

20 Te Haunui Lane, Pegasus

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## Geotechnical Appraisal Report

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Prepared for Howard Stone

Project 51579 - Rev.0 - 14/02/2024

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Our opinions and recommendations are based on our comprehension of the current regulatory standards and must not be considered legal opinions. For legal advice, please consult your solicitor. This opinion is not intended to be advice that is covered by the Financial Advisors Act 2010.

The recommendations and opinions contained in this report are based on our visual reconnaissance of the site, information from geological maps and upon data from the field investigation as well as the results of in situ testing of soil. Inferences are made about the nature and continuity of subsoils away from and beyond the exploratory holes which cannot be guaranteed. The descriptions detailed on the exploratory hole logs are based on the field descriptions of the soils encountered.

This report includes Appendices. These appendices should be read in conjunction with the main part of the report and this report should not be considered complete without them.

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Proposed Plan Change Area

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## 1.0 INTRODUCTION

### 1.1 Terms of Reference

Engineering Design Consultants Ltd (EDC) was commissioned by Howard Stone on 15/01/2024 to provide a Geotechnical Appraisal Report to support a Plan Change Application at 20 Te Haunui Lane, Pegasus (LOT 2 DP 80926 BLKS VIII XII RANGIORA SD). This report assesses the part of the land at 20 Haunui Lane that is intended for plan change and is henceforth referred to as 'the site' (shown in Figure 1).

This report is not considered suitable to support a Resource Consent or building consent submission.

### 1.2 Proposed Development/Works

It is proposed to re-zone the southeast 3.81ha portion of 20 Te Haunui Lane from Rural to Residential. The remainder of the property is to remain as Rural and is excluded from the land change assessment. A map showing the proposed area of the land change has been provided by Woods dated 13/12/23 which forms Appendix A.

It is understood that a 20m set back is proposed off the southwestern boundary, beyond which a creek is located.

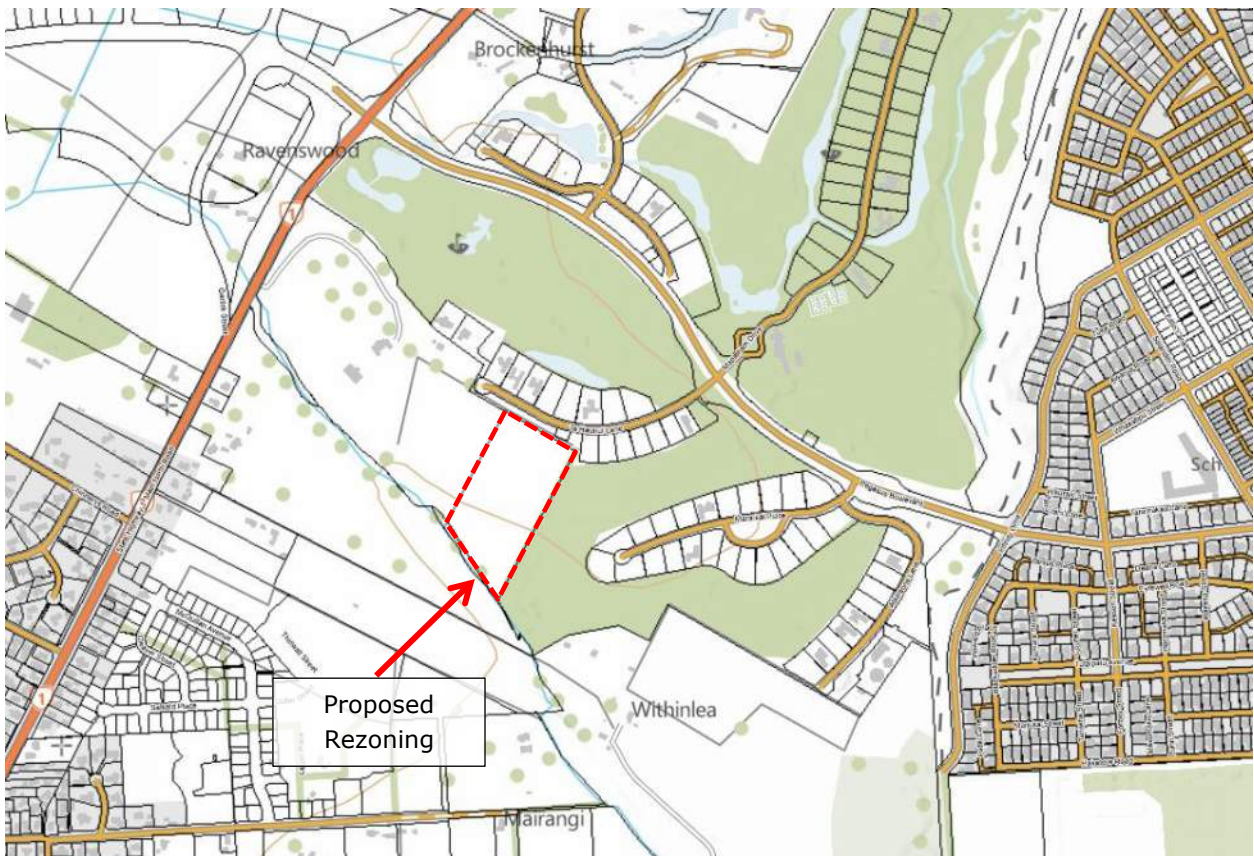


Figure 1: Site Location Plan (Courtesy of Canterbury Maps)

### **1.3 Objective/Scope**

The objective of this report is to assess potential geotechnical hazards and provide comment if the suitability of the site for the proposed change of use to residential.

In order to achieve the outlined objectives this geotechnical investigation comprised the following scope:

- A geotechnical desktop study to review geological mapping and geotechnical information resources.
- A review of freely-available historical aerial photographs.
- A site walkover.
- A shallow intrusive investigation comprising hand auger boreholes and Scala Penetrometer tests.
- A deep machine investigation comprising Cone Penetration Testing and subsequent liquefaction analysis.
- Provision of an interpretive report that identifies possible geohazards, assess the suitability of the site for the proposed rezoning, comment on potential construction issues, and interpretative assessment of ground conditions and likely geotechnical constraints.

## 2.0 SITE DESCRIPTION

### 2.1 Site Details

<b>Address</b>	20 Te Haunui Lane, Pegasus
<b>Legal Description</b>	LOT 2 DP 80926 BLKS VIII XII RANGIORA SD
<b>Approx. Plan Change area</b>	3.81ha
<b>Google Earth coordinates</b>	43°18'55.36"S, 172°40'38.00"E.
<b>District Plan</b>	Rural Life Style Zone
<b>MBIE Residential Foundation Technical Category (TC)</b>	N/A - Rural & Unmapped
<b>Liquefaction Susceptibility</b>	Liquefaction Is Possible

**Table 1: Site Details**



**Figure 2: Site Aerial Photo (Courtesy of Canterbury Maps). Area of the proposed Pland Change is in dashed red**

### 2.2 Topography

A topographical survey by Woods Ltd forms Appendix A.

The survey indicates that the site is generally flat, though undulating up to approximately 1.0m. A lower areathat appears to be a potential flow path crosses the northern half of the site from northwest to southeast.

The land along the southwest boundary slopes down to an adjacent creek at a gradient of approximately 1:v in 1.5:h (34°) and height of approximately 1.8m. An indicative cross section of the creek bank (using Google Earth data) forms Figure 3.

The land on the adjacent golf course, for an approximately 35m length of the southeast boundary, south of the site, is approximately 1m – 1.5m higher than the site, with a slope of approximately 1:v in 2:h (25°).



**Figure 3: Topography of the southern end of the site, with 0.5m contours (above image). Cross section showing the elevation difference stream and the site above (below image).**

### 2.3 Site Walkover

The following are key observations during EDC’s site walkover:

- The site is accessed via an existing concrete right of way off Te Haunui Lane.
- The site is generally grassed land.



- Large shelter belt trees are present around the boundaries and across the middle of the site.
- A creek is located along the southwestern boundary of the site (Figure 3). The creek had a low flow of water, which was approximately 0.5m depth. No instability was noted on this embankment.
- A golf course is located adjacent to the southeast. No instability was noted on this small length of steeper slope adjacent to the site.
- A pole shed (for storing hay) and a small tin storage shed are present in the southern corner of the site.

No other features of note have been identified at the time of EDC's site walkover. Figures 4 to 8 show the site.



**Figure 4: View of the site looking towards the northwestern corner of the site**



**Figure 5: View of the site looking towards the northeastern corner of the site**



**Figure 6: View of the site looking southwest towards the southern boundary**



**Figure 7: View of the site, looking northwest**



**Figure 8: View of the creek, looking northwest. Approximately 0.5m deep**

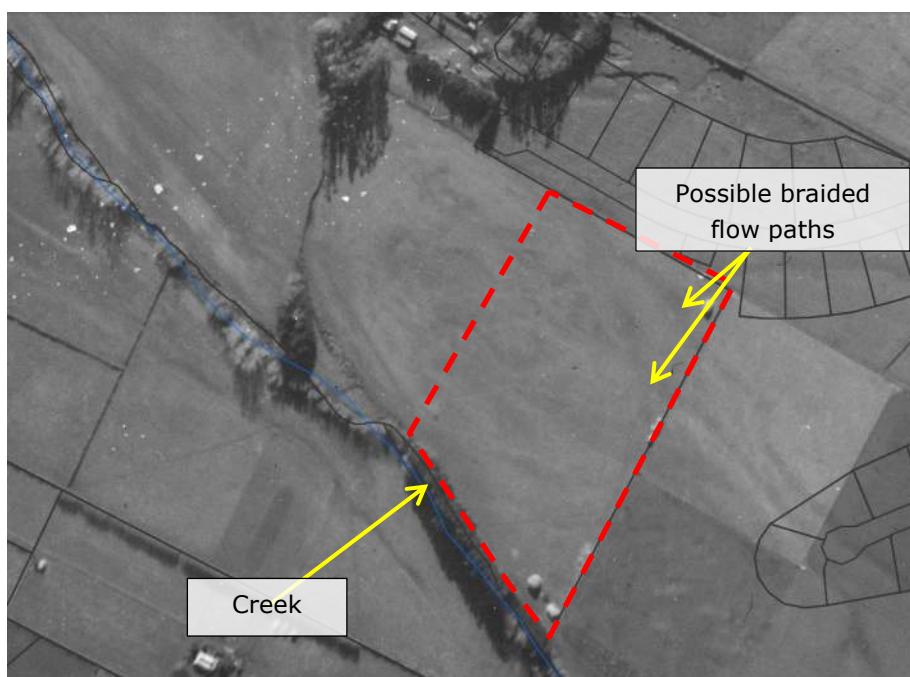
## 3.0 SITE HISTORY

### 3.1 Historical Aerial Mapping

Historical aerial photographs available on Environment Canterbury's (ECan) GIS database (Environment Canterbury, 2016) have been reviewed by EDC for the years 1944 through to 2019. This review indicated that:

- The site remained as undeveloped grassland since 1944, with a creek that forms the site's southwestern boundary. Ephemeral streams are noted to cross the site to the northeast.
- The 1944 image shows a small shed in the southeast corner of the site.
- Shelterbelts formed the site's boundary from 2010. By 2014, a shelterbelt bisects the site.
- By 2010 the golf course to the east has been formed.
- The aerial photos reviewed do not suggest a significant change in the creek position over that period (1944 to present).

No historical features have been identified that might pose a geotechnical constraint to the proposed development.



**Figure 9: Historical Image dated 1944**

### 3.2 Historical Land Use

The ECan Listed Land Use Register (LLUR) holds information regarding sites that have been or currently are used for activities which have the potential to cause contamination.

The LLUR indicates that the site is not within a Hazardous Activities or Industries List (HAIL) site. However, the adjacent property to the east of the site is identified as potentially having

HAIL A10 Activity (persistent pesticide bulk storage or use). The above is considered unlikely to have a geotechnical impact on the site.

### **3.3 Black Maps**

The 1856 Black Map (as published on the NZGD) indicates the site to be located in an area of herbaceous land. Northwest to southeast trending watercourses are identified on-site:

1. One crosses the northern portion of the site in the location of the inferred northwest to southeast trending flowpath described in Section 2.2.
2. One along the southern boundary, which appears to be related to the existing creek.

## 4.0 GEOLOGICAL DESK-BASED INFORMATION

### 4.1 Geological Mapping

According to the GNS Geological Unit QMap, available on the New Zealand Geotechnical Database (Earthquake Commission / Ministry of Business, Innovation & Employment, 2016), the site is underlain by Holocene (<11,700-year-old) river deposits, comprising 'Modern river floodplain/low-level degradation tce. Unweathered, variably sorted gravel/sand/silt/clay' (Q1a).

### 4.2 Geological Investigation Data

Table 2 below is a summary of information obtained from the New Zealand Geotechnical Database (NZGD), from previous investigation holes within the local area:

Hole Reference	Location	Depth	Summary
HA-DCP_109197 (HADCP 1)	~180m NE 3 Te Haunui Lane	1.6m	TOPSOIL to 0.2m SAND, medium dense to dense to 1.6m Hand auger terminated on gravel, groundwater not encountered
BH_37002 (BH3)	~350m SW Woodend	10.0m	TOPSOIL to 0.25m Interbedded layers of SAND and SILT mixtures with trace organics, to 10.0m Target depth reached, groundwater not measured
CPT_112910 (CPTlot51)	~390m NE	3.4m	Interbedded sand and silt mixtures to 2.0m Interbedded silt and clay mixtures to 2.7m Interbedded gravely sand to silty sand to 3.4m CPT terminated due to high top resistance, groundwater not measured

**Table 2: Nearby Geological Investigation Summary**

### 4.3 Ground Water Data

There are no long term groundwater records in the area, with no groundwater levels recorded in nearby NZGD investigations. A nearby well (M35/0432) located 70m NW of the site records 2.2m below the existing ground level (begl) as the shallowest groundwater, with 4.0m being the initial groundwater depth.

### 4.4 Nearby Springs

The ECan GIS (Canterbury Maps) does not have record of any groundwater springs within a 500m radius of the site.

## 5.0 GEO-HAZARDS DESK-BASED INFORMATION

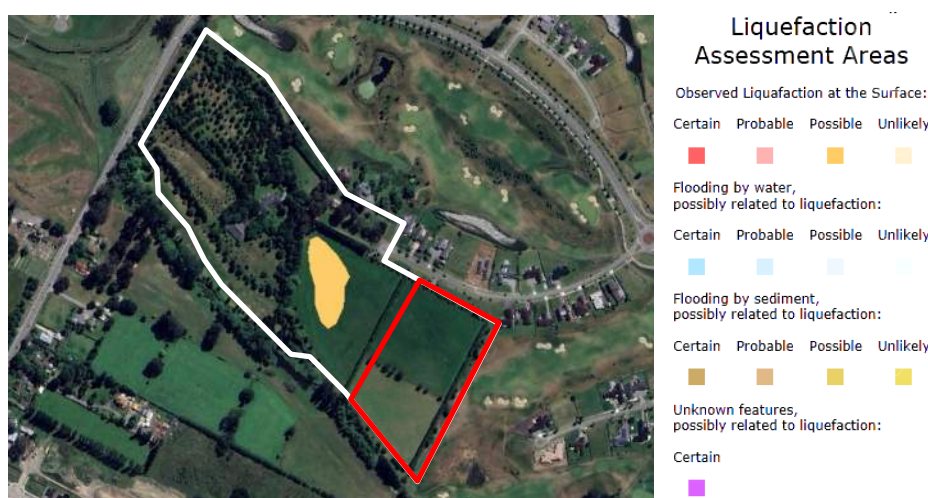
### 5.1 Liquefaction

#### 5.1.1 Liquefaction Assessment Area Map

The Waimakariri District Council Natural Hazards indicate that the site is zoned within an area where 'Liquefaction is possible'.

#### 5.1.2 GNS Post Sept 2010 and Feb 2011 Observations

The NZGD contains GNS Post Sept 2010 and Feb 2011 Observations for possible liquefaction. No possible liquefaction was recorded following the Feb 2011 earthquake; however, possible liquefaction was recorded on a portion of the bigger lot following the Sept 2010 earthquake event.



**Figure 10: GNS Liquefaction Observation Excerpt with the approximate site boundary in red**

#### 5.1 Active Faults

The GNS Active Fault maps, available on the NZGD indicate that the nearest active fault is the Loburn Fault (#9573); trending west-east and located approximately 6.2km northwest of the site. The recurrence interval of this dextral fault is unknown.

#### 5.2 Seismic History

GNS records indicate that the nearest Strong Motion Seismograph location is at Kaiapoi North School (approximately 6.7km south of the site). The following table shows the recorded Peak Ground Accelerations (PGA's) observed at this sensor during the significant earthquakes in the area during 2010 and 2011:

Earthquake event	Ashley School
04 September 2010	0.36g
22 February 2011	0.22g
13 June 2011	0.25g

Earthquake event	Ashley School
23 December 2011	0.08g

**Table 3: Peak Ground Acceleration Records**

**Notes:** Although these PGA's were measured at the seismograph location, it is possible that the site could have been affected by PGA's that were lower or higher.

**5.3 Flooding**

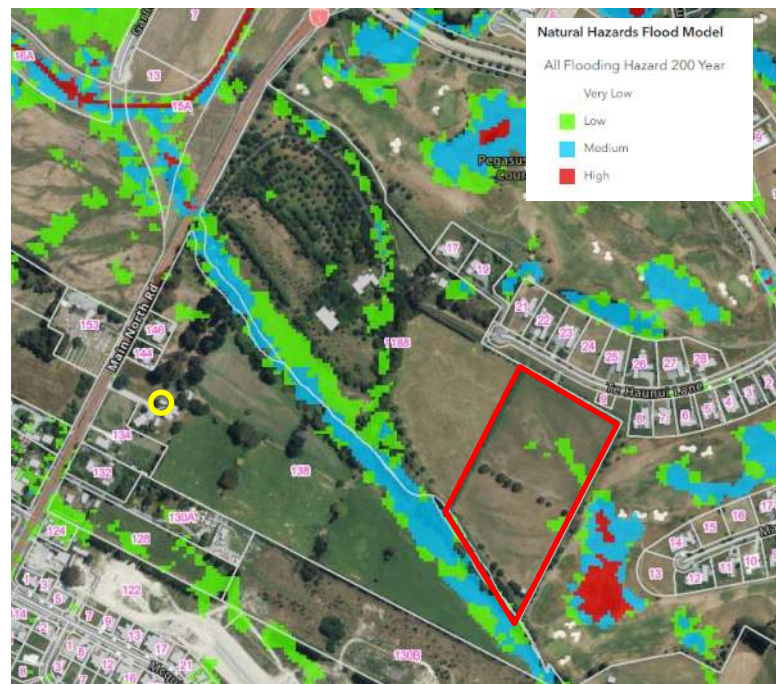
**5.3.1 Flood Management Areas**

The Waimakariri District Council Natural Hazards includes flooding hazard information for a 200-year event. The map indicates that two areas of Low flood risk are on the site (Figure 11):

- an area in the northern half of the site, associated with the overland flow path.
- A small area on the southeast boundary.

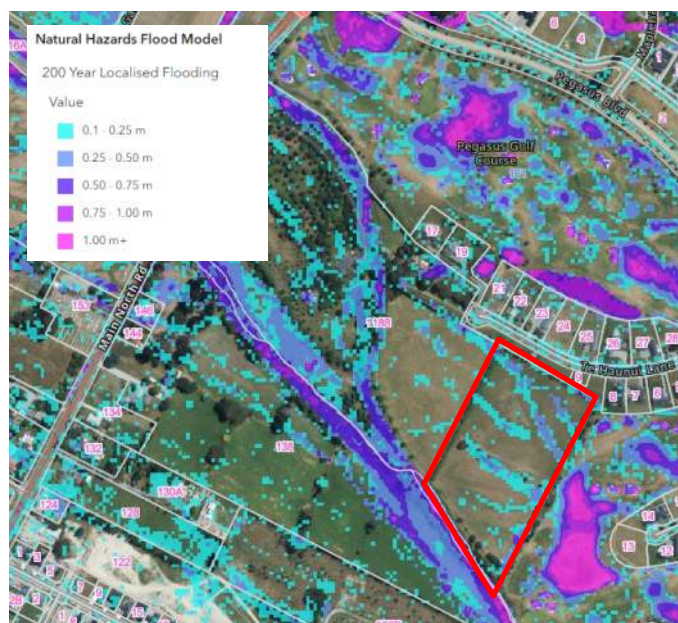
The land beyond to the southwestern boundary (the creek) is of 'Low to Medium' flooding risk (Figure 11). The 200-year localized flood depth map suggests localized flooding between 0.1m and 0.50m (Figure 12).

Consultation with the council is recommended to establish any restrictions / consent requirements.



**Figure 11: WDC Natural Hazards Viewer 200-year flooding excerpt with the approximate site boundary in red**





**Figure 12: WDC Natural Hazards Viewer 200-year localised flood depth excerpt with the approximate site boundary in red**

### 5.3.2 Nearest Water Body/Water Course

An unnamed creek forms the southwestern boundary of the site. The nearest major watercourse is Ashley River, located approximately 4.0km north of the site.

## 6.0 SITE INVESTIGATION

### 6.1 Rationale

To achieve the outlined objectives, shallow hand testing involving hand auger boreholes (HA's), Scala Penetrometer tests (SC's), and Cone Penetration Tests (CPT's) was considered sufficient to determine ground conditions for the proposed works, in accordance with the MBIE guidance.

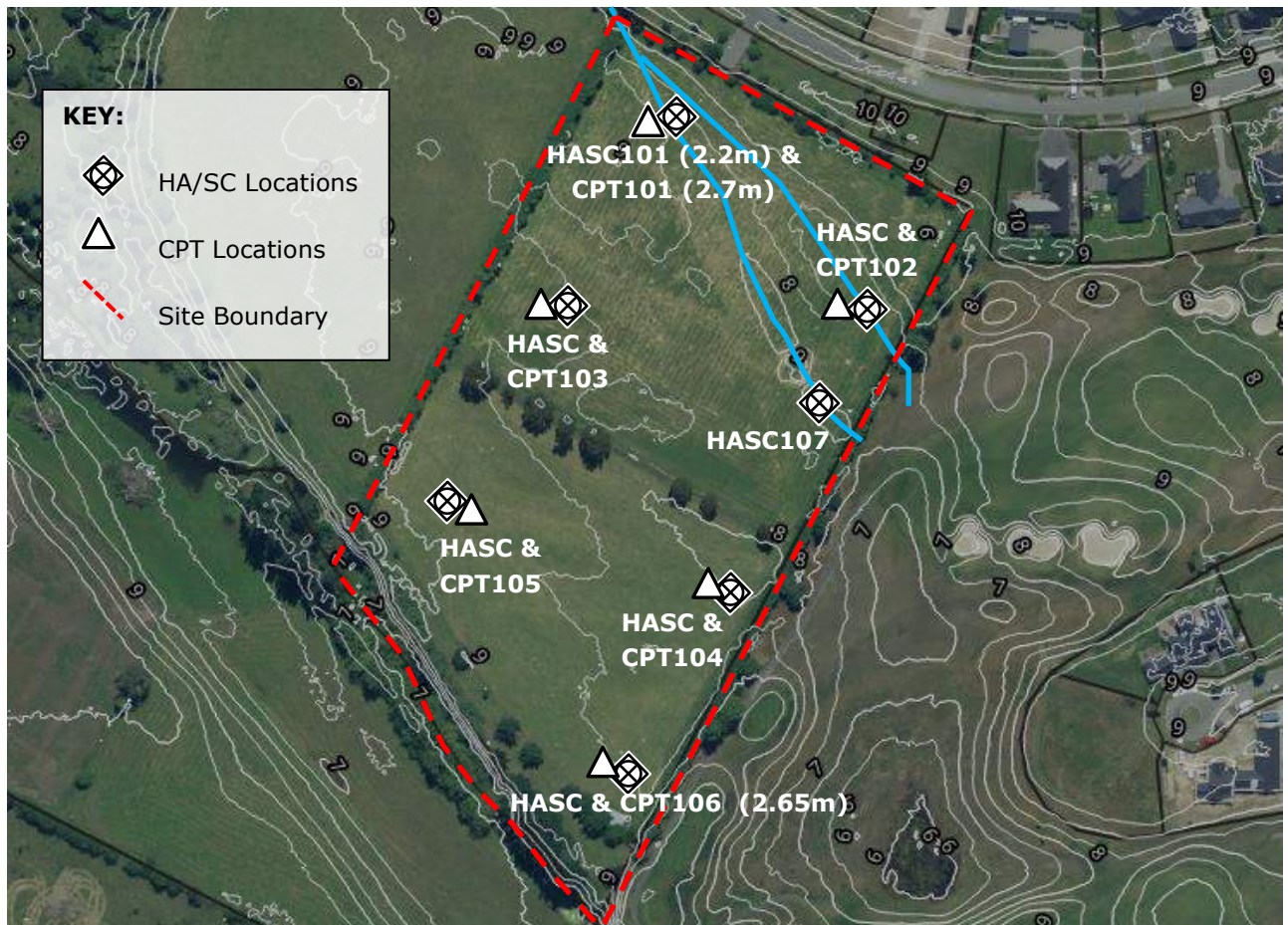
Testing density is in accordance with MBIE Module 2 and have been spaced to provide good coverage of the site, along with CPT/HA 101 and 102 specifically targeting the topographically low flow path.

### 6.2 Intrusive Investigation Summary

#### 6.2.1 Shallow Hand Testing

EDC visited the site on 17/01/2024 to undertake a shallow geotechnical investigation. Hand augered exploratory holes with Scala Penetrometer tests have been undertaken in seven locations (HASC 101-107).

Soils have been described generally in accordance with NZGS: Field Description of Soil and Rock. The results of these investigations are shown on the HA Log sheet attached in Appendix B.



**Figure 13: Intrusive Investigation Approximate Locations Depth to groundwater in brackets. The approximate flow path location is in blue**

The following table shows the depths reached by EDC's hand testing:

Test Ref.	Depth Reached – Reason for Termination
HASC 101	2.8m & 2.9m (Scala) - Refusal on gravels
HASC102	2.6m – Refusal on gravels
HASC 103	1.7m – Refusal on gravels
HASC104	0.9m & 1.0m (Scala) - Refusal on gravels
HASC105	0.6m & 0.85m (Scala) – Refusal on gravels
HASC106	0.7m & 1.5m (Scala) - Refusal on gravels
HASC107	2.3m - Refusal on gravels

**Table 4: Shallow Hand Testing Summary**

All hand tests refused on gravel, which was encountered at variable depths ranging from 0.6m – 2.3m below existing ground level (begl).

### 6.2.2 Deep Machine Testing

Cone Penetration Testing (CPT), at six locations (CPT101-106) was undertaken by McMillian Drilling Ltd on 17 and 18 January 2024. The CPT's refused in gravel soils at depths ranging between 8.66m and 13.81m their target depths of 20.0m begl.

The location of the CPT is indicated on Figure 13. Logs of the Normalised Soil Behaviour Type (SBT) for the CPT results are shown in Appendix C.

### 6.3 Summary of Ground Conditions

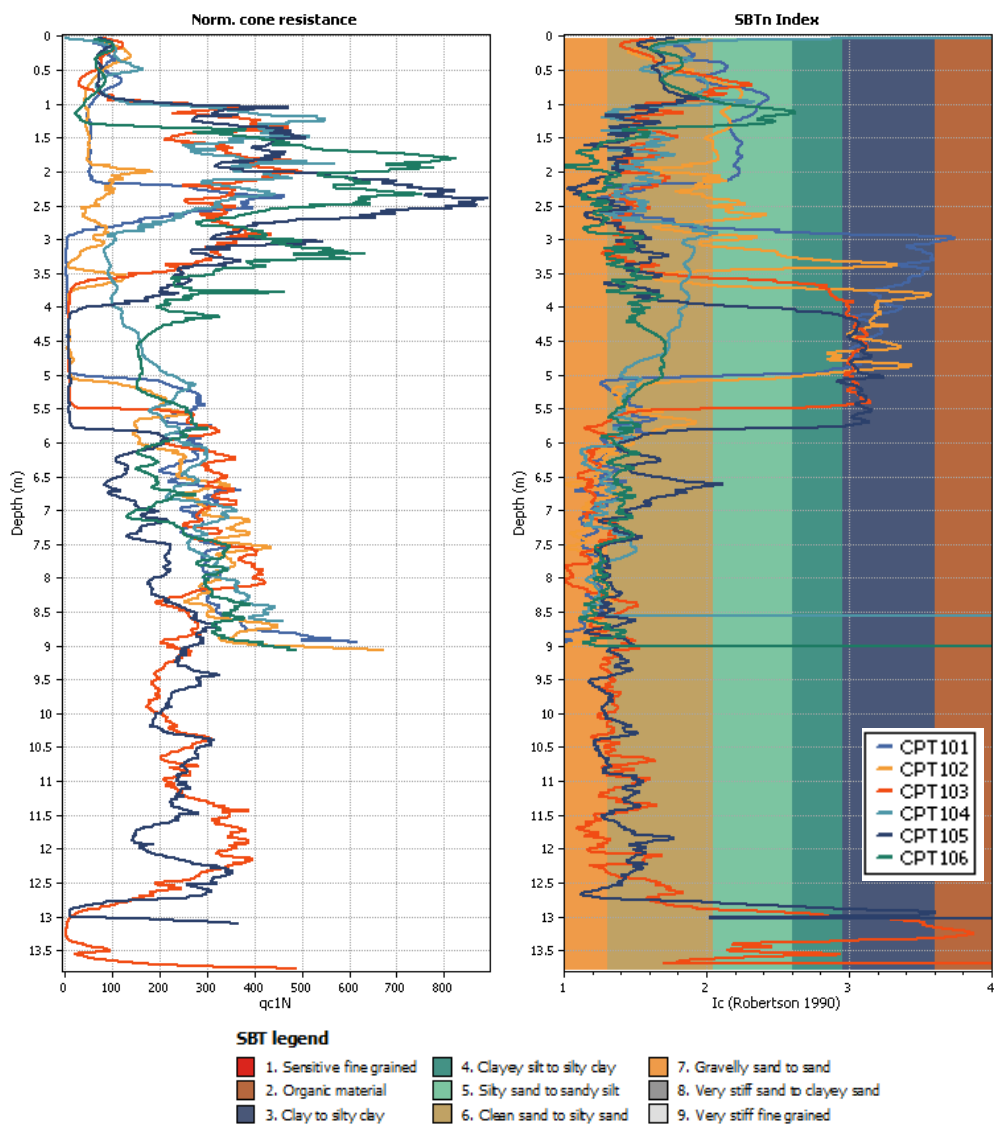
This investigation indicates the following approximate soil section across the site (The soils indicated by the CPT's (shaded in grey below) are based on the normalised SBT's established using the Geologismiki Software "CLiq" v.2.2.1.4):

General Depth Range (m)	Generalised Ground Description	Density/Consistency
Surface to 0.4	Topsoil - Organic silt	
0.4 to 1.0-2.8	Silt over sand	Firm / medium dense (locally loose)
1.0-2.8 to 3.0	Sandy gravel	Medium dense to dense
3.0 to 5.5m	Clay (possible organic)	Soft to Firm
5.5 to 12.7	Sand and sandy gravel	Medium dense to dense
12.7 to 13.8	Clay / organic soils	Soft to Firm

**Table 5: Ground Condition Summary**

- Gravel fill mixed with topsoil was identified in HASC101 to 0.4m

- Shallow gravel soils were encountered at various depths, generally within the upper 1.0m, but as deep as 2.8m.
- Groundwater was encountered at 2.2m in HASC101. CPT101 which was at a slightly higher elevation encountered groundwater at 2.7m. CPT106 encountered groundwater at 2.65m. The remainder of investigation locations did not encounter groundwater/the CPT collapsed dry post testing at depths ranging between 2.6m and 3.6m.
- A unit of generally soft clay soils is generally encountered between 3.0m and 5.5m, but was not encountered in the CPT104 and CPT106.
- A thin unit of clay or organic soil is indicated between 12.7m and 13.8m, with dense gravel below (Figure 14).



**Figure 14: Cone resistance and SBT soil overlay**

## **7.0 GEOTECHNICAL TEST DATA ASSESSMENT**

### **7.1 Static Ultimate Bearing Capacity Assessment**

The CPT results have been assessed using the Geologismiki Software 'CPet-IT' v.3.9.3.7. The data indicates that shallow soils (the upper 3.0m) have relative densities at least 40%, indicating a UBC of 300kPa can be achieved in the natural soils from 0.4m begl.

The Scala Penetrometer results have also been used to assess bearing capacity using a correlation between Scala blow count and allowable bearing capacity by Stockwell (Stockwell, 1977). Using this correlation, the Scala Penetrometer results indicate a geotechnical ultimate bearing capacity (UBC) of 300kPa to be achieved in the natural soils, with localised areas of loose soils having a UBC of 200kPa.

The soft clays below 3.0m have a low shear strength in the area of the flow path (CPT101 and 102), being as low as 10kPa.

### **7.2 Ground Settlement Under Static Conditions**

The ground generally comprises soils of low compressibility. There is however an approximately 2m thick soft clay layer present at a similar topographic level in CPT's 101, 102, 103 and 105. The softest clays appear to be correlated to the overland flow area. The clay soils were not described visually (the hand augers could not achieve the required depth) but based on the CPT SBT it is considered that this cohesive soil could contain organics and, in the absence of adequate intrusive information, should be assumed to be prone to secondary consolidation.

The presence of potentially compressible soil does not preclude the use of the site as residential land from an engineering perspective. It is however considered that further assessment of the clay should be undertaken at Resource Consent stage, to assess the settlement risk associated with enabling earthworks and constraints on building types/designs.

### **7.3 Seismic Site Subsoil Classification**

Based on the exploratory hole information and geological setting it is considered that seismic site subsoil classification 'Class D – Deep soil sites', as defined in NZS:1170.5, applies.

### **7.4 Quantitative Liquefaction Analysis**

#### **7.4.1 Assessment Methods**

Liquefaction analyses to assess estimated ground settlement were undertaken on the data from the CPT's, using the Geologismiki Software "CLiq" v.3.5.10 and the methods prescribed by the current MBIE guidance.

As there is a creek located along the southwestern boundary, a lateral spreading analysis has been undertaken in accordance with the MBIE guidance.

### 7.4.2 Analysis Parameters

Groundwater was encountered in EDC’s hand augers as shallow as 2.2m, which is in line with the minimum groundwater level of a nearby well. Therefore, a static groundwater level of 2.2m begl has been assumed with a groundwater level of 1.7m begl used during an earthquake scenario for the liquefaction analyses.

Regarding the lateral spreading analysis, the level differential between the base of the creek and the general elevation is approximately 2.0m which is considered to be free face height. It is understood there will be an offset of 20m from the stream and the edge of any future lot. This distance (20m) has been used as the CPT offset for CPT105 and CPT106, the closest two CPT’s to the creek.

Three seismic scenarios have been analysed for the purpose of assessing future ground performance, in accordance with the MBIE Guidance. The parameters used in these analyses are shown on Table 6:

Scenario	Earthquake Magnitude (Mw)	Peak Ground Acceleration (g)
SLS 1A	7.5	0.13
SLS 1B	6.0	0.19
ULS	7.5	0.35

**Table 6: Liquefaction Analysis Scenario Parameters**

Notes: Serviceability Limit State (SLS) design assesses the deformations that occur under working conditions, while Ultimate Limit State (ULS) assesses the situation that would lead to the collapse of a structure.

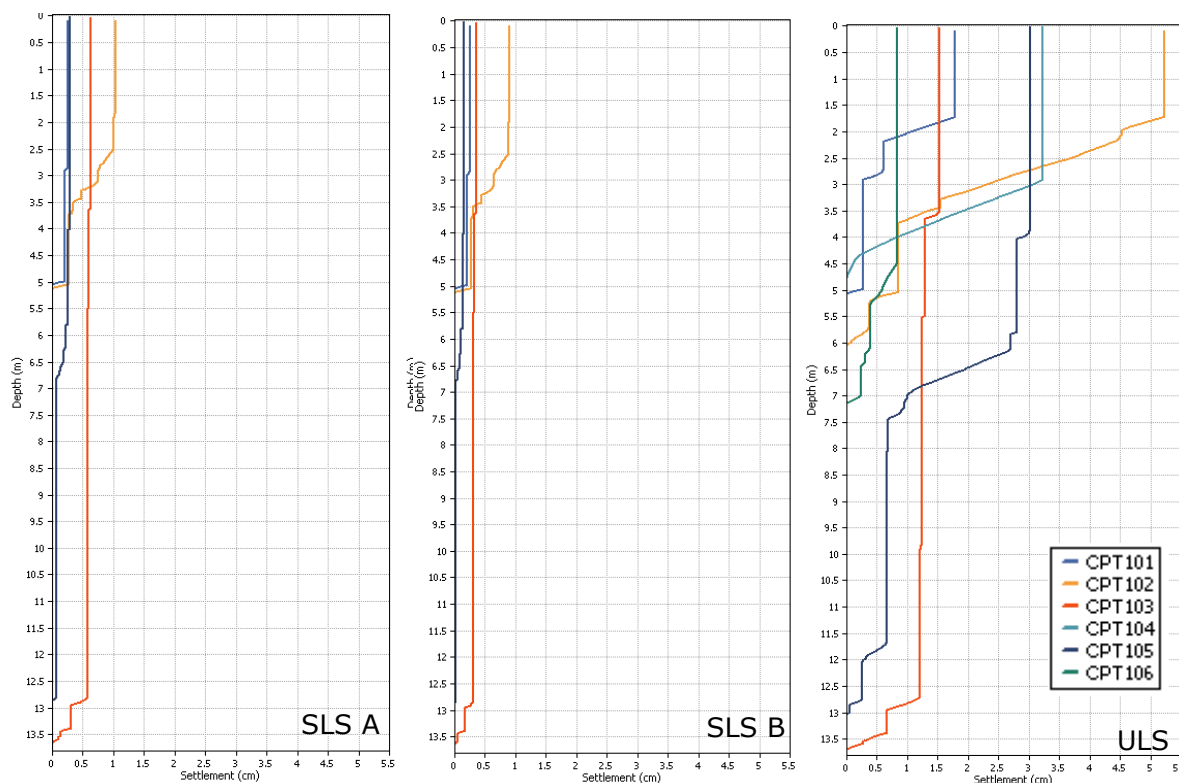
### 7.4.3 Estimated Ground Settlement

The graphical results sheets for each of the analyses are included in Appendix D. The following table summarises the results of estimated settlements:

CPT Test Ref.	CPT Depth (m)	Estimated Free-Field Settlement (mm)					
		SLS Scenario 1A		SLS Scenario 1B		ULS Scenario	
		Index	Full CPT Depth	Index	Full CPT Depth	Index	Full CPT Depth
CPT101	8.95	3	3	3	3	18	18
CPT102	9.06	10	10	9	9	52	52
CPT103	13.77	0	6	0	4	3	15
CPT104	6.83	0	0	0	0	32	32
CPT105	13.10	2	3	2	2	24	30
CPT106	9.07	0	0	0	0	8	8

**Table 7: Summary of Estimated Liquefaction-Induced Settlement**

- The CPT analyses indicated between 0mm and 9mm of estimated indexed settlement under SLS 1B conditions and between 3mm and 52mm under ULS conditions.
- Under SLS 1B conditions, all CPT's with the exception of CPT102 (which did not have a very thick unit of shallow gravel) suggest the soil profile in the upper 10m is generally non-liquefiable. In areas of deeper sands, such as CPT102, liquefaction related free-field settlement occurs from 2.5m to 3.5m.
- Under ULS conditions, the non-clay soils between 1.7m and 7.5m are modelled to liquefy to varying extents (Figure 15), becoming generally non-liquefiable below 7.5m.



**Figure 15: Estimated Total Vertical Settlement under SLS and ULS Conditions**

#### 7.4.4 Estimated Lateral Spread

An estimated quantitative assessment of lateral stretch was undertaken using the CPT closest to the creek along the southwestern boundary, using an offset of 20m and a free face height of 2.0m. Table 8 summarises the results of estimated lateral spread results for CPT105 and CPT106:

Test Ref.	Offset	Estimated Lateral Spread (mm)		
		SLS Scenario 1A	SLS Scenario 1B	ULS Scenario
CPT105	20	0	0	14
CPT106	20	0	0	0

**Table 8: Summary of Estimated Liquefaction-Induced Lateral Spreading**

The results of the estimated global lateral movement for the site do not indicate lateral spreading to under SLS 1A or 1B earthquake conditions, with up to 14mm of global lateral movement under ULS earthquake conditions.

When considering the current ground levels, the amount of global lateral spread is anticipated to be limited. The risk of lateral spread (global and differential) should be considered for any future building at the building consent stage, with potential issues manageable by suitable foundation solutions, building offsets, or engineering design.

#### 7.4.5 Liquefaction Severity

The Liquefaction Severity Number (LSN) is a parameter that predicts the occurrence of damaging liquefaction by recognising that damaging liquefaction is related to the depth at which liquefaction occurs. The LSN's for the CPT analyses are shown below:

CPT ref.	Estimated Ground Damage		
	SLS Scenario 1A	SLS Scenario 1B	ULS Scenario
CPT101	0	0	8
CPT102	3	3	19
CPT103	1	0	1
CPT104	0	0	9
CPT105	0	0	4
CPT106	0	0	2

**LSN Key**

0 – 10 = Little to no expression of liquefaction,      30 – 40 = Moderate to severe expression of liquefaction,  
 10 – 20 = Minor expression of liquefaction,      40 – 50 = Major expression of liquefaction,  
 20 – 30 = Moderate expression of liquefaction,      >50 = Severe damage.

**Table 9: Summary of Estimated Liquefaction-Induced Ground Damage**

The above indicates that in an SLS 1B event, little to no liquefaction ejecta is expected, while in a ULS event, minor to moderate expression of liquefaction could be anticipated.



## 8.0 CONCLUSIONS

### 8.1 Ground Description

GNS mapping indicates that the site is underlain by Holocene age river deposits. Previous investigations around the site, and EDC's on-site investigation, confirm the presence of such soils and indicate a degree of localised variability in soil profile.

Our intrusive investigation indicates shallow soils comprising fill & topsoil up to 0.4m thick across the site, underlain by interbedded firm silt over medium dense but locally loose sand. The depth to gravel soils varies across the site, being as shallow 1.0m, but as deep as 2.8m, with gravel extending to approximately 3.0m. Below gravel, in CPT's; 101, 102, 103 and 105, is an approximately 2m thick soft to firm layer of clay-like (possibly organic) soils to 5.5m, with medium dense to dense sand and sandy gravel to 12.7m.

Groundwater was encountered as shallow as HA101. CPT101 encountered groundwater at 2.7m with CPT106 encountering groundwater at 2.65m.

### 8.2 Seismic Site Subsoil Classification

Based on the exploratory hole information and geological setting it is considered that seismic site subsoil classification 'Class D – Deep soil sites', as defined in NZS:1170.5, applies.

### 8.3 Geotechnical Constraints

Table 10 froms the geotechnical hazards assessment. This is given to provide an assessment of current risk on the site and should be re-assessed at Resource consent stage.

Hazard	Comment
Fault Rupture	No geological faults are mapped on or within close proximity to the site and therefore the risk of rupture on the site within a design seismic event is considered negligible.
Static Ultimate Bearing Capacity	<p>Scala Penetrometer testing indicated a variable strength in the shallow soils (above the gravel) with a geotechnical UBC 300kPa generally achieved in the shallow soils from 0.4m, with localised areas having a geotechnical UBC of 200kPa.</p> <p>The CPT results indicate that shallow soils (the upper 3.0m) have relative densities at least 40%, indicating a UBC of 300kPa can be achieved in the natural soils from 0.4m begl.</p> <p>The soft clays below 3.0m have a low shear strength in the area of the flow path (CPT101 and 102), being as low as 10kPa.</p>
Static Settlement	<p>The ground generally comprises soils of low compressibility. There is however an approximately 2m thick soft clay layer present at a similar topographic level in CPT's 101, 102 , 103 and 105. The softest clays appear to be correlated to the overland flow area. The clay soils were not described visually. It is considered that this cohesive soil could contain oragnics and, in the absence of adequate intrusive information, should be assumed to be prone to secondary consolidation.</p> <p>The presence of potentially compressible soil does not preclude the use of the site as residential land from an engineering perspective. It is however considered that further assessment of the clay should be undertaken at Resource Consent stage, to assess the settlement risk associated with enabling earthworks and constraints on building types/designs.</p>

Hazard	Comment
Liquefaction risk	<p>Quantitative assessment suggests that the upper 10m of soil are largely non-liquefiable in SLS events (up to 10mm free field settlement), though larger free-field settlement of isolated layers is anticipated in a ULS event (generally &lt;30mm free-field settlement, though CPT102 indicates c.50mm).</p> <p>Based on the 20m offset from the creek, no risk of lateral spreading was identified under SLS conditions, with less than 20mm identified under ULS conditions.</p> <p>Based on the above an MBIE Technical Foundation Category of TC 2 and the MBIE planning guidance classification of 'Liquefaction damage is possible – Medium' is considered to apply. However, this higher classification is only driven by the ULS performance of 3 of the 6 CPT's. As such, with additional investigation and knowledge of the earthworks, it is possible that areas of TC 1 and 'liquefaction damage is unlikely – low' can be defined at Resource Consent stage.</p>
Slope Stability	<p>The site is generally flat.</p> <p>No slippage was noted on the embankment to the creek beyond the southwest boundary and the historical aerial photos do not suggest the embankment has moved significantly since the 1940's. It is considered that the slope instability risk is generally low, though cannot be discounted. However, in view the likely 20m development offset from the creek, any future slope failure is unlikely to significantly impact upon the site. If required, further investigation and quatitative analysis can be undertaken at Resource Consent stage.</p> <p>The slope on the golfcourse is considered to be of a height that is unlikely to significantly impact the site should failure occur. If required, further investigation and quatitative analysis can be undertaken at Resource Consent stage.</p>
Erosion	<p>No erosional features were noted and the historical aerial photos do not suggest the embankment has moved significantly since the 1940's. Therefore the risk of erosion is considered to be low.</p>
Flooding	<p>Waimakariri District Council information indicates that the 1 in 200 year flood risk to the site is generally negligible, with only two small areas indicated asbeing within the Low category.</p>

**Table 10: Geohazard Summary**

#### **8.4 Site Suitability for Plan Change**

Based on the findings of this report it is considered that the geotechnical constraints for the site are not prohibitive for the proposed Plan Change.

#### **8.5 Additional Intrusive Investigation**

The information within this report is intended for re-zoning assessment and therefore additional intrusive investigation should be undertaken by a Chartered Professional Engineer for Resource Consent stage to confirm the findings above and further assess:

- Settlement risk associated with the soft clay layer, described in Section 7.2.

In addition to the above, additional investigation and analysis of liquefaction risk may be beneficial if results indicate that areas of the site can be assigned a lesser TC classification.

Dependent on the development plan, quantitative assessment of slope risk might be necessary and the need for this should be assessed by a Geotechnical Engineer as part of the Resource Consent application works.

## 9.0 REFERENCES

- CERA & CCC. (2014). *CERA Maps in collaboration with the Christchurch City Council*. Retrieved from Advanced Flood Viewer: [maps.cera.govt.nz/advanced-viewer/?Viewer=Ccc-Floor-Levels](https://maps.cera.govt.nz/advanced-viewer/?Viewer=Ccc-Floor-Levels).
- Earthquake Commission / Ministry of Business, Innovation & Employment. (2016). *Canterbury Maps*. Retrieved from New Zealand Geotechnical Database: <https://www.nzgd.org.nz/default.aspx>
- Environment Canterbury. (2016). *Canterbury Maps Enhanced Web Mapping Tools*. Retrieved from <http://canterburymaps.govt.nz/Portal/FlexViewer/Index.html>
- Stockwell, M. (1977). *Determination of allowable bearing pressure under small structures*. New Zealand Engineering, Volume 32 Issue 6.

## **APPENDIX A**

### **PROPOSED PLAN CHANGE AREA**



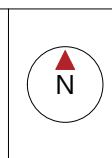
REVISION DETAILS	INT	DATE	SURVEYED	
1 FOR INFORMATION	NC	13.12.23	DESIGNED	
			DRAWN	CC
			CHECKED	NC
			APPROVED	NC

1188 MAIN NORTH ROAD  
WOODEND

H A STONE

# 20 TE HAUNUI LANE / 1188 MAIN NORTH ROAD

## EXISTING CONTOURS



STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:1500 @ A3	1
COUNCIL	WAIMAKARIRI	
DWG NO	P21-414-SU-0902	

## **APPENDIX B**

### **HAND AUGER SHEETS**



DRILLED: 17/01/2024 FILE: 51579

HAND AUGER NO.: **HASC101**

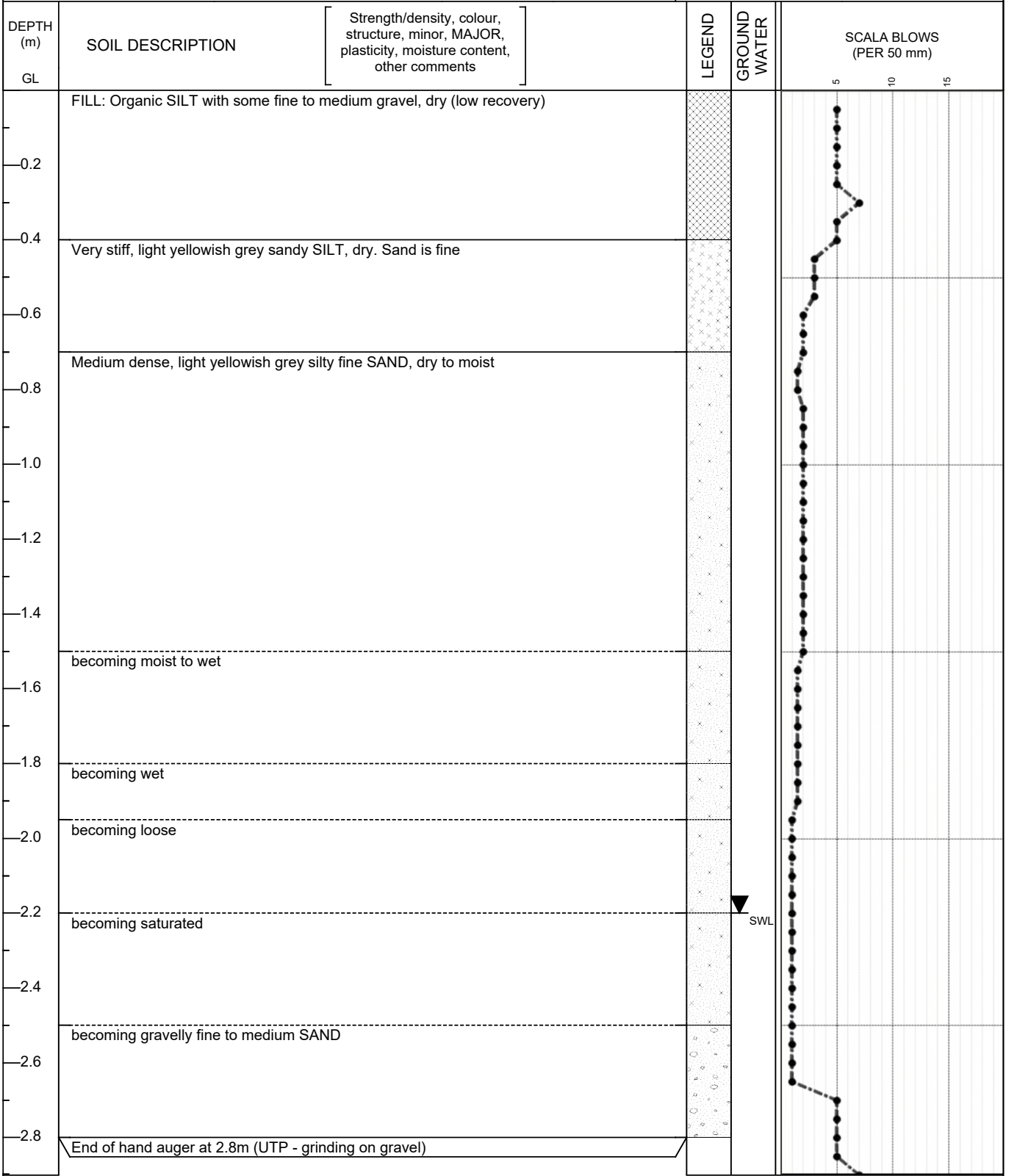
SHEET 1 OF 1

PROJECT: Geotechnical Investigation CLIENT: Howard Stone

LOGGED	PROCESSED	CHECKED
DP	CE	DP

ADDRESS: 20 Te Haunui Lane, Pegasus

BH LOCATION: COORDS: RL GROUND:



**NOTES:**  
Groundwater encountered at 2.2m. Scala Penetrometer reached target depth of 2.90m.

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ALBANY, AUCKLAND

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DRILLED: 17/01/2024 FILE: 51579

HAND AUGER NO.: HASC102

SHEET 1 OF 1

PROJECT: Geotechnical Investigation CLIENT: Howard Stone

LOGGED	PROCESSED	CHECKED
DP	CE	DP

ADDRESS: 20 Te Haunui Lane, Pegasus

BH LOCATION: COORDS: RL GROUND:

DEPTH (m)	SOIL DESCRIPTION	LEGEND	GROUND WATER	SCALA BLOWS (PER 50 mm)
GL	[ Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments ]			
-0.2	TOPSOIL: Light brown organic silty SAND, dry	TS		
-0.4	Medium dense, light yellowish grey silty fine SAND, dry			
-0.6				
-0.8	becoming stained light orange silty fine to medium SAND			
-1.0	becoming light grey			
-1.2				
-1.4				
-1.6	becoming moist			
-1.8				
-2.0	becoming loose, fine to medium SAND with trace silt			
-2.2	becoming medium dense			
-2.4	becoming loose			
-2.6	End of hand auger at 2.6m (UTP - grinding on gravel)			

EOH @ 2.65 m

**NOTES:**  
Groundwater not encountered. Scala Penetrometer reached practical refusal at 2.65m.

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DRILLED: 17/01/2024 FILE: 51579

HAND AUGER NO.:  
**HASC104**

SHEET 1 OF 1

PROJECT: Geotechnical Investigation CLIENT: Howard Stone

LOGGED	PROCESSED	CHECKED
DP	CE	DP

ADDRESS: 20 Te Haunui Lane, Pegasus

BH LOCATION: COORDS: RL GROUND:

DEPTH (m) GL	SOIL DESCRIPTION	Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments	LEGEND	GROUND WATER	SCALA BLOWS (PER 50 mm)		
					5	10	15
0.0 - 0.2	TOPSOIL: Brown organic SILT, dry		TS TS TS TS TS TS TS TS TS TS				
0.2 - 0.4	Medium dense, light grey fine to medium SAND with some silt, dry						
0.4 - 0.6							
0.6 - 0.8							
0.8 - 0.9	End of hand auger at 0.90m (UTP - grinding on gravel)						

EOH @ 1.00 m

**NOTES:**

Groundwater not encountered. Scala Penetrometer reached practical refusal at 1.0m.

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DRILLED: 17/01/2024 FILE: 51579

HAND AUGER NO.: HASC105

SHEET 1 OF 1

PROJECT: Geotechnical Investigation CLIENT: Howard Stone

LOGGED	PROCESSED	CHECKED
DP	CE	DP

ADDRESS: 20 Te Haunui Lane, Pegasus

BH LOCATION: COORDS: RL GROUND:

DEPTH (m)	SOIL DESCRIPTION	Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments	LEGEND	GROUND WATER	SCALA BLOWS (PER 50 mm)
GL					5 10 15
0.2	TOPSOIL: Brown organic SILT, dry		TS		
0.4	Firm to stiff, light greyish yellow sandy SILT, dry		TS		
0.6	End of hand auger at 0.60m (UTP - grinding on gravel)				
0.8					

EOH @ 0.85 m

NOTES:

Groundwater not encountered. Scala Penetrometer reached practical refusal at 0.85m.

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Produced With: GEROCC Core-GS



DRILLED: 17/01/2024 FILE: 51579

HAND AUGER NO.:  
**HASC106**

SHEET 1 OF 1

PROJECT: **Geotechnical Investigation**

CLIENT: **Howard Stone**

LOGGED

PROCESSED

CHECKED

ADDRESS: **20 Te Haunui Lane, Pegasus**

DP

CE

DP

BH LOCATION: COORDS:

RL GROUND:

DEPTH (m)	SOIL DESCRIPTION	Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments	LEGEND	GROUND WATER	SCALA BLOWS (PER 50 mm)
GL					
-0.2	TOPSOIL: Brown organic SILT, dry		TS		
-0.4	Stiff, light yellow sandy SILT, dry. Sand is fine		TS		
-0.6	Loose to medium dense, light grey silty fine to medium SAND, dry		TS		
-1.0	End of hand auger at 0.90m (UTP - grinding on gravel)				
-1.2					
-1.4					

EOH @ 1.50 m

**NOTES:**

Groundwater not encountered. Scala Penetrometer reached practical refusal at 1.5m.

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DRILLED: 17/01/2024 FILE: 51579

HAND AUGER NO.: HASC107

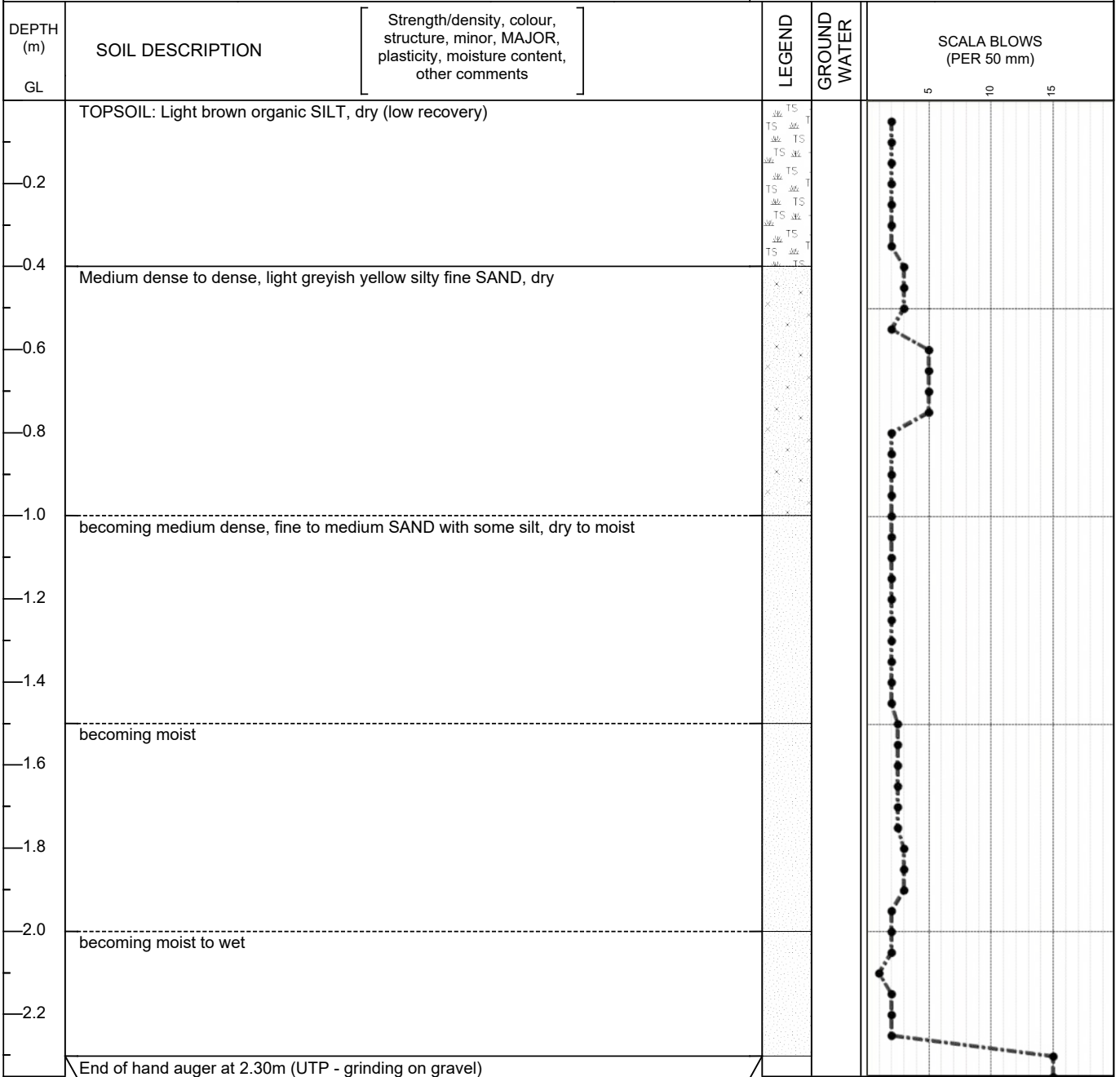
SHEET 1 OF 1

PROJECT: Geotechnical Investigation CLIENT: Howard Stone

LOGGED	PROCESSED	CHECKED
DP	CE	DP

ADDRESS: 20 Te Haunui Lane, Pegasus

BH LOCATION: COORDS: RL GROUND:



EOH @ 2.35 m

NOTES:

Groundwater not encountered. Scala Penetrometer reached practical refusal at 2.35m.

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## **APPENDIX C**

### **LIQUEFACTION ANALYSIS**

**LIQUEFACTION ANALYSIS REPORT**

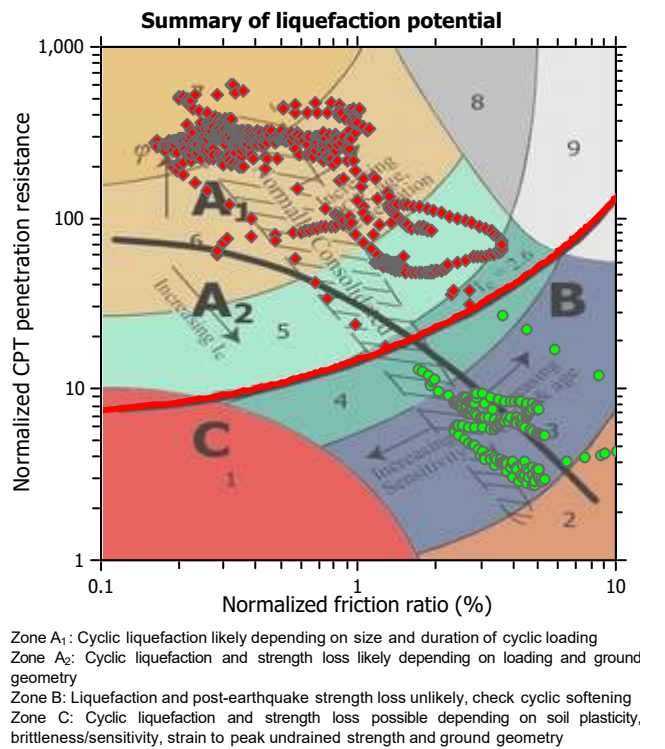
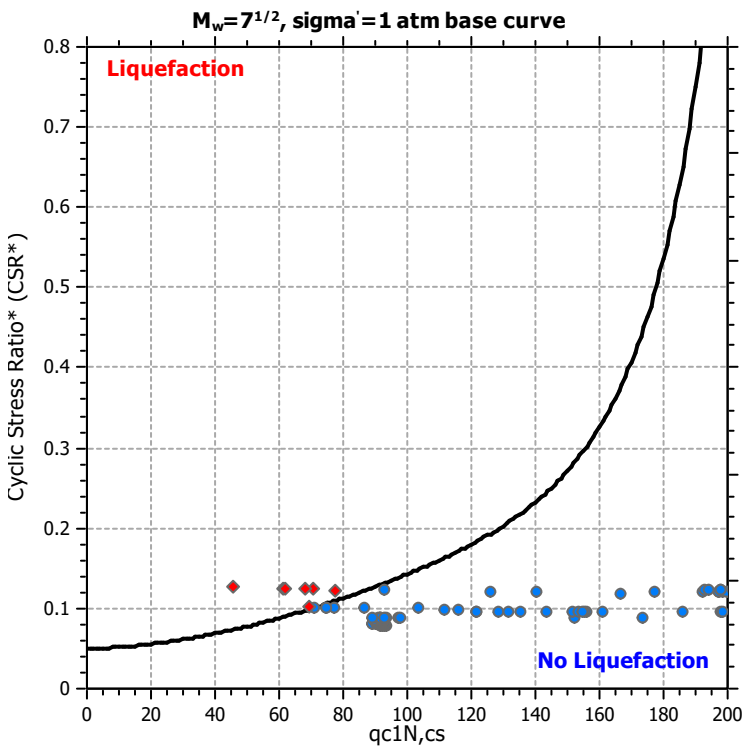
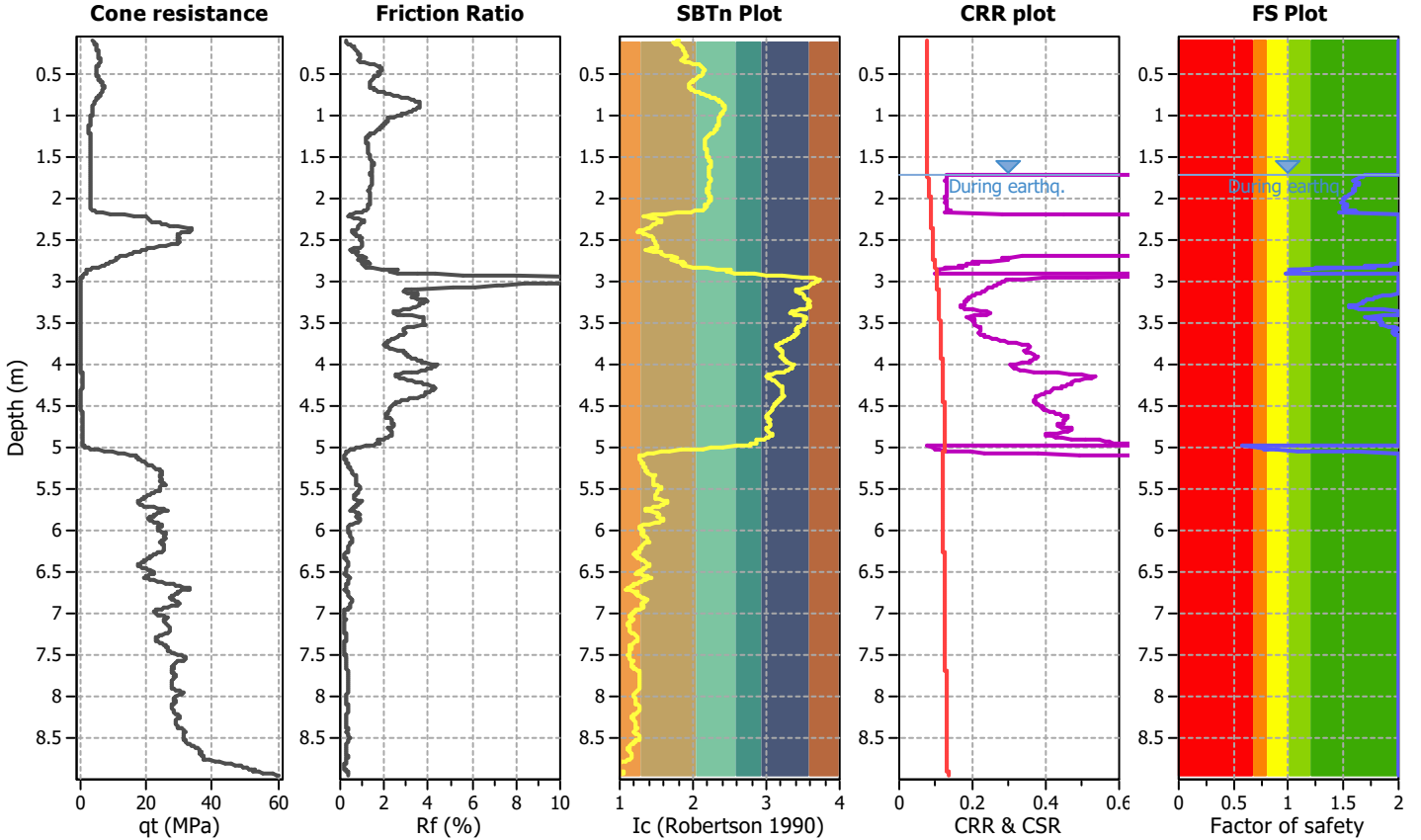
**Project title : Liquefaction Analysis - SLS 1A**

**Location : 20 Te Haunui Lane, Pegasus**

**CPT file : CPT101**

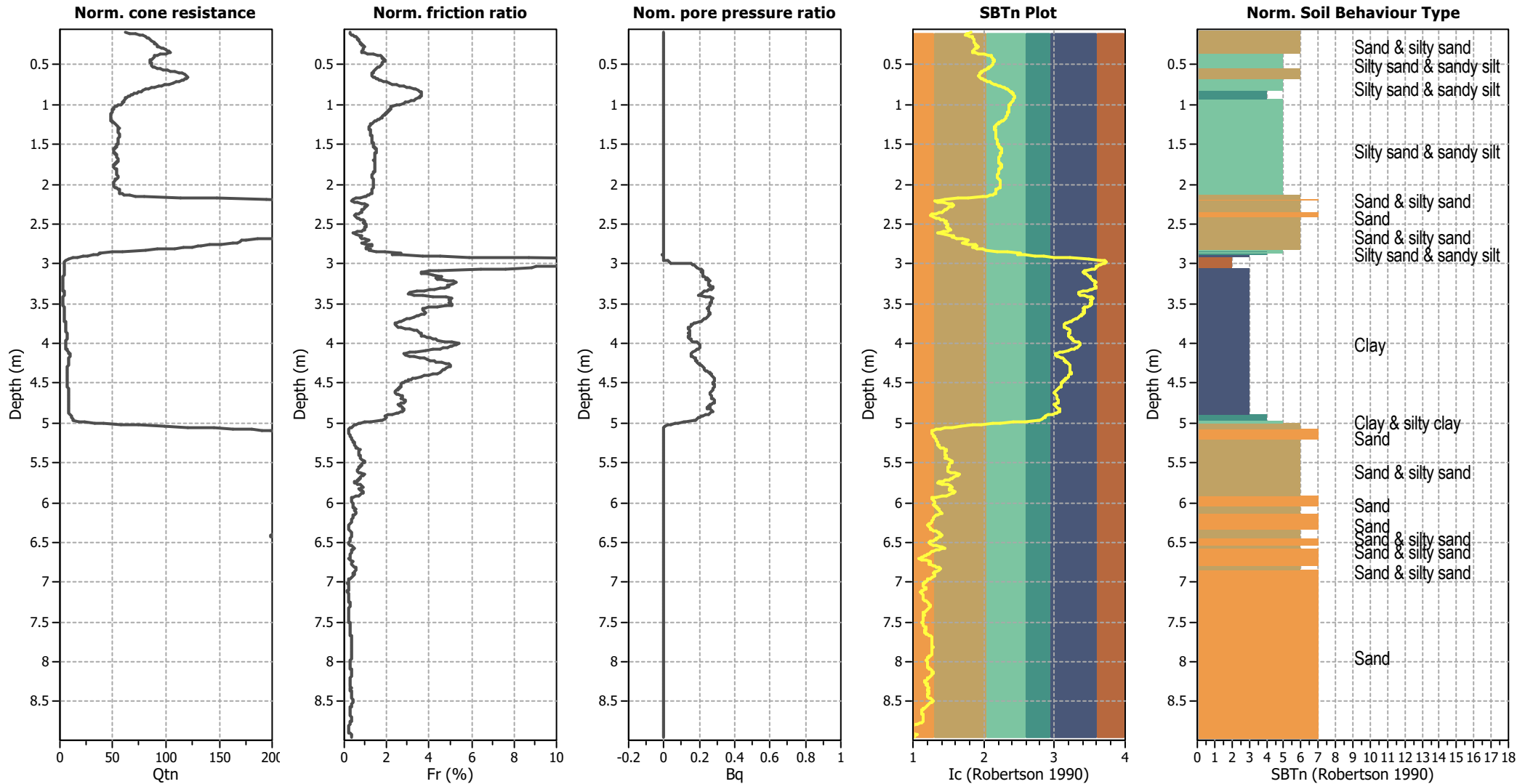
**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes	MSF method:	Method based





### CPT basic interpretation plots (normalized)



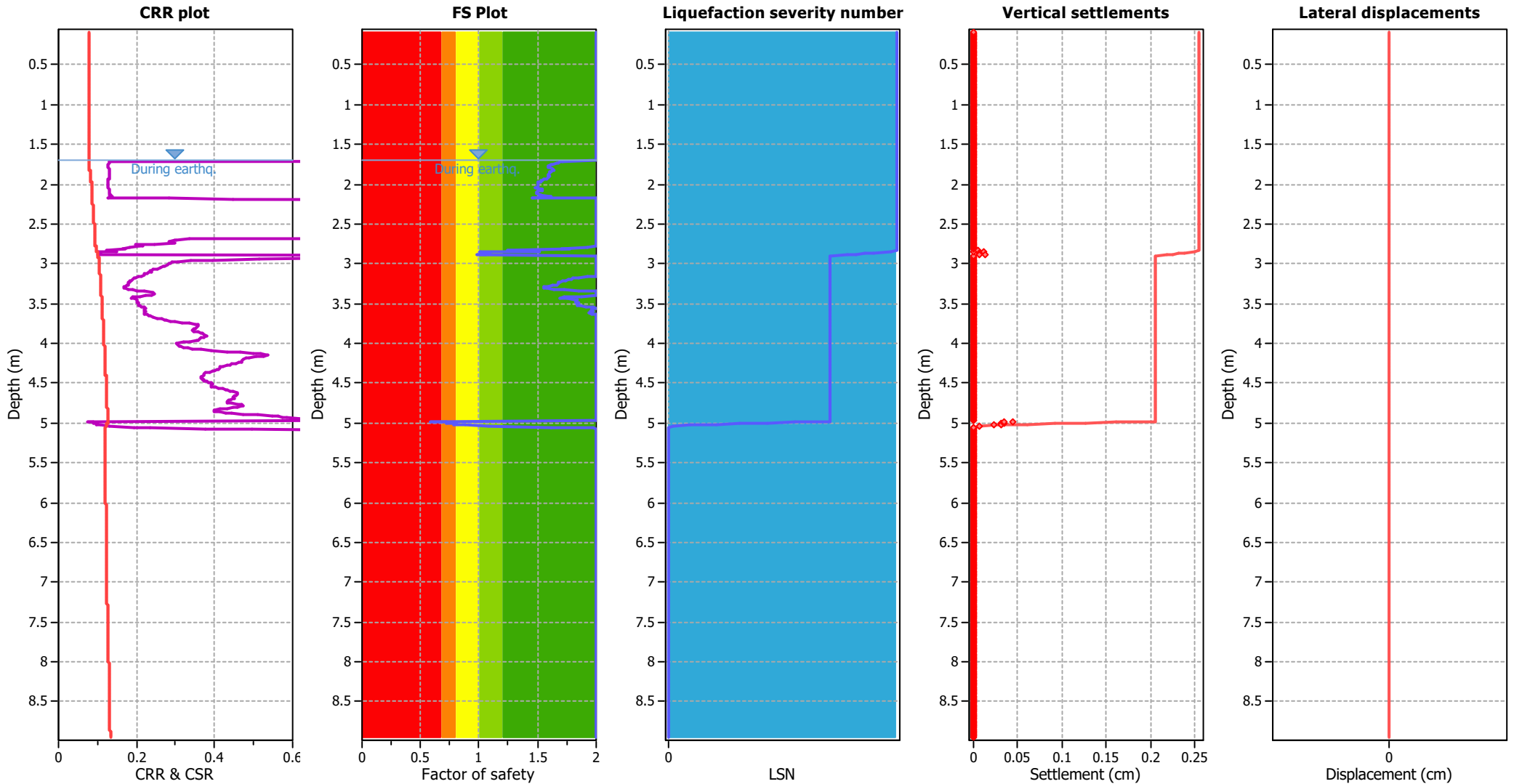
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

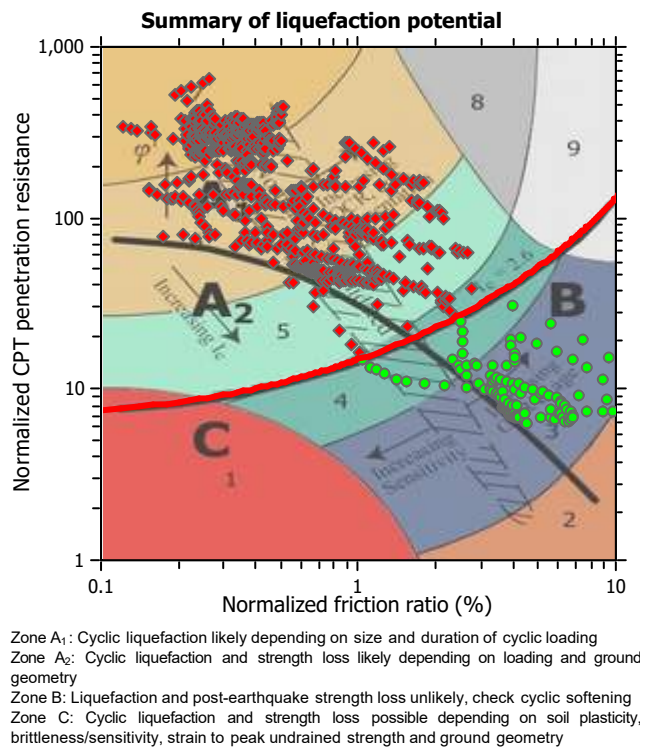
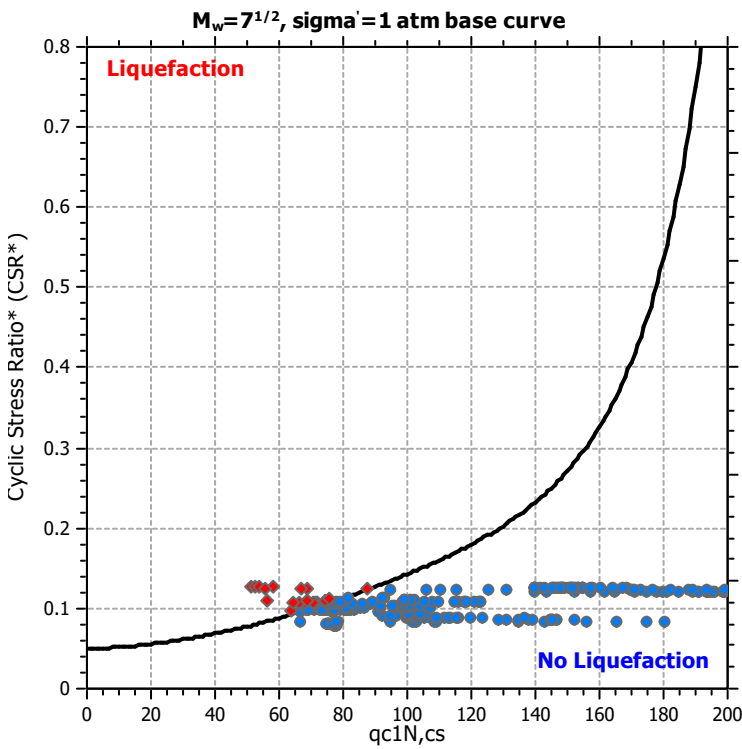
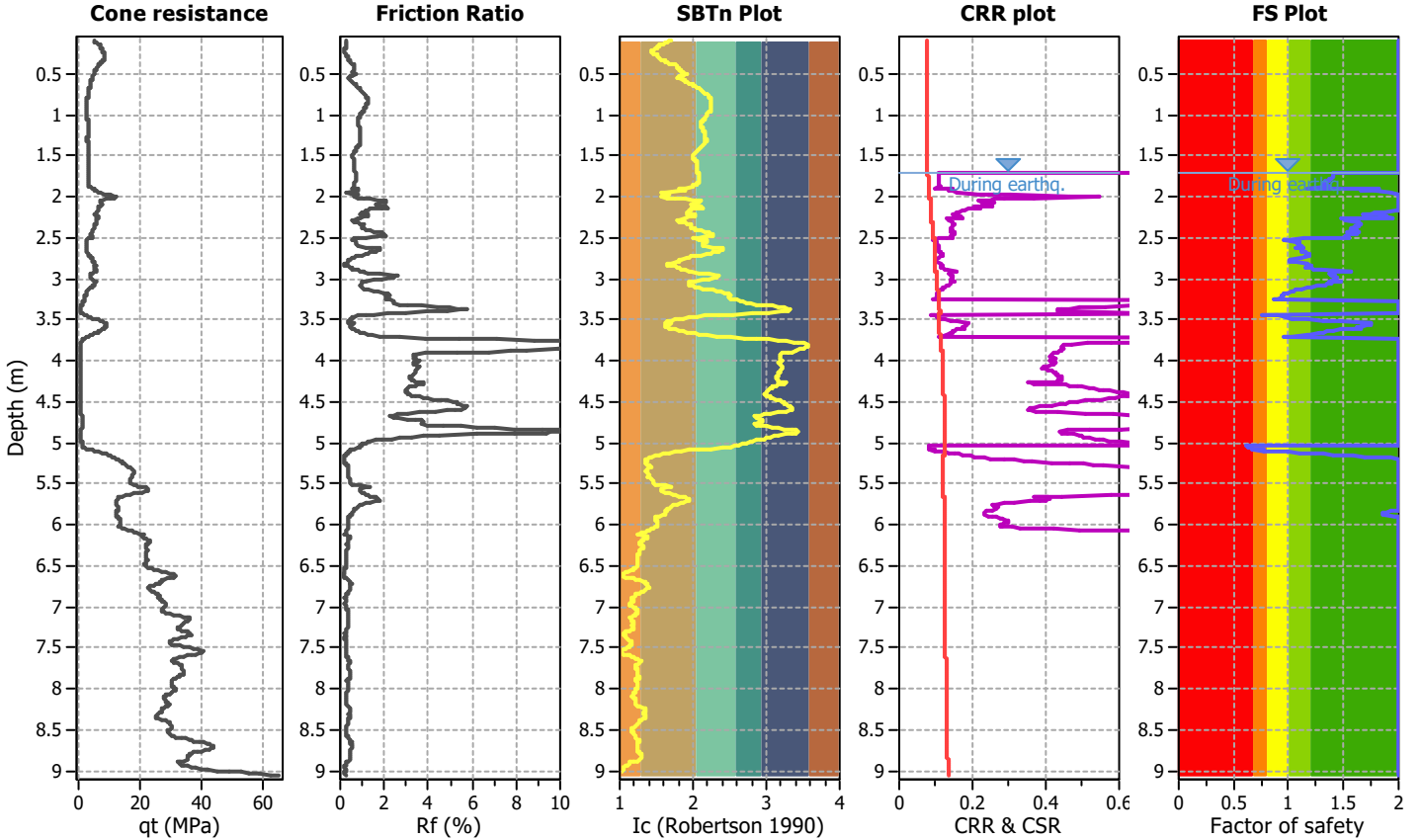
**Project title : Liquefaction Analysis - SLS 1A**

**Location : 20 Te Haunui Lane, Pegasus**

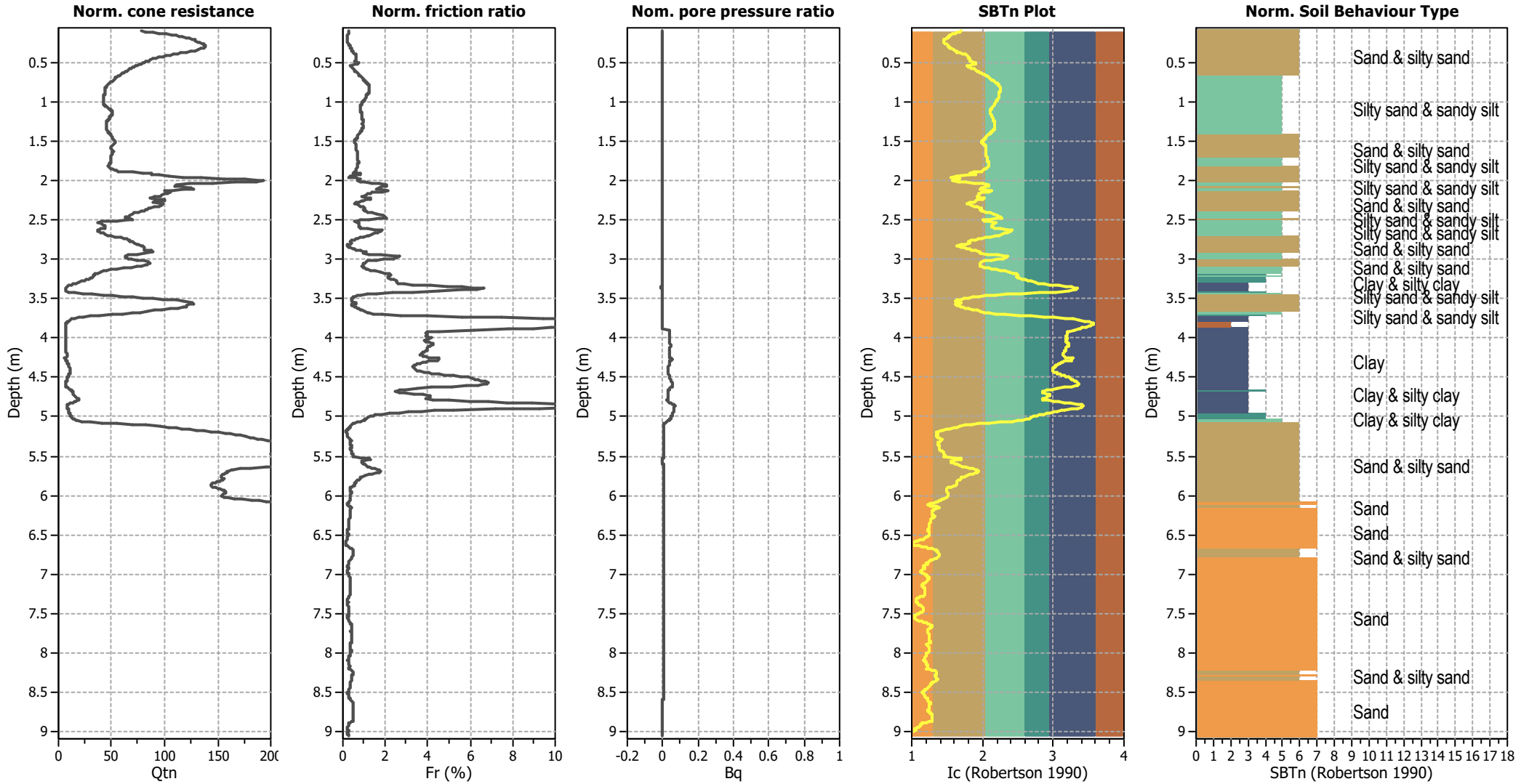
**CPT file : CPT102**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes	MSF method:	Method based



### CPT basic interpretation plots (normalized)



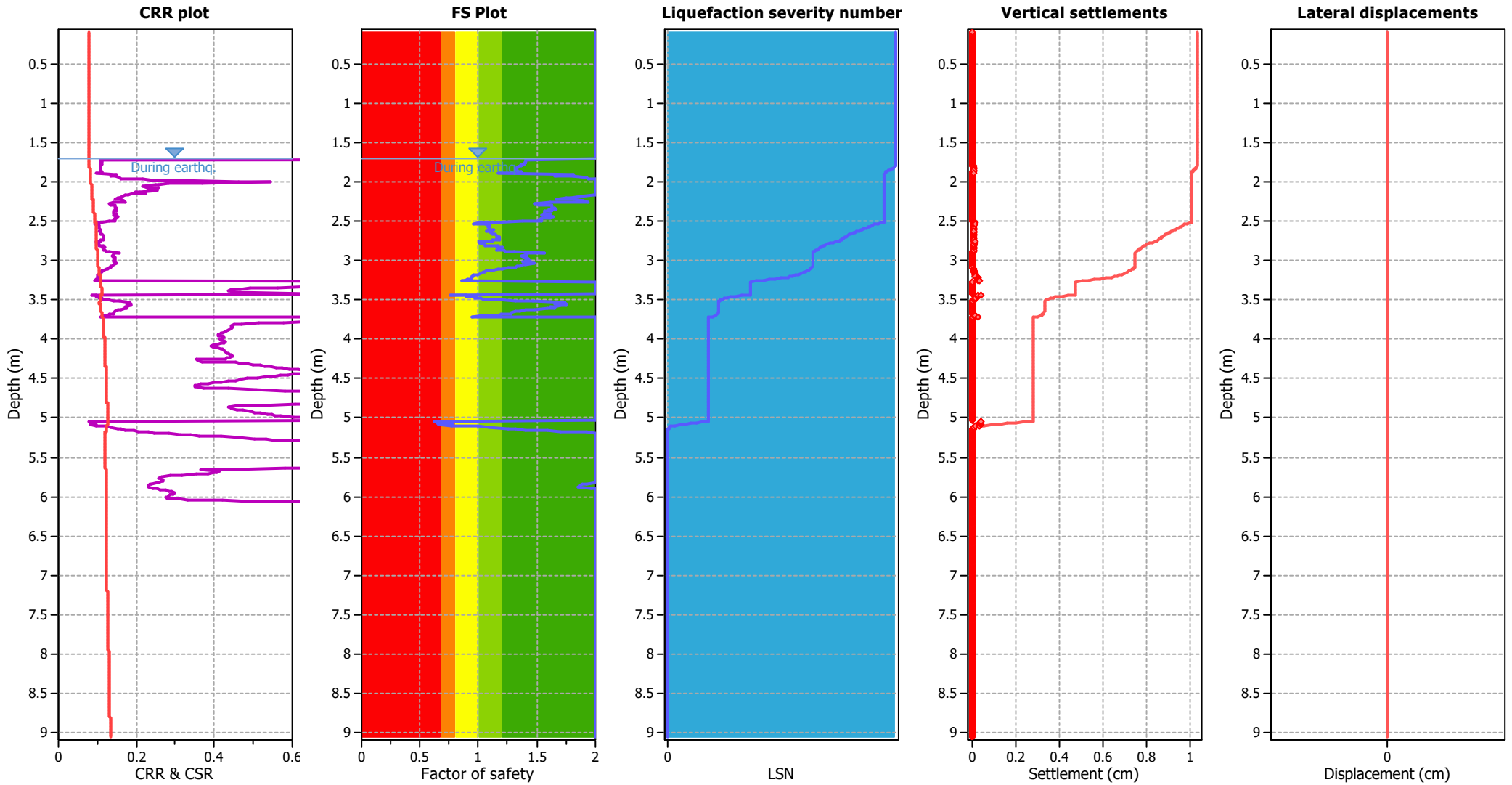
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>o</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

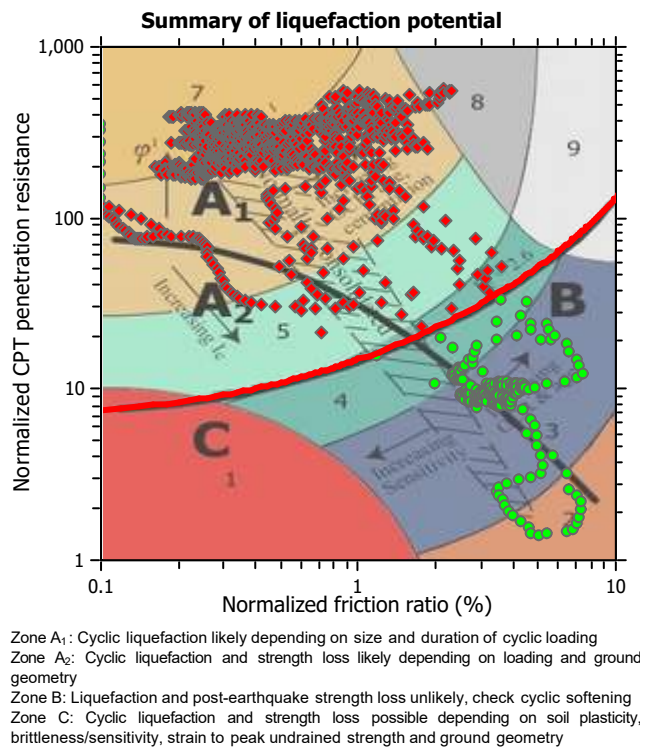
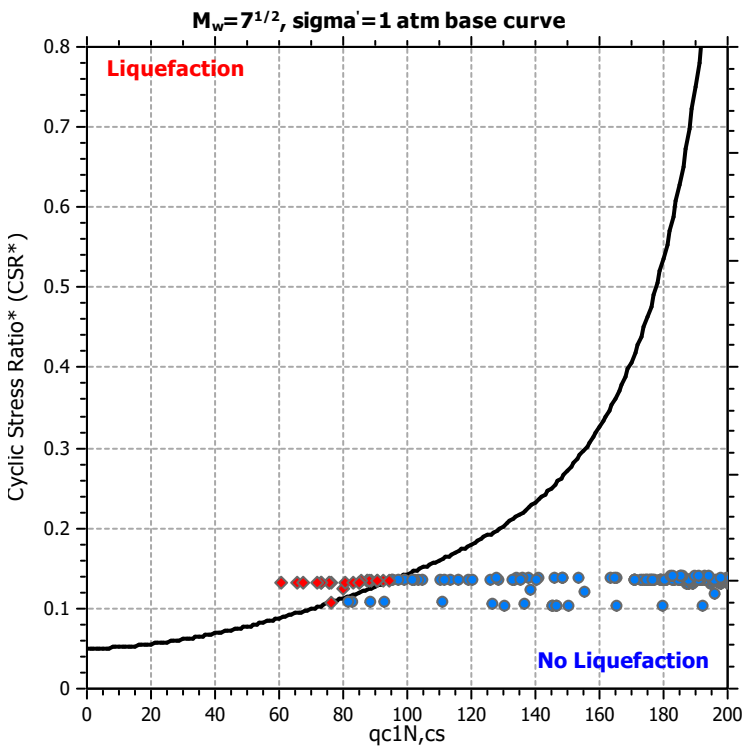
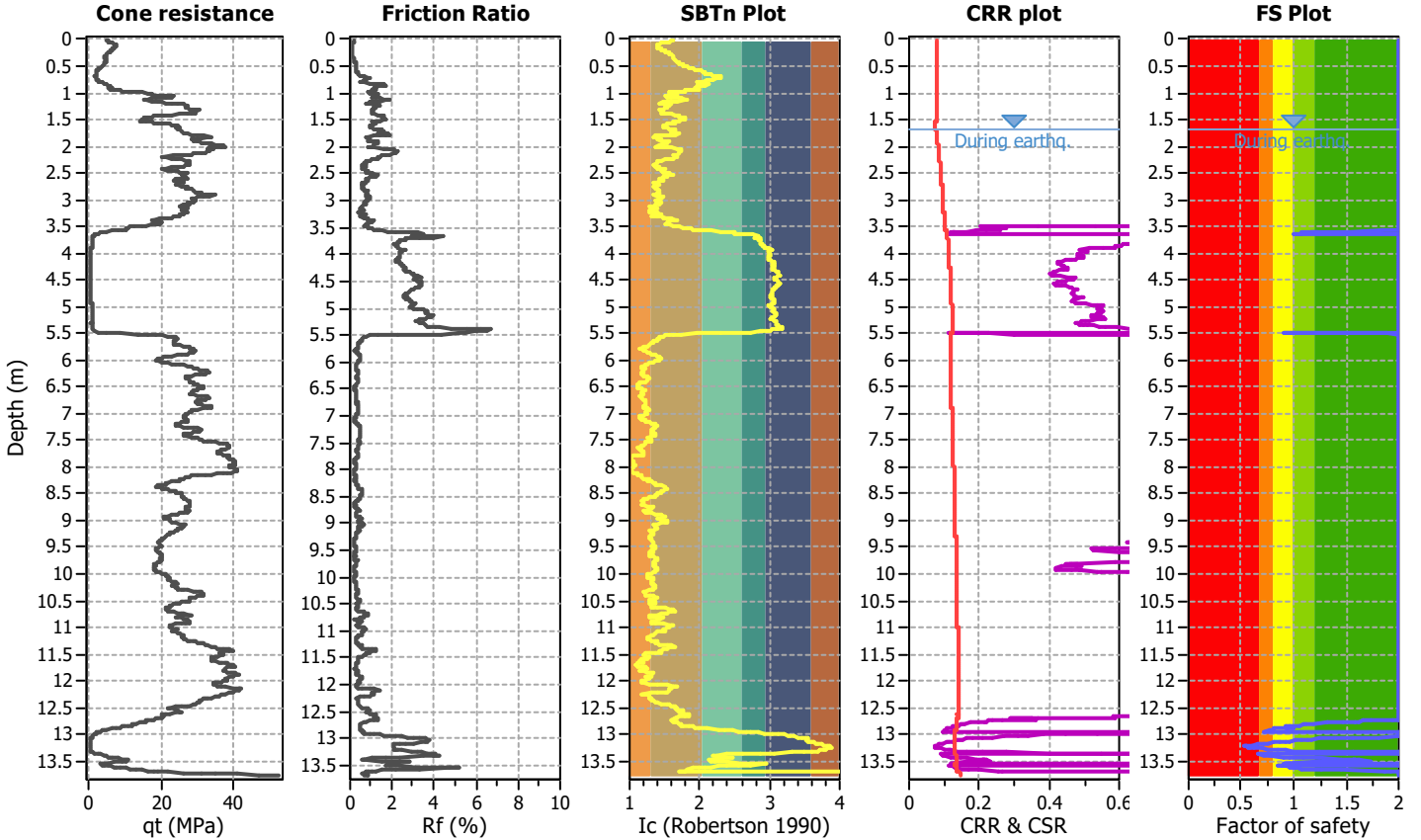
**Project title : Liquefaction Analysis - SLS 1A**

**Location : 20 Te Haunui Lane, Pegasus**

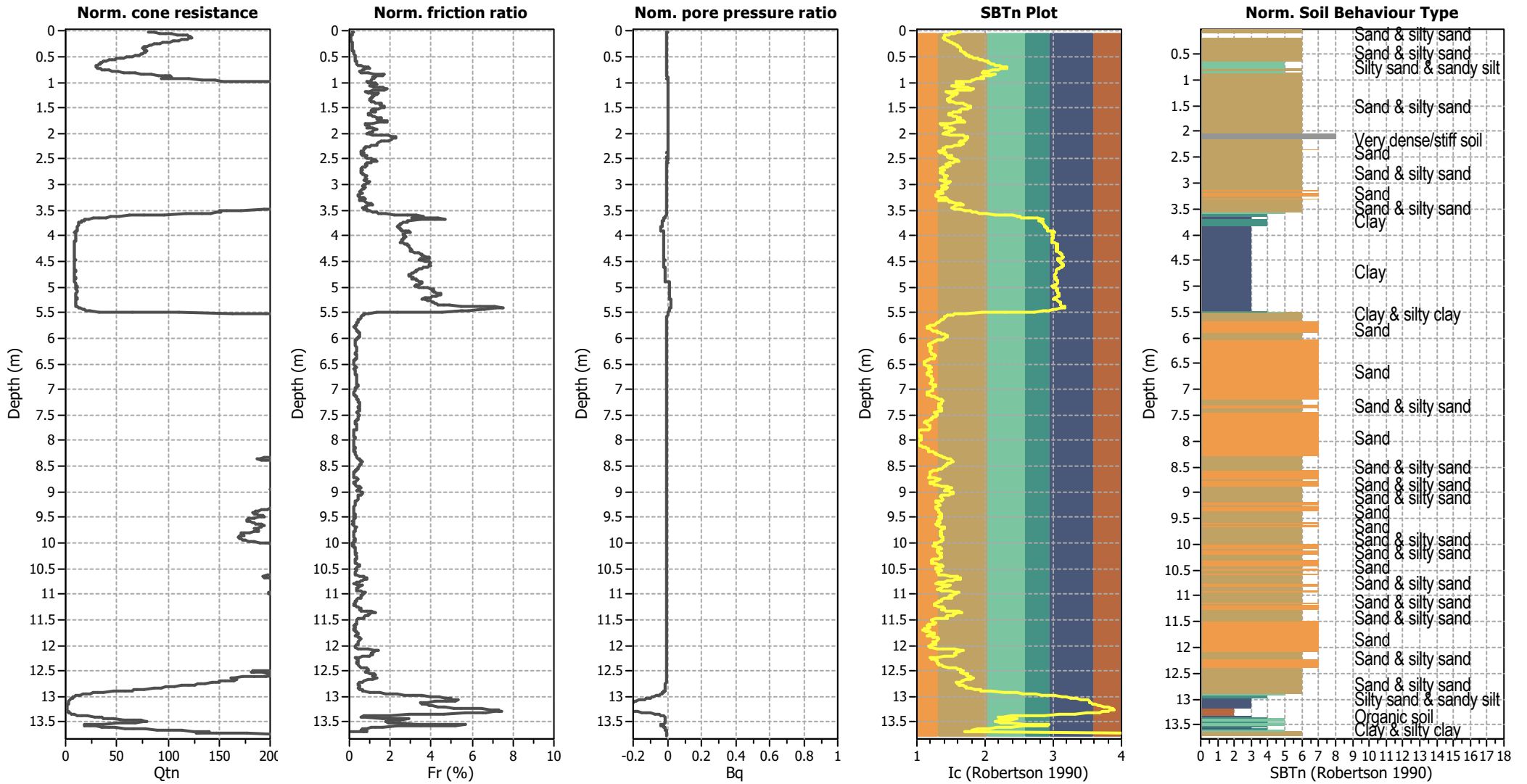
**CPT file : CPT103**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



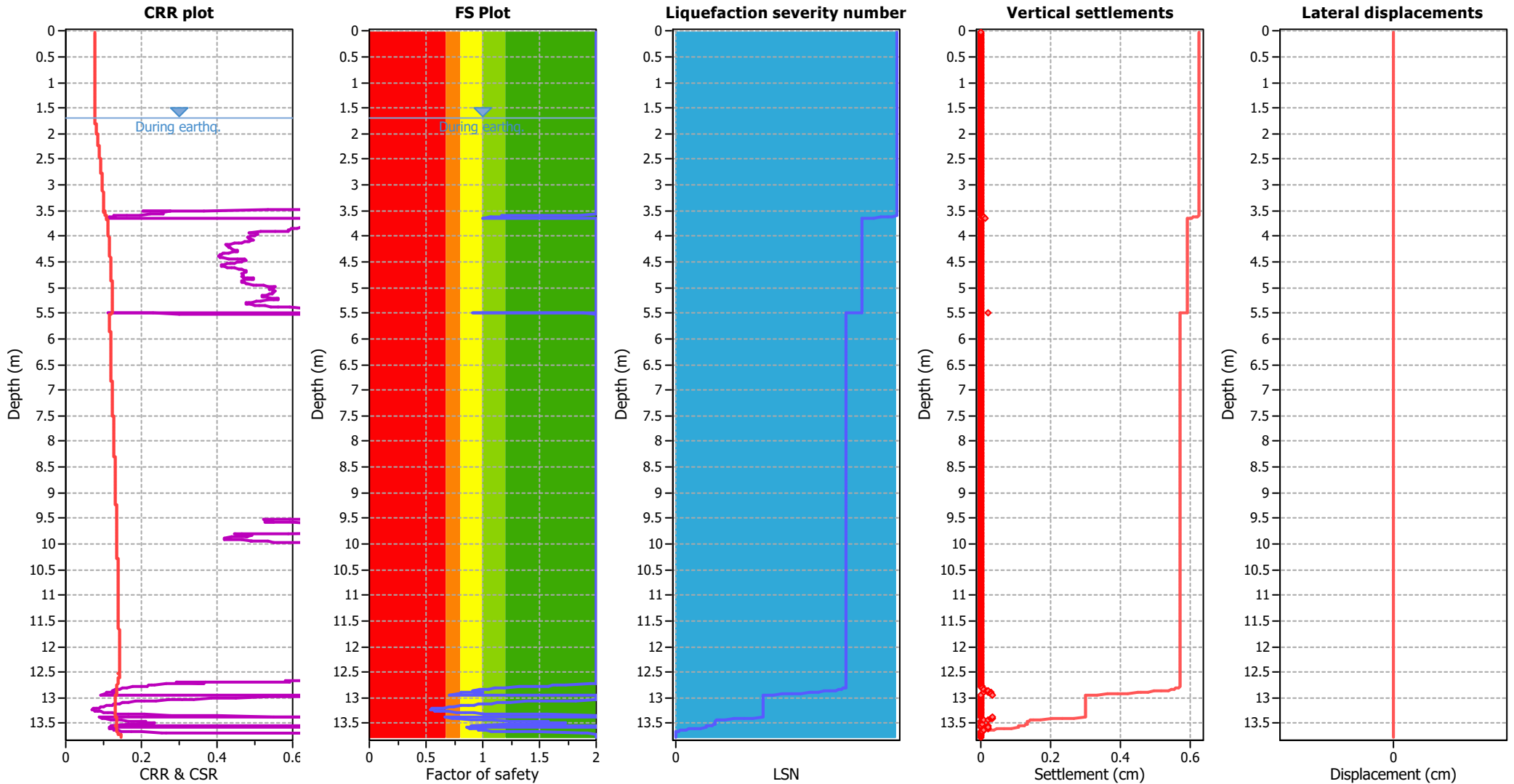
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_o$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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



**LIQUEFACTION ANALYSIS REPORT**

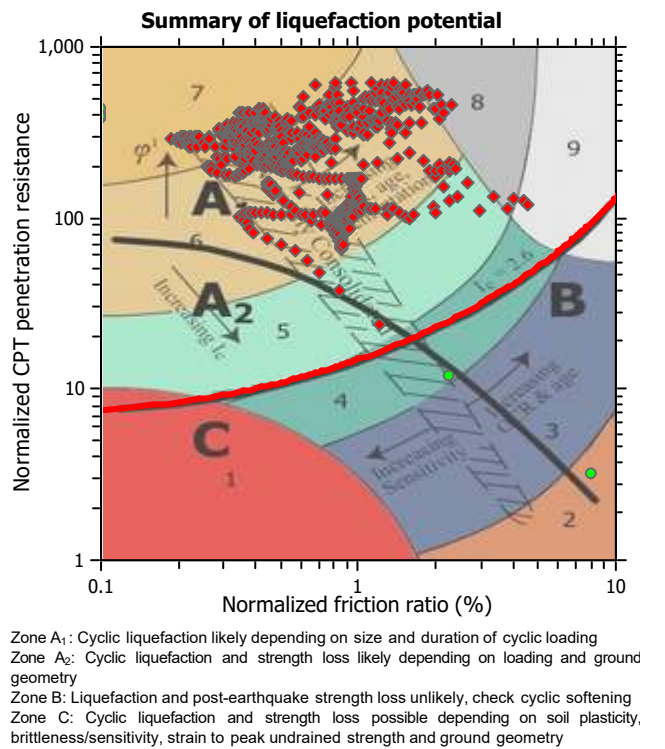
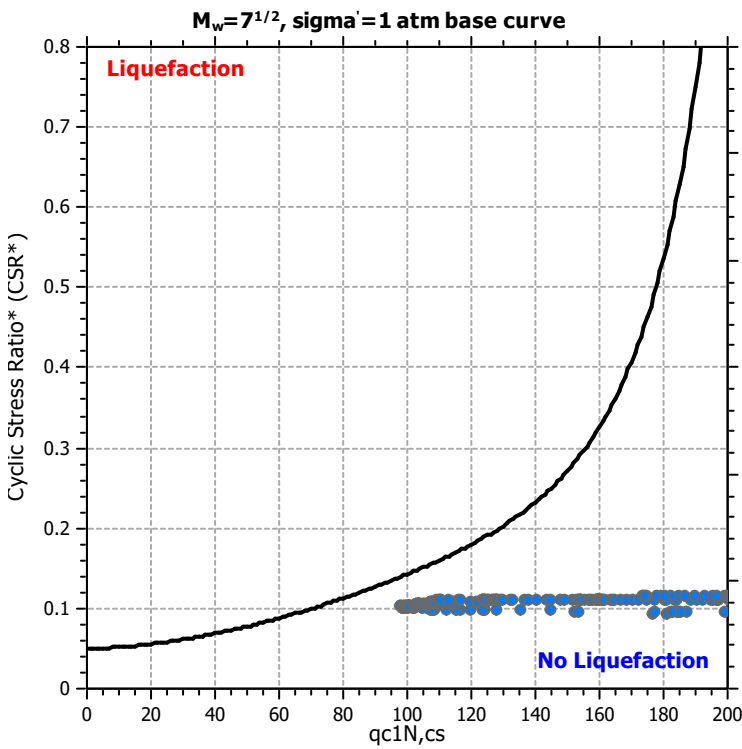
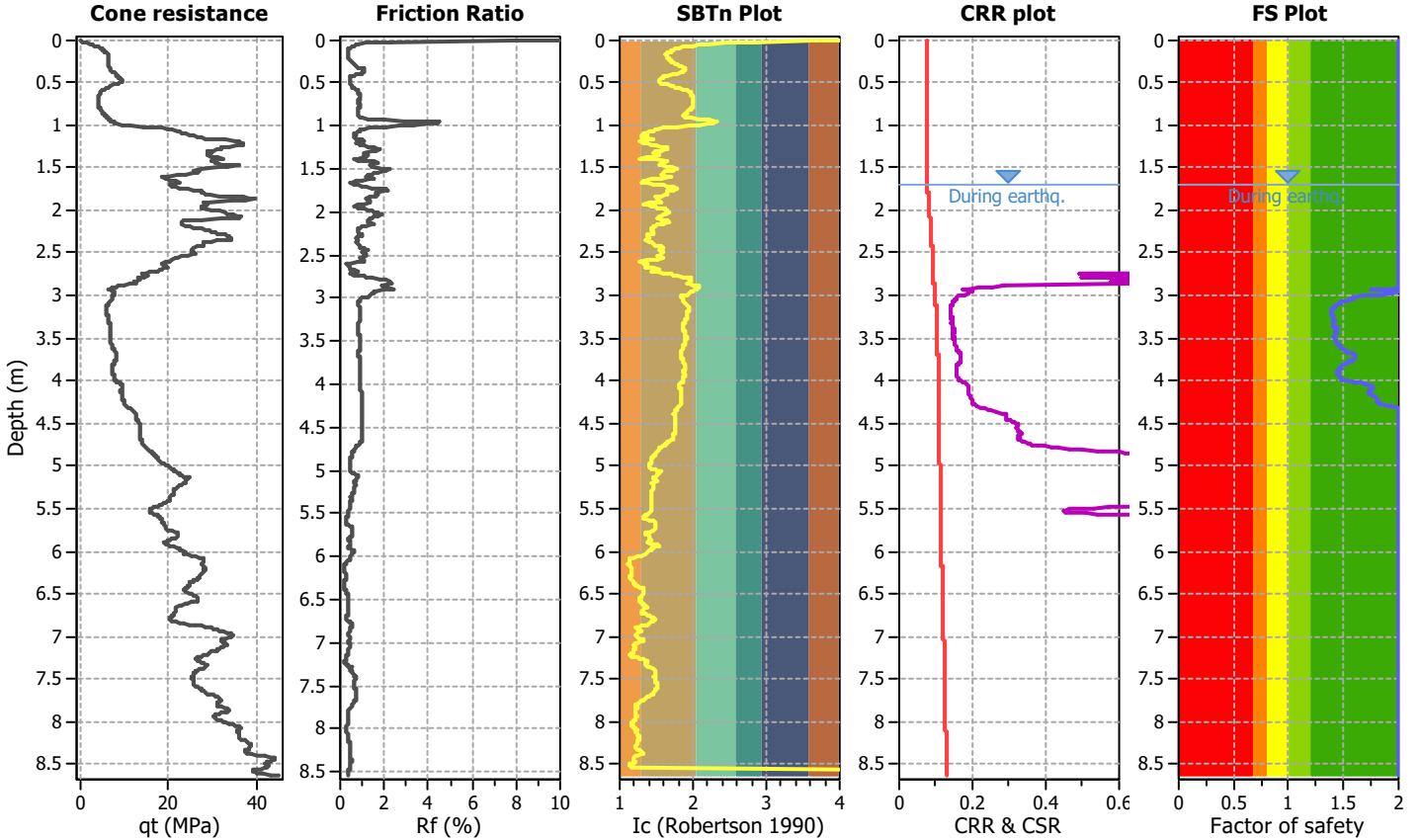
**Project title : Liquefaction Analysis - SLS 1A**

**Location : 20 Te Haunui Lane, Pegasus**

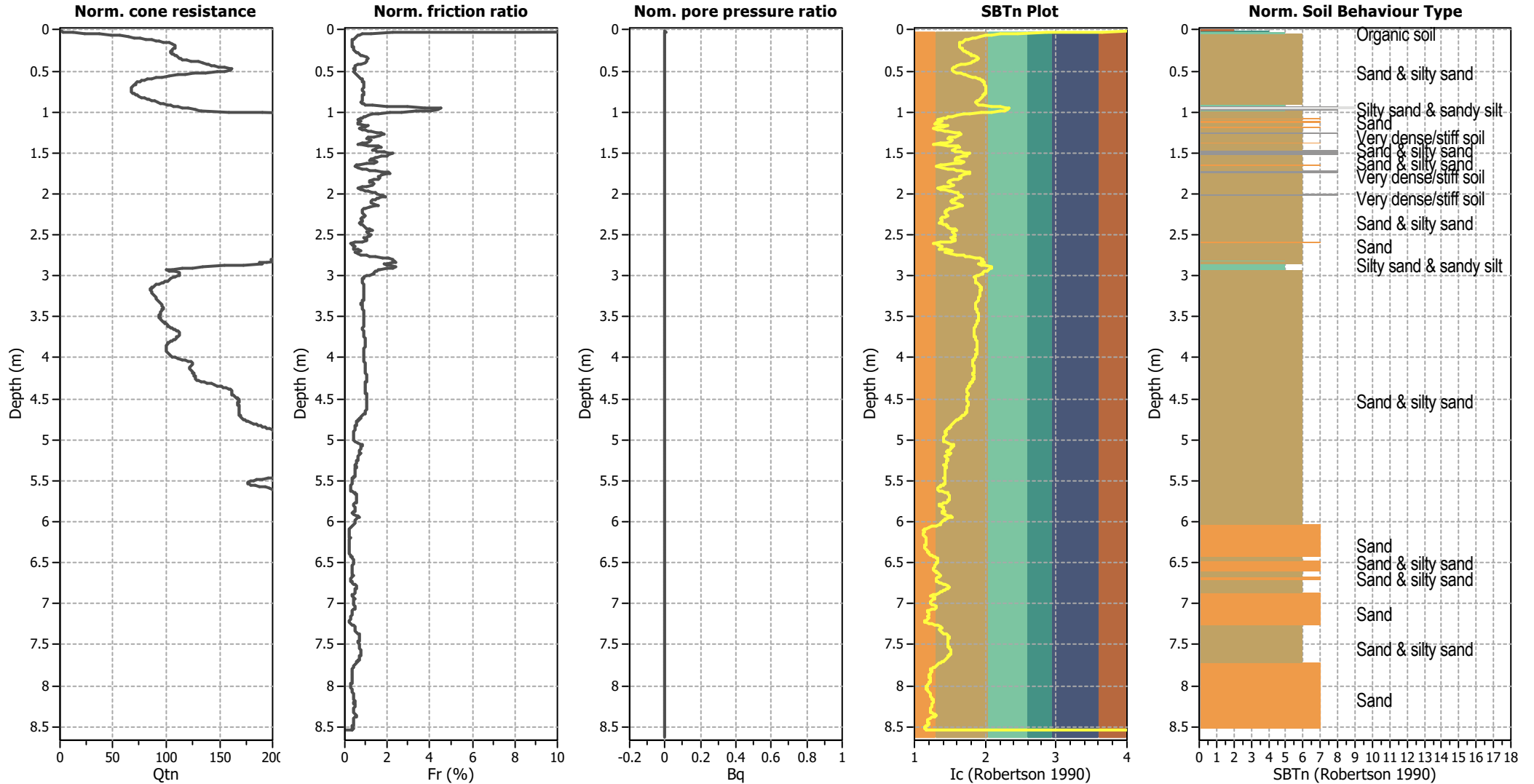
**CPT file : CPT104**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



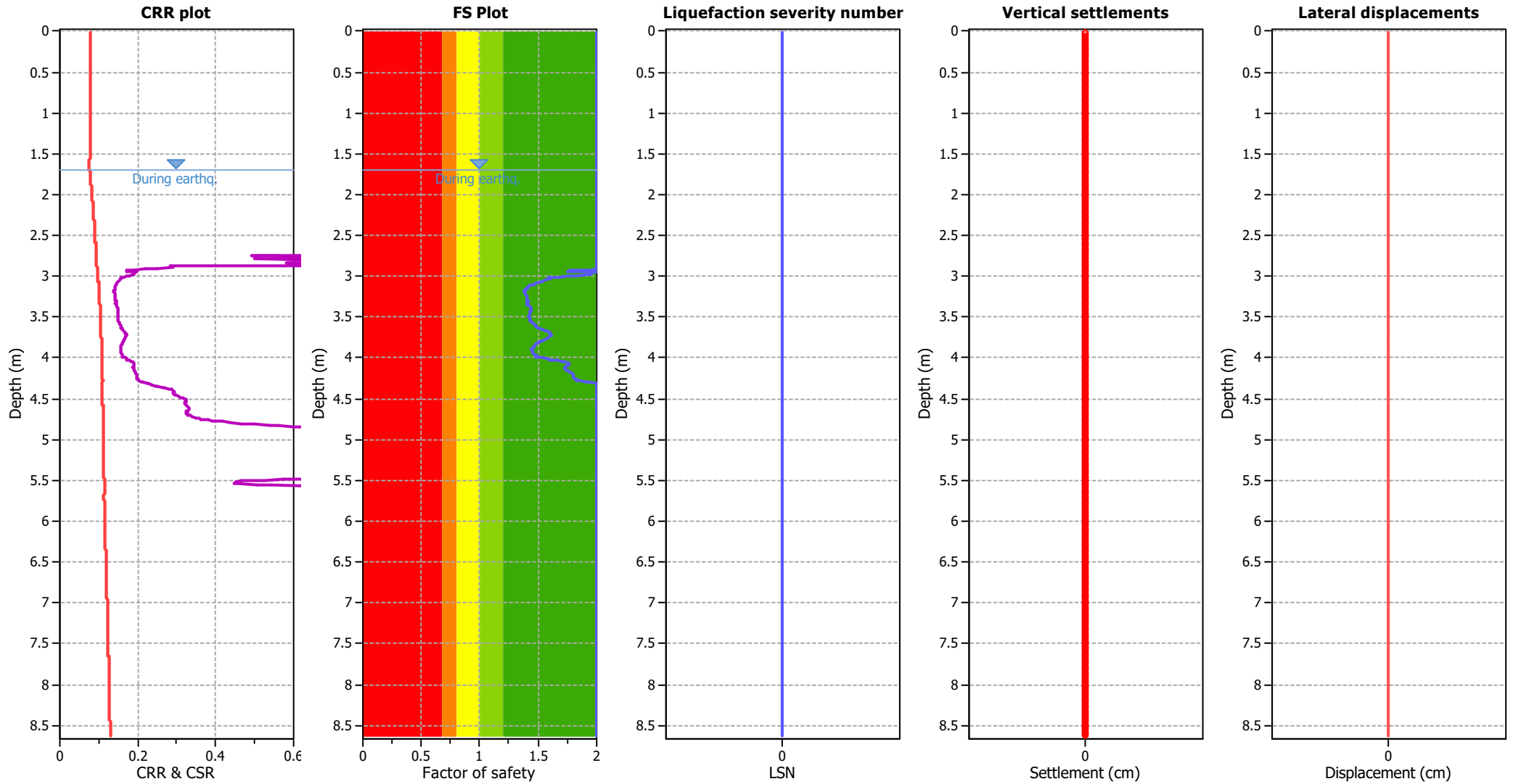
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

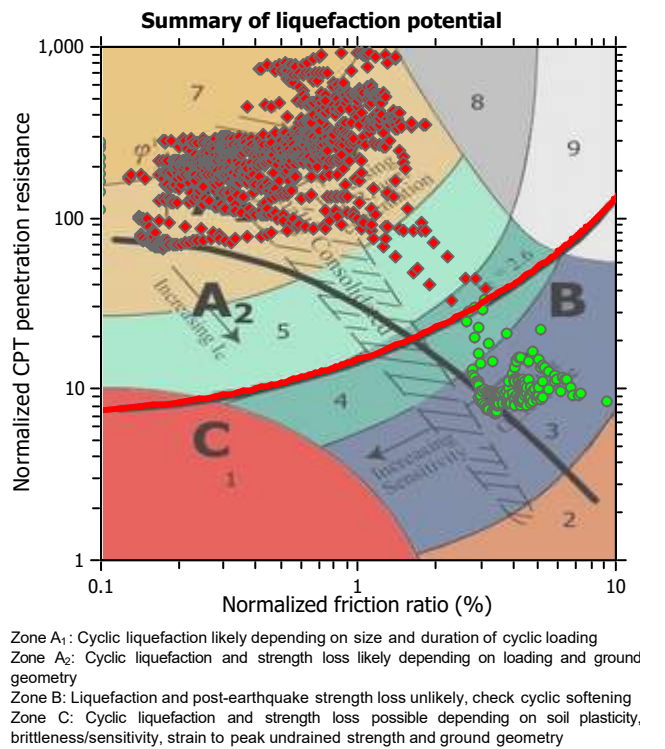
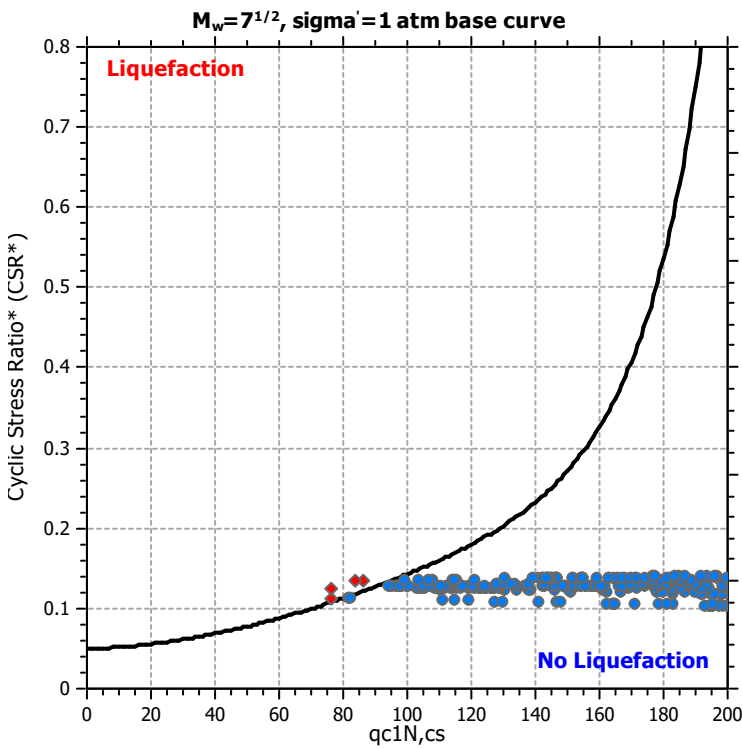
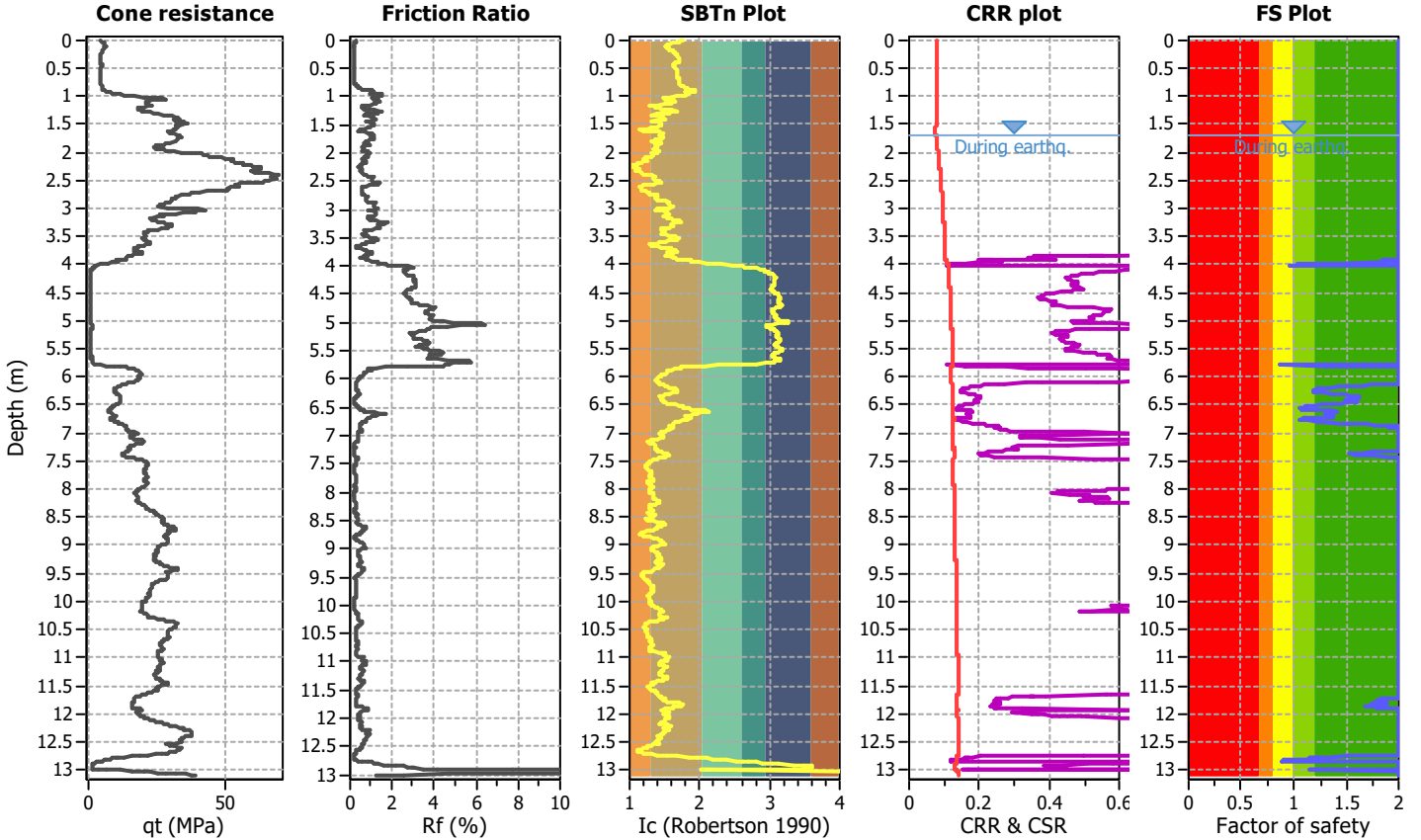
**Project title : Liquefaction Analysis - SLS 1A**

**Location : 20 Te Haunui Lane, Pegasus**

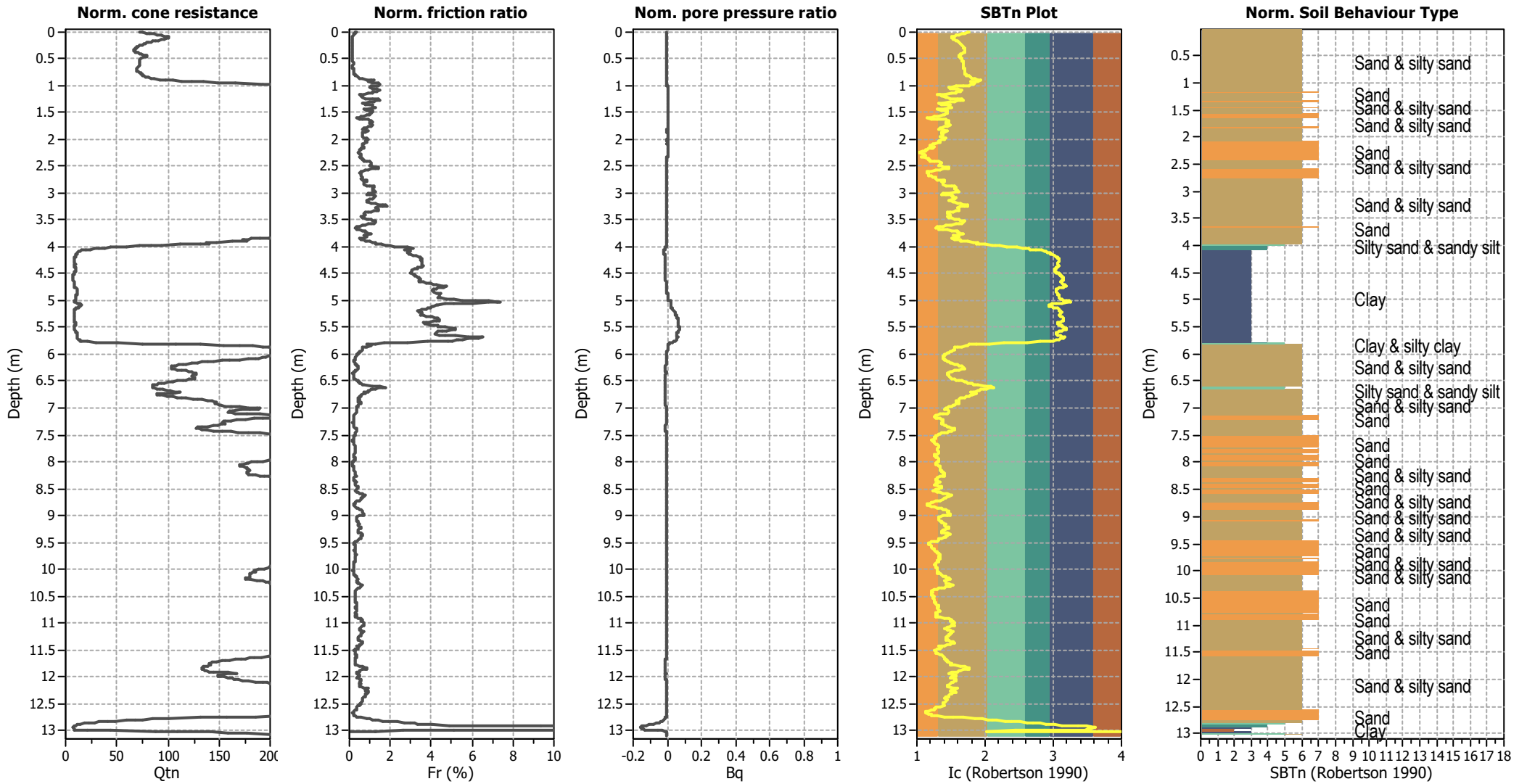
**CPT file : CPT105**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes	MSF method:	Method based



### CPT basic interpretation plots (normalized)



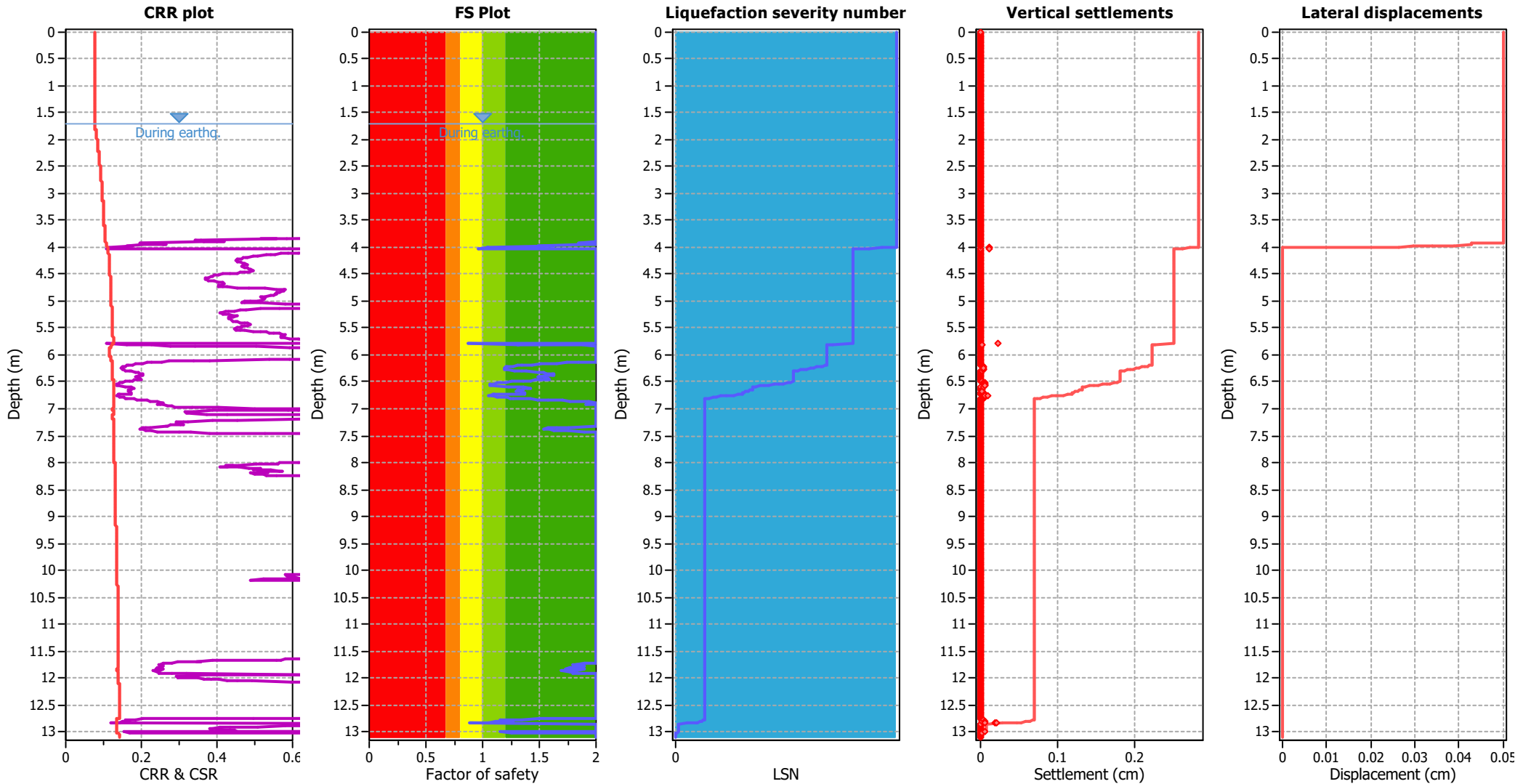
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_v$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

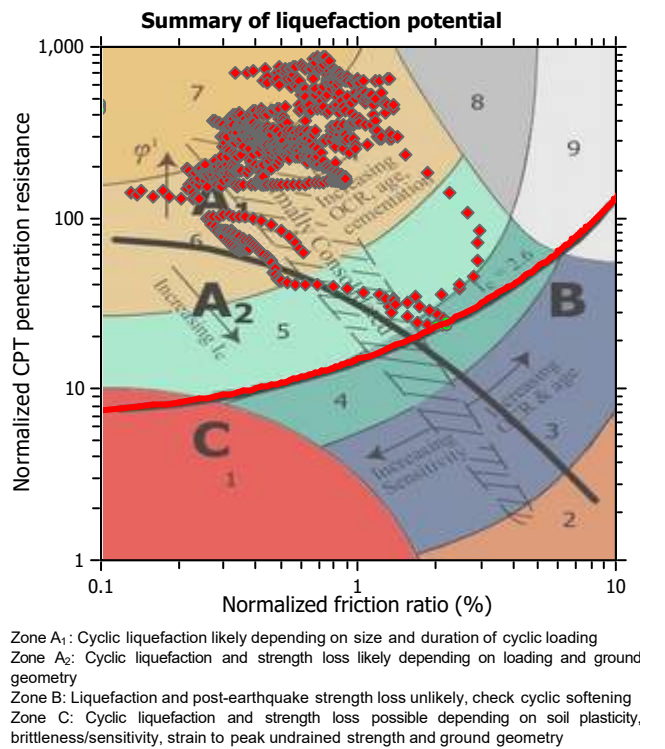
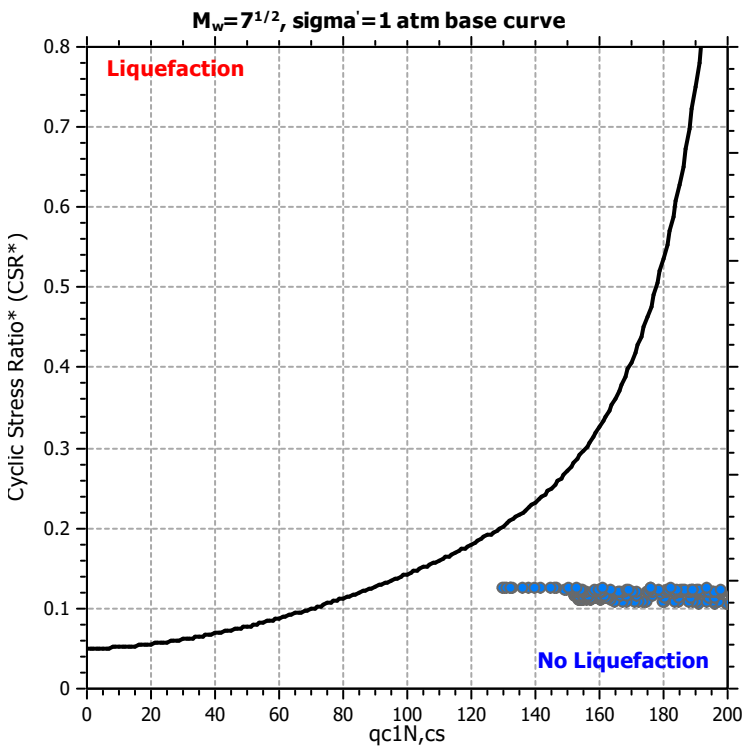
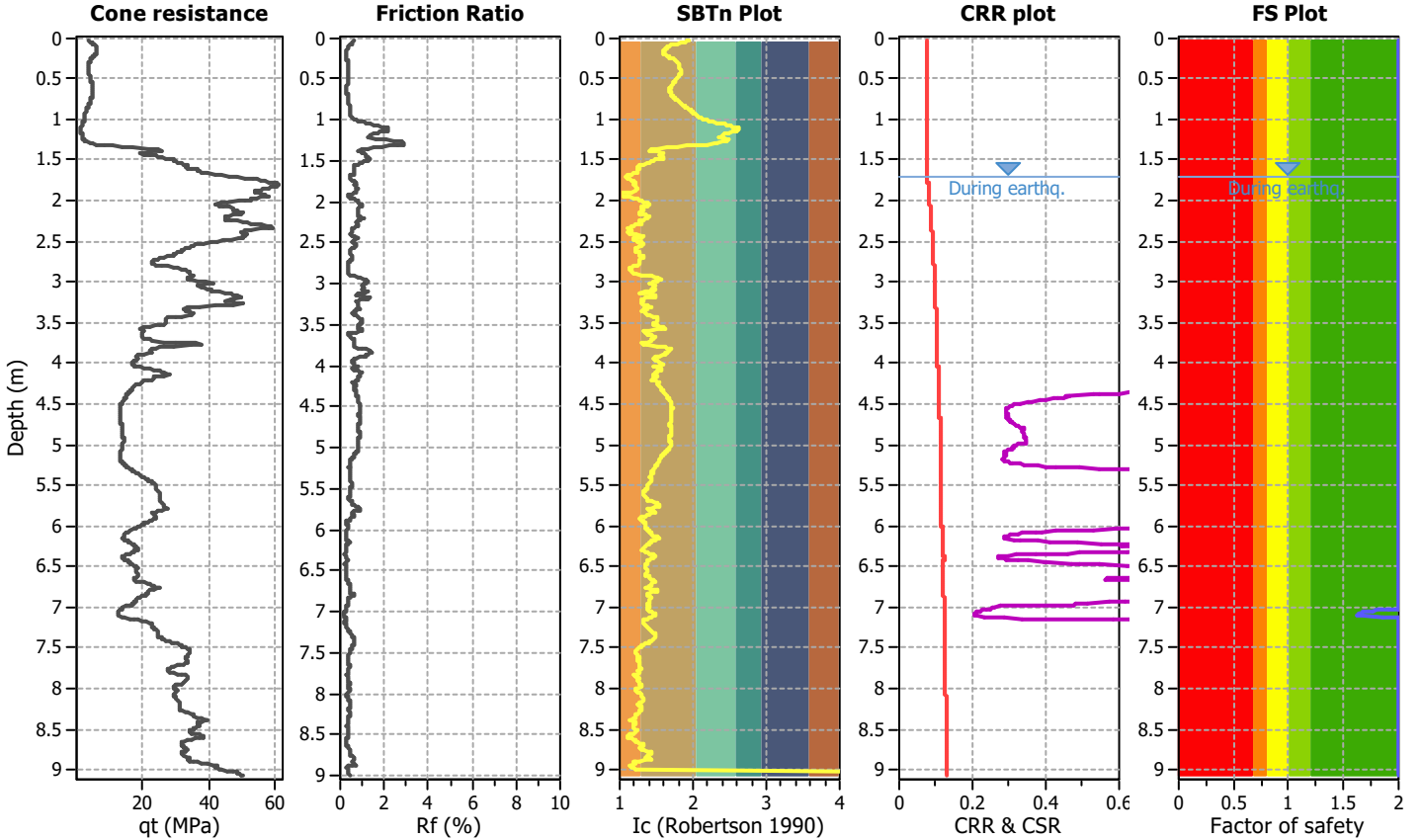
**Project title : Liquefaction Analysis - SLS 1A**

**Location : 20 Te Haunui Lane, Pegasus**

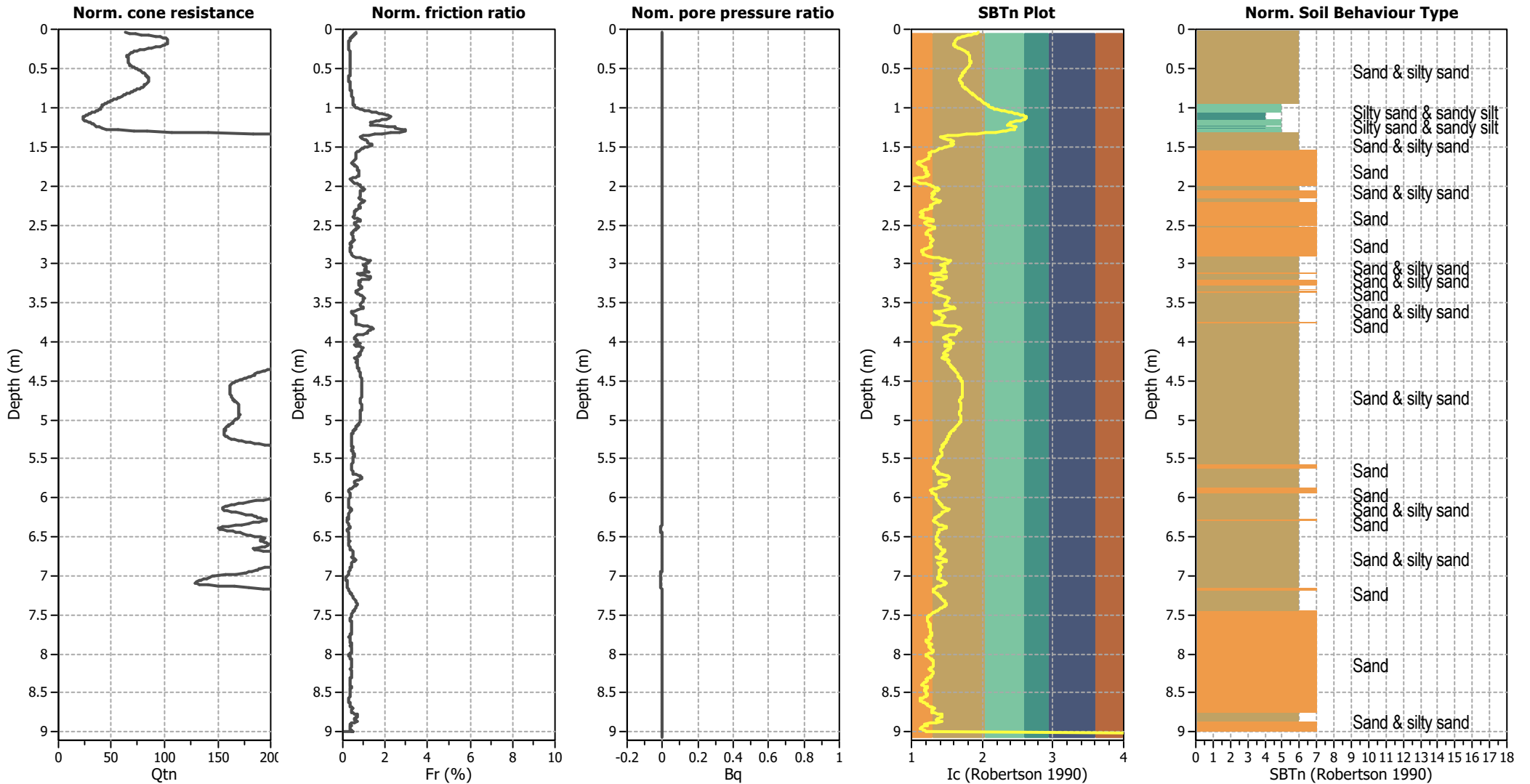
**CPT file : CPT106**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

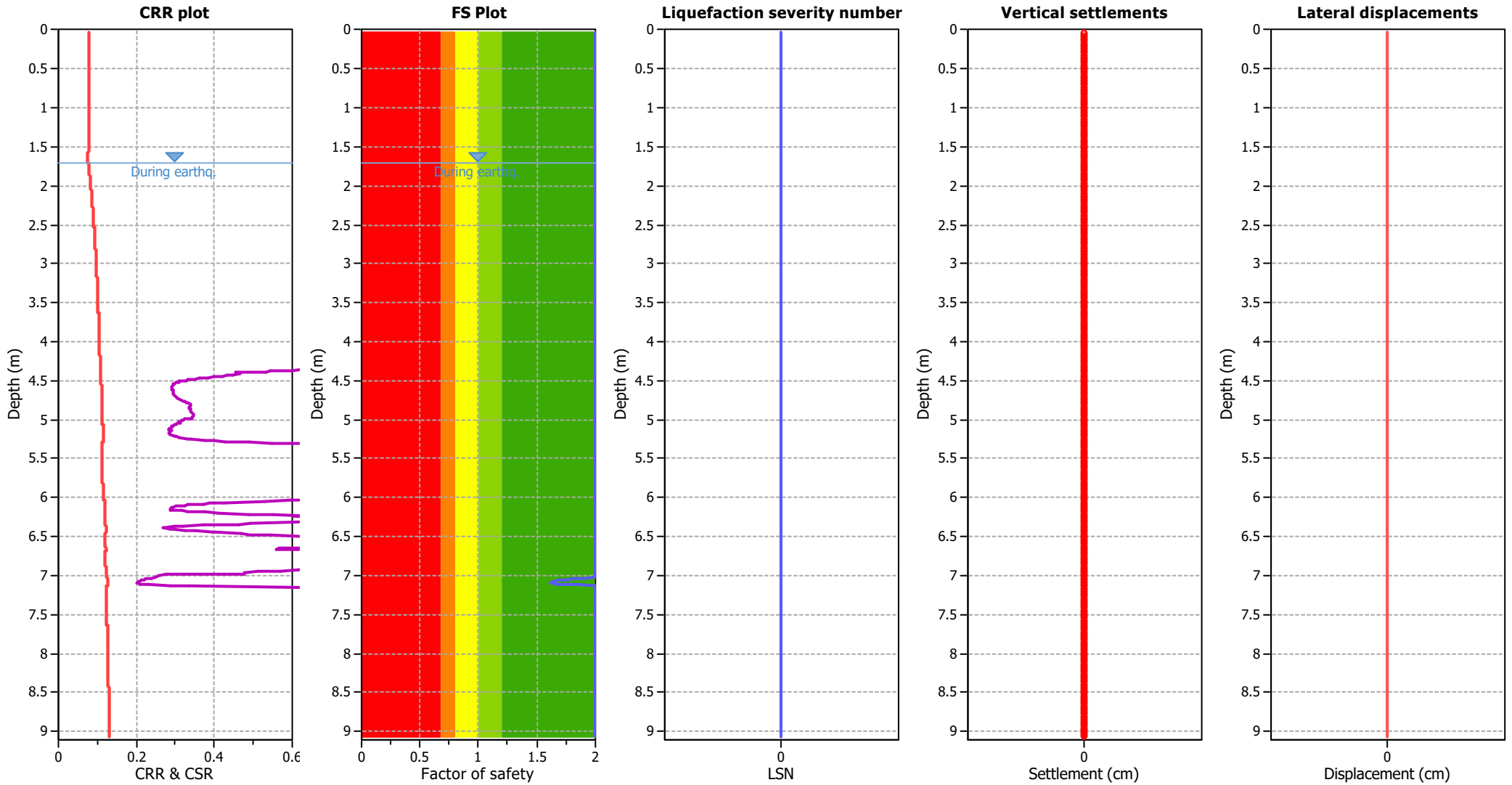
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

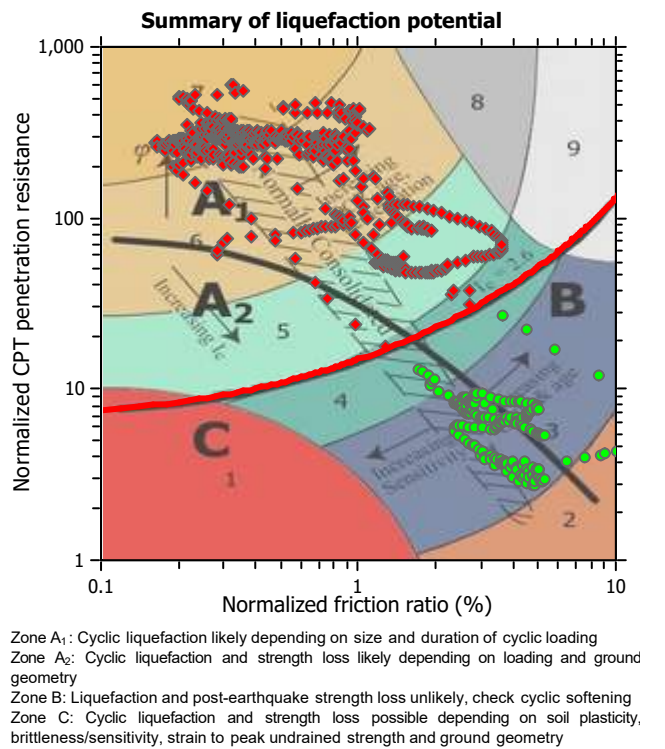
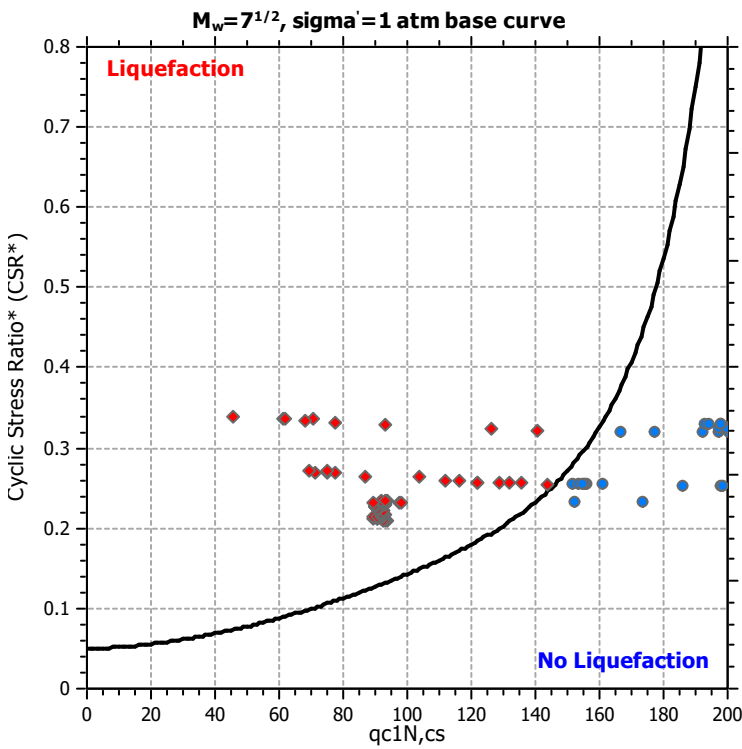
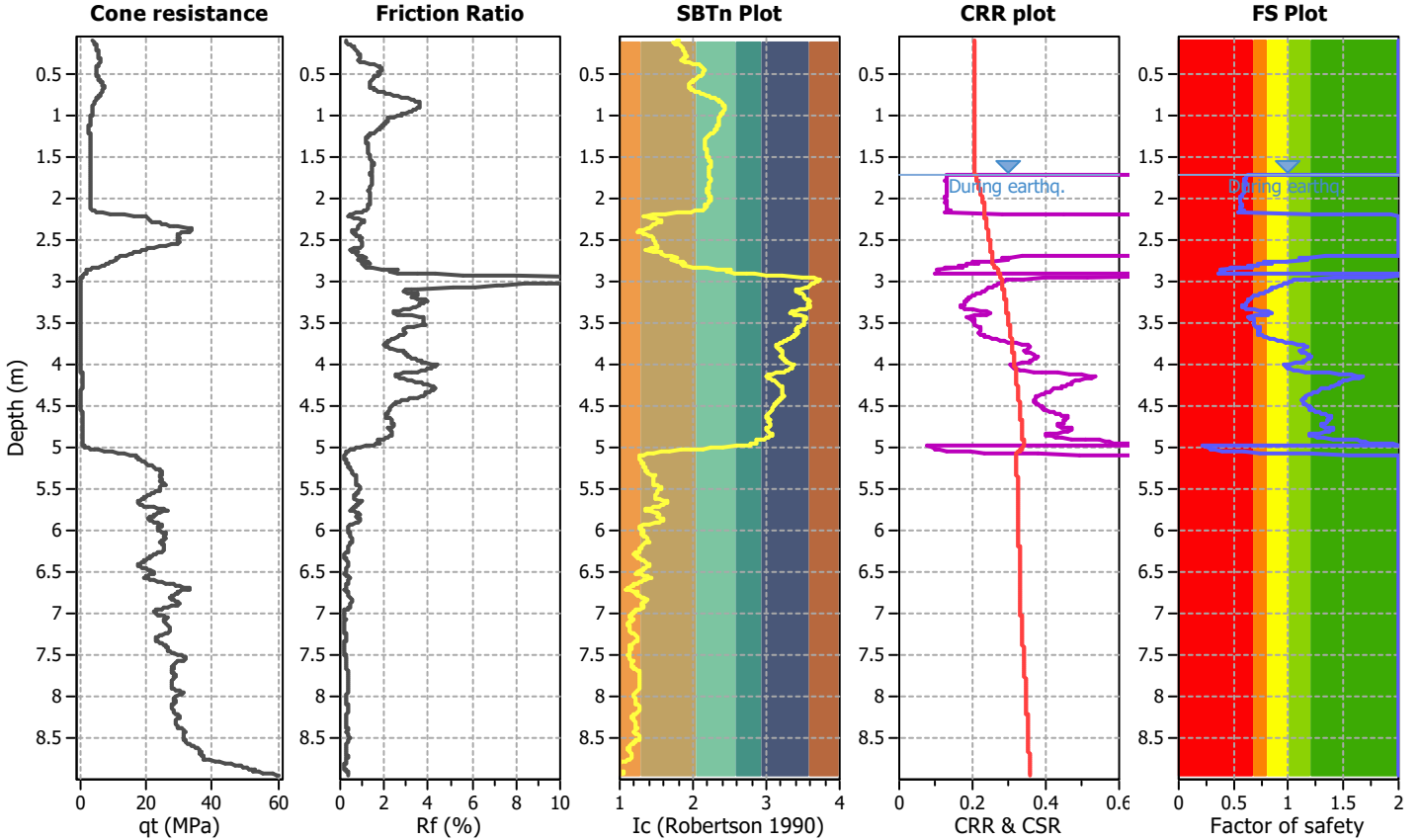
**Project title : Liquefaction Analysis - SLS 1B**

**Location : 20 Te Haunui Lane, Pegasus**

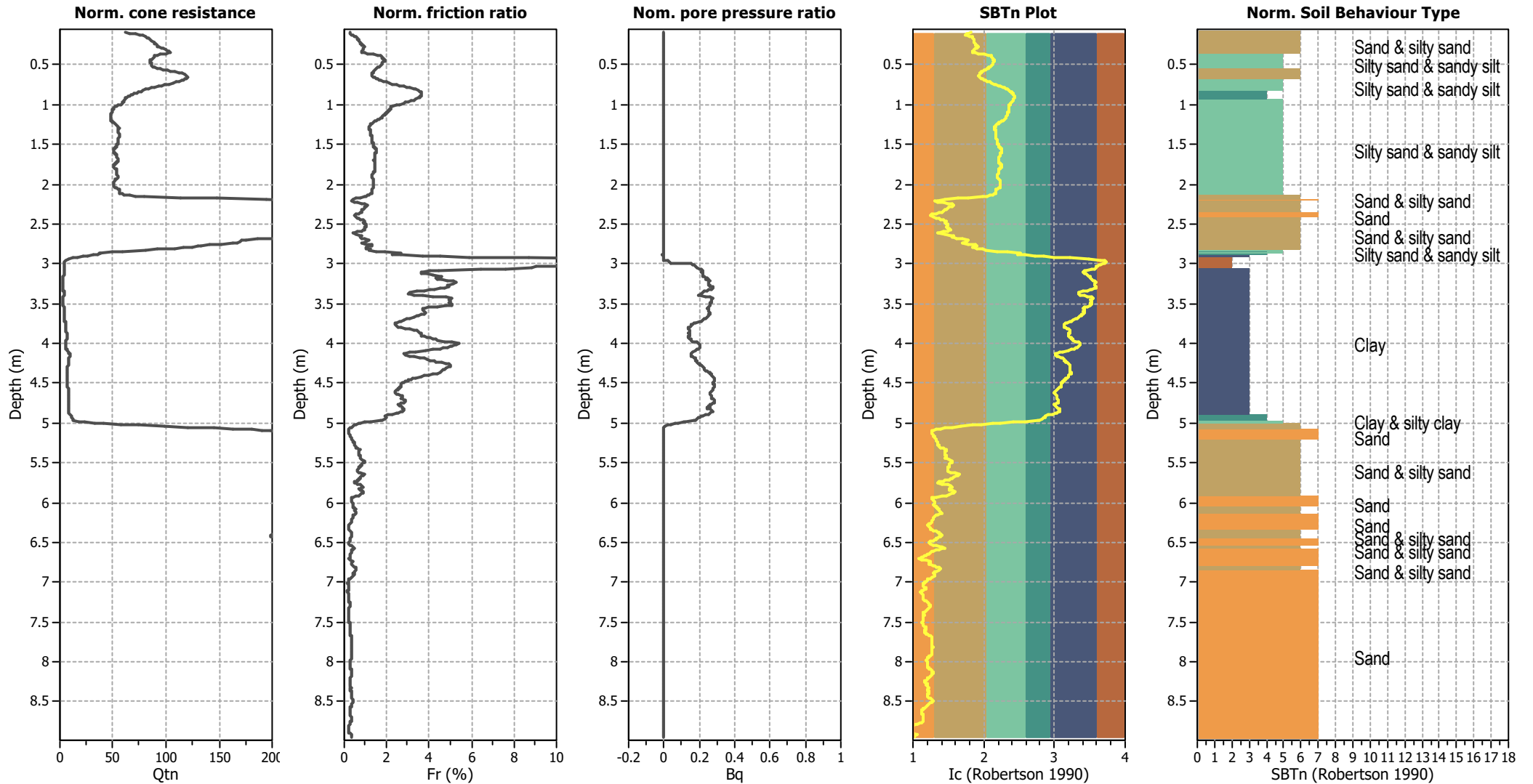
**CPT file : CPT101**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



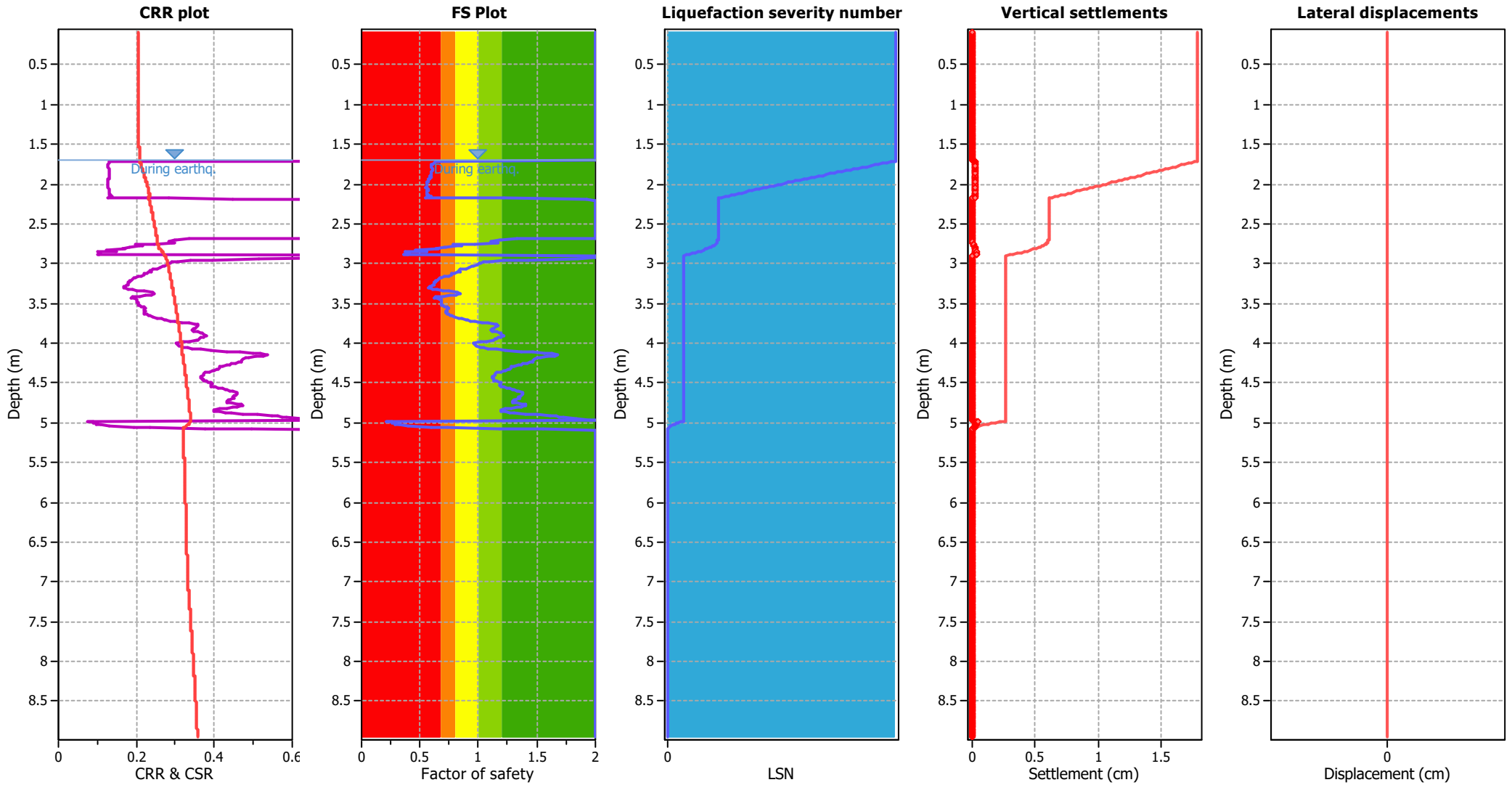
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

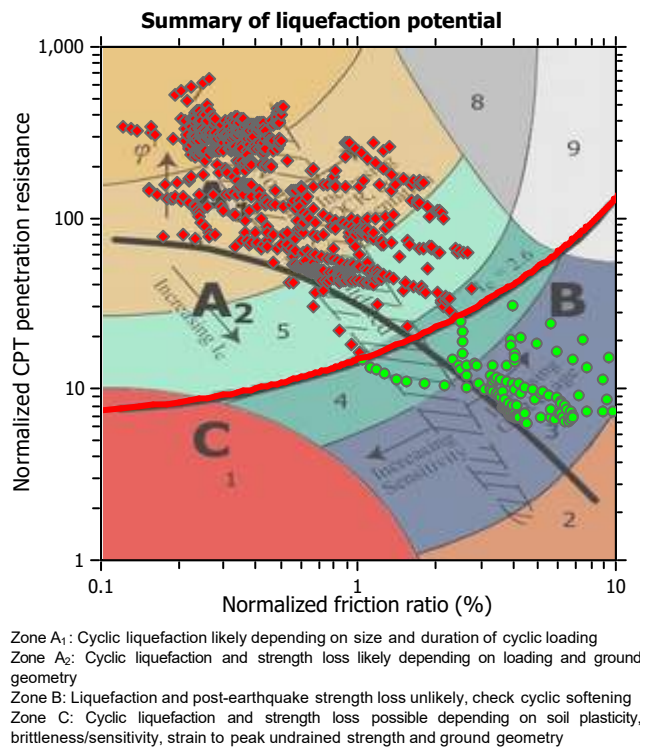
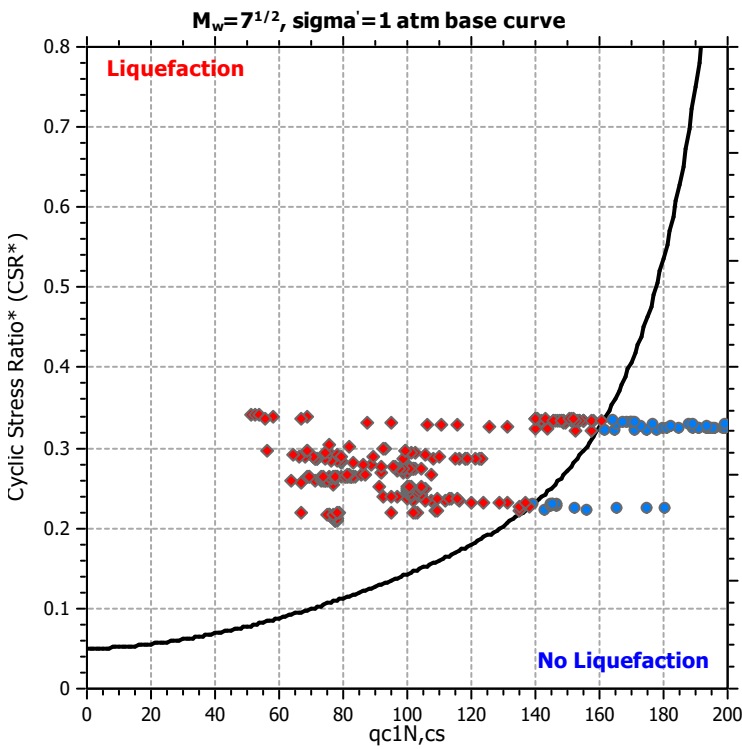
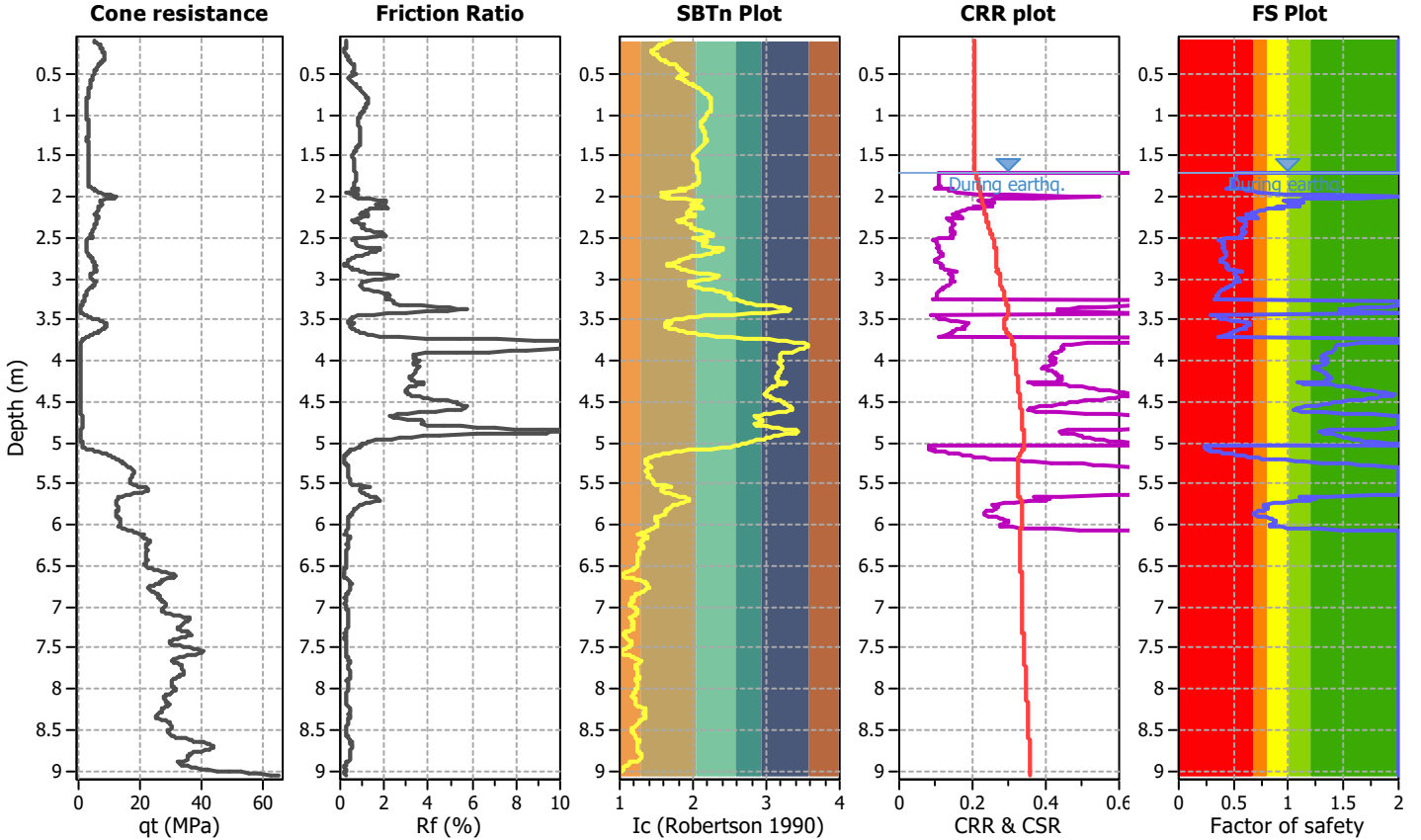
**Project title : Liquefaction Analysis - SLS 1B**

**Location : 20 Te Haunui Lane, Pegasus**

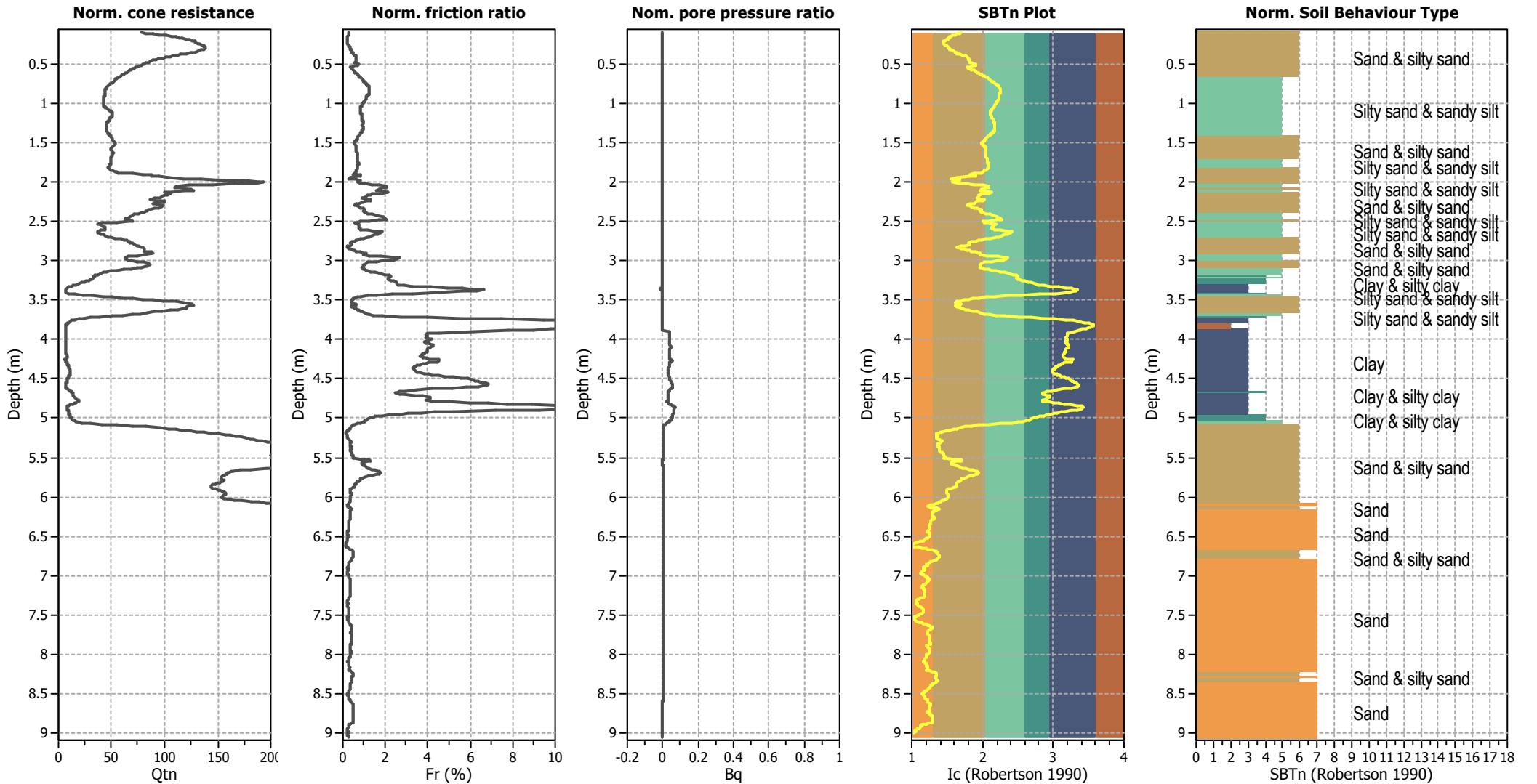
**CPT file : CPT102**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes	MSF method:	Method based



### CPT basic interpretation plots (normalized)



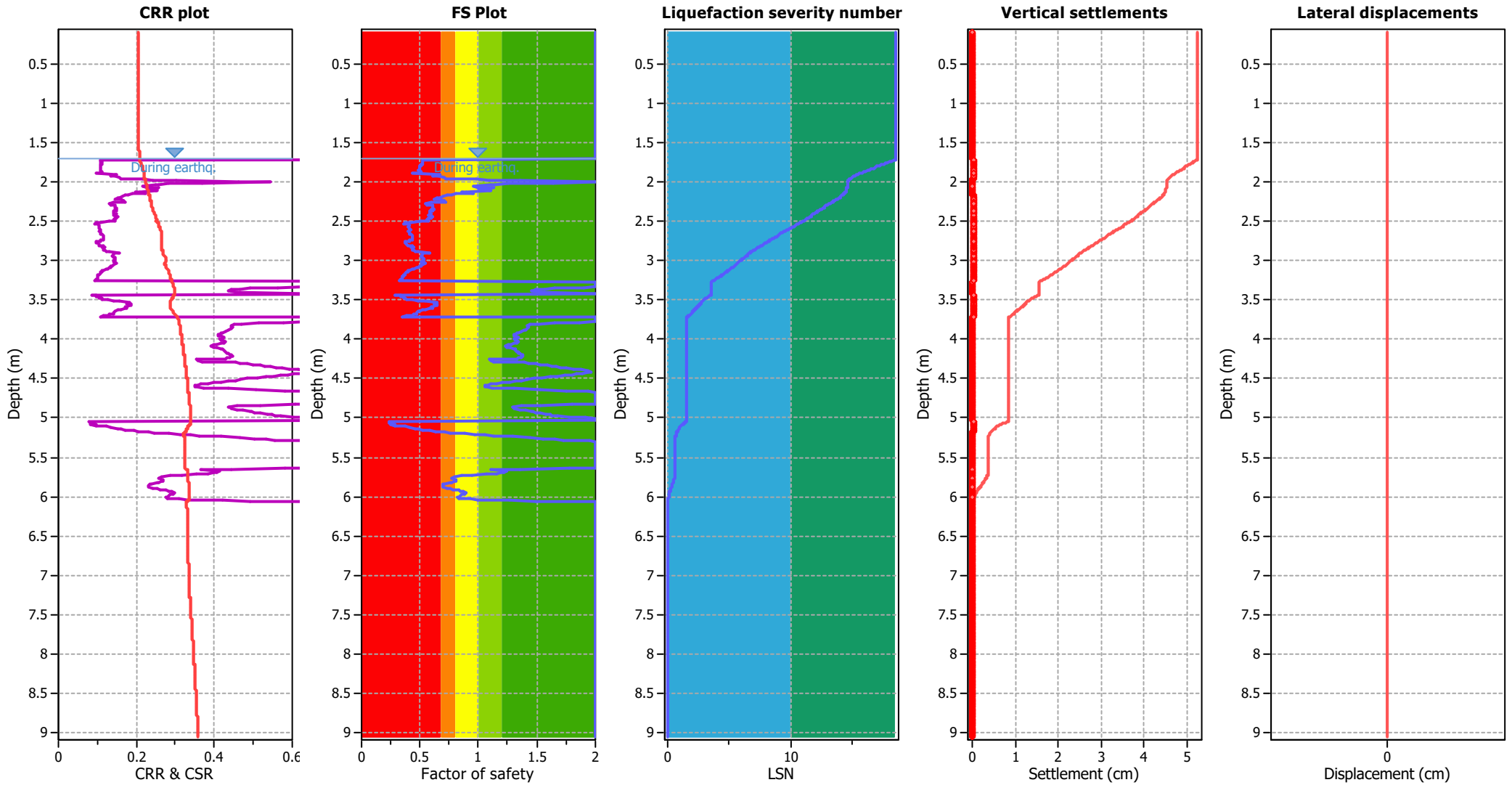
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m
Fines correction method:	R&W (1998)	Average results interval:	3
Points to test:	Based on Ic value	Ic cut-off value:	2.60
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT
Peak ground acceleration:	0.35	Use fill:	No
Depth to water table (insitu):	2.20 m	Fill height:	N/A

Fill weight:	N/A
Transition detect. applied:	No
$K_\sigma$ applied:	Yes
Clay like behavior applied:	Sand & Clay
Limit depth applied:	No
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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

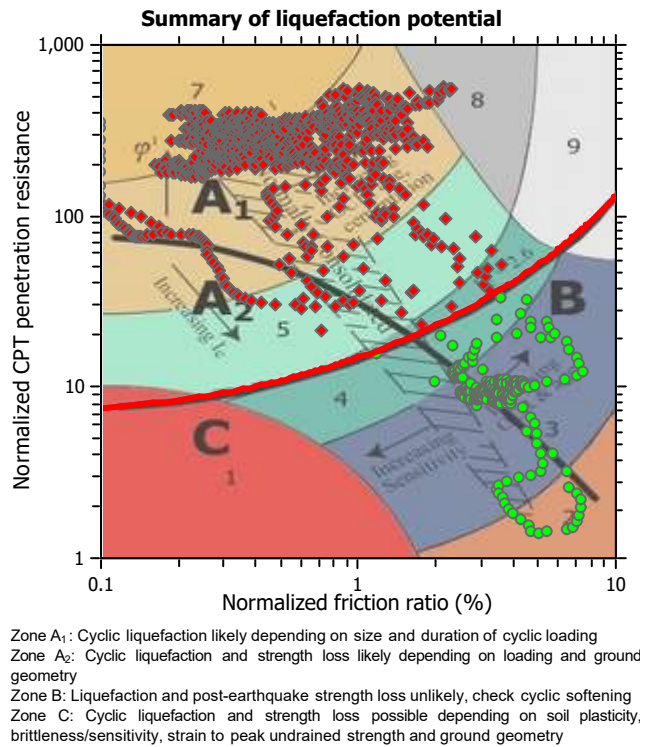
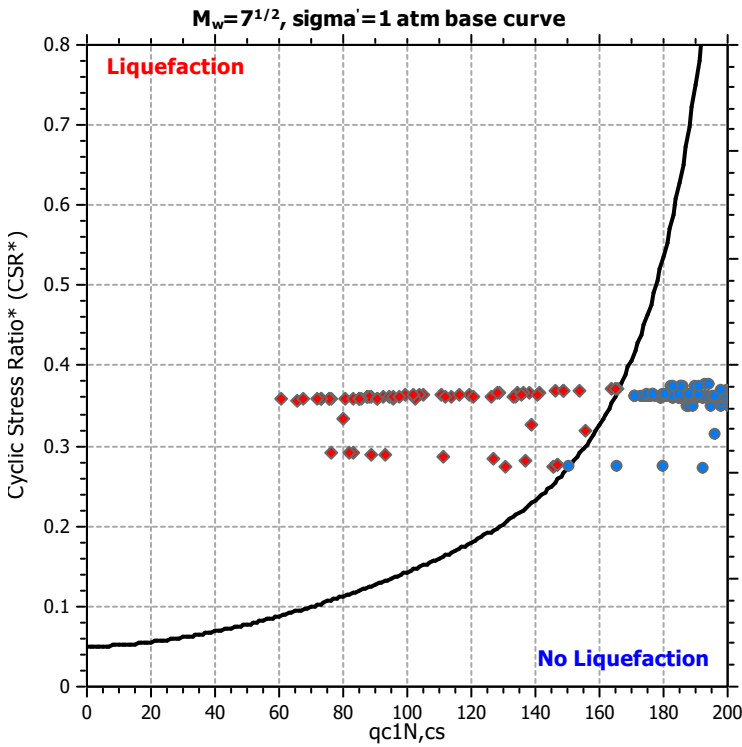
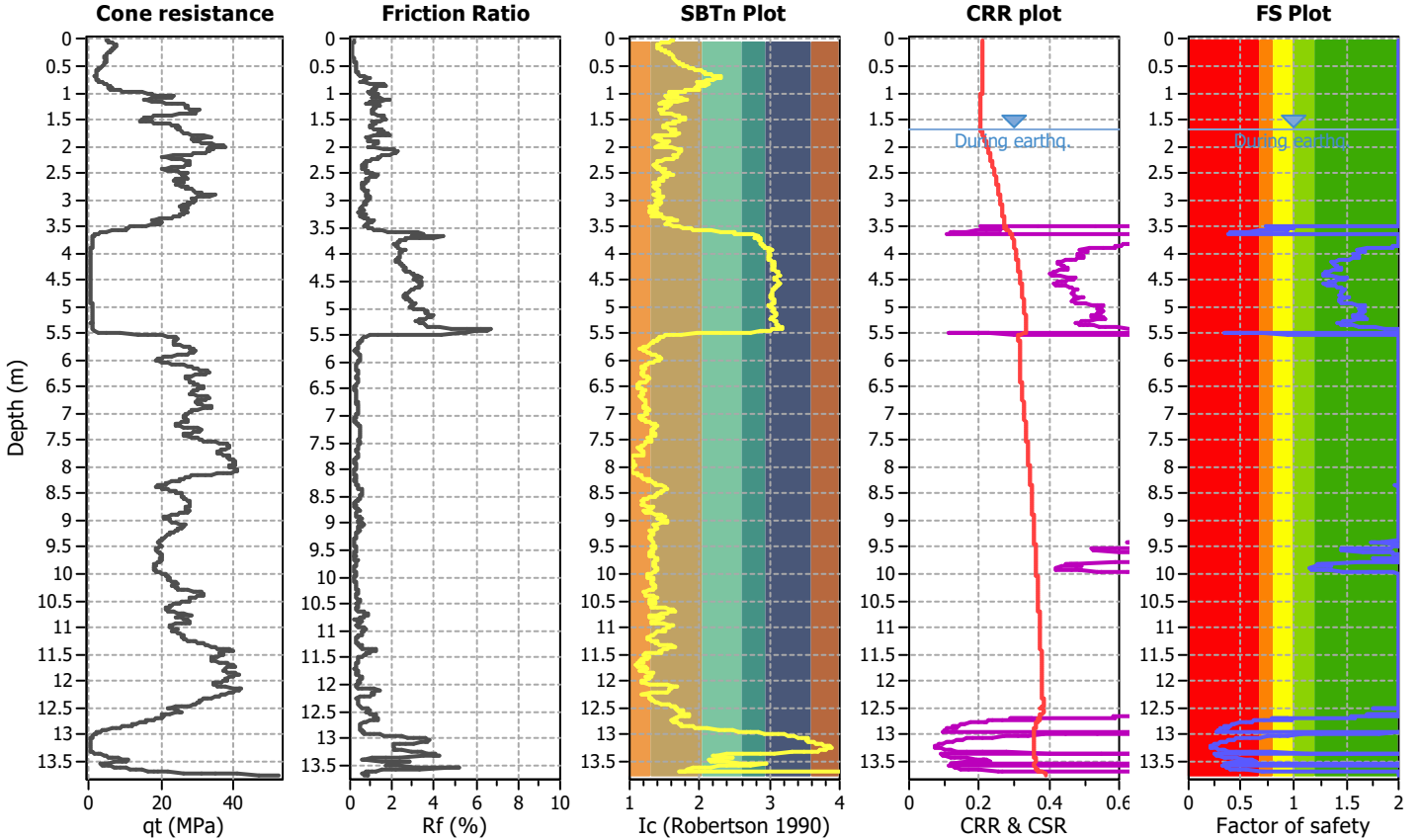
**Project title : Liquefaction Analysis - SLS 1B**

**Location : 20 Te Haunui Lane, Pegasus**

**CPT file : CPT103**

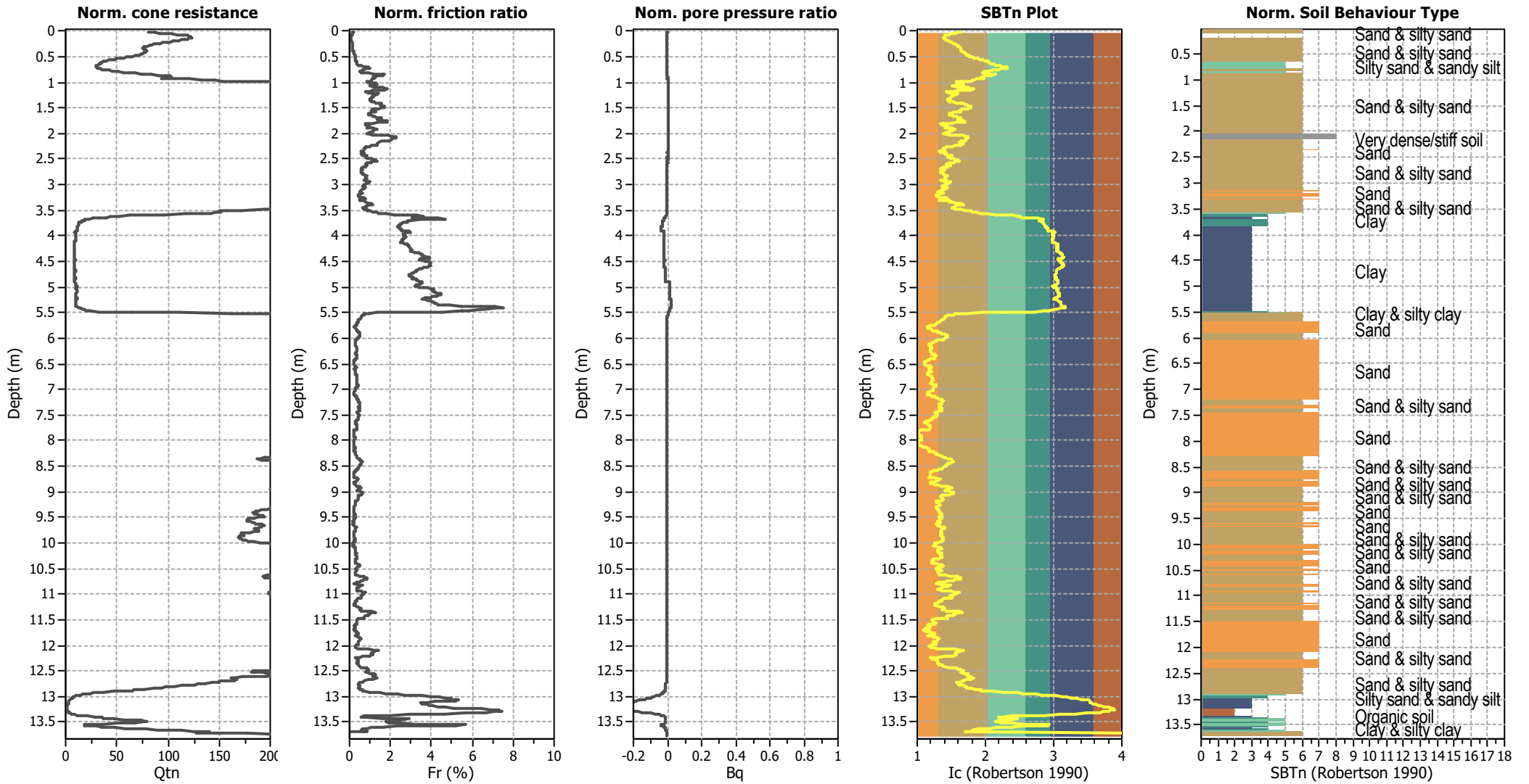
**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		





### CPT basic interpretation plots (normalized)



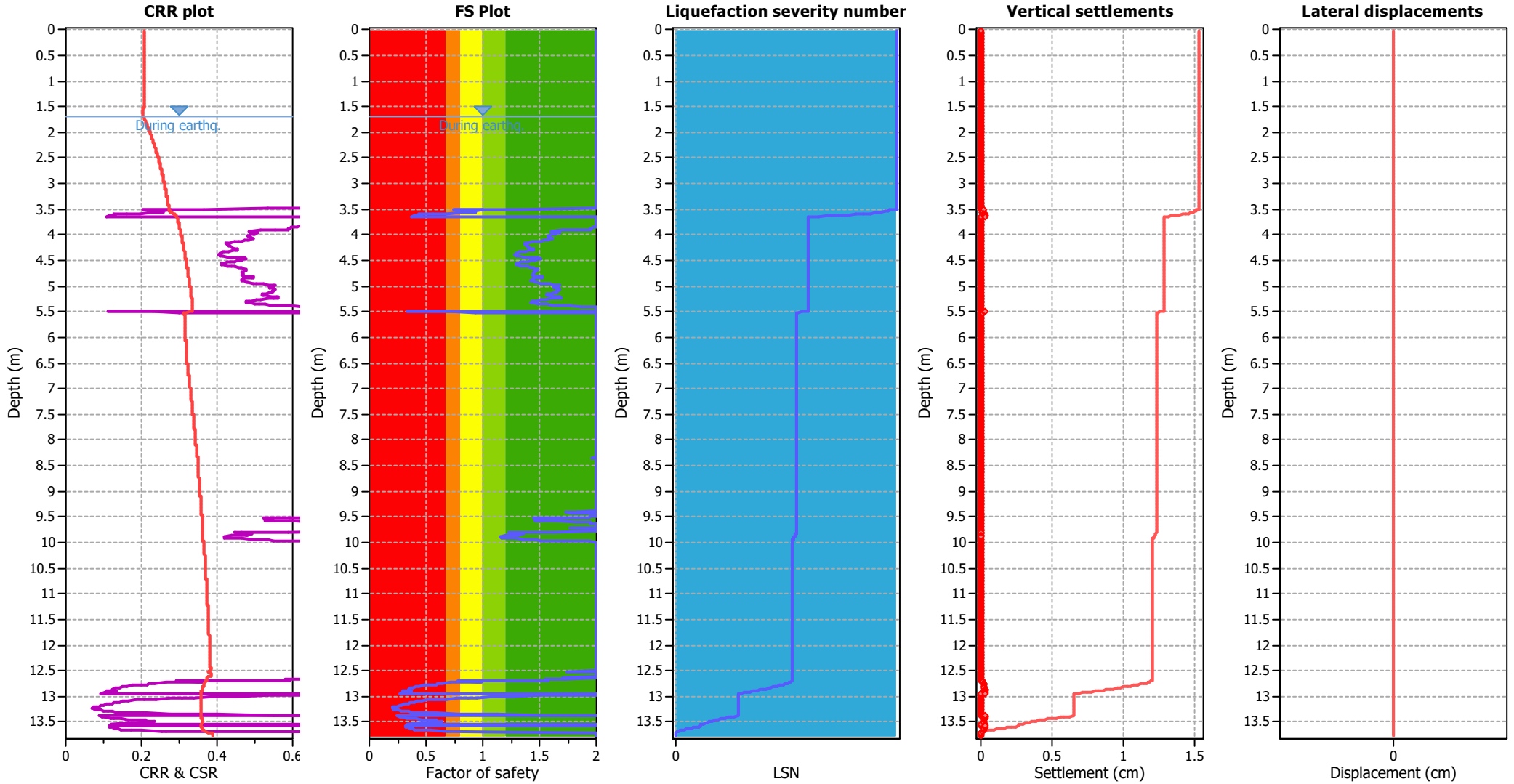
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_o$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	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:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

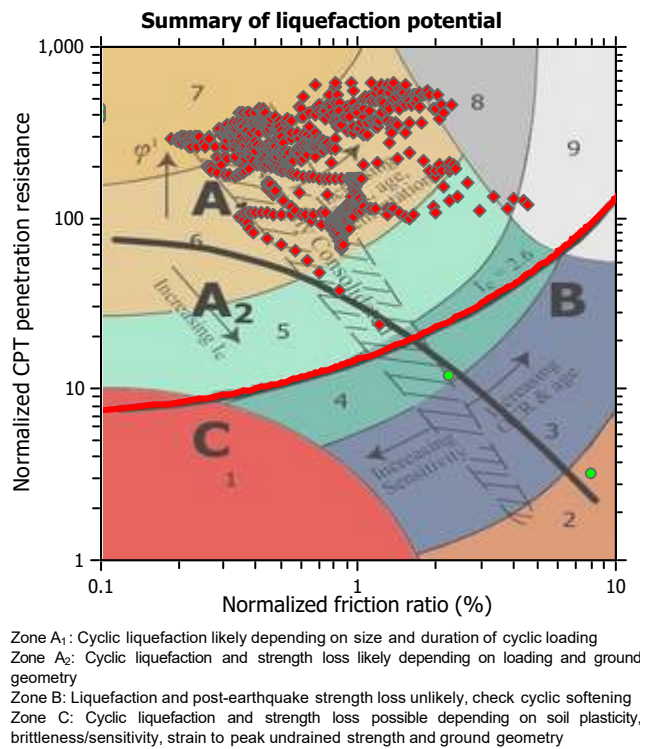
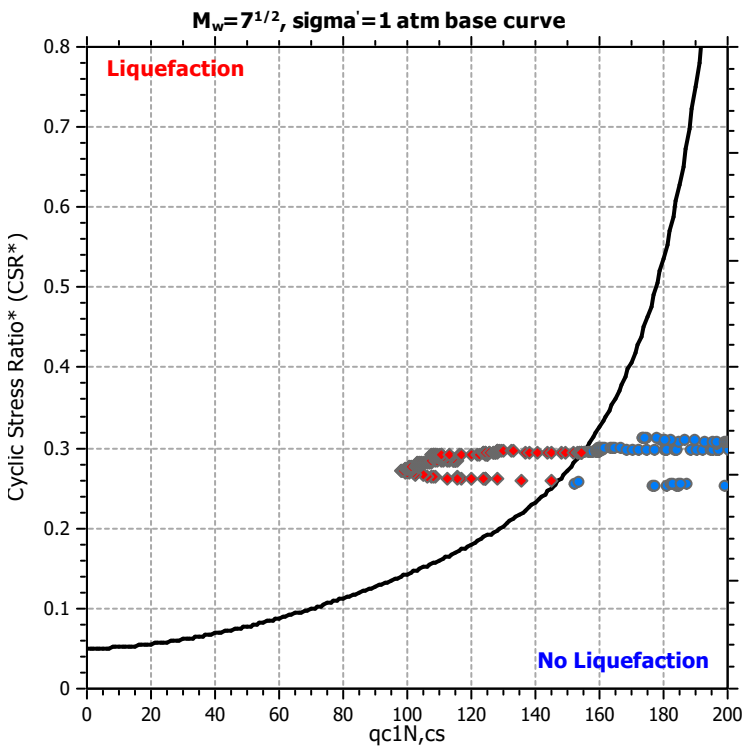
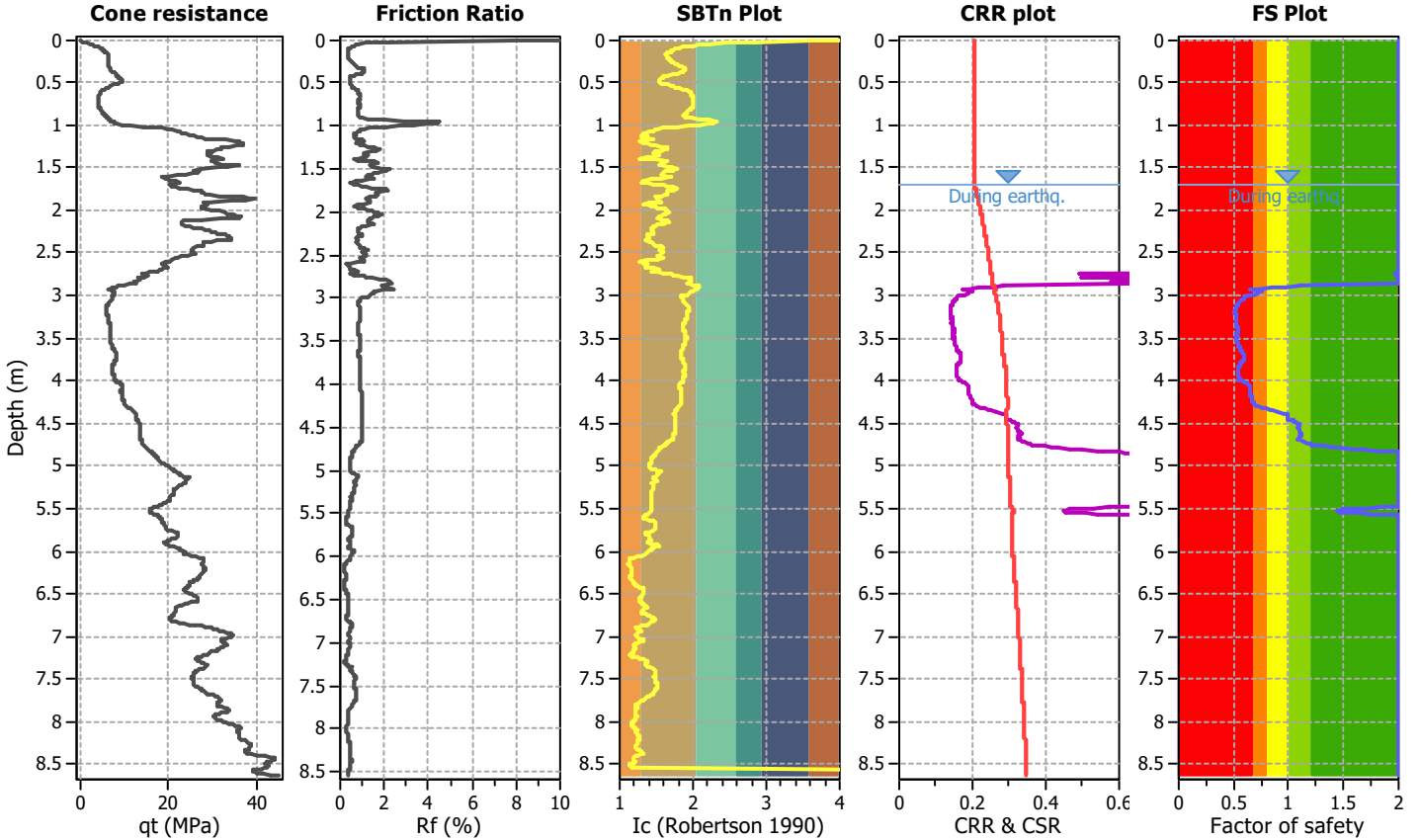
**Project title : Liquefaction Analysis - SLS 1B**

**Location : 20 Te Haunui Lane, Pegasus**

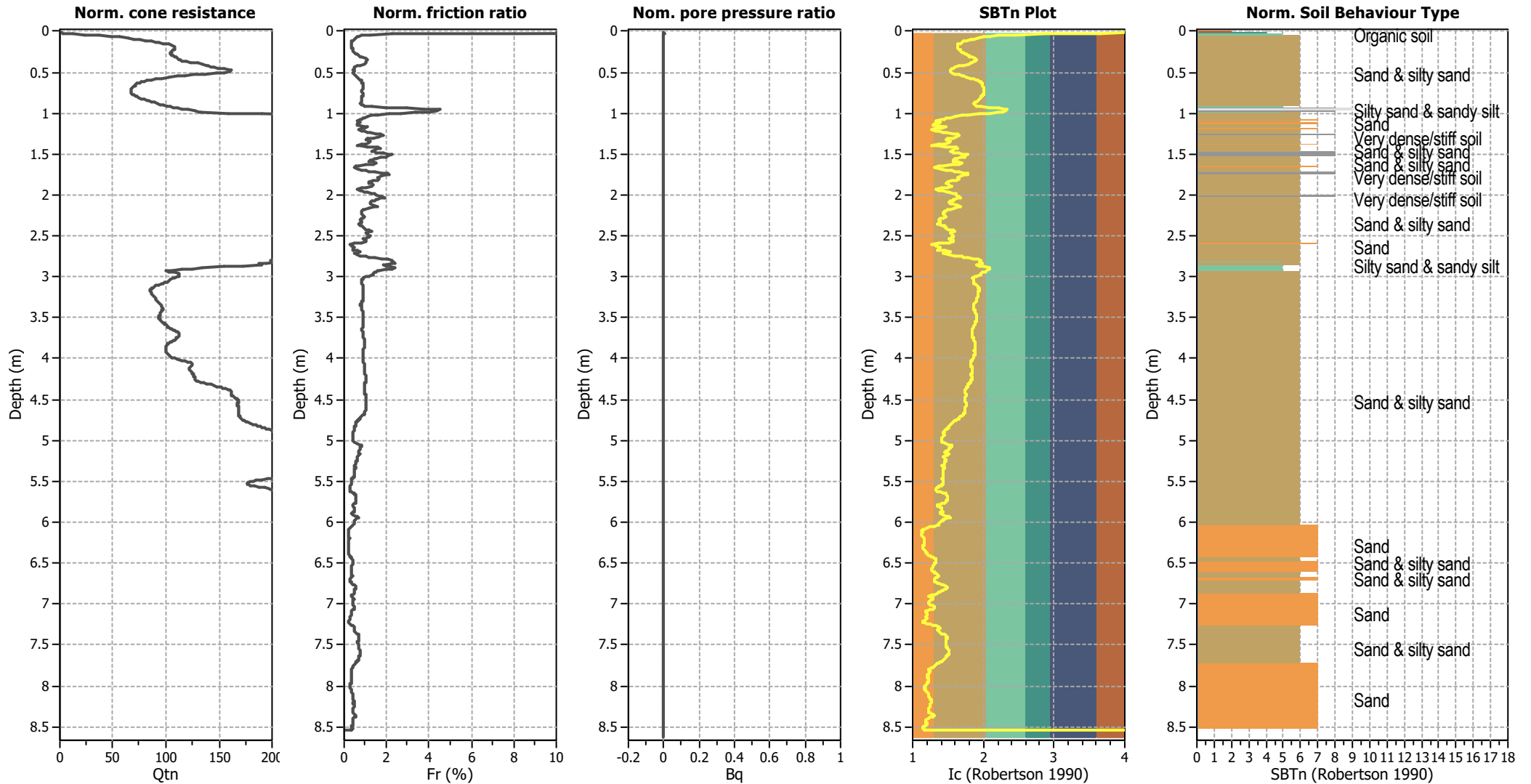
**CPT file : CPT104**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes	MSF method:	Method based



### CPT basic interpretation plots (normalized)



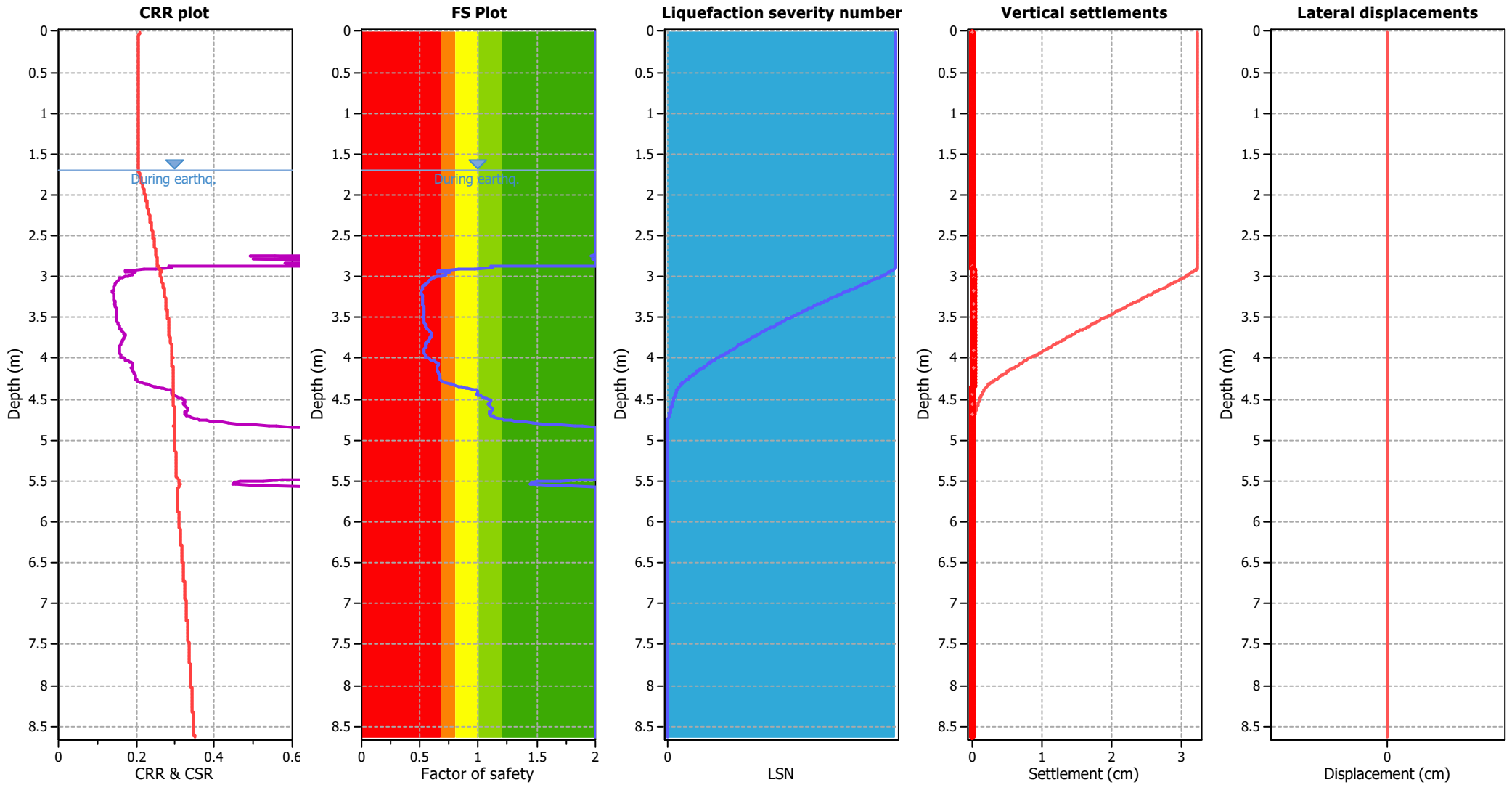
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

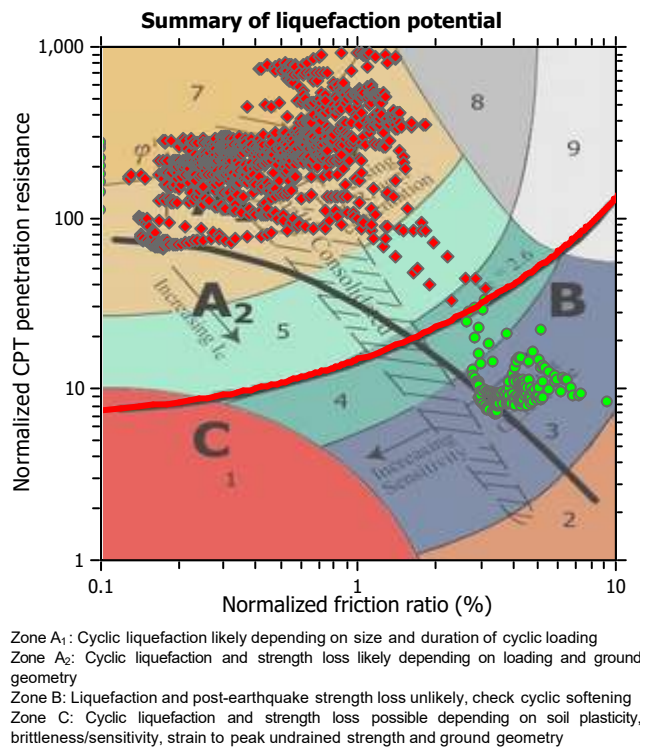
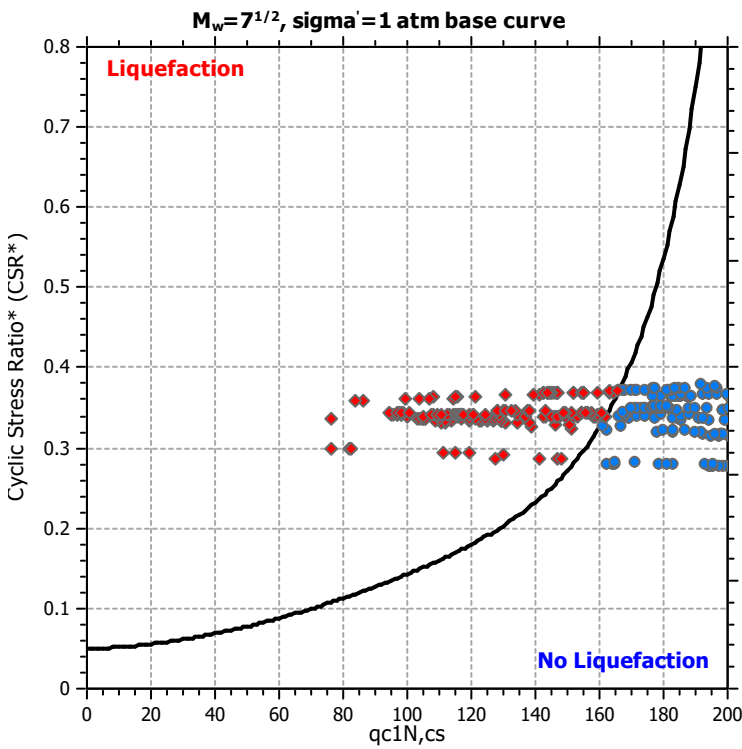
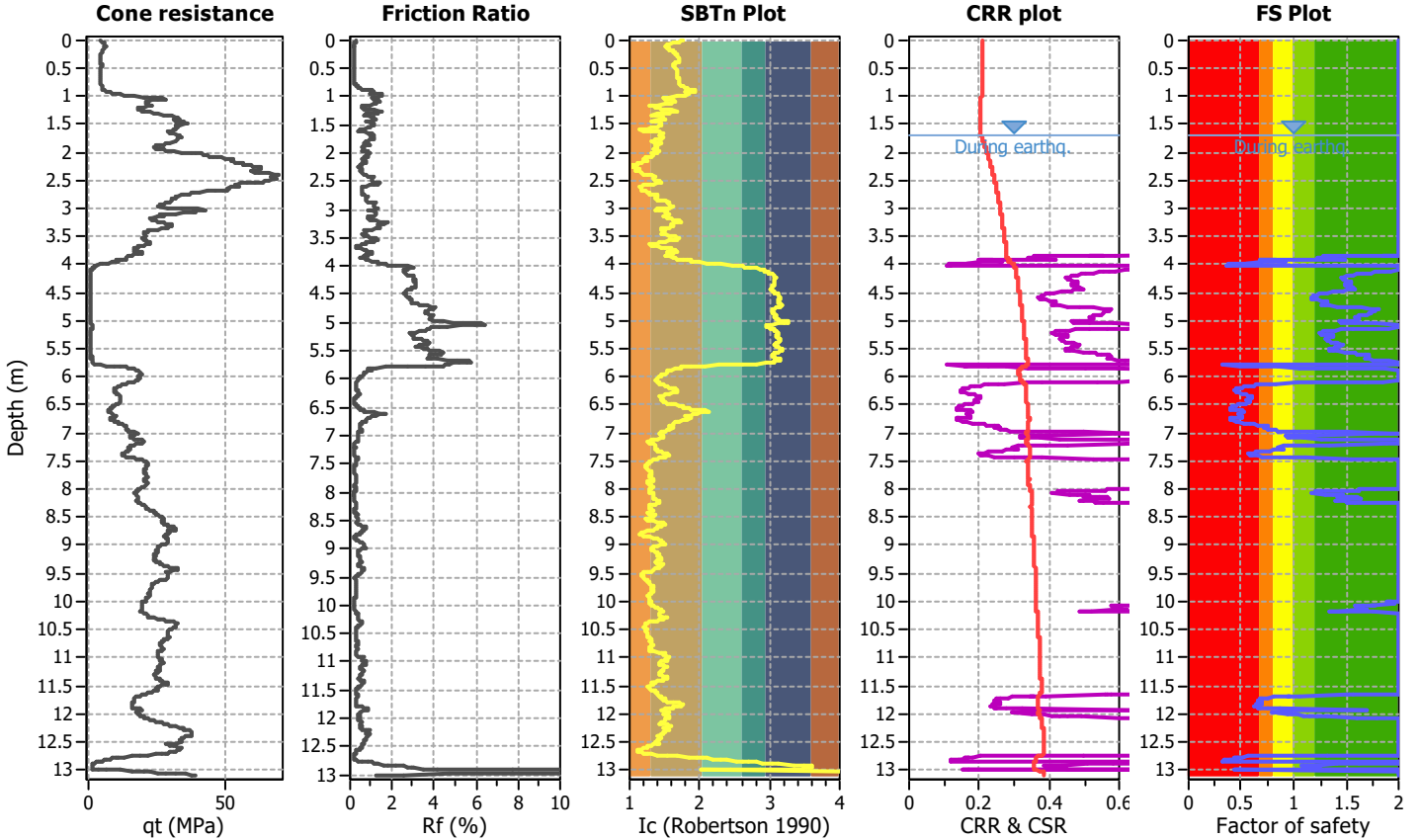
**Project title : Liquefaction Analysis - SLS 1B**

**Location : 20 Te Haunui Lane, Pegasus**

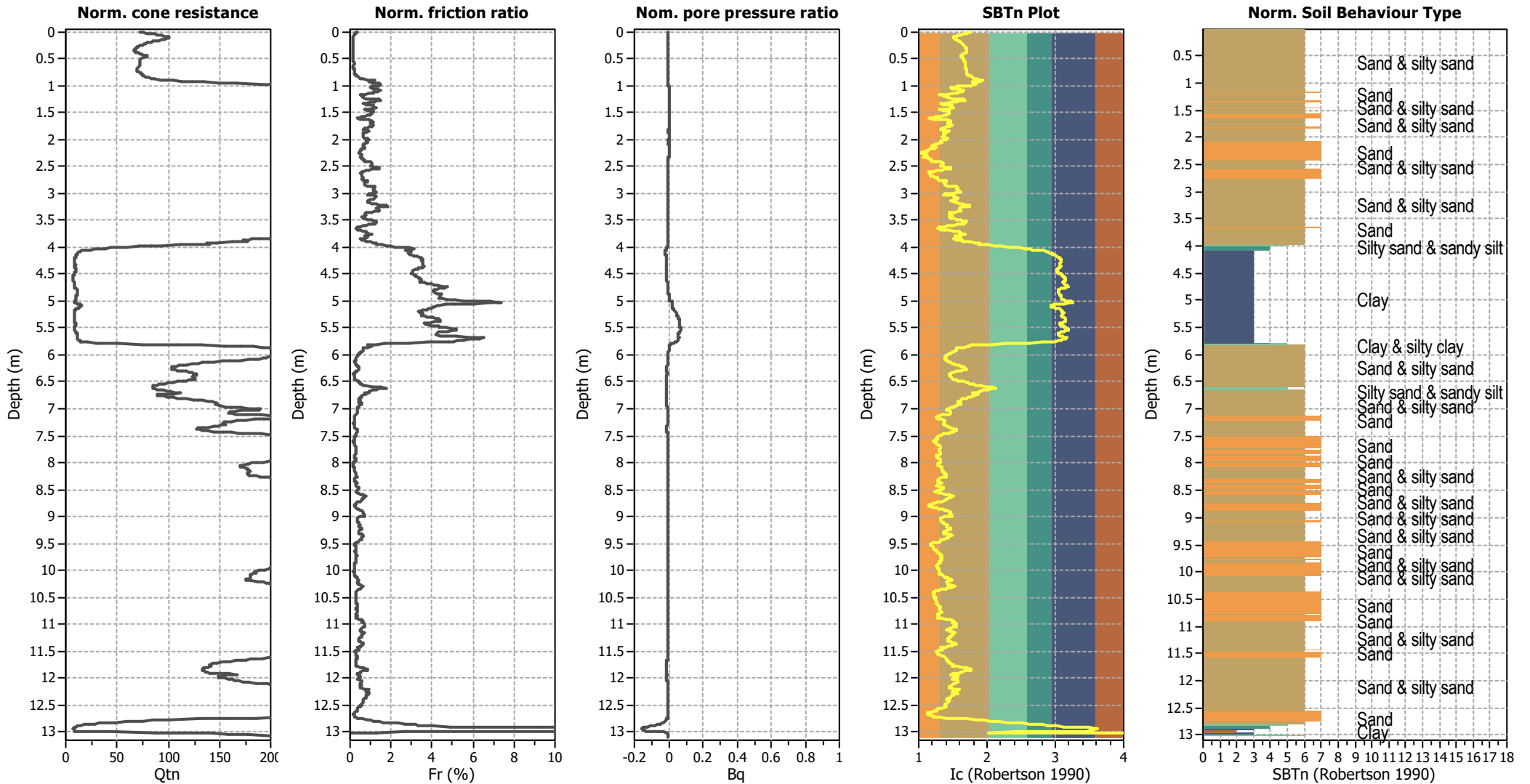
**CPT file : CPT105**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



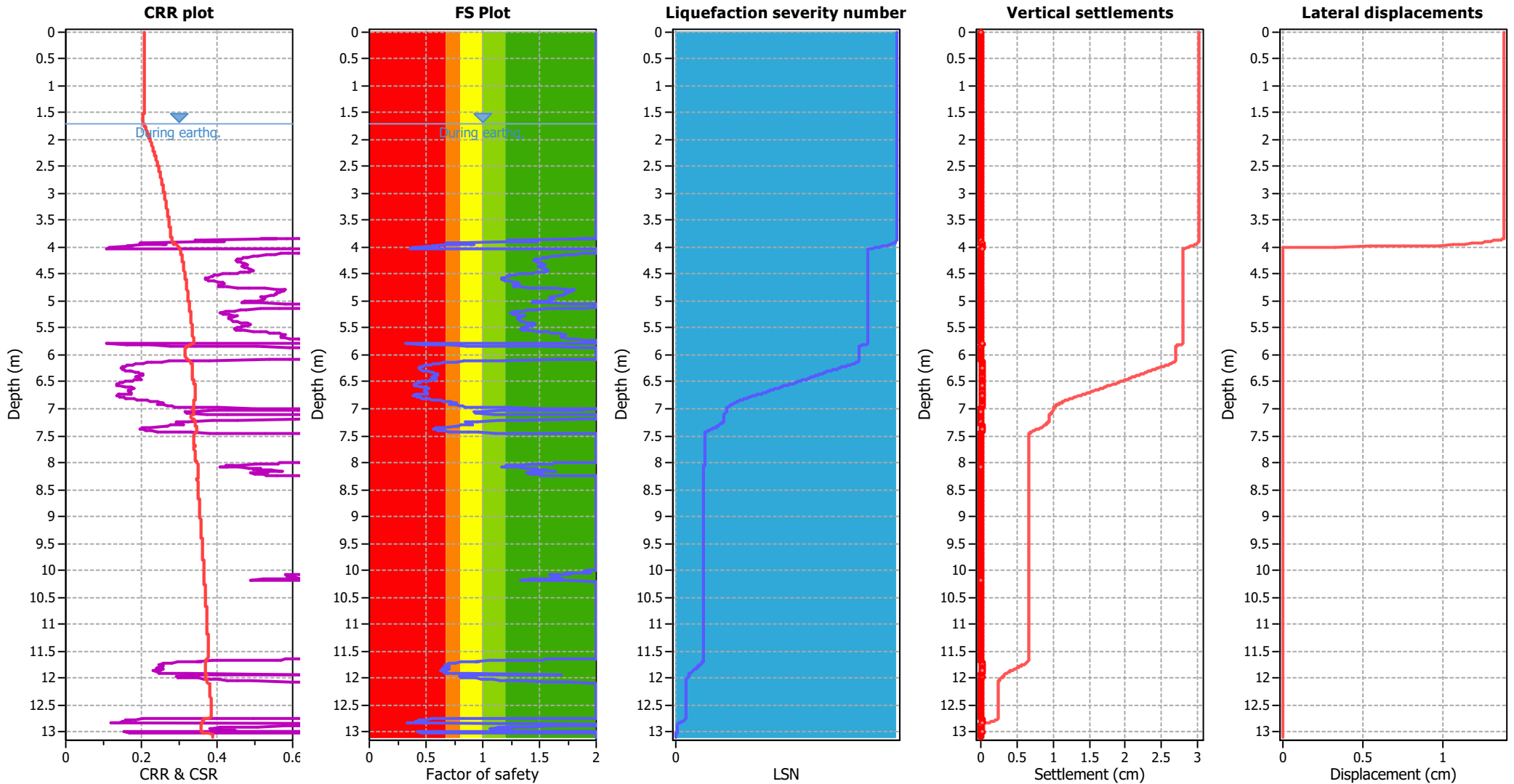
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	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:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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



**LIQUEFACTION ANALYSIS REPORT**

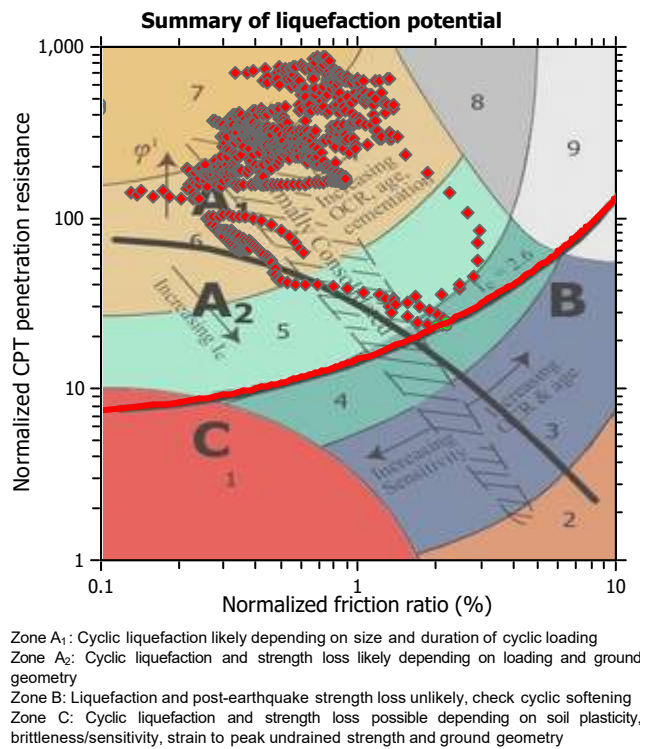
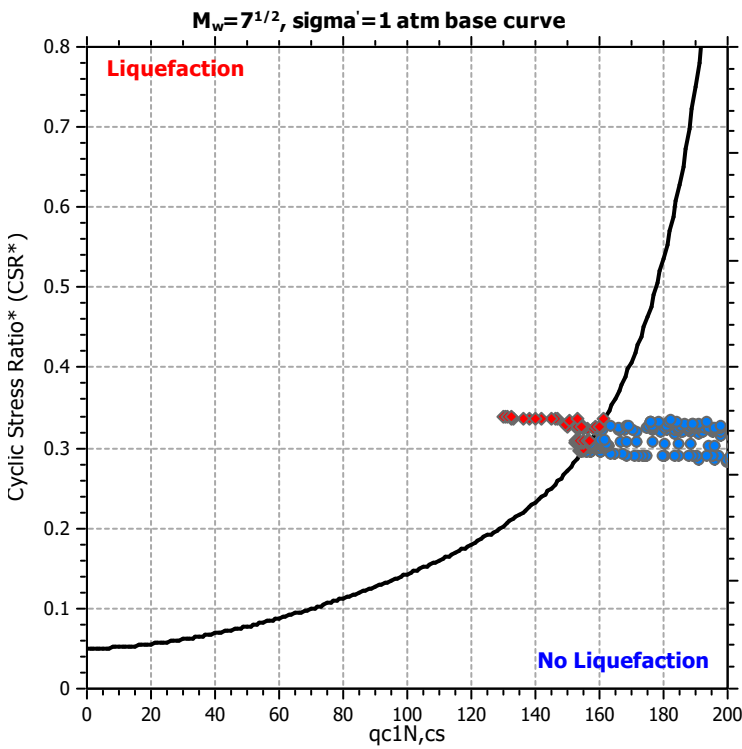
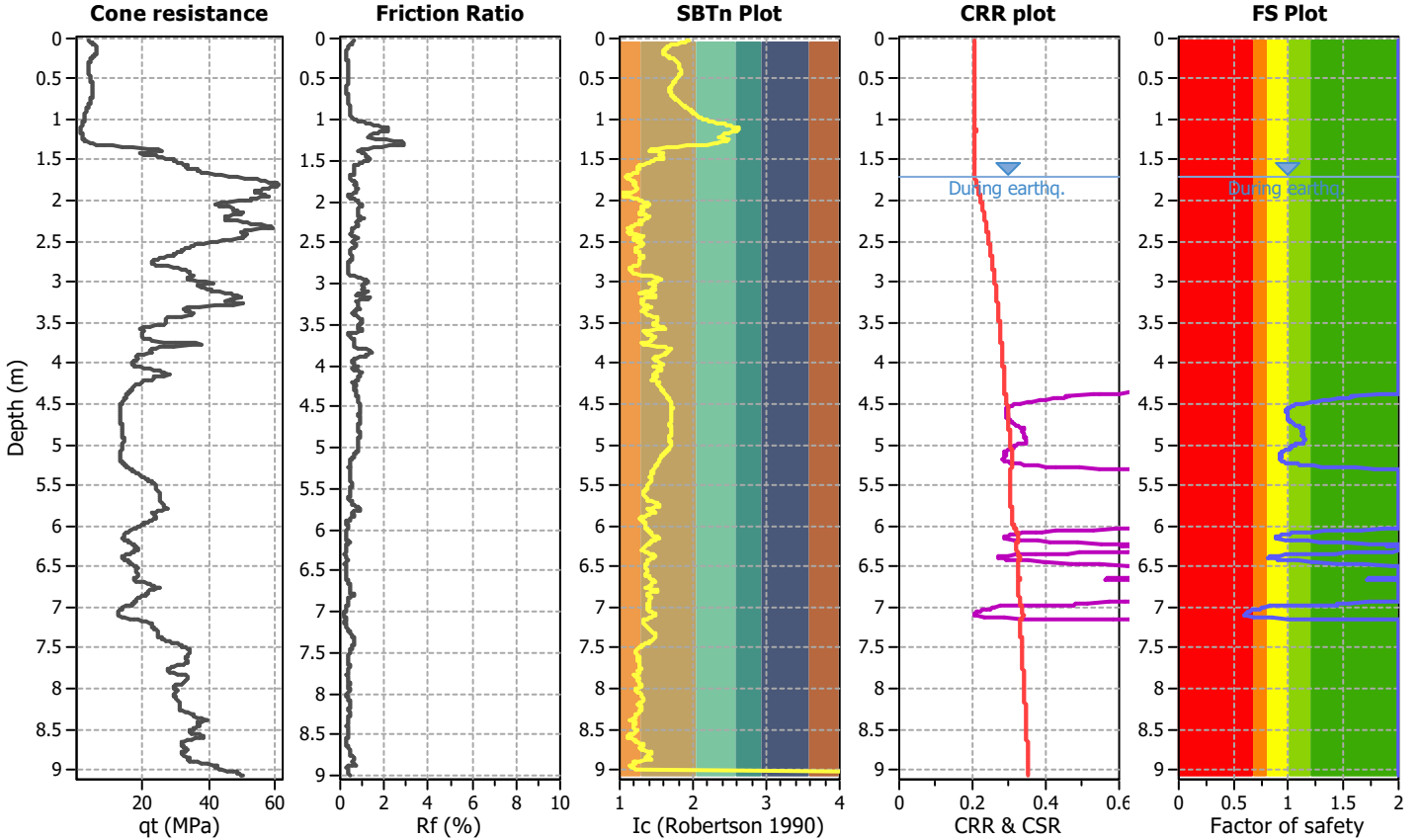
**Project title : Liquefaction Analysis - SLS 1B**

**Location : 20 Te Haunui Lane, Pegasus**

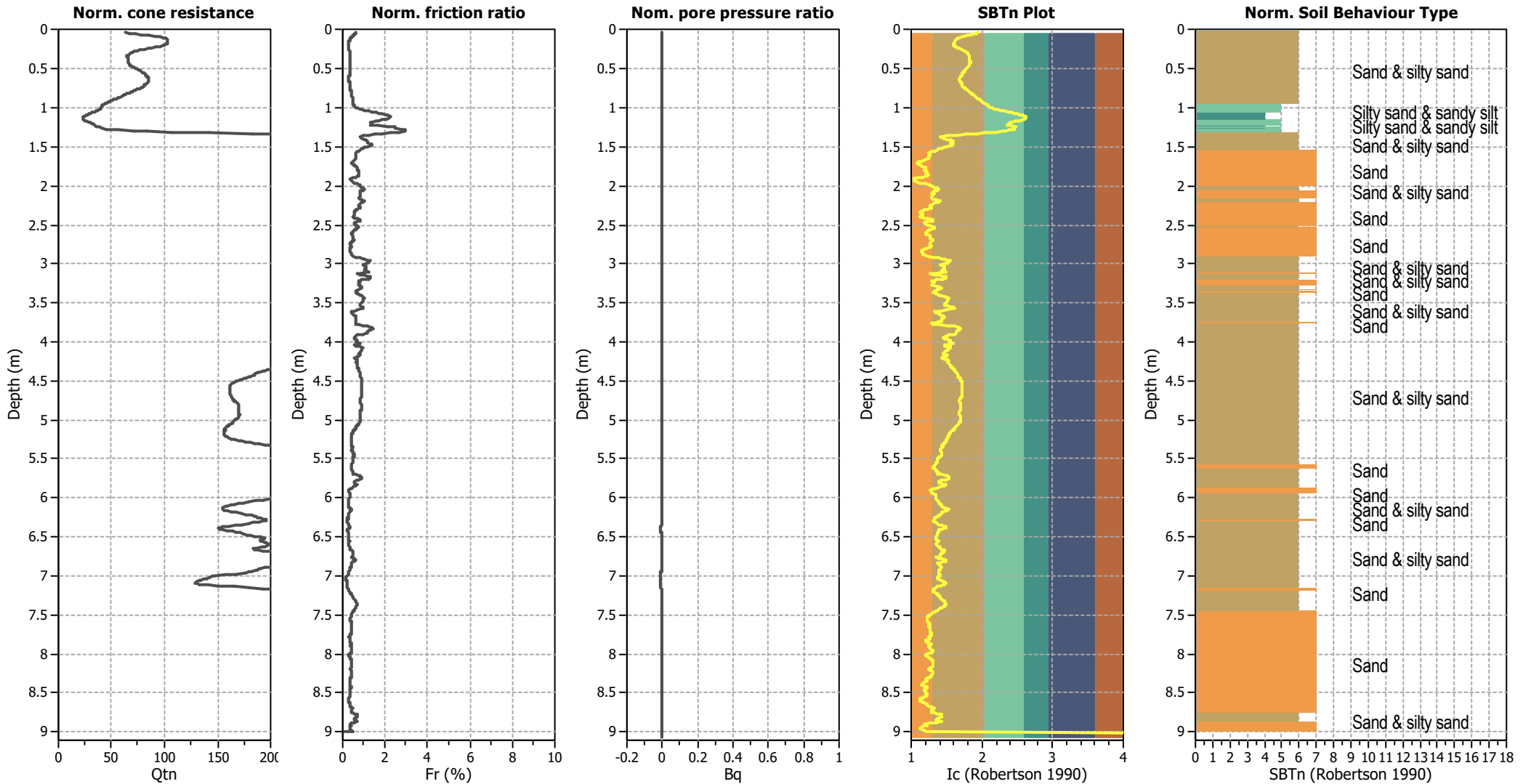
**CPT file : CPT106**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



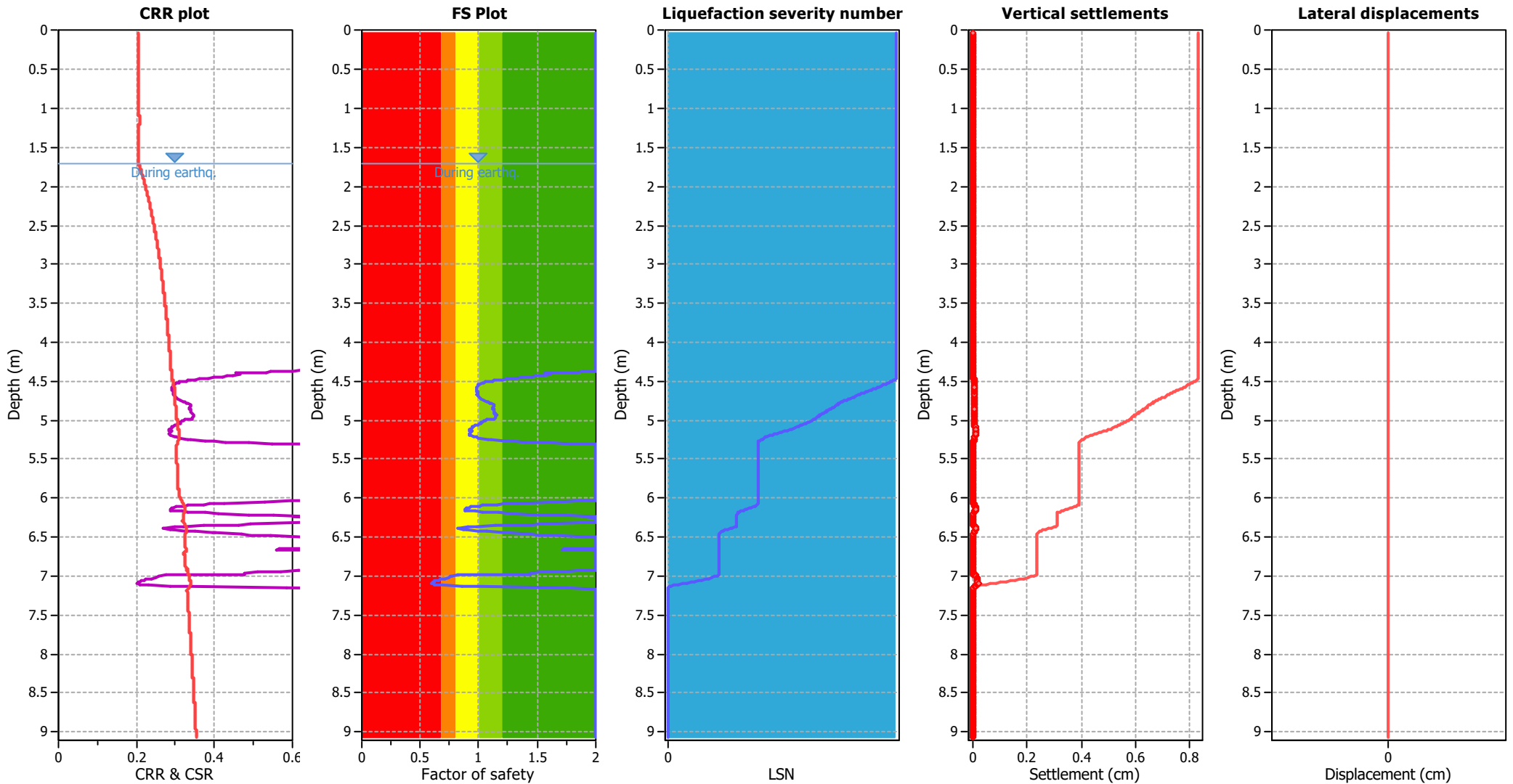
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on $I_c$ value	$I_c$ cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

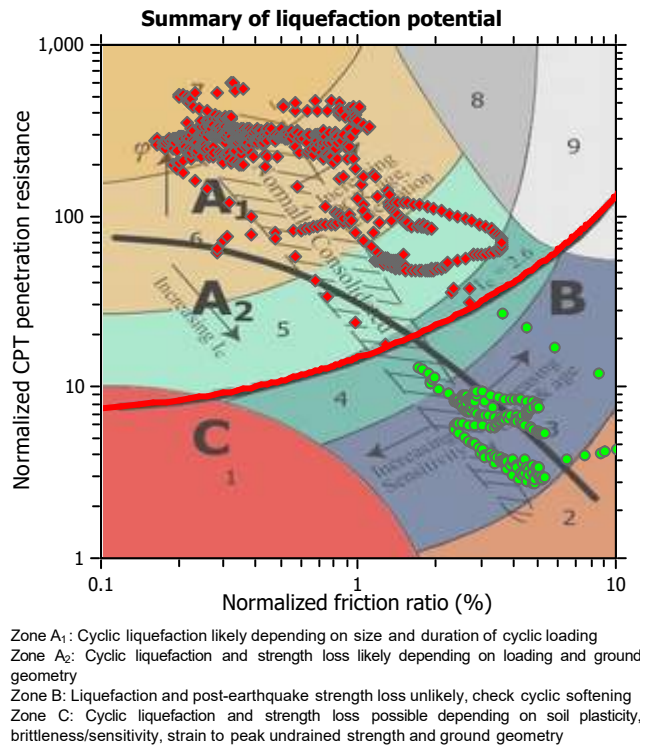
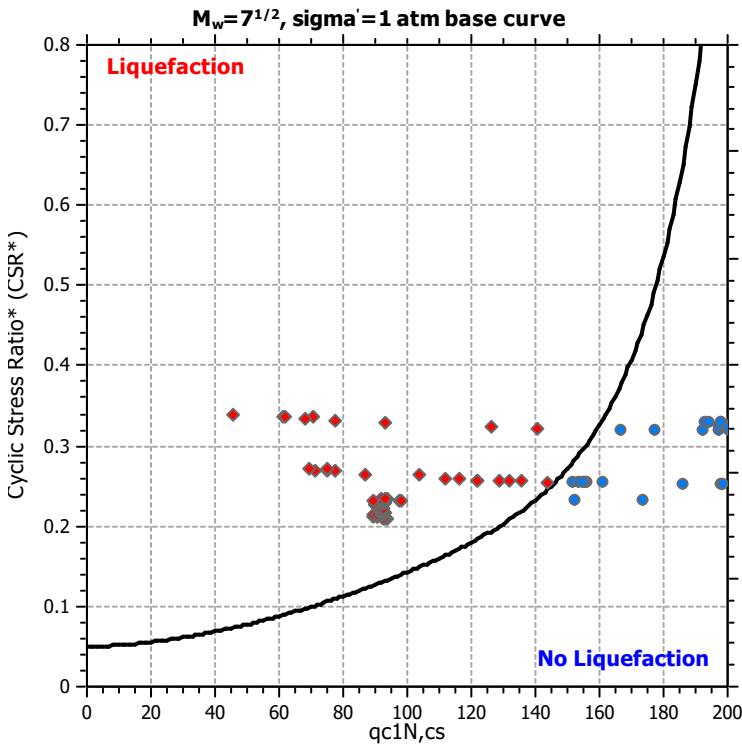
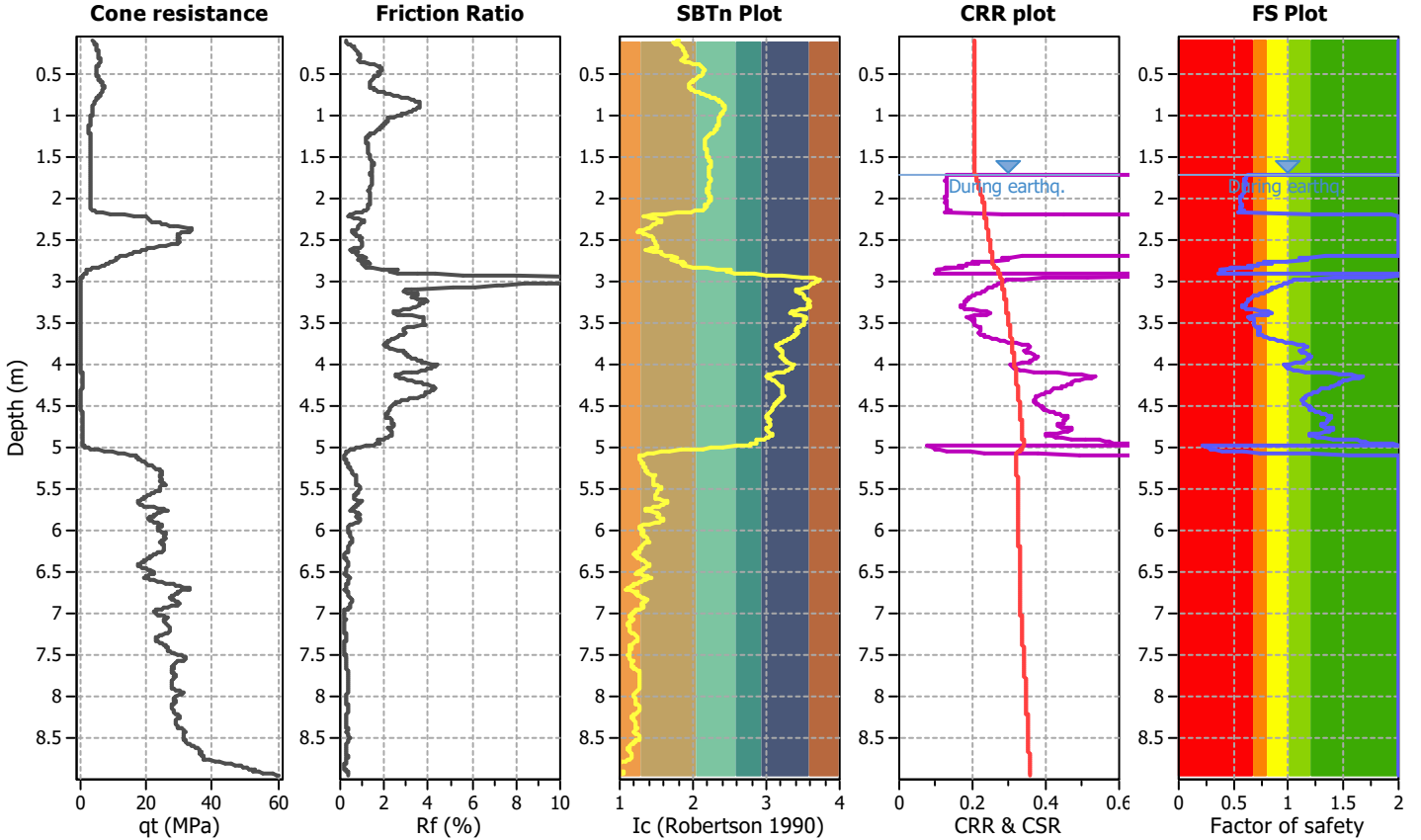
**Project title : Liquefaction Analysis - ULS**

**Location : 20 Te Haunui Lane, Pegasus**

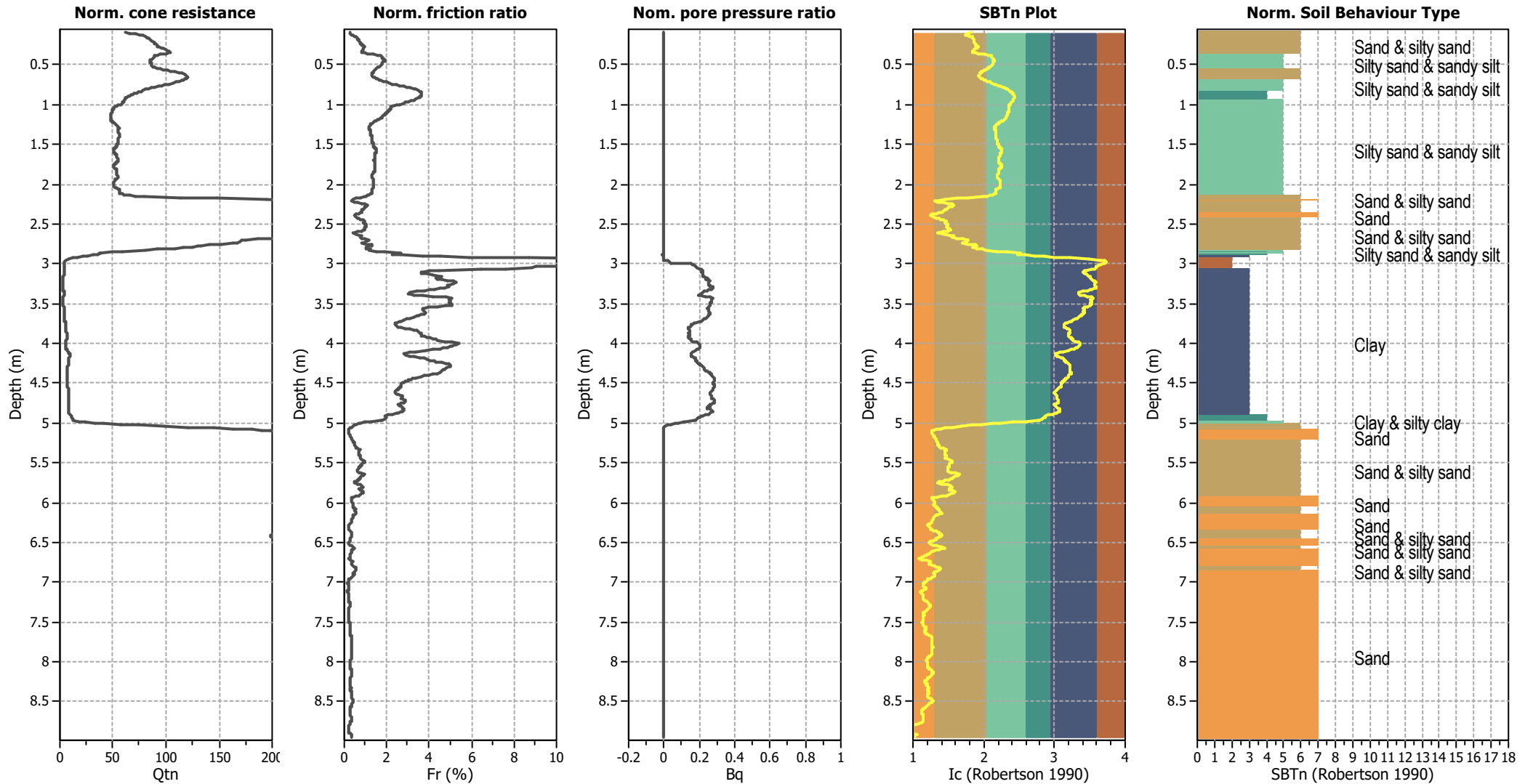
**CPT file : CPT101**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



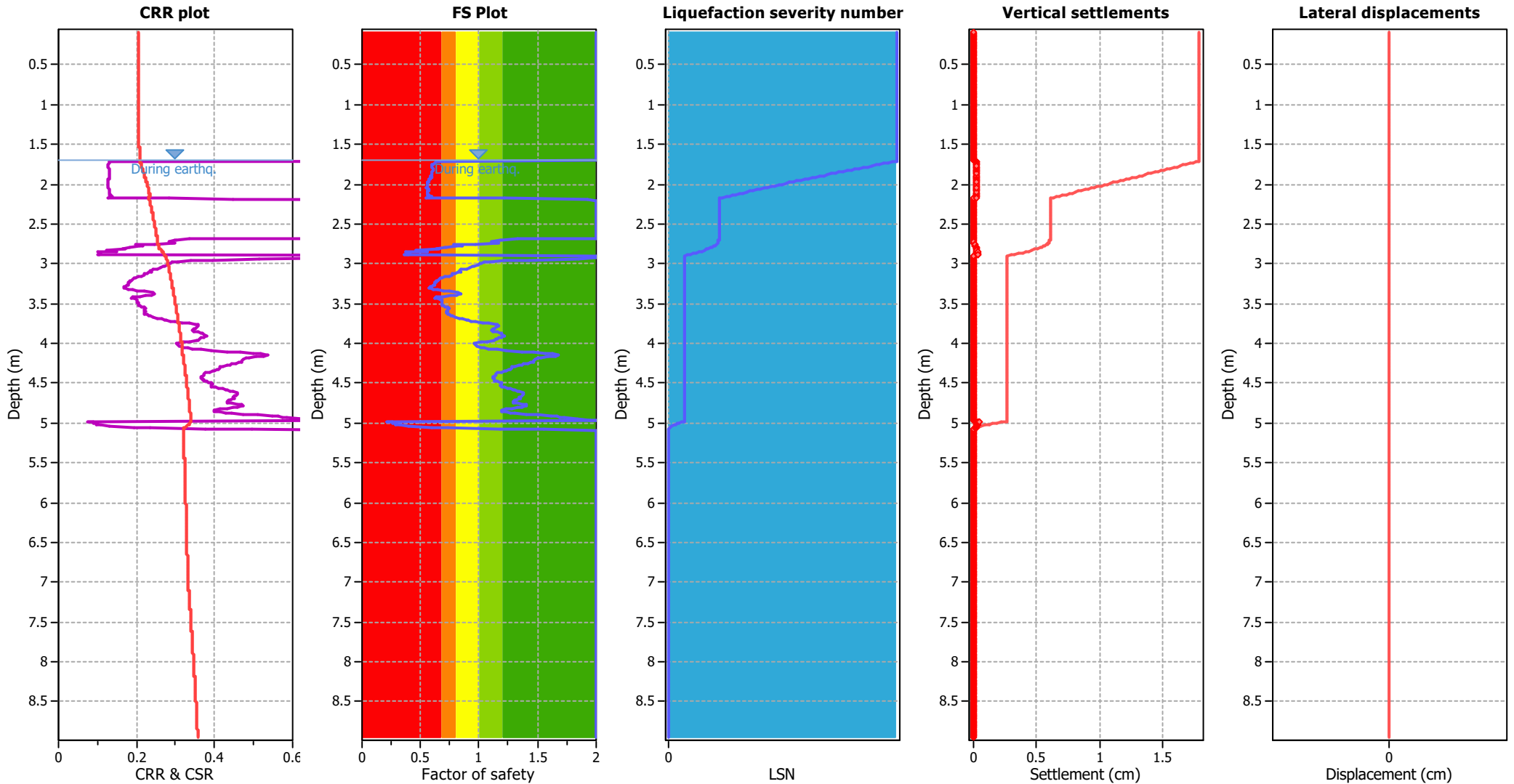
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

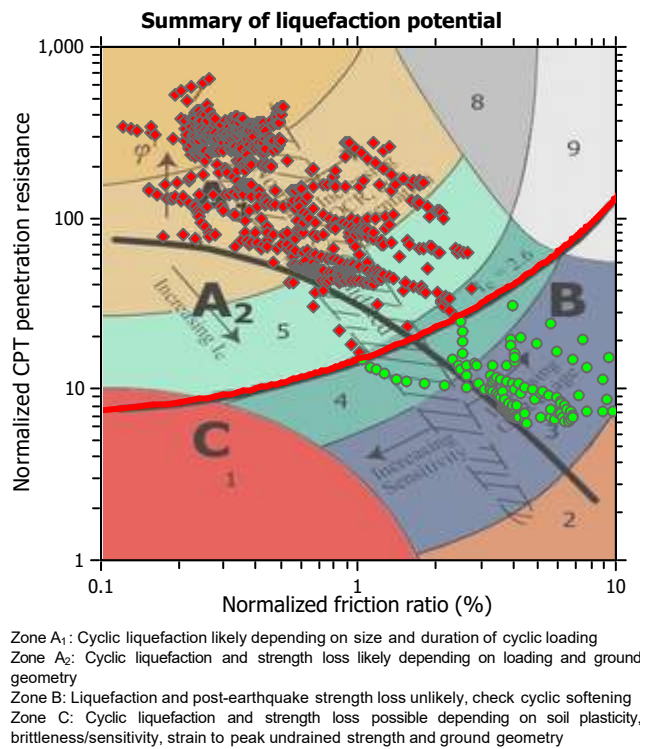
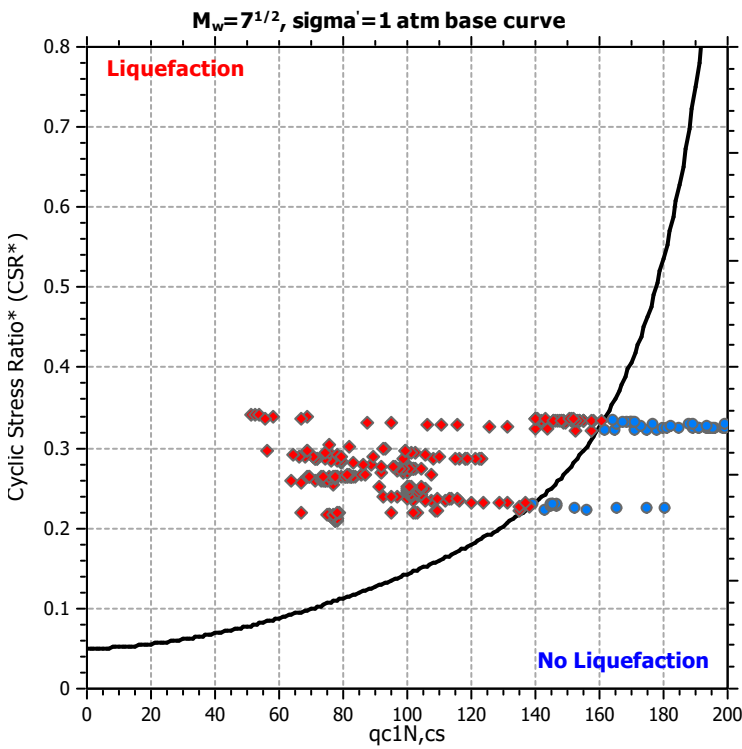
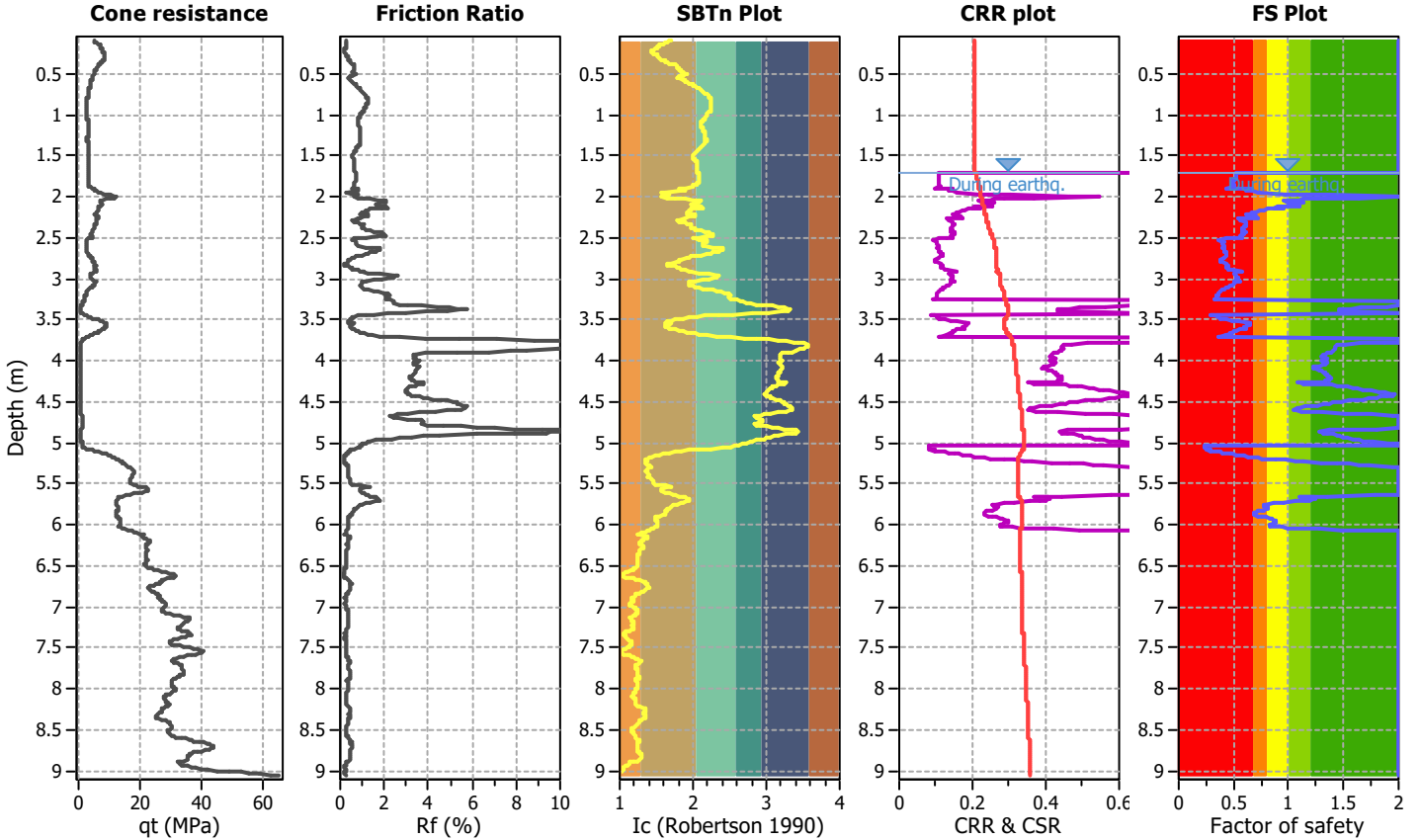
**Project title : Liquefaction Analysis - ULS**

**Location : 20 Te Haunui Lane, Pegasus**

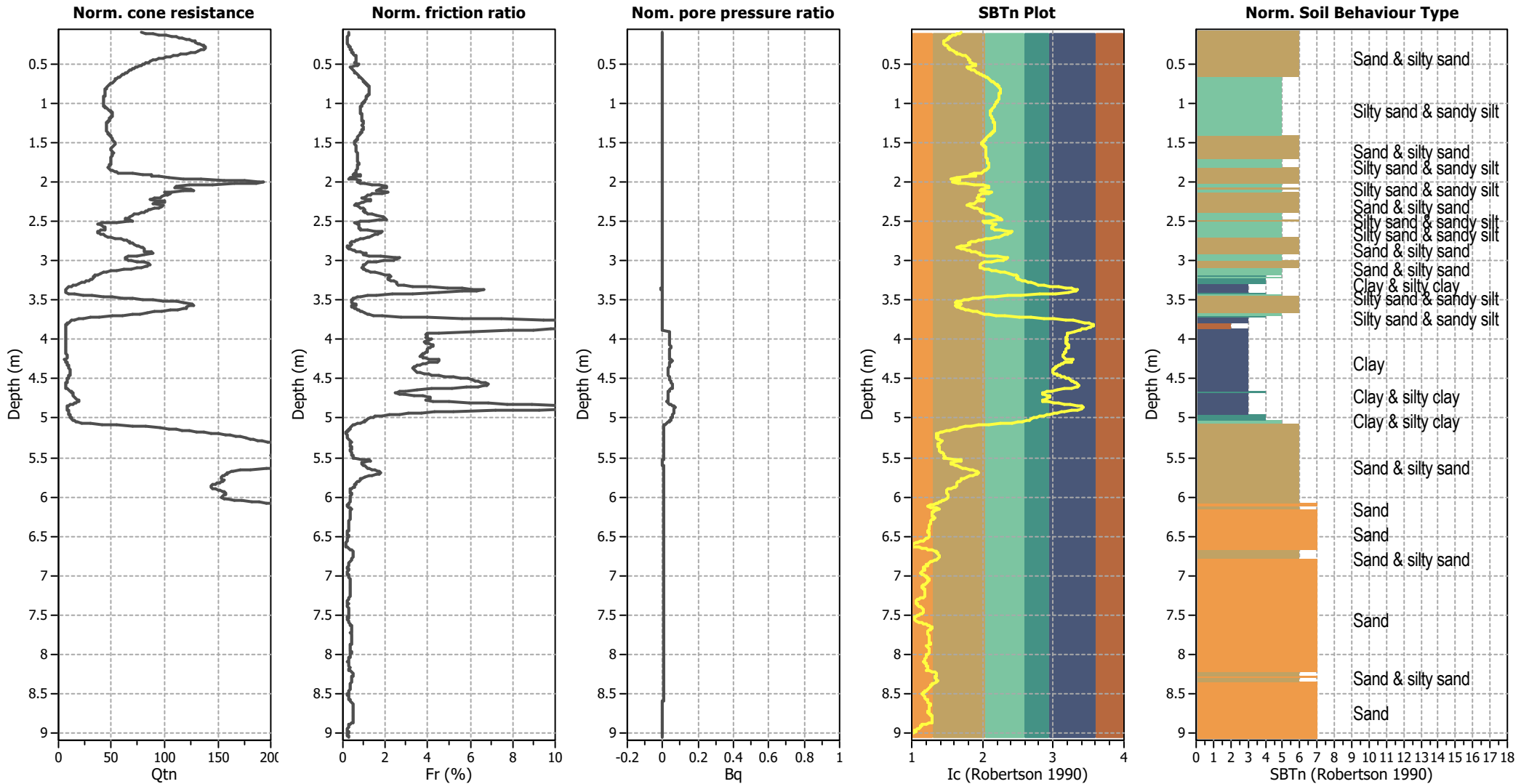
**CPT file : CPT102**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes	MSF method:	Method based



### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

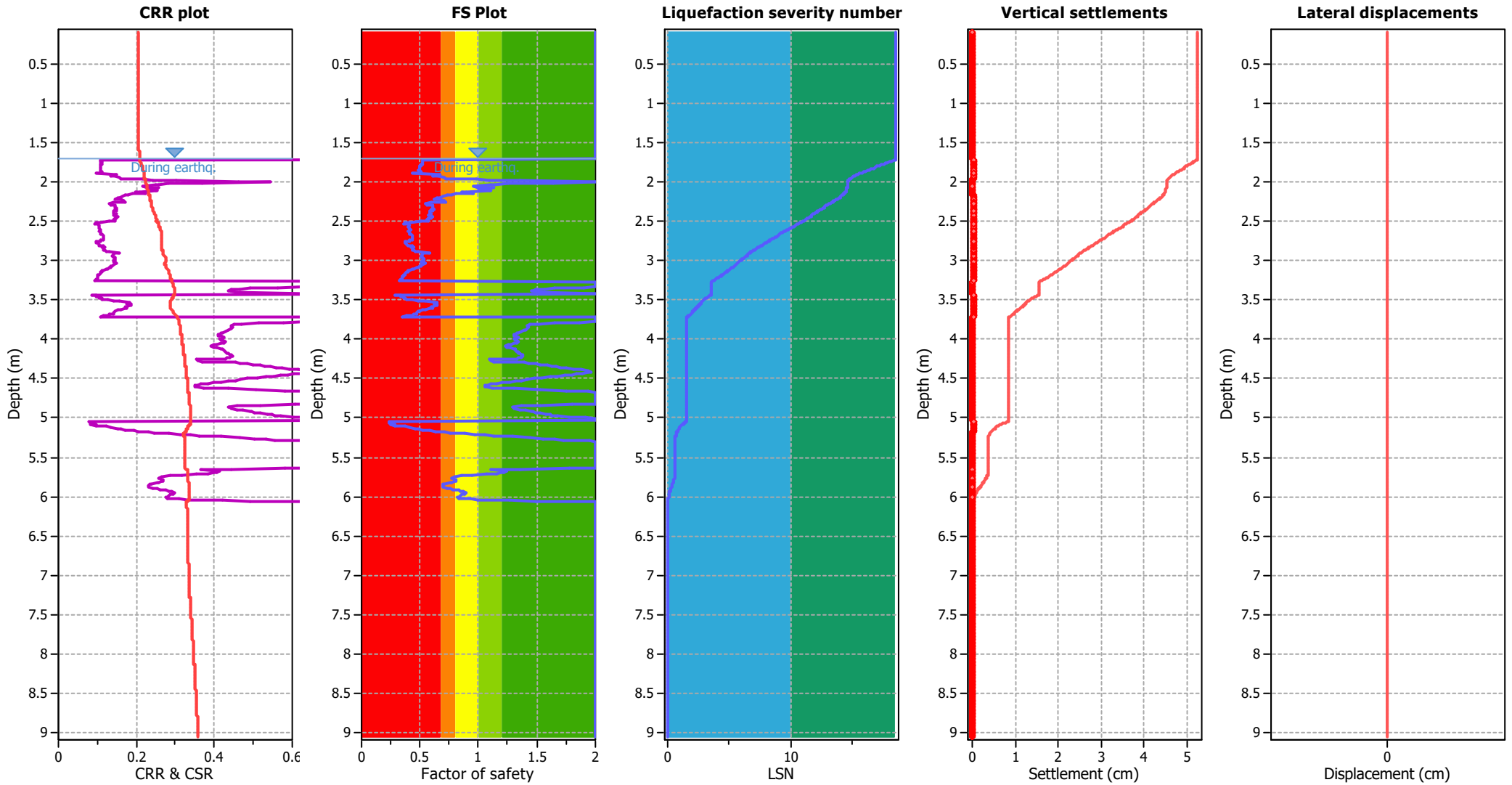
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>o</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

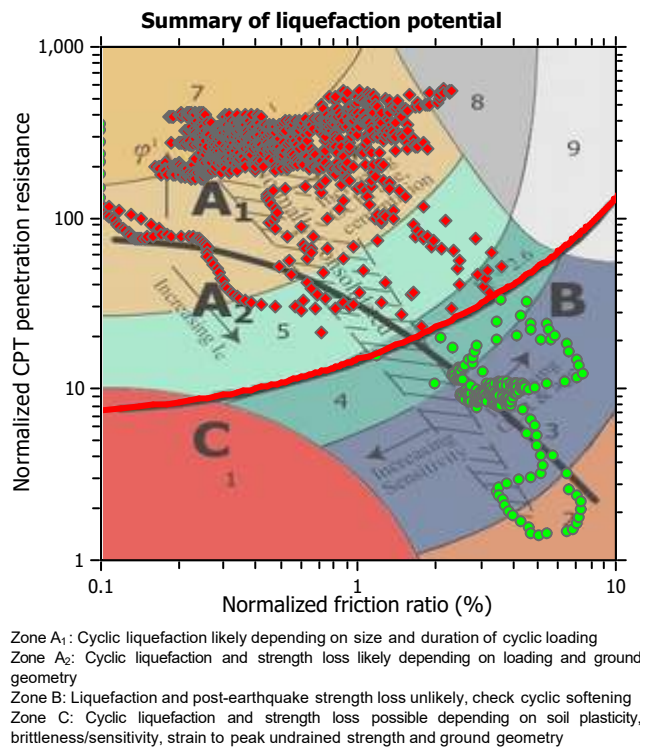
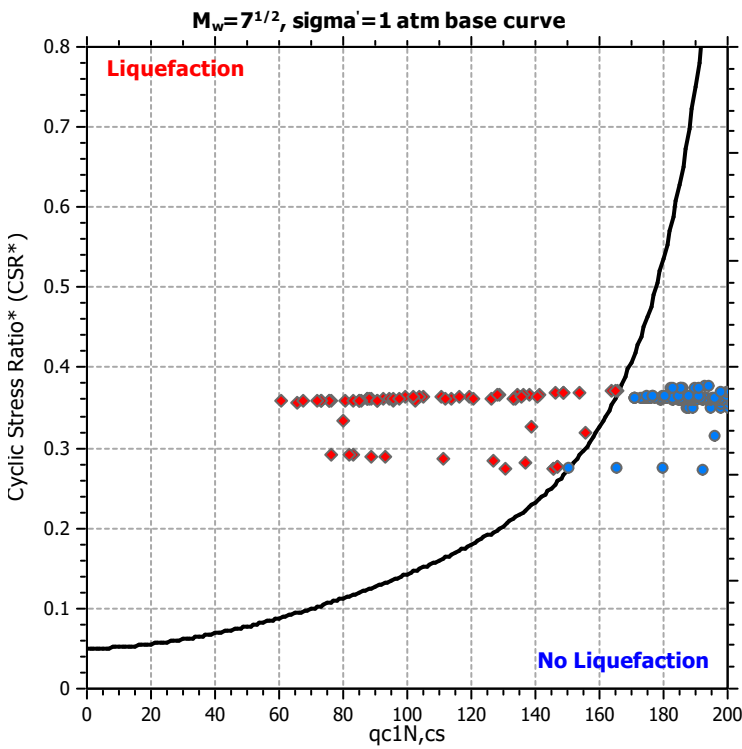
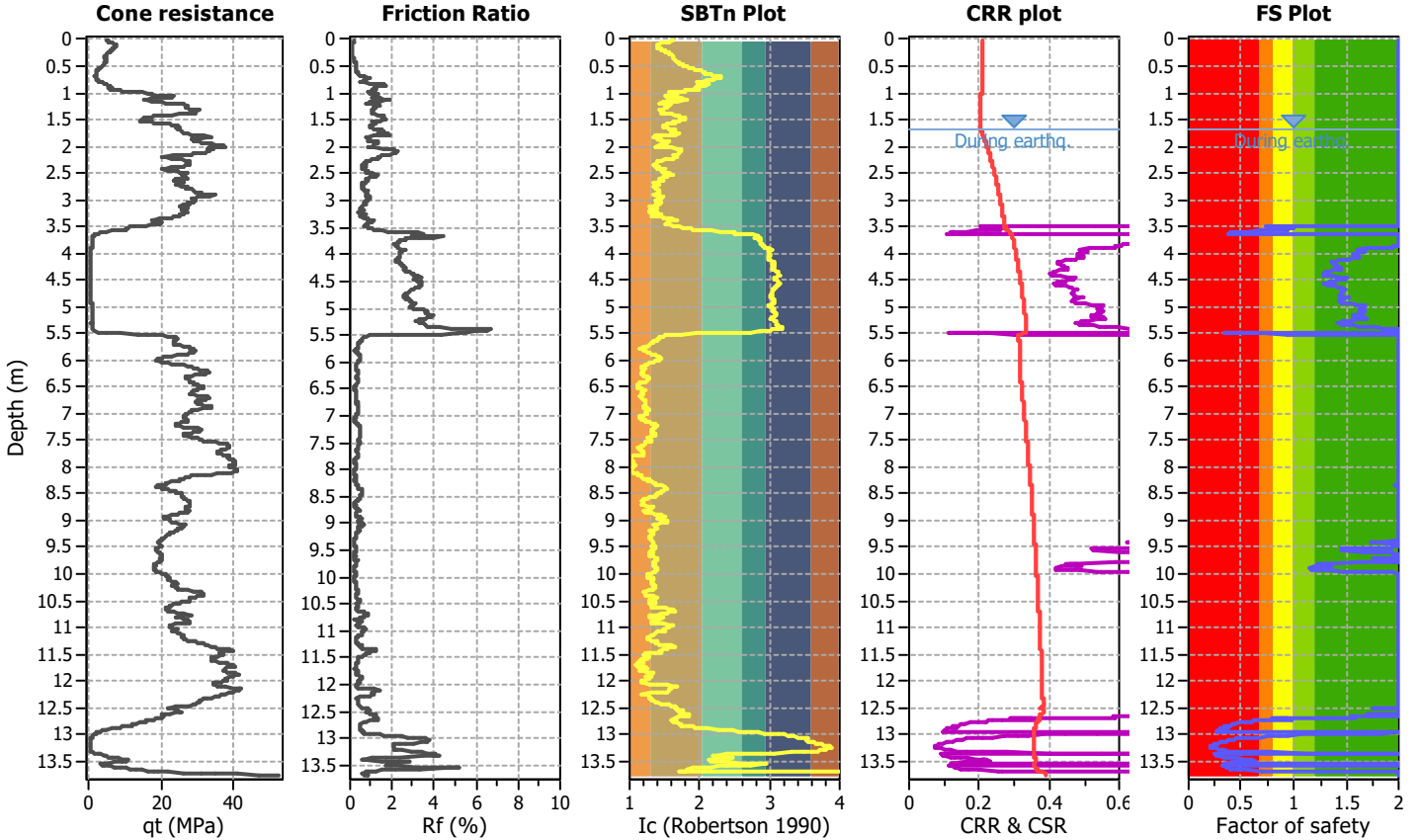
**Project title : Liquefaction Analysis - ULS**

**Location : 20 Te Haunui Lane, Pegasus**

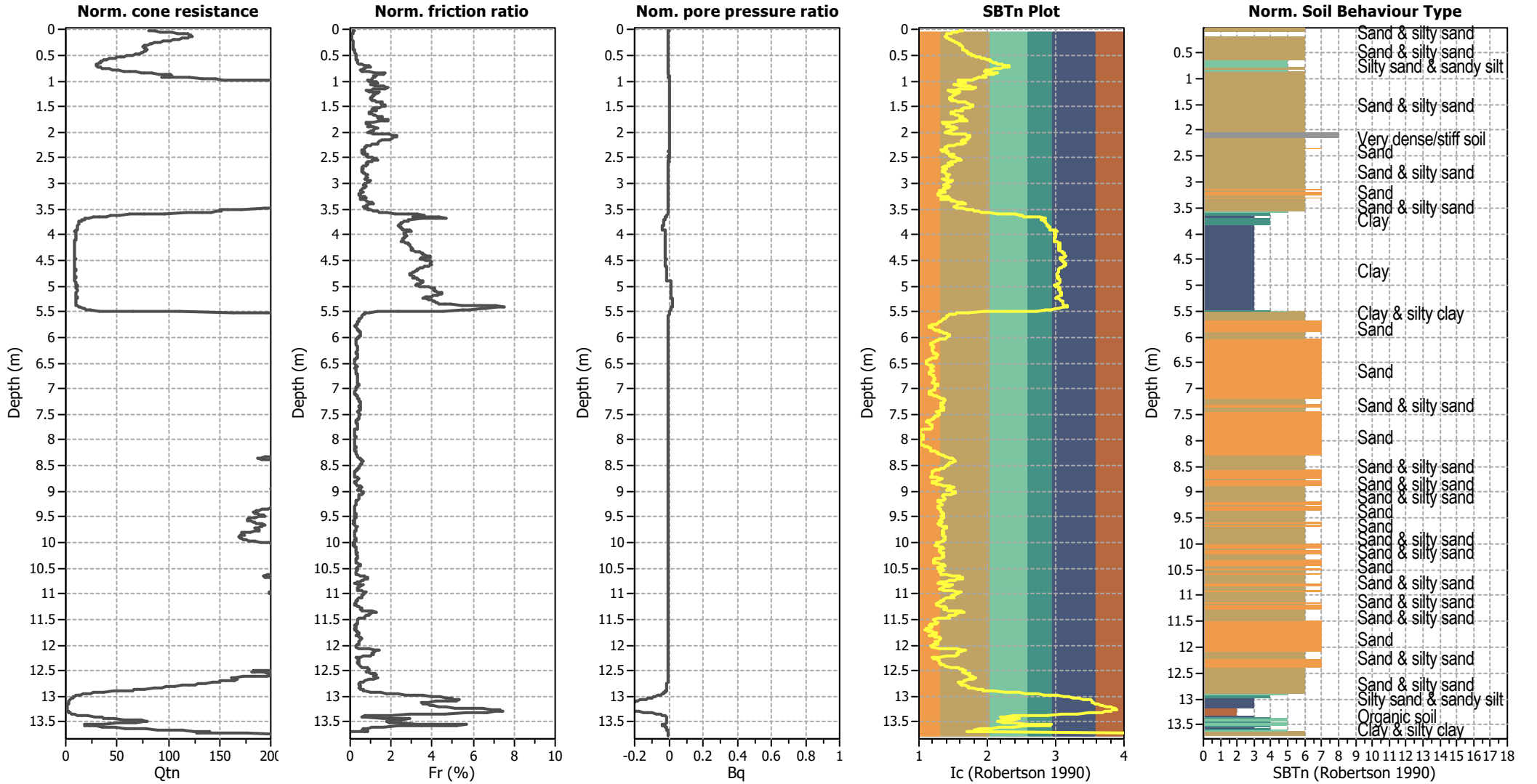
**CPT file : CPT103**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



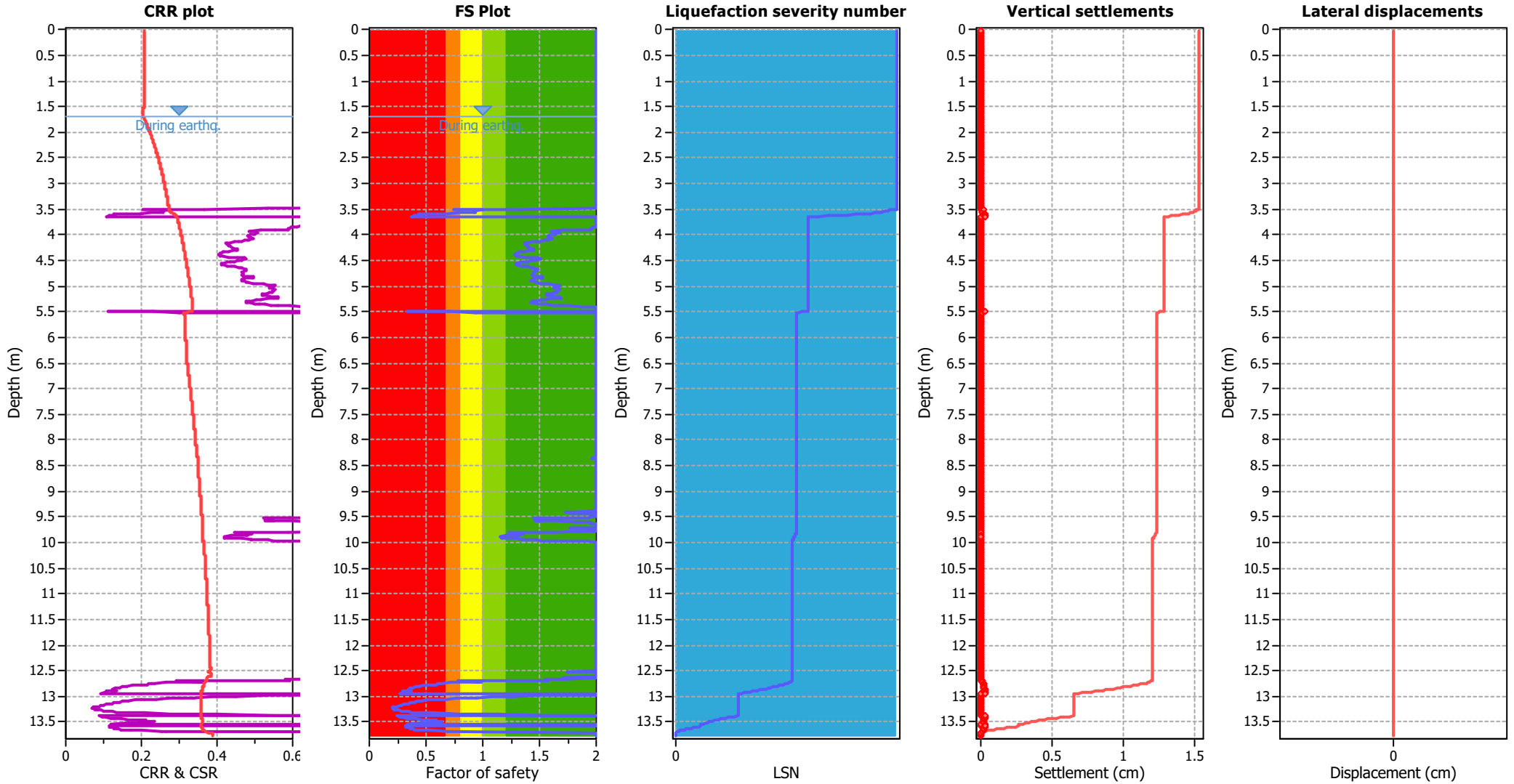
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_o$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

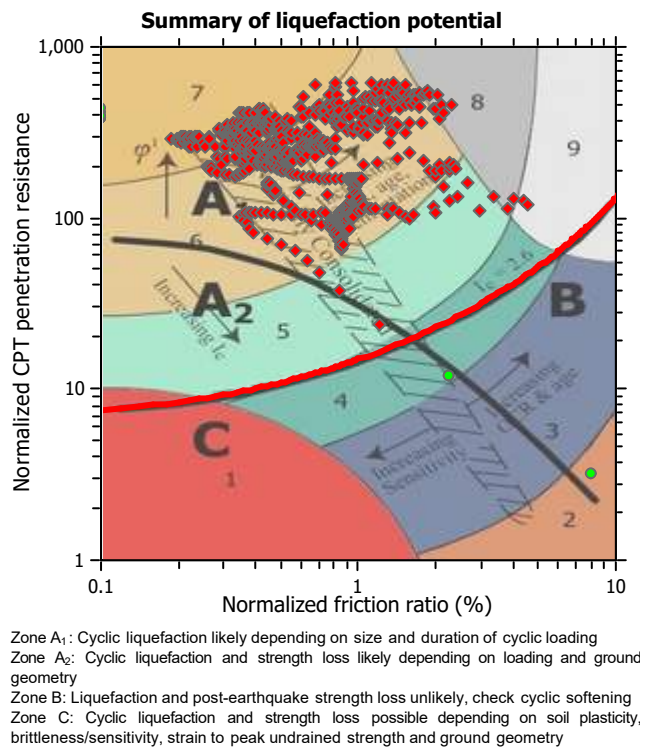
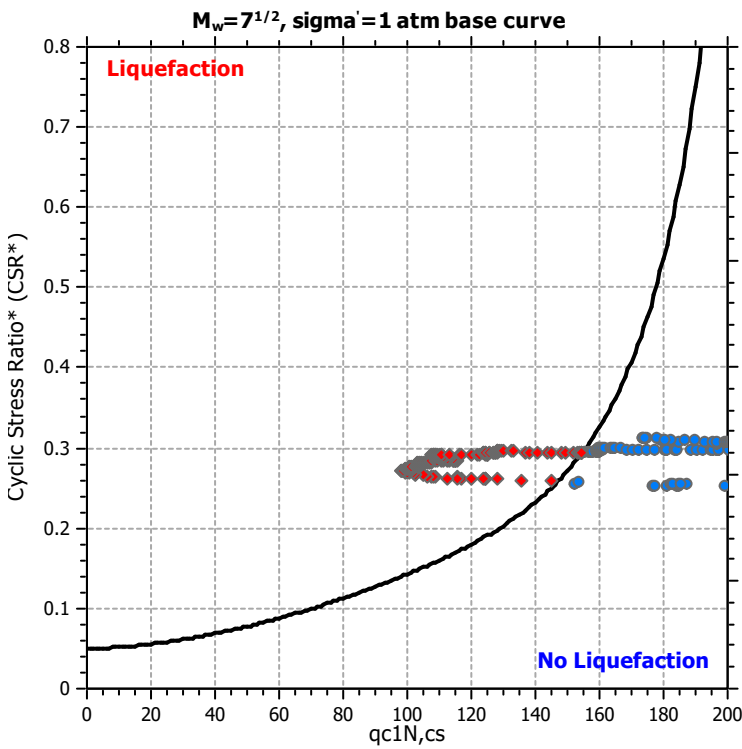
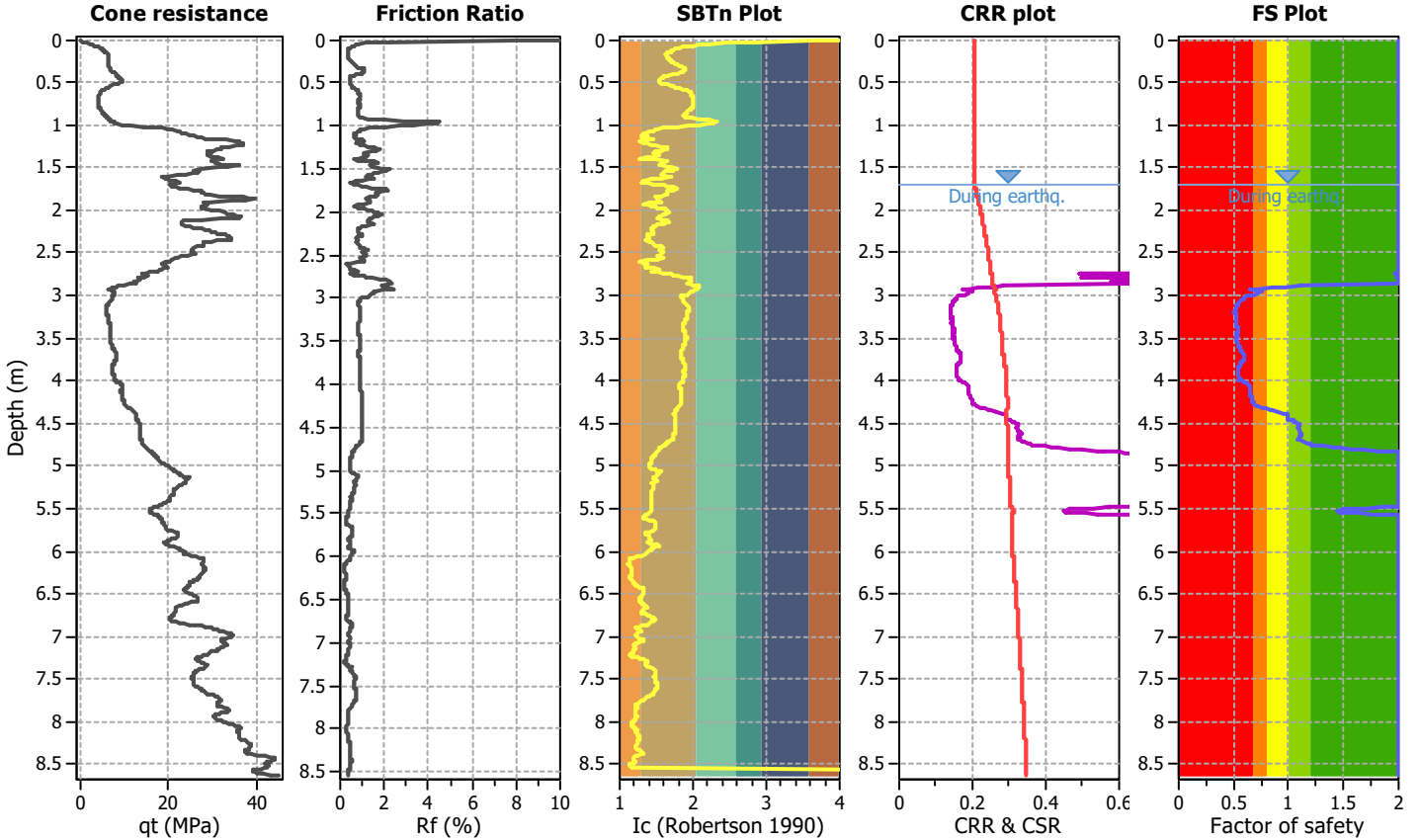
**Project title : Liquefaction Analysis - ULS**

**Location : 20 Te Haunui Lane, Pegasus**

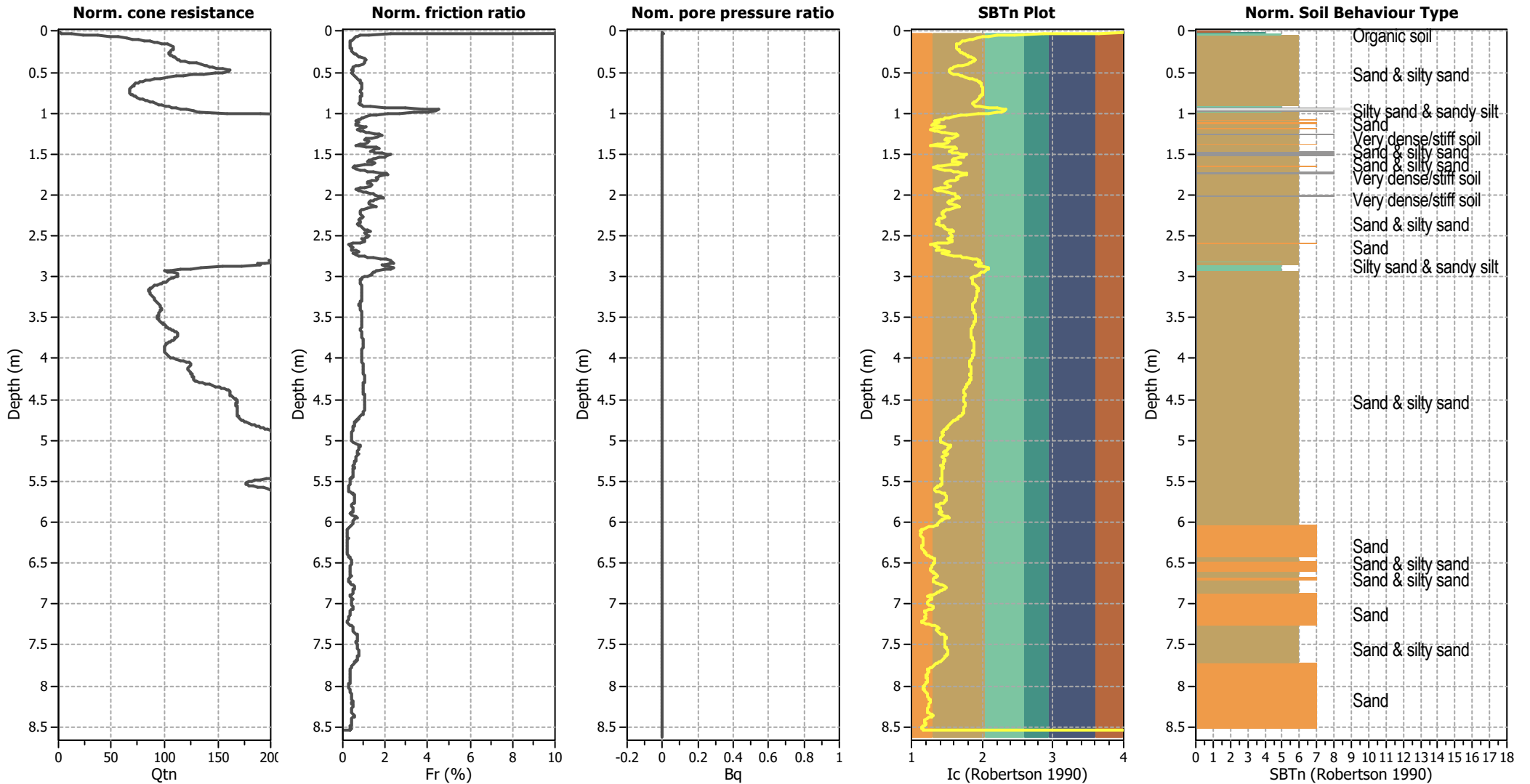
**CPT file : CPT104**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



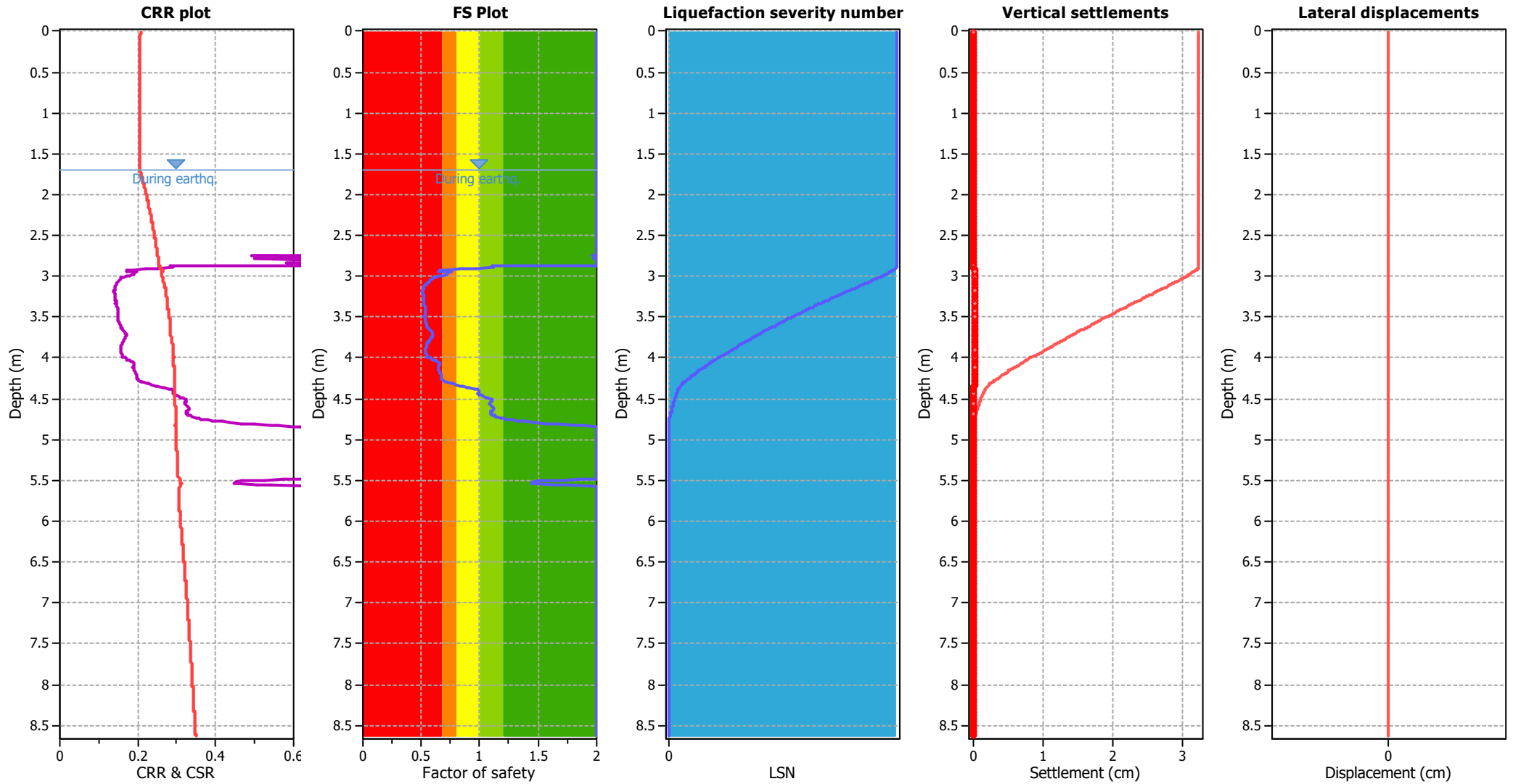
**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>o</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

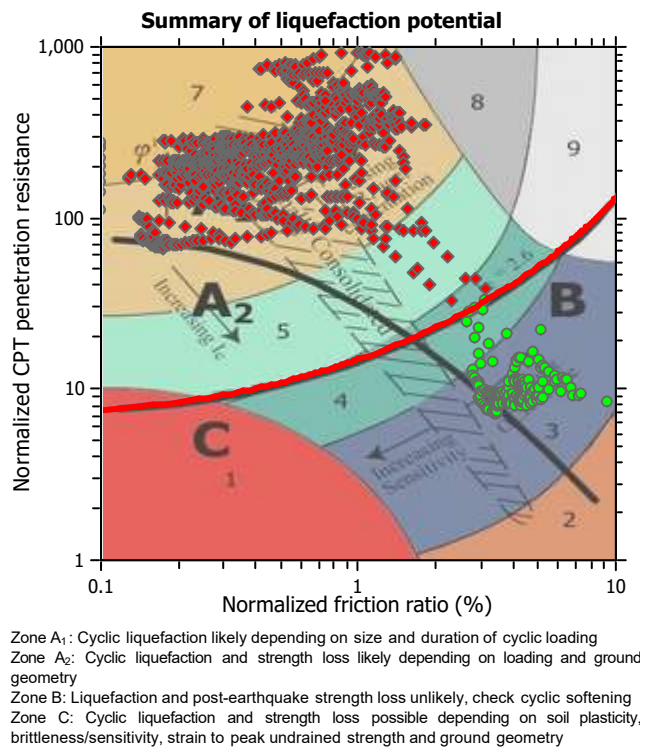
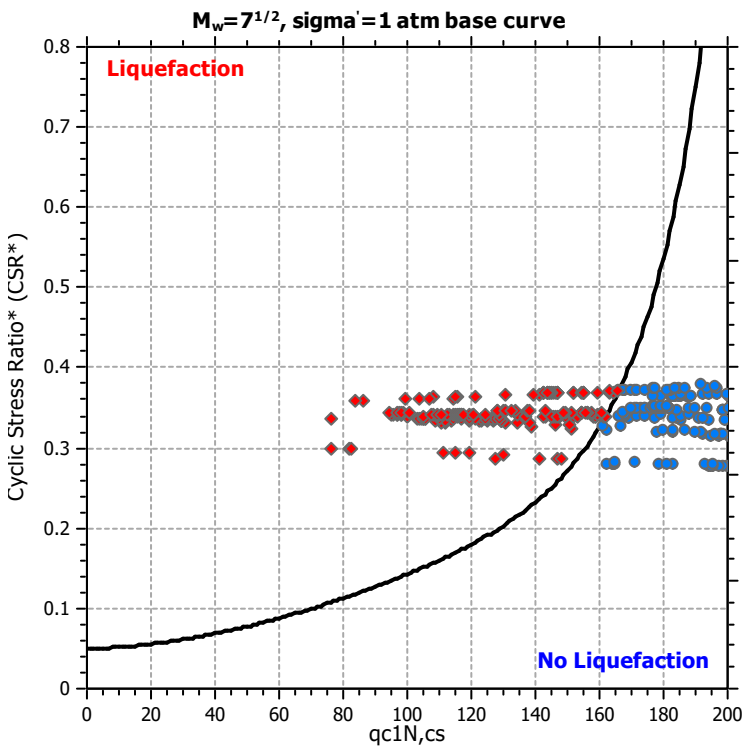
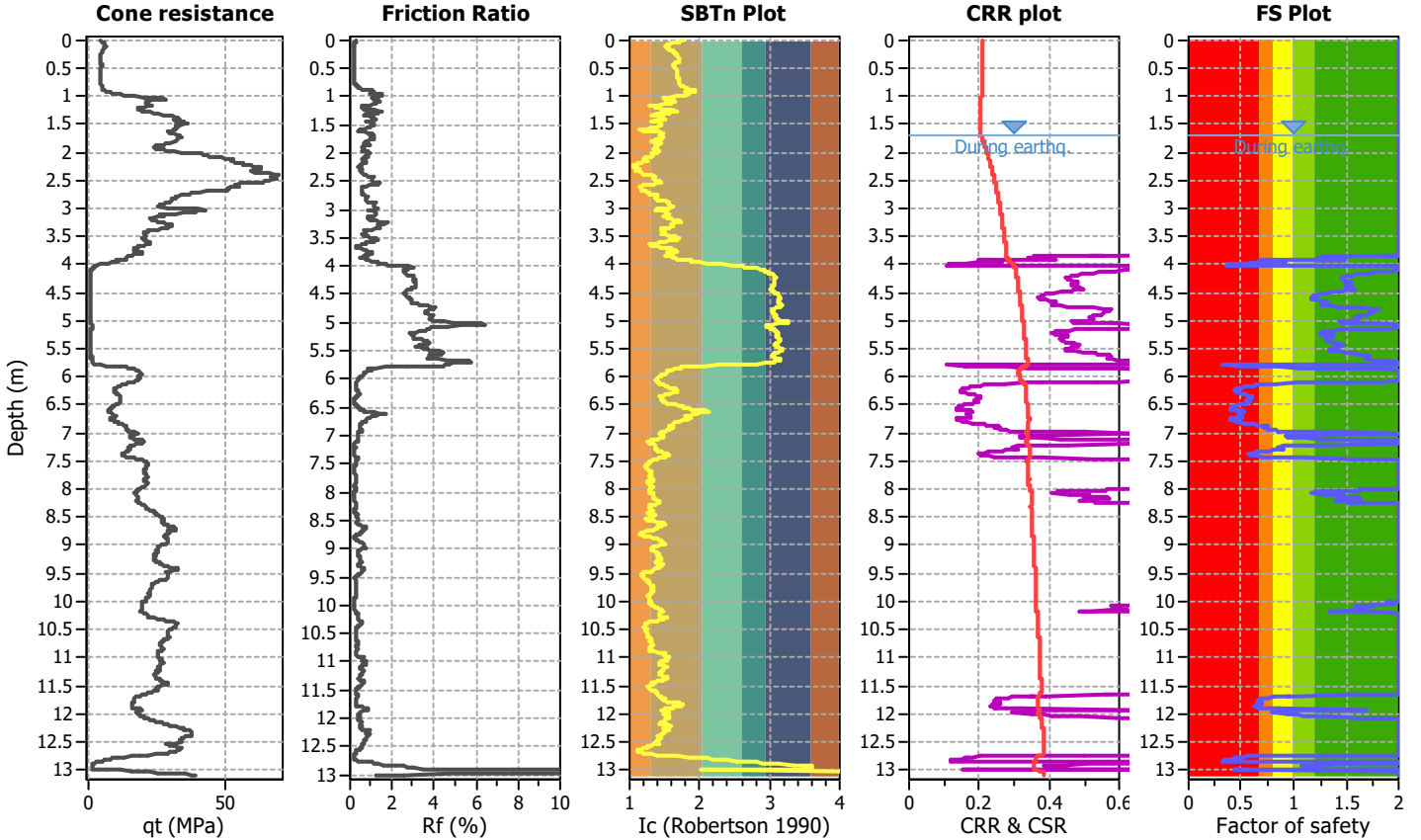
**Project title : Liquefaction Analysis - ULS**

**Location : 20 Te Haunui Lane, Pegasus**

**CPT file : CPT105**

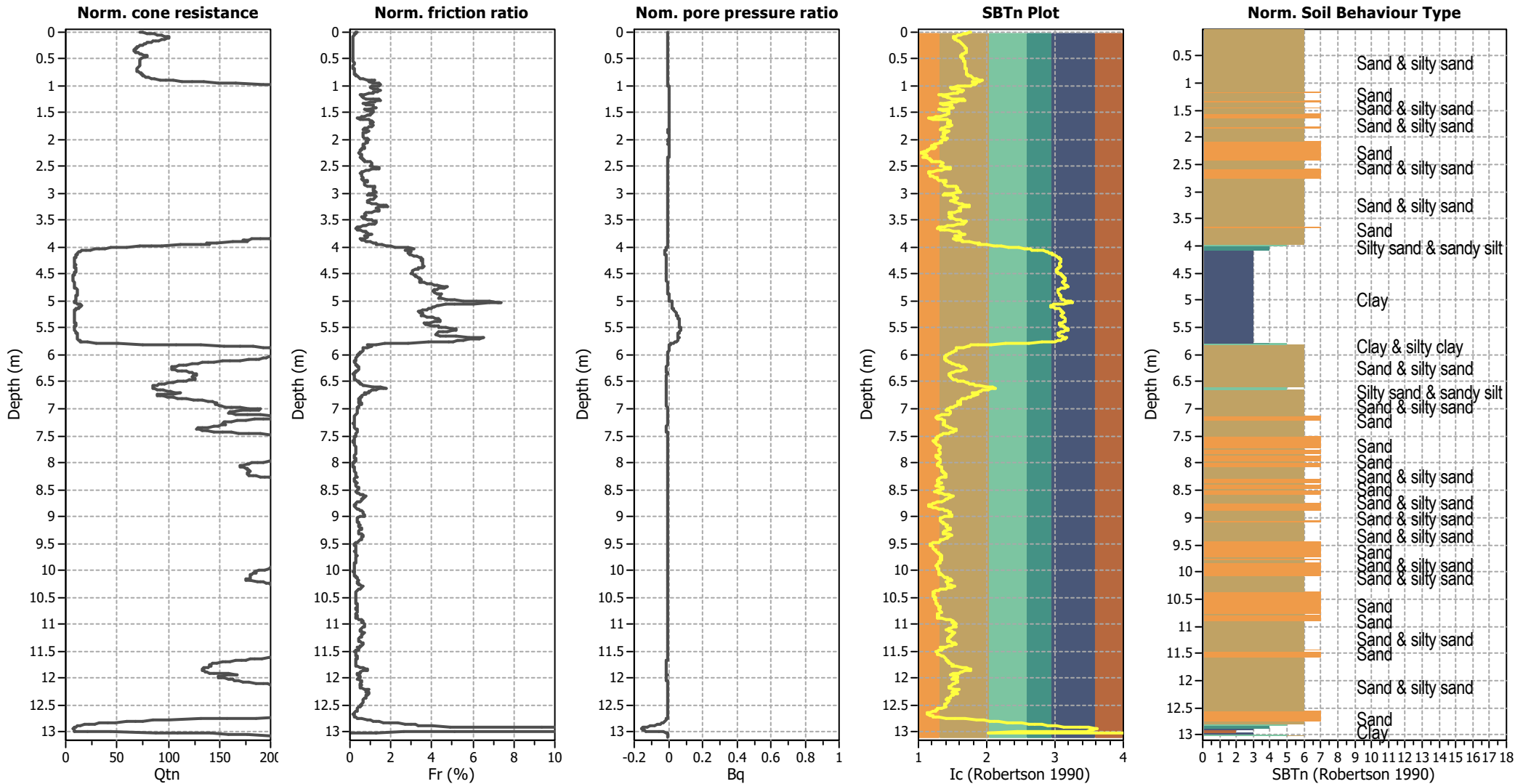
**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		





### CPT basic interpretation plots (normalized)



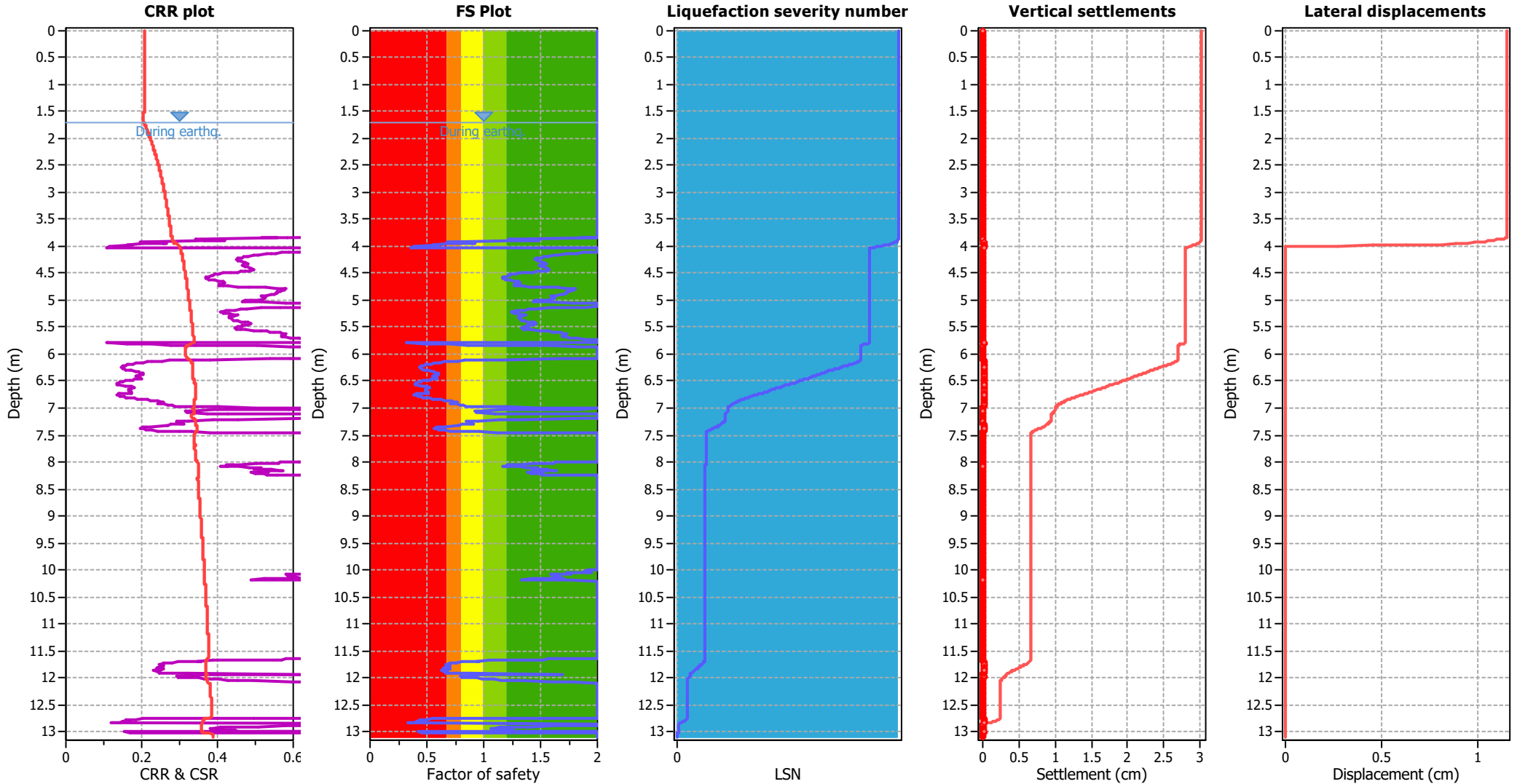
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_v$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

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

**LIQUEFACTION ANALYSIS REPORT**

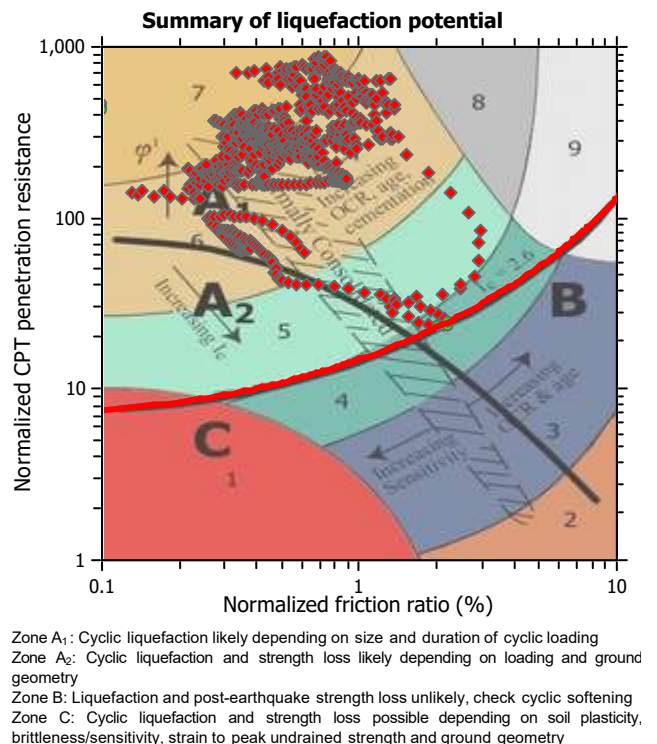
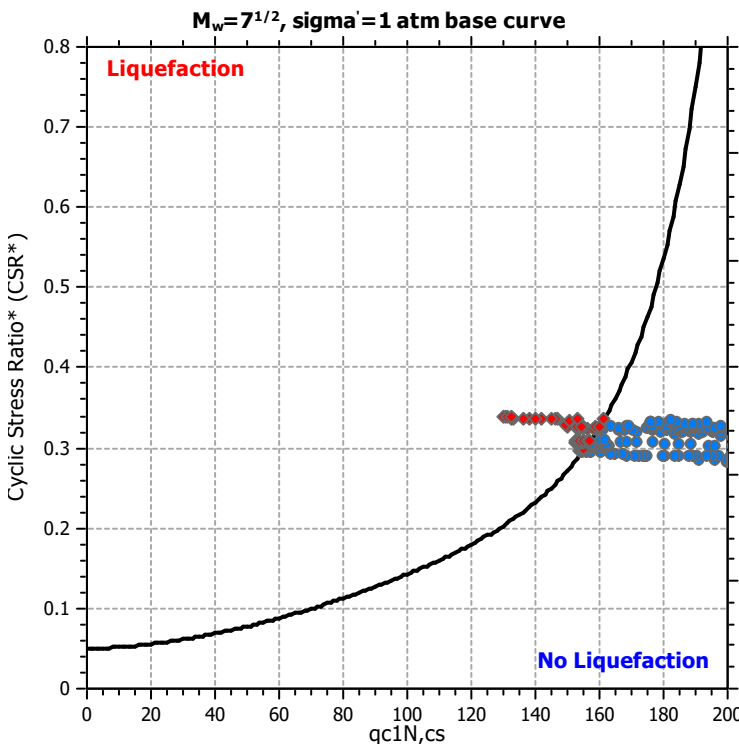
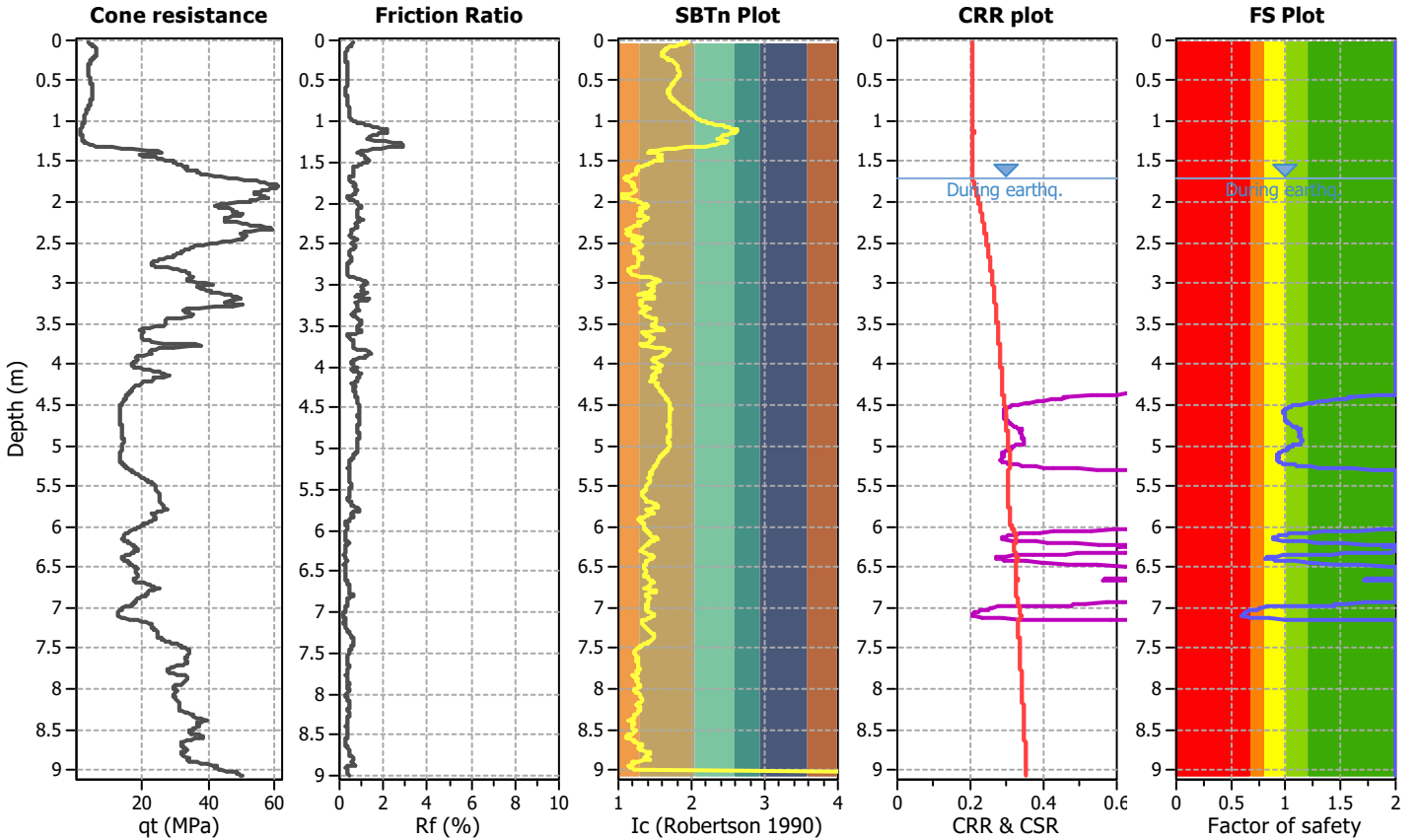
**Project title : Liquefaction Analysis - ULS**

**Location : 20 Te Haunui Lane, Pegasus**

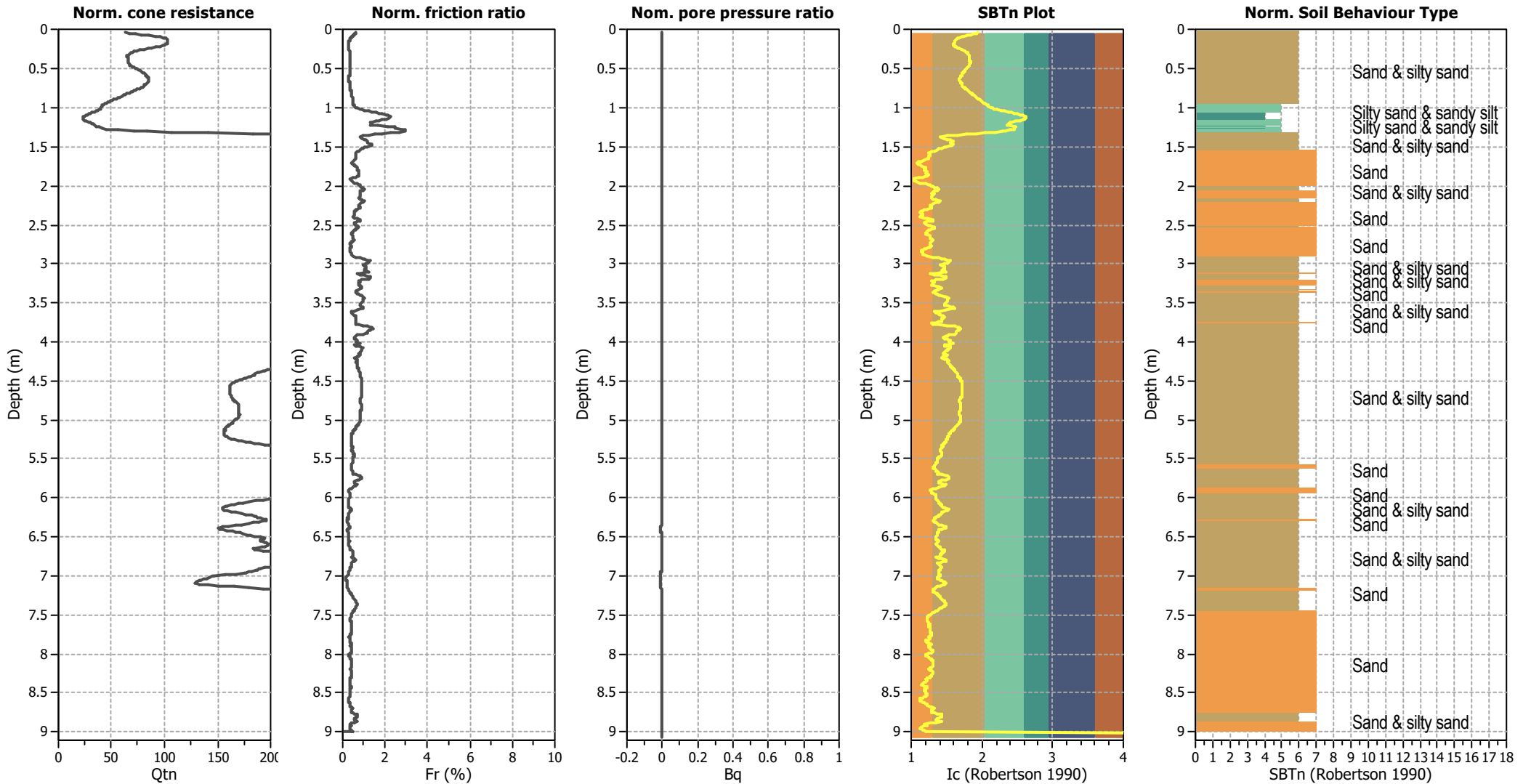
**CPT file : CPT106**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	1.70 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 based
Peak ground acceleration:	0.35	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots (normalized)



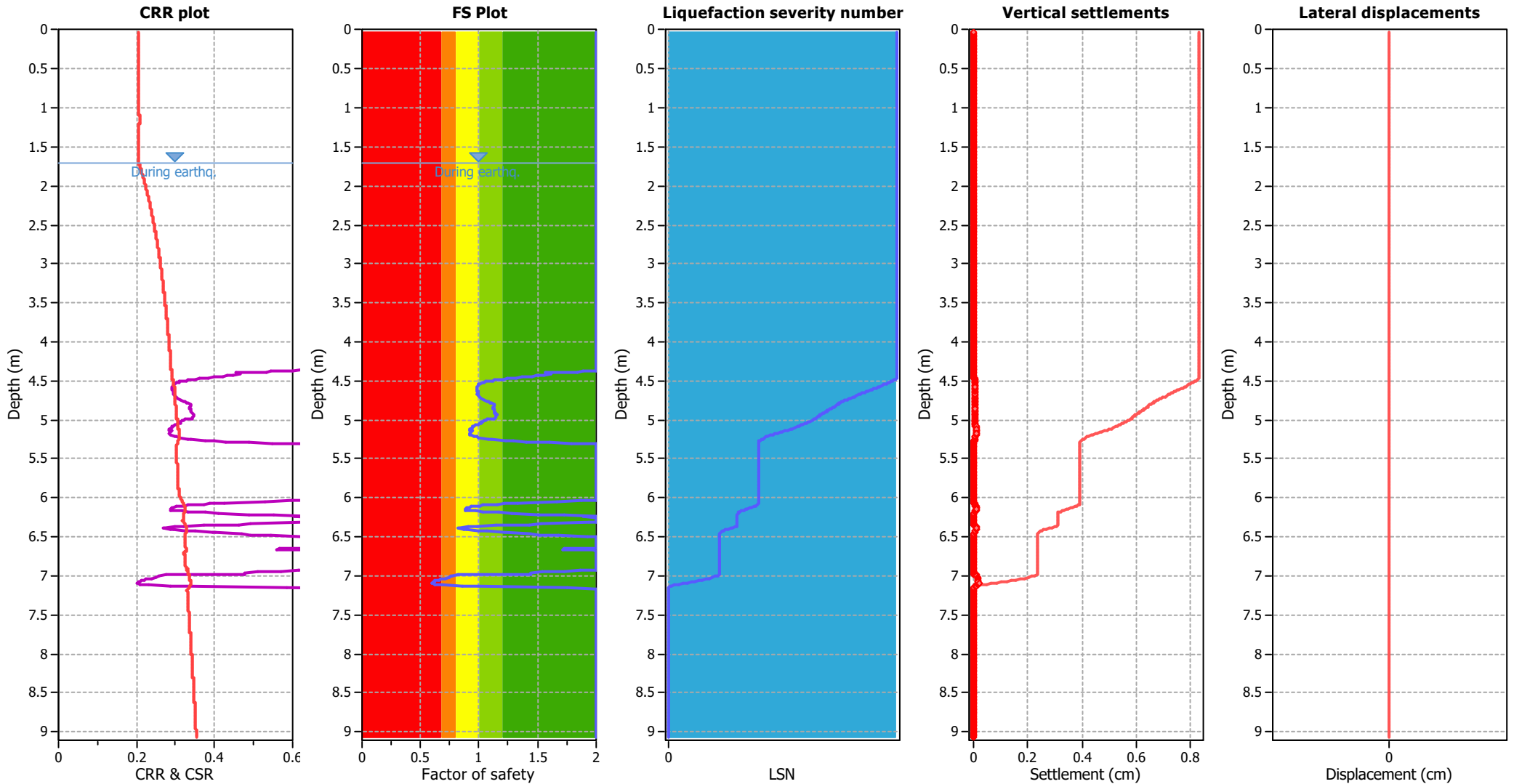
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.20 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

**LSN color scheme**

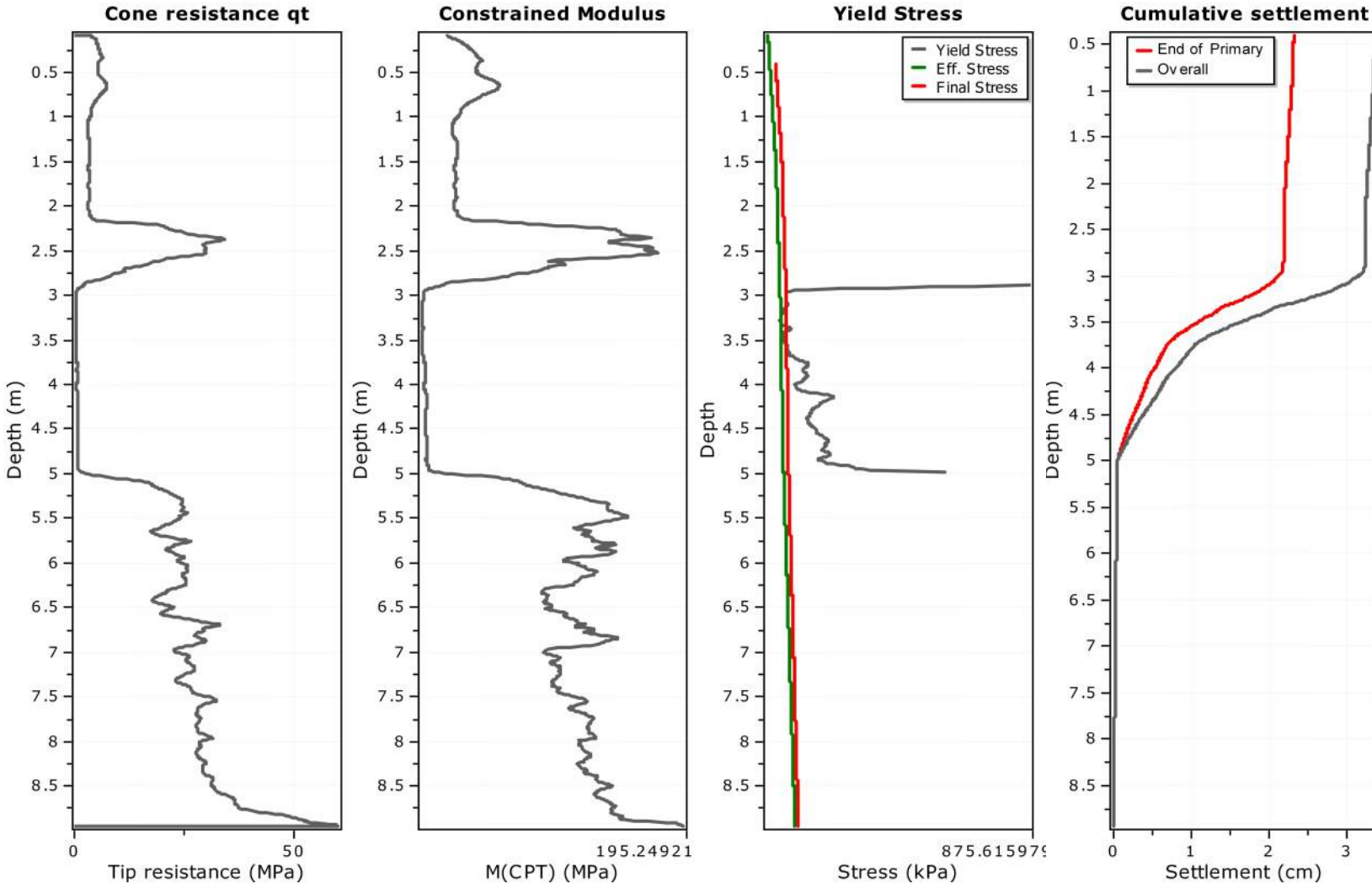
- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

## **APPENDIX D**

### **STATIC SETTLEMENT ANALYSIS**



**Settlements calculation according to theory of elasticity\***



**Calculation properties**

- Footing type: Rectangular
- Footing width: 10.00 (m)
- L/B: 2.0
- Footing pressure: 20.00 (kPa)
- Embedment depth: 0.40 (m)
- Footing is rigid: No
- Remove excavation load: No
- Apply 20% rule: No
- Calculate secondary settlements: Yes
- Time period for primary consolidation: 6 months
- Time period for second. settlements: 600 months

\* Primary settlement calculation is performed according to the following formula:

$$S = \sum \frac{\Delta\sigma_v}{M_{CPT}} \Delta z$$

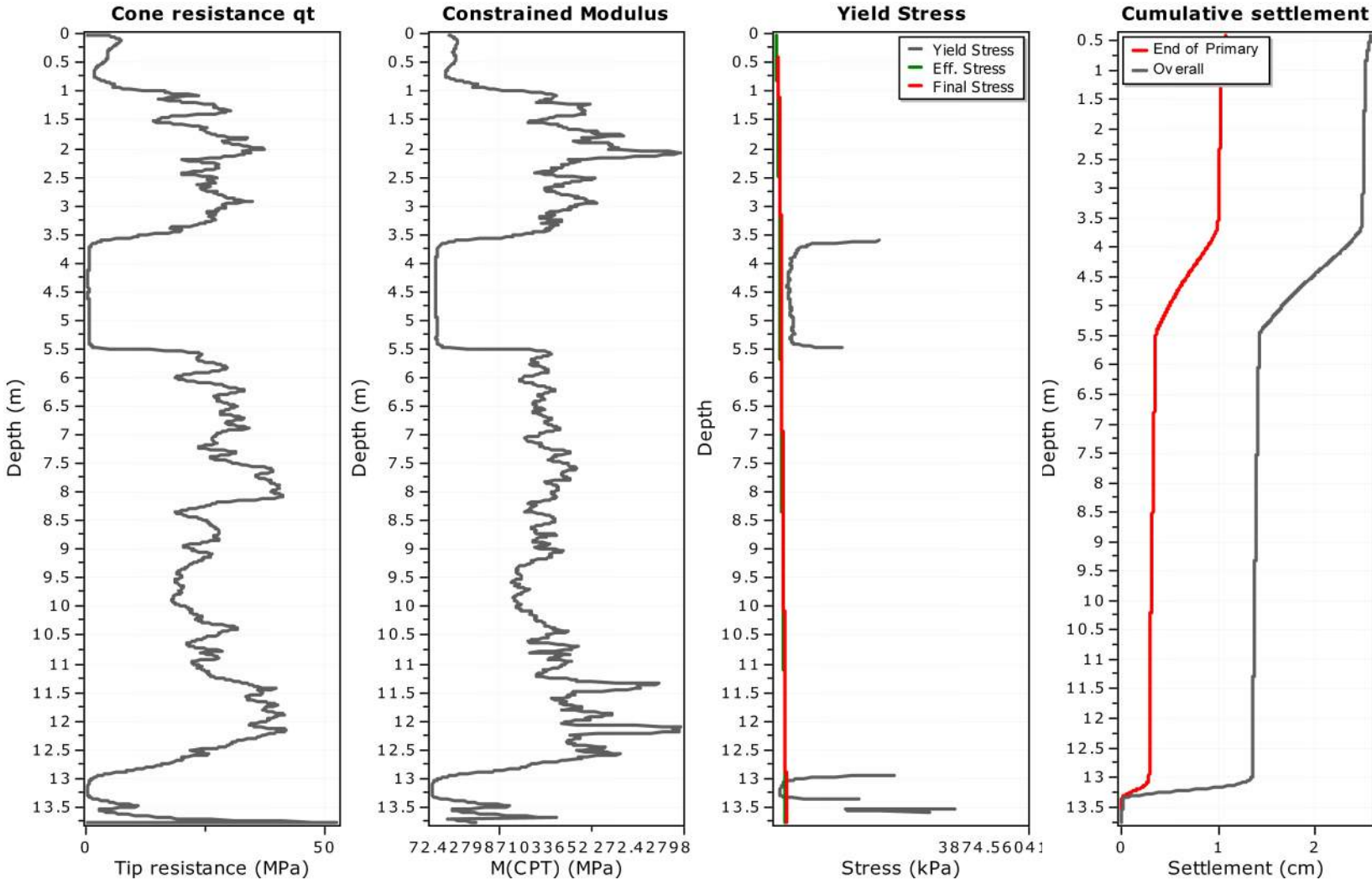
\* Secondary (creep) settlement calculation is performed according to the following formula:

$$s_c = s_p \left( 1 - e^{-\frac{t}{t_p}} \right)$$

where  $t_p$  is the duration of primary consolidation



**Settlements calculation according to theory of elasticity\***



**Calculation properties**

- Footing type: Rectangular
- Footing width: 10.00 (m)
- L/B: 2.0
- Footing pressure: 20.00 (kPa)
- Embedment depth: 0.40 (m)
- Footing is rigid: No
- Remove excavation load: No
- Apply 20% rule: No
- Calculate secondary settlements: Yes
- Time period for primary consolidation: 6 months
- Time period for second. settlements: 600 months

\* Primary settlement calculation is performed according to the following formula:

$$S = \sum \frac{\Delta\sigma_v}{M_{CPT}} \Delta z$$

\* Secondary (creep) settlement calculation is performed according to the following formula:

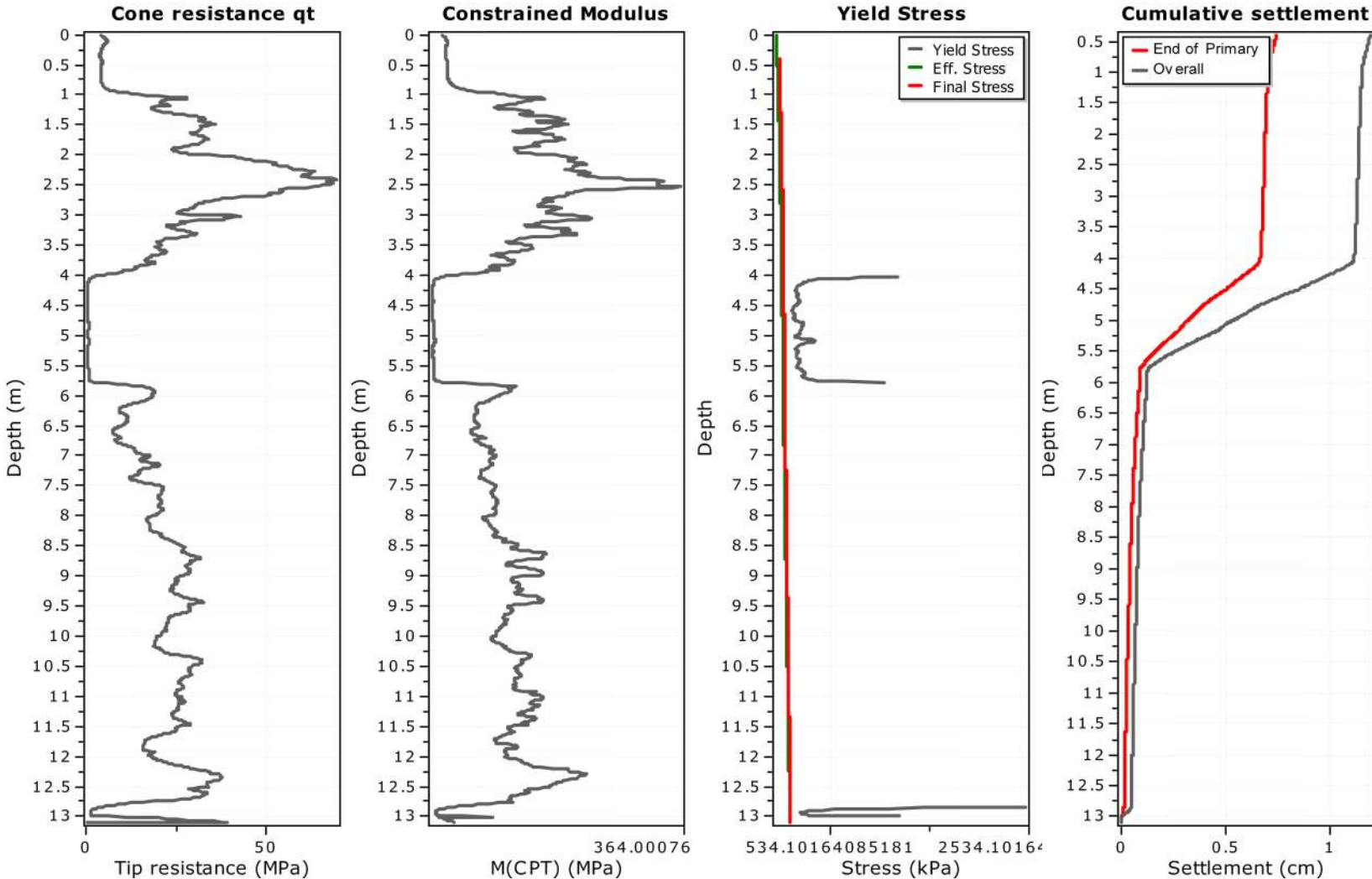
$$s_c = s_p \left( 1 - \exp\left(-\frac{t}{t_p}\right) \right)$$

where  $t_p$  is the duration of primary consolidation





**Settlements calculation according to theory of elasticity\***



**Calculation properties**

- Footing type: Rectangular
- Footing width: 10.00 (m)
- L/B: 2.0
- Footing pressure: 20.00 (kPa)
- Embedment depth: 0.40 (m)
- Footing is rigid: No
- Remove excavation load: No
- Apply 20% rule: No
- Calculate secondary settlements: Yes
- Time period for primary consolidation: 6 months
- Time period for second. settlements: 600 months

\* Primary settlement calculation is performed according to the following formula:

$$S = \sum \frac{\Delta\sigma_v}{M_{CPT}} \Delta z$$

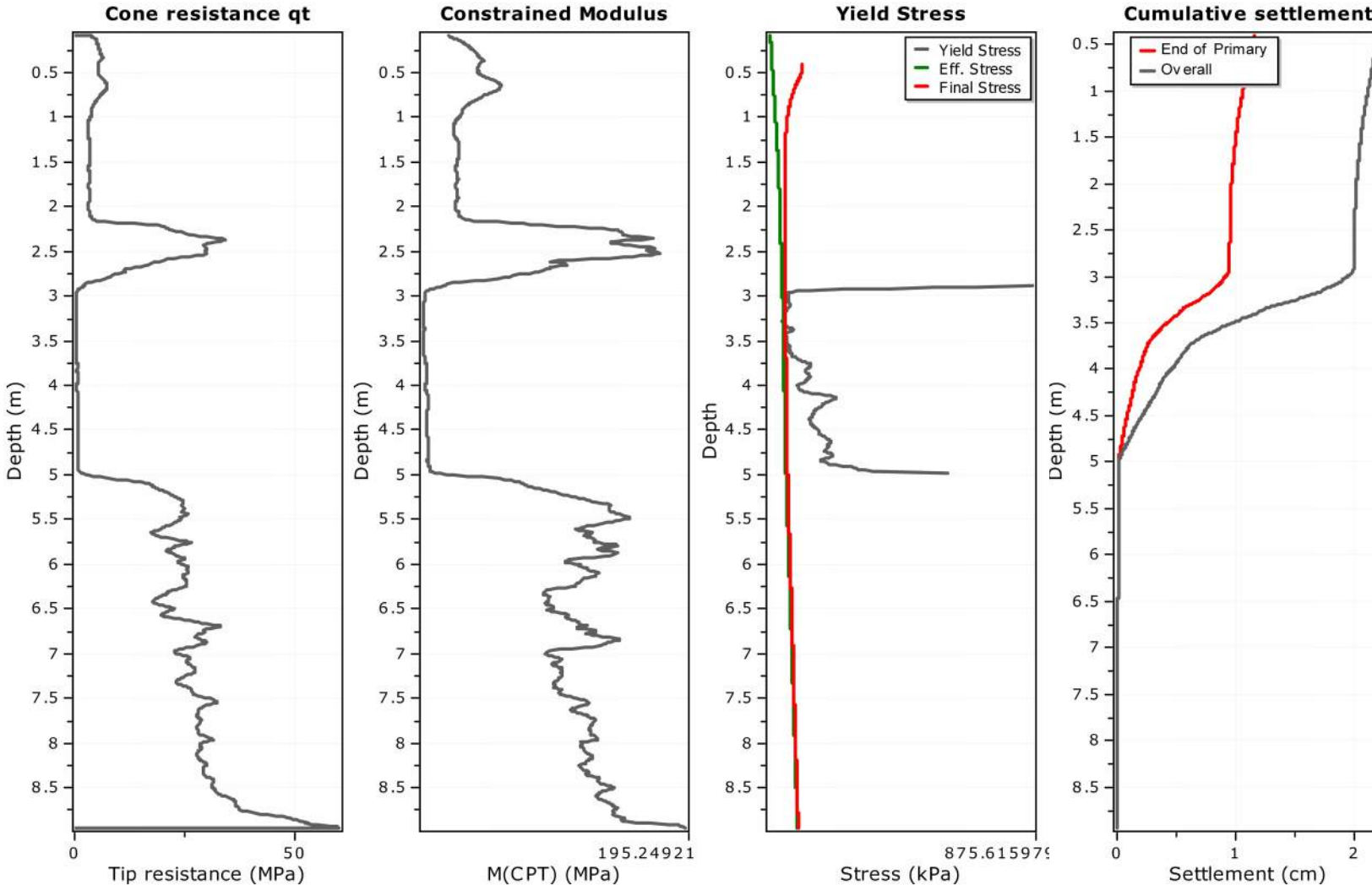
\* Secondary (creep) settlement calculation is performed according to the following formula:

$$s_c = s_p \left( 1 - e^{-\frac{t}{t_p}} \right)$$

where  $t_p$  is the duration of primary consolidation



**Settlements calculation according to theory of elasticity\***



**Calculation properties**

Footing type: Rectangular  
 Footing width: 0.40 (m)  
 L/B: 50.0  
 Footing pressure: 100.00 (kPa)  
 Embedment depth: 0.40 (m)  
 Footing is rigid: No  
 Remove excavation load: No  
 Apply 20% rule: No  
 Calculate secondary settlements: Yes  
 Time period for primary consolidation: 6 months  
 Time period for second. settlements: 600 months

\* Primary settlement calculation is performed according to the following formula:

$$S = \sum \frac{\Delta\sigma_v}{M_{CPT}} \Delta z$$

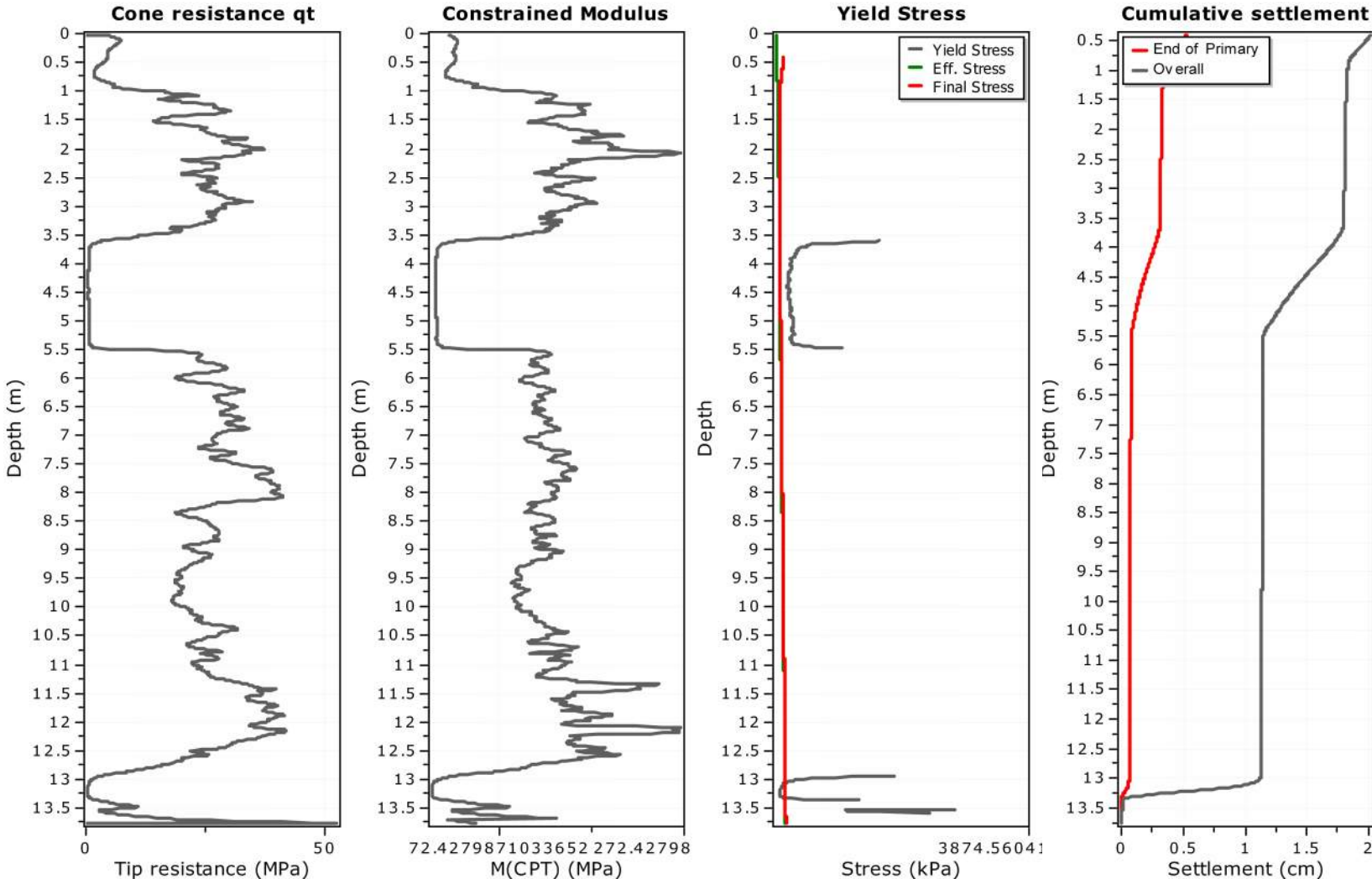
\* Secondary (creep) settlement calculation is performed according to the following formula:

$$s_c = s_p \left( 1 - e^{-\frac{t}{t_p}} \right)$$

where  $t_p$  is the duration of primary consolidation



**Settlements calculation according to theory of elasticity\***



**Calculation properties**

- Footing type: Rectangular
- Footing width: 0.40 (m)
- L/B: 50.0
- Footing pressure: 100.00 (kPa)
- Embedment depth: 0.40 (m)
- Footing is rigid: No
- Remove excavation load: No
- Apply 20% rule: No
- Calculate secondary settlements: Yes
- Time period for primary consolidation: 6 months
- Time period for second. settlements: 600 months

\* Primary settlement calculation is performed according to the following formula:

$$S = \sum \frac{\Delta\sigma_v}{M_{CPT}} \Delta z$$

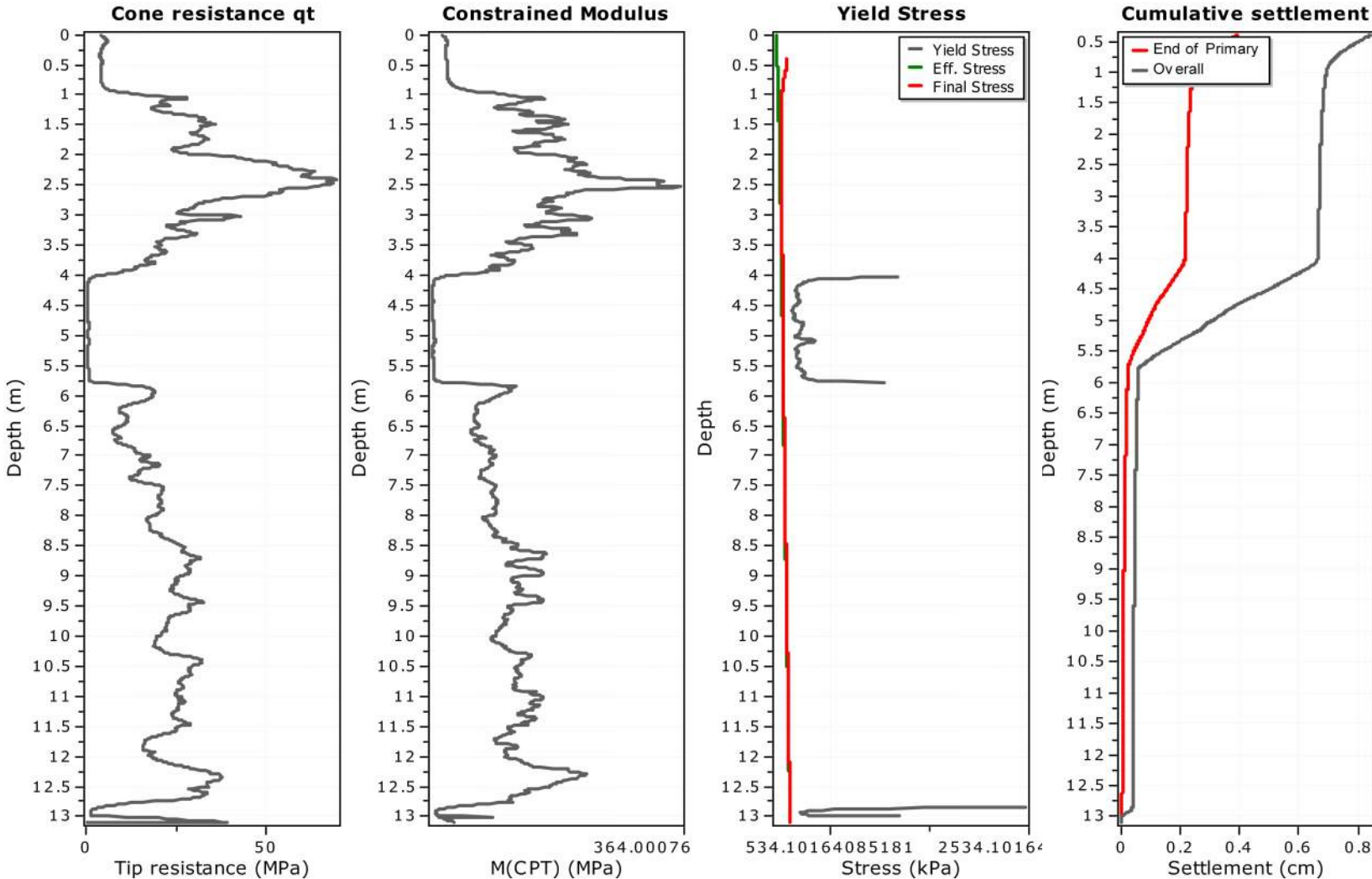
\* Secondary (creep) settlement calculation is performed according to the following formula:

$$s_c = s_p \left( 1 - e^{-\frac{t}{t_p}} \right)$$

where  $t_p$  is the duration of primary consolidation



**Settlements calculation according to theory of elasticity\***



**Calculation properties**

Footing type: Rectangular  
 Footing width: 0.40 (m)  
 L/B: 40.0  
 Footing pressure: 100.00 (kPa)  
 Embedment depth: 0.40 (m)  
 Footing is rigid: No  
 Remove excavation load: No  
 Apply 20% rule: No  
 Calculate secondary settlements: Yes  
 Time period for primary consolidation: 6 months  
 Time period for second. settlements: 600 months

\* Primary settlement calculation is performed according to the following formula:

$$S = \sum \frac{\Delta\sigma_v}{M_{CPT}} \Delta z$$

\* Secondary (creep) settlement calculation is performed according to the following formula:

$$s_c = s_p \left( \frac{t}{t_p} \right)^{-n}$$

where  $t_p$  is the duration of primary consolidation