Appendix M – Geotechnical Suitability Report

GEOTECHNICAL SUITABILITY REPORT

Proposed Private Plan Change at 2025 Ōhaupō Road, Te Awamutu

for Te Awamutu Developments Limited

Rev A - 24/11/2022

BTW COMPANY

SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

Proposed Private Plan Change at 2025 Ōhaupō Road, Te Awamutu

for Te Awamutu Developments Limited

Reviewed

Project Manager

24/11/2022

Mathew Dickey BE (Civil), CPEng

Date

Report Author

Bruce Murdoch

24/11/2022

Bruce Murdoch MSc (Earth Sciences), MEngNZ

Date

Reviewed by

24/11/2022

Art Guadalquiver MSc, MEngSc, CPEng GNA Consultants Ltd

Date

211365
Rev A - 24/11/2022

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

CONTENTS

TABLES

FIGURES

1 INTRODUCTION

BTW Company Ltd. (BTW) has been engaged by Te Awamutu Developments Limited to provide a Geotechnical Suitability Report for the proposed new residential development located at 2050 Ōhaupō Road, Te Awamutu. This is prepared to support a private plan change submission.

1.1 Scope of Document

The scope of work undertaken and documented in this report includes the following geotechnical suitability assessment:

- Factual reporting of the geotechnical investigations.
- Geotechnical assessment of the geotechnical investigation results.
- Geotechnical suitability assessment which includes the following items:
    - Provision of a basic ground model for the site.
    - Review on-site soakage potential.
    - Provide initial soil classes
    - Determine the CBR design values for pavement design.
    - Provide foundation recommendations.
    - Provide commentary on the recommended Earthworks Strategy.
    - Complete a site Geohazard review.
    - Outline initial Overland Flow Paths.

1.2 Site Description

The proposed site is an irregular shaped rectangle located approximately 200 m north of the Te Awamutu peri-urban boundary. The proposed development area comprises of 25.78 hectares which is currently utilised as grassed pasture. The property assessed is currently in two Lots (Lot 1 DPS 36696 and Part Lot 1 DP 35654).

A preliminary concept development plan is included in Figure 1.1 (below).

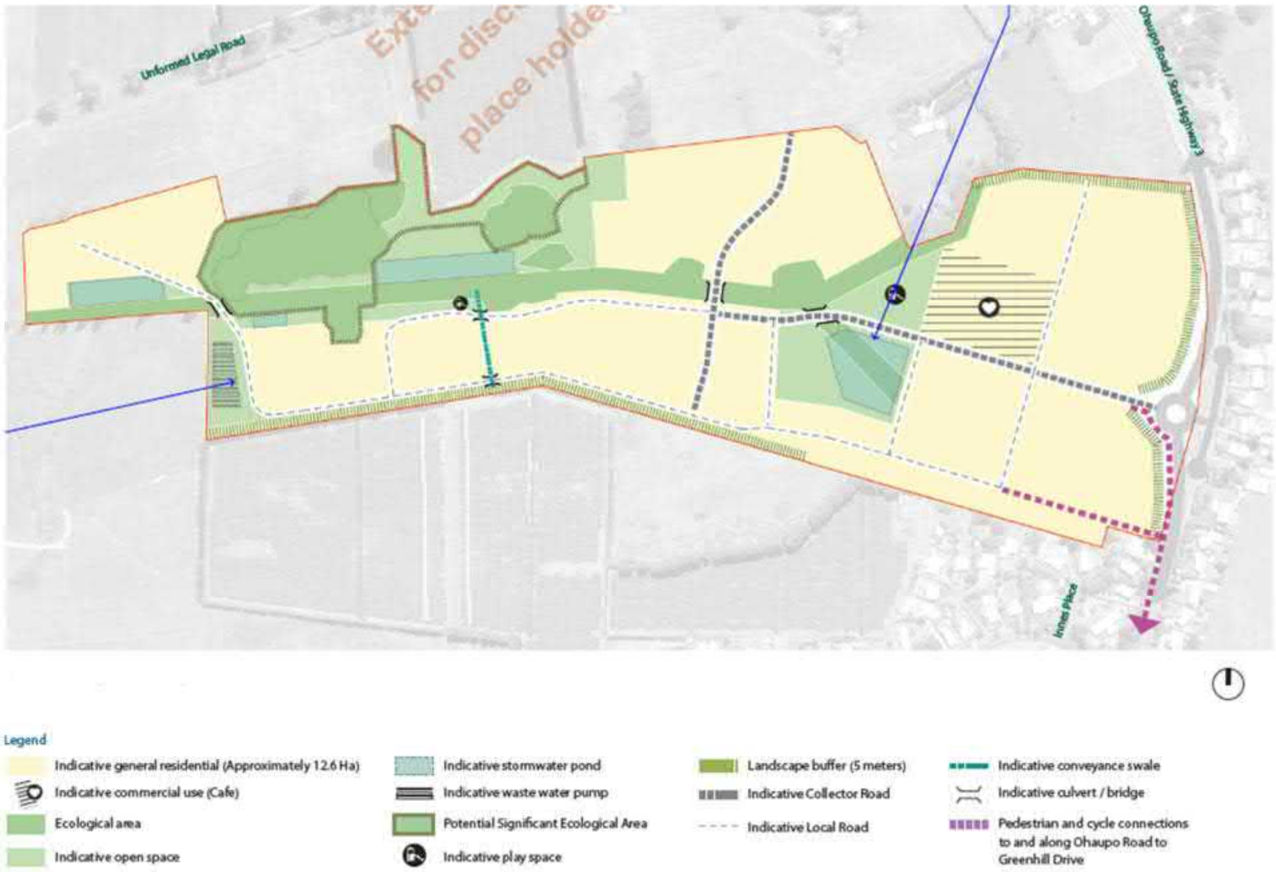


Figure 1.1: Proposed urban development plan[1]

The proposed development area is currently being used as farmland and is lightly vegetated with agricultural grasses and occasional mature trees as well as kahikatea forest remnants[2]. The site is located in an incised drainage channel that has been cut into the underlying 'Hamilton Hill'.

1.3 Previous reporting

BTW previously completed a preliminary three waters and geotechnical report[3] for the farm/property that the proposed development is situated within. Some elements of this previous report have been re-presented and expanded on within this Geotechnical Suitability Report.

---

[1] B&A urban and Environmental; 2022: Urban Design Statement, Ōhaupō Road Plan Change. Prepared for: Ultimate Developments. Dated: Draft – 5 October 2022. 32p.

[2] Waikato Regional Council; 2021: Forest Fragment Management Series; Kahikatea Forest Fragments: Managing a Waikato Icon. Fact Sheet 6. Updated July 2021. https://www.waikatoregion.govt.nz/assets/WRC/WRC-2019/Forest-Fragment-factsheet-6.pdf. Accessed 25/10/2022.

[3] BTW Company Ltd; 2021: Preliminary Three Waters and Geotechnical Assessment – 2025 Ōhaupō Road, Te Awamutu. Report compiled for Ultimate Holding Limited; BTW Report No.: 211365; Revision: A; Dated: 19/09/2021. 34p.

2 PUBLISHED GEOLOGY

Published geological information as shown on Kear and Schofield[4,](refer to Figure 5.1) indicates that the site sits on the surface of the Walton Subgroup on what is described in literature as a 'Hamilton Hill'[5 6]. The Hamilton Hills was mantled with volcanic ash showers which has been named the Hamilton Ash Formation[7]. It is likely that elements of the Kauroa Ash Formation[8] occur within the development area but these layers have been mapped as part of the Hamilton Ash Formation.

The geomorphology and causation of the current morphology is presented in Figure 2.1.

---

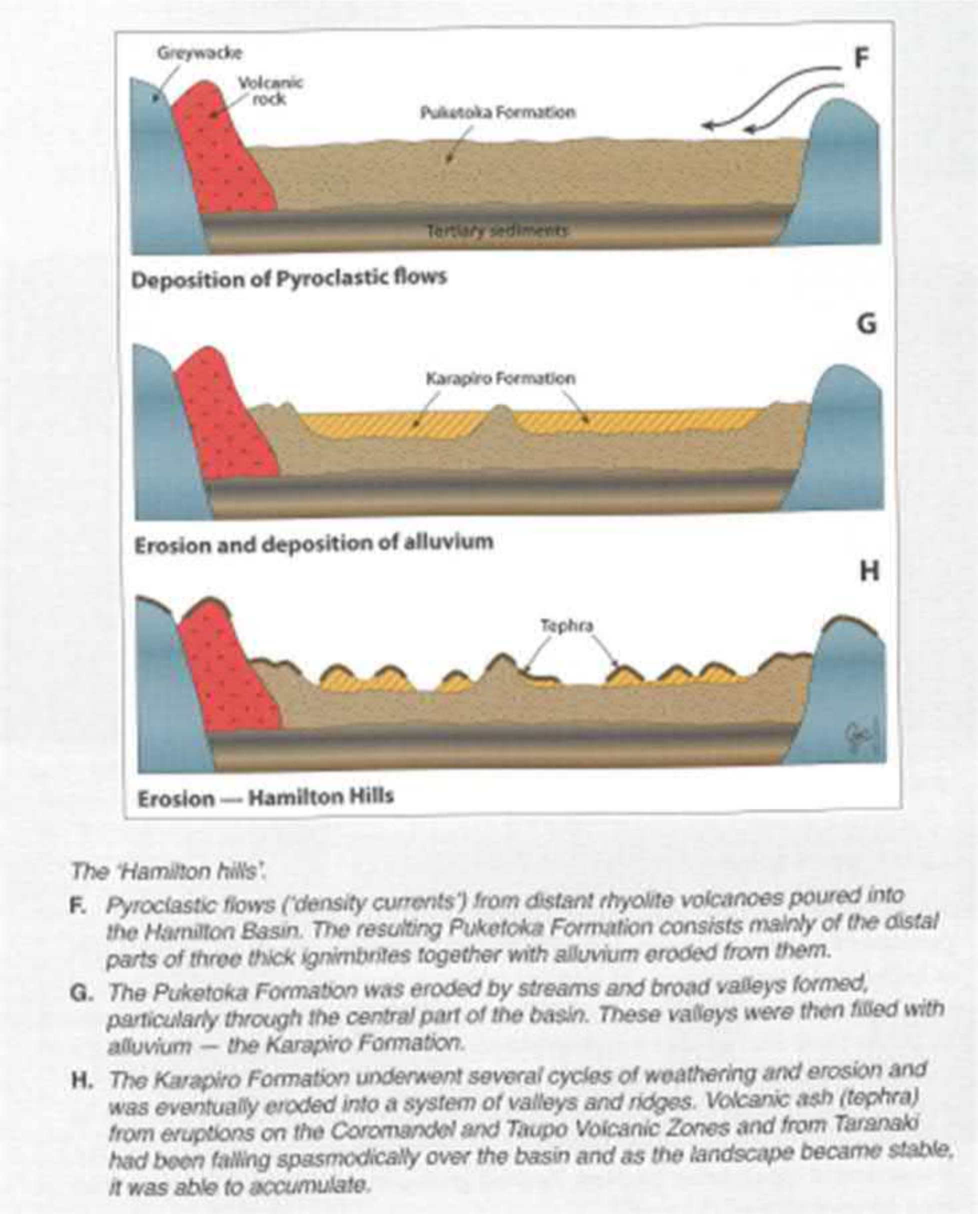
[4] Kear D; Schofield JC; 1976 (reprinted): Sheet N65 Hamilton (1st Edition1966) "Geological Map of New Zealand", 1:63,360. Department of Scientific and Industrial Research Wellington, New Zealand.

[5] McCraw JD;1967: The Surface Features and Soil Pattern of the Hamilton Basin. Earth Sciences Journal. 1:1, 59 – 74.

[6] McCraw J; 2011: The Wandering River, Landforms and geological history of the Hamilton Basin. Geosciences Society of New Zealand, Guidebook. 16p. Refer to pages 13 and 14.

[7] Ward WT; 1967: Volcanic ash beds of the lower Waikato basin, North Island, New Zealand, New Zealand Journal of Geology and Geophysics, 10:4, 1109-1135.

[8] Lowe DJ, Tippett JM; Kamp PPJ; Liddle IJ; Briggs RM; Horrocks JL; 2001: Ages on Weathered Plio-Pleistocene tephra sequences, western North Island, New Zealand. In Juvigne, ET; Raynal J-P (eds): *Tephra Chronology, Archaeology*, CDERAD editeur, Goudet. Les Dossier de l'Archeo-Logis 1:45-60.



The 'Hamilton hills'.

- **F.** *Pyroclastic flows ('density currents') from distant rhyolite volcanoes poured into the Hamilton Basin. The resulting Puketoka Formation consists mainly of the distal parts of three thick ignimbrites together with alluvium eroded from them.*
- **G.** *The Puketoka Formation was eroded by streams and broad valleys formed, particularly through the central part of the basin. These valleys were then filled with alluvium — the Karapiro Formation.*
- **H.** *The Karapiro Formation underwent several cycles of weathering and erosion and was eventually eroded into a system of valleys and ridges. Volcanic ash (tephra) from eruptions on the Coromandel and Taupo Volcanic Zones and from Taranaki had been falling spasmodically over the basin and as the landscape became stable, it was able to accumulate.*

Figure 2.1: Formation of the 'Hamilton Hills'[9]

Dates obtained on the Hamilton Ash Formation show that it was erupted between 380,000 to 180,000 years ago[10]. The eruptive sources are thought to have been within the Taupo Volcanic Zone (with potential from as many five or six different eruptive centres)[11]. The thickness of the sequence in the basin ranges from 0.5 to 1.5 m thick[12] but can be thicker depending on the geomorphology of the site[13].

---

[9] McCraw J; 2011. Refer to page 14.

[10] Lowe DJ, Tippett JM, Kamp PJJ, Liddell IJ, Briggs RM, Horrocks JL; 2001.

[11] Lowe et al. 2001.

[12] Selby MJ and Lowe DJ; 1992: The Middle Waikato Basin and Hills. In Soons JM and Selby MJ (editors); Landforms of New Zealand. Second Edition Longman Paul Limited. 531p.

[13] Selby and Lowe; 1992. Refer to page 239.

The Walton Subgroup comprises of Puketoka[14] and Karapiro[15] Formations, which consist of fluvial sediments comprising sand, silt, clay and weathered pumice gravel. The Walton Subgroup sediments were deposited between 1.2 million to 340 thousand years ago[16].

At the toe of hill, Hinuera Formation sediment has onlapped onto the toe of the 'Hamiton Hill' as it filled the Hamilton Basin. This sediment was deposited between (22,000 to 17,000 years ago)[17] due to changes in the climate and sediment supply, this sediment sequence comprises of course sands at the base and a finer sediments at the top. The sediment composition at the top of the sequence comprises of fine sand and silt which were deposited in a low energy river basin. The finer soil tends to be less well sorted, have lower densities and strength than those deposited during phase one.

2.1 Geomorphic Model

2.1.1 Interpreted Geological Units and Derived Soil Properties

The site comprises of a relatively simple geological model of three major units with several smaller localised units occurred in gully heads and in areas formed by alluvial processes.

2.1.2 Hamilton Ash Formation

The air fall tephra comprises of stiff to very stiff, clayey silt with varying degrees of clay and silt. The plasticity of the soils encountered are generally low. Groundwater is not expected in this unit however, it may be locally perched after periods of intense rainfall. This unit is approximately 5 m thick and likely includes elements of the Kauroa Ash Formation.

2.1.3 Walton Subgroup

Generally, the Karapiro Subgroup[18] generally comprise of a weathered residual soil. In general, this unit comprises of very stiff, silt with clay and or fine sand and weathered pumice gravel. The depth of this soil is on average 8 m thick based on site observations. Based on observations elsewhere in the Hamilton Basin the thickness of the Walton Subgroup could be up to 120 m thick[19].

2.1.4 Hinuera Formation

The Hinuera Formation occurs as a low-density sand soils over denser sand layers. This is typical of the soils deposited in the Hinuera Surface. Where this unit occurs within the development area it is up to 3.5 m thick. The thickness of the Hinuera Surface adjacent to the site is approximately 40 m thick[20].

---

[14] Kear D, Schofield JC; 1978: Geology of the Ngaruawahia Subdivision. Department of Scientific and Industrial Research, Wellington. New Zealand Geological Bulletin 88. Refer to page 100.

[15] Kear and Schofield; 1978. Refer to page 103.

[16] Selby and Lowe; 1992.

[17] Lowe DJ; 2010: Introduction to the landscapes and soils of the Hamilton Basin. In: Lowe DJ; Neall VE, Hedley M; Clothier B; Mackay A; 2010: Guidebook for Pre-conference North Island, New Zealand 'Volcanoes to Oceans' field tour (27-30 July). 19th World Soils Congress, International Union of Soil Sciences, Brisbane. Soil and Earth Sciences Occasional Publication No. 3, Massey University, Palmerston North, pp. 124 to161.

[18] Kear D, Schofield JC; 1978: Geology of the Ngaruawahia Subdivision. Department of Scientific and Industrial Research, Wellington. New Zealand Geological Bulletin 88. Refer to page 103.

[19] New Kear D, Schofield JC; and Kermode LO; 1964: Geological Map of New Zealand 1:25,000. Sheet N65/2 Hamilton (1st Ed). Department of Scientific and Industrial Research Wellington. 1 Sheet.

[20] Lowe DJ: 2010; Introduction to the landscapes and soils of the Hamilton Basin. In: Lowe DJ, Neall VE, Hedley M, Clothier B, Mackay A: 2010; Guidebook for Pre-conference North Island, New Zealand „Volcanoes to Oceans" field

2.1.5 *Other Soils*

Low density colluvium can be found at the toe of the slopes and in the gullies away from water sources. In the stream channels low density alluvium can be found. The thickness of these soils is expected to be up to 4 m thick.

An area to infilled gullies was indicated to BTW field staff who undertook a series of Inspection Pits (IP 1 to 12). These site investigations failed to find any fill soils. However, historic farm filling may occur elsewhere across the property.

2.2 Ground model

The site has been assessed by breaking it into landforms as defined by the dominant slope class and then by assessing the geology.

2.2.1 *Slope Classes*

In order to assess the suitability of the proposed development, the morphology of the land (gradient) was assessed with a focus on developable area for residential dwellings. The slope class by which the site has been assessed is presented in Table 2.1.

Table 2.1: Slope class, landscape units and the physical occurrence of the landscape unit (adapted from Milne et al.[21])

Landscape Unit	Gradient (°)	Description
Near level to gently undulating	0 to 3	Smooth or even surface with a slight gradient
Undulating land	4 to 7	Gentle rolling landscape with significant areas of near level to gently undulating elements
Rolling land	8 to 15	Rolling landscape with areas of near level to gently undulating elements
Hilly Land	16 to 25	Landscape of hills with rolling land on the flanks or margins
Steep Land	>25	Landscape of hills and or mountains

2.3 Landforms based on slope classes

The development area has been broken into its landform elements, presented in Figure 2.2. Note, these landforms are based on an approximate cell size of 5 m square.

---

tour (27-30 July). 19th World Soils Congress, International Union of Soil Sciences, Brisbane. Soil and Earth Sciences Occasional Publication No. 3, Massey University, Palmerston North.124-161 p. Refer to page 7.

[21] Milne JD, Clayden B, Singleton PL, Wilson AD, 1995. Soil Description Handbook, Revised Edition. Manaaki Whenua Press, Landcare Research, Lincoln, Canterbury, New Zealand. 157p.

Figure 2.2: Assessed landforms within the development area

The proposed development can be subdivided into four landform units as shown in Table 2.2. The elements are presented in full size in Appendix C.

Table 2.2: Landscape units within the proposed subdivision

Landscape Unit	Total (%)
Near level to gently undulating	19
Undulating land	42
Rolling land	35
Hilly land	3
Steep land	1
Total	**100**

The site is general dominated by rolling land or undulating land. It is important to note that the lower landform units incorporate elements of the units that precede them i.e. a rolling land unit will incorporate undulating and near level ground within its elements. So, the expected slope gradients in that landscape unit would range from 0 to 15°.

Steeper land is generally in the Hilly landform element and these slopes have been formed through the meandering of the unnamed stream, eroding against the northern flanks of the stream channel, producing overly steeped slopes with angles that are not typical of Hamilton Ash Formation /Walton Subgroup soils. These over steepened slopes also occur at the head of the gullies (possibly spring sap). Some of the steep land along the southern boundary is less likely to be related to observable fluvial process and could be a relic feature attribute to a landscape and land forming process which has since been eroded away/ceased to be active.

3 GEOTECHNICAL INVESTIGAITON

3.1 Site Testing

Geotechnical testing was undertaken over a period in late winter and early spring (July to September 2022) by BTW. Cone Penetrometer Testing (CPT) was undertaken by subconsultant, Topdrill, in late June 2022.

The BTW field investigation comprised a walkover assessment, the drilling of twenty-nine (29) hand auger boreholes, with in-situ shear vane testing and dynamic cone penetrometer tests. Twelve (12) inspection bore holes were made looking for an in-filled gully and comprised of boreholes only. Six (6) double ring infiltration tests and falling head soakage tests were undertaken in various landform elements. The Topdrill field investigation comprised ten (10) Cone Penetrometer Tests (CPTs).

Testing coverage and density in general accordance with MBIE (2017)[22]. The approximate test locations are presented below in Figure 3.1. The results from the geotechnical field investigation are attached in Appendix A.

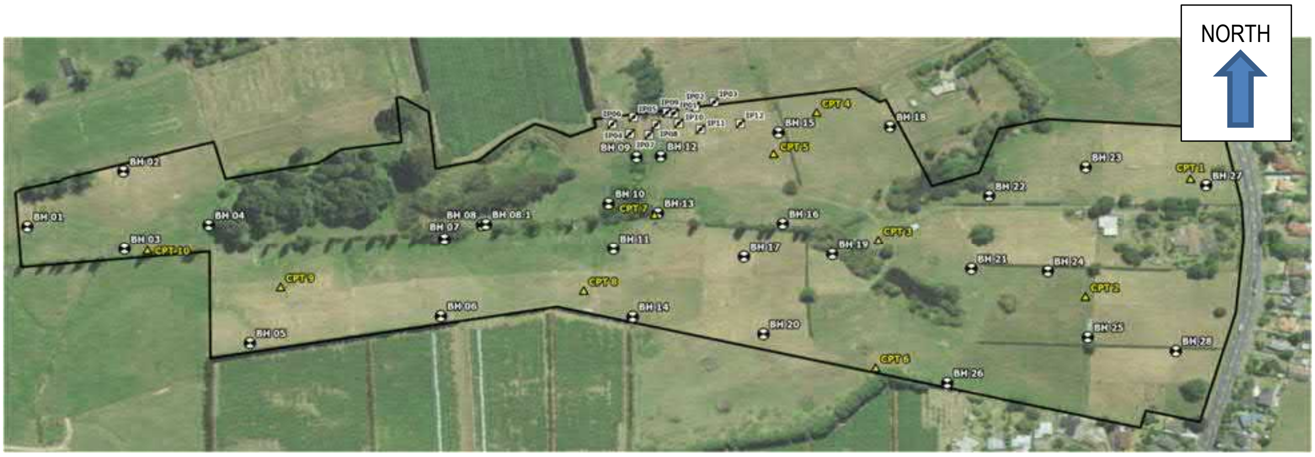


Figure 3.1: Geotechnical testing location plan

A summary of the field investigation activities undertaken by BTW is presented in the following sections below.

3.1.1 Testing Procedures

In-situ testing shear vane testing was carried out within the hand auger boreholes. Shear vane testing was generally performed at intervals of 0.2 m within the boreholes and undertaken in accordance with the procedures outlined by the New Zealand Geotechnical Society (NZGS)[23].

Ground conditions exposed within the hand auger boreholes were logged in accordance with the Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes[24].

---

[22] Ministry of Business Innovation and Employment. 2017: Planning and engineering guidance for potentially liquefaction-prone land. Revision 0.1; Issue Date: September 2017.134p.

[23] New Zealand Geotechnical Society; 2001: Guideline for Handheld Shear Vane Test, August 2001. 11p.

[24] New Zealand Geotechnical Society; 2005: Field description of soil and rock – guideline for the field classification and description of soil and rock for engineering purposes. December 2005. 38p.

Dynamic cone penetrometer testing was conducted at the location of the auger boreholes. Testing was undertaken in accordance with NZS 4402:1988[25].

3.2 Hand Auger Boreholes

A total of twenty-nine (29) hand auger boreholes were completed (excluding stormwater soakage tests) by BTW during the site investigations extending to depths of between approximately 1.5 m and 2.0 m below existing ground level (BEGL). Target depths of 2.0 m BEGL were achieved for most hand auger boreholes. The primary intention of the hand auger boreholes was to provide information on the consistency of the in-situ soils.

A summary of BTW's subsurface hand auger borehole investigation is presented in Table 3.1, and the test locations are presented in Figure 3.1.

---

[25] Standards New Zealand; 1988: NZS 4402 - Test 6.5.2:1988: Determination of the Penetration Resistance of a Soil, Hand method using a dynamic cone penetrometer.

Table 3.1: A summary of the BTW subsurface hand auger borehole investigations

Auger ID	Date of Test	NZTM[26]		Termination Depth (m, BEGL)
		Easting (m)	Northing (m)	
1	22/7/2022	1803422	5792704	2.0
2		1803510	5792765	
3		1803509	5792677	
4		1803585	5792702	
5		1803619	5792567	
6	12/08/2022	1803792	5792593	
7	3/08/2022	1803797	5792680	
8		1803832	5792696	
8.1		1803835	5792697	0.6
9		1803973	5792770	2.0
10		1803947	5792717	
11		1803949	5792666	1.6
12	24/08/2022	1803995	5792770	2.0
13	3/08/2022	1803991	5792705	
14	12/08/2022	1803965	5792588	
15	24/08/2022	1804102	5792795	
16	3/08/2022	1804103	5792691	
17	12/08/2022	1804067	5792653	
18		1804202	5792799	
19		1804147	5792655	
20		1804082	5792565	
21	24/08/2022	1804271	5792635	
22		1804289	5792718	
23		1804377	5792748	
24		1804340	5792630	
25		1804374	5792554	
26		1804246	5792506	1.4
27		1804485	5792725	2.0
28		1804453	5792537	

3.3 Scala Penetrometer Testing

A total of twenty-nine dynamic cone tests were completed by BTW, extending to depths of between 1.6 m and 2.4 m BEGL. The primary intention of the dynamic cone tests was to provide information on the in-situ soil strengths and for and CBR correlation.

---

[26] Easting, Northing from handheld GPS. GPS accuracy + / - 7.5 m.

A summary of BTW's subsurface dynamic cone penetrometer investigation is presented in Table 3.2, and the test locations are presented in Figure 3.1.

Table 3.2: A summary of the BTW subsurface Scala penetrometer investigations

Auger ID	Termination Depth (m, BEGL)	Termination Reason
1	2.0	Target depth achieved
2		
3	3.0	Firm soils encountered
4		
5	2.0	Target depth achieved
6		
7		
8		
8.1	N/A	N/A
9	2.0	Target depth achieved
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22	2.1	Firm soils encountered
23	2.0	Target depth achieved
24		
25		
26		
27		
28		

3.4 Cone Penetrometer Testing

Cone Penetrometer Testing (CPT) was carried by subconsultant, Topdrill on 28 and 29 June 2022. The purpose of the CPT tests was to identify the soil sequence which underlies the property. The CPT test locations are shown in Figure 3.1. The CPT tests had a target design depth of 20 m BEGL.

The penetration depths into the underlying soil from the CPT tests are presented in Table 3.3

Table 3.3: CPT Penetration depth into underlying soil (depth to refusal)

CPT ID	NZTM[27]		Penetration Depth (m BEGL)	CPT Termination Reason
	Easting	Northing		
1	1804472	5792734	20.1	Target Depth Achieved
2	1804374	5792602		
3	1804189	5792671		
4	1804137	1804137		
5	1804097	5792772		
6	1804183	5792526		
7	1803988	5792705		
8	1803922	5792620		
9	1803649	5792631		
10	1803530	5792676	8.3	Anchors pulled out

3.5 Soakage Testing

A total of six (6) falling head and six (6) twin ring soakage tests were completed during the site investigation. These tests were completed to determine the suitability of the existing soils for on-site soakage of stormwater (falling head) and soil permeability class[28]. The location and type of the soakage tests completed are presented in Table 3.4 below.

---

[27] Easting, Northing from handheld GPS. GPS accuracy + / - 7.5 m.

[28] Waikato Regional Council; 2020; Waikato Stormwater Runoff Modelling Guideline, Updated Version May 2020. Waikato regional Council Technical Report 2020/06. 88p. Document #: 16213155.

Table 3.4: A summary of the BTW subsurface Soakage Tests

Test Date	Test Location	Type	NZTM[29]	
			Easting	Northing
07/09/2022	**1**	Twin Ring	1804472	5792734
31/08/2022		Falling Head		
07/09/2022	**2**	Twin Ring	1804283	5792651
		Falling Head		
31/08/2022	**3**	Twin Ring	1804189	5792671
		Falling Head		
07/09/2022	**5**	Twin Ring	1804104	5792496
		Falling Head		
07/09/2022	**7**	Twin Ring	1814671	5796382
		Falling Head		
31/08/2022	**10**	Twin Ring	1803530	5792676
		Falling Head		

3.6 Groundwater

In general, groundwater was not encountered across the proposed development area with the exception of in low lying areas (at the toe of the slope adjacent to the drain) and elsewhere as perched groundwater.

The elevated nature of the site along with the fine grained, multi layered nature of the soils means that the soils encountered are unlikely to hold significant volumes of groundwater across the site in the elevated areas. The rolling nature of the elevated areas next to steeply incised gullies means that a hydraulic gradient will always exist for the water to drain away.

On the alluvial flats within the gully bases, adjacent to flowing streams, it is likely that a water level similar to that encountered within the drain will occur. It is expected that as the alluvial areas extend away from the stream that the groundwater level will occur at increasing depth.

Within the gully bases, after extended periods of rain, groundwater may be either locally elevated for short periods while it drains through the less pervious subsoil layers or be locally perched along the base of the gully. A plan of the boreholes with groundwater in them is presented in Figure 3.2.

---

[29] Easting, Northing from handheld GPS. GPS accuracy + / - 7.5 m.

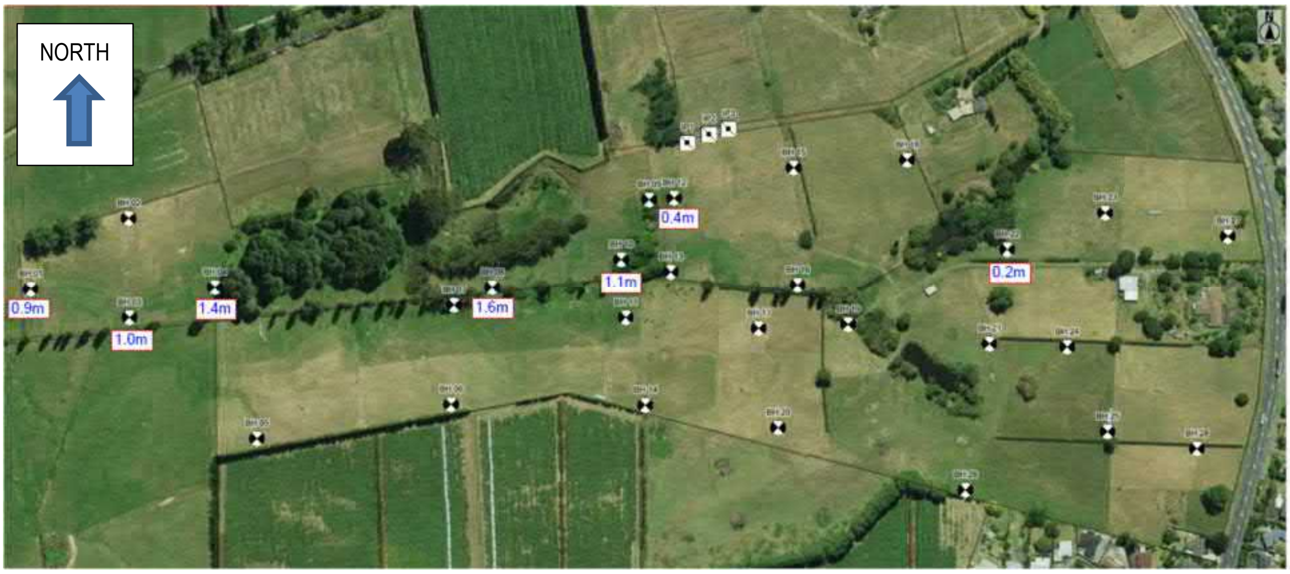


Figure 3.2: Measured Groundwater levels at the boreholes

4 GEOHAZARD REVIEW

4.1 Flood Hazard

Waikato Regional Council flood modelling[30] has identified that during a 1 in 100-year event, the property is not affected by flooding.

Figure 4.1: Extent of flooding with the development area during a 1 in 100-year flood.

A stormwater master plan assessing site stormwater solutions for the proposed residential development in detail has also been completed[31].

4.2 Slope Stability

The site was investigated for various types of soil erosion, comprising of either active or historic land movements. The site was examined, and no obvious active or historic rotational slip or slumps were observed within the development area.

Smaller scale land movement in the form of rills, creep, sheet erosion etc. was also not observed or occurred over very small areas and was not considered to be a problem.

In general, the slopes were considered to be in a state of stability in the sites current land use. However, during earthworks the soils have the possibility to be easily transported by wind or water action and suitable erosion control methods will need to be carefully used to prevent the mobilisation of the soil.

---

[30] Waikato Regional Hazards Portal – River Flooding; n.d.: https://waikatoregion.maps.arcgis.com/apps/MapSeries/index.html?appid=f2b48398f93146e8a5cf0aa3fddce92c. Accessed 22/09/2022.

[31] BTW Company Limited; 2022: Ohaupo Road: Stormwater Masterplanning Assessment; Rev 1.

4.3 Overland Flow Paths

The overland flow paths within the development area are confined to the gully bases. The site is currently made up of many small, localised catchments with a limited ability to generate large, concentrated flows of stormwater in any sort of storm event other than a localised intense rain event. The absence of erosion features in the base of the flow paths such as rills would tend to confirm this theory.

Site-specific flood assessment, stormwater design, and earthworks design will be needed in future design phases to confirm the suitability of this proposed residential development Lots to be situated on flood free building platforms.

4.4 Soil Sensitivity

Sensitivity testing, as presented in soil logs, has identified the in-situ near surface soils are not sensitive to disturbance. It is inferred that these soils are not of the type to undergo catastrophic failure due to development disturbance.

However, the soils will likely require careful management if they are to be used as site won fill, as the repeated working of this material will reduce the fill strength.

4.5 Liquefaction and Fault lines

4.5.1 Liquefaction

The WRC Hazard Portal[32] shows that the site has been classified as liquefaction hazard is ‘unlikely’ or ‘has not been determined’.

4.5.2 Fault Lines

The GNS Active Faults Database[33] shows the closest fault is portions of the Kerepehi Fault, which is located approximately 40 kilometres to the northeast of the development area. The slip rate on this fault is recorded as low.

---

[32] Waikato Regional Hazards Portal - Earthquake and landslides: n.d.; https://waikatoregion.maps.arcgis.com/apps/MapSeries/index.html?appid=f2b48398f93146e8a5cf0aa3fddce92c. Accessed 22/09/2022.

[33] GNS New Zealand Active Faults Database: 20 October 2020; https://data.gns.cri.nz/af/ Accessed 22/09/2022.

5 HYDROLOGICAL SOILS GROUPS

The soils at this site have been classified against the information presented in Waikato Regional Technical Report 2020/06[34] with the soils and site classified against Miline et al.[35] and slope form from Hall and Olson[36].

5.1 Site Description

The site is located on a west facing 'Hamilton Hill'[37] that has been fluvially dissected to from a dendritic drainage pattern. The site is generally comprised of undulating land and rolling land with extensive areas of near level ground occurring across the site and as smaller distributions within the areas of steep land (refer to Section 2.1.1 and Figure 2.2).

The site is currently covered in Grassland[38] within a beef cattle pastoral farming system with the grass cover in the paddocks being covered by approximately 75%. Tree cover is irregular, with a forest remnant comprising of approximately 1 hectare of kahikatea forest. Elsewhere, non-native tree species are concentrated along the stream channel and around the heads of the manmade ponds.

5.2 Geology

Site testing comprising of shallow hand tests (maximum 2.0 m deep) and Cone Penetrometer Tests (CPT) to a depth of 20 m Below Existing Ground Level (BEGL) show that the site is underlain by a sequence of Hamilton Ash Formation overlying the Walton Subgroup sequence (Karapiro and Puketoka Formations). Hinuera Formation soils have onlapped into the toe of the Hamilton Hill. At discrete locations across the site (generally confined to the stream channel) colluvium and or alluvium have been deposited. Steep sided have been formed by the meandering stream as it has flowed up against the northern side of the gully system.

In general, the Hamilton Ash formation soils cover approximately 90% surface of the site to a minimum depth of 2 m. The western end of the site is dominated by Hinuera Formation sediments. A published geological map of the area of investigation is presented in Figure 5.1.

---

[34] Waikato Regional Council; 2020; Waikato Stormwater Runoff Modelling Guideline, Updated Version May 2020. Waikato regional Council Technical Report 2020/06. 88p. Document #: 16213155.

[35] Milne JD, Clayden B, Singleton PL, Wilson AD, 1995. Soil Description Handbook, Revised Edition. Manaaki Whenua Press, Landcare Research, Lincoln, Canterbury, New Zealand. 157p.

[36] Hall GF, Olson CG; 1991: Predicting variability of soils and landforms. SSA special publication 28: 9 - 24.

[37] McCraw J; 2011: The Wandering River, Landforms and geological history of the Hamilton Basin. Geosciences Society of New Zealand, Guidebook. 16p. Refer to pages 13 and 14.

[38] Milne JD, Clayden B, Singleton PL, Wilson AD, 1995. Refer to page 29.

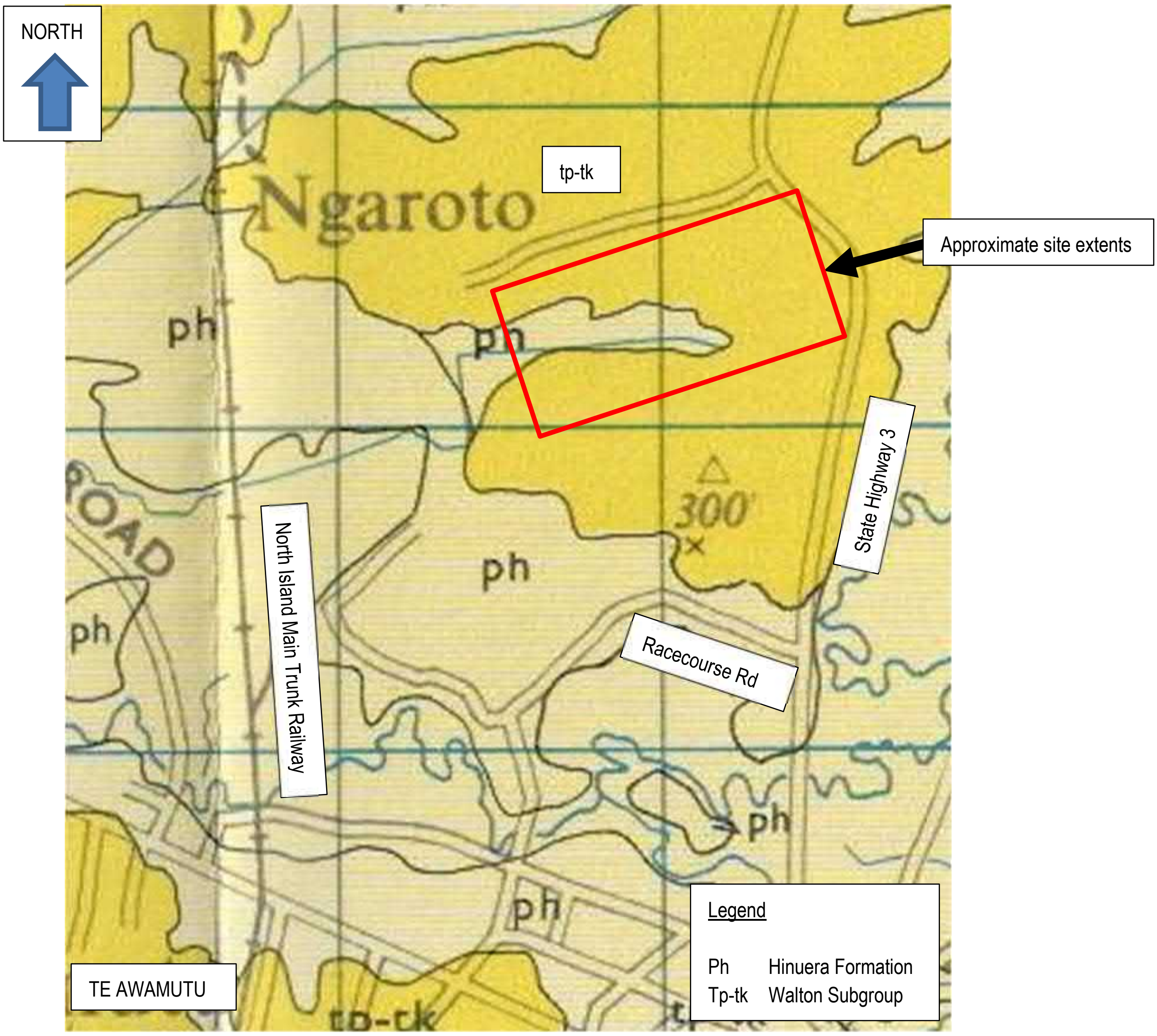


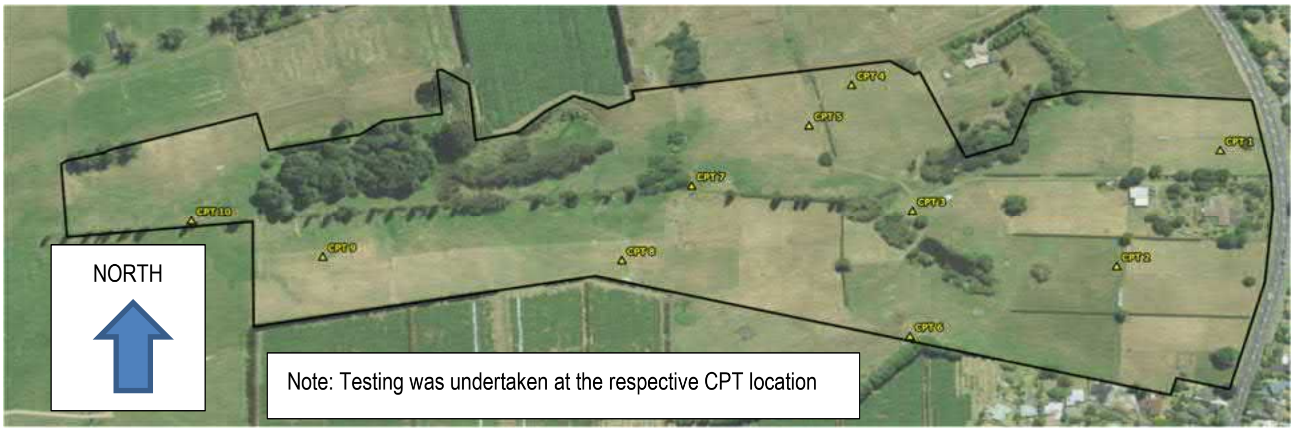
Figure 5.1: Published Geological map[39]

5.3 Hydrological Soil Classification

Six (six) locations across the site were selected as representative sites based on the position on landscape position, slope morphology and geology. These test locations are presented in Figure 5.2. The hillslope elements, landscape unit and geology are summarised in Table 5.1.

---

[39] Kear D; Schofield JC; 1966: Sheet N65 Hamilton (1st Edition1965 – Reprinted 1976) Geological Map of New Zealand, 1:63,360. Department of Scientific and Industrial Research Wellington, New Zealand.



Note: Testing was undertaken at the respective CPT location

Figure 5.2: CPT Test locations

Table 5.1: Hillslope elements, landscape unit and geology at each test location

CPT		1	2	3	5	7	10
Receiving Soil	Colluvium	-	-	Yes	-	-	-
	Organic soil	-	-	-	-	-	Yes
	Hinuera Formation	-	-	-	-	Yes	-
	Hamilton Ash Formation	Yes	Yes	-	Yes	-	-
GW (m BEGL)		Not Encountered			5	20	0.7
Landscape Unit [40]		Undulating Land			Rolling Land	Undulating Land	
Hill slope elements[41]		Summit	Back Slope	Toe Slope	Foot Slope	Toe Slope	

5.3.1 Testing Methods

In order to assess the saturated conductivity of the soils twin ring infiltration testes were undertaken at each test location. The testing methodology is presented below:

The test comprised of 1 x 150 mm Ø by 150 mm long and 300 mm Ø by 200 mm long stainless-steel rings. The test was conducted using the following procedure:

- The 150 mm Ø ring was embedded to a depth of 80 mm into the receiving soil. The ring was checked with a level to ensure it was horizontal.
- The 300 mm Ø ring was placed around the inner ring and imbedded 145 mm into the soil and checked with a level to ensure it was horizontal.
- All loose vegetation was removed, and the inner ring was filled with water to the top of the ring and the outer ring was also filled.
- Readings were taken at 1, 2, 5 and 10 minute intervals, where the depth of the water that had soaked away for the interval was recorded and the inner ring was then filled to the top. The outer ring was topped up as required but was always kept below the level of the inner ring.

---

[40] Modified from Miline et al. refer to Table 2.1.

[41] Hall GF, Olson CG; 1991. Refer to Figure 2-1.

- Once the results achieved a constant soakage rate the test was conducted for an additional 15 minutes or longer if necessary.
- At the conclusion of the testing a 50 mm Ø hand auger boring was undertaken to a depth of 1.0 metre BEGL and the soil logged to the methods prescribed by Miline et al.[42].
- The pedality of the soil was also assessed[43]. The purpose of this assessment was made so that so a soil could be moved between the hydrological soil groups if the measured Ksat exceeded its assigned value range based on soil texture[44]. These results are presented in Table 5.2.

Table 5.2: Assessment of Soil Pedality.

Test Location	Pedality	Aggregated
1	Weak to moderate pedality	Yes
2		
3	-	-
4	Moderate pedality	Yes
5		
6		

5.3.2 *Soakage Results*

The results from the field testing are presented in Appendix A.3 The results were assessed against Table 5-3[45] which has been converted to mm/hr and is presented in Table 5.3. The results are presented in Table 5.3.

Table 5.3: Twin Ring Soakage Results

Test Location	Depth (m) to water impermeable layer [46]	Depth (m) to high water table	K_{sat} (mm/hr)	Soil Texture	Hydrological Soil Group
1	>1	>1	60	Loamy silt	B
2			60	Silt loam	B
3			36		C
4			108	Loamy silt	B
5			60	Silt loam	B
6		0.7	48		B

---

[42] Milne JD, Clayden B, Singleton PL, Wilson AD, 1995. Refer to Figure 5.

[43] Milne JD, Clayden B, Singleton PL, Wilson AD, 1995. Refer to pages 58 to 61.

[44] Waikato Regional Council; 2020. Refer to Section 5.3.

[45] Waikato Regional Council; 2020.

[46] Hewitt AE; 1998: New Zealand Soil Classification (Second Edition). Landacre Research Science Series No.1. 133p. The soil terms presented in Table 5-3, Footnote 1 in WRC 2020/06, has been classified against Diagnostic Horizons and other Differentiae, pages 15 to 34.

6 LIQUEFACTION ANALYSIS

A liquefaction assessment within the proposed development area has been undertaken, using Cone Penetration Tests (CPT) which were undertaken by subconsultants, Topdill, on 28 and 29th June 2022 with a target depth of 20.0 m.

The CPT data has been interpreted in accordance with the MBIE[47] (2021). The raw CPT data was processed using GeoLogismiki Cliq V3.0.3.2 and a directory of these outputs can be found in Table 6.2 and full results in Appendix B.

The ten (10) CPT tests targeted various geological and morphological features which are summarised in Table 6.1. The location of the tests are shown previously in Figure 5.2.

Table 6.1: Locations of CPT testing within the site morphology

CPT ID	Soils	Hill Element[48]	Landform Unit	Slope gradient (degrees) at CPT location	Geomorphology
1	HAF/WSG	Summit	Undulating land	3 - 7	Hamilton Hill
2		Backslope			
3	Colluvium over HAF/WSG	Toeslope		0 - 3	Hamilton Hill toe/head of gully
4	HAF/WSG	Summit	Rolling land	7 - 15	Hamilton Hill
5		Shoulder			
6		Summit	Undulating land	0 - 3	
7	Colluvium over HF/WSG	Toeslope			Hamilton Hill gully
8	HAF/WSG	Summit	Rolling land	3 - 7	Hamilton Hill
9		Shoulder			
10	HF over WSG	Toeslope		0 - 3	Alluvial plain

Hamilton Ash Formation/Walton Subgroup = HAF/WSG
Hinuera Formation = HF

6.1.1 *Earthquake Design Parameters*

In accordance with MBIE 2017[49], an analysis of the liquefaction risk and differential settlement that the proposed development may be subject to.

The following information is provided in Table 6.2 (below), are the parameters used in the CPT analysis software to determine the various liquefaction parameters.

---

[47] Ministry of Business, Innovation and Employment; 2021: Earthquake geotechnical engineering practice, Module 1. overview of the guidelines. 47p. Appendix A. Table A1: Peak Ground Acceleration and Earthquake magnitude values recommended for Geotechnical Assessment for site classes A., B, C, D and E for level ground conditions, pages 36 – 34.

[48] Hall GF, Olson CG; 1991.

[49] Ministry of Business, Innovation and Employment; 2017: Planning and engineering guidance for potentially liquefaction-prone land. Resource Management Act and Building Act aspects. Ministry of Business, Innovation and Employment, Building System Performance Branch, Wellington. 134p.

Table 6.2: Earthquake design parameters for the proposed Growth Cell One

Site seismic classification:	**Class D**[50] (shallow soil sites)
Structure importance level:	**Level 2** (Normal structures)
Peak ground acceleration: **α_{max}(g)**	1 in 25-year event: **0.06g**
	1 in 500-year event: **0.25g**
	1 in 1,000-year event: **0.32g**
Earthquake Magnitude	**5.9**
Groundwater Depth:	CPT 1; As-measured: collapsed dry @ 5.0 m BEGL; **EQ Design: 4.0 m BEGL** CPT 2; As-measured: collapsed dry @ 3.0 m BEGL; **EQ Design: 2.0 m BEGL** CPT 3; As-measured: collapsed dry @ 2.0 m BEGL; **EQ Design: 1.0 m BEGL** CPT 4; As-measured: @ 9.5 m BEGL; **EQ Design: 8.5 m BEGL** CPT 5; As-measured: @ 5.0 m BEGL; **EQ Design: 4.0 m BEGL** CPT 6; As-measured: collapsed dry @ 2.0 m BEGL; **EQ Design: 2.0 m BEGL** CPT 7; As-measured: @ 20.1 m BEGL; **EQ Design: 19.0 m BEGL** CPT 8; As-measured: @ 3.5 m BEGL; **EQ Design: 2.5 m BEGL** CPT 9; As-measured: @ 2.1 m BEGL; **EQ Design: 1.0 m BEGL** CPT 10; As-measured: @ 0.9 m BEGL; **EQ Design: 0.5 m BEGL**
Depth of CPT testing:	CPT 1: 20.1 m BEGL CPT 2: 20.1 m BEGL CPT 3: 20.1 m BEGL CPT 4: 20.1 m BEGL CPT 5: 20.1 m BEGL CPT 6: 20.1 m BEGL CPT 7: 20.1 m BEGL CPT 8: 20.1 m BEGL CPT 9: 20.1 m BEGL CPT 10: 8.3 m BEGL

6.2 Settlement

In accordance with MBIE 2017[51] the proposed earthquake return periods for a damage causing earthquake has been analysed and are presented in Table 6.3 and Table 6.4 (1 in 500 and 1 in 1,000 year events). The 1 in 25 year events were analysed but the results in most cases were zero and the two exceptions generated results of the Liquefaction Potential Index (LPI) were less than 1. Therefore, it can be concluded that the site will not be at risk of liquefaction or lateral spread in the 1 in 25-year event.

---

[50] Jeong S. Wotherspoon LM; 2019: Development of a Waikato Basin T0 and depth model by the H/V spectral ratio method. 2019 Pacific Conference on Earthquake Engineering and Annual NZSEE Conference. Paper 301. 9p.

[51] Ministry of Business, Innovation and Employment; 2017. Section 3.

Table 6.3: Liquefaction and settlement for top 10 m of the soil profile in 1 in 500-year event (0.25g).

CPT ID	**Assumed Groundwater** (m BEGL)	**LPI**	**LPI – Risk**	**LSN**	**LSN – Damage**	**Total settlement** (mm)	**Differential Settlement** (Range – mm)	**Degree of liquefaction induced Ground Damage Expected**
1	4.0	1	Low	4	Little to none	32	0 to 28 Typically: 20	Mild
2	2.0	3		5		42		
3	1.0	2		8		32		
4	8.5	2		1		10		
5	4.0	1		3		25		Insignificant
6	2.0	1		3		16		
7	19.0	0		0		0		None
8	2.5	2		6		41		Mild
9	1.0	1		14	Minor	37		Moderate
10	0.5	4		12		42		

Table 6.4: Liquefaction and settlement for entire soil profile in 1 in 1,000-year event (0.32g).

CPT ID	**Assumed Groundwater** (m BEGL)	**LPI**	**LPI – Risk**	**LSN**	**LSN – Damage**	**Total settlement** (mm)	**Differential Settlement** (Range – mm)	**Degree of liquefaction induced Ground Damage Expected**
1	4.0	1	Low	5	Little to none	41	0 to 33 Typically: 25	Mild
2	2.0	4		6		44		
3	1.0	3		11	Minor	47		Moderate
4	8.5	3		1	Little to none	10		Mild
5	4.0	2		5		37		
6	2.0	1		4		26		
7	19.0	0		0		0		None
8	2.5	3		7		47		Mild
9	1.0	2		16	Minor	46		Moderate
10	0.5	4		15		50		

Discussion of results

In the 1 in 25 year liquefaction analysis, damage and surface expression is expected to be little to none (refer to Appendix A[52] for pictorial representation of the damage classes).

The assumed groundwater level is much higher than what was observed in site. The fine grained low permeable nature of the soils encountered means that true groundwater is unlikely to occur in the fine-grained soils of the Hamilton Ash Formation/Walton Subgroup soils. The absence of groundwater in the Hamilton Ash Formation/Walton Subgroup soils was demonstrated at CPT 7 where groundwater was identified at 19.0 m below existing ground level. Elsewhere, perched water

---

[52] Ministry of Business, Innovation and Employment; 2017. Pages 72 to 87.

was recorded. The soil profile (refer to Section 10.3.1) tends to encourage rapid run off with isolated pockets of perched water developing.

True groundwater for the site is delineated by result at CPT 7, this site occurring at the base of a Hamilton Hill which resulted in no groundwater being identified at the base of this test. True groundwater would have been identified in CPT 10, which occurs in the predominantly sandy soils of the Hinuera Formation soils of the alluvial plan and occurs at a depth of 0.7 m. Soils of the Hamilton Hills should be considered to have a low permeability with the majority of the rainwater falling on them running off as sheet flow with little infiltrating into the soil profile.

If we consider modelled scenarios as correct (i.e. worst case) then in the case of most of the Hamilton hill elements of the site (CPTs 1, 2 4, 5, 6 and 8) to be at very low risk (and in reality with a non-existent water table) to have essentially no risk of liquefaction damage.

CPT 9 was tested on a Hamilton Hill but exhibits higher risk of liquefaction damage. This could be explained by the sometimes-variable mineralogy and density of the Walton Subgroup soils especially that of the basal member the Puketoka Formation. The modelling assumed a groundwater level in an earthquake of 1 m BEGL, which is unlikely, so again overstates the hazard.

CPT 3 is representative of soils based adjacent to the farm ponds and formed on the toe slope next to water. This site has a slightly elevated risk of liquefaction within the more recent soils.

The soils at CPT 10 show that the soils of the alluvial plain are extremely sensitive to the effects of liquefaction damage. The groundwater is expected to be continuous throughout the profile (saturated) and the soils (alluvial sand and silt) is easily transported by fluids moving up through the profile. Development within this area is likely to be a risk from some liquefaction damage.

6.3 Subdivisions Liquefaction Vulnerability Category

On the basis of the CPT testing within this subdivision and the shallow hand testing methods, the subdivision liquefaction vulnerability category has been measured against Table 4.4[53].

While the testing has been extensive - it has not been exhaustive - and therefore it is not possible to give a precise classification of the risk. However, the risk can be quantified based on the geomorphology.

Based on the information contained in in Table 6.4 for a 'Hamilton Hill' that liquefaction damage is unlikely. For the Hamilton Hill toe/head of gully environs, that liquefaction damage is possible. For the soils of the alluvial plain liquefaction damage is possible and is the most liquefaction prone part of the site.

Low risk of liquefaction induced ground damage generally categorised as TC1 site except at areas within the influence of CPT 3, 9 and 10, where TC2 foundation is recommended as shown in Figure 6.1, unless additional tests are conducted for further detailed liquefaction analysis.

---

[53] Ministry of Business, Innovation and Employment; 2017.

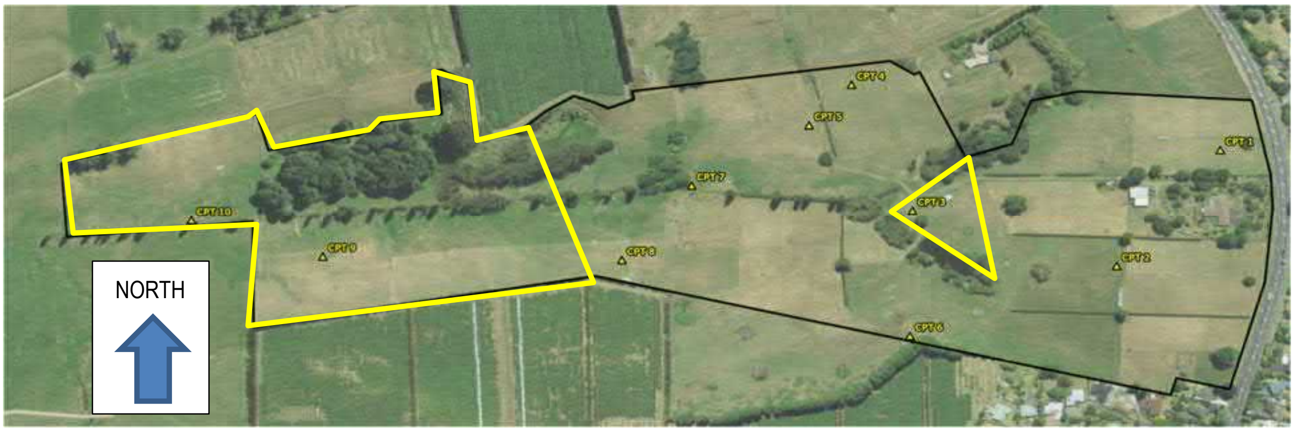


Figure 6.1: Areas in yellow box require TC2 type foundations

7 PRELIMINARY FOUNDATION RECOMMENDATIONS

This soils investigation has determined that the existing soil conditions across the proposed subdivision generally does typically meet the NZS 3604:2011[54] definition of 'Good Ground' – 'any soil or rock capable of permanently withstanding an ultimate bearing capacity of 300 kPa, (i.e. an allowable bearing pressure of 100 kPa using a factor of safety of 3.0).' Therefore, NZS 3604:2011 type foundations will typically be appropriate for the soil in an in-situ state.

7.1 Soil Assessment

The soils in general are suitable for foundation from immediately below the topsoil or may require over excavation to a depth 200 to 500 mm at localised sites. For the majority of sites the soil then has sufficient density to support the proposed structures. However, some areas are beyond the scope of NZS 3604 foundation and may require specific engineer design.

Across the site at a depth of about 1.5 m below existing ground low strength (150 to 200 kPa – ultimate) occur within the underlying Walton Subgroup soils. The softer soils are underlain by dense soil (300 kPa) soils in all instances.

The alluvial soils at the western end of the site are typically low strength with a high groundwater. Elsewhere, soft soils could be found adjacent to wetlands. Isolated pockets of farm fill should be expected but were not encountered during the site investigation.

7.2 NZS 3604 Concrete Foundations

In general, once the topsoil is removed and in places a 200 to 500 mm deep undercut is made, future building platforms within lots will be in accordance with the definition of 'Good Ground'. Proof rolling and a subgrade improvement layer will need to be up to foundation invert level.

In some areas of the site low density ground is encountered at a depth of approximately 1.2 m. Depending on the depth of the foundations and earthworks design surface, this may affect some development areas ability to meet the 'Good Ground' definition.

7.3 Waffle Raft Foundations (Rib-Raft)

The soils, as presented, do allow for the use of either proprietary rib-raft foundation or engineer designed waffle raft foundations, subject to lot specific testing.

Rib-raft type foundations are the recommended foundation type for future dwellings within this proposed subdivision. However, some areas are beyond the scope of NZS 3604 foundation and may require specific engineer design. It is likely that some lots may require a subgrade improvement layer with a typical thickness of 200 mm, however this thickness will be informed by the Lot specific testing.

7.4 Driven Timber Piles

In the area where the low strength alluvial soils are encountered (in the general area of BH03, 04 and the gully area up to and around BH07 – refer to Figure 3.1), driven timber piles may be considered as the most appropriate foundation type. Embedment depth of this piles will be in the order of approximately 6 m, but this would be informed by lot specific testing and preproduction test piles.

---

[54] Standards New Zealand; 2011: New Zealand Standard, Timber Framed Buildings, NZS 3604:2011. 499p.

7.5 Foundations in Bulk Earth Fill

Depending in the depth of the bulk earth fill and the compaction achieved, it may be possible to use NZS 3604:2011 type foundations. For this to be achieved the bulk earth fill will need to be placed in accordance with NZS 4431:2022[55]. For sand fill, this correlates to a minimum of five (5) blows per 100 mm on the Scala penetrometer (minimum ultimate bearing capacity of 300 kPa), and in accordance with NZS 4431:2022.

Some lots in the proposed development may require recontouring either by cutting or filling during subdivision earthworks to provide final building platform levels. In this case, specific building platform and foundation requirements will be dealt with in more detail at the time of the Subdivision Geotechnical Completion Report, when the final development contours are known.

---

[55] Standards New Zealand: 2022: New Zealand Standard, Engineered fill construction for light weighty structures. NZS 4431:2022. 79p.

8 PRELIMINARY PAVEMENT DESIGN

The site investigations completed have been inferred to provide preliminary recommendations on road pavement subgrade strength for this development.

8.1 California Bearing Raito (CBR)

Following the removal of topsoils, typical CBR values of 2 % to 3 % are inferred within the Hamilton Ash Formation sequence to a depth of approximately 2.0 m BEGL. In isolated pockets the CBR values are inferred to be between approximately 6 % to 8 %.

8.2 Pavement Design

Preliminary guidance for pavement design is taken from the RITS[56] and is reproduced below:

> **Sealed Pavement - Default Design**
>
> This method may be used for local residential roads only. Using this design does not exempt the construction from any tests nor compliance with any targets and does not provide any guarantee that the resulting pavement will comply with all testing requirements. Pavements shall comply with the depth and aggregate specified in the following table (Table 8.1).

Table 8.1: Pavement Layer Thickness for Local residential Roads

Road Type	Subbase	Basecourse	Notes
Cul de sac	N/A	150 mm GAP 40	(ESAs 100,000)
Local Road (<800 vpd)	125 mm GAP 40	100 mm NZTA M/4 AP40	(ESAs 250,000)
Local Road (800 – 3000 vpd)	125 mm GAP 40	125 mm NZTA M/4 AP40	(ESAs 500,000)

> These typical designs are based on an insitu subgrade having a soaked CBR of 15 over the full depth. If the insitu subgrade does not achieve this strength then it may be improved by undercutting to a minimum depth of 600 mm and replacing with an imported subgrade of pit sand, brown rock or other material supplied then compacted to achieve the required CBR value.
>
> If a subgrade of 600mm depth and CBR 15 is not practicable, a specific design will be required as per 3.2.12.1 Sealed Pavement - Specific Design.

Section 3.2.12.1[57] is reproduced below:

> **Section 3.2.12.1: Sealed Pavement - Specific Design**
>
> This method shall be used for all industrial and high volume (over 3000 vehicles per day) residential roads. It may be used for roads of lower classification.
>
> Pavement design shall use the methodology of Austroads Guide to Pavement Technology, Part 2 and the NZ Supplement to the Austroads Pavement Design Guide.

---

[56] Waikato Local Authority Shared Services. 2018: Regional Infrastructure Technical Specifications (RITS). Updated May 2018. 601p. Section 3.3.12.1 Pavement Design – Sealed pavement – Default Design page 103.

[57] Waikato Local Authority Shared Services. 2018. Page 102.

Designs for local roads may also use Austroads Pavement Design for Light Traffic.

Use of alternative materials such as recycled aggregates or the treatment of lower grade material is encouraged. The use of stabilisation agents may be considered by Council for subgrade and sub-base improvement, but not basecourse stabilisation.

Factors to be included in the design are:

a) Design Period - 25 years

b) Trips generated per household per day - 10

c) Annual HCV growth factor - 3 % minimum unless otherwise outlined by Council

d) Load factor the Presumptive ESA/HCV of 1.44 shall be used for design purposes unless otherwise outlined by Council.

e) % HCV 1.5% local residential road/3.5% collector and higher classification/10% industrial and 9% rural roads

The design report shall provide the following information as a minimum.

- Results of soils investigations
- Design assumptions and figures
- Material specifications
- Engineering Drawings
- QA measures for construction

Considering the recommended CBR values from this suitability level testing, specific pavement design will likely be required for future roading pavements.

9 EARTHWORKS AND FILL SUITABILITY

In general, the site comprises of rolling hills either side of an incised gully system with alluvial soils located at the toe of the hills. The upper 2 to 4 m comprises of easily worked Hamilton Ash Formation and possibly other ash formations. Underlying the ash formation is the Walton Subgroup soils.

The Walton Subgroup soils can prove to be extremely problematic and as such are not considered to be suitable for use as bulk earth fill. The clay mineralogy is variable and as such drying times can vairy considerably as can the physical properties, thus necessitating various testing parameters to be considered. Generally, when cut to level Walton subgroup soils are stable. In battered slope low batter angles need to be considered and it can be challenging to place as bulk fill.

The Hinuera Formation soils can be used for bulk earthfall depending on the silt content encountered.

Organic soils, colluvium, recent alluvium and uncontrolled fill will need to be cut to waste or used for general landscaping.

9.1 Site Soils Suitability for Earth Fill

The near surface (volcanic ash soils) site soils encountered are generally suitable for the use of fill. These soils will need to be dried back prior to their use, and the amount of drying required will be indicated by laboratory testing. The drying is not expected to be intensive and will only likely require a minimum of manual intervention.

The Walton Subgroup soils can be utilised as bulk earthfall but certain layers in the formation due to their clay mineralogy can be extremely challenging to dry and compact to the required density. The location of these undesirable soil types in the soil column is completely random and the volume of this material is unpredictable.

10 ONSITE SOAKAGE

The permeability of the soils which comprise the proposed development were measured using twin ring infiltration methods and falling head permeameter. The purpose of the twin rings was to measure the near surface permeability of the insitu soils (mainly fine-grained volcanic soils). While the falling head permeameter was intended to assess the suitability of deeper site soils and to assess the suitability of onsite stormwater disposal.

The location of the soakage tests is in the general vicinity of the CPT tests as presented in Table 3.3 and in Table 3.4. Where a soakage test be is described at Double Ring or falling Head Test 1 that test location is the same as CPT 1 etc.

10.1 Stormwater Testing Methods

10.1.1 Double Ring Infiltration Testing (Shallow Soakage)

Double ring testing method procedure has preen presented in Section 5.3.1.

10.1.2 Falling Head Test

To assess the soakage at depth that may be able to be utilised as lot level inground soakage three falling head tests were conducted across the site in accordance with the New Zealand Building Code E1 methodology[58], as described below:

- A 100 mm Ø bored hole was augered to a depth of between 0.7 to 1.1 m BEGL and an 80 mm Ø standpipe was inserted. A head of water was maintained in the standpipe for approximately 30 minutes prior to the running of the falling head test.
- Readings were taken at 1, 2 and 5 minute intervals, the depth of the water that had soaked away for the interval was recorded.

10.2 Results

10.2.1 Double Ring Infiltration

The results from the near surface twin ring soakage tests are summarised in Table 10.1, with the test results presented in Appendix A.3.

Table 10.1: Twin Ring Soakage Rates

Double Ring Infiltration Test	**Test Duration** (minutes)	**Infiltration Rate** (mm/hr)
1	45	**72**
2	30	**60**
3	30	**36**
5	30	**108**
7	35	**60**
10	50	**48**

---

[58] Ministry of Business Innovation and Employment. 2017: Acceptable Solutions and Verification Methods for New Zealand Building Code Clause, E1 Surface Water. Amendment 11. 48p.

10.2.2 *Falling Head Soakage Tests*

The soakage rate obtained from the three tests is presented in Table 10.2 with the results presented in Appendix A.4. The results have had a long-term reduction factor of approximately 50% applied to the measured soakage rates in accordance with the Regional Infrastructure Technical Specification (RITS) requirements[59] to arrive at the design soakage rate.

Table 10.2: Pre-soak methodologies and measured soakage rates.

Soakage Test	**Test Duration** (minutes)	**Measured Soakage Rate** (mm/hr)	**Design Soakage Rate** (mm/hr)
1	30	16	**8**
2		120	**60**
3		156	**78**
5		480	**240**
7		1,200	**600**
10		96	**48**

10.3 On-Site Soakage Summary

The results from Table 10.1 and Table 10.2 have been summarised and compared to their respective receiving soils as presented in Table 10.3.

Table 10.3: On-site soakage testing summary

Soakage Test	**Twin Ring Infiltration Rate** (mm/hr)	**Design Soakage Rate** (mm/hr)	**Receiving soil**
1	72	8	Hamilton Ash Formation
2	60	60	
3	36	78	Colluvium over HAF
5	108	240	Hamilton Ash Formation
7	60	600	Recent alluvium over HF
10	48	48	Hinuera Formation (saturated)

Hamilton Ash Formation = HAF

Hinuera Formation = HF

10.3.1 *Hamilton Ash Formation*

The results show that for the analysed range of Hamilton Ash Formation soils that the soils can consist of rapid drainage over slow drainage within the soil at Test 1. A soil column of constant soakage comprising of a low (Test Location 2) and rapid soakage over increased soakage at depth as presented at Test Location 5.

The soils encountered at Test Location 1 tend to promote perched groundwater in the soil column. The soakage rate at Test Location 2 is typical soakage for Hamilton Ash rate, a constant low rate through the soil column. At Test Location 5 it is likely that the Hamilton Ash Formation is comprised of well structed soil with many internal voids. The soakage capacity of these soils is unlikely to be sustainable over a long period once the inner voids are saturated.

---

[59] Waikato Local Authority Shared Services. 2018. Refer to section 4.2.15 c.

At Test Location 3, an example of the soakage conditions on the toe slope was examined. This represents a very fine-grained soil over the Hamilton Ash Formation. The results show a low soakage rate over a higher (but still practically speaking low soakage rate for the whole soil column).

A typical soakage rate for the Hamilton Ash Formation should be taken as in the order of 60 mm/hr.

10.3.2 Walton Subgroup soils

As the Walton Subgroup soils were concealed by the Hamton Ash soils during the site investigation they could not be tested. However, it is expected that they will have a similar or lower soakage rate that that presented for the Hamilton Ash Formation if these soils are exposed in cut across the site.

10.3.3 Hinuera Formation Soils

Due to the coarser grained nature of the Hinuera Formation soils, these soils have a much higher soakage rate that the Hamton Ash Formation of Walton Subgroup soils.

At Test Location 7 a site was selected with a fine-grained soil layer overlying the Hinuera Formation soils. At this location the higher permeability of the Hinuera Formation is demonstrated (600 mm/hr). Where low groundwater is encountered in the Hinuera Formation this soakage (600 mm/hr) is considered representative.

At Test Location 10 the Hinuera Formation was examined in a high groundwater situation to assess the lateral (side wall soakage capacity of saturated soil conditions. In this case the soakage rate was very low 48 mm/hr (practically speaking there was no soakage for run off from a domestic dwelling).

10.3.4 General Soakage Summary

As the majority of the site is comprised by fine grained soils, the site has low soakage and the majority of the rainfall on the development area will be disposed of by overland flow as in its current configuration.

In the gully areas and at the toe of the slope, some water is disposed of via inground soakage but the areas of high soakage a limited and not sufficient to deal with the stormwater generated by urbanisation of the catchment.

The testing has demonstrated that the insitu soils are of low soakage capacity or where high soakage capacity has been found, the extent of higher capacity receiving soils is too low to be of any practical stormwater soakage design assistance.

11 CONCLUSIONS AND RECOMMENDATIONS

11.1 Site Suitability

The proposed site is deemed suitable for the development of a residential subdivision. The site investigation has identified that the development is to be located on soils that are more than suitable for the construction of buildings, roads and associated infrastructure.

11.2 Liquefaction and Differential Settlement

The modelling shows that liquefaction damage to the site is considered to be low to nil for soils located on the Hamilton Hills elements of the site. For the soils of the alluvial plains or alluvial in deposition, an increase in liquefaction settlements is noted. Differential settlement is not expected to occur due to the low permeability, elevated ground and low groundwater levels. Based on the modelling completed as part of this suitability report, and at a worst-case scenario it is expected to be in the order of less than 20 to 25 mm in the 1 in 500 and 1,000-year event.

Lateral displacement is not expected within the Hamilton Hills portion of the site. No free faces occur within the alluvial plain and so it has not been assessed as a hazard. No damage is expected in the 1 in 25 case, for any landform within the site.

11.3 Foundation Design

The soils as presented allow for the use of either NZS 3604 type foundation, proprietary rib-raft foundation or engineer designed waffle raft foundations, subject to Lot specific testing. Within the alluvial plan driven timber piles (in the area of BH 03, 04 and 07) will likely need to be utilised but this will be informed by lot specific testing during the Building Consent phase.

These preliminary foundation recommendations will be further confirmed in the site specific detailed geotechnical investigation for each lot in the future subdivision.

11.4 Groundwater

The elevated areas within the site have a low permeability and this unlikely to hold significant volumes of groundwater in these areas. The rolling nature of the elevated areas next to steeply incised gullies means that a hydraulic gradient will always exist for the water to drain away.

On the alluvial flats within the gully bases, adjacent to flowing streams, it is likely that elevated ground water will occur during the wetter periods of the year. It is expected that as the alluvial areas extend away from the stream that the groundwater level will occur at increasing depth.

Within the gully bases, after extended periods of rain, groundwater may be either locally elevated for short periods while it drains through the less pervious subsoil layers or be locally perched along the base of the gully.

11.5 Preliminary Pavement Design

Following the removal of topsoils, typical CBR values of 2 % to 3 % are inferred within the Hamilton Ash Formation sequence to a depth of approximately 2.0 metre Below Existing Ground Level (BEGL). In isolated pockets the CBR values are inferred to be between approximately 6 % to 8 %. Considering these CBR values, specific pavement design will likely be required for future roading pavements.

11.6 Earthworks and Fill Suitability

The near surface (volcanic ash) site soils encountered are generally suitable for use as fill. These soils will need to be dried back prior to their use, and the amount of drying required will be indicated by laboratory testing.

The Walton Subgroup soils can be utilised as bulk earthfall, but certain layers in the formation due to their clay mineralogy can be extremely challenging to dry and compact to the required density.

11.7 On-site Soakage

As the majority of the site is comprised by fine grained soils, the site has low soakage and the majority of the rainfall on the development area will be discharge by overland flow.

In the gully areas and at the toe of the slope, some water is disposed of via inground soakage but the areas of high soakage a limited in extent and do not appear sufficient to deal with the stormwater generated by urbanisation of the catchment.

The testing has demonstrated that the insitu soils are of low soakage capacity or where high soakage capacity has been found, the extent of higher capacity soils is limited.

12 DISTRIBUTION AND LIMITATIONS

12.1 Distribution

This report has been produced by BTW Company Ltd for the client, Te Awamutu Developments Limited, and is solely for the clients use for which the report was intended, in accordance with the agreed scope. The reliance/use of this report and/or the information within this report by any person or business which BTW Company Ltd have not given prior consent, is at the persons or business own risk.

12.2 Limitations

The recommendations made within this report have been concluded from the limited geotechnical completed. The nature and continuity of subsoil conditions at locations other than the investigation test locations are inferred and it should be appreciated that actual conditions could vary from the assumed model. If ground conditions are found to vary from that described or assumed, the matter should in the first instance be referred back to BTW for comment.

APPENDIX A PHASE TWO GEOTECHNICAL TESTING RESULTS

A.1 Soil Report

INVESTIGATION LOG

HOLE NO.: BH 01

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 22/07/2022

CO-ORDINATES: 1803422mE, 5792706mN

ELEVATION: Ground

END DATE: 22/07/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: SJ & AM

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION

(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with minor sand; brown .
Very stiff; non-plastic; dry to moist; (HAMILTON ASH FORMATION).

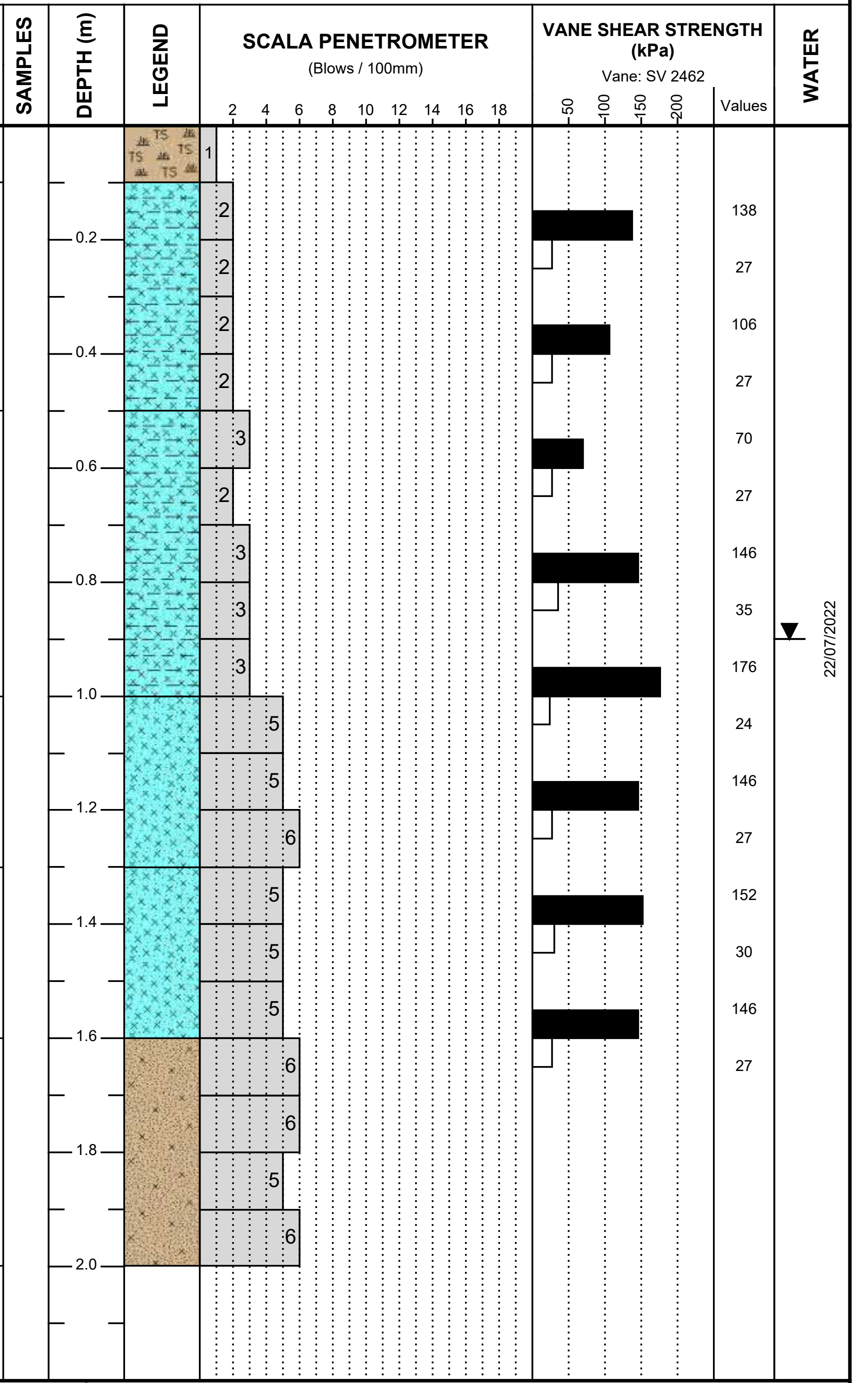
Clayey SILT; light yellowish brown .
Stiff to very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Sandy SILT; light grey.
Very stiff; low plasticity; moist; sand, fine to medium; (WALTON SUBGROUP).

Sandy SILT, with some iron staining, with minor clay; light grey mottled with light brown.
Very stiff; low plasticity; moist; (WALTON SUBGROUP).

Silty SAND; light brown.
Medium dense; non-plastic; wet; sand, fine to coarse; (WALTON SUBGROUP).

EOH: 2.00m



PHOTO(S)

REMARKS

WATER

▼ Standing Water Level

▷ Out flow

◁ In flow

INVESTIGATION TYPE

☑ Hand Auger

☐ Test Pit

BTW COMPANY

INVESTIGATION LOG

HOLE NO.: BH 02

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 22/07/2022

CO-ORDINATES: 1803511mE, 5792766mN

ELEVATION: Ground

END DATE: 22/07/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: SJ & AM

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION

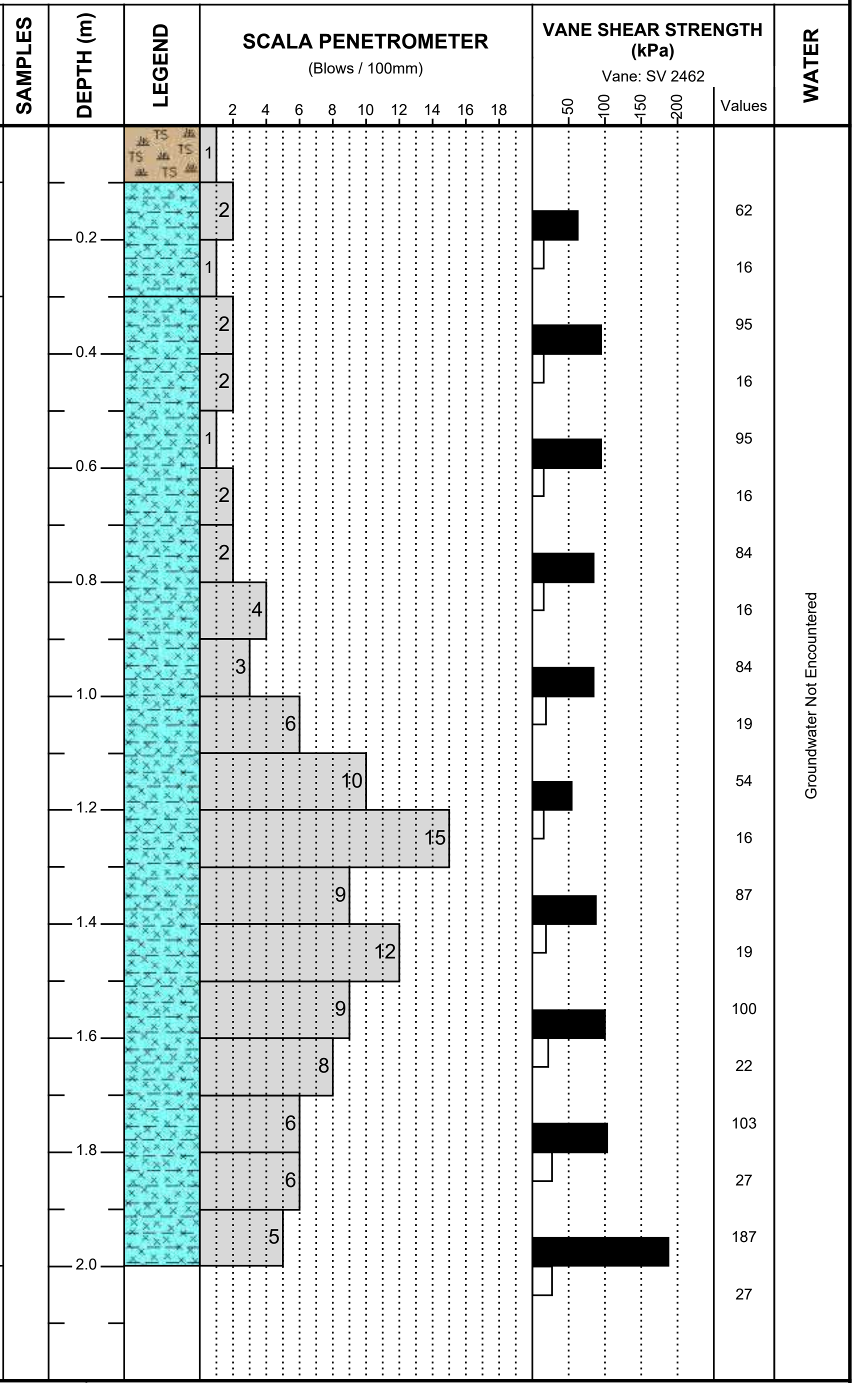
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with minor sand; dark brown.
Firm to stiff; non-plastic; dry; sand, fine to coarse; (PEDOGENIC B HORIZON).

Clayey SILT; light brown.
Stiff to very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

EOH: 2.00m



PHOTO(S)

REMARKS

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

BTW COMPANY

INVESTIGATION LOG

HOLE NO.: BH 03

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 22/07/2022

CO-ORDINATES: 1803509mE, 5792678mN

ELEVATION: Ground

END DATE: 22/07/2022

CONTRACTOR: BTW Co. Ltd.

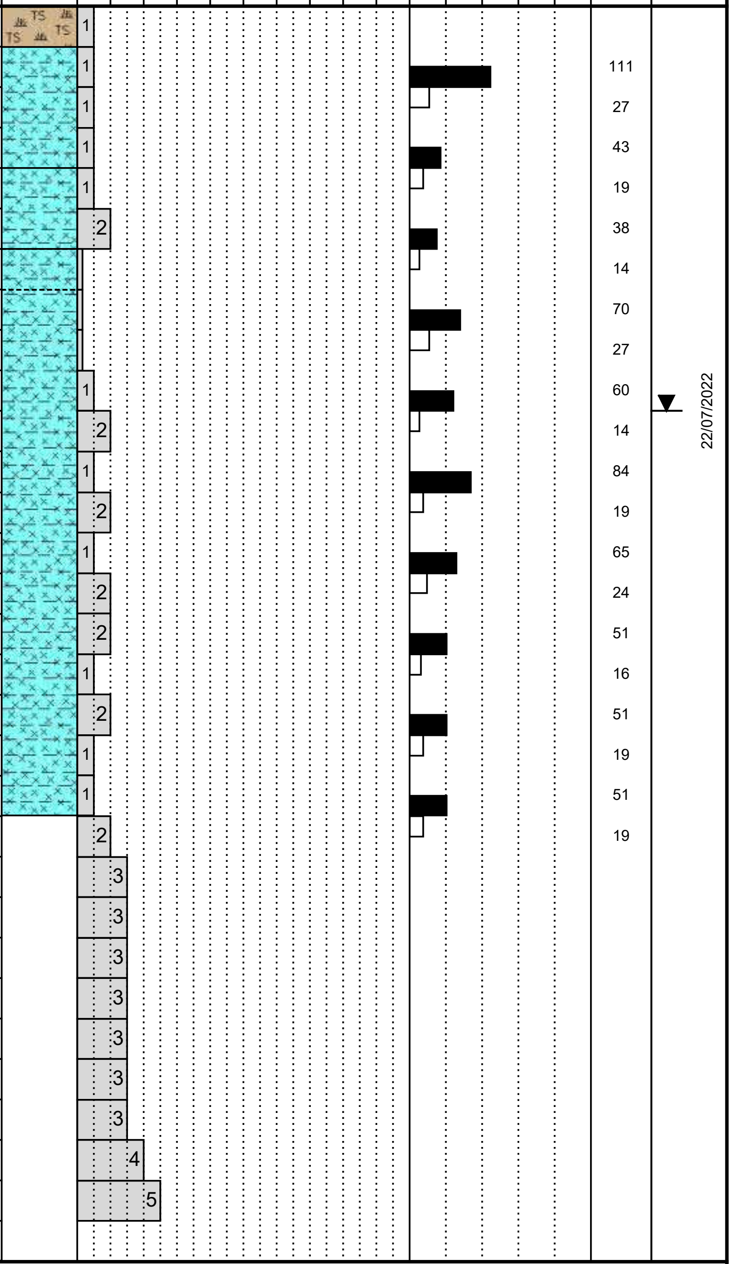
RIG: Hand Auger

DRILLER: SJ & AM

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

DEPTH (m)	MATERIAL DESCRIPTION
0.0 - 0.1	TOPSOIL.
0.1 - 0.4	Clayey SILT, with some sand; light yellowish brown. Very stiff; low plasticity; moist; sand, fine to medium; (HAMILTON ASH FORMATION).
0.4 - 0.6	Clayey SILT, with minor sand; grey . Soft to firm; low plasticity; dry to moist; sand, fine; (WALTON SUBGROUP).
0.6 - 2.0	Clayey SILT; dark brown. Soft to firm; low plasticity; wet; (WALTON SUBGROUP). 0.6m - 0.7m: ROOTLETS. 1.0m: SATURATED.
2.0	EOH: 2.00m



DEPTH (m)	SCALA PENETROMETER (Blows / 100mm)
0.0 - 0.1	1
0.1 - 0.2	1
0.2 - 0.3	1
0.3 - 0.4	1
0.4 - 0.5	1
0.5 - 0.6	2
0.9 - 1.0	1
1.0 - 1.1	2
1.1 - 1.2	1
1.2 - 1.3	2
1.3 - 1.4	1
1.4 - 1.5	2
1.5 - 1.6	2
1.6 - 1.7	1
1.7 - 1.8	2
1.8 - 1.9	1
1.9 - 2.0	1
2.0 - 2.1	2
2.1 - 2.2	3
2.2 - 2.3	3
2.3 - 2.4	3
2.4 - 2.5	3
2.5 - 2.6	3
2.6 - 2.7	3
2.7 - 2.8	3
2.8 - 2.9	4
2.9 - 3.0	5

DEPTH (m)	VANE SHEAR STRENGTH (kPa) Values
0.2	111 27
0.4	43 19
0.6	38 14
0.8	70 27
1.0	60 14
1.2	84 19
1.4	65 24
1.6	51 16
1.8	51 19
2.0	51 19

WATER: ▼ 22/07/2022

PHOTO(S)

REMARKS

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

INVESTIGATION LOG

HOLE NO.: BH 04

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 22/07/2022

CO-ORDINATES: 1803586mE, 5792703mN

ELEVATION: Ground

END DATE: 22/07/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: SJ & AM

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION

(See Classification & Symbology sheet for details)

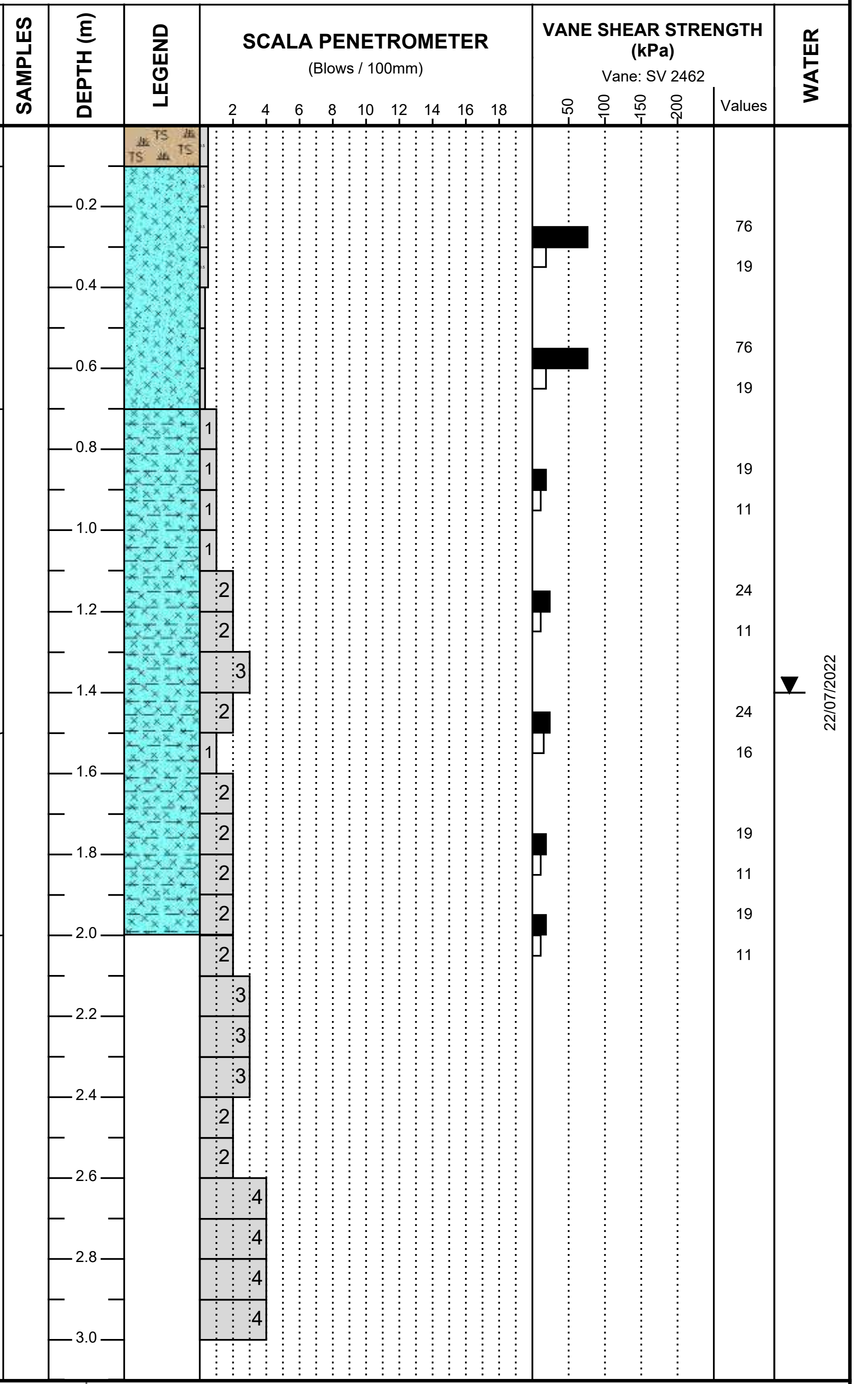
TOPSOIL.

Sandy SILT, with some rootlets; light greyish brown. Soft; moist; sand, fine to medium; (RECENT ALLUVIUM).

Clayey SILT, with some rootlets; light grey. Soft to firm; low plasticity; wet; (ALLUVIUM).

1.5m: NO ROOTLETS.

EOH: 2.00m



PHOTO(S)

REMARKS

COLLUVIAL INFILLED PALEOCHANNEL

WATER

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

INVESTIGATION TYPE

☑ Hand Auger

☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:22 am

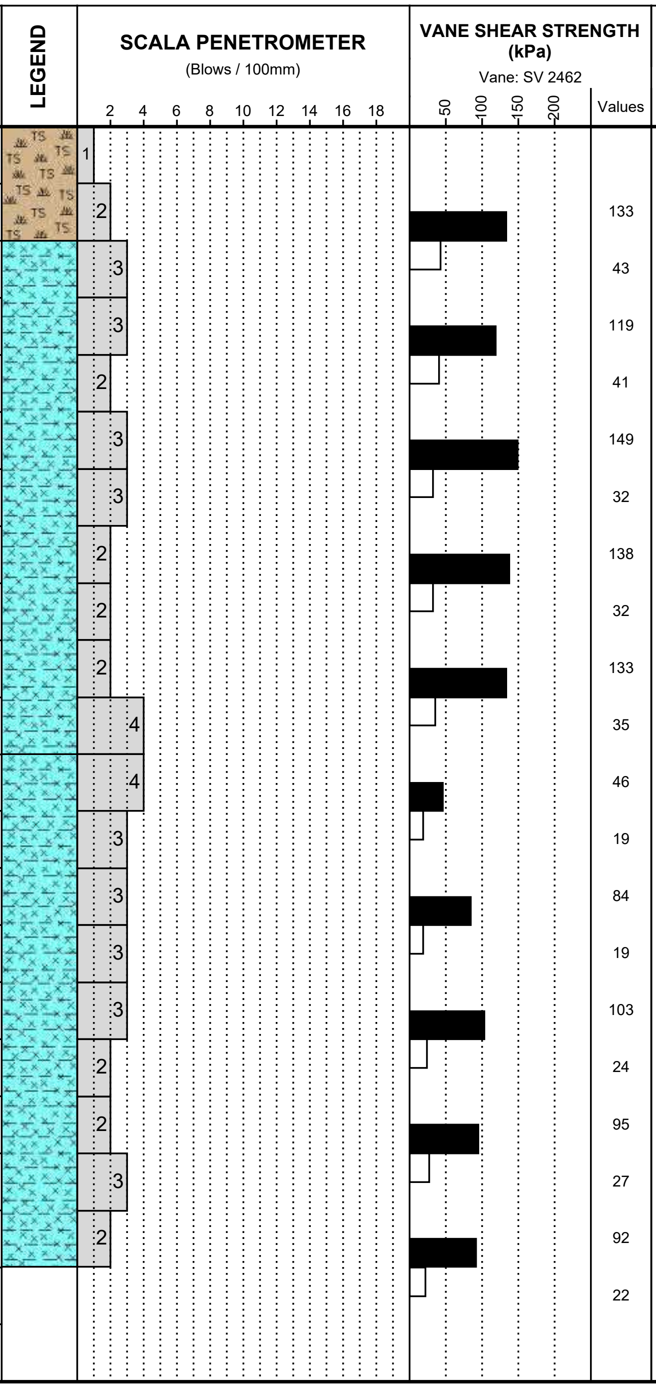
BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 05

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365
SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 22/07/2022
CO-ORDINATES: 1803620mE, 5792568mN
ELEVATION: Ground
END DATE: 22/07/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: SJ & AM
LOGGED BY: Sam Jin

DEPTH (m)	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)
0.0 – 0.2	TOPSOIL.
0.2 – 1.1	Clayey SILT; light brown. Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).
1.1 – 2.0	Clayey SILT, with minor sand; light brown. Low plasticity; dry to moist; sand, fine to medium; (WALTON SUBGROUP).
2.0	EOH: 2.00m



Depth (m)	Scala (Blows / 100mm)
0.0–0.1	1
0.1–0.2	2
0.2–0.3	3
0.3–0.4	3
0.4–0.5	2
0.5–0.6	3
0.6–0.7	3
0.7–0.8	2
0.8–0.9	2
0.9–1.0	2
1.0–1.1	4
1.1–1.2	4
1.2–1.3	3
1.3–1.4	3
1.4–1.5	3
1.5–1.6	3
1.6–1.7	2
1.7–1.8	2
1.8–1.9	3
1.9–2.0	2

Vane shear Values (kPa)
133
43
119
41
149
32
138
32
133
35
46
19
84
19
103
24
95
27
92
22

PHOTO(S)

REMARKS

WATER

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

INVESTIGATION TYPE

- ☑ Hand Auger
- ☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:23 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 06

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 12/08/2022
CO-ORDINATES: 1803793mE, 5792594mN
ELEVATION: Ground
END DATE: 12/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

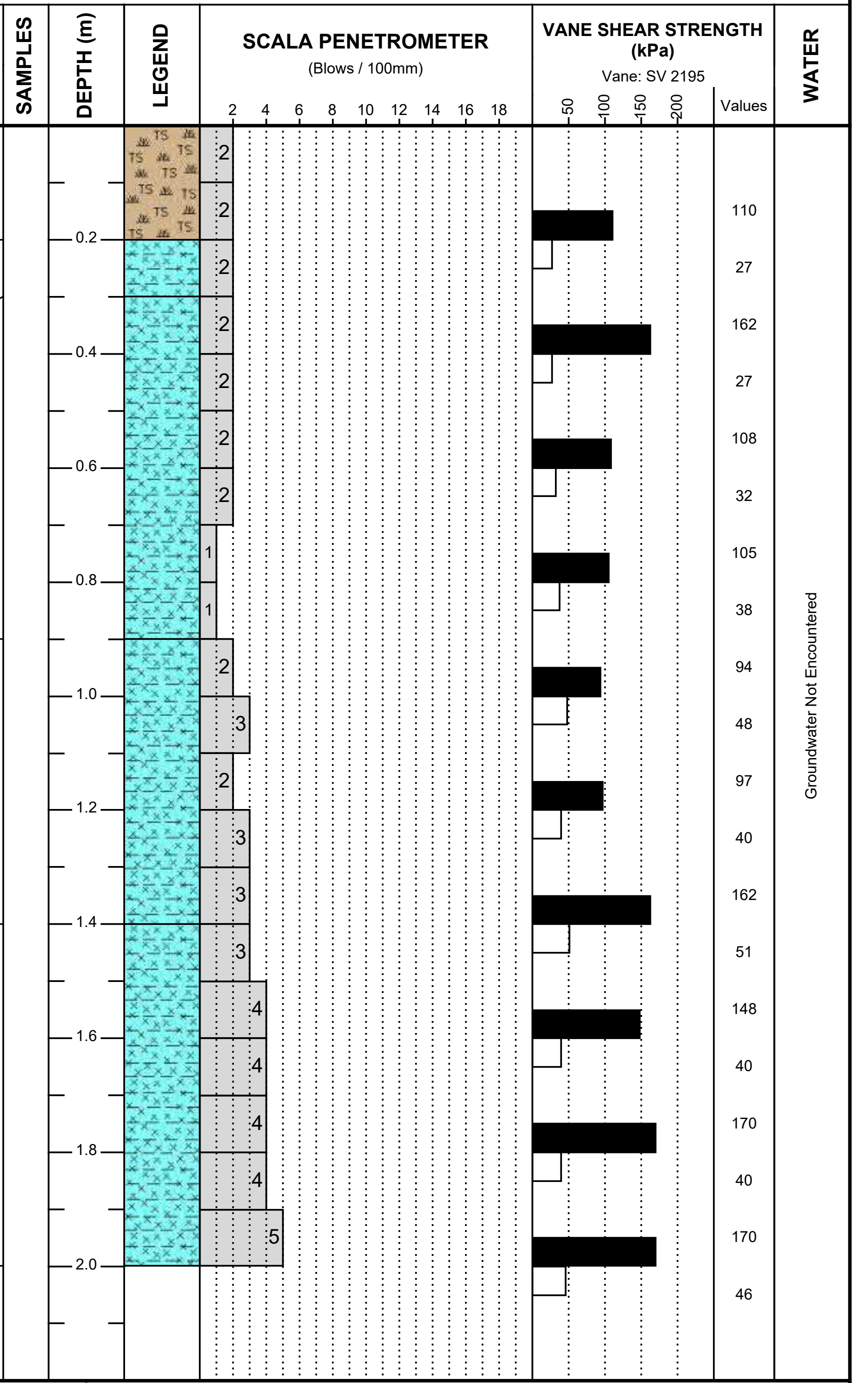
Clayey SILT, with minor sand; brown . Very stiff; low plasticity; dry; sand, fine; (HAMILTON ASH FORMATION).

Clayey SILT, with minor manganese nodules; light brown. Very stiff; low plasticity; dry; (HAMILTON ASH FORMATION).

Clayey SILT, with minor sand; brown . Stiff; high plasticity; dry to moist; sand, medium; (HAMILTON ASH FORMATION).

Clayey SILT, with minor sand; light brown . Very stiff; low plasticity; dry to moist; sand, fine; (HAMILTON ASH FORMATION).

EOH: 2.00m



PHOTO(S)

REMARKS

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

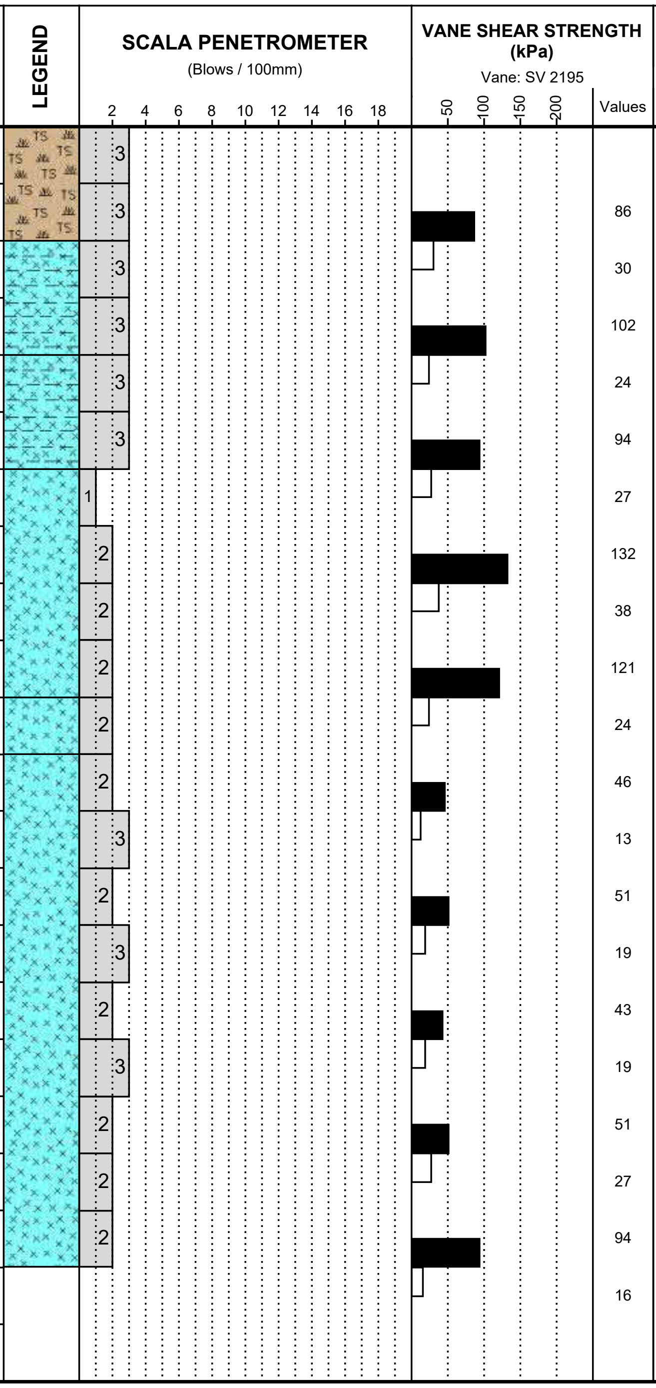
INVESTIGATION LOG

HOLE NO.: BH 07

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 03/08/2022
CO-ORDINATES: 1803798mE, 5792682mN
ELEVATION: Ground
END DATE: 03/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH (m)
TOPSOIL.	0.0 – 0.2
Clayey SILT, with some iron staining and manganese nodules, with minor sand; light brown . Stiff; low plasticity; dry; sand, fine to medium; (HAMILTON ASH FORMATION).	0.2 – 0.4
Clayey SILT, with some iron staining; brown . Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).	0.4 – 0.6
SILT, with minor manganese nodules and clay and sand; dark grey. Very stiff; low plasticity; moist; sand, fine; (WALTON SUBGROUP).	0.6 – 1.0
SILT, with minor manganese nodules and clay and sand; dark greyish brown. Very stiff; moist; sand, fine; (WALTON SUBGROUP).	1.0 – 1.1
SILT, with minor clay and sand; dark grey. Firm to stiff; moist; sand, fine; (WALTON SUBGROUP).	1.1 – 2.0
EOH: 2.00m	2.0



	SCALA PENETROMETER (Blows / 100mm)
0.0 – 0.1	3
0.1 – 0.2	3
0.2 – 0.3	3
0.3 – 0.4	3
0.4 – 0.5	3
0.5 – 0.6	3
0.6 – 0.7	1
0.7 – 0.8	2
0.8 – 0.9	2
0.9 – 1.0	2
1.0 – 1.1	2
1.1 – 1.2	2
1.2 – 1.3	3
1.3 – 1.4	2
1.4 – 1.5	3
1.5 – 1.6	2
1.6 – 1.7	3
1.7 – 1.8	2
1.8 – 1.9	2
1.9 – 2.0	2

VANE SHEAR STRENGTH (kPa) Values
86
30
102
24
94
27
132
38
121
24
46
13
51
19
43
19
51
27
94
16

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

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

INVESTIGATION TYPE
- ☑ Hand Auger
- ☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:26 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 08

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 03/08/2022
CO-ORDINATES: 1803832mE, 5792697mN
ELEVATION: Ground
END DATE: 03/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Sandy SILT, with some iron staining; light grey.
Very stiff to hard; dry to moist; sand, fine to medium; (WALTON SUBGROUP).

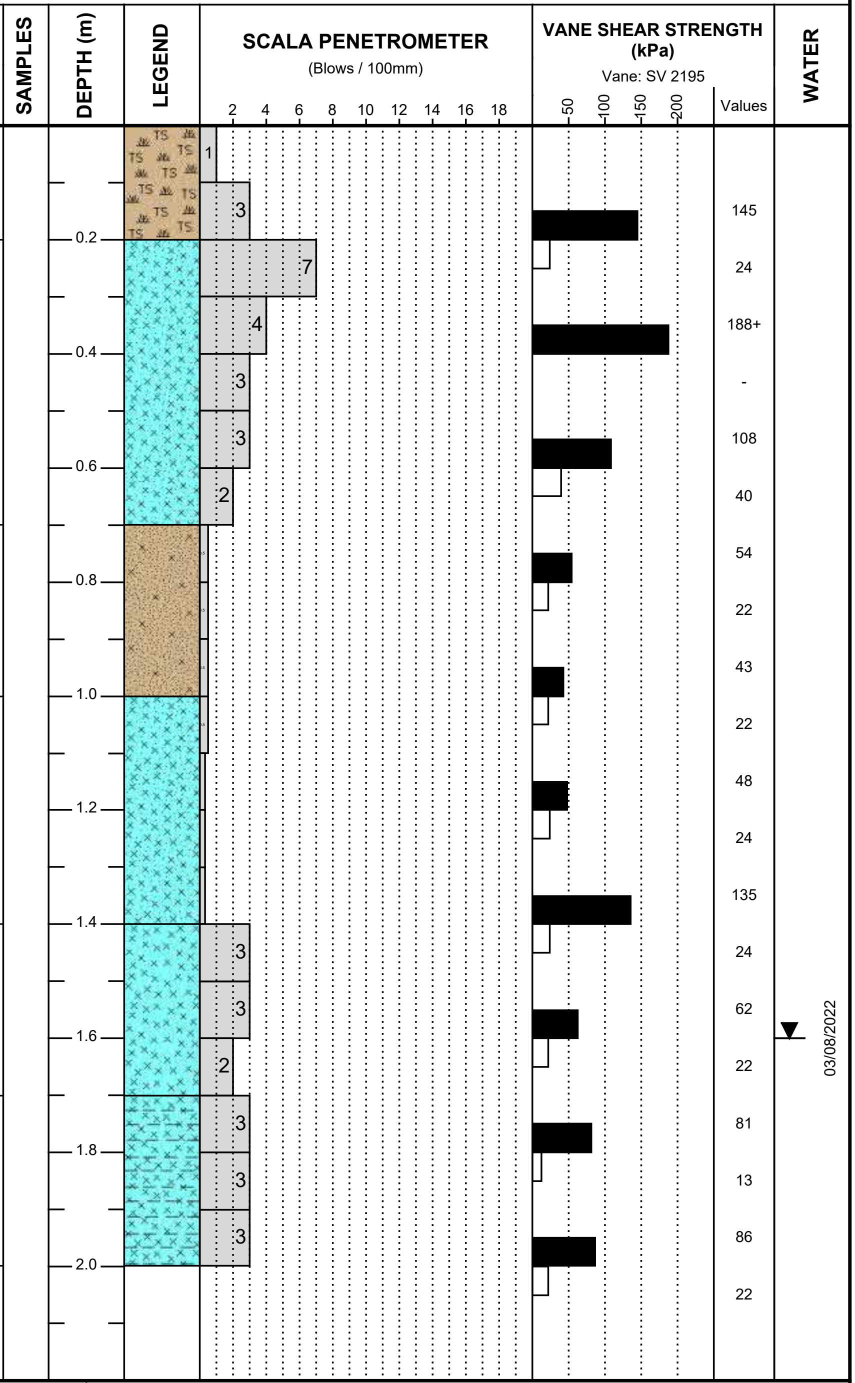
Silty SAND, with some iron staining and manganese nodules; light grey.
Firm to stiff; moist; sand, fine to coarse; (WALTON SUBGROUP).

Sandy SILT, with minor manganese nodules; light brown.
Firm; moist; sand, fine to medium; (WALTON SUBGROUP).

SILT, with minor sand; dark brown.
Soft to very stiff; low plasticity; moist; sand, fine; (WALTON SUBGROUP).

Clayey SILT, with some sand; brown .
Stiff; saturated; sand, fine to medium; (WALTON SUBGROUP).

EOH: 2.00m



PHOTO(S)

REMARKS

Tree Root encountered at 0.6 m BEGL.

WATER

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

INVESTIGATION TYPE

- ☑ Hand Auger
- ☐ Test Pit

INVESTIGATION LOG

HOLE NO.: BH 08.1

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 03/08/2022
CO-ORDINATES: 1803836mE, 5792698mN
ELEVATION: Ground
END DATE: 03/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

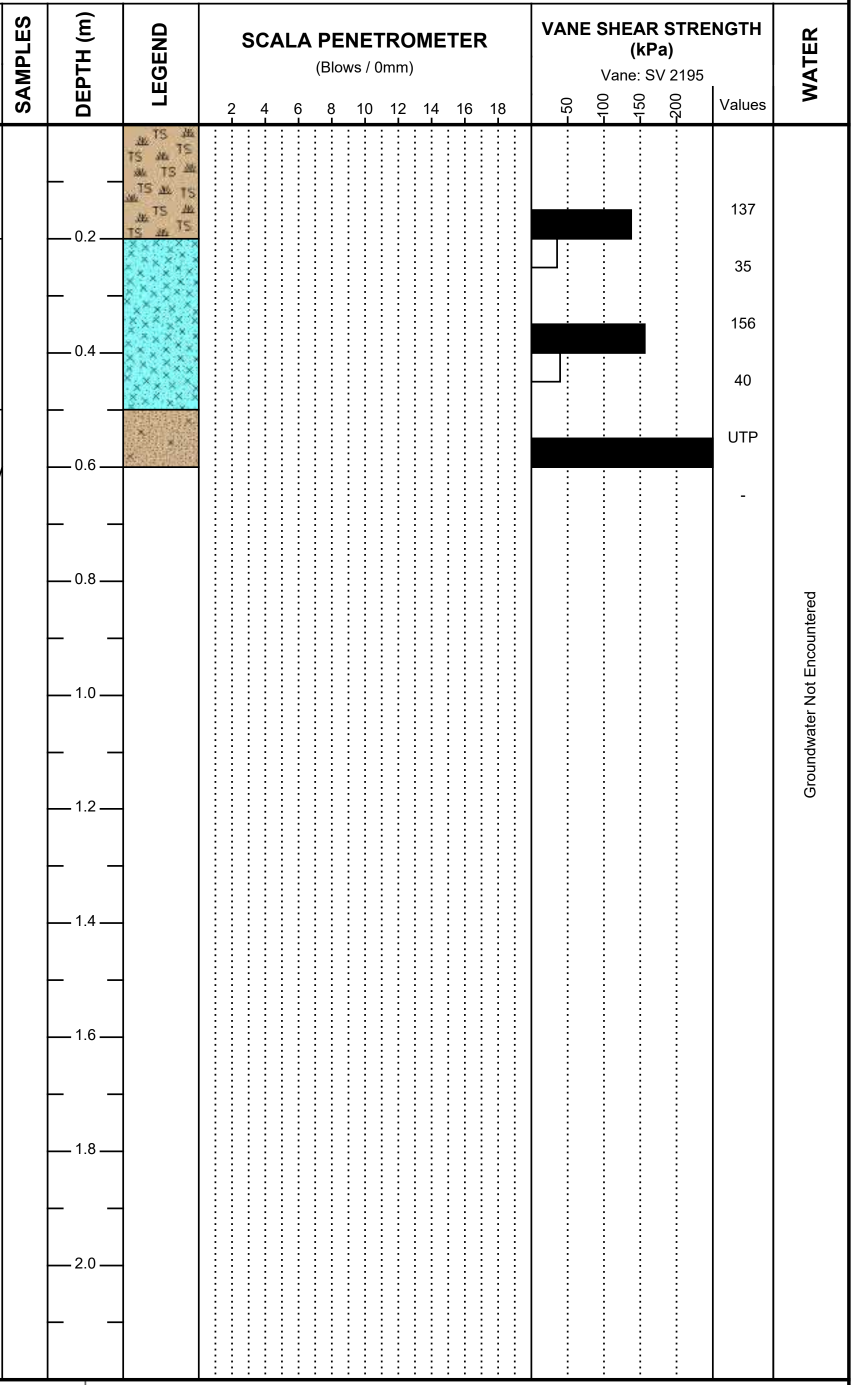
MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Sandy SILT, with some iron staining and manganese nodules; grey . Very stiff; dry to moist; sand, fine; (WALTON SUBGROUP).

Silty SAND, with some iron staining and manganese nodules and minor rootlets; grey . Very stiff; dry to moist; (WALTON SUBGROUP)

EOH: 2.00m



PHOTO(S)

REMARKS

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

INVESTIGATION LOG

HOLE NO.: BH 09

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 03/08/2022

CO-ORDINATES: 1803973mE, 5792771mN

ELEVATION: Ground

END DATE: 03/08/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with minor sand; brown with mottled grey and black. Very stiff; dry; sand, fine to medium; (UNCONTROLLED FILL).

Clayey SILT, with some sand and gravel; light brown with mottled light yellowish brown and whitish grey.
Very stiff; low plasticity; dry to moist; sand, fine to coarse, gravel, fine; (UNCONTROLLED FILL).

Clayey SILT, with some iron staining; grey .
Firm; non-plastic; moist; (WALTON SUBGROUP).

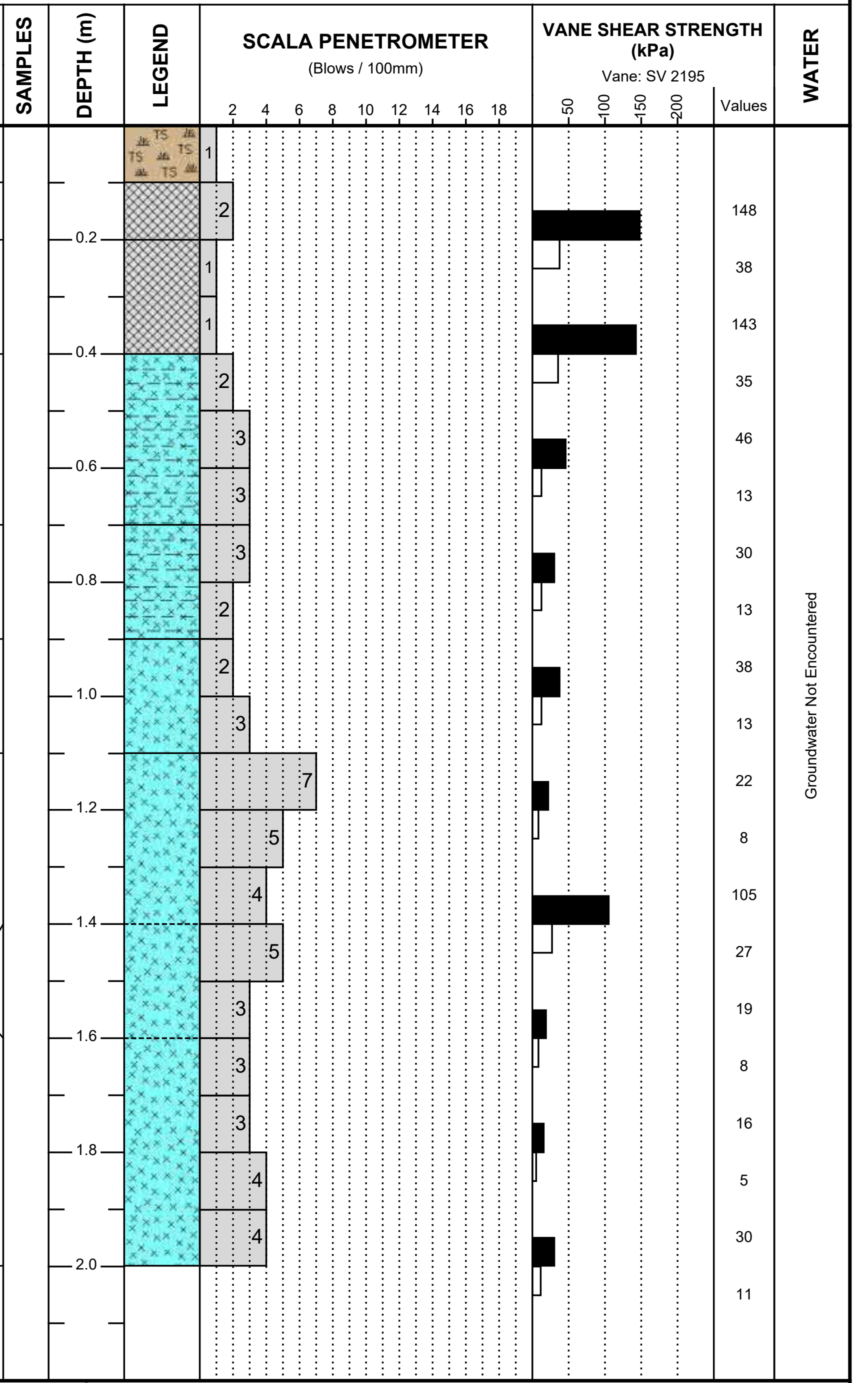
Clayey SILT, with some iron staining; grey .
Firm; non-plastic; moist; (WALTON SUBGROUP).

SILT, with minor iron staining and clay and sand; grey .
Firm; non-plastic; moist; sand, fine; (WALTON SUBGROUP).

SILT, with minor clay, with trace sand; grey .
Soft to firm; non-plastic; saturated; sand, fine; (WALTON SUBGROUP).

1.4m - 1.6m: ROOTLETS.

EOH: 2.00m



PHOTO(S)

REMARKS

WATER

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

INVESTIGATION TYPE

- ☑ Hand Auger
- ☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 10

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365
SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 03/08/2022
CO-ORDINATES: 1803947mE, 5792719mN
ELEVATION: Ground
END DATE: 03/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

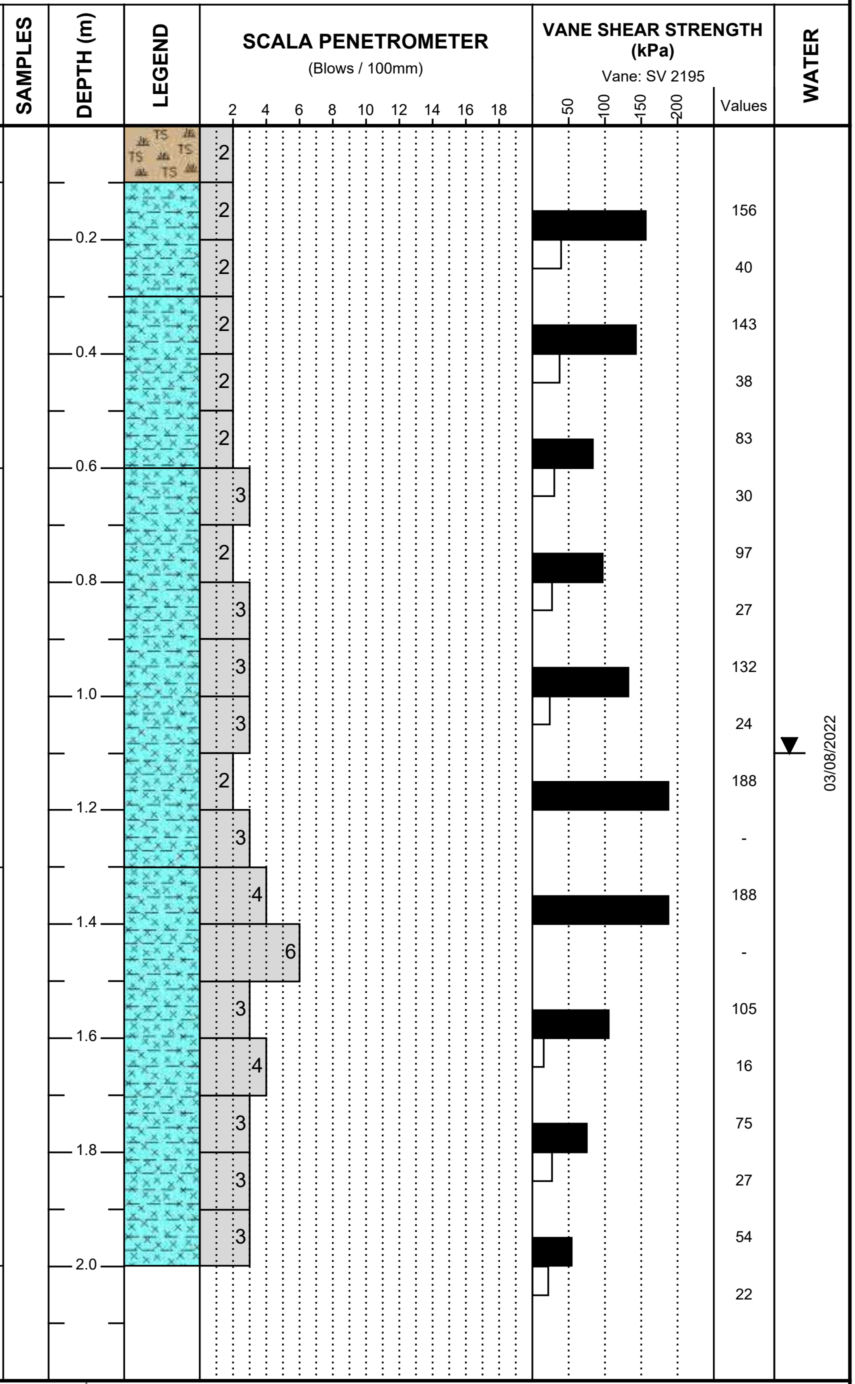
Clayey SILT, with some iron staining and minor manganese nodules; light yellowish brown.
Very stiff; dry to moist; (WALTON SUBGROUP).

Clayey SILT, with some iron staining, with minor sand; light brown mottled with some light grey.
Stiff to very stiff; dry; sand, fine to medium; (WALTON SUBGROUP).

Clayey SILT, with some iron staining and manganese nodules; dark brown.
Stiff to hard; non-plastic; moist; (WALTON SUBGROUP).

Clayey SILT, with minor manganese nodules, with trace sand; light greyish brown.
Stiff to hard; saturated; sand, fine; (WALTON SUBGROUP).

EOH: 2.00m



PHOTO(S)

REMARKS

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:31 am

INVESTIGATION LOG

HOLE NO.: BH 11

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 03/08/2022

CO-ORDINATES: 1803950mE, 5792667mN

ELEVATION: Ground

END DATE: 03/08/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

SAMPLES | **DEPTH (m)** | **LEGEND** | **SCALA PENETROMETER** (Blows / 100mm) | **VANE SHEAR STRENGTH (kPa)** Vane: SV 2195 | Values | **WATER**

TOPSOIL.

Clayey SILT, with minor sand; dark brown .
Very stiff; low plasticity; dry to moist; sand, fine to medium; (PEDOGENIC B HORIZON).

Clayey SILT, with some manganese nodules; light yellowish brown.
Stiff to very stiff; low plasticity; dry to moist; (WALTON SUBGROUP).

Sandy SILT, with some manganese nodules, with minor clay; grey .
Stiff; low plasticity; moist; sand, fine to medium; (WALTON SUBGROUP).

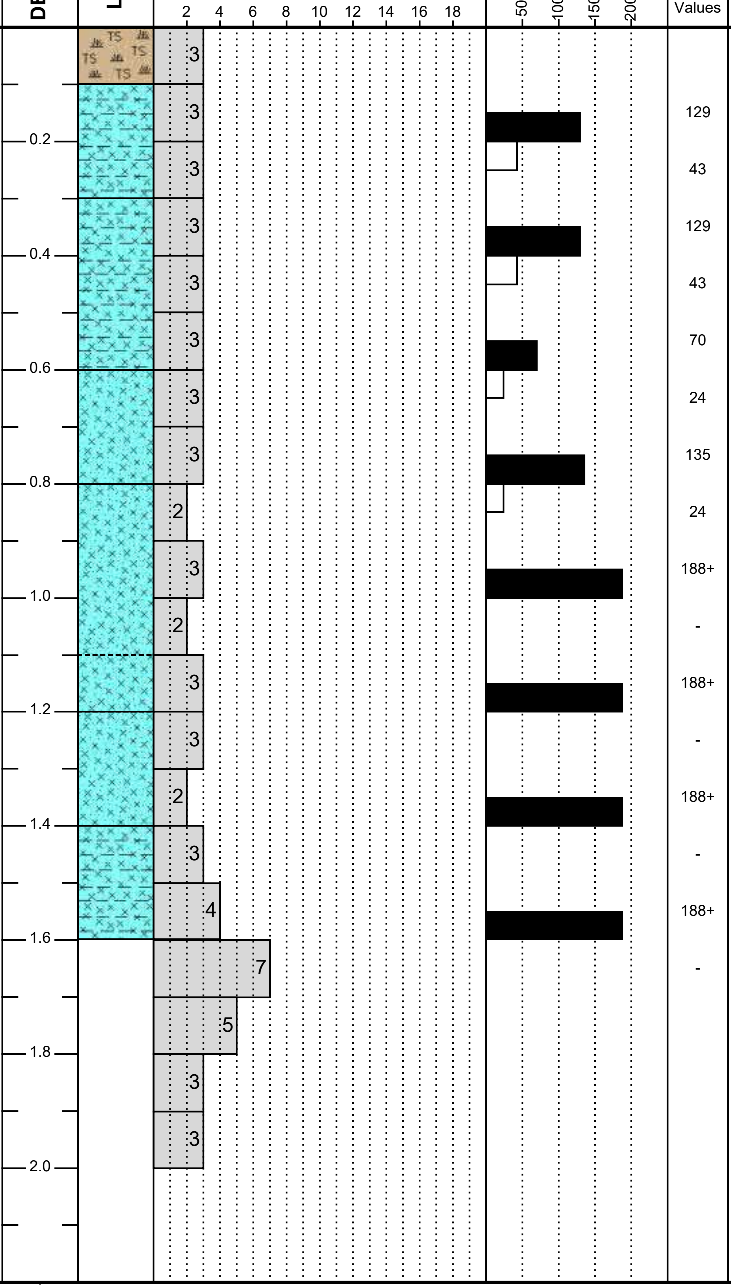
Sandy SILT, with some iron staining; grey with low chroma blue hue.
Very stiff; low plasticity; moist to wet; sand, fine to medium; (WALTON SUBGROUP).

1.1m - 1.2m: Grey - with no bluish hue

Sandy SILT; light grey.
Low plasticity; moist; sand, fine to medium; (WALTON SUBGROUP).

Clayey SILT, with some sand; grey with low chroma bluish hue.
Hard; saturated; sand, fine; (WALTON SUBGROUP).

EOH: 1.60m



PHOTO(S)

REMARKS

Unable to retrieve sample at 1.6 m BEGL.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

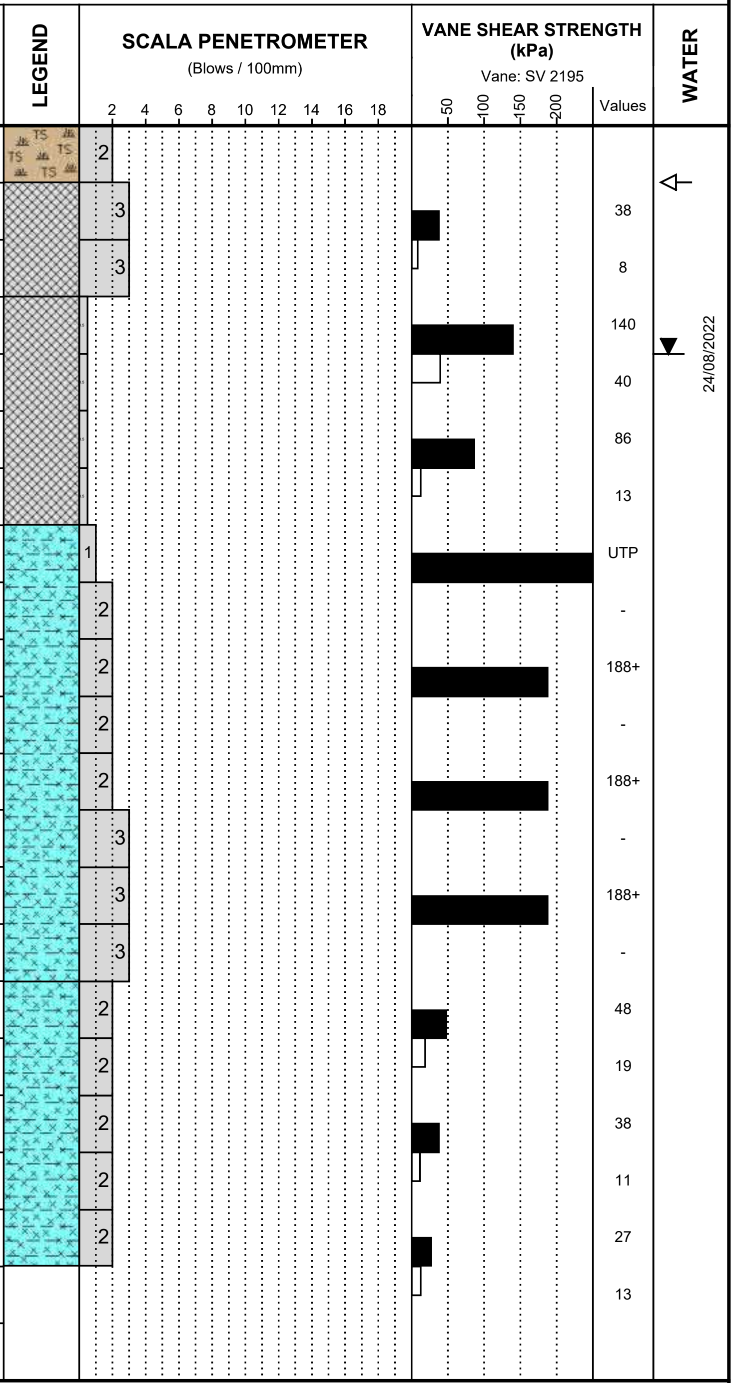
INVESTIGATION LOG

HOLE NO.: BH 12

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 24/08/2022
CO-ORDINATES: 1803995mE, 5792772mN
ELEVATION: Ground
END DATE: 24/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	**SAMPLES**	**DEPTH (m)**
TOPSOIL.		0.0 – 0.1
Clayey SILT, with minor sand, with trace topsoil; dark brown. Soft; wet; sand, fine; (PEDOGENIC B HORIZON).		0.1 – 0.3
Clayey SILT, with some sand; light brown with mottled grey. Stiff to very stiff; low plasticity; dry to moist; sand, fine; (UNCONTROLLED FILL).		0.3 – 0.7
Clayey SILT, with some iron staining and minor manganese nodules, with trace sand; grey . Very stiff; moist to wet; sand, fine; (WALTON SUBGROUP).		0.7 – 1.5
Clayey SILT, with some iron staining and minor manganese nodules and sand; grey . Soft to firm; low plasticity; wet; sand, fine to coarse; (WALTON SUBGROUP). EOH: 2.00m		1.5 – 2.0



Values
38
8
140
40
86
13
UTP
-
188+
-
188+
-
188+
-
48
19
38
11
27
13

PHOTO(S)

REMARKS

Large volume of surface water at borehole location. Test undertaken after heavy rain period.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 13

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 03/08/2022

CO-ORDINATES: 1803991mE, 5792707mN

ELEVATION: Ground

END DATE: 03/08/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

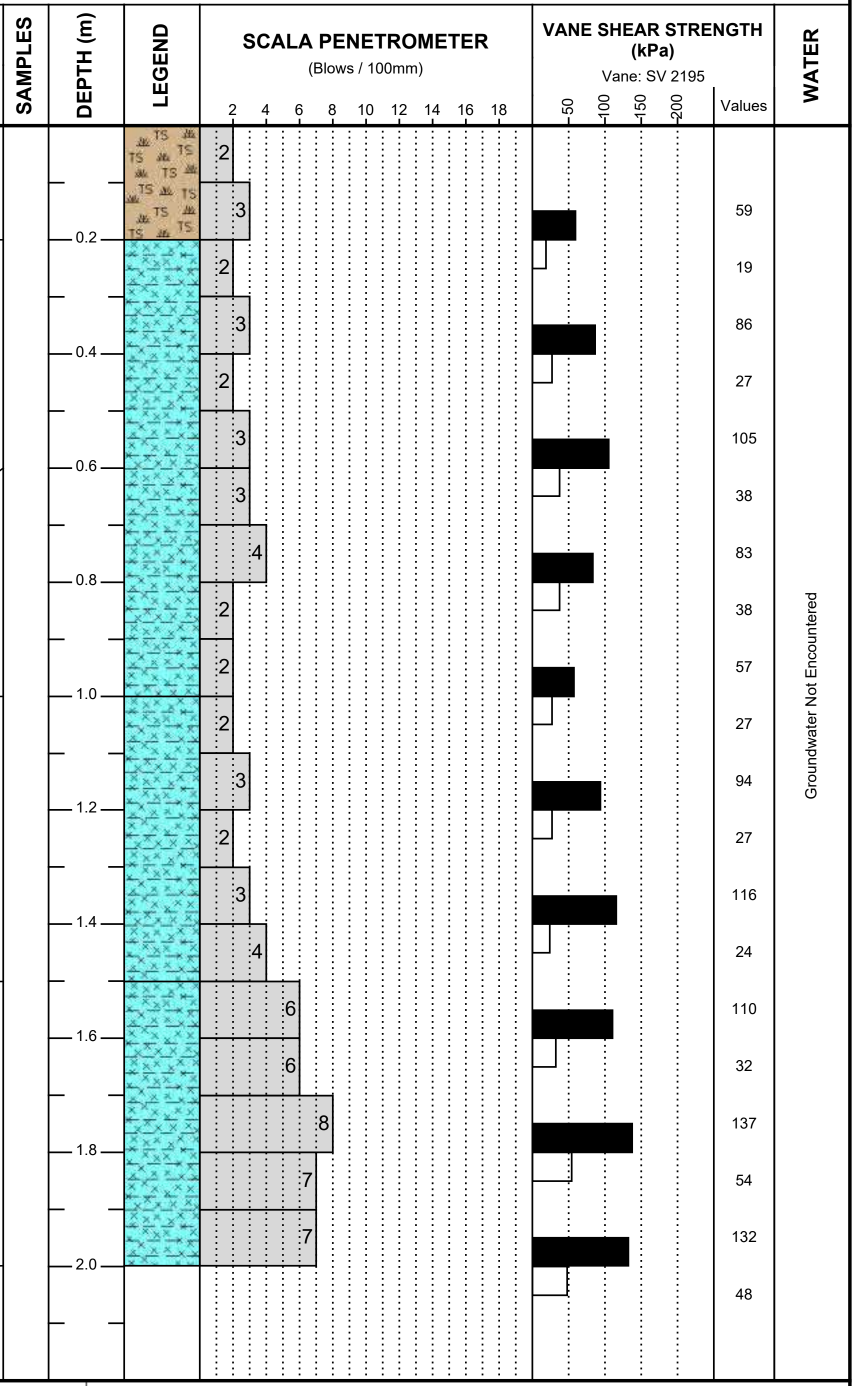
Clayey SILT, with minor iron staining and manganese nodules; light yellowish brown.
Stiff to very stiff; low plasticity; dry; (HAMILTON ASH FORMATION).

0.6m: Higher clay content
Higher iron staining present
Higher plasticity

Clayey SILT, with minor sand, with trace gravel; light yellowish grey.
Stiff to very stiff; moist; sand, fine to coarse; gravel, fine; (WALTON SUBGROUP).

Clayey SILT, with some sand, with trace gravel; greyish brown.
Very stiff; low plasticity; moist; sand, fine to coarse; gravel, fine to medium; (WALTON SUBGROUP).

EOH: 2.00m



PHOTO(S)

REMARKS

WATER

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

INVESTIGATION TYPE

- ☑ Hand Auger
- ☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:34 am

BTWCOMPANY

SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: **BH 14**

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: **211365**

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 12/08/2022

CO-ORDINATES: 1803965mE, 5792589mN

ELEVATION: Ground

END DATE: 12/08/2022

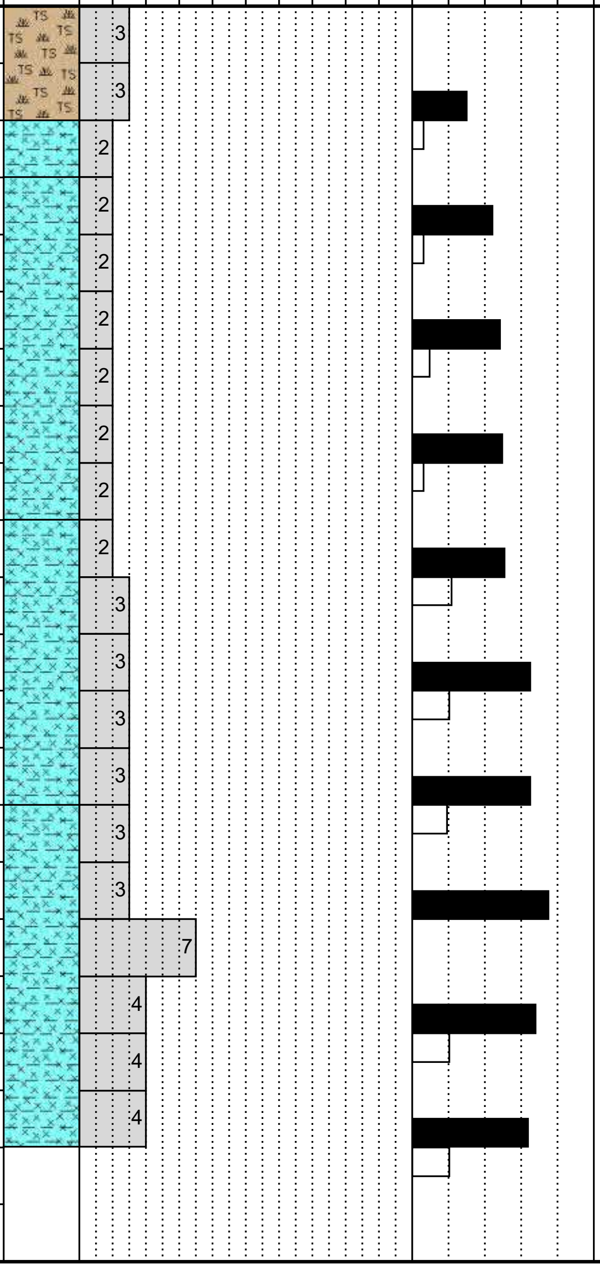
CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)
TOPSOIL.		0.0 – 0.2
Clayey SILT, with some sand; dark brown . Very stiff; non-plastic; dry to moist; sand, fine to medium; (HAMILTON ASH FORMATION).		0.2 – 0.33
Clayey SILT, with trace sand; light brown. Very stiff; low plasticity; moist; sand, fine; (HAMILTON ASH FORMATION).		0.33 – 0.9
Clayey SILT, with trace sand; light brown. Very stiff; high plasticity; moist; sand, fine; (HAMILTON ASH FORMATION).		0.9 – 1.4
Clayey SILT, with trace sand; light yellowish brown. Very stiff to hard; low plasticity; moist; sand, fine; (HAMILTON ASH FORMATION).		1.4 – 2.0
EOH: 2.00m		2.0



DEPTH (m)	SCALA PENETROMETER (Blows / 100mm)	VANE SHEAR STRENGTH (kPa) Values
0.0 – 0.1	3	
0.1 – 0.2	3	75
0.2 – 0.3	2	16
0.3 – 0.4	2	110
0.4 – 0.5	2	16
0.5 – 0.6	2	121
0.6 – 0.7	2	24
0.7 – 0.8	2	124
0.8 – 0.9	2	16
0.9 – 1.0	2	127
1.0 – 1.1	3	54
1.1 – 1.2	3	162
1.2 – 1.3	3	51
1.3 – 1.4	3	162
1.4 – 1.5	3	48
1.5 – 1.6	3	188+
1.6 – 1.7	7	-
1.7 – 1.8	4	170
1.8 – 1.9	4	51
1.9 – 2.0	4	159
2.0 – 2.1		51

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

WATER

▼ Standing Water Level

▷ Out flow

◁ In flow

INVESTIGATION TYPE

☑ Hand Auger

☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:35 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 15

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 24/08/2022
CO-ORDINATES: 1804102mE, 5792796mN
ELEVATION: Ground
END DATE: 24/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with some manganese nodules; brown .
Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT, with minor manganese nodules; light yellowish brown.
Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

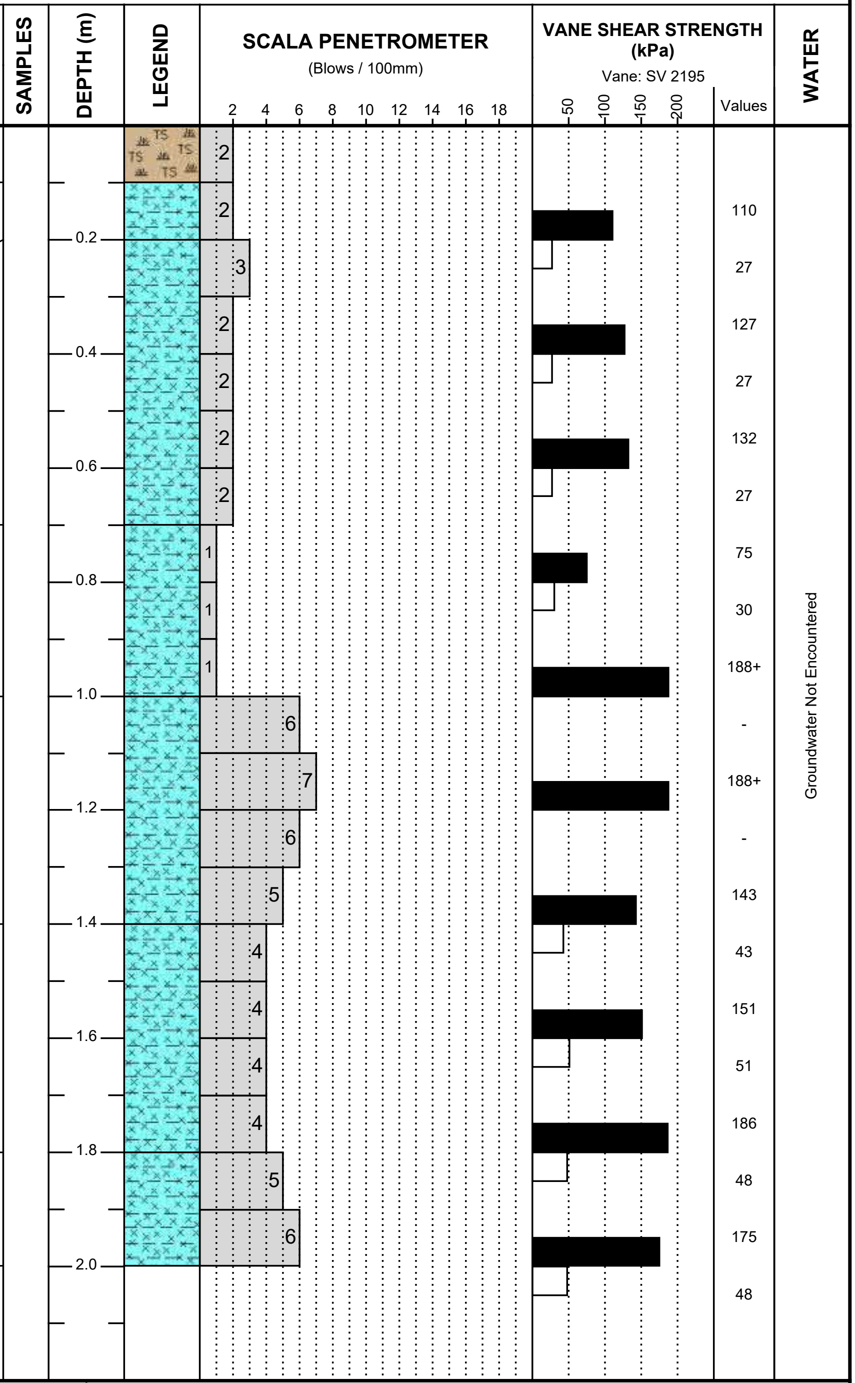
Clayey SILT, with minor manganese nodules; light brown.
Stiff to hard; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT, with minor sand; brown .
Very stiff to hard; high plasticity; dry to moist; sand, fine; (HAMILTON ASH FORMATION).

Clayey SILT, with minor sand; light brown.
Very stiff; low plasticity; dry to moist; sand, fine to medium, pumiceous; (WALTON SUBGROUP).

Clayey SILT, with some sand; light brown.
Very stiff; low plasticity; moist; sand, fine to medium; (WALTON SUBGROUP).

EOH: 2.00m



Values
110
27
127
27
132
27
75
30
188+
-
188+
-
143
43
151
51
186
48
175
48

PHOTO(S)

REMARKS

WATER
▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE
☑ Hand Auger
☐ Test Pit

BTWCOMPANY

INVESTIGATION LOG

HOLE NO.: BH 16

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 03/08/2022

CO-ORDINATES: 1804103mE, 5792692mN

ELEVATION: Ground

END DATE: 03/08/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION

(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with minor sand; dark brown.
Stiff; non-plastic; dry to moist; sand, fine to coarse; (PEDOGENIC B HORIZON).

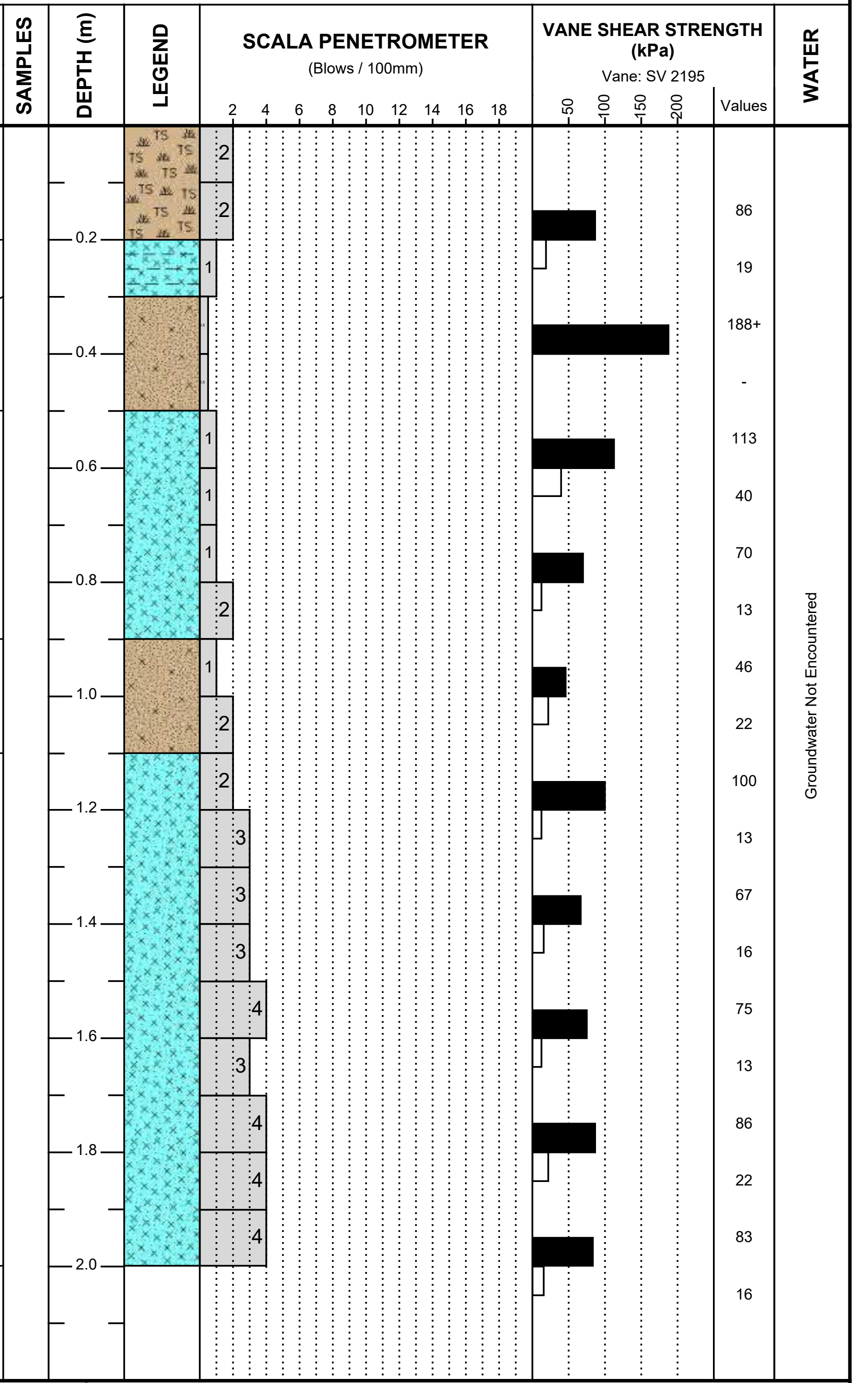
Silty SAND; dark grey mottled with dark brown.
Dense; moist to wet; sand, fine to medium; (WALTON SUBGROUP).

Sandy SILT, with minor clay; light grey.
Firm to stiff; non-plastic; moist; sand, fine; (WALTON SUBGROUP).

Silty SAND, with some manganese nodules; light brown.
Medium dense; wet; sand, fine; (WALTON SUBGROUP).

Sandy SILT; light brown.
Stiff; saturated; sand, fine to medium; (WALTON SUBGROUP).

EOH: 2.00m



PHOTO(S)

REMARKS

WATER

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

INVESTIGATION TYPE

- ☑ Hand Auger
- ☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:38 am

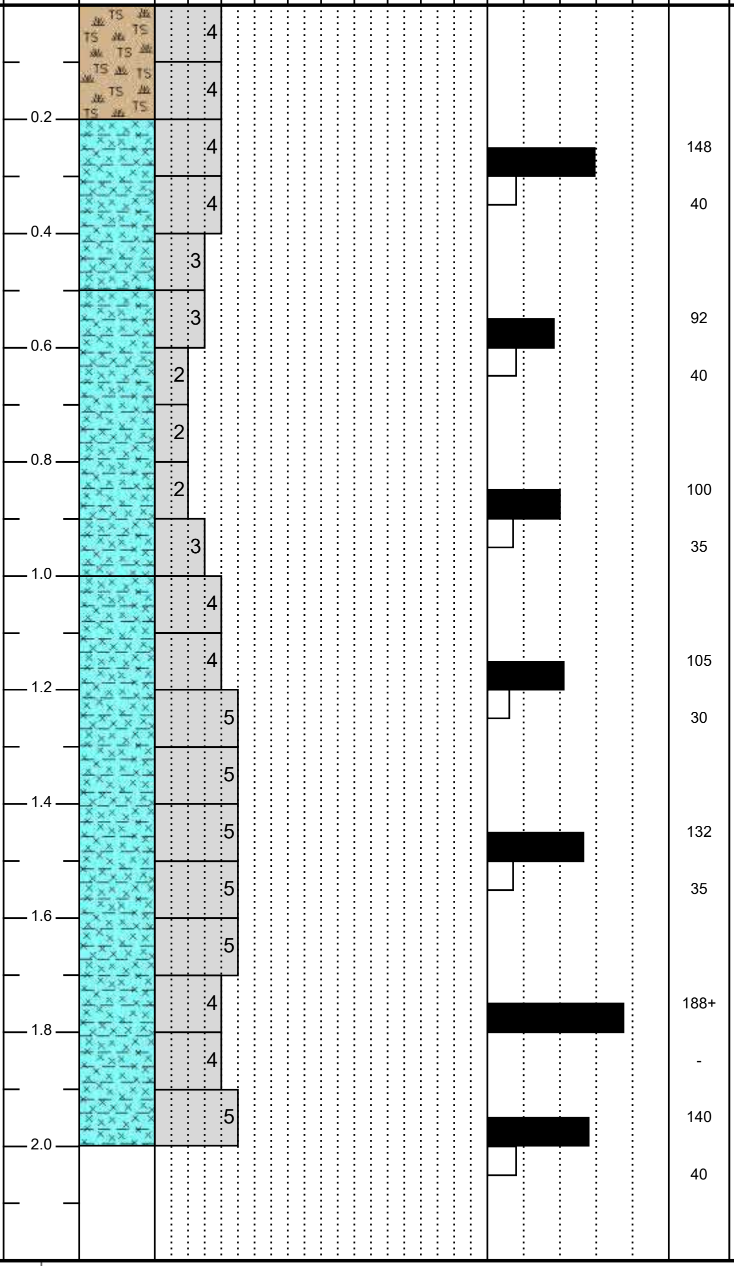
BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: **BH 17**

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: **211365**
SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 12/08/2022
CO-ORDINATES: 1804067mE, 5792655mN
ELEVATION: Ground
END DATE: 12/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)
TOPSOIL.		0.0 – 0.2
Clayey SILT, with minor sand; dark brown. Very stiff; low plasticity; dry to moist; sand, fine; (HAMILTON ASH FORMATION).		0.2 – 0.5
Clayey SILT; light brown. Stiff; high plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.5 – 1.0
Clayey SILT, with some sand; light brown. Very stiff to hard; low plasticity; dry to moist; sand, fine to medium; (HAMILTON ASH FORMATION).		1.0 – 2.0
EOH: 2.00m		2.0



WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

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

INVESTIGATION TYPE
- ☑ Hand Auger
- ☐ Test Pit

BTW COMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 18

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 12/08/2022
CO-ORDINATES: 1804203mE, 5792800mN
ELEVATION: Ground
END DATE: 12/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with minor sand; brown .
Stiff; low plasticity; dry to moist; sand, fine to medium; (HAMILTON ASH FORMATION).

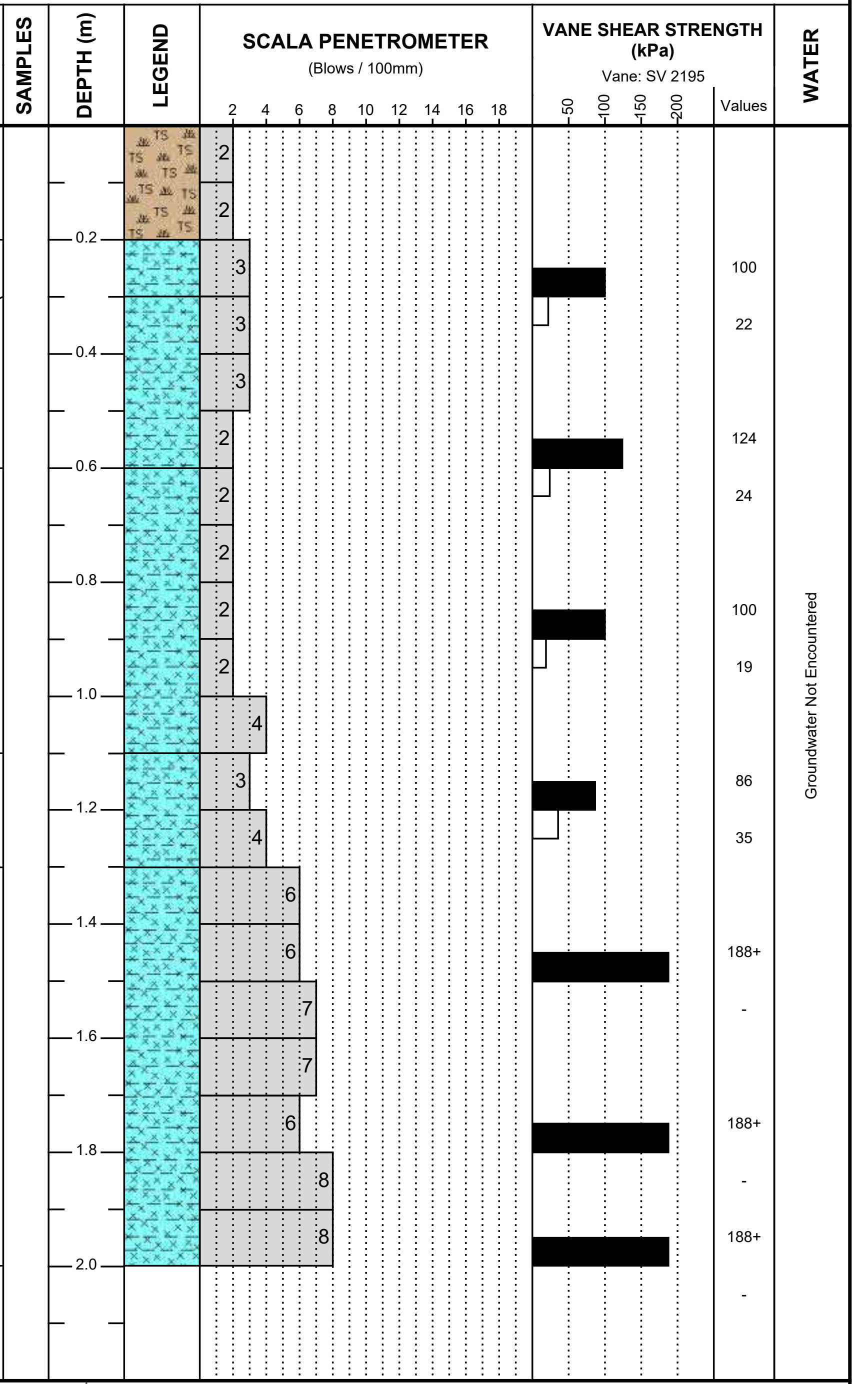
Clayey SILT, with minor manganese nodules; light brown.
Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT; light brown.
Stiff; high plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT, with some manganese nodules; light brown.
Stiff; high plasticity; moist; (HAMILTON ASH FORMATION).

Clayey SILT, with some manganese nodules; light brown.
Hard; non-plastic; dry to moist; (HAMILTON ASH FORMATION).

EOH: 2.00m



PHOTO(S)

REMARKS

WATER
▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE
☑ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:42 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

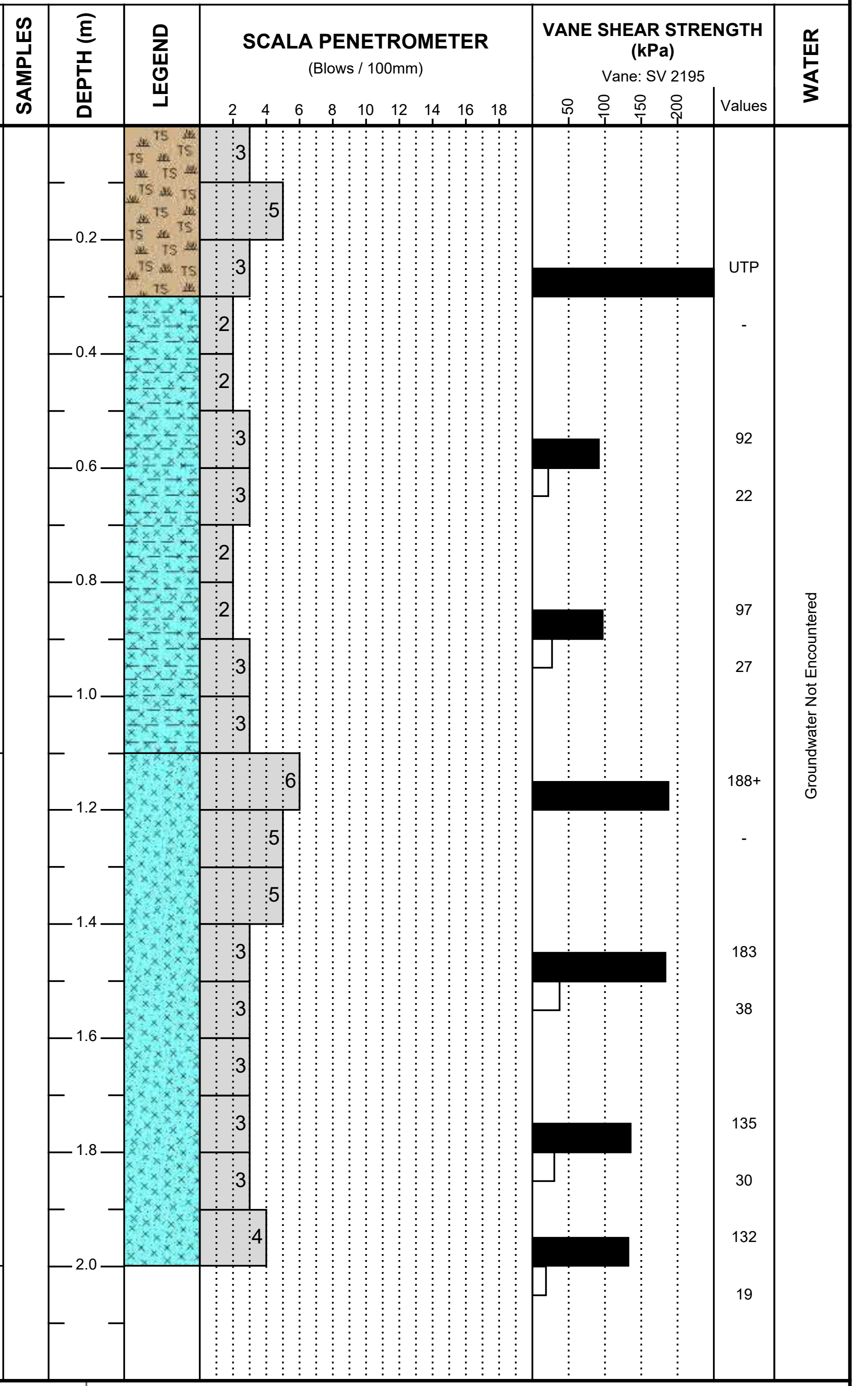
INVESTIGATION LOG

HOLE NO.: BH 19

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 12/08/2022
CO-ORDINATES: 1804147mE, 5792656mN
ELEVATION: Ground
END DATE: 12/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)
Topsoil SILT, with some gravel. Gravel, fine to medium; (TOPSOIL).
Clayey SILT, with trace sand; light brown. Stiff; low plasticity; moist; sand, fine; (HAMILTON ASH FORMATION) .
Sandy SILT, with some clay; grey brown. Very stiff; low plasticity; moist to wet; (WALTON SUBGROUP). EOH: 2.00m



PHOTO(S)

REMARKS

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:43 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 20

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 12/08/2022
CO-ORDINATES: 1804083mE, 5792567mN
ELEVATION: Ground
END DATE: 12/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

SAMPLES | **DEPTH (m)** | **LEGEND** | **SCALA PENETROMETER** (Blows / 100mm) | **VANE SHEAR STRENGTH (kPa)** Vane: SV 2195 | **WATER**

TOPSOIL.

0.2

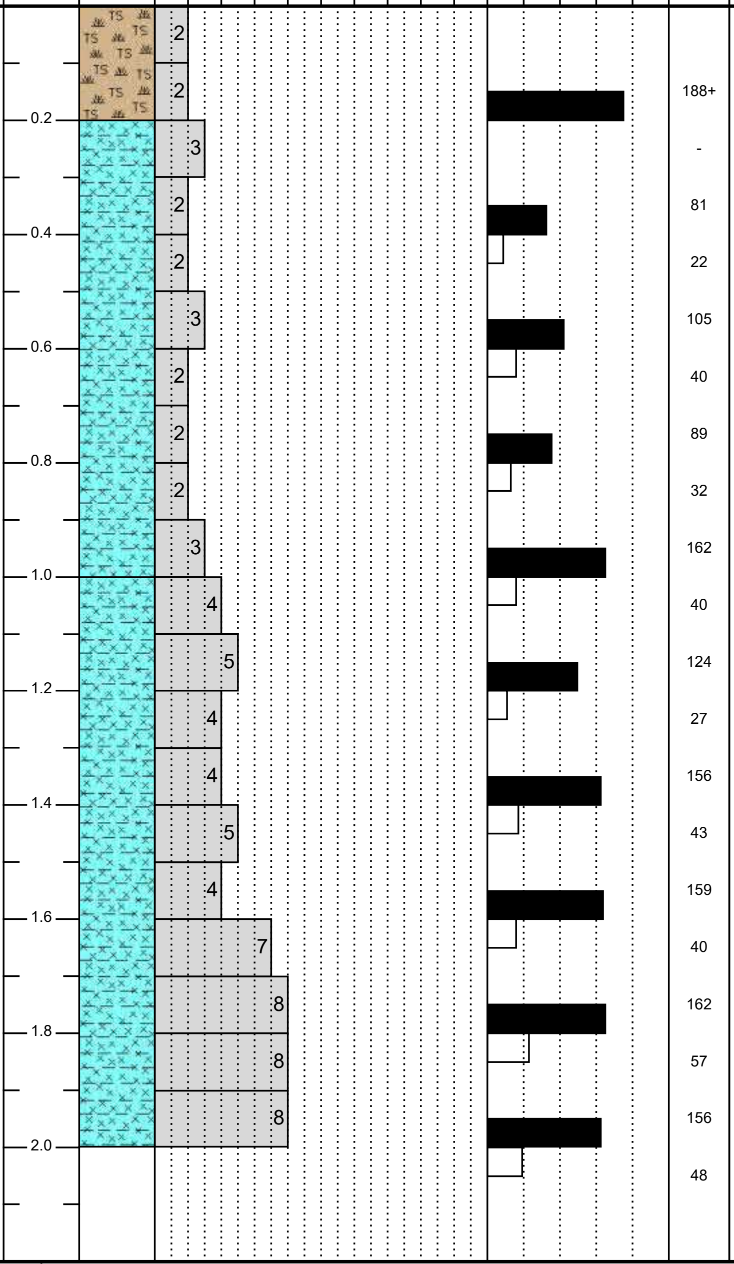
Clayey SILT, with minor sand; dark brown.
Stiff to very stiff; low plasticity; dry to moist; sand, fine; (HAMILTON ASH FORMATION).

1.0

Clayey SILT; brown .
Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

EOH: 2.00m

2.0



SCALA PENETROMETER (Blows / 100mm)	Values
2	
2	188+
3	-
2	81
2	22
3	105
2	40
2	89
2	32
3	162
4	40
5	124
4	27
4	156
5	43
4	159
7	40
8	162
8	57
8	156
	48

PHOTO(S)

REMARKS

WATER
▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE
☑ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:45 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 21

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 24/08/2022
CO-ORDINATES: 1804272mE, 5792636mN
ELEVATION: Ground
END DATE: 24/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

SAMPLES | **DEPTH (m)** | **LEGEND**

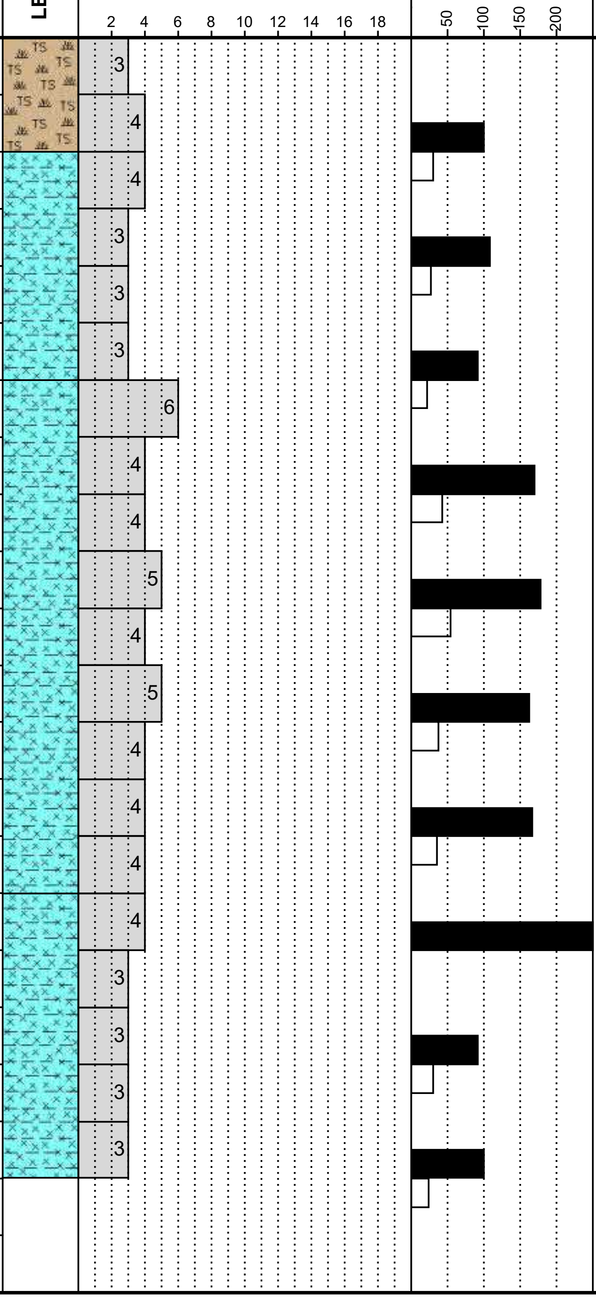
SCALA PENETROMETER
(Blows / 100mm)

VANE SHEAR STRENGTH (kPa)
Vane: SV 2195

WATER

TOPSOIL.	0.0 – 0.2
Clayey SILT, with minor manganese nodules; brown . Stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).	0.2 – 0.6
Clayey SILT, with some manganese nodules; light yellowish brown. Very stiff; low plasticity; moist; (HAMILTON ASH FORMATION).	0.6 – 1.5
Clayey SILT, with minor sand; light brown. Stiff; low plasticity; moist; sand, fine to medium; (HAMILTON ASH FORMATION).	1.5 – 2.0

EOH: 2.00m



DEPTH (m)	SCALA PENETROMETER	Values
	3	
0.2	4	100
	4	30
0.4	3	108
	3	27
0.6	3	92
	6	22
0.8	4	170
	4	43
1.0	5	178
	4	54
1.2	5	162
	4	38
1.4	4	167
	4	35
1.6	4	UTP
	3	-
1.8	3	92
	3	30
2.0	3	100
		24

Groundwater Not Encountered

PHOTO(S)

REMARKS

WATER

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

INVESTIGATION TYPE

- ☑ Hand Auger
- ☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:46 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 22

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 24/08/2022
CO-ORDINATES: 1804290mE, 5792719mN
ELEVATION: Ground
END DATE: 24/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with trace sand; dark brown.
Very stiff; non-plastic; moist; sand, fine; (PEDOGENIC B. HORIZON).

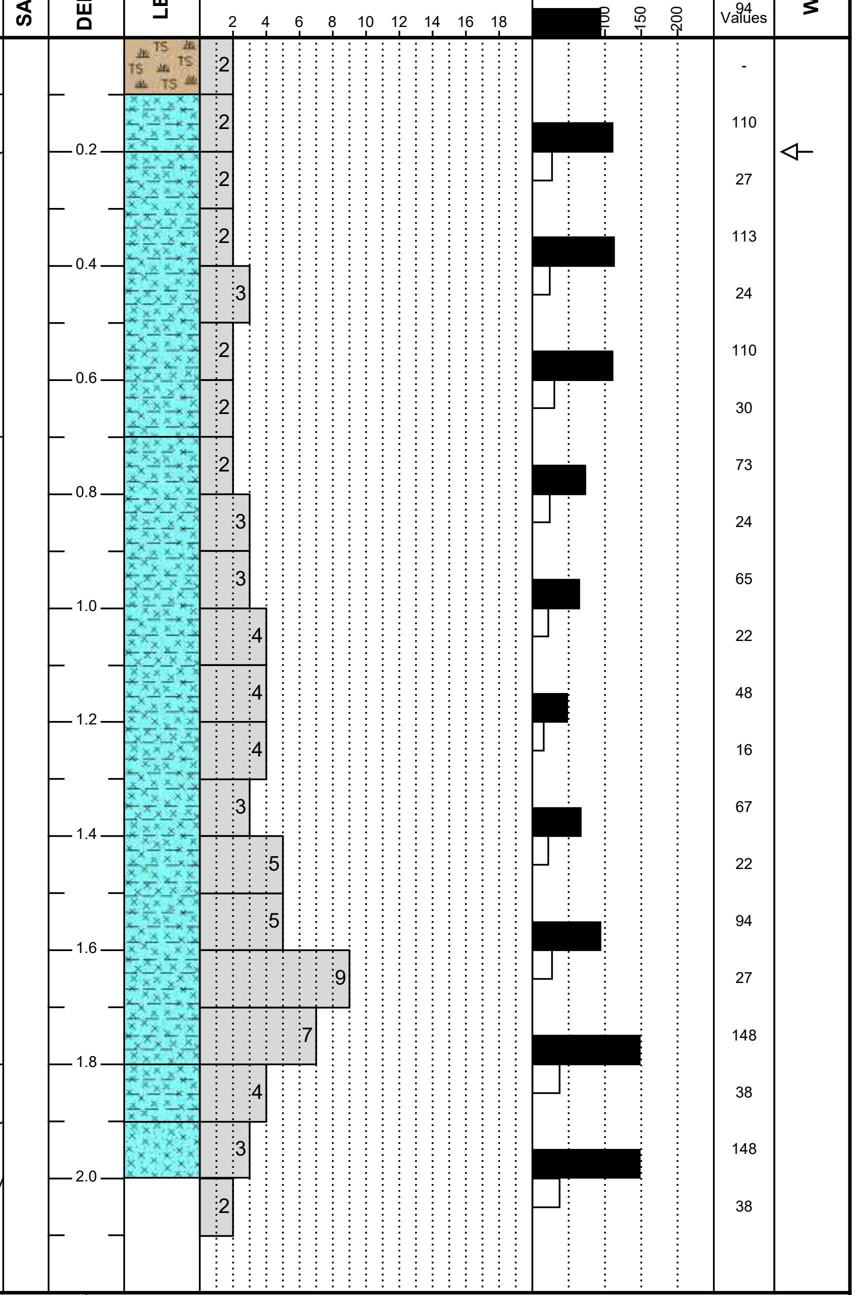
Clayey SILT, with minor manganese nodules; light yellowish brown.
Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT, with minor manganese nodules and sand; light brown.
Firm to stiff; low plasticity; moist; sand, fine to medium, pumiceous sand; (HAMILTON ASH FORMATION).

Clayey SILT, with minor sand; grey brown.
Very stiff; low plasticity; moist; sand, fine to medium, pumiceous sand; (WALTON SUBGROUP).

Sandy SILT, with some iron staining; grey .
Very stiff; low plasticity; moist; sand, fine to coarse, pumiceous sand; (WALTON SUBGROUP)
. EOH: 2.00m

SAMPLES | **DEPTH (m)** | **LEGEND** | **SCALA PENETROMETER** (Blows / 100mm) | **VANE SHEAR STRENGTH (kPa)** Vane: SV 2195 | 94 Values | **WATER**



2	-
2	110
2	27
2	113
3	24
2	110
2	30
2	73
3	24
3	65
4	22
4	48
4	16
3	67
5	22
5	94
9	27
7	148
4	38
3	148
2	38

PHOTO(S)

REMARKS

Perched water encountered at 0.2 mm BEGL.

WATER

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

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:47 am

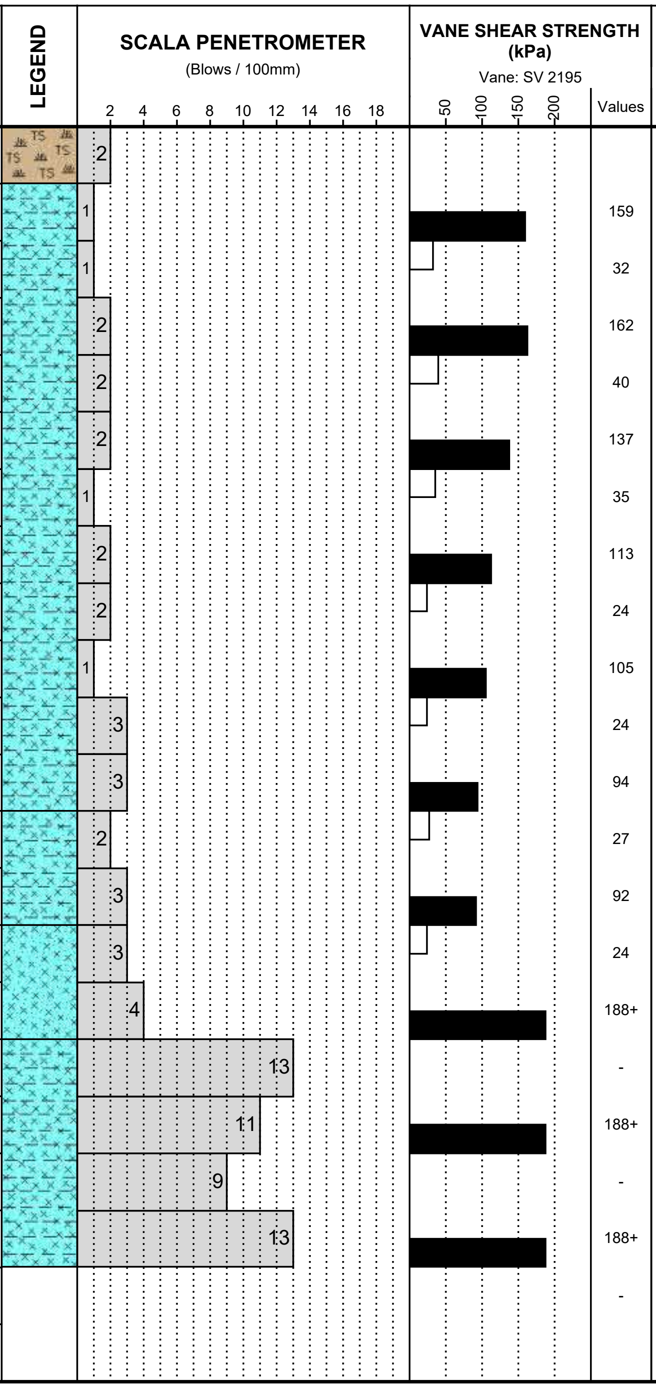
BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 23

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 24/08/2022
CO-ORDINATES: 1804378mE, 5792750mN
ELEVATION: Ground
END DATE: 24/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin



MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 100mm)	VANE SHEAR STRENGTH (kPa) Values	WATER
TOPSOIL.			TS	2		Groundwater Not Encountered
Clayey SILT, with minor manganese nodules; light yellowish brown. Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).				1	159	
		0.2		1	32	
				2	162	
		0.4		2	40	
				2	137	
		0.6		1	35	
				2	113	
		0.8		2	24	
				1	105	
		1.0		3	24	
				3	94	
Clayey SILT, with minor manganese nodules and sand; light brown. Stiff; low plasticity; moist; sand, fine; (HAMILTON ASH FORMATION).		1.2		2	27	
				3	92	
Sandy SILT, with minor iron staining. Stiff; low plasticity; moist; sand, fine to medium; (HAMILTON ASH FORMATION).		1.4		3	24	
				4	188+	
Clayey SILT, with some sand, with minor manganese nodules and iron staining ; light brown. Hard; low plasticity; moist; sand, fine to medium; (HAMILTON ASH FORMATION).		1.6		13	-	
				11	188+	
		1.8		9	-	
EOH: 2.00m				13	188+	
		2.0			-	

PHOTO(S)

REMARKS

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:49 am

INVESTIGATION LOG

HOLE NO.: BH 24

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 24/08/2022
CO-ORDINATES: 1804341mE, 5792631mN
ELEVATION: Ground
END DATE: 24/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

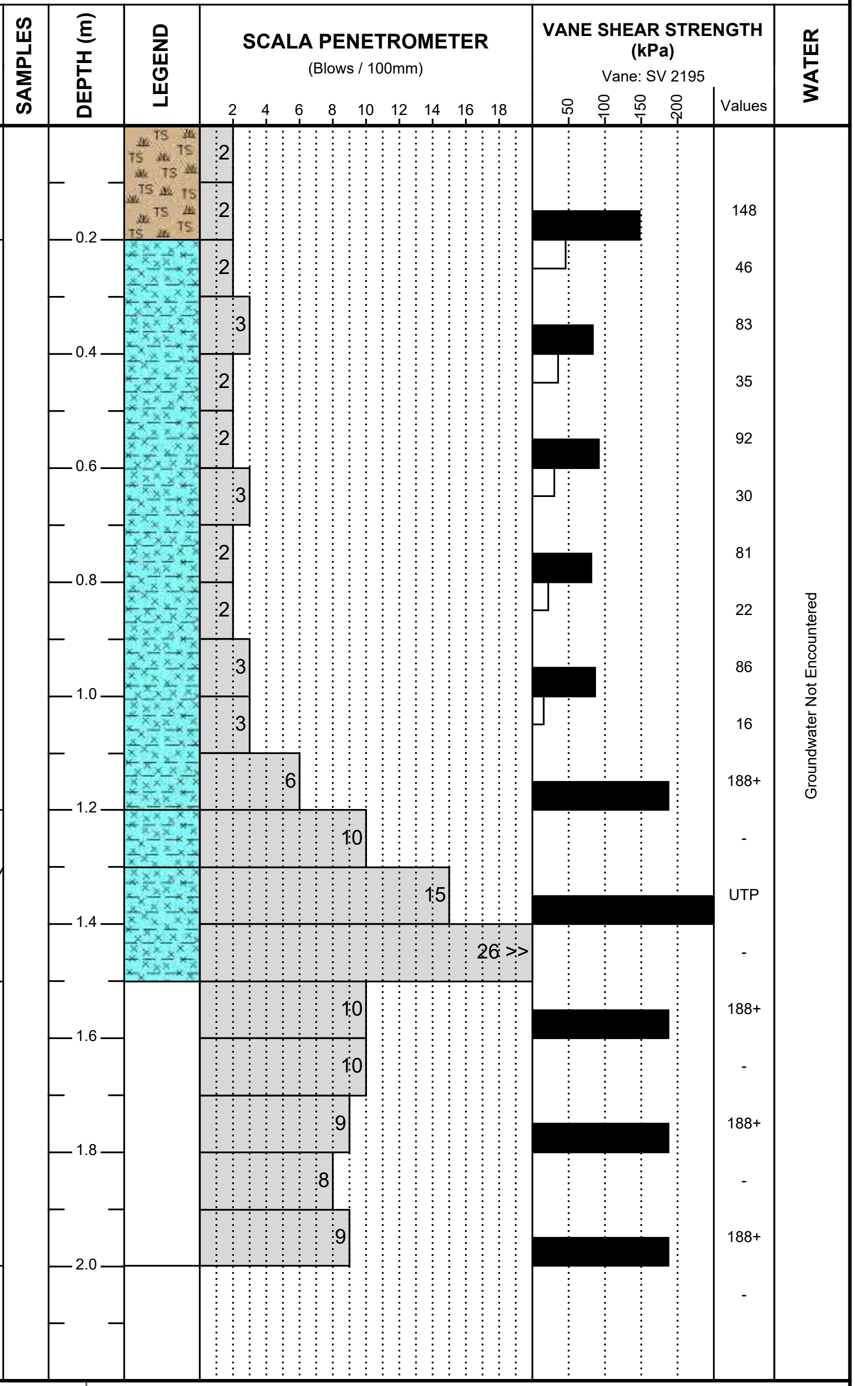
Clayey SILT, with minor manganese nodules.
Stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT, with some manganese nodules and iron staining, with trace sand; brown .
Hard; low plasticity; dry to moist; sand, fine; (HAMILTON ASH FORMATION).

Clayey SILT, with minor manganese nodules and iron staining, with trace sand; brown .
Hard; low plasticity; dry; sand, fine; (PALEOSOL LAYER).

Clayey SILT, with minor manganese nodules and iron staining; light brown.
Hard; dry; (HAMILTON ASH FORMATION).

EOH: 2.00m



PHOTO(S)

REMARKS

WATER
▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE
☑ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:50 am

INVESTIGATION LOG

HOLE NO.: BH 25

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 24/08/2022

CO-ORDINATES: 1804375mE, 5792556mN

ELEVATION: Ground

END DATE: 24/08/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION

(See Classification & Symbology sheet for details)

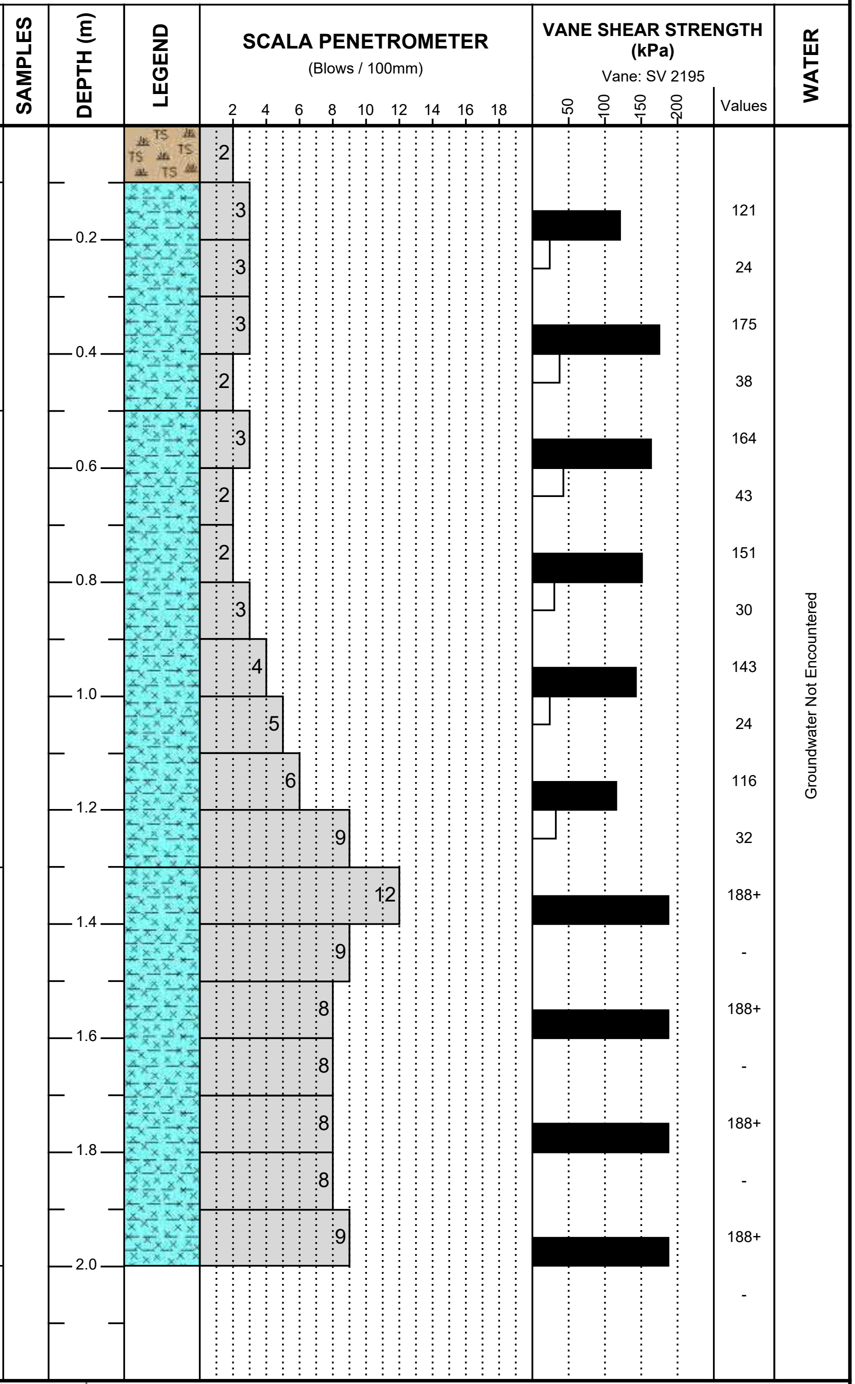
TOPSOIL.

Clayey SILT, with some manganese nodules; dark brown.
Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT, with minor manganese nodules; light brown.
Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT, with some manganese nodules; brown .
Hard; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

EOH: 2.00m



SCALA PENETROMETER	Values
2	
3	121
3	24
3	175
2	38
3	164
2	43
2	151
3	30
4	143
5	24
6	116
9	32
12	188+
9	-
8	188+
8	-
8	188+
8	-
9	188+
	-

PHOTO(S)

REMARKS

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

☑ Hand Auger
☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 26

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 24/08/2022
CO-ORDINATES: 1804247mE, 5792507mN
ELEVATION: Ground
END DATE: 24/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

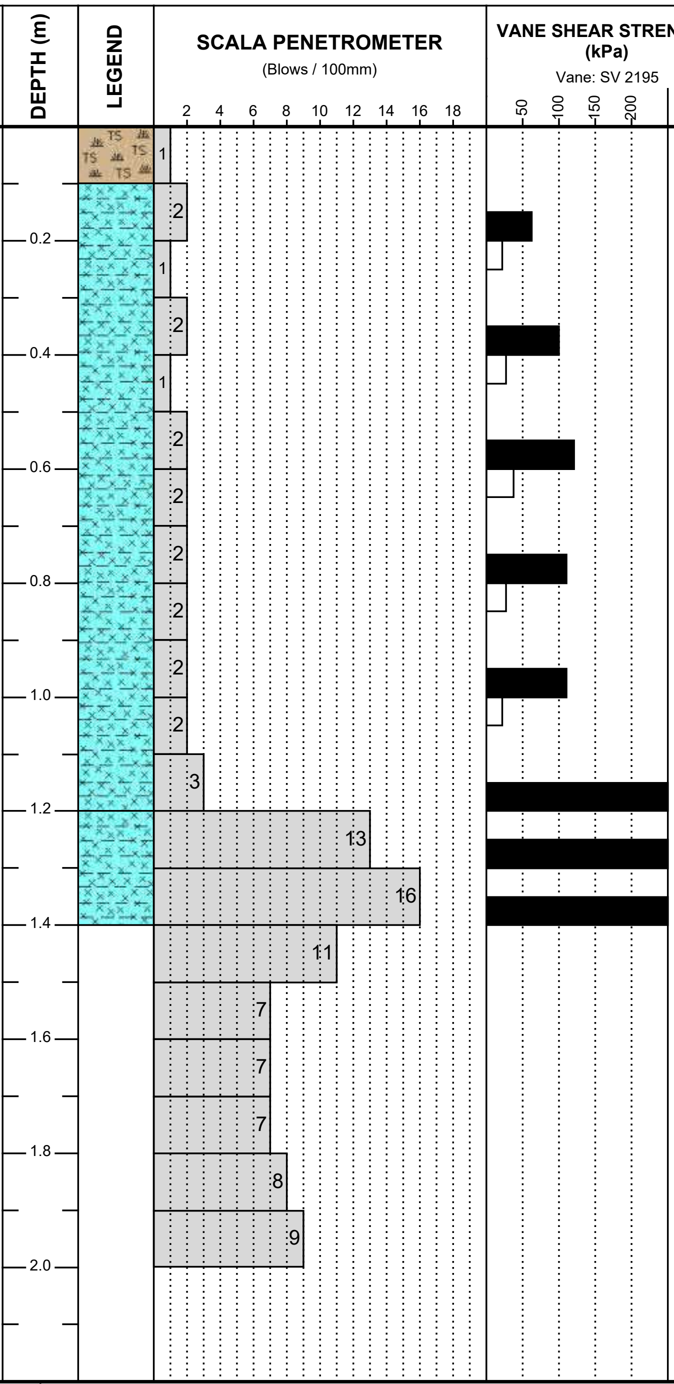
MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with minor manganese nodules; light brown . Stiff to very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).

Clayey SILT, with trace sand; light brown. Hard; low plasticity; dry; sand, fine; (PALEOSOL LAYER).

EOH: 2.00m



Depth (m)	Scala (Blows / 100mm)	Vane Values
0.0–0.1	1	
0.1–0.2	2	62
0.2–0.3	1	22
0.3–0.4	2	100
0.4–0.5	1	27
0.5–0.6	2	121
0.6–0.7	2	38
0.7–0.8	2	110
0.8–0.9	2	27
0.9–1.0	2	110
1.0–1.1	2	22
1.1–1.2	3	UTP
1.2–1.3	13	UTP
1.3–1.4	16	UTP
1.4–1.5	11	-
1.5–1.6	7	
1.6–1.7	7	
1.7–1.8	7	
1.8–1.9	8	
1.9–2.0	9	

WATER
Groundwater Not Encountered

PHOTO(S)

REMARKS

Unable to retrieve sample at 1.4 m BEGL.

WATER
- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE
☑ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:52 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 27

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 24/08/2022

CO-ORDINATES: 1804486mE, 5792726mN

ELEVATION: Ground

END DATE: 24/08/2022

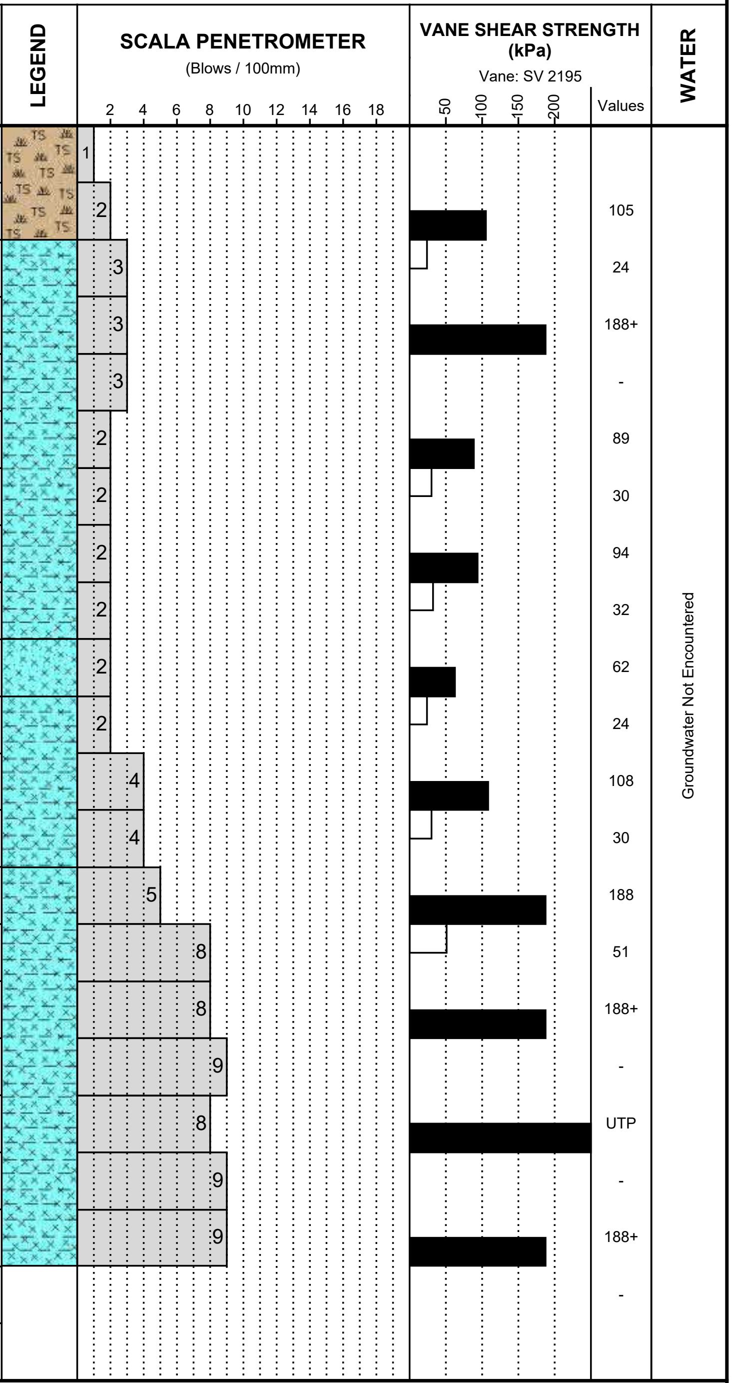
CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)
TOPSOIL.		0.0 – 0.2
Clayey SILT, with minor manganese nodules; light brown. Stiff to hard; low plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.2 – 0.9
Sandy SILT, with some iron staining; whitish grey. Low plasticity; dry to moist; sand, fine to medium, pumiceous sandy SILT; Halloysite Layer, (HAMILTON ASH FORMATION).		0.9 – 1.0
Clayey SILT, with minor manganese nodules; light brown. Stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).		1.0 – 1.3
Clayey SILT, with minor manganese nodules; brown . Hard; low plasticity; dry to moist; (HAMILTON ASH FORMATION).		1.3 – 2.0
EOH: 2.00m		2.0



PHOTO(S)

REMARKS

WATER

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

INVESTIGATION TYPE

- ☑ Hand Auger
- ☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:54 am

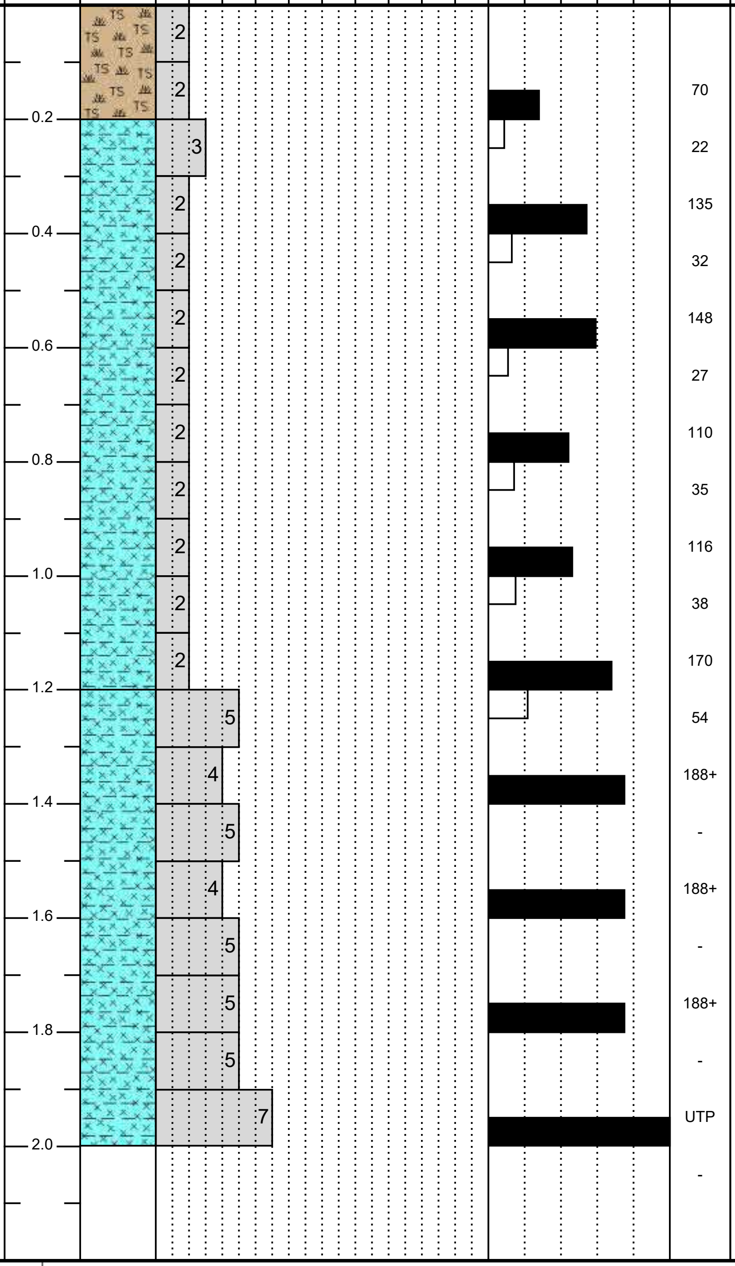
BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: BH 28

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365
SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 24/08/2022
CO-ORDINATES: 1804454mE, 5792538mN
ELEVATION: Ground
END DATE: 24/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	**SAMPLES**	**DEPTH (m)**
TOPSOIL.		0.0 – 0.2
Clayey SILT, with minor manganese nodules; light brown . Very stiff; low plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.2 – 1.2
Clayey SILT, with minor manganese nodules; brown . Hard; low plasticity; dry to moist; (HAMILTON ASH FORMATION). EOH: 2.00m		1.2 – 2.0



WATER
Groundwater Not Encountered

PHOTO(S)

REMARKS

WATER
▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE
☑ Hand Auger
☐ Test Pit

INVESTIGATION LOG

HOLE NO.: IP01

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

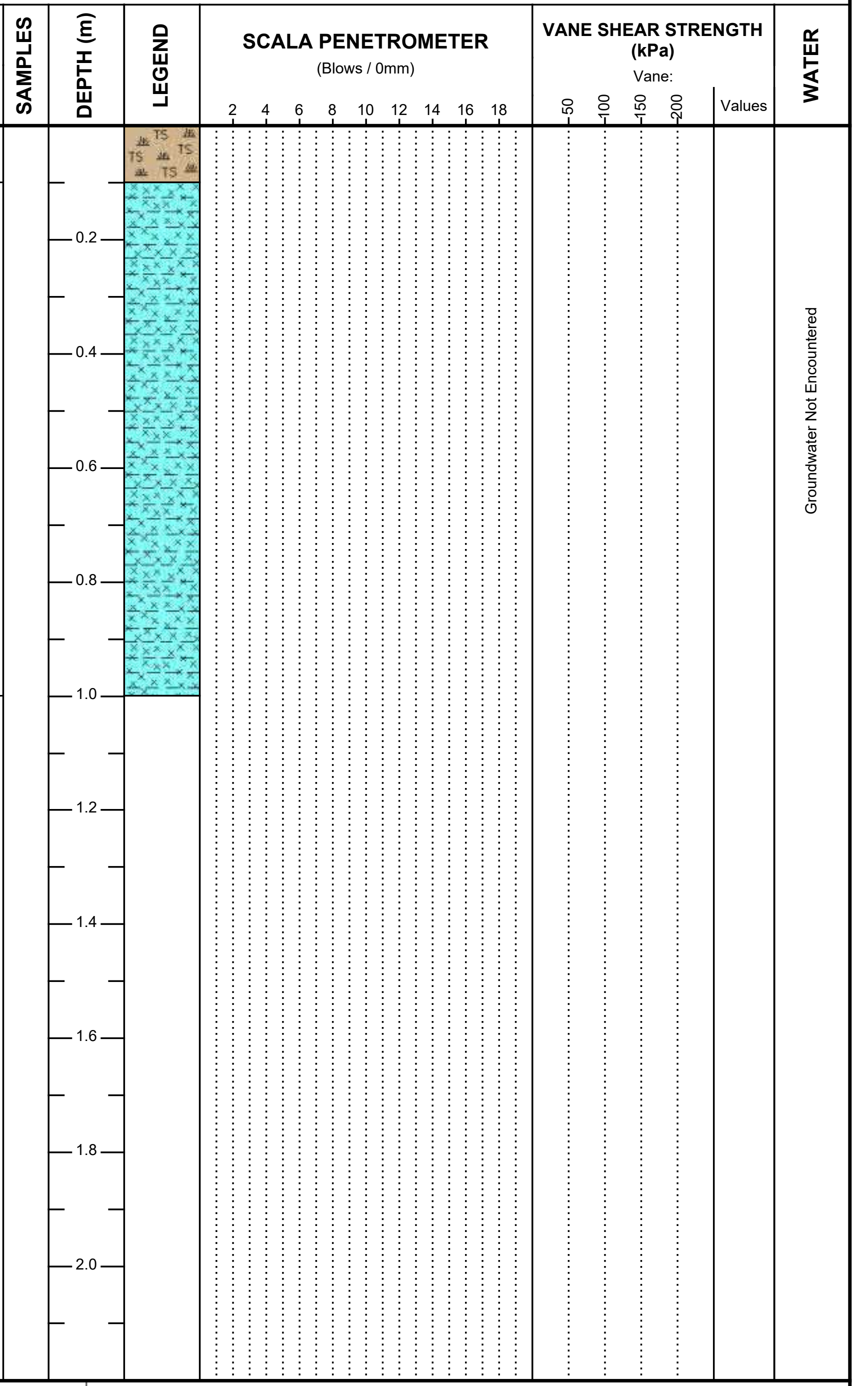
SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 12/08/2022
CO-ORDINATES: 1804008mE, 5792820mN
ELEVATION: Ground
END DATE: 12/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT; brown .
Dry to moist; (HAMILTON ASH FORMATION).

EOH: 1.00m



PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

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

INVESTIGATION TYPE

- ☐ Hand Auger
- ☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP02

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

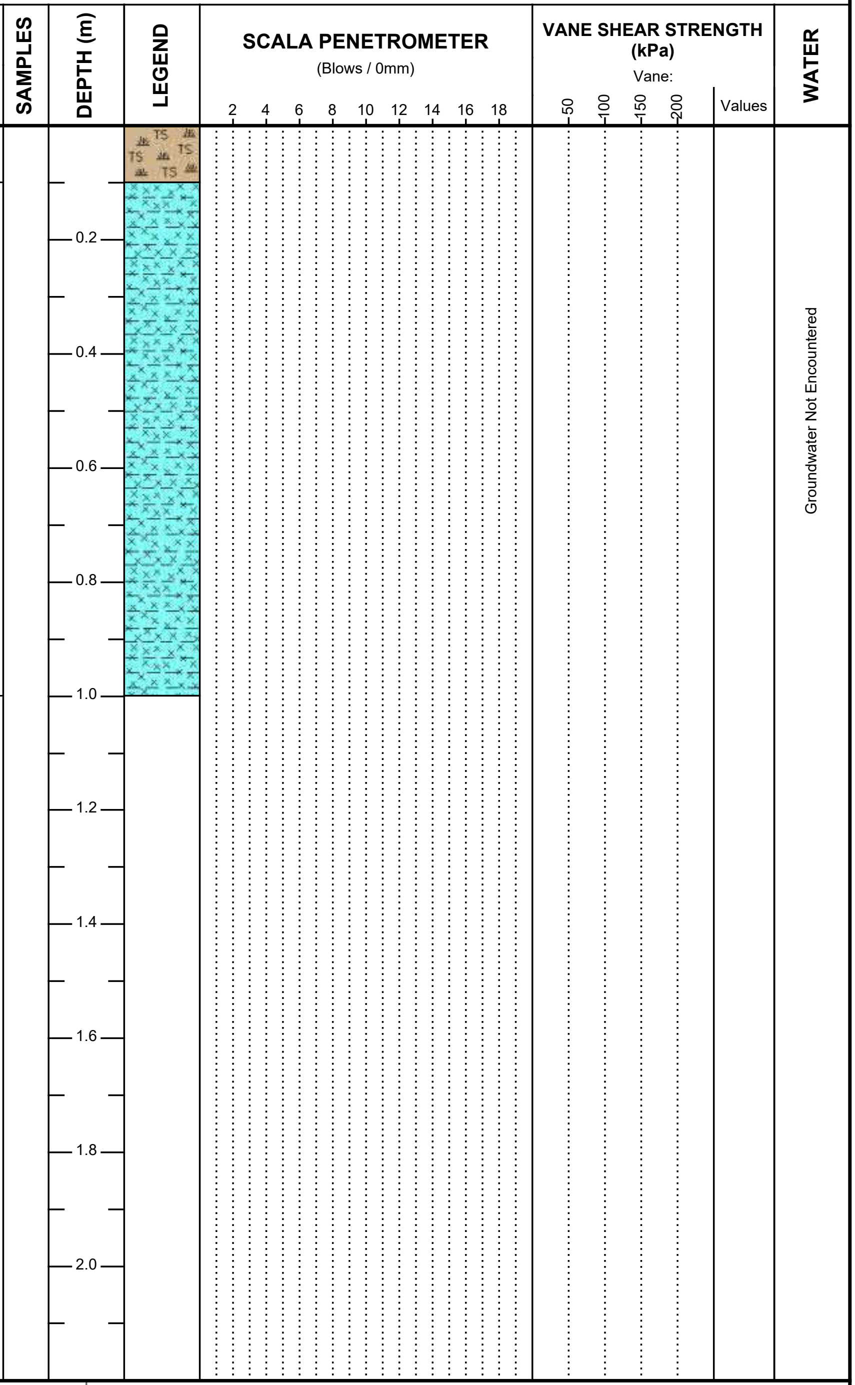
SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 12/08/2022
CO-ORDINATES: 1804028mE, 5792827mN
ELEVATION: Ground
END DATE: 12/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT; brown .
Dry to moist; (HAMILTON ASH FORMATION).

EOH: 1.00m



PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

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

INVESTIGATION TYPE

- ☐ Hand Auger
- ☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP03

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 12/08/2022
CO-ORDINATES: 1804045mE, 5792832mN
ELEVATION: Ground
END DATE: 12/08/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 0mm) 2 4 6 8 10 12 14 16 18	VANE SHEAR STRENGTH (kPa) Vane: 50 100 150 200	Values	WATER
TOPSOIL.		0.0 – 0.1	TS				Groundwater Not Encountered
Clayey SILT; brown . Dry to moist; (HAMILTON ASH FORMATION).		0.1 – 1.0					
EOH: 1.00m		1.0					

Depth scale: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0

PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☐ Hand Auger
☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP04

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

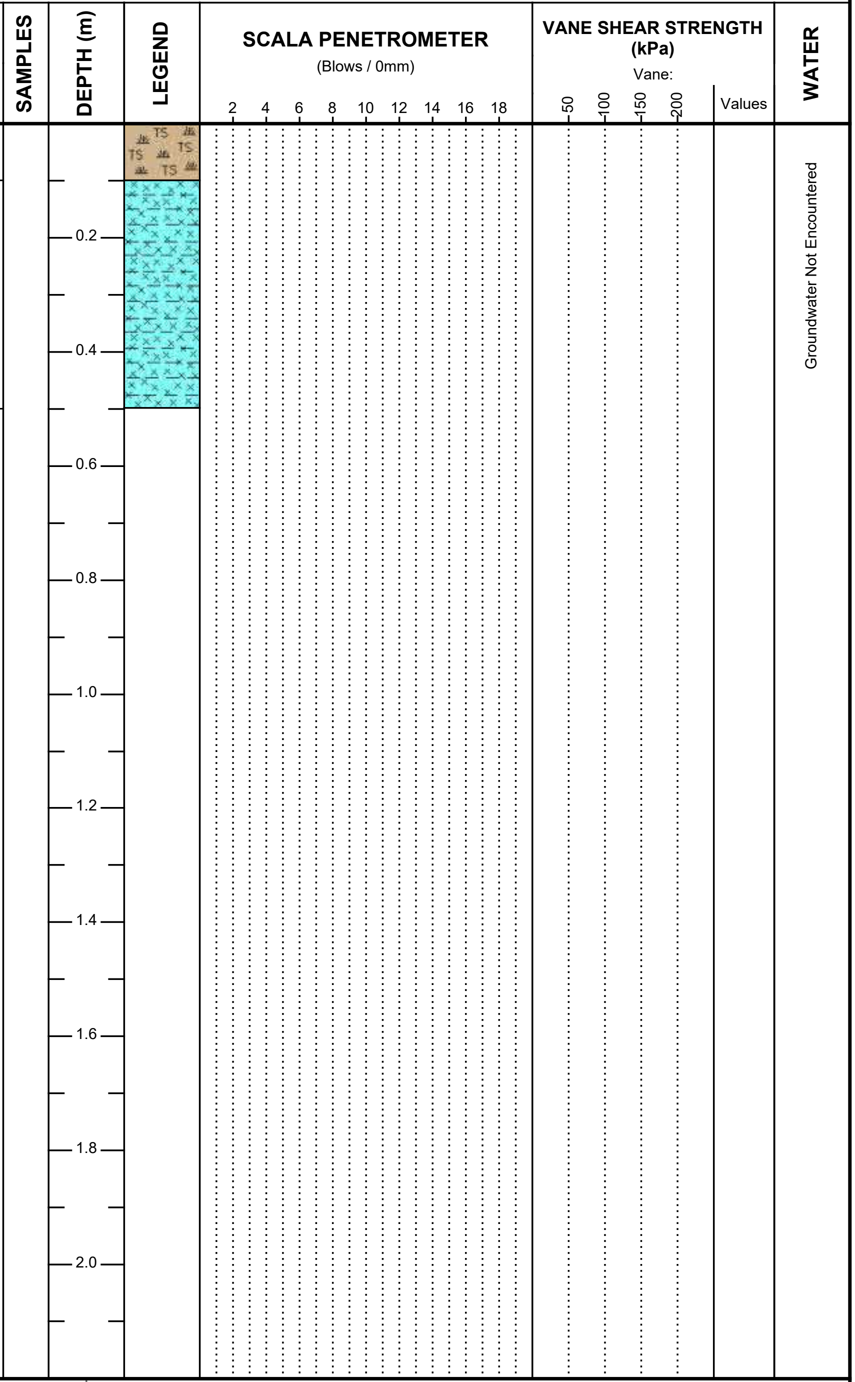
SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 08/09/2022
CO-ORDINATES: 1803968mE, 5792798mN
ELEVATION: Ground
END DATE: 08/09/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with minor manganese nodules.
Low plasticity; dry to moist; (HAMILTON ASH FORMATION).

EOH: 0.50m



PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☐ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:52:59 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP05

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 08/09/2022
CO-ORDINATES: 1803972mE, 5792817mN
ELEVATION: Ground
END DATE: 08/09/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 0mm) 2 4 6 8 10 12 14 16 18	VANE SHEAR STRENGTH (kPa) Vane: 50 100 150 200	Values	WATER
TOPSOIL.			TS				Groundwater Not Encountered
Clayey SILT, with minor manganese nodules. Low plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.2 0.4					
EOH: 0.50m							
		0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0					

PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☐ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:53:00 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP06

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 08/09/2022
CO-ORDINATES: 1803952mE, 5792809mN
ELEVATION: Ground
END DATE: 08/09/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 0mm) 2 4 6 8 10 12 14 16 18	VANE SHEAR STRENGTH (kPa) Vane: 50 100 150 200	Values	WATER
TOPSOIL.			TS				Groundwater Not Encountered
Clayey SILT, with minor manganese nodules. Low plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.2 0.4					
EOH: 0.50m							
		0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0					

PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☐ Hand Auger
☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:53:02 am

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP07

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 08/09/2022
CO-ORDINATES: 1803985mE, 5792796mN
ELEVATION: Ground
END DATE: 08/09/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 0mm) 2 4 6 8 10 12 14 16 18	VANE SHEAR STRENGTH (kPa) Vane: 50 100 150 200	Values	WATER
Clayey SILT, with some topsoil and gravel, with minor sand. Non-plastic; dry to moist; gravel, fine to coarse; sand, fine, pumiceous; (UNCONTROLLED FILL).		0.0 – 0.2	▨				Groundwater Not Encountered
Clayey SILT, with minor manganese nodules. Low plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.2 – 0.5	▨				
EOH: 0.50m							

Depth scale: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0

PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

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

INVESTIGATION TYPE

- ☐ Hand Auger
- ☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:53:03 am

BTW COMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP08

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 08/09/2022
CO-ORDINATES: 1803992mE, 5792807mN
ELEVATION: Ground
END DATE: 08/09/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	**SAMPLES**	**DEPTH (m)**	**LEGEND**	**SCALA PENETROMETER** (Blows / 0mm) 2 4 6 8 10 12 14 16 18	**VANE SHEAR STRENGTH (kPa)** Vane: 50 100 150 200	Values	**WATER**
TOPSOIL.			TS				Groundwater Not Encountered
Clayey SILT, with minor manganese nodules. Low plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.2 0.4					
EOH: 0.50m							
		0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0					

PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☐ Hand Auger
☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP09

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 08/09/2022

CO-ORDINATES: 1804002mE, 5792821mN

ELEVATION: Ground

END DATE: 08/09/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

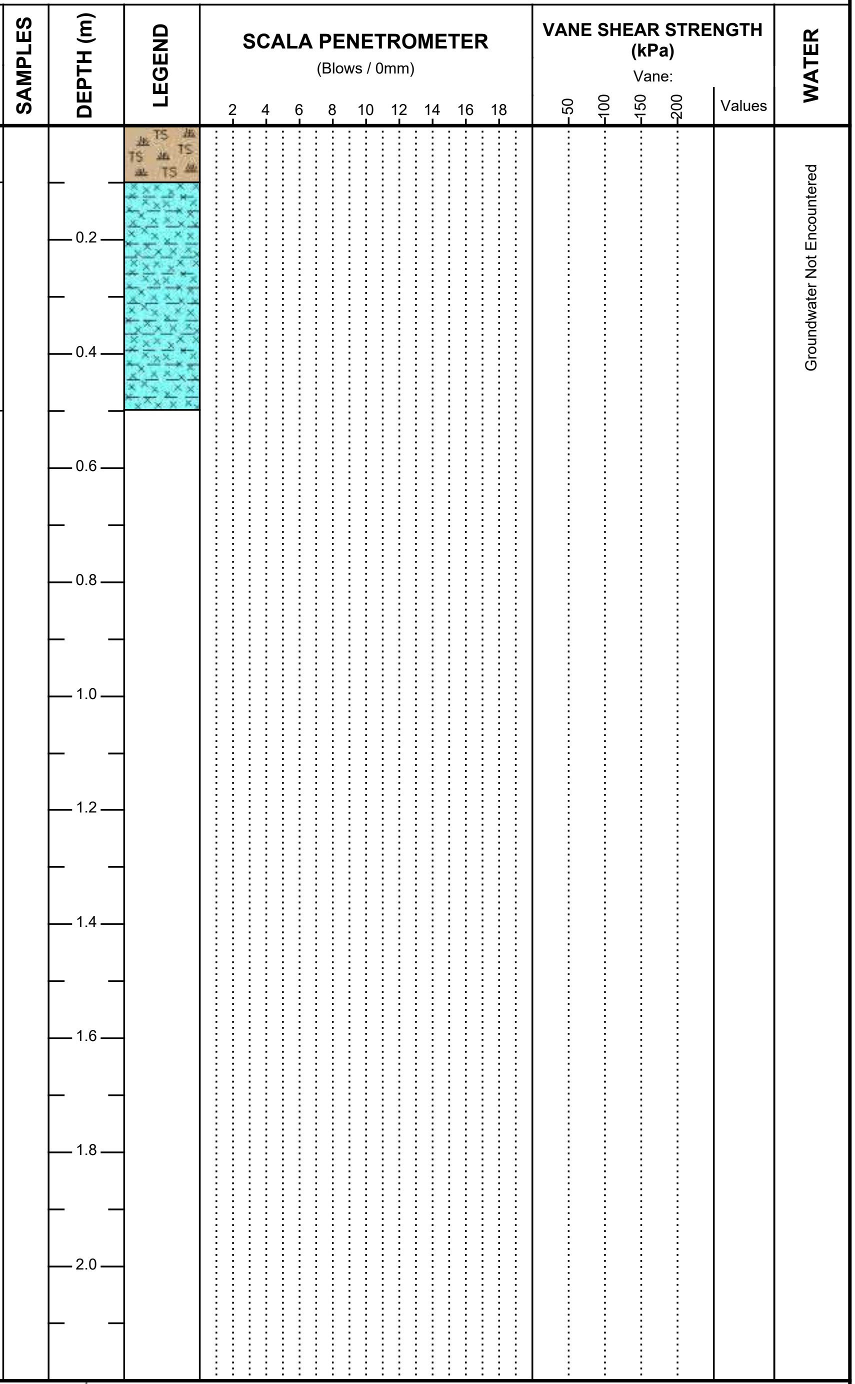
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION
(See Classification & Symbology sheet for details)

TOPSOIL.

Clayey SILT, with minor manganese nodules.
Low plasticity; dry to moist; (HAMILTON ASH FORMATION).

EOH: 0.50m



PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☐ Hand Auger
☐ Test Pit

INVESTIGATION LOG

HOLE NO.: IP10

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 08/09/2022

CO-ORDINATES: 1804012mE, 5792809mN

ELEVATION: Ground

END DATE: 08/09/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	**SAMPLES**	**DEPTH (m)**	**LEGEND**	**SCALA PENETROMETER** (Blows / 0mm) 2 4 6 8 10 12 14 16 18	**VANE SHEAR STRENGTH (kPa)** Vane: 50 100 150 200	Values	**WATER**
TOPSOIL.			TS				Groundwater Not Encountered
Clayey SILT, with minor manganese nodules. Low plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.2 0.4	▨				
EOH: 0.50m							
		0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0					

PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

▼ Standing Water Level

▷ Out flow

◁ In flow

INVESTIGATION TYPE

☐ Hand Auger

☐ Test Pit

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

INVESTIGATION LOG

HOLE NO.: IP11

CLIENT: Te Awamutu Development Ltd
PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report
JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu
START DATE: 08/09/2022
CO-ORDINATES: 1804032mE, 5792802mN
ELEVATION: Ground
END DATE: 08/09/2022
CONTRACTOR: BTW Co. Ltd.
RIG: Hand Auger
DRILLER: Sam Jin
LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 0mm) 2 4 6 8 10 12 14 16 18	VANE SHEAR STRENGTH (kPa) Vane: 50 100 150 200	Values	WATER
TOPSOIL.			TS				Groundwater Not Encountered
Clayey SILT, with minor manganese nodules. Low plasticity; dry to moist; (HAMILTON ASH FORMATION).		0.2 0.4	▨				
EOH: 0.50m							
		0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0					

PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

INVESTIGATION TYPE

☐ Hand Auger
☐ Test Pit

INVESTIGATION LOG

HOLE NO.: IP12

CLIENT: Te Awamutu Development Ltd

PROJECT: Proposed Private Plan Change - Geotechnical Suitability Report

JOB NO.: 211365

SITE LOCATION: 2025 Ohaupo Road, Te Awamutu

START DATE: 08/09/2022

CO-ORDINATES: 1804068mE, 5792807mN

ELEVATION: Ground

END DATE: 08/09/2022

CONTRACTOR: BTW Co. Ltd.

RIG: Hand Auger

DRILLER: Sam Jin

LOGGED BY: Sam Jin

MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	**SAMPLES**	**DEPTH (m)**	**LEGEND**	**SCALA PENETROMETER** (Blows / 0mm) 2 4 6 8 10 12 14 16 18	**VANE SHEAR STRENGTH (kPa)** Vane: 50 100 150 200	Values	**WATER**
Topsoil SILT, with some gravel, with minor sand. Moist; gravel, fine to medium; sand, fine; (UNCONTROLLED FILL).		0.0 – 0.4	▨				Groundwater Not Encountered
Clayey SILT, with minor manganese nodules. Low plasticity; dry to moist; (HAMILTON ASH FORMATION). EOH: 0.50m		0.4 – 0.5	▨				

Depth scale: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0

PHOTO(S)

REMARKS

BTW has been advised of a buried wet area. Undertaken by previous landowner approximately 30 years ago.

WATER

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

INVESTIGATION TYPE

- ☐ Hand Auger
- ☐ Test Pit

Generated with CORE-GS by Geroc - Hand Auger - scala & vane bars - 24/11/2022 8:53:09 am

A.2 Testing Plan

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

SITE PLAN

JOB NO.: 211365

CLIENT:	Te Awamutu Development Ltd
PROJECT:	Proposed Private Plan Change - Geotechnical Suitability Report
LOCATION:	2025 Ohaupo Road, Te Awamutu

A.3 Double Ring Infiltration Test Results

Double Ring Infiltration Test

517 Angelsea Street
07 595 0020
info@btw.nz

Twin Ring CPT 1

Job No: 211365

Client: Te Awamutu Developments Limited

Site Address: 2025 Ohaupo Road, Te Awamutu

Date: 31/08/2022

Site Assessment by: SJ

Calculation Summary

Ring Parameters

Inside	150	mm
Outside	300	mm
Initial Water Level	87	mm

Soil Texture Class at base of ring: **loamy SILT**

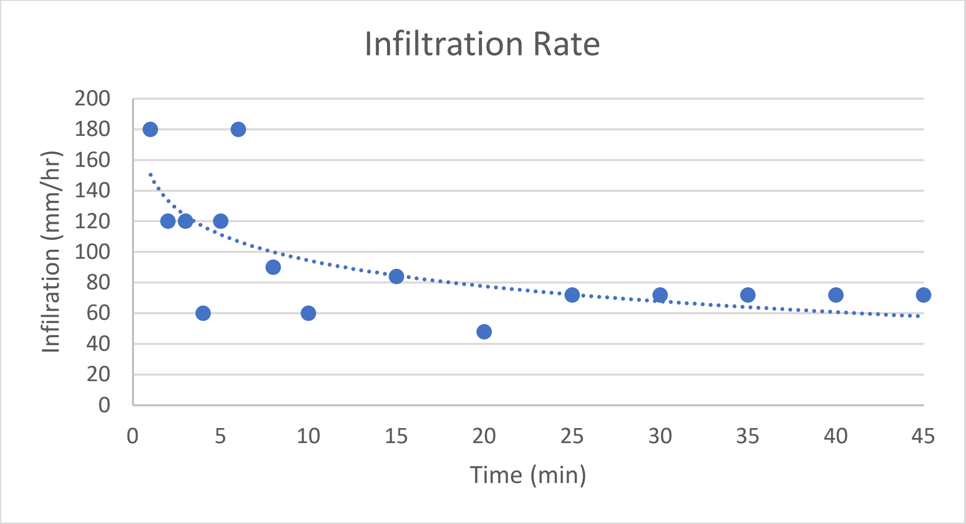
Classified against Figure 5 in Milne et al. (1995)

Double Ring Infiltration

Time	Interval	Water Level (mm)		Infiltration	Infiltration Rate		Cumulative Infiltration
(min)	(min)	Start	Finish	(mm)	mm/min	mm/hr	(mm)
0	x	87	x	x	x	x	x
1	1	87	84	3	3	180	3
2	1	87	85	2	2	120	5
3	1	87	85	2	2	120	7
4	1	87	86	1	1	60	8
5	1	87	85	2	2	120	10
6	1	87	84	3	3	180	13
8	2	87	84	3	1.5	90	16
10	2	87	85	2	1	60	18
15	5	87	80	7	1.4	84	25
20	5	87	83	4	0.8	48	29
25	5	87	81	6	1.2	72	35
30	5	87	81	6	1.2	72	41
35	5	87	81	6	1.2	72	47
40	5	87	81	6	1.2	72	53
45	5	87	81	6	1.2	72	59

Preceding Rainfall (mm)

23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug
1	0	36.2	3.4	0.2	0	0	0



btw company

517 Angelsea Street
07 595 0020
info@btw.nz

Double Ring Infiltration Test

Twin Ring CPT 2

Job No: 211365
Client: Te Awamutu Developments Limited
Date: 7/09/2022
Site Address: 2025 Ohaupo Road, Te Awamutu
Site Assessment by: SJ

Calculation Summary

Ring Parameters

Inside	150	mm
Outside	300	mm
Initial Water Level	105	mm

Pedality: weak to moderately pedal
Sand Content: < 5%

Soil Texture Class at base of ring: **Silt Loam**

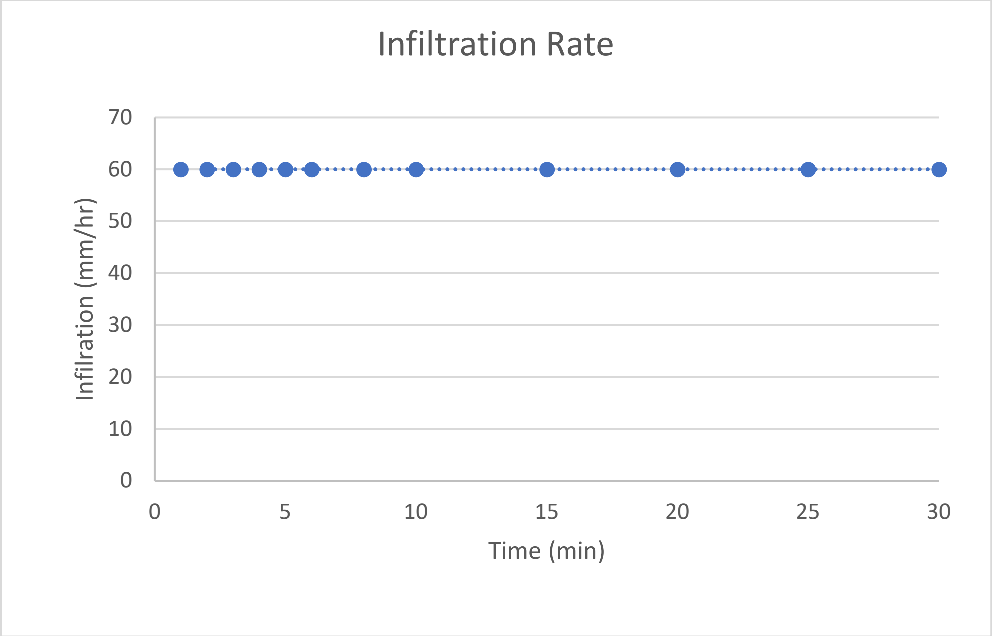
Classified against Figure 5 in Milne et al. (1995)

Double Ring Infiltration

Time	Interval	Water Level (mm)		Infiltration	Infiltration Rate		Cumulative Infiltration
(min)	(min)	Start	Finish	(mm)	mm/min	mm/hr	(mm)
0	x	105	x	x	x	x	x
1	1	105	104	1	1	60	1
2	1	105	104	1	1	60	2
3	1	105	104	1	1	60	3
4	1	105	104	1	1	60	4
5	1	105	104	1	1	60	5
6	1	105	104	1	1	60	6
8	2	105	103	2	1	60	8
10	2	105	103	2	1	60	10
15	5	105	100	5	1	60	15
20	5	105	100	5	1	60	20
25	5	105	100	5	1	60	25
30	5	105	100	5	1	60	30

Preceding Rainfall (mm)

31-Aug	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep
0	0	0	13	0.2	40.8	3.4	0



btw company

Double Ring Infiltration Test

517 Angelsea Street
07 595 0020
info@btw.nz

Twin Ring CPT 3

Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu

Date: 31/08/2022
Site Assessment by: SJ

Calculation Summary

Ring Parameters

Inside	150	mm
Outside	300	mm
Initial Water Level	74	mm

Soil Texture Class at base of ring: **Silt Loam**

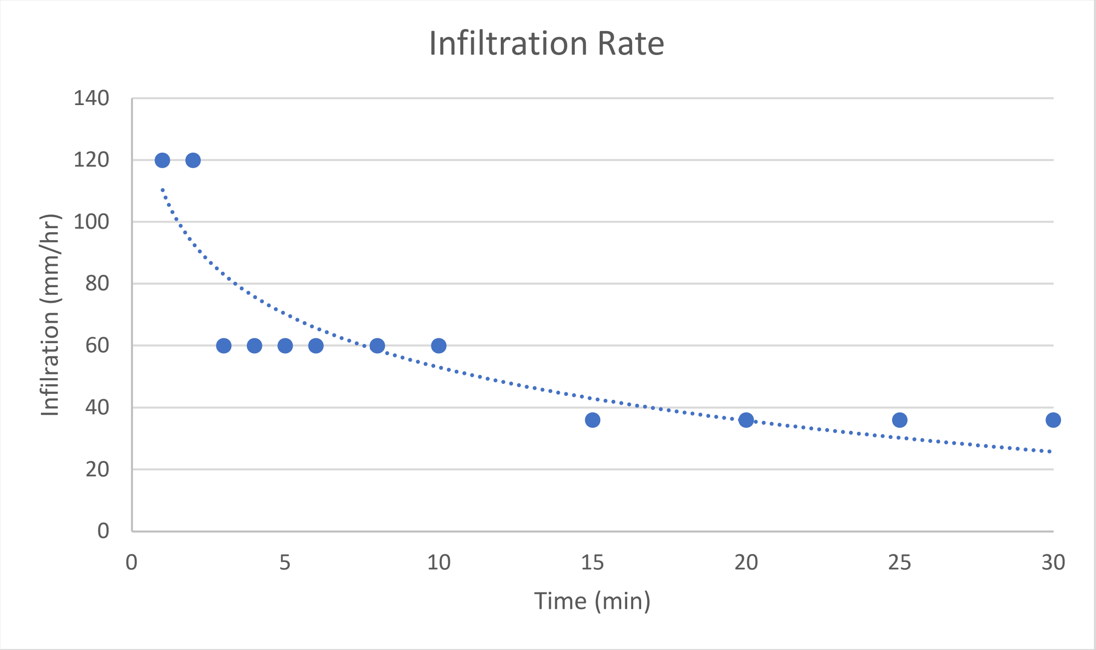
Classified against Figure 5 in Milne et al. (1995)

Double Ring Infiltration

Time	Interval	Water Level (mm)		Infiltration	Infiltration Rate		Cumulative Infiltration
(min)	(min)	Start	Finish	(mm)	mm/min	mm/hr	(mm)
0	x	74	x	x	x	x	x
1	1	74	72	2	2	120	2
2	1	74	72	2	2	120	4
3	1	74	73	1	1	60	5
4	1	74	73	1	1	60	6
5	1	74	73	1	1	60	7
6	1	74	73	1	1	60	8
8	2	74	72	2	1	60	10
10	2	74	72	2	1	60	12
15	5	74	71	3	0.6	36	15
20	5	74	71	3	0.6	36	18
25	5	74	71	3	0.6	36	21
30	5	74	71	3	0.6	36	24

Preceding Rainfall (mm)

23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug
1	0	36.2	3.4	0.2	0	0	0



btw company

517 Angelsea Street
07 595 0020
info@btw.nz

Double Ring Infiltration Test

Twin Ring CPT 5

Job No: 211365

Client: Te Awamutu Developments Limited **Date:** 7/09/2022

Site Address: 2025 Ohaupo Road, Te Awamutu **Site Assessment by:** SJ

Calculation Summary

Ring Parameters

Inside	150	mm
Outside	300	mm
Initial Water Level	104	mm

Pedality: Moderately pedal

Sand Content: 12 to 20%

Soil Texture Class at base of ring: loamy Silt

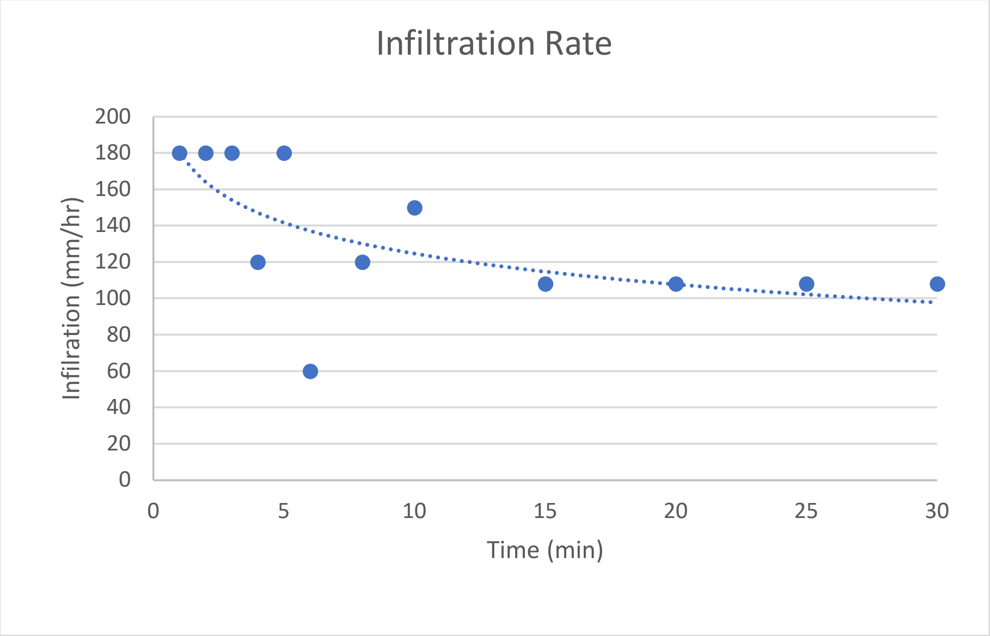
Classified against Figure 5 in Milne et al. (1995)

Double Ring Infiltration

Time (min)	Interval (min)	Water Level (mm) Start	Water Level (mm) Finish	Infiltration (mm)	Infiltration Rate mm/min	Infiltration Rate mm/hr	Cumulative Infiltration (mm)
0	x	104	x	x	x	x	x
1	1	104	101	3	3	180	3
2	1	104	101	3	3	180	6
3	1	104	101	3	3	180	9
4	1	104	102	2	2	120	11
5	1	104	101	3	3	180	14
6	1	104	103	1	1	60	15
8	2	104	100	4	2	120	19
10	2	104	99	5	2.5	150	24
15	5	104	95	9	1.8	108	33
20	5	104	95	9	1.8	108	42
25	5	104	95	9	1.8	108	51
30	5	104	95	9	1.8	108	60

Preceding Rainfall (mm)

31-Aug	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep
0	0	0	13	0.2	40.8	3.4	0



517 Angelsea Street
07 595 0020
info@btw.nz

Double Ring Infiltration Test

Twin Ring CPT 7

Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu
Date: 7/09/2022
Site Assessment by: SJ

Calculation Summary

Ring Parameters

Inside	150 mm
Outside	300 mm
Initial Water Level	96 mm

Pedality: Moderately pedal
Sand Content: < 5%

Soil Texture Class at base of ring: **Silt Loam**

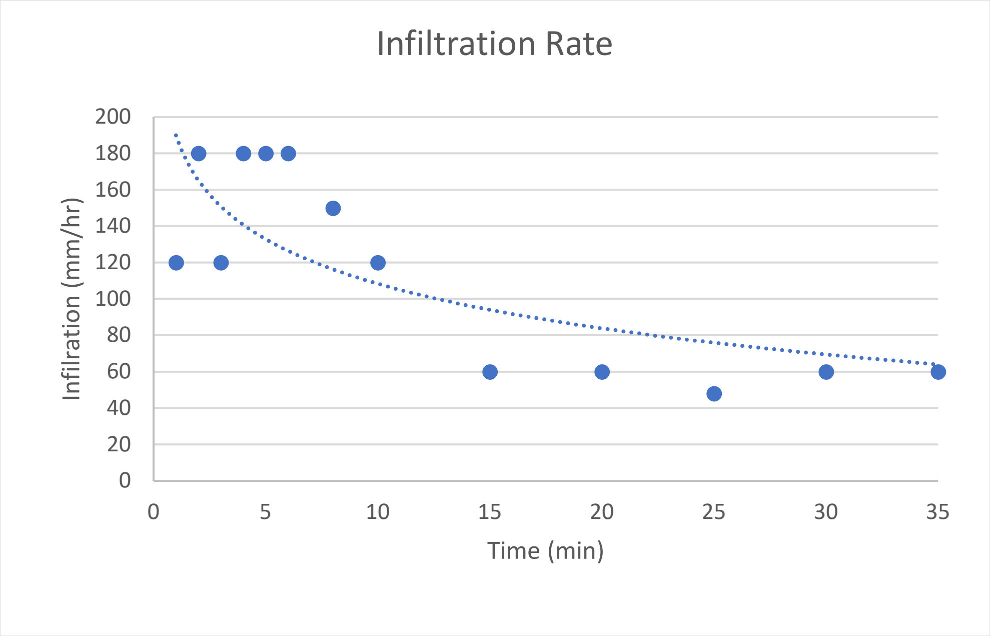
Classified against Figure 5 in Milne et al. (1995)

Double Ring Infiltration

Time	Interval	Water Level (mm)		Infiltration	Infiltration Rate		Cumulative Infiltration
(min)	(min)	Start	Finish	(mm)	mm/min	mm/hr	(mm)
0	x	96	x	x	x	x	x
1	1	96	94	2	2	120	2
2	1	97	94	3	3	180	5
3	1	97	95	2	2	120	7
4	1	97	94	3	3	180	10
5	1	97	94	3	3	180	13
6	1	97	94	3	3	180	16
8	2	97	92	5	2.5	150	21
10	2	97	93	4	2	120	25
15	5	97	92	5	1	60	30
20	5	97	92	5	1	60	35
25	5	97	93	4	0.8	48	39
30	5	97	92	5	1	60	44
35	5	97	92	5	1	60	49

Preceding Rainfall (mm)

31-Aug	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep
0	0	0	13	0.2	40.8	3.4	0



Double Ring Infiltration Test

517 Angelsea Street
07 595 0020
info@btw.nz

Twin Ring CPT 10

Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu

Date: 31/08/2022
Site Assessment by: SJ

Calculation Summary

Ring Parameters

Inside	150 mm
Outside	300 mm
Initial Water Level	104 mm

Soil Texture Class at base of ring: **Silt Loam**

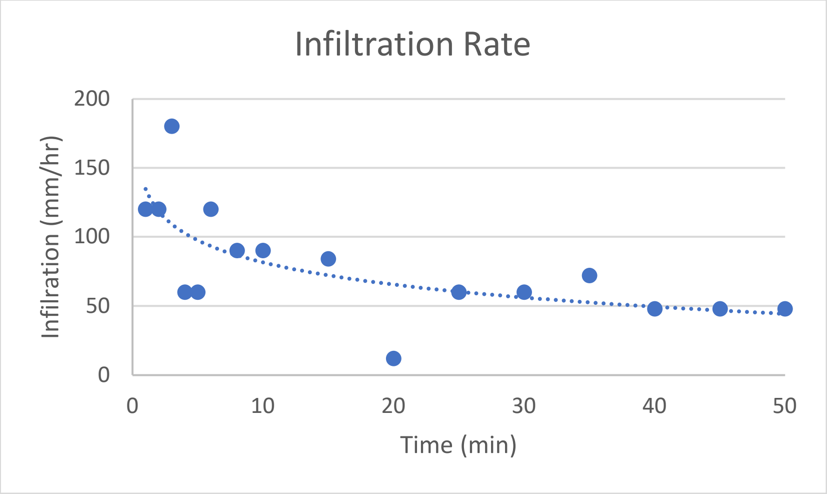
Classified against Figure 5 in Milne et al. (1995)

Double Ring Infiltration

Time (min)	Interval (min)	Water Level (mm) Start	Finish	Infiltration (mm)	Infiltration Rate mm/min	mm/hr	Cumulative Infiltration (mm)
0	x	104	x	x	x	x	x
1	1	104	102	2	2	120	2
2	1	104	102	2	2	120	4
3	1	104	101	3	3	180	7
4	1	101	100	1	1	60	8
5	1	100	99	1	1	60	9
6	1	104	102	2	2	120	11
8	2	102	99	3	1.5	90	14
10	2	99	96	3	1.5	90	17
15	5	104	97	7	1.4	84	24
20	5	97	96	1	0.2	12	25
25	5	104	99	5	1	60	30
30	5	99	94	5	1	60	35
35	5	104	98	6	1.2	72	41
40	5	104	100	4	0.8	48	45
45	5	100	96	4	0.8	48	49
50	5	104	100	4	0.8	48	53

Preceding Rainfall (mm)

23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug
1	0	36.2	3.4	0.2	0	0	0



A.4 Falling Head Test Results

BTW Company Ltd
517 Angelsea Street, Hamilton
07 595 0020
info@btw.nz

Soakage Test

Falling Head CPT 1

Test Number:

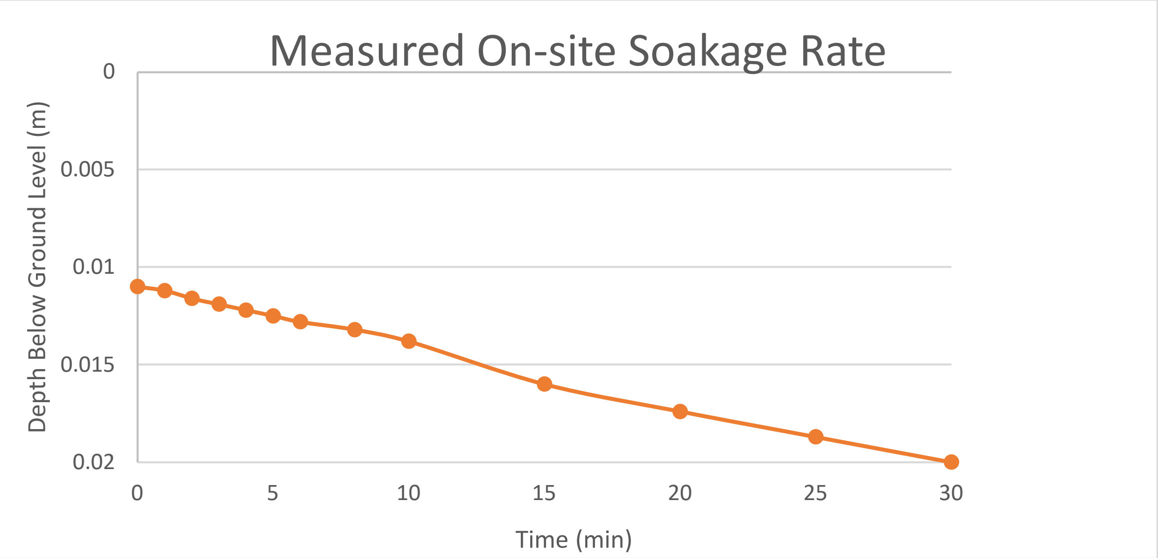
Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu

Date: 31/08/2022
Site Assessment by: SJ

Method:

Test Hole Diameter (m):	0.1
Test Hole Depth (m):	1.1
Height above soil (excluding Topsoil)	0.015

Time	Depth of Water below Surface	Depth of Water below soil (excluding topsoil)	Change in Water Level	*k*	*k*
(min)	(m)		(m)	(m/s)	(mm/hr)
0	0.026	0.011			
1	0.0262	0.0112	0.0002	3.33E-06	12
2	0.0266	0.0116	0.0004	6.67E-06	24
3	0.0269	0.0119	0.0003	5.00E-06	18
4	0.0272	0.0122	0.0003	5.00E-06	18
5	0.0275	0.0125	0.0003	5.00E-06	18
6	0.0278	0.0128	0.0003	5.00E-06	18
8	0.0282	0.0132	0.0004	6.67E-06	12
10	0.0288	0.0138	0.0006	1.00E-05	18
15	0.031	0.016	0.0022	3.67E-05	26.4
20	0.0324	0.0174	0.0014	2.33E-05	16.8
25	0.0337	0.0187	0.0013	2.17E-05	15.6
30	0.035	0.02	0.0013	2.17E-05	15.6
			Measured Soakage rate (mm/hr)		16
			Long term reduction factor (%)		0.50
			Design Soakage Rate (mm/hr)		**8**



Soakage Test

BTW Company Ltd
517 Angelsea Street, Hamilton
07 595 0020
info@btw.nz

Falling Head CPT 2

Test Number:

Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu

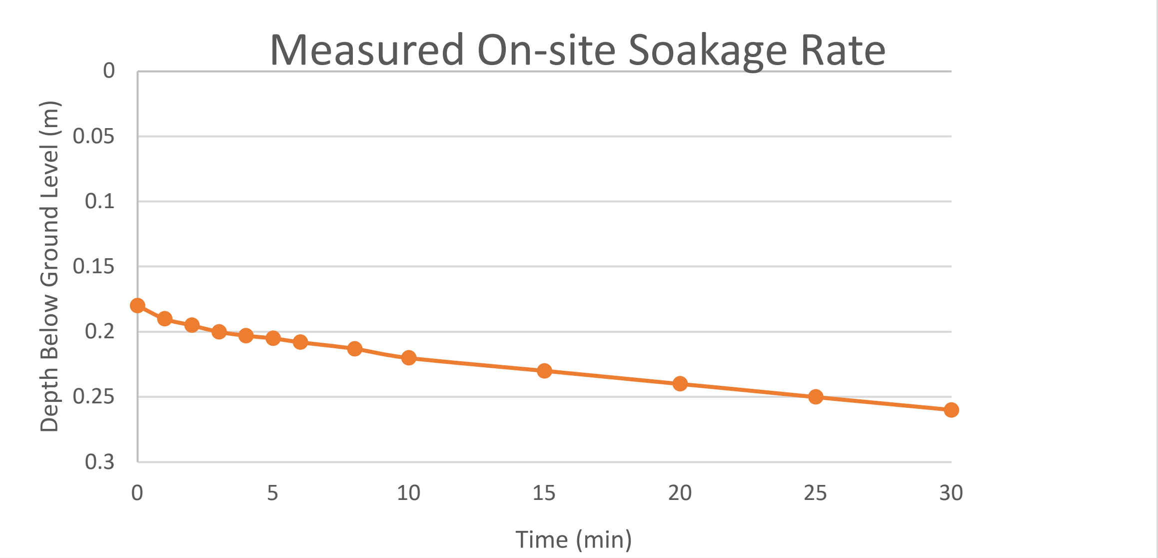
Date: 07/09/2022
Site Assessment by: SJ

Method:

Test Hole Diameter (m):	0.7
Test Hole Depth (m):	1
Height above soil (excluding Topsoil)	0.1

Time	Depth of Water below Surface	Depth of Water below soil (excluding topsoil)	Change in Water Level	*k*	*k*
(min)	(m)		(m)	(m/s)	(mm/hr)
0	0.28	0.18			
1	0.29	0.19	0.01	1.67E-04	600
2	0.295	0.195	0.005	8.33E-05	300
3	0.3	0.2	0.005	8.33E-05	300
4	0.303	0.203	0.003	5.00E-05	180
5	0.305	0.205	0.002	3.33E-05	120
6	0.308	0.208	0.003	5.00E-05	180
8	0.313	0.213	0.005	8.33E-05	150
10	0.32	0.22	0.007	1.17E-04	210
15	0.33	0.23	0.01	1.67E-04	120
20	0.34	0.24	0.01	1.67E-04	120
25	0.35	0.25	0.01	1.67E-04	120
30	0.36	0.26	0.01	1.67E-04	120

Measured Soakage rate (mm/hr)	120
Long term reduction factor (%)	0.50
Design Soakage Rate (mm/hr)	**60**



BTW Company Ltd
517 Angelsea Street, Hamilton
07 595 0020
info@btw.nz

Soakage Test

Falling Head CPT 3

Test Number:

Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu

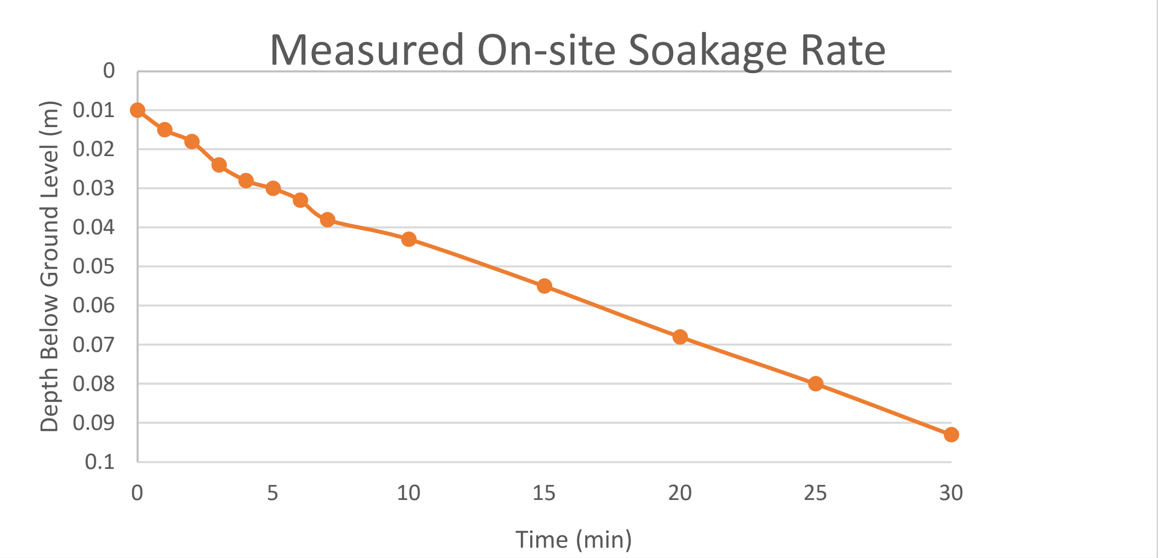
Date: 31/08/2022
Site Assessment by: SJ

Method:

Test Hole Diameter (m):	0.1
Test Hole Depth (m):	1
Height above soil (excluding Topsoil)	0

Time	Depth of Water below Surface	Depth of Water below soil (excluding topsoil)	Change in Water Level	*k*	*k*
(min)	(m)		(m)	(m/s)	(mm/hr)
0	0.01	0.01			
1	0.015	0.015	0.005	8.33E-05	300
2	0.018	0.018	0.003	5.00E-05	180
3	0.024	0.024	0.006	1.00E-04	360
4	0.028	0.028	0.004	6.67E-05	240
5	0.03	0.03	0.002	3.33E-05	120
6	0.033	0.033	0.003	5.00E-05	180
7	0.038	0.038	0.005	8.33E-05	300
10	0.043	0.043	0.005	8.33E-05	100
15	0.055	0.055	0.012	2.00E-04	144
20	0.068	0.068	0.013	2.17E-04	156
25	0.08	0.08	0.012	2.00E-04	144
30	0.093	0.093	0.013	2.17E-04	156

Measured Soakage rate (mm/hr)	156
Long term reduction factor (%)	0.50
Design Soakage Rate (mm/hr)	**78**



BTW Company Ltd
517 Angelsea Street, Hamilton
07 595 0020
info@btw.nz

Soakage Test

Falling Head CPT 5

Test Number:

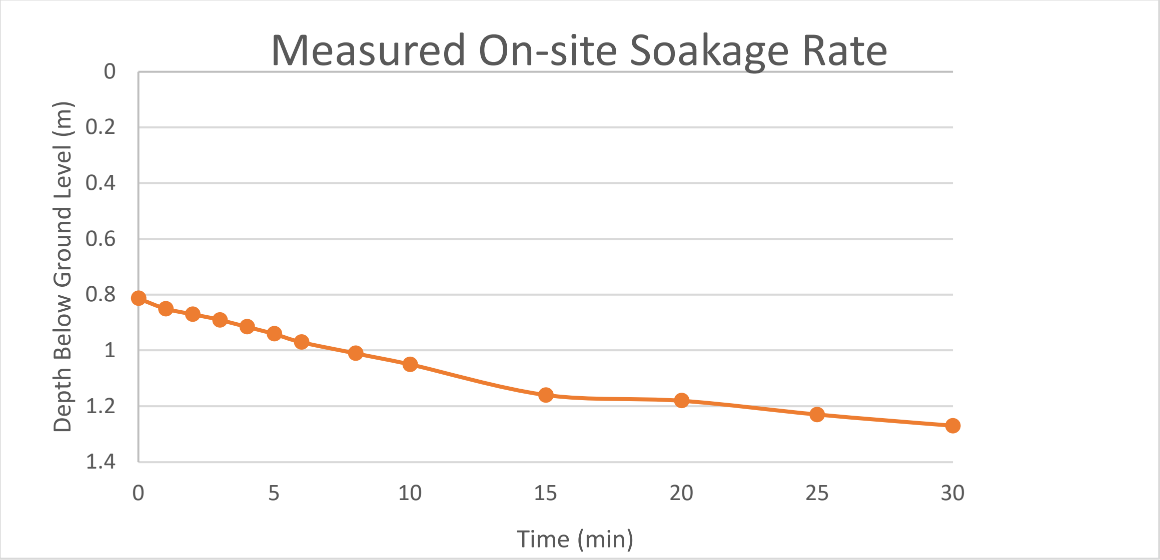
Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu

Date: 07/09/2022
Site Assessment by: SJ

Method:
Test Hole Diameter (m): 0.7
Test Hole Depth (m): 1
Height above soil (excluding Topsoil) 0.1

Time	Depth of Water below Surface	Depth of Water below soil (excluding topsoil)	Change in Water Level	*k*	*k*
(min)	(m)		(m)	(m/s)	(mm/hr)
0	0.913	0.813			
1	0.95	0.85	0.037	6.17E-04	2220
2	0.97	0.87	0.02	3.33E-04	1200
3	0.99	0.89	0.02	3.33E-04	1200
4	1.015	0.915	0.025	4.17E-04	1500
5	1.04	0.94	0.025	4.17E-04	1500
6	1.07	0.97	0.03	5.00E-04	1800
8	1.11	1.01	0.04	6.67E-04	1200
10	1.15	1.05	0.04	6.67E-04	1200
15	1.26	1.16	0.11	1.83E-03	1320
20	1.28	1.18	0.02	3.33E-04	240
25	1.33	1.23	0.05	8.33E-04	600
30	1.37	1.27	0.04	6.67E-04	480

Measured Soakage rate (mm/hr)	480
Long term reduction factor (%)	0.50
Design Soakage Rate (mm/hr)	**240**



Soakage Test

BTW Company Ltd
517 Angelsea Street, Hamilton
07 595 0020
info@btw.nz

Falling Head CPT 7

Test Number:

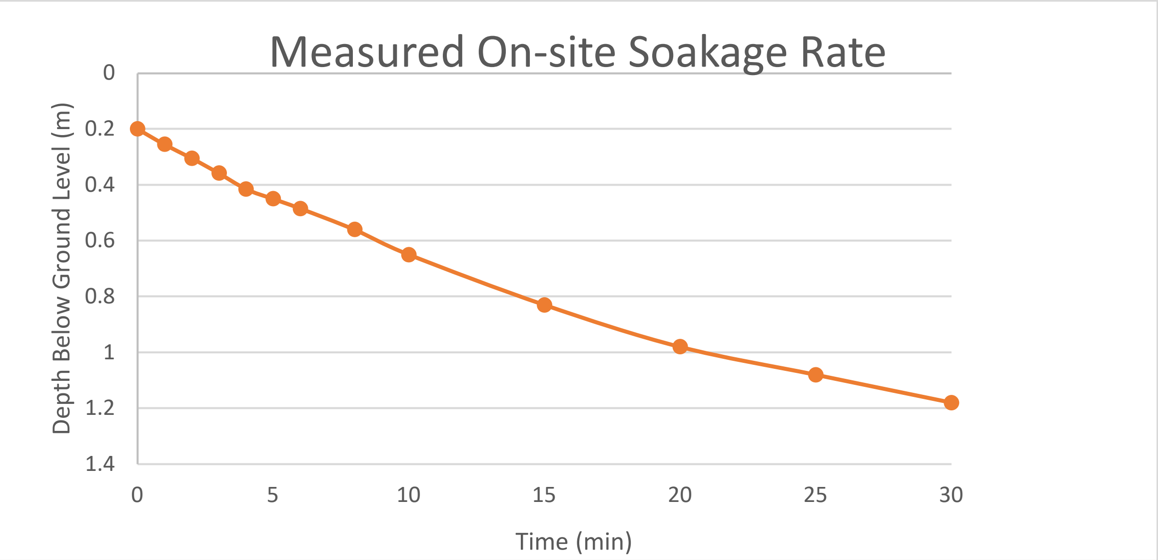
Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu

Date: 07/09/2022
Site Assessment by: SJ

Method:
Test Hole Diameter (m): 0.7
Test Hole Depth (m): 1
Height above soil (excluding Topsoil) 0.1

Time	Depth of Water below Surface	Depth of Water below soil (excluding topsoil)	Change in Water Level	*k*	*k*
(min)	(m)		(m)	(m/s)	(mm/hr)
0	0.3	0.2			
1	0.355	0.255	0.055	9.17E-04	3300
2	0.405	0.305	0.05	8.33E-04	3000
3	0.458	0.358	0.053	8.83E-04	3180
4	0.515	0.415	0.057	9.50E-04	3420
5	0.55	0.45	0.035	5.83E-04	2100
6	0.585	0.485	0.035	5.83E-04	2100
8	0.66	0.56	0.075	1.25E-03	2250
10	0.75	0.65	0.09	1.50E-03	2700
15	0.93	0.83	0.18	3.00E-03	2160
20	1.08	0.98	0.15	2.50E-03	1800
25	1.18	1.08	0.1	1.67E-03	1200
30	1.28	1.18	0.1	1.67E-03	1200

Measured Soakage rate (mm/hr)	1,200
Long term reduction factor (%)	0.50
Design Soakage Rate (mm/hr)	**600**



Soakage Test

BTW Company Ltd
517 Angelsea Street, Hamilton
07 595 0020
info@btw.nz

Table 1

Test Number:

Job No: 211365
Client: Te Awamutu Developments Limited
Site Address: 2025 Ohaupo Road, Te Awamutu

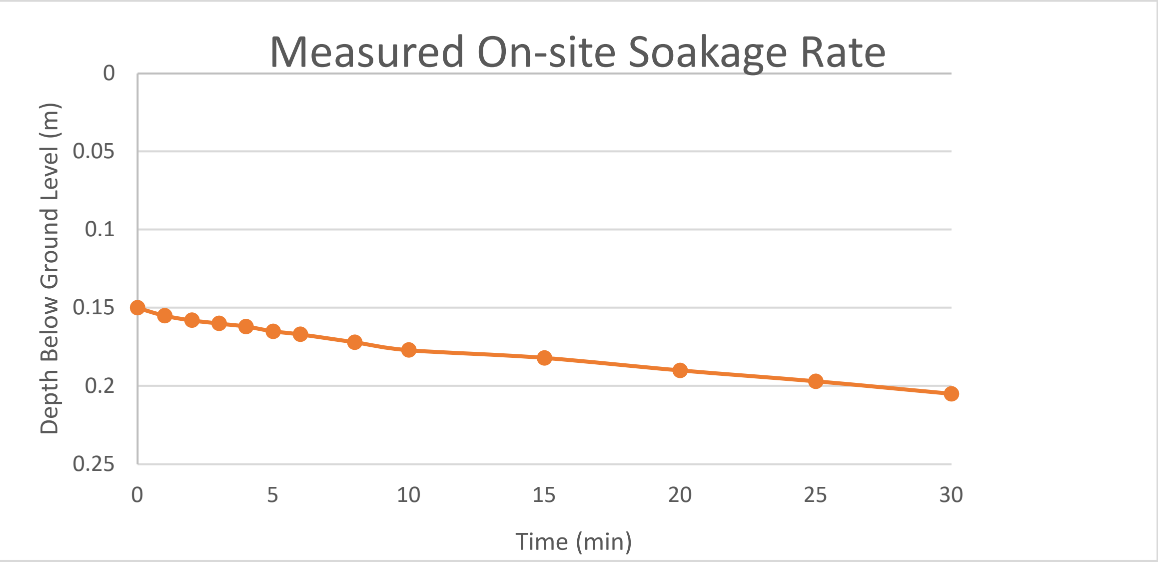
Date: 31/08/2022
Site Assessment by: SJ

Method:

Test Hole Diameter (m):	0.7
Test Hole Depth (m):	1
Height above soil (excluding Topsoil)	0.1

Time	Depth of Water below Surface	Depth of Water below soil (excluding topsoil)	Change in Water Level	*k*	*k*
(min)	(m)		(m)	(m/s)	(mm/hr)
0	0.25	0.15			
1	0.255	0.155	0.005	8.33E-05	300
2	0.258	0.158	0.003	5.00E-05	180
3	0.26	0.16	0.002	3.33E-05	120
4	0.262	0.162	0.002	3.33E-05	120
5	0.265	0.165	0.003	5.00E-05	180
6	0.267	0.167	0.002	3.33E-05	120
8	0.272	0.172	0.005	8.33E-05	150
10	0.277	0.177	0.005	8.33E-05	150
15	0.282	0.182	0.005	8.33E-05	60
20	0.29	0.19	0.008	1.33E-04	96
25	0.297	0.197	0.007	1.17E-04	84
30	0.305	0.205	0.008	1.33E-04	96

Measured Soakage rate (mm/hr)	96
Long term reduction factor (%)	0.50
Design Soakage Rate (mm/hr)	**48**

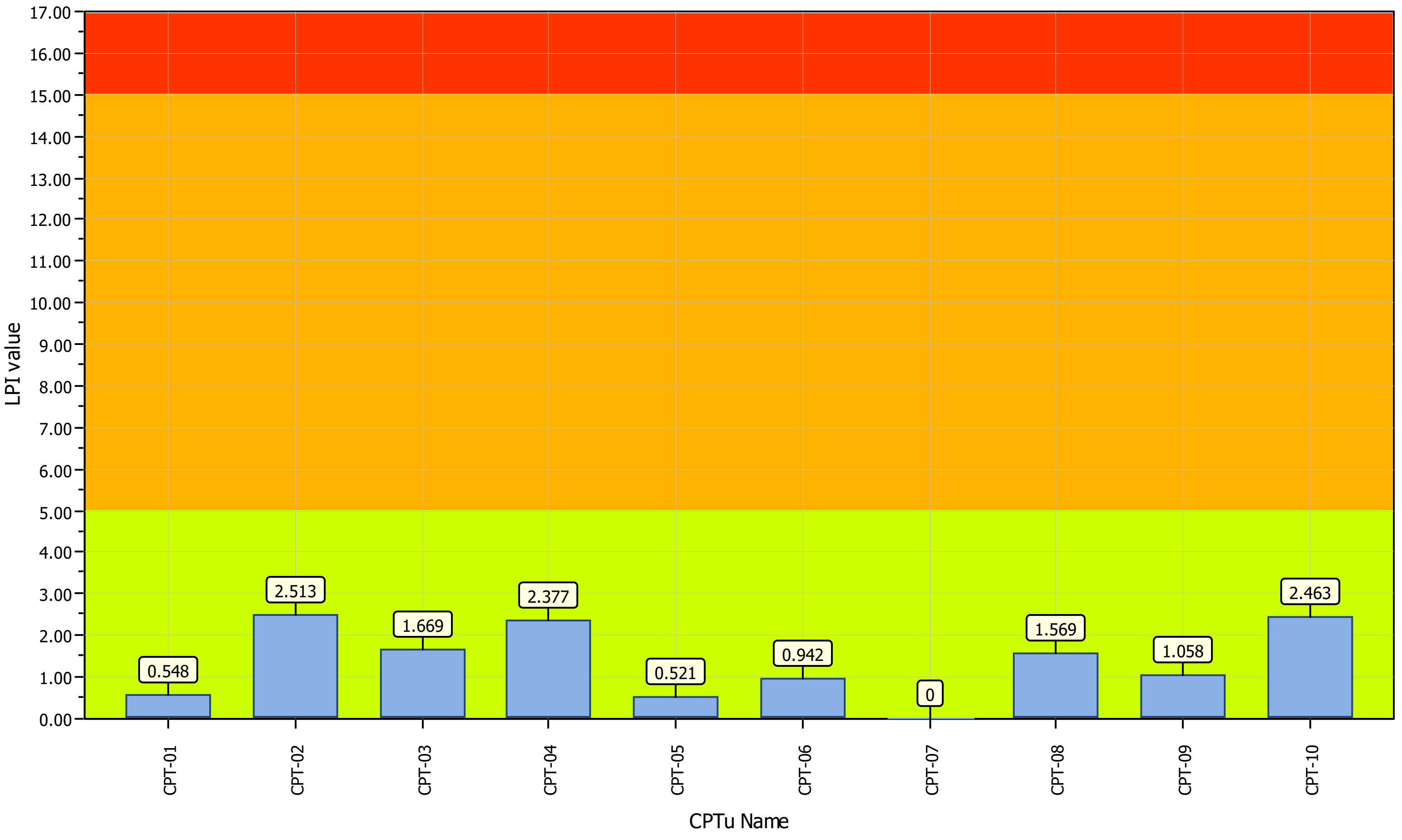


APPENDIX B LIQUEFACTION RESULTS

Project title : Proposed Private Plan Change for Te Awamutu Developments Limited

Location : 2025 Ohaupo Road, Te Awamutu

Overall Liquefaction Potential Index report



LPI color scheme

🟥 Very high risk
🟧 High risk
🟩 Low risk

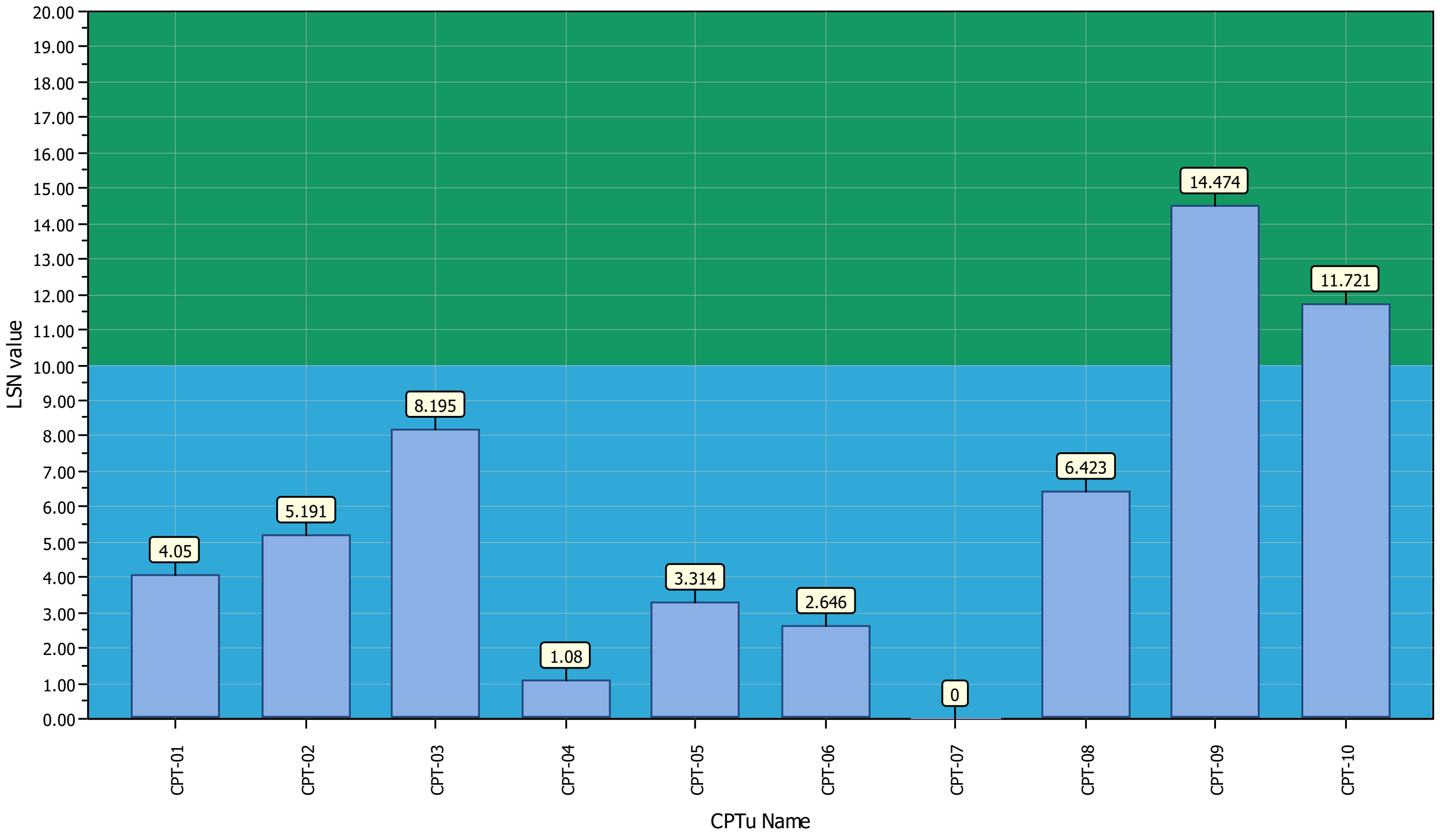
Basic statistics

Total CPT number: 10
100% low risk
0% high risk
0% very high risk

Project title : Proposed Private Plan Change for Te Awamutu Developments Limited

Location : 2025 Ohaupo Road, Te Awamutu

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: 10

80% little liquefaction

20% minor liquefaction

0% moderate liquefaction

0% moderate to major liquefaction

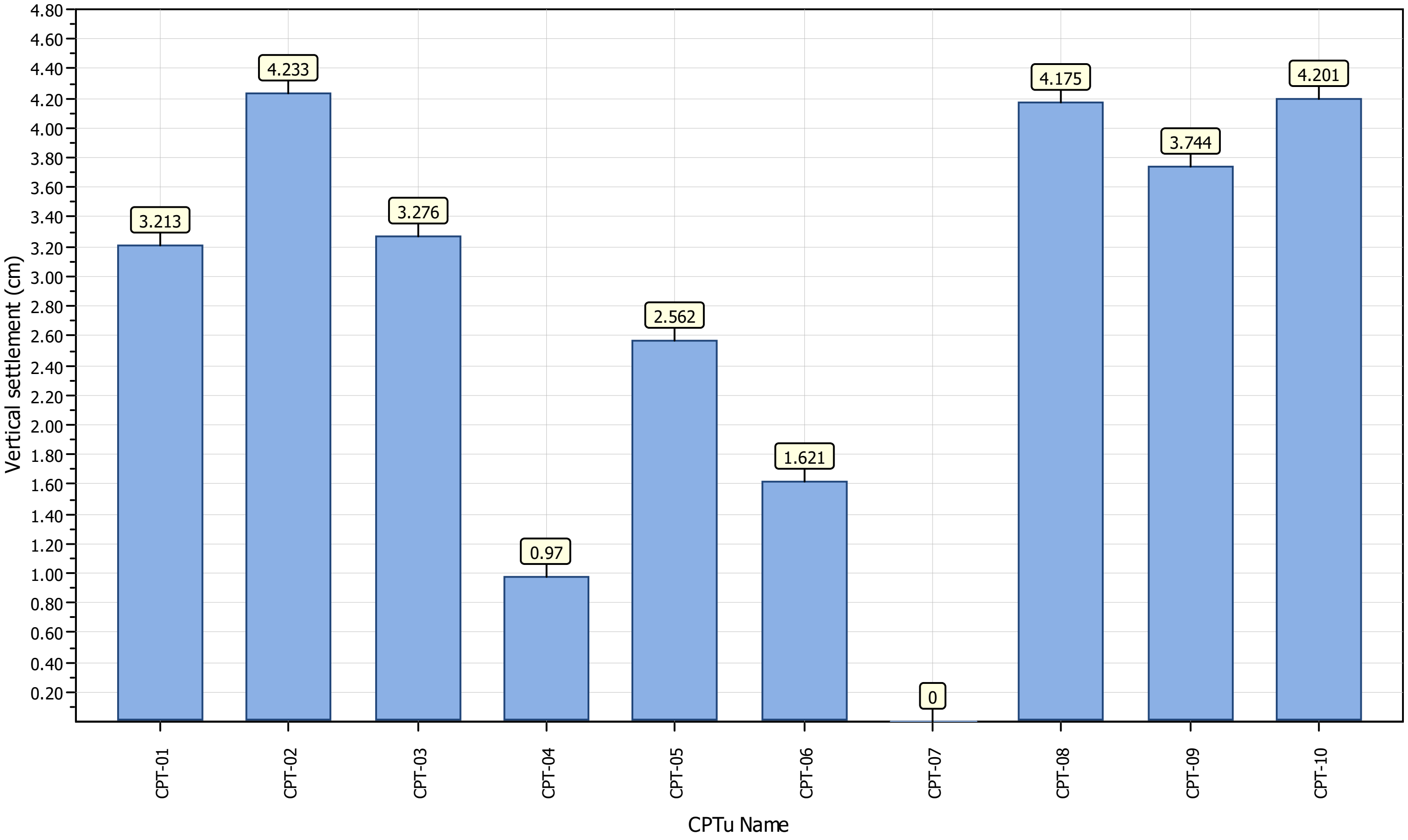
0% major liquefaction

0% severe liquefaction

Project title : Proposed Private Plan Change for Te Awamutu Developments Limited

Location : 2025 Ohaupo Road, Te Awamutu

Overall vertical settlements report



BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

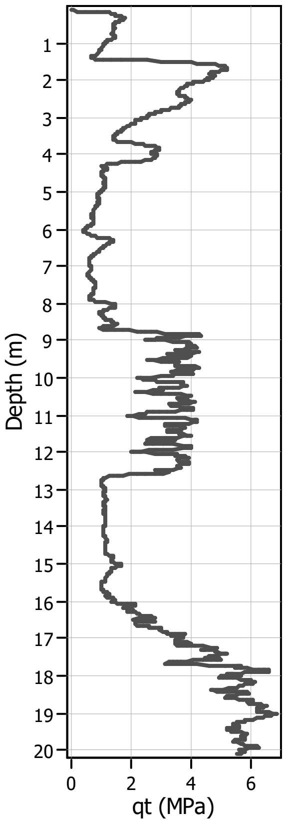
LIQUEFACTION ANALYSIS REPORT

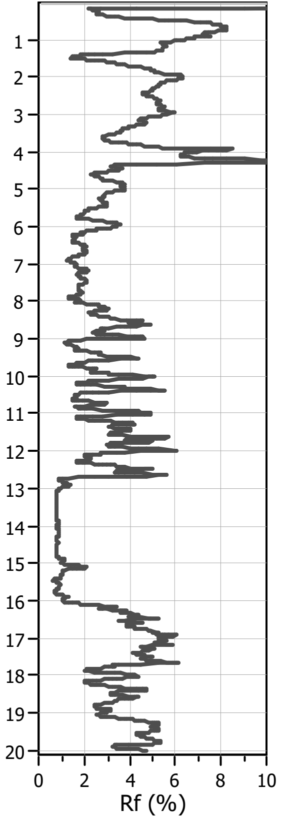
Project title : Proposed Private Plan Change for Te Awamutu   Location : 2025 Ohaupo Road, Te Awamutu

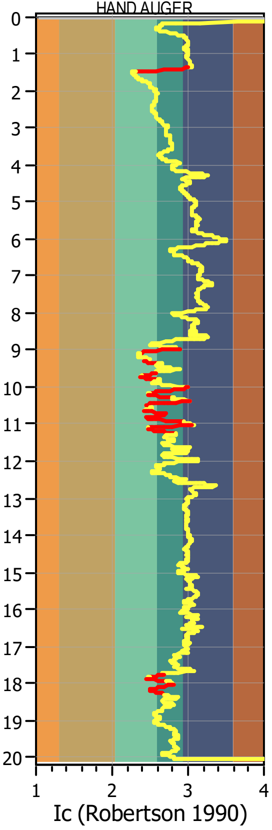
CPT file : CPT-01

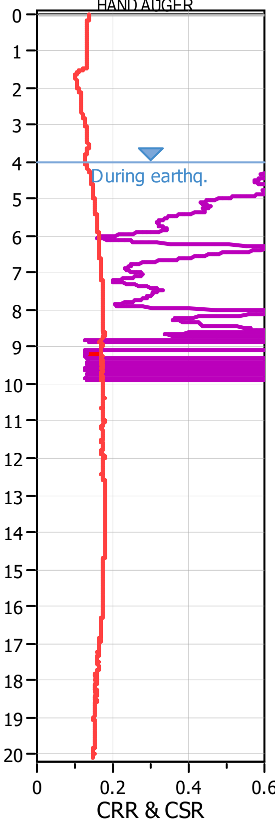
Input parameters and analysis data

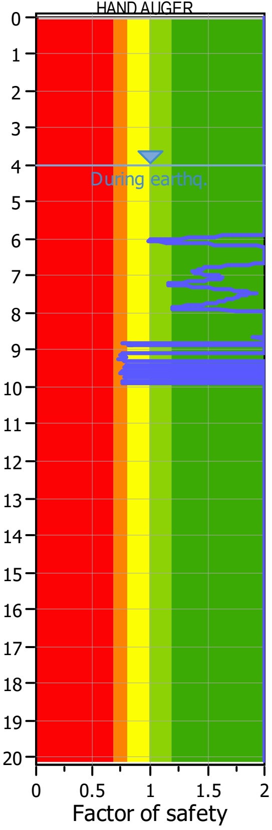
Analysis method:	B&I (2014)	G.W.T. (in-situ):	5.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

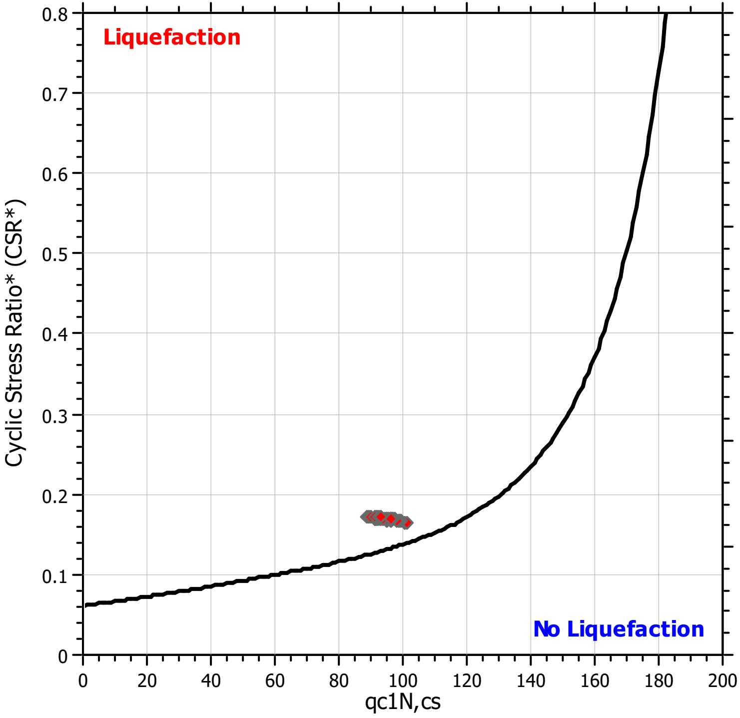

Cone resistance

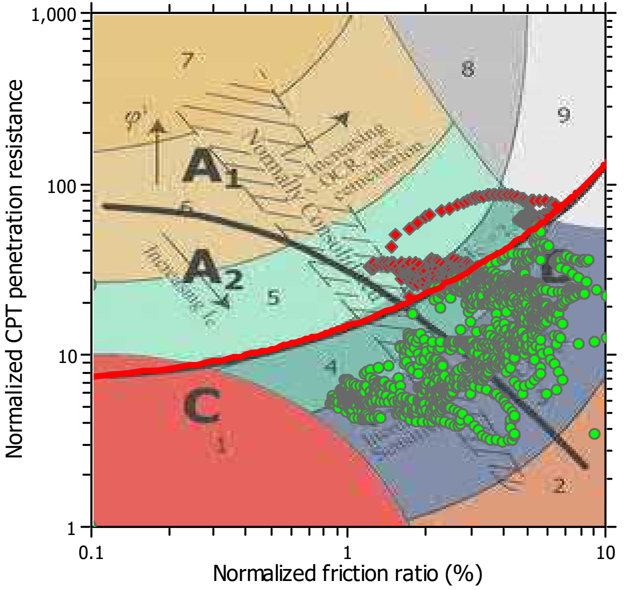

Friction Ratio


SBTn Plot


CRR plot

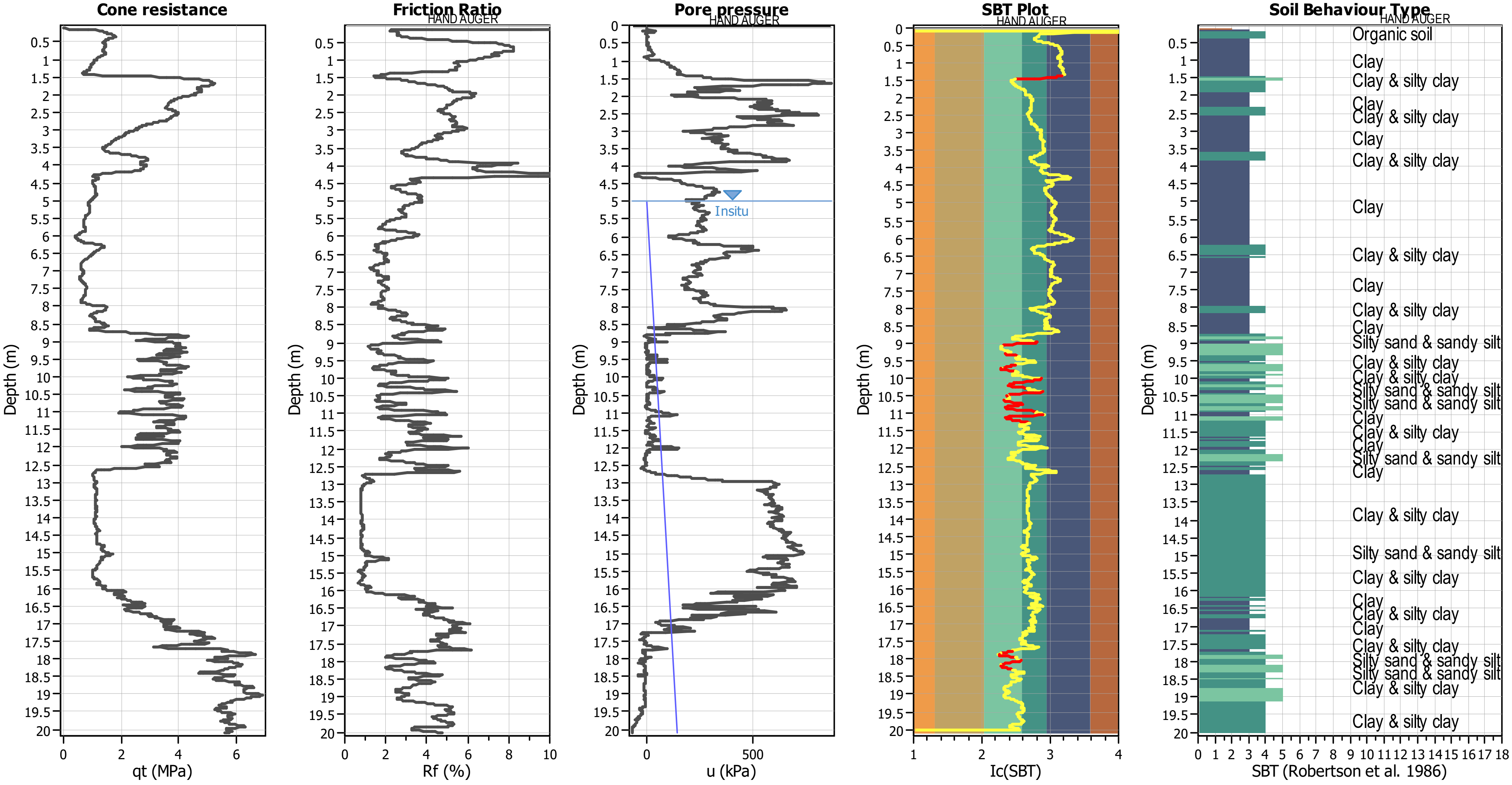

FS Plot


$M_w=7^{1/2}$, sigma'=1 atm base curve


Summary of liquefaction potential

Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: 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



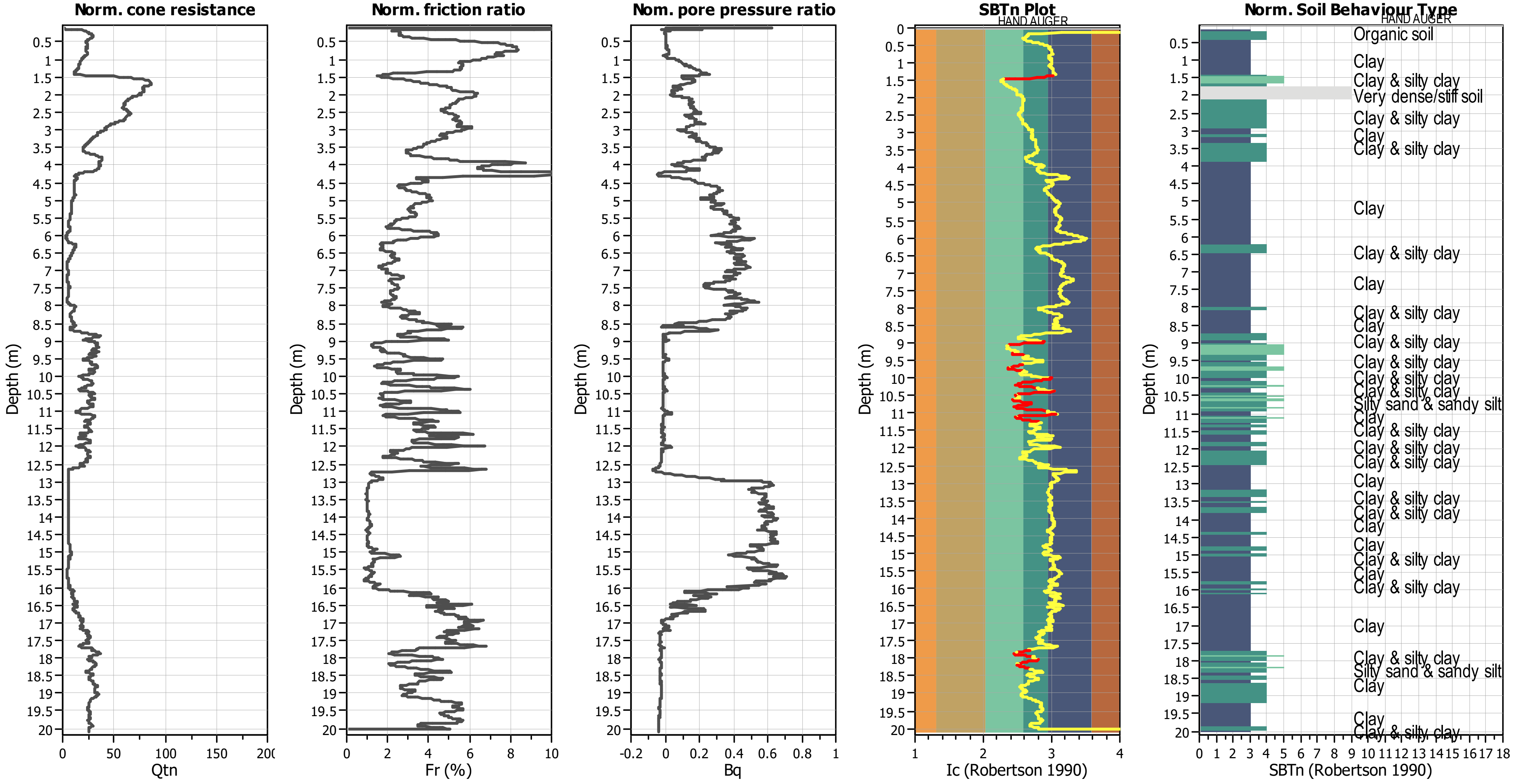
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



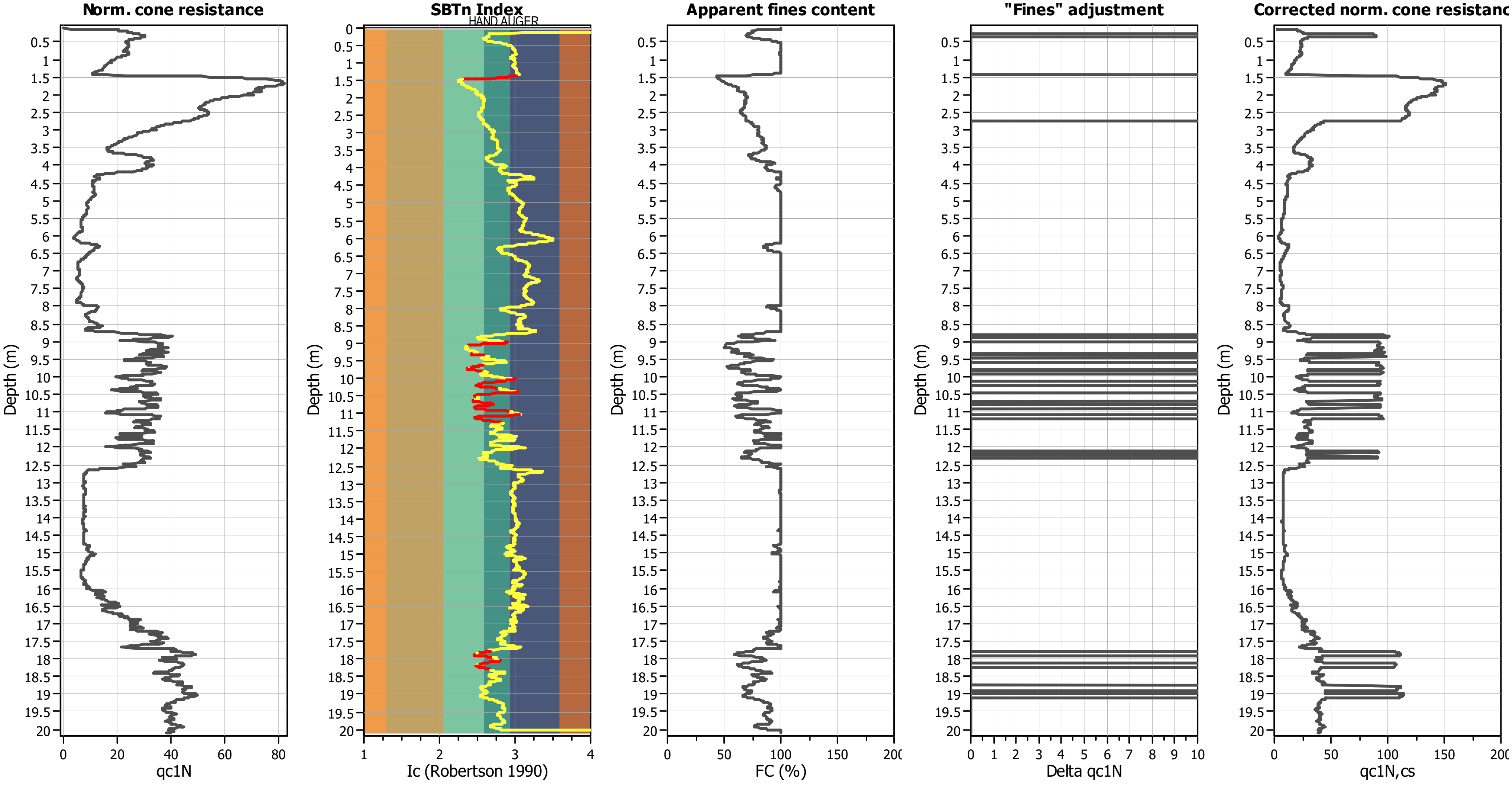
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

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

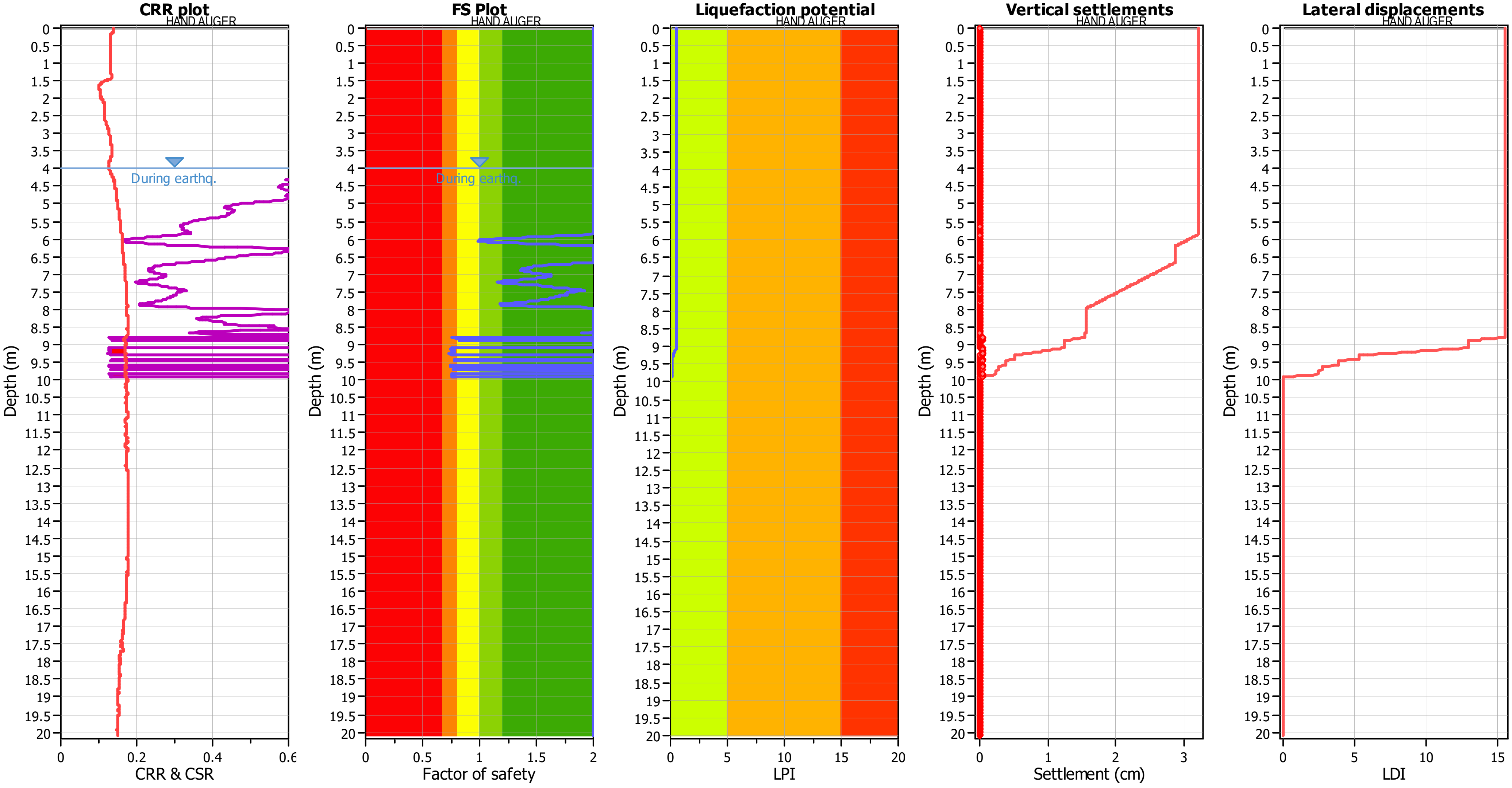
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.25
Depth to water table (insitu): 5.00 m

Depth to GWT (erthq.): 4.00 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

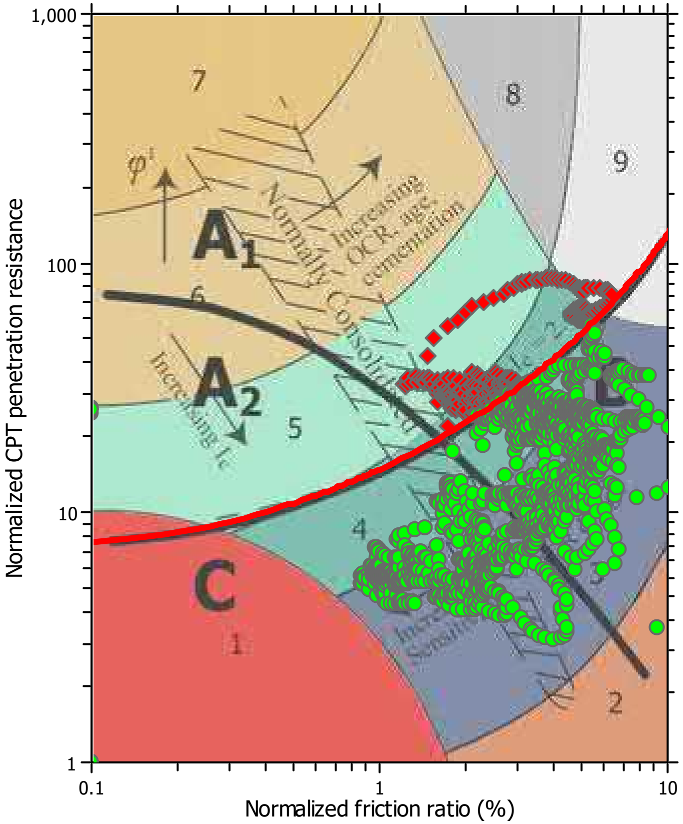
F.S. color scheme

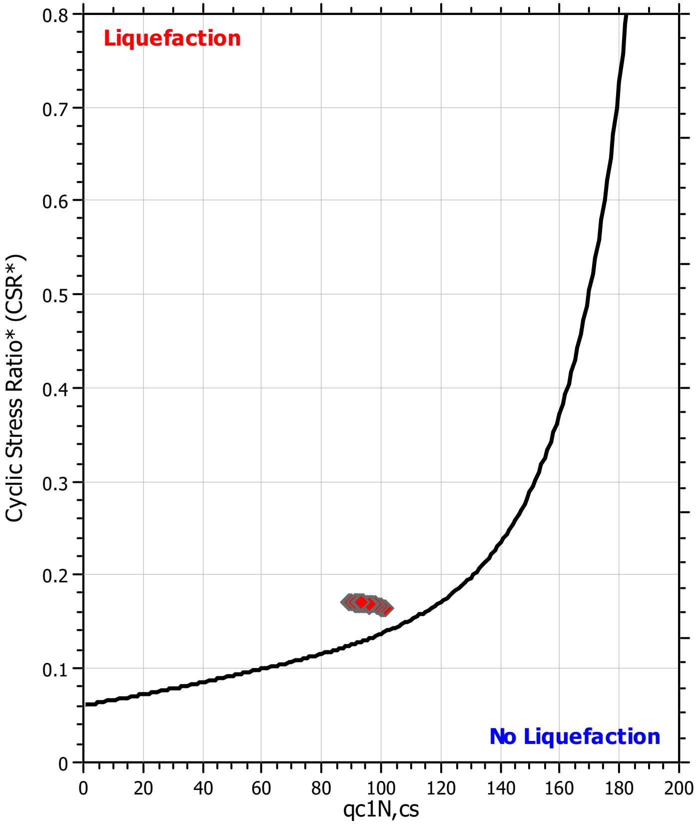
🟥 Almost certain it will liquefy
🟧 Very likely to liquefy
🟨 Liquefaction and no liq. are equally likely
🟩 Unlike to liquefy
🟩 Almost certain it will not liquefy

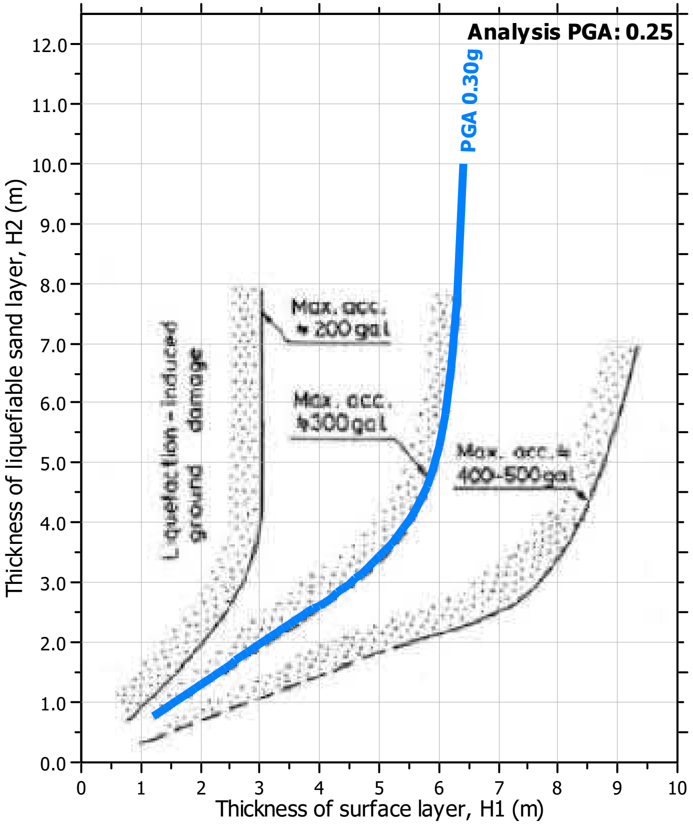
LPI color scheme

🟥 Very high risk
🟧 High risk
🟨 Low risk

Liquefaction analysis summary plots



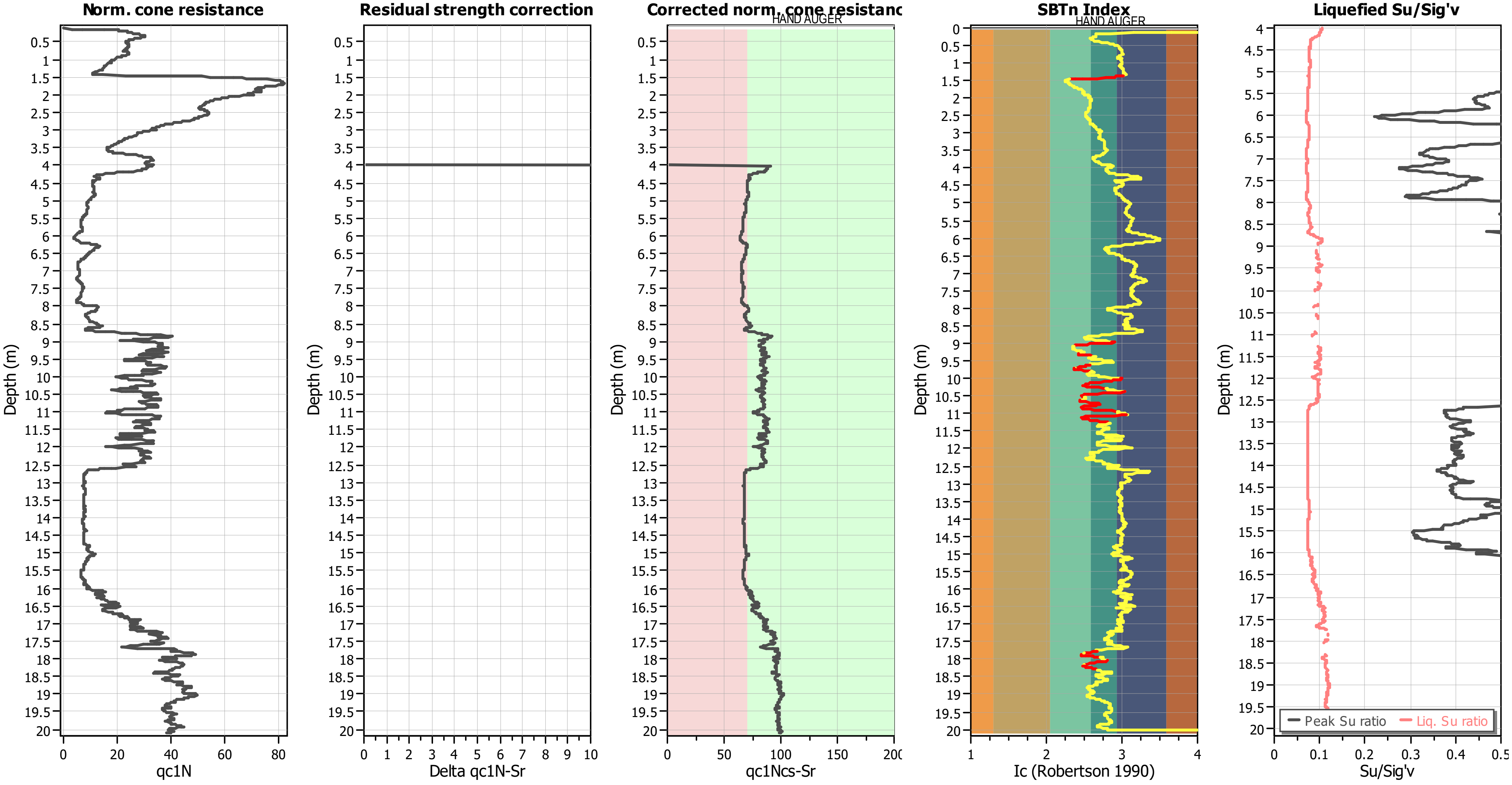




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

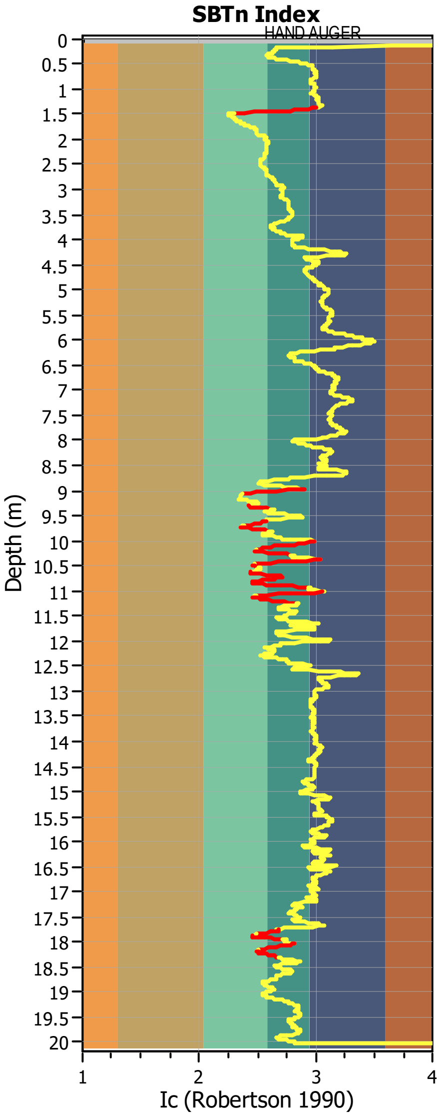
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

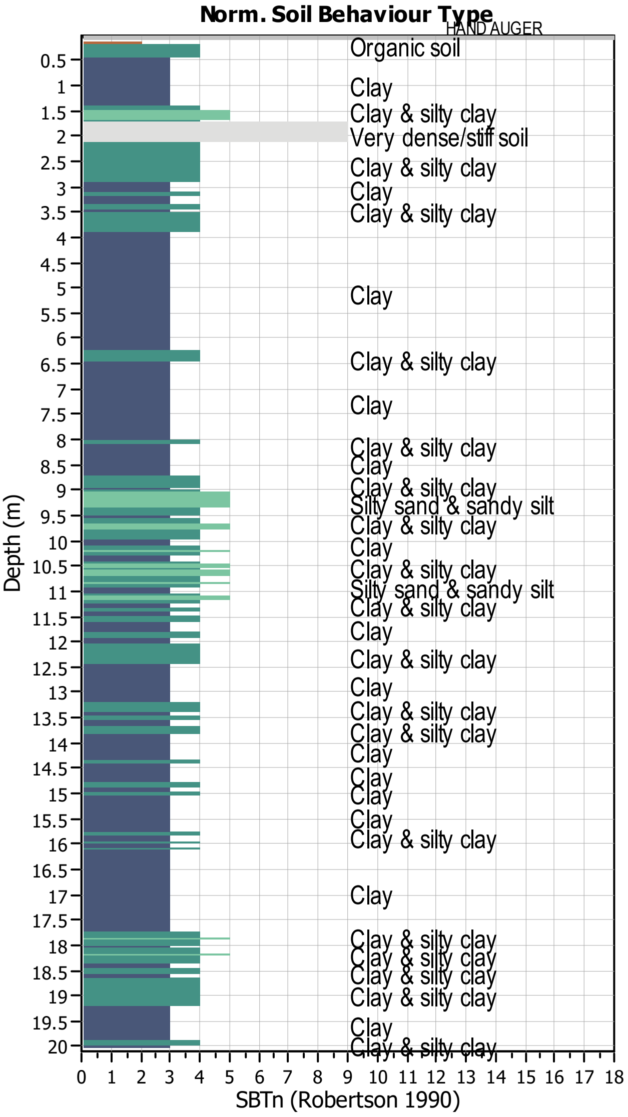
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





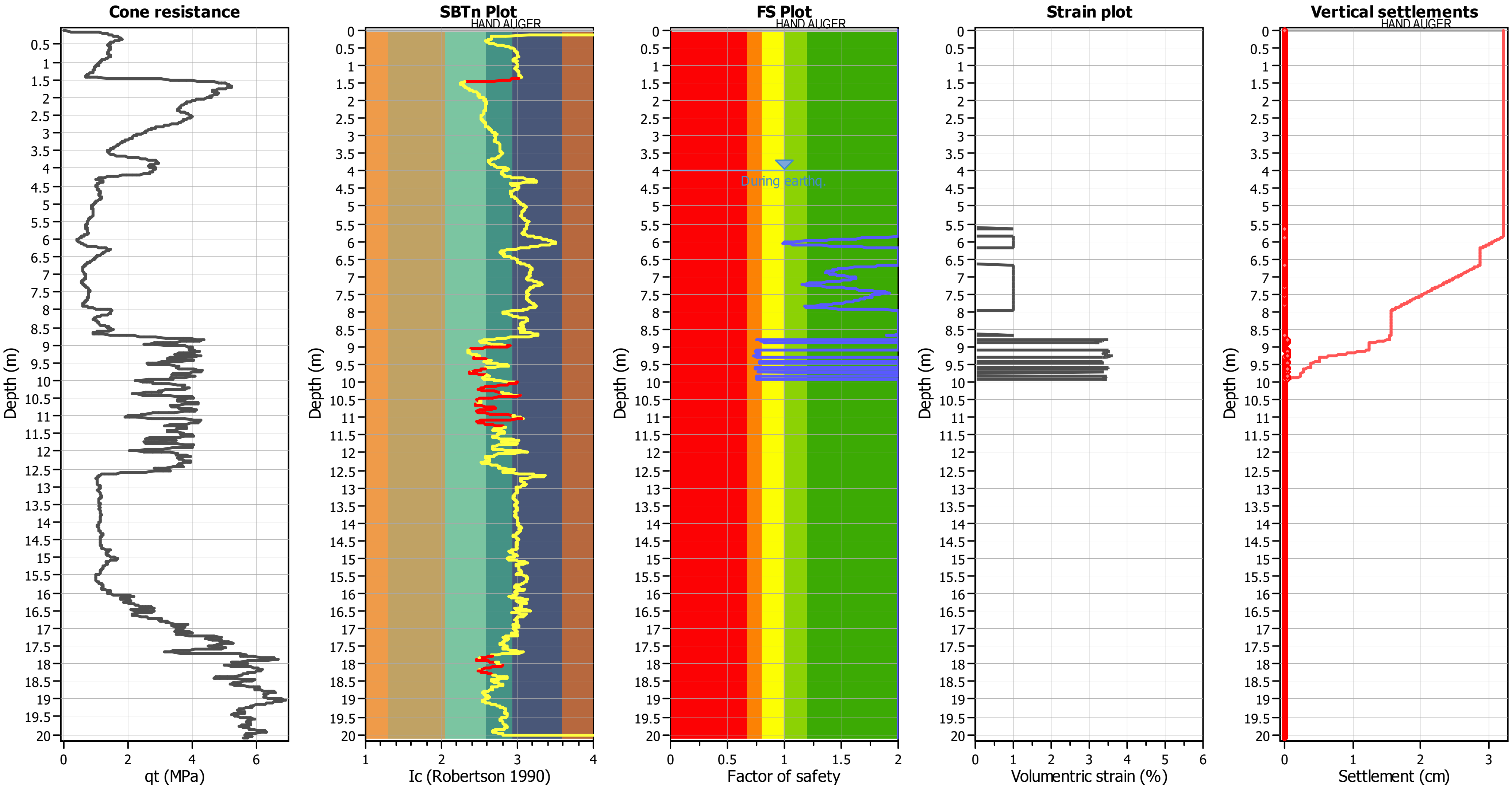
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	195
Exclusion percentage:	9.70%
Number of layers detected:	18

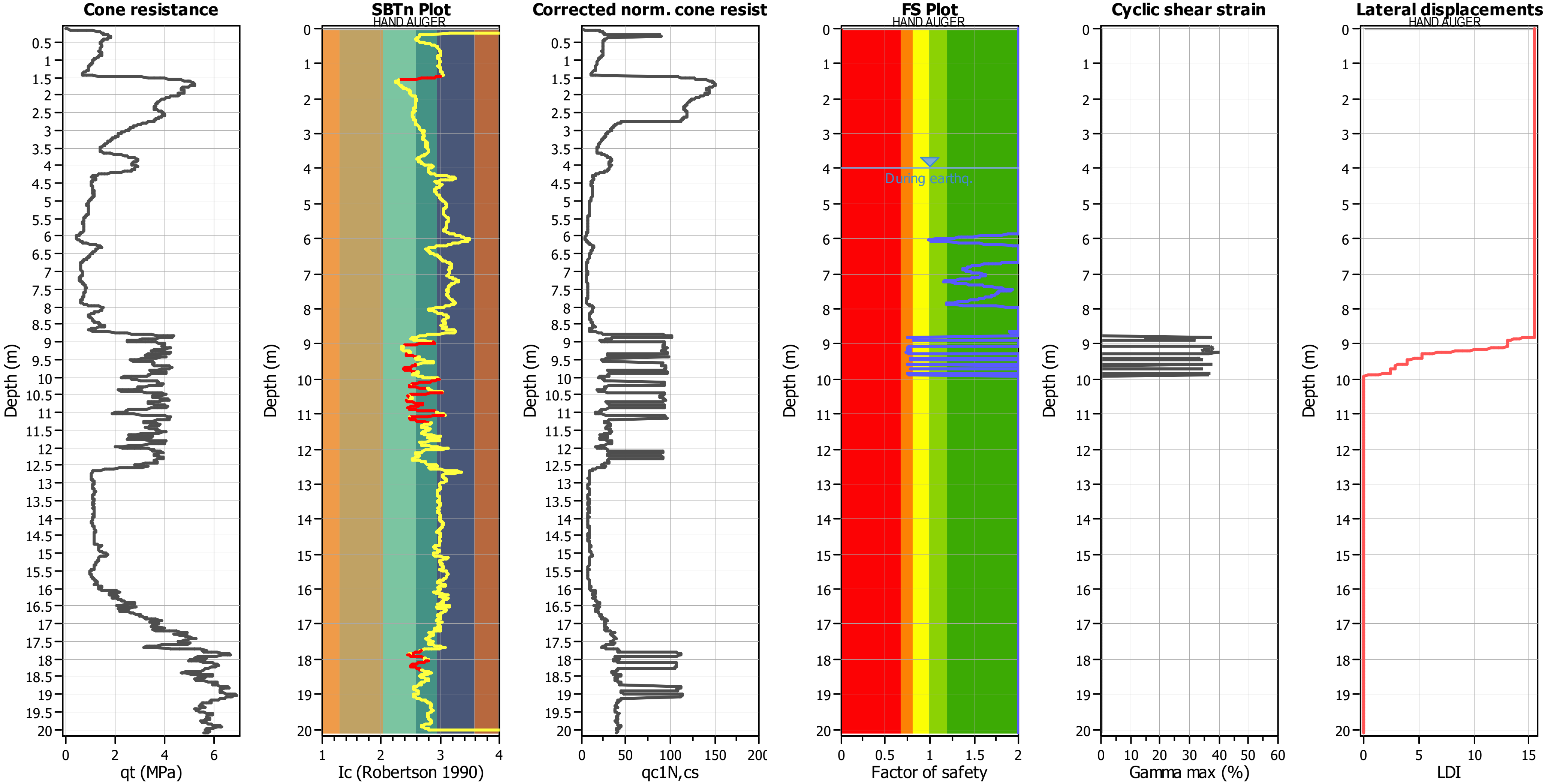
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

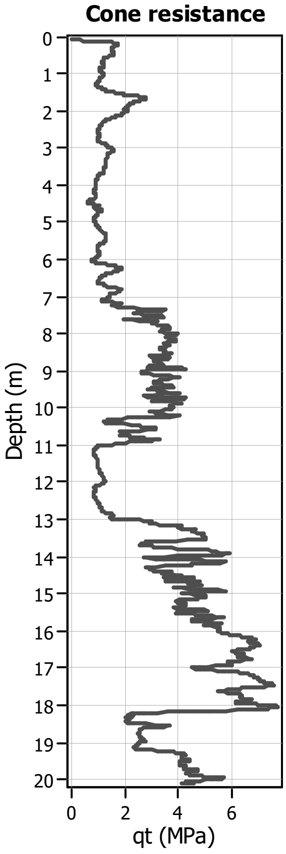
LIQUEFACTION ANALYSIS REPORT

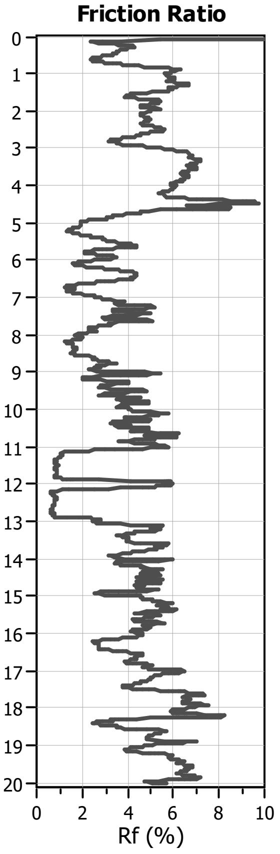
Project title : Proposed Private Plan Change for Te Awamutu   **Location : 2025 Ohaupo Road, Te Awamutu**

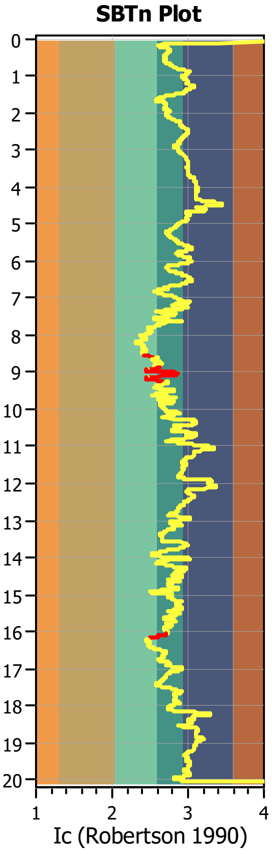
CPT file : CPT-02

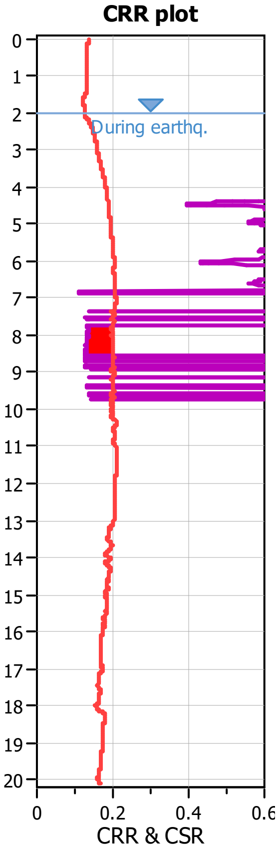
Input parameters and analysis data

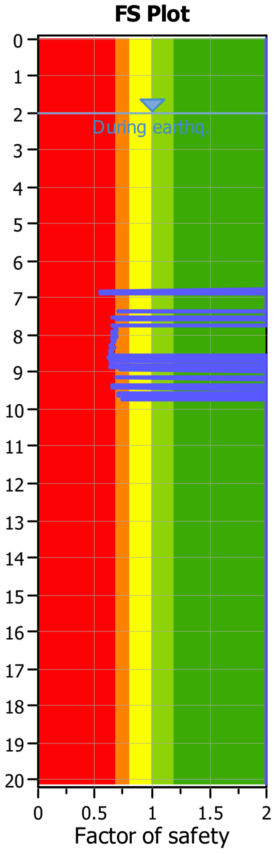
Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

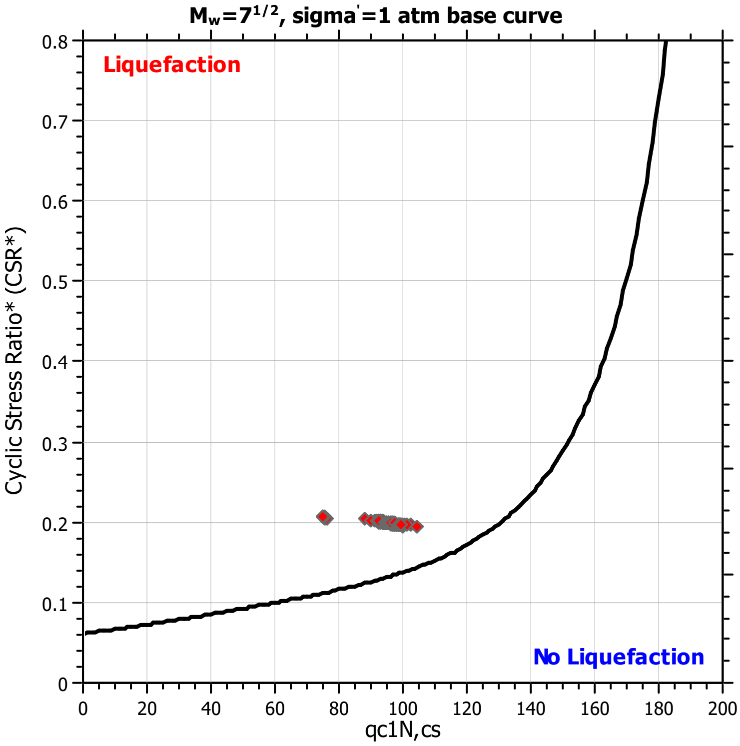


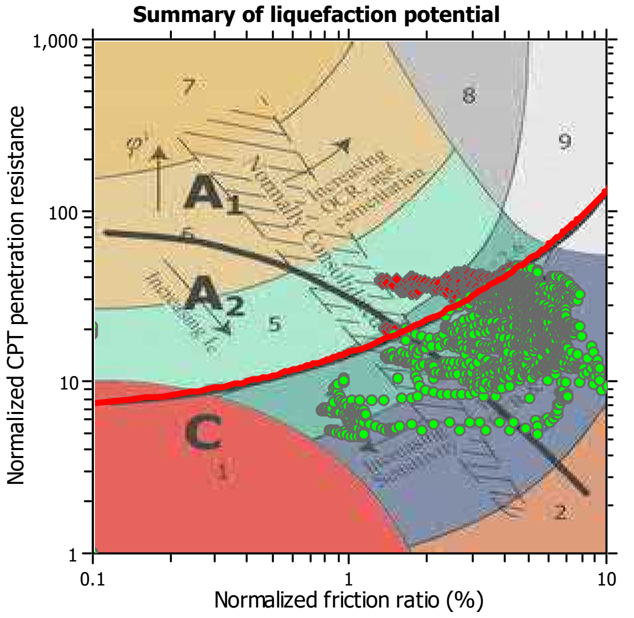






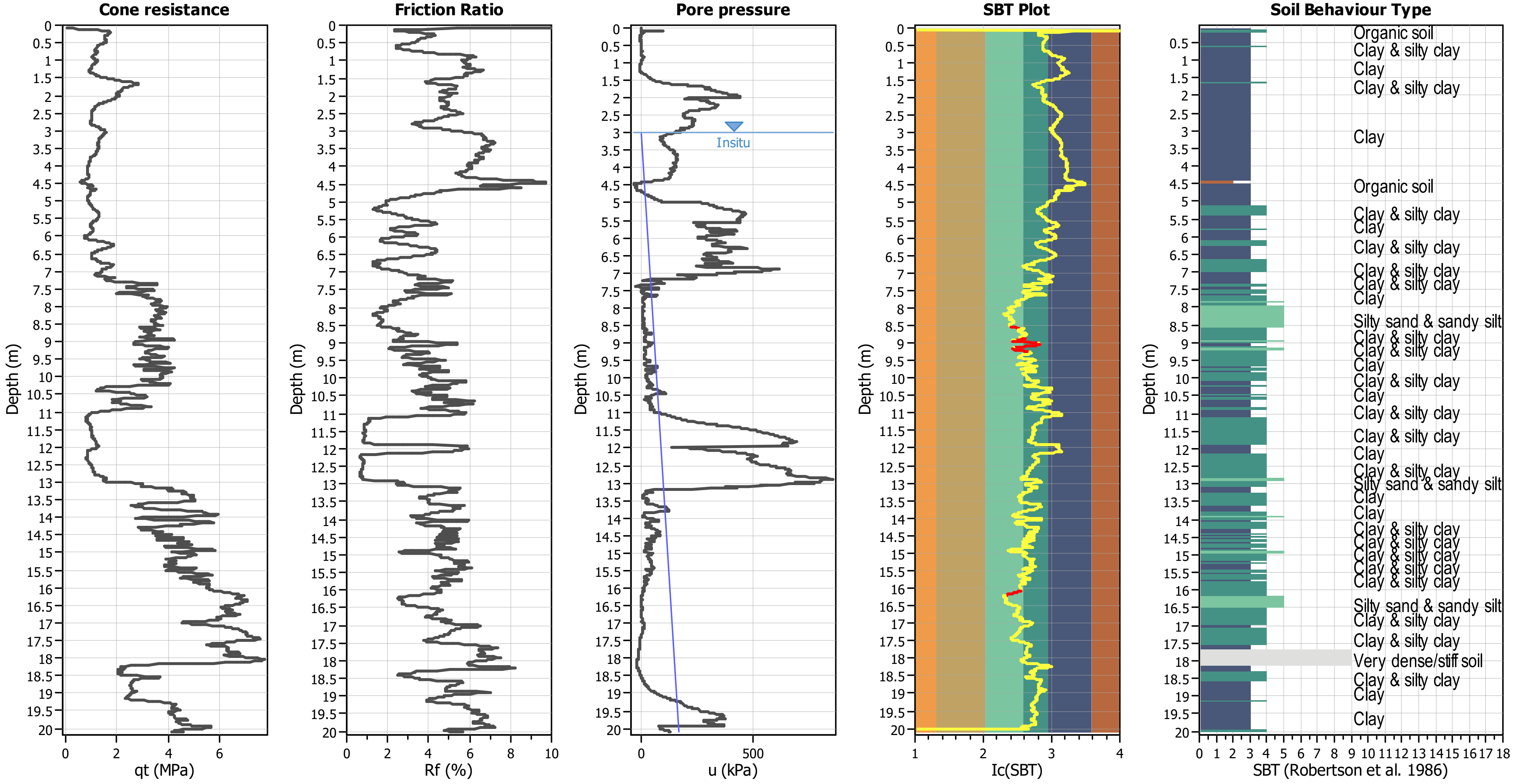






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



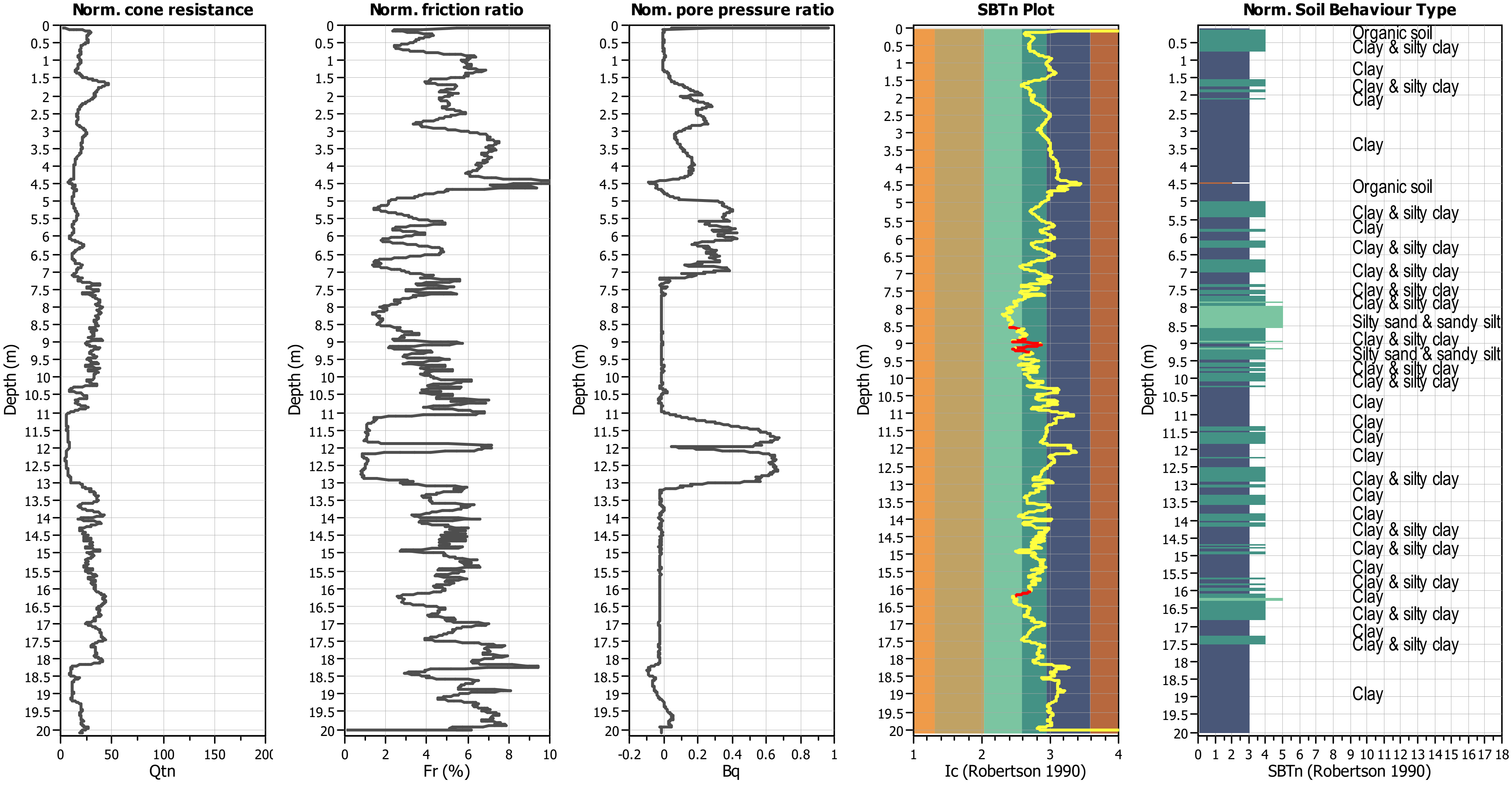
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT 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

CPT basic interpretation plots (normalized)



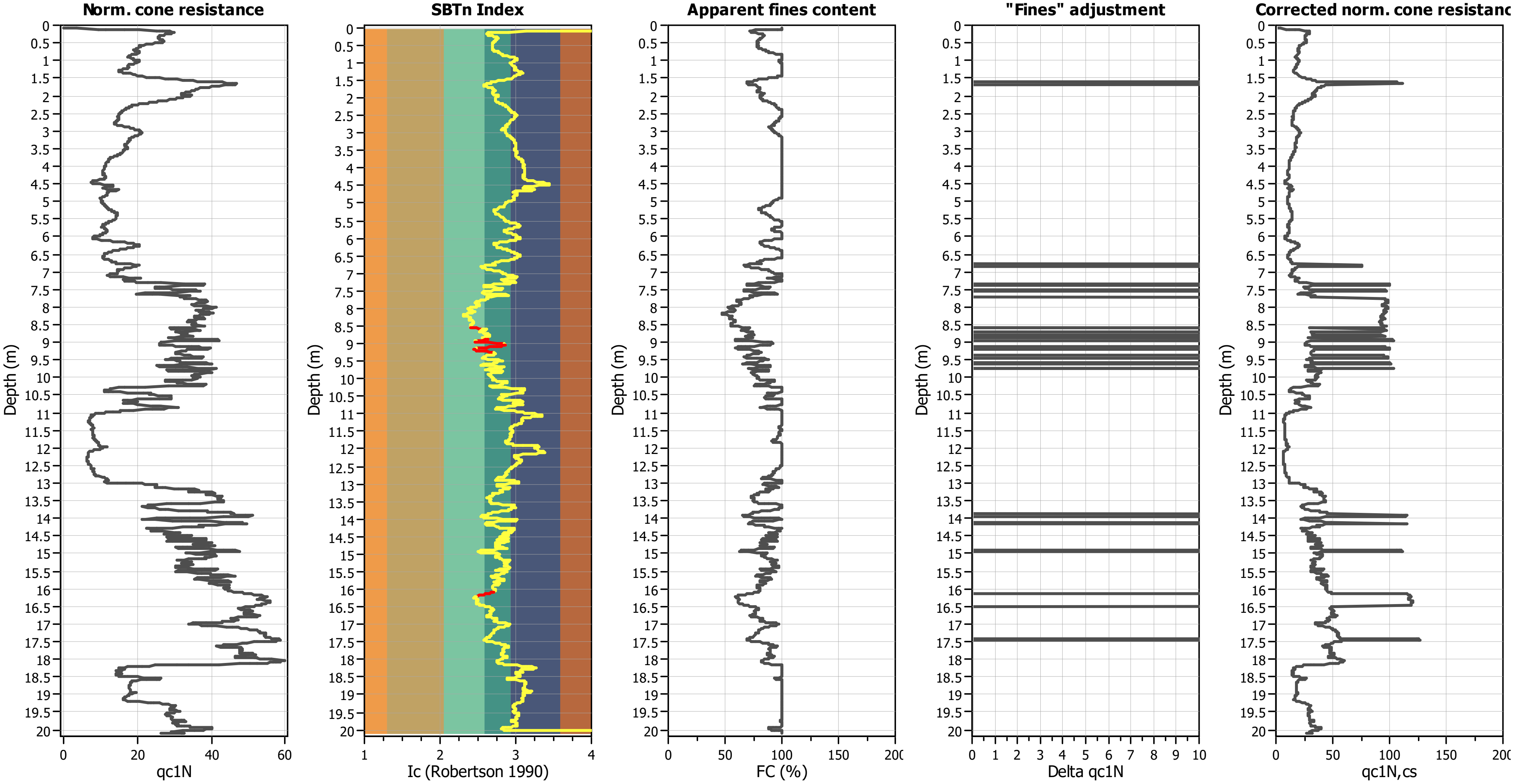
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

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

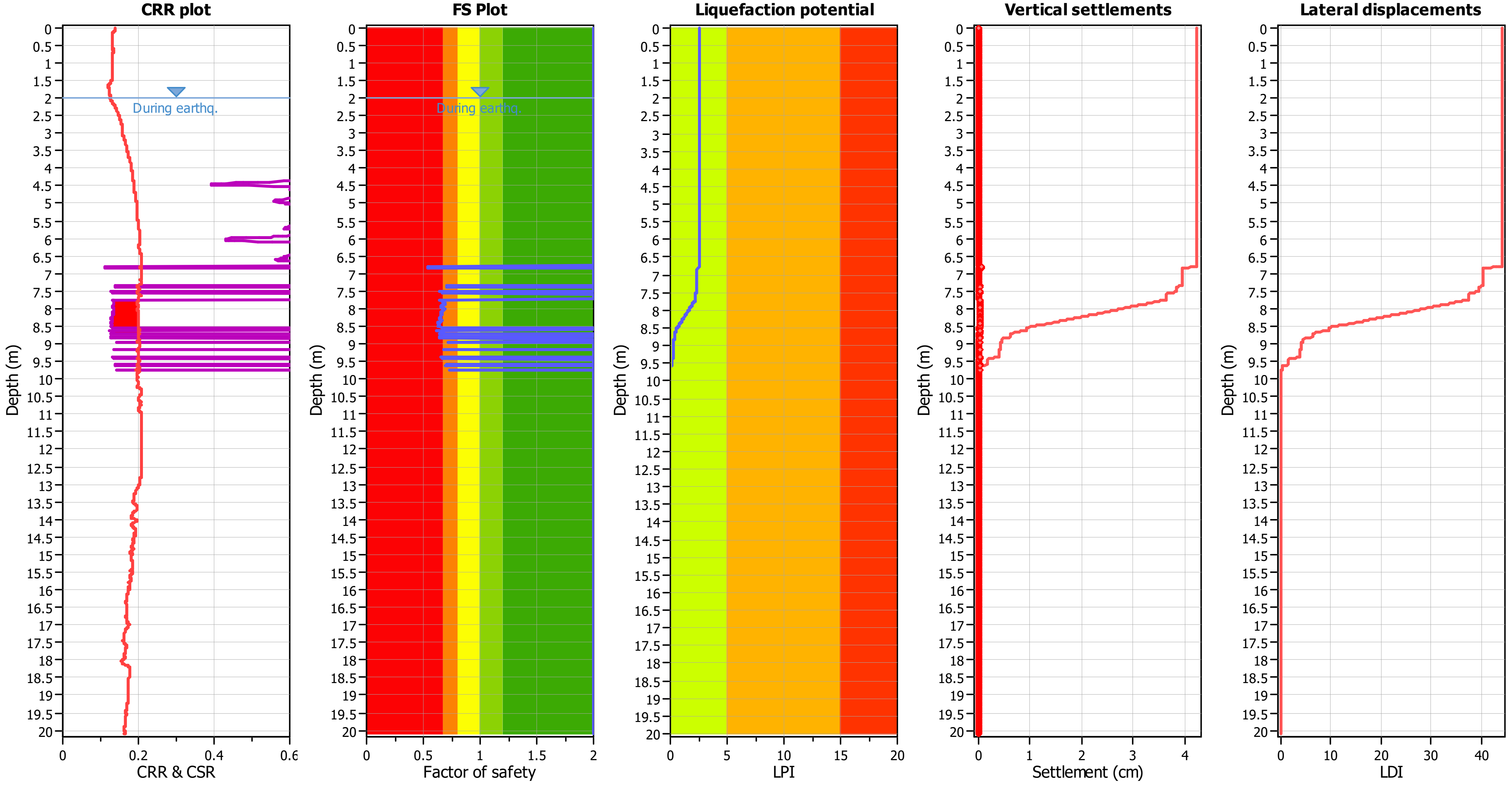
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

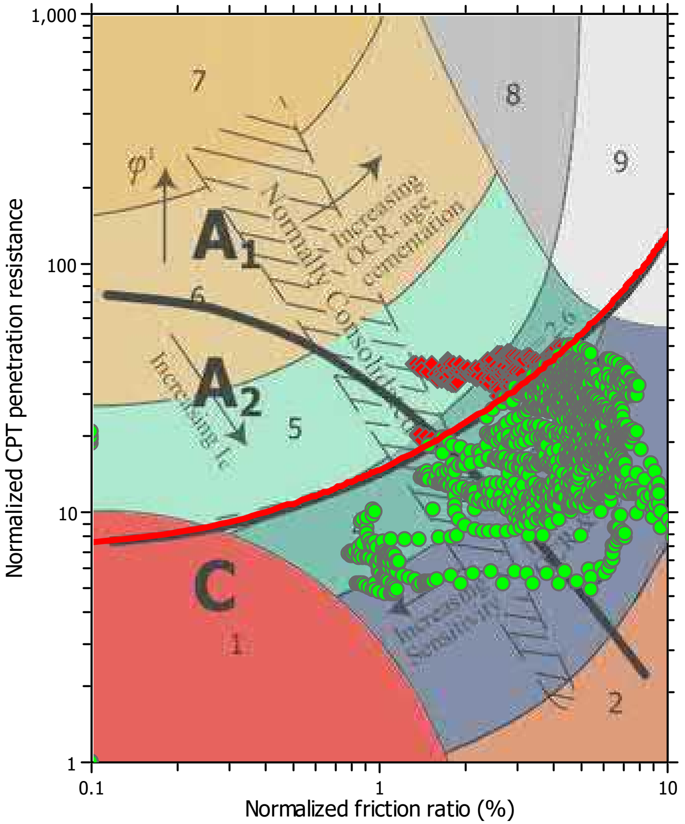
F.S. color scheme

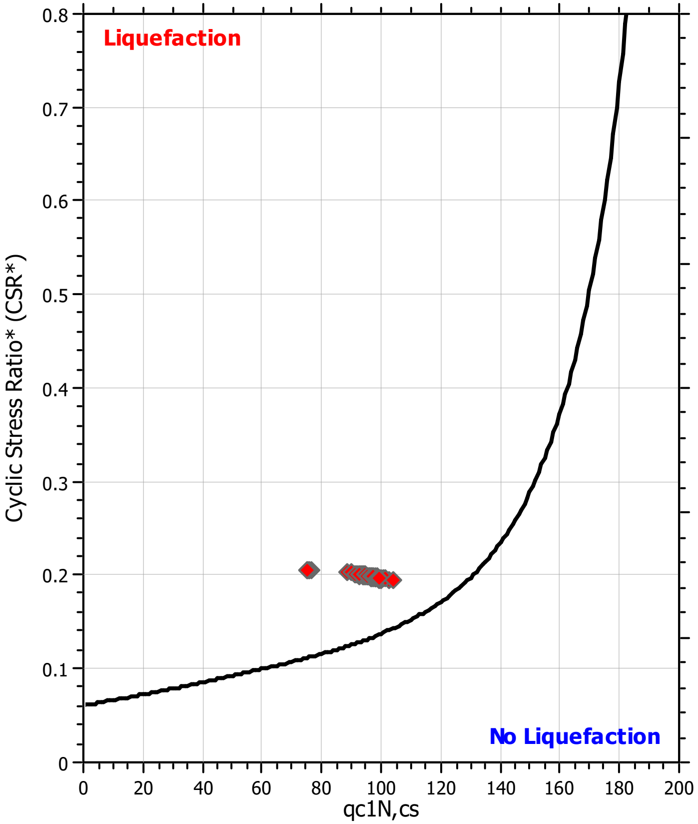
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

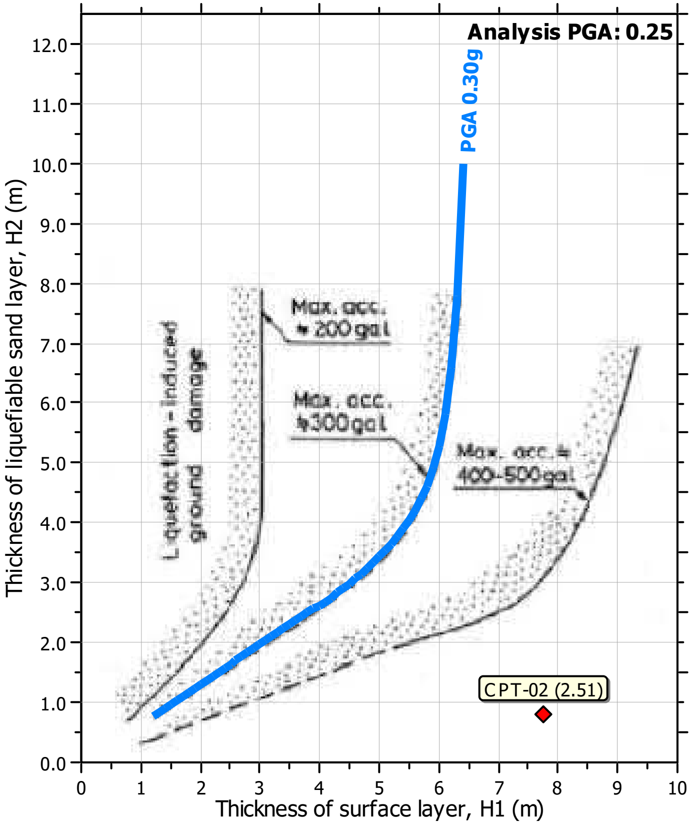
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟩 Low risk

Liquefaction analysis summary plots



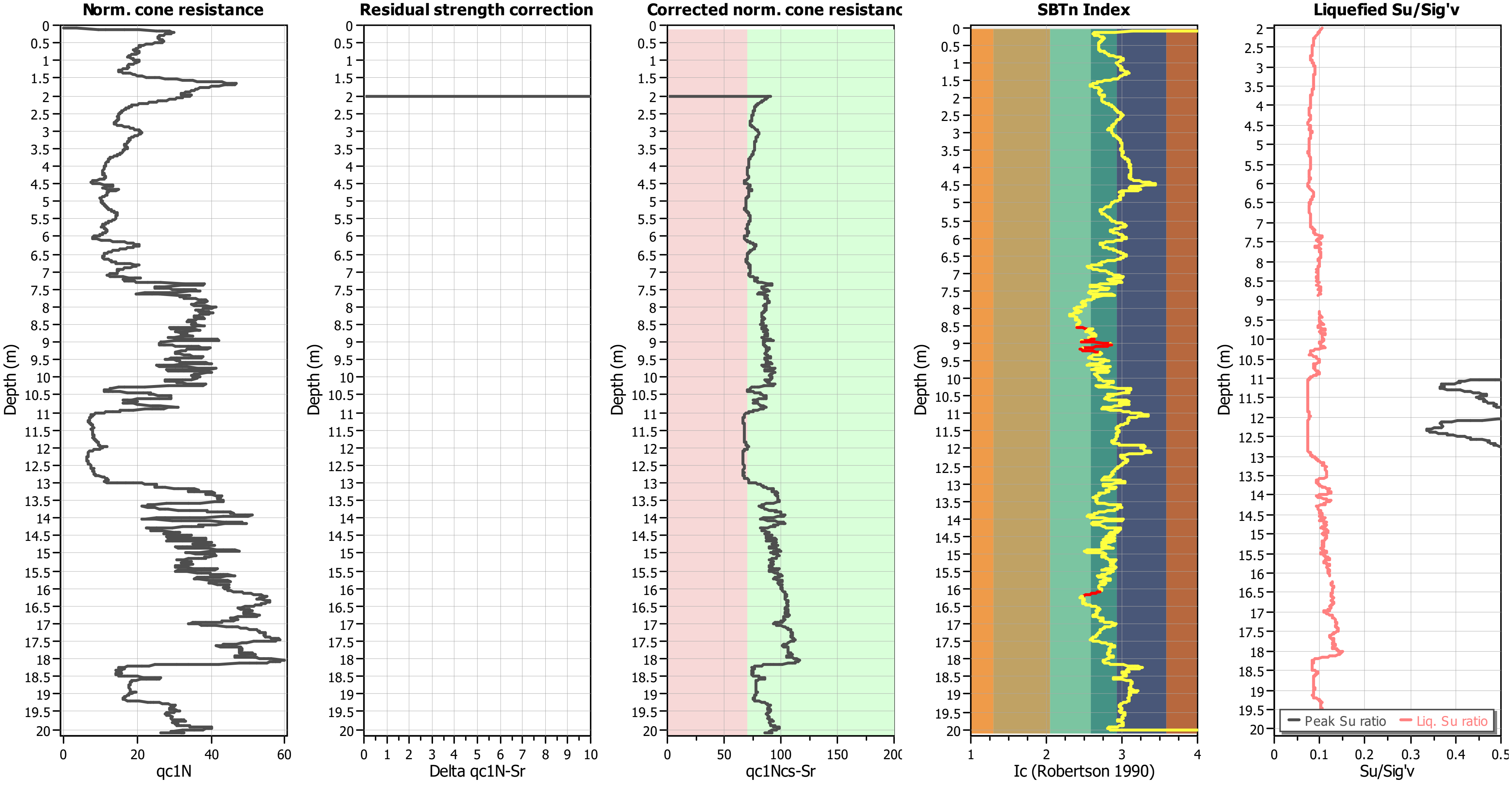




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

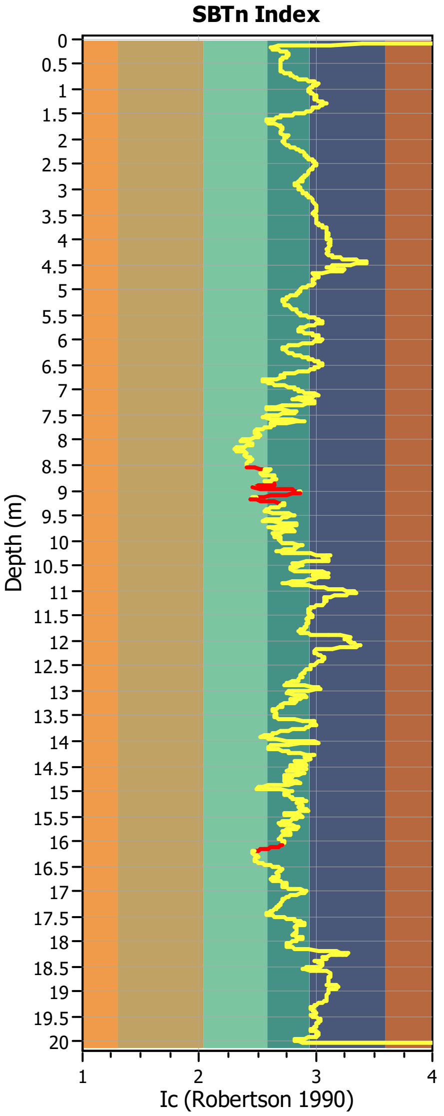
TRANSITION LAYER DETECTION ALGORITHM REPORT

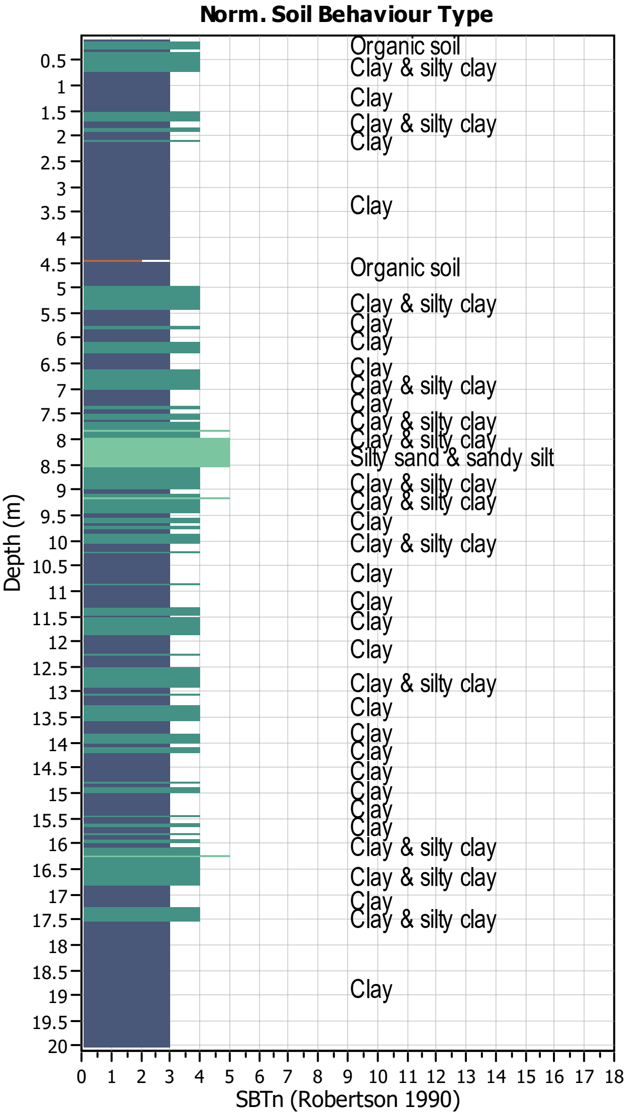
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





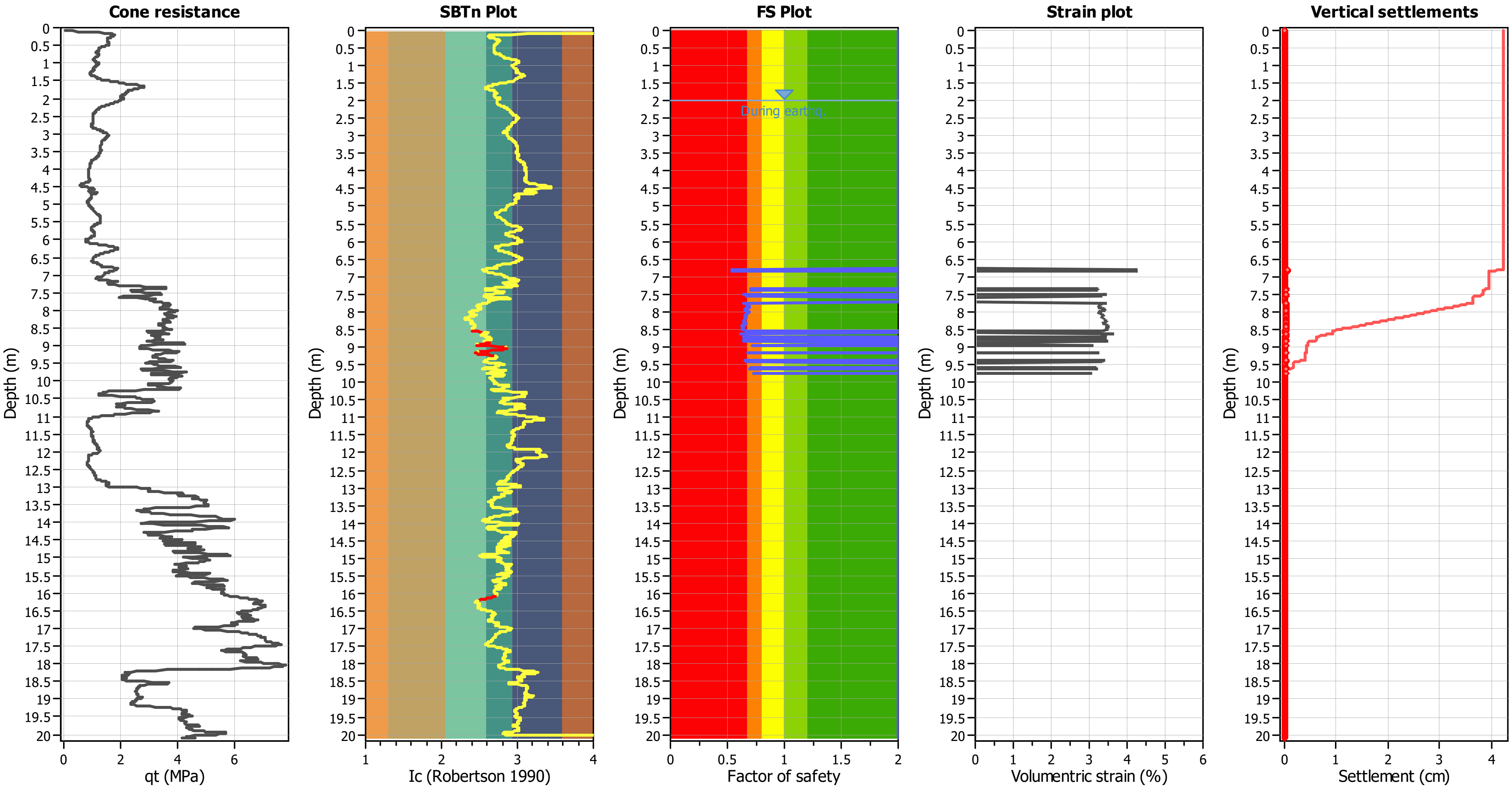
Transition layer algorithm properties

I_c minimum check value: 1.70
I_c maximum check value: 3.00
I_c change ratio value: 0.0100
Minimum number of points in layer: 4

General statistics

Total points in CPT file: 2010
Total points excluded: 56
Exclusion percentage: 2.79%
Number of layers detected: 6

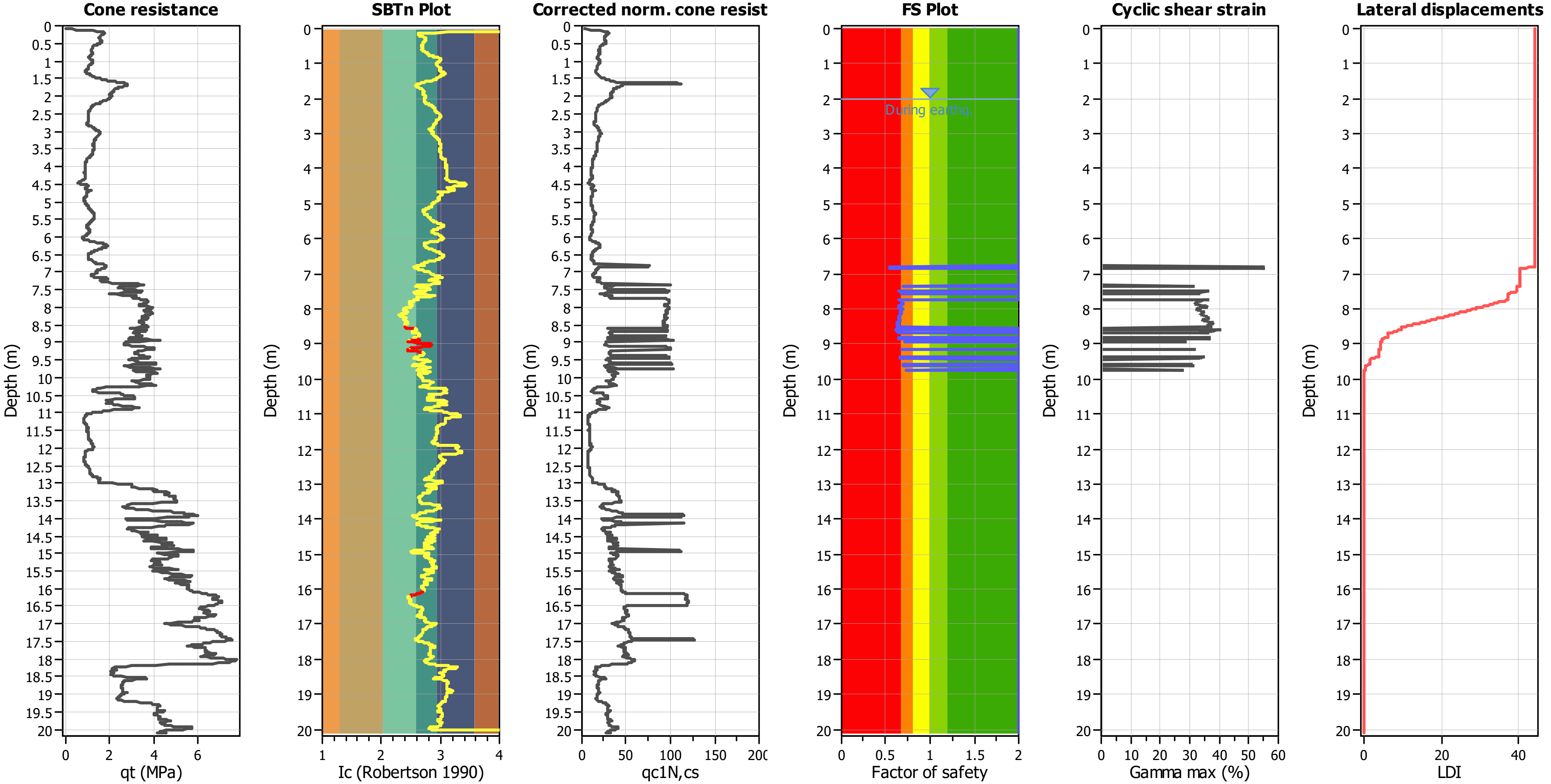
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

BTWCOMPANY
SURVEYING | ENGINEERING | PLANNING & ENVIRONMENT

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

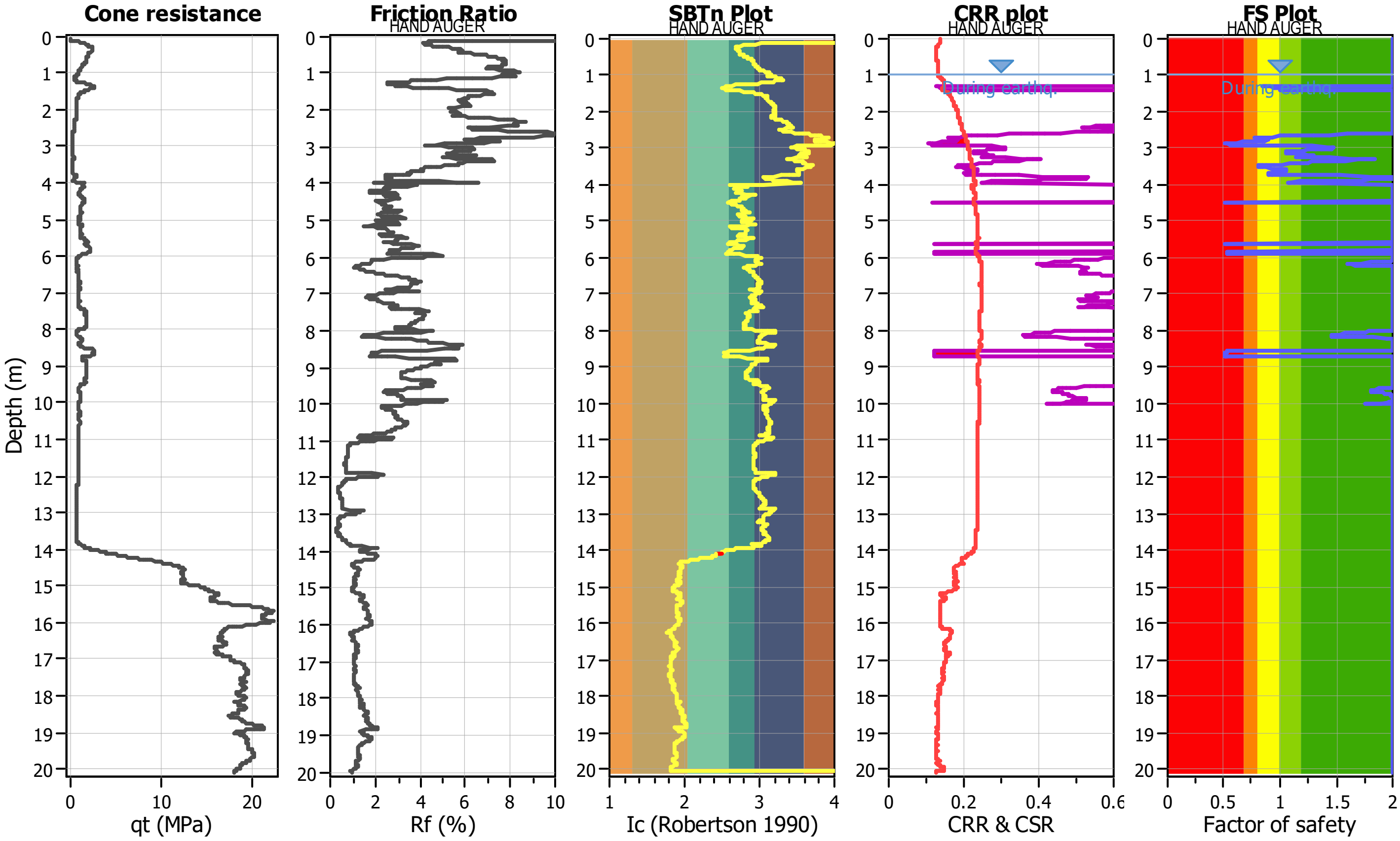
LIQUEFACTION ANALYSIS REPORT

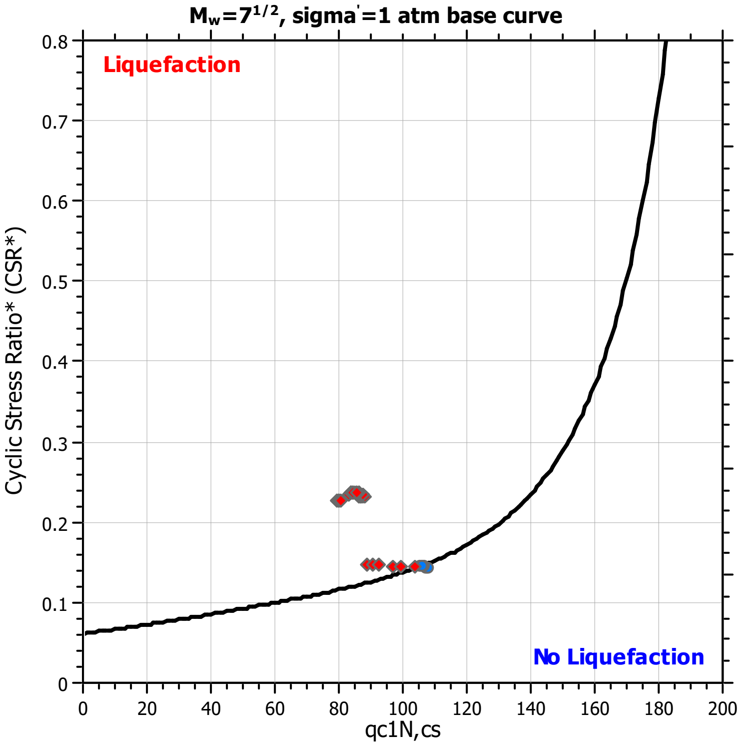
Project title : Proposed Private Plan Change for Te Awamutu   Location : 2025 Ohaupo Road, Te Awamutu

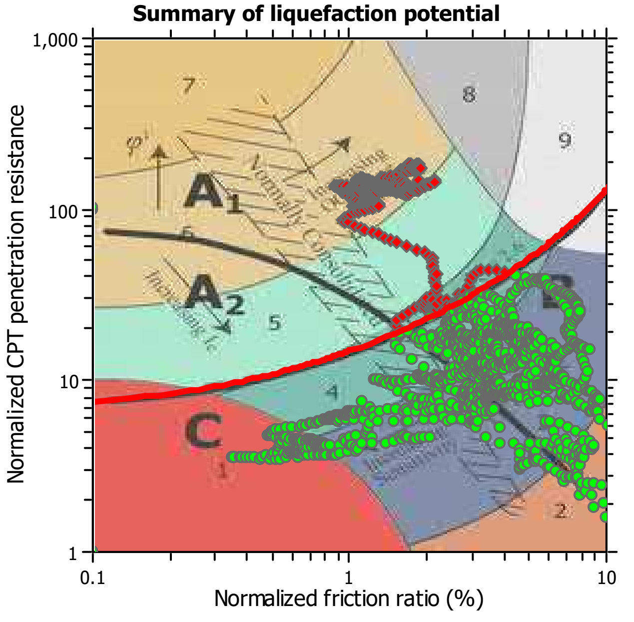
CPT file : CPT-03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

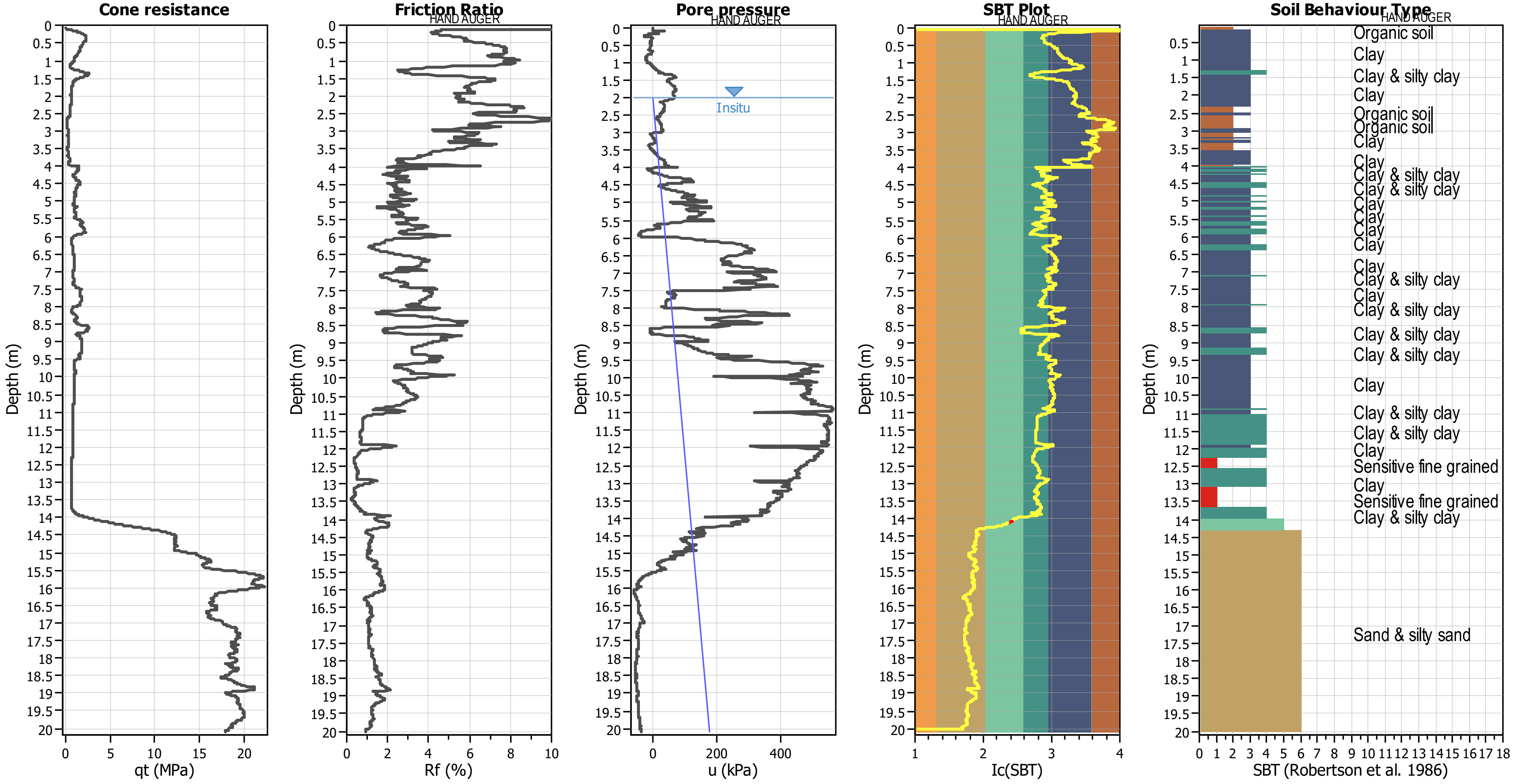






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



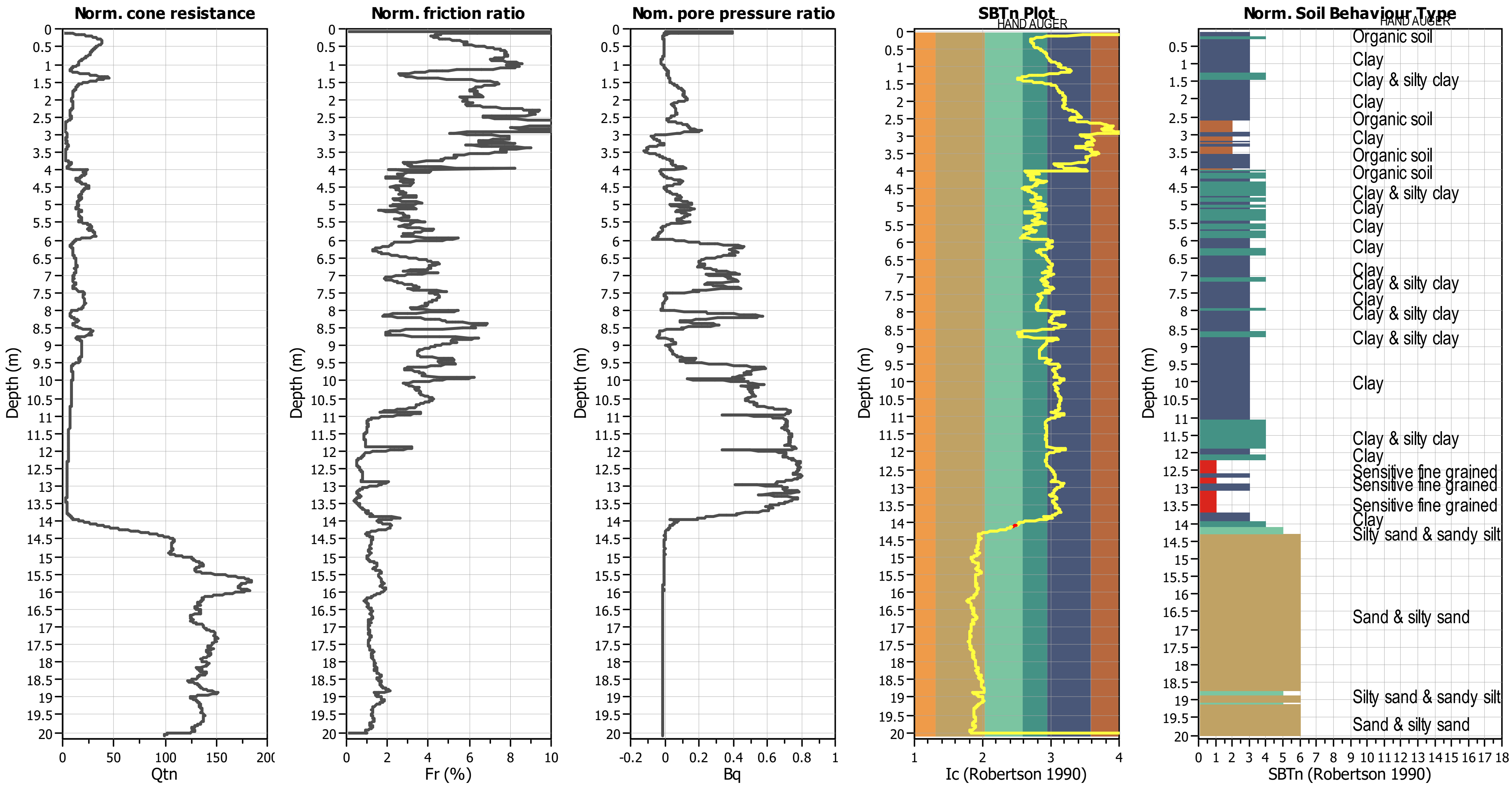
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to
⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



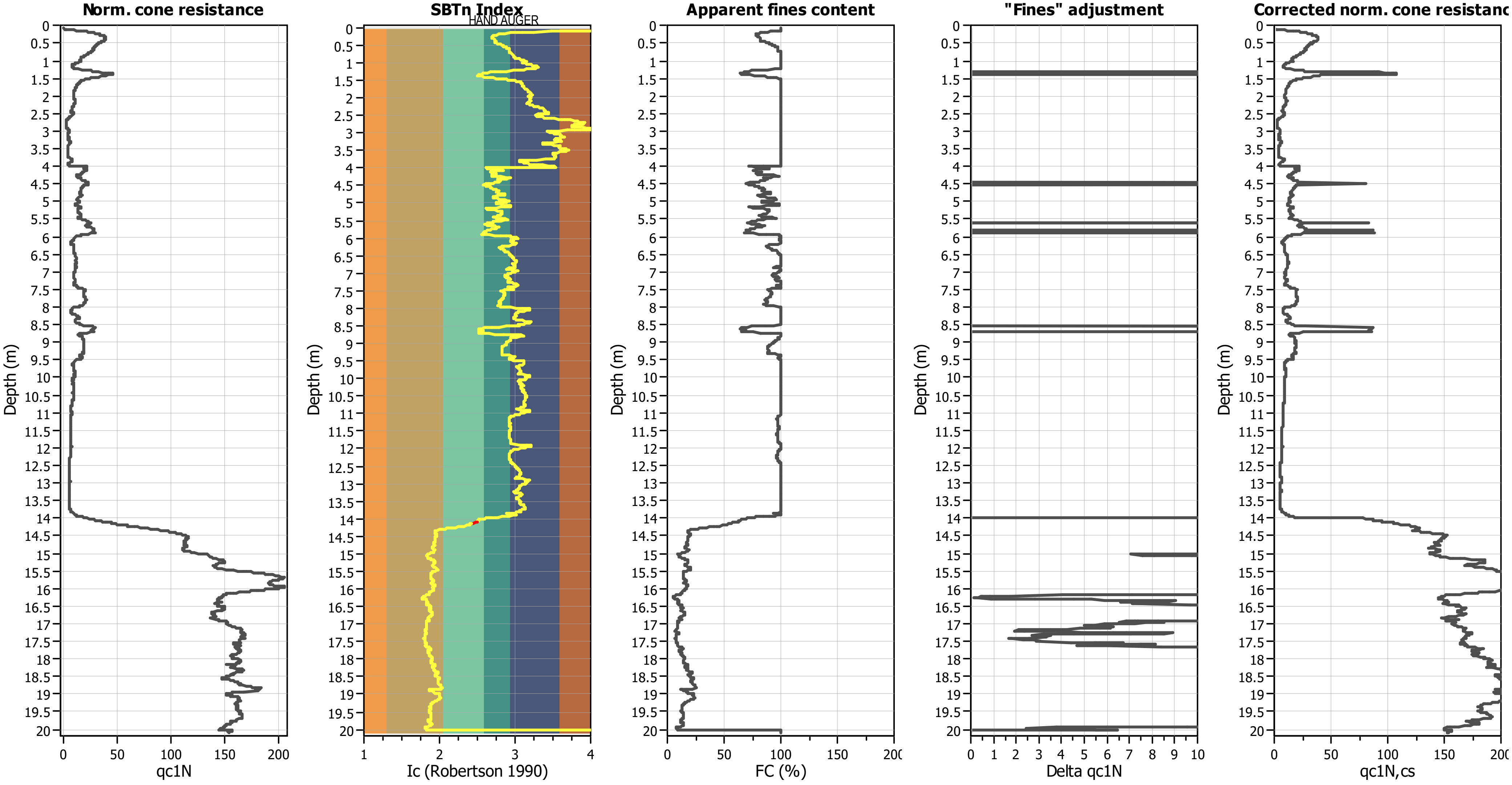
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K$_\sigma$ applied:	Yes
Earthquake magnitude M$_w$:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

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

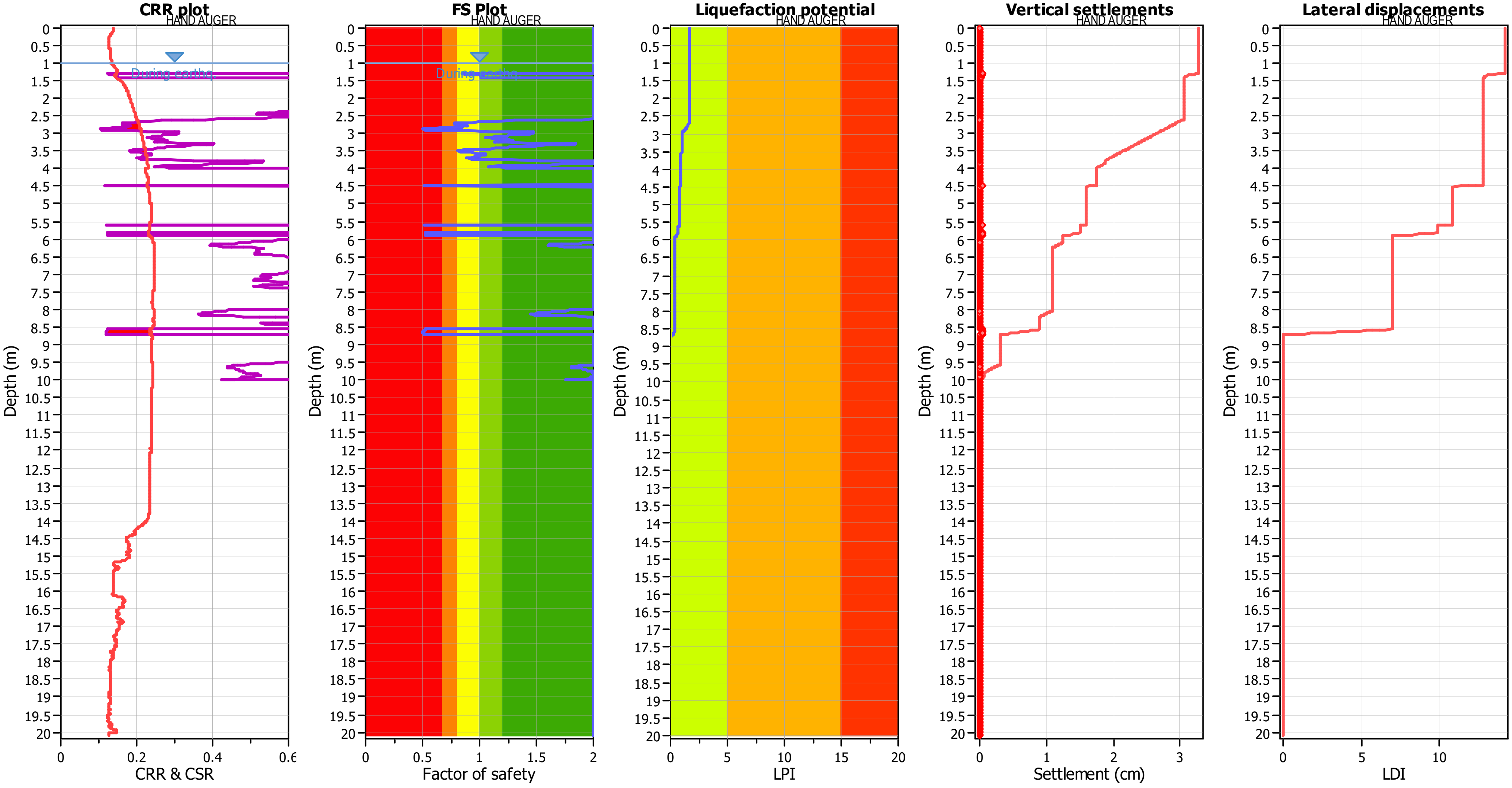
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

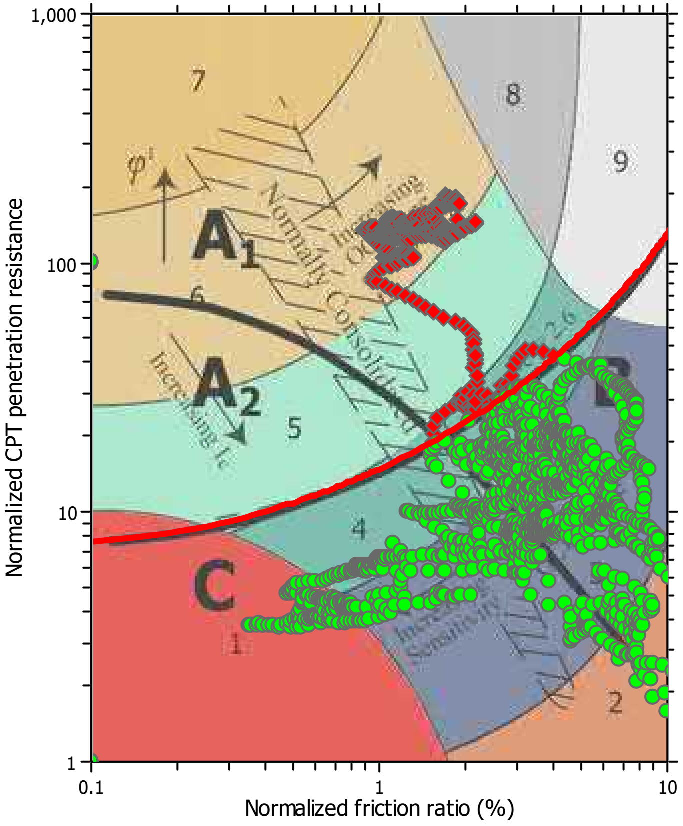
F.S. color scheme

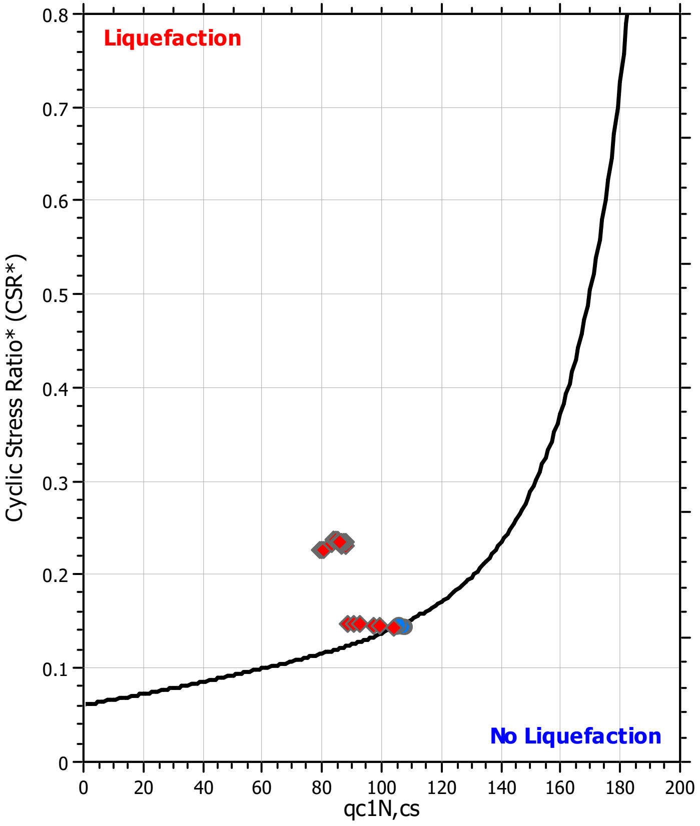
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

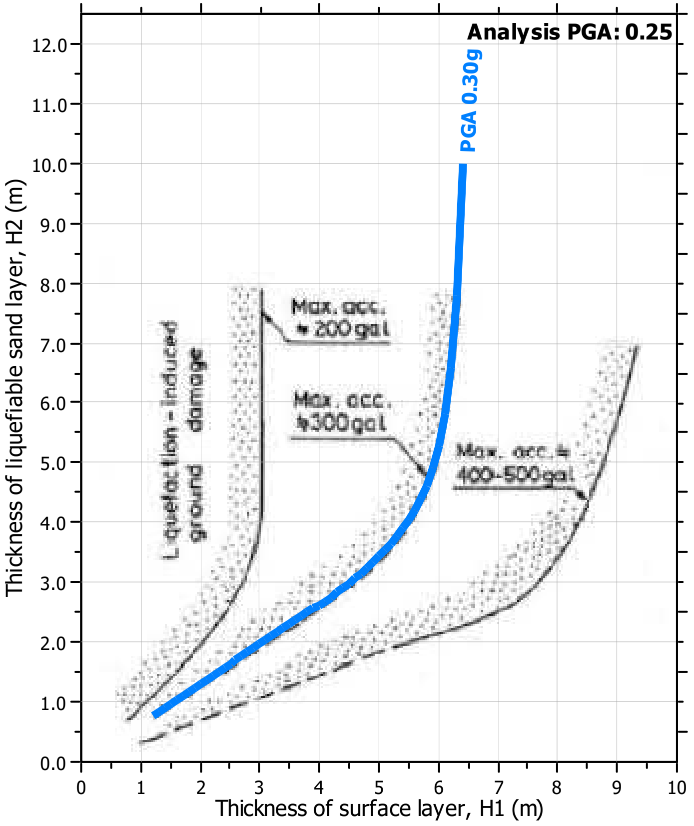
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



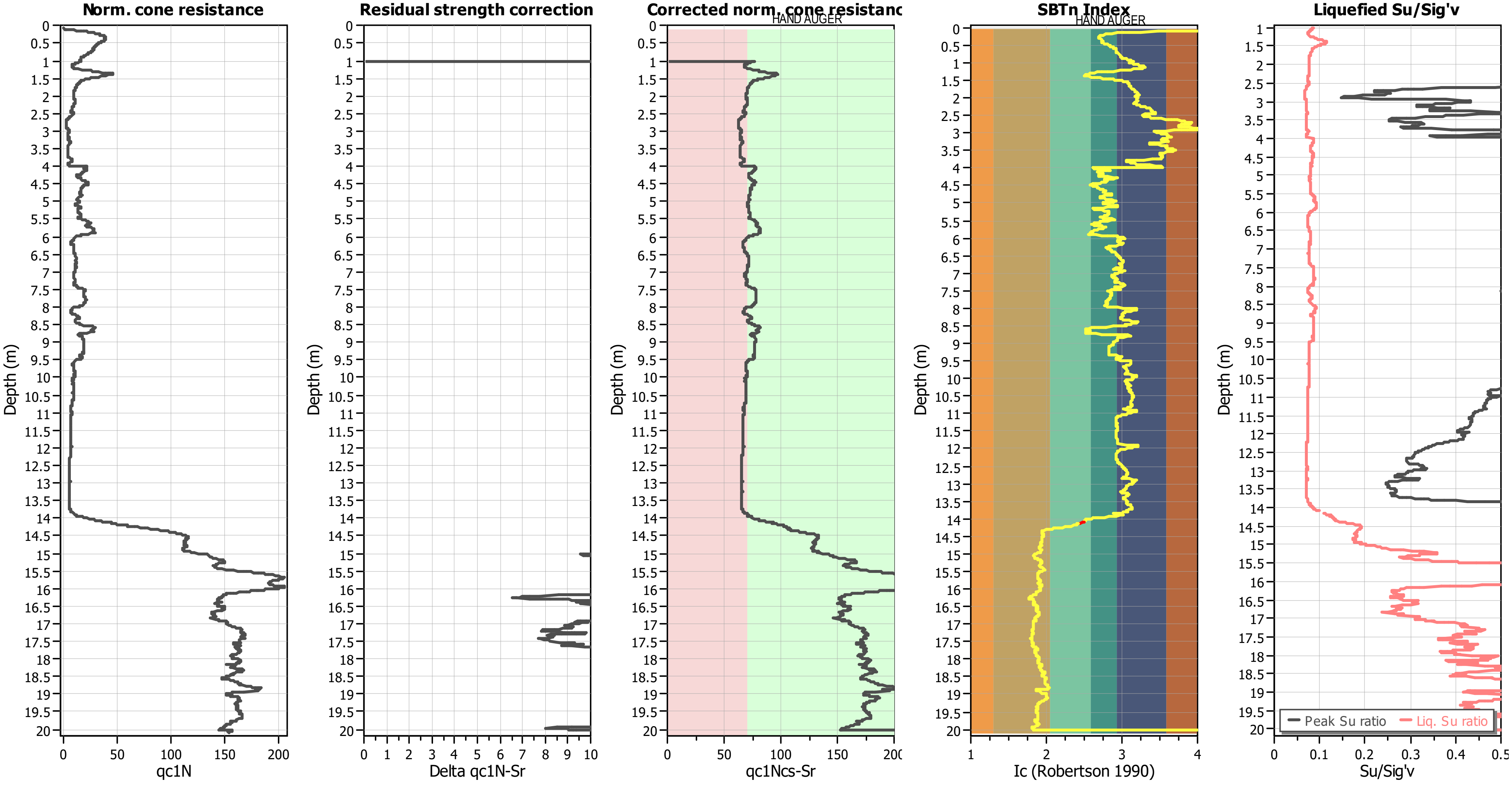




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

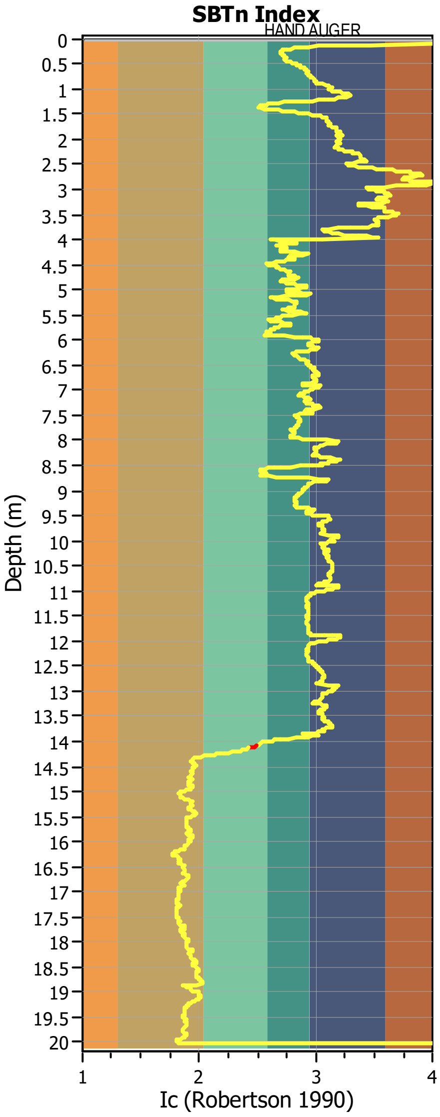
TRANSITION LAYER DETECTION ALGORITHM REPORT

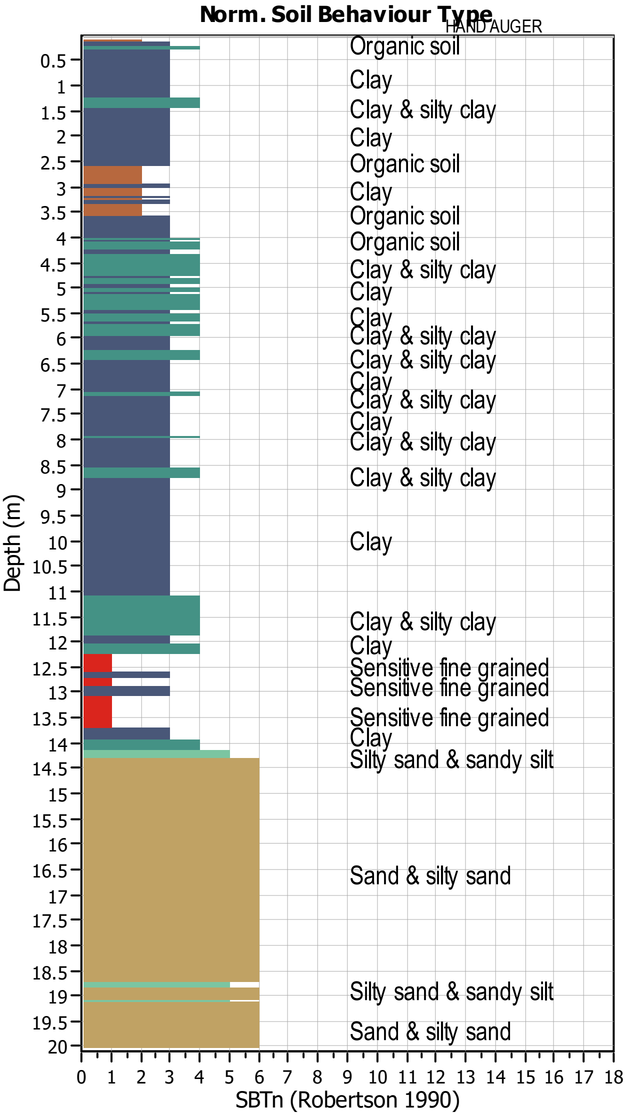
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





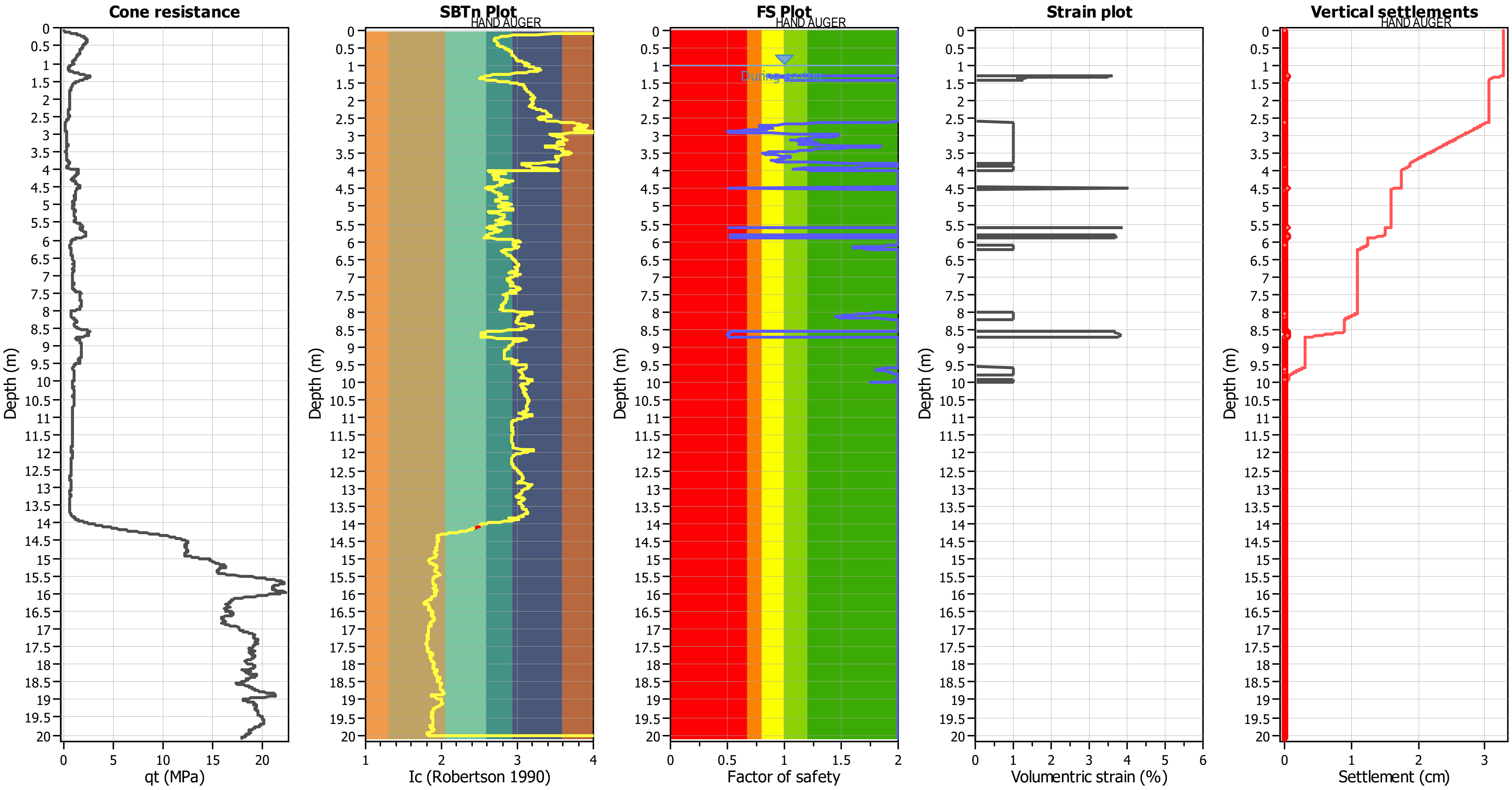
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	5
Exclusion percentage:	0.25%
Number of layers detected:	1

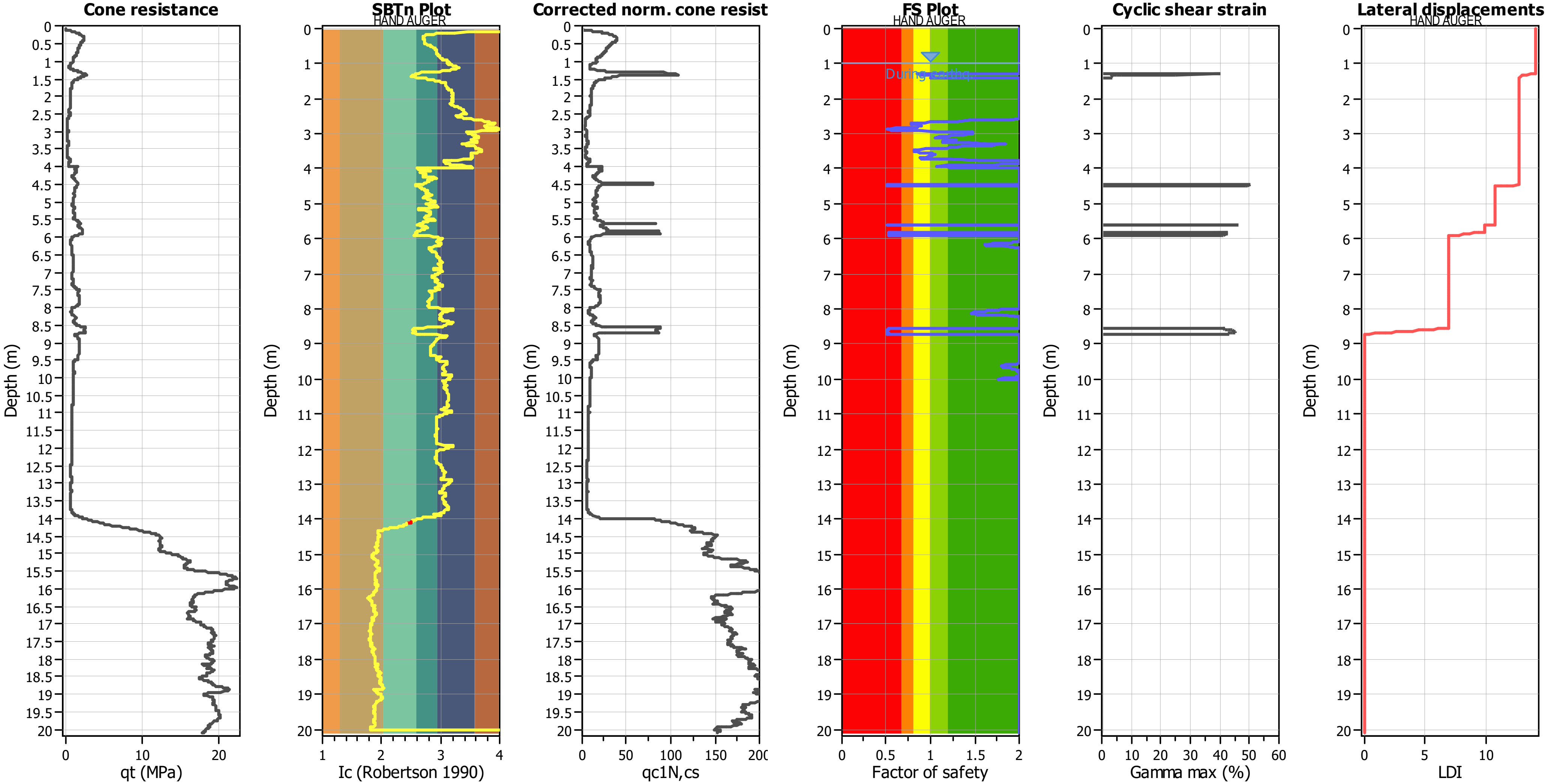
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

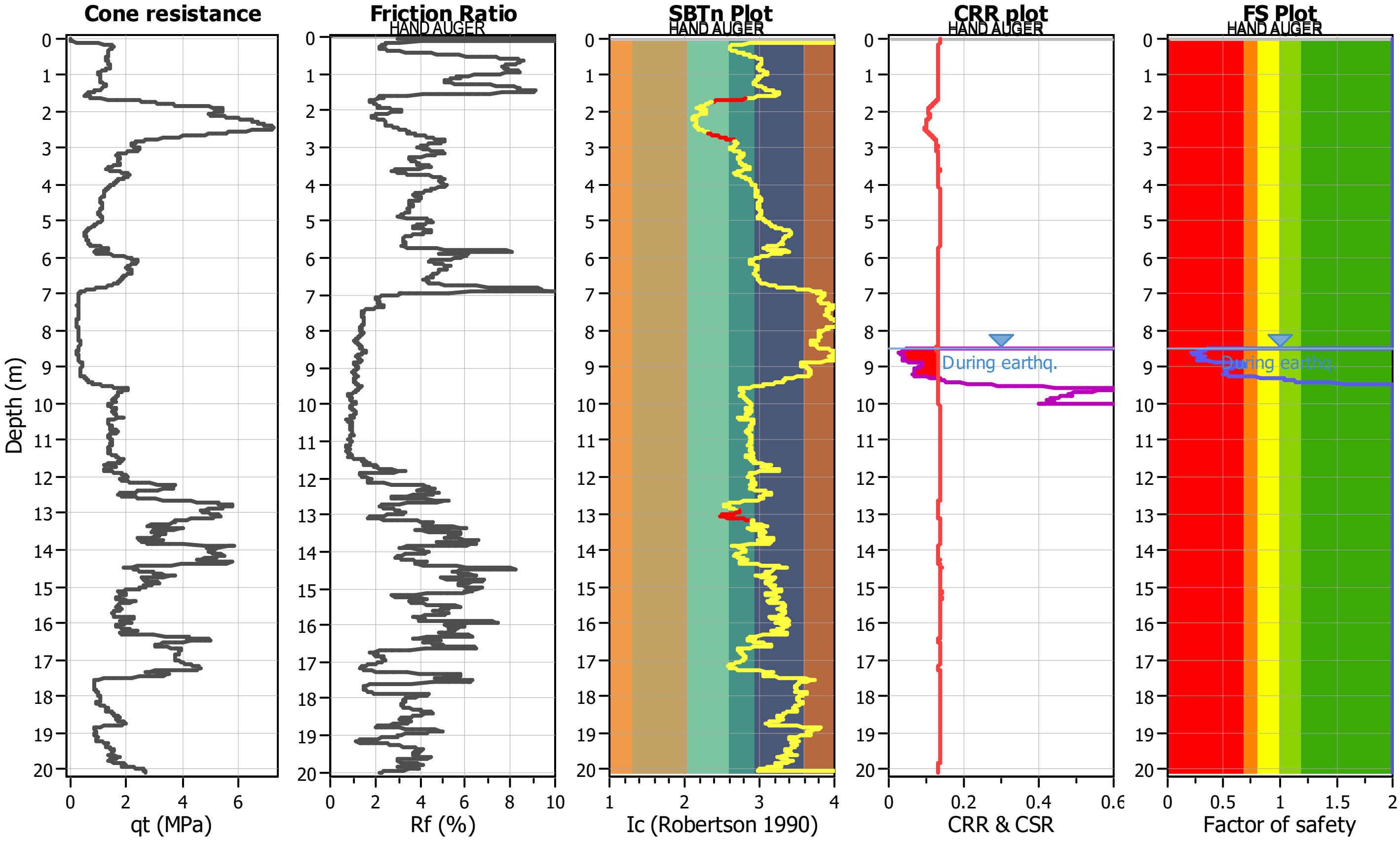
LIQUEFACTION ANALYSIS REPORT

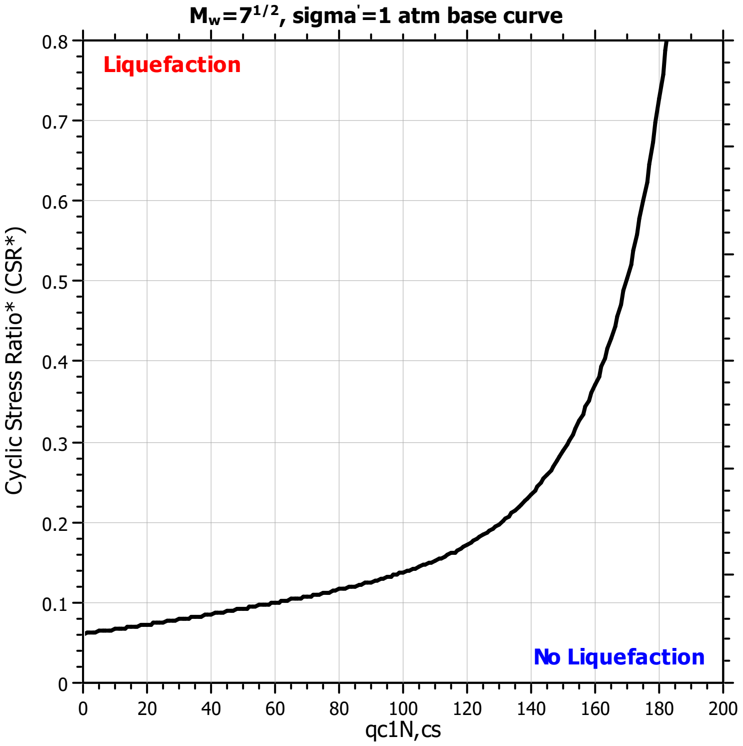
Project title : Proposed Private Plan Change for Te Awamutu   Location : 2025 Ohaupo Road, Te Awamutu

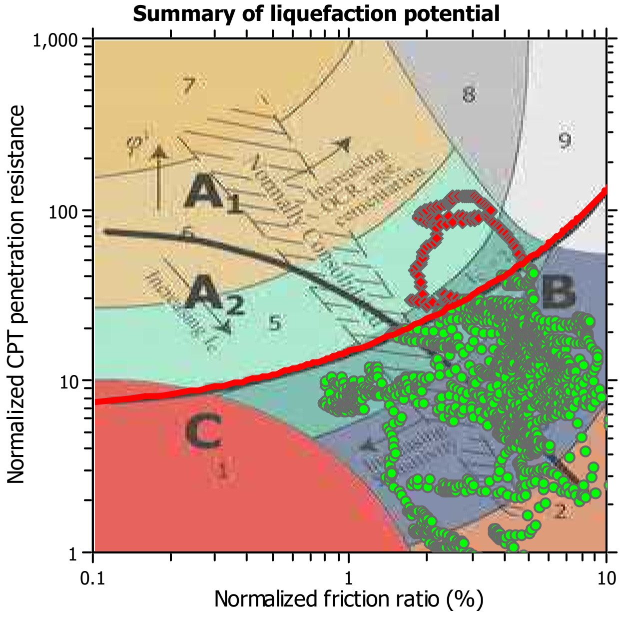
CPT file : CPT-04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	9.50 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	8.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

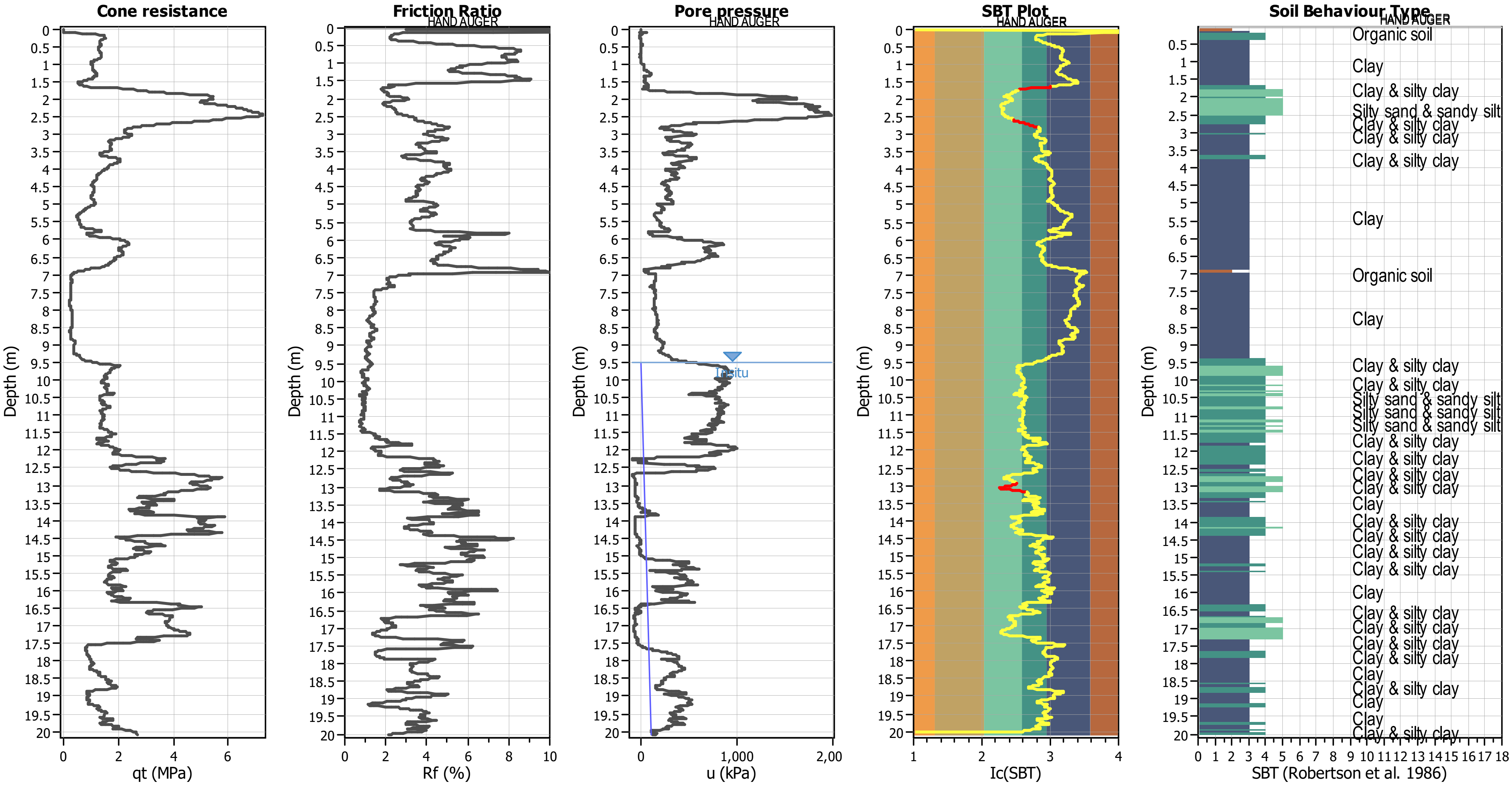






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



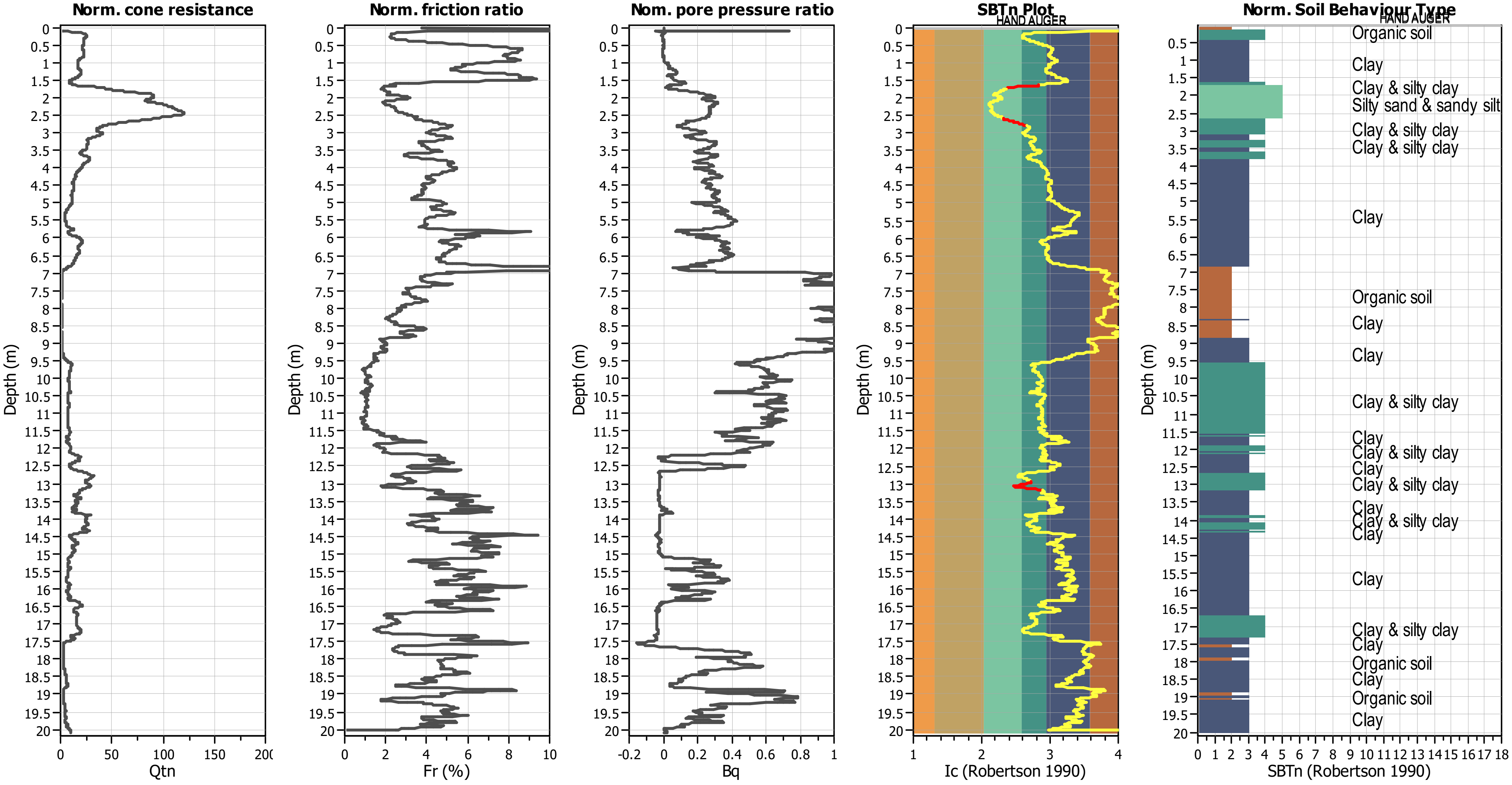
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.25
Depth to water table (insitu): 9.50 m

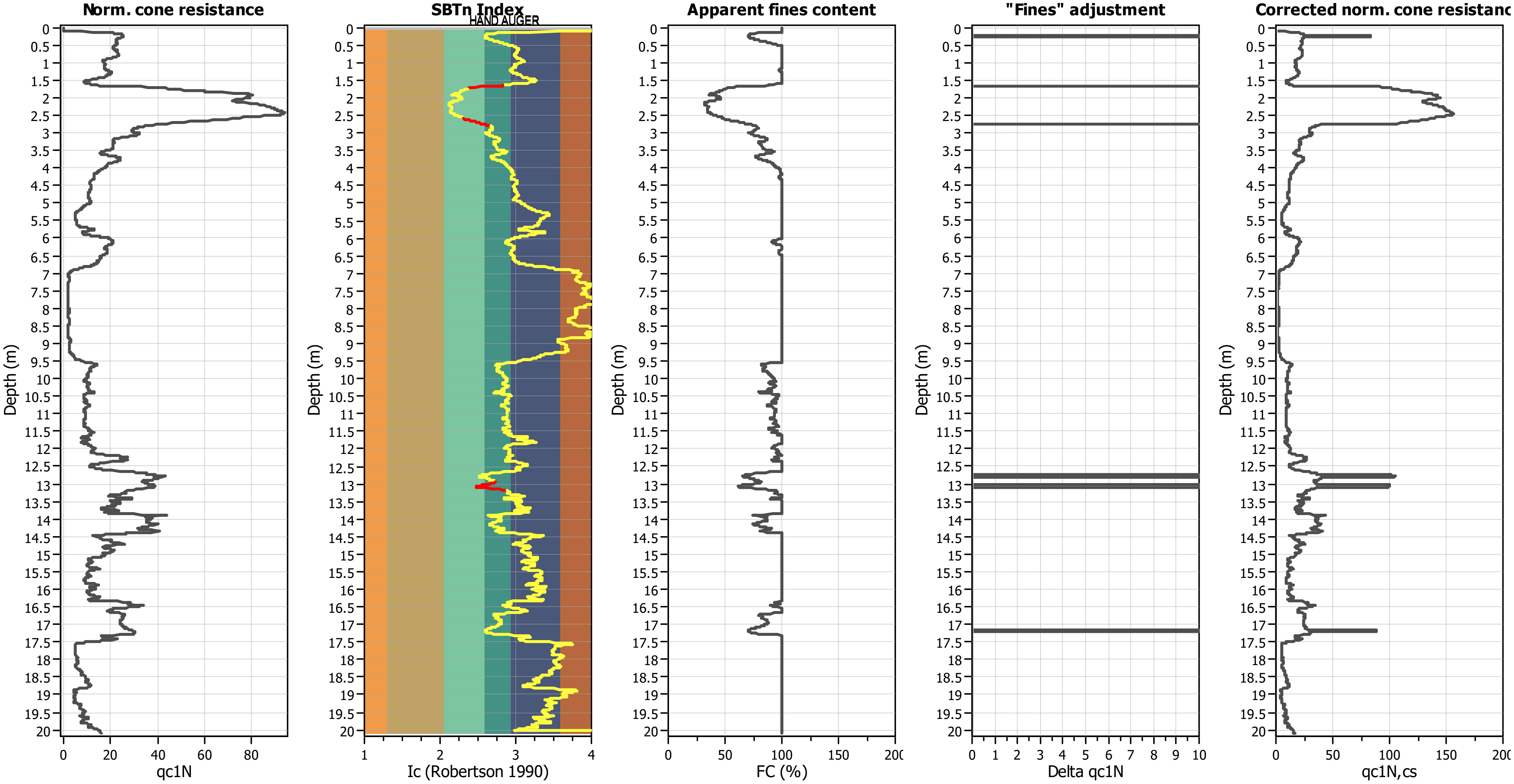
Depth to GWT (erthq.): 8.50 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

SBTn legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to
⬜ 9. Very stiff fine grained

Liquefaction analysis overall plots (intermediate results)



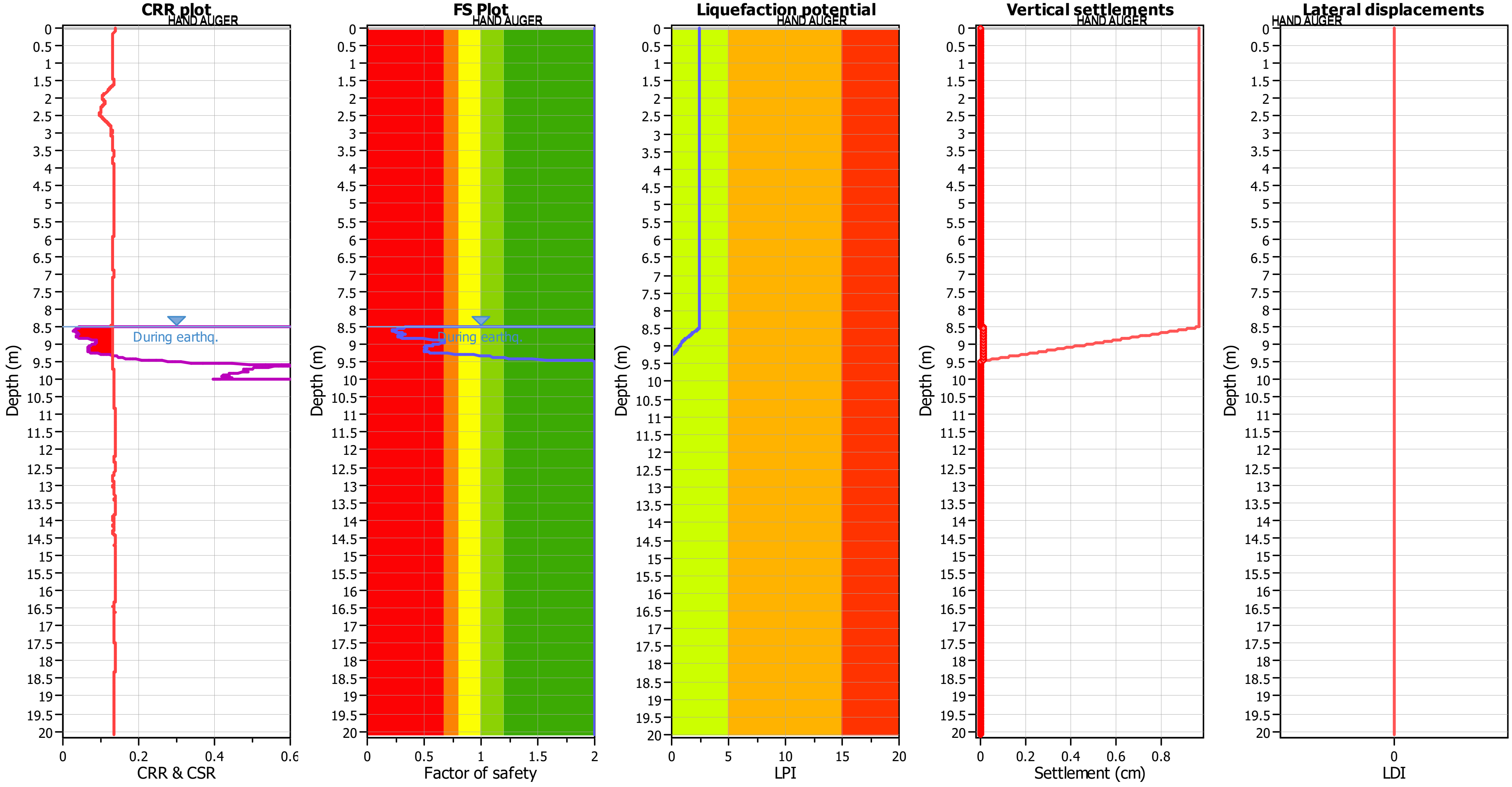
Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.25
Depth to water table (insitu): 9.50 m

Depth to GWT (erthq.): 8.50 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

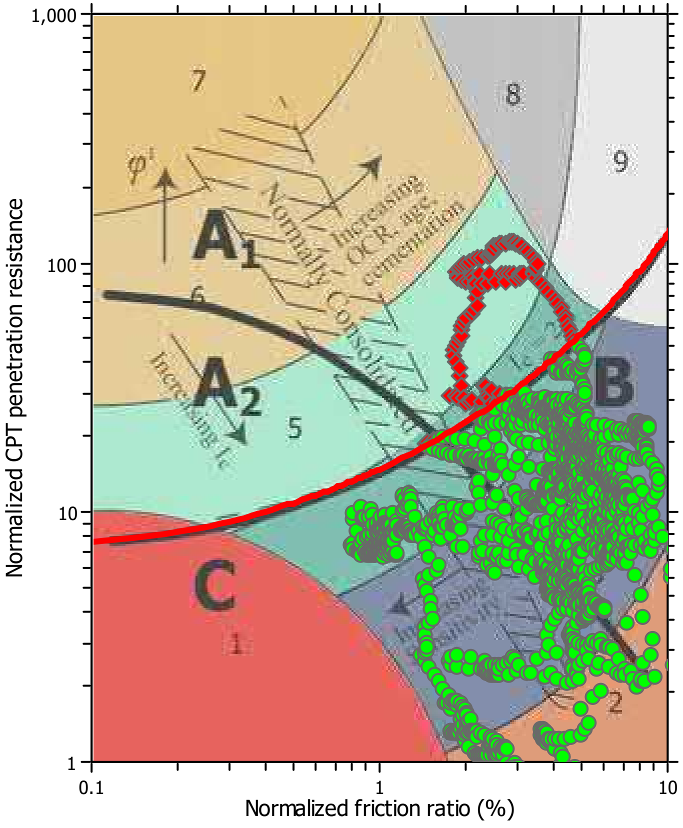
F.S. color scheme

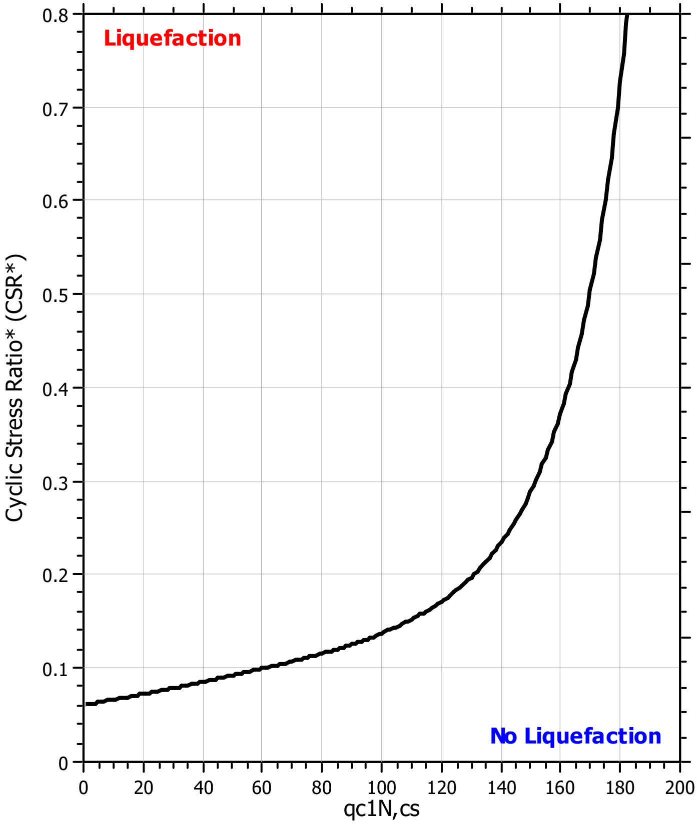
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

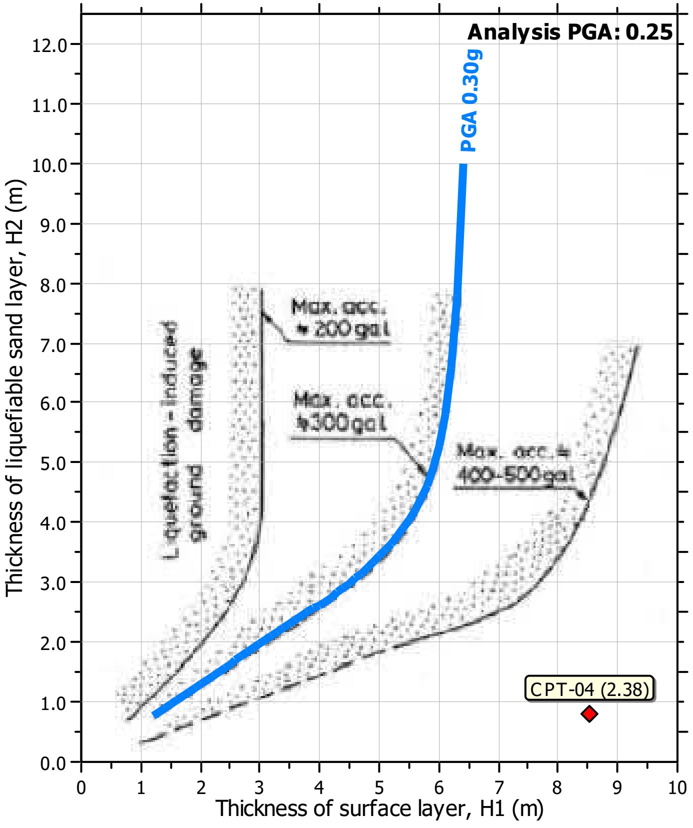
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



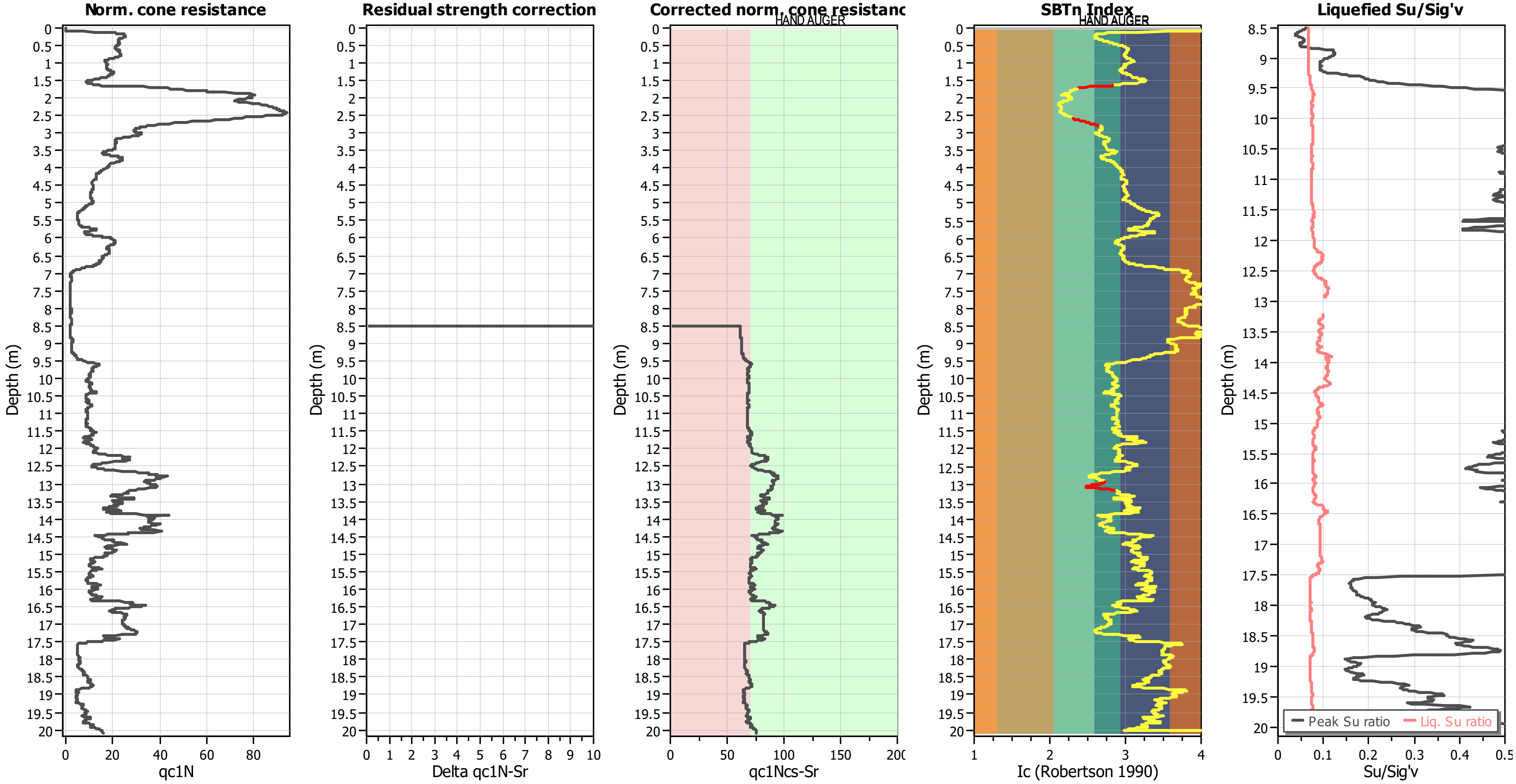




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

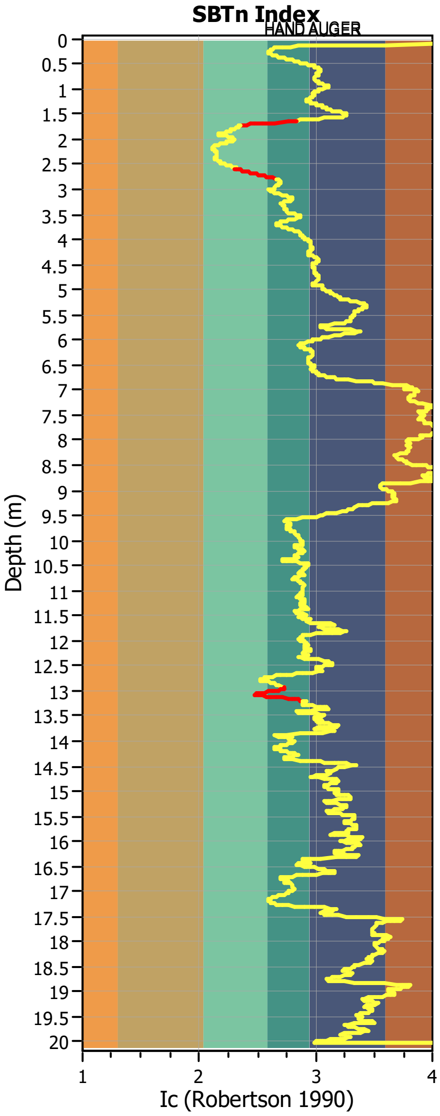
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

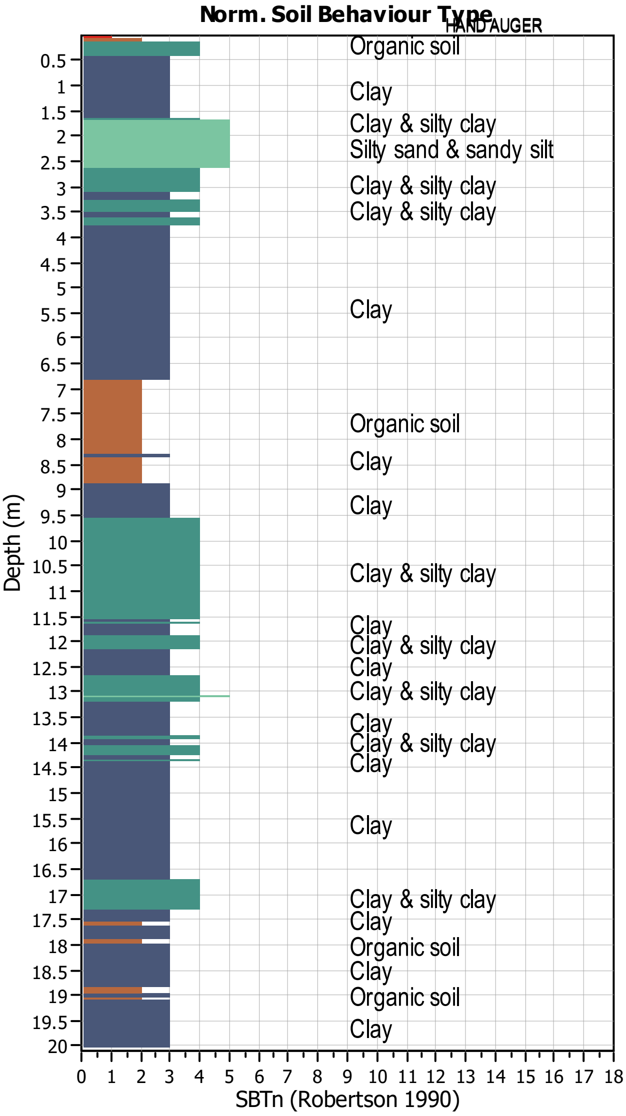
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





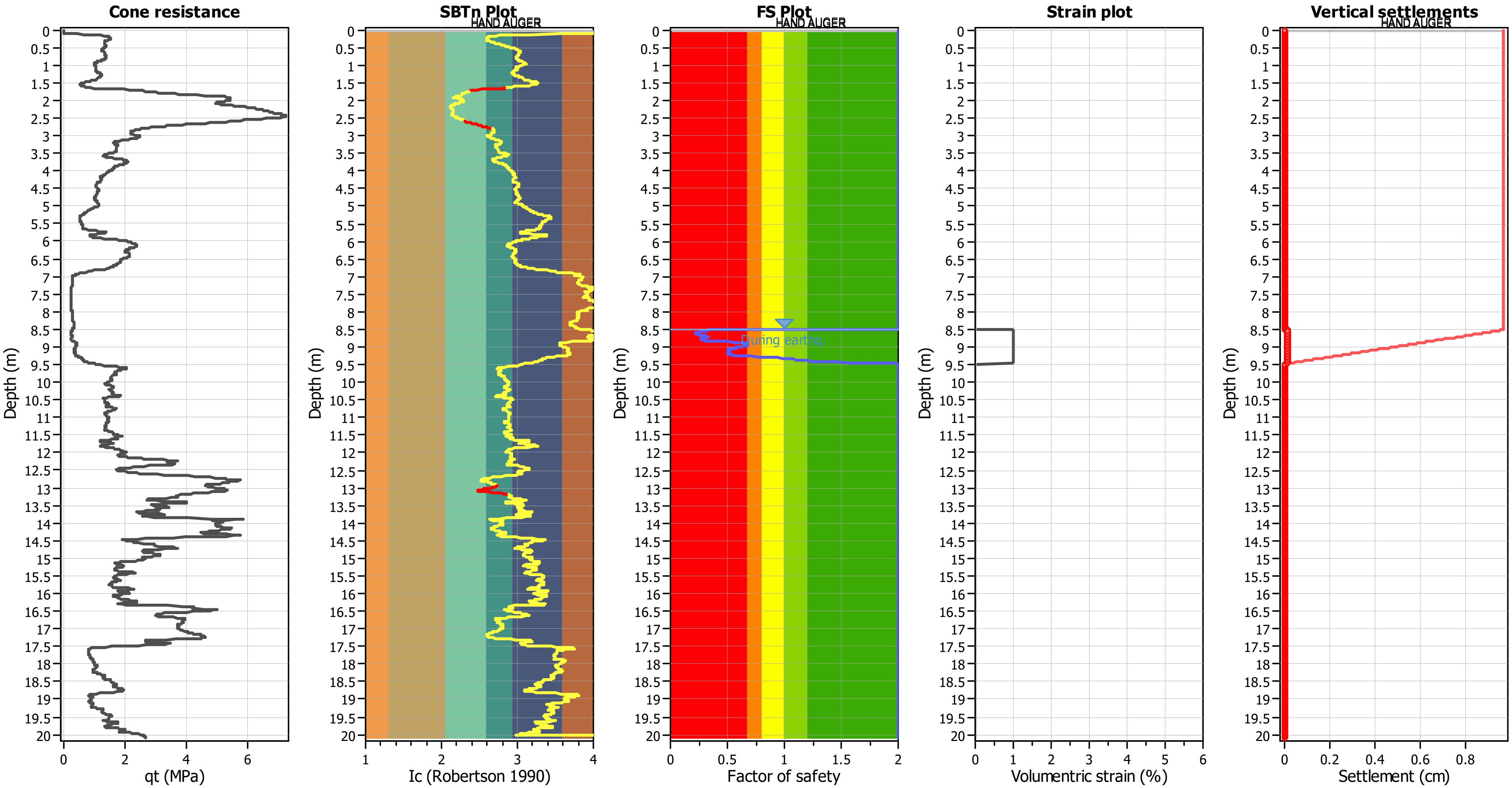
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	59
Exclusion percentage:	2.94%
Number of layers detected:	4

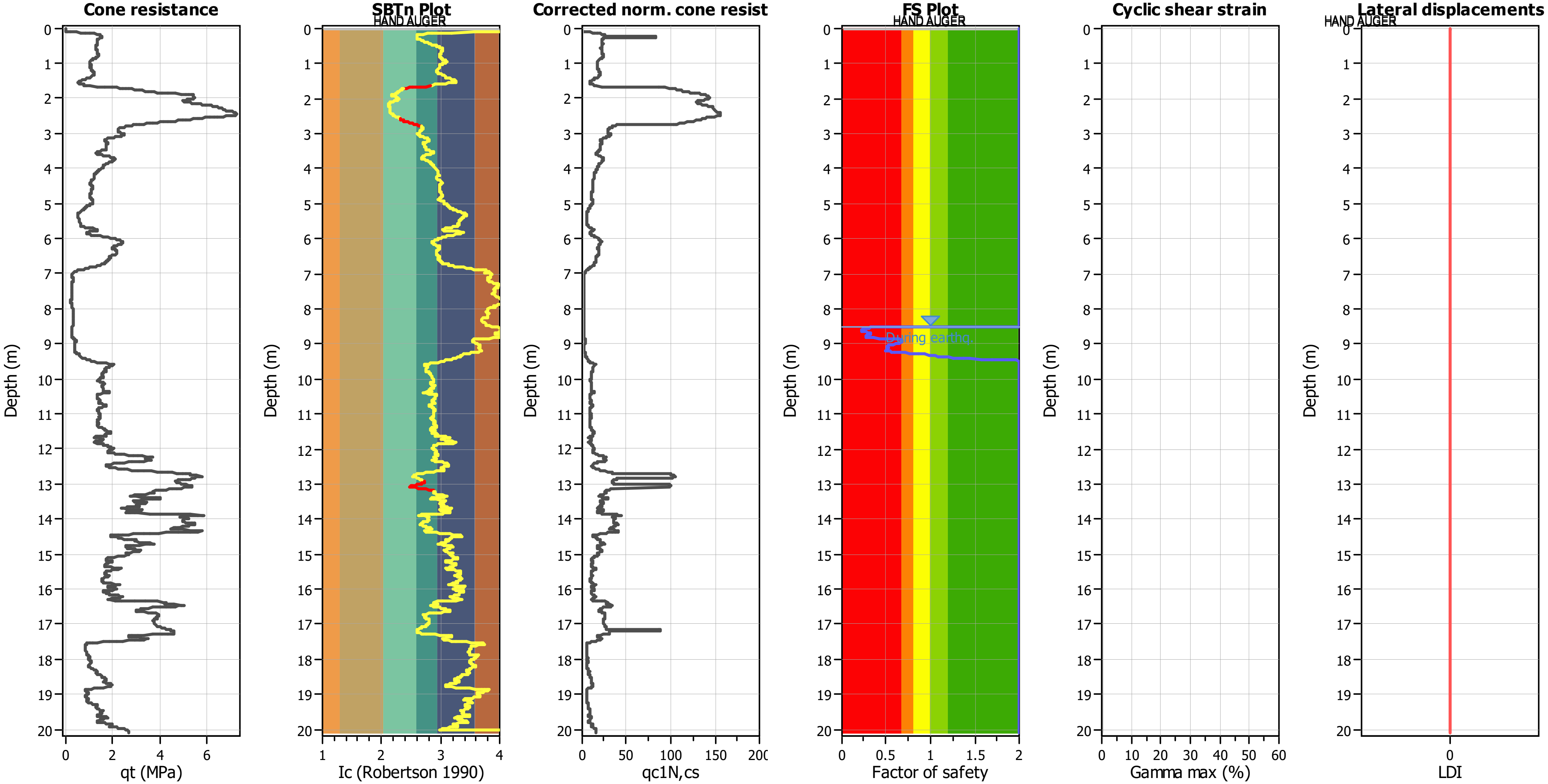
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

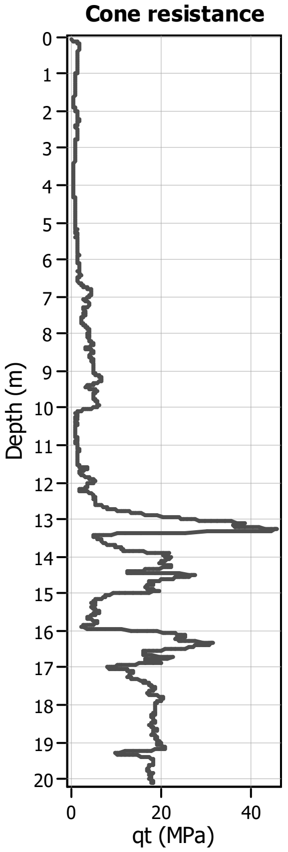
LIQUEFACTION ANALYSIS REPORT

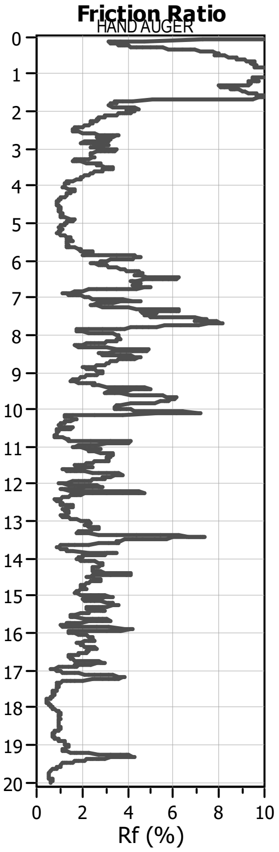
Project title : Proposed Private Plan Change for Te Awamutu   **Location : 2025 Ohaupo Road, Te Awamutu**

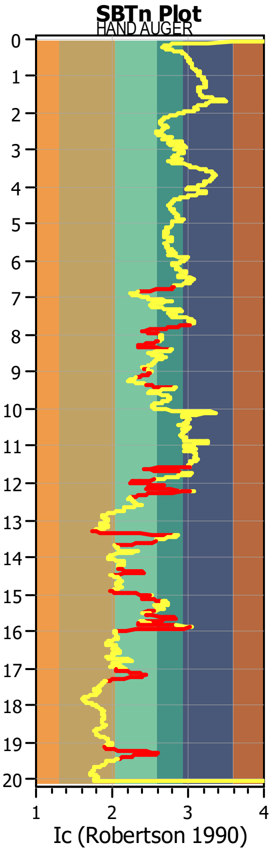
CPT file : CPT-05

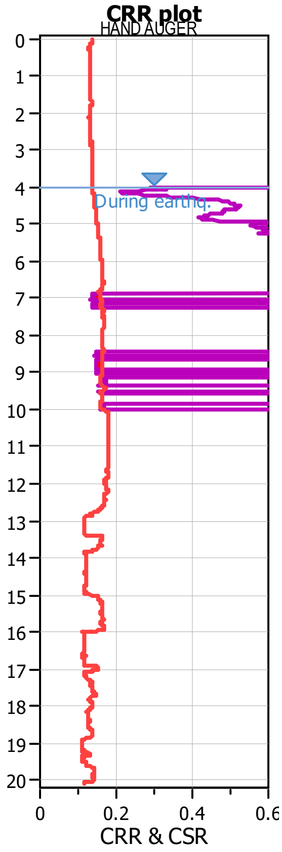
Input parameters and analysis data

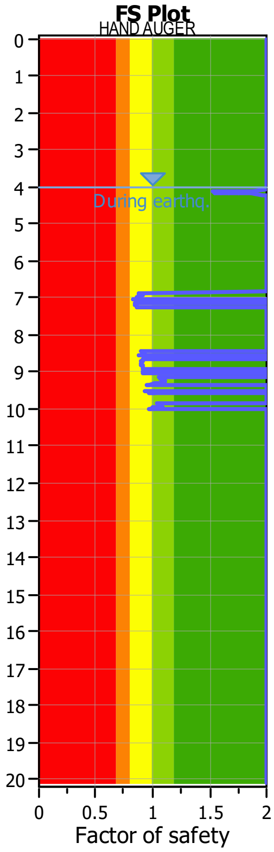
Analysis method:	B&I (2014)	G.W.T. (in-situ):	5.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

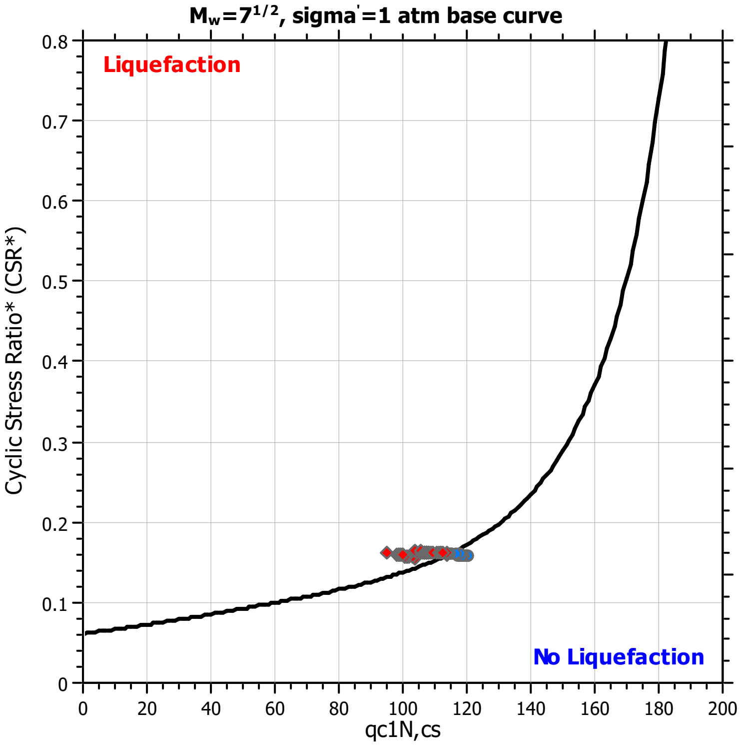


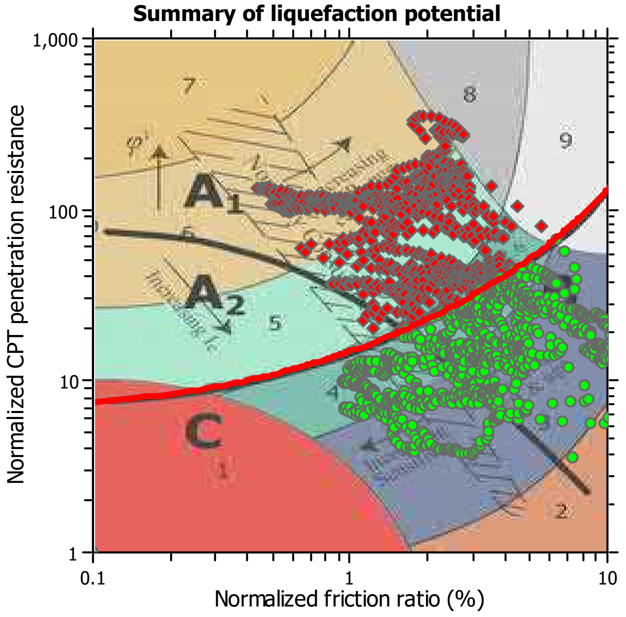






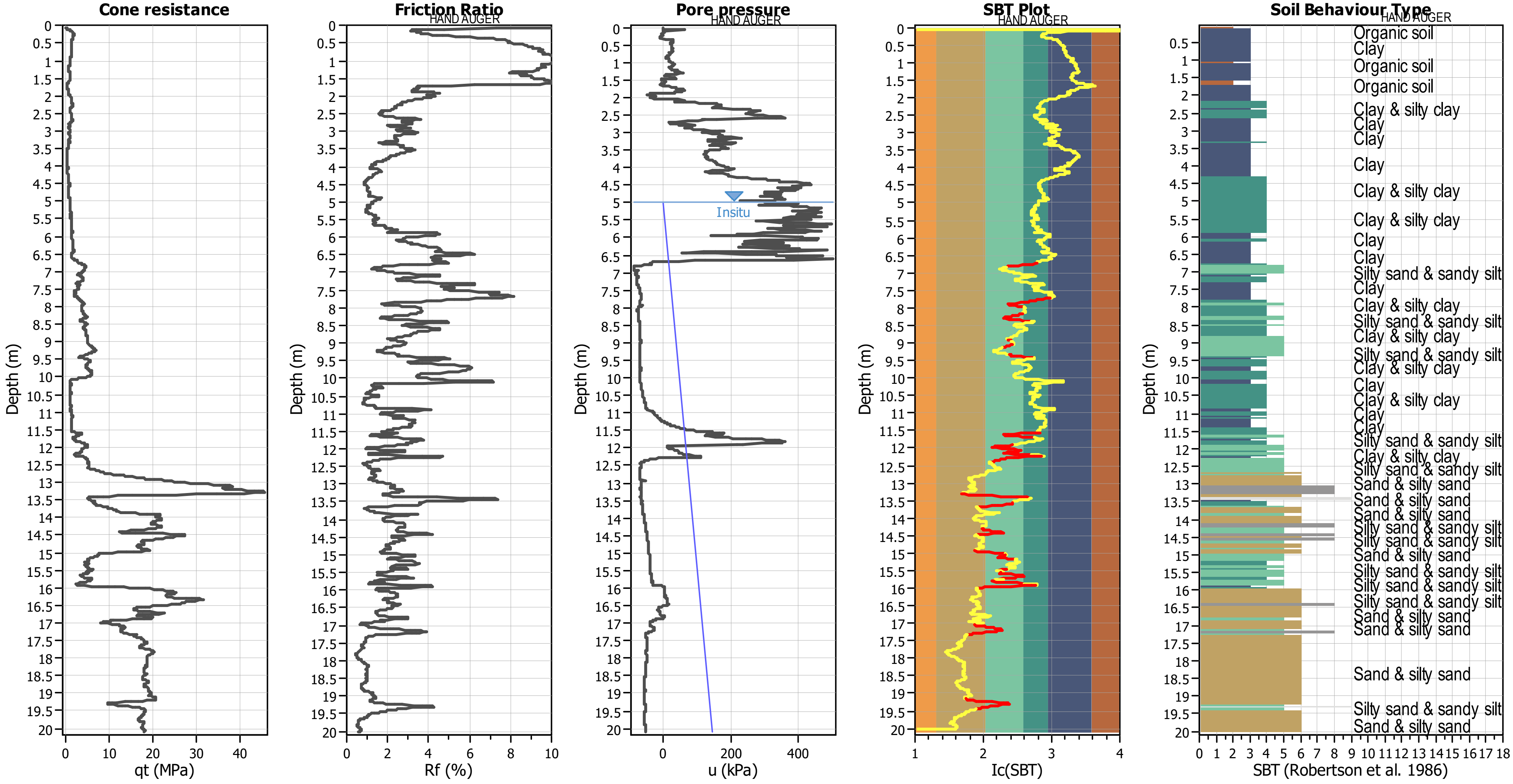






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



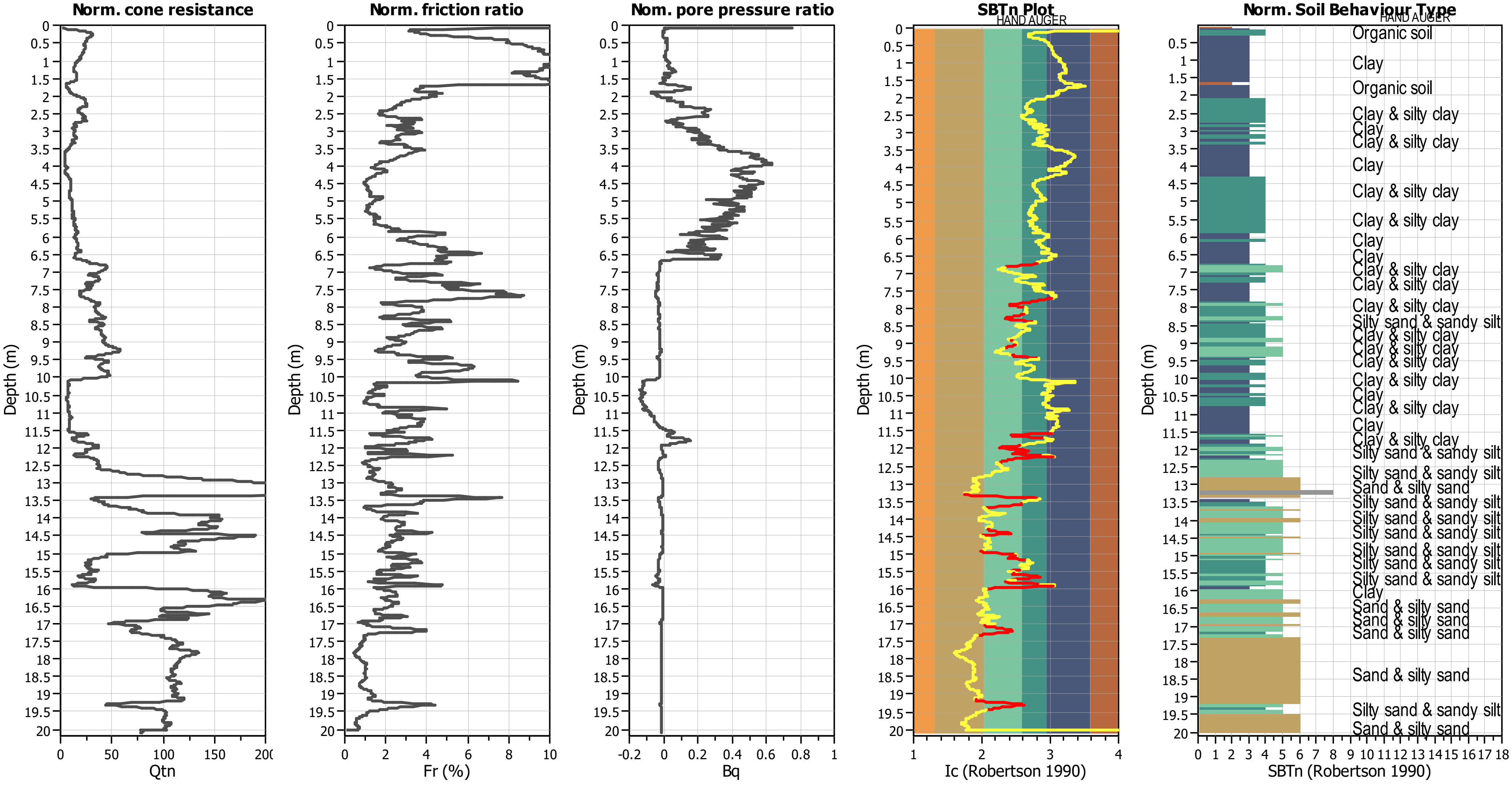
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.25
Depth to water table (insitu): 5.00 m

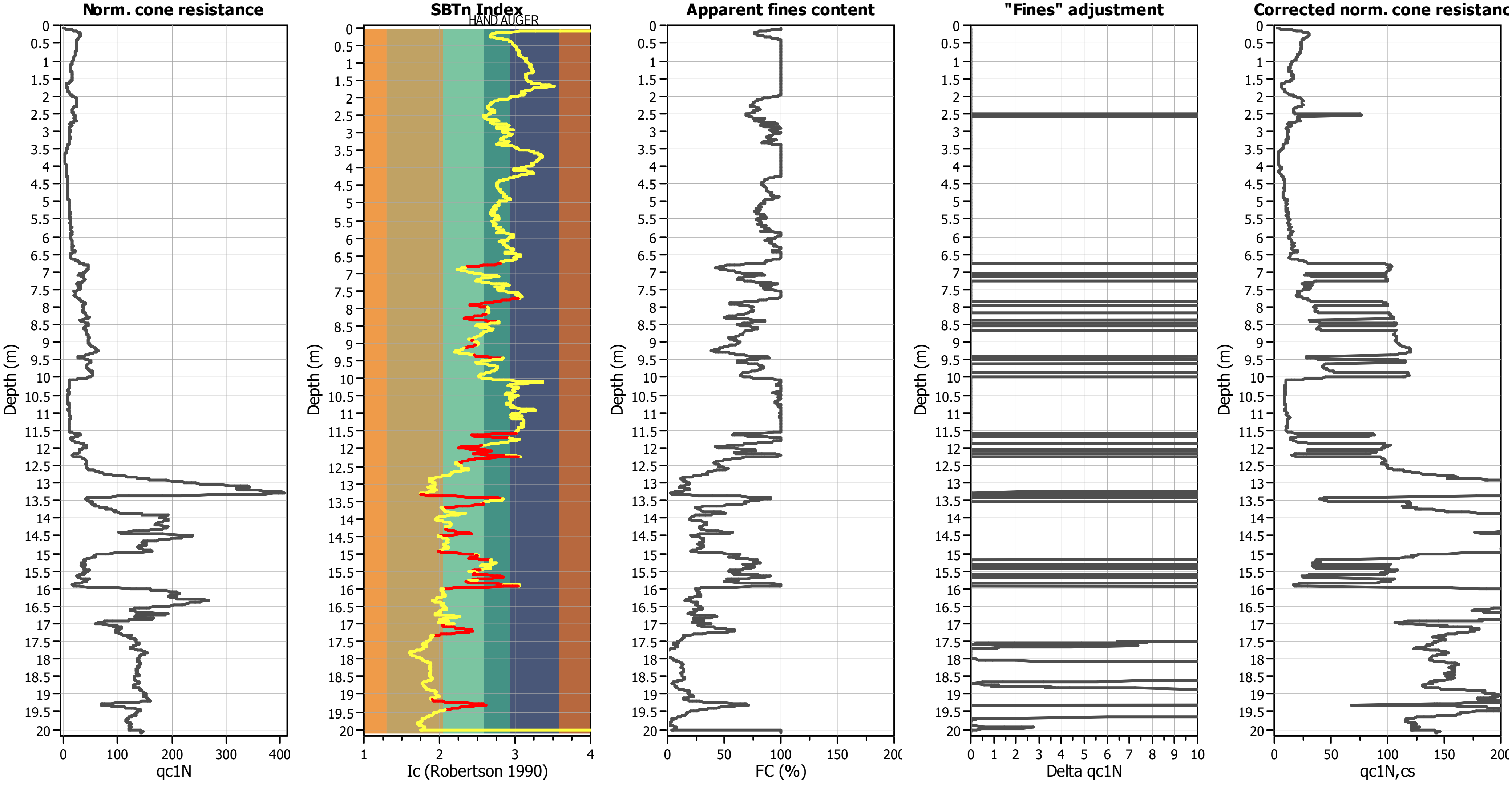
Depth to GWT (erthq.): 4.00 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

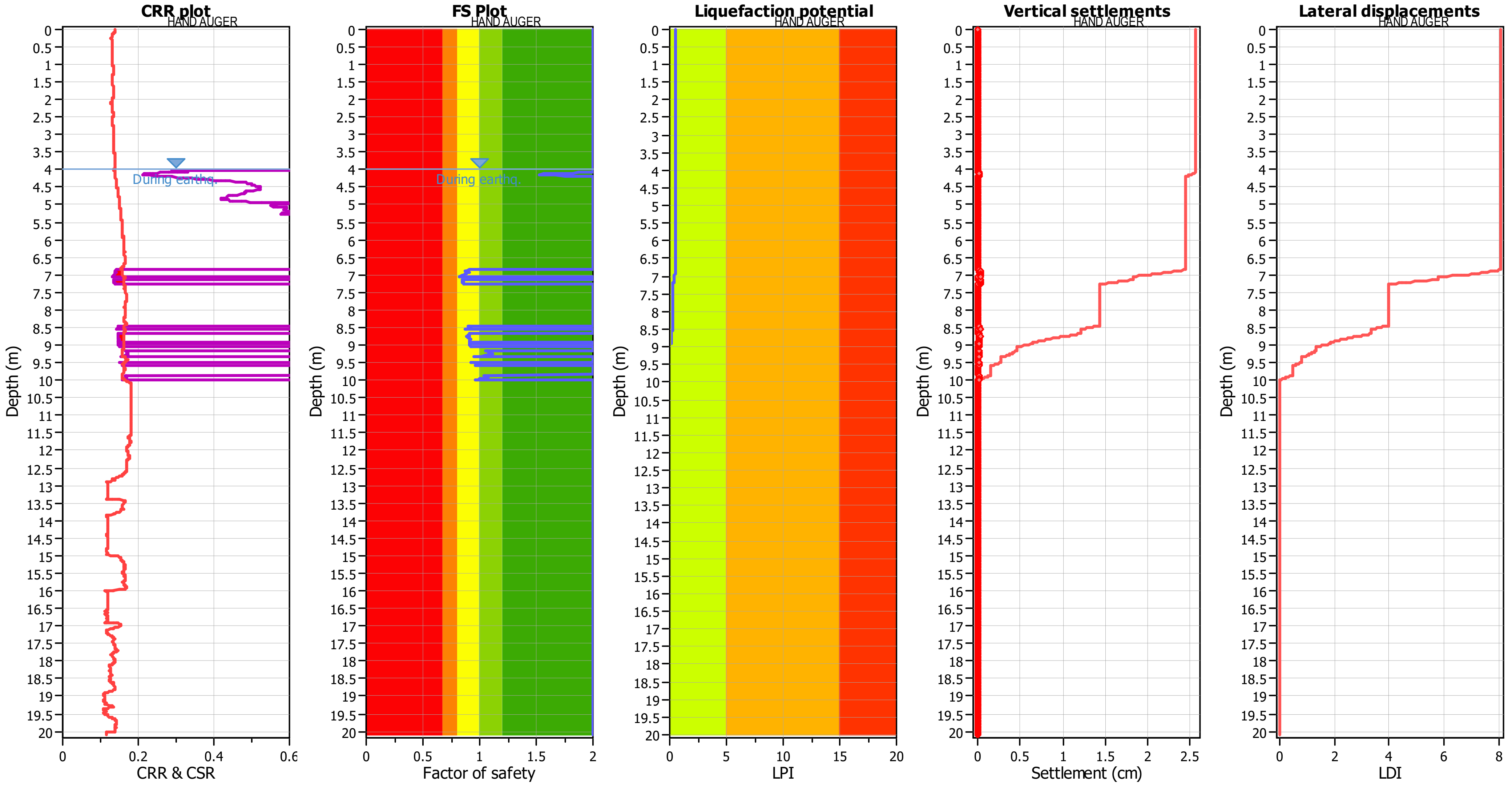
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

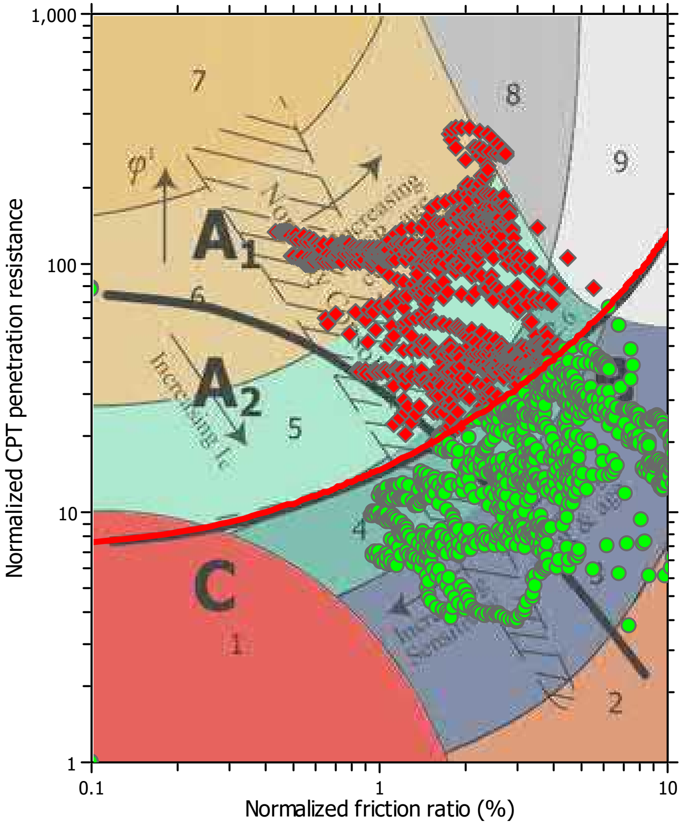
F.S. color scheme

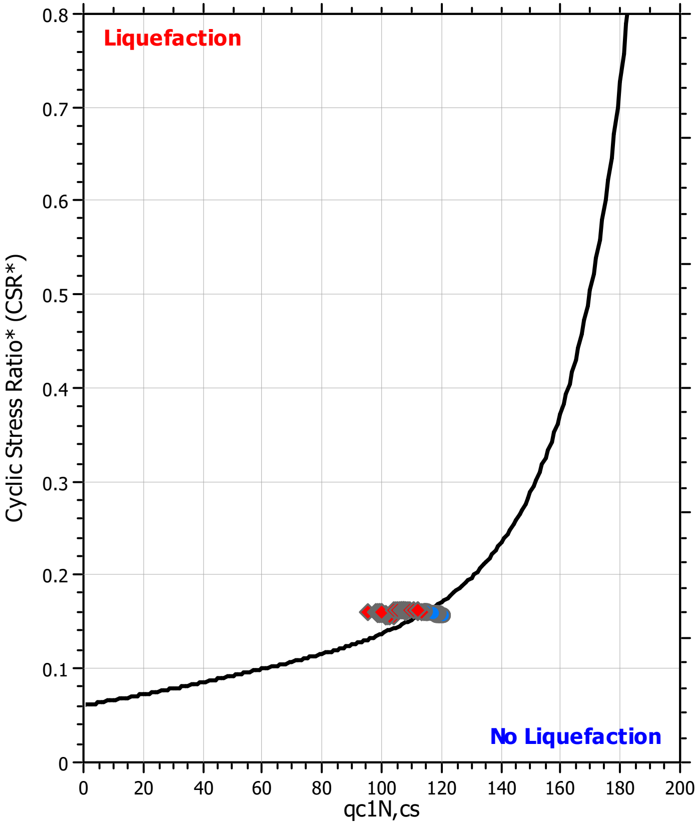
🟥	Almost certain it will liquefy
🟧	Very likely to liquefy
🟨	Liquefaction and no liq. are equally likely
🟩	Unlike to liquefy
🟩	Almost certain it will not liquefy

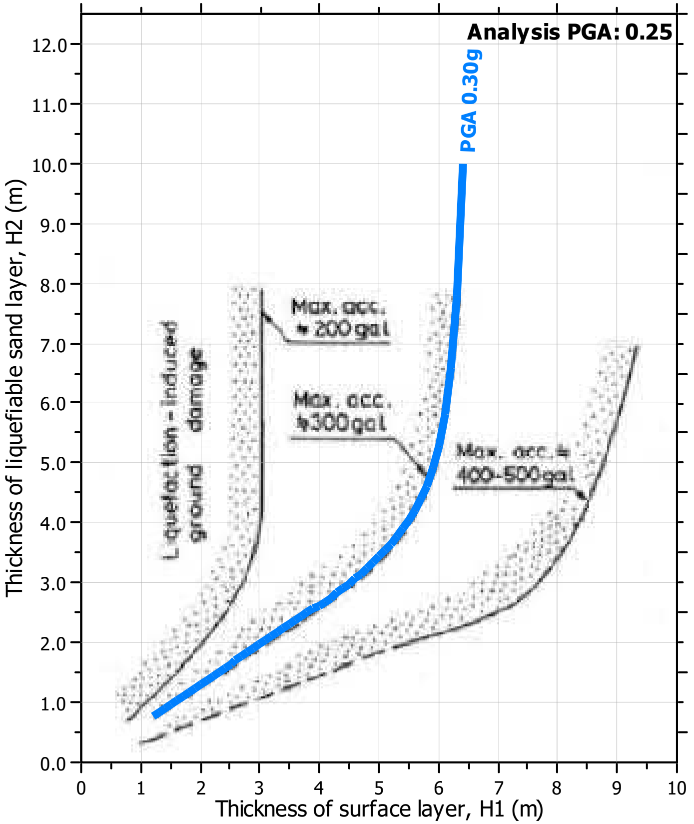
LPI color scheme

🟥	Very high risk
🟧	High risk
🟨	Low risk

Liquefaction analysis summary plots



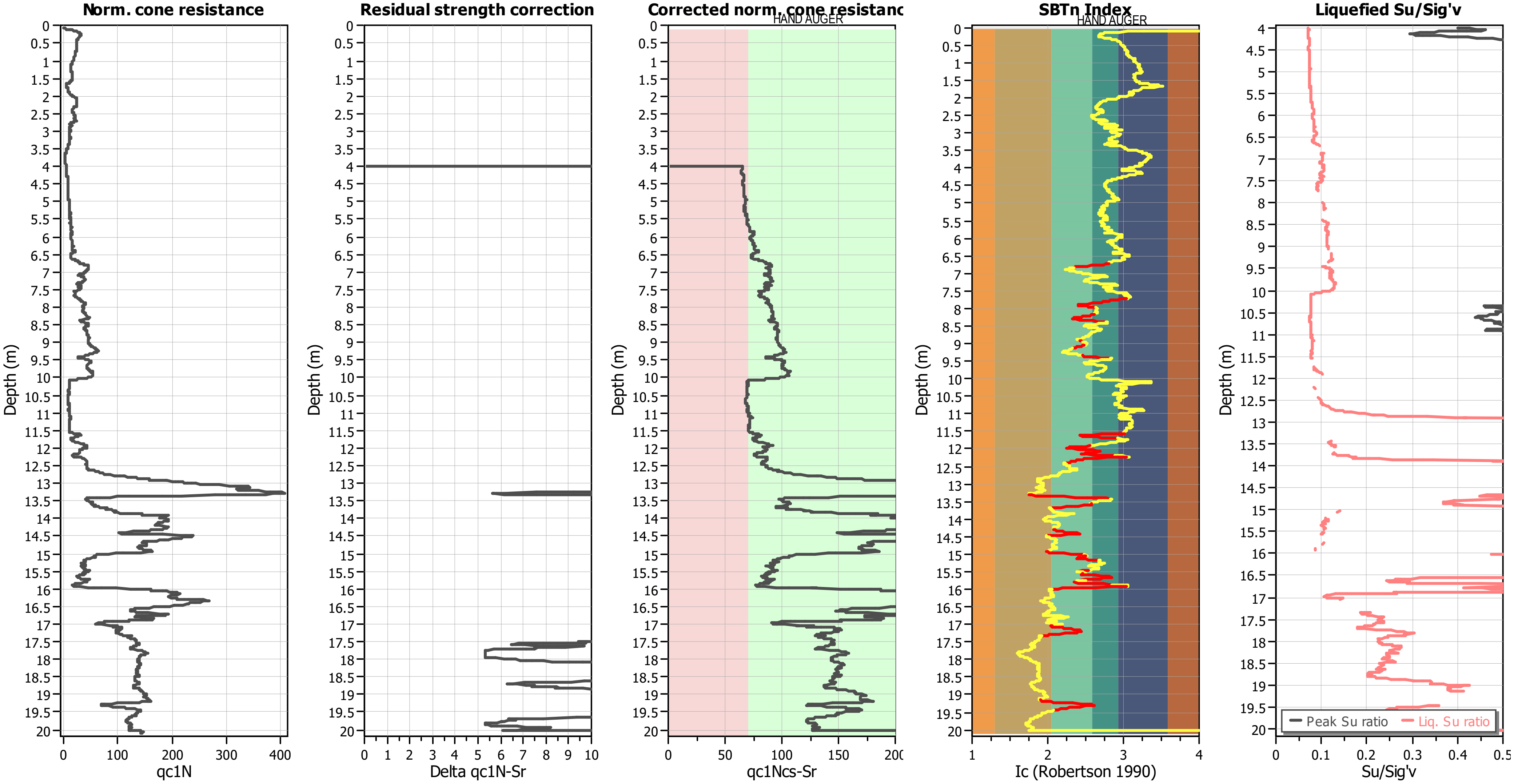




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

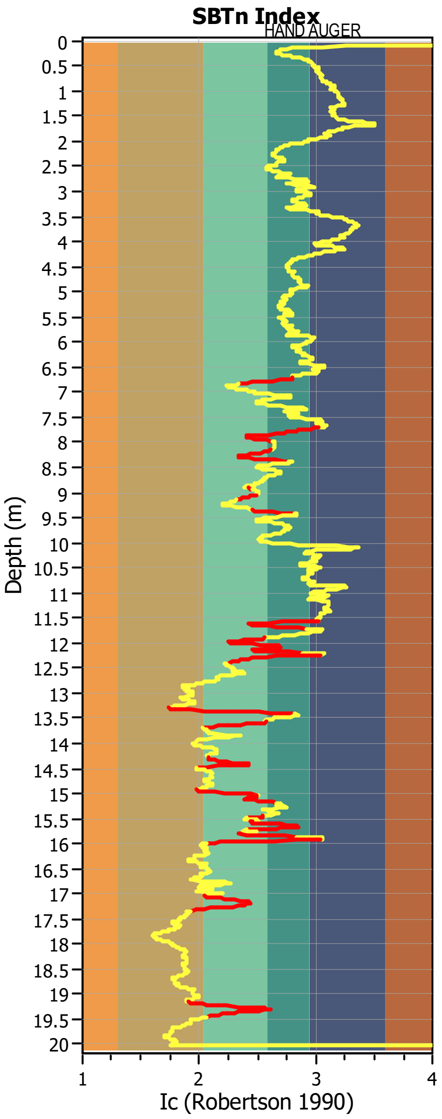
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

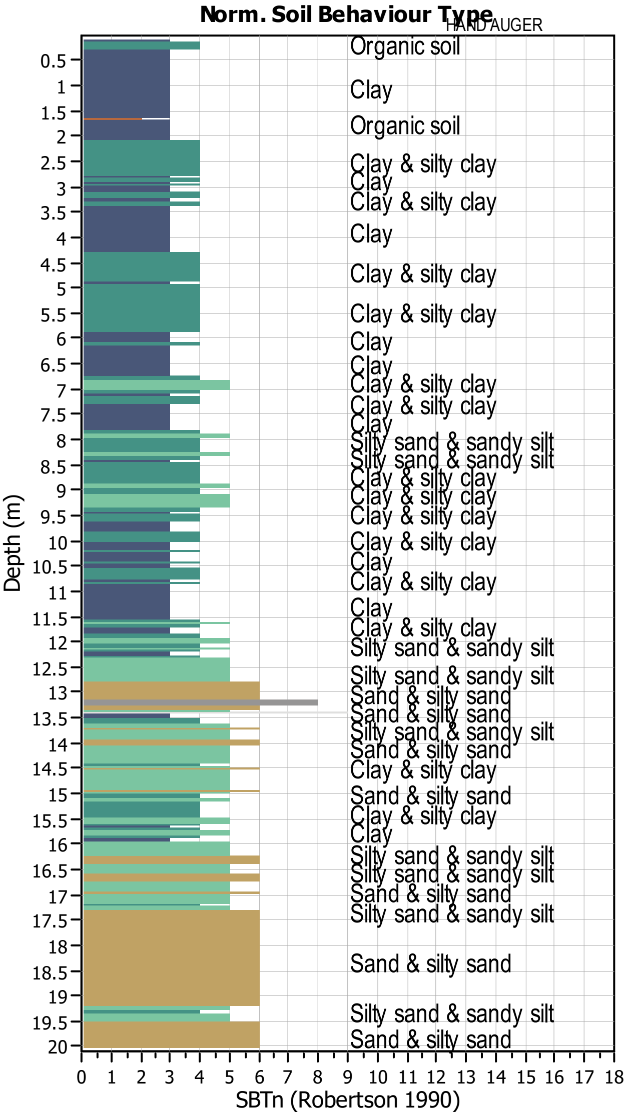
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





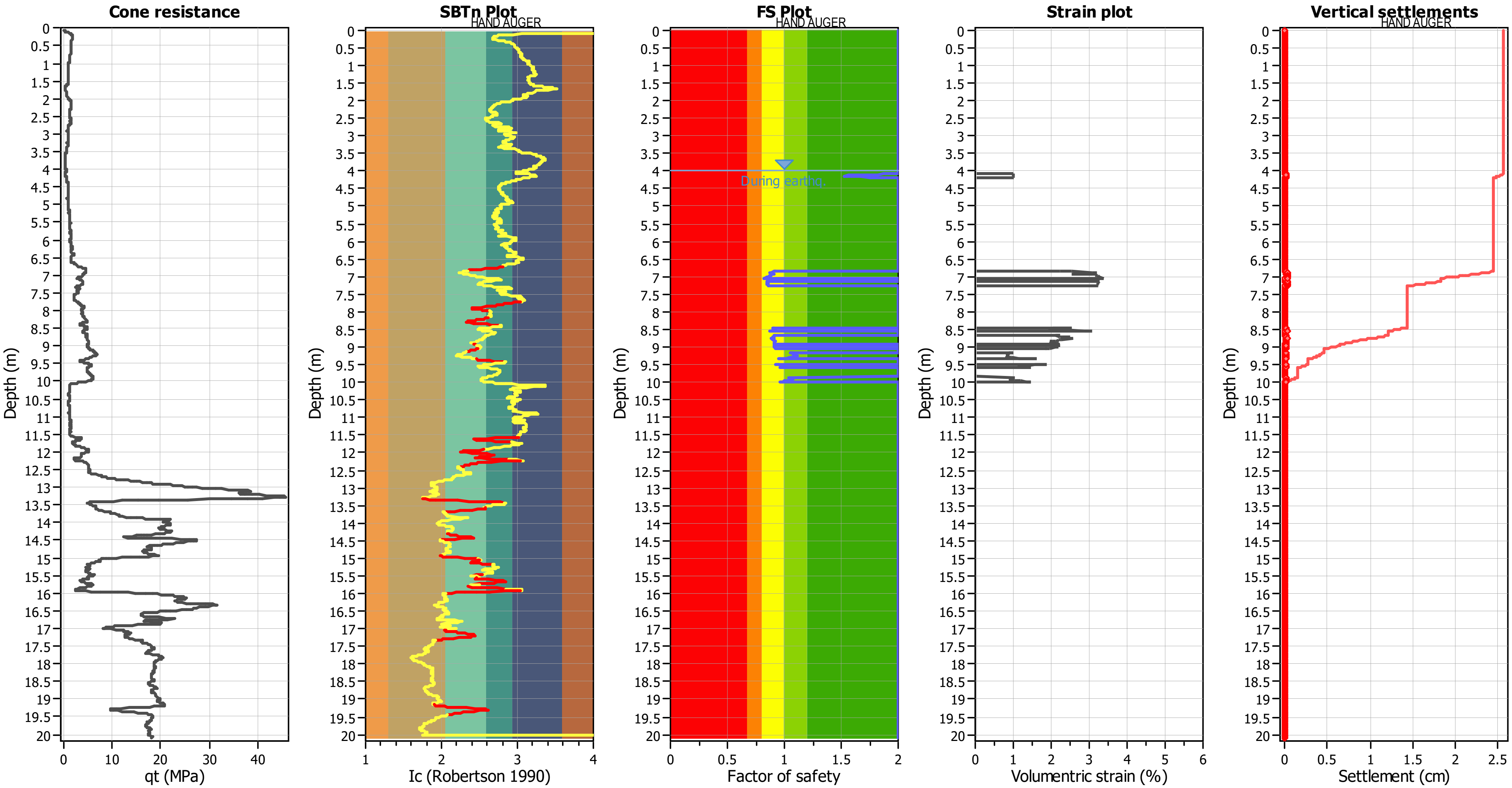
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	329
Exclusion percentage:	16.37%
Number of layers detected:	31

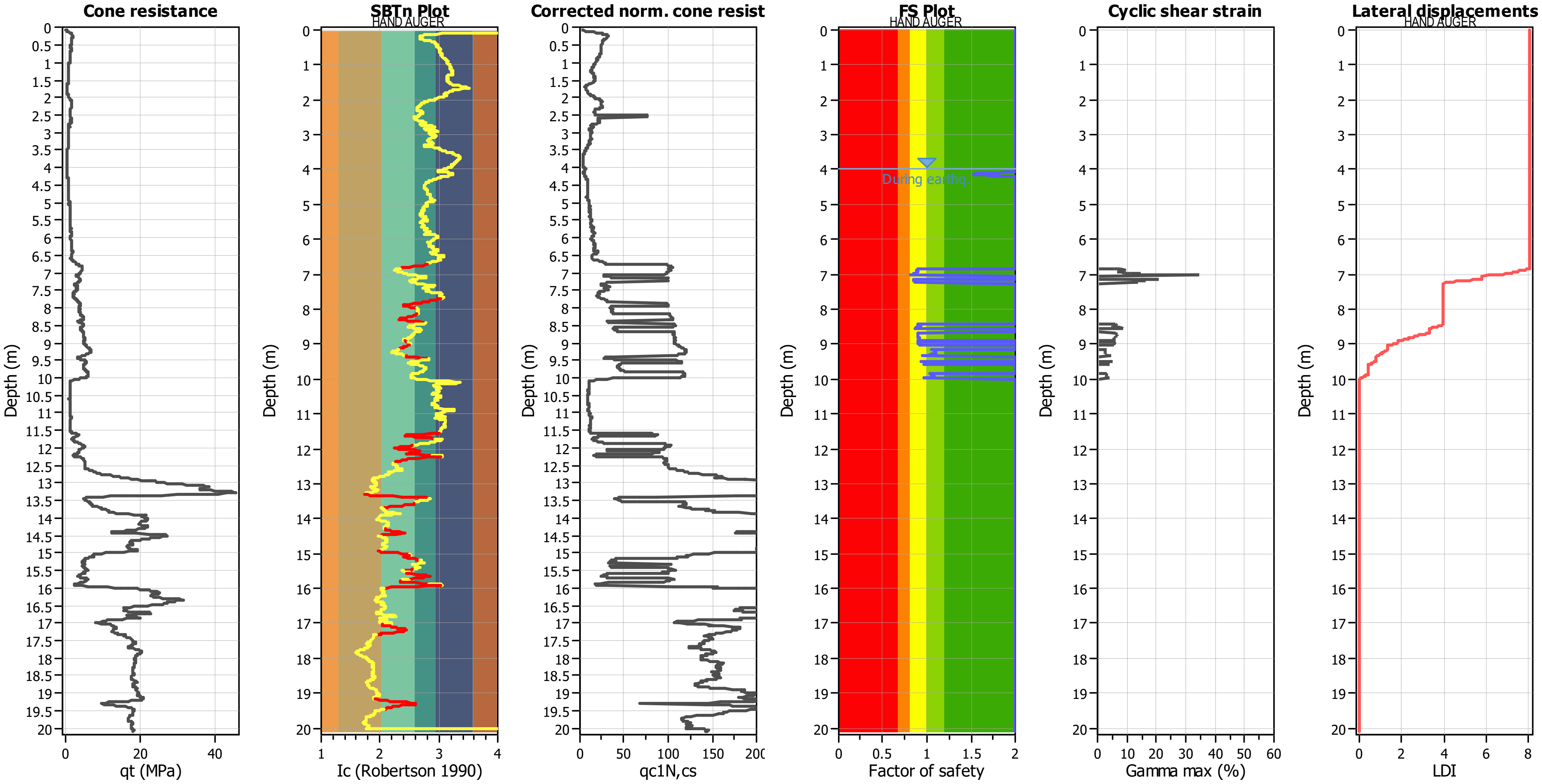
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

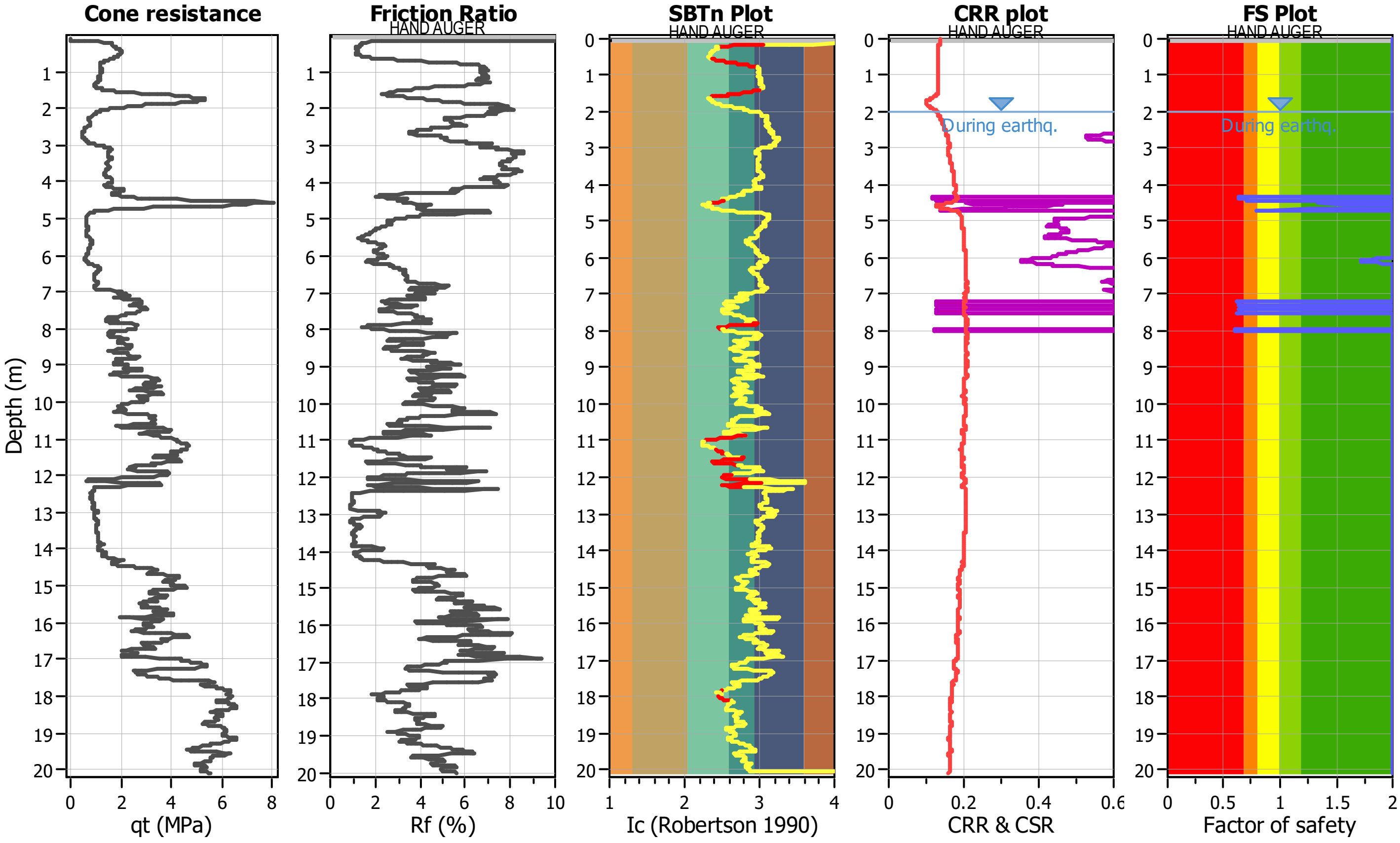
LIQUEFACTION ANALYSIS REPORT

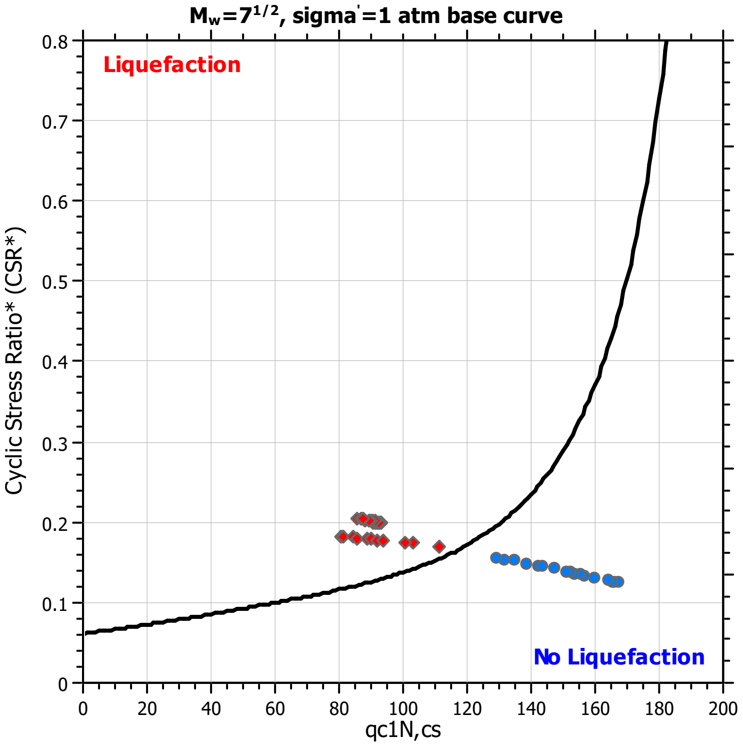
Project title : Proposed Private Plan Change for Te Awamutu Location : 2025 Ohaupo Road, Te Awamutu

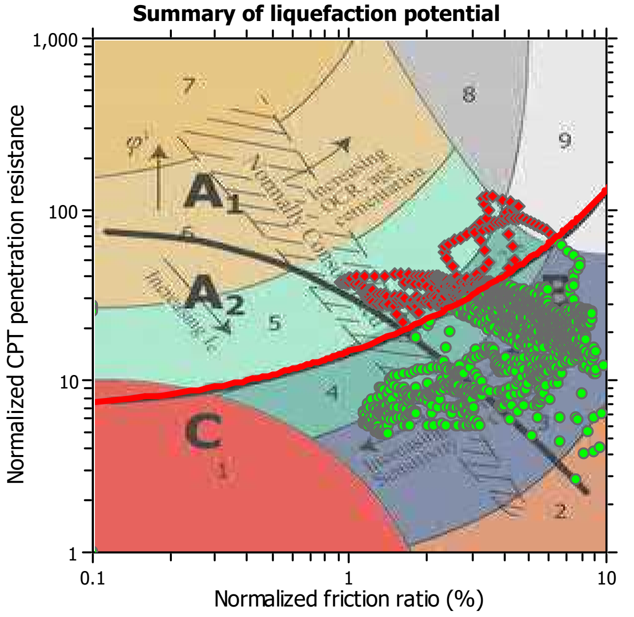
CPT file : CPT-06

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

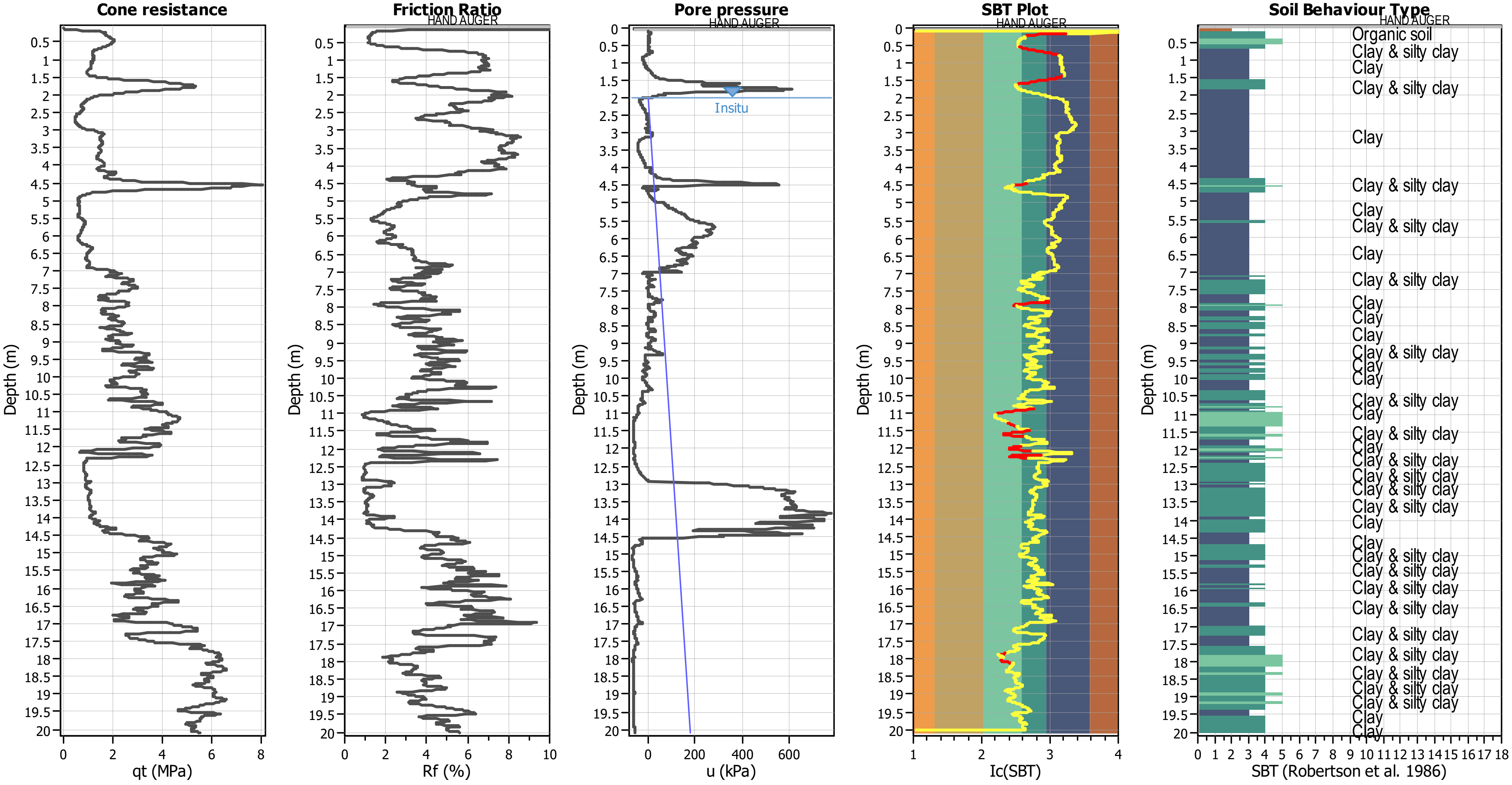






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



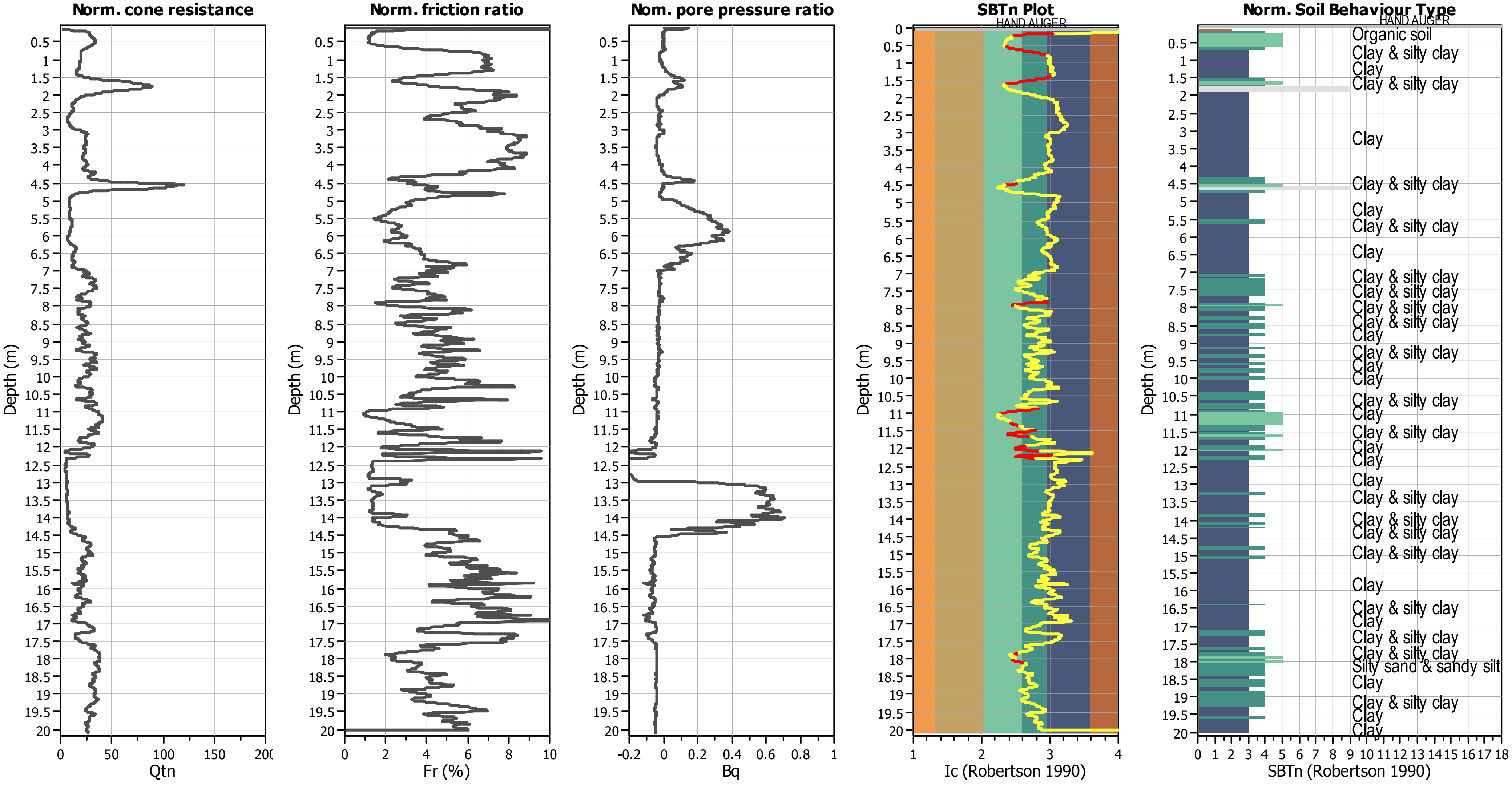
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



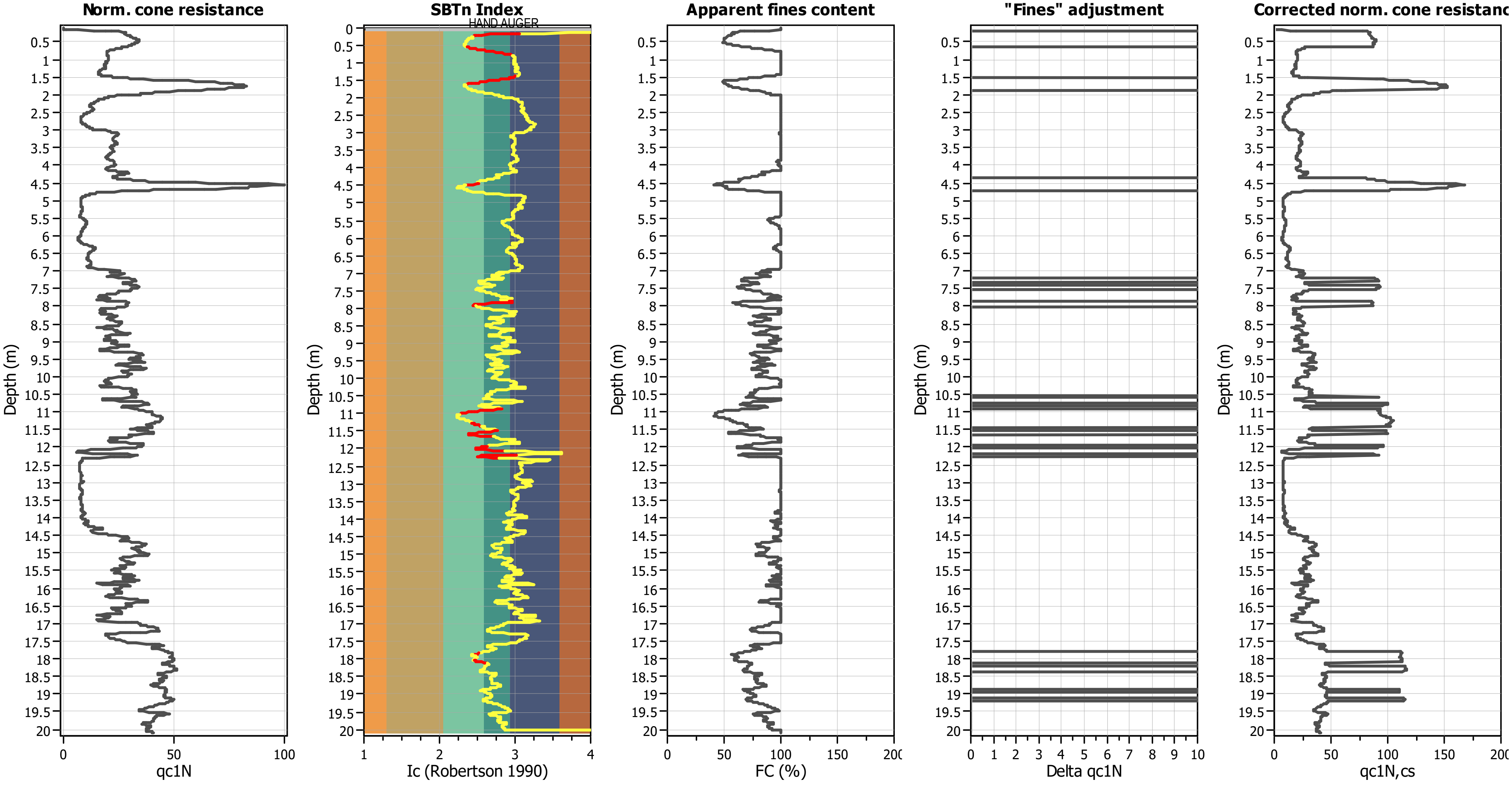
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

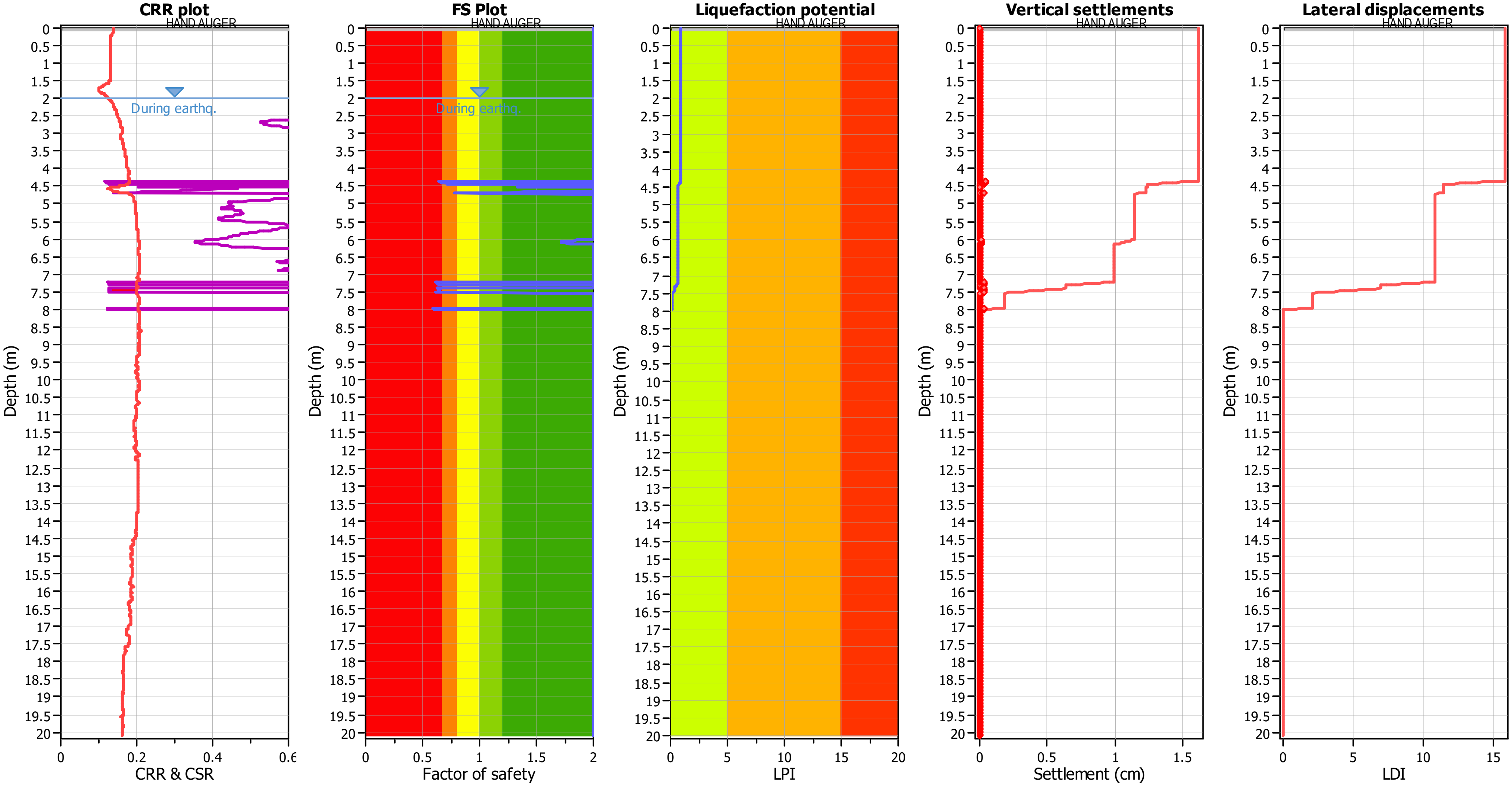
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

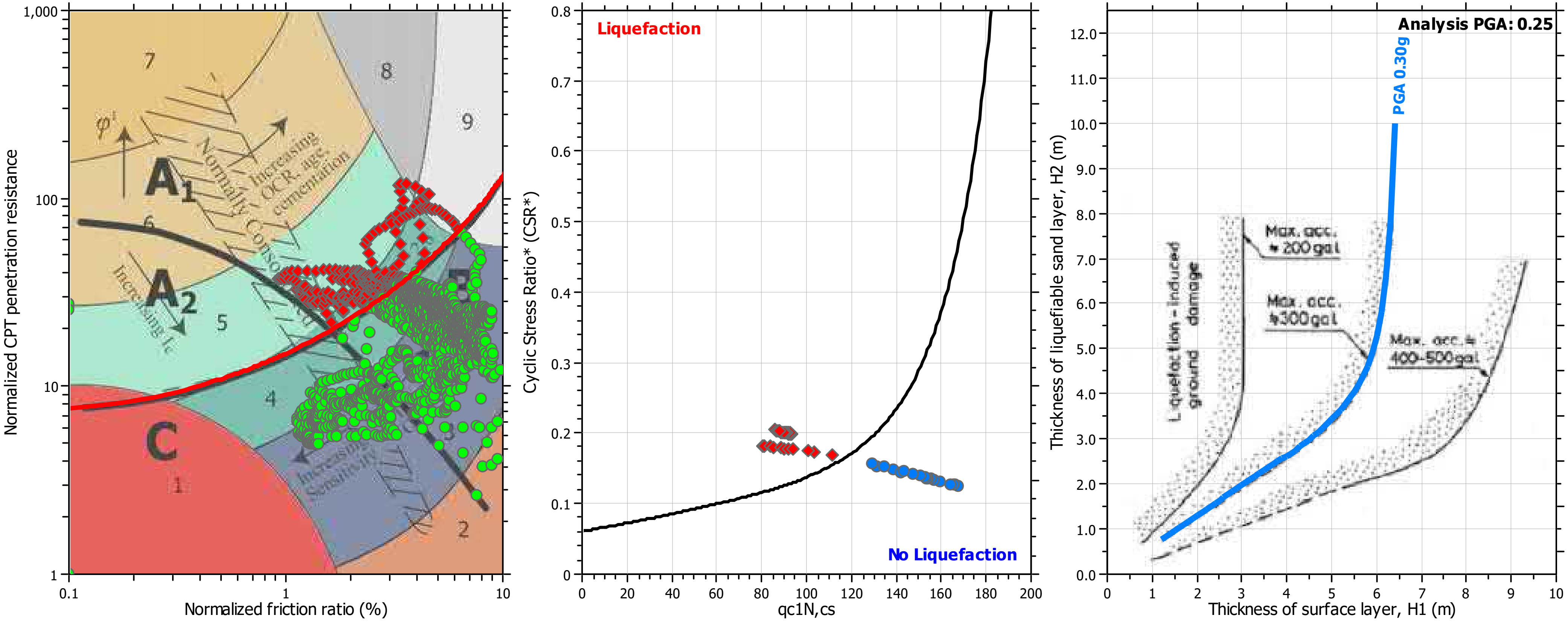
F.S. color scheme

- 🟥 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

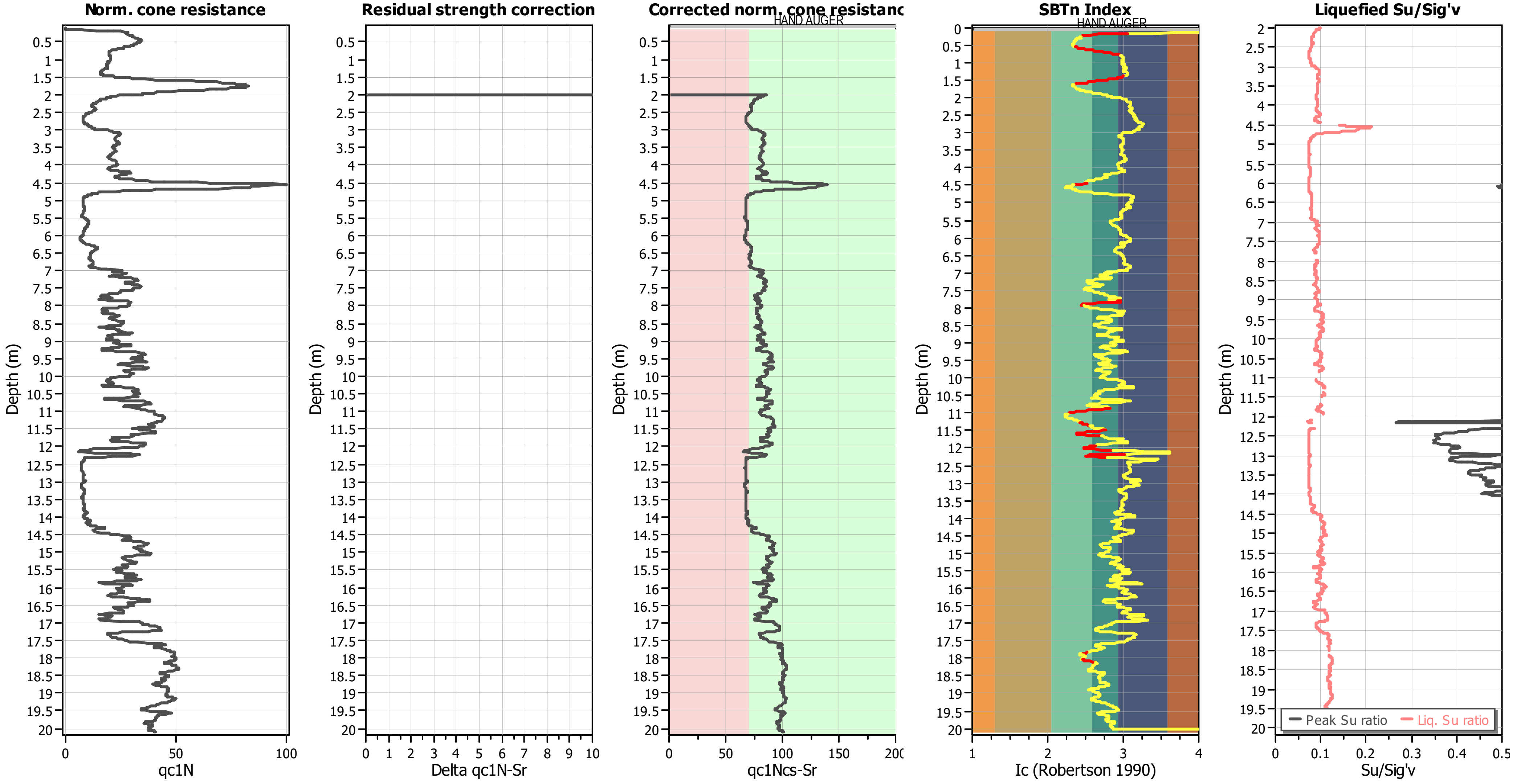
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

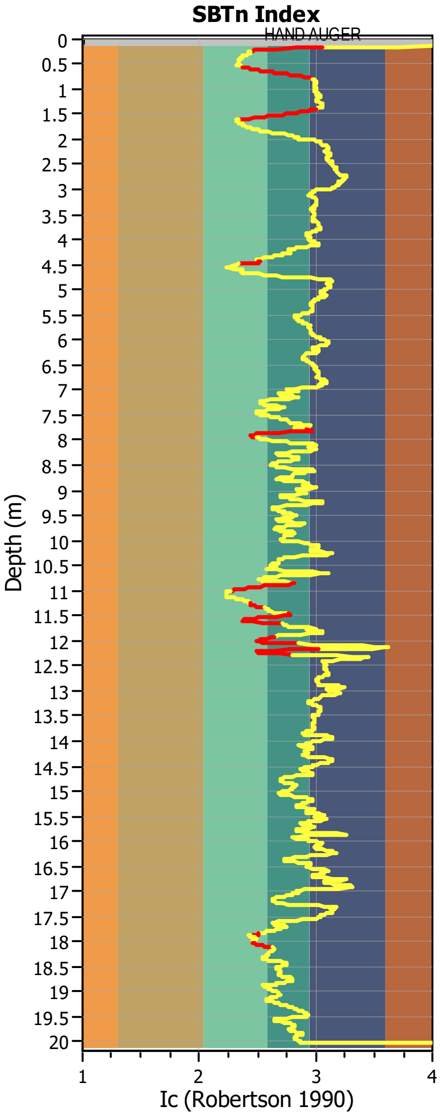
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

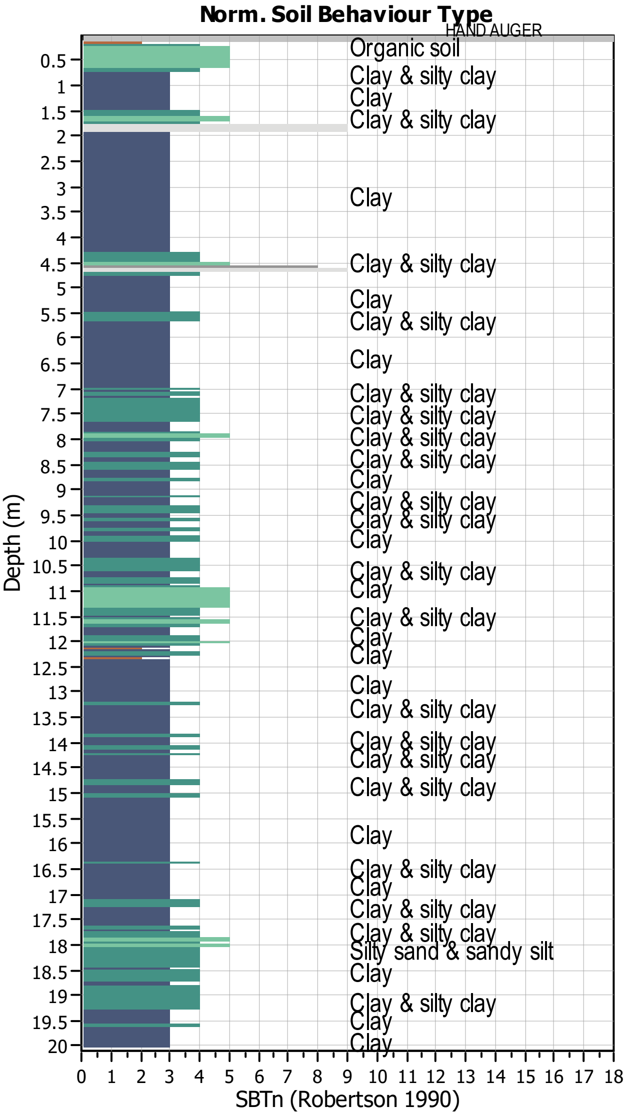
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





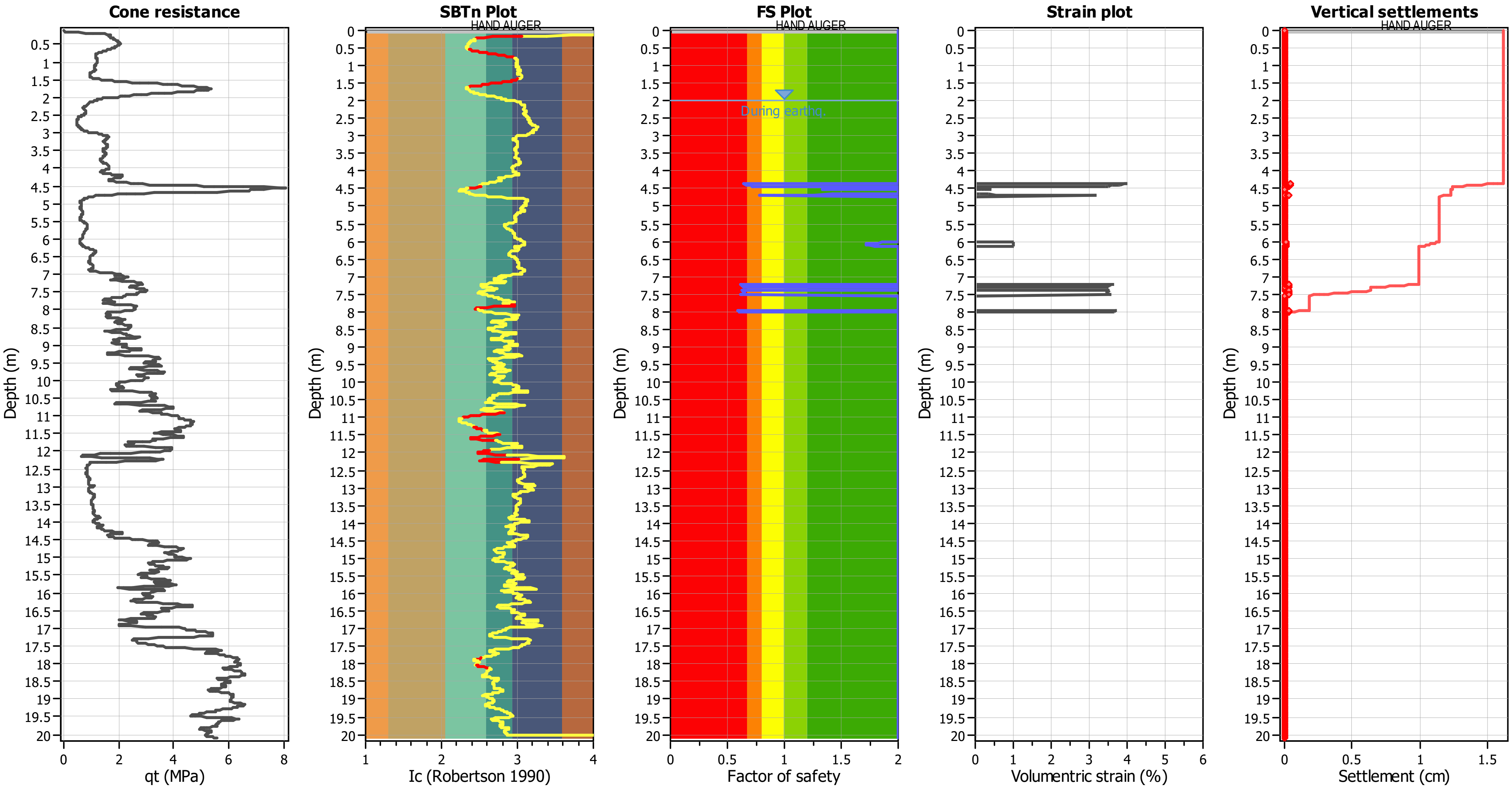
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	165
Exclusion percentage:	8.21%
Number of layers detected:	16

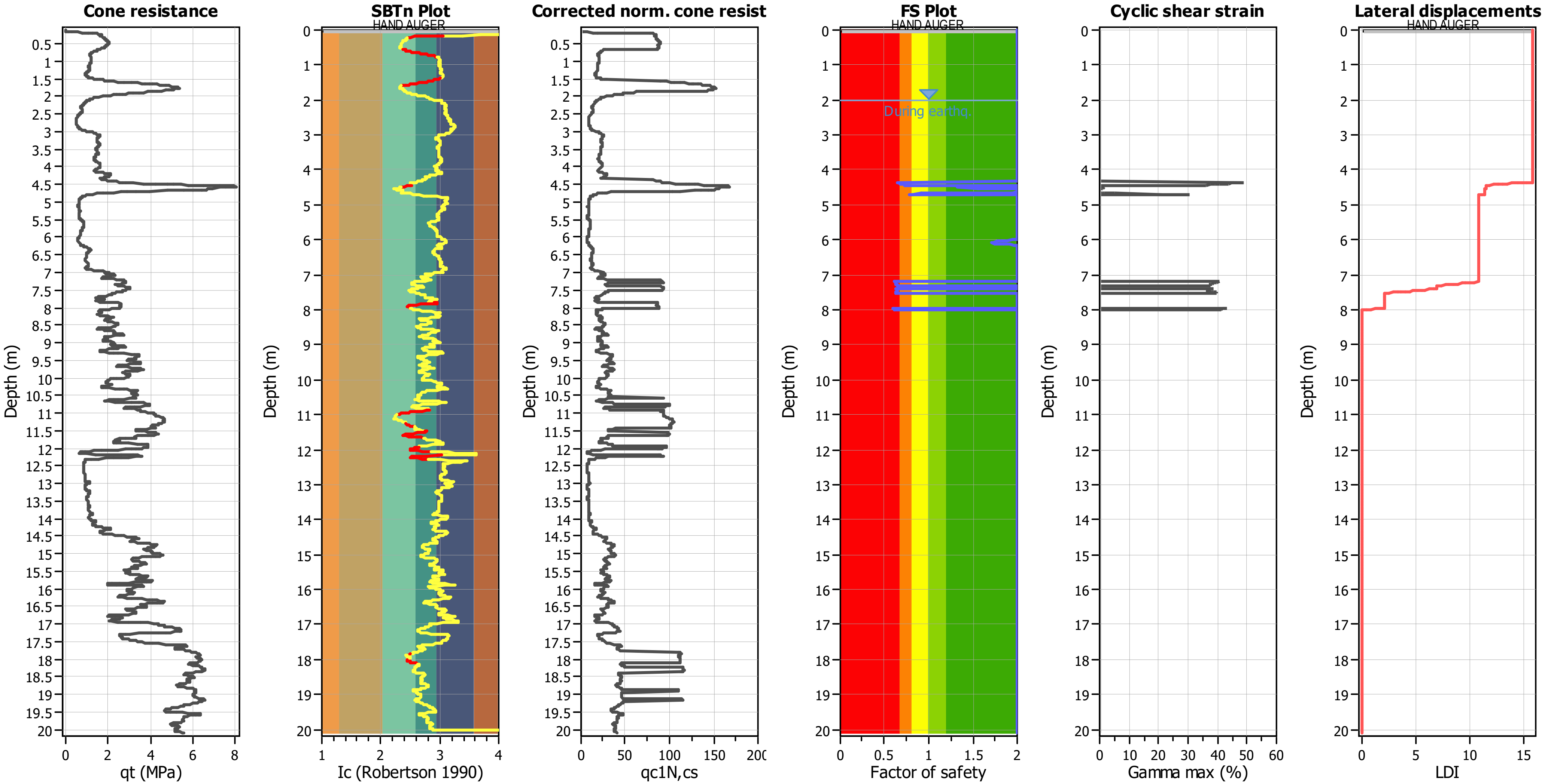
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

LIQUEFACTION ANALYSIS REPORT

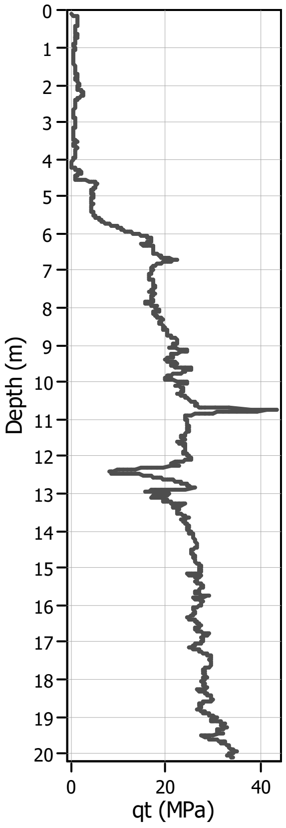
Project title : Proposed Private Plan Change for Te Awamutu **Location : 2025 Ohaupo Road, Te Awamutu**

CPT file : CPT-07

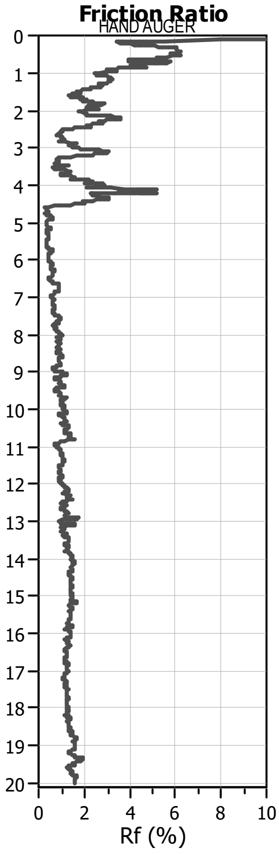
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	20.10 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	19.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

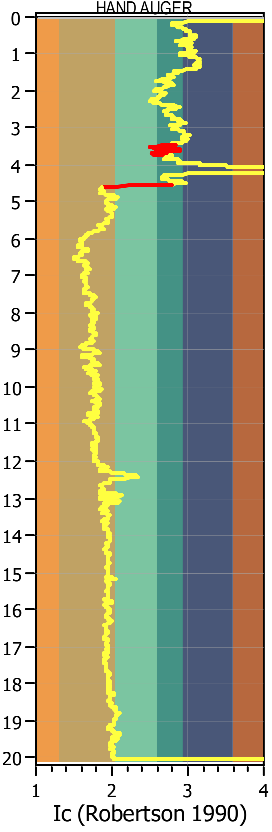
Cone resistance



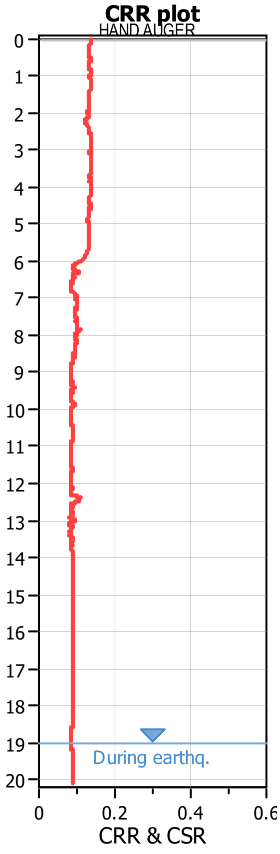
Friction Ratio



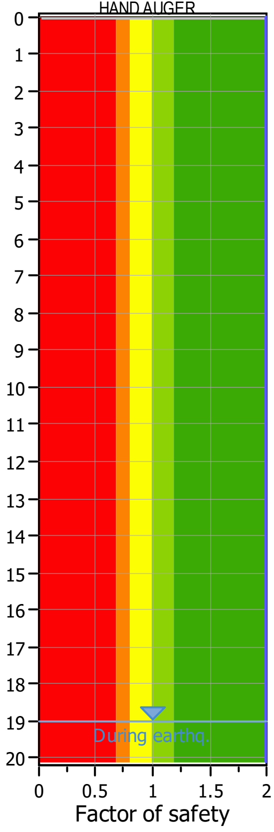
SBTn Plot



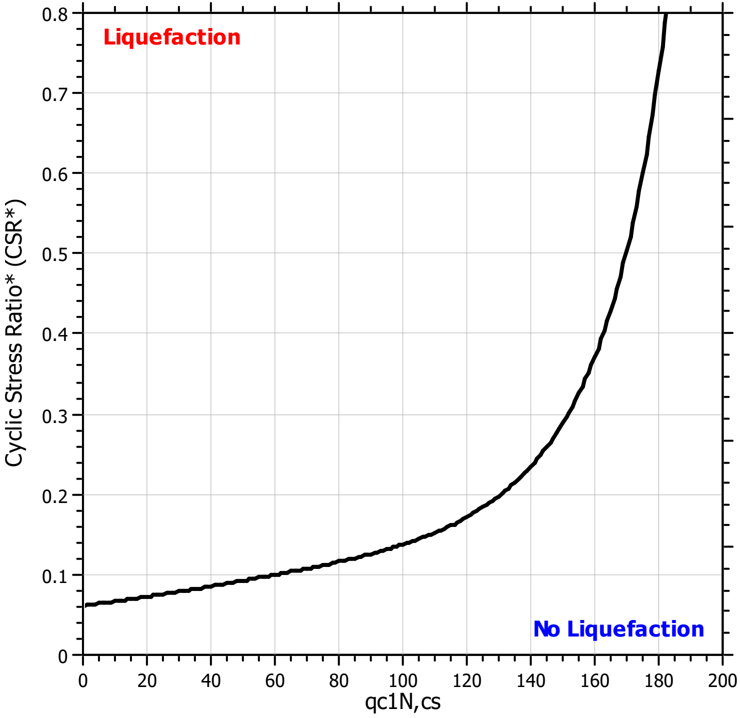
CRR plot



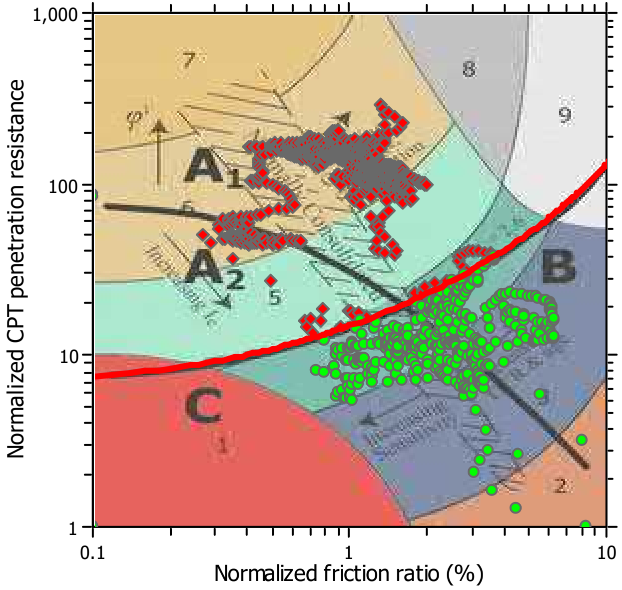
FS Plot



$M_w=7^{1/2}$, sigma'=1 atm base curve

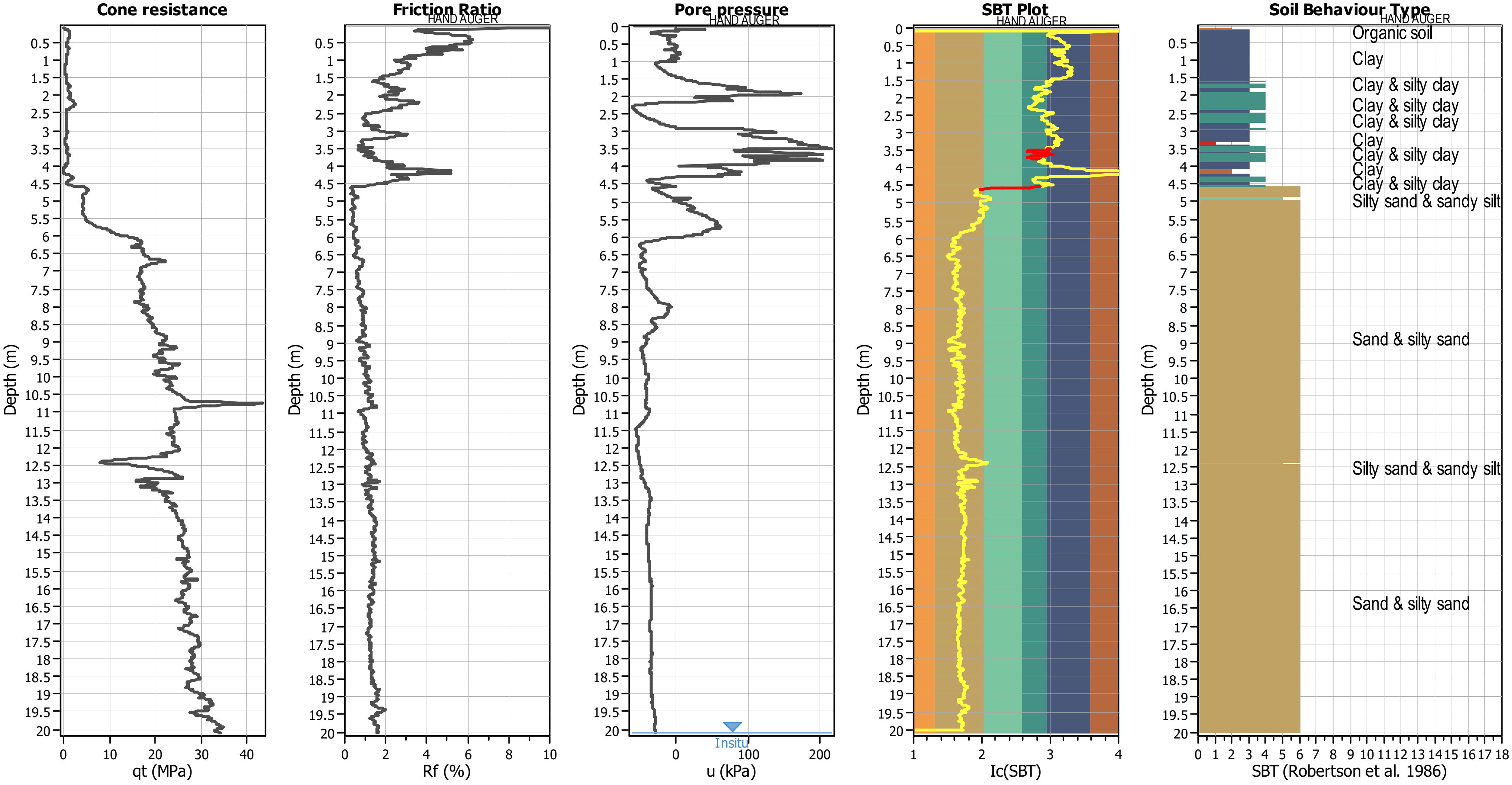


Summary of liquefaction potential



Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: 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



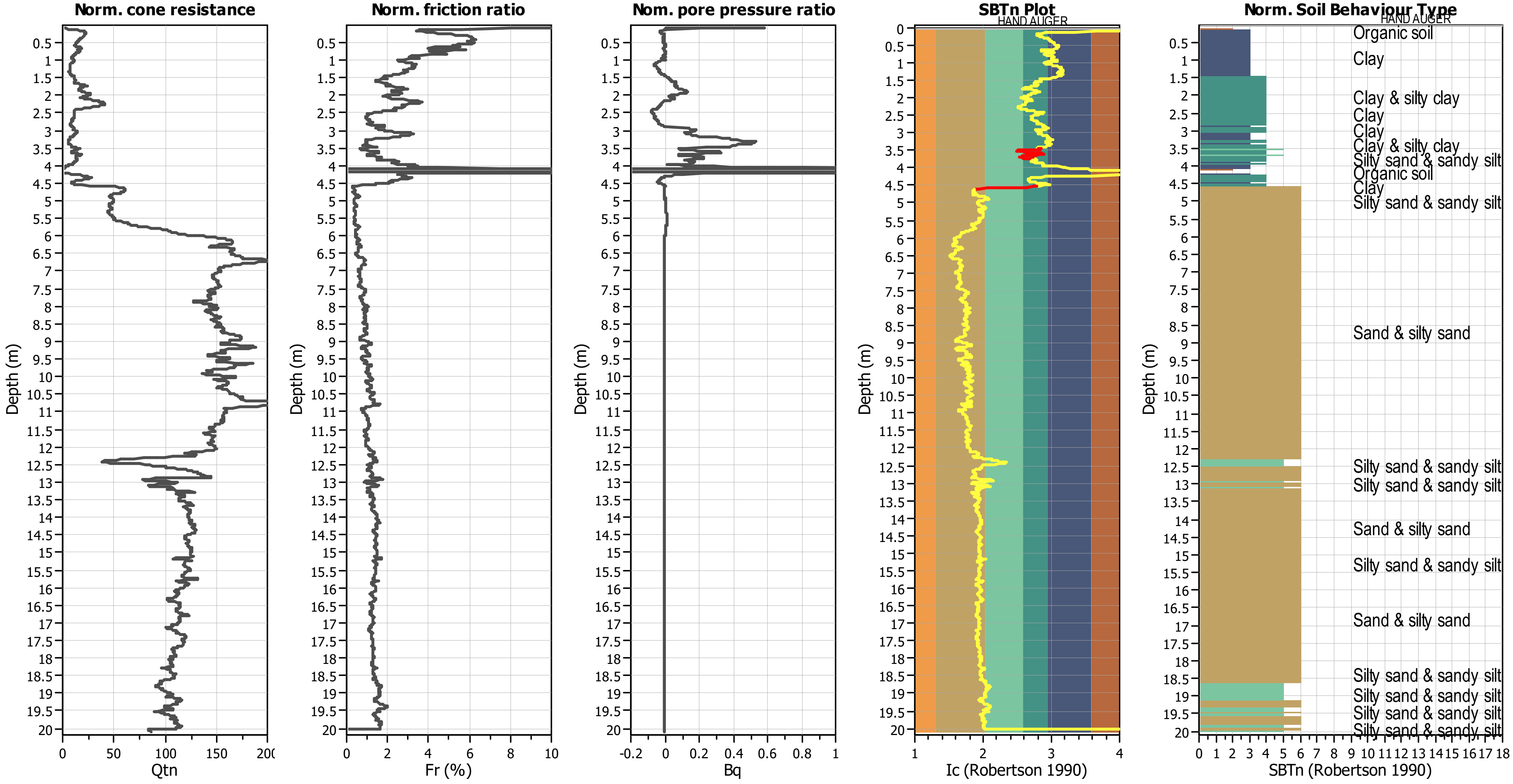
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



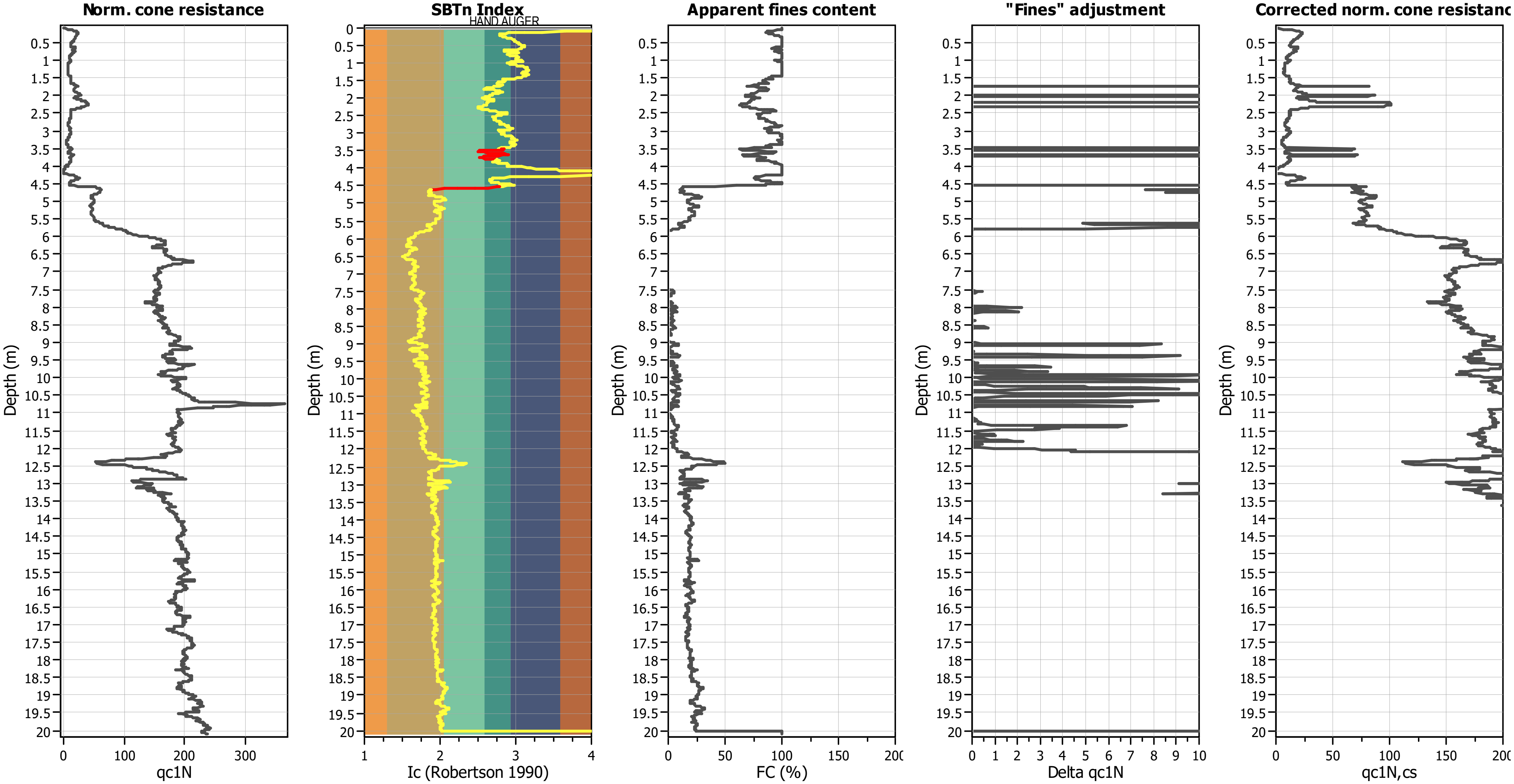
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

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

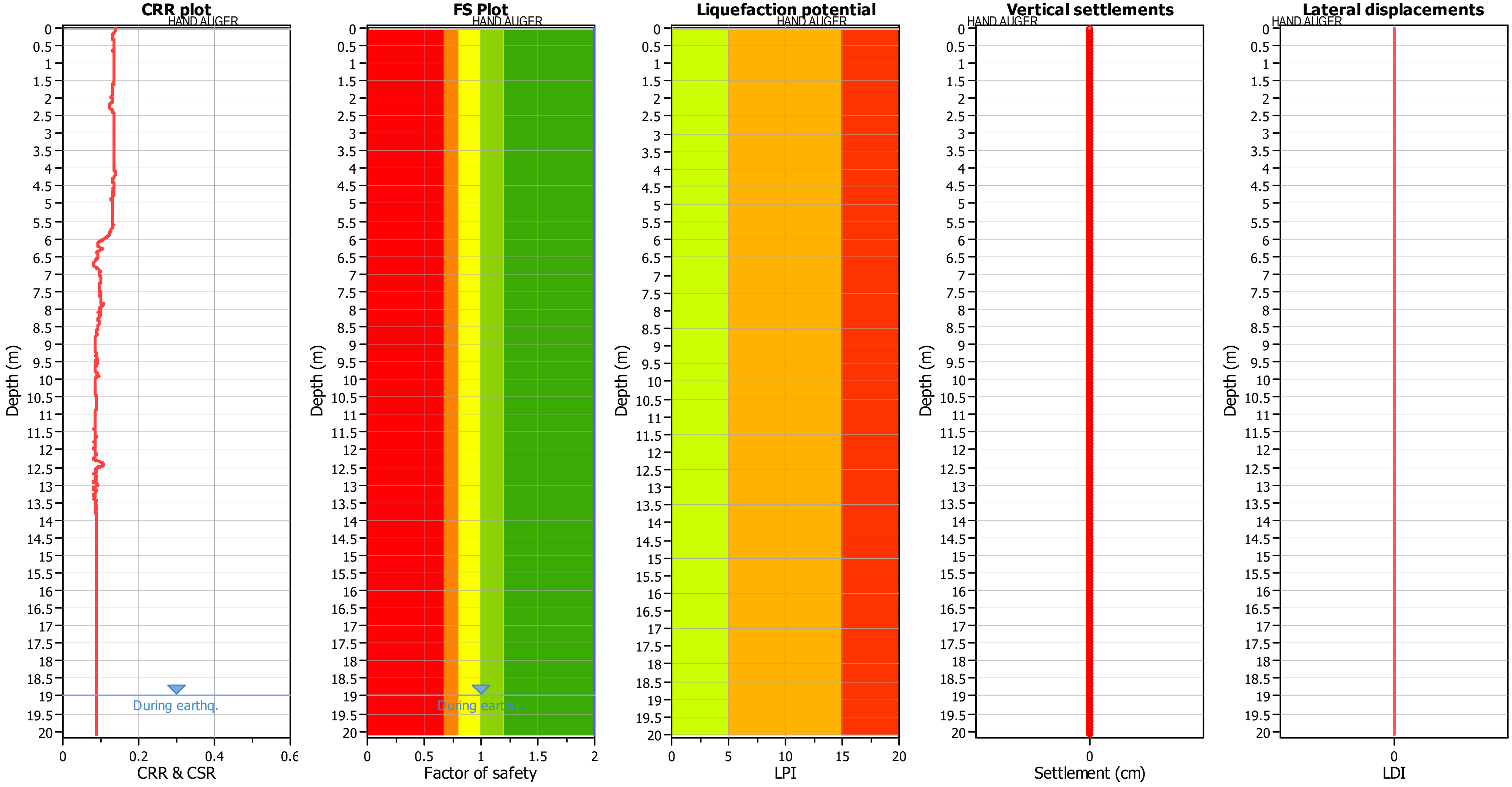
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

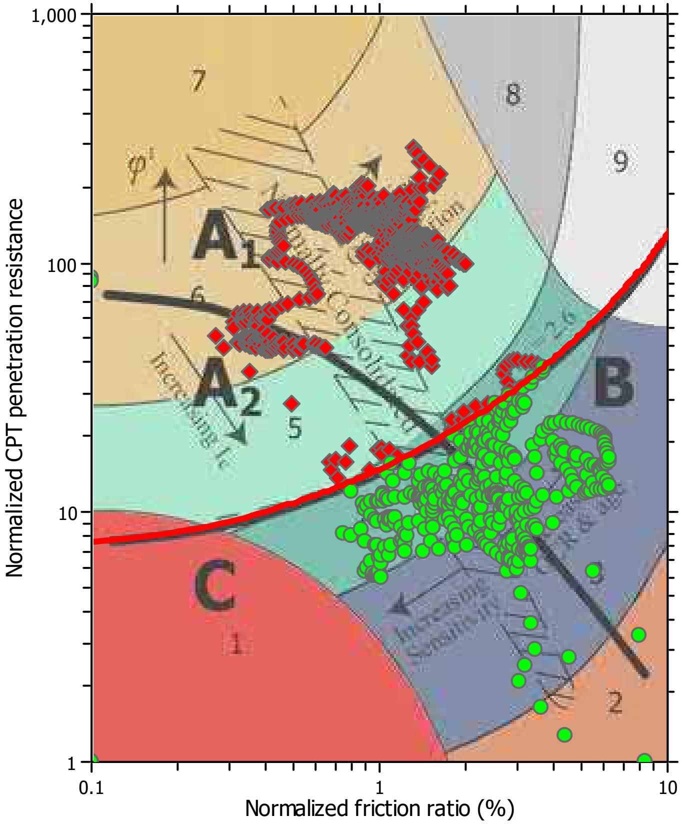
F.S. color scheme

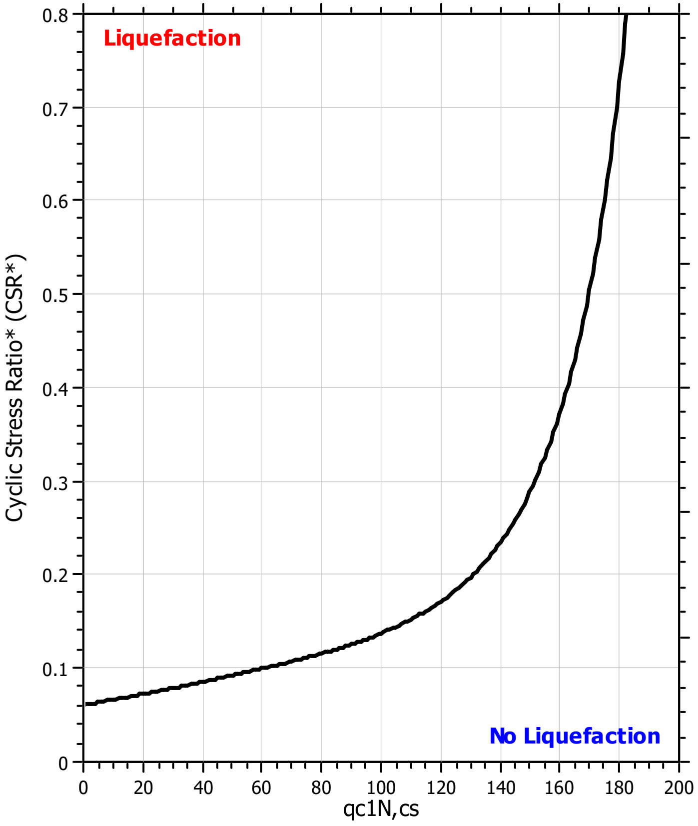
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

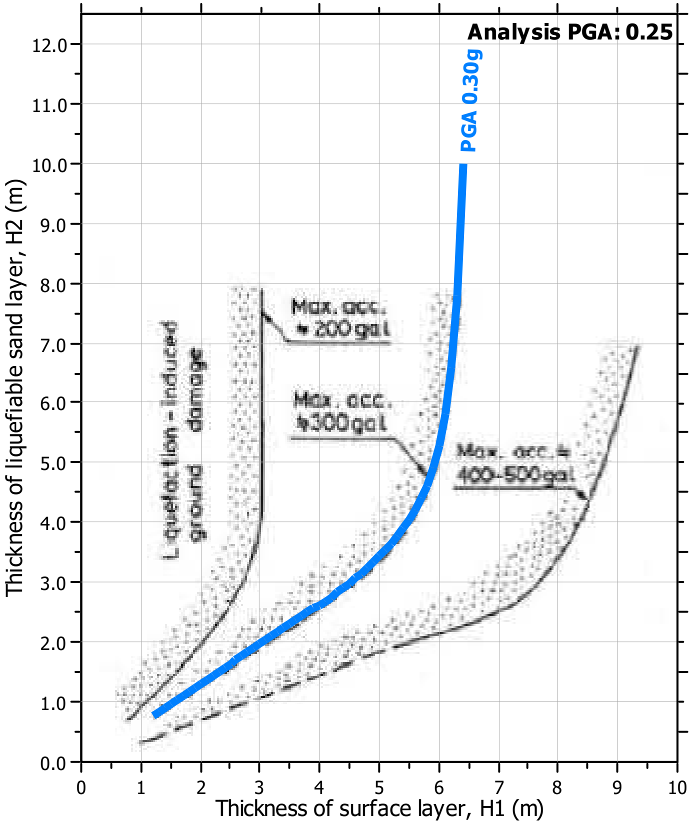
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



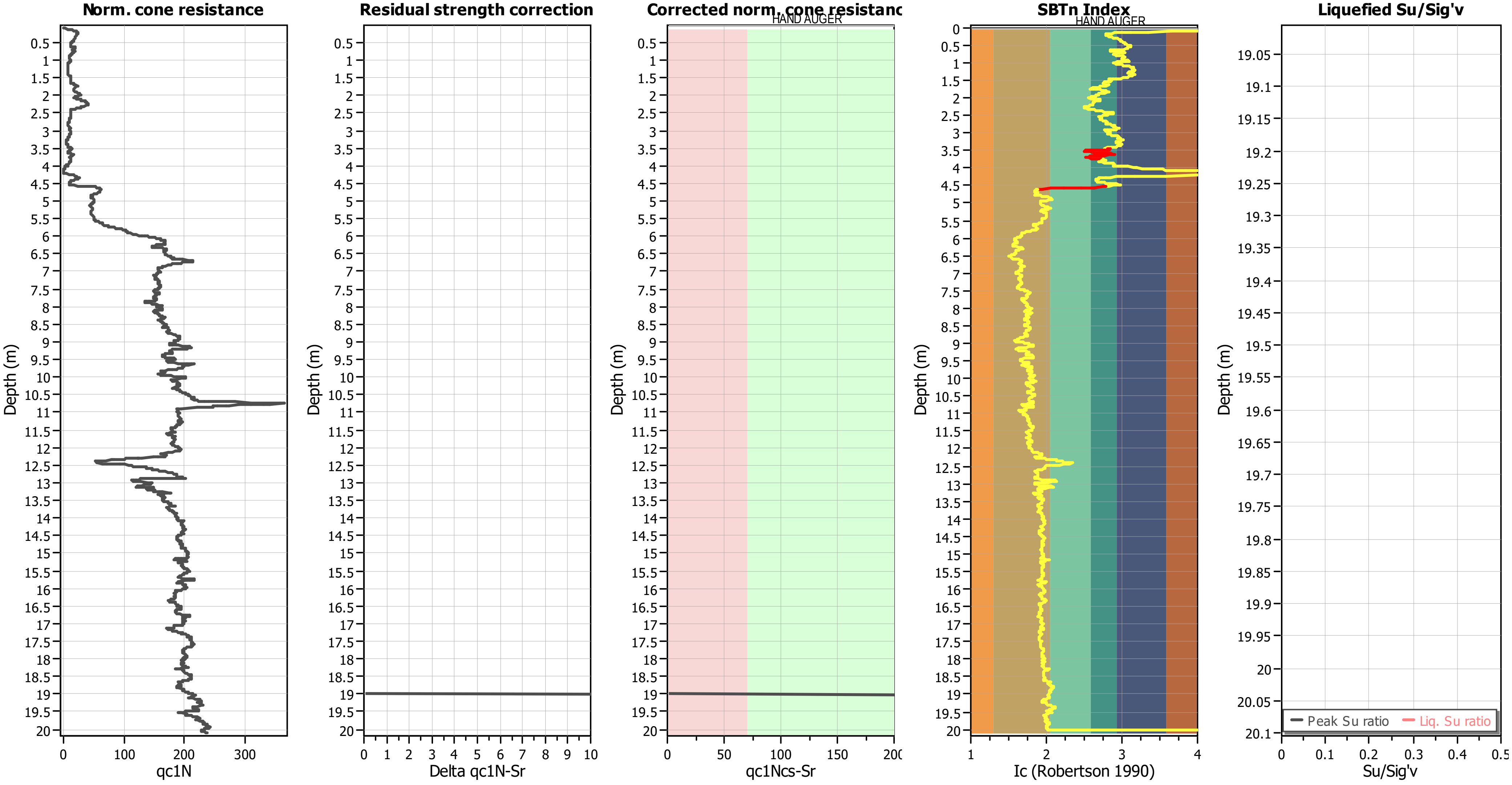




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

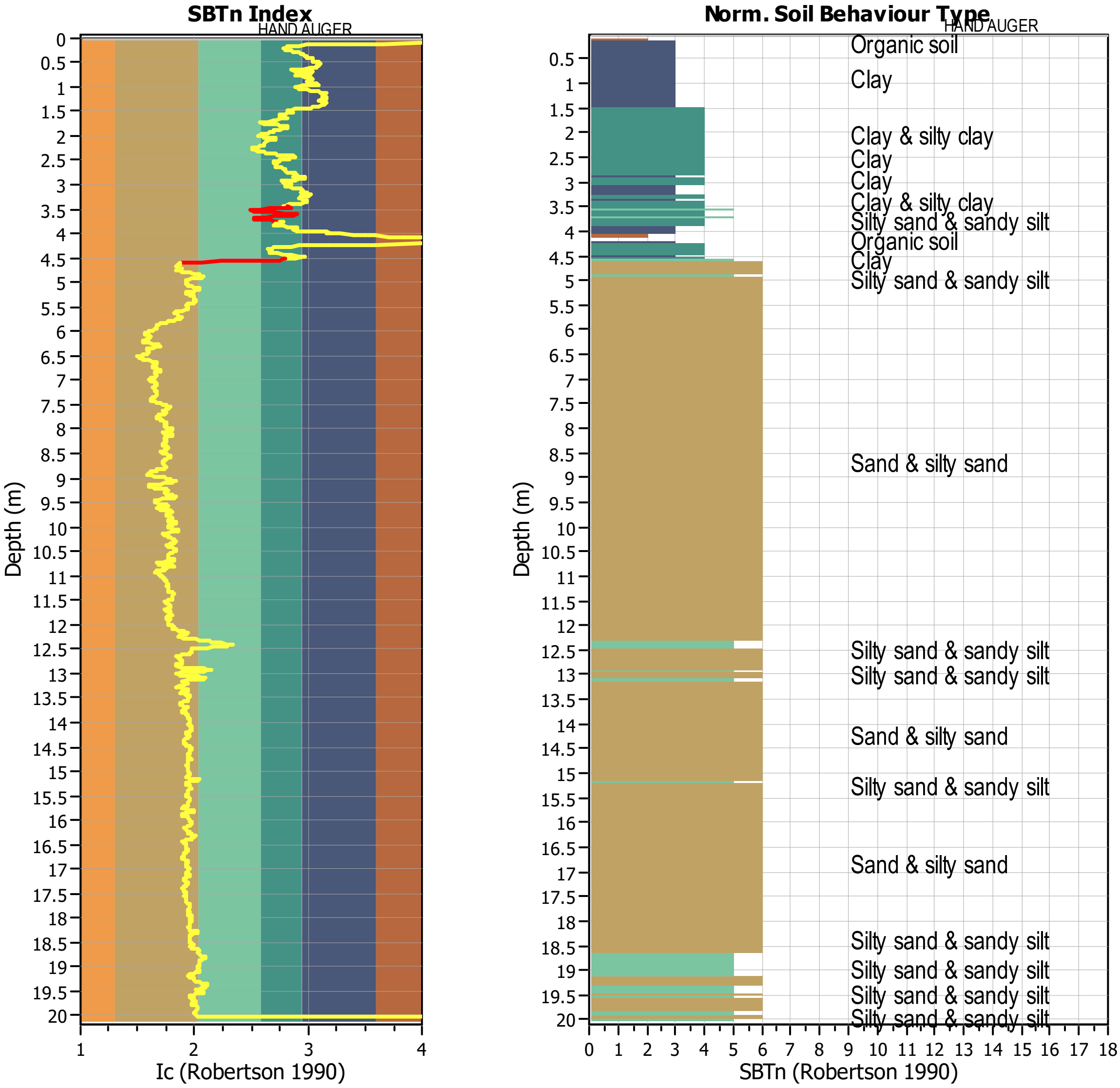
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.



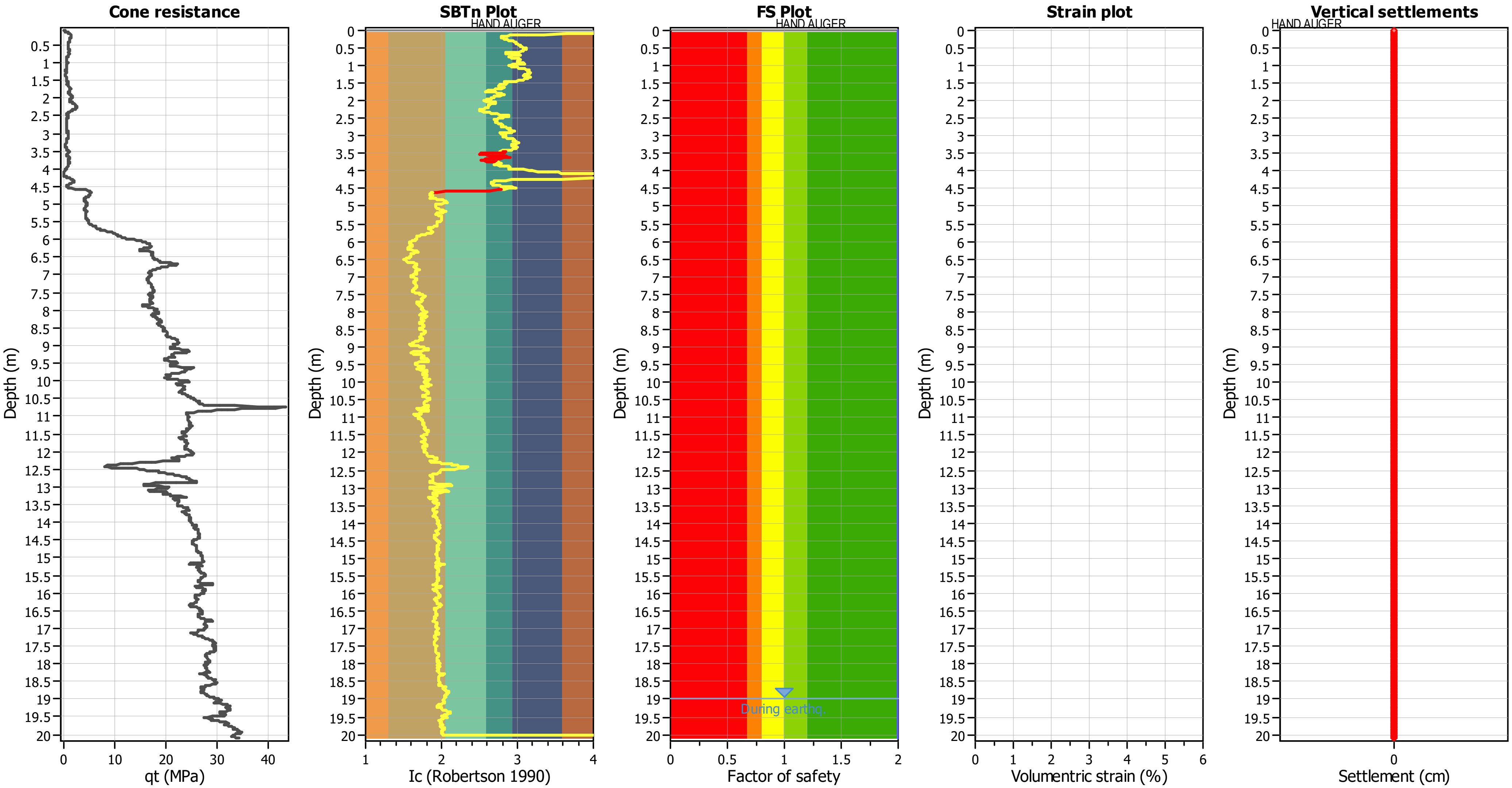
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	40
Exclusion percentage:	1.99%
Number of layers detected:	5

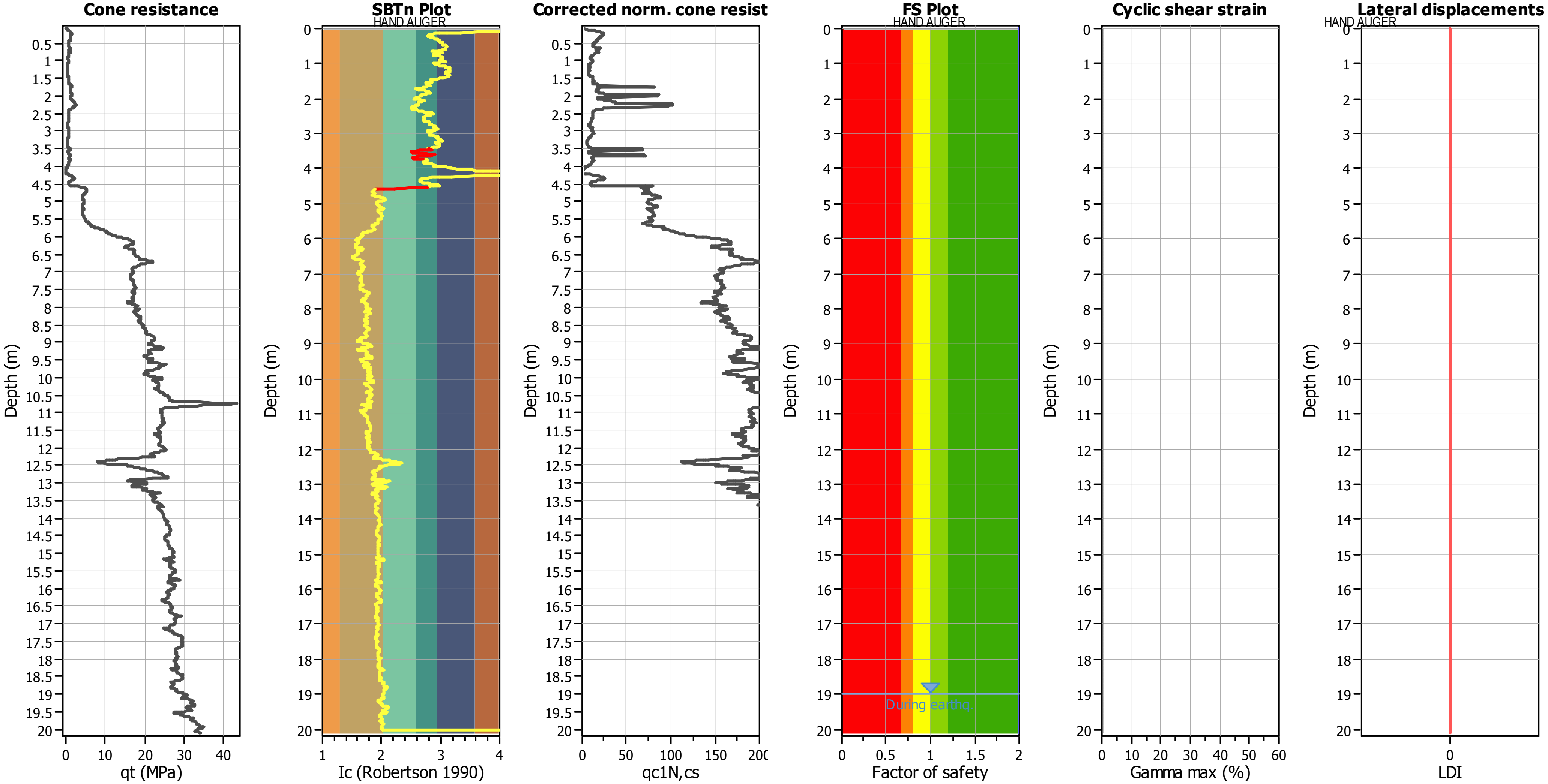
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

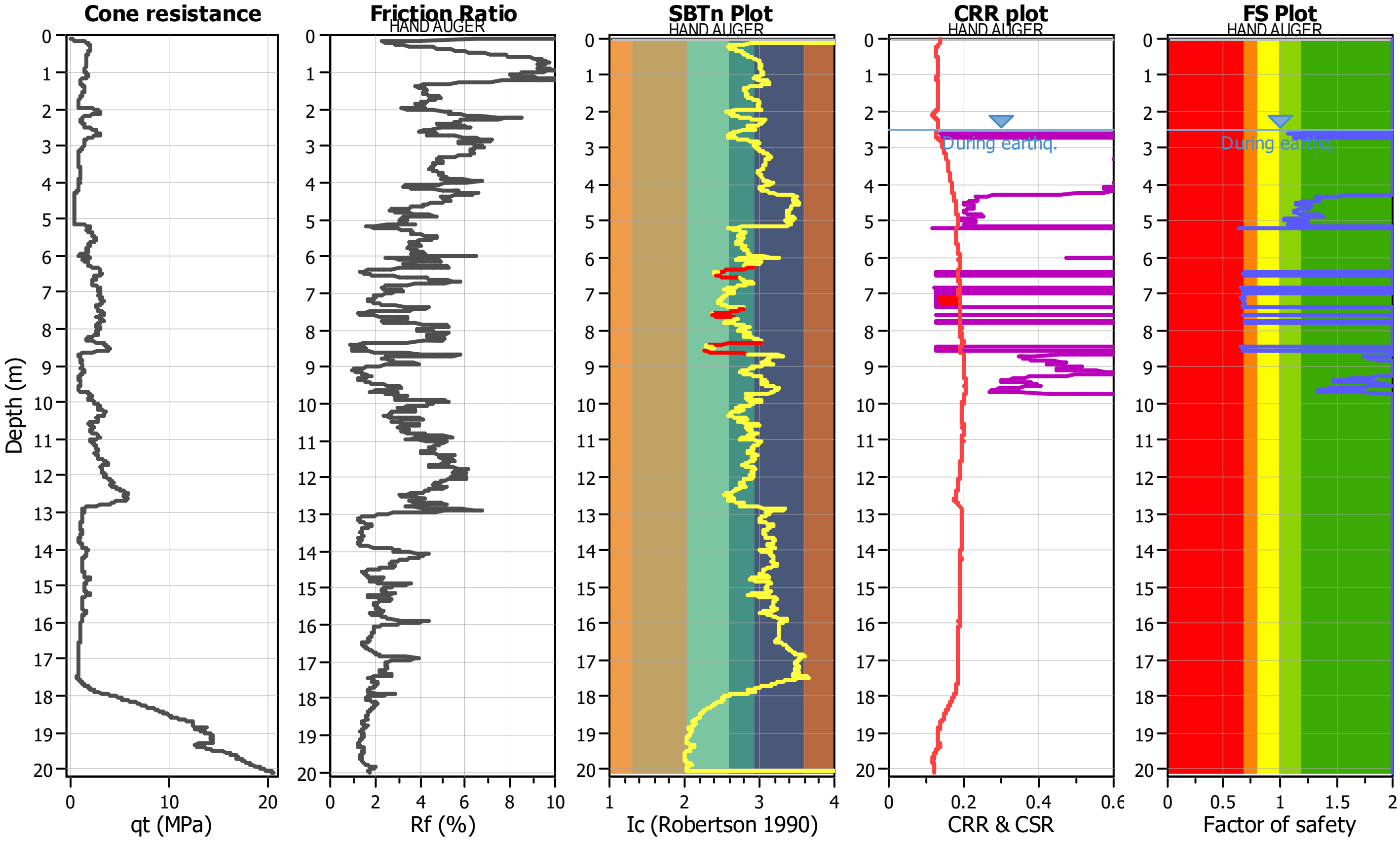
LIQUEFACTION ANALYSIS REPORT

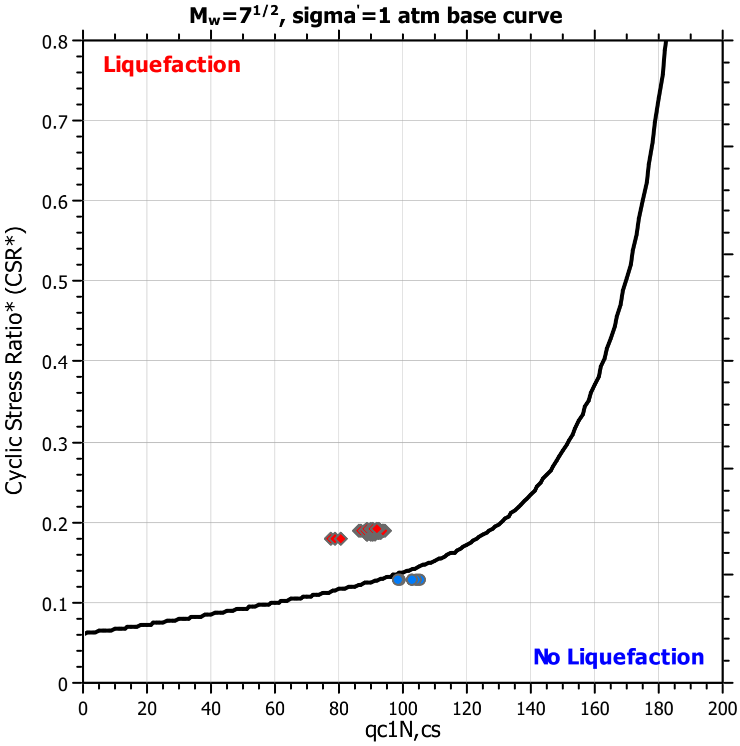
Project title : Proposed Private Plan Change for Te Awamutu   Location : 2025 Ohaupo Road, Te Awamutu

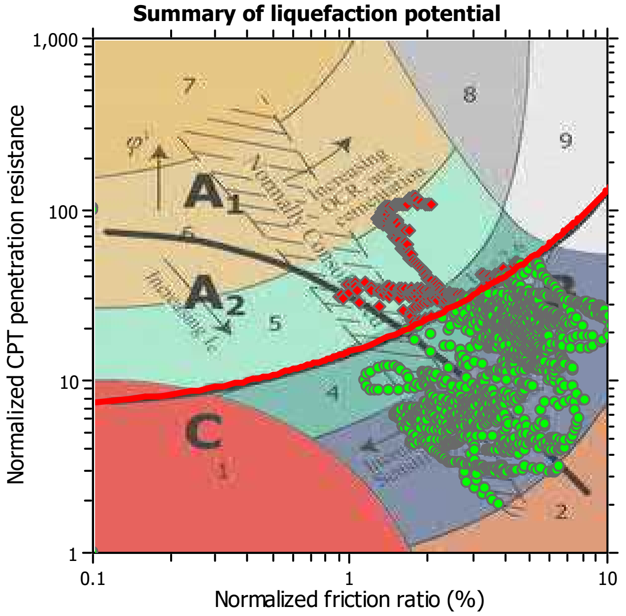
CPT file : CPT-08

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.50 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.50 m	Fill height:	N/A		
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	10.00 m
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method

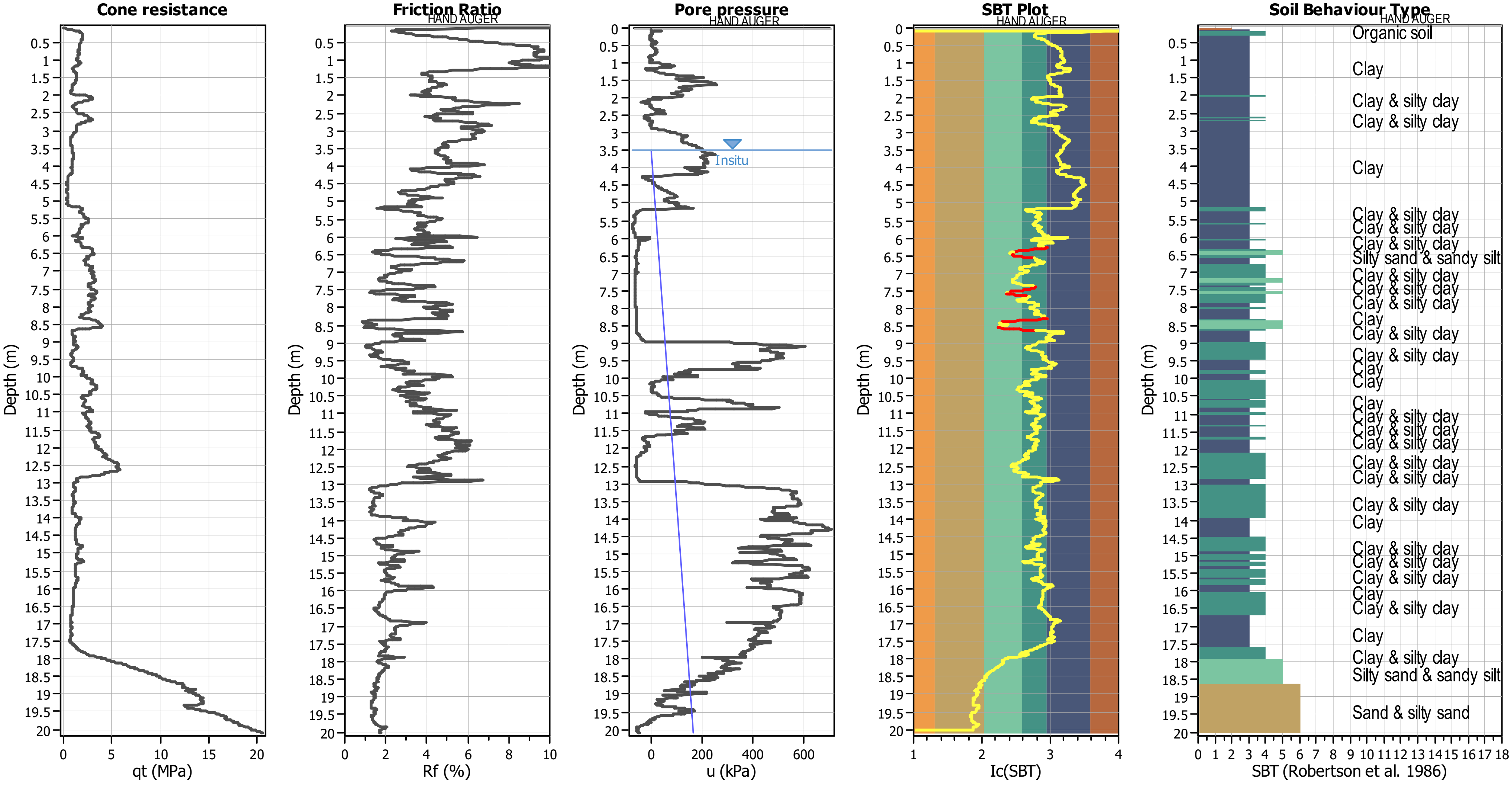






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



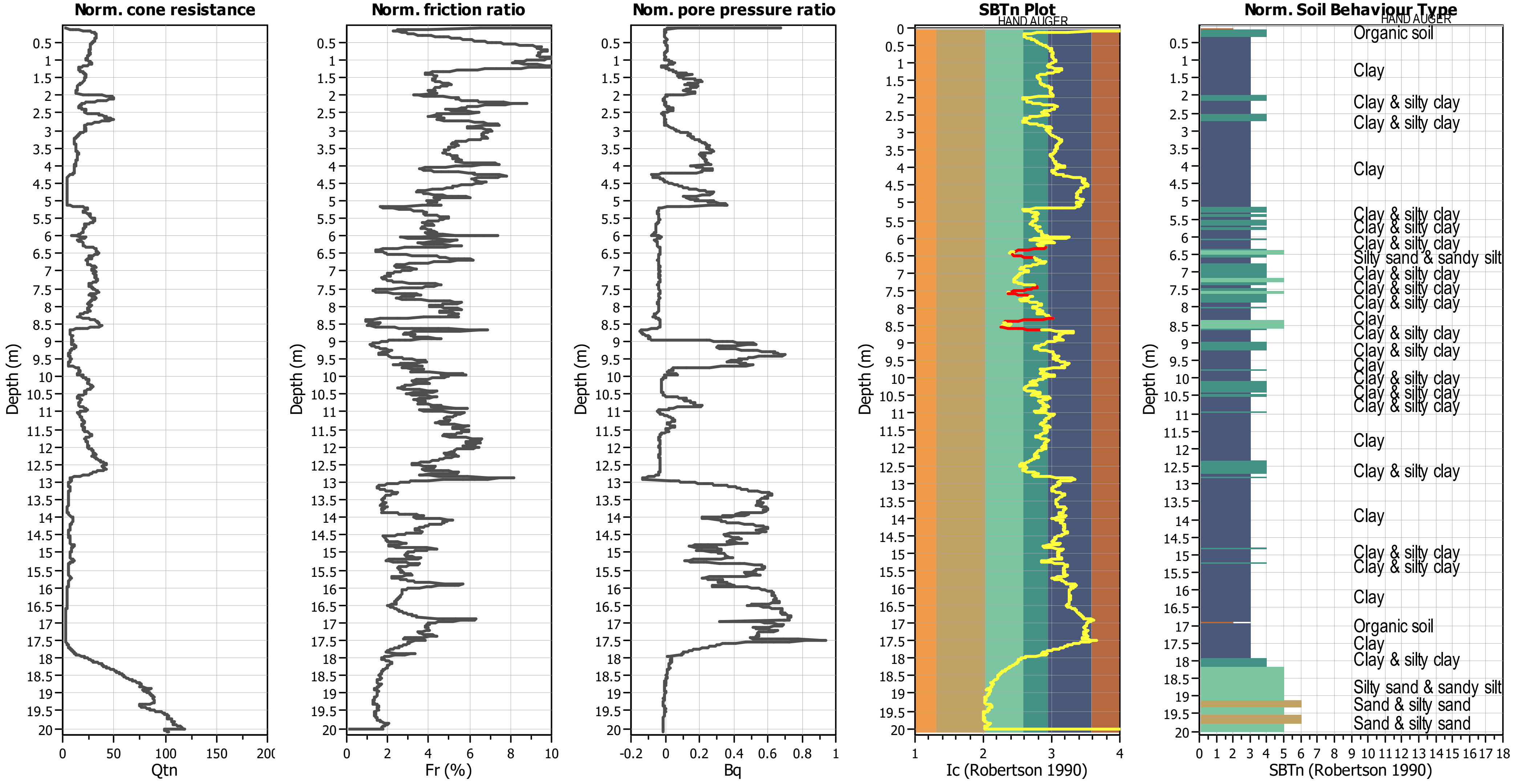
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

SBT 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

CPT basic interpretation plots (normalized)



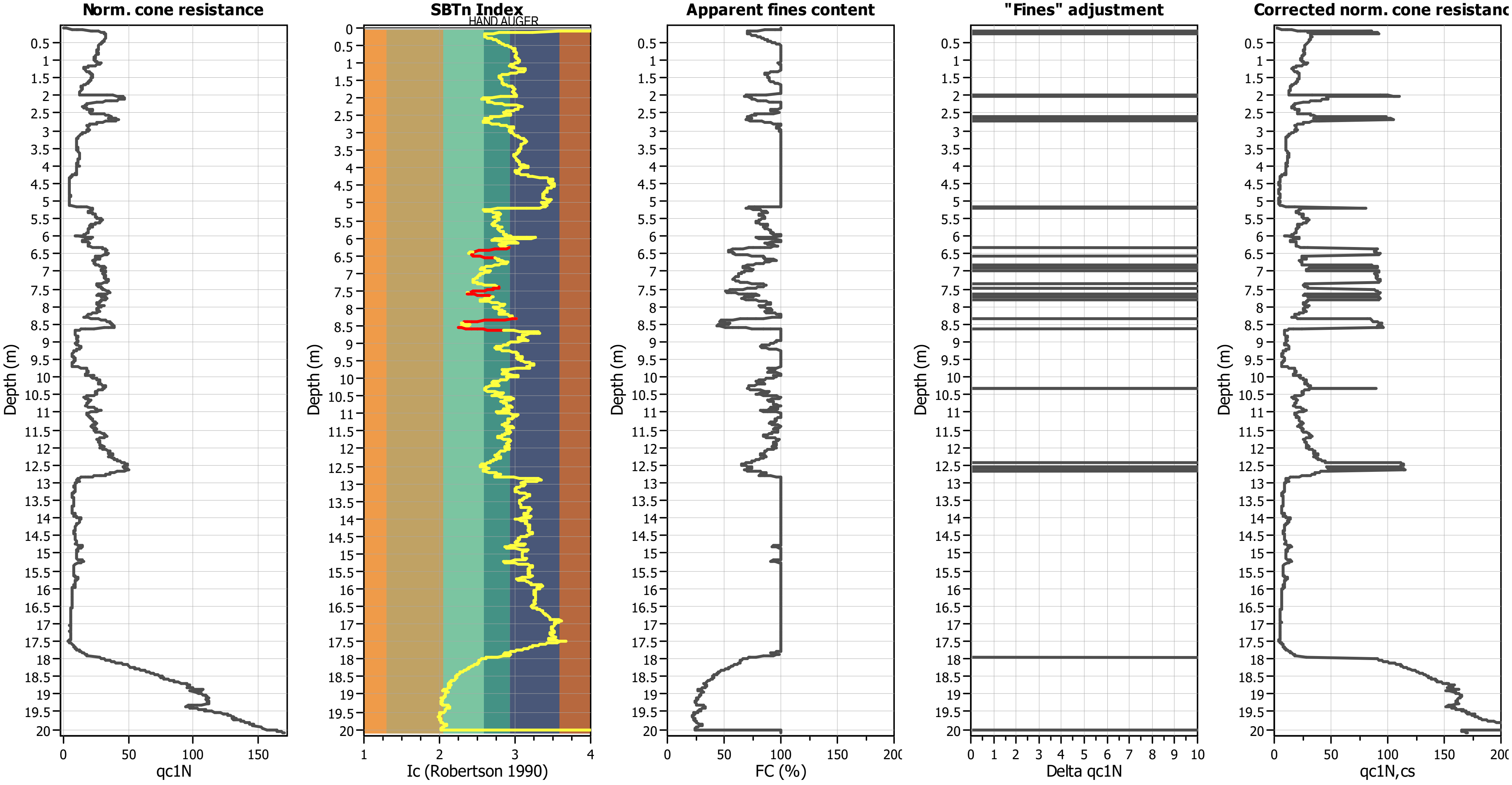
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

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

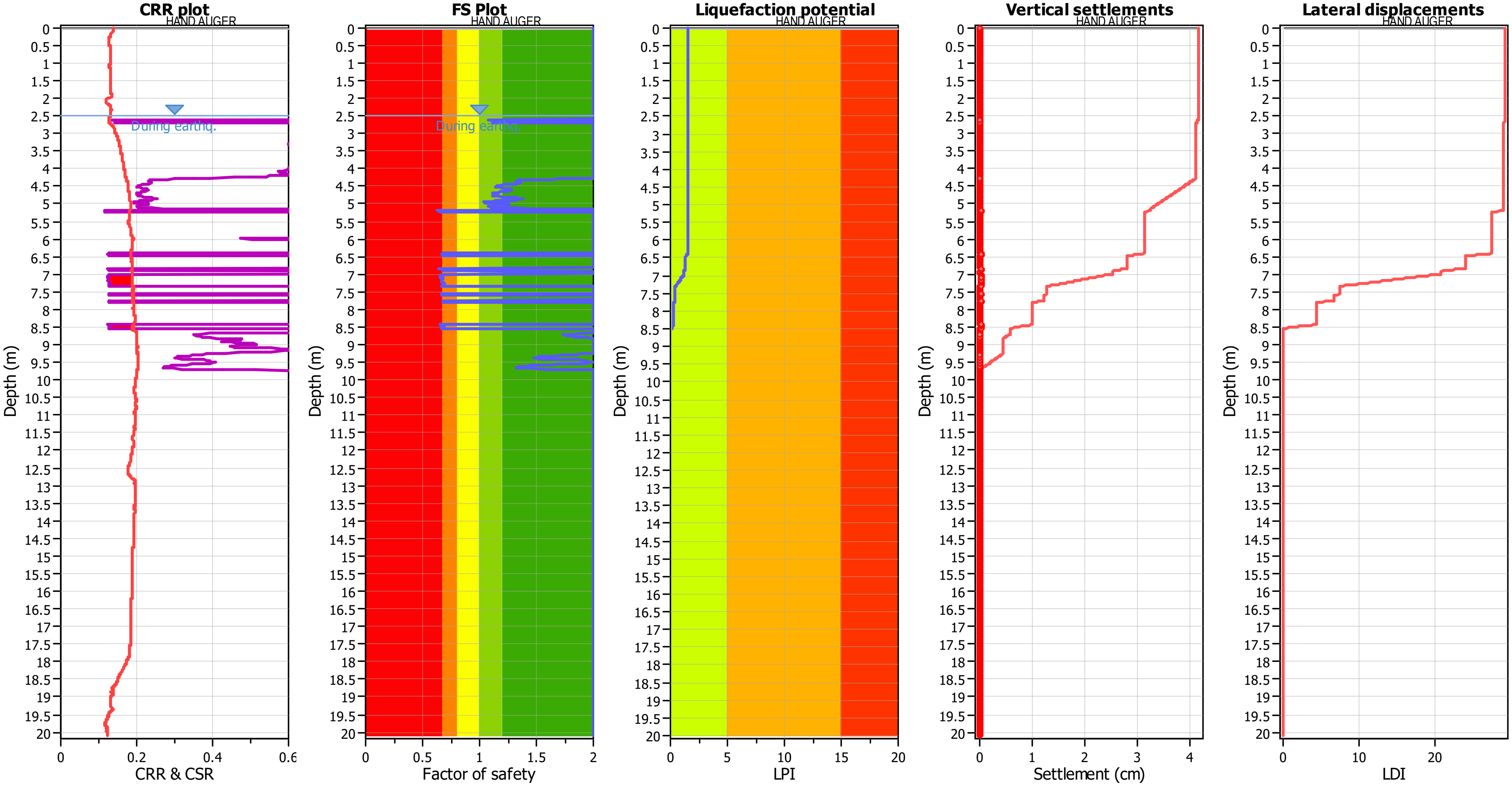
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

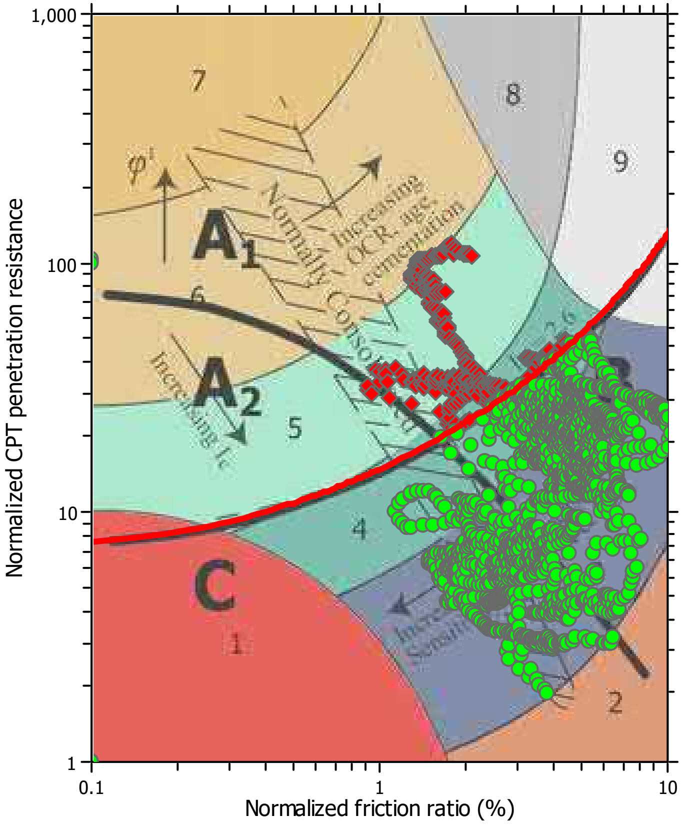
F.S. color scheme

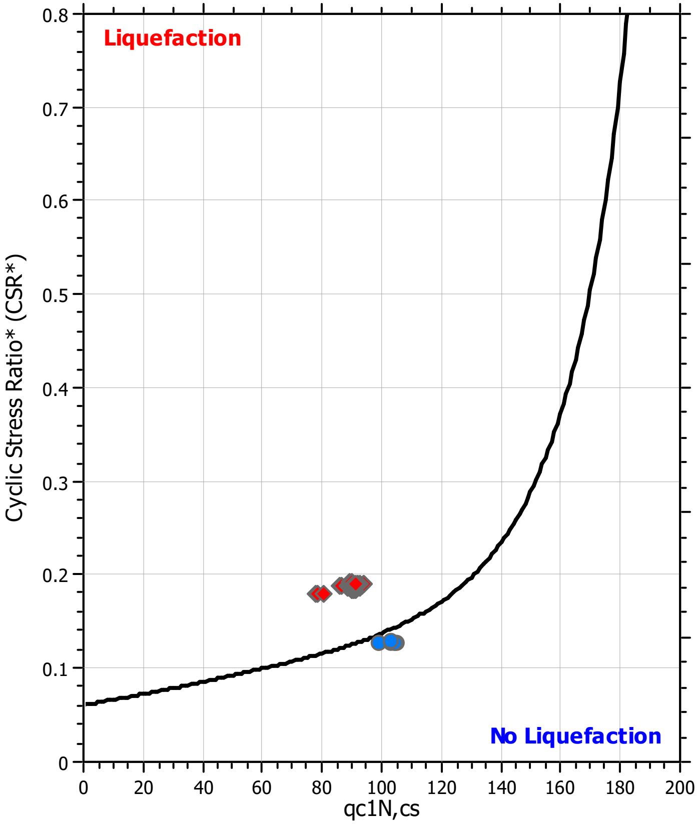
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

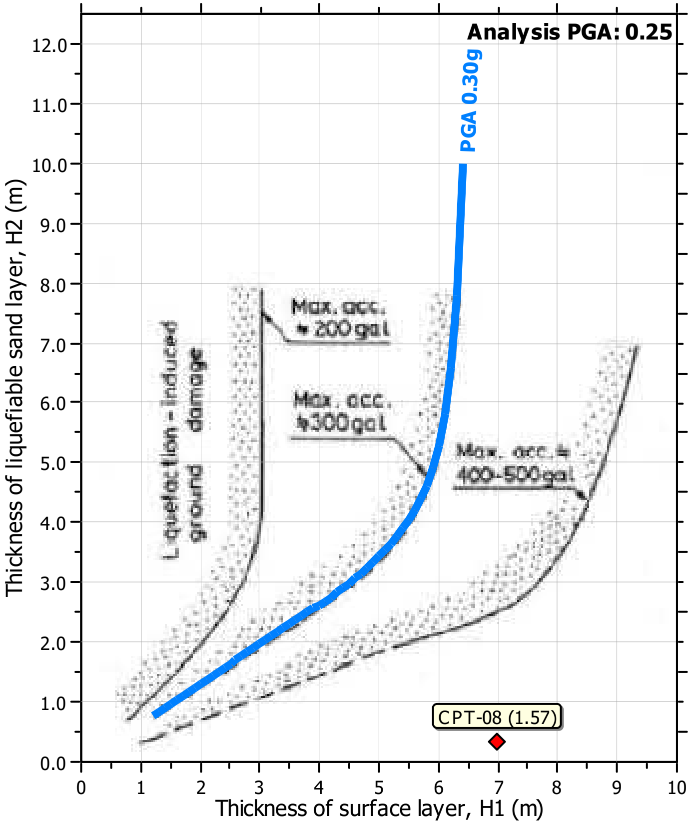
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



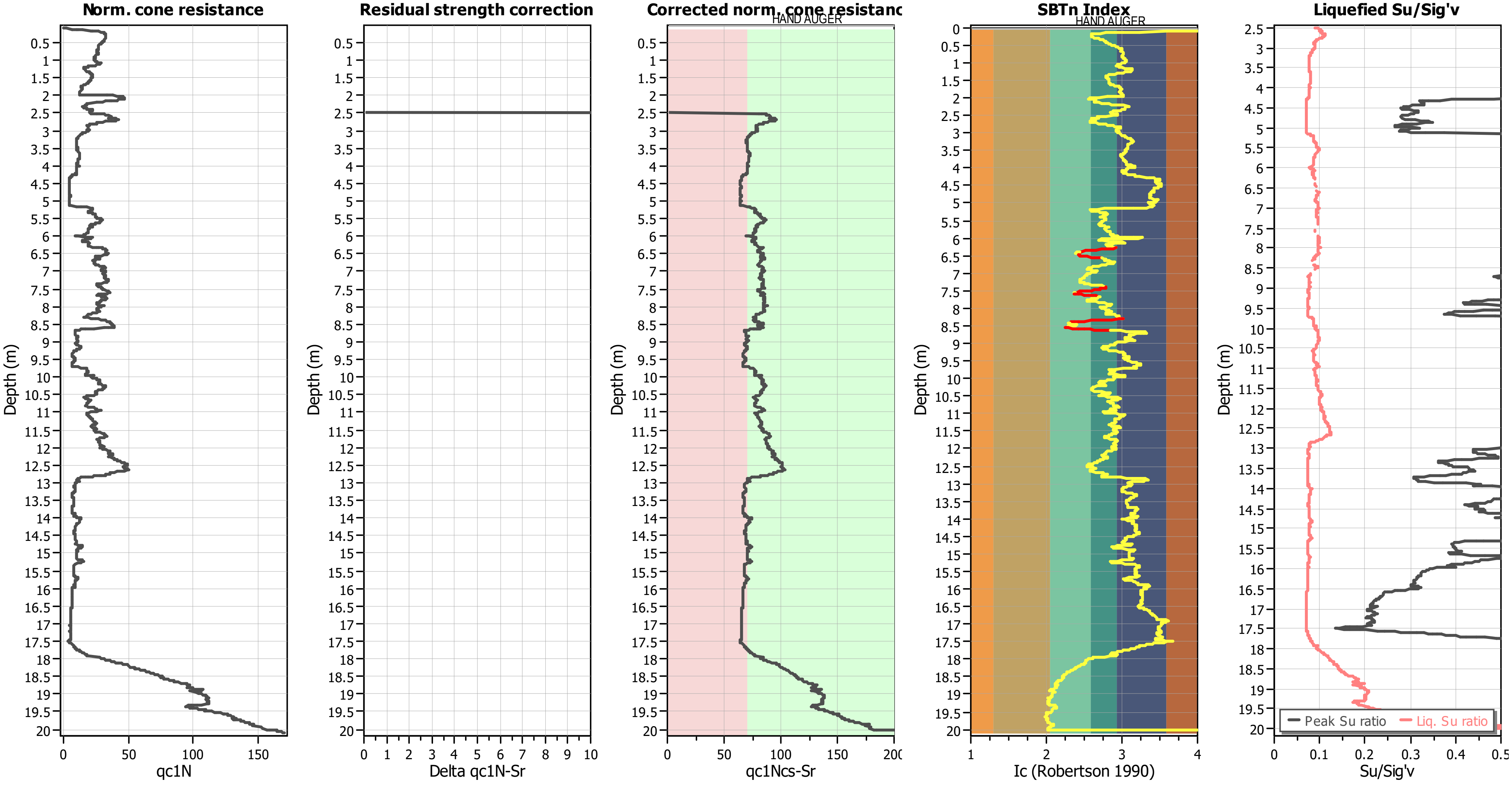




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

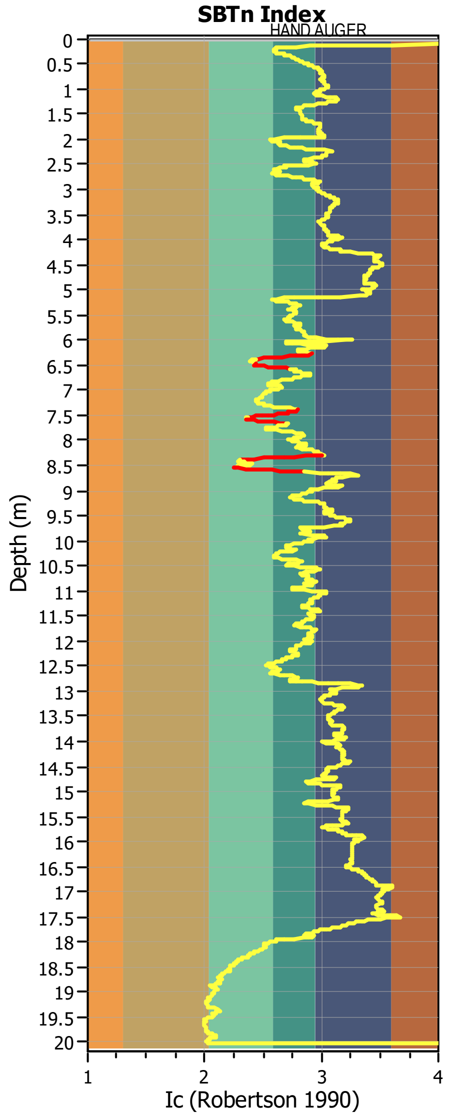
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

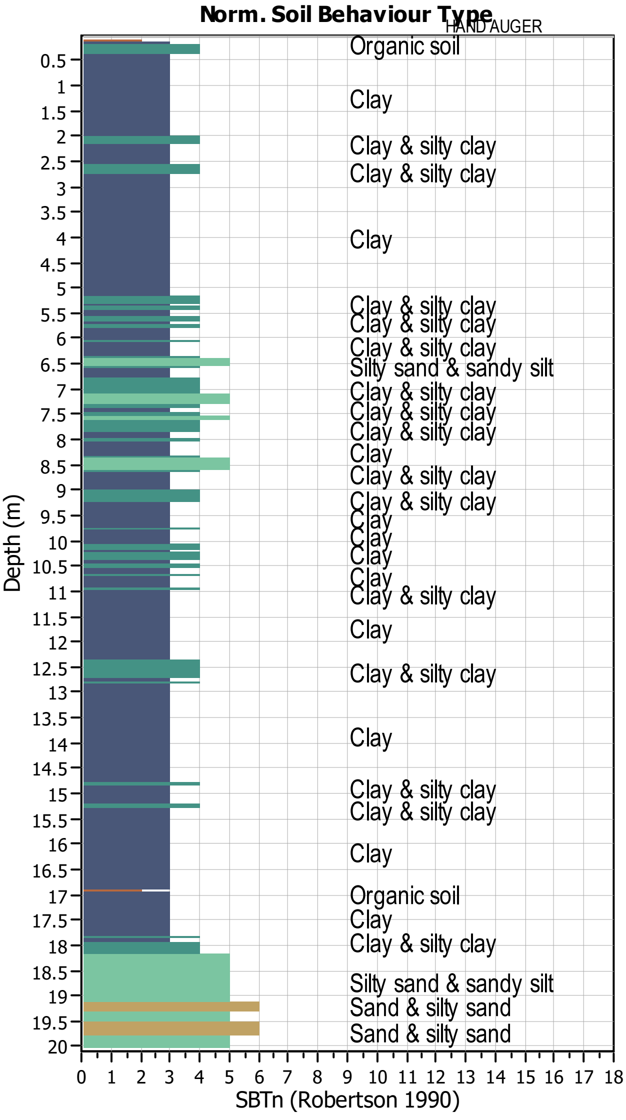
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

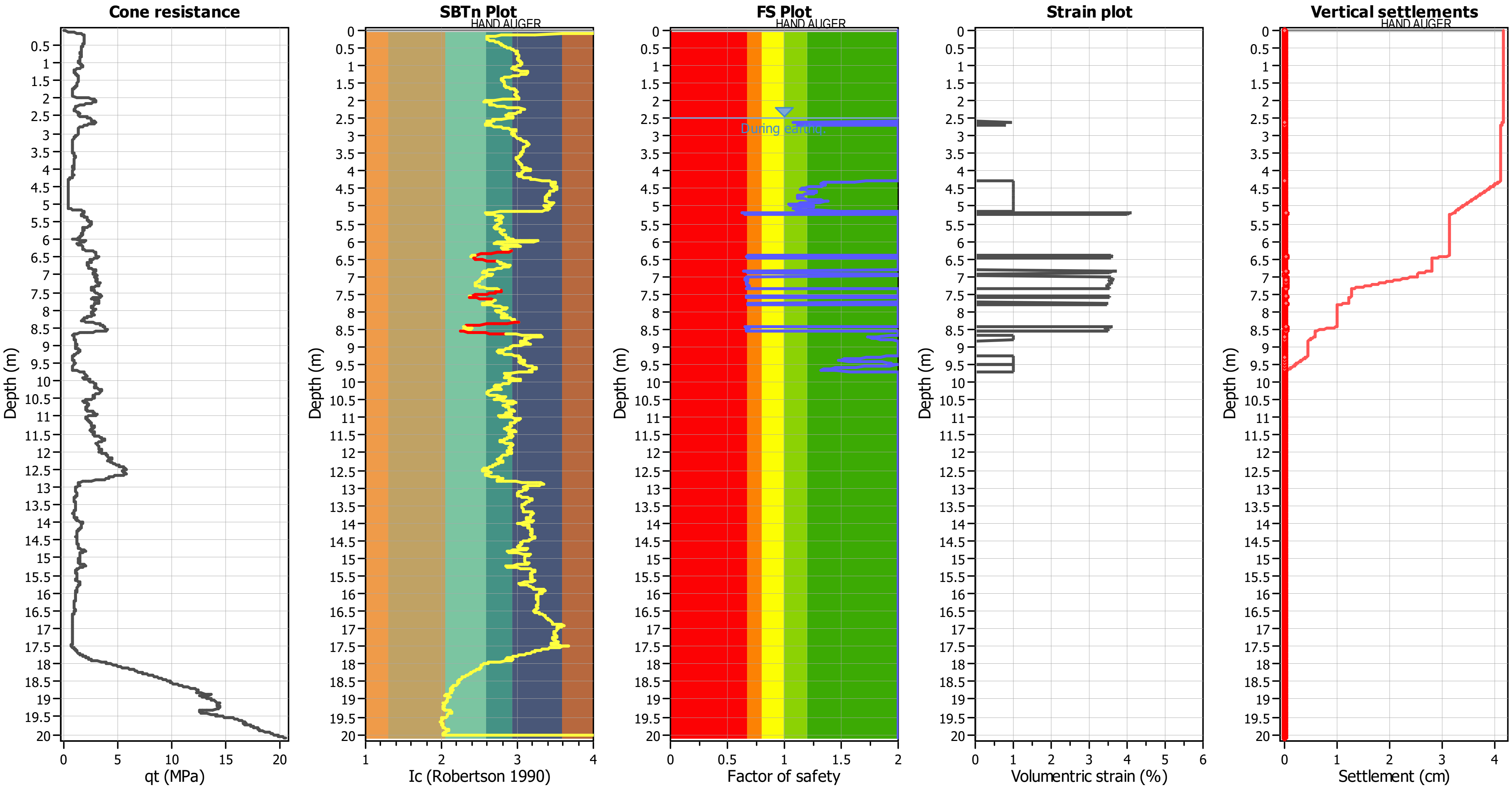
The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





Transition layer algorithm properties		**General statistics**	
I_c minimum check value:	1.70	Total points in CPT file:	2010
I_c maximum check value:	3.00	Total points excluded:	70
I_c change ratio value:	0.0100	Exclusion percentage:	3.48%
Minimum number of points in layer:	4	Number of layers detected:	6

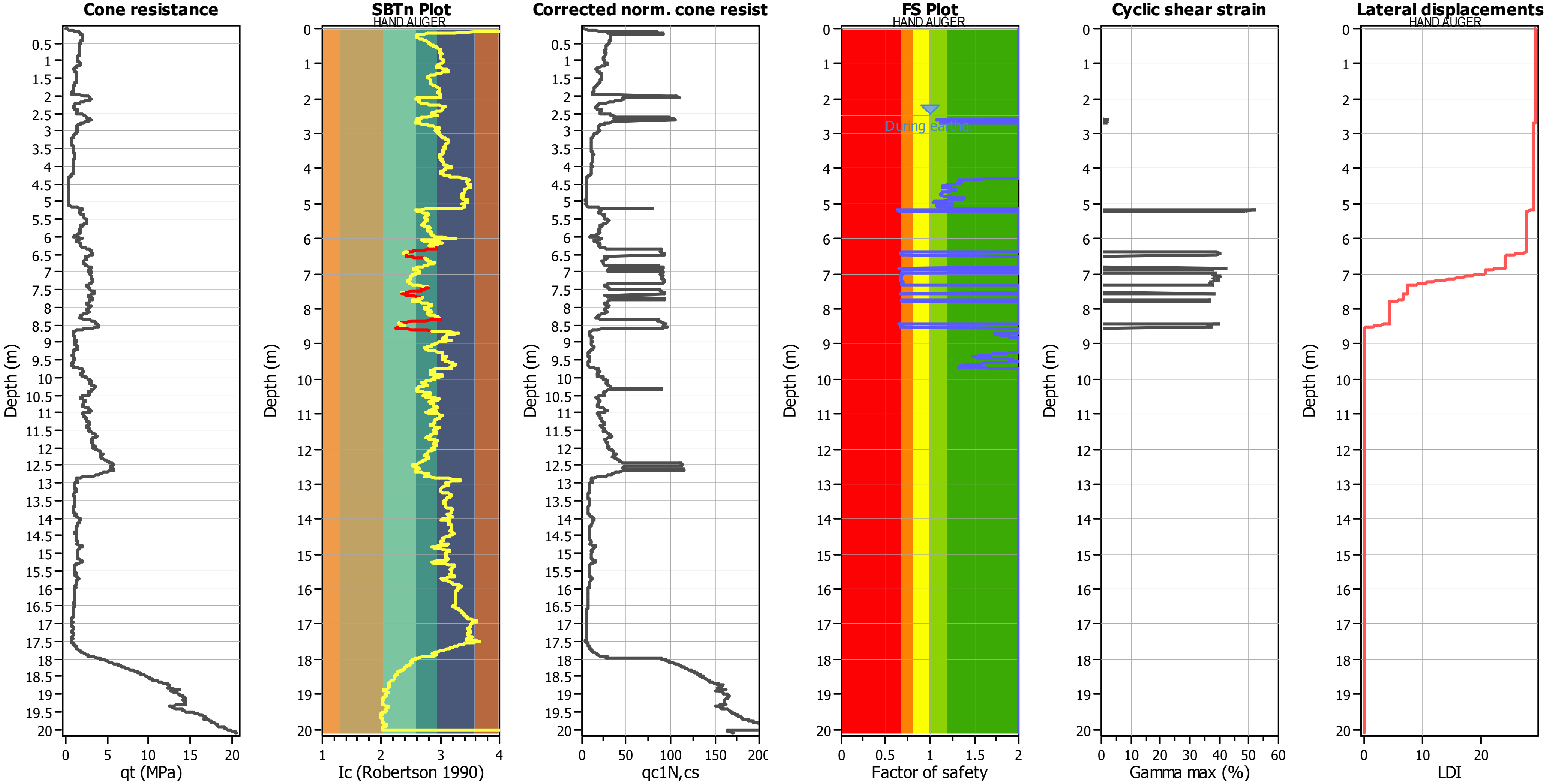
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

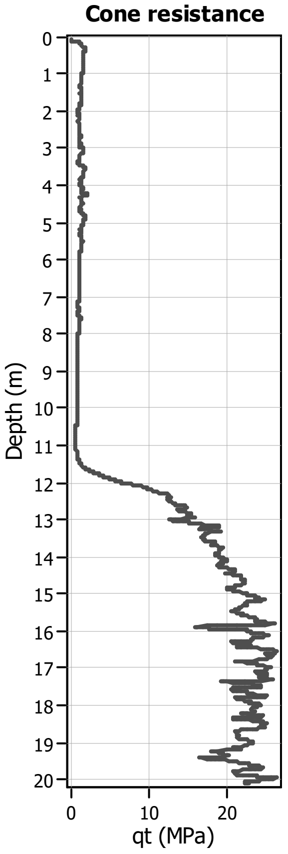
LIQUEFACTION ANALYSIS REPORT

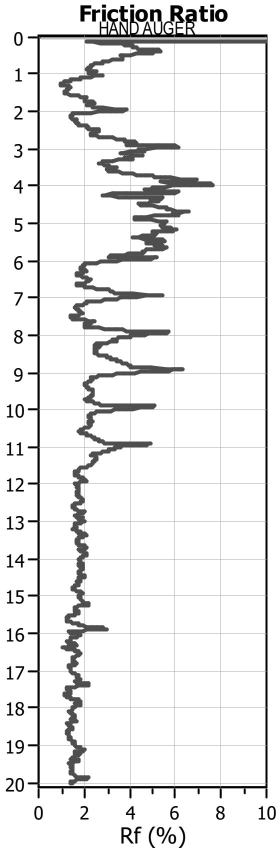
Project title : Proposed Private Plan Change for Te Awamutu **Location : 2025 Ohaupo Road, Te Awamutu**

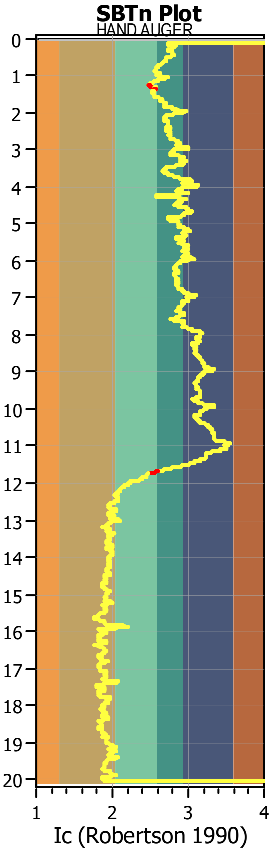
CPT file : CPT-09

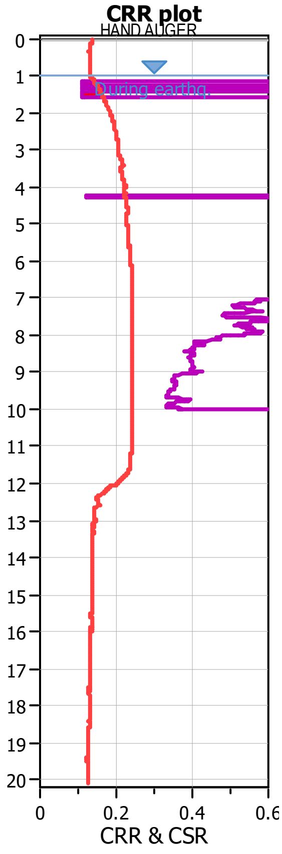
Input parameters and analysis data

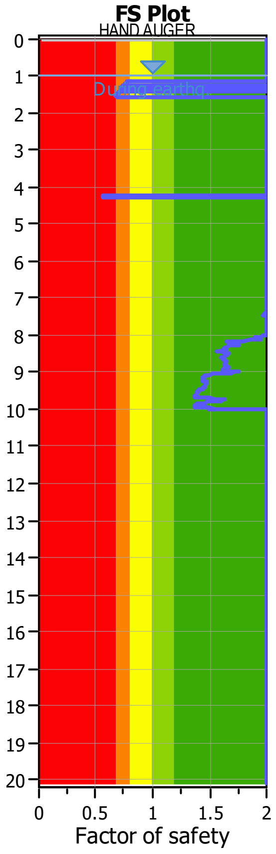
Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.10 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

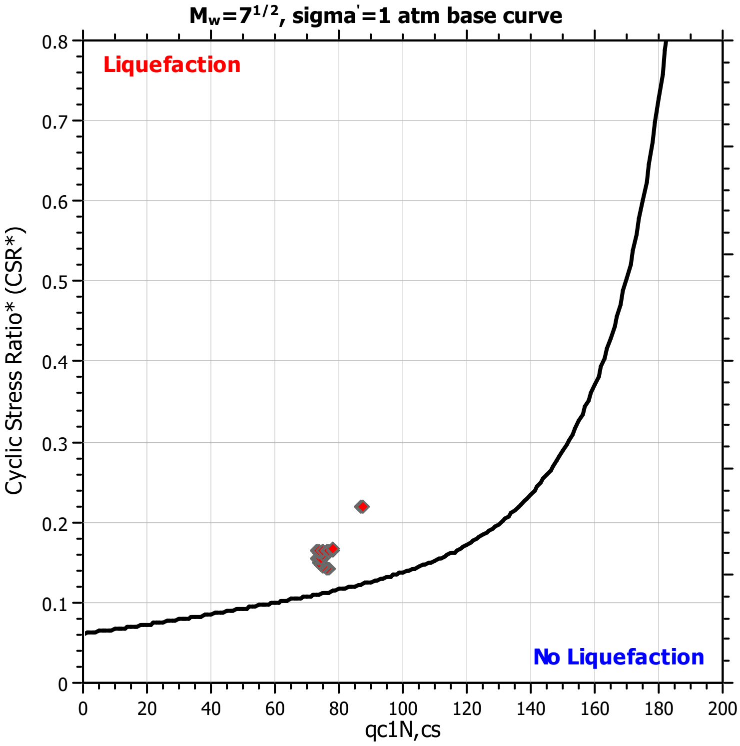

Cone resistance

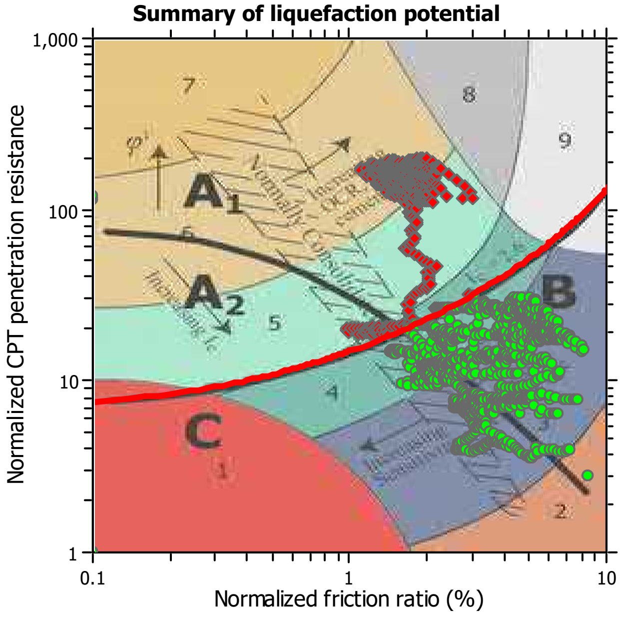

Friction Ratio


SBTn Plot


CRR plot

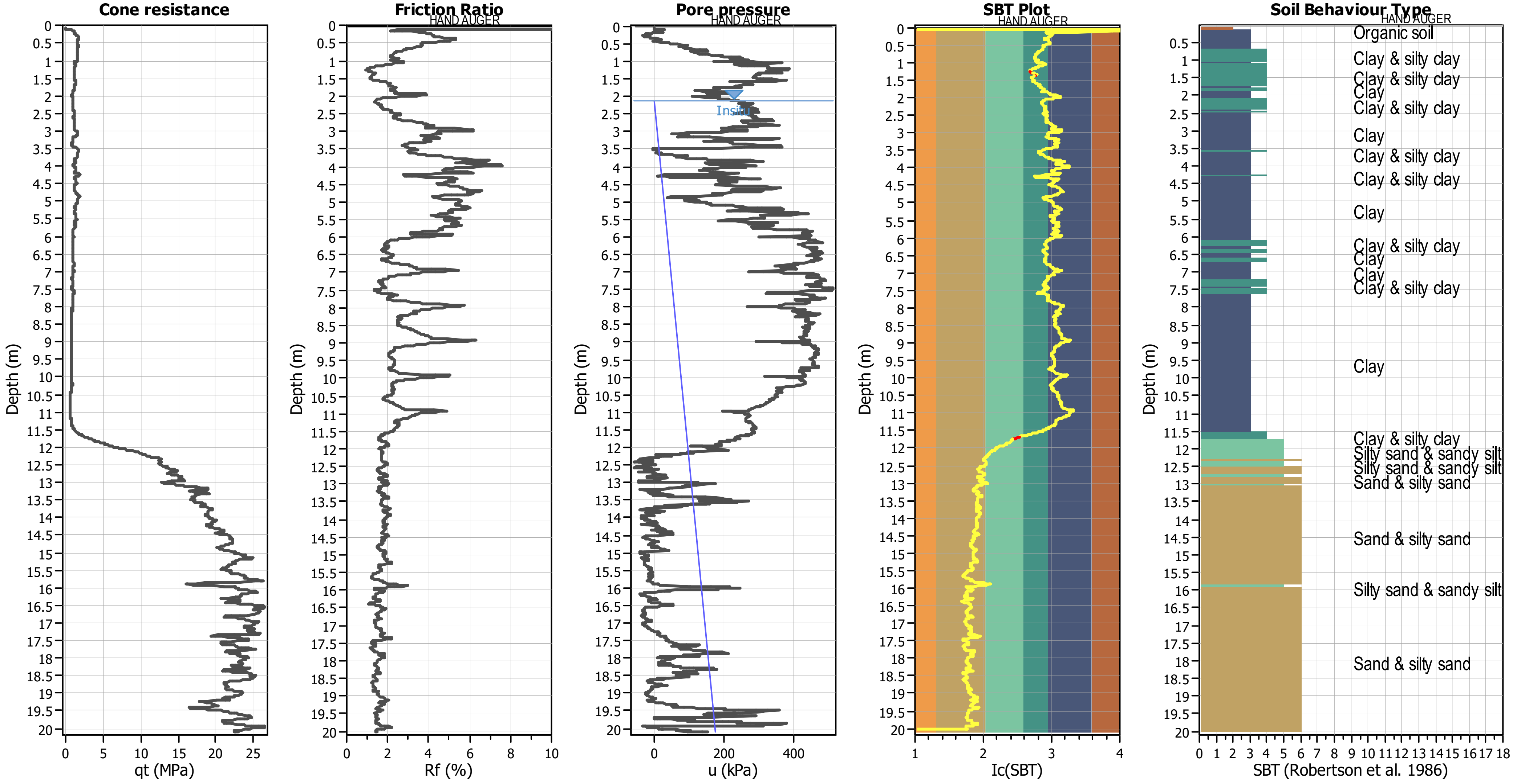

FS Plot


$M_w=7^{1/2}$, sigma'=1 atm base curve


Summary of liquefaction potential

Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: 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



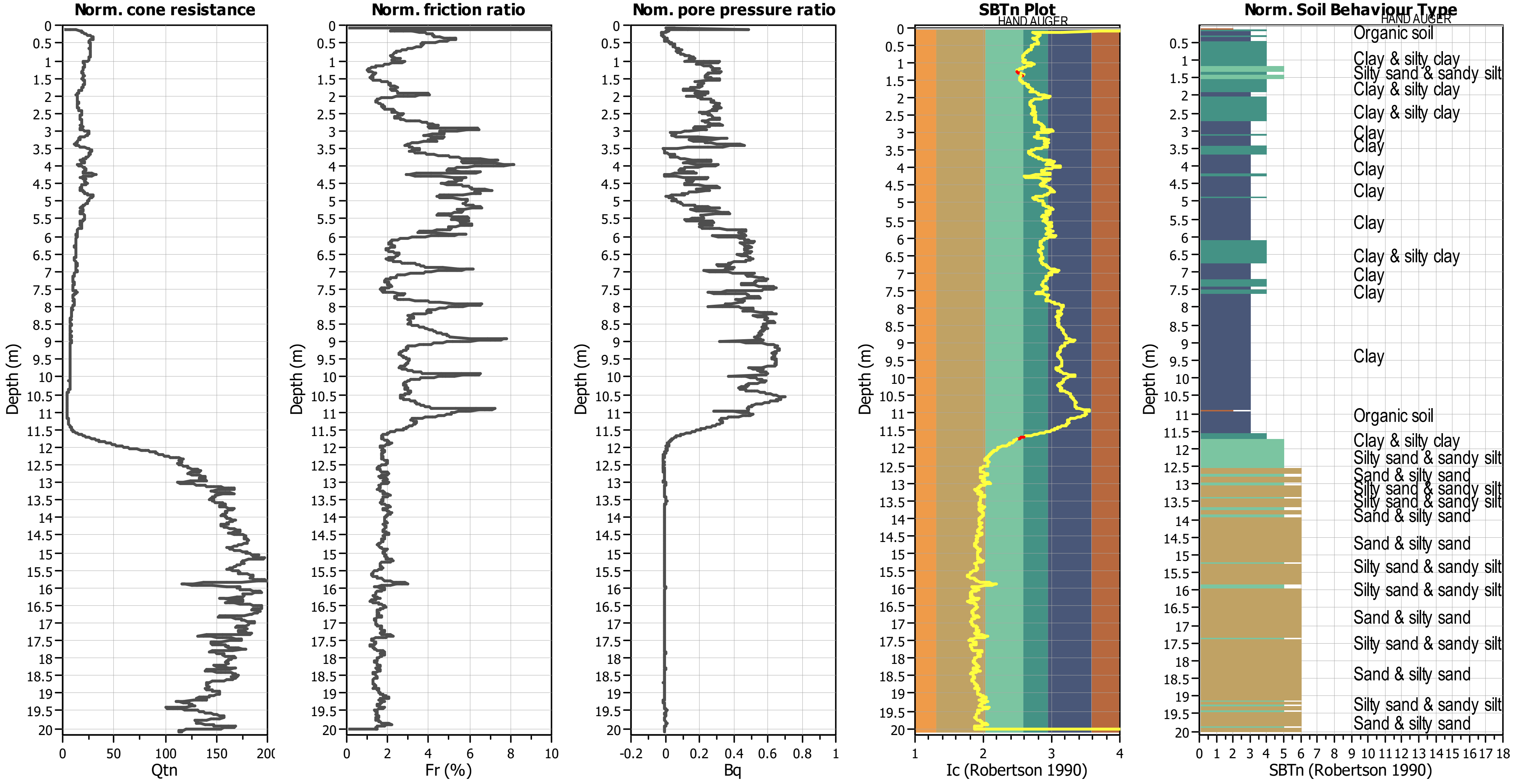
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



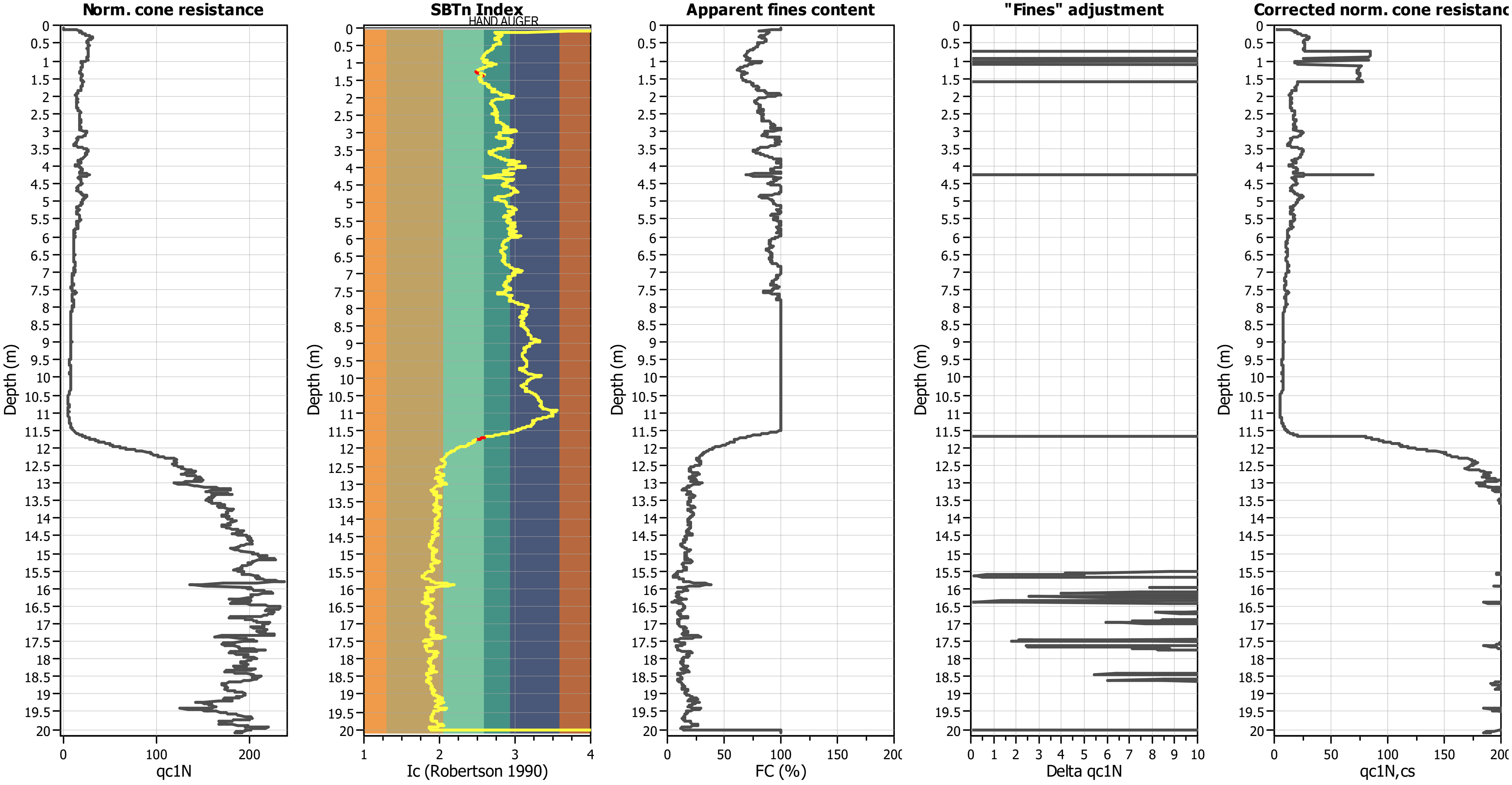
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to
⬜ 9. Very stiff fine grained

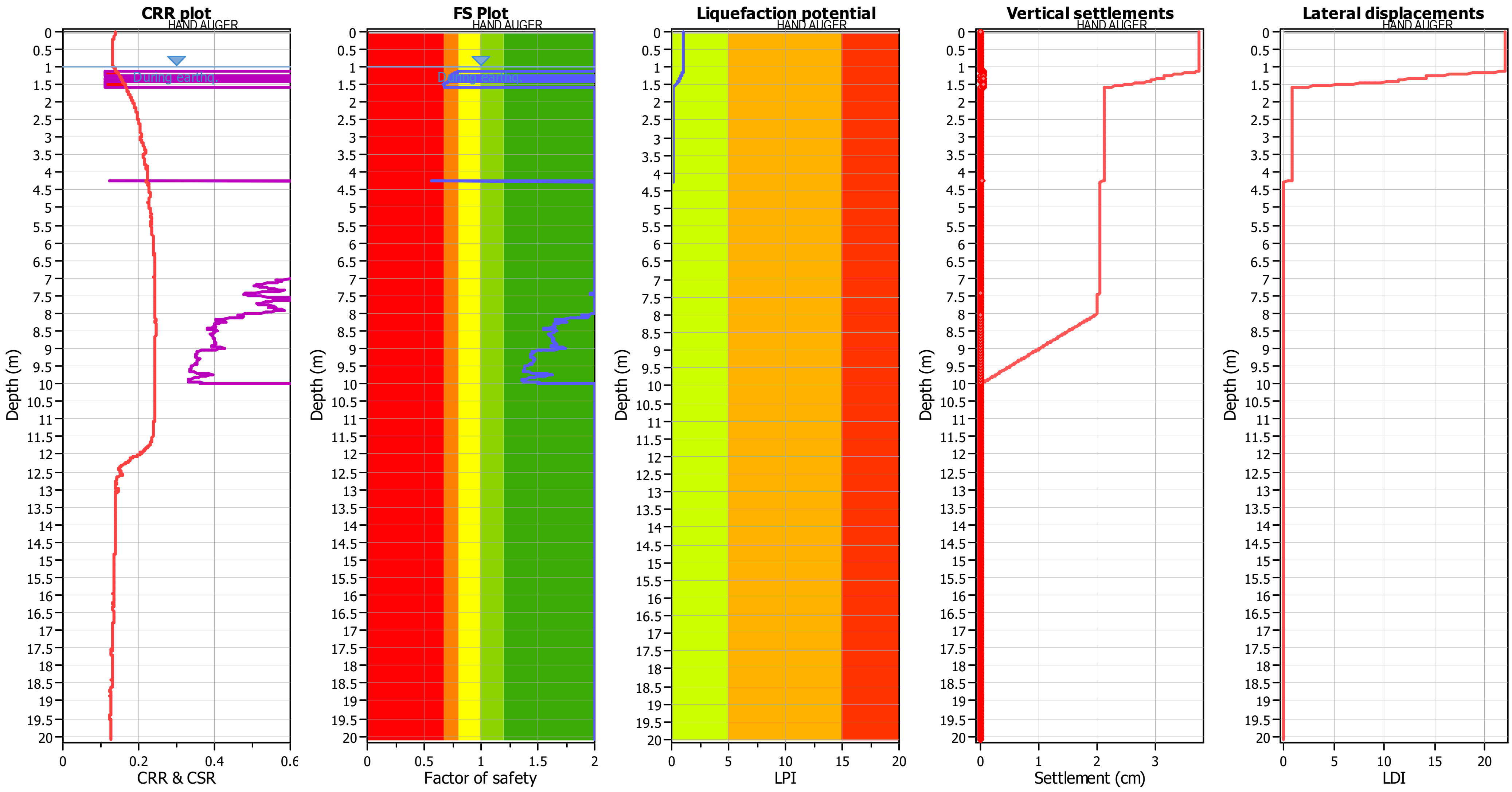
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.25
Depth to water table (insitu): 2.10 m

Depth to GWT (erthq.): 1.00 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

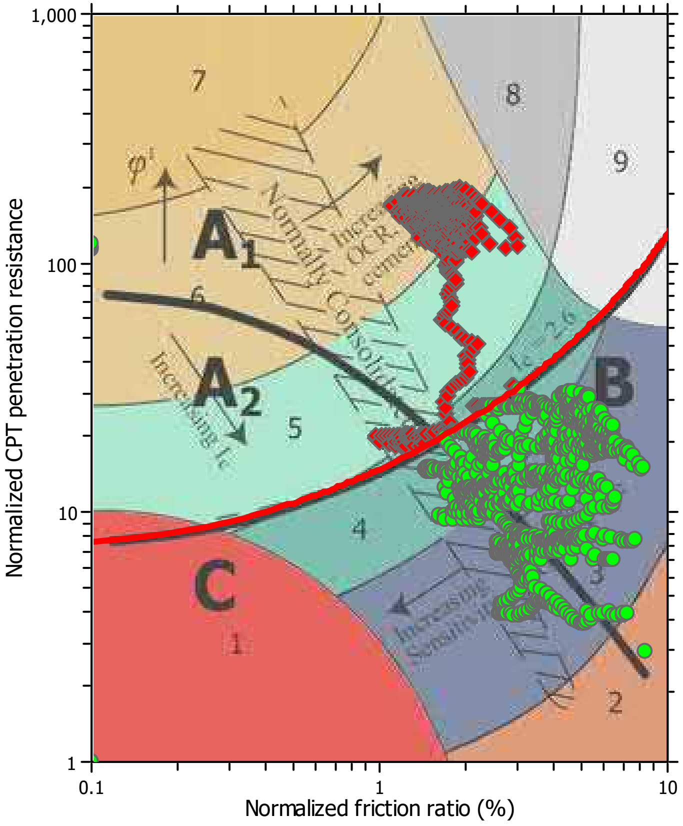
F.S. color scheme

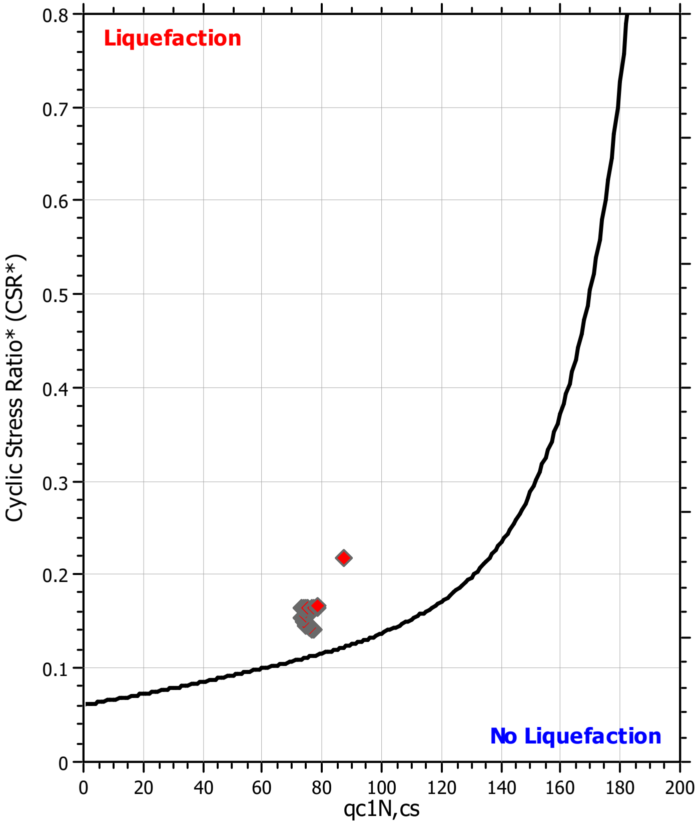
🟥 Almost certain it will liquefy
🟧 Very likely to liquefy
🟨 Liquefaction and no liq. are equally likely
🟩 Unlike to liquefy
🟩 Almost certain it will not liquefy

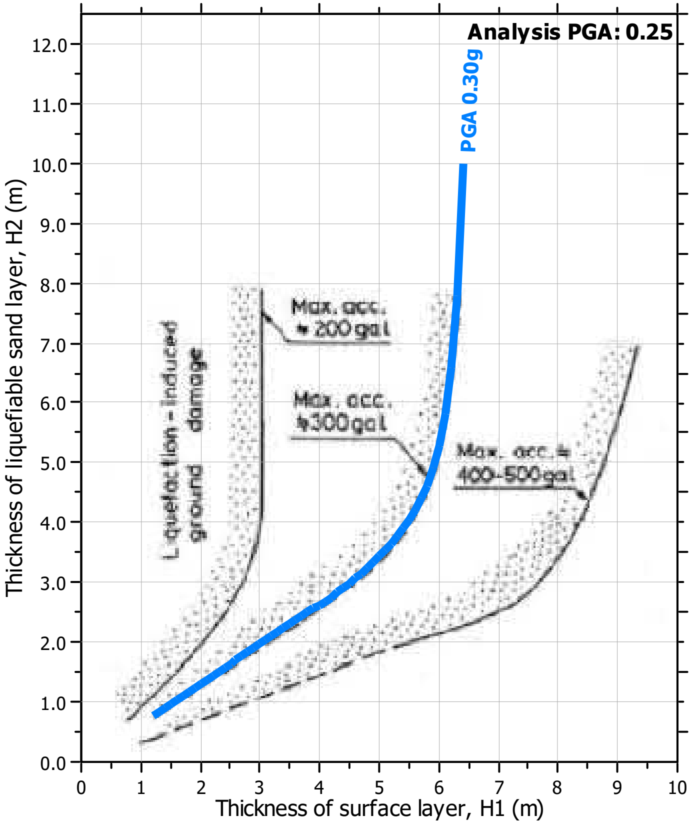
LPI color scheme

🟥 Very high risk
🟧 High risk
🟨 Low risk

Liquefaction analysis summary plots



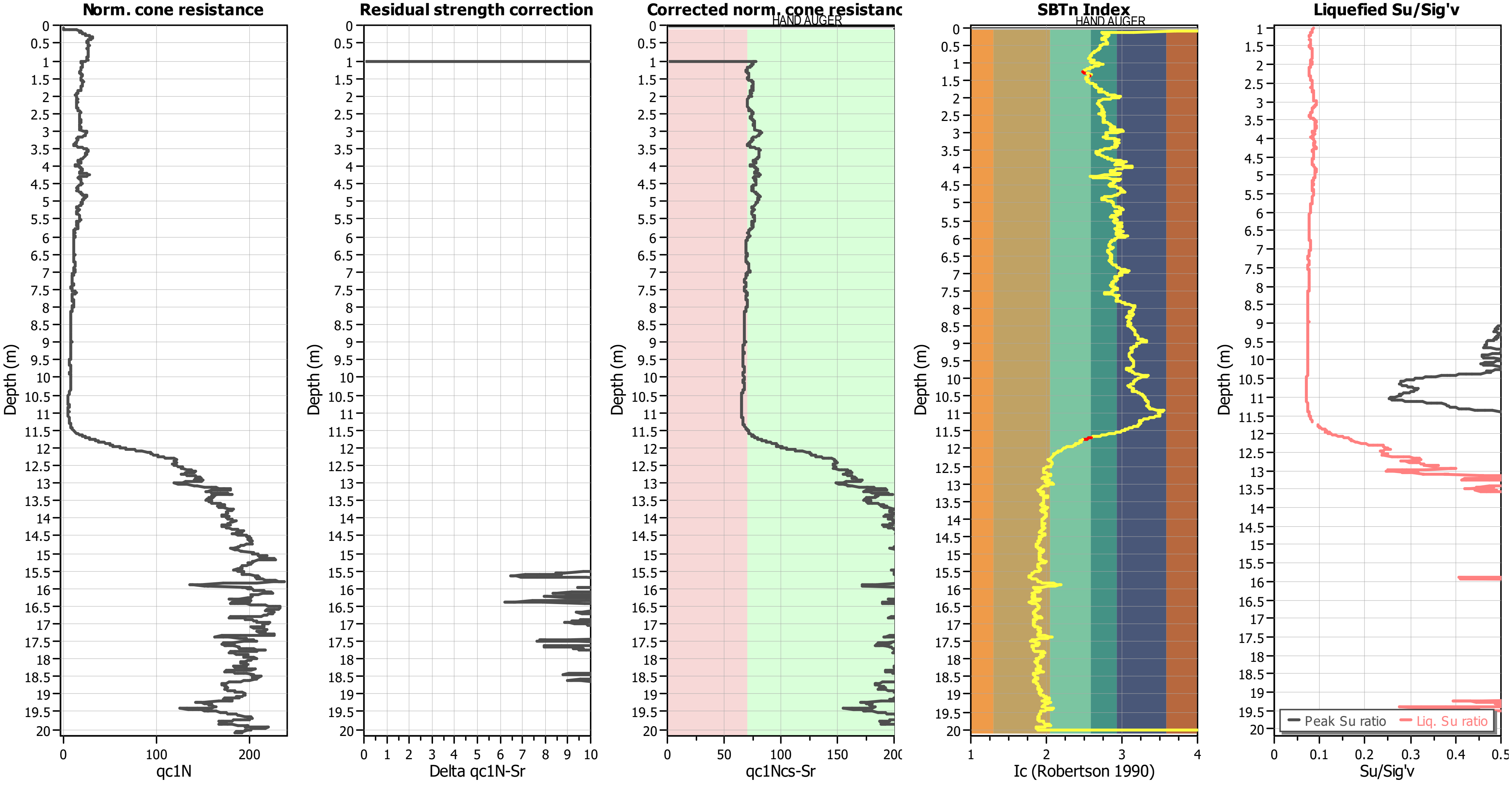




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

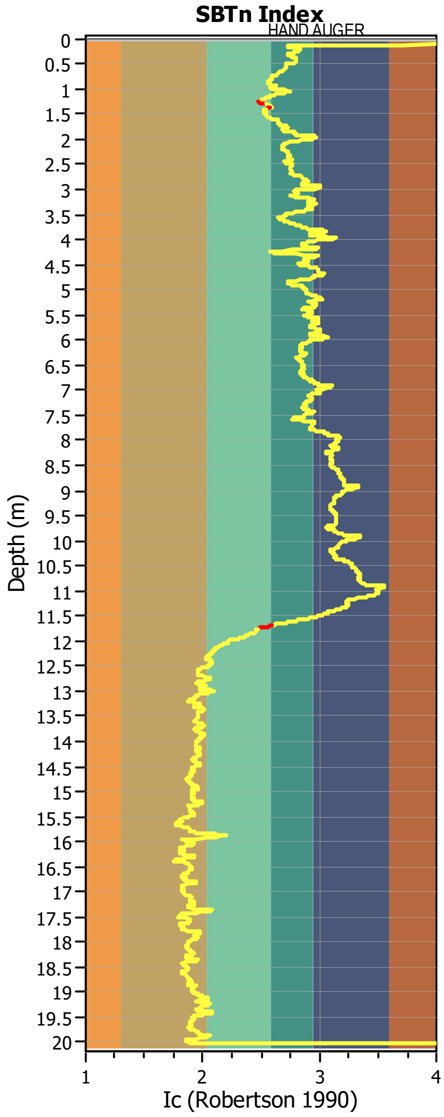
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

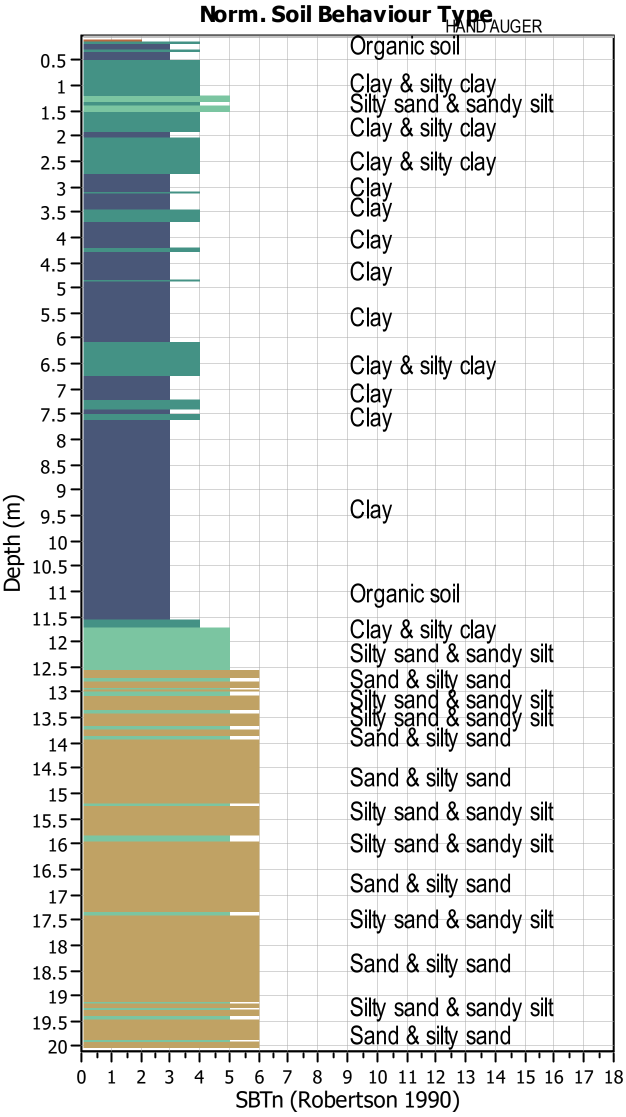
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





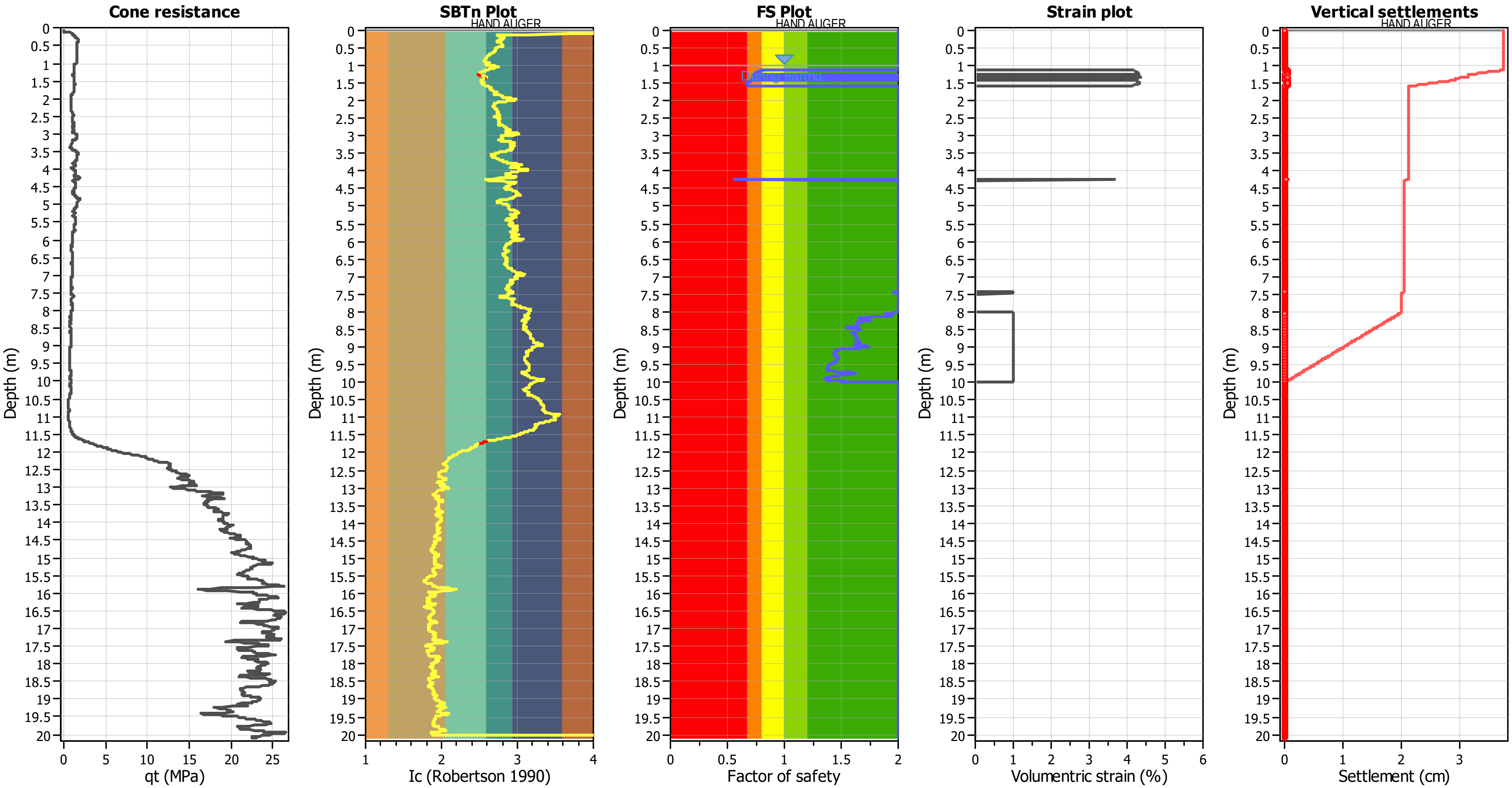
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	17
Exclusion percentage:	0.85%
Number of layers detected:	3

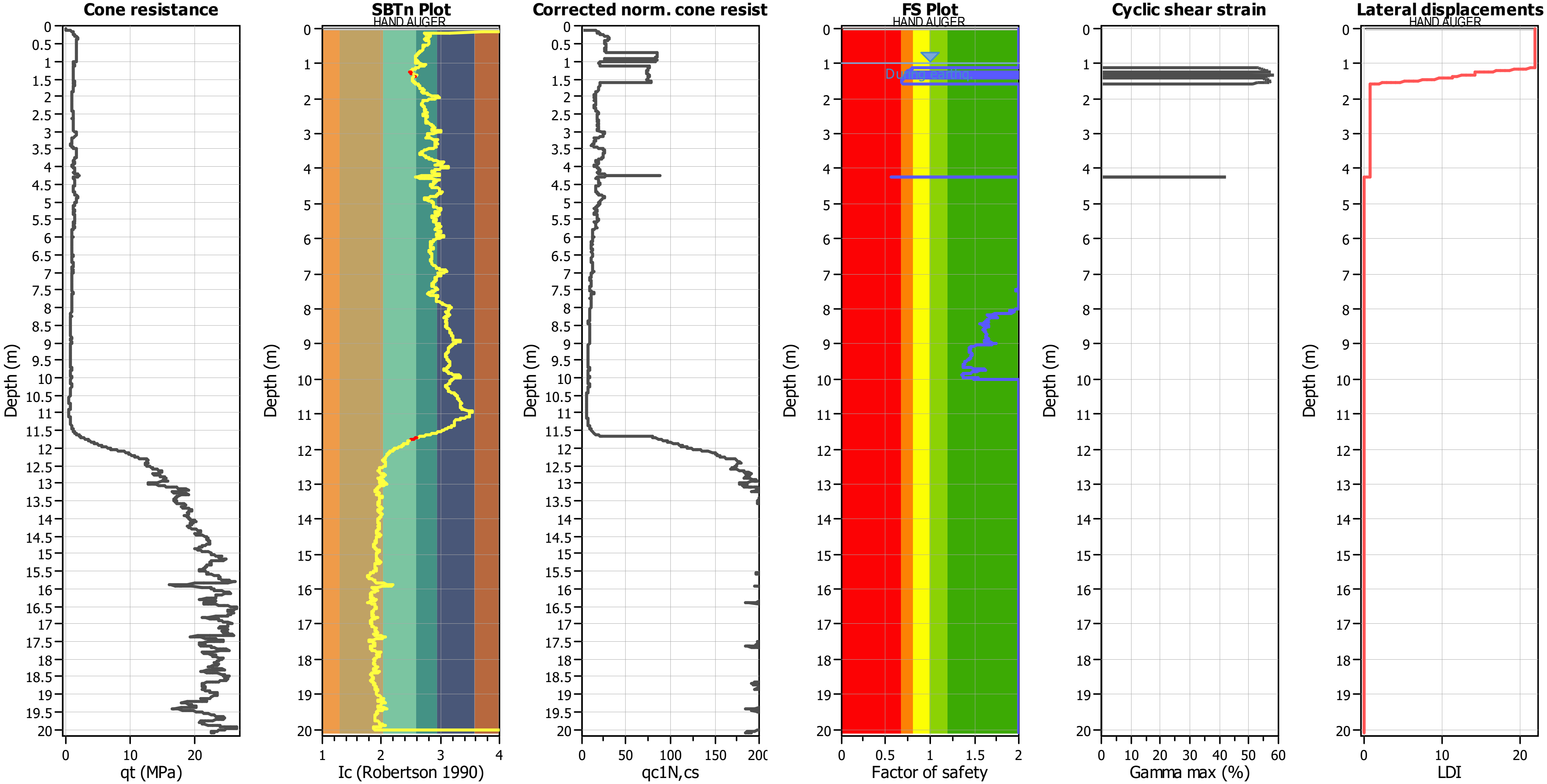
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

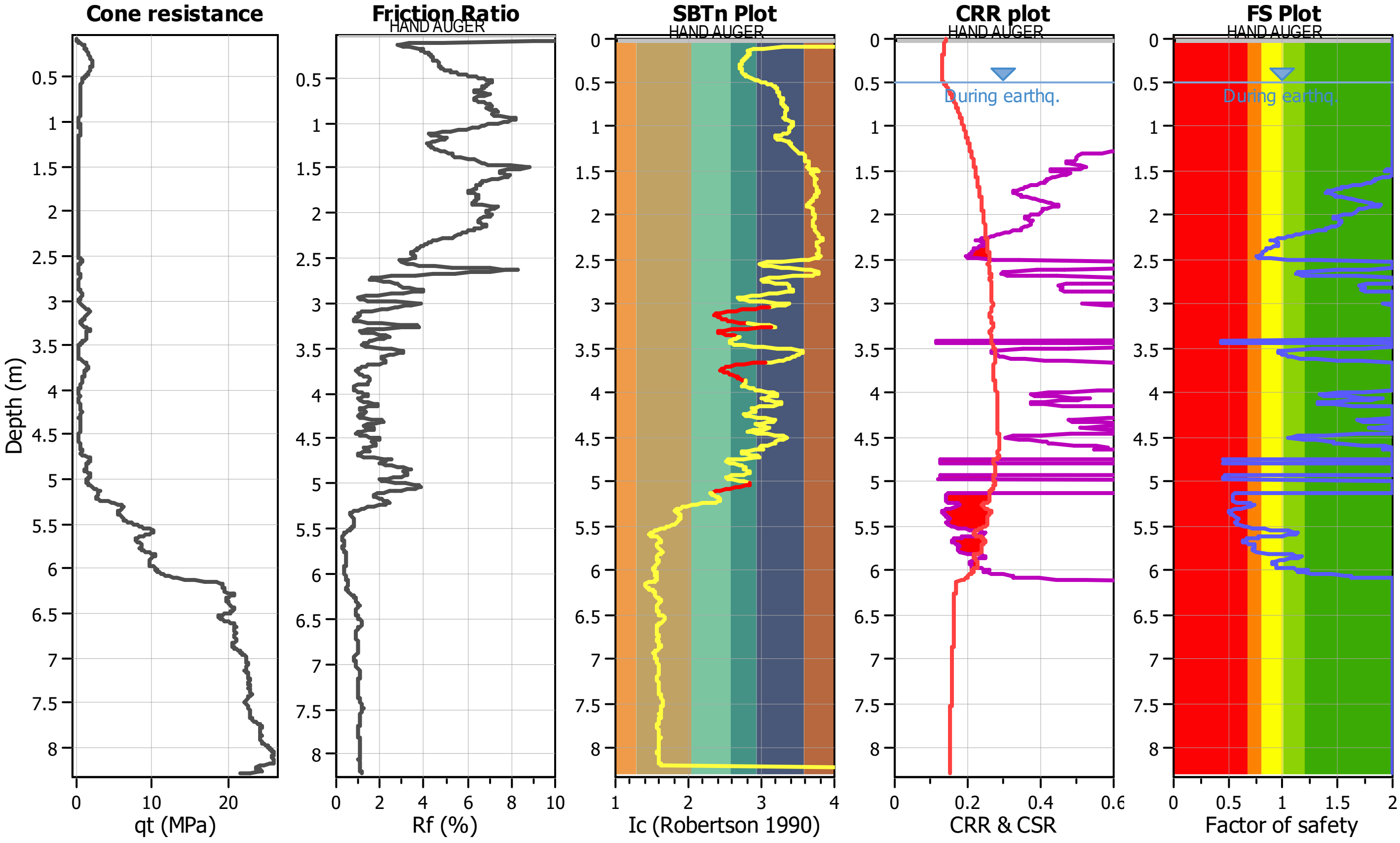
LIQUEFACTION ANALYSIS REPORT

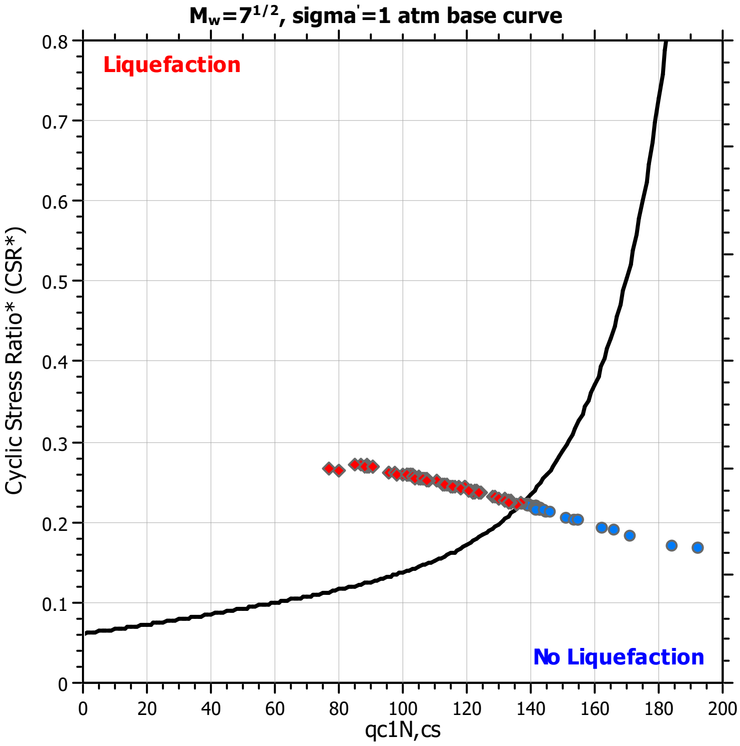
Project title : Proposed Private Plan Change for Te Awamutu   Location : 2025 Ohaupo Road, Te Awamutu

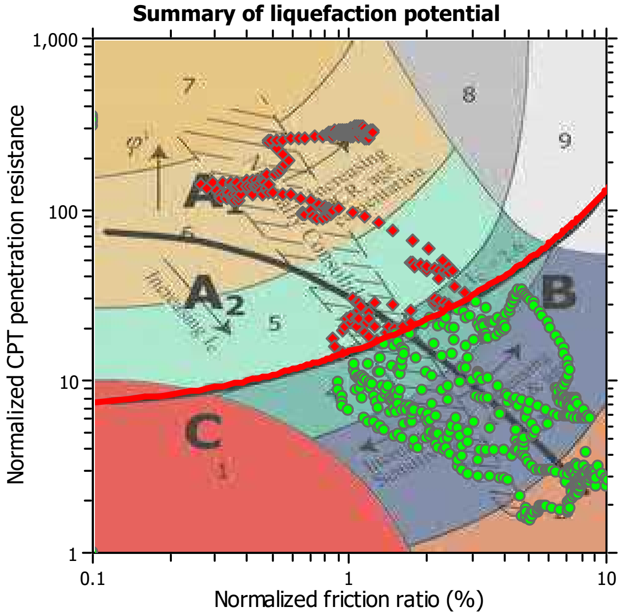
CPT file : CPT-10

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:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

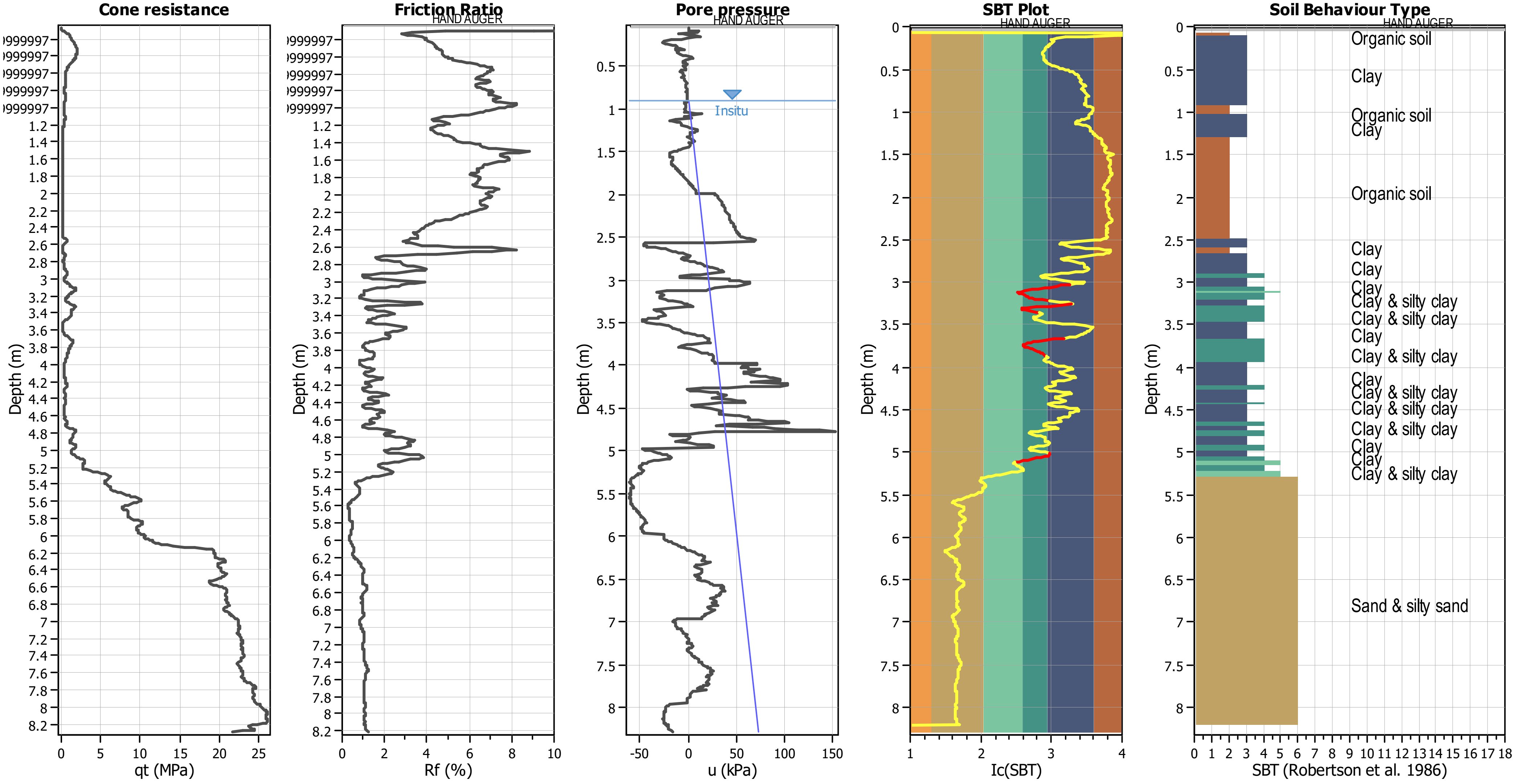






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.25
Depth to water table (insitu): 0.90 m

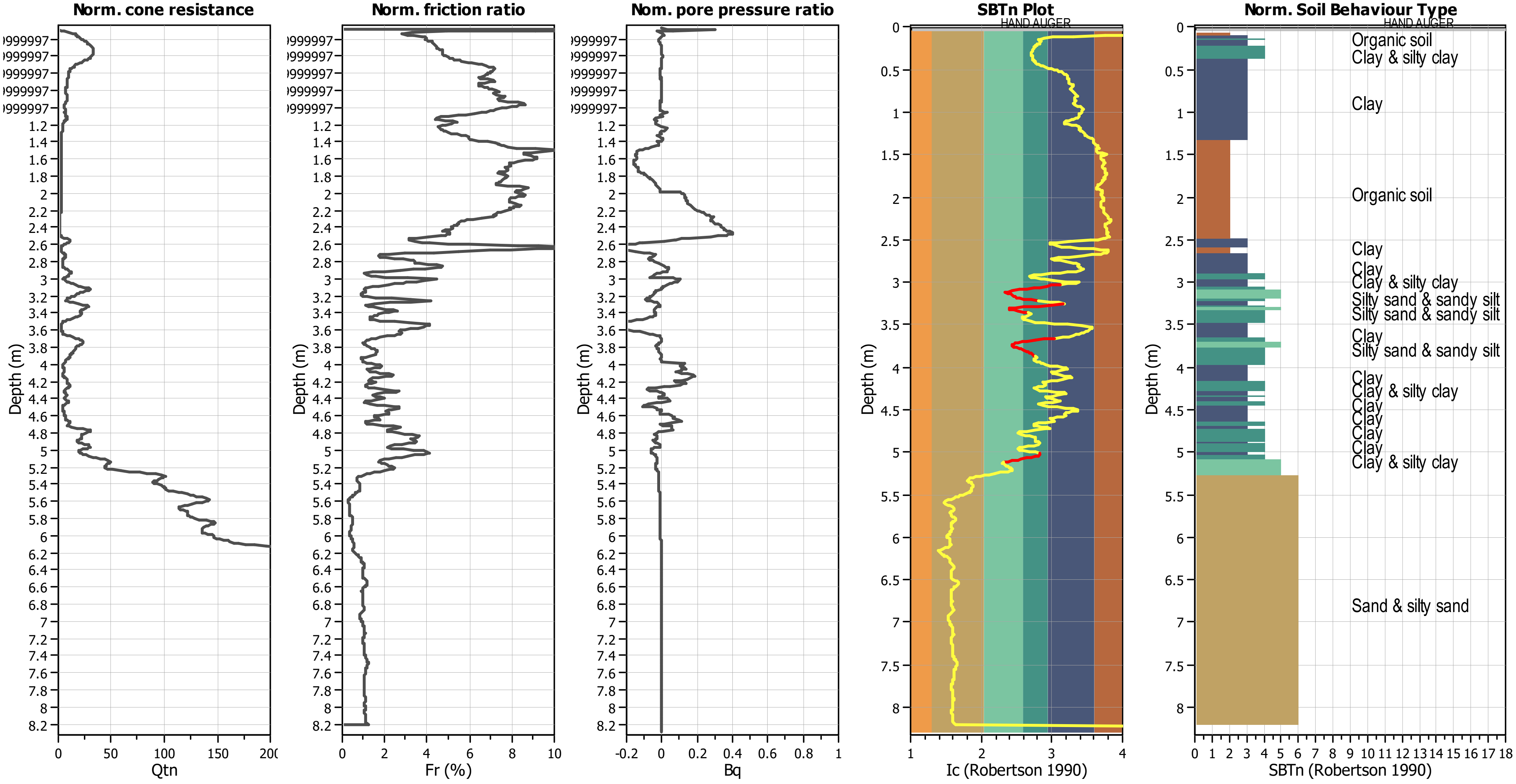
Depth to GWT (erthq.): 0.50 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



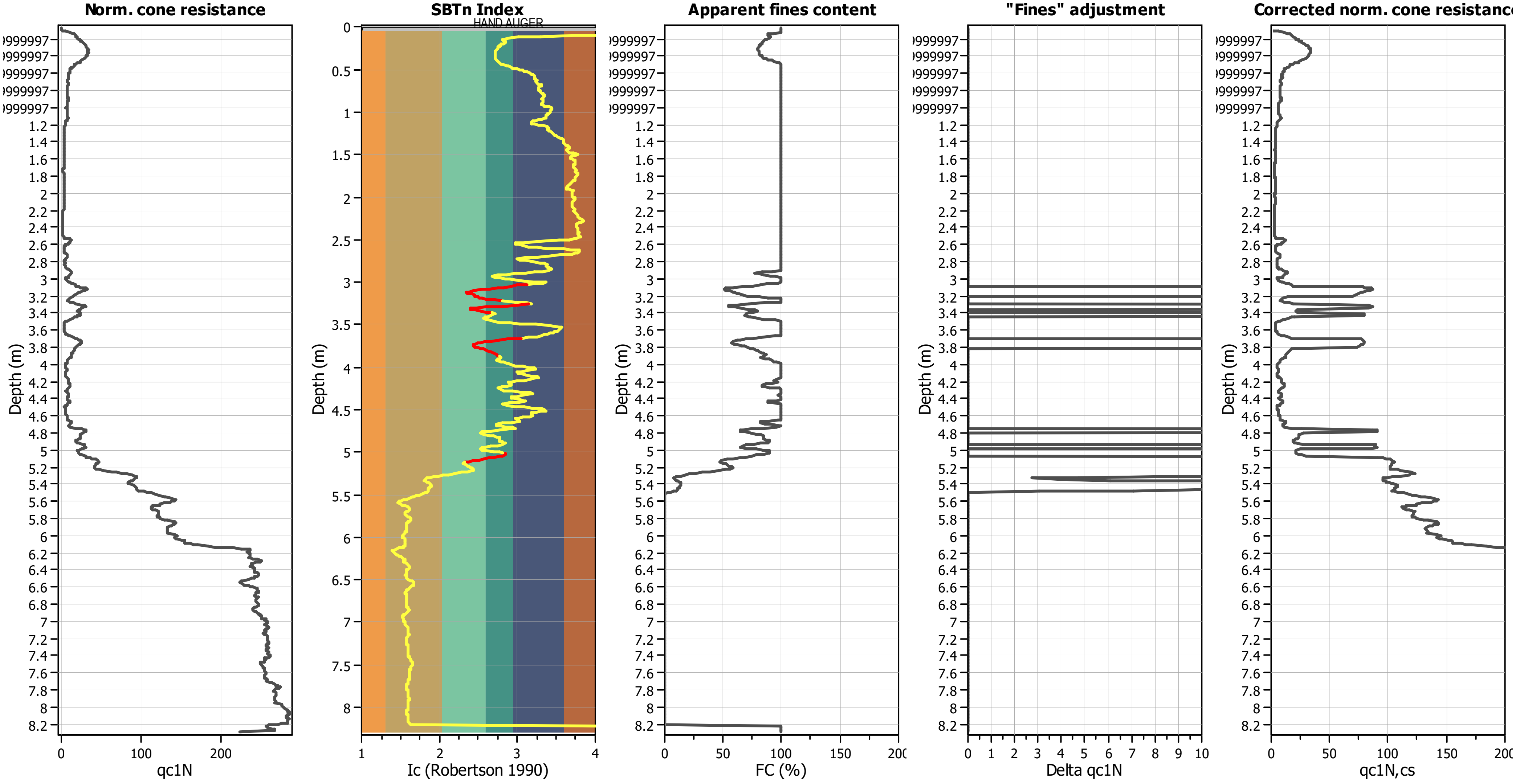
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

Liquefaction analysis overall plots (intermediate results)



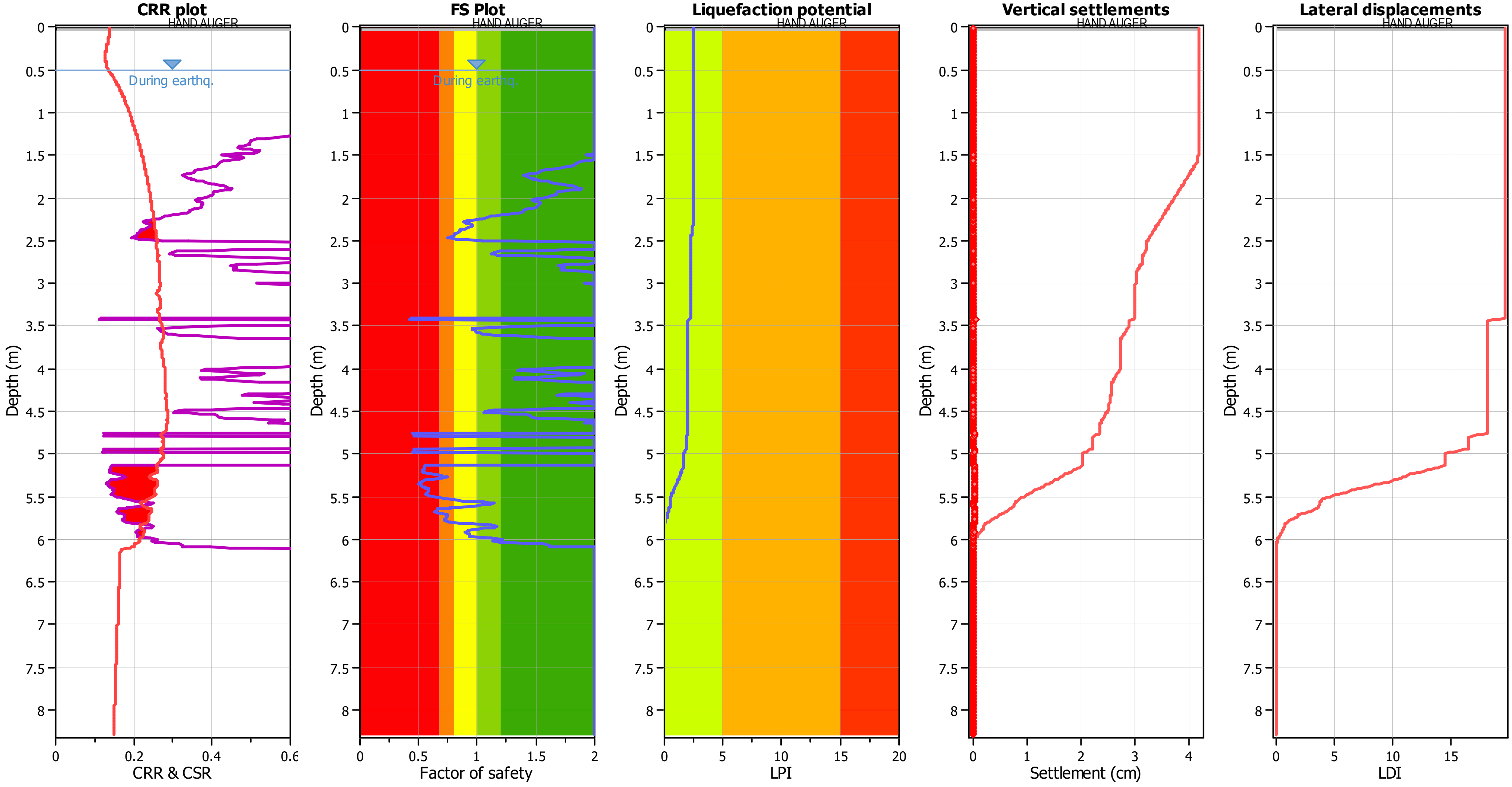
Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.25
Depth to water table (insitu): 0.90 m

Depth to GWT (erthq.): 0.50 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	10.00 m

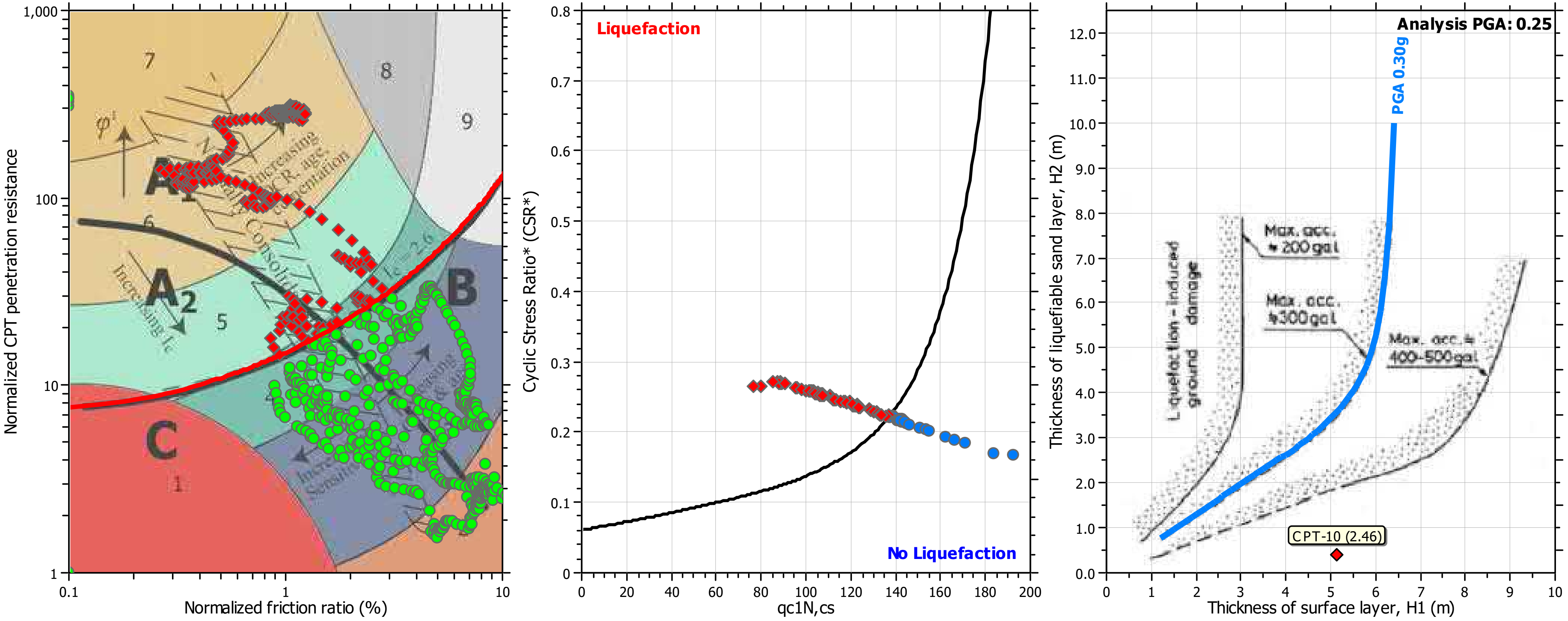
F.S. color scheme

- 🟥 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

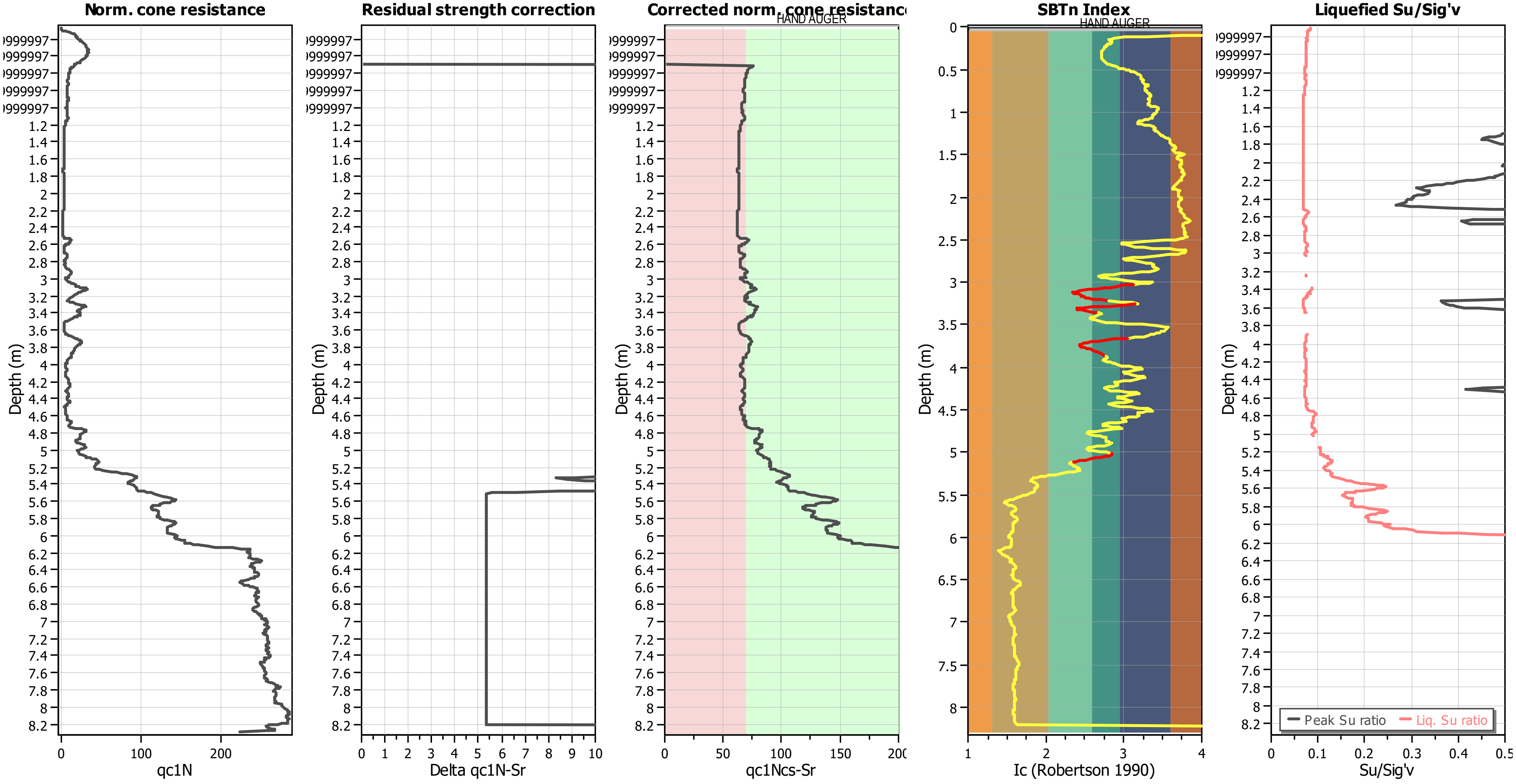
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

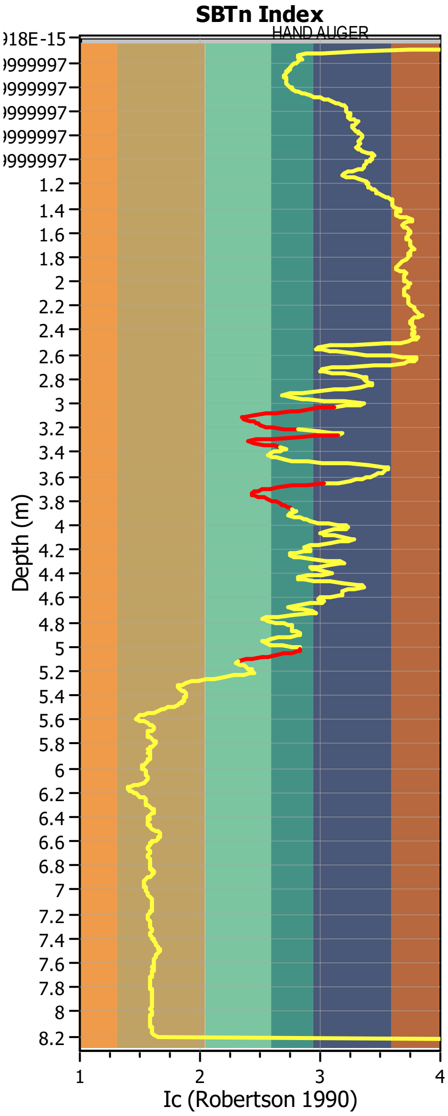
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	10.00 m

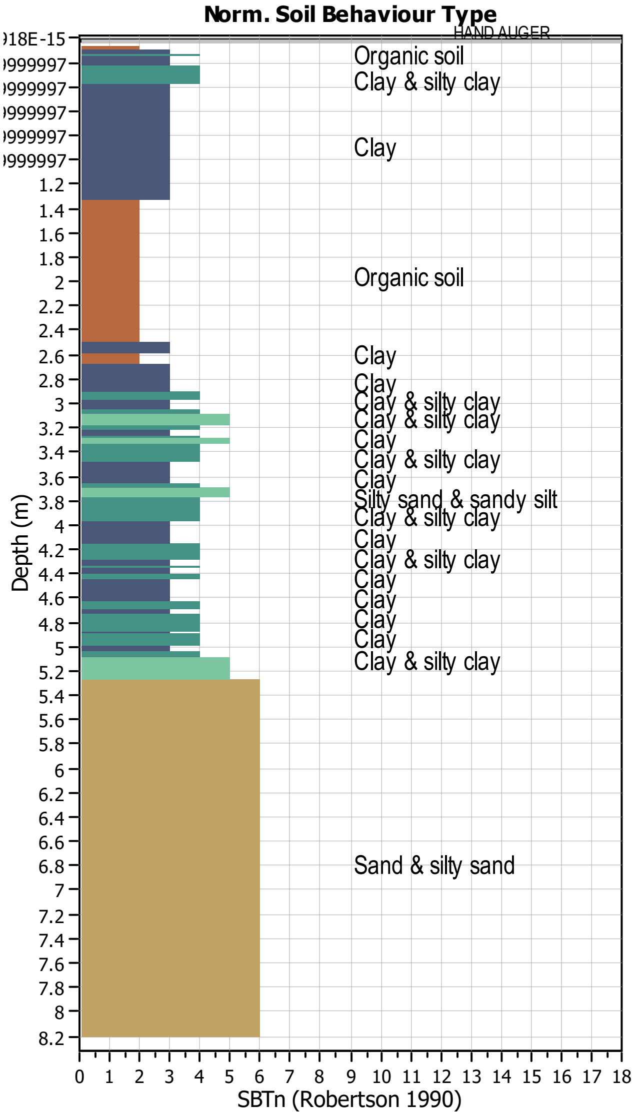
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





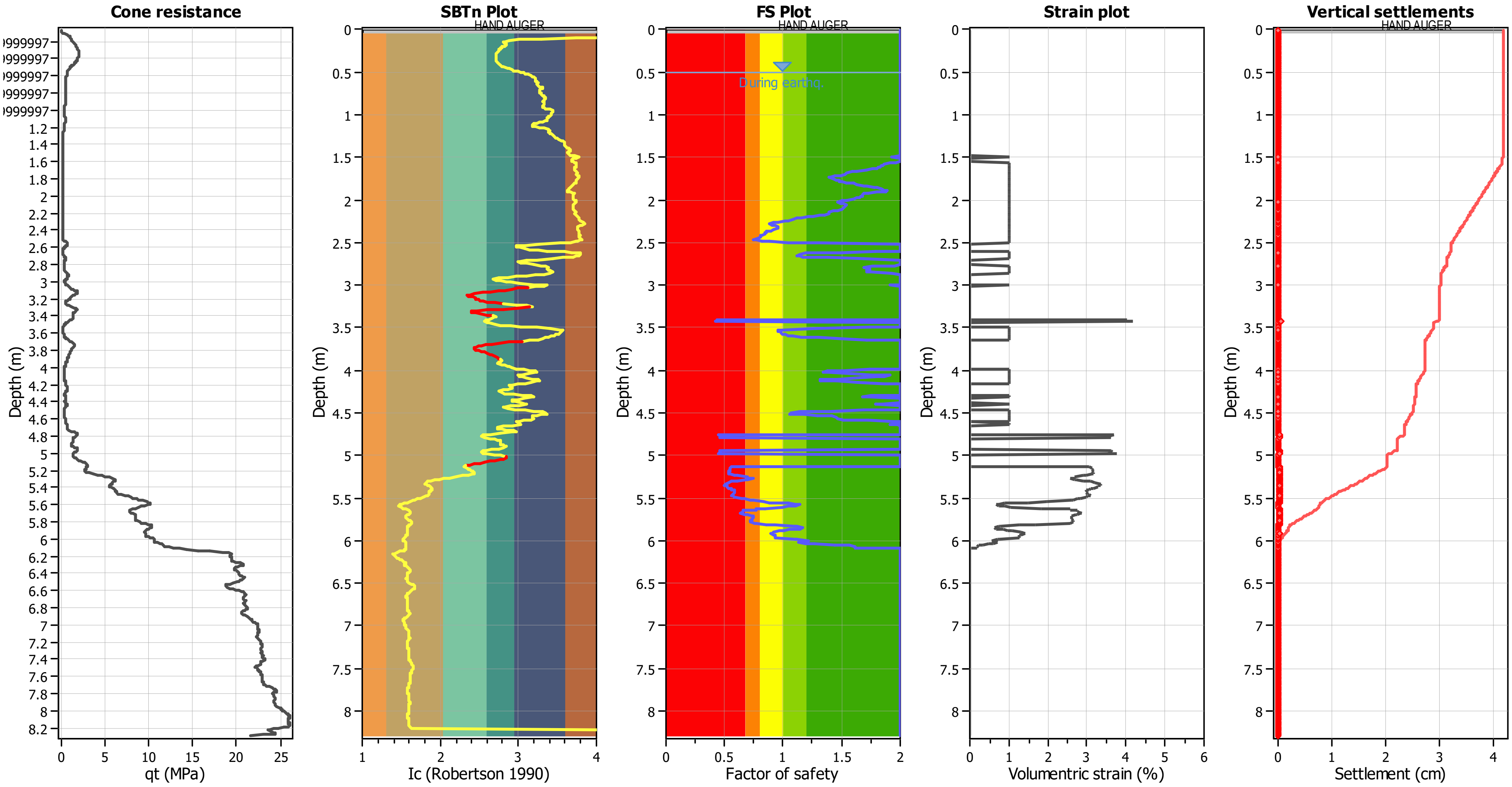
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	829
Total points excluded:	65
Exclusion percentage:	7.84%
Number of layers detected:	7

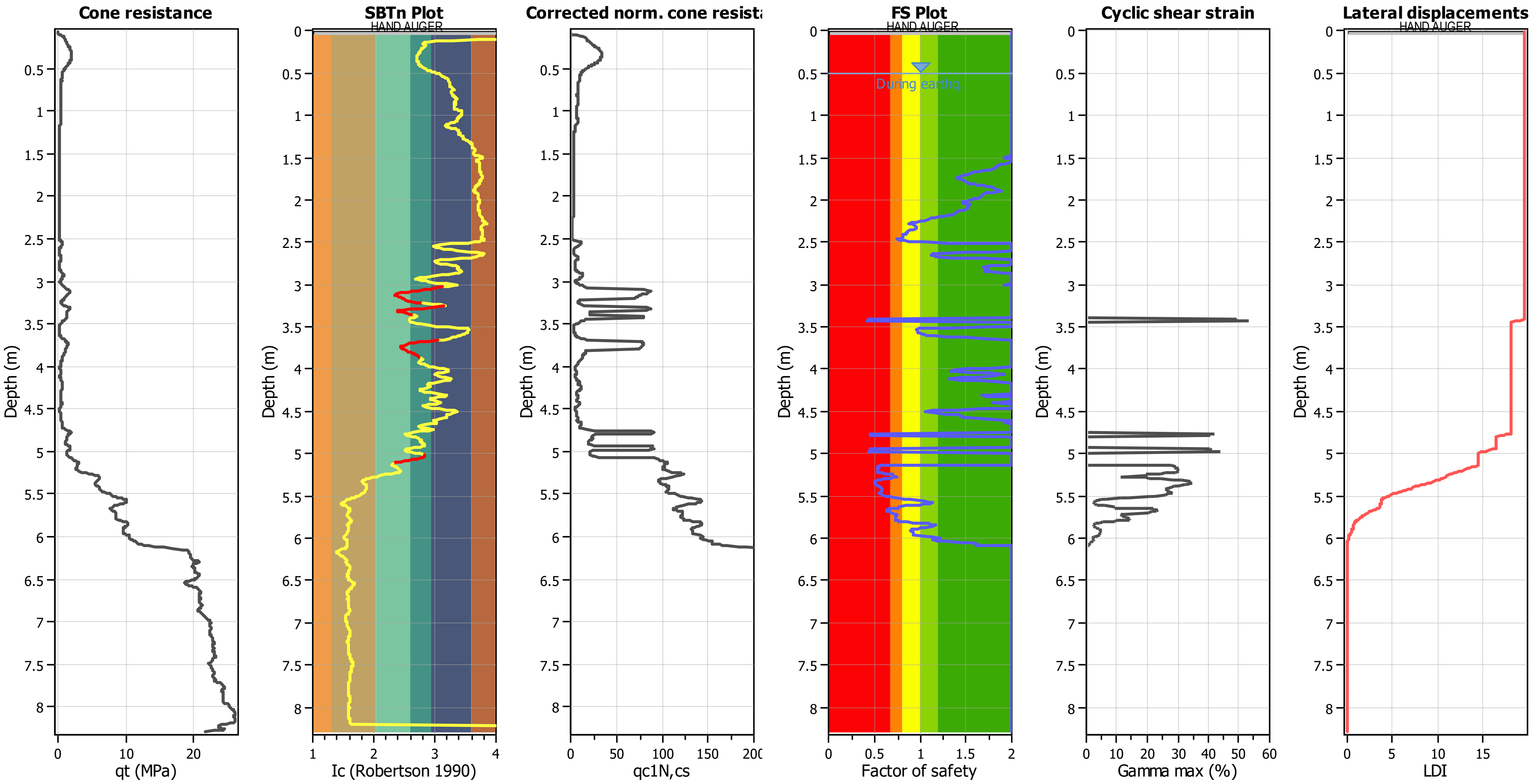
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

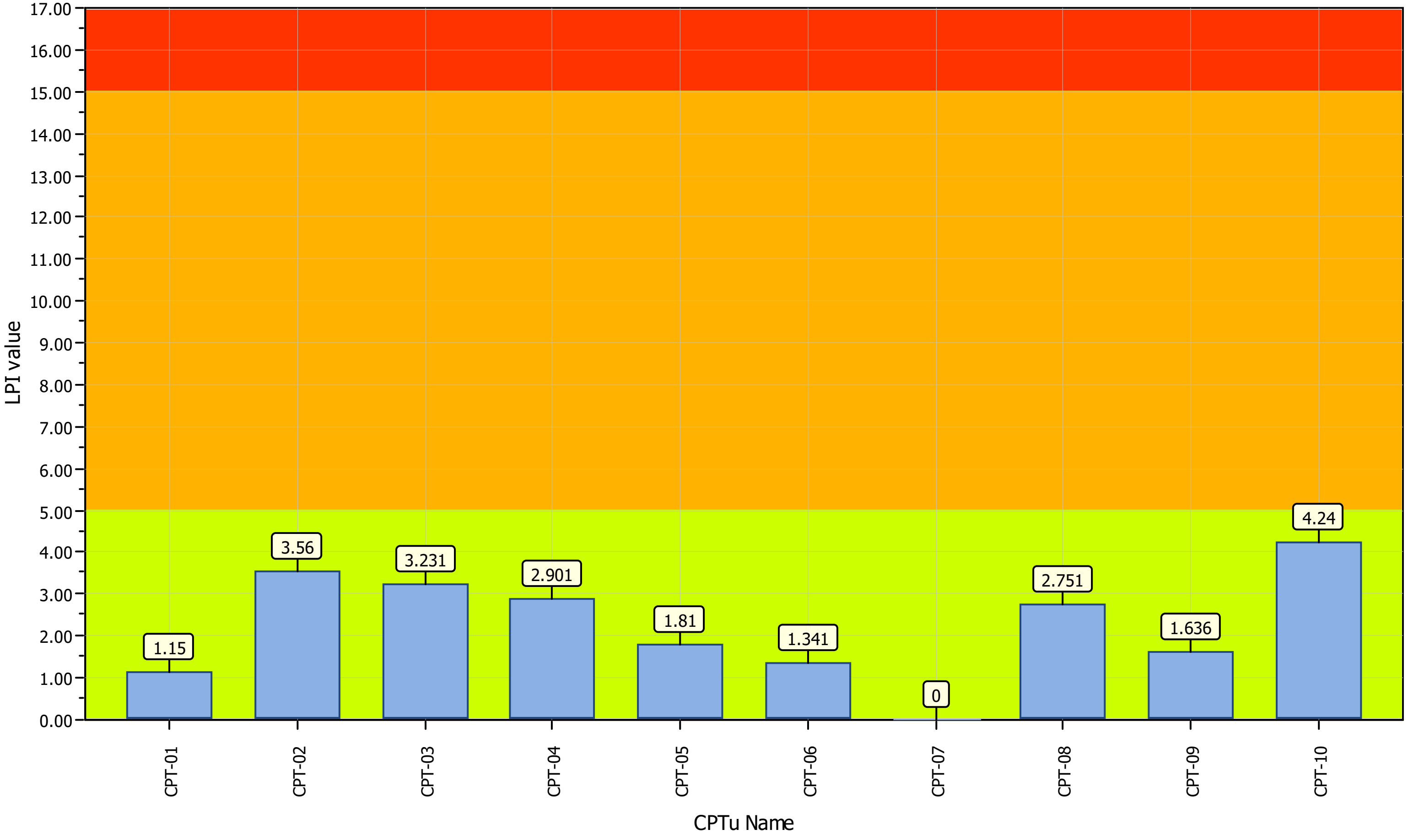
q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Project title : Proposed Private Plan Change for Te Awamutu Developments Limited

Location : 2025 Ohaupo Road, Te Awamutu

Overall Liquefaction Potential Index report



LPI color scheme

🟥 Very high risk
🟧 High risk
🟩 Low risk

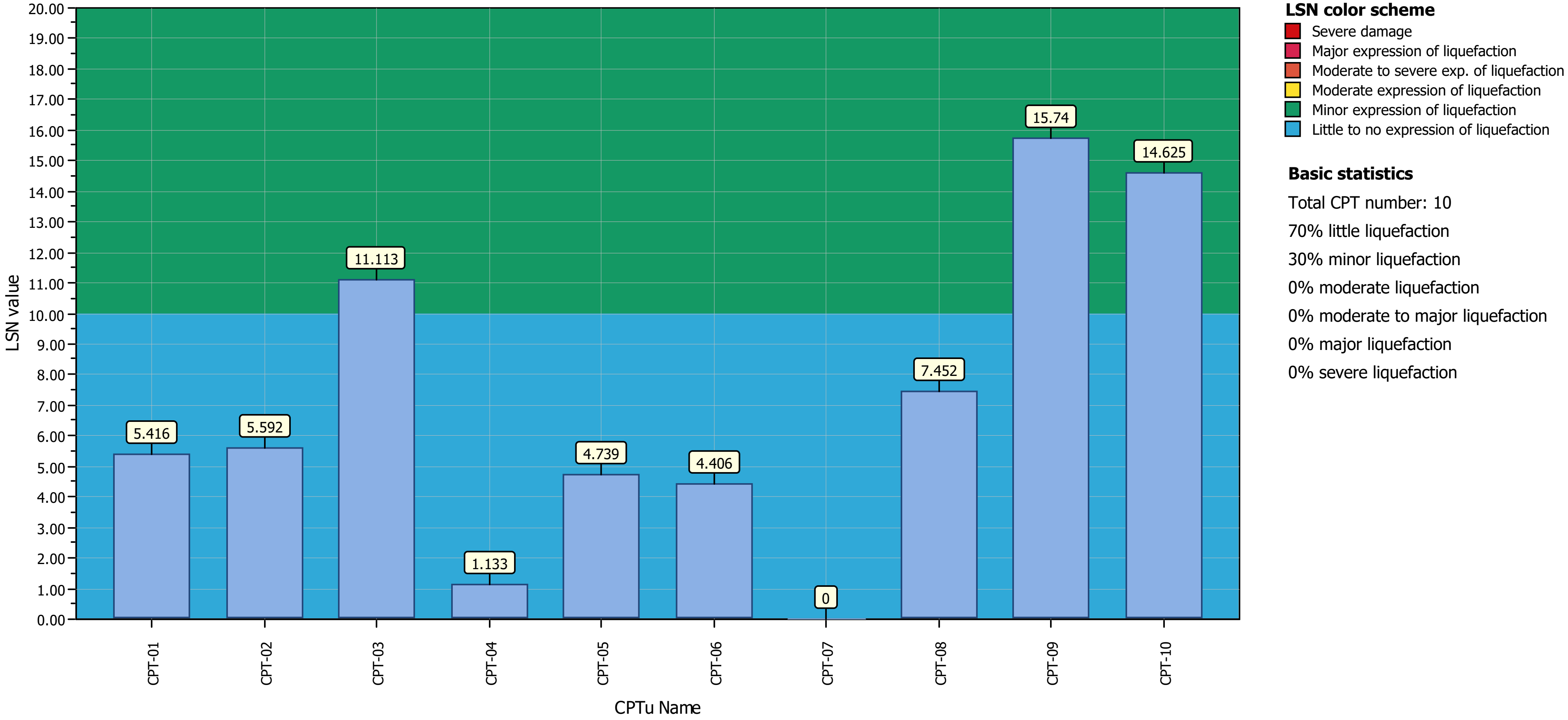
Basic statistics

Total CPT number: 10
100% low risk
0% high risk
0% very high risk

Project title : Proposed Private Plan Change for Te Awamutu Developments Limited

Location : 2025 Ohaupo Road, Te Awamutu

Overall Liquefaction Severity Number report



Basic statistics

Total CPT number: 10

70% little liquefaction

30% minor liquefaction

0% moderate liquefaction

0% moderate to major liquefaction

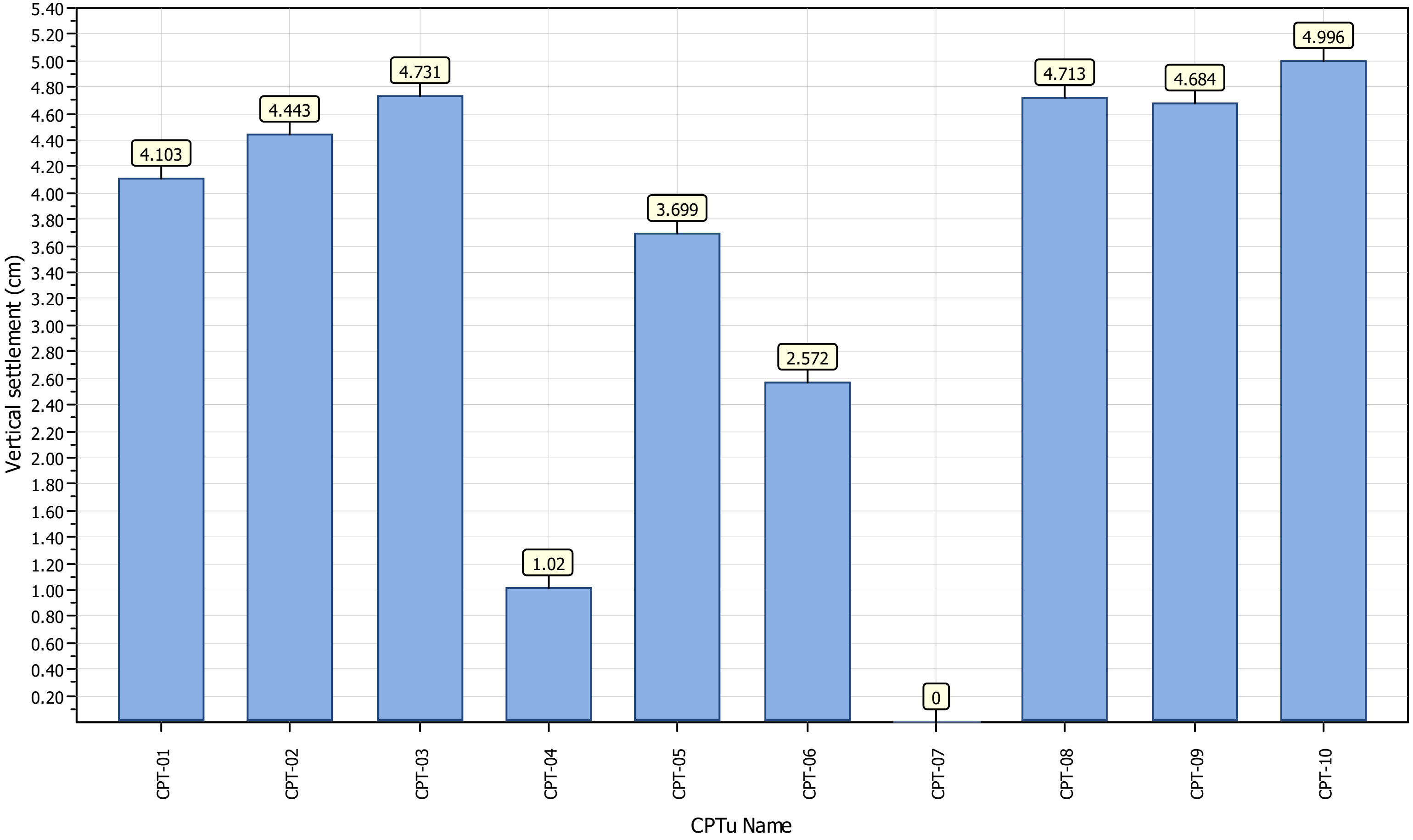
0% major liquefaction

0% severe liquefaction

Project title : Proposed Private Plan Change for Te Awamutu Developments Limited

Location : 2025 Ohaupo Road, Te Awamutu

Overall vertical settlements report



BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

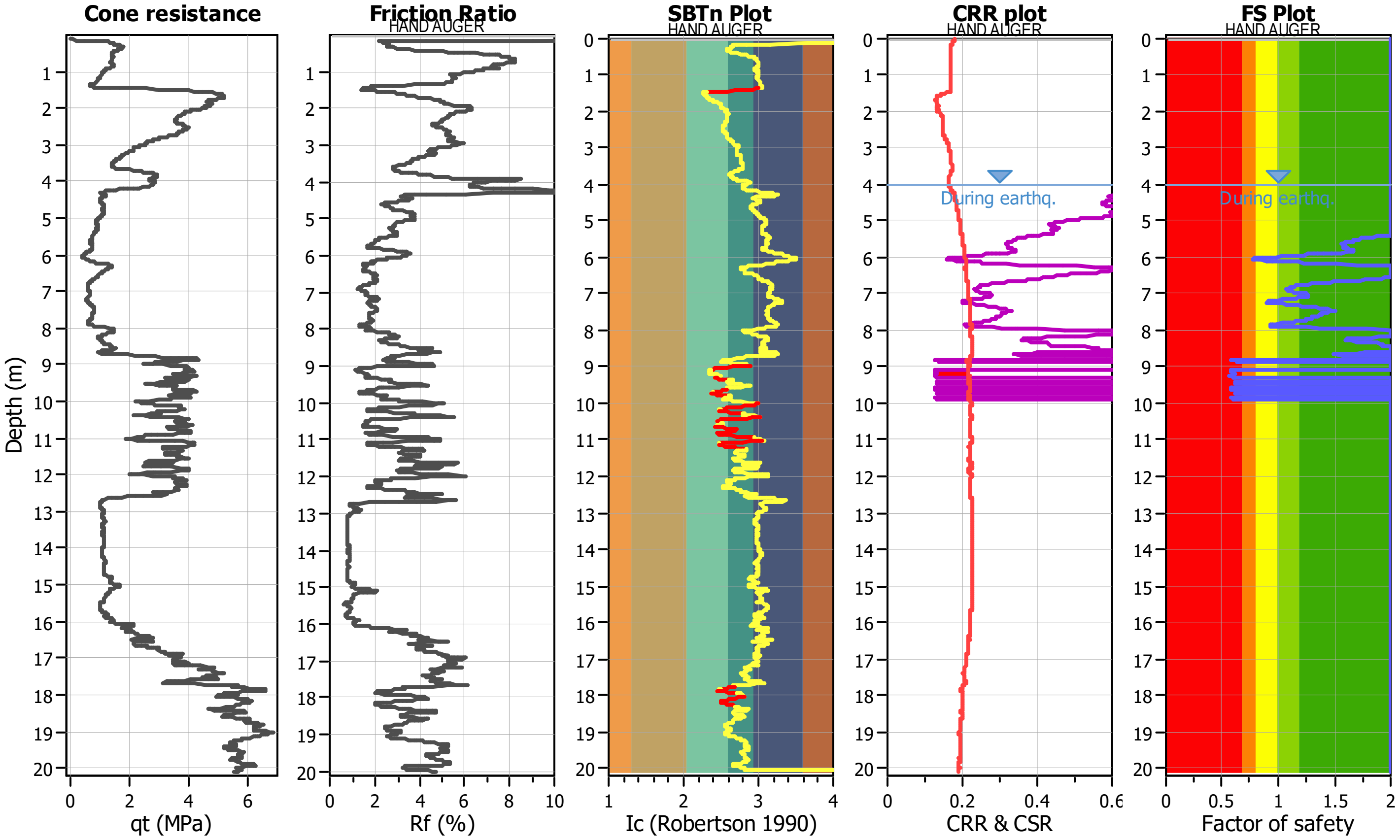
LIQUEFACTION ANALYSIS REPORT

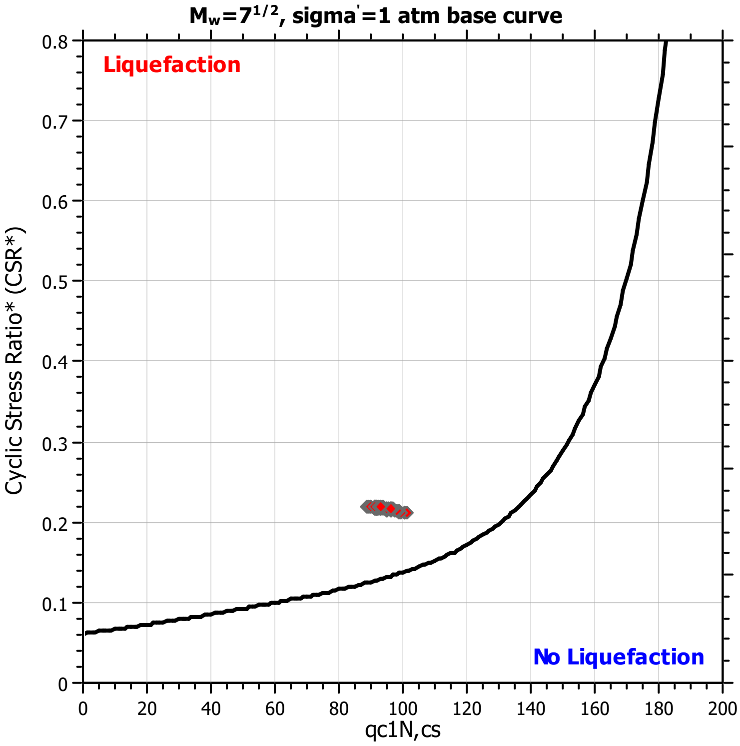
Project title : Proposed Private Plan Change for Te Awamutu Location : 2025 Ohaupo Road, Te Awamutu

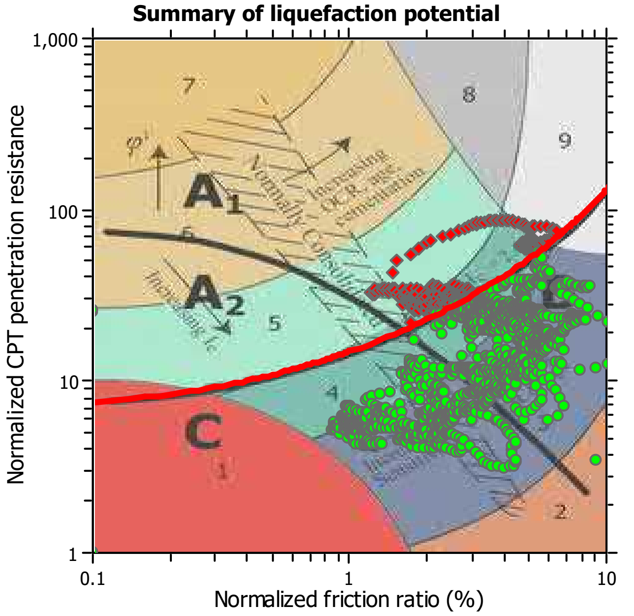
CPT file : CPT-01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	5.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

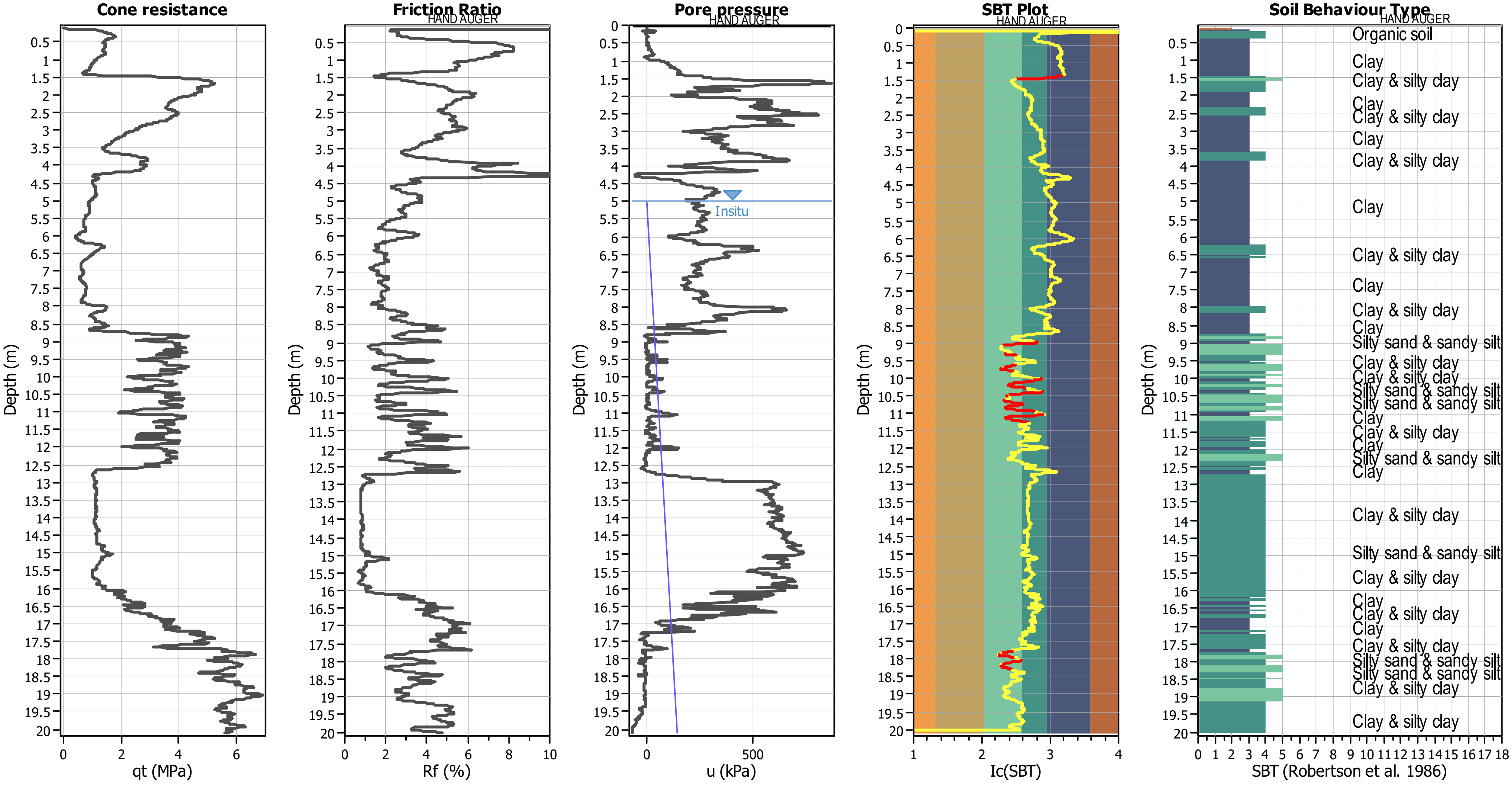






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



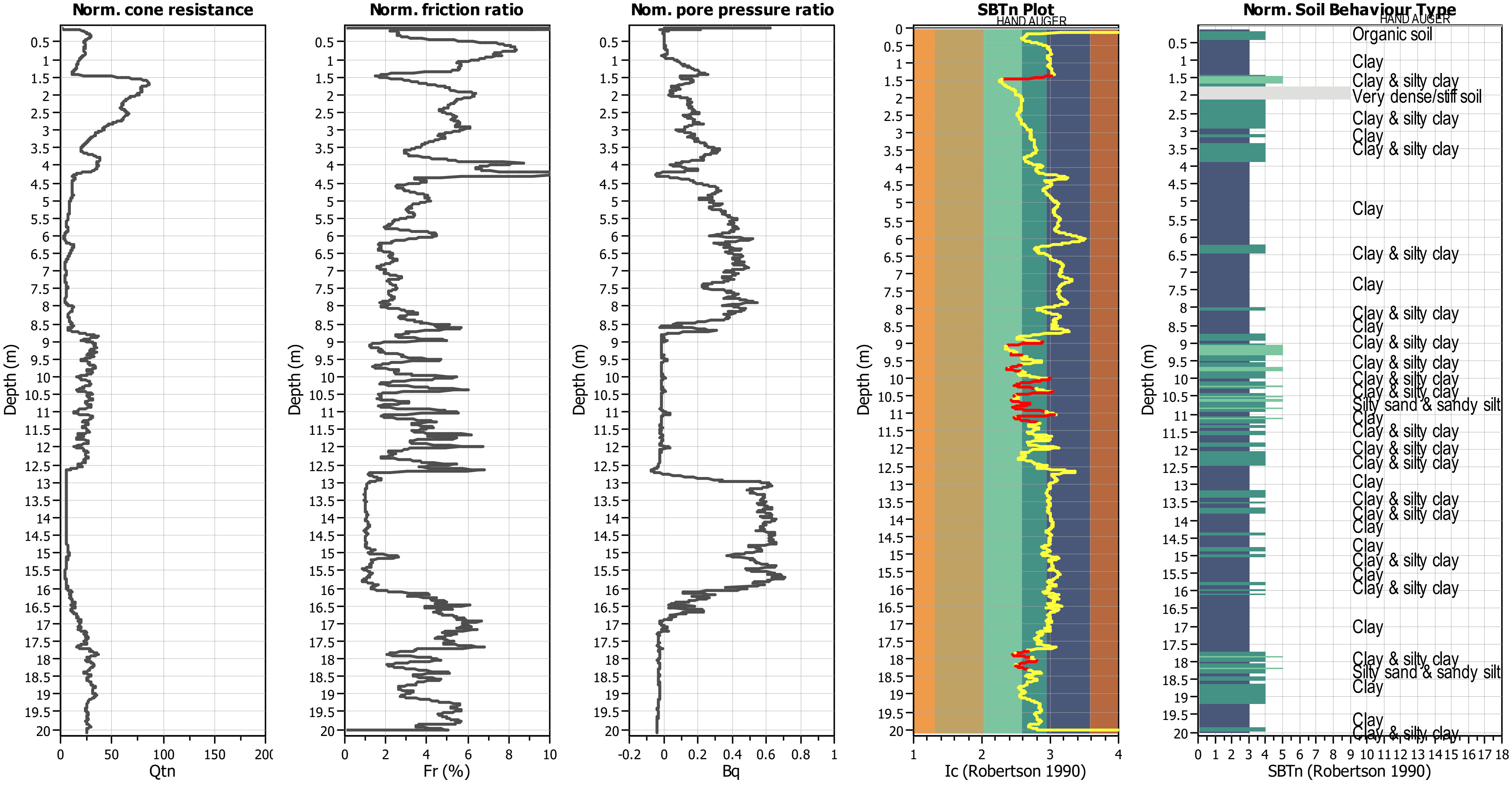
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

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

CPT basic interpretation plots (normalized)



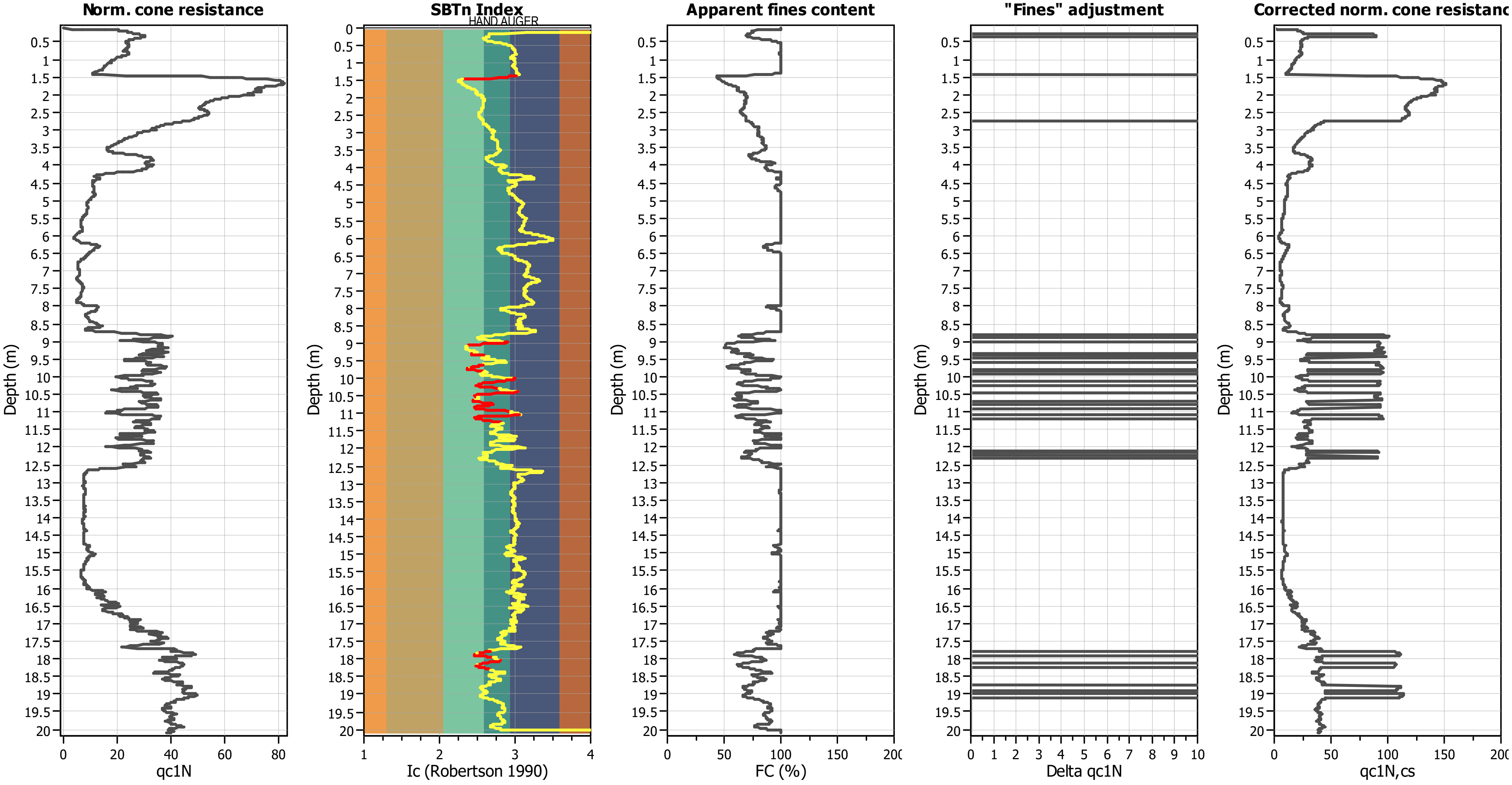
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

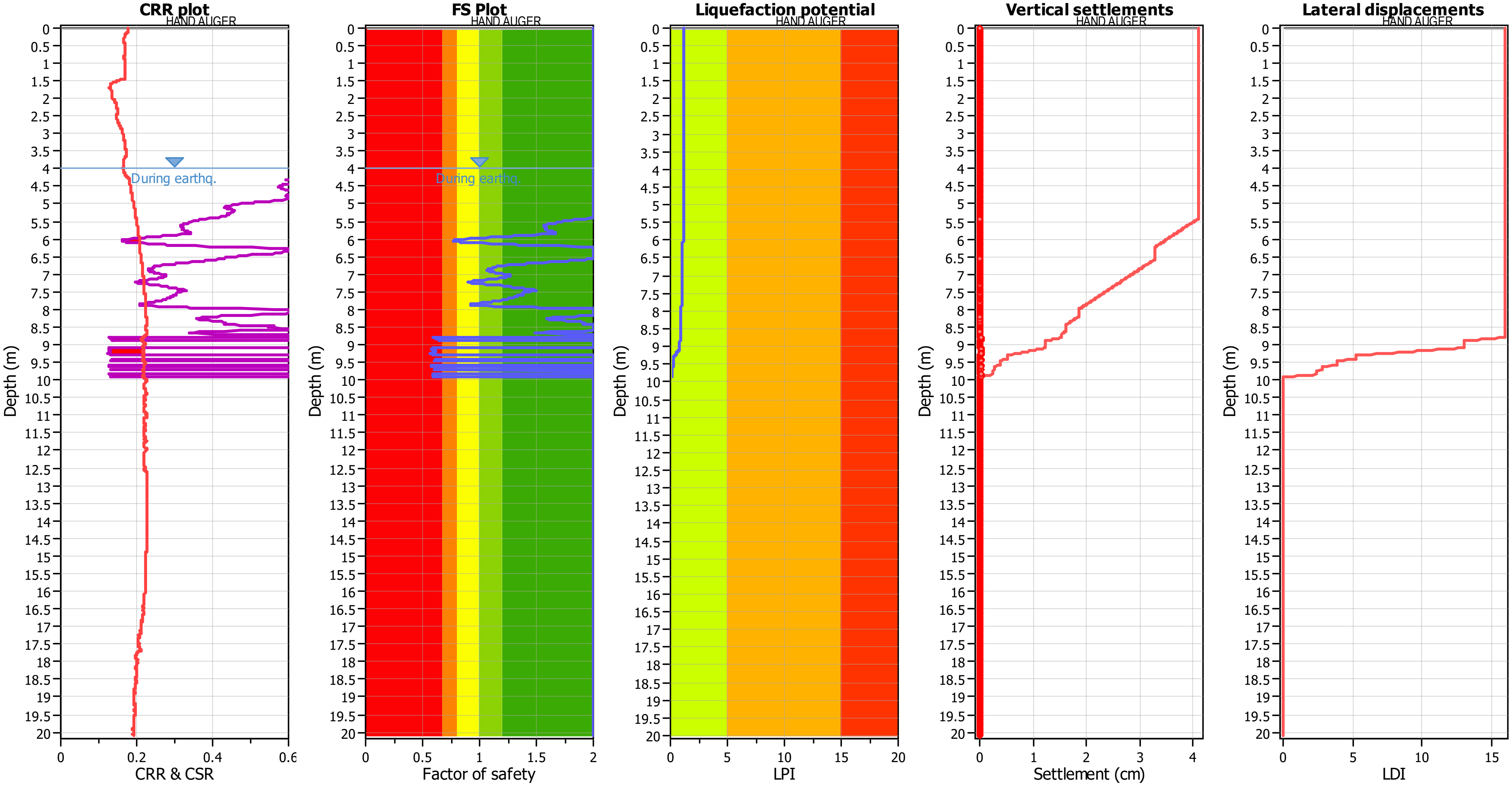
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

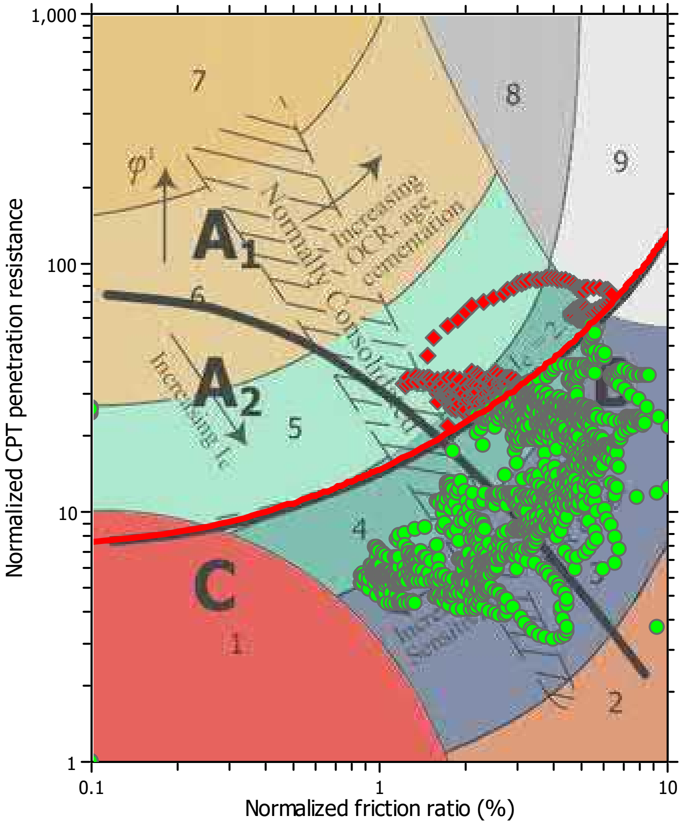
F.S. color scheme

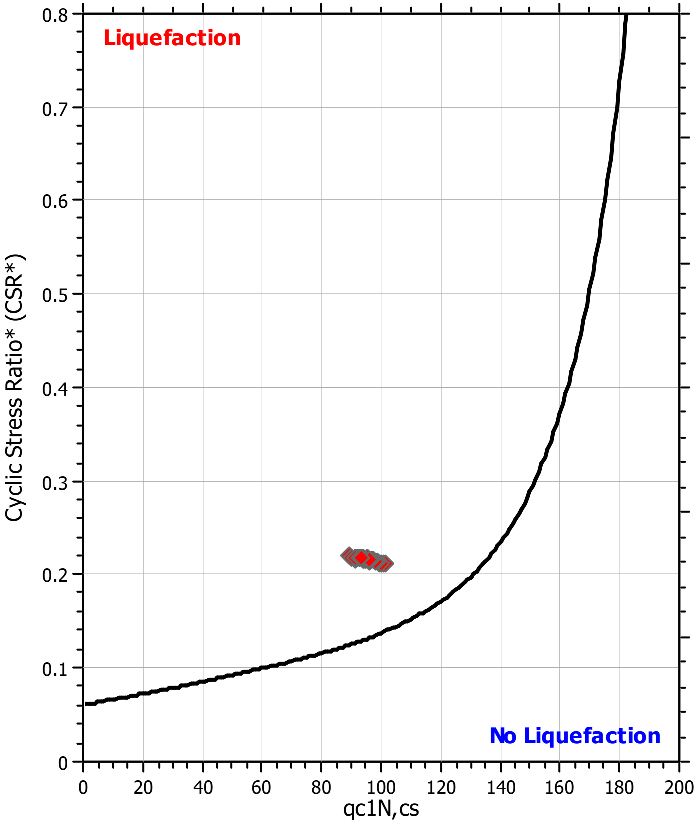
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

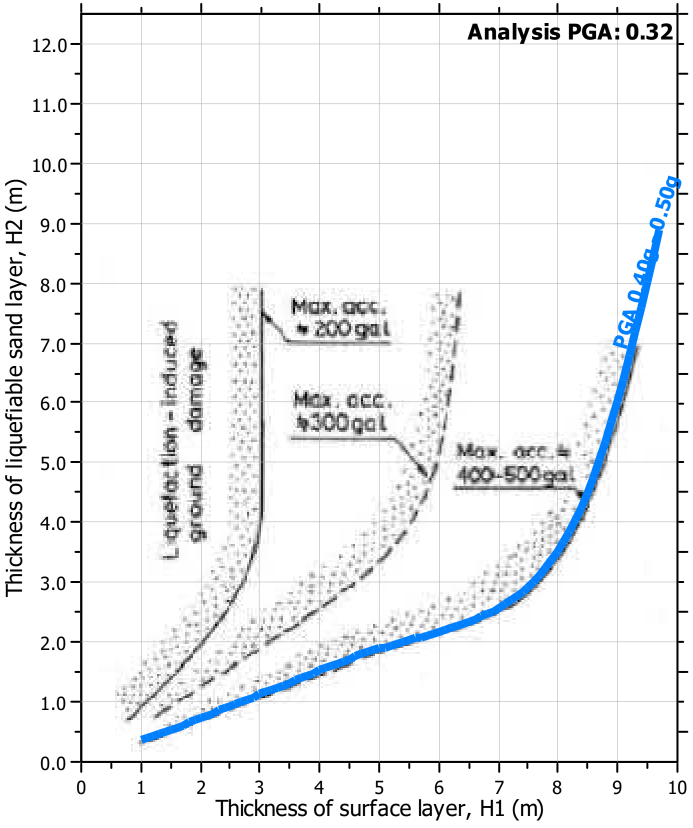
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



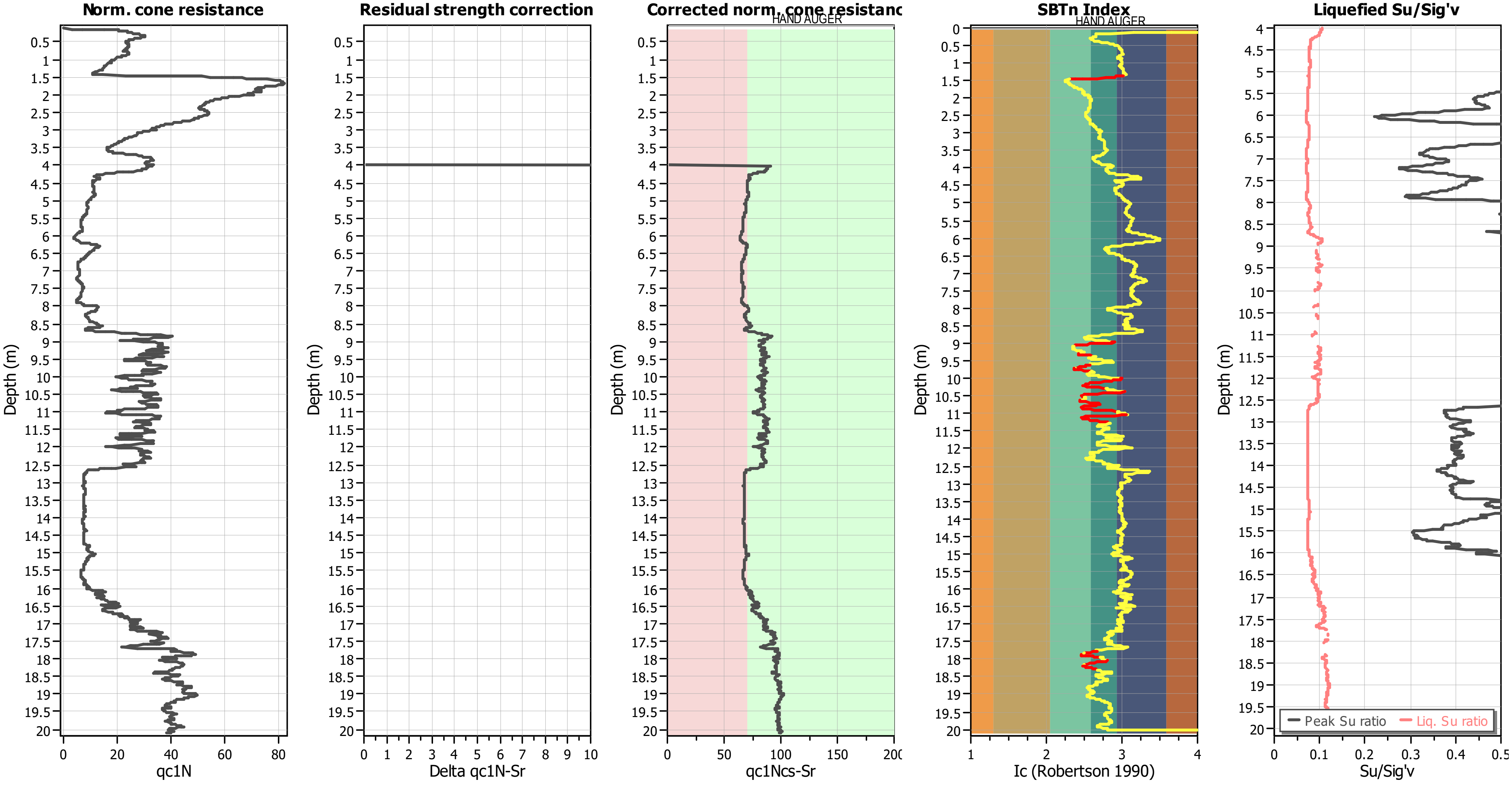




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

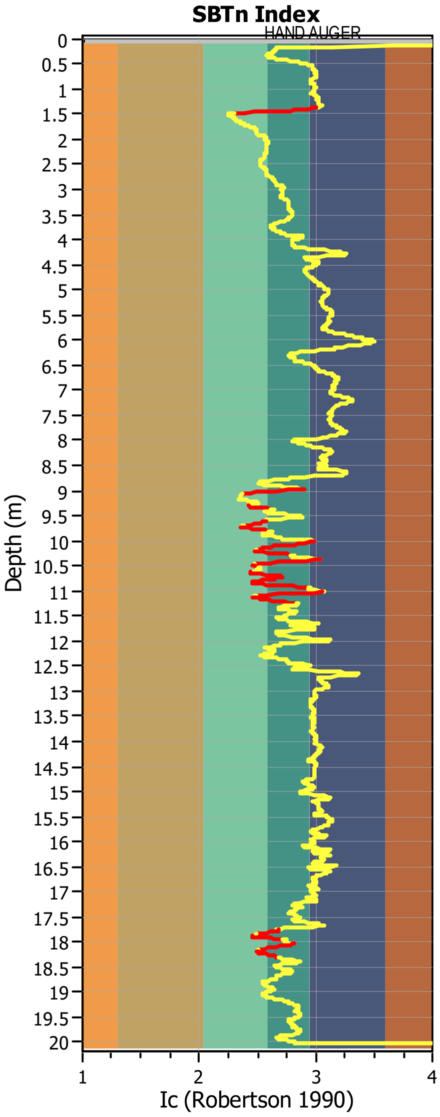
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

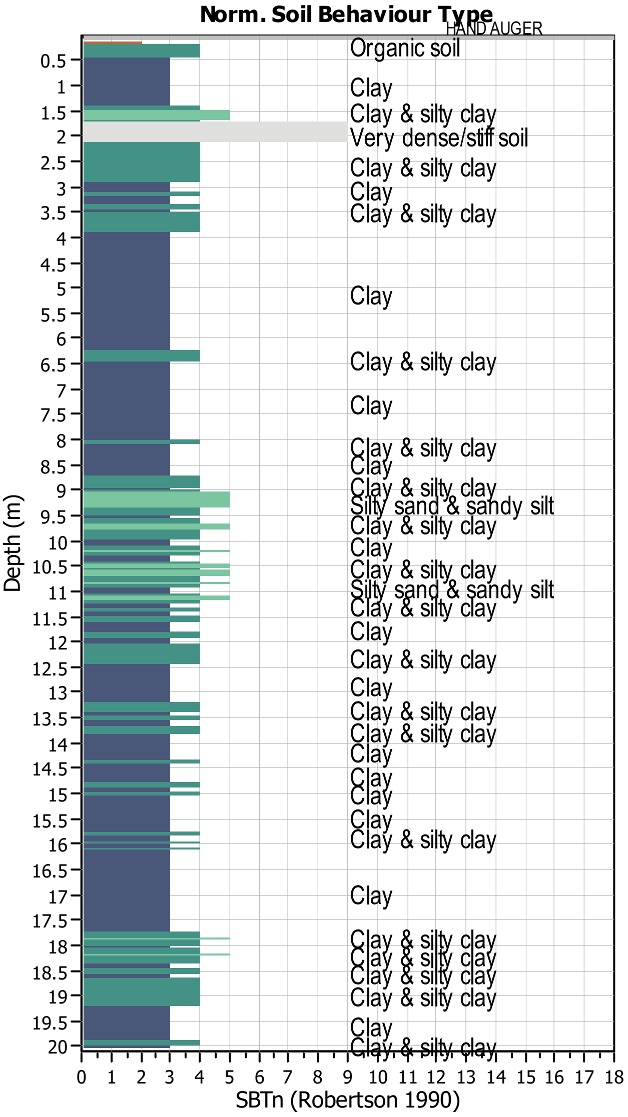
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





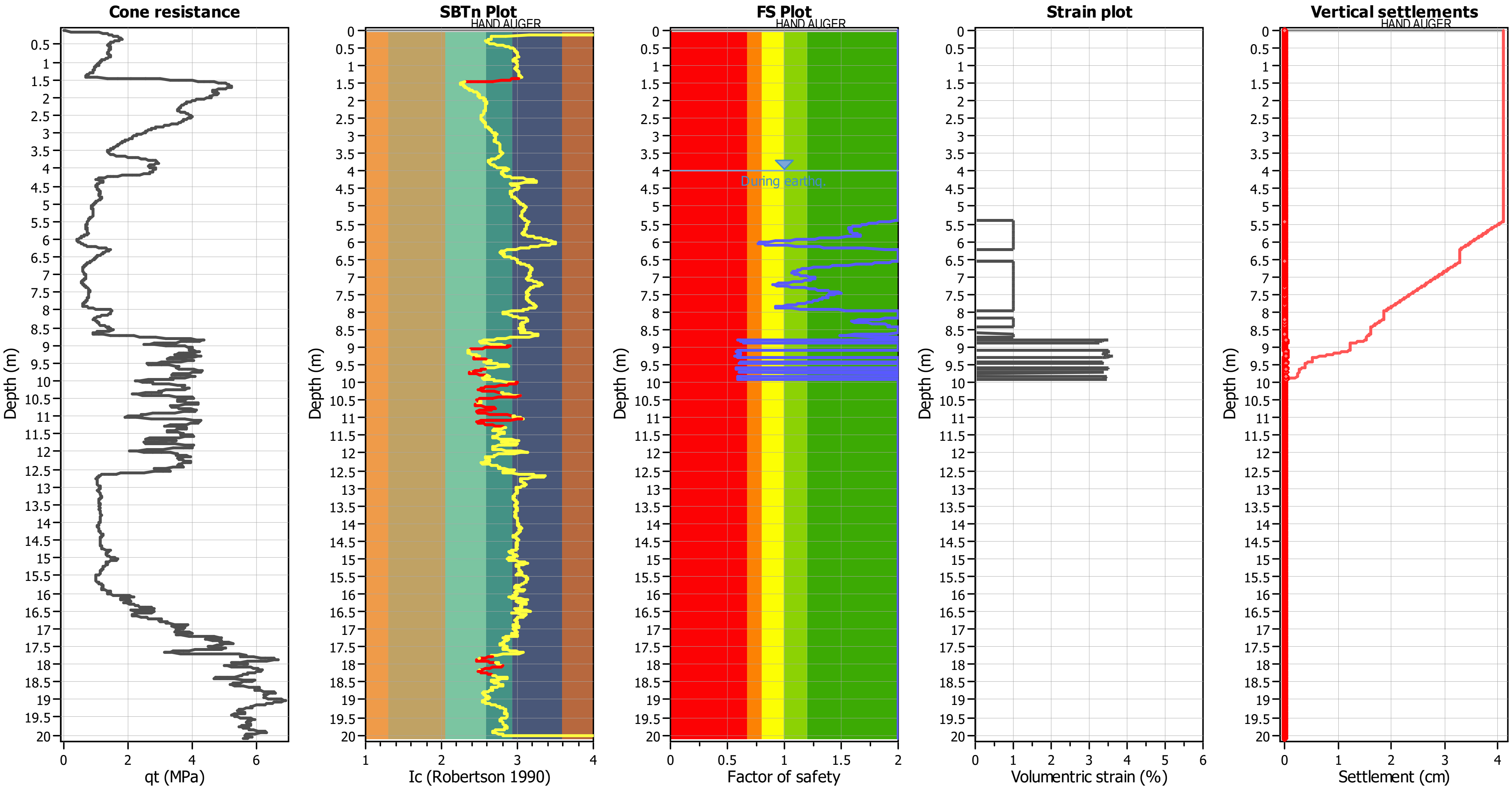
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	195
Exclusion percentage:	9.70%
Number of layers detected:	18

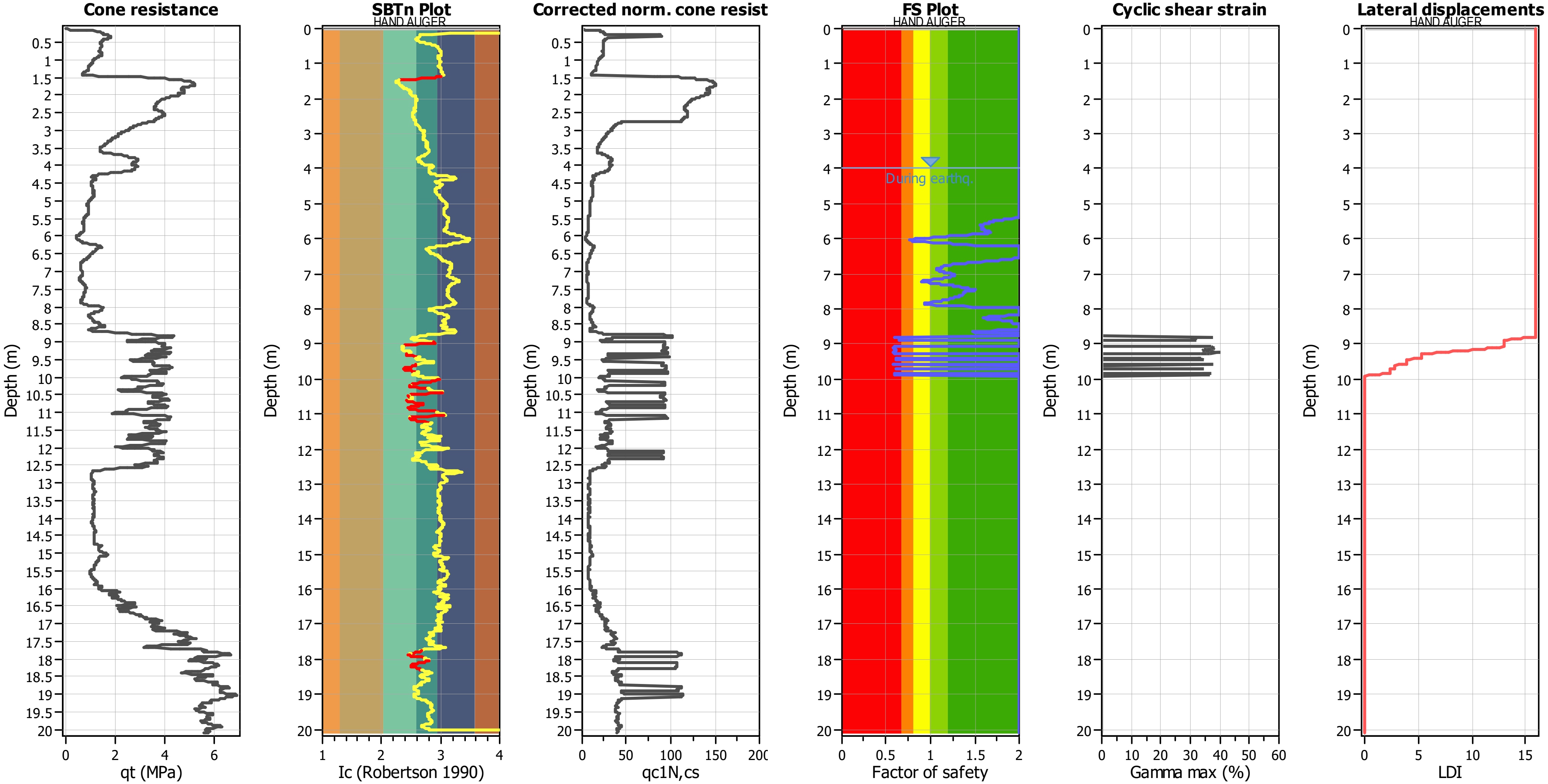
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Cone resistance

SBTn Plot

Corrected norm. cone resist

FS Plot

Cyclic shear strain

Lateral displacements

Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)

I_c: Soil Behaviour Type Index

$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety

γ_{max}: Maximum cyclic shear strain

LDI: Lateral displacement index

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

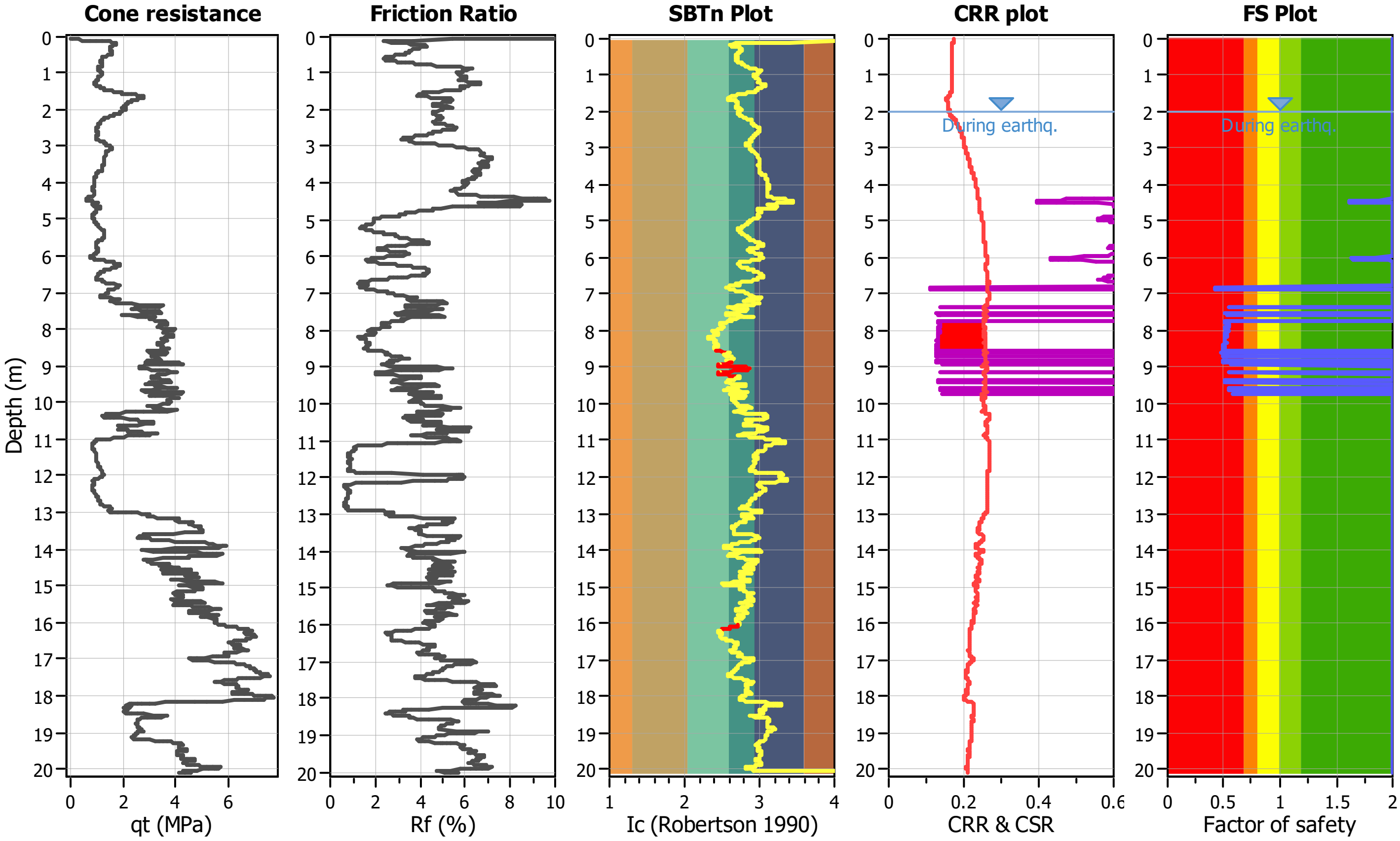
LIQUEFACTION ANALYSIS REPORT

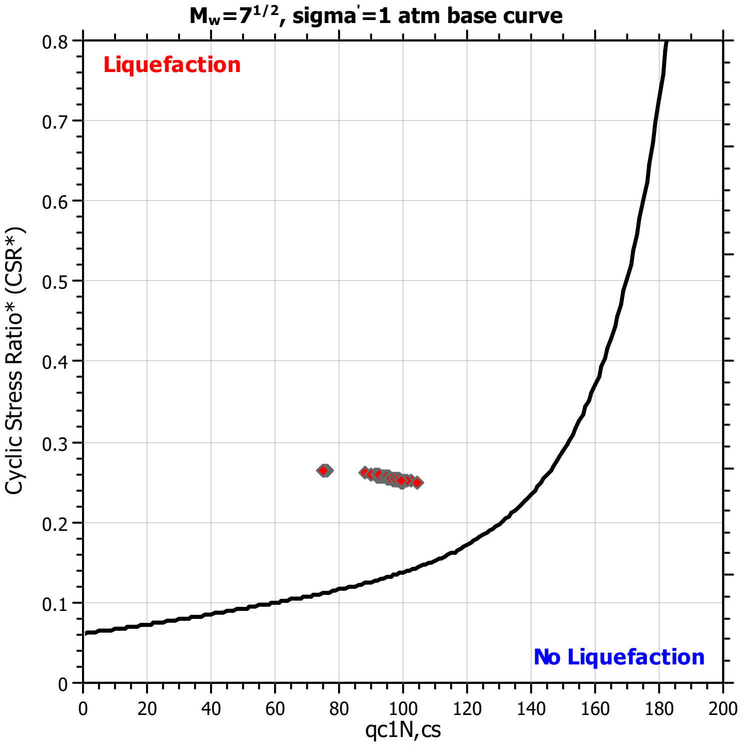
Project title : Proposed Private Plan Change for Te Awamutu   Location : 2025 Ohaupo Road, Te Awamutu

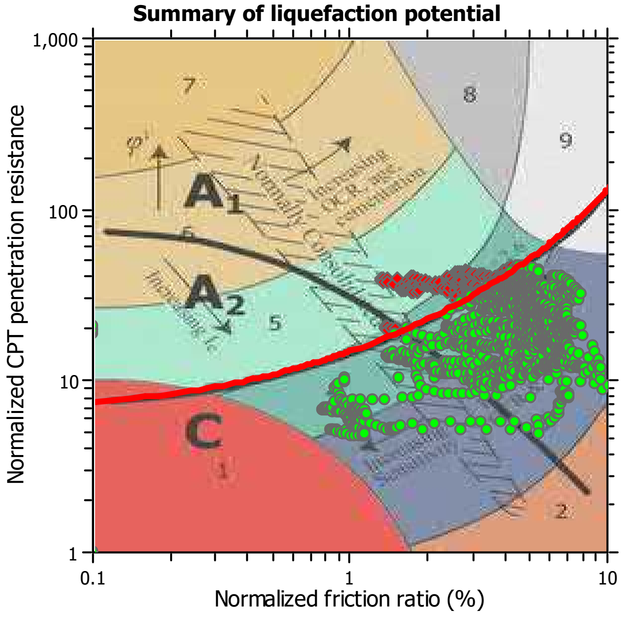
CPT file : CPT-02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

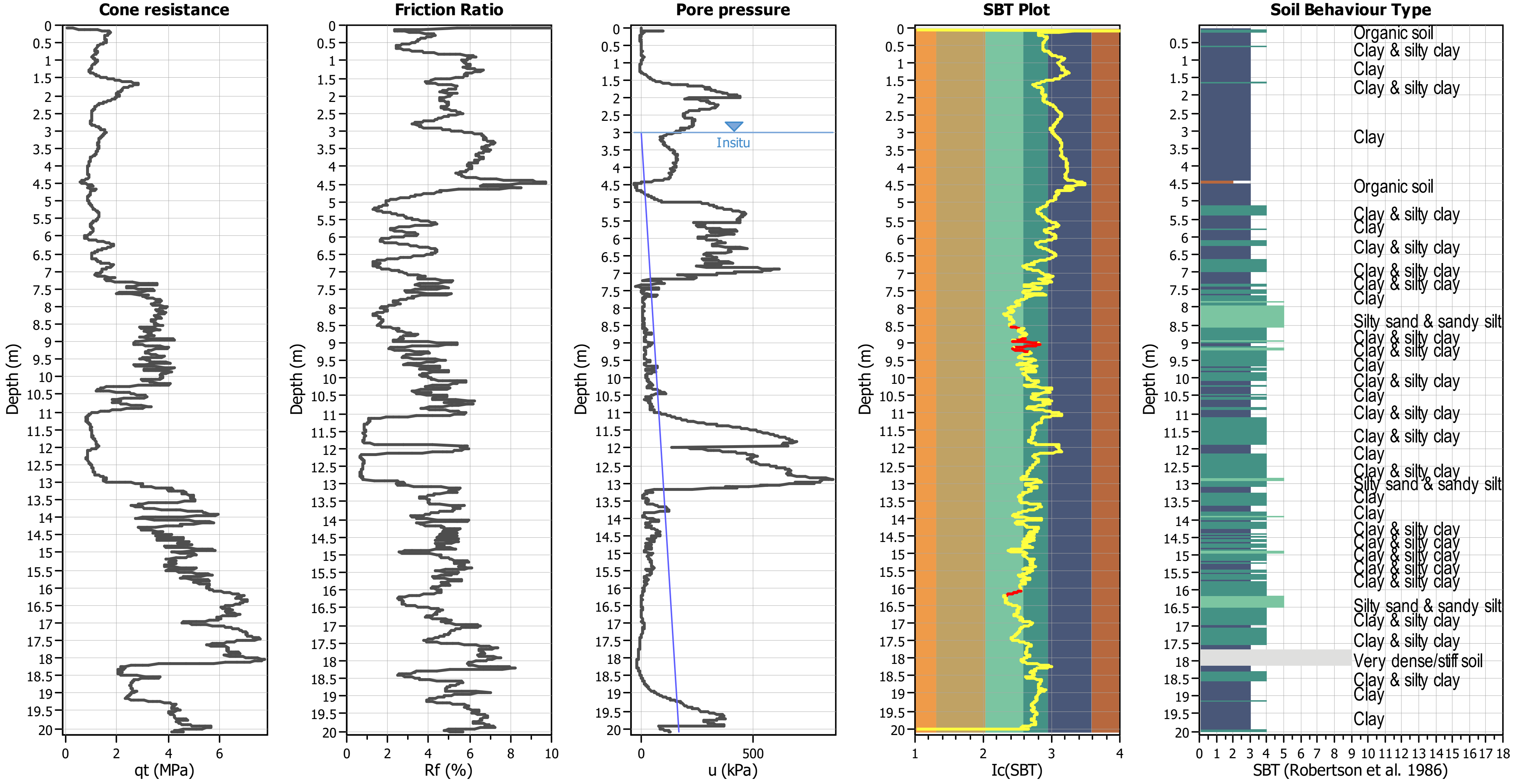






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



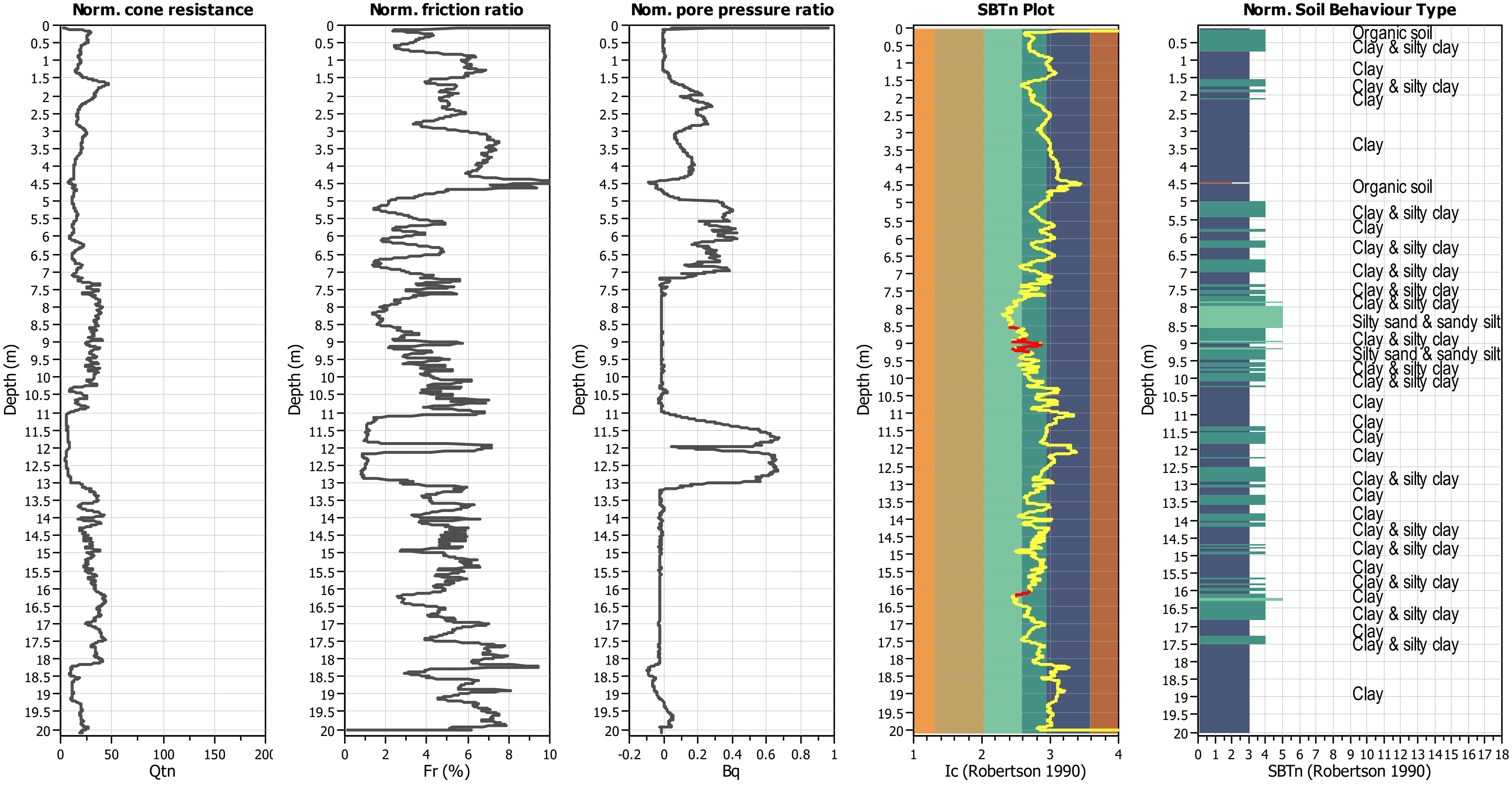
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



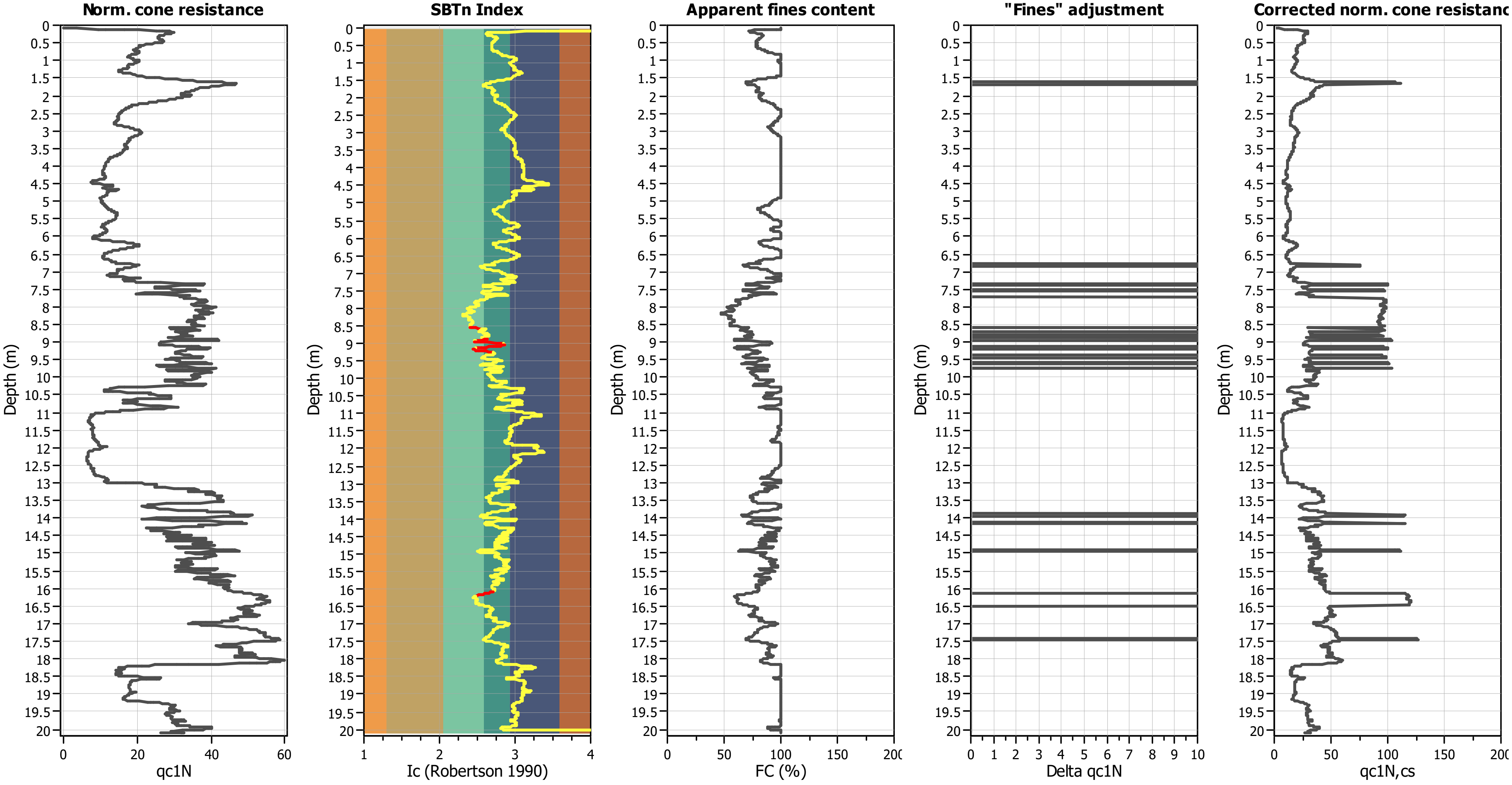
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

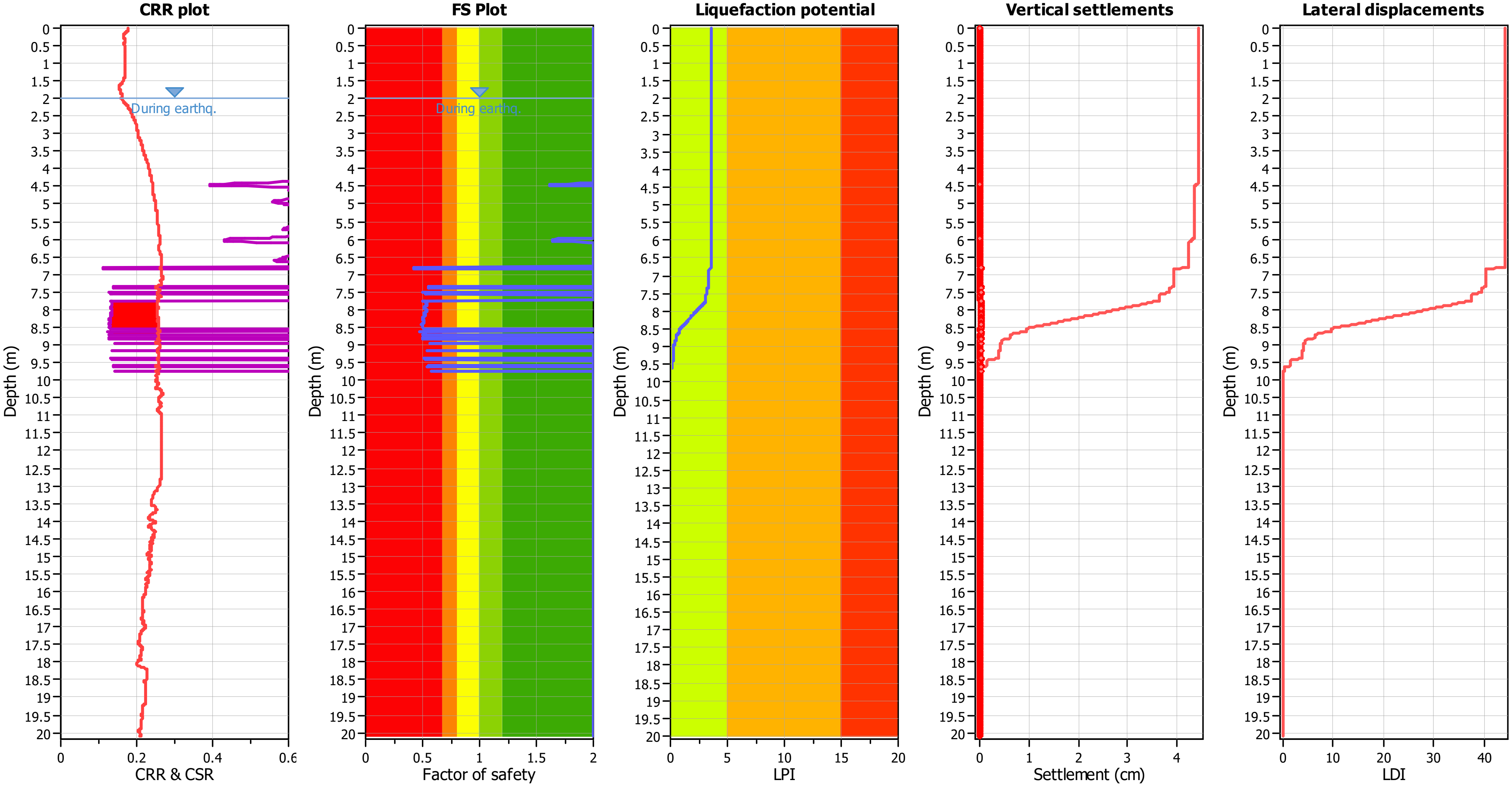
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

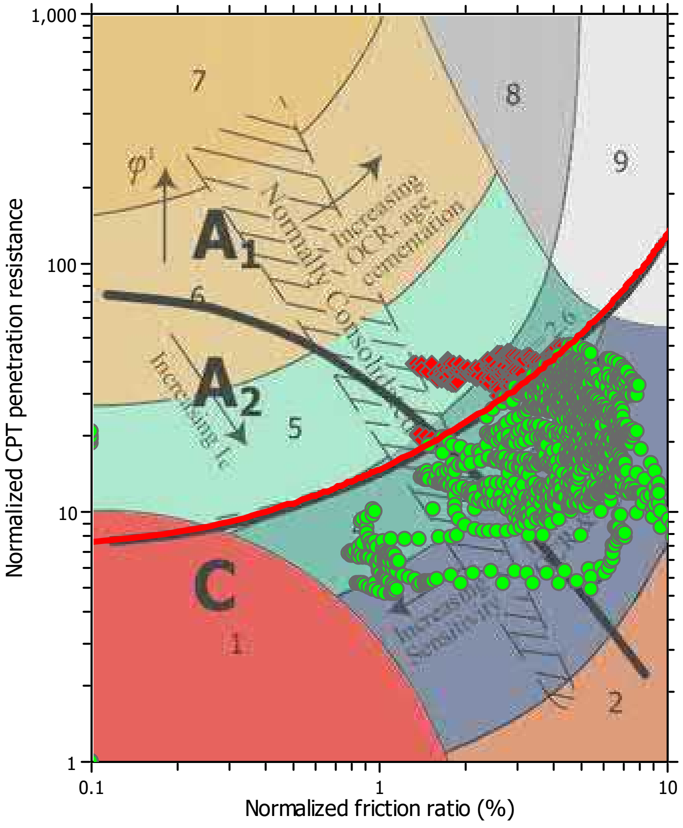
F.S. color scheme

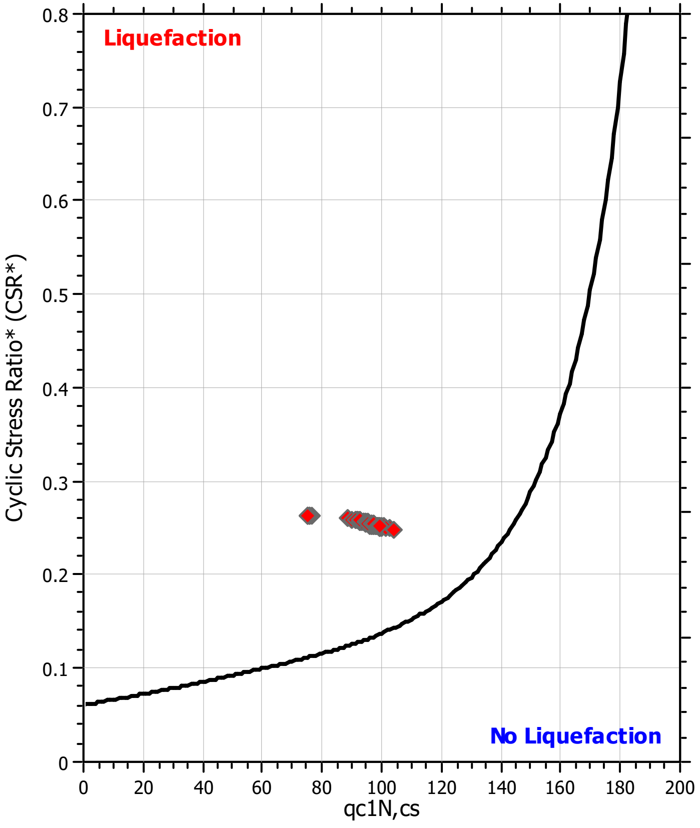
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

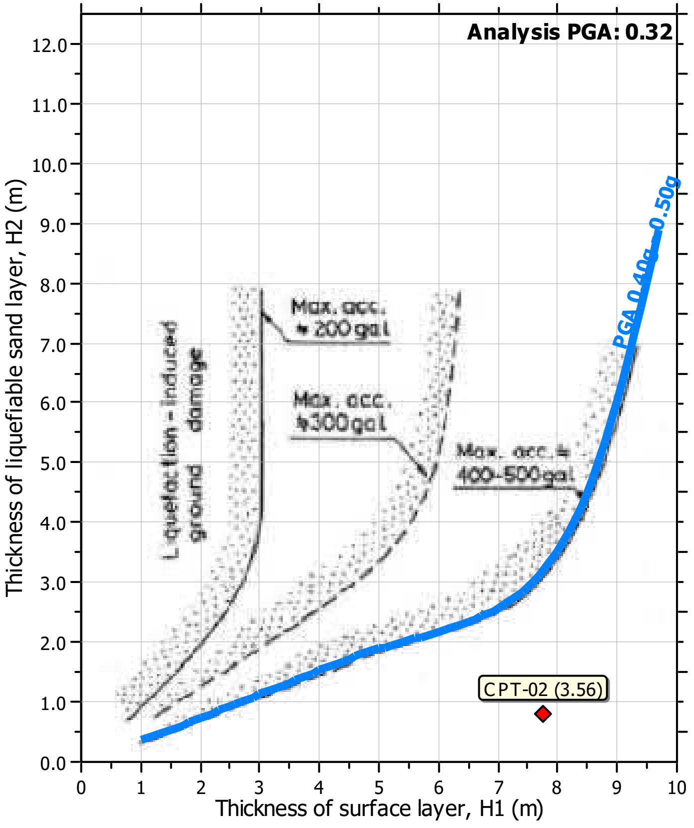
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟩 Low risk

Liquefaction analysis summary plots



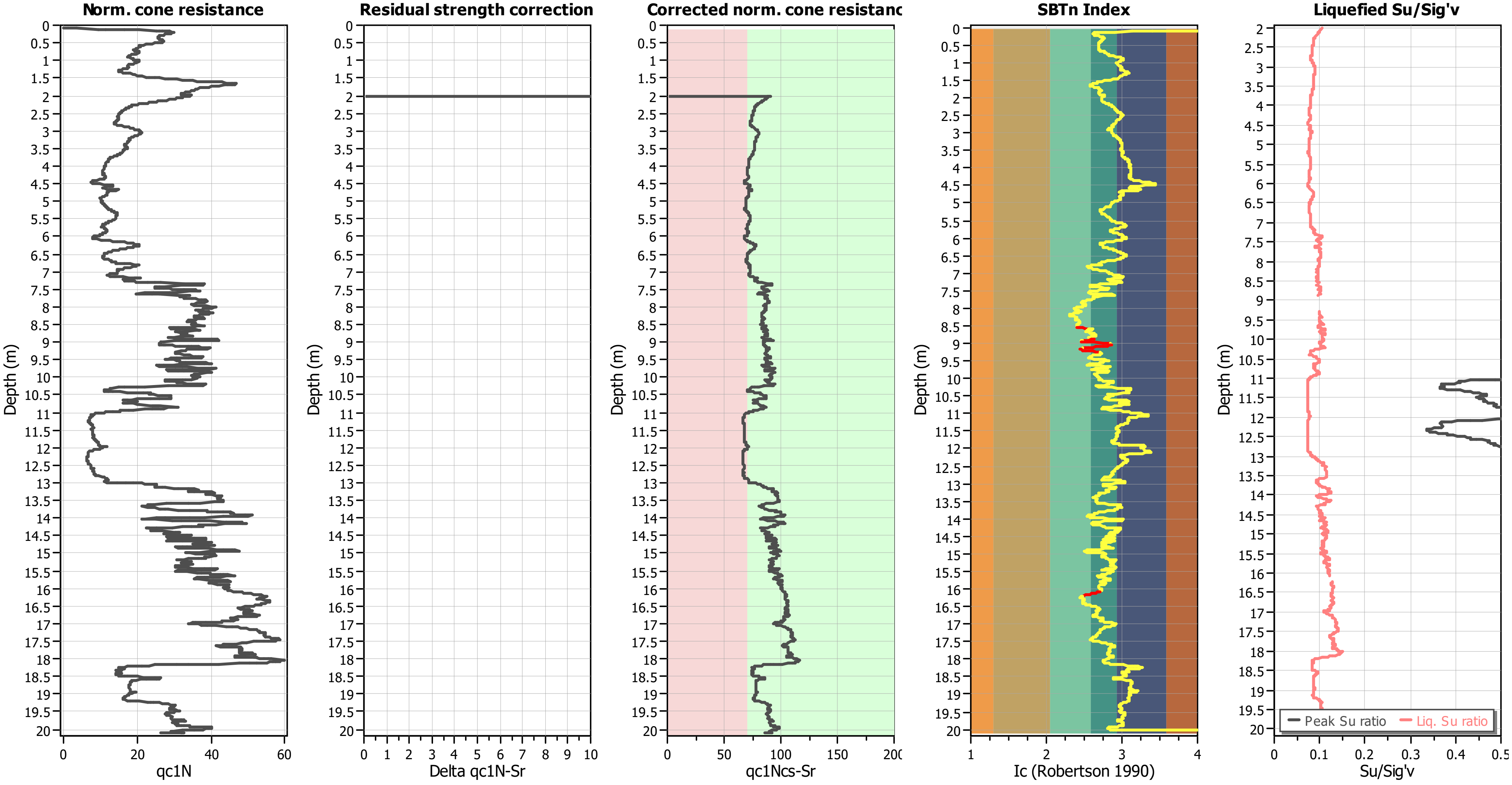




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

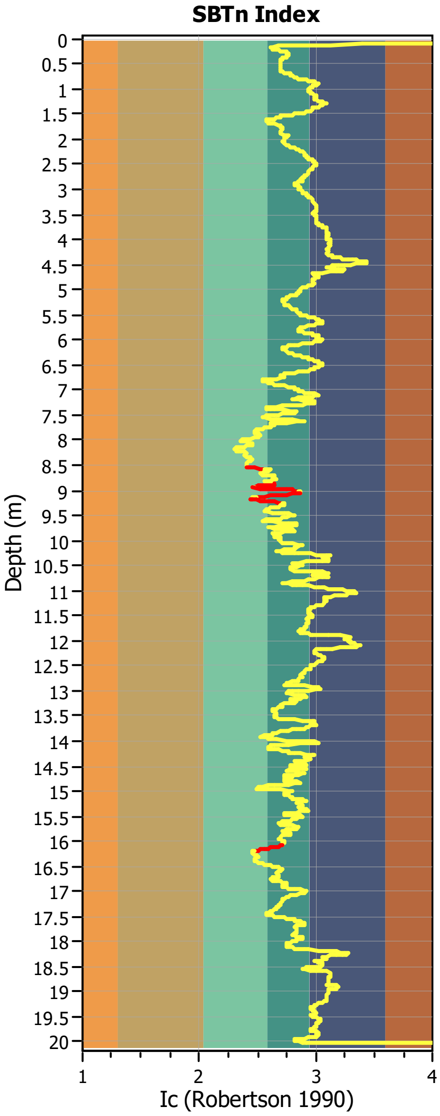
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	10.00 m

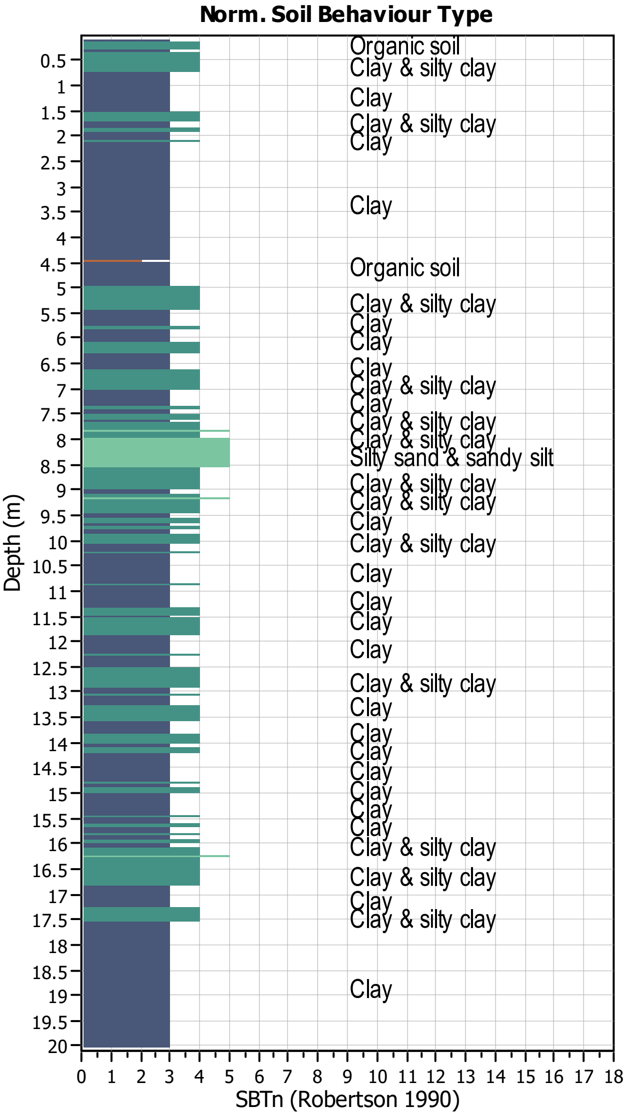
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





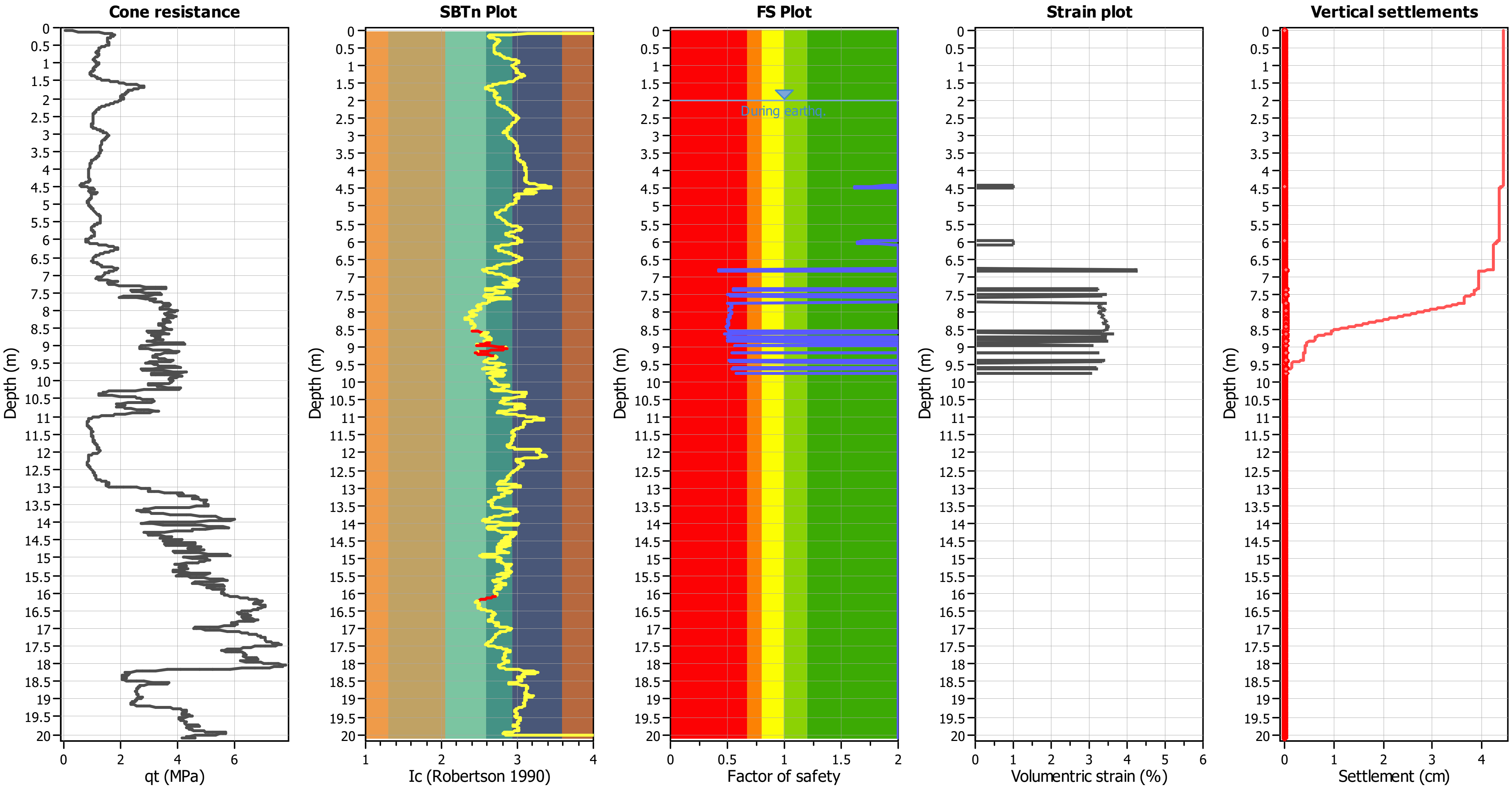
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	56
Exclusion percentage:	2.79%
Number of layers detected:	6

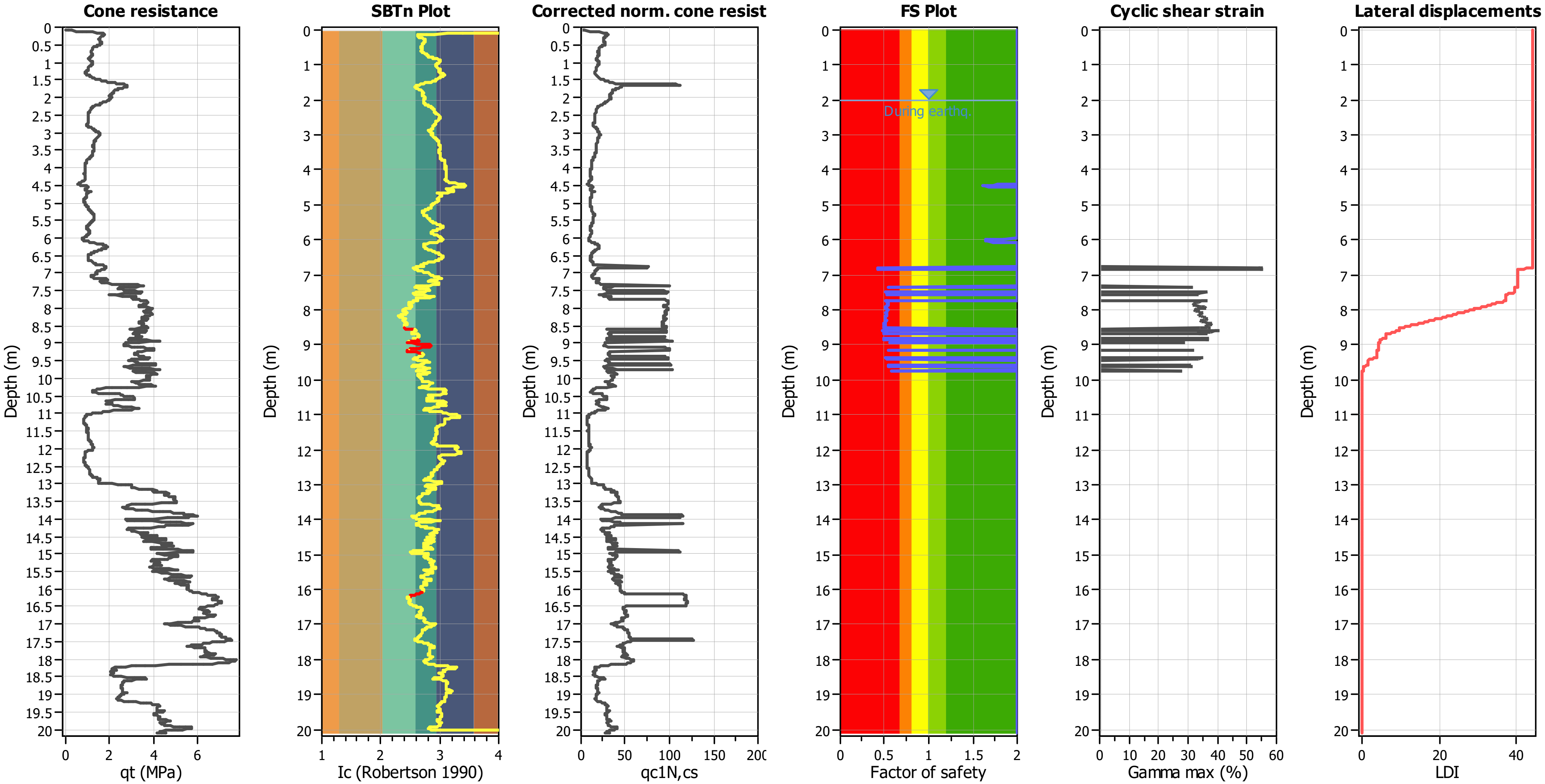
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

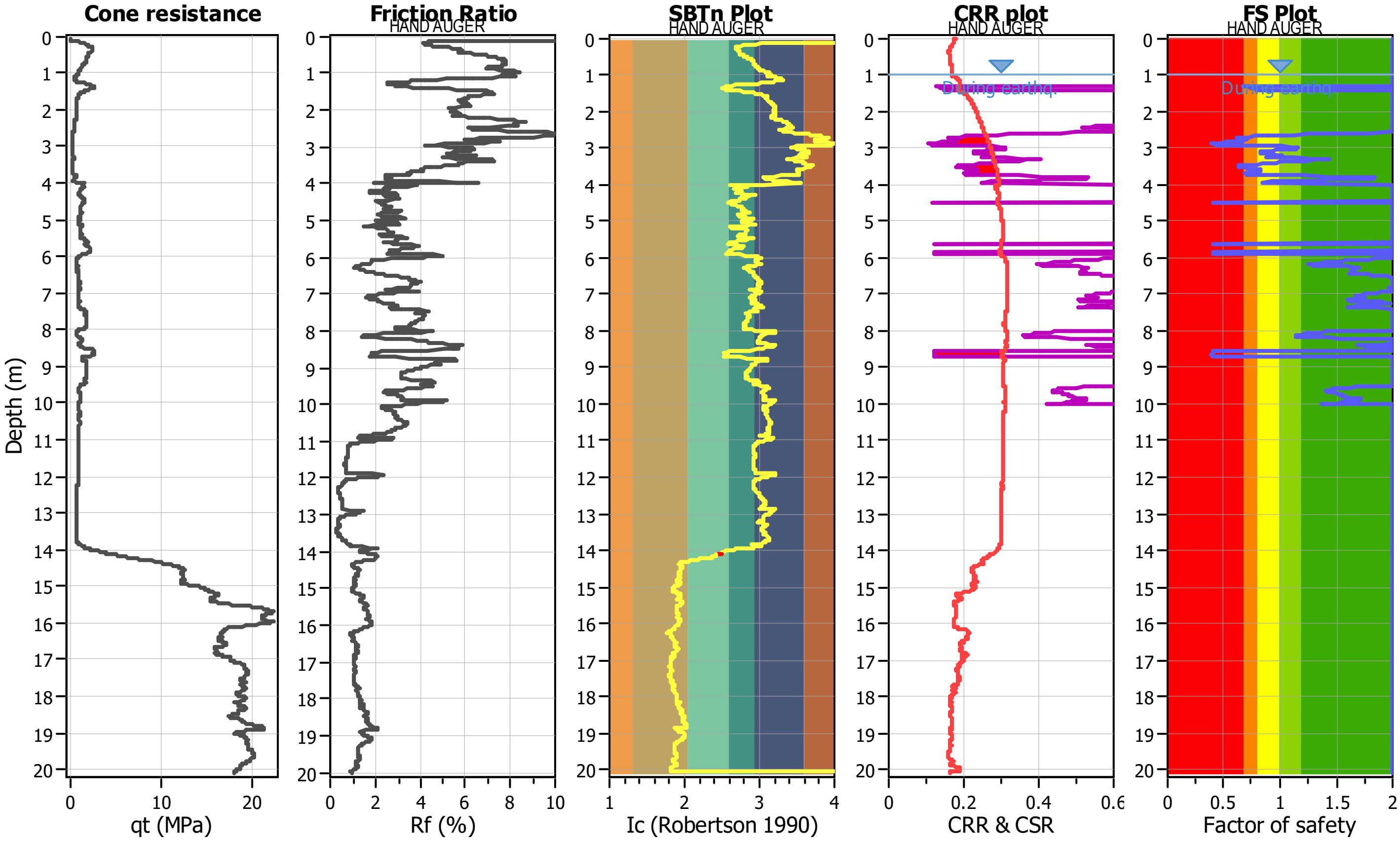
LIQUEFACTION ANALYSIS REPORT

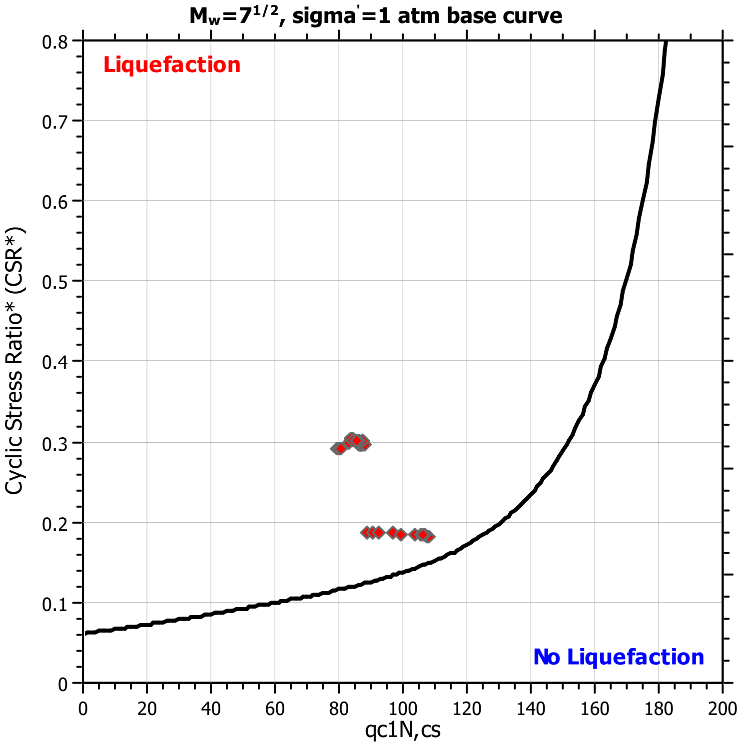
Project title : Proposed Private Plan Change for Te Awamutu **Location : 2025 Ohaupo Road, Te Awamutu**

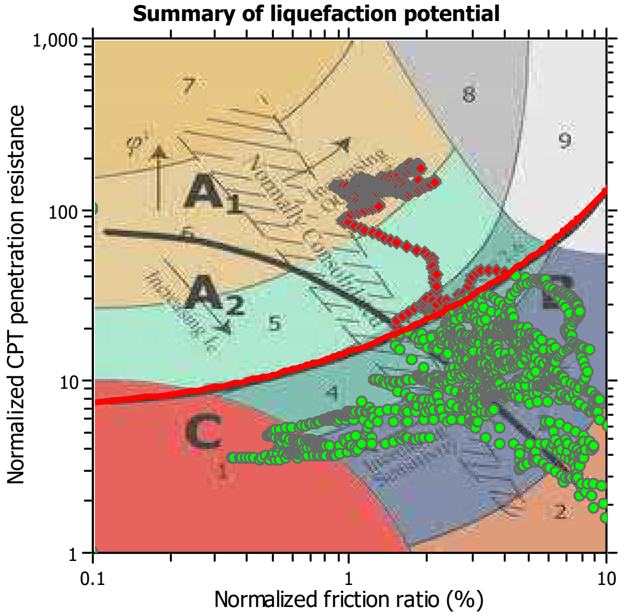
CPT file : CPT-03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	10.00 m
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method

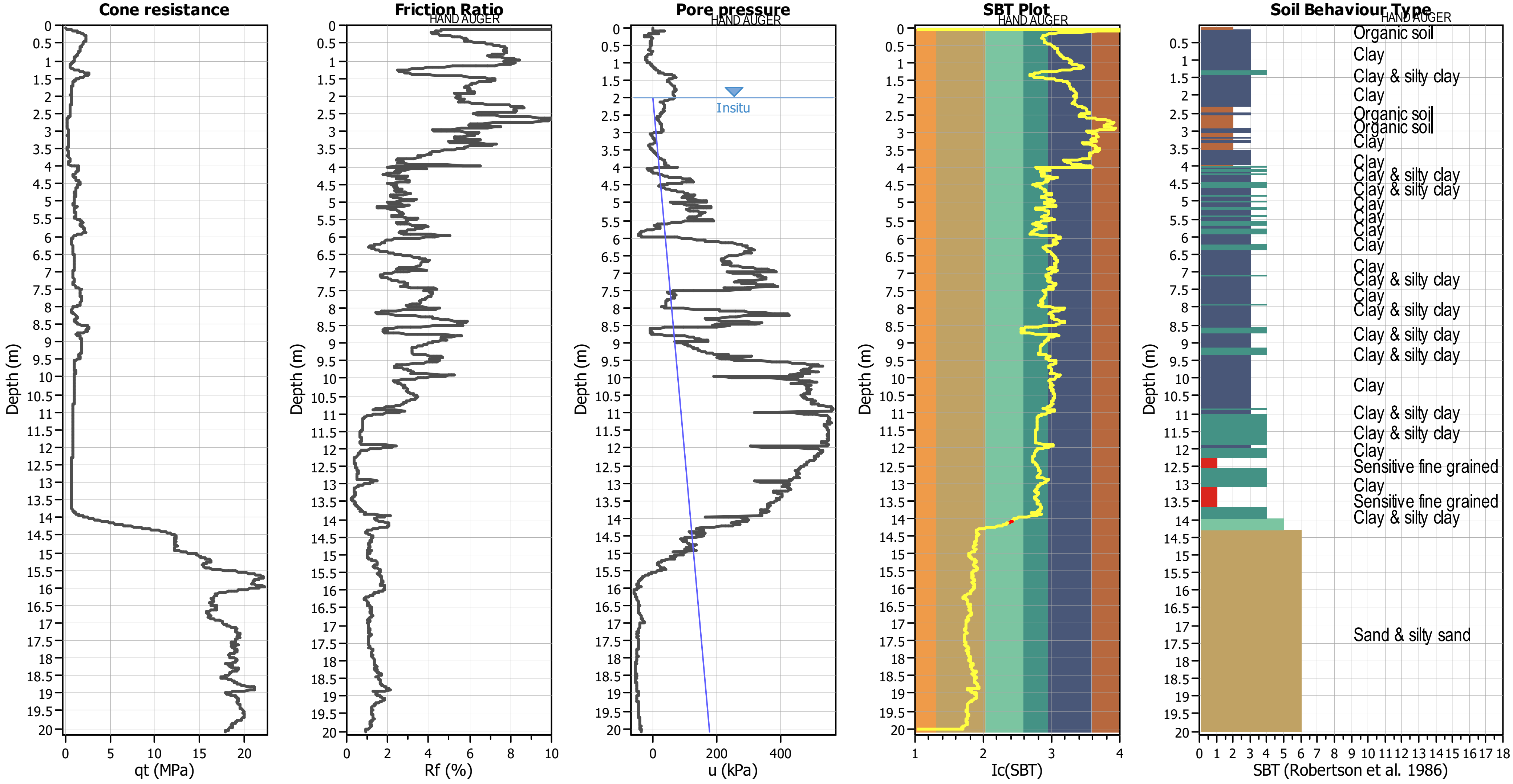






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.32
Depth to water table (insitu): 2.00 m

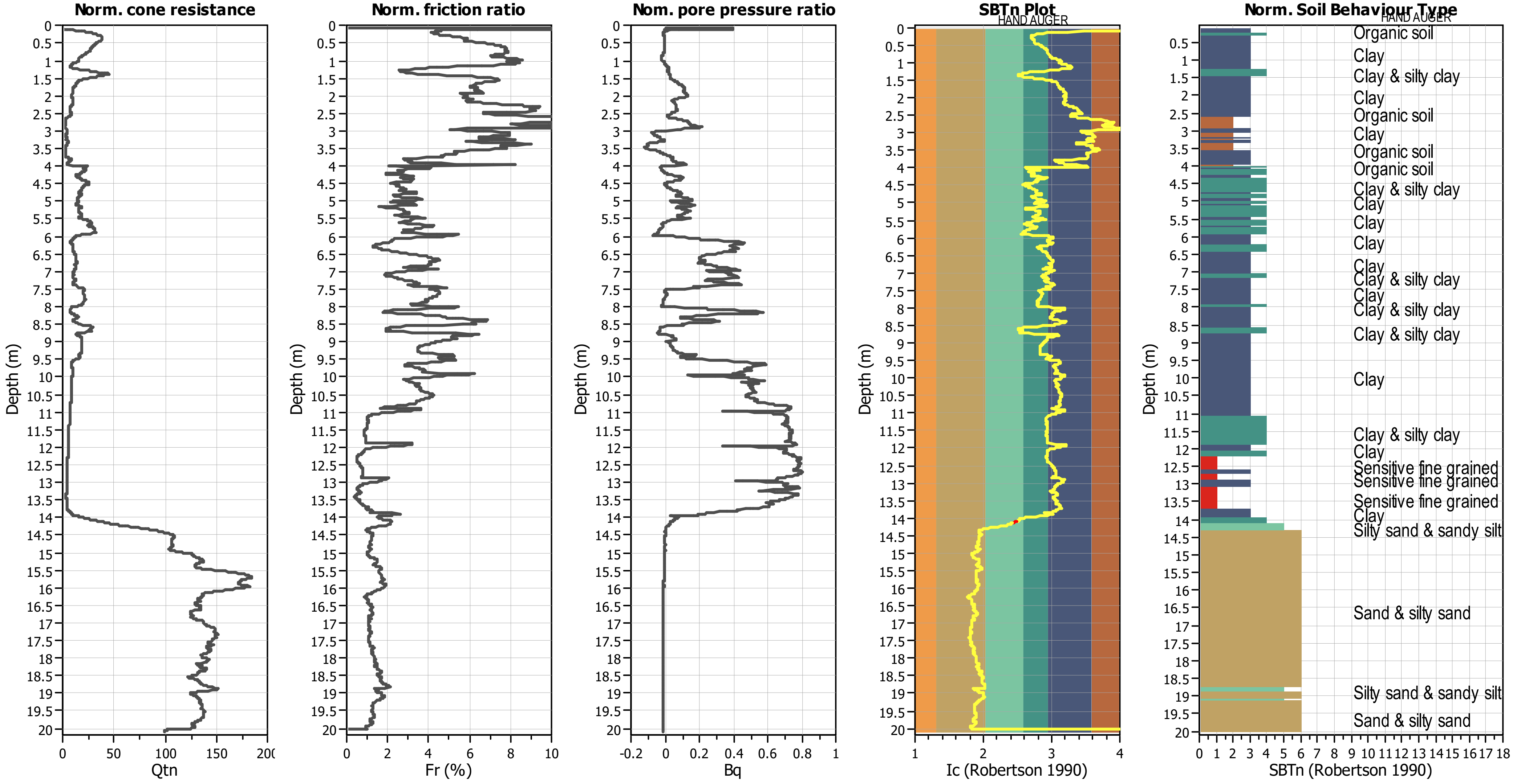
Depth to GWT (erthq.): 1.00 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



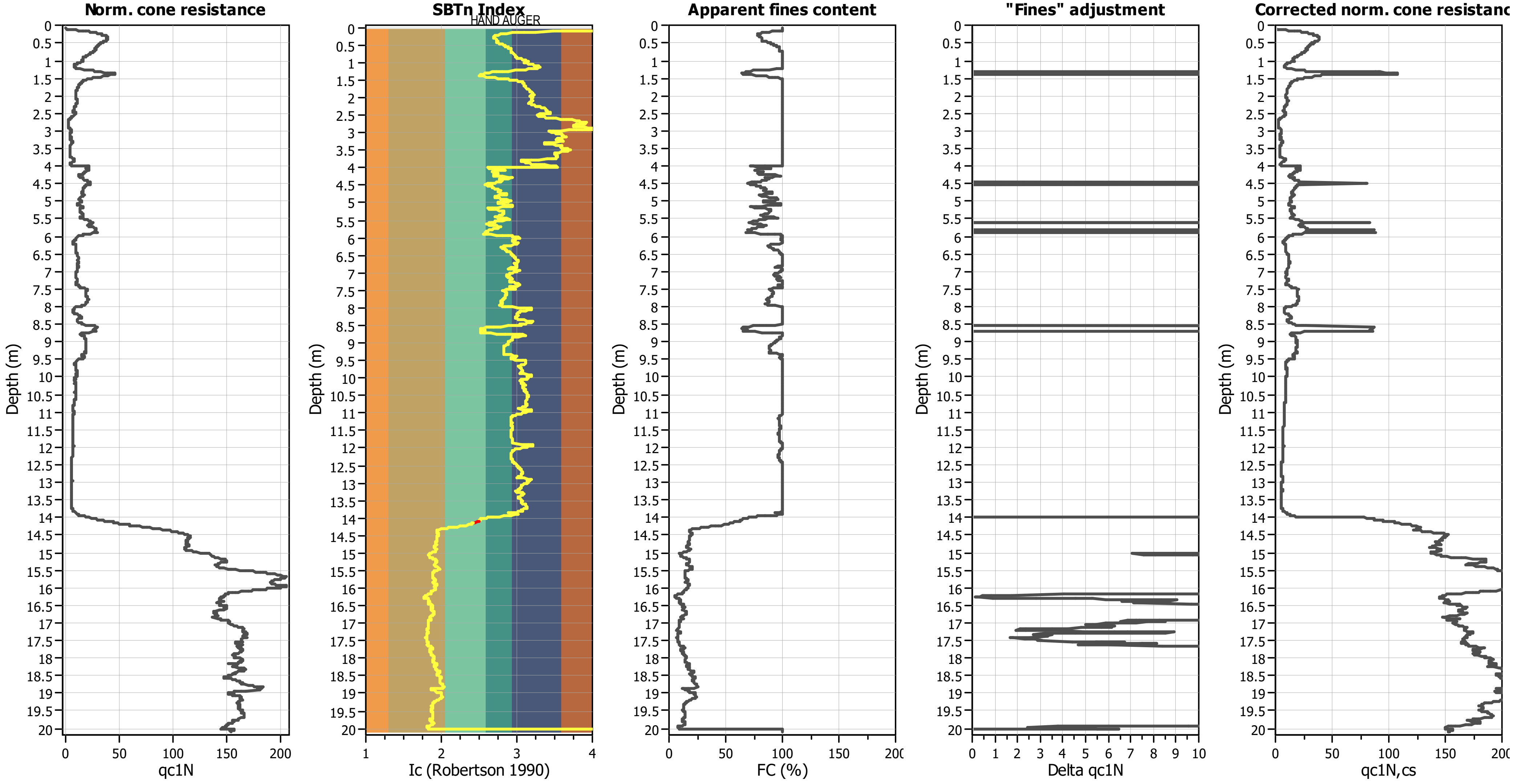
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

Liquefaction analysis overall plots (intermediate results)



Norm. cone resistance

SBTn Index

Apparent fines content

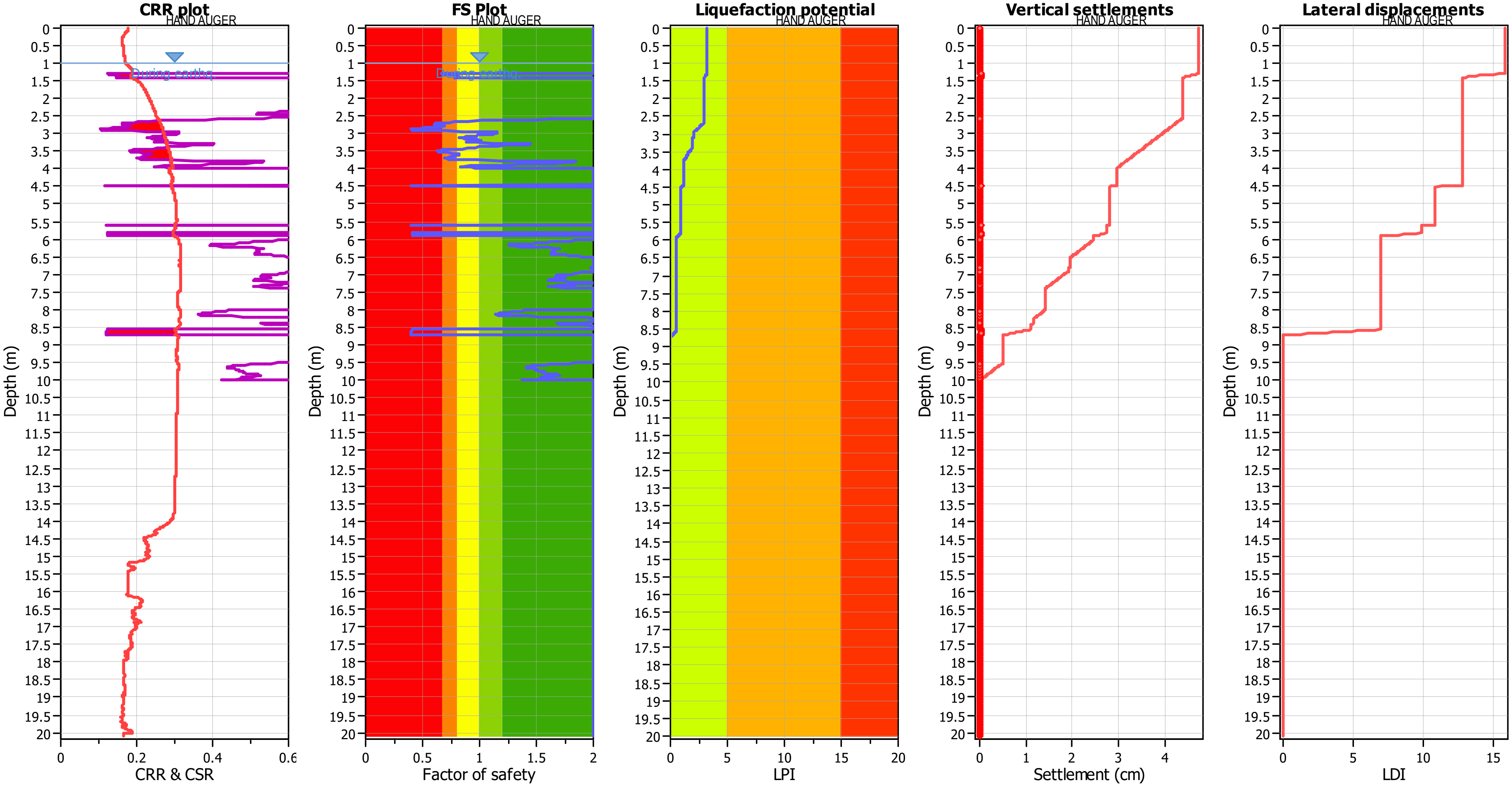
"Fines" adjustment

Corrected norm. cone resistanc

Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

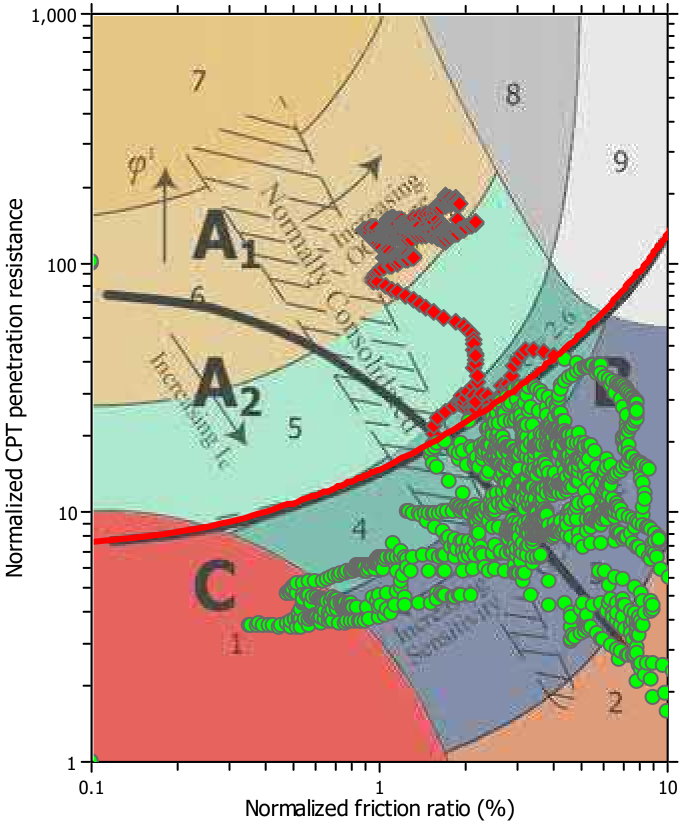
F.S. color scheme

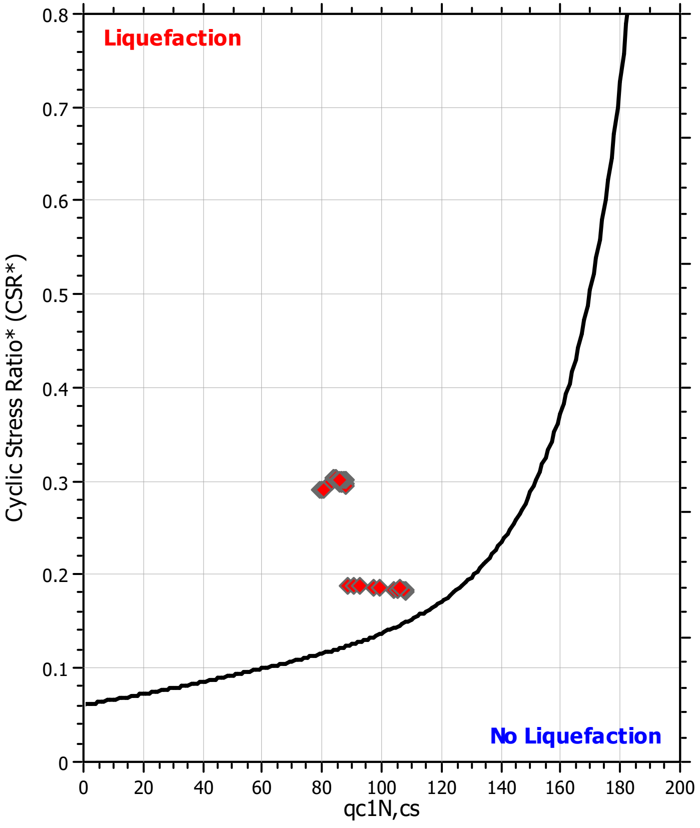
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

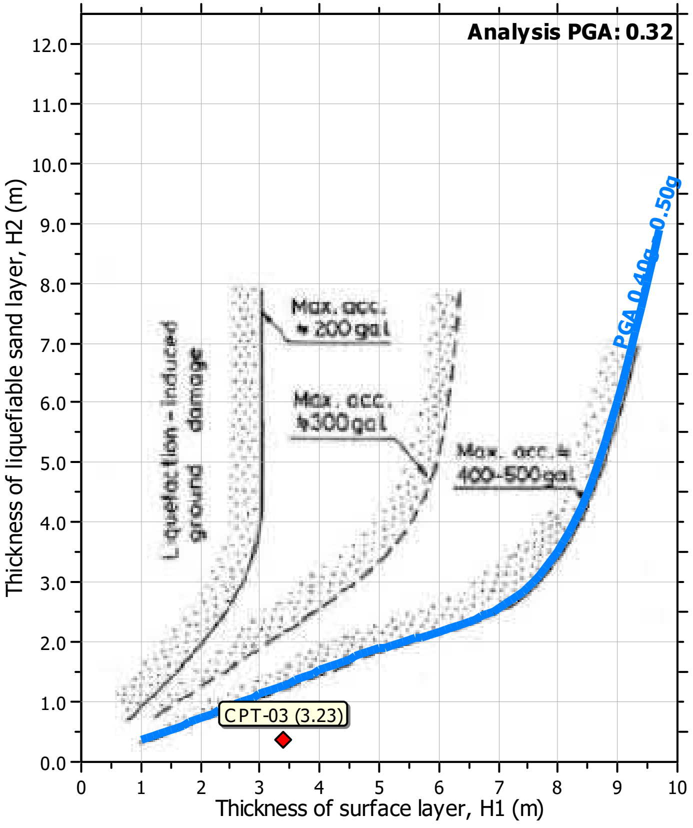
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



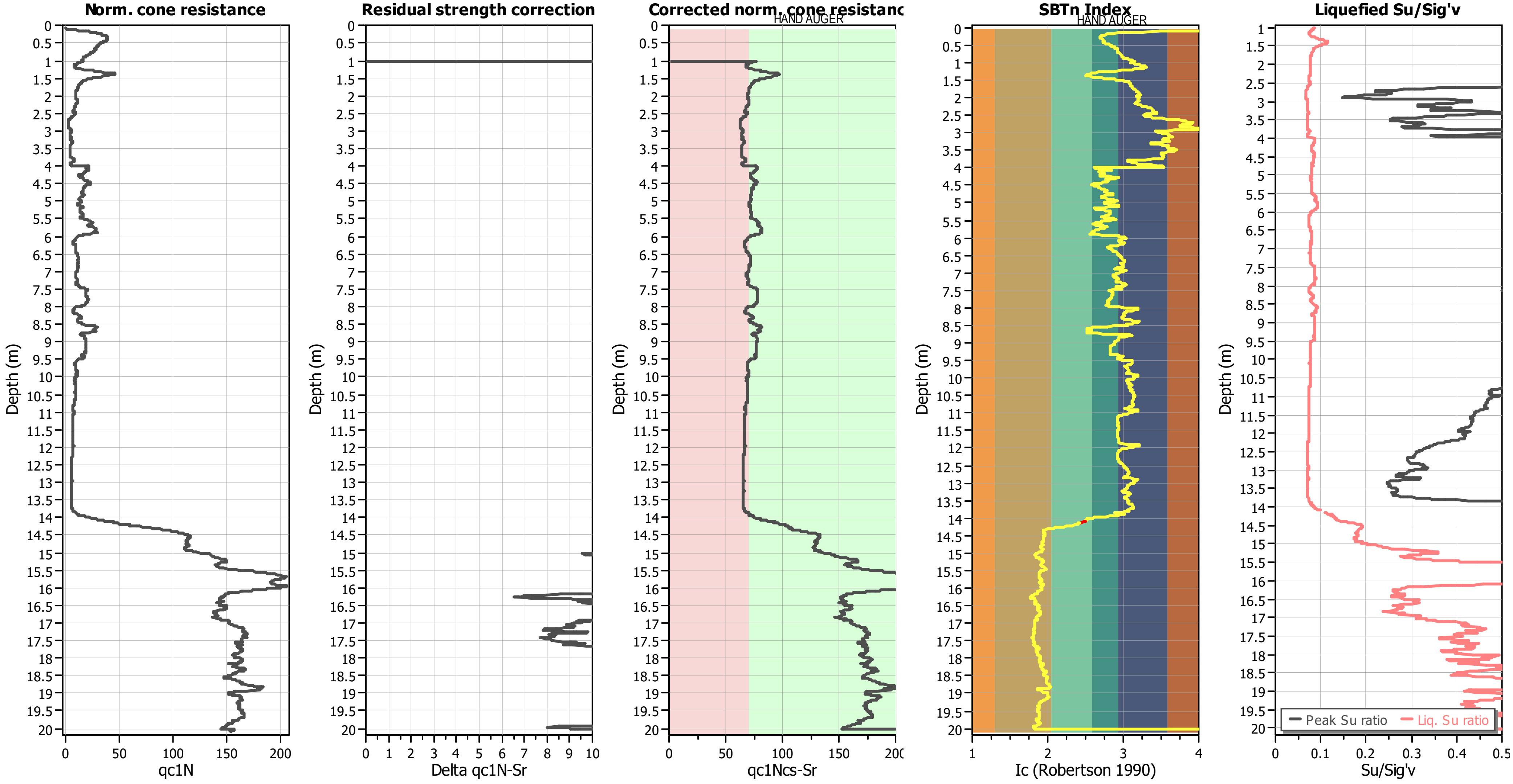




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

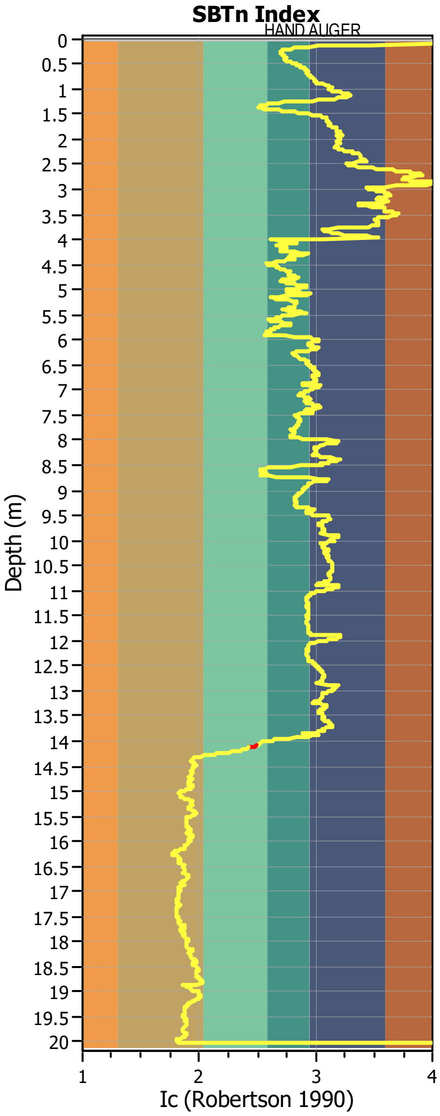
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

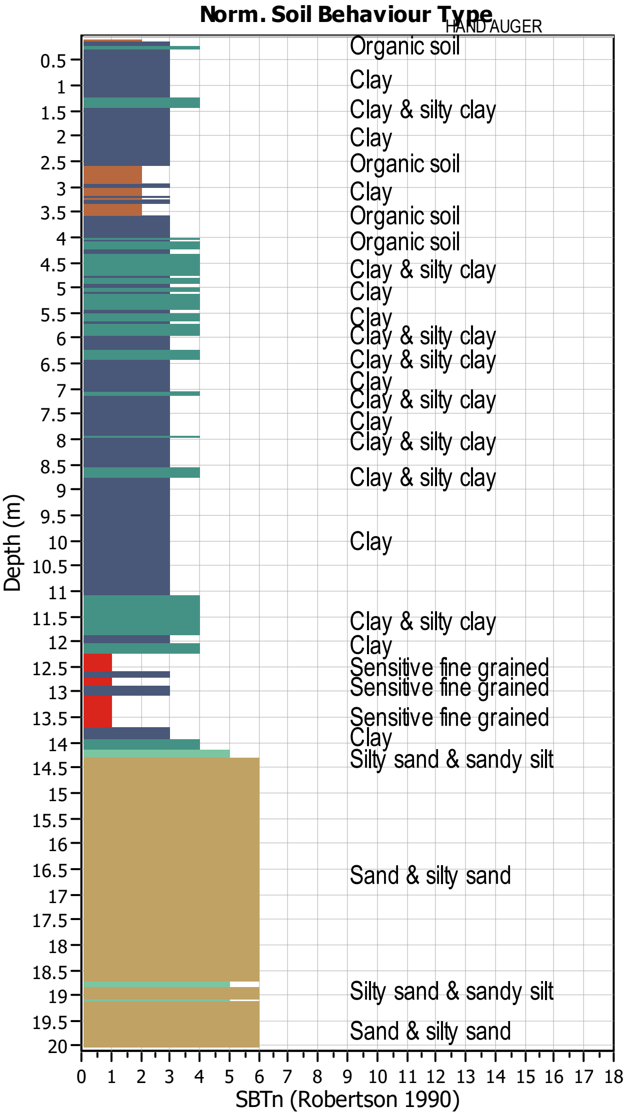
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





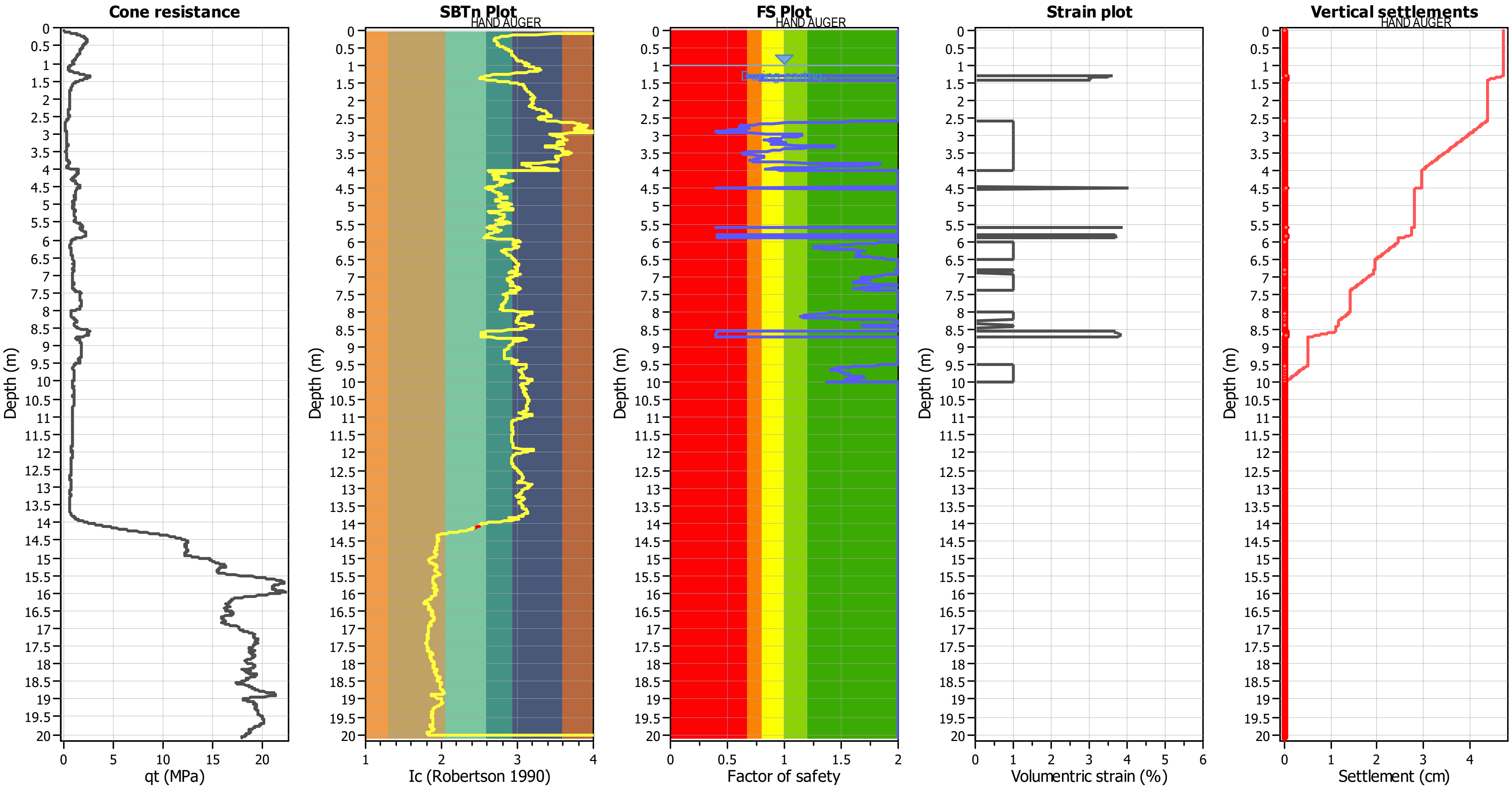
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	5
Exclusion percentage:	0.25%
Number of layers detected:	1

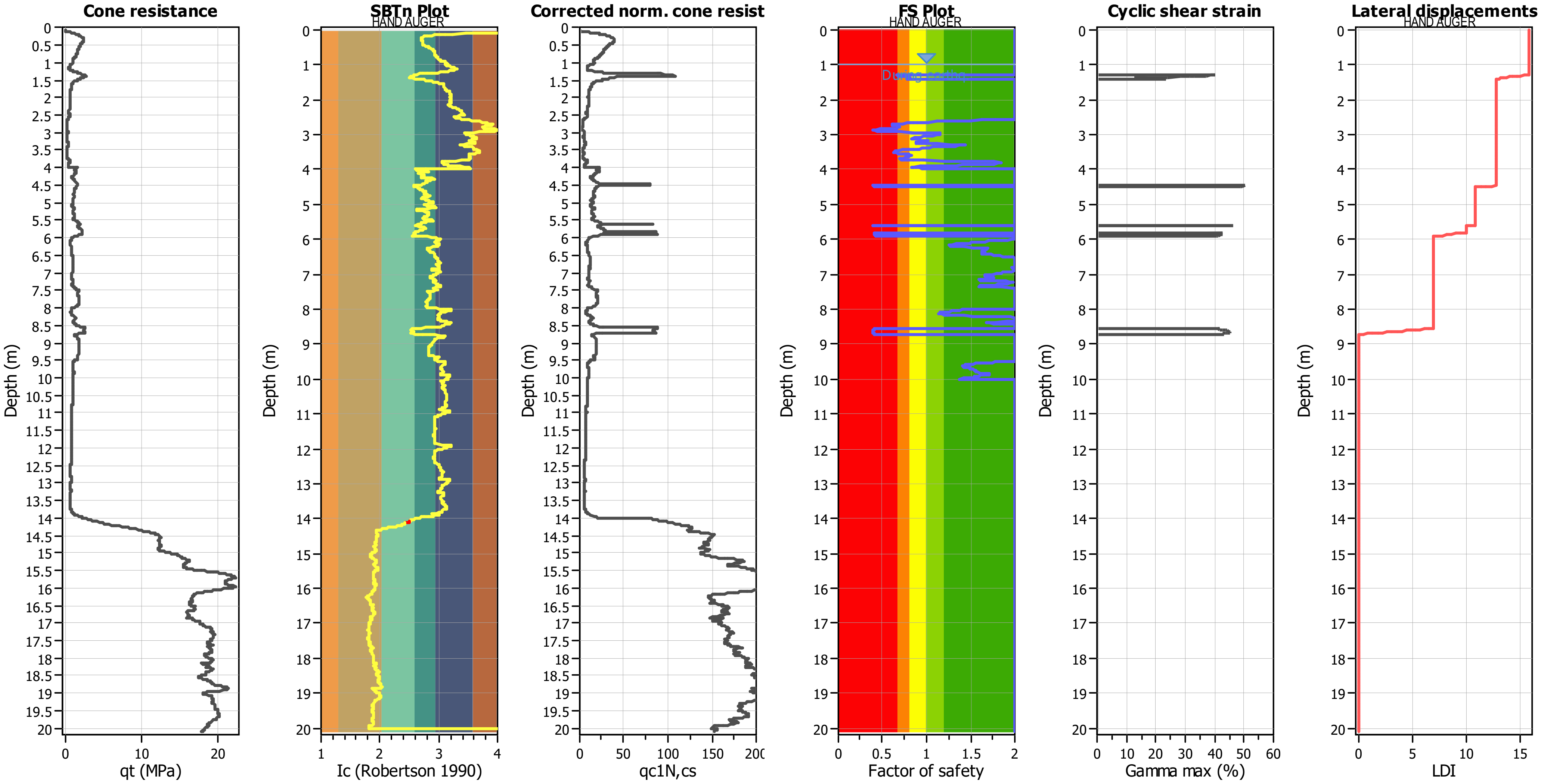
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

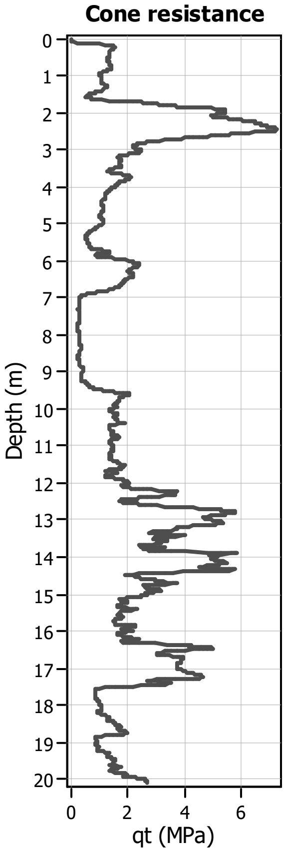
LIQUEFACTION ANALYSIS REPORT

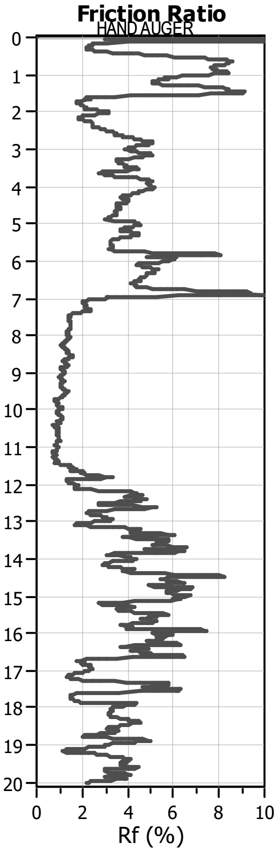
Project title : Proposed Private Plan Change for Te Awamutu **Location : 2025 Ohaupo Road, Te Awamutu**

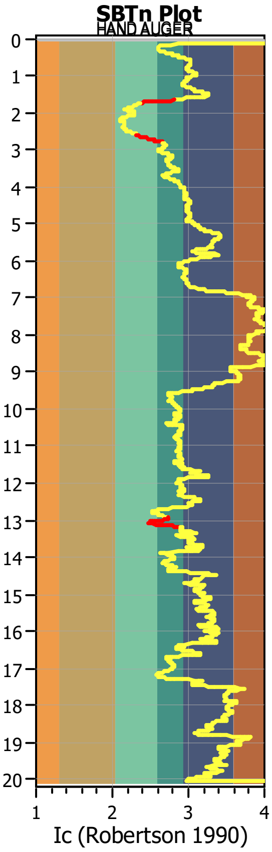
CPT file : CPT-04

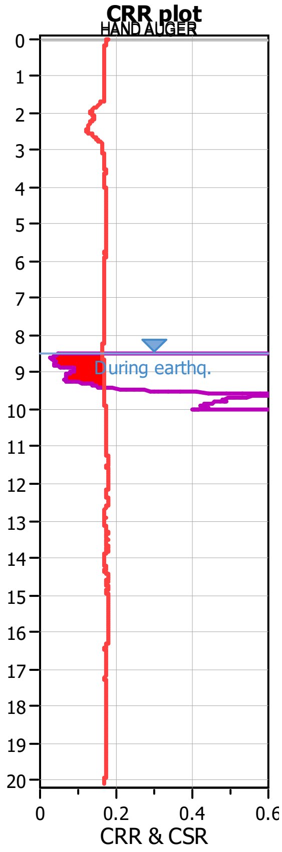
Input parameters and analysis data

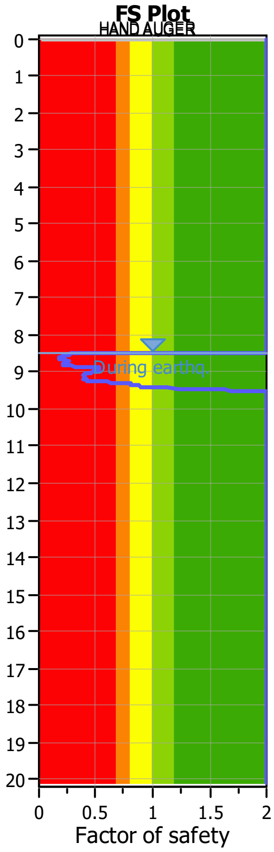
Analysis method:	B&I (2014)	G.W.T. (in-situ):	9.50 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	8.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

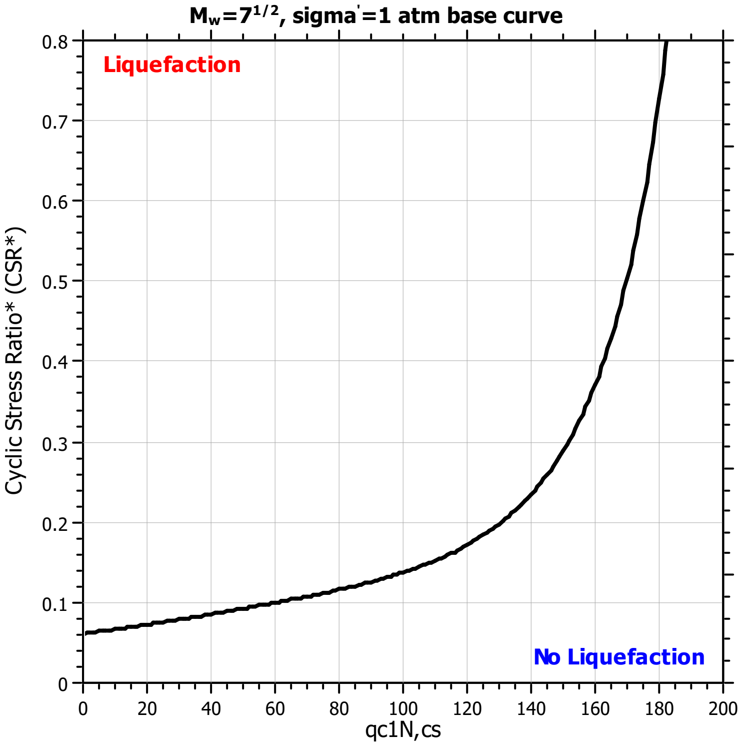


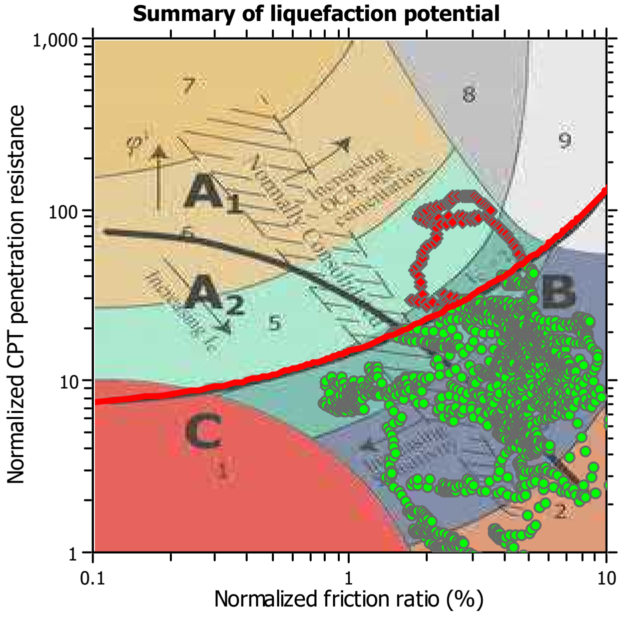






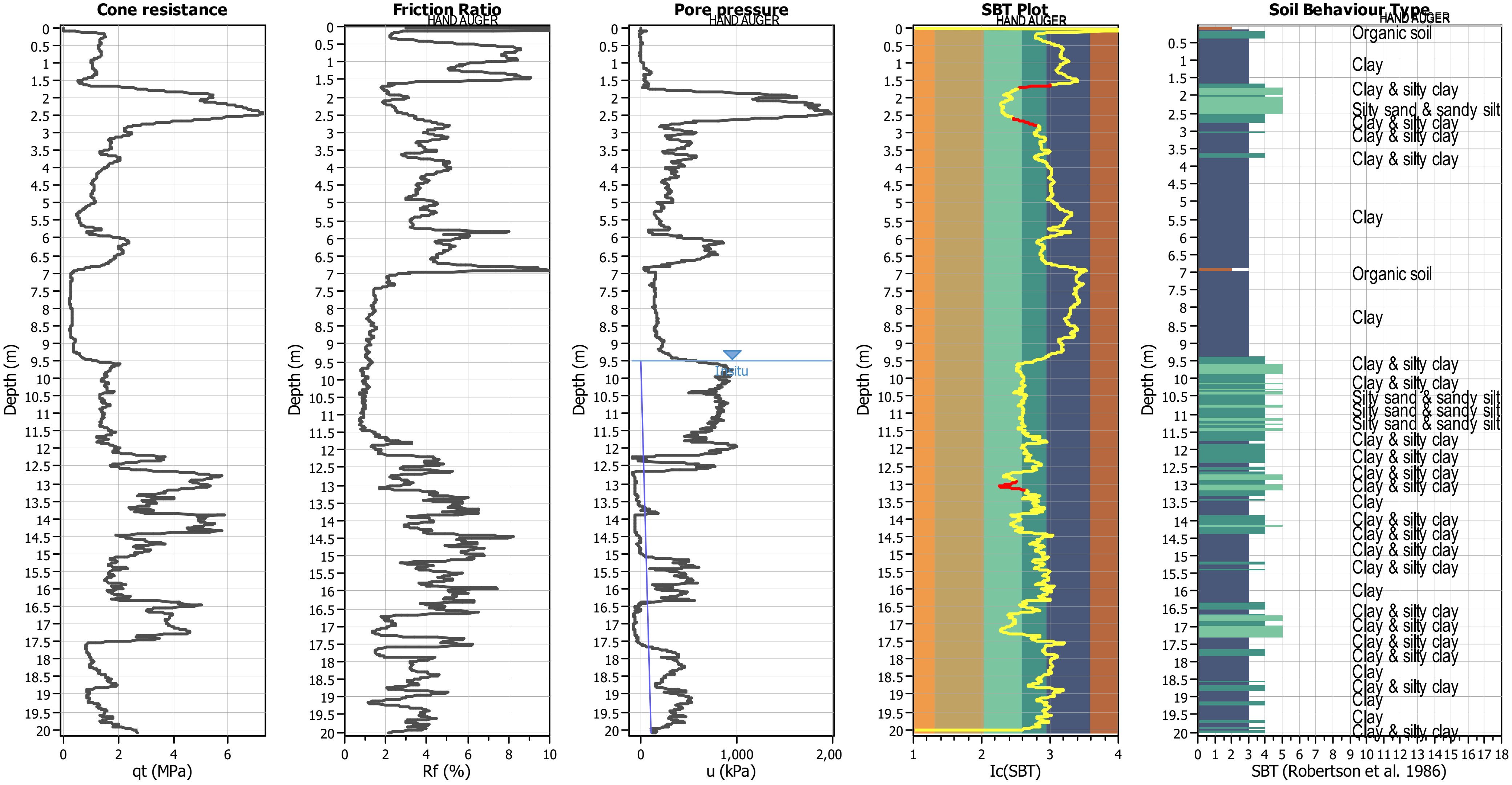






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



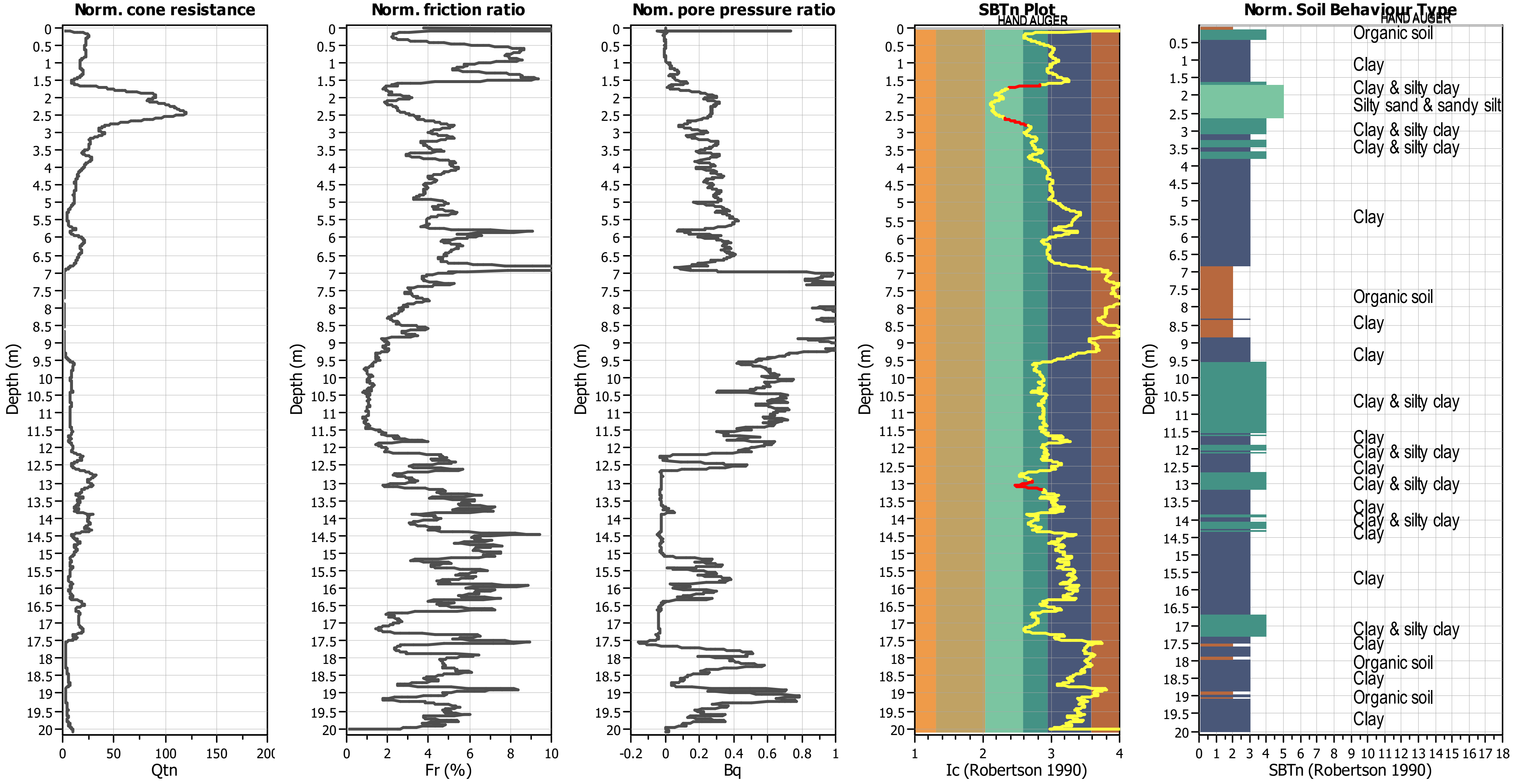
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



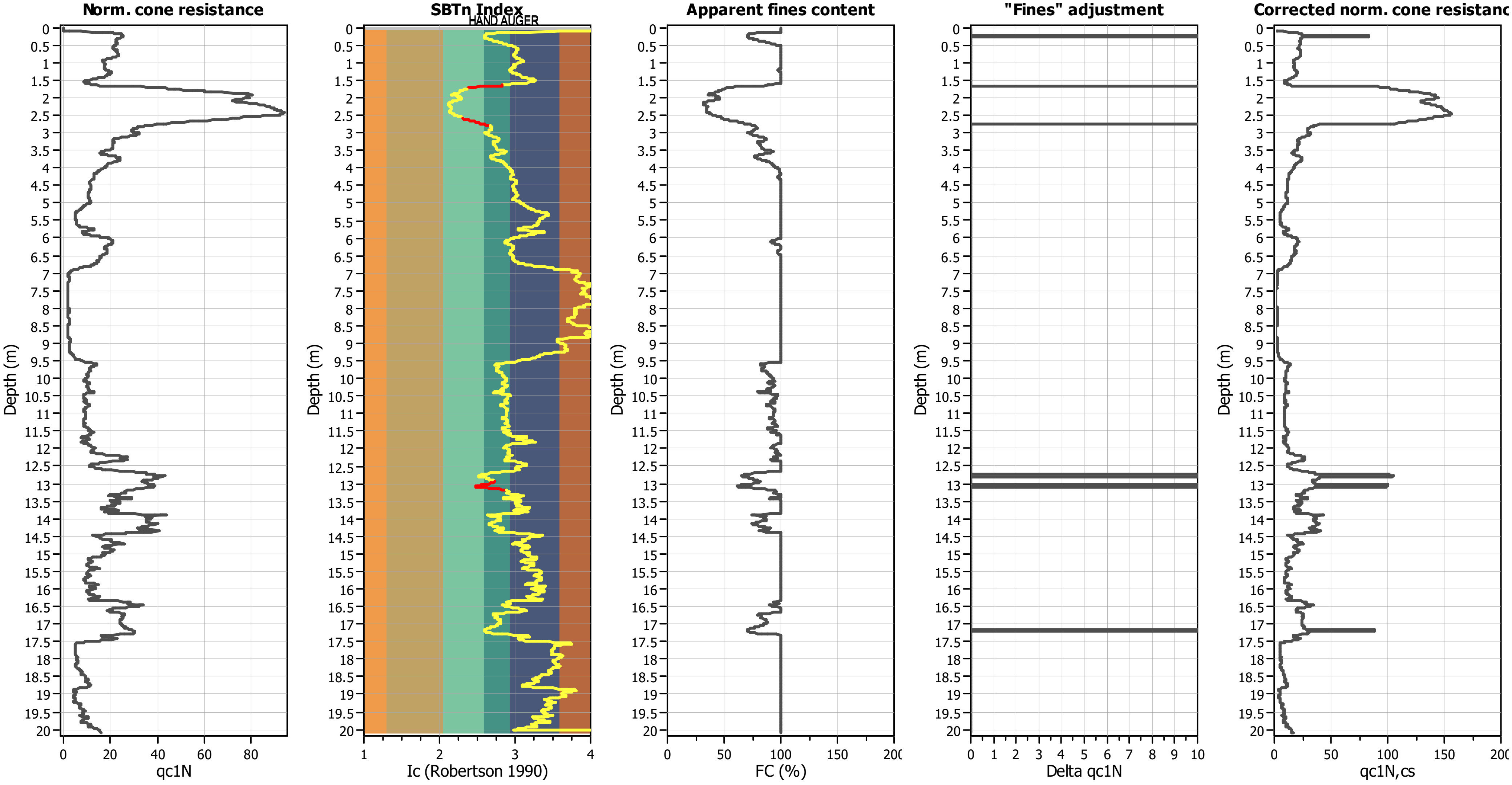
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K$_\sigma$ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to
⬜ 9. Very stiff fine grained

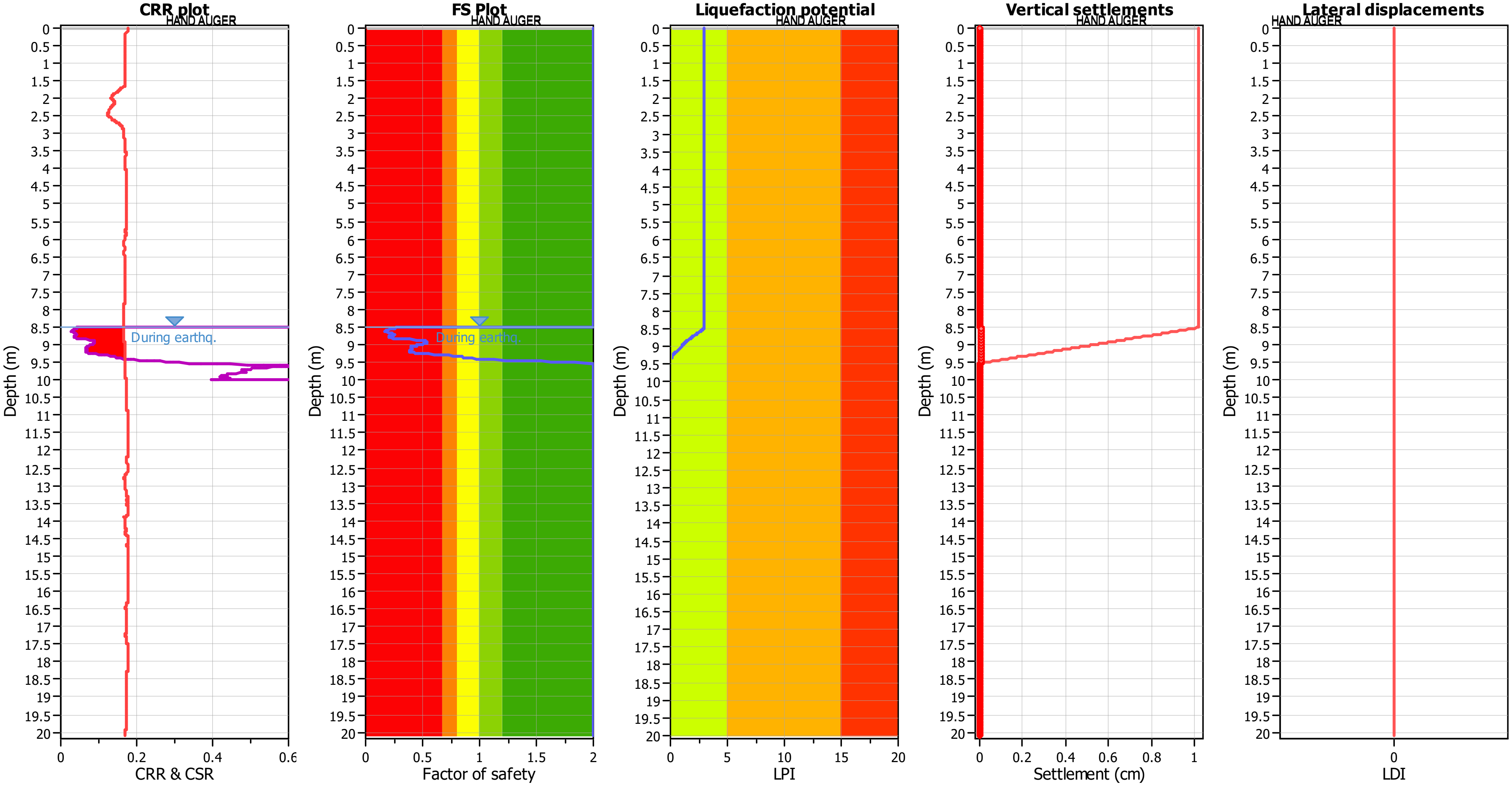
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.32
Depth to water table (insitu): 9.50 m

Depth to GWT (erthq.): 8.50 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

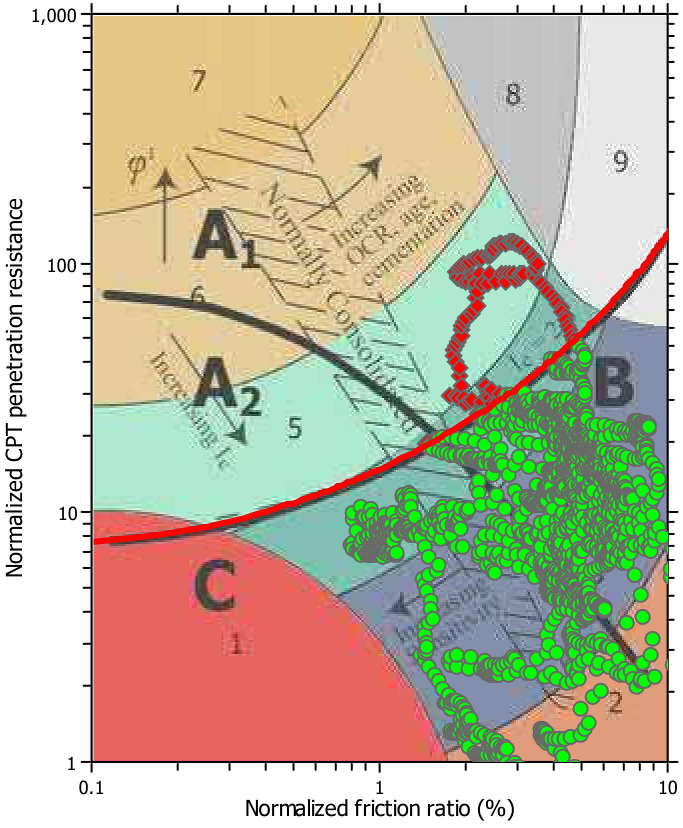
F.S. color scheme

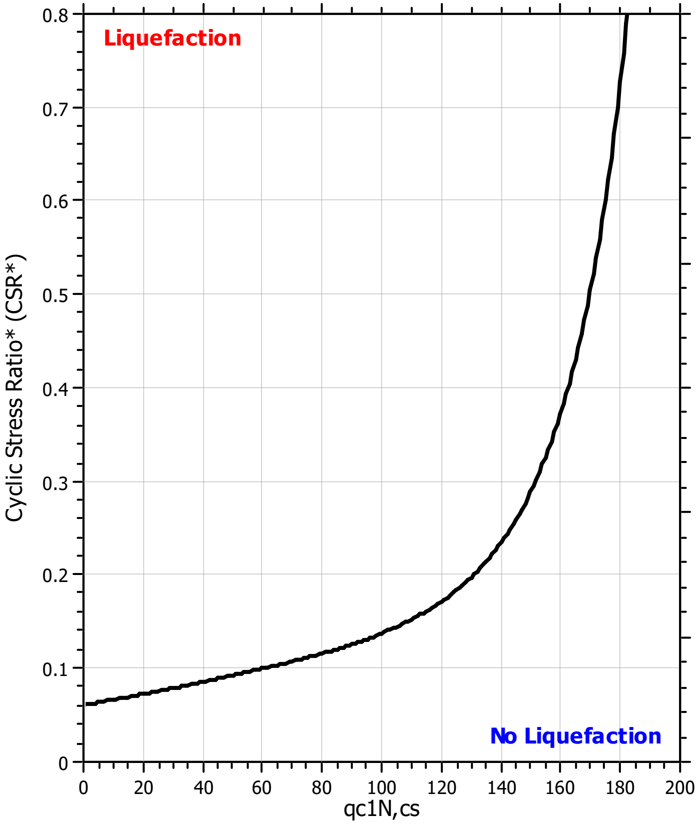
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

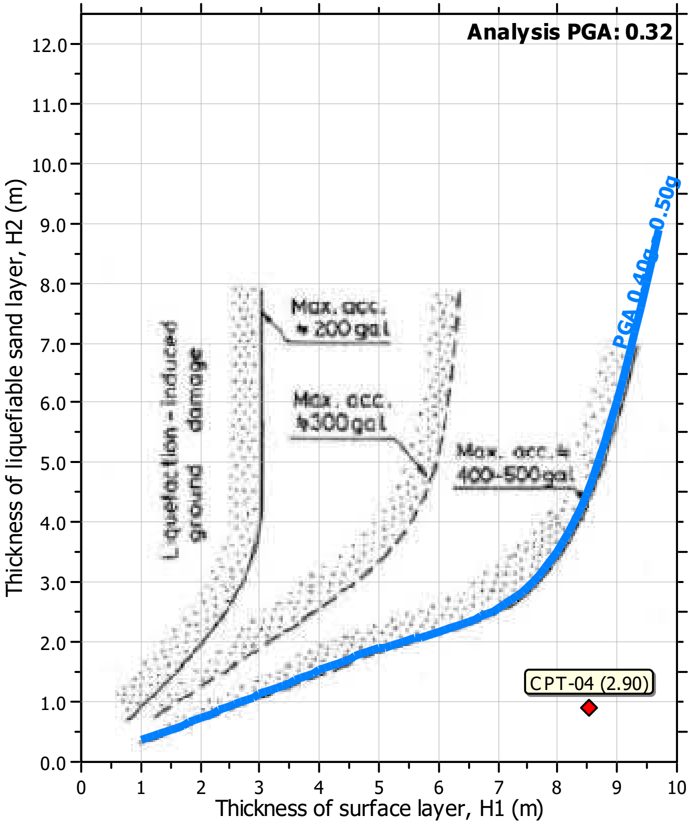
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟩 Low risk

Liquefaction analysis summary plots



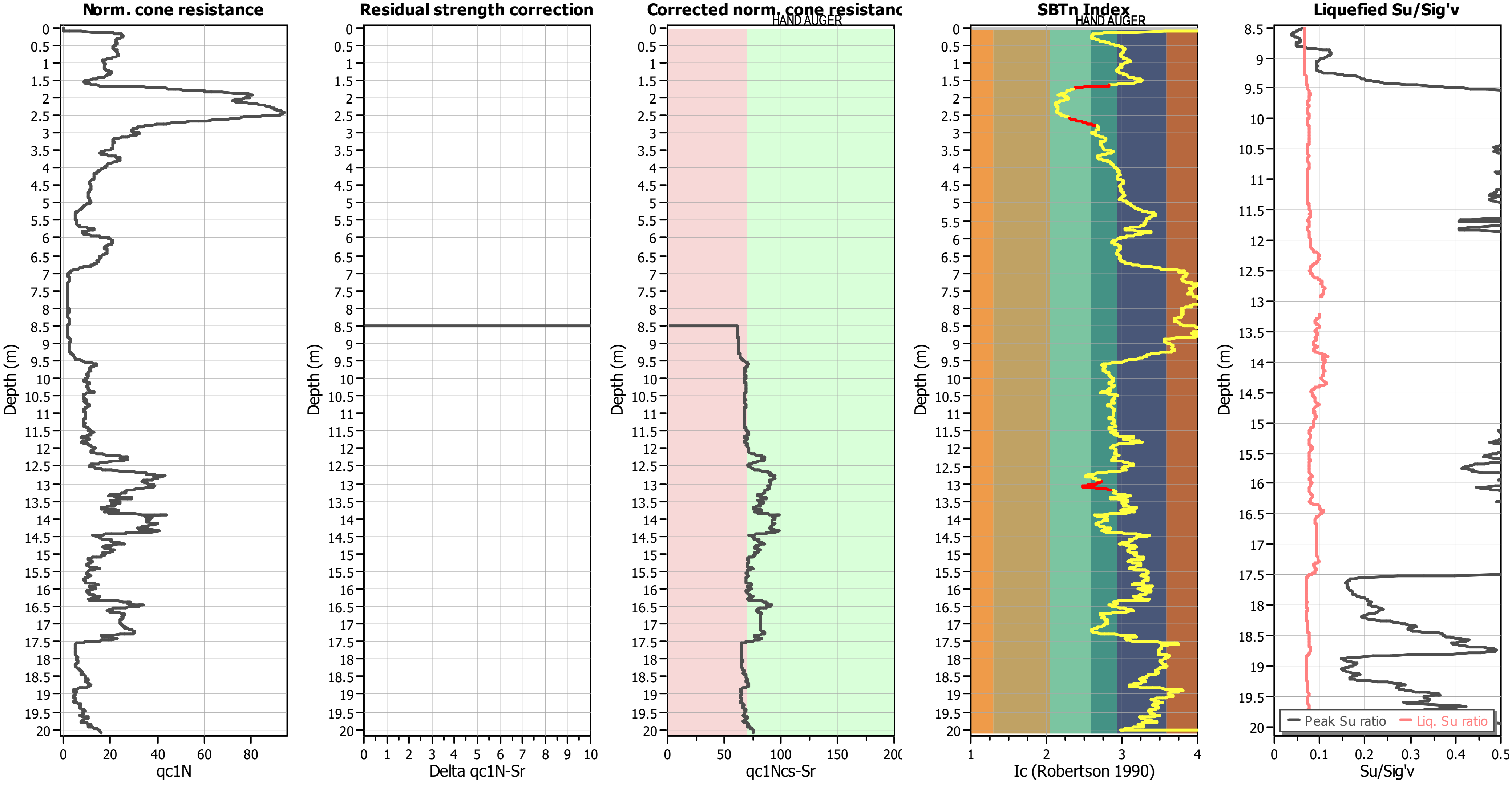




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	8.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	9.50 m	Fill height:	N/A	Limit depth:	10.00 m

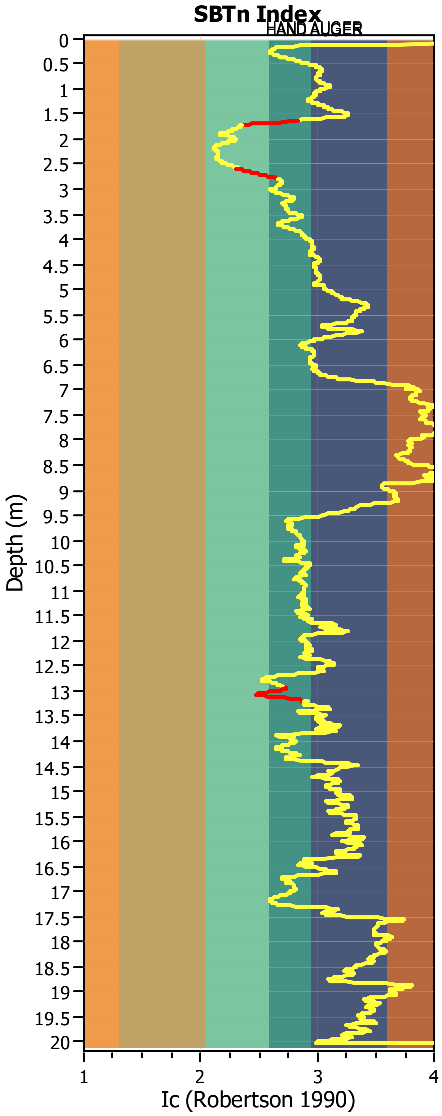
TRANSITION LAYER DETECTION ALGORITHM REPORT

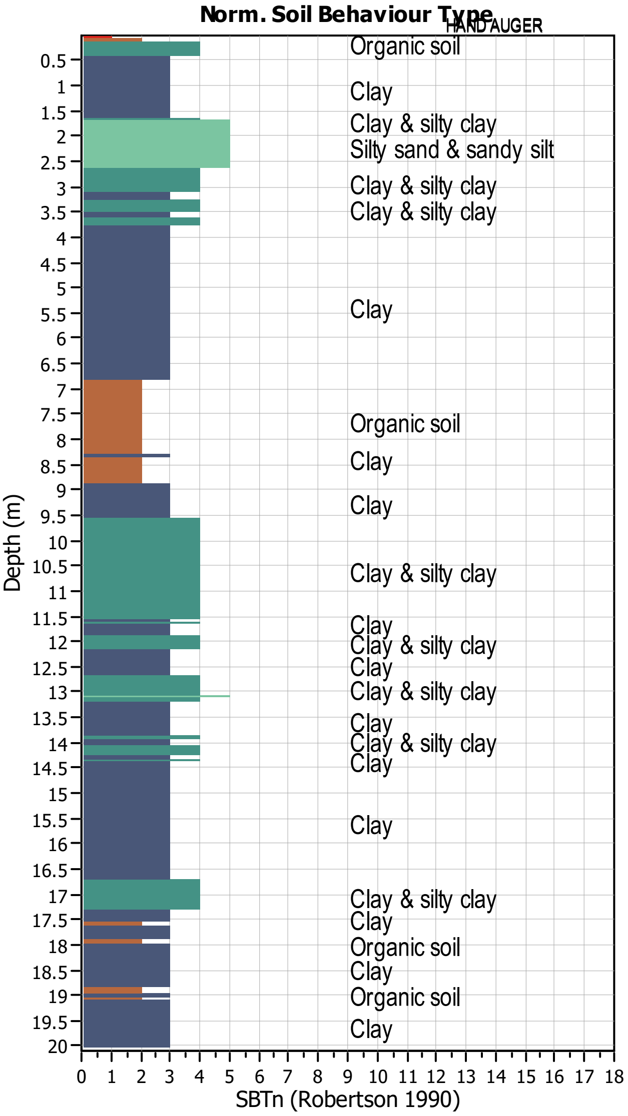
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





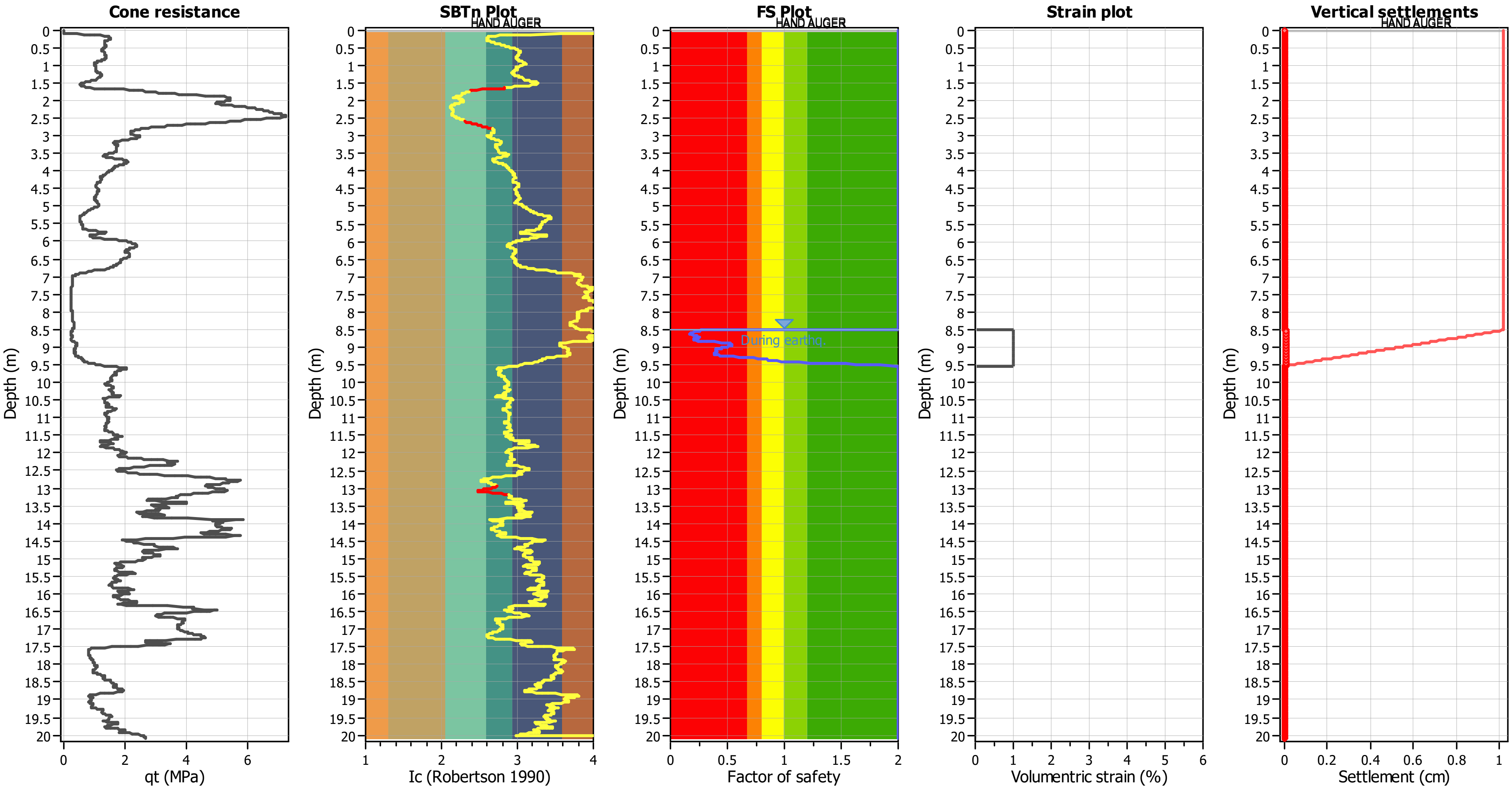
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	59
Exclusion percentage:	2.94%
Number of layers detected:	4

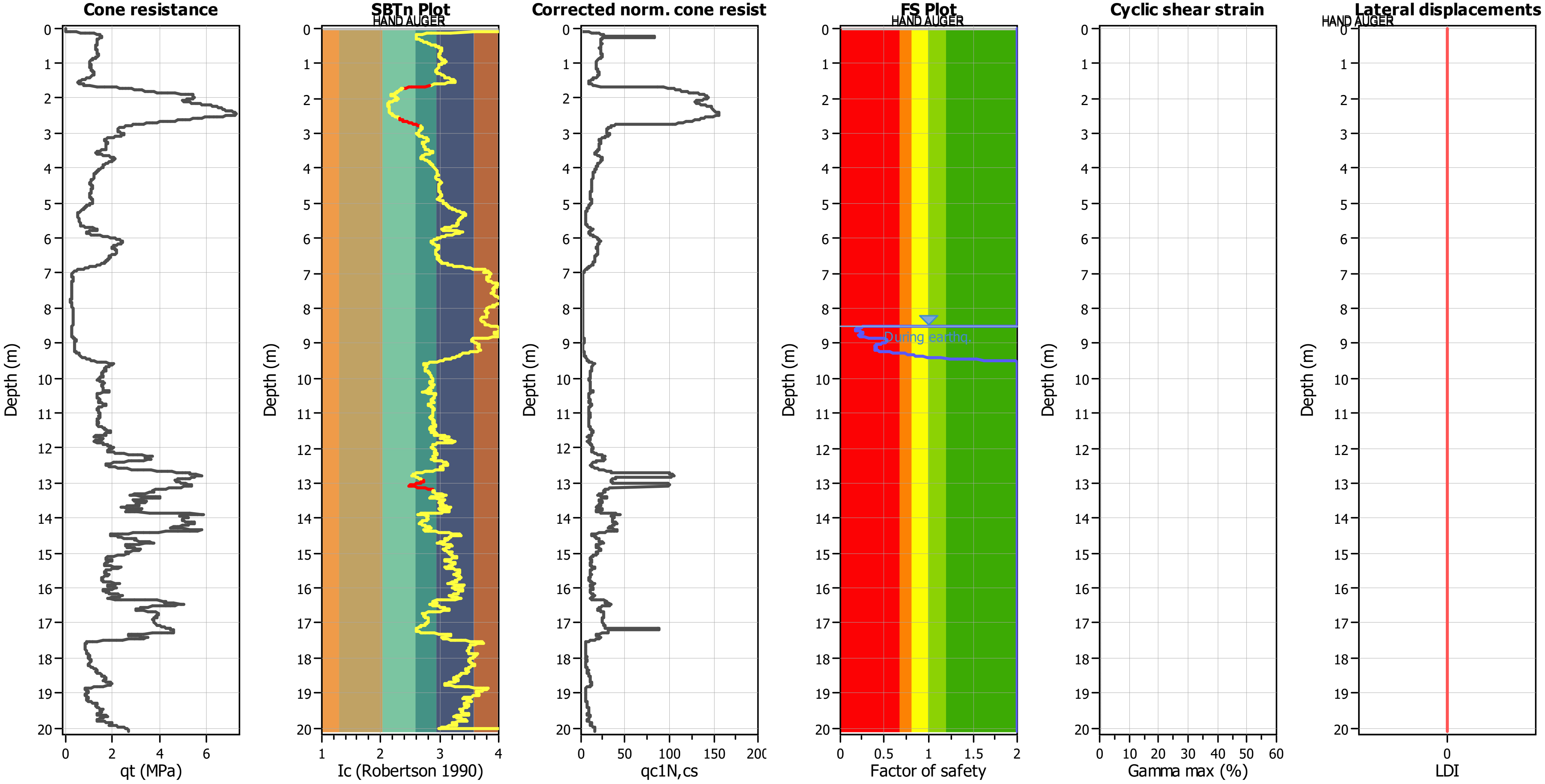
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

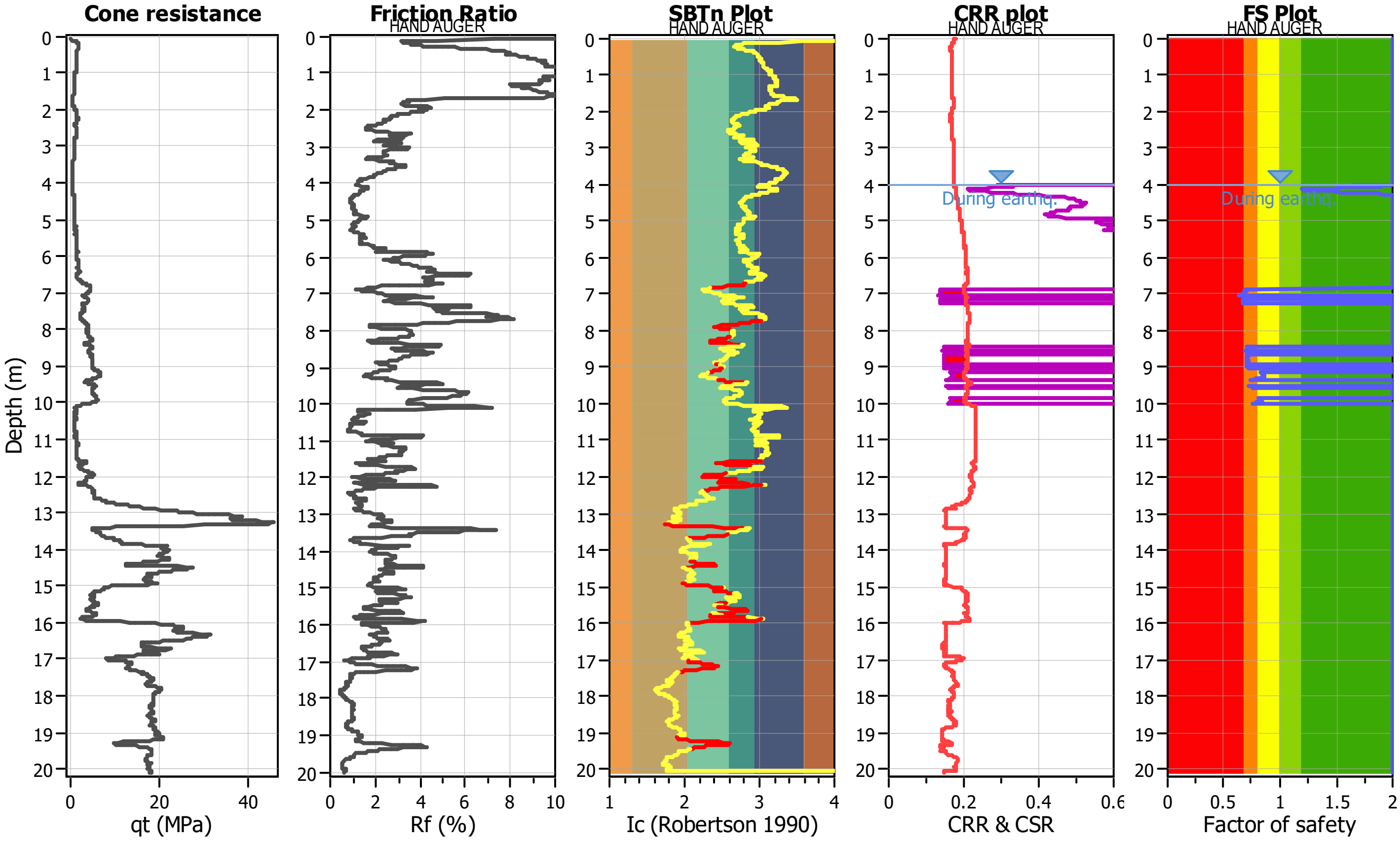
LIQUEFACTION ANALYSIS REPORT

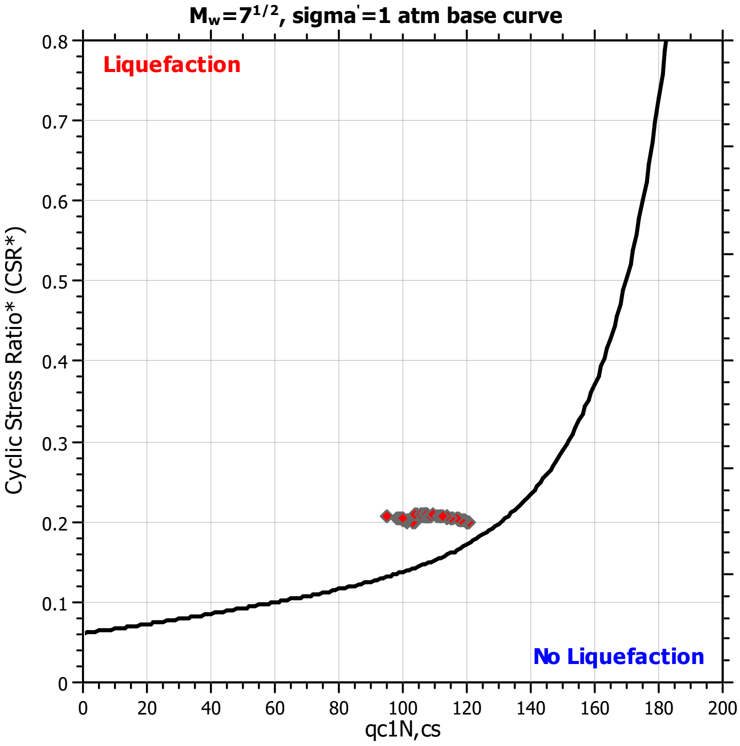
Project title : Proposed Private Plan Change for Te Awamutu **Location : 2025 Ohaupo Road, Te Awamutu**

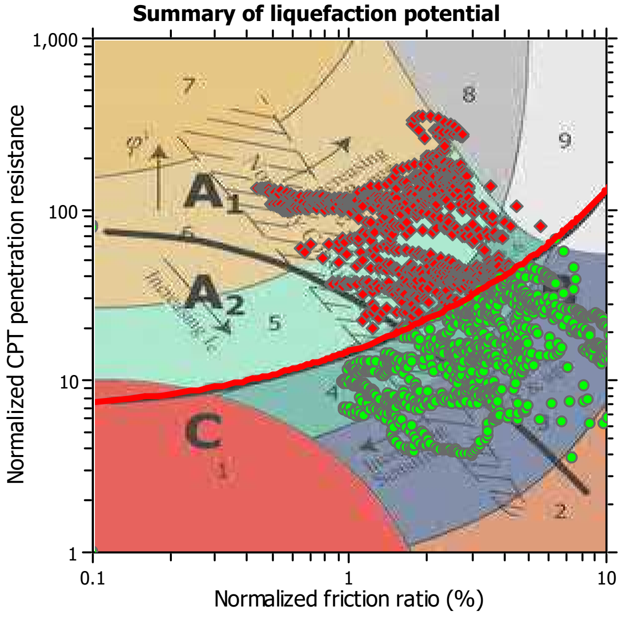
CPT file : CPT-05

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	5.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

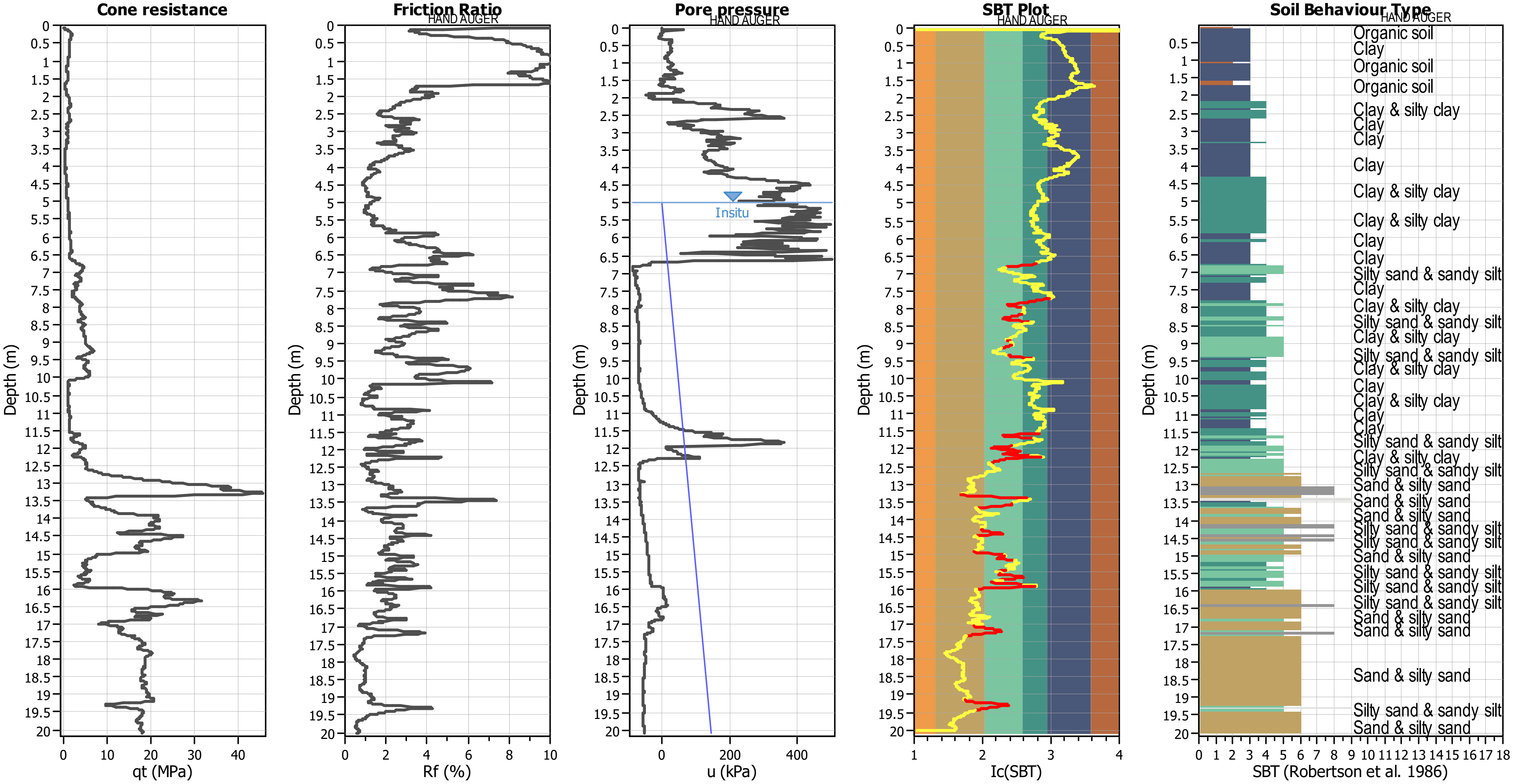






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



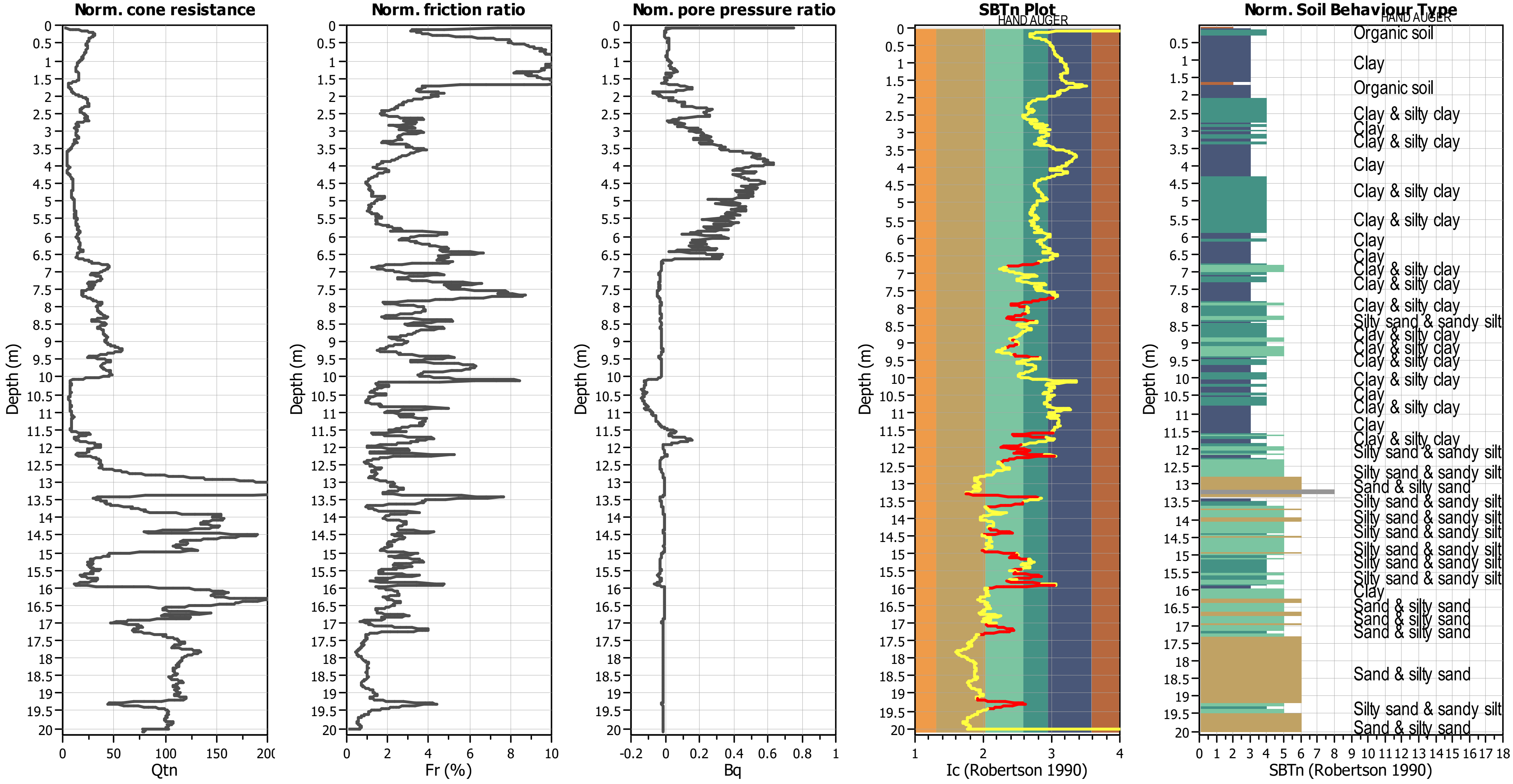
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT 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

CPT basic interpretation plots (normalized)



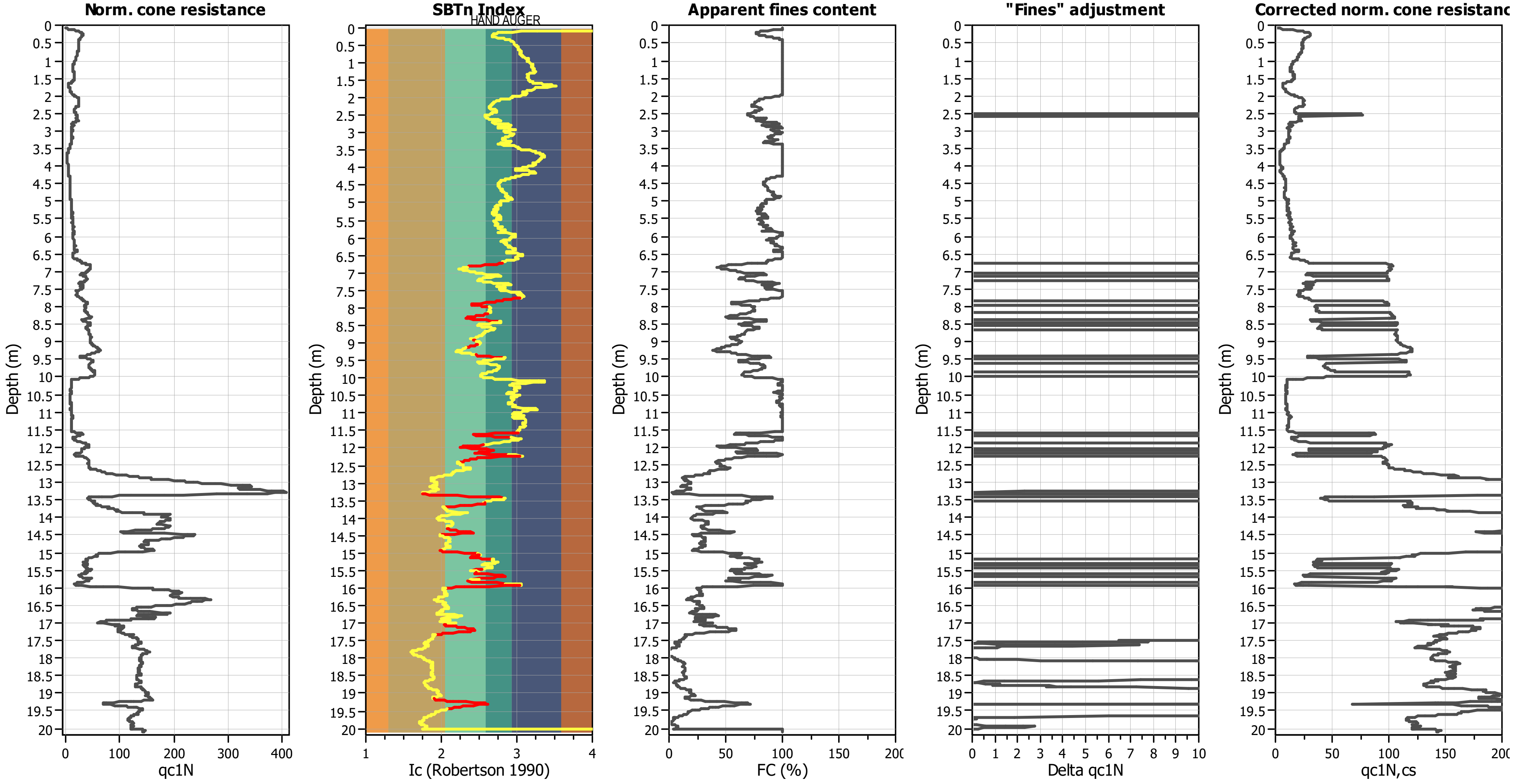
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ▨ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

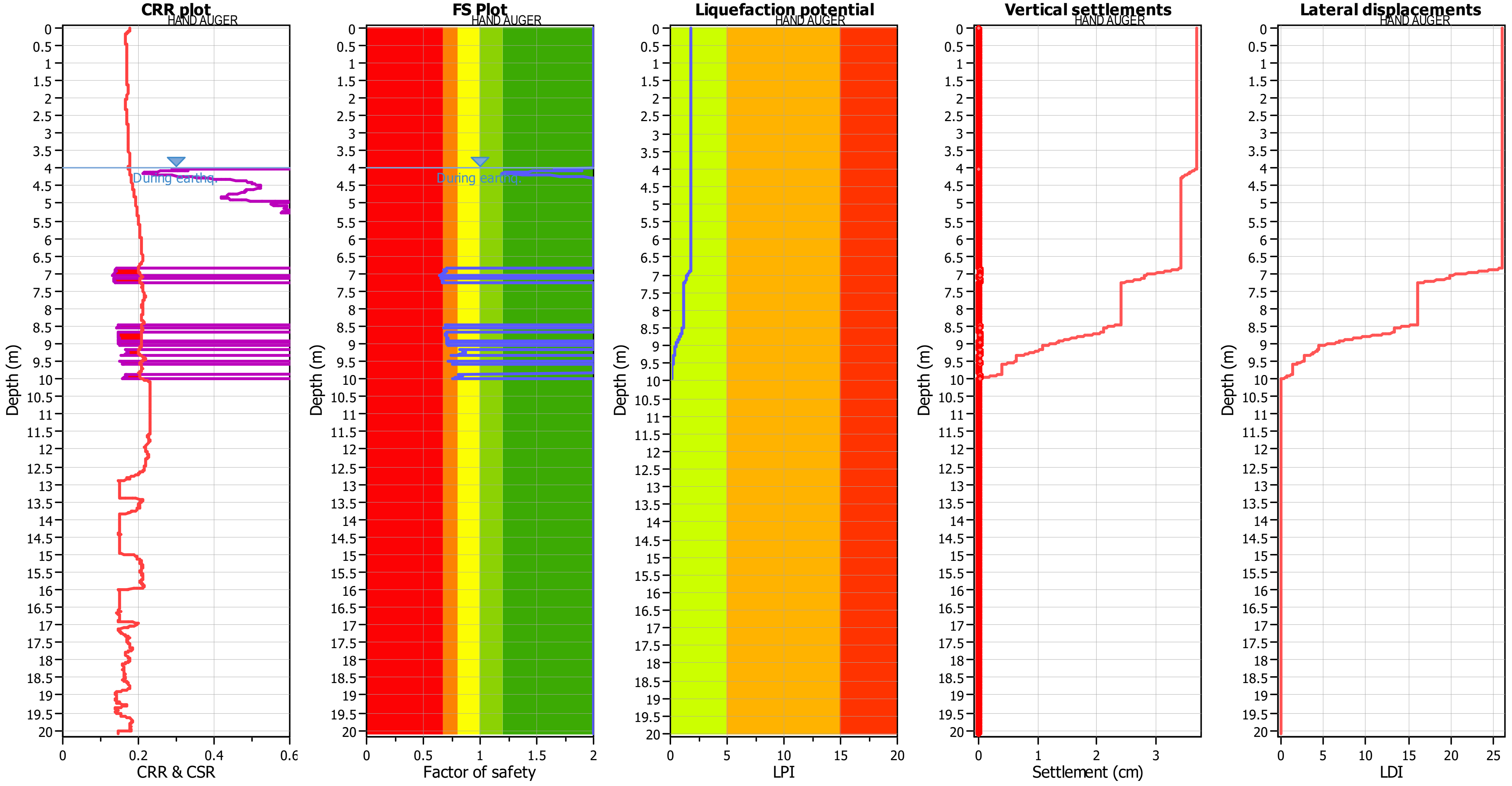
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

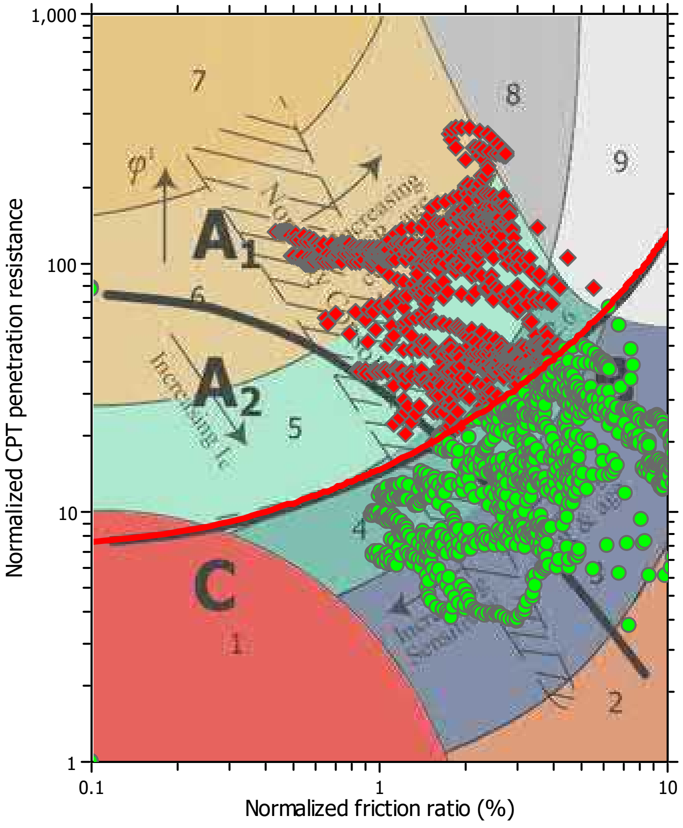
F.S. color scheme

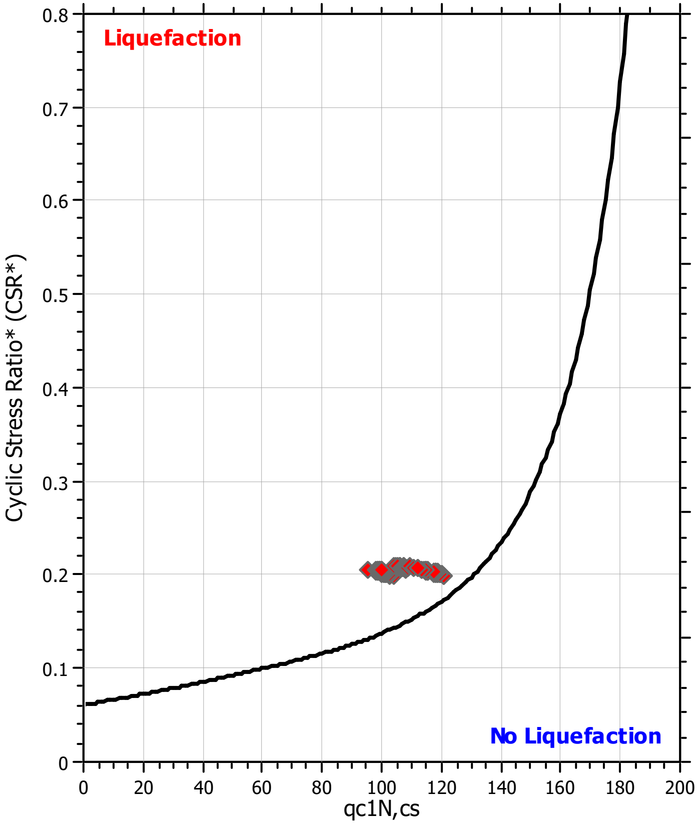
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

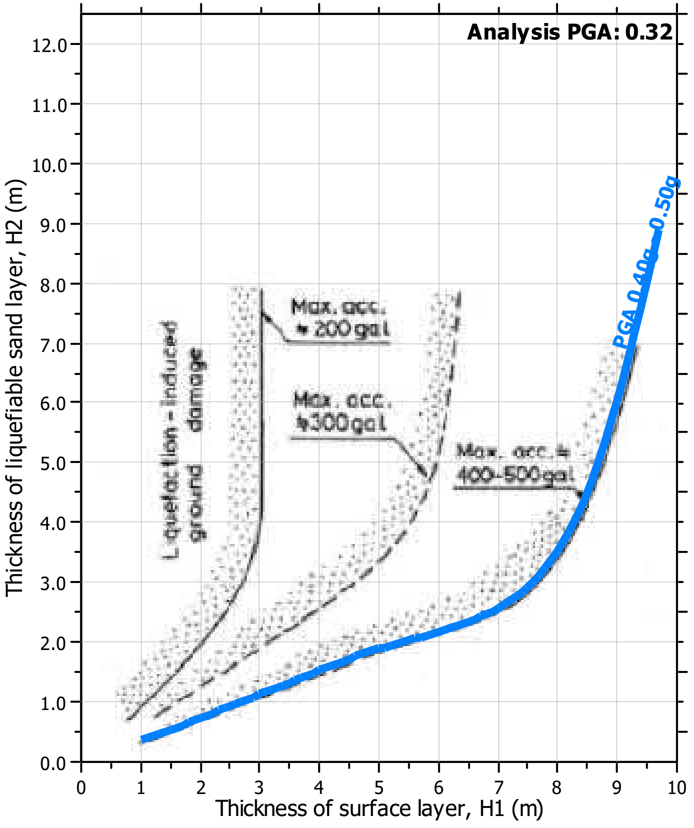
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



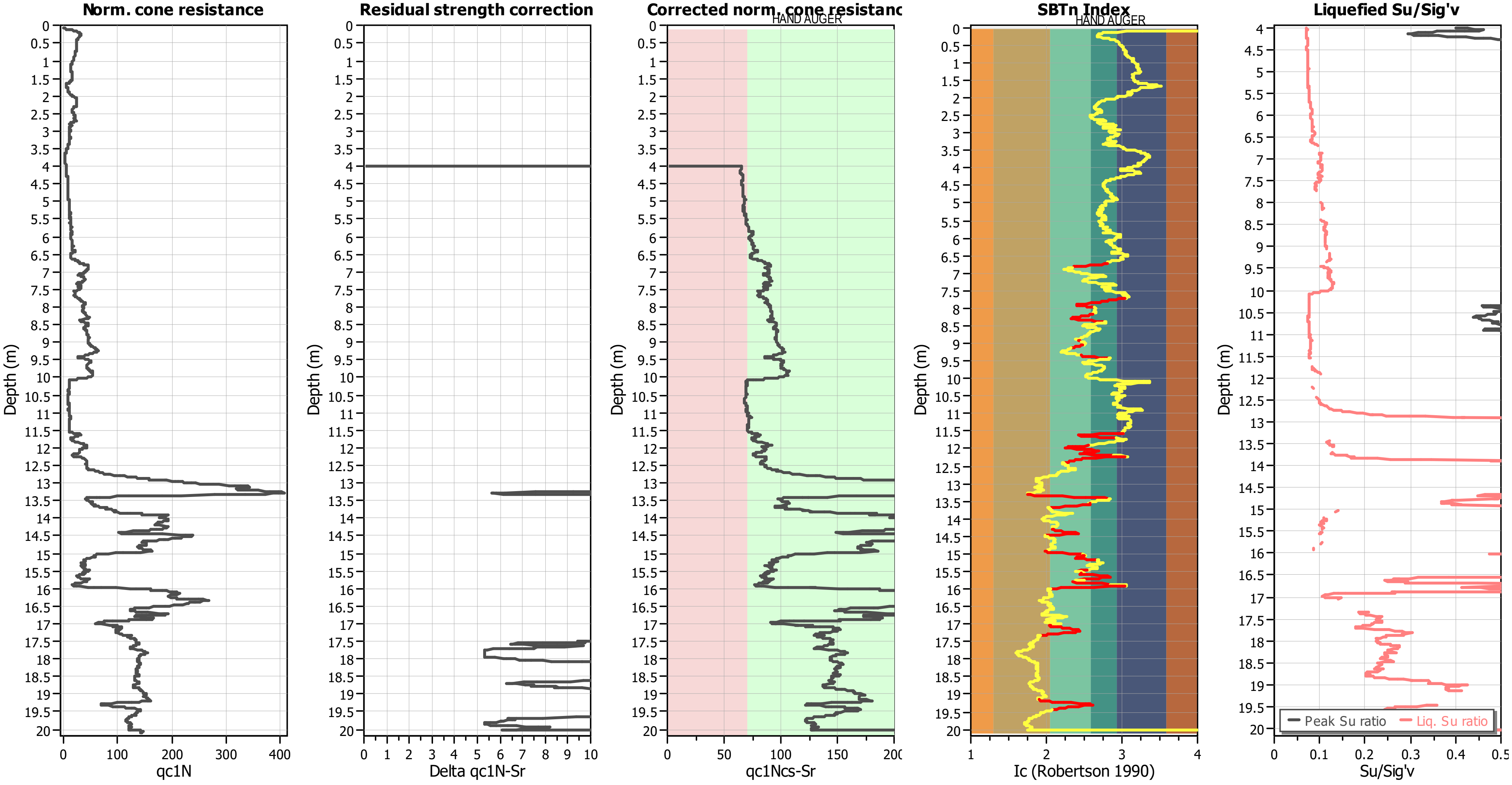




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

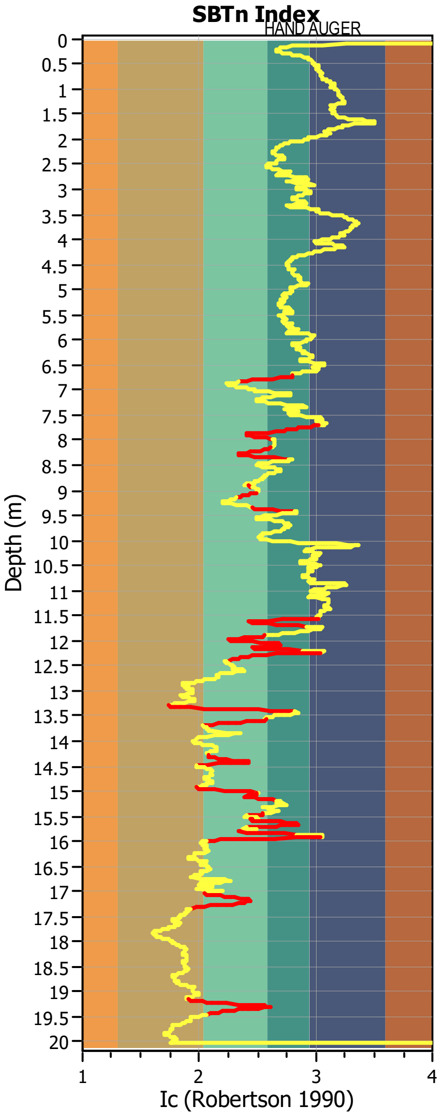
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

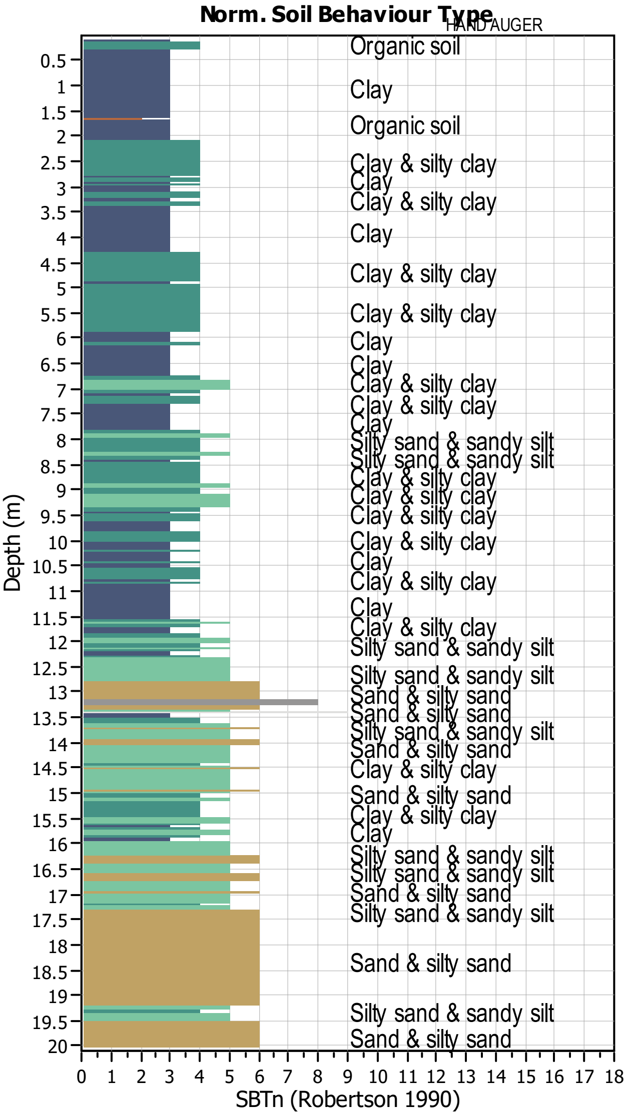
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





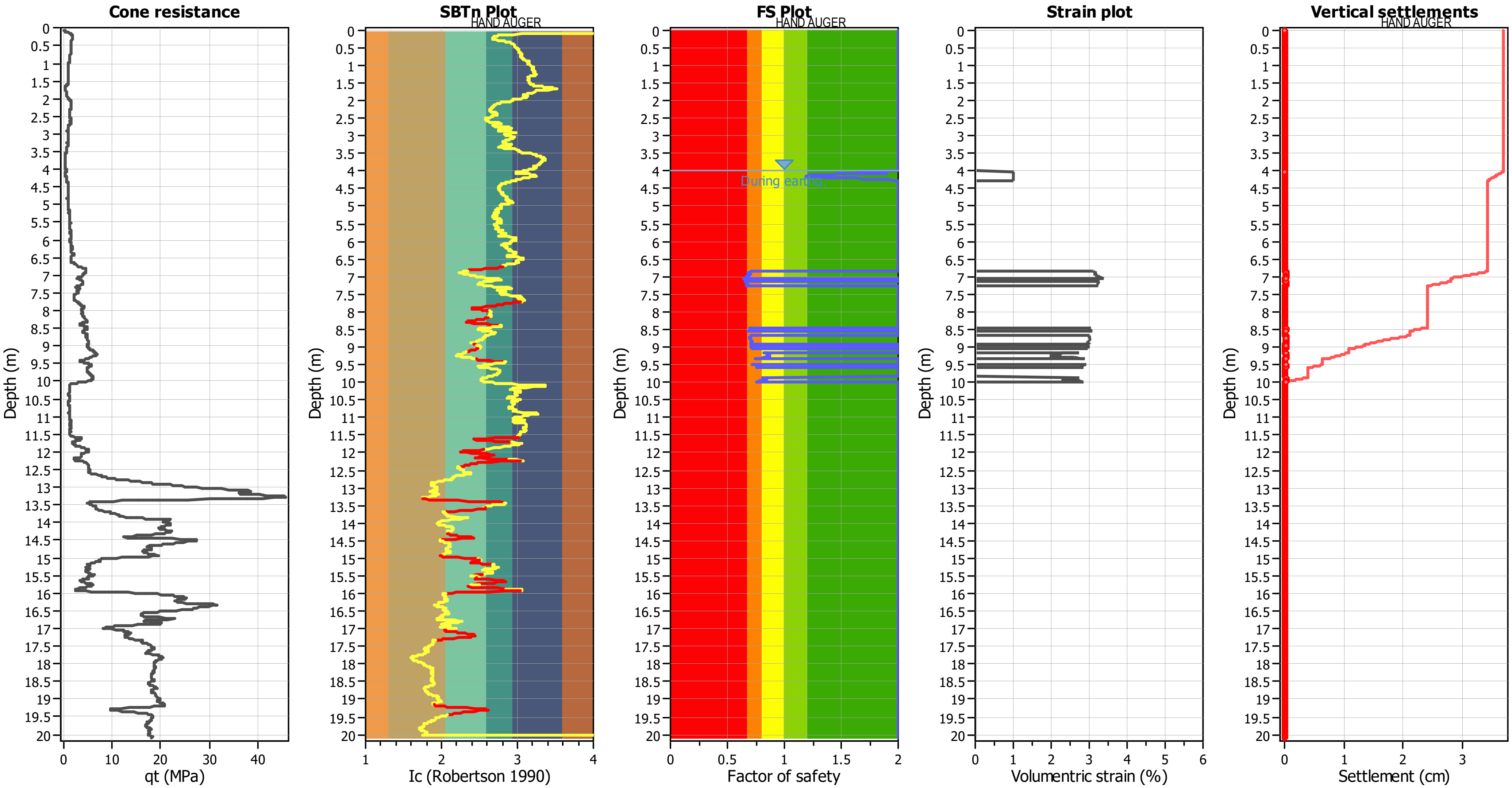
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	329
Exclusion percentage:	16.37%
Number of layers detected:	31

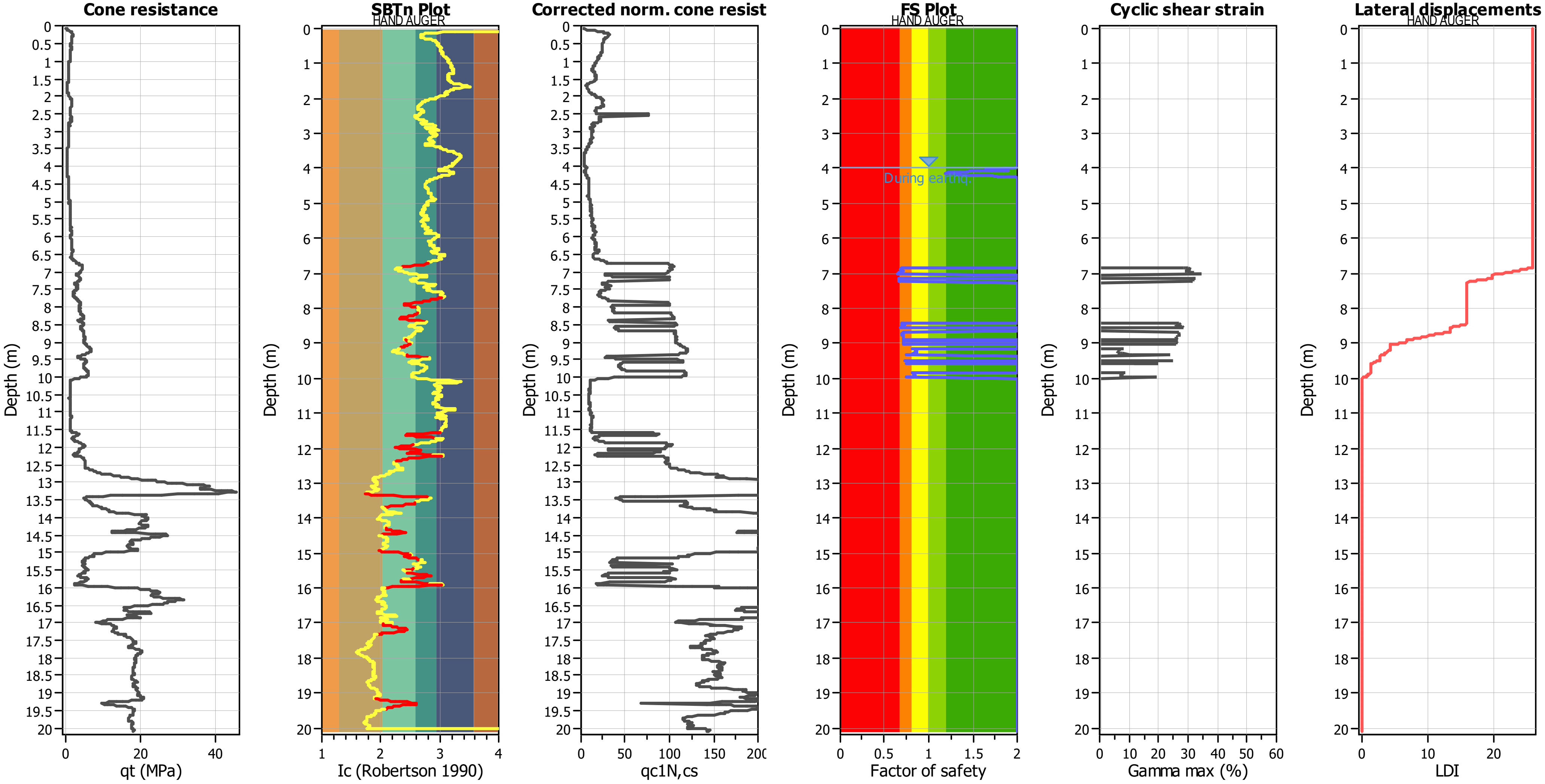
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

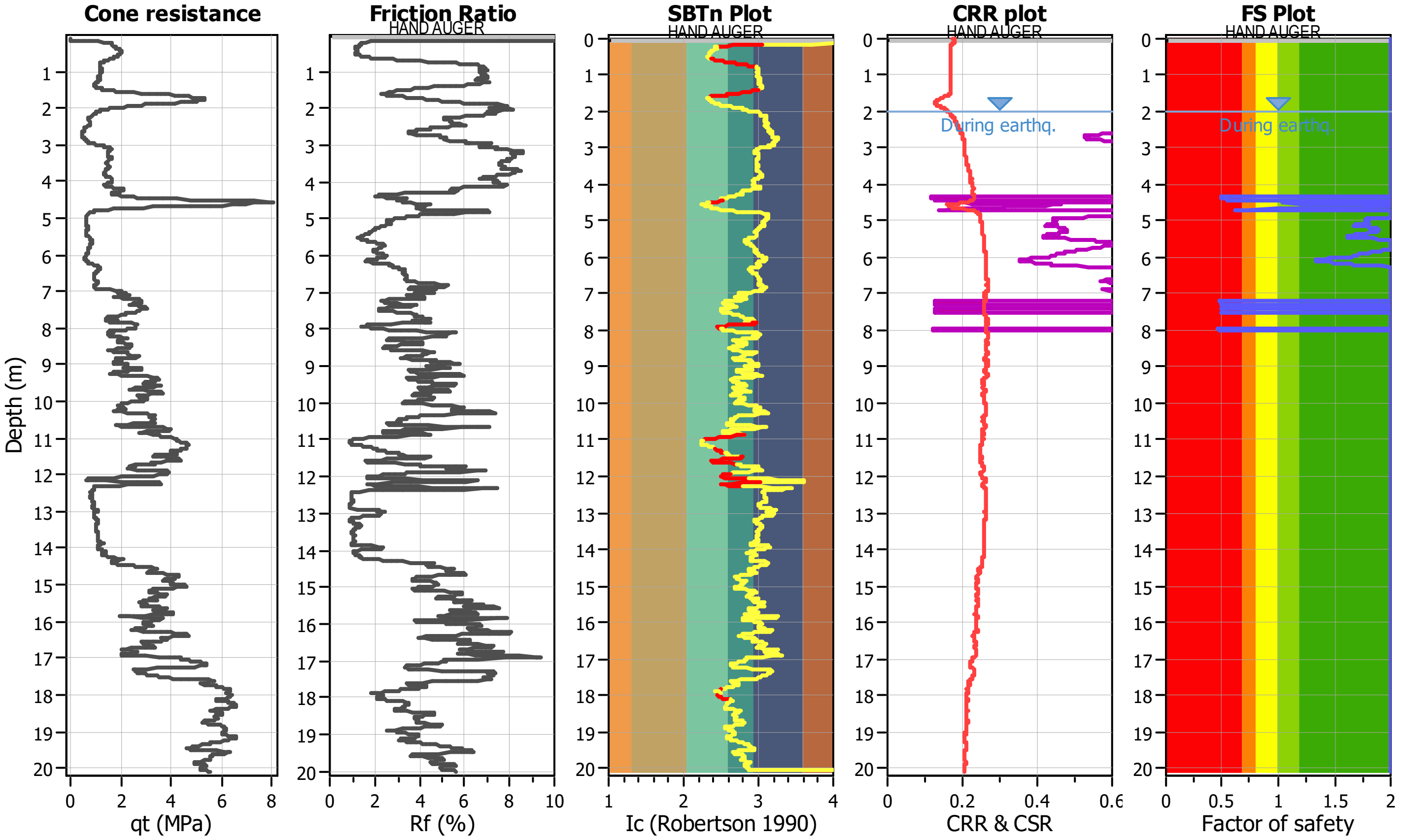
LIQUEFACTION ANALYSIS REPORT

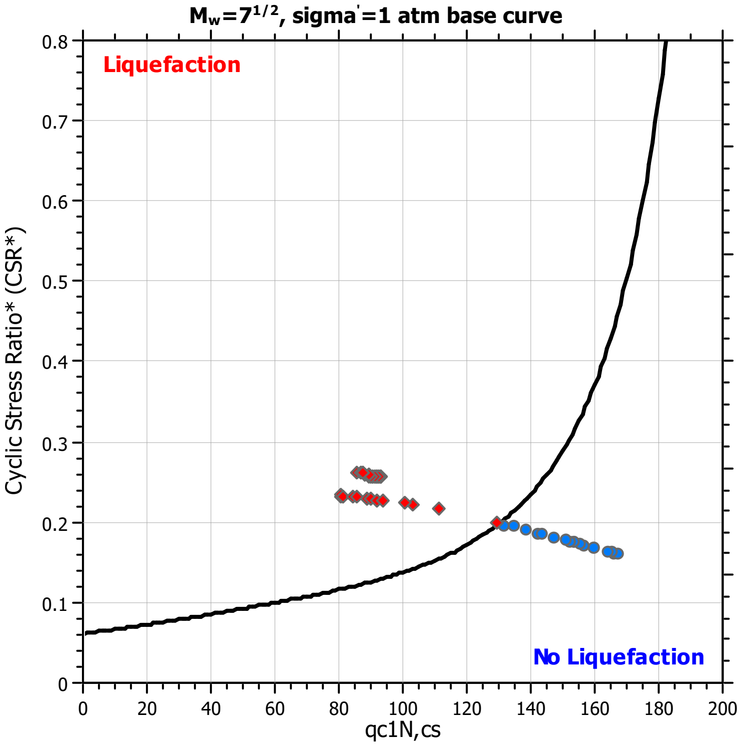
Project title : Proposed Private Plan Change for Te Awamutu   **Location : 2025 Ohaupo Road, Te Awamutu**

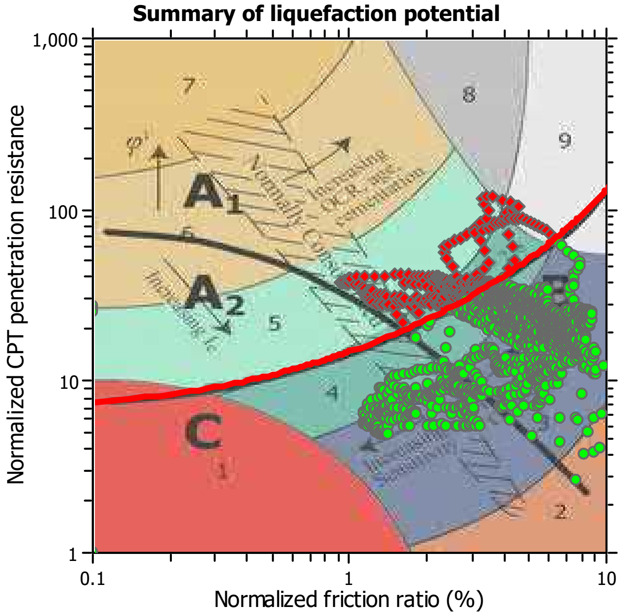
CPT file : CPT-06

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A		
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	10.00 m
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method

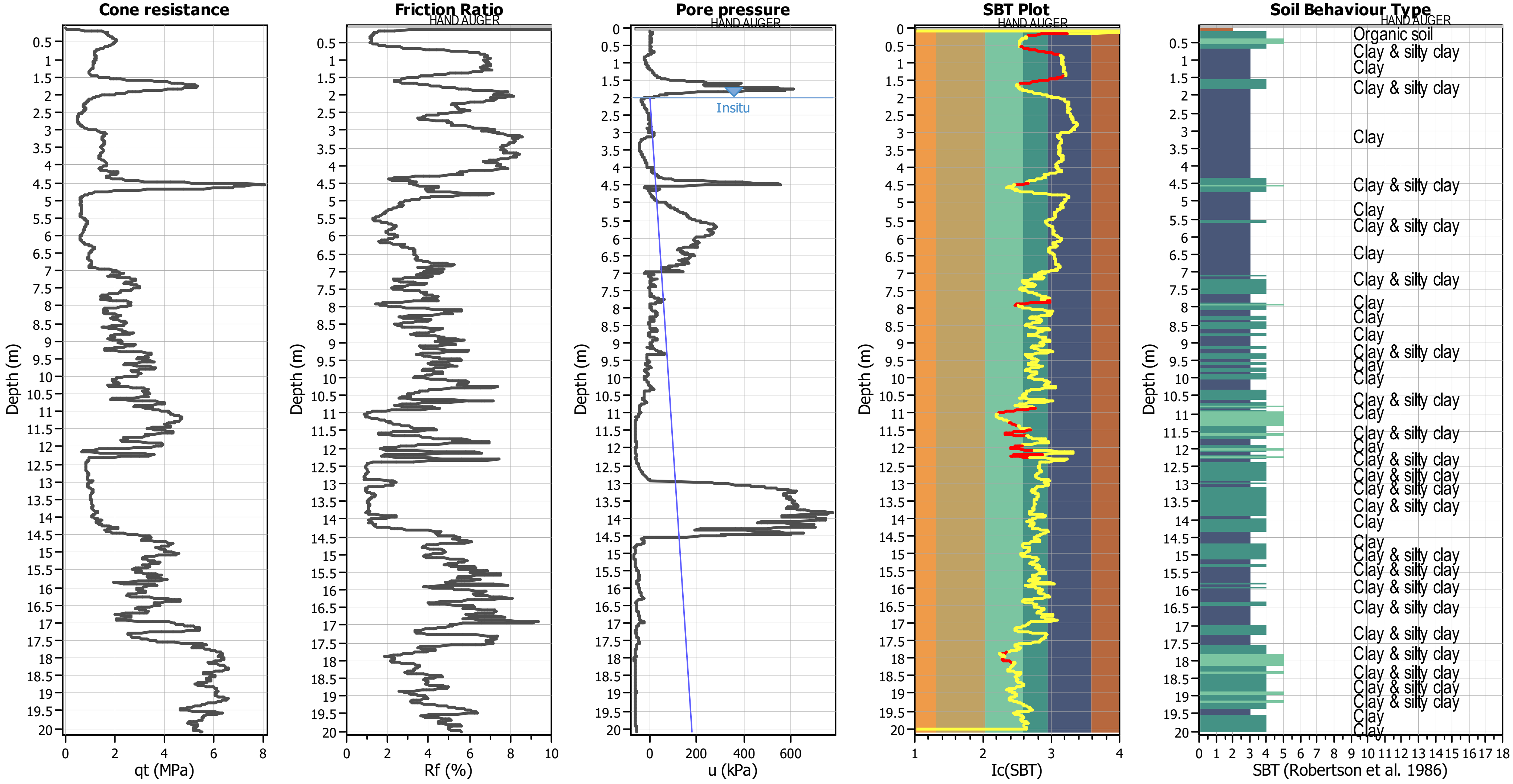






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



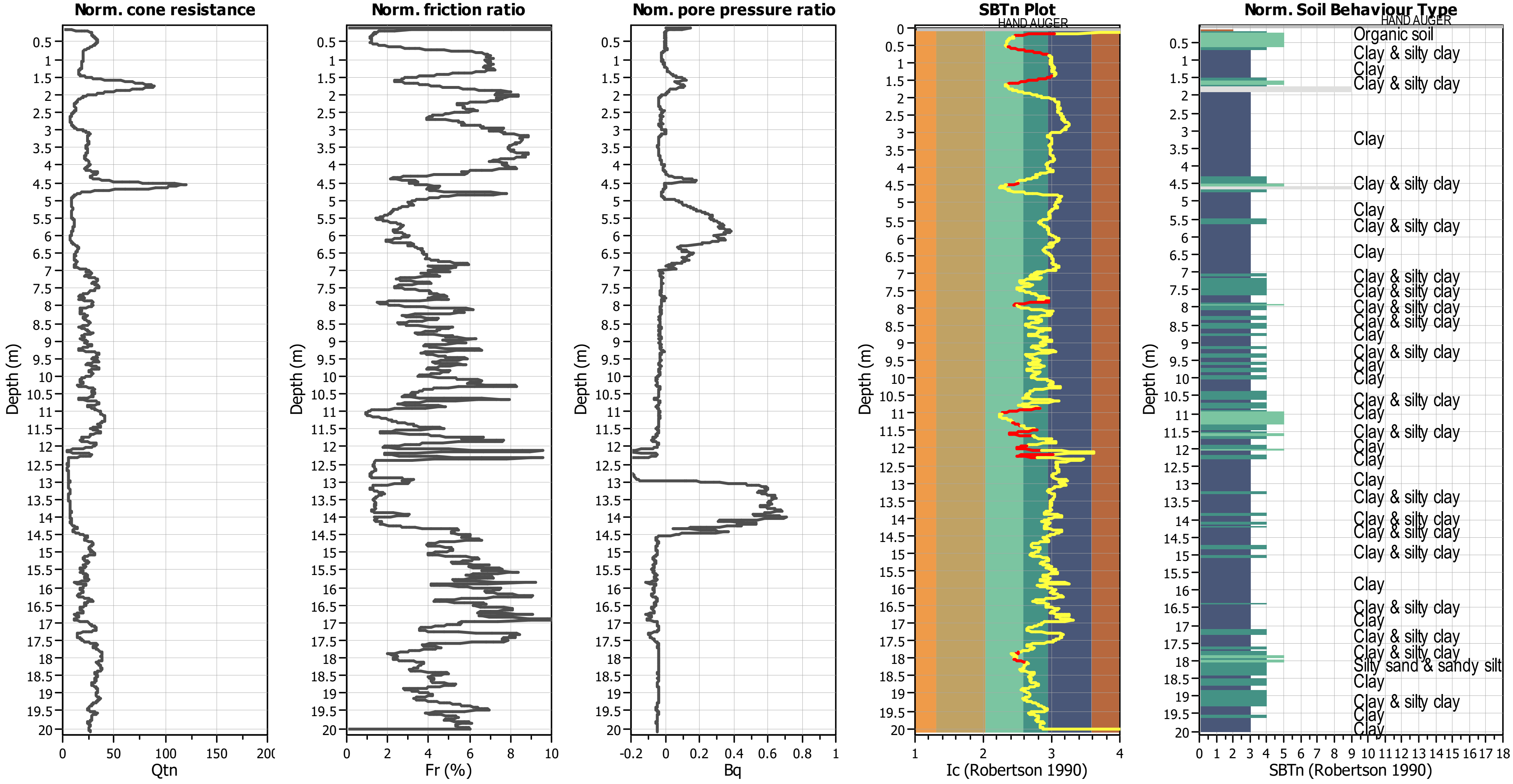
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

SBT 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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.32
Depth to water table (insitu): 2.00 m

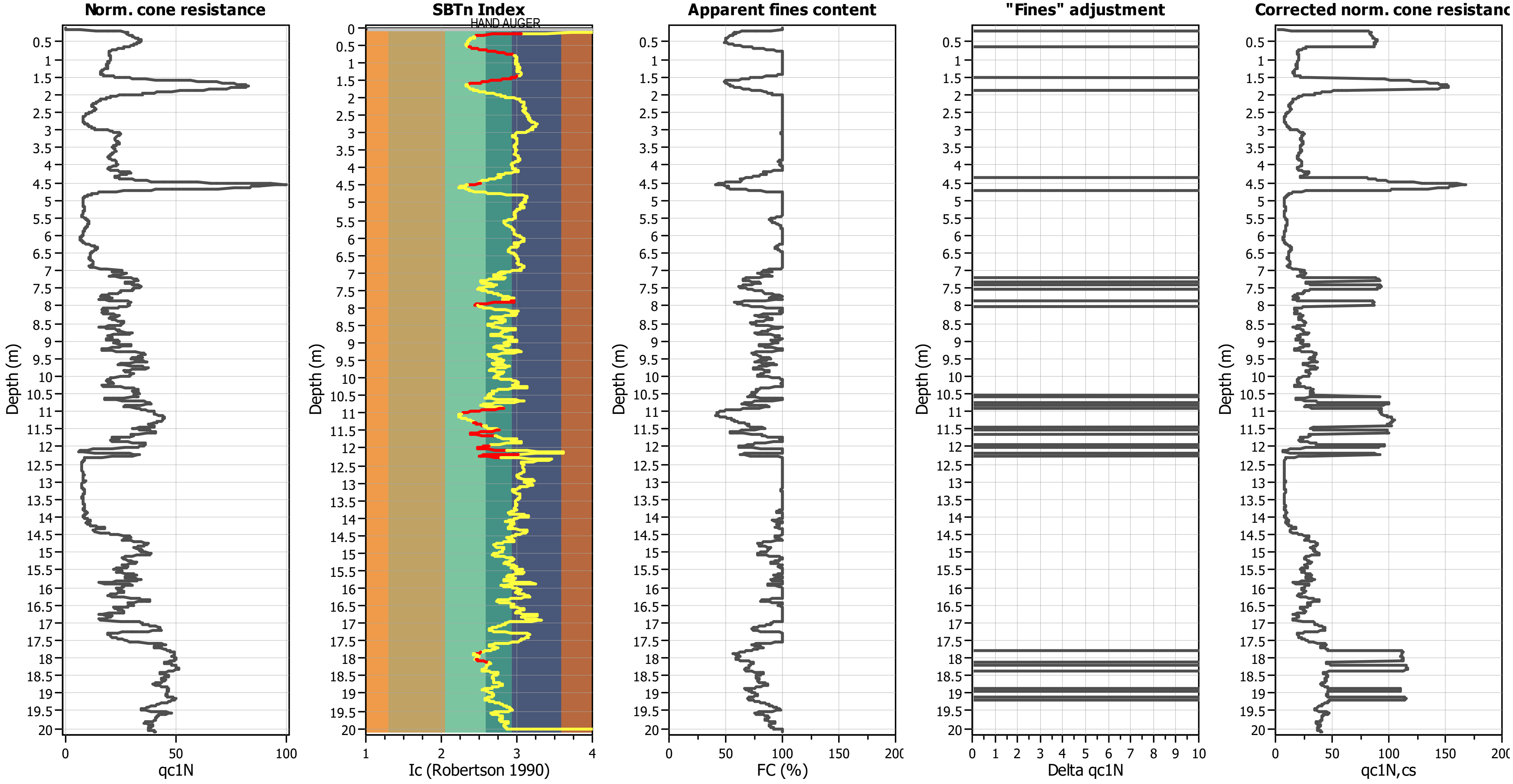
Depth to GWT (erthq.): 2.00 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

SBTn legend

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

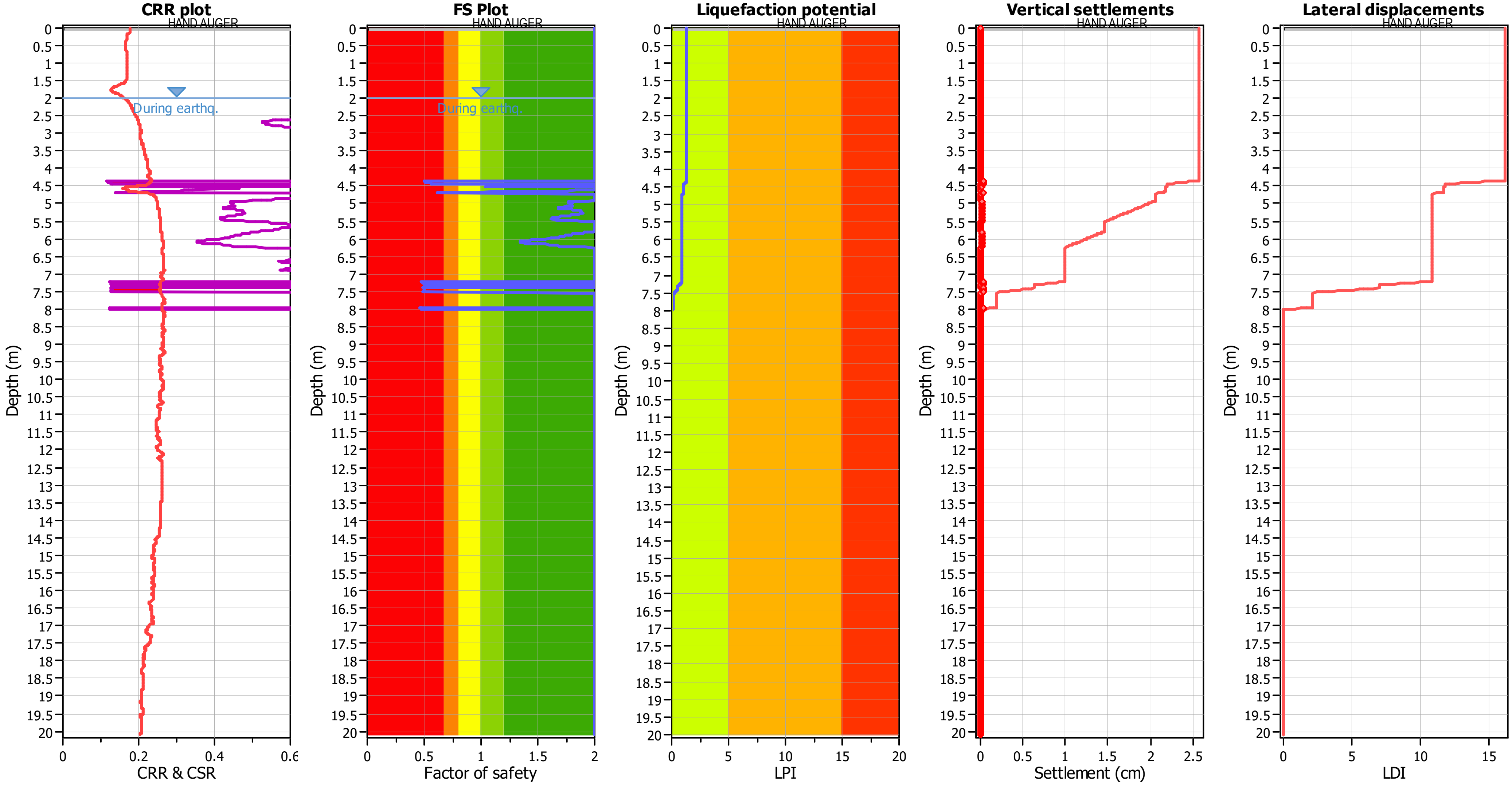
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

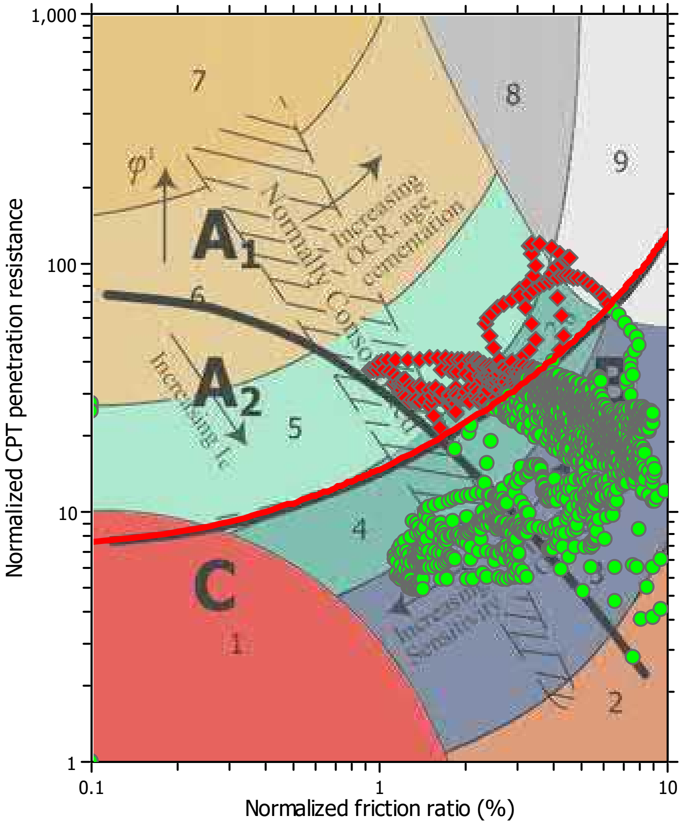
F.S. color scheme

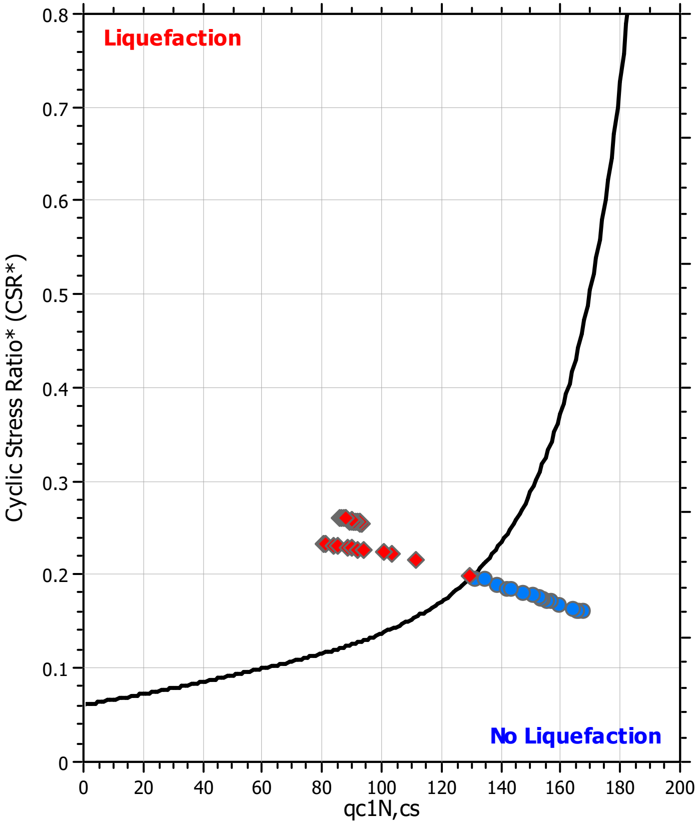
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

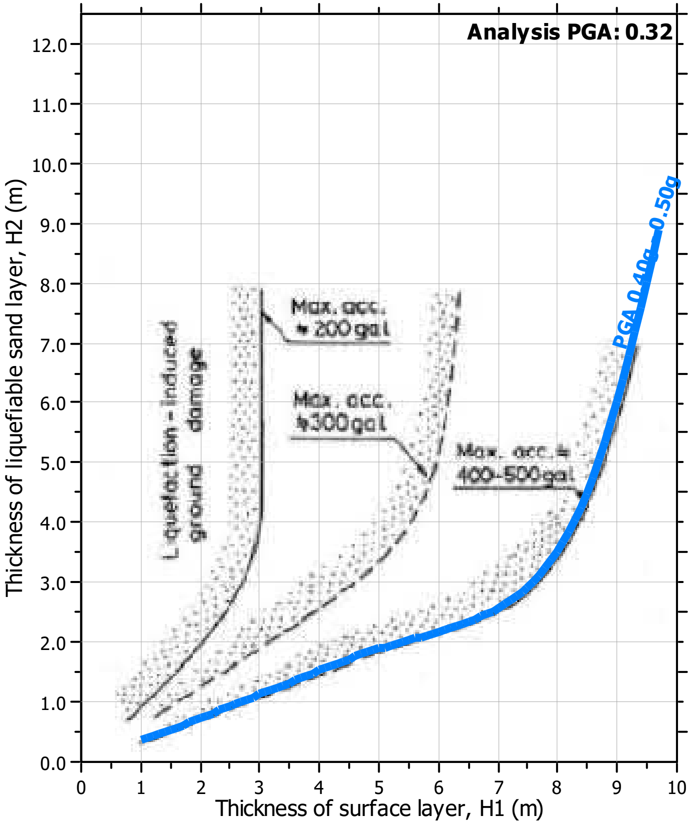
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



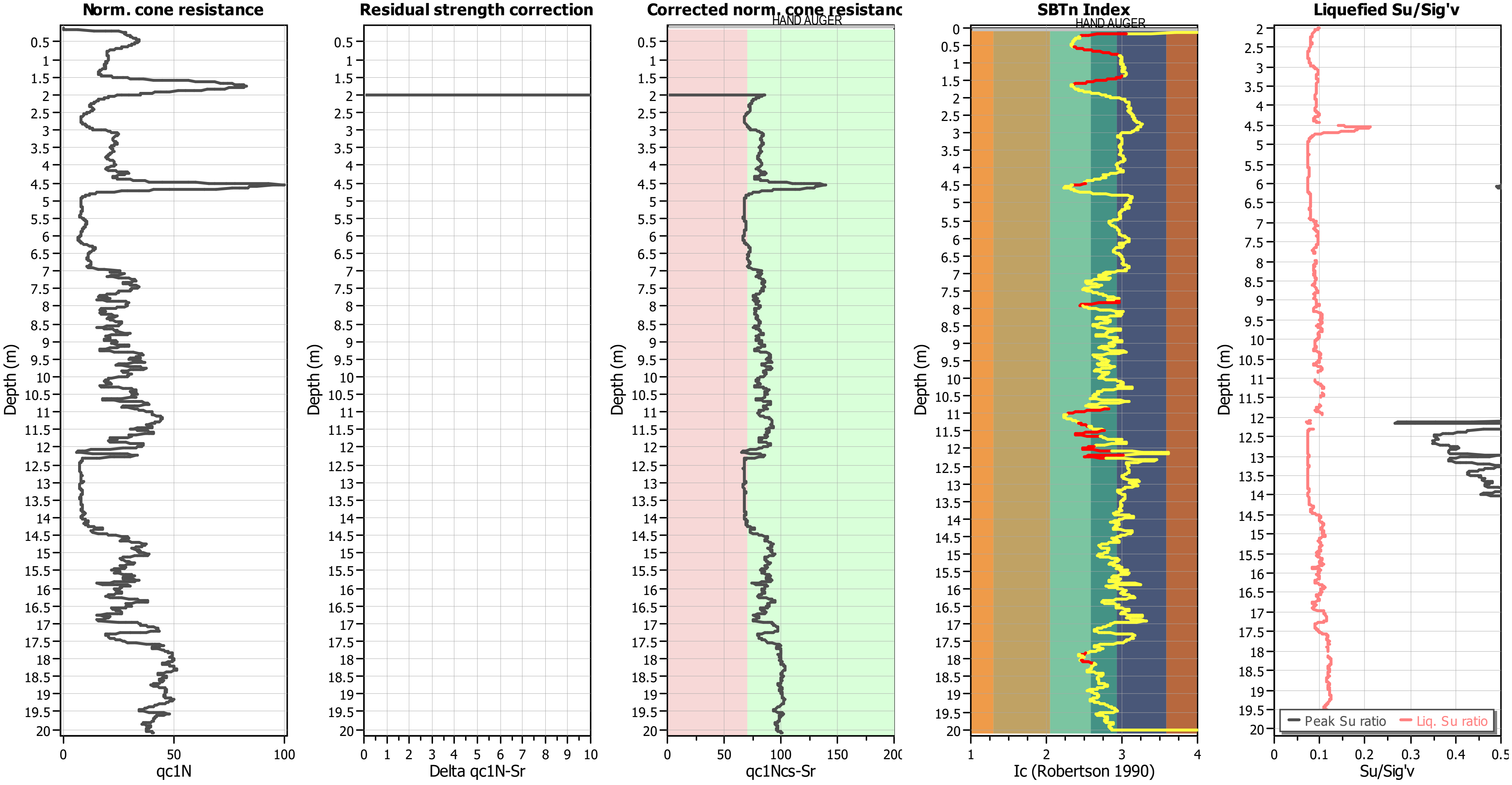




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

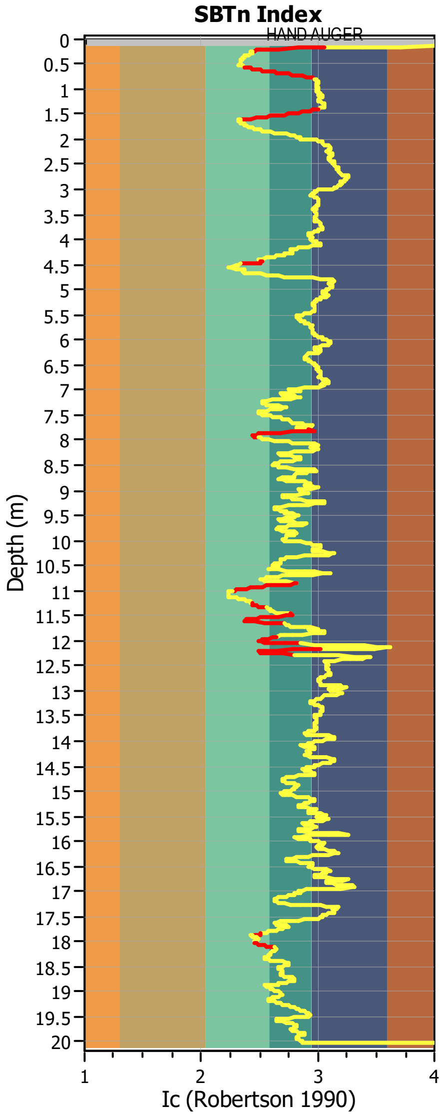
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

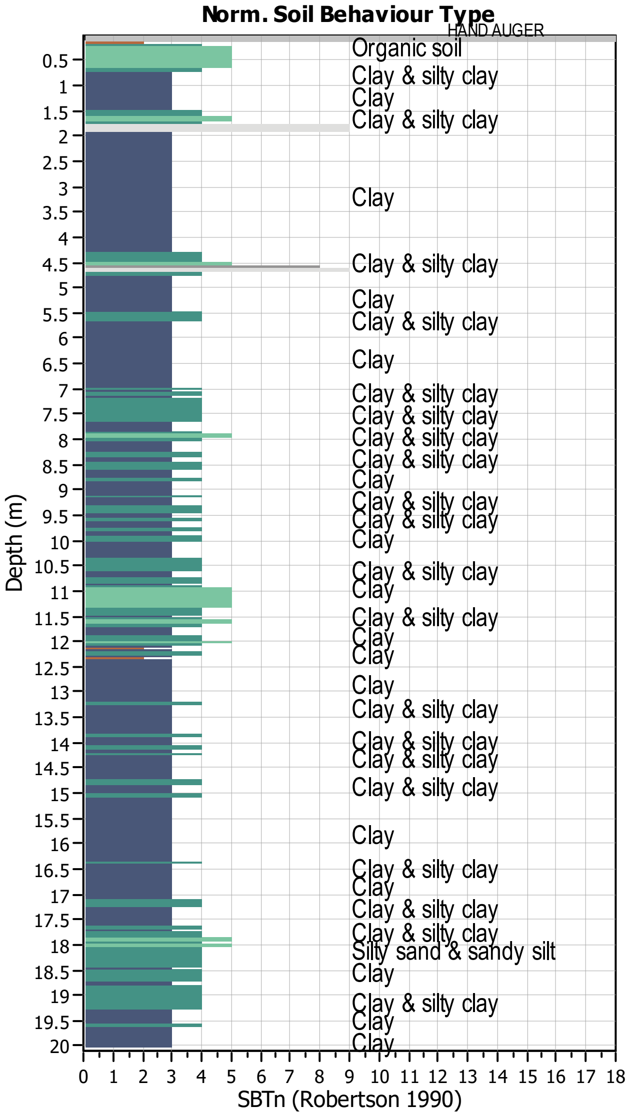
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





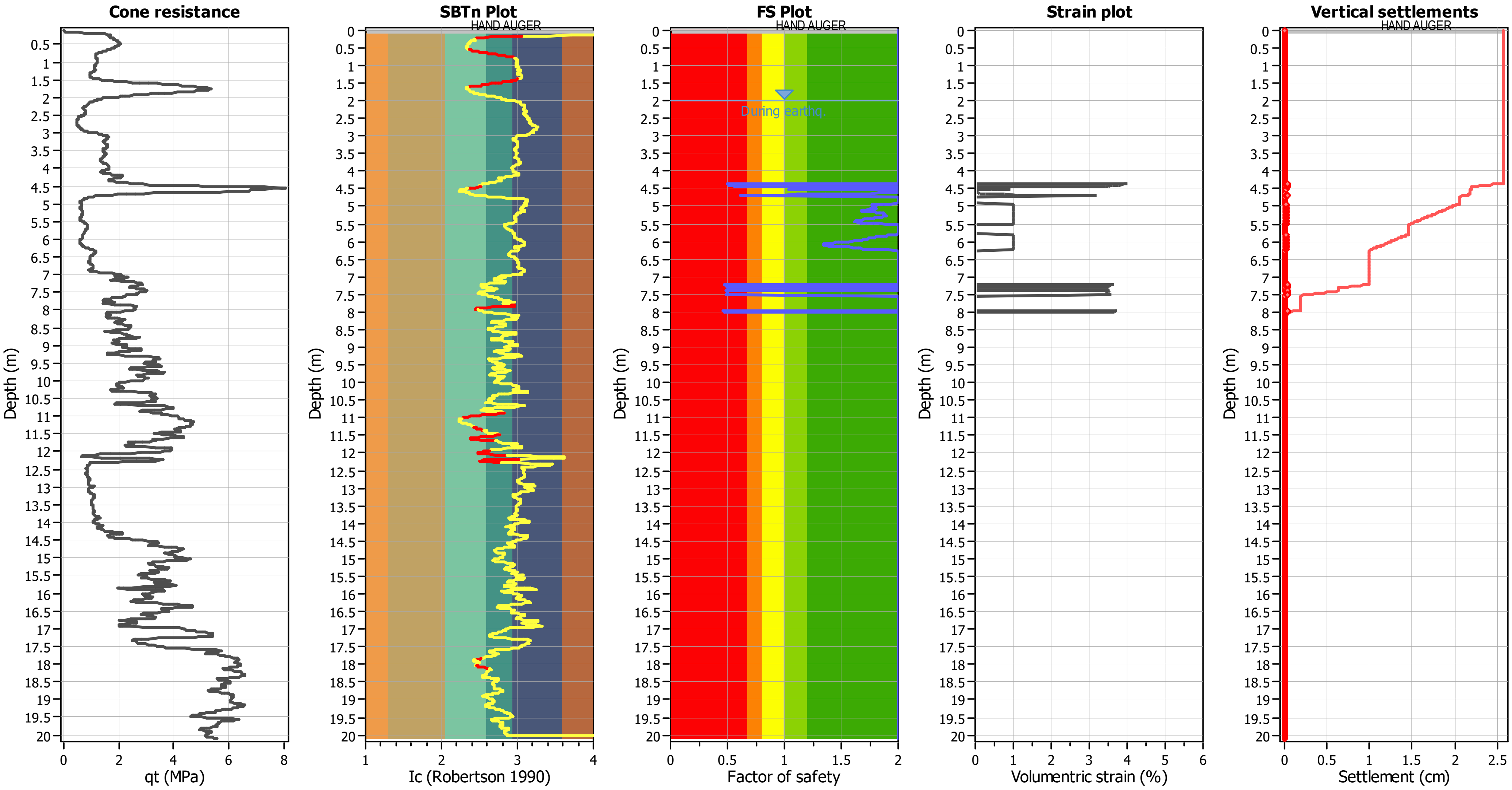
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	165
Exclusion percentage:	8.21%
Number of layers detected:	16

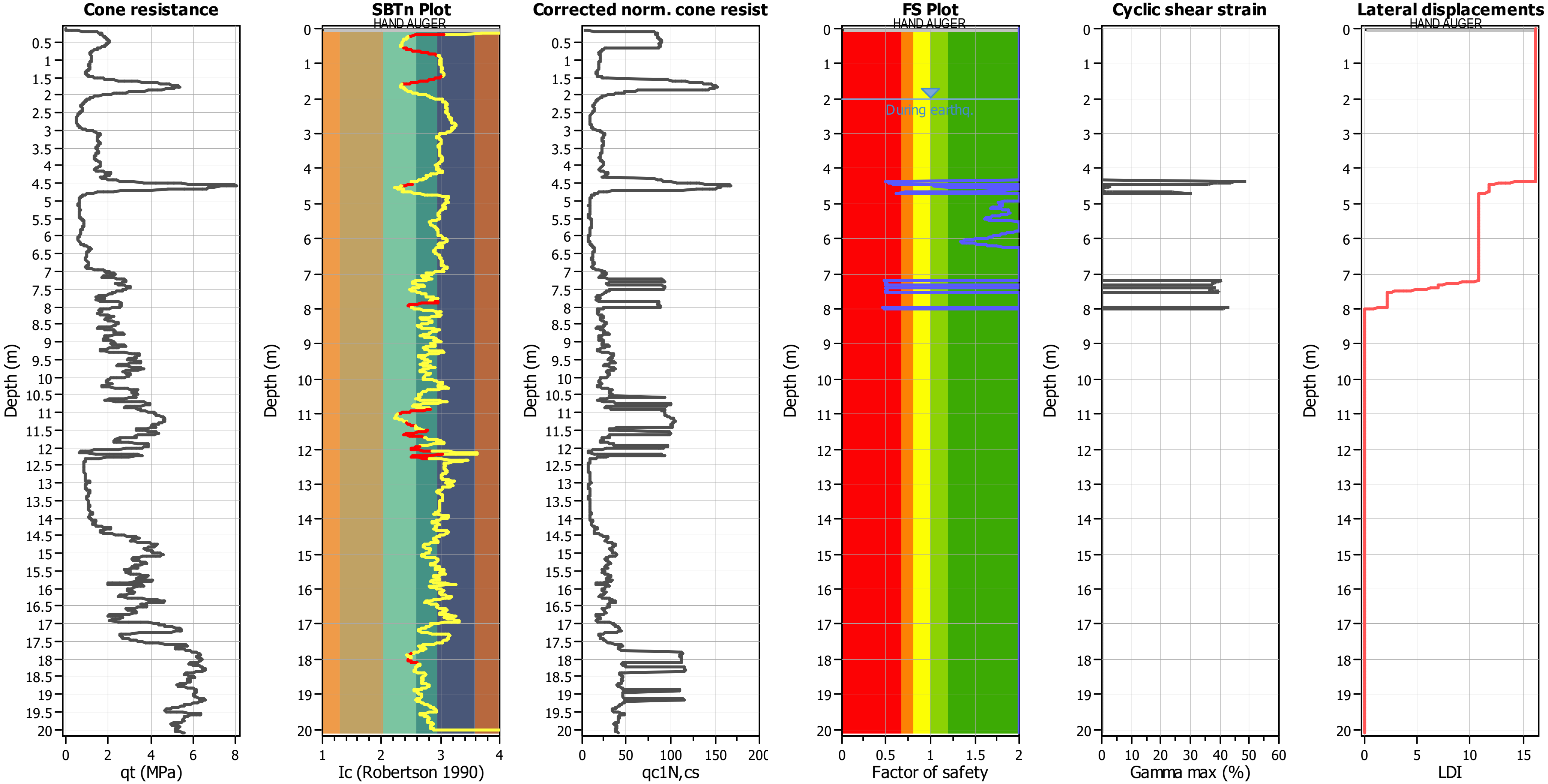
Estimation of post-earthquake settlements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
FS: Calculated Factor of Safety against liquefaction
Volumentric strain: Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

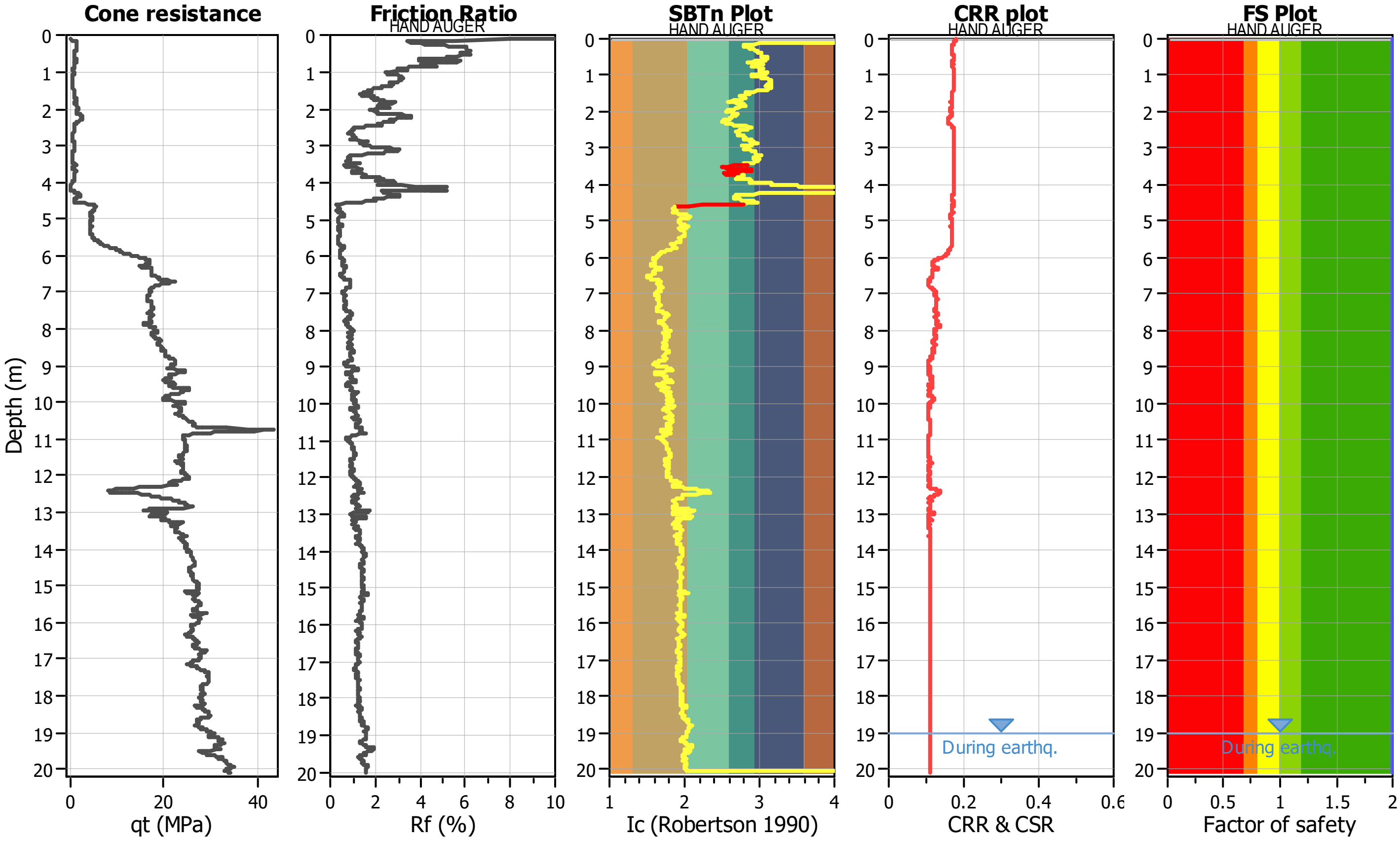
LIQUEFACTION ANALYSIS REPORT

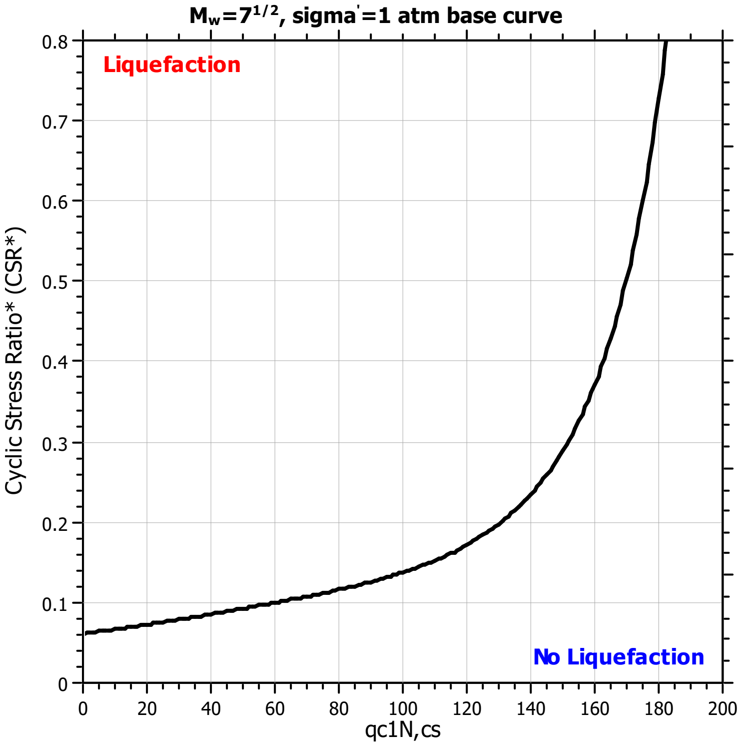
Project title : Proposed Private Plan Change for Te Awamutu   Location : 2025 Ohaupo Road, Te Awamutu

CPT file : CPT-07

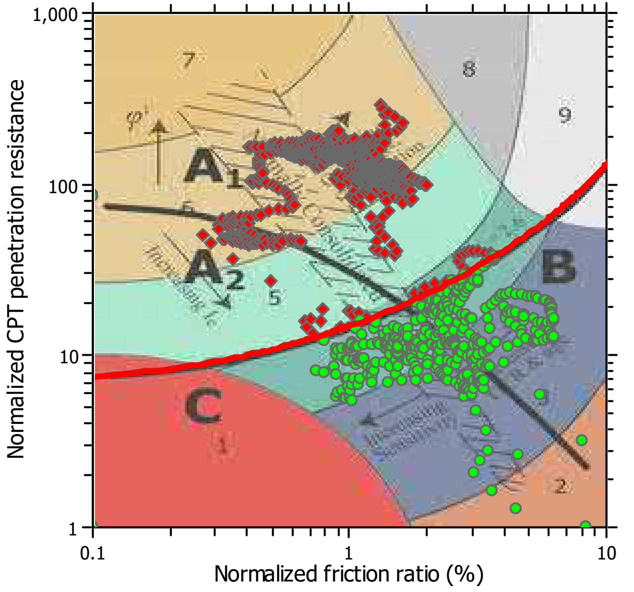
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	20.10 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	19.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		



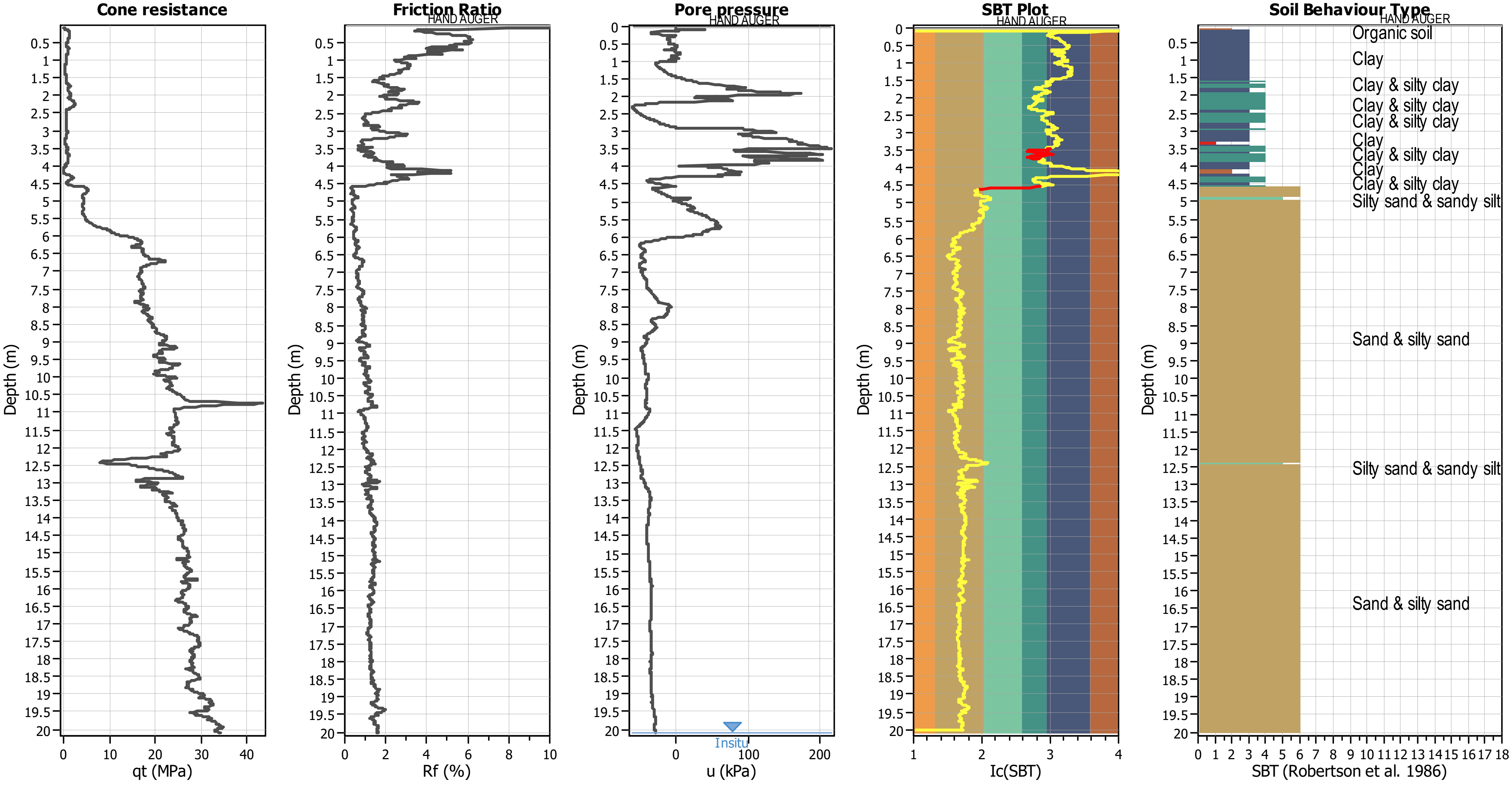


Summary of liquefaction potential



Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: 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



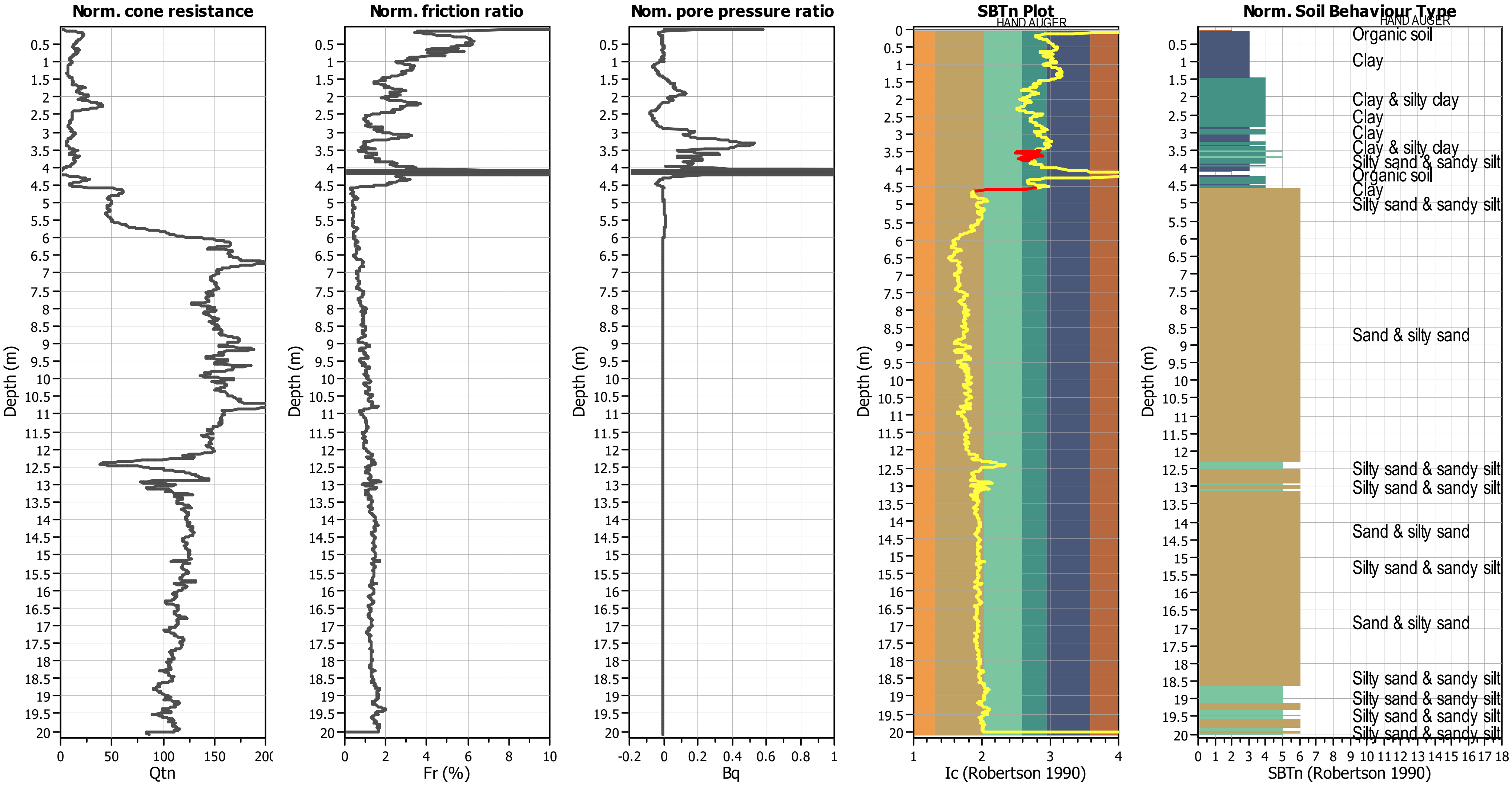
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

SBT 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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.32
Depth to water table (insitu): 20.10 m

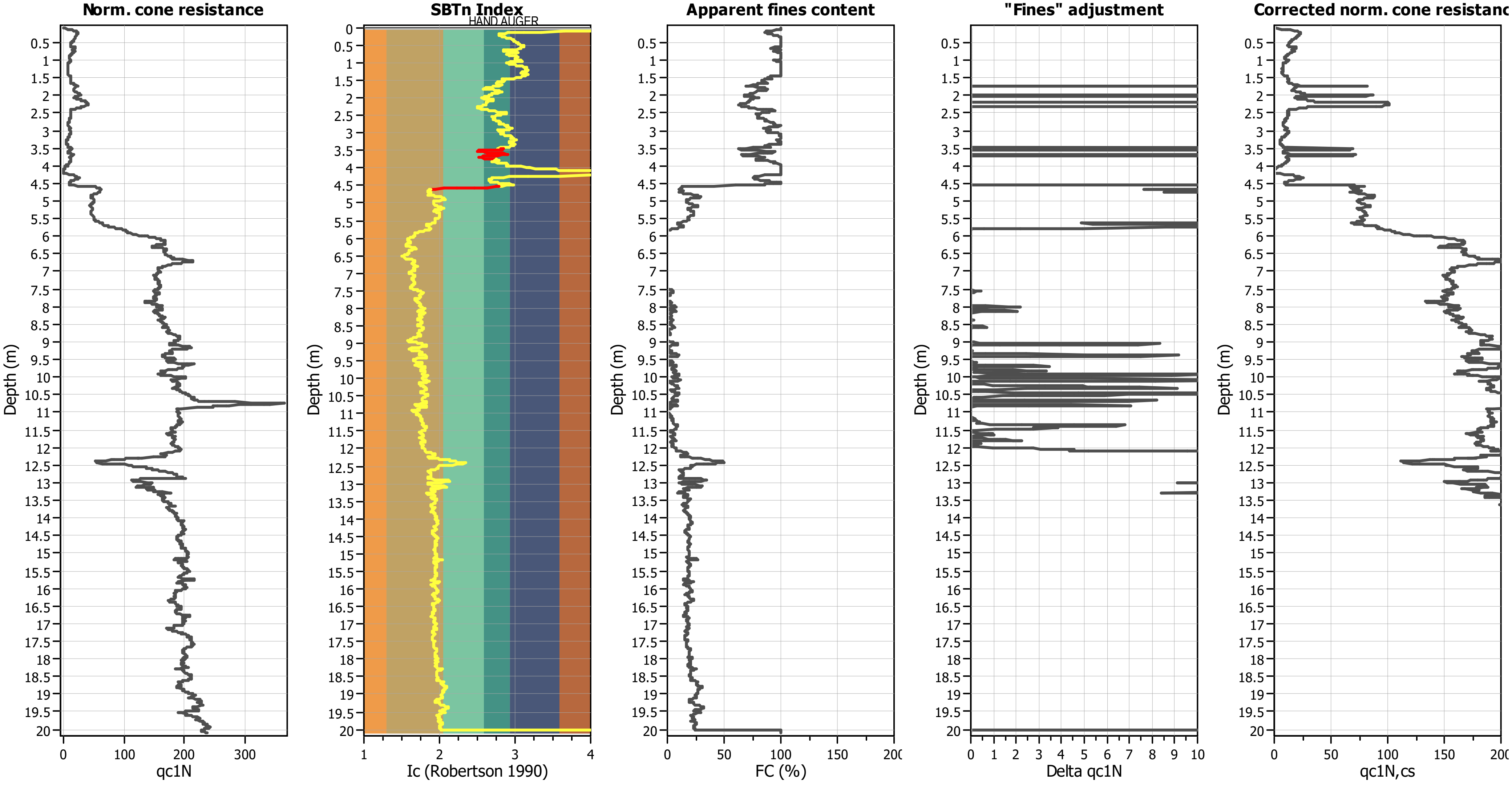
Depth to GWT (erthq.): 19.00 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

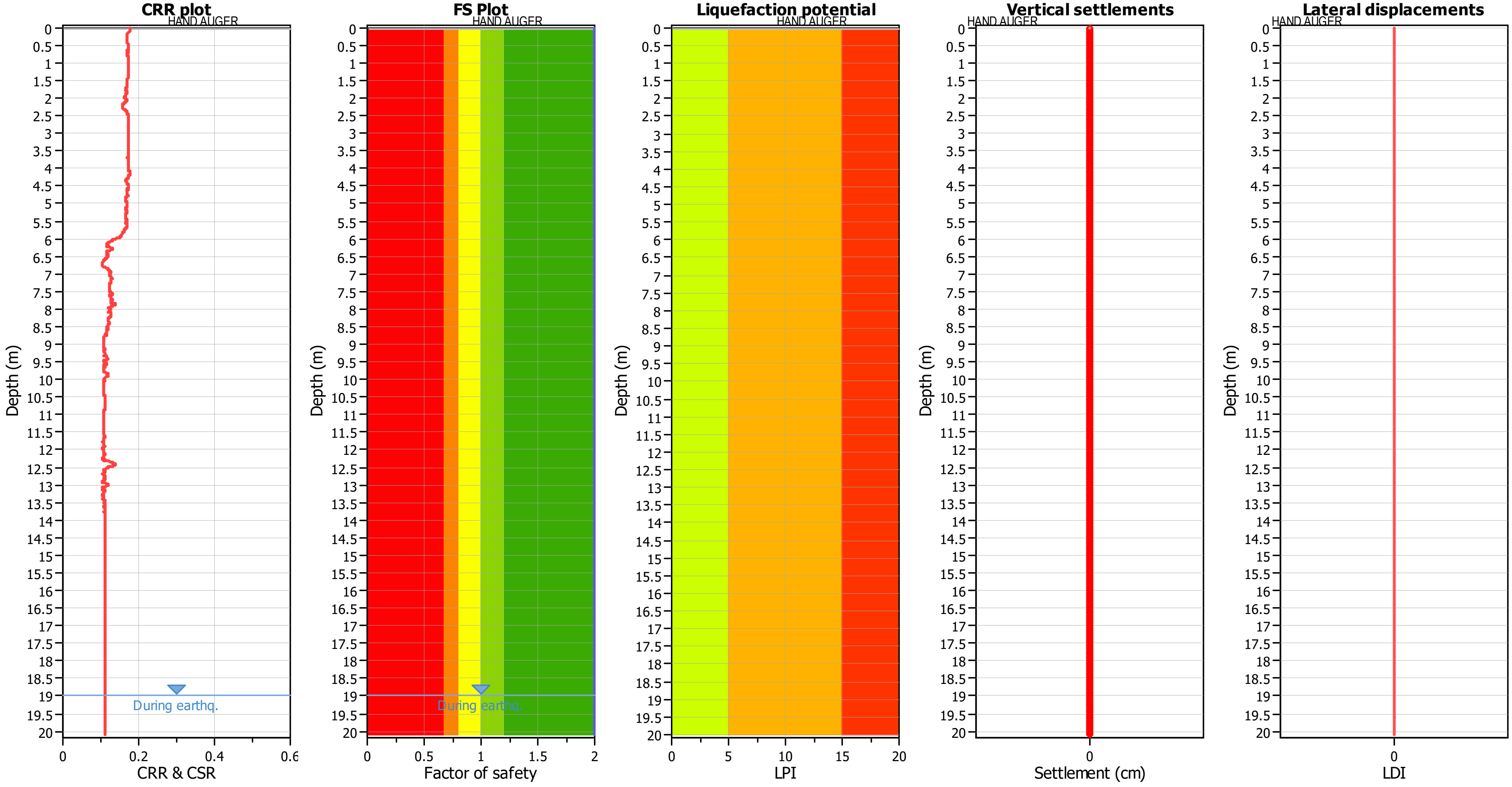
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

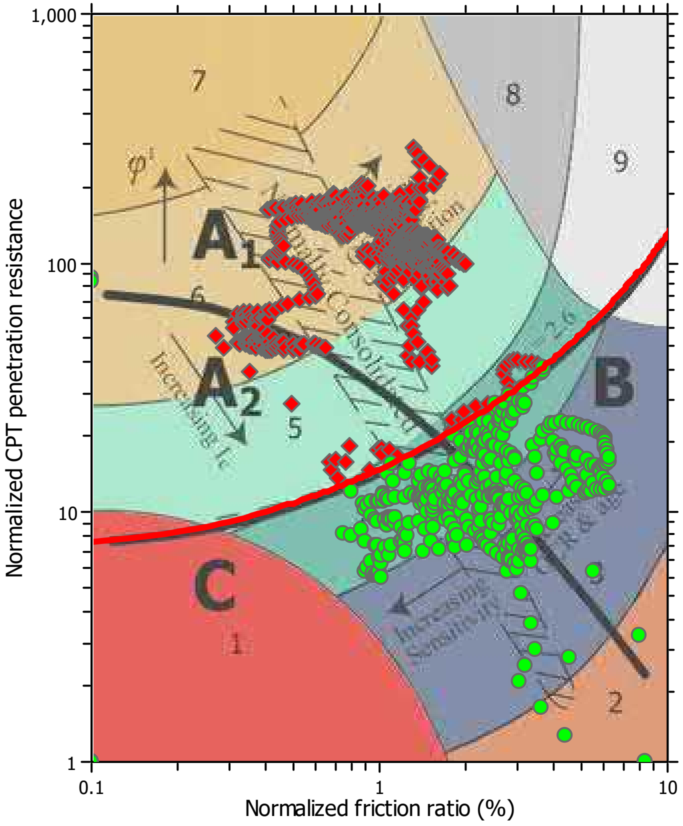
F.S. color scheme

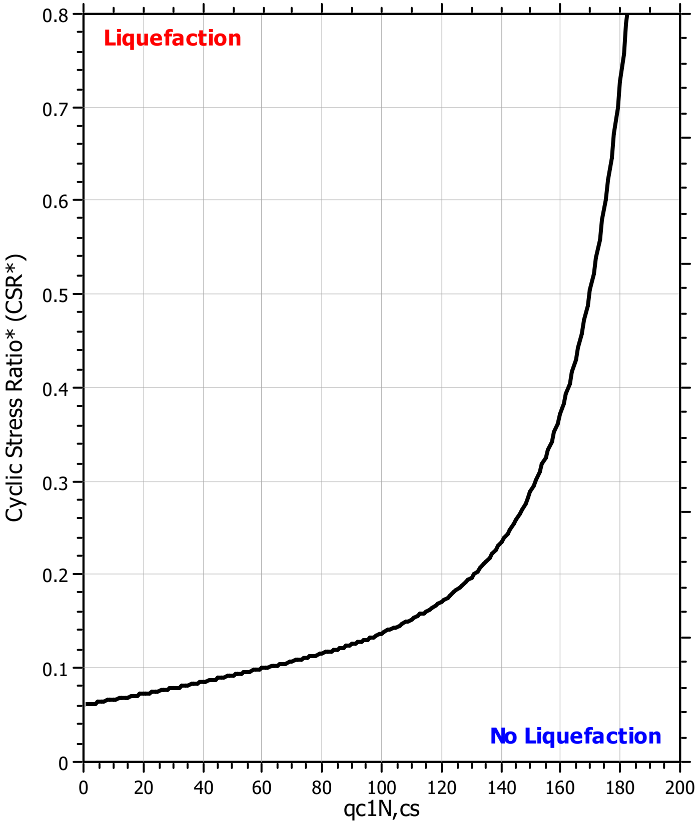
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

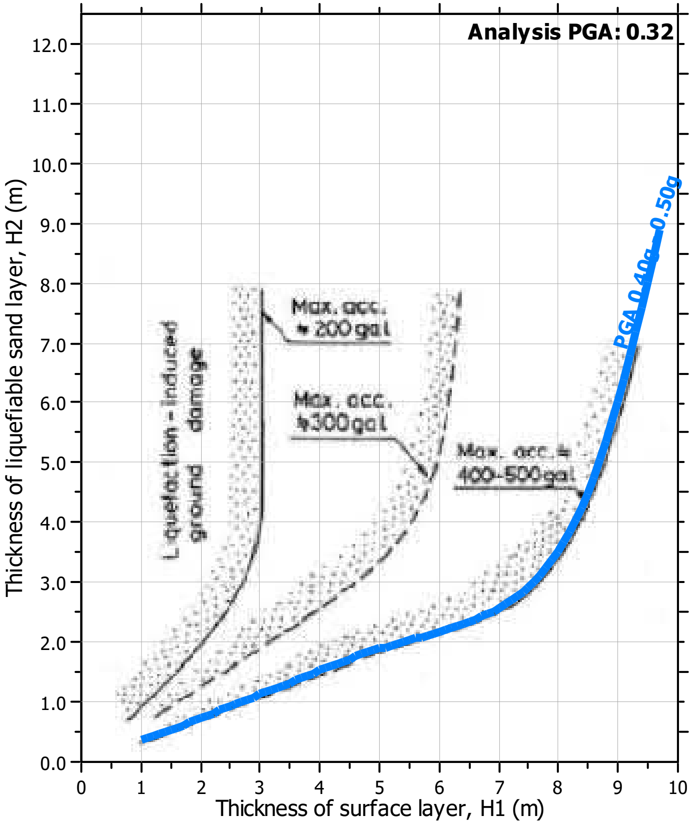
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



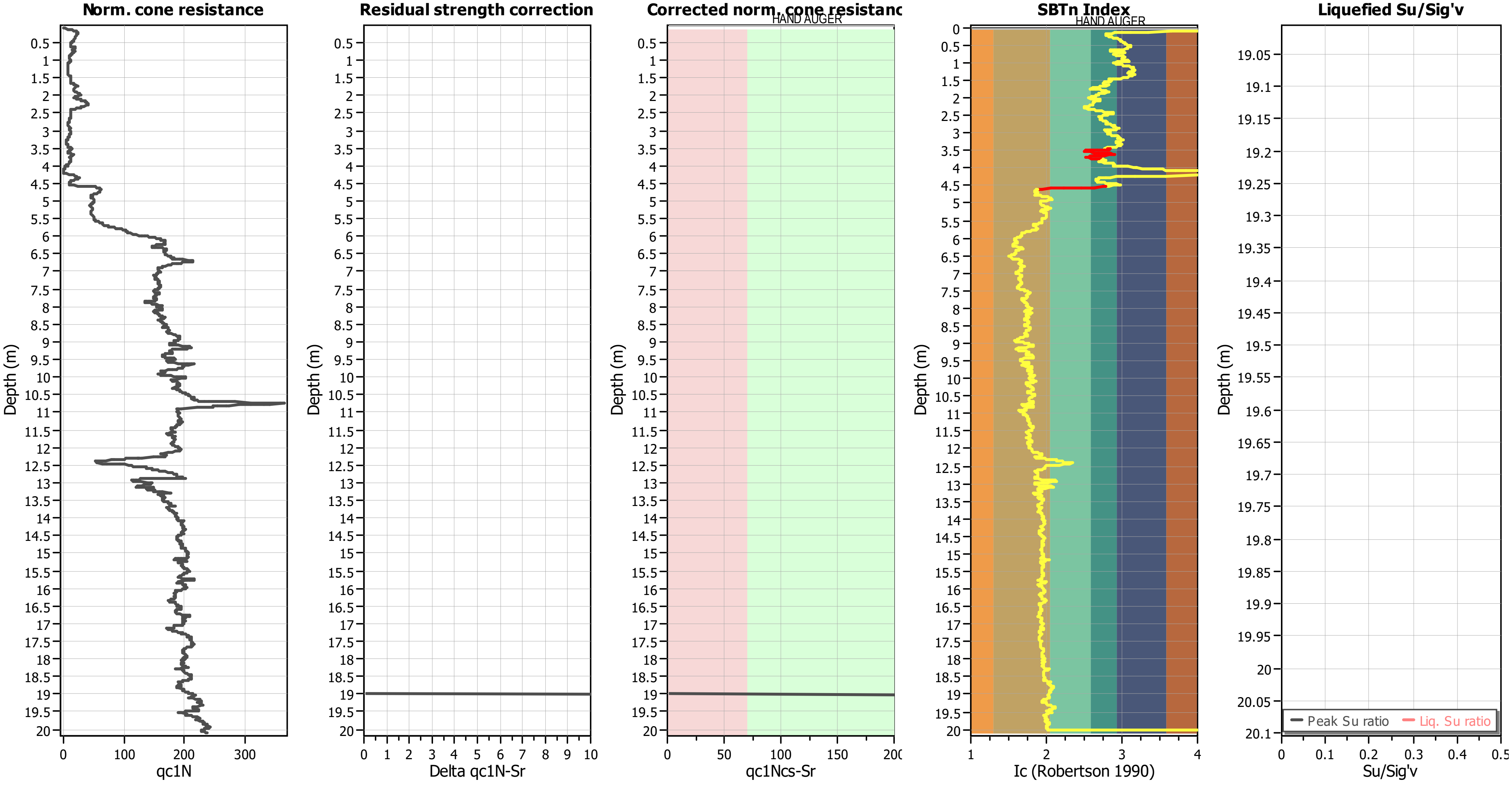




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

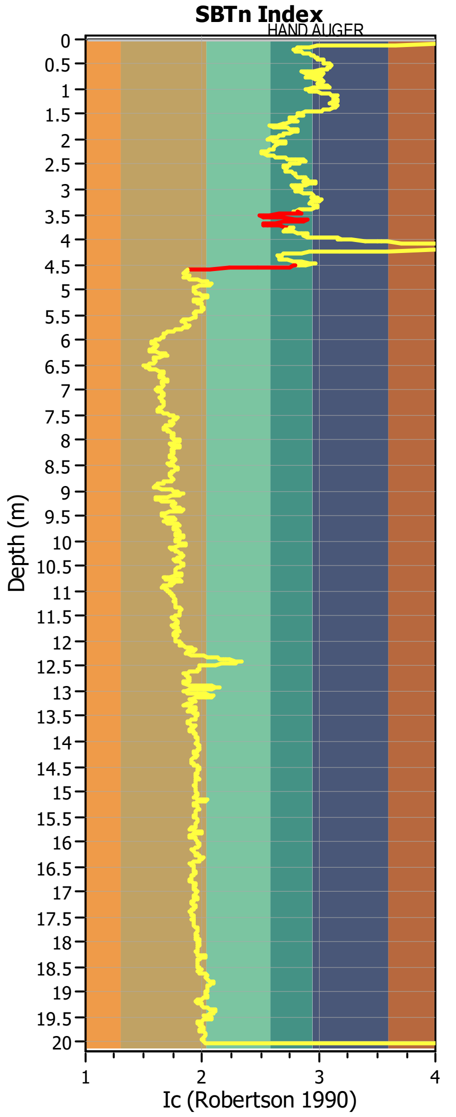
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	19.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	20.10 m	Fill height:	N/A	Limit depth:	10.00 m

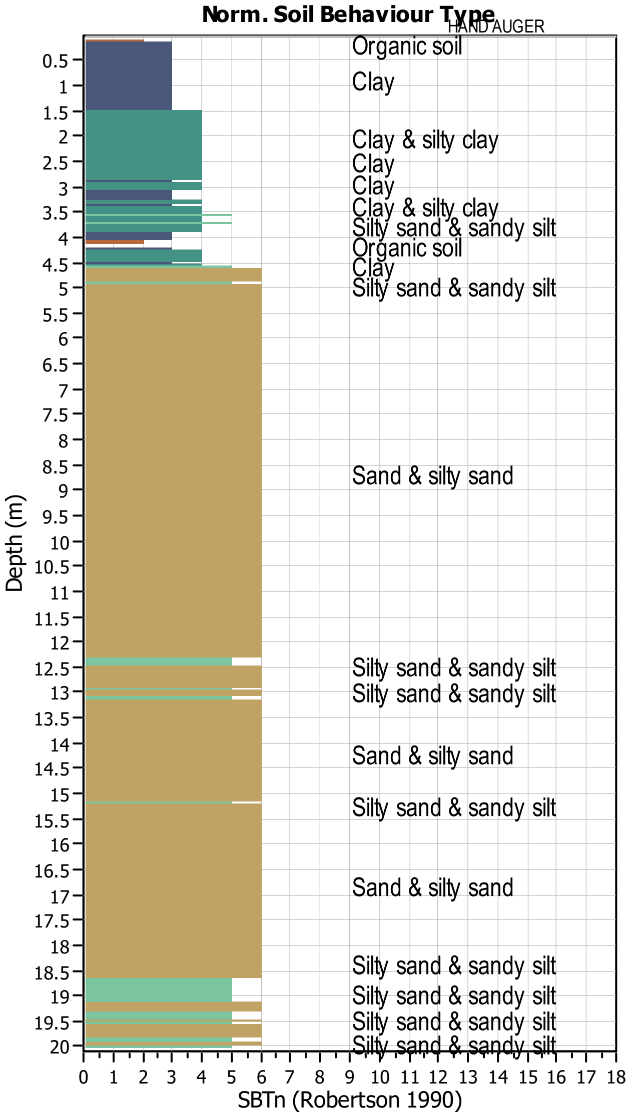
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





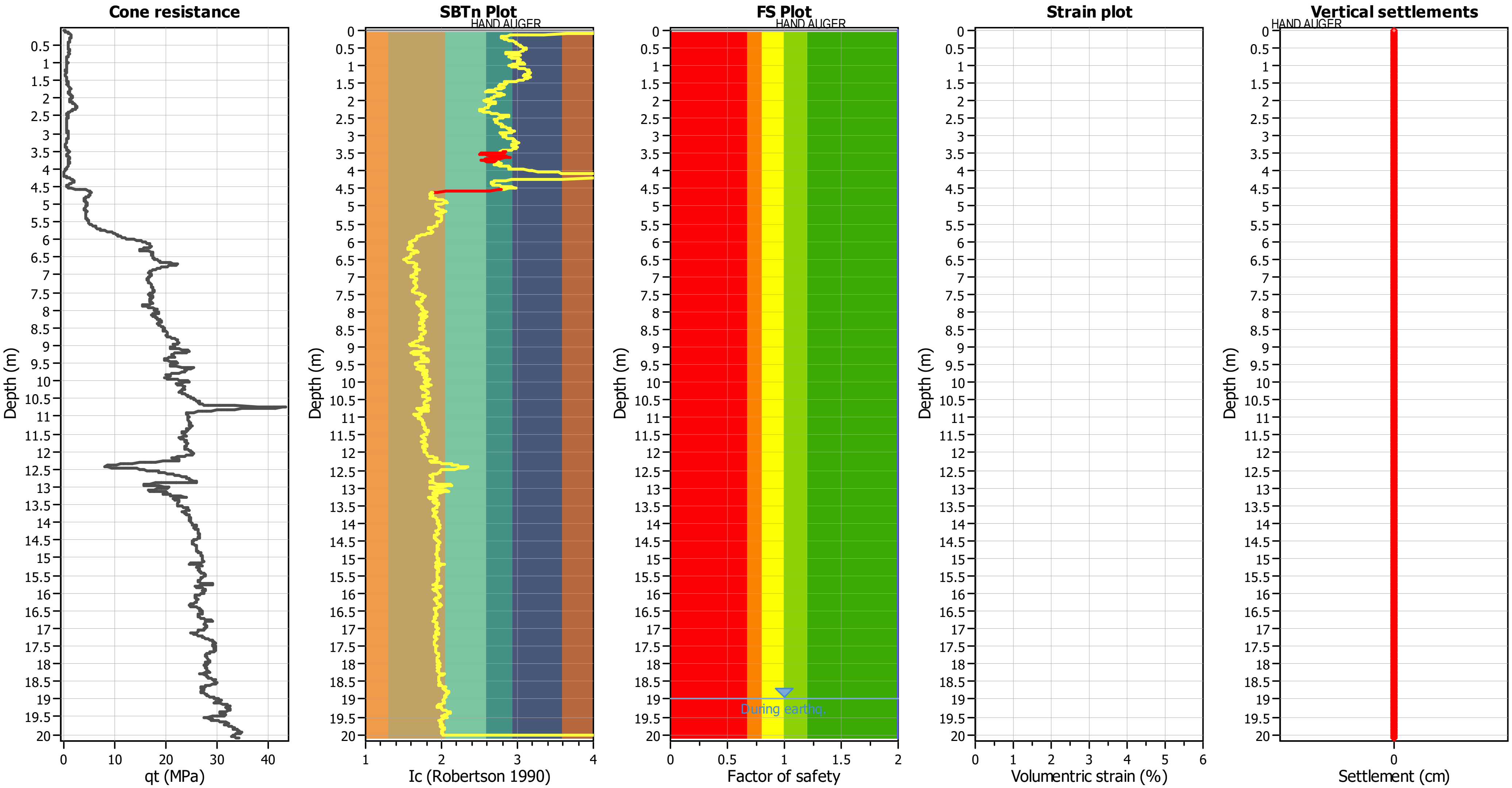
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	40
Exclusion percentage:	1.99%
Number of layers detected:	5

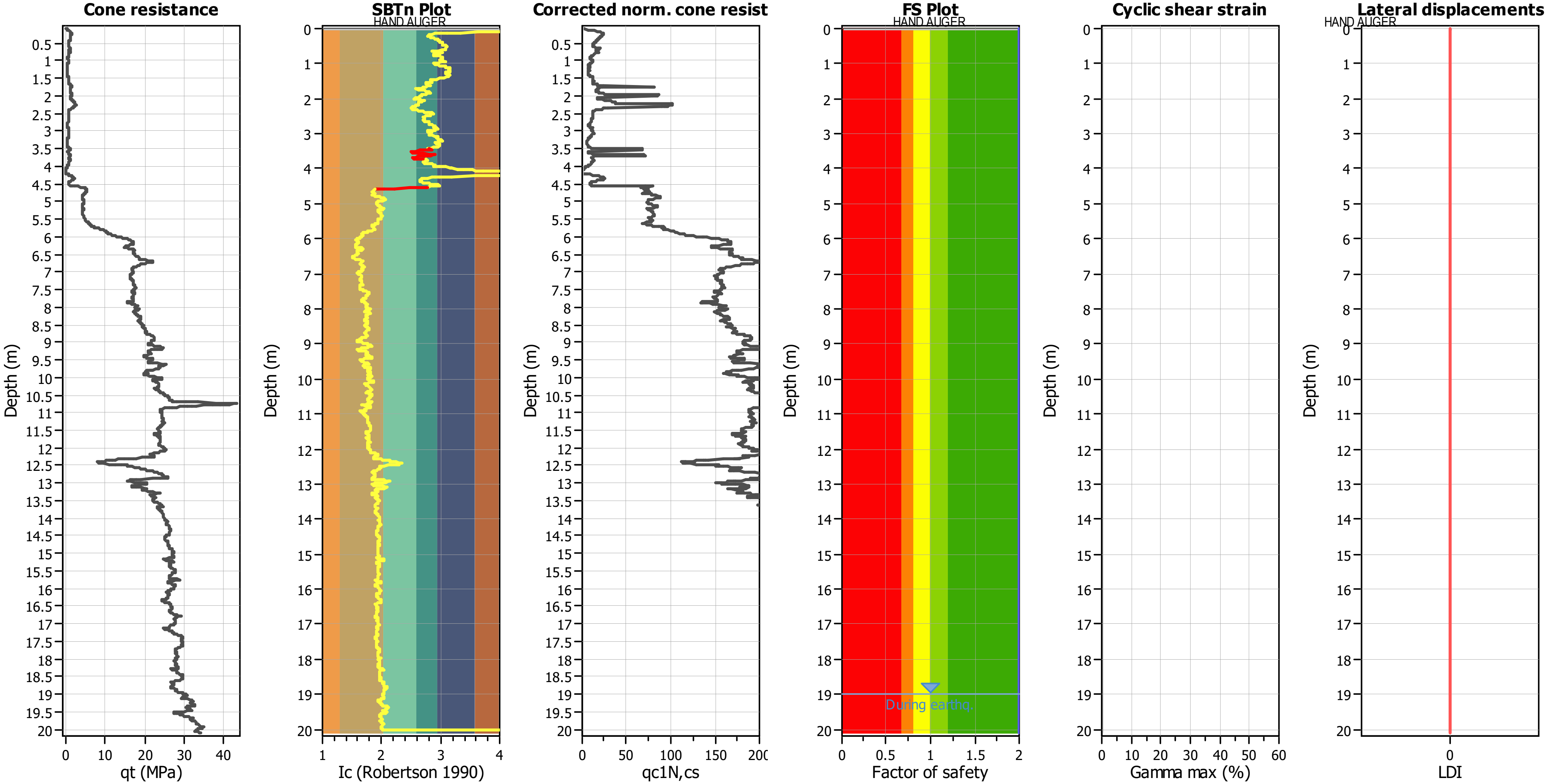
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

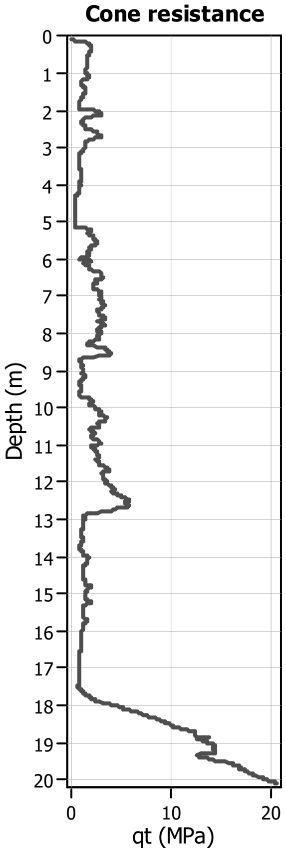
LIQUEFACTION ANALYSIS REPORT

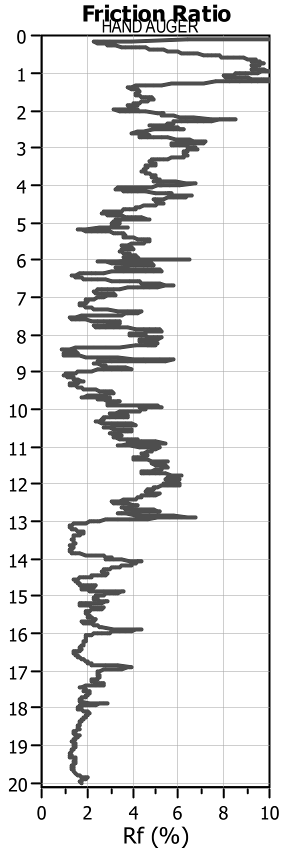
Project title : Proposed Private Plan Change for Te Awamutu   Location : 2025 Ohaupo Road, Te Awamutu

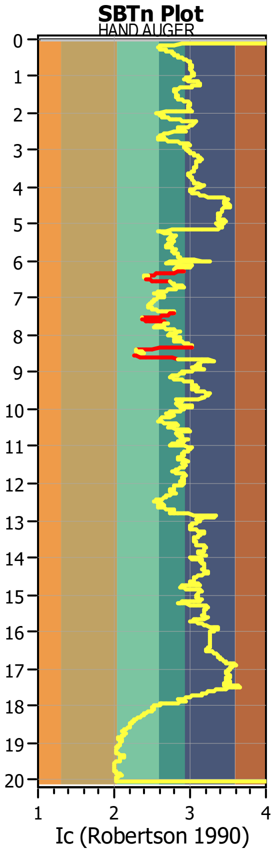
CPT file : CPT-08

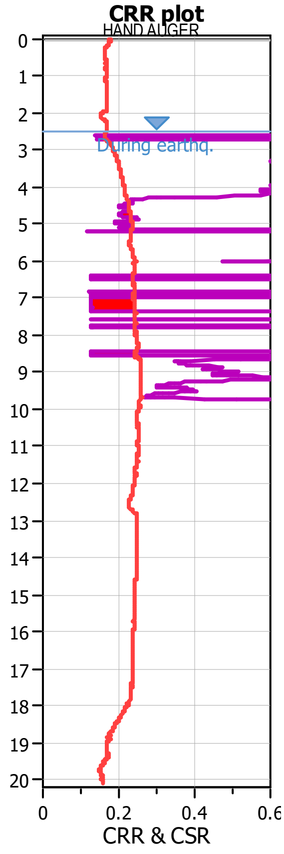
Input parameters and analysis data

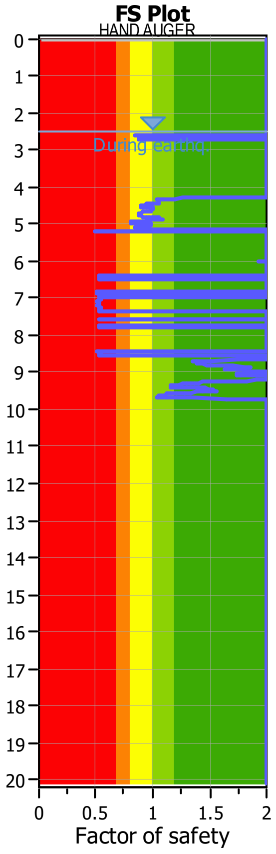
Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.50 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

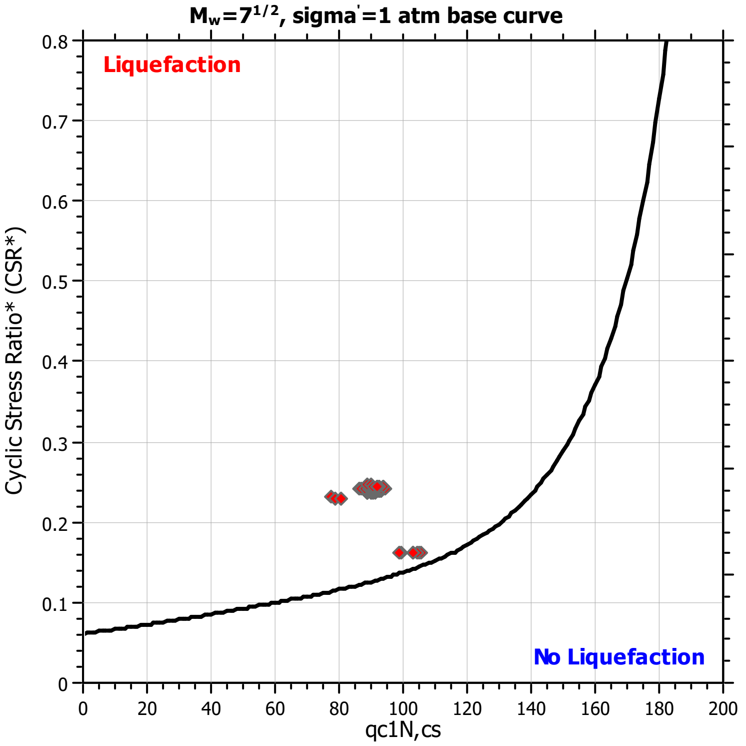

Cone resistance

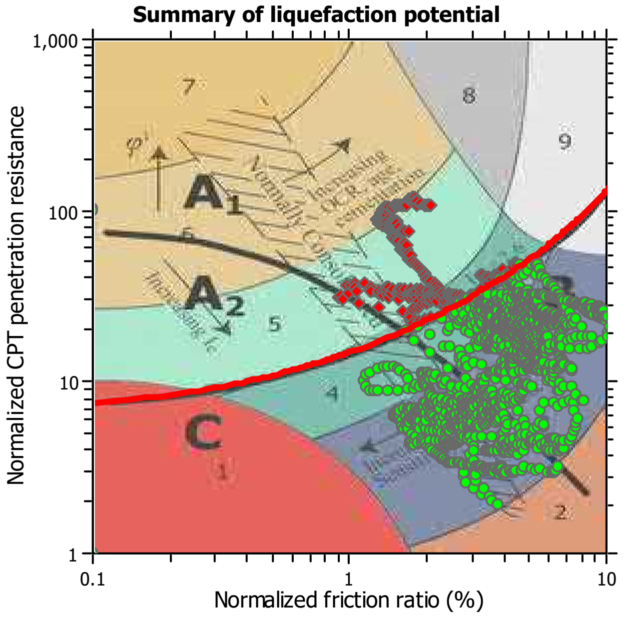

Friction Ratio


SBTn Plot


CRR plot

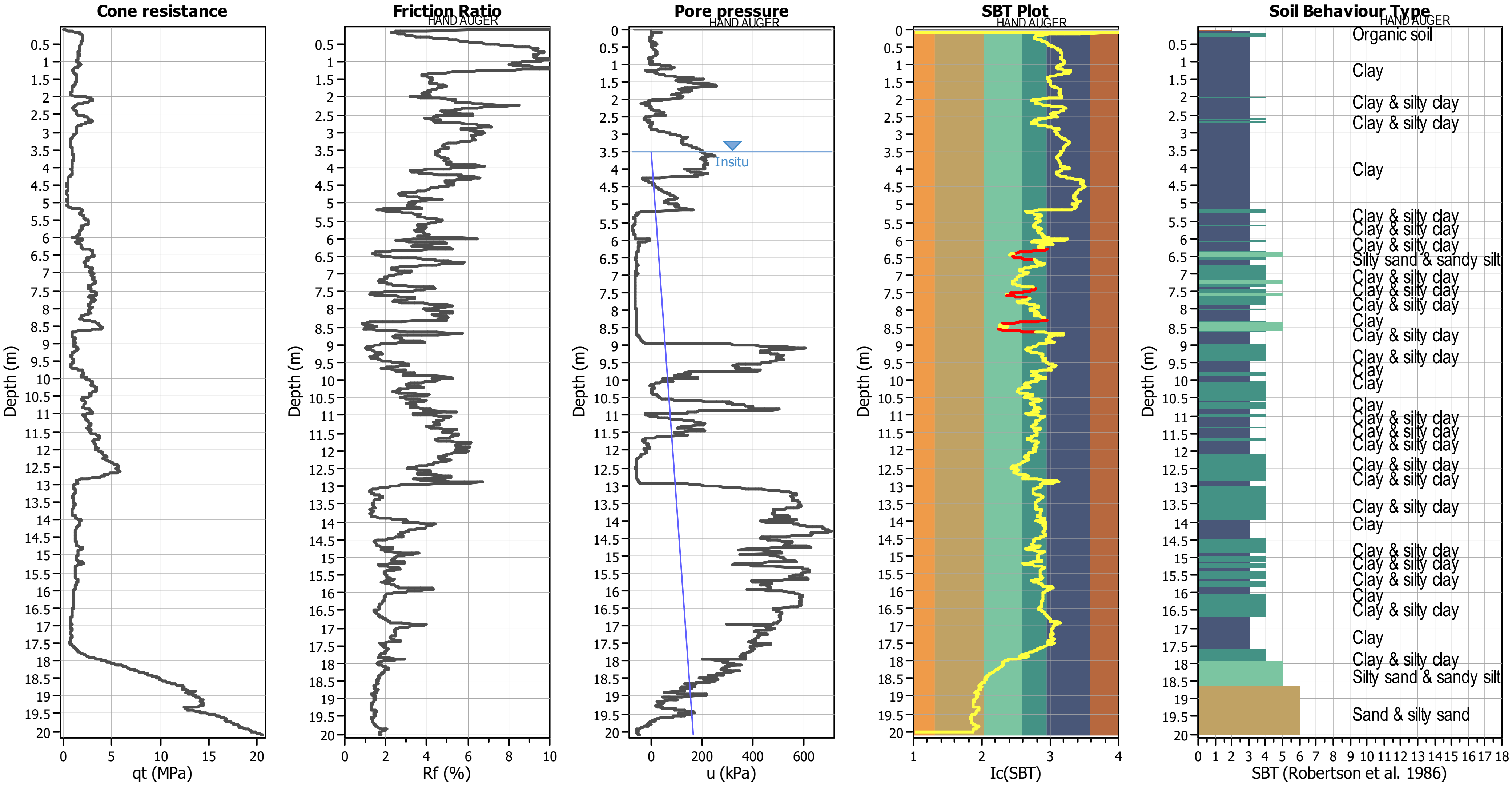

FS Plot


$M_w=7^{1/2}$, sigma'=1 atm base curve


Summary of liquefaction potential

Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: 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



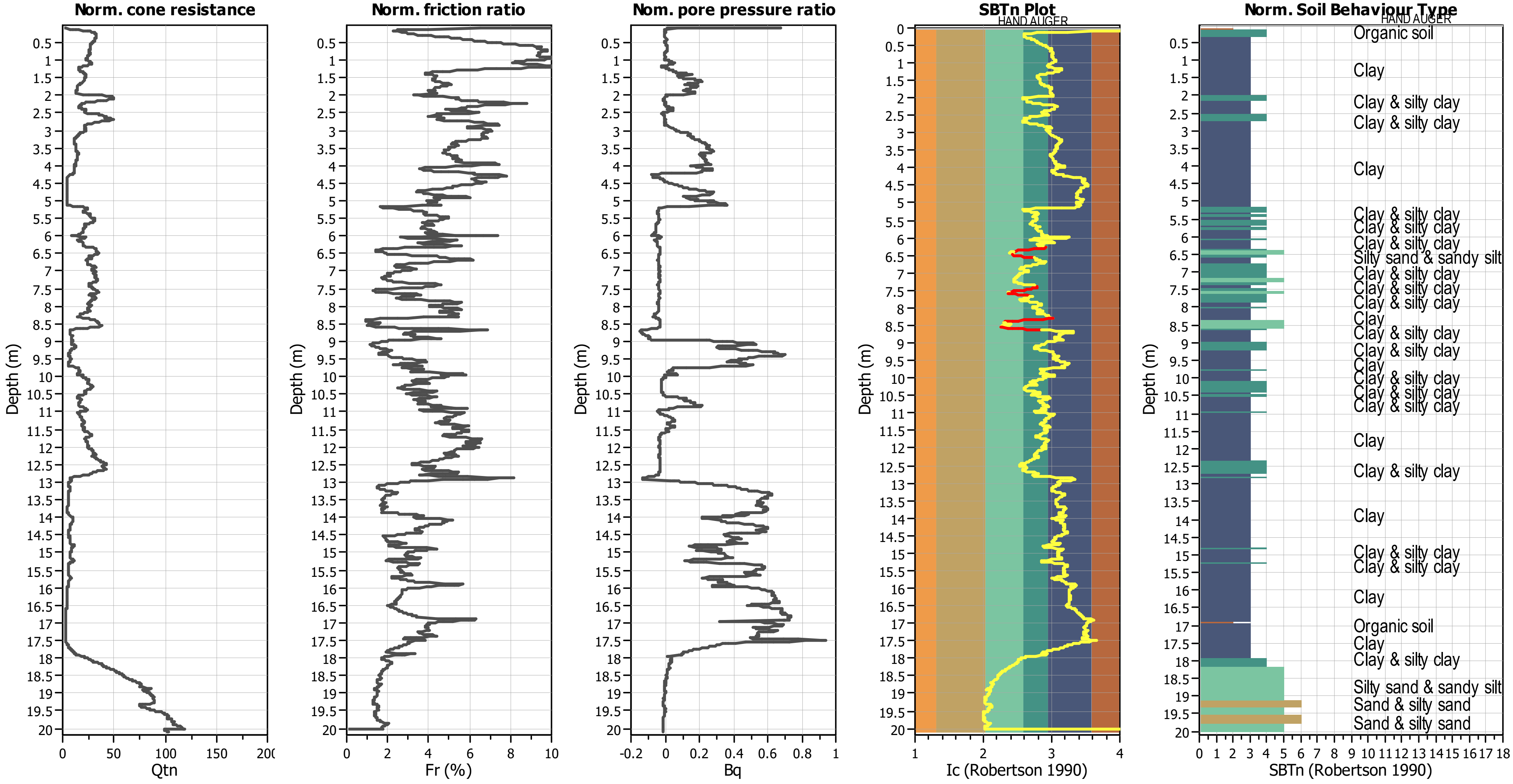
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



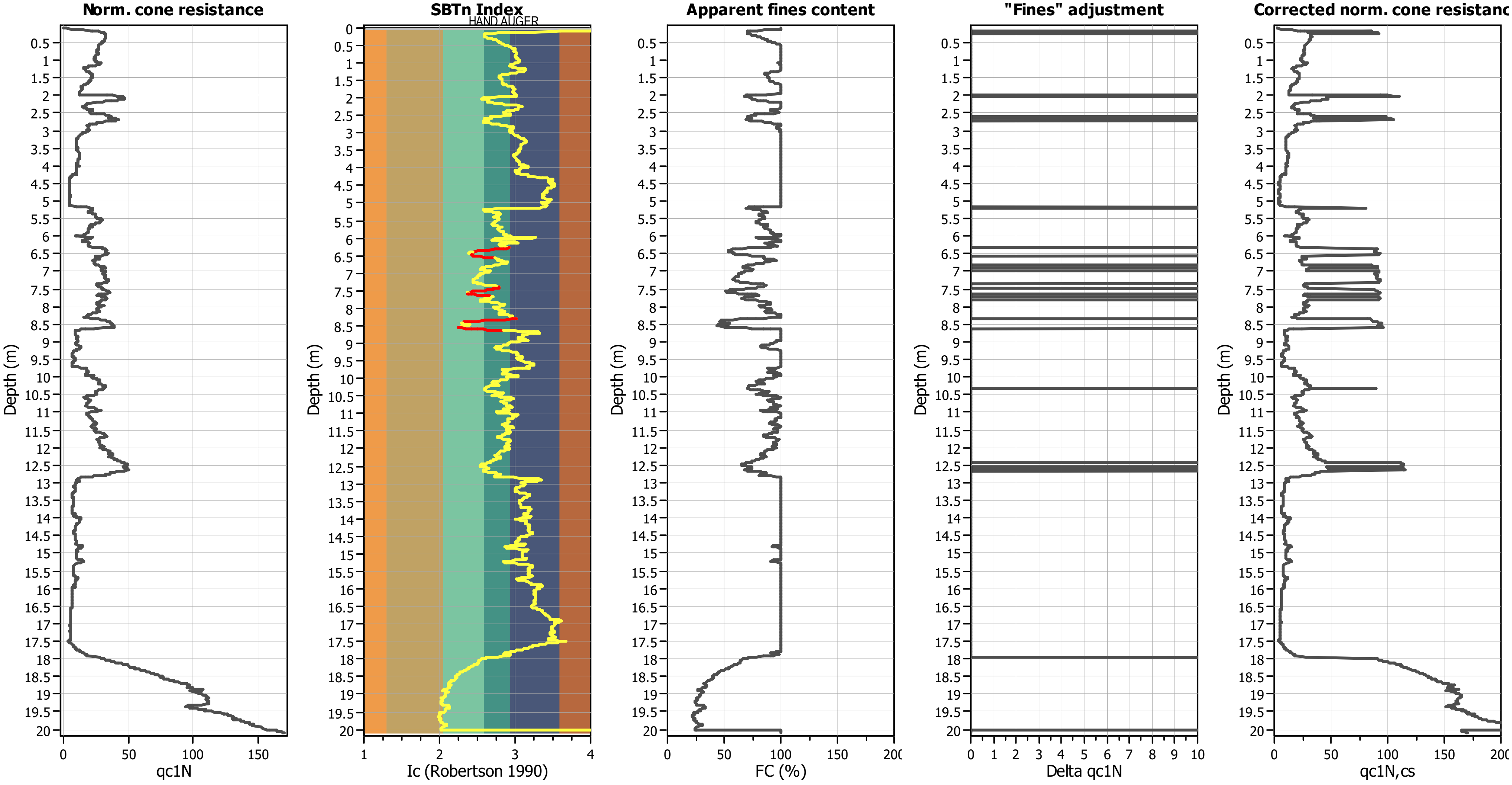
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

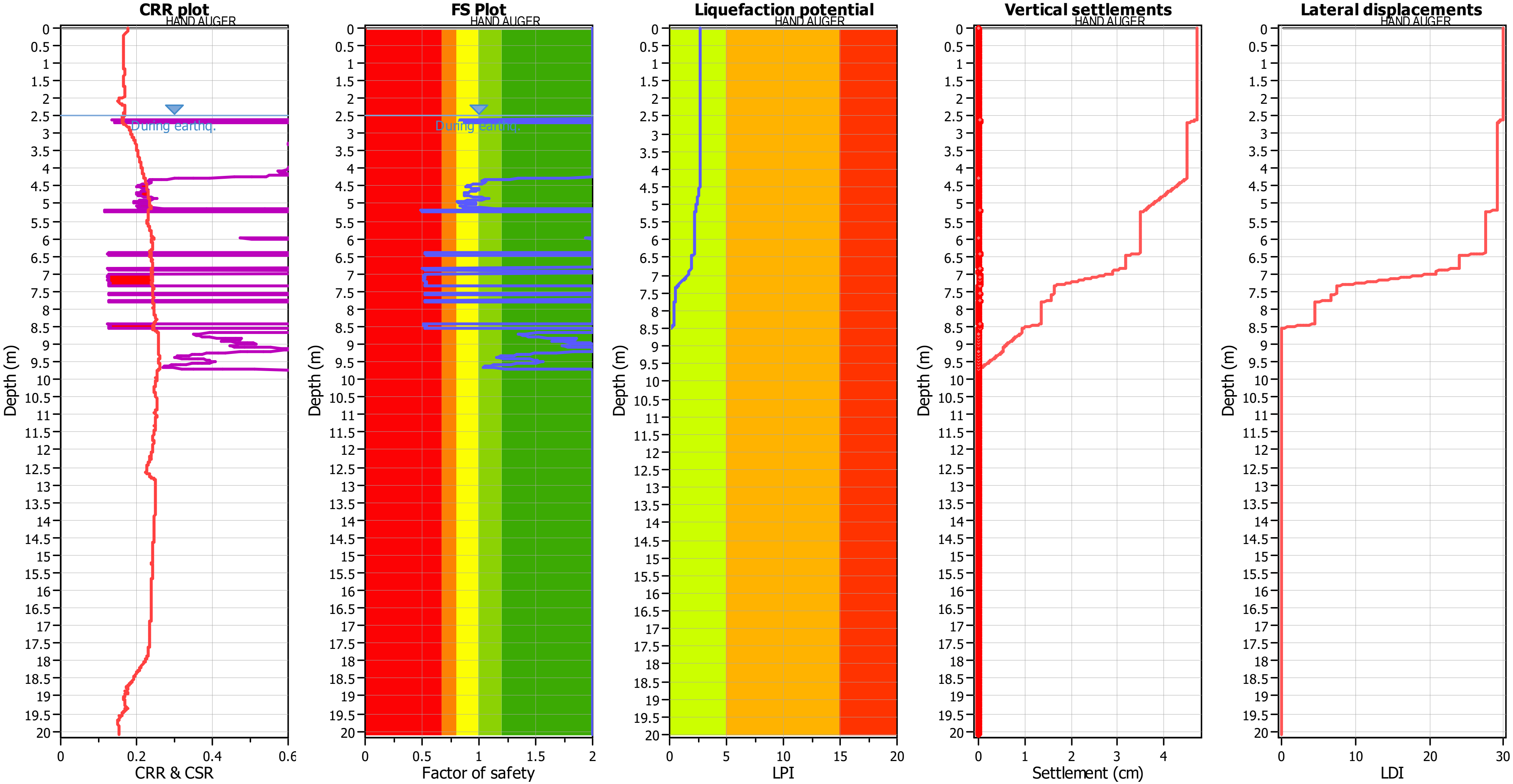
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

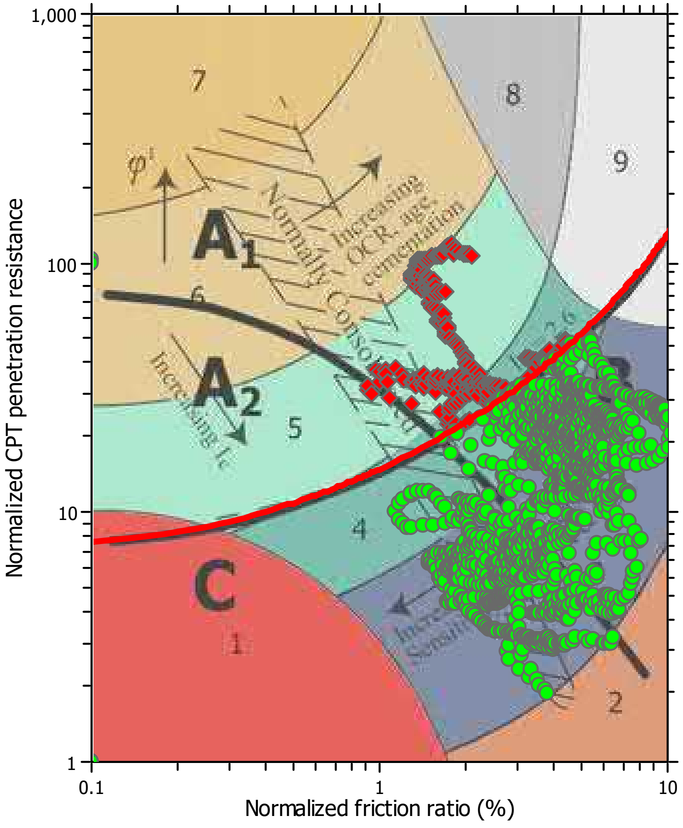
F.S. color scheme

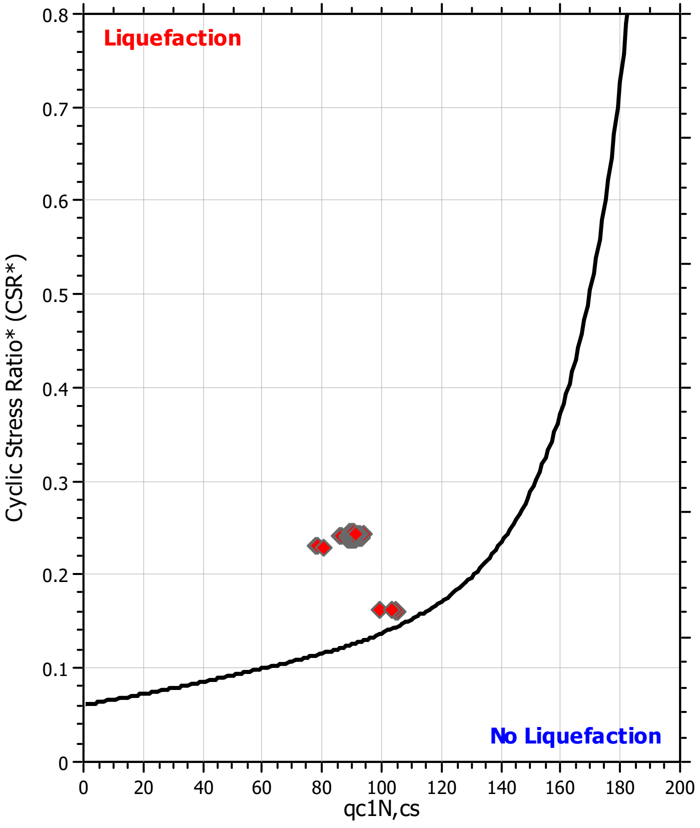
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

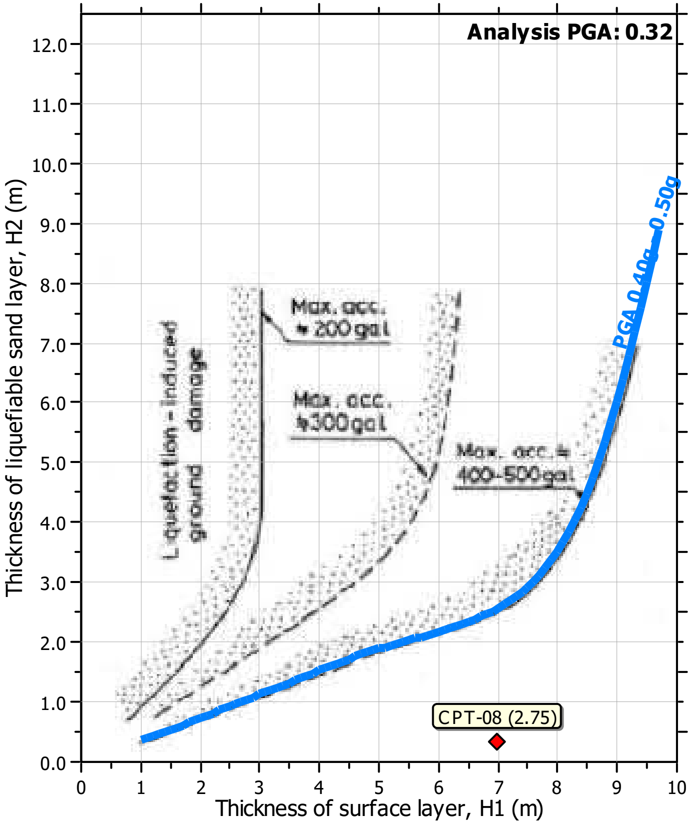
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



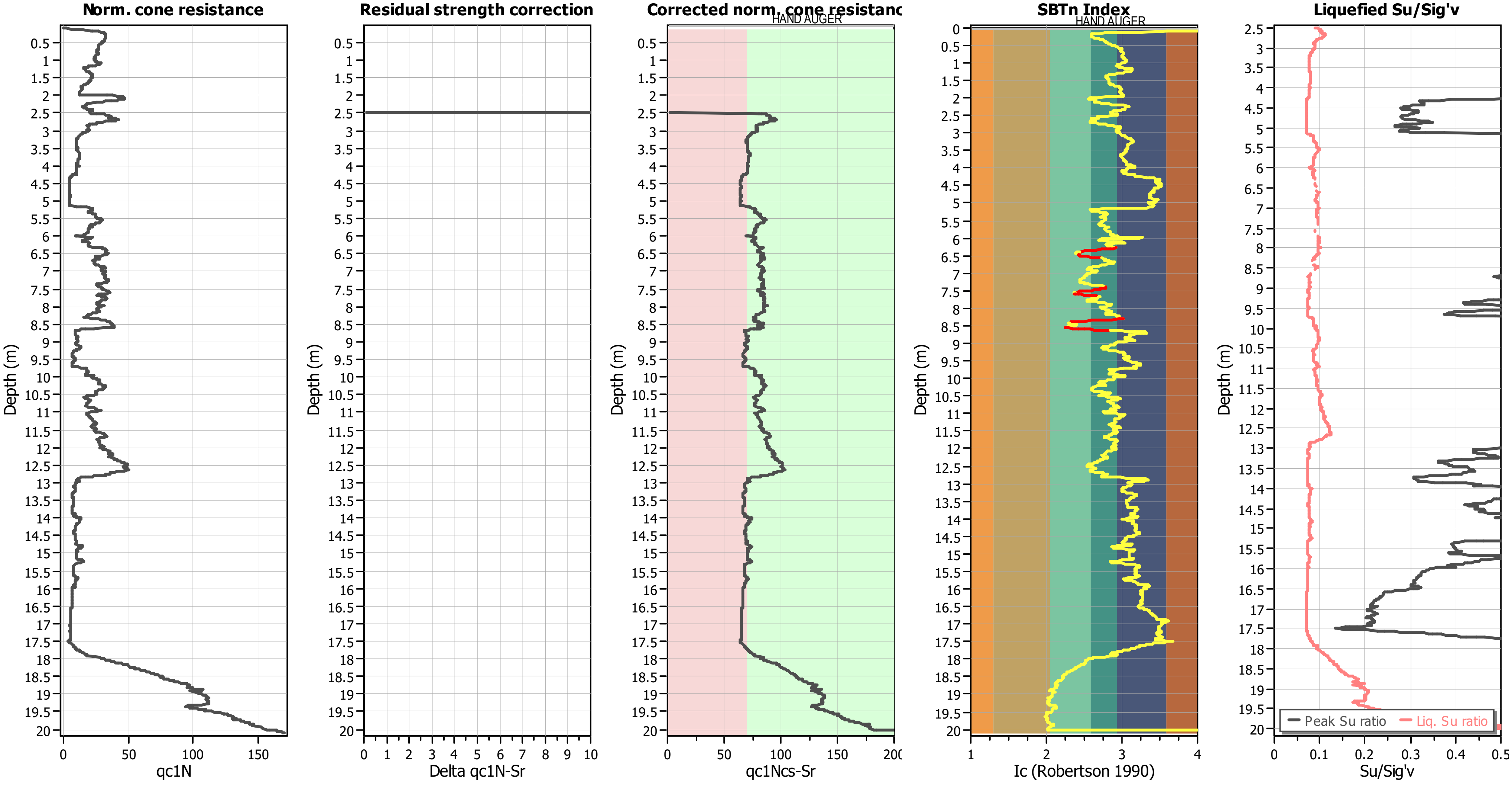




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	10.00 m

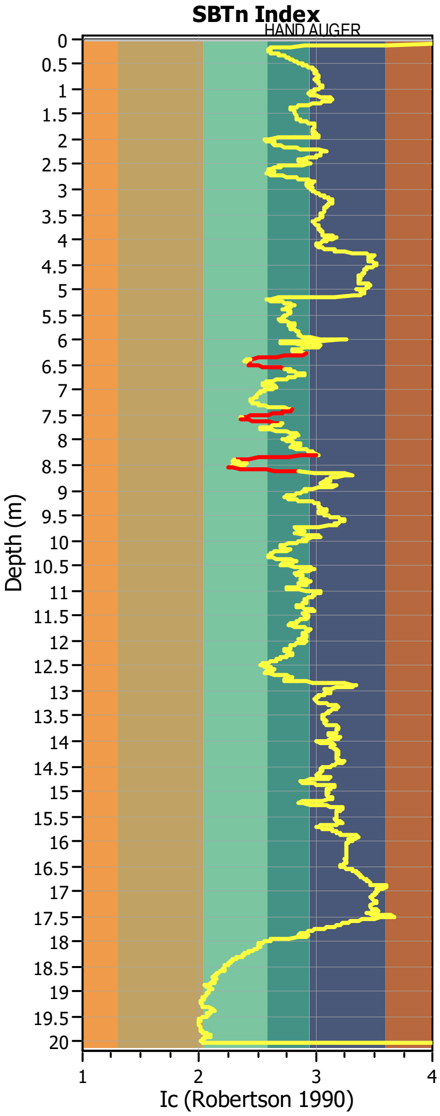
TRANSITION LAYER DETECTION ALGORITHM REPORT

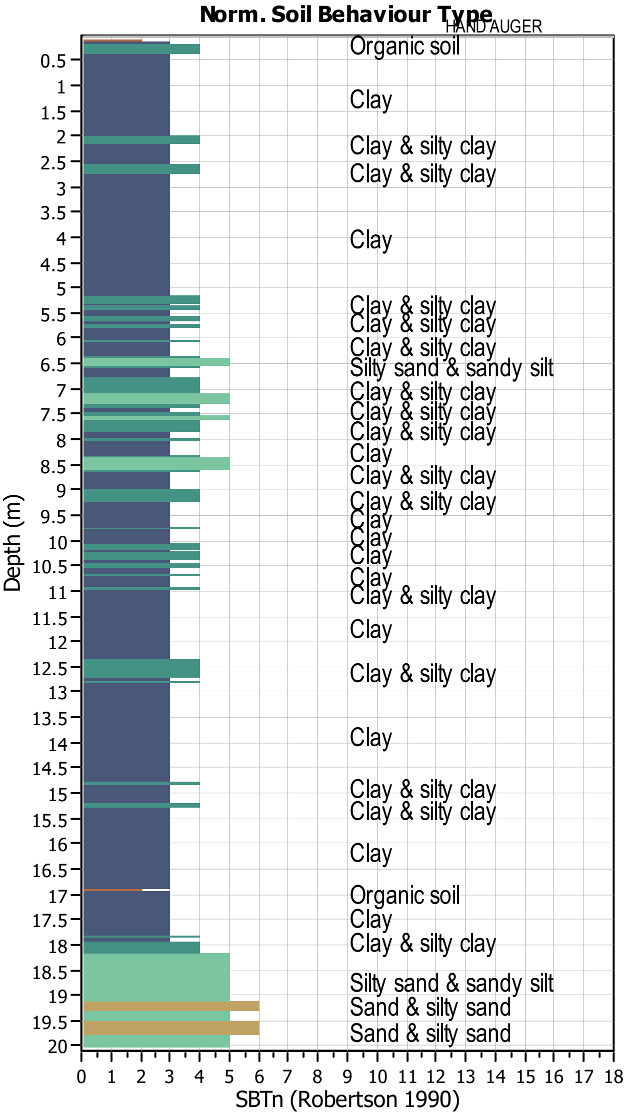
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





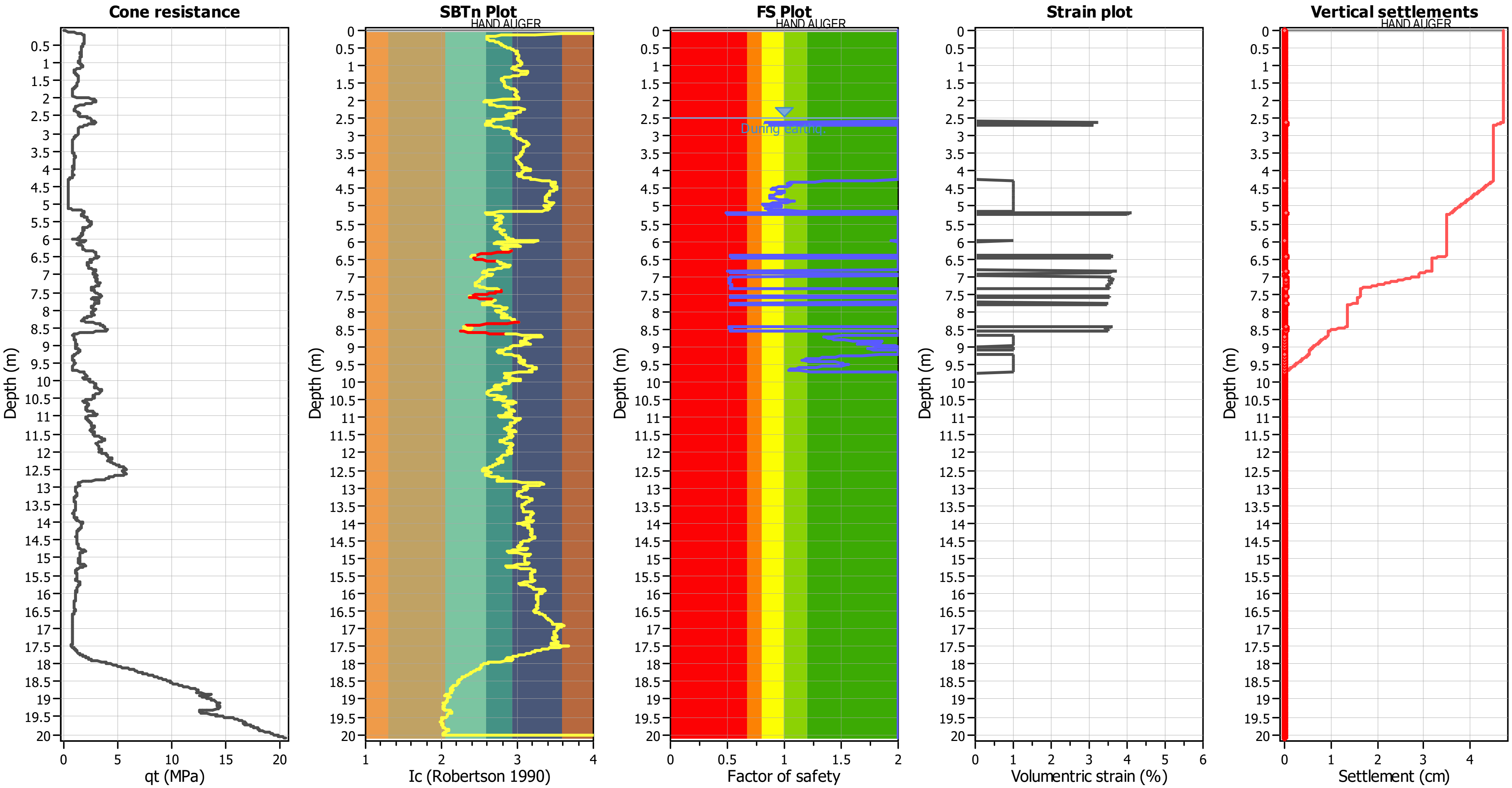
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	70
Exclusion percentage:	3.48%
Number of layers detected:	6

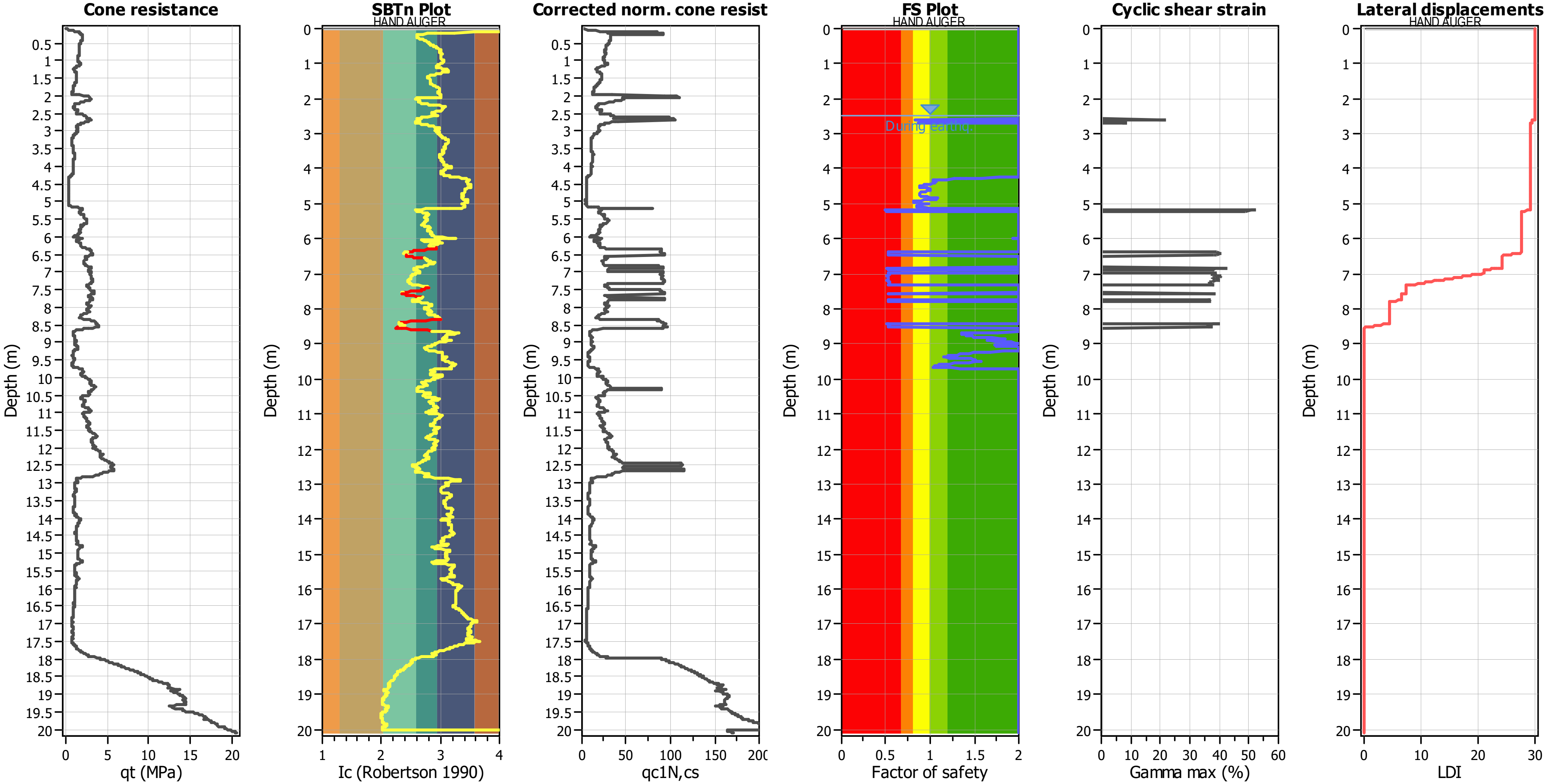
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

BTW Company Ltd
517 Anglesea Street
Hamilton
www.btw.nz

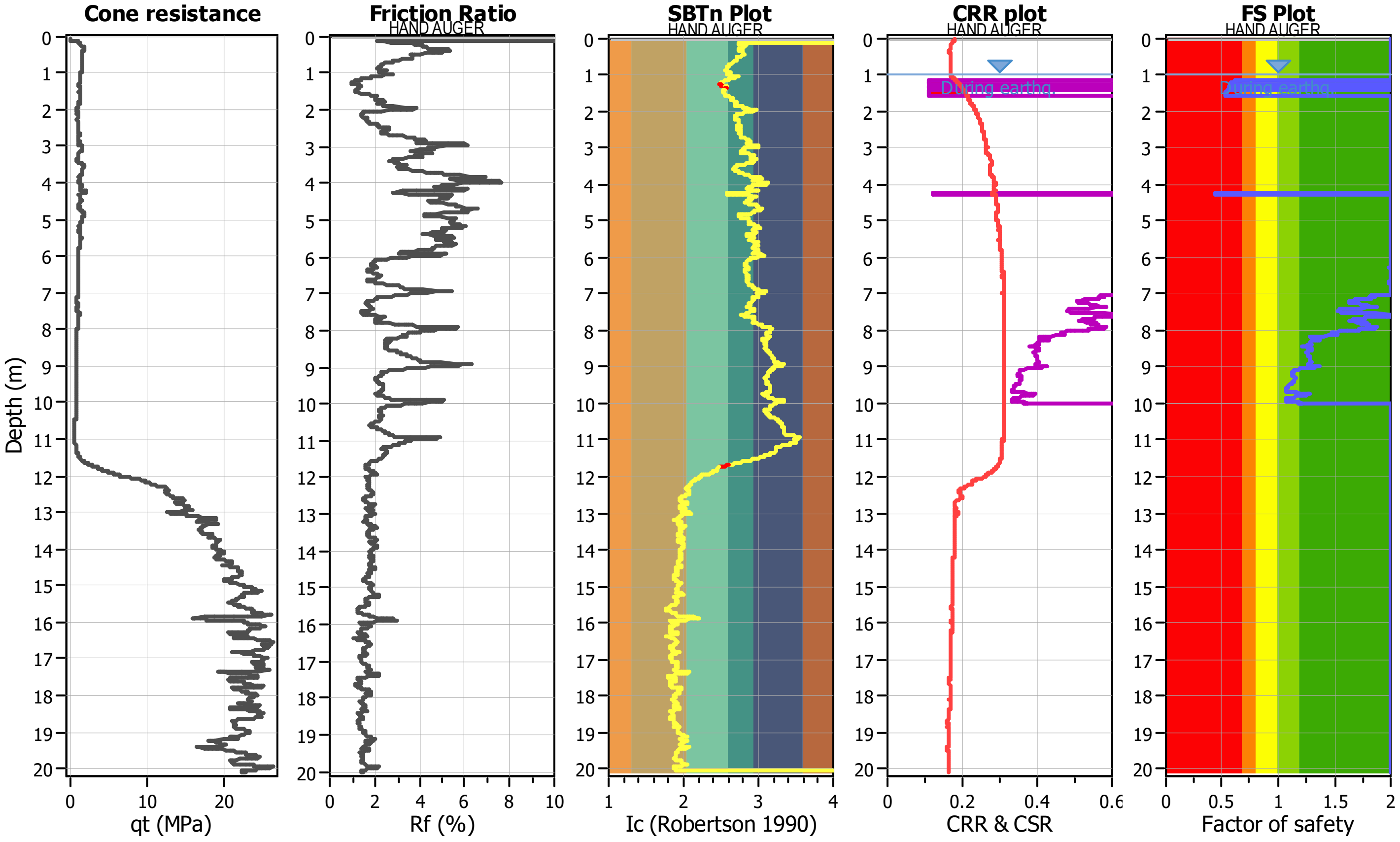
LIQUEFACTION ANALYSIS REPORT

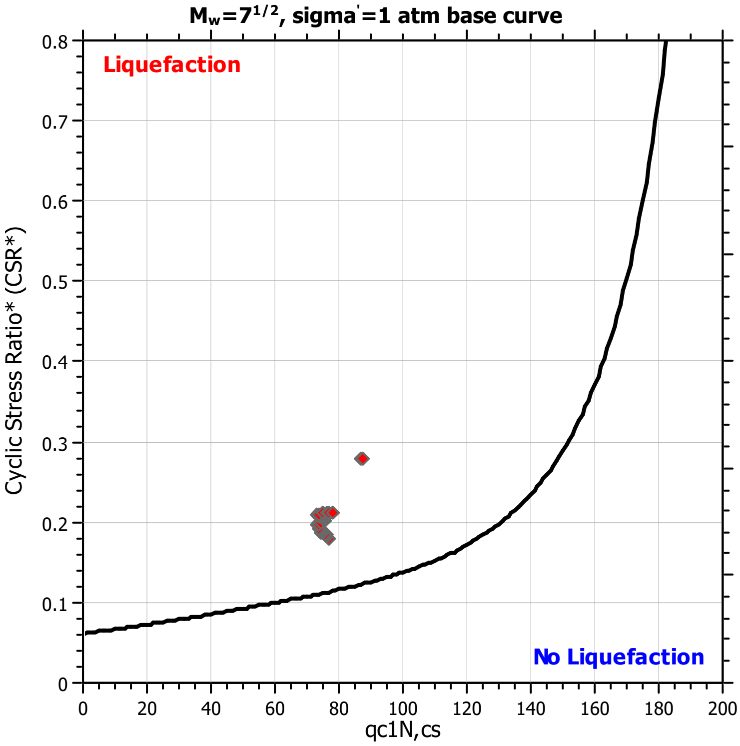
Project title : Proposed Private Plan Change for Te Awamutu **Location : 2025 Ohaupo Road, Te Awamutu**

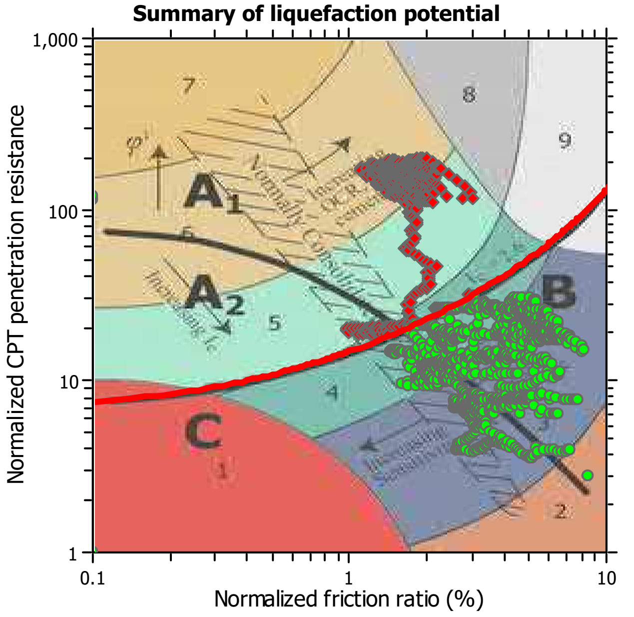
CPT file : CPT-09

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.10 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

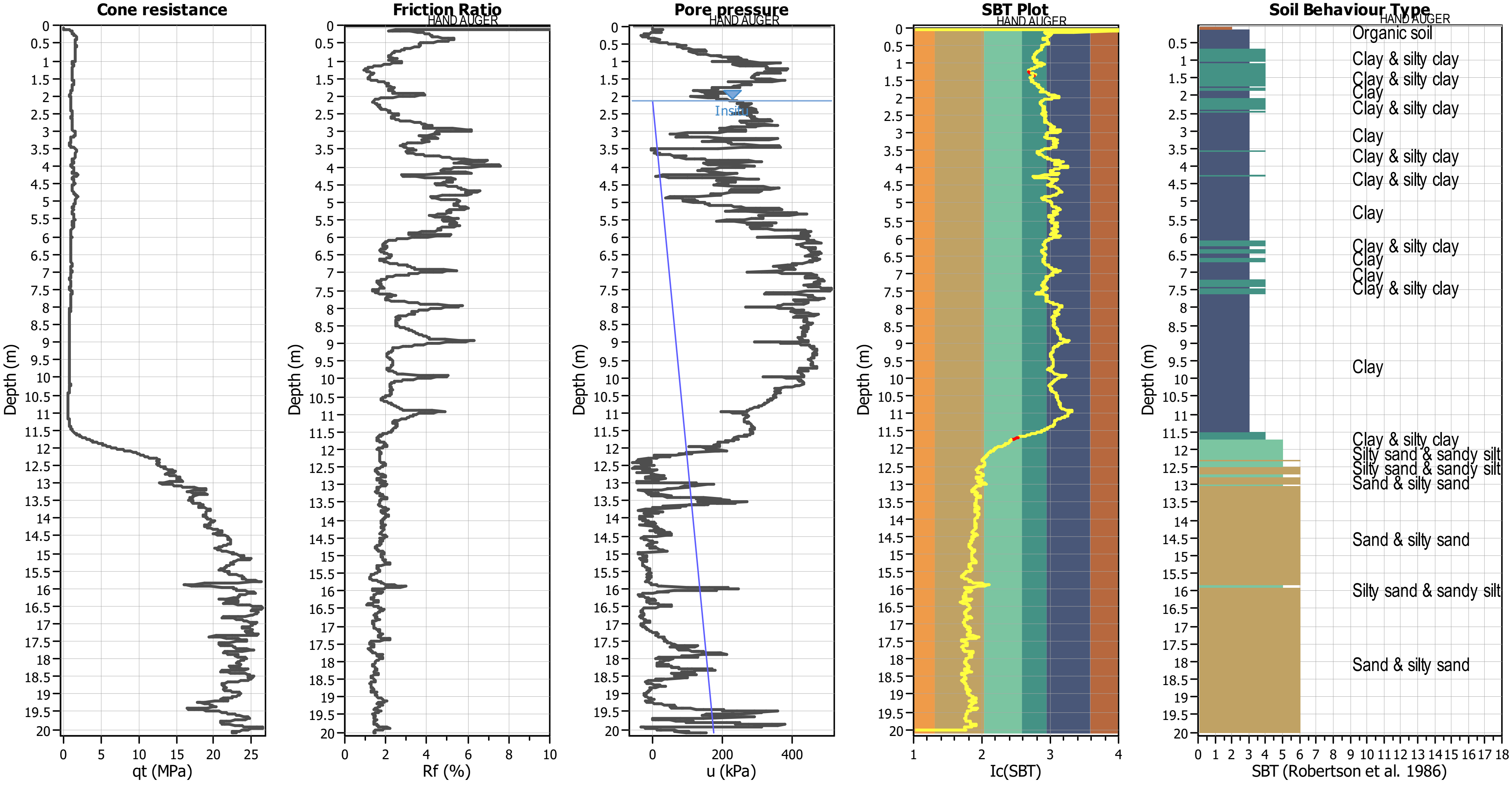






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



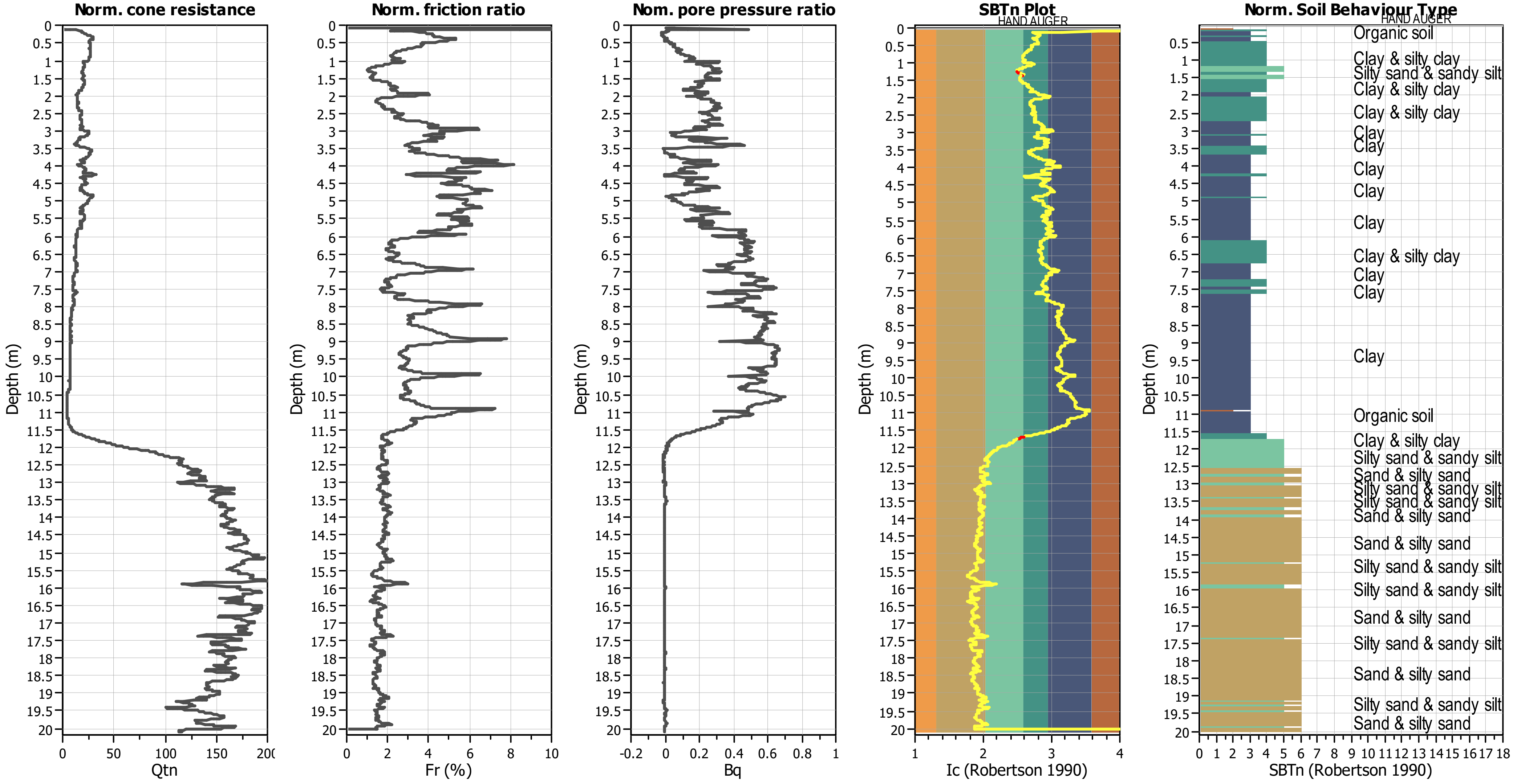
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

SBT 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

CPT basic interpretation plots (normalized)



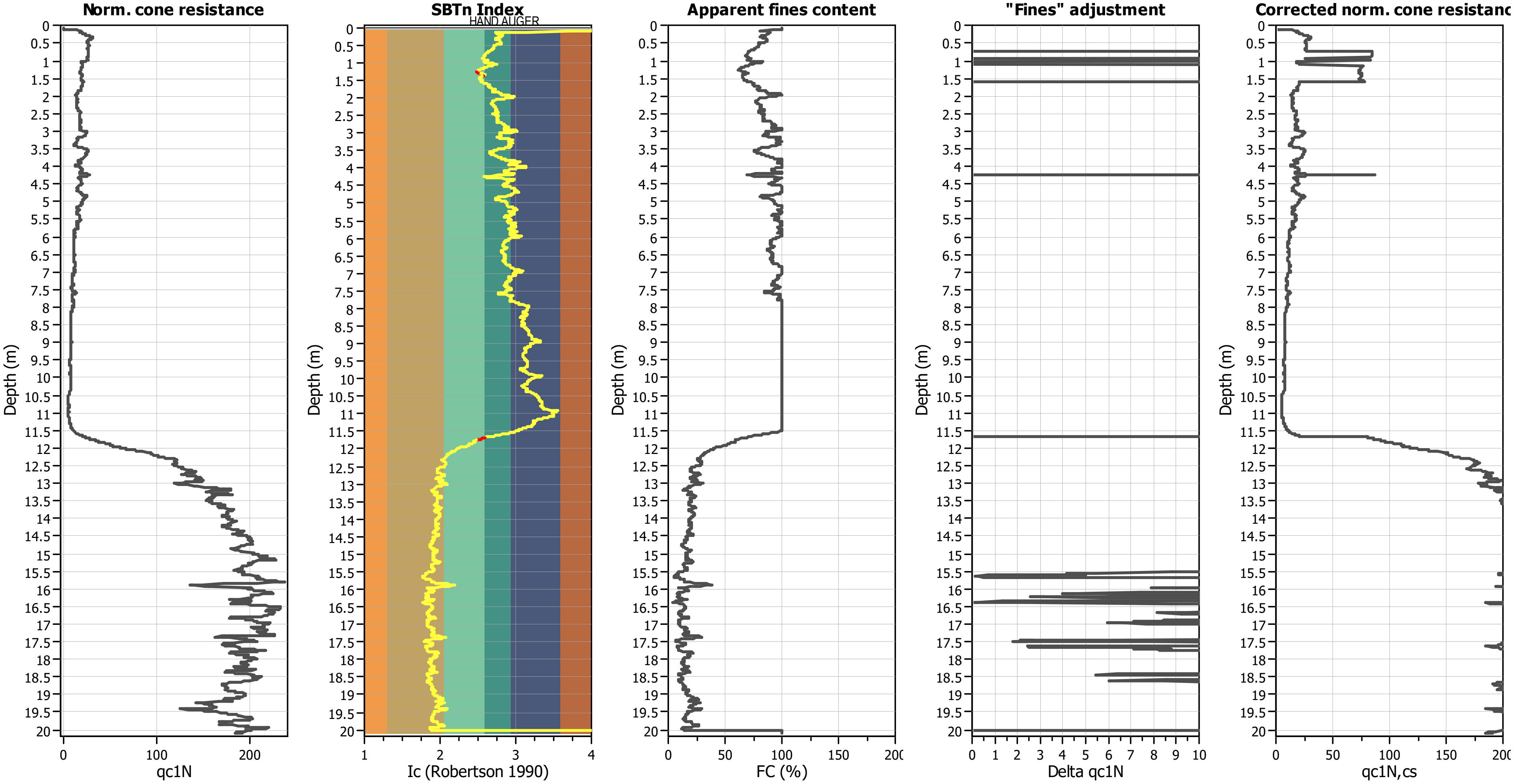
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

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

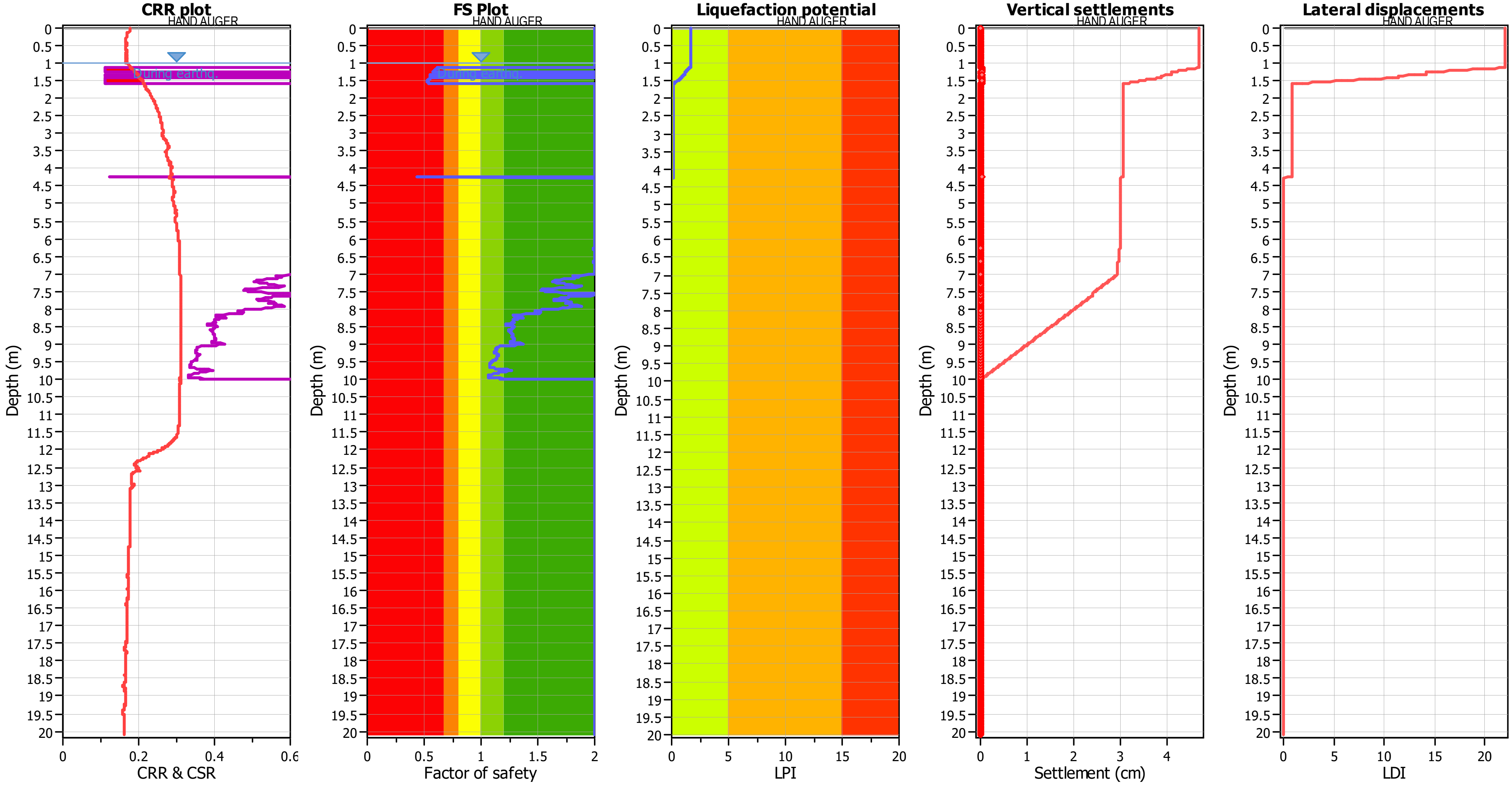
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.32
Depth to water table (insitu): 2.10 m

Depth to GWT (erthq.): 1.00 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

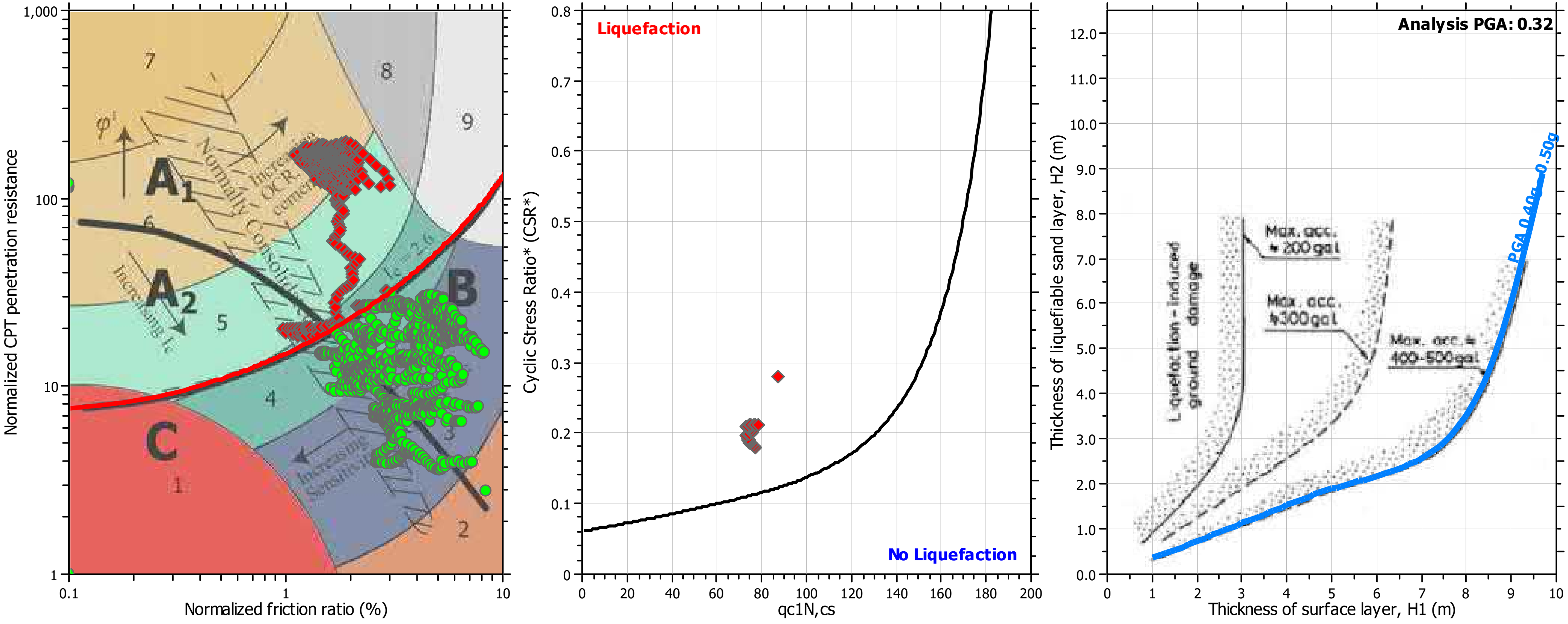
F.S. color scheme

- 🟥 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

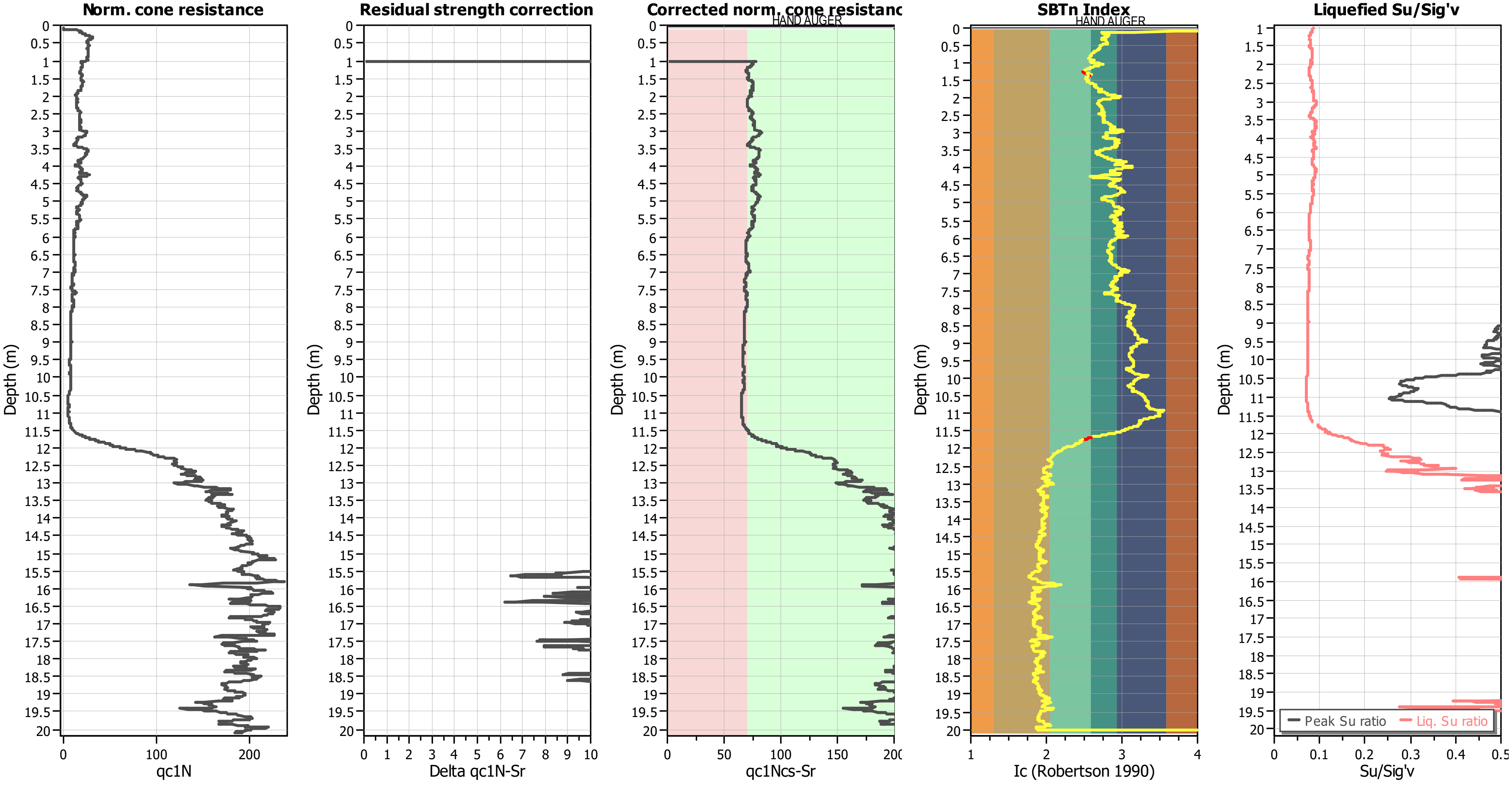
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

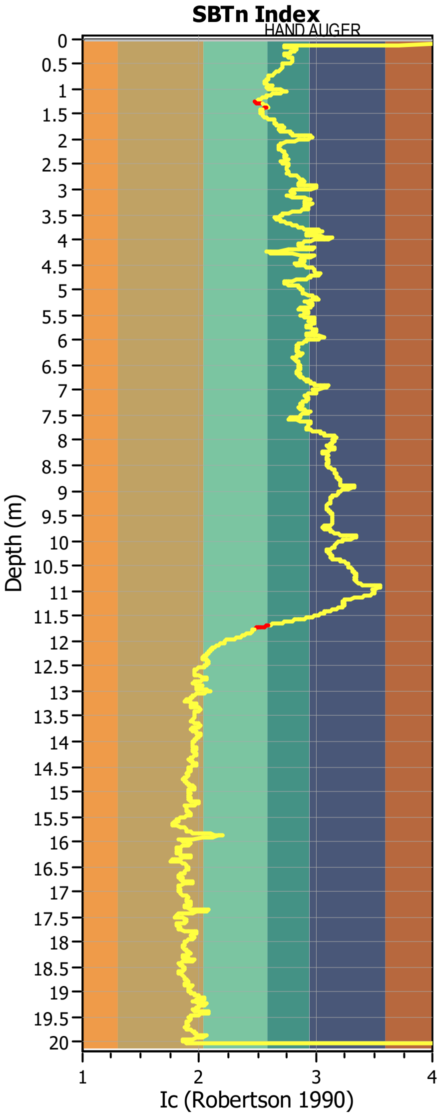
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.10 m	Fill height:	N/A	Limit depth:	10.00 m

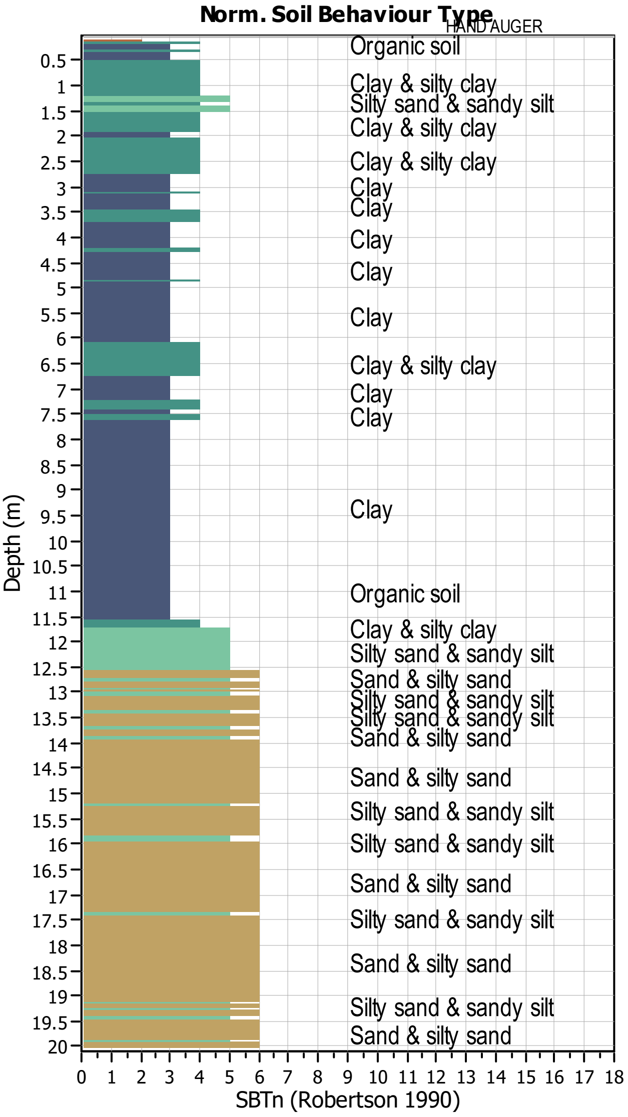
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





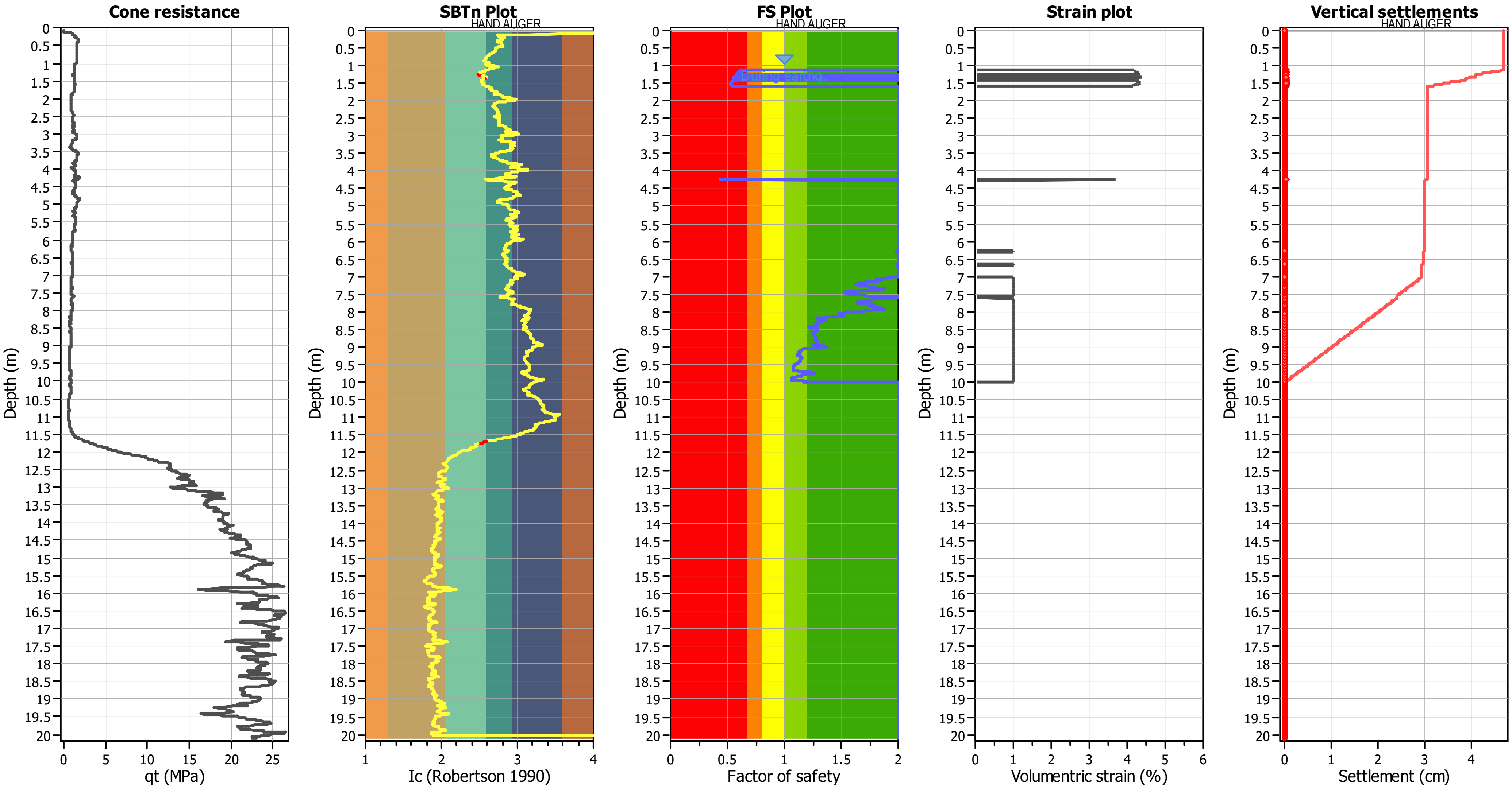
Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0100
Minimum number of points in layer:	4

General statistics

Total points in CPT file:	2010
Total points excluded:	17
Exclusion percentage:	0.85%
Number of layers detected:	3

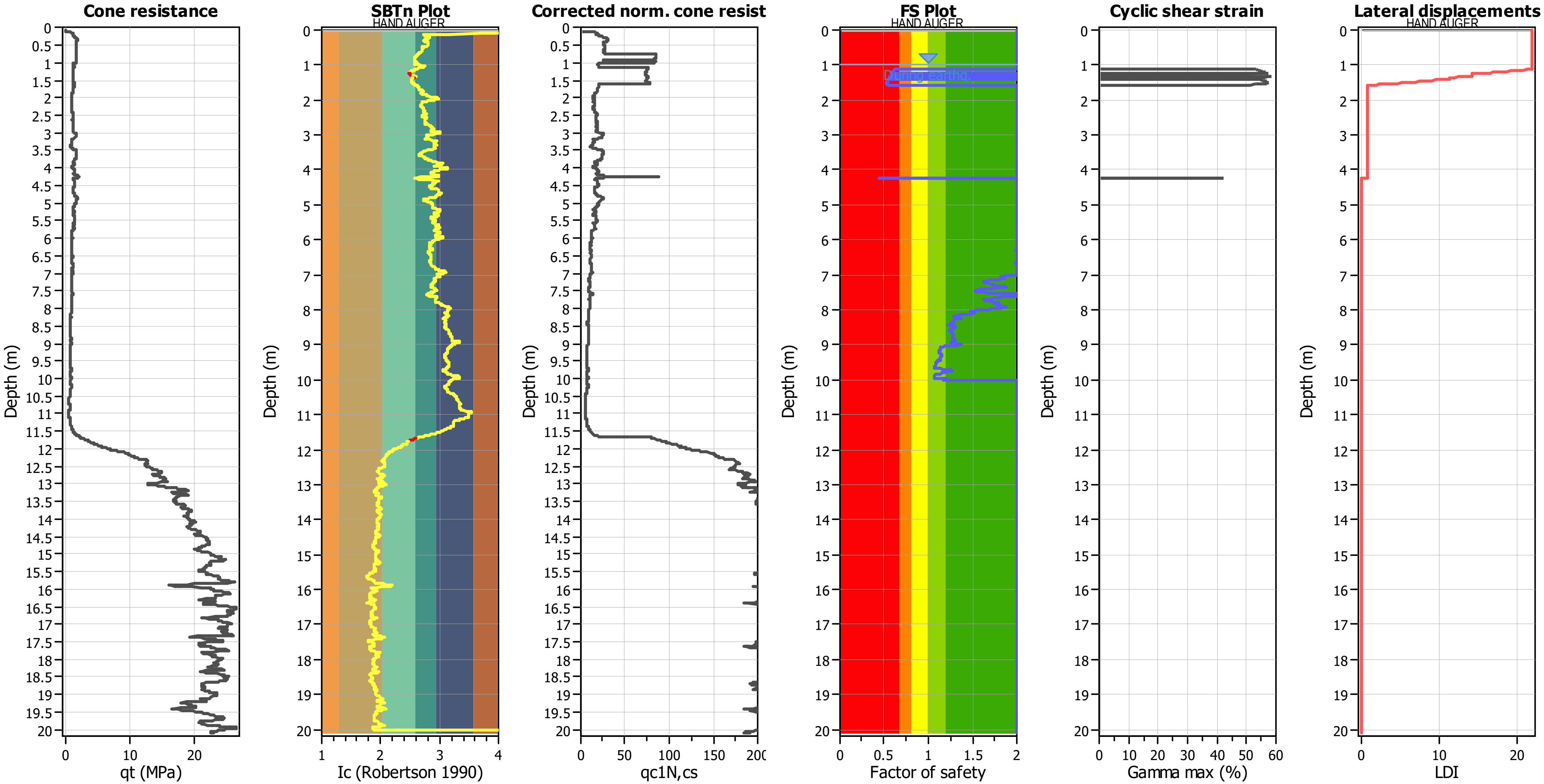
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

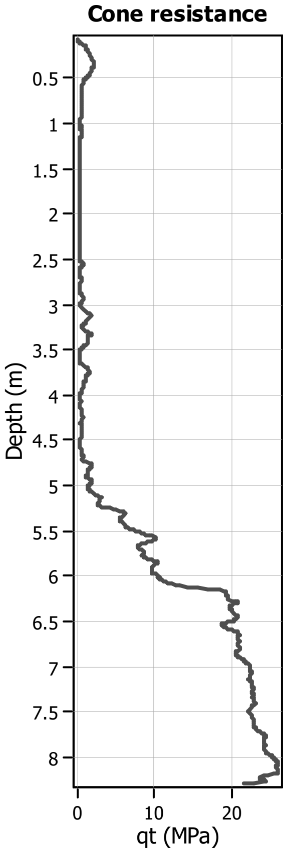
LIQUEFACTION ANALYSIS REPORT

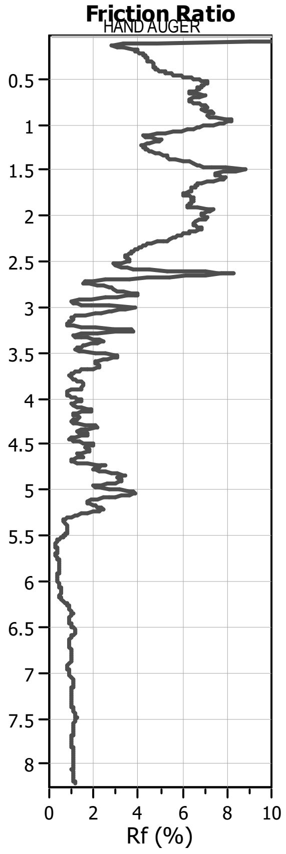
Project title : Proposed Private Plan Change for Te Awamutu **Location : 2025 Ohaupo Road, Te Awamutu**

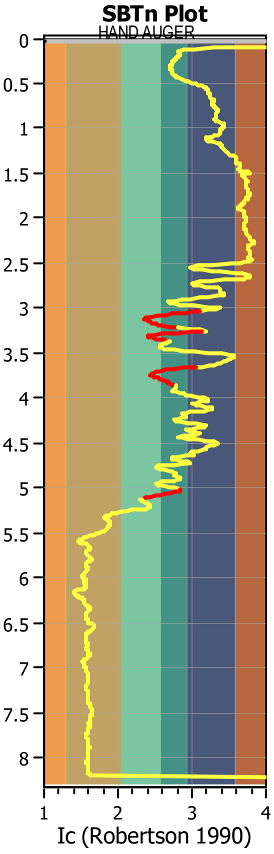
CPT file : CPT-10

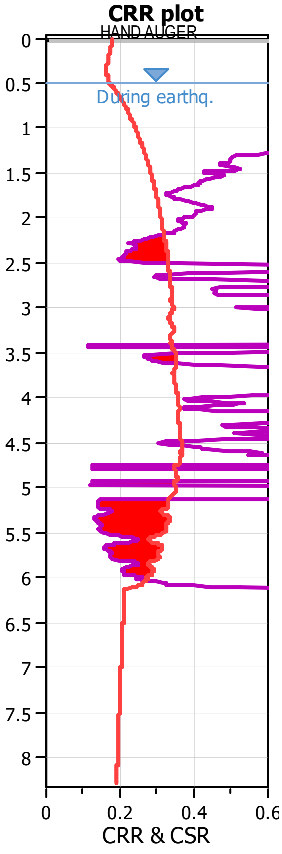
Input parameters and analysis data

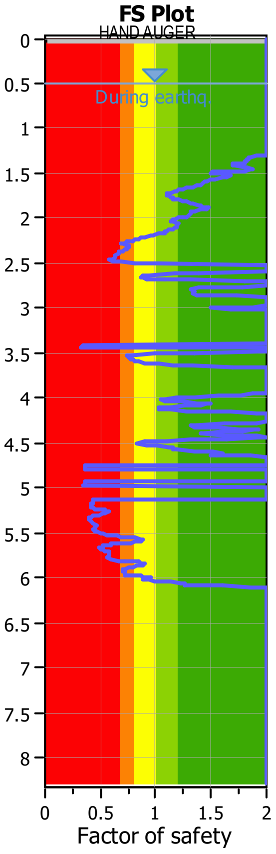
Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	10.00 m
Earthquake magnitude M_w:	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.32	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

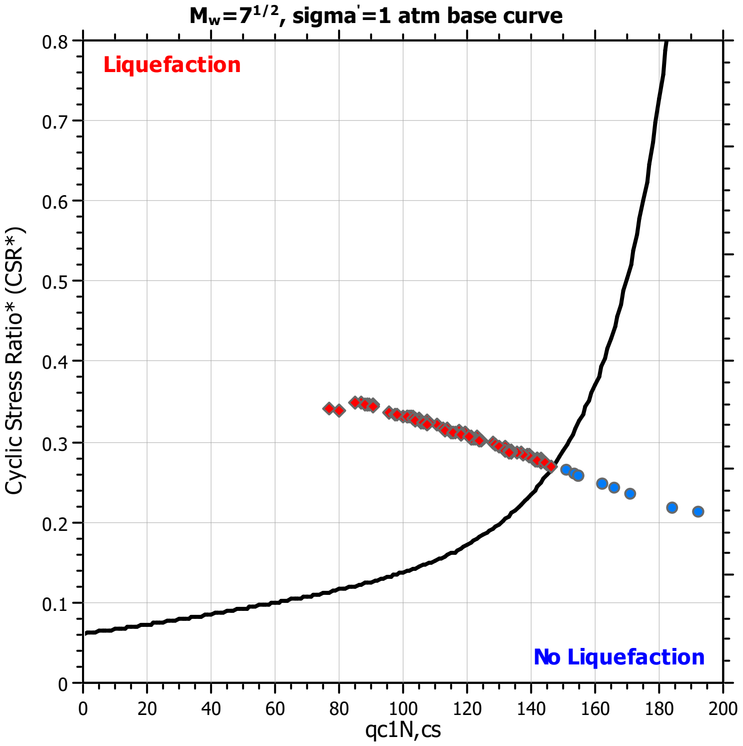


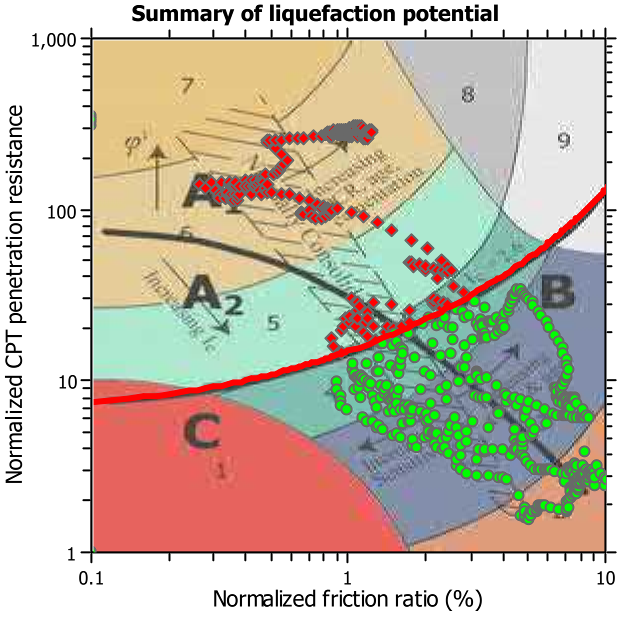






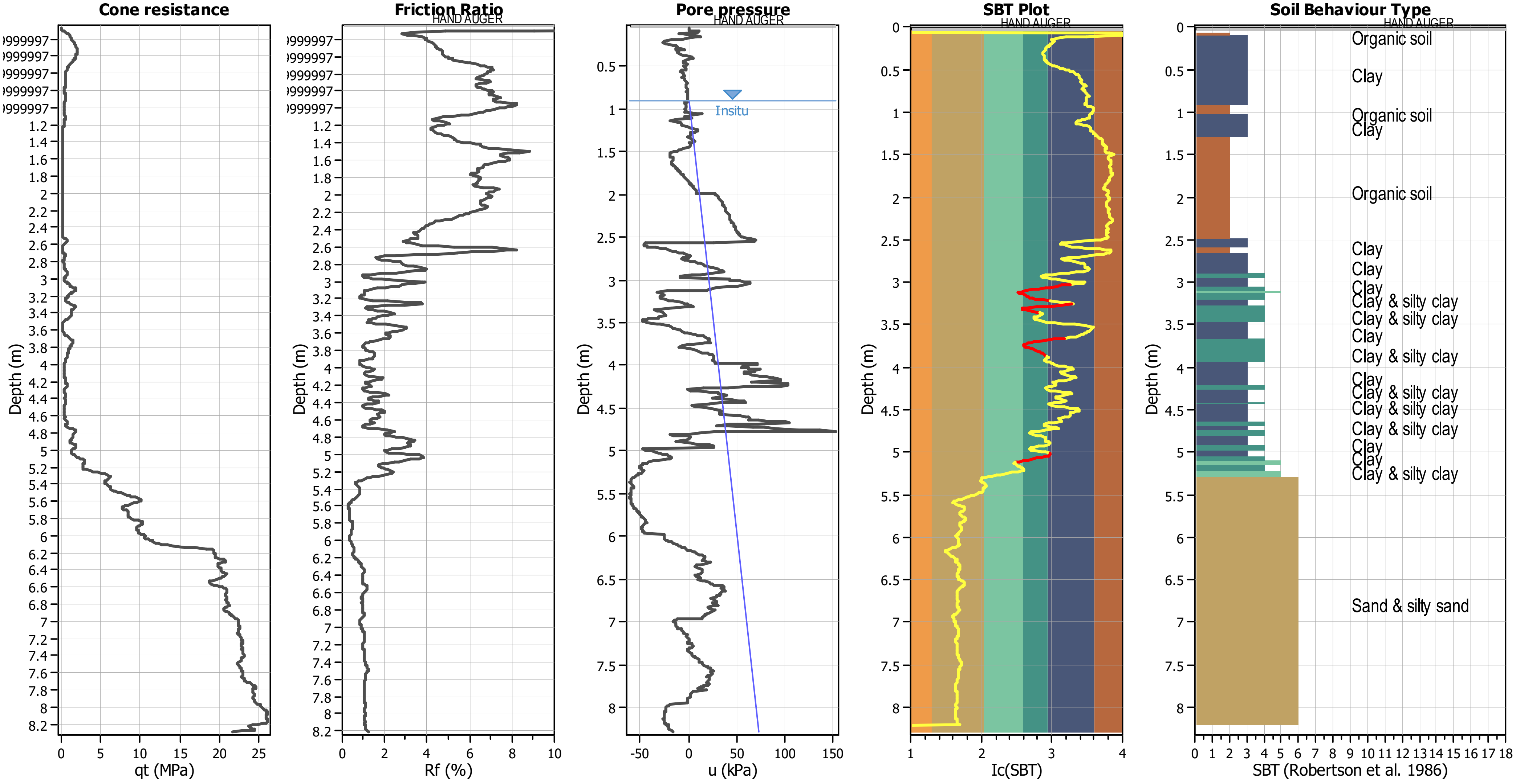






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



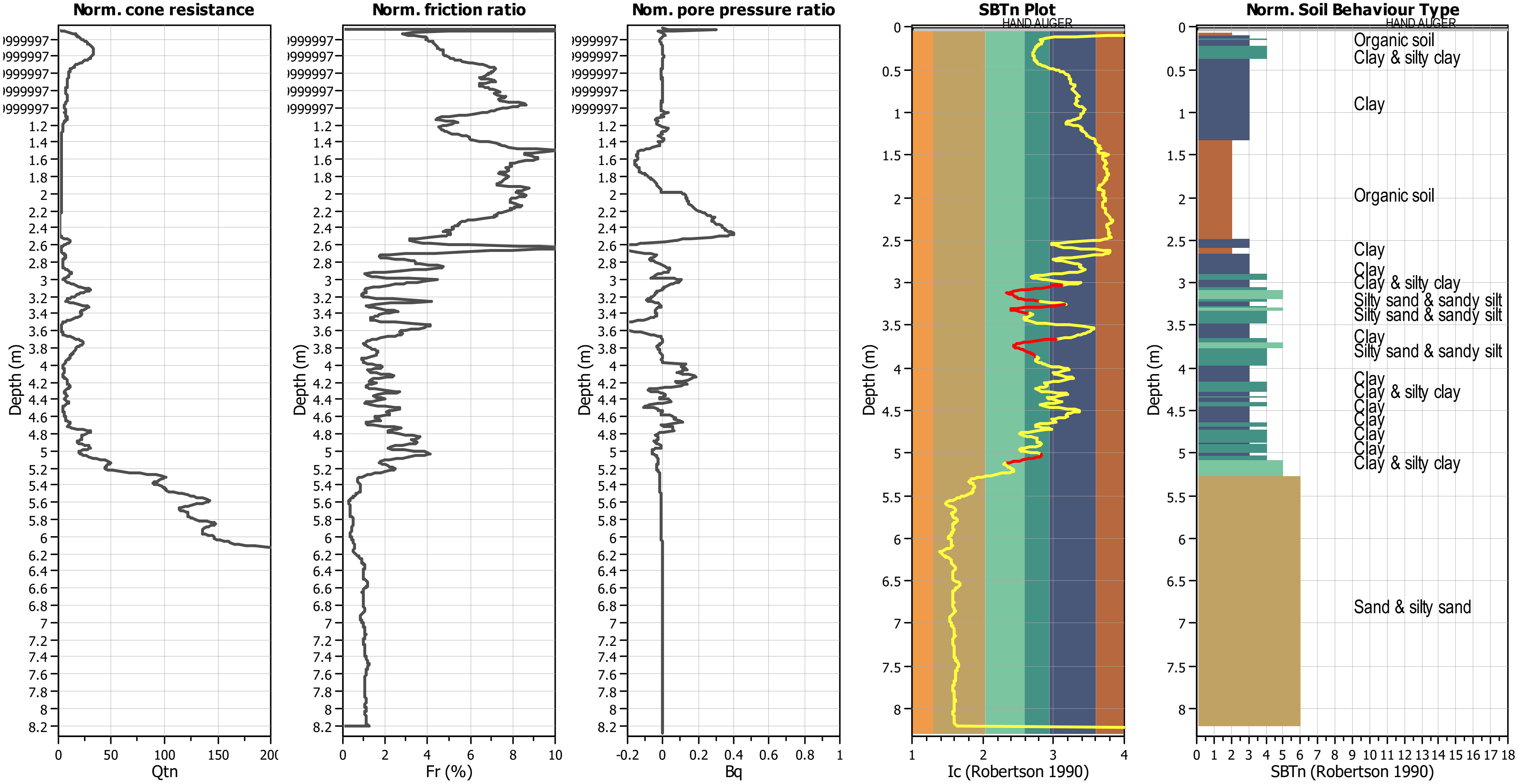
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	10.00 m

SBT 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

CPT basic interpretation plots (normalized)



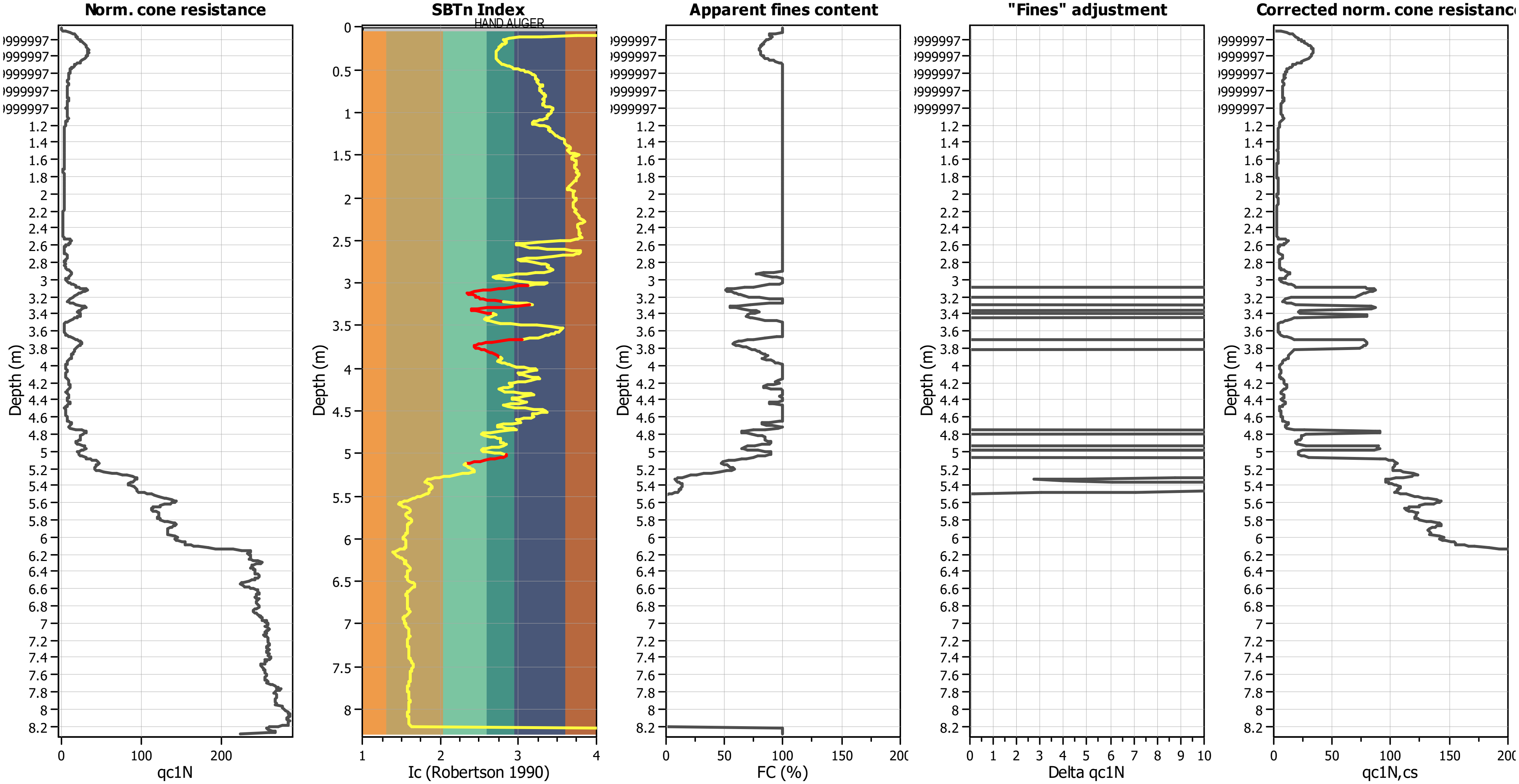
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	10.00 m

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

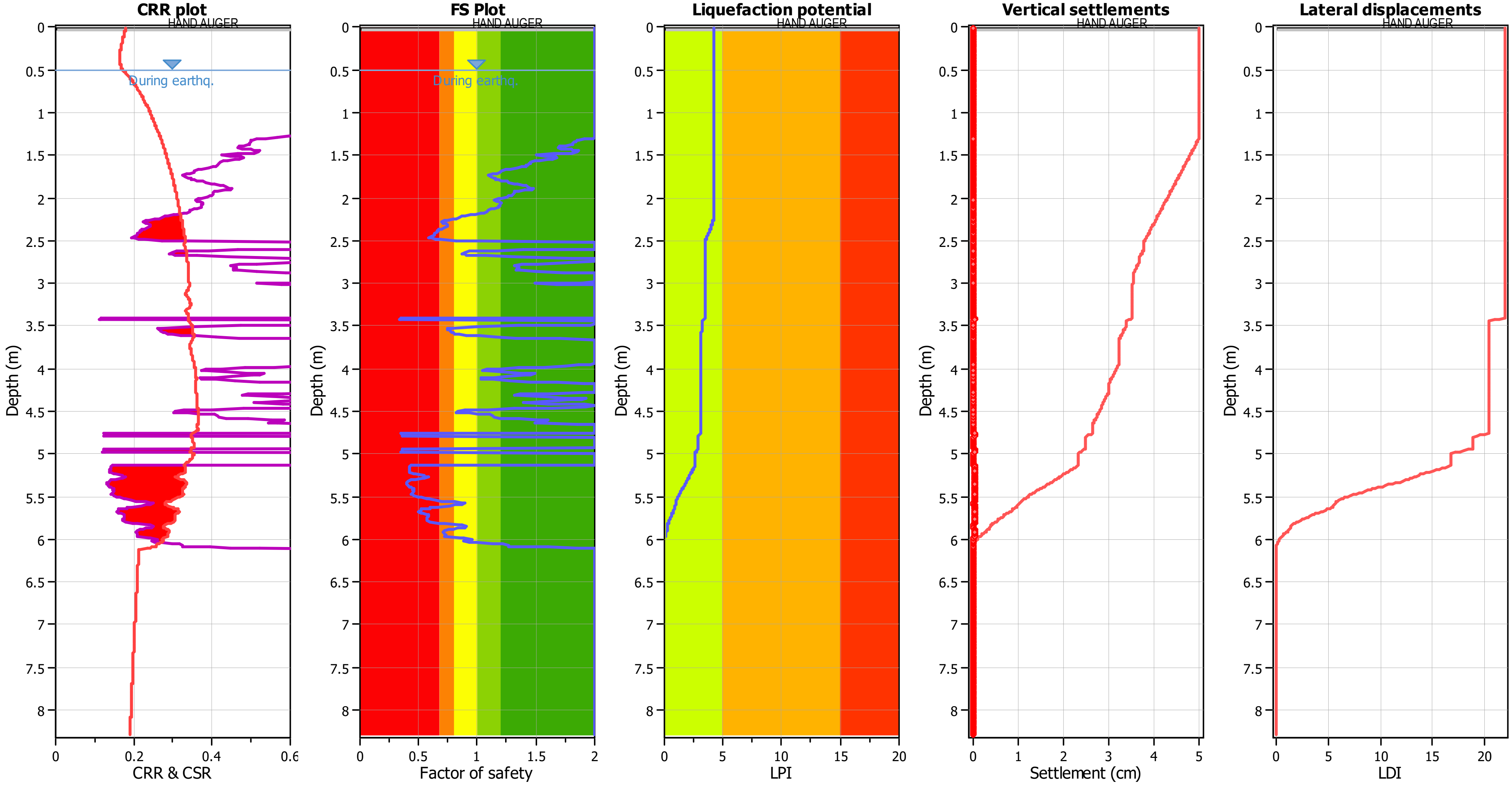
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	10.00 m

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.32
Depth to water table (insitu): 0.90 m

Depth to GWT (erthq.): 0.50 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

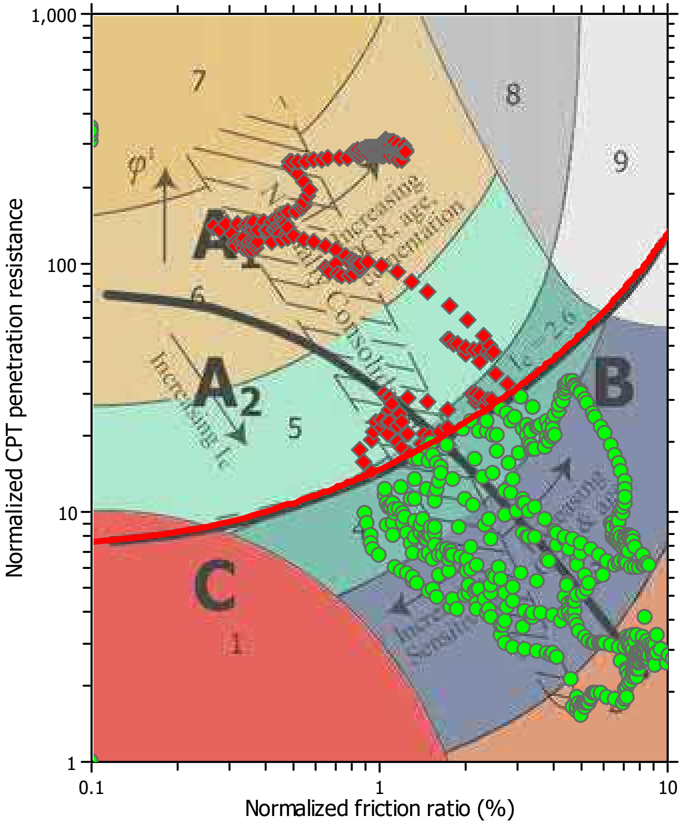
F.S. color scheme

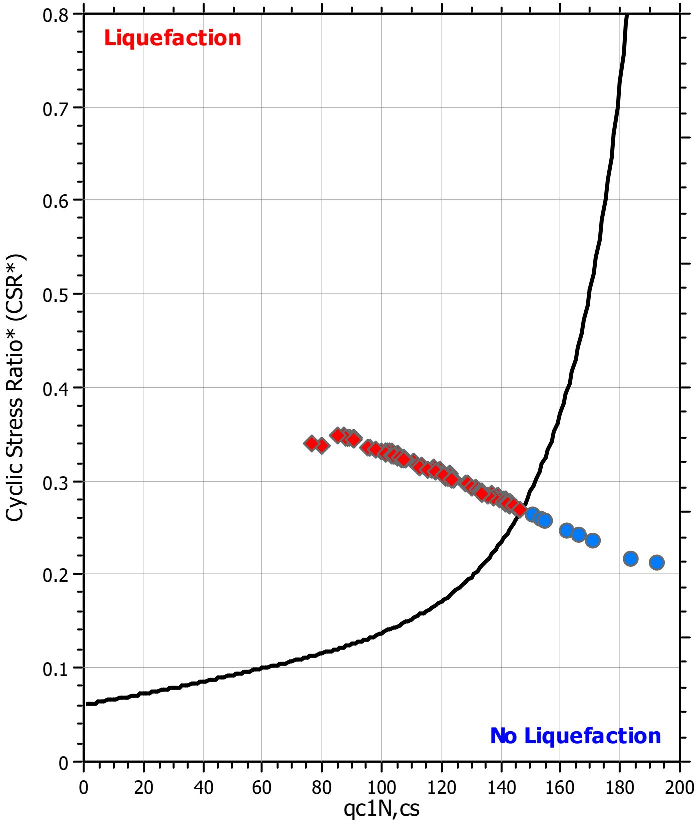
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

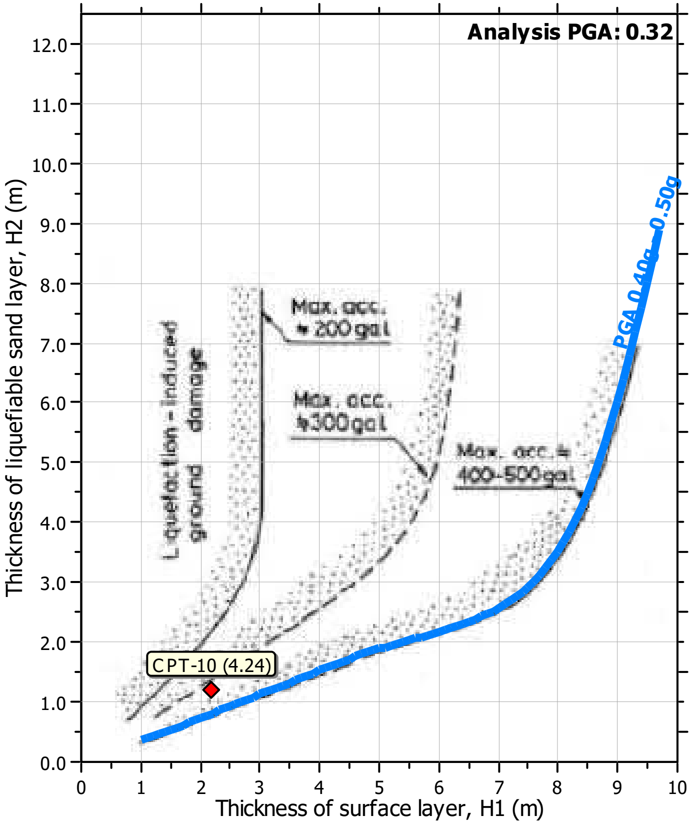
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

Liquefaction analysis summary plots



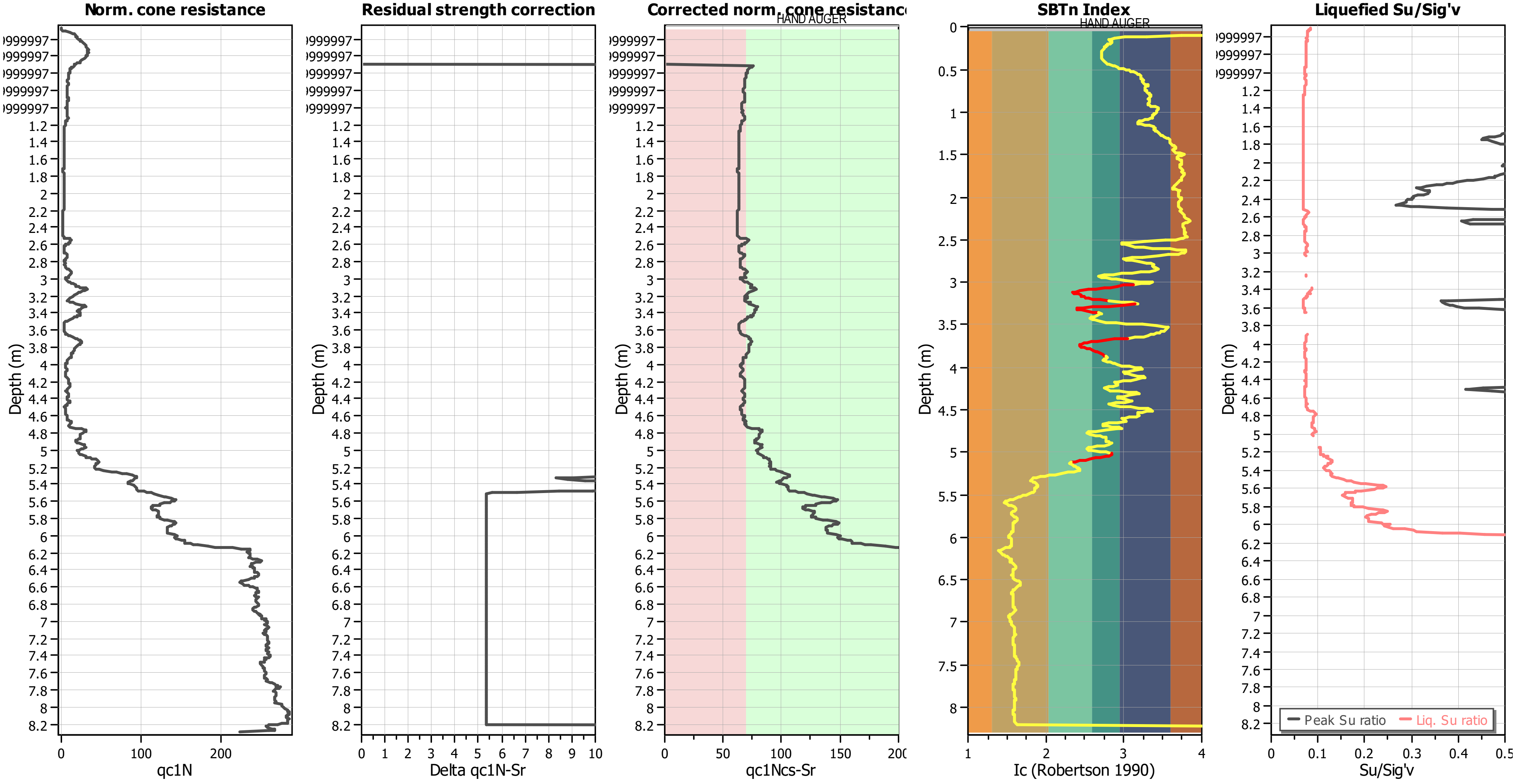




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.32	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	10.00 m

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 5.90
Peak ground acceleration: 0.32
Depth to water table (insitu): 0.90 m

Depth to GWT (erthq.): 0.50 m
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sand & Clay
Limit depth applied: Yes
Limit depth: 10.00 m

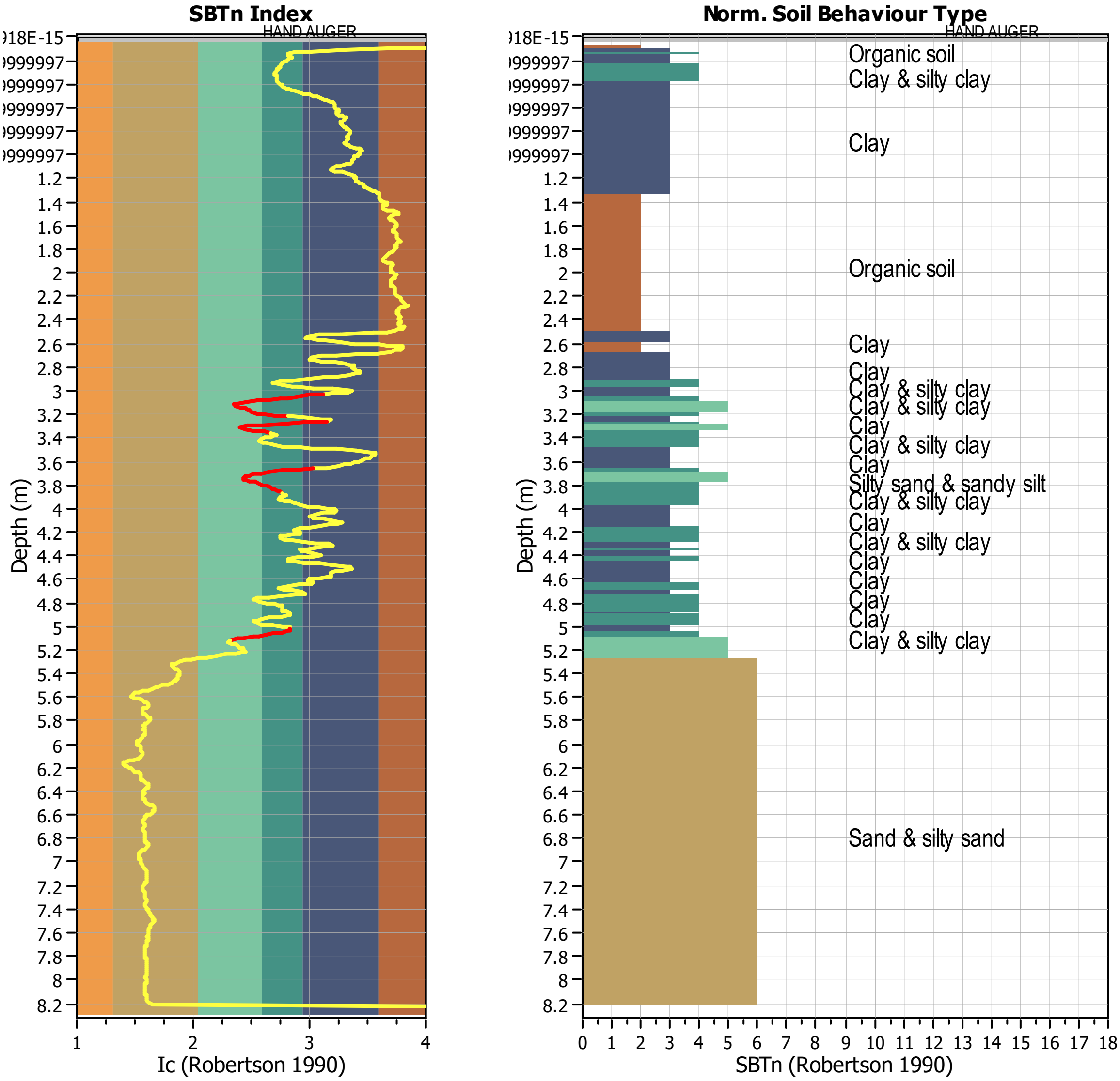
TRANSITION LAYER DETECTION ALGORITHM REPORT

Summary Details & Plots

Short description

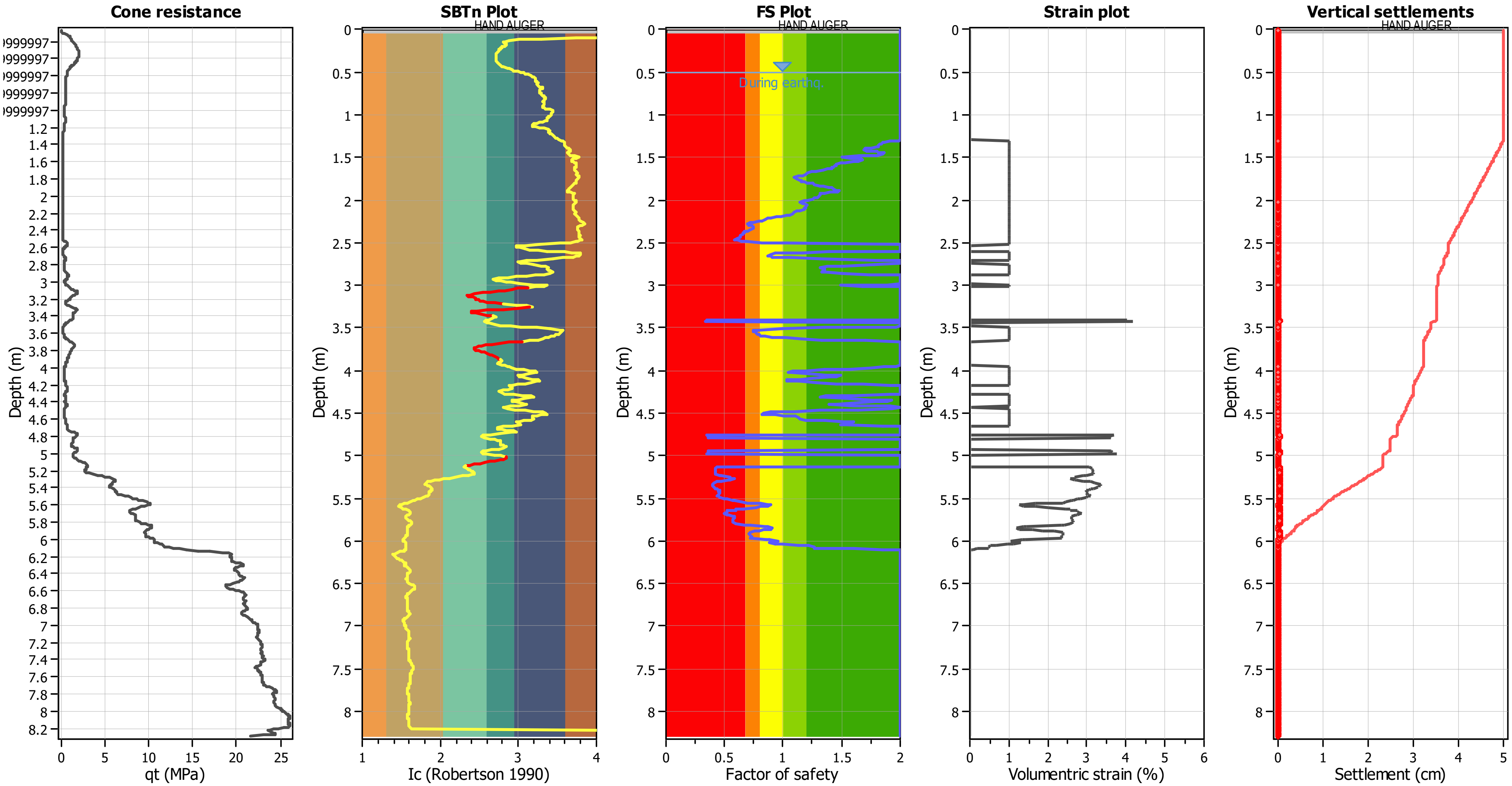
The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between 1.80 < I_c < 3.0) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.



Transition layer algorithm properties		**General statistics**	
I_c minimum check value:	1.70	Total points in CPT file:	829
I_c maximum check value:	3.00	Total points excluded:	65
I_c change ratio value:	0.0100	Exclusion percentage:	7.84%
Minimum number of points in layer:	4	Number of layers detected:	7

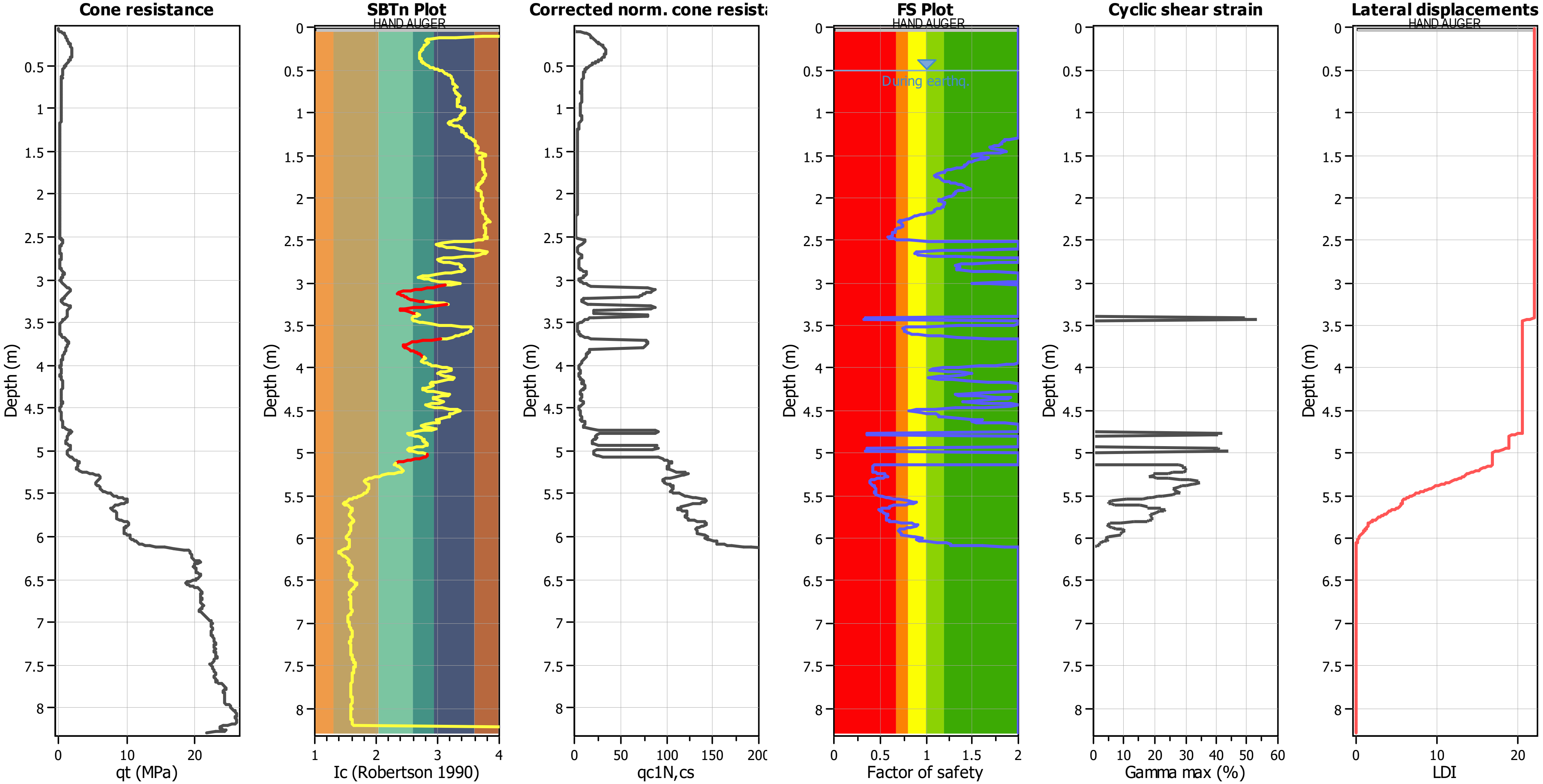
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

APPENDIX C LANDFORMS BASED ON SLOPE CLASS

BTW COMPANY

SURVEYING
ENGINEERING
PLANNING
ENVIRONMENT

GENERAL NOTES
1. Coordinates are in terms of New Zealand Transverse Mercator

DISCLAIMER
GIS data and imagery are for indicative purposes only.
Cadastral information sourced from LINZ. Crown copyright reserved.

0 20 40 80 120 160 Meters
1:3,000

NO	DATE	BY	CHKD.	

REVISIONS

LOCATION Te Awamutu
PROJECT No. 211365

DRAWN	D.Moult	13.09.22
CHECKED	G.Johnston	16.09.22
SCALE	1:3,000	
ORIGINAL SIZE	A3	

Te Awamutu Developments Limited

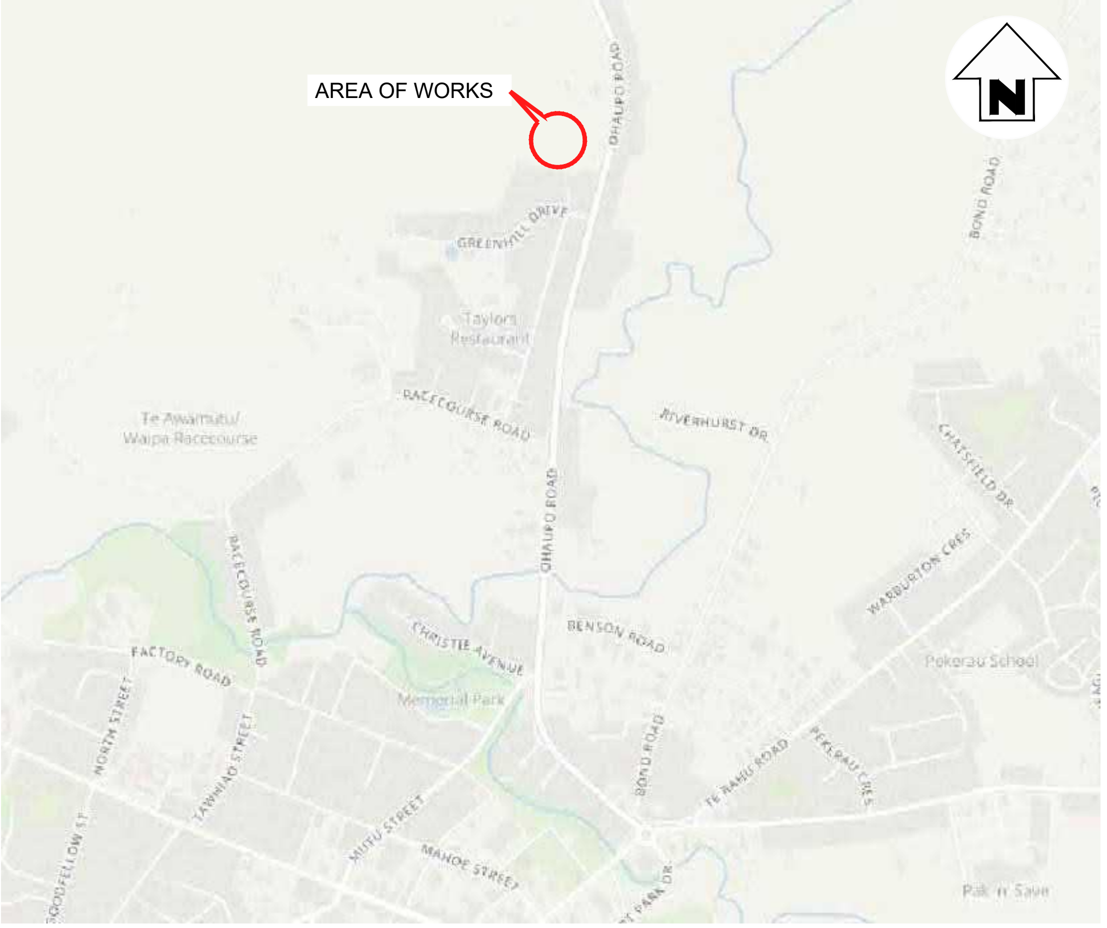
TITLE
Ohaupo Road Landform Analysis

DRAWING No 211365-100-GIS
SHEET 1
REVISION 0

APPENDIX D SITE GEOTECHNICAL CROSS-SECTIONS

2025 OHAUPO ROAD, TE AWAMUTU
GEOTECHNICAL PLAN
TE AWAMUTU DEVELOPMENTS LIMITED

DRAWING	SHEET	TITLE	DATE OF ISSUE / REVISION				
			A				
211365-06	00	COVER SHEET	22/11/2022				
211365-06	01	GENERAL ARRANGEMENT PLAN	22/11/2022				
211365-06	02	GEOTECHNICAL SECTION A	22/11/2022				
211365-06	03	GEOTECHNICAL SECTION A	22/11/2022				
211365-06	04	GEOTECHNICAL SECTION A1 & B	22/11/2022				
211365-06	05	GEOTECHNICAL SECTION B1	22/11/2022				



PROJECT LOCATION PLAN

SCALE N.T.S

KEY

WD	WORKING DRAFT	C	TENDER
A	APPROVAL	0	CONSTRUCTION
B	CONSENTS	AS	AS BUILT

TRANSMITTAL

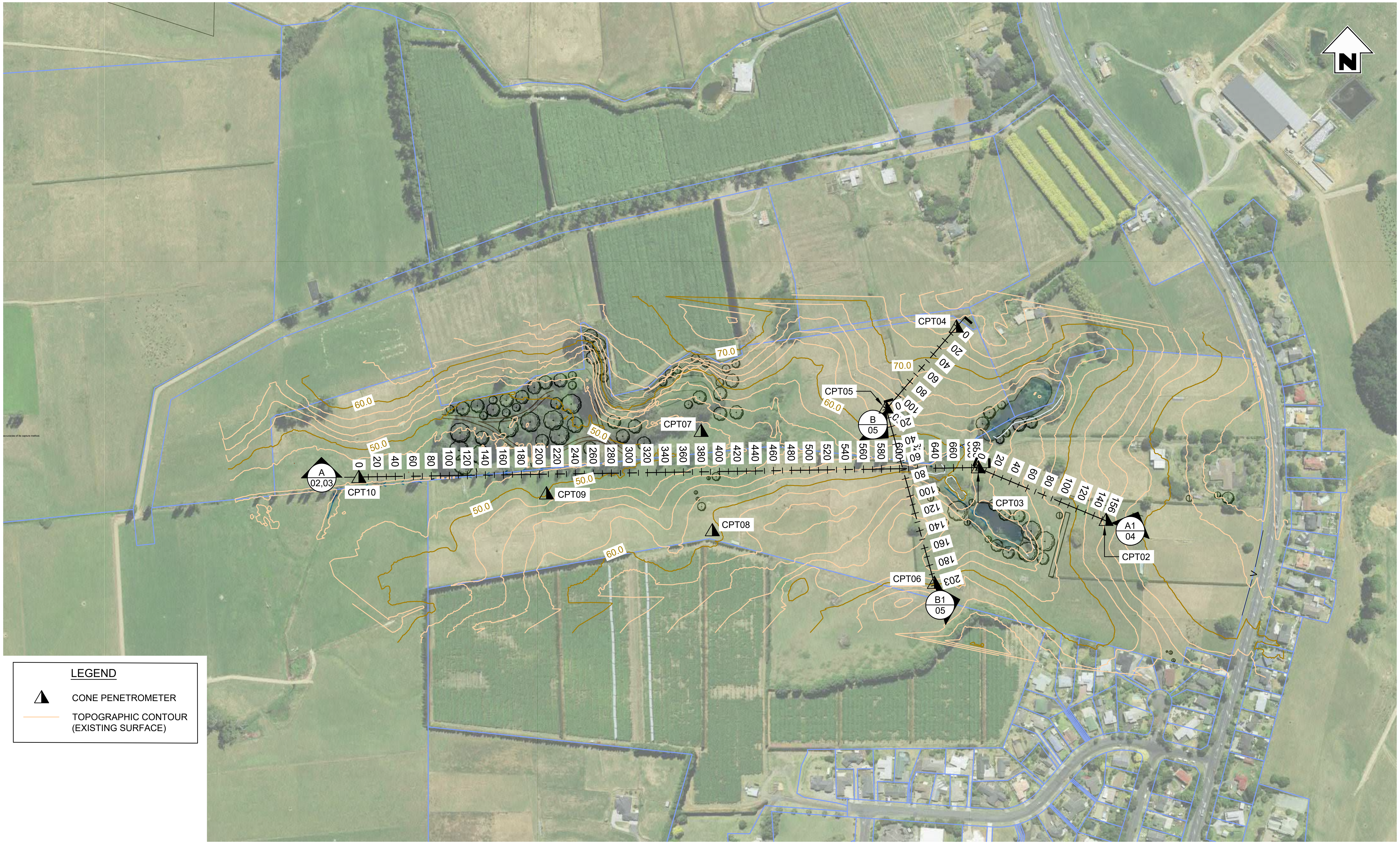
TO	ATTENTION	DATE OF ISSUE / REVISION				
		A				
OWNER / DEVELOPER	ULTIMATE HOLDINGS LIMITED	22/11/2022				
ARCHITECT / DESIGNER						
QUANTITY SURVEYOR						
BUILDER / CONTRACTOR						
TERRITORIAL AUTHORITY						

BTW COMPANY

SURVEYING
ENGINEERING
PLANNING
ENVIRONMENT

ISSUED FOR INFORMATION

File Name: C:\12dS\data\BTW12D\211365 - Ultimate Holdings Ltd, Hamilton_4164\07 Drawings\211365-06 geotechnical plan.dwg - SHT 0 Plot Date: 23/11/2022 Plot Time: 16:48



40 0 40 80 120 160 200m

SCALE 1 : 4000

Disclaimer:
Areas and dimensions may be subject to scale error.
Scaling from this drawing is at the users risk.

PLAN

SCALE 1:4000

ISSUED FOR INFORMATION

BTW COMPANY

SURVEYING
ENGINEERING
PLANNING
ENVIRONMENT

NO	DATE	BY	CHKD.	APPR.	OPER.	DESCRIPTION
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
A	22/11/22	J.S	B.M	M.D	.	ISSUED FOR INFORMATION - PRIVATE PLAN CHANGE SUBMISSION

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

GENERAL NOTES
1. Coordinates in terms of : Geodetic Datum (Mt Eden 2000)
2. Elevations in terms of : NZ Vertical Datum 2016
3. Contour interval is : 2m

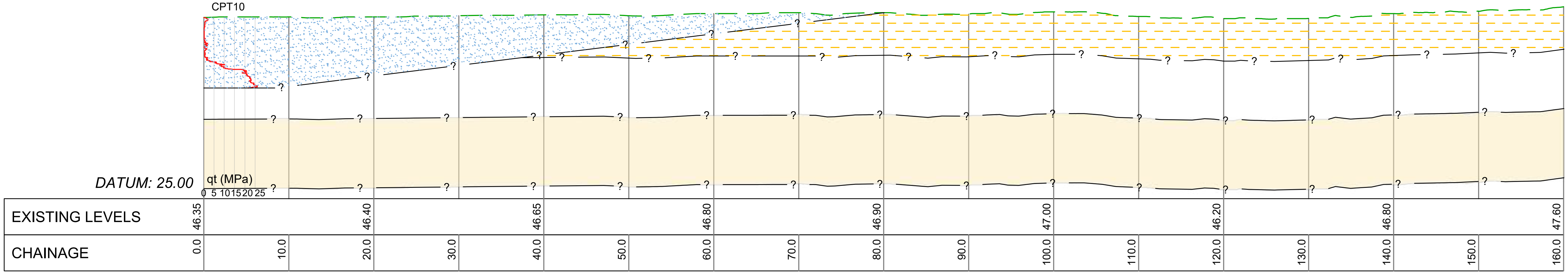
LOCATION: WAIKATO
PROJECT No.: 211365
A3 SCALE: AS SHOWN

SURVEYED	-	-
DRAWN	J.STEPHENSON	21/10/22
CHECKED	-	-

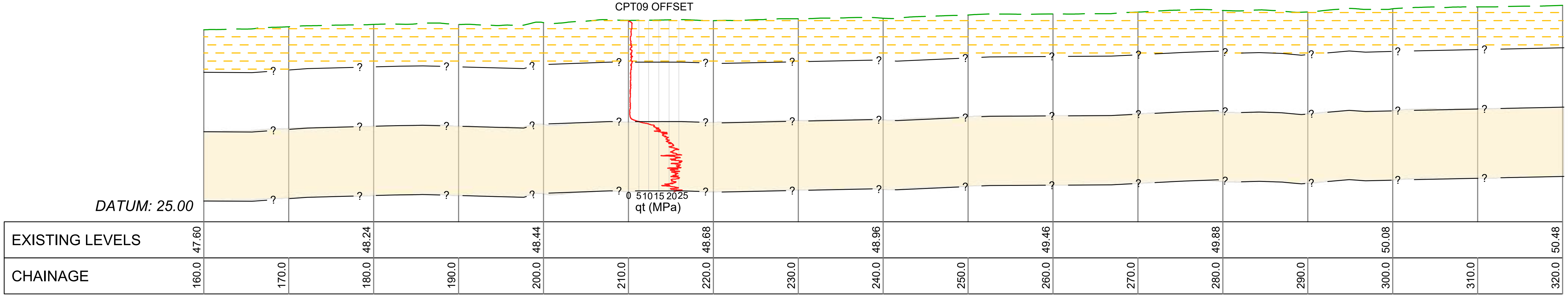
TITLE
TE AWAMUTU DEVELOPMENTS LIMITED
2025 OHAUPO ROAD, TE AWAMUTU
GENERAL ARRANGEMENT PLAN

ORIGINAL SIZE	DRAWING No	SHEET	REVISION
A3	211365-06	01	A

File Name: C:\12d\Sdata\BTW12D\211365 - Ultimate Holdings Ltd, Hamilton_4164\07 Drawings\211365-06 geotechnical plan.dwg - SHT 1 Plot Date: 23/11/2022 Plot Time: 16:48



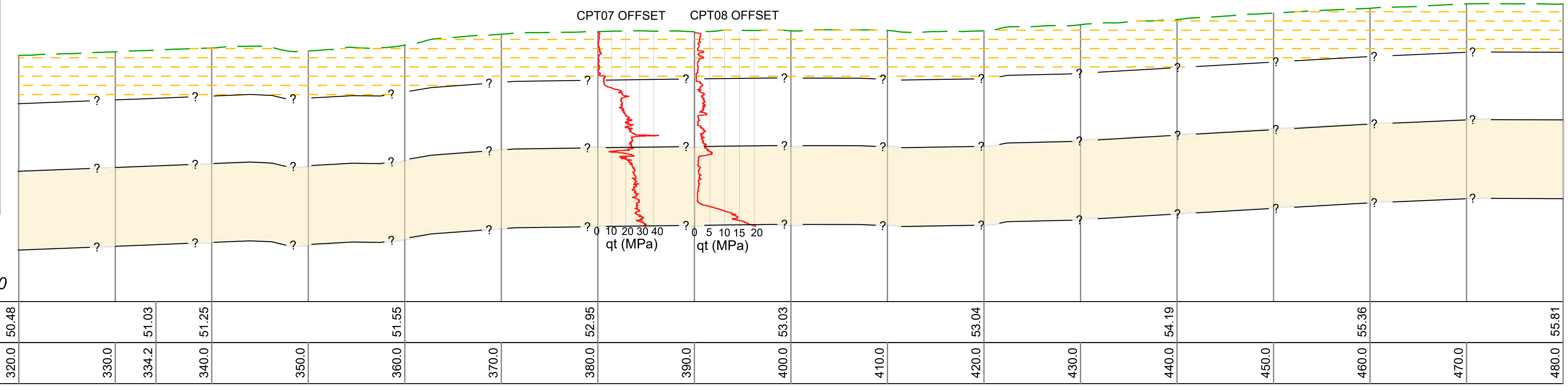
A SECTION
01 SCALE 1:500



A SECTION
01 SCALE 1:500

LEGEND

▨	UNIT 0 = HINUERA FORMATION
▤	UNIT 1 = HAMILTON ASH FORMATION
☐	UNIT 2 = KAUROA FORMATION
▥	UNIT 3 = PUKETOKA FORMATION
——— ? ———	INFERRED GEOLOGICAL BOUNDARY



5 0 5 10 15 20 25
SCALE 1 : 500

Disclaimer:
Areas and dimensions may be subject to scale error.
Scaling from this drawing is at the users risk.

A SECTION
01 SCALE 1:500

ISSUED FOR INFORMATION

File Name: C:\12d\Sdata\BTW12D\211365 - Ultimate Holdings Ltd, Hamilton_4164\07 Drawings\211365-06 geotechnical plan.dwg - SHT 2 (A) Plot Date: 23/11/2022 Plot Time: 16:49

BTW COMPANY

SURVEYING
ENGINEERING
PLANNING
ENVIRONMENT

NO	DATE	BY	CHKD	APPR	OPER	DESCRIPTION
A	22/11/22	J.S	B.M	M.D		ISSUED FOR INFORMATION - PRIVATE PLAN CHANGE SUBMISSION

REVISIONS

NUMBER	TITLE

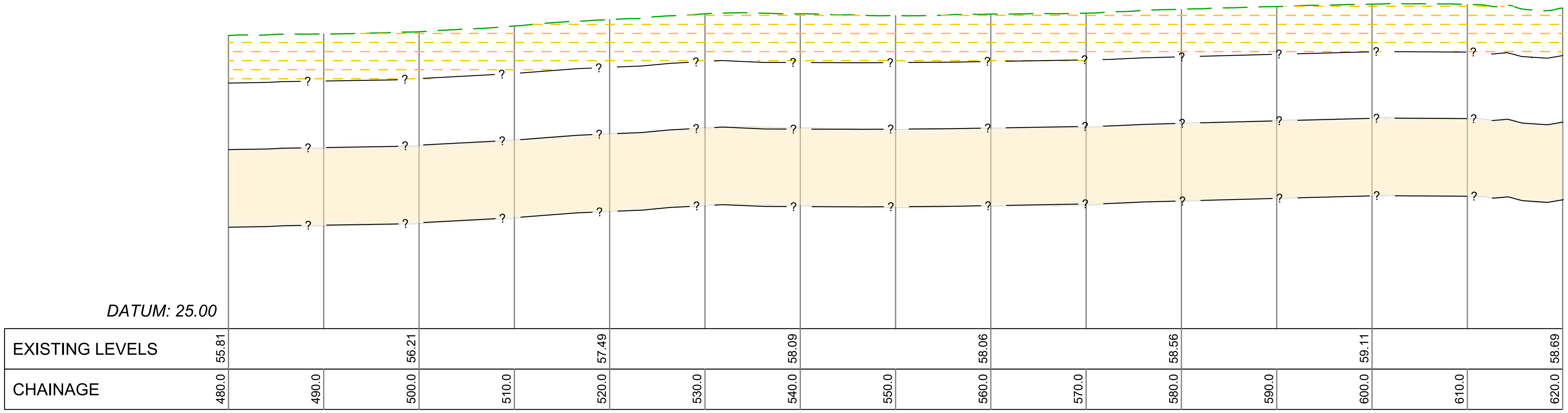
REFERENCE DRAWINGS

GENERAL NOTES
1. Coordinates in terms of : Geodetic Datum (Mt Eden 2000)
2. Elevations in terms of : NZ Vertical Datum 2016
3. Contour interval is : 2m

LOCATION	WAIKATO	
PROJECT No.	211365	
A3 SCALE	AS SHOWN	
SURVEYED	-	-
DRAWN	J.STEPHENSON	21/10/22
CHECKED	-	-

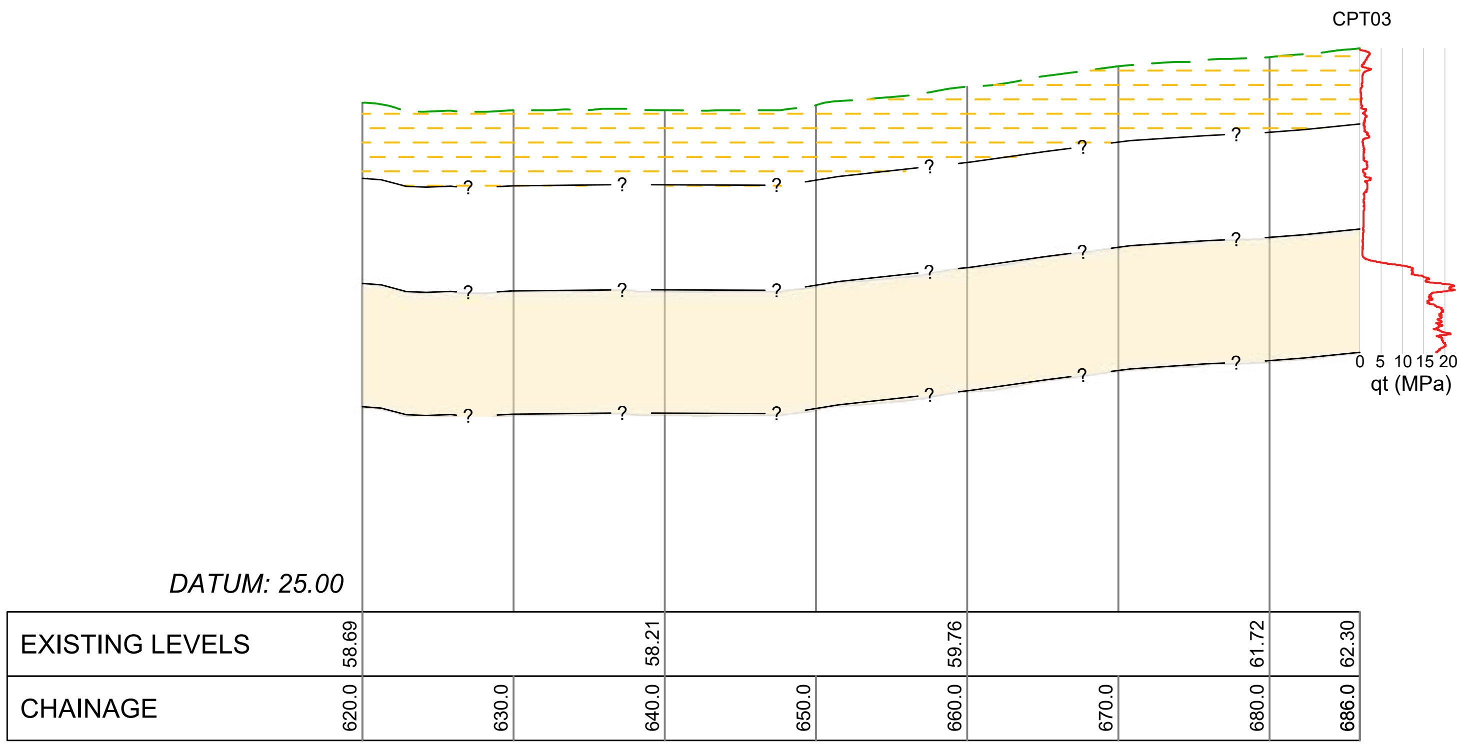
TITLE
TE AWAMUTU DEVELOPMENTS LIMITED
2025 OHAUPO ROAD, TE AWAMUTU
GEOTECHNICAL SECTION A

ORIGINAL SIZE	DRAWING No	SHEET	REVISION
A3	211365-06	02	A



EXISTING LEVELS	55.81		56.21		57.49		58.09		58.06		58.56		59.11		58.69
CHAINAGE	480.0	490.0	500.0	510.0	520.0	530.0	540.0	550.0	560.0	570.0	580.0	590.0	600.0	610.0	620.0

A SECTION
01 SCALE 1:500

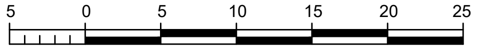


EXISTING LEVELS	58.69		58.21		59.76		61.72	62.30
CHAINAGE	620.0	630.0	640.0	650.0	660.0	670.0	680.0	686.0

A SECTION
01 SCALE 1:500

LEGEND

▤	UNIT 1 = HAMILTON ASH FORMATION
☐	UNIT 2 = KAUROA FORMATION
▨	UNIT 3 = PUKETOKA FORMATION
——— ? ———	INFERRED GEOLOGICAL BOUNDARY



SCALE 1 : 500

Disclaimer:
Areas and dimensions may be subject to scale error.
Scaling from this drawing is at the users risk.

ISSUED FOR INFORMATION

BTW COMPANY

SURVEYING
ENGINEERING
PLANNING
ENVIRONMENT

NO	DATE	BY	CHKD.	APPR.	OPER.	DESCRIPTION
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
A	22/11/22	J.S	B.M	M.D	.	ISSUED FOR INFORMATION - PRIVATE PLAN CHANGE SUBMISSION

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

GENERAL NOTES
1. Coordinates in terms of : Geodetic Datum (Mt Eden 2000)
2. Elevations in terms of : NZ Vertical Datum 2016
3. Contour interval is : 2m

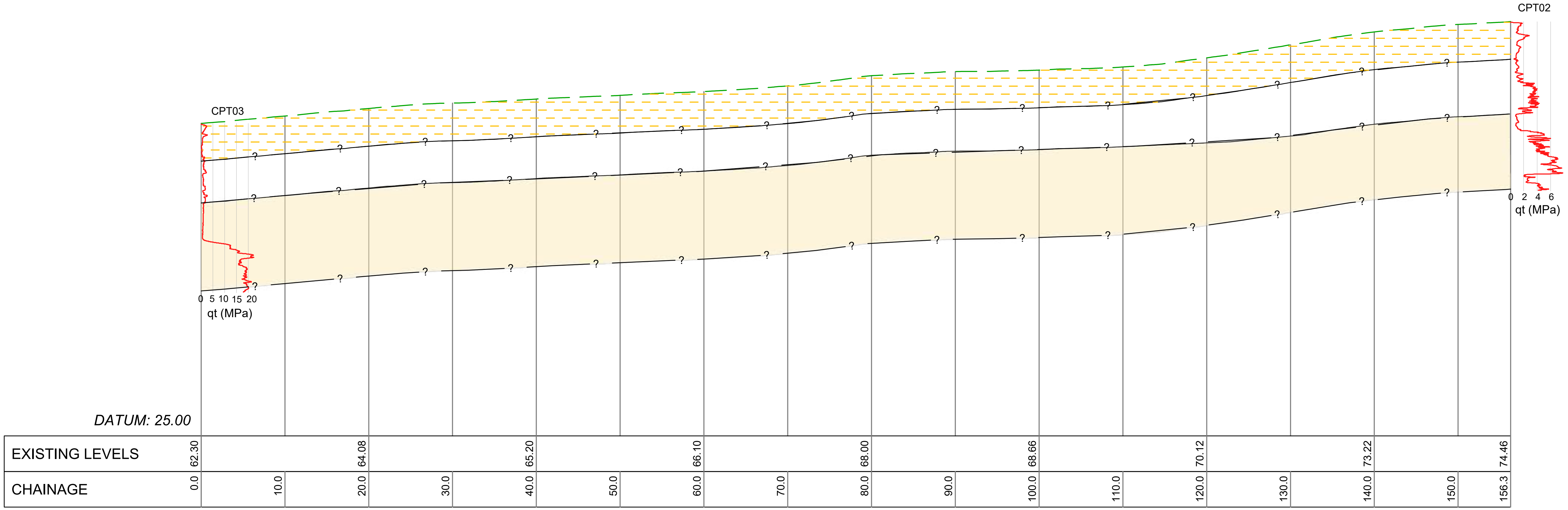
LOCATION WAIKATO
PROJECT No. 211365
A3 SCALE AS SHOWN

SURVEYED	-	-
DRAWN	J.STEPHENSON	21/10/22
CHECKED	-	-

TITLE
TE AWAMUTU DEVELOPMENTS LIMITED
2025 OHAUPO ROAD, TE AWAMUTU
GEOTECHNICAL SECTION A

ORIGINAL SIZE	DRAWING No	SHEET	REVISION
A3	211365-06	03	A

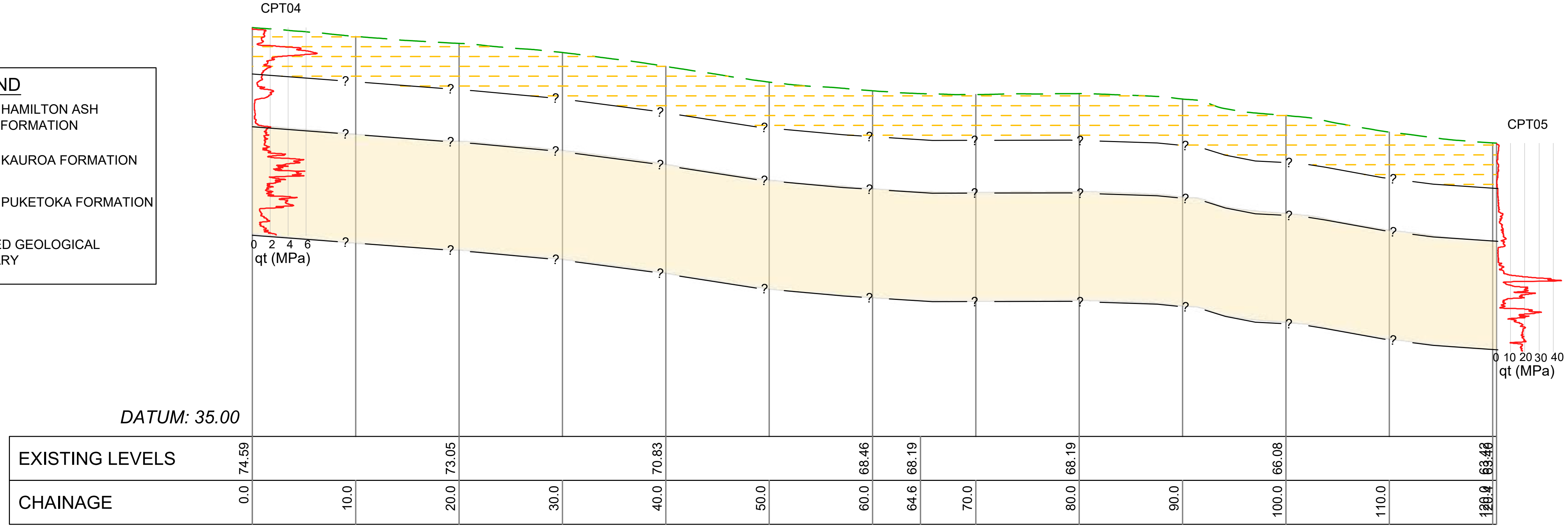
File Name: C:\12dS\data\BTW12D\211365 - Ultimate Holdings Ltd, Hamilton_4164\07 Drawings\211365-06 geotechnical plan.dwg - SHT 3 (A)   Plot Date: 23/11/2022   Plot Time: 16:49



A1 SECTION
01 SCALE 1:500

LEGEND

▨	UNIT 1 = HAMILTON ASH FORMATION
☐	UNIT 2 = KAUROA FORMATION
▨	UNIT 3 = PUKETOKA FORMATION
—— ? ——	INFERRED GEOLOGICAL BOUNDARY



5 0 5 10 15 20 25
SCALE 1 : 500

Disclaimer:
Areas and dimensions may be subject to scale error.
Scaling from this drawing is at the users risk.

B SECTION
01 SCALE 1:500

ISSUED FOR INFORMATION

BTW
COMPANY

SURVEYING
ENGINEERING
PLANNING
ENVIRONMENT

NO	DATE	BY	CHKD.	APPR.	OPER.	DESCRIPTION	NUMBER	TITLE
.	.	.	.	.	.	.		
.	.	.	.	.	.	.		
.	.	.	.	.	.	.		
.	.	.	.	.	.	.		
.	.	.	.	.	.	.		
.	.	.	.	.	.	.		
A	22/11/22	J.S	B.M	M.D	.	ISSUED FOR INFORMATION - PRIVATE PLAN CHANGE SUBMISSION		
REVISIONS							REFERENCE DRAWINGS	

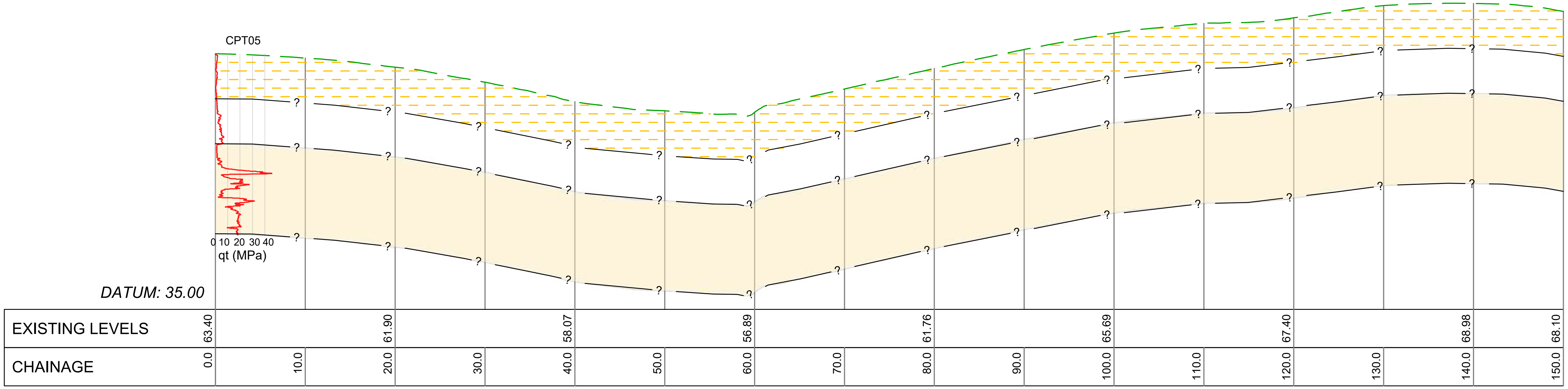
GENERAL NOTES
1. Coordinates in terms of : Geodetic Datum (Mt Eden 2000)
2. Elevations in terms of : NZ Vertical Datum 2016
3. Contour interval is : 2m

LOCATION	WAIKATO	
PROJECT No.	211365	
A3 SCALE	AS SHOWN	
SURVEYED	-	-
DRAWN	J.STEPHENSON	21/10/22
CHECKED	-	-

TITLE
TE AWAMUTU DEVELOPMENTS LIMITED
2025 OHAUPO ROAD, TE AWAMUTU
GEOTECHNICAL SECTION A1 & B

ORIGINAL SIZE	DRAWING No	SHEET	REVISION
A3	211365-06	04	A

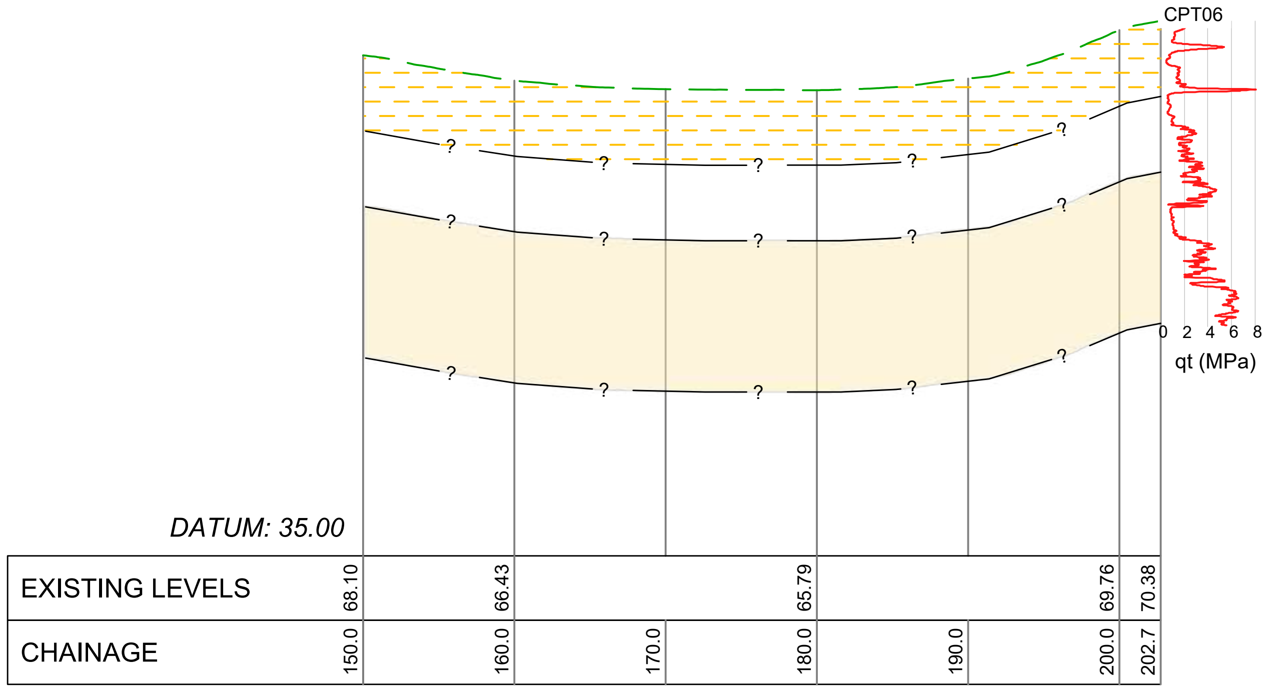
File Name: C:\12dS\data\BTW12D\211365 - Ultimate Holdings Ltd, Hamilton_4164\07 Drawings\211365-06 geotechnical plan.dwg - SHT 4 (A1 & B) Plot Date: 23/11/2022 Plot Time: 16:50



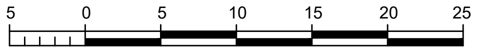
B1 SECTION
01 SCALE 1:500

LEGEND

▨	UNIT 1 = HAMILTON ASH FORMATION
☐	UNIT 2 = KAUROA FORMATION
▨	UNIT 3 = PUKETOKA FORMATION
—— ? ——	INFERRED GEOLOGICAL BOUNDARY



B1 SECTION
01 SCALE 1:500



SCALE 1 : 500

Disclaimer:
Areas and dimensions may be subject to scale error.
Scaling from this drawing is at the users risk.

ISSUED FOR INFORMATION

BTW COMPANY

SURVEYING
ENGINEERING
PLANNING
ENVIRONMENT

NO	DATE	BY	CHKD.	APPR.	OPER.	DESCRIPTION
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
A	22/11/22	J.S	B.M	M.D	.	ISSUED FOR INFORMATION - PRIVATE PLAN CHANGE SUBMISSION

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

GENERAL NOTES
1. Coordinates in terms of : Geodetic Datum (Mt Eden 2000)
2. Elevations in terms of : NZ Vertical Datum 2016
3. Contour interval is : 2m

LOCATION WAIKATO
PROJECT No. 211365
A3 SCALE AS SHOWN

SURVEYED	-	-
DRAWN	J.STEPHENSON	21/10/22
CHECKED	-	-

TITLE
TE AWAMUTU DEVELOPMENTS LIMITED
2025 OHAUPO ROAD, TE AWAMUTU
GEOTECHNICAL SECTION B1

ORIGINAL SIZE	DRAWING No	SHEET	REVISION
A3	211365-06	05	A

File Name: C:\12d\data\BTW12D\211365 - Ultimate Holdings Ltd, Hamilton_4164\07 Drawings\211365-06 geotechnical plan.dwg - SHT 5 (B1)   Plot Date: 23/11/2022   Plot Time: 16:50