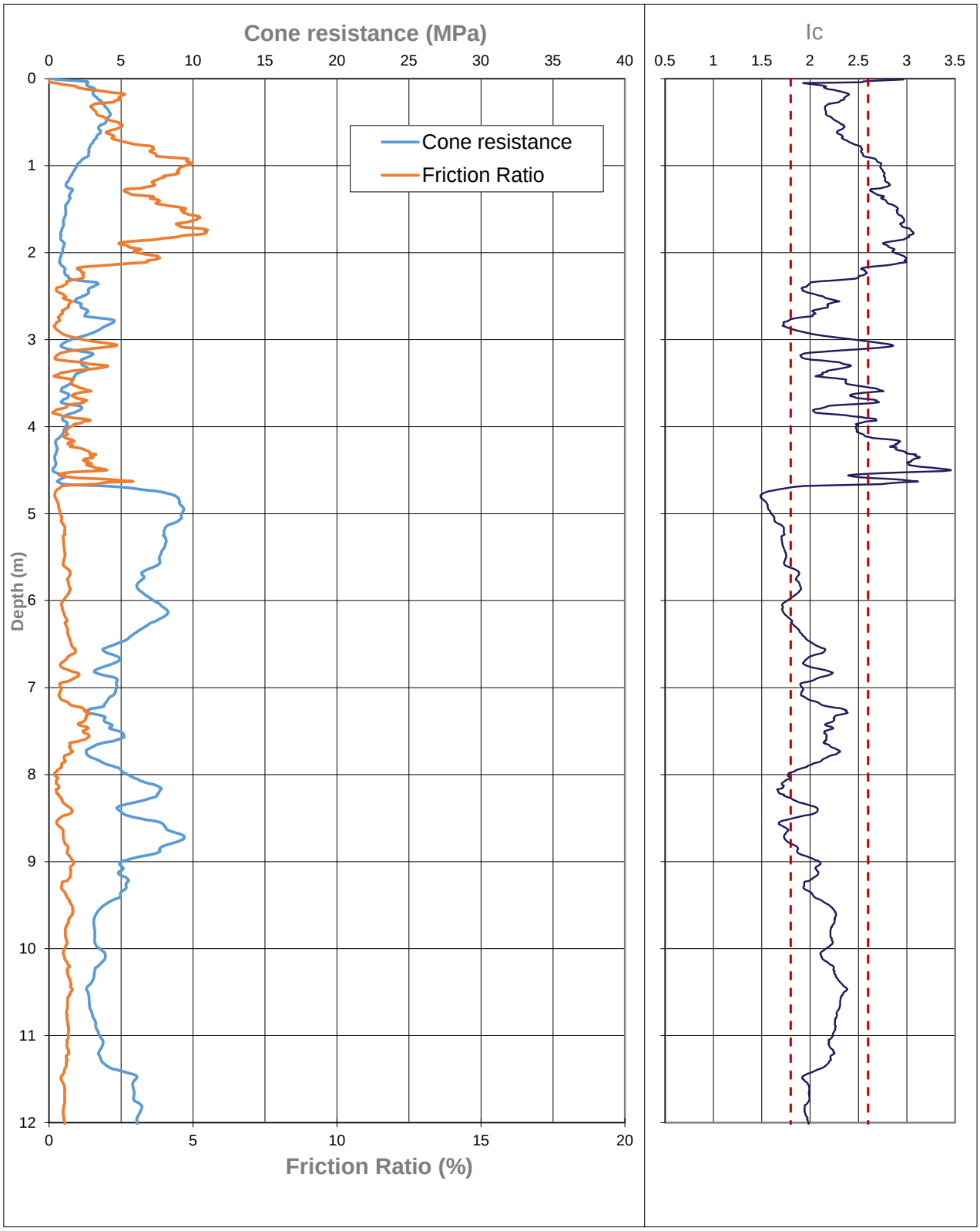
	Client:	W Lewis	Job No:	3933



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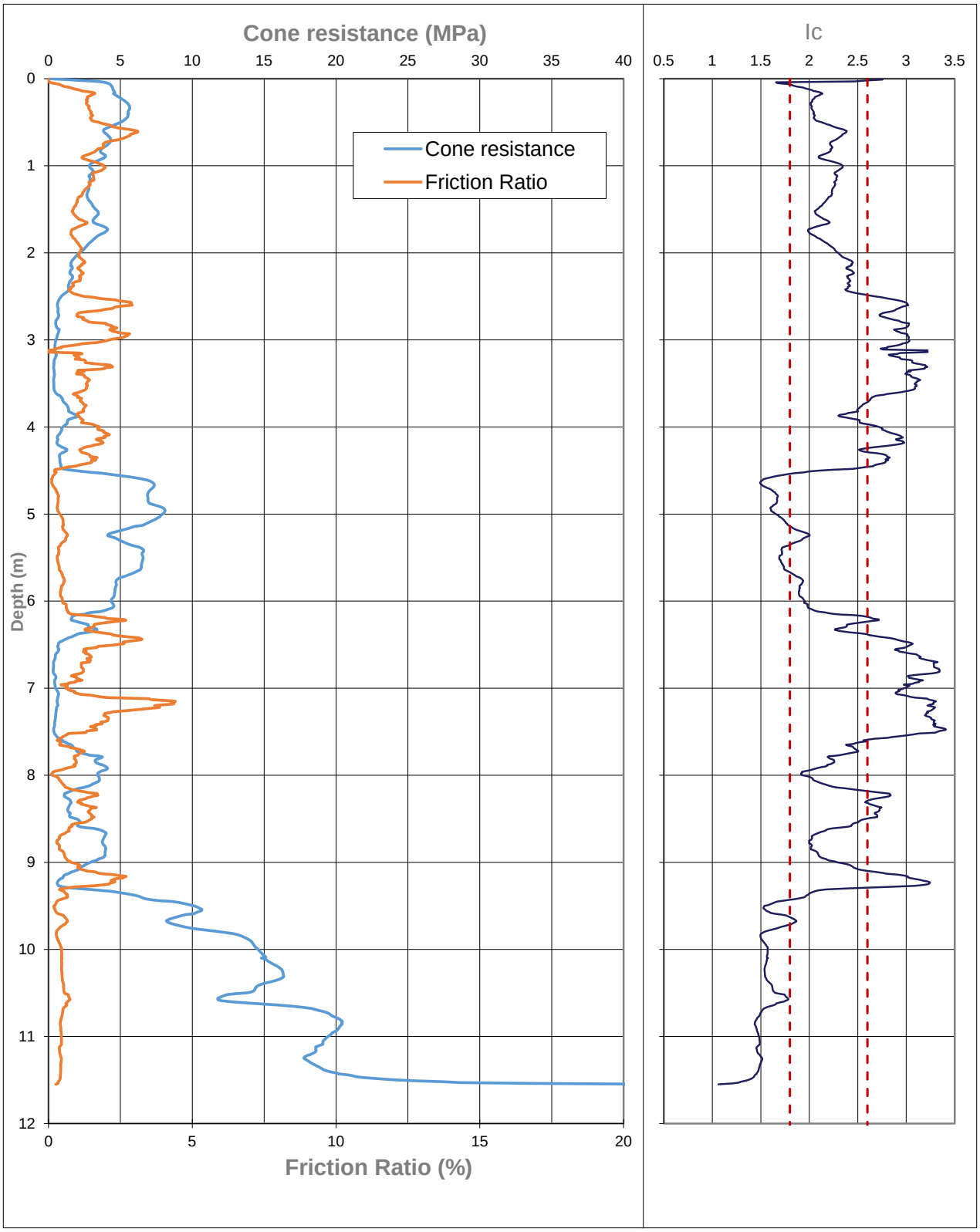
	Client:	W Lewis	Job No:	3933



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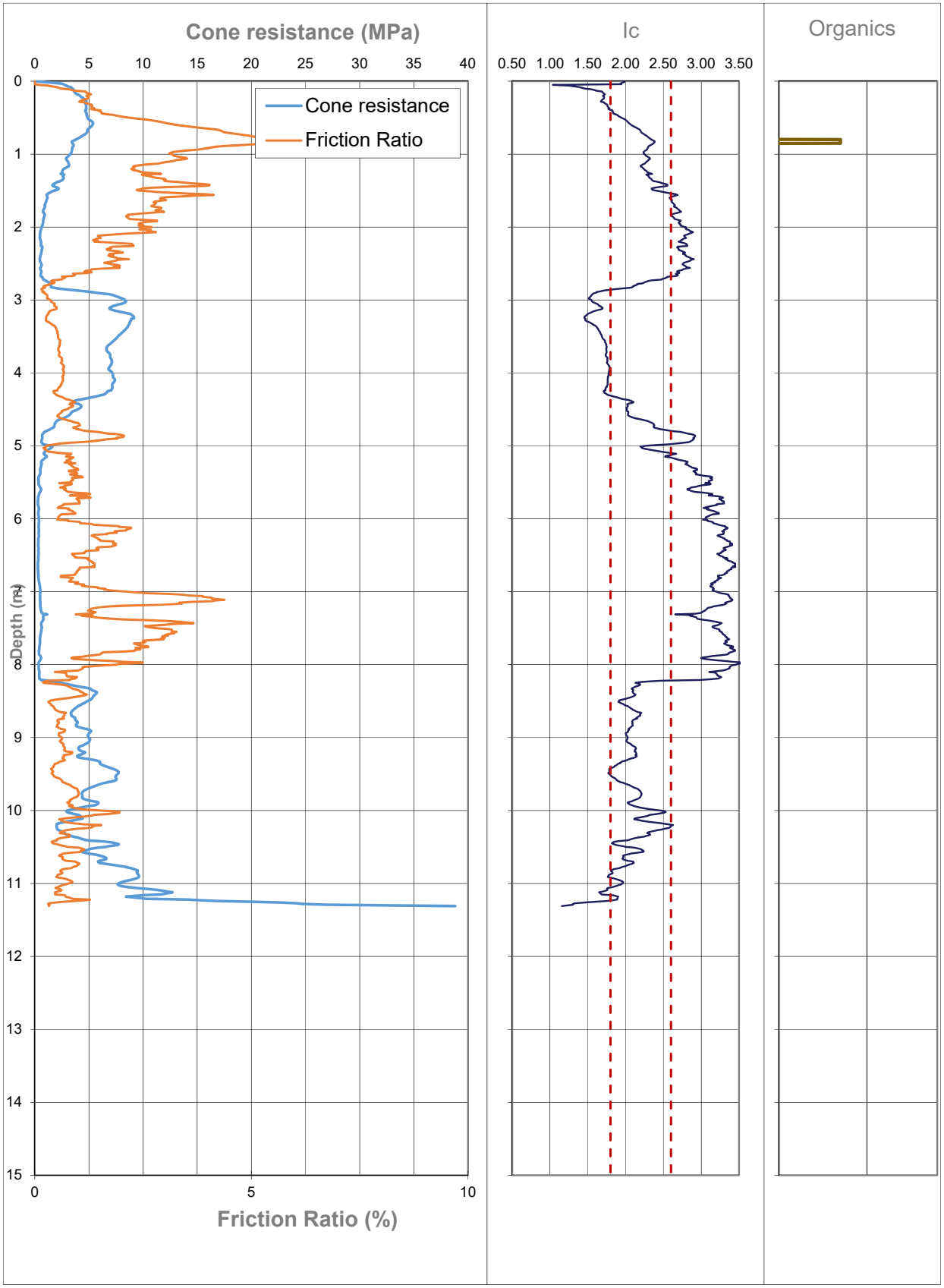

CPT Data Plots

GEOTECH CONSULTING LTD

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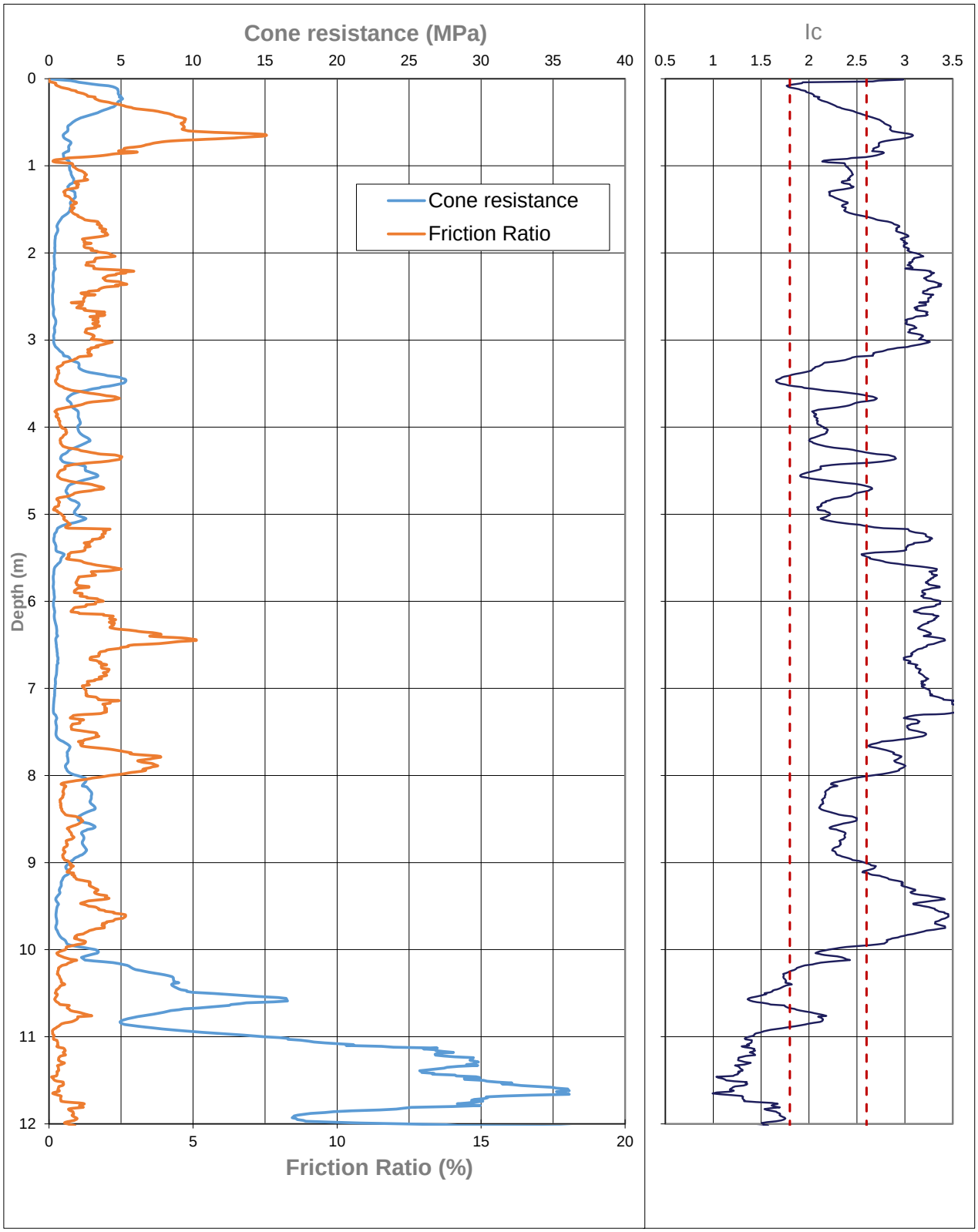

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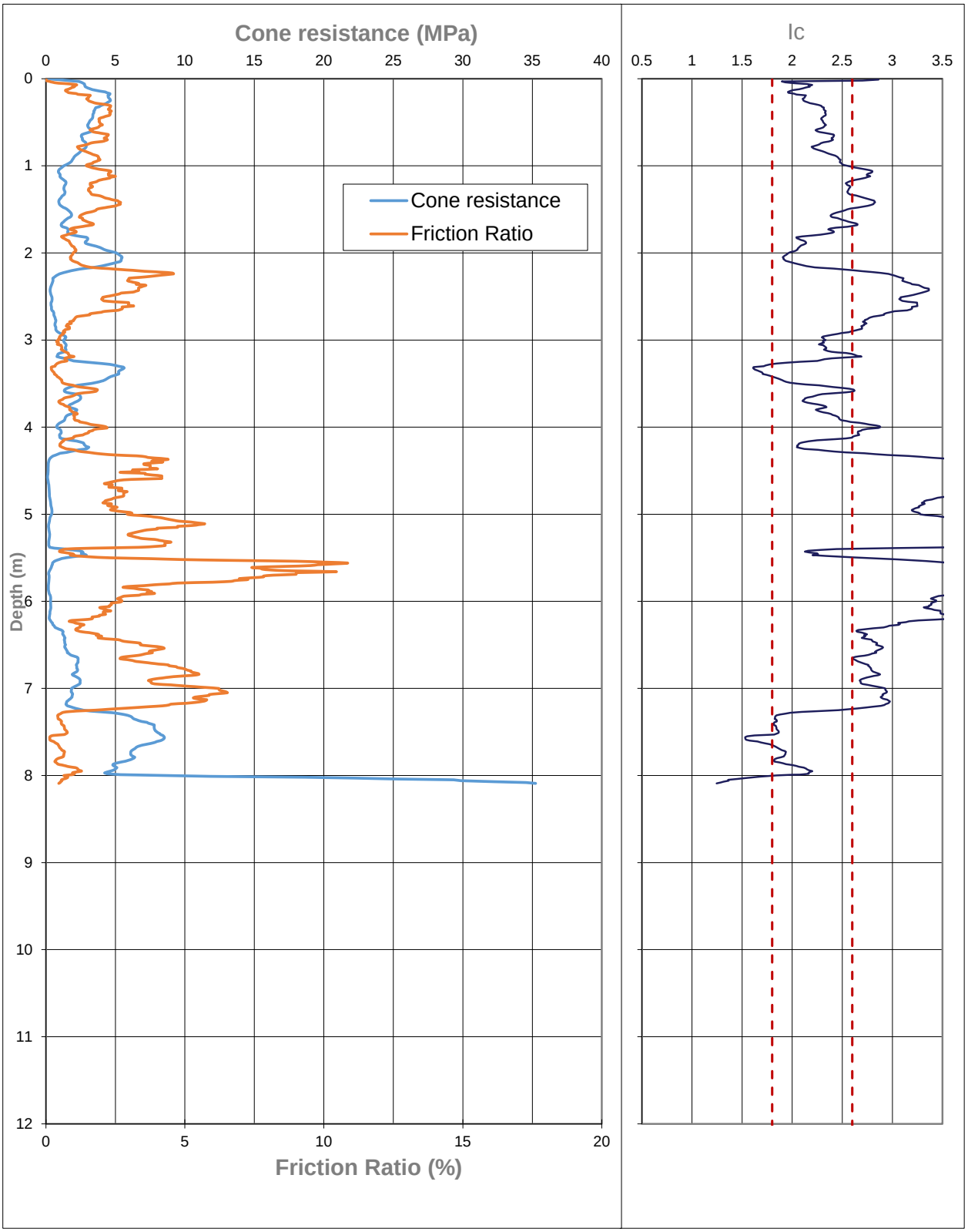

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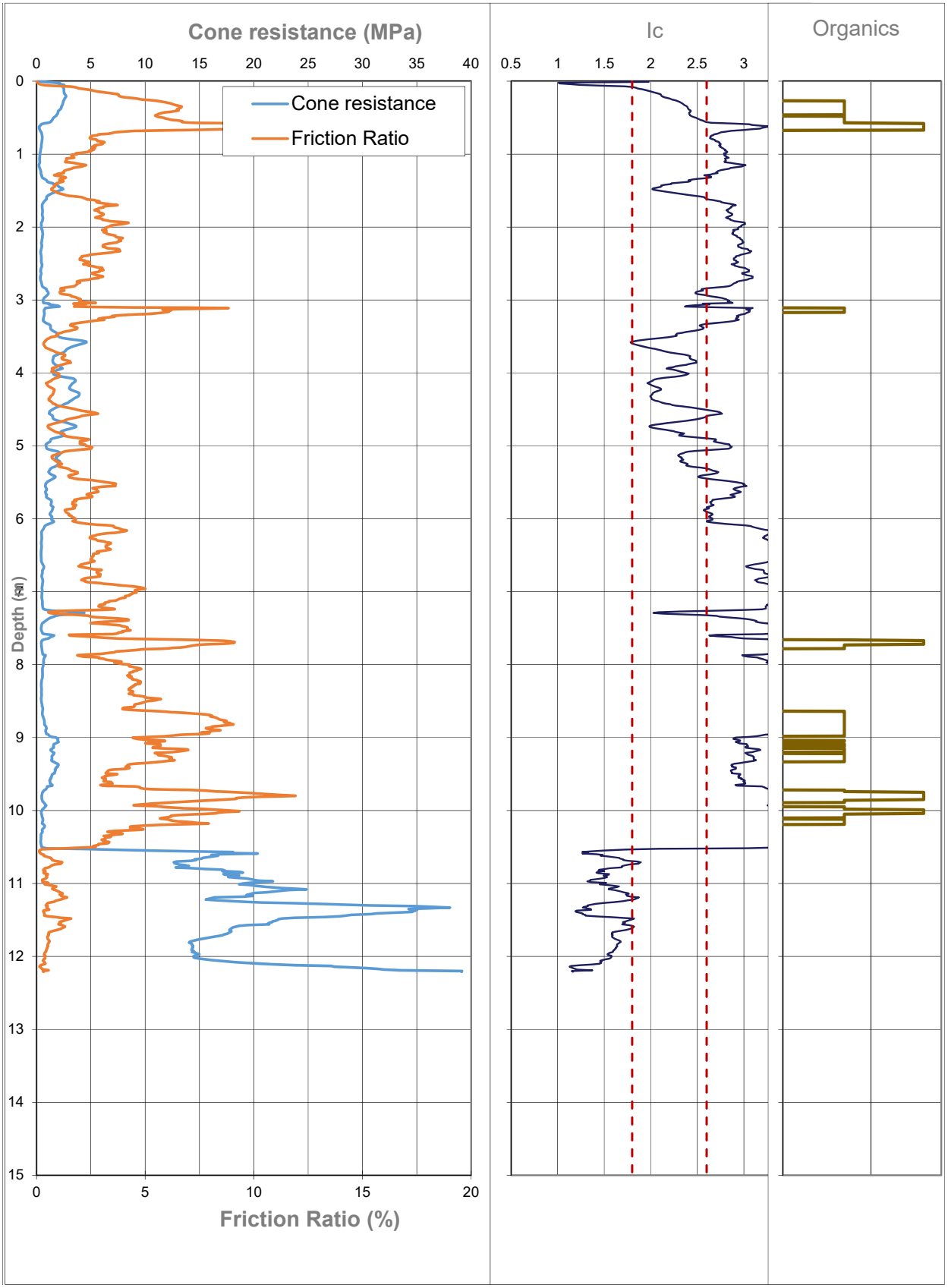

CPT Data Plots

GEOTECH CONSULTING LTD

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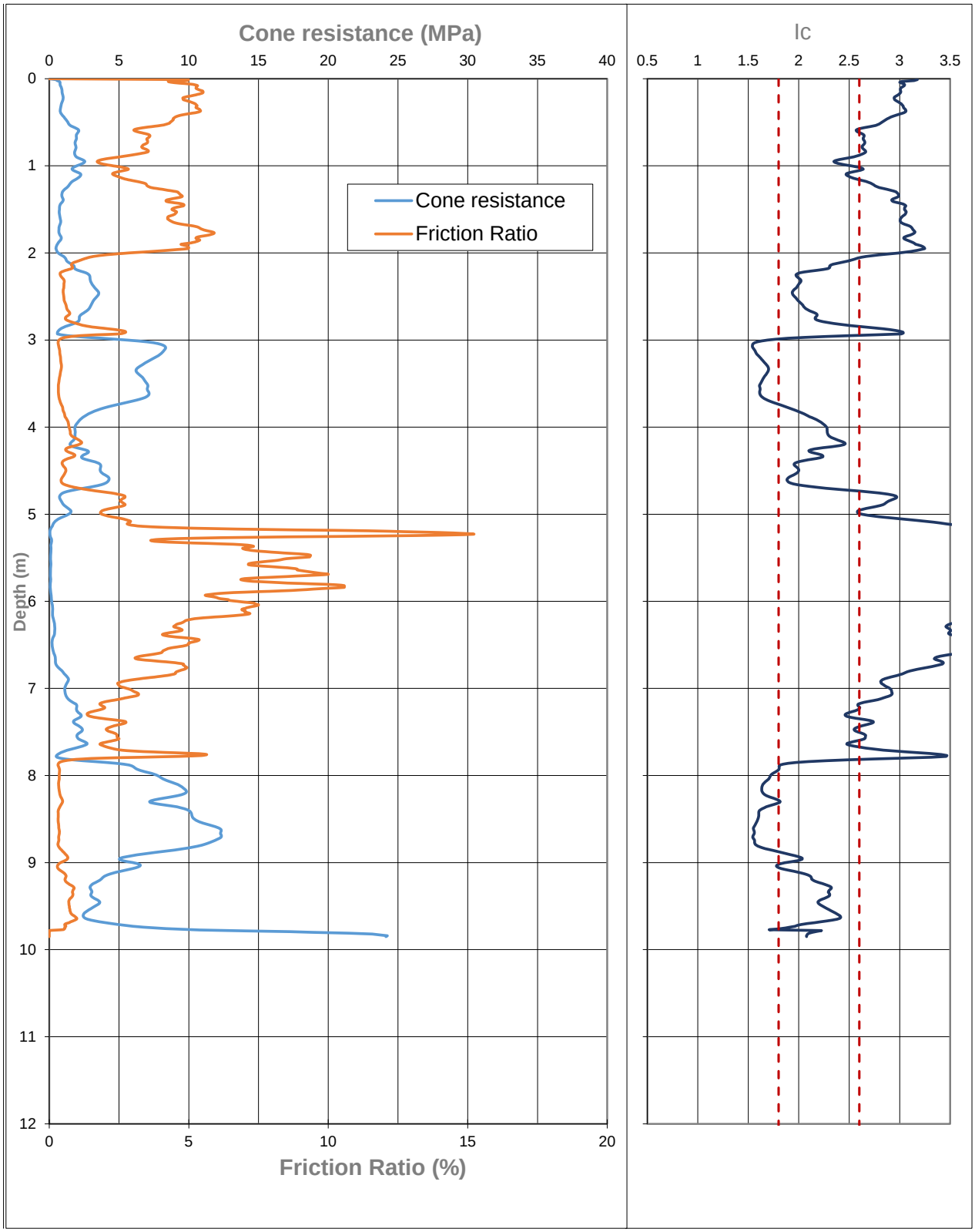
Client:	W Lewis	Job No:	3933



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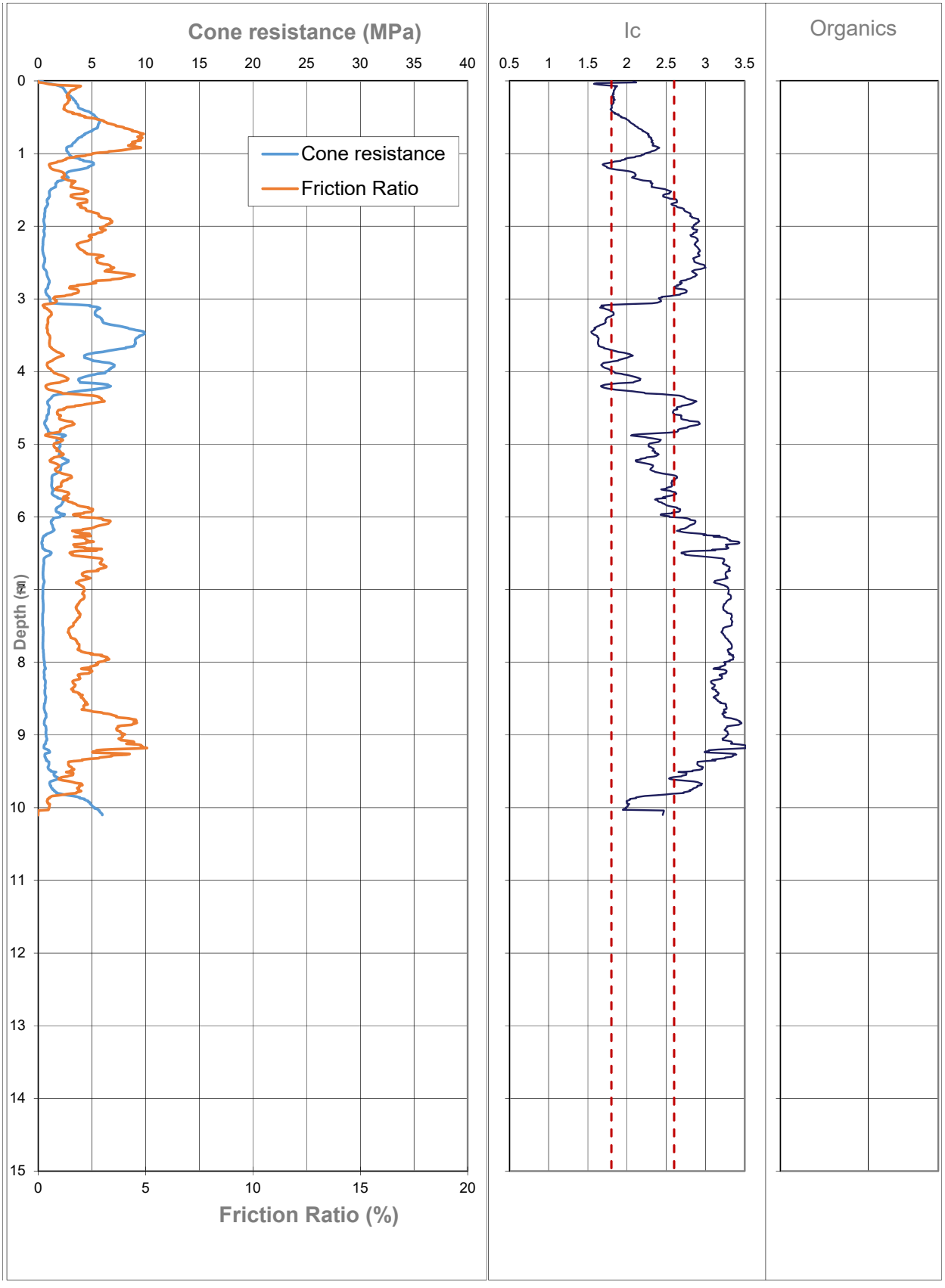

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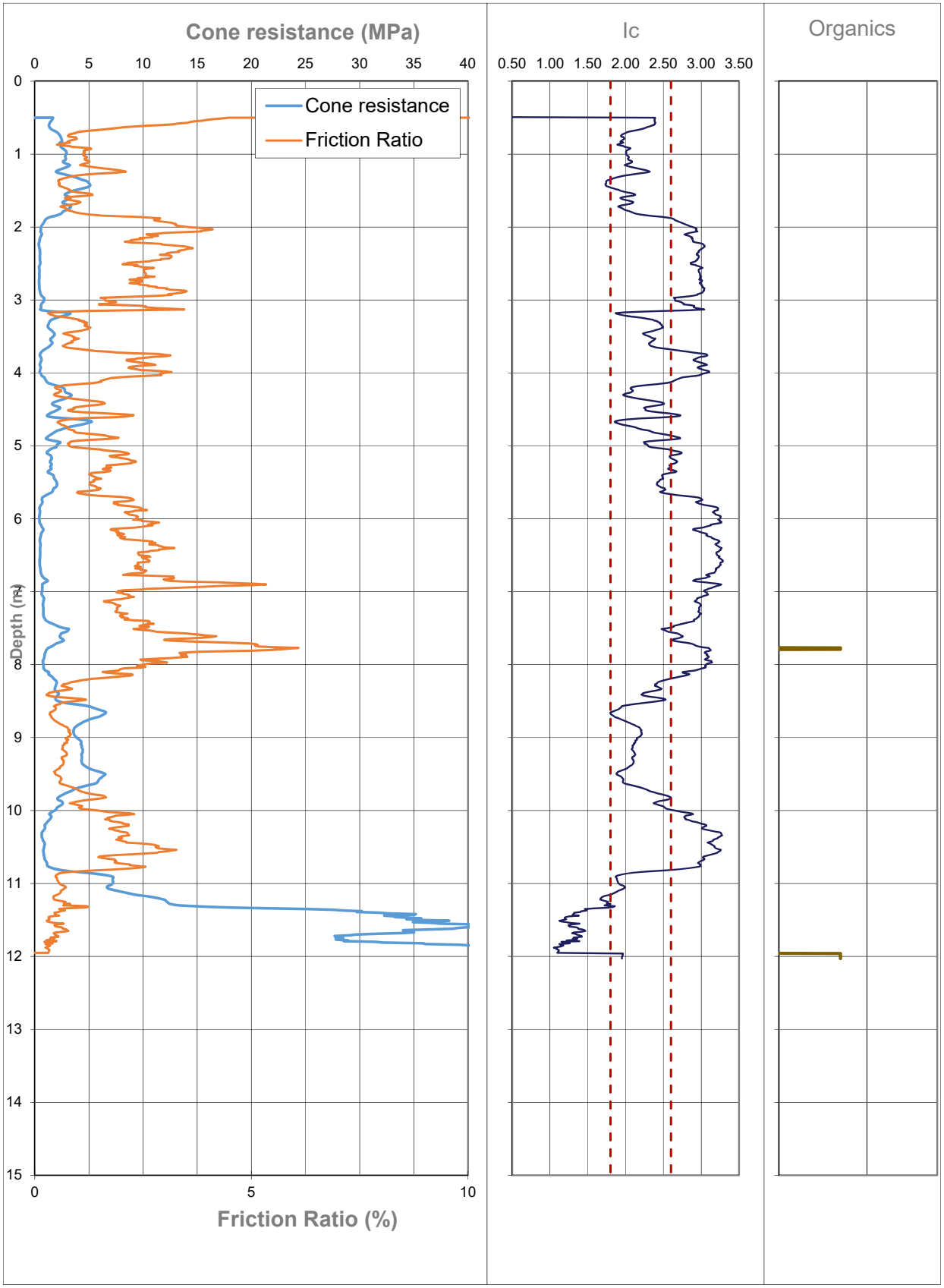

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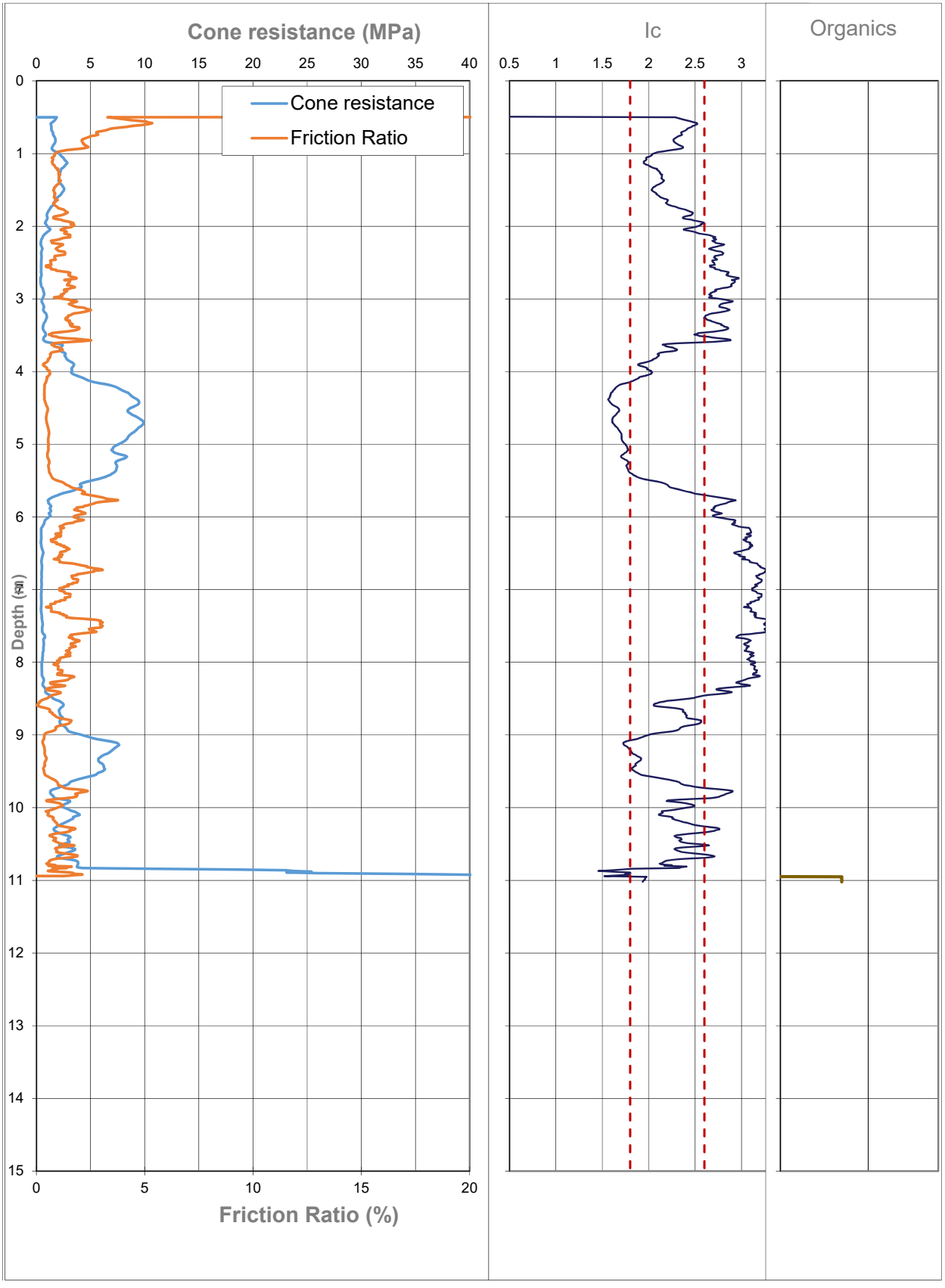

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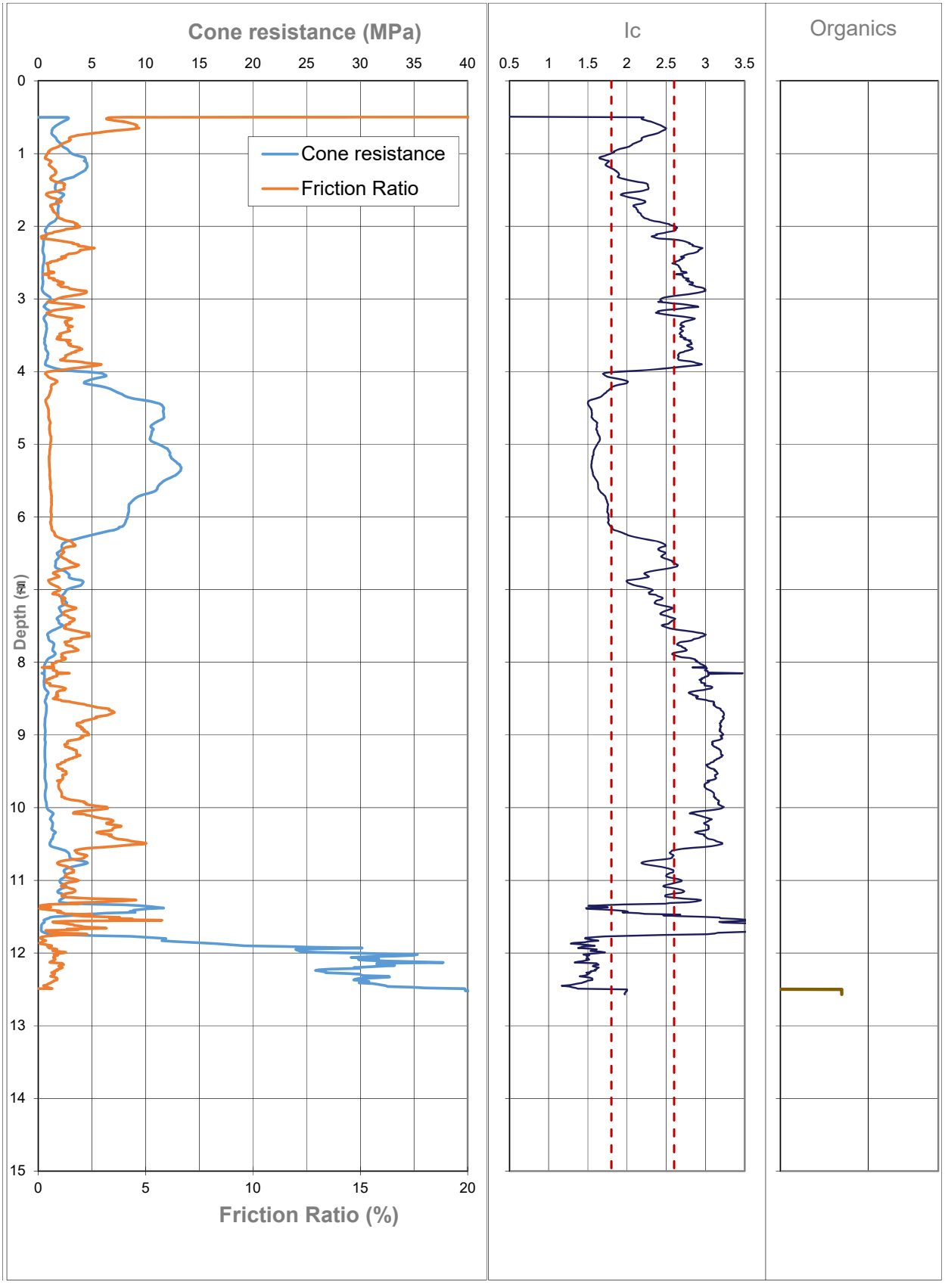

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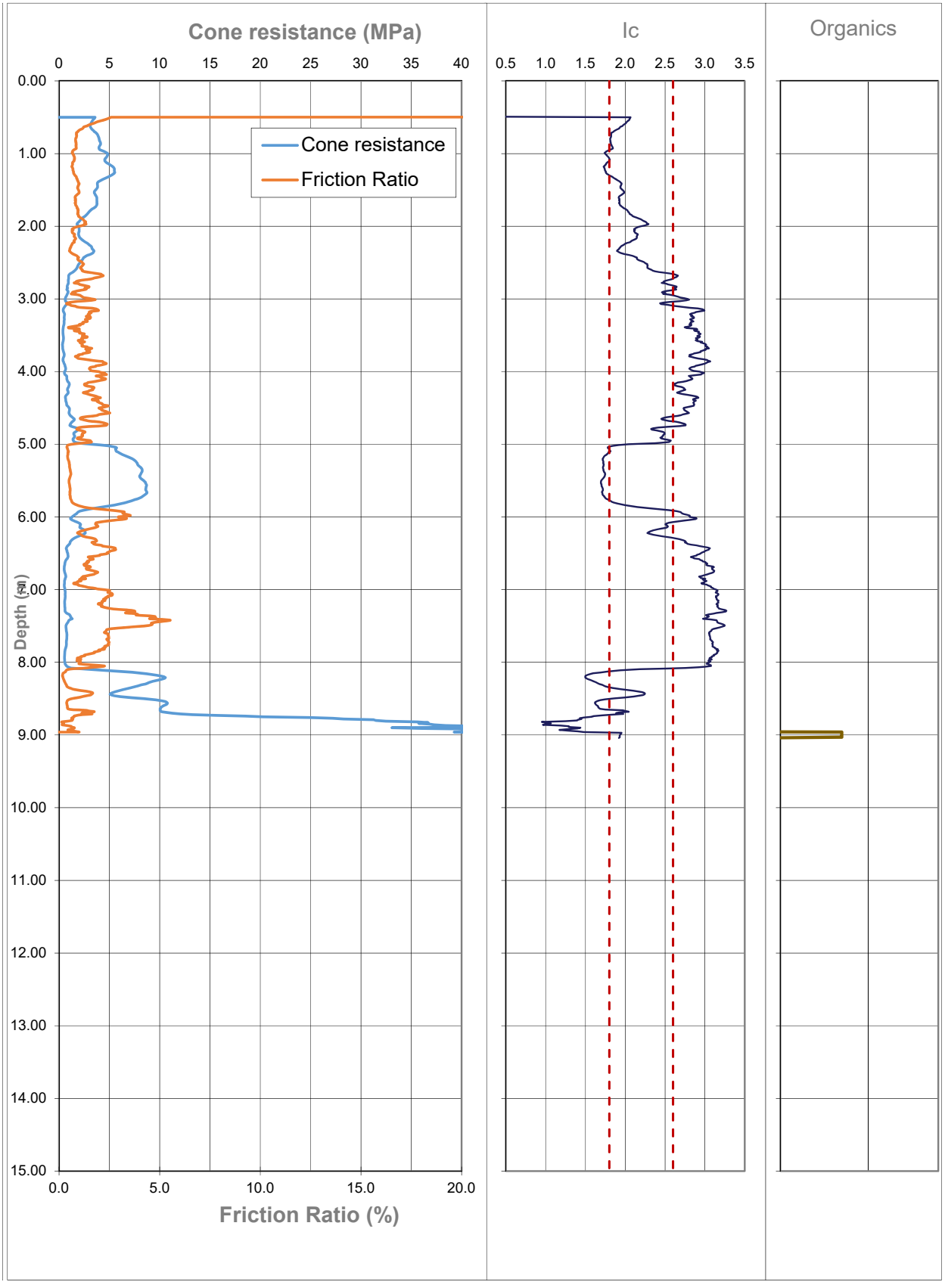

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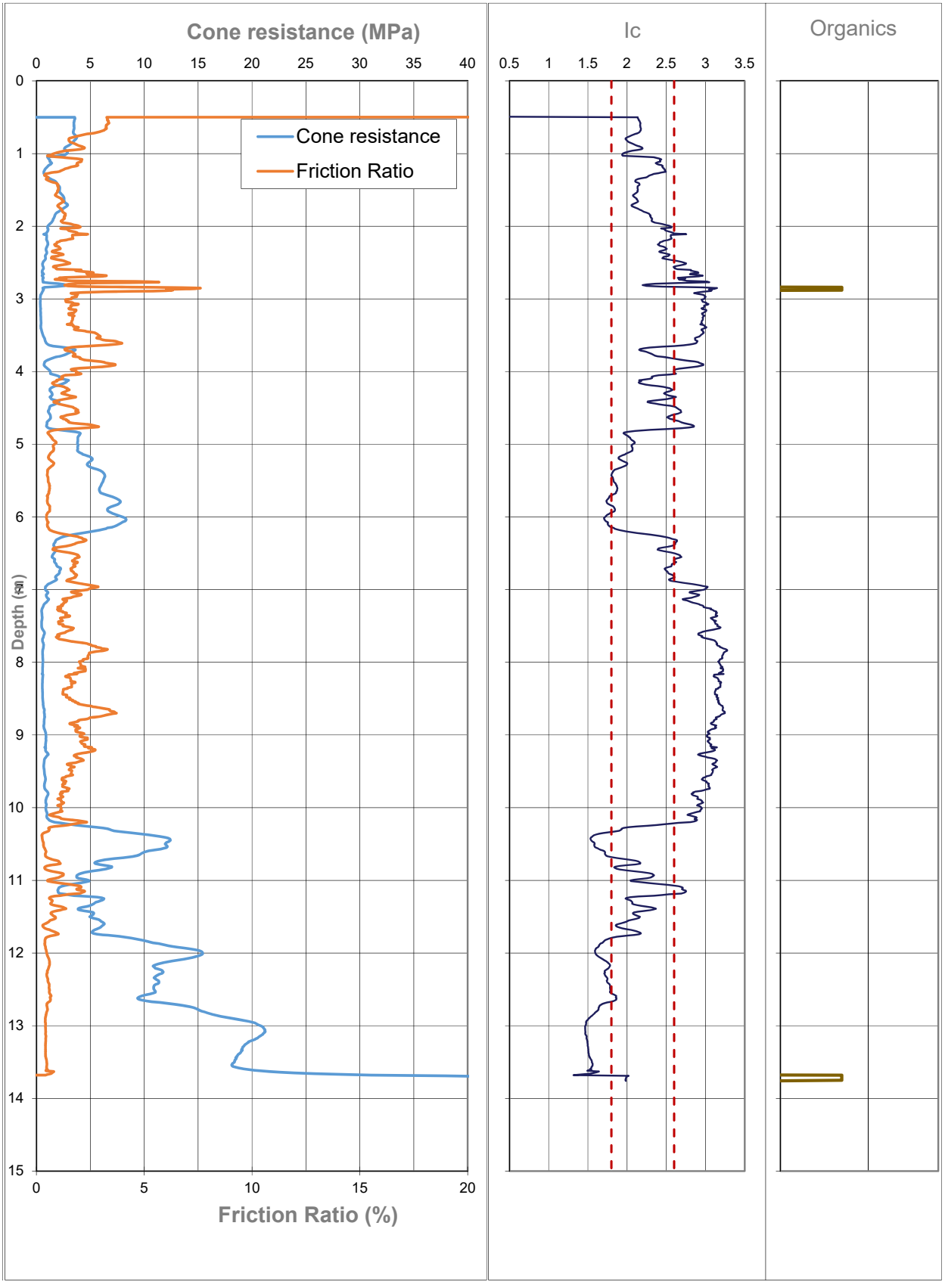

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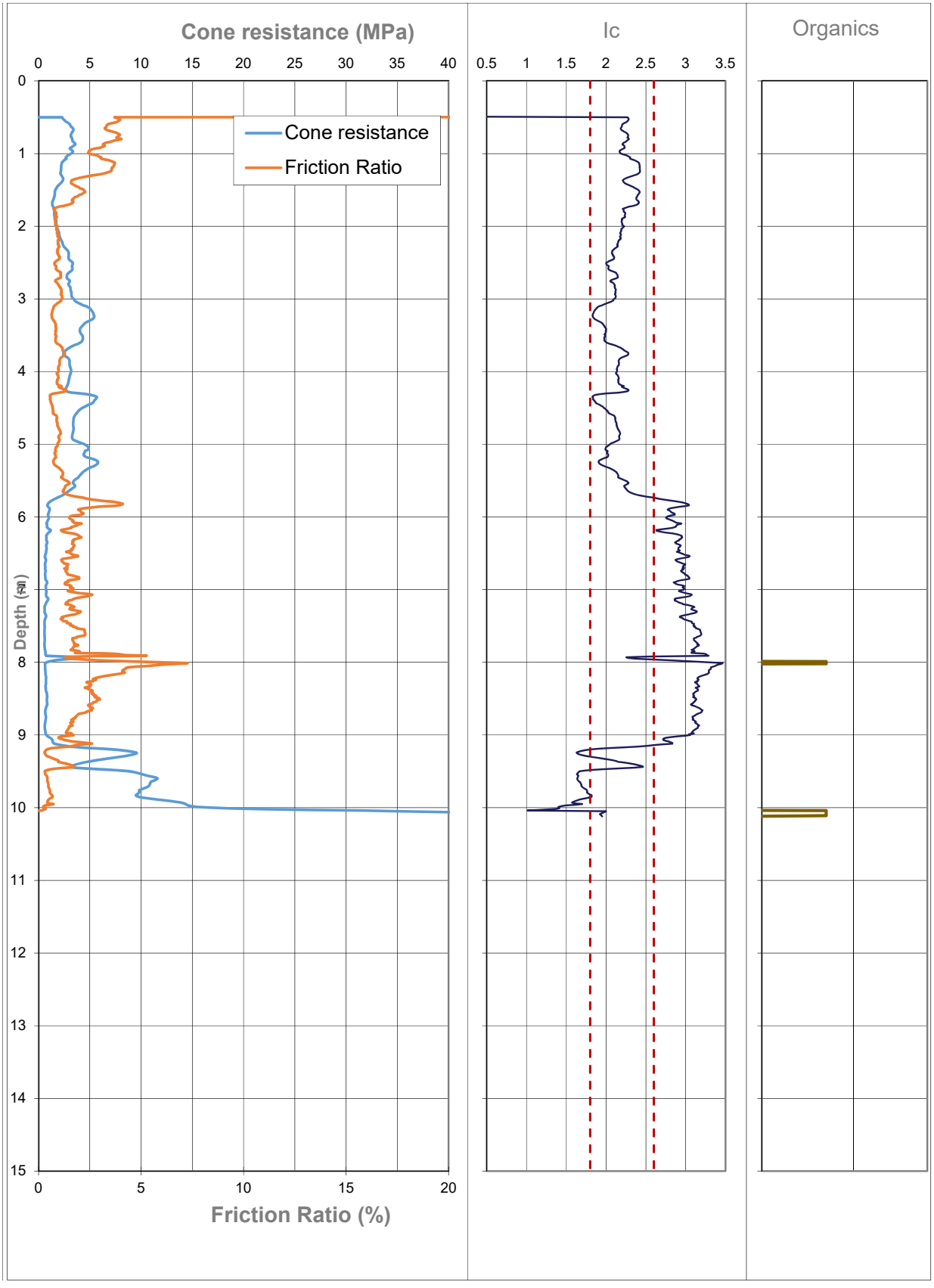

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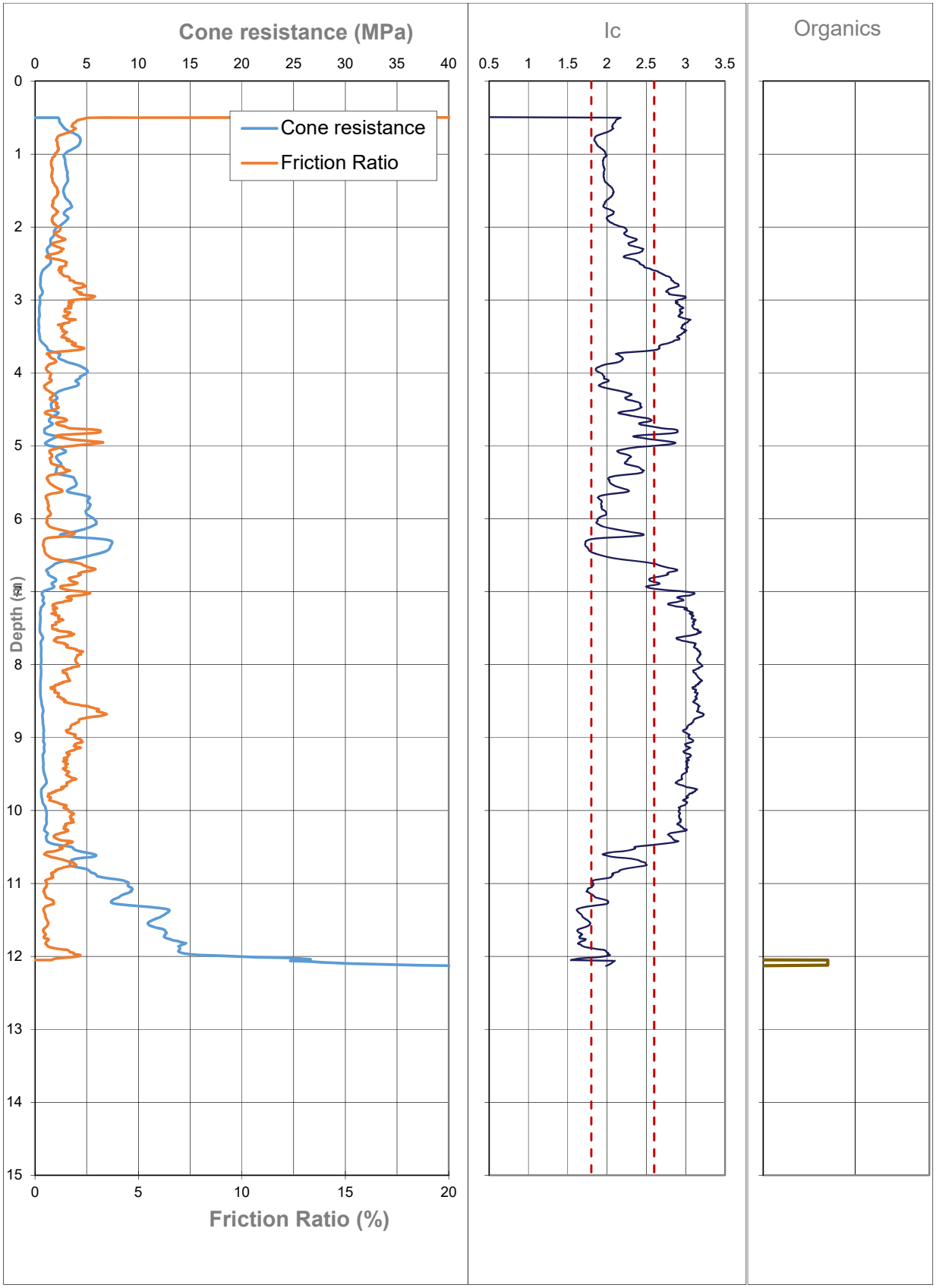

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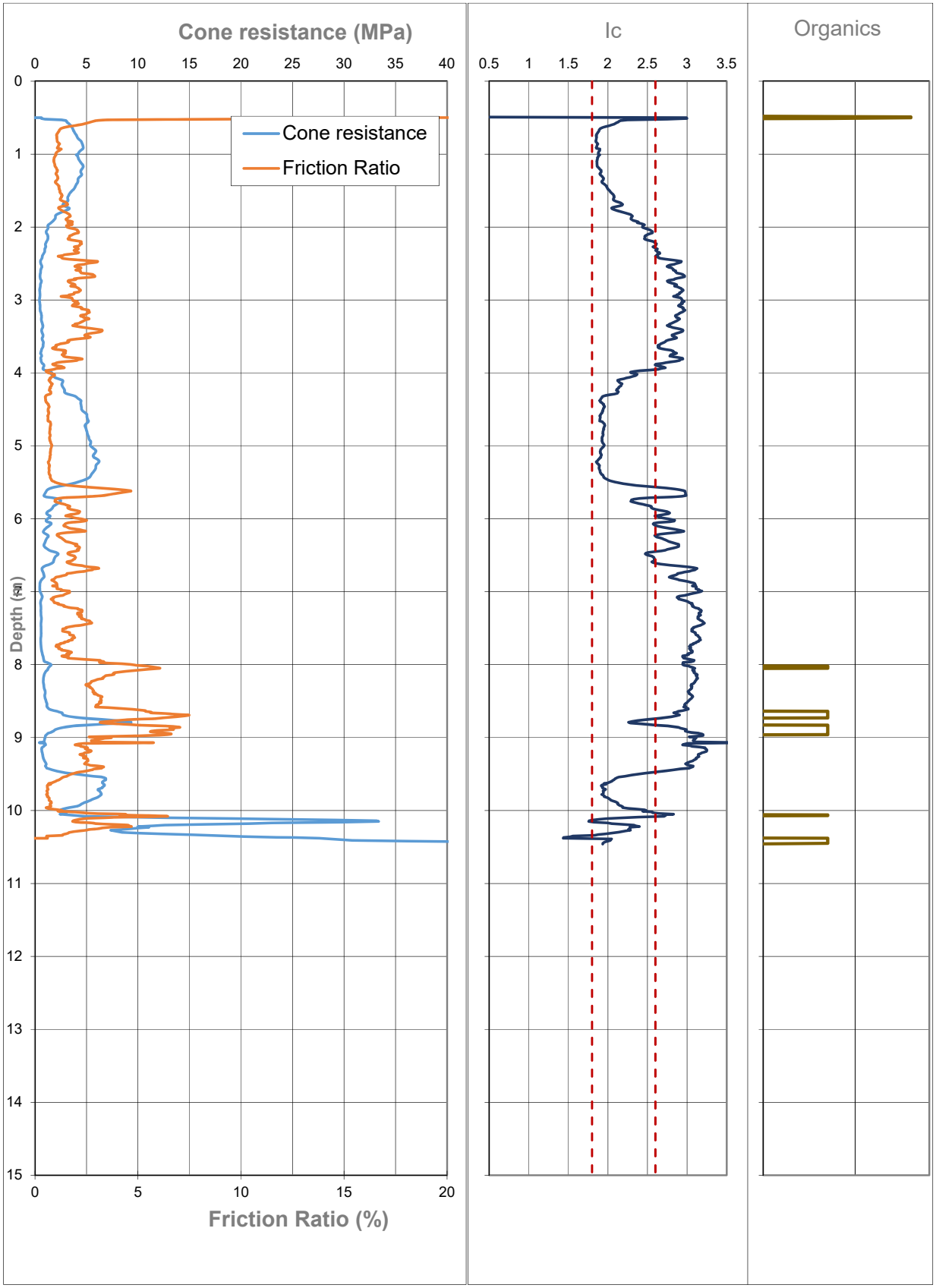

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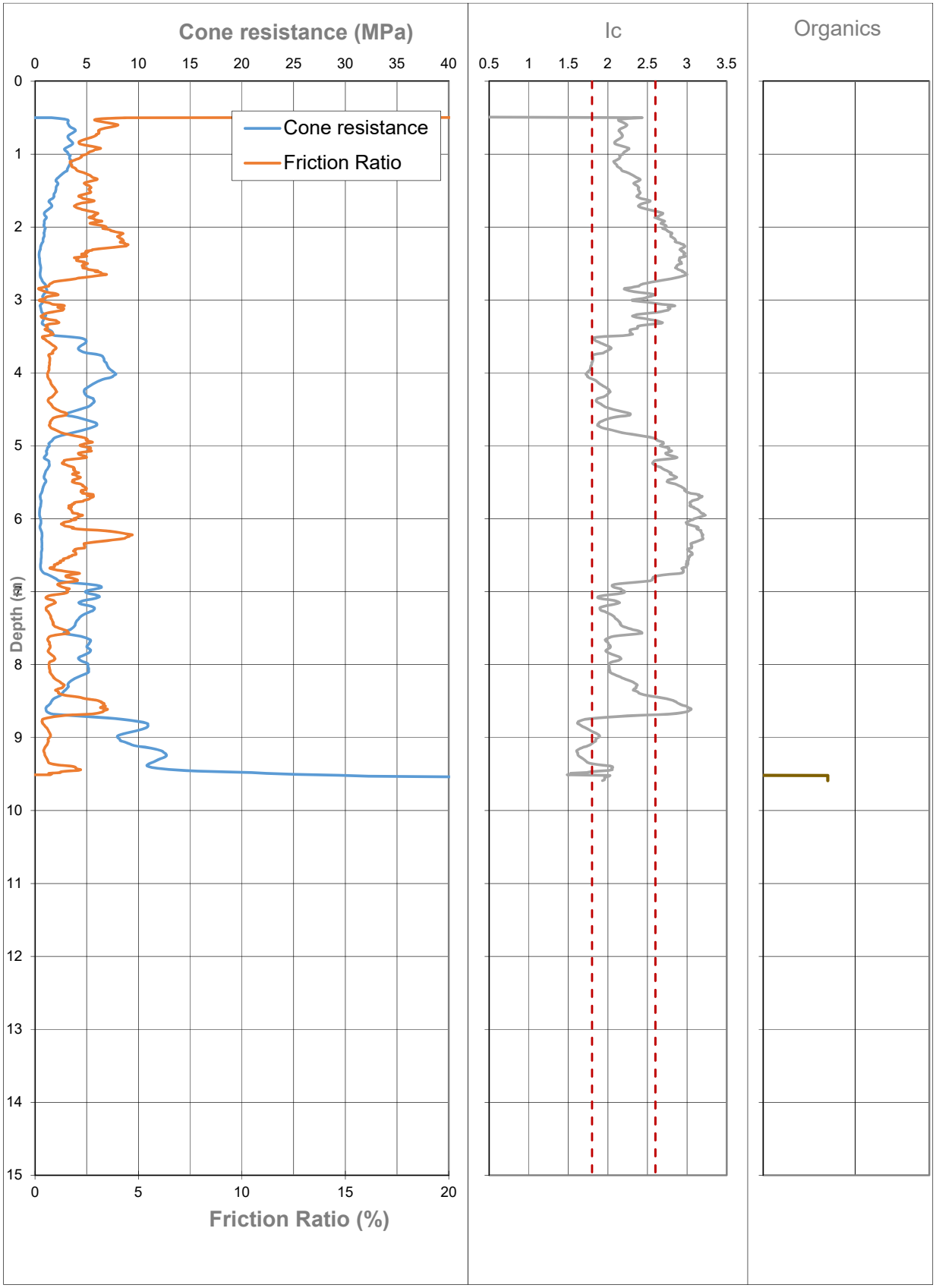

GEOTECH	CPT Data Plots			
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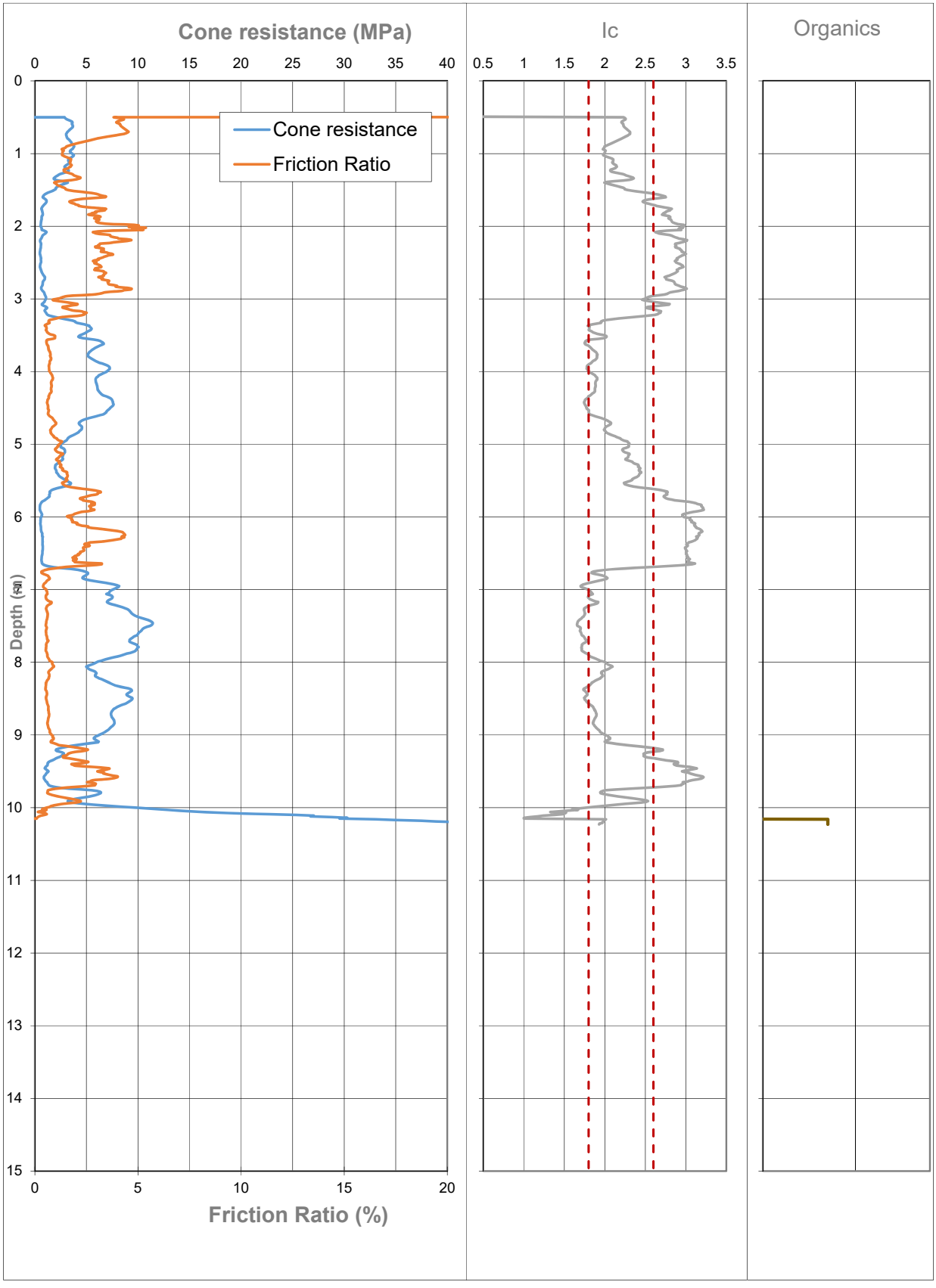
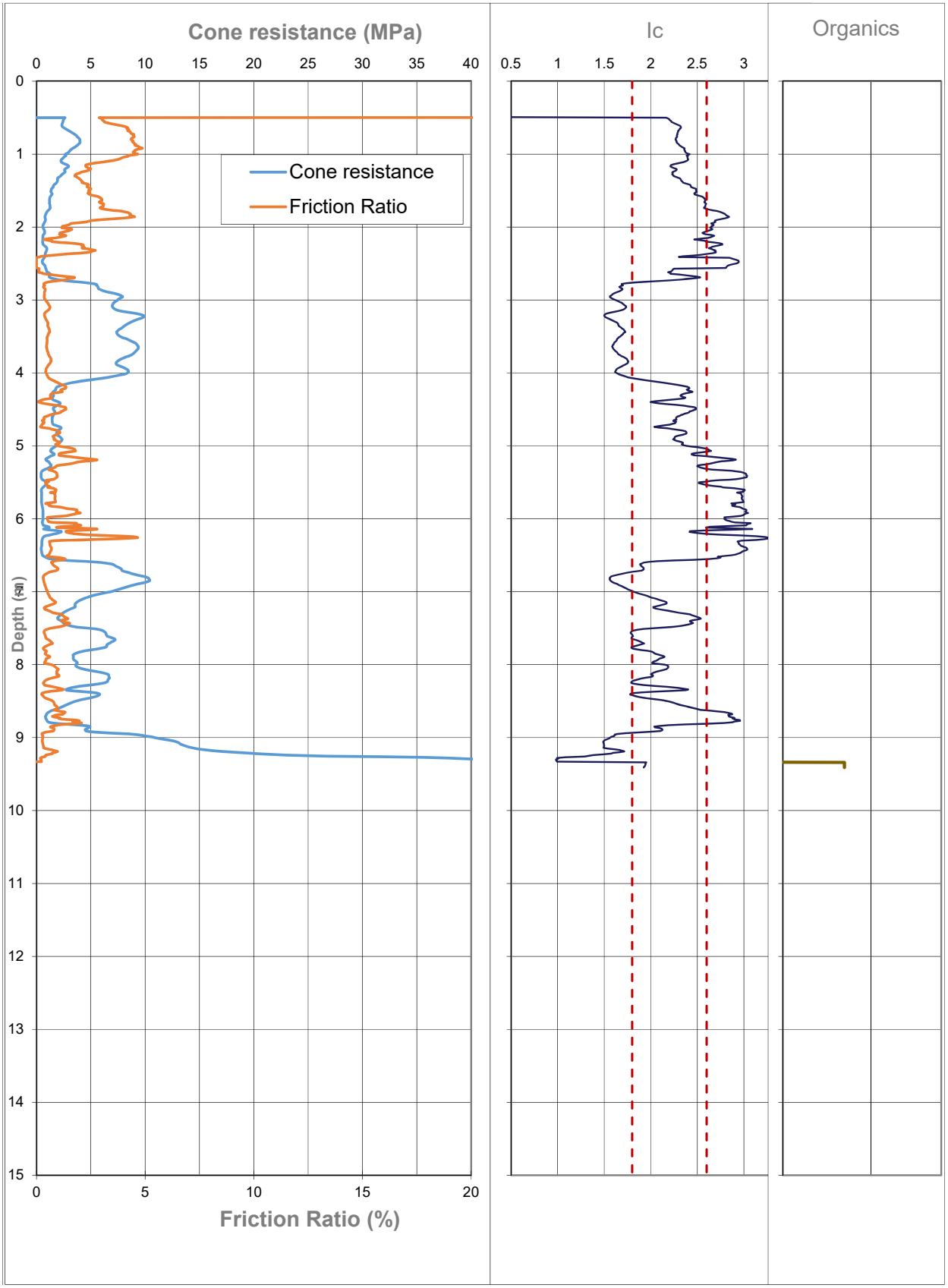
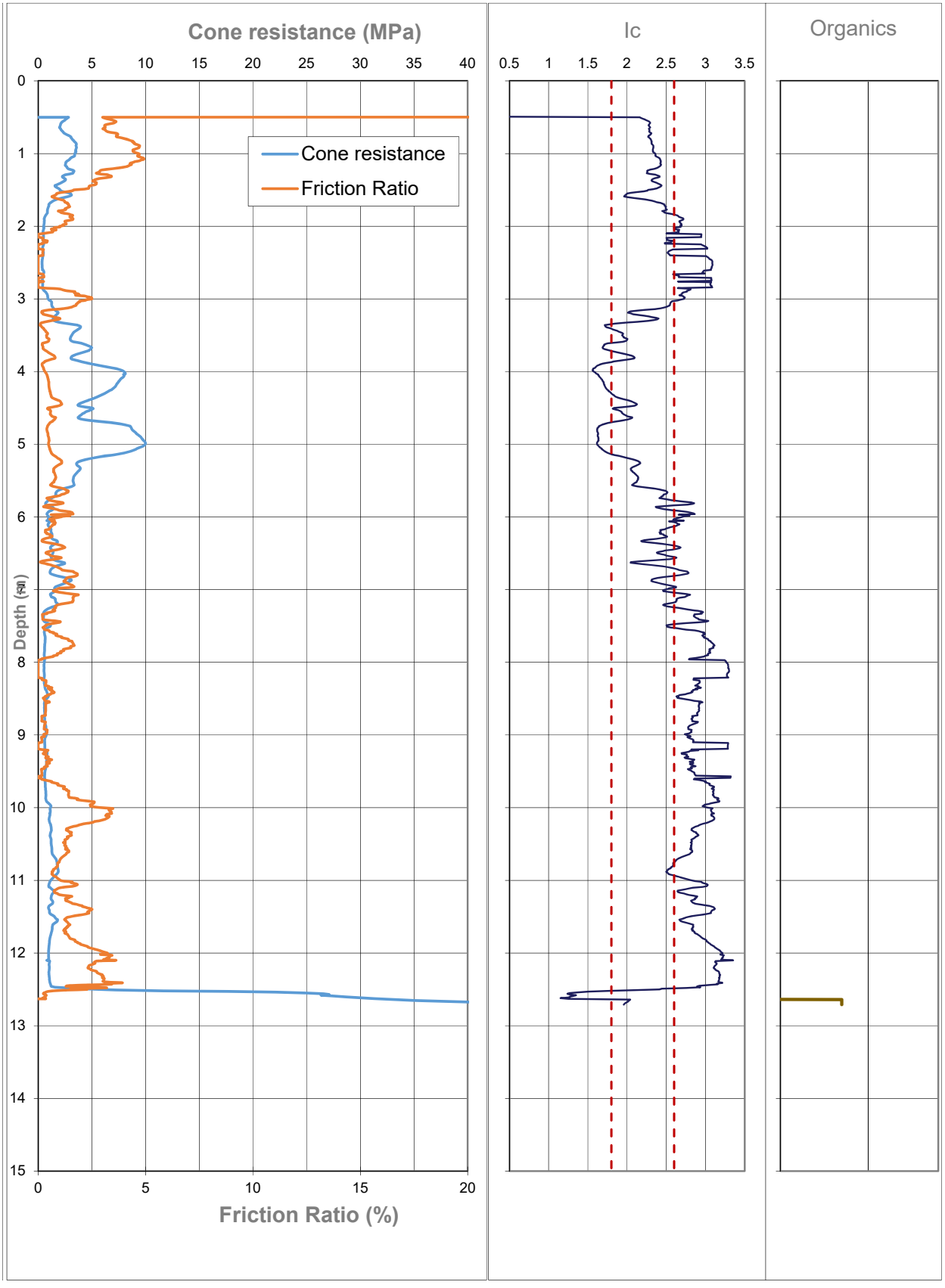
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 19**
	Client:	Cashmere Park Trust	Job No:	3933



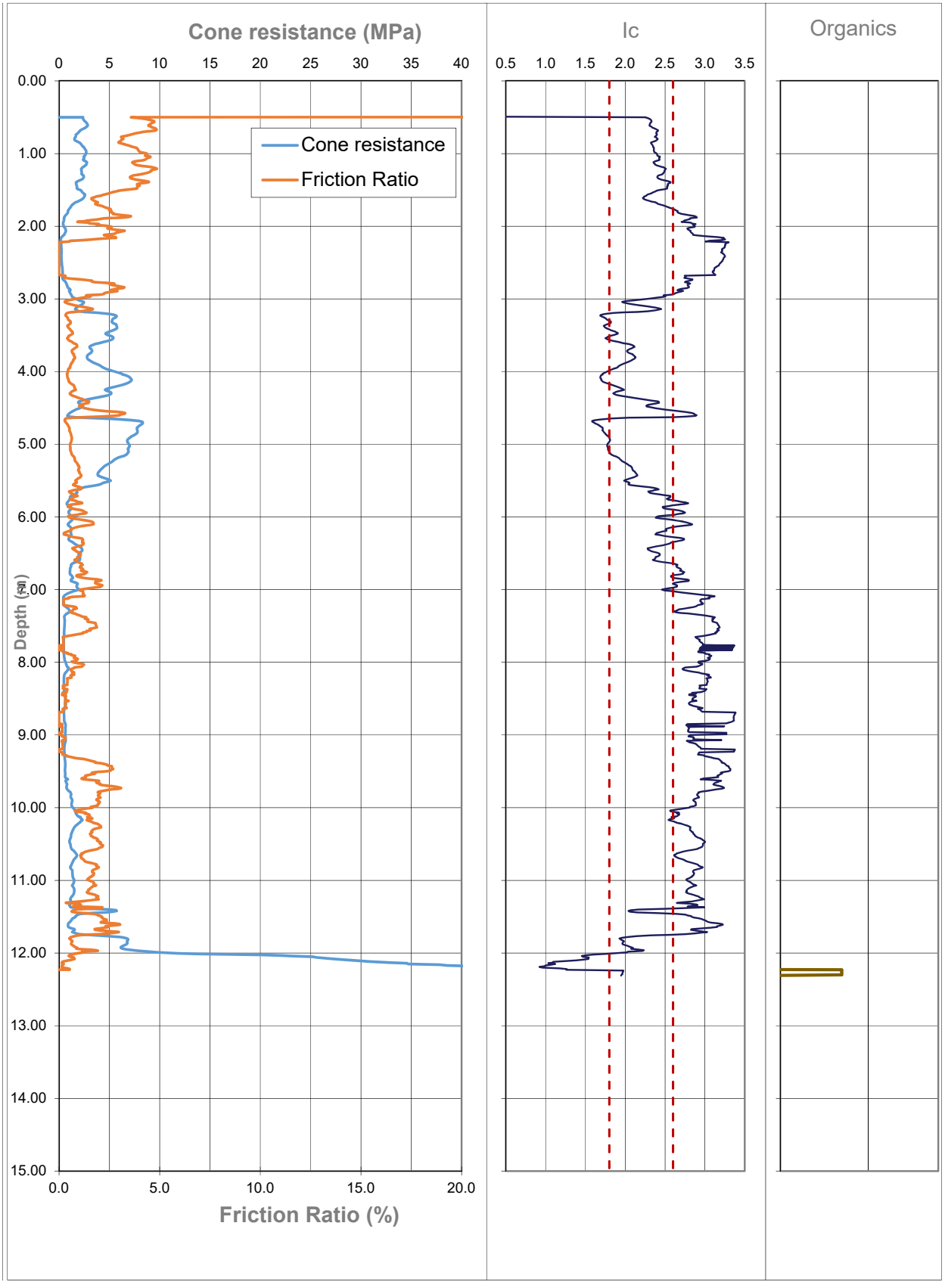
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 20**
	Client:	Cashmere Park Trust	Job No:	3933



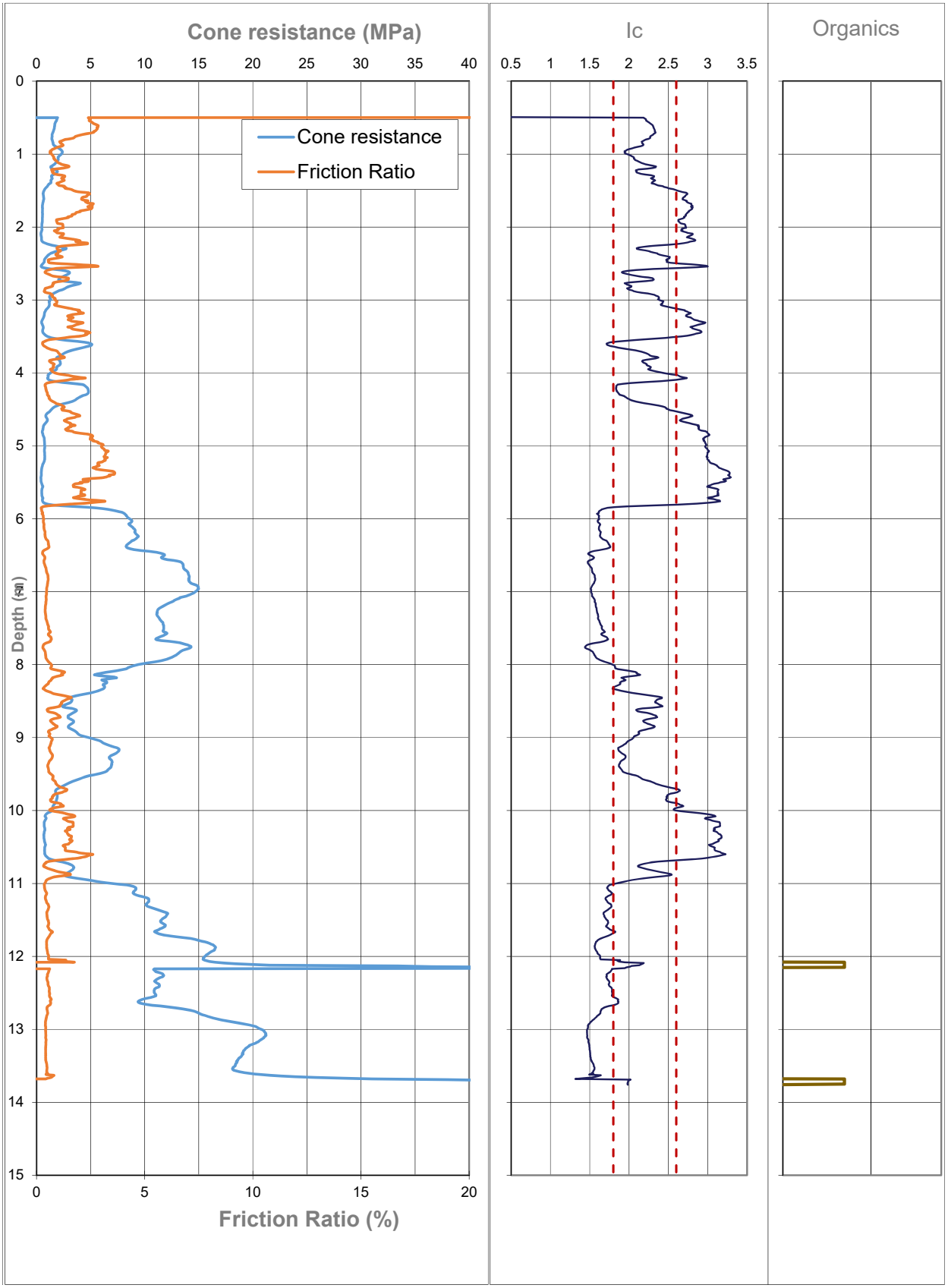
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 21**
	Client:	Cashmere Park Trust	Job No:	3933



GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 22**
	Client:	Cashmere Park Trust	Job No:	3933



GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 23**
	Client:	Cashmere Park Trust	Job No:	3933



GEOTECH	CPT Data Plots			
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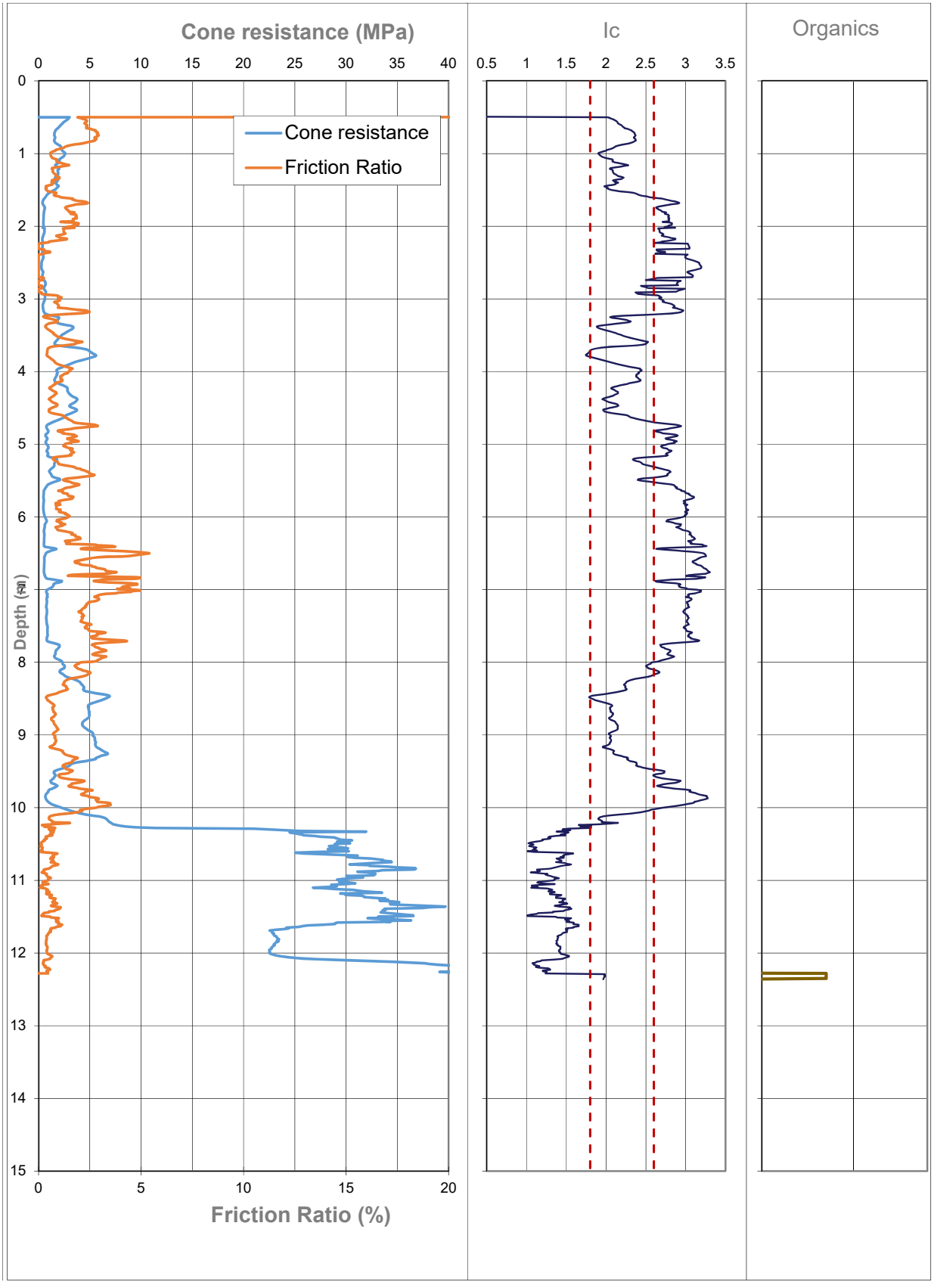
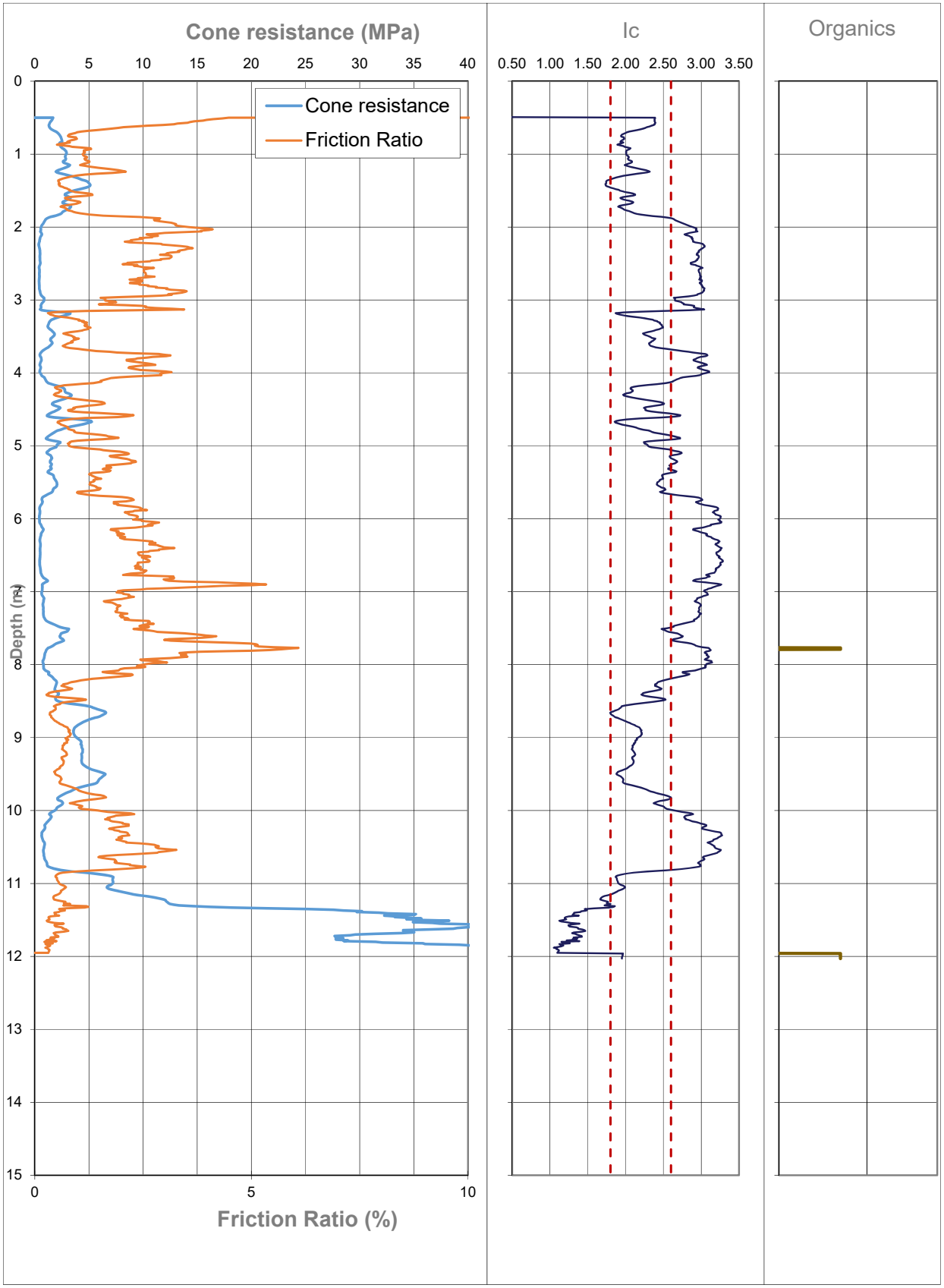
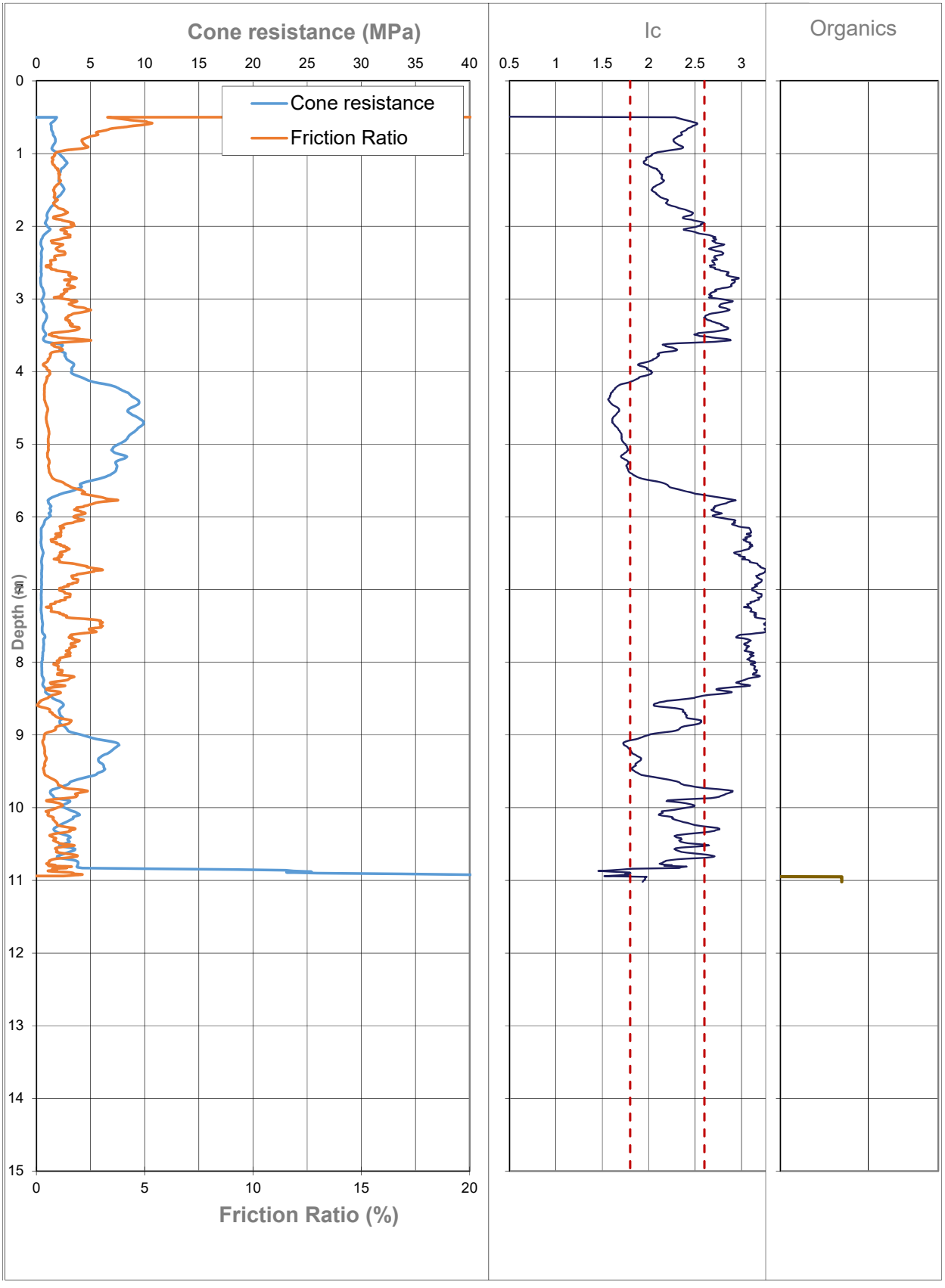
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 27**
	Client:	Cashmere Park Trust	Job No:	3933



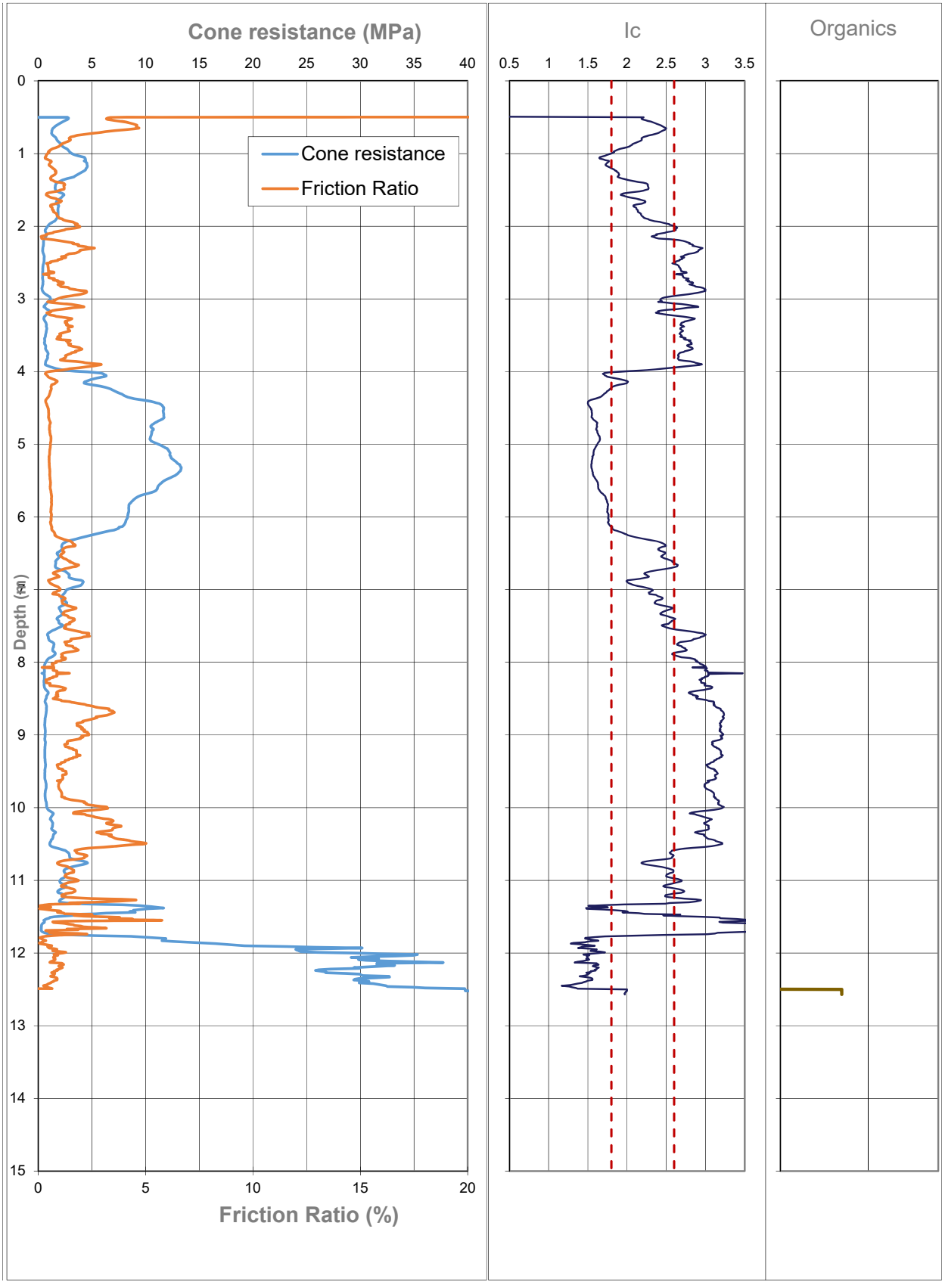
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 10**
	Client:	Cashmere Park Trust	Job No:	3933



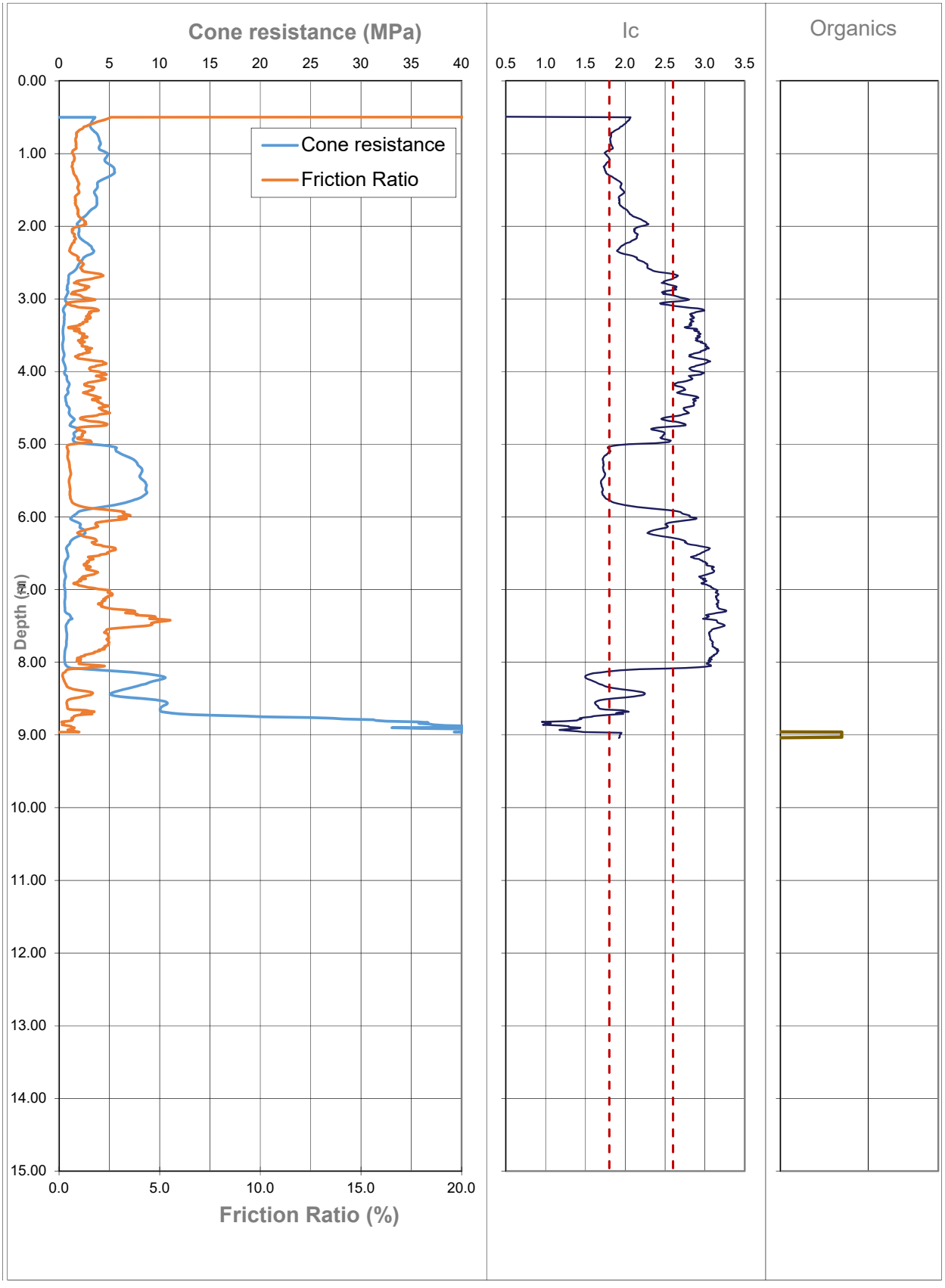
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 11**
	Client:	Cashmere Park Trust	Job No:	3933



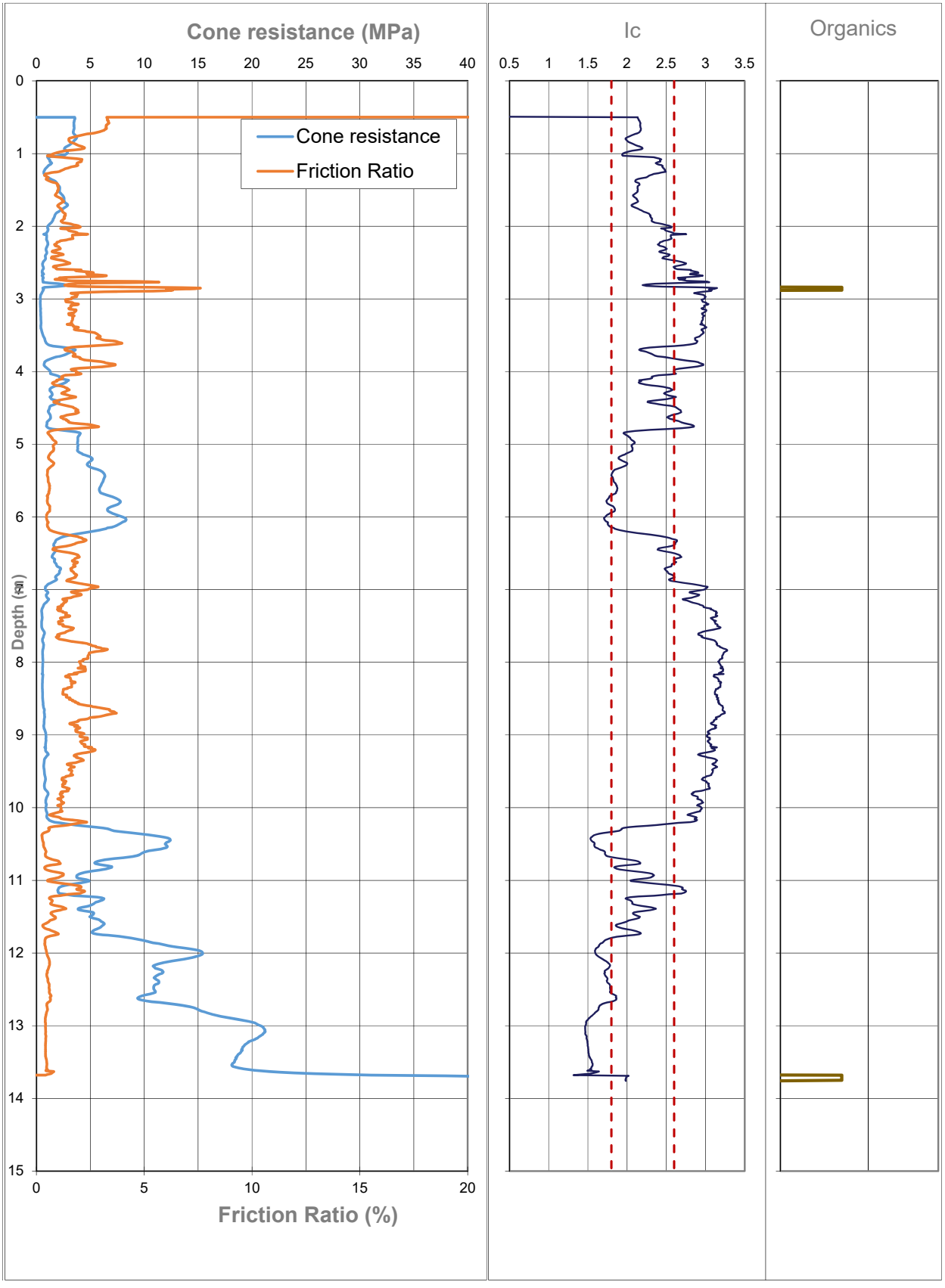
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 12**
	Client:	Cashmere Park Trust	Job No:	3933



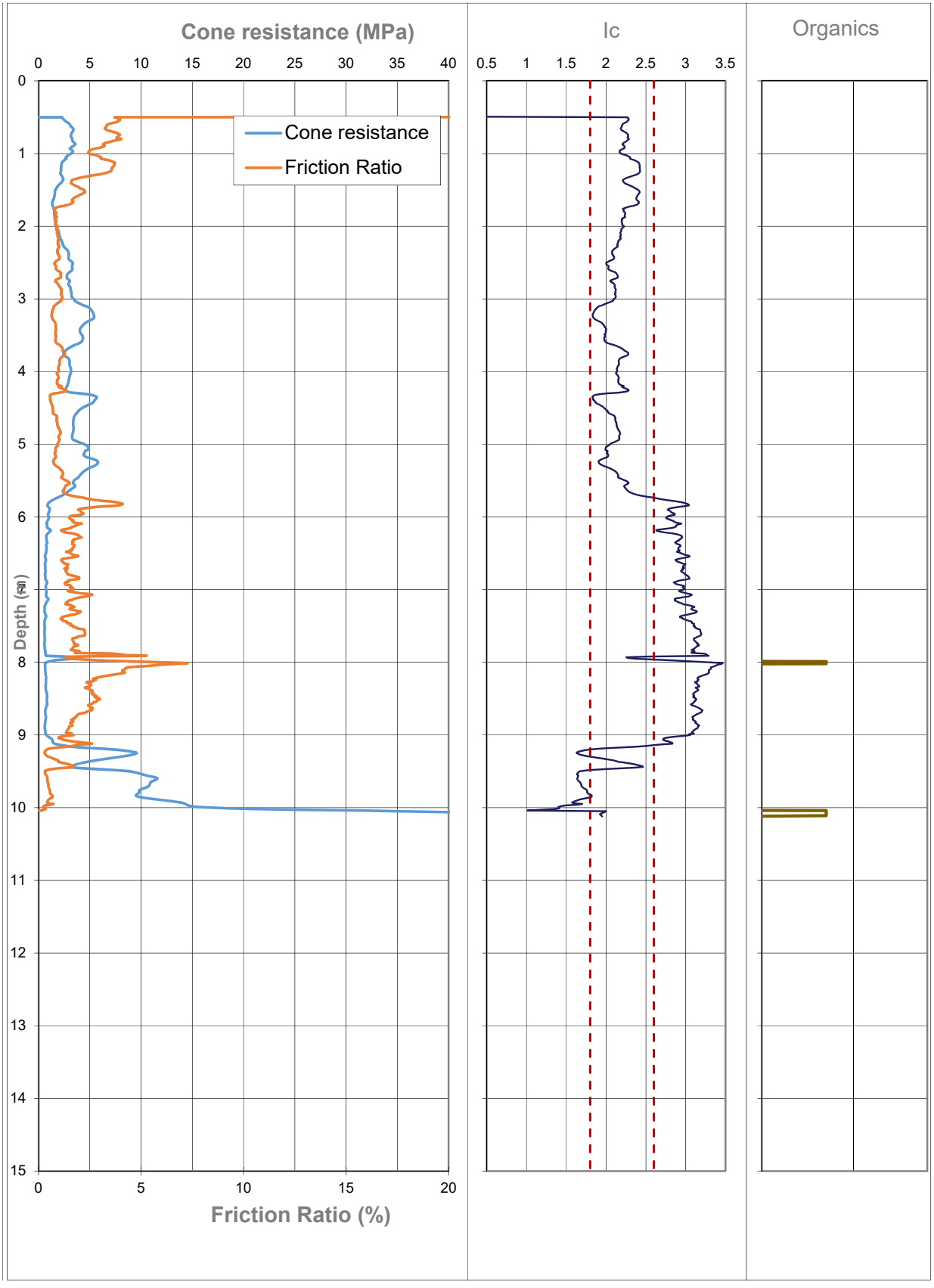
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 13**
	Client:	Cashmere Park Trust	Job No:	3933



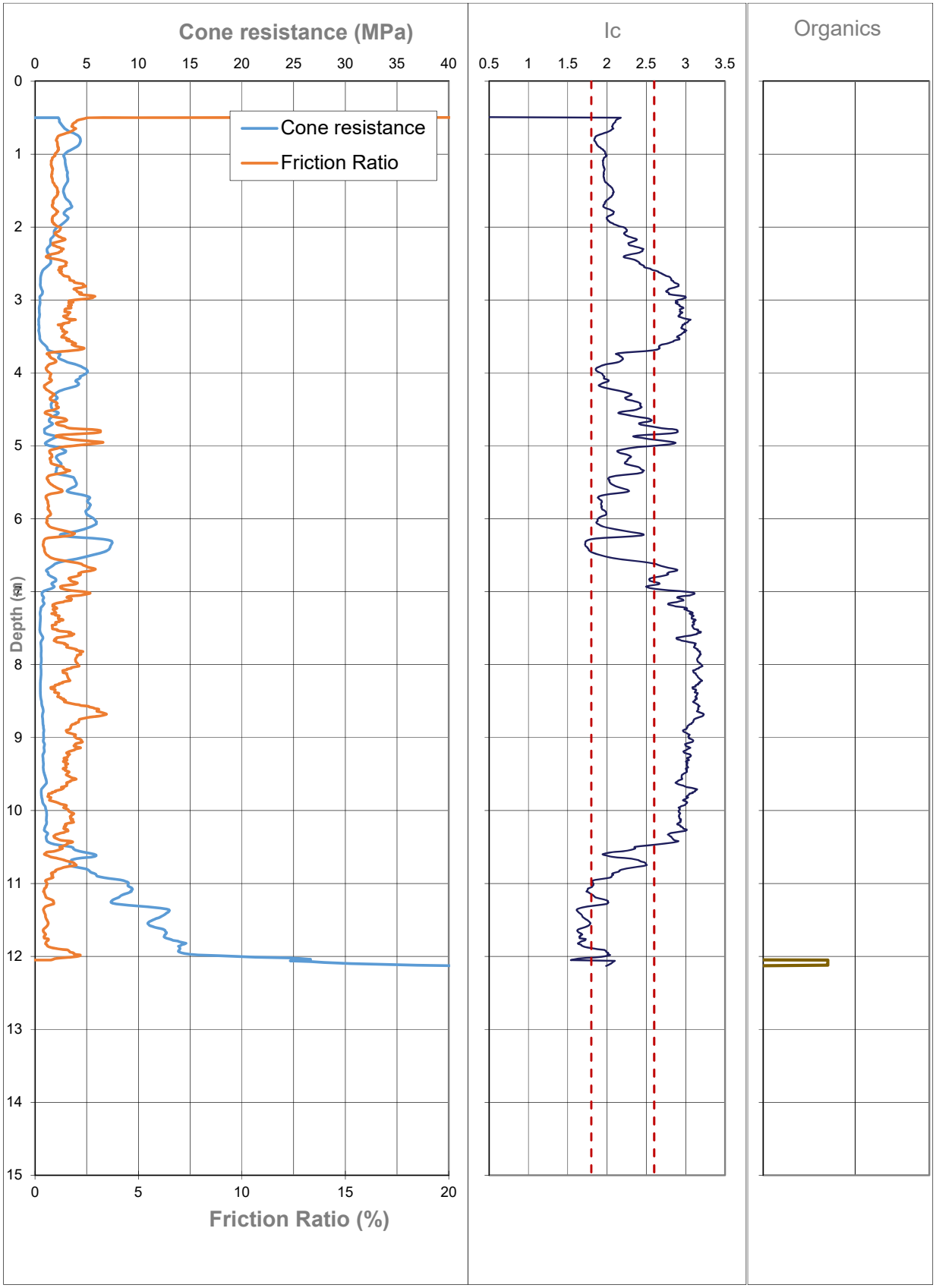
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 14**
	Client:	Cashmere Park Trust	Job No:	3933



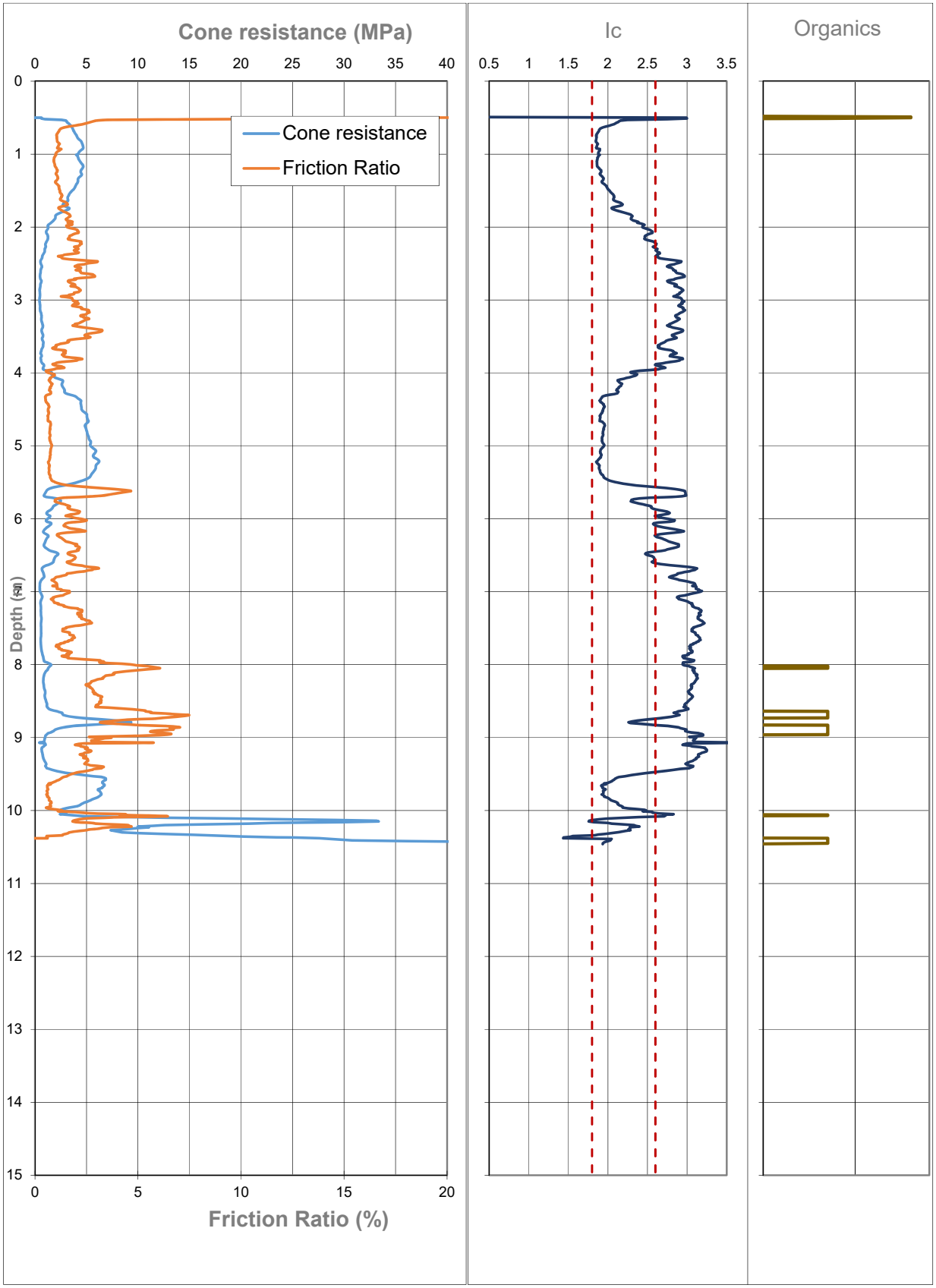
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 15**
	Client:	Cashmere Park Trust	Job No:	3933



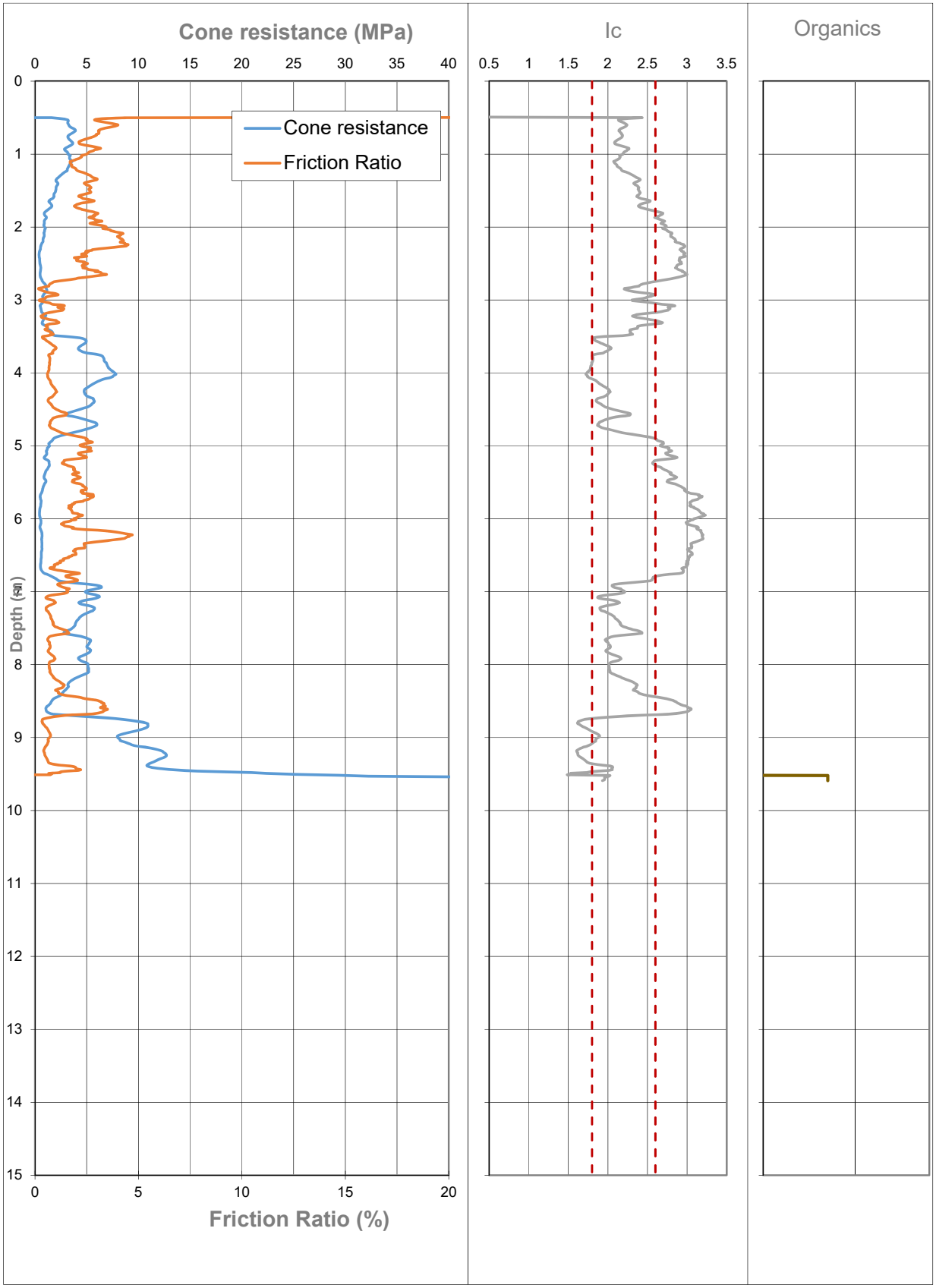
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 16**
	Client:	Cashmere Park Trust	Job No:	3933



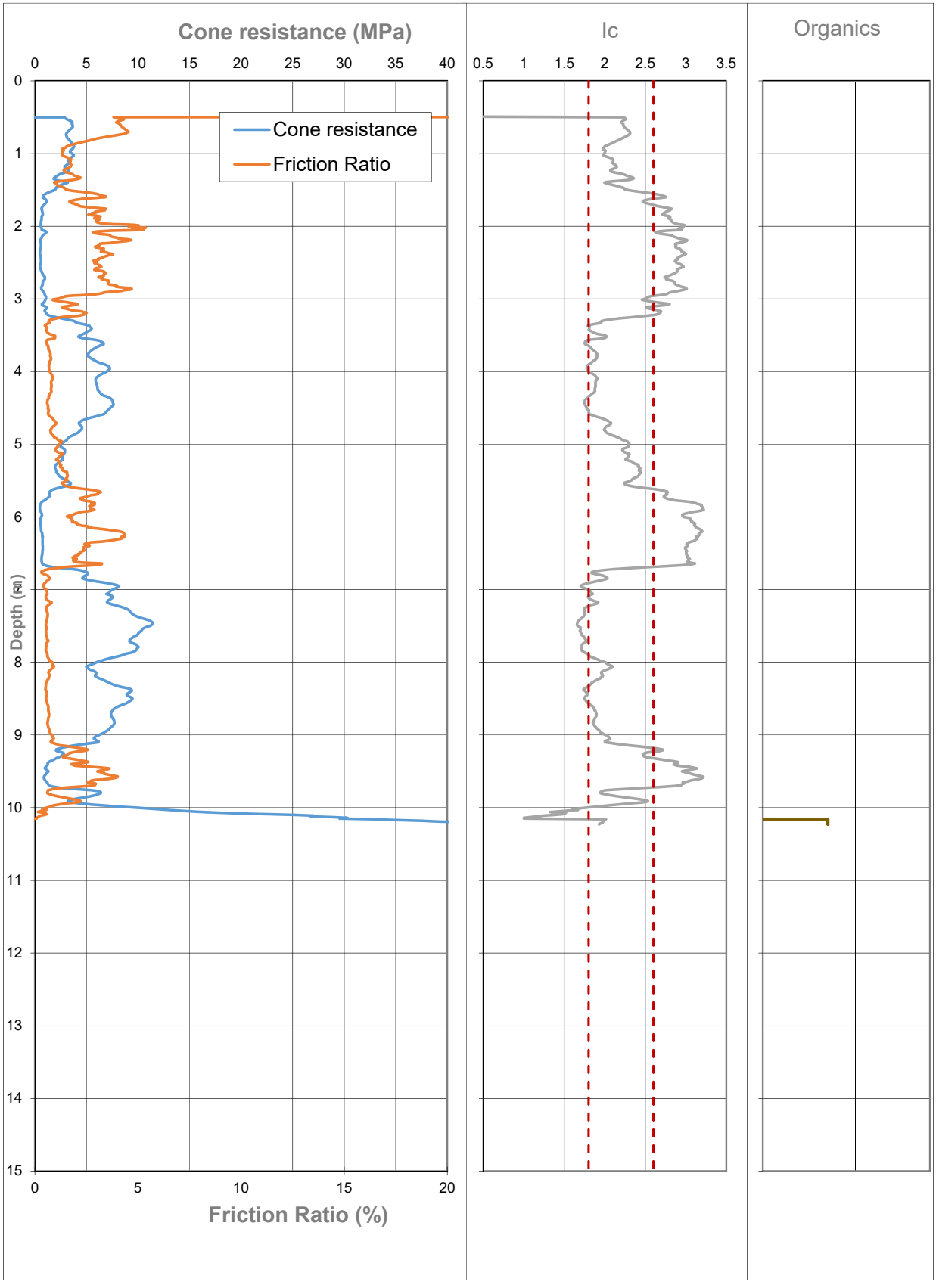
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 17**
	Client:	Cashmere Park Trust	Job No:	3933



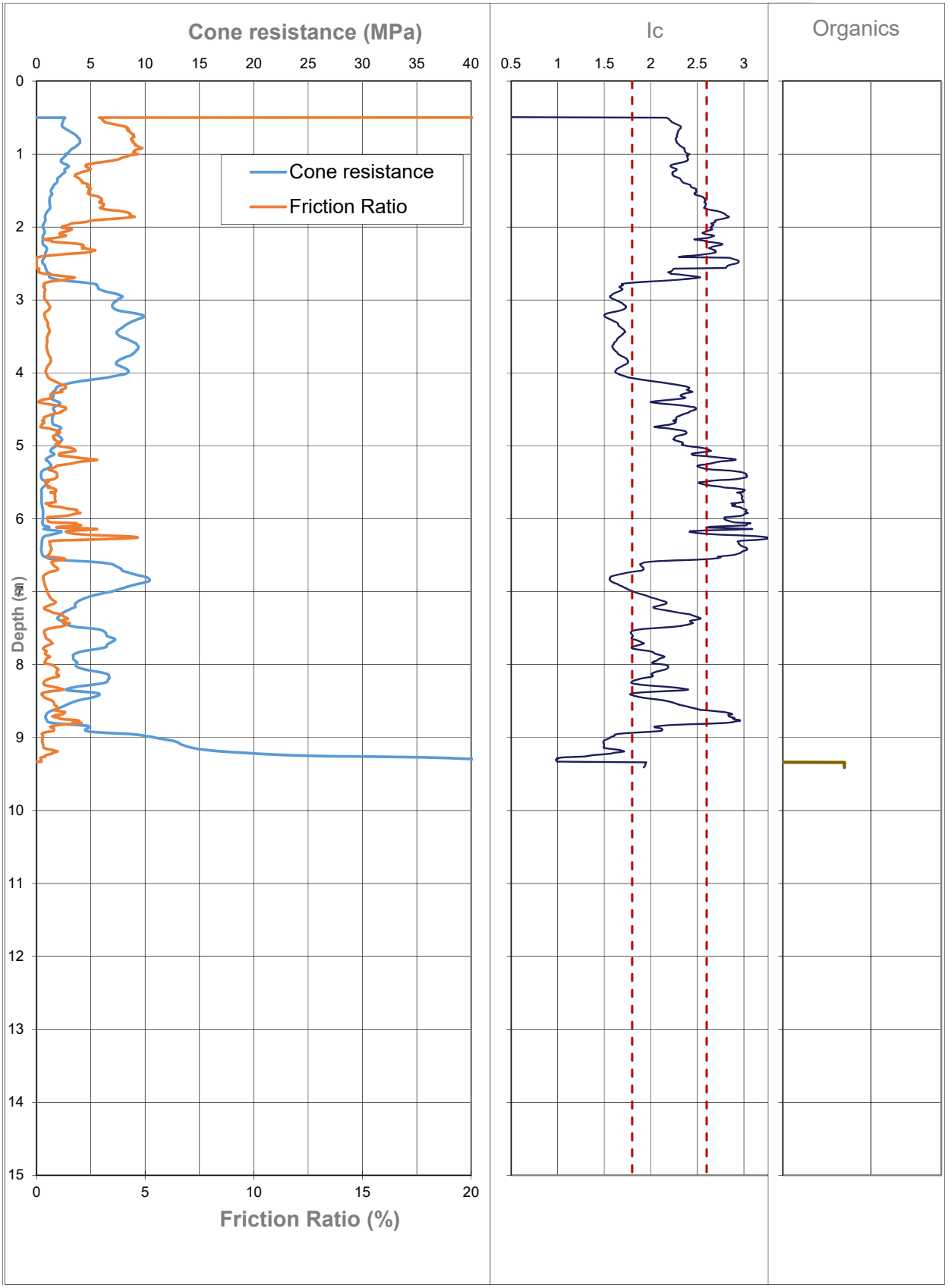
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 18**
	Client:	Cashmere Park Trust	Job No:	3933



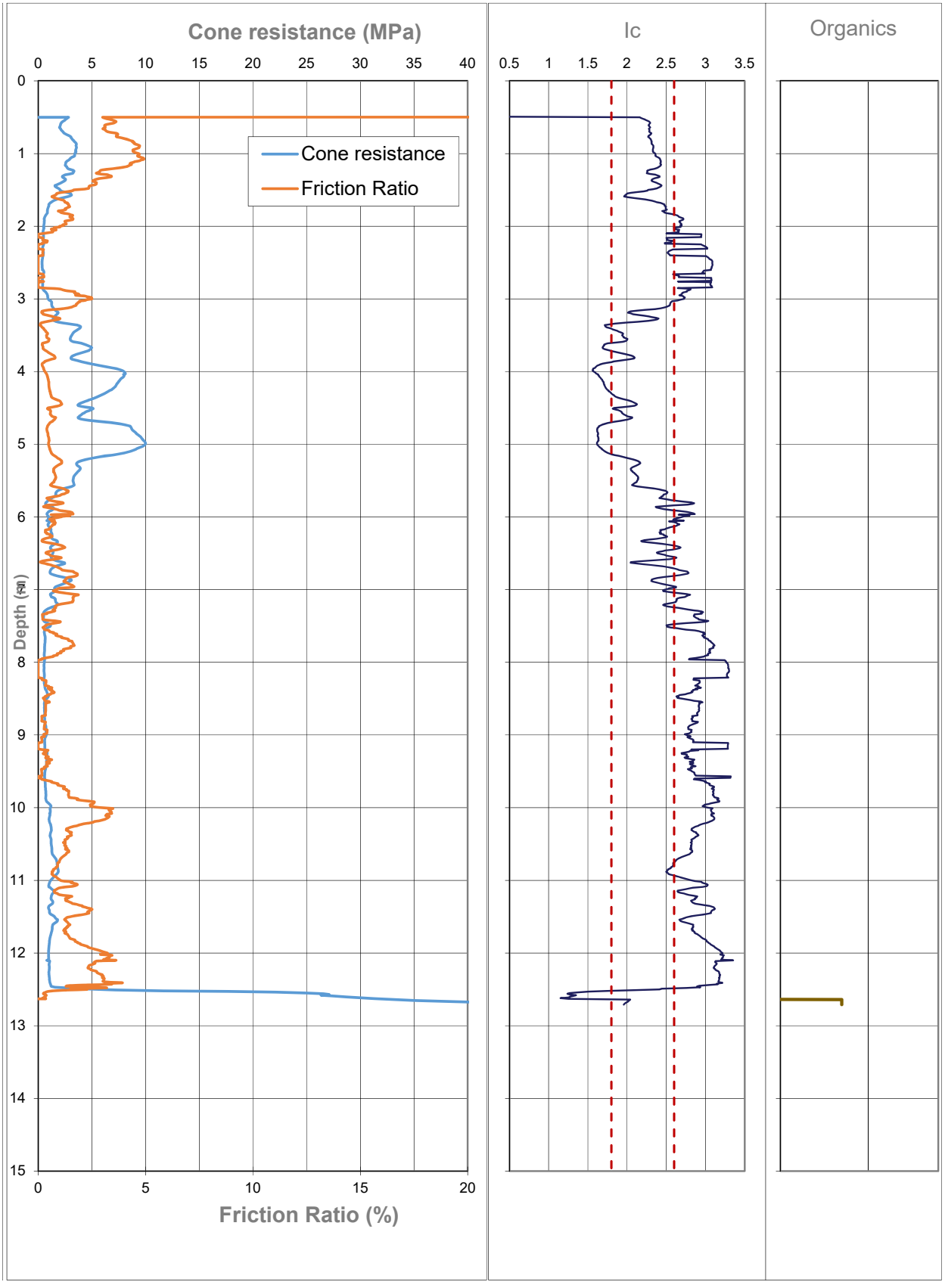
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 19**
	Client:	Cashmere Park Trust	Job No:	3933



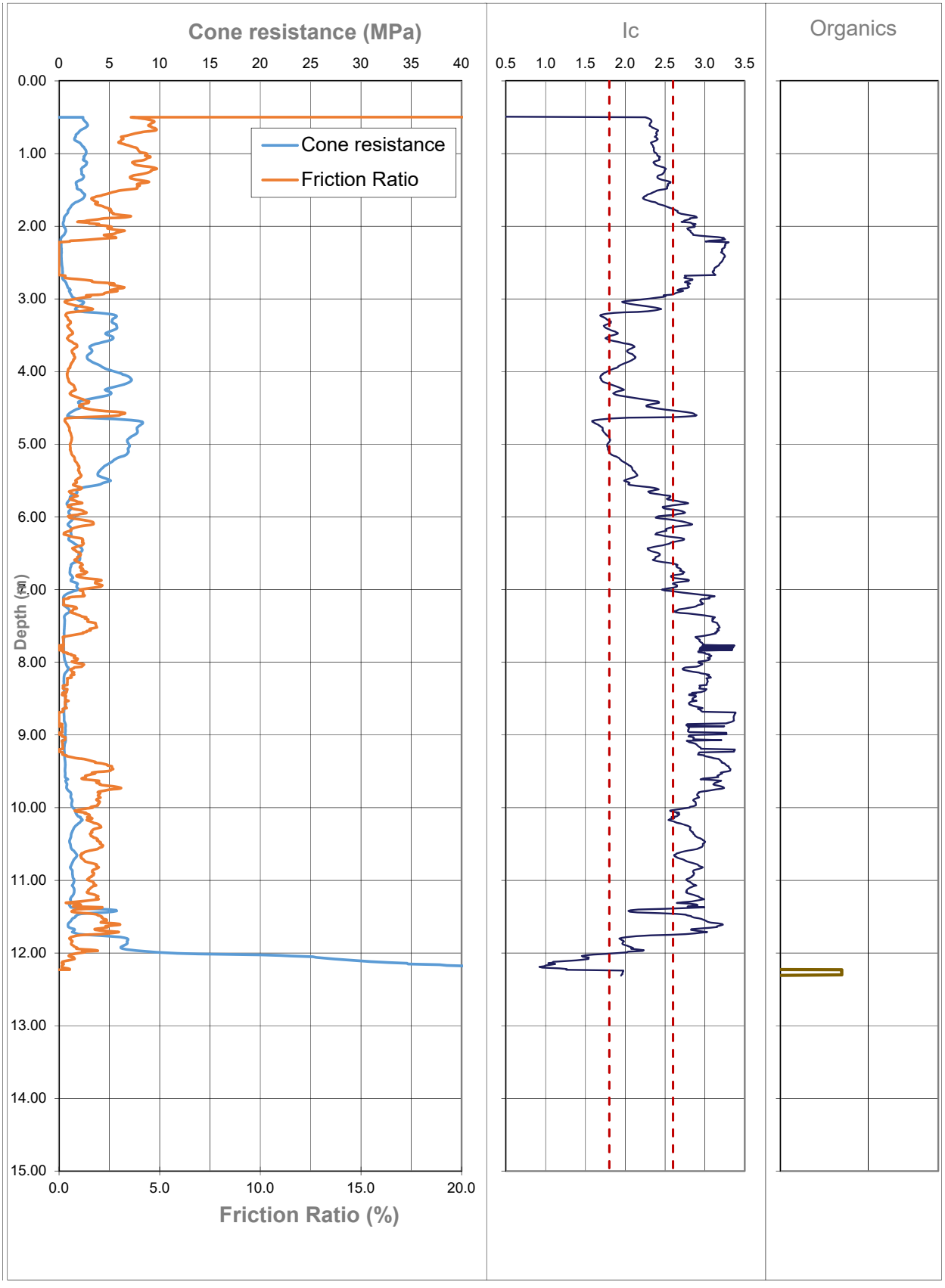
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 20**
	Client:	Cashmere Park Trust	Job No:	3933



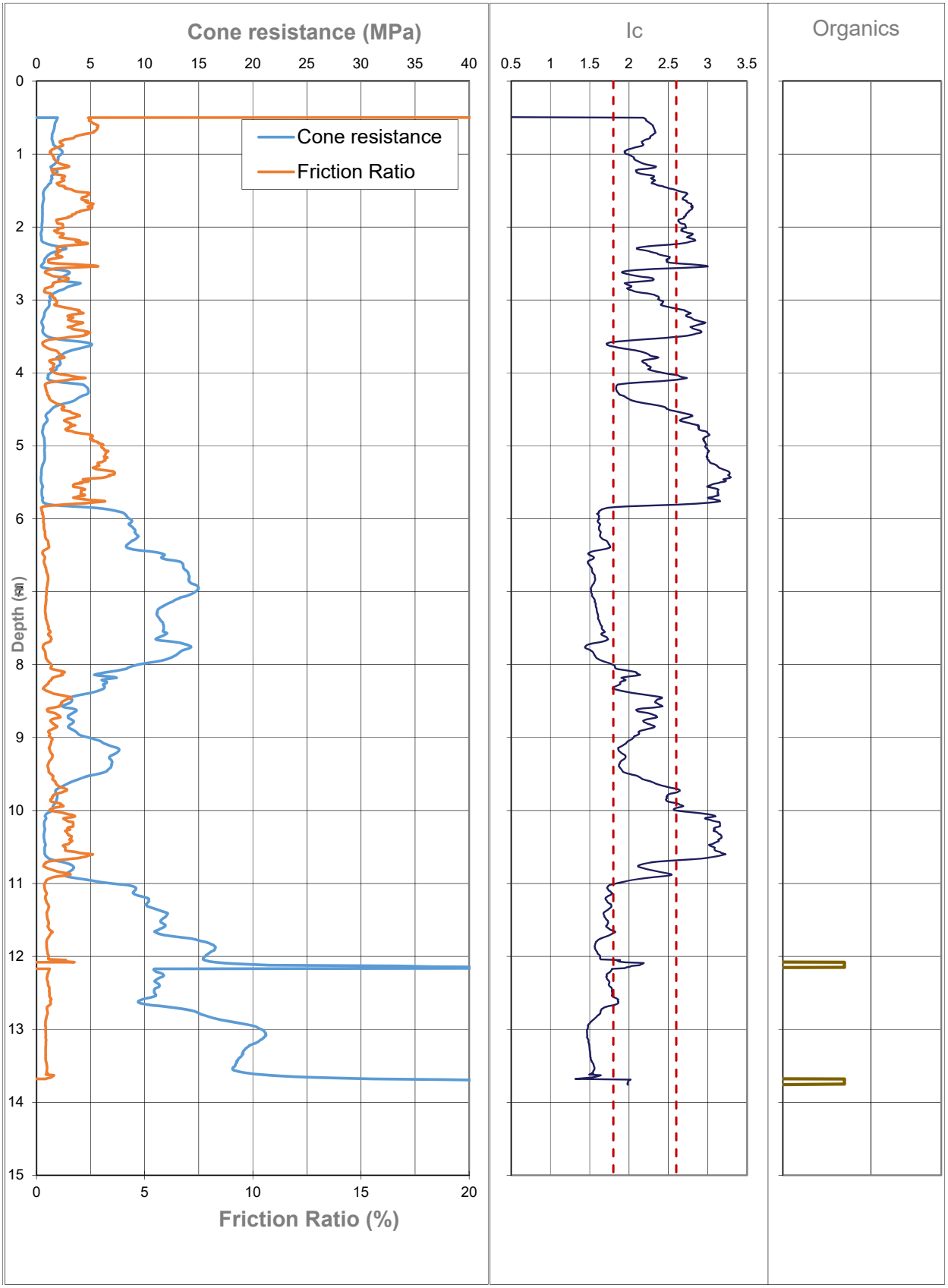
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 21**
	Client:	Cashmere Park Trust	Job No:	3933



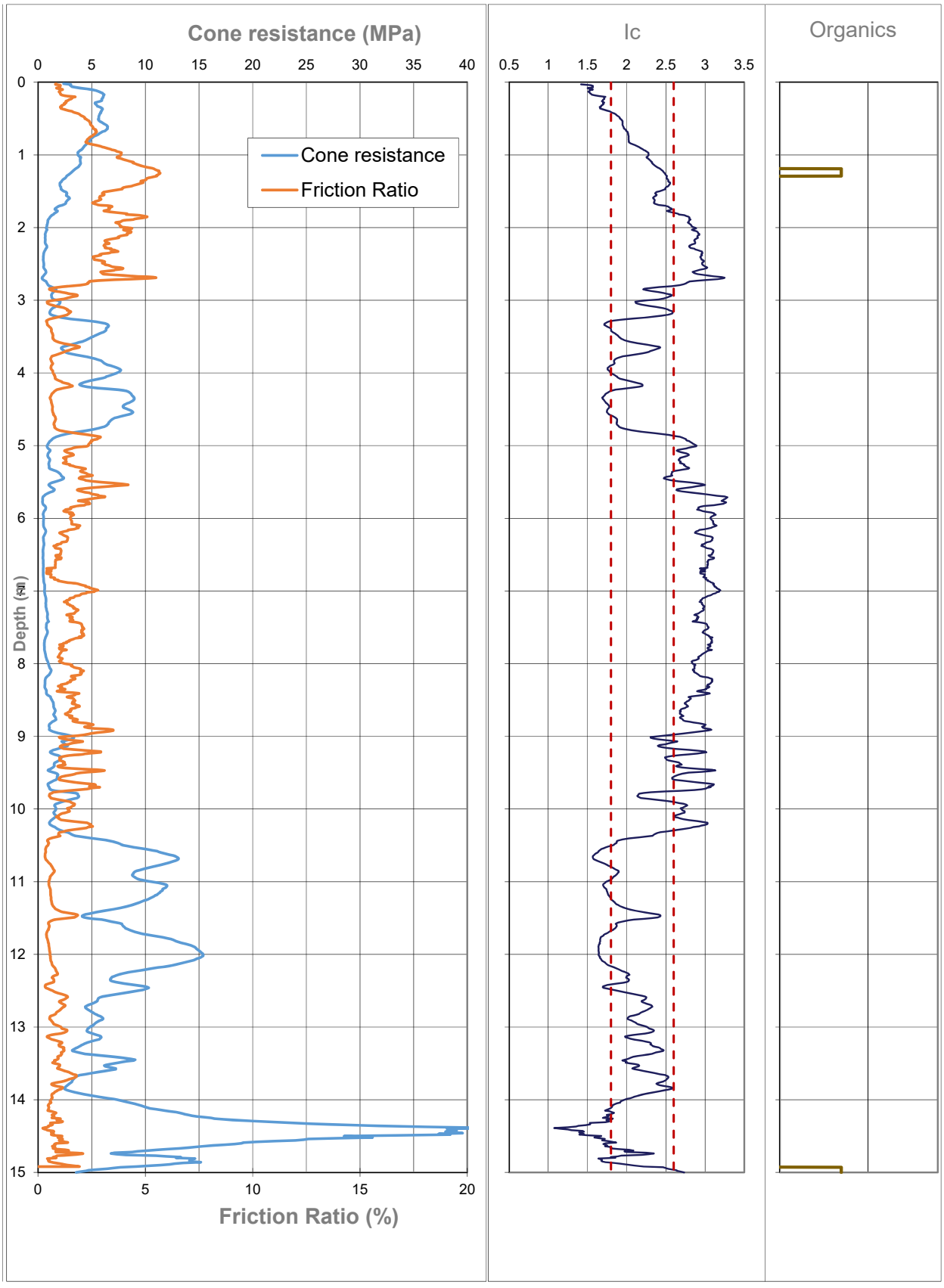
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 22**
	Client:	Cashmere Park Trust	Job No:	3933



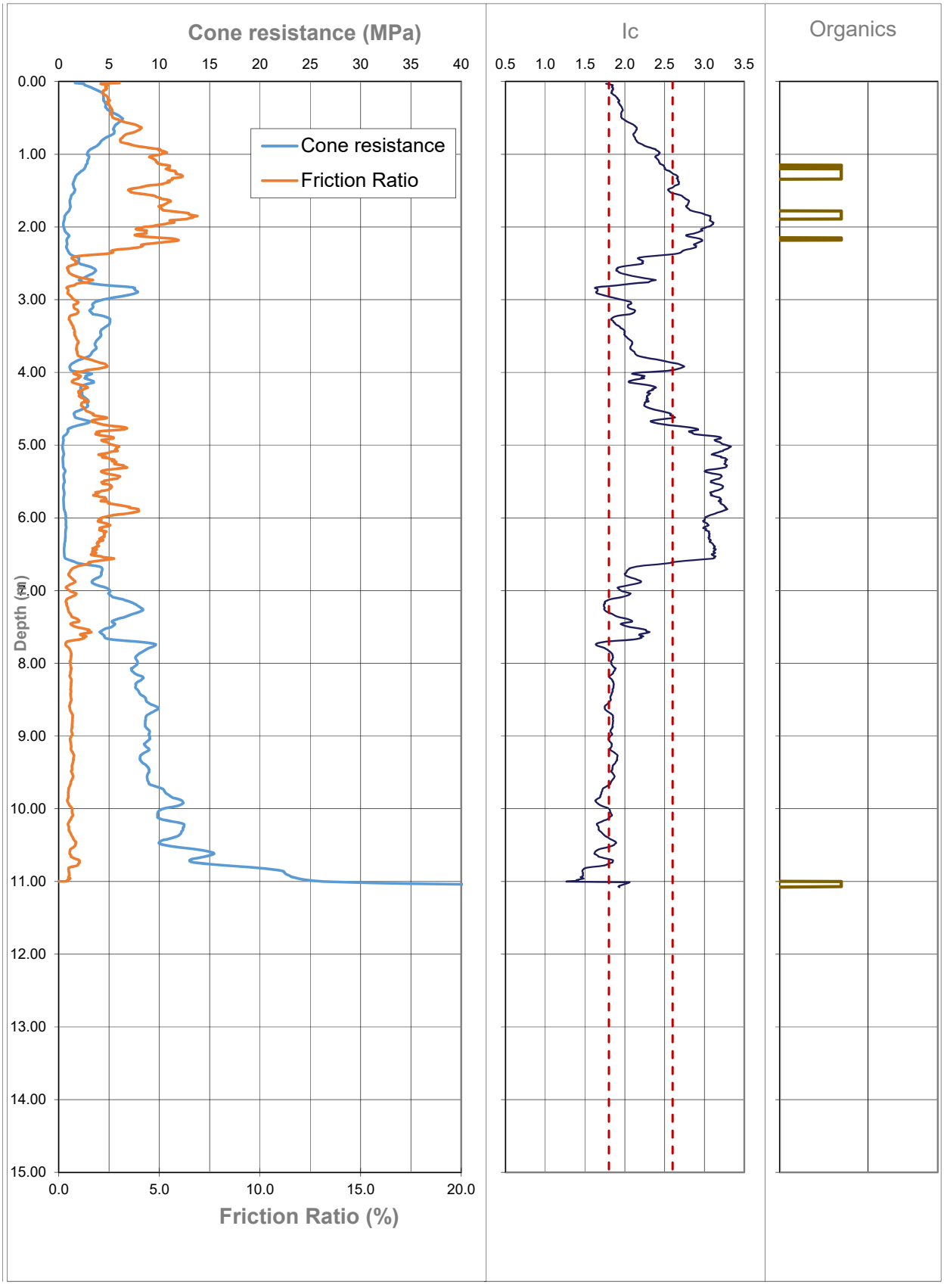
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 23**
	Client:	Cashmere Park Trust	Job No:	3933



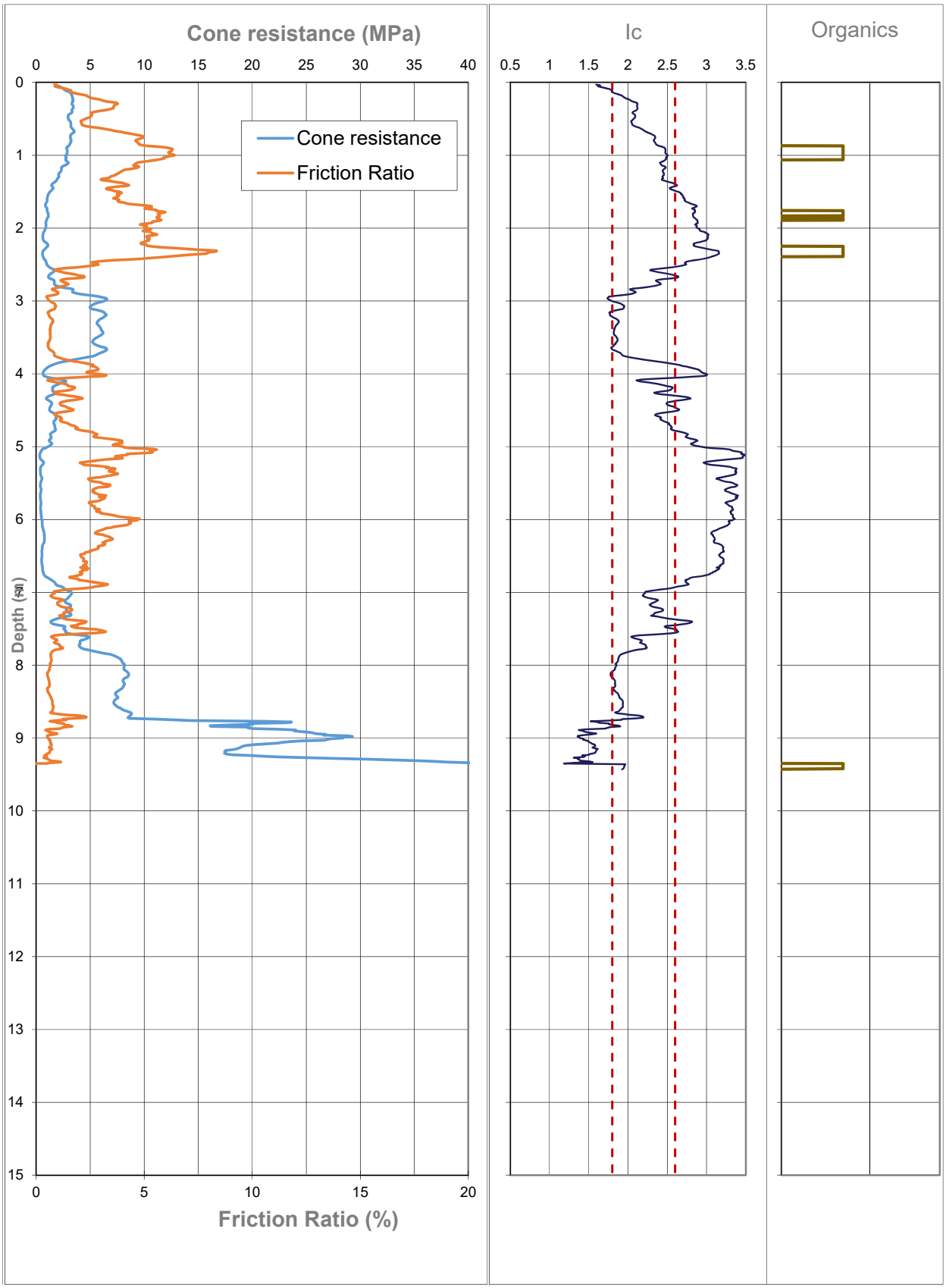
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Park Subdivision	Hole No:	**CPT 24**
	Client:	Cashmere Park Trust	Job No:	3933



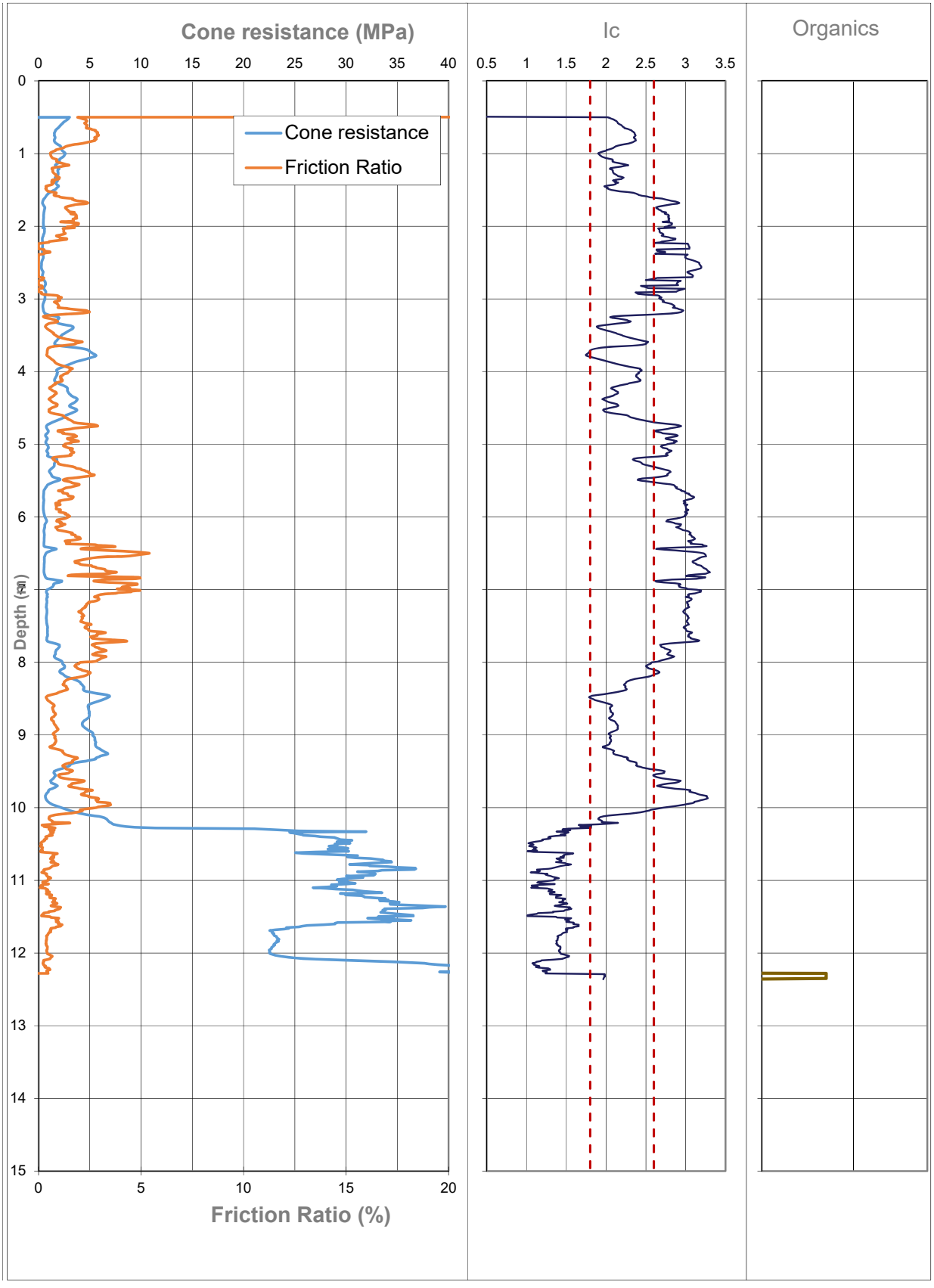
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Park Subdivision	Hole No:	**CPT 25**
	Client:	Cashmere Park Trust	Job No:	3933



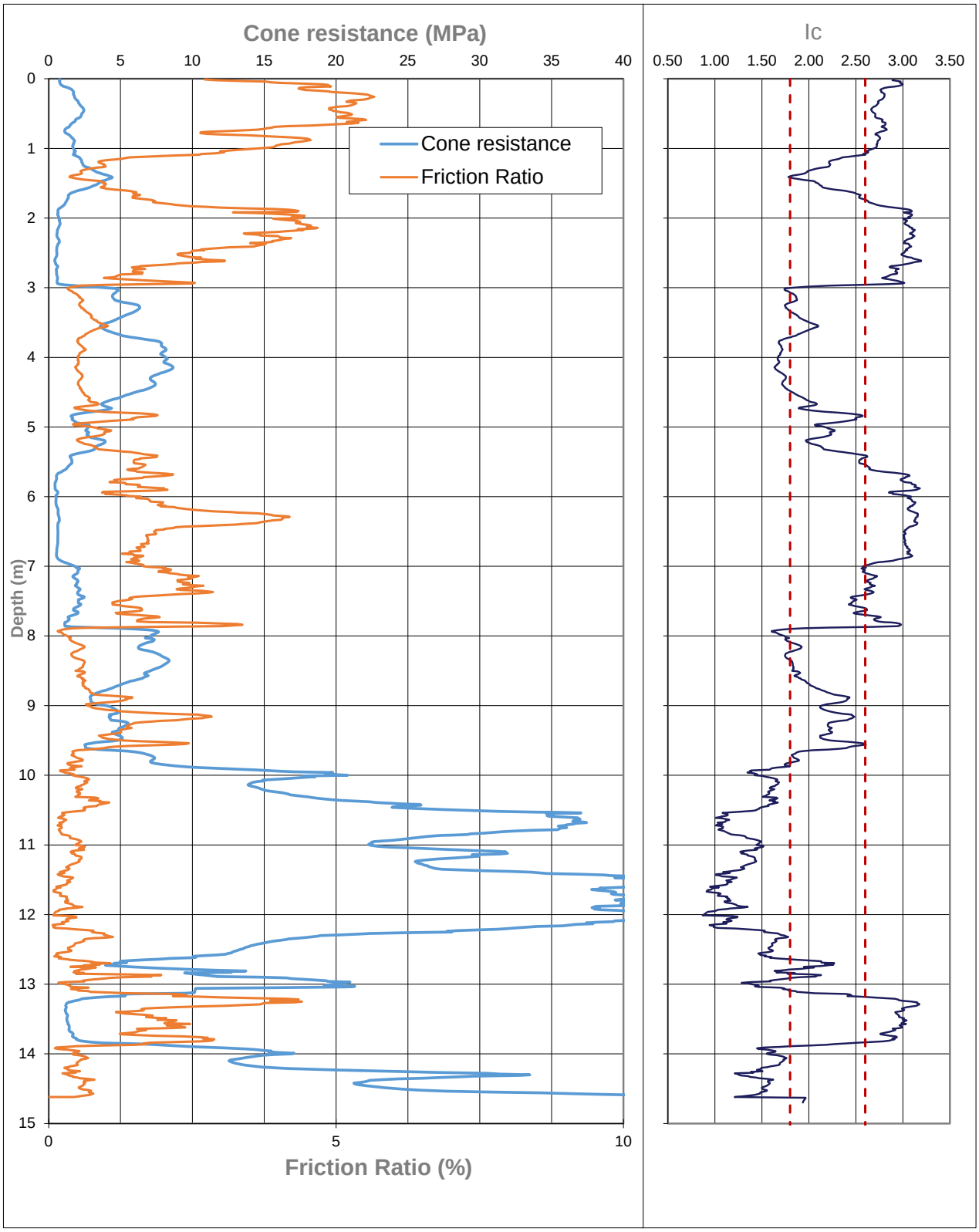
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Park Subdivision	Hole No:	**CPT 26**
	Client:	Cashmere Park Trust	Job No:	3933



GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 27**
	Client:	Cashmere Park Trust	Job No:	3933



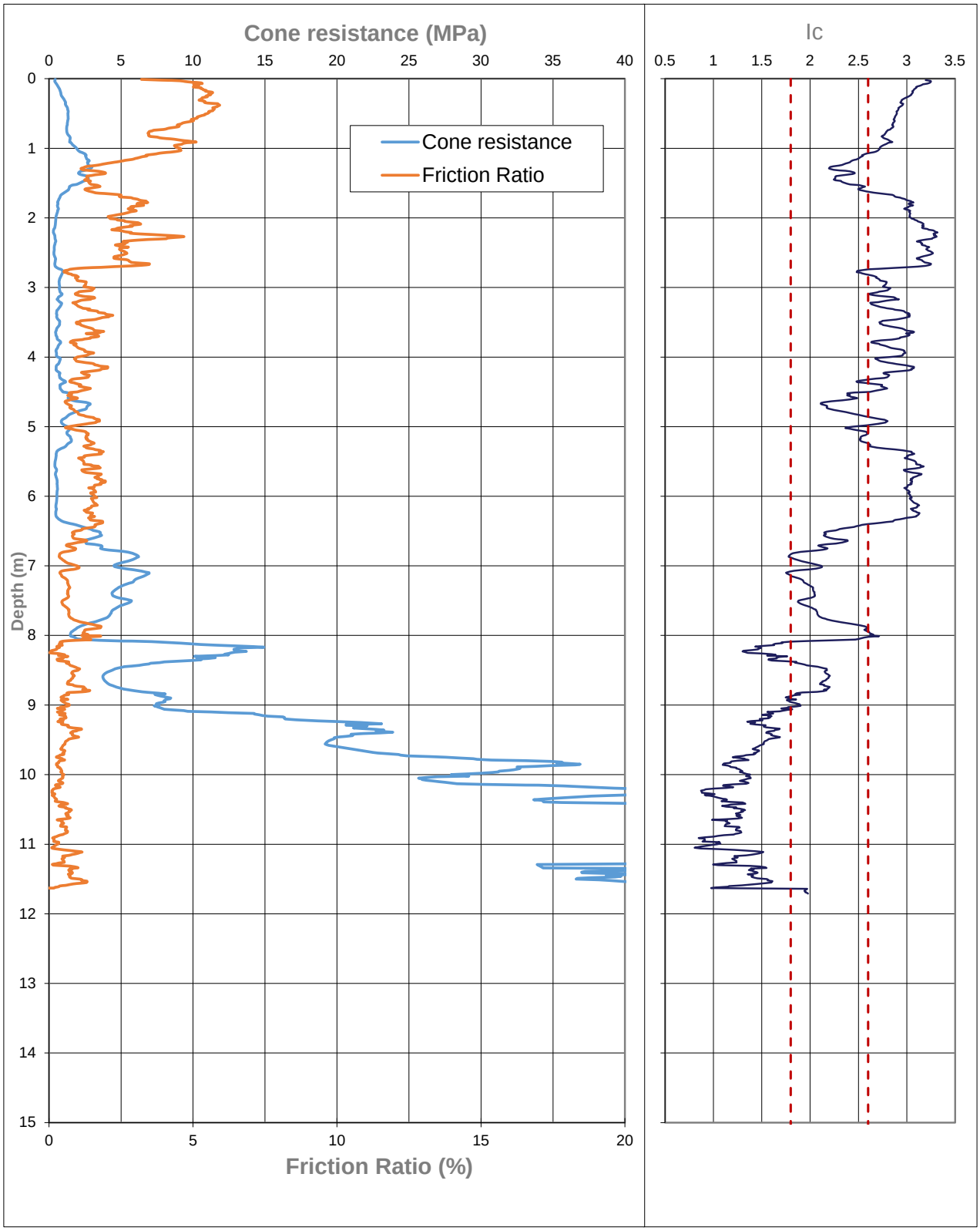
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 23-1**
	Client:	Cashmere Park Ltd	Job No:	3933



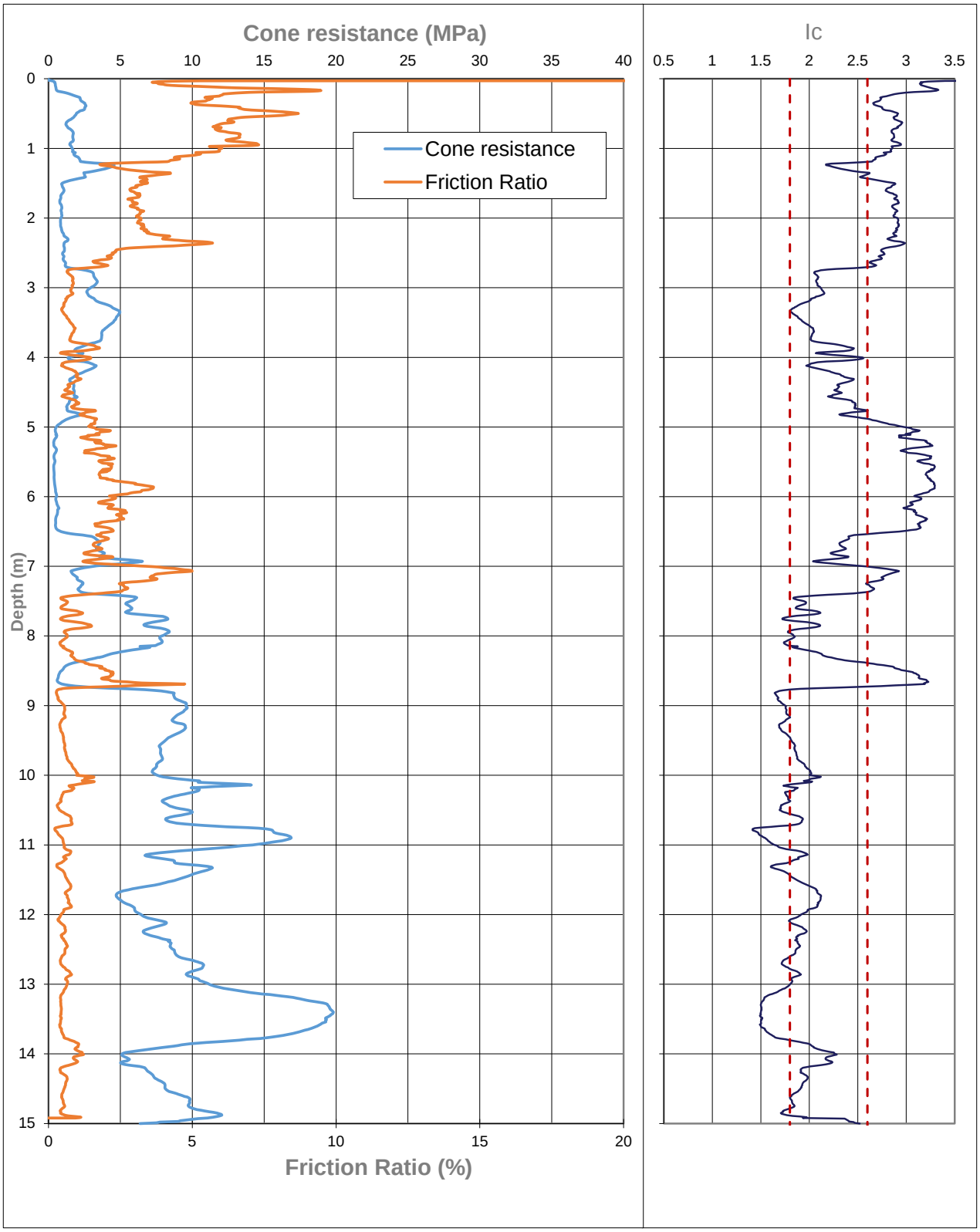
CPT Data Plots

GEOTECH CONSULTING LTD

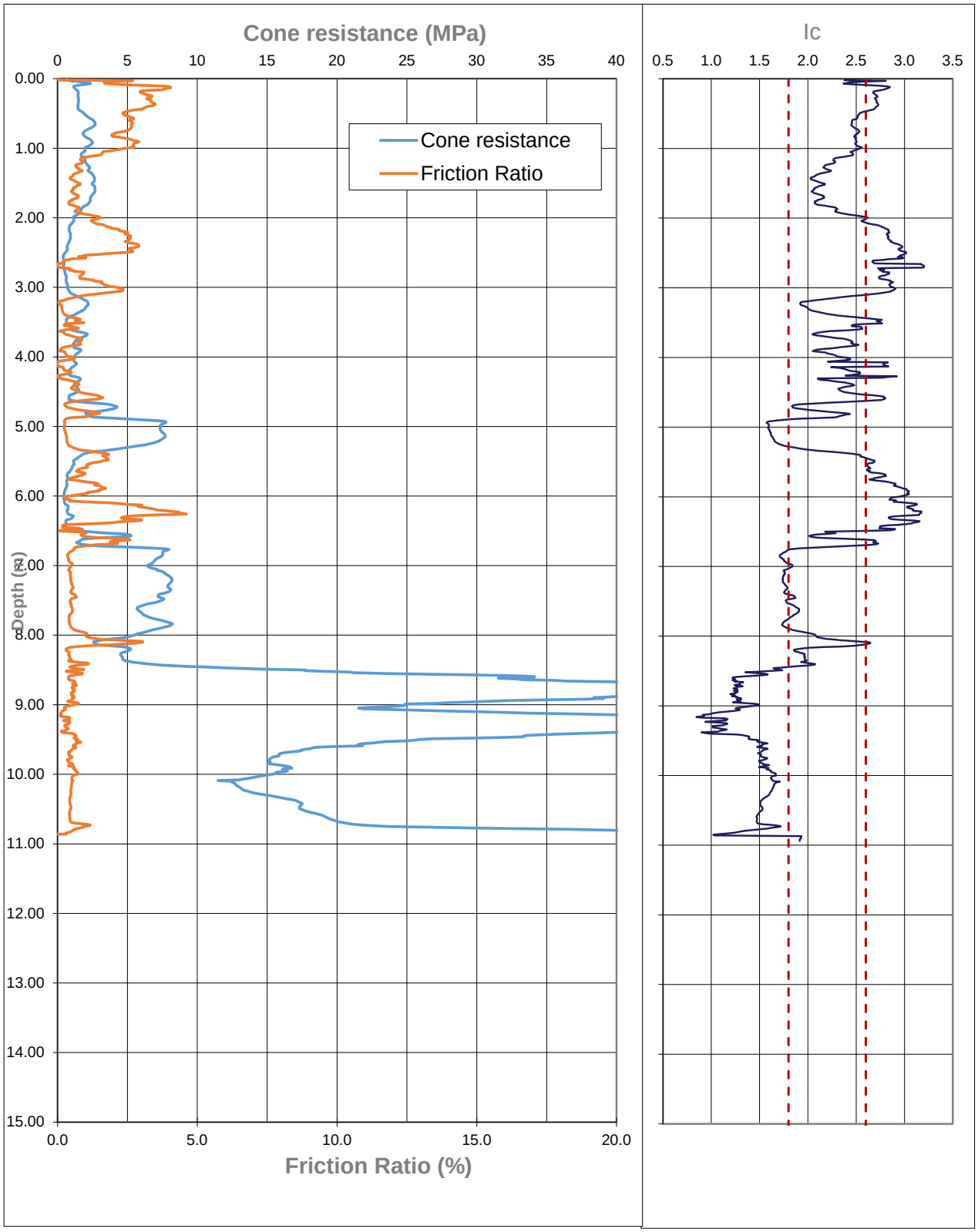
Project:	Cashmere Fields	Hole No:	**CPT 23-2**
Client:	Cashmere Park Ltd	Job No:	3933



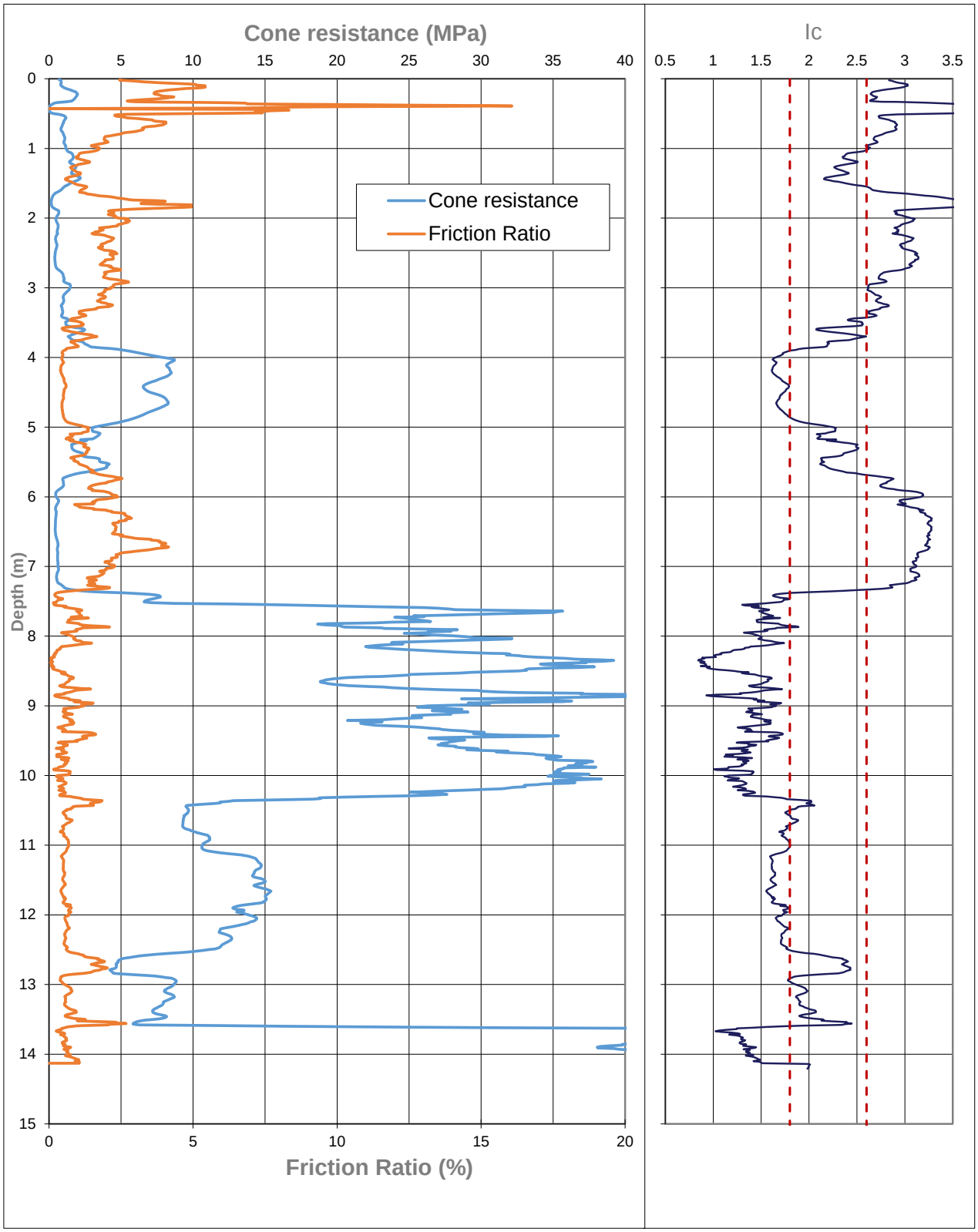
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 23-3**
	Client:	Cashmere Park Ltd	Job No:	3933



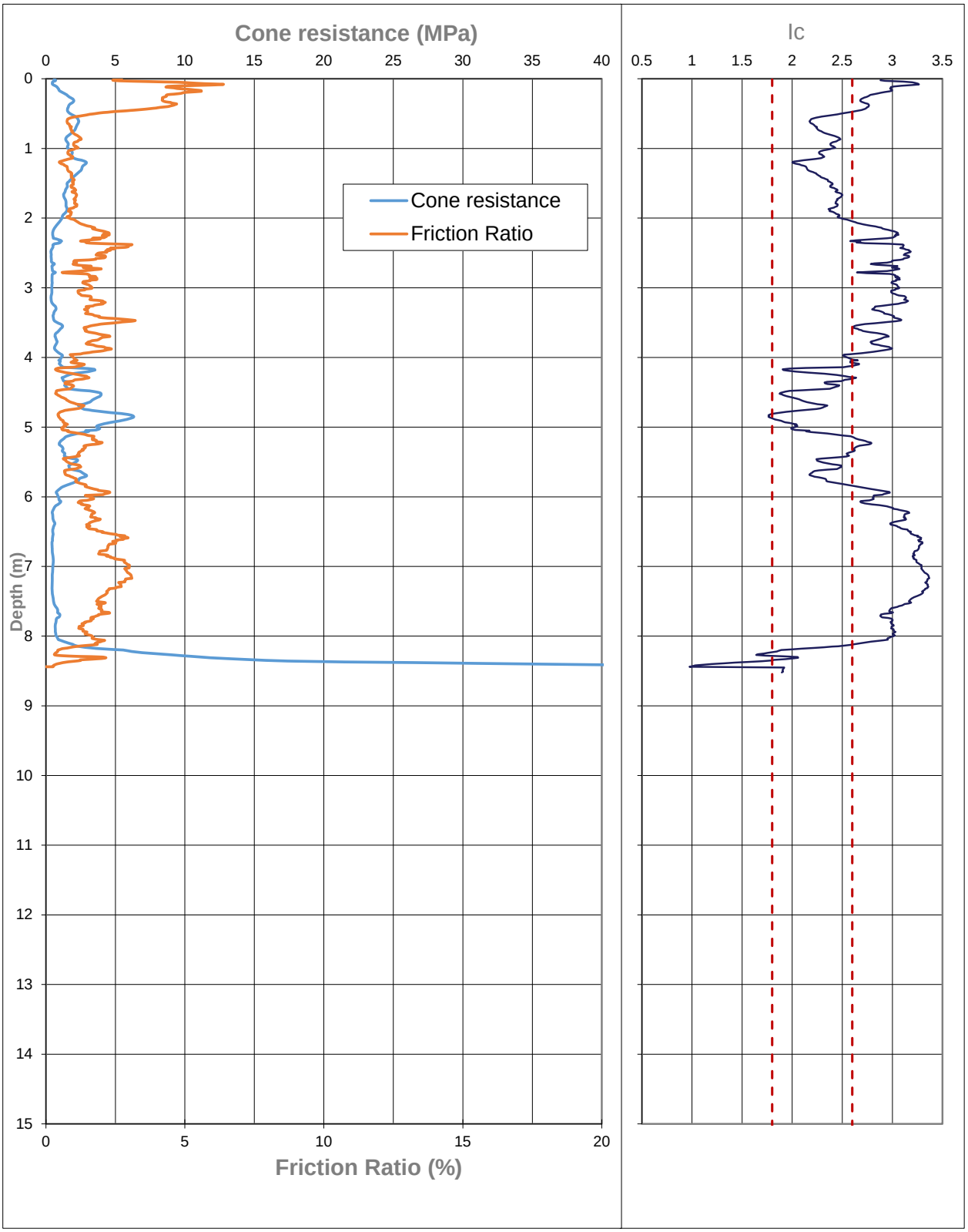
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 23-4**
	Client:	Cashmere Park Ltd	Job No:	3933



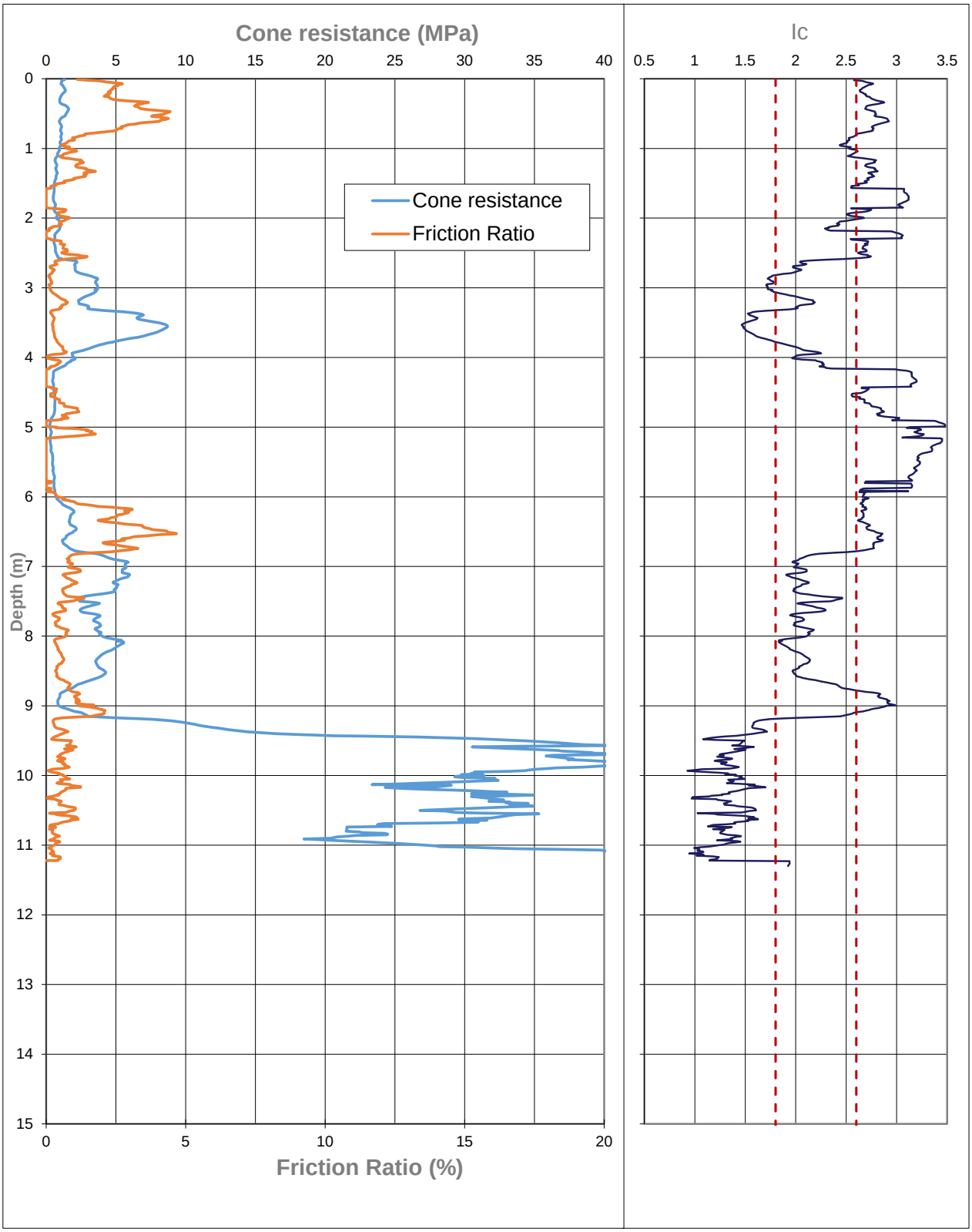
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 23-5**
	Client:	Cashmere Park Ltd	Job No:	3933



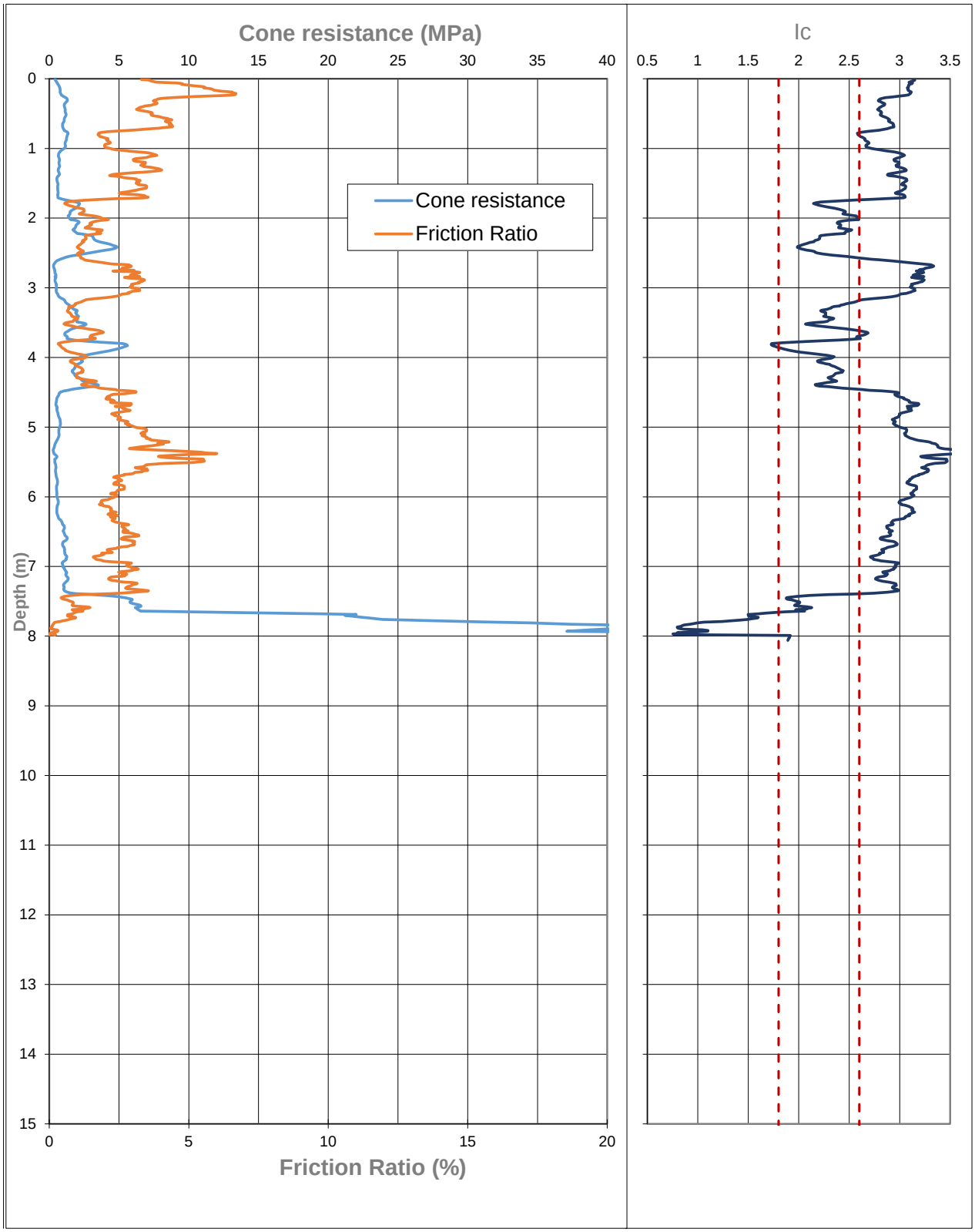
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 23-6**
	Client:	Cashmere Park Ltd	Job No:	3933



GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 23-7**
	Client:	Cashmere Park Ltd	Job No:	3933



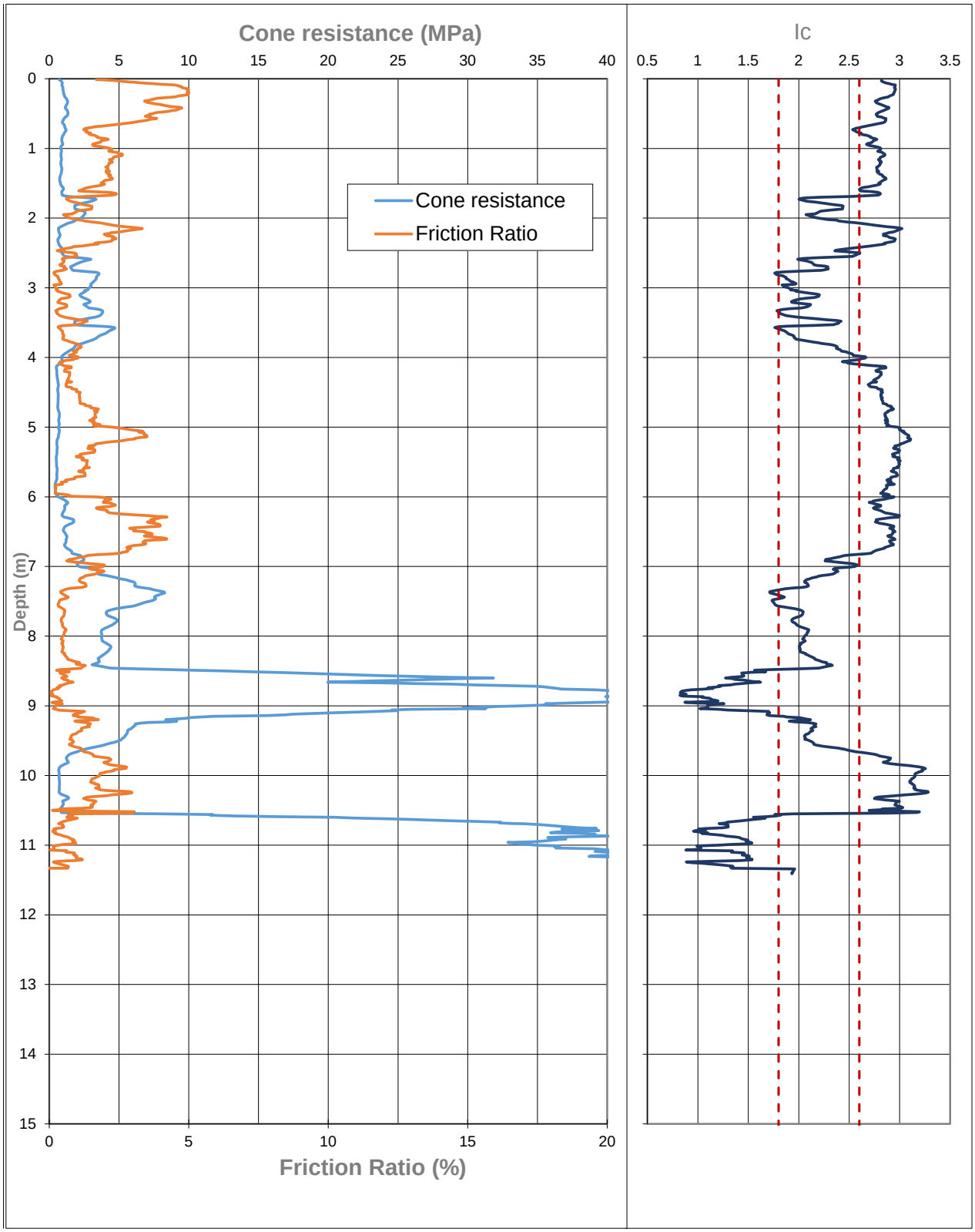
GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 23-8**
	Client:	Cashmere Park Ltd	Job No:	3933



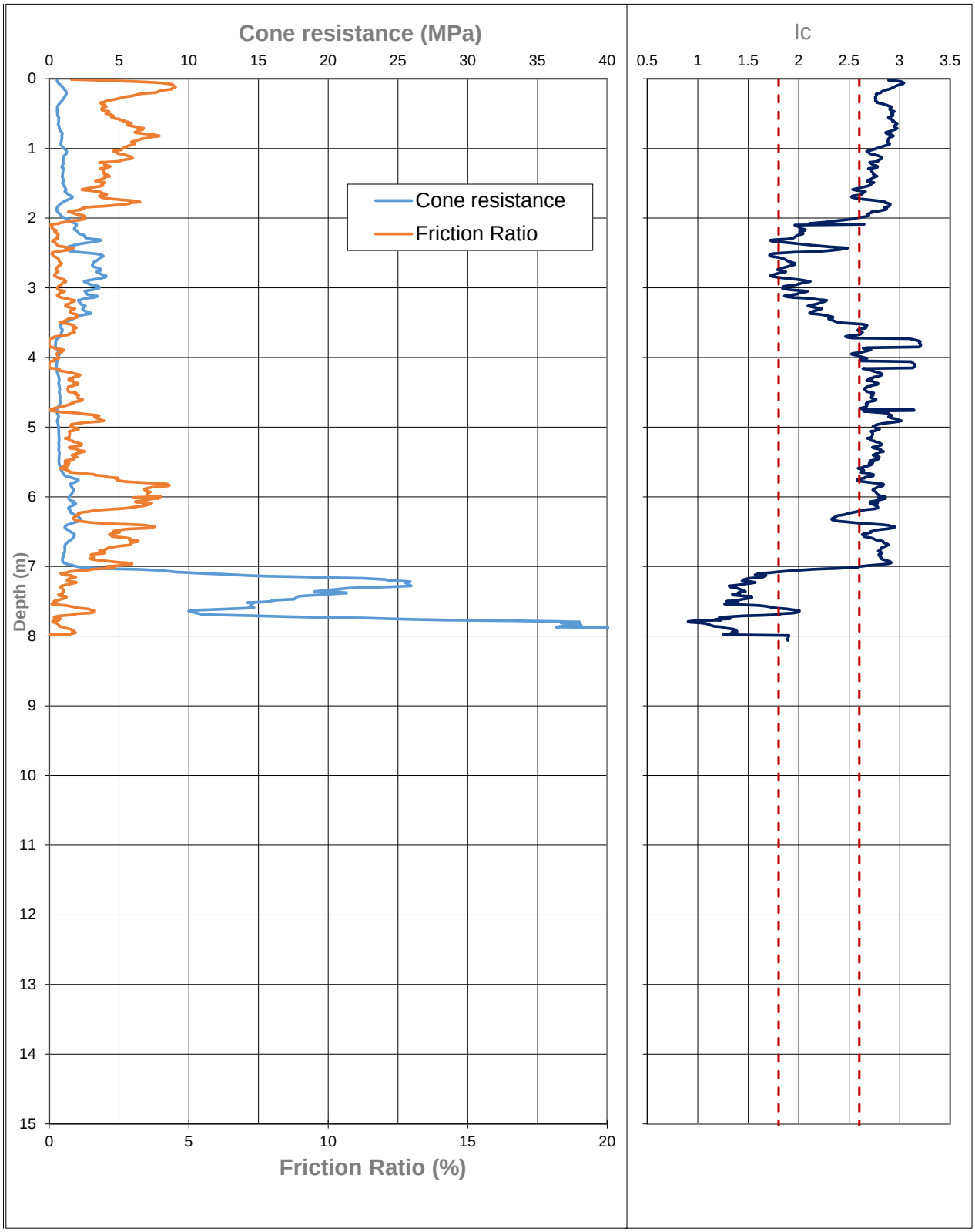
CPT Data Plots

GEOTECH CONSULTING LTD

Project:	Cashmere Fields	Hole No:	**CPT 23-9**
Client:	Cashmere Park Ltd	Job No:	3933



GEOTECH	CPT Data Plots			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 23-10**
	Client:	Cashmere Park Ltd	Job No:	3933



SHALLOW BOREHOLE LOG

GEOTECH

				Hole No:	HA01
				Job No:	3933
				Logged by:	YUY
Project:	Cashmere Field Subdivision			Date drilled:	8/03/2018
Client:	Cashmere Park Trust			Checked by:	NJT
Hole location:	Refer to Site Plan			Date checked:	8/03/2018
Driller: YUY	Contractor:	Equipment:	HA+SC	R.L:	Max depth:
Notes:					

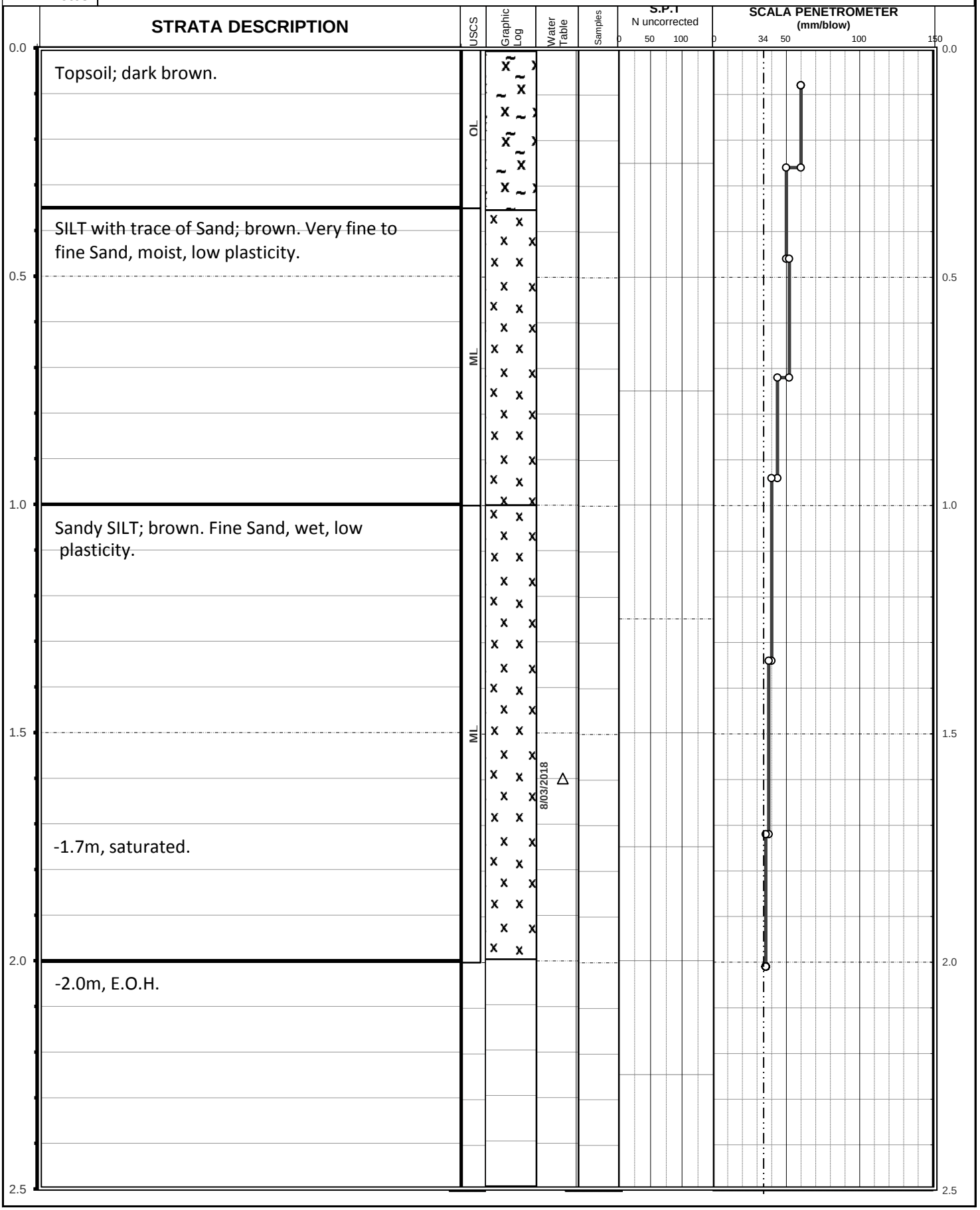
STRATA DESCRIPTION	USCS	Graphic Log	Water Table	Samples	S.P.T N uncorrected (0, 50, 100)	SCALA PENETROMETER (mm/blow) (0, 34, 50, 100, 150)
Topsoil; dark brown.	OL					
SILT with trace of Sand; brown. Very fine to fine Sand, moist, low plasticity.	ML					
Sandy SILT; brown. Fine Sand, wet, low plasticity.	ML		8/03/2018			
-1.1m, saturated.						
-2.0m, E.O.H.						

0.0
0.5
1.0
1.5
2.0
2.5

SHALLOW BOREHOLE LOG

GEOTECH

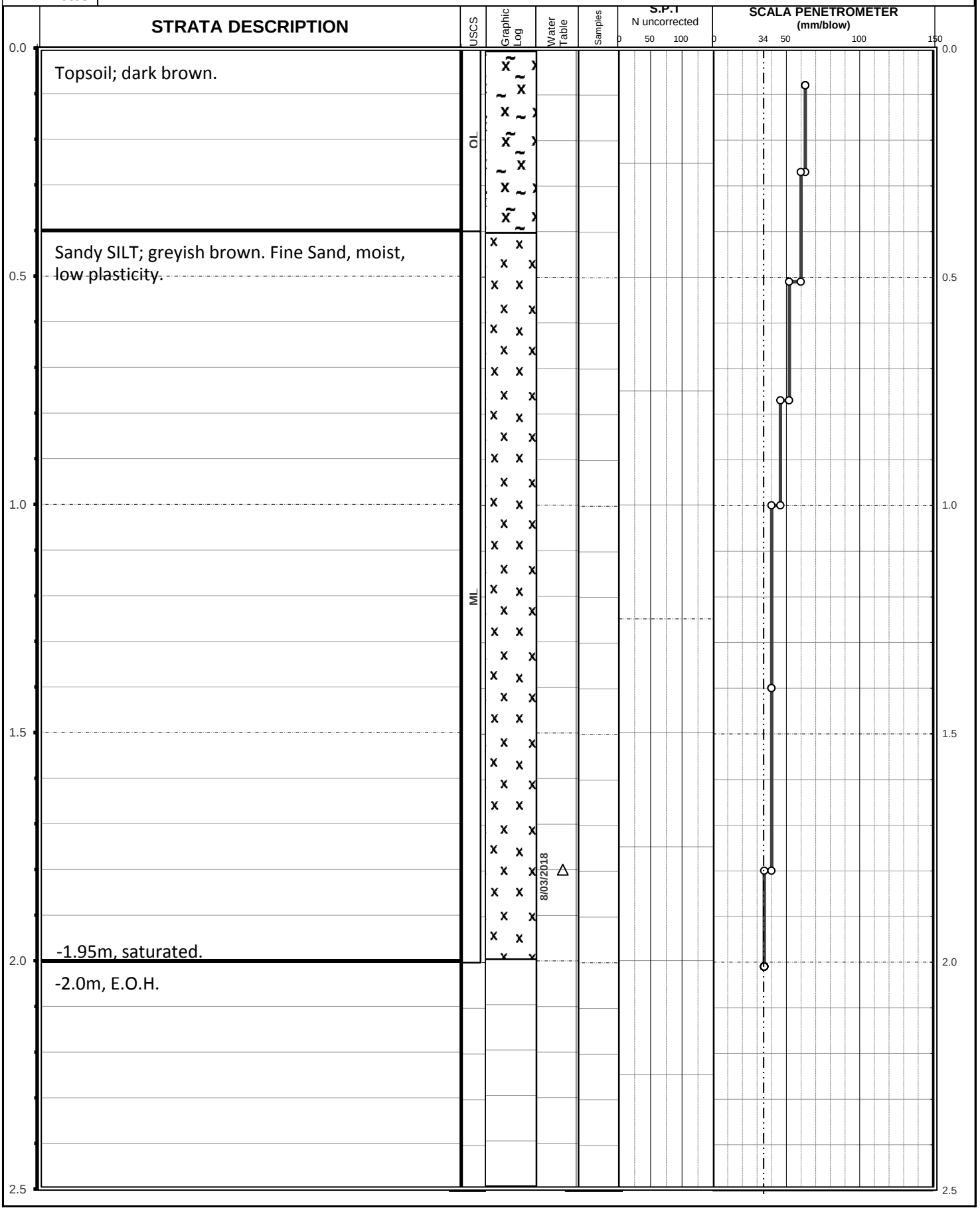
				Hole No:	HA02
				Job No:	3933
				Logged by:	YUY
Project:	Cashmere Field Subdivision			Date drilled:	8/03/2018
Client:	Cashmere Park Trust			Checked by:	NJT
Hole location:	Refer to Site Plan			Date checked:	8/03/2018
Driller: YUY	Contractor:	Equipment:	HA+SC	R.L:	Max depth:
Notes:					



SHALLOW BOREHOLE LOG

GEOTECH

				Hole No:	HA03
				Job No:	3933
				Logged by:	YUY
Project:	Cashmere Field Subdivision			Date drilled:	8/03/2018
Client:	Cashmere Park Trust			Checked by:	NJT
Hole location:	Refer to Site Plan			Date checked:	8/03/2018
Driller: YUY	Contractor:	Equipment:	HA+SC	R.L:	Max depth:
Notes:					



SHALLOW BOREHOLE LOG

GEOTECH

				Hole No:	HA04
				Job No:	3933
				Logged by:	YUY
Project:	Cashmere Field Subdivision			Date drilled:	8/03/2018
Client:	Cashmere Park Trust			Checked by:	NJT
Hole location:	Refer to Site Plan			Date checked:	8/03/2018
Driller: YUY	Contractor:	Equipment:	HA+SC	R.L:	Max depth:
Notes:					

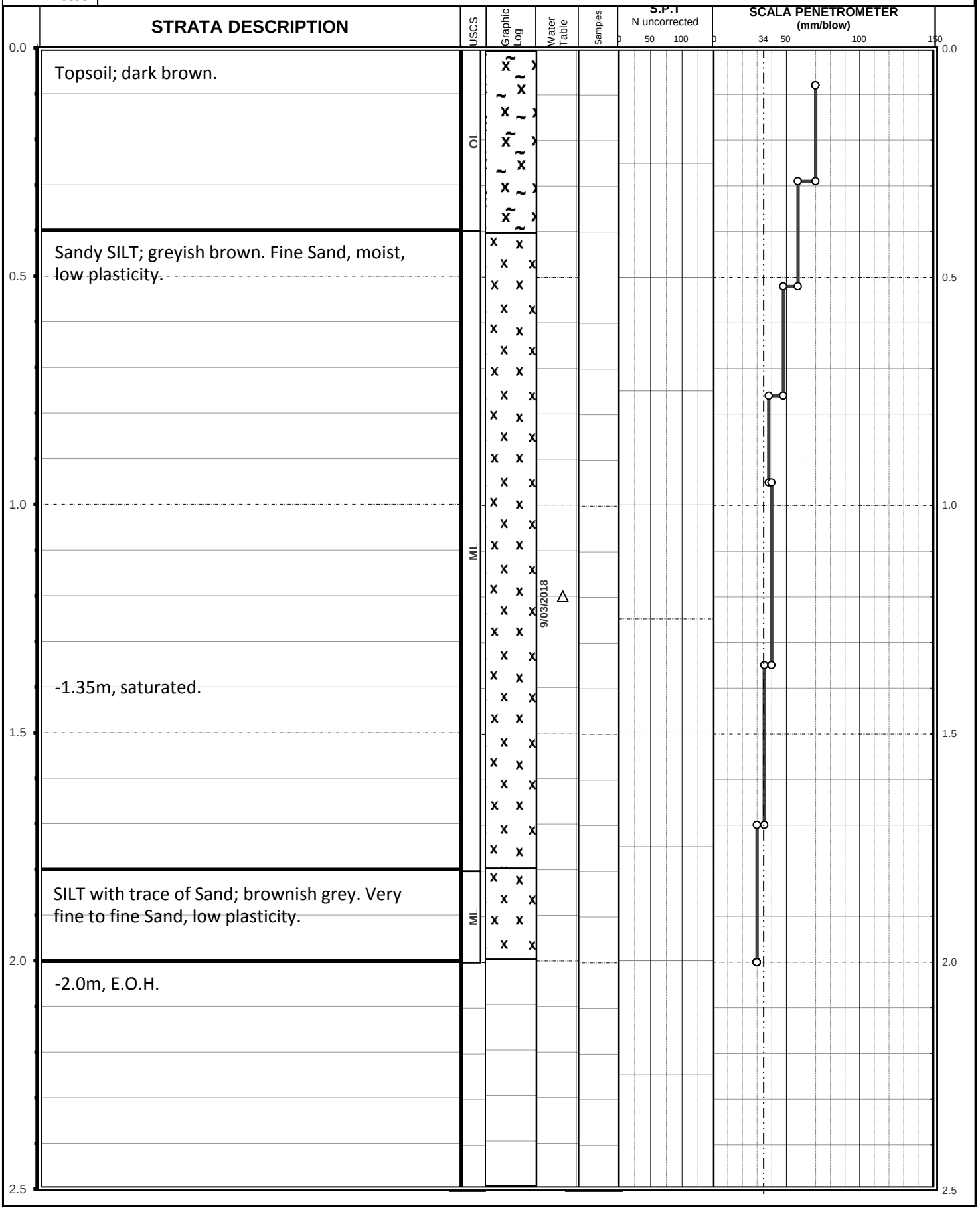
STRATA DESCRIPTION	USCS	Graphic Log	Water Table	Samples	S.P.T N uncorrected (0, 50, 100)	SCALA PENETROMETER (mm/blow) (0, 34, 50, 100, 150)
Topsoil; dark brown.	OL					
Sandy SILT; greyish brown. Fine Sand, moist, low plasticity.	ML					
-1.95m, saturated.			8/03/2018 △			
-2.0m, E.O.H.						

0.0 0.5 1.0 1.5 2.0 2.5

SHALLOW BOREHOLE LOG

GEOTECH

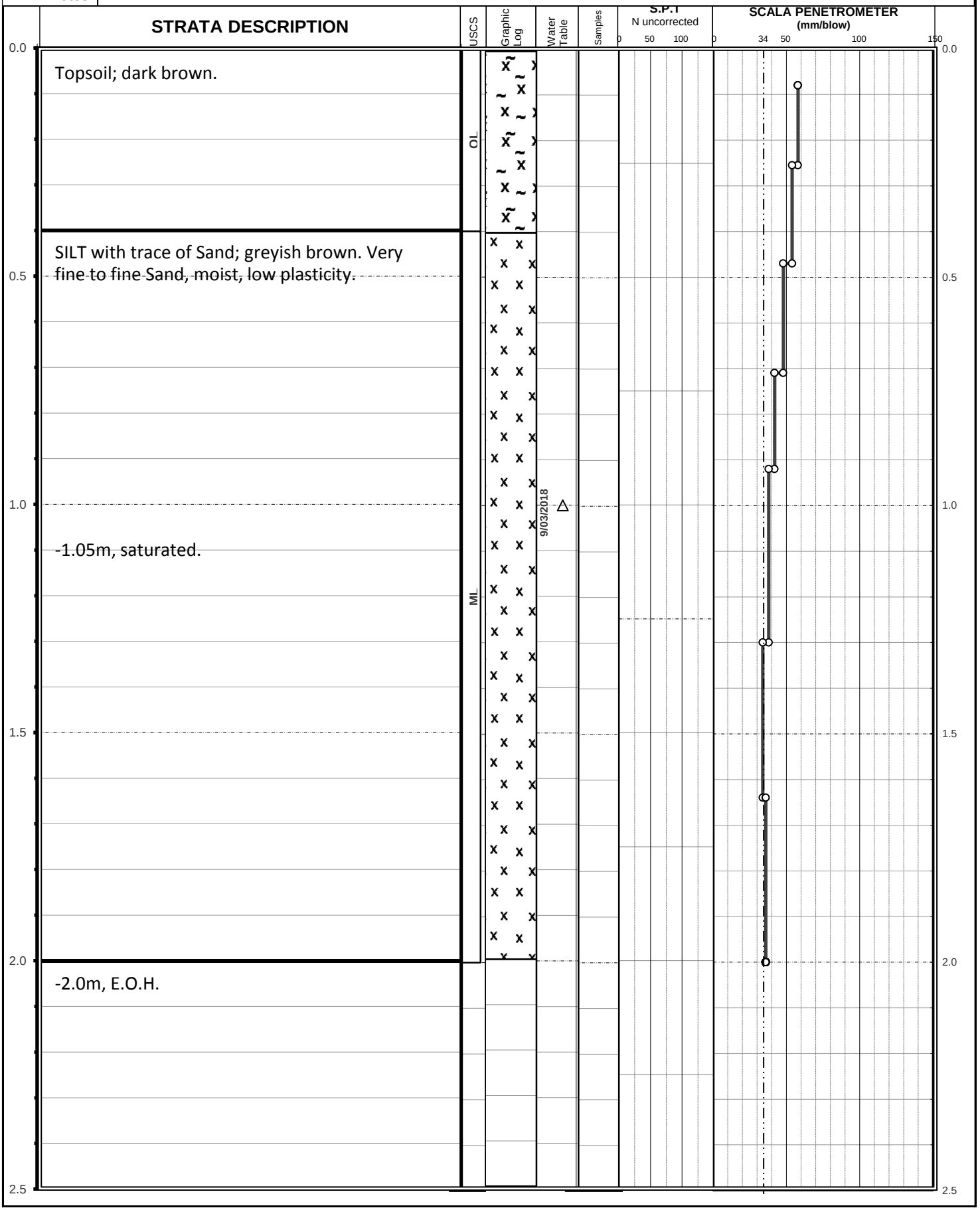
				Hole No:	HA05
				Job No:	3933
				Logged by:	YUY
Project:	Cashmere Field Subdivision			Date drilled:	8/03/2018
Client:	Cashmere Park Trust			Checked by:	NJT
Hole location:	Refer to Site Plan			Date checked:	8/03/2018
Driller: YUY	Contractor:	Equipment:	HA+SC	R.L:	Max depth:
Notes:					



SHALLOW BOREHOLE LOG

GEOTECH

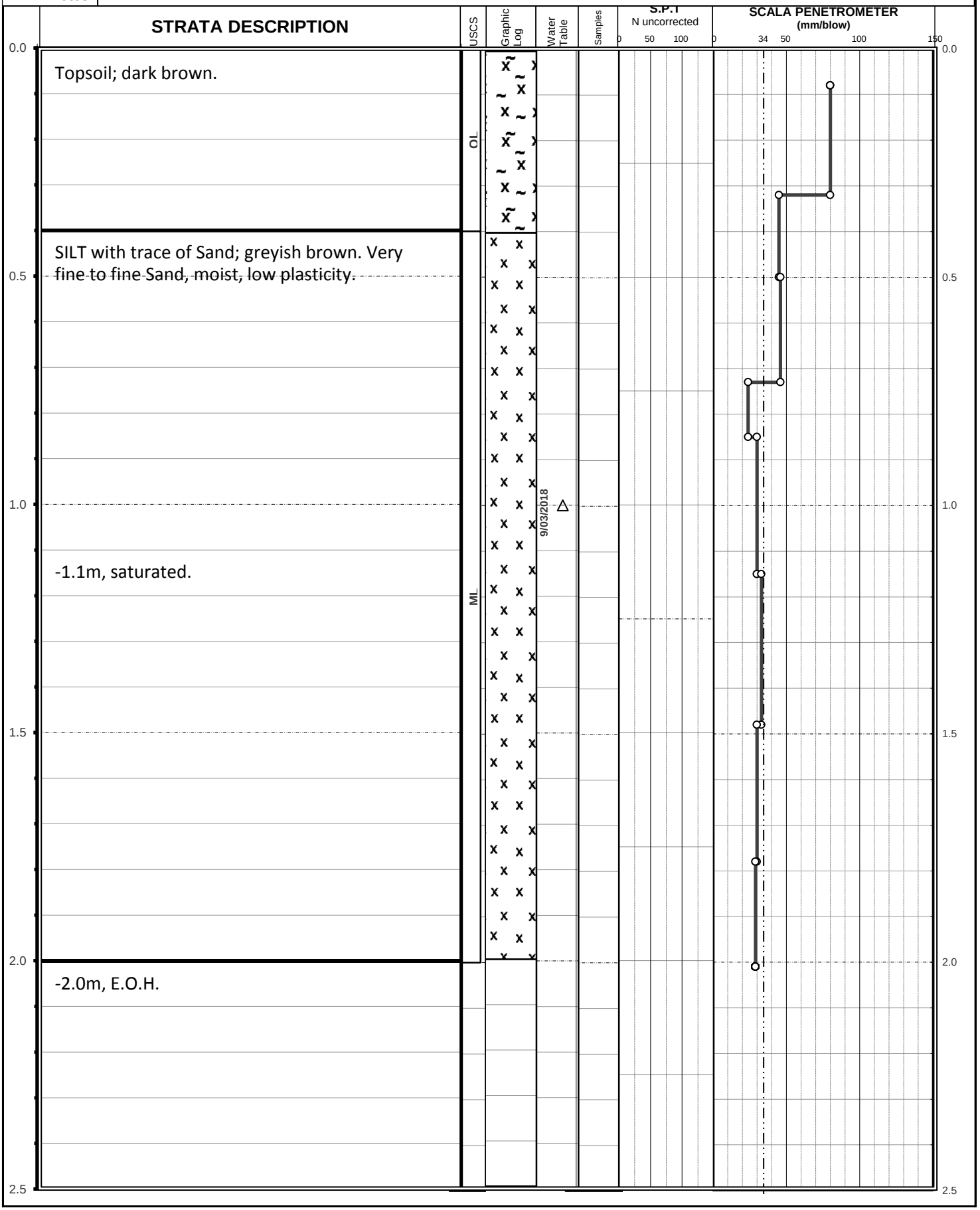
				Hole No:	HA06
				Job No:	3933
				Logged by:	YUY
Project:	Cashmere Field Subdivision			Date drilled:	8/03/2018
Client:	Cashmere Park Trust			Checked by:	NJT
Hole location:	Refer to Site Plan			Date checked:	8/03/2018
Driller: YUY	Contractor:	Equipment:	HA+SC	R.L:	Max depth:
Notes:					



SHALLOW BOREHOLE LOG

GEOTECH

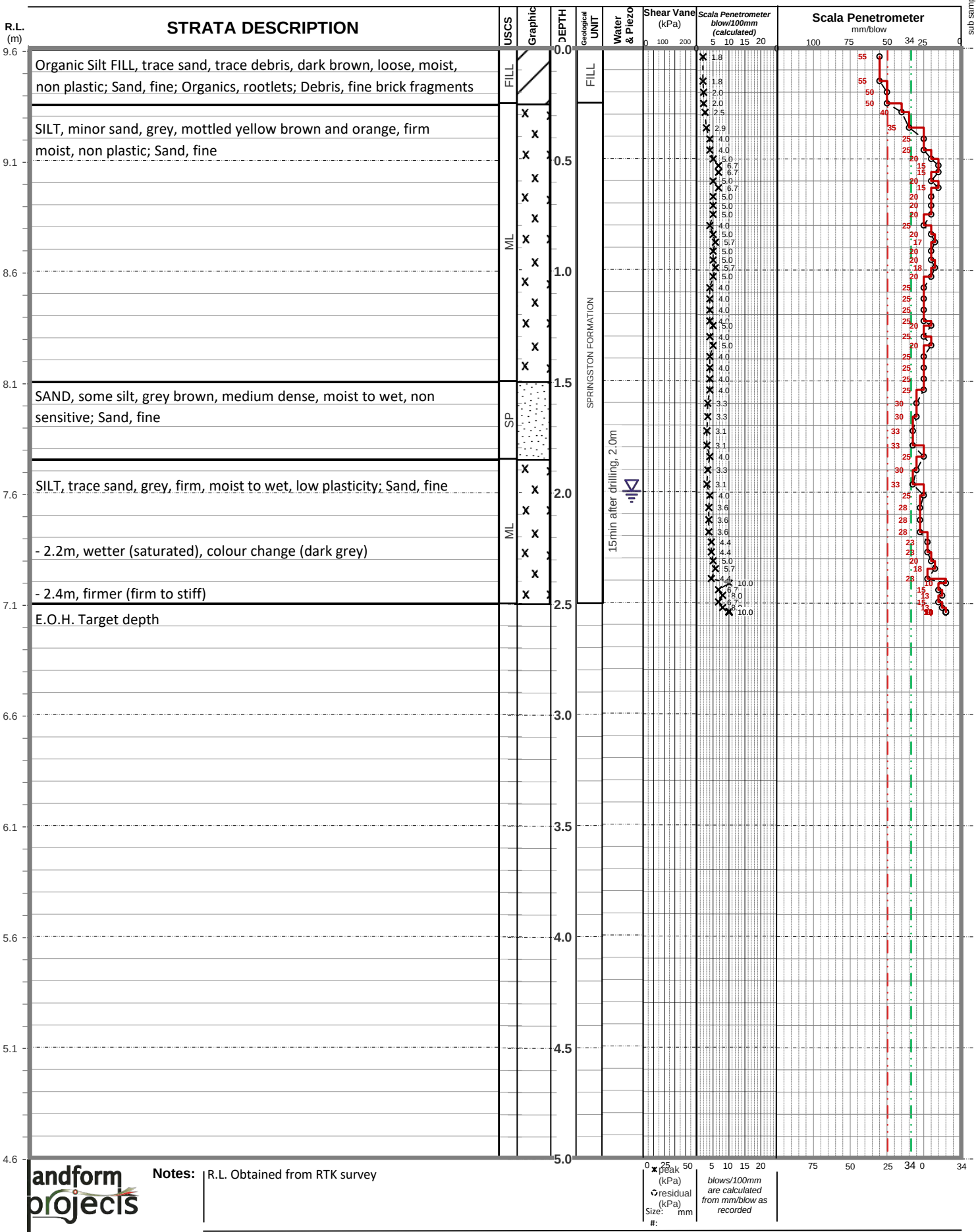
				Hole No:	HA07
				Job No:	3933
				Logged by:	YUY
Project:	Cashmere Field Subdivision			Date drilled:	8/03/2018
Client:	Cashmere Park Trust			Checked by:	NJT
Hole location:	Refer to Site Plan			Date checked:	8/03/2018
Driller: YUY	Contractor:	Equipment:	HA+SC	R.L:	Max depth:
Notes:					



BOREHOLE LOG

Hole # **HA01**

Project:	Cashmere Fields Rezoning	**LFP Ref #:**	1764
For:	Warren Lewis	**Date started:**	8/05/2023
Project #:	3933	**Date finished:**	8/05/2023
Co-ordinates:	1568115.491, 5175414.576	**R.L.:**	9.6 m NZVD(2016)
Grid system:	NZTM2000 (E, N)	**Logged by:**	VT
Drill method:	Hand Auger	**Contractor:**	LFP
Hole depth:	2.50	**Equipment:**	HA + SP
		Checked By:	RBW



Notes: R.L. Obtained from RTK survey

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS. R.L. is inferred and/or interpolated unless otherwise stated.

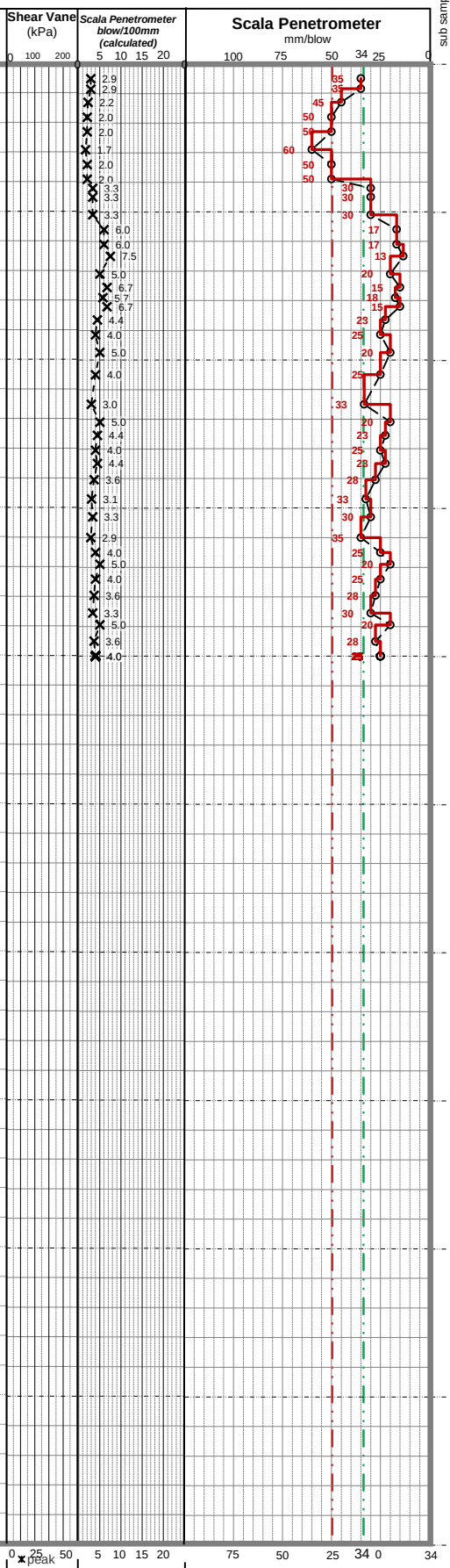
Shear Vane performed and corrected as per NZGS Guidelines. Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

BOREHOLE LOG

Hole # **HA02**

Project:	Cashmere Fields Rezoning	**LFP Ref #:**	1764
For:	Warren Lewis	**Date started:**	8/05/2023
Project #:	3933	**Date finished:**	8/05/2023
Co-ordinates:	1568091.778, 5175535.041	**R.L.:**	10.5 m NZVD(2016)
Grid system:	NZTM2000 (E, N)	**Logged by:**	VT
Drill method:	Hand Auger	**Contractor:**	LFP
Hole depth:	2.00	**Equipment:**	HA + SP
		Checked By:	RBW

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
10.5	Organic SILT, trace sand, dark brown, soft, moist, non plastic; Sand, fine; Organics, rootlets	OL		0.0	TOPSOIL	
10.0	SILT, trace sand, grey, mottled orange and yellow brown, firm, moist, non plastic; Sand, fine	ML		0.5	SPRINGSTON FORMATION	
9.5	- 0.9m, colour change (dark orange brown)			1.0		
9.0	SAND, some silt, greyish brown, medium dense, moist; Sand, fine - 1.3m, less silt (trace) - 1.5m, wetter (wet), more sensitive (slightly) - 1.7m, siltier (silty), more distinct orange mottling	SP		1.5		
8.5	E.O.H. Target depth			2.0		
8.0				2.5		
7.5				3.0		
7.0				3.5		
6.5				4.0		
6.0				4.5		
5.5				5.0		



Notes:
R.L. Obtained from RTK survey.
No static groundwater encoutered

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS.
R.L. is inferred and/or interpolated unless otherwise stated.

Shear Vane performed and corrected as per NZGS Guidelines.
Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

BOREHOLE LOG

Hole # **HA03**

Project:	**Cashmere Fields Rezoning**		
For:	**Warren Lewis**		
Project #:	**3933**	**LFP Ref #:**	1764
Co-ordinates:	1568107.357, 5175651.747	**Date started:**	8/05/2023
Grid system:	NZTM2000 (E, N)	**Date finished:**	8/05/2023
Drill method:	Hand Auger	**R.L:**	9.6 m NZVD(2016)
Contractor:	LFP	**Logged by:**	VT
Hole depth:	2.00	**Checked By:**	RBW
Equipment:	HA + SP		

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
9.6	Organic SILT, trace sand, trace fresh organics, dark brown, soft, moist, non plastic; Sand, fine; Organics, rootlets.	OL		0.0	TOPSOIL	
9.1	SILT, trace sand, trace decayed organics, yellow brown, mottled orange brown, firm, moist, non plastic; Sand, fine; Organics, rootlets - 0.65m, sandier (minor) - 0.7m - softer (soft to firm) - 0.8m, colour change (grey), less mottling with depth	ML		0.5	SPRINGSTON FORMATION	
8.6				1.0		
8.1	SAND, some silt, grey, trace mottled orange, medium dense, moist to wet, non sensitive; Sand, fine - 1.5m, wetter (wet), more sensitive (slightly sensitive)	SP		1.5		
7.6	SILT, some sand, grey, mottled orange, soft, wet, low plasticity; Sand, fine - 1.9m, firmer (firm)	ML		2.0		
	E.O.H. Target depth					
7.1				2.5		
6.6				3.0		
6.1				3.5		
5.6				4.0		
5.1				4.5		
4.6				5.0		

Shear Vane (kPa) 0 100 200 | Scala Penetrometer blow/100mm (calculated) 5 10 15 20 | Scala Penetrometer mm/blow 100 75 50 34 25 0 | sub sampled

Shear Vane: peak (kPa), residual (kPa), Size: mm, #:

Scala Penetrometer blow/100mm (calculated): 1.4 1.4 1.8 2.2 2.9 2.9 3.3 3.3 4.0 4.0 2.9 2.9 2.5 2.5 2.0 2.5 2.5 2.5 2.9 2.7 2.9 3.6 3.1 3.3 3.3 2.9 2.7 2.5 4.0 4.0 4.0 2.5 1.7 2.9 2.9 2.5 2.2 2.9 4.0 2.9

Scala Penetrometer mm/blow: 70 70 55 45 35 35 30 30 25 25 35 35 40 40 50 40 40 40 35 38 35 28 33 30 30 35 38 40 25 25 25 40 60 35 35 40 45 25 35

Scala Penetrometer blow/100mm are calculated from mm/blow as recorded

Notes:
R.L. Obtained from RTK survey.
No static groundwater encoutered

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS. R.L. is inferred and/or interpolated unless otherwise stated.

Shear Vane performed and corrected as per NZGS Guidelines. Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

BOREHOLE LOG

Hole # **HA04**

Project:	Cashmere Fields Rezoning	**LFP Ref #:**	1764
For:	Warren Lewis	**Date started:**	10/05/2023
Project #:	3933	**Date finished:**	10/05/2023
Co-ordinates:	1568369.024, 5175392.018	**R.L.:**	8.6 m NZVD(2016)
Grid system:	NZTM2000 (E, N)	**Logged by:**	VT
Drill method:	Hand Auger	**Contractor:**	LFP
Hole depth:	2.00	**Equipment:**	HA + SP
		Checked By:	RBW

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
8.6	Organic silt FILL, trace sand, trace gravel, dark brown, soft, moist, non plastic; Sand, fine; Gravel, greywacke, rounded, fine; Organics, rootlets	FILL		0.0	FILL	
8.1	SILT, trace decayed organics, grey, mottled orange brown and brown, firm, moist, non plastic; Organics, rootlets	ML		0.5	SPRINGSTON FORMATION	15 minutes after drilling, 0.7m
	- 0.6m, wetter (wet), more plastic (low plasticity)			1.0		
7.6	- 1.1m, iron staining, wetter (saturated), more plastic (moderately plastic)			1.5		
7.1	SILT, trace sand, blue grey, firm, saturated, moderately plastic; Sand, fine	MH		2.0		
6.6	E.O.H. Target Depth			2.5		
6.1				3.0		
5.6				3.5		
5.1				4.0		
4.6				4.5		
4.1				5.0		
3.6						

Shear Vane (kPa) 0 100 200

Scala Penetrometer blow/100mm (calculated) 5 10 15 20

Scala Penetrometer mm/blow 100 75 50 34 25 0

sub sampled

Notes: R.L. sourced from RTK survey

peak (kPa) ✖ residual (kPa) ○ Size: mm #:

blows/100mm are calculated from mm/blow as recorded

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS. R.L. is inferred and/or interpolated unless otherwise stated.

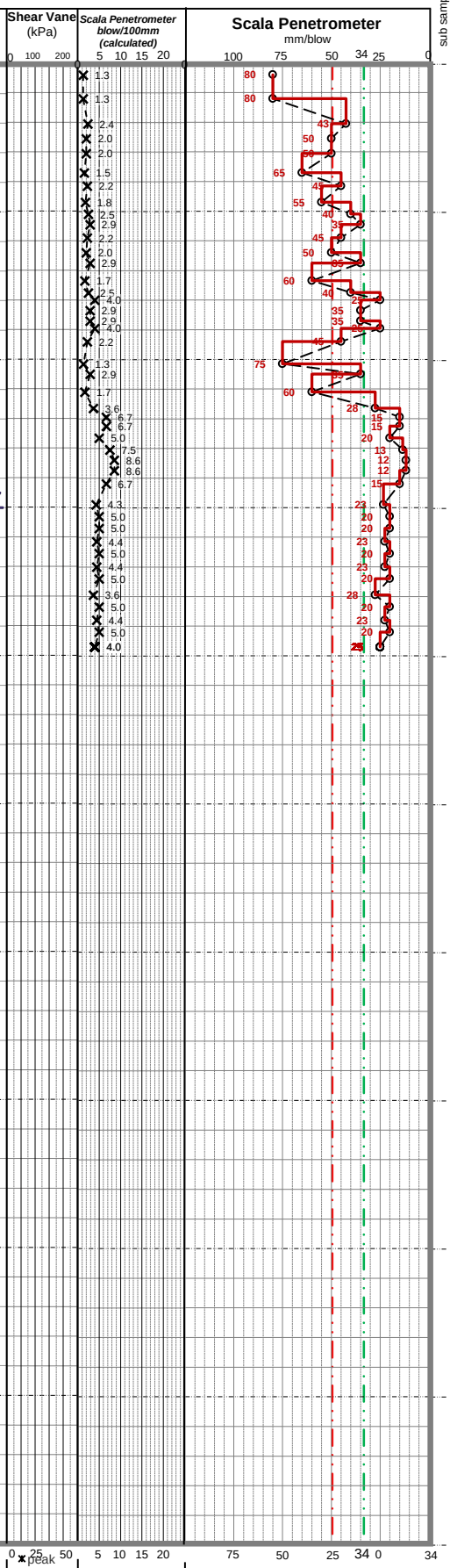
Shear Vane performed and corrected as per NZGS Guidelines. Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

BOREHOLE LOG

Hole # **HA05**

Project:	Cashmere Fields Rezoning	**LFP Ref #:**	1764
For:	Warren Lewis	**Date started:**	10/05/2023
Project #:	3933	**Date finished:**	10/05/2023
Co-ordinates:	1568260.708, 5175421.529	**Grid system:**	NZTM2000 (E, N)
R.L.:	8.7 m NZVD(2016)	**Drill method:**	Hand Auger
Contractor:	LFP	**Logged by:**	VT
Hole depth:	2.00	**Equipment:**	HA + SP
Checked By:	RBW		

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
8.7	Organic SILT, dark brown, soft, moist, non plastic	OL		0.0	TOPSOIL	
	SILT, trace sand, grey, heavily mottled brown and orange brown, soft, moist, non plastic; Sand, fine - 0.15m - 0.5m, cultivation with overlying layer	ML		0.5	SPRINGSTON FORMATION	
7.7	SAND, some silt, grey, strongly mottled brown, loose, wet, slightly sensitive; Sand, fine - 1.25m, siltier (silty), iron staining - 1.4m, wetter (saturated) - 1.5m, more dense (medium dense to dense)	SP		1.0 1.5		15 minutes after drilling, 1.5m
7.2	SILT, blue grey, mottled orange, firm, saturated, moderately plastic	MH		2.0		
6.7	E.O.H. Target Depth					
6.2				2.5		
5.7				3.0		
5.2				3.5		
4.7				4.0		
4.2				4.5		
3.7				5.0		



Notes: R.L. sourced from RTK survey

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS. R.L. is inferred and/or interpolated unless otherwise stated.

Shear Vane performed and corrected as per NZGS Guidelines. Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

BOREHOLE LOG

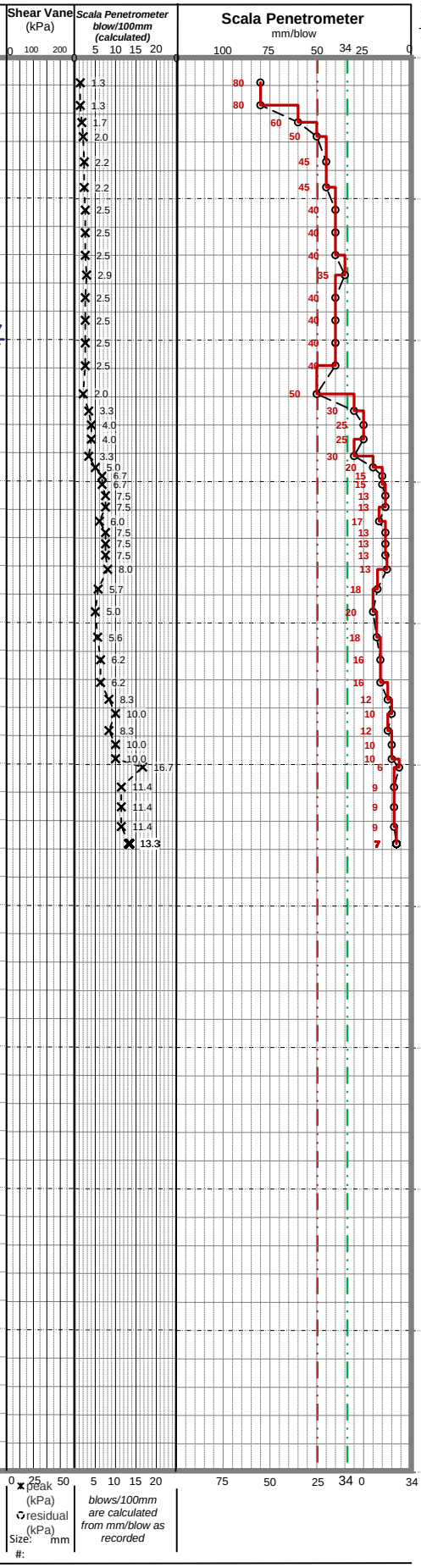
Hole # **HA06**

GEOTECH

Project:	**Cashmere Fields Rezoning**		
For:	**Warren Lewis**		
Project #:	**3933**		
Co-ordinates:	1568168.871, 5176180.715	**Grid system:**	NZTM2000 (E, N)
Drill method:	Hand Auger	**Contractor:**	LFP
Hole depth:	2.50	**Equipment:**	HA + SP

LFP Ref #:	1764
Date started:	16/05/2023
Date finished:	16/05/2023
R.L.:	9.4 m NZVD(2016)
Logged by:	SAS
Checked By:	RBW

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
9.4	Organic SILT, trace fresh organics, dark brown, soft, moist, non plastic; Organics, rootlets	OL		0.0	TOPSOIL	
8.9	SILT, grey, mottled orange, soft, moist, low plasticity	ML		0.5	SPRINGSTON FORMATION	15 minutes after drilling, 1.0m
8.4	- 0.9m, sandier (some, very fine)			1.0		
	- 1.1m, coarser sand (fine)					
7.9	Silty SAND, grey, strongly mottled brown, medium dense to dense, wet, slightly sensitive; Sand, fine	SM		1.5		
	- 1.6m, colour change (dark grey)					
7.4	SILT, dark grey, mottled brown, firm, saturated, moderately plastic	MH		2.0		
	Silty SAND, dark grey, dense, saturated, moderately sensitive; Sand, fine	SM				
6.9	E.O.H. Target Depth			2.5		
6.4				3.0		
5.9				3.5		
5.4				4.0		
4.9				4.5		
4.4				5.0		



Notes: R.L. sourced from RTK survey

landform projects

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS.
R.L. is inferred and/or interpolated unless otherwise stated.

Shear Vane performed and corrected as per NZGS Guidelines.
Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

BOREHOLE LOG

Hole # **HA07**

GEOTECH

Project:	Cashmere Fields Rezoning	**LFP Ref #:**	1764
For:	Warren Lewis	**Date started:**	16/05/2023
Project #:	3933	**Date finished:**	16/05/2023
Co-ordinates:	1568047.784, 5176195.090	**Grid system:**	NZTM2000 (E, N)
R.L:	9.1 m NZVD(2016)	**Contractor:**	LFP
Drill method:	Hand Auger	**Logged by:**	CLS
Hole depth:	2.50	**Equipment:**	HA + SP
		Checked By:	RBW

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
9.1	Organic silt FILL, minor gravel, trace debris, dark brown, soft, moist, non plastic; Gravel, fine to medium; Debris, brick fragments	FILL		0.0	FILL	
	SILT, some sand, grey, mottled orange, soft, moist, low plasticity; Sand, very fine	ML			SPRINGSTON FORMATION	15 minutes after drilling, 1.1m
	- 0.4m, less sand (nil)			0.5		
8.6						
	- 0.8m - 0.85m, minor peat (woody)			1.0		
8.1						
	- 1.4m, sandier (some), wetter (wet), firmer (firm)			1.5		
7.6						
	- 1.7m, wetter (saturated)					
	- 1.85m, more plastic (moderately plastic), less sand (nil), mottling becoming more distinct			2.0		
7.1	- 2.0m, colour change (dark grey) Gradational Contact					
	Silty SAND, trace decayed organics, dark grey, dense, saturated, moderately sensitive; Sand, fine; Organics, peat, woody	SM		2.5		
6.6	E.O.H. Target Depth					
6.1				3.0		
5.6				3.5		
5.1				4.0		
4.6				4.5		
4.1				5.0		

Shear Vane (kPa) — peak / residual; Size: mm; #:

Scala Penetrometer blow/100mm (calculated) — blows/100mm are calculated from mm/blow as recorded

Scala Penetrometer mm/blow — sub sampled

landform projects

Notes: R.L. sourced from RTK survey

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS. R.L. is inferred and/or interpolated unless otherwise stated.

Shear Vane performed and corrected as per NZGS Guidelines. Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

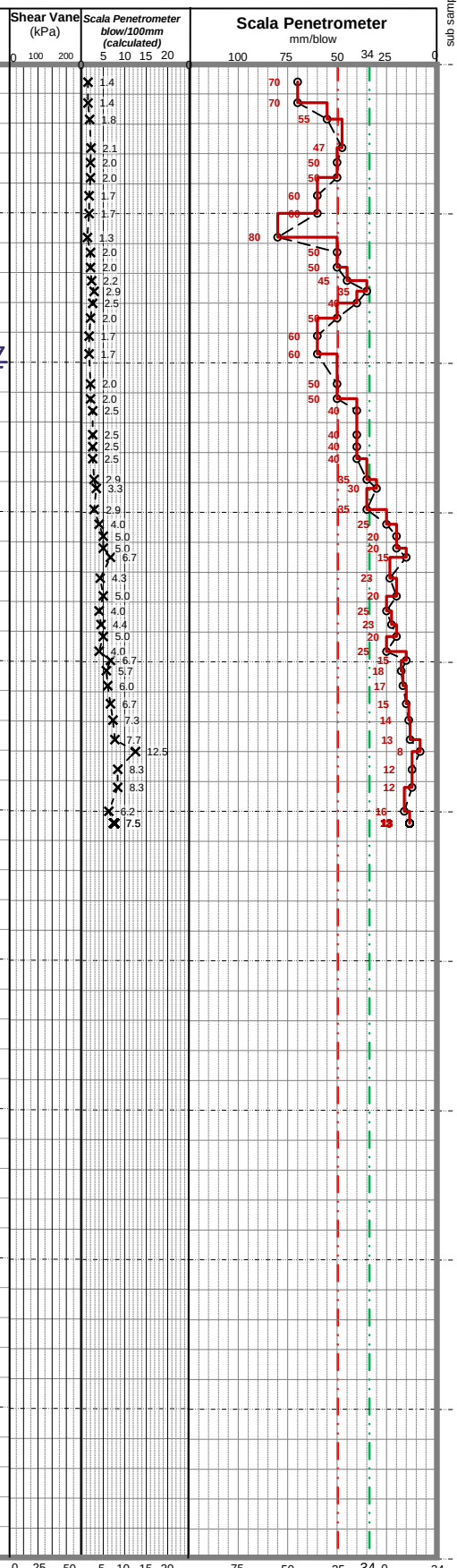
BOREHOLE LOG

Hole # **HA08**

GEOTECH

Project:	Cashmere Fields Rezoning	**LFP Ref #:**	1764
For:	Warren Lewis	**Date started:**	17/05/2023
Project #:	3933	**Date finished:**	17/05/2023
Co-ordinates:	1568057.556, 5176107.091	**Grid system:**	NZTM2000 (E, N)
Drill method:	Hand Auger	**Contractor:**	LFP
Hole depth:	2.50	**Equipment:**	HA + SP
		R.L:	9.0 m NZVD(2016)
		Logged by:	VT
		Checked By:	RBW

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
9.0	Organic SILT, trace fresh organics, dark brown, soft, moist, non plastic; Organics, rootlets	OL		0.0	TOPSOIL	
8.5	SILT, trace sand, greyish brown, soft, moist, non plastic; Sand, fine	ML		0.5	SPRINGSTON FORMATION	15 minutes after drilling, 1.0m
8.0	- 1.0m, colour change (grey, mottled orange), wetter (wet), more plastic (nil to low plasticity)			1.0		
7.5	- 1.4m, wetter (saturated), more plastic (low plasticity) - 1.5m, firmer (firm) - 1.65m, iron staining			1.5		
7.0	SILT, blue grey, mottled orange, firm to stiff, saturated, moderately plastic	MH		2.0		
6.5	- 2.4m, sandier (trace to minor, fine)			2.5		
	E.O.H. Target Depth					
6.0				3.0		
5.5				3.5		
5.0				4.0		
4.5				4.5		
4.0				5.0		



Notes: R.L. approximate only

landform projects

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS. R.L. is inferred and/or interpolated unless otherwise stated.

Shear Vane performed and corrected as per NZGS Guidelines. Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

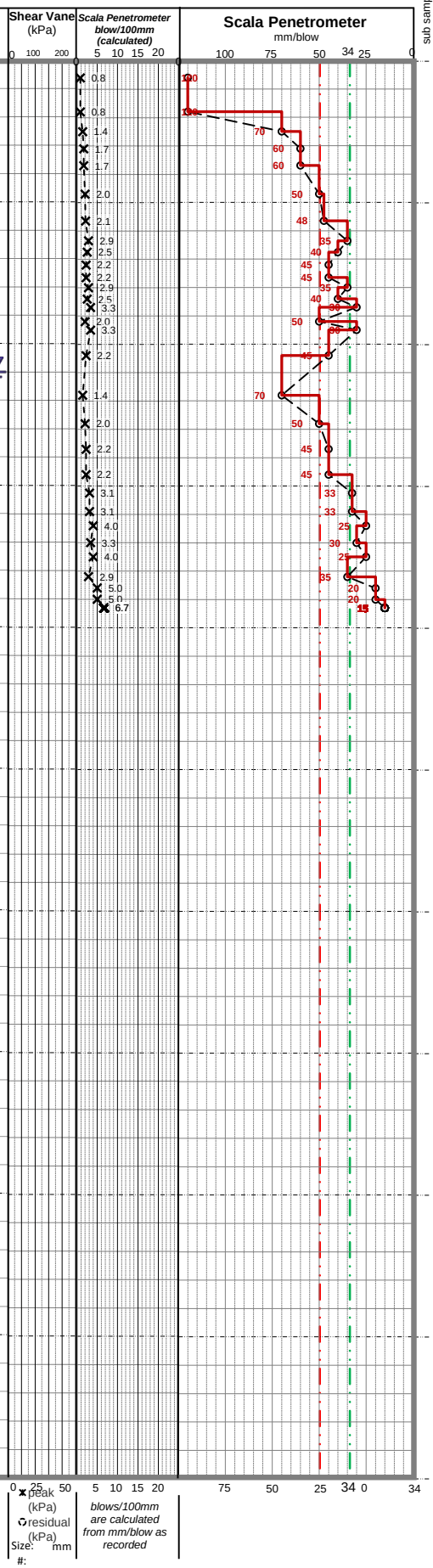
BOREHOLE LOG

Hole # **HA09**

GEOTECH

Project:	Cashmere Fields Rezoning	**LFP Ref #:**	1764
For:	Warren Lewis	**Date started:**	17/05/2023
Project #:	3933	**Date finished:**	17/05/2023
Co-ordinates:	1568147.578, 5175986.205	**R.L:**	8.9 m NZVD(2016)
Grid system:	NZTM2000 (E, N)	**Logged by:**	VT
Drill method:	Hand Auger	**Contractor:**	LFP
Hole depth:	2.00	**Equipment:**	HA + SP
		Checked By:	RBW

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
8.9	Organic SILT, trace sand, trace debris, trace organics, dark brown soft, moist, non plastic; Sand, fine; Debris, charcoal; Organics, rootlets	OL		0.0	TOPSOIL	
8.4	SILT, greyish brown, mottled orange, soft, moist, non plastic	ML		0.5	SPRINGSTON FORMATION	20 minutes after drilling, 1.1m
7.9	- 0.9m, sandier (trace, fine)			1.0		
	SILT, grey, mottled orange and brown, soft, moist, low plasticity	ML				
7.4	- 1.4m, more organics (peaty, decayed, fibrous, woody)			1.5		
	- 1.5m, firmer (soft to firm), wetter (wet)					
6.9	E.O.H Target Depth			2.0		
6.4				2.5		
5.9				3.0		
5.4				3.5		
4.9				4.0		
4.4				4.5		
3.9				5.0		



Notes: R.L. sourced from RTK survey

landform projects

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS. R.L. is inferred and/or interpolated unless otherwise stated.

Shear Vane performed and corrected as per NZGS Guidelines. Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

BOREHOLE LOG

Hole # **HA10**

GEOTECH

Project:	**Cashmere Fields Rezoning**		
For:	**Warren Lewis**		
Project #:	**3933**		
Co-ordinates:	1568124.118, 5175832.073	**Grid system:**	NZTM2000 (E, N)
Drill method:	Hand Auger	**Contractor:**	LFP
Hole depth:	2.80	**Equipment:**	HA + SP

LFP Ref #:	1764
Date started:	30/05/2023
Date finished:	30/05/2023
R.L.:	8.8 m NZVD(2016)
Logged by:	RBW
Checked By:	RBW

R.L. (m)	STRATA DESCRIPTION	USCS	Graphic	DEPTH	Geological UNIT	Water & Piezo
8.8	Organic SILT, trace fresh orgaics, dark brown, soft, moist, non plastic; Organics, rootlets	OL		0.0	TOPSOIL	
8.3	SILT, grey, mottled orange and dark brown (cultivated), soft, moist, non plastic at in situ moisture content	ML		0.5		
7.8	SILT, trace sand, grey, faintly mottled orange, firm, moist to wet, low plasticity; Sand, fine - 0.9m, wetter (wet to saturated) - 1.0m - 1.2m, poor recovery	ML		1.0	SPRINGSTON FORMATION	10 minutes after drilling, 1.0m
7.3				1.5		
6.8	SILT, trace decayed organics, grey to blue grey, mottled orange, firm, saturated, moderately plastic; Organics, rootlets	MH		2.0		
6.3	- 2.3m, colour becoming more blue grey with depth			2.5		
5.8	E.O.H. Target Depth			3.0		
5.3				3.5		
4.8				4.0		
4.3				4.5		
3.8				5.0		

Shear Vane (kPa) — 0 100 200; peak (kPa), residual (kPa), Size: mm, #:

Scala Penetrometer blow/100mm (calculated) — 5 10 15 20

Depth	Shear Vane peak (kPa)	Shear Vane residual (kPa)	Scala blow/100mm (calculated)
0.0	1.3	1.3	1.3
0.1	1.3	1.3	1.3
0.2	1.7	1.7	1.7
0.3	1.7	1.7	1.7
0.4	2.5	2.5	2.5
0.5	2.2	2.2	2.2
0.6	2.7	2.7	2.7
0.7	3.5	3.5	3.5
0.8	4.3	4.3	4.3
0.9	3.6	3.6	3.6
1.0	3.3	3.3	3.3
1.1	3.6	3.6	3.6
1.2	4.2	4.2	4.2
1.3	5.0	5.0	5.0
1.4	5.6	5.6	5.6
1.5	5.0	5.0	5.0
1.6	3.8	3.8	3.8
1.7	3.3	3.3	3.3
1.8	4.5	4.5	4.5
1.9	4.8	4.8	4.8
2.0	3.8	3.8	3.8
2.1	5.0	5.0	5.0

Scala Penetrometer mm/blow — 100 75 50 34 25 0; sub sampled

Depth	Scala mm/blow
0.0	80
0.1	80
0.2	60
0.3	60
0.4	40
0.5	45
0.6	37
0.7	28
0.8	23
0.9	28
1.0	30
1.1	28
1.2	24
1.3	20
1.4	18
1.5	20
1.6	26
1.7	30
1.8	22
1.9	21
2.0	26
2.1	20

blows/100mm are calculated from mm/blow as recorded

Notes: R.L. sourced from RTK survey

landform projects

Borehole logged in accordance with the "Guidelines for the Classification and Description of Soil and Rock for Engineering Purposes" Dec 2005 NZGS.
R.L. is inferred and/or interpolated unless otherwise stated.

Shear Vane performed and corrected as per NZGS Guidelines.
Scala Penetrometer Test carried out to NZS 4402: Test 6.5.2 & field measured as mm per blow(s) .

DRILLHOLE BORELOG

GEOTECH

Hole ID:	BH1
Sheet:	1 of 3
Date:	20/01/2012

Project No:	3933	Equipment:	8140LS (DT45)	G.L. R.L.:		Logged by:	PEW
Project:	Cashmere Fields Rezoning	Drilling Co:	McMillan	Max Depth:	21.4m	Checked by:	NJT
Client:	Cashmere Park Trust	Operator:	D. Keown	Location:	Refer to Site Plan		

Geological Formation	STRATA DESCRIPTION	Graphic Log	Depth	Piezometer and Water Levels	COMMENTS	Drill method	Samples	Tests	SPT blows/mm
	TOP SOIL; dark brown.		0.0		**-0.0 - 1.2m,** 90% sample recovery.	Dual Tube Ø70mm			
	Silty SAND; yellow brown, mottled. Low plasticity.			W.T. 1.1m					
	SILT with minor fine grained **Sand**; grey with yellow brown mottle. Low plasticity. Trace of **Peat**. -1.2m, minor very fine sand. High plasticity. -1.75m, orange brown mottle, low plasticity. -2.25m, minor fine sand.		1.0 2.0		**-1.2 - 2.7m**, 100% sample recovery.				
	Silty SAND; dark grey, fine grained. Sand content increases with depth. -2.67m, grey brown. -3.5m, grey. -3.9m, grey brown. -4.1 - 4.19m, interbedded **SILT** layer; low plasticity. Minor very fine Sand and Organics.		3.0 4.0		**-2.7 -4.2m**, 100% sample recovery. **-4.2 - 5.7m**, 100% sample recovery.	Dual Tube			
	SILT with minor very fine **SAND**; grey brown, high plasticity. -4.7m, grey. -5.0m, wood fragment.		5.0						
	PEAT; dark brown. Soft; Occasional wood fragment.				**-5.7 -7.2m**, 100% sample recovery.				
	SILT with minor very fine SAND; grey.		6.0						
	Silty SAND; grey, fine grained. Trace of woody Peat. -6.7m-7.1m, minor Peat.		7.0						
	NO SAMPLE				**-7.2 - 8.7m**, 100% sample recovery.				
	SILT with minor very fine SAND; grey. High plasticity.								
	SAND with some **Silt**; grey, fine to medium grained.		8.0						
	Gravelly fine to coarse **SAND** with some **Silt**; dark grey. Gravel, fine to medium. -8.75m, coarse sand, minor wood fragment.				**-8.7- 10.2m**, 100% sample recovery.	Dual Tube			
	Sandy fine to coarse **GRAVEL** with some **Silt**; dark grey. Subrounded; Sand, coarse.		9.0 10.0						

SPT blows/mm: 20 40 60 80

DRILLHOLE BORELOG

GEOTECH

Hole ID:	BH1
Sheet:	2 of 3
Date:	20/01/2012

Project No:	3933	Equipment:	8140LS (DT45)	G.L. R.L.:		Logged by:	PEW
Project:	Cashmere Fields Rezoning	Drilling Co:	McMillan	Max Depth:	21.4m	Checked by:	NJT
Client:	Cashmere Park Trust	Operator:	D. Keown	Location:	Refer to Site Plan		

Geological Formation	STRATA DESCRIPTION SOIL DESCRIPTION Major colour, second colour, Subordinate fraction, minor fractions, - plasticity, bedding, moisture, structures ROCK DESCRIPTION Colour, fabric, rock name	Graphic Log	Depth	Piezometer and Water Levels	COMMENTS	Drill method	Samples	Tests	SPT blows/mm (20 40 60 80)
	Sandy fine to coarse **GRAVEL** with some **Silt**; continued. -10.0m, minor cobble; decrease in sand.		10.0		**-10.3 - 11.8m,** 100% sample recovery.	Dual Tube Ø70mm			
	Medium to coarse **SAND** with some **Silt**; dark grey. Minor wood fragments. -11.3m, coarse sand.		11.0						
	Gravelly coarse **SAND**; Gravel, fine to coarse, subrounded.								
	NO SAMPLE							11.8 SPT	12 17 9 26/300mm
	Coarse **SAND**; dark grey.				**-11.8 - 13.3m**, 100% sample recovery.				
	Gravelly coarse **SAND**; dark grey. Gravel, fine to coarse. Medium dense to dense.		12.0						
	Sandy fine to coarse **GRAVEL** with some **Silt**; dark grey. Sand, coarse; some organic and wood fragments. Medium dense to dense.								
	SILT with fine **Sand**; grey; low to medium plasticity. Medium dense to dense. -12.9m, interbedded fine to medium Sand. Plasticity increases with depth.		13.0						
	NO SAMPLE				**-13.3 - 16.4m**, 100% sample recovery.			13.3 SPT	2 10 11 21/300mm
	Medium to coarse **SAND**; brown grey to dark grey. Medium dense.								
	Coarse **SAND** with interbedded **Silt**; dark grey. High plasticity. Medium dense.		14.0						
	Sandy fine to coarse **GRAVEL** with interbedded **Silt**; dark grey. Gravel, subrounded; Sand, coarse. Silt increases with depth.					Dual Tube			
	SILT with minor very fine **Sand**; dark grey; high plasticity. Minor Peat and wood fragments -15.1m, interbedded fine to medium Sand. Soft.		15.0					14.8 SPT	0 0 6 6/300mm
	Very fine **SAND** with some **Silt**; dark grey. -15.8m, medium to coarse Sand; grey brown. -15.9m, fine Sand; grey.		16.0						
	SILT with **Peat**; dark brown to dark grey. Medium to high plasticity; Soft. -16.65m, decrease Silt. -16.75m, increase Silt.				**-16.4 - 17.9m**, 100% sample recovery.			16.4 SPT	0 5 5 10/300mm
	-17.25m, increase organic content; high plasticity.		17.0						
	-17.75m, low plasticity. -17.85m, high plasticity.				**-17.9 - 19.4m**, 100% sample recovery.			17.9 SPT	0 2 4 6/300mm
	-18.8m, wood fragment.		18.0			Dual Tube			
	-19.0m, wood fragment.		19.0						
	Silty fine **SAND** with minor **PEAT**; dark grey.								
	Silty Sandy fine to coarse **GRAVEL**; dark grey to yellow brown. Gravel, subrounded; Sand, coarse; dense.		20.0		**-19.4 - 20.9m**, 100% sample recovery.			19.4 SPT	16 18 18 36/300mm

DRILLHOLE BORELOG

GEOTECH

Hole ID:	BH1
Sheet:	3 of 3
Date:	20/01/2012

Project No:	3933	Equipment:	8140LS (DT45)	G.L. R.L.:		Logged by:	PEW
Project:	Cashmere Fields Rezoning	Drilling Co:	McMillan	Max Depth:	21.4m	Checked by:	NJT
Client:	Cashmere Park Trust	Operator:	D. Keown	Location:	Refer to Site Plan		

Geological Formation	STRATA DESCRIPTION SOIL DESCRIPTION Major colour, second colour, Subordinate fraction, minor fractions, - plasticity, bedding, moisture, structures ROCK DESCRIPTION Colour, fabric, rock name	Graphic Log	Depth	Piezometer and Water Levels	COMMENTS	Drill method	Samples	Tests	SPT blows/mm (20 40 60 80)
	Silty Sandy fine to coarse **GRAVEL**; dark grey to yellow brown. Gravel, subrounded; Sand, coarse; dense. (continued)		20.0		**-19.4 - 20.9m,** 100% sample recovery.	Dual Tube Ø70mm		20.9 SPT	11 6 10 16/300mm
	NO SAMPLE		21.0						
	21.4m E.O.H.		22.0						
			23.0						
			24.0			Dual Tube			
			25.0						
			26.0						
			27.0						
			28.0			Dual Tube			
			29.0						
			30.0						

DRILLHOLE BORELOG

GEOTECH

Hole ID:	BH 2
Sheet:	1 of 3
Date:	20/01/2012

Project No:	3933	Equipment:	8140LS (DT45)	G.L. R.L.:		Logged by:	PEW
Project:	Cashmere Fields Rezoning	Drilling Co:	McMillan	Max Depth:	21.4m	Checked by:	NJT
Client:	Cashmere Park Trust	Operator:	D. Keown	Location:	Refer to Site Plan		

Geological Formation	STRATA DESCRIPTION SOIL DESCRIPTION Major colour, second colour, Subordinate fraction, minor fractions, - plasticity, bedding, moisture, structures ROCK DESCRIPTION Colour, fabric, rock name	Graphic Log	Depth	Piezometer and Water Levels	COMMENTS	Drill method	Samples	Tests	SPT blows/mm (20 40 60 80)
	TOP SOIL; dark brown, organic, wood fragments.		0.0		**-0.0 - 1.2m,** 90% sample recovery.	Dual Tube Ø70mm			
	SAND with minor **Silt**; dark brown with yellow-brown mottling; fine to medium grained.			W.T. 1.1m					
	-1.2m, dark grey. -1.4, very fine to fine sand. -1.7m, increase in Silt content.		1.0		**-1.2 - 2.7m**, 100% sample recovery.				
			2.0						
	Silty very fine to fine **SAND**; grey-brown with yellow-brown mottling. -2.7m, dark grey, very fine.		3.0		**-2.7 -4.2m**, 100% sample recovery.				
	SILT with minor very fine grained **Sand**; dark grey with yellow-brown mottle. High plasticity.								
	Silty very fine **SAND**; dark grey.		4.0		**-4.2 - 5.7m**, 100% sample recovery.	Dual Tube			
	SAND; dark grey, very fine to fine grained; trace of Silt. -4.7m, fine to medium sand. -5.0m, fine to coarse sand.		5.0						
	Silty very fine to fine **SAND**; dark grey.								
	SAND; dark grey, medium to coarse grained. -4.7m, coarse		6.0		**-5.7 -7.2m**, 100% sample recovery.				
	Silty very fine to fine **SAND**; dark grey.								
	SILT; dark grey. High plasticity; trace of very fine Sand.		7.0						
	Peaty SILT; dark grey.								
	SILT; dark grey. High plasticity; trace of very fine Sand.				**-7.2 - 8.2m**, 100% sample recovery.				
	NO SAMPLE								
	SILT; dark grey. High plasticity; trace of very fine Sand.		8.0						
	Peaty SILT; dark grey. Trace of very fine Sand and wood fragments.				**-8.2- 10.2m**, 100% sample recovery.	Dual Tube			
	Sandy SILT; dark grey. High plasticity, fine Sand.								
	Sandy medium to coarse **GRAVEL**; dark grey. Subrounded; Sand, fine to coarse.							16.4 SPT	4 6 10 16/300mm
	SAND; dark grey; Medium to coarse.		9.0						
	Gravelly medium to coarse **SAND**; dark grey. Gravel, subrounded, medium to coarse.								
	SAND with minor fine to coarse **GRAVEL**; dark grey. Sand, fine to coarse; Gravel, subrounded.		10.0						

DRILLHOLE BORELOG

GEOTECH

Hole ID:	BH 2
Sheet:	2 of 3
Date:	20/01/2012

Project No:	3933	Equipment:	8140LS (DT45)	G.L. R.L.:		Logged by:	PEW
Project:	Cashmere Fields Rezoning	Drilling Co:	McMillan	Max Depth:	21.4m	Checked by:	NJT
Client:	Cashmere Park Trust	Operator:	D. Keown	Location:	Refer to Site Plan		

Geological Formation	STRATA DESCRIPTION SOIL DESCRIPTION Major colour, second colour, Subordinate fraction, minor fractions, - plasticity, bedding, moisture, structures ROCK DESCRIPTION Colour, fabric, rock name	Graphic Log	Depth	Piezometer and Water Levels	COMMENTS	Drill method	Samples	Tests	SPT blows/mm (20 40 60 80)
	Gravelly medium to coarse **SAND**; dark grey. Gravel, medium to coarse.		10.0						
	SAND; dark grey. Medium to coarse grained; medium dense to loose (density decreases with depth).				**-10.3 - 11.8m,** 100% sample recovery.	Dual Tube Ø70mm		10.3 SPT	10 10 13 23/300mm
	-11.4 to 11.6m, wood fragments.		11.0						
					-11.8 - 13.3m, 100% sample recovery.			11.8 SPT	6 4 2 6/300mm
	-12.7 to 12.9m, some Peat.		12.0						
			13.0		**-13.3 - 14.8m**, 100% sample recovery.			13.3 SPT	1 1 4 5/300mm
			14.0			Dual Tube			
					-14.8 - 16.4m, 100% sample recovery.			14.8 SPT	3 3 4 7/300mm
	Silty fine to medium **SAND**; dark grey. Loose.		15.0						
	SAND; dark grey; medium to coarse. Trace of Silt.		16.0						
	NO SAMPLE				**-16.4 - 17.9m**, 100% sample recovery.			16.4 SPT	12 13 17 30/300mm
	SAND; dark grey; medium to coarse. Dense.								
	Sandy fine to coarse **GRAVEL**; dark grey. Gravel, subrounded; Sand,coarse; dense.		17.0						
	-17.6m, yellow brown Sand.								
	NO SAMPLE		18.0		**-17.9 - 19.4m**, 75% sample recovery.			17.9 SPT	11 25 14 39/300mm
	GRAVEL; dark grey. Medium to coarse; dense.					Dual Tube			
	Sandy fine to coarse **GRAVEL**; dark grey. Gravel, subrounded; Sand,coarse; dense.		19.0						
	NO SAMPLE				**-19.4 - 20.9m**, 0% sample recovery.			19.4 SPT	10 12 22 34/300mm
			20.0						

DRILLHOLE BORELOG

GEOTECH

Hole ID:	BH 2
Sheet:	3 of 3
Date:	20/01/2012

Project No:	3933	Equipment:	8140LS (DT45)	G.L. R.L.:		Logged by:	PEW
Project:	Cashmere Fields Rezoning	Drilling Co:	McMillan	Max Depth:	21.4m	Checked by:	NJT
Client:	Cashmere Park Trust	Operator:	D. Keown	Location:	Refer to Site Plan		

Geological Formation	STRATA DESCRIPTION **SOIL DESCRIPTION** Major colour, second colour, Subordinate fraction, minor fractions, - plasticity, bedding, moisture, structures **ROCK DESCRIPTION** Colour, fabric, rock name	Graphic Log	Depth	Piezo-meter and Water Levels	COMMENTS	Drill method	Samples	Tests	SPT blows/mm
	NO SAMPLE		20.0			Dual Tube Ø70mm		20.9 SPT	11 20 20 40/300mm
	21.4m E.O.H.		21.0						
			22.0						
			23.0						
			24.0			Dual Tube			
			25.0						
			26.0						
			27.0						
			28.0			Dual Tube			
			29.0						
			30.0						

SPT blows/mm: 20 40 60 80

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:S33_BH-Sc
Hole Location: 200 Cashmere Road
SHEET 1 OF 2

PROJECT: Silty Soil Liquefaction Guidance	LOCATION: 200 Cashmere Road	JOB No: 53399.000
CO-ORDINATES: 5175519.77 mN 1568352.4 mE	DRILL TYPE: Fraste Multidrill - XL	HOLE STARTED: 21/2/14
	DRILL METHOD: Sonic, 95.2% efficiency	HOLE FINISHED: 21/2/14
R.L.:		DRILLED BY: Prodrill - Cam
DATUM:	DRILL FLUID: Drill pro	LOGGED BY: JXXM CHECKED: DAA

GEOLOGICAL									ENGINEERING DESCRIPTION								
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
Topsoil									0		ML	M	S				Topsoil: SILT, with minor rootlets; dark grey. Rootlets, up to 4mm diameter.
Yaldhurst Member of the Springston Formation																	SILT, with trace rootlets; dark grey. Low plasticity; rootlets, fine.
																	0.30m: Becomes brownish grey, with trace iron staining and orange mottles.
									0.5				F				0.50m: Grades to trace sand with rootlets absent. Sand, fine. 0.5
																	0.70m: Grades to minor sand.
									1.0								0.90m: Grades to sandy. Becomes non-plastic. 1.0
		03/03/2014									SM	W					Silty fine SAND; brownish grey, with trace iron staining.
											ML		VS				SILT, with minor sand and trace organics; brownish grey, with trace iron staining. Low plasticity, quick; sand, fine; organics, fibrous. 1.5
									1.5				S				1.50m: Grades to sand absent. Becomes low to moderate plasticity, slow.
																	1.60m: Grades to trace sand. Becomes low plasticity; sand, fine.
			100	Sonic									F				1.70m: Grades to sand absent. Becomes grey, with iron staining absent, low to moderate plasticity, very slow. 2.0
									2.0								1.95m: Grades to trace sand. Becomes slow; sand, fine.
						*PI; PSD & WC @2.05 - 2.15m											2.30m: Grades to some sand. Becomes low plasticity, quick. 2.5
									2.5		SM						Silty fine SAND, with trace organics; grey. Organics, fibrous.
																	No Recovery: 2.60 - 3.00m.
			73	Sonic					3.0								3.0
																	3.20m: Grades to some silt.
									3.5								3.45m: Grades to silty, with thin silt laminations and organics absent. 3.5
											ML						3.80m: 50mm bed of SILT with some sand. Non-plastic.
						*FC; WS & WC @3.8 - 3.9m					SP		F				3.85m: Grades to minor silt with silt laminations absent. 4.0
									4.0		ML		S				SILT, with some sand; grey. Non-plastic, quick; sand, fine.
						*PI; FC & WC @4.05 - 4.15m							F				4.05m: Grades to minor sand. Becomes low plasticity.
																	4.20m: Grades to sandy. Becomes non-plastic. 4.5
			81	Sonic					4.5								No Recovery: 4.30 - 4.60m.
											SM						Silty fine SAND; grey.
						*WS & WC @4.9 - 5.0m			5								

T+T DATATEMPLATE.GDT adw

Log Scale 1:25

BORELOG 2014.02.25.JXXM.200CASHMERERDBOREHOLE.GPJ 23-May-2014

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:S33_BH-Sc
Hole Location: 200 Cashmere Road
SHEET 2 OF 2

PROJECT: Silty Soil Liquefaction Guidance | LOCATION: 200 Cashmere Road | JOB No: 53399.000

CO-ORDINATES: 5175519.77 mN 1568352.4 mE
R.L.:
DATUM:

DRILL TYPE: Fraste Multidrill - XL
DRILL METHOD: Sonic, 95.2% efficiency
DRILL FLUID: Drill pro

HOLE STARTED: 21/2/14
HOLE FINISHED: 21/2/14
DRILLED BY: Prodrill - Cam
LOGGED BY: JXXM CHECKED: DAA

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION / ROCK DESCRIPTION
Yaldhurst Member of the Springston Formation			100	Sonic		*PI; PSD & WC @5.5 - 5.6m			5.5		SM	W					Silty fine SAND; grey.
											ML		F				SILT, with some sand and trace organics; grey. Non-plastic, quick; sand, fine; organics, fibrous. 5.5
																	5.50m: Grades to sandy.
																	5.65m: Grades to some sand.
																	5.75m: Grades to trace sand. Becomes low plasticity, slow.
						*PI & WC @5.9 - 6.0m			6.0								6.0
													S				6.05m: Becomes quick.
			100	Sonic									VS				6.30m: Grades to sand and organics absent. Becomes low to moderate plasticity, slow.
									6.5								6.5
									7.0								7.0
																	7.05m: Grades to trace fibrous organics.
						*PI; PSD & WC @7.4 - 7.5m			7.5								7.5
													S				7.60m: Becomes very slow.
													F				7.75m: Becomes moderate plasticity.
			100	Sonic					8.0				S				8.00m: Becomes low to moderate plasticity. 8.0
																	8.10m: Grades to minor organics.
									8.5								8.5
																	8.50m: Grades to trace fine sand.
																	8.80m: Grades to trace organics.
									9.0				F				8.95m: Grades to sandy. Becomes non-plastic, quick. 9.0
											SM						Silty fine SAND, with trace organics and silt laminations; grey. Organics, fibrous.
											Pt						Fibrous WOOD; brown.
			100	Sonic							SM						Silty fine SAND, with trace organics; grey. Organics, fibrous. 9.5
									9.5								9.50m: Grades to silt laminations absent.
									10								**End of Borehole at 10.00m bgl. Target Depth Reached.**

T+T DATATEMPLATE.GDT adw

Log Scale 1:25


0-1m
1-2m
No recovery: 2.6-3.0m
3-3.0m
Project No: 53399
Site: 200 Cashmere Road
BH No: Site 33
Box No: 1 of 4
Depth From: 0.0 m to 3.0 m
Date: 13 03 2014
Tonkin & Taylor
www.tonkin.co.nz
0
100
200
300
400
500
Scale: mm 600

SOIL BORING LOG

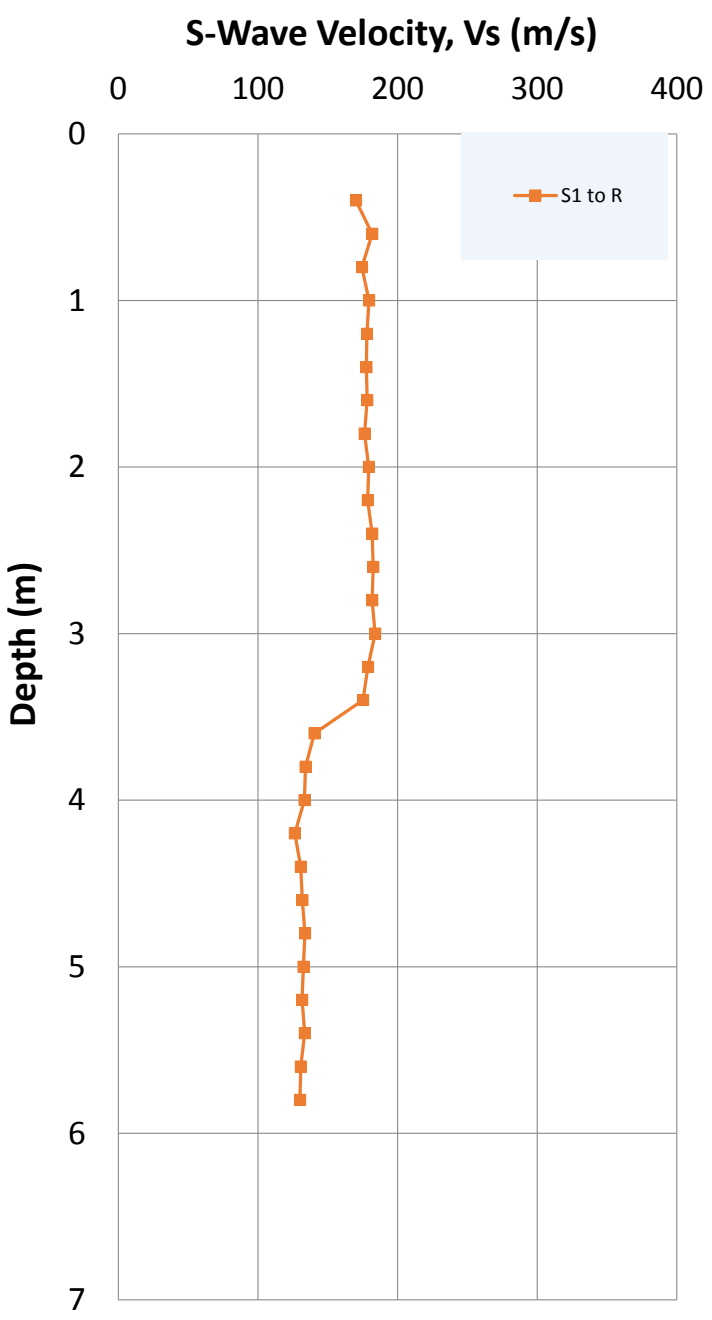
Project Number	Boring Number
n/a	DM-2

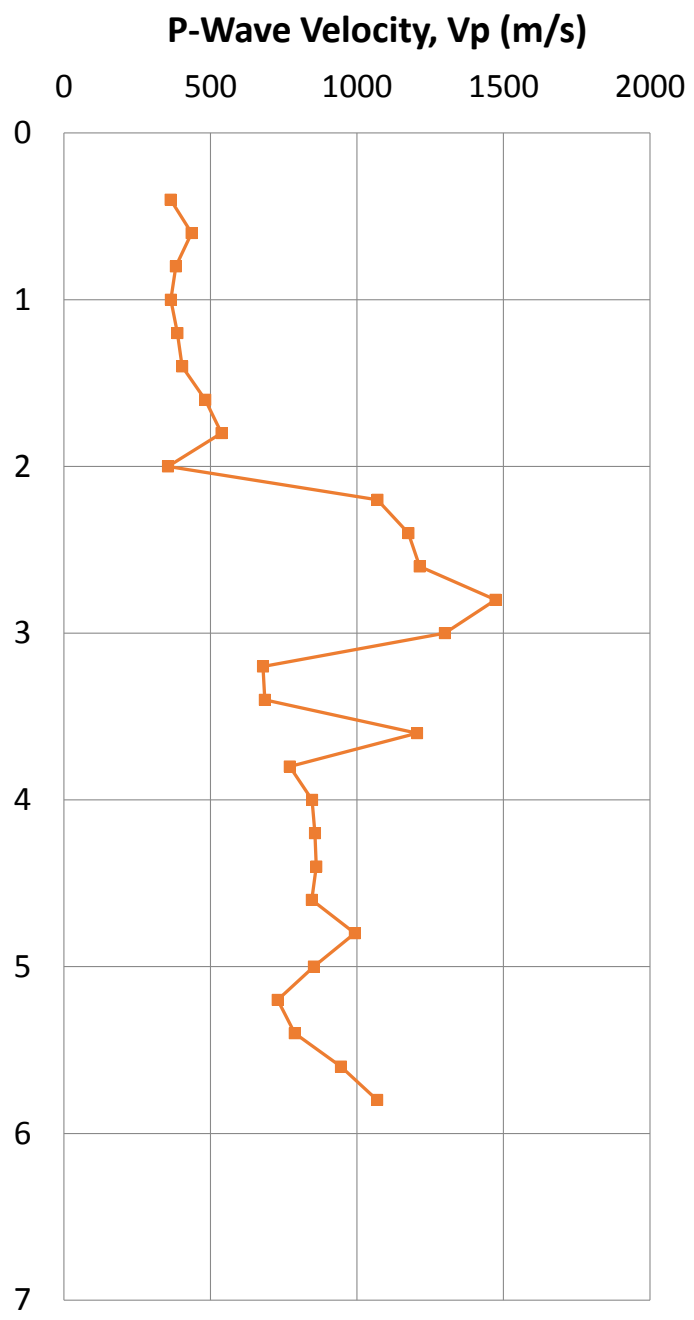
General Comments: Dames & Moore Continuous Sampling
(This is a simplified log. Detailed logging will be provided.)

Project Name:	Mini-Cone/Continuous D&M	**Location:**	200 Cashmere Road ("Site 33"), Christchurch, New Zealand
Elevation:	---	**Drilling Contractor:**	McMillan Drilling Services
Drilling Method and Equipment:			Mud-rotary, Track rig (Geoprobe 8140LS)
Mud Level:	Above ground surface (7 June 2016, 8:30AM)	**Start/Finish:**	3 June 2016 (Friday) - 7 June 2016 (Tuesday)
Logger:	Christine Z. Beyzaei (UC Berkeley)		

Depth below Surface (m)	Sample: Interval	Sample: Number and Type	Sample: Recovery (%)	D&M Sampling Pressure (psi)	Soil Description: Soil Name, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol	Comments: Depth of Casing, Drilling Rate, Drilling Fluid Loss, Tests and Instrumentation
						Hand-augered (0 - 0.5m)
	0.5-0.89 m	1U (DM)	100%	350-400 psi	Gray sandy silt	No casing. Sampler not fully advanced* (estimated advancement approx. 39 cm).
1	0.95-1.40 m	2U (DM)	100%	200 psi	Gray sandy silt	No casing.
	1.40-1.85 m	3U (DM)	100%	100 psi	Gray sandy silt	Casing at 0.78 m.
2	1.85-2.30 m	4U (DM)	99%	100 psi	Gray clayey silt	Casing at 0.78 m.
	2.30-2.75 m	5U (DM)	101%	100 psi	Gray clayey silt	Casing at 1.85 m.
3	2.75-3.20 m	6U (DM)	101%	100 psi	Gray sandy silt to silty sand	Casing at 1.85 m.
	3.20-3.65 m	7U (DM)	100%	150-250 psi	Gray fine sand, some silt	Casing at 2.90 m.
4	3.65-4.10 m	8U (DM)	101%	150-250 psi	Gray silty fine sand (silt/organic bands and laminations)	Casing at 2.90 m.
	4.10-4.55 m	9U (DM)	95%	75 psi	Gray fine sand, some silt & Gray silt with laminations	Casing at 3.80 m.
	4.55-5.00 m	10U (DM)	101%	75 psi	Gray silt & silty fine sand (organic/sand laminations and partings)	Casing at 4.25 m.
5	5.00-5.45 m	11U (DM)	102%	50 psi	Layered silty sand and silt	Casing at 4.25 m.
	5.45-5.90 m	12U (DM)	98%	100 psi	Layered silty sand and silt	Casing at 4.25 m.
6	5.90-6.35 m	13U (DM)	100%	50 psi	Layered silt	Casing at 5.34 m.
	6.35-6.80 m	14U (DM)	101%	75 psi	Layered silt	Casing at 5.34 m.
7						*End of boring at 6.80 m*

*Note: Full sampler advancement = 45 cm.





HNH-TCR01-XH01

Project:

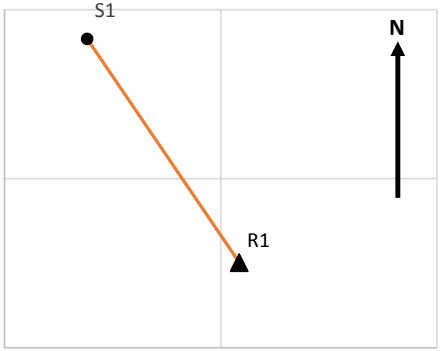
T-Rex Ground Improvement Trials

Test Date: 6 December 2013
Suburb: Hoon Hay
Located By: Survey GPS
Coord System: NZTM
Vertical Datum: Lyttleton Vertical Datum 1937

Probe Positions:

Probe	Easting (mE)	Northing (mN)	Elevation (mRL)
R1	1568355.1	5175519.5	9.3
S1	1568354.4	5175520.8	9.3
S2	0.0	0.0	0.0

Indicative Location Plan



Comments:
200 Cashmere Road: S1 to R; Unimproved ground.

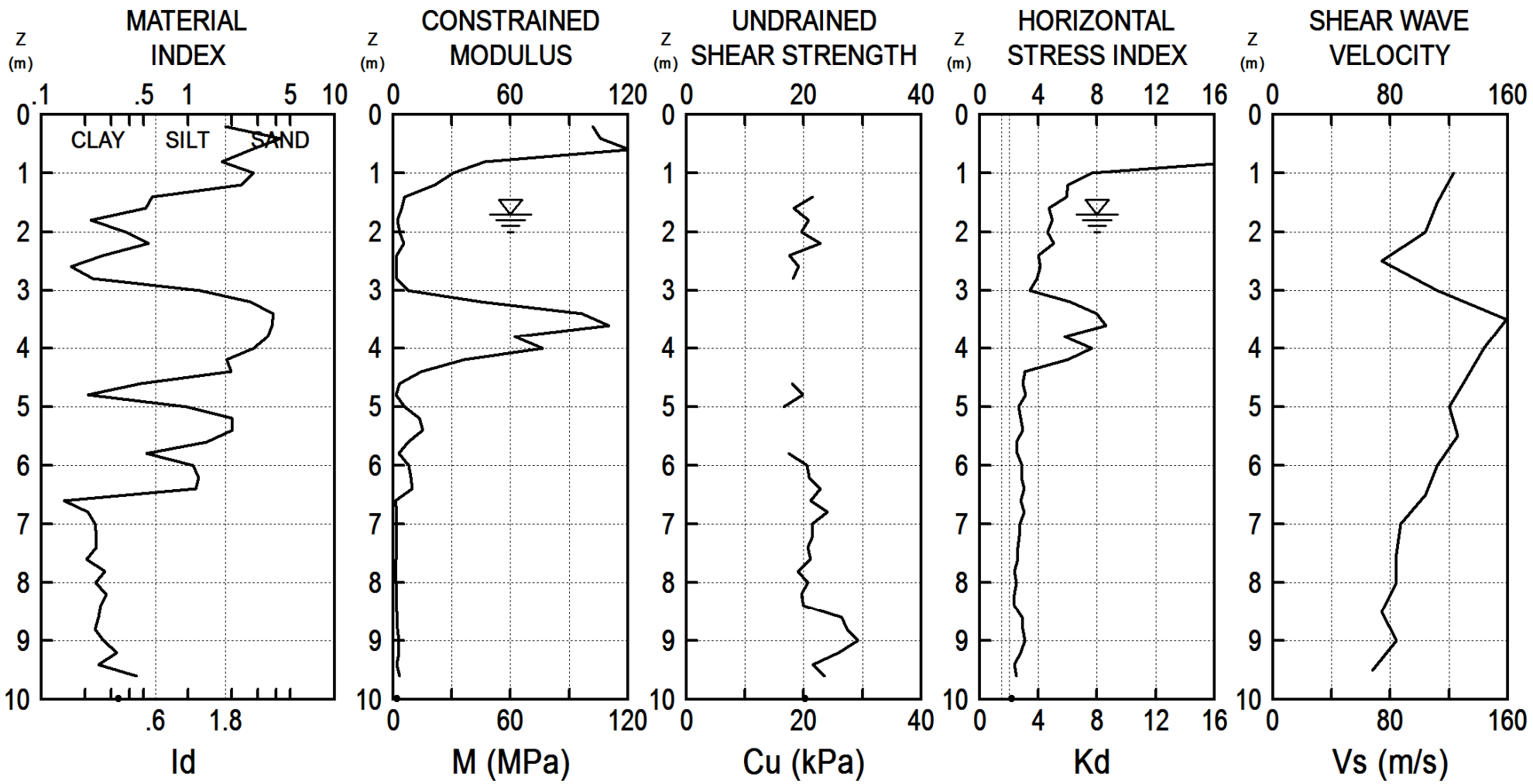
Printed: 13/04/2014 2:25 PM

SEISMIC DILATOMETER TEST (S D M T)

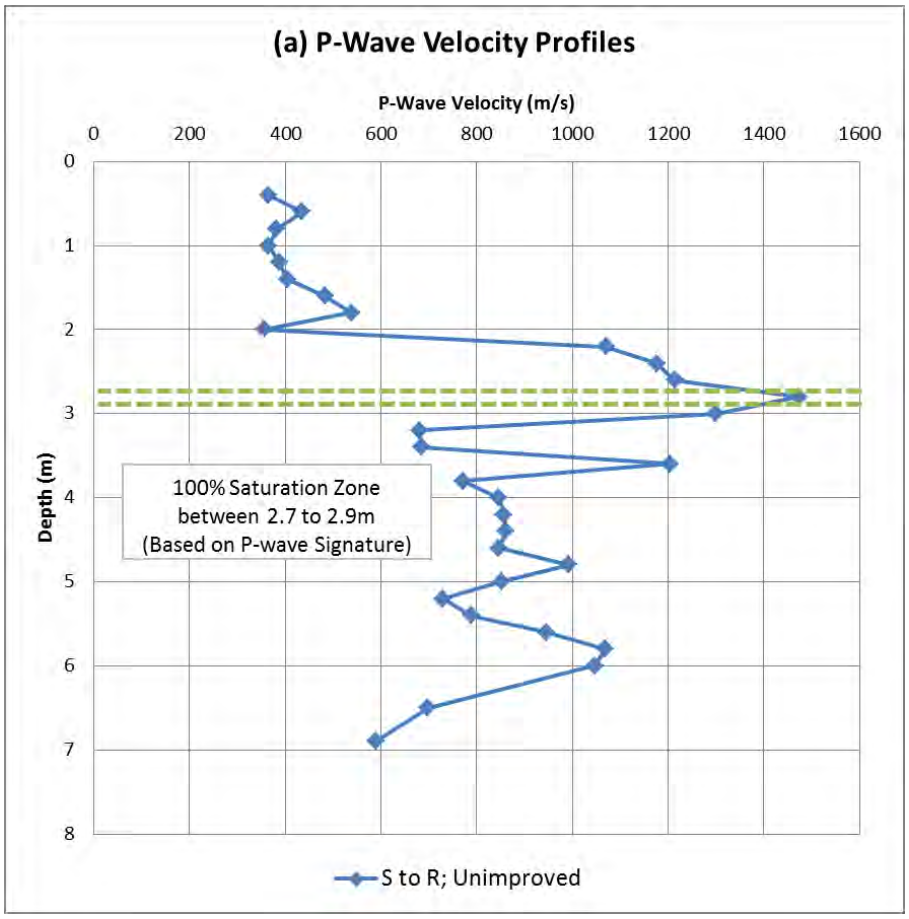
Site 33
200 Cashmere Rd

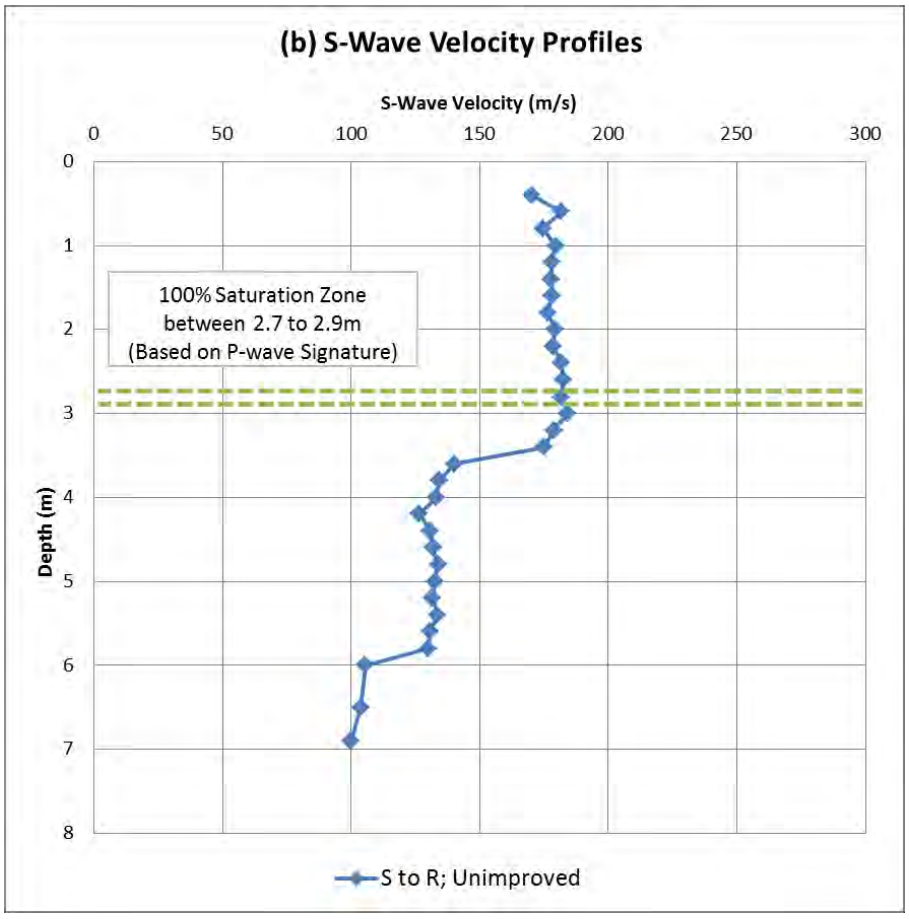
Natural soil
Christchurch

TEST
SDMT1
14 DEC 2013



Site #33


(a) P-Wave Velocity Profiles
P-Wave Velocity (m/s)
0
200
400
600
800
1000
1200
1400
1600
Depth (m)
0
1
2
3
4
5
6
7
8
100% Saturation Zone
between 2.7 to 2.9m
(Based on P-wave Signature)
S to R; Unimproved


(b) S-Wave Velocity Profiles
S-Wave Velocity (m/s)
0
50
100
150
200
250
300
Depth (m)
0
1
2
3
4
5
6
7
8
100% Saturation Zone
between 2.7 to 2.9m
(Based on P-wave Signature)
S to R; Unimproved

Appendix 3

Lab data and C_{FC} Analysis

Research Project for Silty Soil Liquefaction Guidance - Lab Schedule

PI	Atterberg Limits
FC	Wet seive at 75µm and 63µm to provide fines content
WS	Wet seive particle size distribution
Hyd	Hydrometer particle size distribution
Full PSD	Wet seive plus hydrometer PSD
Vis Insp	Visual inspection has confirmed ~100% fines
WC	Water content on as-received sample
Zip Lock Core	Sample was bagged on site soon after drilling, so expected to be close to natural water content

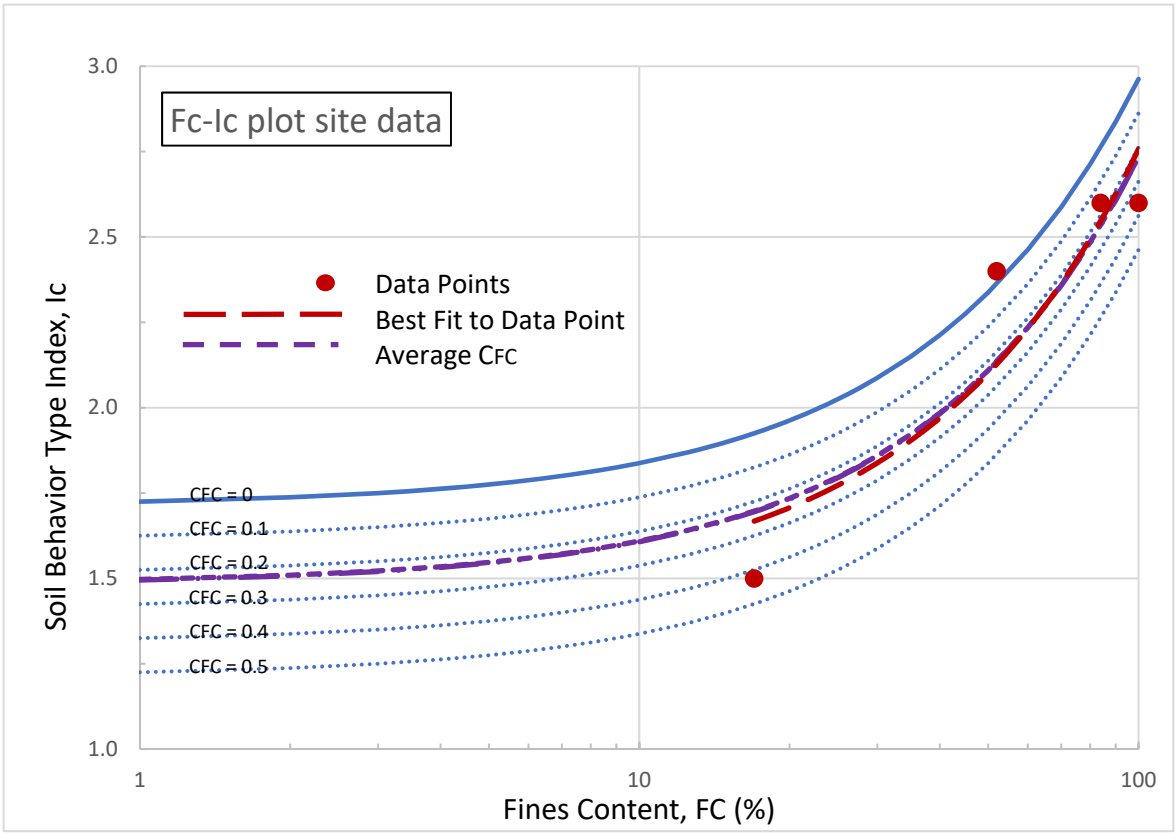
Site 33 - 200 Cashmere Road

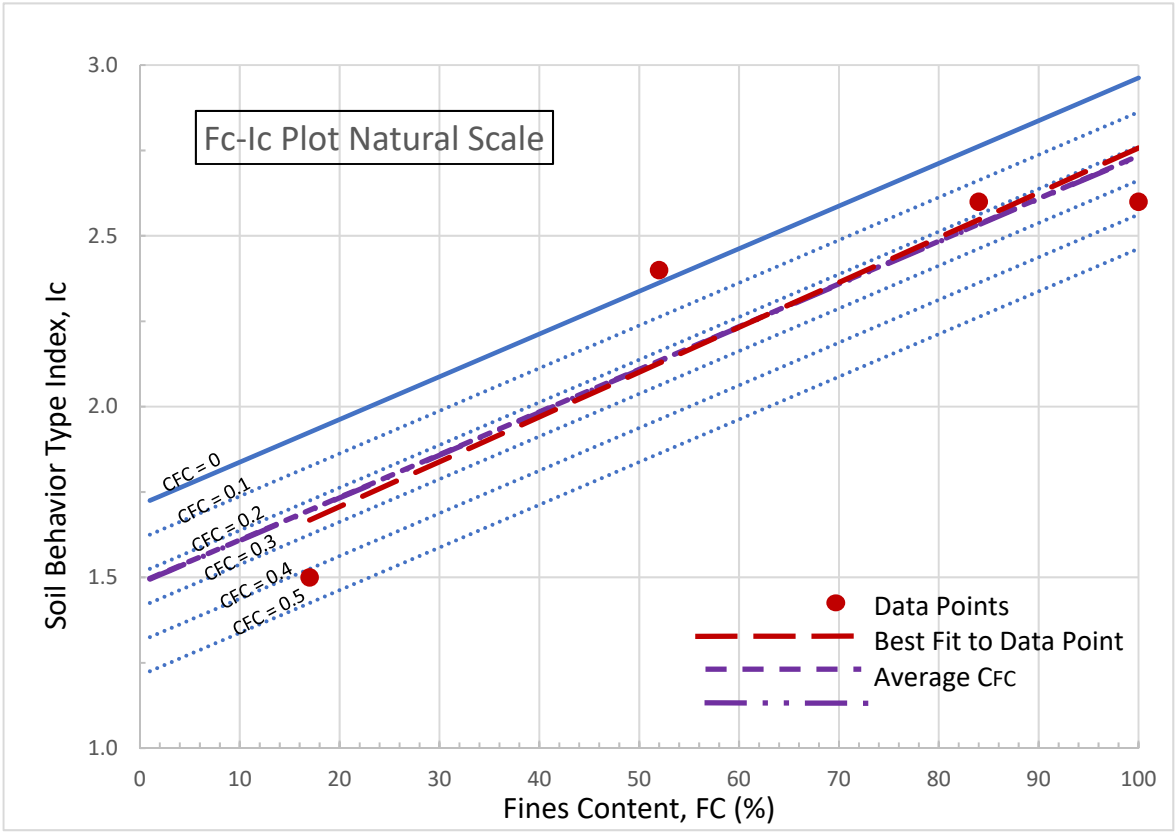
Depth	Description	PI	FC	WS	Full PSD	WC	Hyd	Approx CPT I_C	Vis Insp	Zip Lock Core	Fines content results (75µm)	Lab
2.05 - 2.15m	Clayey SILT/Silty CLAY; minor cyclic softening	X			X	X		3.05			100%	Geotechnics
3.80 - 3.90m	SAND with some silt; classic liquefaction		X	X		X		1.50			17%	Geotechnics
4.05 - 4.15m	SILT, with minor sand; low plasticity, quick.	X	X			X		2.85		Yes	96%	Geotechnics
4.90 - 5.00m	Silty fine SAND; classic liquefaction, non-plastic			X		X		2.40			52%	Geotechnics
5.50 - 5.60m	Low plasticity, softening, without dilation	X			X	X		2.60		Yes	84%	Geotechnics
5.90 - 6.00m	Clayey SILT; low PI, cyclic softening, not much dilatancy, MH?, elastic silt?, ~100% fines	X				X		2.60	Yes		100%	Geotechnics
7.40 - 7.50m	Clayey SILT; low to moderate PI, minor cyclic softening,~100% fines	X			X	X		3.30			99%	Geotechnics

Fines Content vs Ic Analysis

GEOTECH CONSULTING LTD

Project:	Cashmere Park Subdivision	**Borehole No:**	38197
Client:	Cashmere Park Trust	**Job No:**	3933

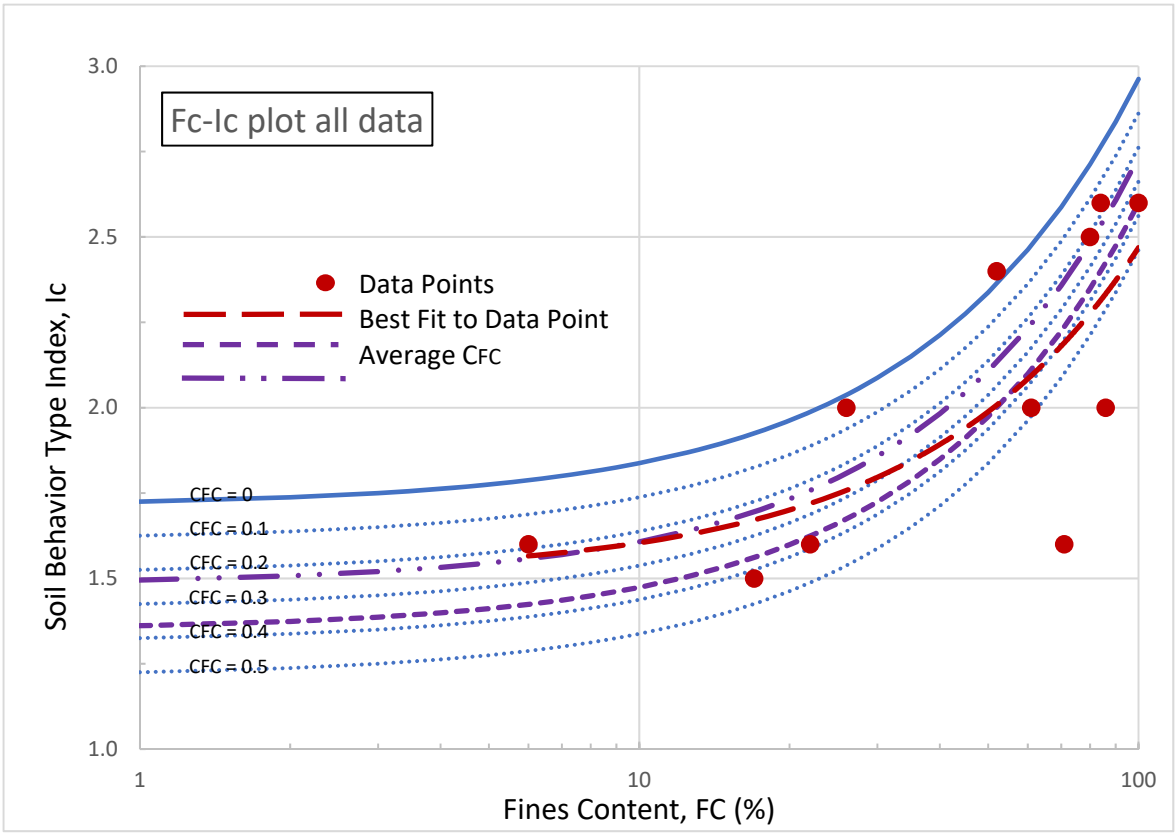


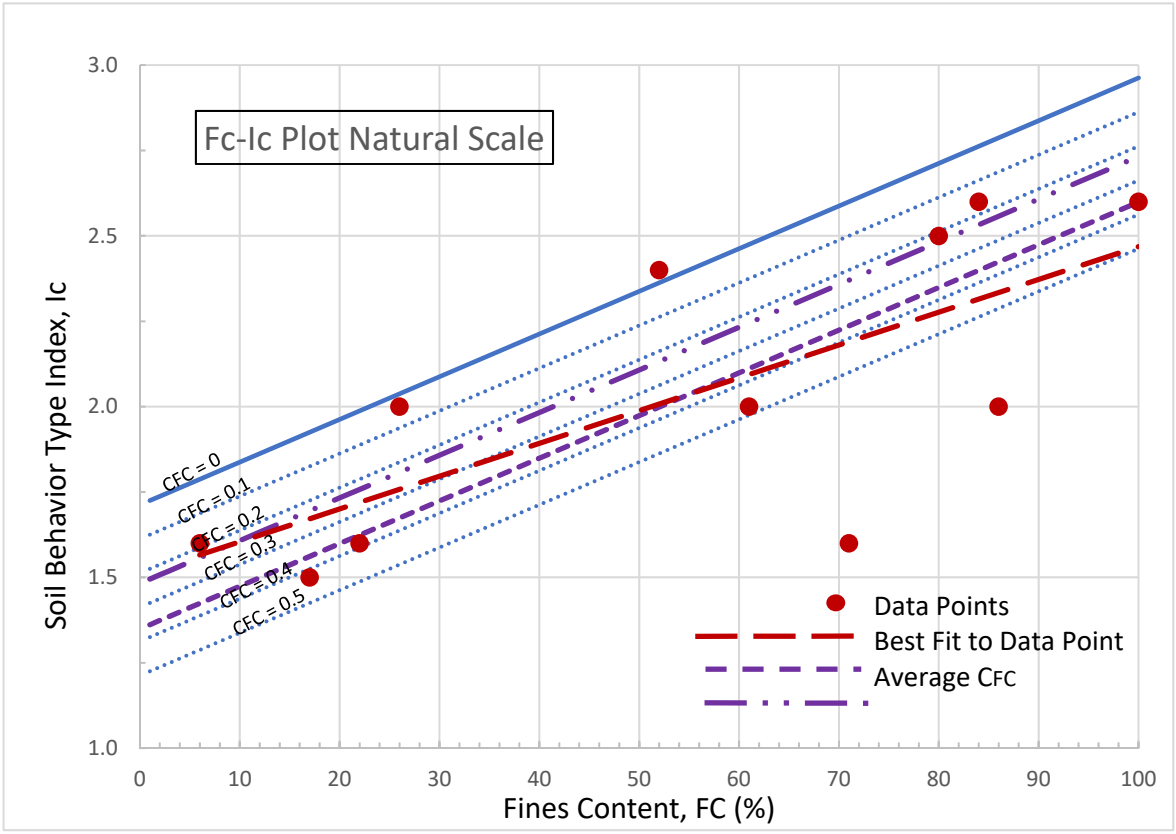


Fines Content vs Ic Analysis

GEOTECH CONSULTING LTD

Project:	Cashmere Park Subdivision	**Borehole No:**	All
Client:	Cashmere Park Trust	**Job No:**	3933





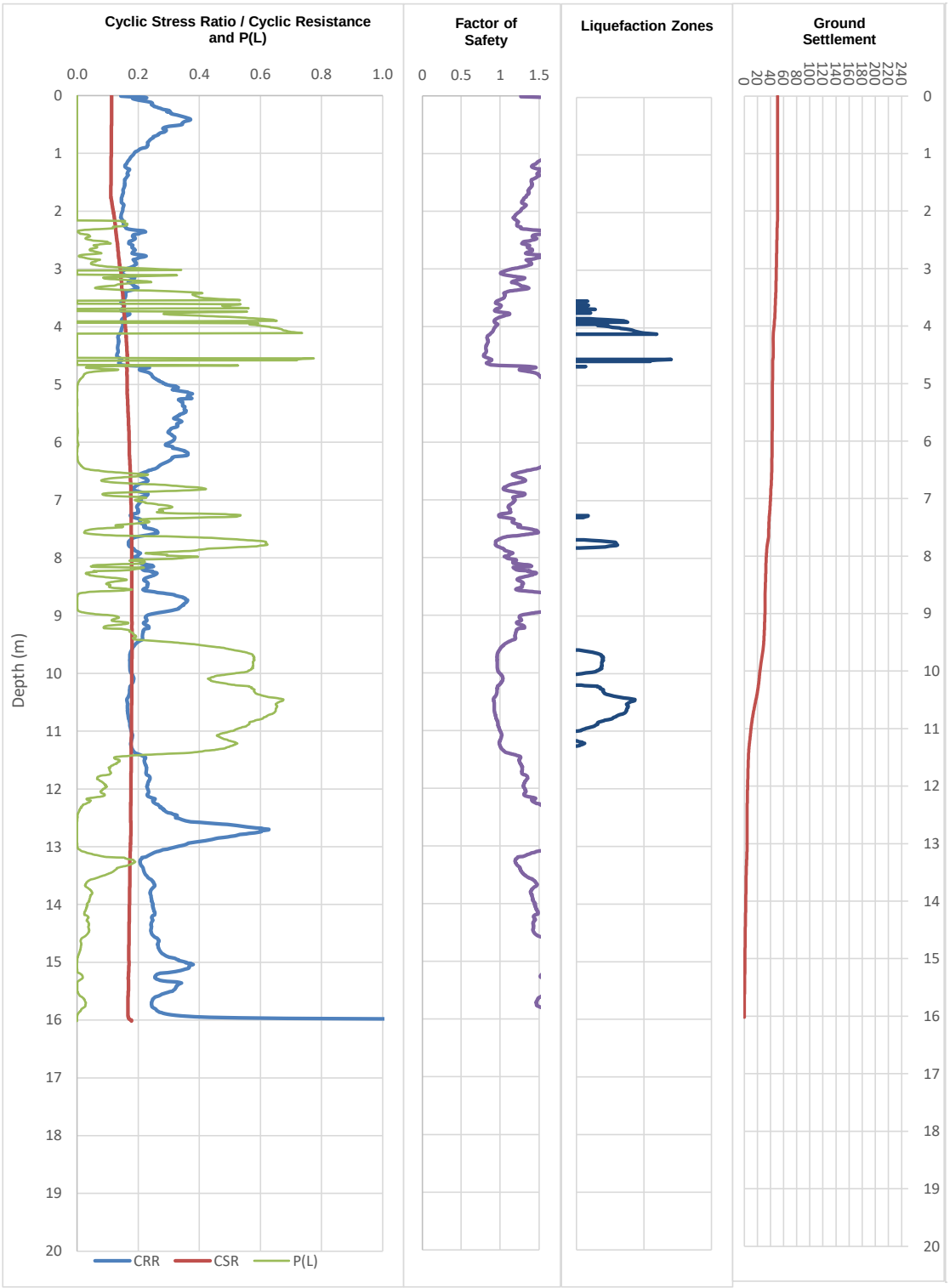
Appendix 4

Liquefaction Profiles

Liquefaction Potential Analysis

GEOTECH CONSULTING LTD

Project:	Cashmere Fields Rezoning	Hole No:	**CPT 02**
Client:	W Lewis	Job No:	3933

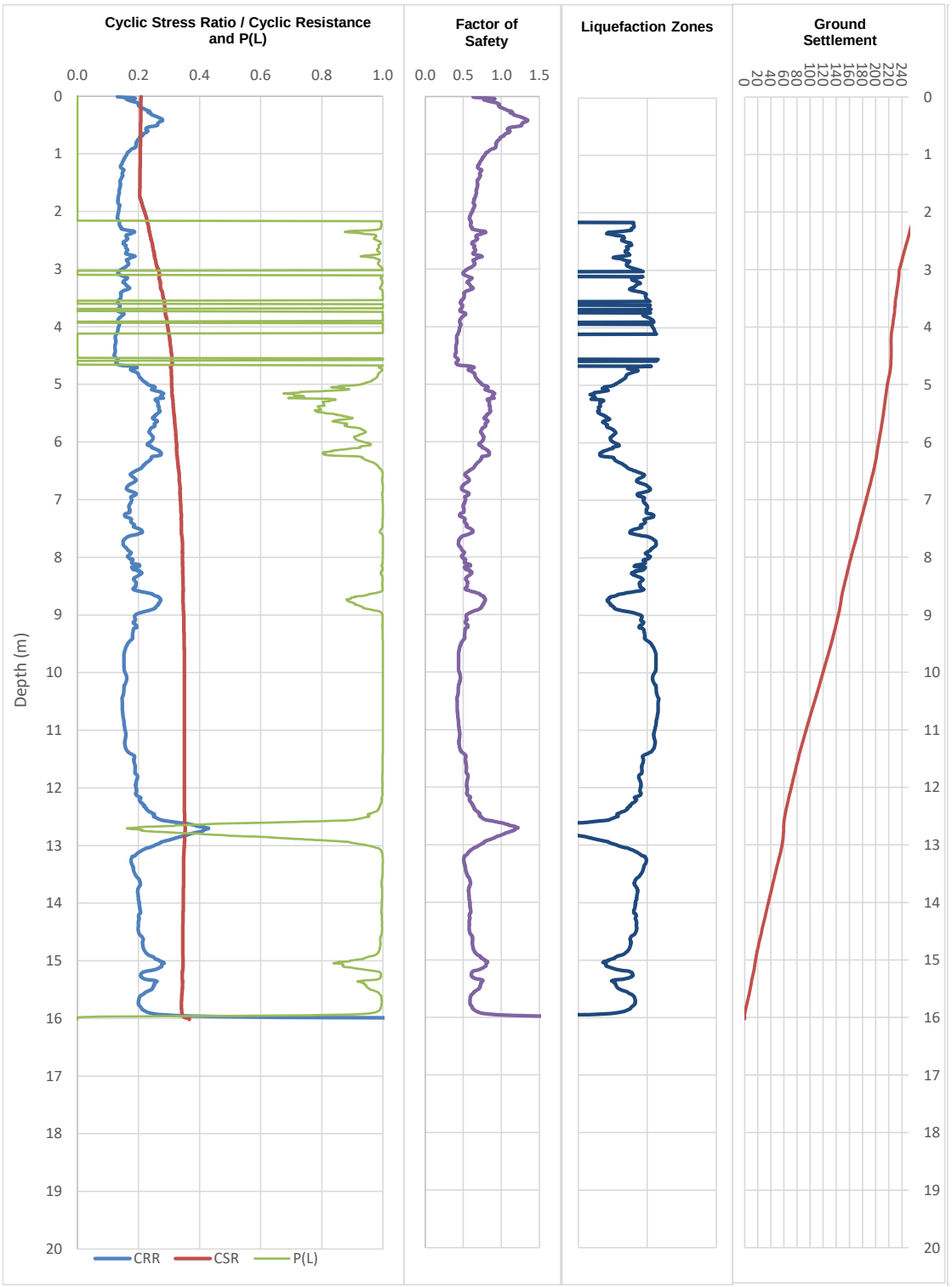


Based on Idriss & Boulanger (2014) and Zhang (2002)

SLS 25yr

a(g) = 0.19 M 6

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Rezoning	Hole No:	**CPT 02**
	Client:	W Lewis	Job No:	3933



Based on Idriss & Boulanger (2014) and Zhang (2002)

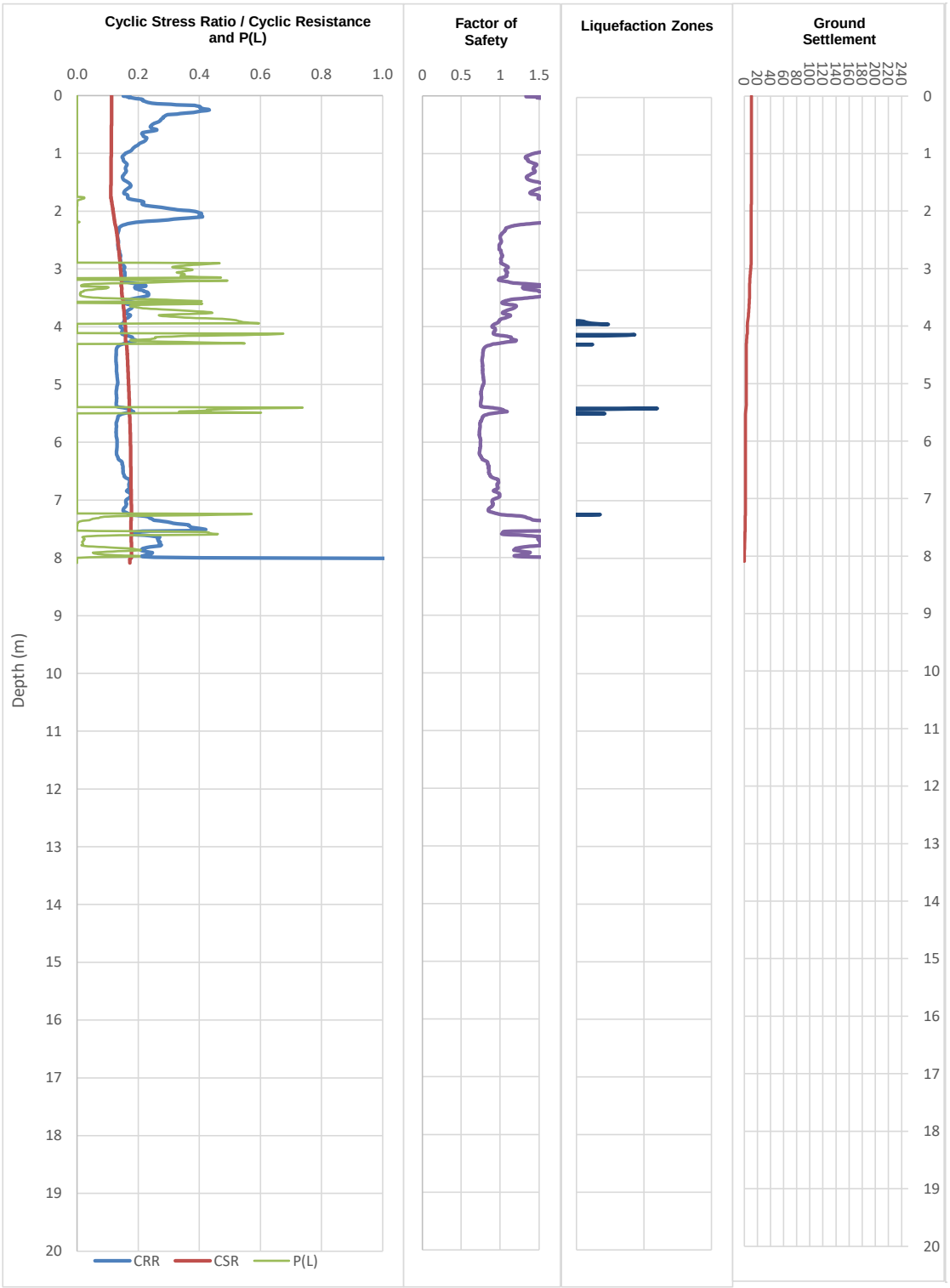
ULS 500 yrs

a(g) = 0.35 M 7.5

Liquefaction Potential Analysis

GEOTECH CONSULTING LTD

Project:	Cashmere Fields Rezoning	Hole No:	**CPT 06**
Client:	W Lewis	Job No:	3933



Based on Idriss & Boulanger (2014) and Zhang (2002)

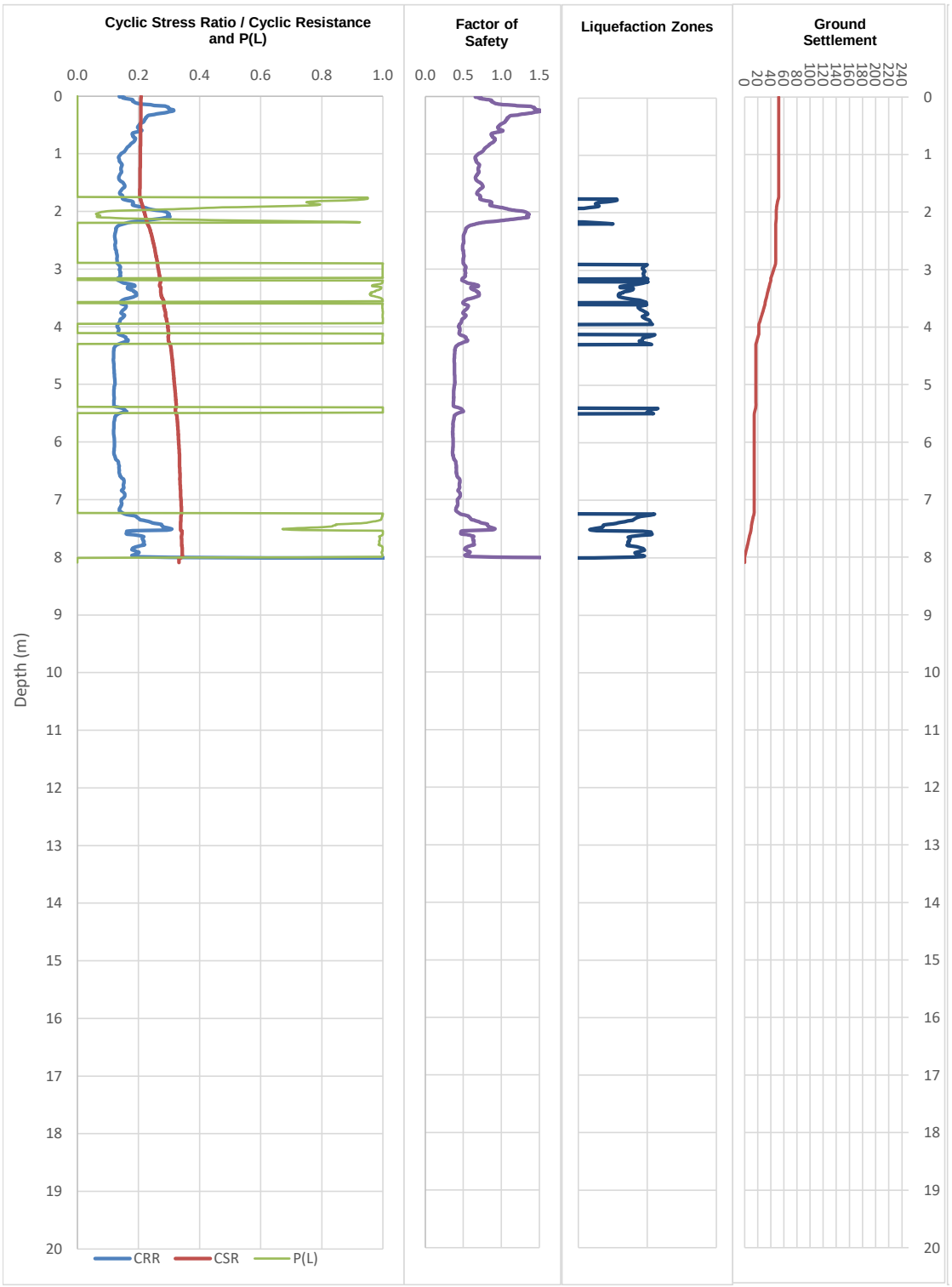
SLS 25yr

a(g) = 0.19 M 6

Liquefaction Potential Analysis

GEOTECH CONSULTING LTD

Project:	Cashmere Fields Rezoning	Hole No:	**CPT 06**
Client:	W Lewis	Job No:	3933

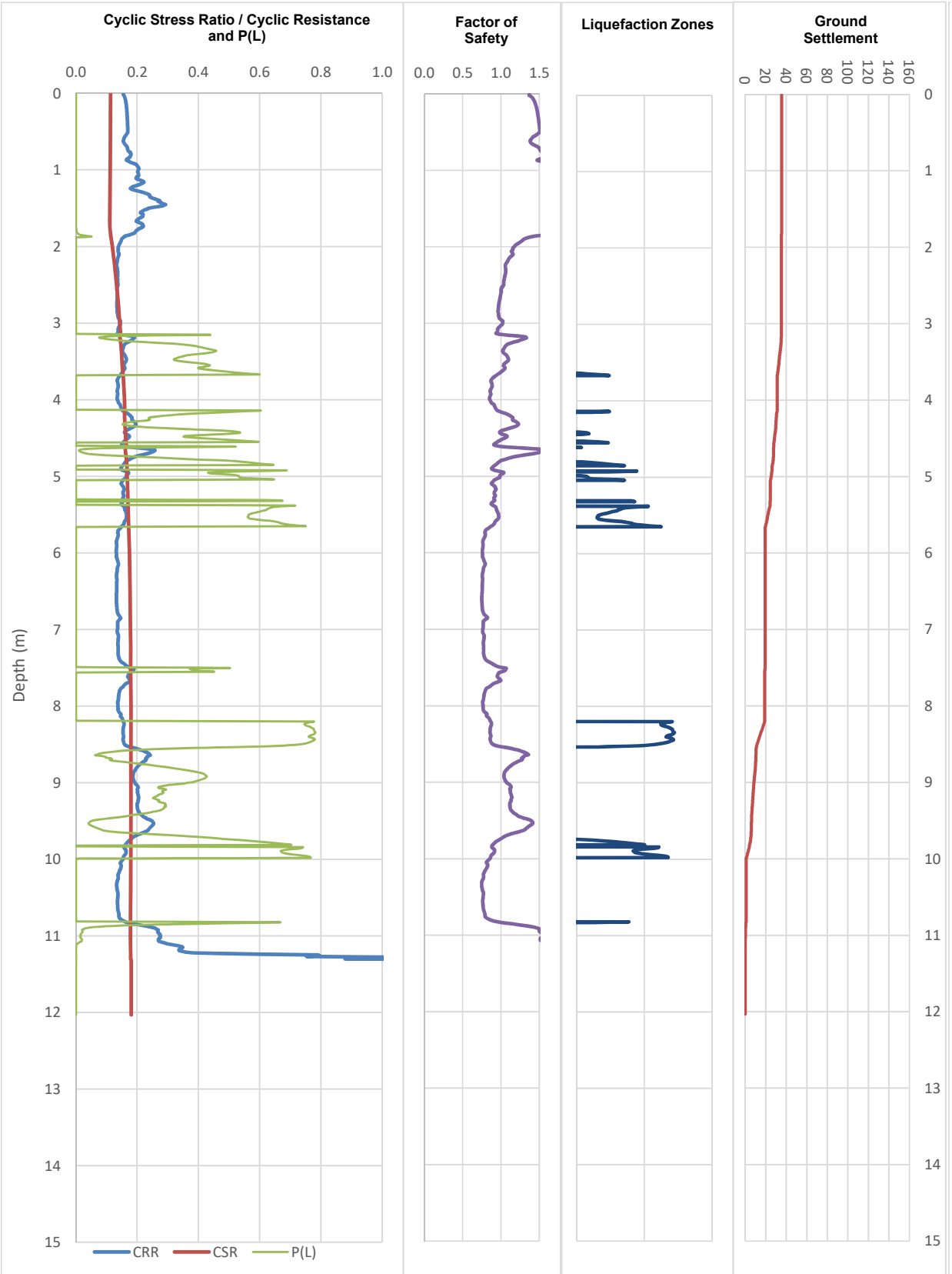


Based on Idriss & Boulanger (2014) and Zhang (2002)

ULS 500 yrs

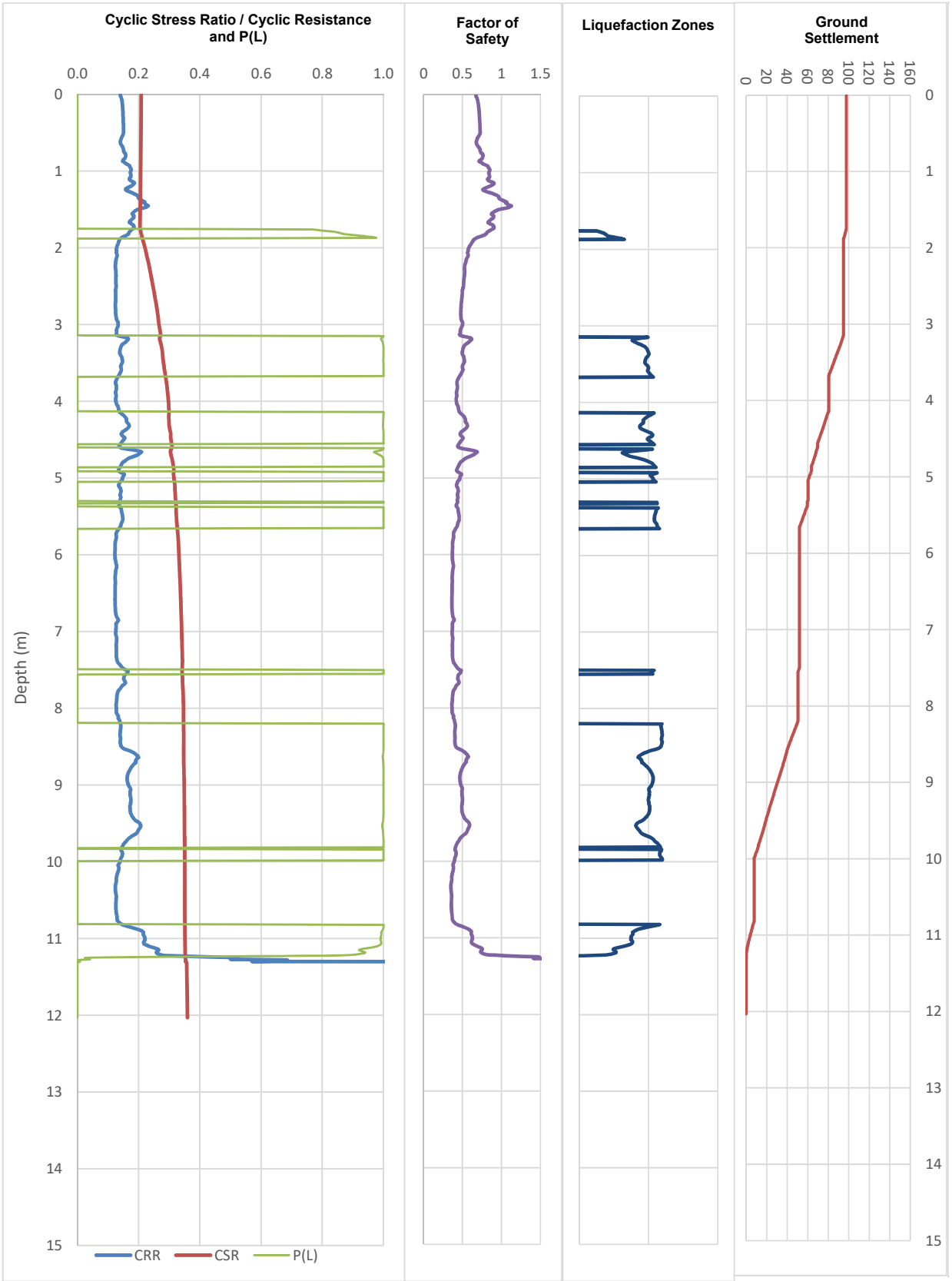
a(g) = 0.35 M 7.5

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Park Subdivision	Hole No:	**CPT 10**
	Client:	Cashmere Park Trust	Job No:	3933



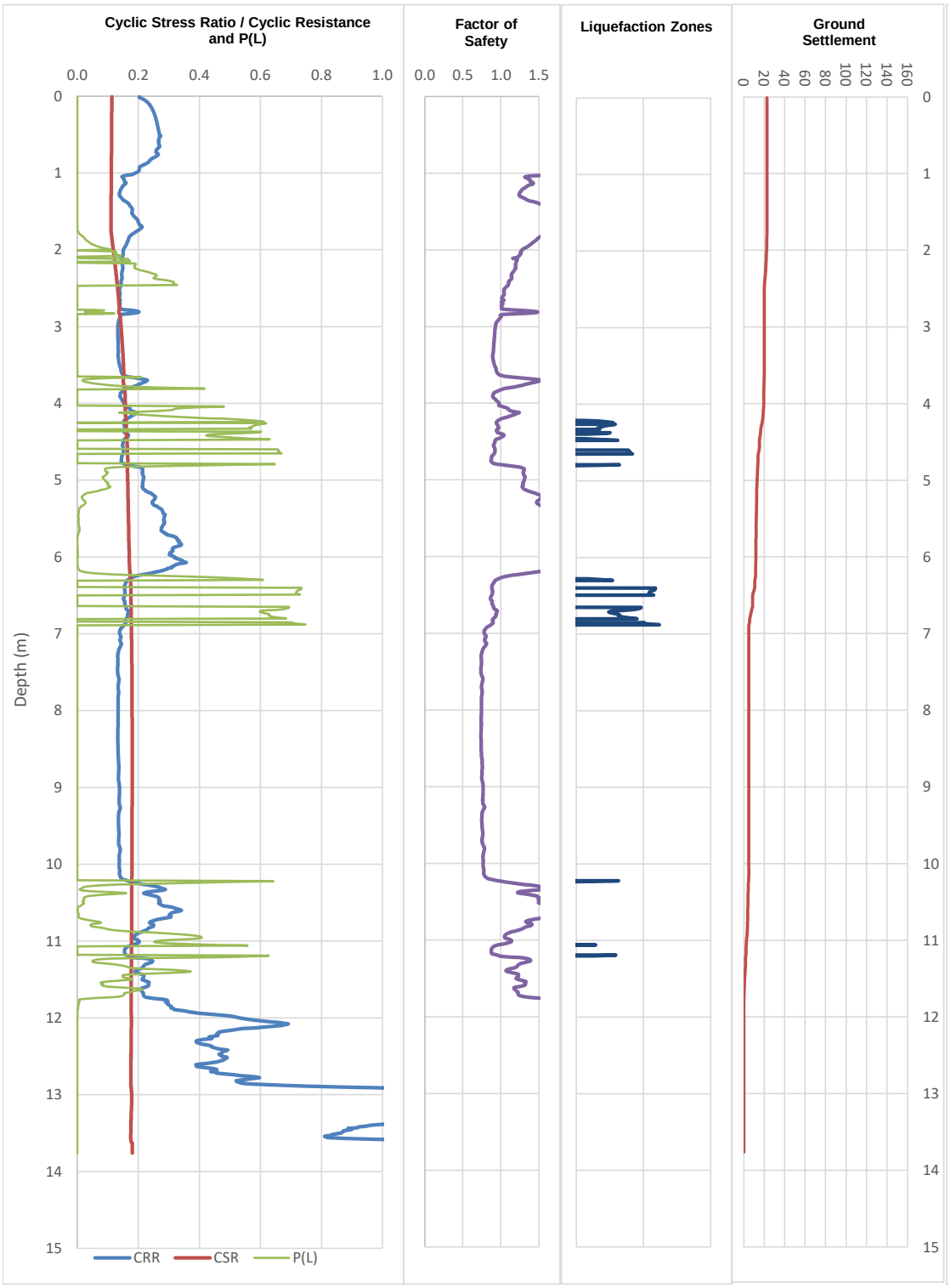
Based on Idriss & Boulanger (2014) and Zhang (2002)		**SLS**
	a(g) = 0.19	M 6

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Park Subdivision	Hole No:	CPT 10
	Client:	Cashmere Park Trust	Job No:	3933



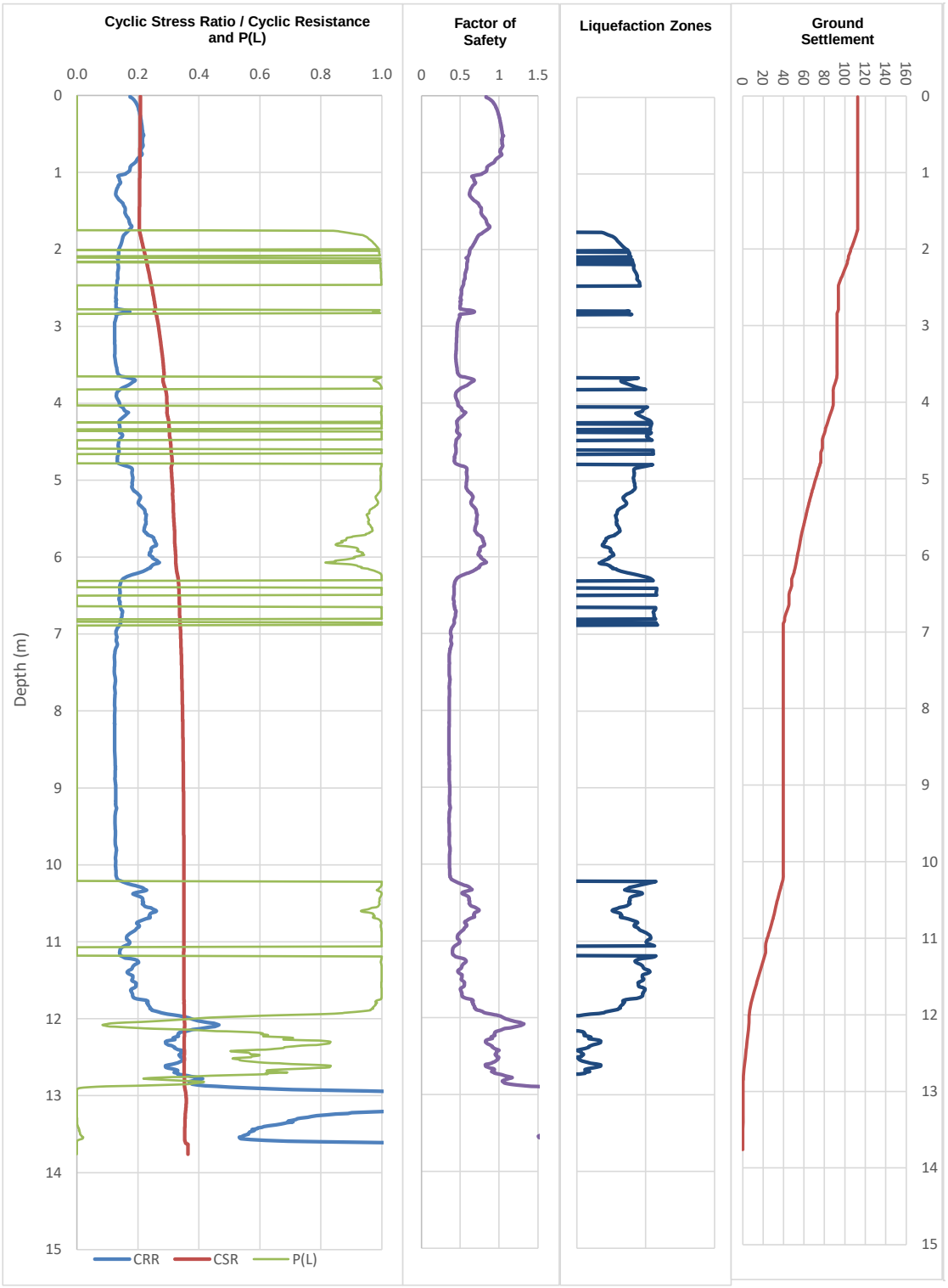
Based on Idriss & Boulanger (2014) and Zhang (2002)		**ULS 1 in 500 yr**
	a(g) = 0.35	M 7.5

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 14**
	Client:	Cashmere Park Trust	Job No:	3933



Based on Idriss & Boulanger (2014) and Zhang (2002)	**SLS**	
	a(g) = 0.19	M 6

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 14**
	Client:	Cashmere Park Trust	Job No:	3933

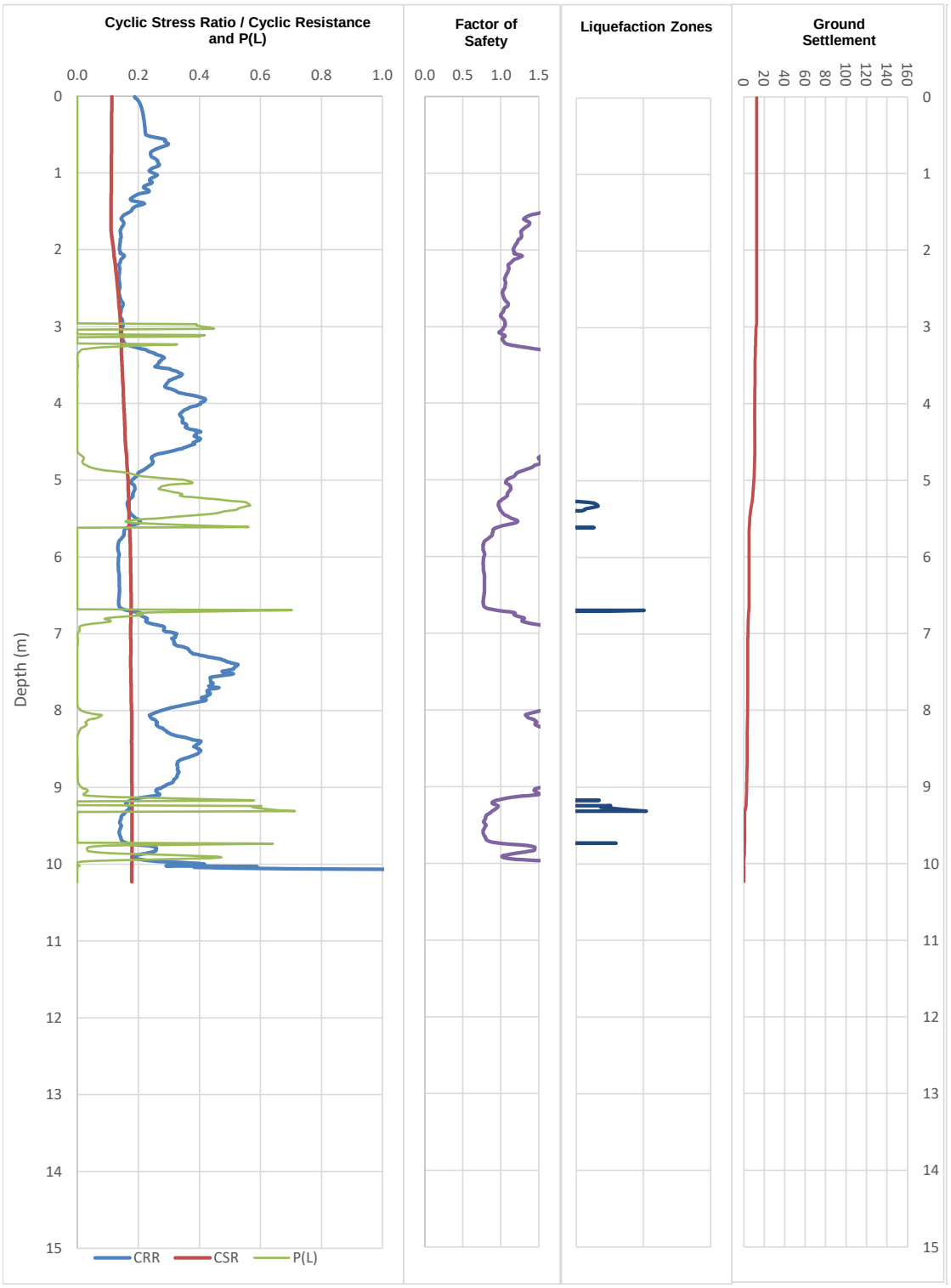


Based on Idriss & Boulanger (2014) and Zhang (2002)

ULS 1 in 500 yr

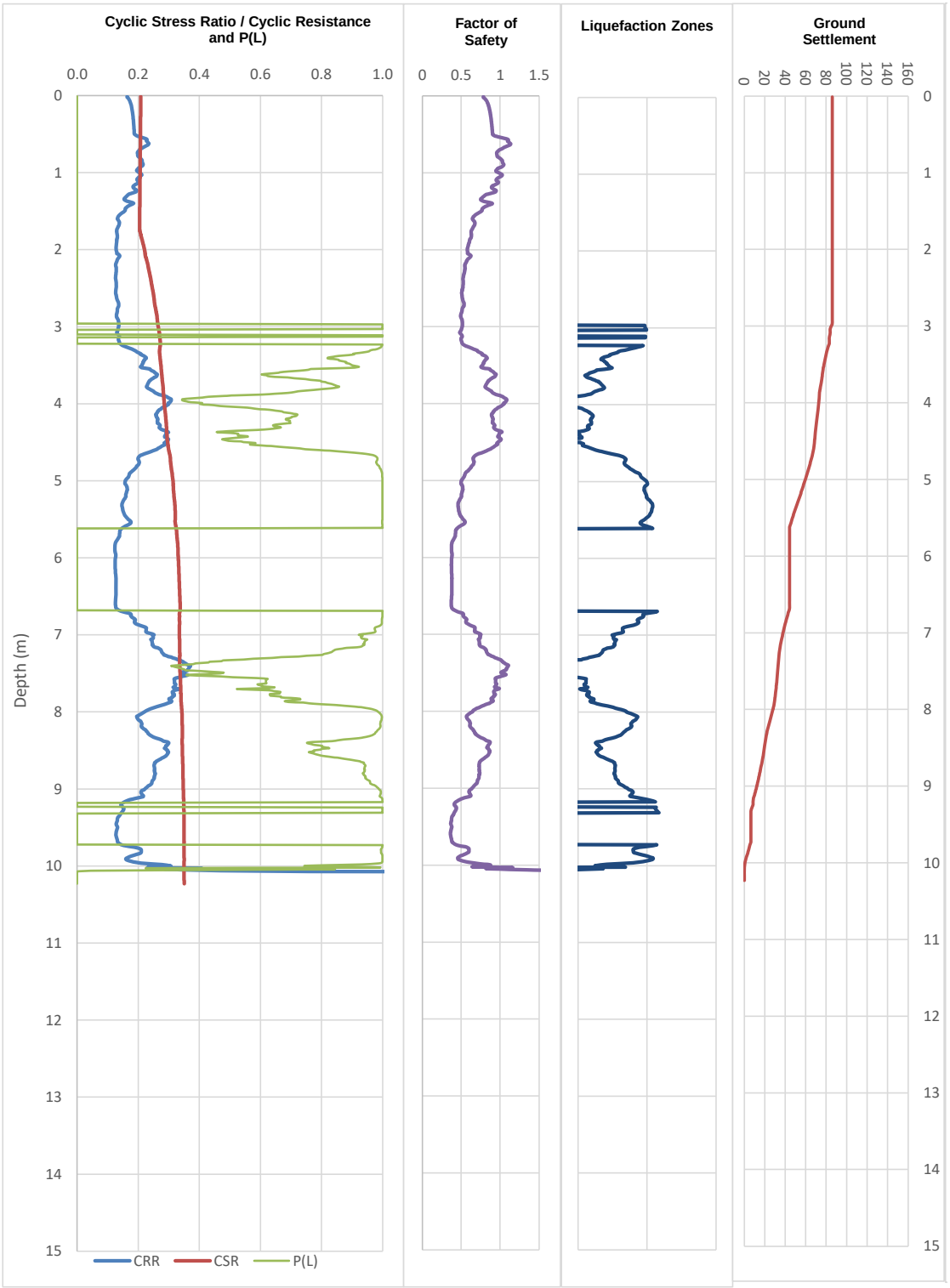
a(g) = 0.35 M 7.5

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 19**
	Client:	Cashmere Park Trust	Job No:	3933



Based on Idriss & Boulanger (2014) and Zhang (2002)	**SLS**	
	a(g) = 0.19	M 6

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Subdivision	Hole No:	**CPT 19**
	Client:	Cashmere Park Trust	Job No:	3933

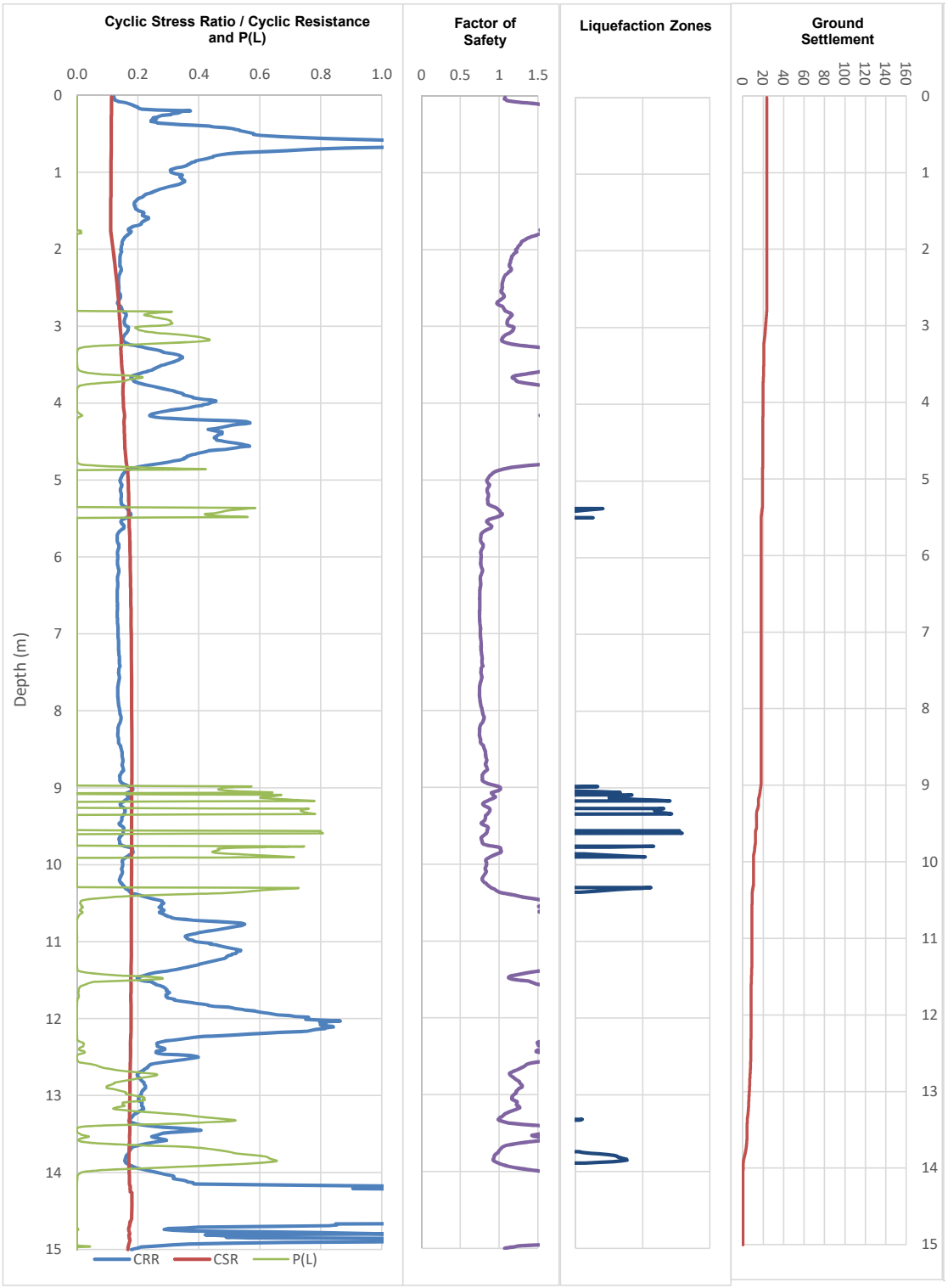


Based on Idriss & Boulanger (2014) and Zhang (2002)

ULS 1 in 500 yr

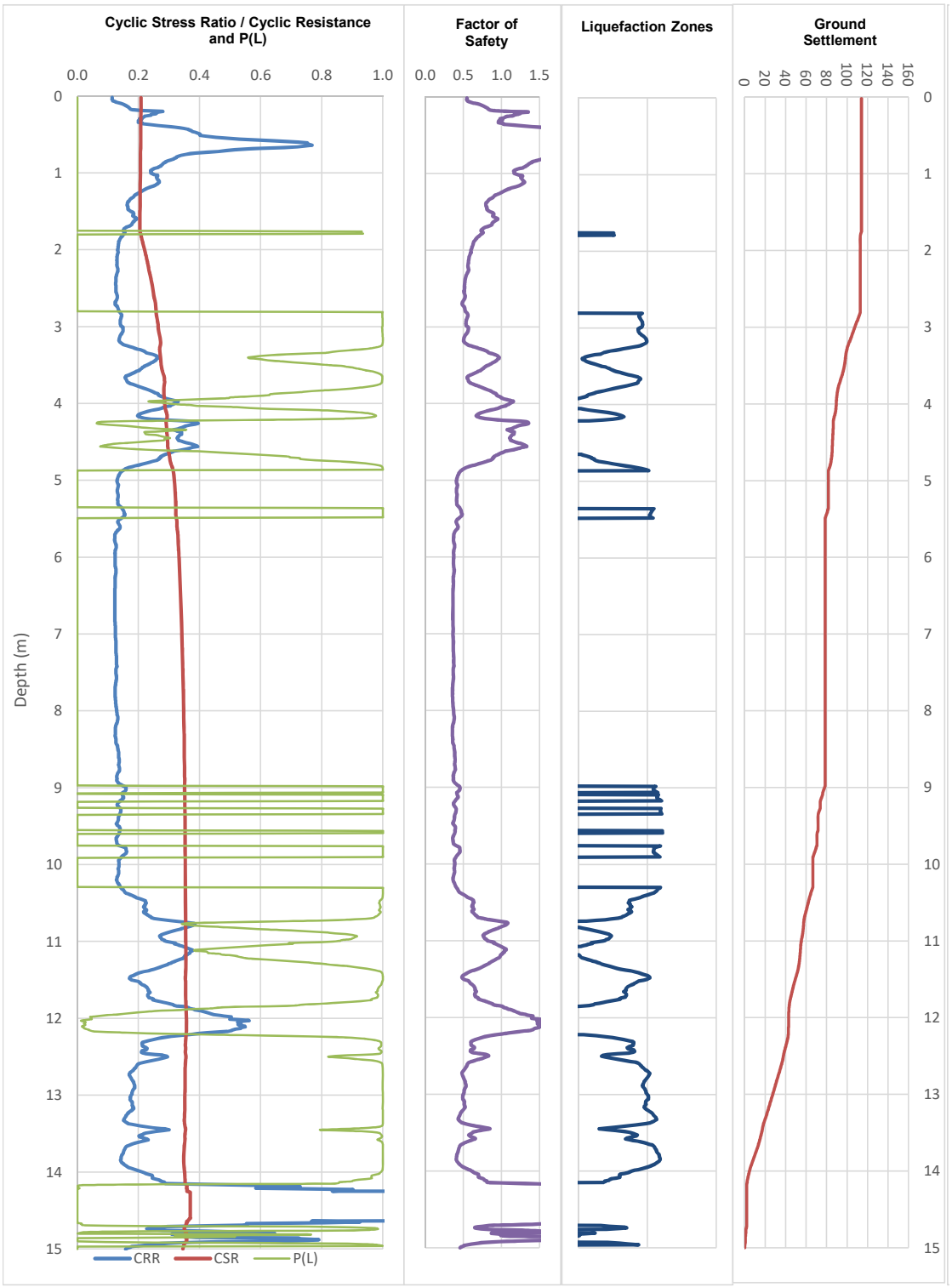
a(g) = 0.35 M 7.5

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 24**
	Client:	Cashmere Park Trust	Job No:	3933



Based on Idriss & Boulanger (2014) and Zhang (2002)		**25 years**
	a(g) = 0.19	M 6

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields	Hole No:	**CPT 24**
	Client:	Cashmere Park Trust	Job No:	3933

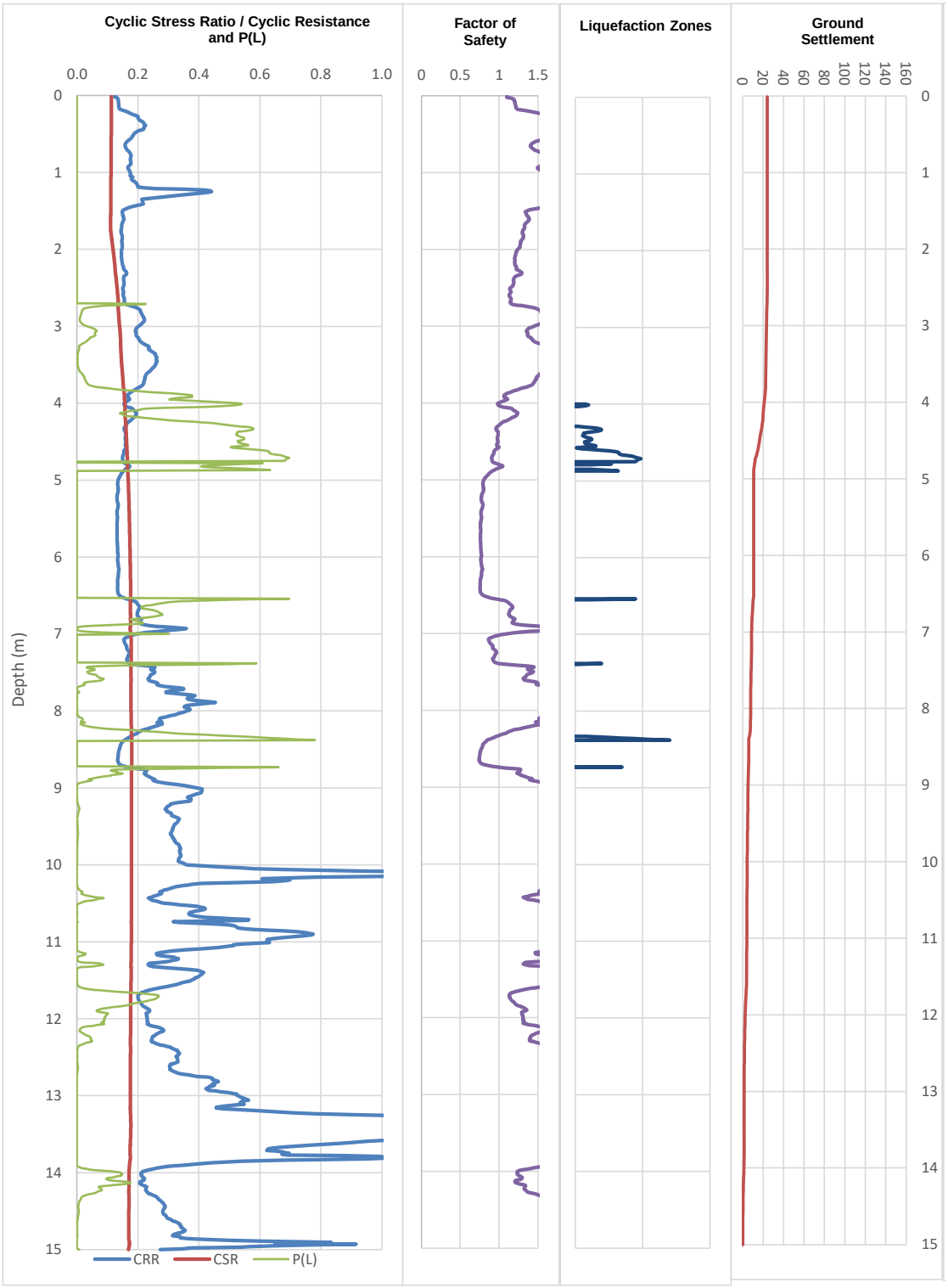


Based on Idriss & Boulanger (2014) and Zhang (2002)	**500 yrs**
a(g) = 0.35	M 7.5

Liquefaction Potential Analysis

GEOTECH CONSULTING LTD

Project:	Cashmere Fields Rezoning	Hole No:	**CPT 23-03**
Client:	Cashmere Park Ltd	Job No:	3933

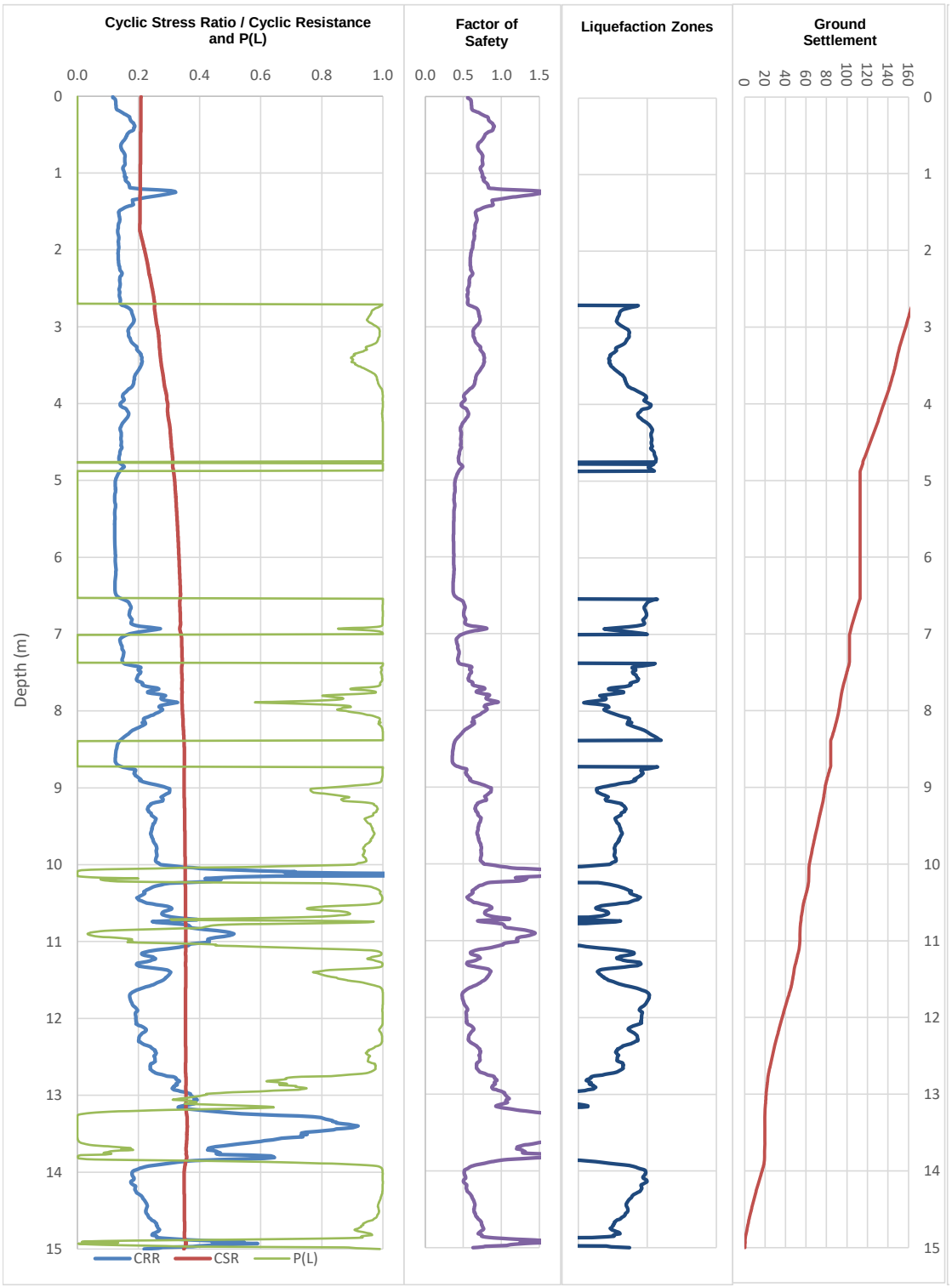


Based on Idriss & Boulanger (2014) and Zhang (2002)

25 years

a(g) = 0.19 M 6

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Rezoning	Hole No:	**CPT 23-03**
	Client:	Cashmere Park Ltd	Job No:	3933



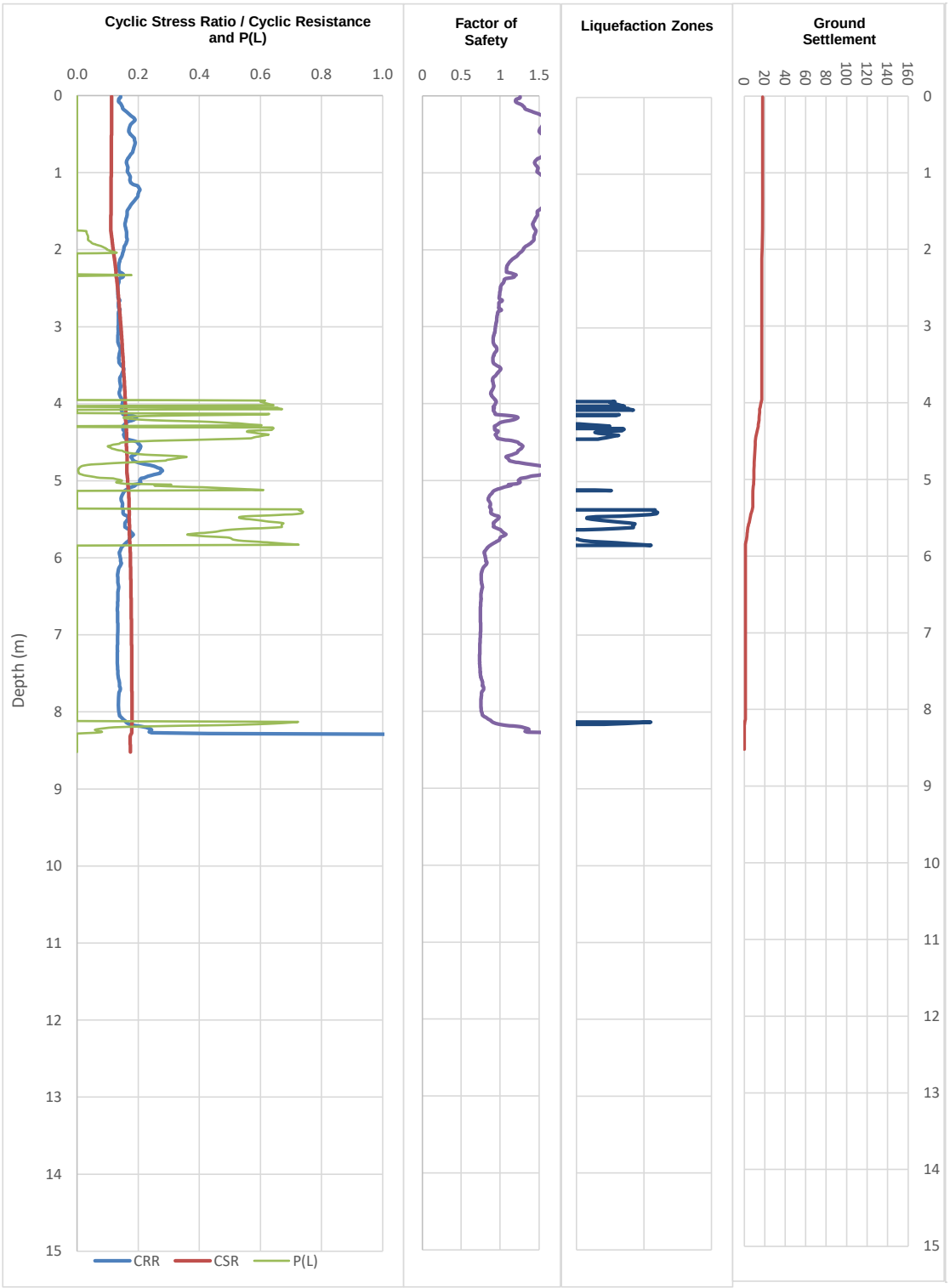
Based on Idriss & Boulanger (2014) and Zhang (2002) **500 yrs**

a(g) = 0.35 M 7.5

Liquefaction Potential Analysis

GEOTECH CONSULTING LTD

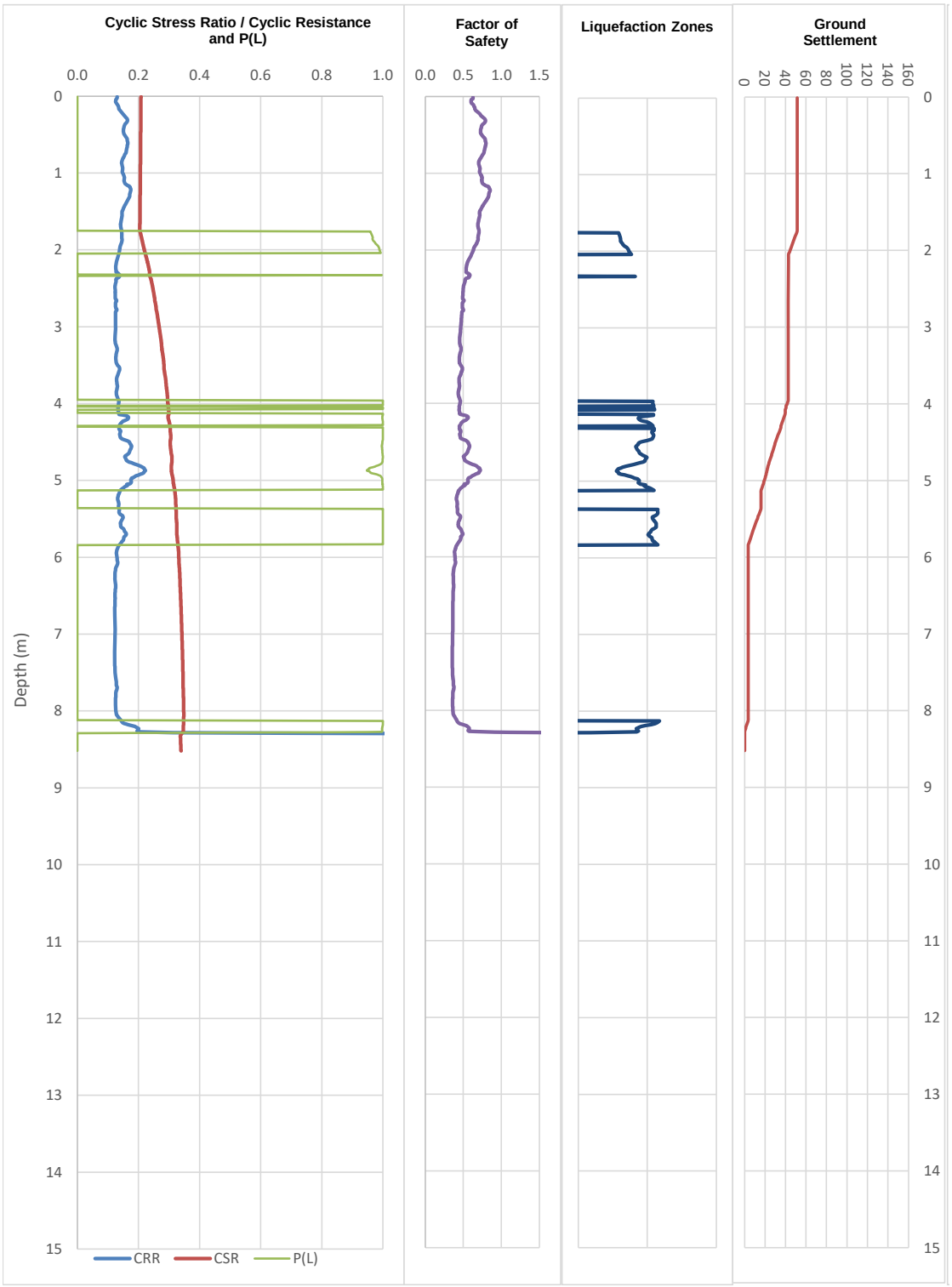
Project:	Cashmere Fields Rezoning	Hole No:	**CPT 23-06**
Client:	Cashmere Park Ltd	Job No:	3933



Based on Idriss & Boulanger (2014) and Zhang (2002) **25 years**

a(g) = 0.19 M 6

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Rezoning	Hole No:	**CPT 23-06**
	Client:	Cashmere Park Ltd	Job No:	3933



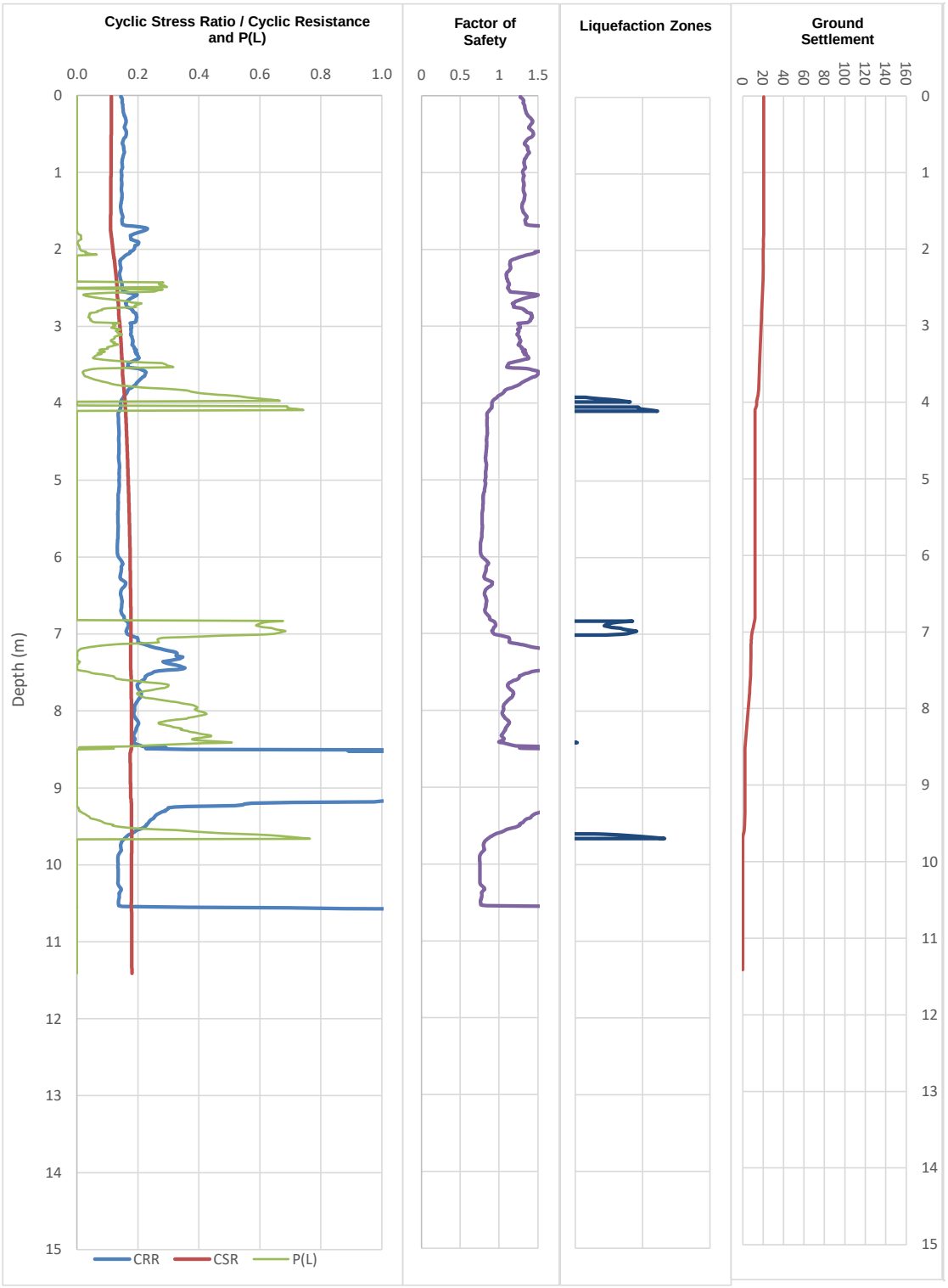
Based on Idriss & Boulanger (2014) and Zhang (2002) **500 yrs**

a(g) = 0.35 M 7.5

Liquefaction Potential Analysis

GEOTECH CONSULTING LTD

Project:	Cashmere Fields Rezoning	Hole No:	**CPT 23-09**
Client:	Cashmere Park Ltd	Job No:	3933

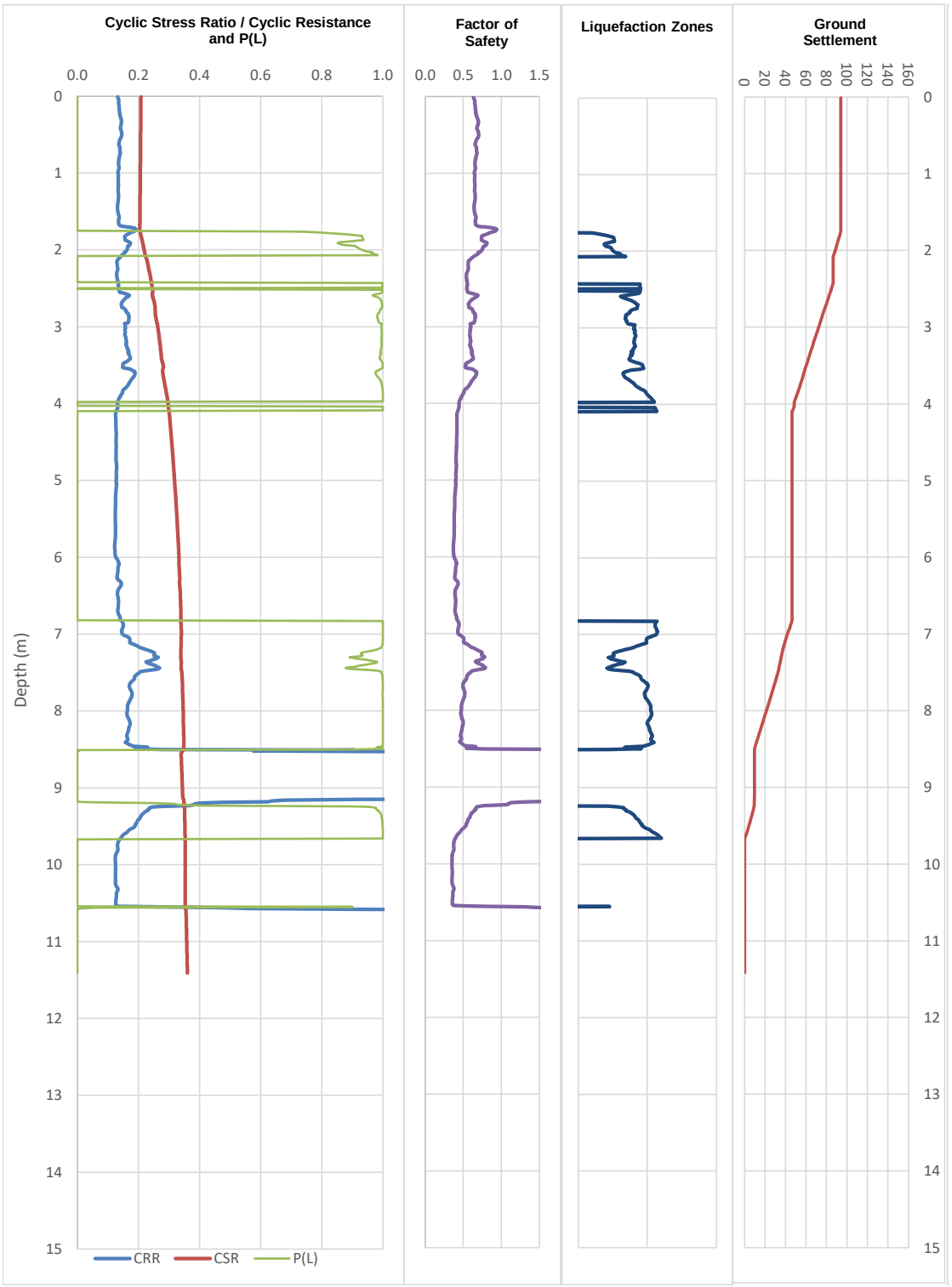


Based on Idriss & Boulanger (2014) and Zhang (2002)

25 years

a(g) = 0.19 M 6

GEOTECH	Liquefaction Potential Analysis			
	GEOTECH CONSULTING LTD			
	Project:	Cashmere Fields Rezoning	Hole No:	**CPT 23-09**
	Client:	Cashmere Park Ltd	Job No:	3933



Based on Idriss & Boulanger (2014) and Zhang (2002) **500 yrs**

a(g) = 0.35 M 7.5