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Project Number #22235.000.001

Geotechnical Investigation Report

Patterson Block, Woolshed Road, Queenstown

Submitted to:
KA Woolshed Limited Partnership
C/- Classic Developments Limited
Tauranga 3112

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Executive Summary

ENGEO Ltd has been retained by KA Woolshed Limited Partnership C/- Classic Developments Limited (Classics) to undertake a geotechnical assessment of the Patterson Block, Woolshed Road, Queenstown (herein referred to as 'the site'). The purpose of this assessment is to inform Resource Consent by Classics who are considering purchase of the site for residential housing development. ENGEO's scope was to complete geotechnical site investigation, develop an engineering geology model of the site and summarise key geotechnical uncertainties or risks that may have impacts to technical feasibility and / or considerable cost implications to the construction of a residential housing subdivision.

The site is situated between Deer Park Heights and the lower slopes of the Remarkables mountain range, approximately 4 km south of Frankton, Queenstown. The site was previously submerged under Lake Wakatipu during glacial retreat following the last glaciation 10,000 to 20,000 years ago. This resulted in the deposition of lacustrine lakebed sediments over the site. Alluvial fan development has also occurred on the western slopes of the Remarkables, overriding lacustrine sediments (where present).

Third party geotechnical site investigations have been completed on two adjacent properties: Woolshed Road and Coneburn by RDA Consulting Ltd (RDA) and GeoSolve, respectively. ENGEO completed a geotechnical investigation of the site in November 2021 and subsequently completed an investigation of the adjacent EIC block in 2022. A site map including site investigation locations is included in Appendix 1. The subsurface geology of the site is interpreted to comprise topsoil overlying silt and silty sand lacustrine sediments of unknown thickness. Silty gravel beds are present in the upper 1 - 2 m of the lacustrine soils in the southern part of the site. Sandy gravel fan alluvium is also inferred to be present in the northeast corner of the site, possibly comprising the distal margin of a fan.

Seismic liquefaction is anticipated to be the dominant geohazard and should be accounted for during development planning. Site-specific seismic liquefaction results suggest no vertical settlements under SLS shaking and up to 85 mm during a ULS event. Based on these results, ENGEO recommend shallow foundations be designed under the Technical Category 2 (TC2) type outlined in Section 5.3 of the Canterbury Residential Technical Guidance, thereby requiring specific engineering design, to 150 kPa ultimate geotechnical bearing capacity. Alternatively, additional testing could be undertaken to further refine areas analogous to TC1 where standard strip and pad foundations could be used.

Perched groundwater was observed in test pits across the site between 1.5 and 1.7 m depth and may be contacted during development earthworks. Where excavation depths exceed 1.5 m, ENGEO recommend subsoil drainage (such as a combination of French drains and wick drains) be assumed necessary for bulk earthworks and well points, ground spears or dewatering sumps be assumed necessary for trenching.

Granular outwash and alluvial fan materials may be suitable for re-use as engineered fill. However, the quantity of this material is expected to be relatively small compared to the lacustrine materials that predominantly underlie the site. A potential alluvial fan borrow area is identified in the northeast corner of the site which may be a suitable source of material. The suitability (or otherwise) of both materials should be confirmed with laboratory testing during subsequent investigations. Lacustrine material is the dominant material encountered in our investigations. This material is only considered suitable for re-use as bulk fill, as defined in the TNZ F/1 Specification, provided it can be moisture conditioned and compacted appropriately. Significant challenges are anticipated with handling and compaction of this material due to its high moisture content, sensitive and dilatant behaviour observed during test pitting.

ENGEO are not aware of the project cut / fill requirements for the site. The current site grades are however relatively level so we recommend Classics work with the existing topography to minimise earthworks cut and fill requirements. Given the fine-grained nature of the lacustrine silt, ENGEO recommend dust suppression including water spraying, polymer application or other methods be accounted for during preliminary cost estimating.

1 Introduction

ENGEO Ltd was requested by KA Woolshed Limited Partnership C/- Classic Developments Limited ('Classics') to provide geotechnical support to a proposed residential development at Patterson Block, Queenstown. The purpose of the services is to support the proposed subdivision development of the Patterson Block and associated infrastructure (CFMA, 2022), through the Resource Consenting.

ENGEO understand Classics have purchased two adjoining properties proposed for residential subdivision development on Woolshed Road. These are the 'EIC Block' to the south, which we have previously carried out a Resource Consent geotechnical scope for (ENGEO, 2022), and the 'Patterson Block' (herein referred to as 'the site') to the north which is the focus of this report. Specific comment on future stages e.g., the EIC Block, is outside of our current scope.

ENGEO completed a due diligence geotechnical assessment for the site in November 2021 (ENGEO, 2021a). This scope developed an engineering geology model of the site and summarised key geotechnical uncertainties or risks that may have impacts to technical feasibility and / or considerable cost implications to the construction of a residential housing subdivision, including:

- Potential for geohazards to adversely impact the development including seismic liquefaction and lateral spreading.
- Suitability of shallow foundations for structures and indicative bearing capacities for the development.
- Assessment of regional groundwater levels beneath the site.

ENGEO's current scope re-evaluated due diligence recommendations and provided a level of analysis suitable for Resource Consent.

This work has been carried out in accordance with our signed agreement (ENGEO, 2023).

2 Site Description

The Patterson Block is situated between Deer Park Heights and the lower slopes of the Remarkables mountain range, approximately 4 km south of Frankton, Queenstown. The region has undergone significant residential development during the past 10 - 15 years with Hanley's Farm and Jacks Point to the south and Coneburn (currently under construction) to the north.

Topography of the site is subdued with an average grade of 1° and northwest aspect. The site elevation ranges from approximately 325 to 335 m RL. A small creek bisects the northeast corner of the site. This is assumed by ENGEO to have been modified for agricultural drainage.

The site is a proposed greenfield development, currently used for farming.

3 Proposed Development

The development of the Patterson and EIC blocks is at master planning stage. The focus of this report is on the Patterson block, which comprises residential lots and associated roading across the bulk of the site. Approximately 4 ha is noted as recreation reserve land, which includes sports fields and grassed areas in the north-eastern site area and landscaping buffers along the western site boundary.

4 Desktop Assessment

4.1 Geologic Setting

The site is located in the Wakatipu Basin, a feature formed predominantly by glacial advances with the last event being approximately 10,000 - 20,000 years ago. Glaciers scoured the flanks of the ranges and the sides and tops of isolated hills. Glaciations have left till, outwash and lake sediments over ice-scoured bedrock. Sub-glacial deformation in the upper few metres of schist is a common feature, with extensive shearing and silt injection into bedrock fractures. The post-glacial period has been dominated by erosion of schist bedrock and glacial sediments, with deposition of alluvial gravels by local watercourses and by deposition of lacustrine sediments.

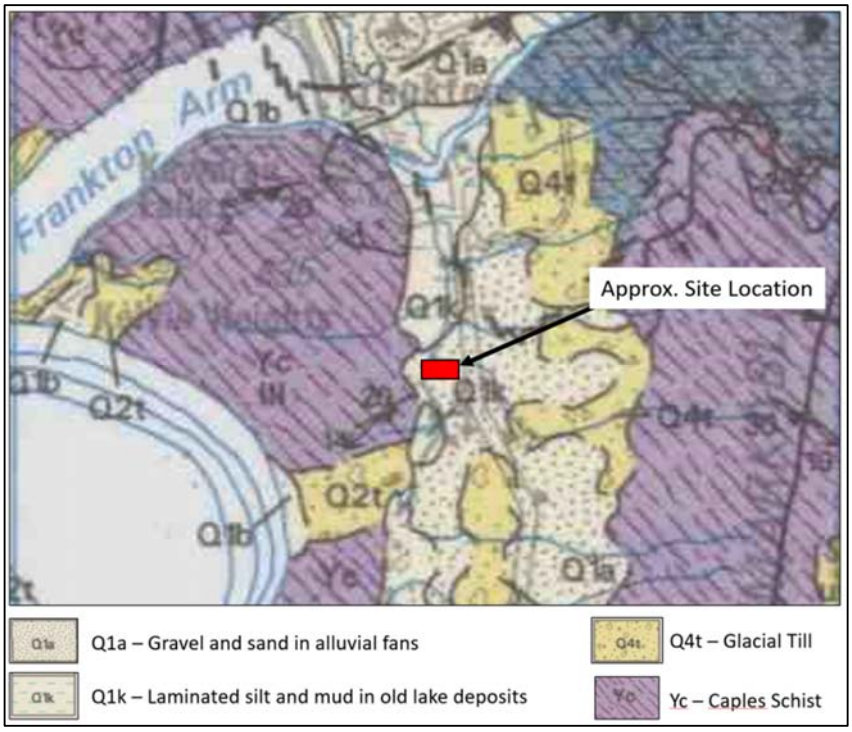

Figure 1: Regional Geology Map (image modified from Turnbull, 2000)

The subject site is geologically mapped at 1:250,000 scale as being underlain by predominantly gravel and sand derived from alluvial fan deposits (Turnbull, 2000) sourced from The Remarkables Range to the east of the site. Laminated silt and clay from lacustrine sediments are also mapped in close vicinity to the site, typically deposited in regions of lower-lying topography.

4.2 Seismicity

No active fault traces were observed in the field nor have been mapped in this vicinity. The known active faults in the area include the Northwest Cardrona and West Wakatipu Faults. The Northwest Cardrona Fault is a reverse fault located approximately 13 km east of the site which has an estimated recurrence interval of 5,000 to 10,000 years. The West Wakatipu Fault is located approximately 25 km southwest of the site and has an indicated recurrence interval of 10,000 to 20,000 years (Barrell, 2019a).

While these are the closest known faults to the site, the Alpine Fault is expected to be the greatest seismic hazard to the region.

The Alpine Fault is an oblique strike-slip fault and is located 80 km to the northwest of the site. The fault has an estimate recurrence interval of < 2,000 years, with four documented earthquakes occurring in the past 900 years. A magnitude (Mw) 8.1 alpine fault earthquake along the Alpine Fault is expected to result in a ground shaking intensity of MMVII (Modified Mercalli intensity scale) across the Queenstown area (Mackey, 2015).

4.3 Hazard Databases

ENGEO have reviewed the Queenstown Lakes District Council (QLDC) and Otago Regional Council (ORC) hazard databases. Relevant information from these databases is summarised in Sections 3.3.1 and 3.3.2.

4.3.1 Liquefaction Susceptibility

The site is regionally mapped as having a low to moderate susceptibility to liquefaction ('Domain B'; Barrell, 2019b) as shown in **Error! Reference source not found.**, due to the presence of poorly consolidated sediments.

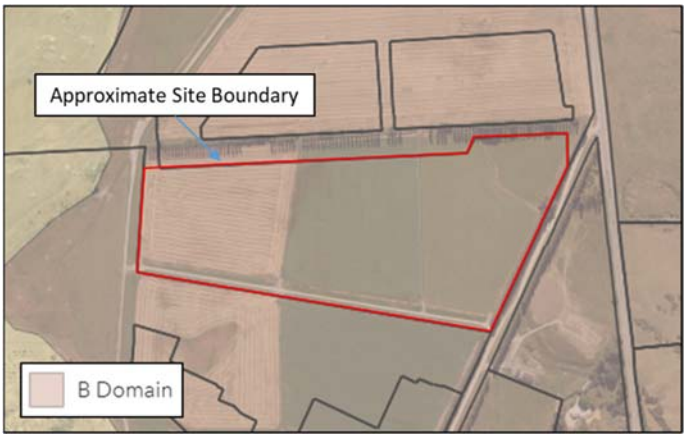

Figure 2: ORC Liquefaction Susceptibility Map of the Site Area. Sourced from QLDC Hazard Database

A more localised liquefaction assessment undertaken by Tonkin + Taylor (2012) for QLDC classifies the site as 'LIC 2 P – Possibly Moderate', a similar result to that above. Both assessments suggest the fundamentals required for seismic liquefaction to occur are present at the site. Liquefaction is discussed further in Section 6.1.

4.3.2 Alluvial Fans

The site is regionally mapped by ORC as being located on a recently active alluvial fan (Figure 3).

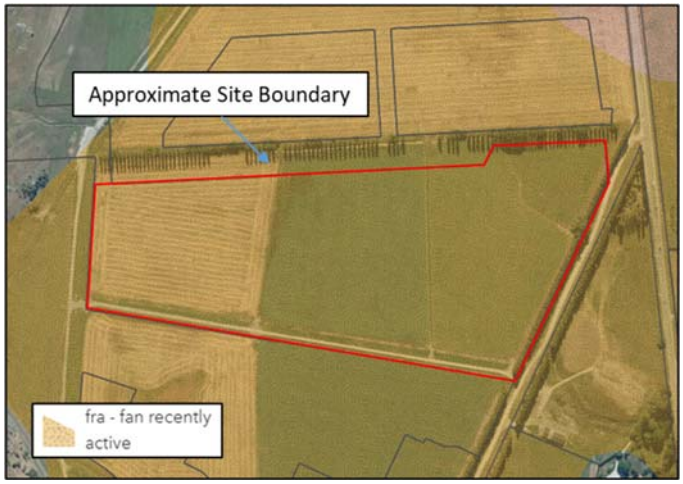

Figure 3: ORC Alluvial Fan Hazard Map of the Site Area. Sourced from QLDC Hazard Database

Active alluvial fans are described (Barrell et al. 2009). as 'relatively recent ('less than 300 years') stream activity, a stream flowing less than 1 m deep, immature forest or a combination of these factors'. This suggests surface water flow may be possible across the site. ENGEO have not completed an assessment of surface water hydrology as this is outside of our scope. Further commentary on the distal margin of the alluvial fan is included in Section 5.1.

4.4 Historic Aerial Photographs

ENGEO has reviewed historical aerial photographs dating from 1956 to 2020. Below are a sample of images of the site available through Retrolens and Nearmap NZ:

Photo 1: Image of the site in 1956 (Source: Retrolens)

Photo 2: Image of the site in 1976 (Source: Retrolens)

Photo 3: Image of the site in 2001 (Source: Retrolens)

Photo 4: Image of the site in 2020 (Source: Retrolens)

Figure 4: Historic Aerial Photographs of the Site

Review of historic aerial images between 1956 and 2020 have been used to assess changes in geomorphological features and landform over this time.

Images from 1956 until present day suggest the site has remained an undeveloped greenfield site, used for farming purposes. There are no distinct geomorphological changes that can be observed from historic photographs, other than suggestions of migration of overland flow paths over time.

4.5 Third Party Data

Geotechnical site investigations have been completed on two adjacent properties: Woolshed Road and Coneburn by RDA Consulting Ltd (RDA) and GeoSolve, respectively.

4.5.1 RDA – Woolshed Road

RDA completed two geotechnical investigations during 2017 and 2019 in support of a Resource Consent application for the proposed adjacent Woolshed Road subdivision development block. RDA investigation scope included:

- 16 Cone penetration tests (CPTs) up to 27 m depth.
- Eleven test pits (TPs) to approximately 5 m depth.
- Four boreholes (BHs) to 20 m depth with standard penetration tests (SPTs) at 1.5 m intervals. The mechanical drilling method used in these investigations is uncertain.
- 43 handheld dynamic cone penetrometers (DCPs) up to 1.8 m depth using a Scala penetrometer.
- Laboratory testing of grab samples retrieved during drill.

Site investigation results interpreted the site to be mantled by loess / colluvium of varying depths overlying sands and gravels of alluvial genesis and silts and fine sand of lacustrine genesis. Coarser grained deltaic outwash materials were observed in the western portion of the site, underlying alluvial and lacustrine sediments.

RDA interpreted regional groundwater depths during drilling of four geotechnical boreholes and one production groundwater bore to vary from 2.6 m to 8 m depth. Perched water was also observed in test pits, within 5 m of ground surface.

4.5.2 GeoSolve - Coneburn

GeoSolve completed a site wide investigation during 2018 in support of a Resource Consent application for the proposed Coneburn subdivision development. GeoSolve Scope included:

- 10 CPTs to approximately 20 m depth.
- Six TPs up to 4.5 m depth.
- Three handheld DCPs up to approximately 2 m using a Scala penetrometer.

Site investigation results interpreted the site stratigraphy to be dominated by soft silt to depths typically exceeding 20 m. Silts were typically interbedded with sand and clay and interpreted to be of lacustrine genesis.

Coarse grained alluvial fan deposits and beach gravels were observed overlying the south-western corner of the site to thicknesses up to 4.5 m. Alluvial fan deposits comprised sandy gravels with cobbles and boulders.

GeoSolve interpreted regional groundwater to be beyond CPT investigation depth (> 20 m). Perched water was observed in TPs and inferred in CPT pore pressure readings at approximately 1 m depth.

5 Site Investigation

ENGEO completed a geotechnical site investigation from 8 and 10 November 2021 including the following scope:

- Mapping of geomorphological and geological features.
- Five CPTs between 6.35 m and 20 m depth.
- Ten TPs to between 1.8 m and 2.3 m depth with associated DCPs and shear vane tests to estimate the *in situ* undrained shear strength and density of subsurface materials.

CPTs were completed by Speight Drilling Ltd and TPs by Donerite Contractors Ltd. Investigations were monitored by ENGEO and logged in the field in accordance with the New Zealand Geotechnical Society (NZGS) field-description of soil and rock guidelines.

Investigation locations are included in Appendix 1 and TP and CPT logs are included in Appendix 2.

6 Engineering Geological Model

6.1 Subsurface Geology

ENGEO has differentiated shallow surficial soils observed during geotechnical investigations based on both the geological and engineering properties of the materials. A summary of the engineering geological units is included in Table 1.

Table 1: Engineering Geological Unit Summary

Unit	Geological Unit	Typical Depth (m bgl)[1]	Typical Material Description	Consistency / Density
1	Topsoil	0 – 0.2	Organic Silt	Firm
2	Fan Alluvium[2]	N/A	Sandy Gravel / Gravelly Sand	Unknown
3	Outwash[3]	0.2 – 1.0	Silt / Sandy Gravel	Firm - Stiff / Medium Dense
4	Lacustrine	0.2 – 20+	Silt / Silty Sand	Very Soft - Stiff / Loose

Notes:

[1] Due to the large area of the site and slightly variable topography the presence of and thicknesses of material units likely varies. As such, the typical thicknesses presented are indicative only. To better understand the subsurface profile in a particular area, specific geotechnical logs should be reviewed.

[2] Fan Alluvium was not observed during site investigations, however, is inferred to be located in a small zone limited to the northeast corner of the site as encountered in CB_GS_CPT07 (GeoSolve, 2019)

[3] Outwash material was only observed in two locations across the site and is not expected to be laterally continuous.

A brief description of these geological units is provided below. Detailed descriptions are included in the test pit logs in Appendix 2.

Topsoil

Topsoil was observed to blanket the site. Topsoil was typically firm, dark brown organic silt and was found to be up to 0.2 m thick.

Fan Alluvium

Although not observed during site investigations, fan alluvium is interpreted to be present in the northeast corner of the site based on the subsurface geology inferred from WR-ENG21-CPT05, site topography and third-party testing data (Section 4.5.2). Based on third party observations, the fan alluvium is likely a sandy gravel or gravelly sand and present to an unknown thickness within the site.

Outwash Material

Material interpreted to be glacial outwash was observed to underlie topsoil in WR-ENG21-TP04 and WR-ENG21-TP06 on the southern and south-eastern parts of the site to depths of approximately 1 m bgl. Outwash typically contained an upper firm to stiff silt unit which was immediately underlain by a medium dense rounded gravel. As the interpreted outwash material was only observed in two of nine TP locations, and based on our understanding of the depositional process, it is not expected to be laterally continuous across the site and is likely present in localised zones such as buried river channels.

Lacustrine Sediments

Underlying the topsoil and outwash material (where present) were silts and silty sands interpreted to be of lacustrine genesis. This unit appears to extend to depths more than 20 m. Where observed in TPs, the lacustrine sediments were typically very soft to stiff (where fine grained) or loose (where coarse grained) within the upper 3 - 4 m and dilatant. Hand shear vane results indicate peak undrained shear strengths vary from approximately 50 kPa to 100 kPa and that the lacustrine is moderately sensitive.

CPT data suggests the lacustrine deposits typically contain a greater sand fraction in the upper 5 m, are generally firm between 5 – 15 m grading from stiff to very stiff from approximately 15 m.

6.2 Groundwater

Groundwater seepage was observed in all TPs except WR-ENG21-TP08 and WR-ENG21-09 at depths between 1.2 and 2.1 m bgl. WR-ENG21-TP08 and WR-ENG21-09 are located in the eastern area of the site at an elevation approximately 2 m higher than the other TPs.

Groundwater was measured by dip tape to be between approximately 1.5 and 1.7 m bgl in CPT holes immediately after the completion of testing. Groundwater gradients are anticipated to be to the northwest, subparallel to the ground surface. Interpreted piezometric contours are included in Appendix 1.

Groundwater data should be interpreted with caution. Site investigation data from Coneburn to the north (Section 3.3.2) indicates the regional groundwater table is > 20 m depth. This suggests that near-surface groundwater encountered during ENGEO site investigations is perched above the lacustrine unit which could be acting as an aquitard. Seasonal fluctuations will also be present within the perched water table and are currently not well understood across the site.

7 Geohazard Assessment

7.1 Seismic Hazards

Seismic hazards resulting from nearby moderate to major earthquakes can generally be classified as primary and secondary. The primary effect is ground rupture, also called surface faulting. The common secondary seismic hazards include ground shaking, regional subsidence or uplift, soil liquefaction, lateral spreading, landslides, tsunamis, flooding, or seiches. The following sections present a discussion of seismic hazards as they apply to the site.

7.1.1 Ground Rupture

There are no known active faults located within the site. Based on our site walkover and review of relevant publications (Section 4.2) ENGEO consider that fault-related ground rupture is unlikely at the subject property.

7.1.1 Soil Classification

Based on the investigation information available, specifically the absence of information on the depth to bedrock, we consider the soil classification in line with NZS 1170.5:2004 to be ‘Class D – Deep or Soft Soil Sites’ for the purpose of seismic design.

7.1.2 Ground Shaking

ENGEO understands from Classics the development will include Importance Level 2 (IL2) buildings. In accordance with NZS1170, IL2 structures are required to withstand events with an annual probability of exceedance of 1 / 500 at an Ultimate Limit State (ULS) and protect the safety of their occupants. At Serviceability Limit State (SLS), which corresponds to a 1 in 25-year event, the design requirement is that deflections do not result in damage causing loss of function of the structure and that damage is readily repairable.

The design peak ground acceleration (PGA) for the site under both ULS and SLS load cases have been adopted from the update site specific probabilistic seismic hazard assessment in Appendix A of MBIE / NZGS Module 1 (2021) and provided in Table 2.

Table 2: Peak Ground Acceleration for Queenstown (for IL2 Structures)

SLS a_{max}(g)	ULS a_{max}(g)
Return Period	
25 – year	500 – year
0.10	0.41

The effective earthquake magnitude is 6.5 for the Queenstown area.

7.1.3 Liquefaction

The QLDC and ORC natural hazard databases (Section 4.3) indicate the site is regionally assessed as having a low to moderate risk of liquefaction due to the presence of poorly consolidated sediments beneath the site (Section 4.3). Additionally, observations of test pitting revealed the presence of unconsolidated lacustrine soils beneath the site that may be susceptible to liquefaction when saturated (Section 6.1).

ENGEO have performed a liquefaction analysis using the results of CPTs, utilising the method recommended by Boulanger and Idriss (2014) to determine the susceptibility of the subsurface materials to liquefaction.

A groundwater level of 1.5 m bgl was adopted for the liquefaction assessment based on site investigation data (Section 6.2). Results of the liquefaction assessment indicate the following:

- No liquefaction is predicted under SLS conditions.
- Liquefaction is likely to occur in the lacustrine silts between 1 - 12 m bgl under ULS seismic loading, if saturated.
- Vertical settlement is predicted to be approximately 10 – 90 mm under ULS seismic loading.

The analysis considers volumetric strain and does not account for ground loss due to ejecta. Owing to the shallow liquefiable layers and potentially liquefiable material below the groundwater table, sand boil formation and ejecta are likely to occur at the site under ULS shaking. Therefore, building settlements may exceed those calculated in the above analysis during ULS shaking.

A summary of our analysis results are presented in Table 3, with full results included in Appendix 4.

Table 3: Summary of Liquefaction Analysis Results

Investigation Identifier	Estimated Vertical Settlement (mm)	
	SLS M6.5, 0.08 g	ULS M6.5, 0.32 g
PB-ENG21-CPT01	Negligible	12
PB-ENG21-CPT02	Negligible	65
PB-ENG21-CPT03	Negligible	65
PB-ENG21-CPT04	Negligible	85
PB-ENG21-CPT05	Negligible	30

Based on NZGS / Ministry of Business Innovation and Employment (MBIE) guidelines (NZGS / MBIE, 2016), it is anticipated that the level of liquefaction to occur corresponds to a Performance Level '*L0 - Insignificant*' under SLS loading and '*L2 – Moderate*' to *'L3 – High'* under ULS loading.

Given the site is proposed for residential development, we have also assessed the liquefaction potential of the site in terms of the Technical Category (TC) classification system developed following the Canterbury earthquake sequence (MBIE, 2012). The classification system is divided into three TCs (TC1, 2 and 3) that reflect future performance expectations and are intended to guide foundation choices for owners / developers. A summary of the TCs, their nominal settlement limits as well as the likely foundation recommendations are provided in Table 4 below.

Table 4: MBIE Liquefaction Technical Category Classification Summary Table

Foundation Technical Category	Future Land Performance Expectation	Nominal ULS Land Settlement (mm)[1]	Possible Foundation Solution
TC1	Liquefaction damage is unlikely in a future large earthquake	0 – 25	NZS 3604 foundations suitable where ULS bearing capacity > 300 kPa, otherwise raft foundation.
TC2	Liquefaction damage is possible in a future large earthquake	0 – 100	Light construction with timber floors and shallow piles as per NZS 3604 or enhanced perimeter foundation wall where ULS bearing capacity > 300 kPa, otherwise enhanced raft foundation.
TC3	Liquefaction damage is possible in a future large earthquake	> 100	Site-specific foundation design (e.g., ground improvement or deep piles).

[1] SLS settlement limits exist, however as negligible settlement was assessed under SLS loading the settlement predicted under ULS loading will govern foundation design.

Estimated vertical settlements (Table 3) suggest the site should be predominantly categorised as TC2 land (Appendix 1).

7.1.4 Lateral Spreading

While there is a small creek currently present on the site, we have not assessed the risk of lateral spreading as development plans are not yet available. Once site development plans are confirmed and the presence (or absence) of a free face is confirmed, a lateral spreading assessment should be completed.

7.2 Slope Stability

No evidence of slope instability was observed within the site during our investigations, nor would be expected at such shallow slope angles. Additionally, no evidence of rockfall was observed at the base of the slopes to the west of the site. As such, we consider the risk of slope stability to the development to be very low.

8 Geotechnical Considerations & Recommendations

Based on our desktop assessment and site investigations completed to date, ENGEO consider the Patterson Block located on Woolshed Road, Queenstown, to be suitable for the proposed development from a geotechnical perspective, subject to the recommendations in Sections 8.1 through 8.3.

8.1 Foundations

ENGEO consider the site to be suitable for shallow foundations bearing directly on *in situ* materials subject to the following recommendations:

- Foundations should bear on *in situ* materials beneath any organic topsoil.
- Foundations should be designed under the TC2 type outlined in Section 5.3 of the Canterbury Residential Technical Guidance, thereby requiring specific engineering design, to 150 kPa ultimate geotechnical bearing capacity. Alternatively, further testing could be undertaken to further refine areas analogous to TC1 where standard strip and pad foundations could be used.
- Development is limited to lightweight timber framed structures and should not contain any heavy elements as defined in the New Zealand Building Code Handbook.
- As required by Section B1/VM4 of the New Zealand Building Code Handbook, a strength reduction factor of 0.33 or 0.50 should be applied to all recommended geotechnical ultimate bearing capacities in factored design load cases for serviceability and ultimate limit state, respectively.

ENGEO recommend the following geotechnical material parameters be used in the design of shallow foundations.

Table 5: Recommended Geotechnical Parameters for Foundation Design

Geological Unit[1]	Typical Description	Estimated Consistency / Density / Strength	Unit Weight (kN/m^3)[2]	Friction Angle (ϕ)[3]	Cohesion (kPa)
Outwash or Alluvial Fan Deposits	Sandy Gravel / Gravelly Sand	Medium Dense	17.5	30º	0
Lacustrine Deposits	Silt / Silty Sand	Very Soft to Stiff / Loose	18	20º	3

Notes:

[1] Geological unit refers to the units defined in Section 6.1.
[2] Unit weight estimated BS8002:2015, Figure 1
[3] Friction angle estimated from Bowles 5th Edition, 1997, Table 3-4 and BS8002:2015, Table 1

The geotechnical design parameters summarised above are based on our current understanding of the inferred geologic units. These should be re-evaluated based on future data should this become available or during construction should observations differ from those made herein.

Given the absence of a suitable bearing layer for piles to depths more than 20 m bgl, piled foundations are likely not practical.

8.2 Dewatering

Perched groundwater is anticipated to be present within 1.5 to 1.7 m below ground surface across much of the site. Given this relatively shallow depth, water may be intercepted during development earthworks and / or trenching for civil infrastructure construction. Where excavation depth exceeds 1.5 m, ENGEO recommend subsoil drainage (such as a combination of French drains and wick drains) be assumed necessary for bulk earthworks and well points, ground spears or dewatering sumps be assumed necessary for trenching.

Excavation dewatering should be reassessed during detailed design following further geotechnical investigation, as the groundwater regime across the site is better understood.

8.3 Site Preparation

All topsoil and any other unsuitable material should be over-excavated from beneath proposed building platform to expose *in situ* silts and sands, approximately 0.2 m thickness across the site. Given the sensitive nature of the fine-grained alluvium beneath the topsoil, the foundation subgrade should be immediately protected from weather and traffic by a minimum of 200 mm of compacted granular fill.

Stripped surfaces should be free of any roots greater than 20 mm in diameter, along with root clusters and areas where more than 5% of the soil is occupied by roots. All stripped surfaces should be observed by a suitably qualified geo-professional.

8.4 Fill Materials

Granular outwash and alluvial fan materials (Units 2 and 3, Section 6.1) may be suitable for re-use as engineered fill. However, the quantity of this material is expected to be relatively small, compared to the lacustrine materials which predominantly underlie the site. A potential alluvial fan borrow area is identified in the northeast part of the site which may be a suitable source of material. The suitability (or otherwise) of both materials should be confirmed with laboratory testing during subsequent investigation.

Lacustrine material (Unit 4, Section 6.1) is the predominant material encountered in our investigations. It is only considered suitable for re-use as bulk fill, as defined in the TNZ F/1 Specification, provided it can be moisture conditioned and compacted appropriately. Significant challenges are anticipated with handling and compaction of this material due to its high moisture content and sensitive and dilatant behaviour as observed during the test pit excavations.

Currently ENGEO are not aware of the project cut fill requirements for the site. The current site grades are however relatively level, so our advice is to work with the existing topography to minimise earthworks cut and fill requirements.

ENGEO recommends that structural fills be supported by retaining walls designed by a suitably qualified engineer familiar with the contents of this report, or else battered at 1V:3H (vertical: horizontal) angle slopes or flatter. If finished cut slopes are to be steeper than 1V:3H, they should be evaluated for stability by a ground engineering professional.

9 Safety in Design

Safety in Design aims to identify, address and minimise or eliminate health and safety risks where it is reasonably practicable to do so. Given the relatively level site and the shallow excavations required, the key safety considerations during construction will likely relate to trenching, groundwater management, the contractor's construction methodology, and how the public interface with the site. ENGEO can provide further advice once the foundation design and earthworks specification has been completed.

10 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, KA Woolshed Limited Partnership, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

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

iv. This Limitation should be read in conjunction with the Engineering NZ / ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on (03) 328 9012 if you require any further information.

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APPENDIX 1:

Site Location Plan with Interpreted Liquefaction Outputs

1265000
1265250
1265500
5002250
5002000
5001750
CB_GS_TP04
CB_GS_CPT06
0
CB_GS_CPT07
95
CONEBURN DEVELOPMENT
WR-ENG21-CPT01
12
WR-ENG21-TP03
WR-ENG21-CPT03
65
WR-ENG21-TP07
30
WR-ENG21-CPT05
WR-ENG21-TP02
WR-ENG21-TP06
WR-ENG21-TP08
A
B
WR-ENG21-TP01
WR-ENG21-TP04
WR-ENG21-CPT02
65
WR-ENG21-CPT04
85
WR-ENG21-TP09
WR-ENG21-TP05
RDA-TP06
RDA_CPT10
24
42
RDA_CPT011
RDA_BH02
40
EIC-ENG22-CPT-01
EIC-ENG22-CPT-02
6
RDA_CPT07
26
RDA-TP07
WB_BH36C
RDA-TP05
20
RDA_CPT012
RDA-TP04
RDA_CPT015
26
RDA-TP09
RDA_CPT06
0
SOUTHERN SCENIC ROUTE
8
EIC-ENG22-CPT-03
RDA_CPT013
46
RDA_BH03
RDA-TP08
6
EIC-ENG22-CPT-04
RDA_CPT09
0
37
RDA_CPT014
RDA_BH01
RDA-TP10
EIC-ENG22-CPT-05
0
RDA_CPT08
2
RDA-TP03
RDA_CPT016
21
RDA_CPT05
0
RDA_BH04
RDA-TP11
RDA_CPT04
12
RDA-TP02
RDA-TP01
RDA_CPT03
36
70
RDA_CPT02
45
RDA_CPT01
HANLEYS FARM DEVELOPMENT

LEGEND

Interpreted Vertical Settlement (ULS)

- < 25 mm (TC1)
- 25 - 100 mm (TC2)
- Interpreted Geological Cross Section (see Appendix 3)
- Interpreted Depth to Groundwater Contours (m bgl)

Cadastrial Boundaries (LINZ)

- Patterson Block
- EIC Block

Geotechnical Investigation Locations (ULS estimated vertical settlement in MM in red next to symbol)

- CPT ENGEO
- Test Pit ENGEO
- CPT Others
- Test Pit Others
- Borehole Others

Notes:

1. Interpreted Vertical Settlement based on CPT investigation data as shown, updated with PGAs from MBIE Module 1.
2. Interpreted Depth to Groundwater Contours based on boreholes, CPT and test pit investigation data. Depths include static and seepage observations throughout various years and seasons. Recorded depth is relative to elevation of ground at the time of investigation.
3. TC is Technical Catigories in accordance with MBIE.
4. ULS is Ultimate Limit State.
5. Interpreted Vertical ULS Settlement for each CPT shown numerically in red.

0 75 150 m

ENGEO

Background: QLDC 2021 Aerial
Coordinate system: NZTM 2000

Interpreted ULS Vertical Settlement Plan

Client: Classic Developments		Appendix No. 1 Size: A3
Project: Woolshed Road	Drawn: BH	
Date: 21/02/2023	Checked:	
Proj No:19651	Scale: 1:2500 @ A3	Version: 1.0

APPENDIX 2:

ENGEO Site Investigation Data

Geotechnical Soil Logging Key

ENGEO borehole and test pit logs are written in general accordance with the New Zealand Geotechnical Society field classification guidelines (2005).
Please refer to this document for the methods of field classification and description for engineering purposes.

Grain Size (mm)

0.06	0.2	0.6	2	6	20	60	200

SILT and CLAY	SAND			GRAVEL			COBBLE	BOULDER
	Fine	Medium	Coarse	Fine	Medium	Coarse		

Additional Info

▼	Standing water level
UTP	Unable to Penetrate
NA	Not Assessed

Graphic Logs

The graphic log shows soil types and their corresponding UCS classification

Granular Soil (>65% of soil >0.06 mm)			Cohesive Soil (>35% of soil <0.06 mm)		
GW	Well graded GRAVEL		MH	High plasticity SILT	
GP	Poorly graded GRAVEL		ML	Low plasticity SILT	
GM	Silty GRAVEL		CH	High plasticity CLAY	
GC	Clayey GRAVEL		CL	Low plasticity CLAY	
SW	Well graded SAND			**Organic Soil**	
SP	Poorly graded SAND		OH	High Plasticity organic SILT or CLAY	
SM	Silty SAND		OL	Low plasticity organic SILT or CLAY	
SC	Clayey SAND		PT	Peat	
Other Soils					
TS/BTS	Topsoil/ Buried Topsoil		F	Fill	

G = Gravel W = Well Graded P = Poorly Graded C = Clay S = Sand M = Silt H = High Plasticity L = Low Plasticity O = Organic

Cohesive Soils - Consistency Index

		Undrained shear strength (kPa)	Field Diagnostic Features
VS	Very Soft	<12	Easily exudes between fingers when squeezed
S	Soft	12 – 25	Easily indented by fingers
F	Firm	25 – 50	Indented by strong finger pressure and can be indented by thumb pressure
St	Stiff	50 – 100	Cannot be indented by thumb pressure
VSt	Very Stiff	100 – 200	Can be indented by thumb nail
H	Hard	200+	Difficult to indent by thumb nail

Moisture Content

D	Dry	Looks and feels dry
M	Moist	Feels cool and darkened in colour and granular soils tend to be cohere
W	Wet	Feels cool and darkened in colour. Granular soils tend to cohere and free water forms when remoulding cohesive soils
S	Saturated	Feels cool, darkened in colour and free water present on the sample

Granular Soils - Density Index

		SPT 'N' Value (blows /300mm)	Scala Penetrometer (blows/100 mm)
VL	Very loose	<4	0 - 2
L	Loose	4 – 10	1 – 3
MD	Medium Dense	10 - 30	3 - 7
D	Dense	30 - 50	7 – 17
VD	Very Dense	<50	>17

Proportional Terms Definition

Fraction	Term	% of Soil	Example
Major	(UPPERCASE)	>50	GRAVEL
Subordinate	(lowercase)y	20 - 50	Sandy
Minor	With some....	12 - 20	With some sand
	With minor....	5 - 12	With minor sand
	With trace....	<5	With trace sand

Soil Structure

Zoning		Cementing	
Layers	Continuous across exposure or sample	Weakly Cemented	Easily broken up by hand in air or water
Lenses	Discontinuous layers of lenticular shape	Moderately cemented	Effort is required to break up the soil by hand in air or water
Pockets	Irregular inclusions of different material		

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP01

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: 2534

Coordinates E: -45.055723
(NZTM) N: 168.745581
Elevation (mRL): 326
Elevation Datum: NZVD2009

Maximum Depth: 2.1 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier – Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
	TS		TOPSOIL					F		
	LACUSTRINE		Silty SAND; grey, mottled orange. Loose; wet; poorly graded [LACUSTRINE].	0.5				L		
325			at 0.7 m depth: occasional fine to coarse sand lenses				W			
			1.0 m : grades to very loose	1.0				VL		
			SILT with minor sand; grey, mottled orange. Stiff; moist to wet; low plasticity; moderately sensitive; sand, fine [LACUSTRINE].	1.5						SV@1.8m 85/24
324				2.0			M-W	St		

Dynamic Cone Penetrometer
Blows per 100mm
2 4 6 8 10 12

Depth of Excavation: 2.1 m
Termination Condition: met target depth

Photos / Sketches

Groundwater inflow encountered at 1.9 m bgl
TS - Topsoil

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP02

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: 2534

Coordinates E: -45.05537
(NZTM) N: 168.746959
Elevation (mRL): 326.5
Elevation Datum: NZVD2009

Maximum Depth: 2.1 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier – Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
	TS		TOPSOIL					F		
326	LACUSTRINE		Silty fine SAND; grey, homogenous. Loose; wet; poorly graded; dilatant [LACUSTRINE].	0.5				L		SV@0.6m 114/40
			1.0 - 1.4 m : very loose	1.0			W	VL		SV@1.2m 31/16
325				1.5				L		
			Fine to coarse SAND with minor gravel; grey. Loose; saturated; well graded; gravel, fine, subrounded [LACUSTRINE].	2.0			S			

Depth of Excavation: 2.1 m
Termination Condition: met target depth

Dynamic Cone Penetrometer
Blows per 100mm
2 4 6 8 10 12

Photos / Sketches

Groundwater inflow encountered at 1.9 m bgl
TS - Topsoil

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP03

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: 2534

Coordinates E: -45.054977
(NZTM) N: 168.748355
Elevation (mRL): 327
Elevation Datum: NZVD2009

Maximum Depth: 2.1 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier – Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
	TS		TOPSOIL					F		
	LACUSTRINE		Sandy SILT; grey, homogenous. Stiff; wet; low plasticity; moderately sensitive; dilatant, [LACUSTRINE].	0.5			W	St		SV@0.5m 83/24 SV@0.9m 53/24
326				1.0						
				1.5						SV@1.5m 53/24
325			Fine to coarse SAND with some gravel and minor silt; grey. Loose to medium dense; saturated; well graded; gravel, fine to medium, subrounded, [LACUSTRINE].	2.0			S	L - MD		

Dynamic Cone Penetrometer
Blows per 100mm
2 4 6 8 10 12

Depth of Excavation: 2.1 m
Termination Condition: met target depth

Photos / Sketches

Groundwater inflow encountered at 1.7 m bgl
TS - Topsoil

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP04

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: 2534

Coordinates E: -45.055896
(NZTM) N: 168.748242
Elevation (mRL): 328.5
Elevation Datum: NZVD2009

Maximum Depth: 2.1 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier – Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
	TS		TOPSOIL					F		
			Fine sandy SILT; grey. Very stiff; dry; low plasticity; moderately sensitive; [OUTWASH].	0.5			D	VSt		SV@0.5m 106/46
328	OUTWASH		Sandy fine to coarse GRAVEL with minor cobbles; grey. Very loose; moist; well graded; subrounded; subhorizontal bedding; sand, fine to coarse; cobbles, subrounded. Maximum particle size 100 mm [OUTWASH].	1.0			M	VL		
327			Silty fine to medium SAND; grey. Loose; wet; poorly graded [OUTWASH]. at 1.6 m depth: decomposing wood inclusions 1.8 m : Medium dense	1.5			W	L		
				2.0				MD		

Dynamic Cone Penetrometer
Blows per 100mm
2 4 6 8 10 12

Depth of Excavation: 2.1 m
Termination Condition: met target depth

Photos / Sketches

Groundwater inflow encountered at 2.1 m bgl
TS - Topsoil

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP05

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: 2534

Coordinates E: -45.056316
(NZTM) N: 168.749704
Elevation (mRL): 330
Elevation Datum: NZVD2009

Maximum Depth: 2.1 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier–Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
	TS		TOPSOIL					F		
	LACUSTRINE		Silty fine SAND; grey, mottled orange. Loose to medium dense; moist; poorly graded, [LACUSTRINE].	0.5			M	L-MD		
329			1.0 m : very loose	1.0				VL		SV@1.3m 61/16
			SILT with minor sand; light grey mottled orange. Stiff; wet; low plasticity; sensitive [LACUSTRINE].	1.5			W	St		SV@1.5m 76/16
328			Fine to coarse SAND with minor gravel; grey. Loose; saturated; well graded; gravel, fine to medium, subangular [LACUSTRINE].	2.0			S	L		

Depth of Excavation: 2.1 m
Termination Condition: met target depth

Dynamic Cone Penetrometer
Blows per 100mm
2 4 6 8 10 12

Photos / Sketches

Groundwater inflow encountered at 1.9 m bgl
TS - Topsoil

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP06

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: N/a

Coordinates E: -45.055456
(NZTM) N: 168.750185
Elevation (mRL): 330
Elevation Datum: NZVD2009

Maximum Depth: 1.8 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier–Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments	Dynamic Cone Penetrometer Blows per 100mm (2 4 6 8 10 12)
	TS		TOPSOIL					F			
	OUTWASH		Silty sandy fine to coarse GRAVEL with minor cobbles; grey. Loose to medium dense; wet; well graded. Gravel, subrounded. Sand, fine to coarse. Maximum particle size 75 mm [OUTWASH].	0.5			W	L-MD			
329	LACUSTRINE		SILT with some sand; grey. Stiff; wet; low plasticity; sand, fine [LACUSTRINE]. at 1.3 m depth: with fine to coarse SAND lenses	1.0		▽		St			
			Silty fine to medium SAND; grey. Medium dense; saturated; poorly graded; dilatant, [LACUSTRINE].	1.5			S	MD			

Depth of Excavation: 1.8 m
Termination Condition: Practical refusal - Pit wall collapse

Photos / Sketches

Groundwater inflow encountered at 1.2 m bgl; TS - Topsoil
The geological profile observed is indicative of the western wall of the TP. Variability in the geology of the pit walls was observed, with the outwash material f

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP07

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: N/a

Coordinates E: -45.054823
(NZTM) N: 168.751308
Elevation (mRL): 330
Elevation Datum: NZVD2009

Maximum Depth: 2.1 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier / Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments	Dynamic Cone Penetrometer Blows per 100mm (2 4 6 8 10 12)
	TS		TOPSOIL					F			
	LACUSTRINE		SILT with minor sand; light grey, mottled orange. Firm to stiff; moist; low plasticity; sand, fine, [LACUSTRINE].	0.5			M	F - St			
329				1.0							
			at 1.5 m depth: occasional silty fine SAND lenses	1.5			W				
328				2.0		▽					

Depth of Excavation: 2.1 m
Termination Condition: met target depth

Photos / Sketches

Groundwater inflow encountered at 2.1 m bgl
TS - Topsoil

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP08

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: N/a

Coordinates E: -45.055556
(NZTM) N: 168.751912
Elevation (mRL): 333
Elevation Datum: NZVD2009

Maximum Depth: 2.1 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier – Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable)	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
	TS		TOPSOIL				D	F		
			Silt fine SAND; brown. Loose; dry; poorly graded, [LACUSTRINE].	0.5				L		
332	LACUSTRINE		SILT with some sand; light grey, mottled orange, homogenous. Firm to stiff; moist; low plasticity; sand, fine [LACUSTRINE].	1.0			M	F-St		
			at 1.4 m depth: grades to wet	1.5			W			
331				2.0						

Dynamic Cone Penetrometer
Blows per 100mm
2 4 6 8 10 12

Depth of Excavation: 2.1 m
Termination Condition: met target depth

Photos / Sketches

TS - Topsoil

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

ENGEO

Test Pit Log

Client: Classic Developments
Project: Woolshed Road
Location: Woolshed Road, Queenstown
Project Number: 19651

Hole I.D:
WR-ENG21-TP09

Method: Bucket Excavator
Contractor: Donerite
Operator: Dawson
Equipment: 3t Digger
Bucket Size: 650 mm
Vane Number: N/a

Coordinates E: -45.056403
(NZTM) N: 168.751478
Elevation (mRL): 334.5
Elevation Datum: NZVD2009

Maximum Depth: 2.3 m
Survey Method: Leica GPS
Start Date: 10/11/2021
Finish Date: 10/11/2021
Logged By: RD
Reviewed By: BC

Elevation (mRL)	Geological Unit	Excavatability (relative scale) Easier–Harder	DESCRIPTION (SOIL: Classification, colour, consistency / density, moisture, plasticity, additional features (grain size, roundness, composition etc. as applicable))	Depth (m BGL)	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density	Sample	Testing / Additional Comments
	TS		TOPSOIL					F		
334	LACUSTRINE		Silty fine SAND; light greyish brown. Loose; dry; poorly graded. [LACUSTRINE].	0.5			D	L		
				1.0						
333			Sandy SILT; light grey. Stiff; moist; poorly graded [LACUSTRINE].	1.5			M	St		
			at 1.6 m depth: 150 mm thick gravelly SAND bed.							
			at 1.8 m depth: grades to silt with minor fine sand.	2.0						
			Depth of Excavation: 2.3 m Termination Condition: met target depth							

Dynamic Cone Penetrometer
Blows per 100mm
2 4 6 8 10 12

Photos / Sketches

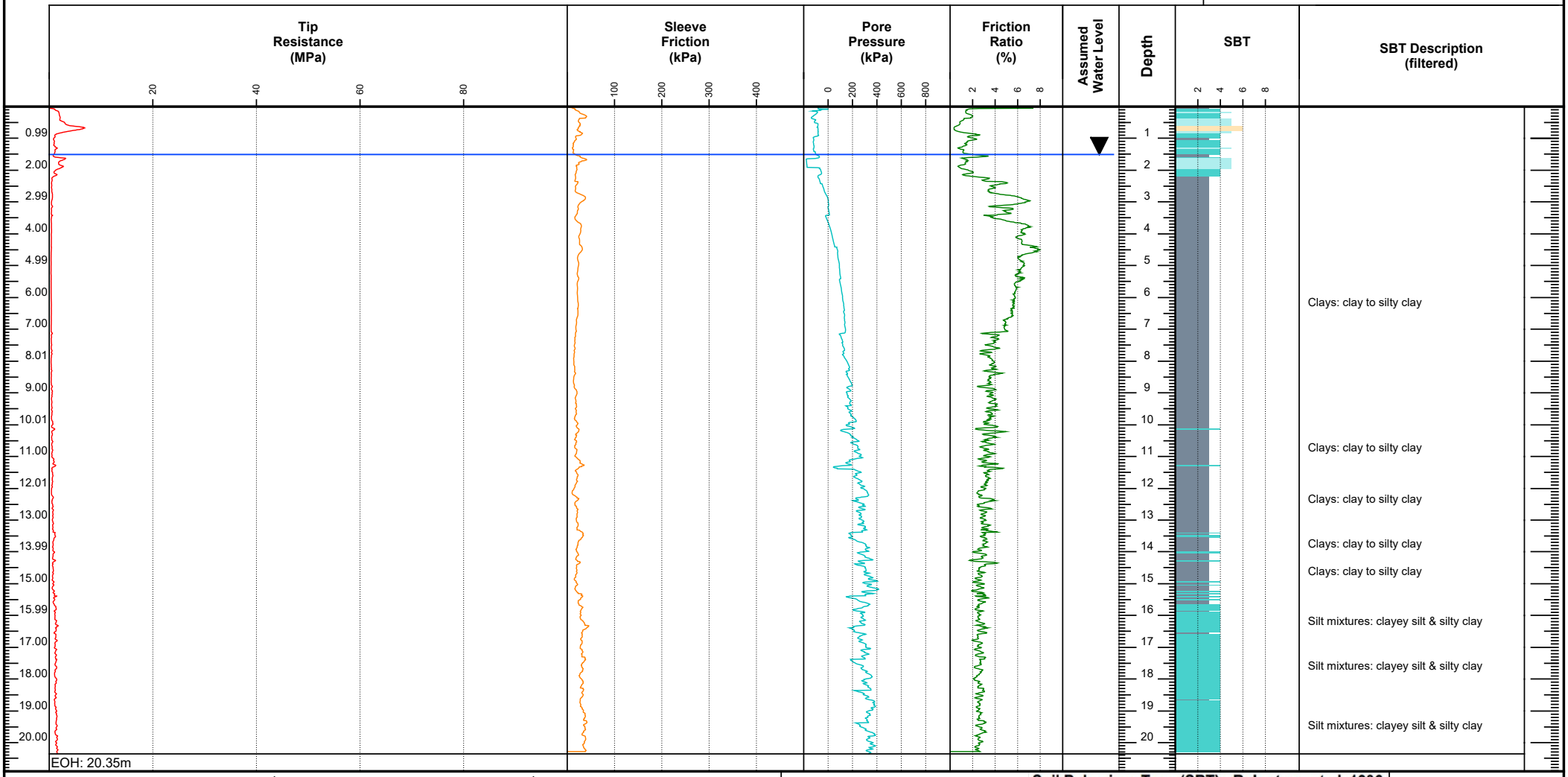
TS - Topsoil

TEST PIT LOG (NZ) LOGS_UPDATE.GPJ NZ MASTER DATA TEMPLATE.GDT 18/11/21

CONE PENETRATION TEST (CPT) LOG

TEST NO.: CPT01

Client Ref.: Woolshed Road



Client: ENGEO

Project: Jacks Point

Location: Woolshed Road

Contractor: Speight Drilling Ltd

Remarks:
Hole backfill with Bentonite chip

Termination Reason:
Target depth reached

Northing: 5002126

Easting: 1265048

System: NZTM

Elevation: 330m

Datum:

Method: Garmin GPS

Rig: Pagani TG63 - 150

Cone ID: Mks844

Cone Area: 10cm²

Sleeve Area: 150cm²

Area Ratio: 0.79

Predrill: 0m

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

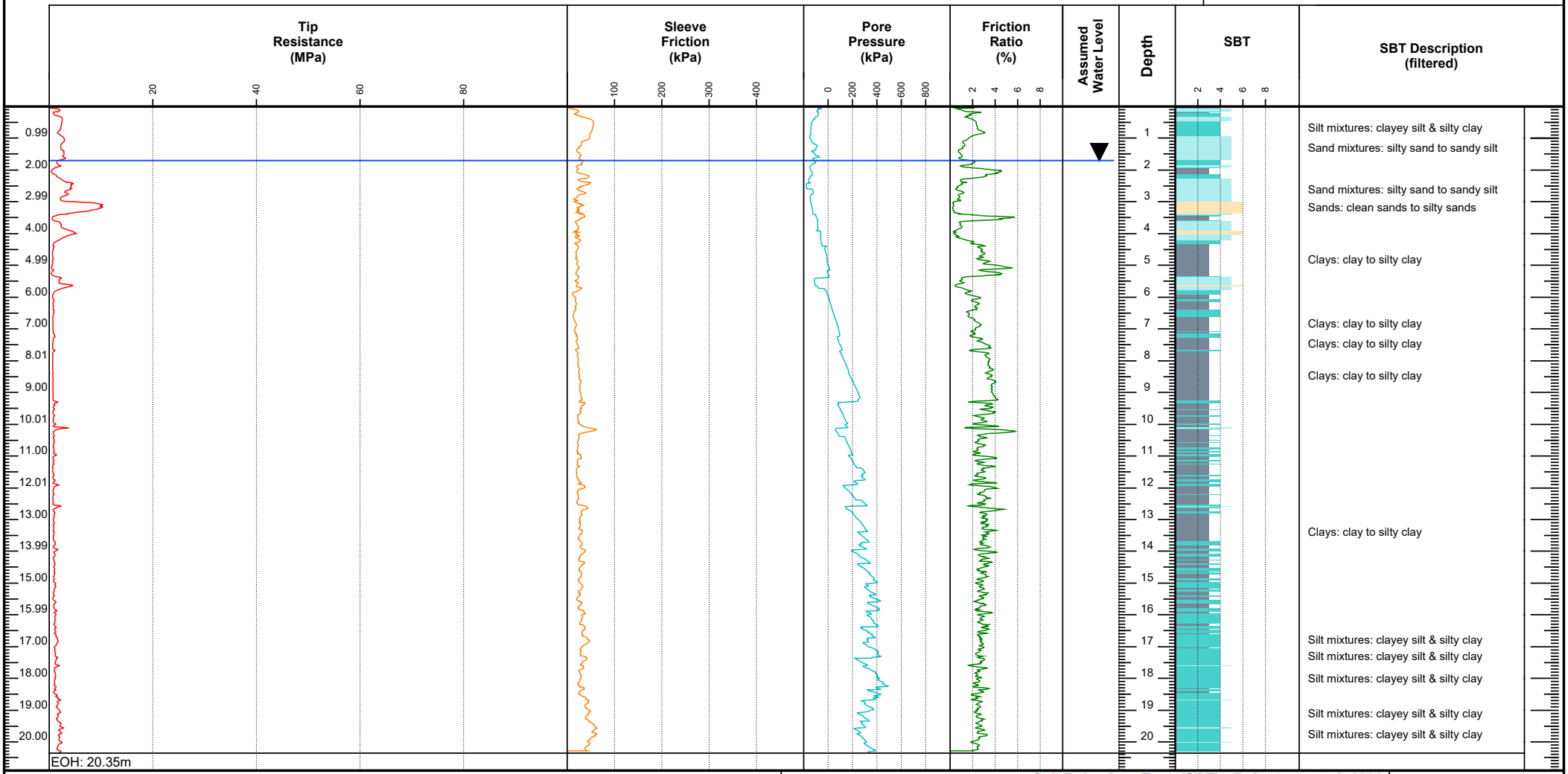
0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Date:
8/11/2021 12:00:00 AM

CONE PENETRATION TEST (CPT) LOG

TEST NO.: CPT02

Client Ref.: Woolshed Road



Client: ENGEO

Project: Jacks Point

Location: Woolshed Road

Contractor: Speight Drilling Ltd

Remarks:
Hole backfill with Bentonite chip

Termination Reason:
Target depth reached

Northing: 5002045

Easting: 1265178

System: NZTM

Elevation: 332m

Datum:

Method: Garmin GPS

Rig: Pagani TG63 - 150

Cone ID: Mks844

Cone Area: 10cm²

Sleeve Area: 150cm²

Area Ratio: 0.79

Predrill: 0m

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

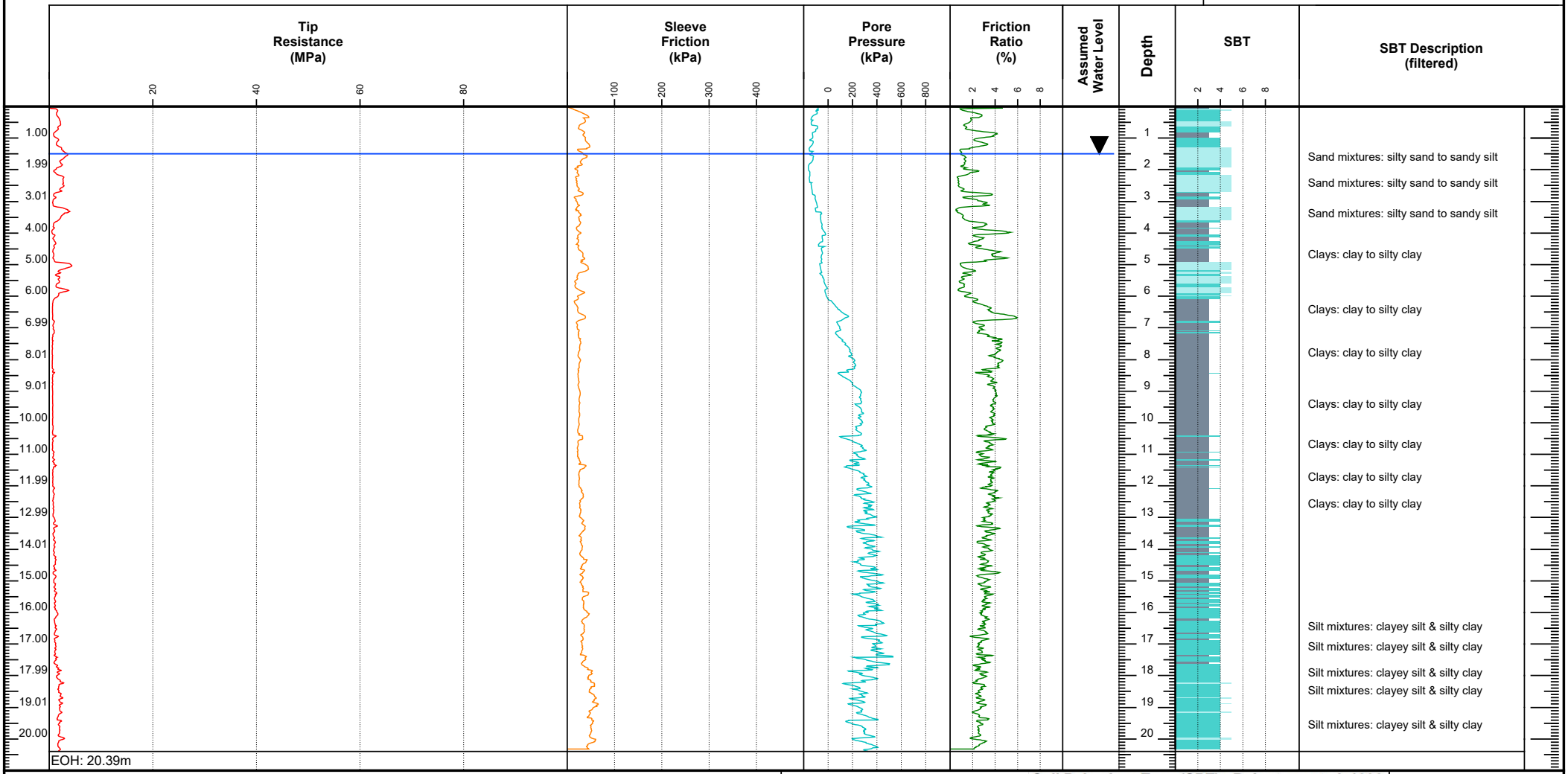
0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Date:
8/11/2021 12:00:00 AM

CONE PENETRATION TEST (CPT) LOG

TEST NO.: CPT03

Client Ref.: Woolshed Road



Client: ENGEO

Project: Jacks Point

Location: Woolshed Road

Contractor: Speight Drilling Ltd

Remarks:
Hole backfill with Bentonite chip

Termination Reason:
Target depth reached

Northing: 5002136

Easting: 1265280

System: NZTM

Elevation: 340m

Datum:

Method: Garmin GPS

Rig: Pagani TG63 - 150

Cone ID: Mks844

Cone Area: 10cm²

Sleeve Area: 150cm²

Area Ratio: 0.79

Predrill: 0m

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

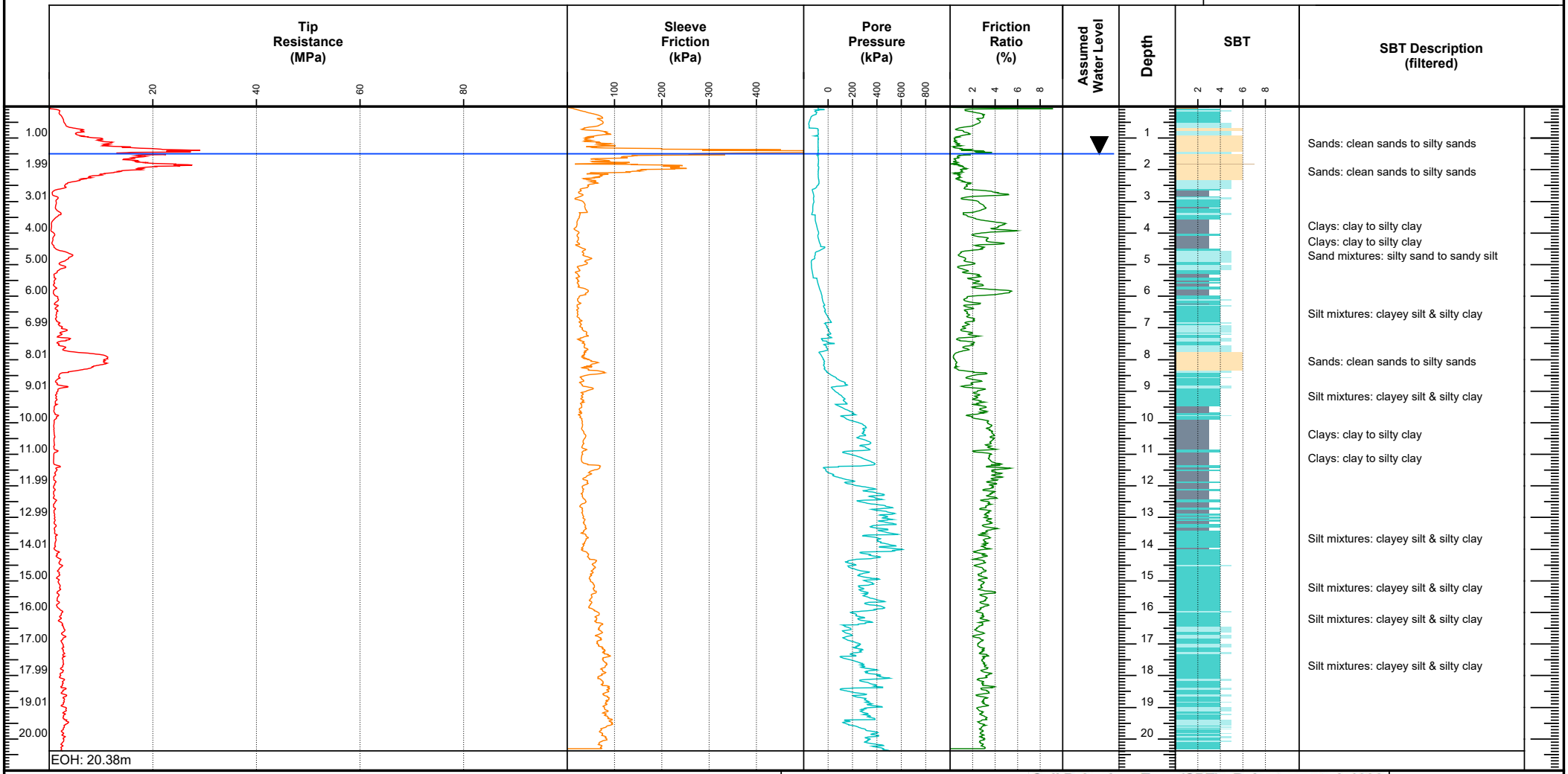
0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Date:
8/11/2021 12:00:00 AM

CONE PENETRATION TEST (CPT) LOG

TEST NO.: CPT04

Client Ref.: Woolshed Road



Client: ENGEO

Project: Jacks Point

Location: Woolshed Road

Contractor: Speight Drilling Ltd

Remarks:
Hole backfill with Bentonite chip

Termination Reason:
Target depth reached

Northing: 5002007

Easting: 1265394

System: NZTM

Elevation: 337m

Datum:

Method: Garmin GPS

Rig: Pagani TG63 - 150

Cone ID: Mks844

Cone Area: 10cm²

Sleeve Area: 150cm²

Area Ratio: 0.79

Predrill: 0m

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

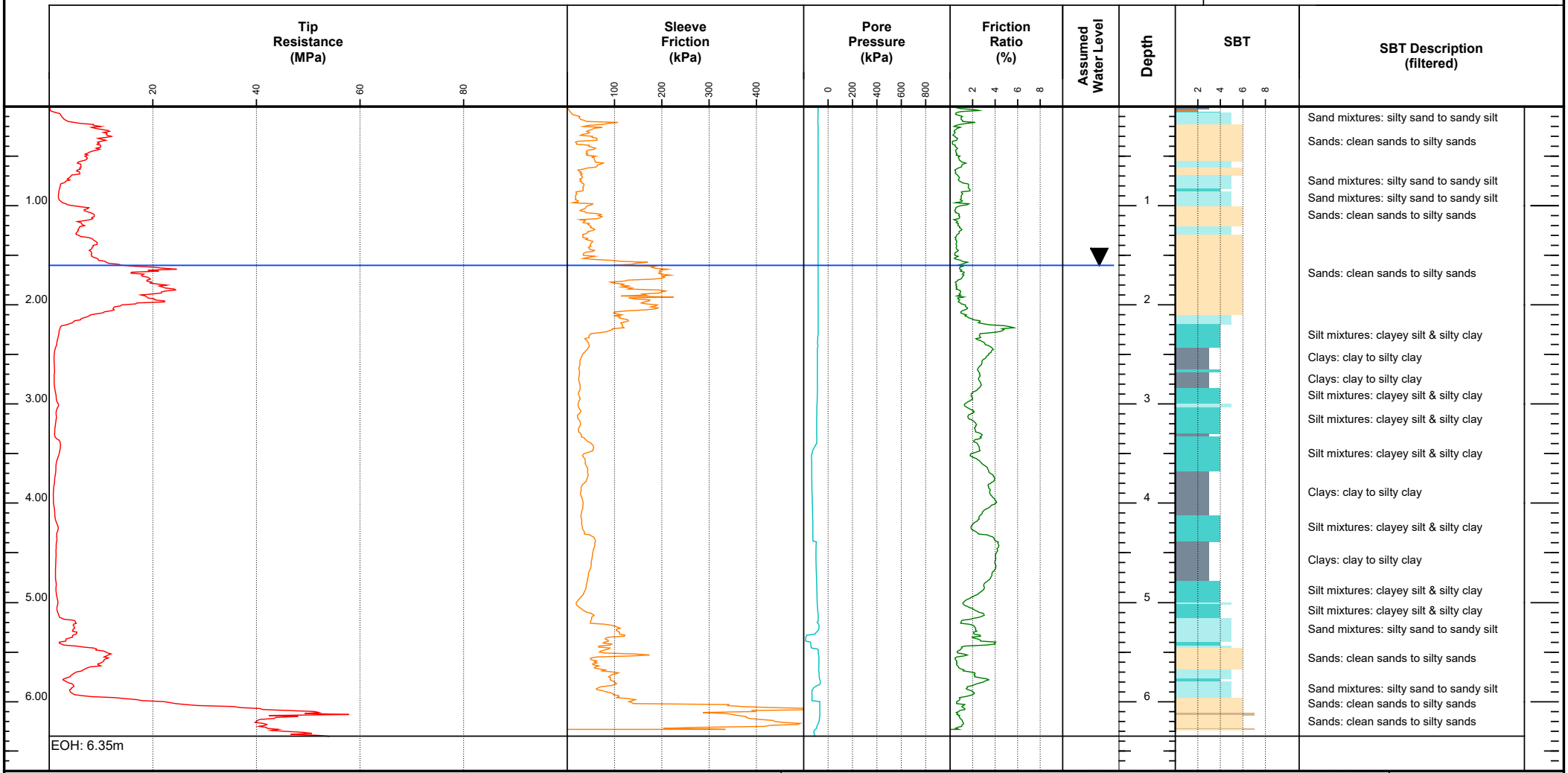
0	Undefined	5	Sand mixtures: silty sand to sandy silt
1	Sensitive fine-grained	6	Sands: clean sands to silty sands
2	Clay - organic soil	7	Dense sand to gravelly sand
3	Clays: clay to silty clay	8	Stiff sand to clayey sand
4	Silt mixtures: clayey silt & silty clay	9	Stiff fine-grained

Date:
8/11/2021 12:00:00 AM

CONE PENETRATION TEST (CPT) LOG

TEST NO.: CPT05

Client Ref.: Woolshed Road



Client: ENGEO

Project: Jacks Point

Location: Woolshed Road

Contractor: Speight Drilling Ltd

Remarks:
Hole backfill with Bentonite chip

Termination Reason:
Refusal due to cone and sleeve resistance

Northing: 5002159

Easting: 1265542

System: NZTM

Elevation: 337m

Datum:

Method: Garmin GPS

Rig: Pagani TG63 - 150

Cone ID: Mks844

Cone Area: 10cm²

Sleeve Area: 150cm²

Area Ratio: 0.79

Predrill: 0m

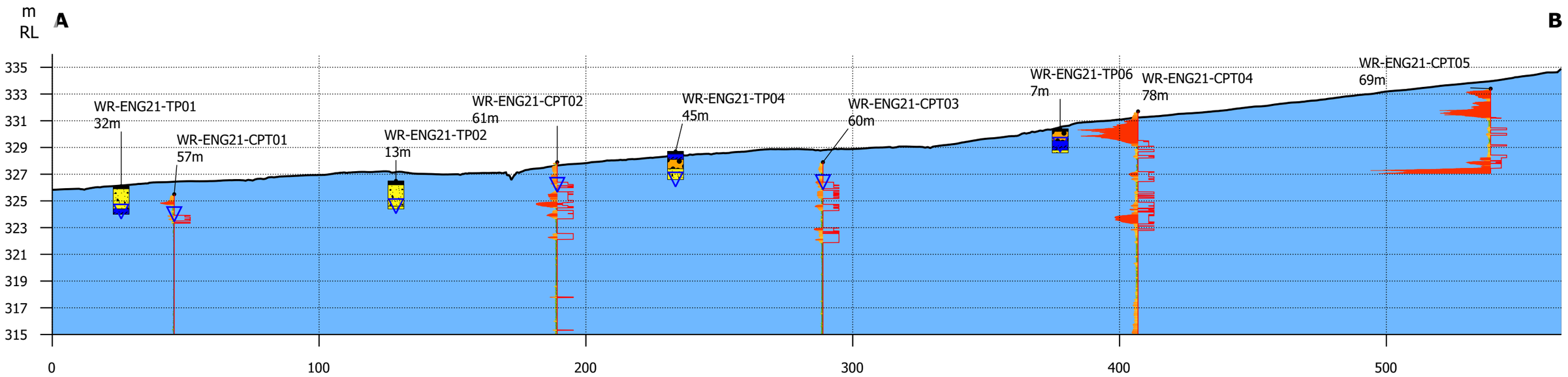
Soil Behaviour Type (SBT) - Robertson et al. 1986

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

Date:
8/11/2021 12:00:00 AM

APPENDIX 3:

Interpreted Geological Cross Section



Legend

Geological Units
- Lacustrine Deposits

USCS Soil Classification
- Topsoil
- ML
- SM
- SW
- GW

Surfaces
- Existing Ground Surface (QLDC LiDAR 2021)

Cone Resistence qc (MPa)
0.2 1.1 2.1 3 4

- Stablised Groundwater Observations

Notes:
1. Cliq Vertical Settelment layers shown on right hand side of stick log (in red).

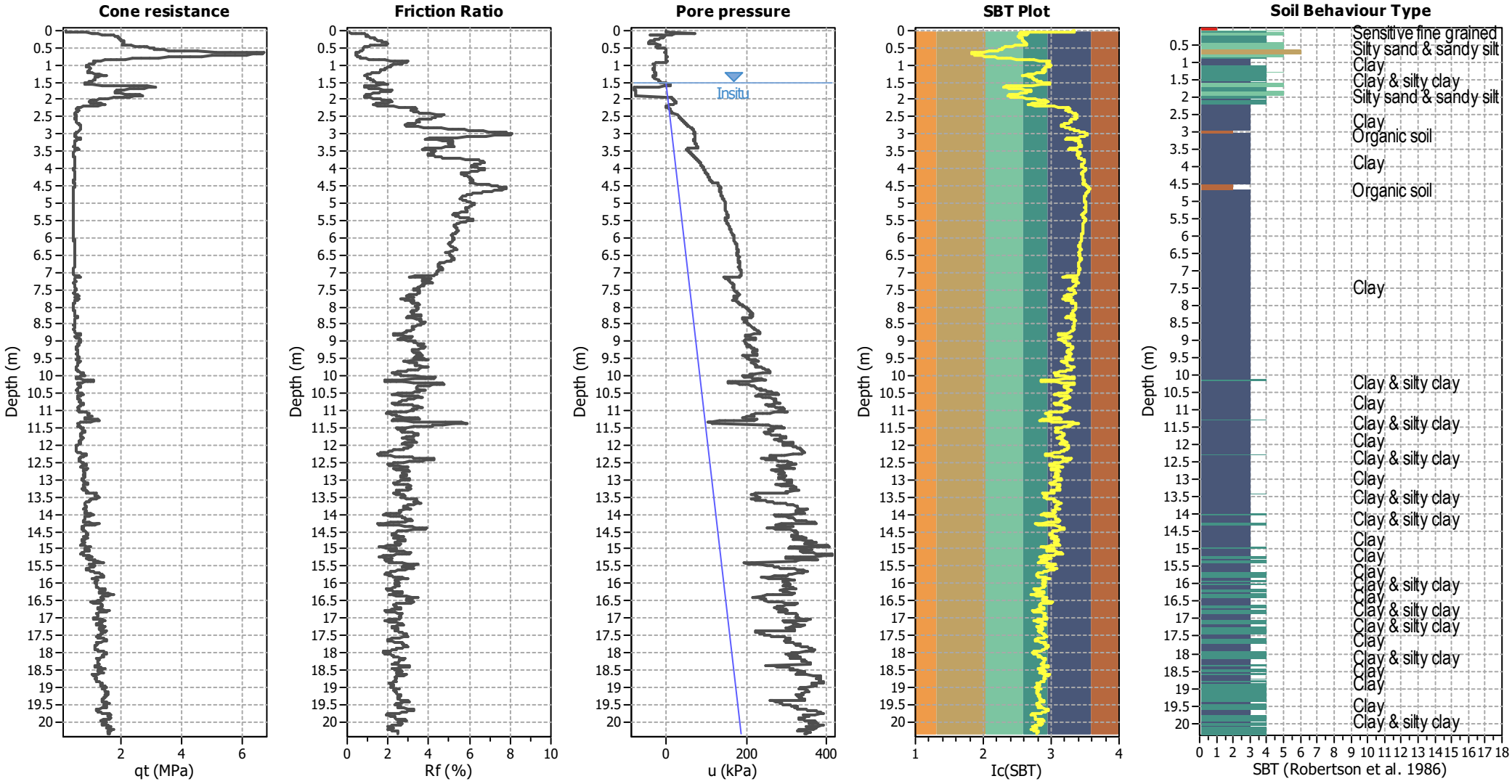
Scale: 1:1,500
Vertical exaggeration: 5x
0m 50m

Responsible dept. Queenstown	Technical reference 19651	Creator BLH	Approved by	
Legal owner ENGEO		Document type Geological Cross section	Document status Issue	
		Title Interpreted Geological Cross Section (A-B)	Identification number Appendix 3	
			Rev. 1	Date of issue / Sheet

APPENDIX 4:

Liquefaction Analysis Outputs

CPT basic interpretation plots



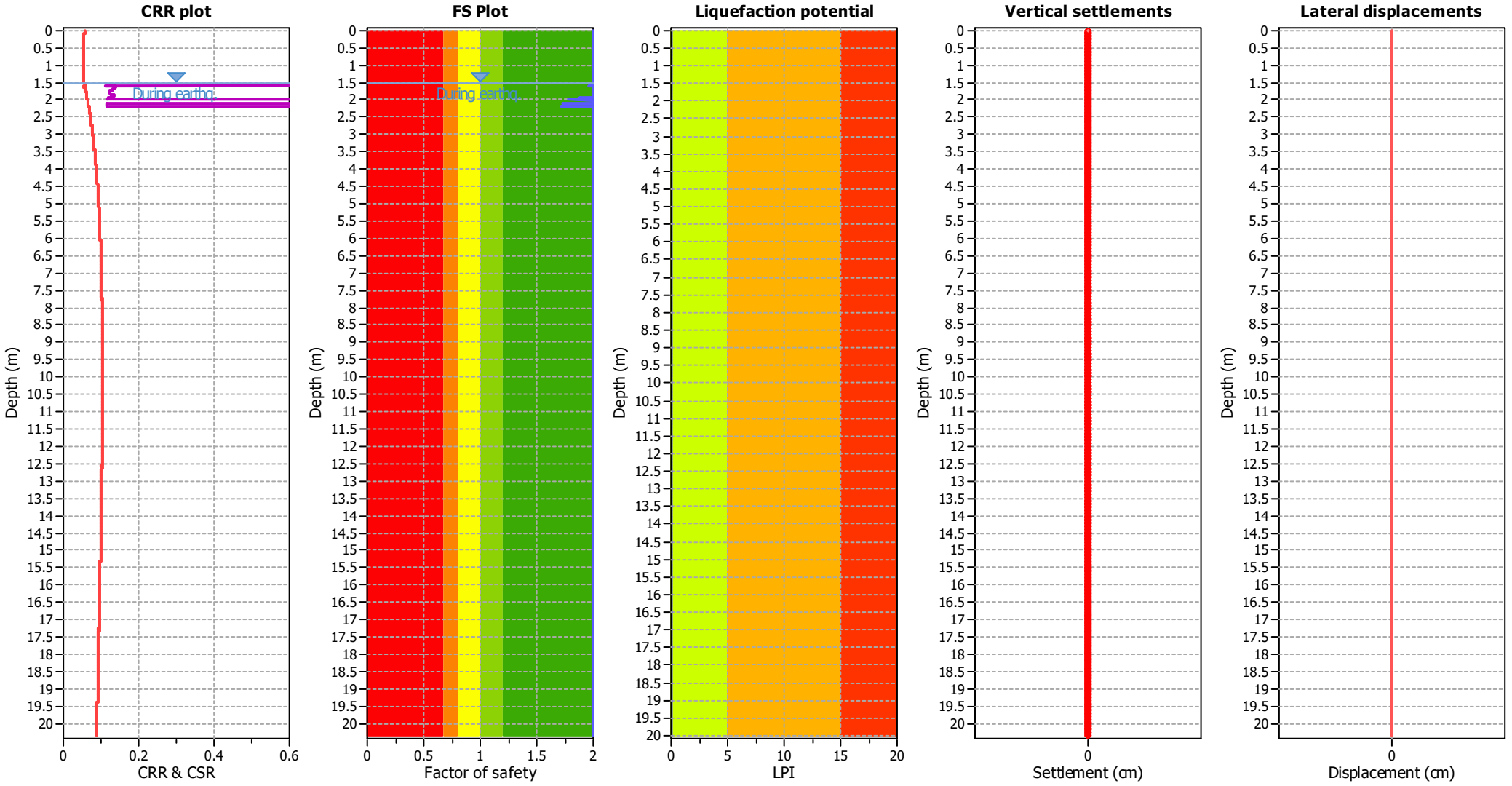
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

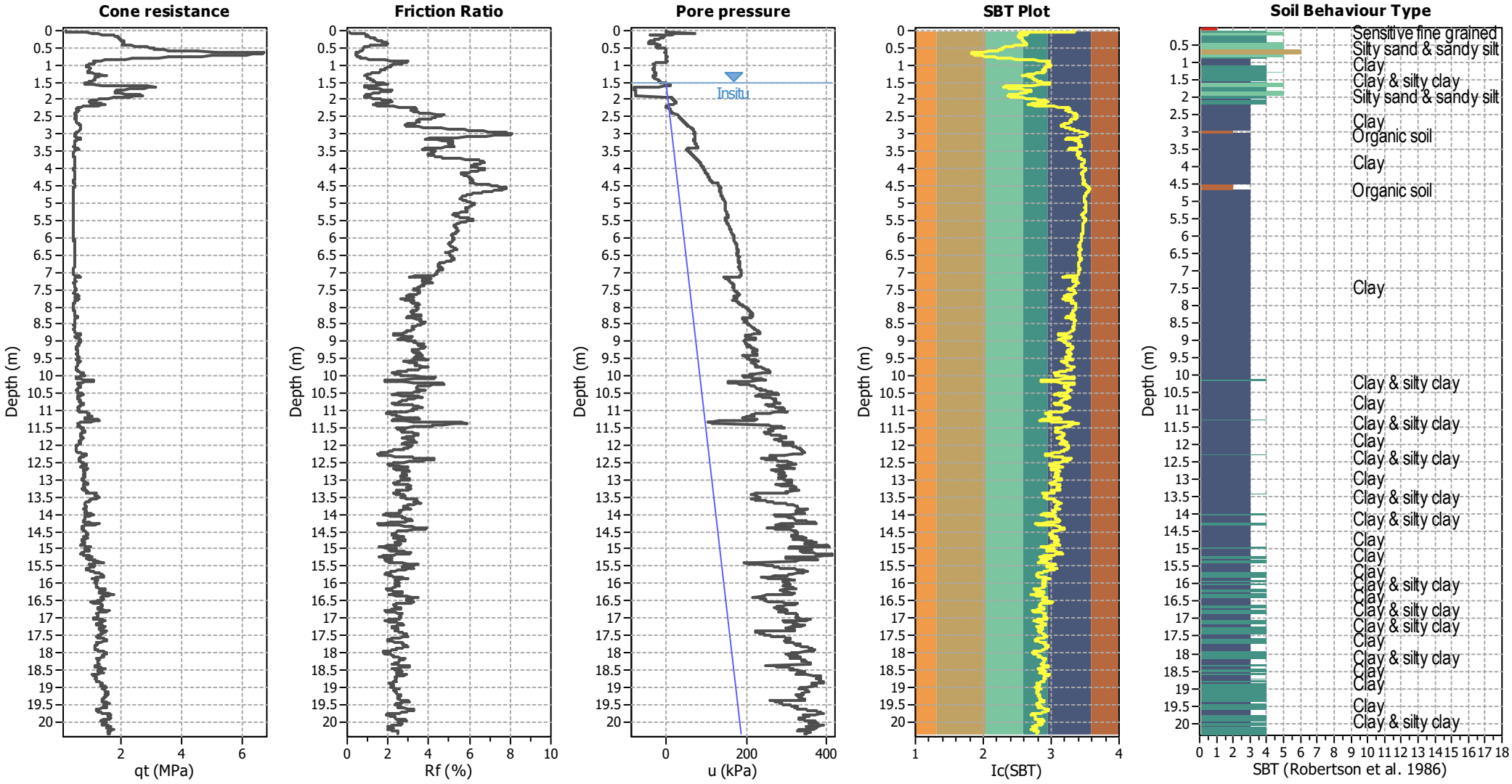
F.S. color scheme

- 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



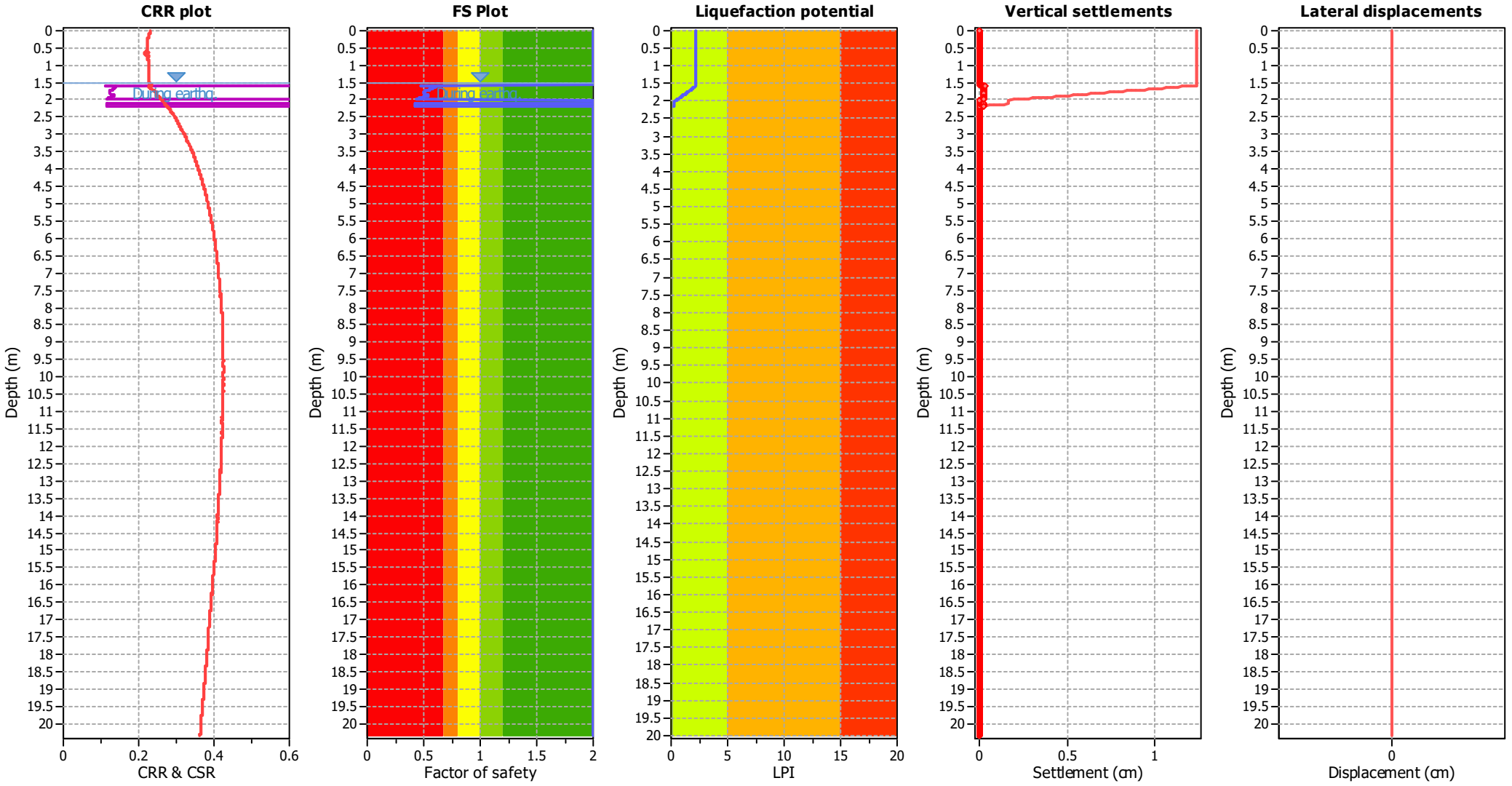
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.41	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.41	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

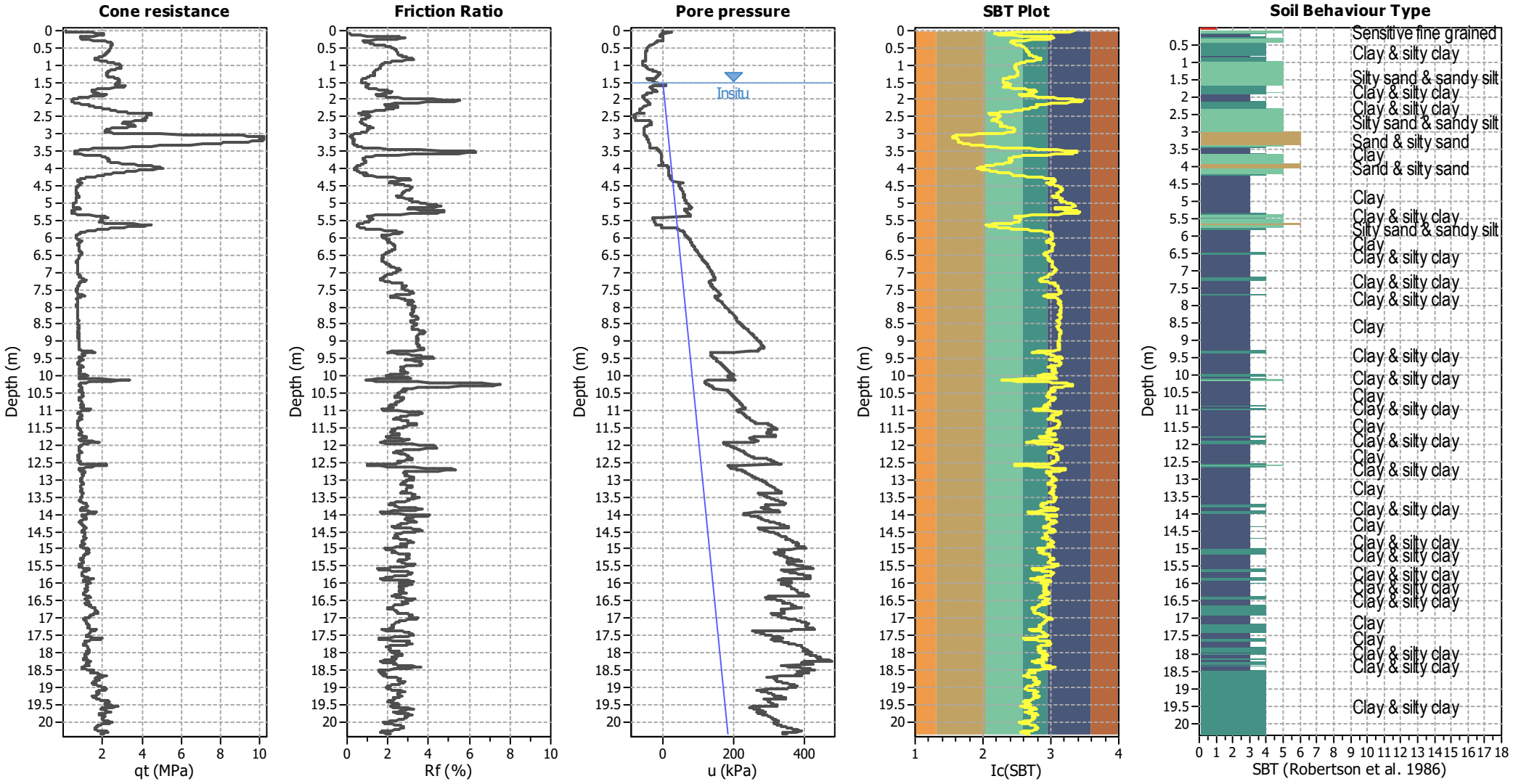
F.S. color scheme

- 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



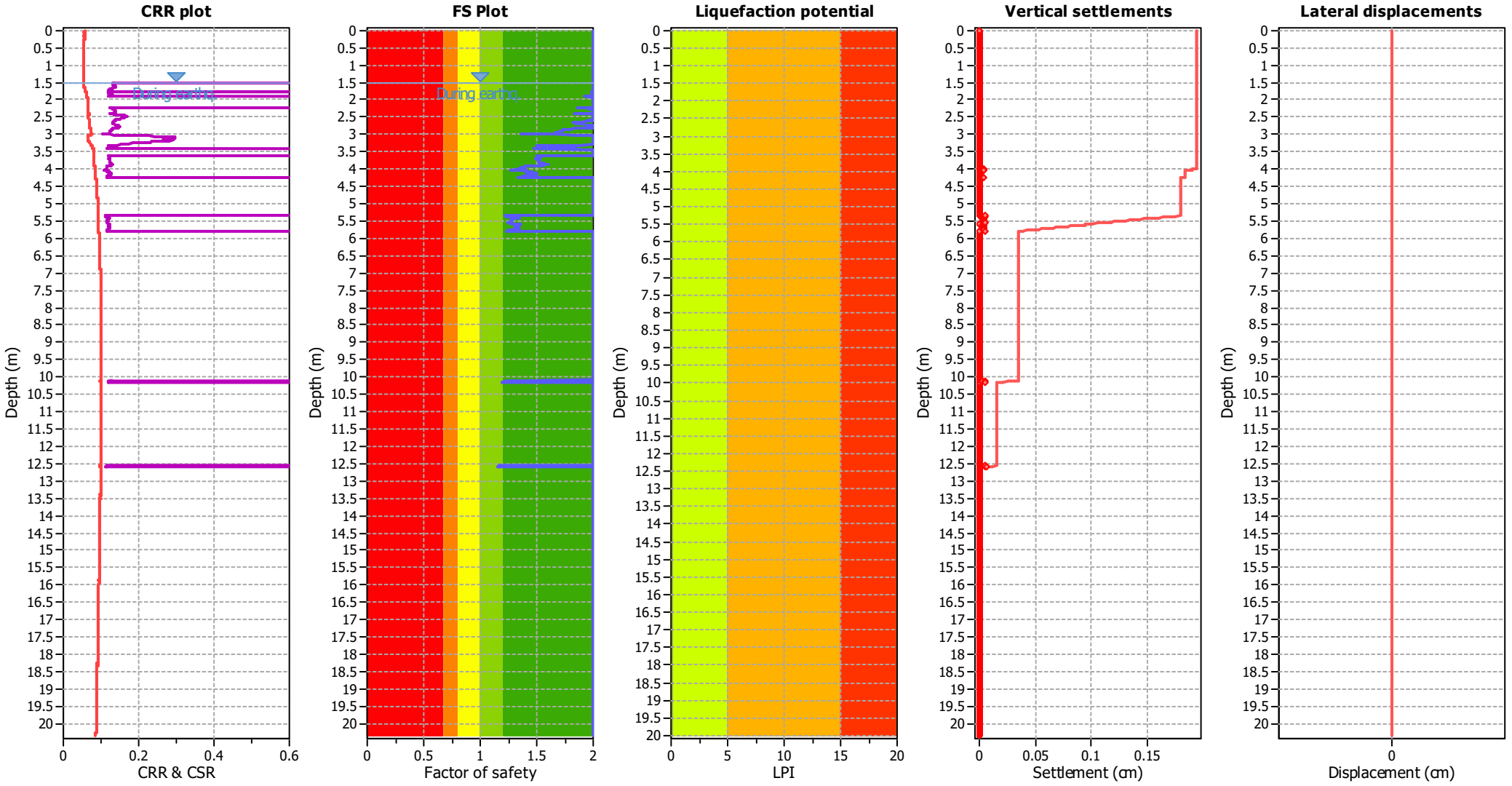
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

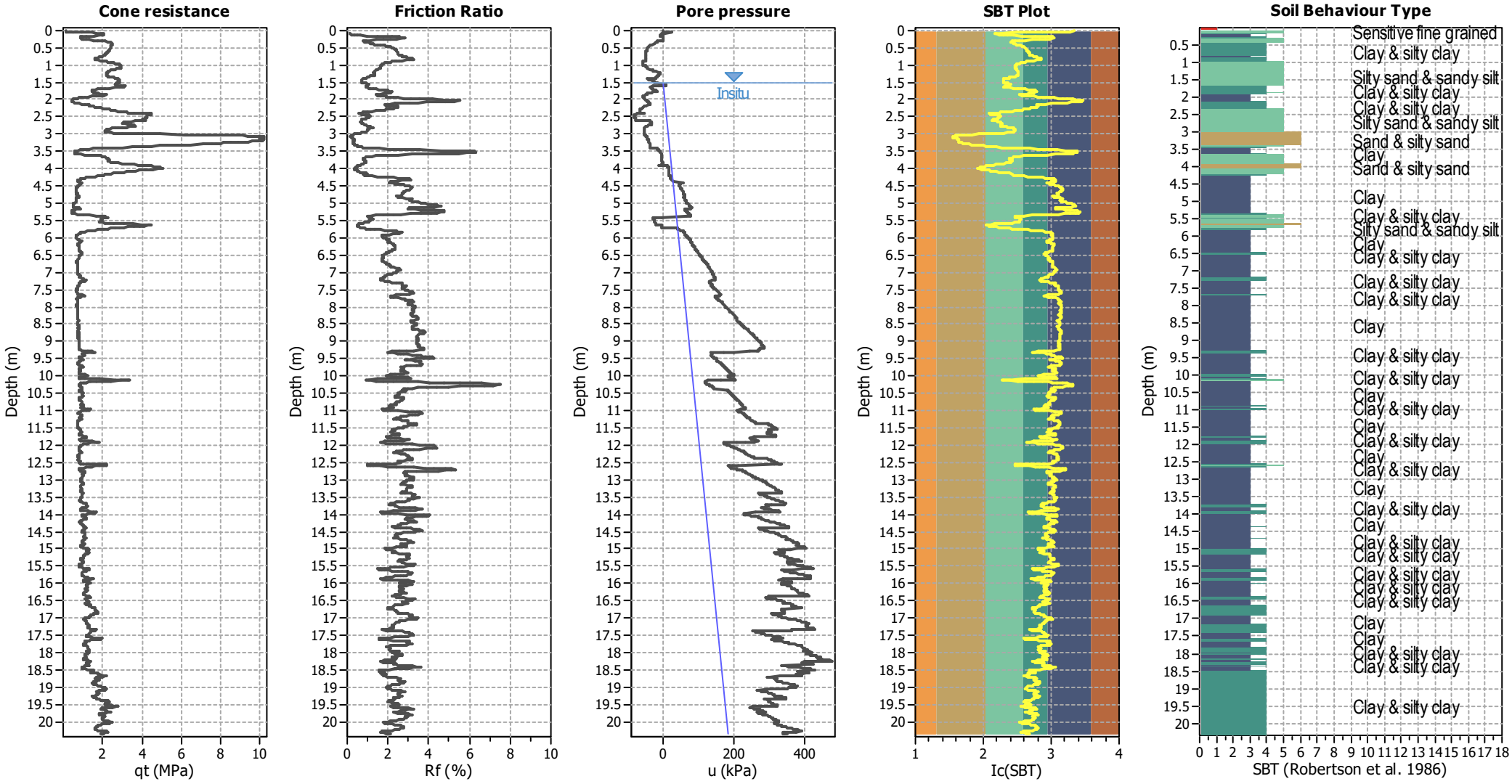
F.S. color scheme

- 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



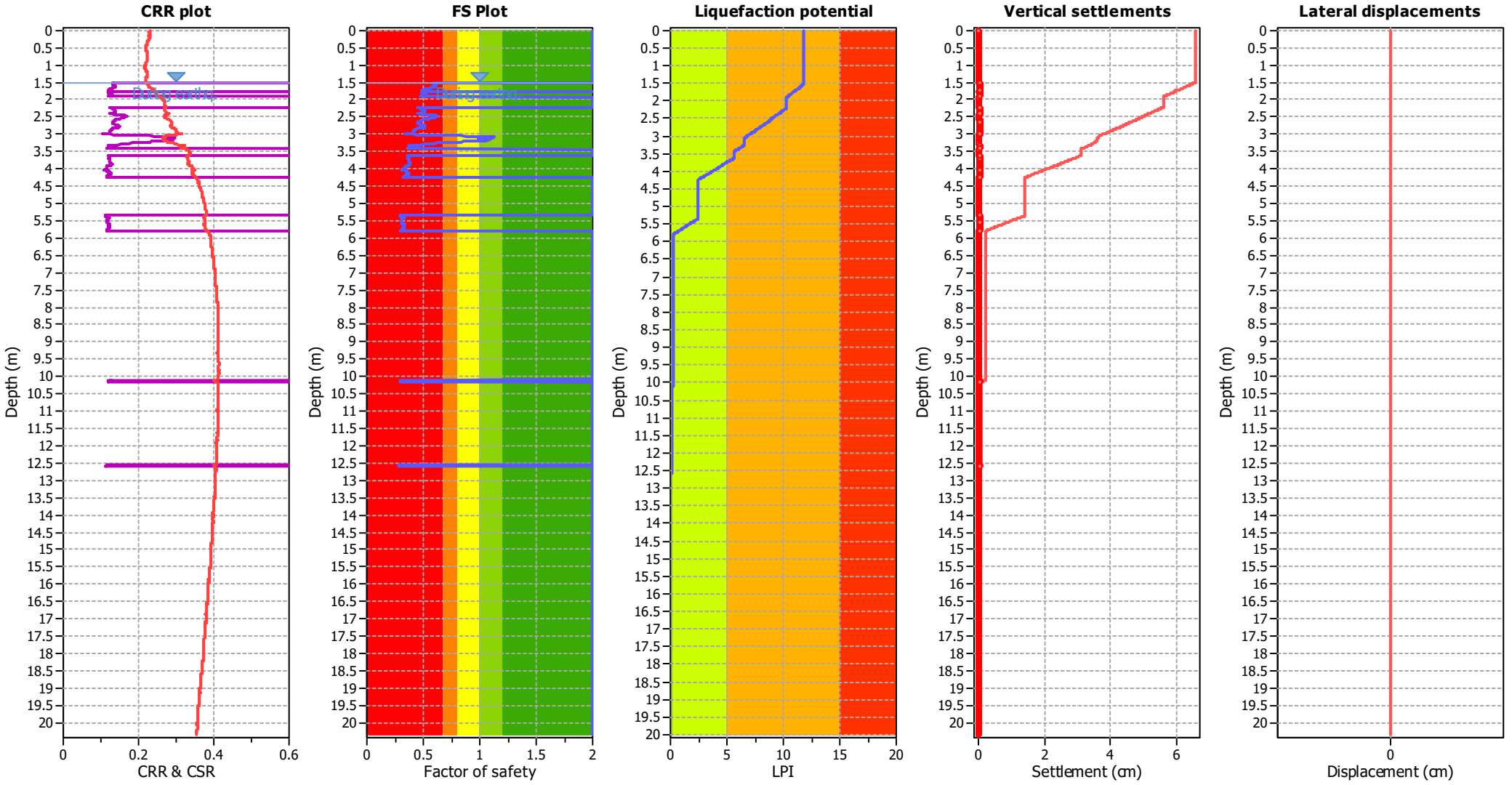
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.41	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.41	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

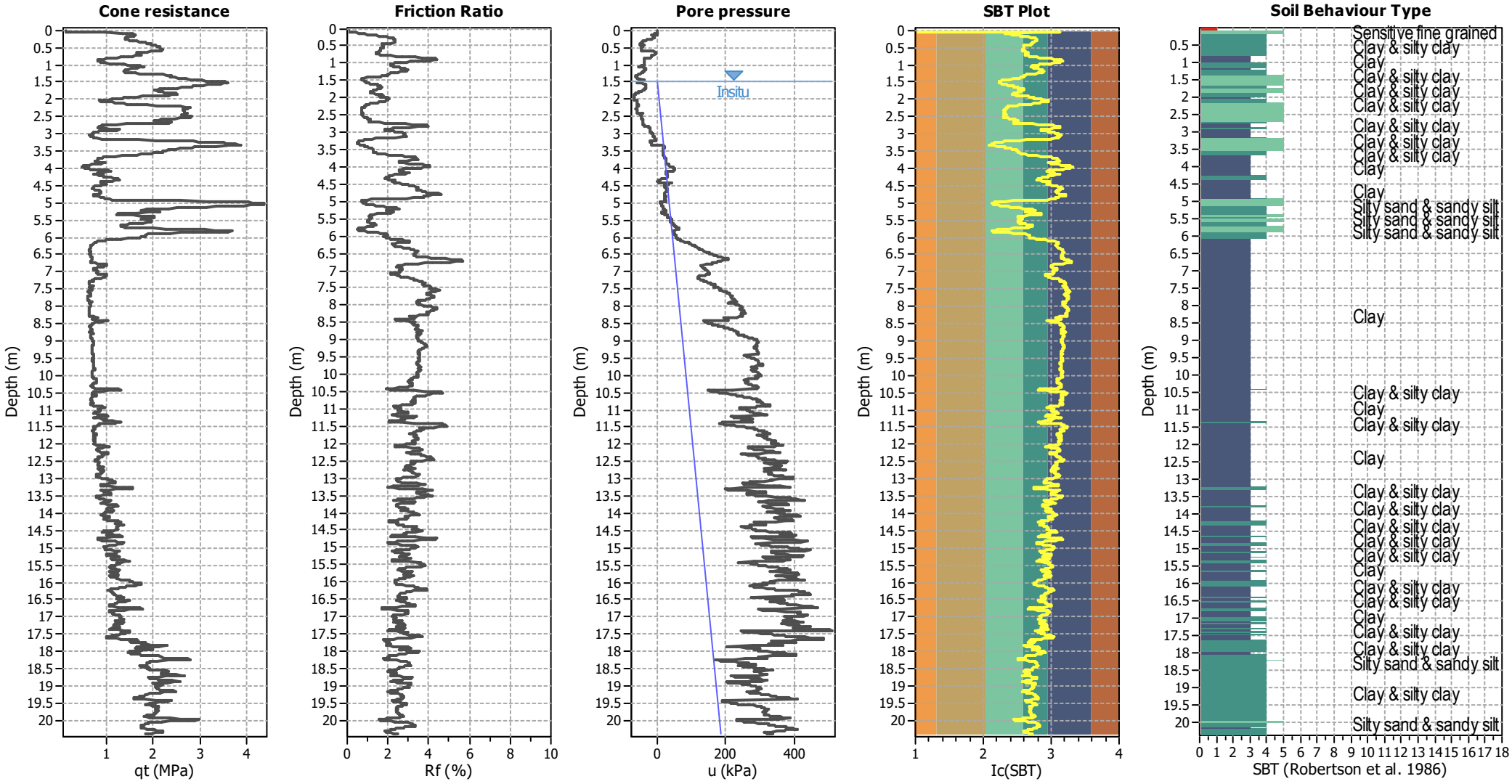
F.S. color scheme

- 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



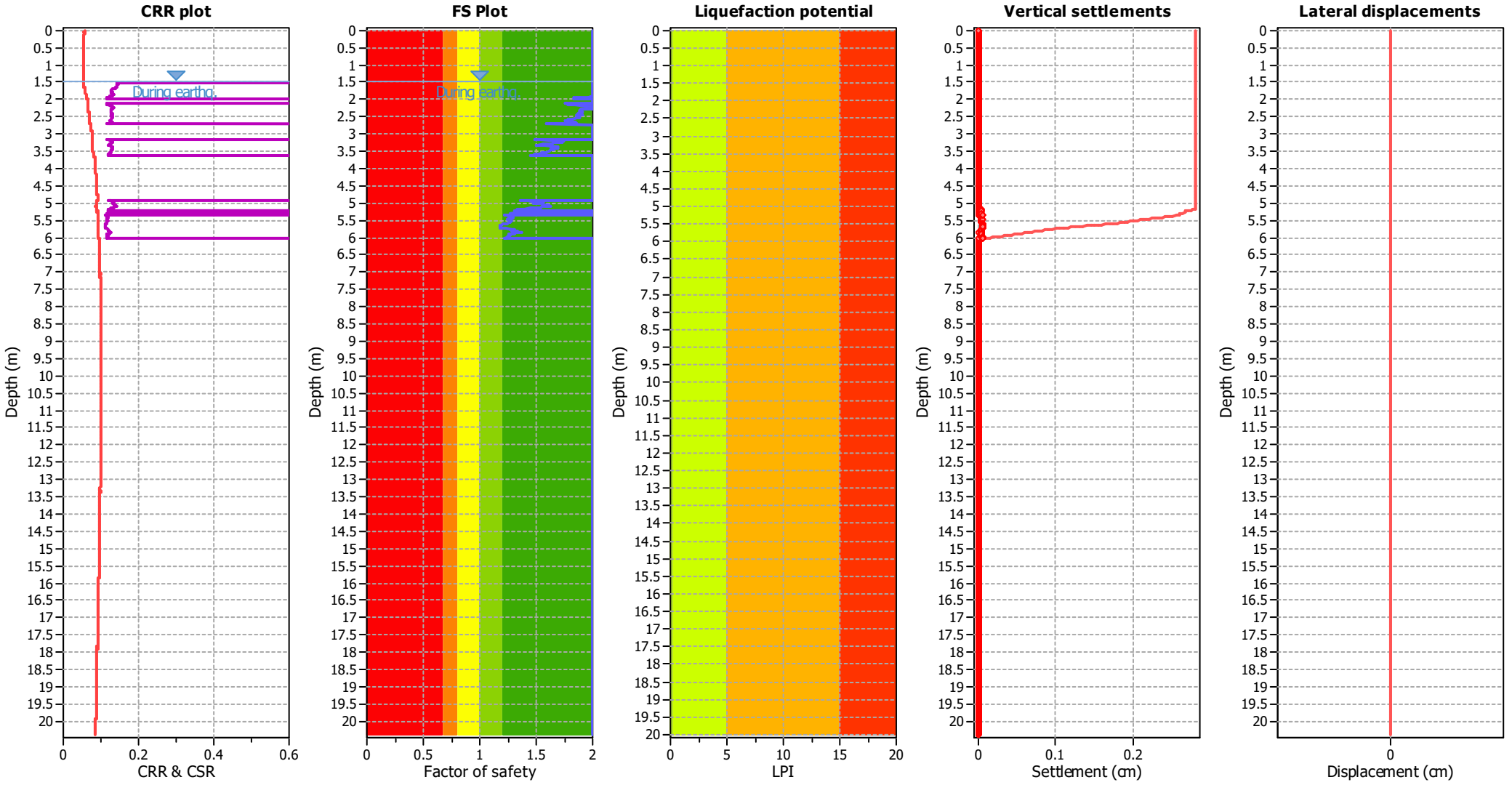
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

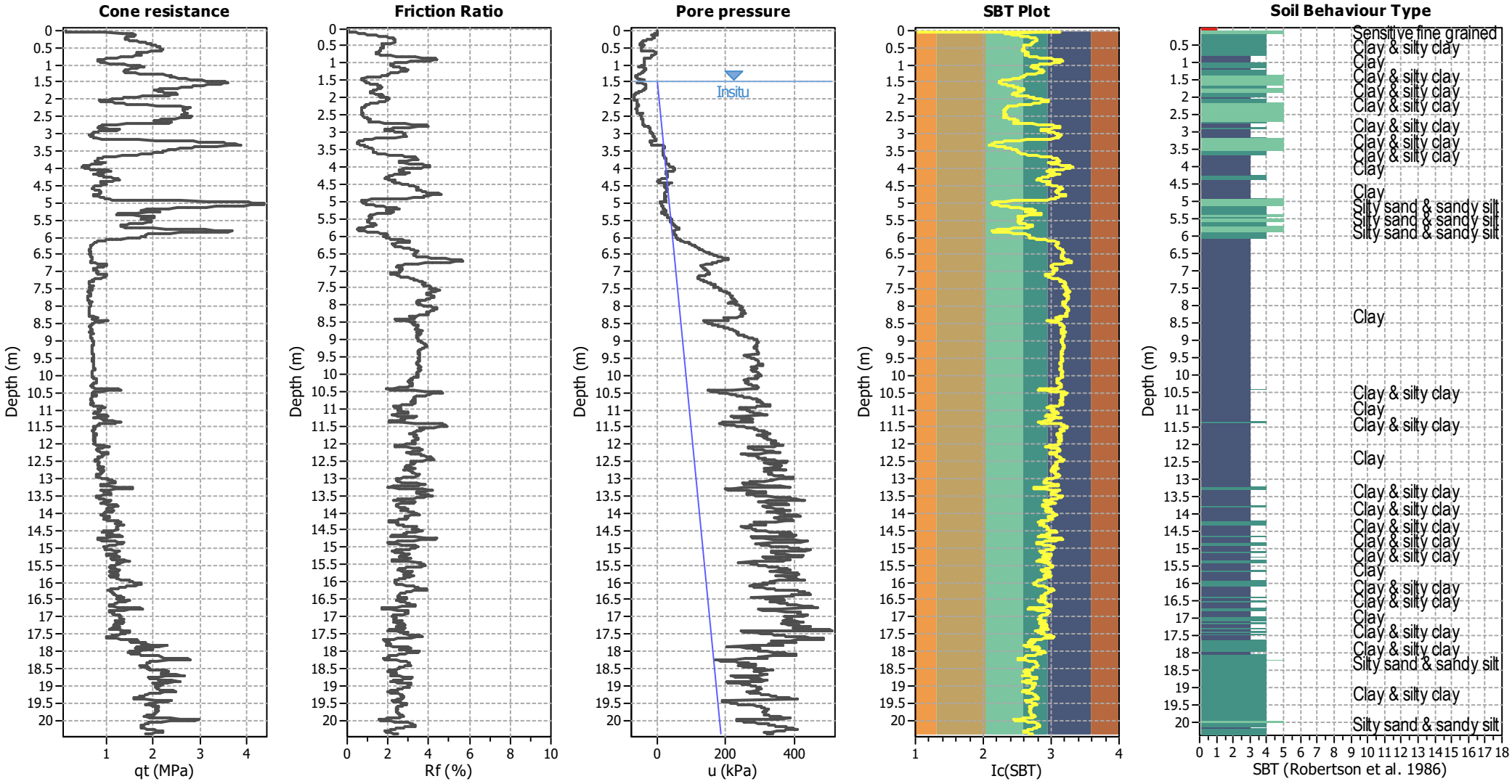
F.S. color scheme

- 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



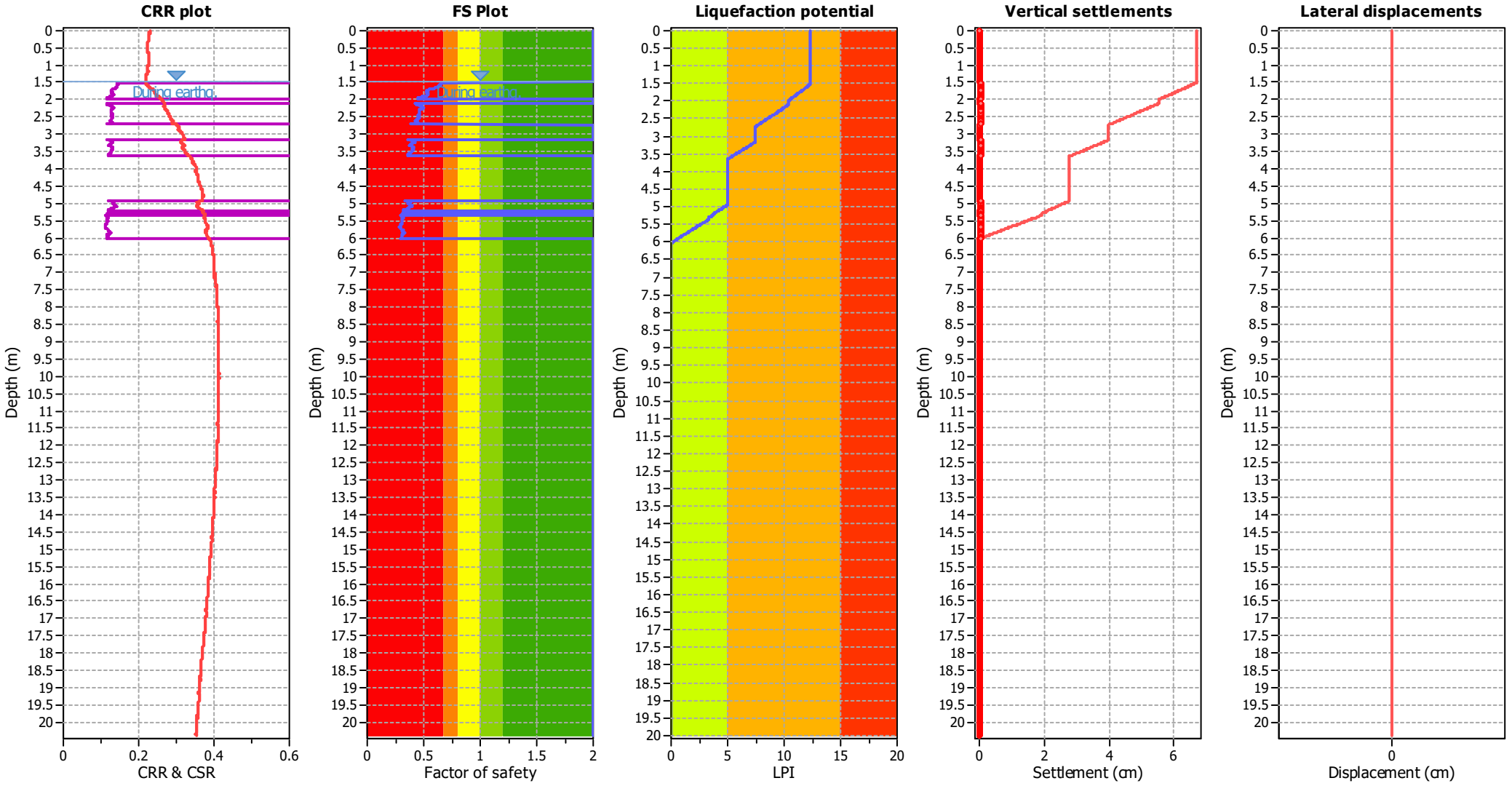
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.41	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.41	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

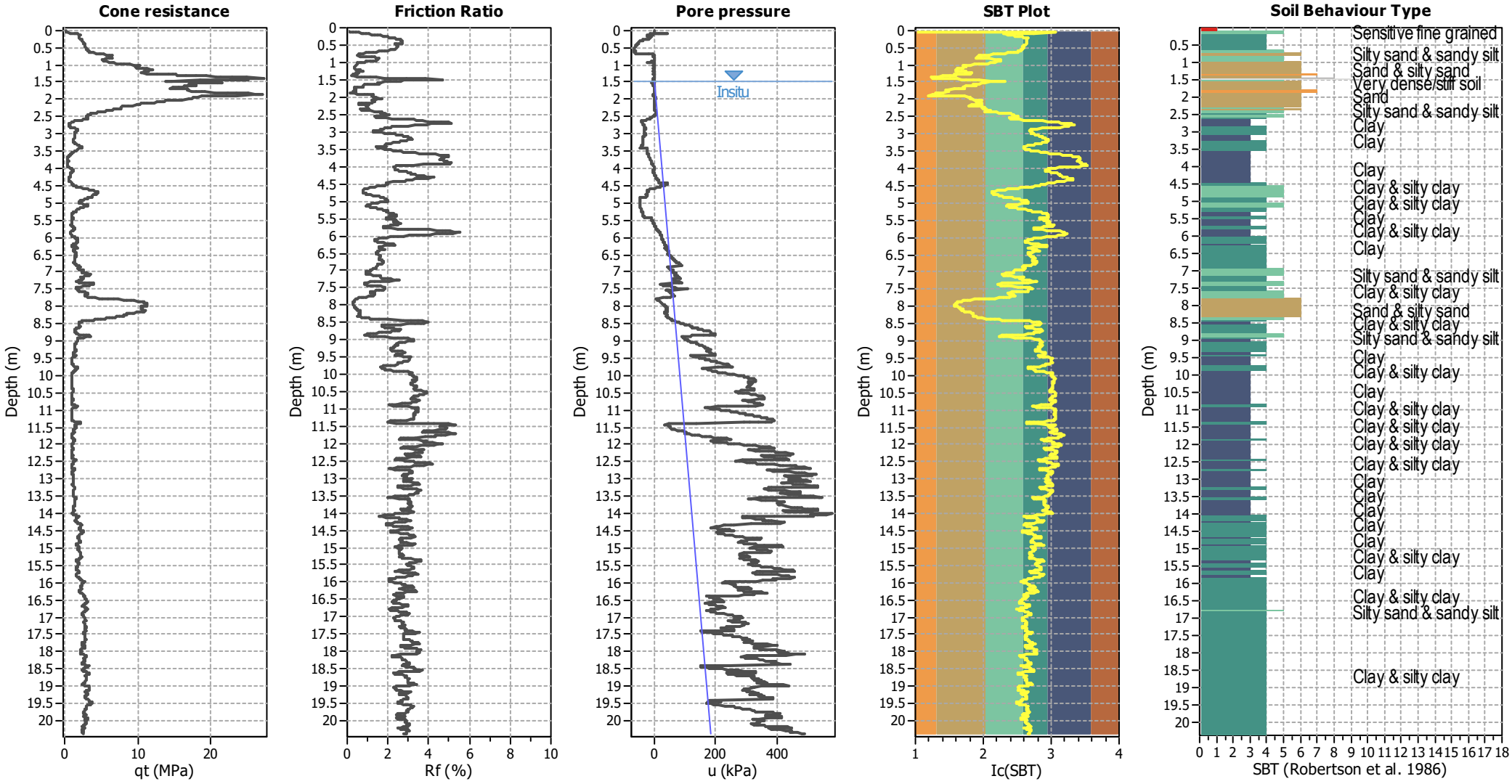
F.S. color scheme

- 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



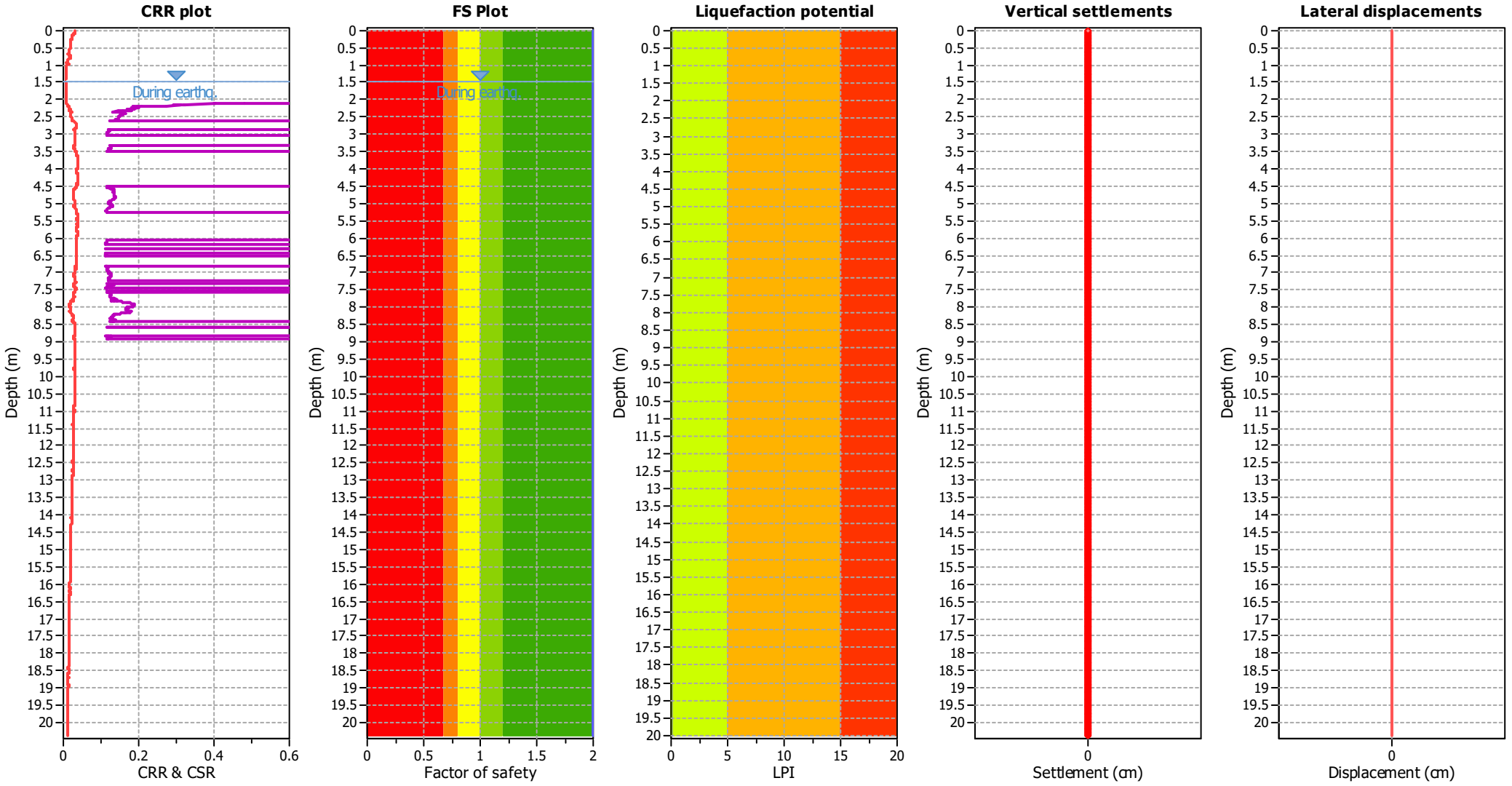
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	0.00	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	0.00	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

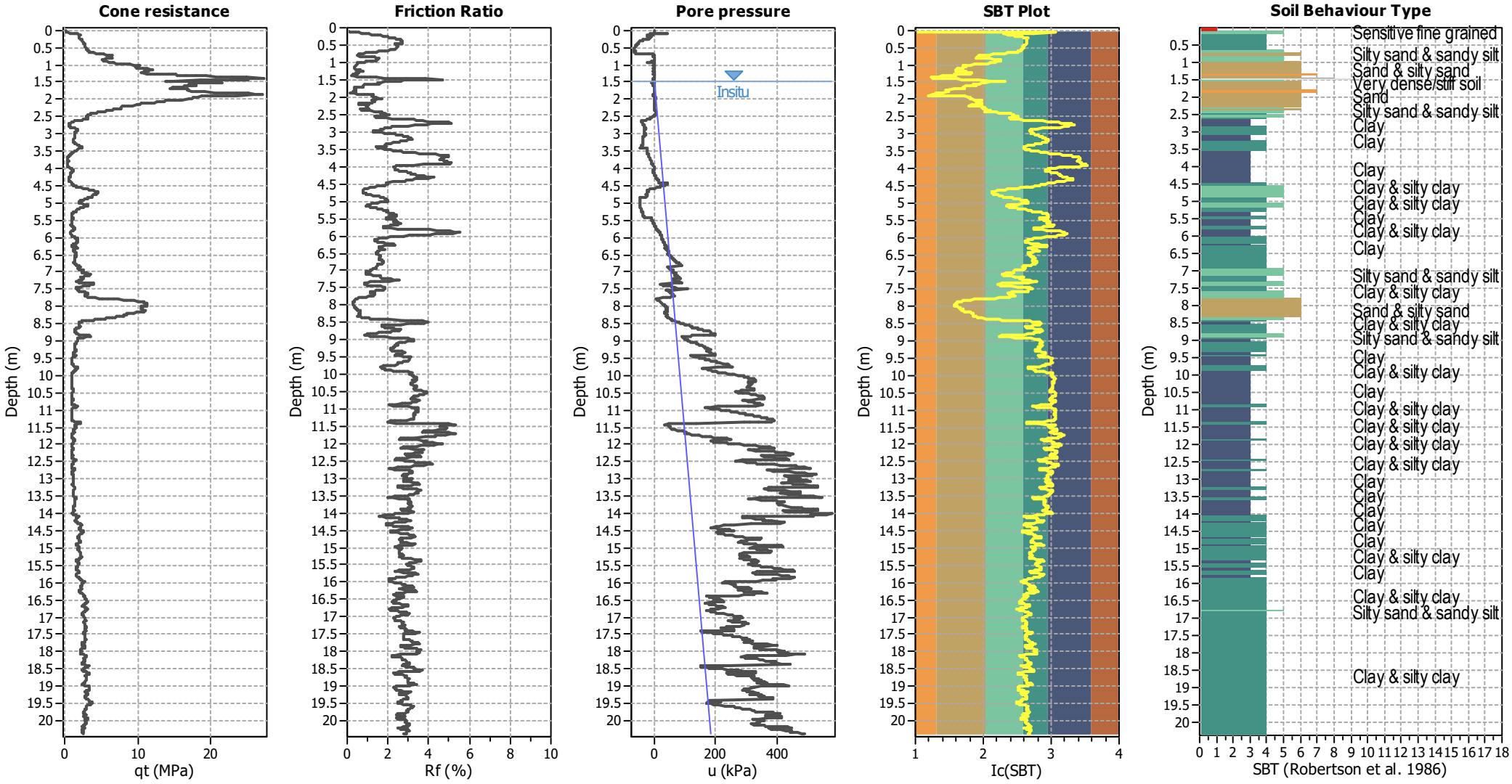
F.S. color scheme

- 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



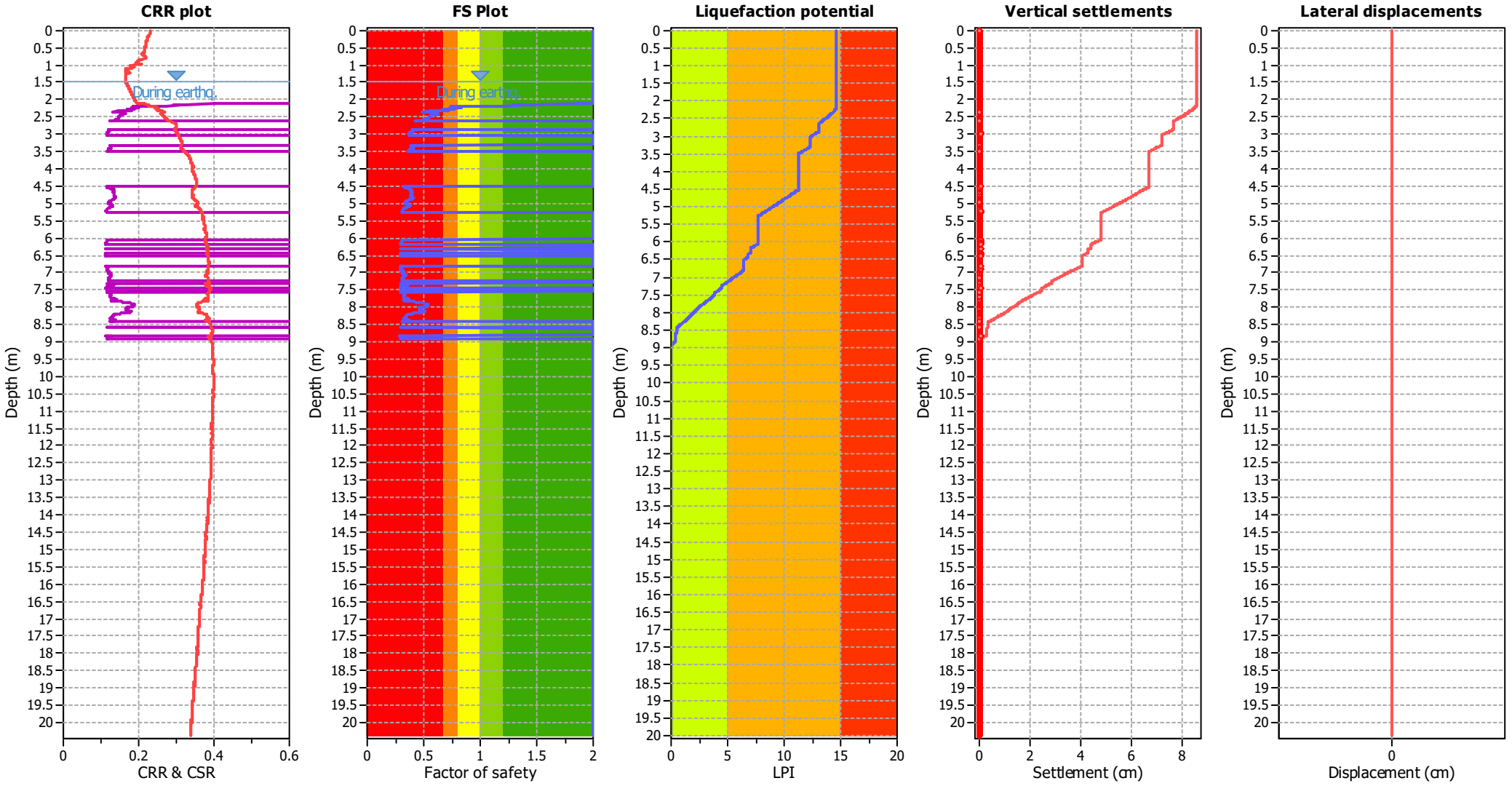
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.50 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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.41	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 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

Liquefaction analysis overall plots



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Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
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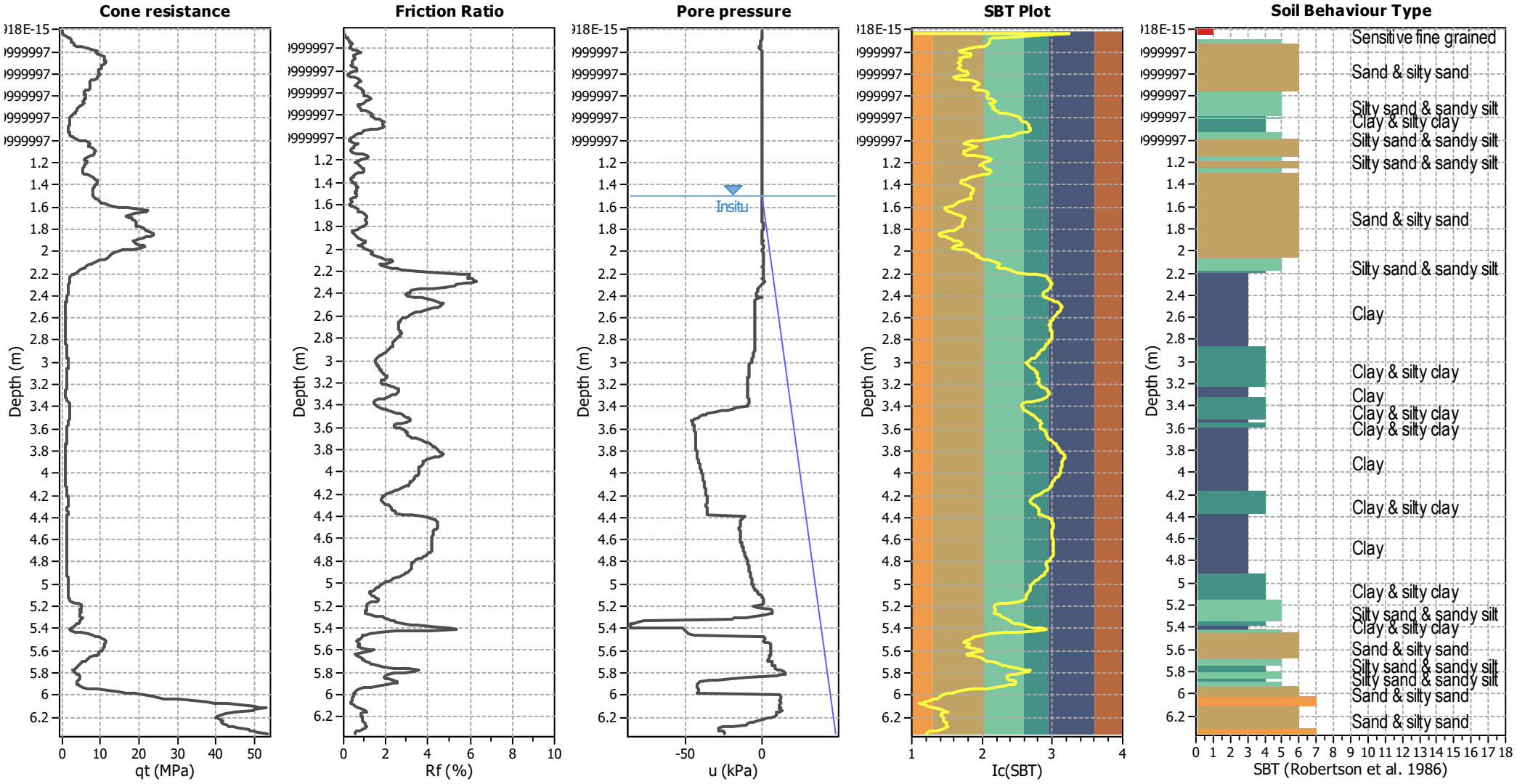
CPT basic interpretation plots



Input parameters and analysis data

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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:	6.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.10	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

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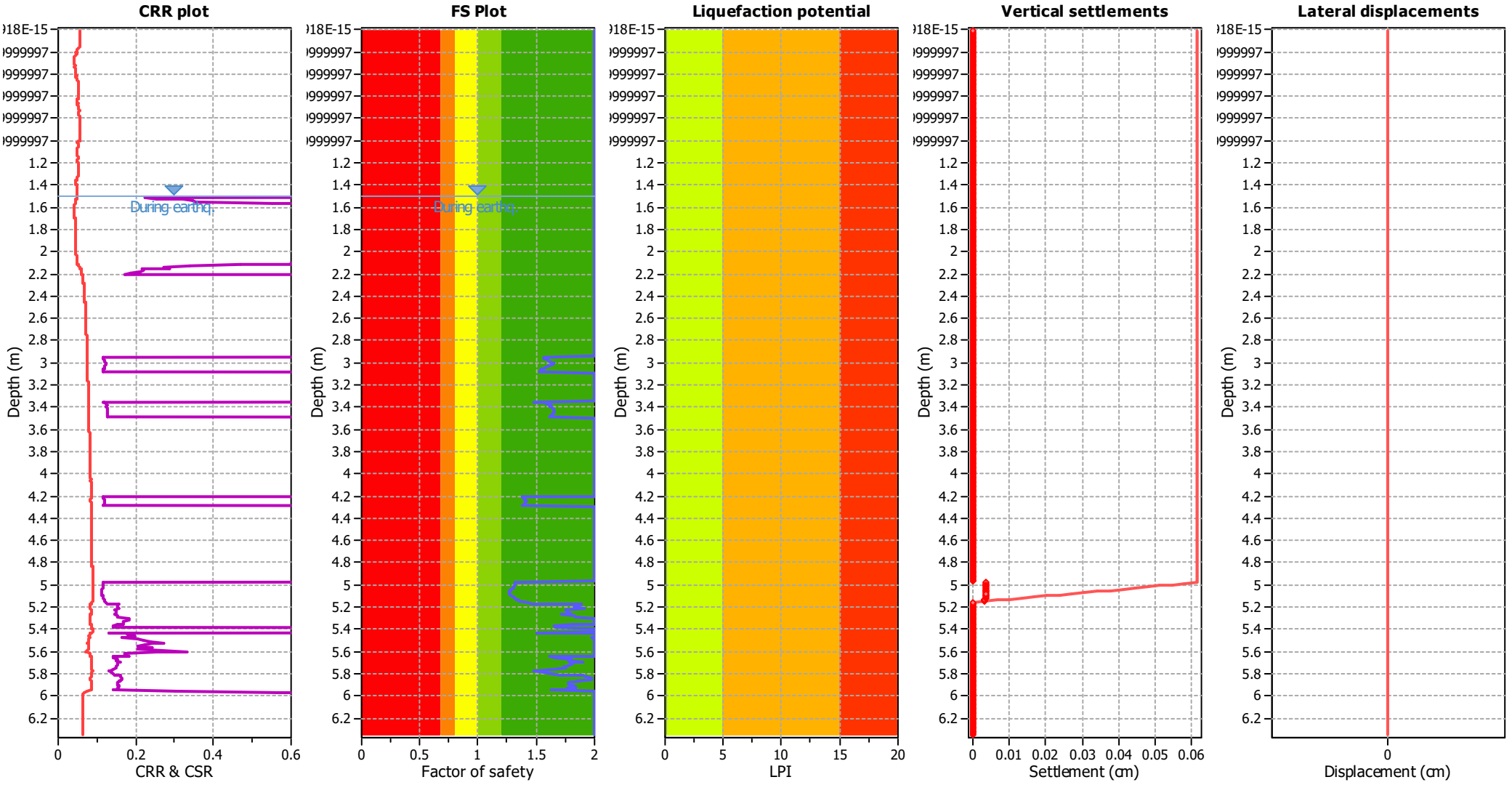
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



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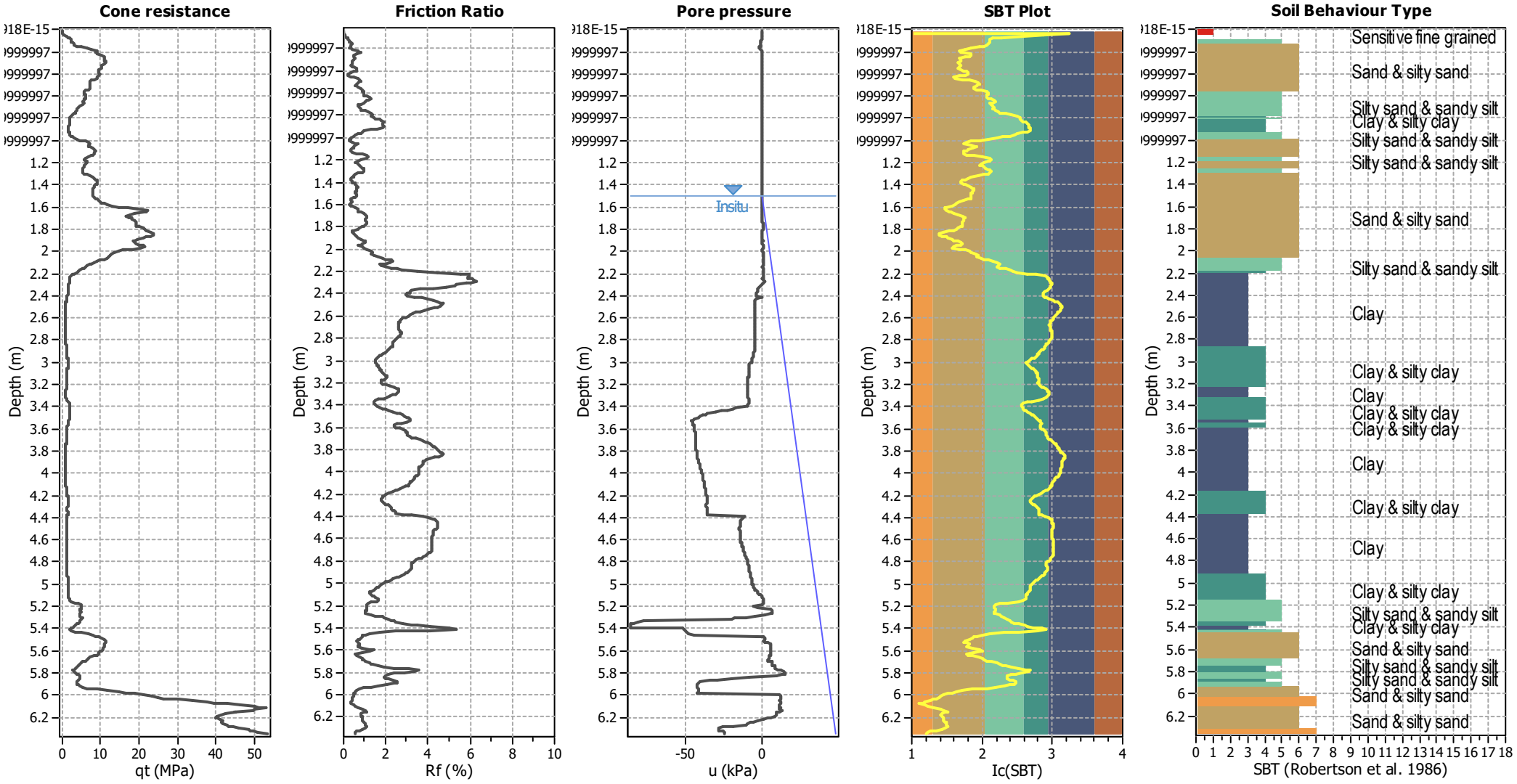

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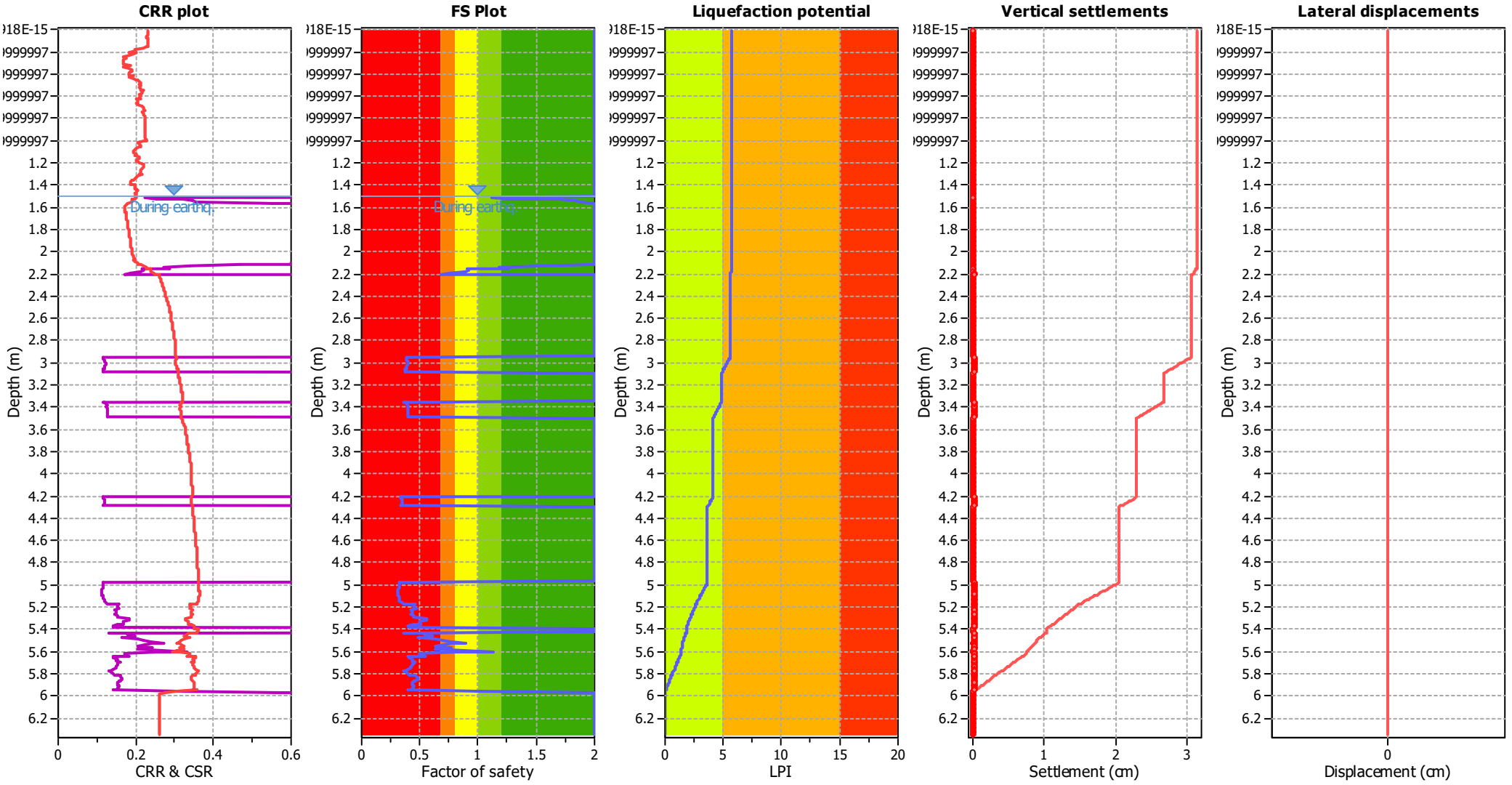
Liquefaction analysis overall plots



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