



**REPORT ON:  
GEOTECHNICAL ASSESSMENT**

**PROJECT:  
160 EVENDEN ROAD,  
TWYFORD 4175**

CLIENT: HAMACHEK HOLDING LTD

Revision table

Revision	Description	Date	Signature
230850-01	Report Issued	11/12/23	
230850-0	Report revised to reflect new layout	13/03/25	

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## EXECUTIVE SUMMARY

Infir on behalf of Hamacheck Holdings Ltd engaged Resource Development Consultants Ltd (RDCL) to undertake a geotechnical assessment for construction of a service station and retail facility at 160 Evenden Road, Twyford.

The findings of this geotechnical investigation identify:

- Minor to Moderate global lateral movement ( $\leq 441$ mm lateral spread) under ULS scenario at distances greater than 15 m from the stormwater detention basin;
- 150 mm of vertical settlement under ULS scenario;
- Shallow groundwater table at 0.9 m bgl;
- 150kPa UBC available from 0.3 m bgl; and,
  - At a level clear of topsoil and unsuitable material,
- 300kPa UBC available from 1.2 m bgl.

To mitigate the risk of lateral spread:

- A specifically engineered designed inground wall is required.

Then, we consider the following foundation suitable:

- A 0.8 m thick reinforced gravel raft with Specific Engineered Designed (SED) foundations.

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## **1 OVERVIEW**

Infir on behalf of Hamachek Holdings Ltd (the client) engaged Resource Development Consultants Ltd (RDCL) to undertake a geotechnical assessment for the construction of a service station and retail facility at 160 Evenden Road, Twyford.

Geotechnical investigation and report are required to support the Structural / Civil design and to submit with application for resource consent with Hastings District Council (HDC).

### **1.1 OUR UNDERSTANDING OF THE PROJECT**

RDCL understand the client intends to construct a service station and retail facility on the corner of State Highway Two (SH2) and Evenden Road.

The client has provided plans for the proposed development, received 12<sup>th</sup> February 2025.

The plans show:

- 468 m<sup>2</sup> Canopy;
- 1580 m<sup>2</sup> Wastewater disposal field;
- 10,390 m<sup>2</sup> Sealed and paved areas;
- 297m<sup>2</sup> Service station shop;
- 303 m<sup>2</sup> Seasonal fruit sales area;
- 305 m<sup>2</sup> Café;
- 6,813 m<sup>2</sup> Stormwater detention area;
- Hydrogen compound; and
- Access off Evenden Road along the western boundary.

### **1.2 SCOPE OF WORK**

Work was undertaken in general accordance with RDCL proposal 230850, dated 5<sup>th</sup> October 2023.

## **2 RELEVANT GUIDELINES AND STANDARDS**

Geotechnical investigation and assessment have been undertaken in accordance with:

- Hastings District Council (June 2019); Geotechnical Site Investigation Guidelines for Residential Building Consents.
- Ministry for Business, Innovation and Employment (MBIE) (2021) Module 1: Overview of the guidelines - Earthquake geotechnical engineering practice
- Ministry for Business, Innovation and Employment (MBIE) (2016) Module 2: Geotechnical Investigations for Earthquake Engineering.
- NZGS (2005) Guidelines for Field Description of Soil and Rock.
- NZS1170.5:2004, part 5: Earthquake Actions – New Zealand.
- Standards New Zealand (2011). *Timber-framed Buildings*. NZS 3604:2011. Wellington: Standards New Zealand.
- Ministry of Business, Innovation and Employment (MBIE) guidelines, revised issue of Repairing and Rebuilding House Affected by the Canterbury Earthquakes. Part A: Technical Guidance (TC1 and TC2) version 3 (December 2012).
- NZ Building Code Clause B1 Structure, 1st edition, Amendment 20.

### 3 SITE DESCRIPTION

The site is located on the corner of Evenden Road and SH2 on relatively flat ground. The neighbouring area generally comprises of orchards.

Ngaruroro River is located approximately 1.3km to the northeast. There are multiple existing dwellings situated to the northeast of the section, which are going to be demolished.

The Legal description of the site is SECT 7 SO 479817.

#### 3.1 PUBLISHED GEOLOGY

Regional geological maps (GNS Science, 2023) indicate the proposed development is underlain by Holocene River deposits comprising:

- Poorly consolidated alluvial gravel, sand, mud and gravel.

A review of HBRC Well Database indicated wells #8416 and #1006 within 150m of the site with lithology as in Table 1.

**TABLE 1: REGIONAL WELL LITHOLOGY**

Depth		Material Description
From (m)	To (m)	
0	1.5 - 2.9	Topsoil
1.5 - 2.9	12.8 – 14.1	Clay with sand
12.8 – 14.1	14.3 – 21.6	Gravel
14.3 – 21.6	29.3 - 31	Clay and Sand mixtures
29.3 - 31	34.1	Gravel

### 3.2 SUMMARY OF POTENTIAL GEOHAZARDS

A summary of potential geological hazards present on site is in Table 2. The risk assessment is based on a review of Hawke’s Bay Hazard Portal (2023) and our geotechnical investigations.

TABLE 2: SUMMARY OF POTENTIAL NATURAL HAZARDS

Geohazard	Risk	Risk Summary
Active Faults	Low	No “known” active faults directly impacting the site. Awanui fault located ~8.2km southwest of the site.
Liquefaction Susceptibility	High	The proposed platform is mapped as “High” liquefaction induced risk.
Ground Shaking	Medium	Medium earthquake amplification due to underlying geology.
Coastal Hazards	No Risk	The property is inland.
Flood and Ponding Risk	At risk	The proposed platform is at risk of flooding where: <ul style="list-style-type: none"> <li>• Flood return Period of 50 years; with</li> <li>• Flood level of 16m.</li> </ul>
HDC Provisional Land Category Risk	1 (Low)	The proposed development is categorized as 1, “Repair to previous state is all that is required to manage future severe weather event risk in accordance with HDC.
Slope Stability	Low	The site is outside zone mapped for slope stability hazard and is located on relatively flat ground.
Shrink Swell Soils	Low	Underlain by silts, sands and clay mixtures of Holocene which are not susceptible to shrink swell.

## **4 SUBSOIL INVESTIGATION**

### **4.1 SUBSURFACE INVESTIGATION**

Sub-surface testing completed for this investigation comprise of (Figure 1):

- Six (6) Cone Penetrometer Tests (CPT):
  - Terminated between ~4.0 m to ~14.5 m bgl.
- Seven (7) Hand Augers:
  - Terminated between 1.5 m and 2.0 m bgl.
- Nine (9) Dynamic Cone Penetrometers (DCP):
  - Terminated between 1.9 m and 2.9 m bgl.

Materials encountered from HA investigations are logged in accordance with NZGS guidelines for rock and soil description (NZGS, 2005). The subsurface investigations logs are attached in Appendix A.

### **4.2 HDC (JUNE 2019) SITE INVESTIGATION GUIDELINE COMPLIANCE**

The site is classified within “high” liquefaction vulnerability (Hawke’s Bay Emergency Management Group hazard portal, 2023), requiring “deep” investigation to depths between 10 m -15 m bgl. This is in accordance with HDC guidelines for geotechnical testing.

All CPT’s except one (CPT01) penetrated to full depth.

The maximum depth reached in CPT01 is 4.0m bgl. CPT01 termination was due to anchor failure indicating a dense material.

We believe the ground model as assessed provides understating sufficient confidence to allow specification of foundations to meet the requirements of the building code clause B1 structural.

### 4.3 SHALLOW SUBSOIL PROFILE

Results of subsurface investigation are shown in the Table 3.

**TABLE 3: SUMMARY OF GROUND CONDITIONS**

Depth (m bgl)		Description	Consistency / Density
From	To		
0	~0.3	Topsoil	Firm
~0.3	1.5	Sandy Silt	Firm
1.5	2.0	Sand / Silty Sand	Medium Dense
2.0*	14.5	Silt and Sand Mixtures with interbedded layers of Clay and Silty Clay	Medium Dense / Stiff

\*Inferred from CPT data.

### 4.4 GROUND WATER

Ground water was encountered at 0.9 m bgl during field investigations (HA03).

## **5 GEOTECHNICAL ASSESSMENT**

### **5.1 SHALLOW BEARING CAPACITY**

Nine (9) DCP tests were completed to provide a preliminary indication of Ultimate Bearing Capacity (UBC). Results of the investigation shows, at the locations tested:

- 150 kPa UBC is available from 0.3 m bgl;
  - At a level clear of topsoil and unsuitable material.
- 300 kPa UBC is available from 1.2 m bgl.

DCP test results have been correlated to UBC in accordance with Stockwell (1977).

DCP logs are attached as Appendix A.

### **5.2 SEISMIC SOIL CLASSIFICATION**

The site subsoil class is estimated “Class D – Deep Soil Site” in accordance with NZS1170.5:2004, part 5: Earthquake Actions – New Zealand.

The site subsoil class was assessed based on an estimate to the depth of bedrock and based on regional geology and HBRC well database (Wells #8416 and #1006).

### **5.3 LIQUEFACTION ASSESSMENT**

#### **5.3.1 BASIS OF ASSESSMENT**

Liquefaction assessment for the site was based on CPT investigations and assessed using program CLiq, accepted industry software package (Geologismiki, 2022) using input parameters in accordance with MBIE Earthquake Geotechnical Engineering Practice in New Zealand. Module 1. Overview of guidelines (November 2021):

- Magnitude (M) = 6.4 (SLS), & 7.1 (ULS).
- Peak Ground Acceleration (PGA) = 0.12g (SLS) & 0.78g (ULS),
- Water table at modelled at 0.9 m bgl;
- A 50-year design life; and
- Importance Level 3 (IL3).

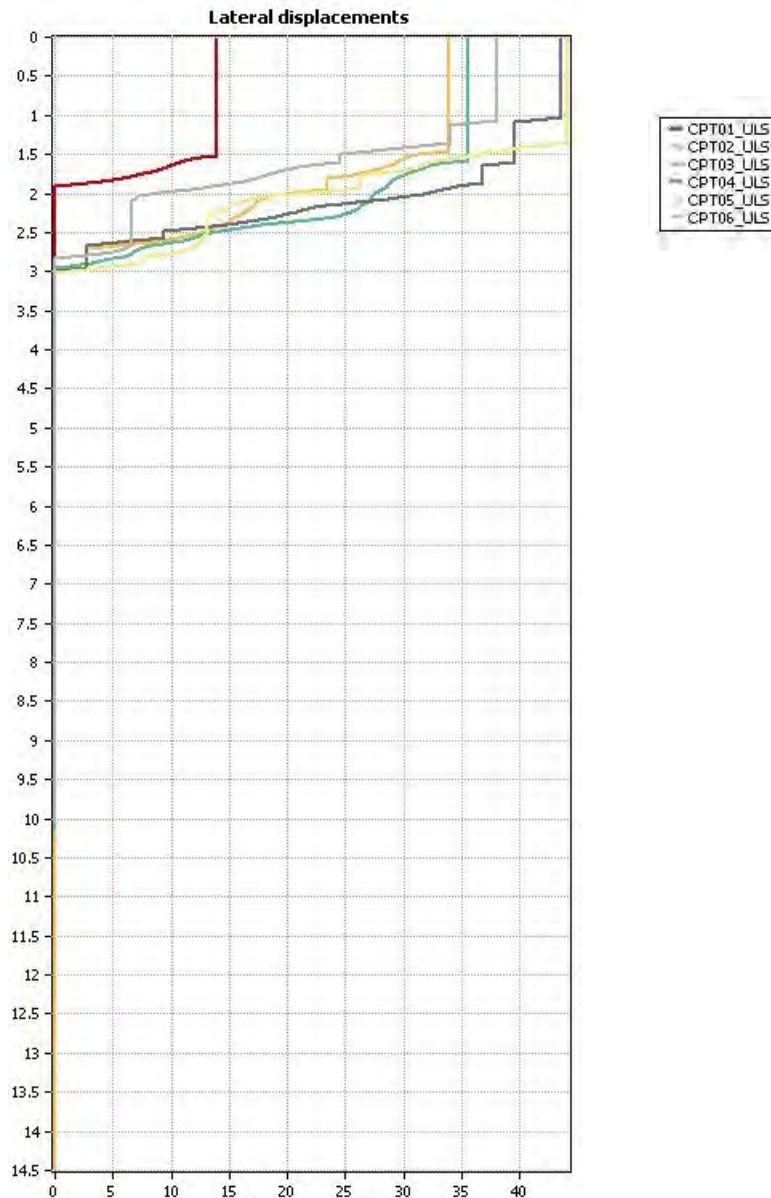
### 5.3.2 LATERAL SPREAD

From correlated Soil Behaviour Type the underlain soils are relatively consistent across the entire site. A lateral spread assessment was performed on the results of the CPT investigation (Appendix B), accounting for the elevation difference (~1.5m) and assumed distance of 15m and the stormwater detention basins.

Results indicate:

- Major to Severe global lateral movement is expected within 15 m from the stormwater detention basin;
  - $\geq 400\text{mm}$  of lateral spread during ULS event; and
  - Magnitude of lateral spread decrease with more distance from the basin.

FIGURE 1: CPT LATERAL DISPLACEMENTS



**5.3.3 OVERALL LIQUEFACTION RISK**

A liquefaction assessment was carried out using the results of CPT investigations and industry standard software CLiq (Appendix B). Assessment is based on the two limit states that are defined by AS/NZ 1170.0:2002; the Serviceability Limit State (SLS) and the Ultimate Limit State (ULS).

Based on this assessment this site is likely to liquefy during ULS design seismic events.

Summary of the assessment is presented in Table 4 and full details are at Appendix B.

**TABLE 4:LSN AND ESTIMATED VERTICAL SETTLEMENT**

<b>CPT ID</b>	<b>Liquefaction Severity (LSN)</b>	<b>Vertical Settlement (mm)</b>	<b>Lateral Spread (mm)</b>
CPT01_SLS	Little to no expression	Negligible	Negligible
CPT02_SLS		14	
CPT03_SLS		Negligible	
CPT04_SLS		18	
CPT05_SLS		12	
CPT06_SLS		21	
CPT01_ULS	Moderate expression	11	140
CPT02_ULS		93	339
CPT03_ULS		72	355
CPT04_ULS		90	436
CPT05_ULS		84	441
CPT06_ULS		89	380

## 6 GEOTECHNICAL RECOMMENDATIONS

Recommendations and opinions contained in this report are based on data from site investigations in Section 4 and geotechnical assessment as outlined in Section 5.

Inferences about the nature and continuity of subsurface geology and ground conditions are made but cannot be guaranteed.

### 6.1 GEOTECHNICAL SUITABILITY FOR DEVELOPMENT

Based on this geotechnical investigation we consider the proposed development is suitable from a geotechnical perspective, considering the geotechnical risks present at the site:

- Major global lateral movement ( $\leq 441$  mm lateral spread) under ULS scenario at distances  $\sim 15$  m from the stormwater detention basin;
- $\sim 90$  mm of vertical settlement under ULS scenario;
- Shallow groundwater table at 0.9m bgl;
- 150kPa UBC available from 0.3m bgl; and
- 300 kPa UBC is available from 1.2 m bgl.

### 6.2 LATERAL SPREAD MITIGATION

#### 6.2.1 INGROUND PALISADE WALL

To protect the proposed Structures against liquefaction induced damage, a specifically engineered designed inground wall is required.

As a guidance to help envisage the wall, following design is likely to be suitable, comprising of:

- Timber SED poles, nominally 300mm diameter,
- Minimum Embedment depth of  $(2 \times Basin Height) + 0.5m$ ;
- Driven on a closely spaced “dice-5” pattern, to
- Form an inground wall:
  - Extending along the line of the stormwater basin adjacent to structures; and,
  - Situated a minimum 5m from the structures.

The concept of the inground wall is to densify the ground sufficient that it will not liquefy. The non-liquefied wall then acts to restrict any liquefaction induced displacement, and to protect the structures.

### **6.3 PRELIMINARY FOUNDATION RECOMMENDATIONS**

Following installation of an inground wall, we consider the following foundation is suitable:

- A 0.8 m thick reinforced gravel raft with Specific Engineered Designed (SED) foundations.

For the gravel raft:

- The excavation base must extend 0.8 m below current ground level;
  - Where 200 kPa UBC is available; and
  - At least 1.0 m horizontal distance outside the foundation footprint.

The reinforced gravel raft should be constructed according to the following specifications:

- Placement of layer of geotextile filter cloth (Strength Class C) is placed at the base of the excavation and wrapped up the sides;
- Placement of one layer of geogrid:
  - The layer placed directly on the filter cloth (at the base), flat and pulled taught with overlap as per manufacturer specifications.
- Hard fill placed in accordance with NZS4431:2022 (Standards New Zealand, 2022); and
  - Well graded granular material such as AP40 or AP65 should be used;
  - Material is placed in 200 mm lifts and each lift must be compacted;
  - Compacted to 95% of the maximum dry density (MDD) at optimum water content.

This is Option 1 in Section 5.3.1 in MBIE guidelines Part A.

### 6.3.1 ALTERNATIVE FOUNDATION OPTION

Due to the distance of the structures from the stormwater detention basin, an alternative foundation option may be to protect the structures in the immediate vicinity of the basin with an in-ground wall while allowing for deformation within the pavement and recreational areas during a ULS event.

In this case, we recommend a design meeting with the project's structural engineer before designing the foundations to agree on a viable solution.

## 6.4 PAVEMENT DESIGN RECOMMENDATIONS

The proposed access alignments, as shown on the development concept plan appear generally suitable from a geotechnical perspective;

As it relates to development of the access and pavement area:

- A Californian Bearing Ratio (CBR) of 3% is generally available from subgrade stripped of topsoil (nominally 0.3m bgl).
- Appropriate surfacing of roadways needs to consider subgrade conditions, drainage, likely traffic loads (especially construction loads during house building), and importantly maintenance over the long term;
  - Subgrade should be stripped of all organic loose and unsuitable materials;
- The carriageway should be shaped to manage surface water flows in a controlled manner, including at a minimum:
  - A well-defined "table drain" on the inside of the access-way.

## 6.5 UNDER GROUND SERVICES

Underground services such as stormwater, water pipes and wastewater should be:

- Designed in accordance with section 5.7 of MBIE guidelines Part A.
- To make sure the installation process is not affecting the integrity of the gravel raft and geofabric reinforcement.
- Due to the potential for lateral movement all underground service lines should be connected with flexible connections allowing up to 150mm differential movement.

## 6.6 FURTHER GEOTECHNICAL ASSESSMENT

Geotechnical inspections are required during construction for certification and issue of a PS4 Producer Statement. These inspections may include the following:

- Inground wall design,
- Excavation Inspection (Geotechnical Engineer),
- Independent compaction testing (NDM),
- Verification of Compaction tests (Geotechnical Engineer); and
- Issue of Producer Statement (PS4); Geotechnical Engineer.

## 7 REFERENCES

1. GNS Science (2023). *New Zealand Geology Web Map 1:250K Geology*. [online] Available at: <https://data.gns.cri.nz/geology/>
1. GNS Science (2022). *New Zealand Active Faults Database: Active Faults 250K*. [online] Available at <https://data.gns.cri.nz/af/>
2. Hawke's Bay Emergency Management Group (HBEMG) (2023). *Hawke's Bay Natural Hazards Database*. [online] Available at <https://gis.hbrc.govt.nz/Hazards/>
3. NZGS (2005): *Field Description of Soil and Rock: Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*.
4. Standards New Zealand (2022). *Code of Practice for Earth fill for Residential Development*. NZS4431:2022. Wellington: Standards New Zealand.
5. Standards New Zealand (2011). *Timber-framed Buildings*. NZS 3604:2011. Wellington: Standards New Zealand
6. Stockwell, M. (1977). *Determination of allowable bearing pressure under small structures*. New Zealand Engineering, 32(6), pp.132-135.
7. Ministry of Business, Innovation and Employment MBIE (2021) Earthquake Geotechnical engineering practice: Module 1. Overview of the guidelines.
8. Ministry of Business, Innovation and Employment MBIE (2021) Earthquake Geotechnical engineering practice: Module 6. Earthquake resistant retaining wall design.

## 8 LIMITATIONS

- This report has been prepared for the particular purpose outlined in the project scope and no responsibility is accepted for the use of any part in other contexts or for any other purpose.
- Ground conditions assessed in this report are inferred from published sources, site inspection and the investigation described. Variations from the interpreted conditions may occur, and special conditions relating to the site may not have been revealed by this investigation, and which are therefore not taken into account. No warranty is included either expressed or implied that the actual conditions will conform to the interpretation contained in this report.
- No responsibility is accepted by Resource Development Consultants Ltd for inaccuracies in data supplied by others. Where data has been supplied by others, it has been assumed that this information is correct.
- Groundwater conditions can vary with season or due to other events. Any comments on groundwater conditions are based on observation at the time.
- This report is provided for sole use by the client and Hastings District Council and is confidential to the client and their professional advisors. No responsibility whatsoever for the contents of this report shall be accepted for any person other than the client.

We trust this meets your current needs. Should you wish to discuss any aspect of the contents of this document please contact the undersigned on 06 877-1652.

Sincerely,

Prepared by:



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H Carrington  
BEng (Hons), MEng NZ  
Geotechnical Engineer

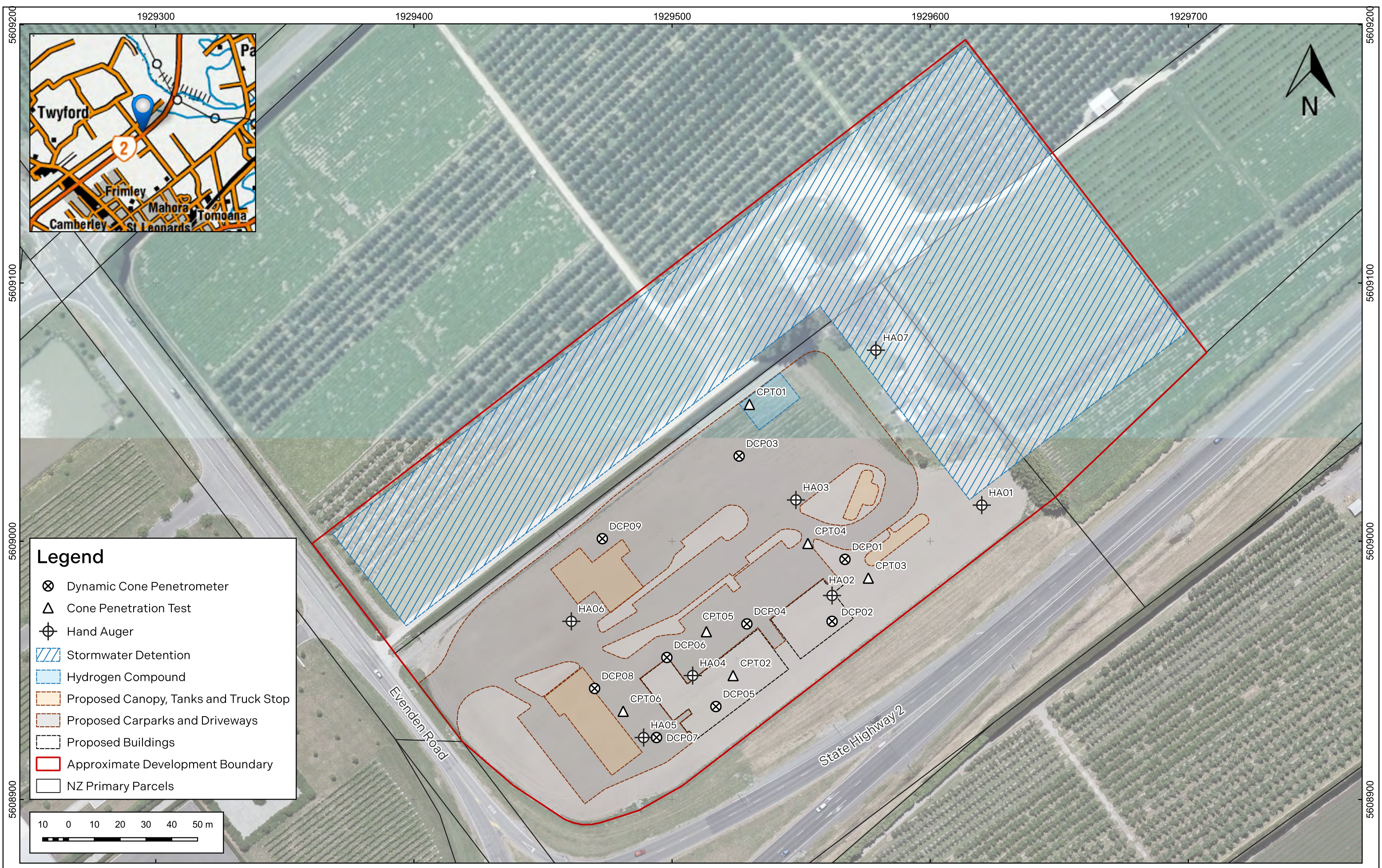
Approved by:



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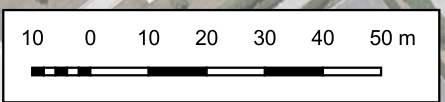
CA Wylie  
MSc; MIPENZ, CPEng  
Principal

**FIGURE 2: SITE INVESTIGATION LAYOUT**



**Legend**

- ⊗ Dynamic Cone Penetrometer
- △ Cone Penetration Test
- ⊕ Hand Auger
- ▨ Stormwater Detention
- ▭ Hydrogen Compound
- ▭ Proposed Canopy, Tanks and Truck Stop
- ▭ Proposed Carparks and Driveways
- ▭ Proposed Buildings
- ▭ Approximate Development Boundary
- ▭ NZ Primary Parcels



Title	Site Investigation Plan	Drawn By	ID	Date	17/02/25	A3
Project	240850_160 Evenden Road, Twyford	Checked By	BB	Date	17/02/25	
Client	Hamachek Holdings Ltd	Approved By	BB	Date	17/02/25	Figure 1

## **APPENDIX A: SITE INVESTIGATION LOGS**



**RDCL**

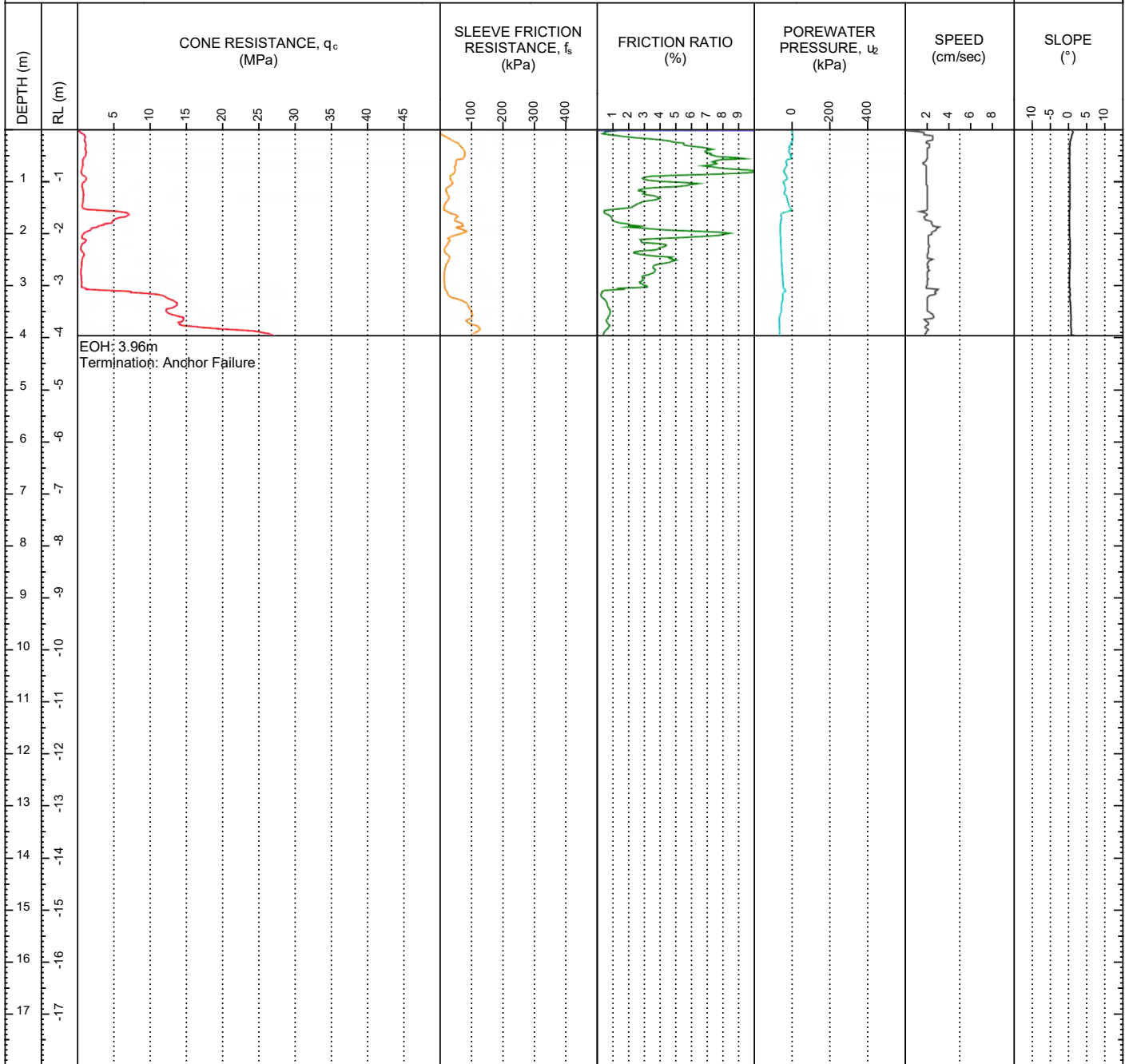
# CONE PENETRATION TEST LOG

## CPT01

SHEET 1 OF 1

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929530.00	LOGGED ON: 25/10/2023 12:00:00 am
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5609053.00	PREPARED BY: ID      DATE: 17/11/2023
OFFICE: RDCL - Hastings	ELEVATION: -	CHECKED BY: HC      DATE: 21/11/2023
	DATUM: NZVD2016	STATUS: Final data

CONTRACTOR: RDCL      MACHINE: Geoprobe 54LT, Max Push Capacity      OPERATOR: PR



<b>CONE INFORMATION</b>		<b>REMARKS</b>
CONE ID: 5940	CONE TYPE: Piezo cone (TE2, U2)	
CONE INFO: Geotech AB Nova, 10cm2, Penetrometer Class: ISO Class1, C		<b>SYMBOLS</b> ▼ Water level
	INITIAL      FINAL	
CONE RESISTANCE:	7.0395      -0.0147	
SLEEVE FRICTION RESISTANCE:	107.3      0	
POREWATER PRESSURE:	269      -2.3	



**RDCL**

# CONE PENETRATION TEST LOG

## CPT02

SHEET 1 OF 1

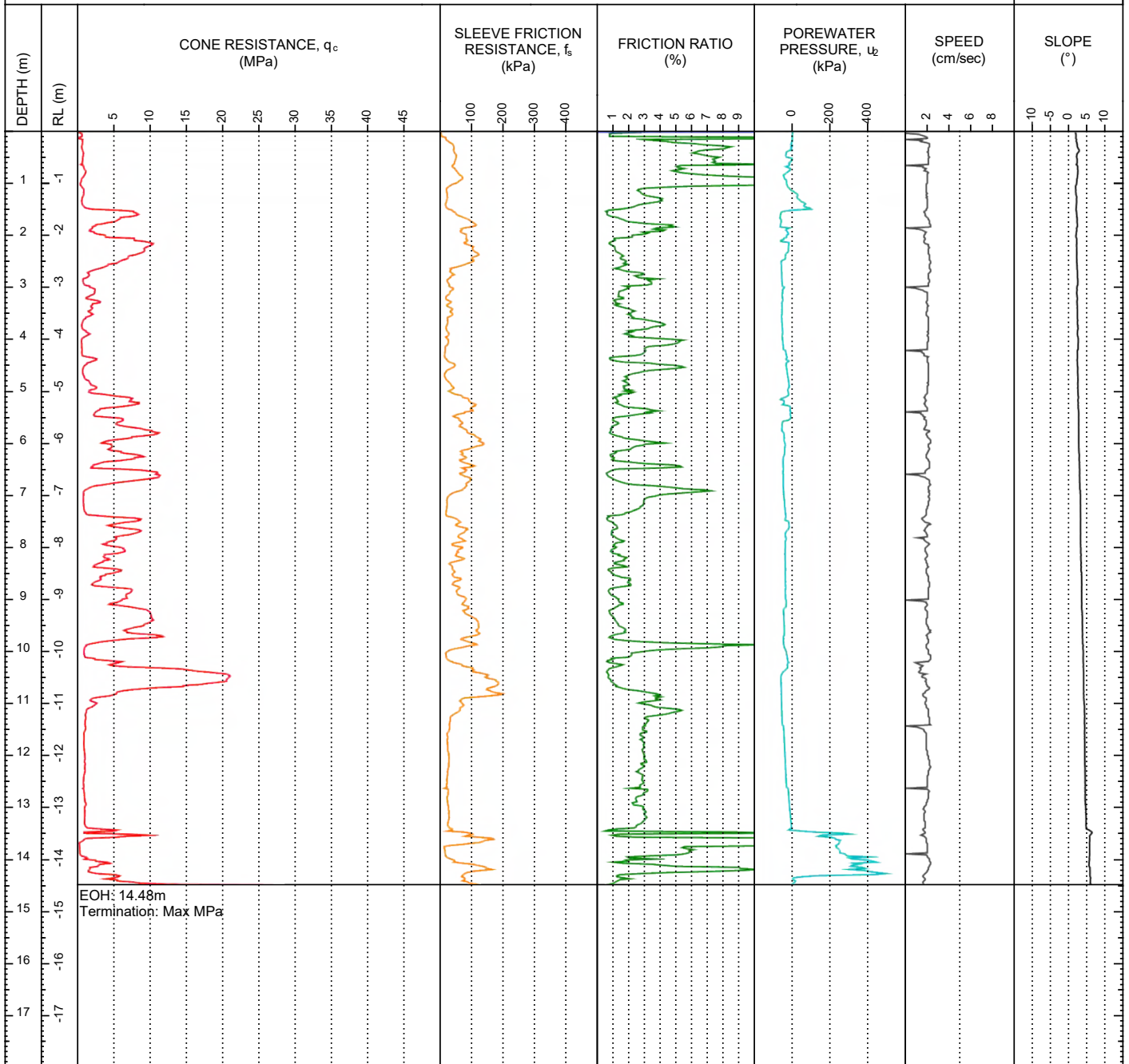
CLIENT: Hamachek Holdings Ltd  
 PROJECT: 230850  
 LOCATION: 160 Evenden Road,  
 Twyford 4175  
 OFFICE: RDCL - Hastings

PROJECTION: NZTM2000  
 EASTING: 1929523.66  
 NORTHING: 5608947.99  
 ELEVATION: -  
 DATUM: NZVD2016

SUB-LOCATION:  
 LOGGED ON: 25/10/2023 12:00:00 am  
 PREPARED BY: ID DATE: 17/11/2023  
 CHECKED BY: HC DATE: 21/11/2023  
 STATUS: Final data

CONTRACTOR: RDCL

MACHINE: Geoprobe 54LT, Max Push Capacity OPERATOR: PR



EOH: 14.48m  
 Termination: Max MPa

### CONE INFORMATION

CONE ID: 5940      CONE TYPE: Piezo cone (TE2, U2)  
 CONE INFO: Geotech AB Nova, 10cm2, Penetrometer Class: ISO Class1, C

	INITIAL	FINAL
CONE RESISTANCE:	7.0282	-0.013
SLEEVE FRICTION RESISTANCE:	107.6	0
POREWATER PRESSURE:	266.6	0.2

### REMARKS

### SYMBOLS

▼ Water level



**RDCL**<sup>®</sup>

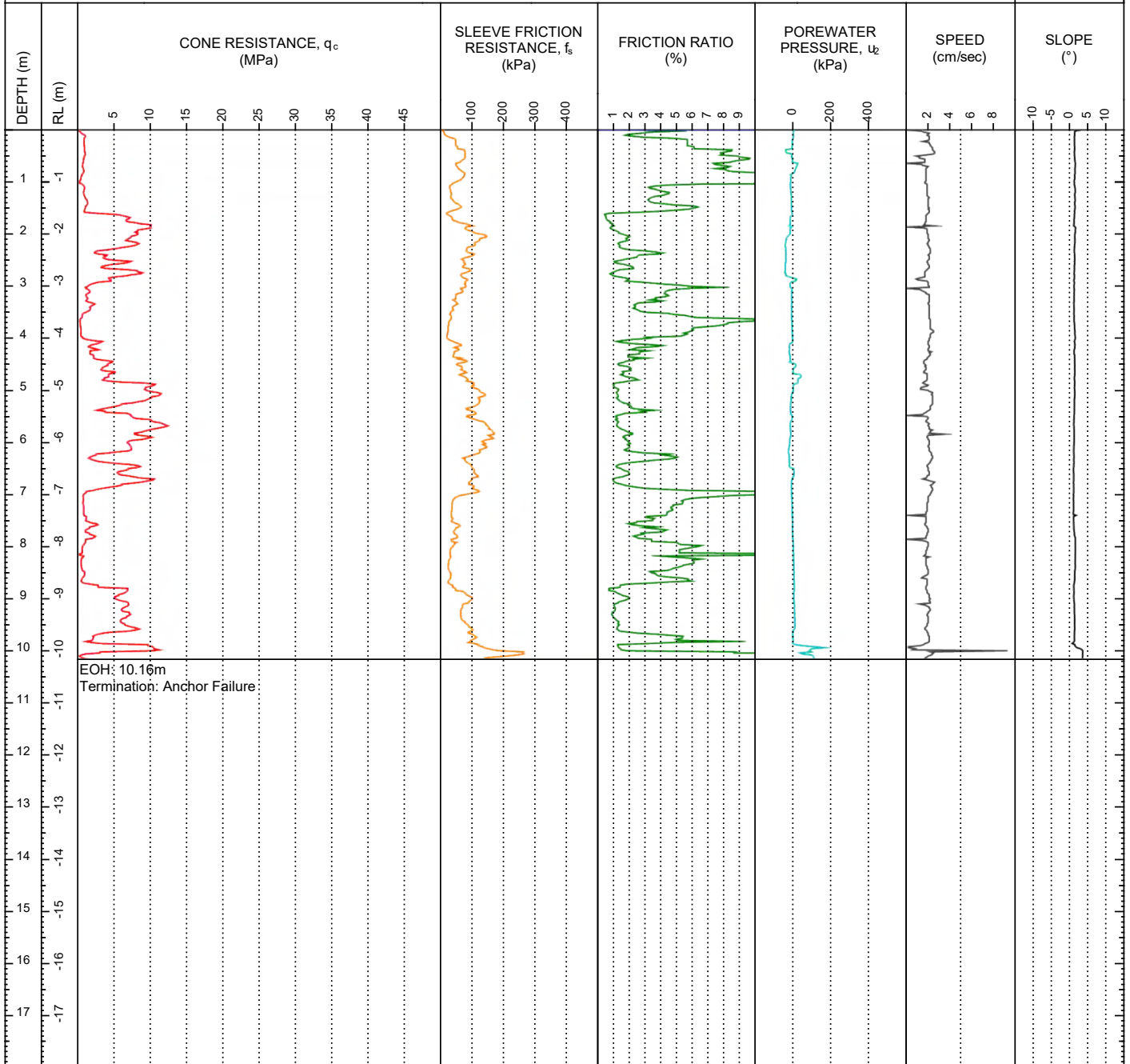
# CONE PENETRATION TEST LOG

## CPT03

SHEET 1 OF 1

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929576.05	LOGGED ON: 25/10/2023 12:00:00 am
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608985.75	PREPARED BY: ID      DATE: 17/11/2023
OFFICE: RDCL - Hastings	ELEVATION: -	CHECKED BY: HC      DATE: 21/11/2023
	DATUM: NZVD2016	STATUS: Final data

CONTRACTOR: RDCL      MACHINE: Geoprobe 54LT, Max Push Capacity      OPERATOR: PR



<b>CONE INFORMATION</b> CONE ID: 5940      CONE TYPE: Piezo cone (TE2, U2) CONE INFO: Geotech AB Nova, 10cm2, Penetrometer Class: ISO Class1, C		<b>REMARKS</b>  <b>SYMBOLS</b> ▼ Water level
CONE RESISTANCE:      7.0197      0.0096 SLEEVE FRICTION RESISTANCE:      108.3      -1.2 POREWATER PRESSURE:      268      -1.4		



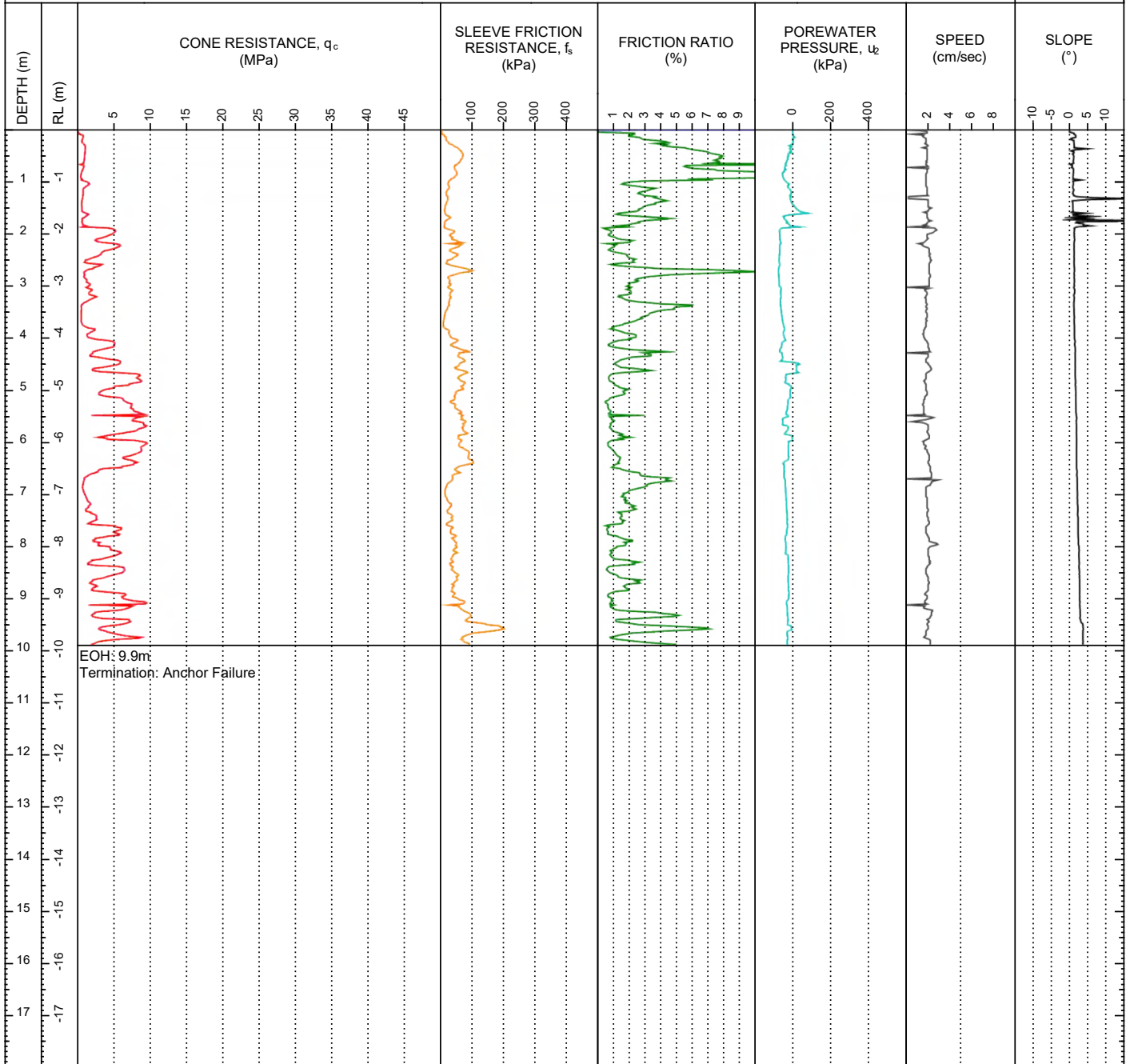
# CONE PENETRATION TEST LOG

## CPT04

SHEET 1 OF 1

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929552.62	LOGGED ON: 25/10/2023 12:00:00 am
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608999.16	PREPARED BY: ID DATE: 17/11/2023
OFFICE: RDCL - Hastings	ELEVATION: -	CHECKED BY: HC DATE: 21/11/2023
	DATUM: NZVD2016	STATUS: Final data

CONTRACTOR: RDCL MACHINE: Geoprobe 54LT, Max Push Capacity OPERATOR: PR



CONE INFORMATION		REMARKS
CONE ID: 5940	CONE TYPE: Piezo cone (TE2, U2)	
CONE INFO: Geotech AB Nova, 10cm2, Penetrometer Class: ISO Class1, C		SYMBOLS ▼ Water level
INITIAL	FINAL	
CONE RESISTANCE:	7.0056 0.026	
SLEEVE FRICTION RESISTANCE:	108.6 -1.1	
POREWATER PRESSURE:	268.6 -1	



**RDCL**

# CONE PENETRATION TEST LOG

## CPT05

SHEET 1 OF 1

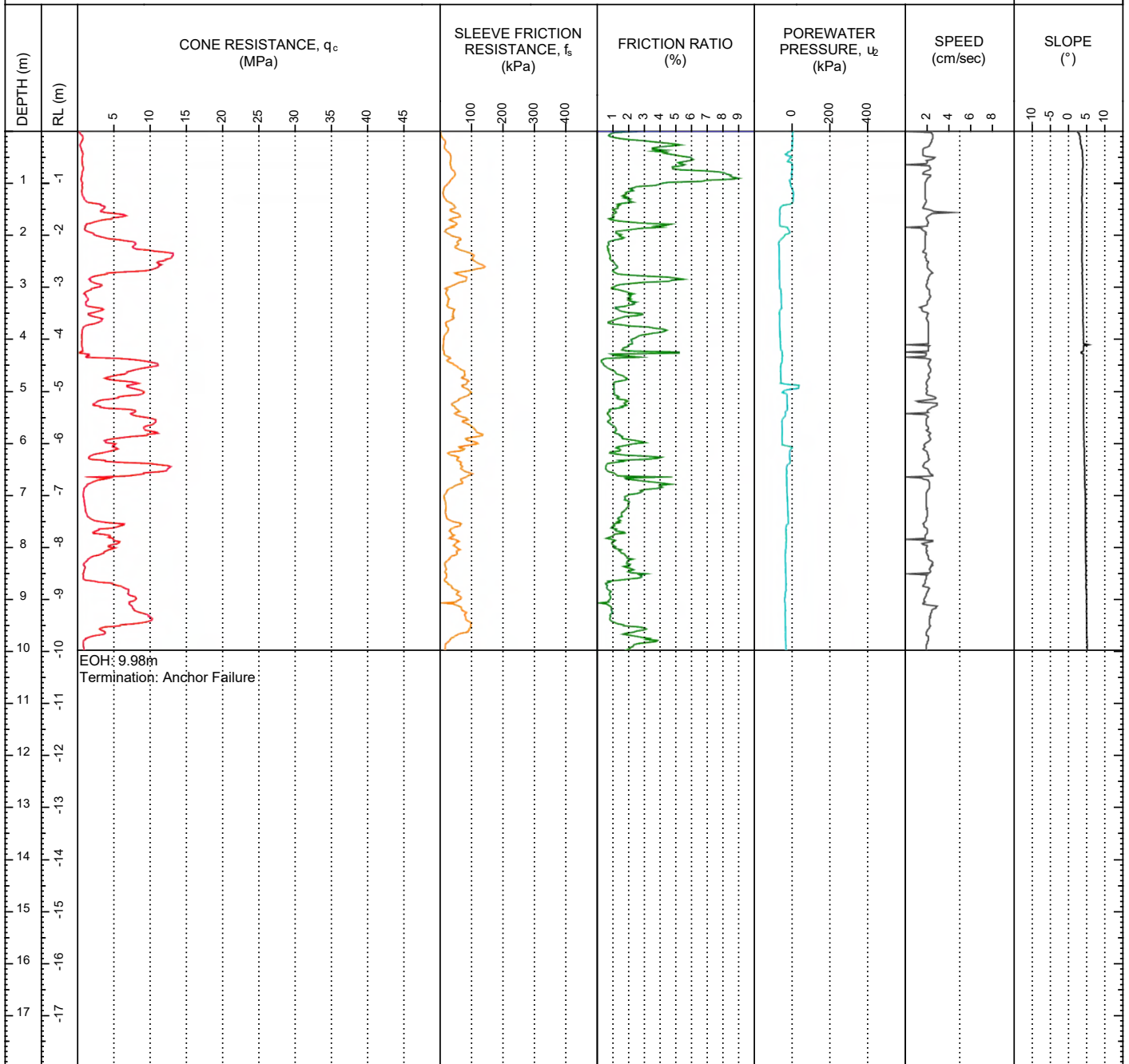
CLIENT: Hamachek Holdings Ltd  
 PROJECT: 230850  
 LOCATION: 160 Evenden Road,  
 Twyford 4175  
 OFFICE: RDCL - Hastings

PROJECTION: NZTM2000  
 EASTING: 1929513.31  
 NORTHING: 5608964.99  
 ELEVATION: -  
 DATUM: NZVD2016

SUB-LOCATION:  
 LOGGED ON: 25/10/2023 12:00:00 am  
 PREPARED BY: ID DATE: 17/11/2023  
 CHECKED BY: HC DATE: 21/11/2023  
 STATUS: Final data

CONTRACTOR: RDCL

MACHINE: Geoprobe 54LT, Max Push Capacity OPERATOR: PR



### REMARKS

### CONE INFORMATION

CONE ID: 5940      CONE TYPE: Piezo cone (TE2, U2)  
 CONE INFO: Geotech AB Nova, 10cm2, Penetrometer Class: ISO Class1, C

	INITIAL	FINAL
CONE RESISTANCE:	7.0169	0.0164
SLEEVE FRICTION RESISTANCE:	107.4	0
POREWATER PRESSURE:	268	-0.1

### SYMBOLS

▼ Water level



**RDCL**<sup>®</sup>

# CONE PENETRATION TEST LOG

## CPT06

SHEET 1 OF 1

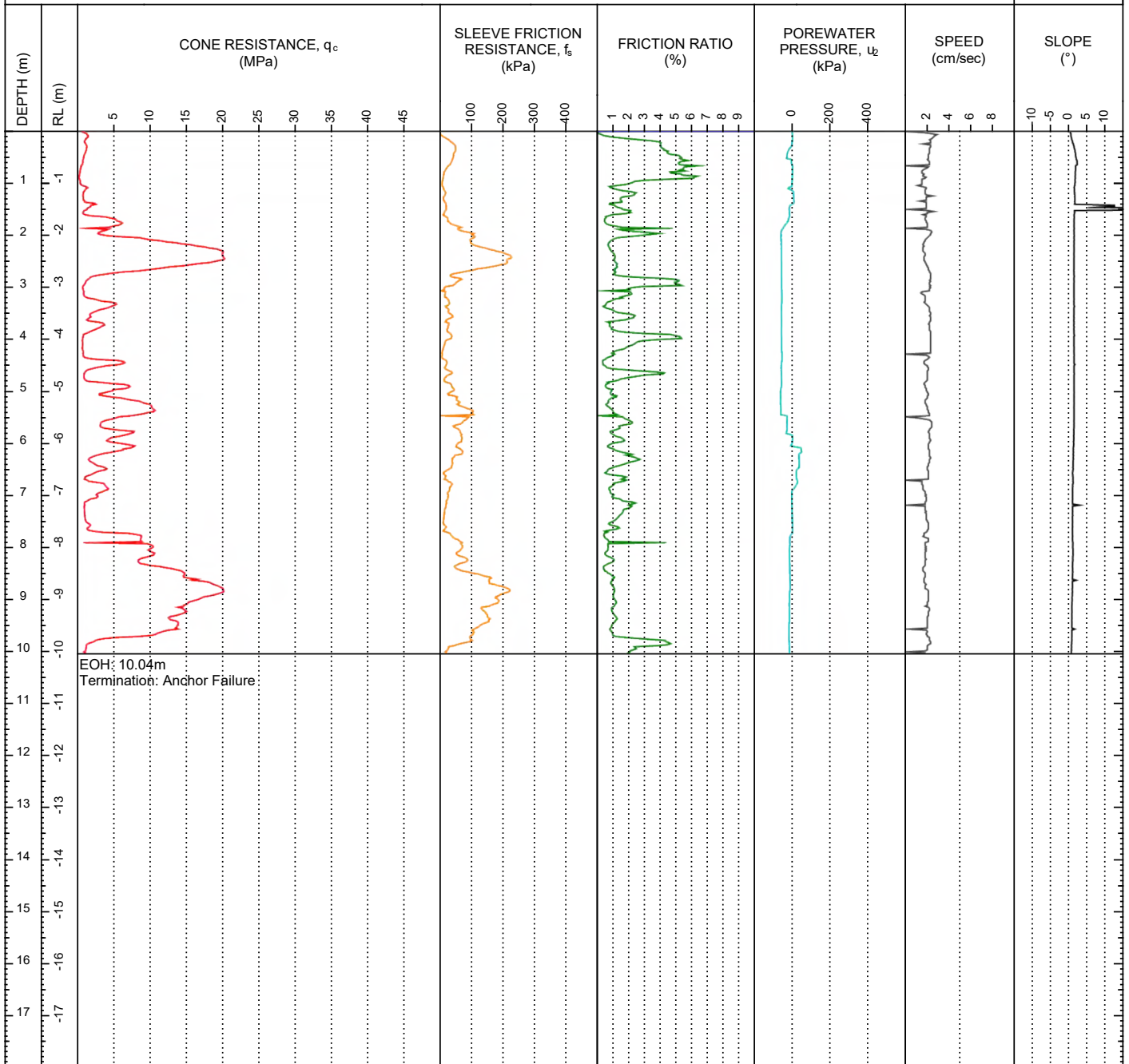
CLIENT: Hamachek Holdings Ltd  
 PROJECT: 230850  
 LOCATION: 160 Evenden Road,  
 Twyford 4175  
 OFFICE: RDCL - Hastings

PROJECTION: NZTM2000  
 EASTING: 1929481.07  
 NORTHING: 5608934.18  
 ELEVATION: -  
 DATUM: NZVD2016

SUB-LOCATION:  
 LOGGED ON: 25/10/2023 12:00:00 am  
 PREPARED BY: ID DATE: 17/11/2023  
 CHECKED BY: HC DATE: 21/11/2023  
 STATUS: Final data

CONTRACTOR: RDCL

MACHINE: Geoprobe 54LT, Max Push Capacity OPERATOR: PR



EOH: 10.04m  
 Termination: Anchor Failure

### CONE INFORMATION

CONE ID: 5444                      CONE TYPE: Piezo cone (TE2, U2)  
 CONE INFO: Geotech AB Nova, 10cm2, Penetrometer Class: ISO Class1, C

	INITIAL	FINAL
CONE RESISTANCE:	7.592	0.0214
SLEEVE FRICTION RESISTANCE:	131.7	0.2
POREWATER PRESSURE:	595.1	-0.2

### REMARKS

### SYMBOLS

▼ Water level





CLIENT: Hamachek Holdings Ltd PROJECT: 230850 LOCATION: 160 Evenden Road, Twyford 4175 OFFICE: RDCL - Hastings ENGINEER: BB	PROJECTION: NZTM EASTING: 1929548.00 NORTHING: 5609016.00 DATUM: NZVD2016 ELEVATION: - DIAMETER: 50mm	SUB-LOCATION: STARTED: 24/10/2023 FINISHED: 24/10/2023 LOGGED BY: PR/IT      DATE: 24/10/2023 CHECKED BY: HC      DATE: 15/11/2023 STATUS: Final data
--	--	--

CONTRACTOR: RDCL      OPERATOR: PR/IT

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
0.0	-0.5		T5 T5 T5	Sandy SILT, with trace rootlets; dark brown. Firm; moist; non-plastic; sand, fine; [TOPSOIL].	M					
0.5	-1.0	▼		Sandy SILT, with minor rootlets and clay; greyish brown with orange mottle. Firm; moist to wet; low plasticity to moderate plasticity; sand, fine.	M to W	FM			FSV: 0.50m 118/47kPa	
1.0	-1.5			0.8m: With minor Pumiceous SAND; sand, fine to coarse; dilatant. 1.0m: Wet.					FSV: 1.20m 145/54kPa	
1.5	-2.0			SAND; blue with orange and grey mottle. Medium dense; wet; sand, fine to coarse, quick.	W	MD				
2.0	-2.5			EOH: 1.60m Termination: Sample Washout - No Sample Recovery						
2.5	-3.0									
3.0	-3.5									
3.5	-4.0									
4.0	-4.5									
4.5	-4.5									



**REMARKS**  
Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

**SYMBOLS**

- ▼ Standing Water Level
- ◁ Out flow
- ▷ In flow

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929508.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608948.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	DIAMETER: 50mm	STATUS: Final data

CONTRACTOR: RDCL      OPERATOR: PR/IT

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
0.0	-0.5		T5	Sandy SILT, with trace rootlets; dark brown. Firm; moist; non-plastic; sand, fine; [TOPSOIL].						
0.5	-1.0			Sandy SILT, with minor clay; greyish brown with orange mottle. Firm; moist; low plasticity; sand, fine to medium.	M	FM			<ul style="list-style-type: none"> <li>FSV: 0.30m 168/50kPa</li> <li>FSV: 0.90m 135/47kPa</li> <li>FSV: 1.10m 185/74kPa</li> </ul>	
1.5	-1.5			SAND, with minor silt; greyish blue with orange and blue mottle. Medium dense; moist to wet; sand, fine to coarse, quick.	M to W	MD				
2.0	-2.0			1.5m: Wet. EOH: 1.60m Termination: Sample Washout - No Sample Recovery						
2.5	-2.5									
3.0	-3.0									
3.5	-3.5									
4.0	-4.0									
4.5	-4.5									



**REMARKS**  
Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

**SYMBOLS**

- ▼ Standing Water Level
- ↖ Out flow
- ↗ In flow

CLIENT: Hamachek Holdings Ltd PROJECT: 230850 LOCATION: 160 Evenden Road, Twyford 4175 OFFICE: RDCL - Hastings ENGINEER: BB	PROJECTION: NZTM EASTING: 1929489.00 NORTHING: 5608924.00 DATUM: NZVD2016 ELEVATION: - DIAMETER: 50mm	SUB-LOCATION: STARTED: 24/10/2023 FINISHED: 24/10/2023 LOGGED BY: PR/IT      DATE: 24/10/2023 CHECKED BY: HC      DATE: 15/11/2023 STATUS: Final data
--	--	--

CONTRACTOR: RDCL      OPERATOR: PR/IT

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
0.0	-0.5		T5 T3 T1	Sandy SILT, with trace rootlets; dark brown. Firm; moist; non-plastic; sand, fine; [TOPSOIL].						
0.5	-1.0			Sandy SILT, with some clay, with minor rootlets; light brown with orange and grey mottle. Firm; moist; low plasticity to moderate plasticity; sand, fine.	M	FM			FSV: 0.30m 135/34kPa	
1.0	-1.5			0.8m - 0.9m: With some Pumiceous SAND.						
1.5	-2.0			SAND, with minor silt; greyish brown with orange and bluish mottle. Medium dense to dense; wet; sand, fine to coarse, quick.	W	MD to D				
2.0	-2.5			EOH: 1.50m Termination: Sample Washout - No Sample Recovery						



**REMARKS**  
Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

**SYMBOLS**

- ▼ Standing Water Level
- ↖ Out flow
- ↗ In flow

CLIENT: Hamachek Holdings Ltd PROJECT: 230850 LOCATION: 160 Evenden Road, Twyford 4175 OFFICE: RDCL - Hastings ENGINEER: BB	PROJECTION: NZTM EASTING: 1929461.00 NORTHING: 5608969.00 DATUM: NZVD2016 ELEVATION: - DIAMETER: 50mm	SUB-LOCATION: STARTED: 24/10/2023 FINISHED: 24/10/2023 LOGGED BY: PR/IT      DATE: 24/10/2023 CHECKED BY: HC      DATE: 15/11/2023 STATUS: Final data
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CONTRACTOR: RDCL      OPERATOR: PR/IT

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
0.0	-0.5		TS TS TS	Sandy SILT, with trace rootlets; dark brown. Firm; moist; non-plastic; sand, fine; [TOPSOIL].						
0.5	-1.0			Sandy SILT, with minor rootlets and clay; greyish brown with orange and grey mottle. Firm; moist; low plasticity to moderate plasticity; sand, fine to medium.	M	FM			FSV: 0.60m 168/64kPa	
1.0	-1.5	▼		0.8m - 0.9m: With some Pumiceous SAND; sand, coarse. 1.0m: Wet.						
1.5	-2.0			SAND, with minor silt; greyish brown with orange and grey mottle. Medium dense; moist to wet; sand, fine to coarse, quick.	M to W	MD				
2.0	-2.5			EOH: 1.60m Termination: Sample Washout - No Sample Recovery						
2.5	-3.0									
3.0	-3.5									
3.5	-4.0									
4.0	-4.5									




**REMARKS**  
 Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

**SYMBOLS**

- ▼ Standing Water Level
- ◁ Out flow
- ▷ In flow

CLIENT: Hamachek Holdings Ltd PROJECT: 230850 LOCATION: 160 Evenden Road, Twyford 4175 OFFICE: RDCL - Hastings ENGINEER: BB	PROJECTION: NZTM EASTING: 1929579.00 NORTHING: 5609074.00 DATUM: NZVD2016 ELEVATION: - DIAMETER: 50mm	SUB-LOCATION: STARTED: 24/10/2023 FINISHED: 24/10/2023 LOGGED BY: PR/IT      DATE: 24/10/2023 CHECKED BY: HC      DATE: 15/11/2023 STATUS: Final data
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CONTRACTOR: RDCL      OPERATOR: PR/IT

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS	
0.5	-0.5	Groundwater Not Encountered		Sandy SILT, with trace rootlets; dark brown with some orange and black mottle. Firm; moist; non-plastic; sand, fine; [TOPSOIL].	M	FM			FSV: 0.60m 118/50kPa		
1.0	-1.0			Sandy SILT, with trace wood fragments; light brown with orange, white and black mottle. Firm; moist; non-plastic; sand, fine to medium.						FSV: 1.10m 124/47kPa	
1.5	-1.5			Silty SAND; greyish brown with some white and orange mottle. Medium dense; moist; sand, fine to medium, quick.					MD		
2.0	-2.0			EOH: 1.60m Termination: Sample Washout - No Sample Recovery							



**REMARKS**  
 Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

**SYMBOLS**

- ▼ Standing Water Level
- ↙ Out flow
- ↘ In flow

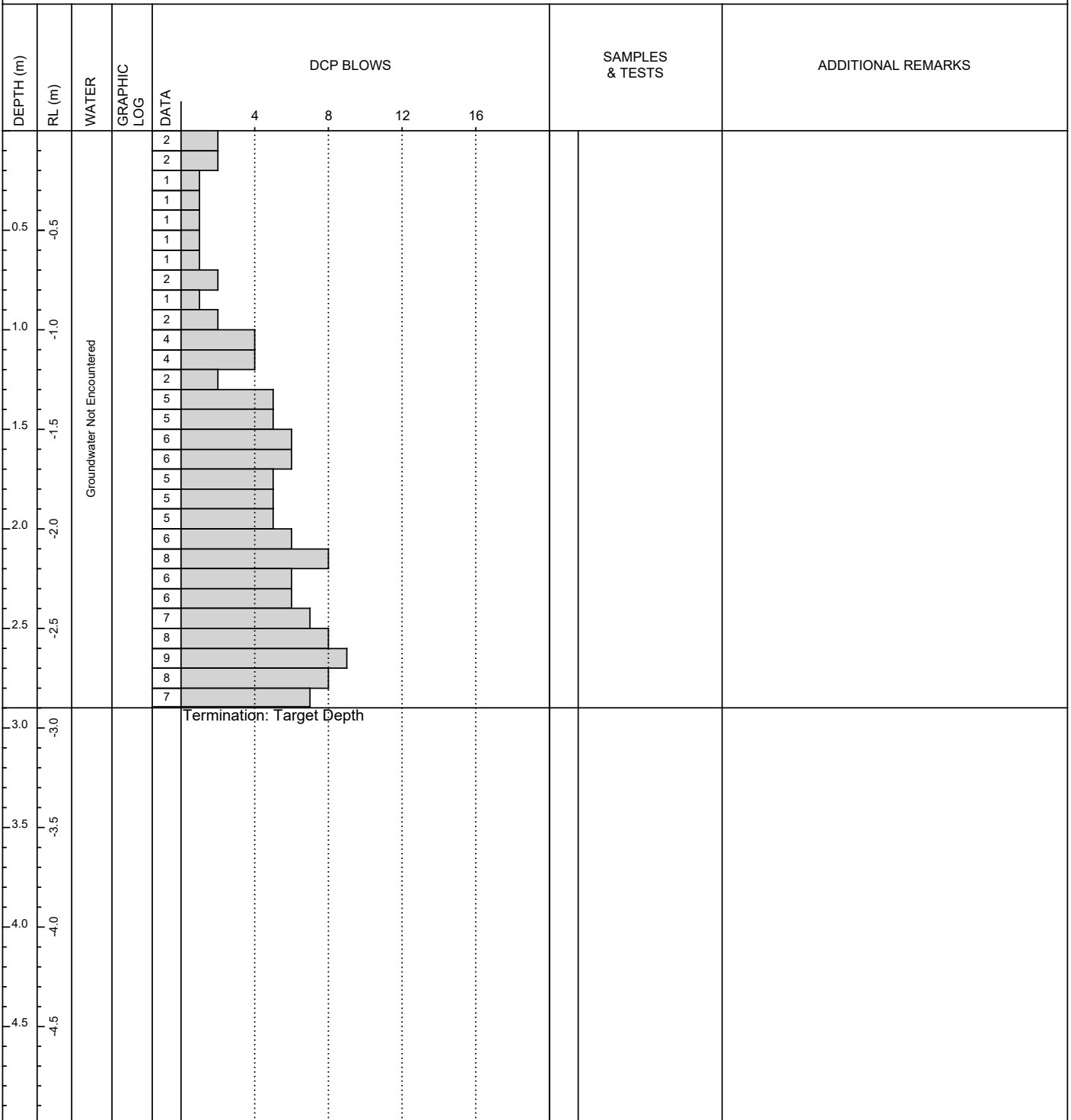


# DCP LOG

## DCP01

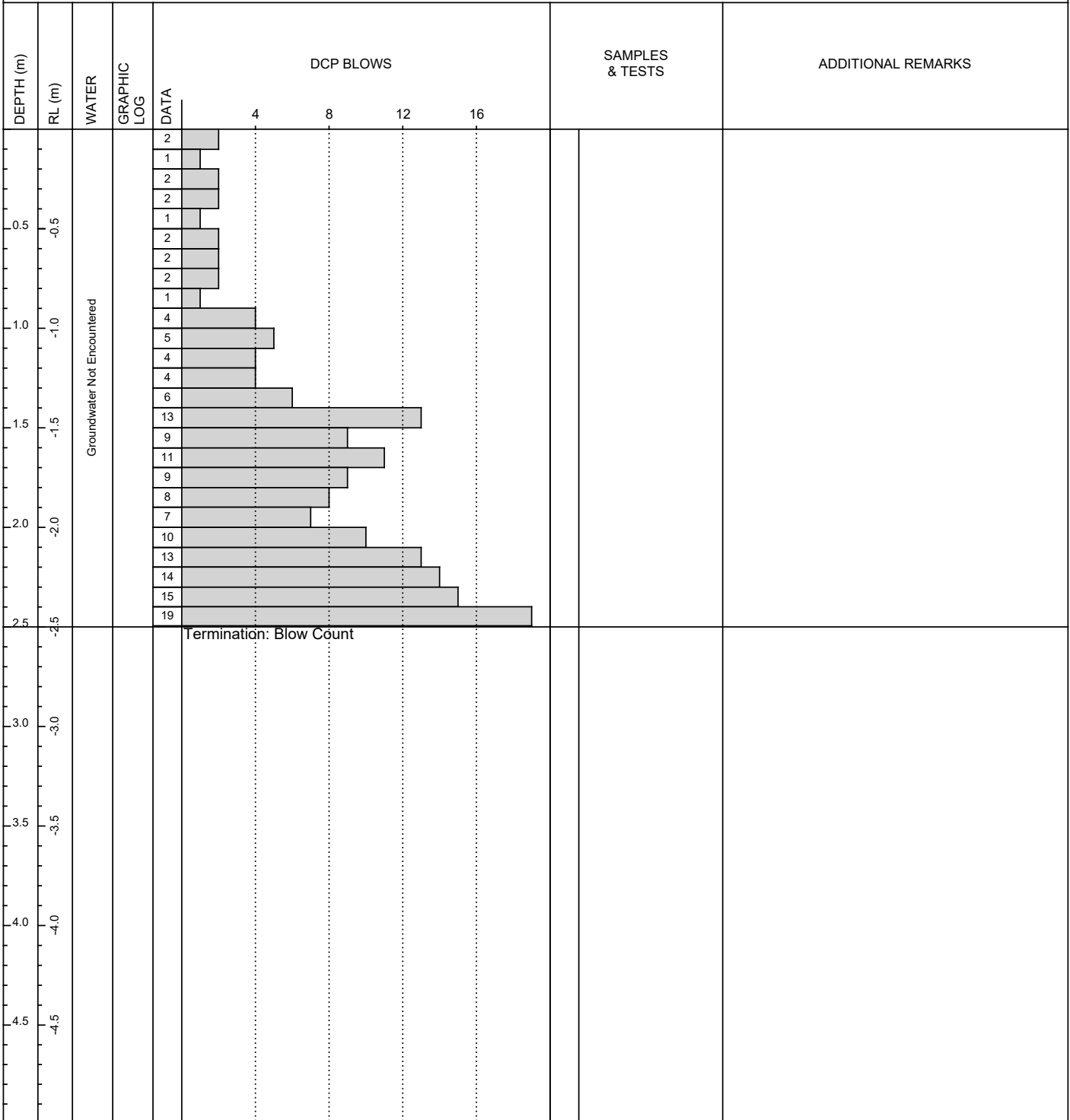
SHEET 1 OF 9




CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929567.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608993.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data



REMARKS Soils tested in accordance with NZGS	SYMBOLS Standing Water Level Out flow In flow
---	--

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929562.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608969.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data



REMARKS Soils tested in accordance with NZGS	SYMBOLS  Standing Water Level  Out flow  In flow
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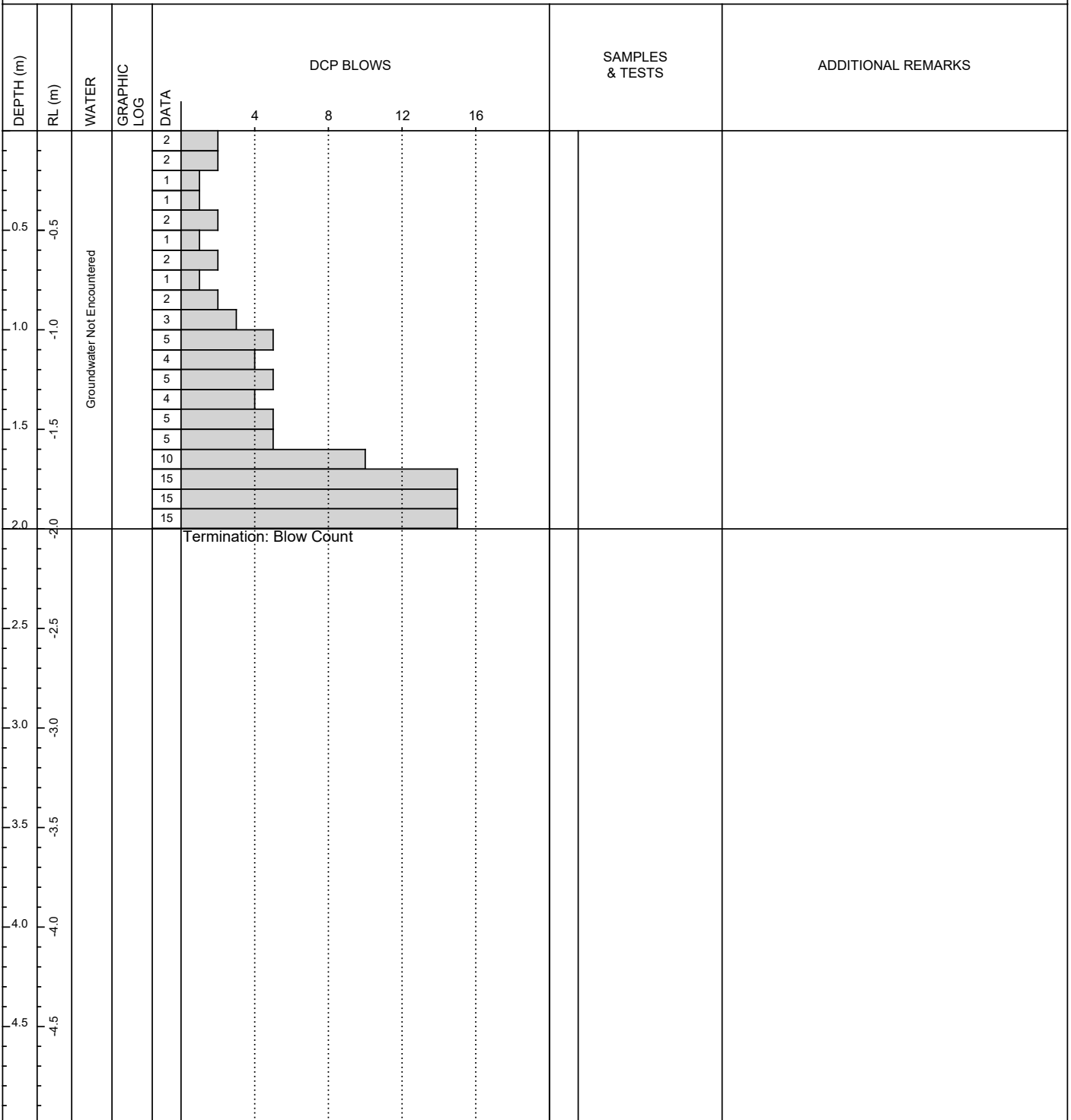


# DCP LOG

## DCP03

SHEET 3 OF 9



CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929526.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5609033.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data



REMARKS Soils tested in accordance with NZGS	SYMBOLS ▼ Standing Water Level ◀ Out flow ▶ In flow
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CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929529.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608968.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	DATA	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS	
					4      8      12      16			
0.5	-0.5	Groundwater Not Encountered		1				
				2				
				1				
				1				
				1				
				2				
				2				
				1				
1.0	-1.0			3				
				4				
				4				
				5				
				5				
1.5	-1.5			10				
				15				
			15					
			15					
2.0	-2.0		Termination: Blow Count					
2.5	-2.5							
3.0	-3.0							
3.5	-3.5							
4.0	-4.0							
4.5	-4.5							

REMARKS Soils tested in accordance with NZGS	SYMBOLS  Standing Water Level  Out flow  In flow
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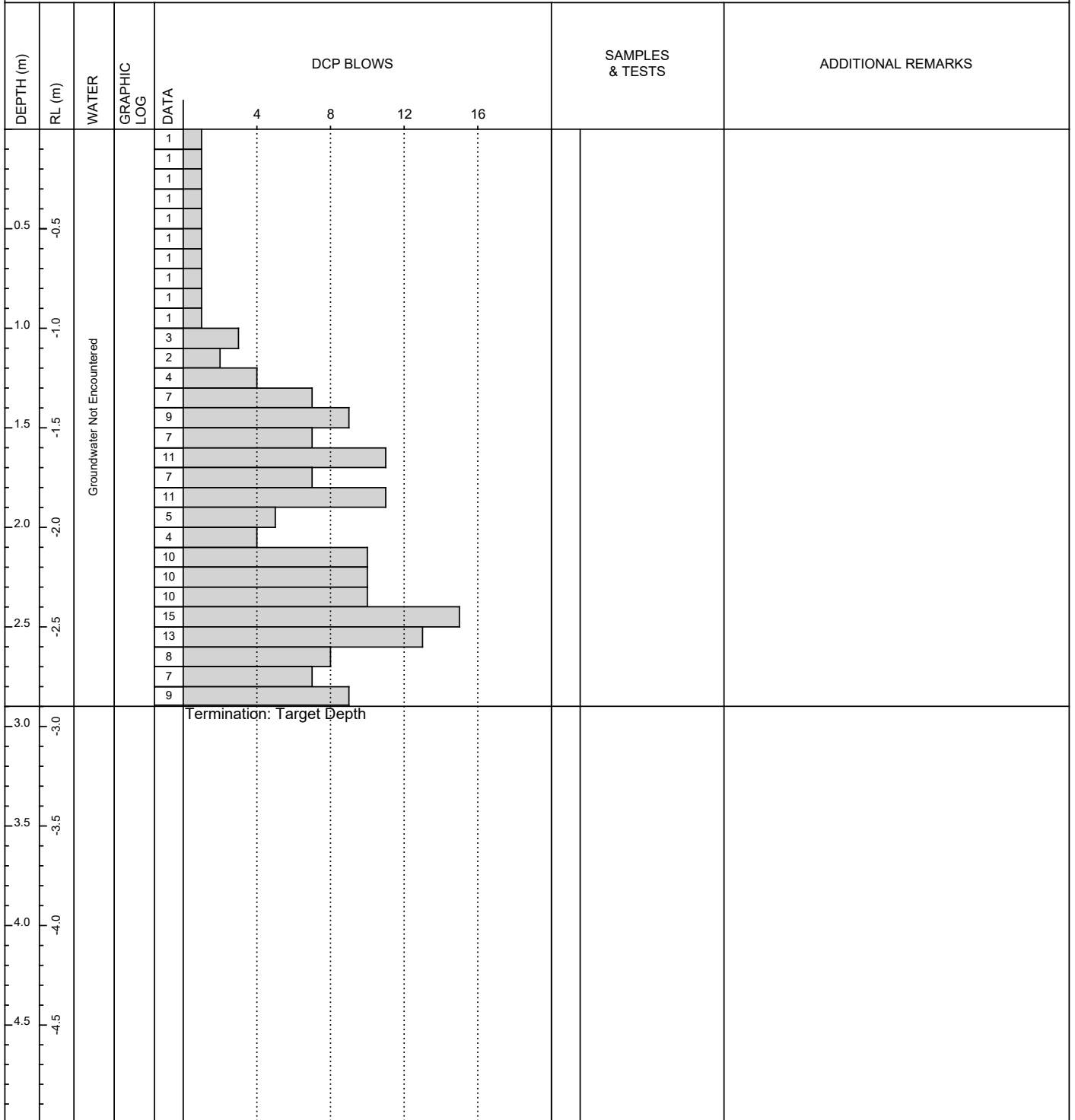


# DCP LOG

## DCP05

SHEET 5 OF 9

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929517.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608936.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data



REMARKS Soils tested in accordance with NZGS	SYMBOLS ▼ Standing Water Level ← Out flow ▷ In flow
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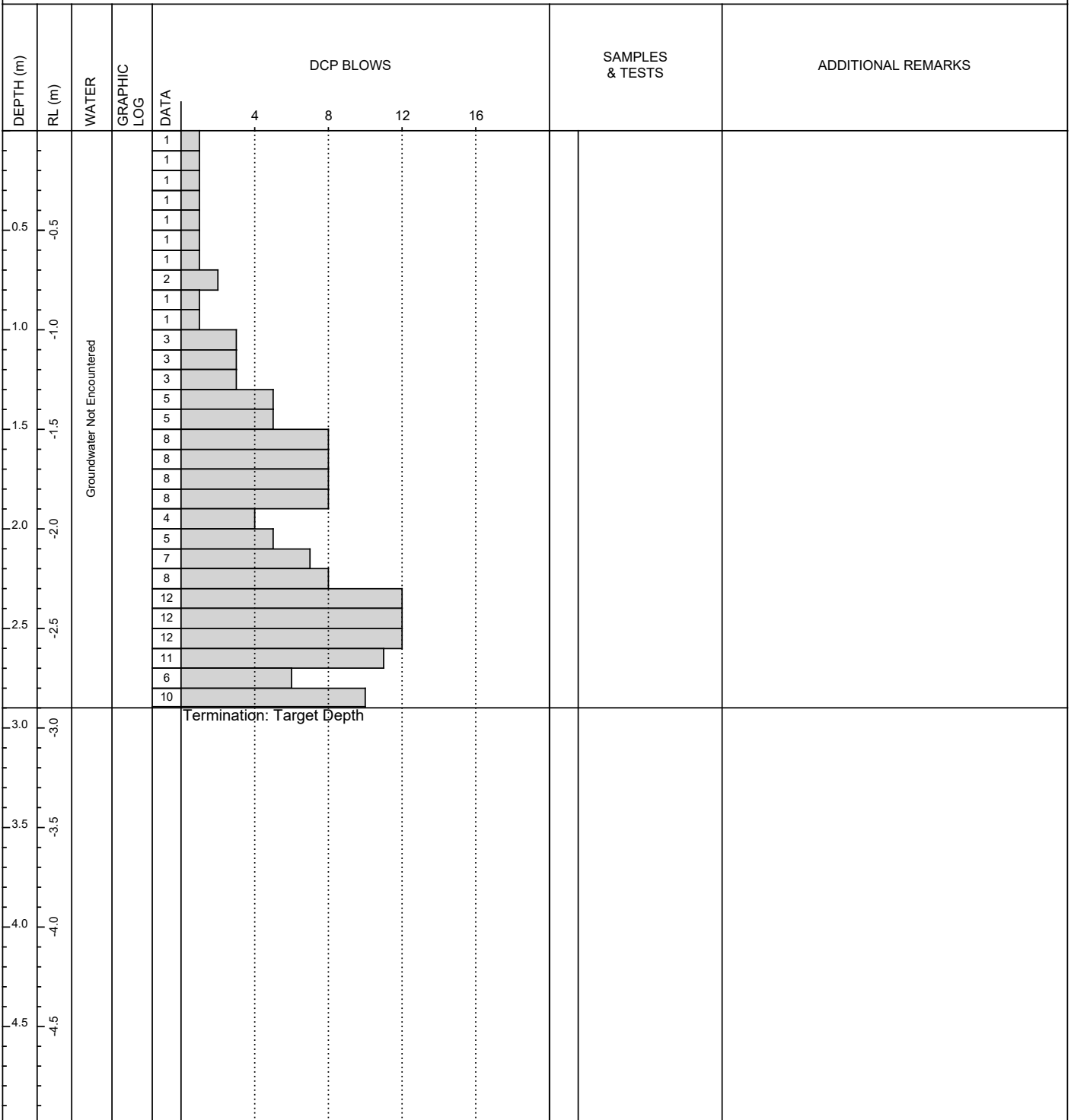


# DCP LOG

## DCP06

SHEET 6 OF 9

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929498.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608955.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data



REMARKS Soils tested in accordance with NZGS	SYMBOLS ▼ Standing Water Level ⇐ Out flow ▷ In flow
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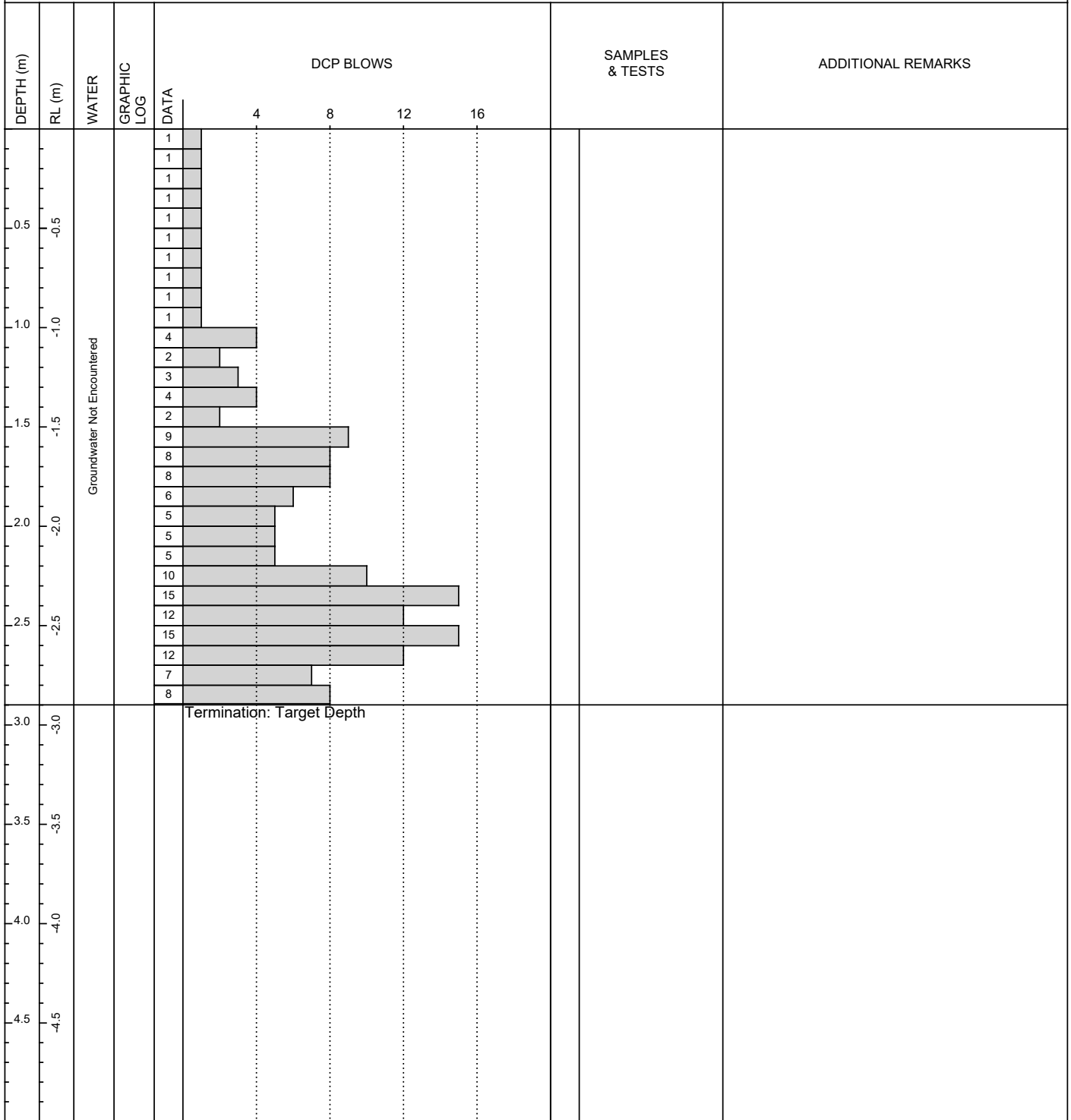


# DCP LOG

## DCP07

SHEET 7 OF 9

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929494.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608924.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data



REMARKS Soils tested in accordance with NZGS	SYMBOLS Standing Water Level Out flow In flow
---	--

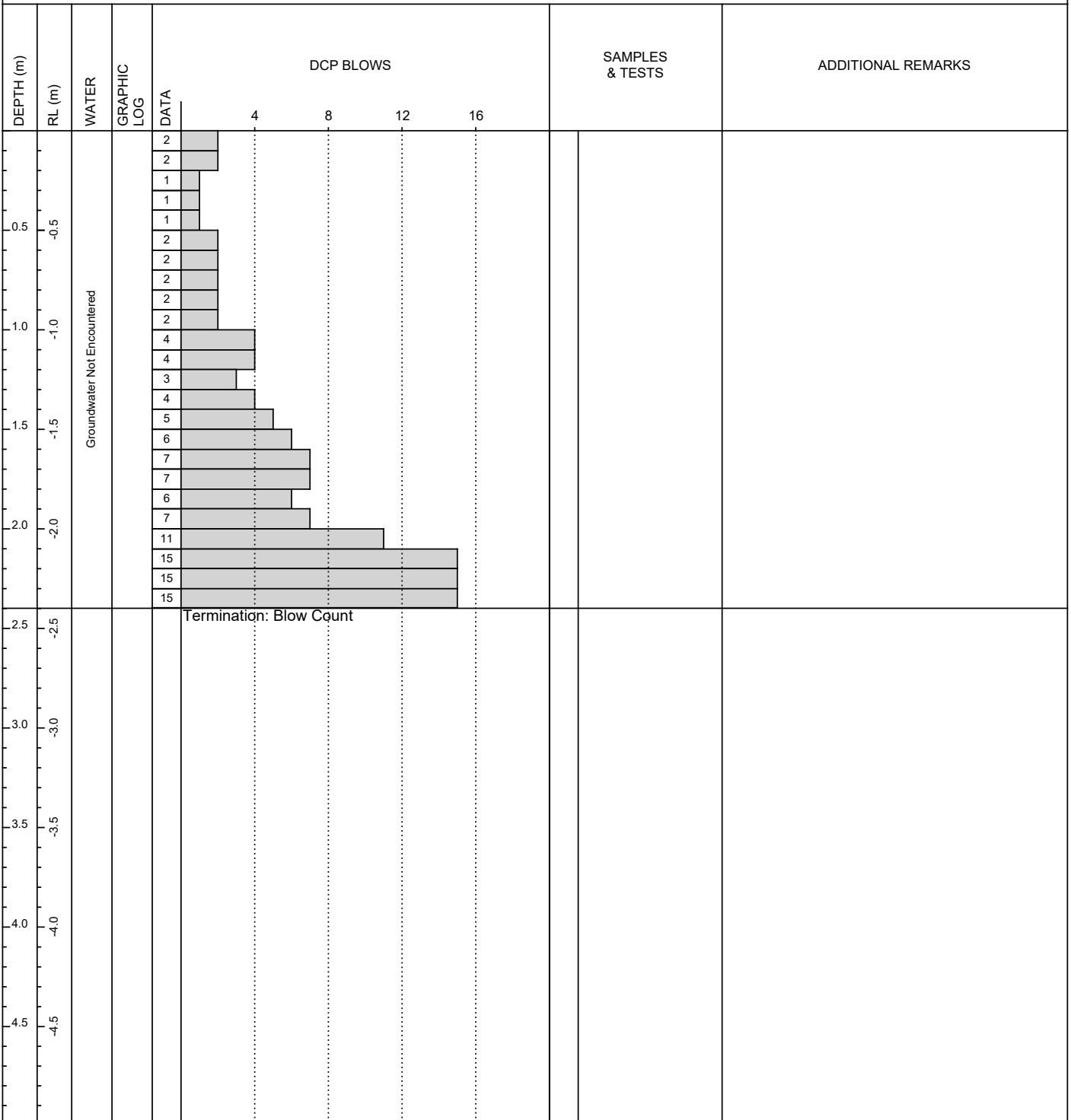


# DCP LOG

## DCP08

SHEET 8 OF 9

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929470.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5608943.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data



REMARKS Soils tested in accordance with NZGS	SYMBOLS ▼ Standing Water Level ◀ Out flow ▶ In flow
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# DCP LOG

## DCP09

SHEET 9 OF 9

CLIENT: Hamachek Holdings Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT: 230850	EASTING: 1929473.00	STARTED: 24/10/2023
LOCATION: 160 Evenden Road, Twyford 4175	NORTHING: 5609001.00	FINISHED: 24/10/2023
OFFICE: RDCL - Hastings	DATUM: NZVD2016	LOGGED BY: PR/IT      DATE: 24/10/2023
ENGINEER: BB	ELEVATION: -	CHECKED BY: HC      DATE: 15/11/2023
	AZIMUTH:      PLUNGE: 90°	STATUS: Final data

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	DATA	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
					4      8      12      16		
0.5	-0.5	Groundwater Not Encountered		2			
			2				
			1				
			2				
			1				
			1				
			2				
			3				
			3				
1.0	-1.0		4				
			3				
			3				
			4				
			4				
			4				
			7				
			7				
			6				
			7				
			7				
			8				
			9				
		8					
		8					
		7					
		8					
		10					
		10					
		12					
		10					
3.0	-3.0			Termination: Target Depth			
3.5	-3.5						
4.0	-4.0						
4.5	-4.5						

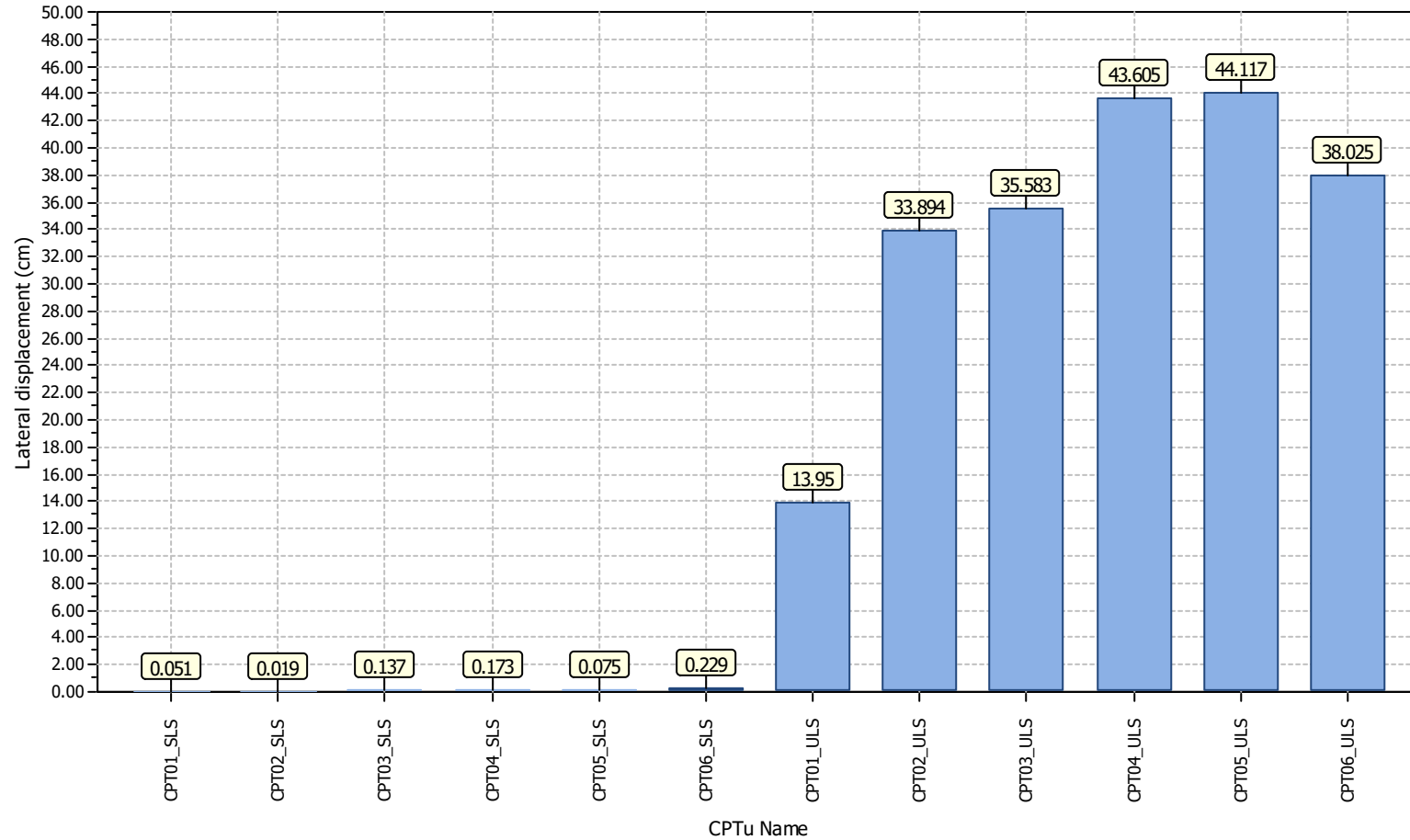
REMARKS Soils tested in accordance with NZGS	SYMBOLS ▼ Standing Water Level ← Out flow ▷ In flow
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## **APPENDIX B: LIQUEFACTION ASSESSMENT**

**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

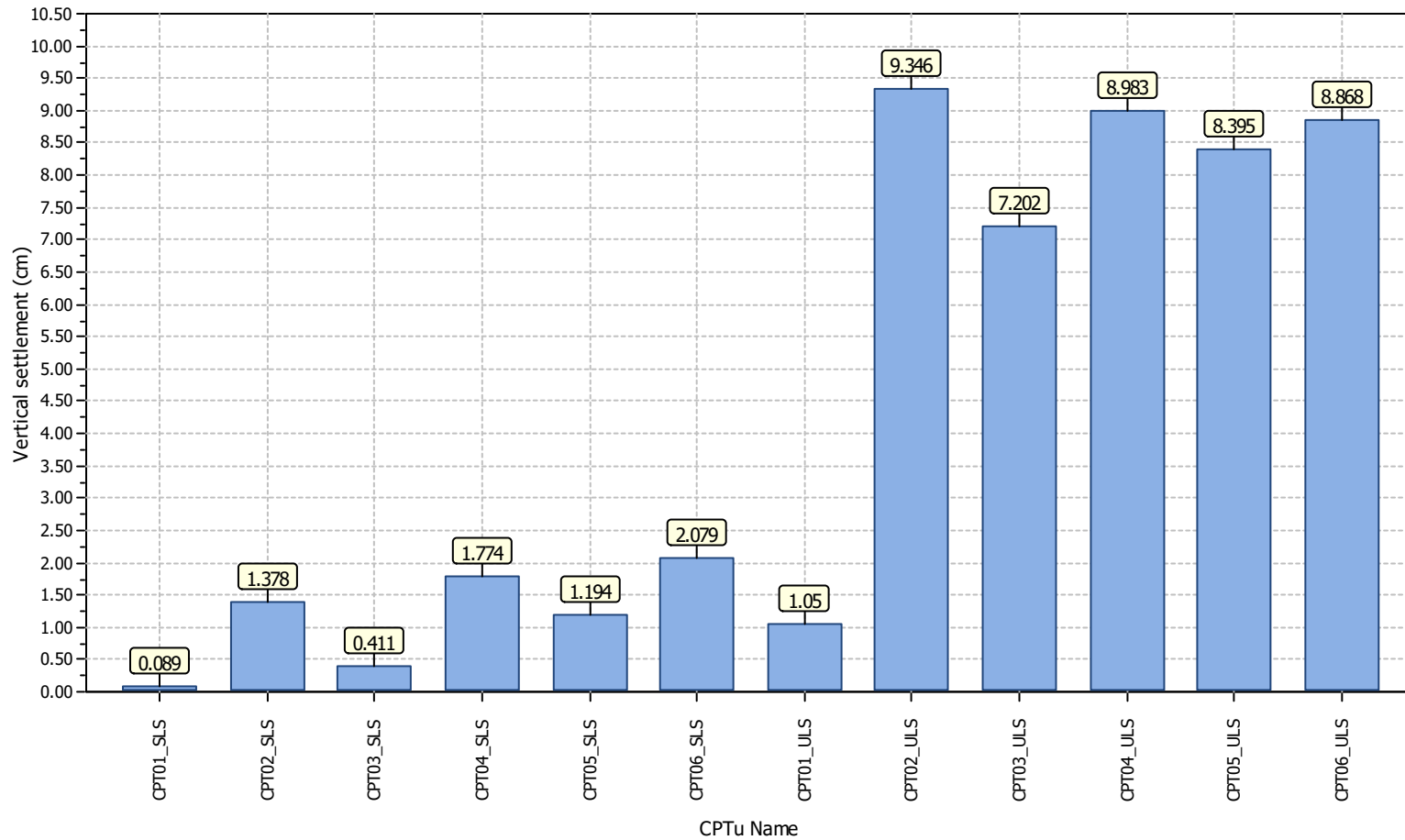
**Overall lateral displacements report**



**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

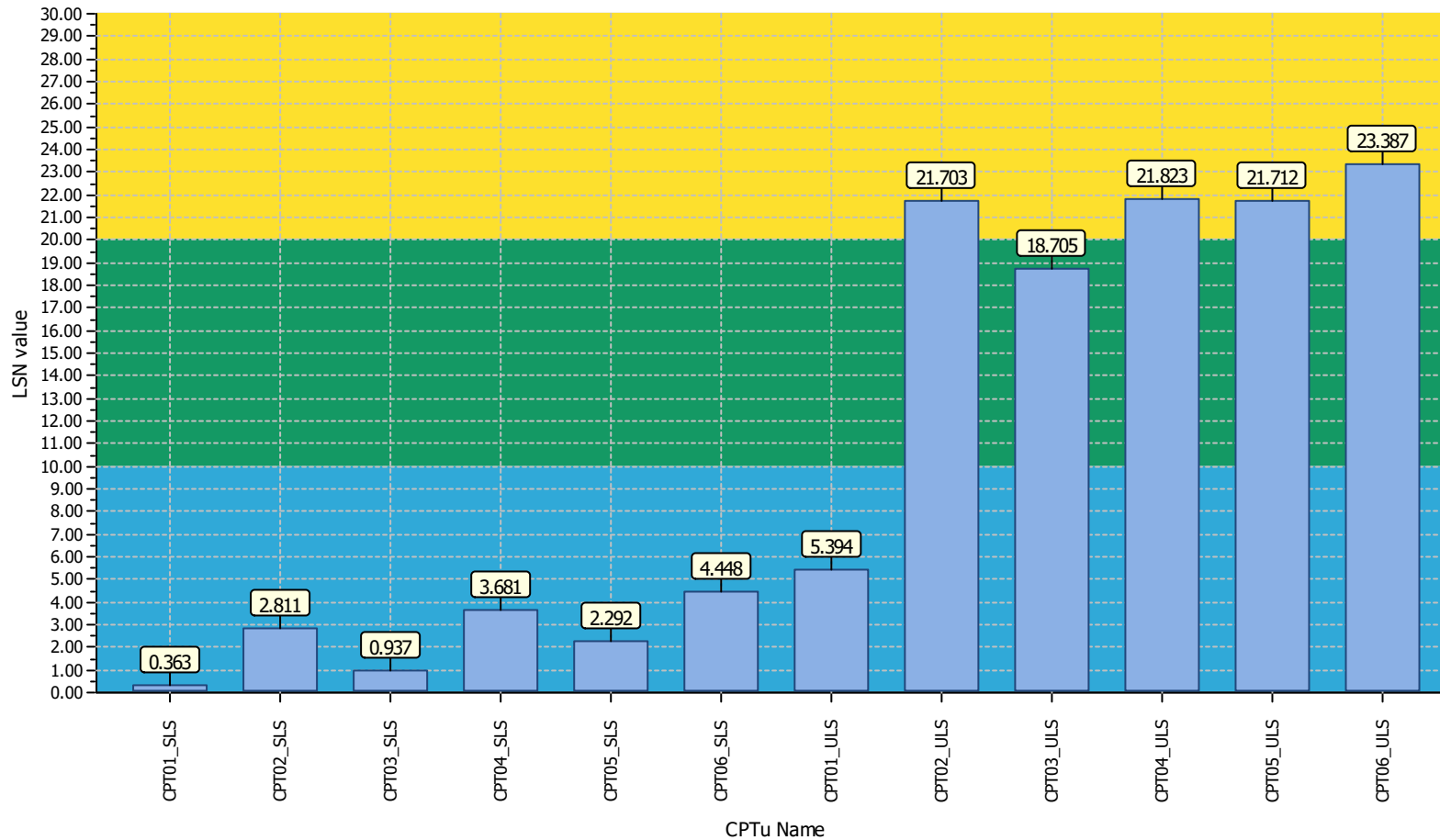
**Overall vertical settlements report**



**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

### Overall Liquefaction Severity Number report



**LSN color scheme**

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

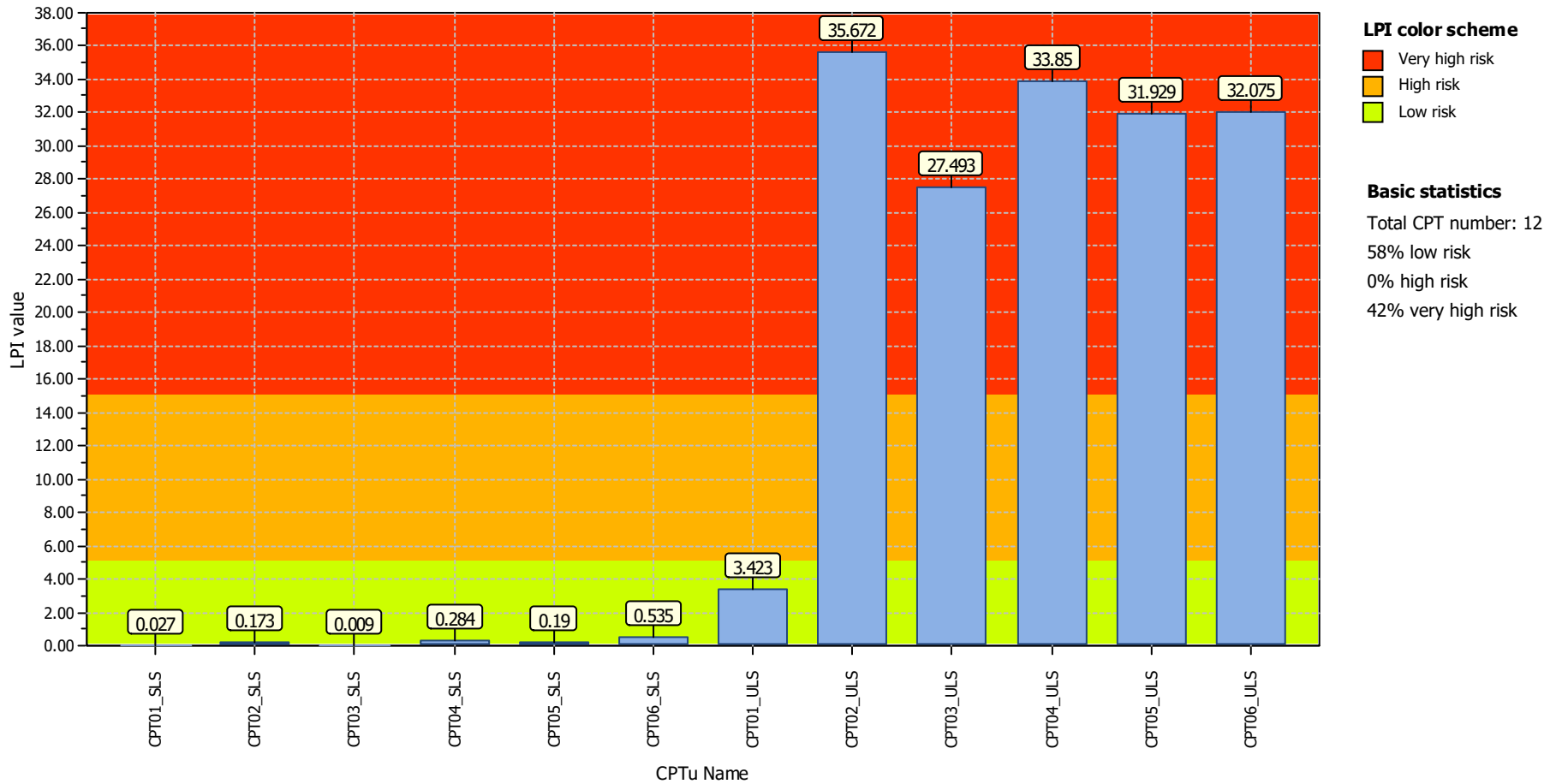
**Basic statistics**

- Total CPT number: 12
- 58% little liquefaction
- 8% minor liquefaction
- 33% moderate liquefaction
- 0% moderate to major liquefaction
- 0% major liquefaction
- 0% severe liquefaction

**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

**Overall Liquefaction Potential Index report**



**LIQUEFACTION ANALYSIS REPORT**

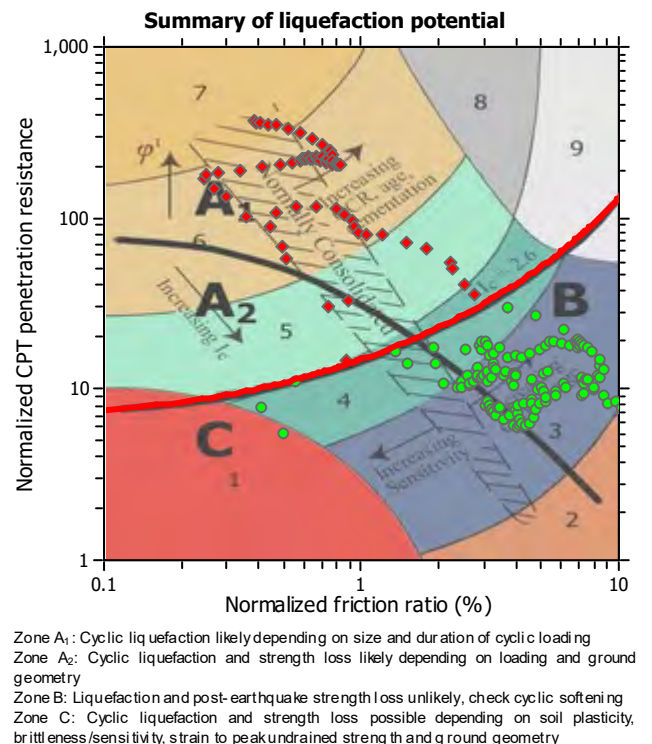
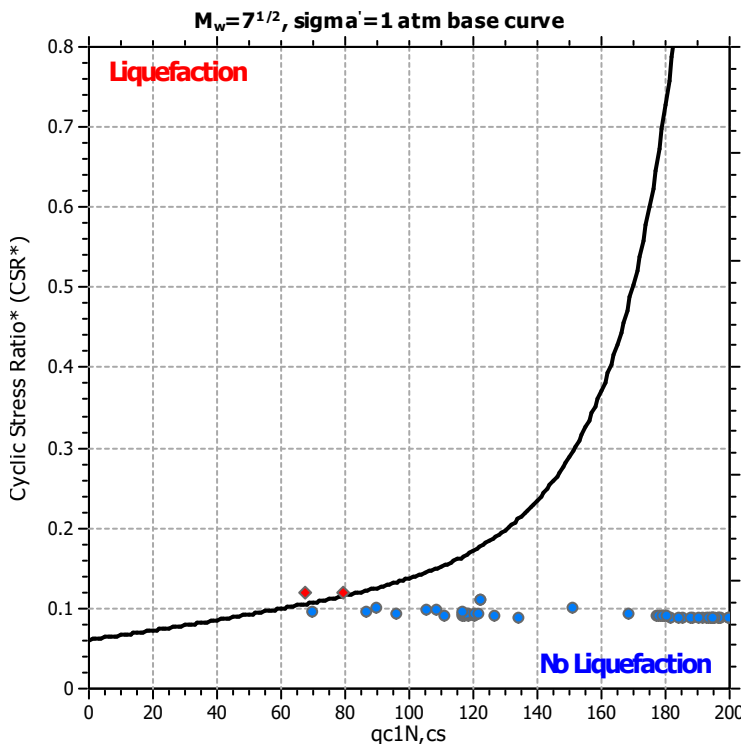
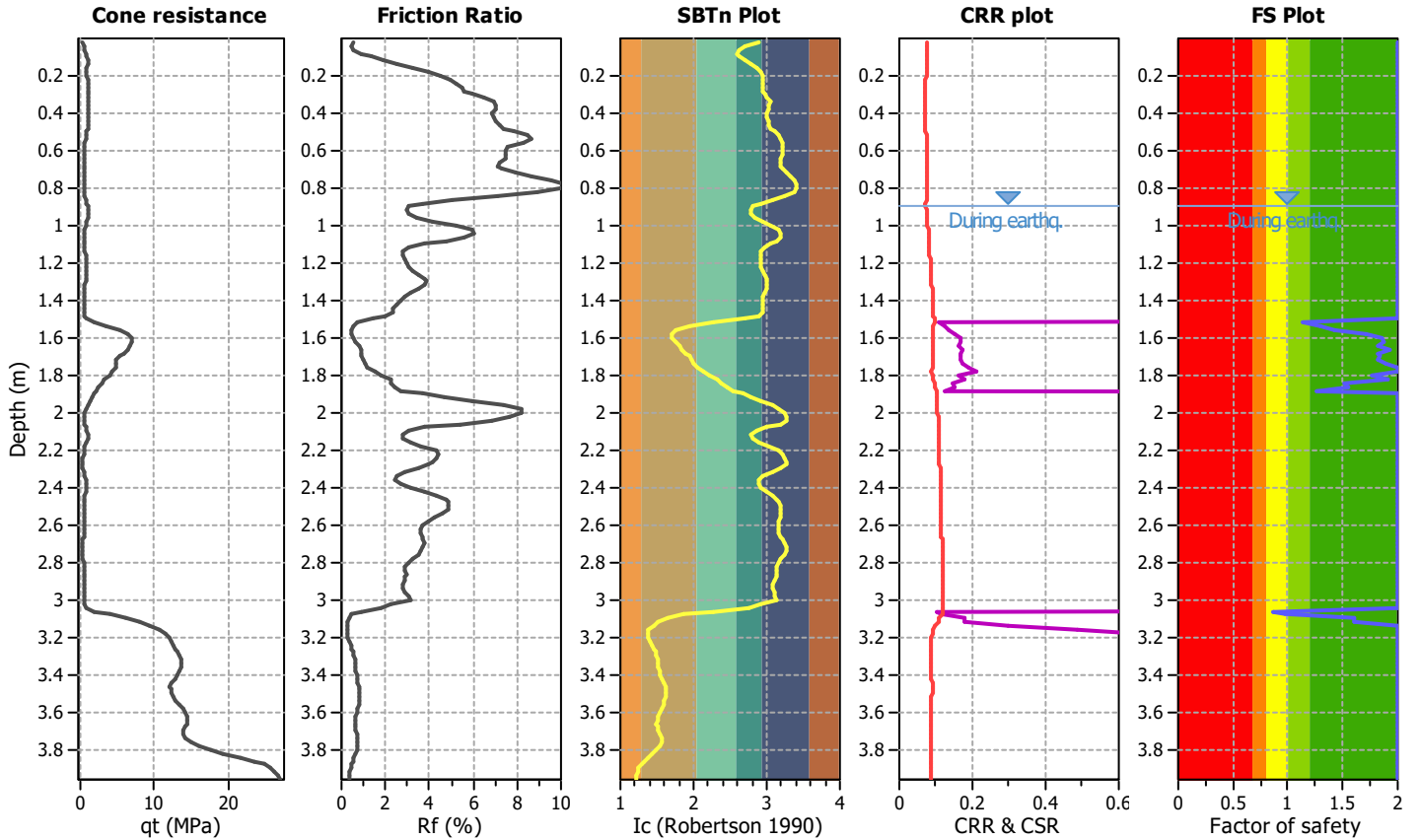
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

**CPT file : CPT01\_SLS**

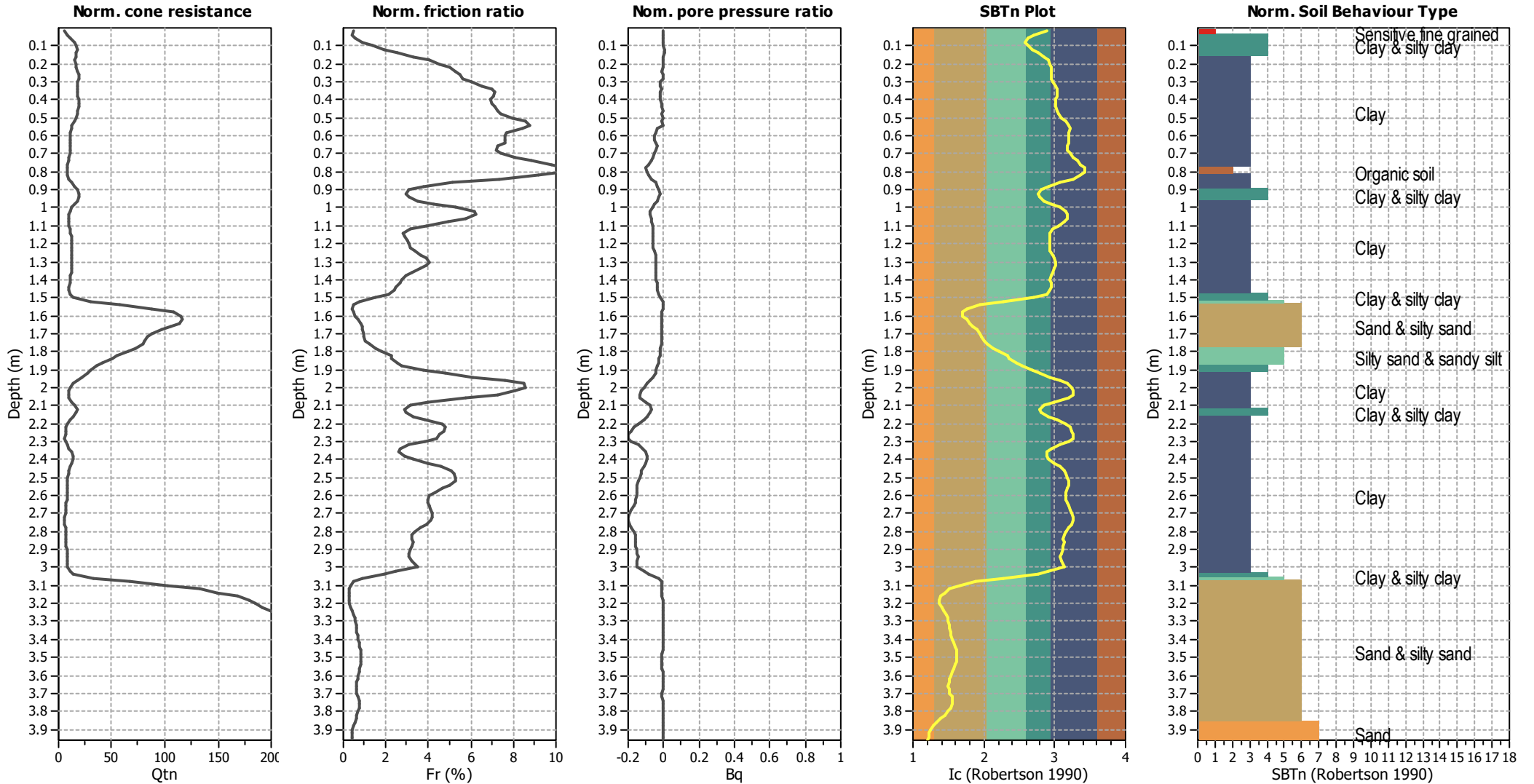
**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	6.40	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.12	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No	MSF method:	Method based



Zone A<sub>1</sub>: Cyclic liquefaction likely depending on size and duration of cyclic loading  
 Zone A<sub>2</sub>: Cyclic liquefaction and strength loss likely depending on loading and ground geometry  
 Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening  
 Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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 <sub>σ</sub> applied:	No
Earthquake magnitude M <sub>w</sub> :	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.12	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

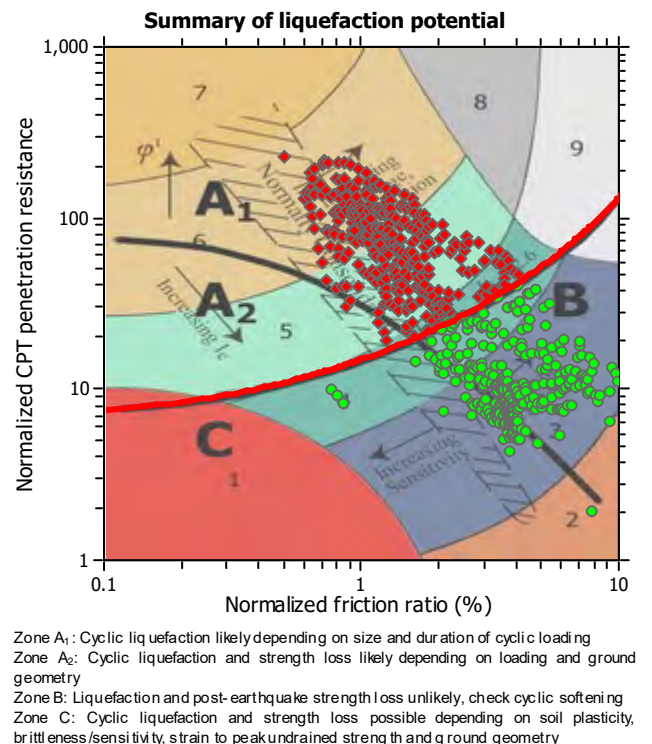
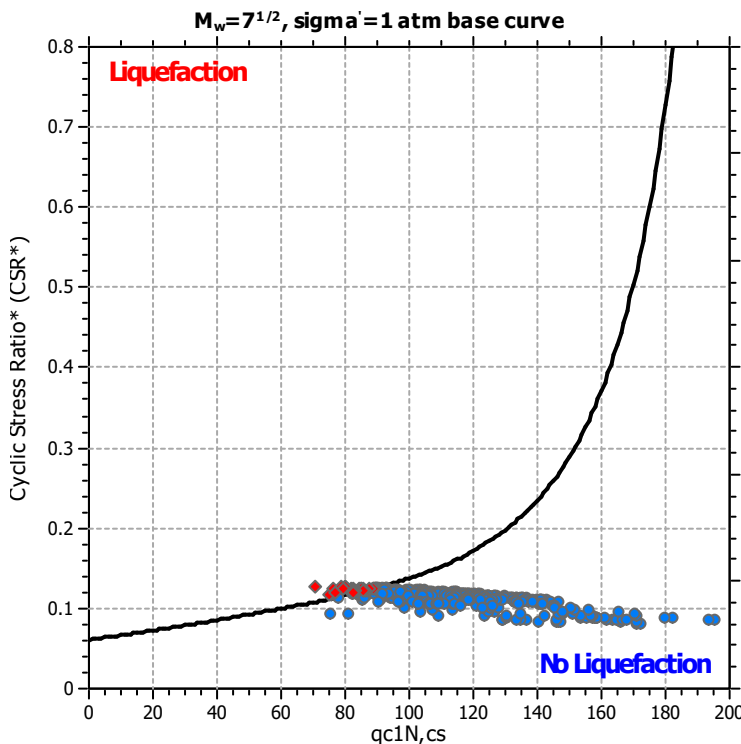
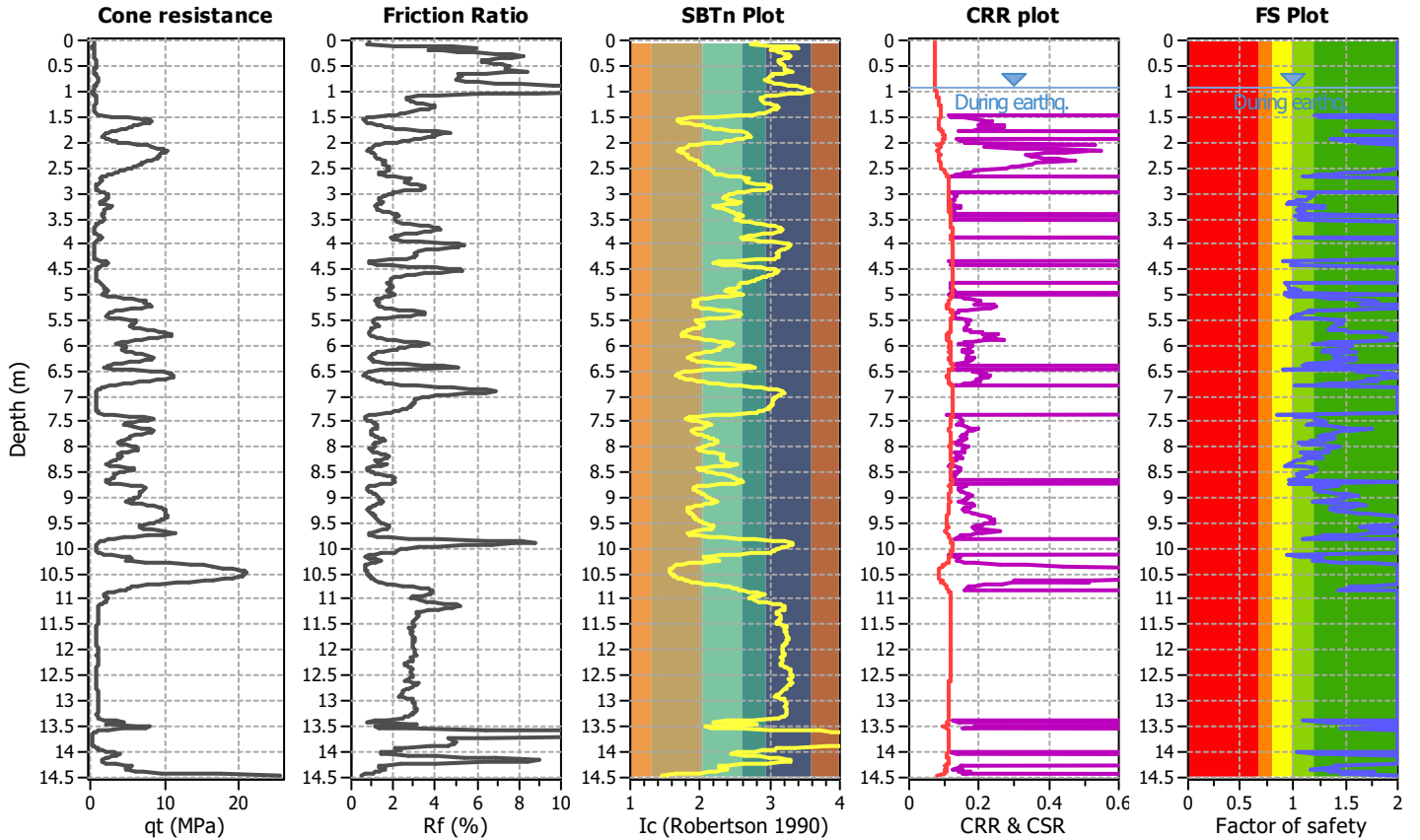
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

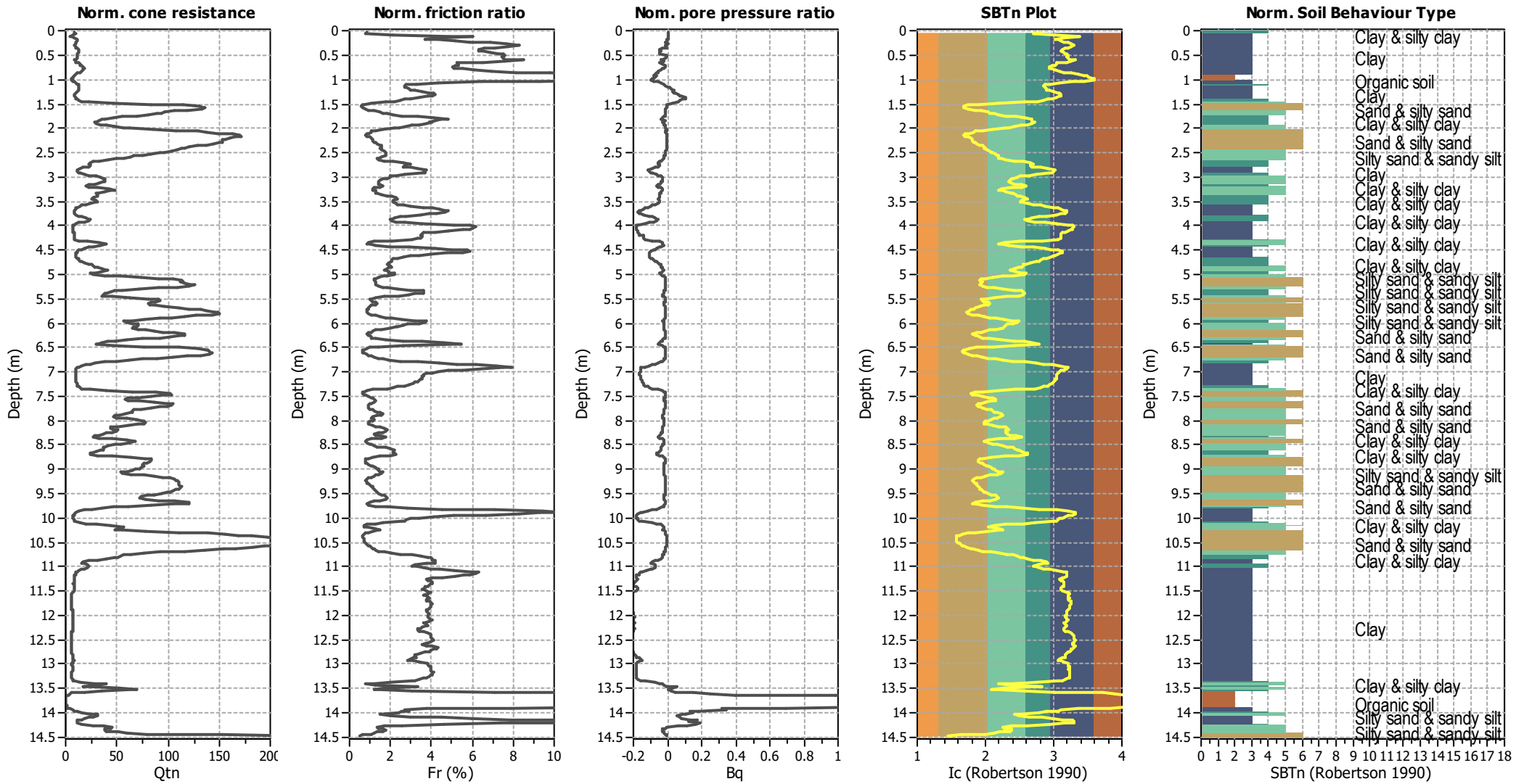
**CPT file : CPT02\_SLS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	6.40	Ic cut-off value:	2.60	Trans. detected. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.12	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No	MSF method:	Method based



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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 <sub>σ</sub> applied:	No
Earthquake magnitude M <sub>w</sub> :	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.12	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

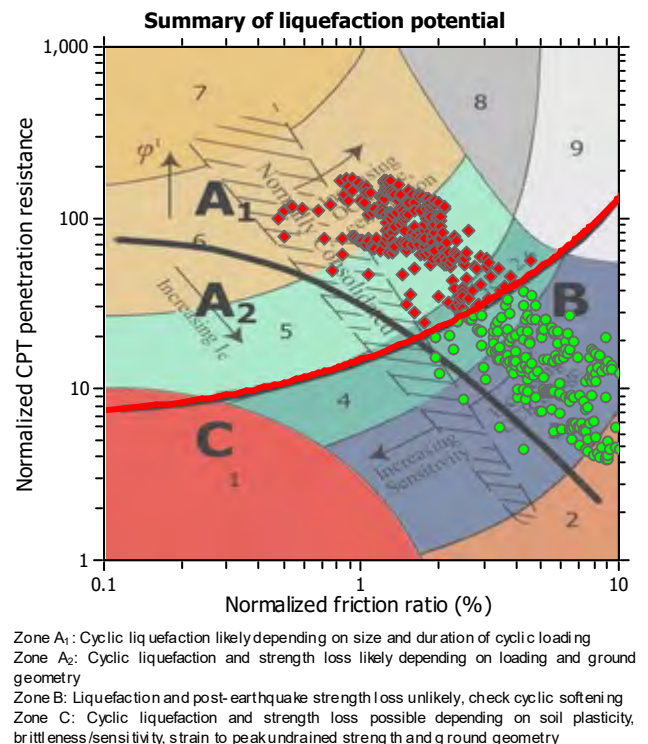
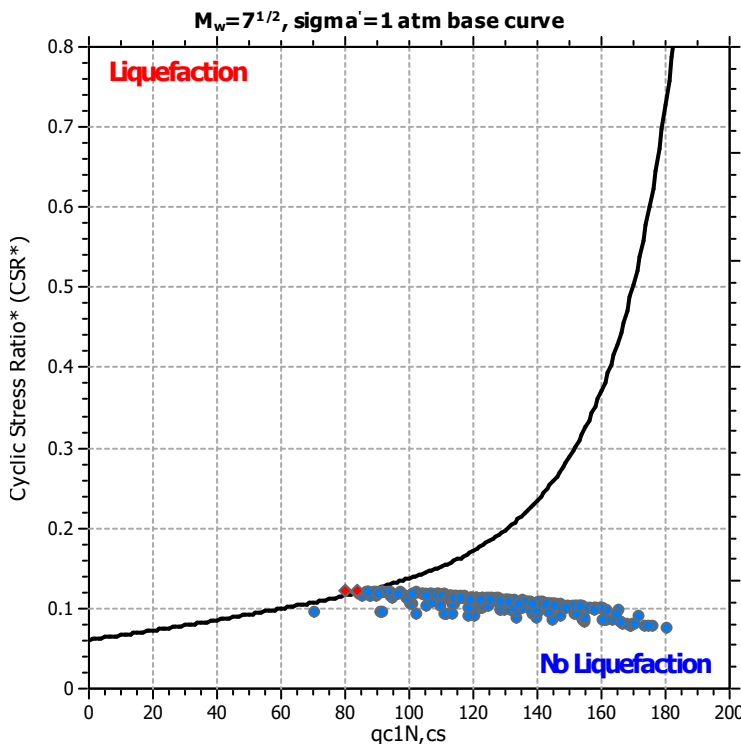
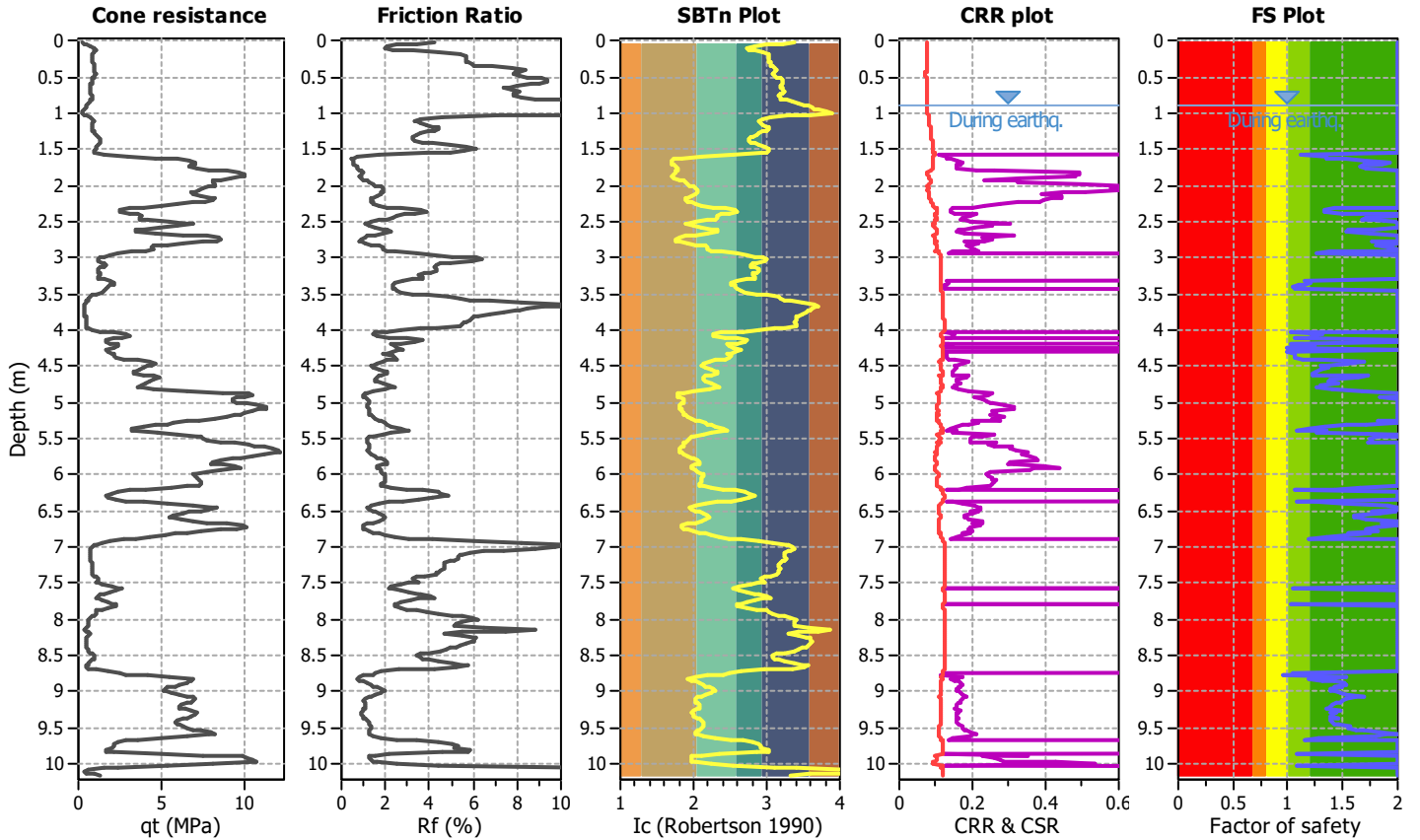
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

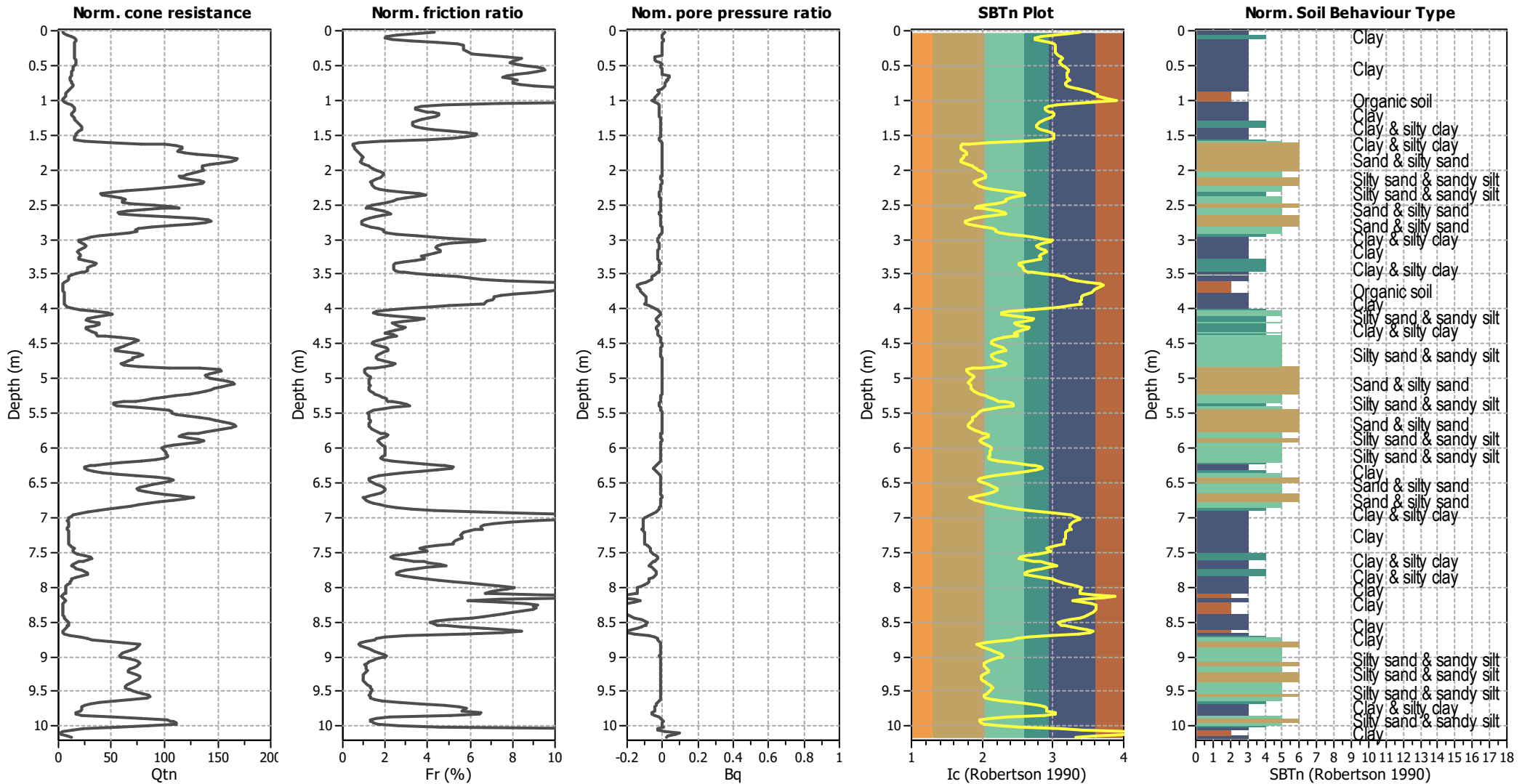
**CPT file : CPT03\_SLS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude $M_w$ :	6.40	Ic cut-off value:	2.60	Trans. detected. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.12	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No		



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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 <sub>o</sub> applied:	No
Earthquake magnitude M <sub>w</sub> :	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.12	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

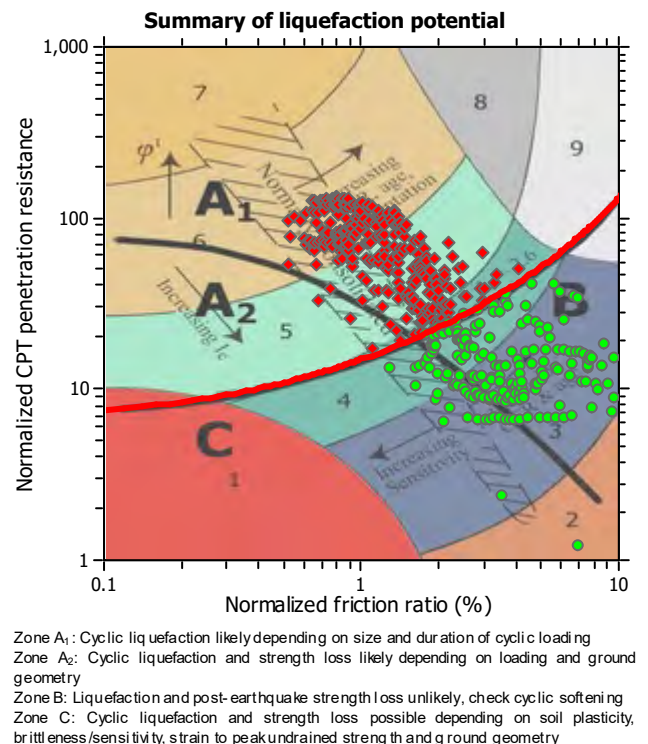
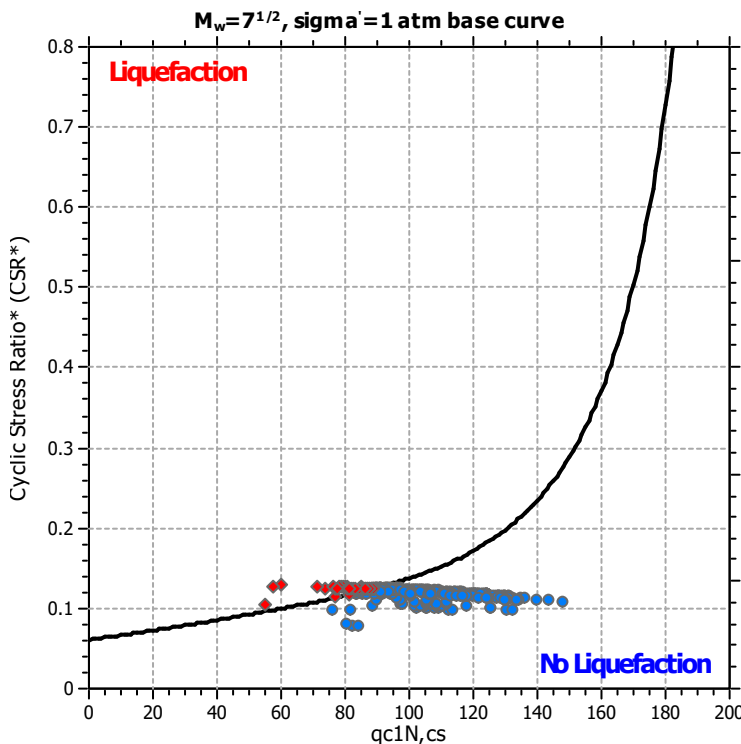
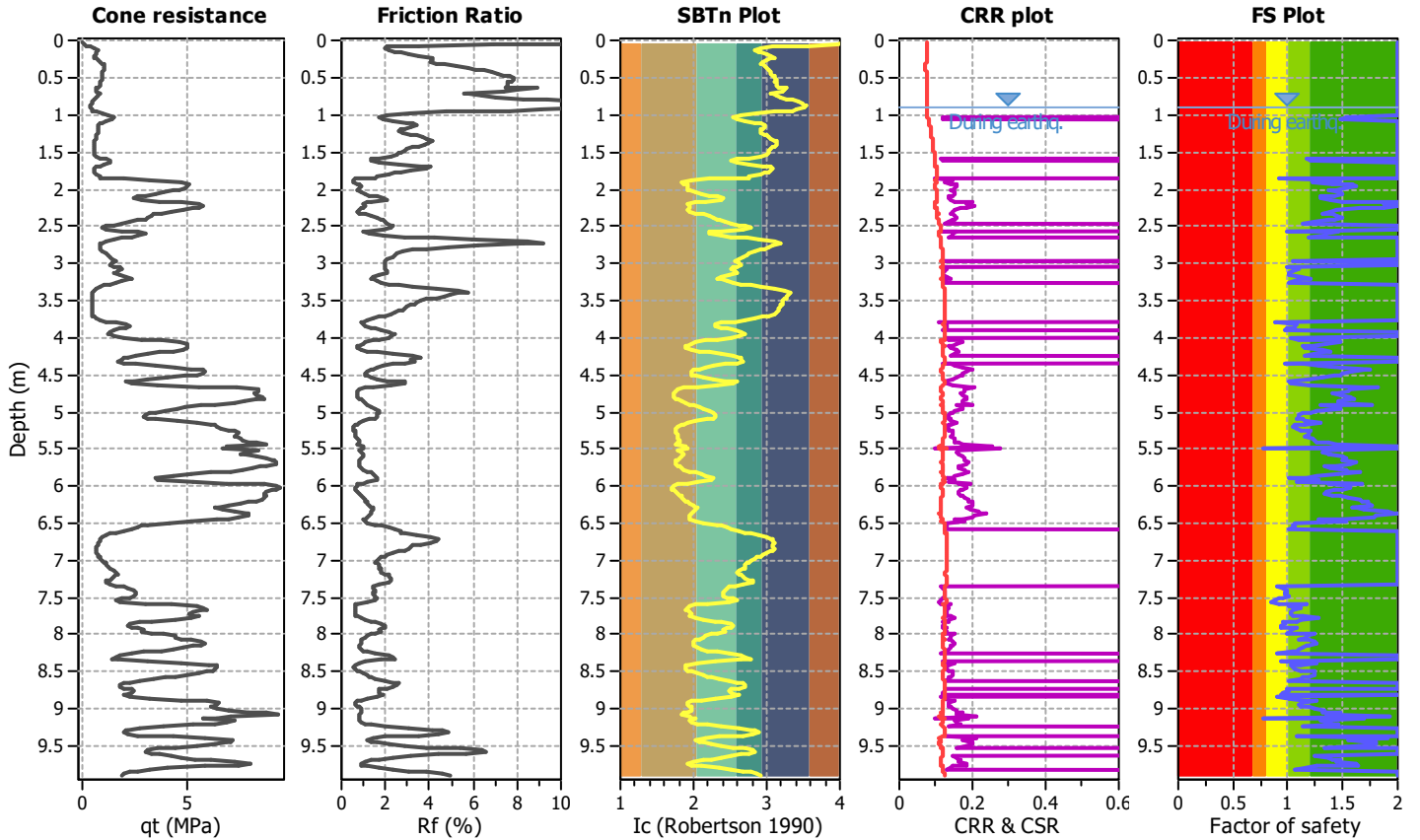
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

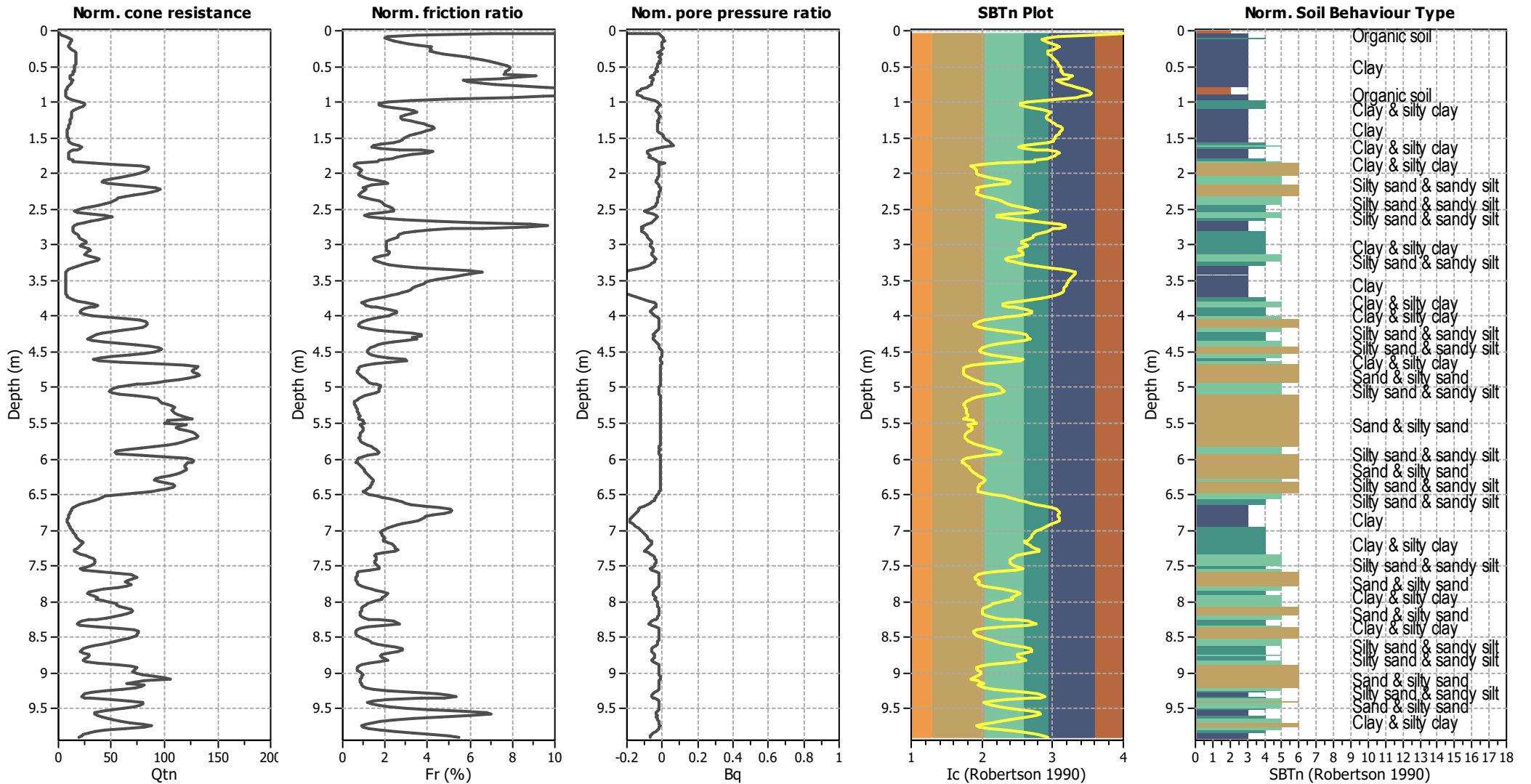
**CPT file : CPT04\_SLS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	6.40	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.12	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No	MSF method:	Method based



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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 <sub>g</sub> applied:	No
Earthquake magnitude M <sub>w</sub> :	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.12	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

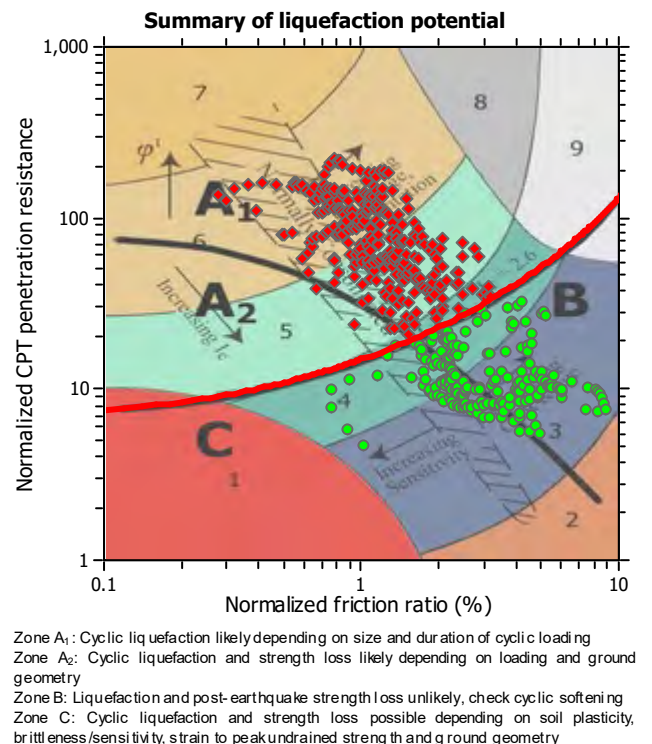
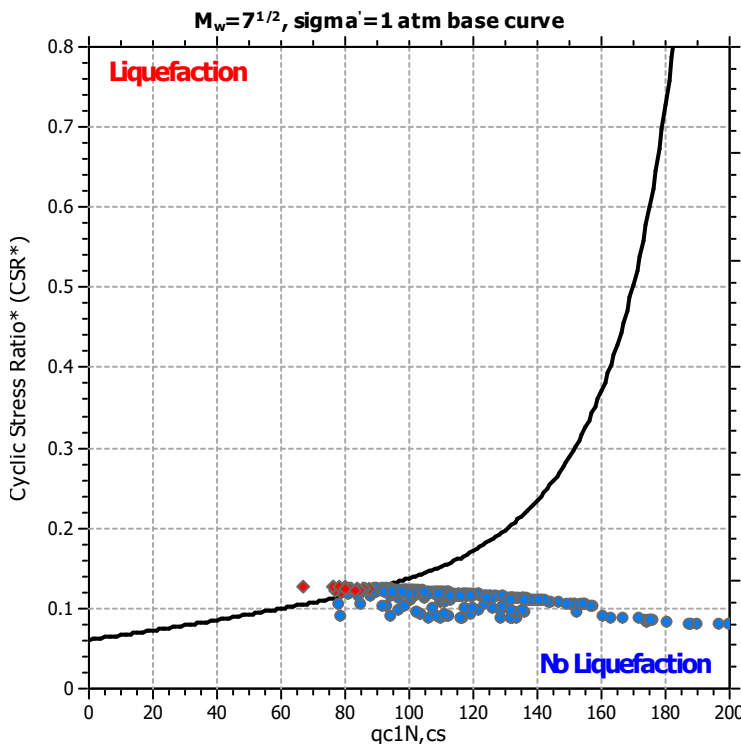
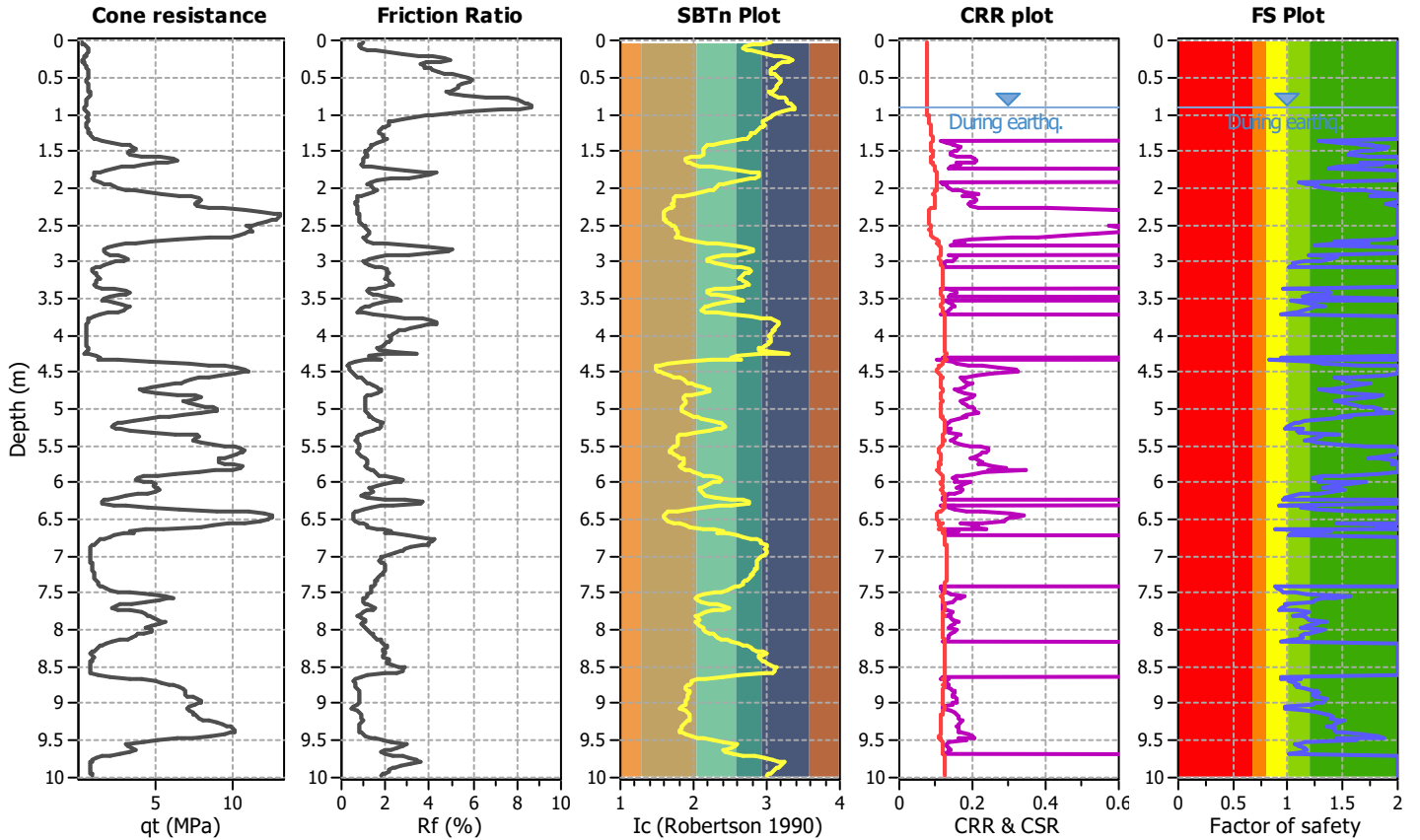
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

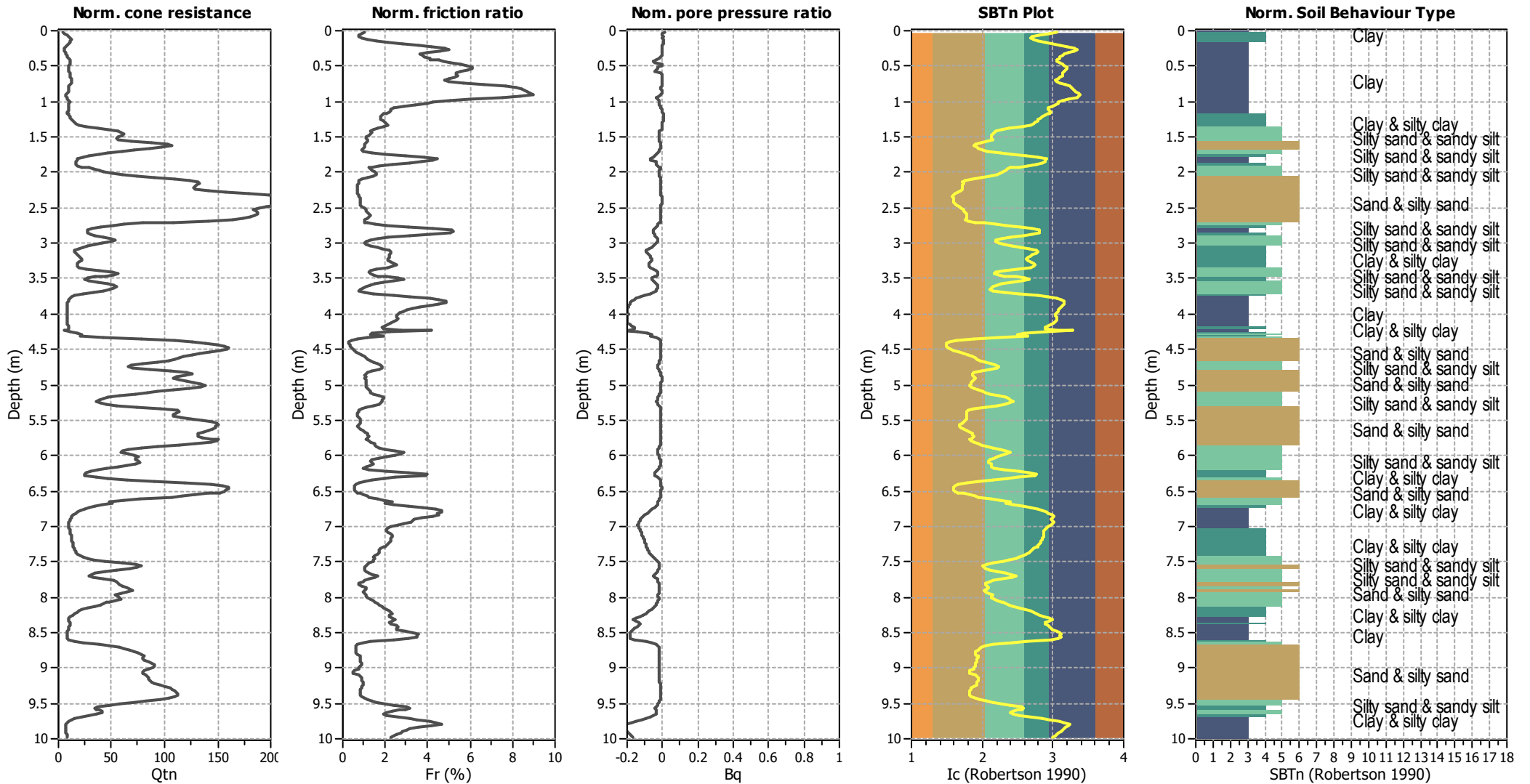
**CPT file : CPT05\_SLS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude $M_w$ :	6.40	Ic cut-off value:	2.60	Trans. detected. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.12	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No		



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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 <sub>o</sub> applied:	No
Earthquake magnitude M <sub>w</sub> :	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.12	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

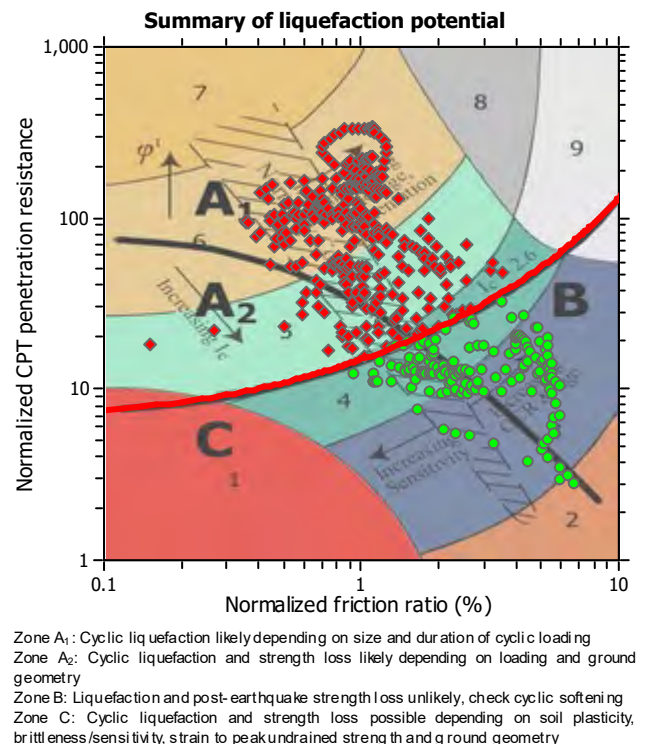
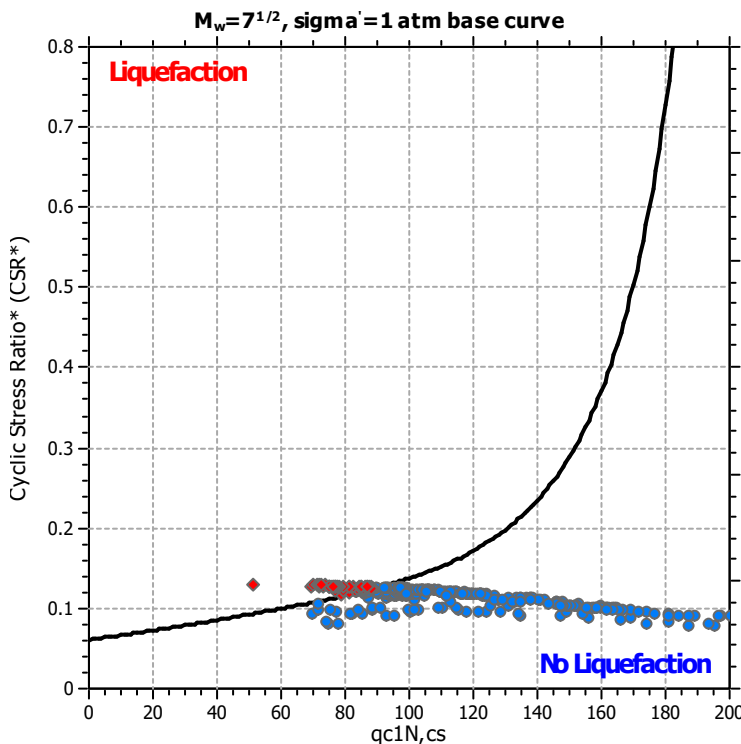
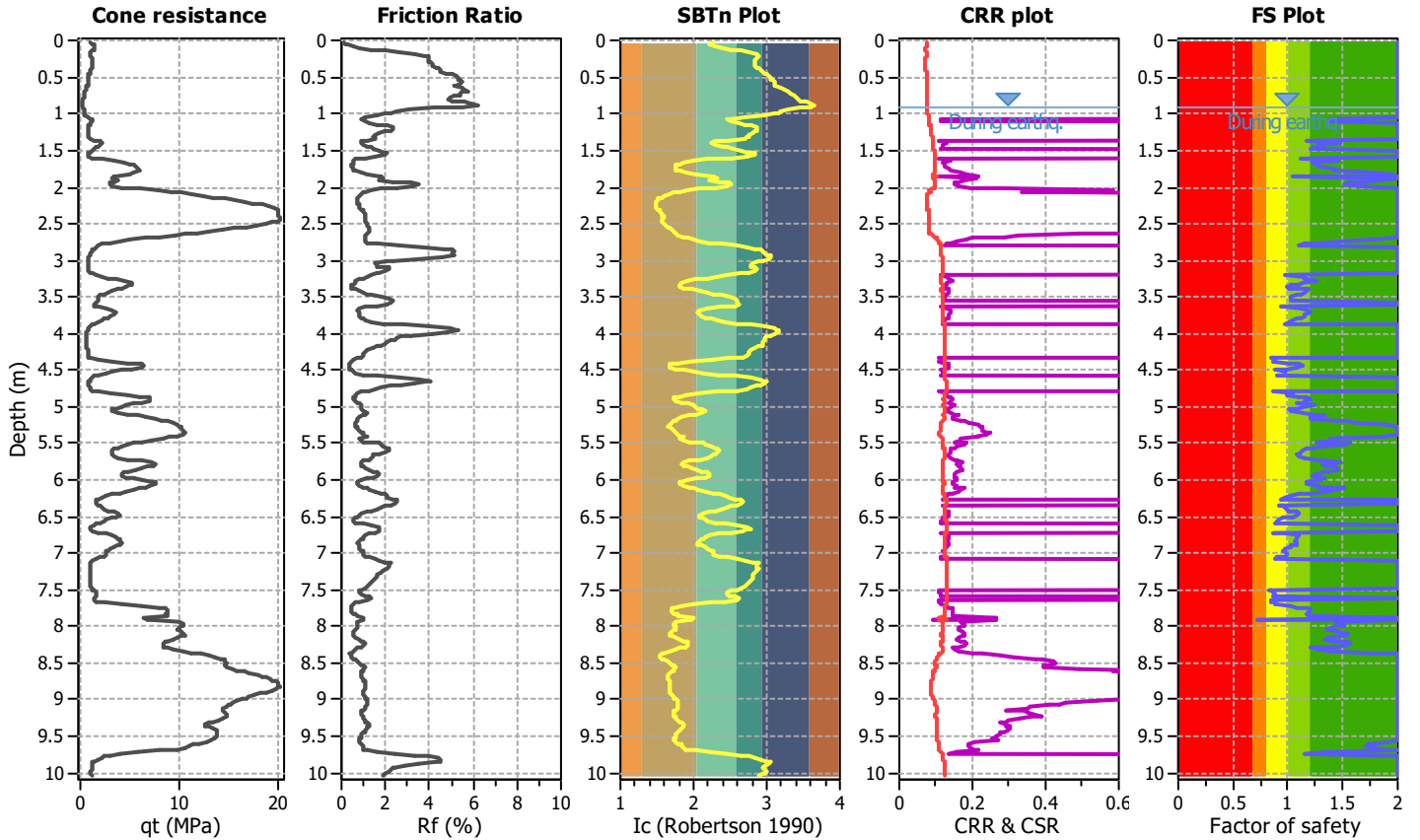
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

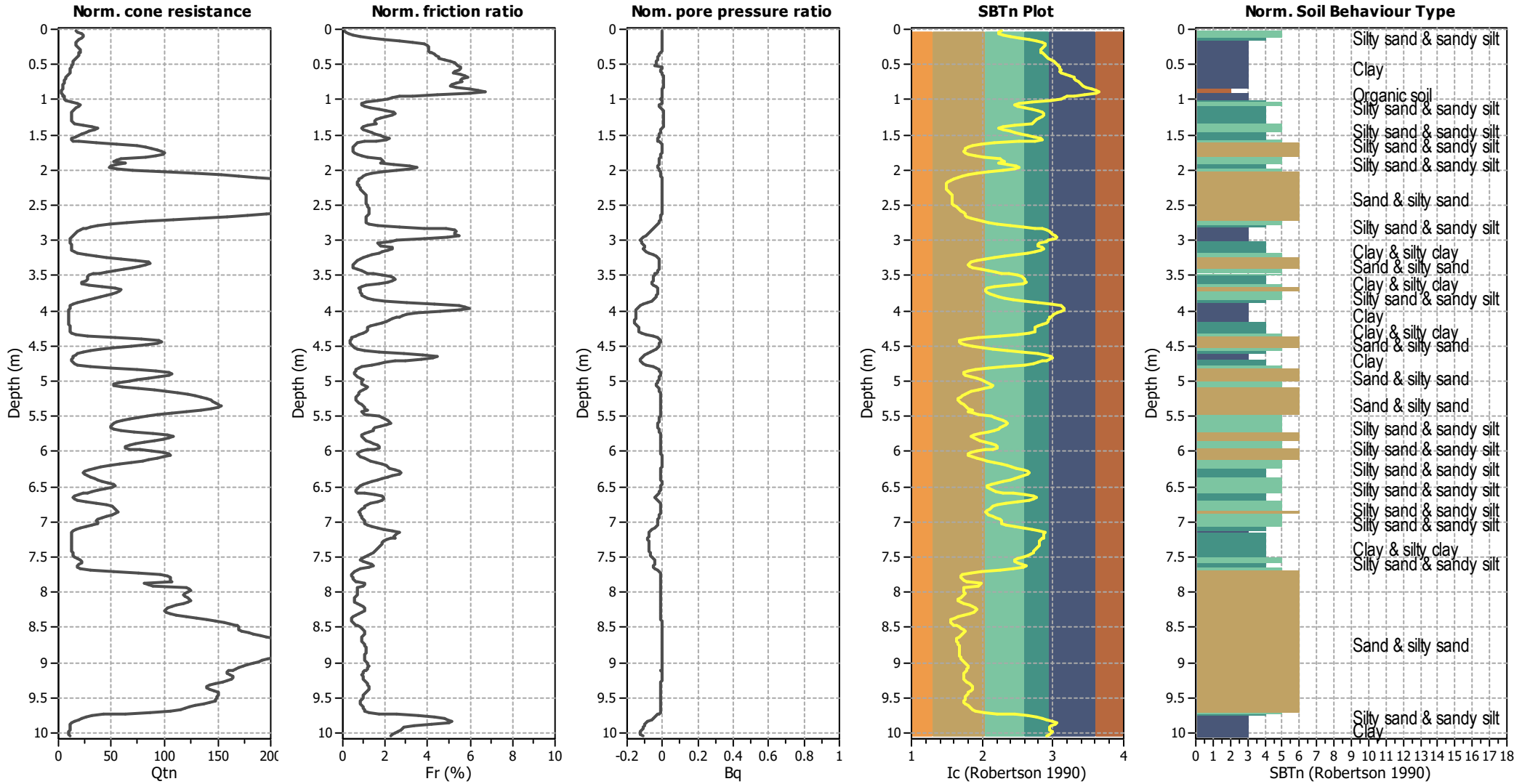
**CPT file : CPT06\_SLS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude $M_w$ :	6.40	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.12	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No		



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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	$K_p$ applied:	No
Earthquake magnitude $M_w$ :	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.12	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

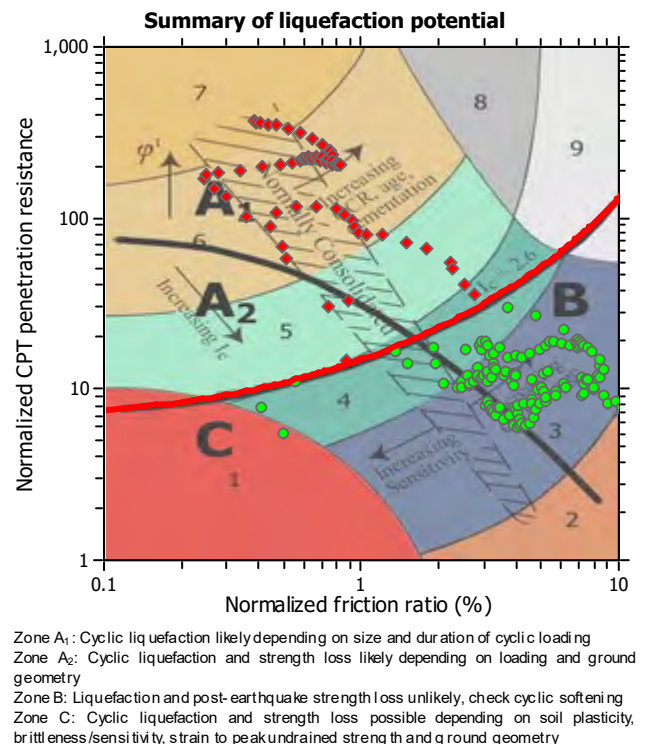
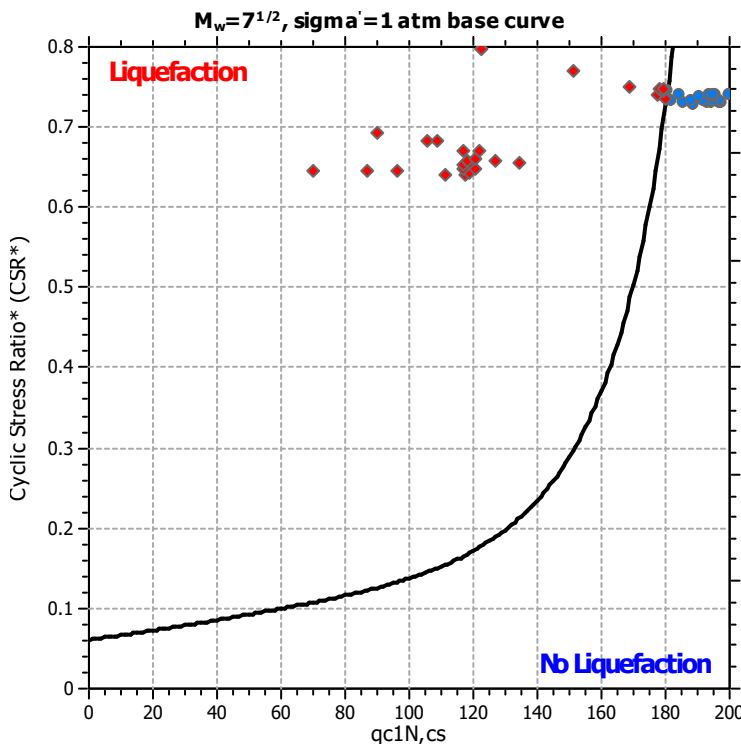
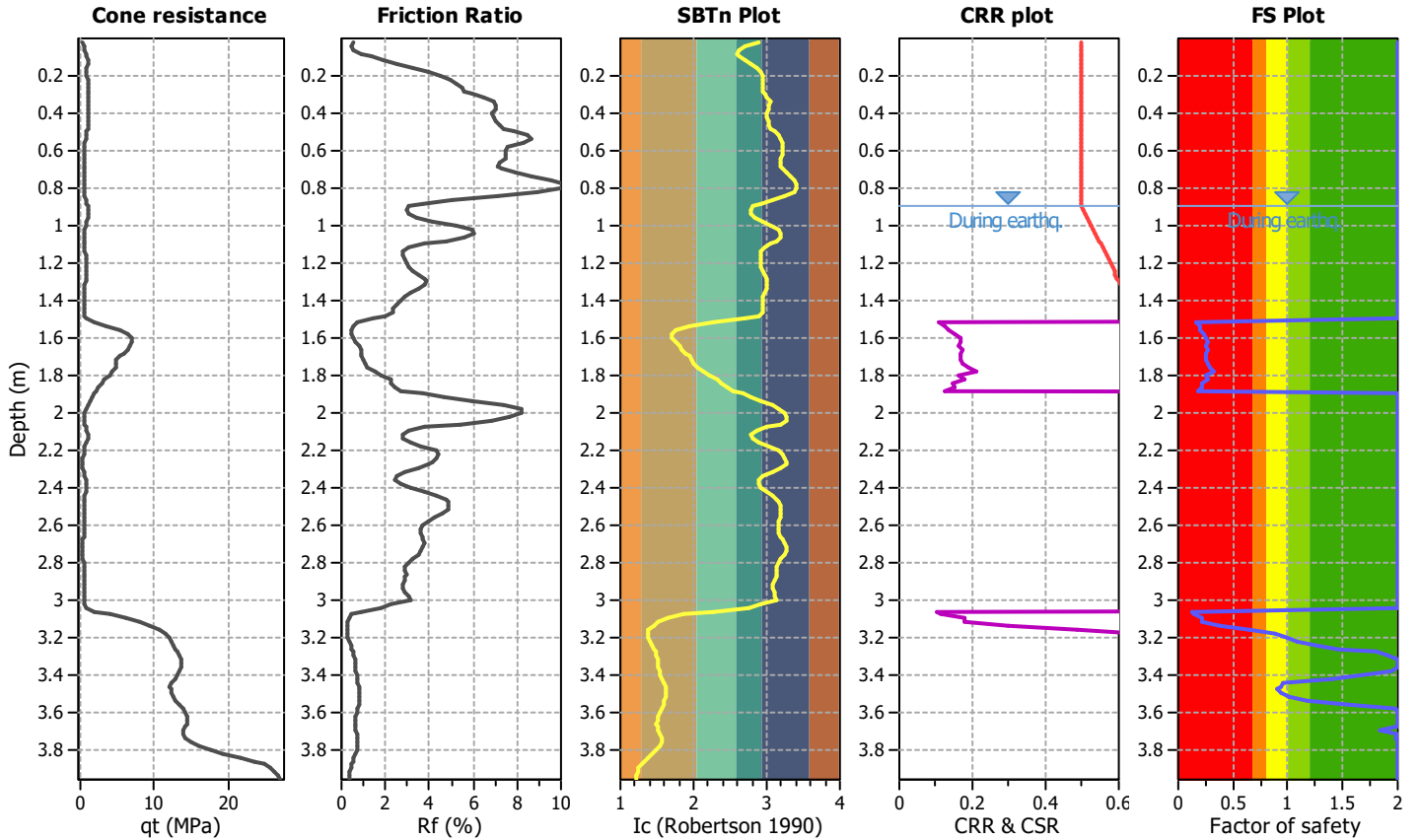
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

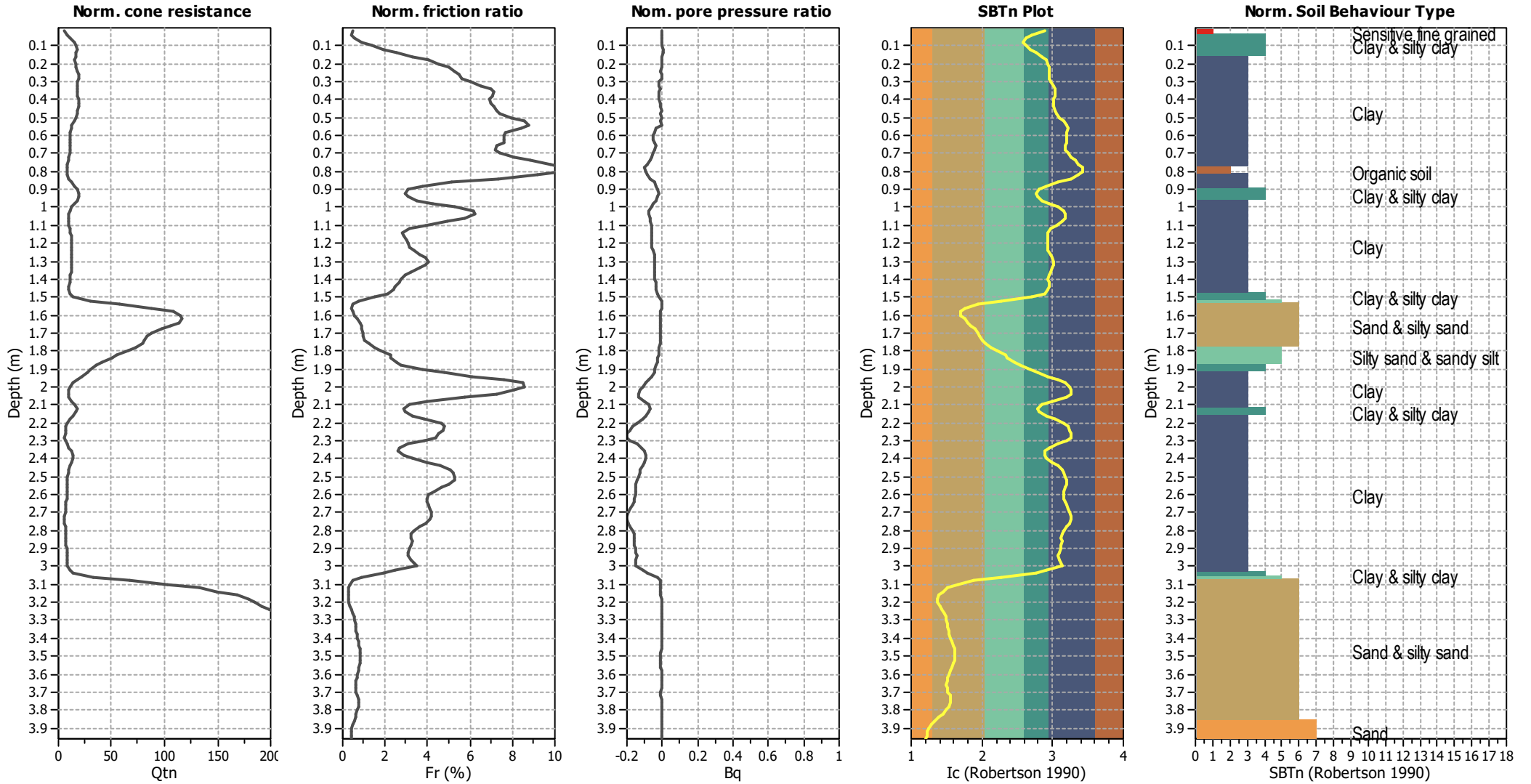
**CPT file : CPT01\_ULS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.78	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No	MSF method:	Method based



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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	$K_{\sigma}$ applied:	No
Earthquake magnitude $M_w$ :	7.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.78	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

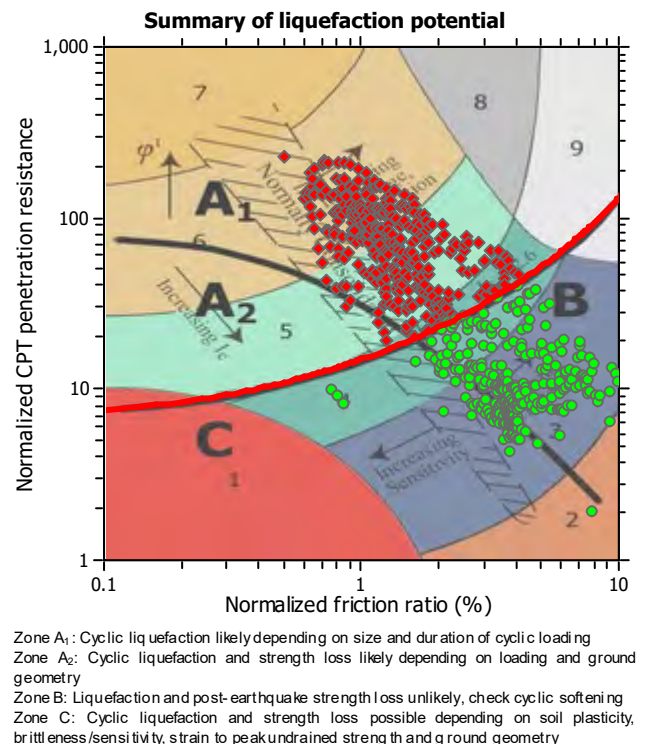
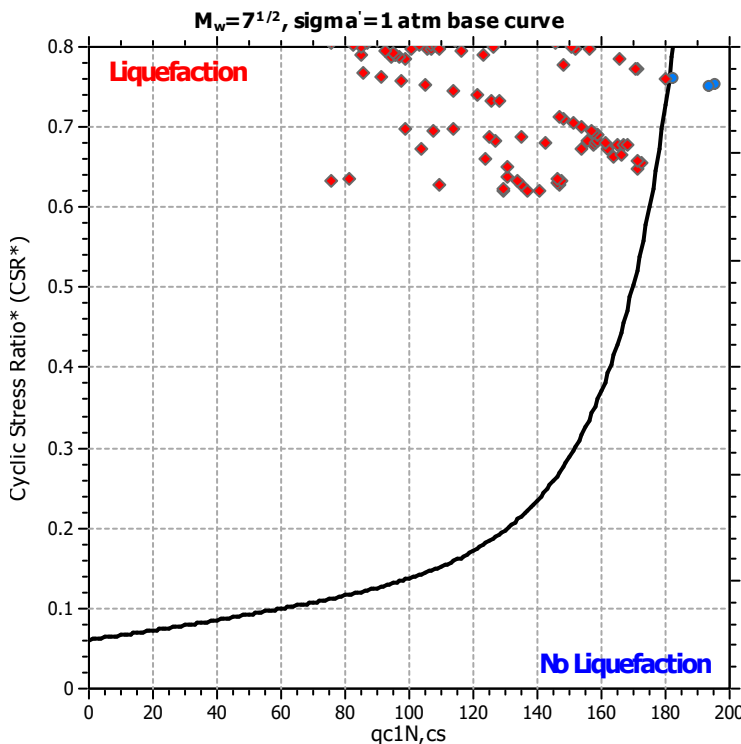
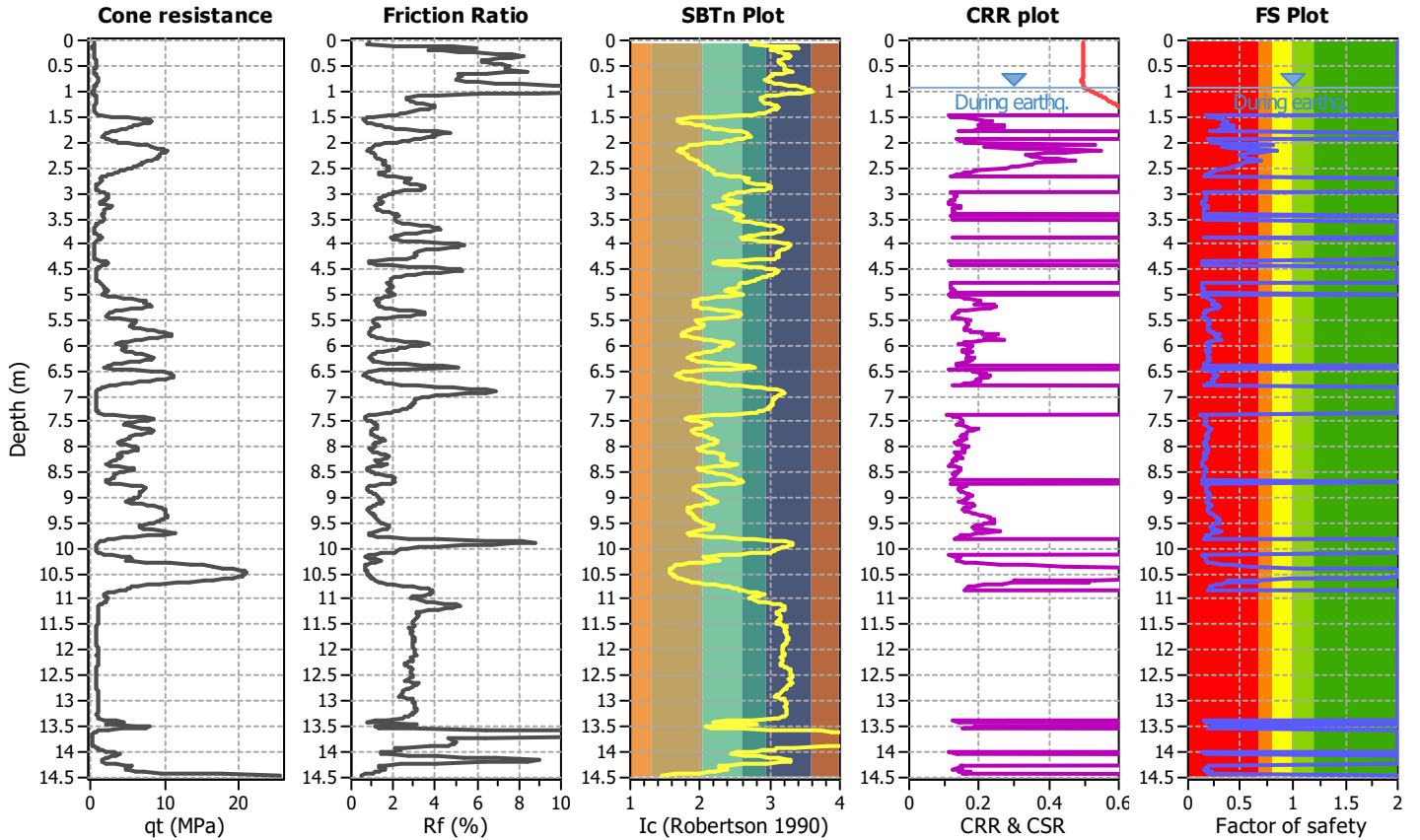
**LIQUEFACTION ANALYSIS REPORT**

**Project title : 230850\_Geotechnical Investigation**  
**CPT file : CPT02\_ULS**

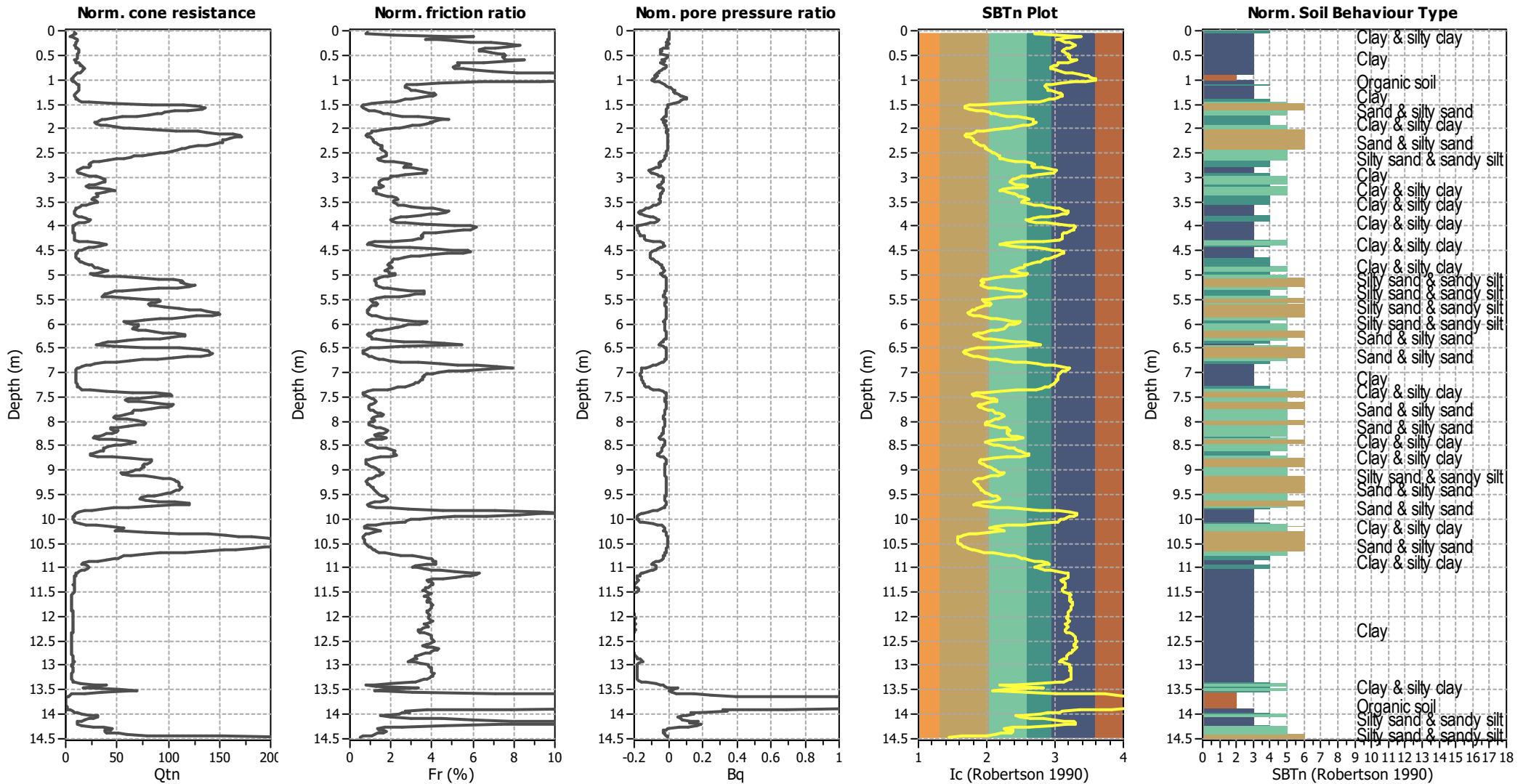
**Location : 160 Evenden Road, Twyford**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.10	Ic cut-off value:	2.60	Trans. detected. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.78	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No	MSF method:	Method based



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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 <sub>σ</sub> applied:	No
Earthquake magnitude M <sub>w</sub> :	7.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.78	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

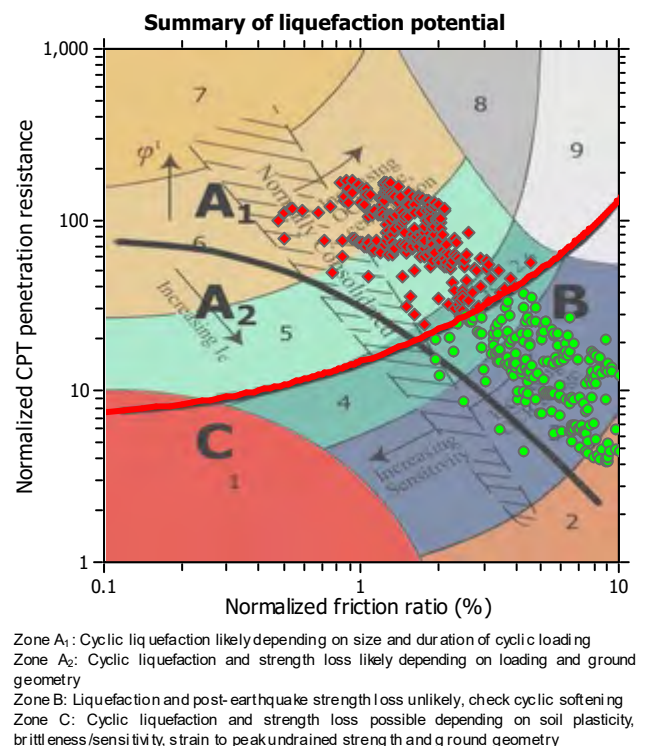
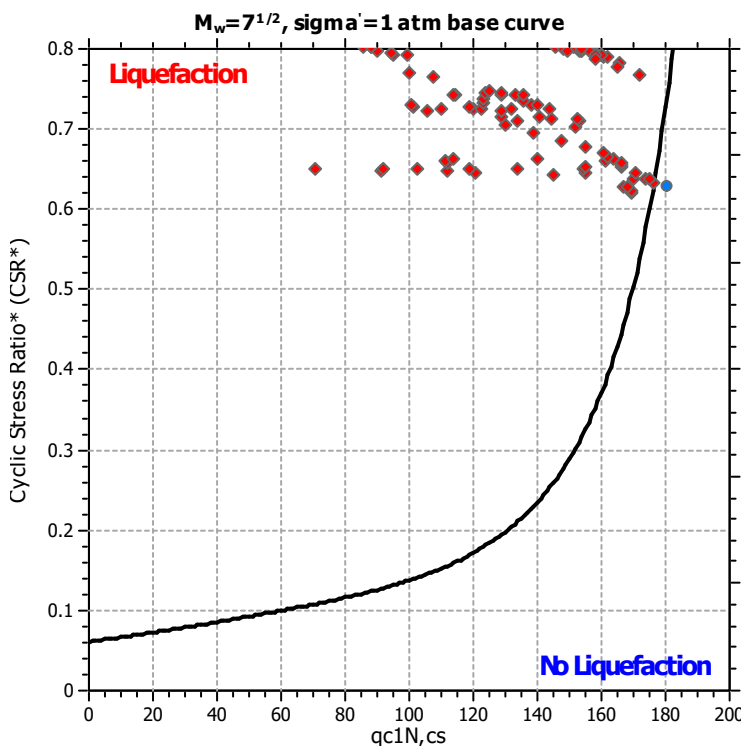
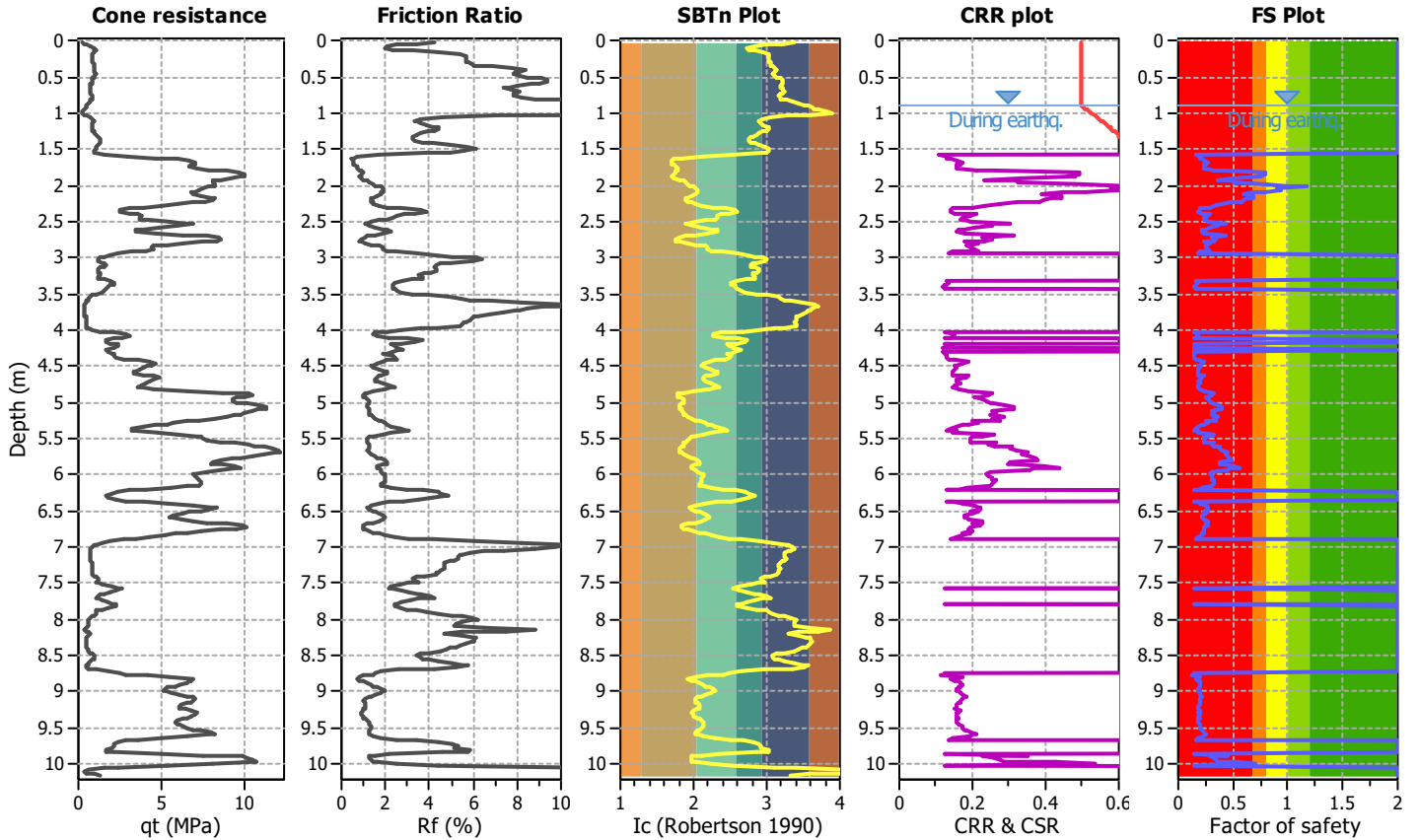
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

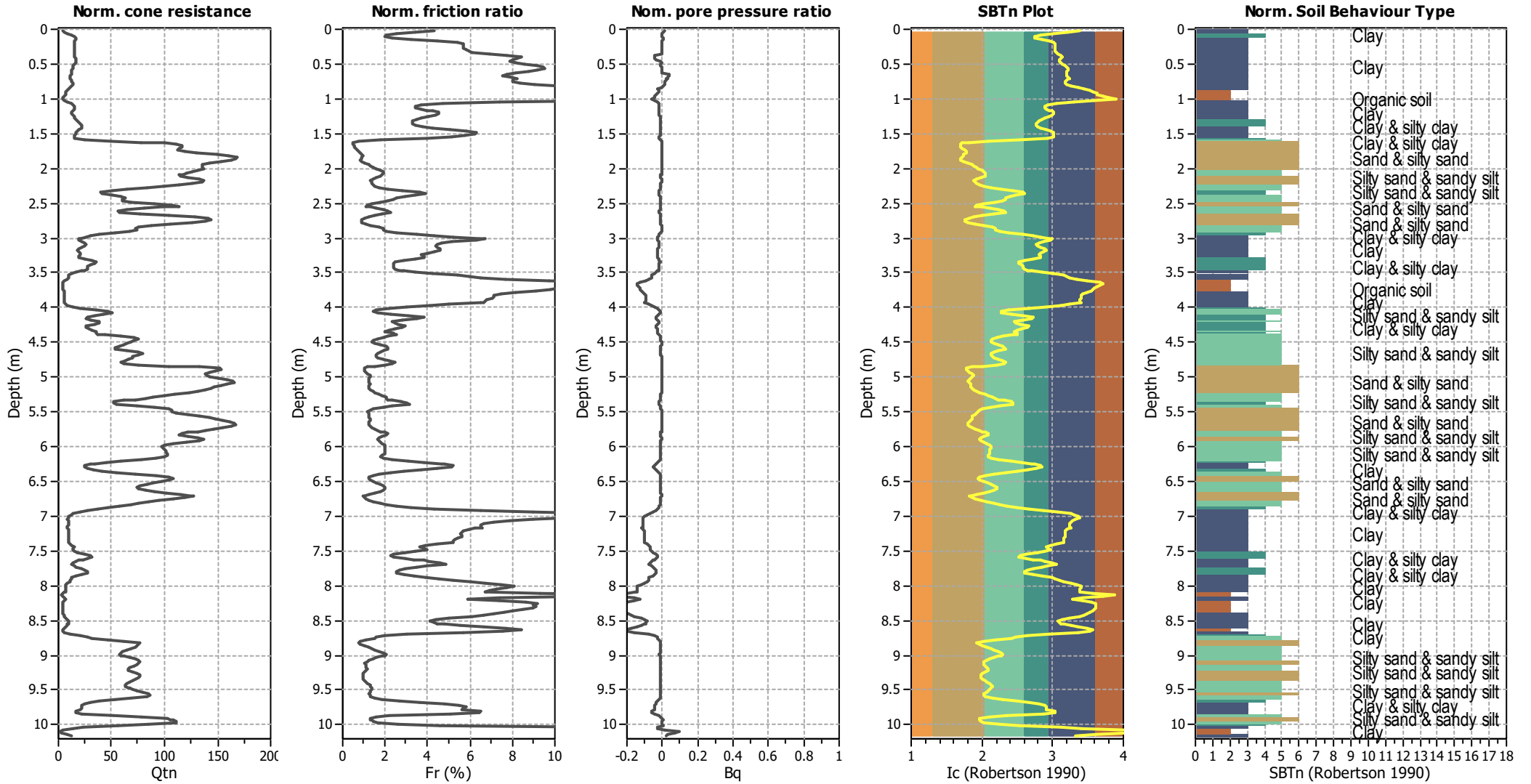
**CPT file : CPT03\_ULS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude $M_w$ :	7.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.78	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No		



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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 <sub>o</sub> applied:	No
Earthquake magnitude M <sub>w</sub> :	7.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.78	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

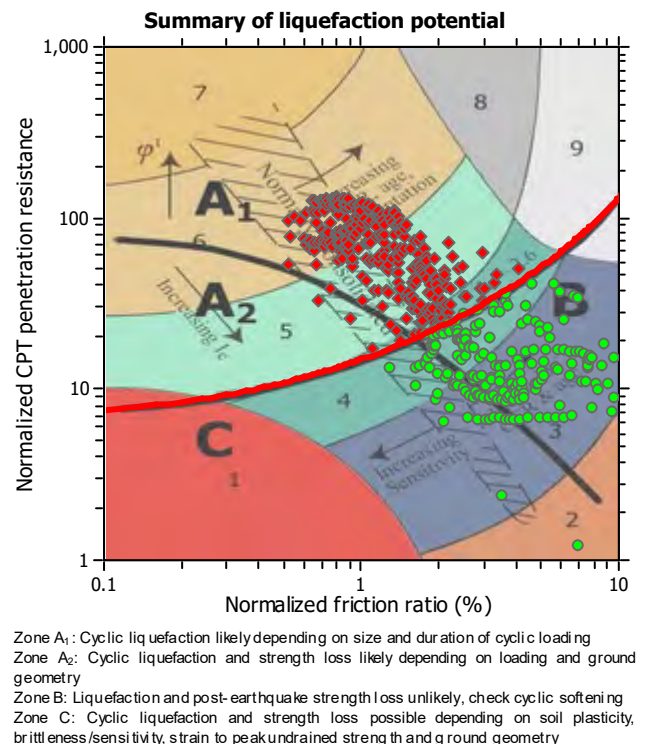
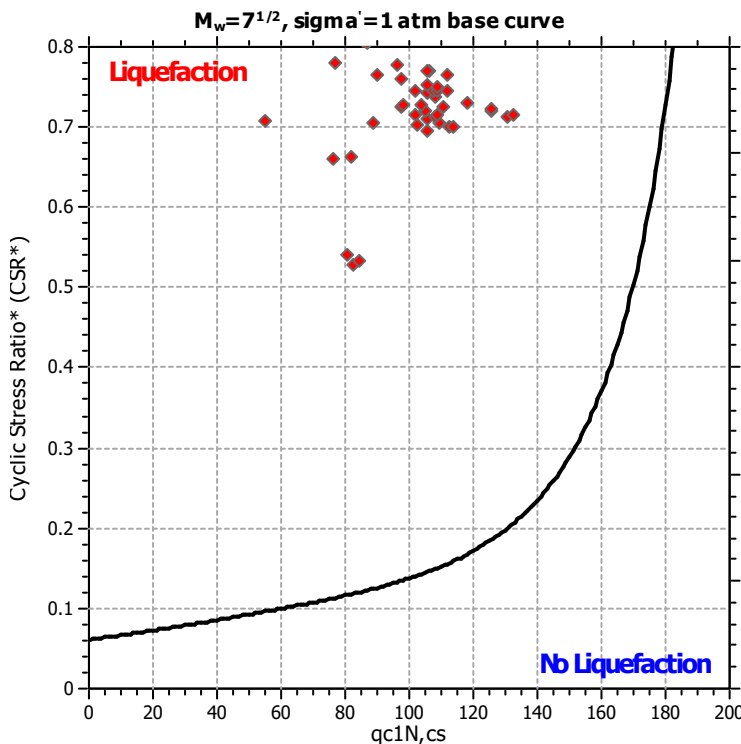
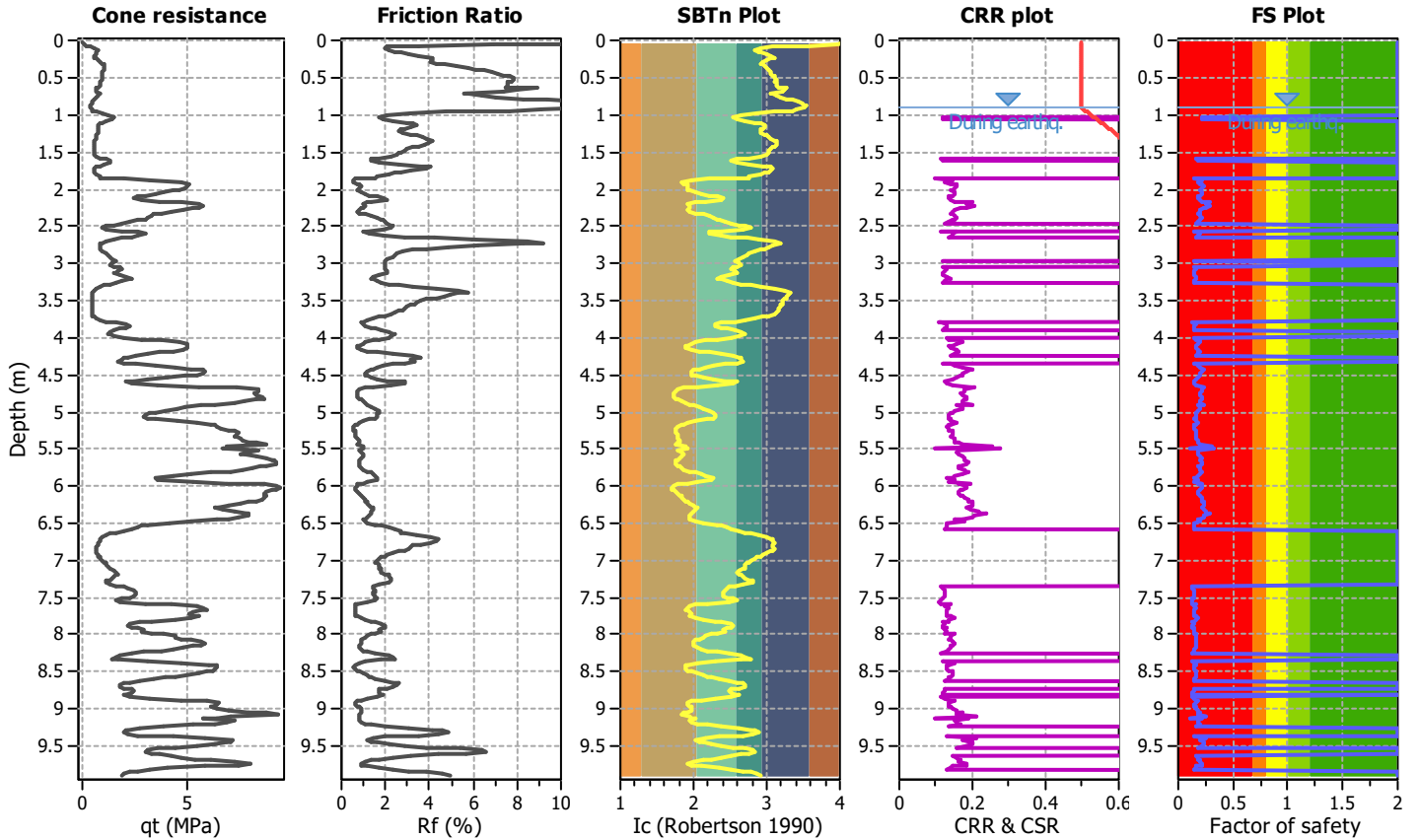
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

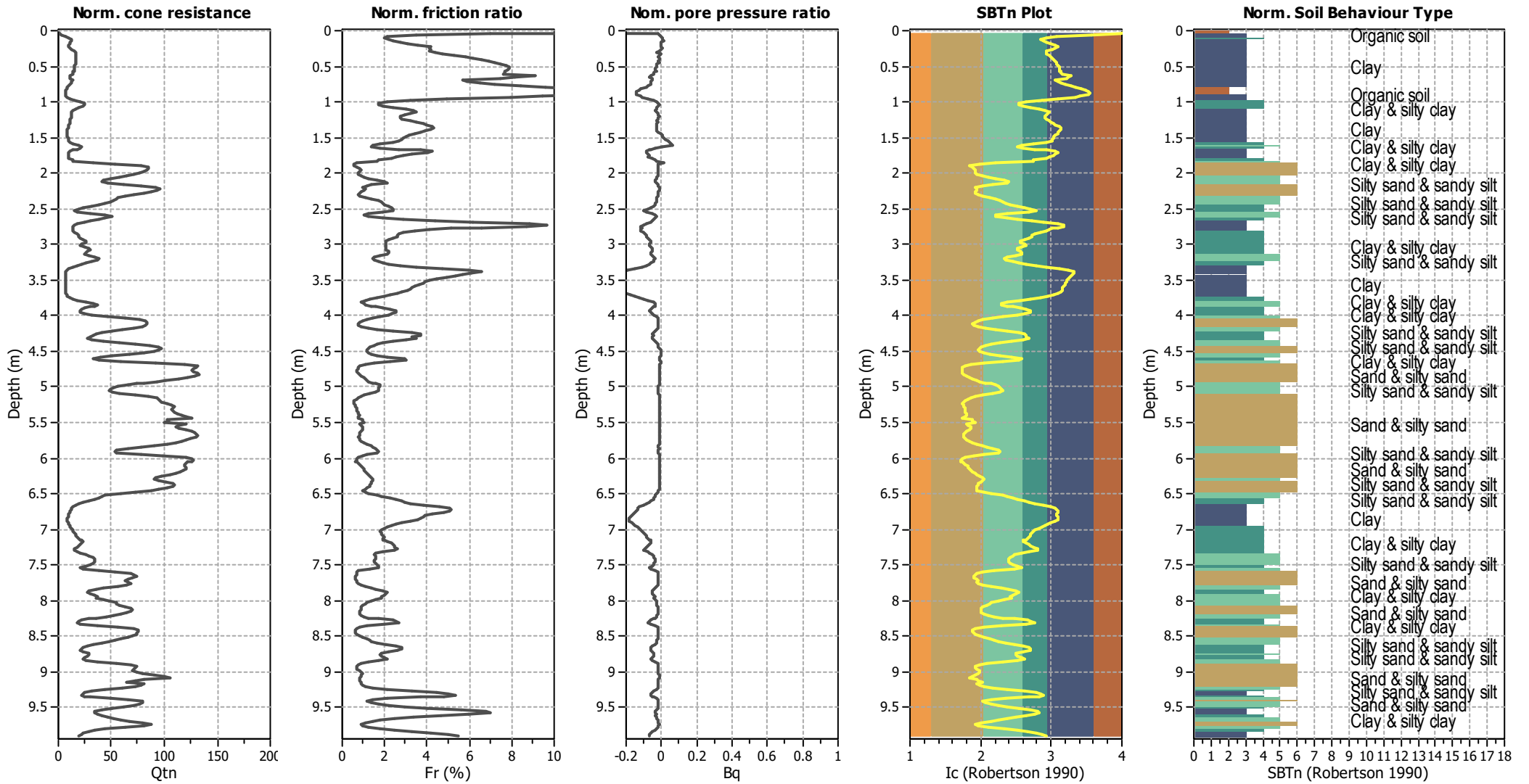
**CPT file : CPT04\_ULS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior	
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Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.10	Ic cut-off value:	2.60	Trans. detected. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.78	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No	MSF method:	Method based



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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	$K_p$ applied:	No
Earthquake magnitude $M_w$ :	7.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.78	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

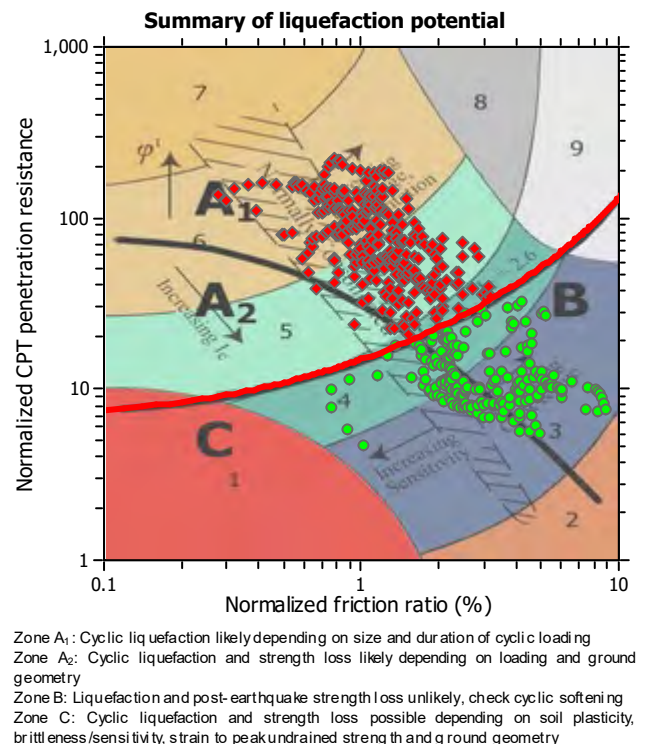
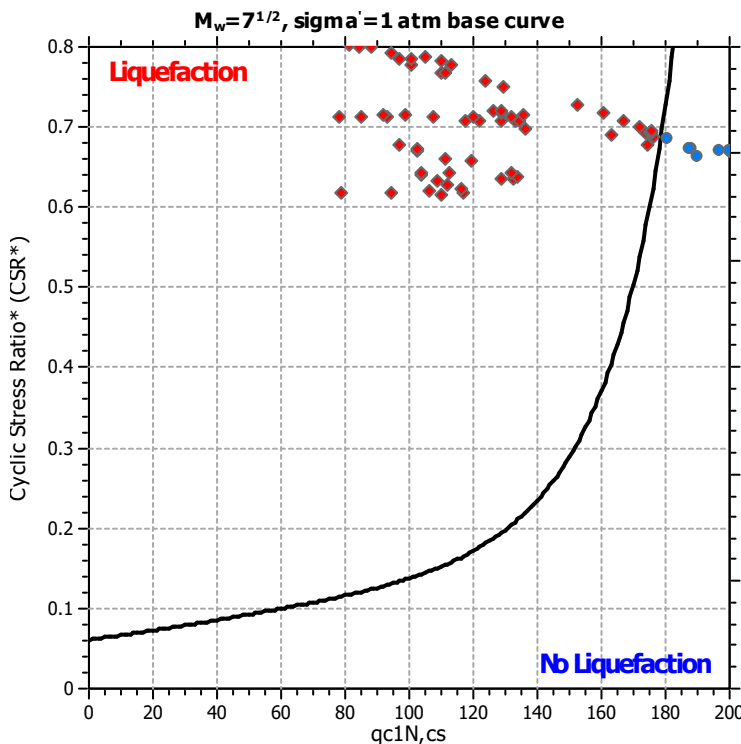
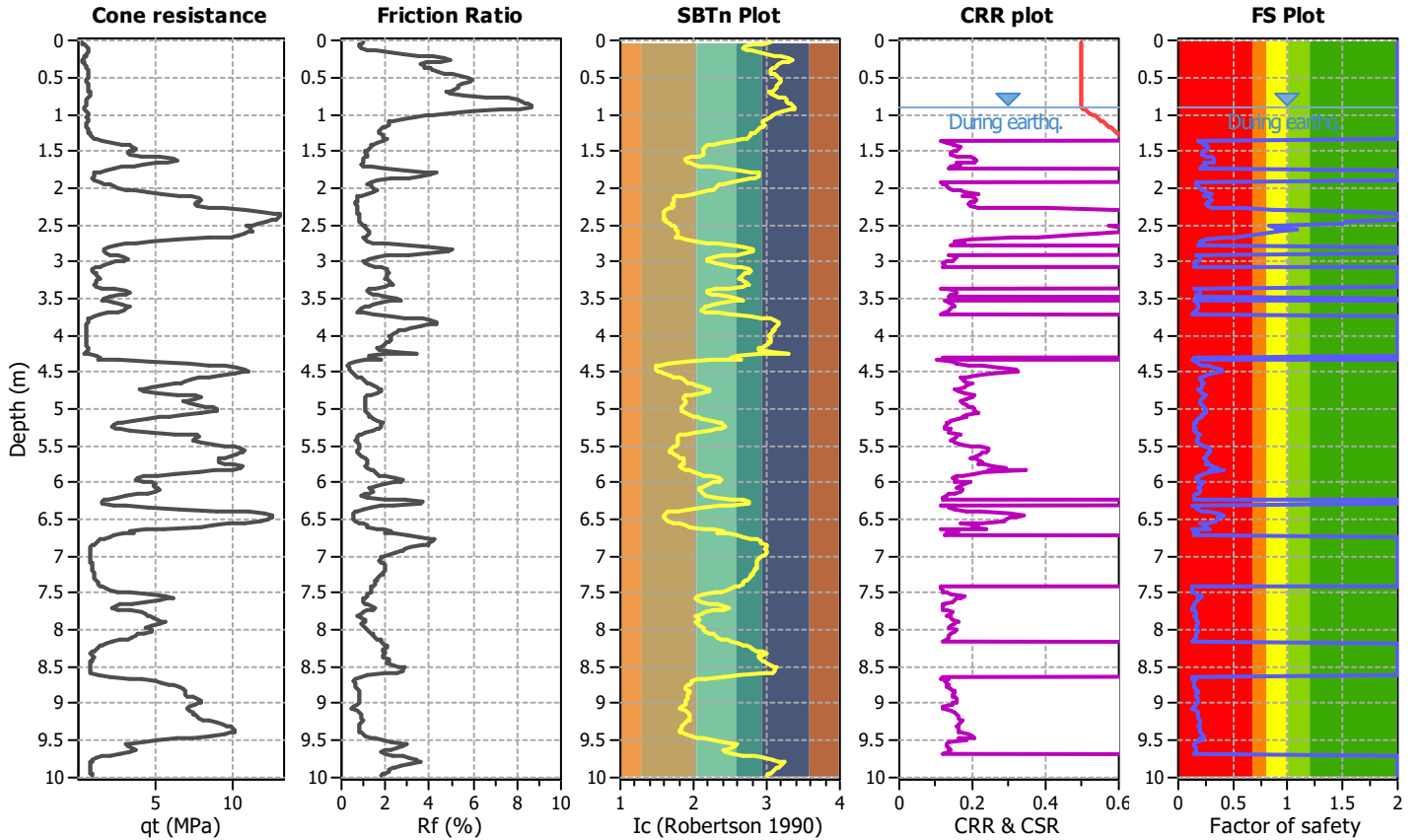
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

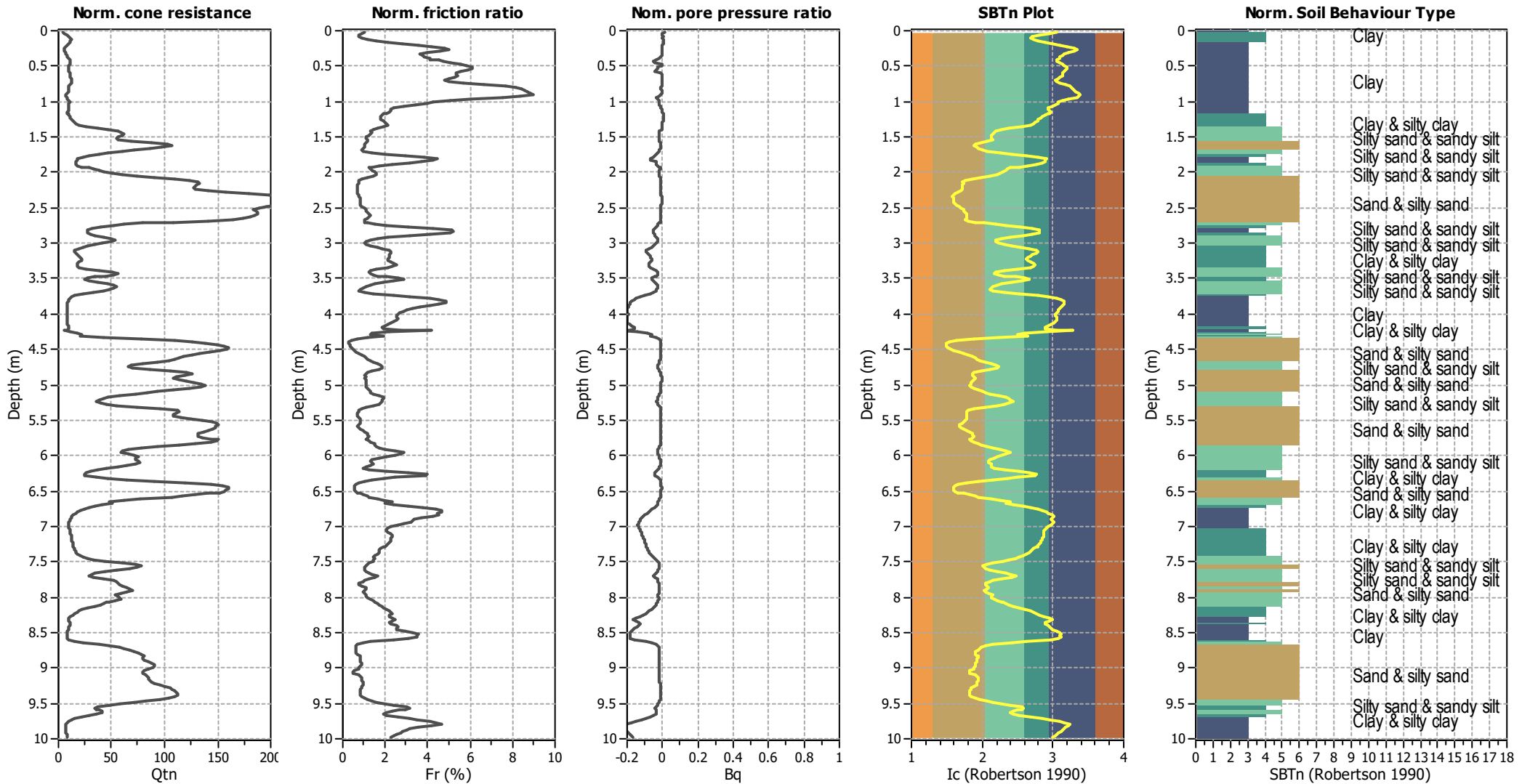
**CPT file : CPT05\_ULS**

**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude $M_w$ :	7.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.78	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No		



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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 <sub>q</sub> applied:	No
Earthquake magnitude M <sub>w</sub> :	7.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.78	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

**LIQUEFACTION ANALYSIS REPORT**

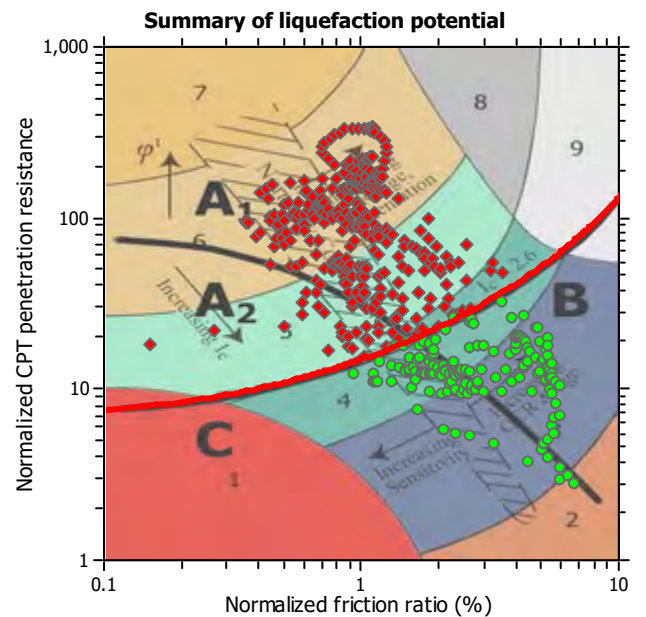
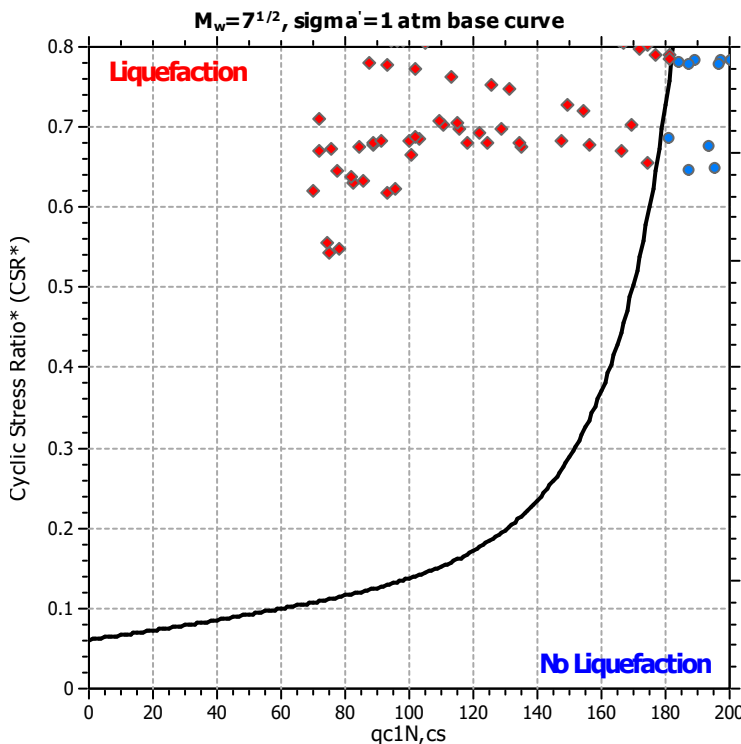
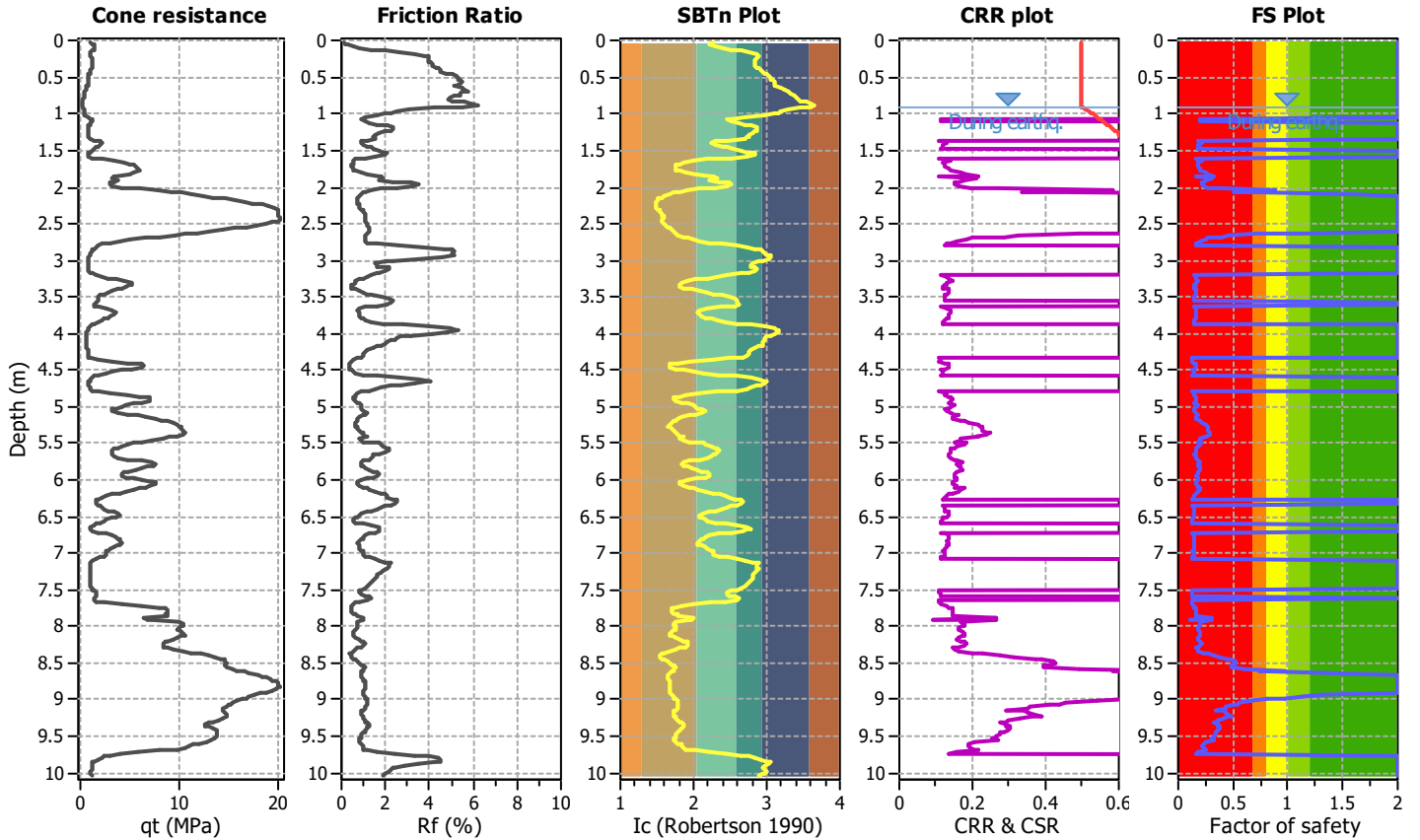
**Project title : 230850\_Geotechnical Investigation**

**Location : 160 Evenden Road, Twyford**

**CPT file : CPT06\_ULS**

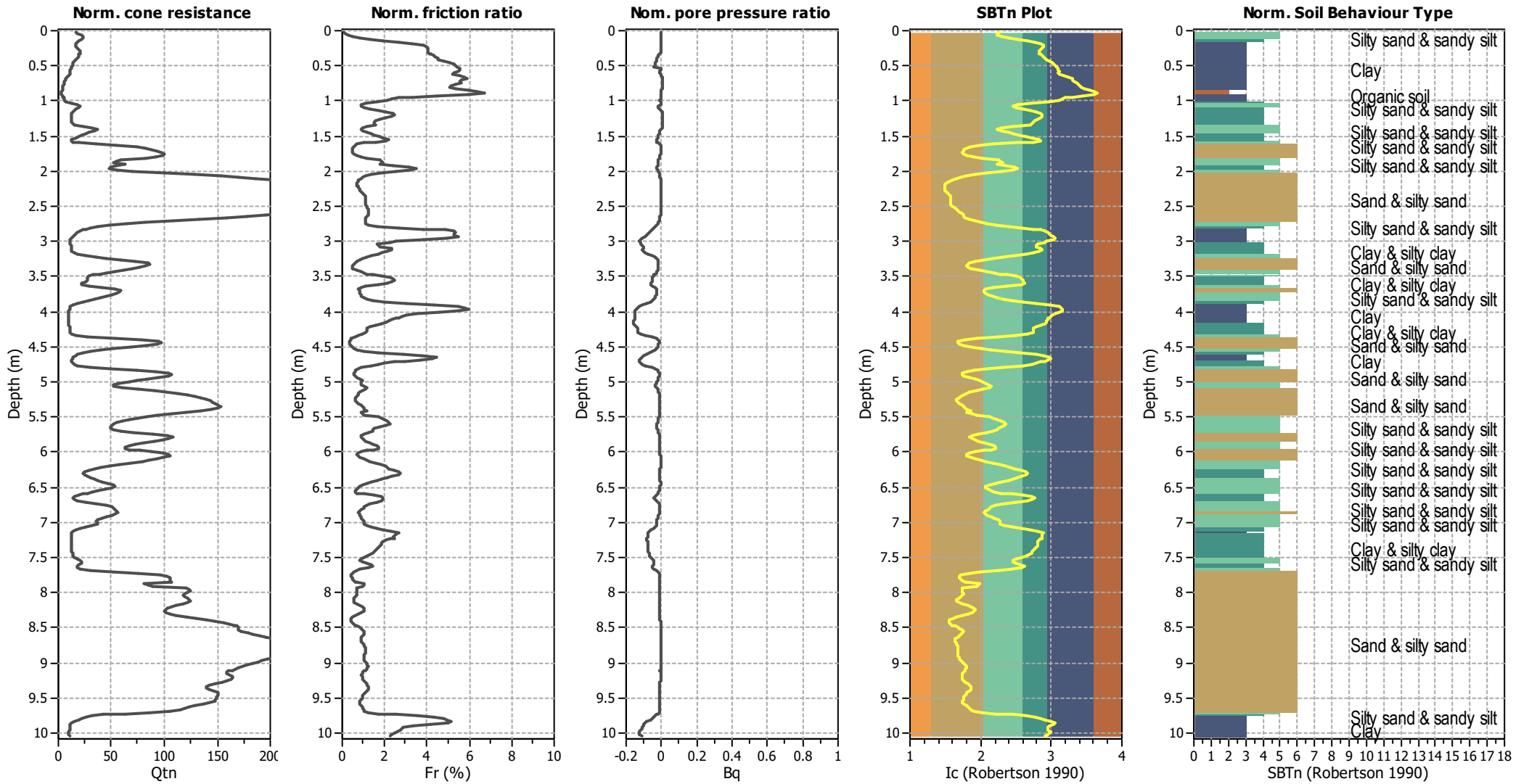
**Input parameters and analysis data**

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.78	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	No	MSF method:	Method based



Zone A<sub>1</sub>: Cyclic liquefaction likely depending on size and duration of cyclic loading  
 Zone A<sub>2</sub>: Cyclic liquefaction and strength loss likely depending on loading and ground geometry  
 Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening  
 Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.90 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	$K_p$ applied:	No
Earthquake magnitude $M_w$ :	7.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.78	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

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

# Important Information about This

# Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

**The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.**

## Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

## Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

## You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

## This Report May Not Be Reliable

*Do not rely on this report* if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be, and, in general, if you are the least bit uncertain about the continued reliability of this report, contact your geotechnical engineer before applying it.* A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

## Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

## This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

## This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

## Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may

perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

## Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

## Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old*.

## Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, *proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration*. Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. *Geotechnical engineers are not building-envelope or mold specialists*.



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