Appendix I - Geotechnical Investigation Reports prepared by CMW Geosciences

7 May 2019

Lockerbie Farm Development
Studholme Street, Morrinsville

GEOTECHNICAL INVESTIGATION REPORT

Lockerbie Estates Limited

HAM2018-0139AB Rev 0

HAM2018-0139AB		
Date	**Revision**	**Comments**
7 May 2019	0	Final Report for client review

	Name	**Signature**	**Position**
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EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation and geohazards assessment for a proposed residential subdivision development at Lockerbie Far,m located off Studholme Street, Morrinsville.

Based on the investigation results, the site is generally underlain by stiff to hard silt and clay soils of the Walton sub group, up to 17.4m deep with dense to very dense sand present at greater depths.

Recent alluvium is locally contained within streams and gully bases. While Peria Formation soils were shown on the published geology in the southern portion of the site, these materials were not encountered during our site investigation.

Design details / recommendations for geotechnical aspects of the development are summarised as follows:

- The risk of liquefaction induced settlement, cyclic softening and lateral spreading during an ultimate limit state or ULS (1 in 500 year) earthquake event is considered low;
- No slope stability issues are expected for the post construction proposed contours for the southern part of the site, or for the northern part of the site if post construction gradients are similar. There is a local slope stability risk adjacent to stream banks and a range of options to reduce this risk are outlined within the report.
- The cut material is generally considered suitable for constructing engineered fills. However they ar sensitive to remoulding and moisture increase and care must be exercised by the earthworks contractor to suitably manage the soils during construction.
- Underfill / subsoil drainage is to be installed where fill is to be placed over the lower-lying areas ans springs;
- Induced settlements from the proposed fill embankments are not are not generally expected to be significant. However locally significant fill induced ground settlements may occur under deeper fills. This should be reassessed following confirmation of cut to fill levels, and settlement monitoring of deeper fill areas may be required;
- Building load induced settlements should be within NZ Building Code limits;
- A preliminary geotechnical ultimate bearing pressure of 300kPa should be available for shallow strip and pad foundations constructed within both the natural cut ground and suitably engineered fill areas;
- Soakage rates are considered suitable to provide a seepage function for the design of attenuation ponds subject to further specific design. It is our opinion that greater soakage rates may be possible in deeper sand layers and further soakage testing is recommended at detailed design stage;
- Further works should include laboratory testing for earthworks including, standard compaction testing, solid densities and moisture contents in proposed borrow materials, plus penetration resistance testing and laboratory soaked CBR testing for road subgrade design purposes.
- The qualitative assessment of natural risk hazard for the site is low to medium for all hazards considered.

The variable soil type with depth will require a close level of geotechnical engineering site observation during earthworks, particularly in deeper cuts.

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1 INTRODUCTION

1.1 Project Brief

CMW Geosciences (CMW) was engaged by Lockerbie Estates Limited to carry out a geotechnical investigation of a site located off Studholme Street, Morrinsville, which is being considered for the construction of a residential subdivision.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced HAM2018-0139AA Rev0 dated 21 December 2018.

This report is to support a resource consent application to Matamata Piako District Council and provides the basis for the Suitability Statement in Section 8.

1.2 Scope of Work

As detailed in our proposal, the instructed scope of work to be conducted by CMW was defined as follows:

- A desktop study of available information relevant to the proposed development;
- Arrange and execute a geotechnical site investigation (SI) including field and laboratory testing;
- Evaluate geological conditions and develop appropriate geological cross sections and a geomorphological plan;
- Identify relevant geohazards to the proposed development, including; liquefaction, static settlements, bearing capacity, groundwater issues and provide strategies to mitigate these;
- Provide an assessment of stormwater soakage feasibility;
- Provide requirements for earthworks;
- Provide an assessment of building foundation suitability and appropriate geotechnical parameters for the design of building foundations and pavements;
- Compile all the above detail into a geotechnical investigation report, incorporating relevant plans, field investigation data, laboratory test data and the results of natural hazards risk assessments.

2 SITE DESCRIPTION

2.1 Site Location and Landform

The site comprises an area of approximately 80 Hectares and is accessed from Studholme Street, Morrinsville as shown on Figure 1 below.

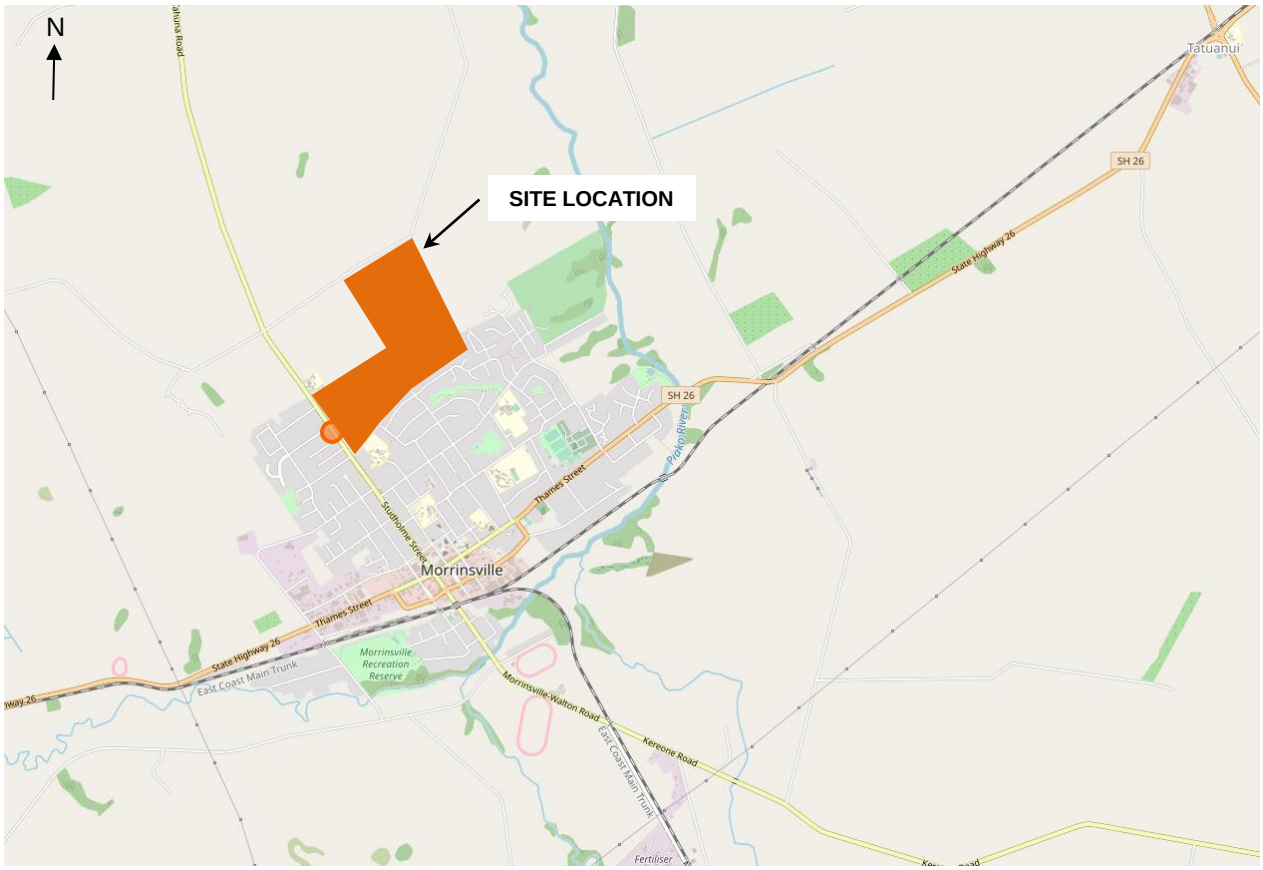


Figure 1: Site Location Plan (Openstreet Maps Image)

The site topography consists low rolling hills and incised shallow gullies, with relatively flat low-lying terraces located in the south-western part of the site.

Ground elevation across the site varies from RL 35m in the northern part to RL 56m in the central rolling hills and back down to RL 35m in the southern corner of the site.

Slope angles are generally moderate with a few steeper slope sections with maximum gradients typically up to 1V:4H present in the elevated south-western corner of the site and adjacent to the incised streams.

The site is bound to the north by Taukoro Road, to the north-west and north-east by farmland, and to the south and south-east by residential buildings.

A stream is present in the south-western corner of the site originating from a spring and flows north to south down a shallow gully and into a culvert beneath Studholme Street.

Two spring fed streams are located in the north-western part of the site and flow in a north-easterly direction. At the time of our investigation each stream was stagnant.

A cowshed and two farm sheds are present in the southern central part of the site with another farm shed located in the central northern part of the site. A residential building and accompanying garage are present centrally on the southern boundary of the site.

Two effluent ponds are present in the central part of the site approximately 30m north of the cowshed.

There is a row of large trees roughly parallel to the southern site boundary of the site. We understand that these trees are to remain as part of the development.

3 PROPOSED DEVELOPMENT

At the time of undertaking this investigation and of writing this report the project was in the early stages of planning and it is anticipated that the results of this geotechnical investigation would contribute to developing preliminary feasibility options for the proposed residential subdivision with associated roading and infrastructure.

No architectural or engineering design drawings have been supplied to date.

A block layout and yield plan for the site and conceptual contour plans for the southern part of the site have been provided by Transurban Ltd and copies of these are presented in **Appendix A**.

These plans indicate that the future development will broadly comprise a series of cuts of up to 4m height and fills of up to 5m depth to reduce slope gradients. These plans identify potential locations for stormwater attenuation and soakage ponds in the northern and southern parts of the site.

We anticipate similar cut and fill depths for the northern part of the site.

4 INVESTIGATION SCOPE

4.1 Desktop Study

The desktop study comprised a review of provided and publicly available aerial photography, geological and historic maps to help assess the potential natural hazards affecting the site.

4.2 Field Investigation

The first stage of field investigations was carried out between 22 and 23 January 2019 with a second stage carried out on 19 February and 2 March 2019. All fieldwork was carried out under the direction of CMW Geosciences in general accordance with the NZGS guidance[1].

The scope of fieldwork carried out was as follows:

- A walkover survey of the site by experienced engineering geologists to assess the general landform, site conditions, select test locations and to carry out geomorphological mapping;
- Twenty-four test pits, denoted TP01 to TP24, were excavated using a 12 tonne hydraulic excavator fitted with a 1m wide blade bucket to depths of between 5.2m and 5.8m below existing ground levels. With the exception of TP21 and TP22 each test pit reached the target depth and were terminated at the maximum reach of the excavator. TP21 and TP22 were excavated to depths of 0.4m and 0.7m respectively adjacent to streams to assess the thickness of soft alluvium. Vane shear strength testing was undertaken within the test pits to provide peak and remoulded vane shear strengths and for comparison with CPT data. Representative bulk and disturbed samples were collected at specified depths to provide samples for subsequent laboratory testing. Engineering logs and photographs of the test pits are presented in **Appendix B**;
- Eight Cone Penetrometer Tests (CPT), denoted CPT01 to CPT08, were carried out to depths of up to 20m to help define the ground model beneath the site. The results of the CPT's, presented as traces of tip resistance (qc), friction resistance (fs) and friction ratio are presented in **Appendix C**;
- Seven hand auger boreholes, denoted HA01 to HA07, were drilled using a 100mm diameter auger to target depths of up to 3.0m below existing ground level. The purpose of these boreholes was to visually observe the near surface soil profile and to facilitate in-situ soil permeability testing. Engineering logs

[1] NZ Geotechnical Society (NZGS) "Ground Investigation Specification" Volume 0, April 2017

of the hand auger boreholes are presented in **Appendix B**. In-situ falling head permeability tests were completed in the hand auger boreholes by lining each hole with perforated PVC pipe then filling the holes with water and monitoring the rate of water level fall over time. The results of the permeability tests are presented in **Appendix D**.

All soil descriptions were made by CMW geotechnical engineers in general accordance with NZGS guidelines.[2]

The approximate locations of the respective test pit, CPT and hand auger sites referred to above are shown on the Site Investigation Plan as ***Drawing 01***. Test locations were measured using hand held GPS. Elevations were inferred from the contour plan provided.

4.3 Laboratory Testing

Laboratory testing was carried out generally in accordance with the requirements of NZS4402[3] (where applicable).

All testing was scheduled by CMW and carried out by Roadtest Ltd, an IANZ registered Testing Laboratory.

Details of laboratory testing carried out for this study are presented in **Table 1**.

Table 1: Laboratory Testing Schedule

Type of Test	Test Method	Quantity
Particle size distribution	NZS4402 – 1986 2.8.1 / 2.8.3	2
Atterberg limits	NZS4402 – 1986 2.3 / 2.4 / 2.5	4

Test results are presented in Appendix E.

5 GROUND MODEL

5.1 Published Geology

The published geological map[4] for the area depict the local geology to comprise the following geological soil units:

"*alluvium dominated by primary and reworked, non-welded ignimbrite"* of the Walton Subgroup, and

"moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying terraces" of the Peria Formation as illustrated in **Figure 2** below.

[2] NZ Geotechnical Society (2005), "Field Description of Soil and Rock, Guideline for the field classification and description of soil and rock for engineering purposes"

[3] New Zealand Standard NZS4402 (1986), Methods of testing soils for civil engineering purposes.

[4] Edbrooke, S.W. (compiler) 2005: Geology of the Waikato area. Institute of Geological & Nuclear Sciences 1:250000 geological map 4.

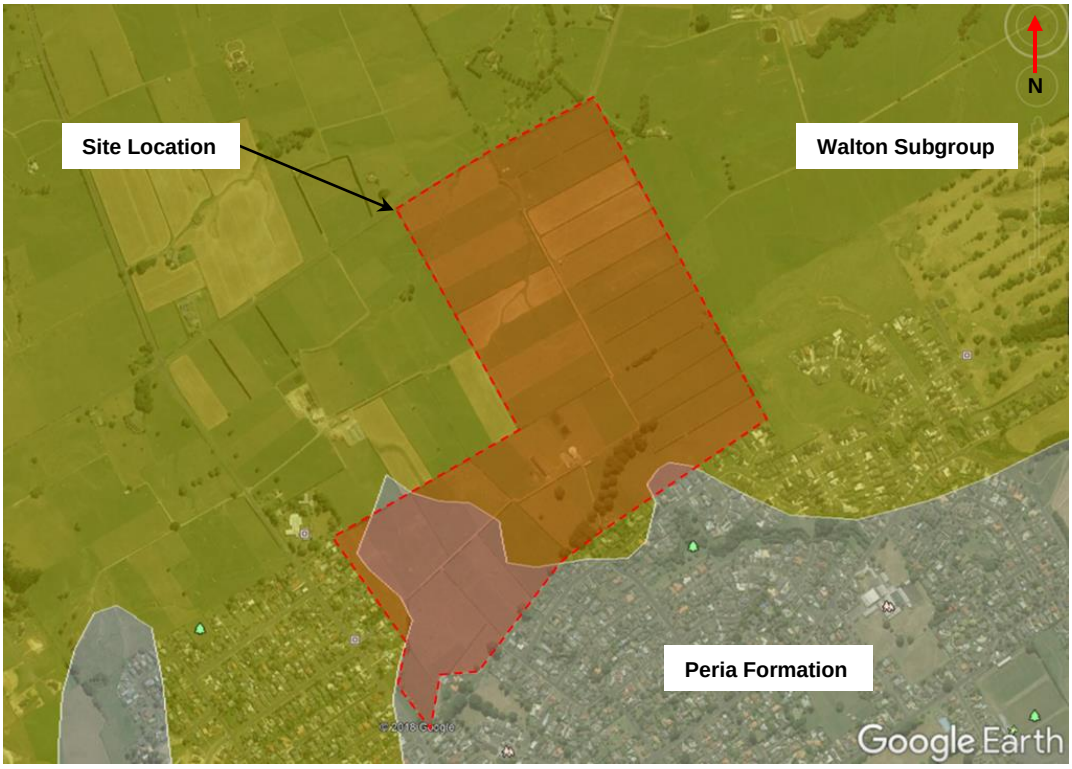


Figure 2: Local Geology (Source: GNS 1:250K geological units map)

5.2 Geomorphology

The geomorphology of the site was mapped by examination of aerial photography, existing contour plans and observations during a site walkover, and is shown in the appended Geomorphology Plan *(**Drawings 02A & 02B**).*

The geomorphology reflects the underlying geology and associated slope processes.

The dominant regional structure at the site comprises low rolling hills which continue to the north, east and west of the site. A main ridge runs in an east to west orientation across the southern part of the site at elevations of between RL 54m and 57m.

An incised gully has been eroded into the hills in the central northern part of the site. The eroded material has washed down into the base of the gully and consolidated as recent alluvium. A spring is located towards the toe of the gully and a second spring is located due west in a low lying area. Both springs feed a stream which flows in a generally northern direction. An area of pugged ground assumed to be swampy in winter months is located towards the gully head and may act as feeder spring in winter months. Two additional areas of pugged/swampy ground are located in low lying areas at the site boundary in the central northern and central southern parts of the site.

In the southern half of the site the ground level falls towards the south and south-west to a minimum elevation to RL 35m. Two prominent gullies orientated north-northeast to south-southwest have been cut into the hills in the south-western corner of the site.

A spring fed stream runs down the western most gully and continues down to the south western corner of the site where it enters a culvert and passes under Studholme Street.

No significant slope movement was observed, however isolated and localised minor slump failures are evident at steeper sections across the site and occasionally along on stream banks.

Evidence of soil creep in the form of terracettes is visible along numerous steep sections in the southwestern part of the site.

5.3 Stratigraphic Units

The ground conditions encountered and inferred from the results of our investigation differ to the published geology for the area. Our exploratory holes did not encounter soils of the Peria Formation and proved only Recent Alluvium over soils of the Walton Subgroup.

The distribution of the soil units encountered is presented in the appended Geological Cross Sections ***(Drawings 03A, 03B & 04)*** and are outlined below.

The cross section locations are depicted on ***Drawing 01***.

5.3.1 Recent Alluvium

Recent alluvium comprising firm silt and silty clay was encountered within TP21 and 22 where the tests were undertaken adjacent to streams in the northern part of the site to assess the depth to stiff material. Both pits were terminated when stiff soils were encountered at depths of 0.4m and 0.7m respectively.

Alluvium is expected to be constrained within the southern stream channel also.

The thickness of the organic silt topsoil encountered within TP13, located within an area of pugged/ swampy ground at the top of the central northern stream, suggests this material likely comprises recent alluvium/colluvium which has been eroded and deposited at the gully head.

Thin layers of alluvium are expected within the southern gullies also.

5.3.2 Uncontrolled fill

Uncontrolled fill material was encountered to a depth of 2m beneath an existing farm race at the location of TP18.

Additional areas of uncontrolled fill may be present across the site, specifically beneath farm races and near buildings.

5.3.3 Walton Subgroup

Topsoil was encountered from ground level to between 0.2m and 0.3m in the test pits.

5.3.3.1 Unit 1: Very Stiff to Hard Silt/Clay

The topsoil was generally underlain by very stiff to hard interbedded silty clay or clayey silt. Peak vane shear strengths (VSS) are variable and ranged between 122 and >200kPa with residual VSS of 12 or 128 kPa. The soils are generally moderately sensitive to sensitive, locally insensitive to extra sensitive .

The locations where extra sensitive soils were encountered are random and the depths to these layers are not consistent across the site.

This material was encountered to the depths of between 2.0m and 8.0m within the CPTs.

CPT cone resistance (qc) values were generally between 0.5 and 3 MPa, and up to 7 MPa .

5.3.3.2 Unit 2: Stiff to Hard Silt/Clay with Occasional Organic and Sand Layers

Beneath the very stiff to hard silty clay /clayey silt the CPTs showed a decrease in strength however this was not reflected our shear vane results.

The stiff to hard interbedded silt/clay had variable peak vane shear strengths (VSS) of between 55 and >200kPa with residual VSS of 12 or 128 kPa. Again, these soils are generally moderately sensitive to sensitive, locally insensitive to extra sensitive .

These soils were encountered to depths of between 4.4 and 15.2m within the CPTs.

Layers of firm organic clay and silty clay were encountered between 4.5 and 5.0m in TP16 and between 4.1 and 5.3m in TP13. Th Peak vane shear strength (VSS) measured were between 36 and 47kPa with residual VSS of 15 to 17kPa, indicating moderately sensitive behaviour.

Thin layers of stiff organic clay were also encountered in between 5.0m to 5.3m TP03 and between 4.8m to 4.9m in TP04. Peak VSS measured in ranged between 61 and 90kPa with residual VSS of 17 to 29kPa, indicating moderately sensitive behaviour.

Hard, amorphous lignite/consolidated peat was encountered in the base of TP04 at 5.4m and the trial pit refused in this material at 5.5m.

All trial pits were terminated in these soils at depths of between 5.2m to 5.7m.

CPT Cone resistance (qc) values are generally between 0.5 - 2 MPa, and up to 4 MPa within this unit. A localised layer of firm to stiff clay/silt was encountered within CPT05 between 12.4 - 15m and CPT04 between 1.2 - 3.2m, with CPT Cone resistance (qc) values of between 0.3 - 0.5 MPa.

5.3.3.3 Unit 3: Loose to Medium Dense Sand and Silty Sand

In the northern part of the site beneath the interbedded silt/clay is a 1 to 3.8m thick layer of sand and silty sand which was encountered between 6.2 - 7.2m in CPT06 and 9.6 -13.4m in CPT07, with Cone resistance (qc) values of between 1 - 6 MPa.

5.3.3.4 Unit 4: Dense to Very Dense Sand Interbedded with Stiff to Very Stiff Silt

Beneath the interbedded silt/clay is dense to very dense sand interbedded with stiff to very stiff silt which was encountered between depths of 13.4 - 17.4m in CPT07 in the north, and at 4.9 - 8.4m in CPT01, 4.4 - 5.1m in CPT02 and between 8.4 - 9.8m within CPT03 in the southwest corner of the site.

CPT Cone resistance (qc) values within these soils are generally between 4.0 - 8 MPa, and up to 18 MPa. The exception was CPT02 where they ranged between 1 - 3 MPa, suggesting a localised thinning out and weakening of the soil at that location.

5.3.3.5 Unit 5: *Dense to Very Dense Sand*

Dense to very dense sand underlies the above units at depths of between 3.6 - 17.4m. CPT Cone resistance (qc) values are generally between 10 MP and >20 MPa.

Most CPTs refused in this unit at depths of between 5.8 -16m, with the exception of TP07 which reached a target depth of 20m.

5.3.4 Summary

The distribution of these units is illustrated on the appended Geological Sections A-A and B-B ***(Drawings 03A, 03B & 04)*** and presented below in Table 2.

Table 2: Summary of Strata Encountered				
Recent Alluvium (Adjacent to Streams)	**Depth to top (m)**		**Thickness (m)**	
	Min	**Max**	**Min**	**Max**
Firm clay and silty clay	GL	GL	0.4	0.7
Walton Subgroup	**Depth to top (m)**		**Thickness (m)**	
	Min	**Max**	**Min**	**Max**
Topsoil	GL	GL	0.2	0.3
Unit 1: Very stiff to hard silt/clay	0.2	0.3	0.8	7.8
Unit 2: Stiff to hard silt/clay with occasional organics and sand layers	1.0	8.0	2.6	7.2
Unit 3: Loose to medium dense sand and silty sand	6.2	9.6	1.0	3.8
Unit 4: Dense to very dense sand interbedded with stiff to very stiff silt	4.4	13.4	0.7	4.0
Unit 5: Dense to very dense sand	5.1	17.4	N/A	N/A
Note: The depth to the top of some soil units varies considerably due to the undulating topography at the site, their being deeper below the higher ground.				

5.4 Laboratory Test Results

Soil laboratory classification tests were carried out by WSP- Opus Laboratories (Hamilton) on selected samples. All samples selected by, and testing specified by CMW.

Results of the civil engineering laboratory tests provided in **Appendix E** are summarised in Table 3.

Table 3: Summary of Soil Laboratory Test Results									
Test Location	**Depth (mbgl)**	**Soil Type**	**Gravel (%)**	**Sand (%)**	**Fines (%)**	**LL (%)**	**PL (%)**	**PI (%)**	**MC (%)**
TP07	2	Silty clay				101	49	52	63.1
TP10	4.3	silty, clayey sand	0	47	53	56	30	26	68.2
TP12	3	Silty clay				103	46	57	57.3
TP19	5.2	silty, clayey sand	0	40	60	48	32	16	44
Note: Gravel, sand and fines percentages are by weight, LL = liquid limit, PL = plasticity limit, PI = plasticity index, MC = Natural Moisture Content.									

5.5 Groundwater

During the investigation, which was completed in summer (January 2019), groundwater was encountered within the CPTs and trial pits at the depths provided in Table 4.

Groundwater levels in selected locations were also recorded where standpipe piezometers were installed.

Table 4: Groundwater Monitoring Data								
Location	Standpipe Screen Installed	Screen Depth Range (mbgl)	22/23 January 2019		19 February 2019		2 March 2019	
			Depth (mbgl)	Level (mRL)	Depth (mbgl)	Level (mRL)	Depth (mbgl)	Level (mRL)
CPT01	Y	2.5 - 5.5	3.5	35.5	3.5	35.5	3.7	35.3
CPT02	Y	2.0 - 5.0	1.2	41.8	1.4	41.6	1.6	41.4
CPT03	N		5.5	45.5				
CPT04	Y	2.0 - 5.0	2.55	39.95	2.6	39.9	2.85	39.65
CPT05	N		11.5	44.5				
CPT06	N		2.80	41.2				
CPT07	Y	2.0 - 5.0	2.85	35.45	2.45	35.85	2.6	35.7
CPT08	N		4.95	43.05				
TP01	N		3.5	40.5				
TP02	N		3.7	38.5				
TP03	N		5.3	34.2				
TP04	N		5.4	31.5				
TP05	N		4.9	39.6				
TP10	N		4.0	38.5				
TP13	N		4.0	40				
TP16	N		5.0	40				
TP18	N		3.0	36				
HA07	N						2.5	39.5

Note: mbgl = metres below ground level
Where no standpipe installed groundwater level is that observed during testing

5.6 Soakage Test Results

Soakage tests were undertaken by hand auguring to depths of up to 3.1 metres below existing ground level to visually observe the near surface soil profile, reaming the boreholes out to 100mm diameter and installing a perforated PVC pipe.

Data logger divers where installed in the base of the boreholes to record the rate of water level fall over time. The pipes were then filled with water to ground level. The head of water above the diver was recorded at 30 second intervals during the test.

We have assessed the hydraulic conductivity of the subsoil using the CIRIA 113 method[5].

Our falling head permeability test data and calculations are presented in Appendix D and our calculated hydraulic conductivities are presented on Table 5.

[5] Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

Table 5: Falling Head Permeability Test Results	
Hand Auger Borehole No.	**Hydraulic Conductivity (ms^{-1})**
HA01*	2.96×10^{-3}
HA02	1.46×10^{-5}
HA03	1.54×10^{-5}
HA04	4.93×10^{-6}
HA05	1.46×10^{-5}
HA06	8.19×10^{-5}
HA07	1.47×10^{-4}
Note: The hydraulic conductivity values above are calculated using the CIRIA 113 method. Any designer using these values may consider other calculation methods and must satisfy themselves as to their suitability. * HA01 – See section 7.8.3 regarding use of this result.	

It should be noted that our falling head permeability test data shows the last 3 readings in HA04 and last reading in HA06 to have higher rates of soakage than the previous readings (***Appendix D***). An increase in soakage rate is not typical for soakage testing is likely due to an error in diver readings. We have disregarded these recommend the use of the more conservative readings above.

6 GEOHAZARDS ASSESSMENT

6.1 Context

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence).

The following sections of this report provide an assessment of the geohazards relevant to this site and provide the basis for the Natural Hazards Risk Assessment presented in Appendix G.

It should be noted that CPT's are considered to underestimate the insitu strength of fine-grained volcanic soils and alluvium comprising fine grained volcanic soils, this is due to disturbance of the soils by the CPT cone resulting in a readings representative of the remoulded shear strength rather than the peak.

Correlation between soil strengths derived from CPTs and strengths recorded from hand shear vanes within trail pits confirm the above. We have therefore used our shear vane test results (where applicable) for analyses in this report.

6.2 Seismicity

A seismic assessment has been carried out in general accordance with NZGS guidance[6] to calculate the peak horizontal ground acceleration or PGA (a_{max}) as follows:

$$a_{max} = C_{0,1000} \frac{R}{1.3} x\ f\ x\ g$$

Where: $C_{0,1000}$ = unweighted PGA coefficient subject to subsoil class (refer Section 7.1 for subsoil class)

R = return period factor given in NZS1170.5, Table 3.5

f = site response factor subject to subsoil class

g = acceleration due to gravity

The ULS PGA was calculated based on a 50-year design life in accordance with the New Zealand Building Code for importance level (IL) 2 structures and a seismic subsoil class D.

The PGA for the serviceability limit state (SLS) and ultimate limit state (ULS) earthquake scenarios is as follows:

Table 6: Design Peak Ground Acceleration (PGA) for Various Limit States

Limit State	AEP	R	PGA(g)	$Magnitude_{eff}$
SLS	25	0.75	0.06	5.9
ULS	500	1.0	0.25	5.9

Note: SLS = serviceability limit state; ULS = ultimate limit state; AEP = annual exceedance probability

6.3 Fault Rupture

The nearest known active fault is the Kerepehi Fault located approximately 15 km north-east of the site.

We therefore consider the risk of fault rupture affecting the site to be low.

6.4 Liquefaction

6.4.1 Context

CMW have only been supplied proposed contours for the southern part of the site. We have therefore undertaken our liquefaction analyses at proposed contour elevations in the southern part of the site and at existing ground level in the northern part of the site.

6.4.2 General

Soil liquefaction is a process where typically saturated, granular soils develop excess pore water pressures during cyclic (earthquake) loading that exceed the effective stress of the soil. In loose soils, some dilation can occur during this process, which can lead to individual soil grains moving into suspension. Following the onset of liquefaction, the shear strength and stiffness of the liquefied soil is effectively lost causing excessive differential settlement of the ground surface, bearing capacity failure and collapse of structures and low-angle lateral spreading of slopes in liquefiable soils.

In accordance with NZGS guidance[7] the liquefaction susceptibility of the soils at this site has been considered with respect to geological age, soil fabric and soil consistency / density.

[6] NZ Geotechnical Society publication “Earthquake geotechnical engineering practice, Module 1: Overview of the standards”, (March 2016)

[7] Earthquake Geotechnical Engineering Practice, Module 3: Identification, assessment and mitigation of liquefaction hazards”, (May 2016)

6.4.3 Geological Age

The vast majority, and nearly all, case history data compiled in empirical charts for liquefaction evaluation come from Holocene deposits or man-made fills (Seed and Idriss, 1971). Youd and Perkins, 1978 also state that young Holocene age (15,000 years) sediments and man-made fills are susceptible to liquefaction. Table 1 of Idriss and Boulanger (extracted from Youd and Perkins (1978)), presents the susceptibility of soil deposits to liquefaction based on geological age, which states that Pleistocene aged alluvium (>12,000 years) has a very low to low risk of liquefaction.

Across the site, soils below the water table comprise clays, silts and sands of the Walton Subgroup. These soils are defined as being of early to mid-Pleistocene geological age with a dated aged at 1.26Ma to 2.18Ma old. These deposits are therefore significantly older than what case history data would suggest as being susceptible to liquefaction.

Notwithstanding this, age alone is often debated as being of insufficient evidence to discount liquefaction potential due to its qualitative nature. Consideration can therefore be given to applying an ageing factor (K_{DR}) to site specific liquefaction analyses in accordance with methods described in Clayton et al[8] based on the following relationship (where t = time (years)):

$$K_{DR}=0.12\cdot\log10(t)+1.28$$

For the purpose of this report an ageing factor of 1.86 (using the younger age of 1.26Ma) has been applied to the early to mid-Pleistocene soils.

6.4.4 Soil Fabric

Soils are also classified with respect to their grain size and plasticity to assess liquefaction susceptibility. Based on more recent case histories, there is general agreement that sands, non-plastic silts, gravels and their mixtures form soils that are susceptible to liquefaction. Clays, although they may significantly soften under cyclic loading, do not exhibit liquefaction features, and therefore are not considered liquefiable. NZGS guidance[5] sets out the plasticity index (PI) criteria for liquefaction susceptibility as follows:

PI < 7: Susceptible to Liquefaction

7 ≤ PI ≥ 12: Potentially Susceptible to Liquefaction

PI ≥ 12: Not Susceptible to Liquefaction

The fines content of the sands beneath the site also has a significant impact on their liquefaction susceptibility.

Specific soil grading and plasticity index laboratory test results are presented in Section 5.4 above and show that the soils tested provided plasticity indices of either greater or much greater than 12 and are therefore not considered liquefiable.

6.4.5 Specific Analyses

Our liquefaction susceptibility analysis was carried out using the computer software package CLiq v.2.2.0.32 (Geologismiki, 2006) based on the CPT data in accordance with the Boulanger and Idriss (2014) method.

Specific liquefaction analyses were undertaken by comparing the cyclic stress ratio (CSR), being a function of the earthquake magnitude for the design return period event, to the cyclic resistance ratio (CRR), being a function of the CPT cone resistance (qc) and friction ratio.

[8] Clayton, P.J.; Sonnenberg, R.; Bothara, J.K. (2011). Considering cumulative seismic experience and ageing effects in liquefaction analysis, Proceedings of the Ninth Pacific Conference on Earthquake Engineering, 14-16 April 2016, NZ

In the SLS case our liquefaction analyses results indicate liquefaction is unlikely to occur at all CPTs locations.

Copies of our analytical results are presented in Appendix F and results for the ULS case are summarised on Table 7.

Table 7: ULS Case Liquefaction Analyses Results

CPT No.	ULS Estimated liquefaction induced Settlement (mm)	Depth to Liquefied Layer (m)	Liquefaction Soil Profile Thickness (m)	
			Individual Lenses (m bgl)	Cumulative Total
*CPT01	Nominal	N/A	N/A	N/A
*CPT02	Nominal	N/A	N/A	N/A
*CPT03	Nominal	N/A	N/A	N/A
*CPT04	Nominal	N/A	N/A	N/A
*CPT05	Nominal	N/A	N/A	N/A
**CPT06	0-30#	4.2	4.2-4.6,5.4-5.5,6.1-6.3,6.4-6.8, 7.0-7.2	approx. 1m
**CPT07	0-35##	9.6	9.6-10, 11.5-12	1.9
**CPT08	Nominal	N/A	N/A	N/A

Notes:

All settlements are approximate only and should be regarded as 'order of' values

*Settlements and depths are based on proposed design ground profile

**Settlements and depths are based on existing ground profile

layers plot as 50:50 liquify/non liquify, range quoted covers zero to maximum indicated liquefaction

layers plot close to "50:50 liquify/non liquify" and "unlikely to liquify" boundary, range quoted covers zero to maximum indicated liquefaction

Nominal = Negligible amount of settlement

A sufficient non-liquefiable crust thickness (greater than 4m) present at each CPT location, which should prevent the surface manifestation of liquefaction in the form of ejecta and surface fissuring, and help smooth out any differential settlements;

Based on the above we consider the risk of unacceptable liquefaction induced settlement occurring at the site is low.

6.5 Cyclic Softening

Although not considered liquefiable, due to the high plasticity of the laboratory tested soils, they may still be susceptible to some strength loss, referred to as cyclic softening, during the ULS seismic event.

Cyclic softening analyses, in accordance with Idriss and Boulanger[9] were carried out and show that the clay like soils (with an Ic value >2.6) have a cyclic softening factor of safety of greater than 1, demonstrating that they are not susceptible to this process and therefore the risk of cyclic softening occurring is low.

6.6 Lateral Spread

Following the onset of liquefaction, the liquefied soils behave as a very weak undrained material, which can give rise to lateral spreading; in sloping ground, where a free face is present within the vicinity of the site, or where proposed cut and fill batters are proposed over or within liquefied soils.

Due to the shallow gradients of the proposed contours and depth to potentially liquefiable soils, we consider the risk of liquefaction induced lateral spread of slopes to be low.

The stream banks present the only free faces which could induce lateral spreading, however, there are no shallow liquefiable layers in proximity to the streams and we consider that the risk of liquefaction induced lateral spread into the stream is low.

6.7 Slope Stability

During our geomorphological mapping no large scale slope failures were observed on the site. However, very small shallow-seated slump failures were observed into the two northern streams at locations shown on ***Drawings 02A and 02B***.

Elsewhere on localised steeper parts of the site, terracettes caused by shallow soil creep were observed.

The earthworks proposals involve cuts and fills to reduce slope gradients across the site. Based on our site observations, and assuming proposed slope gradients for the northern part of the site are to be similar to the southern part, we consider the risk of global slope stability of the site slopes to be low. This should be confirmed at the detailed design stage.

There is however an existing risk of slope instability within close proximity to existing streams and remedial options are presented in Section 7.3.

6.8 Erosion

Minor surface scour and erosion was observed in the north-western part of the site where concentrated surface water runoff from the neighbouring paddock runs into an open drain. No other surficial erosion was noted during our site visits.

Based on the above observations we consider the risk of erosion of cut and fill batters to be low and should be managed by appropriate geotechnical design.

6.9 Load Induced Settlement

6.9.1 Fill Induced Settlements

Based on the strength of soils across the site and the typically shallow depth of fill anticipated, the induced settlements from the proposed fill embankments are not are not expected to be significant.

However, where there are deeper fills (up to 5m is proposed) over lower strength soils, significant settlement could occur.

The interbedded nature of the silty clays, clayey silts and sands will aid consolidation settlement and reduce the time taken for it to occur. This can be assessed at the detailed design stage.

[9] Boulanger, R. W. and Idriss, I. M. (2007). Evaluation of Cyclic Softening in Silts and Clays, Journal of Geotechnical and Geoenvironmental Engineering, Vol 133, Issue 6

6.9.2 Foundation Settlement Suitability

Taking into account anticipated lightweight building construction, the competent soils encountered across the site and that all earthfill material is to be of engineered standard, building load induced settlements should be within NZ Building Code limits.

This should be reassessed at the detailed design stage and following subdivision earthworks and for individual buildings at the Building Consent stage.

6.10 Expansive Soils

NZS 3604:2011 excludes from the definition of 'good ground', soils with a liquid limit of more than 50% and a linear shrinkage of more than 15% due to their potential to shrink and swell as a result of seasonal fluctuations in water content.

This shrinking and swelling results in vertical surface ground movement which can cause significant cracking of floor slabs and walls. There have been instances of concrete floors and/ or foundations that have been poured on dry, desiccated subgrades in summer months on expansive soils and have undergone heaving and cracking requiring extensive repairs or re-building once the soil moisture contents have returned to higher levels.

Results from our laboratory testing show that the samples of silty clay at TP07 (2m) and TP12 (3m), and the samples of silty, clayey sand at TP10 (4.3m) and TP19 (5.2m) have liquid limits above 50% indicating expansive soils.

However, given the lack of known expansive soil issues within the Hamilton Region in the past, we have carried out a review of published literature for Waikato volcanic tephra sourced clay mineralogy which included discussions with Professors from the University of Waikato and the University of Adelaide. The review concluded that Waikato tephra's (including Walton Subgroup) predominantly comprise Halloysite clay minerals. During periods of dry weather, these clay minerals undergo non-recoverable shrinkage i.e.. the volume of the soil is permanently decreased. This behaviour is unique to Halloysite clays and therefore differs from Smectite (swelling) dominated clays.

Based on the above, expansive soils are not expected to be an issue at the site.

6.11 Sensitive Soils

The majority of silt and clay soils that will be encountered within the proposed earthworks cuts are sensitive to remoulding and moisture ingress. Care will be required to avoid over working and trafficking of these materials, and to protect them from moisture ingress.

Further recommendations are provided in Section 7.5.2.

7 GEOTECHNICAL RECOMMENDATIONS

7.1 Seismic Site Subsoil Category

The geological units encountered beneath the site have are soil strength materials with less than 10m of soft soils.

Based on those ground conditions the seismic site subsoil category is assessed as being Class D (deep soil site) in accordance with NZS1170.5.

7.2 Liquefaction / Lateral Spread Mitigation

Based on the assessment of liquefaction and lateral spread outlined in Sections 6.4.5 and 6.6 we consider the risk of surface manifestation of liquefaction and the risk potentially unacceptable liquefaction induced differential settlements or lateral spread to be low.

Therefore, no additional geotechnical recommendations are provided at this stage with the exception of a review of the lateral spreading risk once the earthworks design is completed.

7.3 Slope Stability Management

7.3.1 General Site Slopes

As outlined in Section 6.7, no existing large slope failures were observed during our site walk over.

The proposed contours for the southern section of the site (Appendix A) indicate a reduction in slope gradient over the site, with a maximum gradient of 1V:8H.

Assuming proposed slope gradients for the northern part of the site are similar, post construction slopes for the site are considered suitable to provide an acceptable level of stability.

An assessment of proposed cut slope gradients will need to be done at detailed design stage.

7.3.2 Gully Stream Banks

Shallow slump failures into the streams at the base of the northern gullies were observed during our site walkover.

Our qualitative assessment of the slope stability, with respect to the proposed development, is that there is a slope stability risk adjacent to stream banks.

To reduce the post construction slope stability risk of stream banks, a range of options may be considered, including the following:

1. Leave as is, and adopt a building restriction line (BRL) based on a nominal 1V:3H projection line. All structures requiring building consent must be located outside the BRL unless supported by further geotechnical investigation and/or assessment by a Chartered Professional Geotechnical Engineer;
2. Regrade the slopes to improve long term stability with a reduced BRL;
3. Infill streams with pipes/culverts as part of the subdivision earth works with a reduced BRL;
4. Construct engineered stream banks such as retaining walls
5. In-ground or palisade retaining walls constructed to protect some of the landform beyond the BRL and increase the land area available for building construction.

Each of these options will require a building set back (BRL) to differing degrees however Options 3, and 4 offer the lowest long-term risk of erosion and regression of the bank sides.

Restrictions relating to stream bank stability will need to be re-assessed in a Geotechnical Completion Report (GCR) following completion of subdivision earthworks.

7.4 Static Settlement

The risk of unacceptable settlement under building/foundation loads is anticipated to be low at the site.

However, as outlined in Section 6.9, where there are deeper fills (up to 5m is proposed) over lower strength soils there is a risk of unacceptable static settlement under the fill.

Once cut/fill plans are finalised we recommend that static settlement estimates are carried out for deeper fills with allowance for settlement monitoring if fill induced settlement magnitudes are of significant risk for future buildings and subdivision infrastructure.

7.5 Earthworks

7.5.1 General

All earthwork activities must be carried out in general accordance with the requirements of NZS 4431 and the requirements of the Waikato Local Authority Shared Services - Regional Infrastructure Technical Specifications (RITS) under the guidance of a Chartered Professional Geotechnical Engineer.

The Transurban proposed contour plan depicts up to 5 metres of cut and fill, but generally less than 2 metres, will be required to ease land gradients over the site. The deepest fill known at present will be in the southern low lying areas with cut materials sourced from the elevated portions of the site.

7.5.2 Material Suitability / Conditioning

Within the proposed cut areas the natural subgrade will comprise sensitive silt and clay. We expect that excavation of these materials will be readily achieved with normal earthworks plant, such as scrapers and excavators.

Whilst these materials are considered generally suitable to use for the construction of engineer certified fills, their relatively high sensitivity means that they have a narrow range of moisture contents in which they can be successfully earthworked.

Particular care must therefore be exercised by the earthworks contractor to optimise the moisture condition of these soils to enable compaction to certifiable standards. This is likely to require disking of the soils in both cut and fill areas with adequate allowance for conditioning in dry summer conditions. It is also noted that timeframes for earthworks may be lengthened considerably if intermittent rainfall occurs through the summer months.

7.5.3 Stockpiles

Careful consideration must be given to the location of temporary topsoil / unsuitable stockpiles to ensure that they are not located immediately above steep or unstable slopes or immediately above proposed stormwater pond excavations.

The location of all temporary stockpiles must be approved by the Geotechnical Engineer prior to placement. Where stockpiles cannot be avoided above sloping ground they should be placed over a wide area with the height restricted under the direction of the Geotechnical Engineer.

7.5.4 Underfill Drainage

Where fill is to be placed over the lower-lying areas of the site, specifically where springs are present in gully inverts, it will be necessary to install a series of under-fill / subsoil drains to control groundwater seepages and reduce the impact of softening at the base of the engineered fill materials.

The necessity and locations of the subsoil drains should be identified by the geotechnical engineer on site during construction to optimise the installation positions.

The details for the subsoil drains should also be confirmed during the earthworks phase but is likely to comprise a 500mm x 500mm wide trench, back-filled with approved drainage aggregate (eg 20/40 washed aggregate), with a 110mm or 160mm diameter perforated Hiway grade novaflo pipe, and all wrapped in geotextile to meet the requirements of TNZ F7 Class 2/C or 4/C as appropriate.

7.5.5 Compaction

All earthfill must be placed, spread and compacted in controlled lifts under the supervision of a Chartered Professional Geotechnical Engineer.

Fill is expected to comprise fine-grained (clay and silt) cut materials for the elevated portions of the site subject to being free of any organic material.

7.5.6 Quality Control

The stripping of topsoil and cutting of pre-existing fill materials, where required from across the site must be subject to observation by the project geotechnical engineer to ensure that all unsuitable materials have been removed.

The source and / or type of material used for engineered fill will dictate the type of quality control testing undertaken.

For granular (sand and gravel) fill materials, testing following compaction should be principally in terms of the maximum dry density within the appropriate water content range, which may be calibrated with a dynamic cone (Scala) penetrometer test that is then used as the primary testing measure. Where the source or quality of fill changes, re-calibration will be required.

Where silts and clays are used as fill alternative test criteria using vane shear strength and air voids should be used.

Further earthworks recommendations will be provided during detailed design and a full earthworks specification will be issued at the time of earthworks consent application.

7.6 Foundation Bearing Capacity

Once bulk earthworks are completed in accordance with the recommendations provided in Section 7.4 above, a preliminary geotechnical ultimate bearing pressure of 300kPa should be available for shallow strip and pad foundations constructed within both the natural cut ground and engineered fill areas for lightweight structures designed in accordance with NZS3604.

The reworked silt / clay soils of the Walton Subgroup present at this site can be susceptible to natural strength variability, particularly when they are exposed and become wet. Localised variations in shear strength within the natural cut ground may also occur where the depth of cut varies across the building platforms.

If low-strength soils are encountered (which is possible in deeper areas of cut) they should be undercut and replaced with engineering fill at the time of subdivision earthworks to provide uniform bearing capacity soils within the lots. Alternatively, these soils may be left in place and the affected lots will be tagged in the subdivision Geotechnical Completion Report (GCR). The low-strength soils would then need to be locally undercut and replaced with engineered fill (e.g. imported well graded pit sand) at individual building stage on affected lots.

Further confirmation of available bearing pressures will be addressed at the time of post earthworks soil testing and preparation of the Geotechnical Completion Report (GCR) for the development.

7.7 Geotechnical Strength Reduction Factor

As required by section B1/VM4 of the New Zealand Building Code Handbook, a strength reduction factor of 0.5 and 0.8 must be applied to all recommended geotechnical ultimate soil capacities in conjunction with their use in factored design load cases for static and earthquake overload conditions respectively.

7.8 Civil Works

7.8.1 Subgrade CBR

It is recommended that soaked CBR laboratory testing and a programme of penetration resistance testing is carried out at routine intervals along road alignments, as part of the road pavement design prior to road construction to confirm CBR values.

For preliminary design purposes we recommend a preliminary CBR of 3% for the silty/clay soils likely to form the pavement subgrade.

7.8.2 Service Trenches

All service trenches and open drains beneath the road carriage ways and within a 45 degree zone of influence of any building foundation should be backfilled with compacted trench spoil or imported pit-sand to meet engineered fill standards.

7.8.3 Stormwater Soakage

The soils at this site are considered suitable to provide a seepage function for the design of attenuation ponds based on the hydraulic conductivity results shown in Table 5 (Section 5.6) and our associated comments.

However, it is our opinion that greater soakage rates may be achieved in deeper sand layers located in the south-western and southern parts of the site. Further soakage testing is recommended in these layers at detailed design stage.

The 2.96×10^{-3} m/sec soakage rate for HA01 is typical for clean sands or sand-gravel mixes, however, these soils (at shallow depths) were not encountered during our investigation. It is our opinion that a layer of unsaturated sand may have been present beneath the silt layer at the base of HA01 and this sand layer is simply filling, rather than acting as a free draining layer. Once this layer becomes saturated we believe the soakage rates will be similar to those of HA07, where groundwater was encountered within the borehole.

All soakage systems should be subject to specific design.

8 SUITABILITY STATEMENT

The site investigation carried out is considered suitable for this assessment of geotechnical constraints and associated requirements in support of Resource Consent application.

The qualitative assessment of natural risk hazard for the site is low to medium for all hazards considered.

It is our opinion that the Lockerbie Farm Development site is geotechnically suitable for the proposed development subject to the recommendations contained herein.

9 FURTHER WORK

The site investigation works were carried out prior to the development of the final civil engineering drawings including any cut/fill earthworks and confirmed building layout plans.

If an application for earthworks consent is required, then further geotechnical investigation to provide specific design information in key areas should include:

- Further soakage tests)to target deeper sand layers at the locations of proposed stormwater attenuation ponds;
- Fill induced static settlement assessments for deeper fills over lower strength soils;
- Laboratory testing for earthworks including, standard compaction testing, solid densities and moisture contents in proposed borrow materials, plus penetration resistance testing and laboratory soaked CBR testing for road subgrade design purposes.

This work will be delivered in a geotechnical design report based on the developed earthworks and subdivision scheme plans and will be suitable to support an application for earthworks consent.

Further site investigation and foundation suitability assessment including bearing capacity and static settlement should be carried out prior to Building Consent application for any buildings.

10 LIMITATIONS

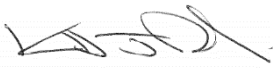
This report has been prepared for use by our client, Lockerbie Estates Limited, their consultants and Matamata Piako District Council. Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

It should be noted that factual data for this report has been obtained from discrete locations using normal geotechnical investigation techniques. As such investigation methods by their nature only provide information about a relatively small volume of subsoils, there may be special conditions pertaining to this site which have not been disclosed by the investigation and which have not been taken into account in the report. If variations in the subsoils occur from those described or assumed to exist, then the matter should be referred back to CMW immediately.

11 CLOSURE

Should you require any further information or clarification regarding the information provided in this report, please do not hesitate to contact the undersigned.

For and on behalf of
CMW Geosciences (NZ) Ltd

Prepared by	Reviewed and Authorised by
	
Ellis Evens	**Ken Read**
Engineering Geologist	Principal Geotechnical Engineer, CMEngNZ

Distribution: 1 copy to Client (electronic); Original held by CMW Geosciences

Attachments:

Drawing 01: Site Investigation Plan

Drawing 02A & 02B: Geomorphological Map

Drawing 03A & 03B: Cross Section A-A

Drawing 04: Cross Section B-B

Appendix A: Transurban Conceptual Contour Plan

Appendix B: Machine Trial Pits & Hand Auger Borehole Logs & Photographs

Appendix C: CPT Investigation Results

Appendix D: Falling Head Permeability Test Data

Appendix E: Laboratory Test Results

Appendix F: Liquefaction Analyses

Appendix G: Natural Hazards Risk Assessment

USE OF THIS REPORT

Site subsurface conditions cause more construction problems than any other factor and therefore are generally the largest technical risk to a project. These notes have been prepared to help you understand the limitations of your geotechnical report.

Your geotechnical report is based on project specific criteria

Your geotechnical report has been developed on the basis of our understanding of your project specific requirements and applies only to the site area investigated. Project requirements could include the general nature of the project; its size and configuration; the location of any structures on or around the site; and the presence of underground utilities. If there are any subsequent changes to your project you should seek geotechnical advice as to how such changes affect your report's recommendations. Your geotechnical report should not be applied to a different project given the inherent differences between projects and sites.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface investigation, the conditions may have changed, particularly when large periods of time have elapsed since the investigations were performed.

Interpretation of factual data

Site investigations identify actual subsurface conditions at points where samples are taken. Additional geotechnical information (e.g. literature and external data source review, laboratory testing on samples, etc) are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can exactly predict what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

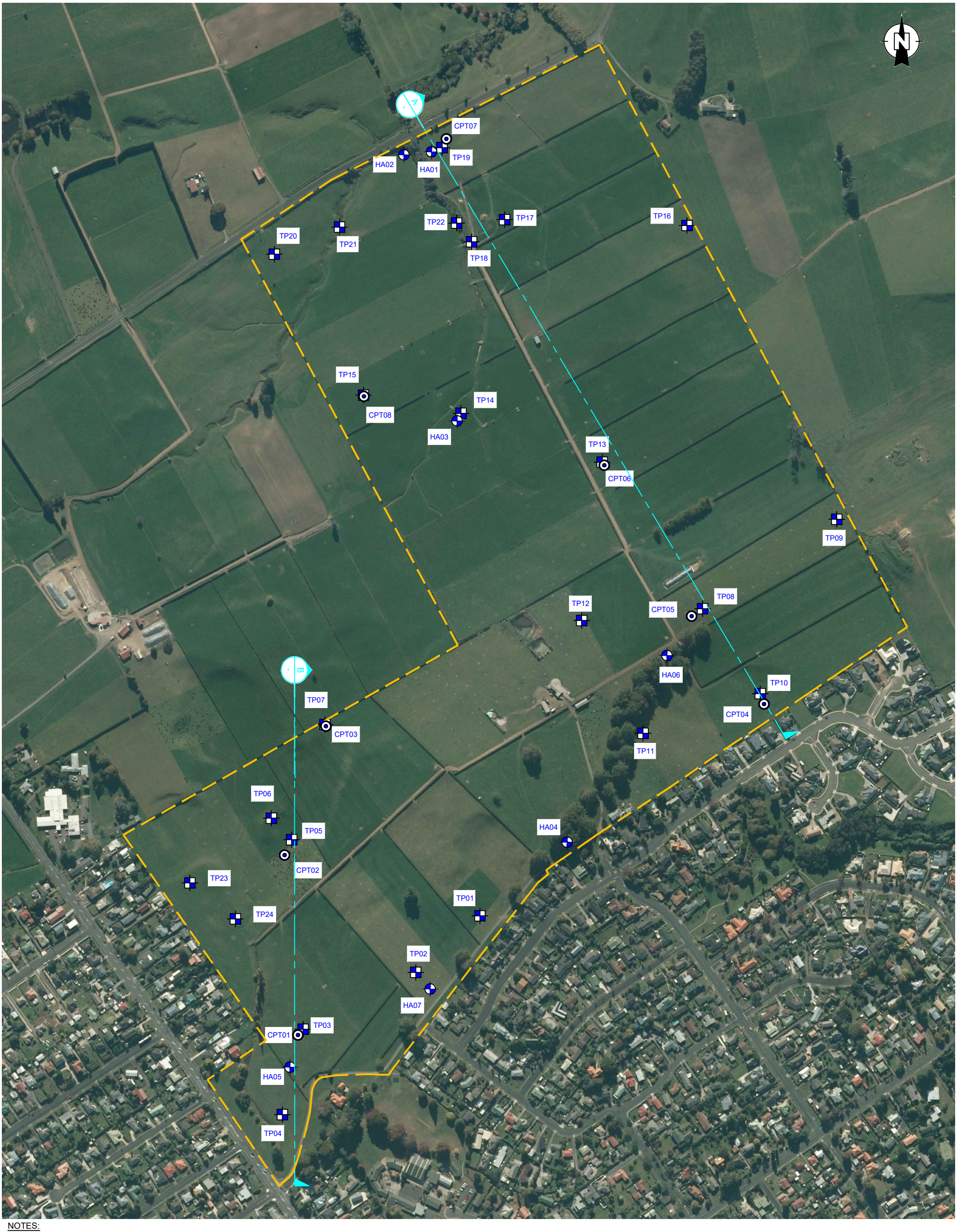
Your report's recommendations require confirmation during construction

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced. For this reason, you should retain geotechnical services throughout the construction stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site. A geotechnical designer, who is fully familiar with the background information, is able to assess whether the report's recommendations are valid and whether changes should be considered as the project develops. An unfamiliar party using this report increases the risk that the report will be misinterpreted.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical report. Read all geotechnical documents closely and do not hesitate to ask any questions you may have. To help avoid misinterpretations, retain the assistance of geotechnical professionals familiar with the contents of the geotechnical report to work with other project design professionals who need to take account of the contents of the report. Have the report implications explained to design professionals who need to take account of them, and then have the design plans and specifications produced reviewed by a competent Geotechnical Engineer.

Drawings



NOTES:

1. BASE IMAGE ADAPTED FROM 2012 - 2013 WAIKATO AERIAL PHOTO SOURCED FROM LAND INFORMATION NEW ZEALAND (LINZ) ONLINE MAPS.
2. TEST LOCATIONS ARE APPROXIMATE ONLY.

1:5000 0 50 100 150 200 250 m

LEGEND:

- CPT01 CONE PENETROMETER TEST (CPT) LOCATION
- TP01 TEST PIT (TP) LOCATION
- HA01 HAND AUGER (HA)/ SOAKAGE TEST LOCATION
- SITE BOUNDARY
- CROSS SECTION LOCATION

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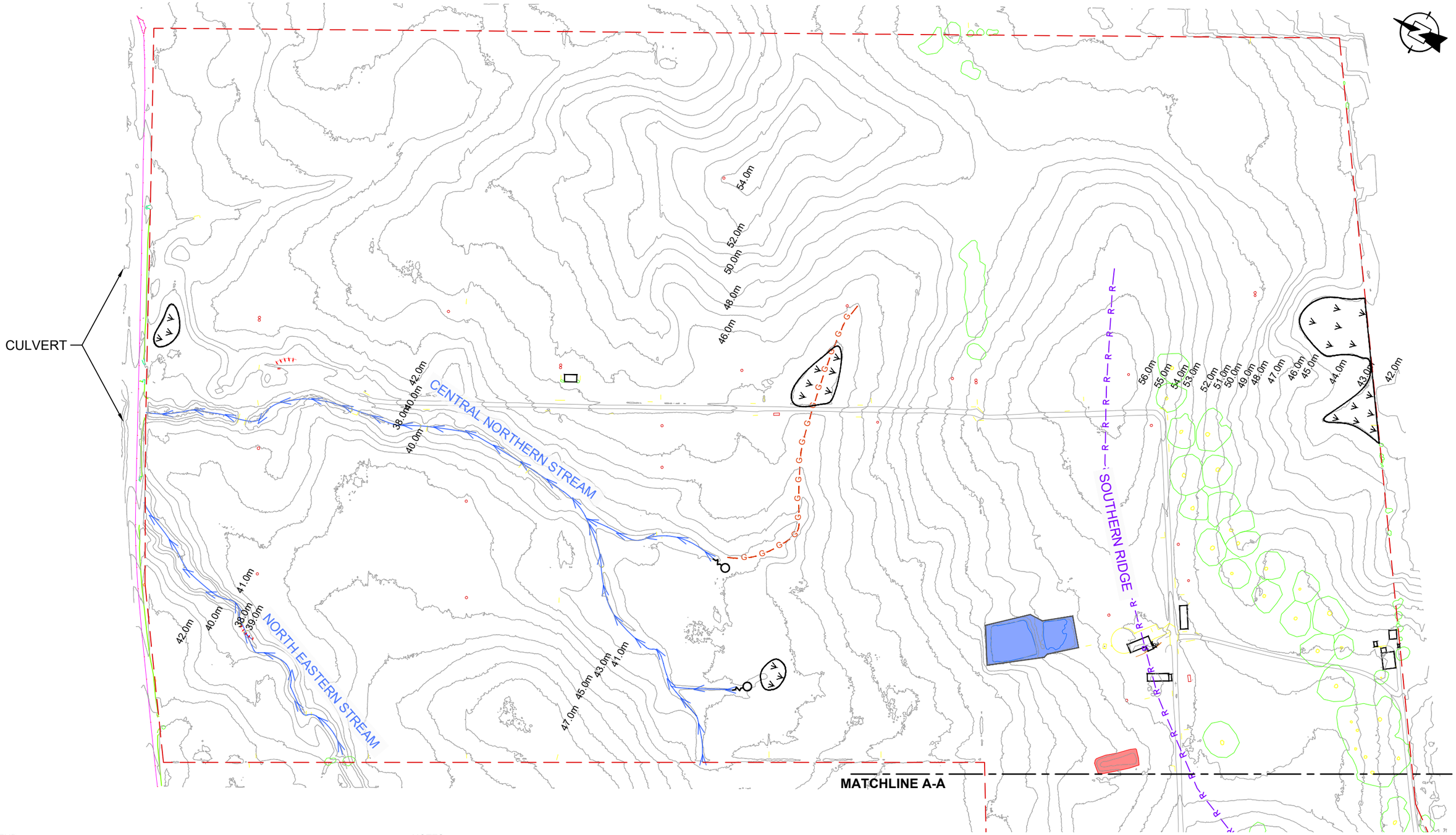
CLIENT: LOCKERBIE ESTATES LTD		DRAWN: WPJ	PROJECT: HAM2018-0139
PROJECT: LOCKERBIE FARM DEVELOPMENT STUDHOLME STREET, MORRINSVILLE		CHECKED: EJE	DRAWING: 01
		REVISION: E	SCALE: 1:5000
TITLE: SITE INVESTIGATION PLAN		DATE: 05/04/2019	SHEET: A3



LEGEND:

- SHOWS DIRECTION OF MOVEMENT BEYOND SCARPS
- STREAM (ARROW IN THE DIRECTION OF FLOW)
- MINOR SCARP: HEAD OF SLIDE/ FLOW (TEETH POINTING DOWNSLOPE)
- VEGETATION
- PUGGED / SWAMPY GROUND
- HUMMOCKY GROUND
- GULLY
- RIDGE
- SPRING
- SOIL CREEP
- SILAGE STACK
- BUILDING
- DAIRY EFFLUENT PONDS
- SITE BOUNDARY

NOTES:

1. BASE PLAN ADAPTED FROM BASEPLAN SUPPLIED BY TRANSURBAN LTD EMAIL DATED 6 MARCH 2019

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CLIENT: LOCKERBIE ESTATES LTD		DRAWN: WPJ	PROJECT No: HAM2018-0139
PROJECT: LOCKERBIE FARM DEVELOPMENT STUDHOLME STREET, MORRINSVILLE		CHECKED: EJE	DRAWING: 02A
		REVISION: B	SCALE: 1:3000
TITLE: GEOMORPHOLOGICAL PLAN		DATE: 17/04/2019	SHEET: A3 L

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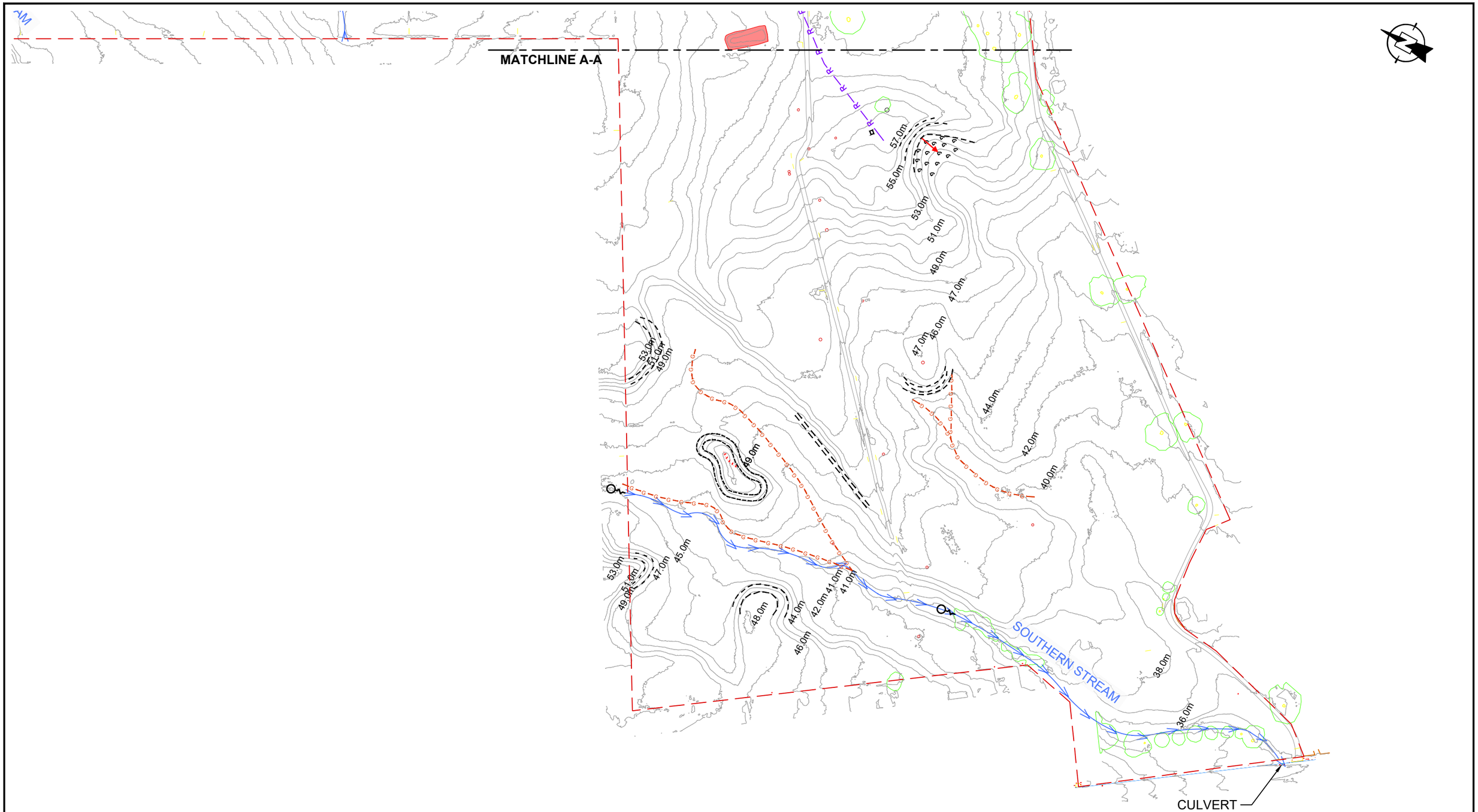

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- RIDGE
- SPRING
- SOIL CREEP
- SILAGE STACK
- BUILDING
- DAIRY EFFLUENT PONDS
- SITE BOUNDARY

NOTES:

1. BASE PLAN ADAPTED FROM BASEPLAN SUPPLIED BY TRANSURBAN LTD EMAIL DATED 6 MARCH 2019

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CLIENT: LOCKERBIE ESTATES LTD		DRAWN: WPJ	PROJECT No: HAM2018-0139
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TITLE: GEOMORPHOLOGICAL PLAN		DATE: 17/04/2019	SHEET: A3 L

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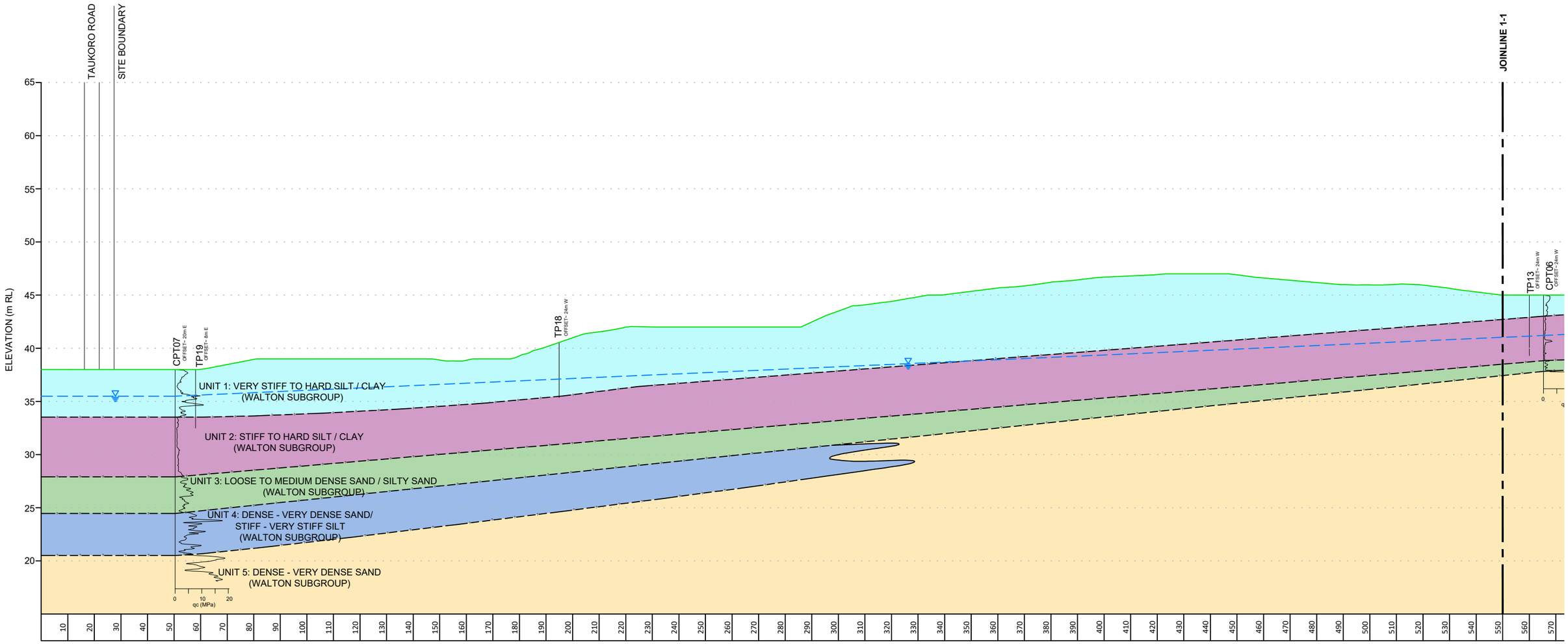

SECTION A

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H: 1:1500

LEGEND:

- EXISTING PROFILE LINE
- PROPOSED PROFILE LINE
- GROUNDWATER TABLE

NOTES:

1. BASE PLAN ADAPTED FROM PROPOSED CONTOUR PLAN SUPPLIED BY TRANSURBAN LTD, EMAIL DATED 6 MARCH 2019.

CMW Geosciences

CLIENT: LOCKERBIE ESTATES LTD		DRAWN: WPJ	PROJECT No: HAM2018-0139
PROJECT: LOCKERBIE FARM DEVELOPMENT STUDHOLME STREET, MORRINSVILLE		CHECKED: EJE	DRAWING: 03A
		REVISION: D	SCALE: AS SHOWN
TITLE: GEOLOGICAL SECTION A-A		DATE: 17/04/2019	SHEET: A3

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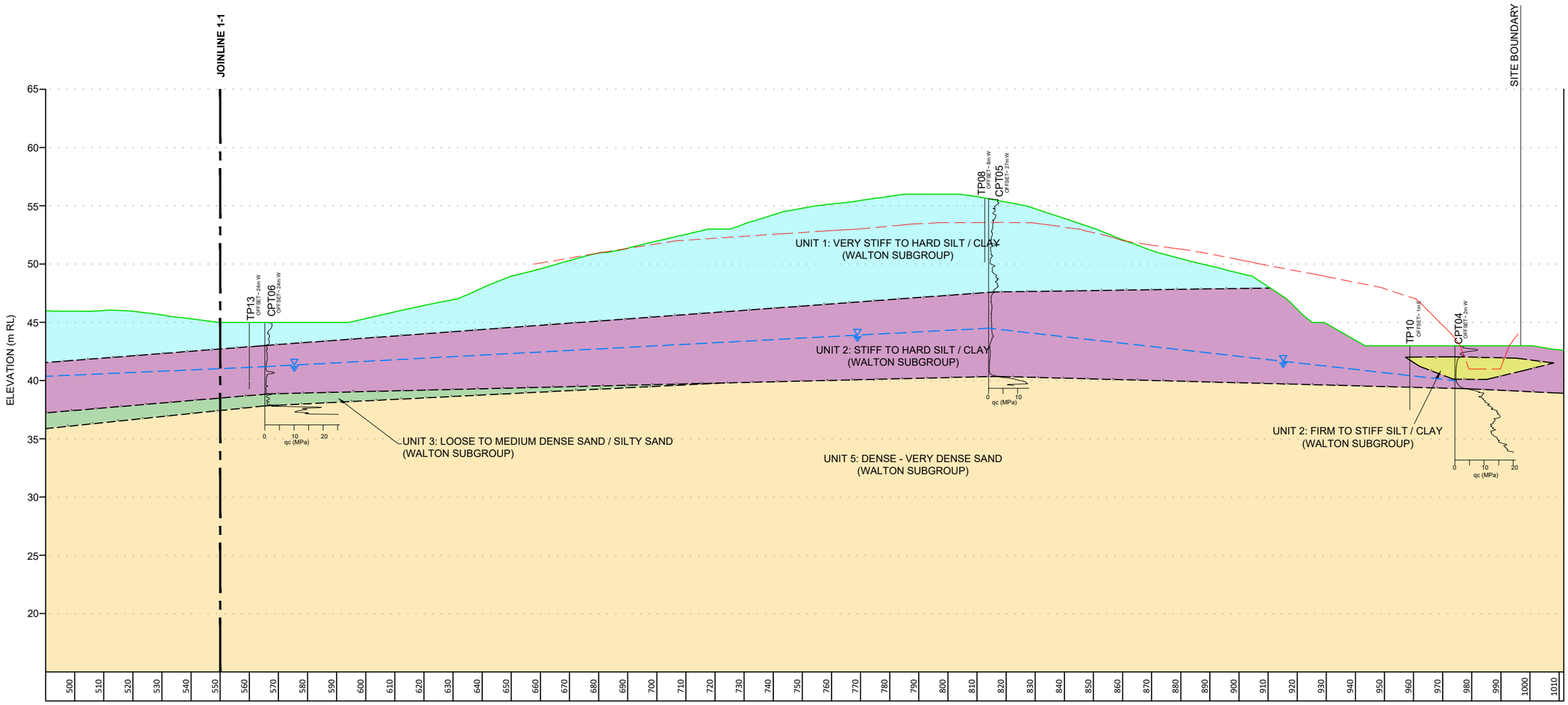


SECTION A

V: 1:375
H: 1:1500

LEGEND:

- EXISTING PROFILE LINE
- PROPOSED PROFILE LINE
- GROUNDWATER TABLE

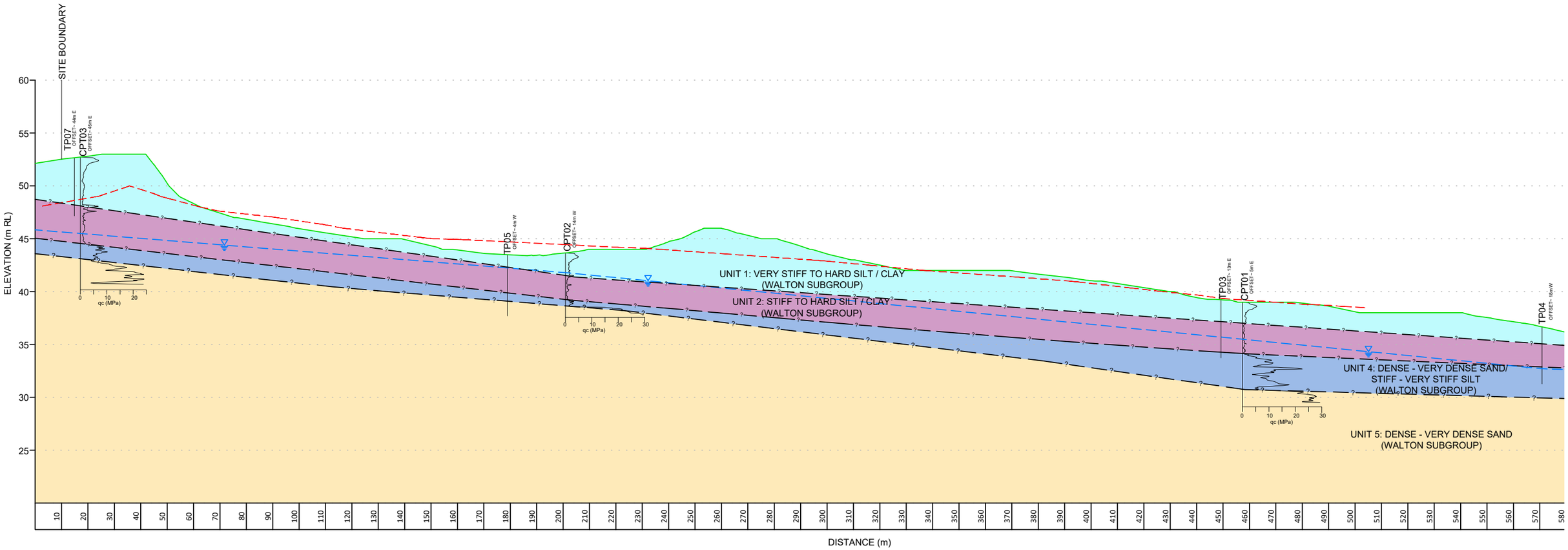
NOTES:

1. BASE PLAN ADAPTED FROM PROPOSED CONTOUR PLAN SUPPLIED BY TRANSURBAN LTD, EMAIL DATED 6 MARCH 2019.

CMW Geosciences

CLIENT: LOCKERBIE ESTATES LTD		DRAWN: WPJ	PROJECT No: HAM2018-0139
PROJECT: LOCKERBIE FARM DEVELOPMENT STUDHOLME STREET, MORRINSVILLE		CHECKED: EJE	DRAWING: 03B
		REVISION: C	SCALE: AS SHOWN
TITLE: GEOLOGICAL SECTION A-A		DATE: 17/04/2019	SHEET: A3

X:\01 PROJECTS\HAM\HAM2018\HAM2018-0101 TO 0150\HAM2018-0139 LOCKERBIE FARM DEVELOPMENT\07 DRAWINGS\HAM2018-0139 SITE INVESTIGATION PLAN REV C_06032019.DWG



SECTION B

V: 1:375
H: 1:1500

LEGEND:

- EXISTING PROFILE LINE
- PROPOSED PROFILE LINE
- GROUNDWATER TABLE

NOTES:

1. BASE PLAN ADAPTED FROM PROPOSED CONTOUR PLAN SUPPLIED BY TRANSURBAN LTD, EMAIL DATED 6 MARCH 2019

CMW Geosciences

CLIENT: LOCKERBIE ESTATES LTD		DRAWN: WPJ	PROJECT No: HAM2018-0139
PROJECT: LOCKERBIE FARM DEVELOPMENT STUDHOLME STREET, MORRINSVILLE		CHECKED: EJE	DRAWING: 04
		REVISION: D	SCALE: AS SHOWN
TITLE: GEOLOGICAL SECTION B-B		DATE: 17/04/2019	SHEET: A3

X:\01 PROJECTS\HAM\HAM2018\HAM2018-0101 TO 0150\HAM2018-0139 LOCKERBIE FARM DEVELOPMENT\07 DRAWINGS\HAM2018-0139 SITE INVESTIGATION PLAN REV C_06032019.DWG

Appendix A: Transurban Conceptual Contour Plan & Block layout and Yield Plan

transurban

Fill or SW Pond -
to be determined

SW pond
Size tbd

Stirling Drive

NOTE: Indicative proposed contours to show intent -
exact modelling and gradients to be undertaken

LEGEND

Proposed contours
Existing contours

Contours are 1m

North

0 25 50 100

-For Coordination-
-Not for construction-

The Site - Conceptual Contours

162 Studholme Street, Morrinsville

Scale 1:1,2000 @A3 Date : 14 February 2019

SC01
Sketch

C:\Transurban Data\projects\9222 - Lockerbie_Estates\4-TU\CAD\222_BASEPLAN.dwg

transurban

Exact location of road connection to be confirmed asd

Exact size and shape of SW pond is subject to change and needs to be confirmed.

Stirling Drive

NOTE: Indicative proposed contours to show intent - exact modelling and gradients to be undertaken

LEGEND

Proposed contours

Existing contours

Contours are 1m

North

0 25 50 100

-For Coordination-

-Not for construction-

The Site - Conceptual Contours

162 Studholme Street, Morrinsville

Scale 1:1,2000 @A3 Date : 14 February 2019

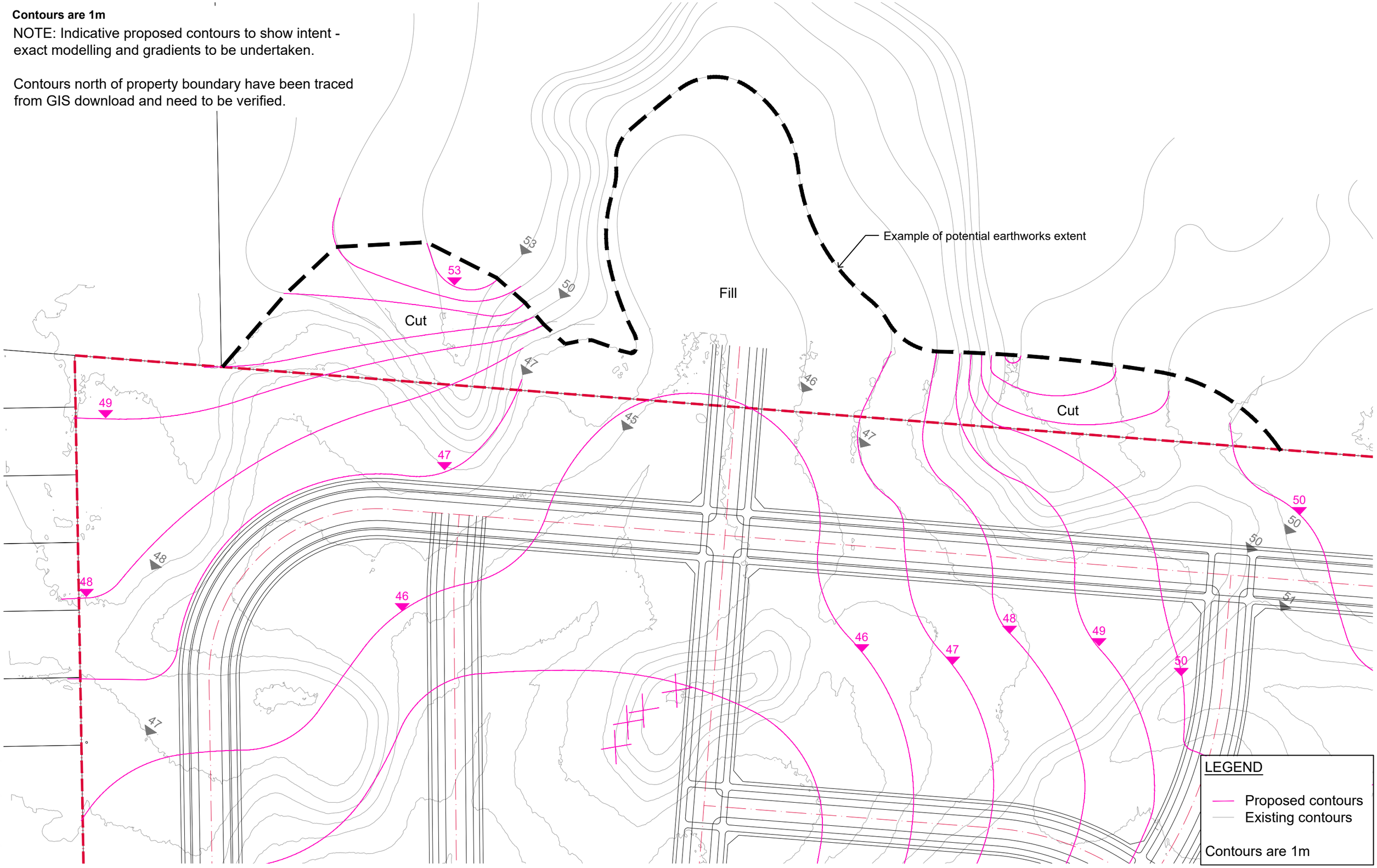
SC02 Sketch

C:\Transurban Data\projects\222 - Lockerbie_Estates\4-TU\CAD\222_BASEPLAN.dwg

Contours are 1m

NOTE: Indicative proposed contours to show intent - exact modelling and gradients to be undertaken.

Contours north of property boundary have been traced from GIS download and need to be verified.



North

0 10 20 50

-For Coordination-
-Not for construction-

The Site - Conceptual Contours

162 Studholme Street, Morrinsville

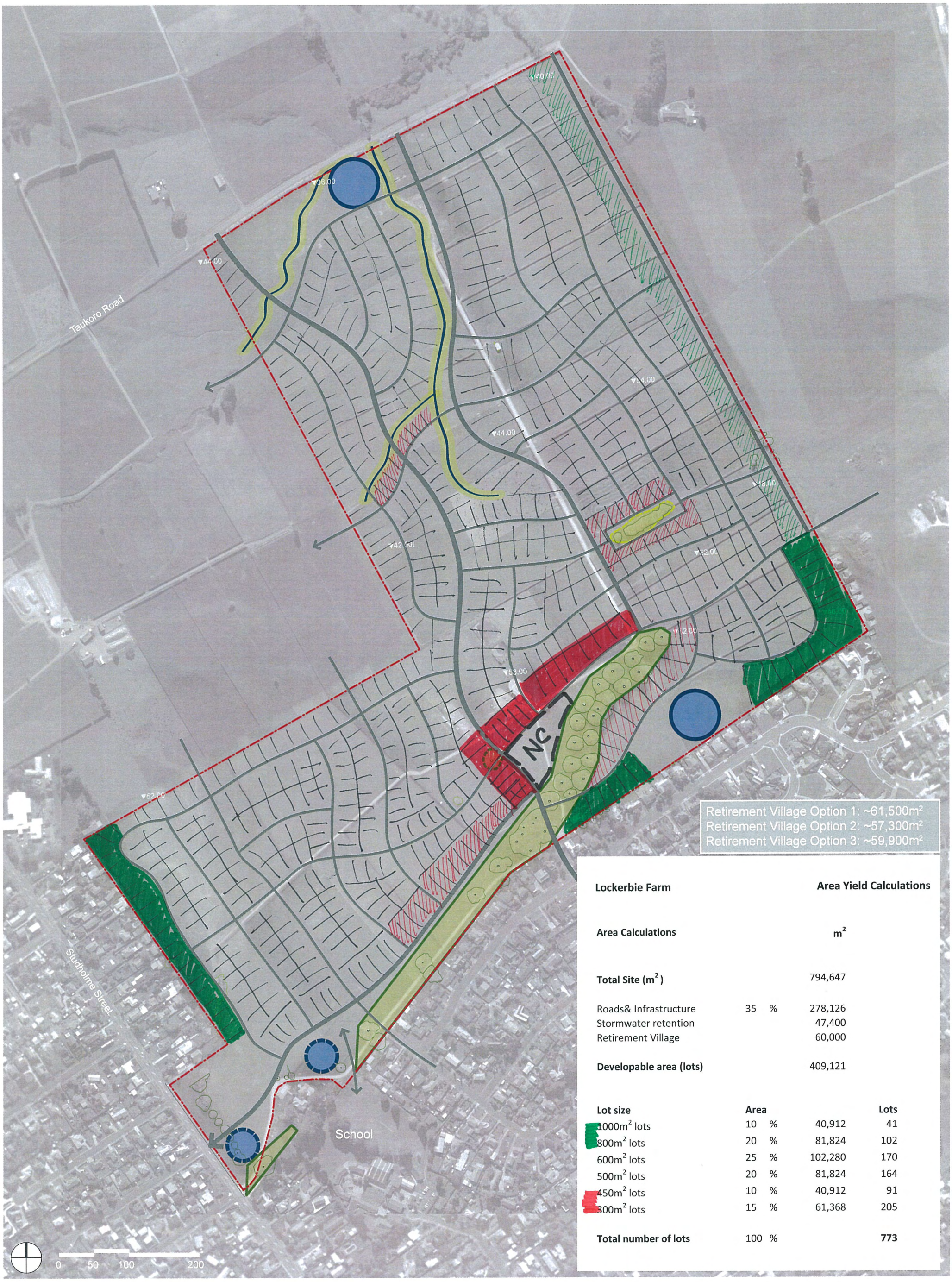
Scale 1:1,1000 @A3 Date : 14 February 2019

SC03 Sketch

C:\Transurban Data\projects\222 - Lockerbie_Estates\4-TU\CAD\222_BASEPLAN.dwg

Block Layout and Yield

transurban



Lockerbie Farm		Area Yield Calculations	
Area Calculations		**m^2**	
Total Site (m^2)		794,647	
Roads& Infrastructure	35 %	278,126	
Stormwater retention		47,400	
Retirement Village		60,000	
Developable area (lots)		409,121	
Lot size	**Area**		**Lots**
1000m^2 lots	10 %	40,912	41
800m^2 lots	20 %	81,824	102
600m^2 lots	25 %	102,280	170
500m^2 lots	20 %	81,824	164
450m^2 lots	10 %	40,912	91
300m^2 lots	15 %	61,368	205
Total number of lots	100 %		**773**

Lockerbie Farm Estate
162 Studholme Street, Morrinville

Scale 1:5,000
19 December 2018

Appendix B: Hand Auger Borehole and Test Pit Logs & Photographs

BOREHOLE LOG - HA01

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 19/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: RS	Position: E.467001.4m N.715716.1m	Elevation: RL 37.50m	Hole Diameter: 50mm
Checked by: EJE	Survey Source: Hand Held GPS	Datum: Mt Eden	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				37.5	0		ML: Clayey SILT: Brown. Low plasticity. (Walton Subgroup)				HA	5 10 15	
				35.9	1		MH: Clayey SILT: Grey, mottled orange. High plasticity. (Walton Subgroup)						
				35.7			ML: SILT: Yellowish brown. Low plasticity, friable. (Walton Subgroup)						
					2		Borehole terminated at 1.8 m						
					3								
					4								
					5								

Termination reason: No recovery. Refusal.

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA02

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 19/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: RS	Position: E.466961.9m N.715711.9m	Elevation: RL 38.50m	Hole Diameter: 50mm
Checked by: EJE	Survey Source: Hand Held GPS	Datum: Mt Eden	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				38.5			ML: SILT: Light brown. Low plasticity, friable. (Walton Subgroup)					5 10 15	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
				37.5	1		CH: CLAY: Orange brown, mottled grey & orange. High plasticity. (Walton Subgroup)				HA		
				36.8			CH: Silty CLAY: Light yellowish brown, mottled grey & orange. High plasticity. (Walton Subgroup)						
				36.7			ML: Clayey SILT: Grey, mottled orange. Low plasticity. (Walton Subgroup)						
					2		*... at 2.00m, turns yellowish brown.*						
				36.4			CH: Silty CLAY: Light yellowish brown, mottled orange & grey. High plasticity. (Walton Subgroup)						
							Borehole terminated at 2.2 m						
					3								
					4								
					5								

Termination reason: No recovery. Refusal.

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA03

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 19/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: RS	Position: E.467037.8m N.715332.6m	Elevation: RL 40.00m	Hole Diameter: 50mm
Checked by: EJE	Survey Source: Hand Held GPS	Datum: Mt Eden	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				40.0			ML: SILT: Light brown. Low plasticity, friable. (Walton Subgroup)	D				5 10 15	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
				39.5			ML: Clayey SILT: Grey. Low plasticity. (Walton Subgroup)						
					1						HA		
				38.8			CH: Silty CLAY: Grey mottled orange. High plasticity. (Walton Subgroup)	M					
					2		Borehole terminated at 2.1 m						
					3								
					4								
					5								

Termination reason: No recovery. Refusal.

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA04

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 19/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: RS | Position: E.467194.5m N.714732.2m | Elevation: RL 50.00m | Hole Diameter: 50mm
Checked by: EJE | Survey Source: Hand Held GPS | Datum: Mt Eden | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				50.0	0		CH: Silty CLAY: Dark brown. High plasticity. (Walton Subgroup)	D					
				49.0	1		CH: CLAY: Brown. High plasticity. (Walton Subgroup)	M			HA		
				47.3	2		CH: Silty CLAY: Light brown. High plasticity. (Walton Subgroup)						
					3		Borehole terminated at 3.0 m						
					4								
					5								

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Structure & Other Observations: Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA05

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 19/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: RS	Position: E.466799.5m N.714411.4m	Elevation: RL 38.50m	Hole Diameter: 50mm
Checked by: EJE	Survey Source: Hand Held GPS	Datum: Mt Eden	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				38.5	0		ML: Clayey SILT: Brown. Low plasticity, friable. (Walton Subgroup)	D			HA	5 10 15	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
				37.3	1		CH: Silty CLAY: Light orange brown. High plasticity. (Walton Subgroup)						
					2		Borehole terminated at 2.1 m						
					3								
					4								
					5								

Termination reason: No recovery. Refusal.

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA06

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 02/04/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: JB
Checked by: EJE
Position: E.467336.7m N.714998.1m
Survey Source: Hand Held GPS
Elevation: RL 42.00m
Datum: Mt Eden
Hole Diameter: 100mm

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				42.0			TOPSOIL:	D				5 10 15	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
				41.7			CL: Silty CLAY: Brown. Low plasticity, friable. (Walton Subgroup)	D to M					
				41.0	1		CH: CLAY: Brown. Low plasticity. (Walton Subgroup)				HA		
							... at 1.20m, becoming brownish orange	M					
					2		Borehole terminated at 2.2 m						
					3								
					4								
					5								

Termination reason: No recovery. Refusal.

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA07

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 02/04/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: JB | Position: E.466999.4m N.714522.7m | Elevation: RL 53.00m | Hole Diameter: 100mm
Checked by: EJE | Survey Source: Hand Held GPS | Datum: Mt Eden

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
	Rises to 2.5m bgl post soakage test.			53.0	0		TOPSOIL:	D				5 10 15	
				52.7			CL: Silty CLAY: Light brown. Low plasticity, friable. (Walton Subgroup)	M					
				52.2	1		CH: CLAY: Light brownish orange, mottled orange. High plasticity. (Walton Subgroup)						
							... at 1.00m, becoming light brownish orange, no mottle.	M to W			HA		
					2		*... at 1.80m, becoming mottled black and orange.*	W					
				50.7			MH: Clayey SILT: Light greyish white. High plasticity. (Walton Subgroup)	W to S					
					3			S					3.0m: Groundwater encountered.
							Borehole terminated at 3.1 m						
					4								
					5								

Termination reason: Target depth

Remarks: Groundwater encountered at 3.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP01

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

1:30 Sheet 1 of 1

Logged by: DMM
Checked by: EJE

Position: E.467070.3m N.714627.1m
Survey Source: Handheld GPS

Elevation: RL 44.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			44.0			OL: TOPSOIL: SILT: Dark brown.				
			43.7			ML: Clayey SILT with trace sand: Greyish brown. Low plasticity, sensitive; sand, fine. (Walton Subgroup)				
	0.4	1 D								
	0.5	Peak = 163kPa Residual = 32kPa								
			43.3			CH: Silty CLAY: Light brown. High plasticity, moderately sensitive. (Walton Subgroup)				
	1.0	Peak = 175kPa Residual = 61kPa		1			M	VSt		
	1.5	Peak = 160kPa Residual = 47kPa								
	2.0	Peak = 102kPa Residual = 20kPa	42.0	2		ML: Clayey SILT with minor sand: Light greyish white. Low plasticity, moderately sensitive; sand, fine. (Walton Subgroup)				
	2.8	Peak = 84kPa Residual = 17kPa					W			
	3.0	2 B		3						
22-01-2019 Some seepage	3.5	3 D								
	3.5	Peak = 84kPa Residual = 20kPa						VSt to St		
	4.0	Peak = 70kPa Residual = 20kPa		4						
	4.6	Peak = 61kPa Residual = 20kPa					W to S			
	5.0	Peak = 61kPa Residual = 23kPa		5						
	5.3	4 D								
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 3.5m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP02

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

1:30 Sheet 1 of 1

Logged by: DMM
Checked by: EJE

Position: E.466978.9m N.714546.5m
Survey Source: Handheld GPS

Elevation: RL 42.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			42.0			OL: TOPSOIL: SILT: Dark brown.			5 10 15 20	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
			41.8			ML: Clayey SILT with trace sand: Light brown. Low plasticity, moderately sensitive; sand, fine (Walton Subgroup)	D			
	0.5	Peak = 116kPa Residual = 35kPa								
			41.3			CH: Silty CLAY: Light brown. High plasticity, moderately sensitive. (Walton Subgroup)				
	1.0	Peak = 175kPa Residual = 73kPa		1						
	1.5	Peak = 145kPa Residual = 55kPa						VSt		
	2.0	Peak = 128kPa Residual = 84kPa		2						
	2.5	Peak = 148kPa Residual = 87kPa								
	3.0	Peak = >200kPa Residual = 70kPa		3			M to W			
22-01-2019 Minor seepage			38.6			CH: CLAY with some silt: Light yellowish orange. High plasticity, insensitive. (Walton Subgroup)				
	3.5	Peak = >200kPa Residual = 102kPa	38.4			ML: SILT with some sand: Grey. Low plasticity, sensitive; sand, fine. (Walton Subgroup)				
	4.0 4.0	1 D Peak = >200kPa Residual = 29kPa		4						
			37.8			SM: Sandy SILT with some gravel: Grey. No plasticity; sand, fine, pumiceous; gravel, fine, pumice. (Walton Subgroup)		H		
	5.0 5.0	2 B Peak = UTP		5						
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 3.7m.

TEST PIT LOG - TP03

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

1:30 Sheet 1 of 1

Logged by: DMM
Checked by: EJE

Position: E.466818.5m N.714465.5m
Survey Source: Handheld GPS

Elevation: RL 39.50m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			39.5			OL: TOPSOIL: SILT: Dark brown.			5 10 15 20	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
			39.3			CL: Clayey SILT with trace sand: Light brown. Low plasticity, sensitive; sand, fine. (Walton Subgroup)				
	0.5	Peak = 134kPa Residual = 20kPa	38.9			CH: Silty CLAY: Light brown. High plasticity, insensitive to moderately sensitive. (Walton Subgroup)				
	1.0	Peak = 198kPa Residual = 87kPa		1						
	1.5	Peak = 145kPa Residual = 52kPa					M	VSt		
	2.0	Peak = 145kPa Residual = 64kPa		2						
	2.5	Peak = 177kPa Residual = 128kPa								
	2.9	Peak = 157kPa Residual = 47kPa								
			36.5	3		CH: CLAY with some silt: Light yellowish grey, mottled brown. High plasticity., moderately sensitive to sensitive. (Walton Subgroup)				
	3.2	Peak = 163kPa Residual = 58kPa								
	3.6	Peak = 93kPa Residual = 26kPa								
	4.0	Peak = 148kPa Residual = 44kPa		4			W	St to VSt		
	4.5	Peak = 113kPa Residual = 15kPa								
22-01-2019	5.0	1 D	34.5	5		CH: Organic CLAY with some rootlets: Dark brown. High plasticity, moderately sensitive. (Walton Subgroup)				
	5.0	Peak = 61kPa Residual = 17kPa	34.4							
	5.2	2 B	34.3			ML: Sandy SILT: Grey. Low plasticity; sand, fine. (Walton Subgroup)		St		
	5.3	3 B	34.2			CH: Organic CLAY: Dark brown. High plasticity. (Walton Subgroup)	S			
						SP: Silty fine to medium SAND: Grey. Poorly graded. (Walton Subgroup)				
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 5.3m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP04

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

1:30 Sheet 1 of 1

Logged by: DMM
Checked by: EJE

Position: E.466788.8m N.714343.7m
Survey Source: Handheld GPS

Elevation: RL 37.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			37.0			OL: TOPSOIL: SILT: Dark brown.				
			36.7			CL: Clayey SILT with trace sand: Light brown. Low plasticity; sand, fine. (Walton Subgroup)	D to M			
	0.5	Peak = >200kPa Residual = 52kPa	36.5			CH: Silty CLAY: Light brown. High plasticity, sensitive. (Walton Subgroup)				
	1.0	Peak = >200kPa Residual = 58kPa		1				VSt to H		
	1.5	Peak = 145kPa Residual = 29kPa					M			
	2.0	1 B	35.0	2		CH: Silty CLAY: Light greyish yellow. High plasticity, moderately sensitive. (Walton Subgroup)				
	2.0	Peak = 145kPa Residual = 29kPa								
	2.5	Peak = 177kPa Residual = 32kPa								
			34.2			MH: Clayey SILT: Light brownish grey. High plasticity, moderately sensitive. (Walton Subgroup)				
	3.0	2 B		3						
	3.0	Peak = 128kPa Residual = 44kPa						VSt		
	3.5	Peak = 148kPa Residual = 55kPa								
			33.2			CH: CLAY with some silt: Light yellow. High plasticity, moderately sensitive. (Walton Subgroup)				
	4.0	Peak = 119kPa Residual = 44kPa		4			W			
	4.8	Peak = 90kPa Residual = 29kPa	32.2			CH: Organic CLAY with some roots: Dark brown. High plasticity, moderately sensitive. (Walton Subgroup)		St		
	5.0	3 B	32.1	5		ML: Sandy SILT: Grey. No plasticity. (Walton Subgroup)				
22-01-2019			31.6			Lignite/consolidated peat: Black. Amorphous, hard, no odour. (Walton Subgroup)	M			
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 5.4m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP05

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.466802.0m N.714735.6m
Survey Source: Handheld GPS

Elevation: RL 44.50m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			44.5			OL: TOPSOIL: SILT: Dark brown.				
			44.2			CL: Clayey SILT with trace sand: Light brown. Low plasticity, extra sensitive; sand, fine. (Walton Subgroup)	D to M	H		
	0.5	Peak = >200kPa Residual = 23kPa	43.9			CH: Silty CLAY: Light brown mottled dark brown. High plasticity, moderately sensitive to extra sensitive. (Walton Subgroup)				
	1.0	Peak = >200kPa Residual = 87kPa		1						
	1.5	Peak = 131kPa Residual = 26kPa								
	1.8	Peak = 131kPa Residual = 15kPa					M	VSt to H		
	2.0	Peak = 119kPa Residual = 35kPa	42.5	2		CL: Clayey SILT with trace sand: Light brownish yellow. Low plasticity, moderately sensitive; sand, fine. (Walton Subgroup)				
	2.5	Peak = >200kPa Residual = 35kPa								
	3.0	Peak = 113kPa Residual = 20kPa	41.5	3		CH: Silty CLAY: Light grey streaked yellow. High plasticity, moderately sensitive. (Walton Subgroup)				
	3.5	Peak = 79kPa Residual = 15kPa								
	4.0	Peak = 87kPa Residual = 20kPa		4				St to VSt		
22-01-2019 Minor seepage	4.8	Peak = >200kPa Residual = 44kPa					M to W			
			39.6					H		
				5		ML: Sandy SILT: Grey. No plasticity. (Walton Subgroup)				
			39.1			SP: Silty fine to medium SAND: Dark greyish yellow. Poorly graded, pumiceous. (Walton Subgroup)				
	5.6	1 B								
						Test pit terminated at 5.80 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 4.9m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP06

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.466773.1m N.714766.3m
Survey Source: Handheld GPS

Elevation: RL 48.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			48.0			OL: TOPSOIL: SILT: Brown.			5 10 15 20	
			47.8			CL: Clayey SILT with trace sand: Light brown. Low plasticity, moderately sensitive; sand, fine. (Walton Subgroup)				
	0.5	Peak = 137kPa Residual = 26kPa					D to M			
	1.0	Peak = 145kPa Residual = 52kPa		1						
			46.9			CH: Silty CLAY: Light brownish orange. High plasticity, moderately sensitive. (Walton Subgroup)				
	1.5	Peak = 172kPa Residual = 41kPa								
	2.0	Peak = 175kPa Residual = 58kPa		2			M to W			
	2.5	Peak = >200kPa Residual = 55kPa						VSt to H		
	3.0	Peak = 143kPa Residual = 26kPa	45.0	3		CL: Clayey SILT with minor sand: Light yellow mottled orange. Low plasticity, moderately sensitive to extra sensitive; sand, fine, pumiceous. (Walton Subgroup)				
	3.5	Peak = 145kPa Residual = 15kPa								
	4.0	Peak = 160kPa Residual = 32kPa		4			W			
				5						
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP07

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.466849.5m N.714899.8m
Survey Source: Handheld GPS

Elevation: RL 51.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			51.0			OL: TOPSOIL: SILT: Brown.				
			50.8			CH: Silty CLAY: Light brown. High plasticity, moderately sensitive. (Walton Subgroup)				
	0.5	Peak = 93kPa Residual = 15kPa						St		
	1.0	Peak = 157kPa Residual = 55kPa		1						
	1.5	Peak = 145kPa Residual = 58kPa								
	2.0	1 D								
	2.0	Peak = 163kPa Residual = 55kPa		2				VSt		
	2.5	Peak = 116kPa Residual = 35kPa					M to W			
	3.0	Peak = 172kPa Residual = 35kPa	48.0	3		ML: Clayey SILT with minor sand: White mottled black. Low plasticity, moderately sensitive; sand, fine. (Walton Subgroup)				
	3.8	Peak = 111kPa Residual = 17kPa								
				4				St to VSt		
	4.3	2 B								
	4.5	Peak = 90kPa Residual = 29kPa								
	5.0	Peak = 99kPa Residual = 29kPa		5						
			45.8			ML: Clayey SILT with trace sand: Light brownish orange. Low plasticity; sand, fine. (Walton Subgroup)				
			45.6			ML: Clayey SILT with minor sand: White mottled black. Low plasticity; sand, fine. (Walton Subgroup)				
						Test pit terminated at 5.50 m				
				6						

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15 20

Structure & Other Observations: Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP08

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467387.4m N.715064.9m
Survey Source: Handheld GPS

Elevation: RL 56.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			56.0			OL: TOPSOIL: SILT: Dark brown.				
			55.7			ML: Clayey SILT with some sand: Light brown. Low plasticity; sand, fine. (Walton Subgroup)				
	0.5	Peak = >200kPa Residual = 58kPa	55.5			CH: Silty CLAY: Light brown. High plasticity, moderately sensitive. (Walton Subgroup)		VSt to H		
	1.0	Peak = 160kPa Residual = 44kPa		1						
			54.8			CH: Silty CLAY: Light brownish orange. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)				
	1.5	Peak = 169kPa Residual = 73kPa								
	2.0	Peak = 157kPa Residual = 44kPa		2				VSt		
	2.5	Peak = 131kPa Residual = 17kPa					M to W			
	3.0	Peak = 122kPa Residual = 20kPa	53.0	3		CH: Silty CLAY: Light brown mottled orange. High plasticity, sensitive. (Walton Subgroup)				
	3.5	Peak = 87kPa Residual = 17kPa						St to VSt		
	4.0	Peak = 189kPa Residual = 29kPa	52.0	4		CH: Silty CLAY: Brown mottled black. High plasticity, sensitive. (Walton Subgroup)				
	4.8	Peak = 145kPa Residual = 32kPa						VSt		
				5						
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP09

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467578.6m N.715192.4m
Survey Source: Handheld GPS

Elevation: RL 47.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			47.0			OL: TOPSOIL: SILT: Dark brown.				
			46.7			ML: Clayey SILT with trace sand: Light brown. Low plasticity, sensitive; sand, fine. (Walton Subgroup)		VSt		
	0.5	Peak = 186kPa Residual = 32kPa								
			46.3			CH: Silty CLAY: Light brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)				
	1.0	Peak = 113kPa Residual = 41kPa		1			D to M			
	1.5	Peak = 143kPa Residual = 32kPa								
	2.0	Peak = 99kPa Residual = 29kPa		2						
	2.5	Peak = 143kPa Residual = 55kPa						St to VSt		
	3.0	Peak = 145kPa Residual = 35kPa		3						
	3.5	Peak = 116kPa Residual = 32kPa					W			
	4.0	Peak = 99kPa Residual = 26kPa		4						
	4.5	Peak = 131kPa Residual = 32kPa								
	5.0	Peak = 105kPa Residual = 26kPa		5						
			41.9			MH: Clayey SILT: Grey mottled dark brown. High plasticity. (Walton Subgroup)				
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP10

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467469.6m N.714943.8m
Survey Source: Handheld GPS

Elevation: RL 42.50m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			42.5			OL: TOPSOIL: SILT: Dark brown.				
			42.3			ML: Clayey SILT: Light grey mottled orange. Low plasticity, moderately sensitive to sensitive. (Walton Subgroup)				
	0.5	Peak = 189kPa Residual = 26kPa						VSt		
	1.0	Peak = 148kPa Residual = 41kPa		1						
			41.4			ML: Clayey SILT: Light brown mottled grey. Low plasticity. (Walton Subgroup)				
			41.2			ML: Clayey SILT with minor sand: Yellowish grey mottled orange. Low plasticity, moderately sensitive to sensitive; sand, fine. (Walton Subgroup)				
	1.5	Peak = 87kPa Residual = 15kPa								
	2.0	Peak = 73kPa Residual = 12kPa		2			M to W			
	2.5	Peak = 73kPa Residual = 12kPa								
	3.0	1 D		3		... at 3.00m, Becoming light orange		St		
	3.0	Peak = 76kPa Residual = 20kPa								
	3.5	Peak = 67kPa Residual = 17kPa								
22-01-2019 Minor seepage	4.0	Peak = 61kPa Residual = 32kPa	38.5	4		ML: Clayey SILT with minor sand: Yellowish grey mottled black. Low plasticity, insensitive to moderately sensitive; sand, fine. (Walton Subgroup)				
	4.3	2 B								
	4.5	Peak = 55kPa Residual = 26kPa					W to S			
	5.0	Peak = 113kPa Residual = 32kPa		5				VSt		
			37.3			ML: Sandy SILT with some pumice: Yellowish grey. Low plasticity. (Walton Subgroup)				
	5.3	3 D								
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 4.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP11

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 22/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467302.6m N.714887.3m
Survey Source: Handheld GPS

Elevation: RL 50.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			50.0			OL: TOPSOIL: SILT: Dark brown.	D to M		5 10 15 20	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
			49.7			ML: Clayey SILT with trace sand: Light brown. Low plasticity; sand, fine. (Walton Subgroup)				
	0.5	Peak = UTP	49.5			CH: Silty CLAY: Light brown. High plasticity, insensitive to sensitive. (Walton Subgroup)				
	1.0	Peak = >200kPa Residual = 116kPa		1						
	1.5	Peak = 195kPa Residual = 105kPa								
	2.0	Peak = >200kPa Residual = 113kPa		2						
	2.5	Peak = >200kPa Residual = 116kPa						VSt to H		
						... at 2.80m, Some wood/roots, up to 800mm long				
	3.0	Peak = >200kPa Residual = 87kPa		3			M to W			
	3.5	Peak = 189kPa Residual = 41kPa								
	4.0	Peak = 198kPa Residual = 61kPa		4						
	4.5	Peak = 148kPa Residual = 29kPa								
	5.0	Peak = UTP	45.0	5		CL: Silty CLAY with minor sand: Brown. Low plasticity; sand, fine. (Walton Subgroup)		H		
			44.7			CL: Silty CLAY with minor sand: Light yellowish brown. Low plasticity; sand, fine. (Walton Subgroup)				
						Test pit terminated at 5.60 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP12

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467215.2m N.715048.1m
Survey Source: Handheld GPS

Elevation: RL 53.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			53.0			TOPSOIL: SILT: Dark brown.				
			52.7			Clayey SILT with trace sand: Light brown. Low plasticity, sensitive; sand, fine. (Walton Subgroup)				
	0.5	Peak = 160kPa Residual = 26kPa								
	1.0	Peak = 148kPa Residual = 32kPa		1						
						... at 1.20m, Mottled black				
	1.5	Peak = >200kPa Residual = 29kPa								
			51.2			Silty CLAY: Brownish orange mottled red. High plasticity, moderately sensitive. (Walton Subgroup)				
	2.0	Peak = 160kPa Residual = 73kPa		2				VSt to H		
	2.5	Peak = >200kPa Residual = 73kPa					M to W			
	3.0	1 D		3						
	3.0	Peak = >200kPa Residual = 70kPa								
	3.5	Peak = >200kPa Residual = 55kPa								
			49.2			Silty CLAY: Light brownish yellow mottled red. High plasticity, moderately sensitive. (Walton Subgroup)				
	3.9	Peak = 108kPa Residual = 32kPa		4				VSt		
	4.1	Peak = >200kPa Residual = 47kPa	48.9			Silty CLAY: Light yellowish grey mottled red. High plasticity, insensitive to sensitive. (Walton Subgroup)				
	4.3	Peak = >200kPa Residual = 128kPa								
	4.8	Peak = 175kPa Residual = 64kPa						VSt to H		
	5.0	2 D		5						
	5.0	Peak = 186kPa Residual = 58kPa								
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP13

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467244.5m N.715273.8m
Survey Source: Handheld GPS

Elevation: RL 44.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			44.0			OL: TOPSOIL: Organic SILT: Dark brown. Low plasticity.				
	0.5	Peak = 166kPa Residual = 29kPa	43.5			ML: Clayey SILT with trace sand: Light brown. Low plasticity, sensitive; sand, fine. (Walton Subgroup)		VSt		
	1.0	Peak = 148kPa Residual = 32kPa	43.0	1		CH: Silty CLAY: Yellowish brown. High plasticity, insensitive to sensitive. (Walton Subgroup)				
	1.4	Peak = 160kPa Residual = 44kPa								
	2.0	Peak = >200kPa Residual = 108kPa		2			M to W	VSt to H		
	2.5	Peak = 119kPa Residual = 26kPa								
			41.0	3		CH: Silty CLAY: Light yellowish grey mottled dark yellow. High plasticity, sensitive. (Walton Subgroup)				
	3.2	Peak = 148kPa Residual = 44kPa						VSt		
23-01-2019 Minor seepage	4.0	Peak = 160kPa Residual = 23kPa		4						
	4.1	Peak = 47kPa Residual = 17kPa	39.9			CH: Organic CLAY: Black. High plasticity, moderately sensitive. (Walton Subgroup)				
			39.8			CH: Silty CLAY: Grey. High plasticity, moderately sensitive. (Walton Subgroup)				
	4.3	Peak = 38kPa Residual = 15kPa						F		
	4.9	Peak = 44kPa Residual = 17kPa		5			W to S			
			38.7			SP: Silty fine SAND: Grey. Poorly graded. (Walton Subgroup)				
			38.5			MH: Organic SILT: Dark greyish brown. High plasticity. (Walton Subgroup)				
			38.4			SP: Silty fine SAND: Grey. Poorly graded. (Walton Subgroup)				
						Test pit terminated at 5.70 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 4.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP14

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467043.3m N.715343.5m
Survey Source: Handheld GPS

Elevation: RL 40.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			40.0			OL: TOPSOIL: SILT: Dark brown.				
			39.9			ML: Clayey SILT: Grey mottled dark yellow. Low plasticity, moderately sensitive to extra sensitive. (Walton Subgroup)				
	0.5	Peak = >200kPa Residual = 79kPa					D			
	1.0	Peak = >200kPa Residual = 76kPa		1						
	1.5	Peak = >200kPa Residual = 55kPa				... at 1.50m, Minor fine sand				
	2.0	Peak = 137kPa Residual = 20kPa		2				VSt to H		
	2.5	Peak = 137kPa Residual = 29kPa								
	3.0	Peak = 116kPa Residual = 58kPa		3			M			
	3.5	Peak = >200kPa Residual = 17kPa								
	4.0	Peak = 192kPa Residual = 35kPa	36.0	4		ML: Sandy SILT with minor gravel: Grey. No plasticity, insensitive to sensitive; gravel, fine, pumiceous. (Walton Subgroup)		VSt		
	4.8	Peak = 131kPa Residual = 70kPa		5						
			34.6			ML: Sandy SILT with some gravel: Grey. No plasticity; gravel, fine, pumiceous. (Walton Subgroup)				
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP15

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.466904.4m N.715369.3m
Survey Source: Handheld GPS

Elevation: RL 48.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15 20	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			48.0			OL: TOPSOIL: SILT: Dark brown.				
			47.7			ML: Clayey SILT with trace sand: Light brown. Low plasticity; sand, fine. (Walton Subgroup)				
	0.5	Peak = >200kPa Residual = 15kPa	47.5			CH: Silty CLAY: Yellowish brown mottled dark red. High plasticity, insensitive to moderately sensitive. (Walton Subgroup)				
	1.0	Peak = >200kPa Residual = 111kPa		1						
	1.5	Peak = >200kPa Residual = 102kPa								
	2.0	Peak = UTP		2				H		
	2.5	Peak = >200kPa Residual = 67kPa					M to W			
	3.0	Peak = >200kPa Residual = 70kPa		3						
	3.5	Peak = 160kPa Residual = 70kPa	44.5			CH: Silty CLAY: Grey mottled red. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)				
	4.0	Peak = 177kPa Residual = 49kPa		4						
	4.5	Peak = 128kPa Residual = 26kPa						VSt		
	5.0	Peak = 145kPa Residual = 41kPa	43.0	5		CH: Silty CLAY: Grey mottled dark yellow. High plasticity, moderately sensitive. (Walton Subgroup)				
			42.6			CH: CLAY: Light grey mottled red. High plasticity, sensitive. (Walton Subgroup)	W			
						Test pit terminated at 5.70 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP16

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467365.2m N.715611.1m
Survey Source: Handheld GPS

Elevation: RL 45.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			45.0			OL: TOPSOIL: SILT: Dark brown.				
			44.7			ML: Clayey SILT with trace sand: Light brown. Low plasticity, moderately sensitive to sensitive; sand, fine. (Walton Subgroup)				
	0.5	Peak = 131kPa Residual = 32kPa								
	1.0	Peak = 113kPa Residual = 26kPa		1						
	1.5	Peak = 128kPa Residual = 55kPa					M			
	2.0	Peak = 116kPa Residual = 35kPa		2				VSt		
	2.5	Peak = 131kPa Residual = 41kPa								
	3.0	Peak = 148kPa Residual = 47kPa		3						
	3.7	Peak = 84kPa Residual = 26kPa	41.4			CH: Silty CLAY: Light grey mottled red. High plasticity, sensitive. (Walton Subgroup)				
				4				St		
Minor seepage	4.5	Peak = 32kPa Residual = 15kPa	40.5			CL: Silty CLAY with minor sand: Light yellowish grey mottled black. Low plasticity, moderately sensitive to sensitive; sand, fine to medium. (Walton Subgroup)	W	F		
	5.0	Peak = 148kPa Residual = 26kPa		5				VSt		
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 5.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP17

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467105.4m N.715619.5m
Survey Source: Handheld GPS

Elevation: RL 43.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			43.0			OL: TOPSOIL: SILT: Dark brown.				
			42.8			ML: Clayey SILT with trace sand: Light brown. Low plasticity, moderately sensitive; sand, fine. (Walton Subgroup)				
	0.5	Peak = 116kPa Residual = 29kPa						VSt		
	1.0	Peak = 102kPa Residual = 26kPa		1						
	1.5	Peak = 73kPa Residual = 17kPa	41.5			CH: Silty CLAY: Reddish brown. High plasticity, sensitive. (Walton Subgroup)		St		
			41.2			CH: Silty CLAY: Greyish yellow mottled brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)				
	2.0	Peak = >200kPa Residual = 79kPa		2			M			
	2.5	Peak = >200kPa Residual = 67kPa						VSt to H		
	3.0	Peak = 102kPa Residual = 23kPa		3						
	3.5	Peak = 70kPa Residual = 15kPa						St		
	4.0	Peak = UTP	39.0	4		CL: Silty CLAY with some sand: Brown. Low plasticity. (Walton Subgroup)		H		
			38.8			CL: Silty CLAY with minor sand: Yellowish orange. Low plasticity, moderately sensitive; sand, fine. (Walton Subgroup)				
	4.5	Peak = 61kPa Residual = 23kPa					W	St to VSt		
	5.0	Peak = 116kPa Residual = 29kPa		5						
			37.7			ML: Sandy SILT with some gravel: Yellowish grey. No plasticity; sand, fine, pumiceous; gravel, fine, pumice. (Alluvium)				
						Test pit terminated at 5.50 m				
				6						

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15 20

Structure & Other Observations: Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP18

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467058.3m N.715587.9m
Survey Source: Handheld GPS

Elevation: RL 39.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15 20	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
			39.0			OL: SILT with some wire, metal, and concrete: Black. No plasticity. (UNCONTROLLED FILL)				
	1.0	Peak = UTP		1			M			
23-01-2019 Some seepage										
	2.0	Peak = 87kPa Residual = 23kPa	37.0	2		ML: SILT: Grey. Low plasticity, moderately sensitive. (Walton Subgroup)	W to S	St		
			36.5			SP: Silty fine to medium SAND with some gravel: Bluish green. Poorly graded; gravel, fine. (Walton Subgroup)	W	TP		
23-01-2019 Garden hose amount of water coming from a single point	3.0	Peak = 134kPa Residual = 47kPa	36.0	3		ML: Sandy SILT with some gravel: Light yellow. No plasticity, moderately sensitive to sensitive; sand, fine; gravel, fine. (Walton Subgroup)				
	3.5	Peak = 131kPa Residual = 41kPa								
	4.0	Peak = 145kPa Residual = 26kPa		4			W to S	VSt		
			34.5			ML: Clayey SILT: Grey. Low plasticity, extra sensitive. (Walton Subgroup)				
	5.0	Peak = 145kPa Residual = 12kPa		5						
						Test pit terminated at 5.20 m				
				6						

Termination reason: Target depth

Remarks: Groundwater encountered at 3.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP19

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467016.3m N.715722.0m
Survey Source: Handheld GPS

Elevation: RL 38.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15 20	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
			38.0			OL: TOPSOIL: SILT: Dark brown.				
			37.8			ML: Clayey SILT with trace sand: Greyish brown. Low plasticity, insensitive; sand, fine. (Walton Subgroup)		VSt to H		
	0.5	Peak = UTP								
	1.0	Peak = 102kPa Residual = 55kPa		1						
			36.8			CH: Silty CLAY: Light yellowish grey. High plasticity, moderately sensitive. (Walton Subgroup)				
	1.5	Peak = 113kPa Residual = 32kPa						St to VSt		
	2.0	Peak = 96kPa Residual = 26kPa		2						
	2.5	Peak = 160kPa Residual = 20kPa	35.5			CH: Silty CLAY: Grey. High plasticity, sensitive. (Walton Subgroup)	M	VSt		
			35.1	3		CH: Silty CLAY: Yellowish grey mottled brown. High plasticity, sensitive. (Walton Subgroup)				
	3.6	Peak = >200kPa Residual = 35kPa								
	3.7	Peak = UTP								
	4.0	1 D		4				H		
	4.2	Peak = UTP								
	5.0	Peak = 134kPa Residual = 17kPa	33.0	5		ML: Clayey SILT with some sand: Bluish grey. Low plasticity, sensitive; sand, fine. (Walton Subgroup)		VSt		
	5.2	2 D								
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP20

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.466777.4m N.715570.3m
Survey Source: Handheld GPS

Elevation: RL 43.50m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			43.5			OL: TOPSOIL: SILT: Dark brown.				
			43.3			ML: Clayey SILT with trace sand: Brown. Low plasticity, sensitive; sand, fine. (Walton Subgroup)	D to M	H		
	0.5	Peak = >200kPa Residual = 35kPa								
			42.8			CH: Silty CLAY: Light brown. High plasticity, insensitive to sensitive. (Walton Subgroup)				
	1.0	Peak = 145kPa Residual = 20kPa		1						
	1.5	Peak = 134kPa Residual = 90kPa								
	2.0	Peak = 113kPa Residual = 87kPa		2				VSt to H		
	2.5	Peak = 160kPa Residual = 55kPa								
	2.8	Peak = 131kPa Residual = 61kPa					M to W			
	3.0	Peak = >200kPa Residual = 76kPa		3		*... at 2.90m, Mottled brown*				
			40.3			CH: Silty CLAY: Yellowish brown. High plasticity, moderately sensitive. (Walton Subgroup)				
	3.5	Peak = 189kPa Residual = 70kPa								
				4						
	4.2	Peak = 160kPa Residual = 44kPa						VSt		
	4.8	Peak = 102kPa Residual = 23kPa	38.7			CH: CLAY with some silt: Grey mottled yellow. High plasticity, sensitive. (Walton Subgroup)				
				5			W			
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP21

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.466870.3m N.715608.9m
Survey Source: Handheld GPS

Elevation: RL 37.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
23-01-2019 ▼	0.2	Peak = 58kPa Residual = 17kPa	37.0	0		ML: SILT: Grey. Low plasticity, moderately sensitive. (Recent Alluvium)	S	St	5 10 15 20	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
	0.4	Peak = 99kPa Residual = 15kPa	36.7			CH: Silty CLAY: Greyish brown. High plasticity, sensitive. (Recent Alluvium)				
						Test pit terminated at 0.40 m				
				1						
				2						
				3						
				4						
				5						
				6						

Termination reason: Test pit terminated at 0.4m when stiff soils encountered.

Remarks: Groundwater encountered from ground level.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP22

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.467037.0m N.715614.6m
Survey Source: Handheld GPS

Elevation: RL 39.00m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
23-01-2019 ▼	0.3	Peak = 47kPa Residual = 15kPa	39.0	0		ML: SILT: Grey. Low plasticity.		F	5 10 15 20	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
	0.7	Peak = UTP				Test pit terminated at 0.70 m		H		
				1						
				2						
				3						
				4						
				5						
				6						

Termination reason: Test pit terminated at 0.7m when stiff soils encountered.

Remarks: Groundwater encountered from ground level.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP23

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.466657.1m N.714674.1m
Survey Source: Handheld GPS

Elevation: RL 47.50m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
			47.5			OL: TOPSOIL: SILT: Dark brown.				
			47.3			ML: Clayey SILT with trace sand: Brown. Low plasticity, sensitive; sand, fine. (Walton Subgroup)				
	0.5	Peak = 160kPa Residual = 26kPa						VSt		
	1.0	Peak = 116kPa Residual = 44kPa	46.5	1		CH: Silty CLAY: Light brown. High plasticity, moderately sensitive. (Walton Subgroup)				
	1.5	Peak = 160kPa Residual = 47kPa								
	2.0	Peak = 76kPa Residual = 26kPa		2		... at 2.00m, Mottled brown				
	2.4	Peak = 172kPa Residual = 76kPa					M			
	2.8	Peak = 128kPa Residual = 58kPa								
				3				St to VSt		
			44.4			CH: Silty CLAY: Light yellowish brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)				
	3.2	Peak = 90kPa Residual = 29kPa								
	3.6	Peak = 81kPa Residual = 20kPa								
	4.0	Peak = 119kPa Residual = 20kPa		4						
	4.8	Peak = 64kPa Residual = 32kPa								
				5						
			42.4			ML: Clayey SILT with some sand: Light yellow. Low plasticity; sand, fine to medium. (Walton Subgroup)				
	5.2	1 D					W			
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP24

Client: Lockerbie Estates Limited
Project: Lockerbie Development
Site Location: Morrinsville
Project No.: HAM2018-0139
Date: 23/01/2019
Test Pit Location: Refer to site plan

CMW Geosciences

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Logged by: DMM
Checked by: EJE

Position: E.466721.9m N.714622.8m
Survey Source: Handheld GPS

Elevation: RL 40.50m
Datum: Mt Eden

Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
23-01-2019 ▼			40.5			OL: TOPSOIL: SILT: dark brown.	M			
	0.5	Peak = 58kPa Residual = 15kPa	40.2			MH: Clayey SILT: Yellowish grey mottled orange. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)				
	1.0	Peak = 90kPa Residual = 12kPa		1				St		
	1.5	Peak = 134kPa Residual = 20kPa	39.0			ML: Sandy SILT: Dark yellowish brown. No plasticity, sensitive. (Walton Subgroup)				
	2.0	Peak = 160kPa Residual = 20kPa		2			W	St to VSt		
	3.0	Peak = 81kPa Residual = 15kPa		3						
			37.4			ML: Clayey SILT with some sand: Light grey mottled orange. Low plasticity, moderately sensitive to sensitive; sand, fine. (Walton Subgroup)				
	3.5	Peak = 58kPa Residual = 17kPa								
	4.0 4.0	1 D Peak = 90kPa Residual = 17kPa		4				St		
	5.0	Peak = 73kPa Residual = 17kPa		5						
			35.4			MH: Clayey SILT: Bluish grey. High plasticity. (Walton Subgroup)				
	5.3	2 D					S			
						Test pit terminated at 5.50 m				
				6						

Termination reason: Target depth

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT PHOTOGRAPHS: TP01

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467070.3m N.714627.1m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 44.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP01 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP02

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.466978.9m N.714546.5m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 42.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP02 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP03

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

Logged by: DMM	Position: E.466818.5m N.714465.5m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 39.5m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP03 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP04

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.466788.8m N.714343.7m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 37.0m	Termination Depth: 5.4m	Contractor: DRN Excavations

TP04 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP05

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.466802.0m N.714735.6m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 44.5m	Termination Depth: 5.8m	Contractor: DRN Excavations

TP05 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP06

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.466773.1m N.714766.3m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 48.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP06 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP07

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

Logged by: DMM	Position: E.466849.5m N.714899.8m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 51.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP07 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP08

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467387.4m N.715064.9m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 56.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP08 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP09

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

Logged by: DMM	Position: E.467578.6m N.715192.4m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 47.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP09 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP10

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467469.6m N.714943.8m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 42.5m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP10 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP11

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467302.6m N.714887.3m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 50.0m	Termination Depth: 5.6m	Contractor: DRN Excavations

TP11 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP12

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

Logged by: DMM	Position: E.467215.2m N.715048.1m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 53.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP12 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP13

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467244.5m N.715273.8m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 44.0m	Termination Depth: 5.7m	Contractor: DRN Excavations

TP13 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP14

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467043.3m N.715343.5m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 40.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP14 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP15

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.466904.4m N.715369.3m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 48.0m	Termination Depth: 5.7m	Contractor: DRN Excavations

TP15 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP16

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467365.2m N.715611.1m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 45.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP16 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP17

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

Logged by: DMM	Position: E.467105.4m N.715619.5m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 43.0m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP17 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP18

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467058.3m N.715587.9m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 39.0m	Termination Depth: 5.2m	Contractor: DRN Excavations

TP18 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP19

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.467016.3m N.715722.0m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 38.0m	Termination Depth: 5.2m	Contractor: DRN Excavations

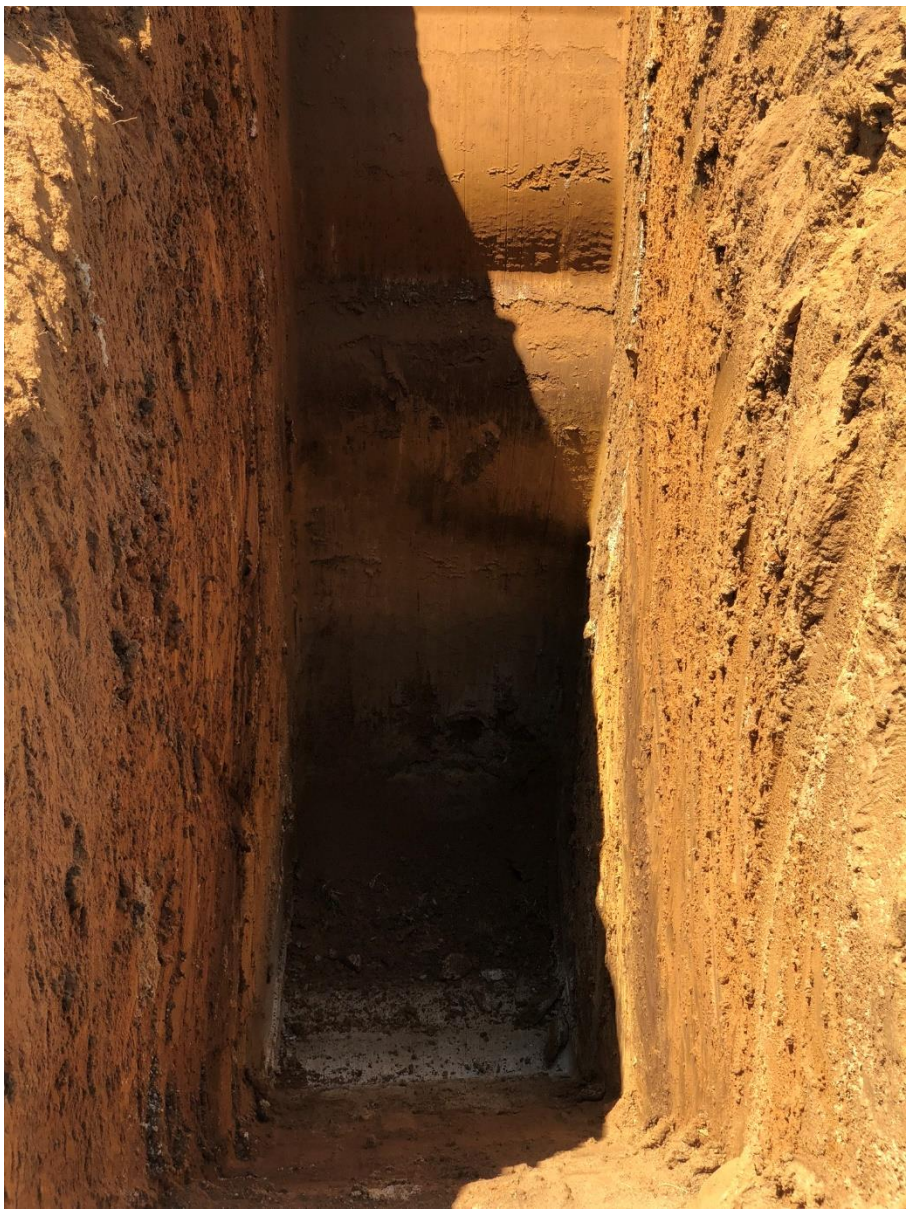
TP19 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP20

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.466777.4m N.715570.3m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 43.5m	Termination Depth: 5.5m	Contractor: DRN Excavations



TP20 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP23

Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.466657.1m N.714674.1m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 47.5m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP23 – TEST PIT EXCAVATION

TEST PIT PHOTOGRAPHS: TP24

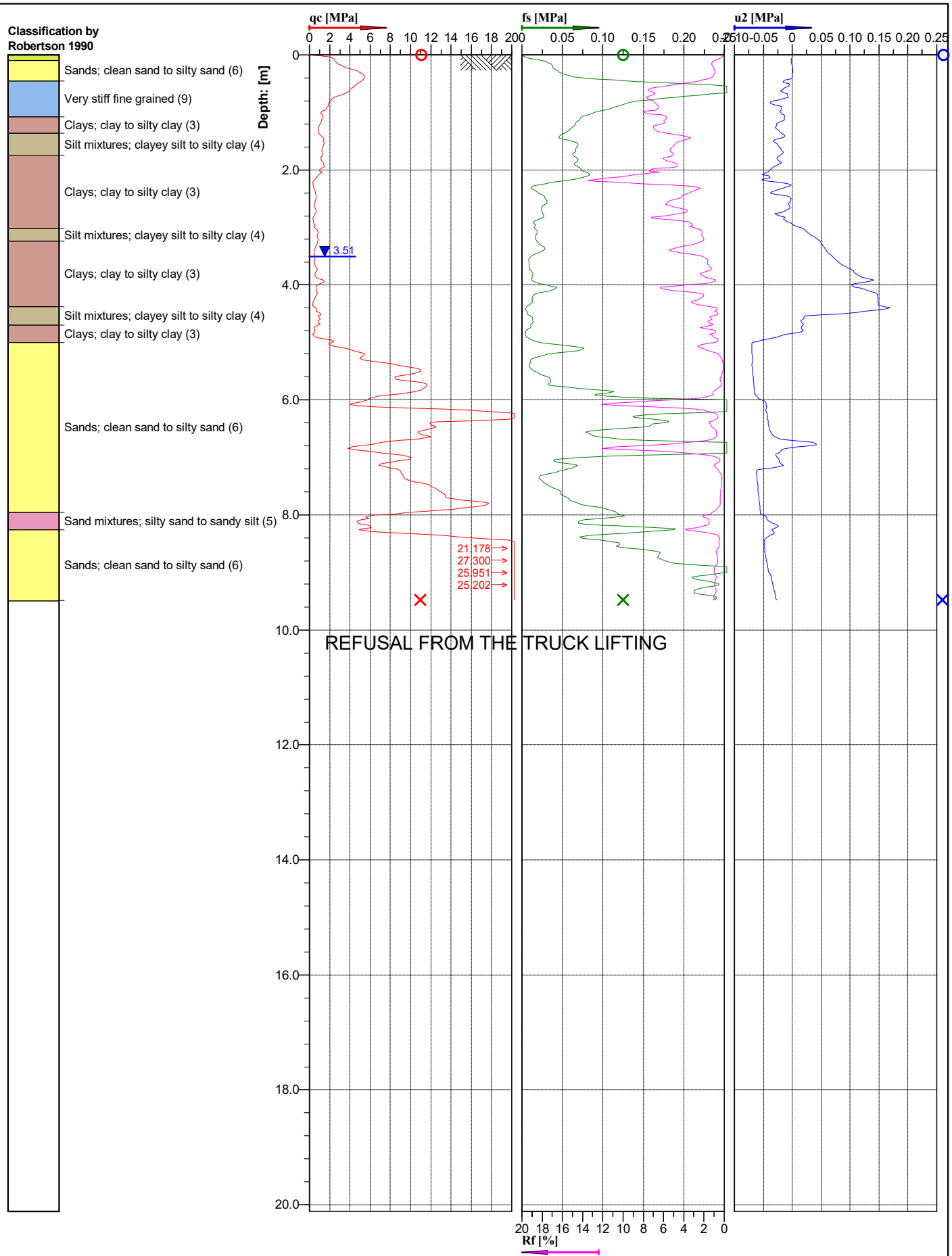
Client: Lockerbie Estates Limited
Project: Lockerbie Farm Development
Location: Studholme Street, Morrinsville
Project No: HAM2018-0139
Date: 22/01/2019

CMW Geosciences

Logged by: DMM	Position: E.466721.9m N.714622.8m	Dimensions: 1.0mx3.0m	Plant: 12 Tonne
Checked by: EJE	Elevation: RL 40.5m	Termination Depth: 5.5m	Contractor: DRN Excavations

TP24 – TEST PIT EXCAVATION

Appendix C: CPT Investigation Results

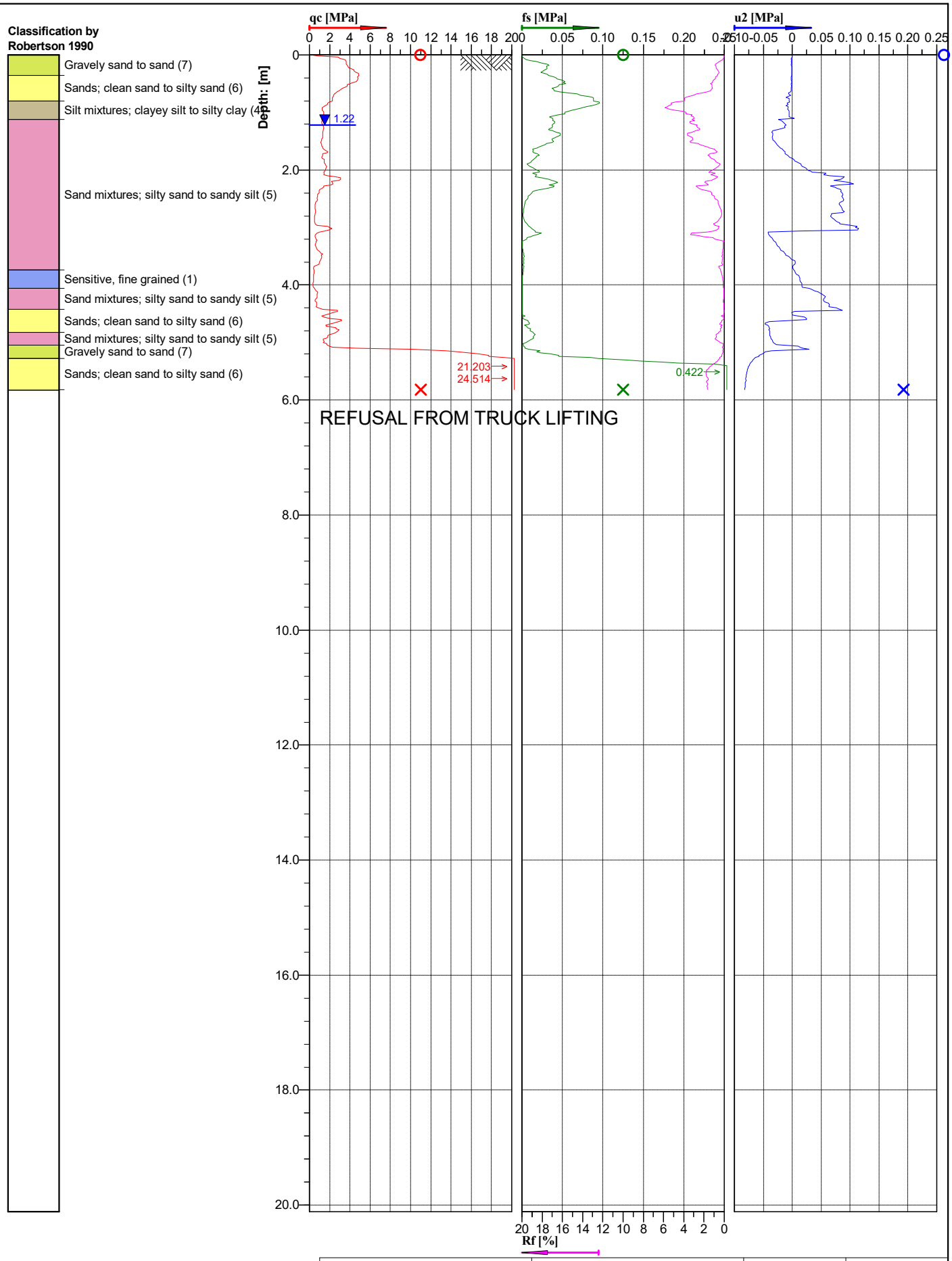


Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT01
Project ID: HAM104562	Client: CMW GEOSCIENCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.64814 E 175.52130		File: CPT01.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

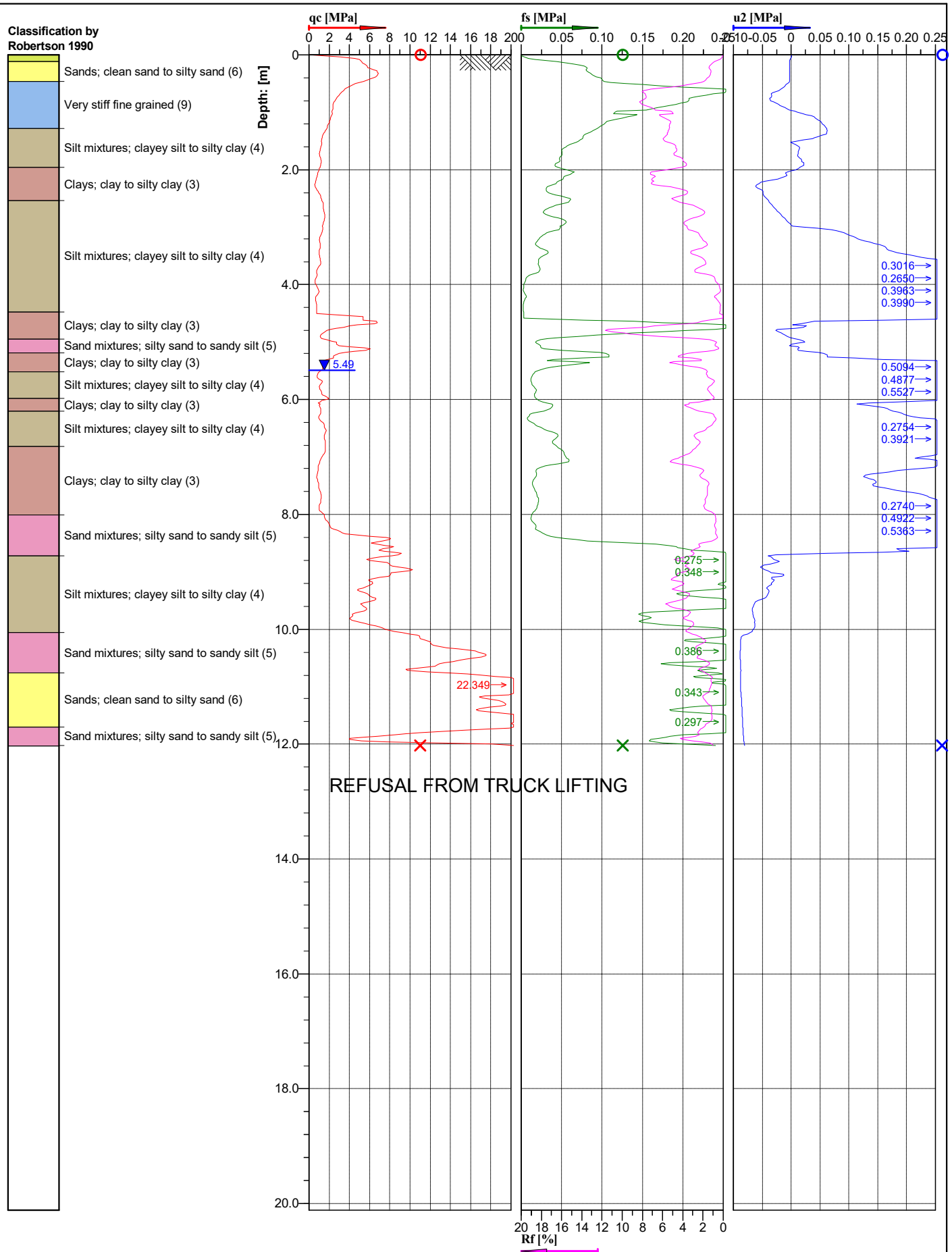


Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT02
Project ID: HAM104562	Client: CMW GEOSCIENCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.64583 E 175.52106		File: CPT02.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

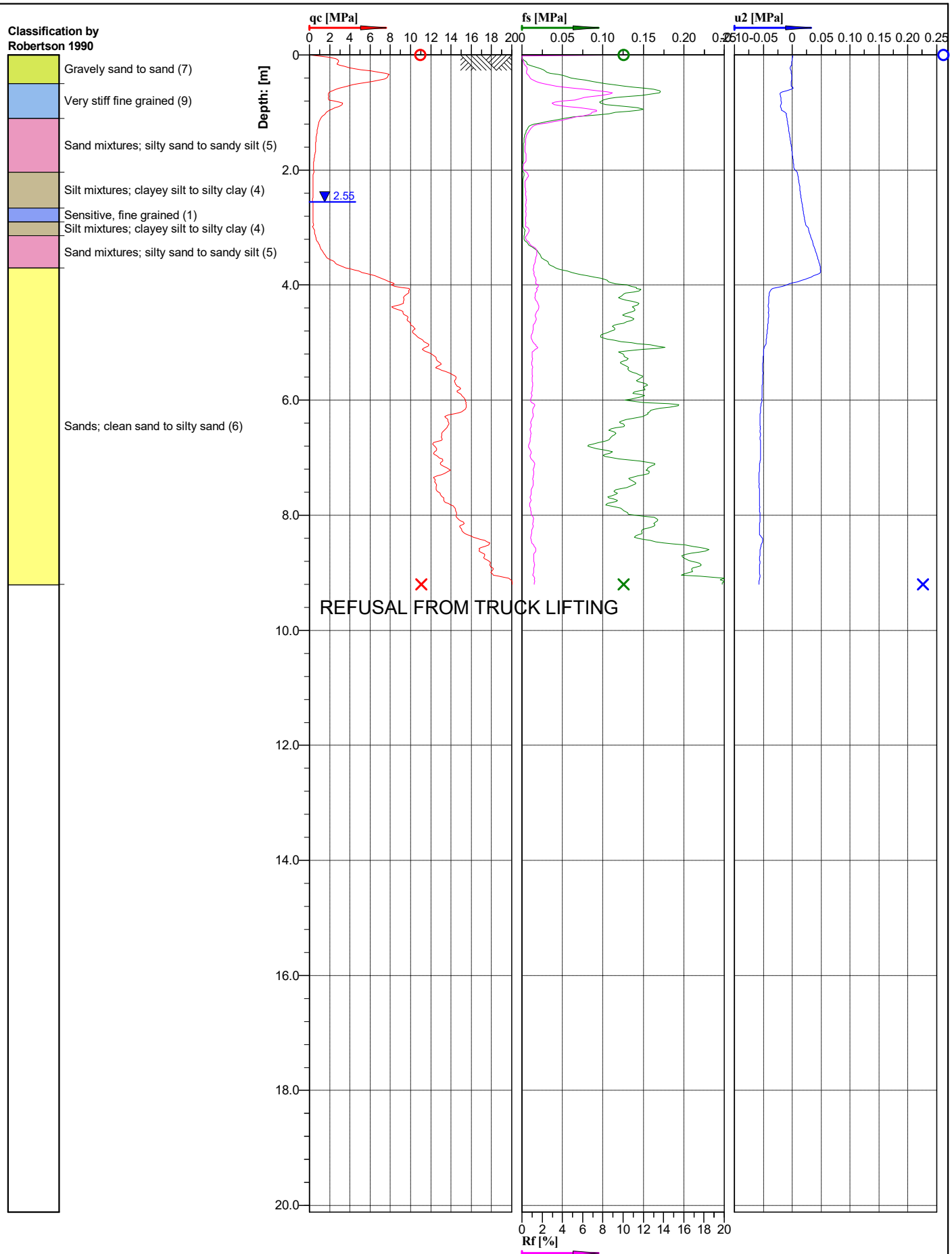


Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT03
Project ID: HAM104562	Client: CMW GEOSCIENCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.64417 E 175.52171		File: CPT03.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

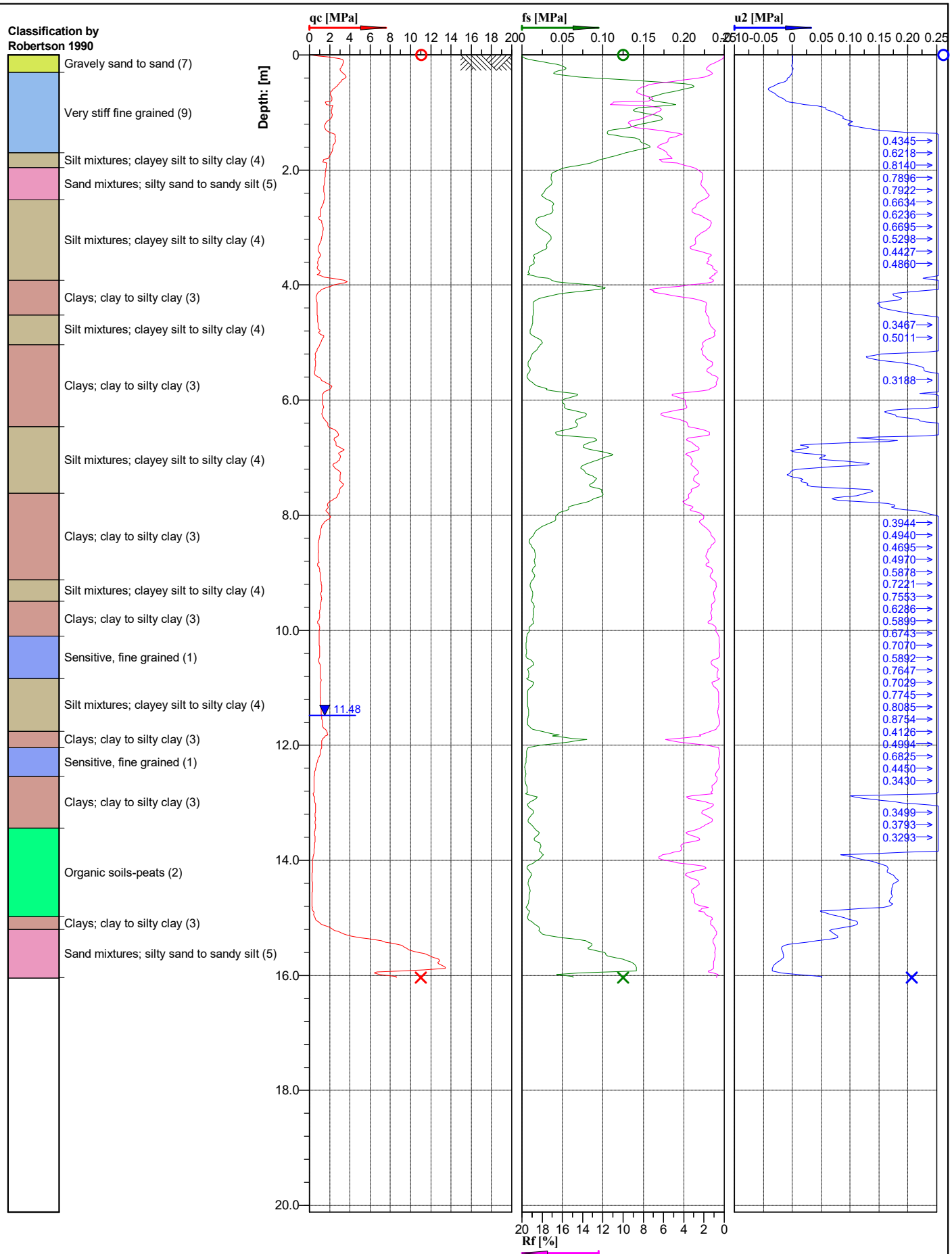


Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT04
Project ID: HAM104562	Client: CMW GEOSCIENCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.64384 E 175.52878		File: CPT04.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

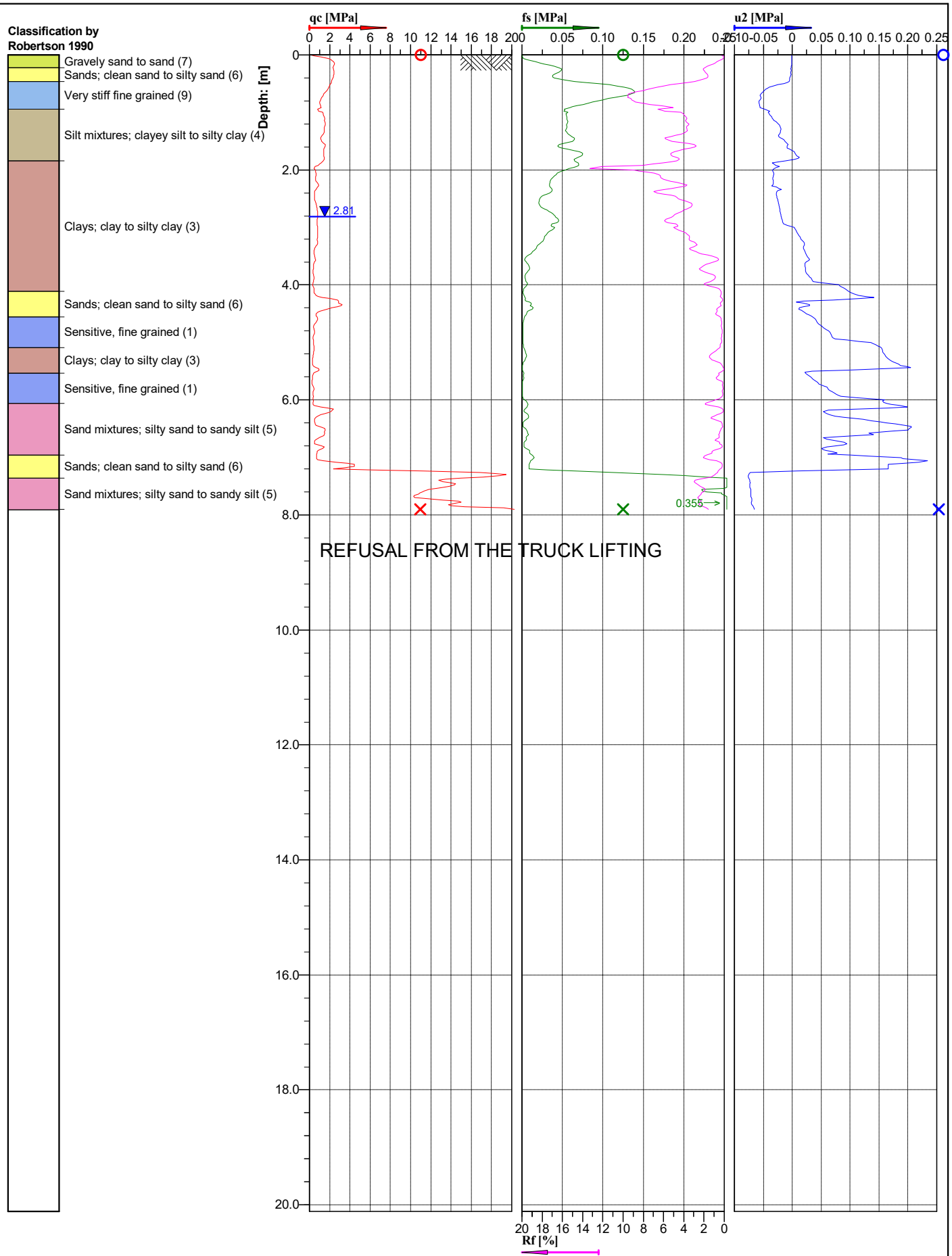


Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT05
Project ID: HAM104562	Client: CMW GEOSCINCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.64272 E 175.52760		File: CPT05.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

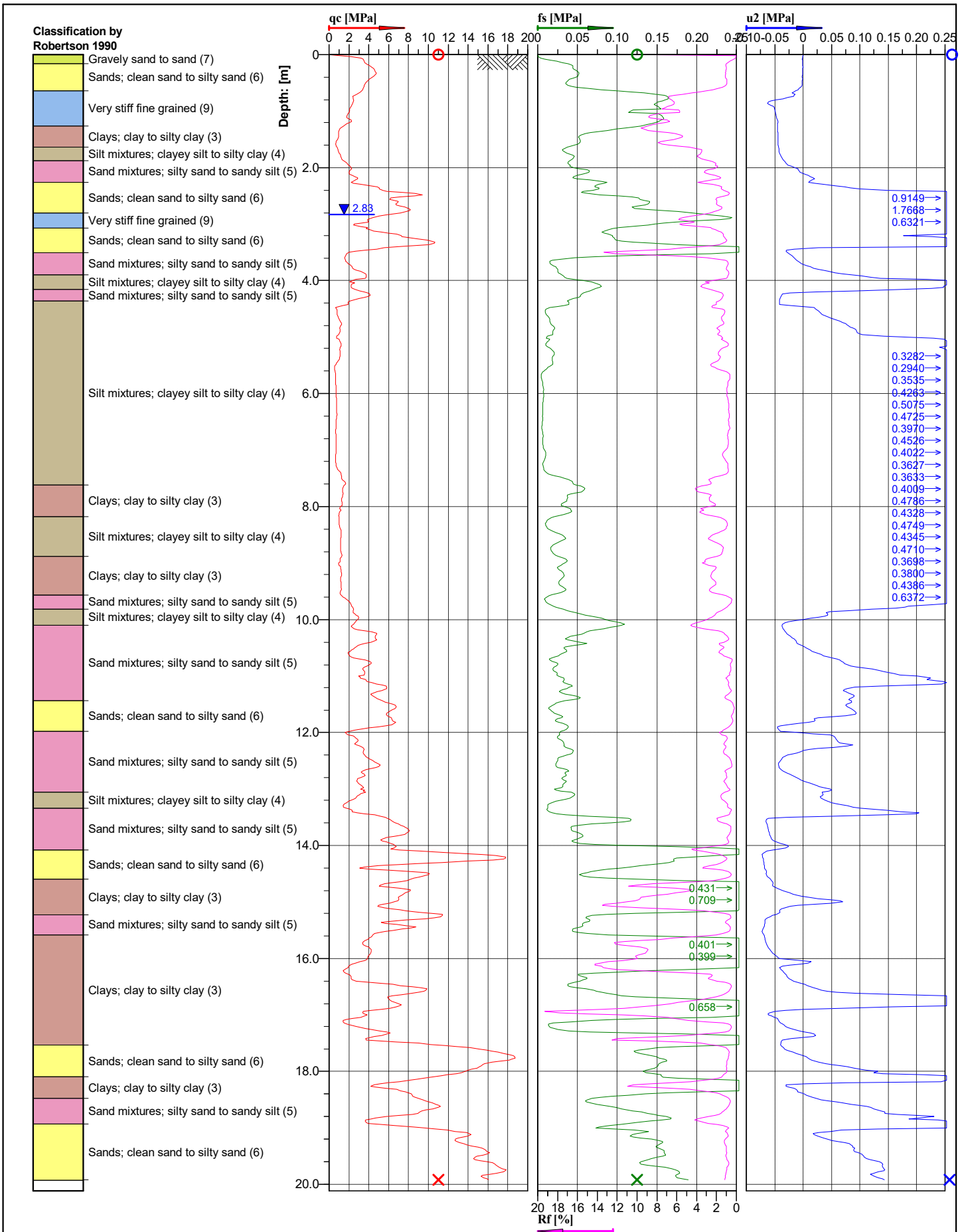


Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT06
Project ID: HAM104562	Client: CMW GEOSCEINCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.64079 E 175.52617		File: CPT06.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

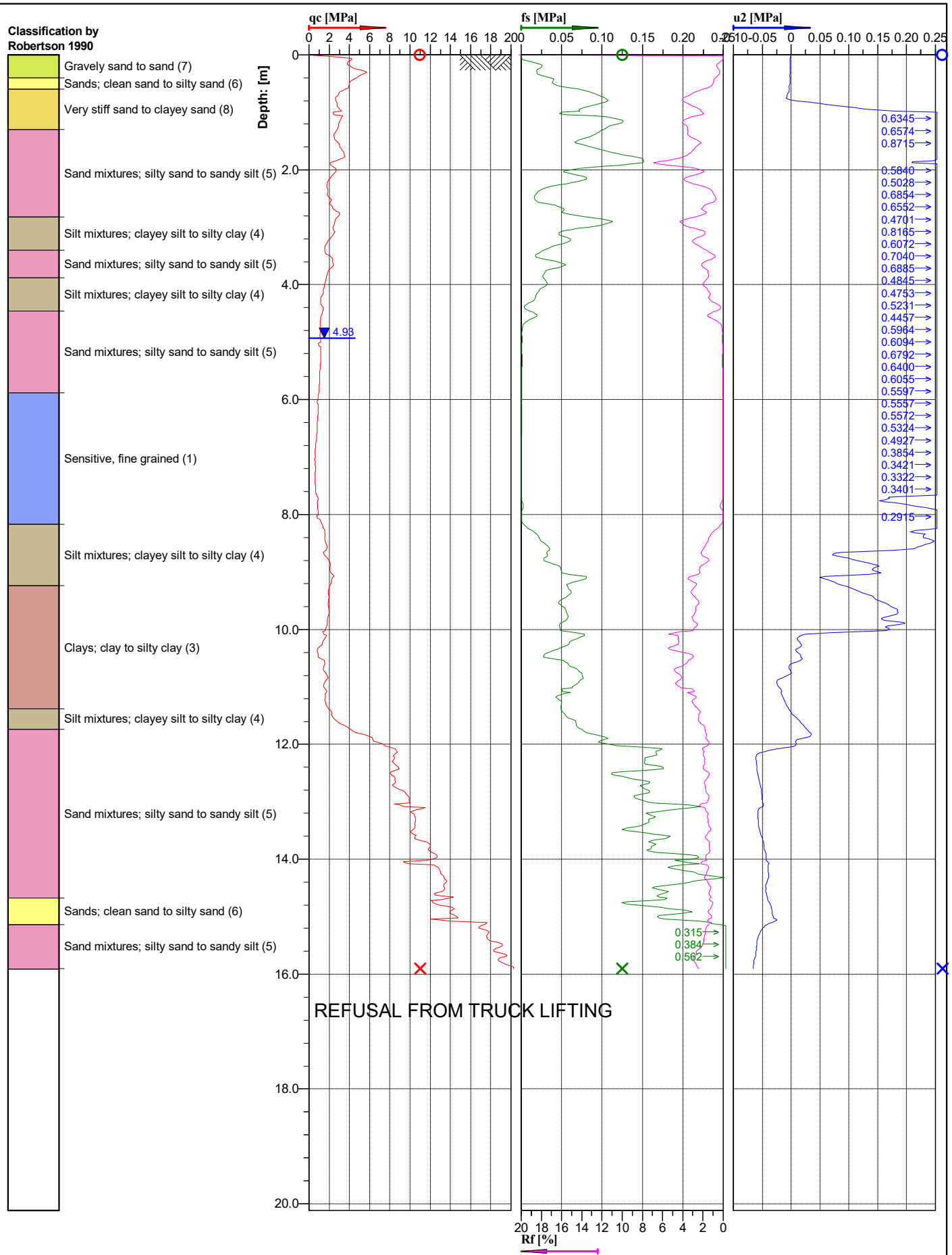


Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT07
Project ID: HAM104562	Client: CMW GEOSCIENCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.63612 E 175.52344		File: CPT07.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150



Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT08
Project ID: HAM104562	Client: CMW GEOSCIENCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.63993 E 175.52228		File: CPT08.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Appendix D: Falling Head Permeability Test Data

CMW Geosciences	CLIENT: **Lockerbie Estates Limited**	DESIGNER:	EE
	PROJECT: **Lockerbie Farm Development, Studholme Street, Morrinsville**	CHECKED:	KJR
		REVISION:	0
	TITLE: **HA01 Falling Head Soakage Test**	DATE:	4/03/2019
		PROJECT:	HAM2018-0139

Specifications - Open-Ended Tube

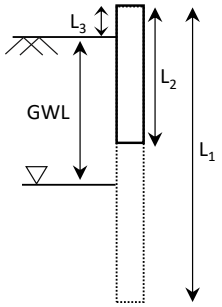
Length L_1:	1.85	m
Diameter:	100	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

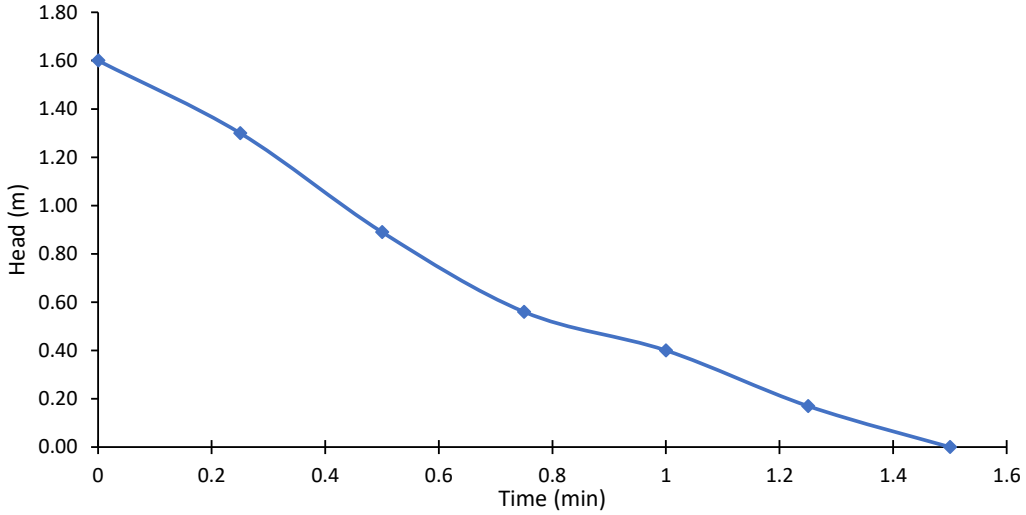
Ground Conditions

GWL: m BGL (Blank = Bottom of hole)

Permeability Anisotropy m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 1.85 m BGL





STRATIGRAPHIC LOG

Clayey SILT

SILT

EOH @ 1.85m

Data

Time (min)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.250	1.600				
0.25	0.550	1.300	1.450		4.02E-05	2.93E-04
0.5	0.960	0.890	1.095		8.91E-05	5.36E-04
0.75	1.290	0.560	0.725		1.43E-04	6.48E-04
1	1.450	0.400	0.480		1.33E-04	4.48E-04
1.25	1.680	0.170	0.285		4.43E-04	1.16E-03
1.5	1.850	0.000	0.085		5.62E-03	1.47E-02

CMW Geosciences	CLIENT: **Lockerbie Estates Limited**	DESIGNER:	EE
	PROJECT: **Lockerbie Farm Development, Studholme Street, Morrinsville**	CHECKED:	KJR
		REVISION:	0
	TITLE: **HA02 Falling Head Soakage Test**	DATE:	4/03/2019
		PROJECT:	HAM2018-0139

Specifications - Open-Ended Tube

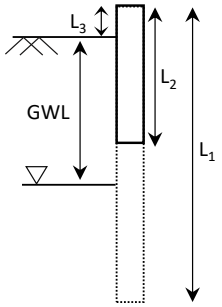
Length L_1:	2.2	m
Diameter:	100	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

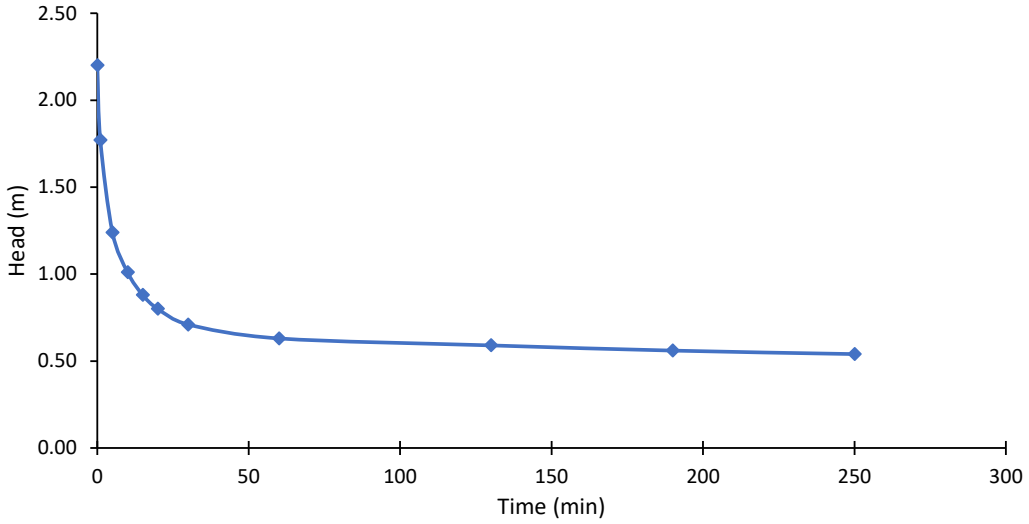
Ground Conditions

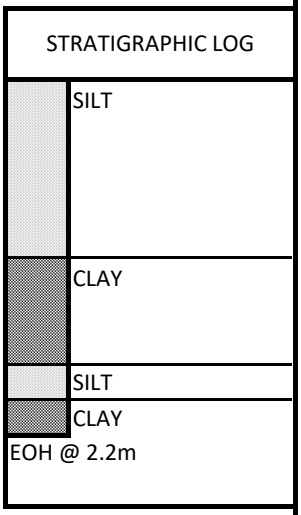
GWL: m BGL (Blank = Bottom of hole)

Permeability Anisotropy m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 2.20 m BGL







Data

Time (min)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	2.200				
1	0.430	1.770	1.985		8.40E-06	7.74E-05
5	0.960	1.240	1.505		4.19E-06	3.18E-05
10	1.190	1.010	1.125		2.37E-06	1.43E-05
15	1.320	0.880	0.945		1.79E-06	9.50E-06
20	1.400	0.800	0.840		1.34E-06	6.52E-06
30	1.490	0.710	0.755		8.95E-07	4.06E-06
60	1.570	0.630	0.670		3.22E-07	1.34E-06
130	1.610	0.590	0.610		8.03E-08	3.14E-07
190	1.640	0.560	0.575		7.72E-08	2.90E-07
250	1.660	0.540	0.550		5.52E-08	2.01E-07

CMW Geosciences	CLIENT: **Lockerbie Estates Limited**	DESIGNER:	EE
	PROJECT: **Lockerbie Farm Development, Studholme Street, Morrinsville**	CHECKED:	KJR
		REVISION:	0
	TITLE: **HA03 Falling Head Soakage Test**	DATE:	4/03/2019
		PROJECT:	HAM2018-0139

Specifications - Open-Ended Tube

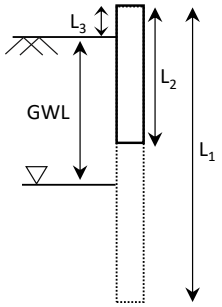
Length L_1:	2.1	m
Diameter:	100	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

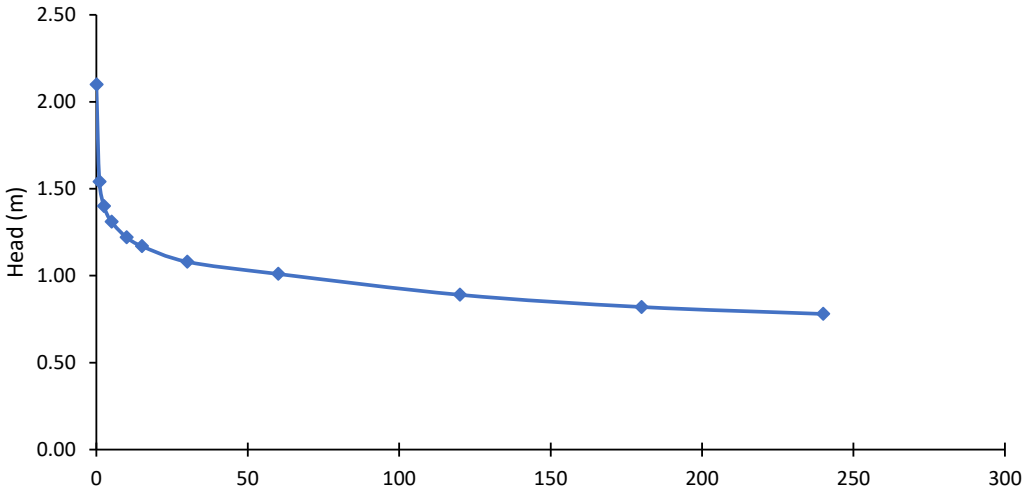
Ground Conditions

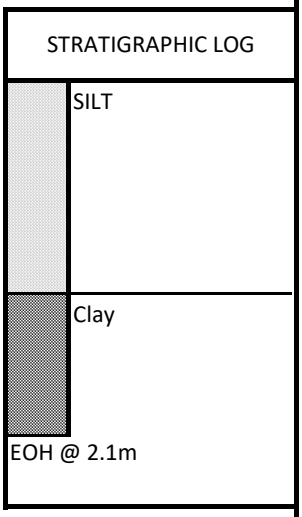
GWL: m BGL (Blank = Bottom of hole)

Permeability Anisotropy m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 2.10 m BGL







Data

Time (min)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	2.100				
1	0.560	1.540	1.820		1.28E-05	1.11E-04
2.5	0.700	1.400	1.470		3.05E-06	2.23E-05
5	0.790	1.310	1.355		1.35E-06	9.28E-06
10	0.880	1.220	1.265		7.58E-07	4.96E-06
15	0.930	1.170	1.195		4.63E-07	2.91E-06
30	1.020	1.080	1.125		3.08E-07	1.85E-06
60	1.090	1.010	1.045		1.35E-07	7.72E-07
120	1.210	0.890	0.950		1.36E-07	7.27E-07
180	1.280	0.820	0.855		9.46E-08	4.67E-07
240	1.320	0.780	0.800		6.03E-08	2.84E-07

CMW Geosciences	CLIENT: **Lockerbie Estates Ltd**	DESIGNER:	EE
	PROJECT: **Lockerbie Farm Development Studholme Street, Morrinsville**	CHECKED:	KAL
		REVISION:	0
	TITLE: **HA04 Falling Head Permeability Test**	DATE:	2/04/2019
		PROJECT:	HAM2018-0319

Specifications - Open-Ended Tube

Length L_1:	3.07	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

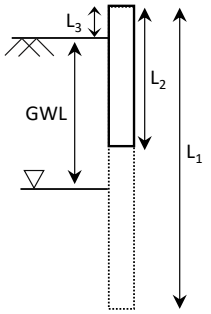
Ground Conditions

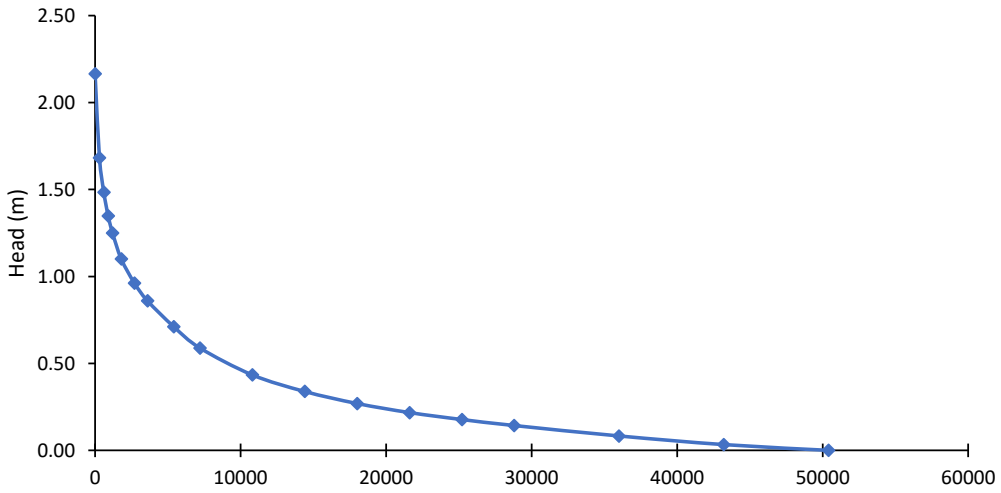
GWL: m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 3.07 m BGL





STRATIGRAPHIC LOG

Clay

EOH @ 3.07m

Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.905	2.165				
300	1.388	1.682	1.924		1.66E-06	1.62E-05
600	1.586	1.484	1.583		9.54E-07	7.98E-06
900	1.722	1.348	1.416		7.90E-07	6.07E-06
1200	1.820	1.250	1.299		6.61E-07	4.76E-06
1800	1.970	1.100	1.175		5.97E-07	4.01E-06
2700	2.108	0.962	1.031		4.58E-07	2.80E-06
3600	2.210	0.860	0.911		4.17E-07	2.33E-06
5400	2.358	0.712	0.786		3.88E-07	1.96E-06
7200	2.481	0.589	0.650		4.38E-07	1.93E-06
10800	2.636	0.434	0.511		4.09E-07	1.54E-06
14400	2.731	0.339	0.386		3.91E-07	1.22E-06
18000	2.801	0.269	0.304		4.08E-07	1.09E-06
21600	2.853	0.217	0.243		4.28E-07	9.92E-07
25200	2.893	0.177	0.197		4.43E-07	9.04E-07
28800	2.927	0.143	0.160		5.08E-07	9.19E-07
36000	2.987	0.083	0.113		7.14E-07	1.09E-06
43200	3.037	0.033	0.058		1.34E-06	1.48E-06
50400	3.070	0.000	0.017		4.96E-05	3.14E-05

CMW Geosciences	CLIENT: **Lockerbie Estates Ltd**	DESIGNER:	EE
	PROJECT: **Lockerbie Farm Development Studholme Street, Morrinsville**	CHECKED:	KAL
		REVISION:	0
	TITLE: **HA05 Falling Head Permeability Test**	DATE:	2/04/2019
		PROJECT:	HAM2018-0319

Specifications - Open-Ended Tube

Length L_1:	2.14	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

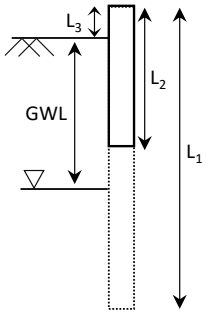
Ground Conditions

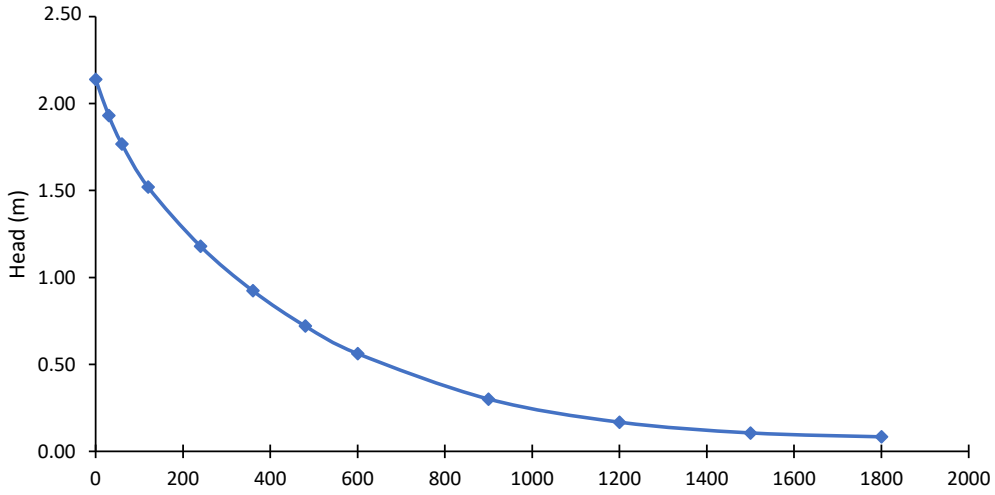
GWL: m BGL (Blank = Bottom of hole)

Permeability Anisotropy

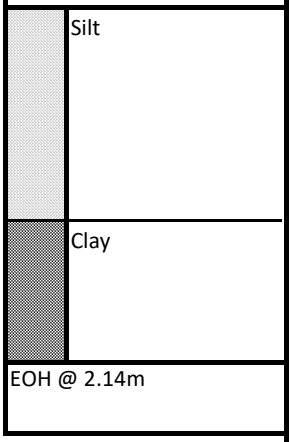
m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 2.14 m BGL





STRATIGRAPHIC LOG



EOH @ 2.14m

Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	2.140				
30	0.209	1.931	2.035		6.50E-06	6.56E-05
60	0.372	1.768	1.849		5.99E-06	5.62E-05
120	0.620	1.520	1.644		5.58E-06	4.81E-05
240	0.960	1.180	1.350		5.38E-06	4.03E-05
360	1.217	0.924	1.052		6.20E-06	3.86E-05
480	1.420	0.720	0.822		7.41E-06	3.87E-05
600	1.578	0.562	0.641		8.70E-06	3.82E-05
900	1.839	0.301	0.431		1.11E-05	3.90E-05
1200	1.972	0.168	0.234		1.42E-05	3.33E-05
1500	2.034	0.106	0.137		1.37E-05	2.30E-05
1800	2.056	0.084	0.095		7.76E-06	1.05E-05

CMW Geosciences	CLIENT: **Lockerbie Estates Limited**	DESIGNER:	EE
	PROJECT: **Lockerbie Farm Development Studholme Street, Morrinsville**	CHECKED:	KAL
		REVISION:	0
	TITLE: **HA06 Falling Head Permeability Test**	DATE:	2/04/2019
		PROJECT:	HAM2018-0139

Specifications - Open-Ended Tube

Length L_1:	2.25	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

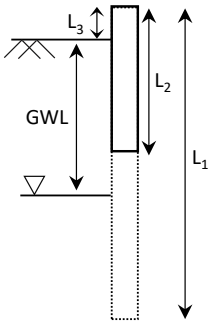
Ground Conditions

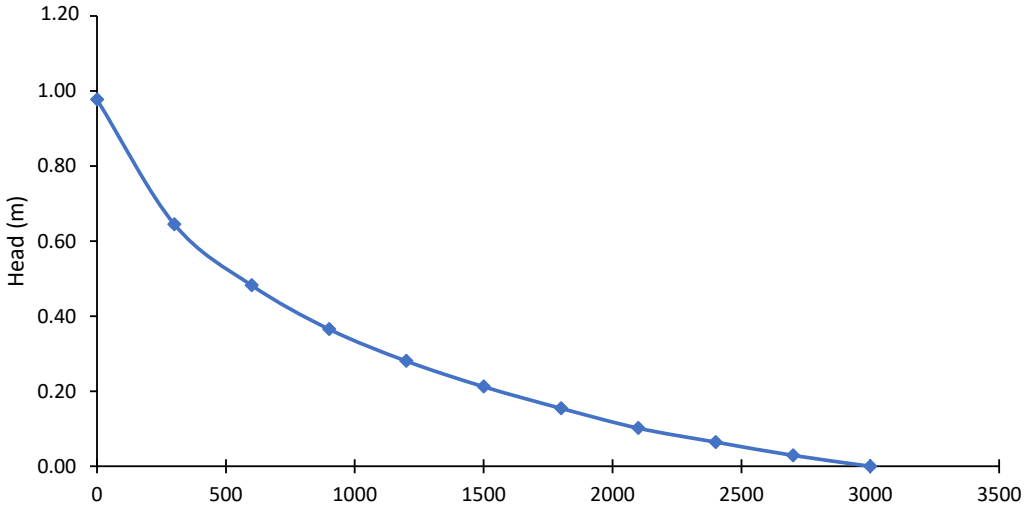
GWL: m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 2.25 m BGL





STRATIGRAPHIC LOG

Clay

EOH @ 2.25m

Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	1.273	0.977				
300	1.605	0.645	0.811		5.01E-06	2.63E-05
600	1.768	0.482	0.564		4.42E-06	1.78E-05
900	1.885	0.365	0.424		4.97E-06	1.65E-05
1200	1.970	0.280	0.323		5.51E-06	1.53E-05
1500	2.038	0.212	0.246		6.63E-06	1.55E-05
1800	2.096	0.154	0.183		8.52E-06	1.68E-05
2100	2.149	0.102	0.128		1.27E-05	2.06E-05
2400	2.186	0.064	0.083		1.53E-05	1.96E-05
2700	2.221	0.029	0.047		2.87E-05	2.75E-05
3000	2.250	0.000	0.015		1.16E-03	6.43E-04

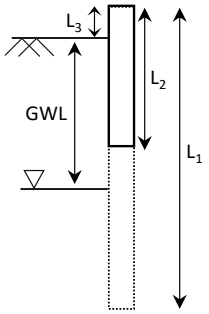
CMW Geosciences	CLIENT: **Lockerbie Estates Ltd**	DESIGNER:	EE
	PROJECT: **Lockerbie Farm Development** **Studholme Street, Morrinsville**	CHECKED:	KAL
		REVISION:	0
	TITLE: **HA07 Falling Head Permeability Test**	DATE:	2/04/2019
		PROJECT:	HAM2018-0319

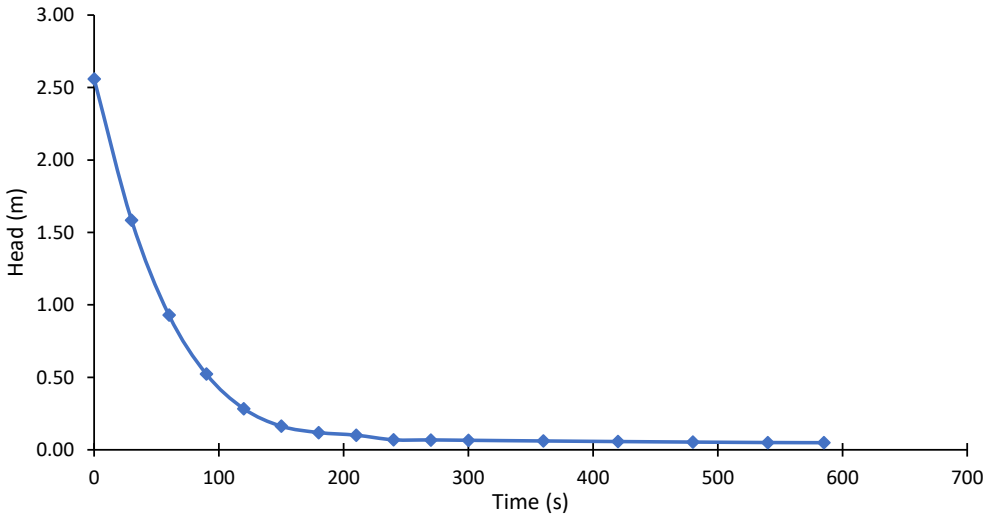
Specifications - Open-Ended Tube

Length L_1:	3.06	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0.05	m

Ground Conditions

GWL:	2.51	m BGL	(Blank = Bottom of hole)
Permeability Anisotropy			
m:	1		$m = \sqrt{k_h / k_v}$
Bottom of Test Hole:	3.01	m BGL	





STRATIGRAPHIC LOG

Clay

EOH @ 3.01m

Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	2.560				
30	0.975	1.585	2.572		2.55E-05	3.17E-04
60	1.631	0.929	1.757		3.76E-05	3.51E-04
90	2.038	0.523	1.226		5.24E-05	3.71E-04
120	2.276	0.284	0.903		6.84E-05	3.76E-04
150	2.397	0.163	0.724		7.20E-05	3.13E-04
180	2.441	0.119	0.641		4.38E-05	1.56E-04
210	2.459	0.101	0.610		2.39E-05	7.68E-05
240	2.491	0.069	0.585		5.64E-05	1.64E-04
270	2.492	0.068	0.569		1.76E-06	4.58E-06
300	2.494	0.066	0.567		6.10E-06	1.57E-05
360	2.499	0.061	0.563		5.52E-06	1.38E-05
420	2.503	0.057	0.559		5.17E-06	1.25E-05
480	2.507	0.053	0.555		5.14E-06	1.20E-05
540	2.510	0.050	0.552		4.61E-06	1.04E-05
585	2.511	0.049	0.550		2.07E-06	4.59E-06

Appendix E: Laboratory Test Results

PLASTICITY INDEX TEST REPORT

WSP OPUS

Project:	**Lockerbie Farm**
Location:	**TP07 (2.0m)**
Client:	**Road Test Ltd**
Contractor:	**Not Stated**
Sampled by:	**Client**
Sampling method:	**Not Stated**
Sample description:	***Brown; silty CLAY**
Sample condition:	**As Received**
Sample reference:	**094I**
Sample depth:	**2.0m**

Date sampled: **13/02/19**

Project number:	**1-LA371.00**
Lab ref number:	**AL3518/1**
Client ref number:	**Zach Hooton**
Folder number:	**-**

Test Results

As rec'd water content:	**63.1%**
Liquid limit:	**101**
Plastic limit:	**49**
Plasticity Index:	**52**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	*Sample description is not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 19/02/19
Date reported: 20/02/19

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 21/02/19

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WSP Opus
Auckland Laboratory
Quality Management Systems Certified to ISO 9001

7A Ride Way, Albany
Private Bag 101982, NS Mail Centre, North Shore City 0745, New Zealand

Telephone +64 9 415 4660
Website www.wsp-opus.co.nz

PLASTICITY INDEX TEST REPORT

WSP OPUS

Project:	**Lockerbie Farm**
Location:	**TP12 (3.0m)**
Client:	**Road Test Ltd**
Contractor:	**Not Stated**
Sampled by:	**Client**
Sampling method:	**Not Stated**
Sample description:	***Brownish Red; silty CLAY**
Sample condition:	**As Received**
Sample reference:	**096I**
Sample depth:	**3.0m**

Date sampled: **13/02/19**

Project number:	**1-LA371.00**
Lab ref number:	**AL3518/2**
Client ref number:	**Zach Hooton**
Folder number:	**-**

Test Results

As rec'd water content:	**57.3%**
Liquid limit:	**103**
Plastic limit:	**46**
Plasticity Index:	**57**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	*Sample description is not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 19/02/19
Date reported: 20/02/19

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 21/02/19

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PLASTICITY INDEX TEST REPORT

WSP OPUS

Project:	**Lockerbie Farm**
Location:	**TP10 (4.3m)**
Client:	**Road Test Ltd**
Contractor:	**Not Stated**
Sampled by:	**Client**
Sampling method:	**Not Stated**
Sample description:	**Grey; silty Clayey SAND**
Sample condition:	**As Received**
Sample reference:	**095I**
Sample depth:	**4.3m**

Date sampled: **13/02/19**

Project number:	**1-LA371.00**
Lab ref number:	**AL3518/3**
Client ref number:	**Zach Hooton**
Folder number:	**-**

Test Results

As rec'd water content:	**68.2%**
Liquid limit:	**56**
Plastic limit:	**30**
Plasticity Index:	**26**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	*Sample description is not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 18-19/02/19
Date reported: 20/02/19

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 21/02/19

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PLASTICITY INDEX TEST REPORT

WSP OPUS

Project:	**Lockerbie Farm**
Location:	**TP19 (5.2m)**
Client:	**Road Test Ltd**
Contractor:	**Not Stated**
Sampled by:	**Client**
Sampling method:	**Not Stated**
Sample description:	**Grey; clayey Silty SAND**
Sample condition:	**As Received**
Sample reference:	**097I**
Sample depth:	**5.2m**

Date sampled: **13/02/19**

Project number:	**1-LA371.00**
Lab ref number:	**AL3518/4**
Client ref number:	**Zach Hooton**
Folder number:	**-**

Test Results

As rec'd water content:	**44.0%**
Liquid limit:	**48**
Plastic limit:	**32**
Plasticity Index:	**16**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	*Sample description is not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 18/02/19
Date reported: 20/02/19

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 21/02/19

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PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

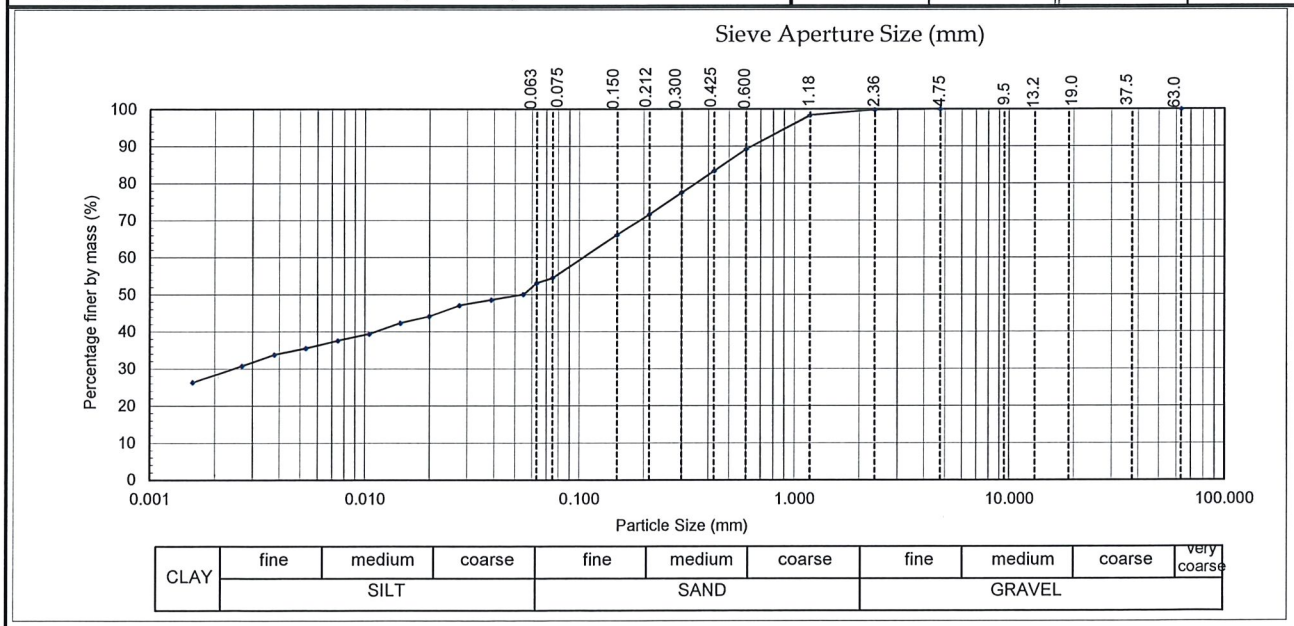
TEST REPORT

WSP | OPUS

Project :	**Lockerbie Farm**
Location :	**TP10 (4.3m)**
Client :	**Road Test Ltd**
Client/Sample Ref :	**Zach Hooten**
Contractor :	**Not Stated**
Borehole No:	**095I** Depth: **4.30 metres**
Sampled by :	**Client**
Date received :	**13/02/19**
Sampling method :	**Not Stated**
Sample condition :	**As Received**
Sample description :	***Grey; silty Clayey SAND**
Solid Particle Density (t/m^3)	**2.22** **Assumed**
Water Content (as received)	**68.2** **%**

Project No:	**1-LA371.00**
Lab Ref No:	**AL3518/5**
Client Ref:	**Zach Hooton**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	100	0.300	78	0.0545	50	0.0075	38
37.5	--	2.36	100	0.212	72	0.0389	49	0.0053	36
19.0	--	1.18	98	0.150	66	0.0277	47	0.0038	34
13.2	--	0.600	89	0.075	55	0.0199	44	0.0027	31
9.5	--	0.425	83	0.063	53	0.0147	42	0.0016	26
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0105	39		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 9.7 (Electrometric Method) *Sample description is not covered by IANZ Accreditation.

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 15-19/02/19 **This report may only be reproduced in full**

Date Reported: 19/02/19

IANZ Approved Signatory *Thirushen Pillay*

Designation : *Senior Civil Engineering Technician*

Date : 20/02/19

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PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

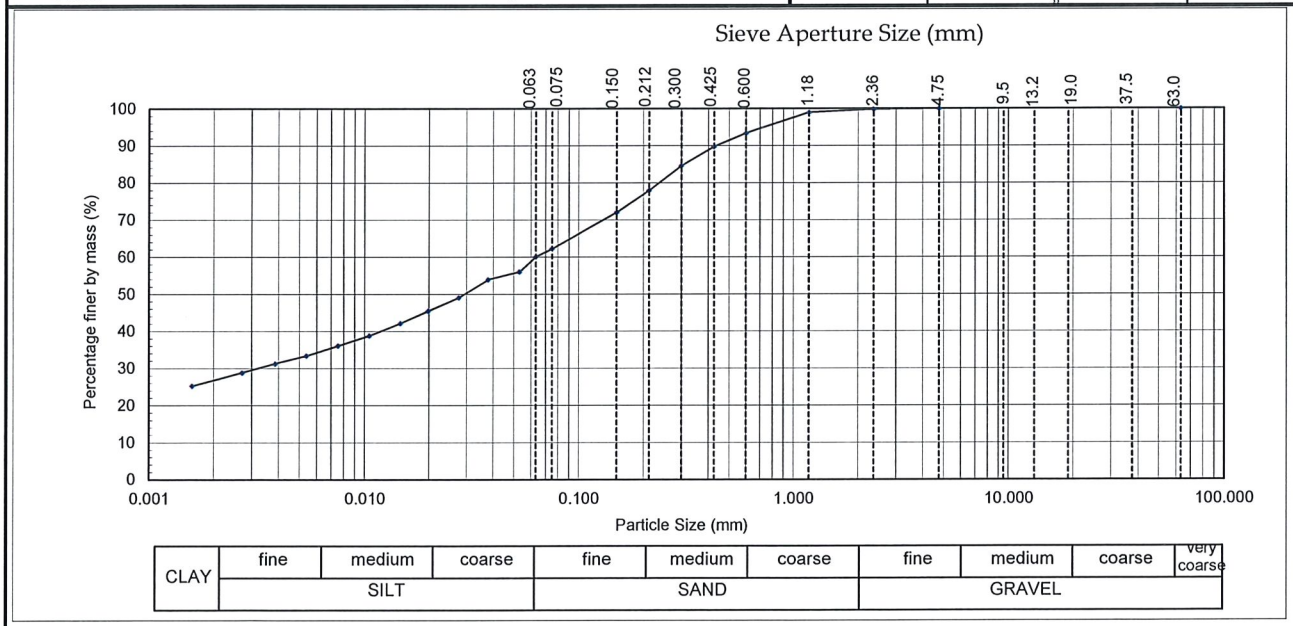
TEST REPORT

WSP | OPUS

Project :	**Lockerbie Farm**
Location :	**TP19 (5.2m)**
Client :	**Road Test Ltd**
Client/Sample Ref :	**Zach Hooten**
Contractor :	**Not Stated**
Borehole No:	**097I** Depth: **5.20 metres**
Sampled by :	**Client**
Date received :	**13/02/19**
Sampling method :	**Not Stated**
Sample condition :	**As Received**
Sample description :	***Grey; clayey Silty SAND**
Solid Particle Density (t/m^3)	**2.22** **Assumed**
Water Content (as received)	**44.0** **%**

Project No:	**1-LA371.00**
Lab Ref No:	**AL3518/6**
Client Ref:	**Zach Hooton**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	100	0.300	85	0.0530	56	0.0075	36
37.5	--	2.36	100	0.212	78	0.0379	54	0.0054	33
19.0	--	1.18	99	0.150	72	0.0275	49	0.0038	31
13.2	--	0.600	93	0.075	62	0.0198	45	0.0027	29
9.5	--	0.425	90	0.063	60	0.0147	42	0.0016	25
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0105	39		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 9.6 (Electrometric Method) *Sample description is not covered by IANZ Accreditation.

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 15-19/02/19 **This report may only be reproduced in full**

Date Reported: 19/02/19

IANZ Approved Signatory *Thirushen Pillay*

Designation : *Senior Civil Engineering Technician*

Date : 20/02/19

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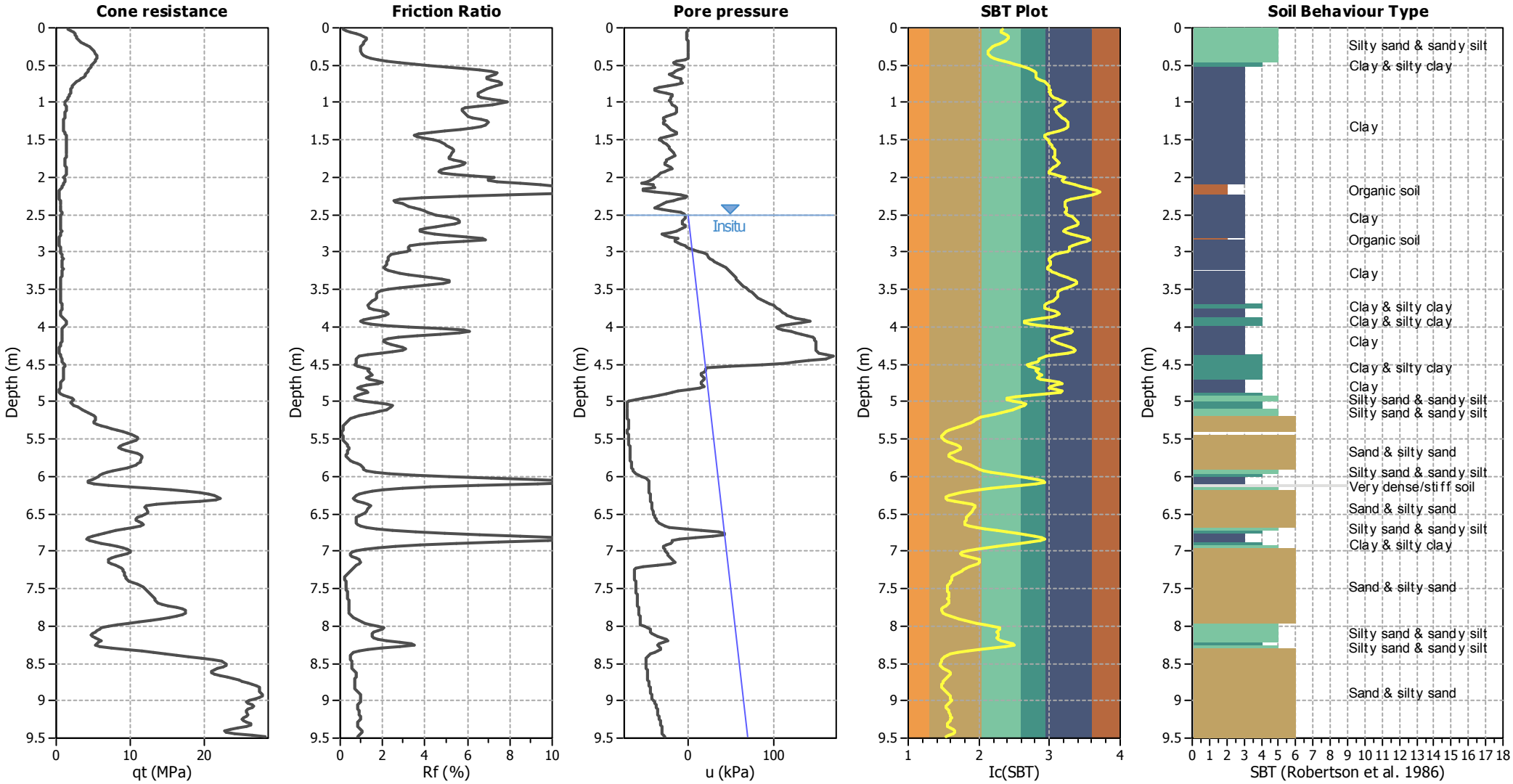
Appendix F: Liquefaction Analyses

CPT basic interpretation plots



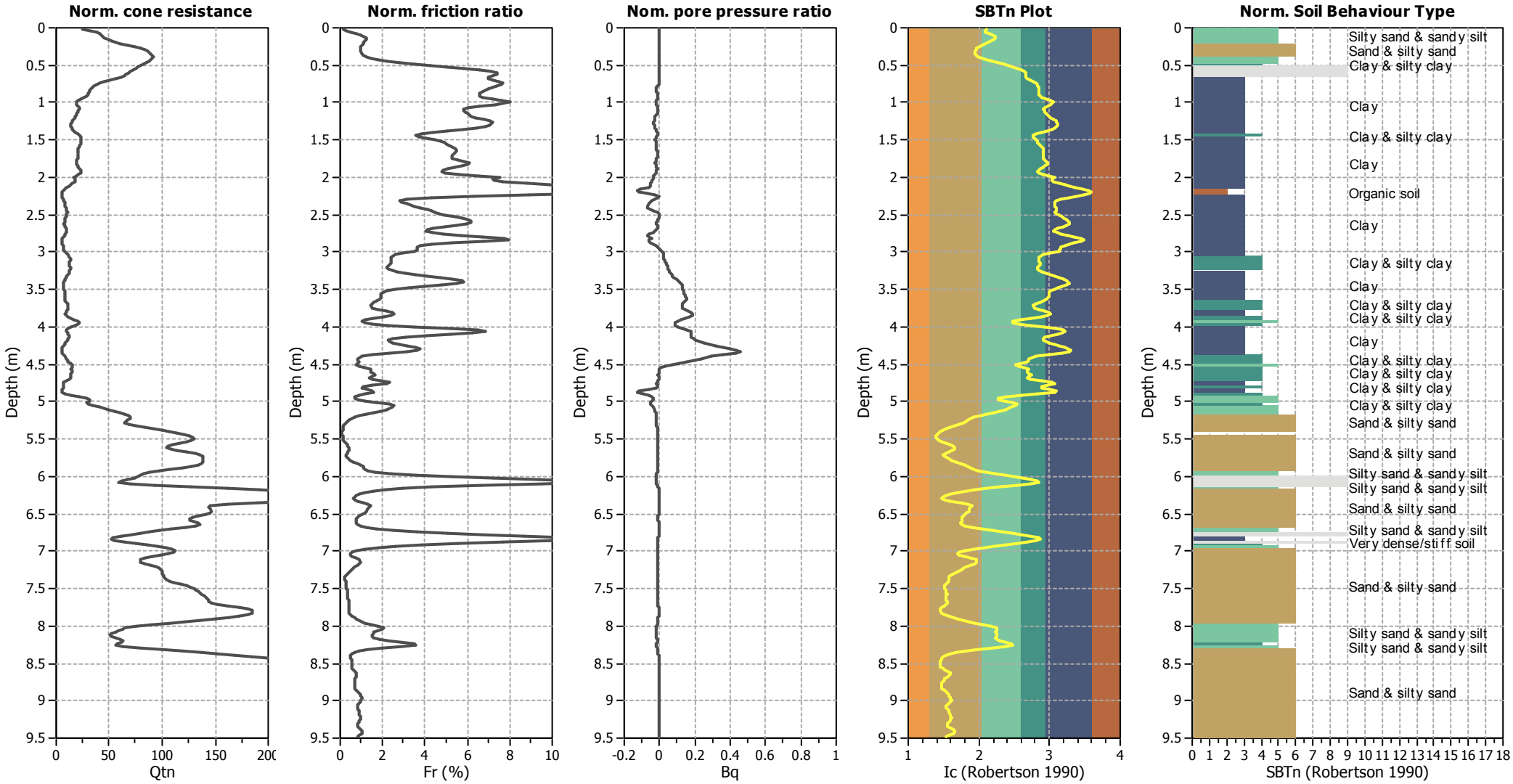
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



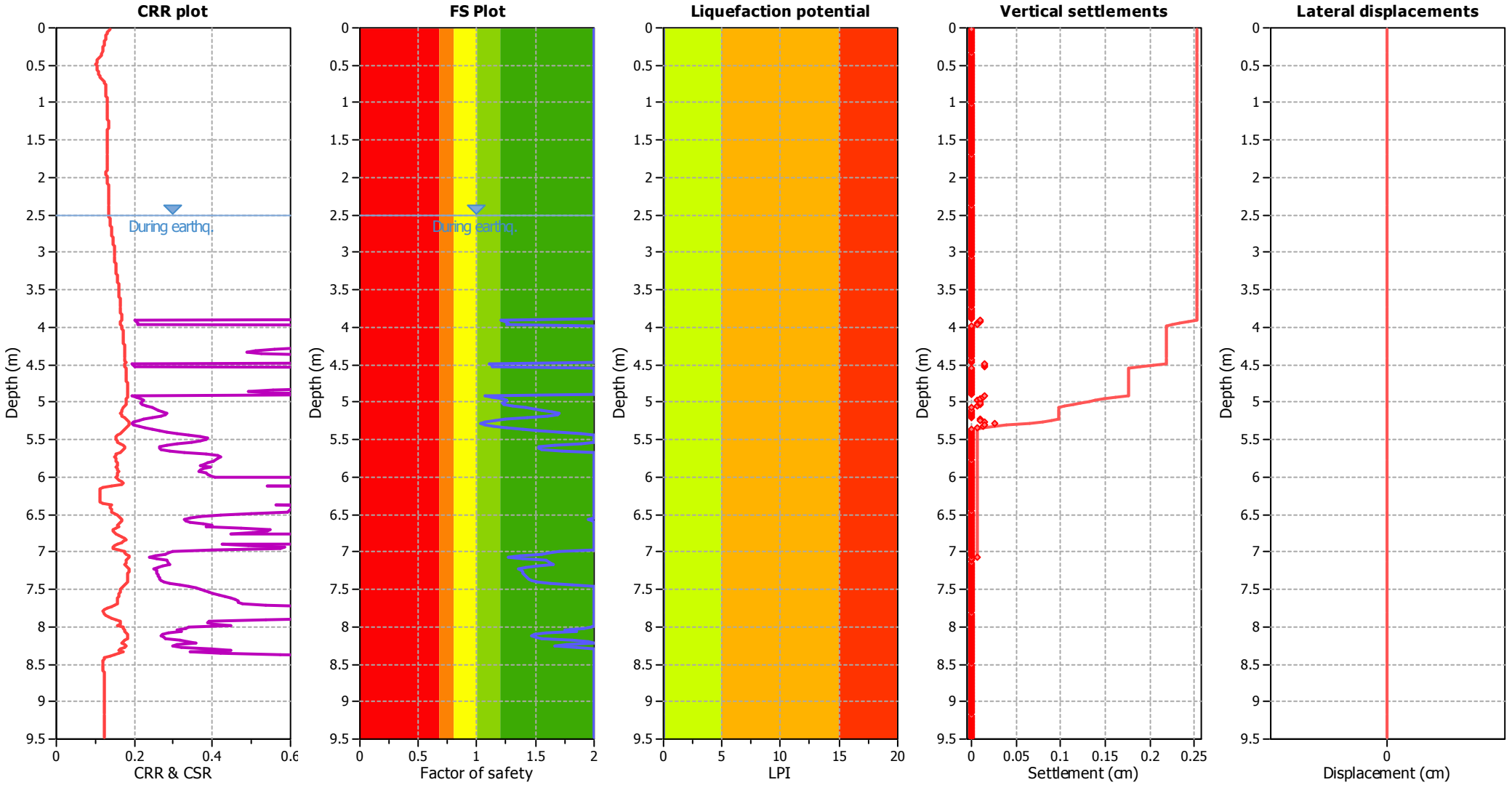
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

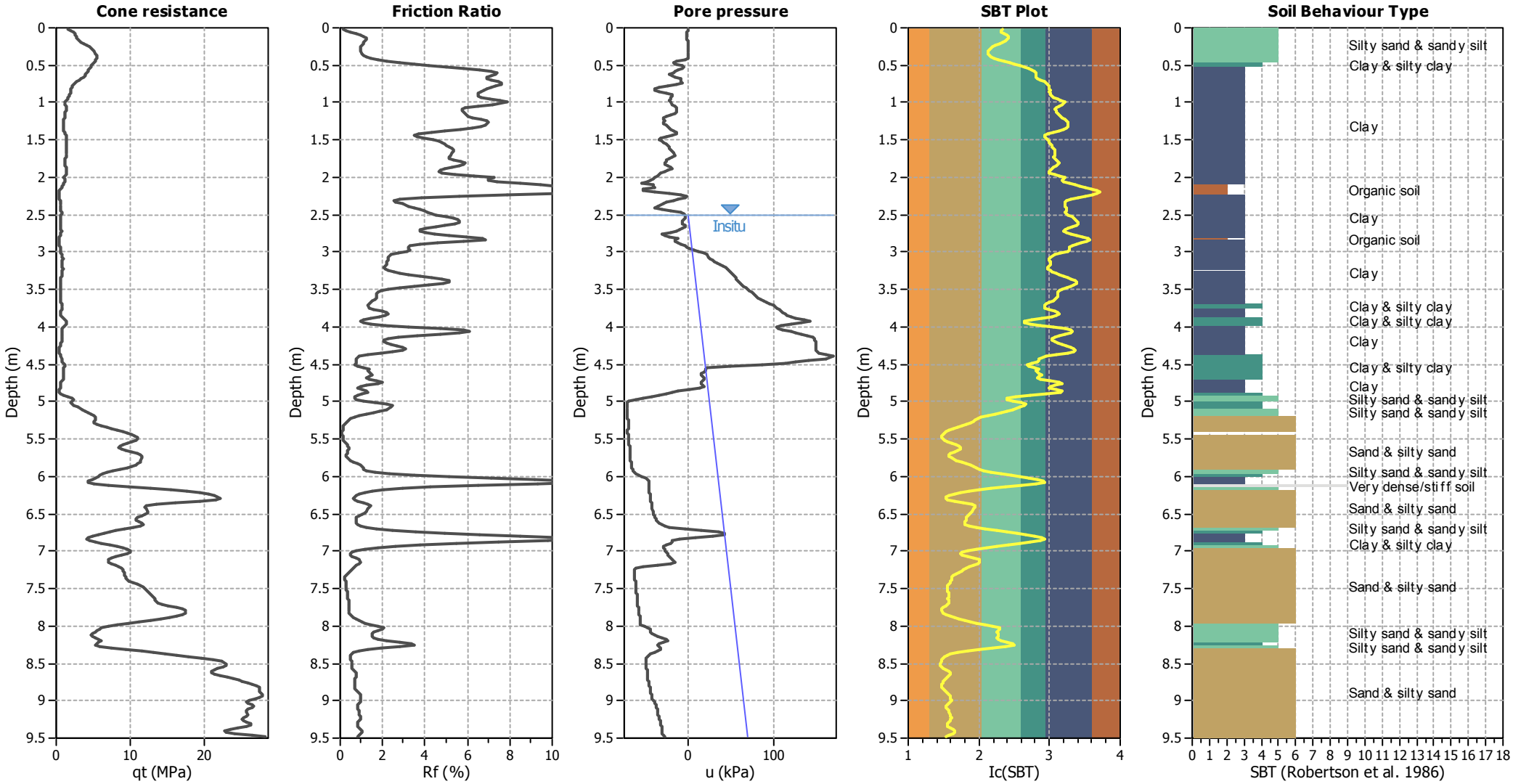
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



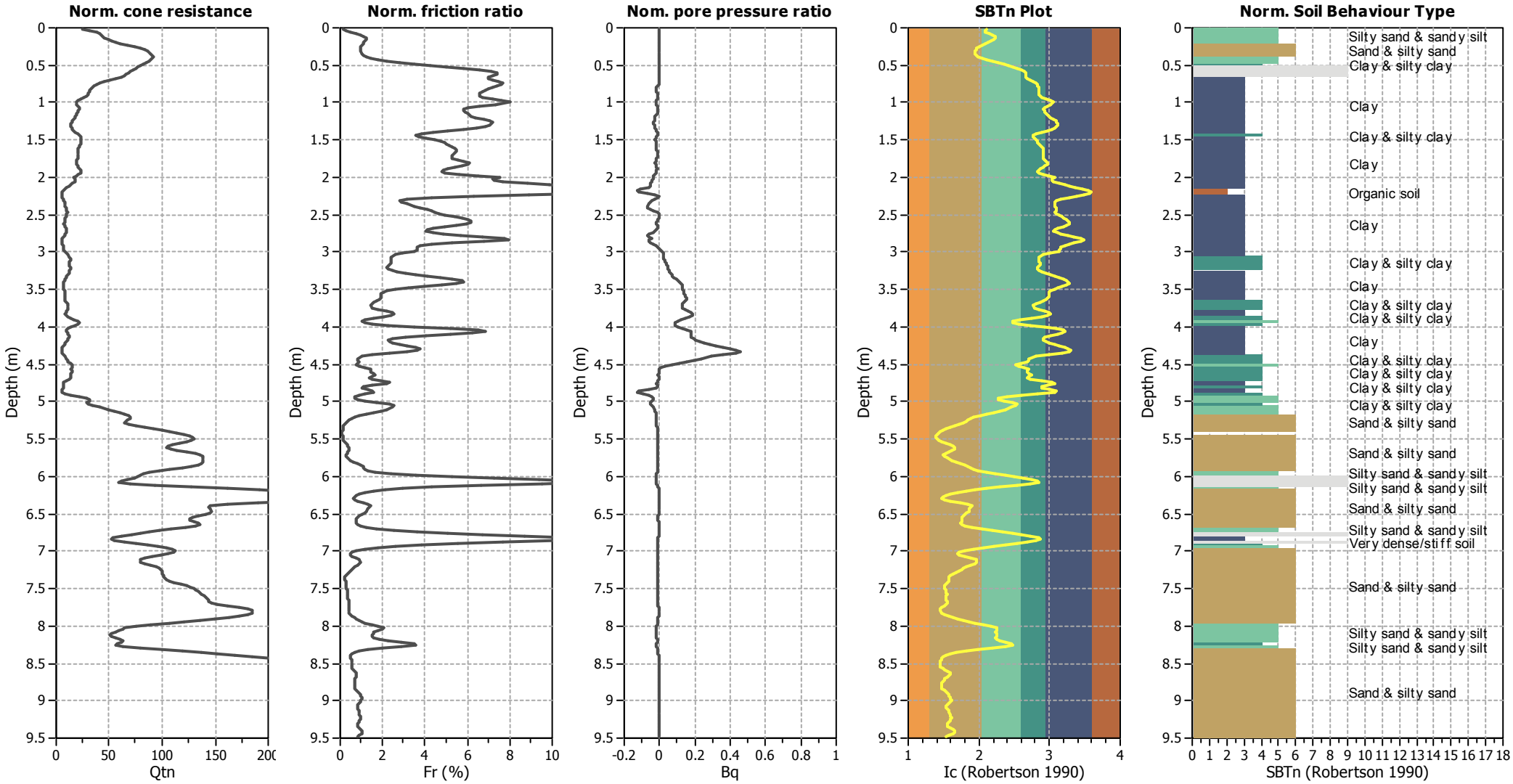
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



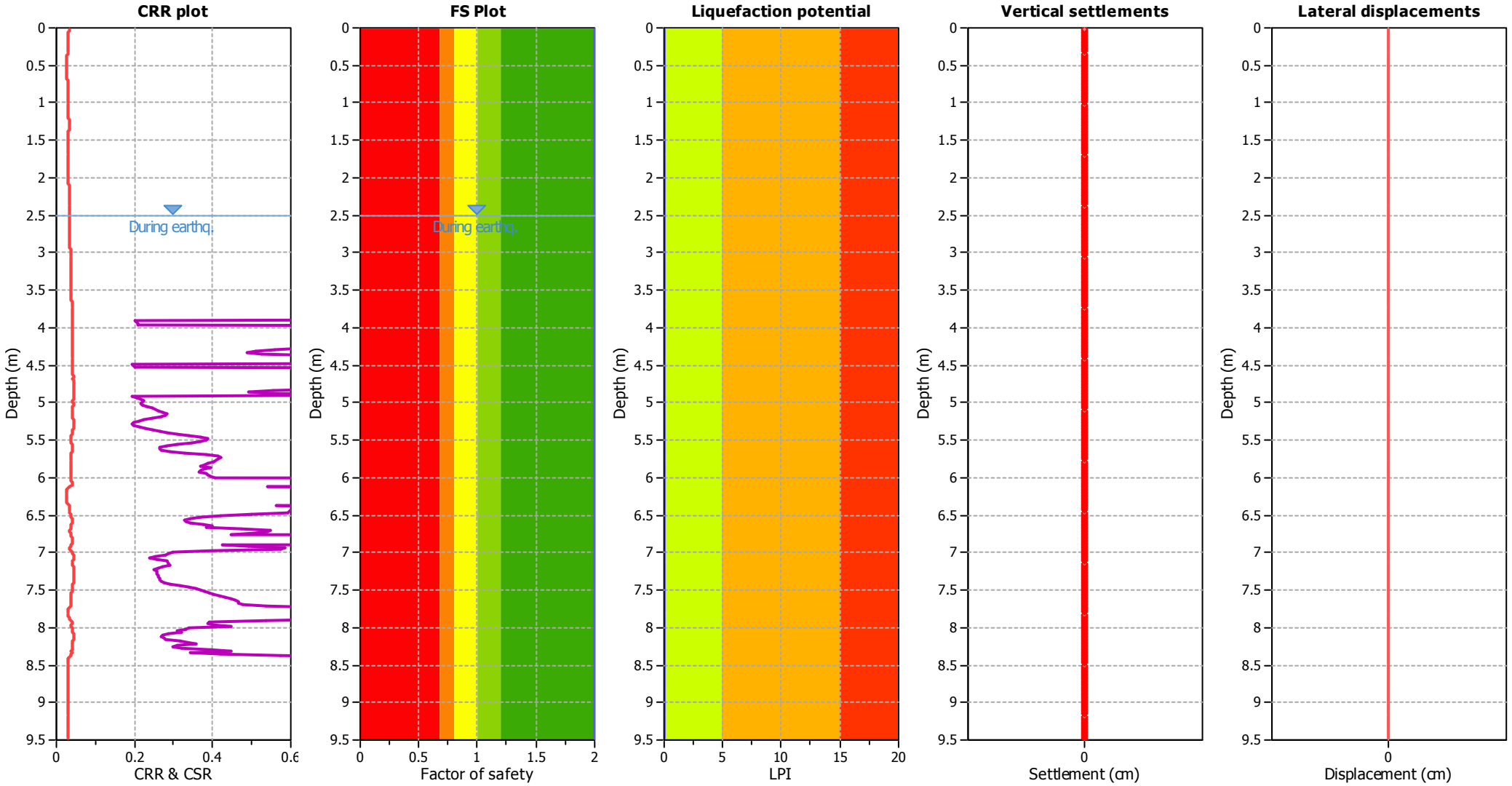
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

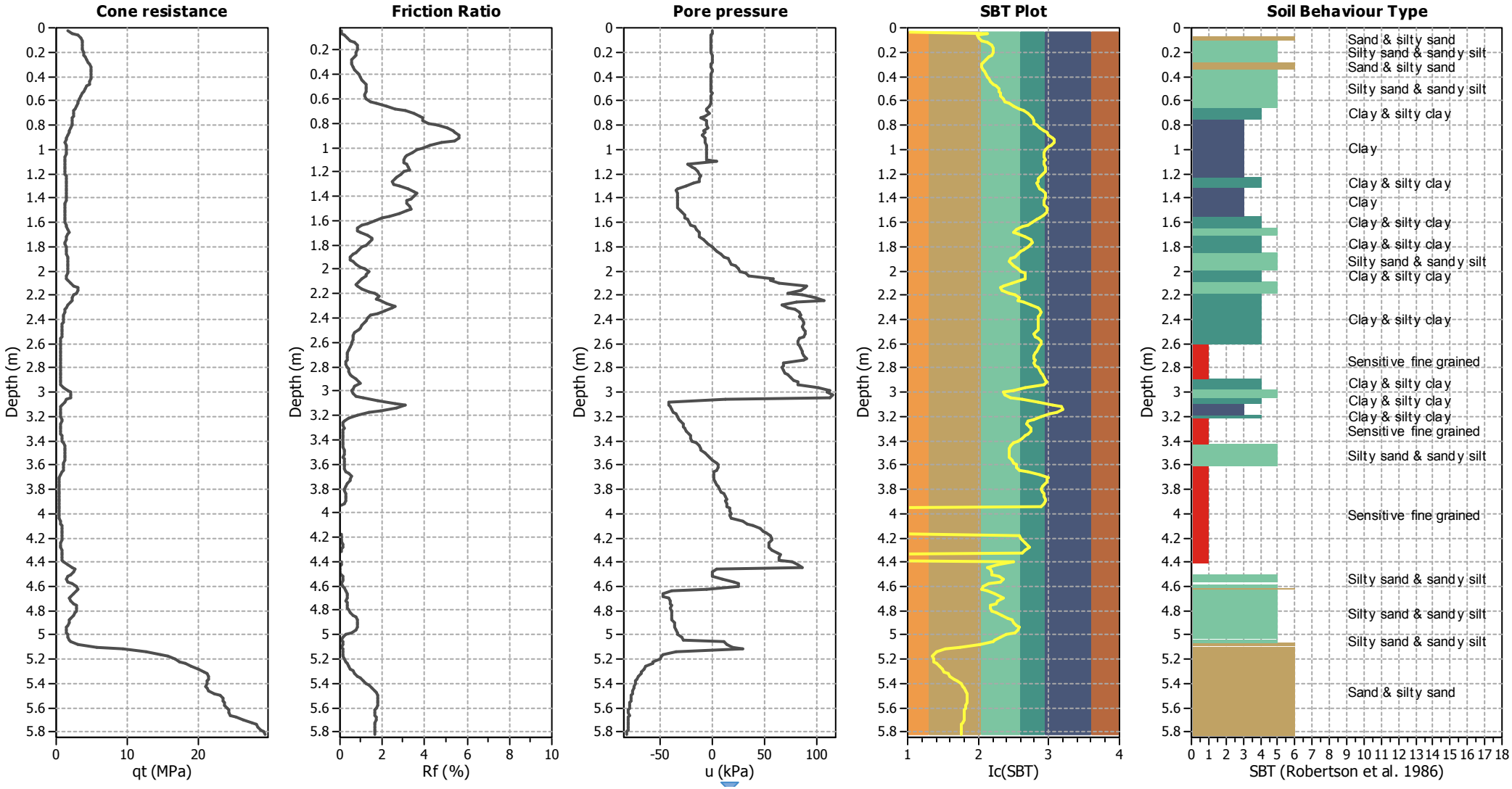
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



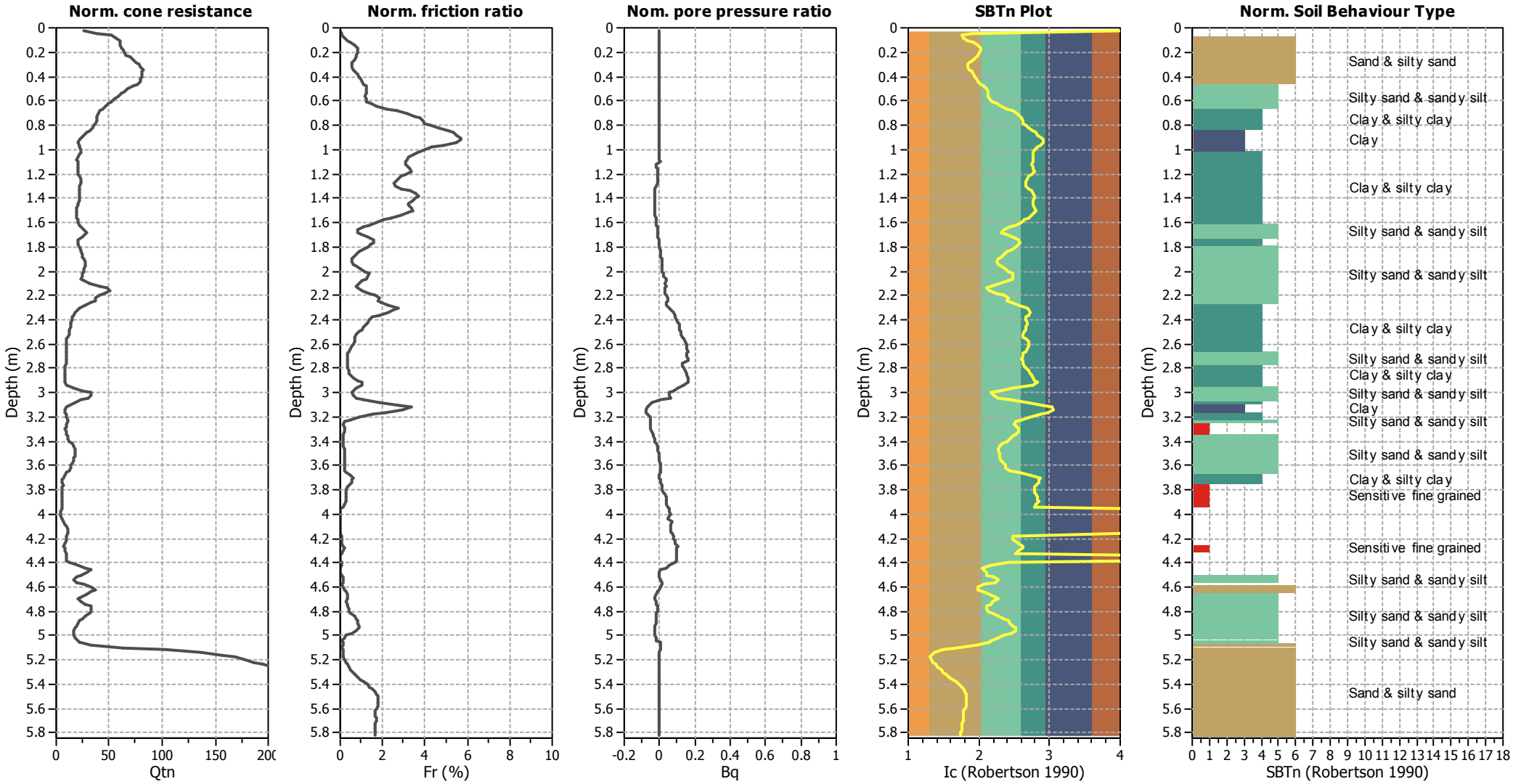
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	6.30 m	Fill weight:	17.00 kN/m³
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	Yes	Limit depth applied:	No
Depth to water table (insitu):	6.30 m	Fill height:	1.50 m	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



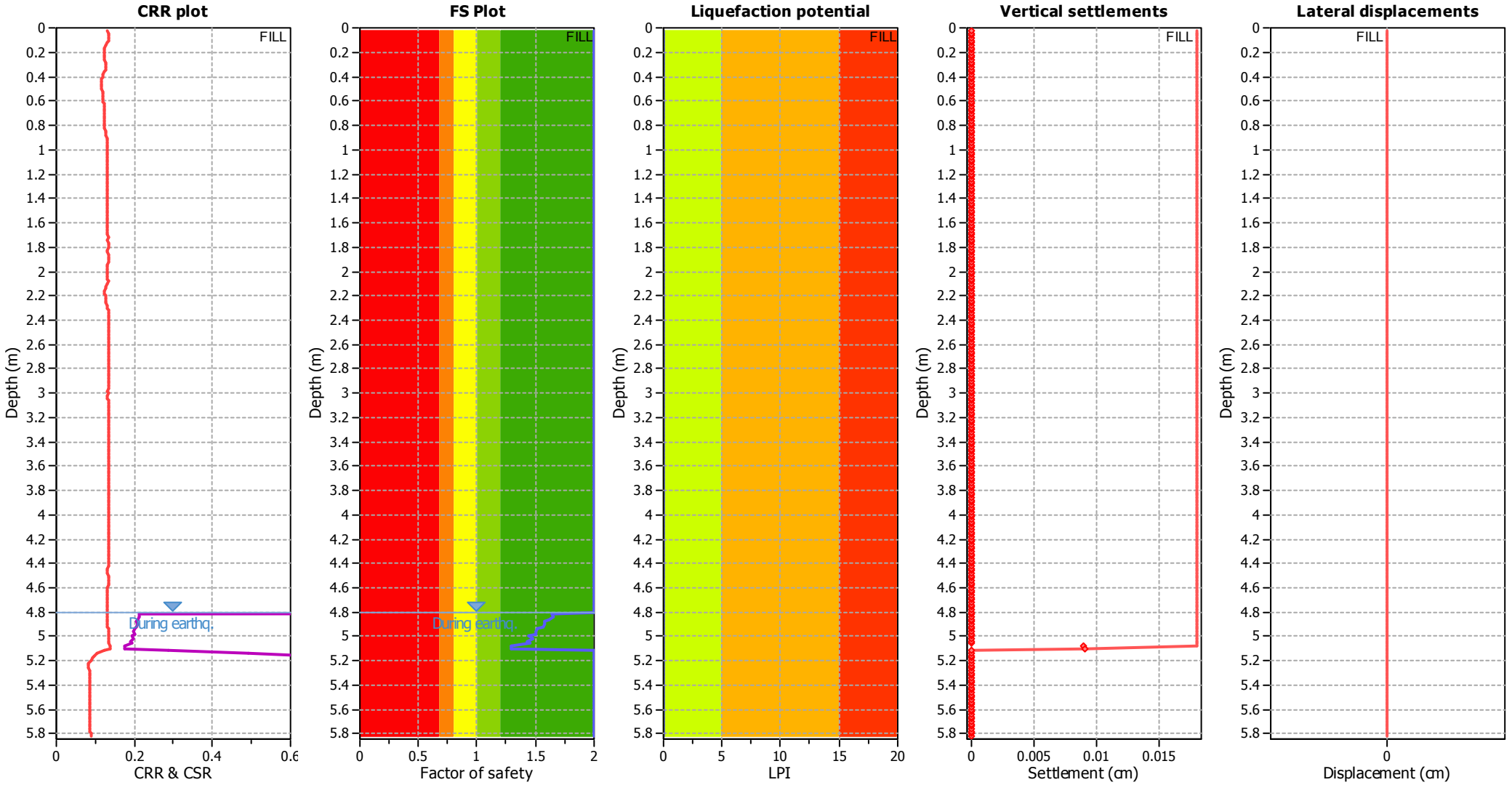
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	6.30 m	Fill weight:	17.00 kN/m³
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	Yes	Limit depth applied:	No
Depth to water table (insitu):	6.30 m	Fill height:	1.50 m	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	6.30 m	Fill weight:	17.00 kN/m³
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	Yes	Limit depth applied:	No
Depth to water table (insitu):	6.30 m	Fill height:	1.50 m	Limit depth:	N/A

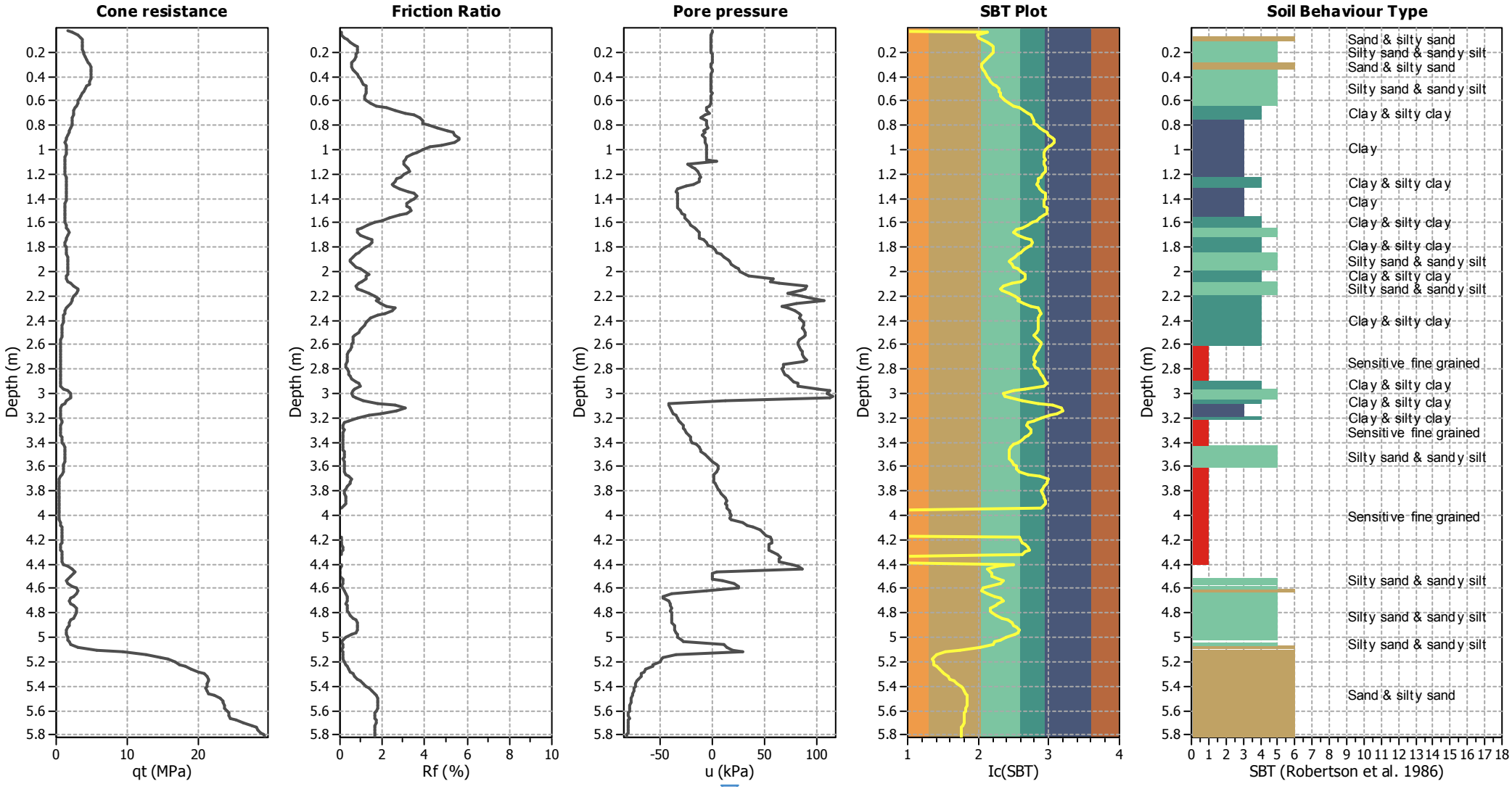
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



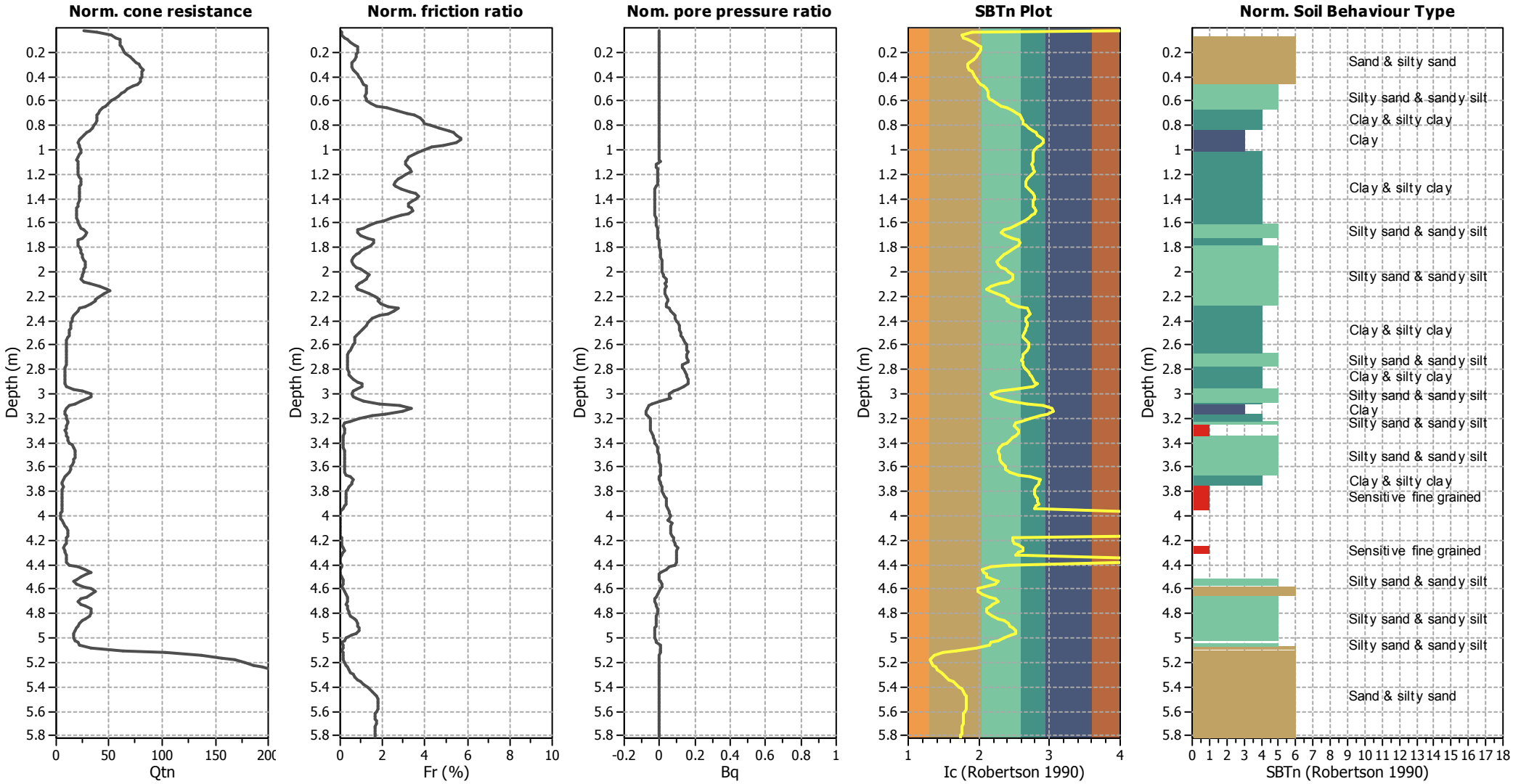
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	6.30 m	Fill weight:	17.00 kN/m³
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	Yes	Limit depth applied:	No
Depth to water table (insitu):	6.30 m	Fill height:	1.50 m	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	6.30 m	Fill weight:	17.00 kN/m³
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	Yes	Limit depth applied:	No
Depth to water table (insitu):	6.30 m	Fill height:	1.50 m	Limit depth:	N/A

SBTn legend

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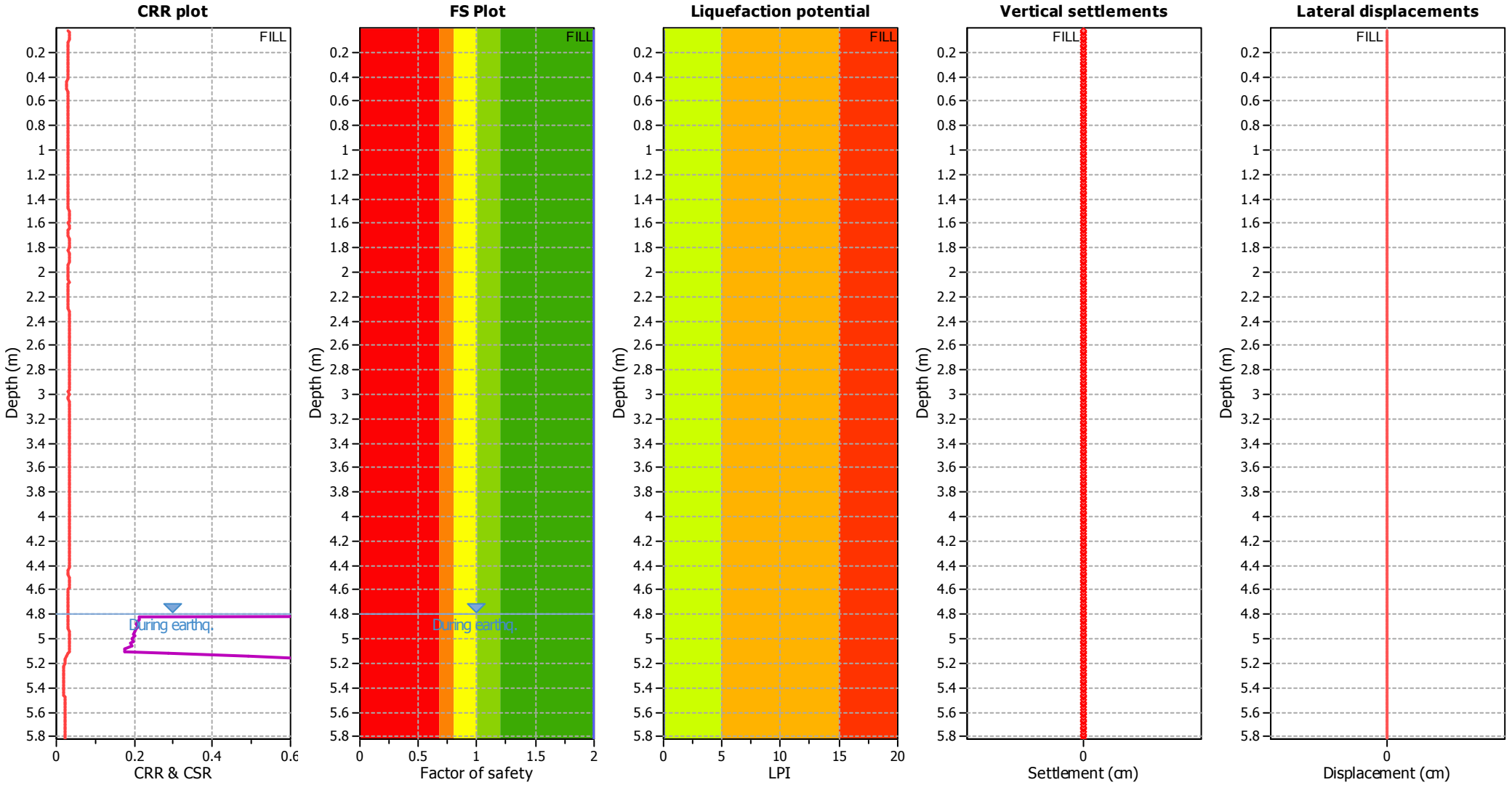
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	6.30 m	Fill weight:	17.00 kN/m³
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	Yes	Limit depth applied:	No
Depth to water table (insitu):	6.30 m	Fill height:	1.50 m	Limit depth:	N/A

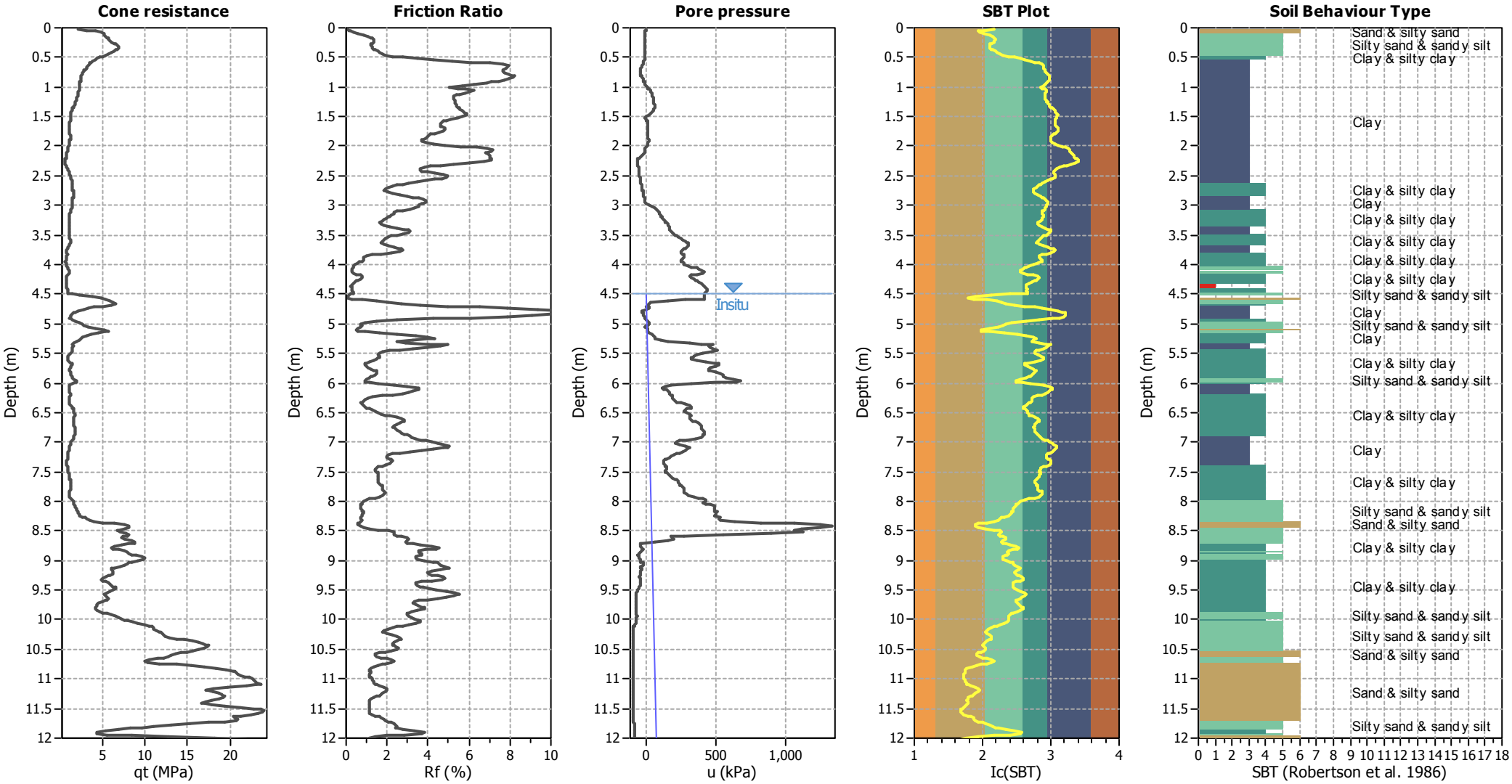
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



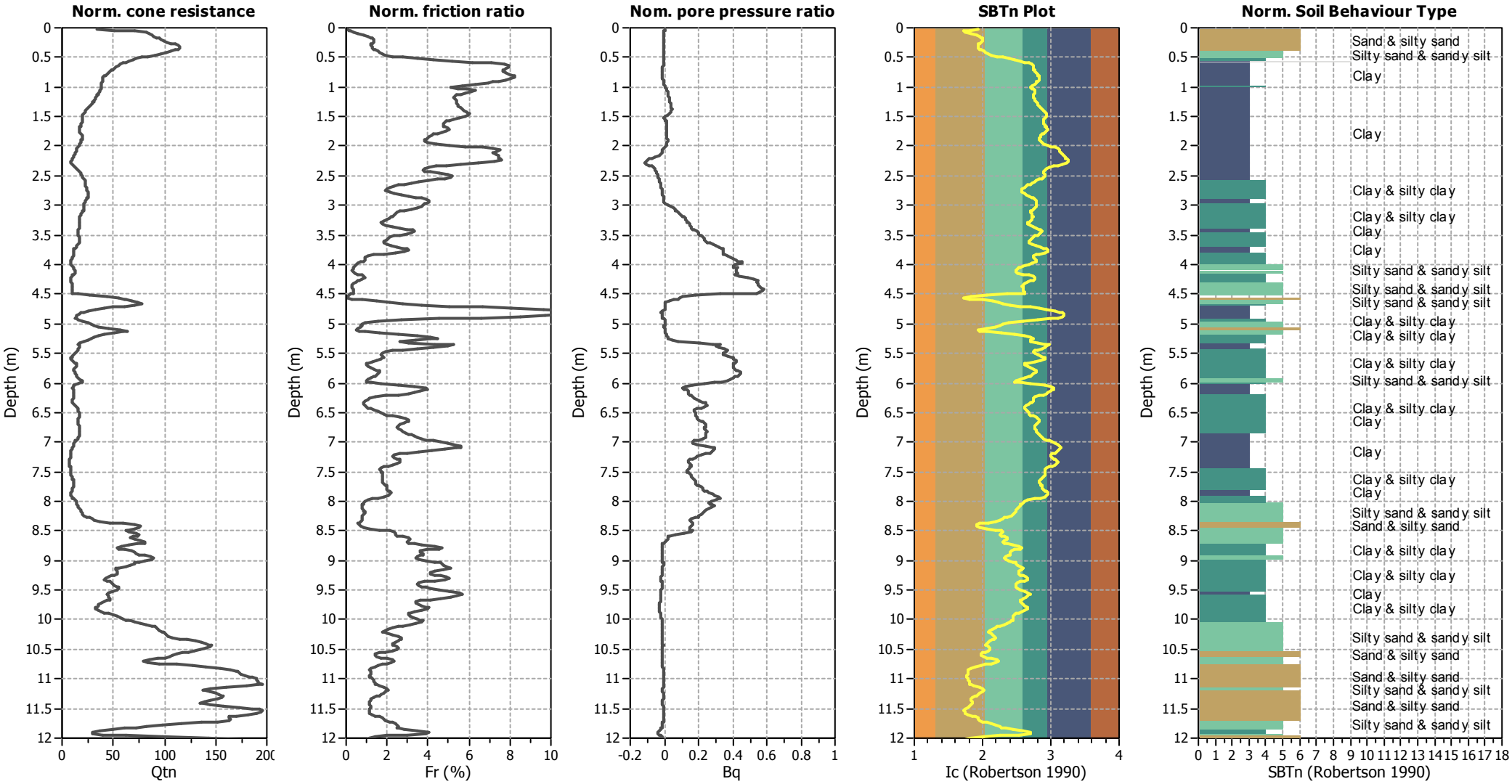
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	4.50 m	Excavation depth:	1.00 m	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



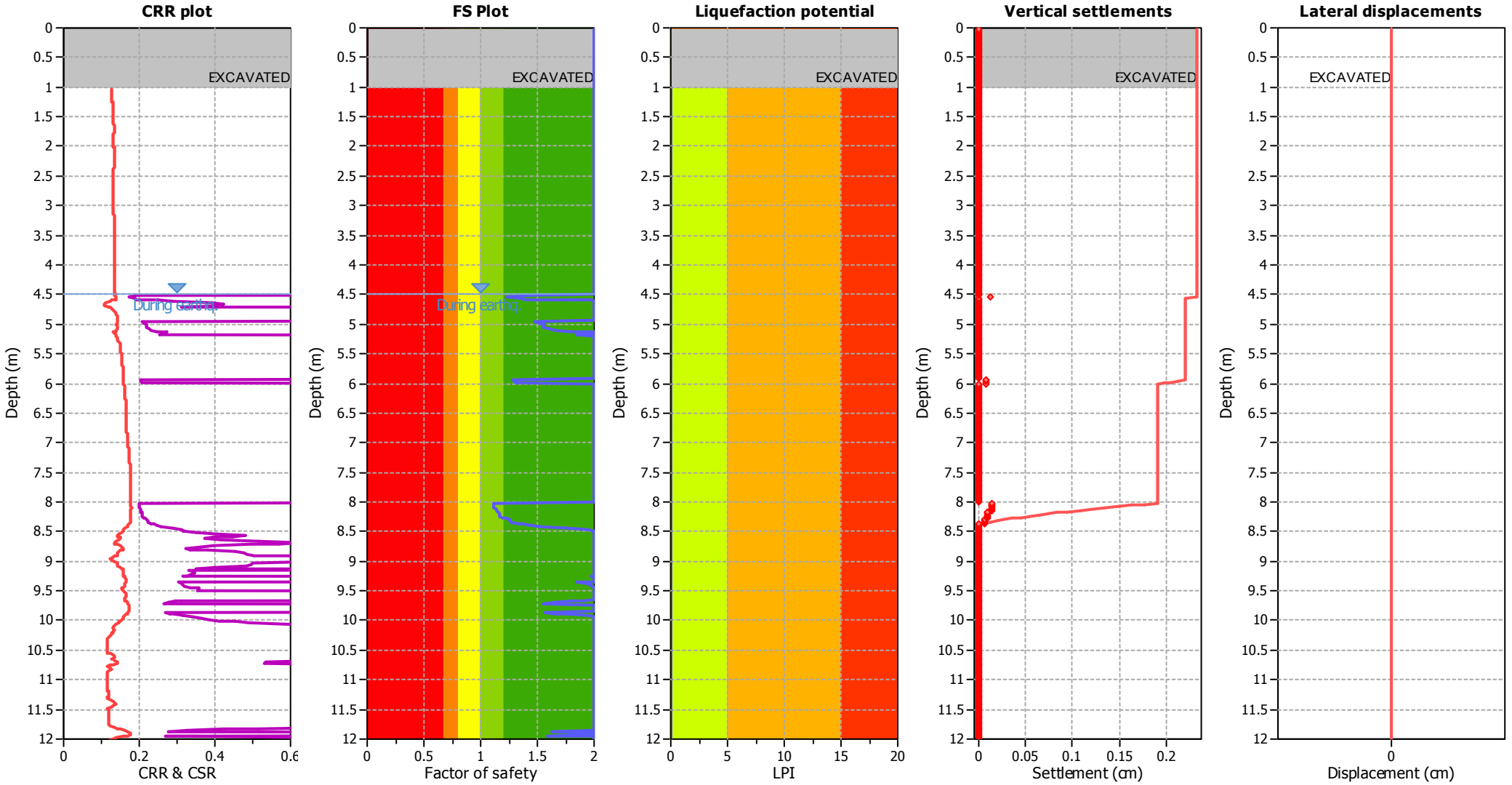
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	4.50 m	Excavation depth:	1.00 m	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	4.50 m	Excavation depth:	1.00 m	Limit depth:	N/A

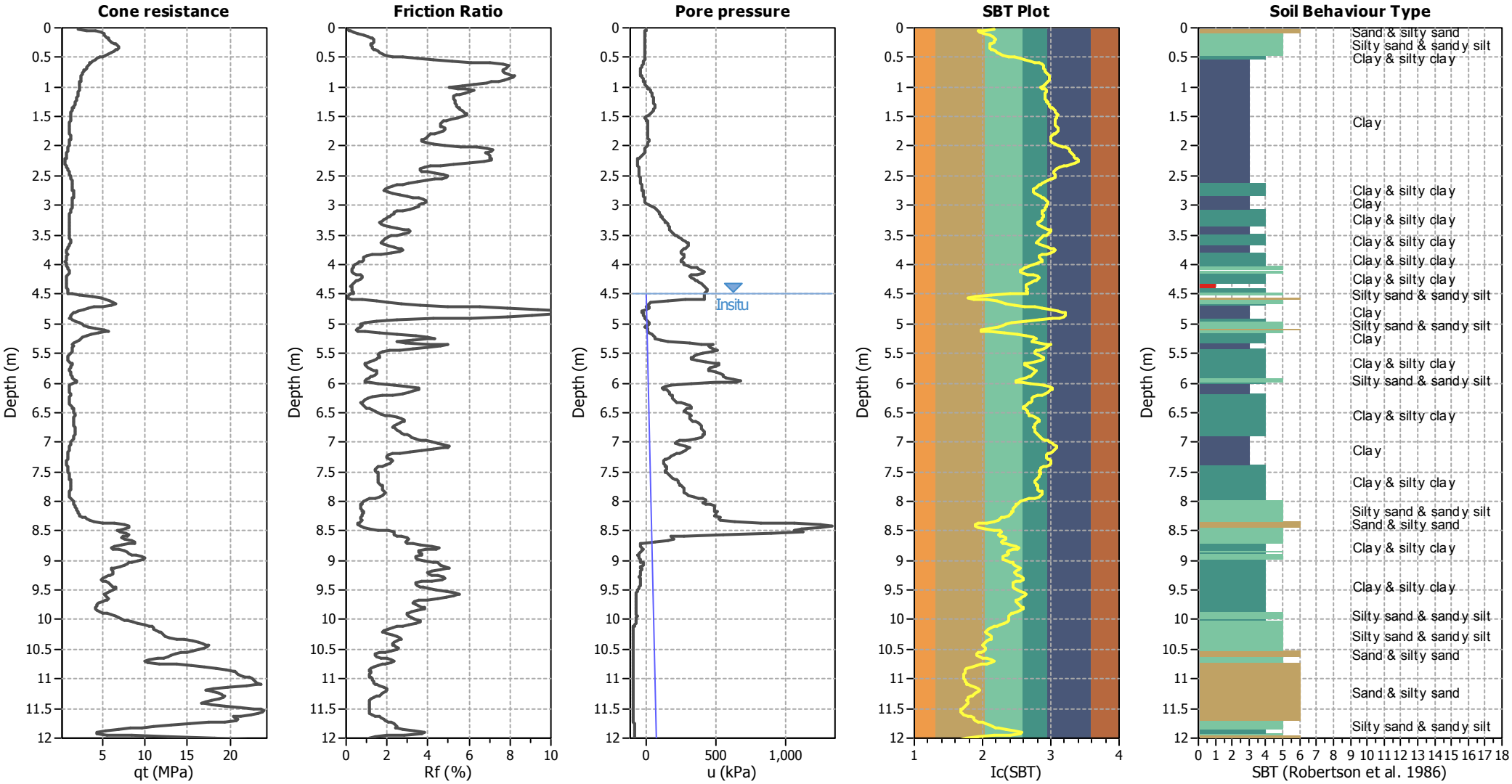
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



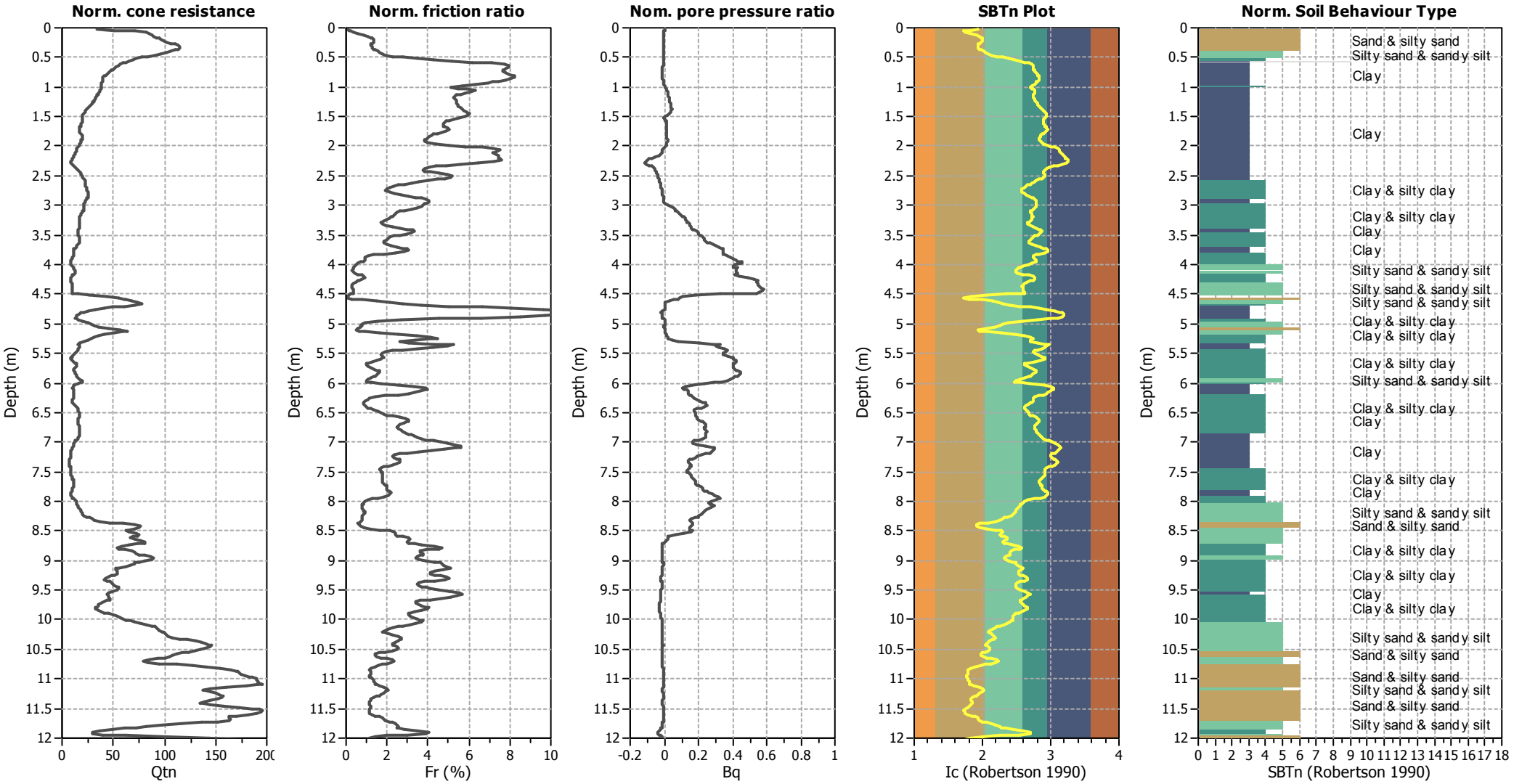
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	4.50 m	Excavation depth:	1.00 m	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	4.50 m	Excavation depth:	1.00 m	Limit depth:	N/A

SBTn legend

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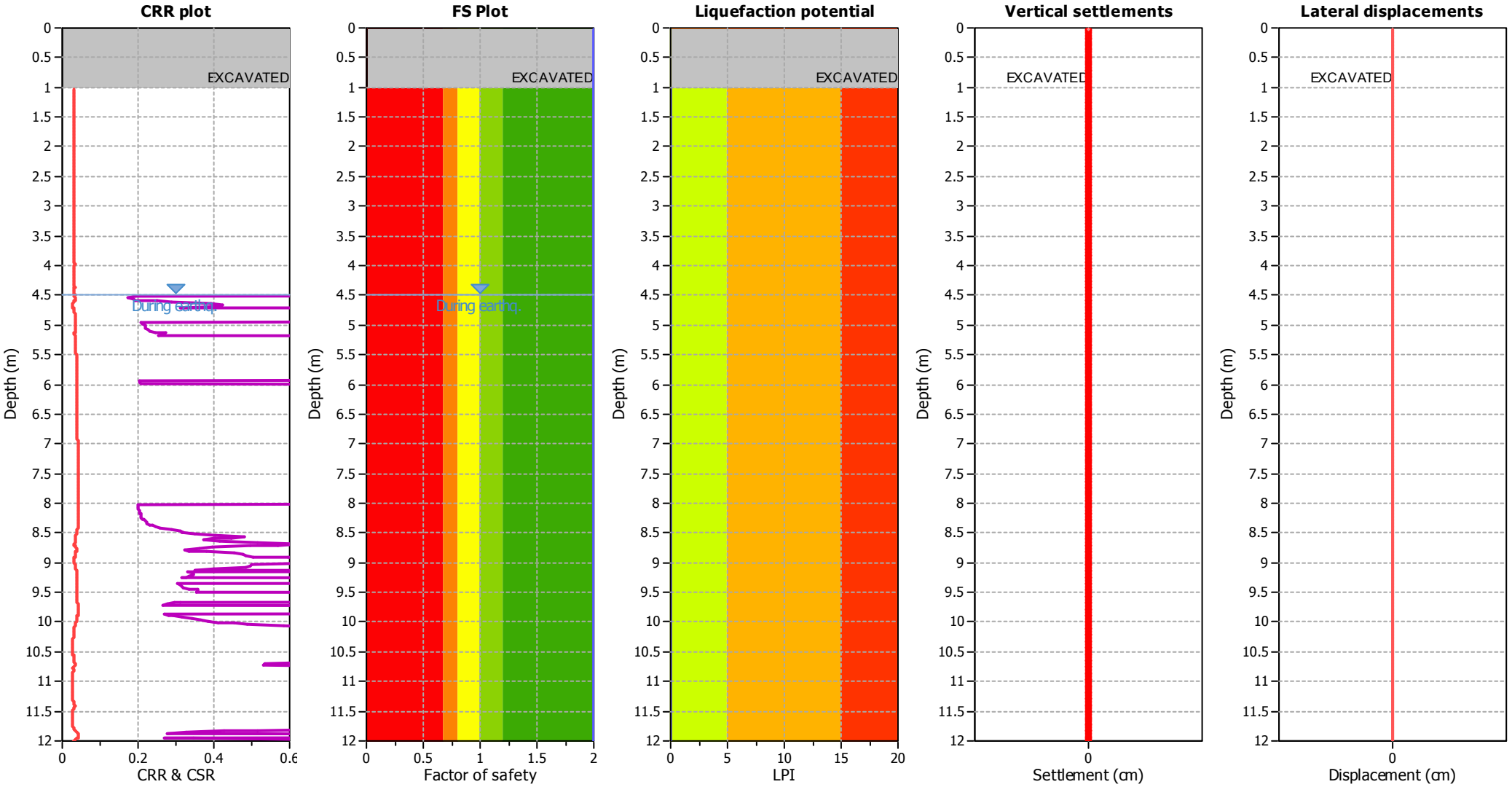
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	4.50 m	Excavation depth:	1.00 m	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
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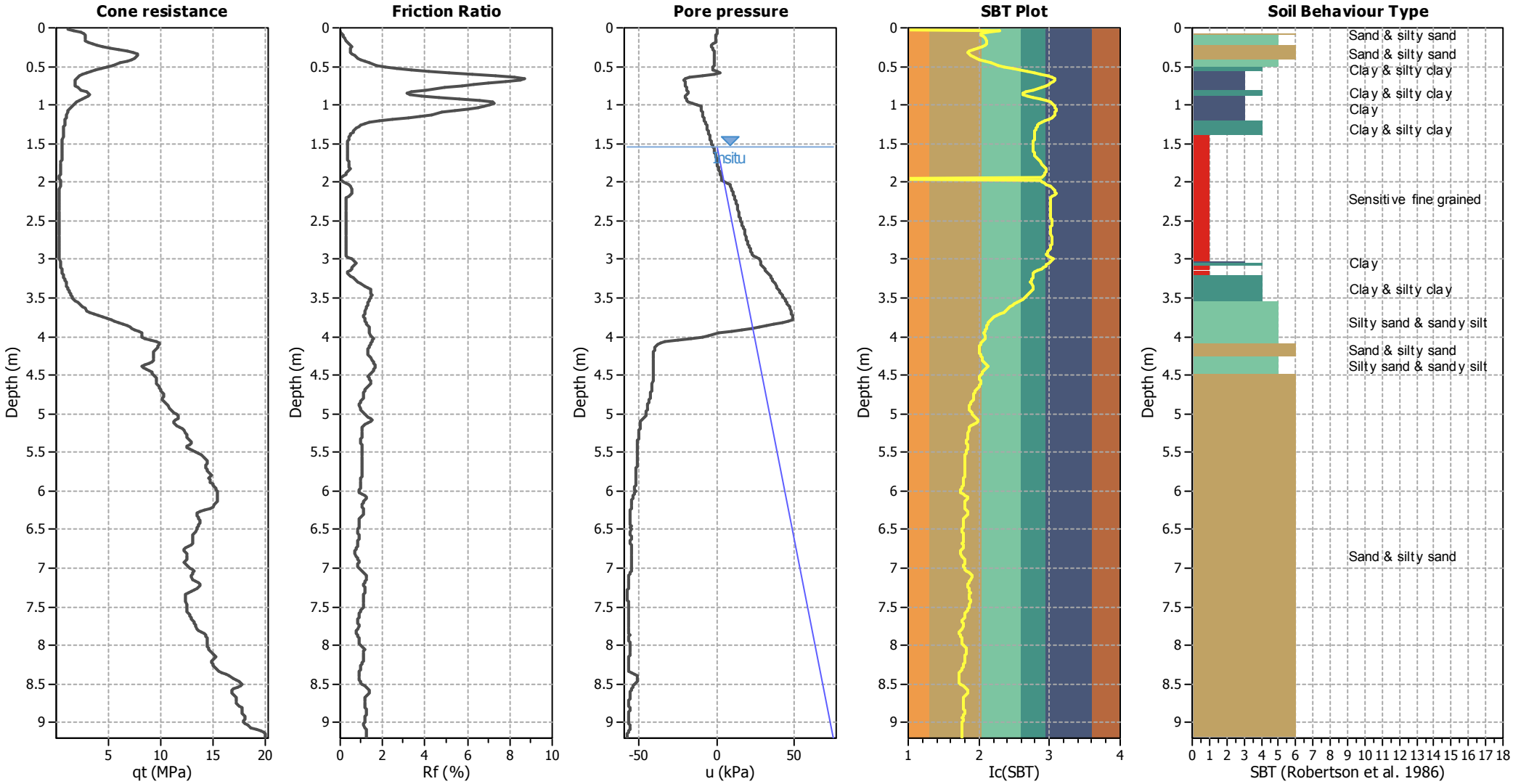
LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



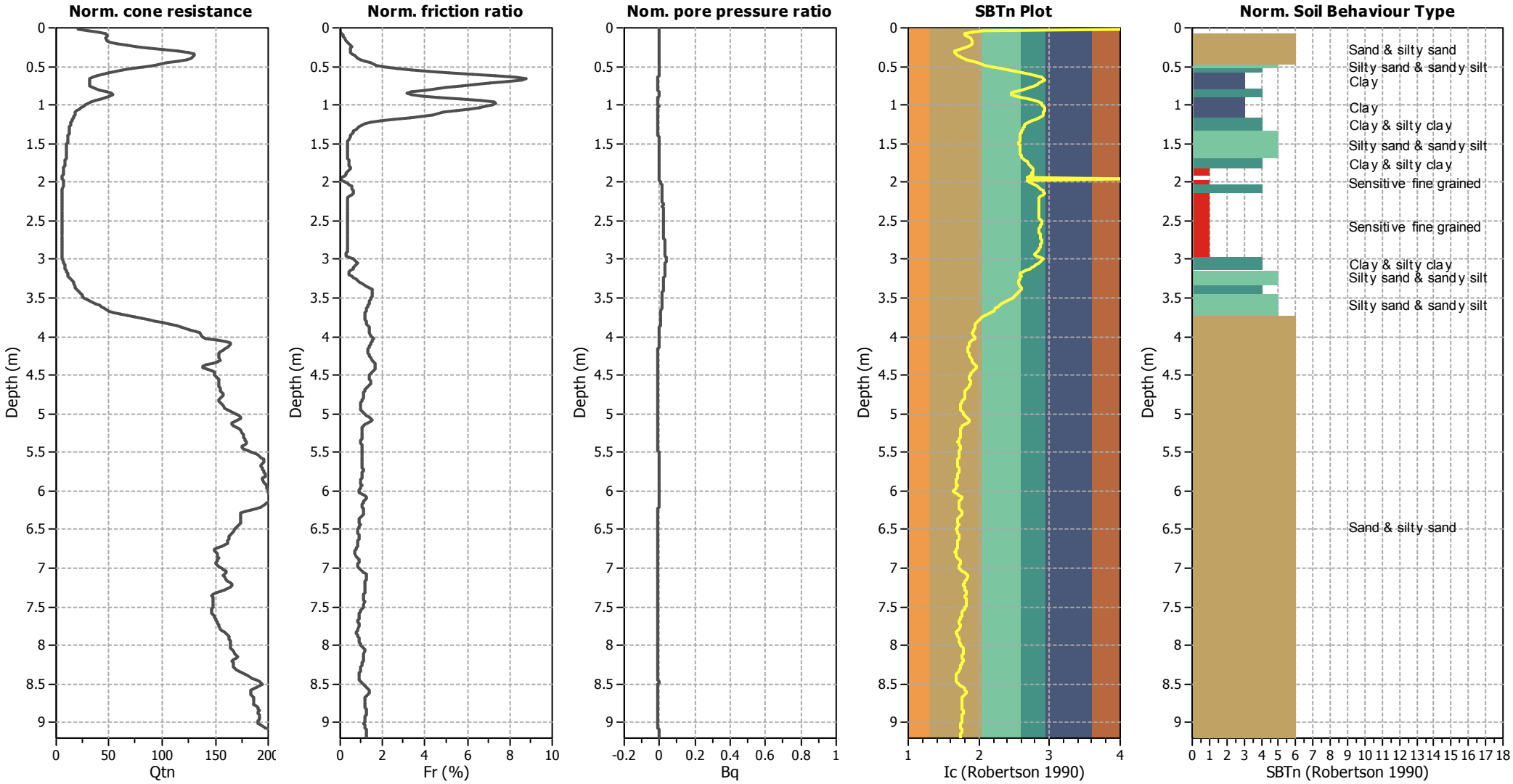
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.55 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.55 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



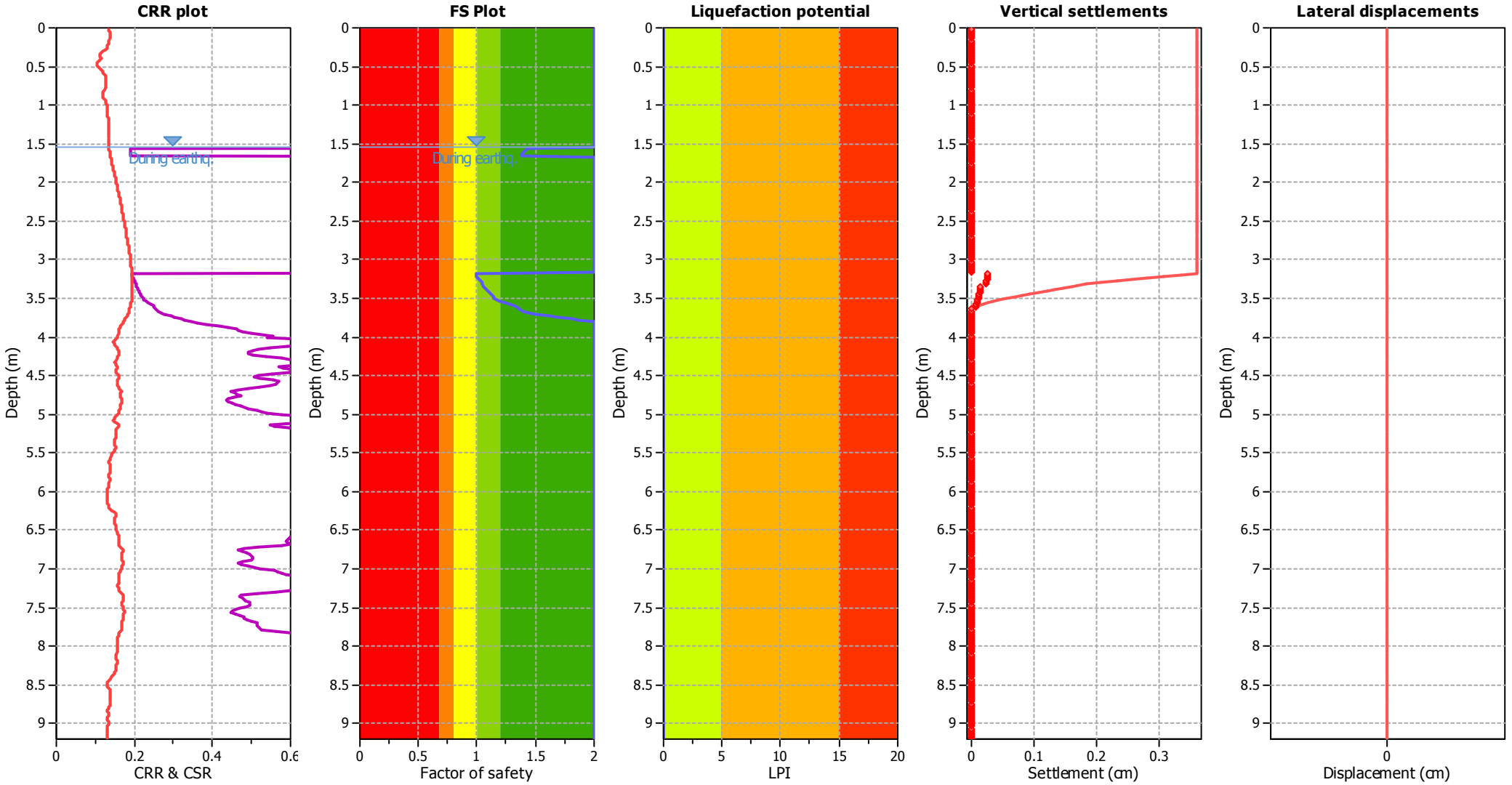
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.55 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.55 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.55 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.55 m	Fill height:	N/A	Limit depth:	N/A

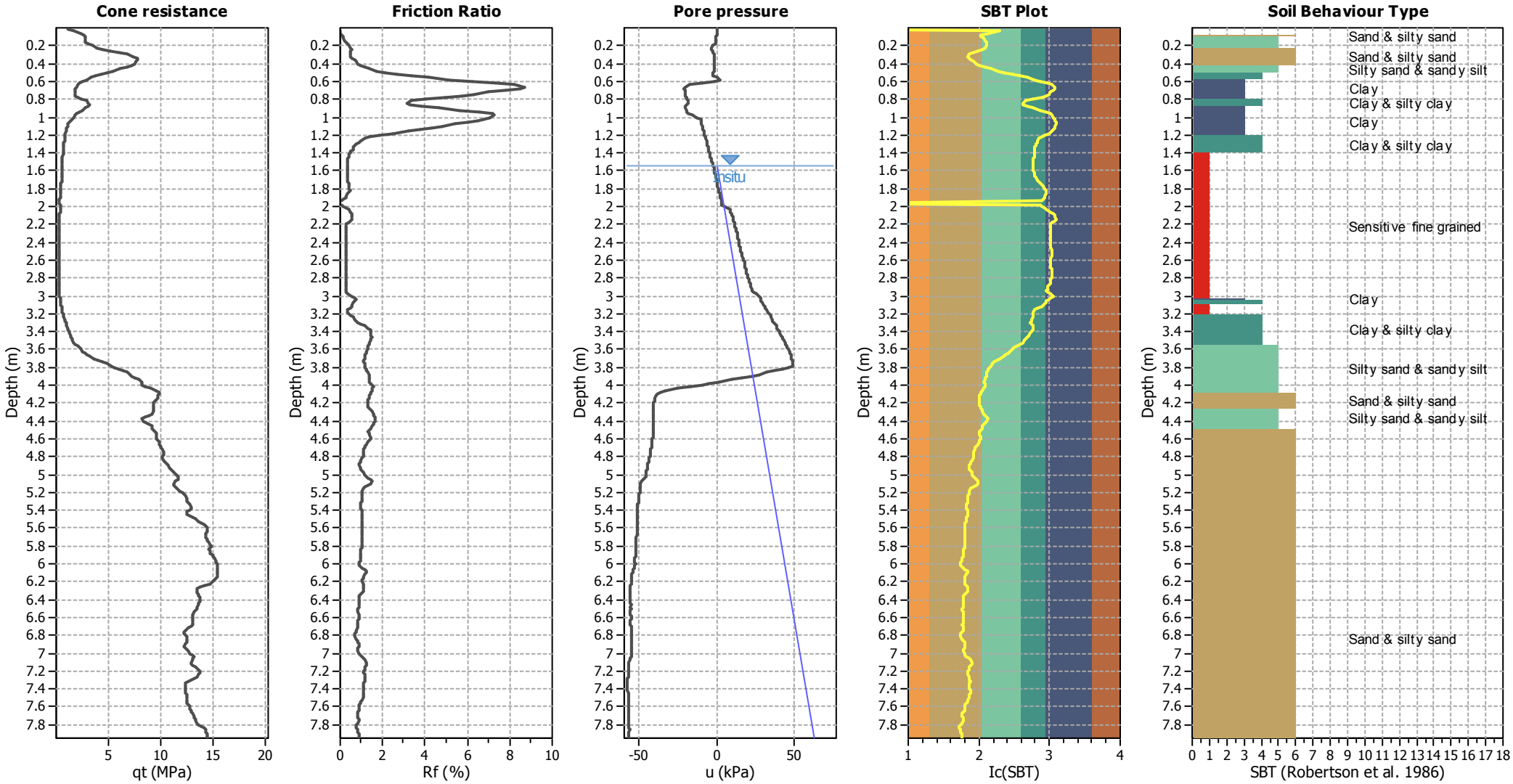
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



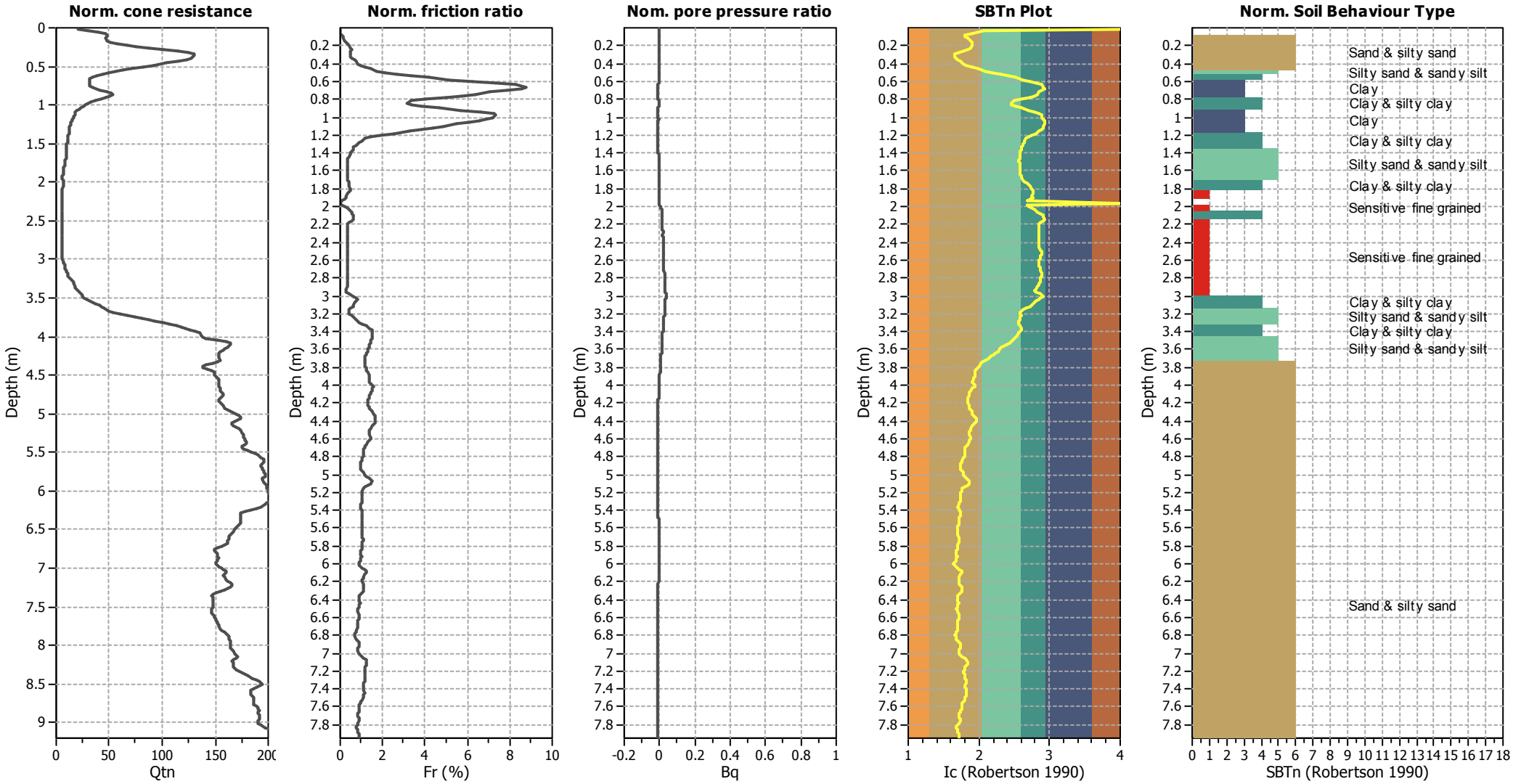
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.55 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.55 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



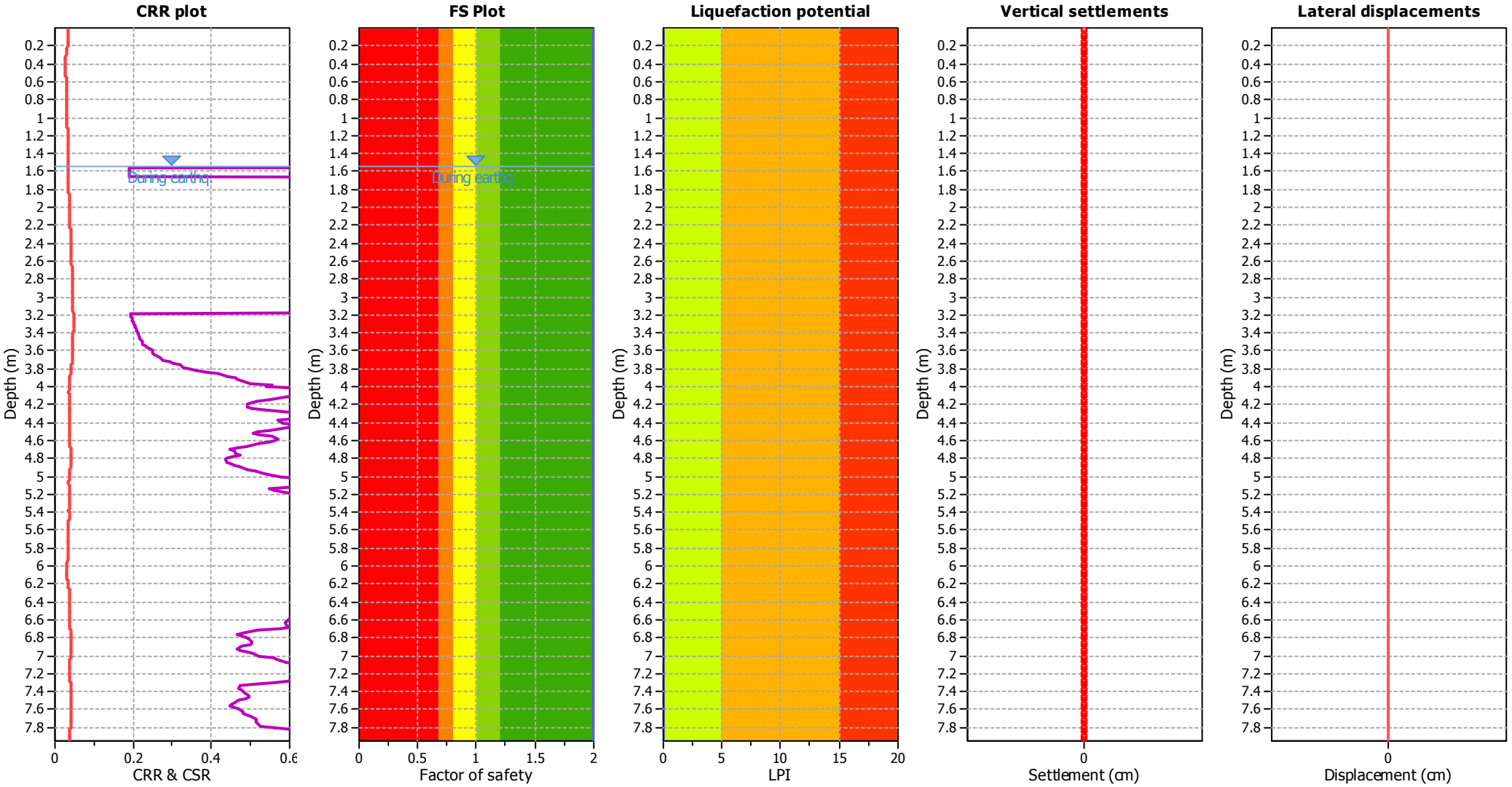
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.55 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.55 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.55 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.55 m	Fill height:	N/A	Limit depth:	N/A

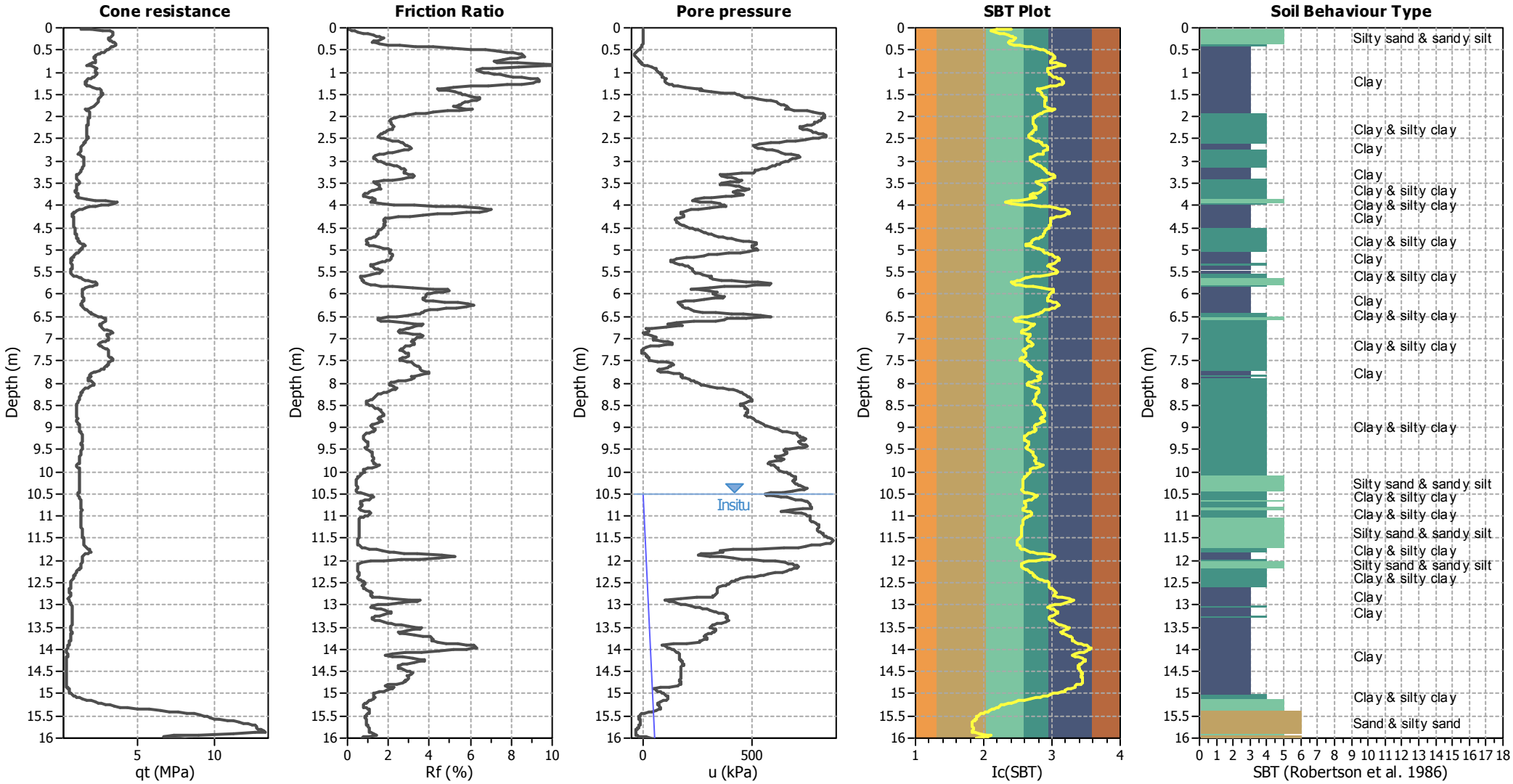
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



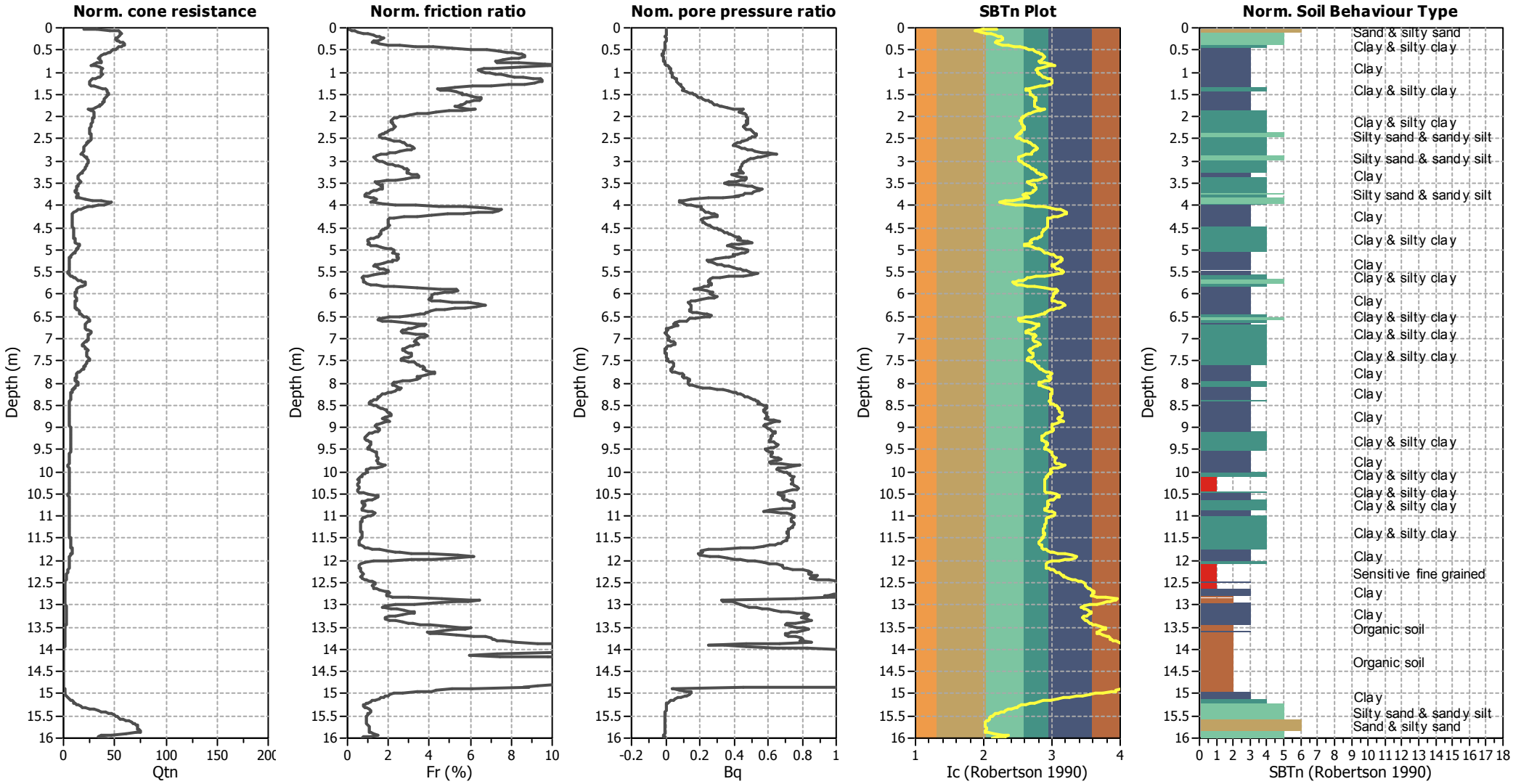
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	10.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	10.50 m	Excavation depth:	2.00 m	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



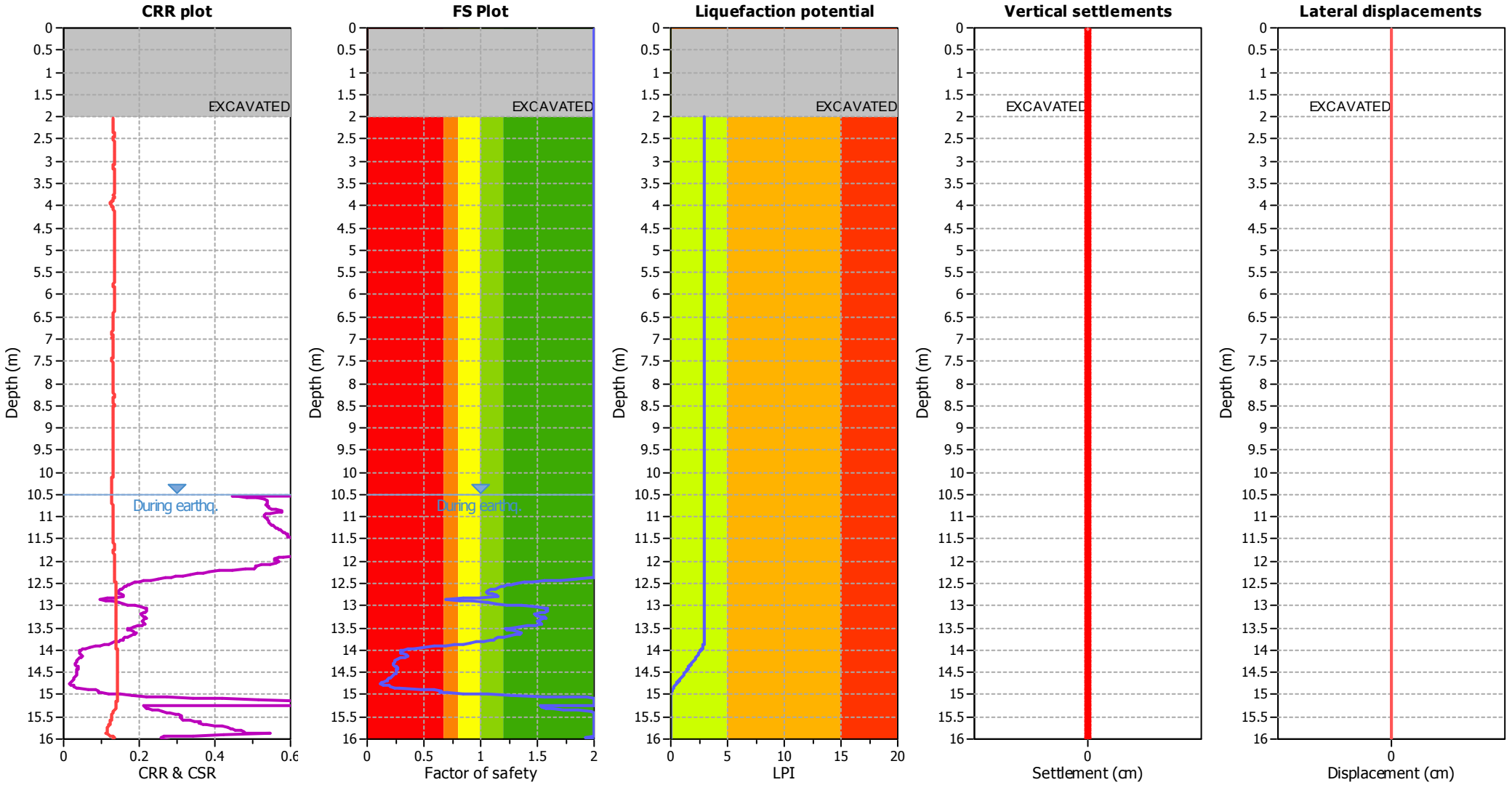
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	10.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	10.50 m	Excavation depth:	2.00 m	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	10.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	10.50 m	Excavation depth:	2.00 m	Limit depth:	N/A

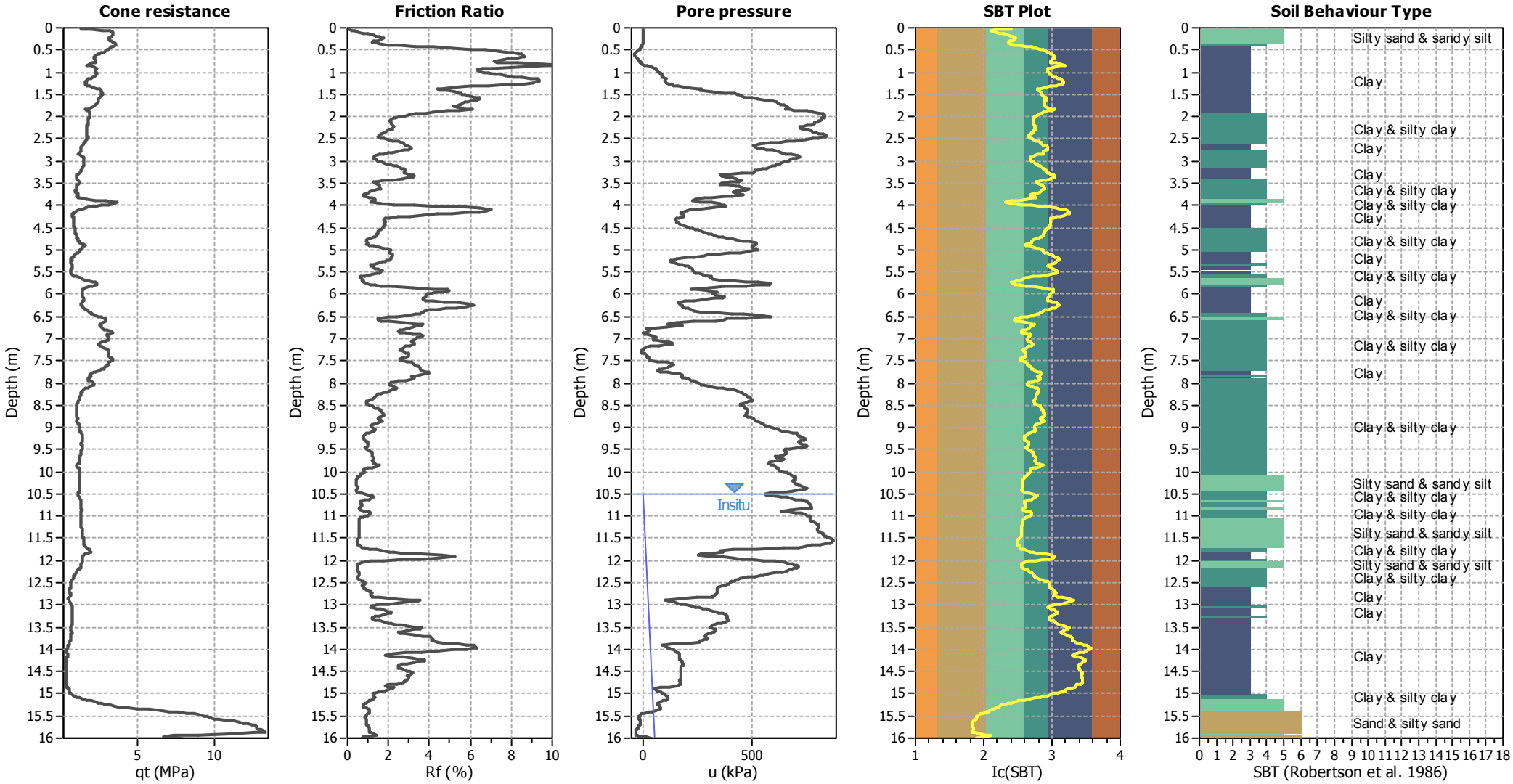
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



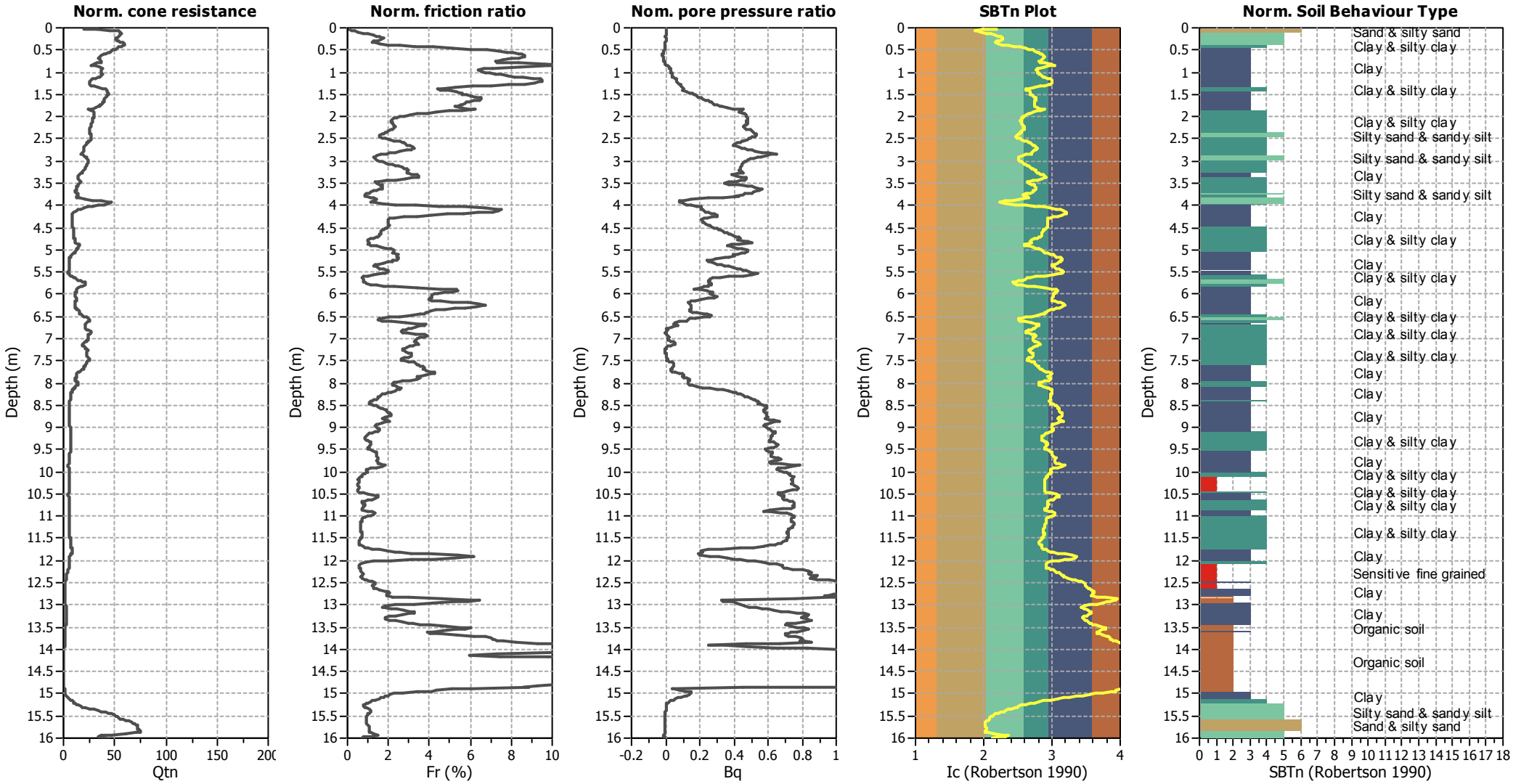
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	10.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	10.50 m	Excavation depth:	2.00 m	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



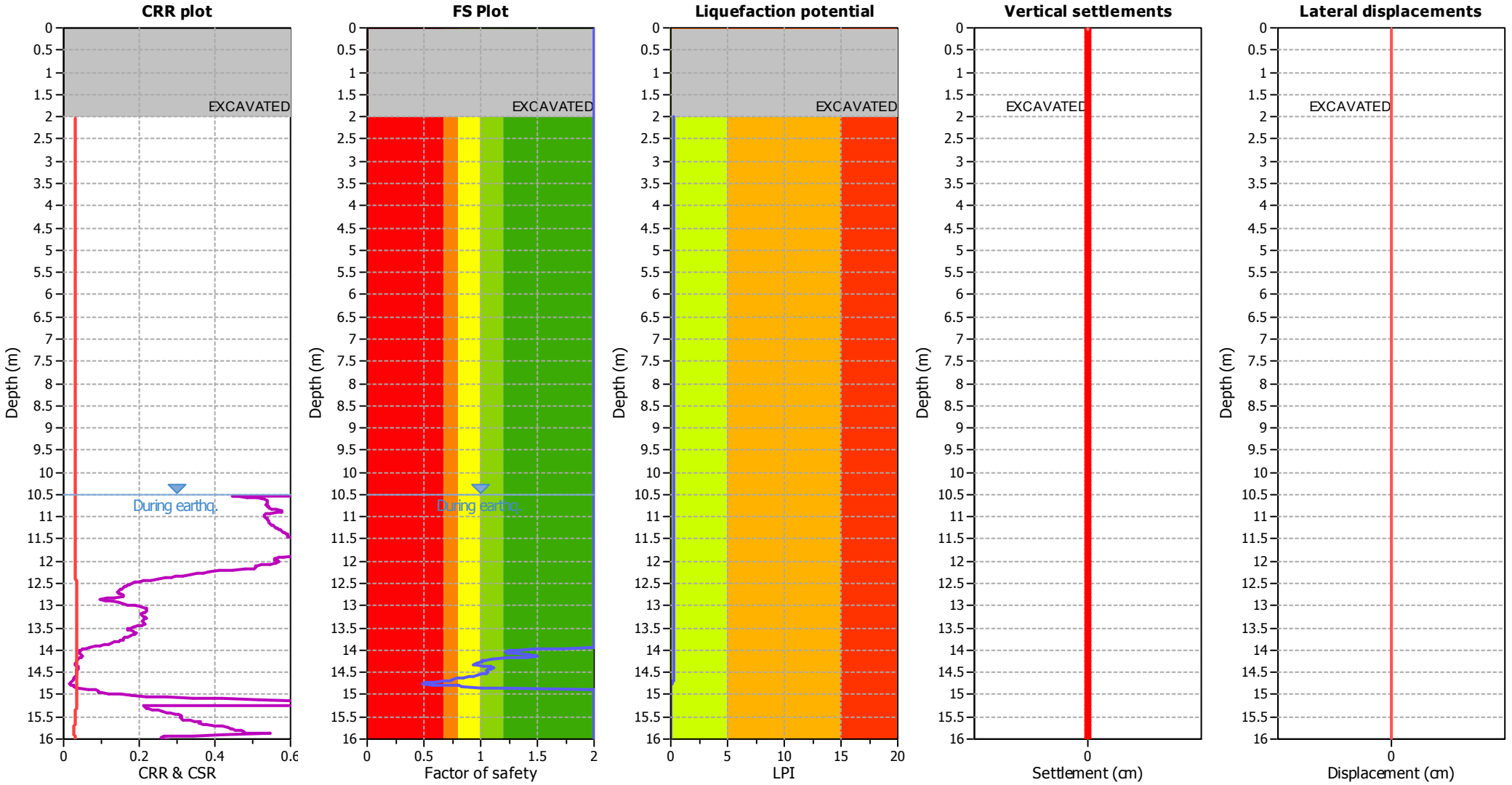
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	10.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	10.50 m	Excavation depth:	2.00 m	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	10.50 m	Footing load:	0.00 kPa
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Excavation:	Yes	Limit depth applied:	No
Depth to water table (insitu):	10.50 m	Excavation depth:	2.00 m	Limit depth:	N/A

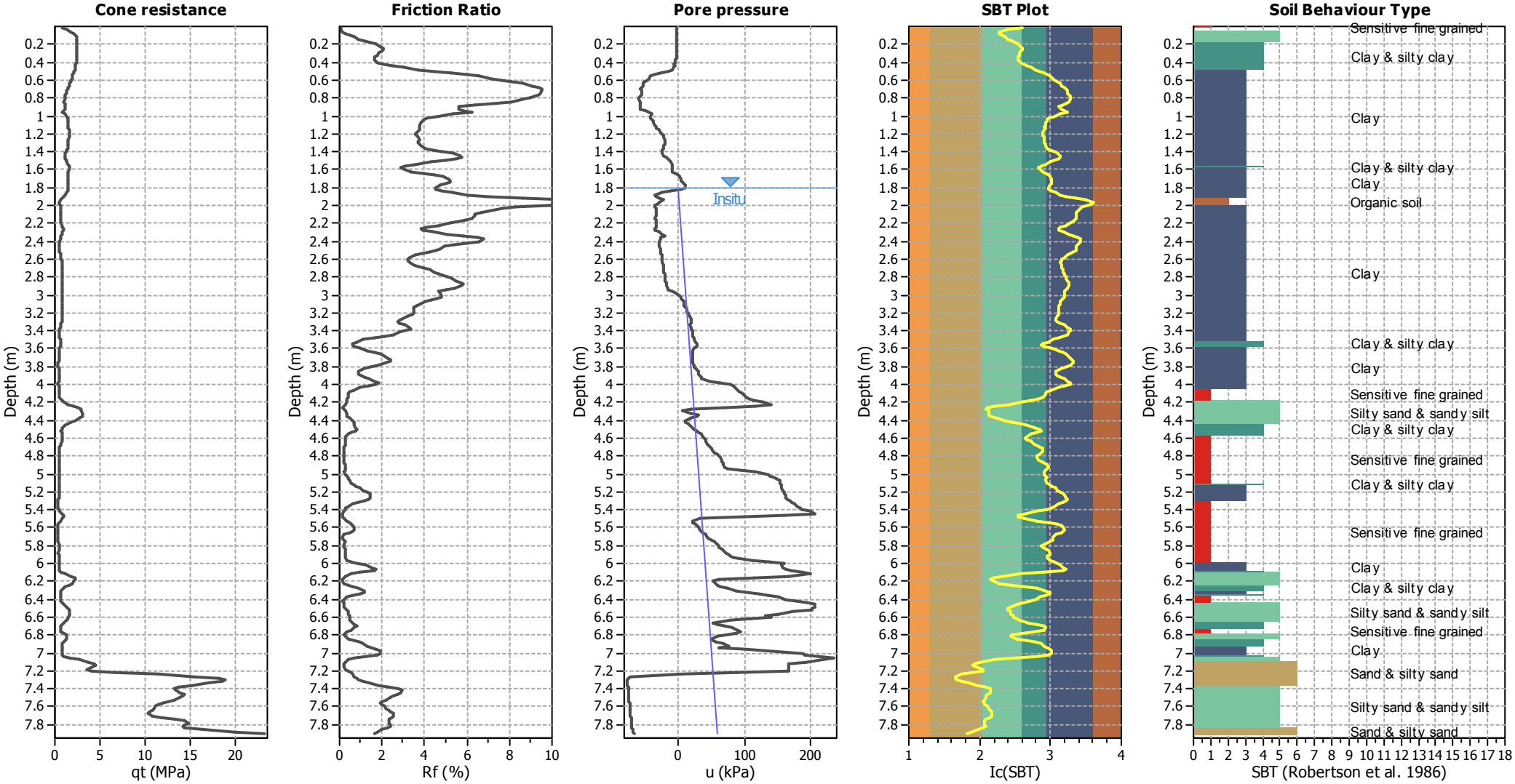
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



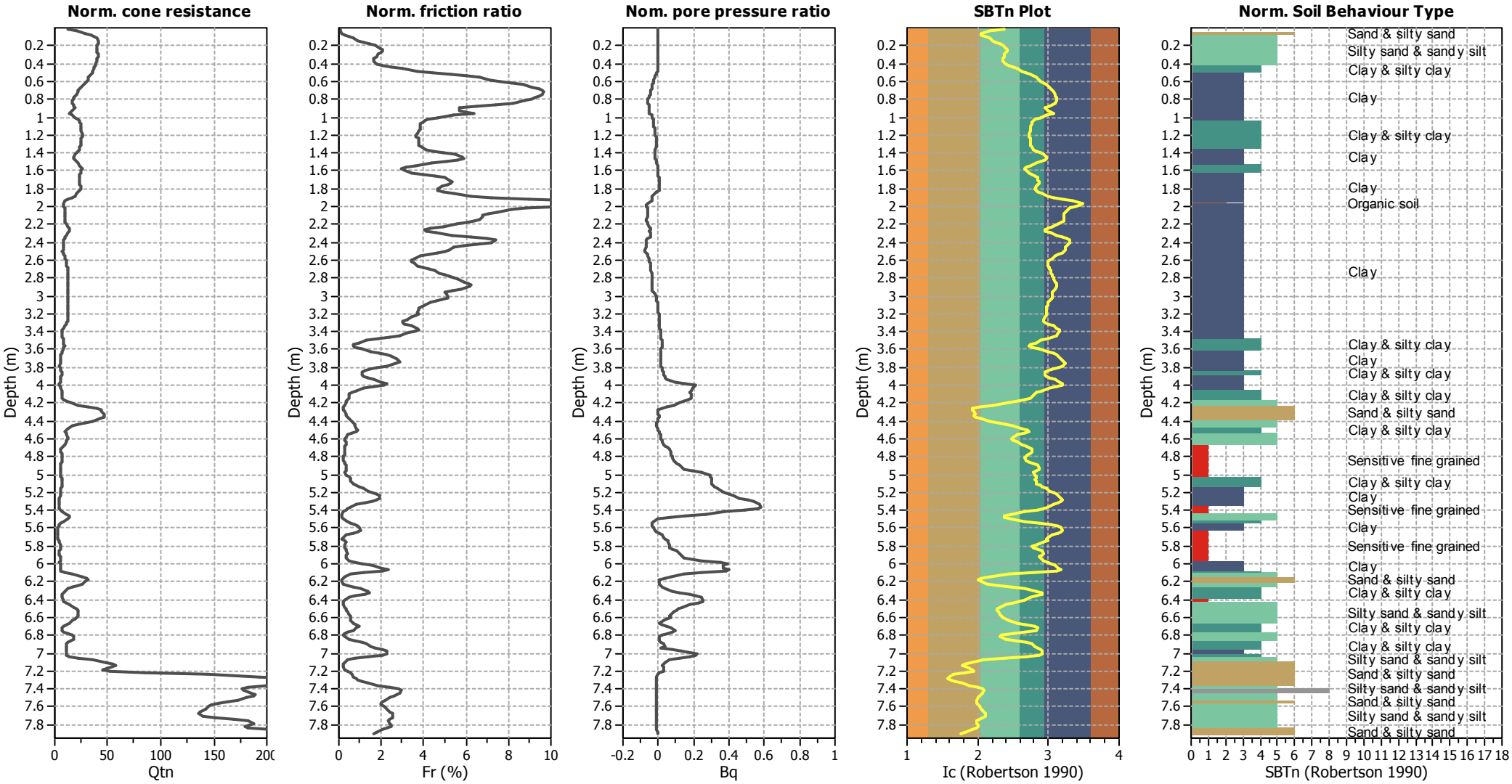
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



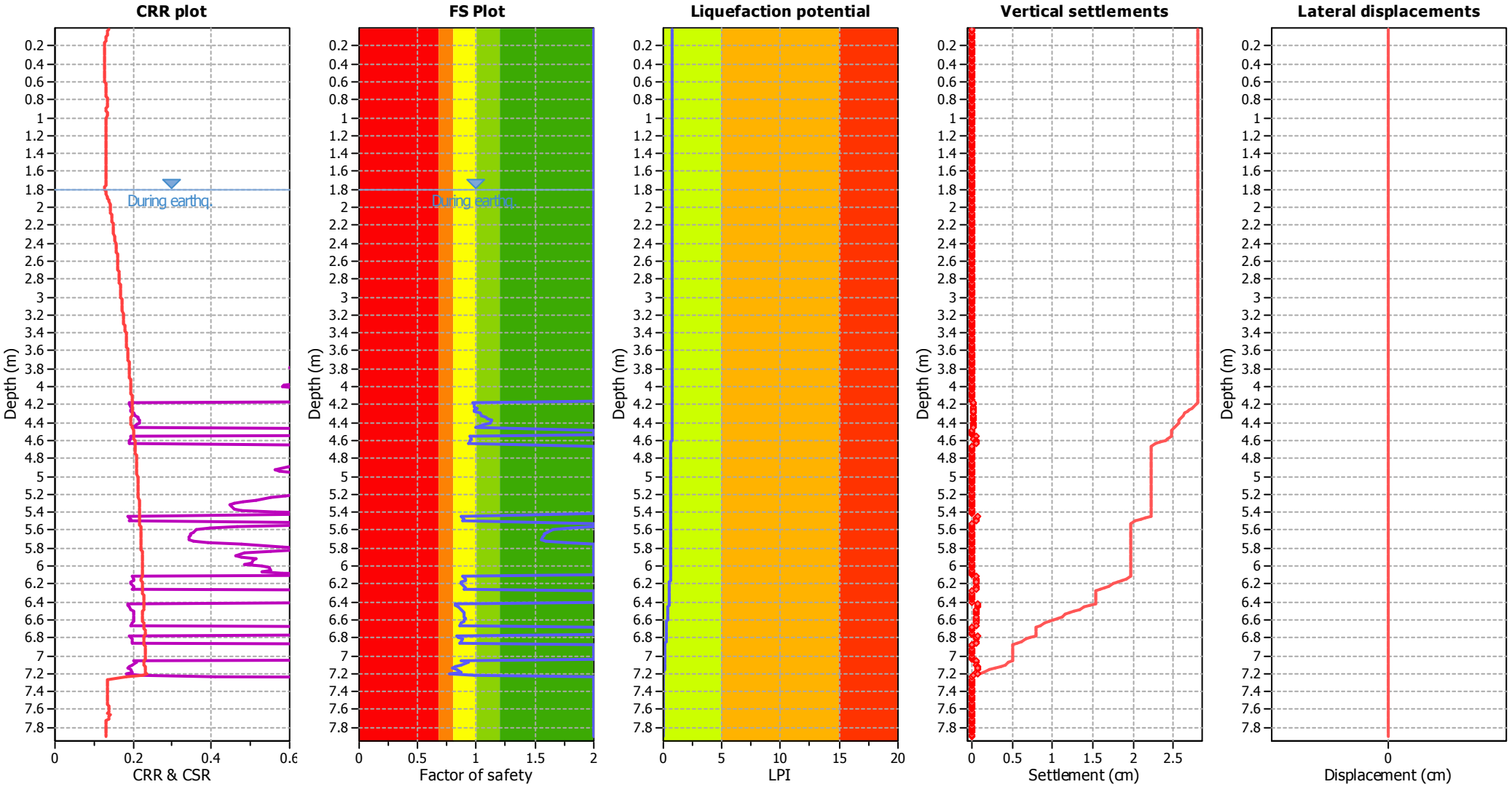
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

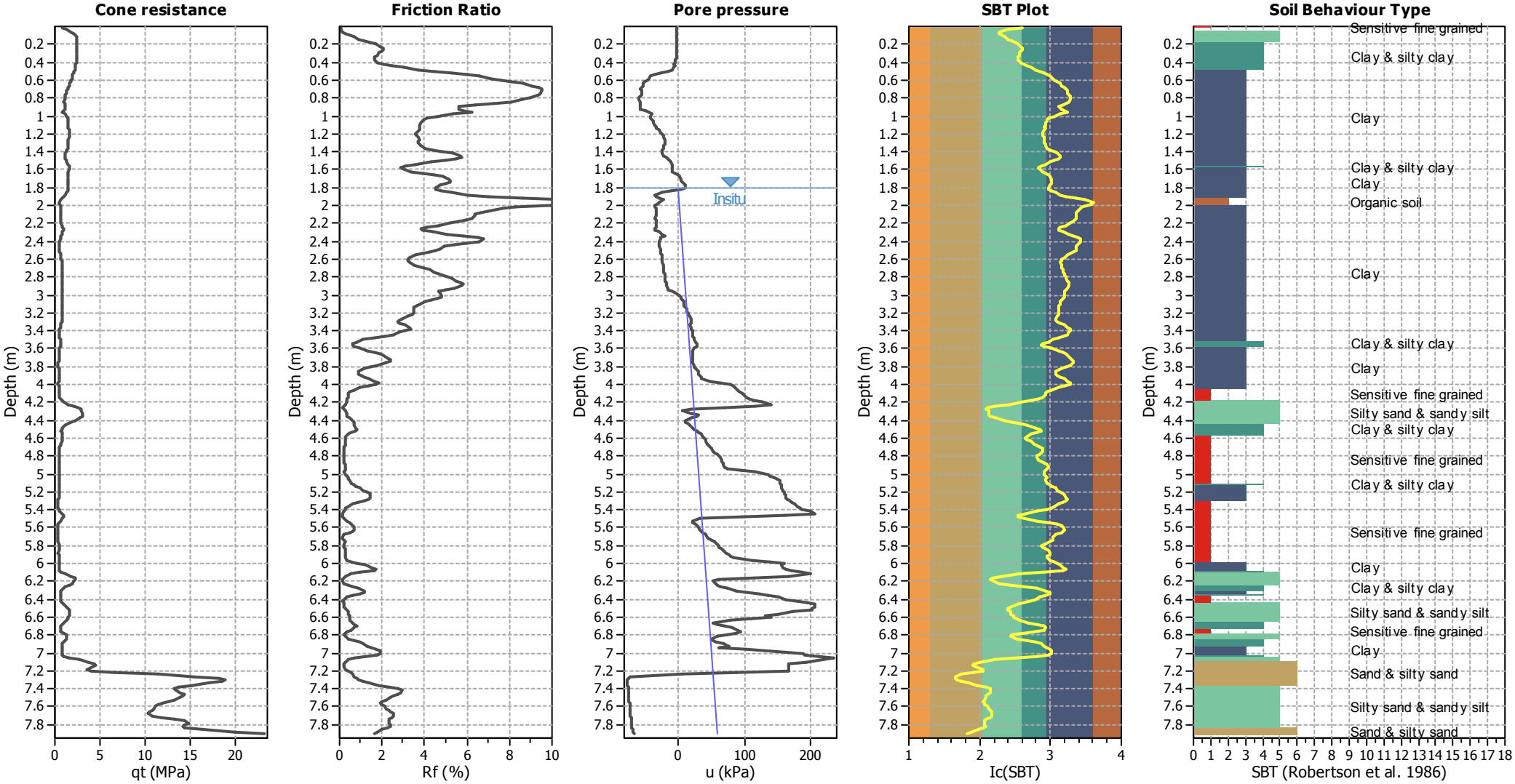
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



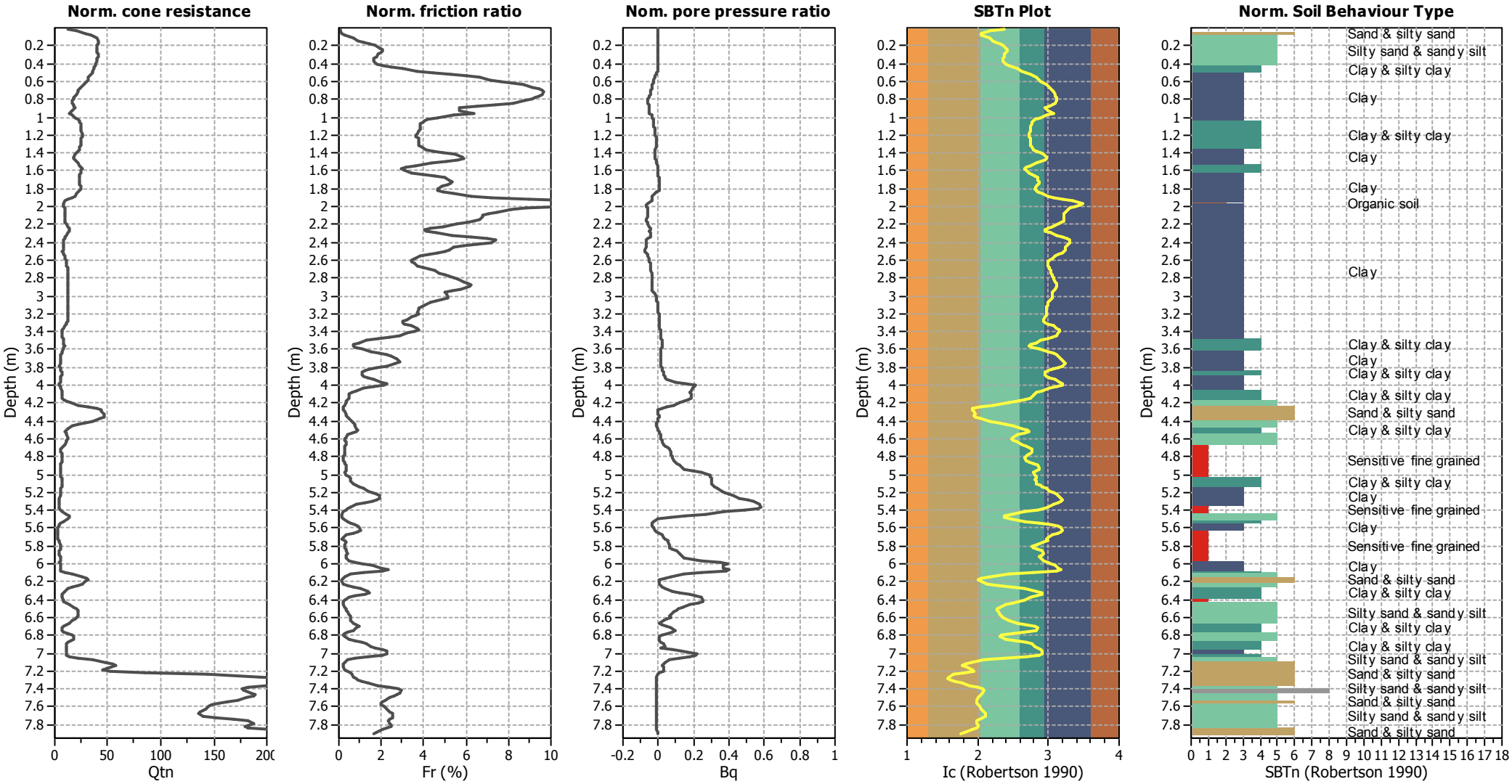
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



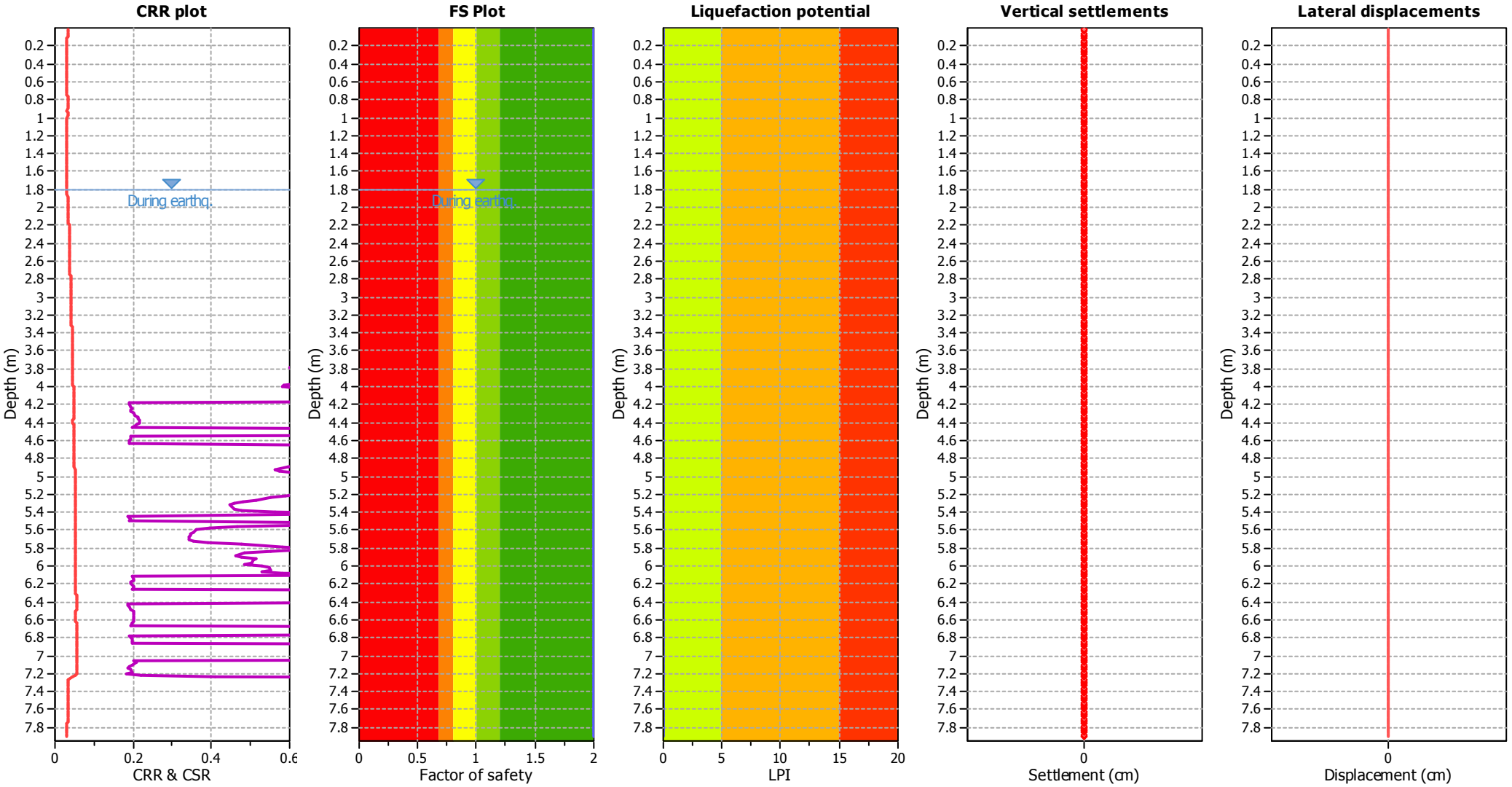
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.06	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

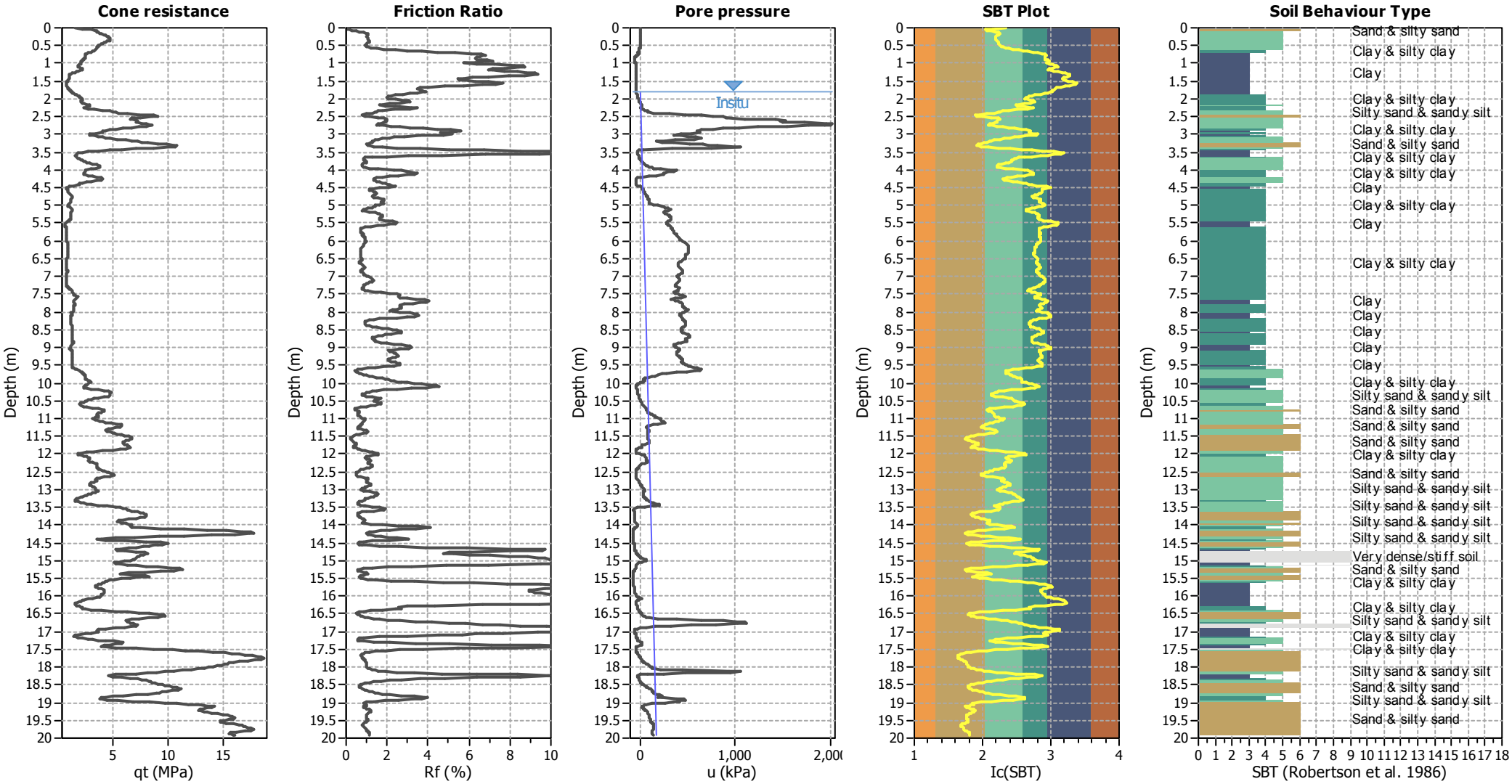
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



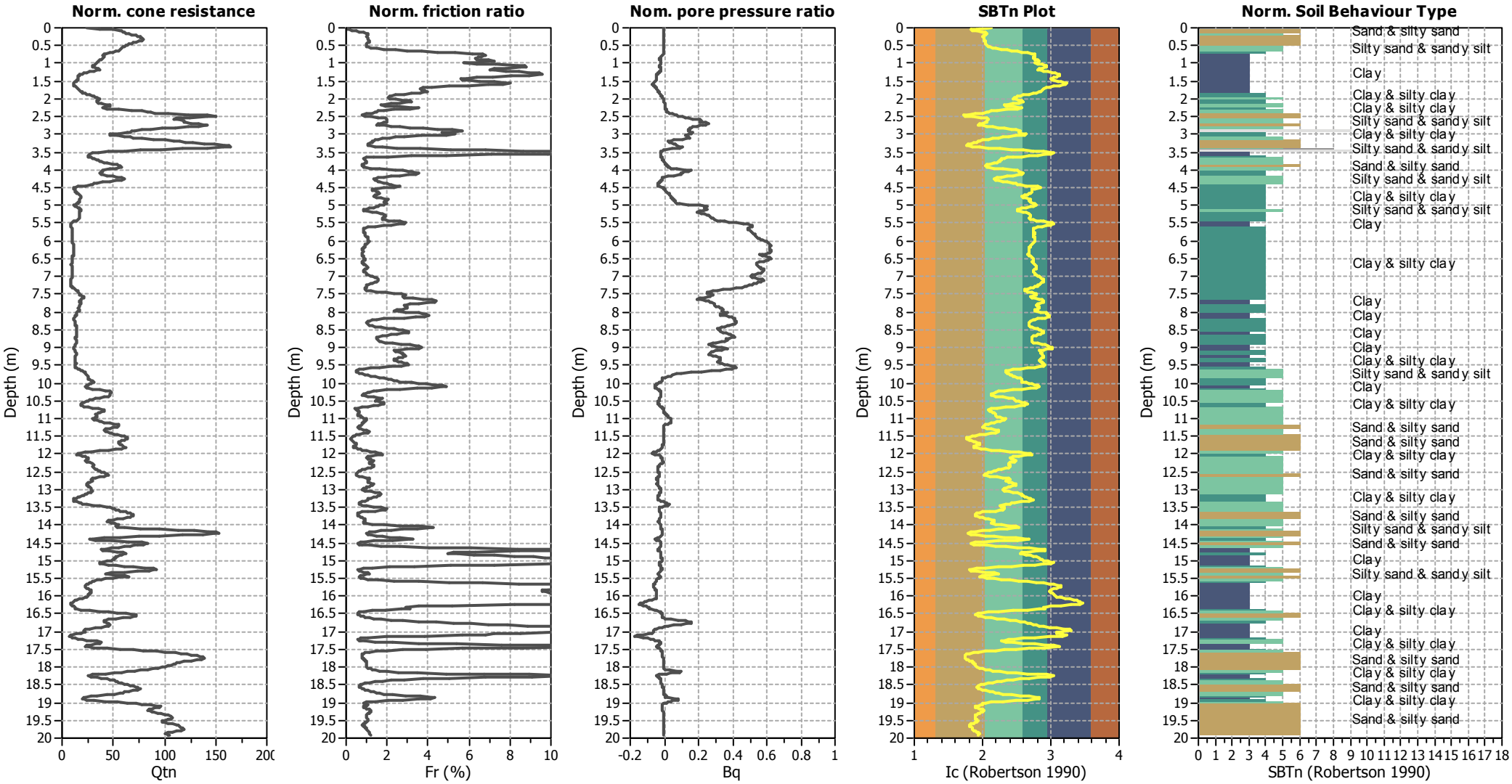
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



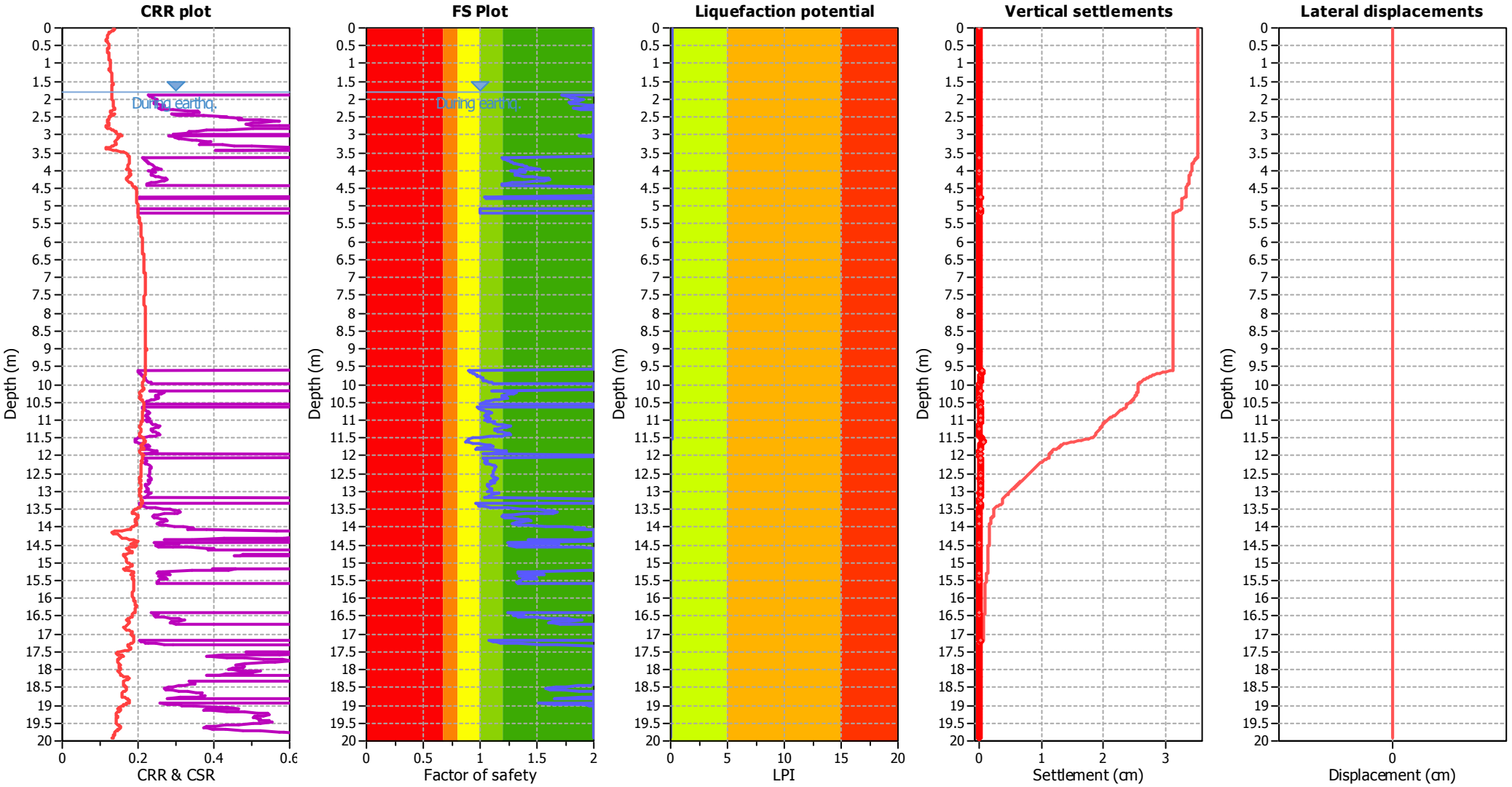
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.80 m	Fill weight:	N/A
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Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

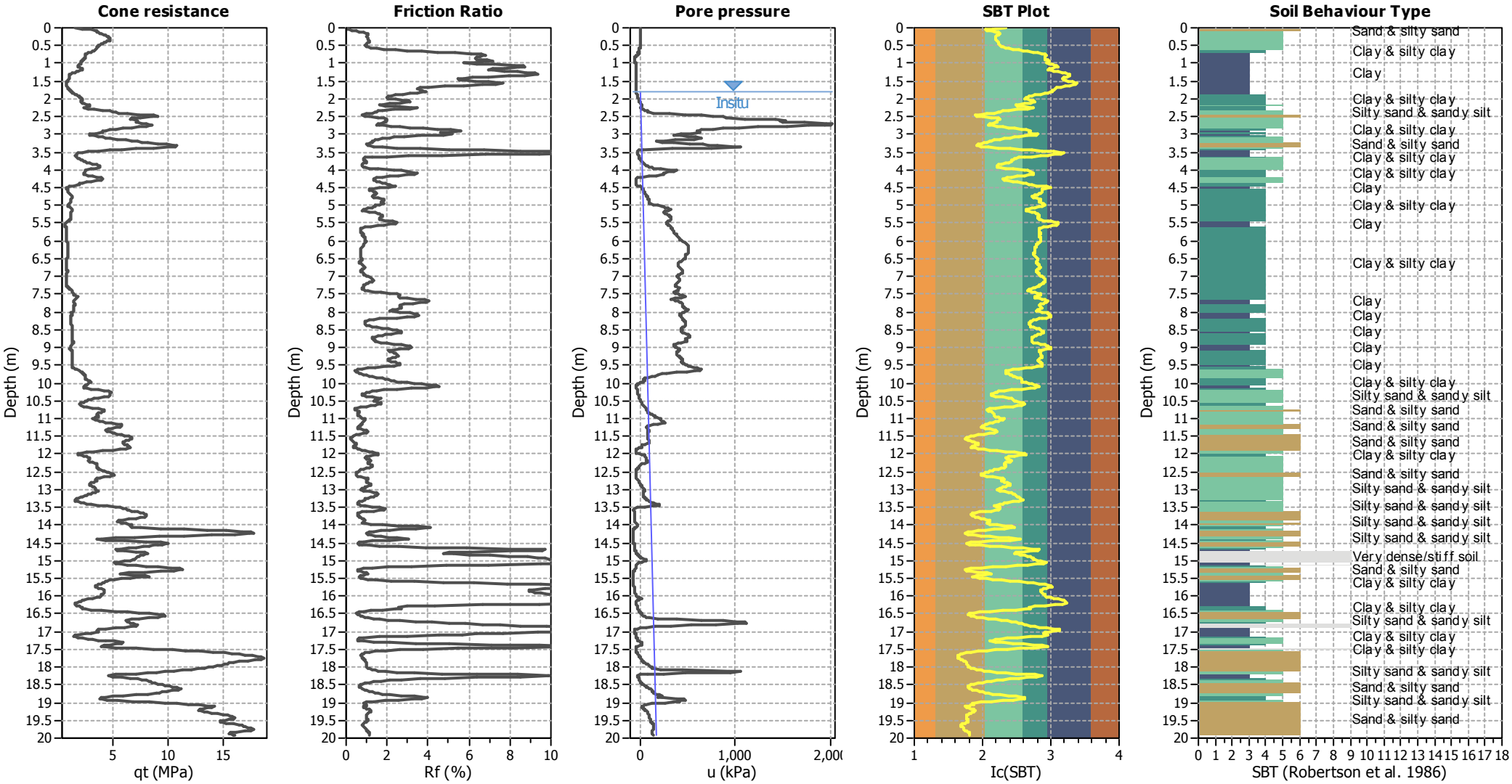
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

CPT basic interpretation plots



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Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
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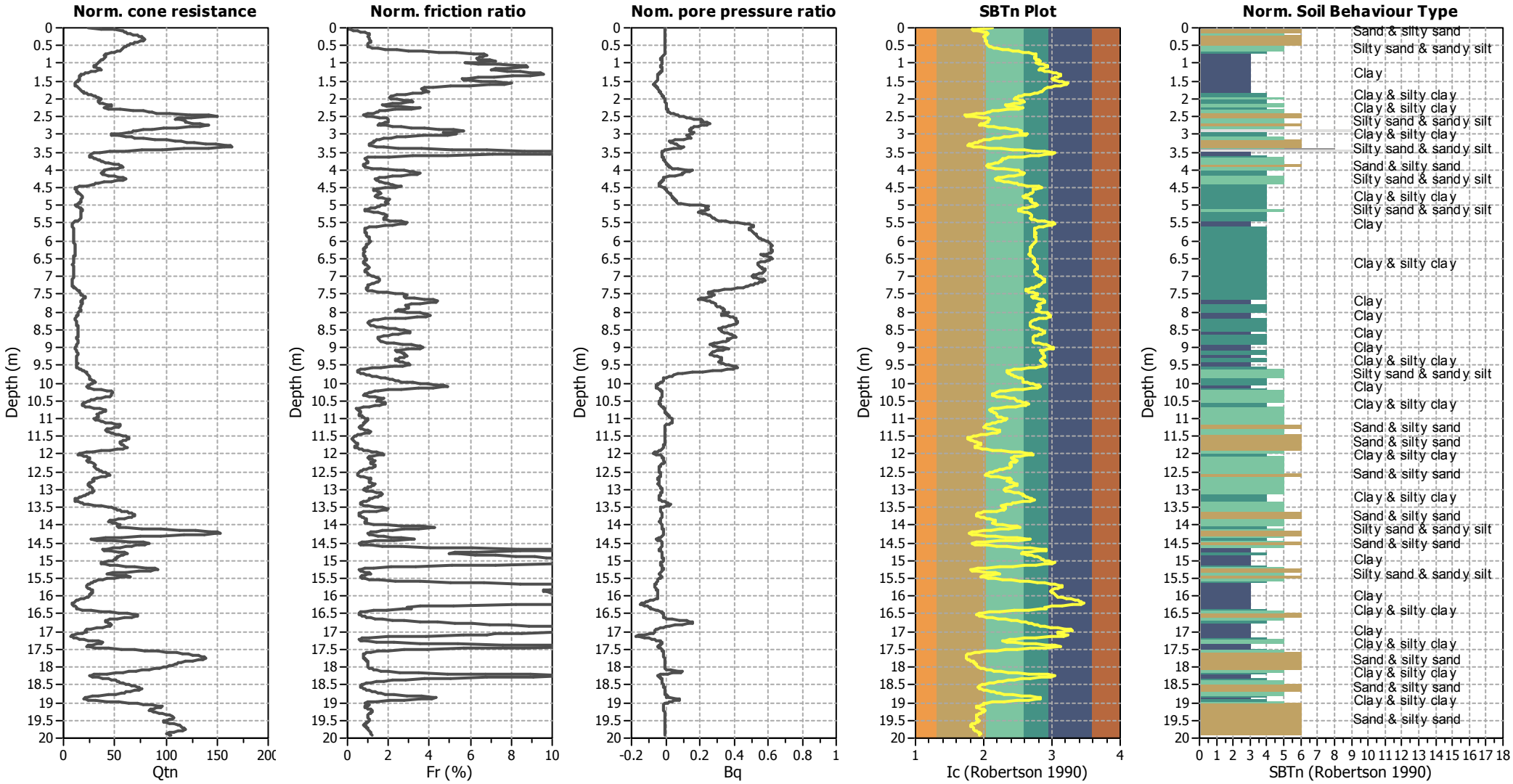
SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



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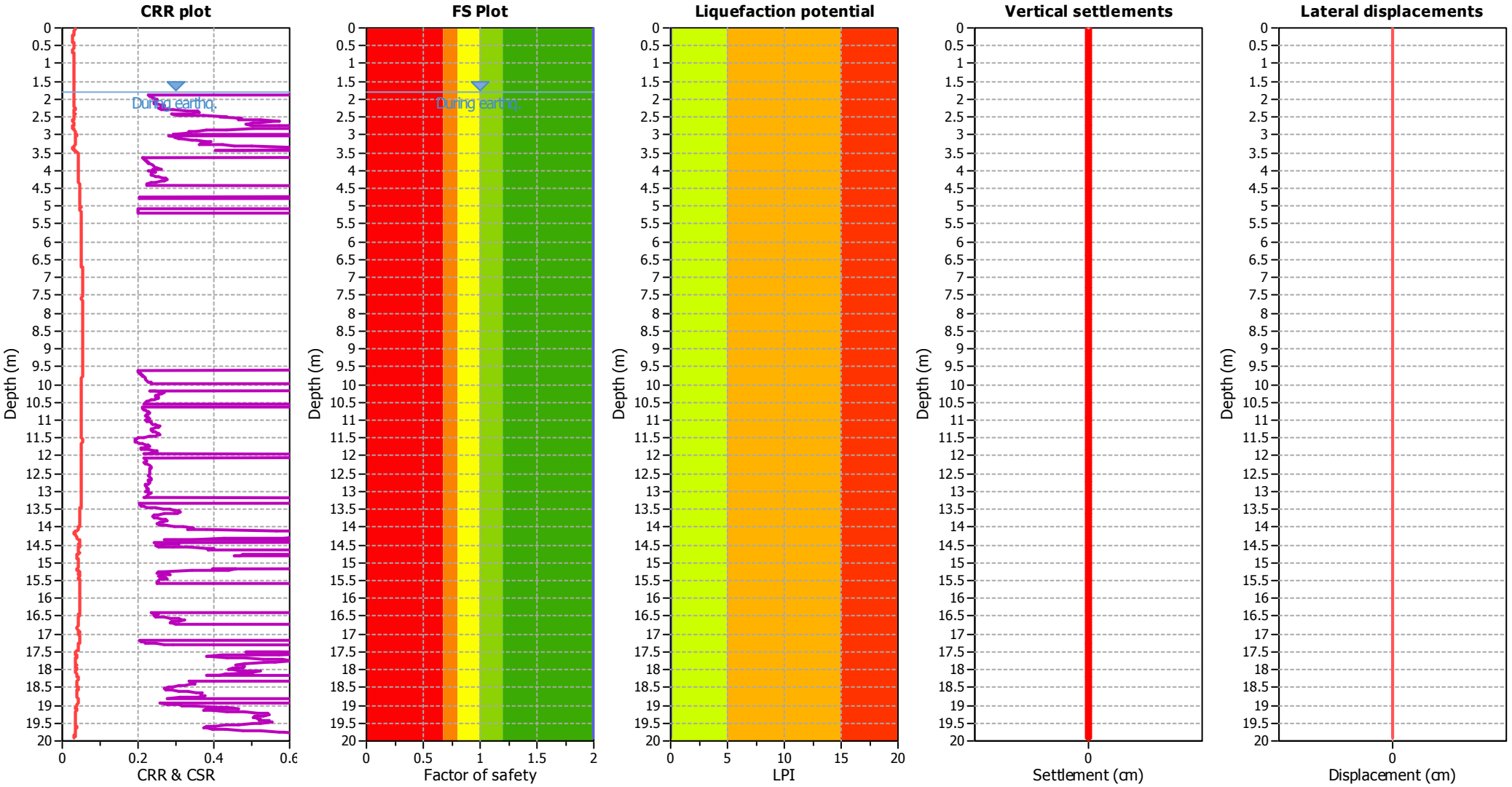
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



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LPI color scheme

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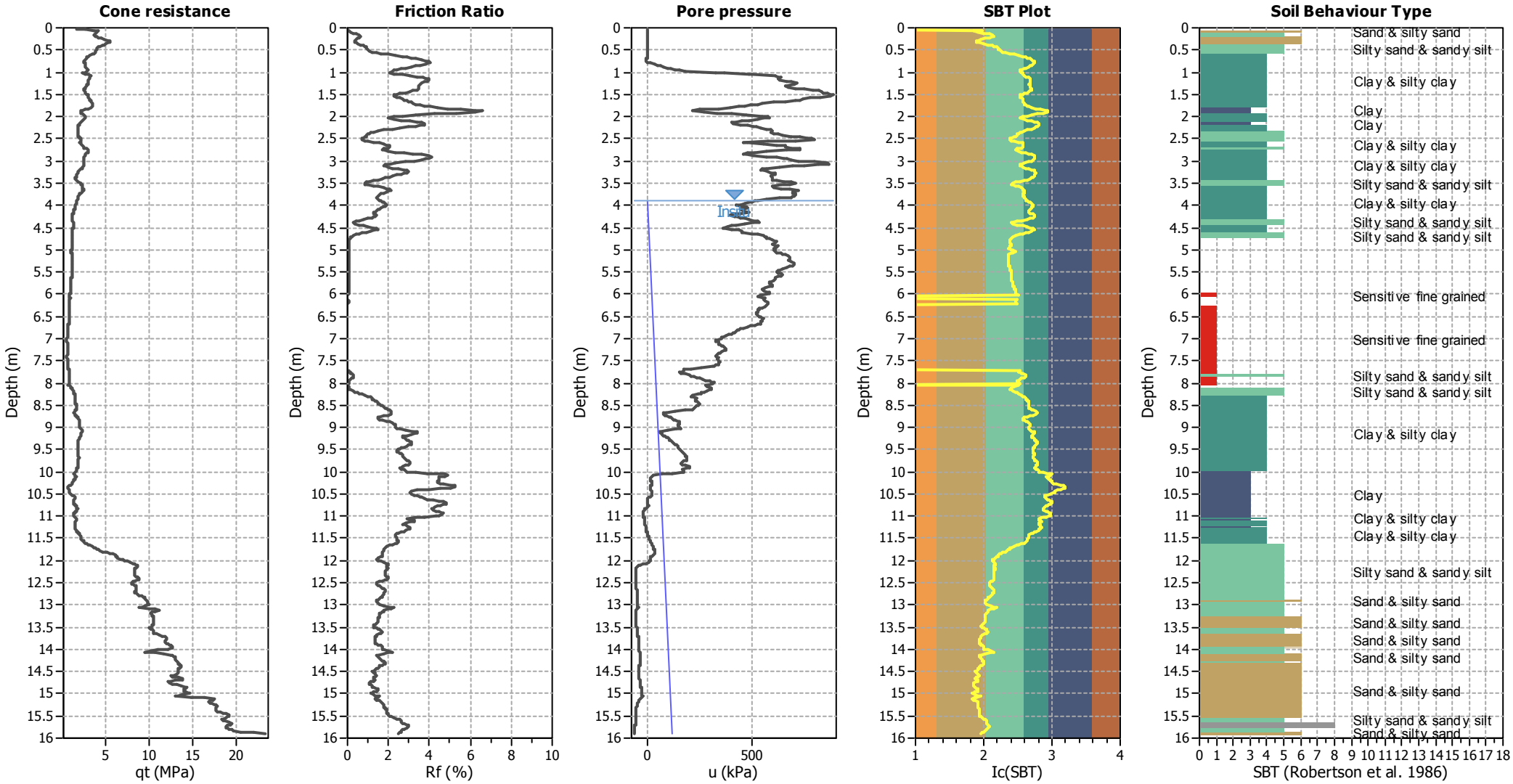
- High risk
- Low risk

CPT basic interpretation plots



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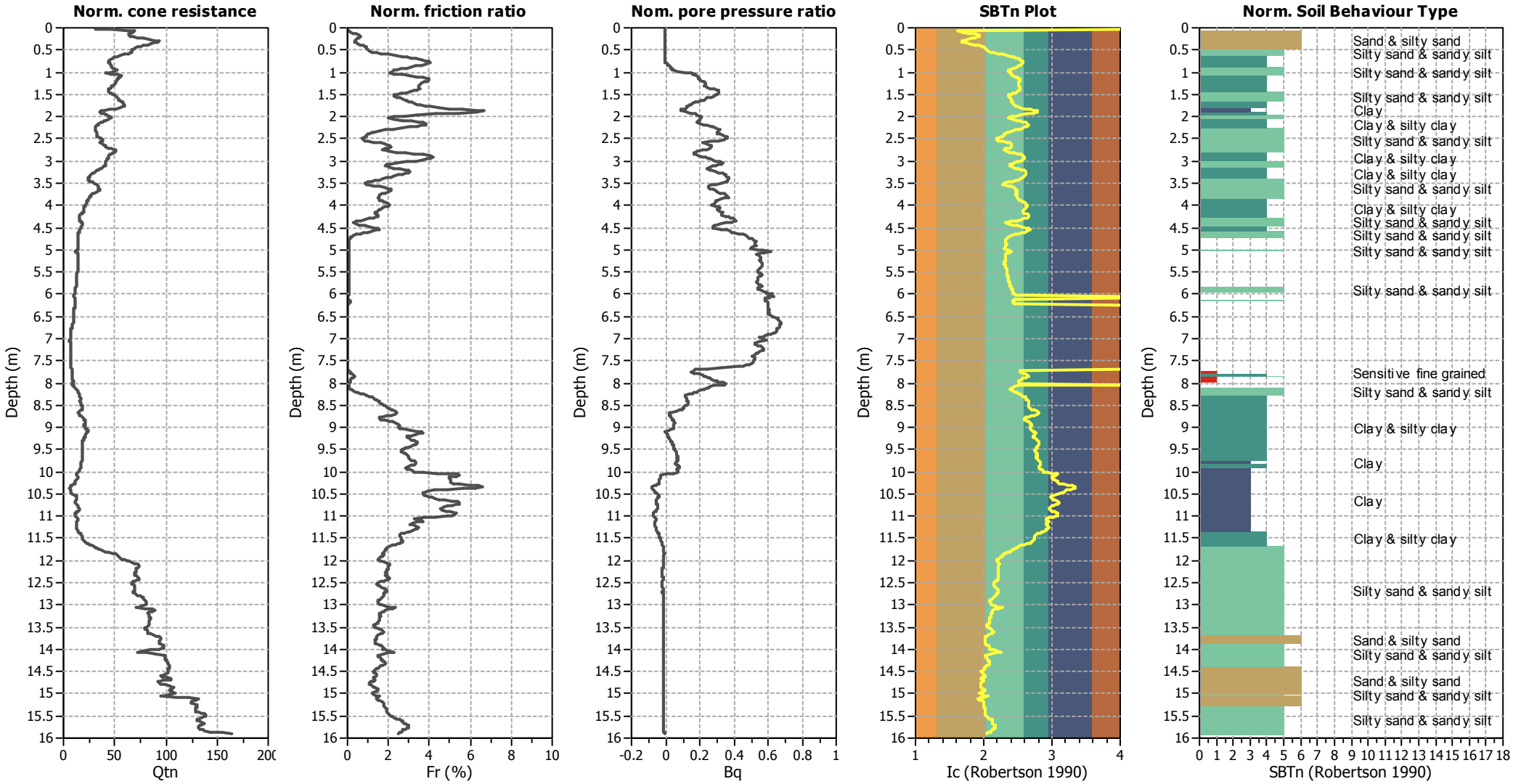
CPT basic interpretation plots (normalized)



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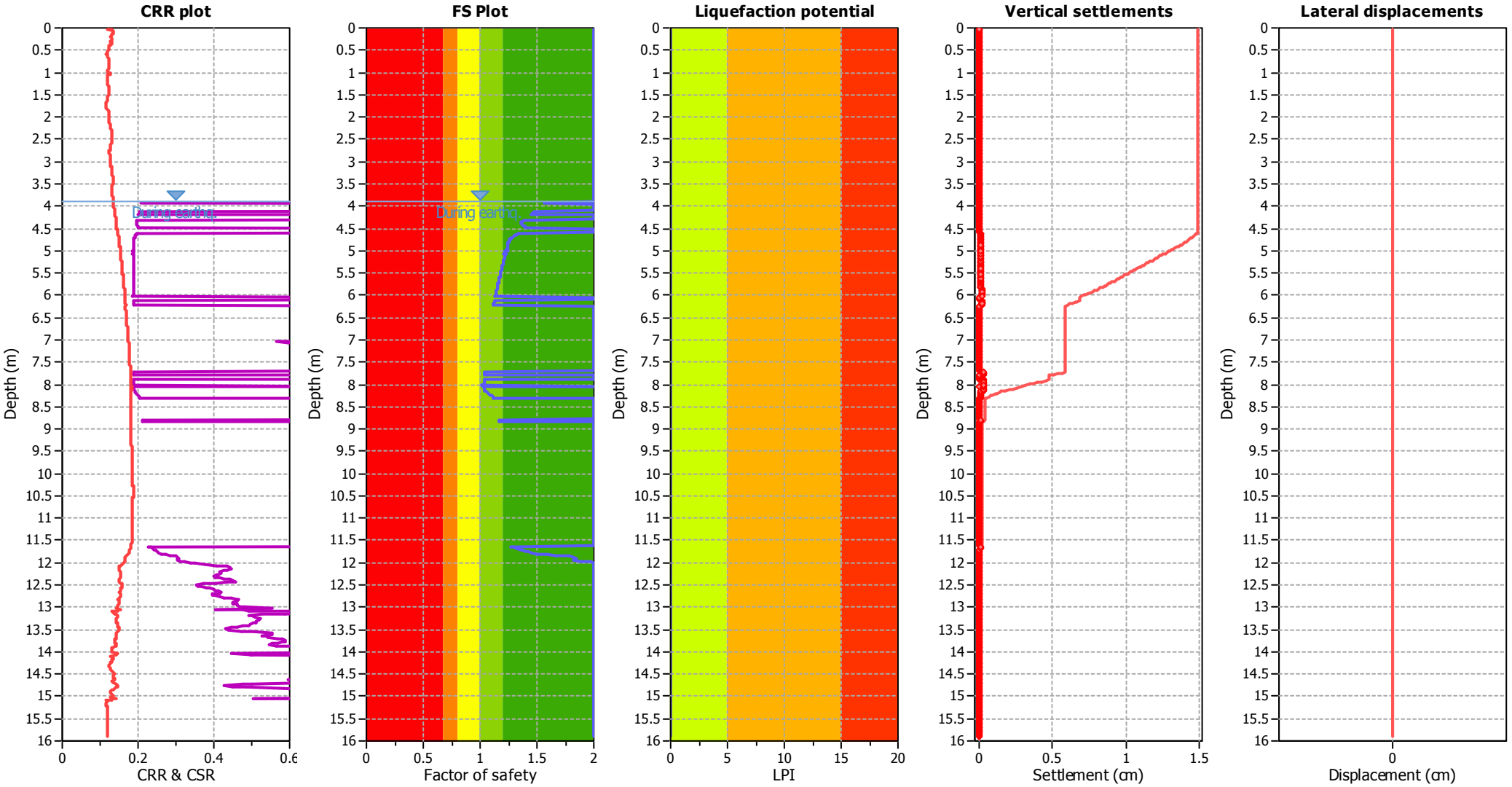
Liquefaction analysis overall plots



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LPI color scheme

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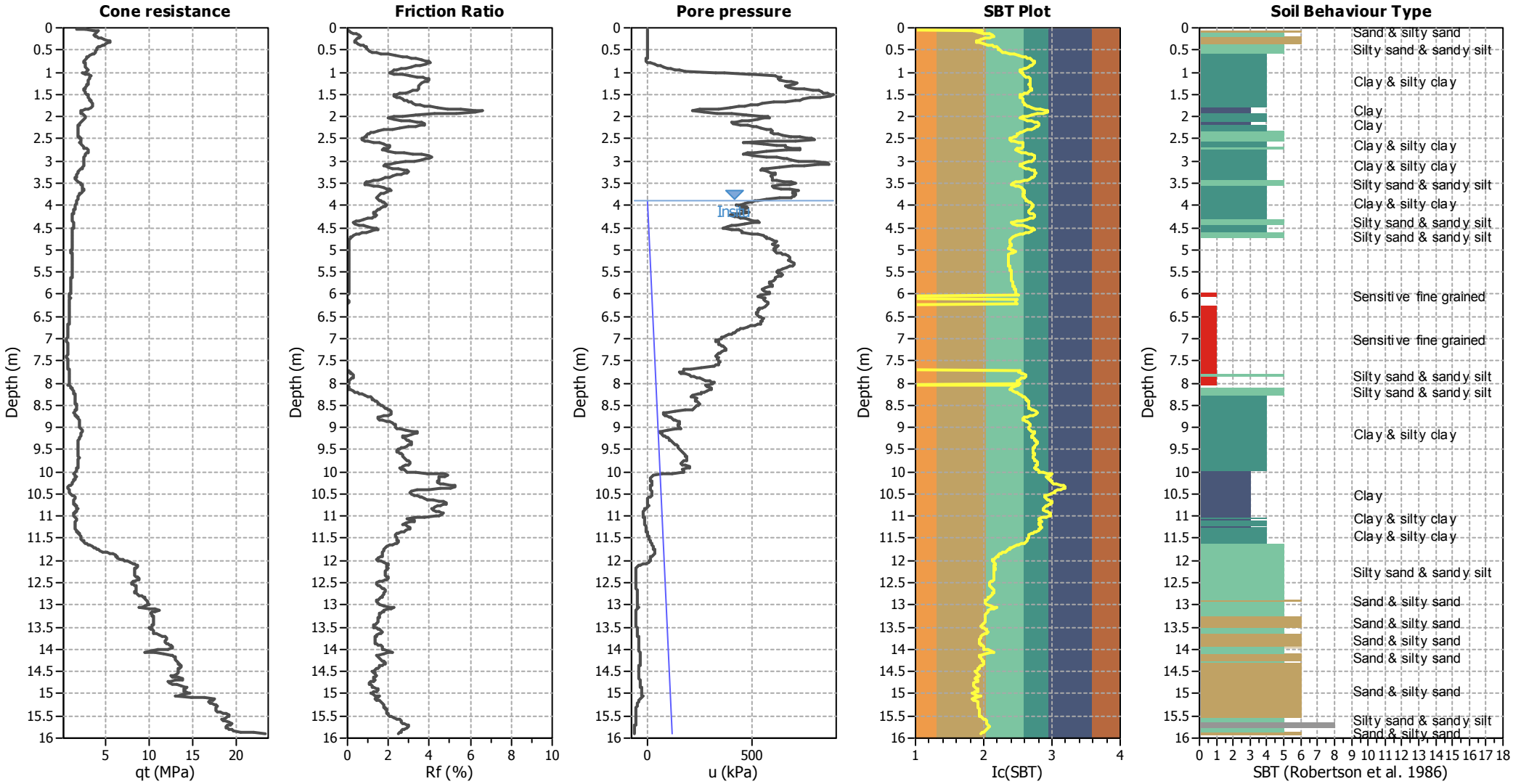
CPT basic interpretation plots



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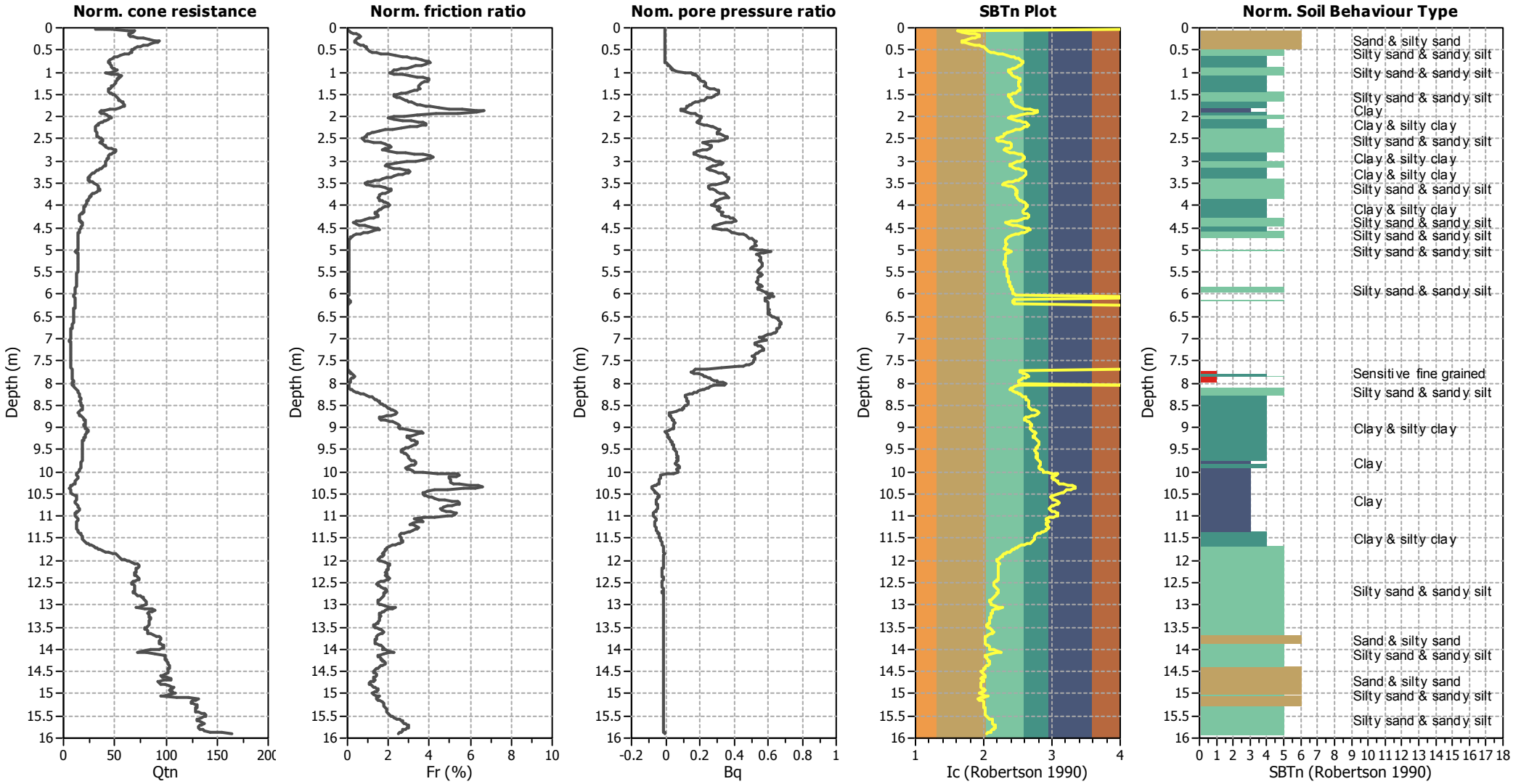

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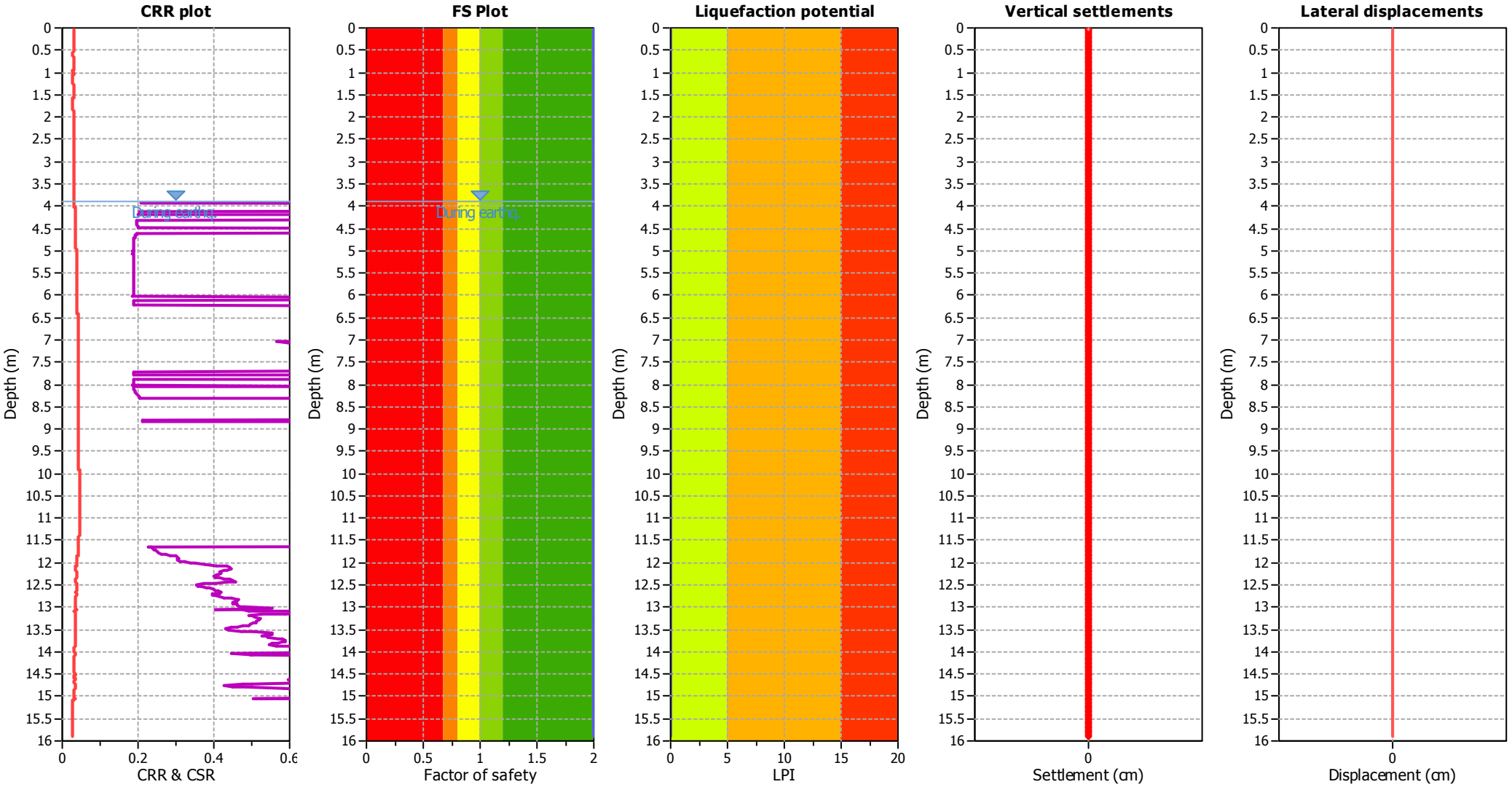
Liquefaction analysis overall plots



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LPI color scheme

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Appendix G: Natural Hazards Risk Assessment

NATURAL HAZARDS RISK ASSESSMENT FOR LAND SUBDIVISION LOCKERBIE FARM DEVELOPMENT, STUDHOLME STREET, MORRINSVILLE

A. CONTEXT

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence).

Section 2 of the RMA defines natural hazards as any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding) the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment.

This appendix to CMW report reference HAM2018-0139AB Rev0 sets out the criteria for and presents the results of an assessment of the following geotechnical-related natural hazards associated with this proposed subdivision development:

(a) Earthquake;
(b) Erosion;
(c) Landslip;
(d) Subsidence.

B. BASIS OF ASSESSMENT

B1. Risk Classification

The occurrence of natural hazards and their potential impacts on the proposed subdivision development is assessed in terms of risk significance, which is based on likelihood and consequence factors. A risk table is used to help assess the likelihood and consequence factors, the form of which used by CMW for this project is presented in Table B1.

Table B1: Natural Hazard Risk Classification

		Consequence				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	Almost Certain 5	Medium 5	High 10	Very high 15	Extreme 20	Extreme 25
	Likely 4	Low 4	Medium 8	High 12	Very high 16	Extreme 20
	Moderate 3	Low 3	Medium 6	Medium 9	High 12	Very high 15
	Unlikely 2	Very low 2	Low 4	Medium 6	Medium 8	High 10
	Rare 1	Very low 1	Very low 2	Low 3	Low 4	Medium 5

B2. Likelihood

With respect to assessing the likelihood or chance of the risk occurring, the qualitative definitions used by CMW for this project are provided in Table B2 for each likelihood classification.

Table B2: Qualitative Natural Hazard Likelihood Definitions		
1	Rare	The natural hazard is not expected to occur during the design life of the project
2	Unlikely	The natural hazard is unlikely, but may occur during the design life
3	Moderate	The natural hazard will probably occur at some time during the life of the project
4	Likely	The natural hazard is expected to occur during the design life of the project
5	Almost Certain	The natural hazard will almost definitely occur during the design life of the project

B3. Consequence

In terms of determining the consequence or severity of the natural hazard occurring, the qualitative definitions used by CMW for this project are provided in Table B3 for each consequence classification.

Table B3: Qualitative Natural Hazard Consequence Definitions		
1	Insignificant	Very minor to no damage, not requiring any repair, no people at risk, no economic effect to landowners.
2	Minor	Minor damage to land only, any repairs can be considered normal property maintenance no people at risk, very minor economic effect.
3	Moderate	Some damage to land requiring repair to reinstate within few months, minor cosmetic damage to buildings being within relevant code tolerances, does not require immediate repair, no people at risk, minor economic effect.
4	Major	Significant damage to land requiring immediate repair, damage to buildings beyond serviceable limits requiring repair, no collapse of structures, perceptible effect to people, no risk to life, considerable economic effect.
5	Catastrophic	Major damage to land and buildings, possible structure collapse requiring replacement, risk to life, major economic effect or possible site abandonment.

B4. Risk Acceptance

It is recognised that the natural hazard risk assessment provided herein is qualitative and, due to the wide range of possible geohazards that could occur, is somewhat subjective. Other methods are available to quantitatively assess an acceptable level of geotechnical related natural hazard risk, such as defining an acceptable factor of safety with respect to slope stability or acceptable differential ground settlements with respect to recommended building code limits.

Therefore, to give this qualitative natural hazard risk assessment some relevance to more commonly adopted numerical or quantitative geotechnical assessment techniques, a residual risk rating of very low

to medium (risk value = 1 to 9 inclusive) is considered an acceptable result for the proposed subdivision development.

A risk rating of high to extreme (risk value ≥ 10) is considered an unacceptable result for the proposed subdivision development.

C. RISK ASSESSMENT

The natural hazards relevant to this proposed subdivision development have been assessed with respect to the criteria outlined above.

Assessment is based on pre and post development ground conditions. The latent risk was first assessed with the site in its current undeveloped state to consider the natural landform within and surrounding the proposed development. The specific geotechnical mitigation measures and engineering design solutions outlined in the CMW report, where relevant, were then considered to determine the natural hazard residual risk remaining after the proposed development works have been completed.

Results of this assessment are presented in Table C1 below.

Table C1: Natural Hazard Risk Assessment Results

RMA S2 Hazard	Description	Undeveloped Site Latent Risk			Comments and Geotechnical Control	Developed Site Residual Risk		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Earthquake	Fault Rupture	N/A - No known active faults within or in close proximity to the site.						
	Liquefaction	2	2	Low 4	Foundation design	2	2	Low 4
	Lateral spread	2	2	Low 4	Low risk – review final site layout	1	2	Very Low 2
Erosion	Cut batters	N/A			Max 1:3 gradient	2	2	Low 4
	Fill batters	N/A			Stormwater control / benches / geotextiles / gradient control	2	2	Low 4
Landslip	Global stability	2	2	Low 4	Slope gradients to be reduced during earthworks	1	2	Very Low 2
	Soil creep	3	2	Med 6	Slope gradients to be reduced during earthworks	1	2	Low 2

	Bearing Capacity Failure	2	2	Low 4	Undercut and replace weak soils if encountered	1	2	Very Low 2
	Cut & Fill batter stability	N/A			Engineering design of slopes	1	4	Low 4
Subsidence	Expansive soils	1	2	Very Low 2	No expansive soils encountered during our investigation	1	4	Low 4
	Sinkholes	2	2	Low 4	Identify and remove if encountered during earthworks	1	4	Low 4
	Soft Soils	2	2	Low 4	Identify and address if encountered during earthworks	1	4	Low 4
Sedimentation	Inundation	3	2	Med 6	Stormwater drainage design	1	4	Low 4

16 July 2021

Dave's Farm, Lockerbie Estate, Morrinsville-Tahuna Road, Morrinsville

GEOTECHNICAL INVESTIGATION REPORT

Lockerbie Estates Limited

HAM2021-0060AB Rev. 0

HAM2021-0060AB		
Date	**Revision**	**Comments**
16/07/2021	0	Final Report for client review

	Name	**Signature**	**Position**
Prepared by	Luke Stanley		Engineering Geologist
Reviewed by	Kori Lentfer		Associate Engineering Geologist
Authorised by	Ken Read		Principal Geotechnical Engineer

EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation and geohazards assessment for a proposed residential subdivision development located off Morrinsville-Tahuna Road, Morrinsville.

Based on the investigation results, the site is generally underlain by stiff to hard silt and clay soils up to 7.8m deep with dense to very dense sand present at greater depths. Walton Subgroup soils underly the entire site.

Recent alluvium is locally contained within gully bases. While Peria Formation soils were shown on the published geology in the southern portion of the site, these materials were not encountered during our site investigation.

Geotechnical aspects of the development, based on our findings, are summarised as follows:

- The risk of liquefaction induced settlement, cyclic softening and lateral spreading during an ultimate limit state or ULS (1 in 500 year) earthquake event considered low;
- No significant slope stability issues were observed o the site or and anticipated from properly designed earthworks.
- Localized instability due to erosion of gully banks was observed however this can be easily remediated by conventional earthworks practice.
- The cut material is generally considered suitable for use as engineered fill, but due to their sensitivity care must be exercised by the earthworks contractor to control moisture contents and ensure that compaction to structural specification is achieved;
- Underfill / subsoil drainage may be required locally where fill is to be placed over the lower lying land and groundwater seepages are encountered.
- Induced settlements from fill placement are not not expected to be significant. This should be assessed following confirmation of cut to fill levels. Where fill is to be placed over possible alluvium or colluvial soils consideration may be given to undercutting those soils or preloading to remove settlement prior to construction of dwellings.
- A preliminary geotechnical ultimate bearing pressure of 300kPa should be available for foundations constructed within both the natural cut ground and proposed engineered fill;
- Foundations will require to be designed to accommodate Class M expansive soil conditions.
- Building load induced settlements should be within NZ Building Code limits;
- Soil permeabilities measured on site are considered typical of the soil types present.
- Further works prior to resource consent application should include further field investigation including cone penetrator testing, followed by detailed slope stability analyses and settlement estimation for the proposed landform, and site-specific quantitative liquefaction risk analyses.
- Laboratory testing for earthworks including, standard compaction testing, solid densities and moisture contents in proposed borrow materials should also be undertaken.

We conclude that the site is suitable for the proposed development subject the recommendations given here in.

Table of Contents

Drawings

Drawing 01: Site Investigation Plan

Drawing 02: Geomorphological Plan

Drawing 03: Geological Section A-A

Appendices

Appendix A: Hand Auger Borehole Logs

Appendix B: Soakage Test Results

Appendix C: Previous Investigation Data

Appendix D: Natural Hazards Risk Assessment

1 INTRODUCTION

1.1 Project Brief

CMW Geosciences (CMW) was engaged by Lockerbie Estates Limited to carry out a geotechnical investigation of a site located off the Morrinsville-Tahuna Road, Morrinsville, which is being considered for the extension of the greater Lockerbie Estate residential subdivision.

The scope of work and associated terms and conditions of our engagement were detailed in our geotechnical services proposal letter referenced HAM2021-0060AA Rev0 dated 09 June 2021.

This report is to support a change in land use application to Matamata-Piako District Council.

1.2 Scope of Work

As detailed in our proposal, the agreed scope of work to be conducted by CMW was defined as follows:

- Site walkover and geomorphological mapping of the site;
- Buried service check;
- Drill fourteen hand auger boreholes across the site to target depths of up to 8m, with associated strength testing to assess the near surface soil profile;
- Carry out five hand auger boreholes with in-situ soakage tests to depths of up to 5m to provide soakage rates for stormwater design by others;
- Install standpipe piezometers and groundwater monitoring level-loggers at the soakage test locations to measure seasonal groundwater level fluctuations;
- Prepare and present a geotechnical site investigation plan, a representative geotechnical cross section through the site and site investigation records;
- Groundwater level monitoring: two subsequent site visits for manual groundwater level measurement and datalogger download, compilation and presentation of results;
- Preparation of a geotechnical investigation report to support a plan change application including preliminary recommendations on liquefaction (qualitative assessment), slope stability (qualitative assessment), foundation requirements, earthworks and factual soakage data.

2 SITE DESCRIPTION AND LANDFORM

The 40 ha site is located immediately east of the Morrinsville-Tahuna Road, Morrinsville as shown on Figure 1 below.

Figure 1: Site Location Plan (Openstreet Maps Image)

The site generally comprises gently rolling hills which rise from RL42 to RL59m in the middle of the site. Two prominent east to west orientated ridges create four separate water catchment zones with associated seepages. The most prominent gully falls from the centre of the site to the southern boundary at RL44m with associated slope gradients of up to 30 degrees.

The site is bound to the north by Taukoro Road and to the west by the Morrinsville-Tahuna Road. To the east and the south the site is bounded by the existing Lockerbie Estate development area.

An ephemeral watercourse is present in the north-eastern corner of the site originating from an ephemeral spring, flowing to the north-east within a shallow incised gully and into the existing Lockerbie Estate development. At the time of our investigation this watercourse was stagnant with small areas of pooling water. Further upstream there is a decanting pond which was filled with water to depths of approximately 0.8m at the time of investigation.

Five agricultural storerooms, a cowshed and a concrete feed pad are present in the central part of the site. A small residential dwelling (farm house) and garage are located in the south-western corner of the site.

Two farm dairy effluent ponds are present in the central part of the site approximately 50m north of the feed pad.

There is a small stand of trees growing around the north-eastern gully area.

3 PROPOSED DEVELOPMENT

At the time of undertaking the work the project was in the early stages of planning. It is anticipated that the results of this geotechnical investigation will contribute to developing preliminary feasibility options for the proposed residential subdivision.

No architectural or engineering design drawings have been supplied to date.

Conversations with the wider development team have suggested that there will be four potential stormwater attenuation locations in the four corners of the site. These may be in the form of soakage/attenuation basins.

It is understood that the site will be modified by cut and fill techniques to form a consistent gently sloping gradient with up to 8m of cut and up to 4m of filling taking place.

4 INVESTIGATION SCOPE

4.1 Desktop Study

The desktop study comprised a review of provided and publicly available aerial photography, geological and historic maps, and data from the adjacent Lockerbie Estates Development to help assess the likely ground conditions potential natural hazards affecting the site.

Aerial photography, including Google Earth imagery has shown the site has remained the same with no major changes in landform or land use since the earliest available images in 1941.

Historic maps of the area show land use changes in the surrounding agricultural land due to the urban expansion of Morrinsville and the recent development of the Lockerbie Estate immediately to the south.

Field investigation data from CMW Geosciences previous ground investigation on the adjacent Lockerbie Estate site was considered prior to the beginning of fieldwork. Copies of the relevant investigation data are presented in ***Appendix C*** and have been summarised within this report.

A natural hazard risk assessment has been completed and is presented in ***Appendix D***.

4.2 Field Investigation

The field investigation was carried out between 22 and 30 June 2021. All fieldwork was carried out under the direction of CMW Geosciences in general accordance with the NZGS guidance[1].

The scope of fieldwork carried out was as follows:

- A walkover survey of the site by experienced engineering geologists and the wider development team to assess the general landform, site conditions, select test locations and to carry out geomorphological mapping;
- Fifteen hand auger boreholes, denoted HA01 to HA15, were drilled using a 50mm diameter auger to target depths of up to 7.8m below existing ground level. The purpose of these boreholes was to visually observe the near surface soil profile and to facilitate in-situ soil permeability testing. Engineering logs of the hand auger boreholes are presented in ***Appendix A***.
- In-situ falling head permeability tests were carried out in 5 no. 100mm diameter hand auger boreholes, denoted SO1 to SO5. Each hole was lined with 90mm diameter perforated PVC pipe then filled with water to monitor the rate of water level fall over time. The holes were pre-soaked by filling them to surface level and allowing them to drain for 24 hours. The holes were then re-filled and left to drain for a period of between 24 and 48 hours while being monitored every 10 seconds using electronic downhole dataloggers. The results of the permeability tests are presented in ***Appendix B***.
- Ongoing monitoring of groundwater levels within these standpipes to establish seasonal water level variation is being undertaken at the time of preparing this report.

All soil descriptions were made by CMW geotechnical engineers in general accordance with NZGS guidelines.[2]

The approximate locations of the respective hand auger and soakage testing sites referred to above are shown on the Site Investigation Plan as ***Drawing 01***. Test locations were measured using hand held GPS. Elevations were inferred from publicly available LIDAR contour plans of the area.

[1] NZ Geotechnical Society (NZGS) "Ground Investigation Specification" Volumes 0 – 2, April 2017

[2] NZ Geotechnical Society (2005), "Field Description of Soil and Rock, Guideline for the field classification and description of soil and rock for engineering purposes"

4.3 Laboratory Testing

No laboratory testing was carried out as part of this investigation.

However laboratory soil plasticity index testing carried out on the same soils types as part of previous works on the adjacent site[3] has been considered.

A qualitative assessment of those laboratory test results is presented in section 5.4.

5 GROUND MODEL

5.1 Geology

The published geological map[4] for the area depicts the local geology to comprise the following geological soil strata:

"Moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying terraces" of the late Pleistocene to Holocene aged Peria Formation, overlying -

"*Alluvium dominated by primary and reworked, non-welded ignimbrite"* of the Early to Middle Pleistocene aged Walton Subgroup. The published distribution of these is illustrated in ***Figure 2*** below. Weathered volcanic ash deposits are also known to mantle the older Walton Subgroup soils.

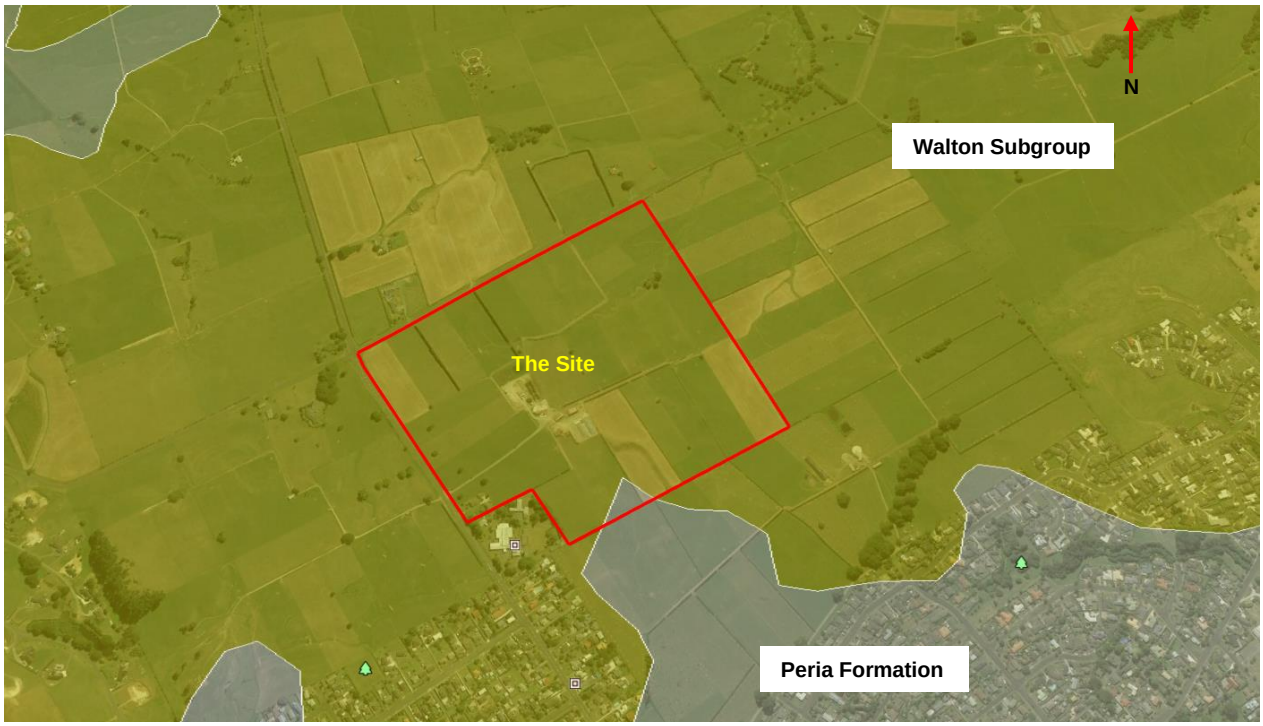


Figure 2: Local Geology (Source: GNS 1:250K geological units map)

5.2 Geomorphology

The geomorphology of the site was mapped by examination of aerial photography, existing contour plans and observations during a site walkover, and is shown in the appended Geomorphology Plan ***(Drawing 02)***.

[3] CMW Geosciences Lockerbie Farm GIR (Report reference HAM2018-0139AB Rev. 0)
[4] Edbrooke, S.W. (compiler) 2005: Geology of the Waikato area. Institute of Geological & Nuclear Sciences 1:250000 geological map 4.

The dominant regional structure at the site comprises low rolling hills which continue to the north, east and west of the site. A dominant ridge crosses the central part of the site from east to west at elevations of between RL 54m and RL 57m.

Evidence of soil creep, in the form of terracette's, is visible on several steep slopes in the northern, western and southern parts of the site. No evidence of deep-seated slope instability was observed.

A broad gully has been eroded into the hills in the central-southern part of the site. Eroded material has washed down into the base of the gully and consolidated as recent alluvium. Swampy ground is present towards the lower western base of the gully.

A north-east trending gully represents an ephemeral spring fed watercourse that continues beyond the site into the greater Lockerbie Estate development.

A minor area of wet ground is located to the north of a small open drain within the north-eastern most part of the site. This drain feeds into the natura gully to the west of the site boundary.

In the most deeply incised areas of the north-eastern gully there are small shallow-seated slump failures of the gully bank, representing ongoing minor erosion.

5.3 Stratigraphy

The ground conditions encountered and inferred from the results of our investigation differ from the published geology for the area.

Our exploratory holes did not encounter soils of the Peria Formation and encountered only recent alluvium and colluvium over soils of the Walton Subgroup.

The near surface Walton Subgroup soils were also confirmed to be weathered volcanic ash deposits.

The distribution of the soil strata encountered is presented in the appended Geological Cross Section ***(Drawing 03)*** and are outlined below.

5.3.1 Existing Fill

Existing fill is located in the central area of the site beneath the milking platform and associated agricultural buildings. This fill is thought to have been placed in order to create a level platform for the construction of agricultural infrastructure.

The uncontrolled fill strata comprise stiff to hard clays and clayey silts with trace to minor fine to medium sands. Peal vane shear strengths (VSS) within this stratum vary between 61kPa to >200kPa.

There is relic topsoil buried beneath the uncontrolled fill layer at approximately 3-3.2m below the existing ground level.

5.3.2 Topsoil

Topsoil was encountered from ground level to between 0.1m and 0.3m depth in the hand auger boreholes.

5.3.3 Recent Alluvium and Colluvium

Recent alluvium comprising firm silt and silty clay was encountered in HA03 where the tests were undertaken within a gully bed in the north-eastern part of the site to assess the depth to groundwater. The auger was terminated when groundwater was encountered at 1.1m below the base of the gully.

Alluvium was encountered within the base of the north-eastern gulley and comprises silts and sandy silts with peak VSS of between 76 and 78kPa. The alluvium is expected to be constrained to within the gully channel and immediate vicinity. The maximum thickness encountered during our investigation was 1.1m at the base of the north-eastern gully.

Colluvium comprising sensitive clayey silts with some fine to medium sands was encountered in SO4 and HA14 to depths of up to 0.6m below the existing ground level. Peak VSS in the clayey silts ranged between 76 to 135kPa.

5.3.4 Walton Subgroup

Soils of the Walton Subgroup underlie the site and compromise a variable sequence of weathered volcanic ashes overlying older alluvial soils. For ease of description we have categorised them into four broad strata groups based on their engineering soil types and properties. In stratigraphic order from the top down these are:

5.3.4.1 Stiff to Hard Silt/Clay

The topsoil is generally underlain by very stiff to hard interbedded silty clay or clayey silt. Peak VSS range between 76 and >200kPa with residual VSS of 20 to 71kPa. The soils are generally moderately sensitive to sensitive, however they are locally extra sensitive.

The depth and location of the extra sensitive soils vary considerably across the site, with no discernible pattern to their distribution.

5.3.4.2 Stiff to Hard Clayey Silt and Silt

The stiff to hard interbedded clayey silt has variable VSS generally between 76 and >200kPa with residual VSS of 7 to 70 kPa. Again, these soils are generally moderately sensitive to sensitive, locally insensitive to extra sensitive.

A localised firm to stiff stratum of clayey silt was identified within the base of SO3 which featured peak VSS of between 41 and 57kPa with residual VSS of between 11 and 27kPa.

5.3.4.3 Stiff to hard Sandy Silt with Clay

Throughout of the site beneath the stiff to hard clayey silt and silt, a 0.5 to 1.6m thick layer of sandy silt which was encountered between 1.4m to 5m below existing ground level. Peak VSS are variable and ranged between 93 and >200kPa with residual VSS of 17 to 44kPa. The soils are generally moderately sensitive to sensitive, locally extra sensitive.

5.3.4.4 Dense to Very Dense Sand Interbedded with Stiff to Very Stiff Silt

Beneath the interbedded silt/clay is dense to very dense sand interbedded with stiff to very stiff silt which was encountered between depths of between 8.4 - 9.8m within CPT03 of the previous site investigation. This test location is located approximately 25m to the south of SO4.

5.3.5 Summary

The distribution of these strata are illustrated on the appended Geological Section A-A ***(Drawing 3)*** and presented below in Table 1.

Table 1: Summary of Strata Encountered

Strata/Stratum	Depth to top (m)		Thickness (m)	
	Min	Max	Min	Max
Topsoil	GL	GL	0.1	0.3
Existing Fill	GL	GL	3	3
Firm silt and sandy silt (Alluvium)	0.1	0.1	0.6	1.1
Firm silt and sandy silt (Colluvium)	0.2	0.2	0.6	1.1
Stiff to Hard Silt/Clay (Walton Subgroup)	0.1	4.65	0.35	3.45
Stiff to Hard Clayey Silt and Silt (Walton Subgroup)	0.2	3.6	0.4	4.2
Stiff to Very Stiff Sandy Silt with Clay (Walton Subgroup)	1.4	3.7	0.7	1.6

Dense to very dense sand interbedded with stiff to very stiff silt (Walton Subgroup)	8.4	8.4	1.4	1.4
Note: The depth to the top of some soil strata varies considerably due to the undulating topography at the site, their being deeper below the higher ground.				

5.4 Laboratory Test Results

Soil laboratory classification tests were carried out on samples of the same soil groups as a part of the adjacent Lockerbie Farms development.

Results of the civil engineering soil laboratory tests are summarised in Table 2.

Table 2: Summary of Soil Laboratory Test Results

Test Location	Depth (mbgl)	Soil Type	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	MC (%)
TP07	2	Silty clay				101	49	52	63.1
TP10	4.3	Silty, sandy clay	0	47	53	56	30	26	68.2
TP12	3	Silty clay				103	46	57	57.3
TP19	5.2	Silty, sandy clay	0	40	60	48	32	16	44

Note: Gravel, sand and fines percentages are by weight, LL = liquid limit, PL = plasticity limit, PI = plasticity index, MC = Natural Moisture Content.

5.5 Groundwater

During the investigation, which was carried out in winter (June 2021), groundwater was encountered within some of the hand auger boreholes at the depths provided in Table 3 and within installed standpipe piezometers in Table 4.

Table 3: Groundwater - Encountered Depths in Boreholes

Borehole	Groundwater Level - June 2021
	Depth (mbgl)
HA01	Not encountered
HA02	Not encountered
HA03	1.1
HA04	Not encountered
HA05	Not encountered
HA06	3.2
HA07	2
HA08	3.9
HA09	3.1
HA10	Not encountered
HA11	Not encountered

Table 3: Groundwater - Encountered Depths in Boreholes	
Borehole	**Groundwater Level - June 2021**
	Depth (mbgl)
HA12	Not encountered
HA13	Not encountered
HA14	3.8
HA15	Not encountered

Table 4: Groundwater records – Measured in Standpipe piezometers		
Borehole	**Slotted screen Depth interval (mbgl)**	**Groundwater Level - June 2021**
		Depth (mbgl)
SO1	0.5 to 5	Not encountered
SO2	0.5 to 5	Not encountered
SO3	0.5 to 5	2
SO4	0.5 to 5	0.6
SO5	0.5 to 5	Not encountered
Note: mbgl = metres below ground level		

At the time of writing this report, electronic downhole dataloggers (set to take hourly readings of temperature compensated water level data) have been installed within piezometers in boreholes SO1 to SO5. These have been left in place to record water levels over the next 6 months to help assess seasonal groundwater variation.

5.6 Soakage Testing Results

Permeability (Soakage) testing was undertaken following the methods outlined in Section 4.2.

We have presented below average hydraulic conductivity of the subsoils using the CIRIA 113 method[5].

Falling head permeability test data and calculations are presented in ***Appendix B*** and our calculated hydraulic conductivities are presented on Table 5.

[5] Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

Table 5: Falling Head Permeability Test Results	
Borehole No.	**Hydraulic Conductivity (m/s)***
SO1	1.46 x 10^{-6}
SO2	2.14 x 10^{-5}
SO3	4.21 x 10^{-7}
SO4	2.61 x 10^{-5}
SO5	4.07 x 10^{-5}
Note: *The hydraulic conductivity values above are calculated using the CIRIA 113 method averaged over the full data set. Any designer using these values must consider the raw data, other calculation methods, appropriate factors of safety, and must satisfy themselves as to their suitability.	

The test result for SO3 is considered typical of a clay-silt soil, the remainder of the test results are generally within expectations for fine sand silty soils.

6 GEOHAZARDS ASSESSMENT

6.1 Context

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence). Although not a requirement at plan change stage we have prepared a natural hazards risk assessment to aid our assessment of the site suitability.

The following sections of this report provide an assessment of the geohazards relevant to this site and provide the basis for the Natural Hazards Risk Assessment presented in ***Appendix D***.

6.2 Seismicity

A seismic assessment has been carried out in general accordance with NZGS guidance[6] to calculate the peak horizontal ground acceleration or PGA (a_{max}) as follows:

$$a_{max} = C_{0,1000} \frac{R}{1.3} x\ f\ x\ g$$

Where: $C_{0,1000}$ = unweighted PGA coefficient subject to Subsoil Class D. (See Section 7.1 for derivation)

R = return period factor given in NZS1170.5, Table 3.5

f = site response factor subject to Subsoil Class D

g = acceleration due to gravity

The ULS PGA was calculated based on a 50-year design life in accordance with the New Zealand Building Code for importance level (IL) 2 structures and a seismic subsoil class D.

[6] NZ Geotechnical Society publication "Earthquake geotechnical engineering practice, Module 1: Overview of the standards", (March 2016)

The PGA for the serviceability limit state (SLS) and ultimate limit state (ULS) earthquake scenarios is as follows:

Table 6: Design Peak Ground Acceleration (PGA) for Various Limit States				
Limit State	**AEP**	**R**	**PGA(g)**	**$Magnitude_{eff}$**
SLS	25	0.75	0.06	5.9
ULS	500	1.0	0.25	5.9
Note: SLS = serviceability limit state; ULS = ultimate limit state; AEP = annual exceedance probability				

6.3 Fault Rupture

The nearest known active fault is the Kerepehi Fault located approximately 15 km north-east of the site.

We therefore consider the risk of fault rupture affecting the site to be low.

6.4 Liquefaction

6.4.1 Context

Liquefaction risk has been assessed in consideration of the recommendations in "Planning and Engineering Guidance for Potentially Liquefaction - Prone Land" MBIE/EQC/MoE September 2017.

The site has an area of 40Ha (0.4km^2) and is to be developed for an 'urban residential development'. Based on Figure 3.2 and Table 3.5 of the above publication, the site requires a Level A or B assessment for a plan change.

The following liquefaction assessment is considered to be a "Level B: Calibrated desktop assessment" as defined in "Planning and Engineering Guidance for Potentially Liquefaction - Prone Land" MBIE/EQC/MoE September 2017. However, as we demonstrate below the liquefaction risk for the site is considered to be very low, and a "Level A desktop assessment" is sufficient for this plan change application.

6.4.2 General

Soil liquefaction is a process where typically saturated, granular soils develop excess pore water pressures during cyclic (earthquake) loading that exceed the effective stress of the soil. In loose soils, some dilation can occur during this process, which can lead to individual soil grains moving into suspension. Following the onset of liquefaction, the shear strength and stiffness of the liquefied soil is effectively lost causing excessive differential settlement of the ground surface, bearing capacity failure and collapse of structures and low-angle lateral spreading of slopes in liquefiable soils.

In accordance with NZGS guidance[7] the liquefaction susceptibility of the soils at this site has been considered with respect to geological age, soil fabric and soil consistency / density.

6.4.3 Geological Age

The vast majority, and nearly all, case history data compiled in empirical charts for liquefaction evaluation come from Holocene deposits or man-made fills (Seed and Idriss, 1971). Youd and Perkins, 1978 also state that young Holocene age (15,000 years) sediments and man-made fills are susceptible to liquefaction. Table 1 of Idriss and Boulanger (extracted from Youd and Perkins (1978)), presents the susceptibility of soil deposits to liquefaction based on geological age, which states that Pleistocene aged alluvium (>12,000 years) has a very low to low risk of liquefaction.

[7] Earthquake Geotechnical Engineering Practice, Module 3: Identification, assessment and mitigation of liquefaction hazards", (May 2016)

Across the site, soils below the water table comprise stiff clays, silts and sands of the Walton Subgroup. These soils are defined as being of early to mid-Pleistocene geological age with a dated aged at 1.26Ma to 2.18Ma old. These deposits are therefore significantly older than what case history data would suggest as being susceptible to liquefaction.

6.4.4 Soil Fabric

Soils are also classified with respect to their grain size and plasticity to assess liquefaction susceptibility. Based on more recent case histories, there is general agreement that sands, non-plastic silts, gravels and their mixtures form soils that are susceptible to liquefaction. Clays, although they may significantly soften under cyclic loading, do not exhibit liquefaction features, and therefore are not considered liquefiable. NZGS guidance[5] sets out the plasticity index (PI) criteria for liquefaction susceptibility as follows:

PI < 7: Susceptible to Liquefaction

7 ≤ PI ≥ 12: Potentially Susceptible to Liquefaction

PI ≥ 12: Not Susceptible to Liquefaction

The fines content of the sands beneath the site also has a significant impact on their liquefaction susceptibility.

Specific soil grading and plasticity index laboratory test results for the same soils on the adjacent site are presented in Section 5.4 above and show that the cohesive soils tested provided plasticity indices of either greater or much greater than 12 and are therefore not considered liquefiable.

6.4.5 Specific Analyses

Site specific liquefaction analysis was not undertaken as part of this geotechnical investigation.

Data and conclusions from previous deep ground investigation and quantitative liquefaction risk analyses based on cone penetrometer test (CPT) data within the same soil profile in the adjacent site has been reviewed.

That analysis was based on the same seismic risk as presented above, for Importance Level 2 (IL2) structures, and comprised analysis of 8 CPT's.

That assessment concluded that the risk of unacceptable liquefaction induced settlement occurring beneath the adjacent as a whole site is very low.

Two of the CPT's (No's. 03 and 08 of that investigation) border the southern and eastern edges of the subject site respectively. Liquefaction risk in these two CPT's was determined to be very low.

6.4.6 Conclusion

Based on the above we consider that the risk of liquefaction of the soils beneath the site, for the ULS scenario considered is very low.

Based on the above we consider the risk of liquefaction induced settlement occurring at the site is low.

6.5 Cyclic Softening

Although not considered liquefiable, due to the high plasticity of the laboratory tested soils, they can still be susceptible to some strength loss, referred to as cyclic softening, during the ULS seismic event.

Cyclic softening analysis, in accordance with Idriss and Boulanger[8] was carried out for the data in the same soils on the adjacent site and show that the clay like soils (with an Ic value >2.6) have a cyclic softening

[8] Boulanger, R. W. and Idriss, I. M. (2007). Evaluation of Cyclic Softening in Silts and Clays, Journal of Geotechnical and Geoenvironmental Engineering, Vol 133, Issue 6

factor of safety of greater than 1, demonstrating that they are not susceptible to this process and therefore the risk of cyclic softening occurring is low.

6.6 Lateral Spread

Following the onset of liquefaction, the liquefied soils behave as a very weak undrained material, which can give rise to lateral spreading; in sloping ground, where a free face is present within the vicinity of the site, or where proposed cut and fill batters are proposed over or within liquefied soils.

The risk of liquefaction is considered very low and it follows that the risk of associated lateral spread is also likely to be very low.

6.7 Slope Stability

During our geomorphological mapping no large-scale slope failures were observed on the site.

However, small shallow-seated slump failures were observed into the north-eastern watercourse.

Elsewhere on localised steeper parts of the site, terracette's indicating shallow soil creep are present.

The earthworks proposals involve cuts and fills to reduce slope gradients across the site and the risk of any further small/shallow seated or deep seated slope instability affecting the development is considered low.

6.8 Erosion

Minor surface scour and erosion was observed in the north-eastern part of the site where concentrated surface water runoff from neighbouring paddocks runs into an open gully. No other surficial erosion was noted during our site visits.

Based on the above observations we consider the risk of erosion of proposed cut and fill batters to be low and can be suitably managed by appropriate geotechnical design.

6.9 Load Induced Settlement

6.9.1 Fill Induced Settlements

Based on the stiffness of the majority of the soils beneath the site induced settlements from fill are not expected to be significant.

Localised softer recent alluvial and colluvial soils may give risk to locally greater settlements.

The interbedded nature of the silty clays, clayey silts and sands will aid consolidation and reduce the time taken for it to occur. This can be assessed at the detailed design stage.

6.9.2 Foundation Settlement Suitability

Taking into account anticipated lightweight building construction, the competent soils encountered across the site and that all earthfill material is to be of engineered standard, building load induced settlements should be within NZ Building Code limits.

This should be reassessed at the detailed design stage and following subdivision earthworks and for individual buildings at the Building Consent stage.

6.10 Expansive Soils

The AS2870 site classification system was established for assessment of expansive soil class primarily for Australian soils. This standard has been adopted in New Zealand and has been further assessed to

encompass the Auckland/Northland soils[9] (BRANZ Report, 2008). These documents are relevant where swelling clays are present with mineralogy being predominantly of Smectite / Montmorillonite clays.

The November 2019 update to the NZ Building Code, B1/AS1, includes significant detail on the assessment of expansive soil class and associated foundation design which may be relevant where clay soils are present.

With reference to published literature (Lowe & Percival, 1993[10], Lowe et al., 2001[11]) the Waikato region clay soils of the Walton Subgroup (the dominant surficial soil type at Lockerbie) have the potential to contain Halloysite, Kaolinite and some Allophane clay mineralogy's.

Upon exposure to air during periods of dry weather, these clay minerals can undergo non-recoverable shrinkage i.e. the volume of the soil is permanently decreased. In this case significant surface cracking can occur. This behaviour is unique to Halloysite dominant clays and therefore differs from Smectite / Montmorillonite (swelling/shrinking) dominated clays, on which AS2870 and the BRANZ report are based. Specific testing for expansive soils has not been carried out for this site or the adjacent Lockerbie Estate Development site and our advice is based on research in the greater Waikato region.

Based on our visual - tactile identification of the soils in accordance with AS2870, and the plasticity test data available foundation designers should consider adopting raft foundation systems or NZ3604 type foundations to comply with expansive soil class M. These recommendations may be subject to change by a suitably qualified geotechnical engineer for specific building foundations.

6.11 Sensitive Soils

The majority of silt and clay soils that will be encountered within the proposed earthworks cuts are sensitive to remoulding and moisture ingress. Care will be required to avoid over working and trafficking of these materials, and to protect them from moisture ingress.

7 GEOTECHNICAL RECOMMENDATIONS

7.1 Seismic Site Subsoil Category

The geological strata encountered beneath the site have soil strength materials with less than 10m of soft soils.

Based on those ground conditions the seismic site subsoil category is assessed as being Class D (deep soil site) in accordance with NZS1170.5.

7.2 Liquefaction / Lateral Spread Mitigation

Based on the qualitative assessment of liquefaction and lateral spread outlined in Sections 6.4.4 and 6.6 we consider the risk of surface manifestation of liquefaction and the risk potentially damaging liquefaction induced differential settlements or lateral spread to be very low.

Nevertheless, further cone penetrometer testing are recommended for earthworks design at the resource consent stage and the liquefaction risk should be reviewed as part of the earthworks design at that stage.

[9] Fraser Thomas Ltd, 2008. Addendum Study Report No.120A [2008] Soil Expansivity in the Auckland Region. BRANZ.
[10] Lowe, D.J. & Percival, H. J. 1993. Clay Mineralogy of Tephras and Associated Paleosols and Soils, and Hydrothermal Deposits, North Island. 10th International Clay Conference, Adelaide.
[11] Lowe, D.J. et al, 2001. Ages on Weathered Plio-Pleistocene Tephra Sequences, Western North Island, New Zealand. Le Dossiers de l'Archeo-Logis 1, 45-60.

7.3 Slope Stability Management

7.3.1 General Site Slopes

As outlined in Section 6.7, no large slope failures have been observed on the site.

Earthworks prosed are part of the development are expected to create a near level gently sloping landform. No special engineering works are anticipated to ensure slope stability, with the possible exception of localised undercut of soft, thin alluvial and colluvial soils and installation of engineer designed subsoil drainage in the gully bases.

7.3.2 Gully Banks

Small shallow slump failures into the northern gully were observed during our site walkover.

Our qualitative assessment of the slope stability, with respect to the proposed development, is that there is a slope stability risk adjacent to gully banks should the gullies not be filled in during the earthworks stage of the site's development.

To reduce the post construction slope stability risk of these banks, a range of options may be considered, including the following:

1. Regrade the slopes to improve long term stability with erosion protection and an engineer defined building restriction line (BRL). All structures requiring building consent must be located outside the BRL unless supported by further geotechnical investigation and/or assessment by a Chartered Professional Geotechnical Engineer;
2. Construct engineered gully banks such as retaining walls and a reduced BRL compared to Option 1 above.
3. Infill gullies with pipes/culverts as part of the subdivision earth works.

Each of these options will require a building set back (BRL) to differing degrees however Options 2, and 3 offer the lowest long-term risk of erosion and regression of the bank sides.

Restrictions relating to gully bank stability will need to be re-assessed as part of the earthworks design at resource consent stage and in a Geotechnical Completion Report (GCR) following completion of subdivision earthworks.

7.4 Static Settlement

The risk of unacceptable settlement under building/foundation loads is anticipated to be low at the site.

However, as outlined in Section 6.9, where there are fills over lower strength soils there is a risk of unacceptable static settlement under the fill.

It is considered that this can be easily managed by conventional earthworks techniques such as either undercutting and removing the soft soils before fill placement where practical, or preloading of the soils to minimise long term settlement.

Once earthwork designs are finalised we recommend that static settlement estimates are carried out for fills with appropriate mitigation measures adopted where necessary.

7.5 Earthworks

7.5.1 General

All earthwork activities must be carried out in general accordance with the requirements of NZS 4431 and the requirements of the Waikato Local Authority Shared Services - Regional Infrastructure Technical Specifications (RITS) under the guidance of a Chartered Professional Geotechnical Engineer.

7.5.2 Material Suitability / Conditioning

Within the likely cut areas the natural subgrade will comprise sensitive silts and clays. We expect that excavation of these materials will be readily achieved with normal earthworks plant, such as scrapers and excavators.

Whilst these materials are considered generally suitable to use for the construction of engineer certified fills, their relatively high sensitivity means that they have a narrow range of moisture contents in which they can be successfully earthworked.

Particular care must therefore be exercised by the earthworks contractor to optimise the moisture condition of these soils to enable compaction to certifiable standards. This is likely to require disking of the soils in both cut and fill areas with adequate allowance for conditioning in dry summer conditions. It is also noted that timeframes for earthworks may be lengthened considerably if intermittent rainfall occurs through the summer months.

Experience on the adjacent site, in the same soils, indicates that earthworking of these soils can be readily undertaken without major difficulties.

7.5.3 Stockpiles

Careful consideration must be given to the location of temporary topsoil / unsuitable stockpiles to ensure that they are not located immediately above steep or unstable slopes or immediately above proposed stormwater pond excavations.

7.5.4 Underfill Drainage

Where fill is to be placed over the lower-lying areas of the site, specifically where springs are present in gully bases, it will be necessary to install a series of under-fill / subsoil drains to control groundwater seepages and reduce the impact of softening at the base of the engineered fill materials.

Management of known ephemeral springs and seepages can be addressed at resource consent stage.

During construction the necessity for and locations of any additional subsoil drains can be identified by the geotechnical engineer on site.

7.6 Foundation Bearing Capacity

Once bulk earthworks are completed in accordance with the recommendations provided in Section 7.4 above, a preliminary geotechnical ultimate bearing pressure of 300kPa should be available for shallow strip and pad foundations constructed within both the natural cut ground and engineered fill areas for lightweight structures designed in accordance with NZS3604.

The reworked silt / clay soils of the Walton Subgroup present at this site can be susceptible to natural strength variability, particularly when they are exposed and become wet. Localised variations in shear strength within the natural cut ground may also occur where the depth of cut varies across the building platforms.

If low-strength soils are encountered (which is possible in deeper areas of cut) they should be undercut and replaced with engineering fill at the time of subdivision earthworks to provide uniform bearing capacity soils within the lots.

7.7 Civil Works

7.7.1 Subgrade CBR

For preliminary design purposes we recommend a preliminary CBR of 3% for the silty/clay soils likely to form the pavement subgrade.

7.7.2 Service Trenches

All service trenches should be readily excavated by conventional plant and excavators.

Localised groundwater inflows may be encountered in lower lying parts of the site however major trench side instability is not anticipated.

7.7.3 Stormwater Soakage

Stormwater soakage relies heavily on the type of strata in which the soakage system is installed.

The soil silty clay soil types generally present have low permeabilities however, the sandier silts/silty sand in the southwest of the site offer better soakage rates.

All soakage systems should be subject to specific design.

8 SUITABILITY STATEMENT

The site investigation carried out is considered suitable for this assessment of geotechnical constraints and associated requirements in support of a plan change application.

The qualitative assessment of natural risk hazard for the site is low to medium for all hazards considered in the undeveloped state, and these can be reduced to very low and low with appropriately designed development.

It is our opinion that the Dave's Farm, Lockerbie Estate Development site is geotechnically suitable for the proposed development subject to the recommendations contained herein.

9 FURTHER WORK

The site investigation works were carried out prior to the development of the final civil engineering drawings including any cut/fill earthworks and confirmed building layout plans.

Further geotechnical investigation and assessment is required for resource consent to provide specific design information in key areas should include:

- Fill induced static settlement assessments for deeper fills over lower strength soils;
- Laboratory testing for earthworks including, standard compaction testing, solid densities and moisture contents in proposed borrow materials;
- Quantitative liquefaction risk assessment for the proposed finished ground profiles.

This work will be delivered in a geotechnical design report based on the developed earthworks and subdivision scheme plans and will be suitable to support an application for resource consent.

A post earthworks geotechnical completion report will be necessary to confirm the suitability of the final ground profile for development.

10 LIMITATIONS

This report has been prepared for use by our client, Lockerbie Estates Limited, their consultants and Matamata Piako District Council. Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

It should be noted that factual data for this report has been obtained from discrete locations using normal geotechnical investigation techniques. As such investigation methods by their nature only provide information about a relatively small volume of subsoils, there may be special conditions pertaining to this site which have not been disclosed by the investigation and which have not been taken into account in the report. If variations in the subsoils occur from those described or assumed to exist, then the matter should be referred back to CMW immediately.

USE OF THIS REPORT

Site subsurface conditions cause more construction problems than any other factor and therefore are generally the largest technical risk to a project. These notes have been prepared to help you understand the limitations of your geotechnical report.

Your geotechnical report is based on project specific criteria

Your geotechnical report has been developed on the basis of our understanding of your project specific requirements and applies only to the site area investigated. Project requirements could include the general nature of the project; its size and configuration; the location of any structures on or around the site; and the presence of underground utilities. If there are any subsequent changes to your project you should seek geotechnical advice as to how such changes affect your report's recommendations. Your geotechnical report should not be applied to a different project given the inherent differences between projects and sites.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface investigation, the conditions may have changed, particularly when large periods of time have elapsed since the investigations were performed.

Interpretation of factual data

Site investigations identify actual subsurface conditions at points where samples are taken. Additional geotechnical information (e.g. literature and external data source review, laboratory testing on samples, etc) are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can exactly predict what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

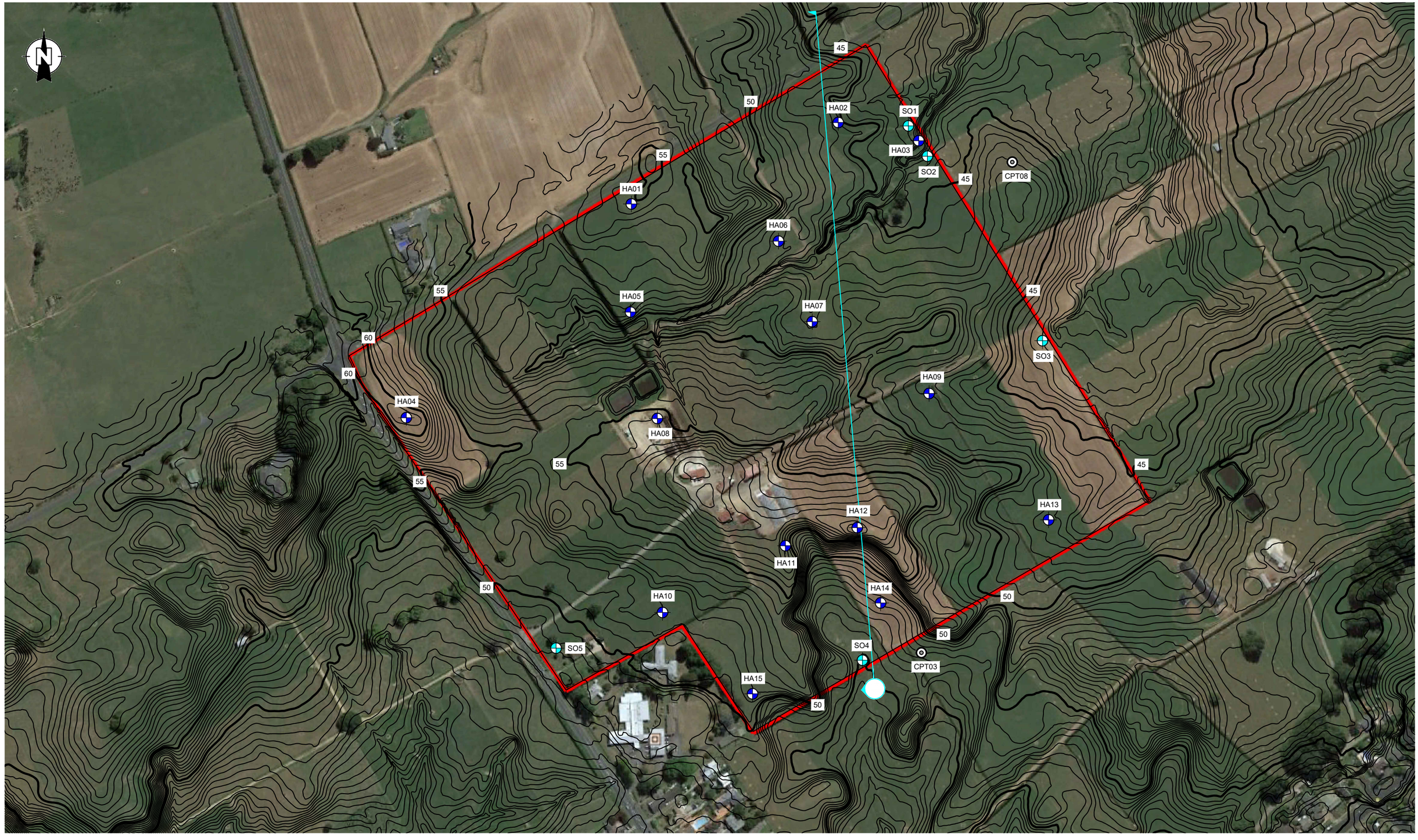
Your report's recommendations require confirmation during construction

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced. For this reason, you should retain geotechnical services throughout the construction stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site. A geotechnical designer, who is fully familiar with the background information, is able to assess whether the report's recommendations are valid and whether changes should be considered as the project develops. An unfamiliar party using this report increases the risk that the report will be misinterpreted.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical report. Read all geotechnical documents closely and do not hesitate to ask any questions you may have. To help avoid misinterpretations, retain the assistance of geotechnical professionals familiar with the contents of the geotechnical report to work with other project design professionals who need to take account of the contents of the report. Have the report implications explained to design professionals who need to take account of them, and then have the design plans and specifications produced reviewed by a competent Geotechnical Engineer.

Drawings



LEGEND:

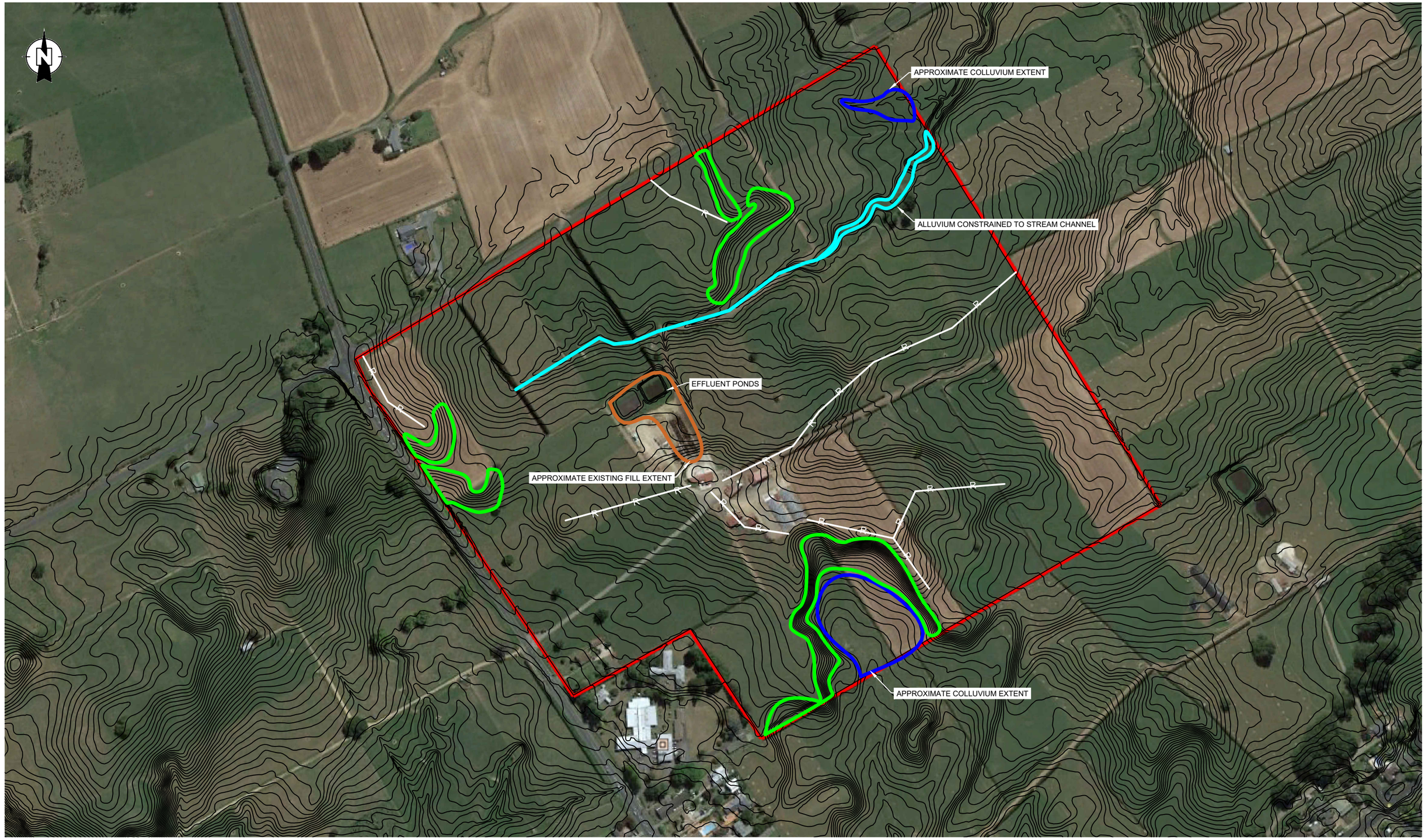
- HA01 — HAND AUGER (HA) LOCATION
- SO1 — SOAKAGE TEST (SO) LOCATION
- SITE BOUNDARY
- HISTORIC CPT LOCATION

NOTES:

1. BASE PLAN ADAPTED FROM: GOOGLE EARTH IMAGERY.

CMW Geosciences

CLIENT: LOCKERBIE ESTATE LIMITED		DRAWN: LS	PROJECT: HAM2021-0060
PROJECT: DAVE'S FARM, LOCKERBIE ESTATE MORRINSVILLE		CHECKED: KL	FIGURE: 01
		REVISION: 0	SCALE: 1:4000
TITLE: SITE INVESTIGATION PLAN		DATE: 14/07/2021	SHEET: A3 L



LEGEND:

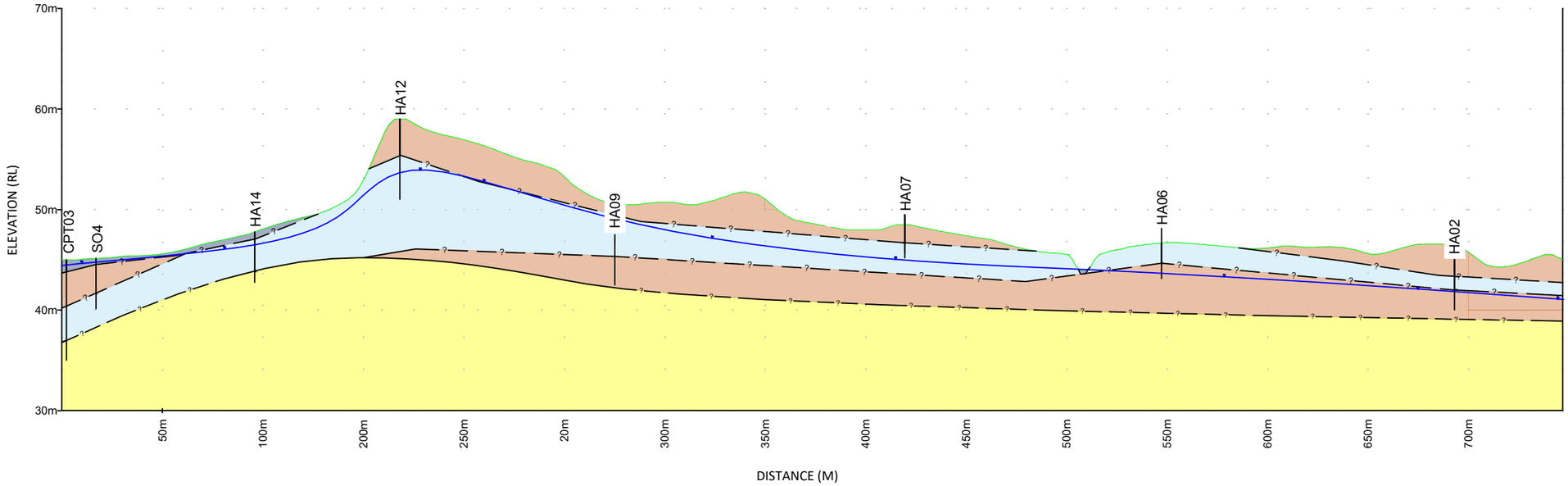
- SLOPES SHOWING SOIL CREEP
- MARSHY GROUND OVERLYING COLLUVIUM
- EXISTING FILL
- STREAM OVERLYING ALLUVIUM
- SITE BOUNDARY
- R — RIDGE LINE

NOTES:

1. BASE PLAN ADAPTED FROM: GOOGLE EARTH IMAGERY.

CMW Geosciences

CLIENT: LOCKERBIE ESTATE LIMITED		DRAWN: LS	PROJECT: HAM2021-0060
PROJECT: DAVE'S FARM, LOCKERBIE ESTATE MORRINSVILLE		CHECKED: KL	FIGURE: 02
		REVISION: 0	SCALE: 1:4000
TITLE: GEOMOPHOLOGY PLAN		DATE: 14/07/2021	SHEET: A3 L



LEGEND:

- STIFF TO HARD SILTY CLAY AND CLAY
- STIFF TO HARD CLAYEY SILT, SANDY SILT AND SILT
- DENSE TO VERY DENSE SAND
- STIFF TO VERY STIFF COLLUVIUM
- GROUNDWATER LEVEL

CMW Geosciences

CLIENT: **LOCKERBIE ESTATE LIMITED**		DRAWN: LS	PROJECT: HAM2021-0060
PROJECT: **DAVE'S FARM, LOCKERBIE ESTATE MORRINSVILLE**		CHECKED: KR	DRAWING: 03
		REVISION: 0	SCALE: H:1:2500 V:1:375
TITLE: **SECTION A**		DATE: HAM2021-0060	SHEET: A3 L

Appendix A: Hand Auger Borehole Logs

HAND AUGER BOREHOLE LOG - HA01

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 24/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466502.4mE; 715409.7mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 131kPa Residual = 29kPa				CH: Silty CLAY: brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)			
	0.6	Peak = 177kPa Residual = 44kPa						VSt	
	0.9	Peak = 138kPa Residual = 42kPa		1					
						MH: Clayey SILT: greyish brown. High plasticity, sensitive to extra sensitive. (Walton Subgroup)	D to M		
	1.2	Peak = 148kPa Residual = 15kPa							
	1.5	Peak = >200kPa Residual = 35kPa						VSt to H	
	2.0	Peak = 189kPa Residual = 41kPa		2					
						MH: Clayey SILT: with trace medium to coarse sand; greyish brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)			
	2.4	Peak = 174kPa Residual = 38kPa					M to W		
	2.8	Peak = 125kPa Residual = 35kPa							
				3					
	3.2	Peak = 134kPa Residual = 26kPa				MH: Clayey SILT: greyish brown. High plasticity, sensitive. (Walton Subgroup)			
	3.6	Peak = 131kPa Residual = 26kPa						VSt	
							W		
	4.0	Peak = 166kPa Residual = 26kPa		4					
	4.4	Peak = 154kPa Residual = 22kPa							
						CH: Silty CLAY: brown. High plasticity, moderately sensitive. (Walton Subgroup)			
	4.8	Peak = >200kPa Residual = 65kPa					M to W	H	
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA02

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 24/06/2021
Borehole Location: Refer to site plan. Logged by: IP Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466714.4mE; 715456.9mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: dark brown. Low plasticity. (Topsoil)			
	0.3	Peak = 115kPa Residual = 17kPa				ML: Clayey SILT: with some fine sand; light grey mottled orange. Low plasticity, sensitive. (Colluvium)		VSt	
	0.6	Peak = >200kPa Residual = 61kPa				CH: CLAY: light grey mottled orange. High plasticity, moderately sensitive. (Walton Subgroup)			
	0.9	Peak = UTP							
				1		... at 1.00m, becoming orange mottled light grey.			
	1.2	Peak = UTP					D to M		
	1.6	Peak = UTP							
						ML: Clayey SILT: with some fine sand; light grey. Low plasticity, sensitive. (Walton Subgroup)		H	
	2.0	Peak = UTP		2					
	2.4	Peak = UTP							
	2.8	Peak = >200kPa Residual = 34kPa							
				3		CH: Silty CLAY: light grey mottled orange. High plasticity, sensitive. (Walton Subgroup)			
	3.2	Peak = >200kPa Residual = 27kPa							
	3.6	Peak = >200kPa Residual = 20kPa							
						... at 3.80m, with minor fine to medium Sand.			
	4.0	Peak = >200kPa Residual = 34kPa		4			M to W	VSt to H	
	4.4	Peak = 176kPa Residual = 30kPa							
	4.8	Peak = 139kPa Residual = 30kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2087 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA03

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 24/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466795.7mE; 715449.4mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
24-06-2021	0.3	Peak = 76kPa Residual = 17kPa		0		OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			5 10 15
						MH: SILT: dark grey. High plasticity, sensitive. (Recent Alluvium)	W	St	
	0.6	Peak = 76kPa Residual = 9kPa							
	0.9	Peak = 78kPa Residual = 8kPa		1		ML: Sandy SILT: light grey mottled yellow. Low plasticity, pumiceous sand, sensitive. Sand, fine to medium. (Recent Alluvium)			
	1.2	Peak = 81kPa Residual = 17kPa				ML: SILT: with trace fine to coarse sand; light grey streaked dark brown. Low plasticity, sensitive. (Walton Subgroup)	S	St to VSt	
	1.5	Peak = 105kPa Residual = 26kPa				Borehole terminated at 1.5 m			
				2					
				3					
				4					
				5					

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater encountered at 1.1m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA04

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 25/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466288.1mE; 715049.2mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 116kPa Residual = 26kPa				MH: Clayey SILT: with trace medium to coarse sand; greyish brown. High plasticity, sensitive. (Walton Subgroup)		St to VSt	
	0.6	Peak = 81kPa Residual = 17kPa							
	0.9	Peak = >200kPa Residual = 17kPa		1		ML: SILT: with some fine sand; light grey mottled yellow. Low plasticity, sensitive to extra sensitive. (Walton Subgroup)	D		
	1.2	Peak = >200kPa Residual = 29kPa							
	1.6	Peak = UTP				ML: Sandy SILT: light grey. Low plasticity. Sand, fine to medium. (Walton Subgroup)		H	
	2.0	Peak = UTP		2					
	2.4	Peak = UTP				CL: Sandy CLAY: with trace fine to medium gravel; dark reddish brown. Low plasticity. Sand, fine to medium. (Walton Subgroup)			
						Borehole terminated at 2.5 m			18
									23
				3					
				4					
				5					

Termination Reason: Refusal on dense strata
Shear Vane No: 2993 DCP No: 7
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA05

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 24/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466458.8mE; 715220.7mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
						CH: Silty CLAY: brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)			
	0.3	Peak = 119kPa Residual = 23kPa							
	0.6	Peak = 123kPa Residual = 32kPa						St to VSt	
	0.9	Peak = 76kPa Residual = 26kPa		1					
	1.2	Peak = UTP				CH: Silty CLAY: brownish grey. High plasticity. (Walton Subgroup)			
	1.6	Peak = UTP					D to M		
	2.0	Peak = UTP		2		CH: Silty CLAY: with trace fine to coarse sand; brown streaked yellowish brown. High plasticity. (Walton Subgroup)		H	
	2.4	Peak = UTP							
	2.8	Peak = UTP		3					
	3.2	Peak = 102kPa Residual = 32kPa				MH: Clayey SILT: greyish brown. High plasticity, moderately sensitive. (Walton Subgroup)		VSt to H	
	3.6	Peak = >200kPa Residual = 70kPa							
	4.0	Peak = 116kPa Residual = 57kPa		4		ML: SILT: with some clay; light grey. Low plasticity, moderately sensitive. (Walton Subgroup)	M to W		
	4.4	Peak = 105kPa Residual = 23kPa						VSt	
	4.8	Peak = 122kPa Residual = 29kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA06

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 24/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466649.0mE; 715317.6mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 123kPa Residual = 26kPa				CH: Silty CLAY: brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)			
	0.6	Peak = 131kPa Residual = 29kPa							
	0.9	Peak = 134kPa Residual = 29kPa		1					
	1.2	Peak = 109kPa Residual = 29kPa						VSt	
	1.6	Peak = 123kPa Residual = 26kPa				MH: Clayey SILT: greyish brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)	M		
	2.0	Peak = 109kPa Residual = 29kPa		2					
	2.4	Peak = 94kPa Residual = 15kPa				ML: Sandy SILT: light grey mottled yellow. Low plasticity, sensitive. (Walton Subgroup)			
	2.8	Peak = 93kPa Residual = 29kPa						St	
24-06-2021				3					
	3.2	Peak = 145kPa Residual = 44kPa				MH: Clayey SILT: brown. High plasticity, moderately sensitive. (Walton Subgroup)			
	3.6	Peak = 189kPa Residual = 61kPa				CH: Silty CLAY: brown. High plasticity, moderately sensitive. (Walton Subgroup) *... from 3.50m to 5.00m, poor recovery.*			
	4.0	Peak = >200kPa Residual = 67kPa		4			W to S	VSt to H	
	4.4	Peak = UTP							
	4.8	Peak = UTP							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater encountered at 3.2m.

HAND AUGER BOREHOLE LOG - HA07

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 24/06/2021
Borehole Location: Refer to site plan. Logged by: IP Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466656.9mE; 715228.6mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: dark brown. Low plasticity. (Topsoil)			
	0.3	Peak = 132kPa Residual = 27kPa				CH: Silty CLAY: dark orange brown. High plasticity, sensitive. (Walton Subgroup)			
	0.6	Peak = 166kPa Residual = 41kPa				CH: Silty CLAY: with some fine to medium sand; light brown. High plasticity, sensitive. (Walton Subgroup)		VSt	
	0.9	Peak = UTP							
Seepage				1		CL: Silty CLAY: with some fine to medium sand; light grey mottled orange. Low plasticity, sensitive. (Walton Subgroup)			
	1.2	Peak = >200kPa Residual = 20kPa							
	1.6	Peak = UTP				CH: CLAY: with some silt; grey. High plasticity. (Walton Subgroup)			
						SW: Clayey Fine to coarse SAND: light grey. Well graded, subangular to subrounded. (Walton Subgroup)			
						CL: CLAY: with some fine to medium sand; light grey mottled orange. Low plasticity, sensitive. (Walton Subgroup)			
	2.0	Peak = >200kPa Residual = 27kPa		2			S		
						CL: Sandy CLAY: dark reddish orange. Low plasticity. (Walton Subgroup)			
						... at 2.20m, becoming light orange brown.			
	2.4	Peak = UTP							
	2.8	Peak = UTP				SW: Sandy SILT: with trace fine gravel; light grey mottled dark brown. Subangular, Sand, fine to coarse. (Walton Subgroup)		H	
				3					
	3.2	Peak = UTP							
	3.6	Peak = UTP					S		
	4.0	Peak = UTP		4					
	4.3	Peak = UTP				Borehole terminated at 4.3 m			
				5					

Termination Reason: Hole collapse
Shear Vane No: 2087 DCP No:
Remarks: Groundwater encountered at 2.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA08

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 25/06/2021
Borehole Location: Refer to site plan. Logged by: IP Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466485.8mE; 715116.0mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
	0.3	Peak = 95kPa Residual = 17kPa				CH: CLAY: with some silt, with minor fine to medium sand; light orange brown. High plasticity. (Uncontrolled Fill)		St	
	0.6	Peak = 81kPa Residual = 30kPa				MH: Clayey SILT: with trace fine to medium sand; light brown mottled dark brown. High plasticity. (Uncontrolled Fill)			
	0.9	Peak = 61kPa Residual = 14kPa		1					
	1.2	Peak = 169kPa Residual = 61kPa							
	1.6	Peak = 91kPa Residual = 30kPa						St to VSt	
	2.0	Peak = 135kPa Residual = 34kPa		2			M		
	2.4	Peak = >200kPa Residual = 30kPa							
	2.8	Peak = 152kPa Residual = 34kPa				CL: Sandy CLAY: with some silt; light brownish grey. Low plasticity. (Uncontrolled Fill)			
				3		OL: Organic SILT: dark brown. High plasticity, Odorous. (Topsoil)			
	3.2	Peak = 135kPa Residual = 47kPa				CH: Silty CLAY: brown. High plasticity, moderately sensitive. (Walton Subgroup)			
	3.6	Peak = UTP							
▼	4.0	Peak = >200kPa Residual = 122kPa		4		CL: CLAY: with minor fine to medium sand; light orange brown. Low plasticity, insensitive to sensitive. (Walton Subgroup)		VSt to H	
	4.4	Peak = UTP					W to S		
	4.8	Peak = >200kPa Residual = 34kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2087 DCP No:
Remarks: Groundwater encountered at 3.9m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA09

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 25/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 445232.0mE; 698765.0mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 160kPa Residual = 38kPa				CH: Silty CLAY: brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)	D		
	0.6	Peak = 107kPa Residual = 26kPa							
	0.9	Peak = 76kPa Residual = 17kPa		1		MH: Clayey SILT: greyish brown. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)		St to VSt	
	1.2	Peak = 87kPa Residual = 26kPa							
	1.6	Peak = 102kPa Residual = 20kPa							
	2.0	Peak = 116kPa Residual = 12kPa		2			M to W		
						MH: SILT: with minor clay, with trace fine to coarse sand; light yellowish brown. High plasticity, sensitive. (Walton Subgroup)		St	
	2.4	Peak = 93kPa Residual = 15kPa							
	2.8	Peak = 78kPa Residual = 15kPa							
▼				3					
	3.2	Peak = 87kPa Residual = 15kPa							
	3.6	Peak = 78kPa Residual = 15kPa							
	4.0	Peak = 84kPa Residual = 17kPa		4			S		
	4.4	Peak = 148kPa Residual = 49kPa				CH: Silty CLAY: orange yellow. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)		VSt to H	
	4.8	Peak = >200kPa Residual = 30kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater encountered at 3.1m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA10

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 25/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 125kPa Residual = 28kPa				CH: Silty CLAY: greyish brown. High plasticity, sensitive. (Walton Subgroup)		VSt	
	0.6	Peak = 120kPa Residual = 22kPa							
	0.9	Peak = 131kPa Residual = 56kPa		1		ML: SILT: with minor clay; greyish brown. Low plasticity, moderately sensitive. (Walton Subgroup)			
	1.2	Peak = 142kPa Residual = 46kPa						VSt to H	
	1.6	Peak = 200kPa Residual = 60kPa					D to M		
	2.0	Peak = 198kPa Residual = 71kPa		2					
	2.4	Peak = 200kPa Residual = 61kPa				CH: Silty CLAY: orange brown. High plasticity, moderately sensitive. (Walton Subgroup)		H	
	2.8	Peak = >200kPa Residual = 75kPa		3					
	3.2	Peak = 200kPa Residual = 48kPa				MH: SILT with some clay: light grey. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)			
	3.6	Peak = 187kPa Residual = 61kPa						VSt to H	
	4.0	Peak = UTP		4			M to W		
	4.4	Peak = UTP				ML: SILT: with minor fine sand; light yellowish brown. Low plasticity. (Walton Subgroup)		H	
						SP: Fine to coarse SAND: with some silt; grey. Poorly graded. (Walton Subgroup)			
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA11

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 23/06/2021
Borehole Location: Refer to site plan. Logged by: IP Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466625.6mE; 714970.6mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: dark brown. Low plasticity. (Topsoil)			
	0.3	Peak = >200kPa Residual = 68kPa				CH: Silty CLAY: dark brown. High plasticity, insensitive to extra-sensitive. (Walton Subgroup)	M	H	
	0.6	Peak = 85kPa Residual = 7kPa				*... at 0.50m, becoming light brown.*		St	
	0.9	Peak = 81kPa Residual = 17kPa		1					
	1.2	Peak = >200kPa Residual = 68kPa				CH: Silty CLAY: with some fine to medium sand; light orange brown. High plasticity, moderately sensitive to extra-sensitive. (Walton Subgroup)			
						... at 1.30m, becoming light brownish grey mottled orange.			
	1.6	Peak = UTP				*... at 1.50m, becoming light brown.*	M to W		
	2.0	Peak = UTP		2				H	
	2.4	Peak = UTP							
	2.8	Peak = >200kPa Residual = 24kPa							
				3					
	3.2	Peak = 156kPa Residual = 20kPa				ML: Clayey SILT: with minor fine to coarse sand; light brown. Low plasticity, sensitive to extra-sensitive. (Walton Subgroup)			
	3.6	Peak = 112kPa Residual = 14kPa							
	4.0	Peak = 115kPa Residual = 14kPa		4			W	St to VSt	
	4.4	Peak = 84kPa Residual = 17kPa							
	4.8	Peak = 84kPa Residual = 17kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2087 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA12

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 29/06/2021
Borehole Location: Refer to site plan. Logged by: LS/ NM Checked by: AWC Scale: 1:25
Position: 445160.8mE; 698729.8mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
						CH: Silty CLAY: brown. High plasticity, insensitive to moderately sensitive. (Walton Subgroup)			
	0.3	Peak = 131kPa Residual = 90kPa							
	0.6	Peak = >200kPa Residual = 131kPa					M		
	0.9	Peak = UTP		1					
	1.2	Peak = UTP							
	1.5	Peak = >200kPa Residual = 87kPa							
	2.0	Peak = UTP		2				VSt to H	
	2.4	Peak = UTP							
	2.8	Peak = >200kPa Residual = 73kPa							
	3.2	Peak = UTP		3			M to W		
	3.6	Peak = >200kPa Residual = 107kPa				MH: Clayey SILT: greyish brown. High plasticity, insensitive. (Walton Subgroup)		H	
	4.0	Peak = 160kPa Residual = 49kPa		4		ML: SILT: with minor fine sand; light grey mottled yellowish brown. Low plasticity, moderately sensitive. (Walton Subgroup)			
	4.4	Peak = 119kPa Residual = 41kPa						St to VSt	
29-06-2021	4.8	Peak = 84kPa Residual = 29kPa							
				5		ML: SILT: light grey. Low plasticity, insensitive to sensitive. (Walton Subgroup)			

Termination Reason: Hand auger abandoned due to equipment breakage.
Shear Vane No: 2993 DCP No:
Remarks: Groundwater encountered at 5m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA12

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 29/06/2021
Borehole Location: Refer to site plan. Logged by: LS/ NM Checked by: AWC Scale: 1:25
Position: 445160.8mE; 698729.8mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
	5.2	Peak = 116kPa Residual = 46kPa		6		ML: SILT: light grey. Low plasticity, insensitive to sensitive. (Walton Subgroup)	S	St to VSt	
	5.6	Peak = 102kPa Residual = 55kPa							
	6.0	Peak = 142kPa Residual = 38kPa						VSt to H	
	6.4	Peak = UTP							
	6.8	Peak = UTP		7					
	7.2	Peak = UTP							
	7.6	Peak = 188kPa Residual = 26kPa							
						Borehole terminated at 7.8 m			
				8					
				9					
				10					

Termination Reason: Hand auger abandoned due to equipment breakage.
Shear Vane No: 2993 DCP No:
Remarks: Groundwater encountered at 5m.

HAND AUGER BOREHOLE LOG - HA13

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 25/06/2021
Borehole Location: Refer to site plan. Logged by: IP Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466946.2mE; 715014.3mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
	0.3	Peak = 163kPa Residual = 30kPa				OL: Organic SILT: dark brown. Low plasticity. (Topsoil)			
						CH: Silty CLAY: dark brown. High plasticity, moderately sensitive. (Walton Subgroup)			
	0.6	Peak = 129kPa Residual = 34kPa							
	0.9	Peak = 132kPa Residual = 37kPa		1				VSt	
	1.2	Peak = 169kPa Residual = 42kPa					M		
	1.6	Peak = >200kPa Residual = 51kPa				CL: CLAY: with some silt, with minor fine to medium sand; light orange brown mottled orange. Low plasticity, insensitive to moderately sensitive. (Walton Subgroup)			
						... at 1.90m, becoming light grey, mottled orange.			
	2.0	Peak = >200kPa Residual = 34kPa		2				H	
	2.4	Peak = UTP				CL: Sandy CLAY: light orange brown. Low plasticity, sensitive. Sand, fine to coarse. (Walton Subgroup)			
						... at 2.40m, becoming light grey mottled orange.			
	2.6	Peak = 119kPa Residual = 17kPa						VSt	
						ML: Sandy SILT: light brownish white. Low plasticity, moderately sensitive. Sand, fine to coarse. (Walton Subgroup)			
	3.0	Peak = >200kPa Residual = 44kPa		3					
	3.4	Peak = UTP					W		
	3.8	Peak = UTP							
				4				H	
	4.2	Peak = UTP							
						... at 4.50m, becoming light yellowish brown.			
	4.6	Peak = UTP							
	5.0	Peak = UTP		5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2087 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA14

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 23/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466752.9mE; 714910.2mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 76kPa Residual = 12kPa				CL: Silty CLAY: dark brown streaked light orange brown. Low plasticity, sensitive. (Colluvium)		St	
	0.6	Peak = 176kPa Residual = 58kPa				ML: SILT: with some clay; greyish brown. Low plasticity, moderately sensitive. (Walton Subgroup)		VSt	
	0.9	Peak = >200kPa Residual = 61kPa		1		ML: SILT: with minor fine sand; light grey mottled yellow. Low plasticity, moderately sensitive. (Walton Subgroup)		H	
	1.2	Peak = >200kPa Residual = 70kPa							
	1.6	Peak = 124kPa Residual = 12kPa				ML: SILT: light grey. Low plasticity, sensitive to extra-sensitive. (Walton Subgroup)	M	VSt	
	2.0	Peak = 110kPa Residual = 9kPa		2					
	2.4	Peak = 189kPa Residual = 26kPa							
	2.8	Peak = 160kPa Residual = 29kPa		3					
	3.2	Peak = 136kPa Residual = 29kPa				ML: SILT: with trace medium to coarse sand; light grey streaked light yellowish brown. Low plasticity, moderately sensitive to sensitive.	W to S		
23-06-2021	3.6	Peak = 109kPa Residual = 30kPa							
	4.0	Peak = UTP		4		ML: SILT: with minor fine sand; light greyish brown. Low plasticity. (Walton Subgroup)	S	H	
	4.4	Peak = UTP							
	4.8	Peak = UTP							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater encountered at 3.8m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA15

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 25/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466587.2mE; 714792.7mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 163kPa Residual = 44kPa				CL: Silty CLAY: dark brown light. Low plasticity, moderately sensitive. (Walton Subgroup)	D to M	VSt	
	0.6	Peak = 99kPa Residual = 26kPa				MH: Clayey SILT: greyish brown. High plasticity, moderately sensitive. (Walton Subgroup)			
	0.9	Peak = 96kPa Residual = 29kPa		1				St to VSt	
	1.2	Peak = 166kPa Residual = 64kPa							
	1.6	Peak = UTP				CH: Silty CLAY: light brown. High plasticity. (Walton Subgroup)		H	
	2.0	Peak = UTP		2					
	2.4	Peak = 166kPa Residual = 58kPa				MH: Clayey SILT: greyish brown. High plasticity, moderately sensitive. (Walton Subgroup)	M		
	2.8	Peak = 150kPa Residual = 54kPa		3					
	3.2	Peak = 189kPa Residual = 35kPa				ML: SILT: with minor fine to medium sand; light grey mottled yellow. Low plasticity, sensitive. (Walton Subgroup)		VSt	
	3.6	Peak = 122kPa Residual = 44kPa							
	4.0	Peak = 110kPa Residual = 20kPa		4		ML: Sandy SILT: light grey mottled yellow. Low plasticity, sensitive. (Walton Subgroup)			
	4.4	Peak = 122kPa Residual = 17kPa					W		
	4.8	Peak = 93kPa Residual = 20kPa				MH: SILT: dark grey. High plasticity, sensitive. (Walton Subgroup)		St	
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - SO1

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 22/06/2021
Borehole Location: Refer to site plan. Logged by: IP Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466853.1mE; 715182.3mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: dark brown. Low plasticity. (Topsoil)			
	0.3	Peak = 135kPa Residual = 20kPa				ML: SILT: dark brown. Low plasticity, sensitive. (Walton Subgroup)		VSt	
	0.6	Peak = >200kPa Residual = 64kPa				ML: SILT: with some clay; light brown mottled orange. Low plasticity, moderately sensitive. (Walton Subgroup)			
	0.9	Peak = UTP				CL: CLAY: orange mottled light brown. Low plasticity. (Walton Subgroup)			
				1					
	1.2	Peak = UTP							
						... from 1.50m to 1.60m, with minor medium to coarse sand.			
	1.6	Peak = UTP						H	
	2.0	Peak = UTP		2			M to W		
	2.4	Peak = UTP							
						CL: Silty CLAY: with some fine to medium sand; light brown. Low plasticity. (Walton Subgroup)			
	2.8	Peak = UTP							
				3					
	3.2	Peak = 102kPa Residual = 47kPa				MH: SILT: with some clay, with minor fine to medium sand; light brownish grey mottled orange. High plasticity, moderately sensitive. (Walton Subgroup)			
	3.6	Peak = 68kPa Residual = 17kPa						St to VSt	
	4.0	Peak = UTP		4		CL: CLAY: with some fine to coarse sand; dark orange. Low plasticity. (Walton Subgroup)		H	
						CH: Silty CLAY: light brownish grey. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)			
	4.4	Peak = 51kPa Residual = 20kPa							
						... at 4.60m, becoming bluish grey.	W to S	St to VSt	
						... at 4.90m, becoming dark grey.			
	5.0	Peak = 85kPa Residual = 14kPa		5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2087 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - SO2

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 22/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 445243.5mE; 698853.1mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 110kPa Residual = 25kPa				ML: SILT: with minor clay; greyish brown. Low plasticity, moderately sensitive to sensitive. (Walton Subgroup)			
	0.6	Peak = 191kPa Residual = 42kPa						VSt	
	0.9	Peak = 191kPa Residual = 71kPa		1		CH: Silty CLAY: greyish brown. High plasticity, moderately sensitive. (Walton Subgroup)			
	1.2	Peak = UTP							
						CH: Silty CLAY: orange brown. High plasticity. (Walton Subgroup)			
	1.6	Peak = UTP							
	2.0	Peak = UTP		2			D to M		
						ML: Sandy SILT: light grey mottled yellow. Low plasticity. (Walton Subgroup)			
	2.4	Peak = UTP							
	2.8	Peak = UTP						VSt to H	
				3		SP: Silty Fine SAND: light grey. Uniformly graded. (Walton Subgroup)			
	3.2	Peak = UTP							
						ML: SILT: with minor fine sand; light grey mottled yellow. Low plasticity. (Walton Subgroup)			
	3.6	Peak = UTP							
	4.0	Peak = 191kPa Residual = 30kPa		4		ML: SILT: light grey mottled yellow. Low plasticity, sensitive. (Walton Subgroup)			
						SP: Fine SAND: light grey. Uniformly graded. (Walton Subgroup)			
	4.4	Peak = UTP					W		
	4.8	Peak = 136kPa Residual = 33kPa				MH: SILT: dark grey. High plasticity, sensitive. (Walton Subgroup)			
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2560 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - SO3

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 23/06/2021
Borehole Location: Refer to site plan. Logged by: NK Checked by: AWC Scale: 1:25 Sheet 1 of 1

CMW Geosciences

Position: Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: SILT: dark brown. No plasticity. (Topsoil)			
	0.3	Peak = 153kPa Residual = 35kPa				ML: SILT: orange brown. Low plasticity, sensitive. (Walton Subgroup)	M	VSt	
	0.6	Peak = 191kPa Residual = 35kPa							
	0.9	Peak = 191kPa Residual = 79kPa				CH: Silty CLAY: grey mottled orange. High plasticity, moderately sensitive. (Walton Subgroup)			
				1		MH: Clayey SILT: grey. High plasticity, sensitive. (Walton Subgroup)			
	1.2	Peak = 191kPa Residual = 38kPa							
						MH: Sandy SILT: grey. High plasticity. (Walton Subgroup)			
						... from 1.30m to 1.40m, pumiceous sand.			
	1.5	Peak = 153kPa Residual = 38kPa				MH: Clayey SILT: grey. High plasticity, sensitive to extra sensitive. (Walton Subgroup)	W		
23-06-2021	1.8	Peak = 136kPa Residual = 16kPa							
				2					
	2.1	Peak = 191kPa Residual = 27kPa							
	2.4	Peak = UTP				ML: Sandy SILT: dark grey. Low plasticity. (Walton Subgroup)		H	
	2.7	Peak = UTP							
	3.0	Peak = UTP		3					
	3.3	Peak = UTP					S		
	3.6	Peak = UTP							
	3.9	Peak = UTP				MH: Clayey SILT: dark brownish grey. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)			
				4		*... from 3.90m to 5.00m, with minor rootlets.*			
	4.2	Peak = 41kPa Residual = 11kPa						F to St	
	4.5	Peak = 57kPa Residual = 22kPa							
	4.9	Peak = 57kPa Residual = 27kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2560 DCP No:
Remarks: Groundwater encountered at 2.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - SO4

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 23/06/2021
Borehole Location: Refer to site plan. Logged by: IP Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466726.8mE; 714845.1mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: dark brown. Low plasticity, Trace rootlets. (Topsoil)			
	0.3	Peak = 135kPa Residual = 34kPa				ML: Clayey SILT: with some fine to medium sand; light brown mottled orange. Low plasticity, moderately sensitive. (Colluvium)	M	VSt	
▼	0.6	Peak = >200kPa Residual = 10kPa				CH: Silty CLAY: with minor fine to medium sand; light brownish grey mottled orange. High plasticity, sensitive to extra sensitive. (Walton Subgroup)			
	0.9	Peak = >200kPa Residual = 18kPa		1					
	1.2	Peak = 190kPa Residual = 30kPa							
	1.6	Peak = 135kPa Residual = 10kPa						VSt to H	
	2.0	Peak = 102kPa Residual = 17kPa		2					
	2.4	Peak = 146kPa Residual = 17kPa							
	2.8	Peak = 78kPa Residual = 14kPa					S	St	
				3					
	3.2	Peak = UTP				CL: Sandy CLAY: with some silt; orange brown. Low plasticity. (Walton Subgroup)			
	3.6	Peak = 135kPa Residual = 17kPa				ML: Sandy SILT: dark grey. Low plasticity, sensitive. (Walton Subgroup)			
	4.0	Peak = 135kPa Residual = 10kPa		4		ML: Clayey SILT: light grey. Low plasticity, moderately sensitive to sensitive. (Walton Subgroup)		VSt to H	
	4.4	Peak = >200kPa Residual = 51kPa							
	4.8	Peak = >200kPa Residual = 102kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2087 DCP No:
Remarks: Groundwater encountered at 0.6m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - SO5

Client: Lockerbie Estate Limited
Project: Lockerbie - Dave's Farm
Site Location: 162 Morrinsville-Tahuna Road, Morrinsville
Project No.: HAM2021-0060
Date: 23/06/2021
Borehole Location: Refer to site plan. Logged by: LS Checked by: AWC Scale: 1:25 Sheet 1 of 1

Position: 466385.2mE; 714860.6mN Projection: NZVD 2016
Datum: Mt Eden 2000 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: with trace rootlets; dark brown. (Topsoil)			
	0.3	Peak = 131kPa Residual = 32kPa				CH: Silty CLAY: greyish brown. High plasticity, sensitive. (Walton Subgroup)			
	0.6	Peak = 105kPa Residual = 22kPa				ML: SILT: with minor clay; greyish brown. Low plasticity, moderately sensitive to sensitive. (Walton Subgroup)	M		
	0.9	Peak = 131kPa Residual = 61kPa		1					
	1.2	Peak = 180kPa Residual = 54kPa						VSt to H	
	1.6	Peak = >200kPa Residual = 76kPa							
	2.0	Peak = >200kPa Residual = 70kPa		2		CH: Silty CLAY: orange brown. High plasticity, moderately sensitive. (Walton Subgroup)			
	2.4	Peak = >200kPa Residual = 78kPa							
	2.8	Peak = >200kPa Residual = 78kPa		3					
	3.2	Peak = >200kPa Residual = 26kPa				ML: SILT: with minor fine sand; light grey mottled yellow. Low plasticity, sensitive. (Walton Subgroup)	W	H	
	3.6	Peak = UTP							
	4.0	Peak = UTP		4					
						SP: Fine to coarse SAND: with some silt; grey streaked yellowish brown. Poorly graded. (Walton Subgroup)			
	4.8	Peak = >200kPa Residual = 38kPa				ML: SILT: with minor fine sand; light yellowish brown. Low plasticity, sensitive. (Walton Subgroup)		H	
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth
Shear Vane No: 2993 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

Appendix B: Soakage Testing Results

CMW Geosciences	CLIENT: **Lockerbie Estate Limited**	DESIGNER:	LS
	PROJECT: **Lockerbie Estate - Dave's Farm Morrinsville-Tahuna Road, Morrinsville**	CHECKED:	-
		REVISION:	4
	TITLE: **SO-1 Falling Head Permeability Test**	DATE:	1/06/2021
		PROJECT:	HAM2021-0060

Specifications - Open-Ended Tube

Length L_1:	5	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

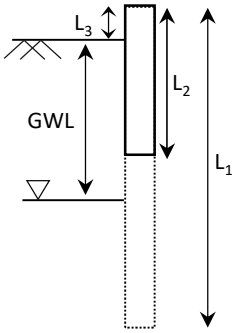
Ground Conditions

GWL: 5 m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 5.00 m BGL



Hydraulic Conductivity (k)

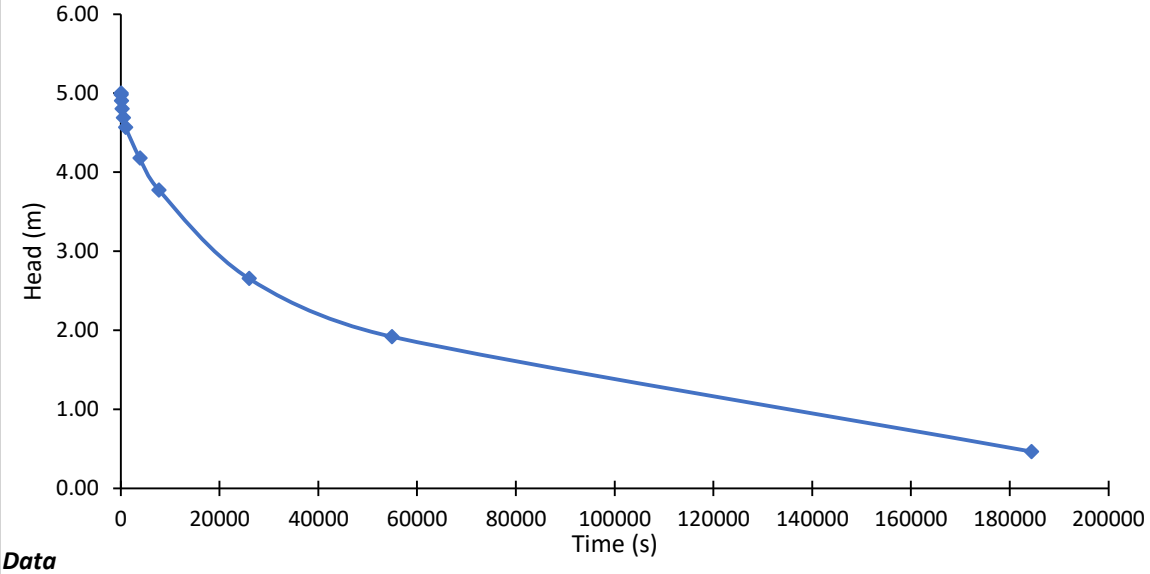
Note: CMW considers the CIRIA 113 value the most appropriate method for most purposes, but also provides the analysis method as outlined by Hvorslev if desired.

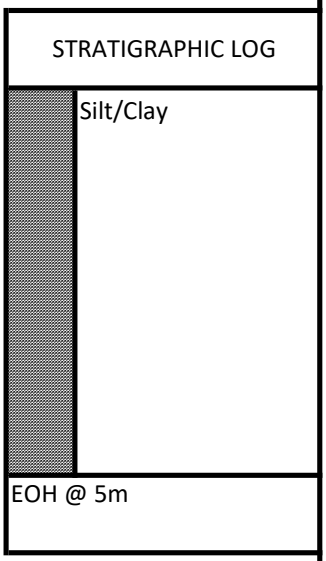
CIRIA 113: Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

$$k = \left(log\frac{h_1}{h_2} - log\frac{2h_1 + d}{2h_2 + d} \right) . \frac{(h_1 + h_2)}{2(t_2 - t_1)} =$$ 1.46E-06 ms^{-1} = 0.13 m/day

Hvorslev: Hvorslev (1951) *Time Lag and Soil Permeability in Ground-Water Observations* , Fig 18, p49

$$k = \frac{d^2 \, ln\left(\frac{mL}{d} + \sqrt{\left(\frac{mL}{d}\right)^2 + 1} \right)}{8L(t_2 - t_1)} ln\frac{H_1}{H_2} =$$ 7.73E-08 ms^{-1} = 0.01 m/day





Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	5.000				
60	0.021	4.979	4.990		6.64E-08	1.35E-06
120	0.095	4.905	4.942		2.41E-07	4.85E-06
240	0.199	4.801	4.853		1.74E-07	3.44E-06
480	0.309	4.691	4.746		9.67E-08	1.88E-06
960	0.432	4.568	4.629		5.58E-08	1.07E-06
3840	0.823	4.177	4.373		3.29E-08	6.02E-07
7680	1.226	3.774	3.976		3.01E-08	5.11E-07
25980	2.346	2.654	3.214		2.59E-08	3.79E-07
54840	3.082	1.919	2.286		1.96E-08	2.19E-07
184368	4.536	0.464	1.191		3.05E-08	2.77E-07

The hydraulic conductivity values above are calculated as an average across the whole data set. Any designer using these values may consider the raw data and other calculation methods, and must satisfy themselves as to their suitability.

CMW Geosciences	CLIENT: **Lockerbie Estate Limited**	DESIGNER:	LS
	PROJECT: **Lockerbie Estate - Dave's Farm Morrinsville-Tahuna Road, Morrinsville**	CHECKED:	-
		REVISION:	4
	TITLE: **SO-2 Falling Head Permeability Test**	DATE:	1/06/2021
		PROJECT:	HAM2021-0060

Specifications - Open-Ended Tube

Length L_1:	5	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

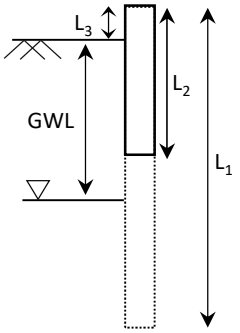
Ground Conditions

GWL: 5 m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 5.00 m BGL



Hydraulic Conductivity (k)

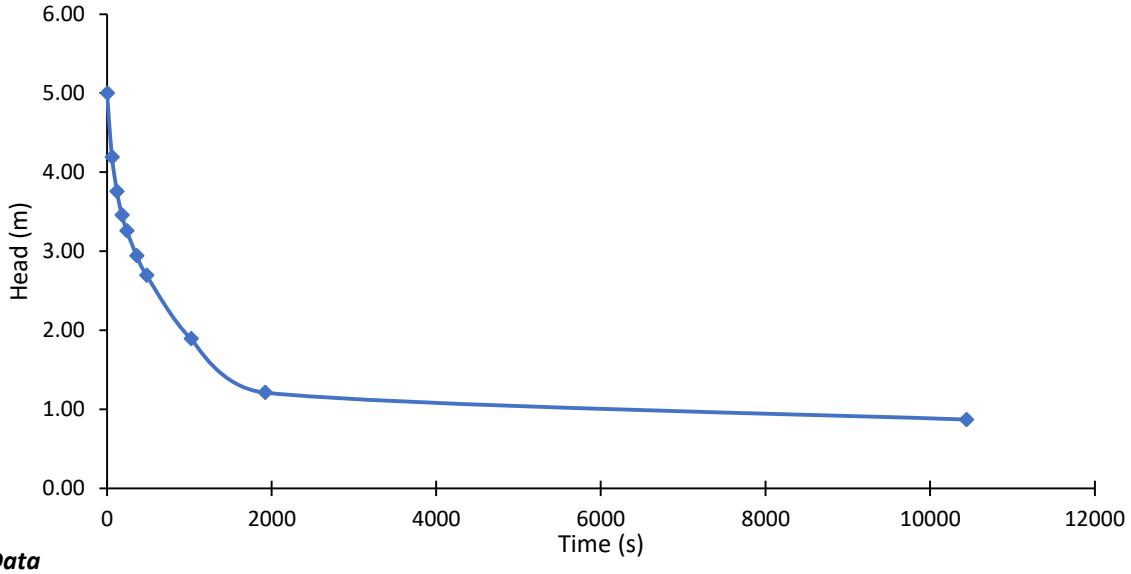
Note: CMW considers the CIRIA 113 value the most appropriate method for most purposes, but also provides the analysis method as outlined by Hvorslev if desired.

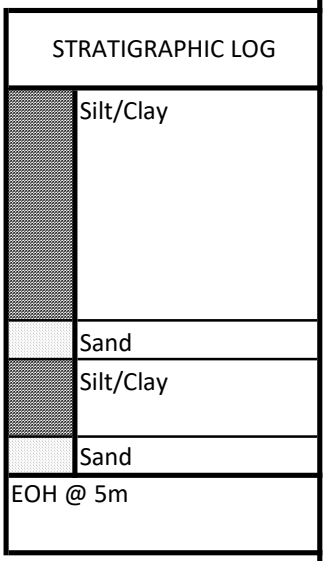
CIRIA 113: Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

$$k = \left(log\frac{h_1}{h_2} - log\frac{2h_1 + d}{2h_2 + d} \right) . \frac{(h_1 + h_2)}{2(t_2 - t_1)} =$$ 2.14E-05 ms^{-1} = 1.84 m/day

Hvorslev: Hvorslev (1951) *Time Lag and Soil Permeability in Ground-Water Observations* , Fig 18, p49

$$k = \frac{d^2 \, ln\left(\frac{mL}{d} + \sqrt{\left(\frac{mL}{d}\right)^2 + 1} \right)}{8L(t_2 - t_1)} ln\frac{H_1}{H_2} =$$ 1.41E-06 ms^{-1} = 0.12 m/day





Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	5.000				
60	0.808	4.192	4.596		3.00E-06	5.72E-05
120	1.244	3.756	3.974		2.09E-06	3.54E-05
180	1.542	3.458	3.607		1.69E-06	2.66E-05
240	1.743	3.257	3.358		1.30E-06	1.92E-05
360	2.056	2.944	3.101		1.16E-06	1.63E-05
480	2.306	2.694	2.819		1.10E-06	1.42E-05
1020	3.107	1.894	2.294		1.13E-06	1.28E-05
1920	3.787	1.213	1.553		1.14E-06	9.70E-06
10440	4.131	0.869	1.041		1.19E-07	7.45E-07

The hydraulic conductivity values above are calculated as an average across the whole data set. Any designer using these values may consider the raw data and other calculation methods, and must satisfy themselves as to their suitability.

CMW Geosciences	CLIENT: **Lockerbie Estate Limited**	DESIGNER:	LS
	PROJECT: **Lockerbie Estate - Dave's Farm Morrinsville-Tahuna Road, Morrinsville**	CHECKED:	-
		REVISION:	4
	TITLE: **SO-3 Falling Head Permeability Test**	DATE:	1/06/2021
		PROJECT:	HAM2021-0060

Specifications - Open-Ended Tube

Length L_1:	5	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

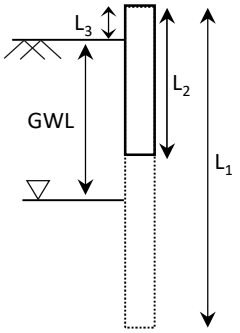
Ground Conditions

GWL: 2 m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 5.00 m BGL



Hydraulic Conductivity (k)

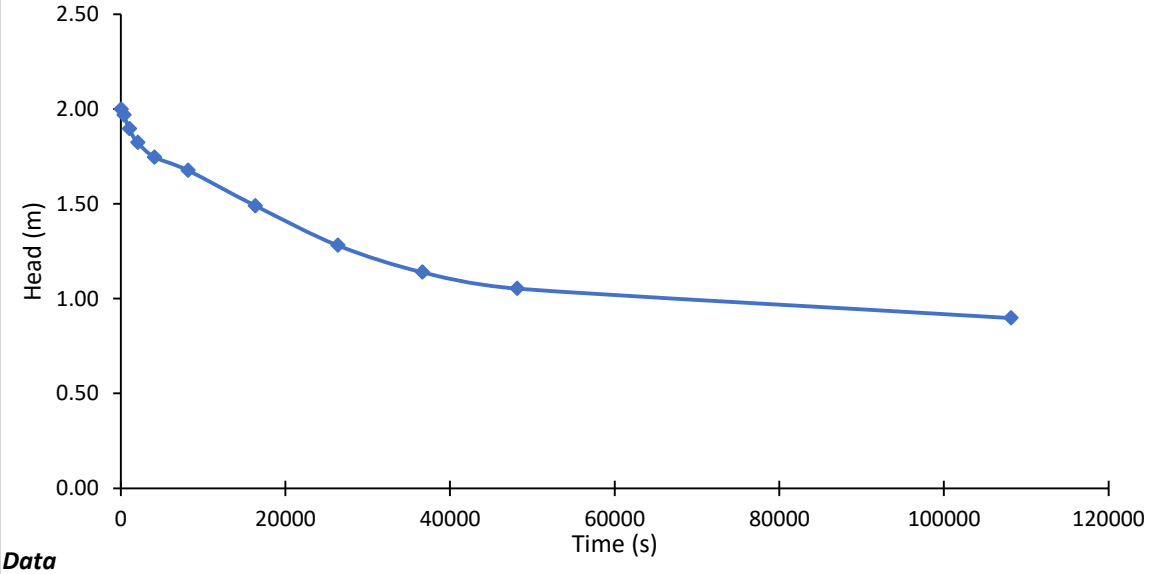
Note: CMW considers the CIRIA 113 value the most appropriate method for most purposes, but also provides the analysis method as outlined by Hvorslev if desired.

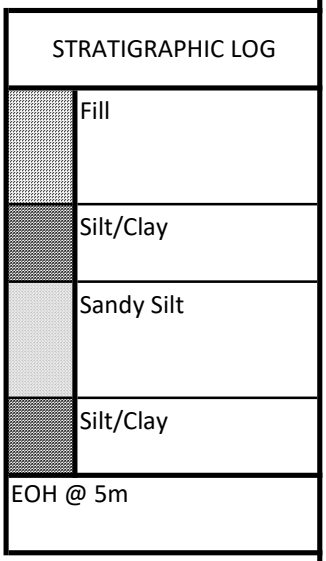
CIRIA 113: Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

$$k = \left(log\frac{h_1}{h_2} - log\frac{2h_1 + d}{2h_2 + d} \right) . \frac{(h_1 + h_2)}{2(t_2 - t_1)} =$$ 4.21E-07 ms^{-1} = 0.04 m/day

Hvorslev: Hvorslev (1951) *Time Lag and Soil Permeability in Ground-Water Observations* , Fig 18, p49

$$k = \frac{d^2 \, ln\left(\frac{mL}{d} + \sqrt{\left(\frac{mL}{d}\right)^2 + 1} \right)}{8L(t_2 - t_1)} ln\frac{H_1}{H_2} =$$ 2.19E-08 ms^{-1} = 0.00 m/day





Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	2.000				
360	0.032	1.968	4.984		4.26E-08	8.51E-07
1020	0.104	1.896	4.932		5.44E-08	1.08E-06
2040	0.176	1.824	4.860		3.71E-08	7.25E-07
4080	0.254	1.747	4.785		2.10E-08	4.06E-07
8160	0.323	1.677	4.712		9.99E-09	1.90E-07
16320	0.510	1.490	4.583		1.48E-08	2.75E-07
26340	0.719	1.282	4.386		1.59E-08	2.86E-07
36611	0.861	1.140	4.211		1.25E-08	2.16E-07
48131	0.946	1.054	4.097		7.58E-09	1.28E-07
108131	1.102	0.898	3.976		3.03E-09	4.98E-08

The hydraulic conductivity values above are calculated as an average across the whole data set. Any designer using these values may consider the raw data and other calculation methods, and must satisfy themselves as to their suitability.

CMW Geosciences	CLIENT: **Lockerbie Estate Limited**	DESIGNER:	LS
	PROJECT: **Lockerbie Estate - Dave's Farm Morrinsville-Tahuna Road, Morrinsville**	CHECKED:	-
		REVISION:	4
	TITLE: **SO-4 Falling Head Permeability Test**	DATE:	1/06/2021
		PROJECT:	HAM2021-0060

Specifications - Open-Ended Tube

Length L_1:	5	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

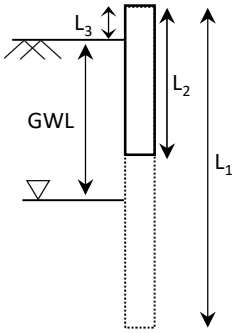
Ground Conditions

GWL: 0.6 m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 5.00 m BGL



Hydraulic Conductivity (k)

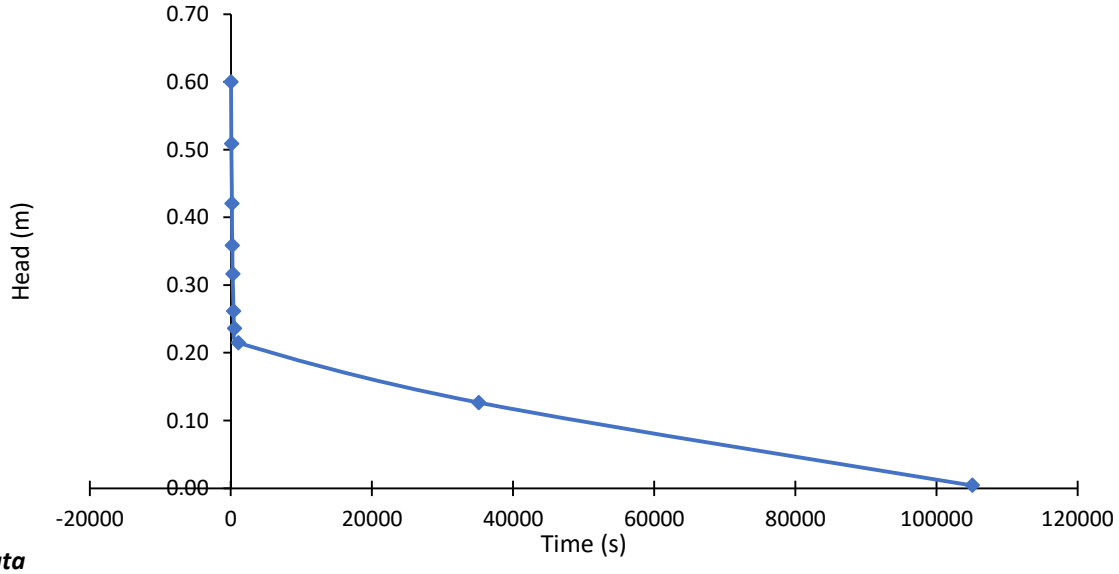
Note: CMW considers the CIRIA 113 value the most appropriate method for most purposes, but also provides the analysis method as outlined by Hvorslev if desired.

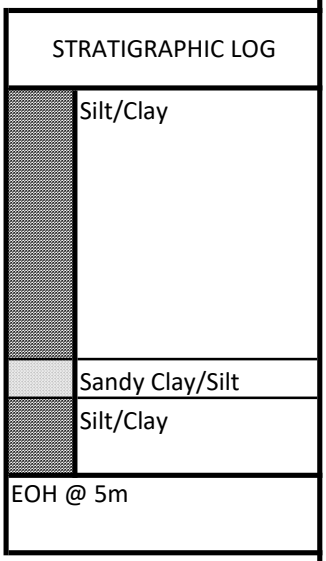
CIRIA 113: Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

$$k = \left(log\frac{h_1}{h_2} - log\frac{2h_1 + d}{2h_2 + d} \right) . \frac{(h_1 + h_2)}{2(t_2 - t_1)} =$$ 2.61E-05 ms^{-1} = 2.25 m/day

Hvorslev: Hvorslev (1951) *Time Lag and Soil Permeability in Ground-Water Observations* , Fig 18, p49

$$k = \frac{d^2 \, ln\left(\frac{mL}{d} + \sqrt{\left(\frac{mL}{d}\right)^2 + 1} \right)}{8L(t_2 - t_1)} ln\frac{H_1}{H_2} =$$ 1.46E-06 ms^{-1} = 0.13 m/day





Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	0.600				
60	0.091	0.509	4.954		2.64E-06	4.99E-05
120	0.179	0.421	4.865		3.10E-06	5.69E-05
180	0.242	0.359	4.790		2.62E-06	4.67E-05
240	0.284	0.316	4.737		2.08E-06	3.62E-05
360	0.338	0.262	4.689		1.58E-06	2.68E-05
480	0.364	0.236	4.649		8.67E-07	1.42E-05
1020	0.385	0.215	4.626		1.75E-07	2.81E-06
35113	0.474	0.127	4.571		1.59E-08	2.49E-07
105073	0.596	0.004	4.465		5.00E-08	8.59E-07

The hydraulic conductivity values above are calculated as an average across the whole data set. Any designer using these values may consider the raw data and other calculation methods, and must satisfy themselves as to their suitability.

CMW Geosciences	CLIENT: **Lockerbie Estate Limited**	DESIGNER:	LS
	PROJECT: **Lockerbie Estate - Dave's Farm Morrinsville-Tahuna Road, Morrinsville**	CHECKED:	-
		REVISION:	4
	TITLE: **SO-5 Falling Head Permeability Test**	DATE:	1/06/2021
		PROJECT:	HAM2021-0060

Specifications - Open-Ended Tube

Length L_1:	5	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

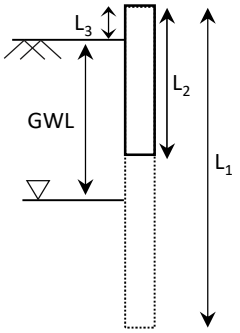
Ground Conditions

GWL: 5 m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$

Bottom of Test Hole: 5.00 m BGL



Hydraulic Conductivity (k)

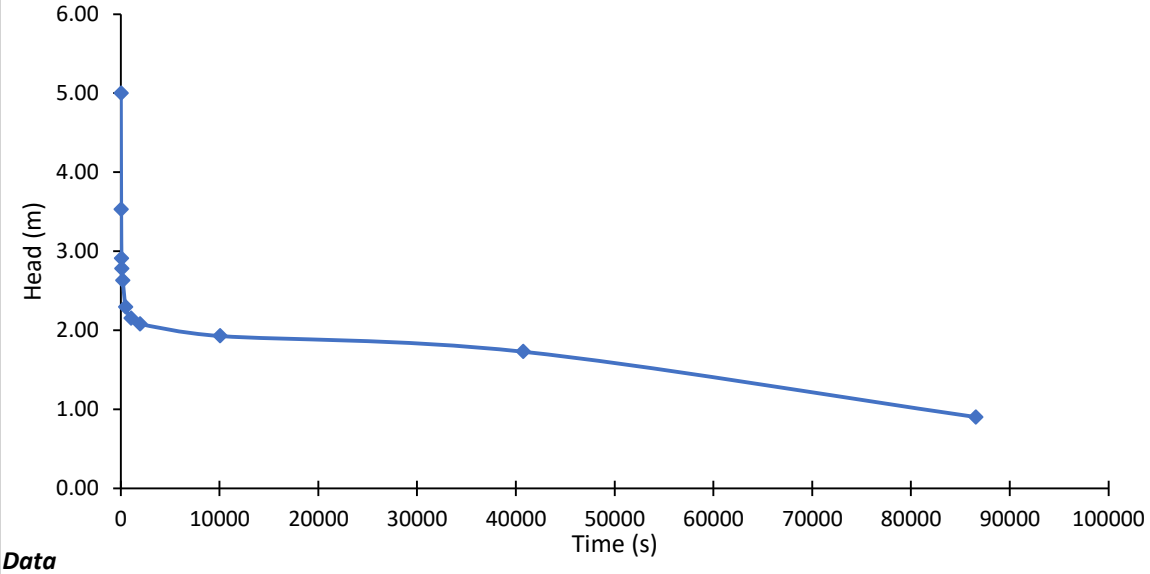
Note: CMW considers the CIRIA 113 value the most appropriate method for most purposes, but also provides the analysis method as outlined by Hvorslev if desired.

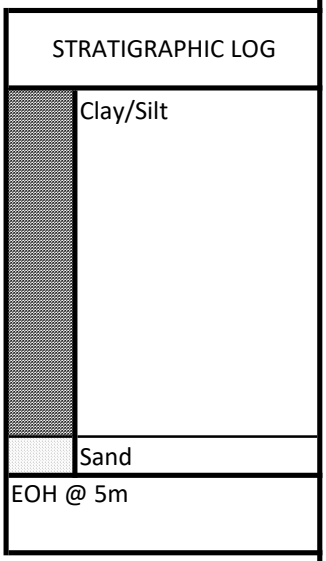
CIRIA 113: Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

$$k = \left(log\frac{h_1}{h_2} - log\frac{2h_1 + d}{2h_2 + d} \right) . \frac{(h_1 + h_2)}{2(t_2 - t_1)} =$$ 4.07E-05 ms^{-1} = 3.51 m/day

Hvorslev: Hvorslev (1951) *Time Lag and Soil Permeability in Ground-Water Observations* , Fig 18, p49

$$k = \frac{d^2 \, ln\left(\frac{mL}{d} + \sqrt{\left(\frac{mL}{d}\right)^2 + 1} \right)}{8L(t_2 - t_1)} ln\frac{H_1}{H_2} =$$ 2.54E-06 ms^{-1} = 0.22 m/day



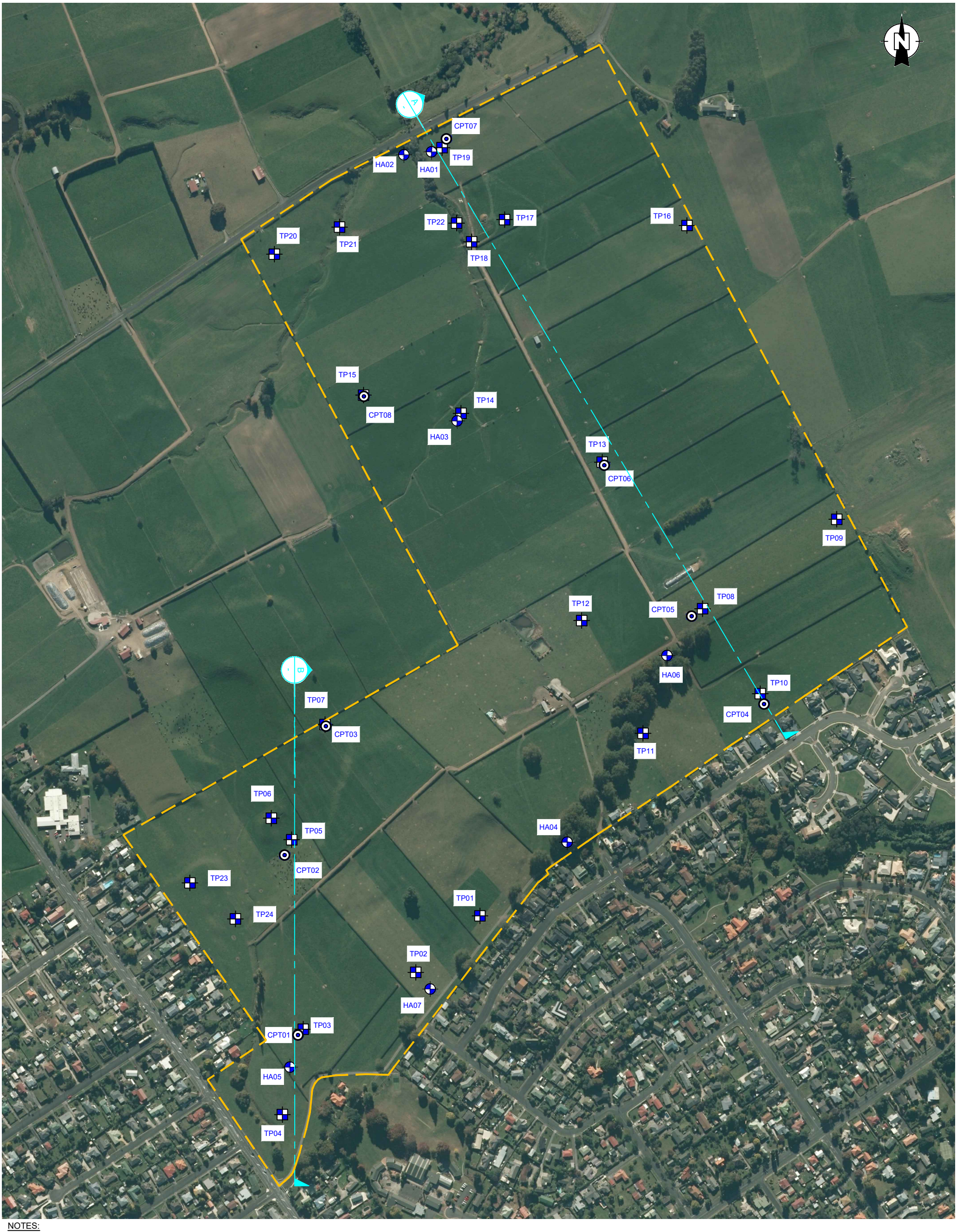


Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	5.000				
30	1.469	3.531	4.266		1.25E-05	2.29E-04
60	2.088	2.912	3.222		8.63E-06	1.25E-04
90	2.218	2.782	2.847		2.24E-06	2.92E-05
180	2.369	2.631	2.707		9.48E-07	1.19E-05
480	2.705	2.295	2.463		7.51E-07	8.79E-06
1020	2.847	2.153	2.224		2.09E-07	2.26E-06
1920	2.918	2.082	2.117		6.91E-08	7.18E-07
10020	3.072	1.928	2.005		1.81E-08	1.81E-07
40715	3.270	1.730	1.829		7.24E-09	6.75E-08
86525	4.098	0.902	1.316		3.69E-08	2.87E-07

The hydraulic conductivity values above are calculated as an average across the whole data set. Any designer using these values may consider the raw data and other calculation methods, and must satisfy themselves as to their suitability.

Appendix C: Previous Investigation Data



NOTES:

1. BASE IMAGE ADAPTED FROM 2012 - 2013 WAIKATO AERIAL PHOTO SOURCED FROM LAND INFORMATION NEW ZEALAND (LINZ) ONLINE MAPS.
2. TEST LOCATIONS ARE APPROXIMATE ONLY.

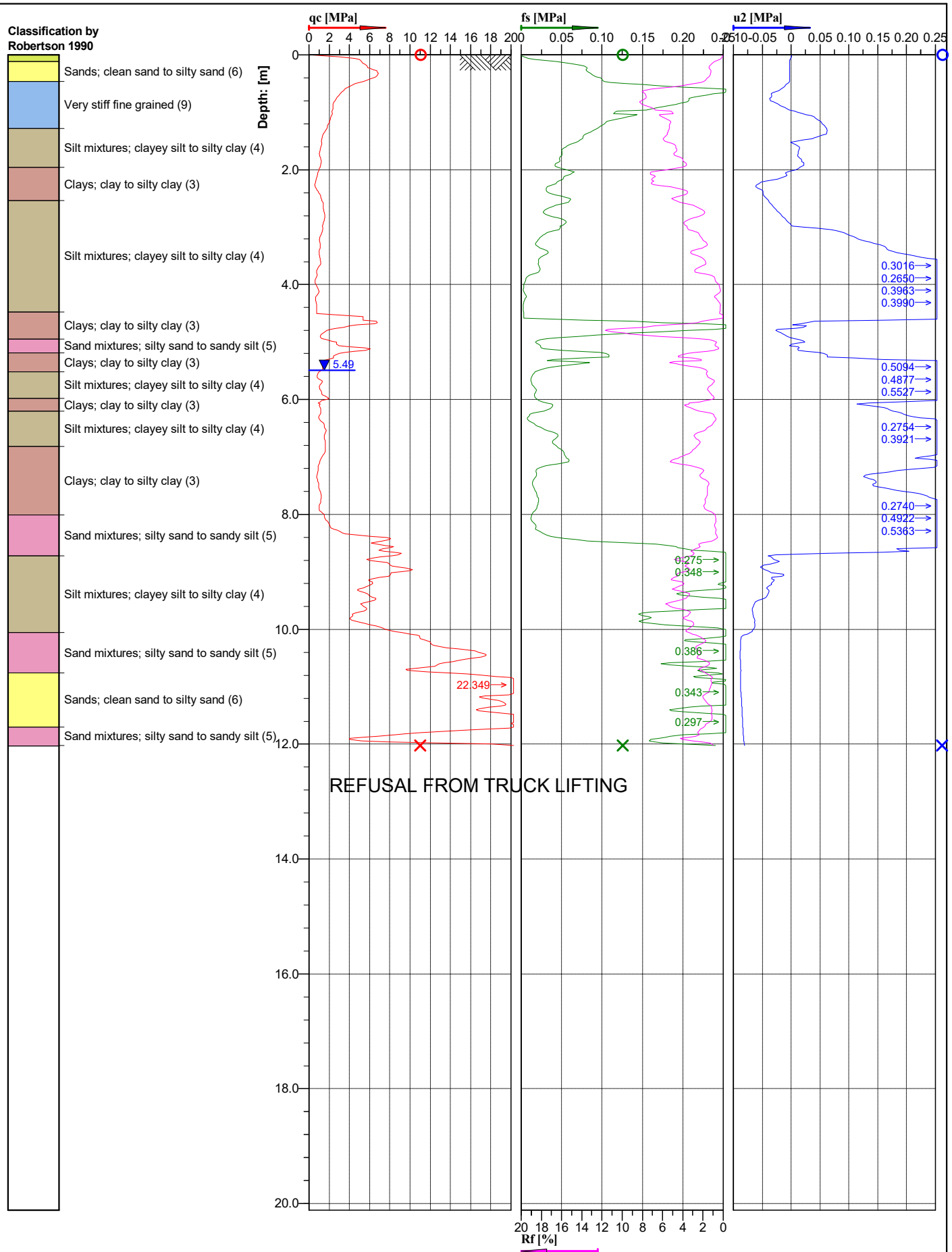
1:5000 0 50 100 150 200 250 m

LEGEND:

- CPT01 CONE PENETROMETER TEST (CPT) LOCATION
- TP01 TEST PIT (TP) LOCATION
- HA01 HAND AUGER (HA)/ SOAKAGE TEST LOCATION
- SITE BOUNDARY
- CROSS SECTION LOCATION

CMW Geosciences

CLIENT: LOCKERBIE ESTATES LTD		DRAWN: WPJ	PROJECT: HAM2018-0139
PROJECT: LOCKERBIE FARM DEVELOPMENT STUDHOLME STREET, MORRINSVILLE		CHECKED: EJE	DRAWING: 01
		REVISION: E	SCALE: 1:5000
TITLE: SITE INVESTIGATION PLAN		DATE: 05/04/2019	SHEET: A3

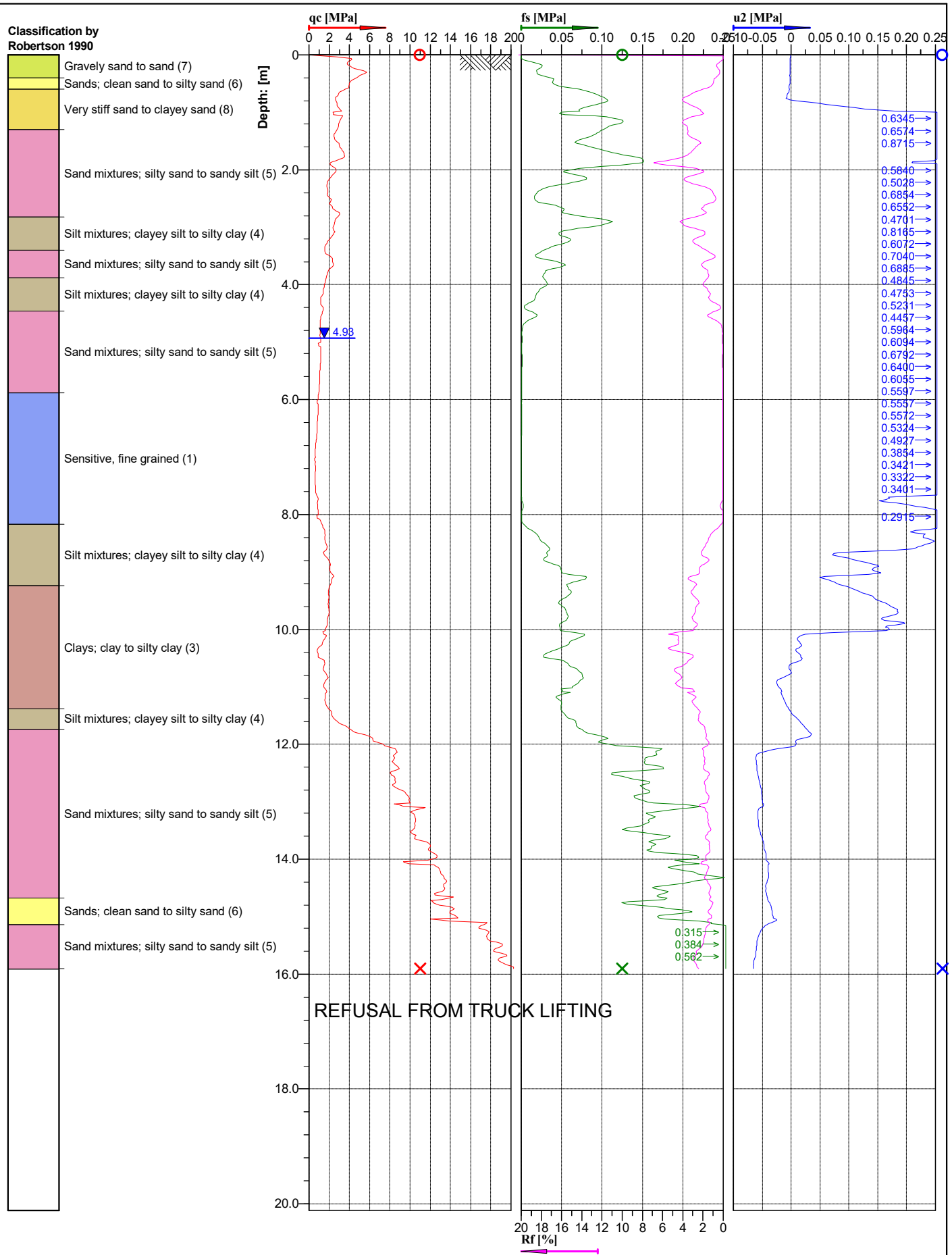


Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT03
Project ID: HAM104562	Client: CMW GEOSCIENCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.64417 E 175.52171		File: CPT03.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150



Location: MORRINSVILLE	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT08
Project ID: HAM104562	Client: CMW GEOSCIENCES	Date: 22/01/2019	Scale: 1 : 89
Project: 162 STUDHOLME ST		Page: 1/1	Fig.:
S 37.63993 E 175.52228		File: CPT08.cpt	

GEOTECH DRILLING

u2

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Appendix D: Natural Hazards Risk Assessment

NATURAL HAZARDS RISK ASSESSMENT FOR LAND SUBDIVISION DAVE'S FARM, LOCKERBIE ESTATE DEVELOPMENT, MORRINSVILLE-TAHUNA ROAD, MORRINSVILLE

A. CONTEXT

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence).

Section 2 of the RMA defines natural hazards as any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding) the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment.

This appendix to CMW report reference HAM2021-0060 Rev0 sets out the criteria for and presents the results of an assessment of the following geotechnical-related natural hazards associated with this proposed subdivision development:

(a) Earthquake;
(b) Erosion;
(c) Landslip;
(d) Subsidence.

B. BASIS OF ASSESSMENT

B1. Risk Classification

The occurrence of natural hazards and their potential impacts on the proposed subdivision development is assessed in terms of risk significance, which is based on likelihood and consequence factors. A risk table is used to help assess the likelihood and consequence factors, the form of which used by CMW for this project is presented in Table B1.

Table B1: Natural Hazard Risk Classification

		Consequence				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	Almost Certain 5	Medium 5	High 10	Very high 15	Extreme 20	Extreme 25
	Likely 4	Low 4	Medium 8	High 12	Very high 16	Extreme 20
	Moderate 3	Low 3	Medium 6	Medium 9	High 12	Very high 15
	Unlikely 2	Very low 2	Low 4	Medium 6	Medium 8	High 10
	Rare 1	Very low 1	Very low 2	Low 3	Low 4	Medium 5

B2. Likelihood

With respect to assessing the likelihood or chance of the risk occurring, the qualitative definitions used by CMW for this project are provided in Table B2 for each likelihood classification.

Table B2: Qualitative Natural Hazard Likelihood Definitions		
1	Rare	The natural hazard is not expected to occur during the design life of the project
2	Unlikely	The natural hazard is unlikely, but may occur during the design life
3	Moderate	The natural hazard will probably occur at some time during the life of the project
4	Likely	The natural hazard is expected to occur during the design life of the project
5	Almost Certain	The natural hazard will almost definitely occur during the design life of the project

B3. Consequence

In terms of determining the consequence or severity of the natural hazard occurring, the qualitative definitions used by CMW for this project are provided in Table B3 for each consequence classification.

Table B3: Qualitative Natural Hazard Consequence Definitions		
1	Insignificant	Very minor to no damage, not requiring any repair, no people at risk, no economic effect to landowners.
2	Minor	Minor damage to land only, any repairs can be considered normal property maintenance no people at risk, very minor economic effect.
3	Moderate	Some damage to land requiring repair to reinstate within few months, minor cosmetic damage to buildings being within relevant code tolerances, does not require immediate repair, no people at risk, minor economic effect.
4	Major	Significant damage to land requiring immediate repair, damage to buildings beyond serviceable limits requiring repair, no collapse of structures, perceptible effect to people, no risk to life, considerable economic effect.
5	Catastrophic	Major damage to land and buildings, possible structure collapse requiring replacement, risk to life, major economic effect or possible site abandonment.

B4. Risk Acceptance

It is recognised that the natural hazard risk assessment provided herein is qualitative and, due to the wide range of possible geohazards that could occur, is somewhat subjective. Other methods are available to quantitatively assess an acceptable level of geotechnical related natural hazard risk, such as defining an acceptable factor of safety with respect to slope stability or acceptable differential ground settlements with respect to recommended building code limits.

Therefore, to give this qualitative natural hazard risk assessment some relevance to more commonly adopted numerical or quantitative geotechnical assessment techniques, a residual risk rating of very low

to medium (risk value = 1 to 9 inclusive) is considered an acceptable result for the proposed subdivision development.

A risk rating of high to extreme (risk value ≥ 10) is considered an unacceptable result for the proposed subdivision development.

C. RISK ASSESSMENT

The natural hazards relevant to this proposed subdivision development have been assessed with respect to the criteria outlined above.

Assessment is based on pre and post development ground conditions. The latent risk was first assessed with the site in its current undeveloped state to consider the natural landform within and surrounding the proposed development. The specific geotechnical mitigation measures and engineering design solutions outlined in the CMW report, where relevant, were then considered to determine the natural hazard residual risk remaining after the proposed development works have been completed.

Results of this assessment are presented in Table C1 below.

Table C1: Natural Hazard Risk Assessment Results

RMA S2 Hazard	Description	Undeveloped Site Latent Risk			Comments and Geotechnical Control	Developed Site Residual Risk		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Earthquake	Fault Rupture	N/A - No known active faults within or in close proximity to the site.						
	Liquefaction	2	1	Very Low 2	Foundation design	2	1	Very Low 2
	Lateral spread	2	1	Very Low 2	Low risk – review final site layout	1	1	Very Low 1
Erosion	Cut batters	N/A			Max 1:3 gradient	2	2	Low 4
	Fill batters	N/A			Stormwater control / benches / geotextiles / gradient control	2	2	Low 4
Landslip	Global stability	2	2	Low 4	Slope gradients to be reduced during earthworks	1	2	Very Low 2
	Soil creep	3	2	Med 6	Slope gradients to be reduced during earthworks	1	2	Very Low 2

	Bearing Capacity Failure	2	2	Low 4	Undercut and replace weak soils if encountered	1	2	Very Low 2
	Cut & Fill batter stability	N/A			Engineering design of slopes	1	4	Low 4
Subsidence	Expansive soils	2	3	Med 6	Foundation design.	1	3	Low 3
	Sinkholes	2	2	Low 4	Identify and remove if encountered during earthworks	1	4	Low 4
	Soft Soils	2	2	Low 4	Identify and address if encountered during earthworks	1	4	Low 4
Sedimentation	Inundation	3	2	Med 6	Stormwater drainage design	1	4	Low 4