

Report

MOE Drury West Due Diligence - Geotechnical Assessment Report

Prepared for Ministry of Education (NZ)

Prepared by Beca Limited



7 September 2018



Revision History

Revision N°	Prepared By	Description	Date
0	Benjamin Roy	Issue for Client	07/09/2018

Document Acceptance

Action	Name	Signed	Date
Prepared by	Benjamin Roy		7/09/2018
Reviewed by	CY Chin		7/09/2018
Approved by	Jamie Swan		7/09/2018
on behalf of	Beca Limited		

© Beca 2018 (unless Beca has expressly agreed otherwise with the Client in writing).

This report has been prepared by Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Executive Summary

The Ministry of Education (MoE) has commissioned Beca Ltd (Beca), to supply consultancy services to evaluate, assess and designate a site for a potential secondary school in the Drury West Special Housing Area (SHA), in Drury, South Auckland. This preliminary geotechnical interpretative report is part of the due diligence assessment of two adjacent properties (281 and 401 Jesmond Road, Karaka), making up one site selected from the initial desk top evaluation.

The investigation undertaken comprised eight Cone Penetrometer Tests (CPTs), two machine drilled Boreholes (BH's), six hand drilled auger boreholes (HA's) and laboratory testing. The results of this investigation at this site formed the basis of the geotechnical analysis and assessment.

The two sites vary in elevation, with the higher ground consisting of a narrow ridge along the southern extent of site 281, moderately sloping downwards to the north east. The central portion of the two sites gently flattens before sloping again to the north. Swampy ground and ponded water is mapped at the base of slope, in the north eastern portion of site 281, and the north western corner of site 401. The land is currently used for farming and urban development is proposed for the wider area.

The subsurface profile is varied and is typical of the area. A 2 to 8m crust of stiff reworked soils of intermixed volcanic air fall source cover the site. These soils overlie variable subsoil profiles of a completely weathered non-welded ignimbrite intermixed with volcanic air fall deposits, and deeper (6m to 20m depth) fine and coarse grained Puketoka Formation sands and silts.

For the purpose of the geotechnical analysis, groundwater level was measured at available investigation locations. The depth varied between 0.4m and 5m below ground level (bgl). No long-term monitoring data is available for the site.

Based on the geotechnical assessment undertaken, the major geotechnical considerations for this project relate to potential slope instability relating to excess loading, poor drainage adjacent to the boundary slopes, and potential differential settlement.

Stability analyses of the existing slopes suggest that the current static conditions are stable. However, further considerations of proposed earthworks (excavations and additional loads) and stability checks for flooding, temporary groundwater rise and seismic analyses should be undertaken at detailed design stage.

It is recommended that stormwater is collected at the site and disposal is discharged to the base of the slopes and not into the ground above or on the faces of the slopes surrounding the site. In the case of any water retaining structures such as swimming pools, under-structure drainage draining to the base of the slopes would be recommended to divert any leakage from these structures.

It is recommended that any earthworks to alter the topography of the site should be subject to a geotechnical design review.

Uniform light structural loads could be resisted by a shallow foundation consisting of either reinforced concrete slab on grade or ribbed raft foundation slab, due to a stronger surficial crust. For higher structural loads (such as two or three storey buildings), large structure footprints or where there is differential loading, either ground improvements or piled foundations may be necessary. These will vary depending on loading and location, with higher likelihood of deep piles or more extensive ground improvements for structures located in the western side of the site.

Assessments for total and differential settlements should be undertaken at detailed design when structure location and loading have been finalised.

Additional geotechnical investigations are recommended at the detailed design stage once there is greater certainty around proposed building locations.

Contents

1	Introduction	1
2	Site Description	1
3	Proposed Development	2
4	Scope of Investigations	2
4.1	Previous Investigations	2
4.2	Current Investigation	2
4.2.1	Machine Boreholes	2
4.2.2	Cone Penetration Tests	3
4.2.3	Hand Augers	4
4.2.4	Lab Testing	4
5	Ground Model	4
5.1	Regional Geology	4
5.1.1	Faulting	5
5.2	Ground or Subsurface Profile	5
5.3	Ground Water Conditions	6
6	Geotechnical Assessment and Design Considerations	6
6.1	Seismic Design Criteria	6
6.1.1	Seismic Settlement	7
6.2	Liquefaction	7
6.3	Slope Stability	9
6.4	Foundations	9
7	Recommendations for Further Geotechnical Work	10
8	Conclusions and Recommendations	10
9	Applicability	11
10	References	11

Appendices

Appendix A

Site Plan

Appendix B

Site Investigation Logs

Appendix C

CPT Logs

Appendix D

Laboratory Testing

Appendix E

Cross Sections

Appendix F

Liquefaction Analyses and CPT Interpretation

Appendix G

Slope Stability Analysis

1 Introduction

The Ministry of Education (MoE) has commissioned Beca Ltd (Beca) to supply consultancy services to evaluate, assess and designate a site for a potential secondary school in the Drury West Special Housing Area (SHA), in Drury, South Auckland. The designated school is proposed to be over two sites, specifically, at 281 & 401 Jesmond Rd. This preliminary geotechnical interpretative report is part of the due diligence assessment of the overall site.

This report presents the results of a preliminary geotechnical investigation, which included both on-site and laboratory-based testing to assess the main geotechnical considerations for construction of a school on this site. It includes a preliminary assessment of the ground model, liquefaction potential and foundation conditions, along with other site specific hazards at this site, and provides information for planning documentation and identifies further geotechnical investigation and assessment required during detailed design of the school.

The assessment has followed the guidance provided in the Ministry of Education guidelines (MoE, 2016).

2 Site Description

The site is located to the west of Drury township and SH1, near the upper reaches of the Drury Creek north of Karaka Road. Figure 1 shows the location of the site.



Figure 1 – Drury West Secondary School Proposed Site

281 Jesmond Rd varies in elevation from approximately RL 15.5m to 26.5m. The higher ground comprises a narrow ridge extending from the existing house adjacent to Jesmond Rd eastward across the land parcel. The ground slopes to the northeast and southwest from the ridge, with moderate slopes (1V:5H to 1V:7H) from the top of the ridge for 20 to 35m, then gently slopes beyond the ridge at gradients flatter than 1V:10H. Seepage points across both sites are mapped on the plan in Appendix A. No other water courses are mapped on this property.

401 Jesmond Rd topography ranges from RL12.5 to 16.5m, the ground surface contour lines are shown on the appended site plan, appendix A. The ground surface is generally gently sloping (<1V:10H) from the highest point in the south west corner, adjacent the 281 Jesmond Rd property boundary, to the lowest point in the northeast. Undulating areas are present in the centre of the site in the form of two small mounds that rise about 1.5 m. In addition to this, contours also show a gully with slopes of 1V:8H is present in the northeast (NE) corner of the property. A spring (groundwater seep) also occurs in this area. Shallow surface drains are also apparent along the northern property boundary as indicated by 2018 Google earth imagery. An overland flow path is mapped across the northern part of the site, with some secondary branching into the site. The above data is provided by the Auckland Council GIS map viewer.

3 Proposed Development

The concept design for the proposed development has not yet been undertaken, and as such, the preferred layout of the school buildings has not yet been determined. We assume up to 2 storey buildings will be placed on the site, and will provide general comments on conditions across the site. Specific geotechnical assessment and design will be required prior to construction.

4 Scope of Investigations

4.1 Previous Investigations

One water bore was drilled on 401 Jesmond Rd and a further nine water bores were drilled within a 400m radius of the sites for domestic supply in the area. These boreholes are between 62 and 210m deep and provide information on general geological conditions and static groundwater levels.

Geotechnical investigations and a preliminary geotechnical assessment were undertaken for a proposed structure plan change (Lander, 2017) in the area of the secondary school sites. Investigations comprised 28 shallow (up to 3m deep) hand augers and included one hand auger in the centre of each secondary school sites, both 281 and 401 Jesmond Road.

4.2 Current Investigation

The current investigation was carried out in mid-August 2018 to further inform geotechnical risk assessment. This comprised two machine boreholes, eight cone penetrometer tests (CPTs), six hand augers, and geological mapping of the site. Both machine boreholes reached the target depth of ~20m, with undisturbed push tube samples taken at selected intervals. Only three CPTs reached the target depth of 20m with the remaining refusing at between 15 and 18m below ground level (bgl). One CPT also refused at around 6m bgl despite repositioning around 2m from its original position. No hand augers reached the target depth due to lack of recovery (Practical refusal and collapsing with water infiltration). The site plan in Appendix A shows all current investigation locations, findings from geological mapping and section lines.

4.2.1 Machine Boreholes

Machine boreholes were drilled on the 7th and 8th of August 2018 by Pro-Drill (Auckland) Ltd using a tractor rotary machine borehole rig. Drilling was undertaken using open barrel and triple-tube rotary drilling methods. A summary of all machine boreholes undertaken is given Table 1, with logs presented in Appendix B.

Table 1 - Summary of Boreholes Drilled

BH No.	Location	Easting	Northing	R.L. ground (m)	Total Depth (m)	Borehole Inclination (degrees from horizontal)
BH1	401 Jesmond Rd	1771578	5891771	27	20.45	-90
BH2	281 Jesmond Rd	1771629	5891489	34	19.95	-90

Notes: All coordinates are given in NZTM. All elevations (Ground reduced levels) are given in MSL

Field testing, undertaken during drilling of the machine boreholes comprised:

- Standard Penetration Tests (SPTs), carried out at approximately 1.5 m centres with the uncorrected N-values recorded on borehole logs. SPT hammer efficiencies are presented on the borehole log sheets. The use and requirement (or lack of) a liner within the SPT Raymond Split Spoon is presented on the borehole logs sheets.
- Hand held shear vane tests were carried out within the end of the core barrel in cohesive soils. The corrected and uncorrected shear vane values are reported on the machine borehole logs.

4.2.2 Cone Penetration Tests

Static Cone Penetration Tests (CPTs) were conducted on the 11th of August 2018 by Pro-Drill (Auckland) Ltd using a Geoprobe 6622 CPT rig fitted with a 1500 mm² electric subtraction cone to measure cone resistance, sleeve friction and water pressure. CPT test locations are summarised in Table 2 below and are logs are presented in Appendix C.

Table 2 - Summary of CPT Locations

CPT No.	Location	Easting	Northing	R.L. ground (m)	Total Depth (m)	Type of Test
CPT01	Adjacent BH1 at 401 Jesmond Rd	1771575	5891771	14	25.2	Static
CPT02	Swampy area at northwest corner of 401 Jesmond Rd	1771536	5891824	13	14.2	Static
CPT03	Northeast corner of persimmon orchard in eastern half of 401 Jesmond Rd	1771669	5891865	14	17.4	Static
CPT04	Southern end of persimmon orchard in eastern half of 401 Jesmond Rd	1771646	5891699	16	18.3	Static
CPT05	Adjacent horse dressage arena at northwest corner of 281 Jesmond Rd	1771530	5891635	18	25.4	Static
CPT06 & CPT06a	Swampy area in northeast paddock of 281 Jesmond Rd	1771647	5891638	16	3.3	Static
CPT07	Adjacent BH2 at 281 Jesmond Rd	1771629	5891494	26	22.4	Static
CPT08	Back paddock behind main dwelling at 281 Jesmond Rd	1771582	5891444	22	16.6	Static

Notes: All coordinates are given in NZTM. All elevations (Ground reduced levels) are given in MSL

4.2.3 Hand Augers

Hand augers were drilled and logged on the 7th and 8th of August 2108 by Beca staff. A summary of all hand augers undertaken is given below in Table 3. The hand auger logs and photographs are attached in Appendix B.

In-situ testing comprised:

- Down-hole hand held shear vanes, undertaken at 300 mm centres;
- Scala penetrometer tests undertaken from the ground surface and at the base of the hole.

Table 3 - Summary of Hand Augers Drilled

HA No.	Location	Easting	Northing	R.L. ground (m)	Total Depth (m)
HA1	Persimmon orchard in the south eastern corner of 401 Jesmond Rd	1771617	5891836	13	3.2
HA2	North of dwelling at 401 Jesmond Rd	1771520	5891737	14	2.6
HA3	South east corner of 281 Jesmond Rd near BH2	1771677	5891467	23	3.9
HA4	Middle paddock along southern fence line of 281 Jesmond Rd	1771634	5891536	21	2.4
HA5	Swampy area in the centre of middle paddock at 281 Jesmond Rd	1771650	5891596	16	2.7
HA6	Horse dressage arena at south western corner of 281 Jesmond Rd	1771543	5891656	16	0.3

Notes: All coordinates are given in NZTM. All elevations are given in MSL

4.2.4 Lab Testing

Laboratory testing was undertaken on intervals selected from the Direct Push sample tubes, as scheduled by Beca, and was carried out by Geotest Ltd. The tests undertaken, and the testing specifications, were as follows:

- Wash Grading/Hydrometer Grading: NZS4402: 1986, Test 2.8.4
- Atterberg Limits: NZS4402, 1986; Tests 2.2, 2.3 and 2.4
- One Dimensional Consolidation (Oedometer) Test: NZS4402: 1986, Test 7.1

The results of the laboratory testing are included in Appendix D.

5 Ground Model

5.1 Regional Geology

The published geological map (Edbrooke, 2001) indicates that this site is underlain by Puketoka Formation sediments, including mud, silts, pumiceous silty sands, interbedded with organic layers, and overlain by weathered volcanic soils. The Puketoka Formation is less than 2 million years old and, based on well logs in the area, is potentially up to 45m thick. These sediments overlie 5 million year old Kaawa Formation shelly sandstones and mudstones, and the 20 million year old Waitemata Group rock at depth.

5.1.1 Faulting

The nearest active faults to the sites, being faults that have shown activity within the last 125,000 years (GNS active fault database), are:

- Drury Fault - approximately 7.5km east,
- Wairoa North Fault - approximately 19km east, and
- Kerepehi Fault – approximately 56km east

Of these faults, the Kerepehi Fault has shown the most recent activity between 2,000 to < 3500 years ago.

5.2 Ground or Subsurface Profile

The subsurface profile outlined in Table 4 has been determined for the site, based on CPT results, machine borehole logs, hand auger logs and geological mapping. Appendix E provides four geological sections across the site showing the subsurface profile and likely thickness of the deposits.

Table 4 - Typical Subsurface Profile

Unit no.	Name	Description	Depth to top of layer (m)	Thickness (m)	Typical Cone Resistance (mPa)	SPT N Value (blows/ 300 mm)	Shear Strength (kPa)
-	Surficial organic deposits	Inferred from geological mapping.	0	0-1	0-2	-	-
1a	Puketoka Formation intermixed with volcanic air fall deposits	Very stiff to stiff clayey SILT; brownish orange; high plasticity.	0-1	2-8	1-3	4-10	70-160
1b	Puketoka formation volcanic air fall deposits	Hard CLAY-SILT; pink mottled white; high plasticity.	3-5	0-2	3-20+	9-20	140-204+
1c	Completely weathered non-welded ignimbrite intermixed with volcanic air fall deposits	Stiff clayey SILT, minor fine to coarse pumiceous sand and gravel; red mottled pink and white; high plasticity.	3-6	0-8	2-4	4-7	50-130
1d	Fine grained Puketoka Formation	Firm SILT-CLAY; dark greyish blue; high plasticity.	6-14	1-4	0.5-2	1-4	30-80
1e	Interbedded fine and coarse grained Puketoka Formation	Loose silty SAND interbedded with high plasticity clayey SILT; bluish grey.	7-18	2-4	1-3	1-20	-
1f	Coarse grained Puketoka Formation	Medium dense to dense fine to coarse SAND; bluish grey.	8-12	12+	6-20	20-40	-

The site is mapped as Puketoka Formation by the Qmap. Previous investigations indicate that sites nearby are underlain by predominantly clayey silt and sand of the Puketoka Formation. This is confirmed by the current investigation which also highlights the existence of variably thick ignimbrite inter mixed with volcanic air fall deposits. The current investigation showed:

- The upper unit, comprising of Puketoka Formation intermixed with volcanic air fall deposits, covers much of the site providing a very stiff to stiff crust of clayey silt approximately 2 to 8 m thick.
- Due to the impermeable nature of some surface soils, zones of ground water seepage have caused surface water ponding in areas of low topography.
- Subsurface profiles vary across the site, however the surface crust of volcanic airfall deposits generally transitioned to non-welded ignimbrite deposit mixtures, and deeper fine to coarse grained silt and sand mixtures.
- CPT06 and CPT06a stopped due to refusal at approximately 3m depth. It is inferred that the hardness of the completely weathered ignimbrite may locally increase beneath the swampy area. An extent of this possible harder layer has not been defined by the investigation testing to date.
- Underlying this is approximately 2 to 4 m of interbedded Loose Silty SAND and clayey SILT marking the start of the underlying Puketoka Formation dense to medium dense SAND unit.

5.3 Ground Water Conditions

Ground water measurements across both sites range between 10 and 22 m RL. At 401 Jesmond Rd, ground water ranged from 10 to 15 m RL with surface water observed at 12.5 m RL toward the north of the site. In the northwest corner of the site, an easterly flowing drain with running water was also observed at 12.5 m RL. A seepage point was also present just north of the main dwelling at 14.5 m RL. Despite the north-south oriented drains present in the west of the site, ground water levels tend to be higher toward the northwest. The low water table observed in the east and southeast is likely the result of better drainage conditions created by earthworks undertaken to create the persimmon orchard.

Ground water at 281 Jesmond Rd is markedly higher, with levels between 15 and 22 m RL, and surface water observed at 15 m RL. Ground water levels tend to slope downward to the north where they manifest at the surface, creating a swampy area in the northeast corner of the property at 15 m RL. A lack of surface water north of the swampy area indicates a lowering of the ground water table. This is likely the effect of a cut off drain running west-east through the swampy area. Southward, the ground water level tends to increase in elevation, mantling the hard CLAY-SILT layer present at around 22 m RL. This increasing elevation of ground water suggests the presence of perched water above this layer. Additionally, seepage points on the northern face of the ridge at 22 m RL indicate the presence of springs or daylighting ground water. From observations on site, it is likely that the swampy area is fed from these seepage points. This, along with the effect of cut off drains, could mean that this area is also a zone of perched water. At the south of the site, ground water levels are inferred to mantle the ignimbrite layer, sloping gradually southward from 22 m RL.

6 Geotechnical Assessment and Design Considerations

6.1 Seismic Design Criteria

Geotechnical seismic loads for determining liquefaction susceptibility and global stability have been assessed as per recommendations made in New Zealand Geotechnical Society Module 1: Overview of the Guidelines (2016) and in accordance with the NZ Transport Agency Bridge Manual 3rd Edition (NZTA BM, 2014). Structural design should be undertaken using seismic loads calculated in accordance with NZS1170.5 (2004).

Peak Ground Accelerations (PGAs) have been calculated based on the design Annual Probability of Exceedance selected from NZS1170.5 for the following:

- 50 year Design Life

- Importance Level 3 (IL3), in accordance with the MoE Structural and Geotechnical Guidelines (2016)

Based on the findings of the limited ground investigation, a preliminary assessment of the site subsoil class indicates the site to be Class C (Shallow soil site). Further ground investigation to identify soils below the current investigation depth is recommended to confirm this site subsoil class. Design PGAs and effective magnitudes calculated based on the following input parameters are presented in Table 6.1 below, for Serviceability Limit State 1 (SLS1), Serviceability Limit State 2 (SLS2) and seismic Ultimate Limit State (ULS) events.

- $f = 1.33$ for Site Class C
- $C_{0,1000} = 0.13$ for Pukekohe

Table 6.1 - Seismic PGAs

Design Case	Annual Probability of Exceedance	PGA Design Value (g)	Effective Magnitude (M_{eff})
Serviceability Limit State 1 (SLS1)	1/25	0.05	7.5
Serviceability Limit State 2 (SLS2)*	1/500*	0.173*	7.5*
Seismic Ultimate Limit State (ULS)	1/1000	0.225	7.5

Notes: *Serviceability Limit State 2 only applies to importance level 4 structures, it is included in this table for reference

6.1.1 Seismic Settlement

Liquefaction induced vertical settlements should be expected at the site following a ULS event, in the order of 60-300mm, refer table 6.2 below. Differential settlements, depending on the final structural founding pressures and foundation type should be assessed.

Table 6.2 - Estimated Liquefaction Induced Settlement

SLS1	SLS2	ULS
<10mm	45-300mm	60-320mm ¹

¹. Estimated based on CPT data

6.2 Liquefaction

Liquefaction occurs when loose, saturated cohesionless soils lose strength under earthquake or other applied cyclic loading. The loose soil will tend to contract or densify under this loading resulting in pore water pressure increases and loss of shear strength.

This condition will persist until excess pore water pressures dissipate. Effects may continue for a period of time after the earthquake shaking has stopped.

The effects of liquefaction can include localised movements during an earthquake where the static and earthquake loads exceed the available strength of the liquefied soil profile. More substantial lateral movements and widespread failures can occur where the soil strength loss is sufficiently great.

In addition to liquefaction and densification, cyclic strain softening can occur in the more clayey deposits. Cyclic strain softening is the onset of strength loss resulting in significant strains in saturated silts and clays during earthquakes. The cyclic strain softening causes the shear strength of the soil to reduce under successive cyclic action.

A preliminary assessment of seismic performance of materials at the site, including liquefaction and potential cyclic softening, has been undertaken based on a combination of:

- CPT data using the procedure described in Boulanger and Idriss (2014)
- Laboratory Testing
- Soil descriptions from boreholes investigation at the site

Several layers of potentially liquefiable material were identified at the site. Results of the liquefaction assessment are presented in Appendix F and summarised in Table 6.3 below.

Table 6.3 - Liquefaction Assessment Results

Unit Name	Seismic behavior	Liquefaction/Cyclic Softening Potential		
		SLS1	SLS2	ULS
Puketoka Formation intermixed with volcanic air fall deposits	Mostly clay like with silt like materials.	Not liquefiable	Partial liquefaction of thin sand like layers	Partial liquefaction of thin sand like layers
Puketoka formation volcanic air fall deposits	Mostly clay like with interbedded silt like materials.	Not liquefiable	Partial liquefaction	Partial liquefaction
Completely weathered non-welded ignimbrite intermixed with volcanic air fall deposits	Mostly clay like with silt like materials and isolated sand like bands.	Not liquefiable	Partial liquefaction	Partial liquefaction
Fine grained Puketoka Formation	Interbedded clay like and sand like materials.	Not liquefiable	Partial liquefaction	Partial liquefaction
Interbedded fine and coarse grained Puketoka Formation	Mostly sand like interbedded with silt like materials.	Not liquefiable	Partial liquefaction	Partial liquefaction
Coarse grained Puketoka Formation	Interbedded sand like and silt like materials.	Not liquefiable	Not liquefiable	Not liquefiable

Resilience to these levels of liquefaction will need to be considered in detailed design. Possible ground improvement schemes such as the introduction of a cement stabilised soil crust and use of geogrids under structures could reduce the propensity of longitudinal cracking in structures when lateral spreading occurs. This provides some post-seismic resilience allowing the re-positioning of displaced structures.

Although South Auckland is generally an area of low seismic risk (Edbrooke, 2001), and the clay rich soils of the Puketoka Formation are considered to have a low risk of liquefaction susceptibility, we recommend site investigations be undertaken to determine the site subsoil class to allow appropriate design of the foundations and building structures.

6.3 Slope Stability

Based on a building footprint of at least 30m width and loaded to 20kPa (refer to slope stability output B-B in Appendix G), static slope stability analyses of the more critical existing slopes suggest that current conditions are stable. This is based on an assumed building footprint, and will require further investigation at the detailed design stage.

We assume that the concept layout of the school structures may include some buildings and fill extending across the slopes. Further considerations of proposed earthworks (excavations and additional loads) and stability checks for flooding, temporary groundwater rise and seismic analyses should be undertaken at detailed design stage.

The packages of land are generally gently sloping and these slopes have low risk of slope instability.

The gentle slopes along the minor ridges of sites 281 and 401 Jesmond Road do not show obvious signs of recent instability as viewed from Auckland Council GIS map viewer. However, a seepage point is mapped approximately half way up the slope near the NW corner of the 281 site. Potential for instability on this northern slope is considered moderate and would need to be confirmed by site inspection. It is likely that earthworks would be undertaken to make this area of the site achieve the nearly flat ground requirements for the school development. Cutting down of this ridge will likely reduce the risk of slope instability. However, this would require confirmation after investigation and assessment as to whether these works would require additional ground improvement and/or subsoil drainage measures.

The northern part of site 401 has a surface drainage path that extends to a scruffy dome at the north-eastern corner of the site. The orchard on the east half of the site has also likely been subject to previous drainage alterations (surface cut-off drains) and earthworks. The extent of these alteration is unknown. Both sites have been mapped as having areas of swamp due to the collection and ponding of surface water. We recommend that an extensive subsoil drainage network be allowed for in both sites to control ground water flows and risk of localised instability. A 30m building setback from the NE corner is recommended at this stage and to be confirmed after further assessment.

6.4 Foundations

The preliminary investigations identified a 2 to 6m crust at the site that is potentially suitable to resist loads from light structures (typically single storey) with shallow foundations. This layer was variable across the site. The CPT investigations also identified weaker layers at 3 to 20m depth, which should be considered for detailed foundation design.

We understand the development would typically include:

- Up to three storey buildings
- Limited earthworks to accommodate proposed building footprints
- Potentially large structure footprints where differential settlement may be critical

Uniform light structural loads could be resisted by a shallow foundation consisting of either reinforced concrete slab on grade or ribbed raft foundation slab.

For higher structural loads (e.g., greater than single storey) or where there is differential loading, either ground improvements or piled foundations may be necessary. Such ground improvements could include pre-consolidation measures in conjunction with cement stabilised soil crust. For piled solutions, piling depths at this site are likely to be variable, with potentially deeper piles in the west.

It is noted that the preliminary investigations were of variable depth and typically largely spaced. These may not be sufficiently comprehensive to identify discrete deposits of soft material across the site and additional investigations should be considered when the design and location of the proposed structure(s) have been finalised.

Sufficient resilience to mitigate effects of seismic settlements should be incorporated into the design of connections to other services, pipework, drainage, and assessment of levels governing fall gradients, to ensure functionality following a significant seismic event.

Shallow investigations indicate that the surface soils provide good ground conditions for shallow foundations. However, without undertaking site-specific ground investigations, softer ground, lenses of organics and the presence of liquefiable soils should be allowed for which could pose constraints to the use of shallow foundations. Ground investigations to identify the presence of soft ground would be recommended.

There is uncertainty over soil strength and settlement characteristics particularly for multi-story buildings or for structures carrying high loads. Clay rich soils of the Puketoka Formation are considered to be susceptible to settlement by large loads, as well as being sensitive and expansive for which foundation design will need to consider. There is also the possibility of high regional groundwater levels close to the ground surface in low lying areas.

7 Recommendations for Further Geotechnical Work

Once a site layout and building design is confirmed, further geotechnical testing specific to these structures is recommended as part of the detailed design stage to address any specific design issues. Design assumptions should be confirmed on site during construction using in-situ testing methods as appropriate.

8 Conclusions and Recommendations

The site is underlain by a stiff soil crust overlying weathered ignimbrite and alluvial Puketoka Formation deposits. These generally present as Silt with the presence of Sand, clay and organic mixtures. There is a trend in our investigation data results indicating typically weak and sensitive soils underlying the western portion of the site. These conditions are typical for the area.

Based on the geotechnical assessment undertaken, the major geotechnical considerations for this project are potential slope instability relating to proposed loading or poor drainage adjacent to the boundary slopes, and potential differential settlement from variable ground conditions (though both static construction/earthworks loading and seismic liquefaction induced settlement).

It is recommended that slope stability checks be undertaken when final structures and loads have been finalised to ensure the stability of the slopes. Stormwater disposal for this site is proposed to be collected and we recommend it is discharged to the base of the slopes, and into a suitable water course, not into the ground above or on the faces of the slopes surrounding the site. In the case of any water retaining structures such as swimming pools, under-structure drainage draining to the base of the slopes, is required to divert any leakage from these structures.

It is recommended that any earthworks to alter the topography of the site should be subject to a geotechnical design review due to the following:

- a) Sensitive near-surface organic soils, identified in the geomorphic mapping (Appendix D) over lower elevation portions of the site. These soils are sensitive to moisture and loading.

- b) Localised weaker sand and highly plastic clay layers in relation to sloping ground. The overall stability of some slopes are likely to be sensitive to the surcharge loading, depending on the geometry of fill.

Based on a preliminary assessment, shallow foundations supporting uniform lightly loaded structures could be acceptable for uniform lightly loaded structures which do not have a high risk of differential settlement. Assessments for total and differential settlements should be undertaken at detailed design when structure location and loading has been finalised. Foundations are likely to vary depending on structural loads and locations of structures, from shallow foundations comprising ribbed rafts, to either ground improvements or piled foundations for higher differential loads or larger structural footprints particularly in the western part of the site and for structures along the slope crests.

Additional geotechnical investigation is recommended for detailed design.

9 Applicability

This report has been prepared by Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

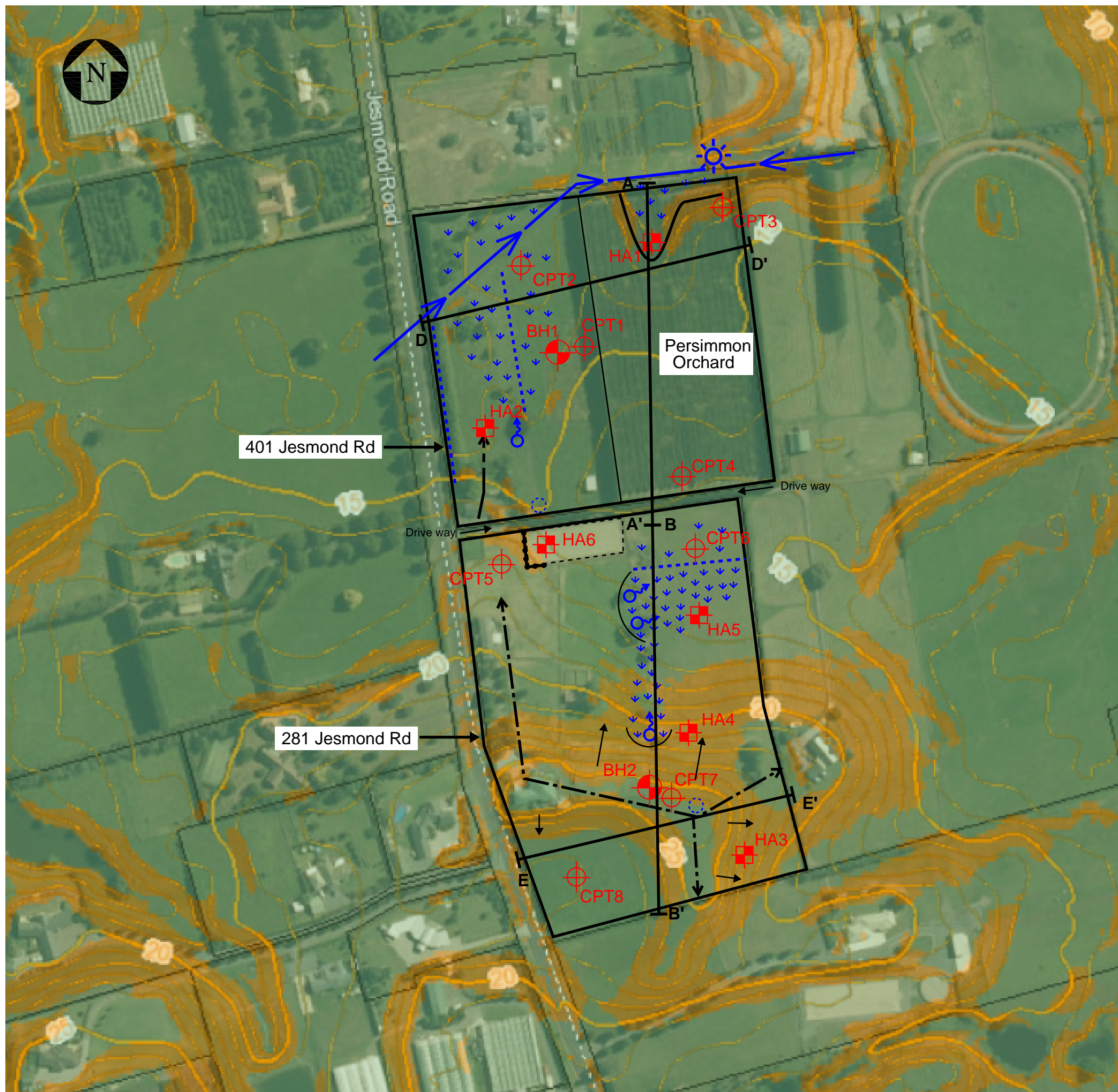
10 References

- Alloway, B., Westgate, J., Pillans, B., Pearce, N., Newnham, R., Byrami, M., Aarburg, S., 2004. *Stratigraphy, age and correlation of middle Pleistocene silicic tephra in the Auckland region, New Zealand: a prolific distal record of Taupo Volcanic Zone volcanism*. New Zealand Journal of Geology and Geophysics, v.47, p. 447-479.
- Boulanger & Idriss, 2014. *CPT and SPT Based Liquefaction Triggering Procedures*. Report no. UCD/CGM-14/01, Centre for Geotechnical Modelling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134pp.
- Ministry of Education (MoE), 2016. *Designing Schools in New Zealand: Structural and Geotechnical Guidelines*, Version 2.0.
- New Zealand Geotechnical Society, 2016. *New Zealand Geotechnical Society Module 1: Overview of the Guidelines*.
- Standards New Zealand. 2004. *Structural Design Actions Part 5: Earthquake Actions – New Zealand*. Wellington: Standards New Zealand, (NZS 1107.5.2004).
- Edbrooke, S.W (compiler), 2001: *Geology of the Auckland Area*. Institute of Geological and Nuclear Sciences 1:250,000 geological map 3.
- Lander Geotechnical, 2017: *Preliminary Geotechnical Appraisal Report for Auranga Development B1, Drury*.
- Papakura District Council (unknown date): *Papakura District CBR strength of soils, CBR01 Rev 0, 1:25,000 at A1 map*.

Appendix A

Site Plan





Geomorphic Key

- Ridge line
- Down slope direction
- Swamp
- Drain
- Flowing water
- Surface water ponding
- Seepage point
- Scuffy dome

Investigation Localities

- Hand Auger
- Cone Penetrometer Test (CPT)
- Machine Borehole

PDF ONLY
NO DWG FILE

No.	Revision	By	Chk	Appd	Date

Drawing Originator:
Beca

Original Scale (A1)	Design	Approved For Construction*
Reduced Scale (A3)	Drawn	Date
	Dwg Verifier	
	Dwg Check	

* Refer to Revision 1 for Original Signature

Client: Ministry of Education

Project: MOE - Drury West Secondary School Due Diligence

Title: 281-401 Jesmond Rd Proposed Geotechnical Investigations

Discipline	GEOTECHNICAL	
Drawing No.	4216997-G1	Rev.
		0

Appendix B

Site Investigation Logs



PROJECT: Drury West Secondary School					JOB NUMBER: 4216997									
SITE LOCATION: 281 and 401 Jesmond Rd, Karaka					CLIENT: Ministry of Education									
CIRCUIT: NZTM					BOREHOLE LOCATION: 401 Jesmond Rd									
COORDINATES: N 5,891,771 m					R L: 27 m									
E 1,771,578 m					DATUM: MSL									
					COORDINATE ORIGIN: hhGPS									
					ACCURACY: 5									
DRILLING							IN-SITU TESTS			DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R.L. (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	τ (kPa)	SPT #	SAMPLES					
	8/08/2018 7:45:00 AM	100 %	HA						2 2 2 3 3 3 N=10	1		Soft SILT, some clay, some organics; blackish brown; moist, high plasticity. Organics: Roots, rootlets, amorphous. (Topsoil)	Puketoka Formation	
		100 %	SPT							2		Soft clayey SILT; reddish brown; moist, high plasticity.		
		67 %	OB			110/35	161/54			3		1.20 m, brownish orange.		
		100 %	SPT							4		Stiff clayey SILT; grey mottled brownish orange; moist, high plasticity.		
		33 %	OB							5		Very stiff SILT-CLAY; light brownish orange mottled grey and red; moist, high plasticity.		
		100 %	SPT			70/10	103/18			6		2.95 m, reddish brown mottled grey and orange; sensitive.		
		76 %	OB							7		Very stiff clayey SILT; brownish orange mottled grey; wet, high plasticity.		
		100 %	SPT			90/48	131/71			8		5.50 m, firm, brownish orange.		
		100 %	PT							9		6.00 m, very stiff, grey.		
		100 %	SPT							10		6.00-6.50 m: Push tube (not logged).		
		100 %	OB							11		Firm clayey SILT; brownish orange mottled grey; wet, high plasticity.		
		100 %	PT							12		Firm SILT-CLAY; dark bluish grey; wet, high plasticity.		
		100 %	OB			40/10	60/18			13		7.50 m, stiff.		
		44 %	SPT							14		7.50-8.00 m: Push tube (not logged).		
		100 %	TT							15		Firm SILT-CLAY; dark bluish grey; wet, high plasticity.		
		56 %	SPT							16		Medium dense silty fine to medium SAND; dark greyish blue; wet, non plastic. Sand: Subangular to subrounded.		
										17		8.70 m, 50 mm thick lens of fine to coarse SAND; orange; wet, non plastic. Sand: Subangular to subrounded.		
										18		9.50 m, very dense.		

DATE STARTED: 7/8/18 DRILLED BY: Pro-Drill (Auck) Ltd
 DATE FINISHED: 7/8/18 EQUIPMENT: Tractor Rig
 LOGGED BY: BHTF DRILL METHOD: HA/OB/PT/SPT/TT
 SHEAR VANE No: GEO2242 DRILL FLUID: Polymer
 DIAMETER/INCLINATION: -/0°

COMMENTS:
 Hole terminated at target depth.
 Ground water level dipped in open hole on completion of drilling.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

MACHINE BOREHOLE LOG

PROJECT: Drury West Secondary School **JOB NUMBER:** 4216997
SITE LOCATION: 281 and 401 Jesmond Rd, Karaka **CLIENT:** Ministry of Education

CIRCUIT: NZTM **BOREHOLE LOCATION:** 401 Jesmond Rd
COORDINATES: N 5,891,771 m **R L:** 27 m **COORDINATE ORIGIN:** hhGPS
 E 1,771,578 m **DATUM:** MSL **ACCURACY:** 5

DRILLING						IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	τ (kPa)	SPT 'N'						
		29 %	TT					6 7 N=27		X X	10.10 m, 30 mm thick lens of fine to coarse SAND; orange; wet, non plastic. Sand: Subangular to subrounded. 10.25-11.00 m: Core loss	Puketoka Formation		
		78 %	SPT					5 7 8 9 9 N=35			Dense fine to coarse SAND, some silt; dark grey; wet, non-plastic. Sand: Subangular to subrounded, quartz.			
		100 %	TT					8 7 6 5 5 6 N=22			'Medium dense' fine to coarse SAND, minor silt; dark greenish grey; wet, non plastic. Sand: Subangular to subrounded. 12.20 m, fine to medium.			
		100 %	SPT					6 7 9 10 12 17 N=48			14.00 m, dense.			
		100 %	TT					3 5 7 7 10 12 N=36			16.05-17.00 m: Core loss			
		100 %	SPT					5 7 9 10 11 13 N=43			Dense fine to coarse SAND, minor silt; dark greenish grey; wet, non-plastic. Sand: Subangular to subrounded.			
		76 %	TT					7 7 9 10 11 13 N=33						
		100 %	SPT					10						
		70 %	TT											

DATE STARTED: 7/8/18 **DRILLED BY:** Pro-Drill (Auck) Ltd
DATE FINISHED: 7/8/18 **EQUIPMENT:** Tractor Rig
LOGGED BY: BHTF **DRILL METHOD:** HA/OB/PT/SPT/TT
SHEAR VANE No: GEO2242 **DRILL FLUID:** Polymer
DIAMETER/INCLINATION: -/0°


COMMENTS:
Hole terminated at target depth.
Ground water level dipped in open hole on completion of drilling.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

MACHINE BOREHOLE LOG

PROJECT: Drury West Secondary School **JOB NUMBER:** 4216997
SITE LOCATION: 281 and 401 Jesmond Rd, Karaka **CLIENT:** Ministry of Education

CIRCUIT: NZTM **BOREHOLE LOCATION:** 401 Jesmond Rd
COORDINATES: N 5,891,771 m R L: 27 m **COORDINATE ORIGIN:** hhGPS
 E 1,771,578 m **DATUM:** MSL **ACCURACY:** 5

DRILLING						IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	τ (kPa)	SPT 'N'						
			SPT					14 18 24 8 for 25 mm N=50+			 Dense fine to coarse SAND, minor silt; dark greenish grey; wet, non-plastic. Sand: Subangular to subrounded.	Puketoka Formation		
									21		END OF LOG @ 20.45 m			
									22					
									23					
									24					
									25					
									26					
									27					
									28					
									29					

DATE STARTED: 7/8/18 **DRILLED BY:** Pro-Drill (Auck) Ltd
DATE FINISHED: 7/8/18 **EQUIPMENT:** Tractor Rig
LOGGED BY: BHTF **DRILL METHOD:** HA/OB/PT/SPT/TT
SHEAR VANE No: GEO2242 **DRILL FLUID:** Polymer
 DIAMETER/INCLINATION: - / 0°

COMMENTS:
 Hole terminated at target depth.
 Ground water level dipped in open hole on completion of drilling.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

MACHINE BOREHOLE LOG

PROJECT: Drury West Secondary School **JOB NUMBER:** 4216997
SITE LOCATION: 281 and 401 Jesmond Rd, Karaka **CLIENT:** Ministry of Education

CIRCUIT: NZTM **BOREHOLE LOCATION:** 281 Jesmond Rd
COORDINATES: N 5,891,489 m **R L:** 34 m **COORDINATE ORIGIN:** hhGPS
 E 1,771,629 m **DATUM:** MSL **ACCURACY:** 5

DRILLING						IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	τ (kPa)	SPT N						
		100 %	OB			130/42	191/63				Firm SILT, some clay, minor organics; brown; moist, high plasticity. Organics: Roots, rootlets, amorphous. (Topsoil)	Puketoka Formation		
		100 %	OB			70/28	103/43		1	X	Very stiff clayey SILT; light brownish orange; moist, high plasticity.			
		100 %	OB			42/22	63/35	1	2	X	1.50 m, stiff.			
		100 %	SPT					2	2	X				
		100 %	SPT					1	2	X				
		100 %	SPT					2	3	X				
		86 %	OB					3	3	X	2.25 m, light brownish orange.			
		100 %	OB			70/32	103/49	1	0	X	3.00 m, very stiff.			
		100 %	SPT					1	0	X				
		76 %	OB					1	0	X				
		100 %	SPT			140+	204+	3	4	X	Hard CLAY, minor silt; pink mottled white; moist, high plasticity.			
		100 %	SPT					4	4	X				
		100 %	OB			110/44	161/66	6	6	X	5.50 m, very stiff.			
		100 %	OB			98/42	142/63	1	2	X				
		100 %	SPT					2	2	X				
		100 %	SPT					2	2	X				
		100 %	OB			52/10	77/18	3	3	X	Stiff clayey SILT, some fine to coarse sand, minor fine gravel; white mottled pink speckled orange and grey; moist, high plasticity. Sand: Subangular, pumiceous, white and red. Gravel: Subangular to subrounded, black, completely weathered, volcanic lithics. Sensitive.			
		100 %	OB					3	3	X	6.85 m, 60 mm thick lens of CLAY; brown; wet, high plasticity.			
		100 %	OB			30/4	51/7	1	1	X	6.90 m, 2 mm thick seam, reddish orange, iron oxide.			
		100 %	PT					1	1	X	7.00 m, stiff.			
		100 %	PT					1	1	X	7.10 m, pink mottled white.			
		100 %	PT					1	1	X	7.50-8.00 m: Push tube (not logged).			
		100 %	SPT					1	1	X				
		100 %	SPT					1	1	X	Very stiff clayey SILT, some fine to coarse sand, minor fine gravel; bluish red and pink speckled orange and grey; moist, high plasticity. Sand: Subangular, pumiceous, white and red. Gravel: Subangular to subrounded, completely weathered, volcanic lithics.			
		100 %	OB			40/14	60/24	1	1	X	Firm SILT-CLAY; reddish brown mottled pinkish white and bluish red; moist, high plasticity.			
		100 %	OB					1	1	X	9.00 m, stiff.			
		100 %	SPT					1	1	X				
		100 %	SPT					1	1	X				
		100 %	OB			40/4	60/7	2	3	X	Stiff clayey SILT, trace fine to medium sand; grey mottled reddish pink; moist, high plasticity. Sand: Subangular, silica.			
		100 %	OB					3	3	X				

DATE STARTED: 8/8/18 **DRILLED BY:** Pro-Drill (Auck) Ltd
DATE FINISHED: 8/8/18 **EQUIPMENT:** Tractor Rig
LOGGED BY: BHTF **DRILL METHOD:** OB/PT/SPT
SHEAR VANE No: GEO2242 **DRILL FLUID:** Polymer
DIAMETER/INCLINATION: - / 0°

COMMENTS:
 Hole terminated at target depth.
 Ground water level dipped in open hole on completion of drilling.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

MACHINE BOREHOLE LOG

PROJECT: Drury West Secondary School **JOB NUMBER:** 4216997
SITE LOCATION: 281 and 401 Jesmond Rd, Karaka **CLIENT:** Ministry of Education

CIRCUIT: NZTM **BOREHOLE LOCATION:** 281 Jesmond Rd
COORDINATES: N 5,891,489 m **R L:** 34 m **COORDINATE ORIGIN:** hhGPS
 E 1,771,629 m **DATUM:** MSL **ACCURACY:** 5

DRILLING						IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)				
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	ROD	SV	τ (kPa)	SPT N										
		100 %	OB			60/12	89/21	1	UT2	11	10.00 m, stiff.	Puketoka Formation						
		100 %	SPT					1			11			Stiff SILT, some clay, minor fine to medium gravel, trace fine to medium sand; brownish orange; moist, high plasticity. Gravel: Angular, completely weathered, black. Sand: Subangular, silica.				
		100 %	OB					1							11	11.40 m, 2 x thin beds of fine SAND; black; moist, non plastic. Subangular to subrounded.		
		100 %	SPT					1									12	Stiff fine sandy SILT; yellowish brown; moist, non plastic. Sand: Subangular to subrounded.
		100 %	OB			30/2	46/4	2										
		100 %	PT					2	12	12.00-12.50 m: Push tube (not logged).								
		100 %	SPT					1			13			Firm clayey SILT; red; moist, high plasticity.				
		100 %	OB					1							13	Firm Silty CLAY, trace fine sand; brownish orange; moist, high plasticity. Sand: Subangular to subrounded.		
		100 %	SPT			37/10	57/18	2									14	13.50 m, stiff, minor fine sand.
		100 %	OB					2										
		100 %	SPT					2	15	15.00 m, stiff.								
		44 %	SPT			30/5	46/9	2			16			Firm SILT-CLAY; greyish blue; moist, high plasticity.				
		86 %	OB					2							17	Loose silty fine to coarse SAND; bluish grey; moist, non plastic. Sand: Subangular to subrounded, quartz.		
		100 %	SPT					2									18	Stiff clayey SILT, trace fine sand; greyish blue; moist, high plasticity. Sand: Subangular to subrounded.
		100 %	OB			56/12	83/21	2										
		100 %	SPT					2	19	Firm clayey SILT; greyish blue; moist, high plasticity.								
		100 %	OB					3			19			Loose silty fine to coarse SAND; bluish grey; moist, non plastic. Sand: Subangular to subrounded.				
		100 %	SPT			50/12	74/21	3							19	Stiff SILT, some clay, some fine to coarse sand; bluish grey; moist, high plasticity. Sand: Subangular to subrounded.		
		100 %	OB					4									19	Medium dense silty fine to coarse SAND; bluish grey; moist, non plastic. Sand: Subangular to subrounded.
		100 %	SPT					4										

DATE STARTED: 8/8/18 **DRILLED BY:** Pro-Drill (Auckland)
DATE FINISHED: 8/8/18 **EQUIPMENT:** Tractor Rig
LOGGED BY: BHTF **DRILL METHOD:** OB/PT/SPT
SHEAR VANE No: GEO2242 **DRILL FLUID:** Polymer
DIAMETER/INCLINATION: -/0°

COMMENTS:
 Hole terminated at target depth.
 Ground water level dipped in open hole on completion of drilling.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

MACHINE BOREHOLE LOG

PROJECT: Drury West Secondary School **JOB NUMBER:** 4216997
SITE LOCATION: 281 and 401 Jesmond Rd, Karaka **CLIENT:** Ministry of Education

CIRCUIT: NZTM **BOREHOLE LOCATION:** 281 Jesmond Rd
COORDINATES: N 5,891,489 m **R L:** 34 m **COORDINATE ORIGIN:** hhGPS
 E 1,771,629 m **DATUM:** MSL **ACCURACY:** 5

DRILLING						IN-SITU TESTS			SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	R L (m)
FLUID LOSS	DAILY WATER LEVEL	CORE RECOVERY	METHOD	CASING	RQD	SV	τ (kPa)	SPT 'N'						
								6 2 N=14		21				
										22				
										23				
										24				
										25				
										26				
										27				
										28				
										29				

DATE STARTED: 8/8/18 DATE FINISHED: 8/8/18 LOGGED BY: BHTF SHEAR VANE No: GEO2242	DRILLED BY: Pro-Drill (Auck) Ltd EQUIPMENT: Tractor Rig DRILL METHOD: OB/PT/SPT DRILL FLUID: Polymer DIAMETER/INCLINATION: - / 0°	COMMENTS: Hole terminated at target depth. Ground water level dipped in open hole on completion of drilling.
--	--	---

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

Drury West Secondary School



BOX: 1

DEPTH: 0.00 to 1.50 m



BOX: 2

DEPTH: 1.50 to 5.50 m

Drury West Secondary School



BOX: 3

DEPTH: 5.50 to 9.95 m



BOX: 4

DEPTH: 9.95 to 13.95 m

Drury West Secondary School



BOX: 5

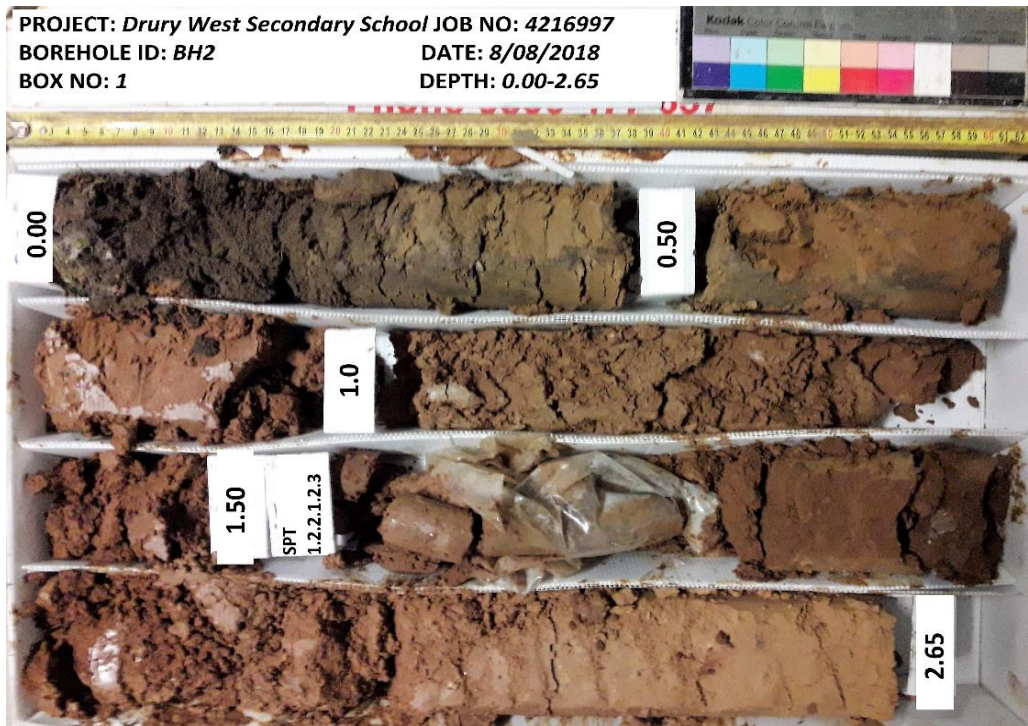
DEPTH: 13.95 to 18.95m



BOX: 6

DEPTH: 18.95 to 20.45 m

Drury West Secondary School



BOX: 1

DEPTH: 0.00 to 2.65 m



BOX: 2

DEPTH: 2.65 to 6.00 m

Drury West Secondary School



BOX: 3

DEPTH: 6.00 to 9.45 m



BOX: 4

DEPTH: 9.45 to 11.70 m

Drury West Secondary School



BOX: 5

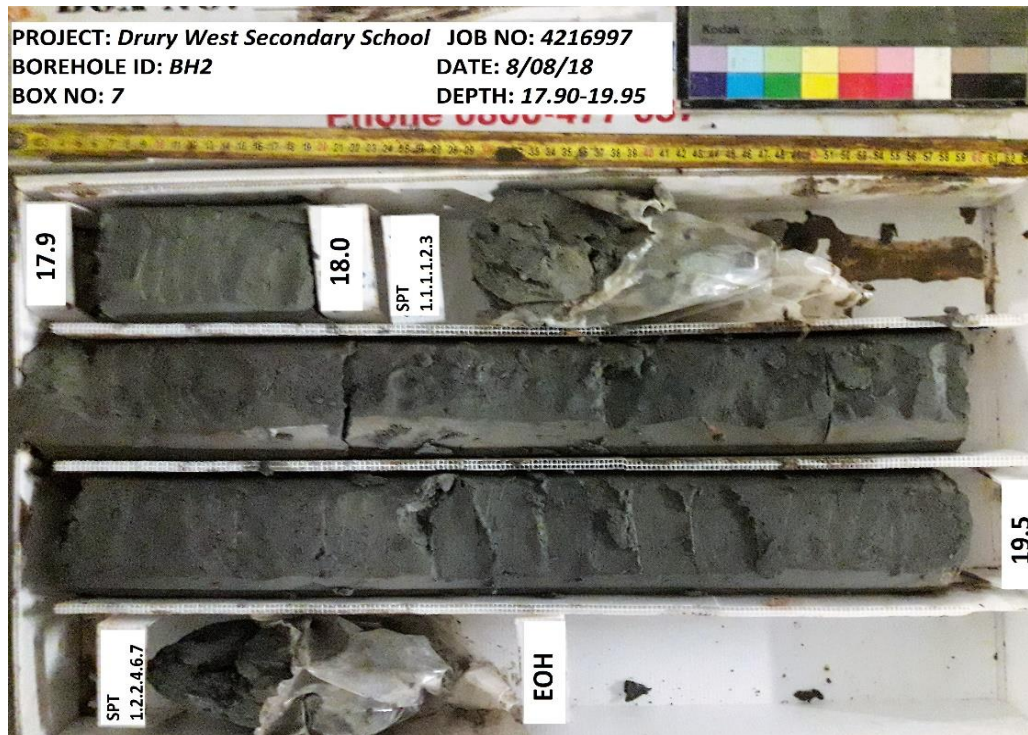
DEPTH: 11.70 to 15.00 m



BOX: 6

DEPTH: 15.00 to 17.90 m

Drury West Secondary School



BOX:

DEPTH: 17.90 to 19.95 m

HAND AUGER LOG

PROJECT: Drury West Secondary School		JOB NUMBER: 4216997	
SITE LOCATION: 281 and 401 Jesmond Rd, Karaka		CLIENT: Ministry of Education	
CIRCUIT: NZTM		AUGER LOCATION: Persimon orchard in the south eastern corner of 401 Jesmond Rd	
COORDINATES: N 5,891,836 m E 1,771,617 m		R L: 13 m DATUM: MSL	
		COORDINATE ORIGIN: hhGPS ACCURACY: 5	

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	Scales (Blows/100mm)		WATER LEVEL	R L (m)
					SV	τ (kPa)		
0.0		X X X X	Stiff SILT, minor clay, trace organics; brown; wet, low plasticity. [TOPSOIL]	Puketoka Formation	0			
0.1		X X X X			1			
0.2		X X X X	Very stiff SILT, some clay; brown; wet, high plasticity.		2	68/2	98/3	
0.3		X X X X			2			
0.4		X X X X	Very stiff SILT, some clay, trace organics; greyish brown; wet, high plasticity. Organics: Fibrous.		2			
0.5		X X X X			2			12.5
0.6		X X X X	Very stiff SILT, some clay, trace fine to medium sand, trace organics; grey speckled white; wet, high plasticity. Sand: Subangular to subrounded. Organics: Fibrous.		3	112/24	157/37	
0.7		X X X X			3			
0.8		X X X X			3			
0.9		X X X X			4			
1.0		X X X X		4	122/70	170/100		
1.1		X X X X						
1.2		X X X X	Very stiff SILT, some clay, trace fine sand; brownish orange mottled grey; wet, high plasticity. Sand: Subangular to subrounded.		124/54	172/78		
1.3		X X X X						
1.4		X X X X						
1.5		X X X X			124/48	172/69		
1.6		X X X X						
1.7		X X X X						
1.8		X X X X			110/24	155/37		
1.9		X X X X						
2.0		X X X X	Very stiff clayey SILT; brownish orange mottled greyish white; wet, high plasticity.		126/60	175/87		
2.1		X X X X						
2.2		X X X X						
2.3		X X X X						
2.4		X X X X			140+	193		
2.5		X X X X	2.50 m, sensitive.				8/08/2018	
2.6		X X X X						
2.7		X X X X			124/20	172/31		
2.8		X X X X						
2.9		X X X X						
3.0		X X X X			88/32	123/48		
3.1		X X X X						
3.2		X X X X	3.20 m, saturated. END OF LOG @ 3.2 m					
3.3					3			
3.4					5			
3.5					5			
3.6					7			
3.7					10		9.5	
3.8					11			
3.9					11			
4.0					18			
4.1					18		9.0	
4.2					18			
4.3					18			
4.4								
4.5							8.5	

DATE AUGERED: 8/8/18	DIAMETER: 50 mm	COMMENTS: Hole terminated due to lack of recovery. Coordinates and elevation obtained from Auckland Council Geomaps.
LOGGED BY: LC	METHOD: HA	
SHEAR VANE No: GEO2243		

BEQA 2.01 LIB.GLB Log BEQA HAND AUGER DRURY WEST SECONDARY SCHOOL 4.27 PM 22.08.2018.GPJ <<DrawingFiles>> 23/08/2018 13:52 8.30.004 - Digital Lab and In Situ Tool - DGD | Lib: Beqa 2.01 2016-04-19 Pdf Beqa 1.07 2014-12-16

HAND AUGER LOG

PROJECT: Drury West Secondary School		JOB NUMBER: 4216997								
SITE LOCATION: 281 and 401 Jesmond Rd, Karaka		CLIENT: Ministry of Education								
CIRCUIT: NZTM		AUGER LOCATION: South east corner of 281 Jesmond Rd near BH2								
COORDINATES: N 5,891,467 m E 1,771,677 m		R L: 23 m DATUM: MSL								
		COORDINATE ORIGIN: hhGPS ACCURACY: 5								
DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	Scale (Blows/100mm)	SV	τ (kPa)	WATER LEVEL	R L (m)	
		X X X X	Stiff SILT, minor clay, trace organics; dark brown; moist, low plasticity. Organics: Rootlets, amorphous. [TOPSOIL]	Puketoka Formation	1					
		X X X X	Very stiff SILT, trace clay; brown speckled white; moist, low plasticity.		2					
0.5		X X X X			3	94/34	131/50			
		X X X X	1.00 m, some clay, high plasticity.		3					22.5
		X X X X			4					
		X X X X			2	84/38	118/54			
1.0		X X X X			3					
		X X X X	Very stiff SILT, some clay; brown; moist, high plasticity.		3					22.0
		X X X X			3	102/56	143/81			
1.5		X X X X						140+	193	
		X X X X	Very stiff SILT, some clay; light brown speckled white; moist, high plasticity.				140+	193		21.5
2.0		X X X X								
		X X X X	2.50 m, inferred ground water table.			118/46	165/66		21.0	
		X X X X					140+	193		
2.5		X X X X								
		X X X X	Very stiff SILT, minor clay; reddish brown; moist, low plasticity.			104/62	146/90		20.5	
		X X X X					140+	193		
3.0		X X X X	Very stiff SILT, some clay; bluish grey speckled white; moist, high plasticity.					1/08/2018		
		X X X X					140+	193		
		X X X X	END OF LOG @ 3.9 m						20.0	
3.5		X X X X					140+	193		
		X X X X							19.5	
4.0					4	140+	193			
					6				19.0	
					8					
					11					
					12					
					13					
4.5					14				18.5	
					15					
					15					
					15					
					18					
DATE AUGERED: 7/8/18		DIAMETER: 50 mm		COMMENTS: Hole terminated due to lack of recovery. Coordinates and elevation obtained from Auckland Council Geomaps.						
LOGGED BY: LC		METHOD: HA								
SHEAR VANE No: GEO2243										

BECA 2.01 LIB.GLB Log BECA HAND AUGER DRURY WEST SECONDARY SCHOOL 4.27 PM 22/08/2018.GPJ <<DrawingFile>> 23/08/2018 13:52 8:30:004 - Digital Lab and In Situ Tool - DGD | Lib: Beca 2.01 2016-04-19 Pdf Beca 1.07 2014-12-16

HAND AUGER LOG

PROJECT: **Drury West Secondary School** JOB NUMBER: **4216997**
 SITE LOCATION: **281 and 401 Jesmond Rd, Karaka** CLIENT: **Ministry of Education**

CIRCUIT: **NZTM** AUGER LOCATION: **Middle paddock along southern fence line of 281 Jesmond Rd**
 COORDINATES: **N 5,891,536 m R L: 21 m COORDINATE ORIGIN: hhGPS**
E 1,771,634 m DATUM: MSL ACCURACY: 5

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	Scale (Blows/100mm)	SV	τ (kPa)	WATER LEVEL	R L (m)
0.0		X X X X	Stiff SILT, minor clay, trace organics; dark brown; moist, low plasticity. Organics: Rootlets. [TOPSOIL]	Puketoka Formation	1				
0.2		X X X X	Very stiff SILT, minor clay; brown; moist, low plasticity.		2				
0.5		X X X X			3	122/56	170/81		
0.8		X X X X	Very stiff SILT, some clay; bluish grey mottled brown; moist, high plasticity.	Puketoka Formation	3				20.5
1.0		X X X X			2	80/30	112/46		
1.2		X X X X			3				
1.5		X X X X	'Loose' SILT; reddish brown; moist, non plastic.	Puketoka Formation	7				20.0
1.8		X X X X	Very stiff SILT, trace clay; reddish brown; moist, low plasticity.		10	140+	193+		
2.0		X X X X	Very stiff SILT, some clay; light brown; wet, high plasticity.	Puketoka Formation					19.5
2.2		X X X X	1.90 m, saturated.		102/24	143/37			
2.4		X X X X	END OF LOG @ 2.4 m						19.0
2.5					6				
3.0					6				
3.5					8				
4.0					9				
4.5					11				
					15				18.0
					14				
					15				
					15				
					21				17.5
									17.0
									16.5

DATE AUGERED: **7/8/18** DIAMETER: **50 mm** COMMENTS:
 LOGGED BY: **LC** METHOD: **HA** Hole terminated due to lack of recovery.
 SHEAR VANE No: **GEO2243** Coordinates and elevation obtained from Auckland Council Geomaps.

FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

BECA 2.01 LIB.GLB Log BECA HAND AUGER DRURY WEST SECONDARY SCHOOL 4.27 PM 22.08.2018.GPJ <<DrawingFiles>> 23/08/2018 13:52 8.30.004 -Digital Lab and In Situ Test - DGD | Lib: Beas 2.01 2016-04-19 Pdf Beas 1.07 2014-12-16

HAND AUGER LOG

PROJECT: Drury West Secondary School JOB NUMBER: 4216997
 SITE LOCATION: 281 and 401 Jesmond Rd, Karaka CLIENT: Ministry of Education

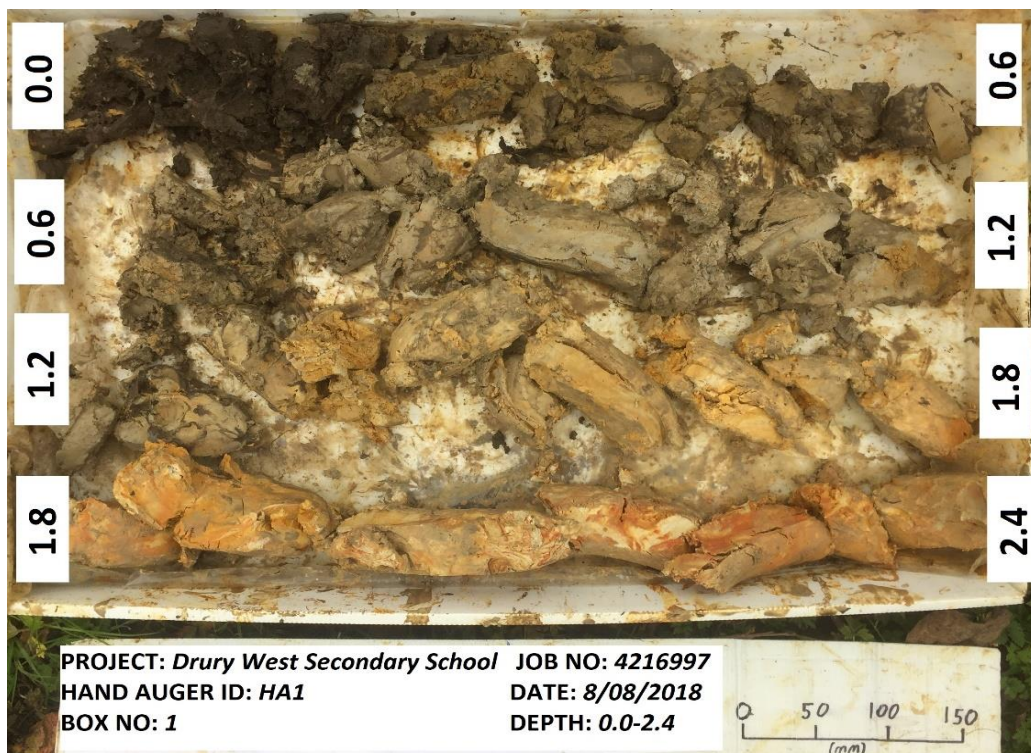
CIRCUIT: NZTM AUGER LOCATION: Horse dressage arena at south western corner of 281 Jesmond Rd
 COORDINATES: N 5,891,656 m R L: 16 m COORDINATE ORIGIN: hhGPS
 E 1,771,543 m DATUM: MSL ACCURACY: 5

DEPTH (m)	SAMPLES	GRAPHIC LOG	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	Scale (Blows/100mm)	SV	γ (kPa)	WATER LEVEL	R L (m)
		X X X X X X X X	Very stiff SILT, minor clay, trace organics; dark brown; moist, low plasticity	Puketaka Formation					
		'Very dense' fine to coarse SAND; grey; moist, non-plastic. Sand: Subangular to subrounded. 0.30 m, gravel, UTP. END OF LOG @ 0.3 m		20				
0.5									15.5
1.0									15.0
1.5									14.5
2.0									14.0
2.5									13.5
3.0									13.0
3.5									12.5
4.0									12.0
4.5									11.5

DATE AUGERED: 8/8/18 DIAMETER: 50 mm COMMENTS:
 LOGGED BY: LC METHOD: HA Ground water not encountered.
 SHEAR VANE No: Coordinates and elevation obtained from Auckland Council Geomaps.

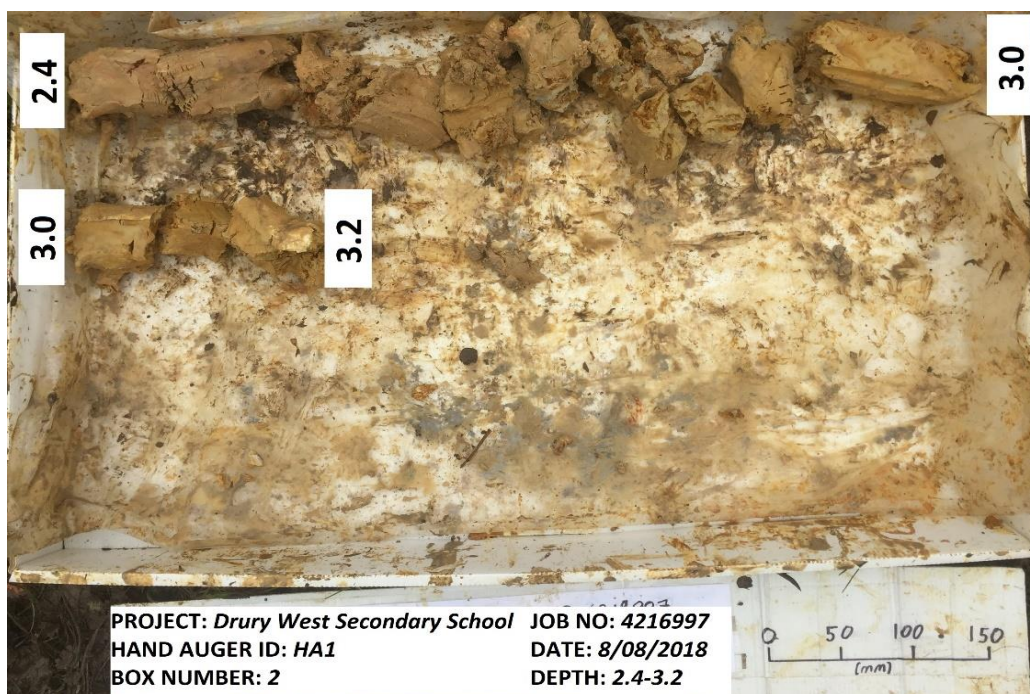
FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS SEE KEY SHEET

Drury West Secondary School



BOX: 1

DEPTH: 0.00 to 2.40 m



BOX: 2

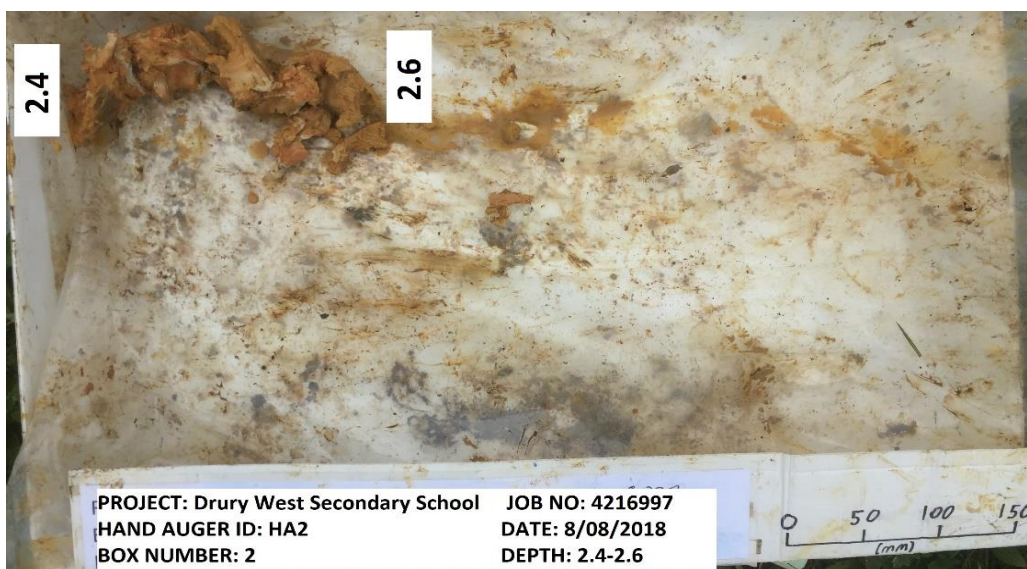
DEPTH: 1.30 to 3.20 m

Drury West Secondary School



BOX: 1

DEPTH: 0.00 to 2.40 m



BOX: 2

DEPTH: 2.40 to 2.60 m

Drury West Secondary School



BOX: 1

DEPTH: 0.00 to 2.70 m



BOX: 2

DEPTH: 2.70 to 3.90 m

Drury West Secondary School



BOX: 1

DEPTH: 0.00 to 2.70 m

Drury West Secondary School



BOX: 1

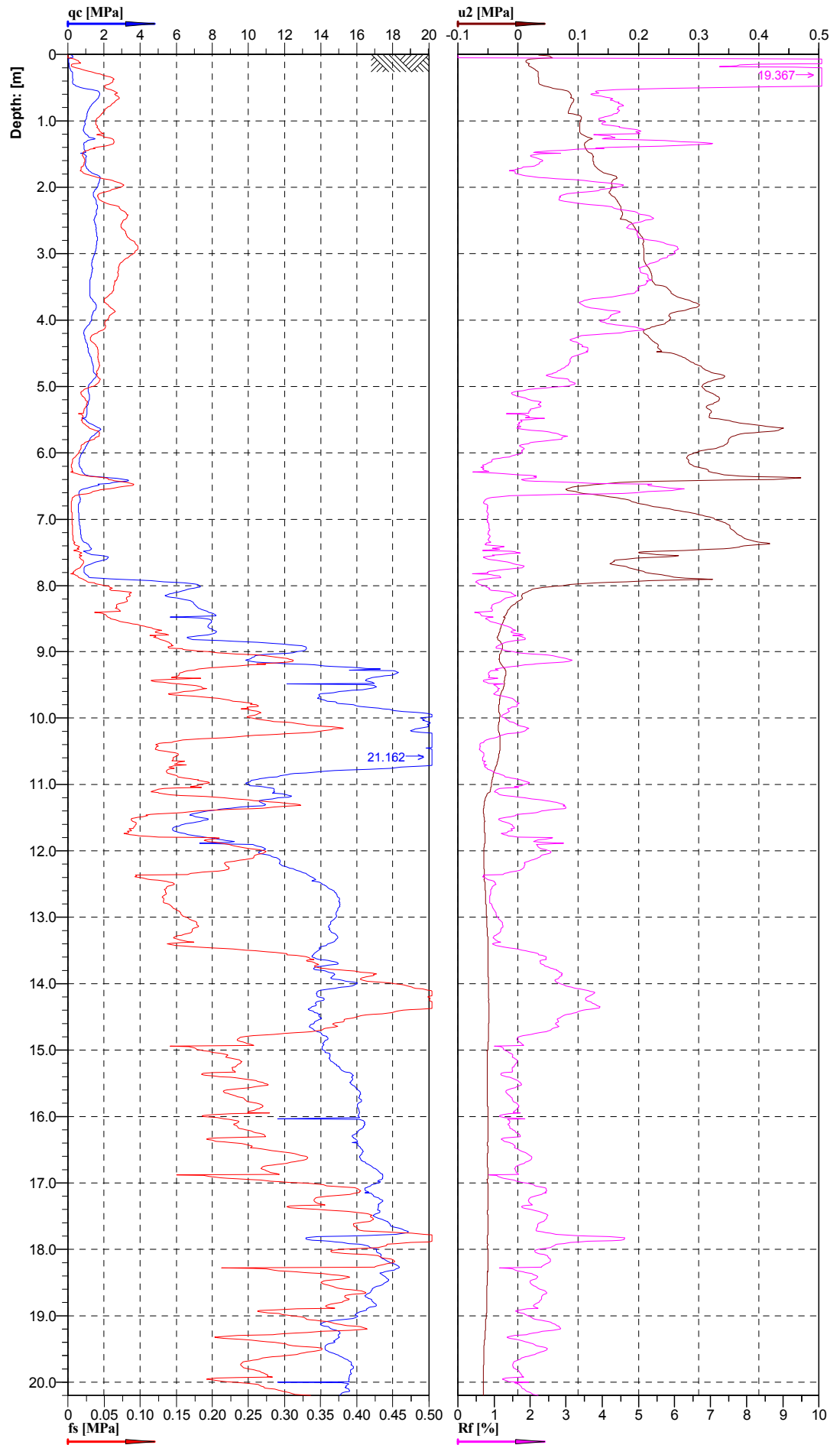
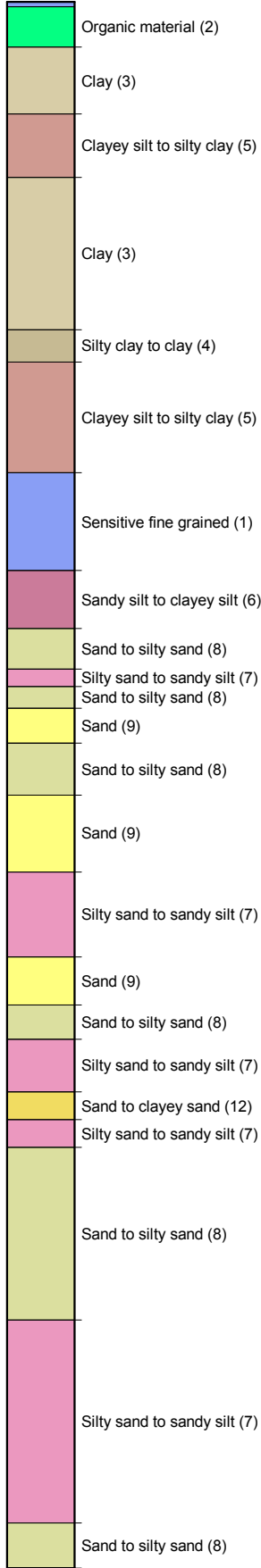
DEPTH: 0.00 to 0.30 m

Appendix C

CPT Logs



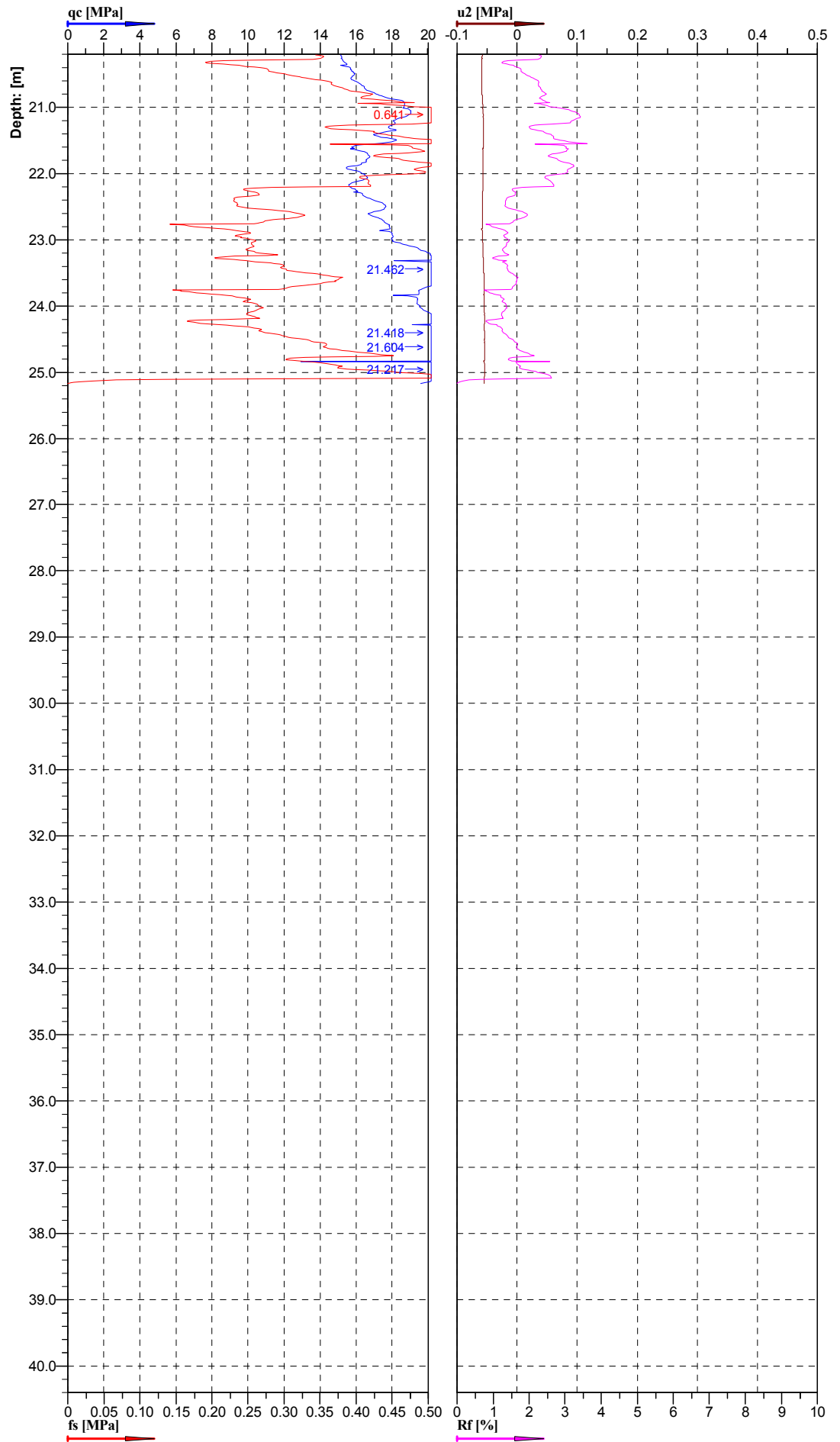
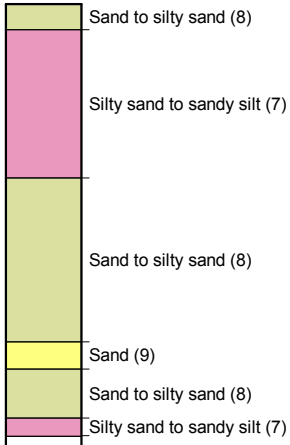
**Classification by
Robertson 1986**



Cone No: S15CFIIP.1423
Tip area [cm²]: 15
Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT01
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/2	Fig.:
		File: Beca281-401JesmondRd_CPT01.GEF	

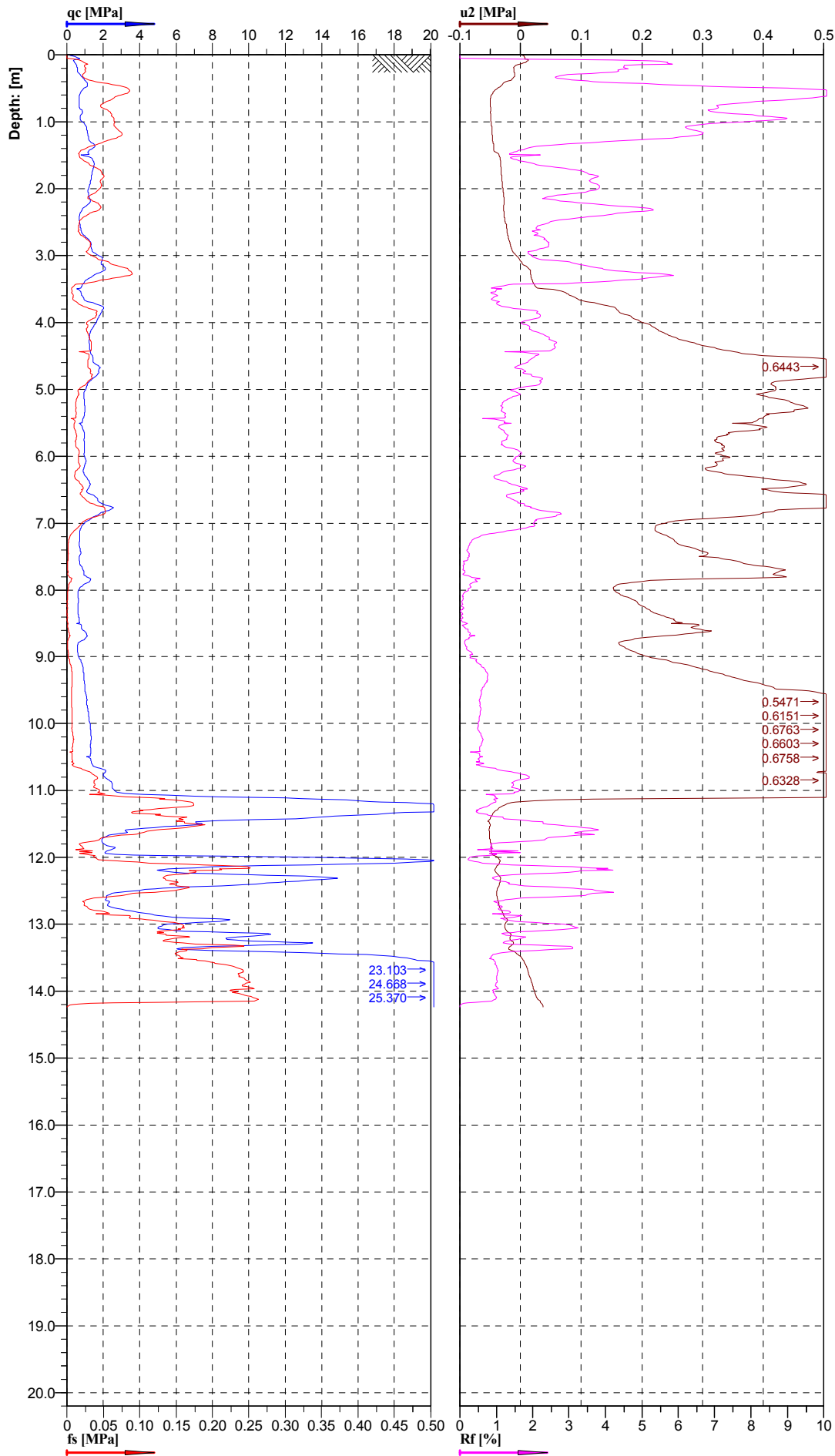
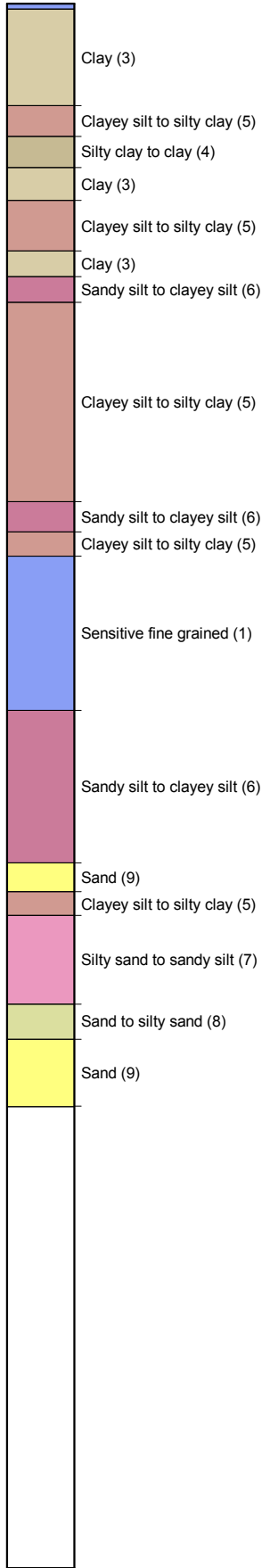
**Classification by
Robertson 1986**



Cone No: S15CFIIP.1423
Tip area [cm²]: 15
Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT01
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 2/2	Fig.:
		File: Beca281-401JesmondRd_CPT01.GEF	

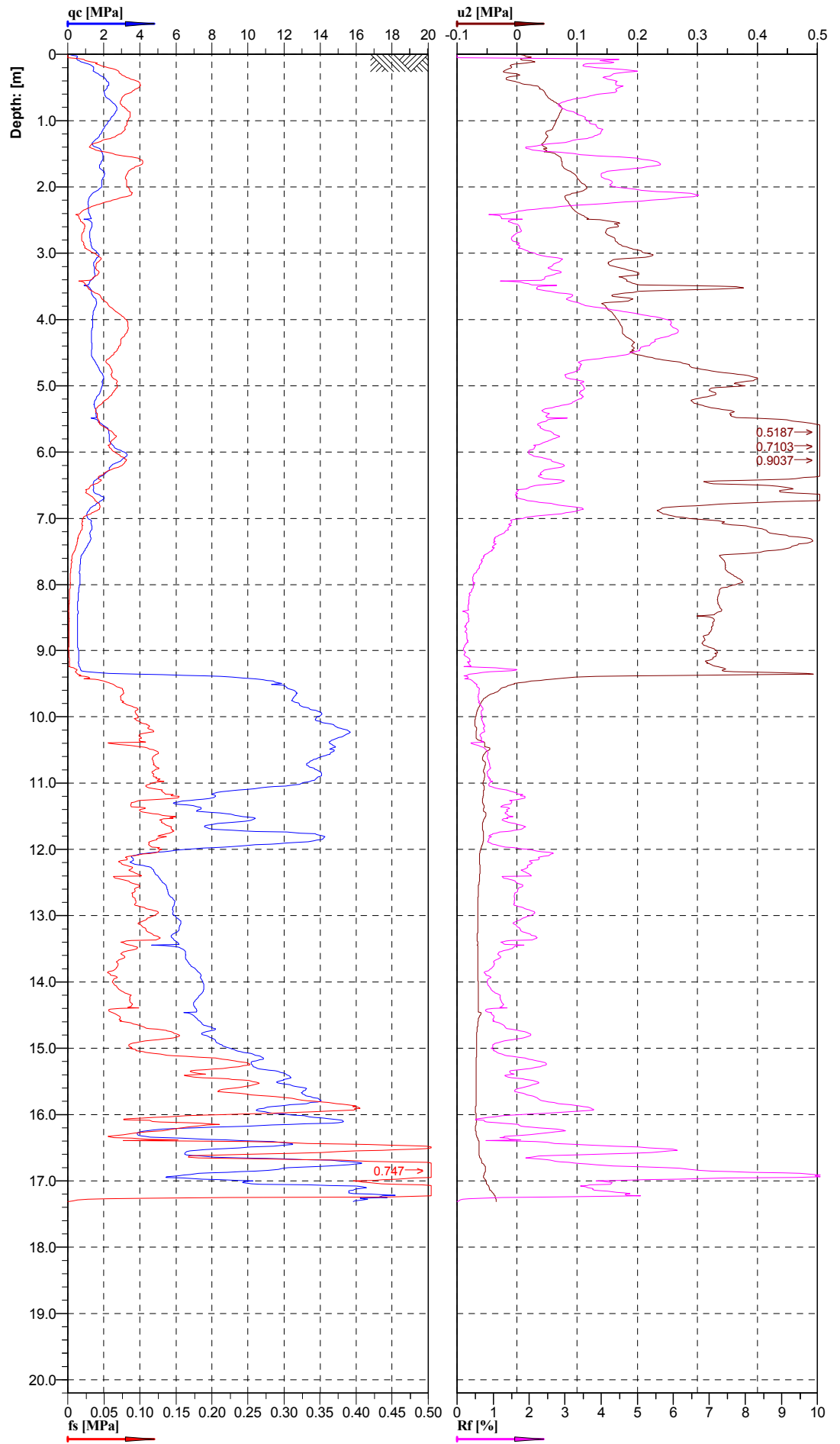
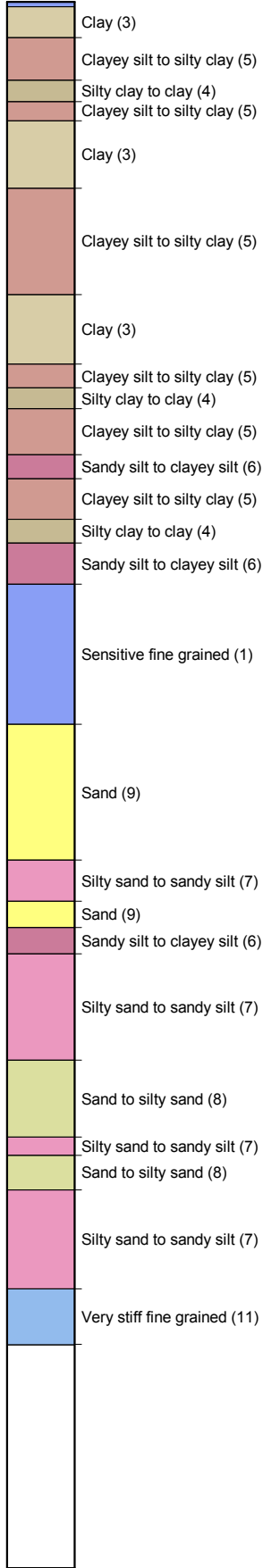
Classification by Robertson 1986



Cone No: S15CFIIP.1423
 Tip area [cm²]: 15
 Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT02
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/1	Fig.:
		File: Beca281-401JesmondRd_CPT02.GEF	

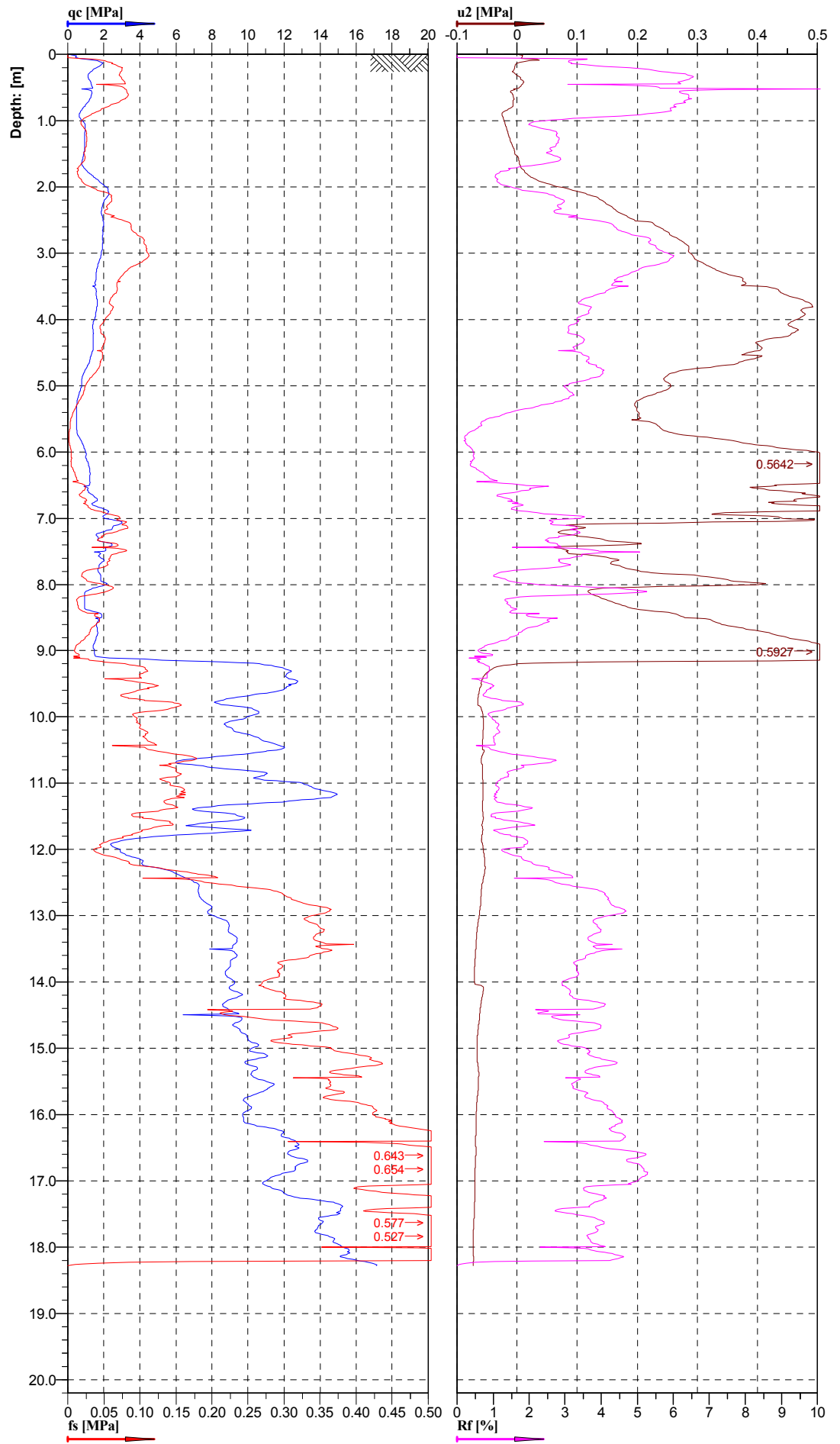
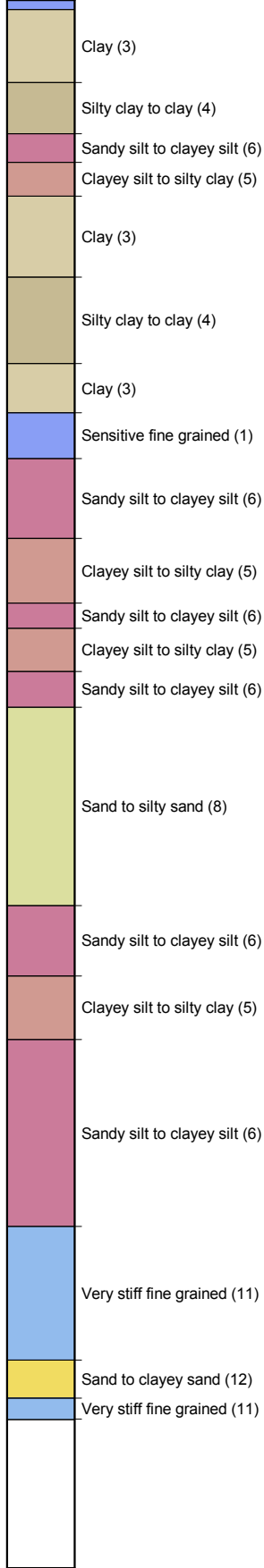
**Classification by
Robertson 1986**



Cone No: S15CFIIP.1423
Tip area [cm²]: 15
Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT03
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/1	Fig.:
		File: Beca281-401JesmondRd_CPT03.GEF	

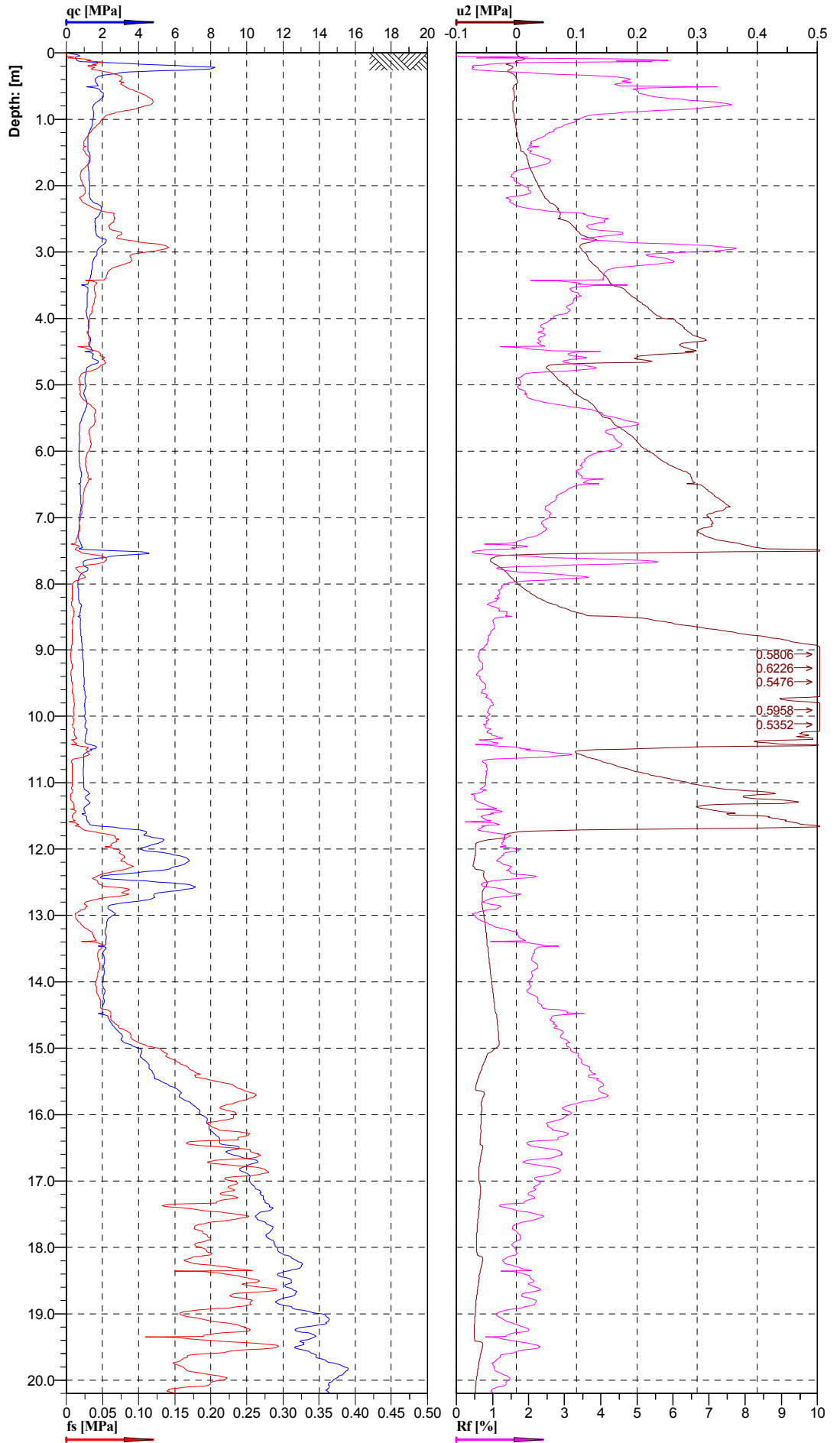
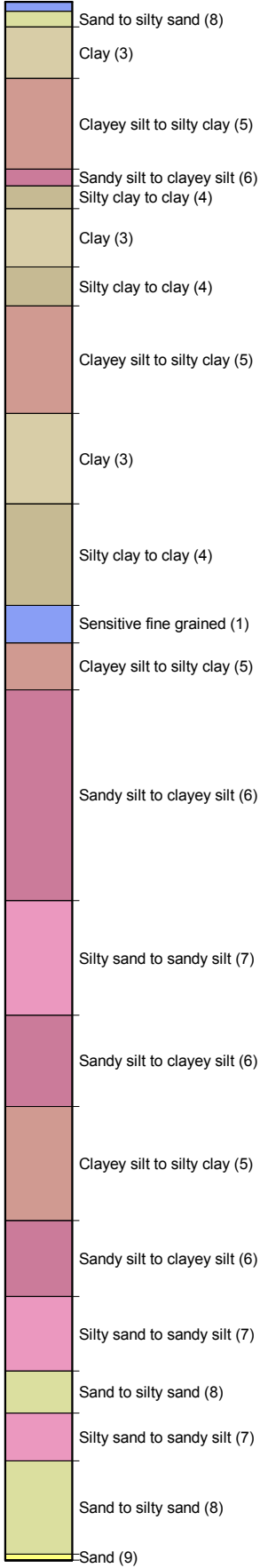
Classification by Robertson 1986



Cone No: S15CFIIP.1423
 Tip area [cm²]: 15
 Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT04
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/1	Fig.:
		File: Beca281-401JesmondRd_CPT04.GEF	

**Classification by
Robertson 1986**

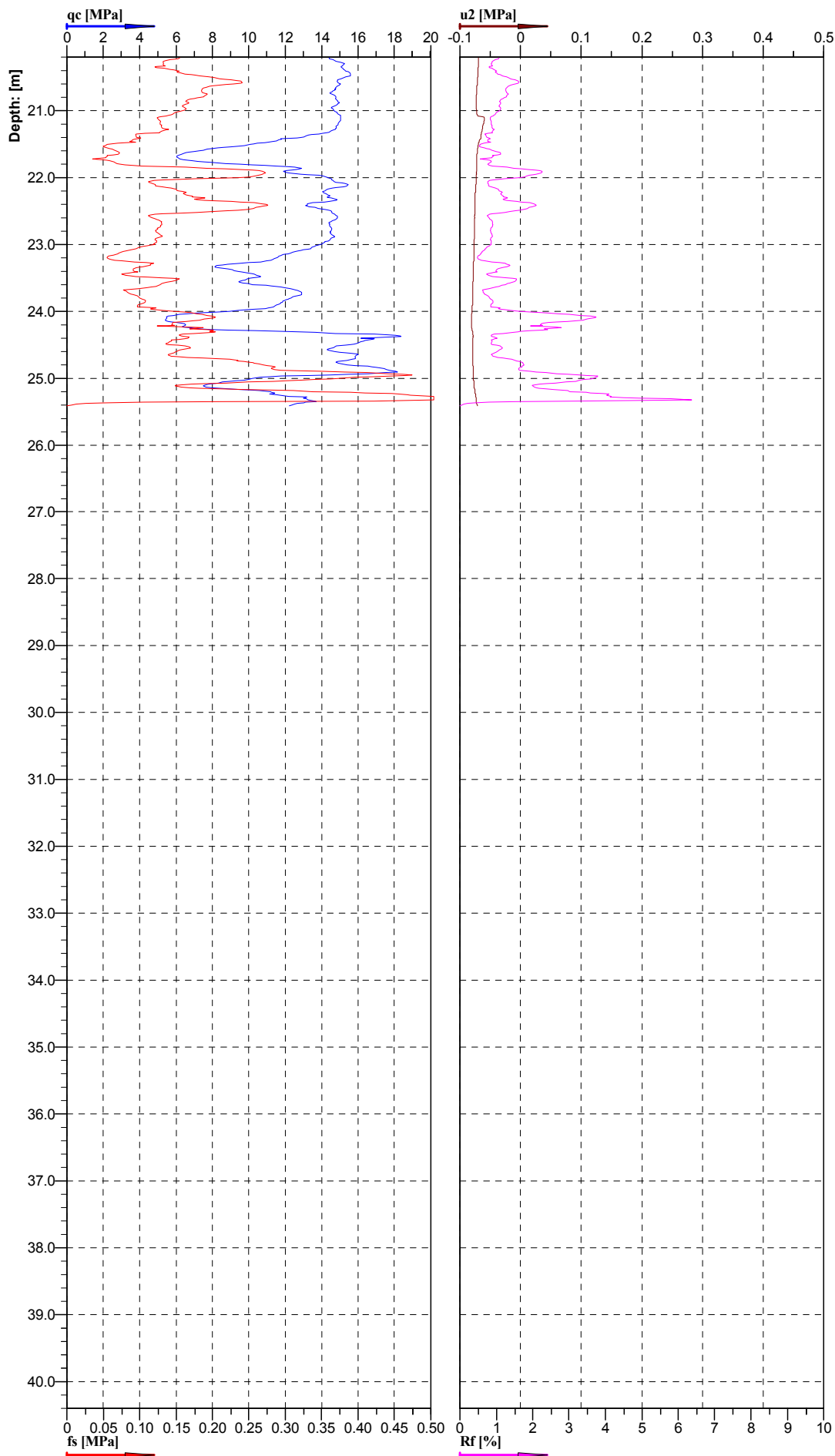


Cone No: S15CFIIP.1423
Tip area [cm²]: 15
Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT05
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/2	Fig.:
		File: Beca281-401JesmondRd_CPT05.GEF	

Classification by Robertson 1986

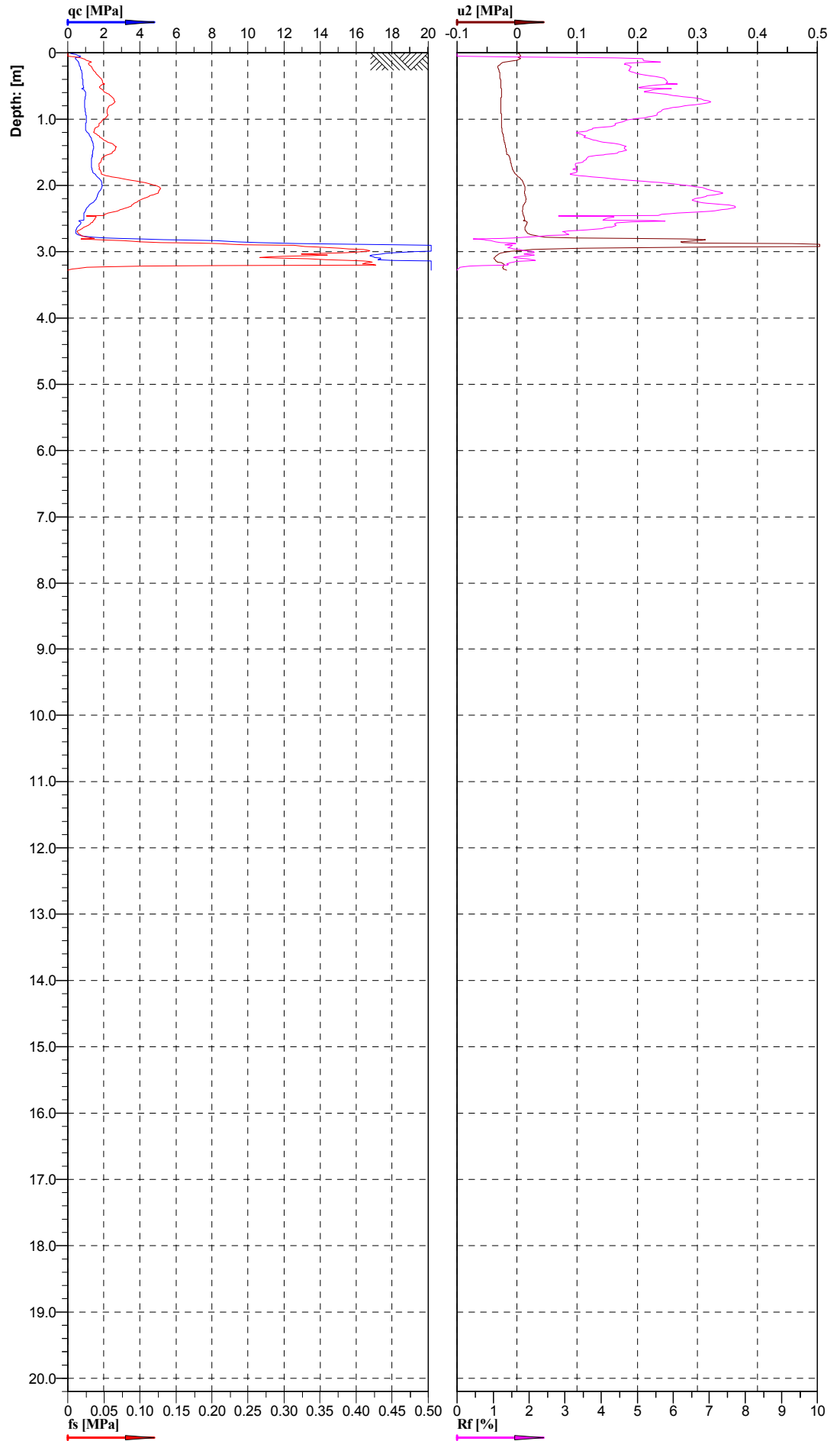
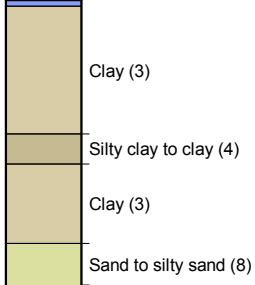
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Very stiff fine grained (11)



Cone No: S15CFIIP.1423
 Tip area [cm²]: 15
 Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT05
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 2/2	Fig.:
		File: Beca281-401JesmondRd_CPT05.GEF	

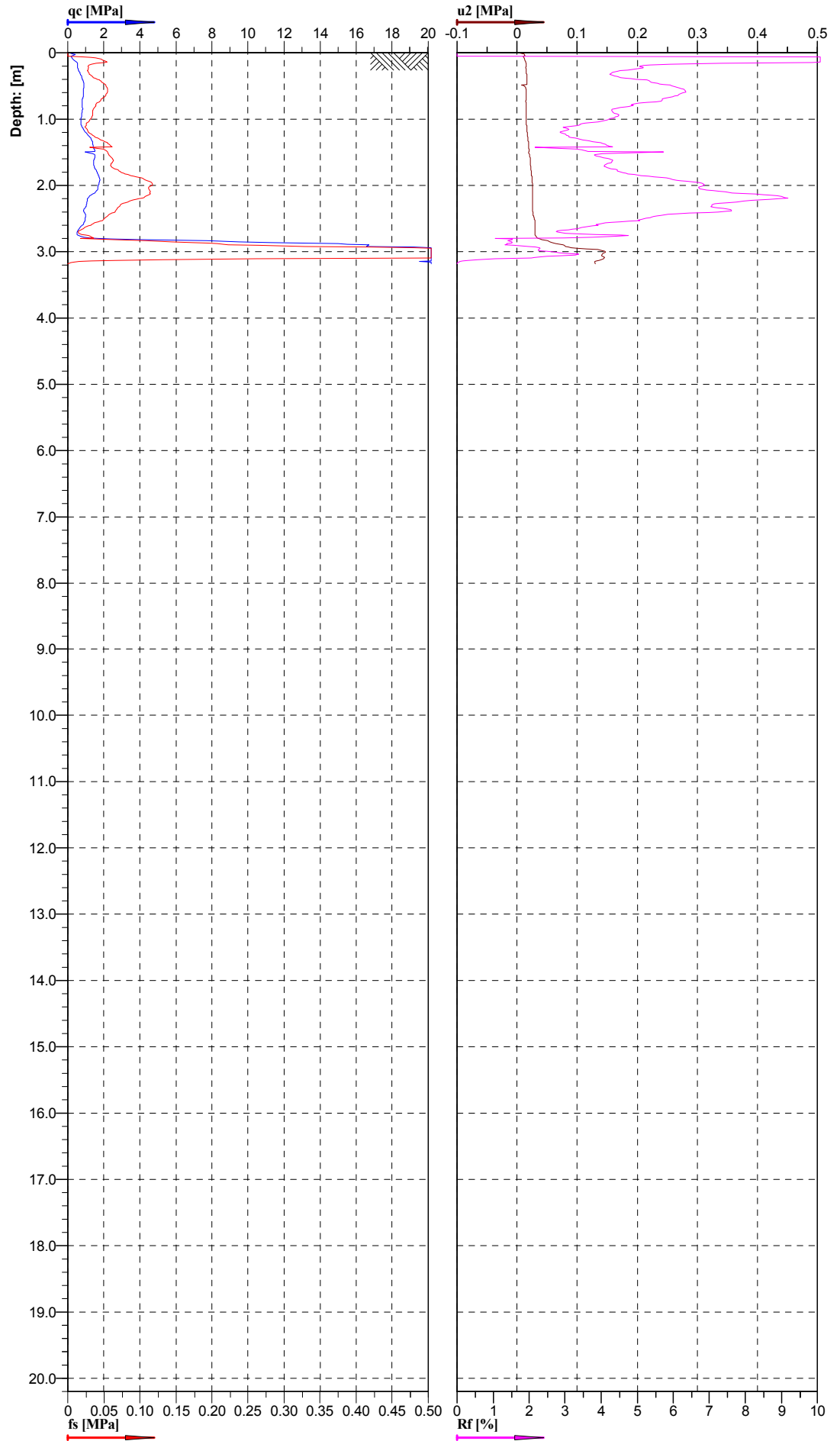
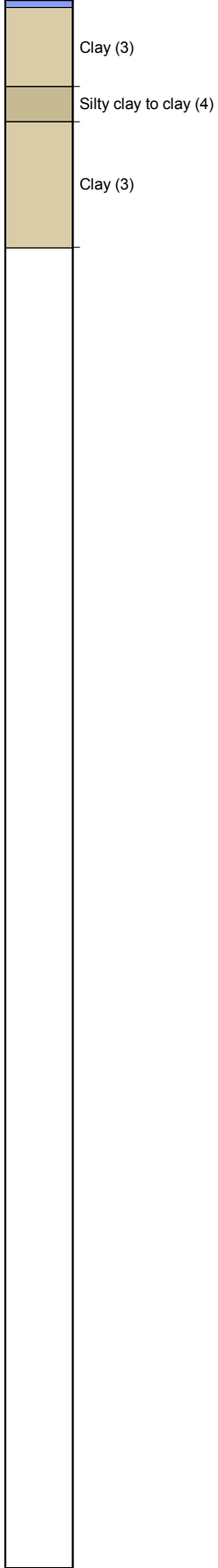
Classification by Robertson 1986



Cone No: S15CFIIP.1423
 Tip area [cm²]: 15
 Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT06
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/1	Fig.:
		File: Beca281-401JesmondRd_CPT06.GEF	

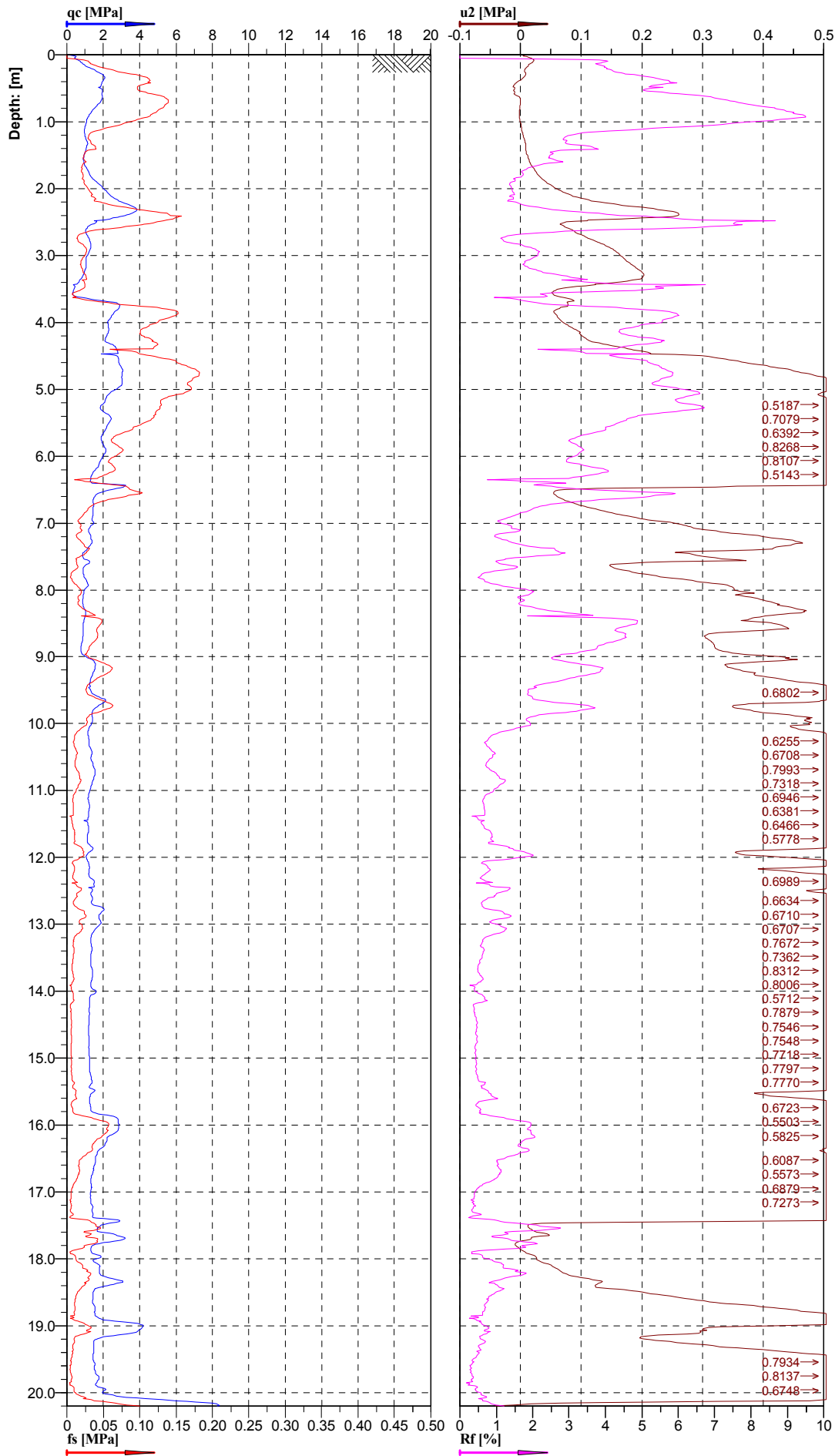
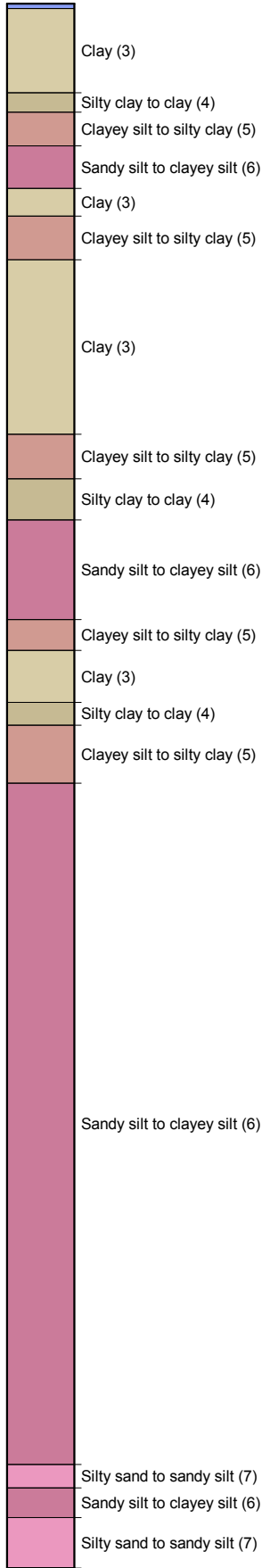
Classification by
Robertson 1986



Cone No: S15CFIIP.1423
Tip area [cm²]: 15
Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT06a
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/1	Fig.:
		File: Beca281-401JesmondRd_CPT06a.GEF	

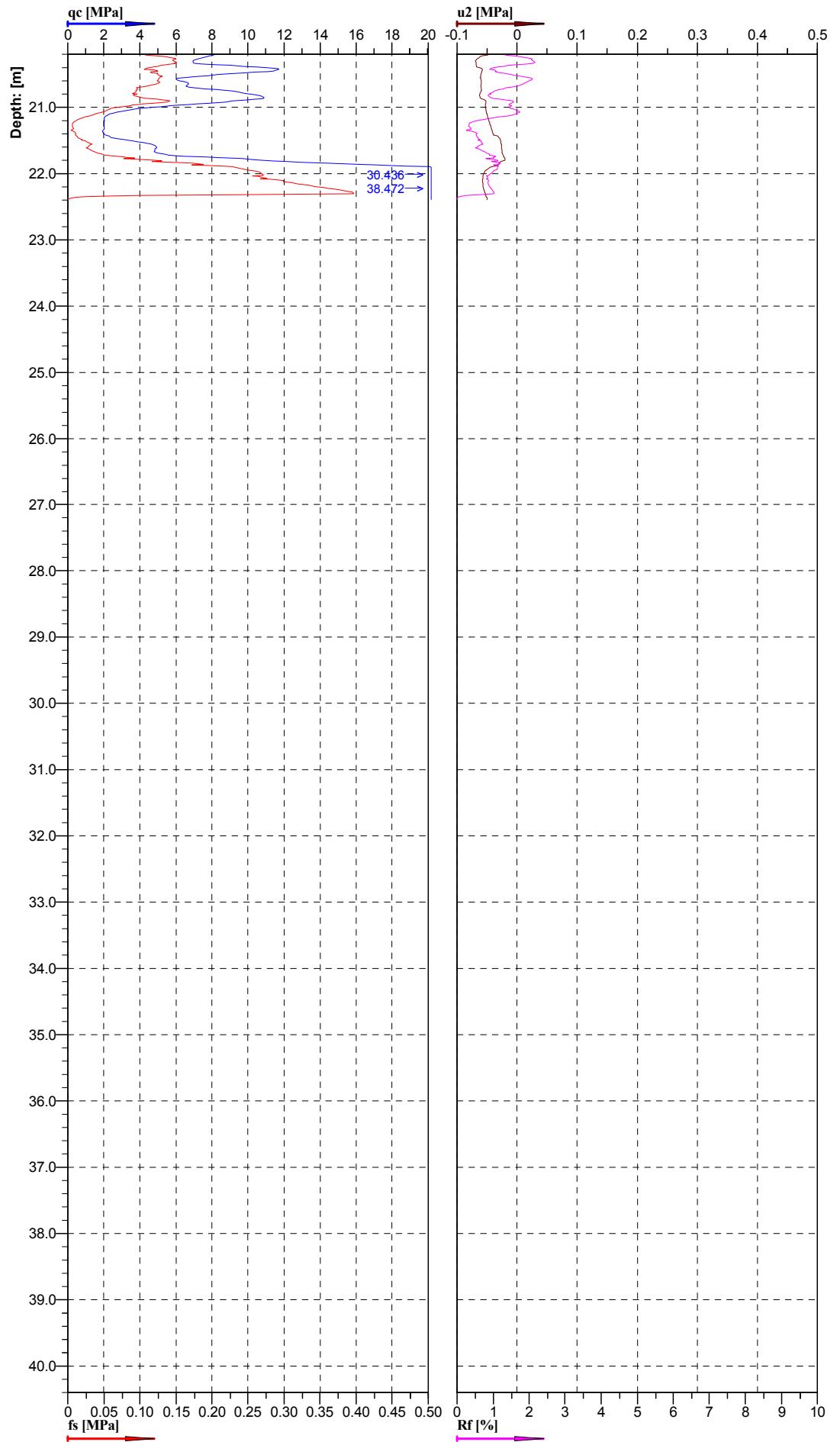
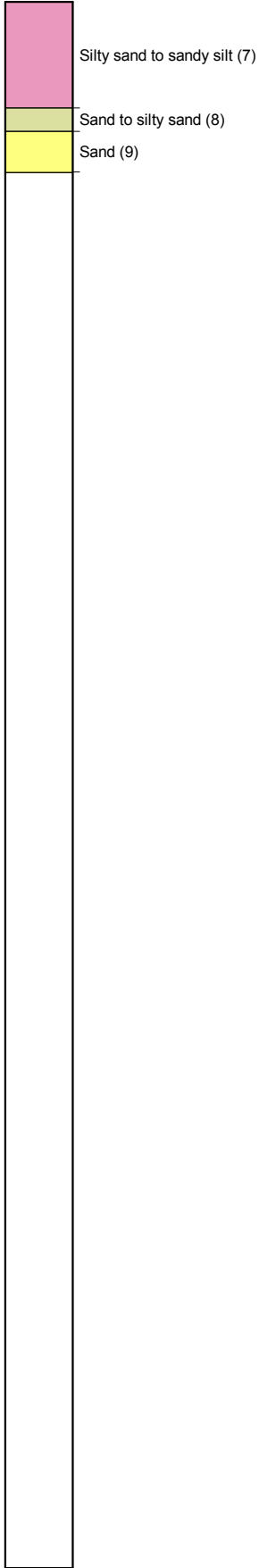
Classification by Robertson 1986



Cone No: S15CFIIP.1423
 Tip area [cm²]: 15
 Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT07
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/2	Fig.:
		File: Beca281-401JesmondRd_CPT07.GEF	

Classification by
Robertson 1986



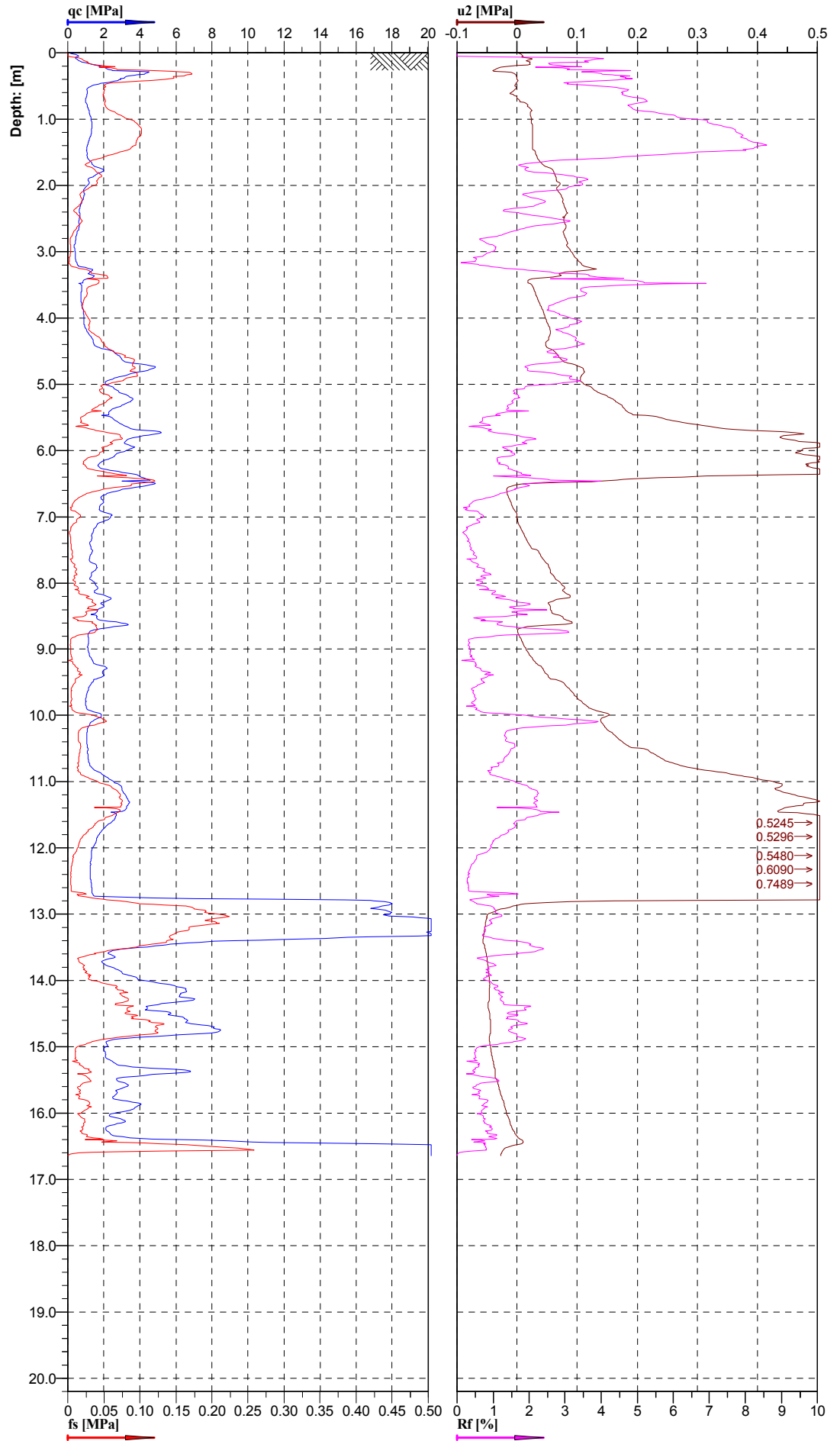
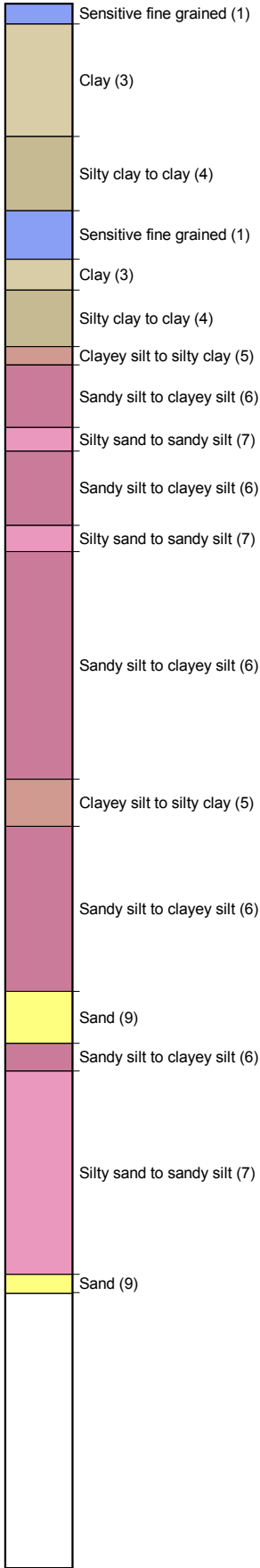
PRO-DRILL
SPECIALITY DRILLING SOLUTIONS



Cone No: S15CFIIP.1423
Tip area [cm²]: 15
Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT07
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 2/2	Fig.:
		File: Beca281-401JesmondRd_CPT07.GEF	

**Classification by
Robertson 1986**



Cone No: S15CFIIP.1423
Tip area [cm²]: 15
Sleeve area [cm²]: 225

Location: Jesmond Rd Drury	Position: X: 0 m, Y: 0 m	Ground level: 0.000	Test No.: CPT08
Project ID: Beca281-401JesmondRd	Client: BECA	Date: 10/08/2018	Scale: 1 : 87
Project: Beca281-401JesmondRd		Page: 1/1	Fig.:
		File: Beca281-401JesmondRd_CPT08.GEF	

Rijksstraatweg 22F
2171 AL Sassenheim
Tel. : +31 71 301 92 51
Fax : +31 71 301 92 52
E-mail : info@geopoint.nl
BTW : NL814690178.B01
IBAN : NL28 INGB0682301396
BIC : INGBNL2A

Cone Calibration Certificate

Certificate: **GS-1423-001**
Instrument Type: Electric Subtraction Cone
Model: S15-CFIIP
Serial number: 1423
Calibration date: 18-04-2016
Client: Pro-Drill
Calibrated by: H. Smit

Calibration instruments

Manufacturer: Hottinger Baldwin Messtechnik GmbH
HBM certificate no. : 49046

Calibration conditions

Ambient temperature: 20.6 °C
Atmospheric pressure: 1020 mBar

Cone specifications

Cone base area: 1500 mm²
Load tip resistance (nom.): 100 kN
Friction sleeve area: 22500 mm²
Load tip + local friction (nom.): 100 kN
Load friction sleeve (nom.): 22.5 kN
Load pore pressure (nom.): 5 MPa
Inclination (nom.): +/- 20 °
Temperature compensation (all channels): 0...+40 °C
Maximum overload capacity (all channels): 100 %
Cone area ratio (a): 0.79
Max. Inaccuracy, relative to measurement value: 1.0 %

	Tip:		Sleeve:		Pore Pressure:		Inclinometer:		
	qc in kN	mV	fs in kN	mV	MPa	mV	Degrees	X (mV)	Y (mV)
Zero points:		0223		0246		0217			
	0	0	0	0	0	0	0	2520	2561
	5	0304	5	0313	1.0	1309	-20	0329	0468
	10	0610	10	0627	2.0	2617	20	4617	4621
	15	0914	15	0939	3.0	3925			
	20	1220	20	1252	4.0	5234			
	25	1525	25	1566	5.0	6541			
	30	1831	30	1880					
	35	2137	35	2194					
	40	2443	40	2508					
	45	2748	45	2821					
	50	3051	50	3133					
	75	4565	75	4687					
	100	6078	100	6244					

Max. error, abs. qc: 35 kPa
Max. error, abs. fs: 2 kPa
Max. error, abs. u2: 10 kPa
Max. error, abs. l: 1 °

This calibration is compliant with GeoPoint Systems internal quality system, internal calibration procedures and meets the requirements of NEN2649, NEN-EN-ISO 22476-1, NORSOK G-001, ISSMFE and ASTM using calibration equipment traceable to (Inter-) National Standards.

Approved by: B. van Eijk
Date: 18-04-2016

Appendix D

Laboratory Testing



Project: MOE Drury West Schools
 Disciplines: 320 Biotechnical

Sheet: 1 of 1

We enclose the documents indicated below.

Please destroy or mark superseded all previous issues.				Date of Issue																	
Drawings		Specs	Day	22																	
Sketches	✓	Manuals	Month	08																	
Reports		Other	Year	18																	
Doc N ^o	Document Title										Revision										
1984L.01	Lab Testing Report																				

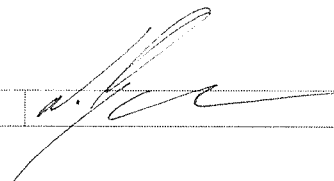
Distribution: Attention	Size/Media*	Copies
Alicia Newton	A4	1

Reason for Issue	A - Approval	P - Preliminary	T - Tender
B - Building Consent	Q - Scheduling	V - Verification	R
C - Construction	R - Requested		
I - Information	S - Shop Drawing		

*Size/Media
 Options: A4 / A3 / A2 / A1 / A0 / D (Disk) / CD
 Disk/CD virus check: Sender: Yes/No Receiver: Yes/No

Method of Delivery:
 Mail: _____ Courier: _____ Messenger: _____ Other: *encit*

Remarks:

Please destroy or mark superseded all previous issues of this document
 Signed: 

SUMMARY OF TEST RESULTS

Report:
1984L:01

Job Name: MOE Drury West Schools **Job No:** 4216997/600/GA

Client: Ministry of Education (NZ) **Date:** 22 August 2018

Test Pit No.	Sample No.	Depth (m)	Sample Type	Sample Description	Natural		Atterberg Limits		Grading (Hydro)	P _o t/m ³	Clay Index	Consol	CBR	Compaction	Perm k m/s	Triaxial CU/PP
					WC%	Bulk Density t/m ³	LL/ CPL	PL								
BH01	R284	6.0-6.5	UT	Clayey SILT, some sand, minor organics; dark brownish grey; wet, highly plastic.	45.7							X				
BH01	R304	8.5-9.5	CORE	Silty fine to medium SAND, minor clay, trace organics; blueish grey, speckled dark brown; wet, moderately plastic.	30.2		X	X								
BH02	R286	7.5-8.0	UT	Clayey SILT, minor sand; reddish brown mottled light grey; wet, highly plastic.	108							X				
BH02	R305	17.0-17.8	CORE	Fine to coarse sandy SILT, some clay, trace fine gravel, trace organics; blueish grey, speckled dark brown; wet, slightly plastic.	37.9			X								
BH02	R306	18.5-19.0	CORE	Fine sandy SILT, some clay; blueish grey; wet, slightly plastic.	28.5			X								



ENVIROLAB GEOTEST IS ACCREDITED BY INTERNATIONAL ACCREDITATION NEW ZEALAND. ALL TESTS REPORTED HEREIN HAVE BEEN PERFORMED IN ACCORDANCE WITH THE LABORATORY'S SCOPE OF ACCREDITATION. THIS REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL.
NOTE: IANZ ENDORSEMENT DOES NOT COVER SOIL DESCRIPTIONS.

REPORT RELATES ONLY TO SAMPLES TESTED. SAMPLING WAS UNDERTAKEN BY OTHERS.

X = DATA ATTACHED, CORE = CORE SAMPLES, UT = UNDISTURBED TUBE SAMPLES

TEST STANDARDS:

NZS 4402: 1986; Test 2.1, 2.2, 3.2, 4.2, 5.2, 8.4, 7.1

AUTHORISED SIGNATORY

N. Agarkova - Authorised Signatory

ATTERBERG LIMITS

Job Name: MOE Drury West Schools

Date: 22 August 2018

Job No: 4216997/600/GA

Report No: 1984L:01

Client: Ministry of Education (NZ)

Tested By: S.Shah

Sample Type: Core

Checked By: Agarkova

Test Standard: NZS 4402: 1986, Test 2.1,2.3,2.4,2.5

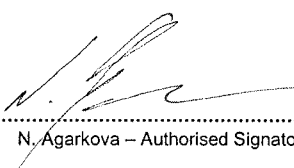
History: As Received

Test Performed On: Sub 425µm

Bore No.	Sample No.	Depth (m)	Sample Description	Water Content (%)	Cone Penetration Limit	Plastic Limit	Plasticity Index
BH01	R304	8.5-9.5	Silty fine to medium SAND, minor clay, trace organics; blueish grey, speckled dark brown; wet, moderately plastic.	30.2	33	21	12

Comments:



Authorised Signatory: 
 N. Agarkova – Authorised Signatory

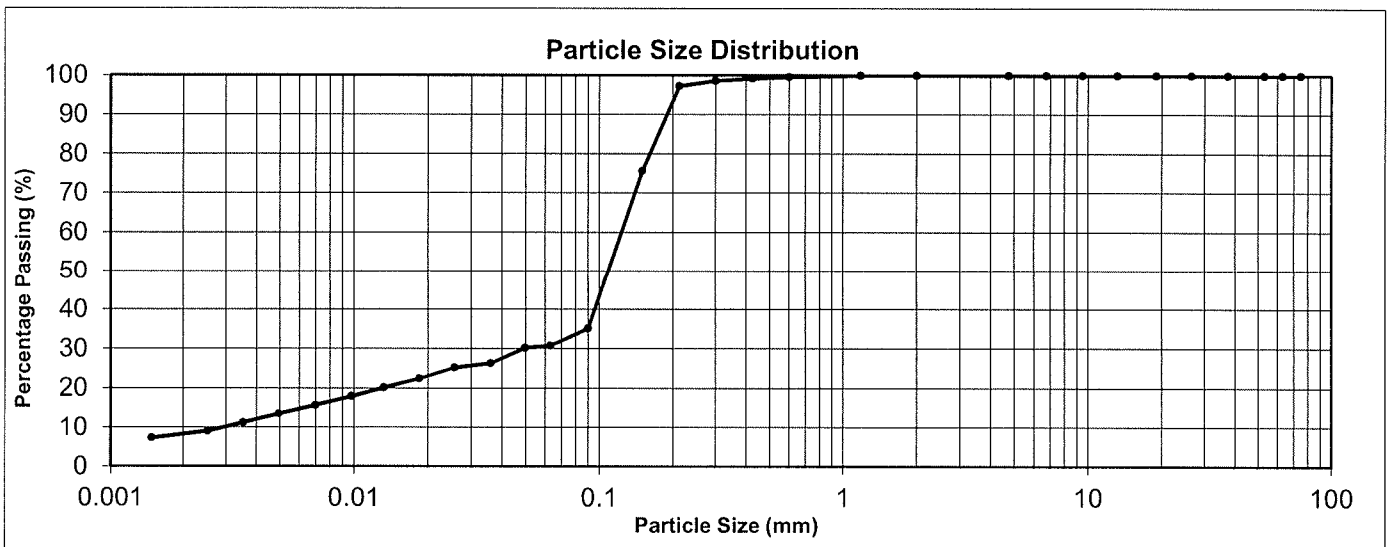
PARTICLE SIZE DISTRIBUTION - WET SIEVE/HYDROMETER METHOD

Job Name: MoE Drury West Schools Client: Ministry of Education Date: 22 August 2018
 Job No.: 4216997/600/GA Tested By: S.Shah Checked By: N.Agarkova
 Bore No.: BH01 Sample No.: R304 Depth (m): 8.5-9.5
 Sample Type: Core History: As Received Report No.: 1984L:01

Sample Description: Silty fine to medium SAND, minor clay, trace organics; blueish grey, speckled dark brown; wet, moderately plastic.

Test Standard: NZS4402: 1986, Test 2.8.4 Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving				Fraction Determined by Hydrometer			
Sieve Size mm	% Passing	Sieve Size mm	% Passing	Part. Size mm	% Passing	Part. Size mm	% Passing
75	100	2.0	100	0.050	30	0.001	7
63	100	1.18	100	0.036	26		
53	100	0.600	100	0.026	25		
37.5	100	0.425	99	0.018	22		
26.5	100	0.300	99	0.013	20		
19	100	0.212	97	0.010	18		
13.2	100	0.150	76	0.007	16		
9.5	100	0.090	35	0.005	13		
6.75	100	0.063	31	0.004	11		
4.75	100			0.003	9		



% Clay	% Silt	% Sand	% Gravel	Max. size:
8	23	69	0	425µm



Authorised Signatory.....
 N.Agarkova - Authorised Signatory

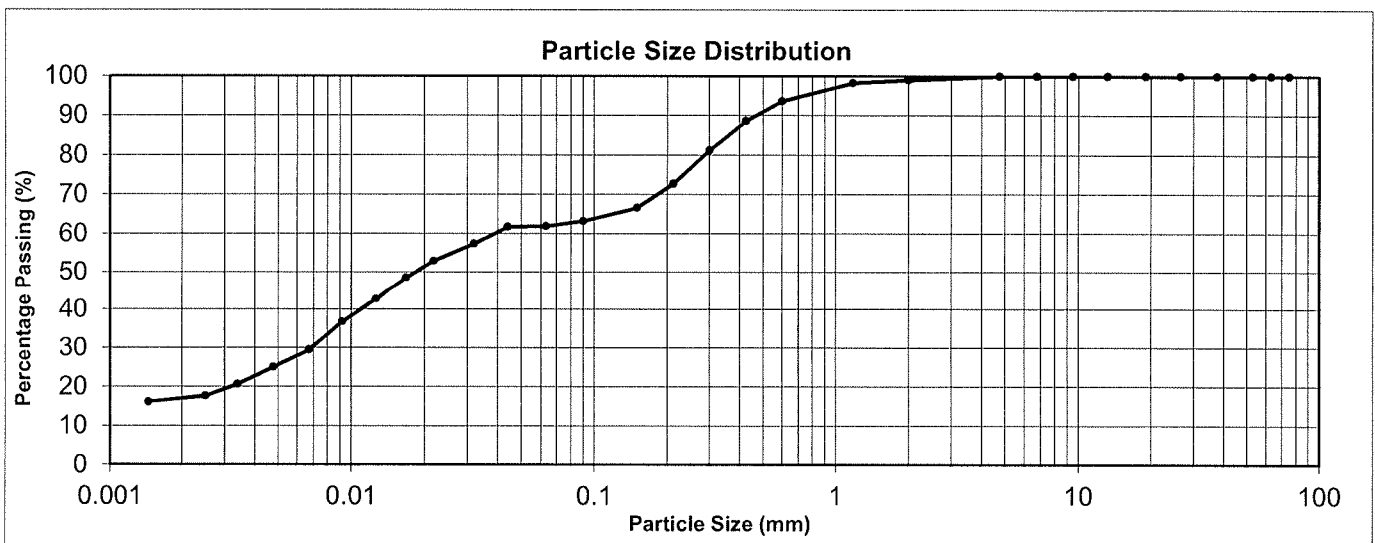
PARTICLE SIZE DISTRIBUTION - WET SIEVE/HYDROMETER METHOD

Job Name: MoE Drury West Schools Client: Ministry of Education Date: 22 August 2018
 Job No.: 4216997/600/GA Tested By: S.Shah Checked By: N.Agarkova
 Bore No.: BH02 Sample No.: R305 Depth (m): 17.0-17.8
 Sample Type: Core History: As Received Report No.: 1984L:01

Sample Description: Fine to coarse sandy SILT, some clay, trace fine gravel, trace organics; blueish grey, speckled dark brown; wet, slightly plastic.

Test Standard: NZS4402: 1986, Test 2.8.4 Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving				Fraction Determined by Hydrometer			
Sieve Size mm	% Passing	Sieve Size mm	% Passing	Part. Size mm	% Passing	Part. Size mm	% Passing
75	100	2.0	99	0.044	62	0.001	16
63	100	1.18	98	0.032	57		
53	100	0.600	94	0.022	53		
37.5	100	0.425	89	0.017	48		
26.5	100	0.300	81	0.013	43		
19	100	0.212	73	0.009	37		
13.2	100	0.150	67	0.007	29		
9.5	100	0.090	63	0.005	25		
6.75	100	0.063	62	0.003	21		
4.75	100			0.003	18		



% Clay	% Silt	% Sand	% Gravel	Max. size:
17	45	37	1	2.0mm



Authorised Signatory *[Signature]*
 N.Agarkova - Authorised Signatory

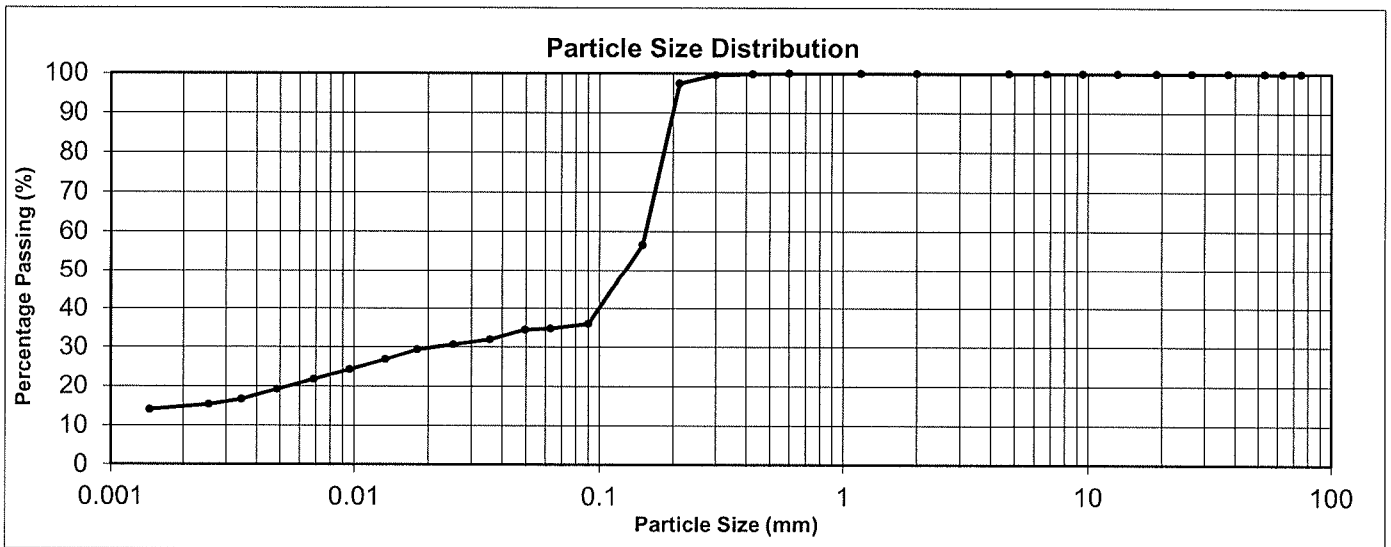
PARTICLE SIZE DISTRIBUTION - WET SIEVE/HYDROMETER METHOD

Job Name: MoE Drury West Schools Client: Ministry of Education Date: 22 August 2018
 Job No.: 4216997/600/GA Tested By: S.Shah Checked By: N.Agarkova
 Bore No.: BH02 Sample No.: R306 Depth (m): 18.5-19.0
 Sample Type: Core History: As Received Report No.: 1984L:01

Sample Description: Fine sandy SILT, some clay; blueish grey; wet, slightly plastic.

Test Standard: NZS4402: 1986, Test 2.8.4 Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving				Fraction Determined by Hydrometer			
Sieve Size mm	% Passing	Sieve Size mm	% Passing	Part. Size mm	% Passing	Part. Size mm	% Passing
75	100	2.0	100	0.050	35	0.001	14
63	100	1.18	100	0.036	32		
53	100	0.600	100	0.025	31		
37.5	100	0.425	100	0.018	29		
26.5	100	0.300	100	0.013	27		
19	100	0.212	97	0.010	24		
13.2	100	0.150	57	0.007	22		
9.5	100	0.090	36	0.005	19		
6.75	100	0.063	35	0.003	17		
4.75	100			0.003	15		



% Clay	% Silt	% Sand	% Gravel	Max. size:
15	20	65	0	212µm



Authorised Signatory.....
N.Agarkova - Authorised Signatory

ONE DIMENSIONAL CONSOLIDATION (OEDOMETER) TEST

Project: MoE Drury West Schools **Client:** Ministry of Education **Date:** 22 August 2018

Job No: 4216997/600/GA **Location:** - **Depth (m):** 6.0-6.5

Bore/Test Pit No.: BH01 **Sample No.:** R284 **Report No:** 1984L:01

Sample Type: Undisturbed Tube **History:** Natural

Sample Description: Clayey SILT, some sand, minor organics; dark brownish grey; wet, highly plastic.

Test Standard: NZS 4402:1986, Test 7.1 **Tested By:** N.Agarkova **Checked By:** S.Shah

Test Condition: Inundated at 1 minute interval on initial load sequence

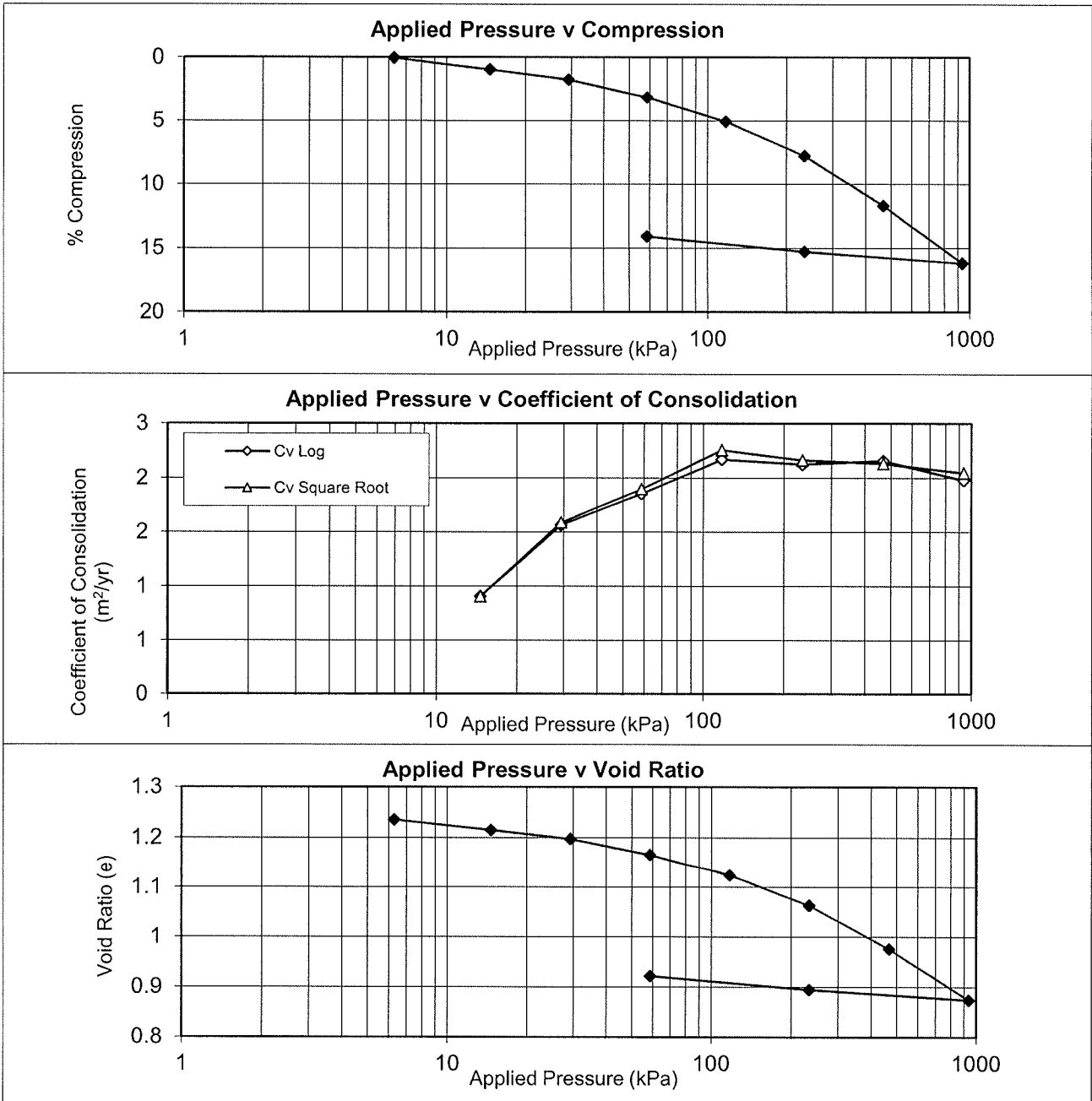
Initial Water Content (%)	45.7	Solid Density (assumed) (t/m ³)	2.65
Initial Bulk Density (t/m ³)	1.73	Saturation Ratio (Initial)	0.98
Initial Dry Density (t/m ³)	1.19	Saturation Ratio (Final)	1.00
Cycle Time (Ave) (Hrs)	2	Temperature Range (°C)	19.5-23.5
Area of Ring (mm ²)	1957	Initial Void Ratio (e)	1.24
Height of Ring (mm)	15.9	Date Tested	16 - 21 August 2018

Applied Pressure (kPa)	6	15	29	59	117	234	468	936	234	59
Compression (%)	0.1	1.0	1.8	3.2	5.1	8	12	16	15	14
Void Ratio (e)	1.2	1.2	1.2	1.2	1.1	1.1	1.0	0.87	0.89	0.92
Coefficient of consolidation Cv Log (m ² /yr)	-	0.91	1.6	1.9	2.2	2.1	2.2	2.0	-	-
Coefficient of consolidation Cv Square root (m ² /yr)	-	0.91	1.6	1.9	2.3	2.2	2.1	2.0	-	-
Coefficient of volume compressibility Mv (m ² /MN)	0.08	1.1	0.56	0.48	0.34	0.24	0.18	0.11	-	-

***Comment:**

ONE DIMENSIONAL CONSOLIDATION (OEDOMETER) TEST

Project: MoE Drury West Schools	Client: Ministry of Education	Date: 22 August 2018
Job No: 4216997/600/GA	Location: -	Depth (m): 6.0-6.5
Bore/Test Pit No.: BH01	Sample No.: R284	Report No: 1984L:01



Authorised Signatory.....
 N. Agarkova - Authorised Signatory

ONE DIMENSIONAL CONSOLIDATION (OEDOMETER) TEST

Project: MoE Drury West Schools **Client:** Ministry of Education **Date:** 22 August 2018

Job No: 4216997/600/GA **Location:** - **Depth (m):** 7.5-8.0

Bore/Test Pit No.: BH02 **Sample No.:** R286 **Report No:** 1984L:01

Sample Type: Undisturbed Tube **History:** Natural

Sample Description: Clayey SILT, minor sand; reddish brown mottled light grey; wet, highly plastic.

Test Standard: NZS 4402:1986, Test 7.1 **Tested By:** N.Agarkova **Checked By:** S.Shah

Test Condition: Inundated at 1 minute interval on initial load sequence

Initial Water Content (%)	108	Solid Density (assumed) (t/m ³)	2.70
Initial Bulk Density (t/m ³)	1.43	Saturation Ratio (Initial)	0.99
Initial Dry Density (t/m ³)	0.68	Saturation Ratio (Final)	-
Cycle Time (Ave) (Hrs)	2	Temperature Range (°C)	19.5-23.5
Area of Ring (mm ²)	1960	Initial Void Ratio (e)	2.95
Height of Ring (mm)	15.7	Date Tested	16 - 21 August 2018

Applied Pressure (kPa)	6	15	30	60	119	238	475	949	238	60
Compression (%)	0.0	0.0	0.4	1.0	2.2	7	18	27	26	26
Void Ratio (e)	2.9	2.9	2.9	2.9	2.9	2.7	2.3	1.9	1.9	1.9
Coefficient of consolidation Cv Log (m ² /yr)	-	-	-	40	35	36	34	27	-	-
Coefficient of consolidation Cv Square root (m ² /yr)	-	-	-	32	31	32	31	24	-	-
Coefficient of volume compressibility Mv (m ² /MN)	-	-	0.26	0.22	0.20	0.42	0.47	0.24	-	-

*Comment:

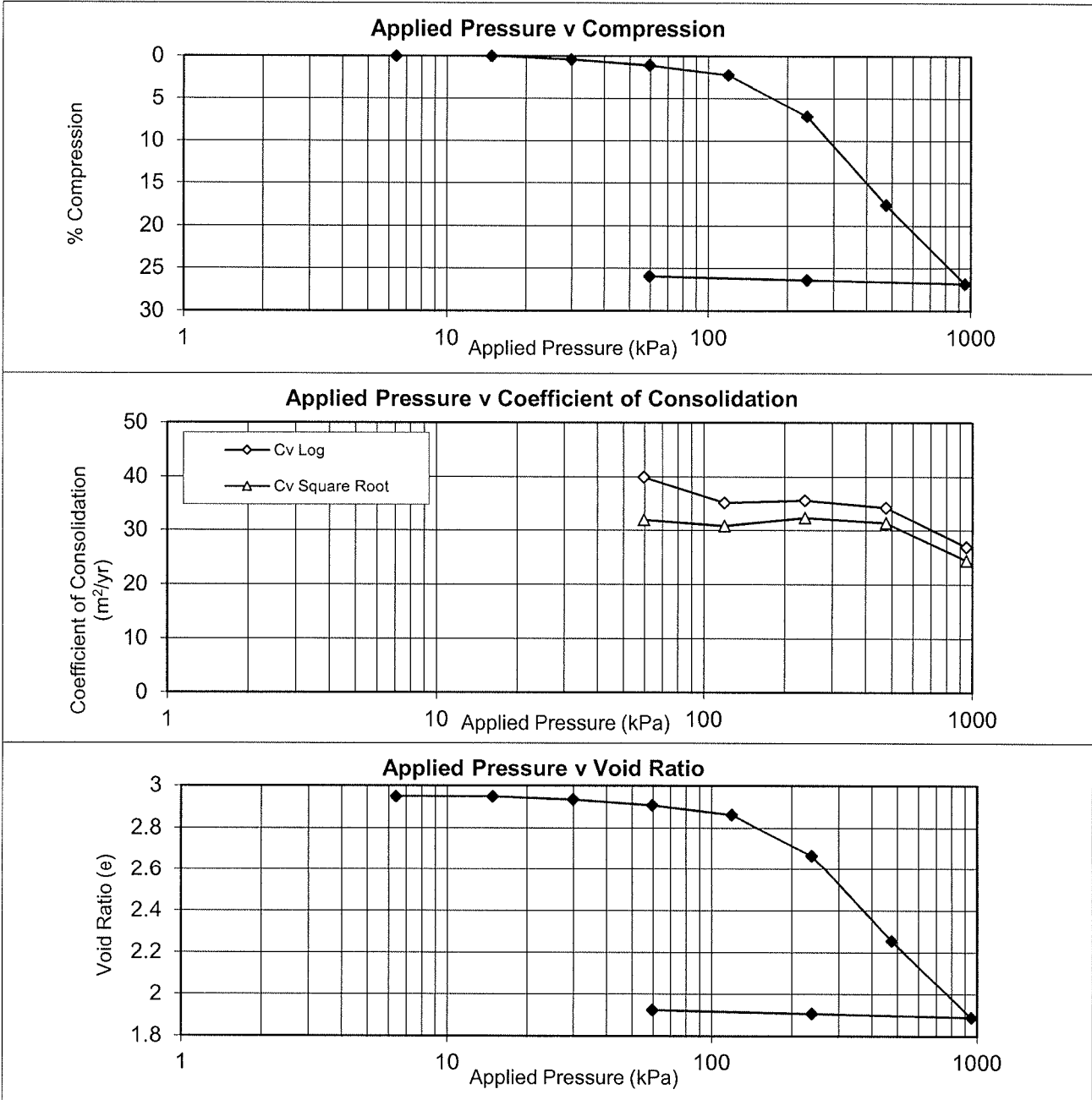


GS-362R-462-F01
Rev. No. 10

Authorized Signatory.....
N. Agarkova - Authorised Signatory

ONE DIMENSIONAL CONSOLIDATION (OEDOMETER) TEST

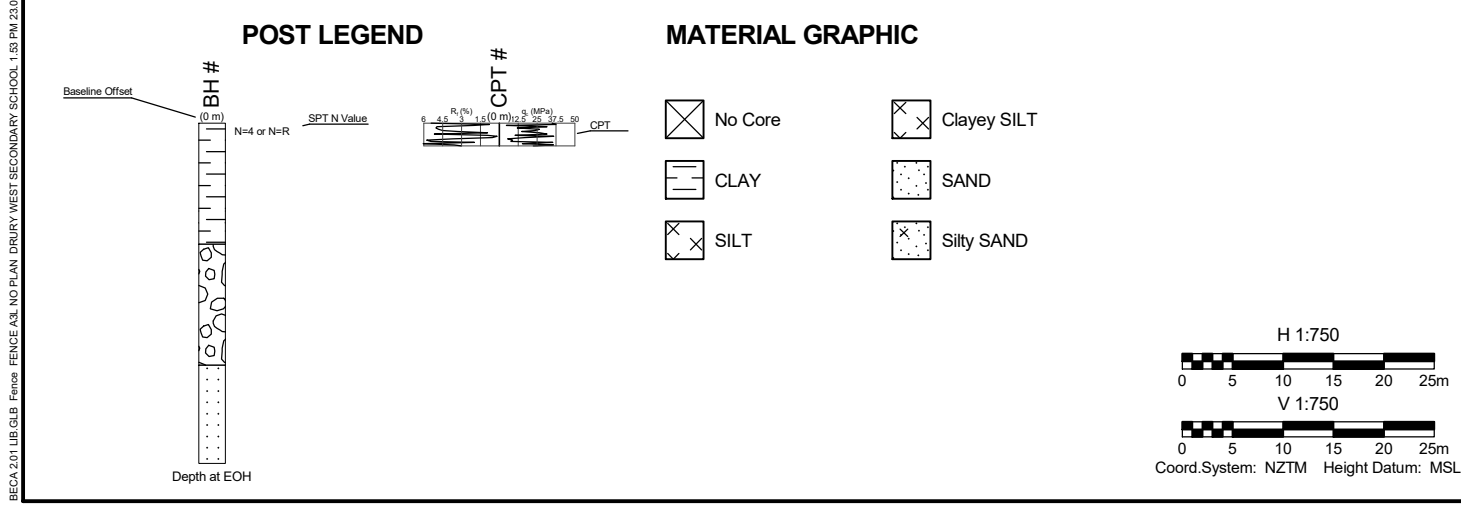
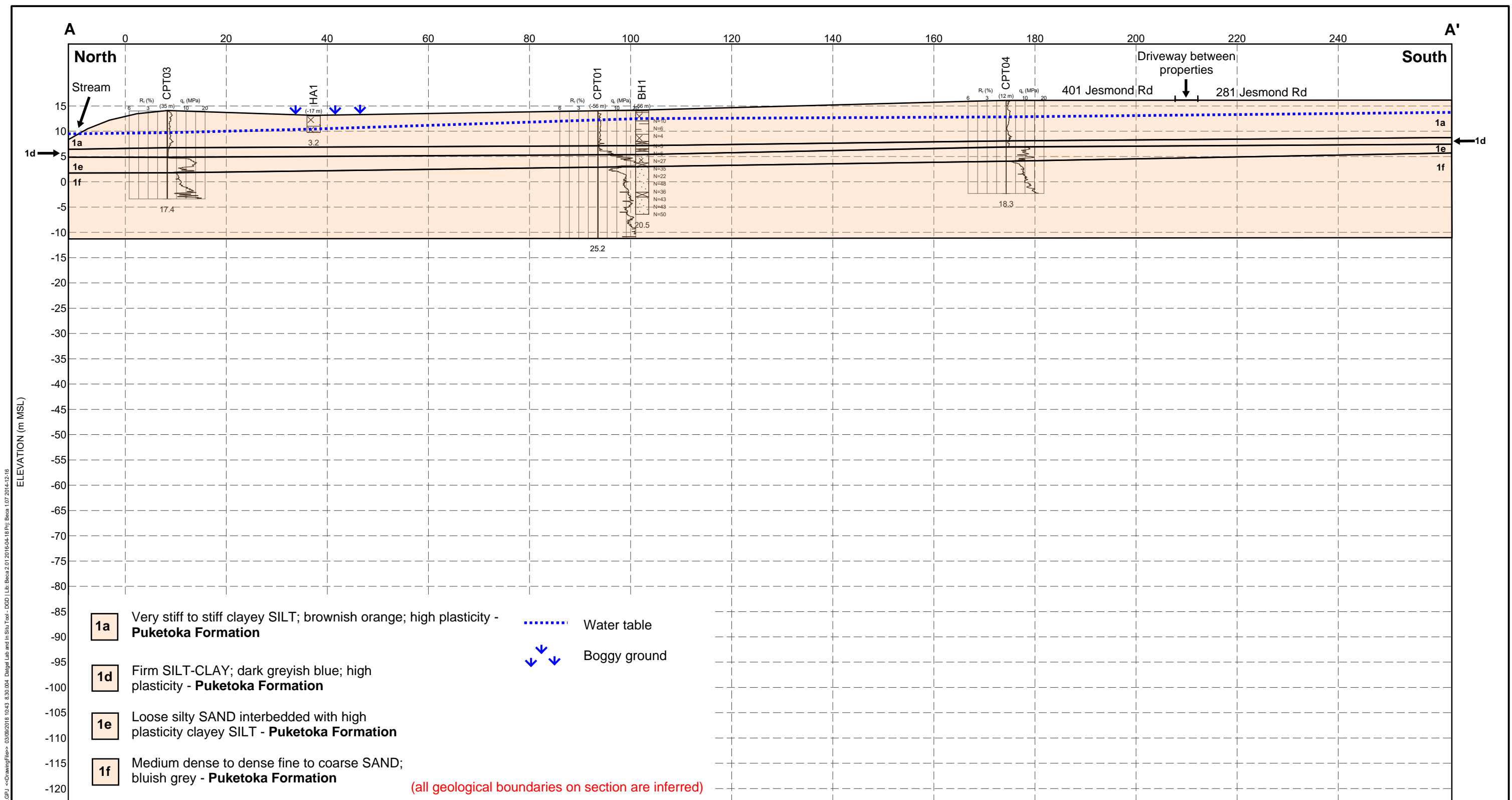
Project: MoE Drury West Schools	Client: Ministry of Education	Date: 22 August 2018
Job No: 4216997/600/GA	Location: -	Depth (m): 7.5-8.0
Bore/Test Pit No.: BH02	Sample No.: R286	Report No: 1984L:01



Appendix E

Cross Sections

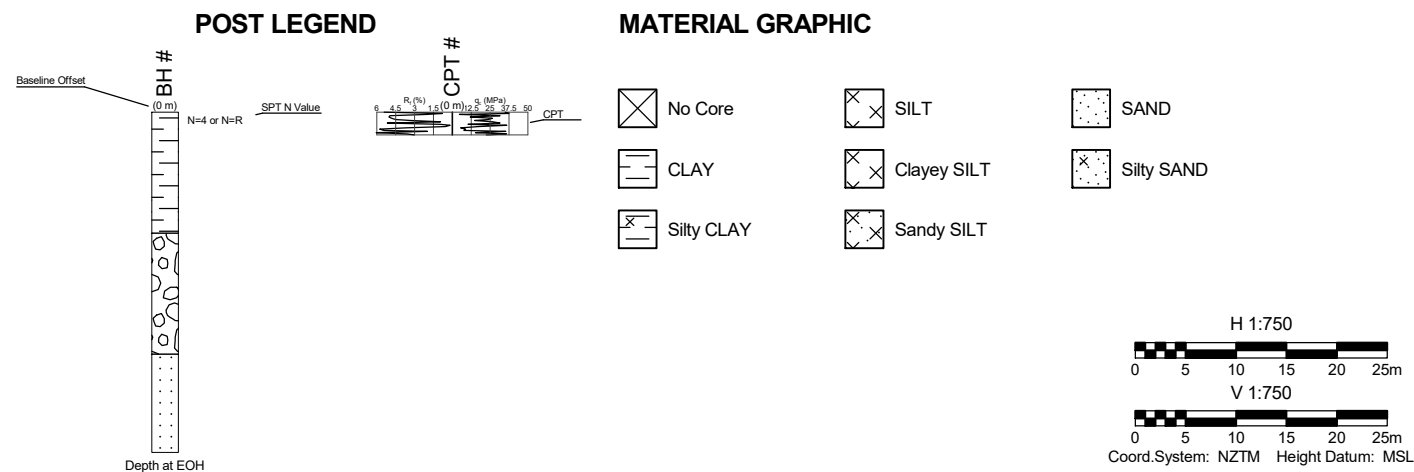
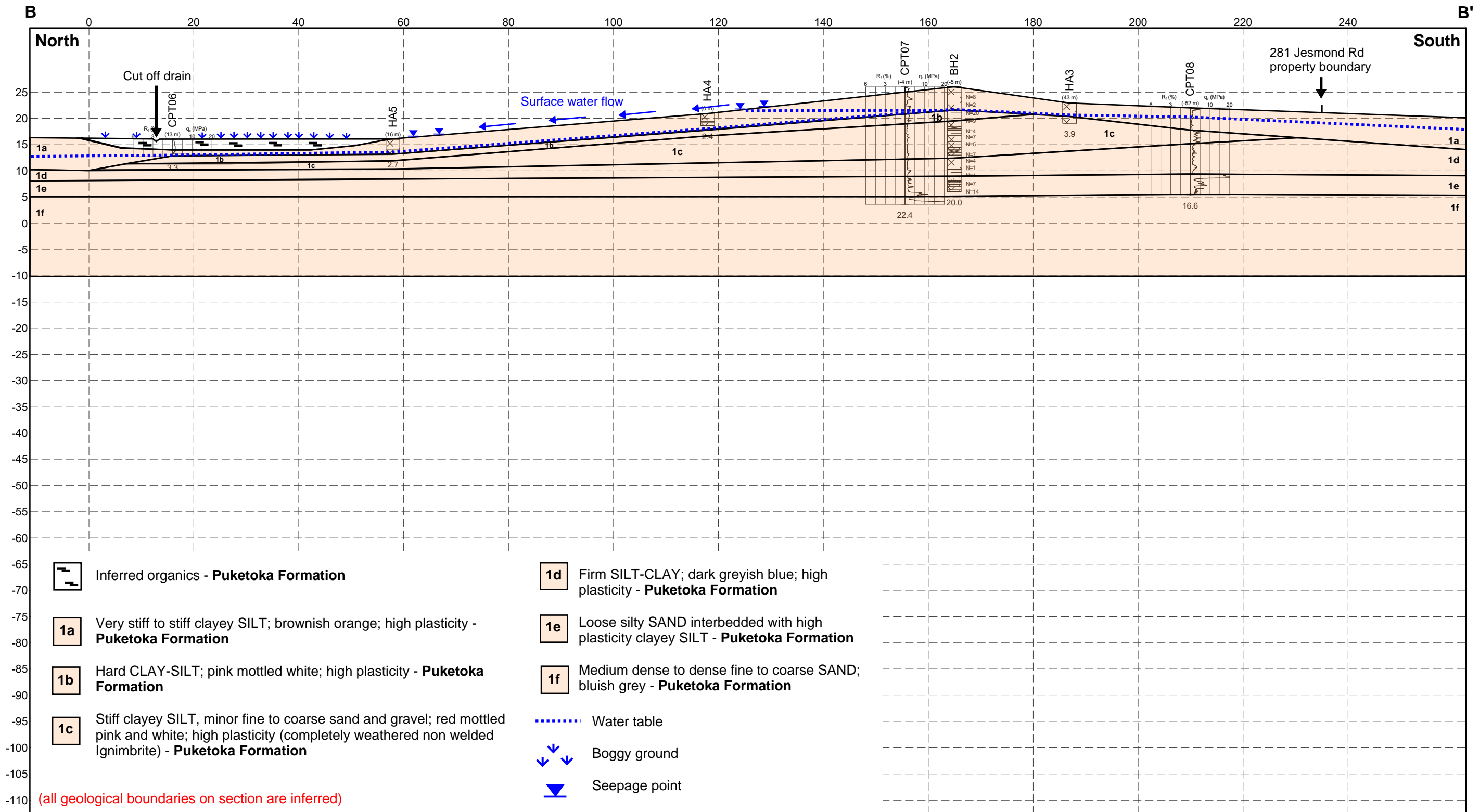




	Ministry of Education Berrick Fitzsimons 281 and 401 Jesmond Rd, Karaka Drury West Secondary School Subsurface Section		DRAWN BHTF	DATE 03/09/2018
			CHECKED	DATE 03/09/2018
	SCALE H 1:750 V 1:750		A3	
			PROJECT No 4216997	FIGURE No

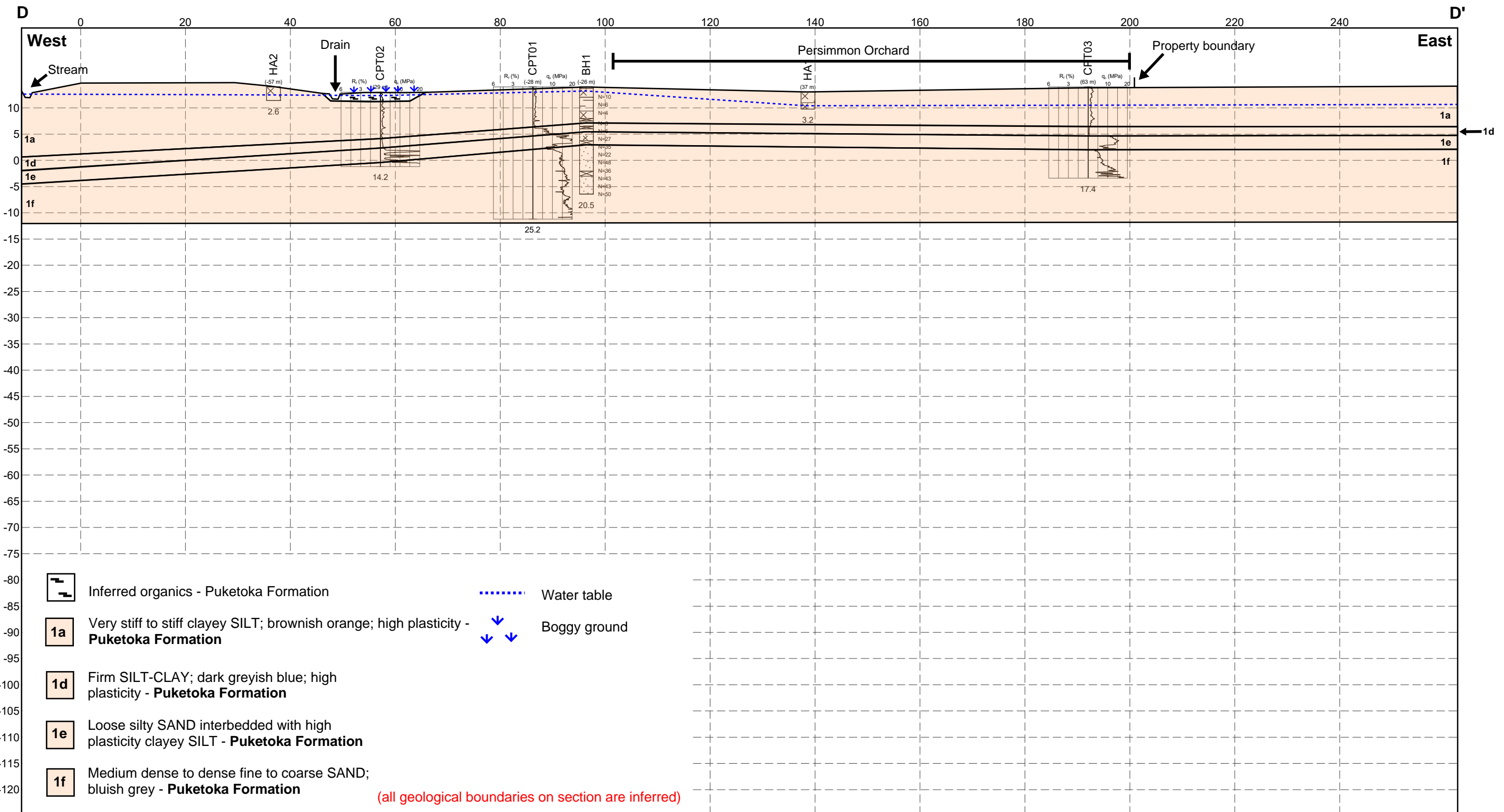
BECA 2.01 LIB GLE FENCE ASL NO PLAN DRURY WEST SECONDARY SCHOOL 1.03 PM 23/08/2018 GPJ ->DrawingFile-> 03/09/2018 10:43 830.004 Digital Lab and In Situ Tool - DGD Lib BeCa 2.01 2016-04-18 PJ: BeCa 1.07 2014-12-16

BECA 2.01 LIB GLEB FENCE A3L NO PLAN DRURY WEST SECONDARY SCHOOL 1.03 PM 23/08/2018 GPJ ->DrawingFile- 03/09/2018 10:51 6330.004 D:\glb\lab and in situ\tool - DGD Lib\Bece 2.01\2016-04-18\PI; Bece 1.07\2014-12-16



	Ministry of Education Berrick Fitzsimons 281 and 401 Jesmond Rd, Karaka Drury West Secondary School Subsurface Section		DRAWN BHTF	DATE 03/09/2018	
			CHECKED	DATE 03/09/2018	
	SCALE H 1:750 V 1:750			A3	
	PROJECT No 4216997			FIGURE No	

BECA 2.01 LIB GLE FENCE ASL NO PLAN DRURY WEST SECONDARY SCHOOL 1.03 PM 23/08/2018 GPJ ->DrawingFile-> 03/09/2018 11:52 830.004 Dlgel Lab and In Situ Tool - DGD Lib Beca 2.01 2016-04-18 PJ: Beca 1.07 2014-12-16



POST LEGEND

BH # (0 m) CPT #

Baseline Offset SPT N Value

N=4 or N=8 R_f (%) q_c (MPa) N_f

Depth at EOH

MATERIAL GRAPHIC

No Core Clayey SILT

CLAY SAND

SILT Silty SAND

H 1:750

V 1:750

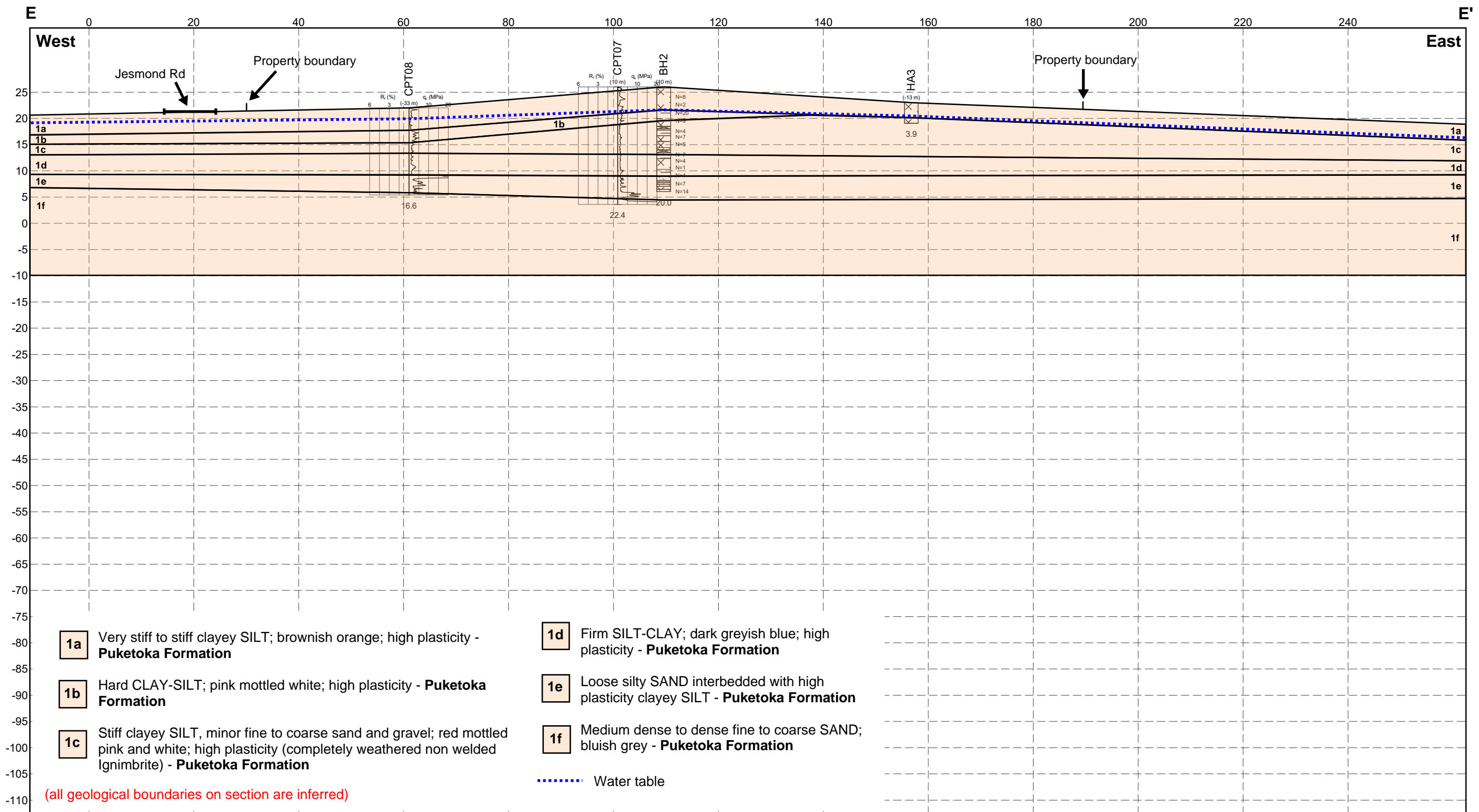
0 5 10 15 20 25m

0 5 10 15 20 25m

Coord. System: NZTM Height Datum: MSL

	TITLE Ministry of Education Berrick Fitzsimons 281 and 401 Jesmond Rd, Karaka Drury West Secondary School Subsurface Section		DRAWN BHTF	DATE 03/09/2018	
			CHECKED	DATE 03/09/2018	
	SCALE H 1:750 V 1:750			A3	
	PROJECT No 4216997			FIGURE No	

BECA 2.01 LIB GLE FENCE ASL NO PLAN DRURY WEST SECONDARY SCHOOL 1.03 PM 23/08/2018 GPJ ->DrawingFile- 03/09/2018 11:47 630.004 D:\git\Lab and In Situ Tool - DGD \Lib\Bece 2.01\2016-04-18\Fig\Bece 1.07\2014-12-16



- 1a** Very stiff to stiff clayey SILT; brownish orange; high plasticity - **Puketoka Formation**
 - 1b** Hard CLAY-SILT; pink mottled white; high plasticity - **Puketoka Formation**
 - 1c** Stiff clayey SILT, minor fine to coarse sand and gravel; red mottled pink and white; high plasticity (completely weathered non welded Ignimbrite) - **Puketoka Formation**
 - 1d** Firm SILT-CLAY; dark greyish blue; high plasticity - **Puketoka Formation**
 - 1e** Loose silty SAND interbedded with high plasticity clayey SILT - **Puketoka Formation**
 - 1f** Medium dense to dense fine to coarse SAND; bluish grey - **Puketoka Formation**
- Water table
- (all geological boundaries on section are inferred)

POST LEGEND

BH # (0 m) SPT N Value N=4 or N=6

CPT #

Depth at EOH

MATERIAL GRAPHIC

- No Core
- CLAY
- Silty CLAY
- SILT
- Clayey SILT
- Sandy SILT
- SAND
- Silty SAND

H 1:750
V 1:750

0 5 10 15 20 25m

0 5 10 15 20 25m

Coord. System: NZTM Height Datum: MSL

	TITLE Ministry of Education Berrick Fitzsimons 281 and 401 Jesmond Rd, Karaka Drury West Secondary School Subsurface Section		DRAWN BHTF	DATE 03/09/2018	
			CHECKED	DATE 03/09/2018	
	SCALE H 1:750 V 1:750			A3	
	PROJECT No 4216997			FIGURE No	

Appendix F

Liquefaction Analyses and CPT Interpretation



TABLE OF CONTENTS

Beca281-401JesmondRd_CPT01 results Summary data report	1
Beca281-401JesmondRd_CPT02 results Summary data report	8
Beca281-401JesmondRd_CPT03 results Summary data report	15
Beca281-401JesmondRd_CPT04 results Summary data report	22
Beca281-401JesmondRd_CPT05 results Summary data report	29
Beca281-401JesmondRd_CPT06 results Summary data report	36
Beca281-401JesmondRd_CPT06a results Summary data report	43
Beca281-401JesmondRd_CPT07 results Summary data report	50
Beca281-401JesmondRd_CPT08 results Summary data report	57

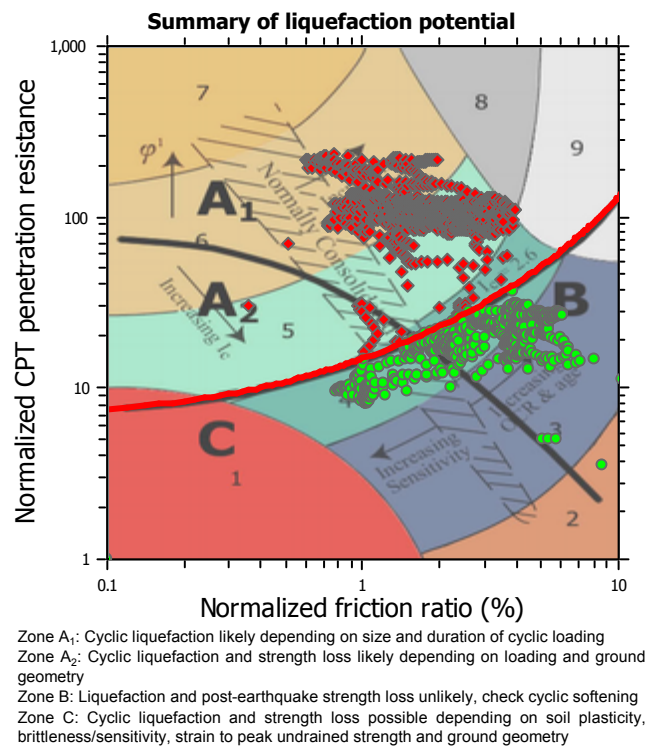
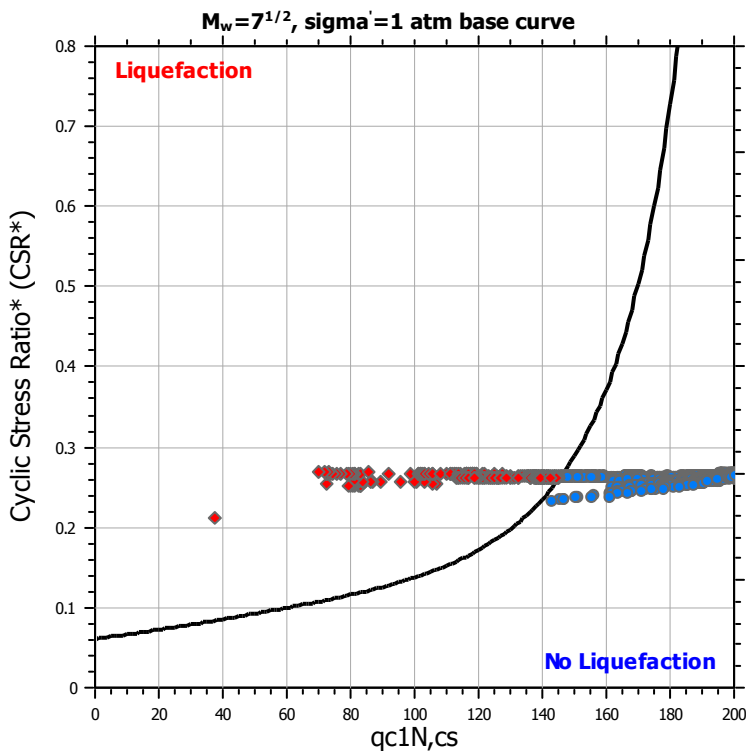
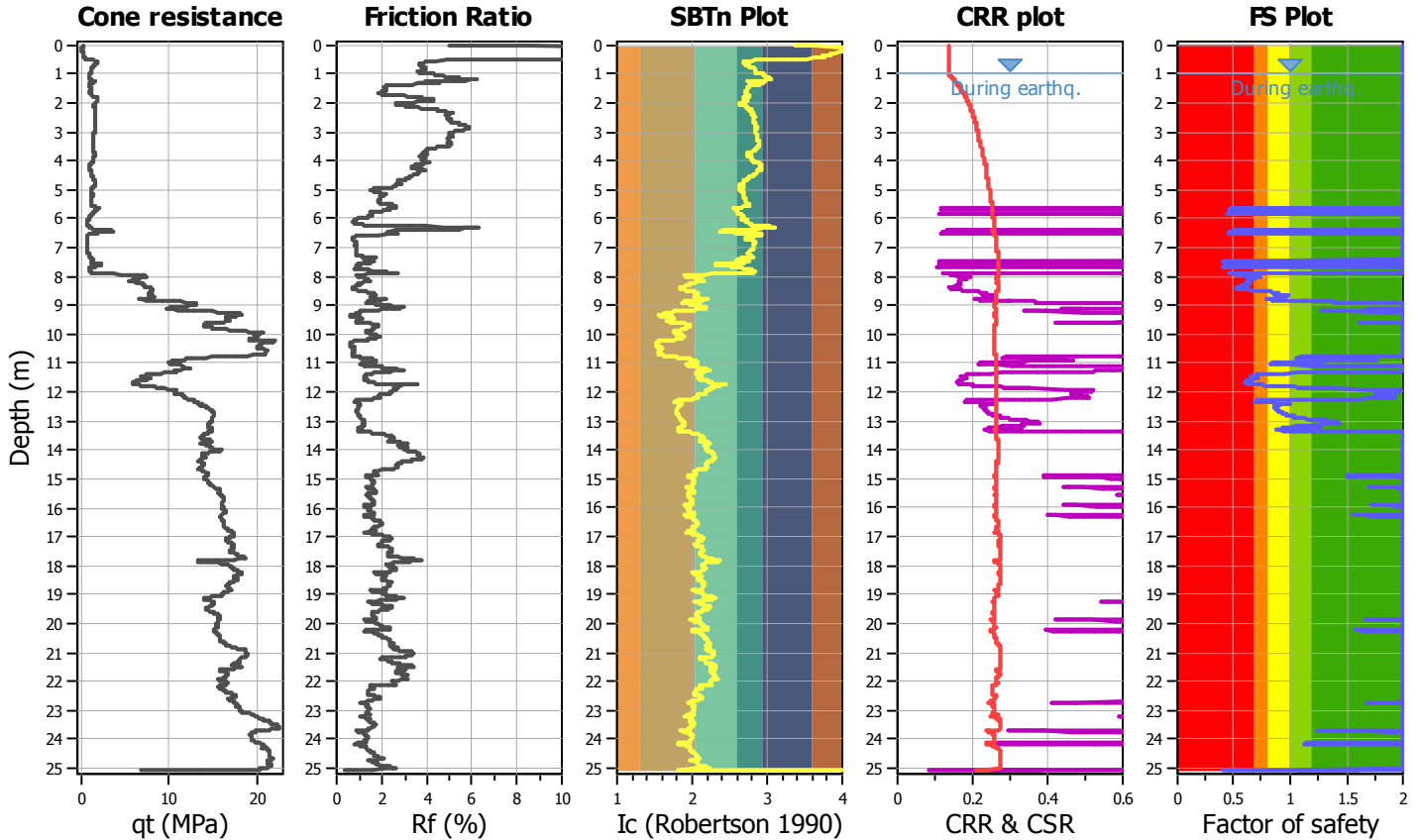
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT01

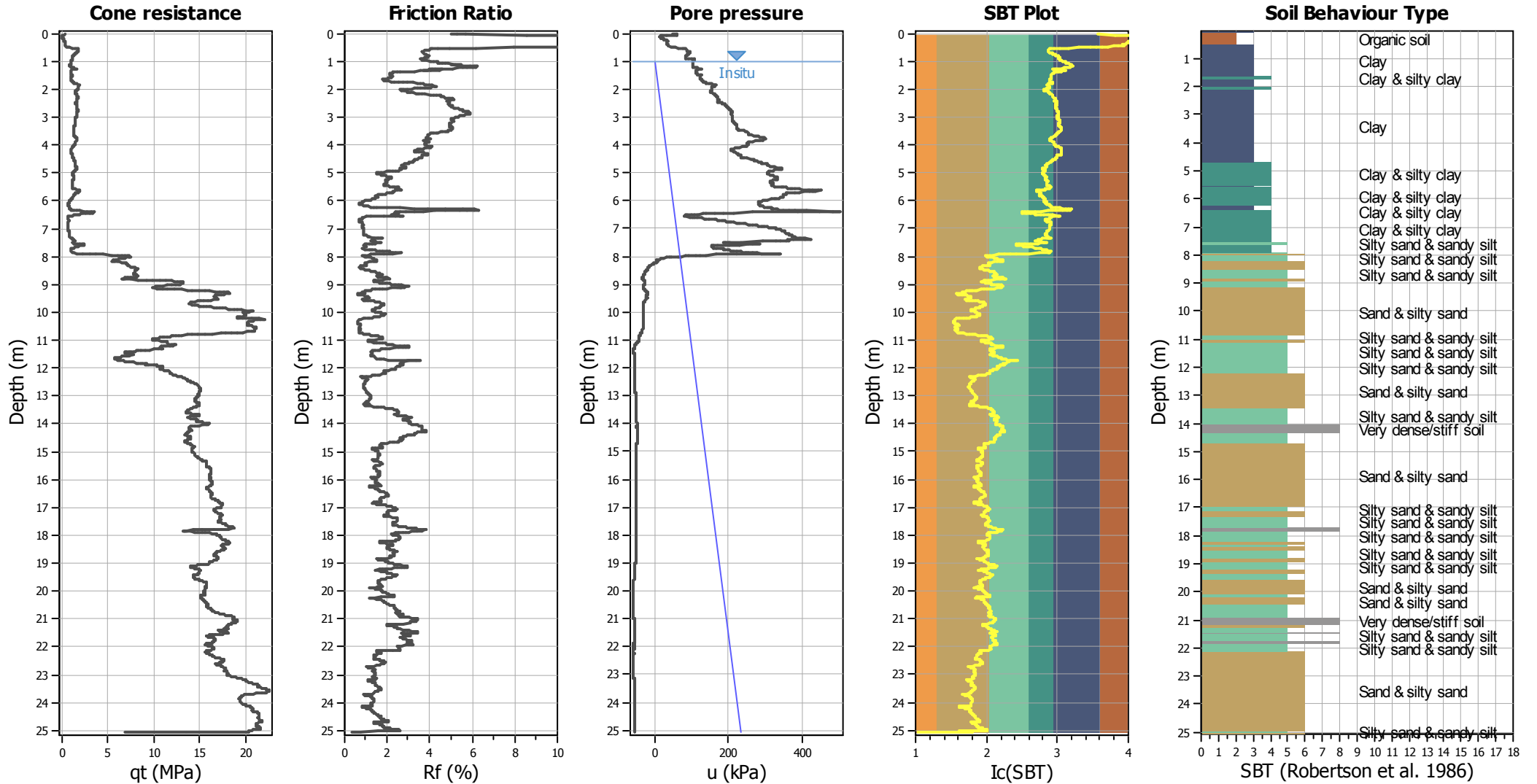
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	No
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Sands only	
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_f applied:	Yes	MSF method:	Method



CPT basic interpretation plots



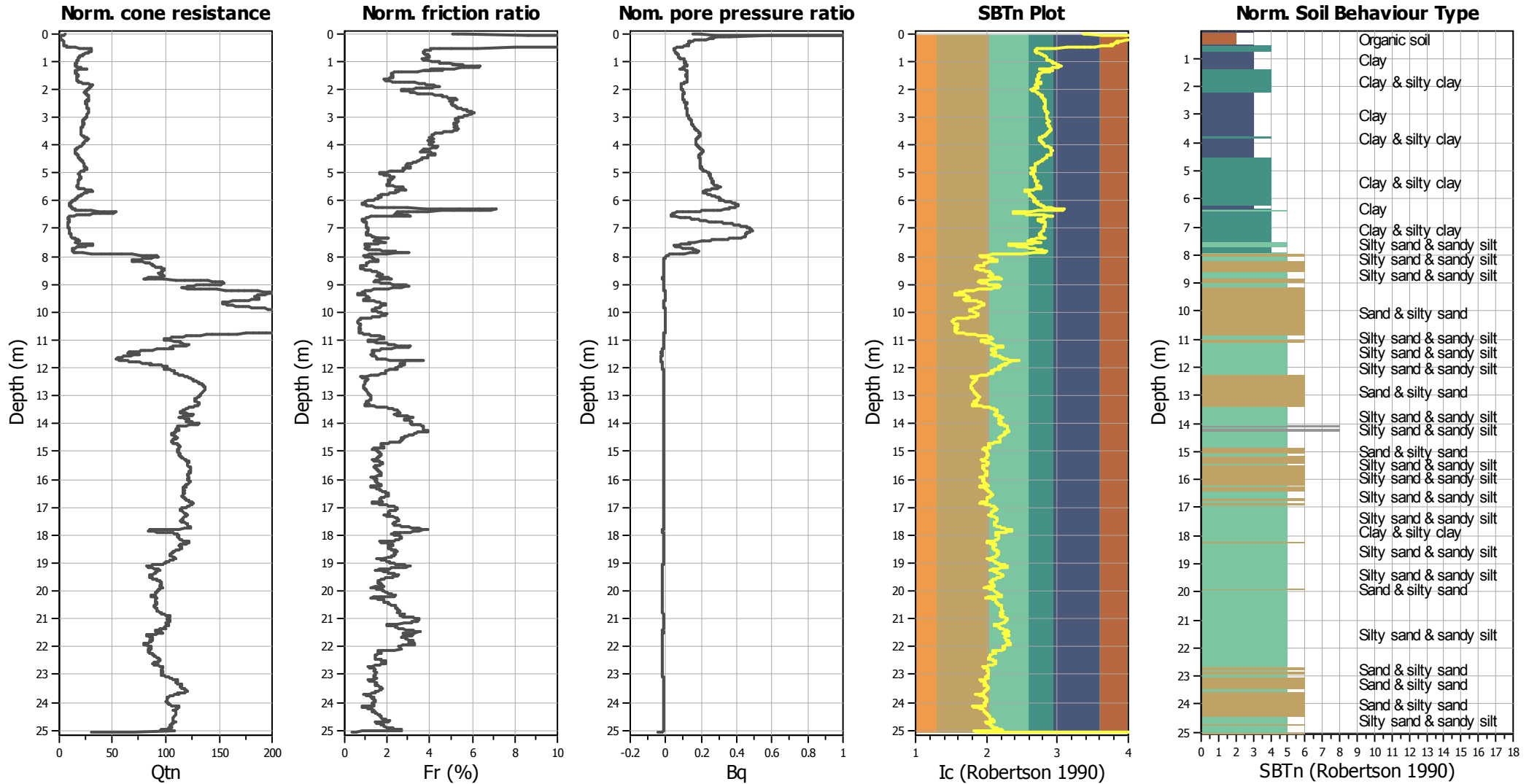
Input parameters and analysis data

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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

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)



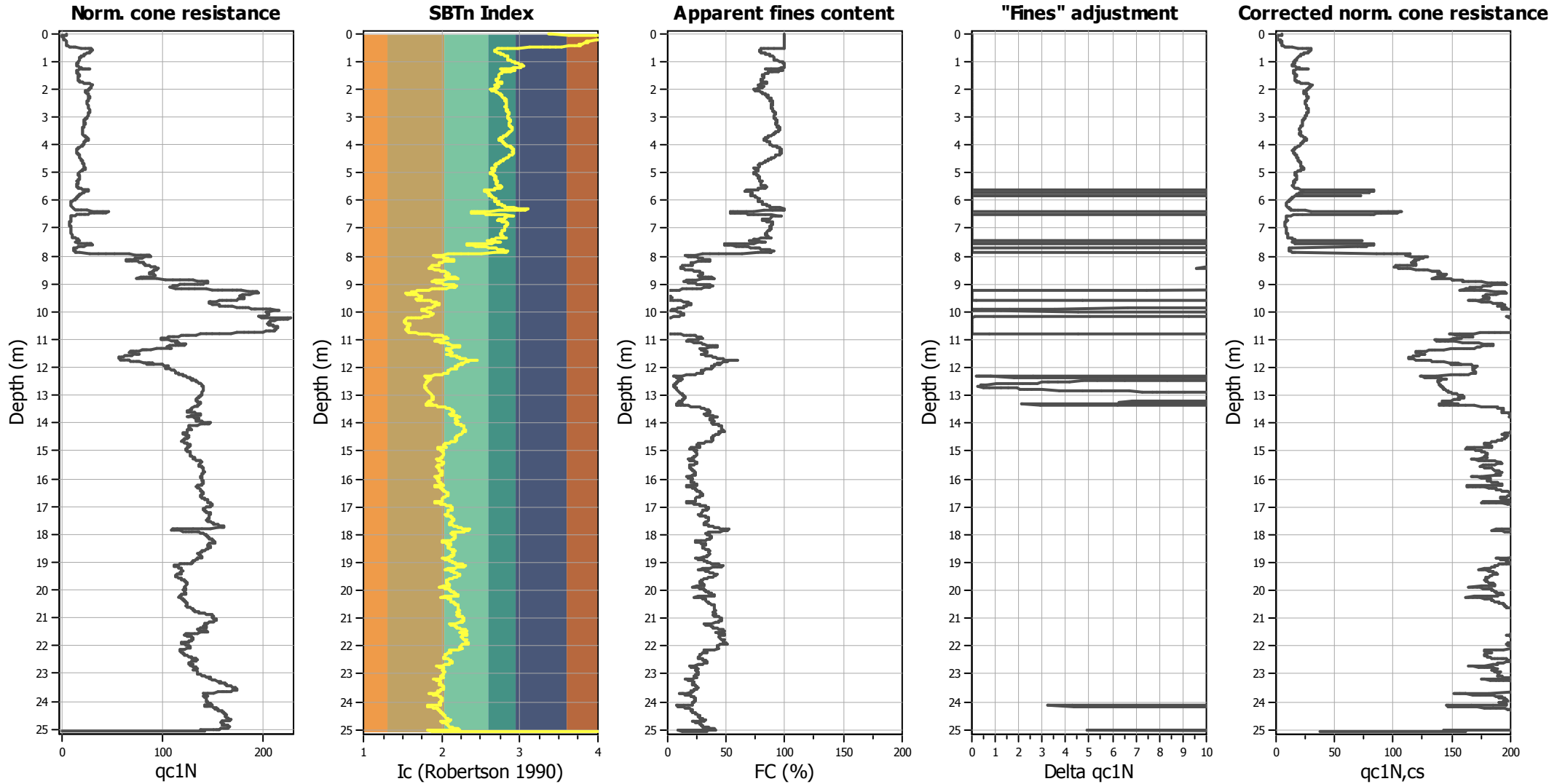
Input parameters and analysis data

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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

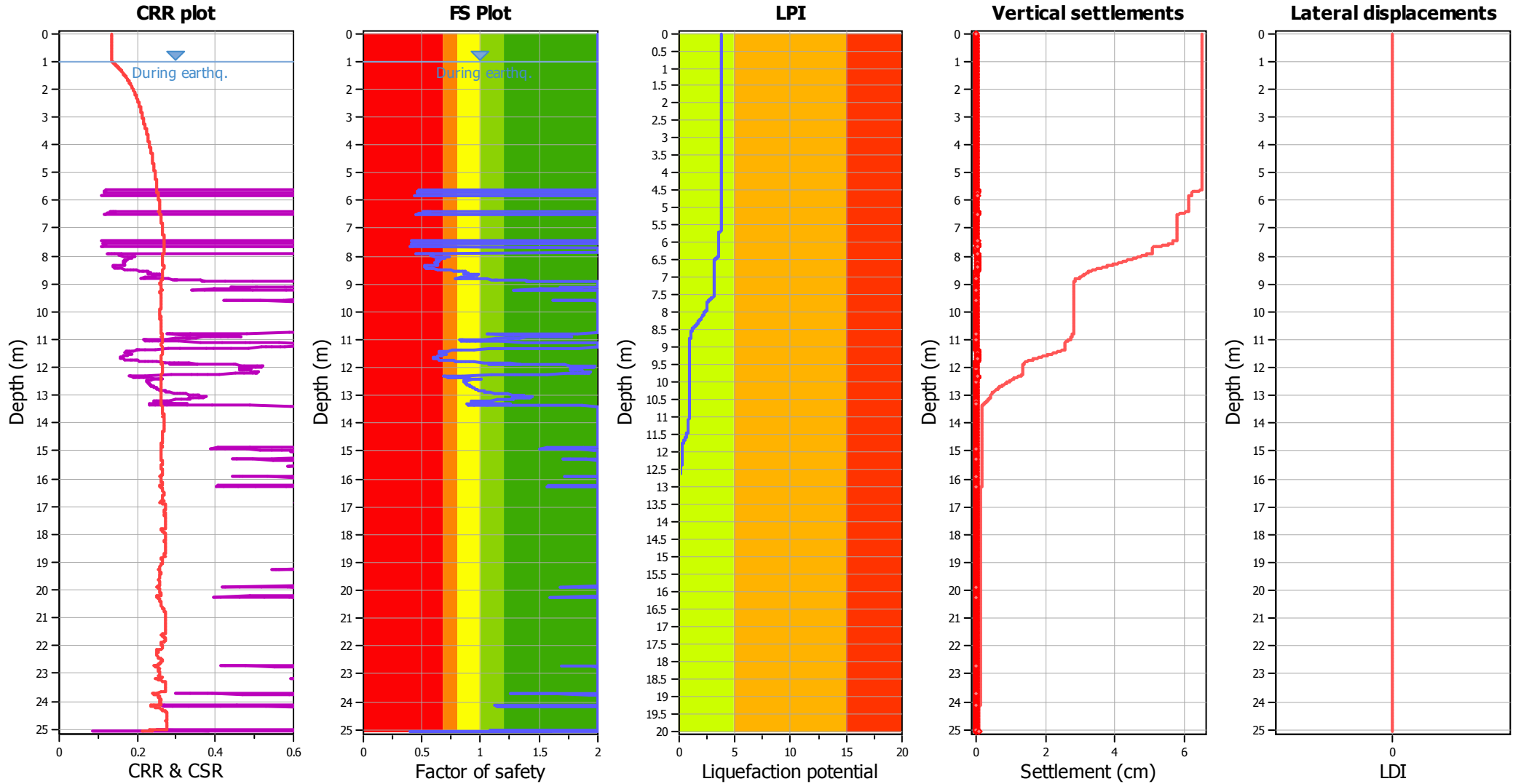
Liquefaction analysis overall plots (intermediate results)



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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _σ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (earthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

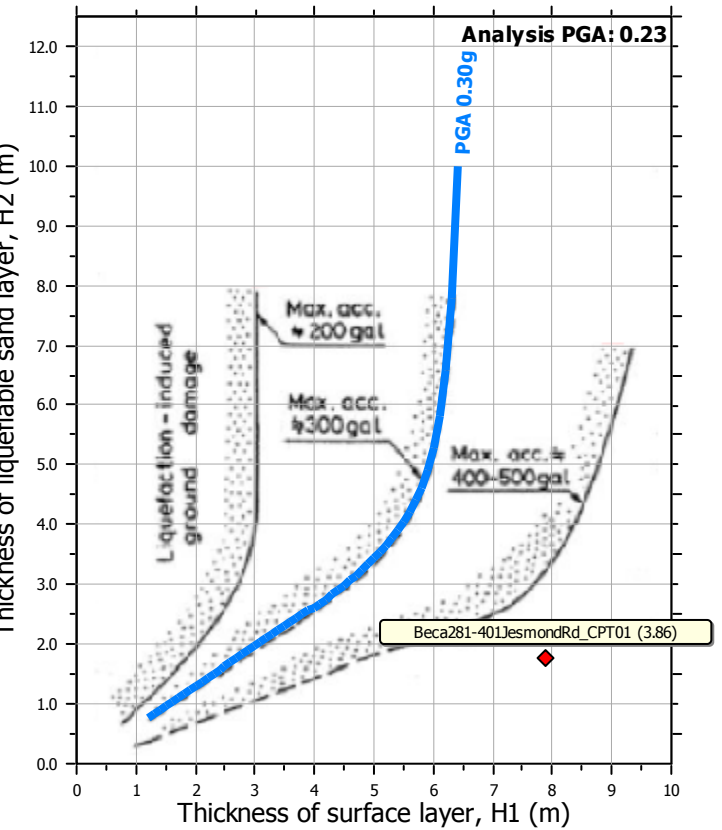
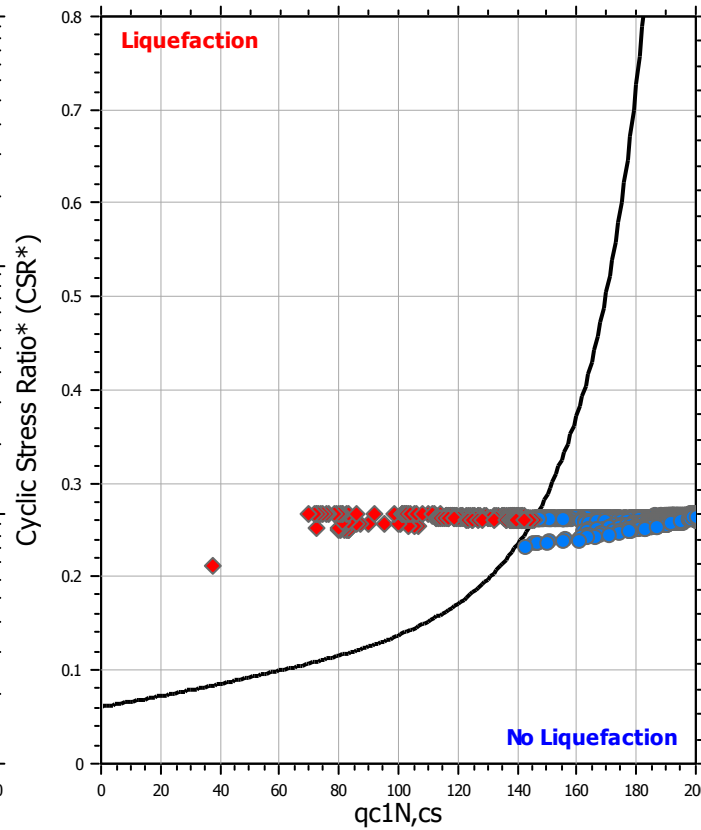
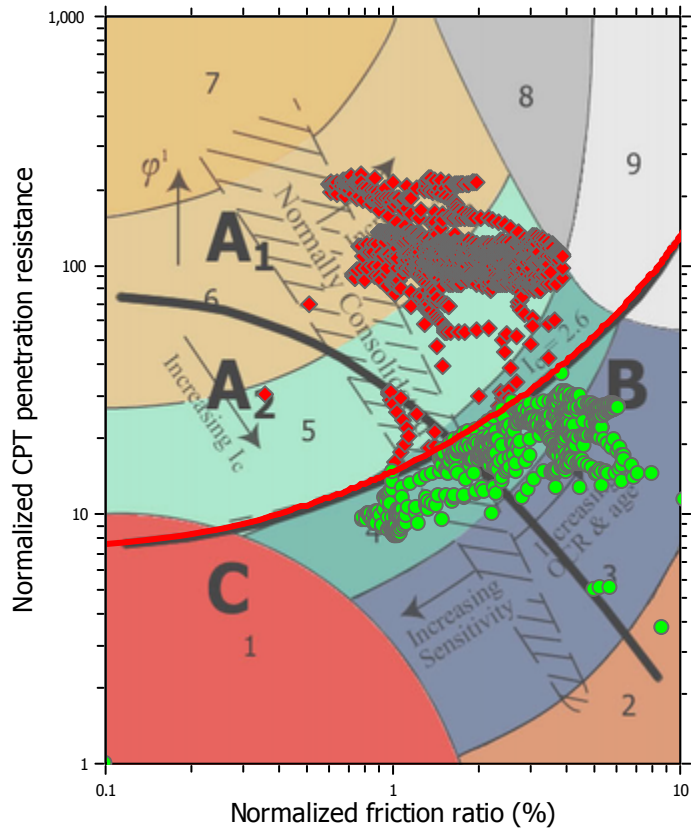
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

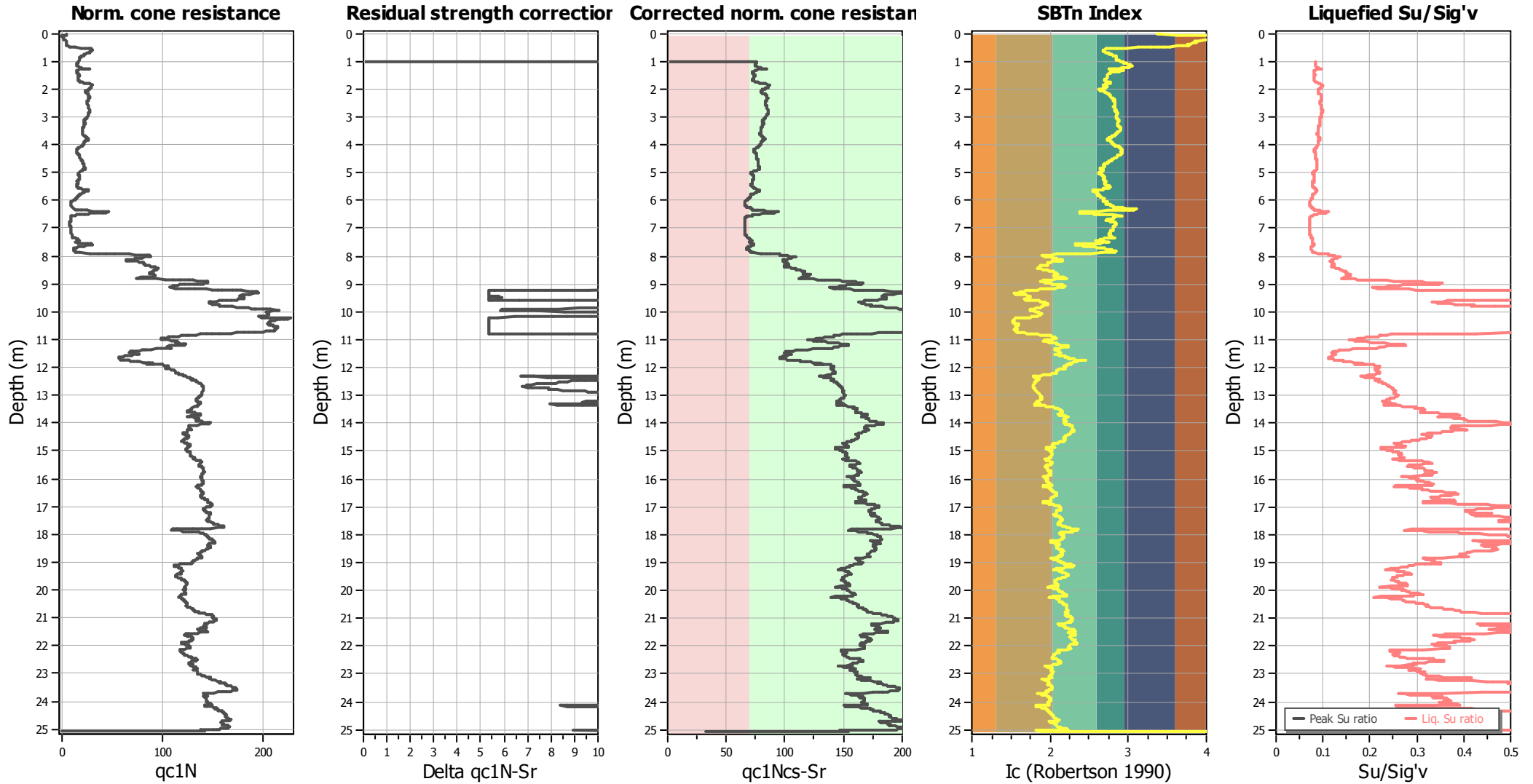
Liquefaction analysis summary plots



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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

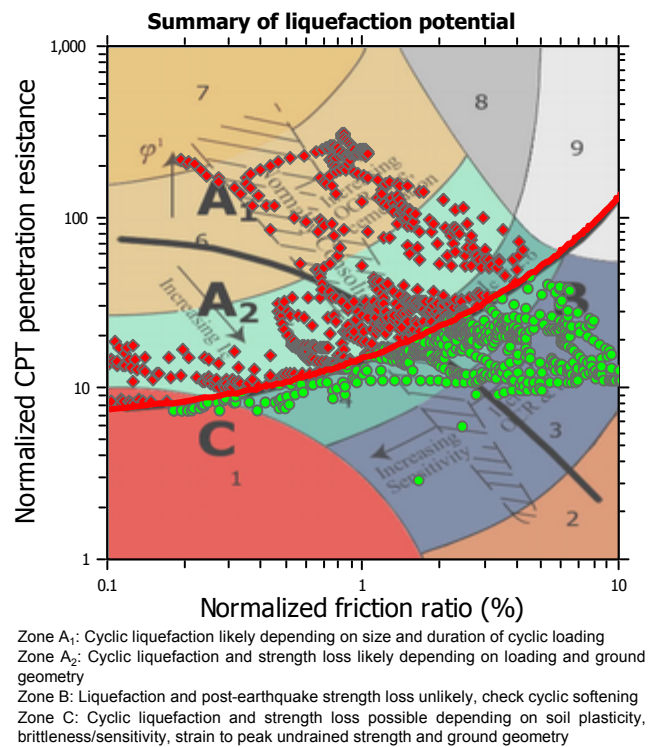
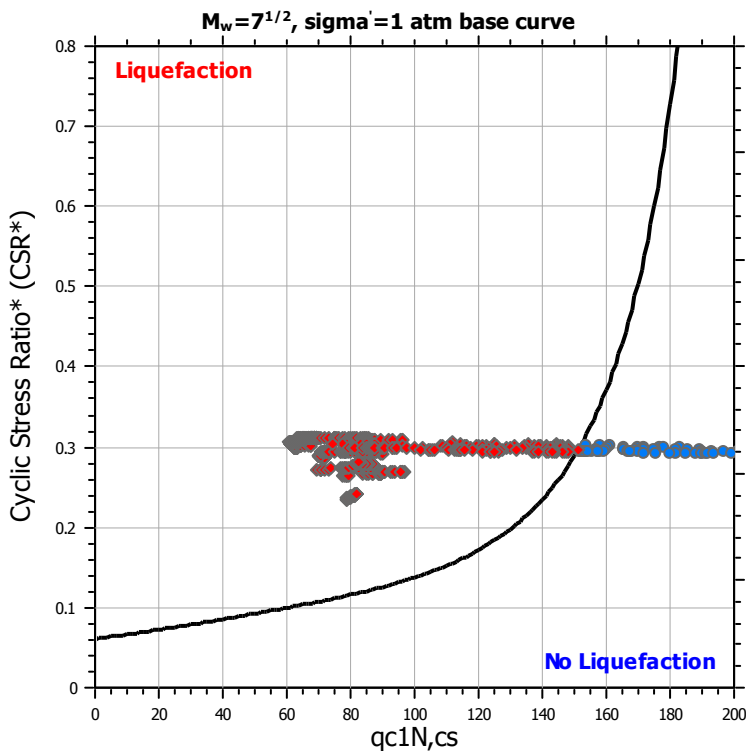
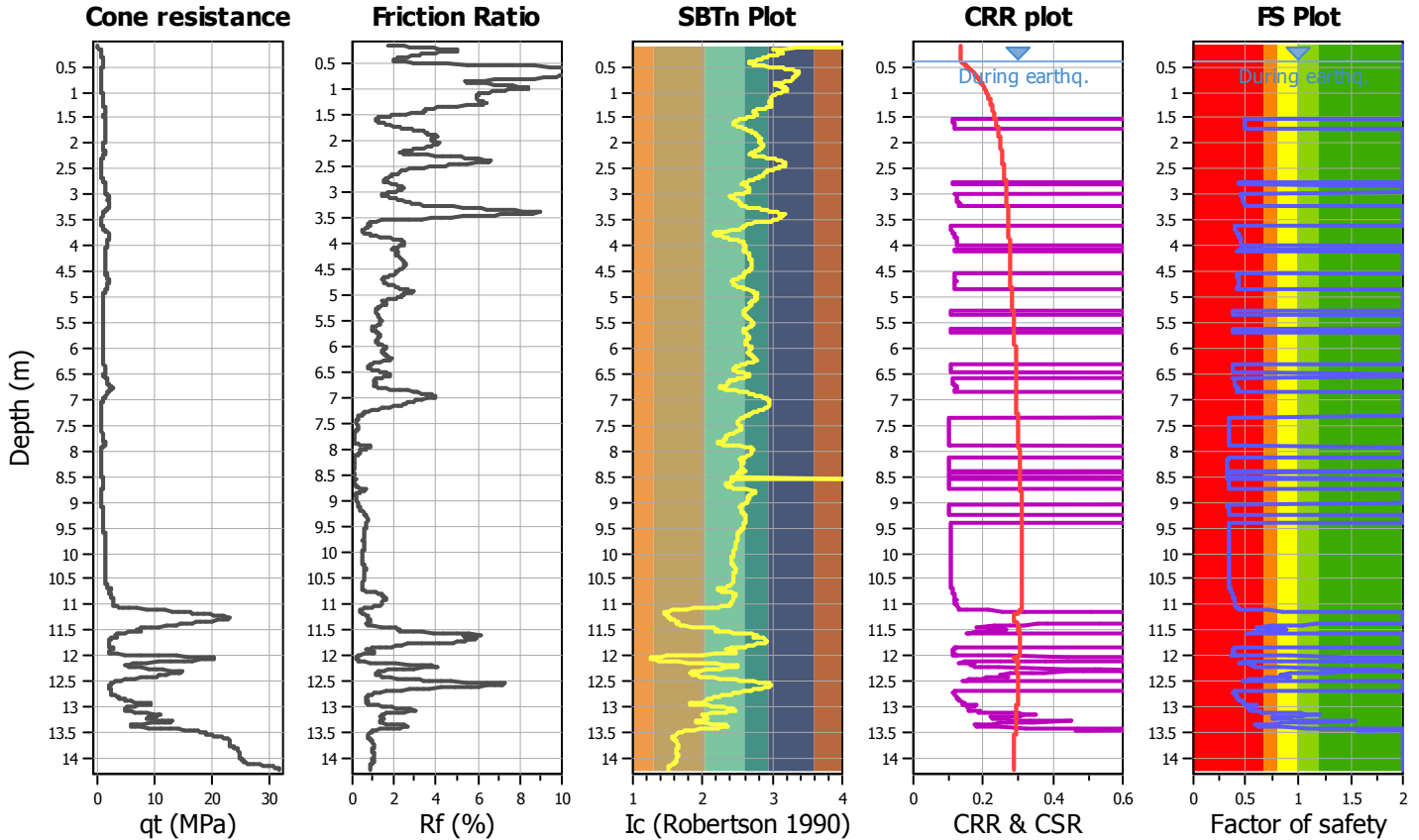
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT02

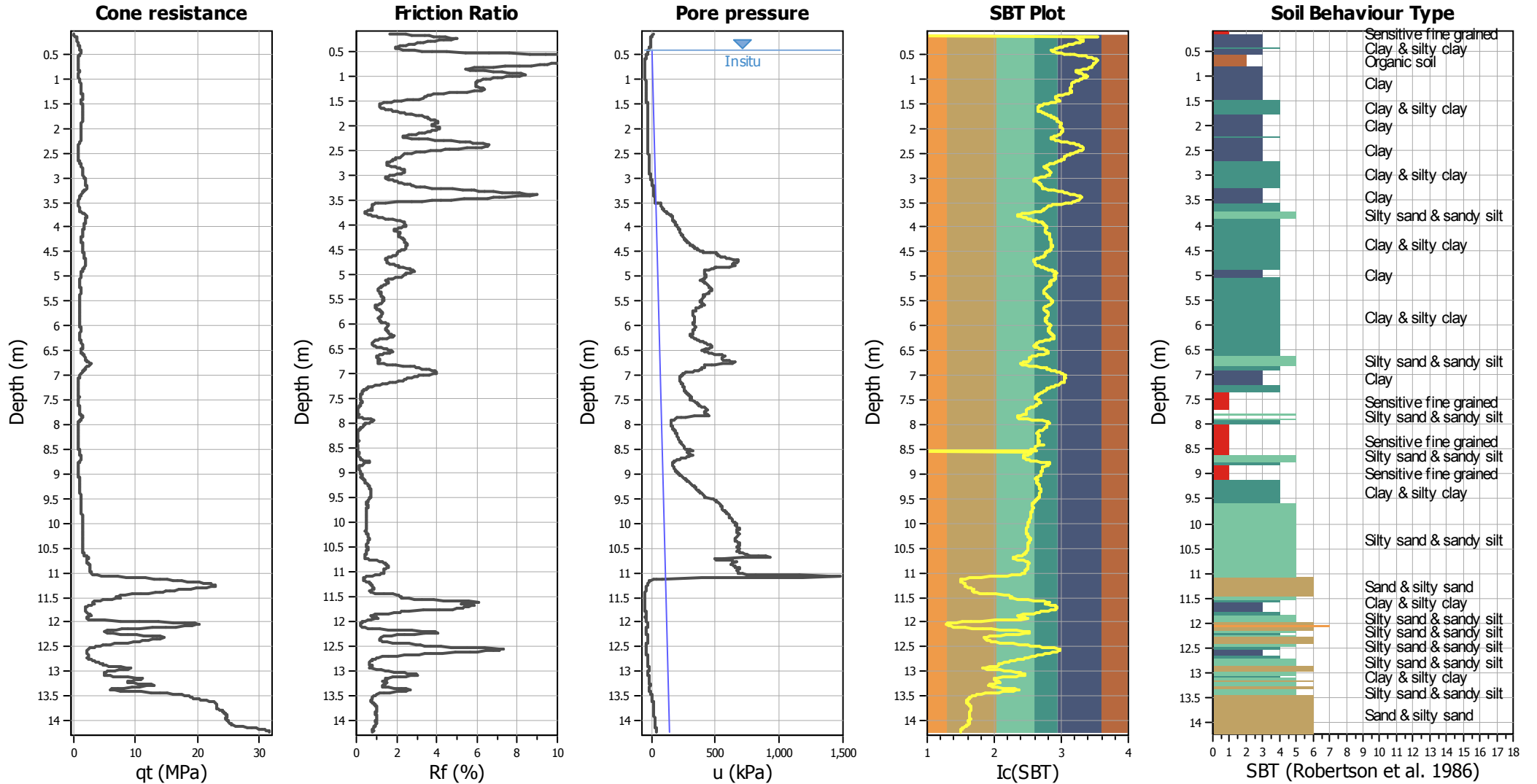
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.40 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.40 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_f applied:	Yes		



CPT basic interpretation plots



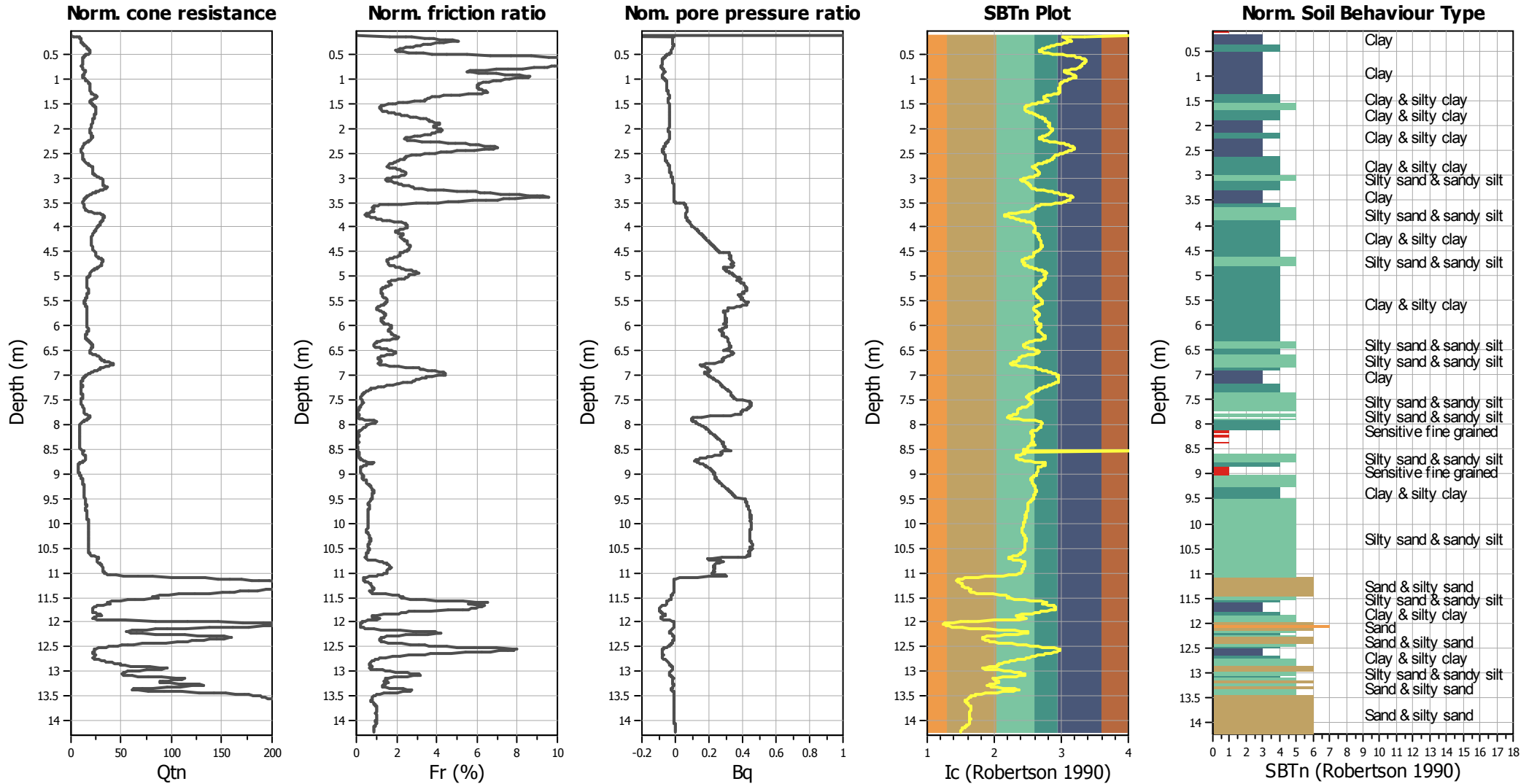
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.40 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.40 m	Fill height:	N/A	Limit depth:	N/A

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)



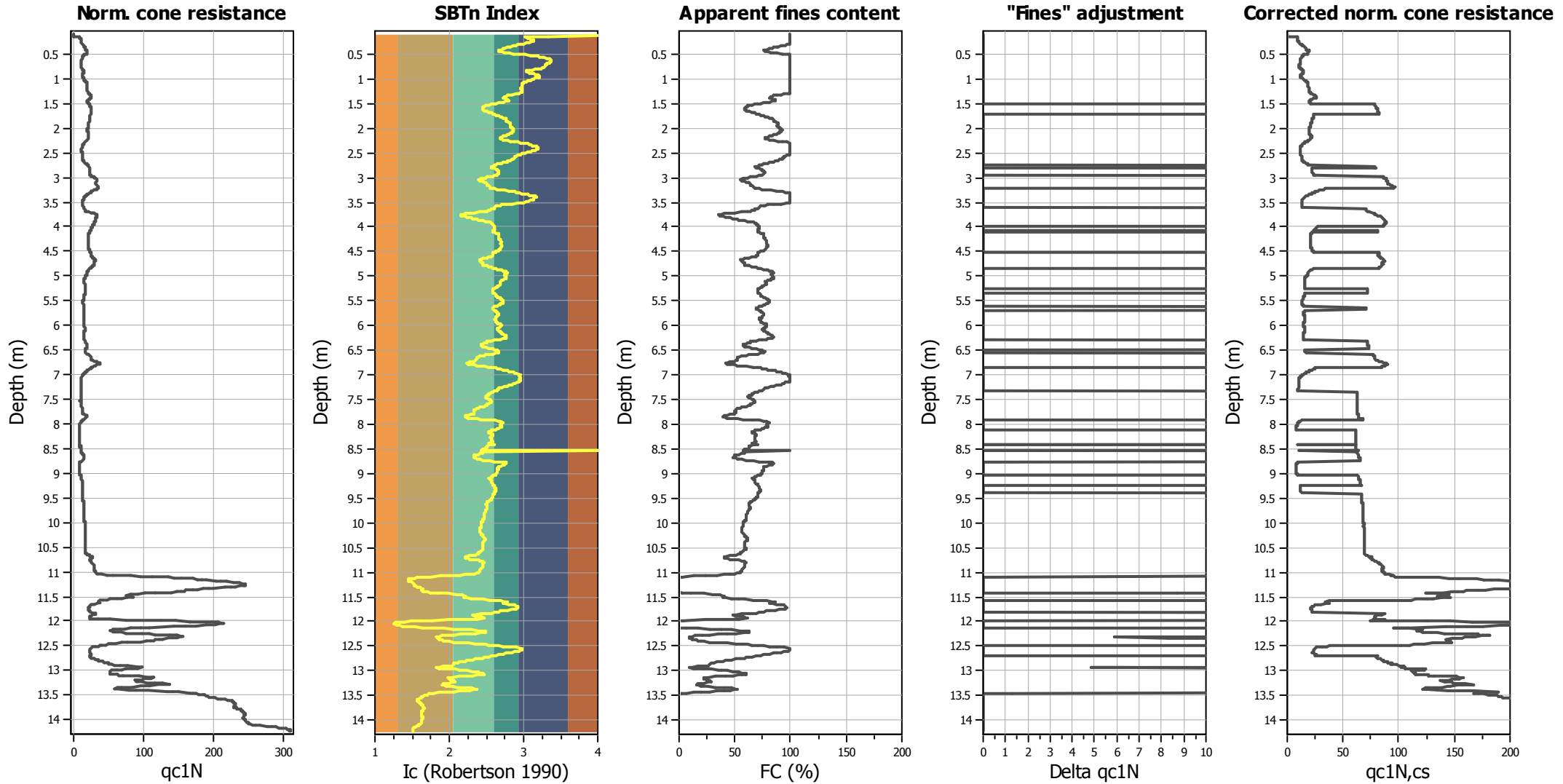
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.40 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.40 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

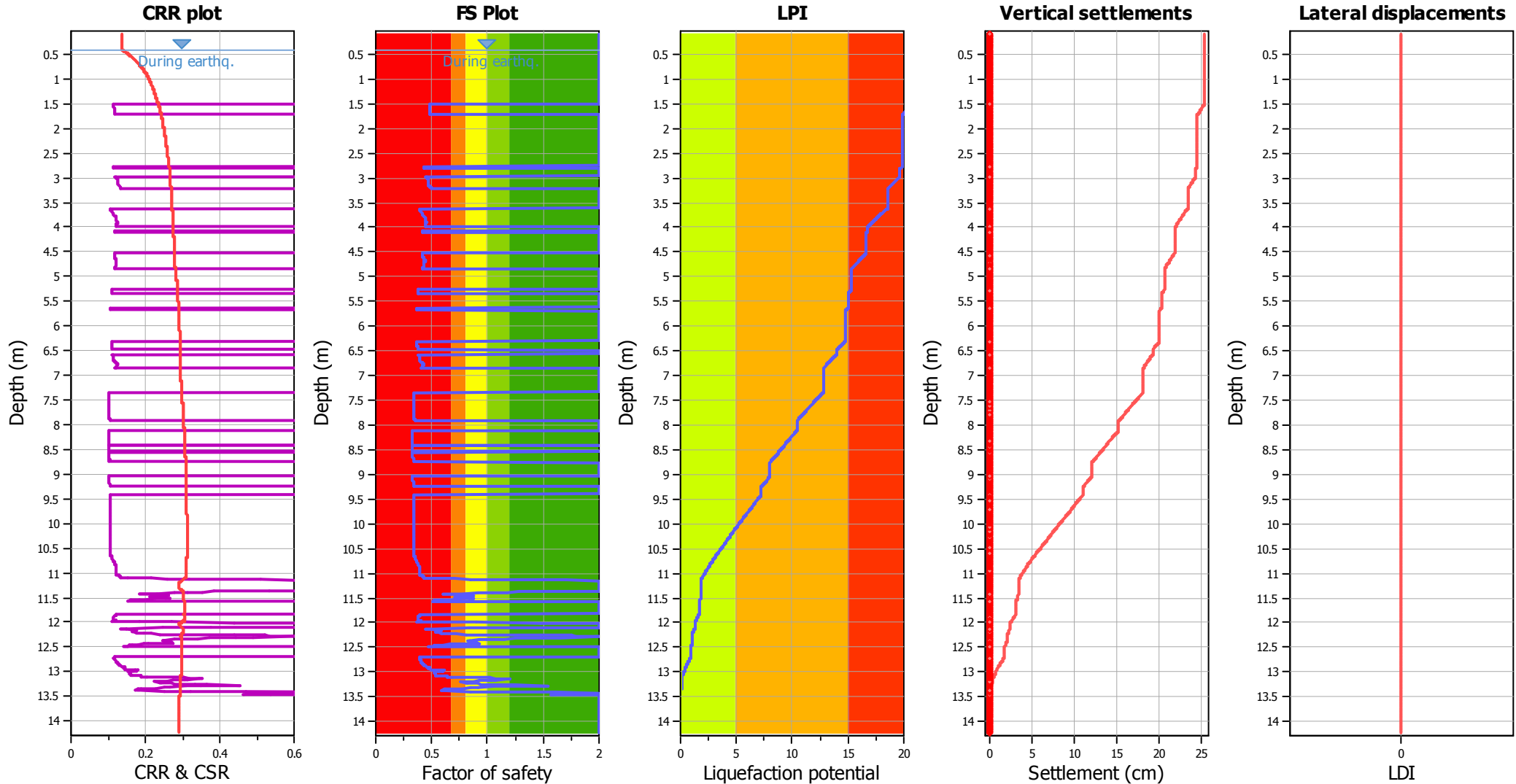
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.40 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.40 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (earthq.):	0.40 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.40 m	Fill height:	N/A	Limit depth:	N/A

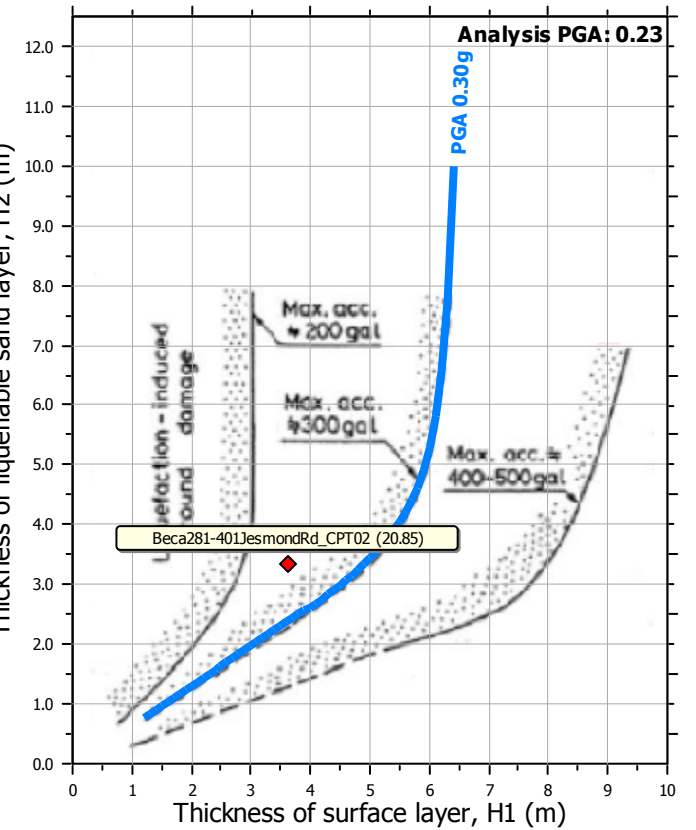
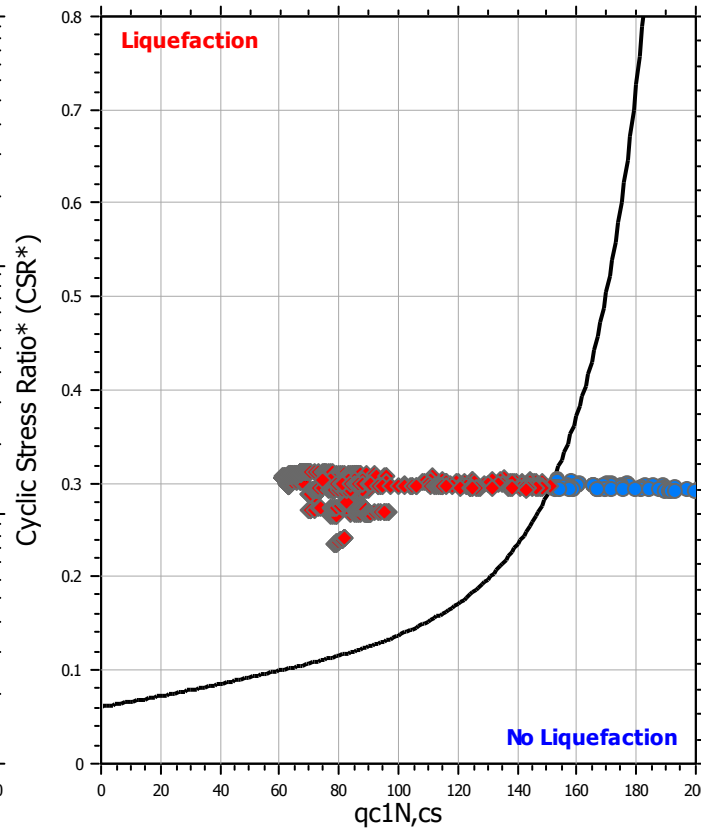
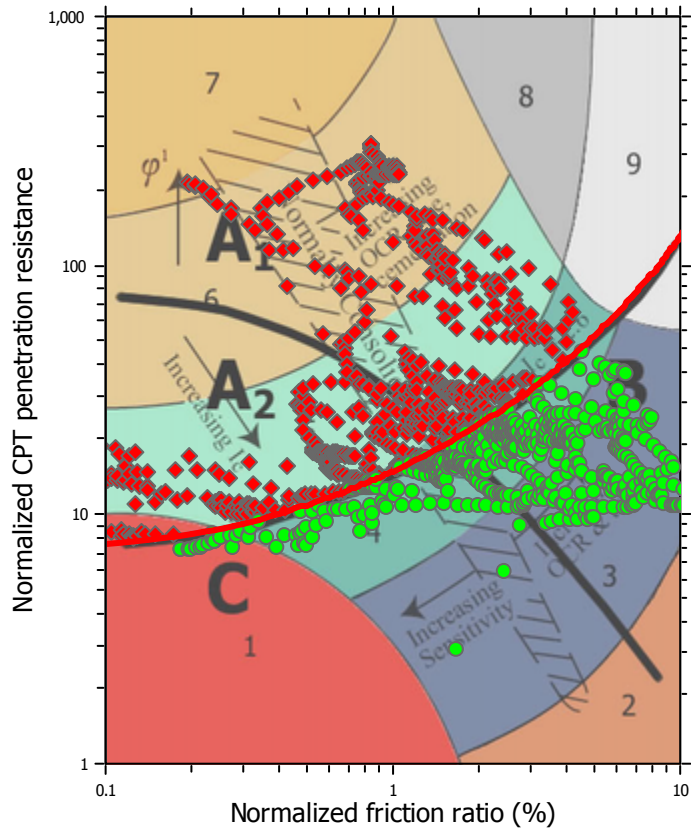
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

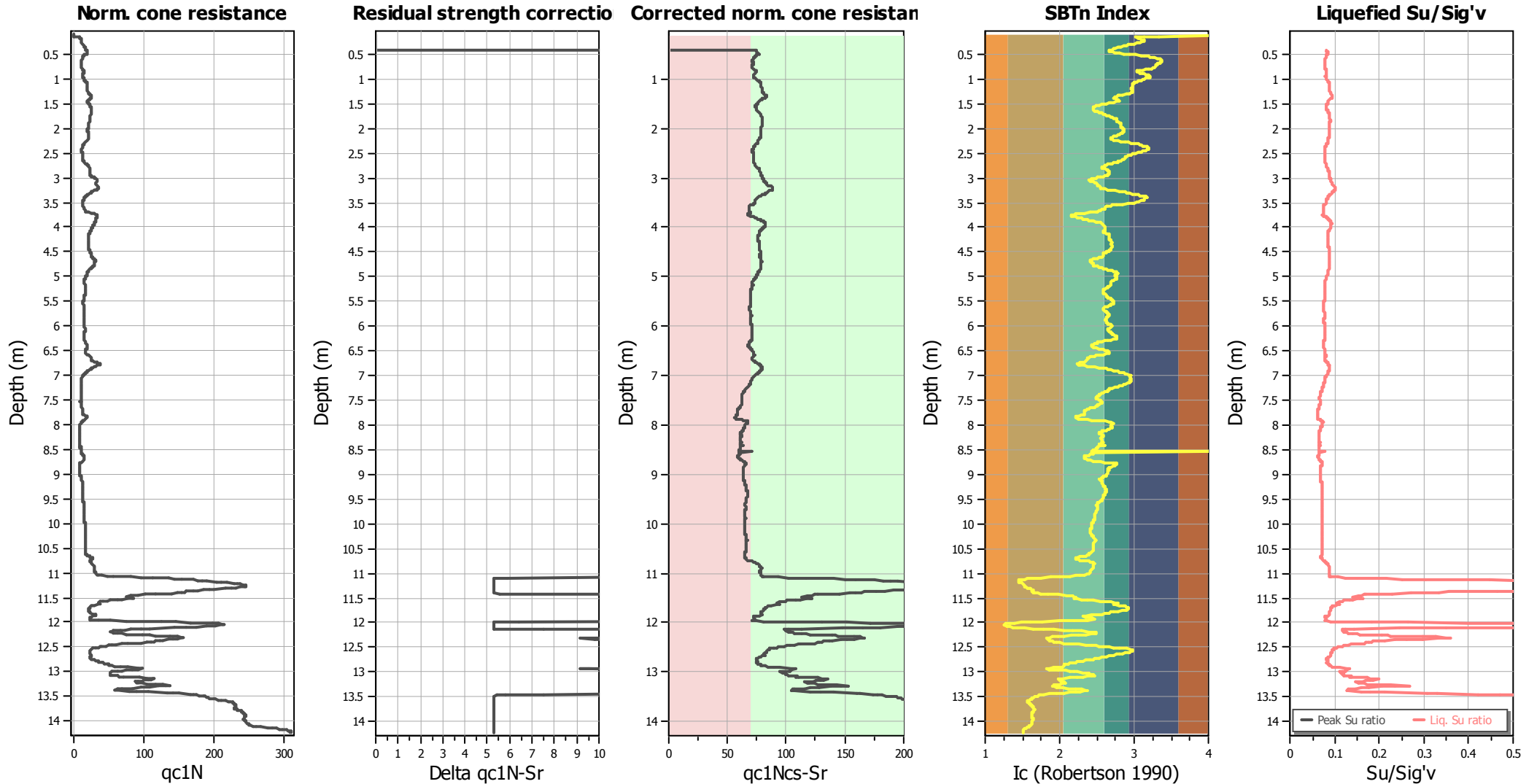
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.40 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_f applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.40 m	Fill height:	N/A	Limit depth:	N/A

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



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.40 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _σ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.40 m	Fill height:	N/A	Limit depth:	N/A

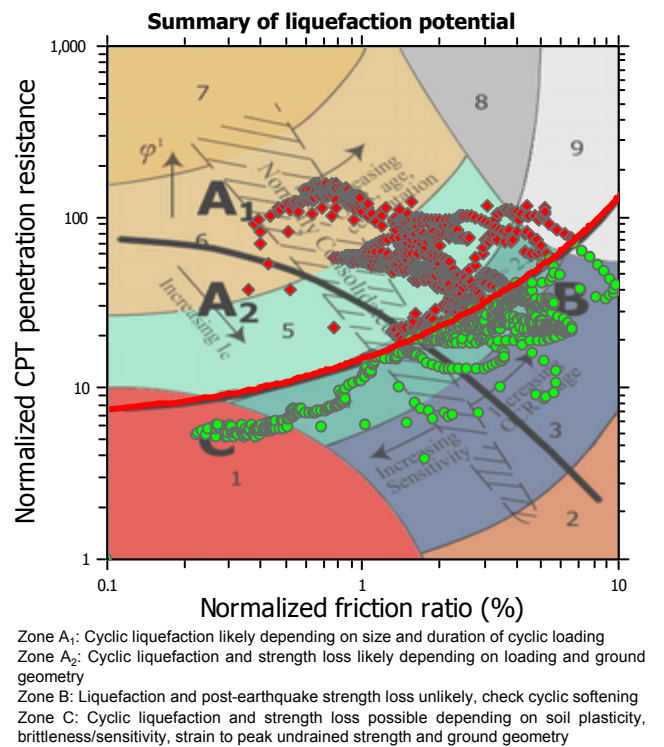
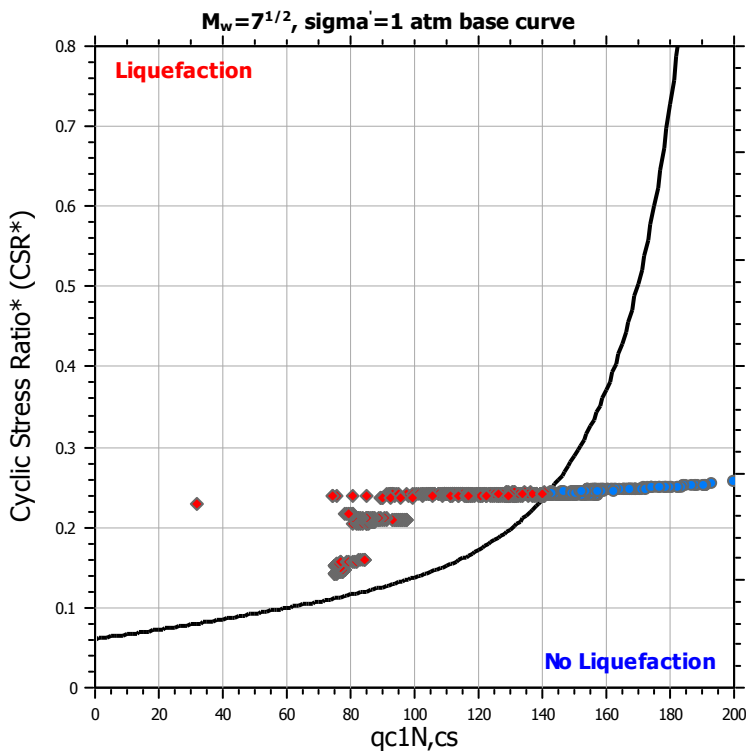
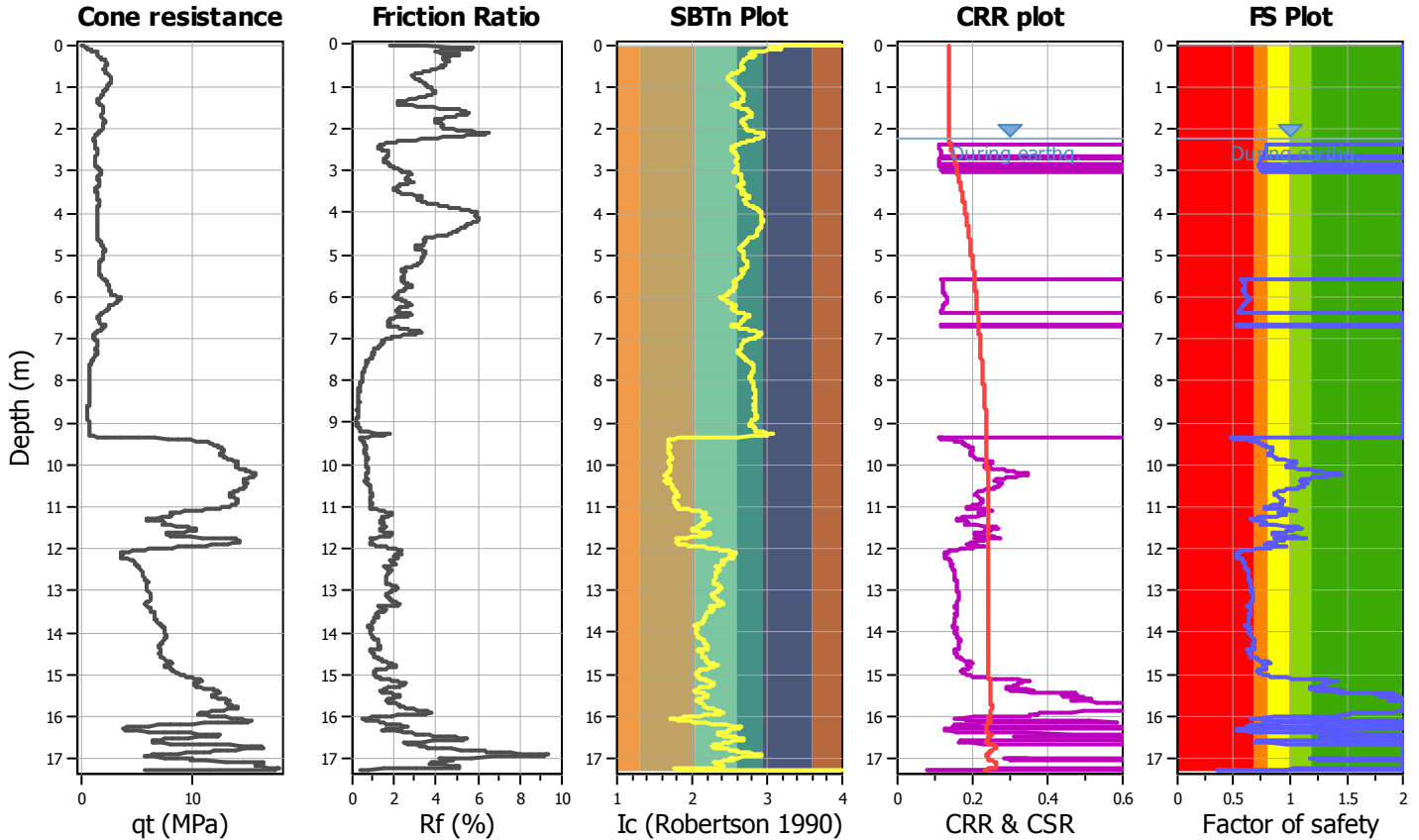
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT03

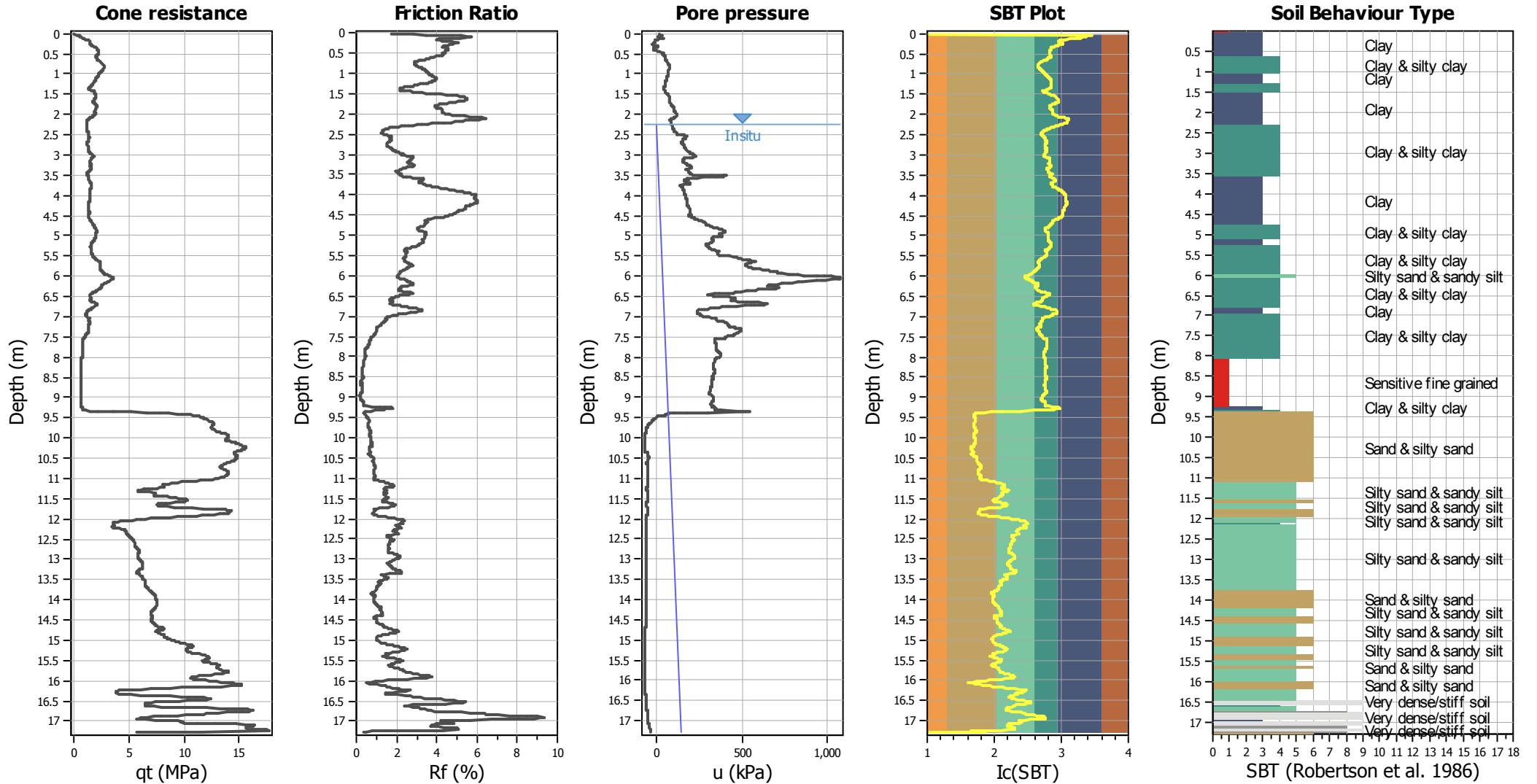
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.25 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.25 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		



CPT basic interpretation plots



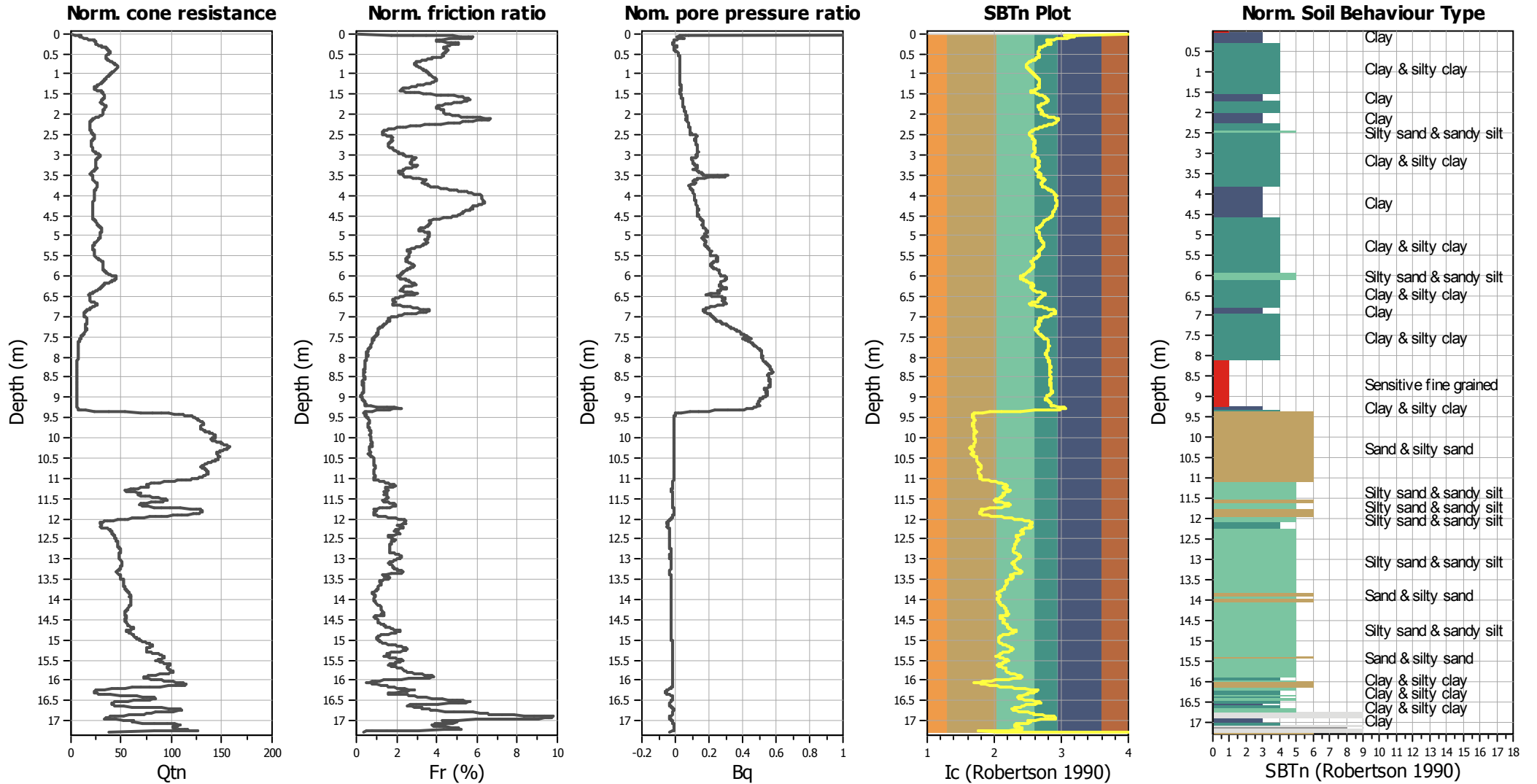
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.25 m	Fill height:	N/A	Limit depth:	N/A

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)



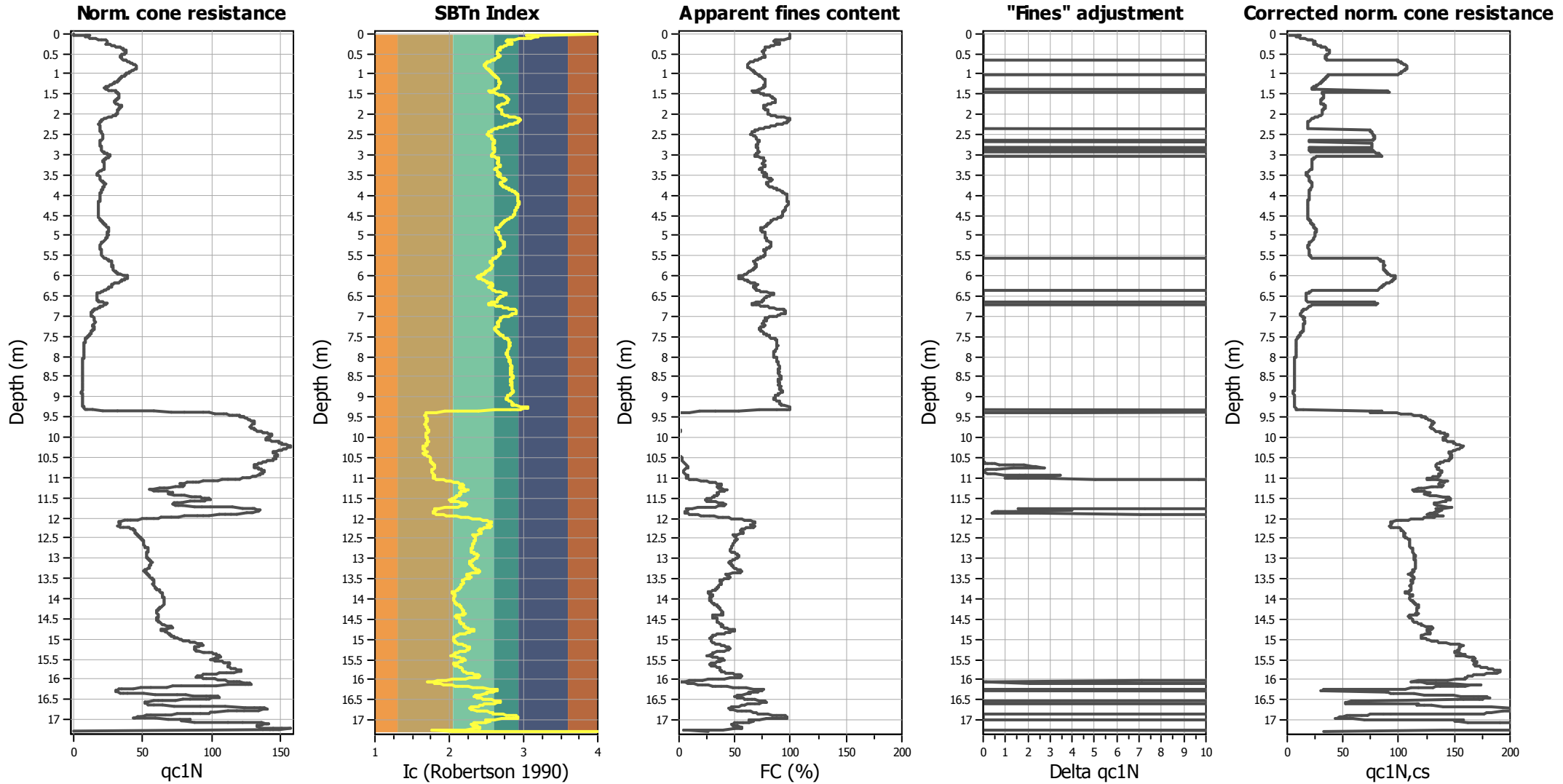
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.25 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

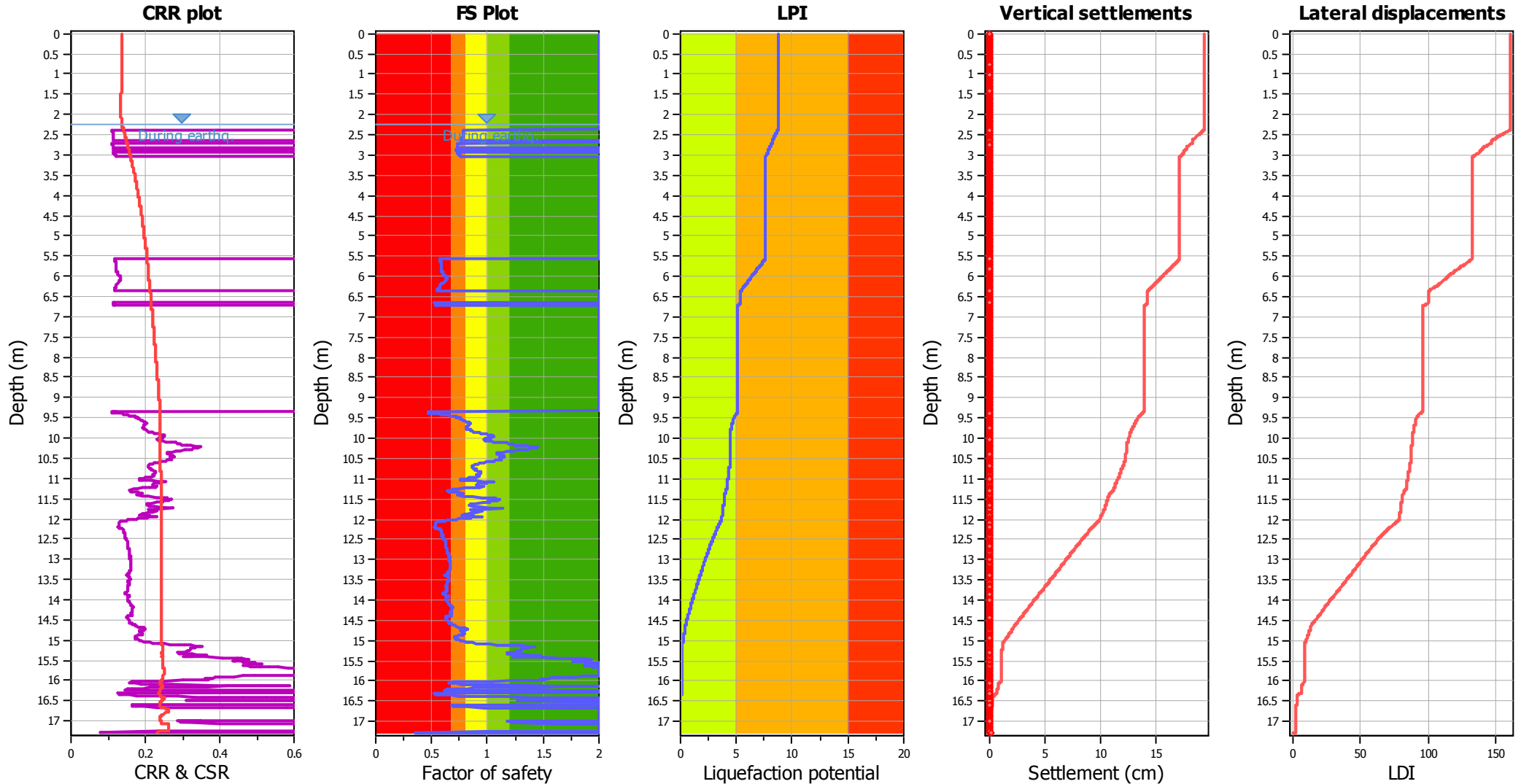
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _σ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.25 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.25 m	Fill height:	N/A	Limit depth:	N/A

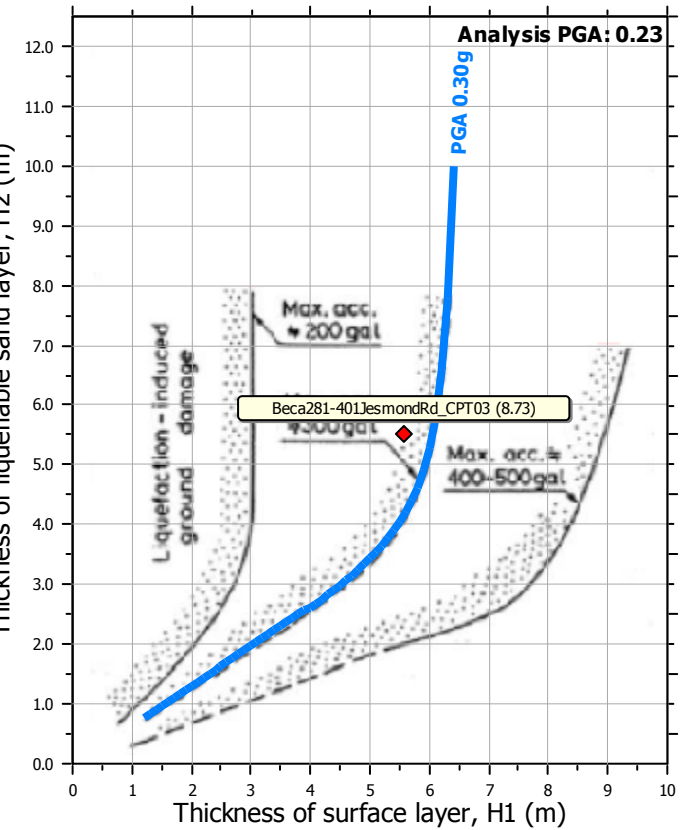
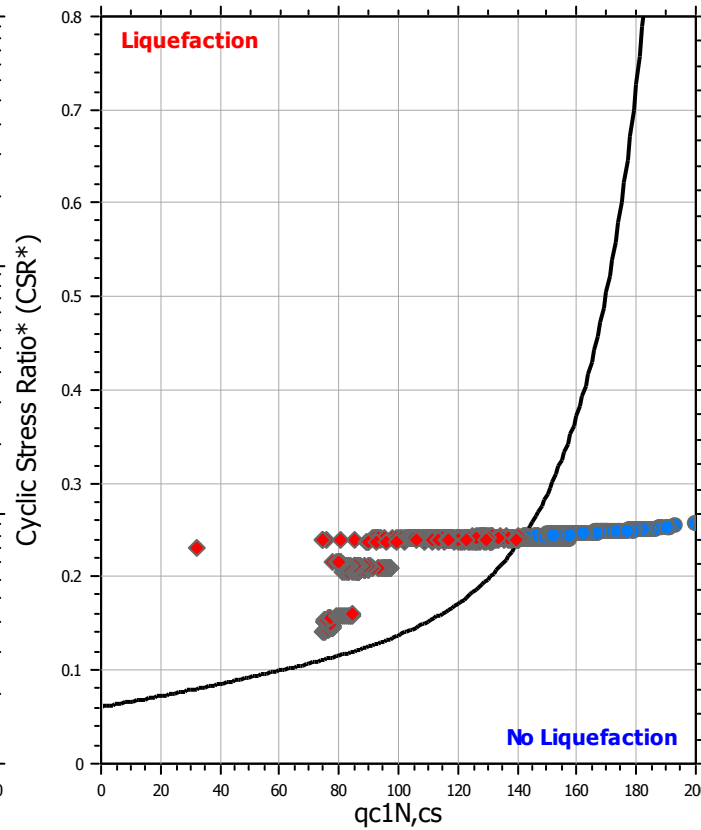
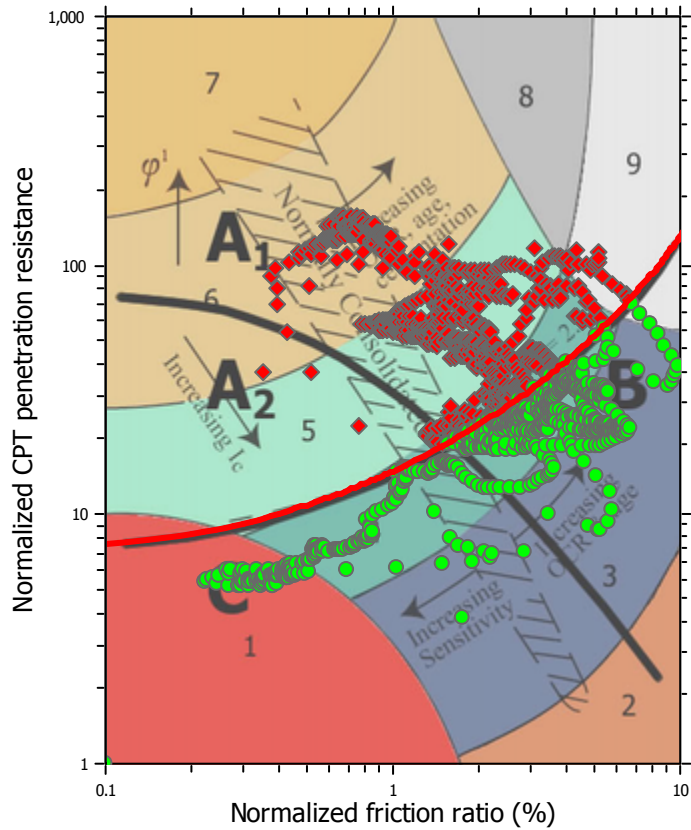
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

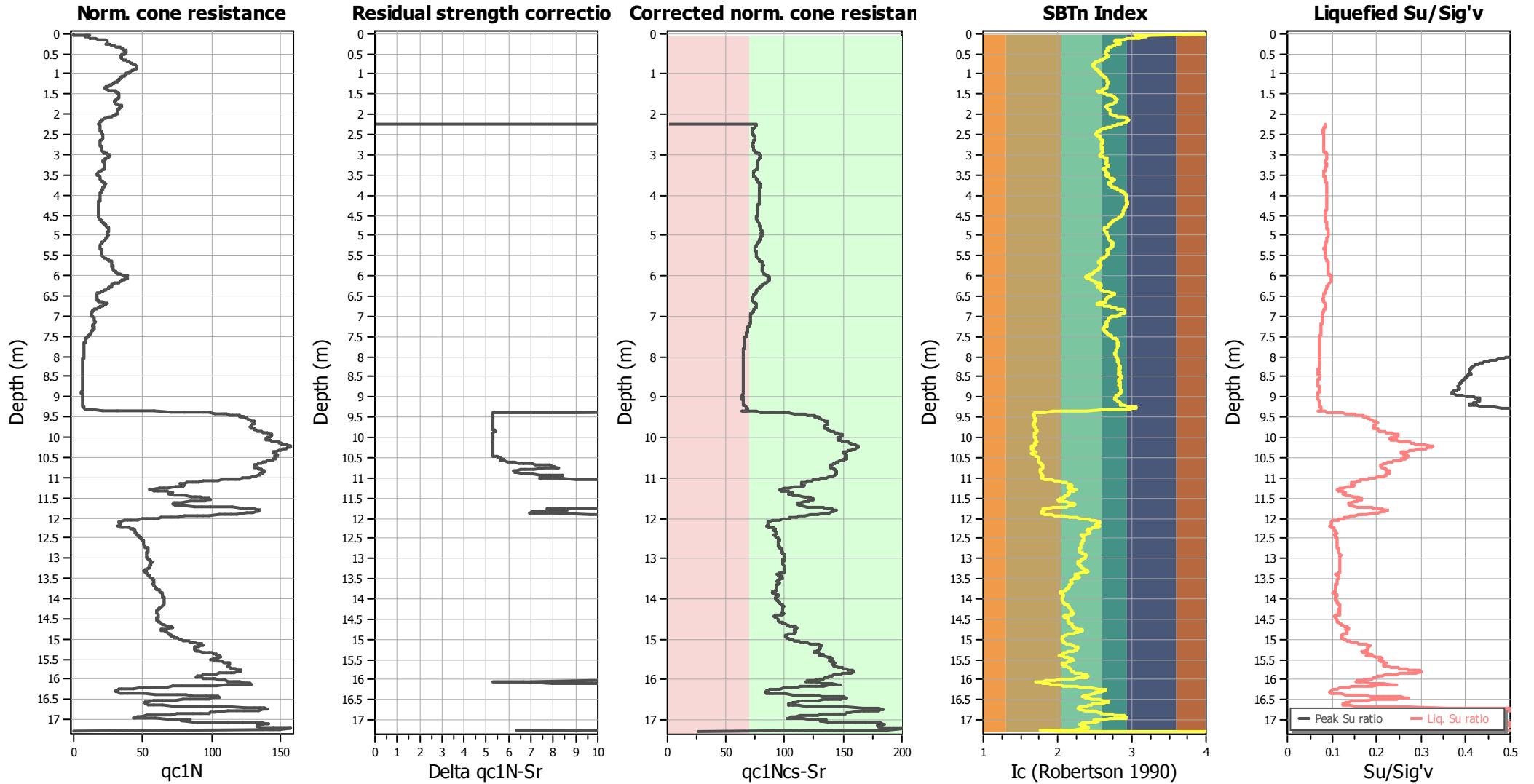
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.25 m	Fill height:	N/A	Limit depth:	N/A

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



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _σ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.25 m	Fill height:	N/A	Limit depth:	N/A

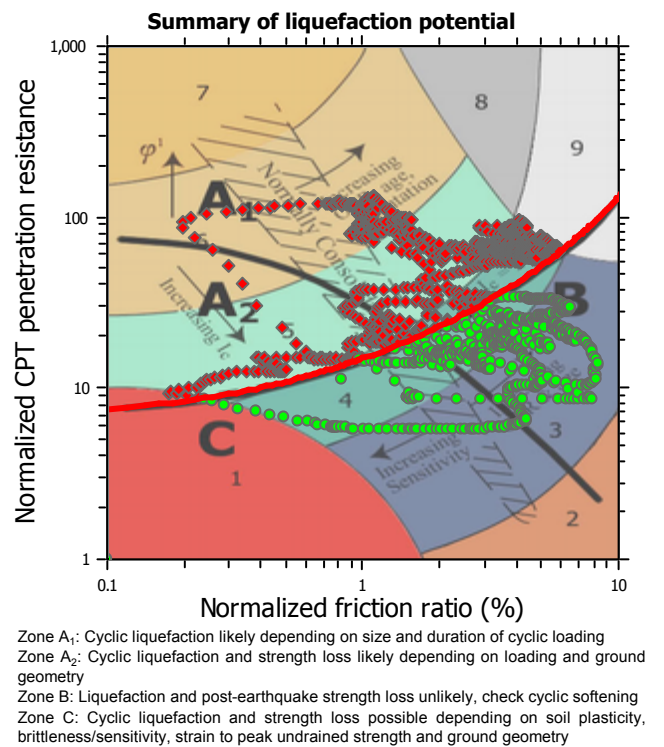
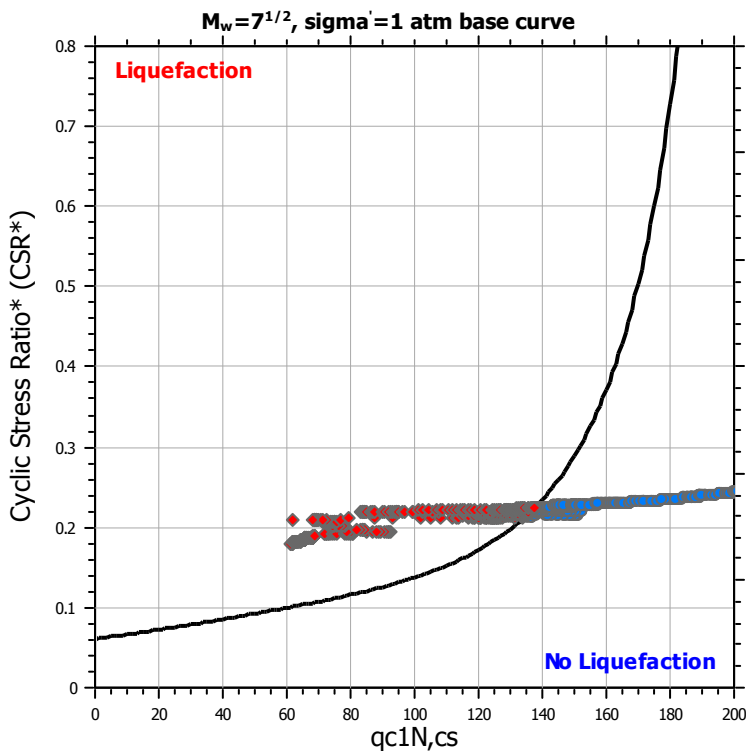
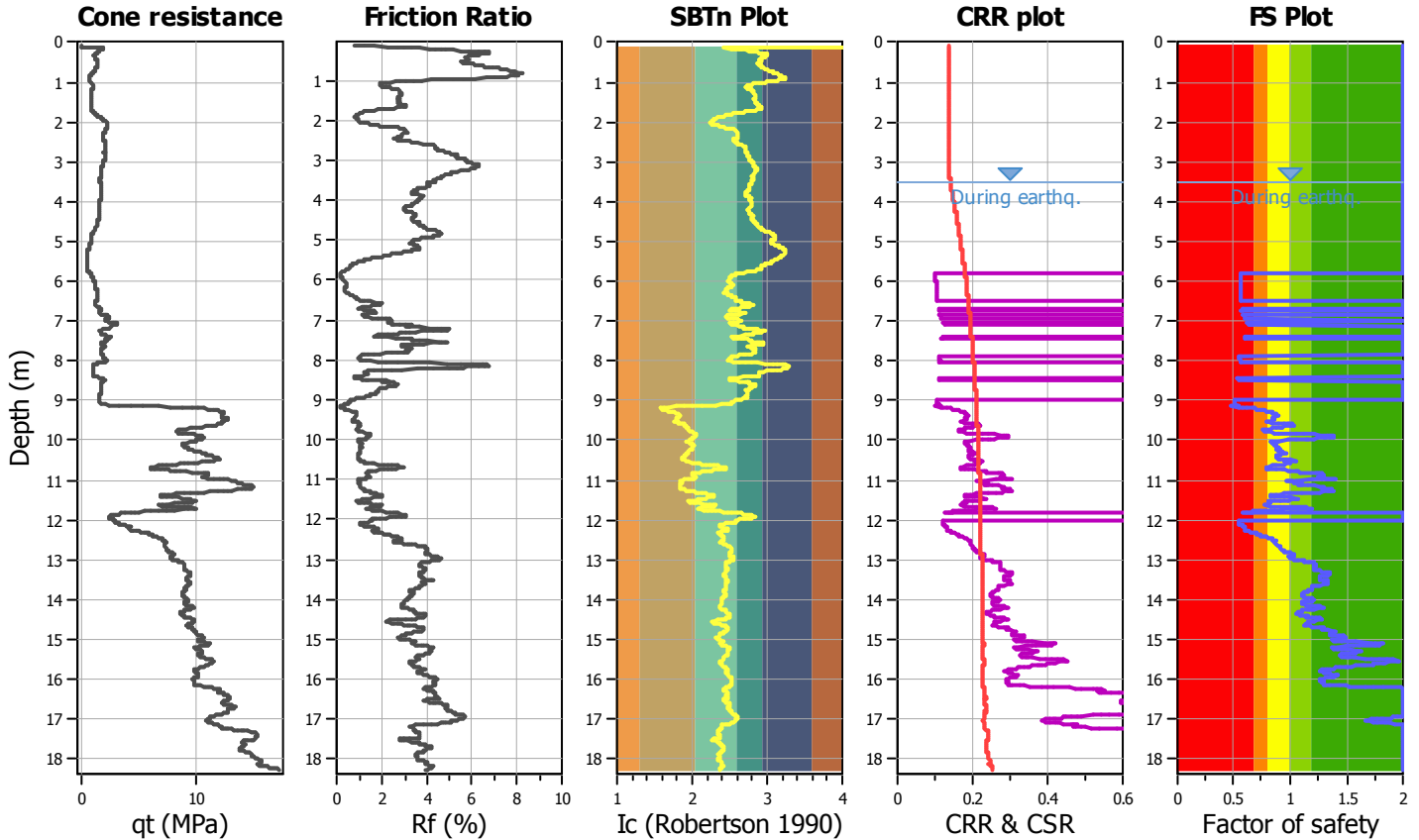
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT04

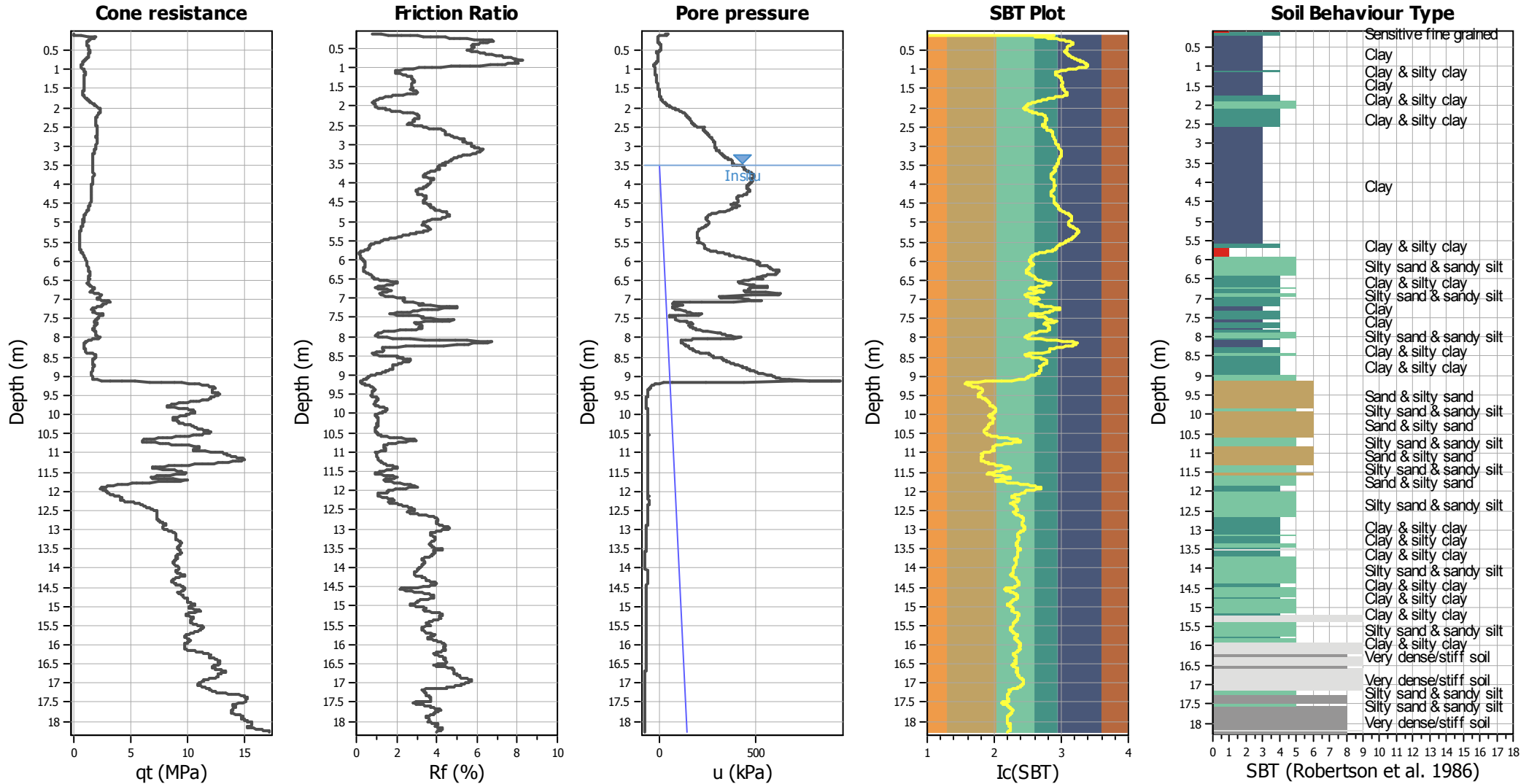
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.50 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method



CPT basic interpretation plots



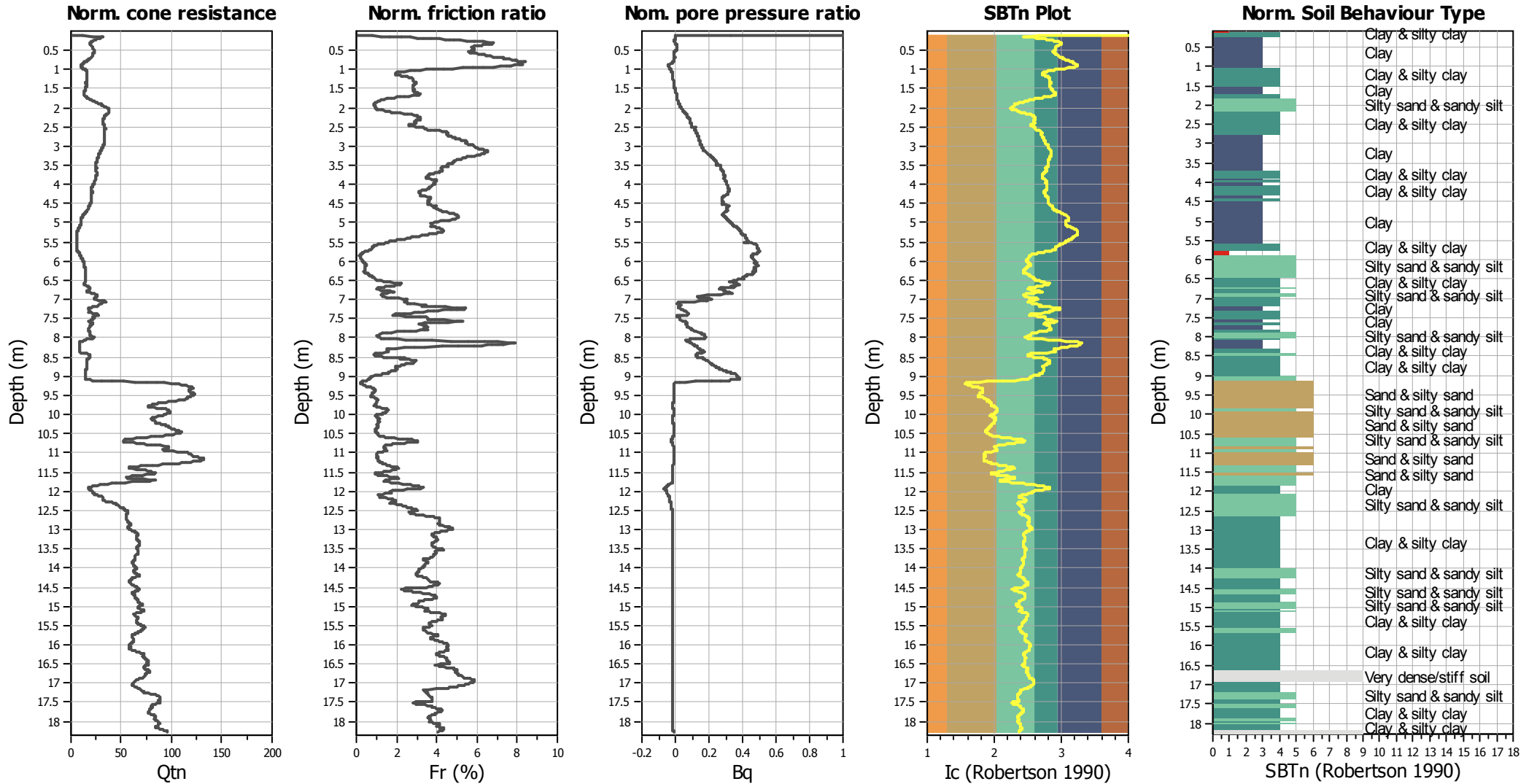
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	N/A

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)



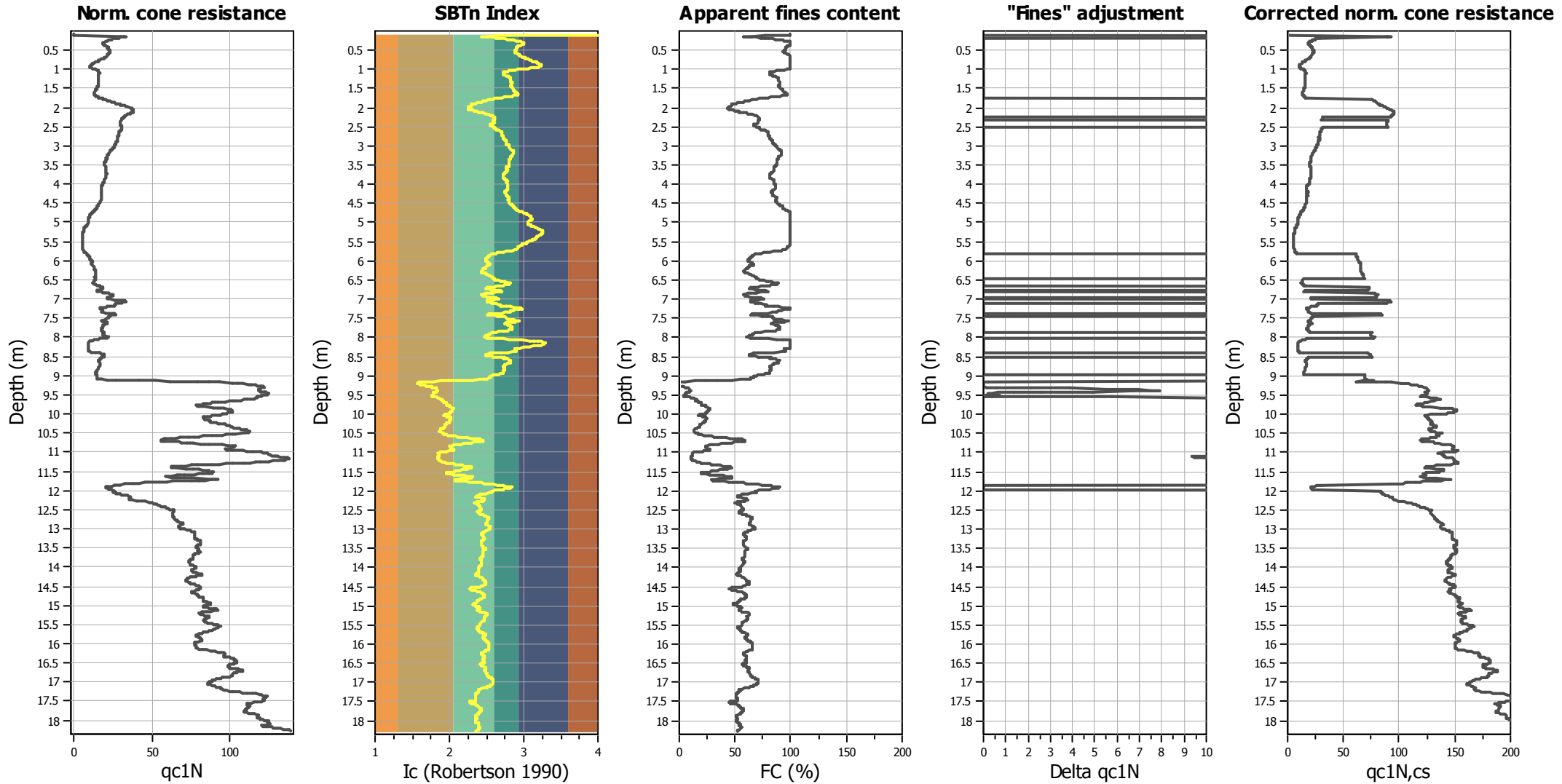
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

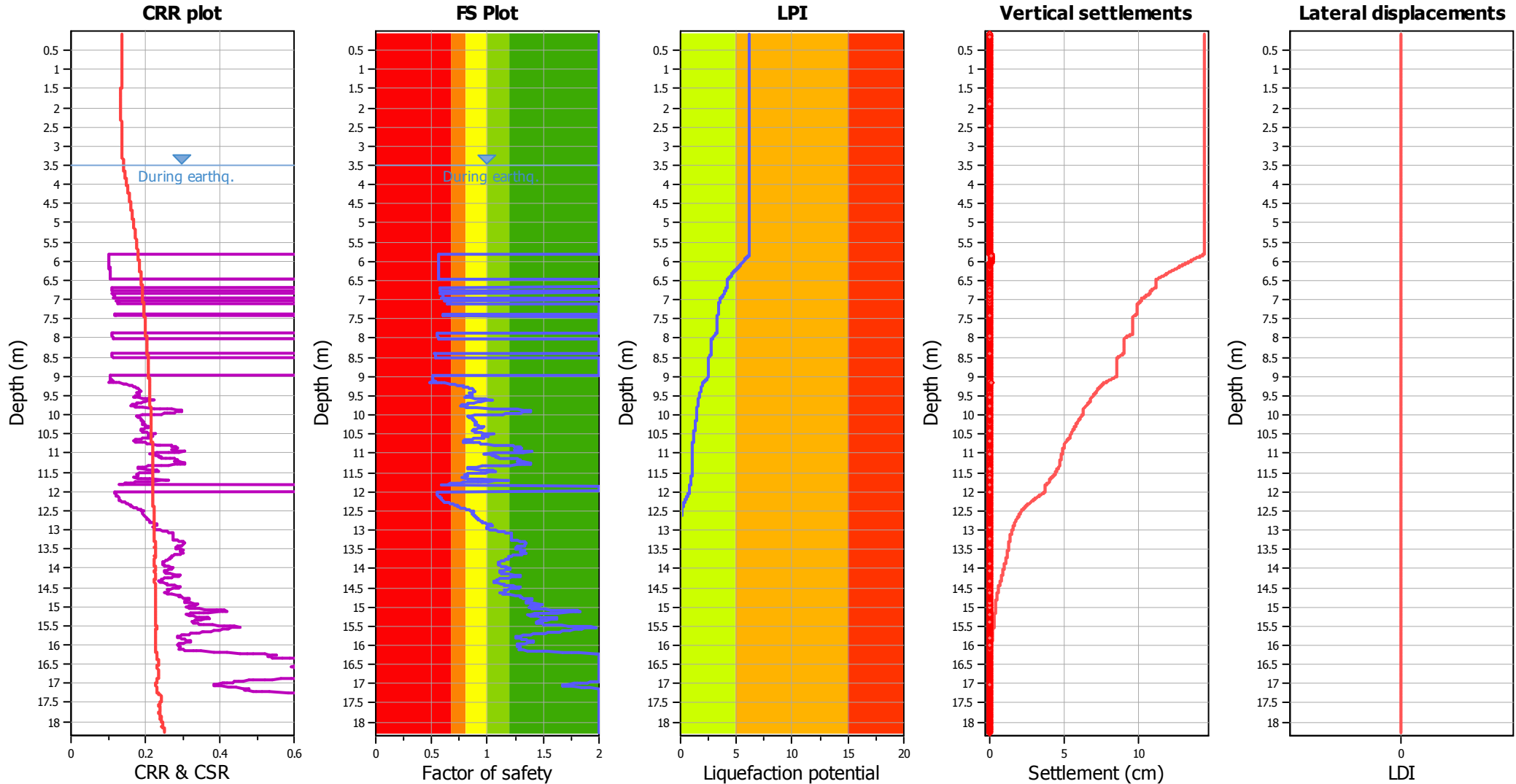
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (earthq.):	3.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	N/A

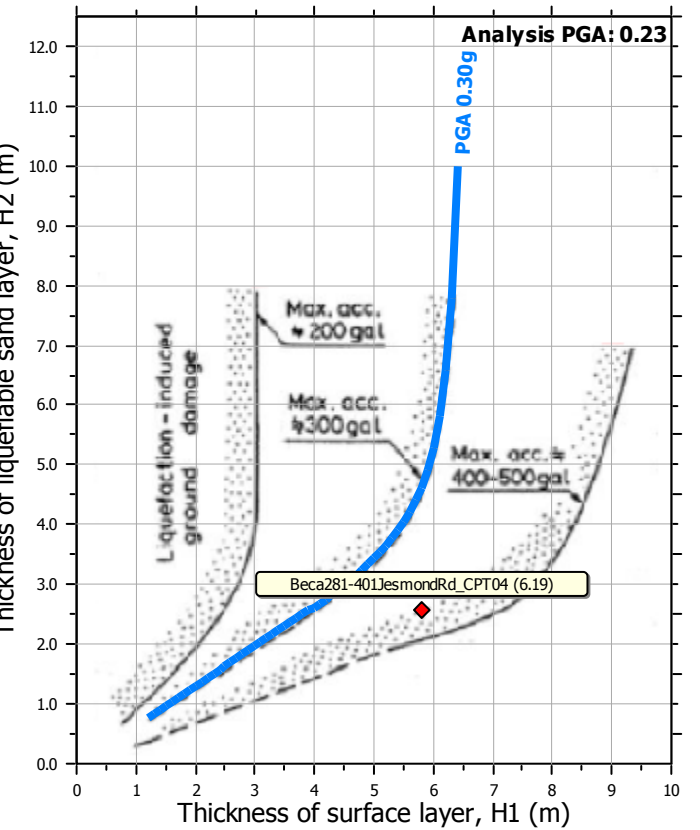
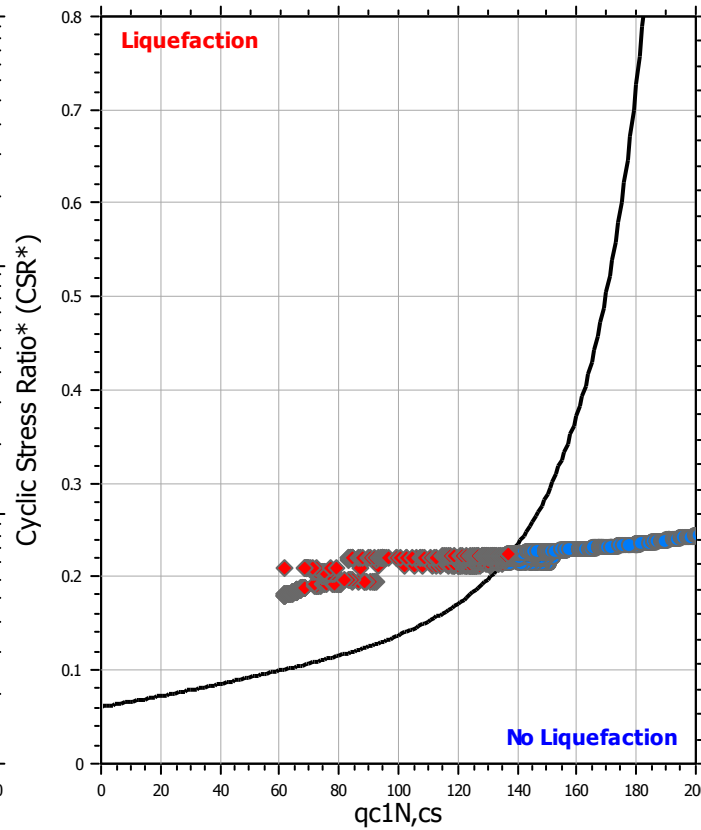
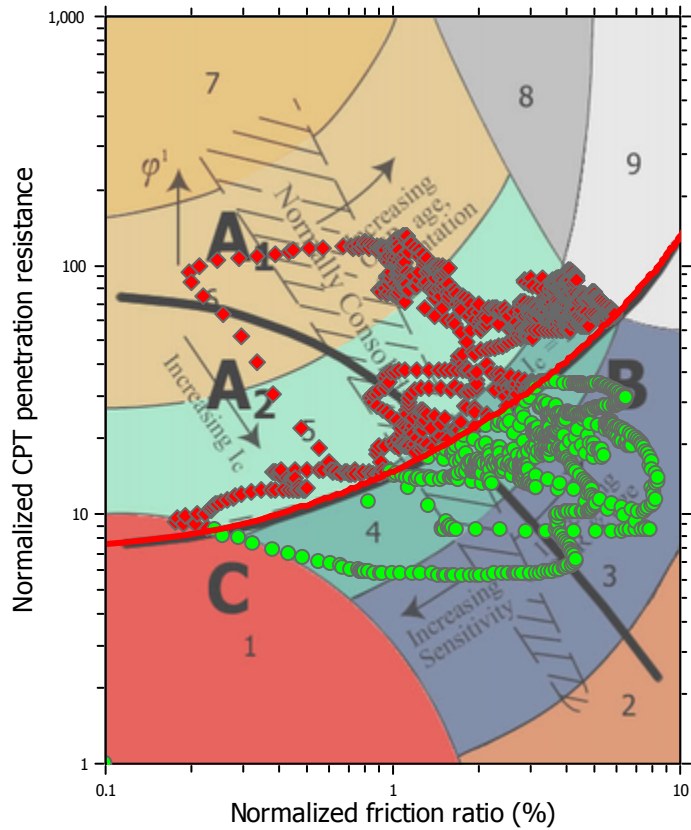
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

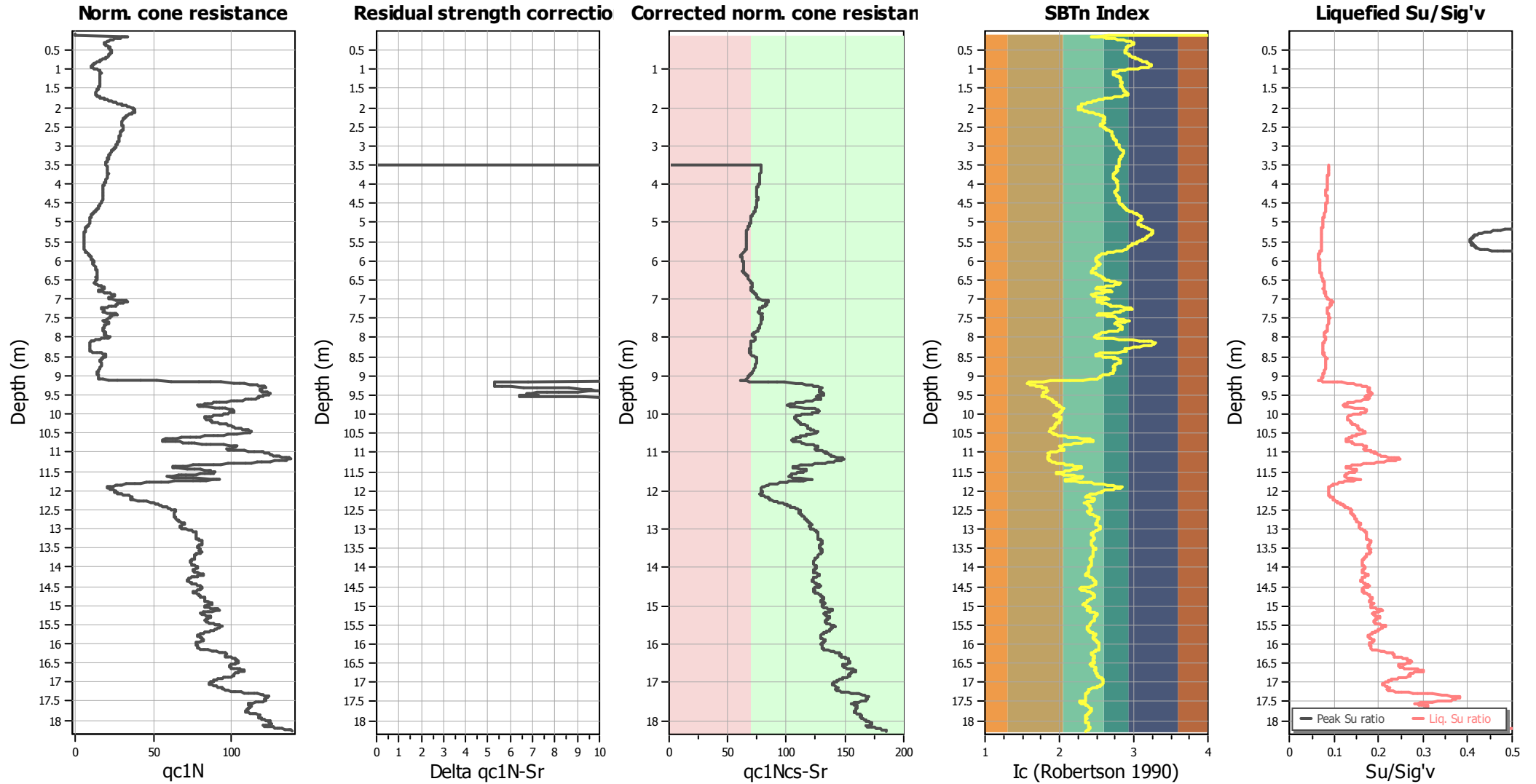
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	N/A

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



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.50 m	Fill height:	N/A	Limit depth:	N/A

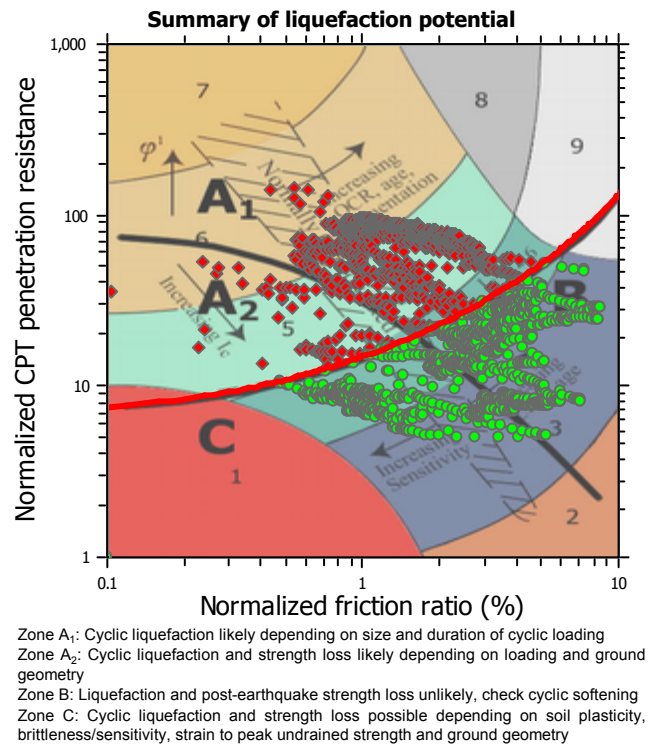
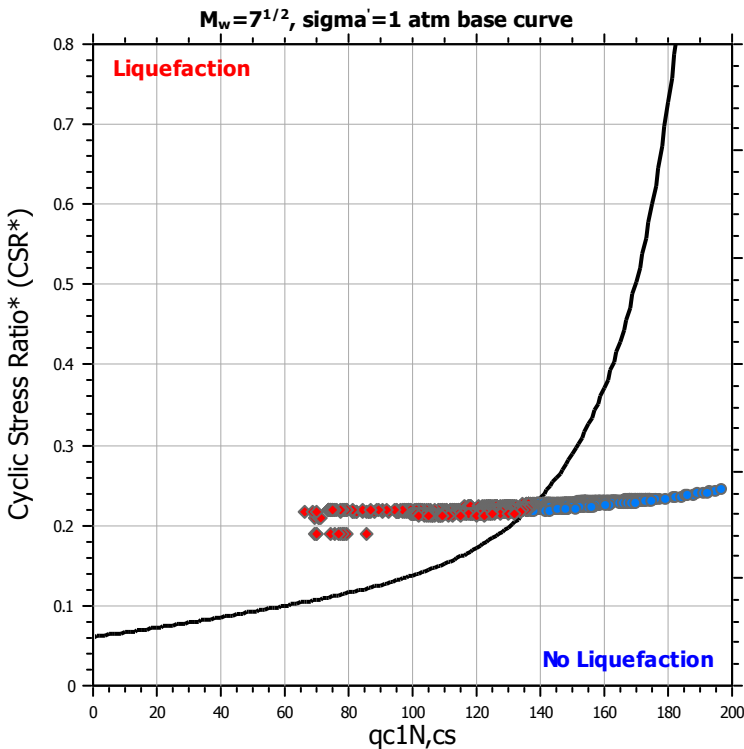
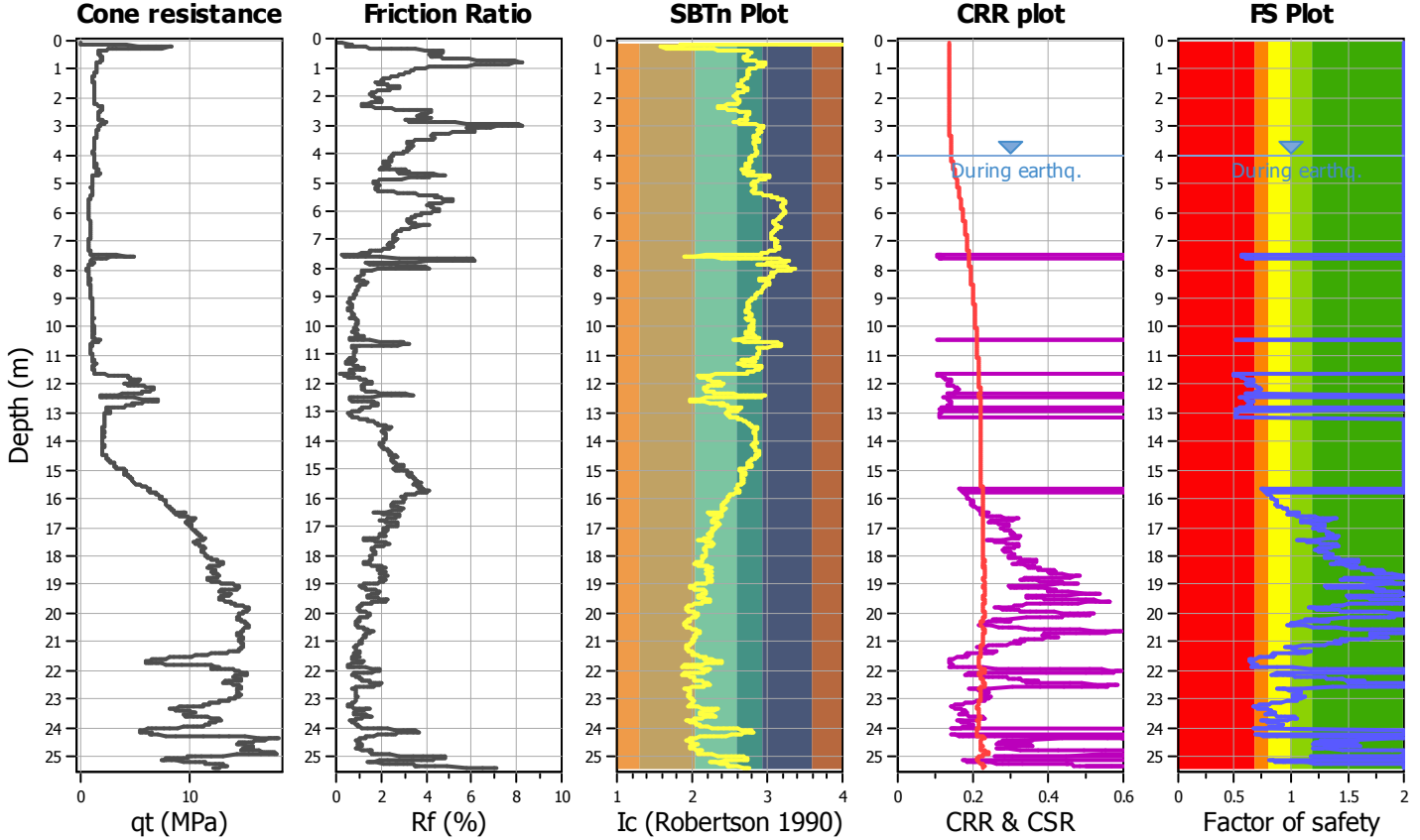
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT05

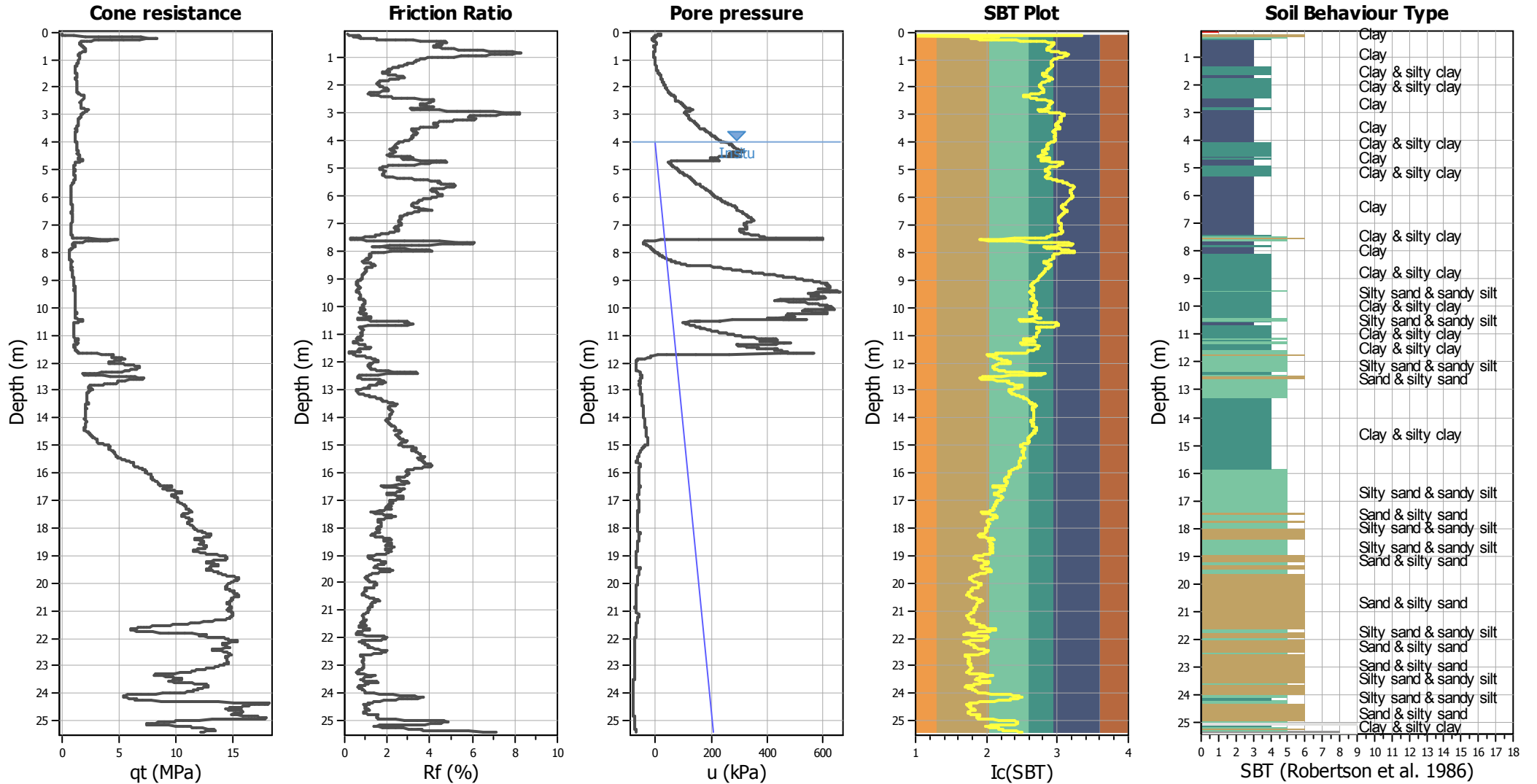
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_γ applied:	Yes		



CPT basic interpretation plots



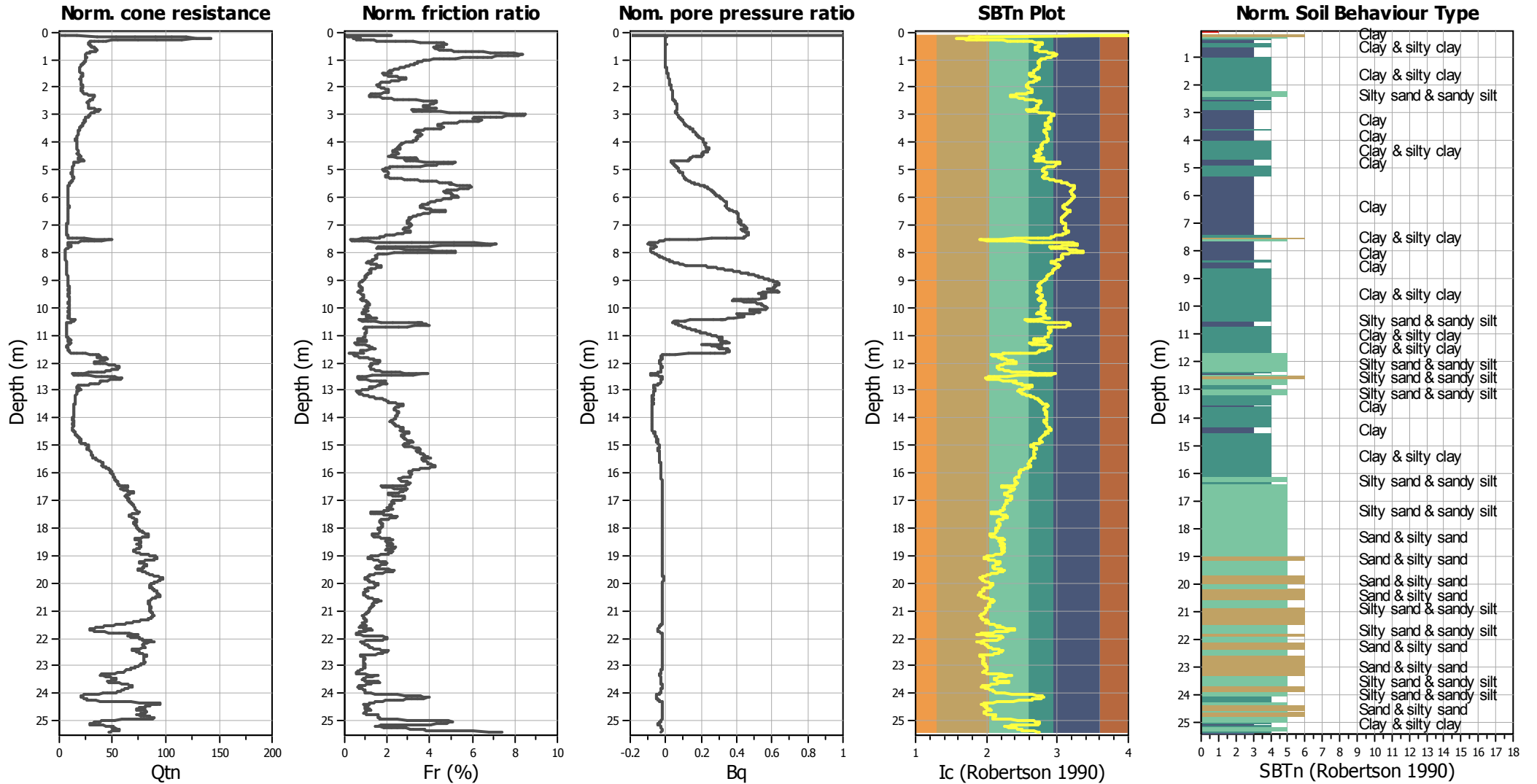
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (earthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 m	Fill height:	N/A	Limit depth:	N/A

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)



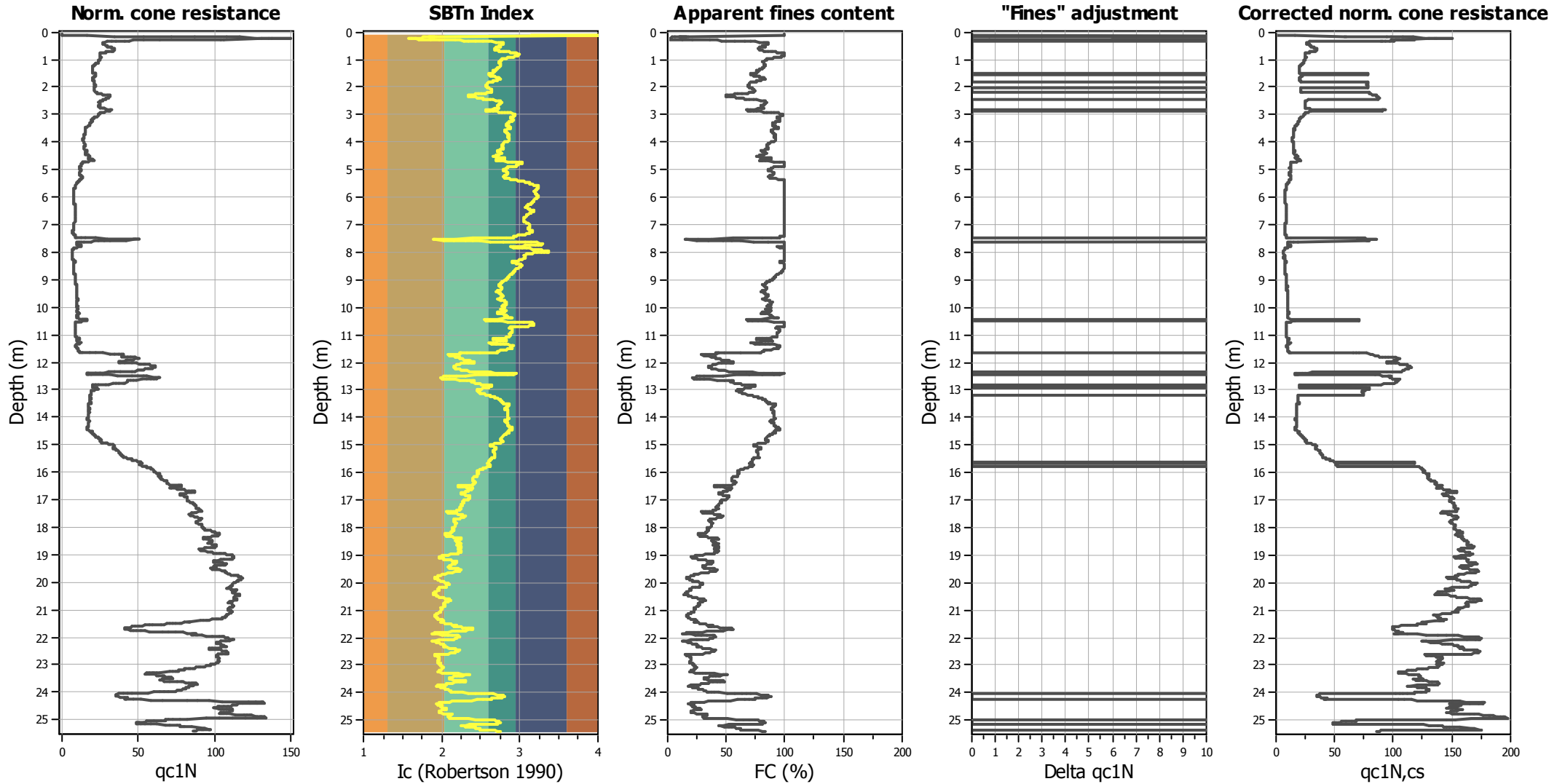
Input parameters and analysis data

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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

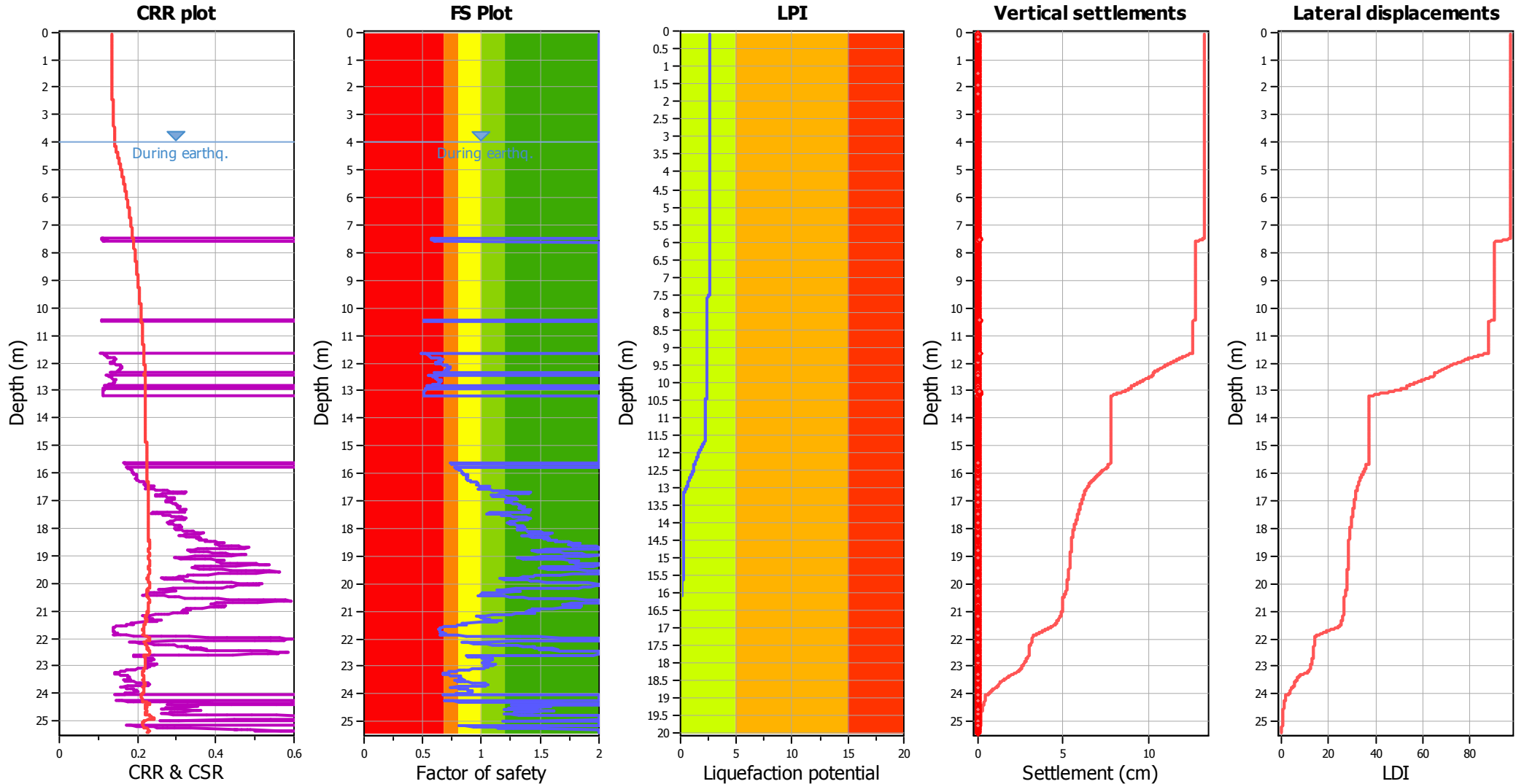
Liquefaction analysis overall plots (intermediate results)



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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (earthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 m	Fill height:	N/A	Limit depth:	N/A

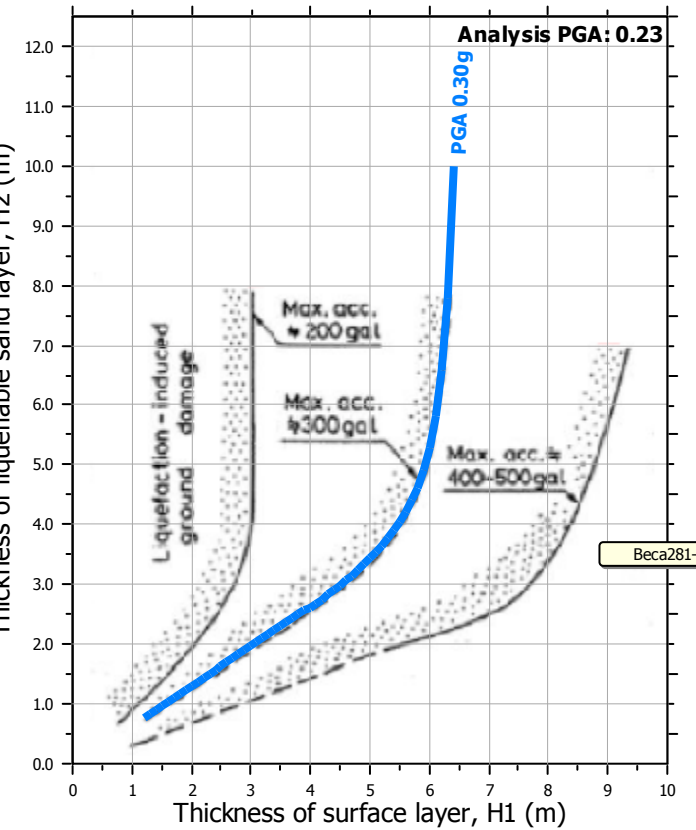
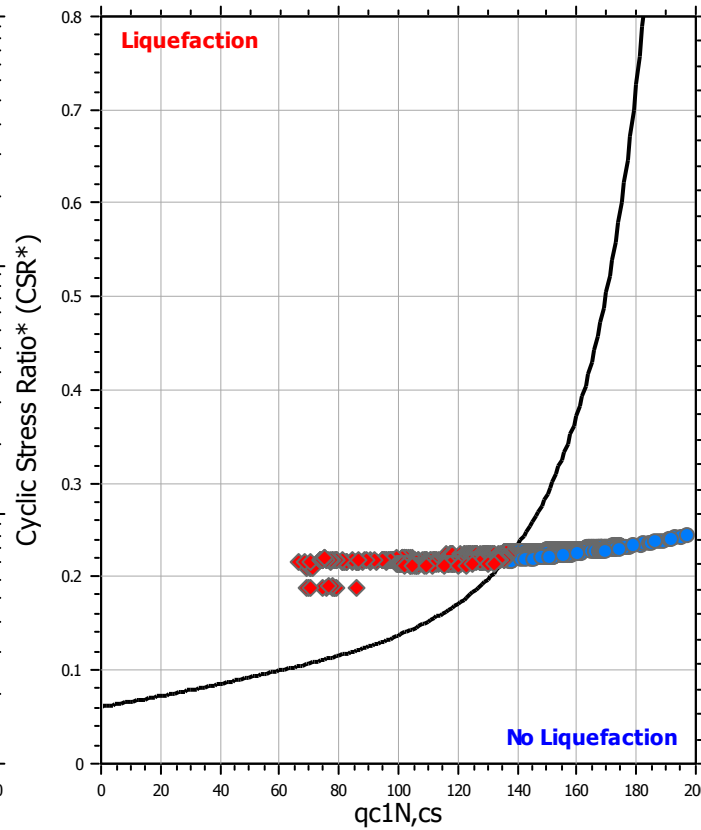
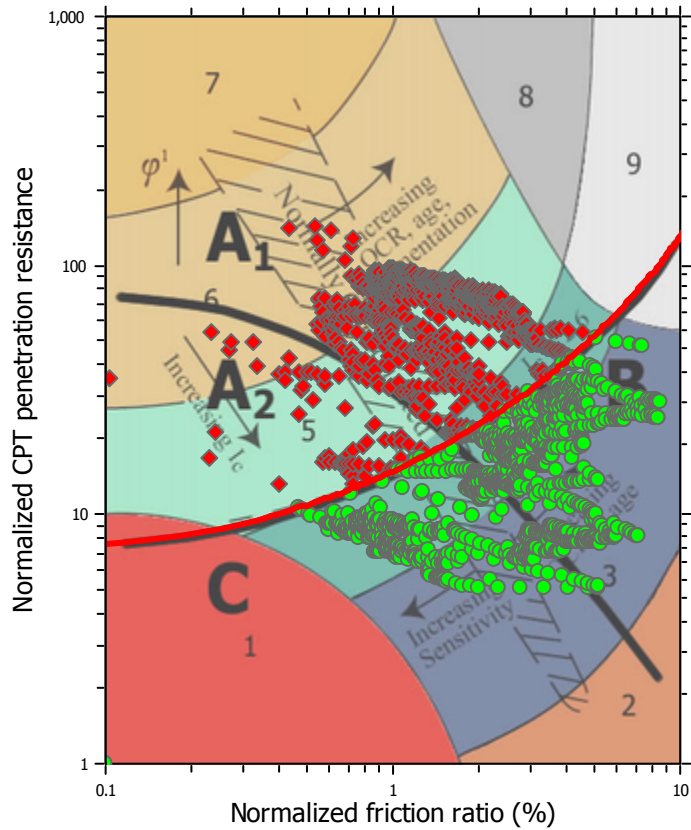
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

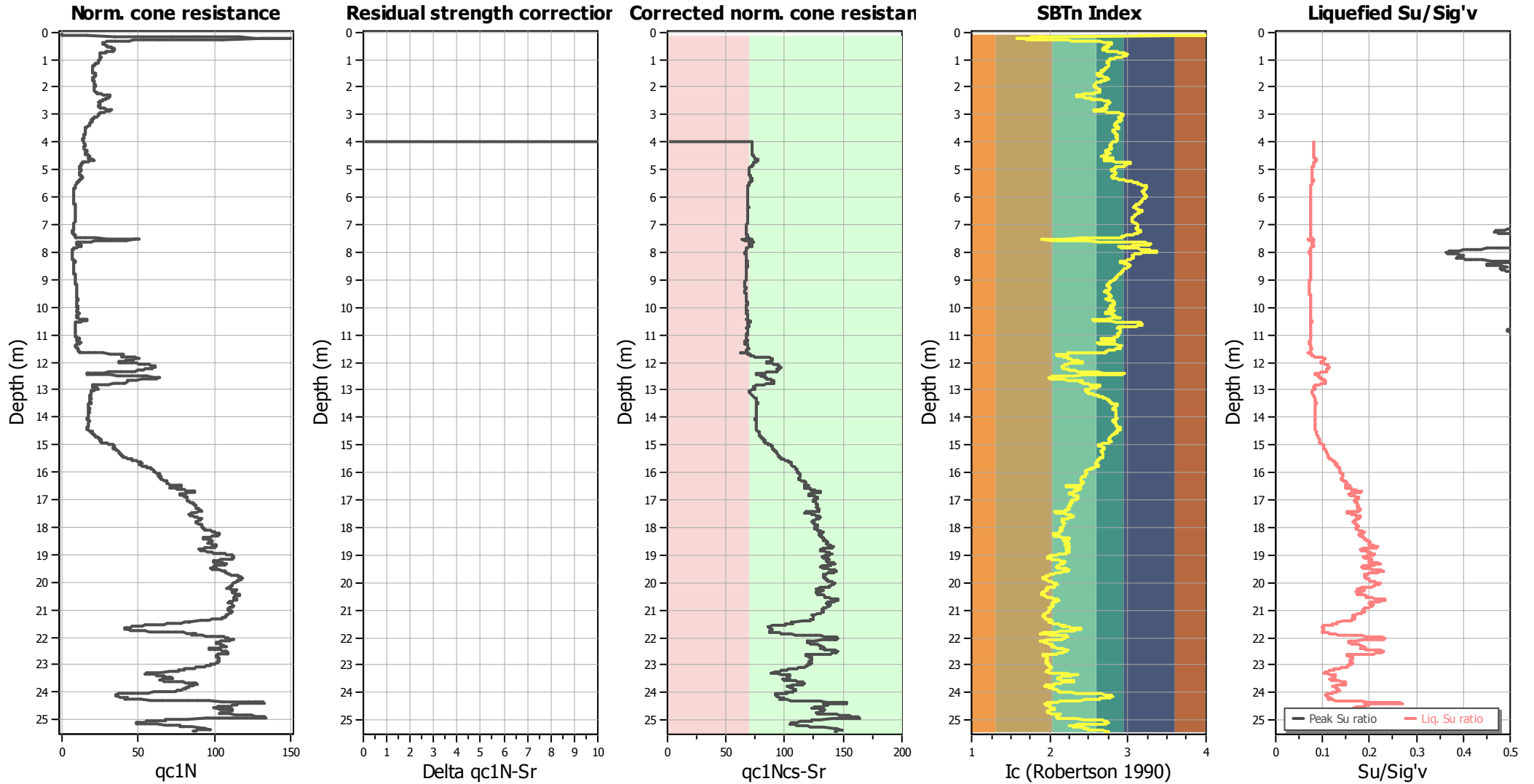
Liquefaction analysis summary plots



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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 m	Fill height:	N/A	Limit depth:	N/A

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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 m	Fill height:	N/A	Limit depth:	N/A

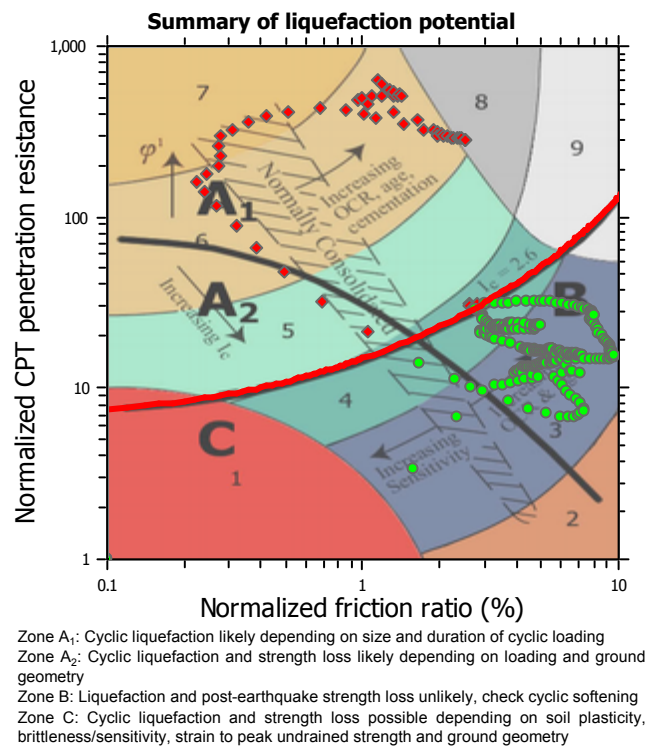
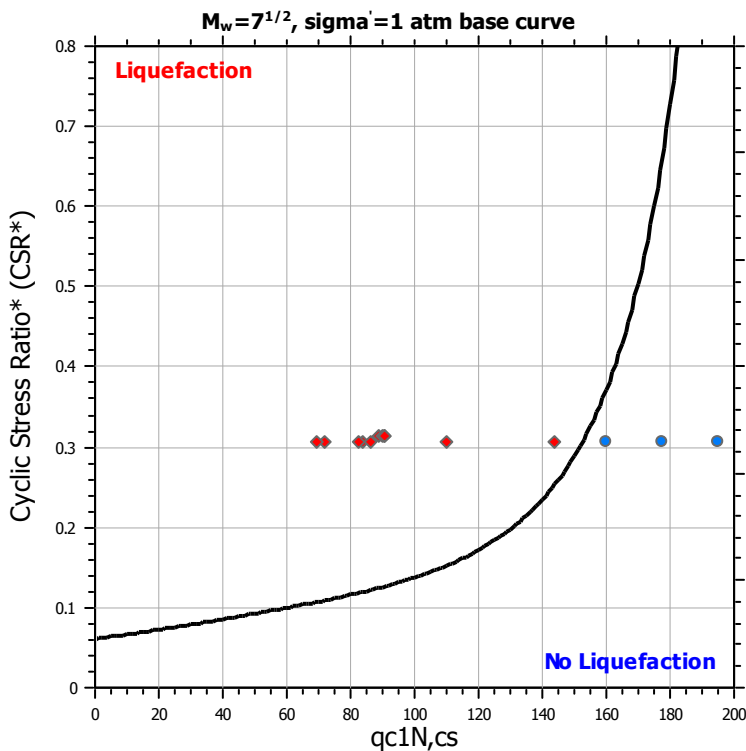
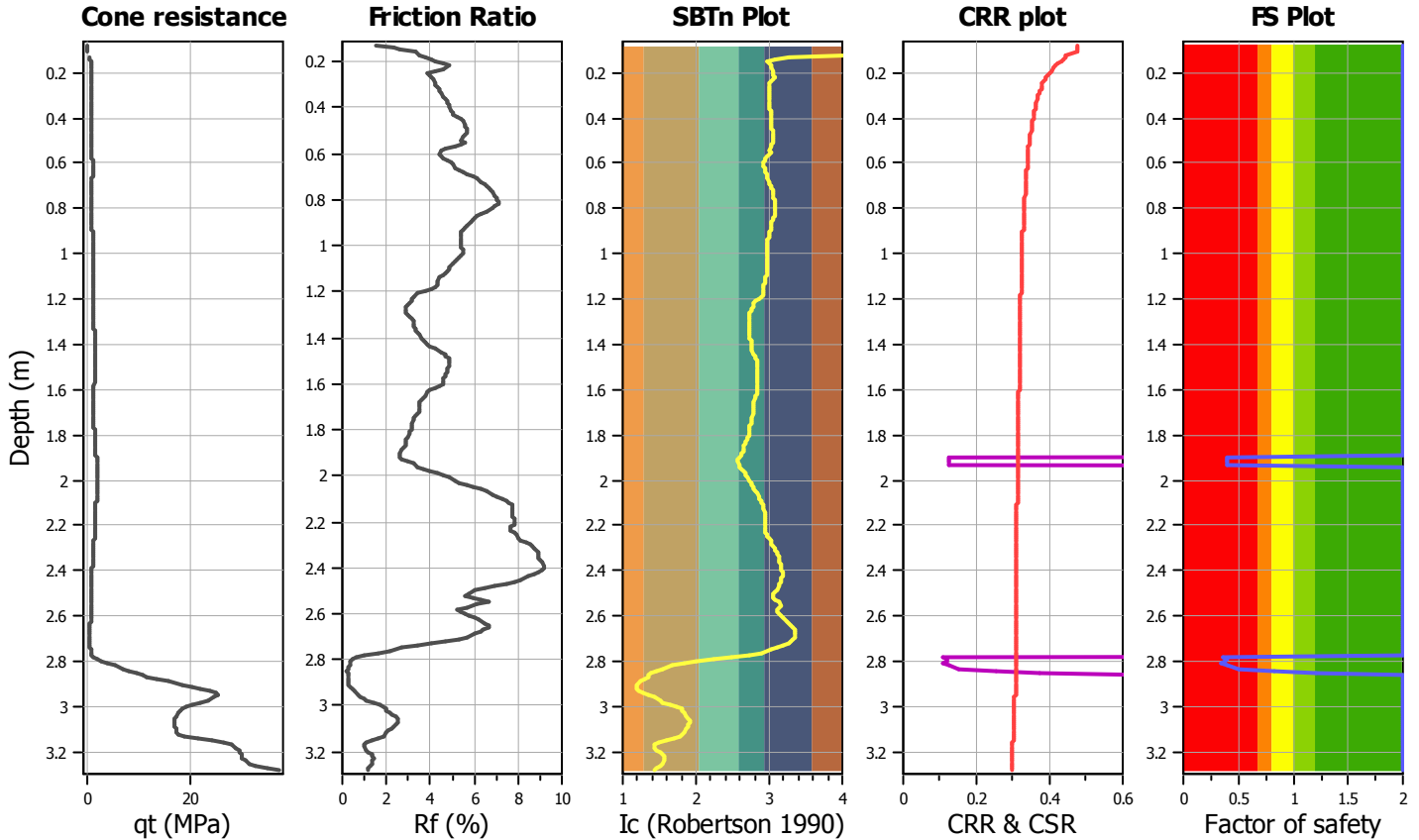
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT06

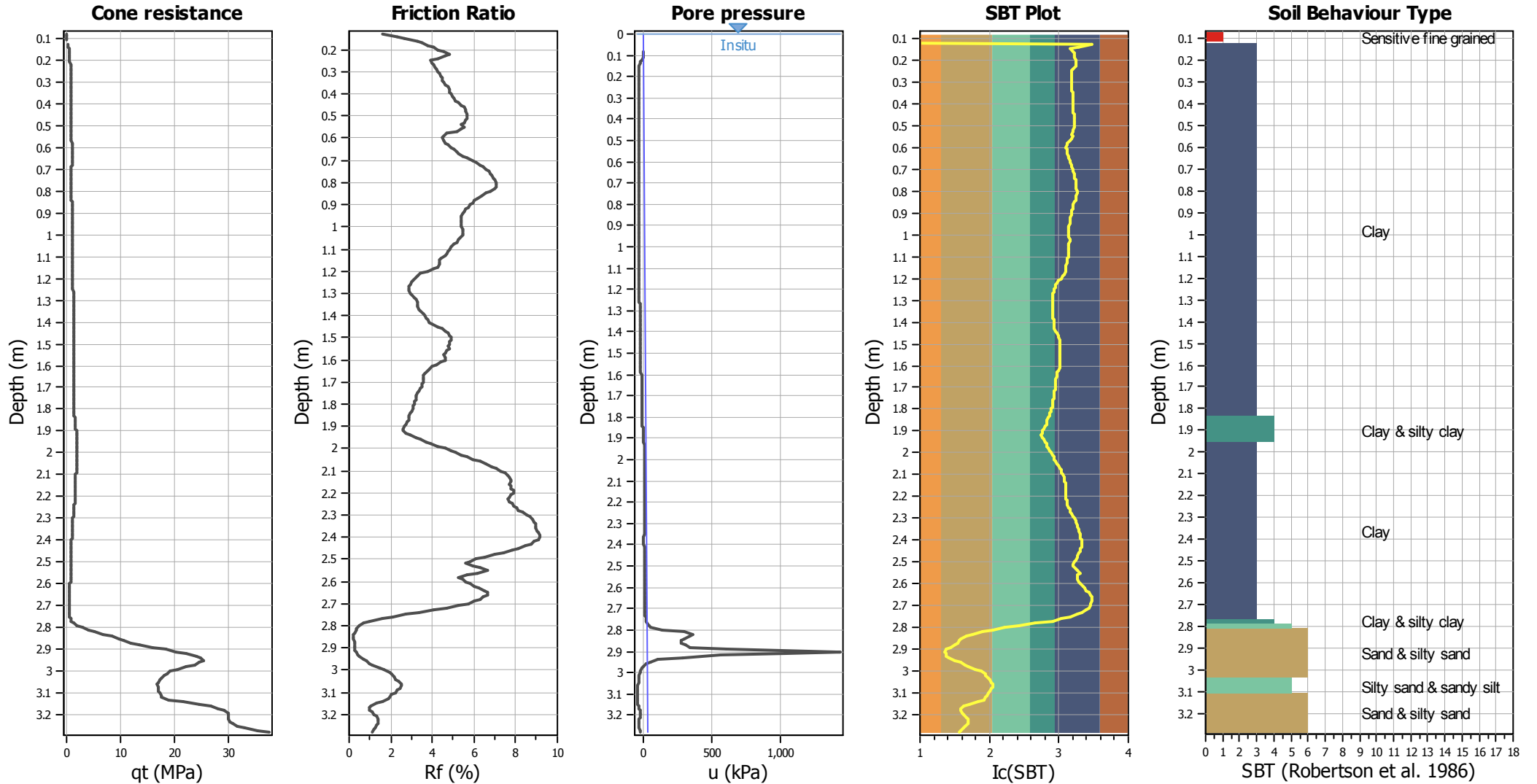
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		



CPT basic interpretation plots



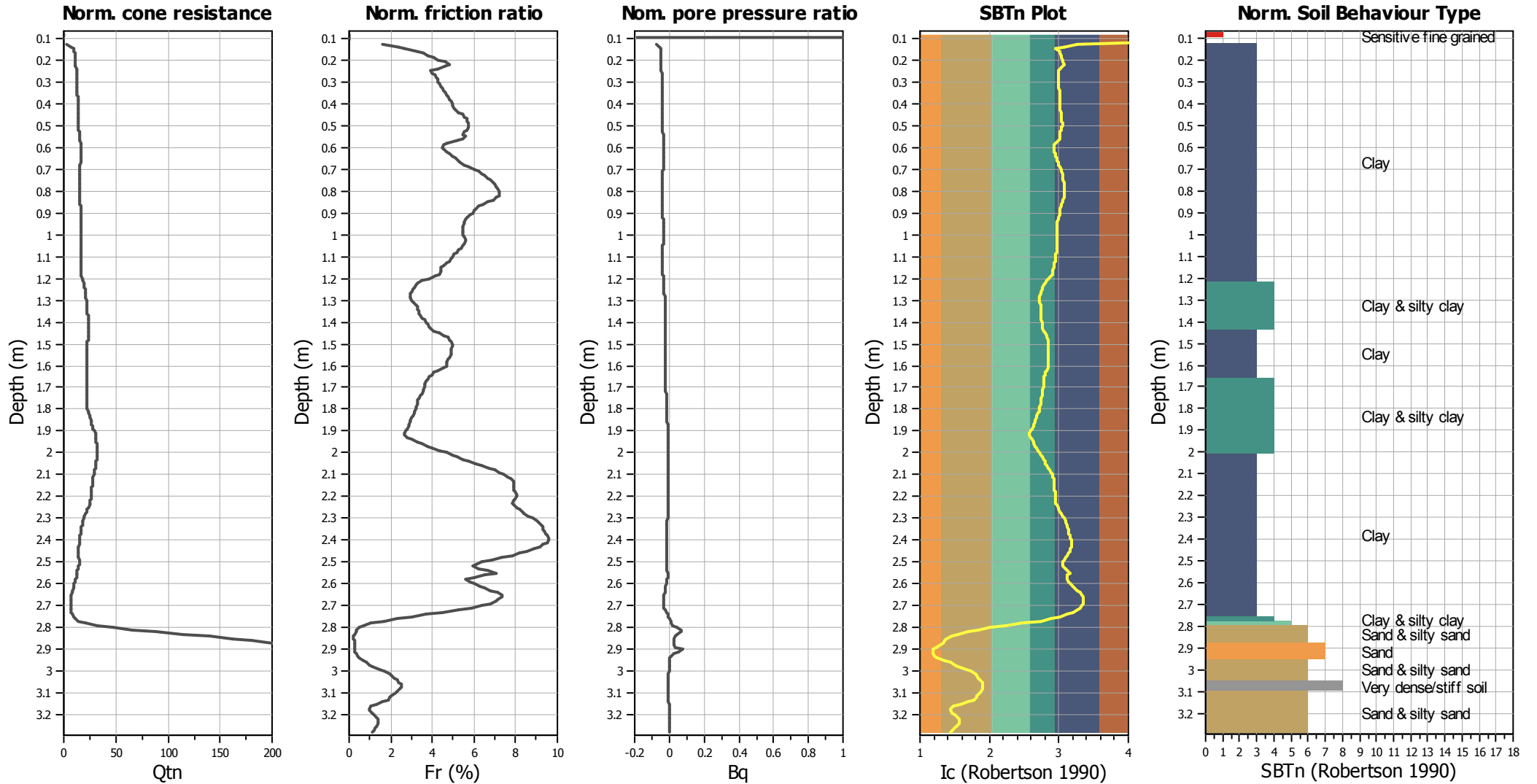
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_f applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

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)



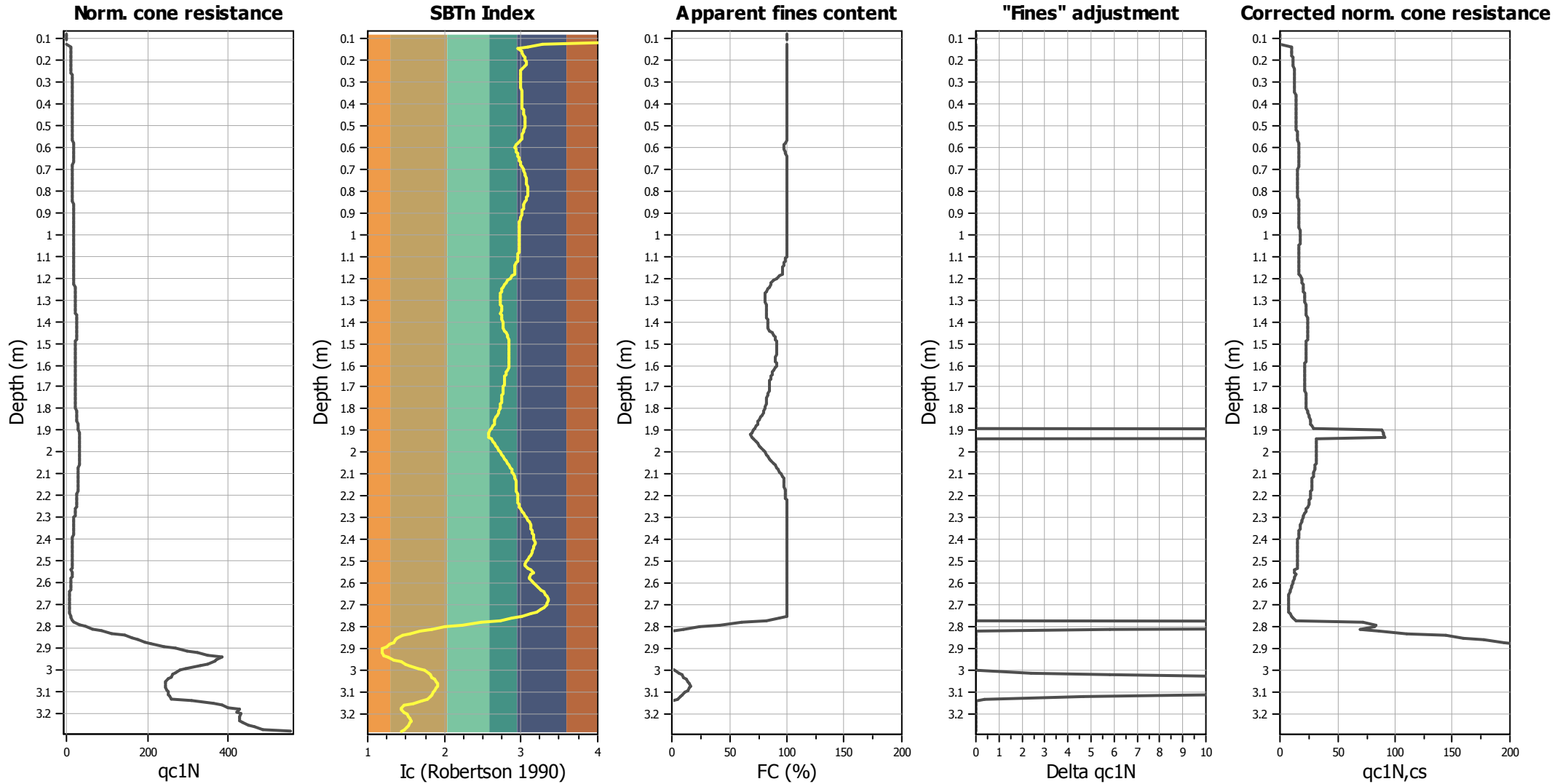
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

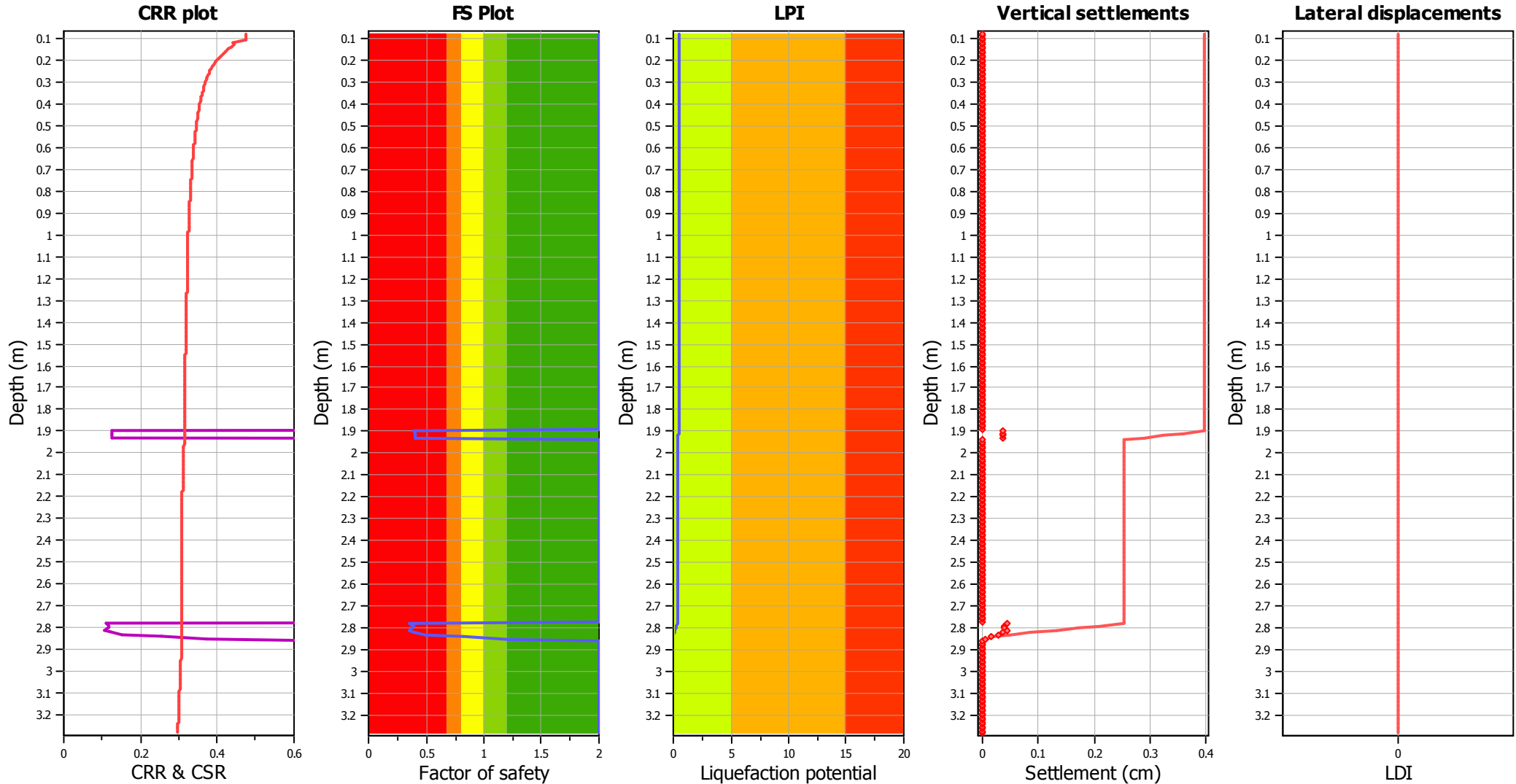
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

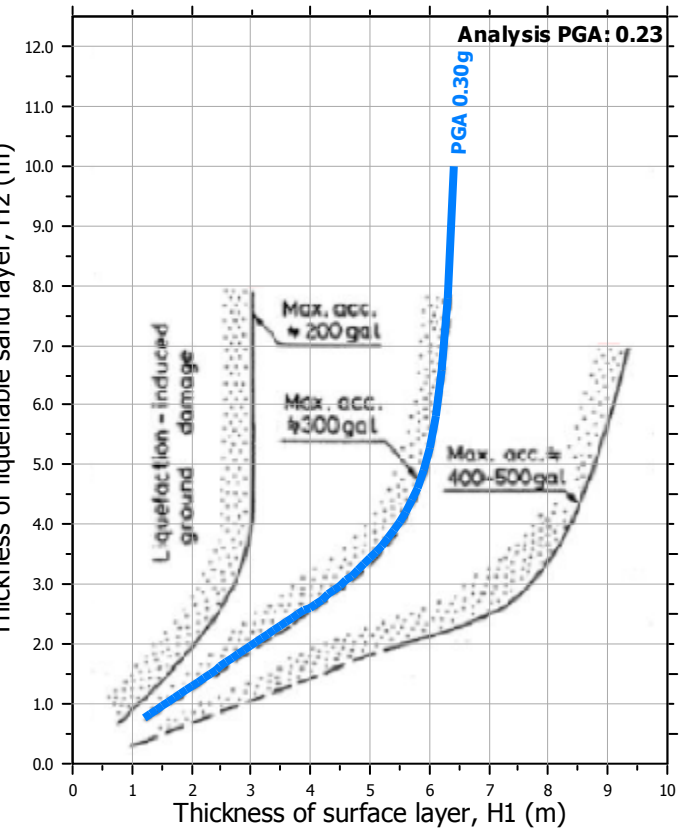
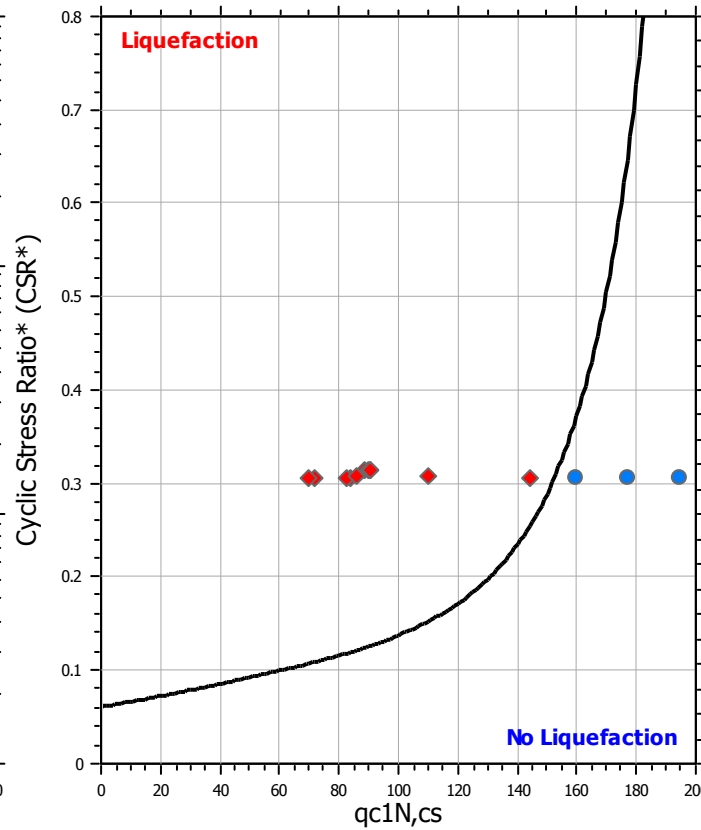
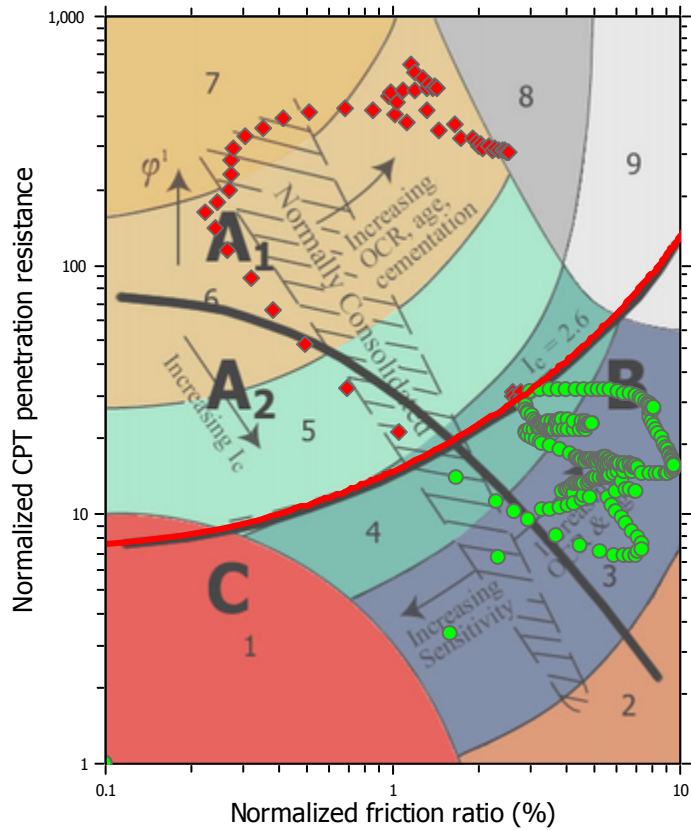
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

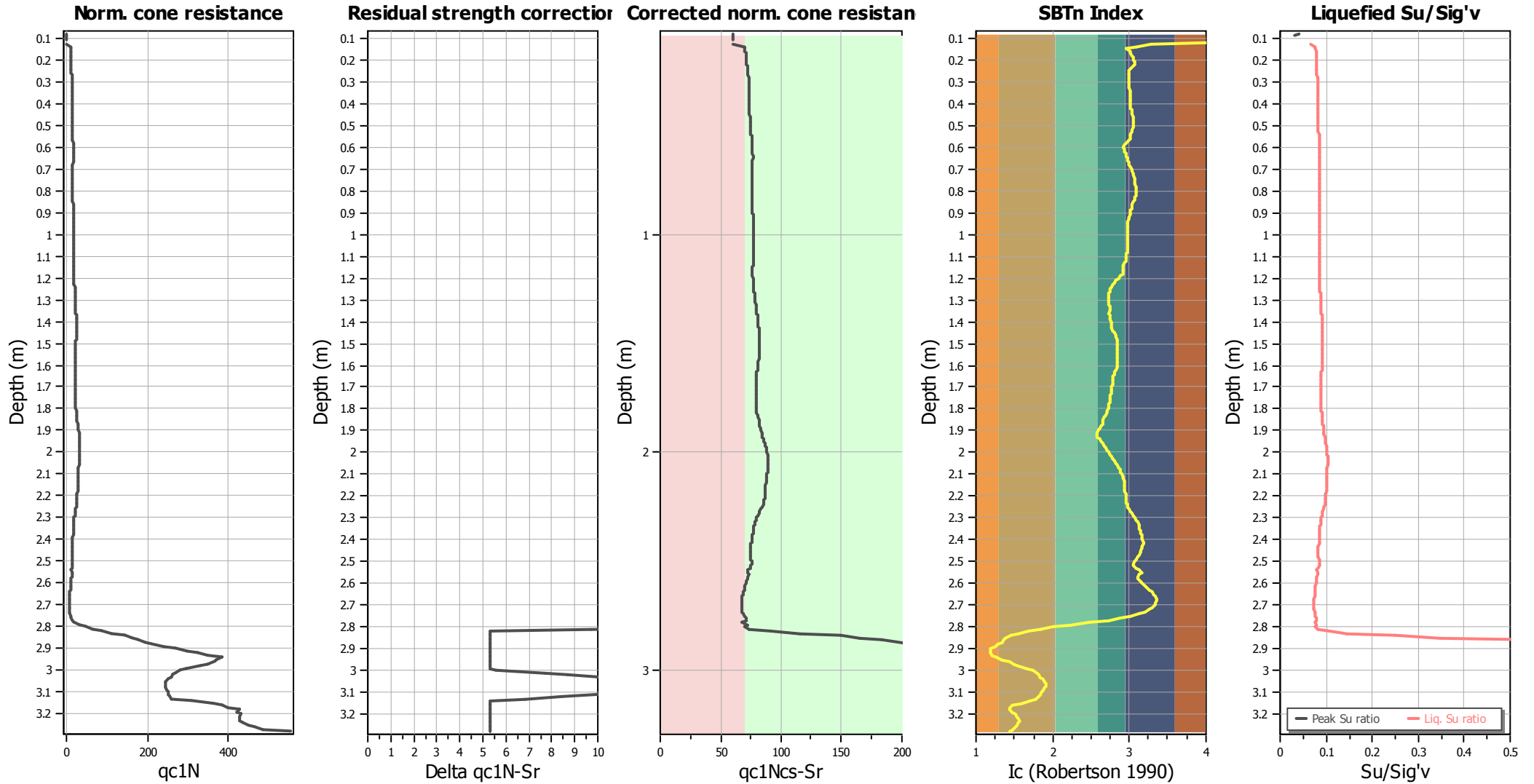
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

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



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

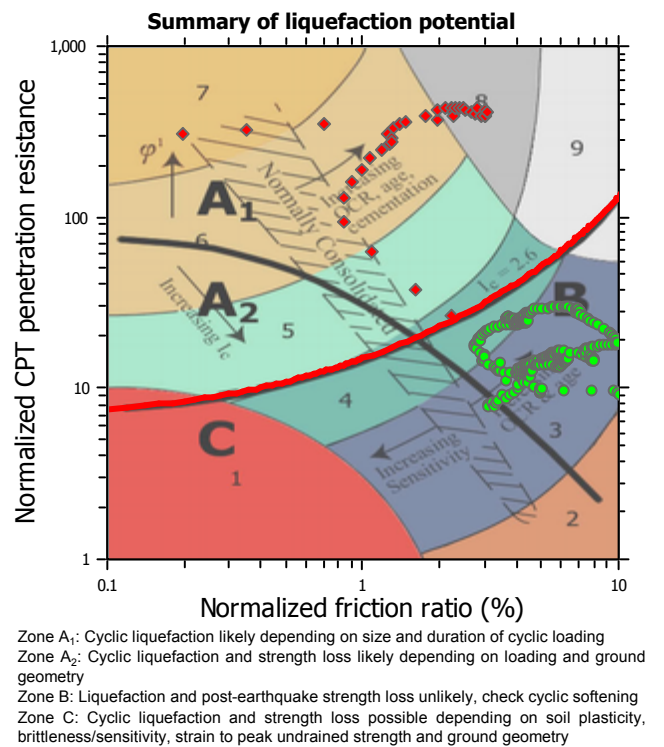
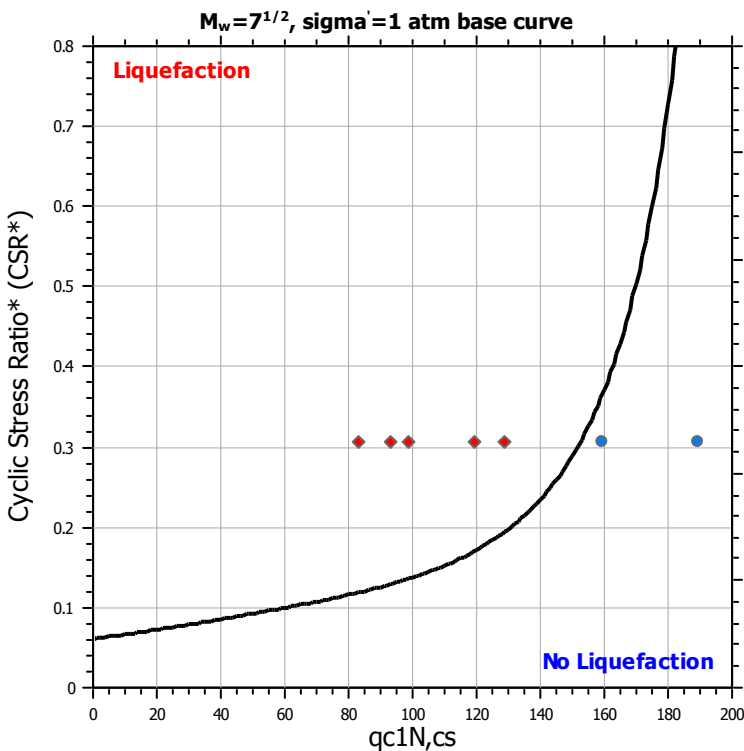
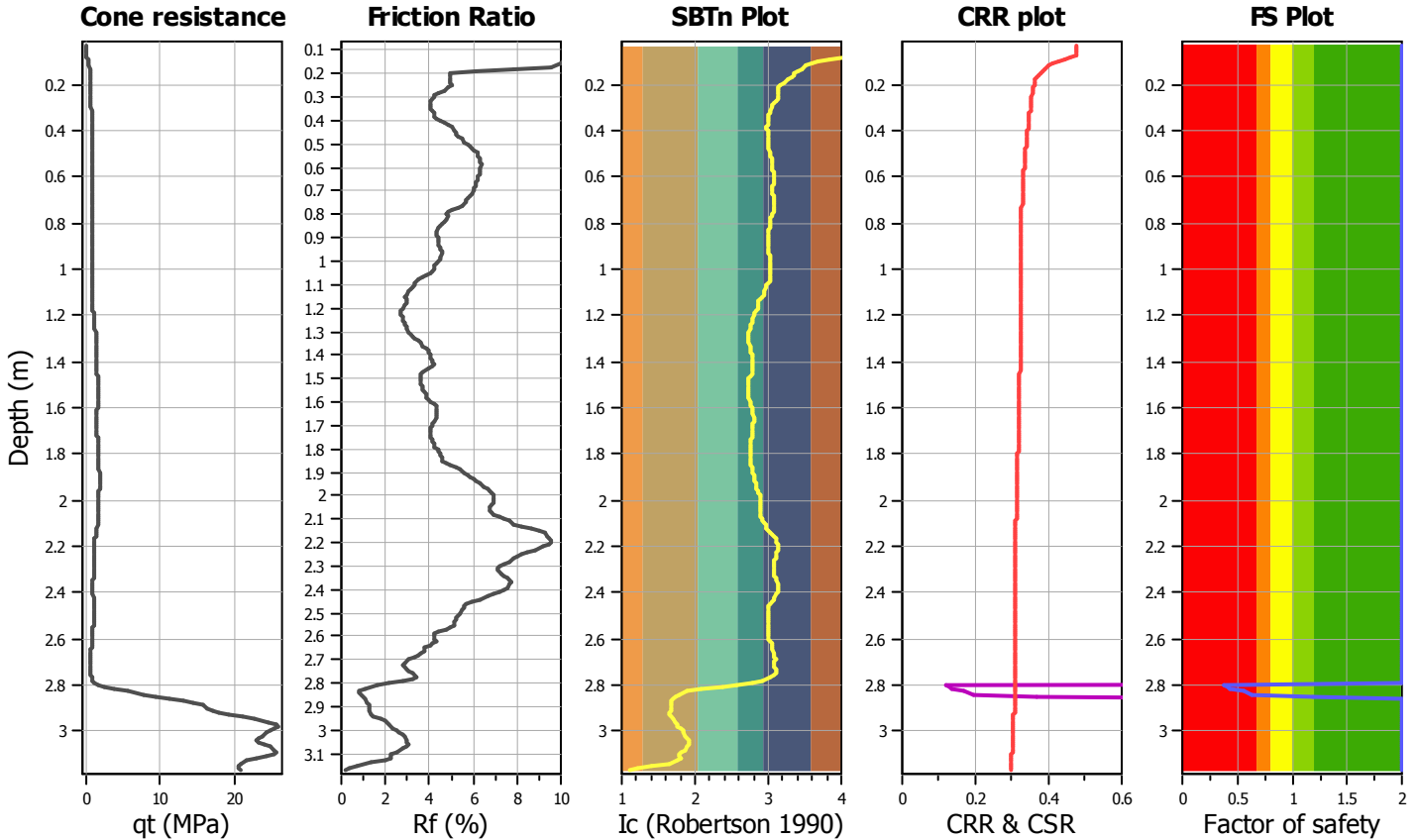
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT06a

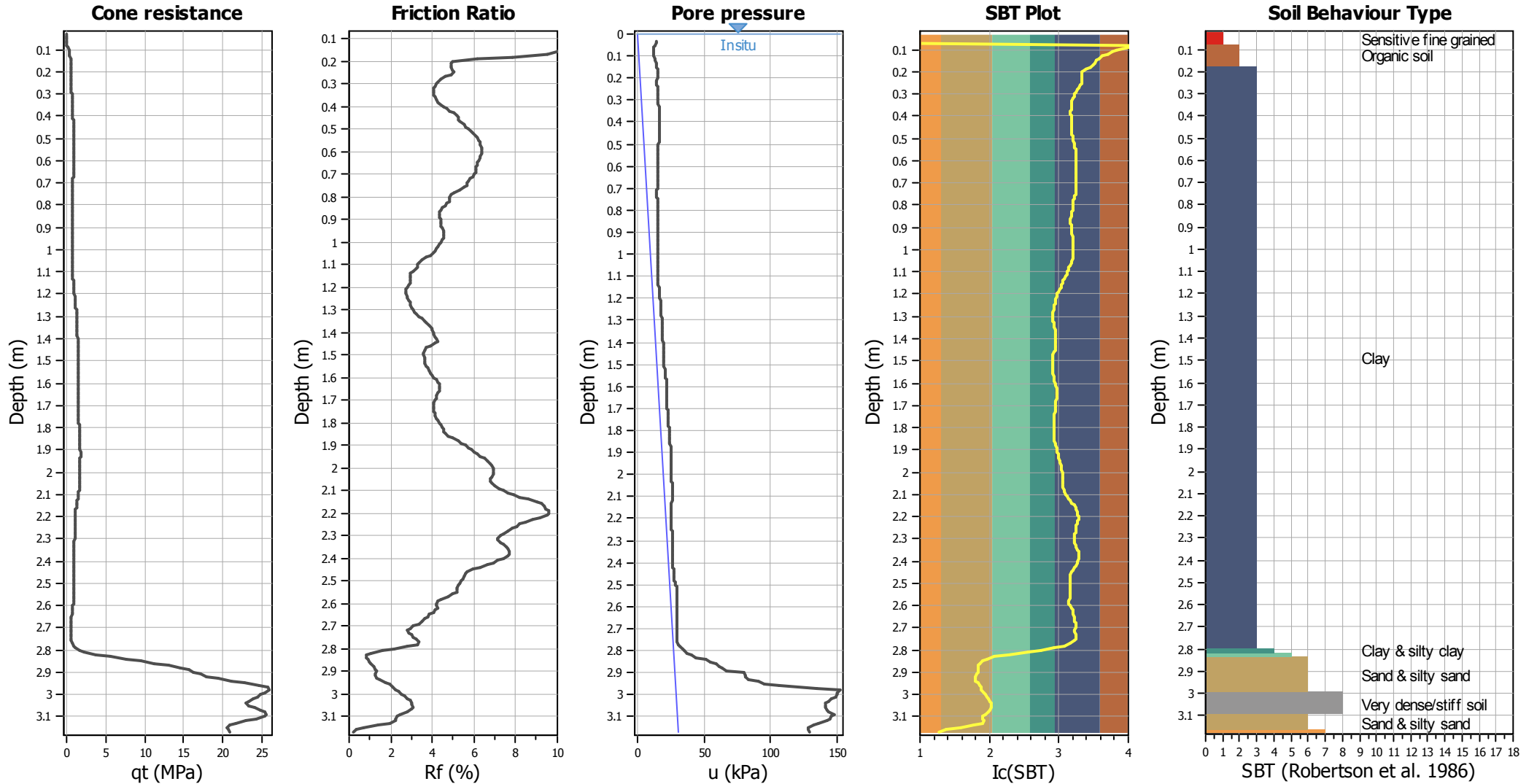
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	0.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	0.00 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method



CPT basic interpretation plots



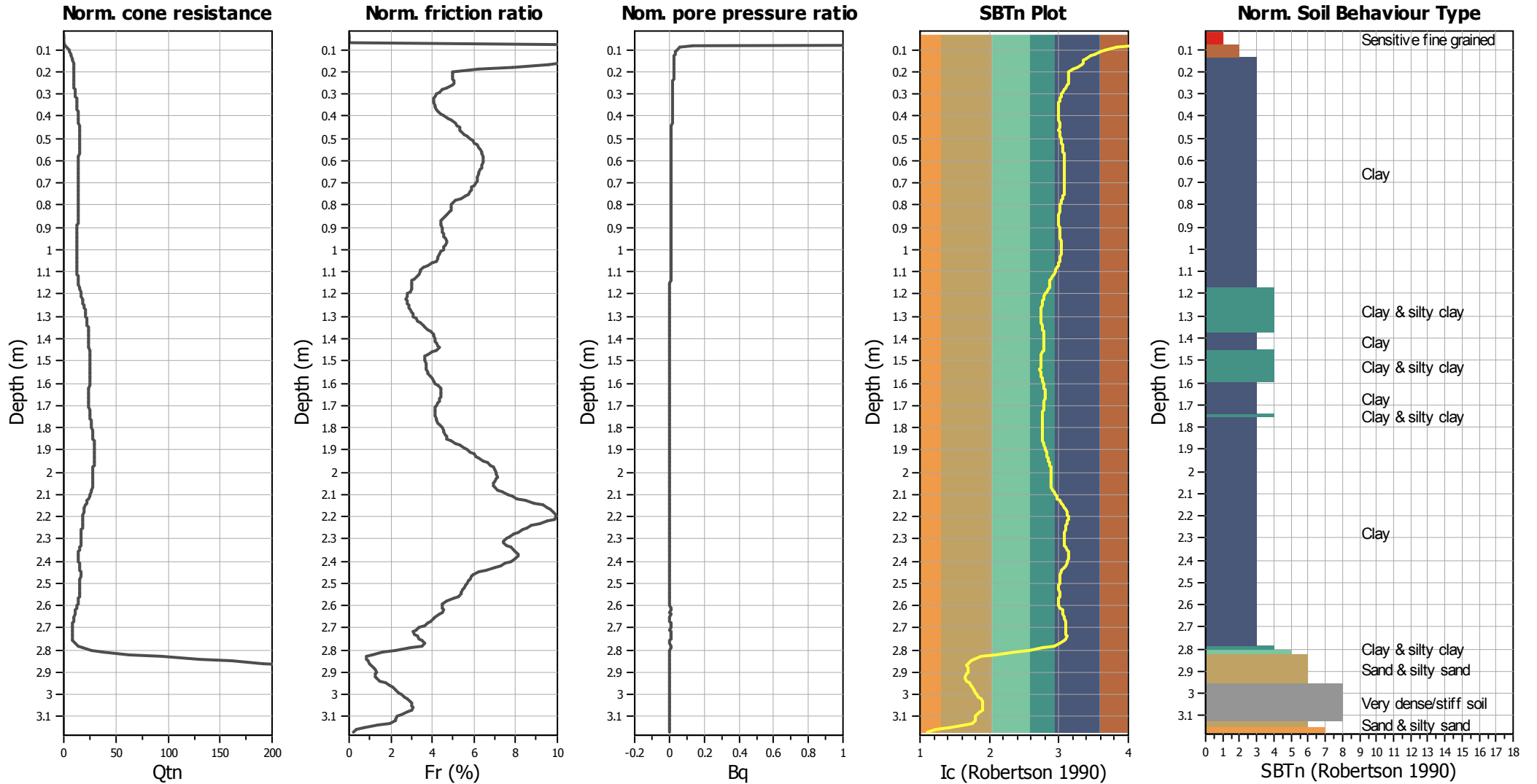
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

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)



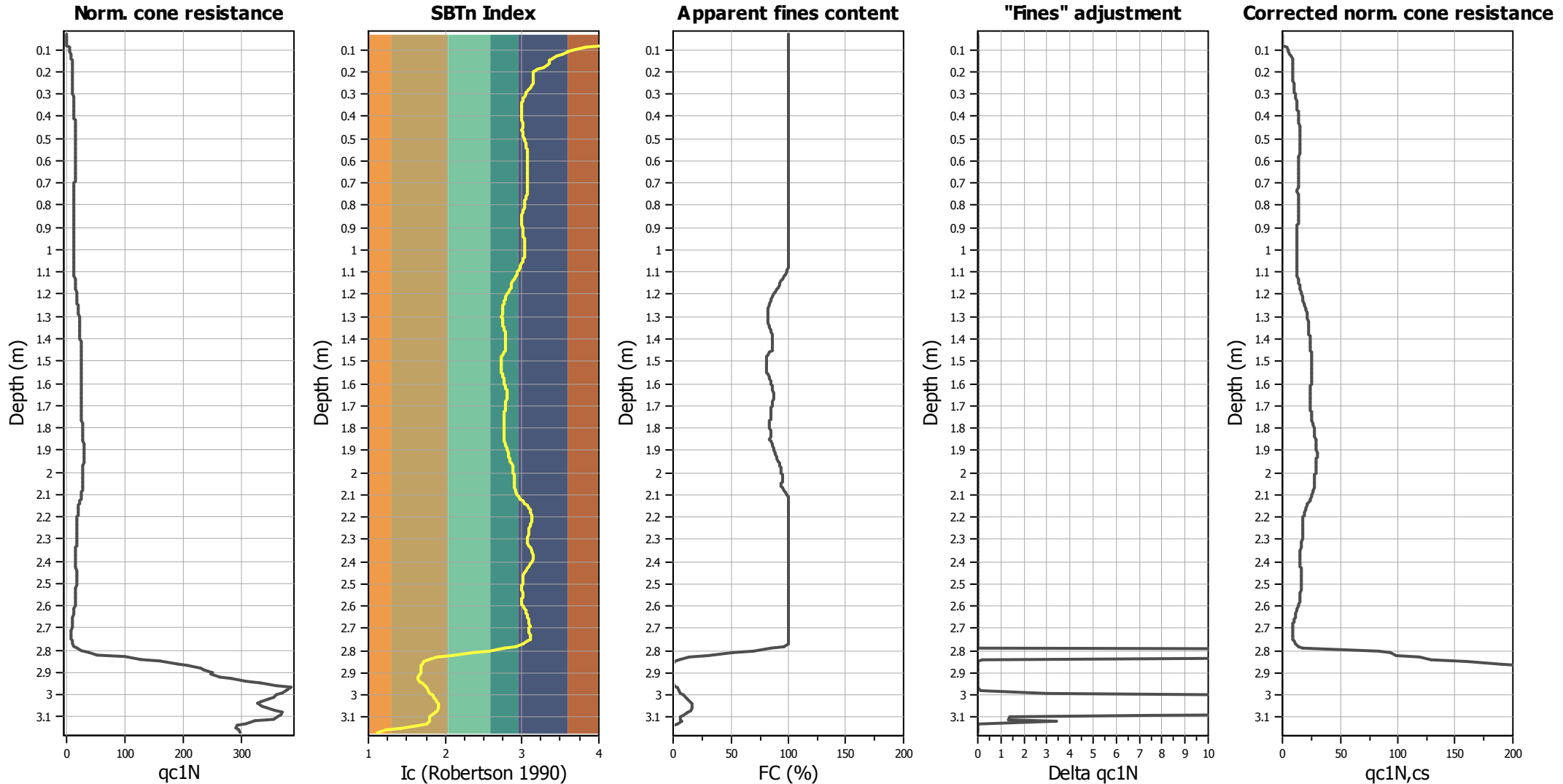
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

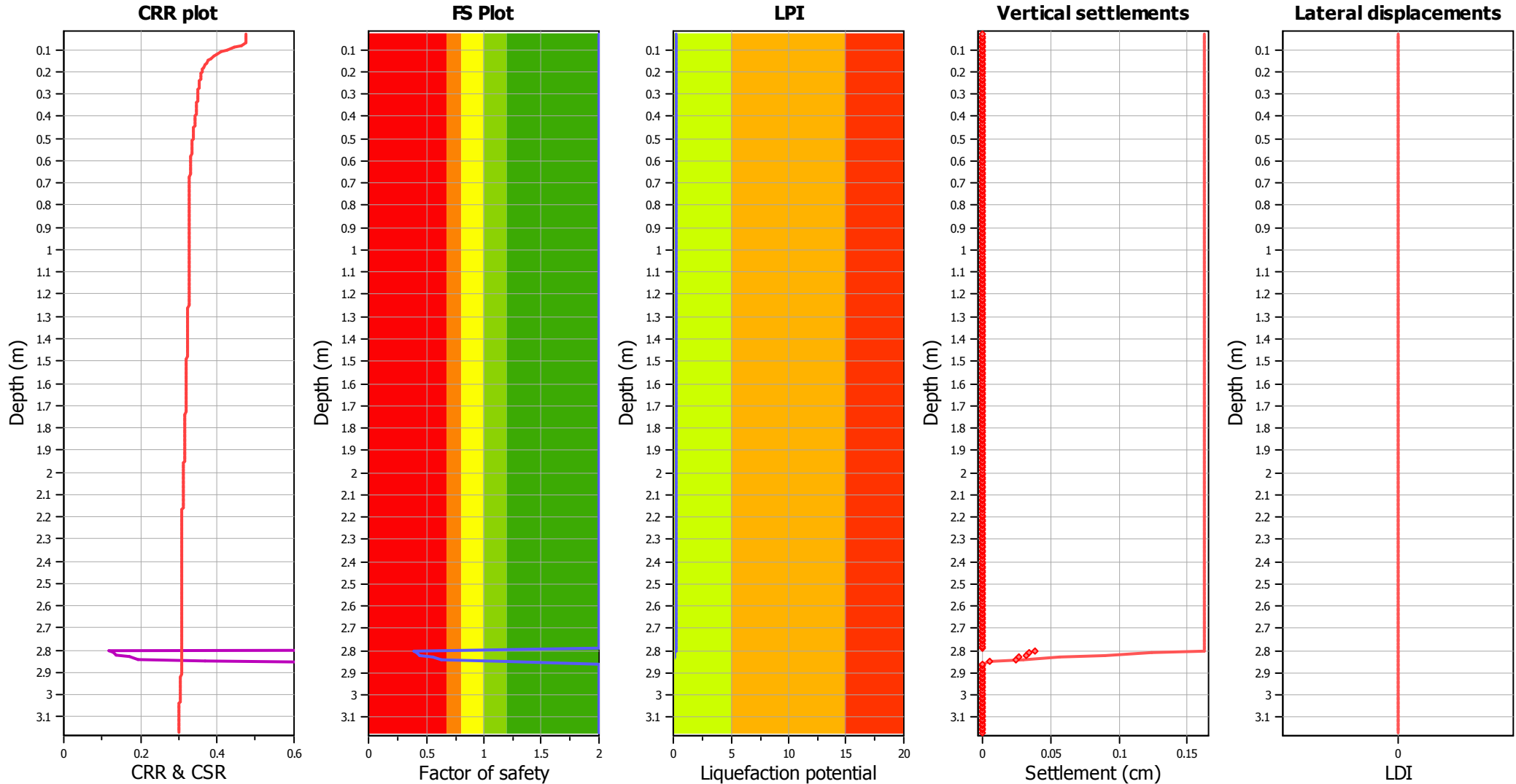
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

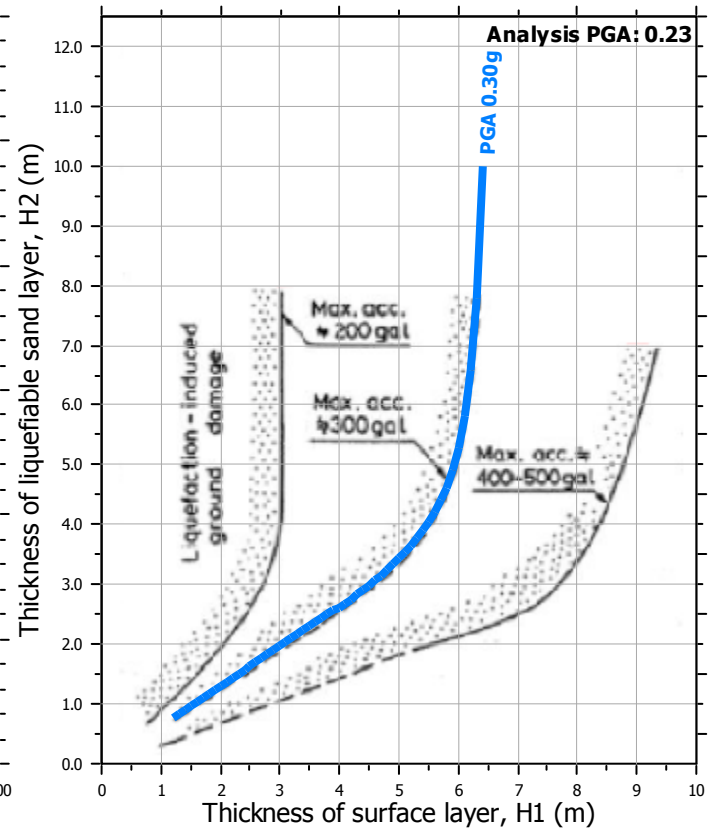
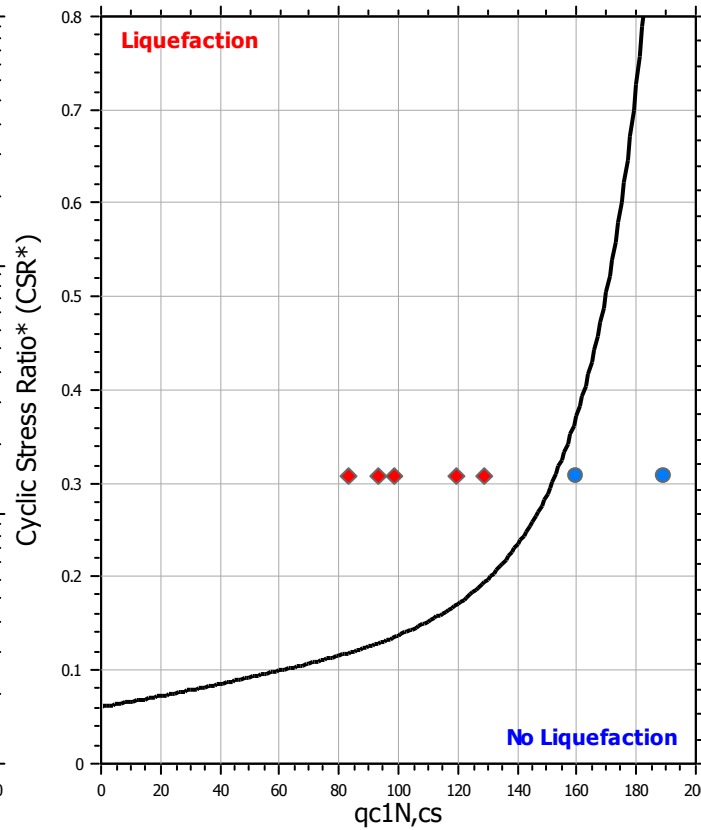
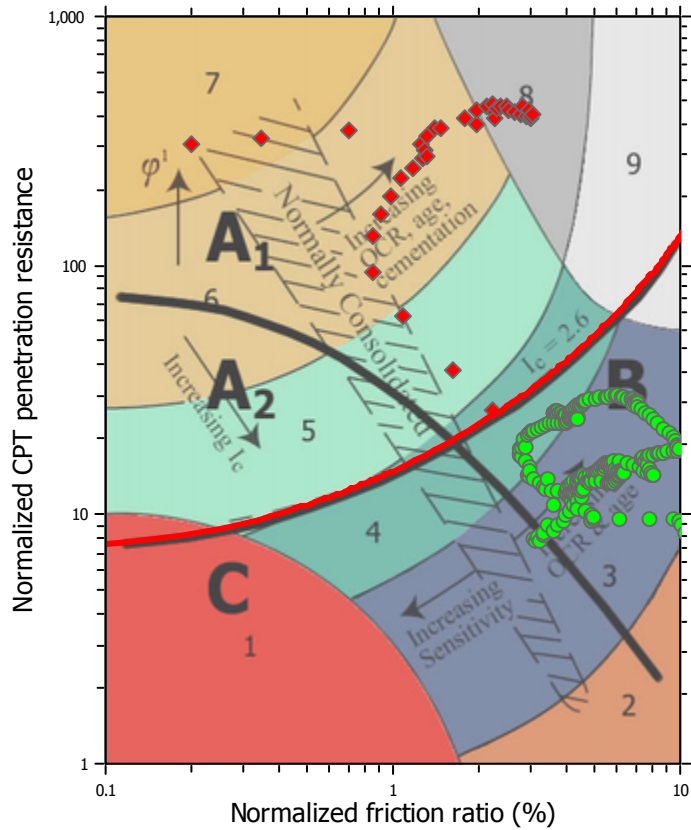
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

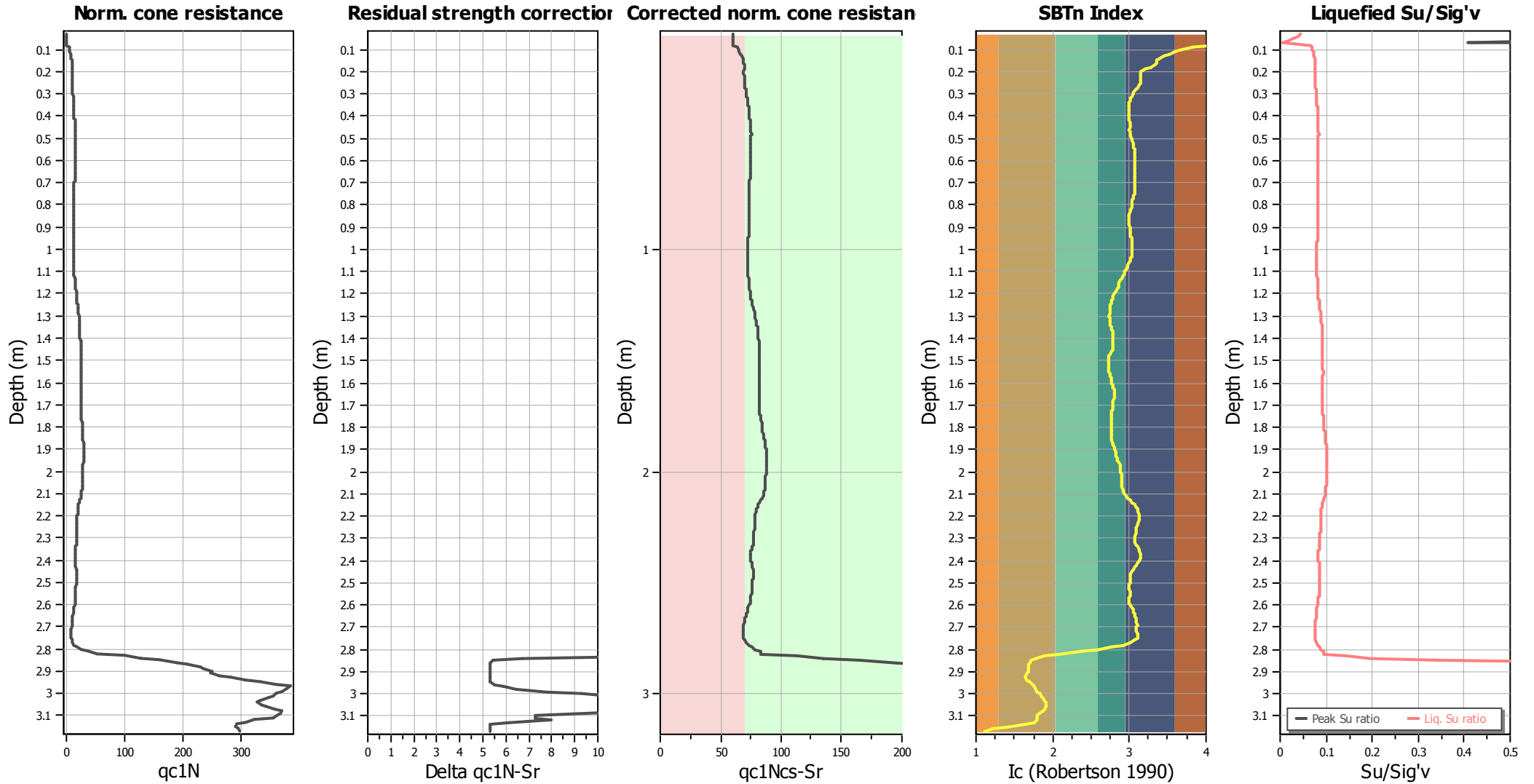
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

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



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.00 m	Fill height:	N/A	Limit depth:	N/A

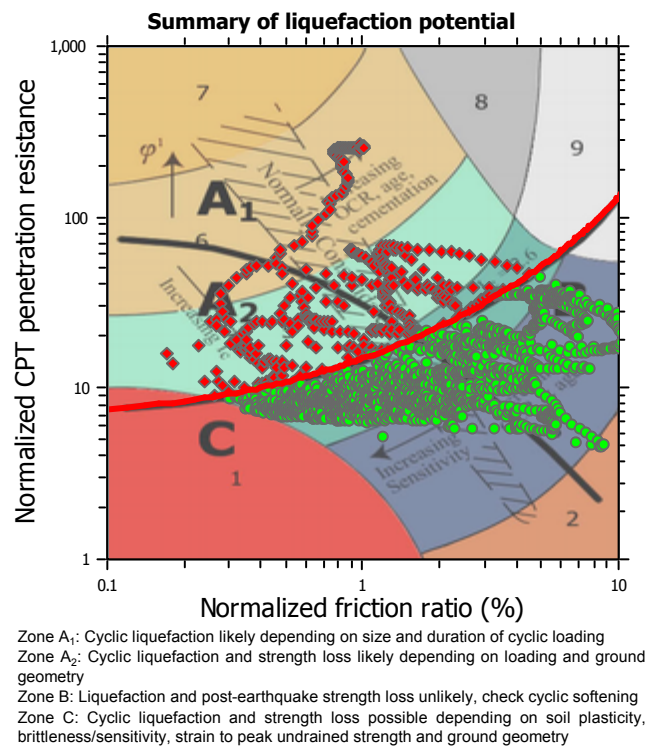
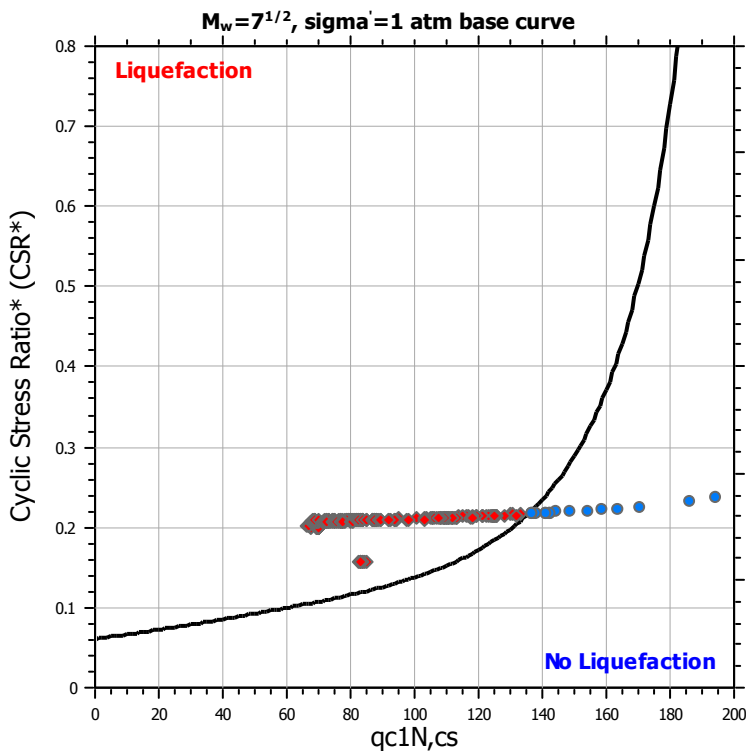
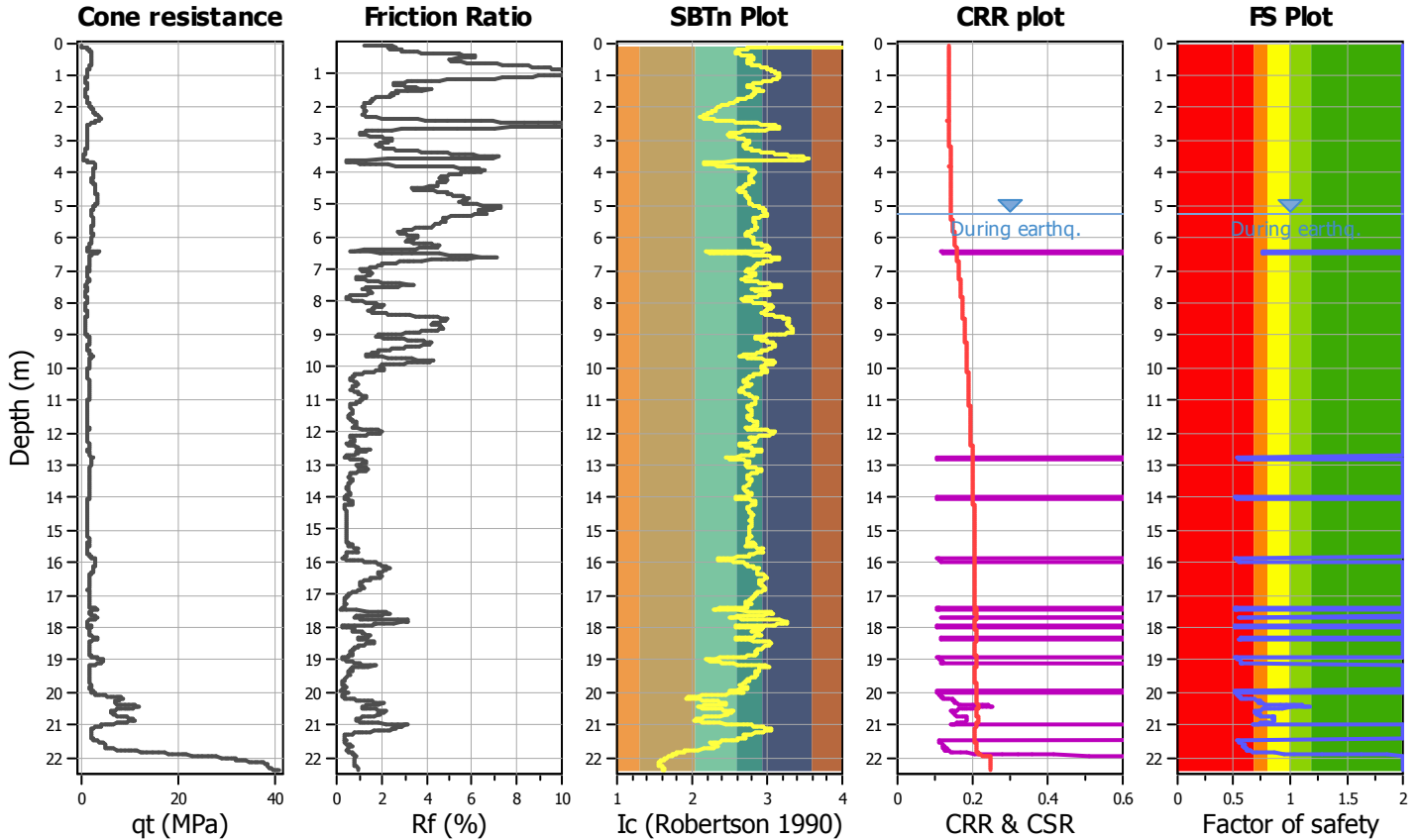
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT07

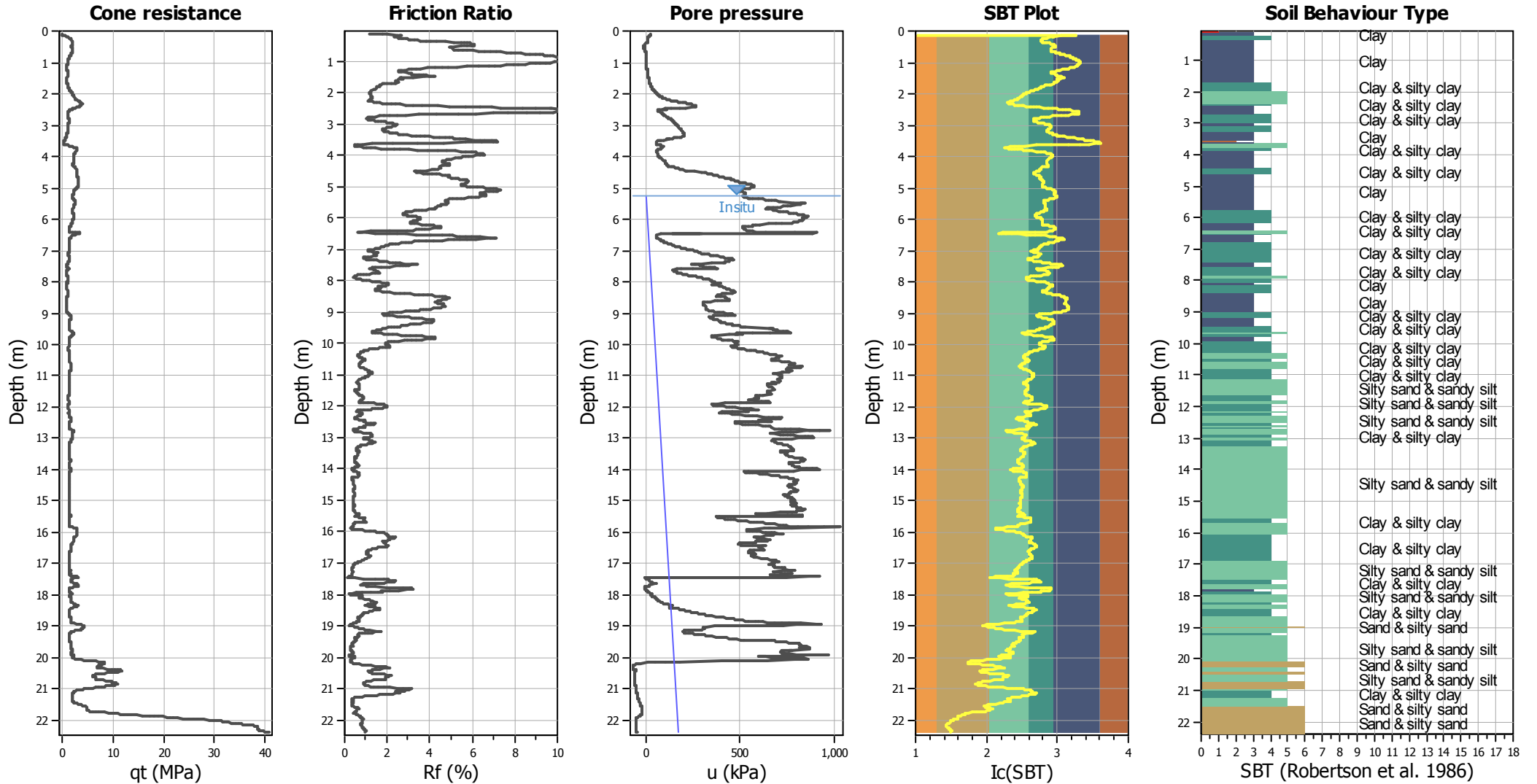
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	5.25 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	5.25 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		



CPT basic interpretation plots



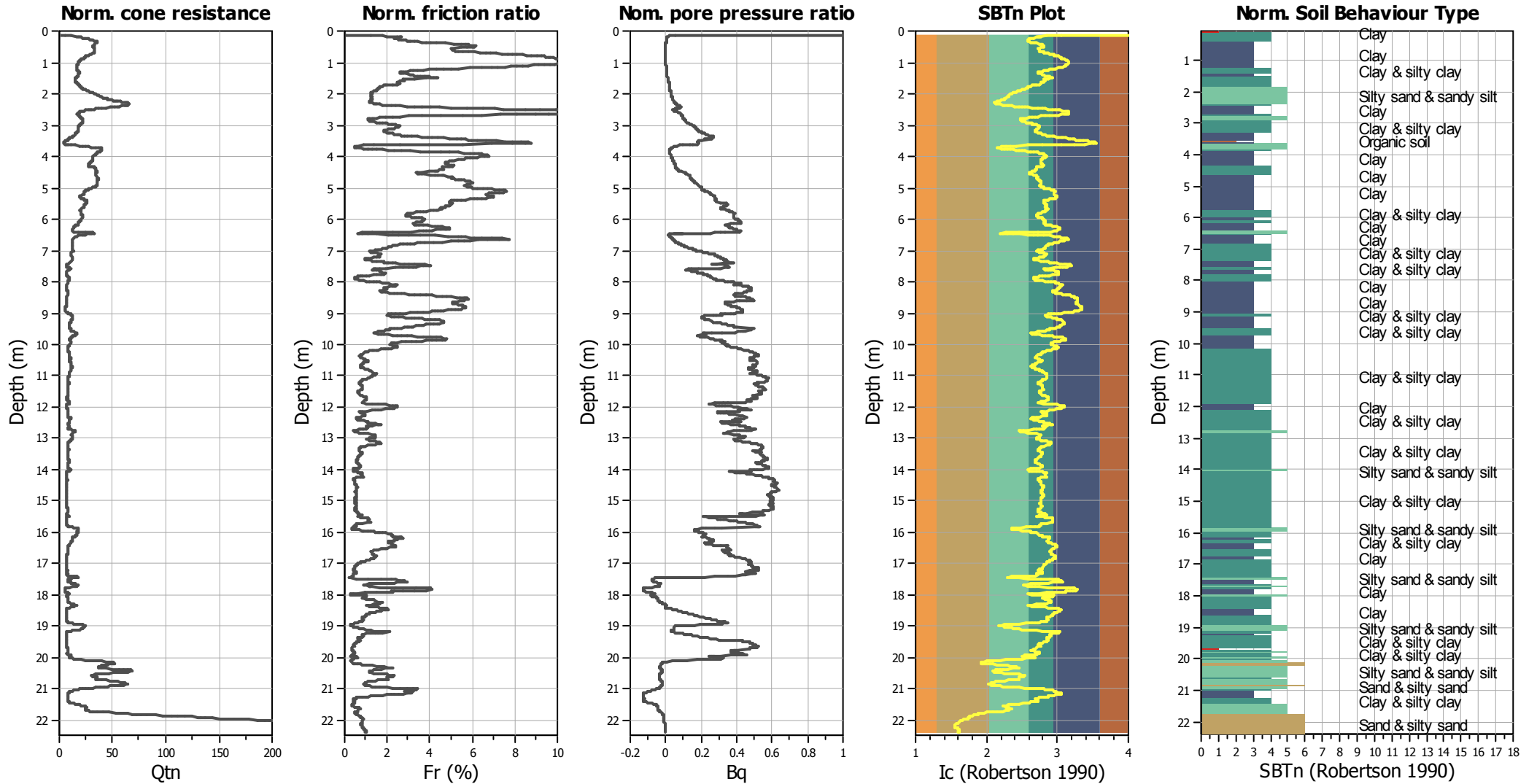
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	5.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.25 m	Fill height:	N/A	Limit depth:	N/A

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)



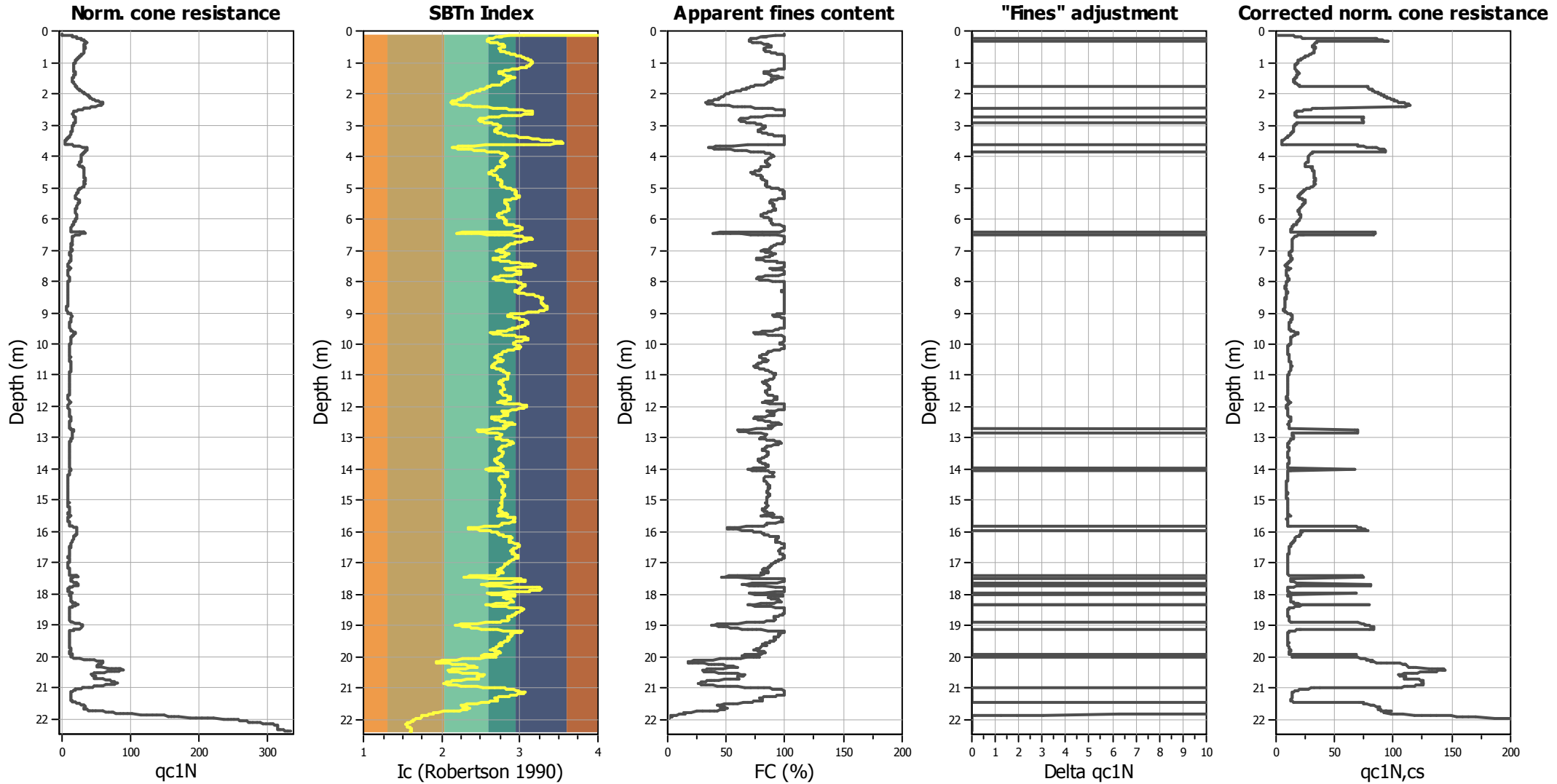
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	5.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.25 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

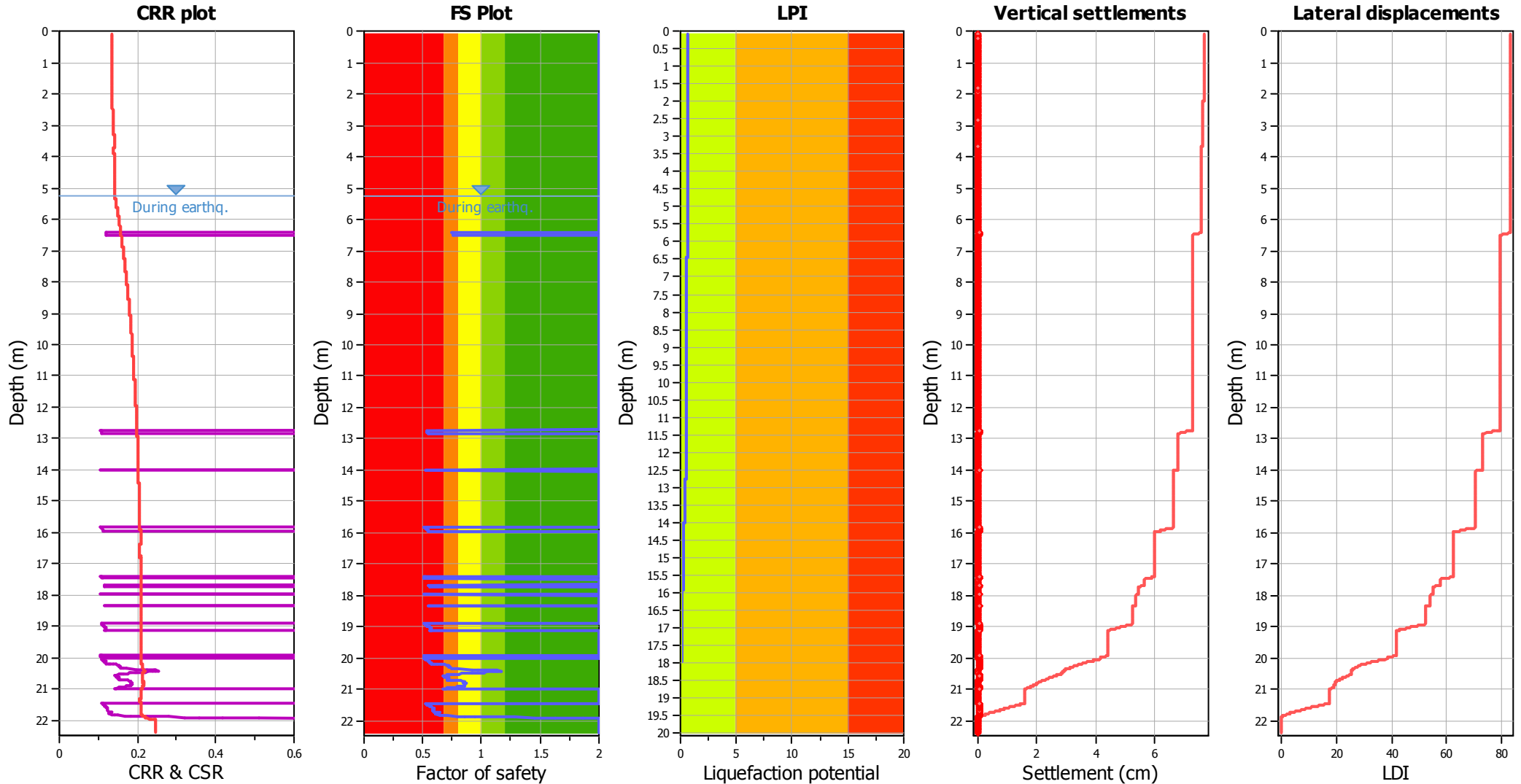
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	5.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _σ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.25 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (earthq.):	5.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.25 m	Fill height:	N/A	Limit depth:	N/A

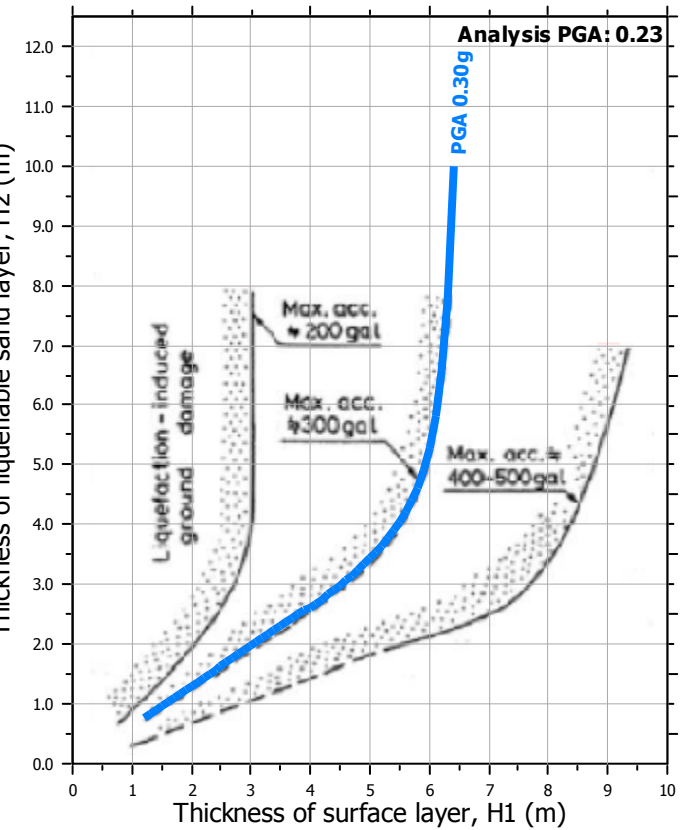
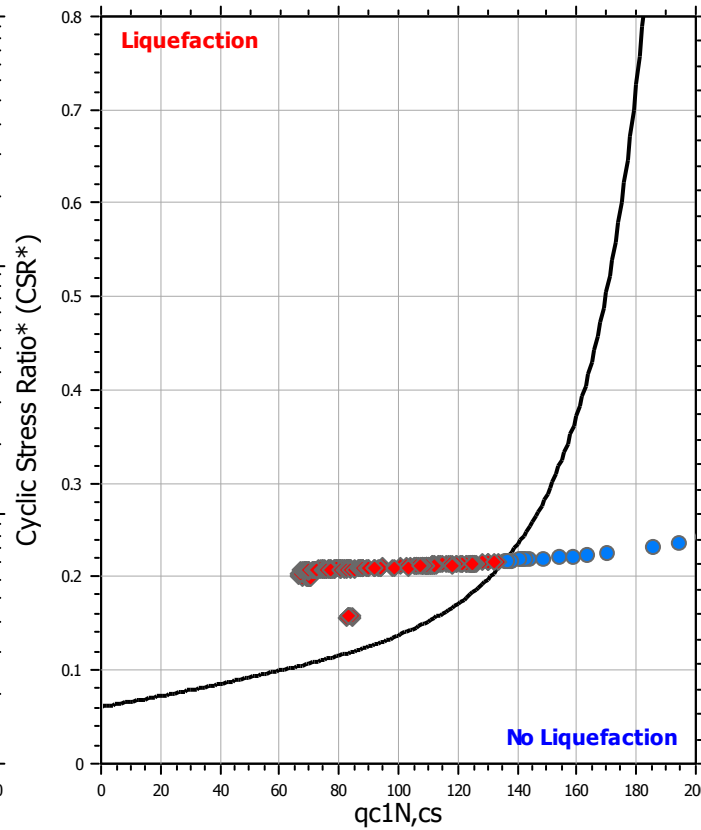
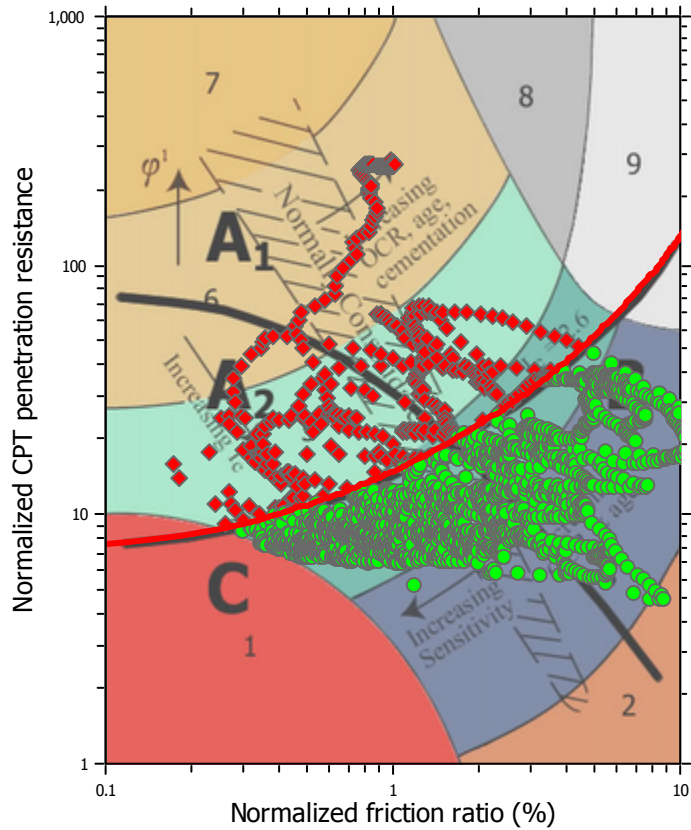
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

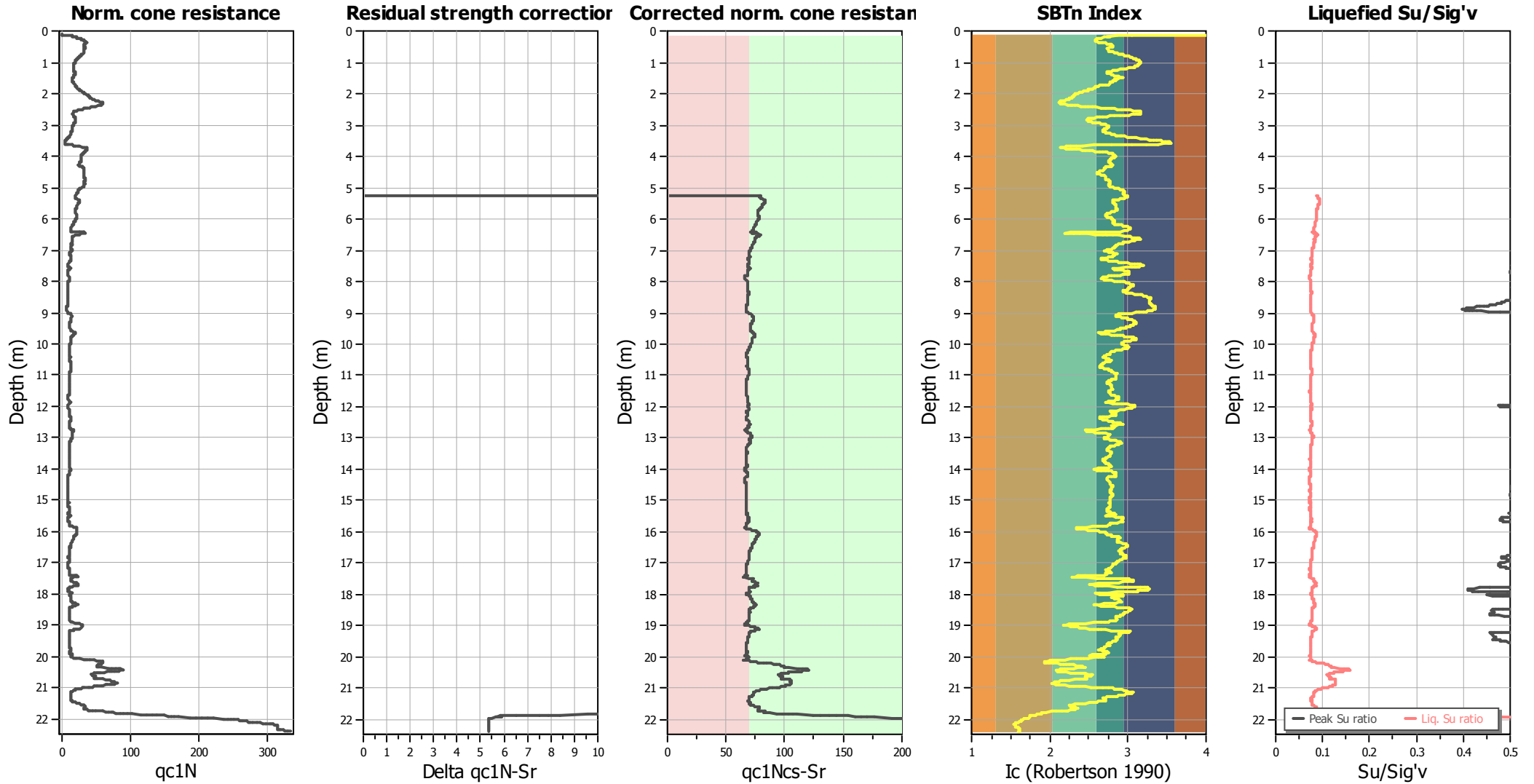
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	5.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.25 m	Fill height:	N/A	Limit depth:	N/A

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



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	5.25 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _σ applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.25 m	Fill height:	N/A	Limit depth:	N/A

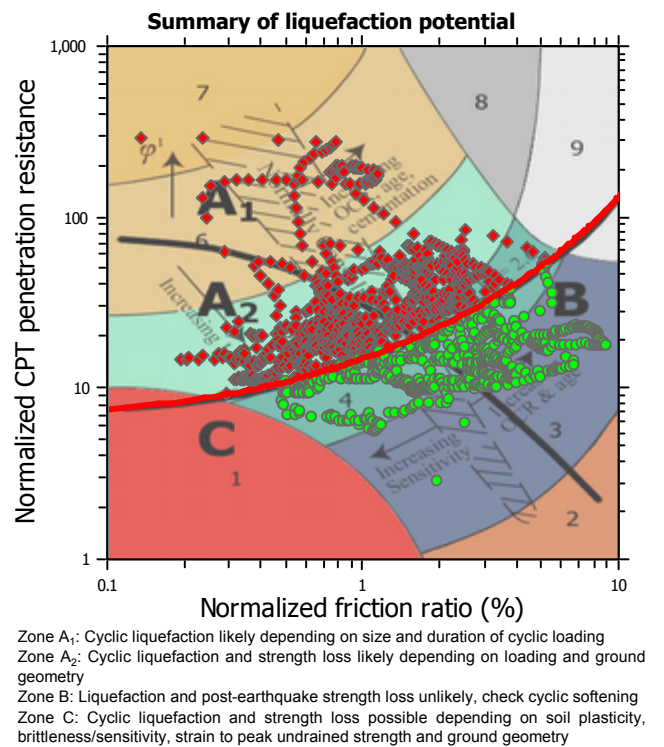
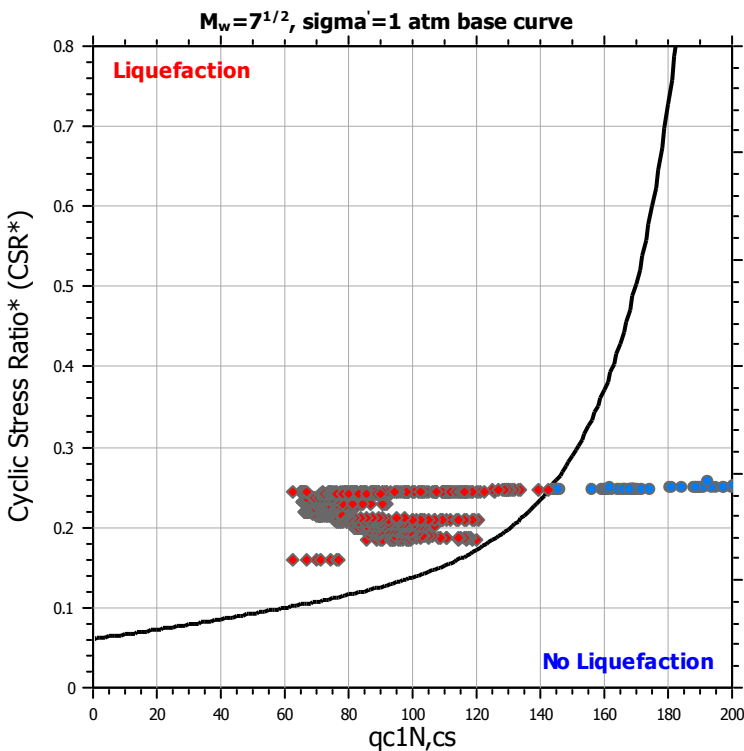
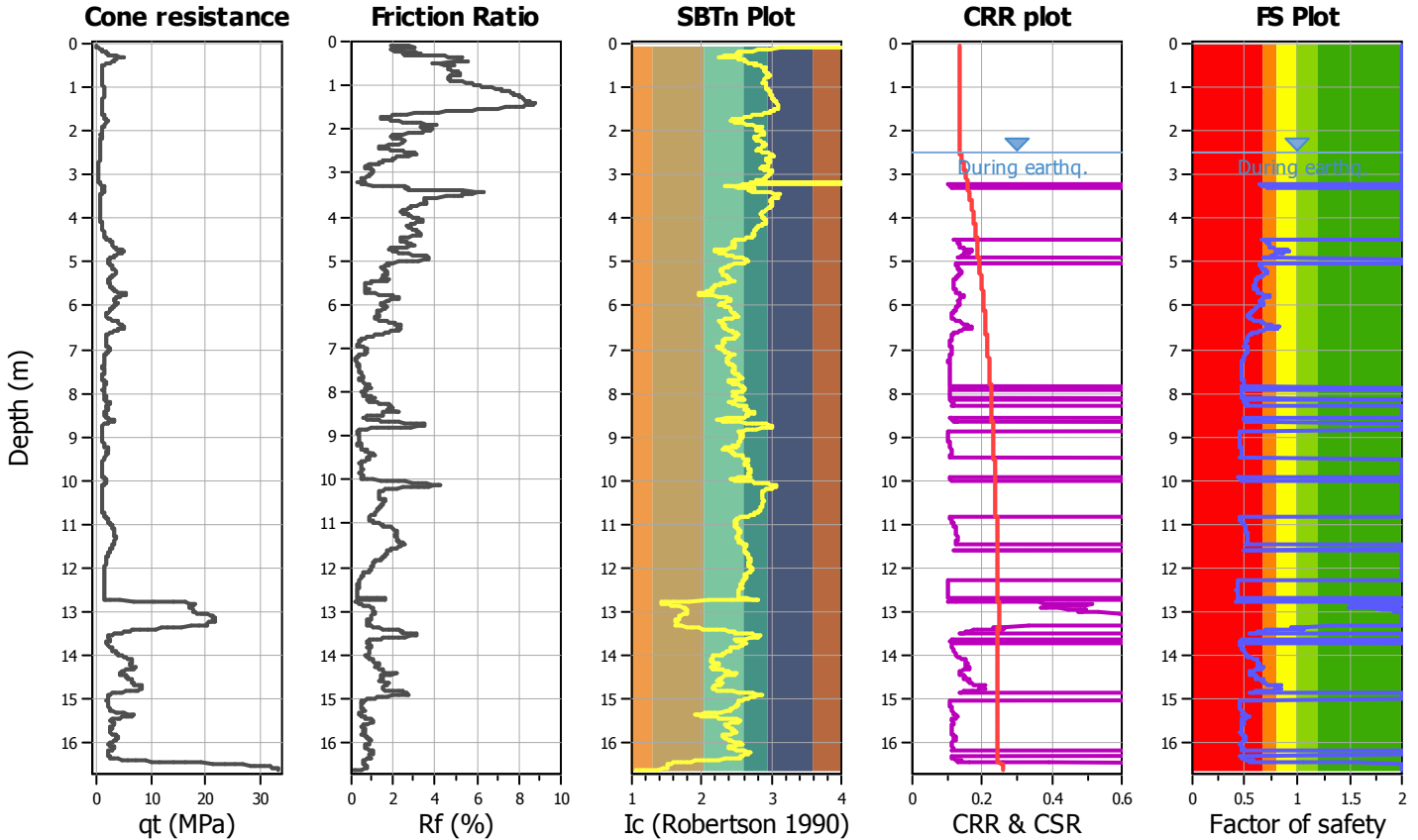
LIQUEFACTION ANALYSIS REPORT

Project title : Drury West Secondary School
CPT file : Beca281-401JesmondRd_CPT08

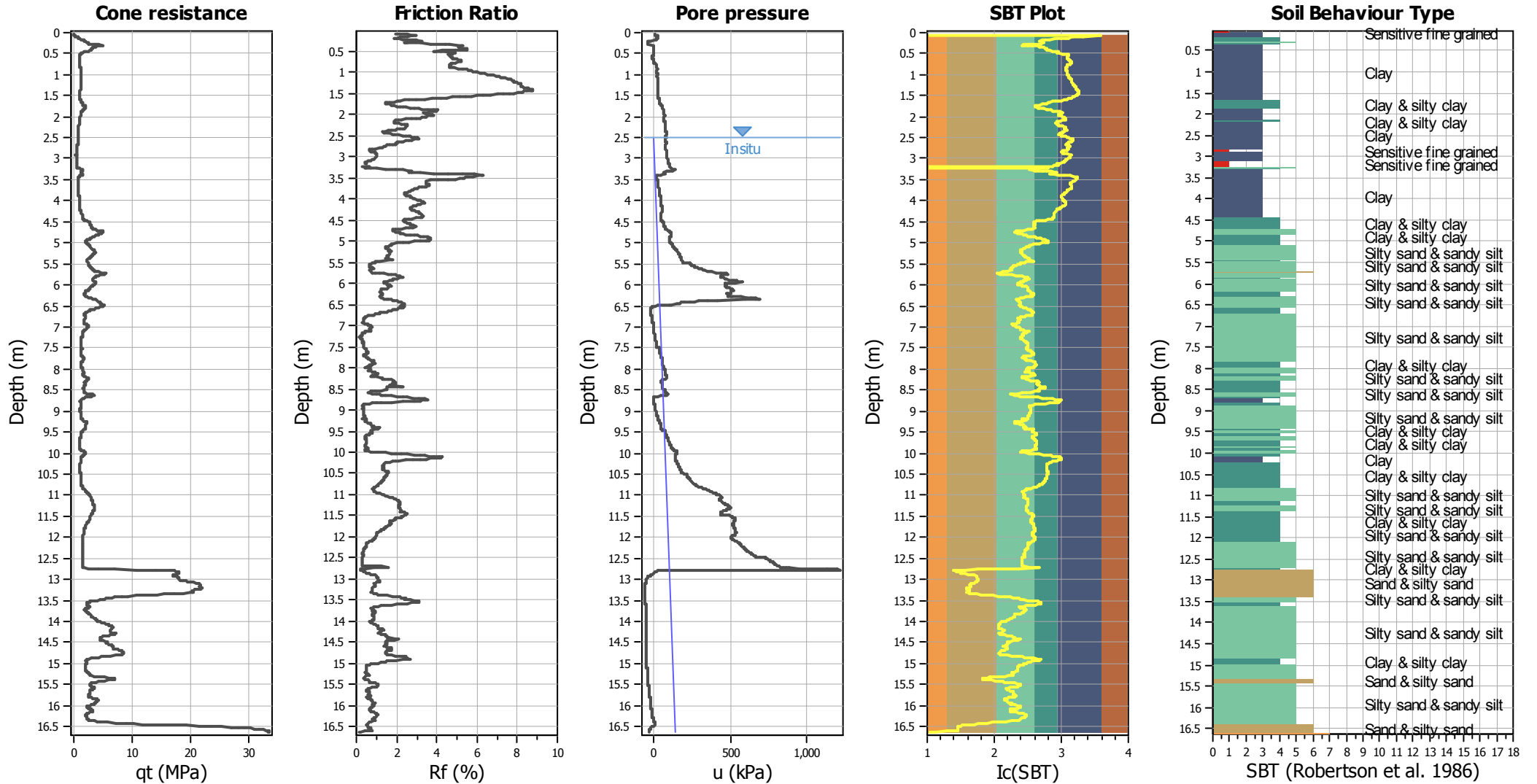
Location :

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.50 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude M_w :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method



CPT basic interpretation plots



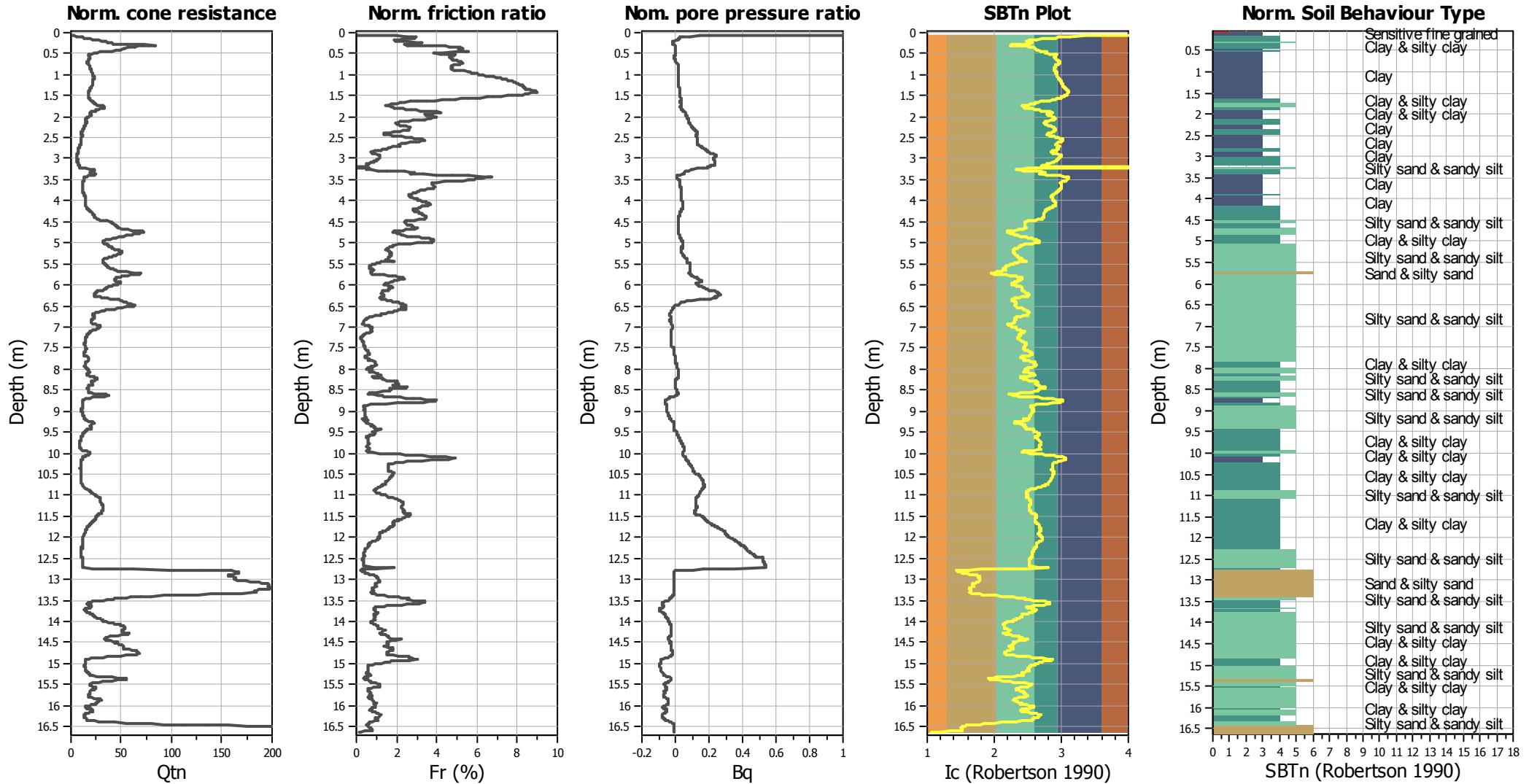
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained	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)



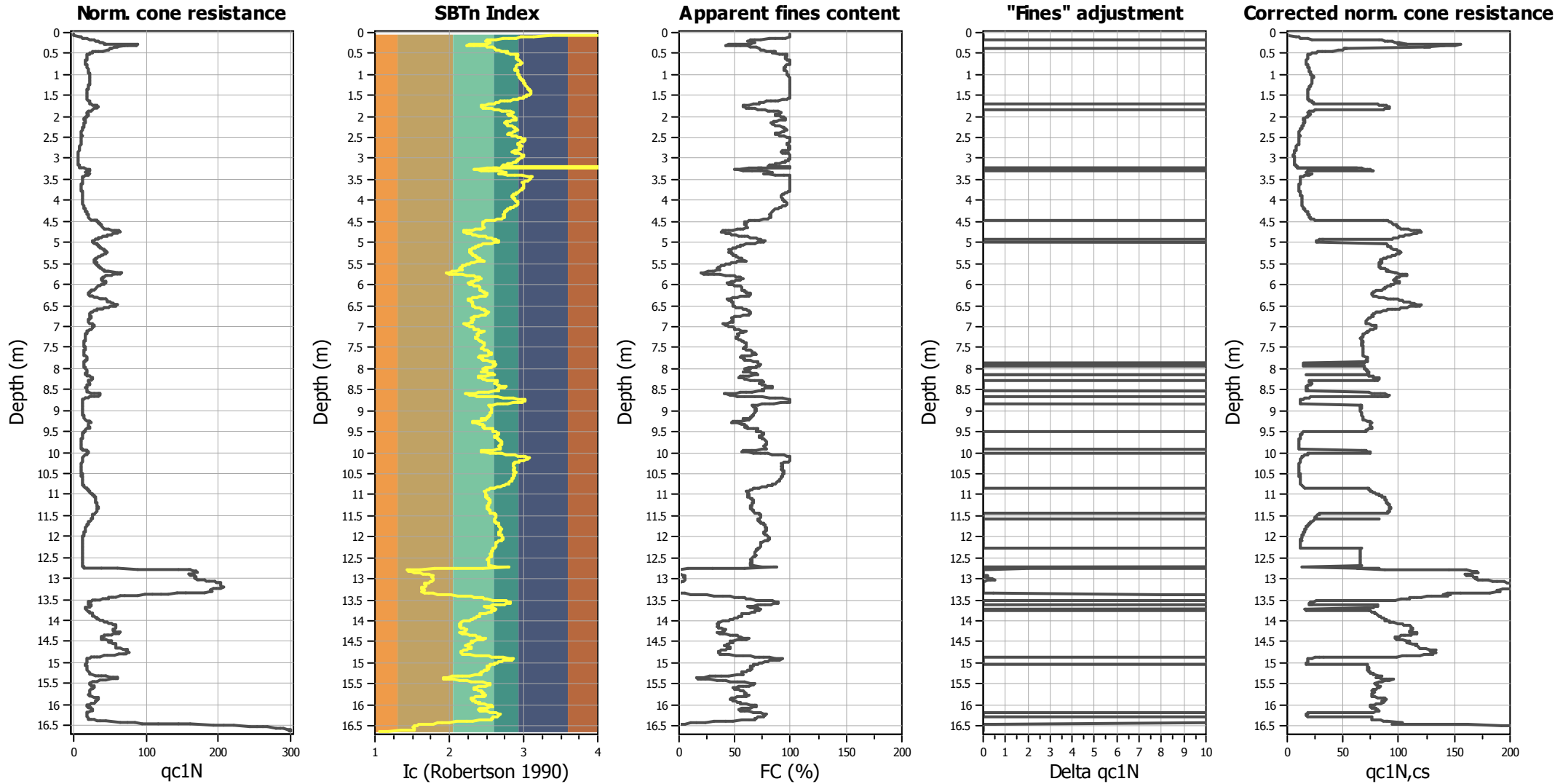
Input parameters and analysis data

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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_p applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained	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

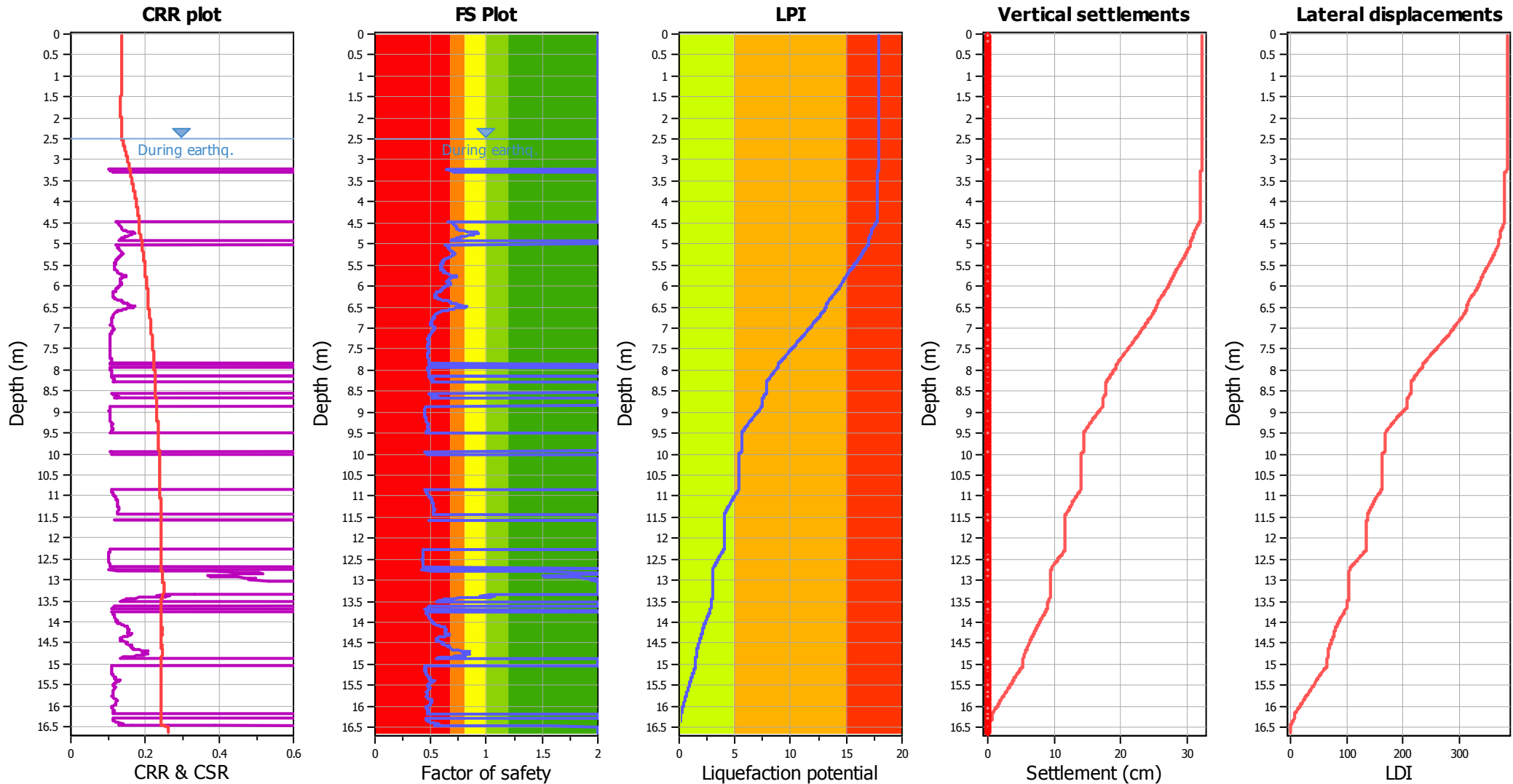
Liquefaction analysis overall plots (intermediate results)



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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (earthq.):	2.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

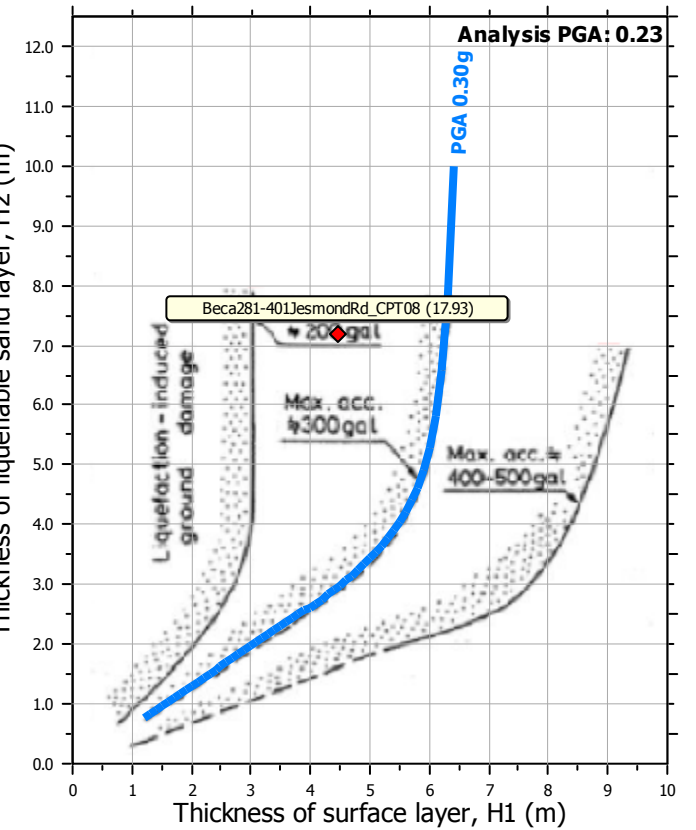
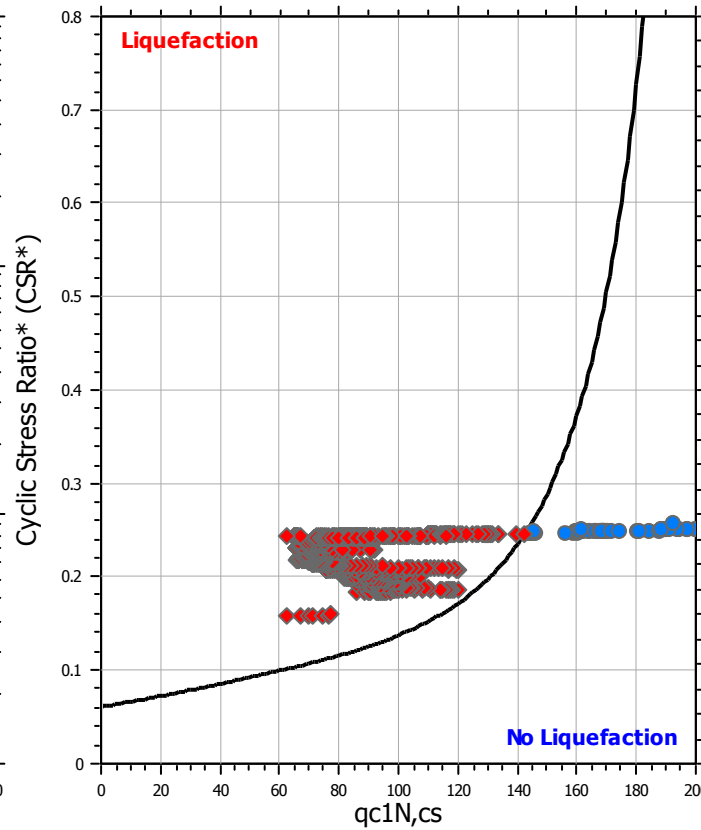
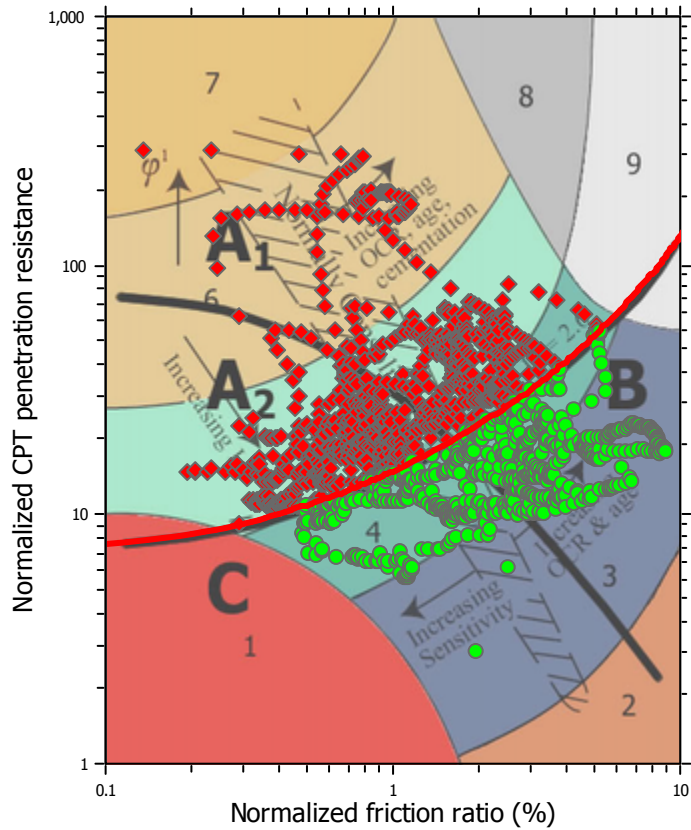
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

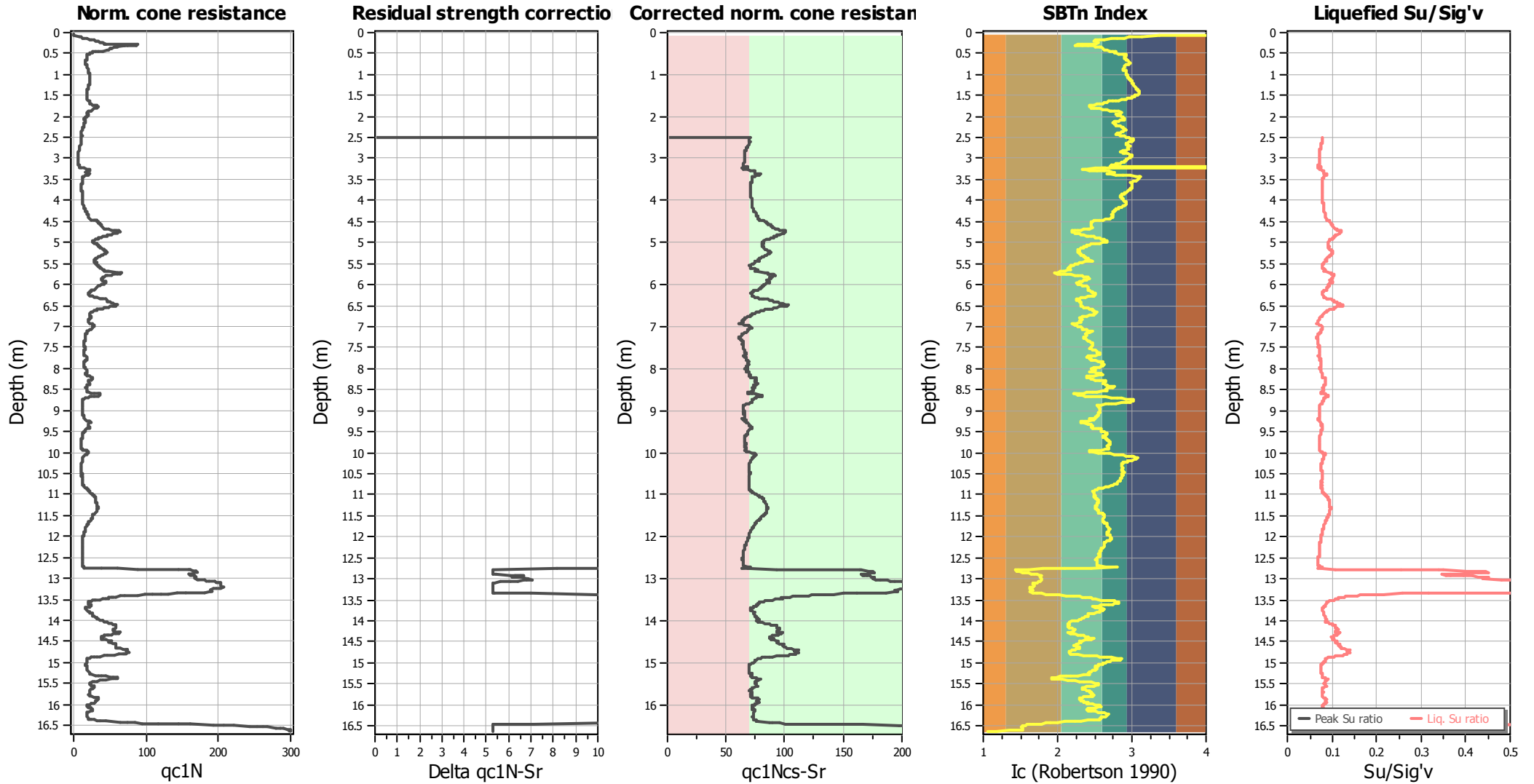
Liquefaction analysis summary plots



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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_f applied:	Yes
Earthquake magnitude M_w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

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

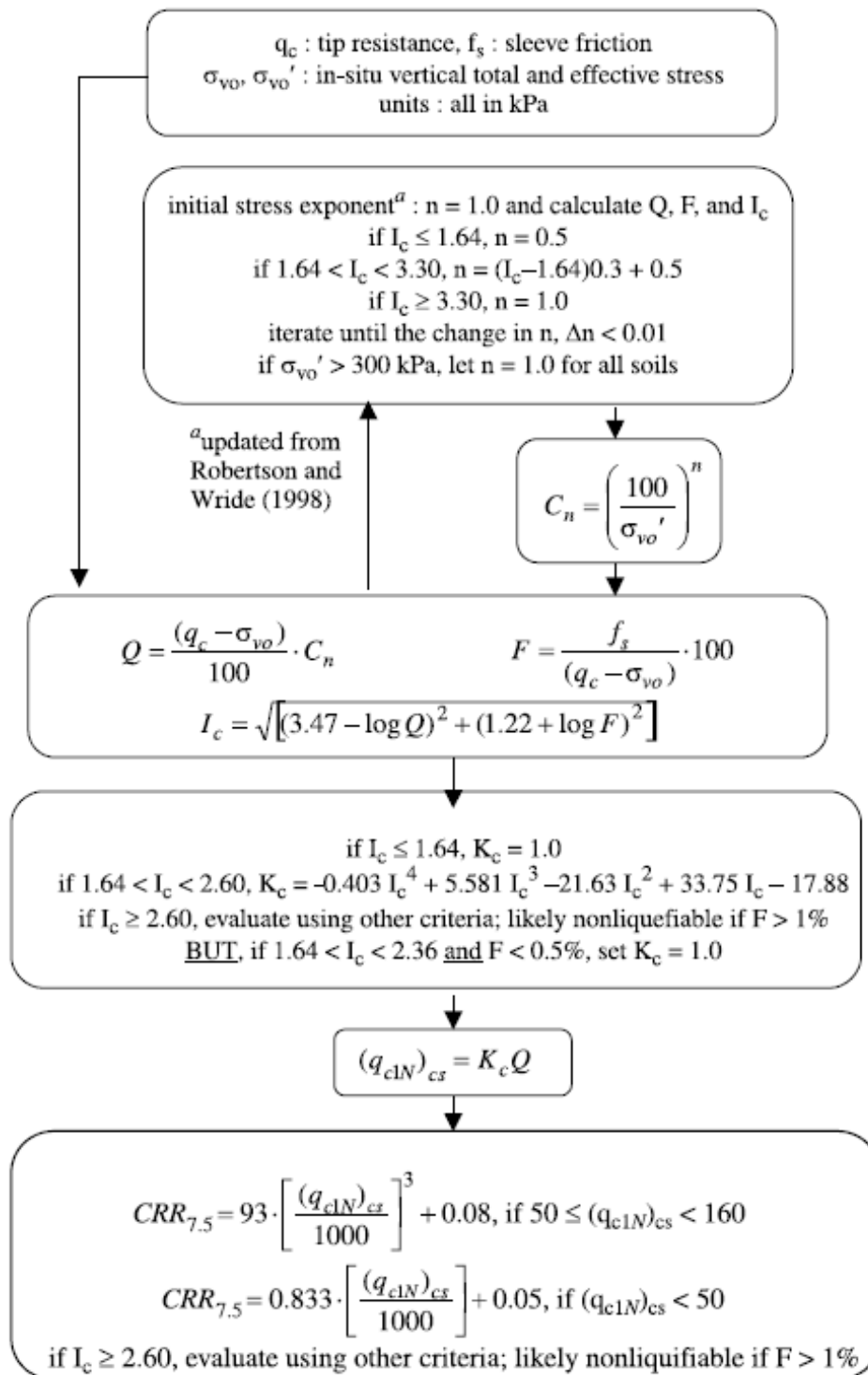


Input parameters and analysis data

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:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _q applied:	Yes
Earthquake magnitude M _w :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	N/A

Procedure for the evaluation of soil liquefaction resistance, NCEER (1998)

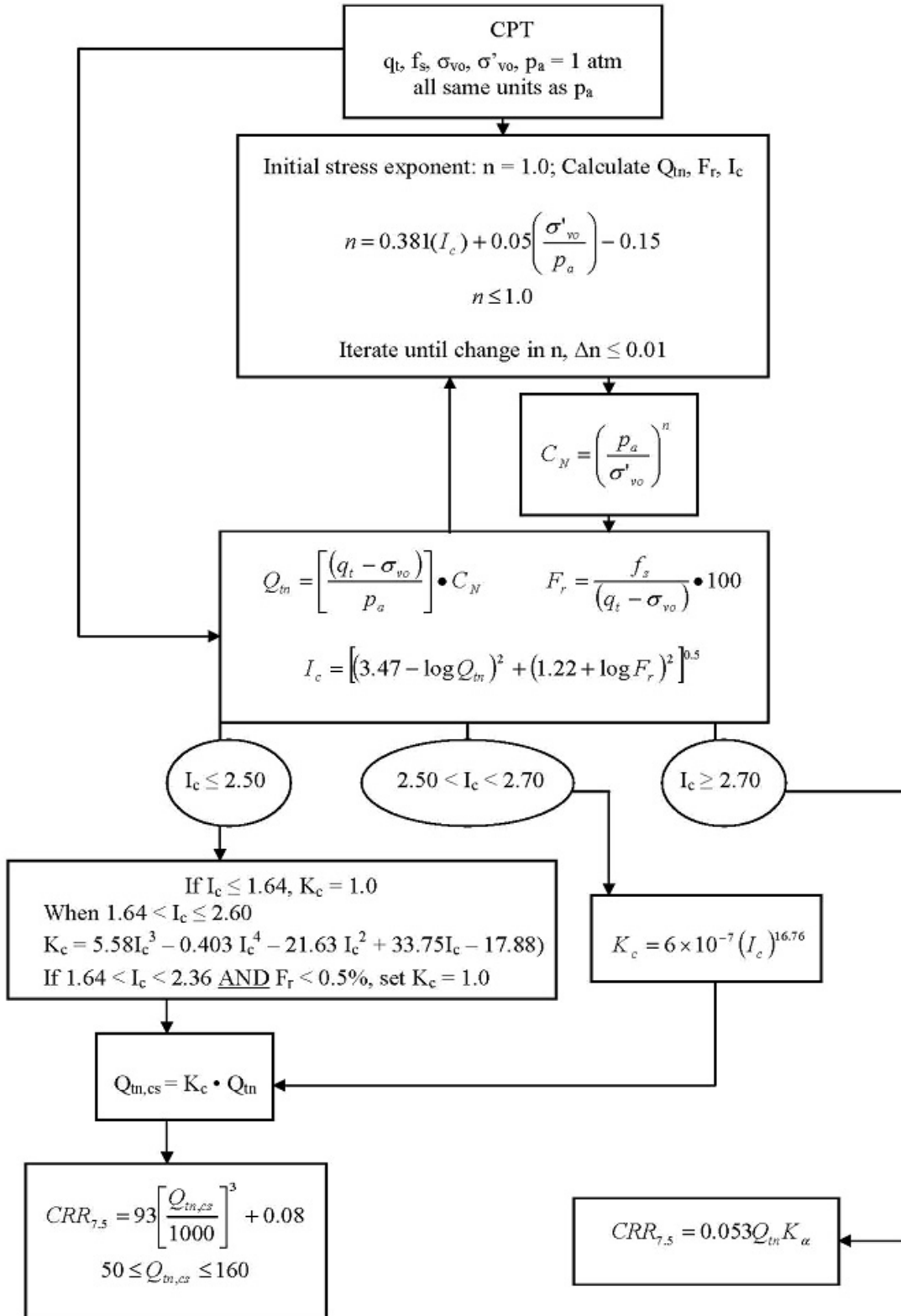
Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart¹:



¹ "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

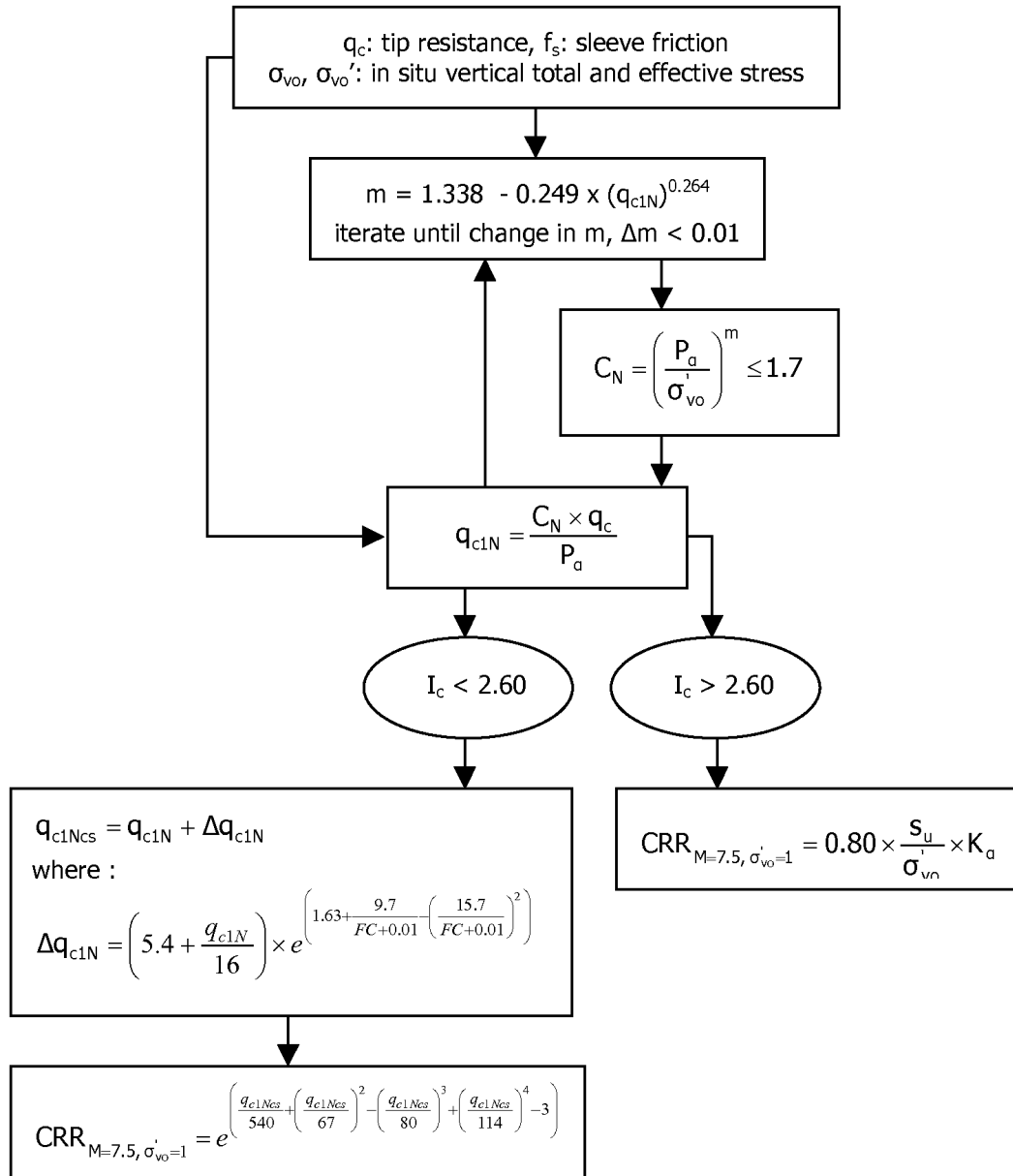
Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart¹:

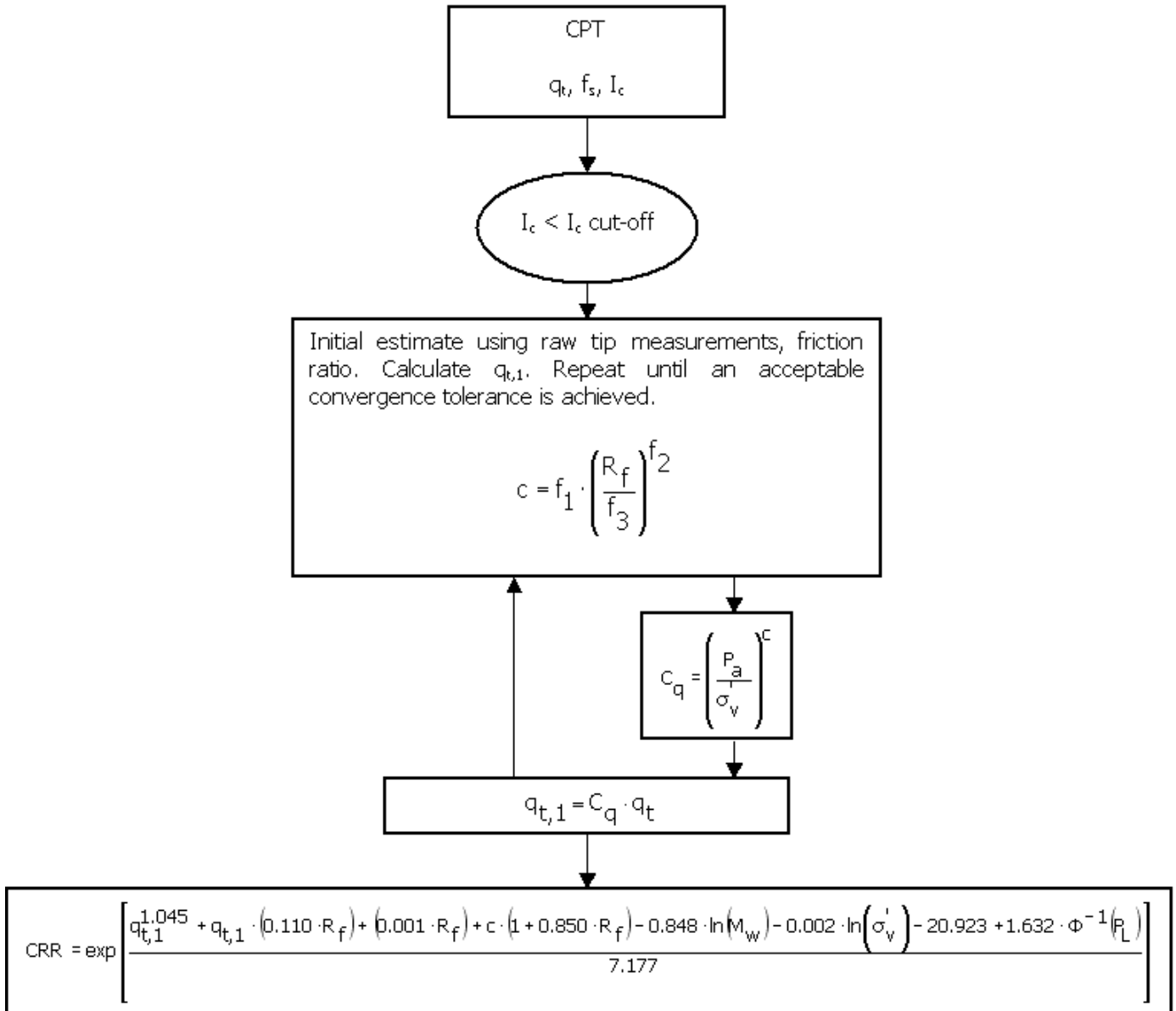


¹ P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

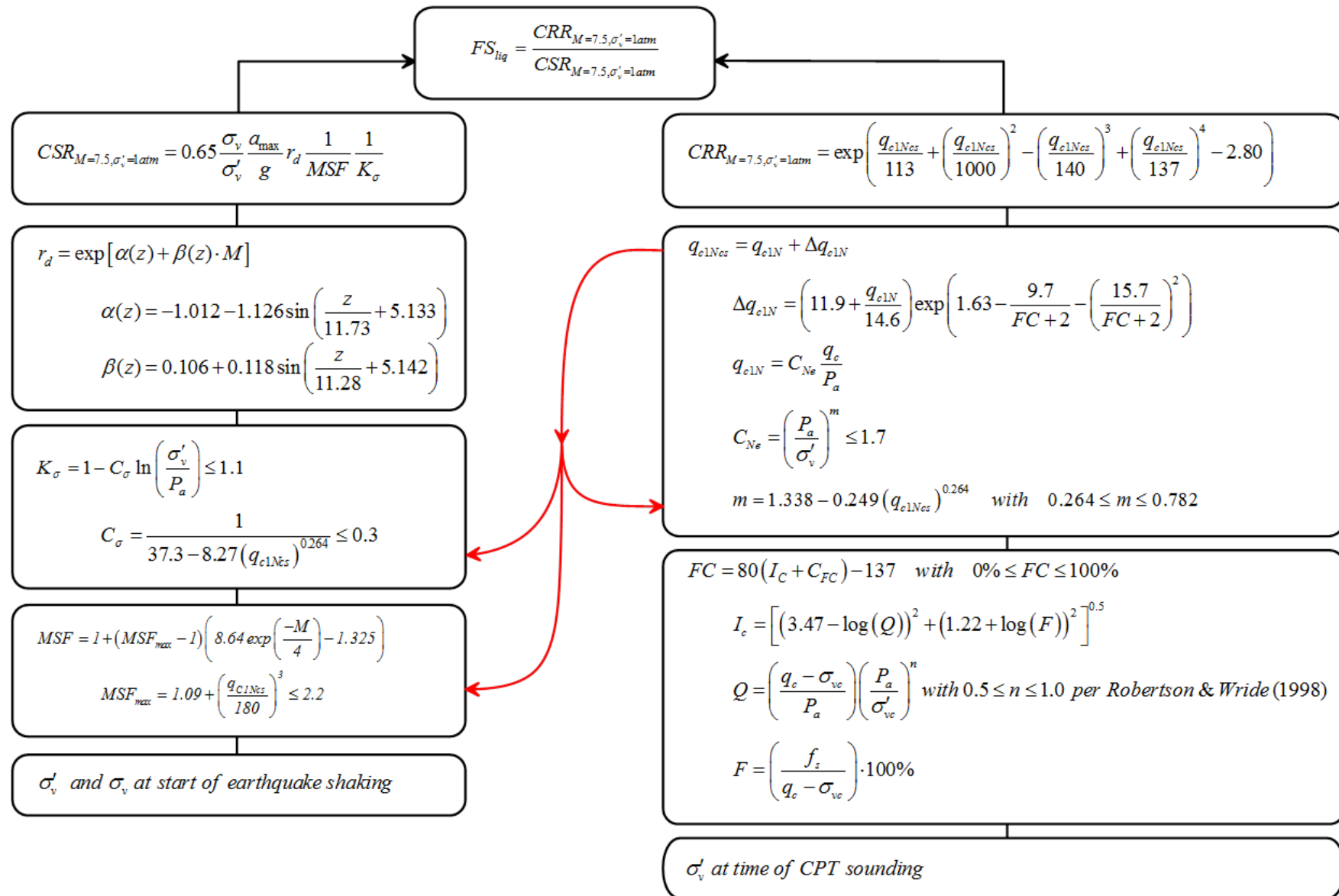
Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



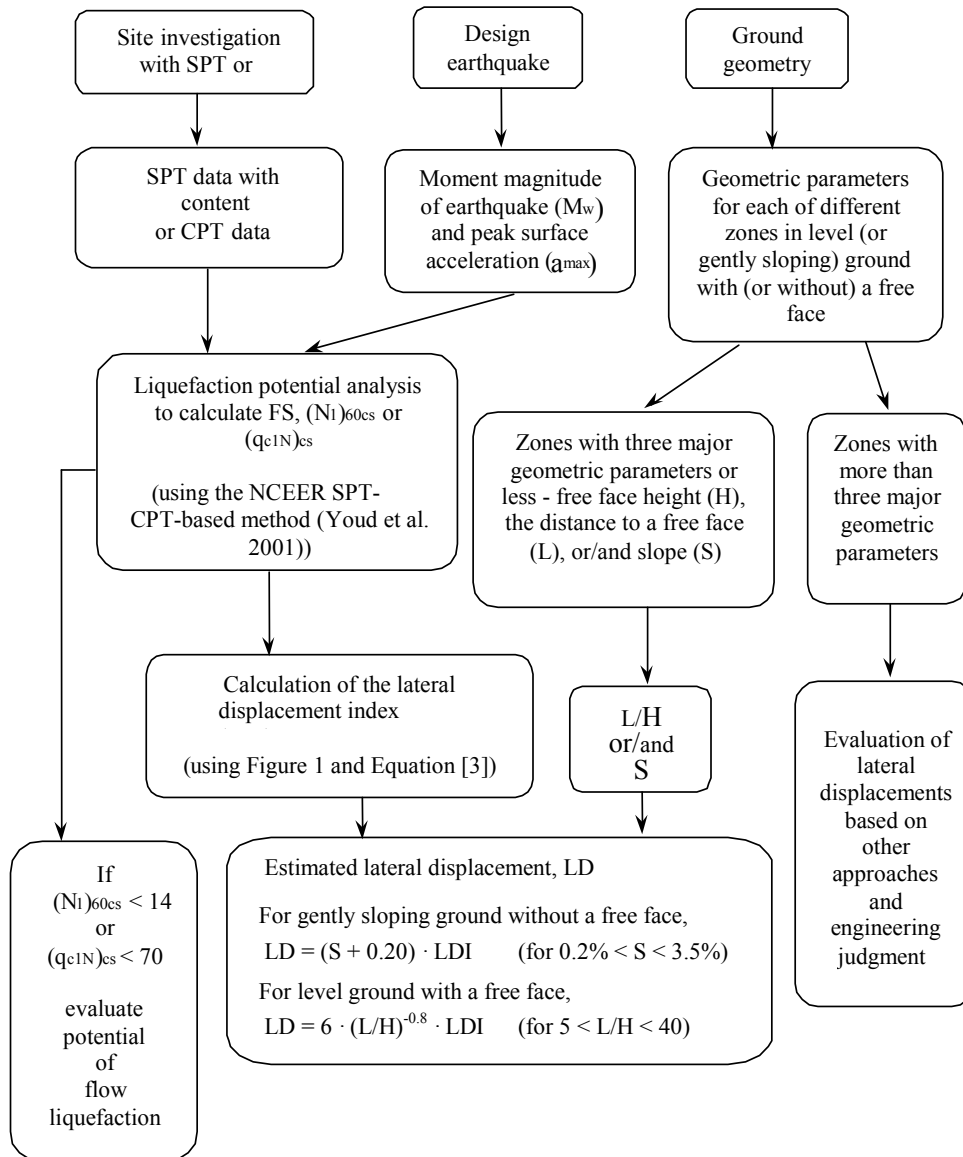
Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



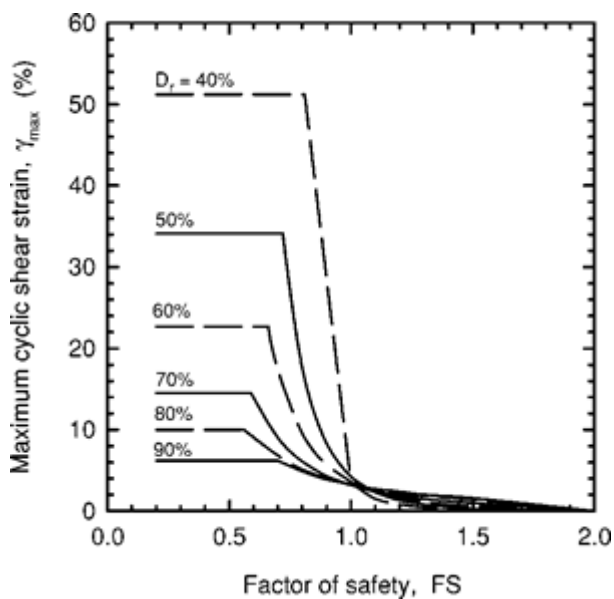
Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)



Procedure for the evaluation of liquefaction-induced lateral spreading displacements



¹ Flow chart illustrating major steps in estimating liquefaction-induced lateral spreading displacements using the proposed approach



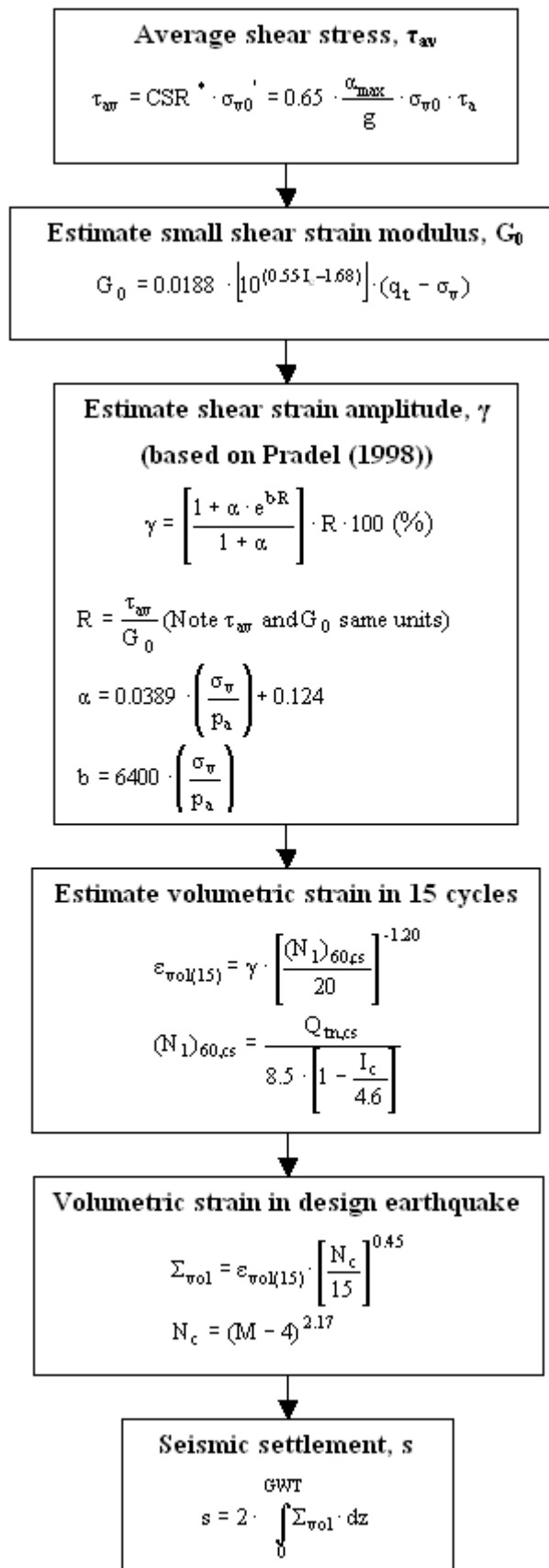
¹ Figure 1

$$LDI = \int_0^{Z_{max}} \gamma_{max} dz$$

¹ Equation [3]

¹ "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the estimation of seismic induced settlements in dry sands



Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, Symposium in honor of professor I. M. Idriss, San Diego, CA

Liquefaction Potential Index (LPI) calculation procedure

Calculation of the Liquefaction Potential Index (LPI) is used to interpret the liquefaction assessment calculations in terms of severity over depth. The calculation procedure is based on the methodology developed by Iwasaki (1982) and is adopted by AFPS.

To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

$$LPI = \int_0^{20} (10 - 0,5z) \times F_L \times dz$$

where:

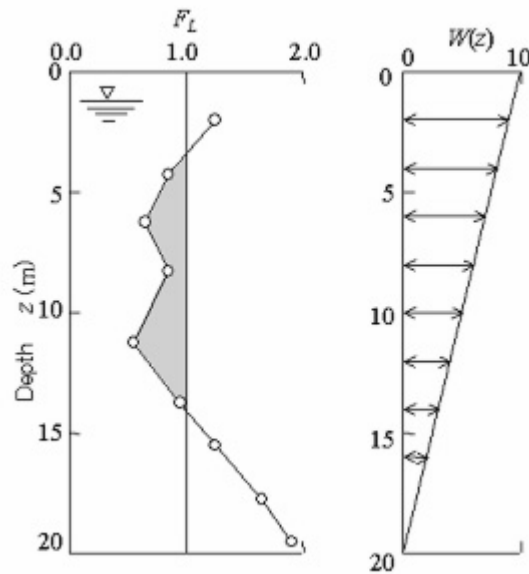
$F_L = 1 - F.S.$ when F.S. less than 1

$F_L = 0$ when F.S. greater than 1

z depth of measurement in meters

Values of LPI range between zero (0) when no test point is characterized as liquefiable and 100 when all points are characterized as susceptible to liquefaction. Iwasaki proposed four (4) discrete categories based on the numeric value of LPI:

- $LPI = 0$: Liquefaction risk is very low
- $0 < LPI \leq 5$: Liquefaction risk is low
- $5 < LPI \leq 15$: Liquefaction risk is high
- $LPI > 15$: Liquefaction risk is very high



Graphical presentation of the LPI calculation procedure

Shear-Induced Building Settlement (Ds) calculation procedure

The shear-induced building settlement (Ds) due to liquefaction below the building can be estimated using the relationship developed by Bray and Macedo (2017):

$$\begin{aligned} \ln(D_s) = & c_1 + c_2 * LBS + 0.58 * \ln\left(\tanh\left(\frac{HL}{6}\right)\right) + \\ & 4.59 * \ln(Q) - 0.42 * \ln(Q)^2 - 0.02 * B + \\ & 0.84 * \ln(CAVdp) + 0.41 * \ln(Sa1) + \varepsilon \end{aligned}$$

where Ds is in the units of mm, c1= -8.35 and c2= 0.072 for LBS ≤ 16, and c1= -7.48 and c2= 0.014 otherwise. Q is the building contact pressure in units of kPa, HL is the cumulative thickness of the liquefiable layers in the units of m, B is the building width in the units of m, CAVdp is a standardized version of the cumulative absolute velocity in the units of g-s, Sa1 is 5%-damped pseudo-acceleration response spectral value at a period of 1 s in the units of g, and ε is a normal random variable with zero mean and 0.50 standard deviation in Ln units. The liquefaction-induced building settlement index (LBS) is:

$$LBS = \sum W * \frac{\varepsilon_{shear}}{z} dz$$

where z (m) is the depth measured from the ground surface > 0, W is a foundation-weighting factor wherein W = 0.0 for z less than Df, which is the embedment depth of the foundation, and W = 1.0 otherwise. The shear strain parameter (ε_{shear}) is the liquefaction-induced free-field shear strain (in %) estimated using Zhang et al. (2004). It is calculated based on the estimated Dr of the liquefied soil layer and the calculated safety factor against liquefaction triggering (FSL).

References

- Lunne, T., Robertson, P.K., and Powell, J.J.M 1997. Cone penetration testing in geotechnical practice, E & FN Spon Routledge, 352 p, ISBN 0-7514-0393-8.
- Boulanger, R.W. and Idriss, I. M., 2007. Evaluation of Cyclic Softening in Silts and Clays. ASCE Journal of Geotechnical and Geoenvironmental Engineering June, Vol. 133, No. 6 pp 641-652
- Boulanger, R.W. and Idriss, I. M., 2014. CPT AND SPT BASED LIQUEFACTION TRIGGERING PROCEDURES. DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING COLLEGE OF ENGINEERING UNIVERSITY OF CALIFORNIA AT DAVIS
- Robertson, P.K. and Cabal, K.L., 2007, Guide to Cone Penetration Testing for Geotechnical Engineering. Available at no cost at <http://www.geologismiki.gr/>
- Robertson, P.K. 1990. Soil classification using the cone penetration test. Canadian Geotechnical Journal, 27 (1), 151-8.
- Robertson, P.K. and Wride, C.E., 1998. Cyclic Liquefaction and its Evaluation based on the CPT Canadian Geotechnical Journal, 1998, Vol. 35, August.
- Youd, T.L., Idriss, I.M., Andrus, R.D., Arango, I., Castro, G., Christian, J.T., Dobry, R., Finn, W.D.L., Harder, L.F., Hynes, M.E., Ishihara, K., Koester, J., Liao, S., Marcuson III, W.F., Martin, G.R., Mitchell, J.K., Moriwaki, Y., Power, M.S., Robertson, P.K., Seed, R., and Stokoe, K.H., Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshop on Evaluation of Liquefaction Resistance of Soils, ASCE, Journal of Geotechnical & Geoenvironmental Engineering, Vol. 127, October, pp 817-833
- Zhang, G., Robertson. P.K., Brachman, R., 2002, Estimating Liquefaction Induced Ground Settlements from the CPT, Canadian Geotechnical Journal, 39: pp 1168-1180
- Zhang, G., Robertson. P.K., Brachman, R., 2004, Estimating Liquefaction Induced Lateral Displacements using the SPT and CPT, ASCE, Journal of Geotechnical & Geoenvironmental Engineering, Vol. 130, No. 8, 861-871
- Pradel, D., 1998, Procedure to Evaluate Earthquake-Induced Settlements in Dry Sandy Soils, ASCE, Journal of Geotechnical & Geoenvironmental Engineering, Vol. 124, No. 4, 364-368
- Iwasaki, T., 1986, Soil liquefaction studies in Japan: state-of-the-art, Soil Dynamics and Earthquake Engineering, Vol. 5, No. 1, 2-70
- Papathanassiou G., 2008, LPI-based approach for calibrating the severity of liquefaction-induced failures and for assessing the probability of liquefaction surface evidence, Eng. Geol. 96:94–104
- P.K. Robertson, 2009, Interpretation of Cone Penetration Tests - a unified approach., Canadian Geotechnical Journal, Vol. 46, No. 11, pp 1337-1355
- P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering - from case history to practice, IS-Tokyo, June 2009
- Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, *Symposium in honor of professor I. M. Idriss*, SAN diego, CA
- R. E. S. Moss, R. B. Seed, R. E. Kayen, J. P. Stewart, A. Der Kiureghian, K. O. Cetin, CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 1, 2006
- I. M. Idriss and R. W. Boulanger, 2008. Soil liquefaction during earthquakes, Earthquake Engineering Research Institute MNO-12
- Jonathan D. Bray & Jorge Macedo, Department of Civil & Environmental Engineering, Univ. of California, Berkeley, CA, USA, Simplified procedure for estimating liquefaction-induced building settlement, *Proceedings of the 19th International Conference on Soil Mechanics and Geotechnical Engineering, Seoul 201*


Appendix G


Slope Stability Analysis





Slope Stability Analyses
 Ministry of Education
 281 and 401 Jesmond Road, Karaka
 Drury West Secondary School
 Project No: 4216997
 Analysis by: BPR


Title: Section B- B
 Slip Surface Option: Grid and Radius


 Name: Highly Plastic SILT-CLAY (Puketoka Formation)
 Model: Mohr-Coulomb
 Unit Weight: 17.5 kN/m³
 Cohesion: 2 kPa
 Phi: 26 °
 Piezometric Line: 1

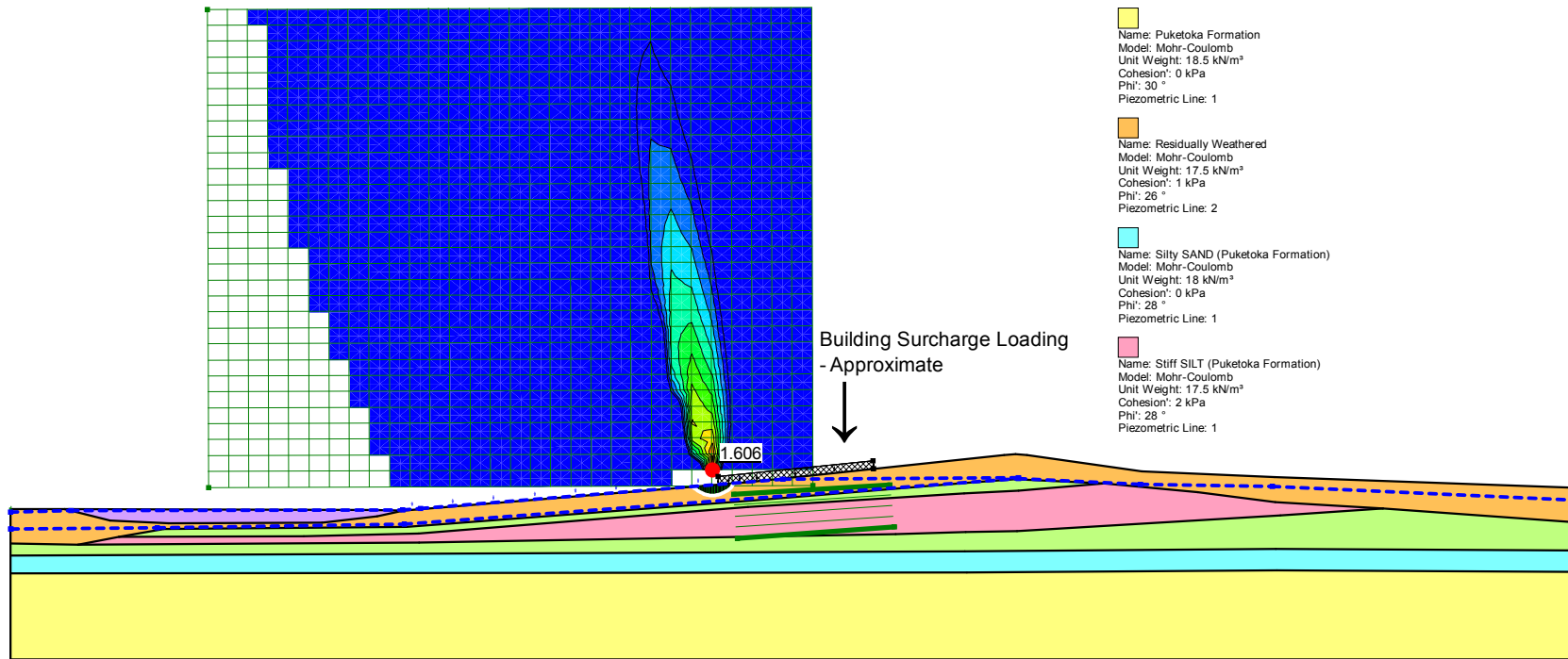
 Name: Organics (Puketoka Formation)
 Model: Mohr-Coulomb
 Unit Weight: 17 kN/m³
 Cohesion: 1 kPa
 Phi: 22 °
 Piezometric Line: 1

 Name: Puketoka Formation
 Model: Mohr-Coulomb
 Unit Weight: 18.5 kN/m³
 Cohesion: 0 kPa
 Phi: 30 °
 Piezometric Line: 1

 Name: Residually Weathered
 Model: Mohr-Coulomb
 Unit Weight: 17.5 kN/m³
 Cohesion: 1 kPa
 Phi: 26 °
 Piezometric Line: 2

 Name: Silty SAND (Puketoka Formation)
 Model: Mohr-Coulomb
 Unit Weight: 18 kN/m³
 Cohesion: 0 kPa
 Phi: 28 °
 Piezometric Line: 1

 Name: Stiff SILT (Puketoka Formation)
 Model: Mohr-Coulomb
 Unit Weight: 17.5 kN/m³
 Cohesion: 2 kPa
 Phi: 28 °
 Piezometric Line: 1



Slope Stability - Loading

Drury West - Section B-B.gsz

5/09/2018

1:1,250