



Housing Re-Zone

Havelock Road and Howard Road -
Geotechnical Investigation Report

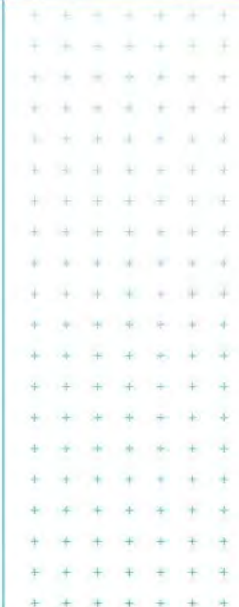
Prepared for
Hastings District Council

Prepared by
Tonkin & Taylor Ltd

Date

April 2016

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1 Introduction

Tonkin & Taylor Ltd (T+T) has been engaged by Hastings District Council (HDC) to provide geotechnical consultancy services for the residential re-zone review being undertaken for a block of land in Parkvale, Hastings. This report presents the results of the geotechnical investigations undertaken on sites between Havelock Road and Howard Street, Hastings, in February 2016 and outlines the geotechnical issues that may affect future residential developments at those sites.

The scope of work undertaken for this report comprised:

- Geotechnical investigations comprising 2 No. machine drilled boreholes with in situ strength testing as well as 24 Cone Penetration Tests (CPTs);
- Development of a geological model for the site, including cross sections;
- Development of recommended geotechnical design parameters including site seismic design characteristics;
- Assessment of the groundwater regime;
- Assessment of liquefaction and lateral spreading potential under seismic loading;
- Assessment of potential foundation options; and
- Preparation of this report.

2 Site Description

The sites being considered as part of the re-zone review are located between 204 to 260 Havelock Road and 1217 to 1259 Howard Street, Hastings, as shown on Figure 1 in Appendix A. The sites are generally flat with a slight grade down to the southeast.

Watercourses in the area include a tributary of the Awahou Stream that runs along the site's southern and north-western boundary.

At present, the sites are divided into greenfield agricultural pasture, industrial warehousing, residential dwellings, and the Parkvale Primary School site (at 1217 Howard Street).

3 Geotechnical Investigations

Investigations were carried out in February 2016 under the supervision of a geotechnical engineer from T+T. The investigations comprised two (2) machine boreholes (BH1 and BH2) drilled to 10.5 m and 10.95 m depth respectively. In addition to the machine boreholes, 24 No. CPTs were pushed to between 12.7 m and 25.1 m depths coinciding with refusal. The machine boreholes were logged on site and in situ strength testing was conducted in the machine boreholes (Standard Penetration Tests (SPT) at 1.5 intervals). All boreholes were backfilled on completion of the drilling investigations.

The locations of the geotechnical investigations are presented on the layout plan (ref. Figure 1) in Appendix A.

The geotechnical investigations were carried out to assess subsurface conditions for the site as well as to provide in situ strength measurements of the subsurface materials. The information obtained from the investigations has been used in developing a typical ground model for the site, shown on Figures 2 to 5 in Appendix A.

4 Geological Model

4.1 Published Geology

Published geology¹ indicates the site is underlain by alluvial deposits comprising gravel, sand, silt and mud, forming alluvial terraces. These alluvial deposits typically comprise moderately to well-sorted, sandy gravel.



Figure 4.1: Published geology of the site (source: *Geology of Hawkes Bay Area*, Institute of Geological and Nuclear Sciences)

4.2 Stratigraphy

Subsurface conditions encountered during the geotechnical investigations are identified as alluvial deposits and are generally consistent with the geology presented on the published geological maps.

The subsurface materials encountered during the site investigations are outlined below, and in the four geological cross sections included in Appendix A.

4.2.1 Topsoil

Up to 400mm of topsoil was encountered in BH01 and BH02. The topsoil comprises organic dark brown sandy and gravelly silt.

¹ Institute of Geological and Nuclear Sciences, Geological Map 8, 1:250,000

4.2.2 Upper Alluvial Sediments – Clayey Silt and Sandy Silt

Underlying the topsoil are interbedded layers of silty sand and sand with fragments of fine to coarse pumice gravels. SPT 'N' values ranged between 6 to 7 indicating that the material is very soft to soft, or very loose to loose.

4.2.3 Upper Alluvial Sediments – Pumiceous Silty Sand and Sand

Underlying the topsoil are interbedded layers of silty sand and sand with fragments of fine to coarse pumice gravels. SPT 'N' values ranged between 2 and greater than 50 indicating that the material is loose to dense.

4.2.4 Lower Alluvial Sediment – Clayey Silt and Sandy Silt

Marine sediments were encountered below the alluvial sediments. These marine sediments comprised bluish grey clayey silt and sandy silt with fragments of shell. SPT 'N' values typically ranged between 0 and 7 indicating the material is very soft to soft or very loose to loose.

4.2.5 Lower Alluvial Sediments - Gravel

Small to large gravel underlies the interbedded sand and silty sand. The thickness of this layer was not proved during the investigations. While borehole investigations terminated above this layer, all CPTs refused in this material, indicating the material is very dense.

4.3 Groundwater

Groundwater was encountered between 1.9 and 4.23 m (as shown on Figures 2-4) below existing ground levels following drilling of the machine boreholes and CPTs. These readings indicate that groundwater levels grade gently downwards across the site from the south to north.

As such, for most of the site a typical design groundwater level of 2.6 m below existing ground level (begl) has been adopted, but a design groundwater level of 2.0 m begl has been applied to assessment of the southern quadrant of the site.

We note groundwater levels are likely to be subject to seasonal variation and should be subject to further assessment in later stages of design.

5 Geotechnical Engineering Considerations

5.1 General

Recommendations and opinions in this report are based on data obtained at point locations. The nature and continuity of subsoil conditions away from test locations is inferred but it must be appreciated that actual conditions could vary from the assumed model.

5.2 Seismic Assessment

5.2.1 Site Subsoil Class

A seismic assessment has been undertaken for the proposed development in accordance with the recommendations in the NZTA Bridge Manual² and the New Zealand Code of Practice NZS 1170.5:2004³ to represent the following design performance requirements:

- Ultimate Limit State (ULS) – to avoid collapse of the structural system, and
- Serviceability Limit State (SLS) – to avoid damage that would prevent the structure from being used as originally intended without repair.

The design earthquakes for serviceability and ultimate limit states have been adopted as 1 in 25 years and 1 in 500 years respectively, with a building Importance Level 2.

While the CPTs and boreholes were terminated at depths before rock, published geology indicates the alluvial soils encountered could be hundreds of metres thick. Accordingly, we consider the site be classified as a Class D soil category – Deep or Soft Soil.

5.2.2 Seismic Loading for Liquefaction Assessment

The peak ground acceleration (PGA) for liquefaction assessment under serviceability limit state and ultimate limit state are set out in Table 5.1 below. The design PGA is derived based on the recommended return periods (T) in NZS 1170.5:2004³ and using the following formula, as given in NZTA Bridge Manual² (which is considered more appropriate for liquefaction analysis)

$$PGA = C_{0,1000} Ru/1.3 f g$$

where:

- $C_{0,1000} = 0.43$ for Subsoil Class D, Hastings
- $Ru = 1.0$ and 0.25 for (T = 1 in 500 and 1 in 25 years respectively)
- $f = 1.0$, Subsoil Class D

Table 5.1: Design Peak Ground Acceleration – Liquefaction Assessment

Design Case	SLS Event		ULS Event	
	Return Period (T)	Design PGA (proportion of g)	Return Period (T)	Design PGA (proportion of g)
Importance Level 2	1 in 25 years	0.08 g	1 in 500 years	0.33 g

² The NZ Transport Agency's Bridge Manual Sp/M/022, Third Edition, Amendment 0, May 2013

³ NZS1170.5:2004. *Structural Design Actions – Earthquake Actions (New Zealand)*, SANZ.

The corresponding effective magnitudes given by the NZTA Bridge Manual are earthquake magnitude $M_{\text{eff}} = 6.9$ and 6.2 for design return periods of 1000 years and 50 – 100 years, respectively.

5.3 Liquefaction Assessment

5.3.1 General

Seismic liquefaction occurs when excess pore pressures are generated in loose, saturated, generally cohesionless soil during earthquake shaking, causing the soil to undergo a partial to near-complete loss of shear strength. Such a loss of shear strength can result in settlement, bearing capacity yield or failure and/or horizontal movement of the soil mass.

The occurrence of liquefaction is dependent on several factors, including the intensity and duration of ground shaking, soil density, particle size distribution, and elevation of the groundwater table.

5.3.2 Liquefaction Potential

The liquefaction susceptibility of material at the site has been assessed using the results of the 24 site specific CPTs (undertaken to depths ranging between 12.7 m and 25.1 m). The susceptibility of various layers has been considered for both the ULS (0.33 g) and the SLS (0.08 g) seismic loadings as presented in Table 5.1 above.

The groundwater depth adopted for liquefaction analyses is 2.6 m depth below existing ground level for most of the site, and 2.0 m for the southern quadrant, as detailed in Section 4.3.

Quantitative analyses have carried out using the liquefaction assessment method developed by Boulanger and Idriss (2014) and Zhang, Robertson & Brachman (2004) for both SLS and ULS events.

Analyses indicate the risk of liquefaction being triggered under SLS conditions is negligible across the sites.

Analyses indicate that under ULS conditions there are non-continuous bands of liquefiable material within the soil profile as indicated on the analysis plots in Appendix C.

For the purposes of detailed design we recommend that laboratory testing including particle size distributions (PSD's) and Atterberg limits tests (plasticity tests) are undertaken to further characterise the subsurface materials for liquefaction analysis.

5.3.3 Effects of Liquefaction

5.3.3.1 Settlement

Liquefaction induced settlement has been estimated using the methodology developed by Zhang, Robertson and Brachman (2002) and is expected to range between 15 mm and 230 mm under ULS conditions. Higher settlements were estimated for the north-eastern sites.

It should be noted that estimated settlements are total, "free-field" settlement estimations. This describes the liquefaction induced settlement of the ground surface, which is caused by dissipation of excess pore water pressure generated during earthquake shaking. The settlement of the proposed structures may differ from the estimated ground settlement and is dependent on the interaction of the building and soil it is founded on.

Analyses indicate there is a 2 m to 4 m crust above the liquefiable layers. This crust will assist in minimising the effects of liquefaction on the ground. However, structures and services should be detailed to accommodate a reasonable level of differential settlement (to be assessed during detailed design) particularly if near surface material is lost through sand ejection.

5.3.3.2 Effects on Foundations

To give a quantitative indication of the effects of liquefaction that may be observed at the ground surface, the liquefaction severity number (*LSN*) is utilised. The LSN parameter was developed following the Canterbury Earthquake Sequence (CES) and is based on observations of damage caused to land and foundations as a result of liquefaction. The formula used to calculate liquefaction severity number is presented below.

$$LSN = \int \frac{\varepsilon_v}{z} dz$$

Where ε_v is the calculated volumetric densification strain using Idriss & Boulanger (2014) and z is the depth to the layer of interest.

As the value of the LSN increases, so does the risk of severe effects of liquefaction on the land and buildings. Table 5. summarises the correlation of LSN with damage based on observations from the CES for light weight residential units.

Table 5.2: Correlation of *LSN* with damage based on observations from the CES

LSN	Effects and expression of liquefaction on structures and land
0 - 5	Negligible to Minor: No major effects expected
5 – 20	Minor: Generally consistent with acceptable performance under SLS conditions (i.e. little settlement or permanent building damage). Ejection of material can be expected at the ground surface, but likely to be localised in nature.
20 – 40	Moderate: Liquefaction evidence possible. Generally consistent with acceptable performance under ULS conditions (i.e. settlement).
> 40	Severe: High risk of substantial damage to the site and/or building if on shallow foundations.

LSN values calculated using the results of the CPT range between 4 and 23 indicating there is a minor to moderate risk of damage resulting from liquefaction under a ULS magnitude event with PGA of 0.33g.

5.3.4 Lateral Spreading

Lateral spreading is generally defined as the horizontal displacement of surficial block of soil towards an open slope face as a result of liquefaction of the underlying soils. Typically, the presence of a relatively continuous liquefiable layer extending to a free face like a river bank or open channel is required for lateral spreading to occur. Case histories suggest lateral spreading can affect zones up to 300 m from a free face.

An approximately 6 m wide open channel stormwater drain and tributary of the Awahou Stream runs along the site's southern boundary. The open channel is approximately 2 m begl with sides battered to approximately 45°. This free face creates a risk of lateral spread if liquefaction was to occur during an earthquake event, however the potential for and extent of horizontal ground movement will be dependent on the presence and continuity of liquefiable layers near the free face.

We recommend further investigation be undertaken in detailed design to determine the risk and potential extent of lateral displacement near this watercourse. Structures may need to be set back from the free face or treatment options detailed to minimise the risk of lateral deformations.

5.4 Foundation Considerations

5.4.1 General

Foundation options for the development need to consider the following risks:

- Total settlements,
- Differential settlements,
- Seismic implications, including the risk of liquefaction and lateral spread, and
- Construction risks/uncertainties.

It will be essential for developers to have clearly considered these risks and the associated mitigation measures.

5.4.2 Potential Foundation Options

Based on the results of site investigations and the results of the seismic assessment, we consider robust shallow foundations for light weight timber structures, no greater than 2 storeys to be suitable for the sites being considered for residential re-zoning.

To prevent building structures pulling apart under seismic loading we recommend as a minimum, shallow pad and strip footings be tied together in both longitudinal and lateral directions across the building footprint using a series of ground beams. Foundations adjacent to the stream bank may need to be detailed to adequately withstand potential ground rupture and/or lateral spreading. However, this should be confirmed following further assessment.

Shallow foundation designs should be subject to analyses of total and differential settlements once structural loads are verified. Tolerances of structural elements to differential settlements will need to be confirmed by the structural engineer.

Due to the generally low strength near surface materials, the soils are unlikely to be classified as 'good ground' in accordance with NZS 3604 and therefore specific foundation design will be required.

6 Conclusions

On the basis of the available subsurface information and our experience with similar materials, we summarise our conclusions and recommendations regarding the residential re-zone review for sites between Havelock Road and Howard Street as follows:

- Stratigraphy of the sites comprises alluvial sediments;
- The seismic site category is Class D – Deep Soil, in accordance with the New Zealand code of practice. Peak ground accelerations are presented in Section 5.2.2;
- The risk of liquefaction being triggered under SLS conditions is considered to be negligible;
- Under ULS conditions there is a minor to moderate risk of damage resulting from liquefaction of non-continuous bands of liquefiable material within the soil profile;
- We recommend further investigation to support detailed design including geotechnical laboratory testing.
- An open water channel has been identified along the southern boundary. This free face creates a risk of lateral spread that will be dependent on the presence and continuity of liquefiable layers near the free face;
We recommend further investigation and analysis be undertaken in detailed design to determine the risk and potential extent of lateral displacement near this watercourse;
- Shallow foundations may be suitable for the proposed development provided they are constructed in accordance with the recommendations in Section 5.4.2;
- The site is unlikely to comprise 'good ground' in accordance with NZS3604.
- Analyses of total and differential settlements as well as tolerances of structures and services to differential settlements should be undertaken as part of the detailed design process;

7 Applicability

This report has been prepared for the exclusive use of our client Hastings District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:



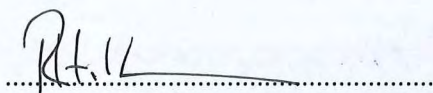
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Report Reviewed by:



Andy Pomfret
Senior Geotechnical Engineer

Authorised for Tonkin & Taylor Ltd by:



Robert Hillier
Project Director


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Appendix A: Geotechnical Investigation Plan and Geological Sections

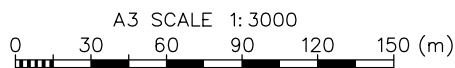
- Figure 1: Site Investigation Plan
- Figure 2: Geological Section 1
- Figure 3: Geological Section 2
- Figure 4: Geological Section 3
- Figure 5: Geological Section 4



LEGEND

 CPT14 Tonkin & Taylor Cone Penetrometer Test Location (Feb. 2016)

 BHM1 Tonkin & Taylor Borehole Machine Location (Feb. 2016)



ORIGINAL IN COLOUR

NOTES:

1. Aerial photo sourced from Linz Data Service <<https://data.linz.govt.nz/set/2-nz-aerial-imagery/>> , licensed by LINZ for re-use under the Creative Commons Attribution 3.0 New Zealand licence (CC BY 3.0 NZ)
2. Site investigation locations obtained using hand held GPS: accuracy ±5m in plan.



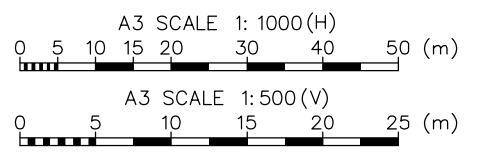
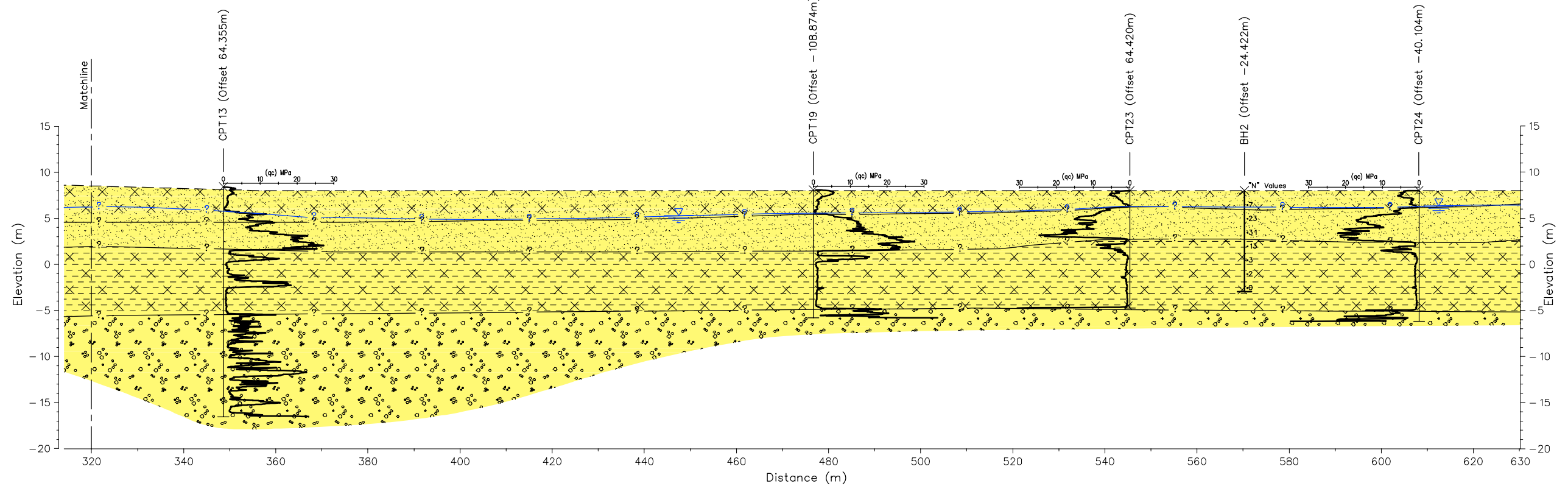
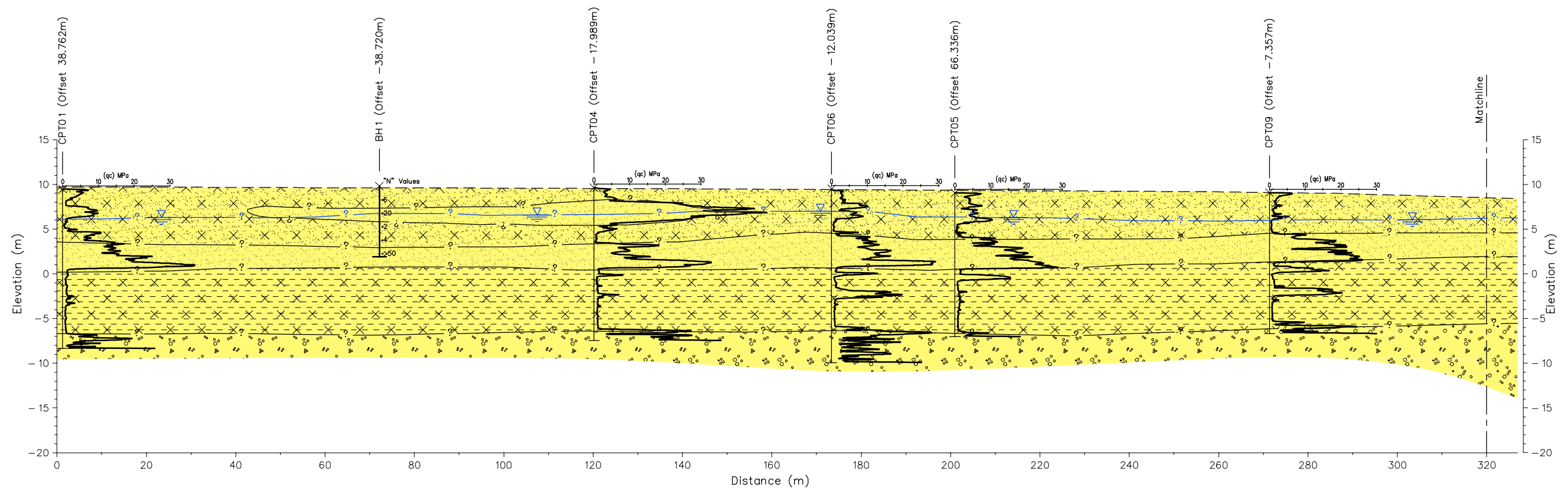
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HASTINGS DISTRICT COUNCIL
HOUSING RE-ZONE
HAVELOCK ROAD & HOWARD ST
Site Investigation Plan

FIG. No. Figure 1

REV. 0



LEGEND	
-----	Existing Ground Profile
— ? —	Inferred Geological Boundary
— ? —	Inferred Water Level
	Upper Alluvial Sediments - clayey Silt & sandy Silt
	Upper Alluvial Sediments - pumiceous silty Sand & Sand
	Lower Alluvial Sediments - interbedded clayey Sand & sandy Silt with fragments of shell
	Lower Alluvial Sediments - Gravel

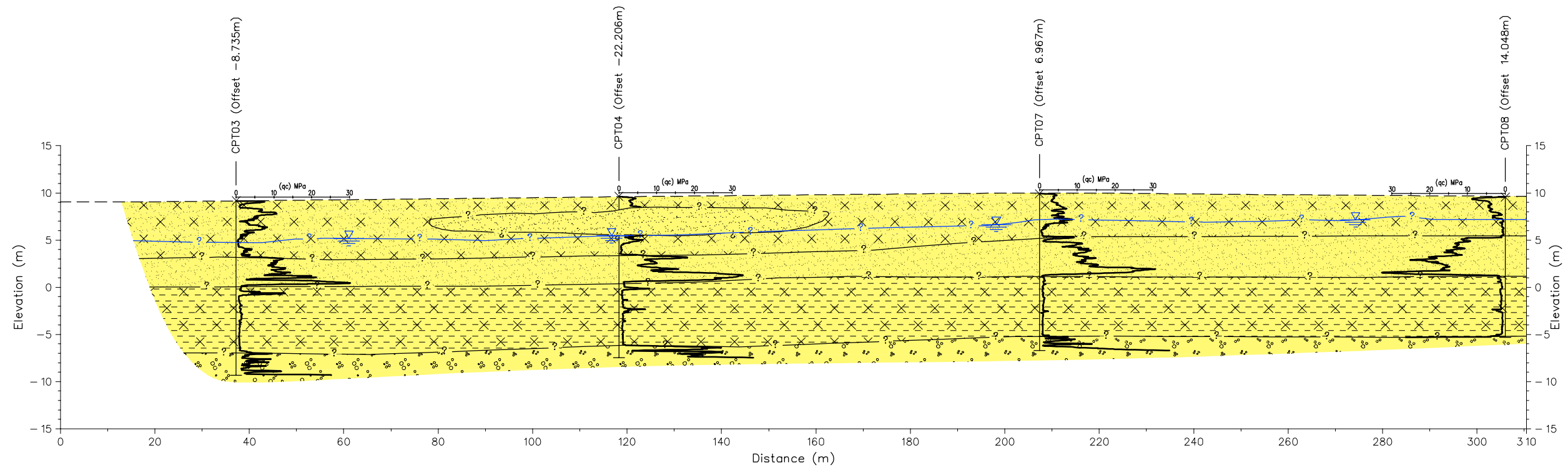
SECTION 1
SCALE 1: 1000(H)
1: 500(V)

NOTES:
1. All dimensions are in metres unless noted otherwise.

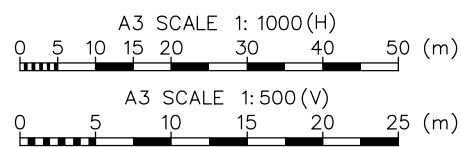
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HASTINGS DISTRICT COUNCIL HOUSING RE-ZONE HAVELOCK ROAD & HOWARD ST Geological Section 1	
FIG. No.	Figure 2
REV.	0

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SECTION 2
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 1:500(V)



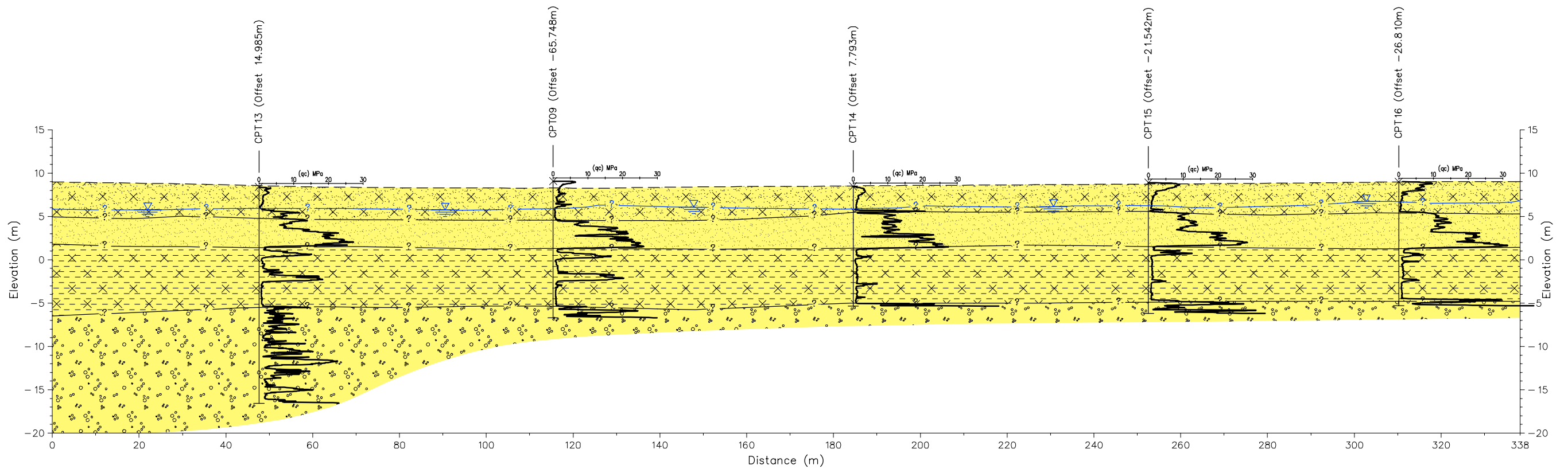
LEGEND	
---	Existing Ground Profile
— ? —	Inferred Geological Boundary
— ? —	Inferred Water Level
[Pattern: X's]	Upper Alluvial Sediments —clayey Silt & sandy Silt
[Pattern: Dotted]	Upper Alluvial Sediments —pumiceous silty Sand & Sand
[Pattern: X's with dashes]	Lower Alluvial Sediments —interbedded clayey Sand & sandy Silt with fragments of shell
[Pattern: Circles]	Lower Alluvial Sediments —Gravel

NOTES:
 1. All dimensions are in metres unless noted otherwise.

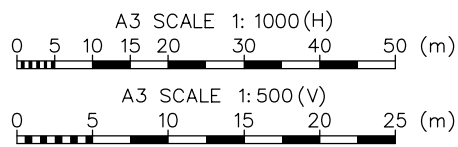
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SECTION 3
SCALE 1:1000(H) F1
1:500(V)

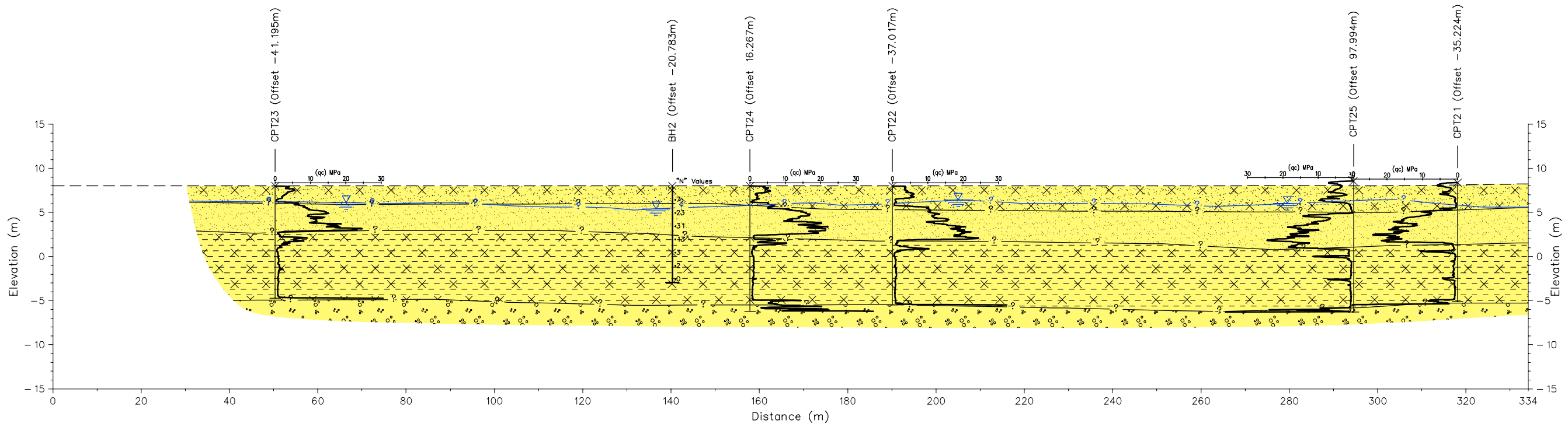


LEGEND	
-----	Existing Ground Profile
— ? —	Inferred Geological Boundary
— ? —	Inferred Water Level
[Pattern: X's]	Upper Alluvial Sediments —clayey Silt & sandy Silt
[Pattern: Dotted]	Upper Alluvial Sediments —pumiceous silty Sand & Sand
[Pattern: X's with dashes]	Lower Alluvial Sediments —interbedded clayey Sand & sandy Silt with fragments of shell
[Pattern: Circles]	Lower Alluvial Sediments —Gravel

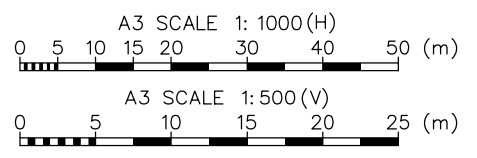
NOTES:
1. All dimensions are in metres unless noted otherwise.

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SECTION 4
SCALE 1:1000(H)
1:500(V)



LEGEND	
-----	Existing Ground Profile
--- ? ---	Inferred Geological Boundary
--- ? ---	Inferred Water Level
[Pattern: Yellow with 'x' marks]	Upper Alluvial Sediments - clayey Silt & sandy Silt
[Pattern: Yellow with dots]	Upper Alluvial Sediments - pumiceous silty Sand & Sand
[Pattern: Yellow with 'x' and dots]	Lower Alluvial Sediments - interbedded clayey Sand & sandy Silt with fragments of shell
[Pattern: Yellow with circles]	Lower Alluvial Sediments - Gravel

NOTES:
1. All dimensions are in metres unless noted otherwise.

 Tonkin+Taylor 105 Carlton Gore Road, Newmarket, Auckland www.tonkintaylor.co.nz	DRAWN: JC Apr. 16 DRAFTING CHECKED: APPROVED: CADFILE: \\31464.1000-F2_F4.dwg SCALES (AT A3 SIZE): AS SHOWN PROJECT No.: 31464.1000	HASTINGS DISTRICT COUNCIL HOUSING RE-ZONE HAVELOCK ROAD & HOWARD ST Geological Section 4	FIG. No. Figure 5 REV. 0
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Appendix B: Geotechnical Investigation Data

- Borehole Logs
- Borehole Photographs
- Cone Penetration Tests

BOREHOLE LOG

BOREHOLE No: BH1
 Hole Location: Refer site plan.
 SHEET 1 OF 2

PROJECT: Hastings Housing	LOCATION: Havelock Road and Howard Street, Havelock North 41464.1000
CO-ORDINATES: 39.65284 °S 176.85881 °E	DRILL TYPE: SONIC RIG HOLE STARTED: 16/2/16 HOLE FINISHED: 16/2/16
R.L.: DATUM:	DRILL METHOD: SONIC/SPT DRILLED BY: Geotech Drilling Ltd LOGGED BY: SRS CHECKED:

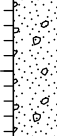
GEOLOGICAL										ENGINEERING DESCRIPTION																					
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.										FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION	WEATHERING STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION					
TOPSOIL												100	SONIC							M	F					Gravelly SILT; dark brown. Firm, moist, non-plastic.					
UPPER ALLUVIAL SEDIMENTS												100	SONIC						1		L-MD					0.3m: reducing gravel. Silty, fine SAND; dark orangey brown. Loose to medium dense, moist.					
												100	SPT		3 3 3 N=6			2		W	L					Fine to medium coarse SAND, trace shells; dark brown. Loose, wet.					
												100	SONIC								W					2.5m: becomes medium coarse to coarse SAND; dark reddish brown. Loose, wet. 2.8m: becomes saturated.					
												100	SPT		11 12 18 N=31			3			D					3.1m: becomes bluish grey. Dense, saturated.					
												100	SONIC												4	Fine to medium coarse SAND, trace silt and shell fragments; bluish grey. Loose, saturated.					
												100	SPT		2 1 1 N=2			5			F-St					5	Sandy SILT; bluish grey. Firm to stiff, saturated, non-plastic.				
												100	SONIC								M						6	Clayey SILT; bluish grey. Firm to stiff, low plasticity. SILT; dark grey. Moist, non-plastic.			
												100	SPT		0 0 4 N=4			6			W	F-St						6	Gravelly, medium coarse to coarse SAND; bluish grey. Firm to medium dense; gravels are sandstone and pumice.		
												100	SPT								Sat	F						7	Sandy SILT; dark brown. Firm to stiff, wet, non-plastic. SILT; bluish grey. Firm, saturated, sensitive.		
												100	SONIC																7	Silty, fine SAND. Loose to medium dense, saturated, with interbedded lenses of pumice deposits (>0.1m).	
												100	SPT		10 24 26 for 110m N>50			8			W	F							8	Gravelly SILT. Firm, wet; gravels are medium to coarse pumice, rounded. Silty, fine SAND, trace pumice fragments. Medium dense to dense. 7.4m: becomes medium coarse to coarse SAND and trace pumice fragments.	
												100	SONIC																	9	
												100	SPT		0 3 4 N=7			9													

T-T DATATEMPLATE.GDT.jlb

BOREHOLE LOG

BOREHOLE No: BH1
 Hole Location: Refer site plan.
 SHEET 2 OF 2

PROJECT: Hastings Housing	LOCATION: Havelock Road and Howard Street, Havelock North 1464.1000
CO-ORDINATES: 39.65284 °S 176.85881 °E	DRILL TYPE: SONIC RIG HOLE STARTED: 16/2/16
R.L.:	DRILL METHOD: SONIC/SPT HOLE FINISHED: 16/2/16
DATUM:	DRILL FLUID: Water LOGGED BY: SRS CHECKED:

GEOLOGICAL										ENGINEERING DESCRIPTION												
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE / WEATHERING CONDITION	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)			COMPRESSIVE STRENGTH (MPa)			DEFECT SPACING (mm)	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.	
														10	25	100	5	10	100			250
UPPER ALLUVIAL SEDIMENTS			100	SONIC		0 3 5 N=8	█				W	L									7.4m: becomes medium coarse to coarse SAND and trace pumice fragments.	
									11													END OF BOREHOLE AT 10.95m.
									12													
									13													
									14													
									15													
									16													
									17													
									18													
									19													
									20													

T-T DATATEMPLATE.GDT.jib



Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No: BH2
Hole Location: Refer site plan.

SHEET 1 OF 2

PROJECT: Hastings Housing	LOCATION: Havelock Road and Howard Street, Havelock North 1464.1000
CO-ORDINATES: 39.65608 °S 176.86307 °E	DRILL TYPE: SONIC RIG HOLE STARTED: 16/2/16 HOLE FINISHED: 16/2/16
R.L.: DATUM:	DRILL METHOD: SONIC/SPT DRILLED BY: Geotech Drilling Ltd LOGGED BY: SRS CHECKED:
DRILL FLUID: Water	

GEOLOGICAL			ENGINEERING DESCRIPTION																																																	
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION	WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSION STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION <small>Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION <small>Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.</small></small>																																		
TOPSOIL UPPER ALLUVIAL SEDIMENTS			After drilling	100	SONIC	1			1	0-1.5m	M	St						TOPSOIL; dark brown, organic.																																		
																		Sandy SILT; dark brown with light brown mottles. Stiff, moist, moderate to low plasticity.																																		
LOWER ALLUVIAL SEDIMENTS			After drilling	100	SONIC	3			2	1.5-2.2m	W	L						Silty, fine to medium coarse SAND; light brown. Loose, wet (liquefied in barrel), sensitive.																																		
																		2.2m: becomes loose to medium dense.																																		
																		2.9m: becomes dark brown, medium dense.																																		
																		3.5m: becomes silty, fine SAND; dark brown. Wet, sensitive.																																		
																		7	11	12	N=23	3	3			3	2.2-3.5m	MD								SILT; dark brown. Firm to stiff, wet, low plasticity, sensitive.																
																																				9	15	16	N=31	5	5			5	F-St							Clayey SILT; bluish grey. Stiff, wet, moderate plasticity.
																																																				6
																																				0	0	3	N=3	8	8			8	6-8m	St-VSt						
																		7	7	7	7	7	7	7	7	St	Clayey SILT; light bluish grey. Stiff, wet, moderate plasticity.																									
																		2	0	2	N=2	9	9			9	8-9m	St-VSt								Clayey SILT; light bluish grey. Stiff to very stiff, wet, low plasticity.																
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	MD-L																																				

T-T-DATATEMPLATE.GDT.ilb

PROJECT: Hastings Housing	LOCATION: Havelock Road and Howard Street, Havelock North 464.1000
CO-ORDINATES: 39.65608 °S 176.86307 °E	DRILL TYPE: SONIC RIG HOLE STARTED: 16/2/16
R.L.:	DRILL METHOD: SONIC/SPT HOLE FINISHED: 16/2/16
DATUM:	DRILL FLUID: Water LOGGED BY: SRS CHECKED:

GEOLOGICAL	ENGINEERING DESCRIPTION																									
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE / WEATHERING CONDITION	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)					COMPRESSIVE STRENGTH (MPa)					DEFECT SPACING (mm)	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.	
														10	25	50	100	200	50	100	200	500	1000			2000
LOWER ALLUVIAL SEDIMENTS			100	SONIC		0	■		x	x		W	F-St													Silty, fine SAND; light bluish grey. Medium dense to loose.
			100	SPT		0 0 0 N=0	■		x	x	x														Clayey SILT; light bluish grey. Firm to stiff, saturated, low plasticity.	
								11																	END OF BOREHOLE AT 10.95m.	
																									Target depth.	
								12																		
								13																		
								14																		
								15																		
								16																		
								17																		
								18																		
								19																		
								20																		

T-T DATATEMPLATE.GDT .jlb



BH01 - 0.0 m to 2.7 m



BH01 - 2.7 m to 5.69 m



BH 01 – 8.55 m to 10.95 m

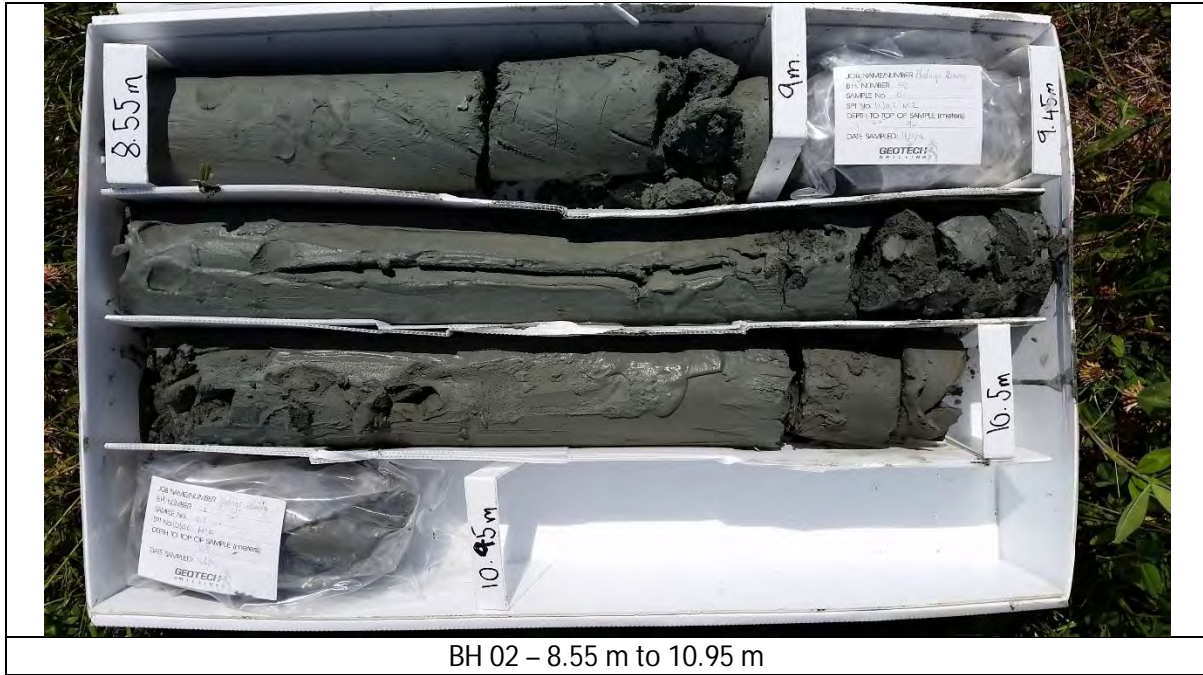


BH 02 – 0.0 m to 2.9 m



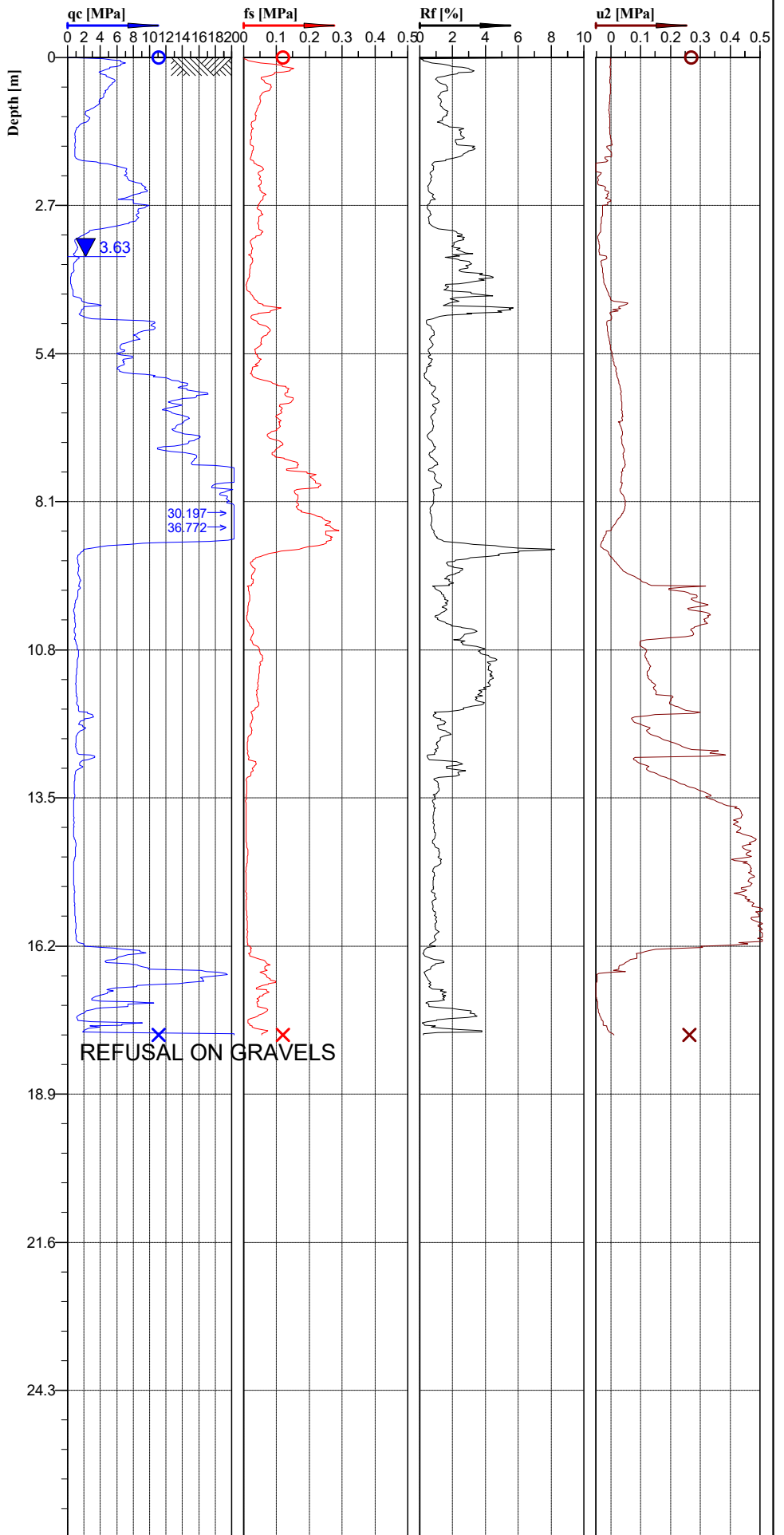
BH 02 – 2.9 m to 5.7 m

BH 02 – 5.7 m to 8.55 m



**Classification by
Robertson 1986**

- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Silty clay to clay (4)
- Sand to silty sand (8)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clay (3)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clay (3)
- Silty clay to clay (4)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Sand to silty sand (8)
- Sand (9)
- Silty sand to sandy silt (7)
- Silty clay to clay (4)

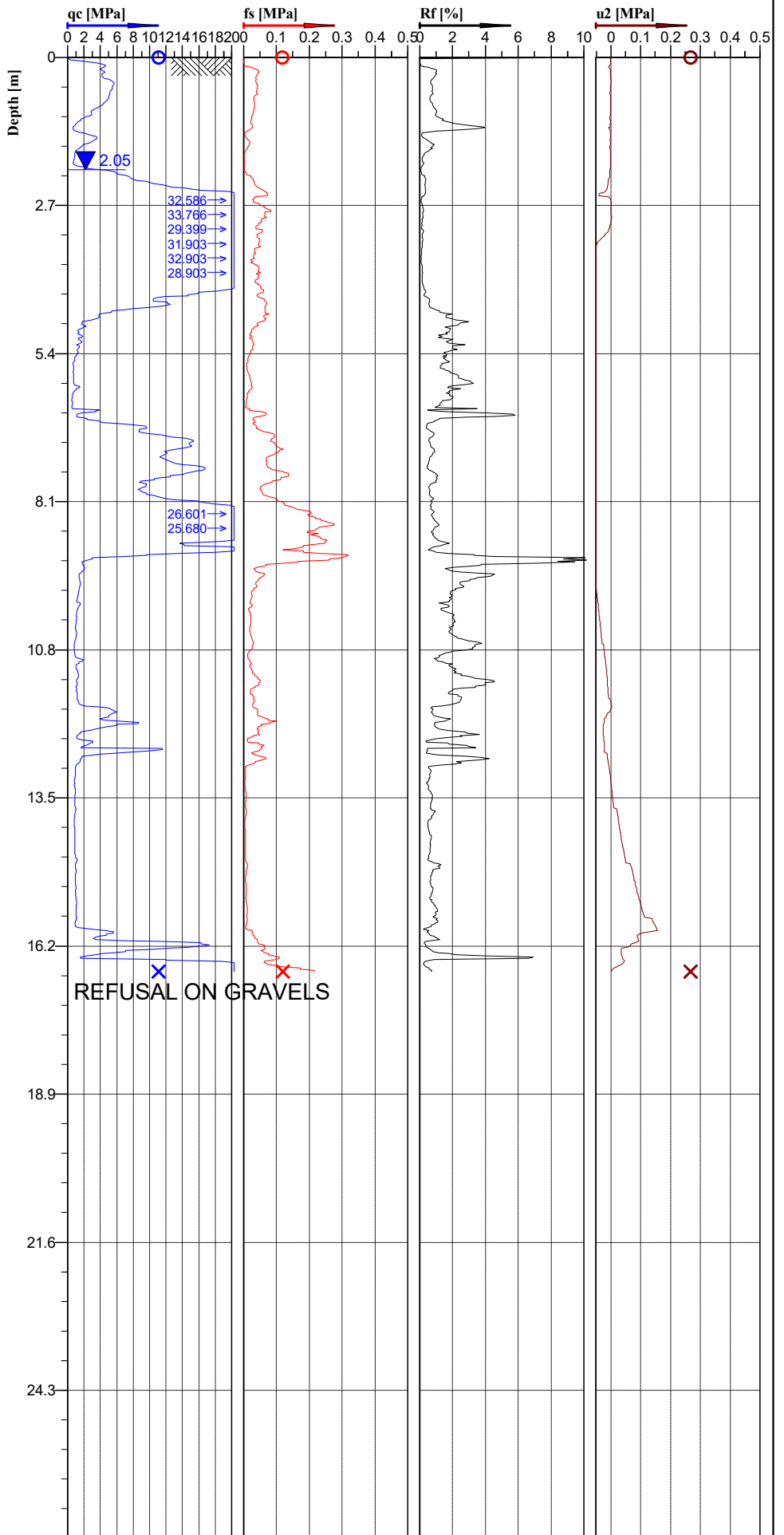


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 01
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65336 E 176.85760		File: CPT01.CPT	

**Classification by
Robertson 1986**

- Silty sand to sandy silt (7)
- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sensitive fine grained (1)
- Sand to silty sand (8)
- Sand (9)
- Gravelly sand to sand (10)
- Sand (9)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Sensitive fine grained (1)
- Silty sand to sandy silt (7)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Clayey silt to silty clay (5)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand to silty sand (8)
- Clayey silt to silty clay (5)
- Sand (9)
- Sandy silt to clayey silt (6)
- Sensitive fine grained (1)
- Sandy silt to clayey silt (6)
- Sensitive fine grained (1)
- Sandy silt to clayey silt (6)
- Sand to silty sand (8)
- Sand (9)
- Gravelly sand to sand (10)

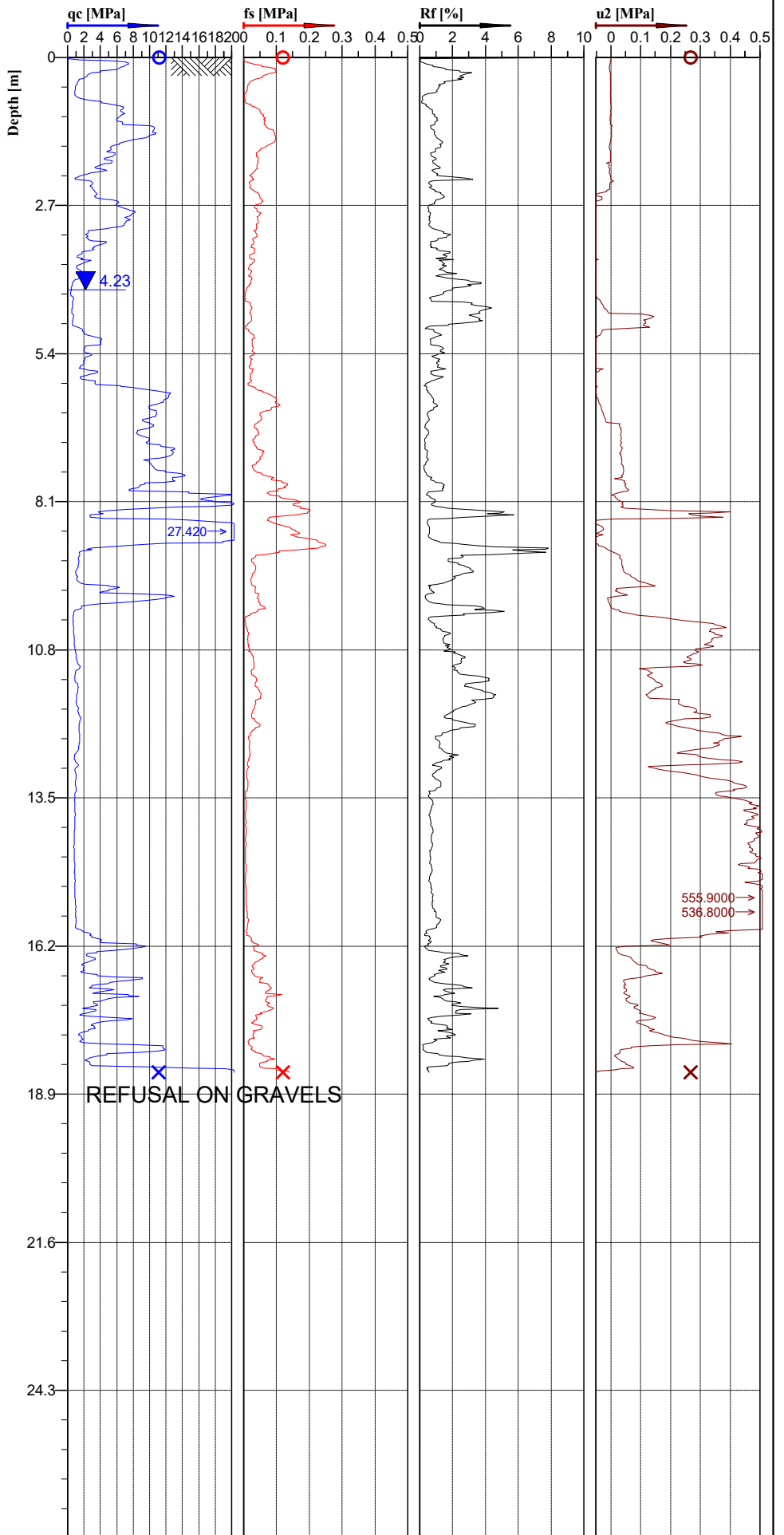


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 02
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65258 E 176.85910		File: CPT02.CPT	

**Classification by
Robertson 1986**

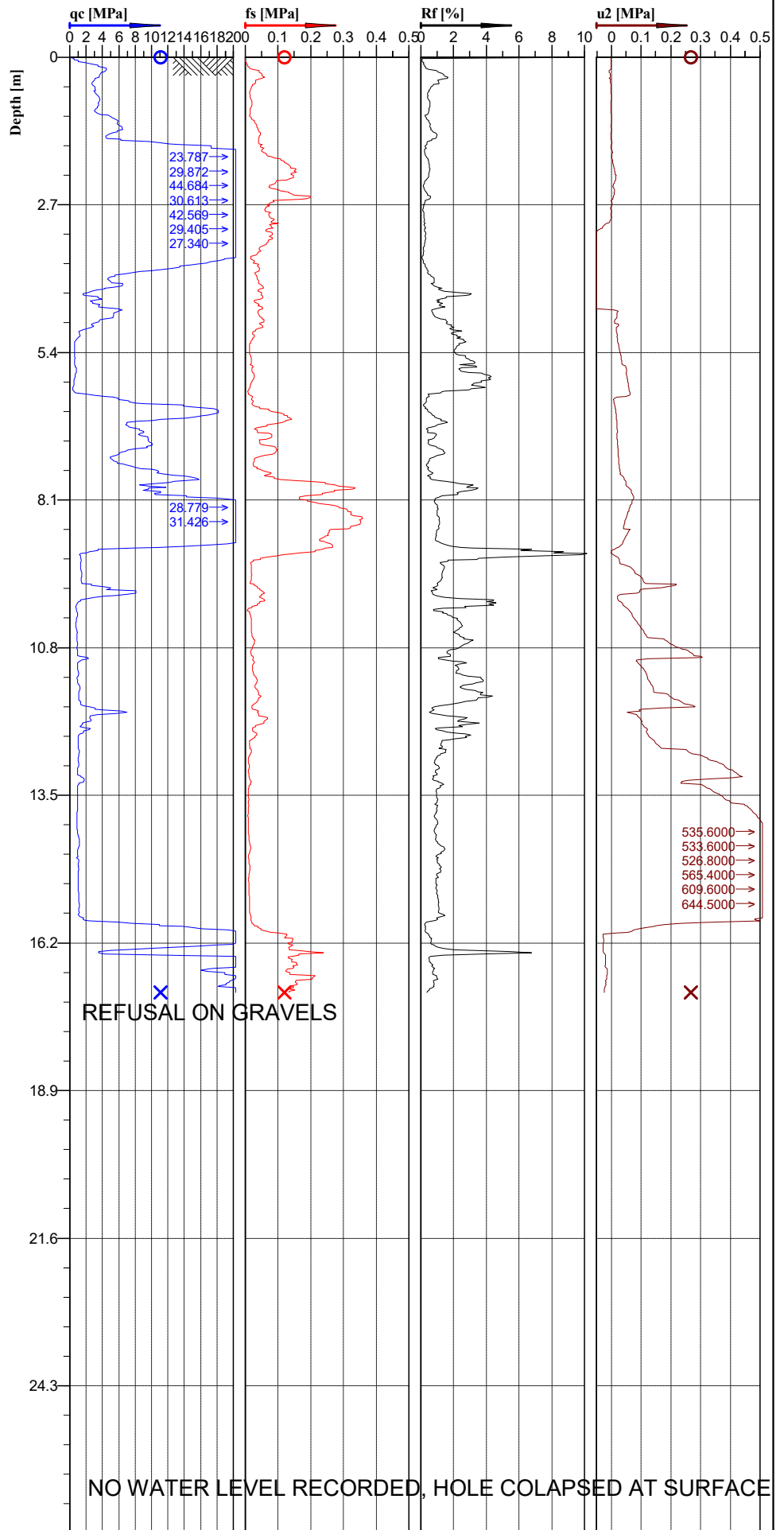
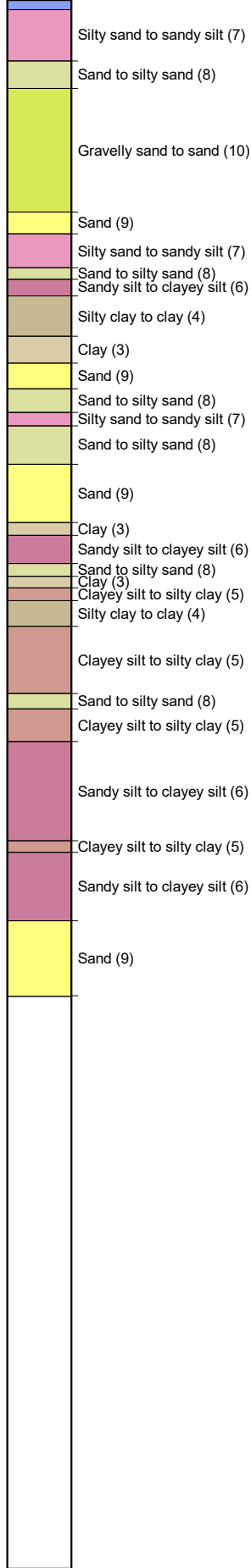
- Sand to silty sand (8)
- Clayey silt to silty clay (5)
- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sand to silty sand (8)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Sensitive fine grained (1)
- Clay (3)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Gravelly sand to sand (10)
- Clayey silt to silty clay (5)
- Sand (9)
- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Clay (3)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Sensitive fine grained (1)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 03
Project ID:	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65386 E 176.85863		File: CPT03.CPT	

**Classification by
Robertson 1986**



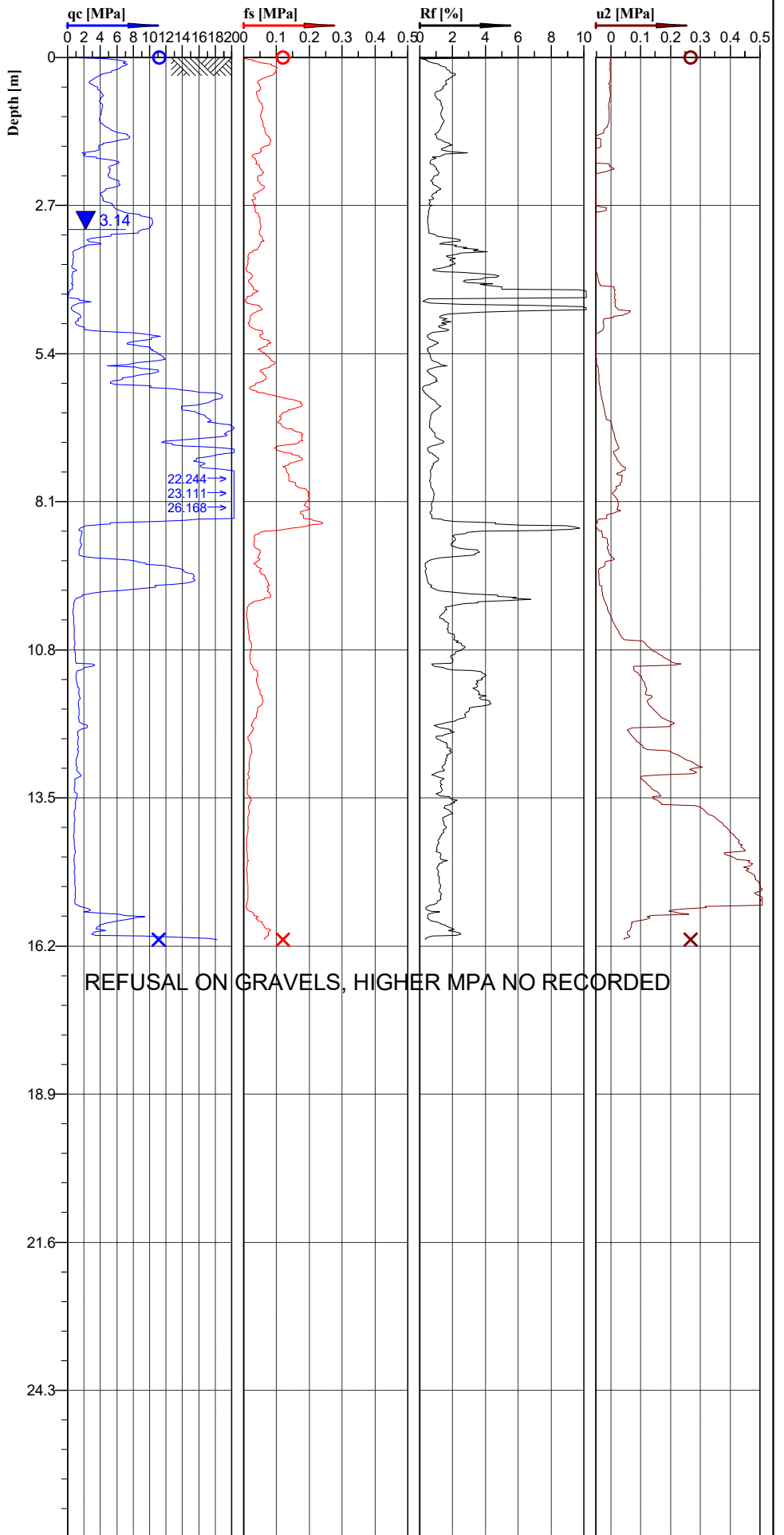
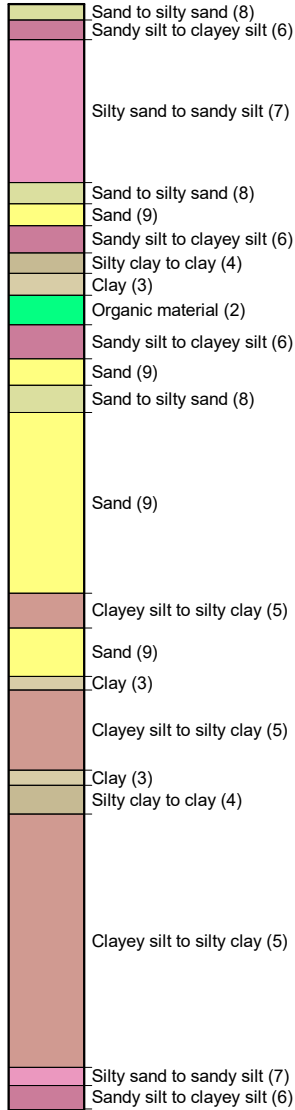
NO WATER LEVEL RECORDED, HOLE COLLAPSED AT SURFACE



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 04
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65323 E 176.85893		File: CPT04.CPT	

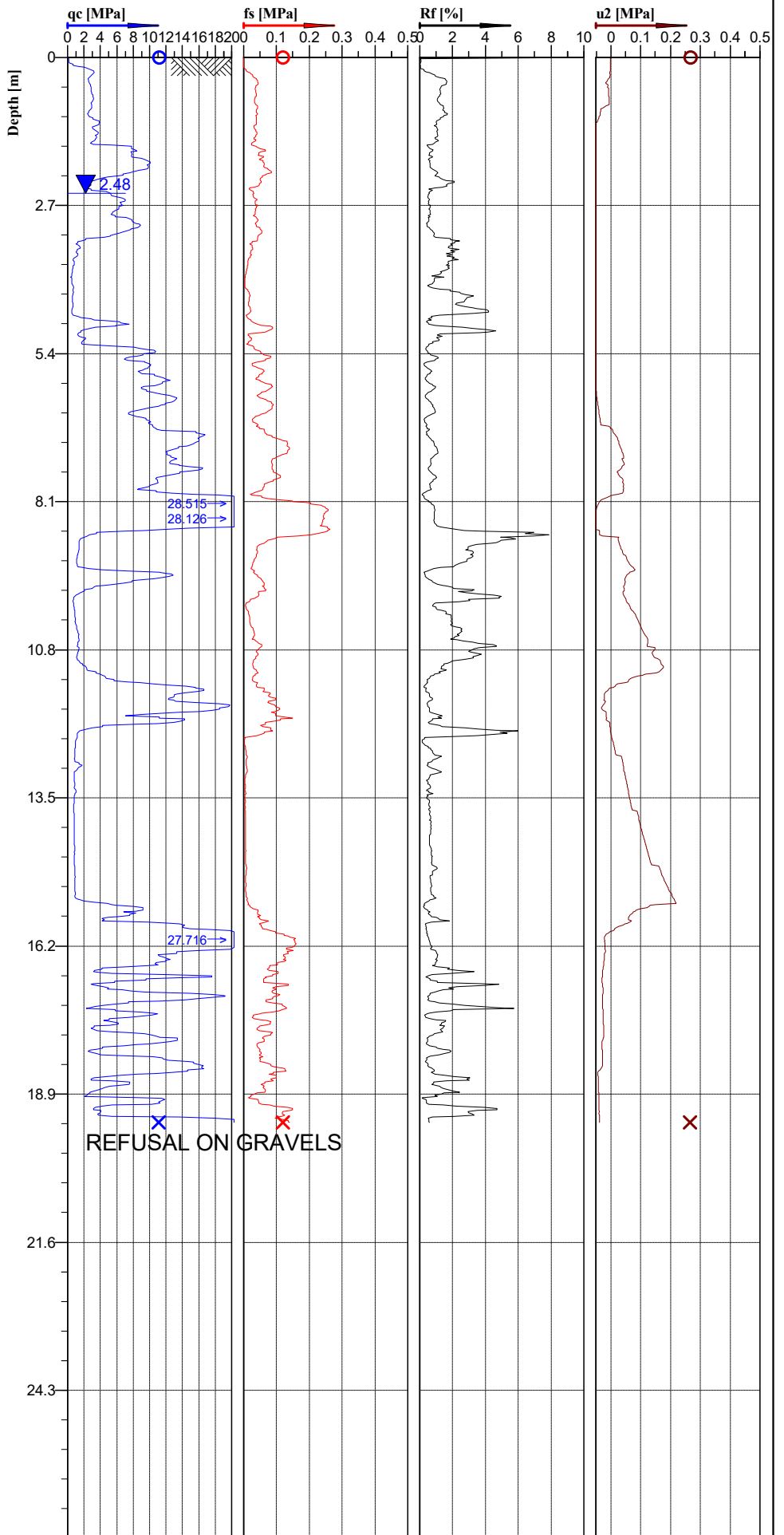
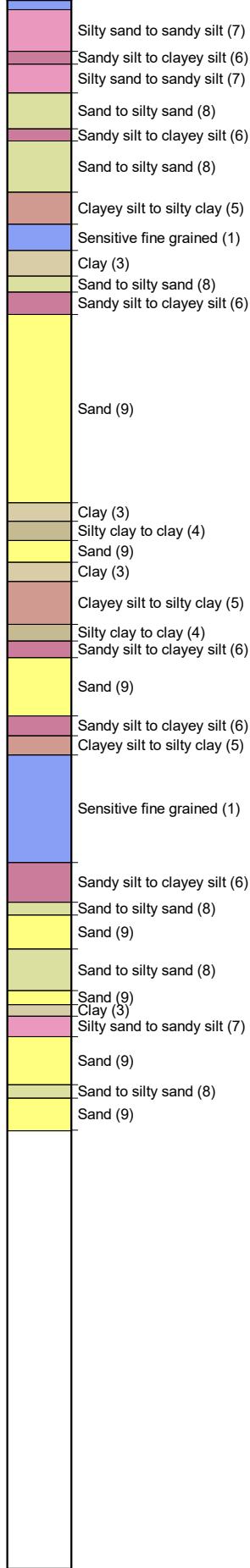
**Classification by
Robertson 1986**



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 05
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65444 E 176.85905		File: CPT05.CPT	

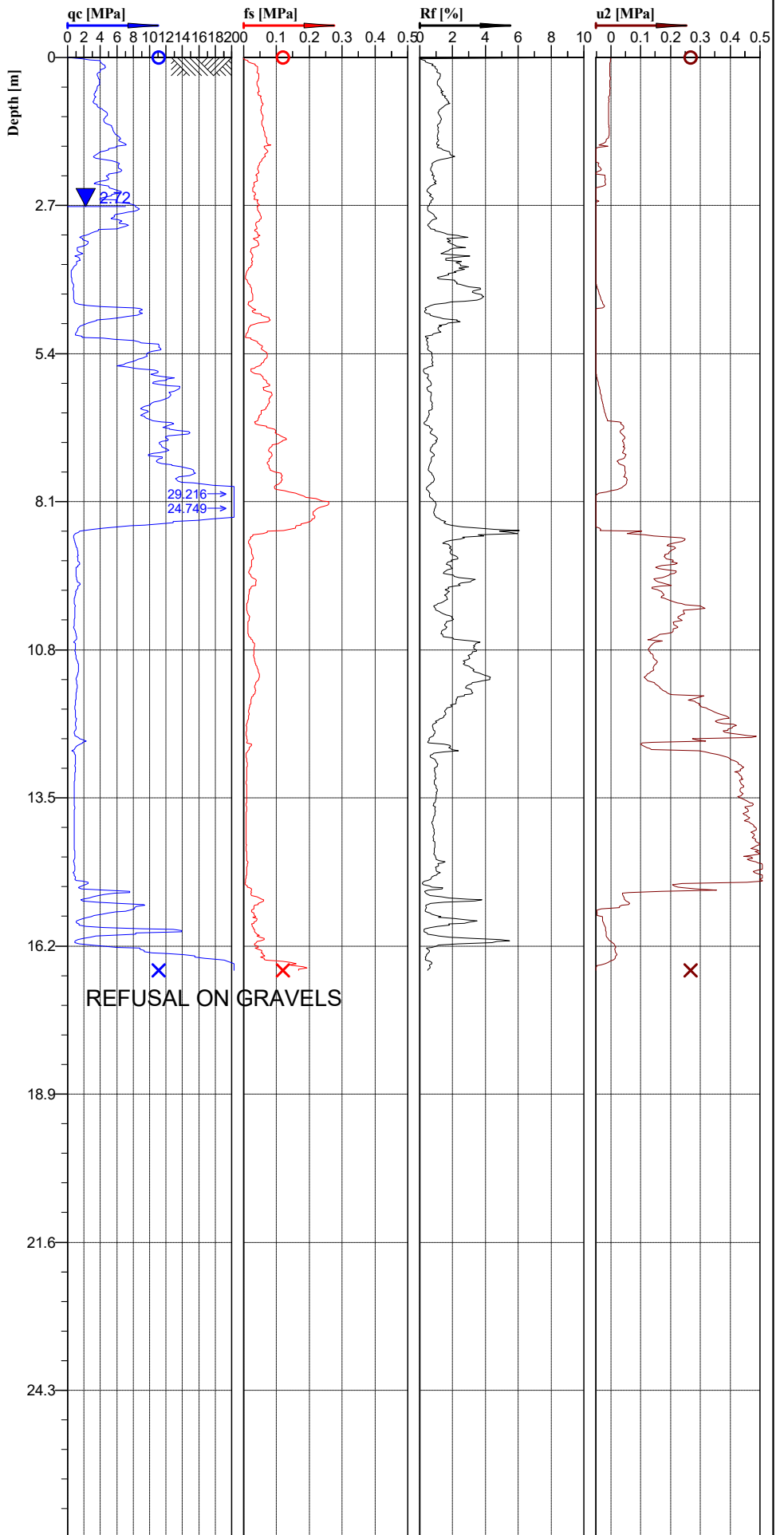
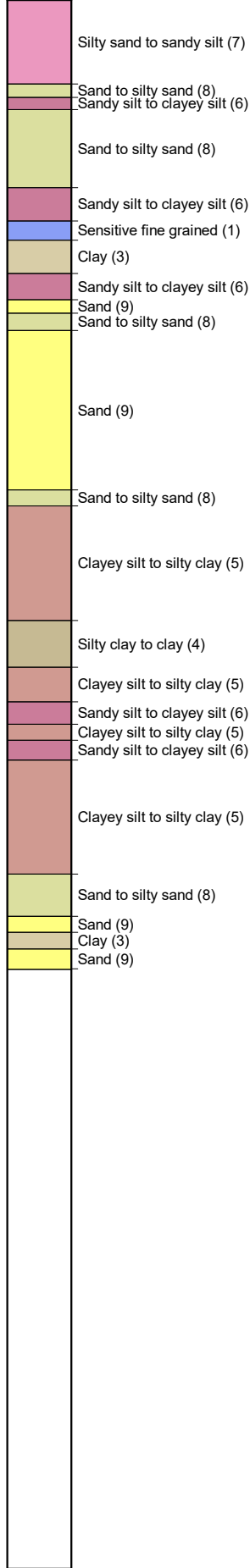
**Classification by
Robertson 1986**



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 06
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65351 E 176.85960		File: CPT06.CPT	

**Classification by
Robertson 1986**

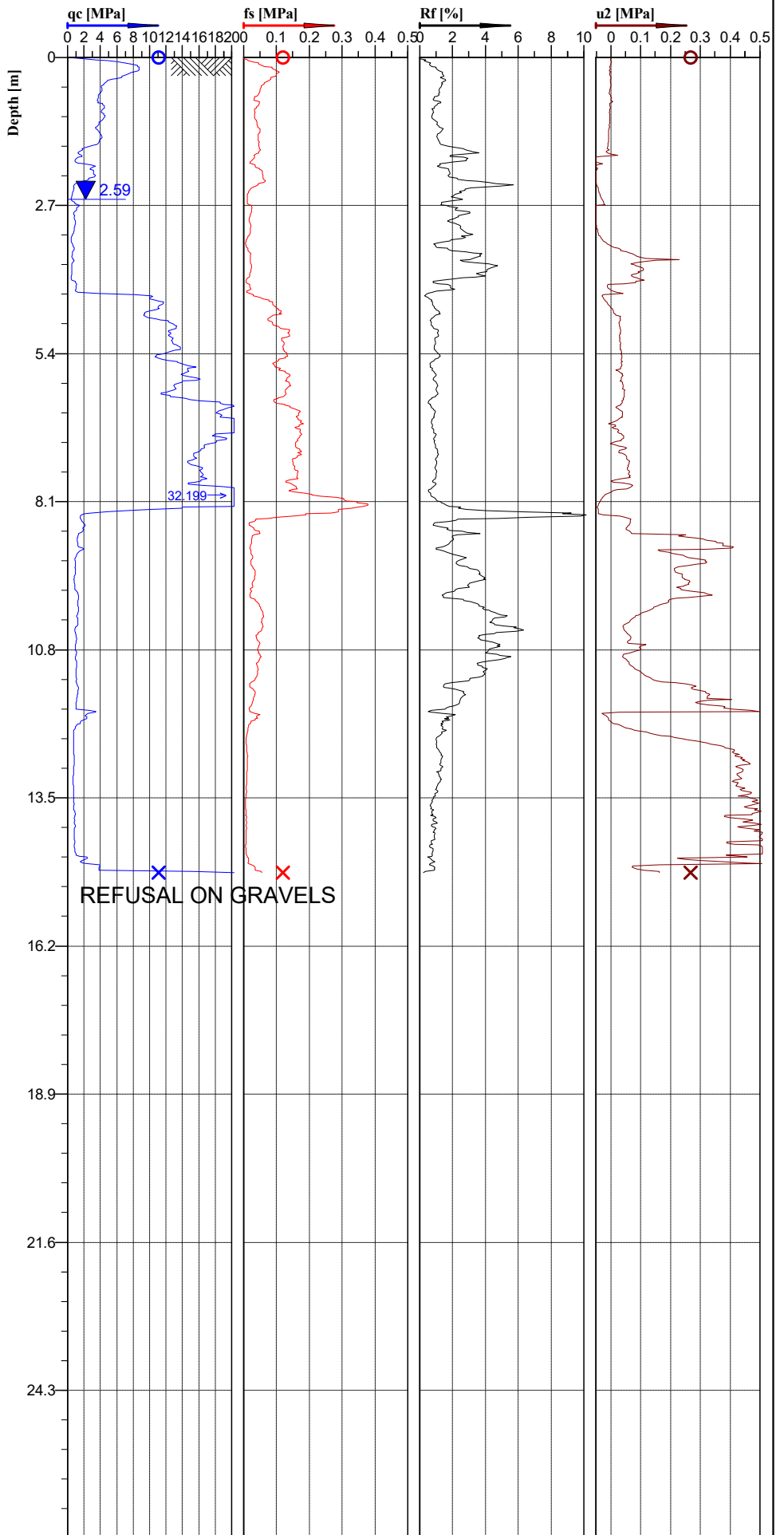


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 07
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65295 E 176.86006		File: CPT07.CPT	

**Classification by
Robertson 1986**

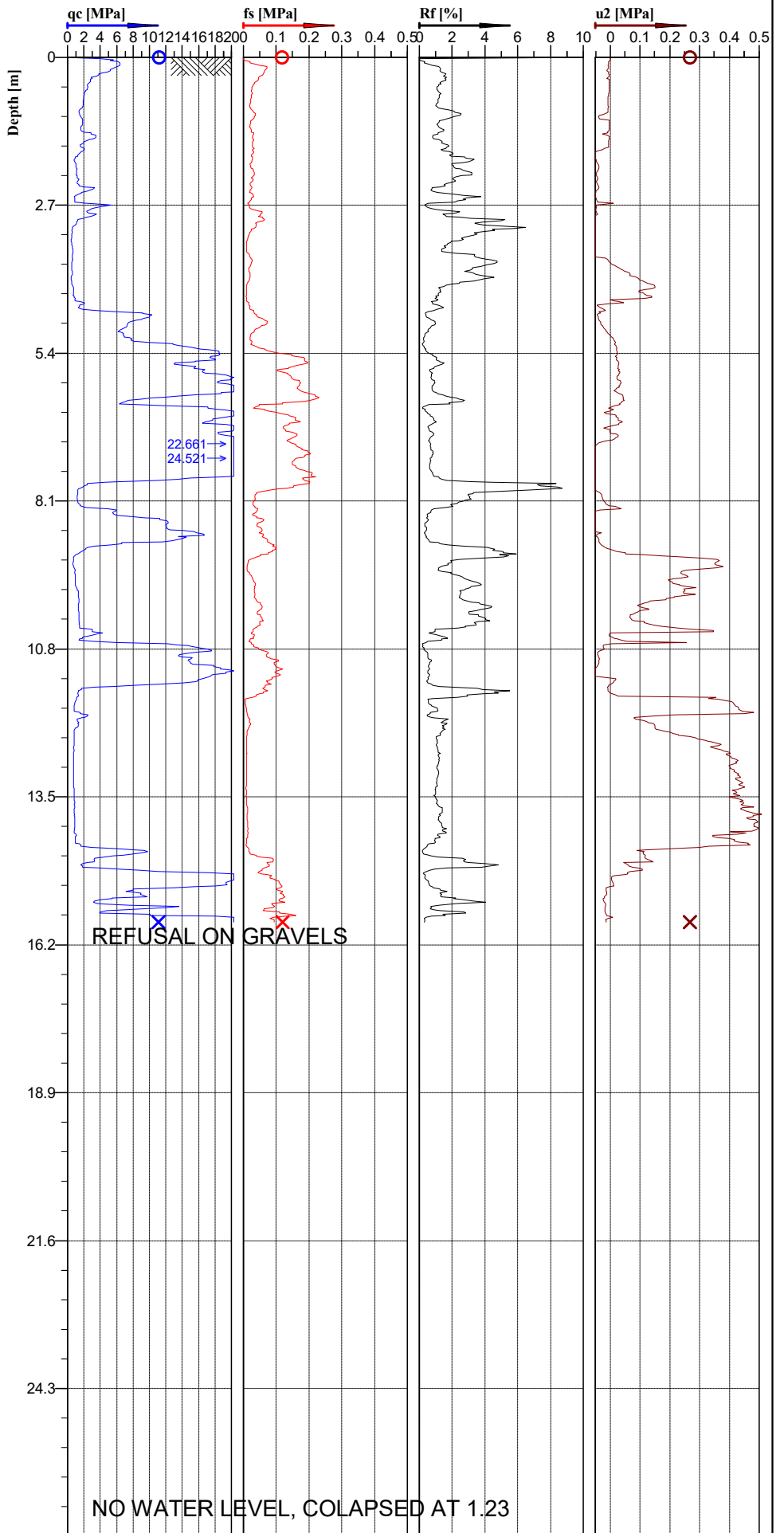
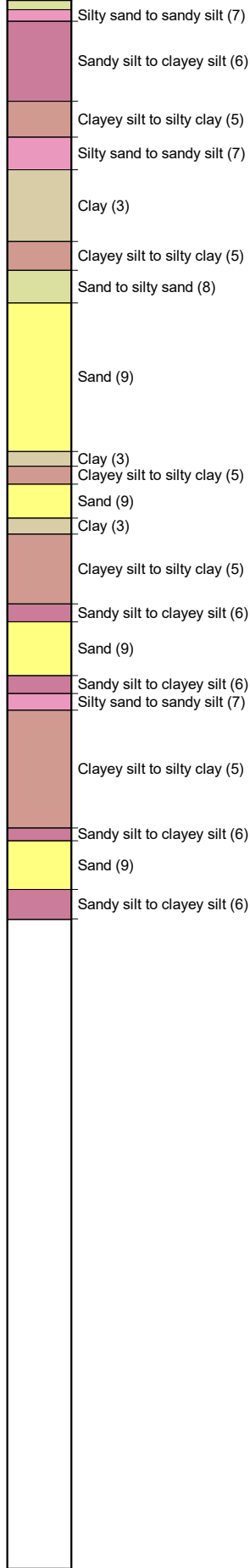
- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Sensitive fine grained (1)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Clay (3)
- Clayey silt to silty clay (5)
- Clay (3)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 08
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65254 E 176.56086		File: CPT08.CPT	

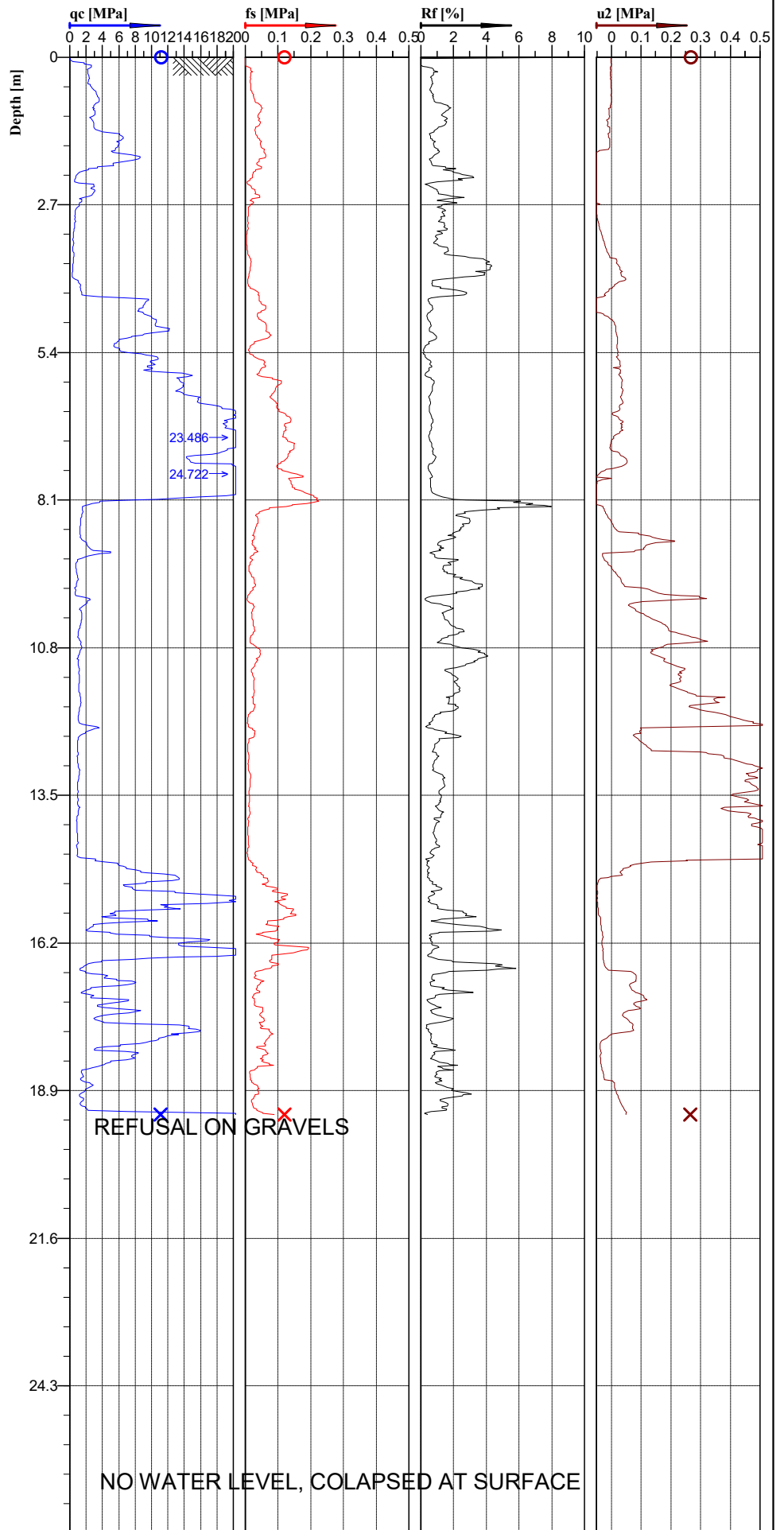
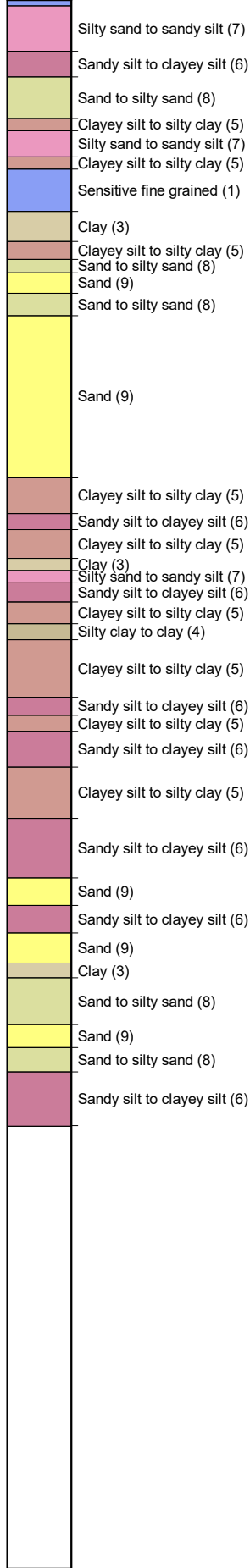
**Classification by
Robertson 1986**



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 09
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65446 E 176.86009		File: CPT09.CPT	

**Classification by
Robertson 1986**

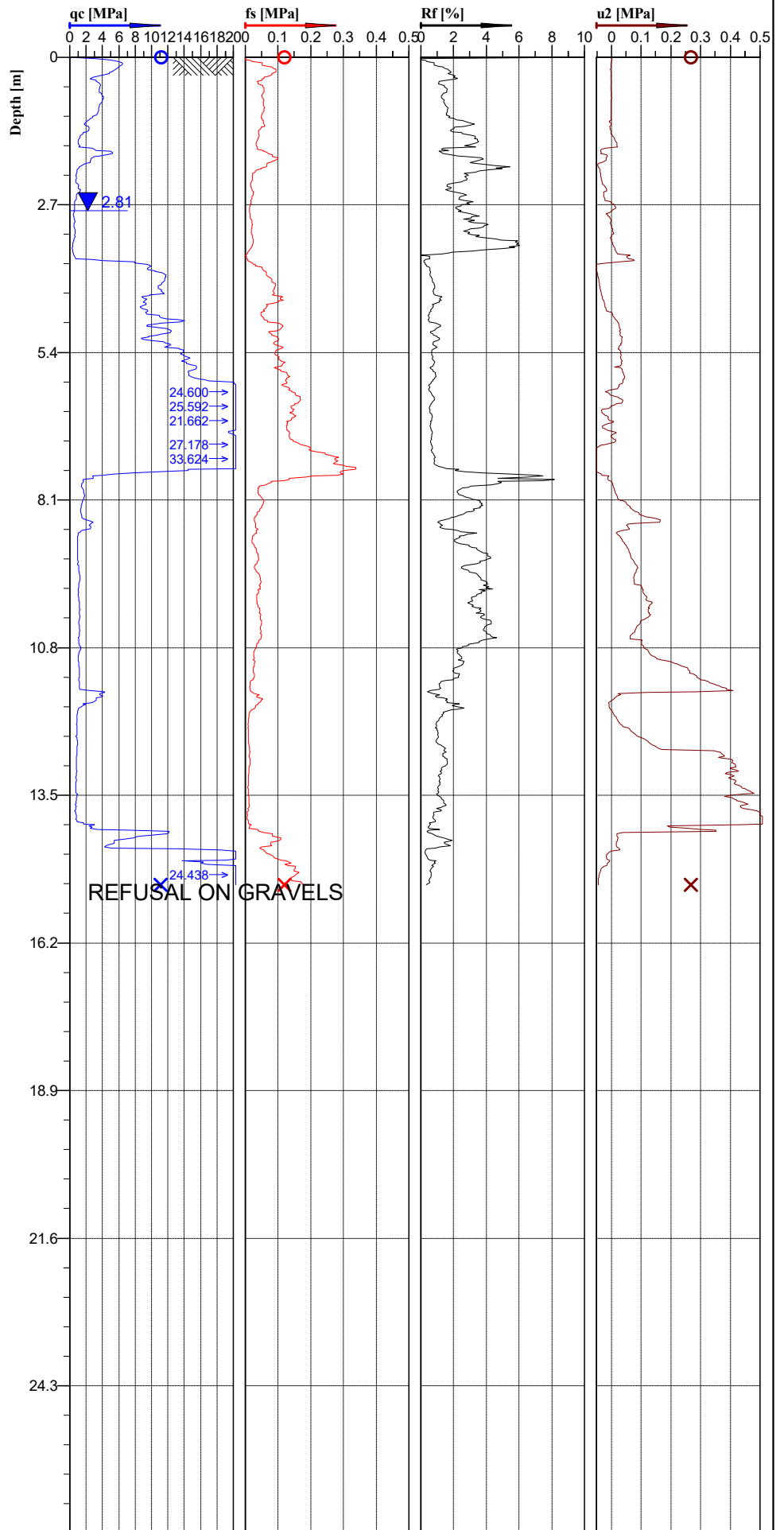


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 10
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65353 E 176.86041		File: CPT10.CPT	

**Classification by
Robertson 1986**

- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Silty clay to clay (4)
- Silty sand to sandy silt (7)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clay (3)
- Sensitive fine grained (1)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Clay (3)
- Silty clay to clay (4)
- Clay (3)
- Silty clay to clay (4)
- Clay (3)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Sensitive fine grained (1)
- Silty sand to sandy silt (7)
- Sand (9)

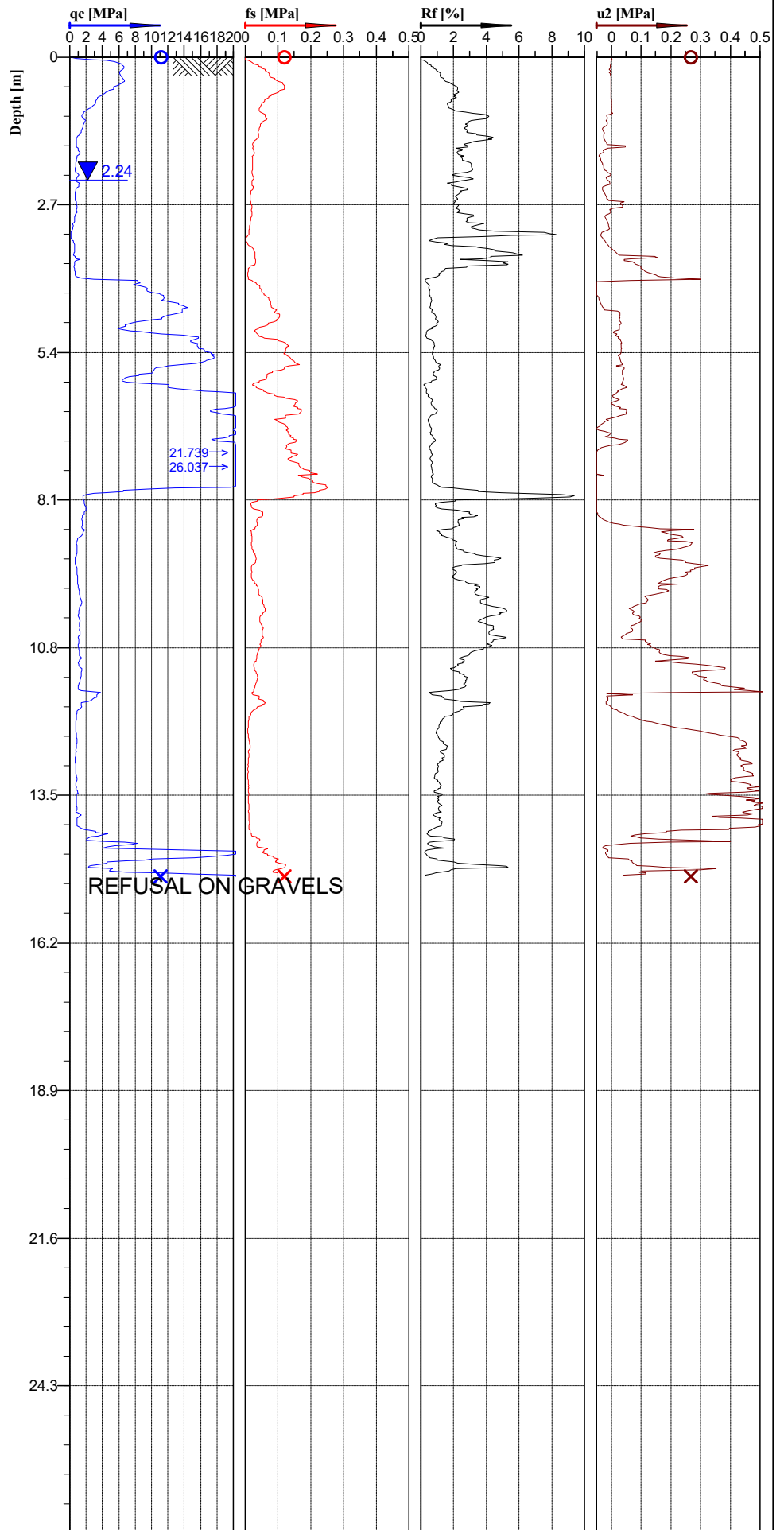


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 11
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65340 E 176.86099		File: CPT11.CPT	

**Classification by
Robertson 1986**

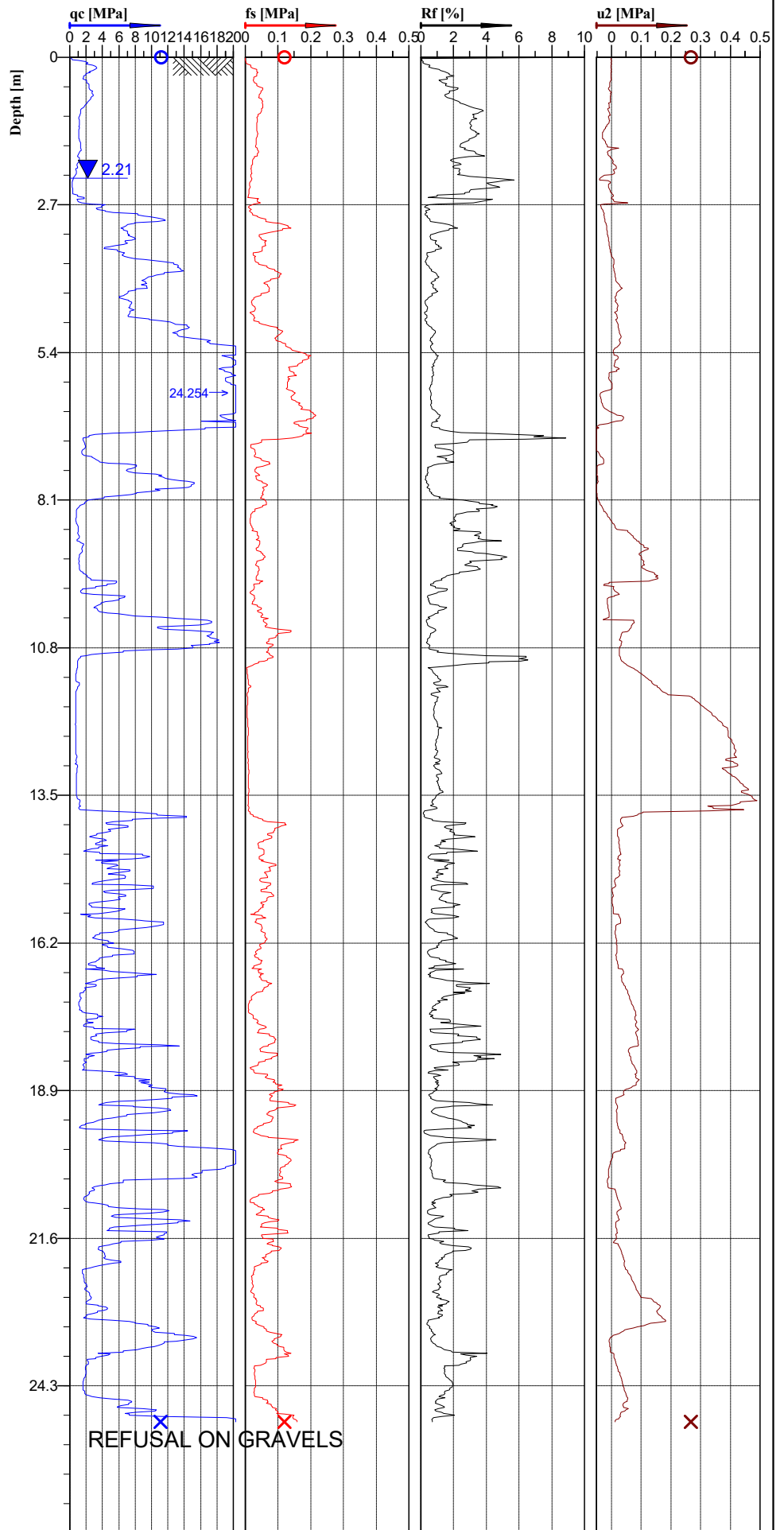
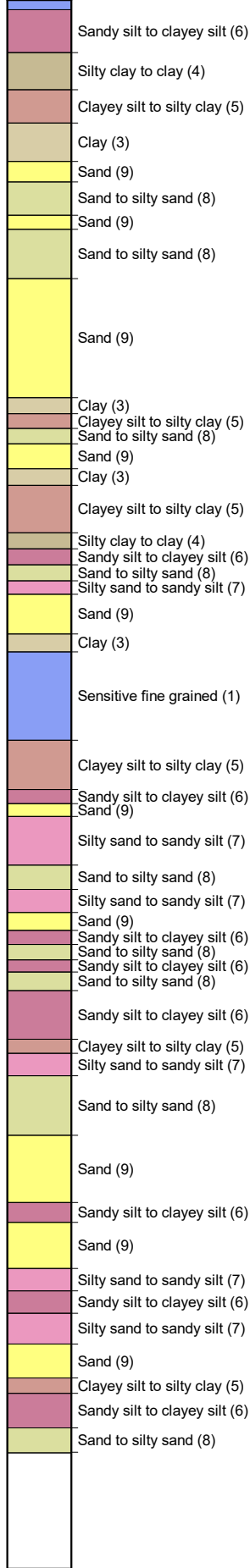
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Clay (3)
- Sensitive fine grained (1)
- Clay (3)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Clayey silt to silty clay (5)
- Clay (3)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 12
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65290 E 176.86134		File: CPT12.CPT	

**Classification by
Robertson 1986**

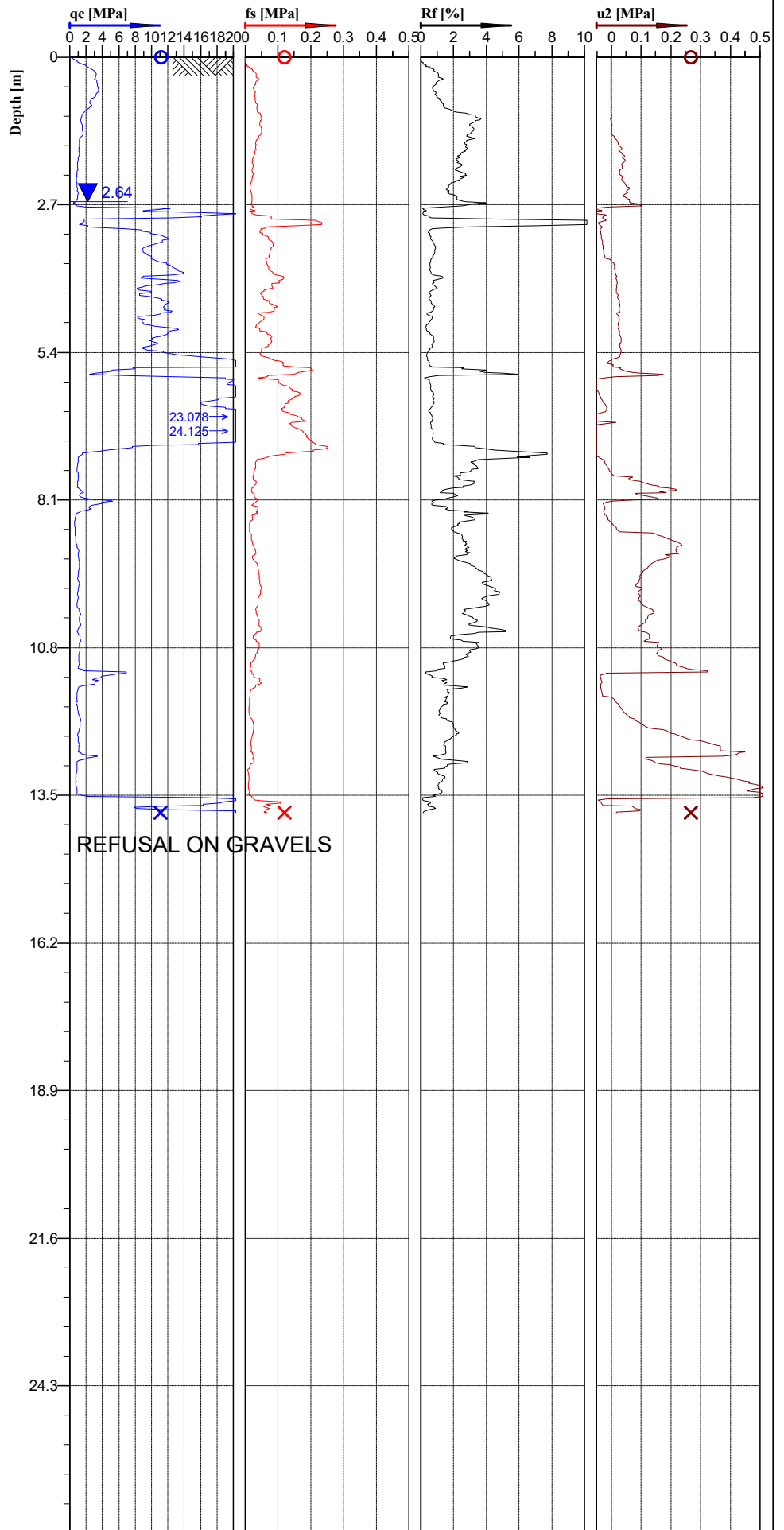
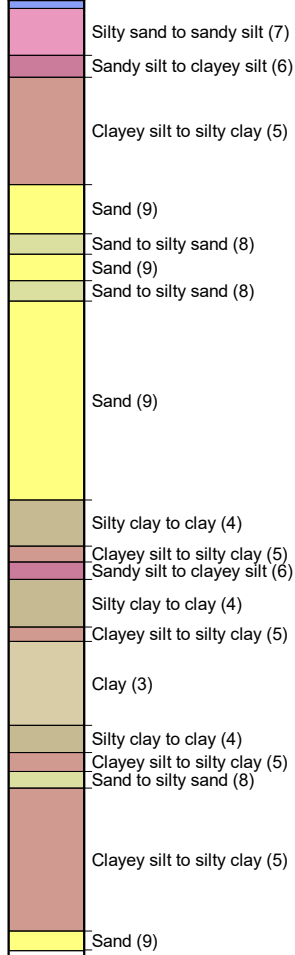


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150



Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 13
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65511 E 176.86018		File: CPT13.CPT	

**Classification by
Robertson 1986**

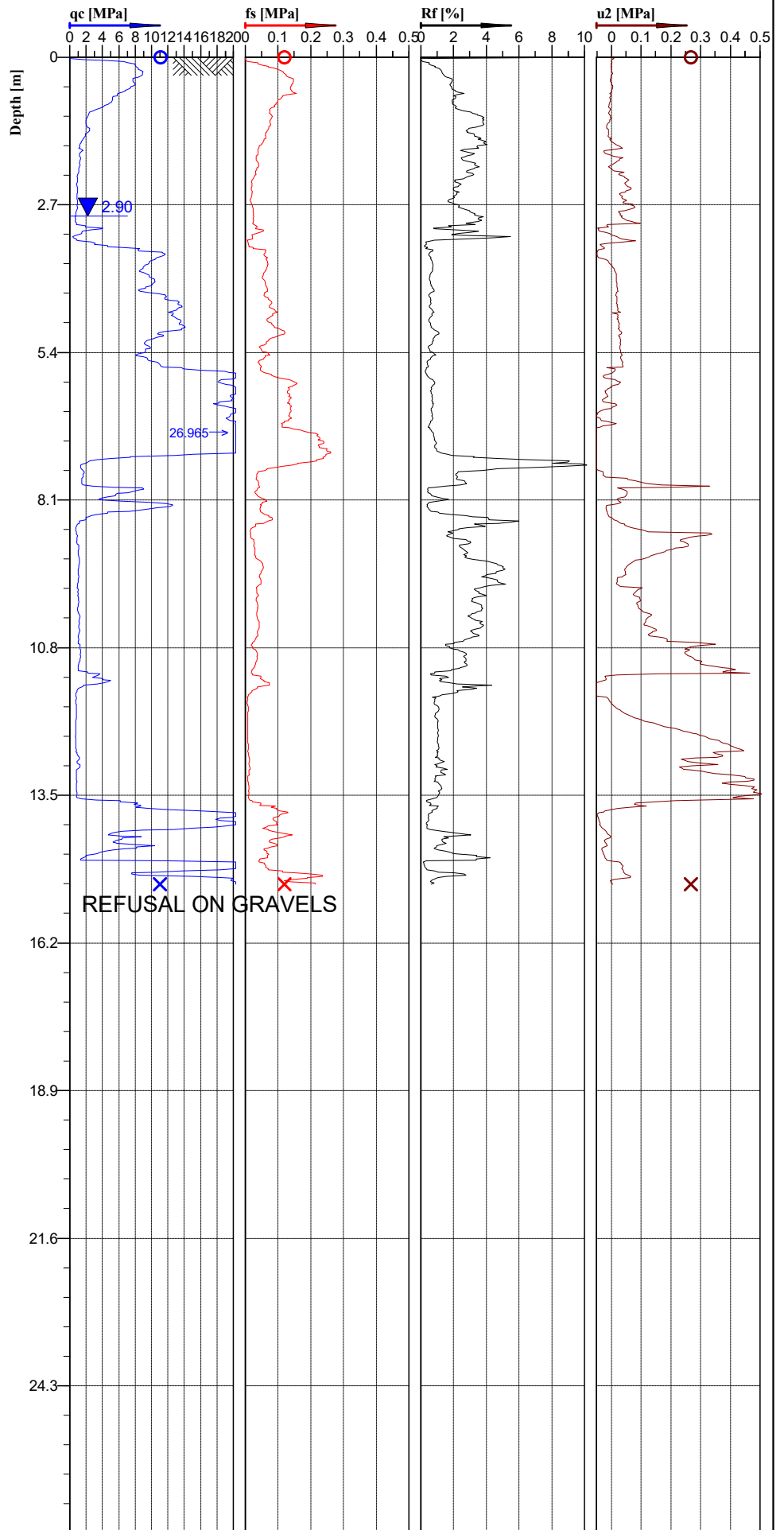


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 14
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 9/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65422 E 176.86142		File: CPT14.CPT	

**Classification by
Robertson 1986**

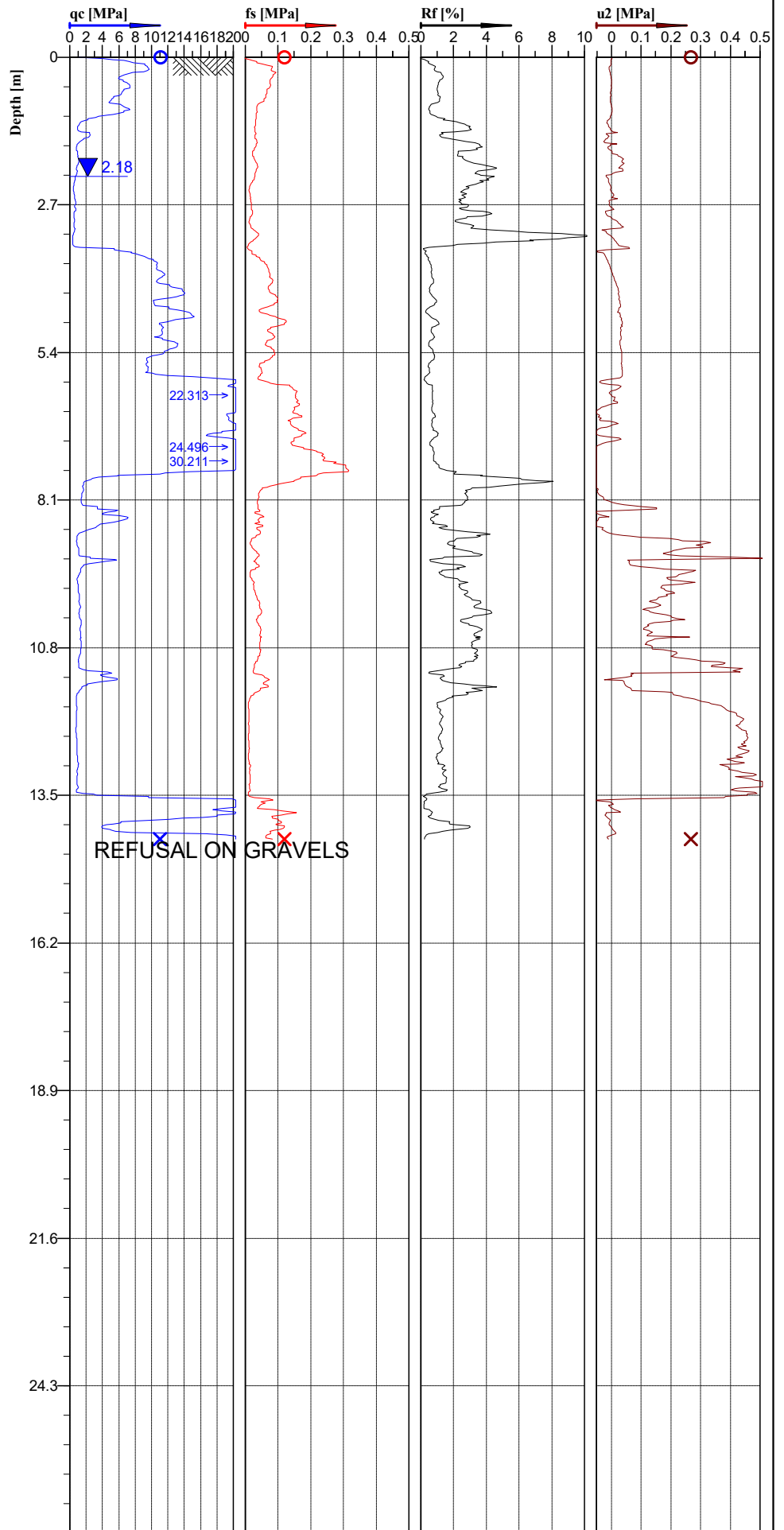
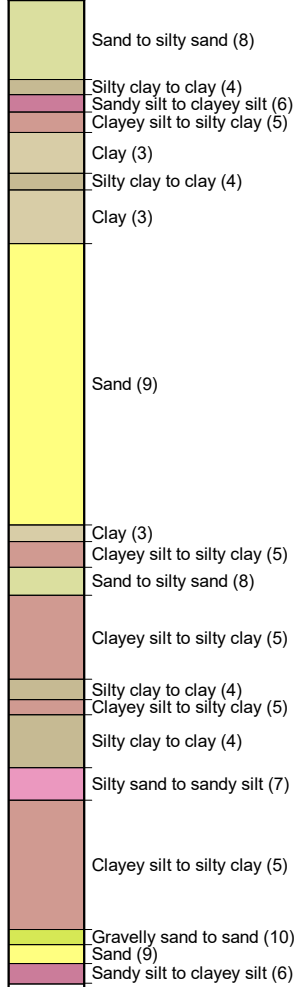
- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand to silty sand (8)
- Sand (9)
- Silty clay to clay (4)
- Clay (3)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty sand to sandy silt (7)
- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Sand (9)
- Sandy silt to clayey silt (6)
- Sand (9)



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 15
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65378 E 176.86174		File: CPT15.CPT	

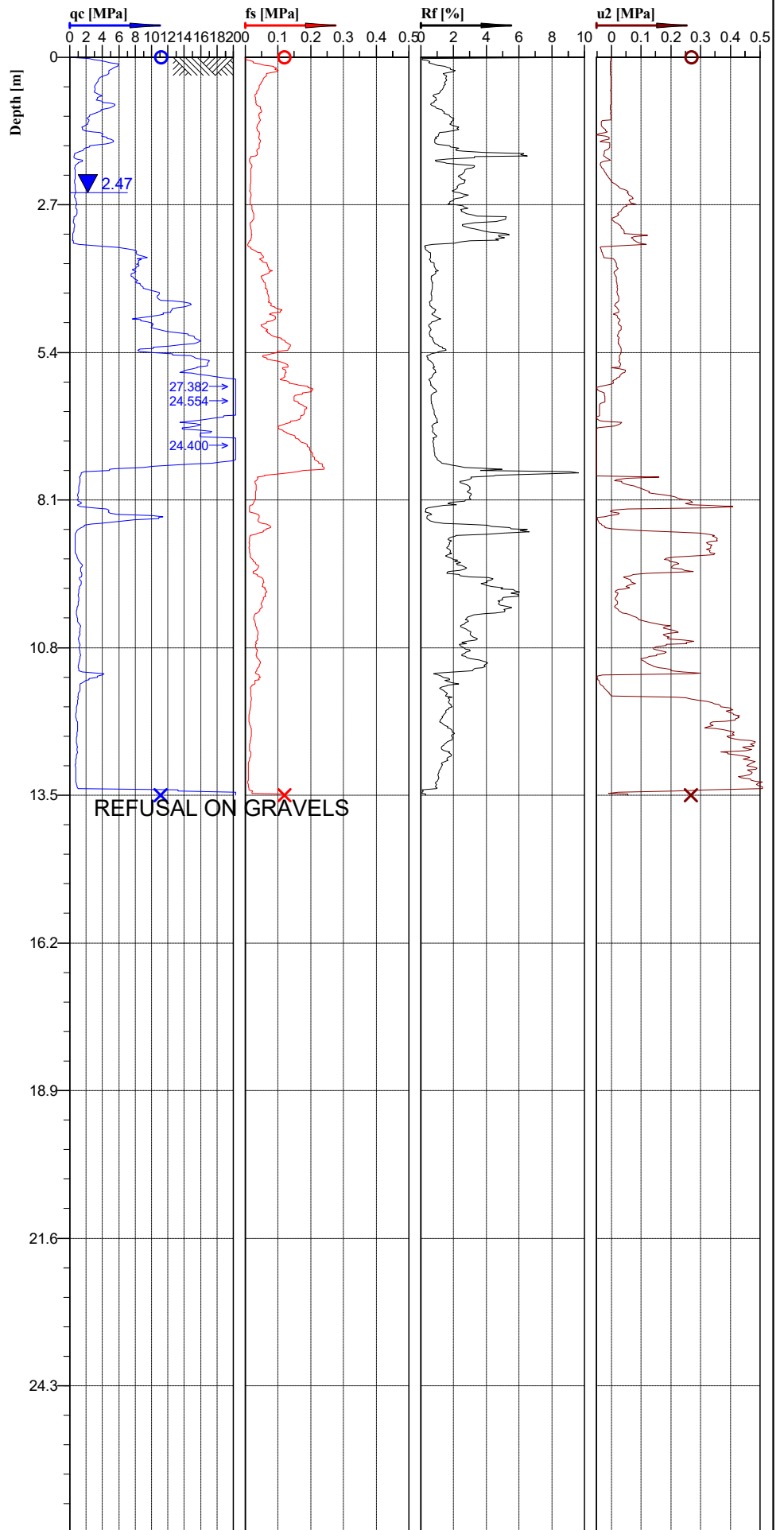
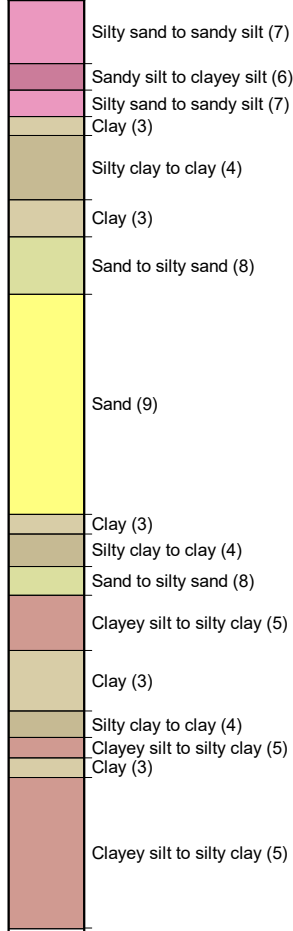
Classification by
Robertson 1986



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 16
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig: 1
S 39.65340 E 176.86215		File: CPT16.CPT	

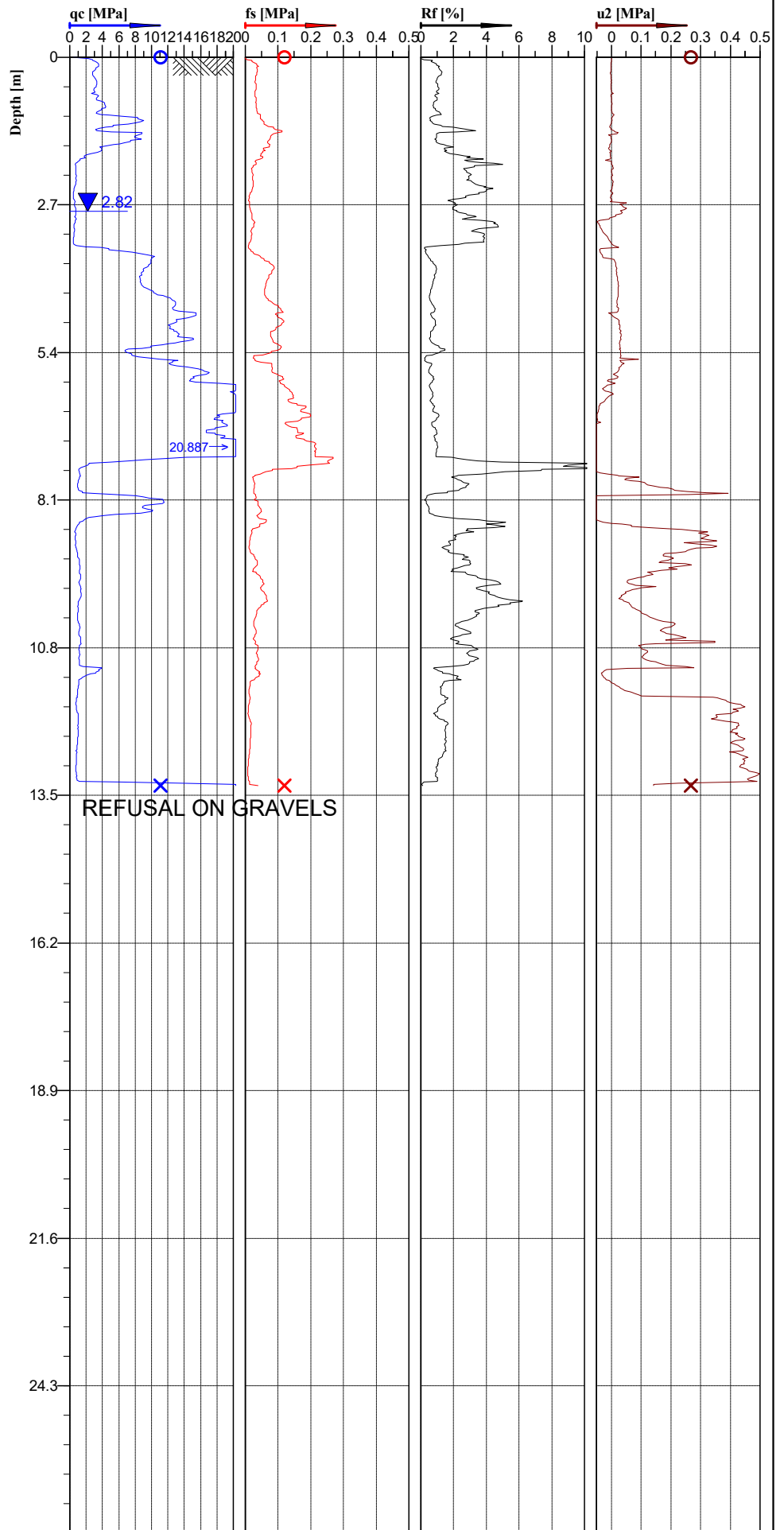
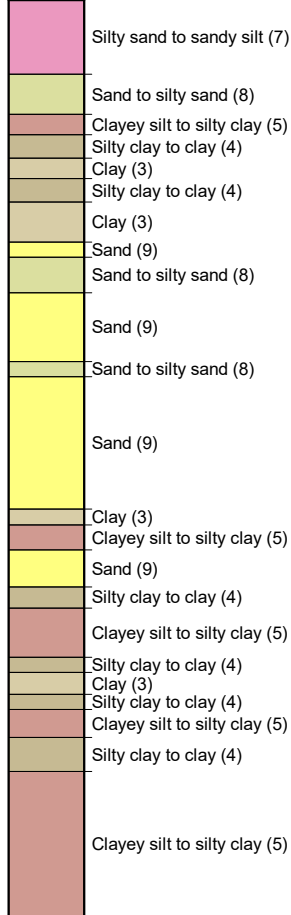
Classification by
Robertson 1986



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 17
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65398 E 176.86258		File: CPT17.CPT	

Classification by
Robertson 1986

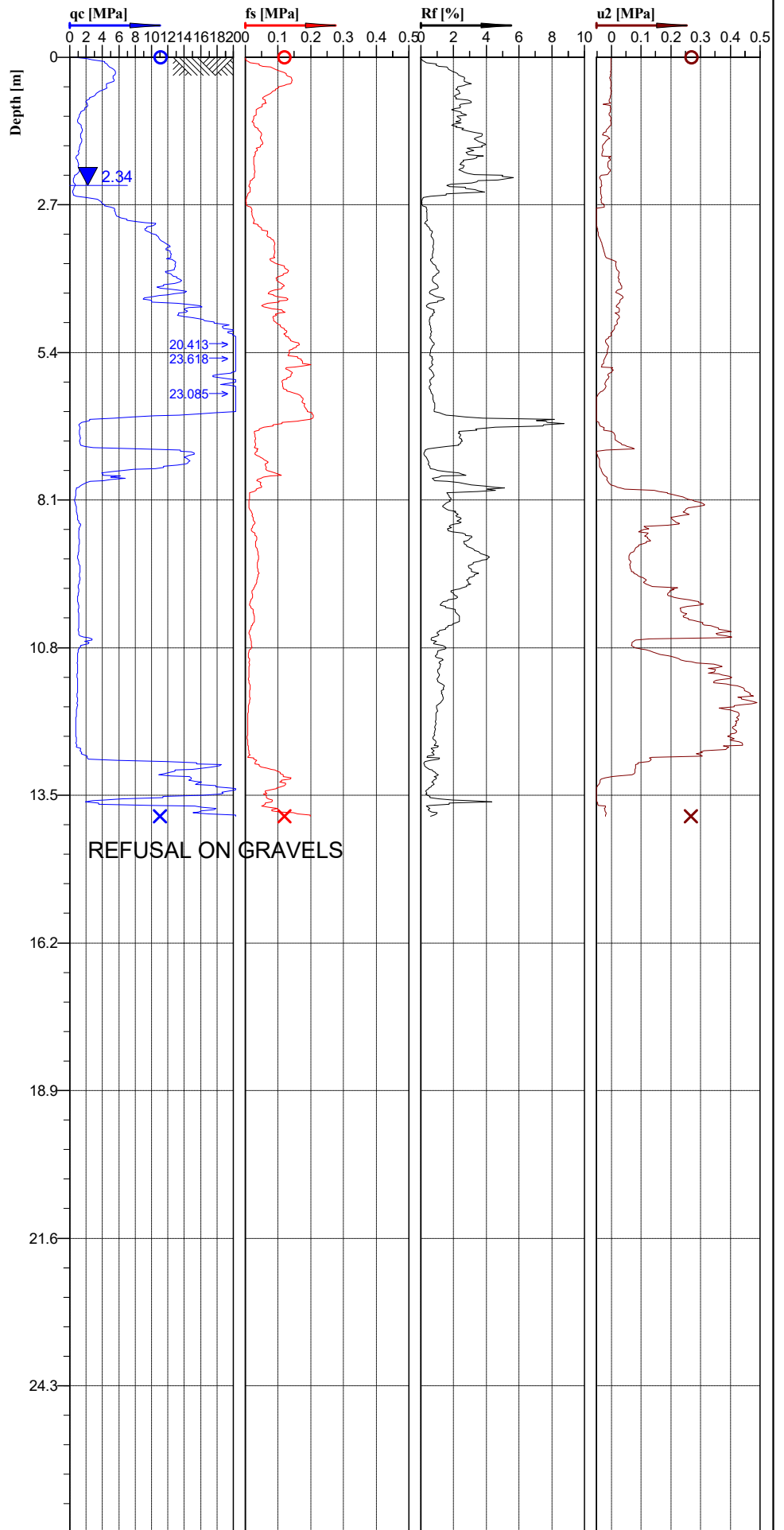


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 18
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 11/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65442 E 176.86336		File: CPT18.CPT	


**Classification by
Robertson 1986**

- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Clay (3)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand (9)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Clay (3)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Sensitive fine grained (1)
- Sandy silt to clayey silt (6)
- Sand (9)



REFUSAL ON GRAVELS





 Cone No: 4221 100KN

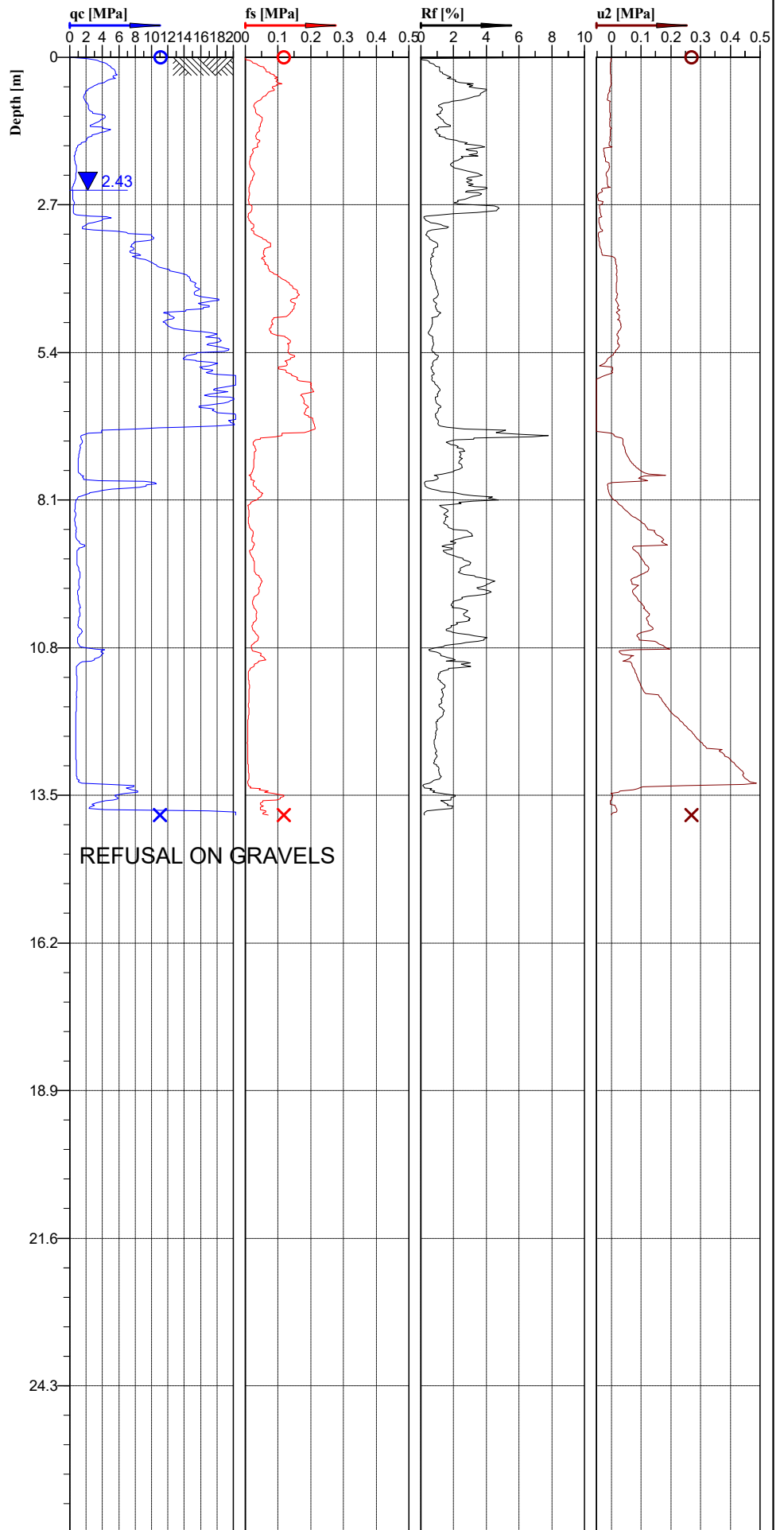
 Tip area [cm²]: 10

 Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 19
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 11/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65491 E 176.86270		File: CPT19.CPT	

**Classification by
Robertson 1986**

- Silty sand to sandy silt (7)
- Silty clay to clay (4)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)
- Clay (3)
- Clayey silt to silty clay (5)
- Clay (3)
- Sandy silt to clayey silt (6)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand (9)
- Clayey silt to silty clay (5)
- Clay (3)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Sand to silty sand (8)
- Sandy silt to clayey silt (6)



REFUSAL ON GRAVELS

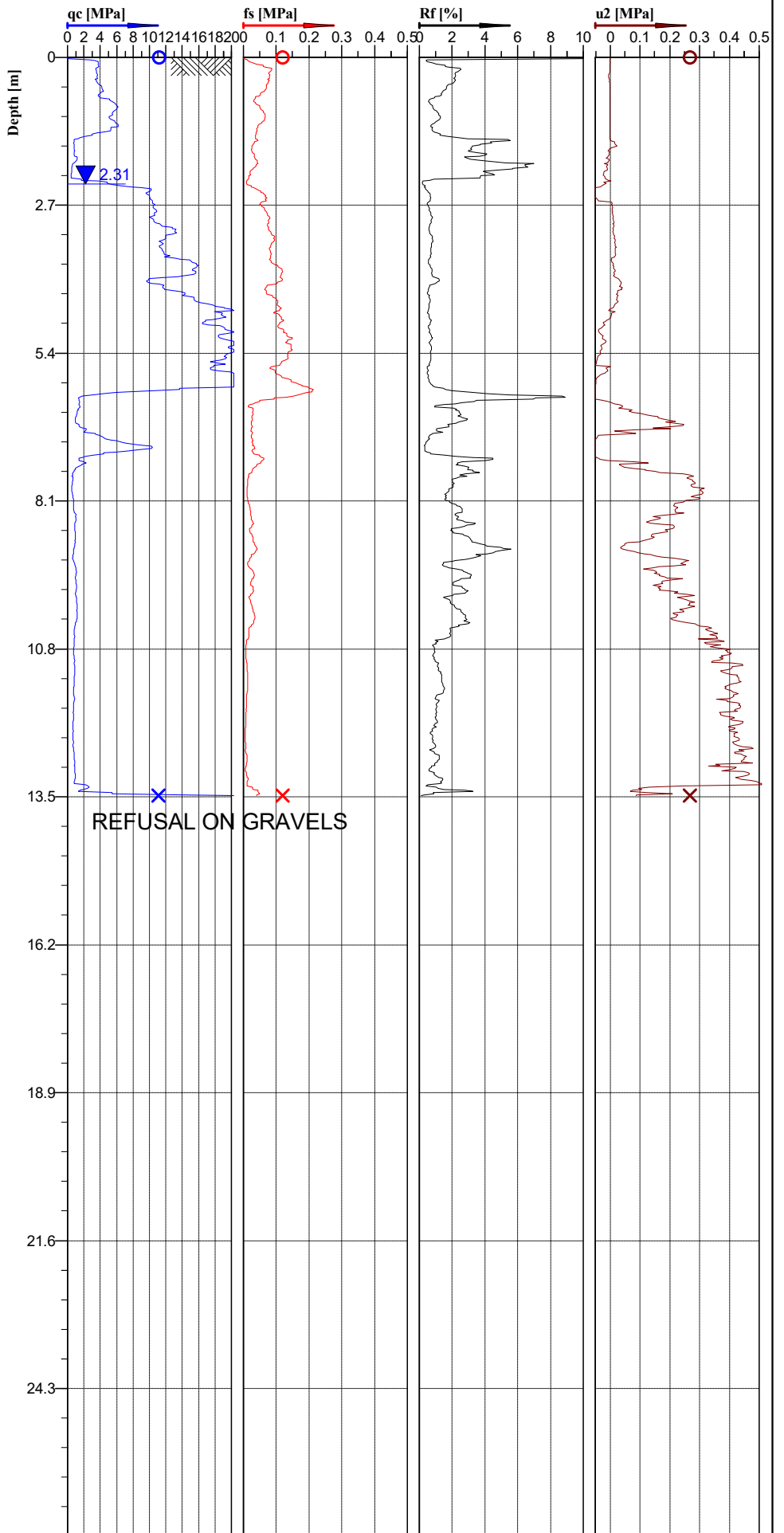


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 21
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 11/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65491 E 176.86412		File: CPT21.CPT	

**Classification by
Robertson 1986**

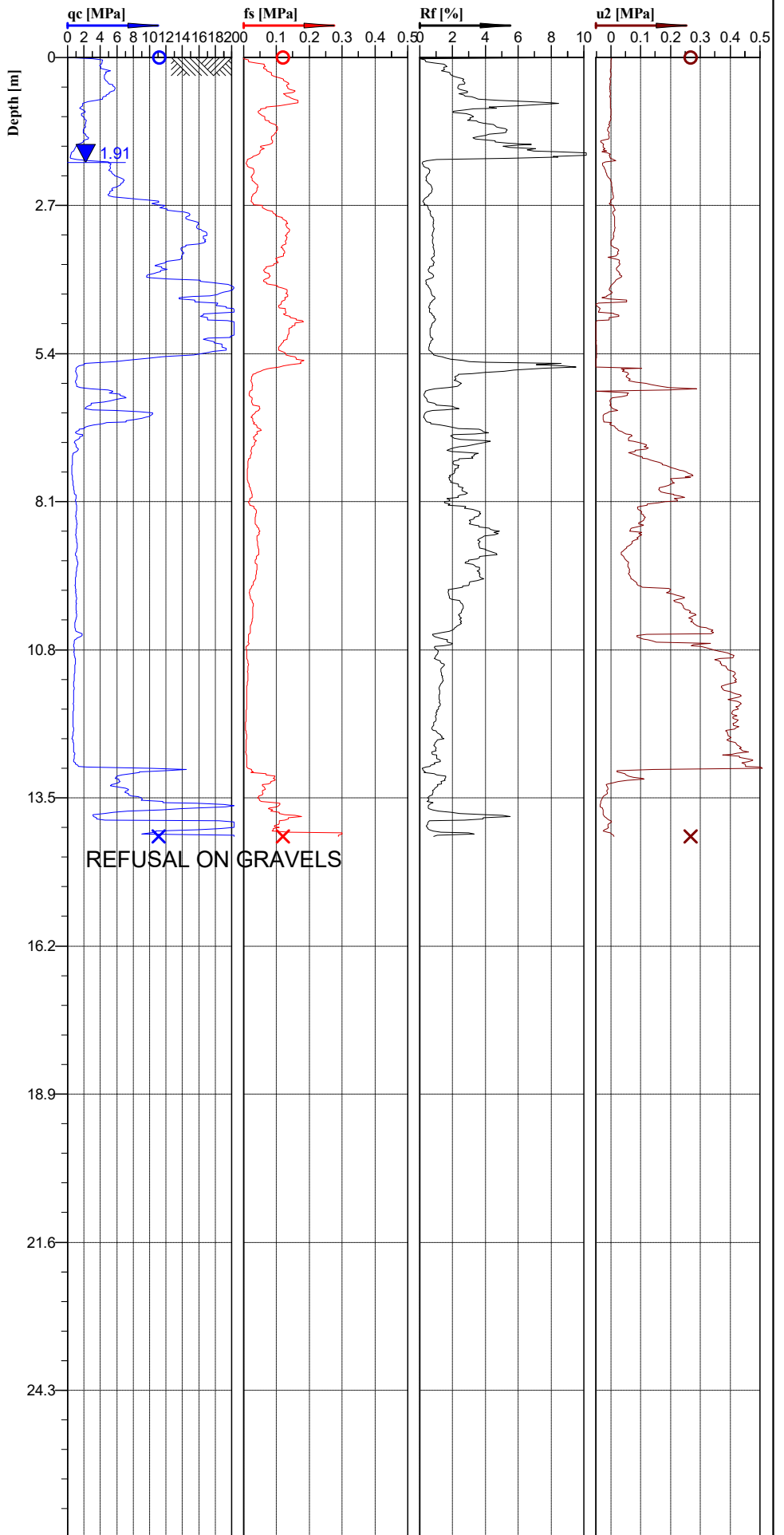
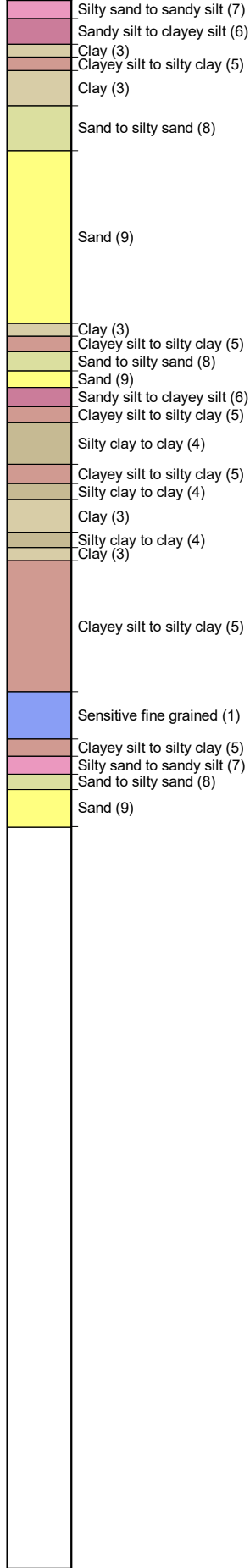
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)
- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sand to silty sand (8)
- Clay (3)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand to silty sand (8)
- Clay (3)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Clay (3)
- Clayey silt to silty clay (5)
- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)



Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 22
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65563 E 176.86288		File: CPT22.CPT	

**Classification by
Robertson 1986**

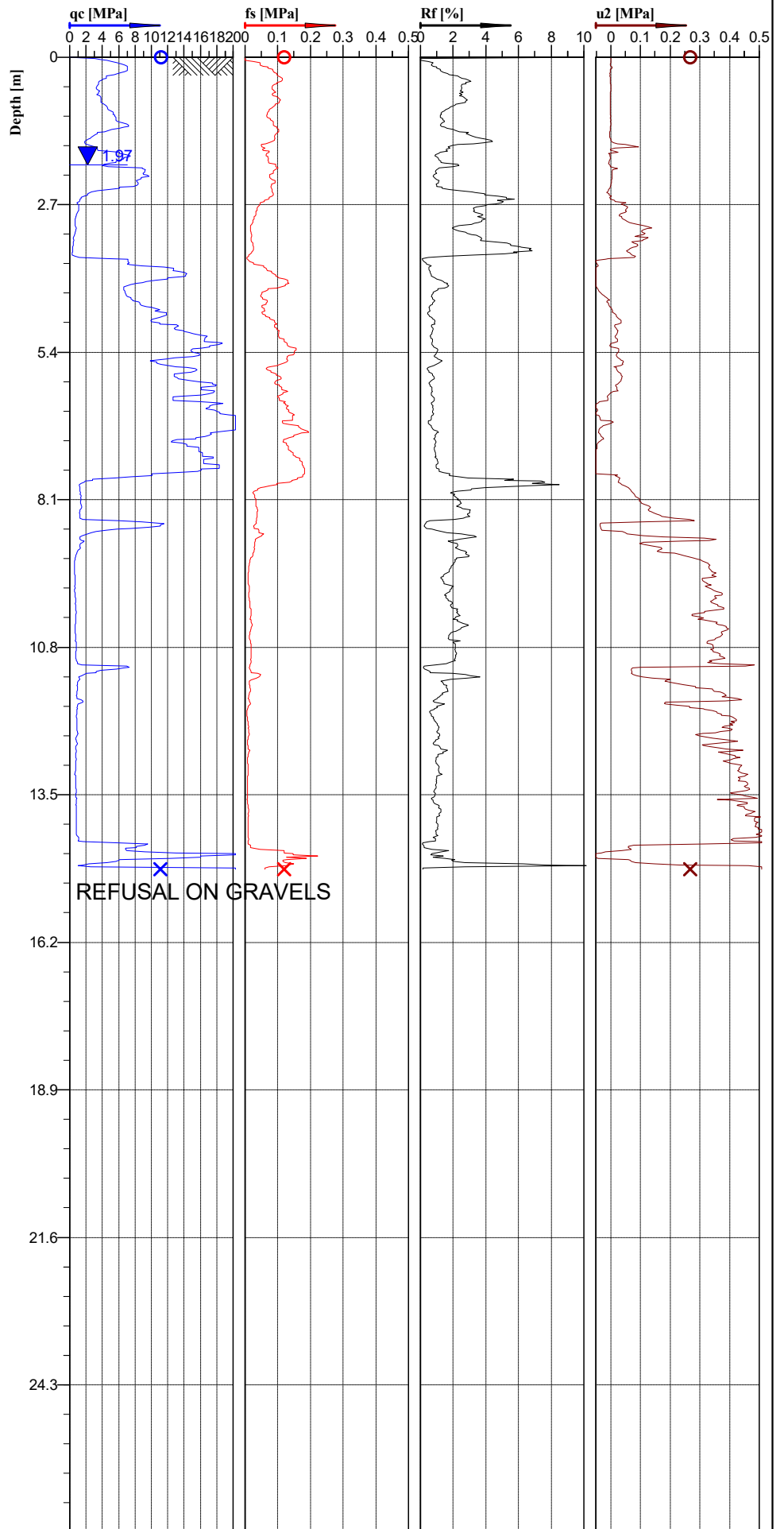


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 24
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65621 E 176.86311		File: CPT24.CPT	

**Classification by
Robertson 1986**

- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Sand to silty sand (8)
- Clay (3)
- Sand (9)
- Sand to silty sand (8)
- Sand (9)
- Clay (3)
- Clayey silt to silty clay (5)
- Sand (9)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Sand (9)



REFUSAL ON GRAVELS

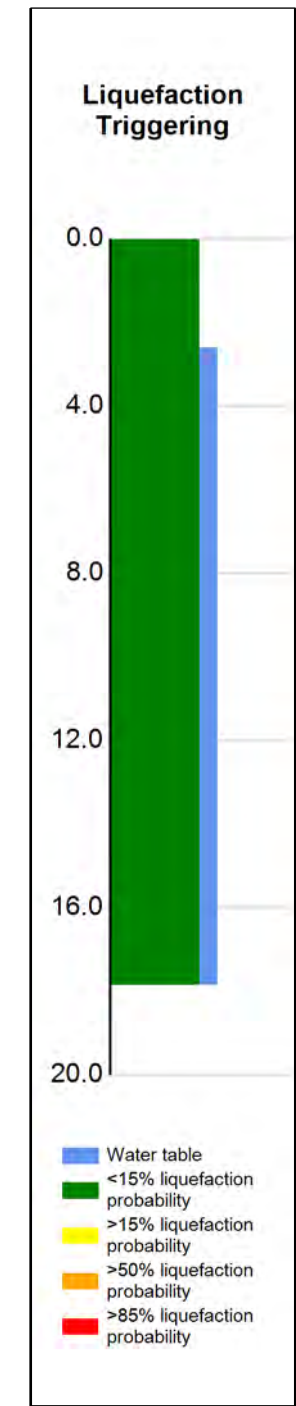
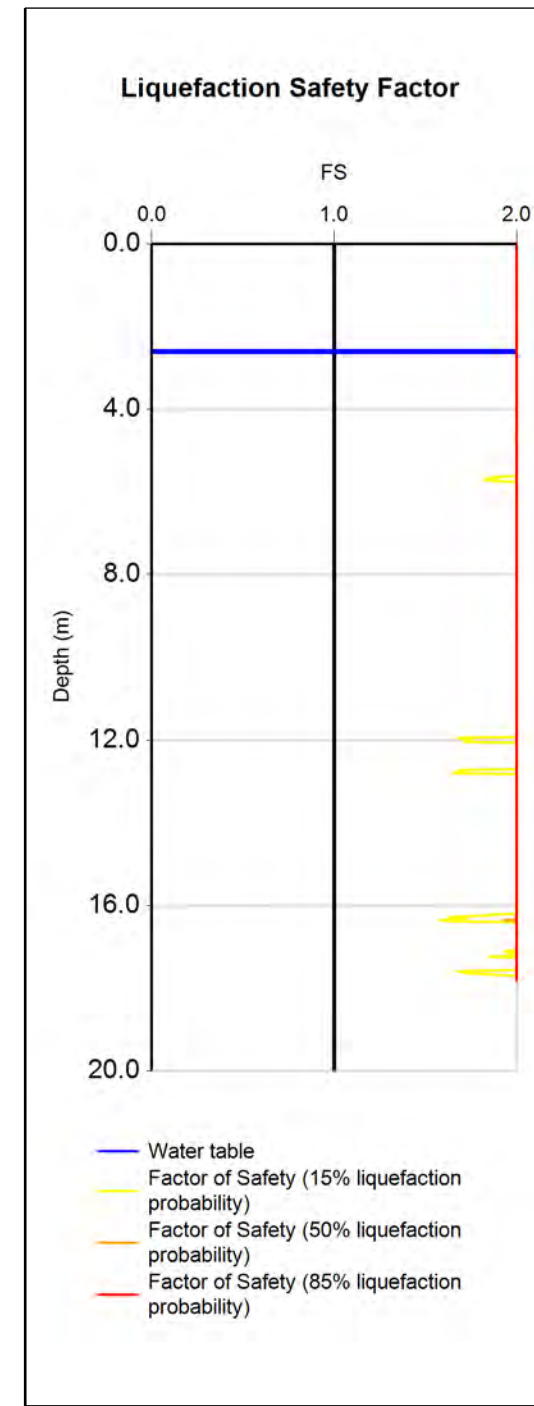
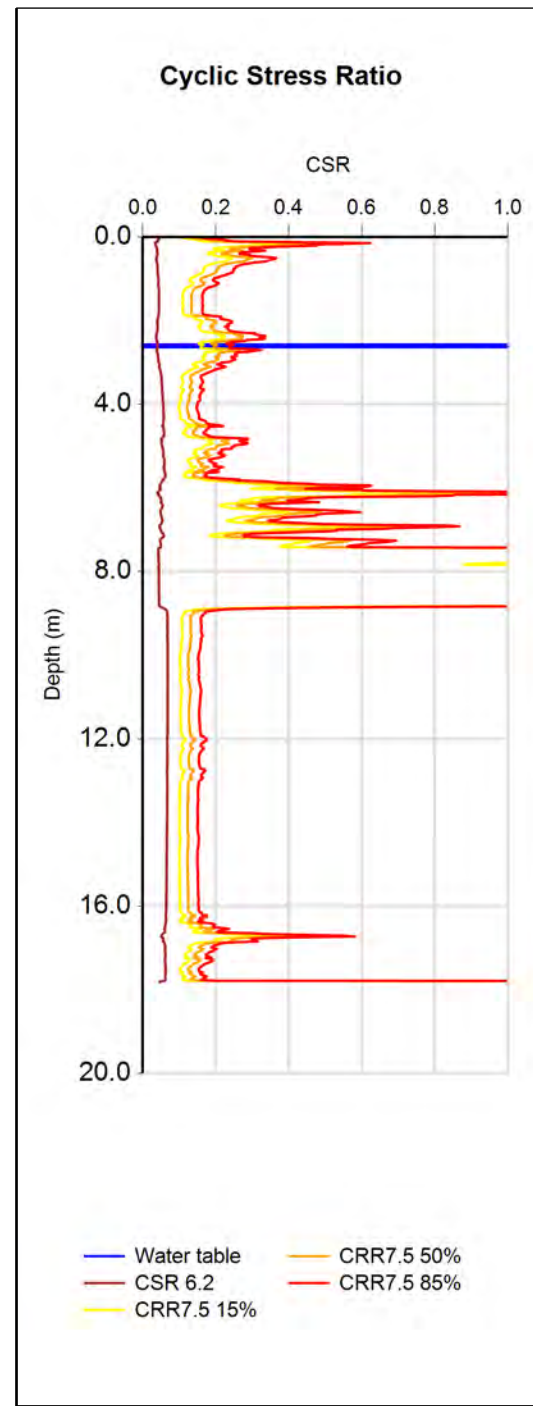
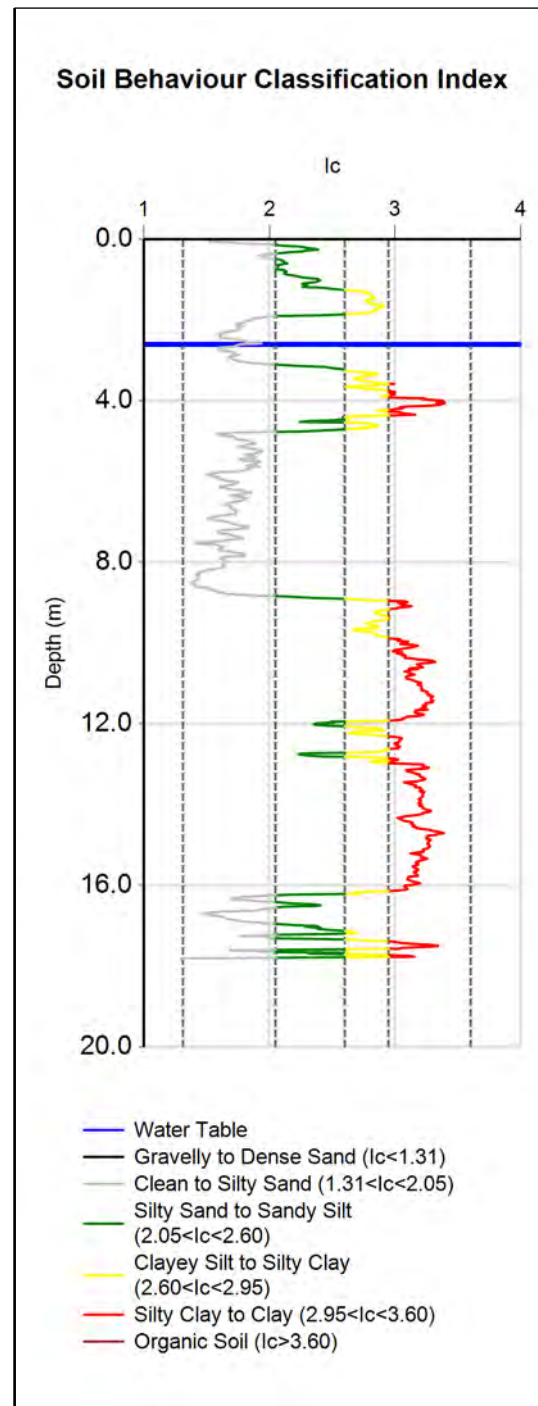
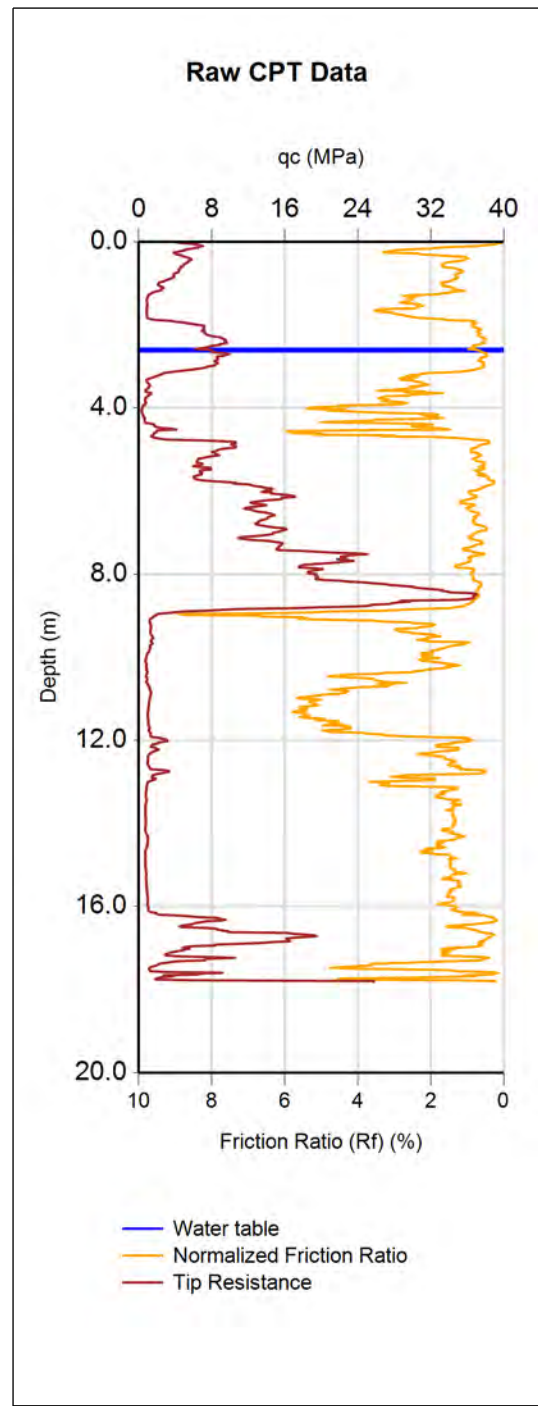


Cone No: 4221 100KN
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: HASTINGS	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: 25
Project ID: 31464	Client: TONKIN & TAYLOR LTD	Date: 10/02/2016	Scale: 1 : 110
Project: HASTINGS REZONE		Page: 1/1	Fig:
S 39.65594 E 176.86472		File: CPT25.CPT	

Appendix C: Liquefaction Analyses

- SLS Liquefaction Analyses
- ULS Liquefaction Analyses



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT01 - Coordina	60498	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	17.8	0						
	50%	0	0	0	0	17.8	0						
	85%	0	0	0	0	17.8	0						



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 1-4

LOCATION
Havelock Road / Howard Street

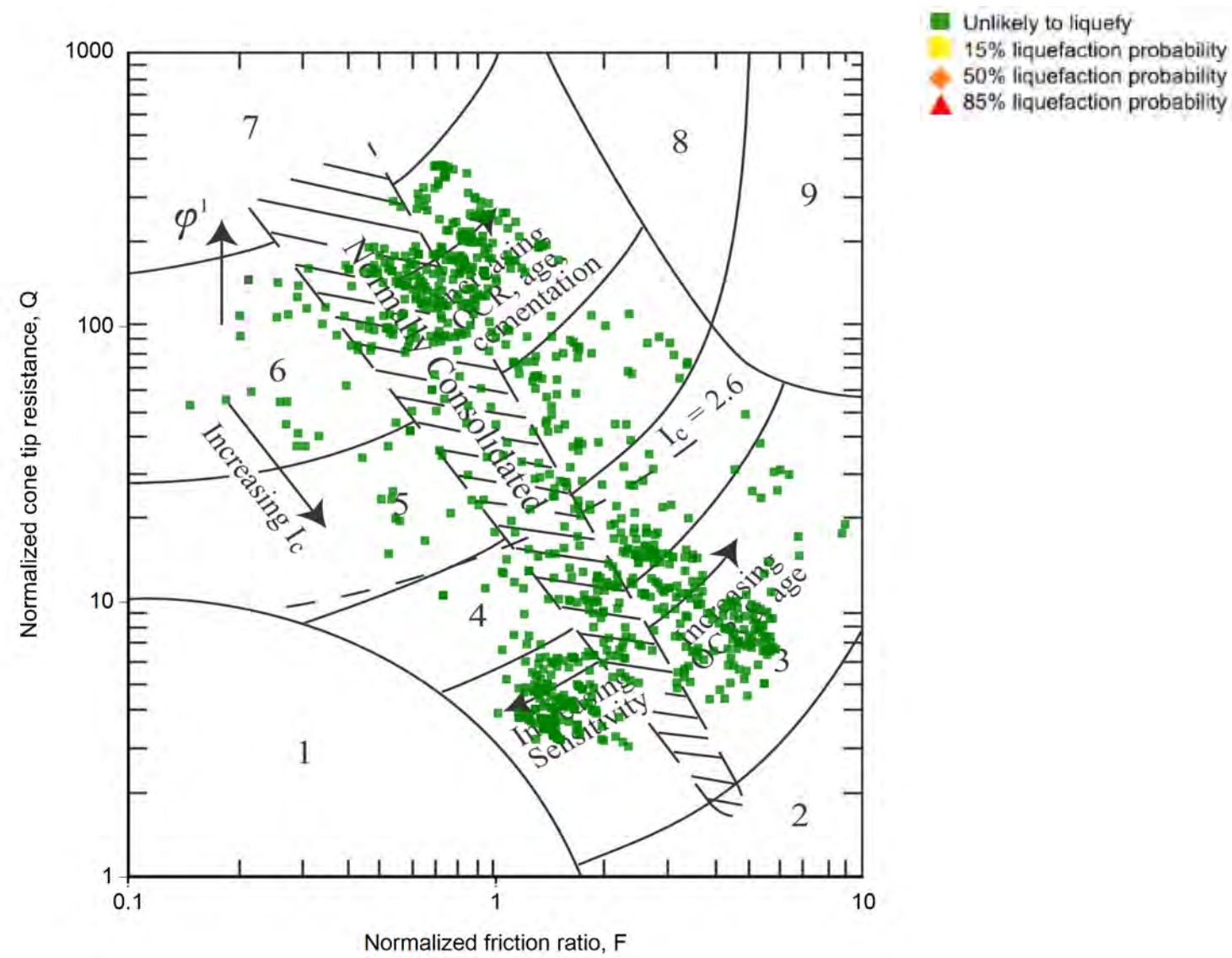
JOB NUMBER
31464.1000

DATE
17/02/2016

ANALYSED
cjc

CHECKED


PAGE
1 of 12 pages

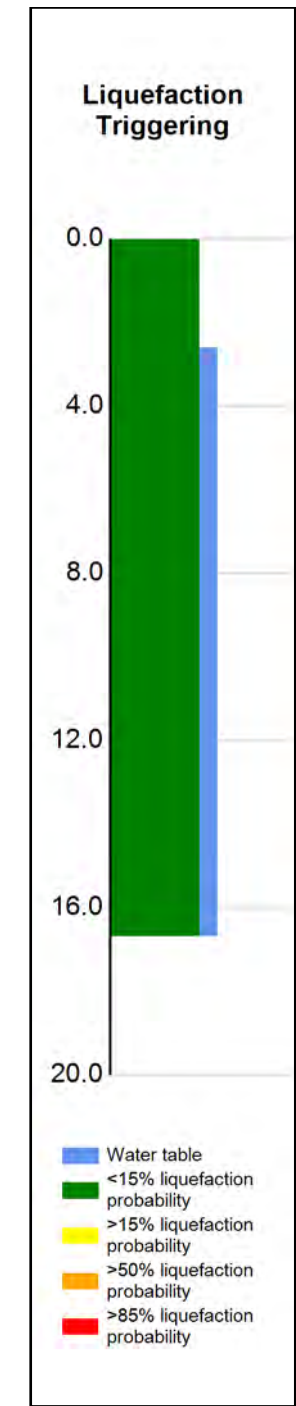
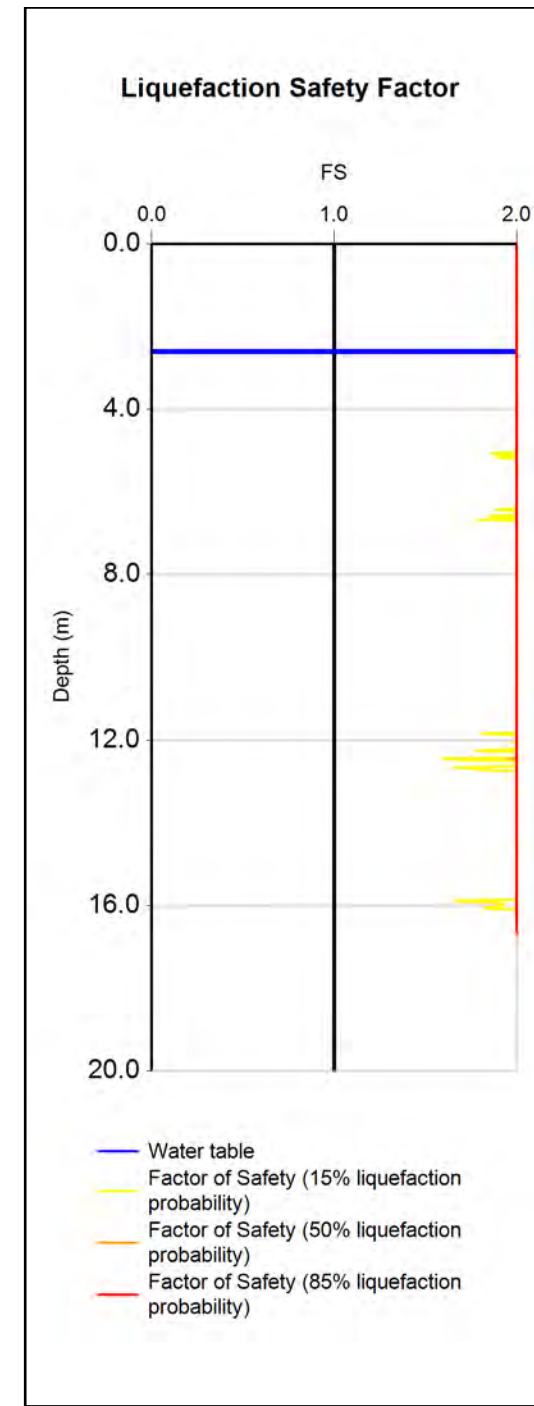
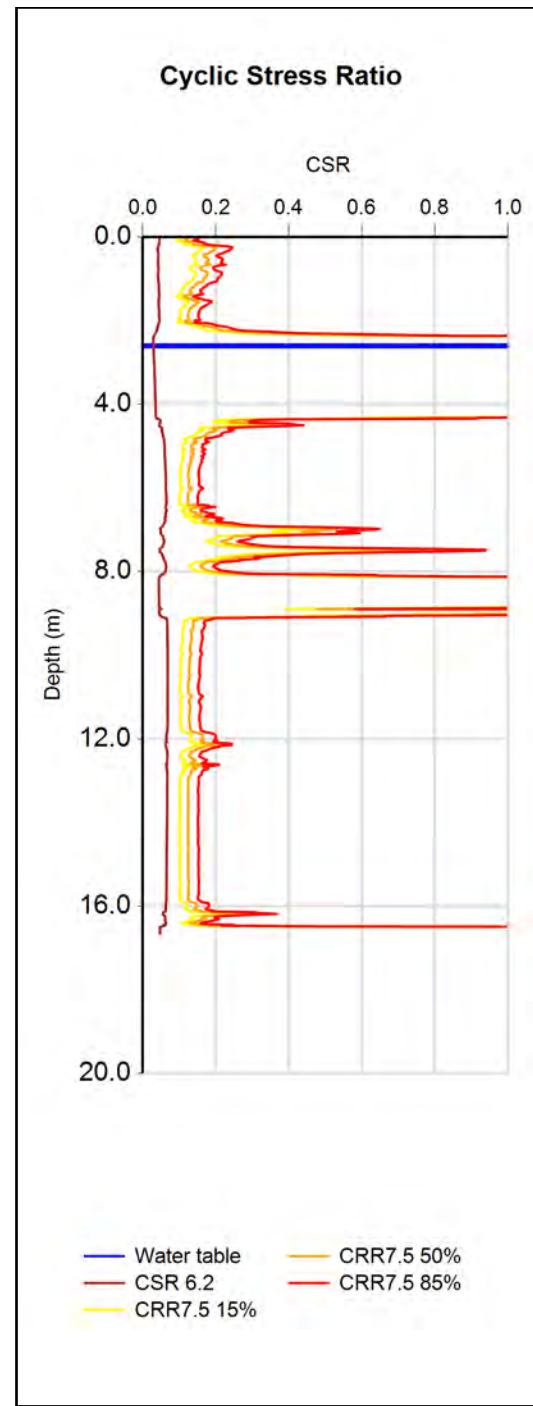
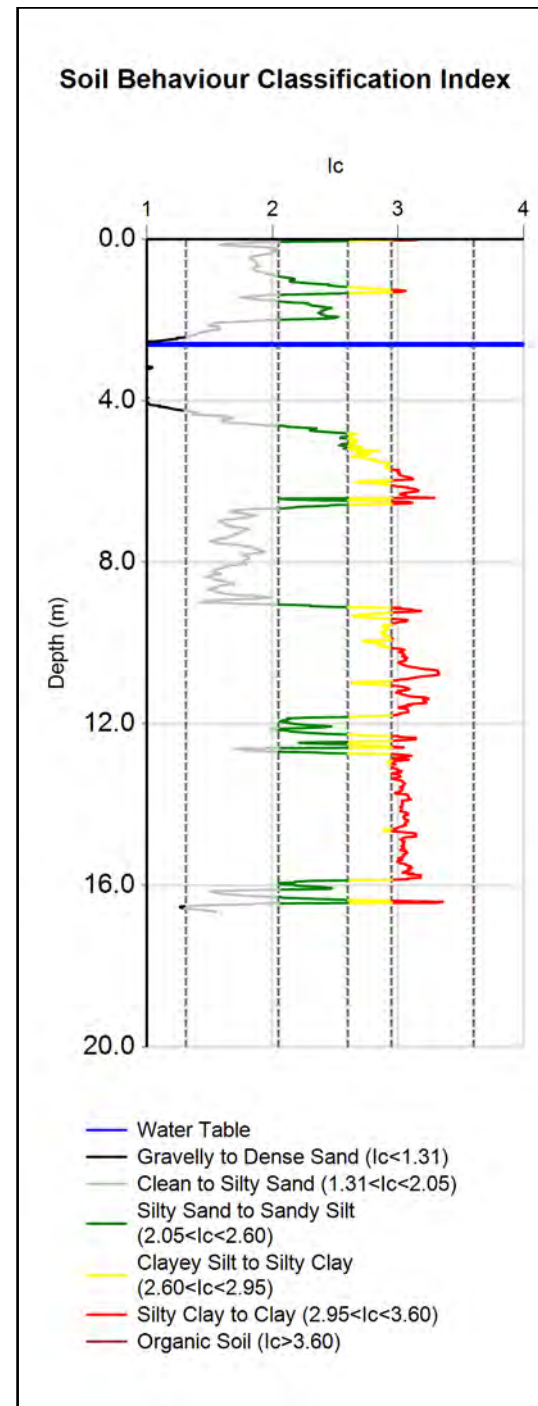
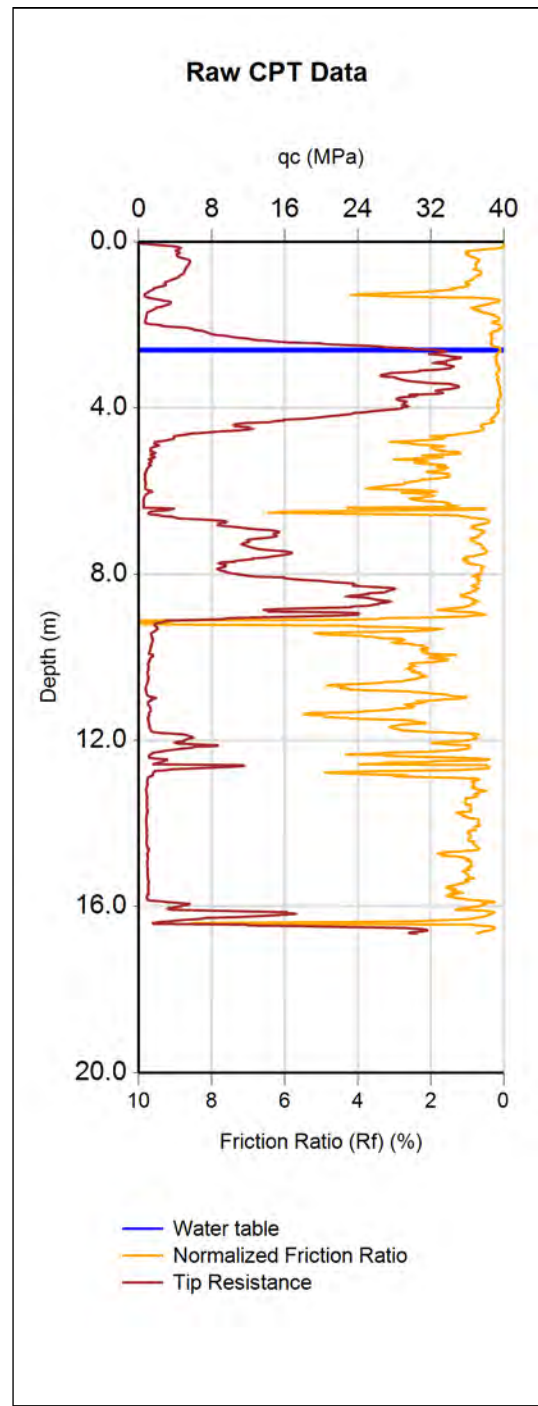


- | | |
|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
| 2. Organic soils - peats | 7. Gravelly sand to dense sand |
| 3. Clays - silty clay to clay | 8. Very stiff sand to clayey sand * |
| 4. Silt mixtures - clayey silt to silty clay | 9. Very stiff, fine grained * |
| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE SLS Liquefaction Assessment CPT 1-4	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT02	60500	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	16.7	0						
	50%	0	0	0	0	16.7	0						
	85%	0	0	0	0	16.7	0						



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 1-4

LOCATION
Havelock Road / Howard Street

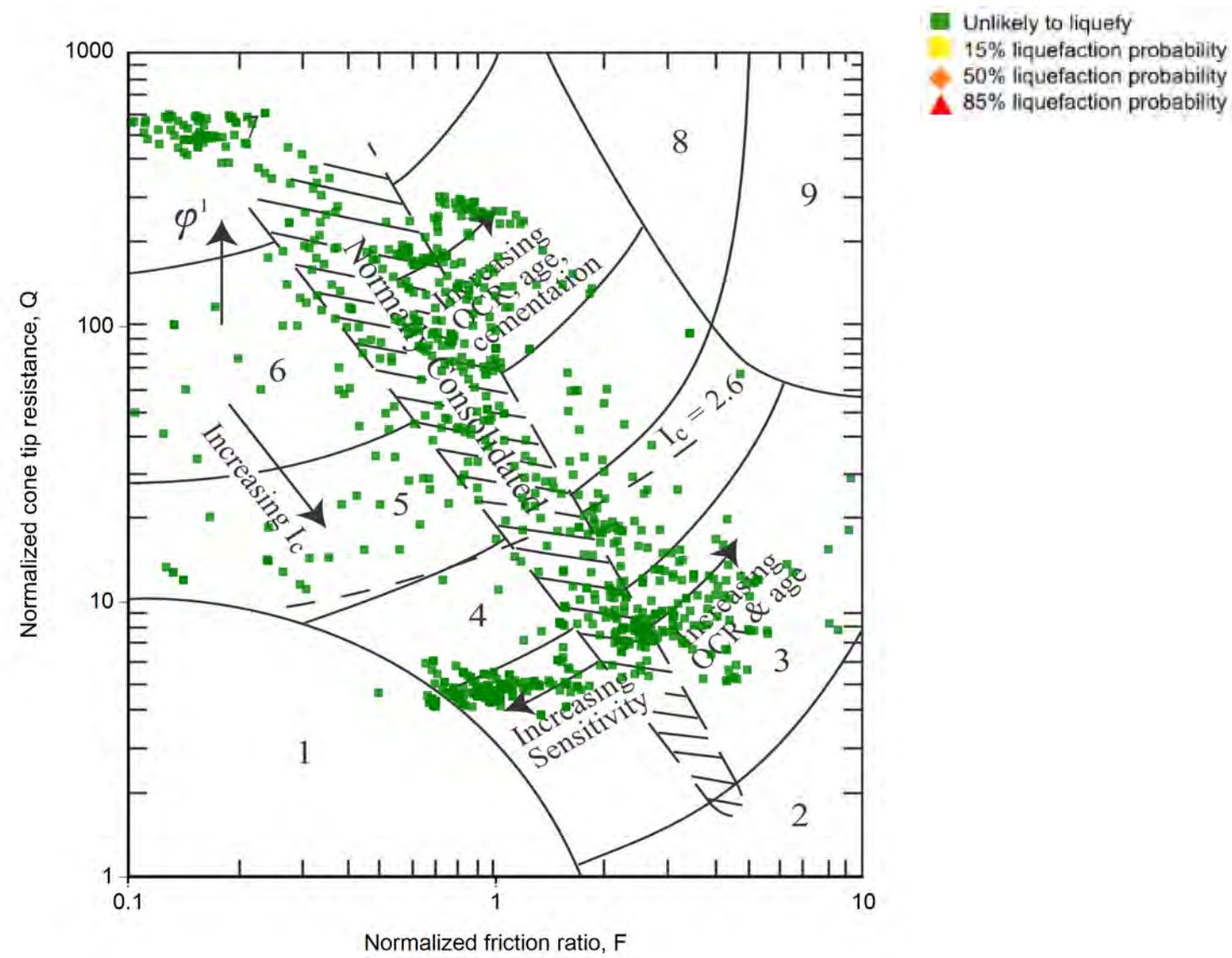
DATE
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ANALYSED
cjc

JOB NUMBER
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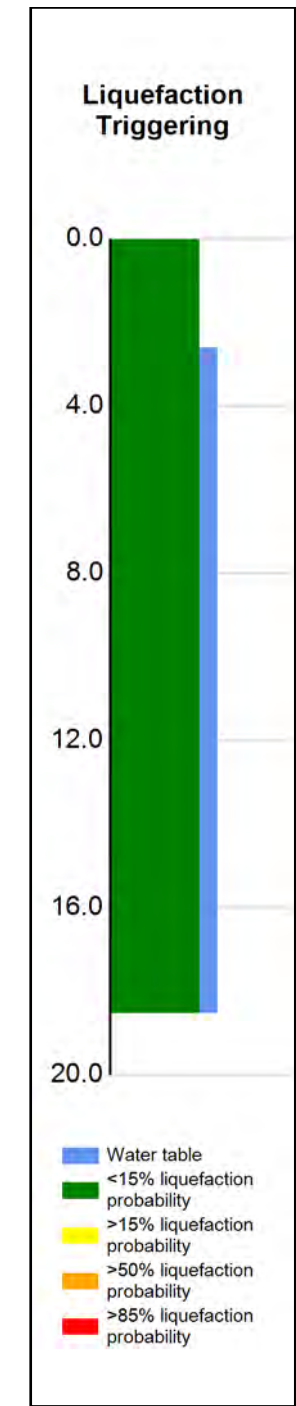
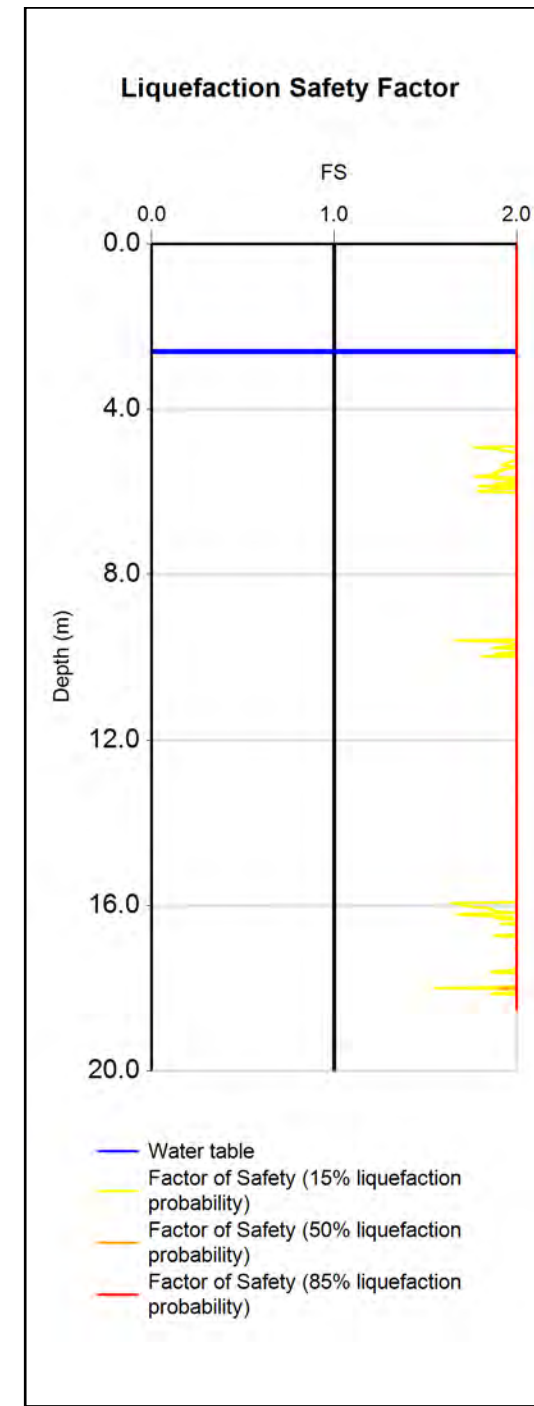
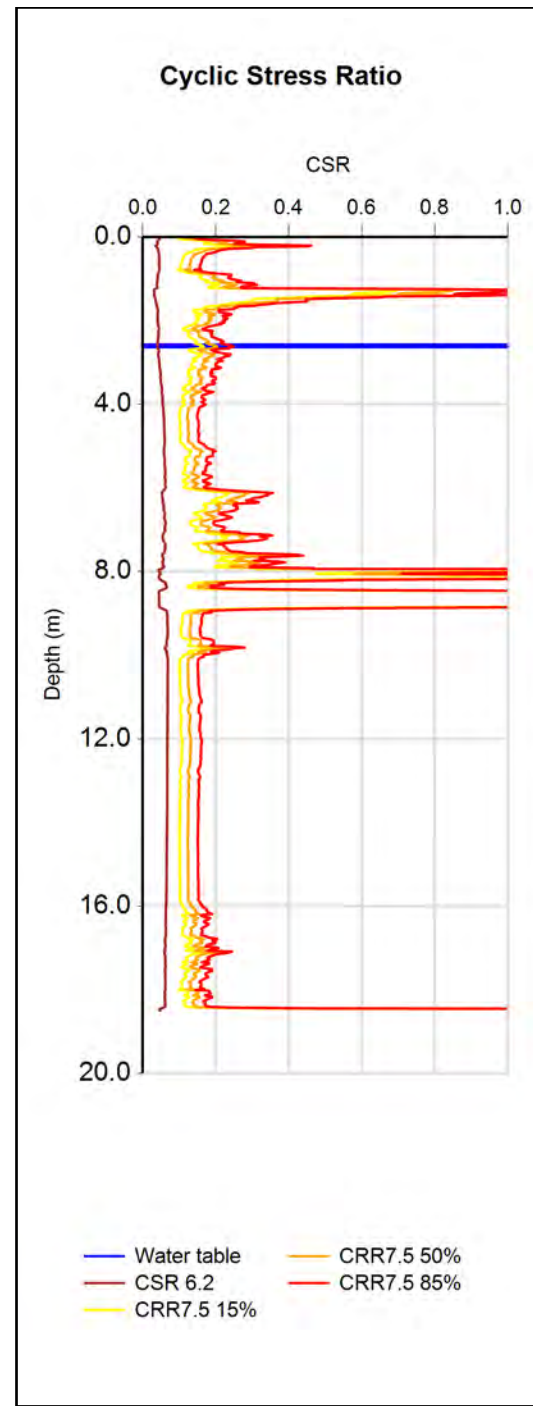
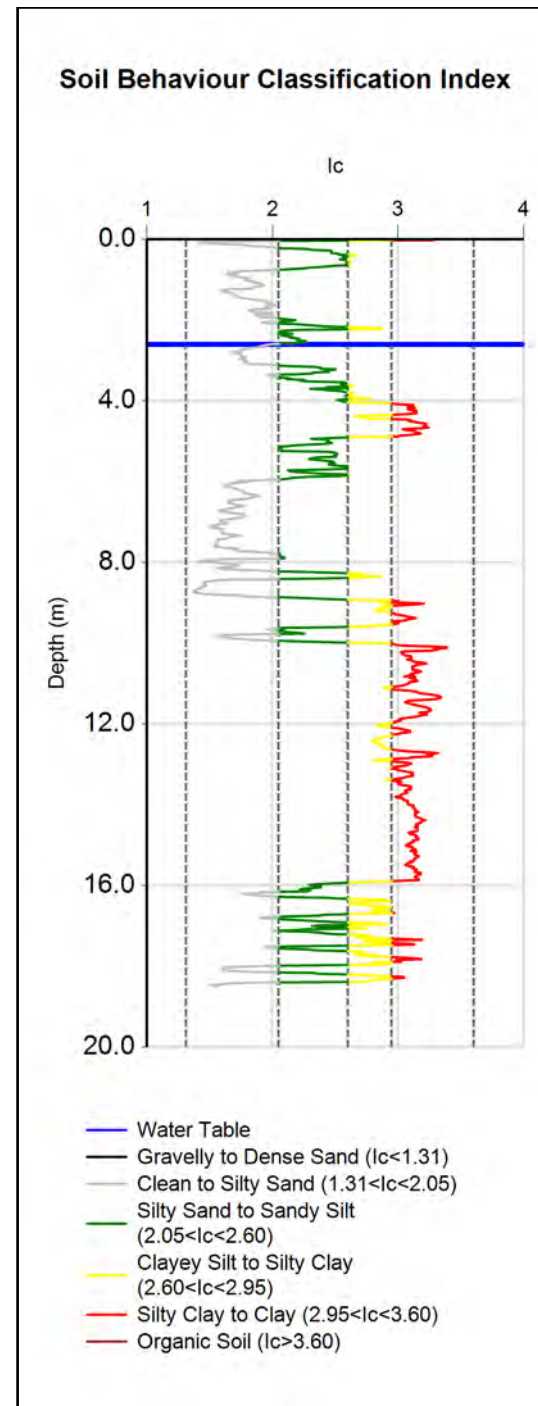
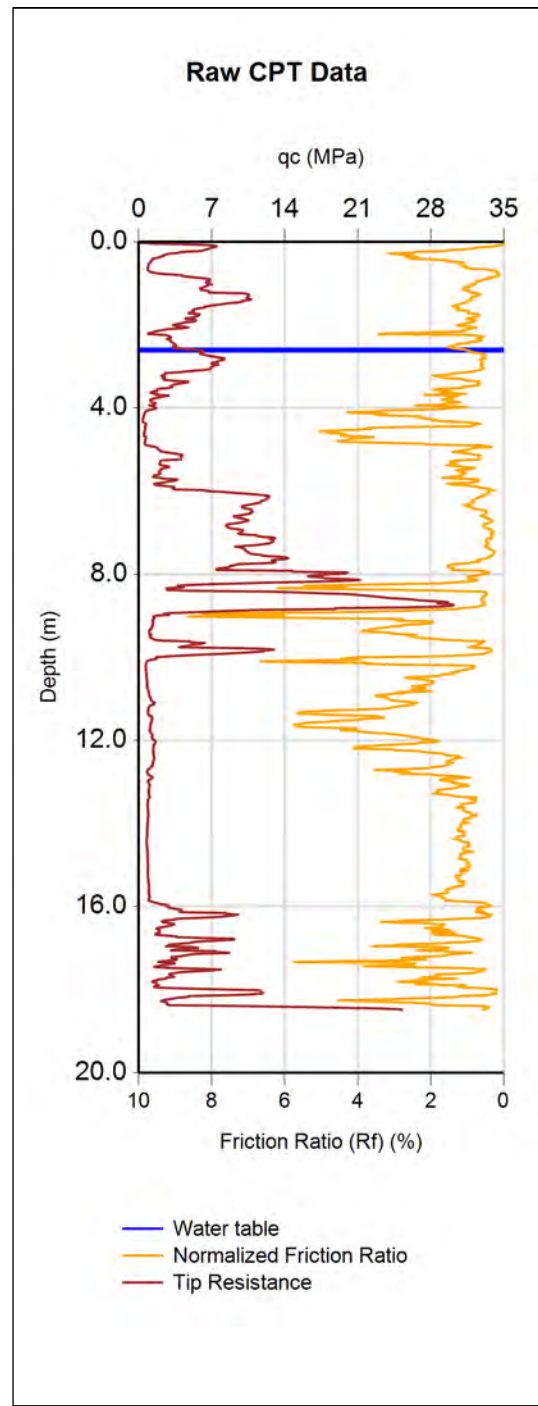


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
| 2. Organic soils - peats | 7. Gravelly sand to dense sand |
| 3. Clays - silty clay to clay | 8. Very stiff sand to clayey sand * |
| 4. Silt mixtures - clayey silt to silty clay | 9. Very stiff, fine grained * |
| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE SLS Liquefaction Assessment CPT 1-4	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT03	60501	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	1	0	0	0	18.5	0						
	50%	0	0	0	0	18.5	0						
	85%	0	0	0	0	18.5	0						



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 1-4

LOCATION
Havelock Road / Howard Street

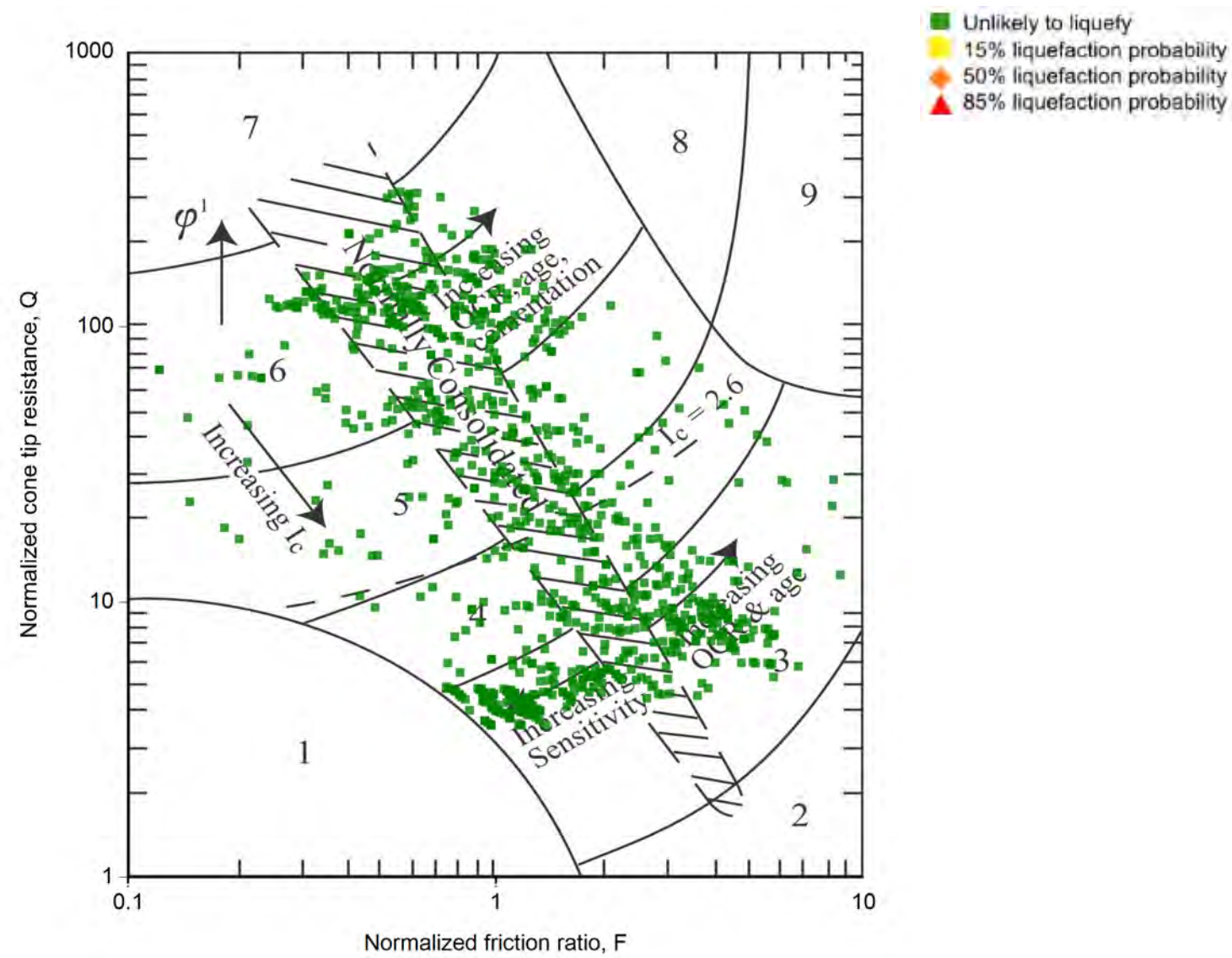
DATE
17/02/2016

ANALYSED
cjc

JOB NUMBER
31464.1000

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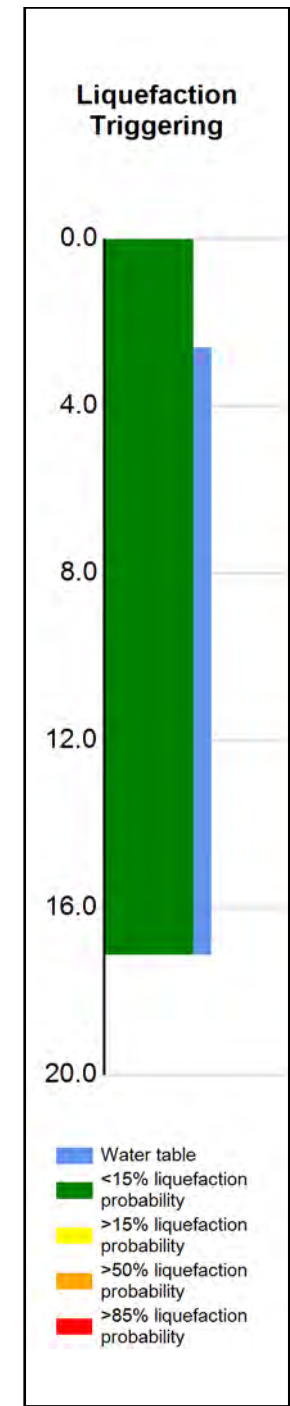
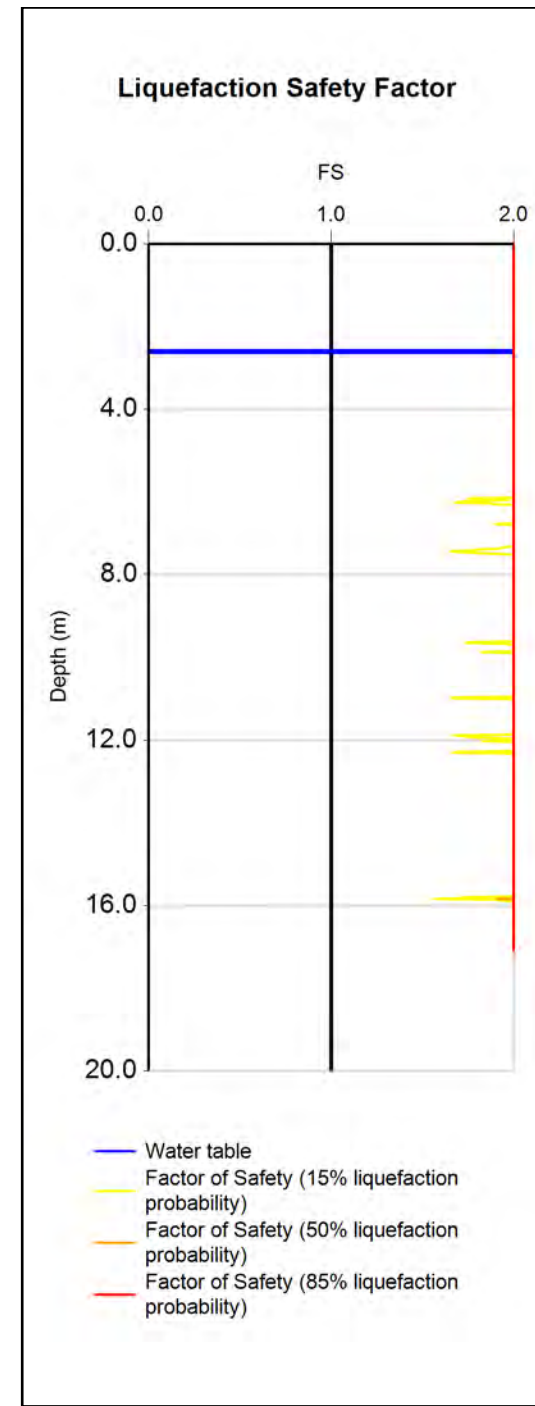
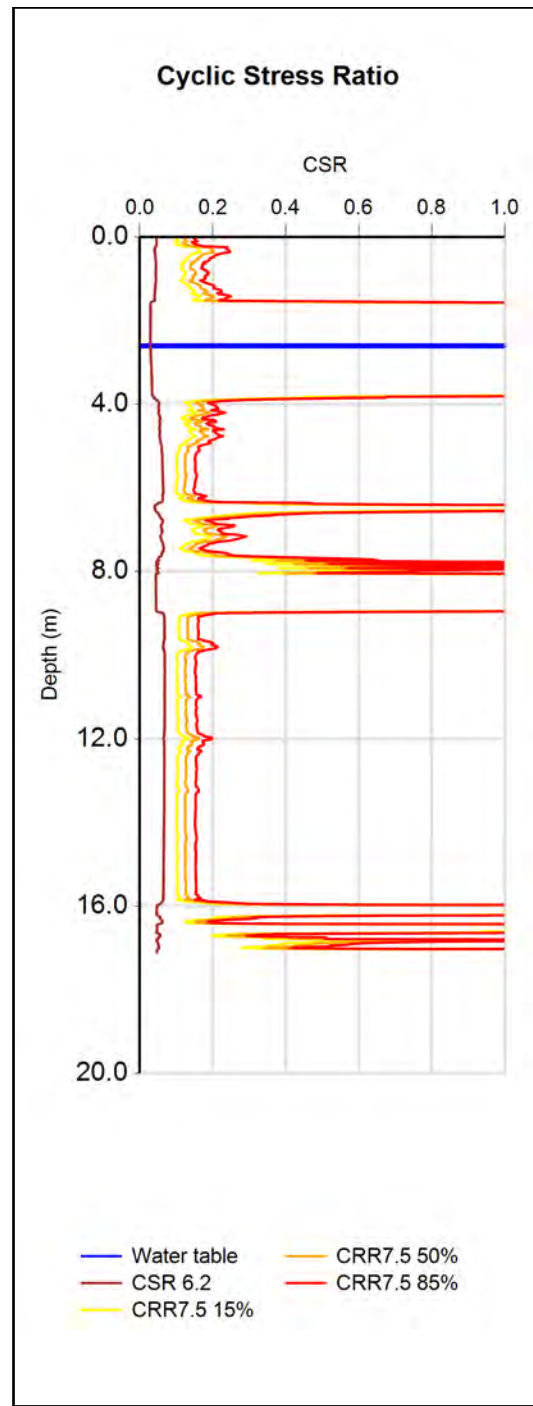
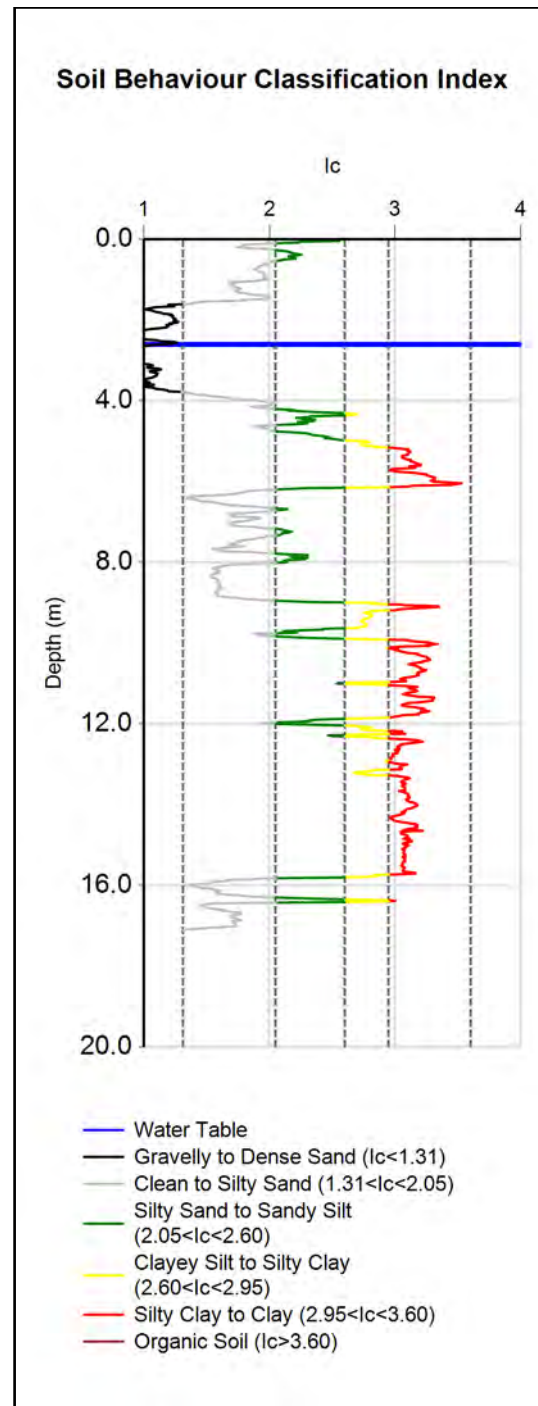
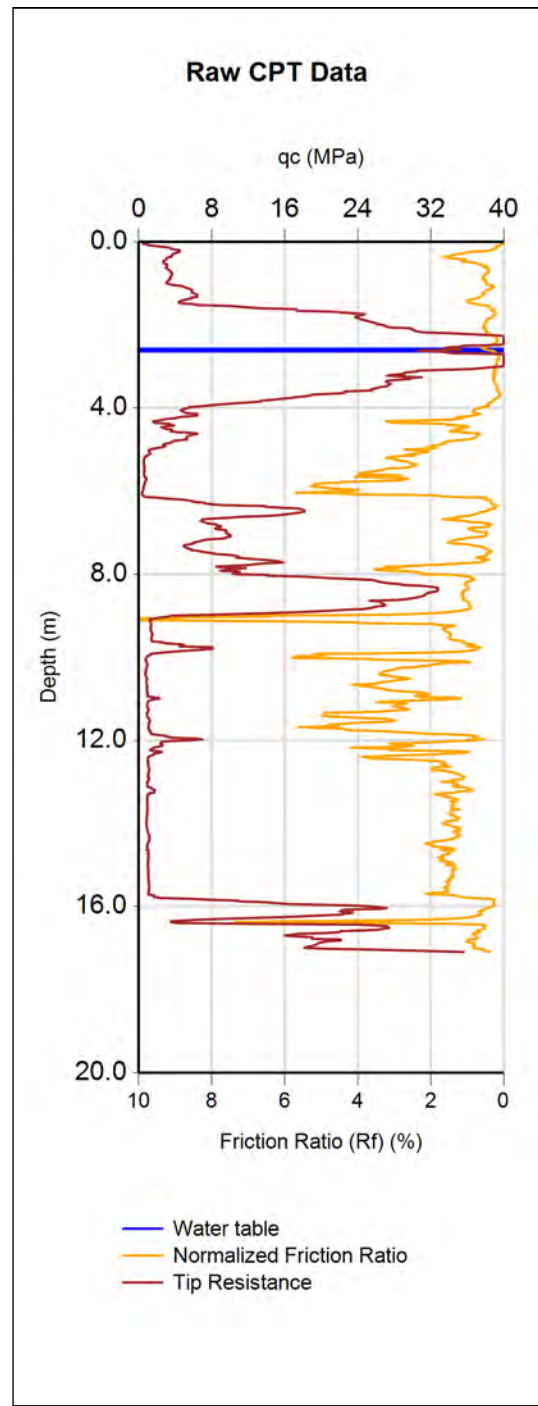


- | | |
|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
| 2. Organic soils - peats | 7. Gravelly sand to dense sand |
| 3. Clays - silty clay to clay | 8. Very stiff sand to clayey sand * |
| 4. Silt mixtures - clayey silt to silty clay | 9. Very stiff, fine grained * |
| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE SLS Liquefaction Assessment CPT 1-4	JOB NUMBER 31464.1000	ANALYSED cjc
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(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT04	60502	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	17.1	0						
	50%	0	0	0	0	17.1	0						
	85%	0	0	0	0	17.1	0						



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CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 1-4

LOCATION
Havelock Road / Howard Street

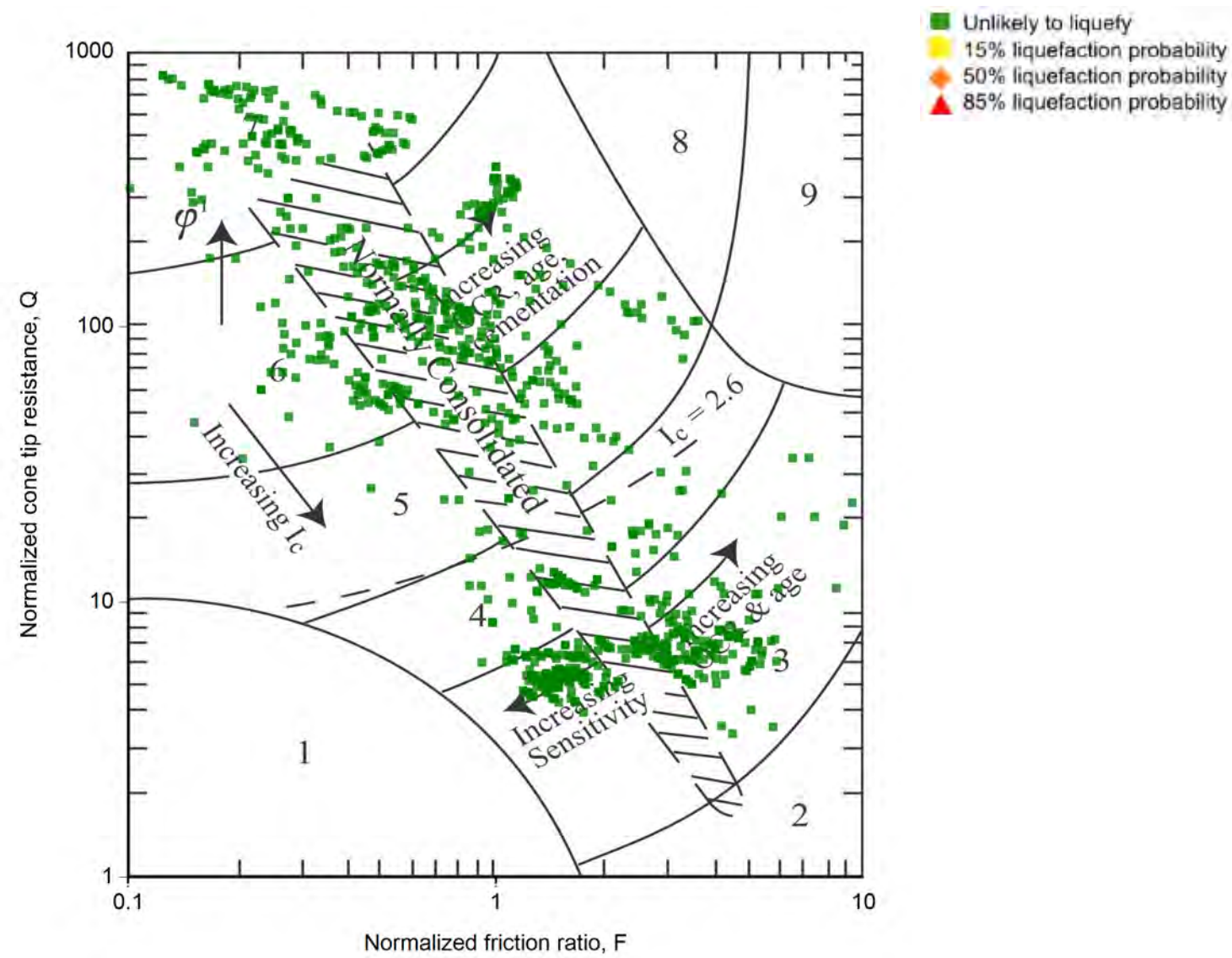
DATE
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JOB NUMBER
31464.1000

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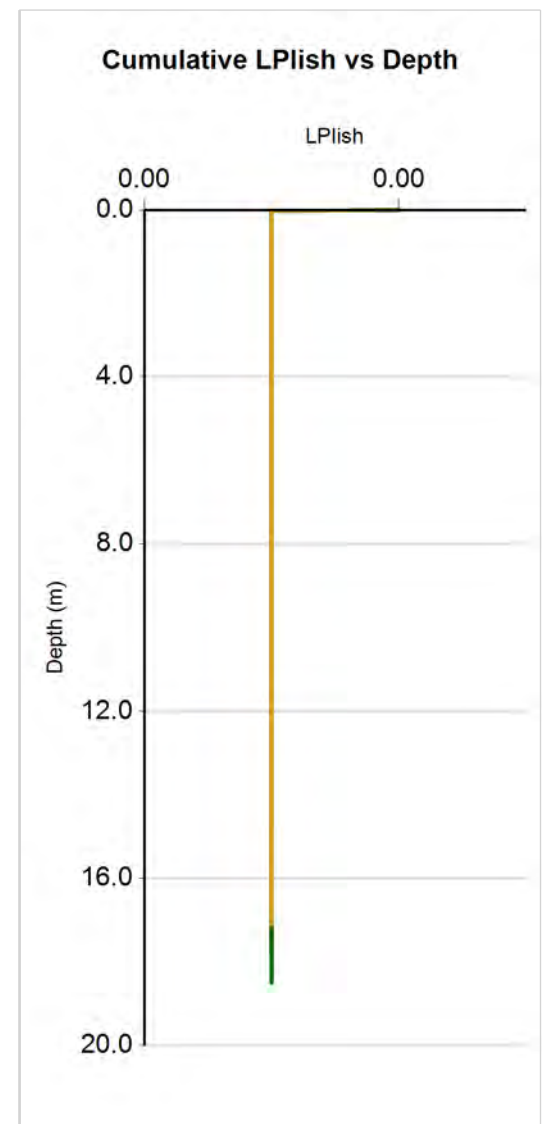
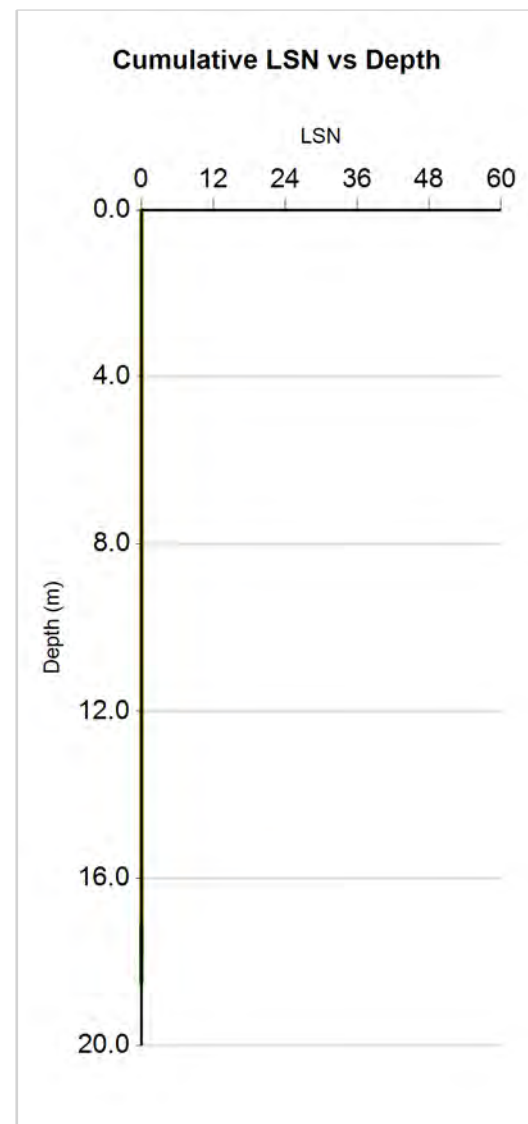
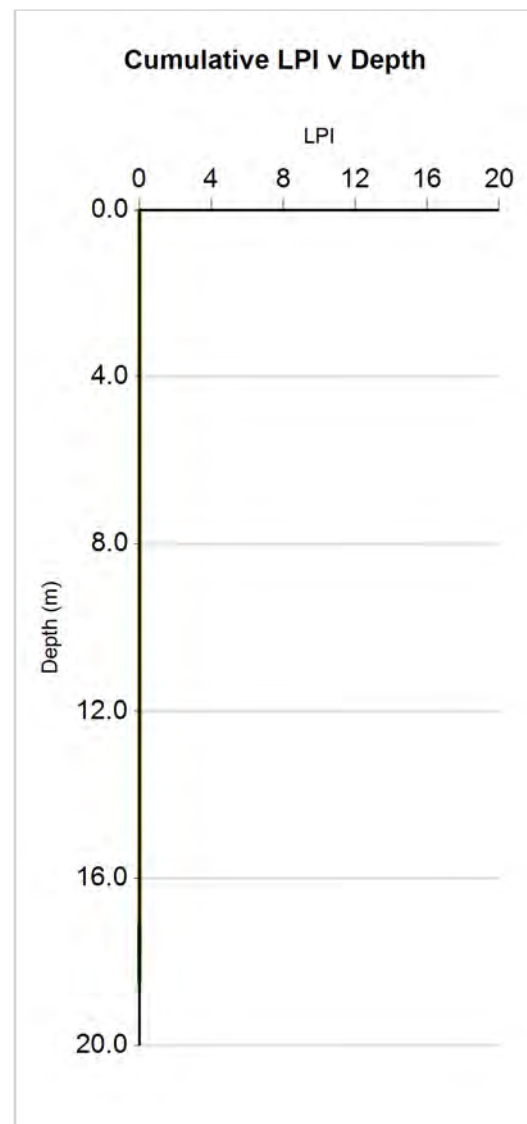
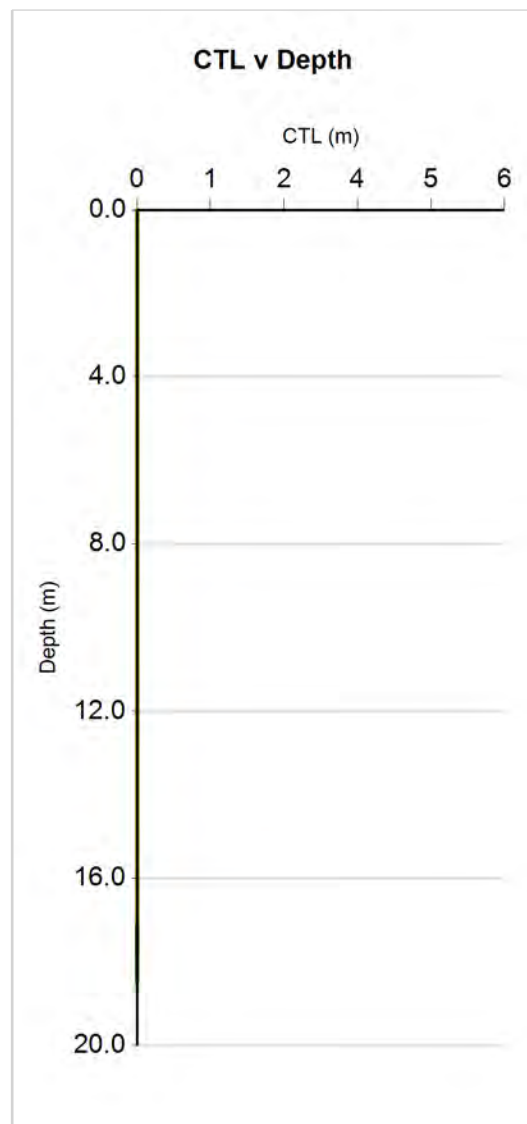
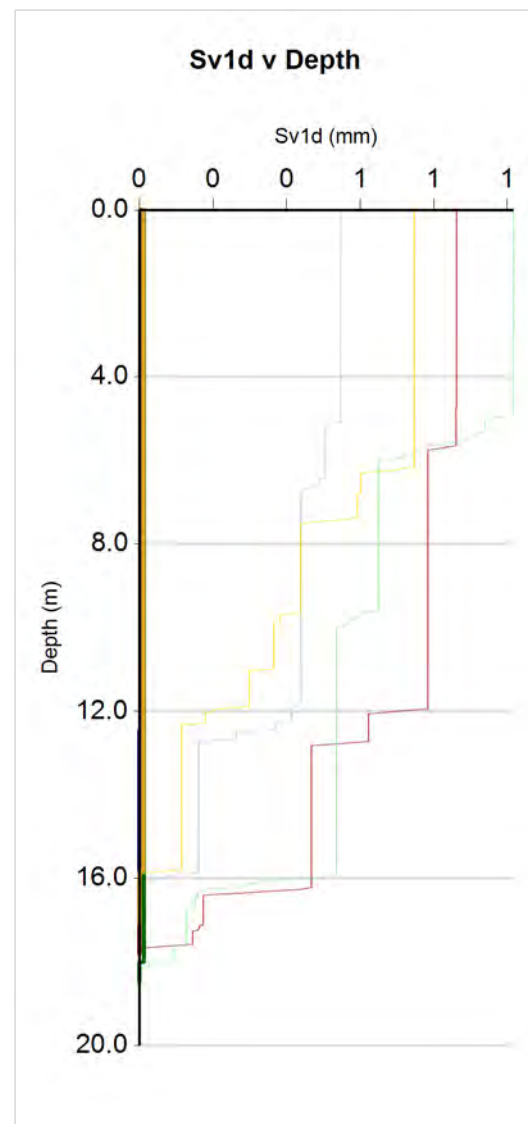


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
| 2. Organic soils - peats | 7. Gravelly sand to dense sand |
| 3. Clays - silty clay to clay | 8. Very stiff sand to clayey sand * |
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| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE SLS Liquefaction Assessment CPT 1-4	JOB NUMBER 31464.1000	ANALYSED cjc
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(Assumed pre-drill values)

CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT01 - Coordina	60498	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT02	60500	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT03	60501	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT04	60502	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



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CLIENT, PROJECT

Hastings District Council
Housing Rezone

TITLE

SLS Liquefaction Assessment CPT 1-4

LOCATION

Havelock Road /
Howard Street

JOB NUMBER

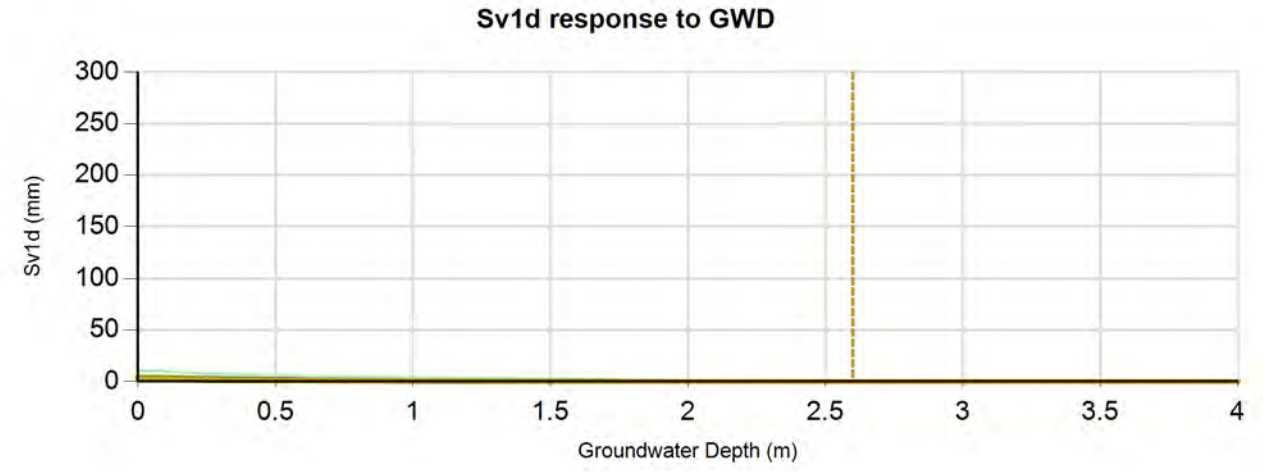
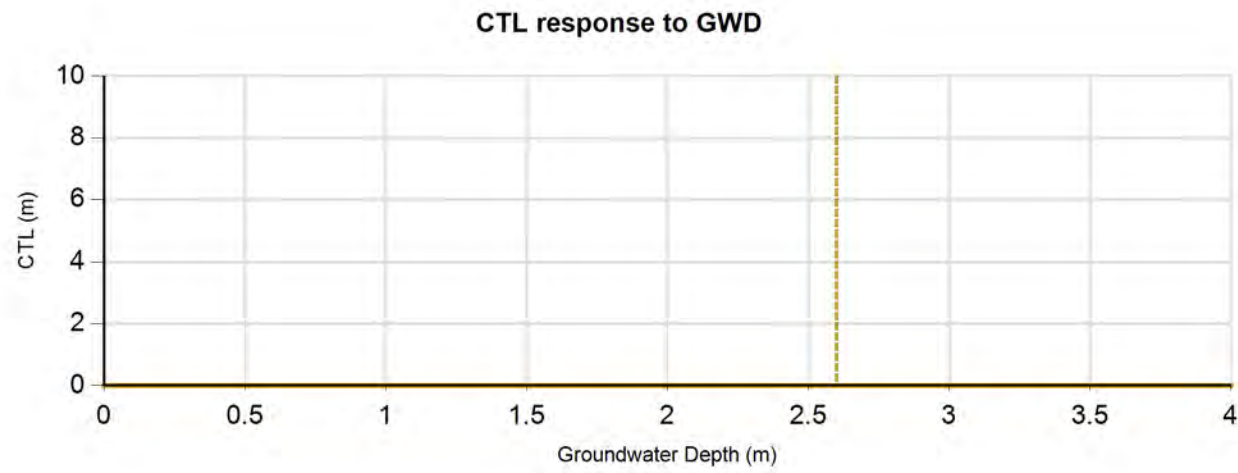
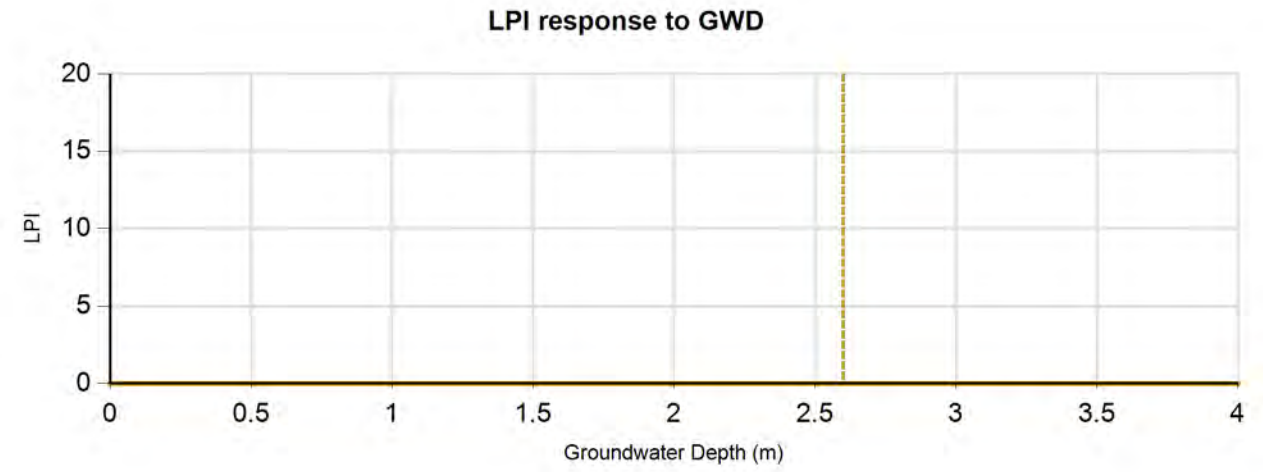
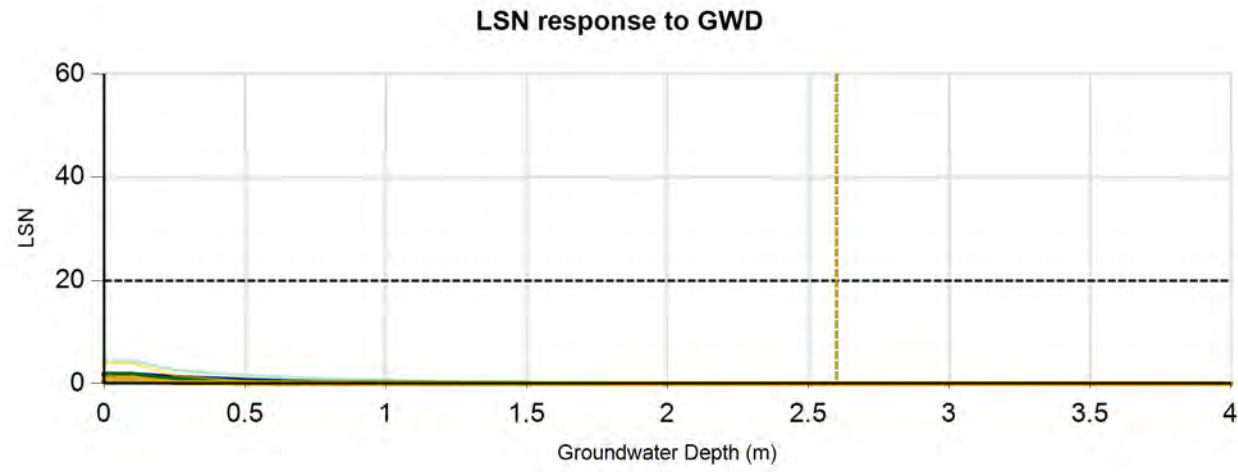
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DATE 17/02/2016

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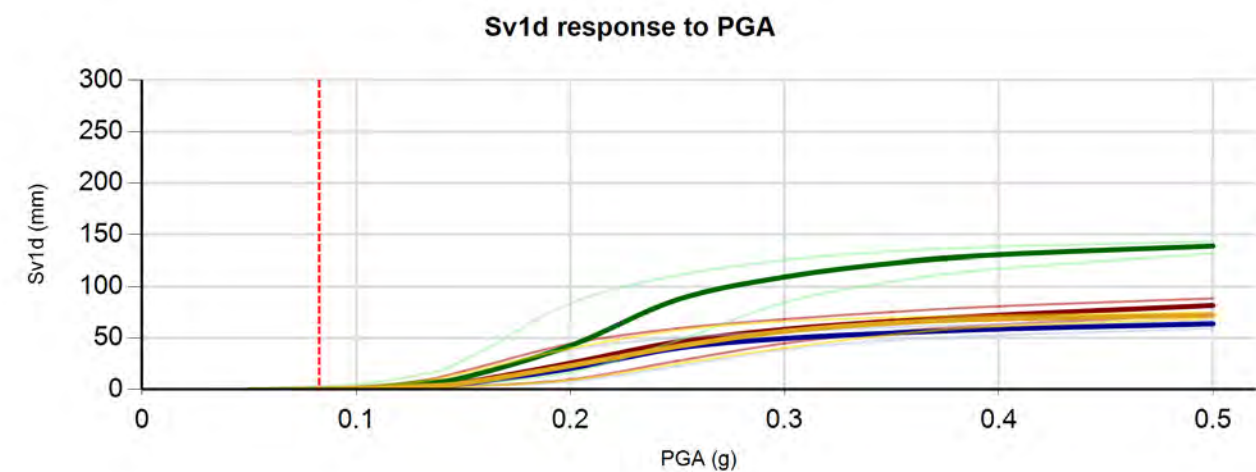
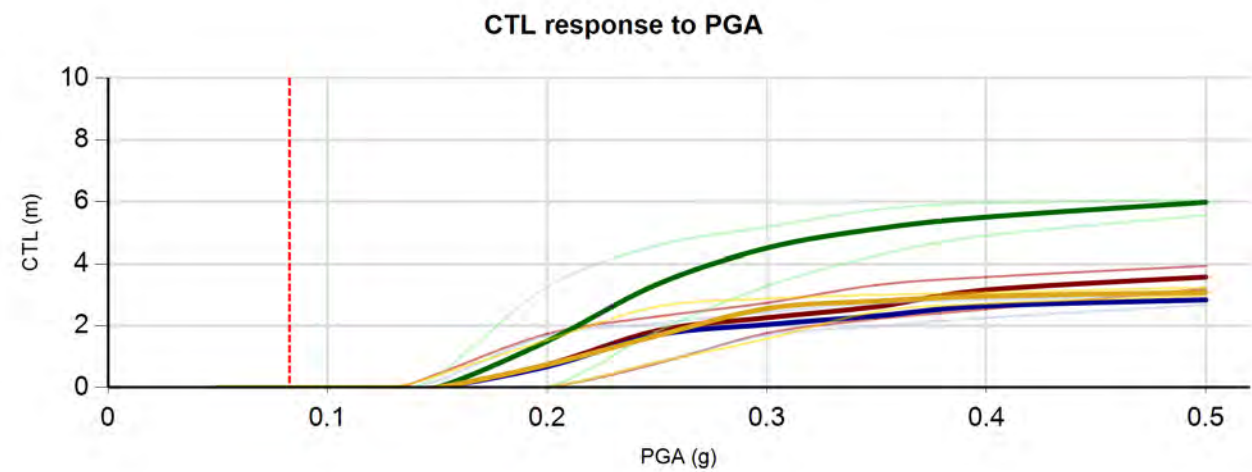
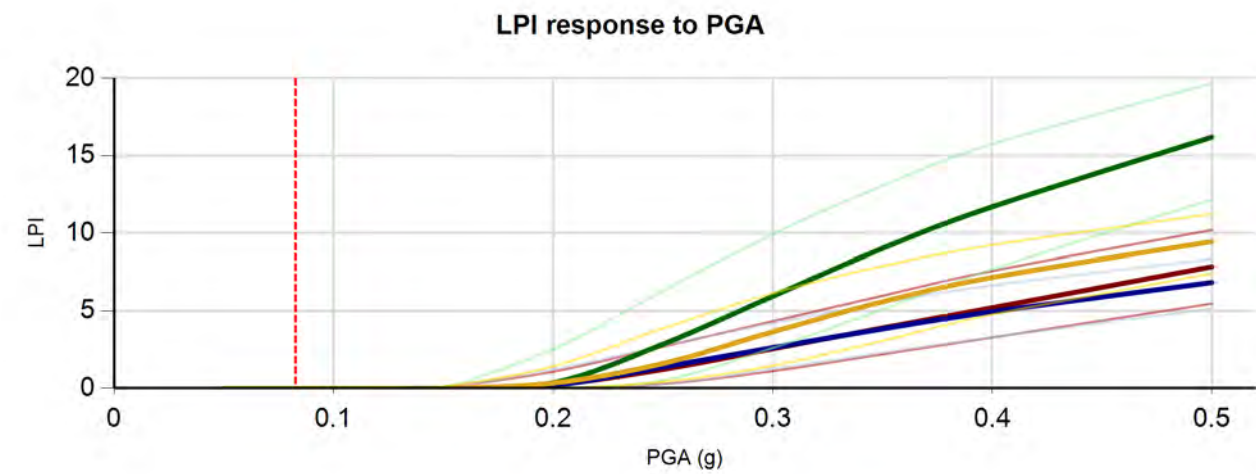
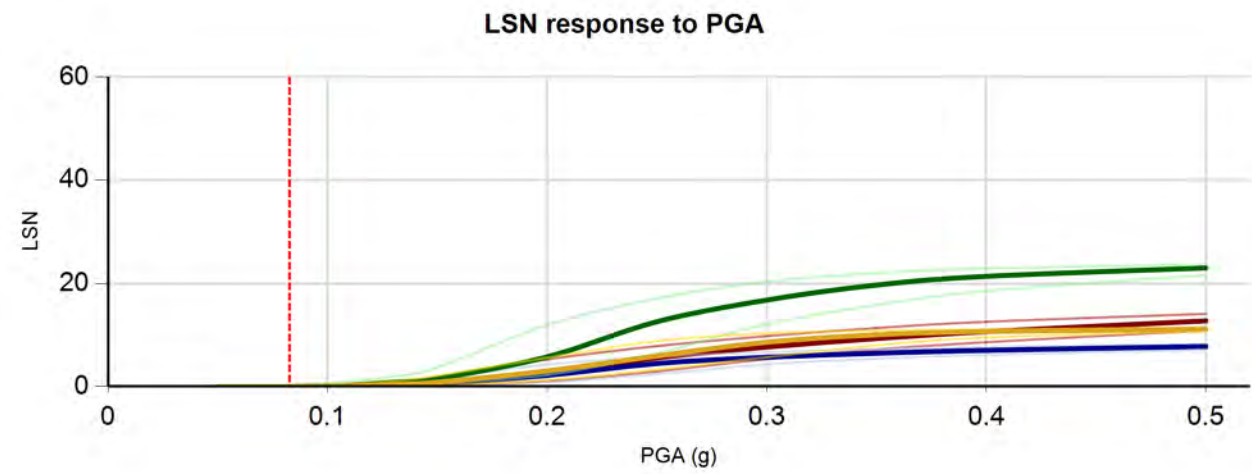
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Vertical dotted line/s indicate user specified GWD at the CPT locations. (actual GWD)

											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)	
CPT01 - Coordina	60498	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT02	60500	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT03	60501	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT04	60502	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT01 - Coordina	60498	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT02	60500	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT03	60501	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT04	60502	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18

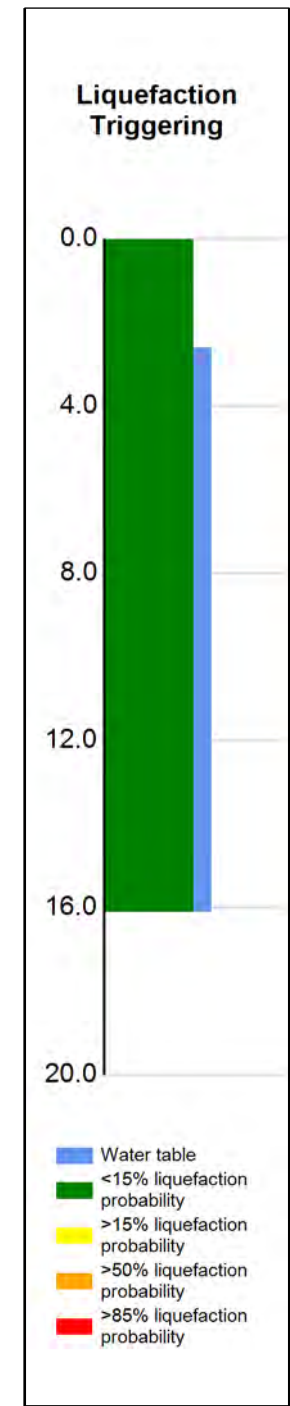
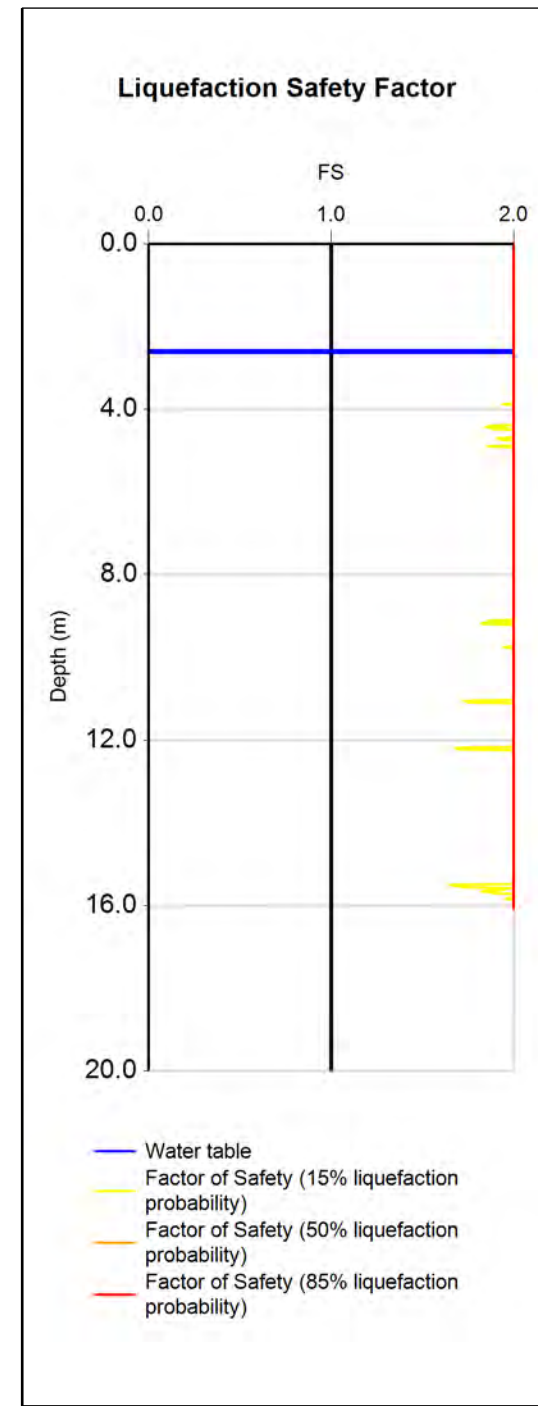
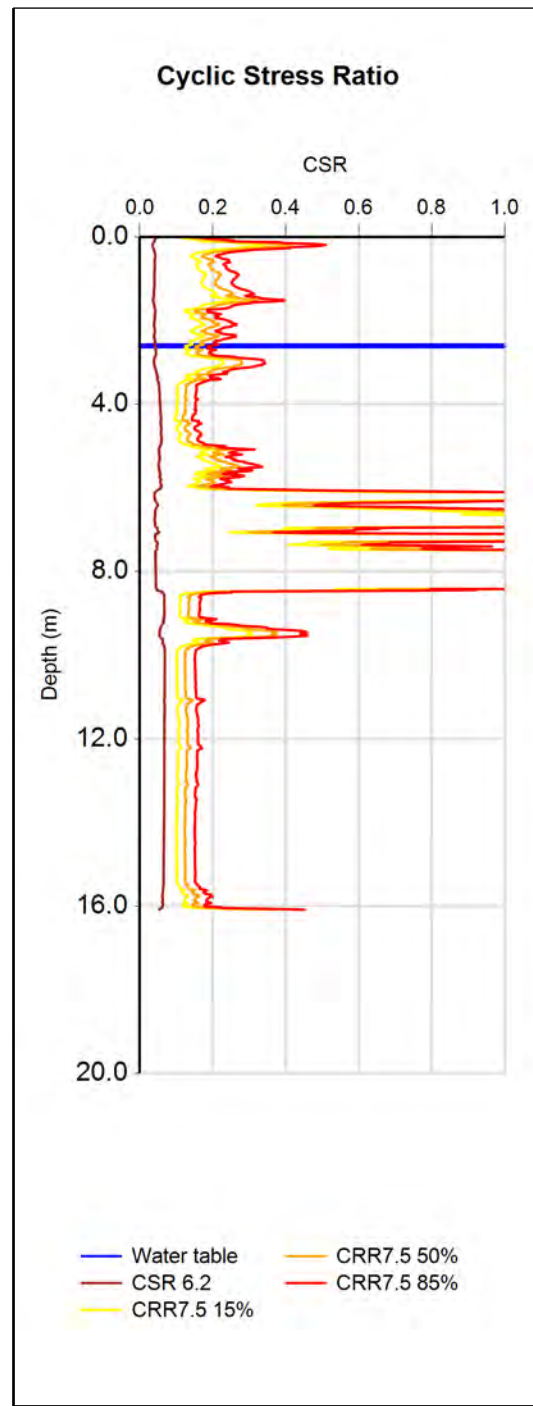
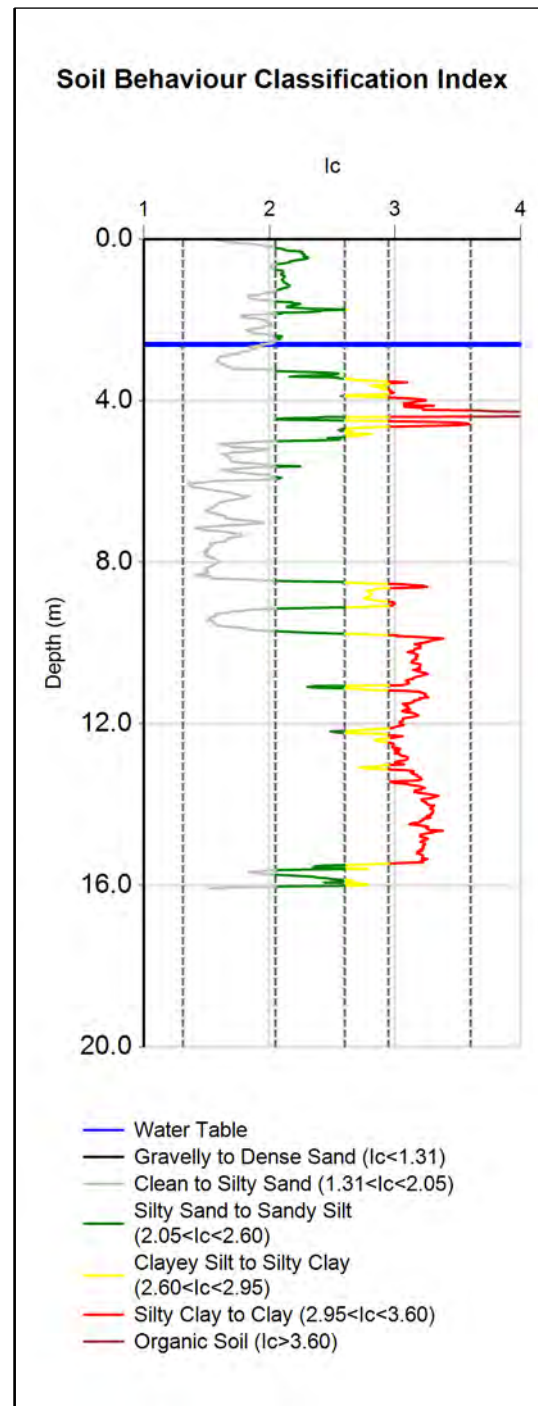
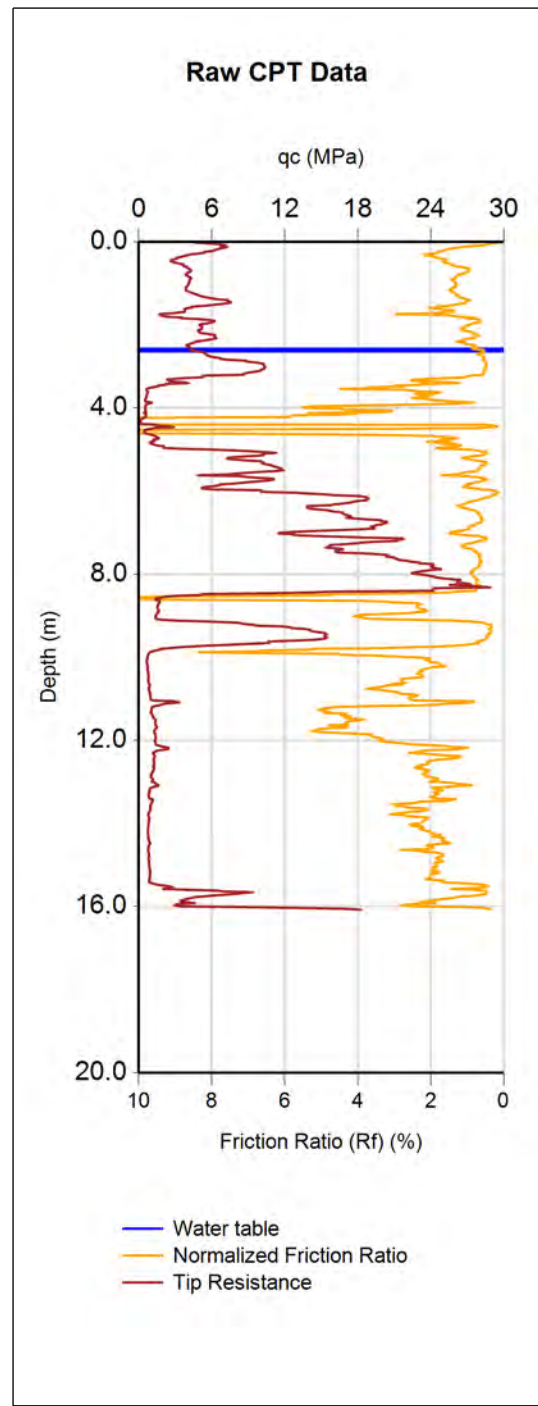
(Assumed pre-drill values)

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60498	60500	60501	60502
CPT Name	CPT01 - Coordinates	CPT02	CPT03	CPT04
PGA	0.0827g	0.0827g	0.0827g	0.0827g
Magnitude	6.2	6.2	6.2	6.2
Depth to groundwater	2.6m	2.6m	2.6m	2.6m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	17.82m	16.66m	18.5m	17.1m
Maximum depth of analysis	17.82m	16.66m	18.5m	17.1m
RL	n/a	n/a	n/a	n/a



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT05	60503	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	16.1	0						
	50%	0	0	0	0	16.1	0						
	85%	0	0	0	0	16.1	0						



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CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 5-8

LOCATION
Havelock Road / Howard Street

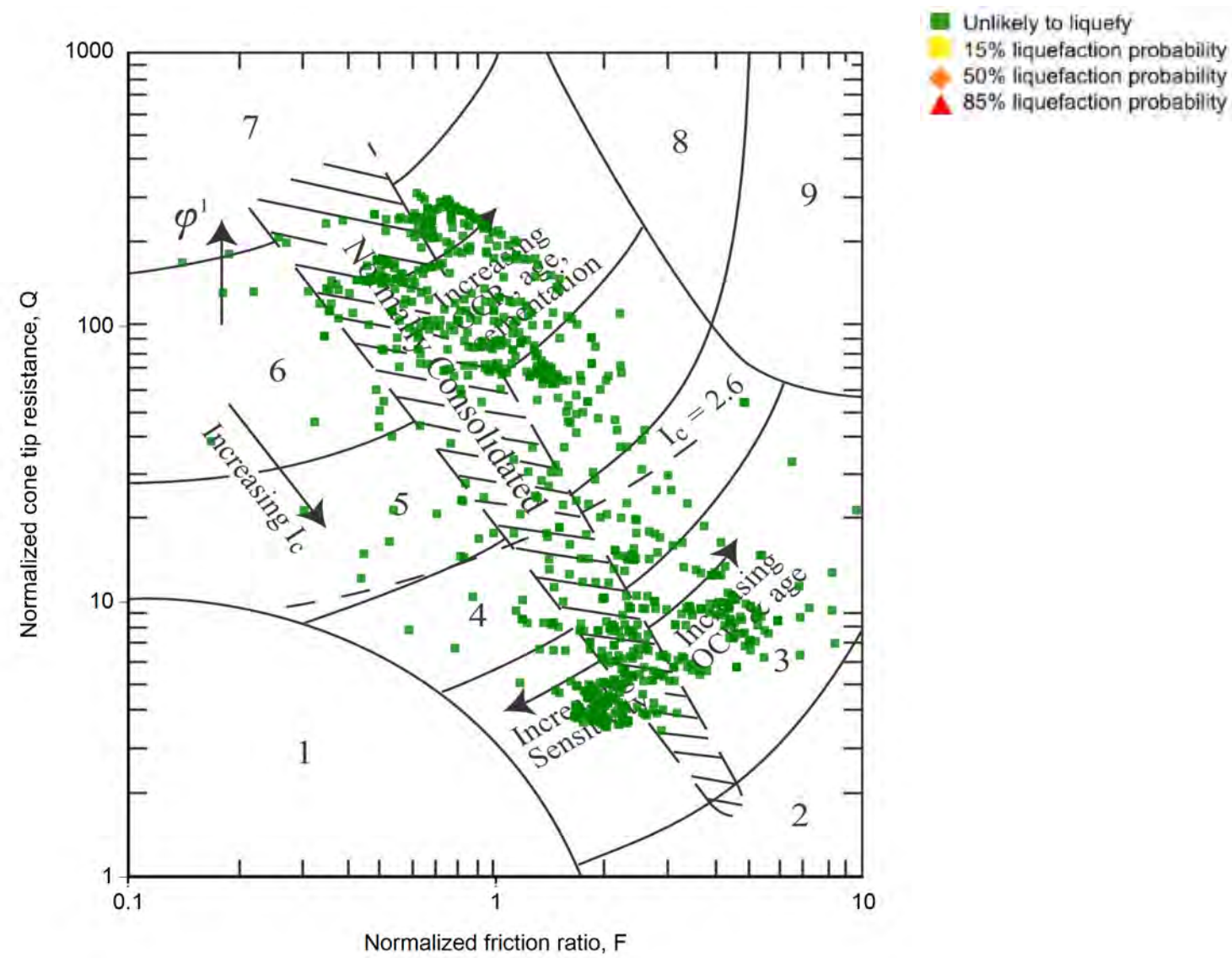
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| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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*Heavily overconsolidated or cemented

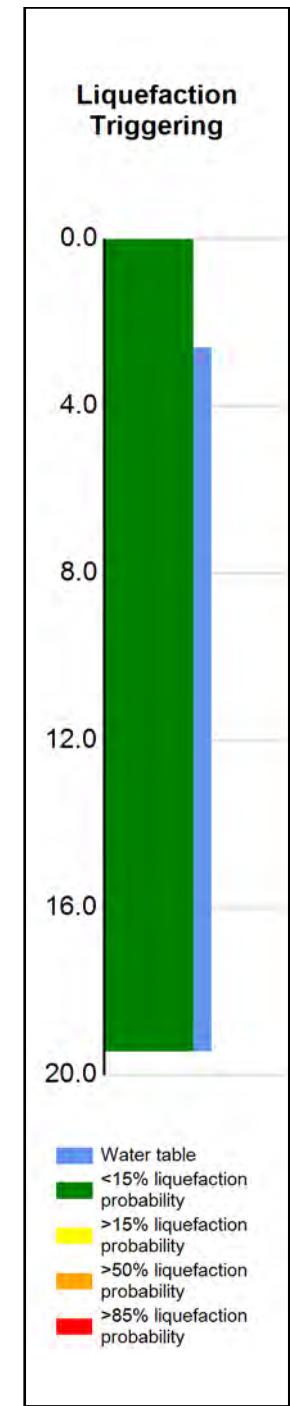
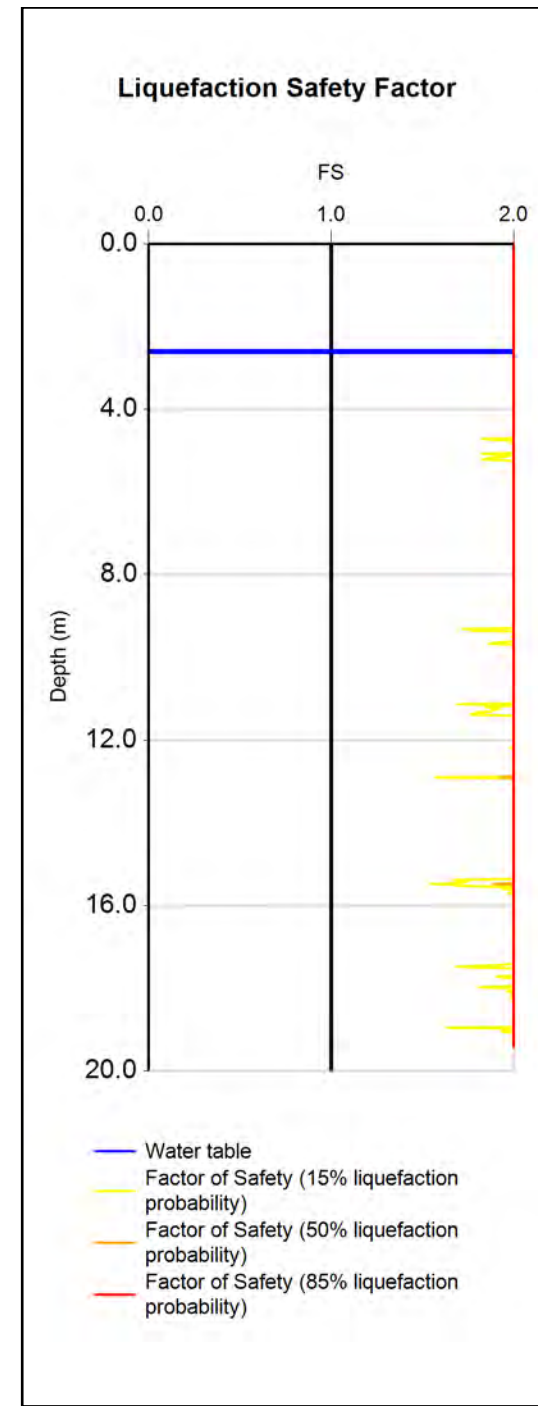
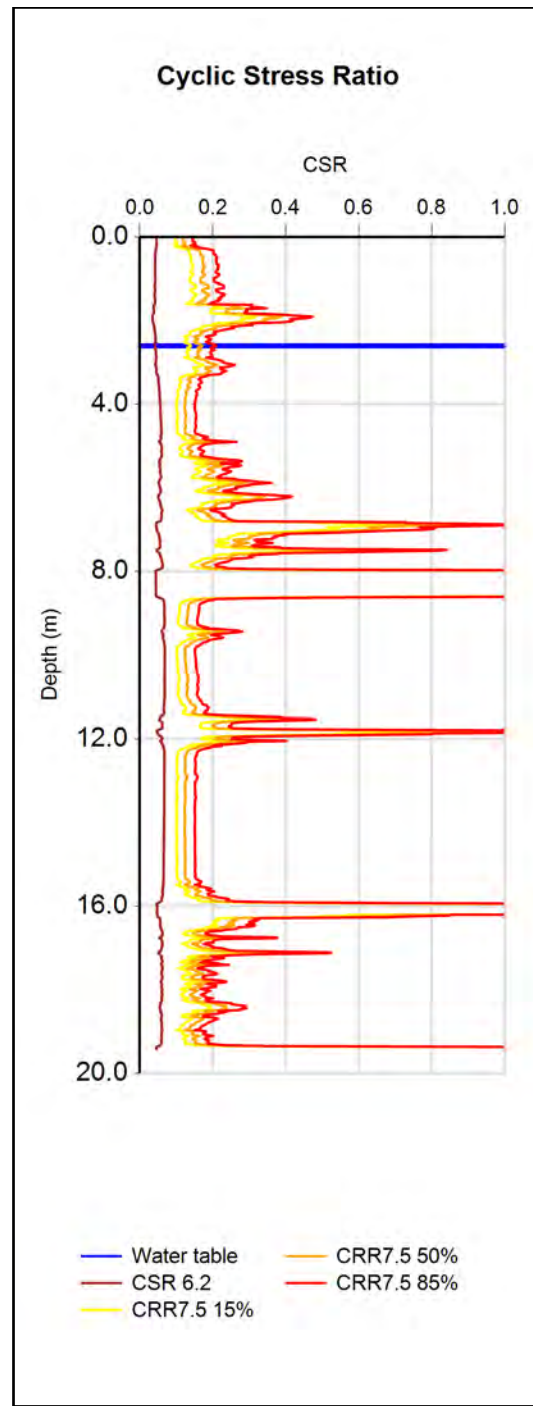
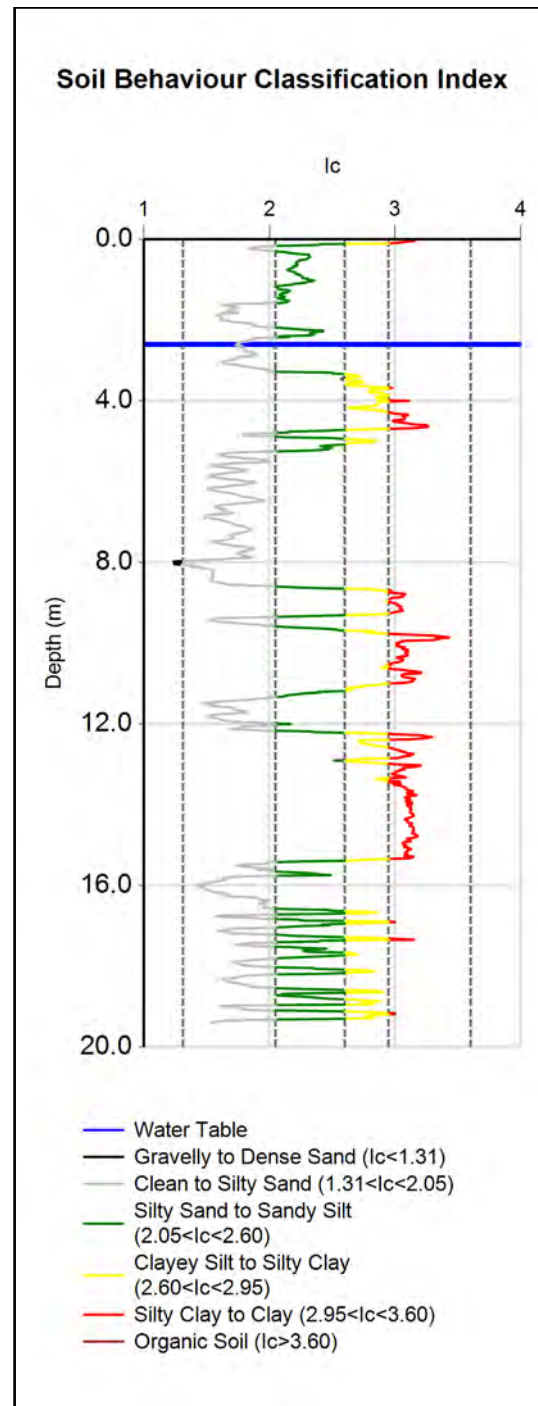
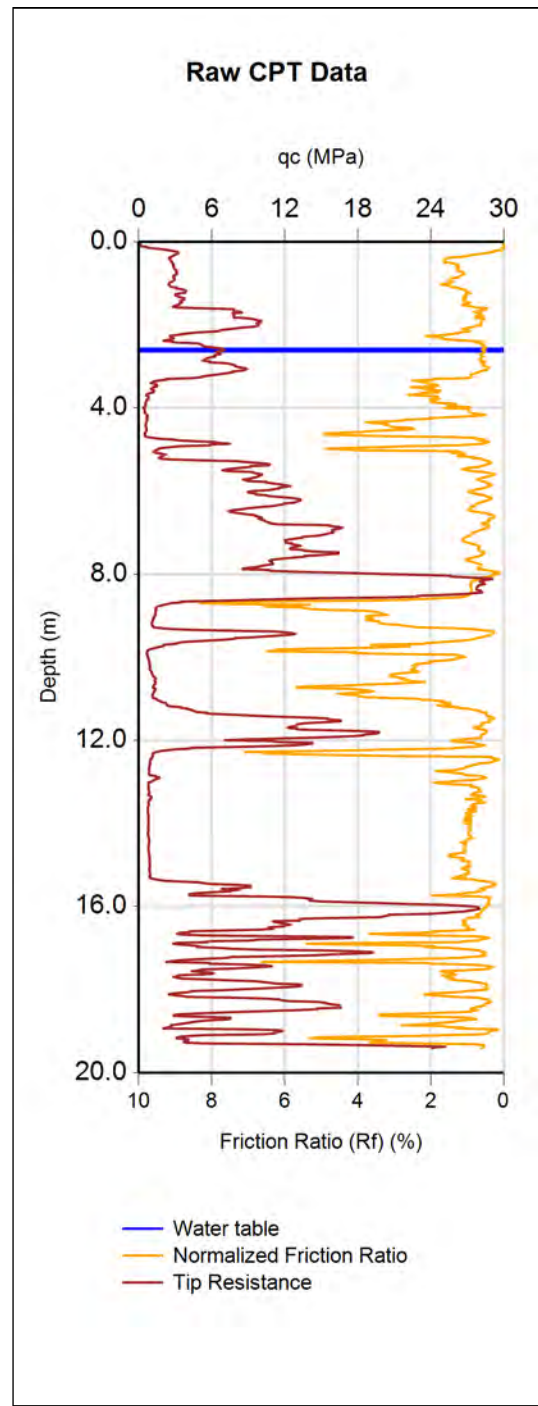
CPT-based soil behavior type classification chart by Robertson (1990)



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 5-8

LOCATION	Havelock Road / Howard Street	DATE	17/02/2016
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(Assumed pre-drill values)

INPUT	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
	CPT06	60504	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	1	0	0	0	19.4	0						
	50%	0	0	0	0	19.4	0						
	85%	0	0	0	0	19.4	0						



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CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 5-8

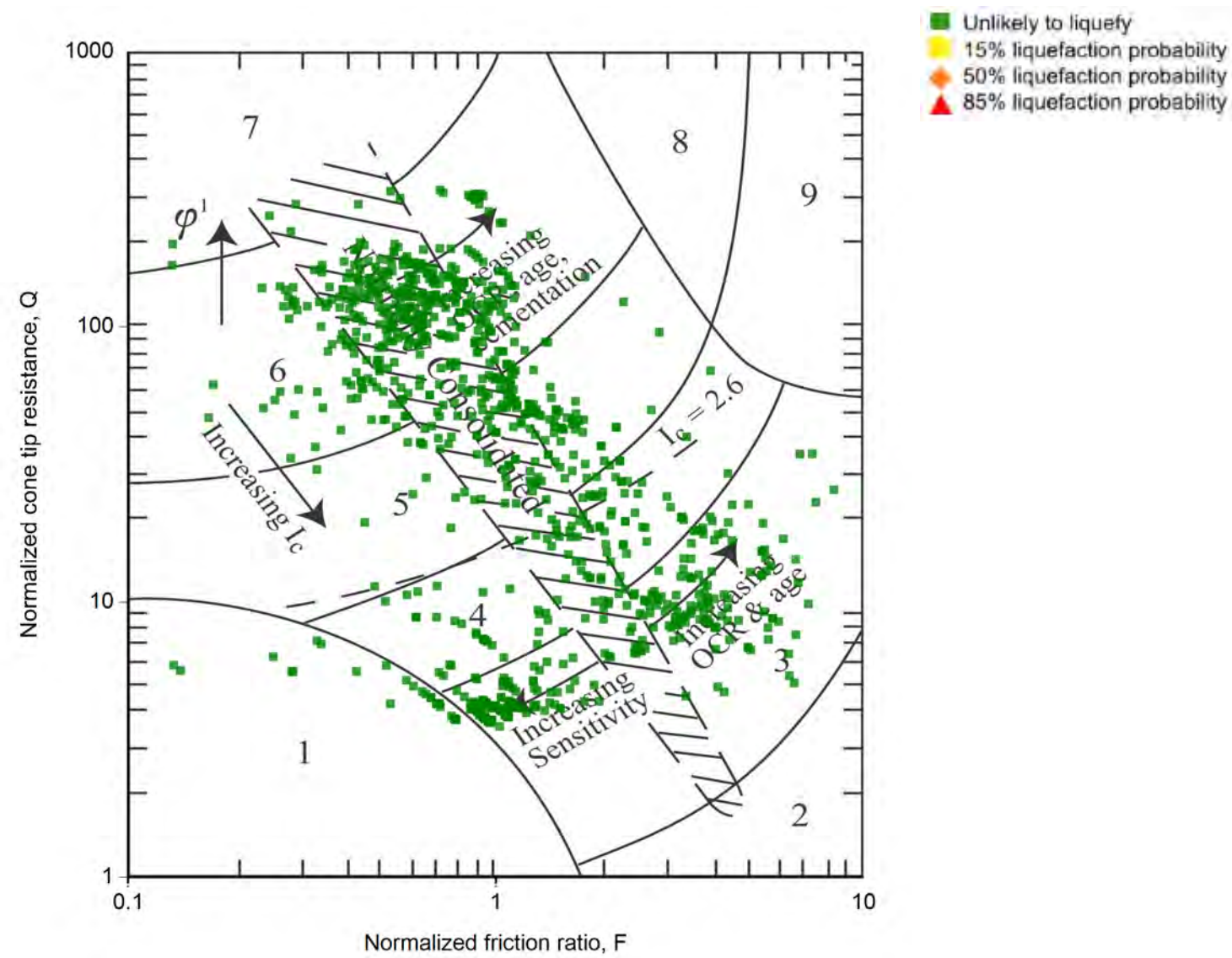
LOCATION
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DATE
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JOB NUMBER
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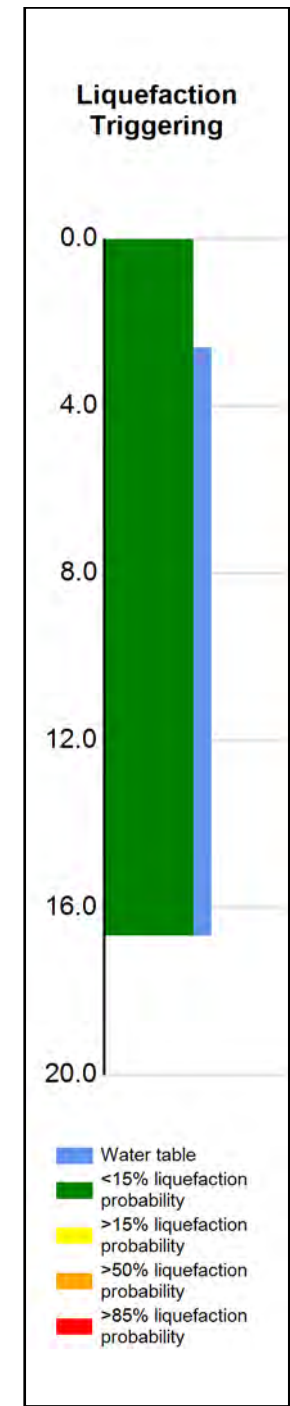
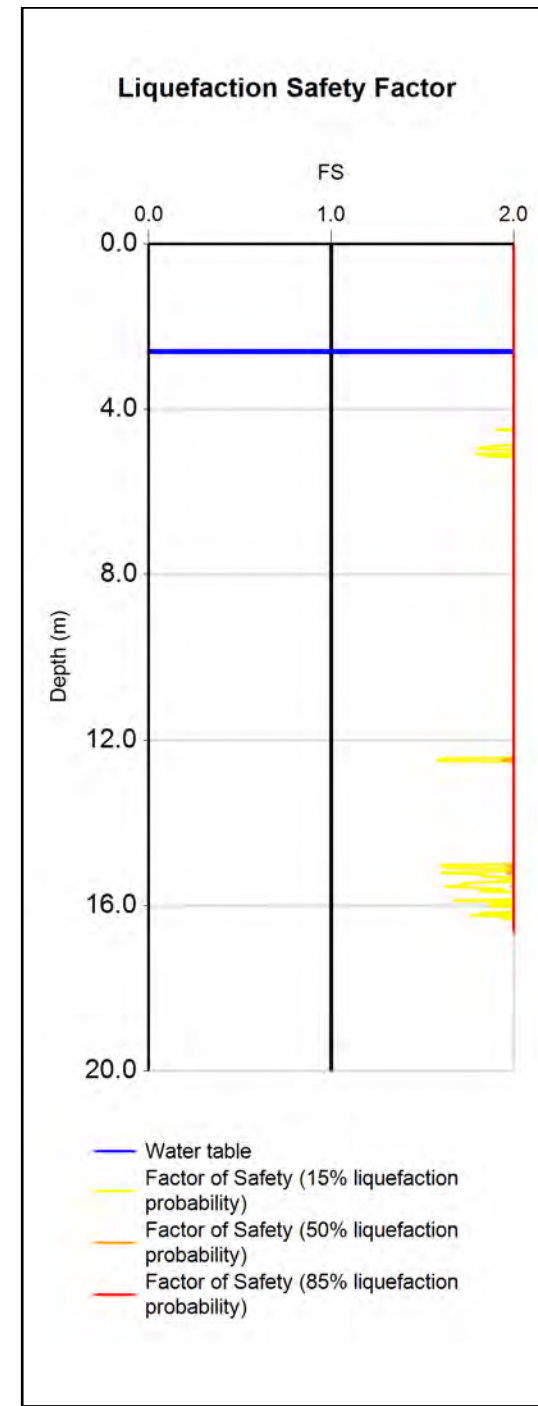
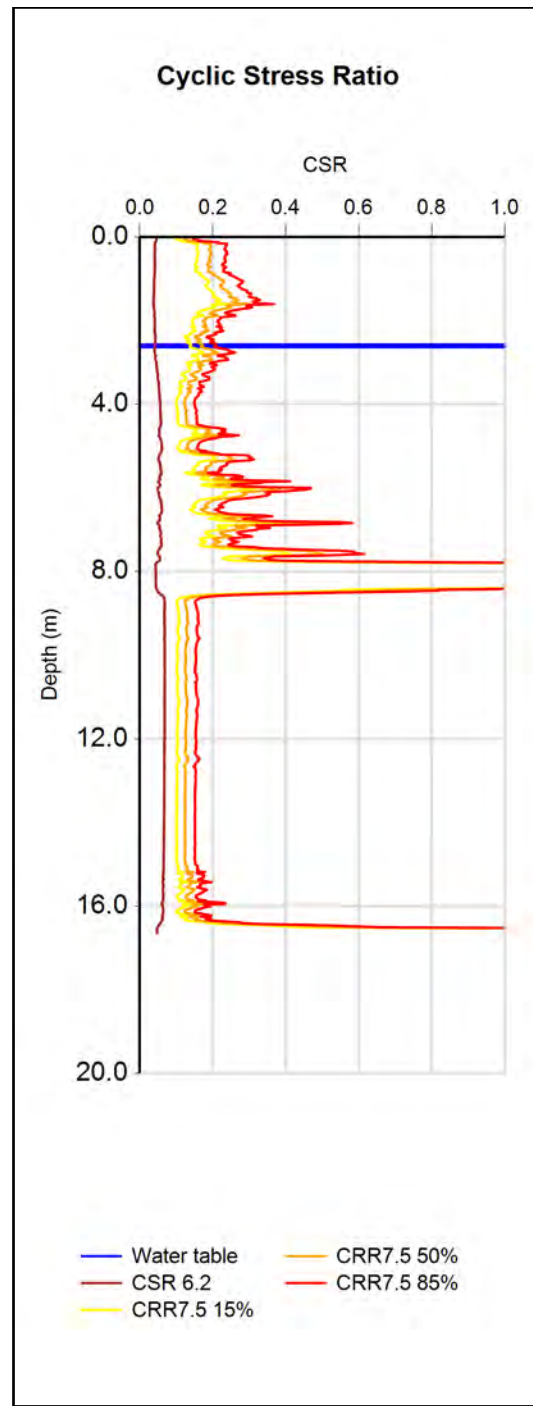
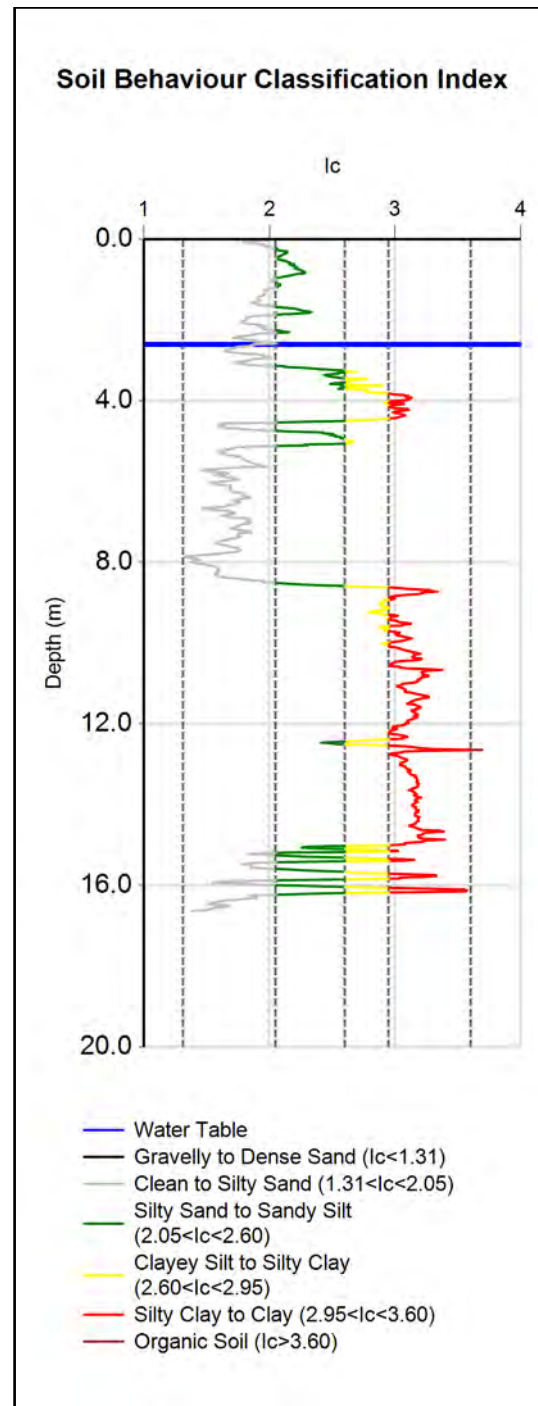
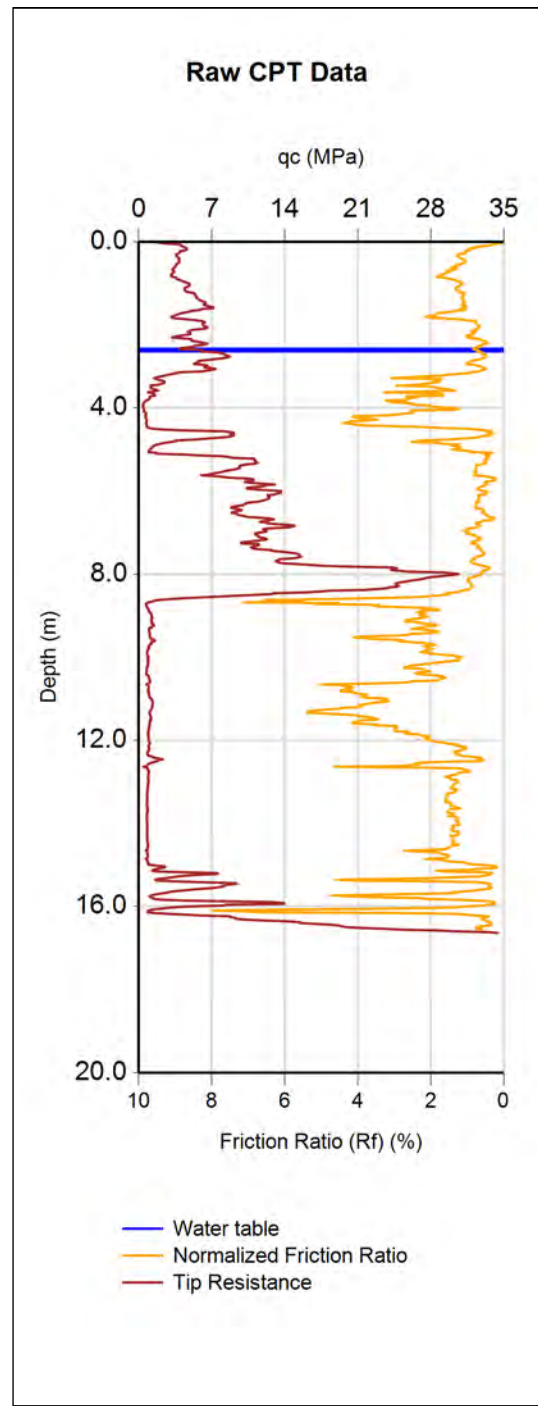
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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT07	60505	10/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	16.6	0						
	50%	0	0	0	0	16.6	0						
	85%	0	0	0	0	16.6	0						



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CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 5-8

LOCATION
Havelock Road / Howard Street

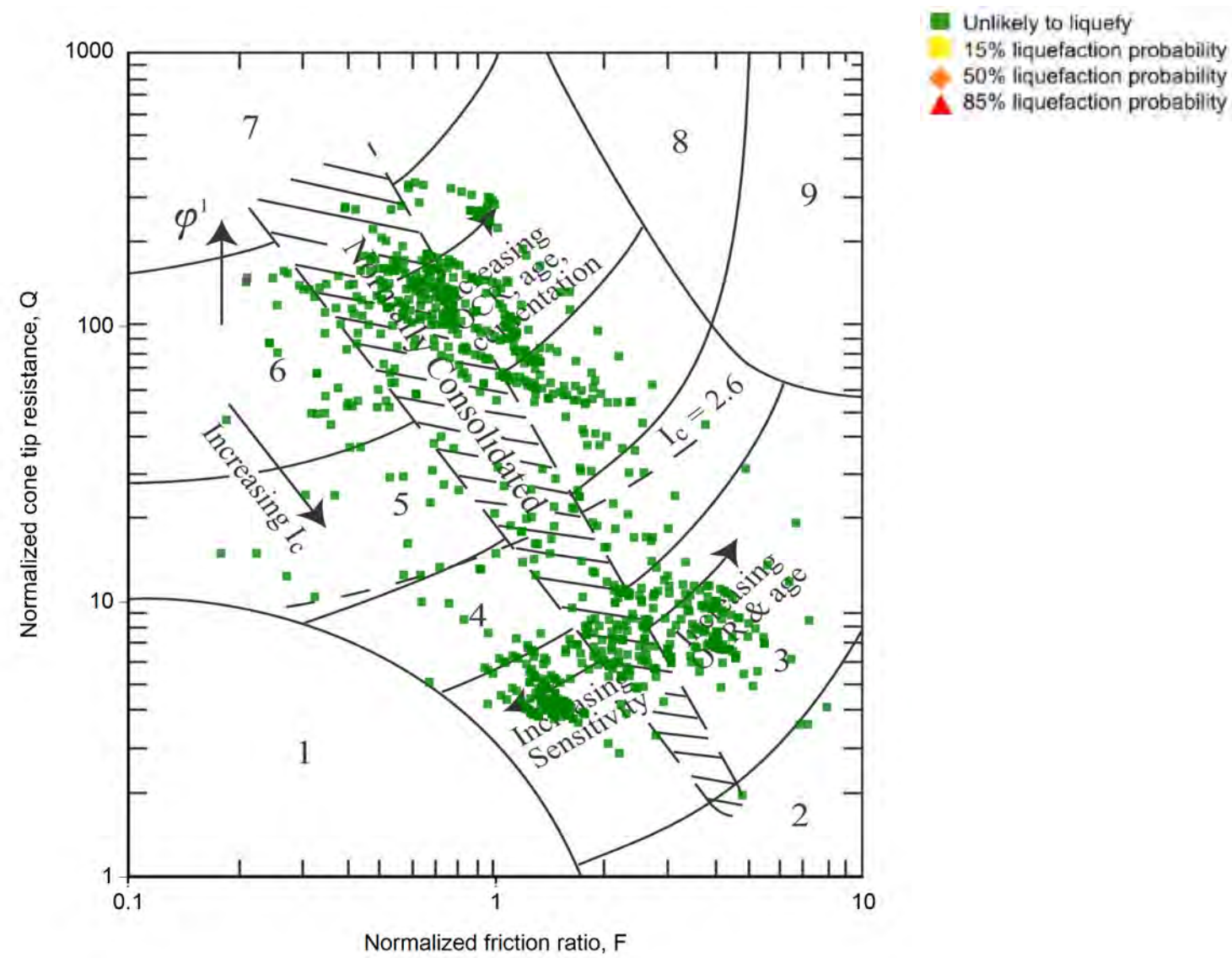
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JOB NUMBER
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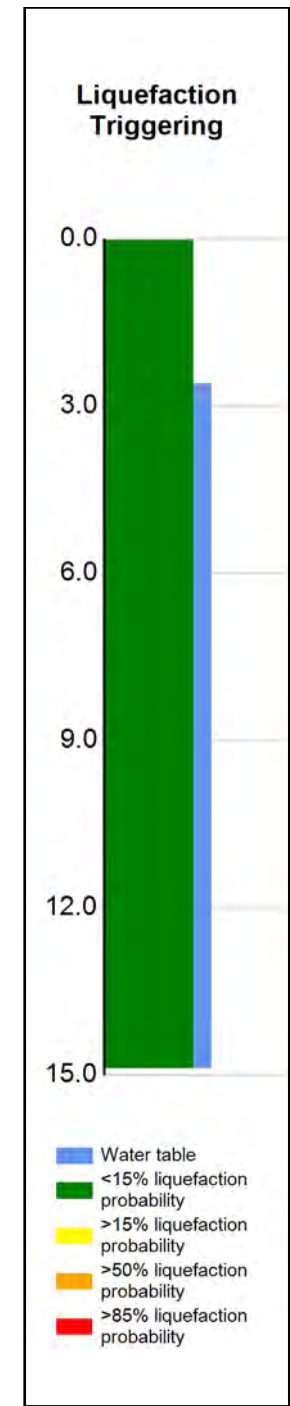
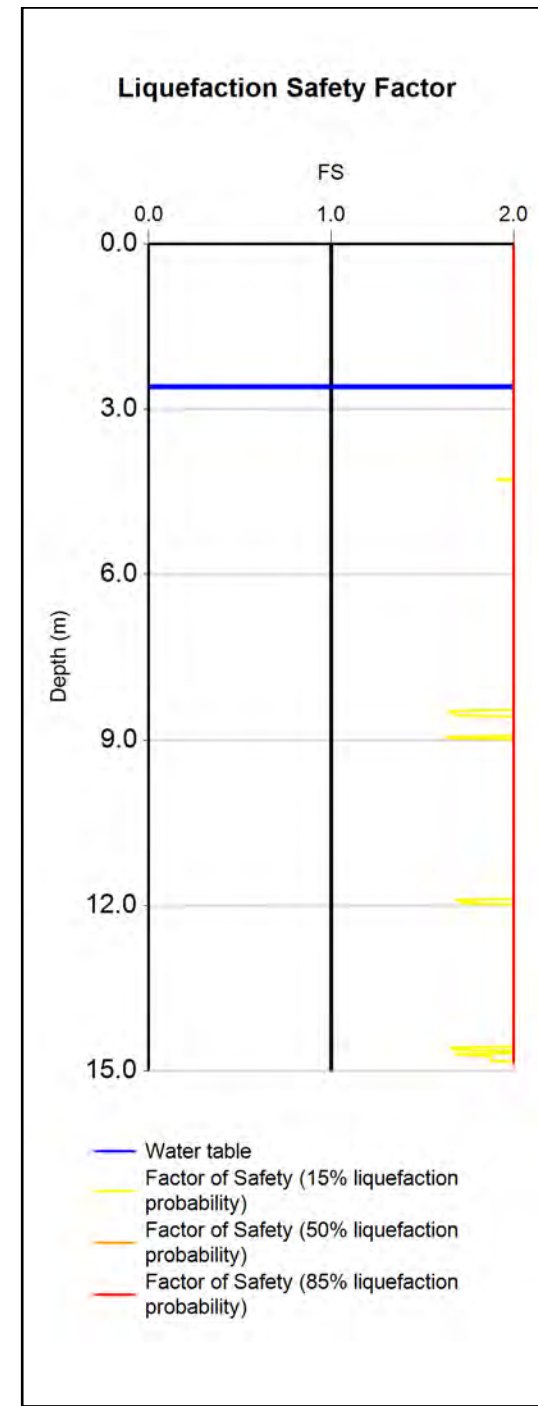
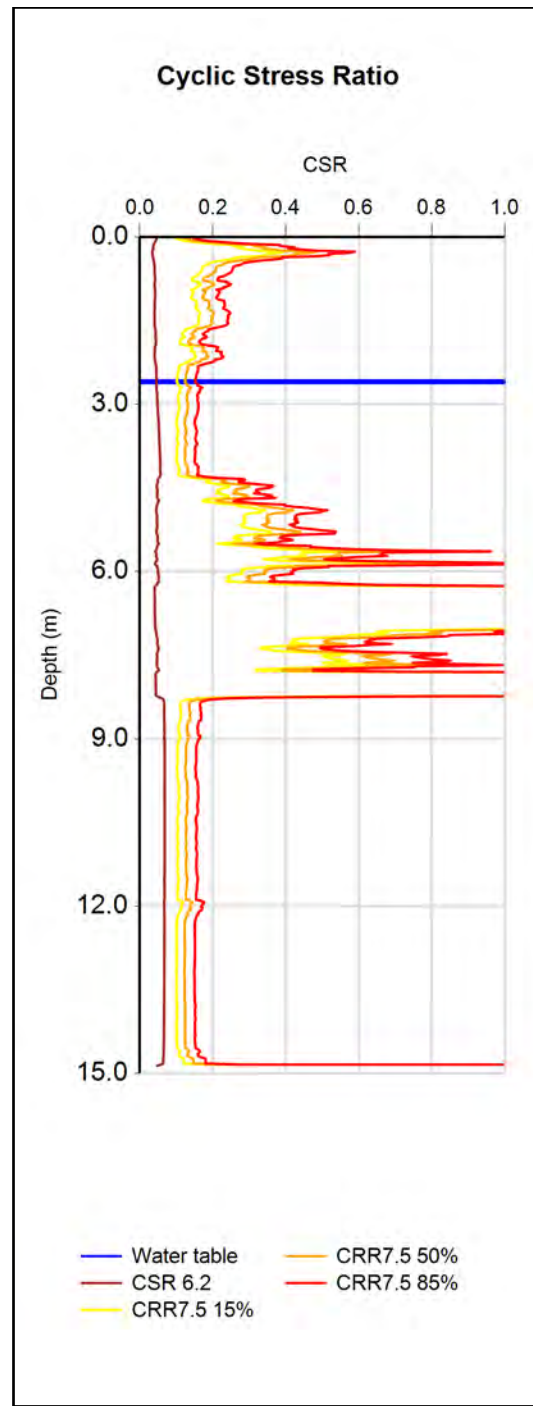
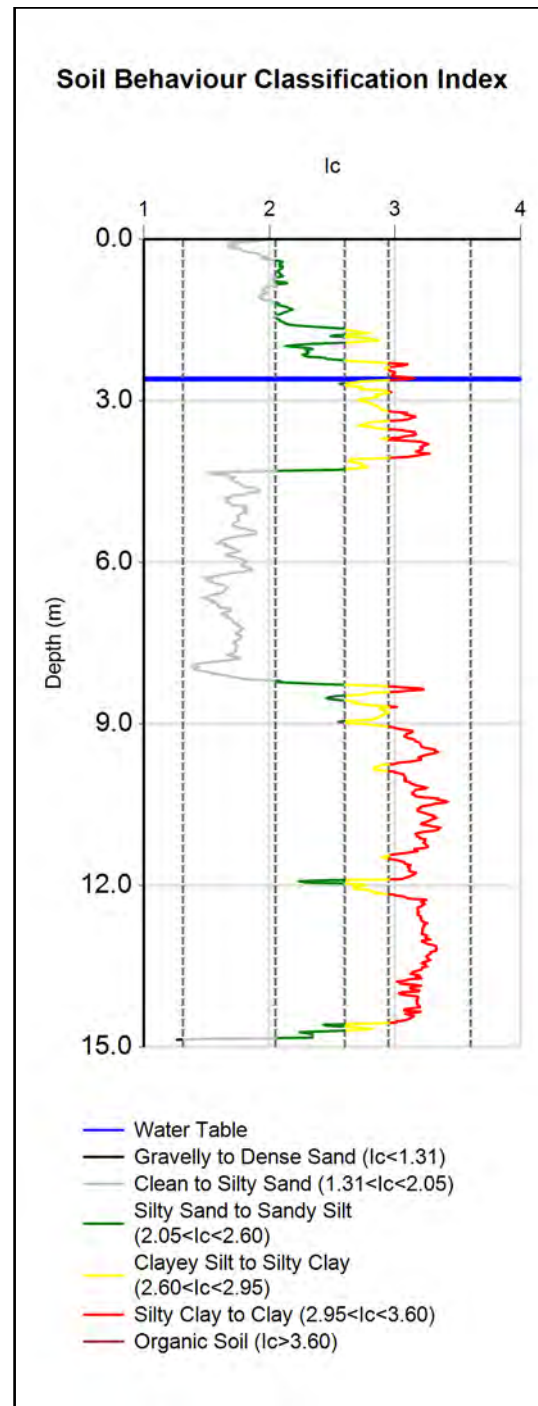
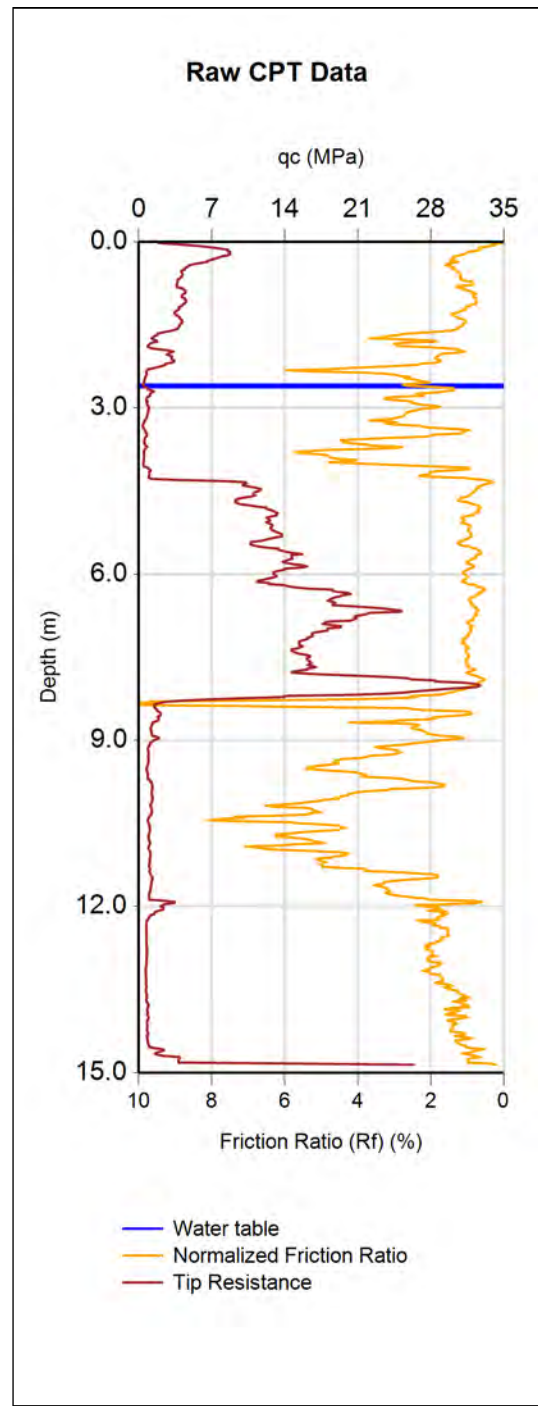


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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

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	TITLE SLS Liquefaction Assessment CPT 5-8	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT08	60506	10/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	14.9	0						
	50%	0	0	0	0	14.9	0						
	85%	0	0	0	0	14.9	0						



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CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 5-8

LOCATION
Havelock Road / Howard Street

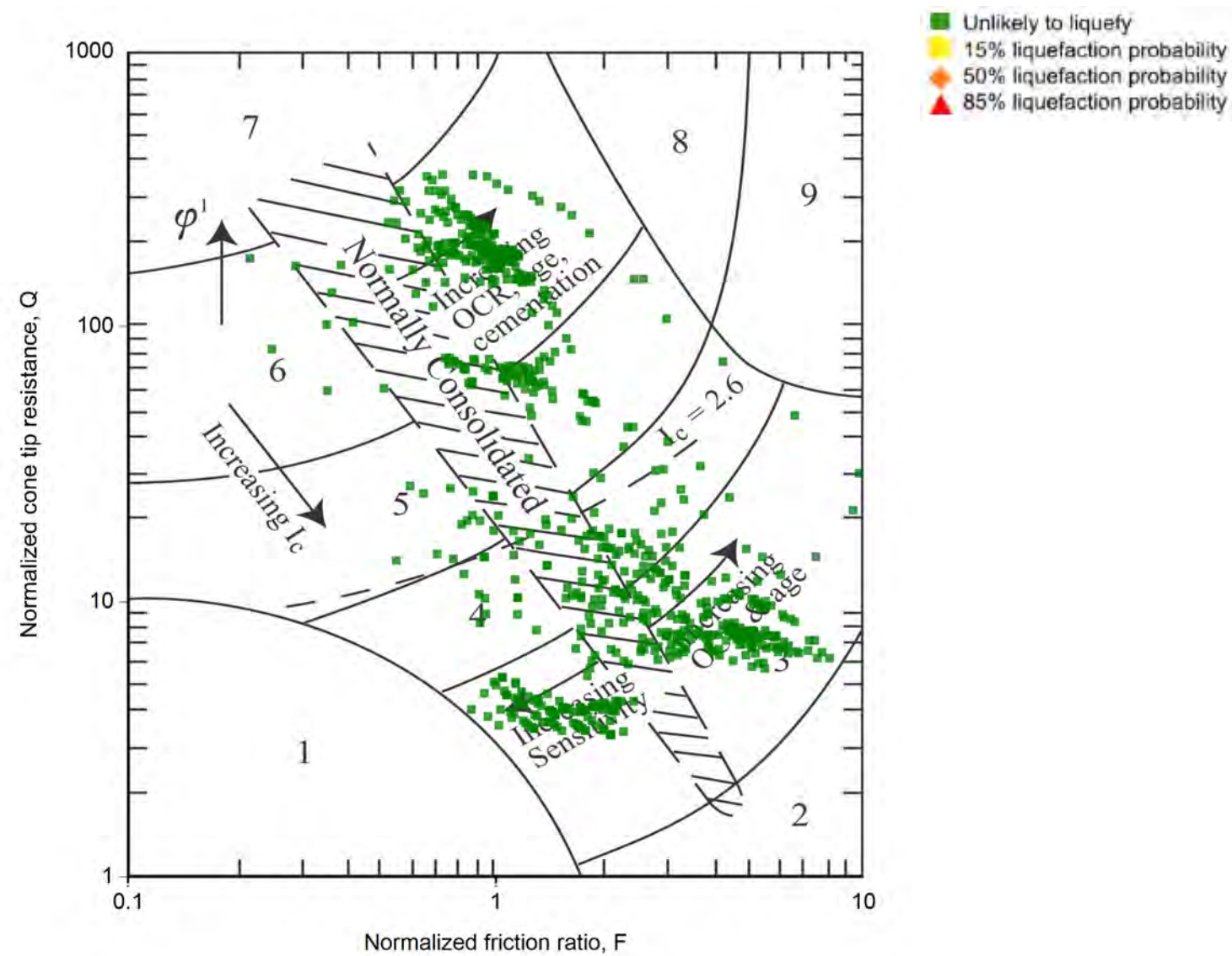
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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

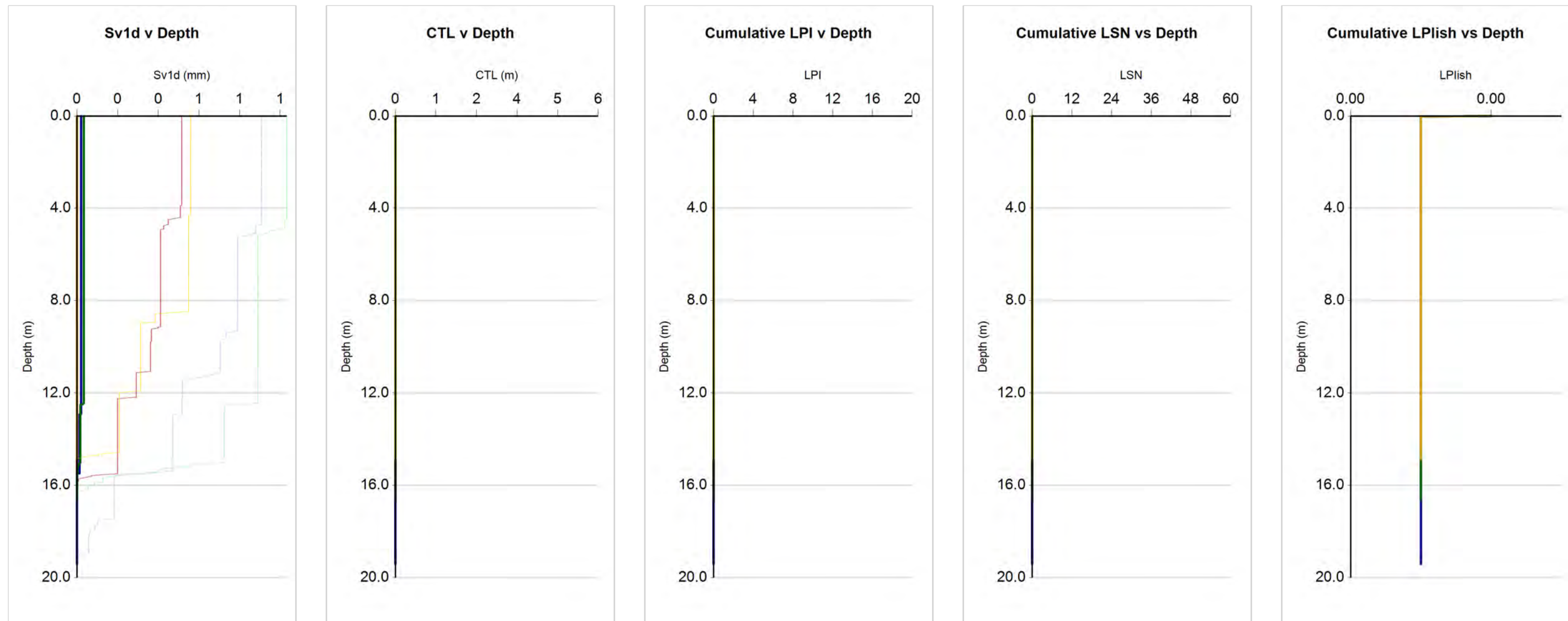
CPT-based soil behavior type classification chart by Robertson (1990)



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 5-8

LOCATION	Havelock Road / Howard Street	DATE	17/02/2016
JOB NUMBER	31464.1000	ANALYSED	cjc
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(Assumed pre-drill values)

CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT05	60503	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT06	60504	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT07	60505	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT08	60506	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



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CLIENT, PROJECT

Hastings District Council
Housing Rezone

TITLE

SLS Liquefaction Assessment CPT 5-8

LOCATION

Havelock Road /
Howard Street

JOB NUMBER

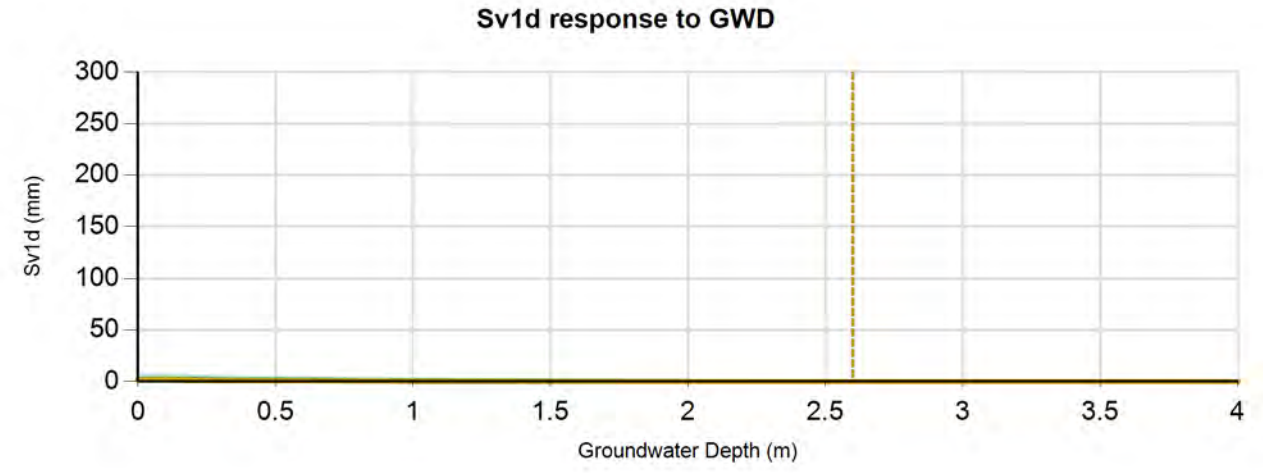
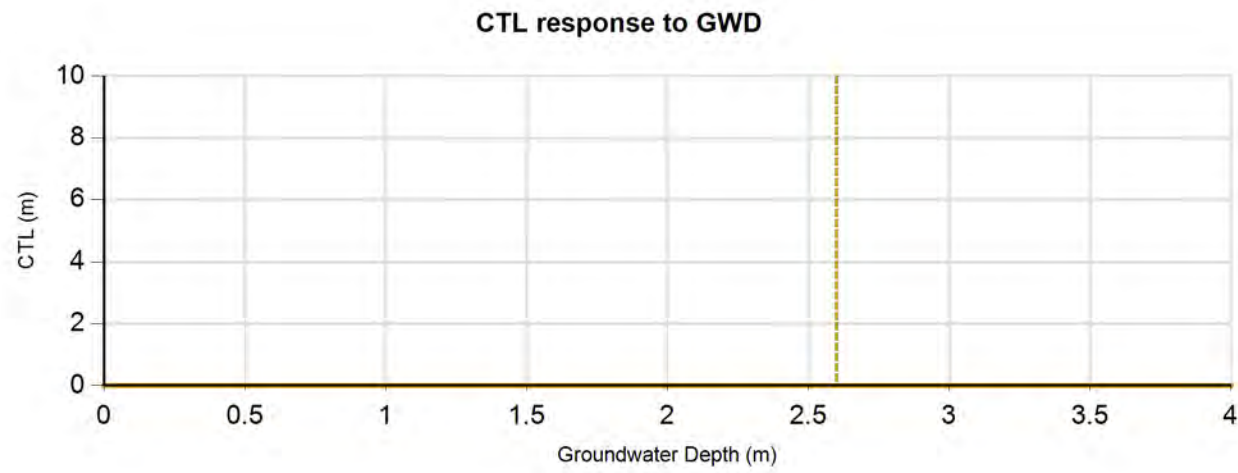
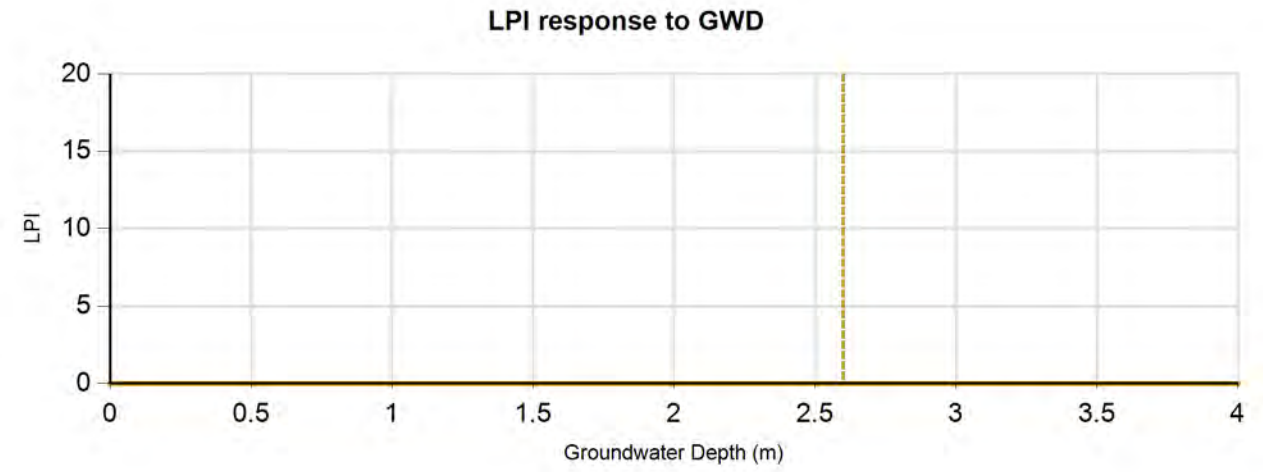
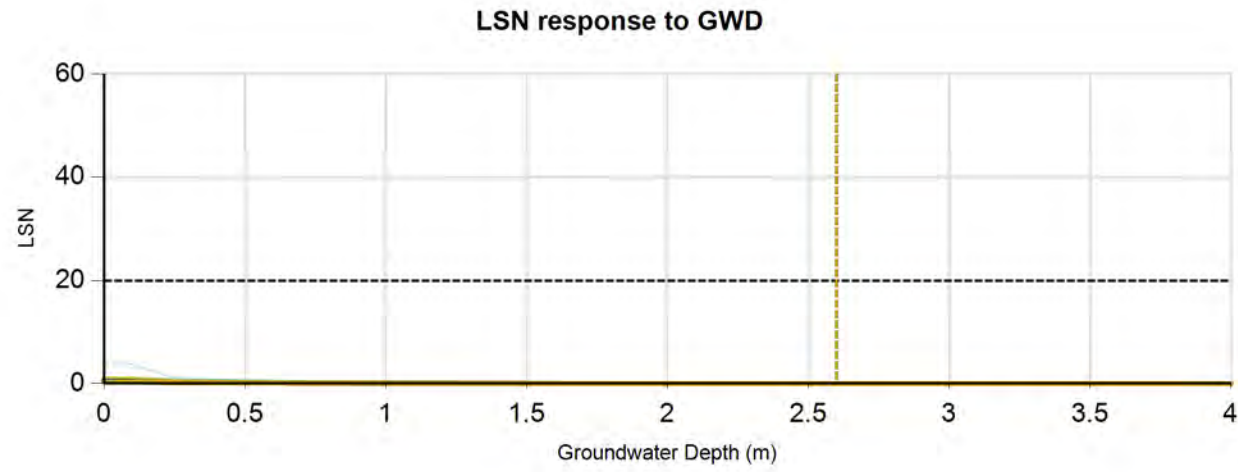
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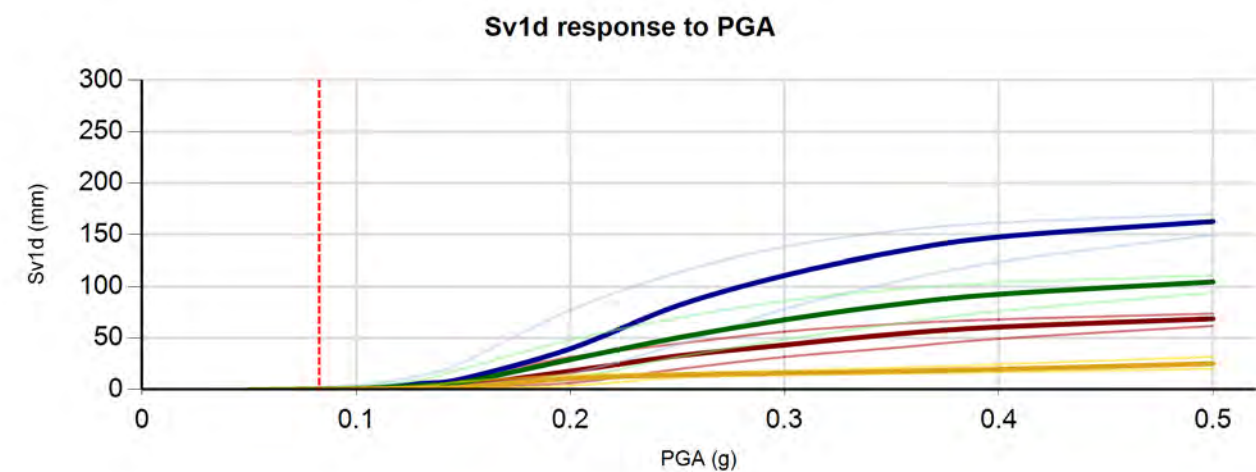
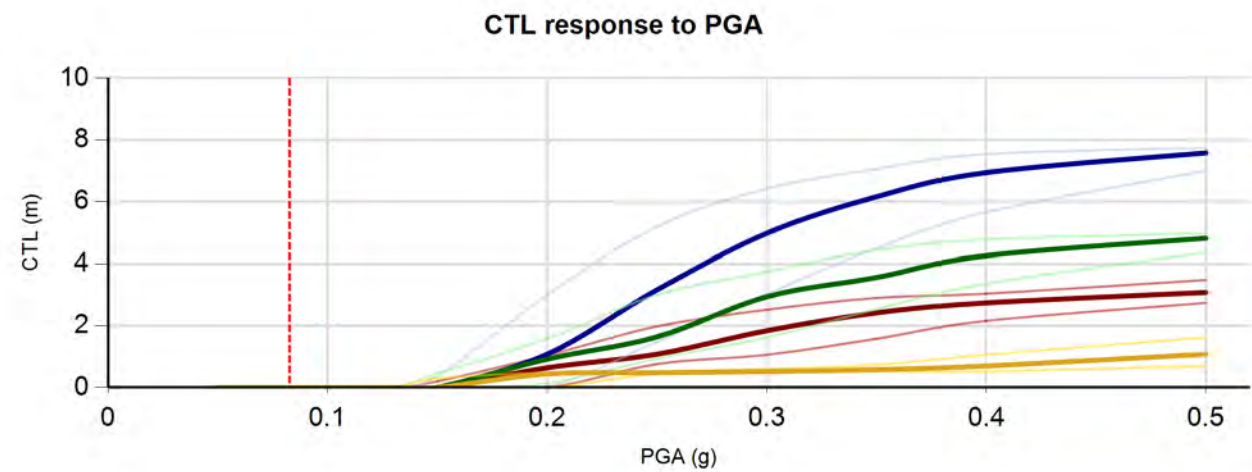
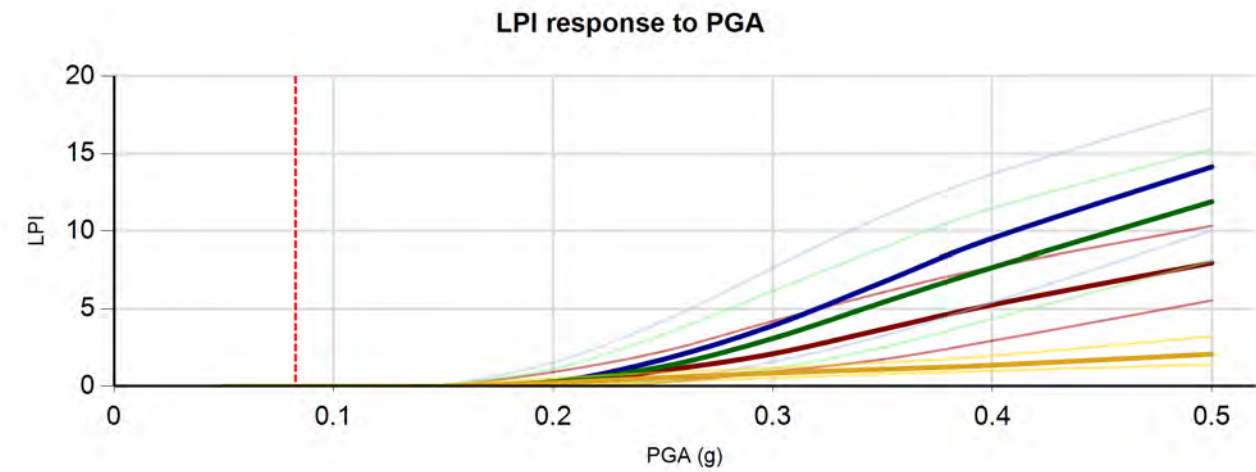
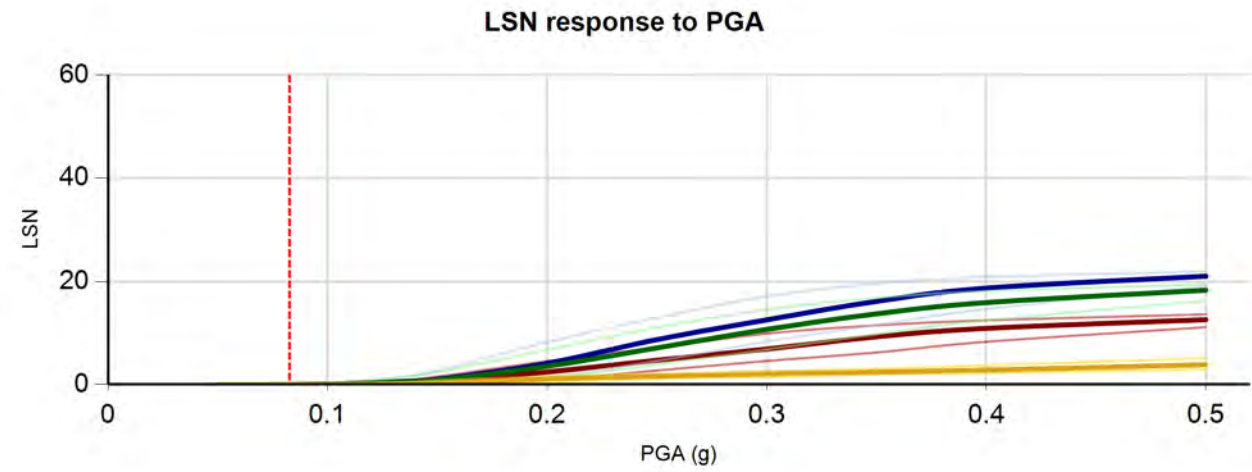
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Vertical dotted line/s indicate user specified GWD at the CPT locations. (actual GWD)

											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT05	60503	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT06	60504	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT07	60505	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT08	60506	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

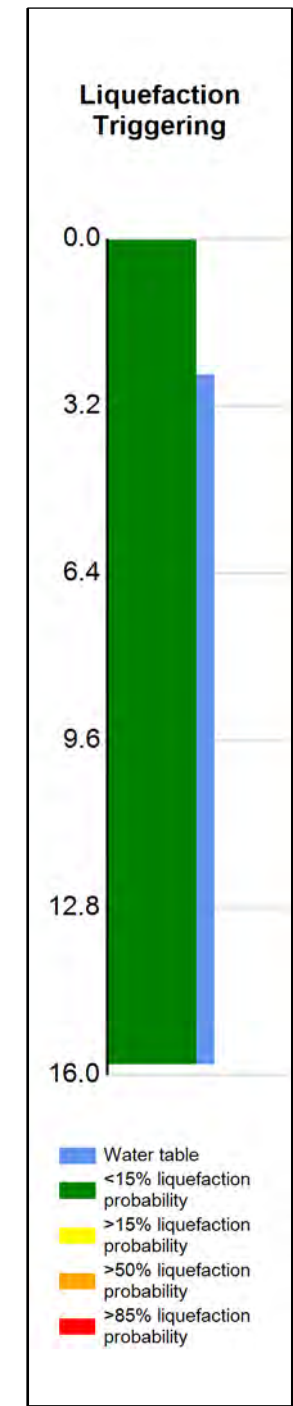
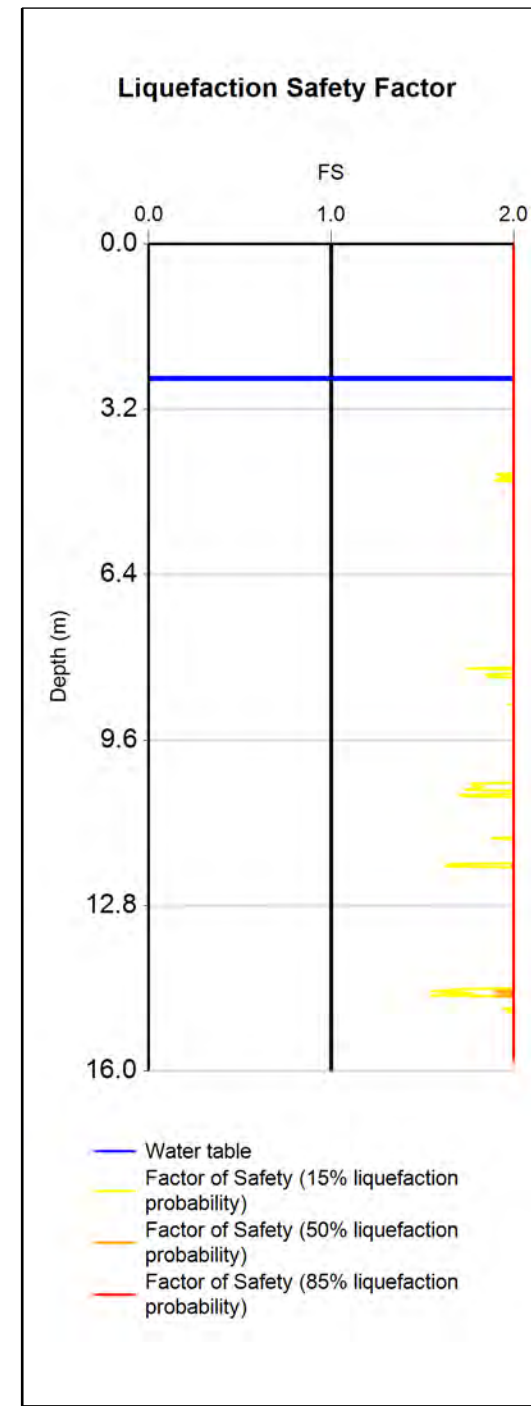
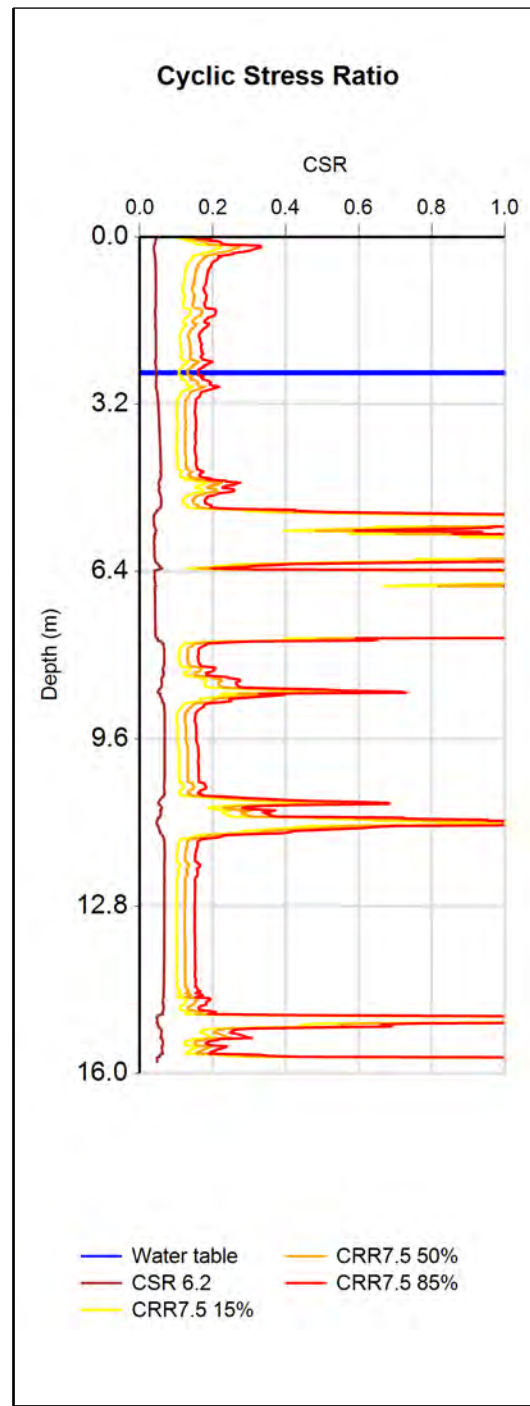
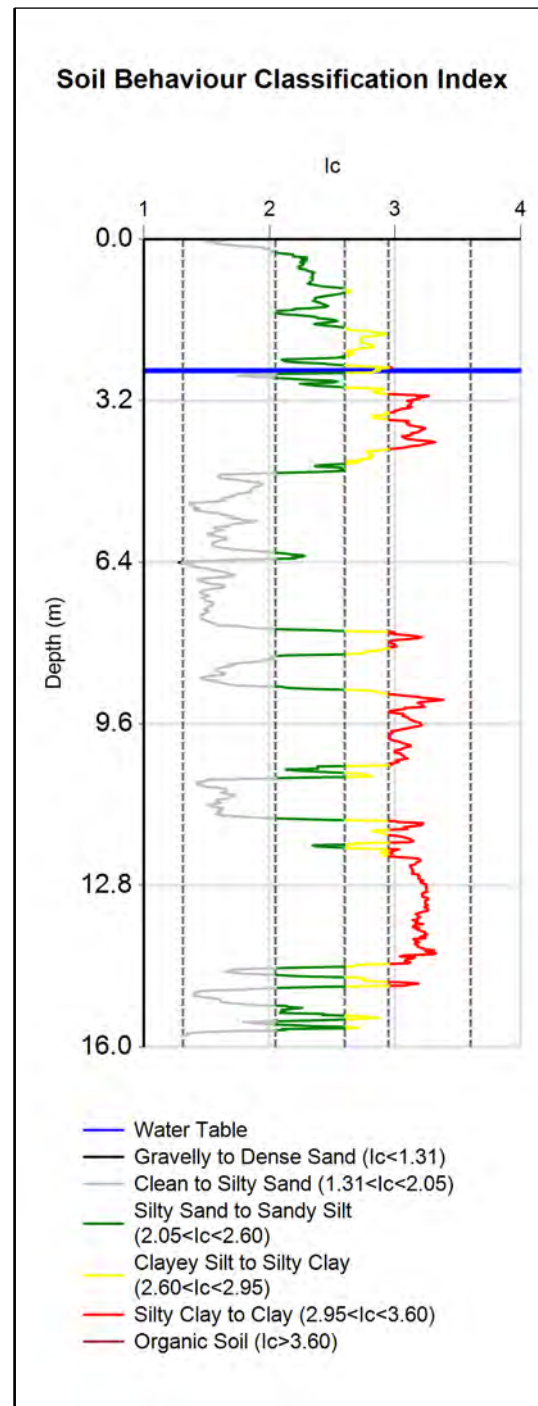
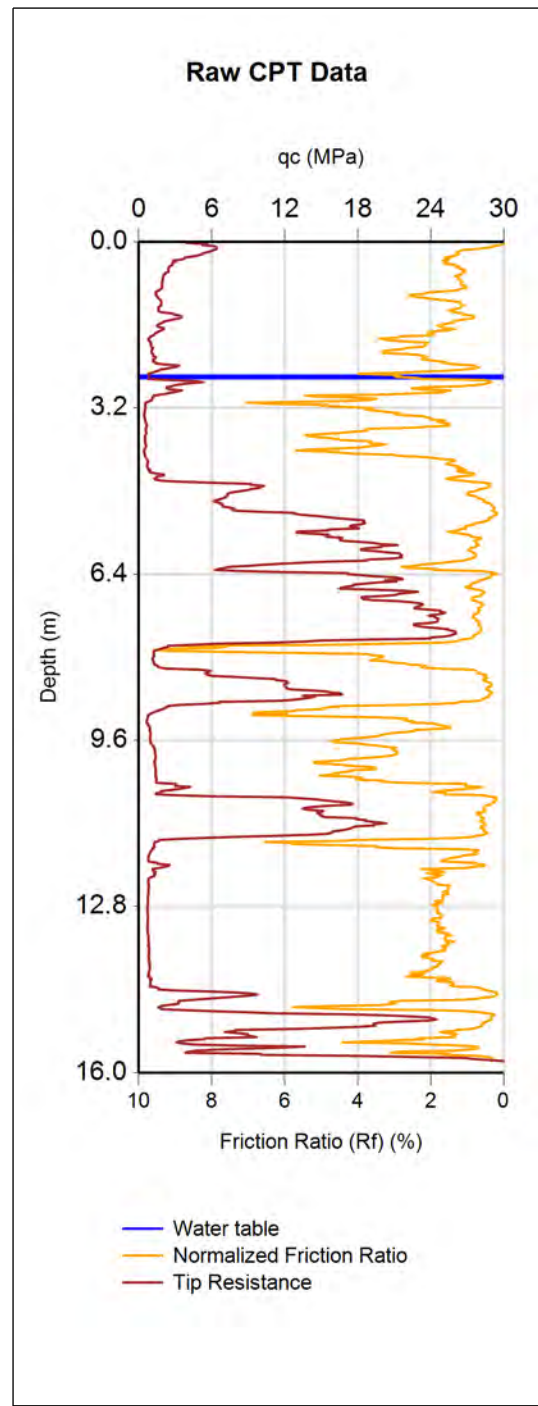
											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT05	60503	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT06	60504	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT07	60505	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT08	60506	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60503	60504	60505	60506
CPT Name	CPT05	CPT06	CPT07	CPT08
PGA	0.0827g	0.0827g	0.0827g	0.0827g
Magnitude	6.2	6.2	6.2	6.2
Depth to groundwater	2.6m	2.6m	2.6m	2.6m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	16.08m	19.42m	16.64m	14.86m
Maximum depth of analysis	16.08m	19.42m	16.64m	14.86m
RL	n/a	n/a	n/a	n/a



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT09	60507	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	15.8	0						
	50%	0	0	0	0	15.8	0						
	85%	0	0	0	0	15.8	0						



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V1.3

CLIENT, PROJECT

Hastings District Council
Housing Rezone

TITLE

SLS Liquefaction Assessment CPT 9-12

LOCATION

Havelock Road /
Howard Street

JOB NUMBER

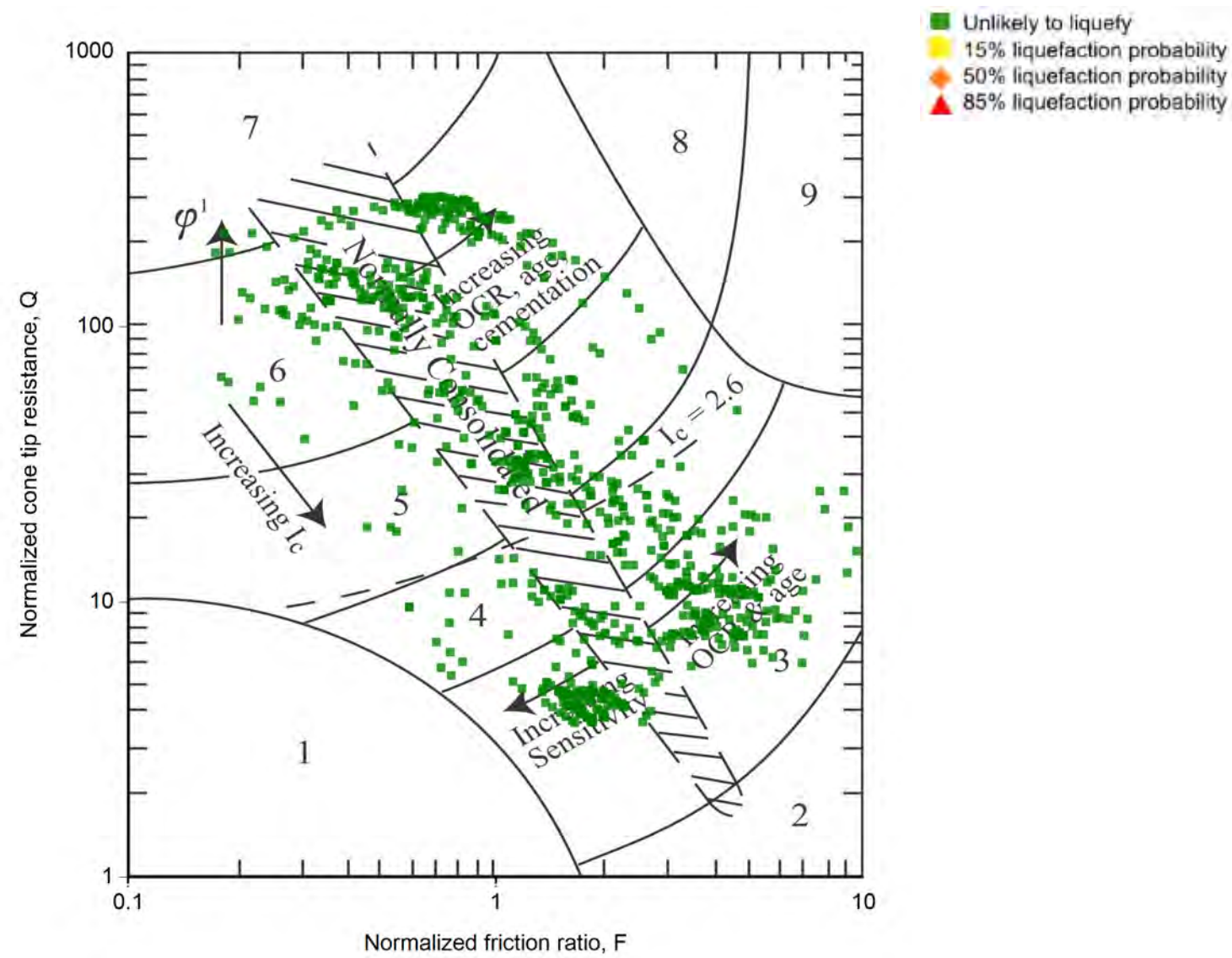
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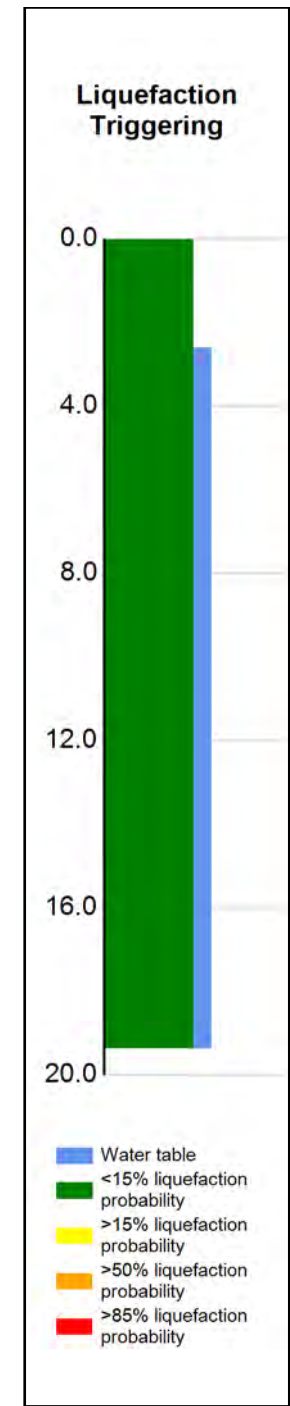
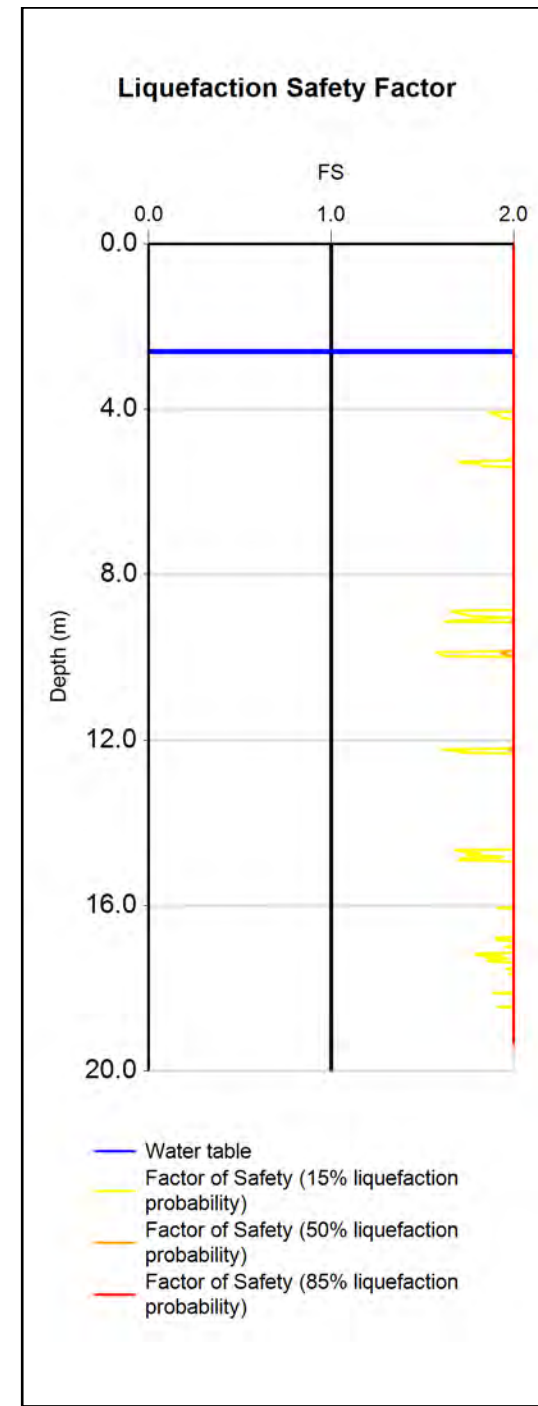
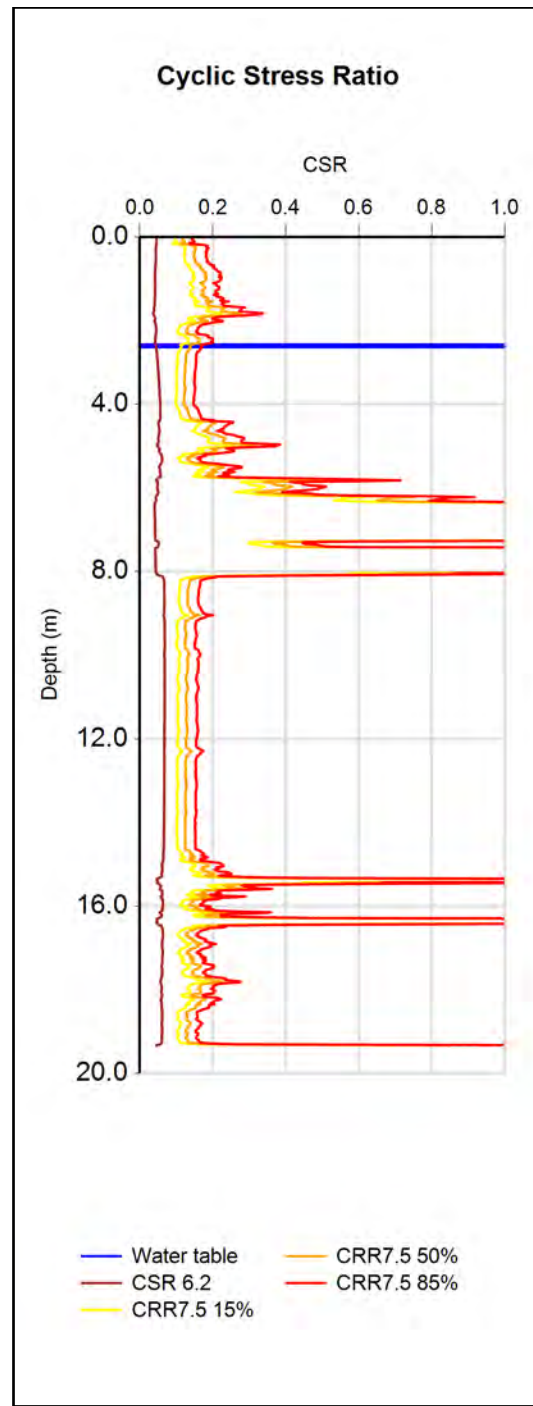
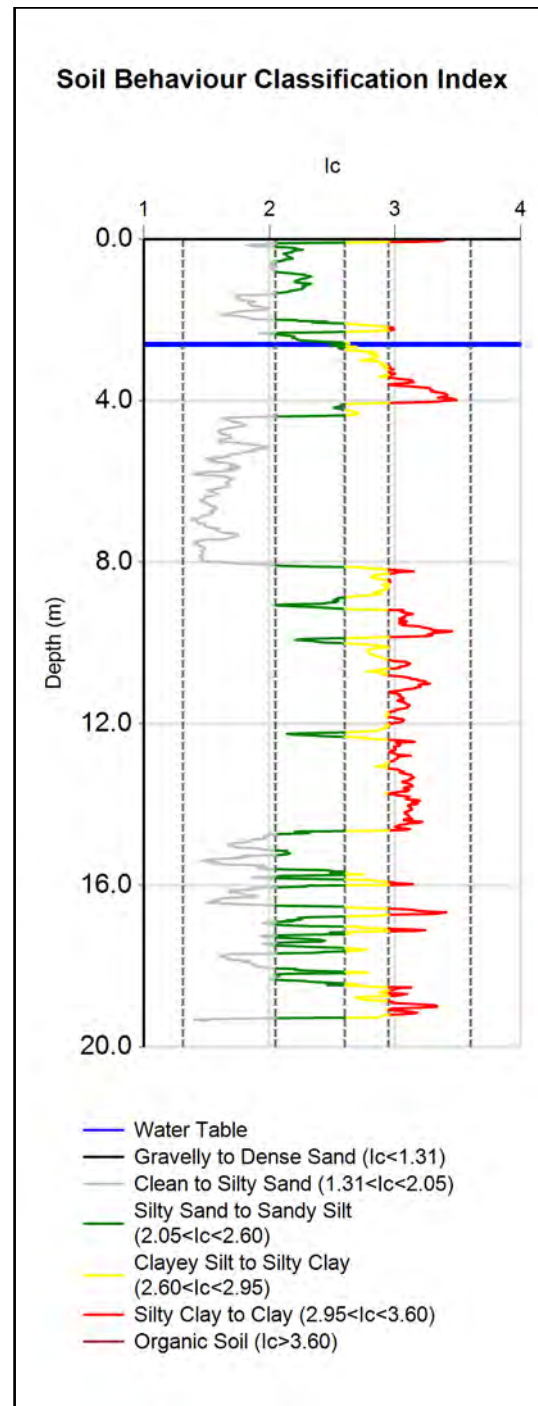
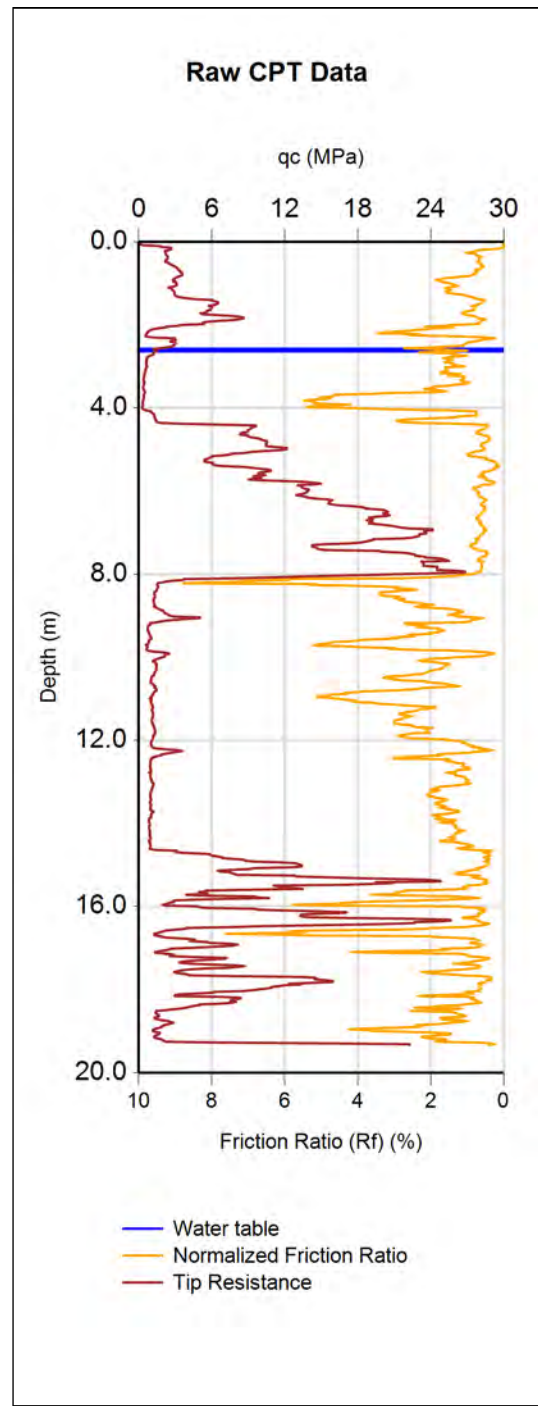


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
| 2. Organic soils - peats | 7. Gravelly sand to dense sand |
| 3. Clays - silty clay to clay | 8. Very stiff sand to clayey sand * |
| 4. Silt mixtures - clayey silt to silty clay | 9. Very stiff, fine grained * |
| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE SLS Liquefaction Assessment CPT 9-12	JOB NUMBER 31464.1000	ANALYSED cjc
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(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT10	60509	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	1	0	0	0	19.3	0						
	50%	0	0	0	0	19.3	0						
	85%	0	0	0	0	19.3	0						



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V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 9-12

LOCATION
Havelock Road / Howard Street

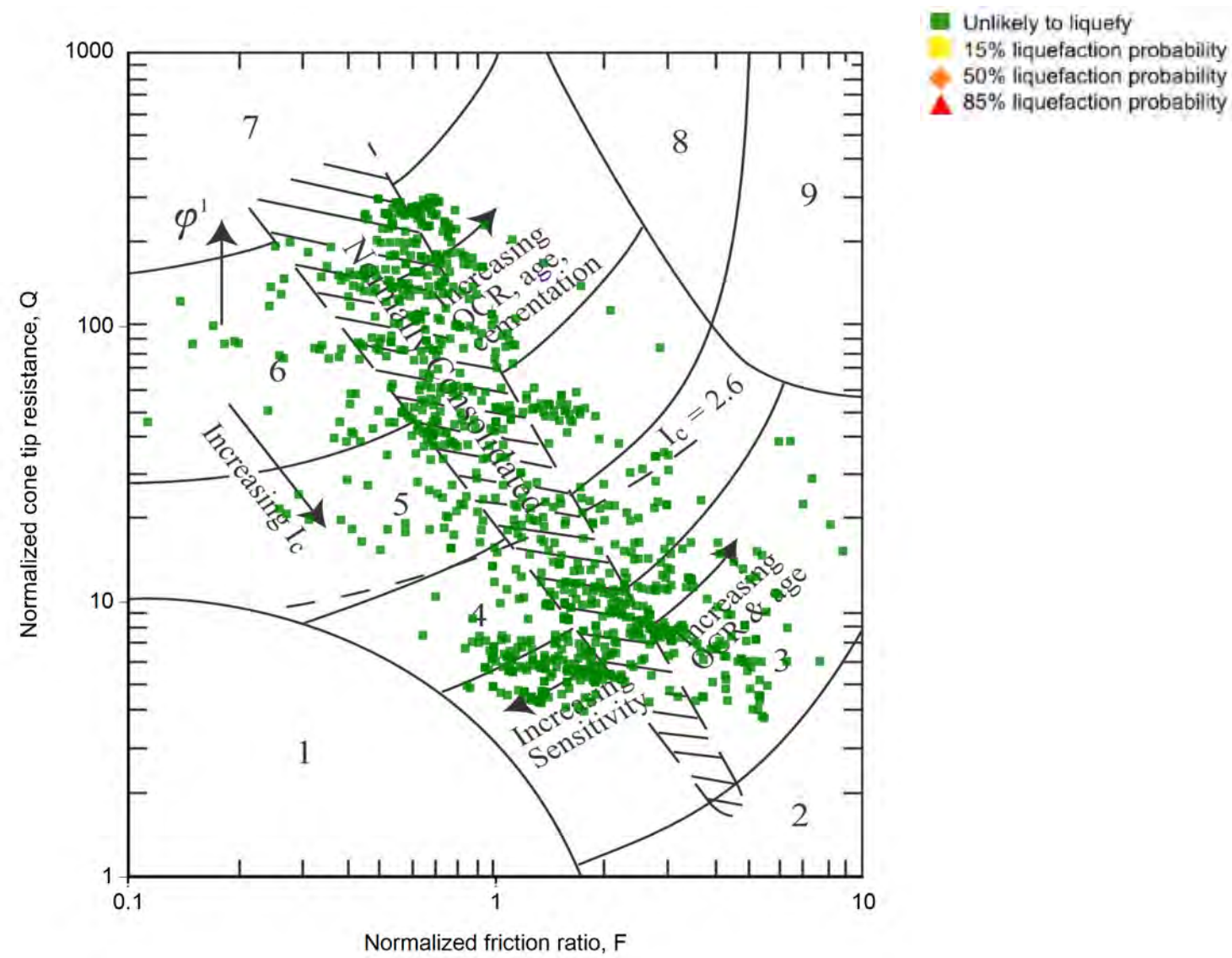
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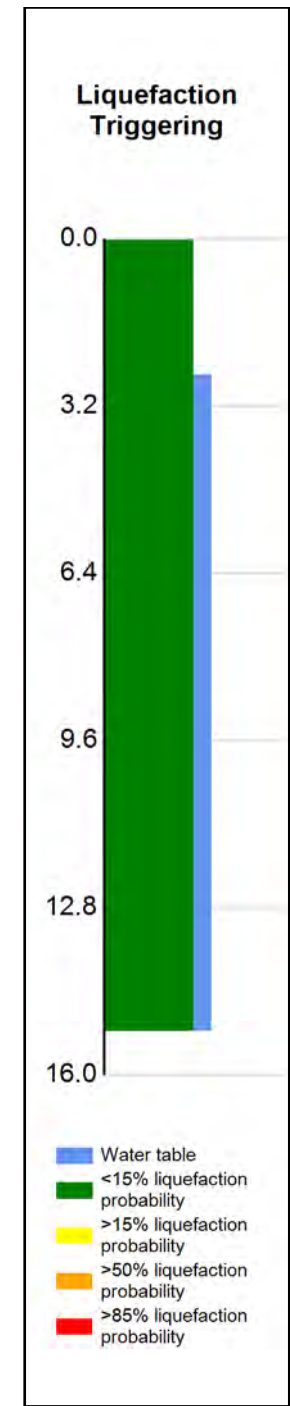
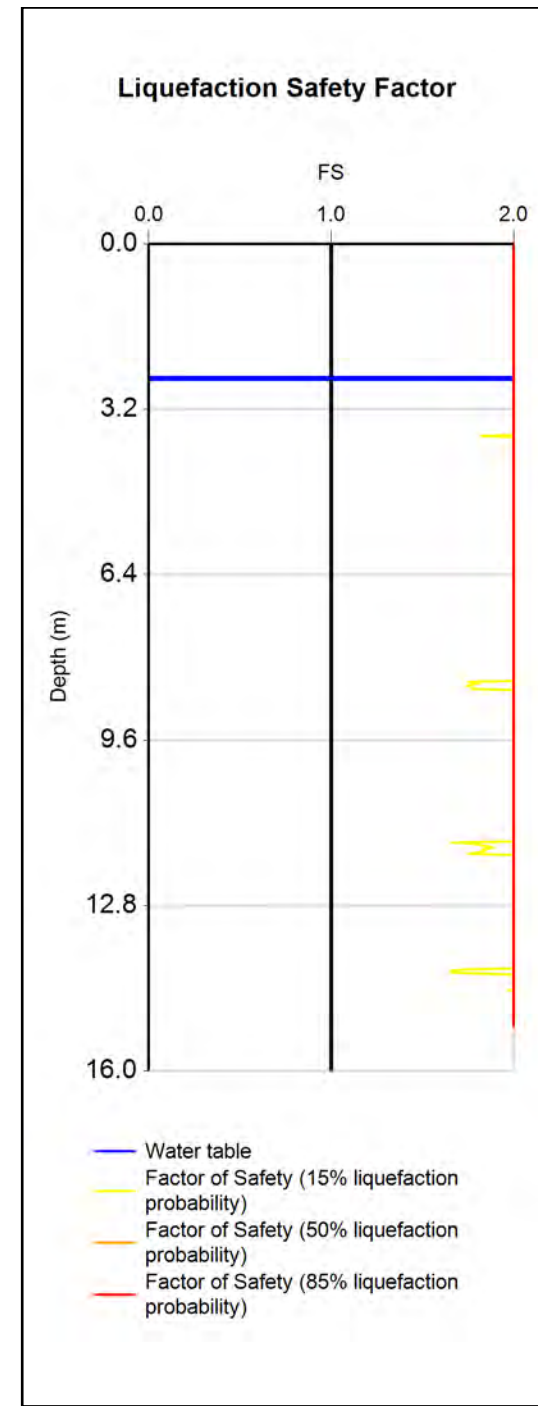
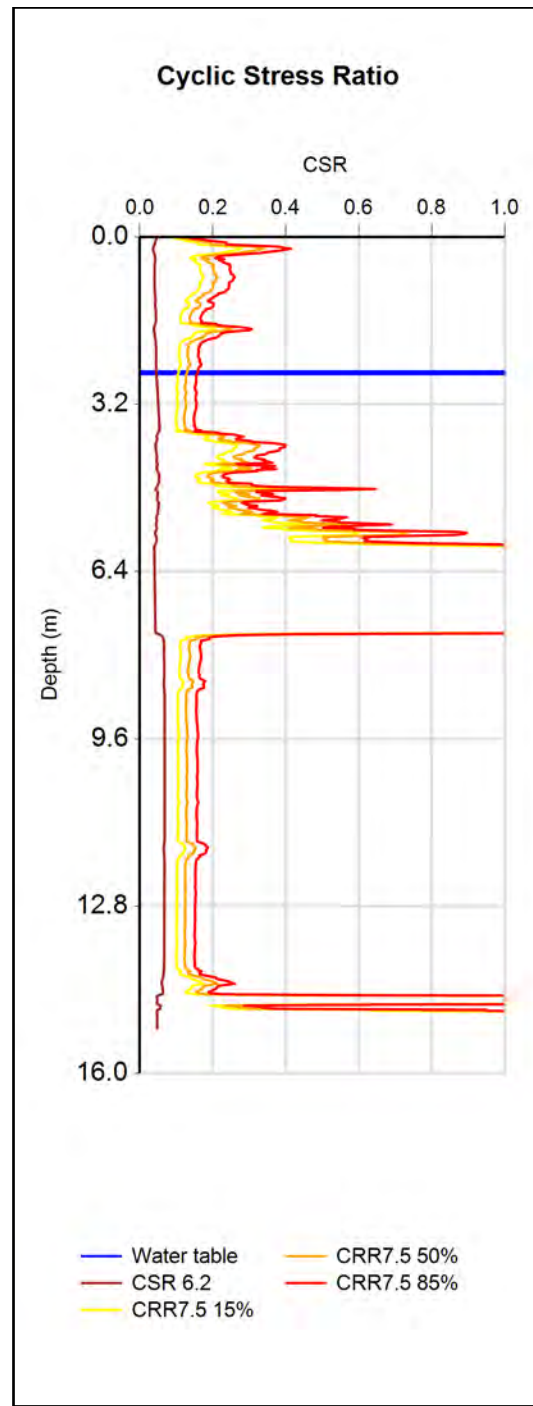
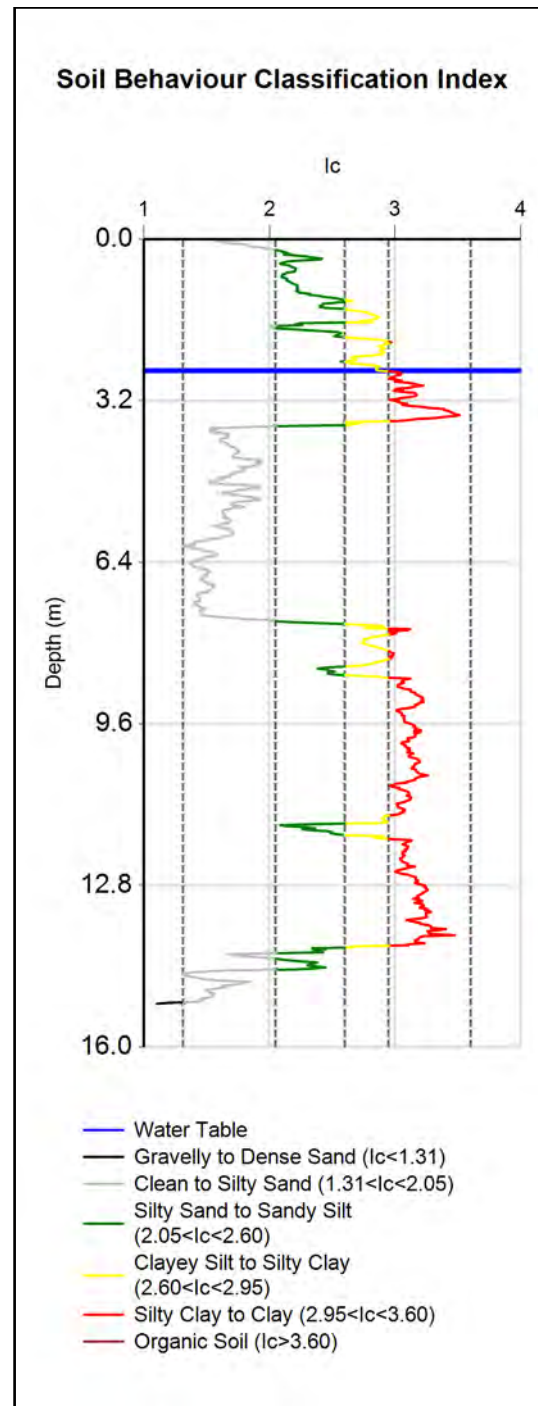
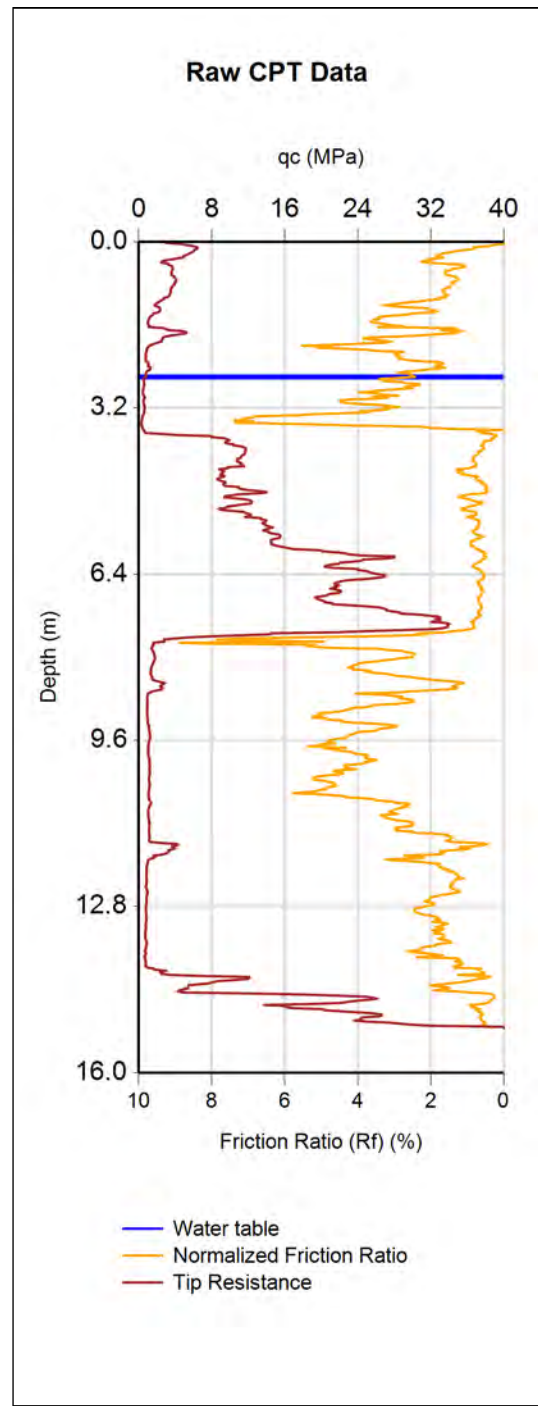


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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE SLS Liquefaction Assessment CPT 9-12	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT11	60510	10/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	15.1	0						
	50%	0	0	0	0	15.1	0						
	85%	0	0	0	0	15.1	0						



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V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 9-12

LOCATION
Havelock Road / Howard Street

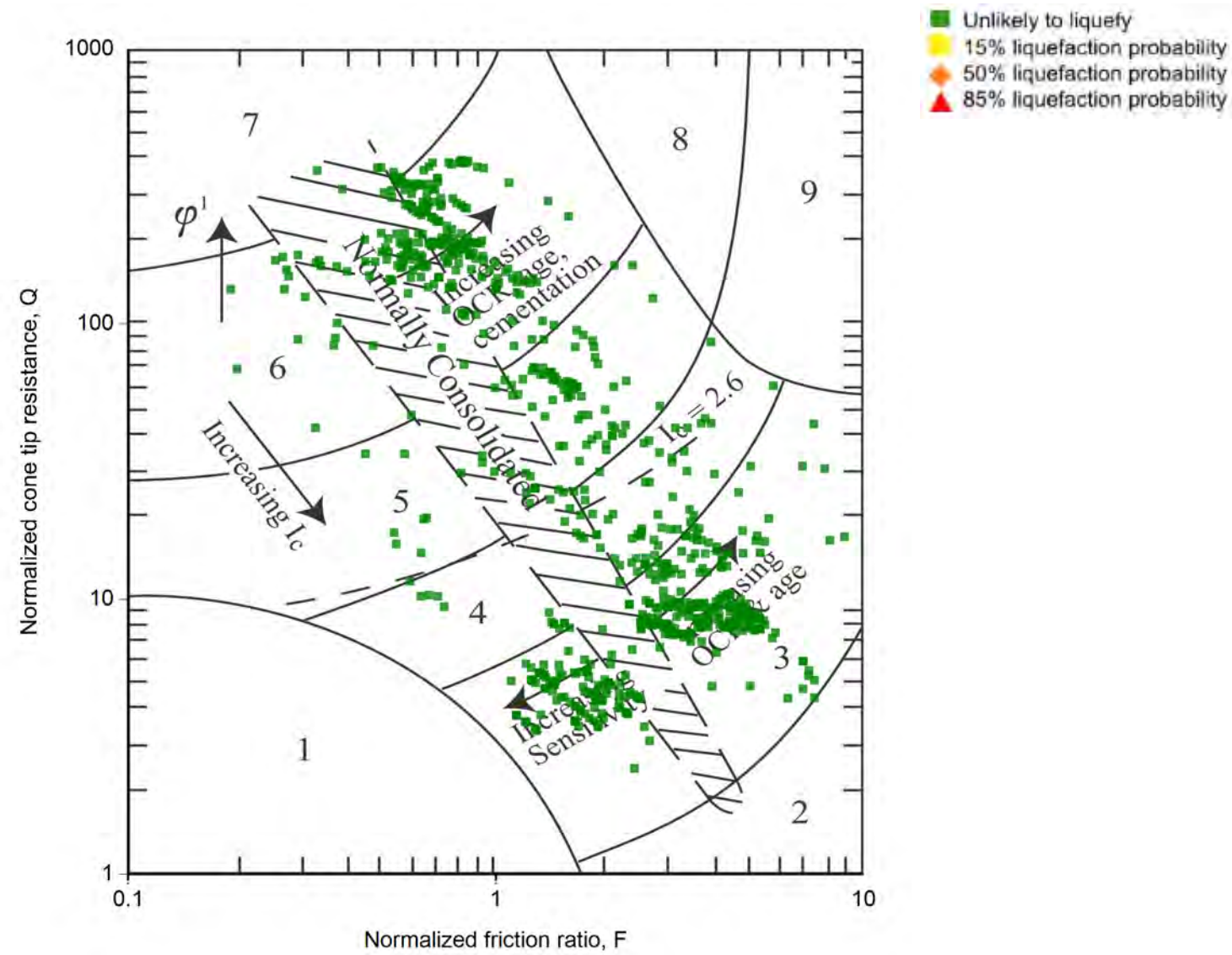
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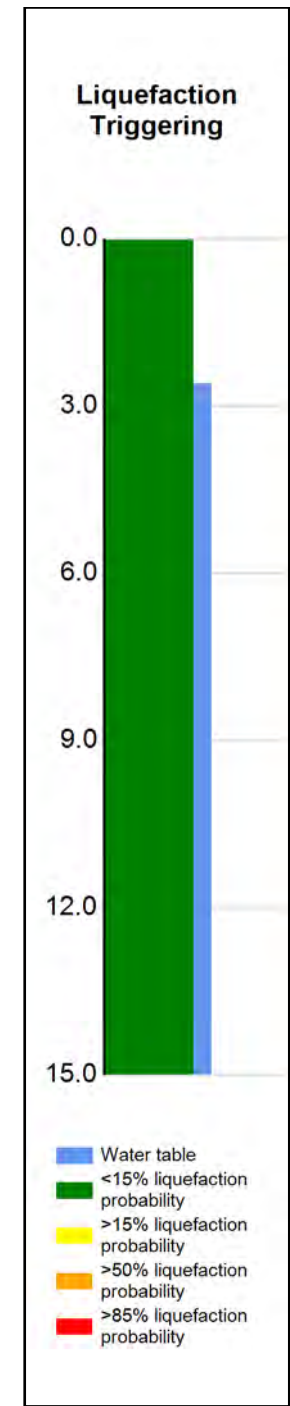
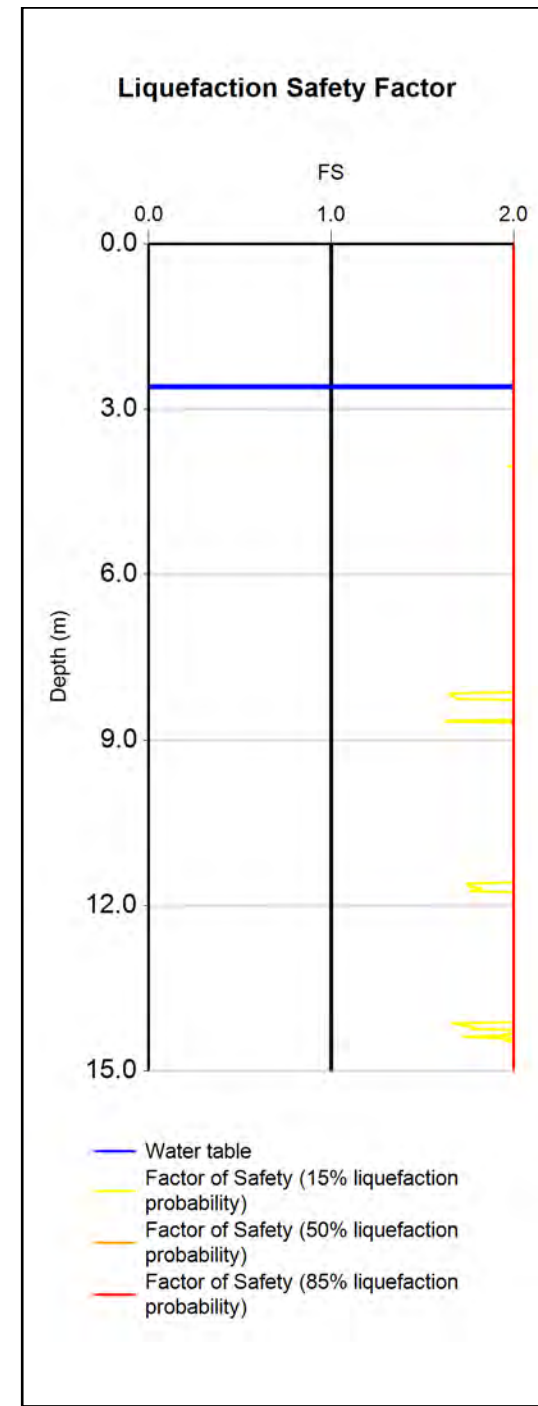
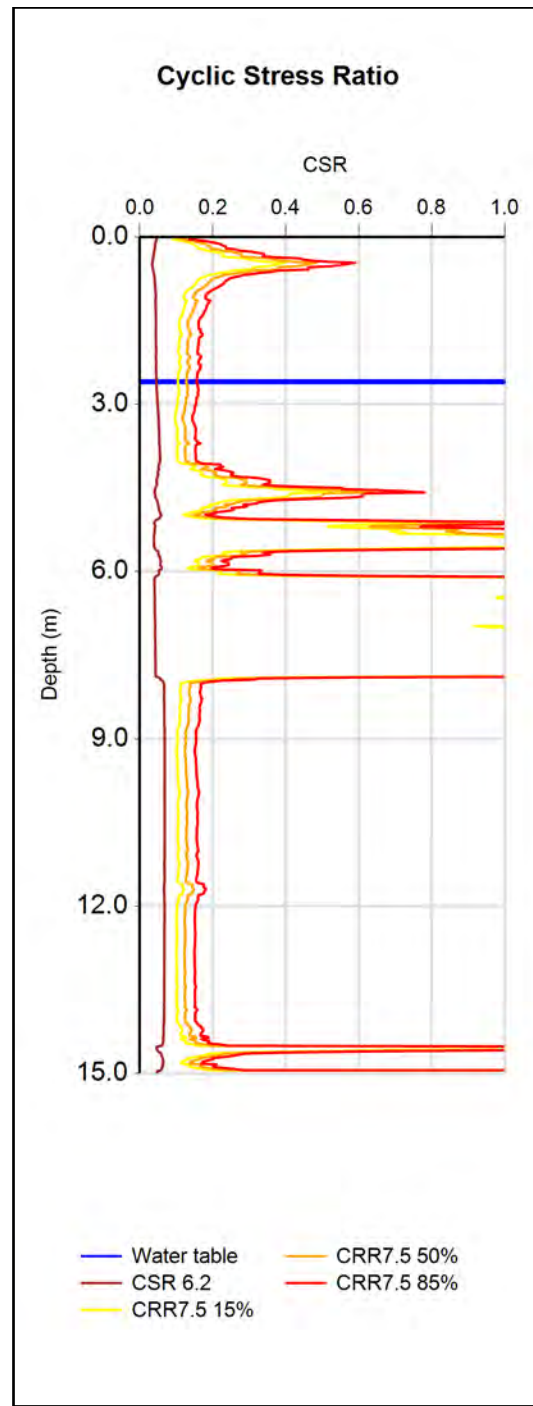
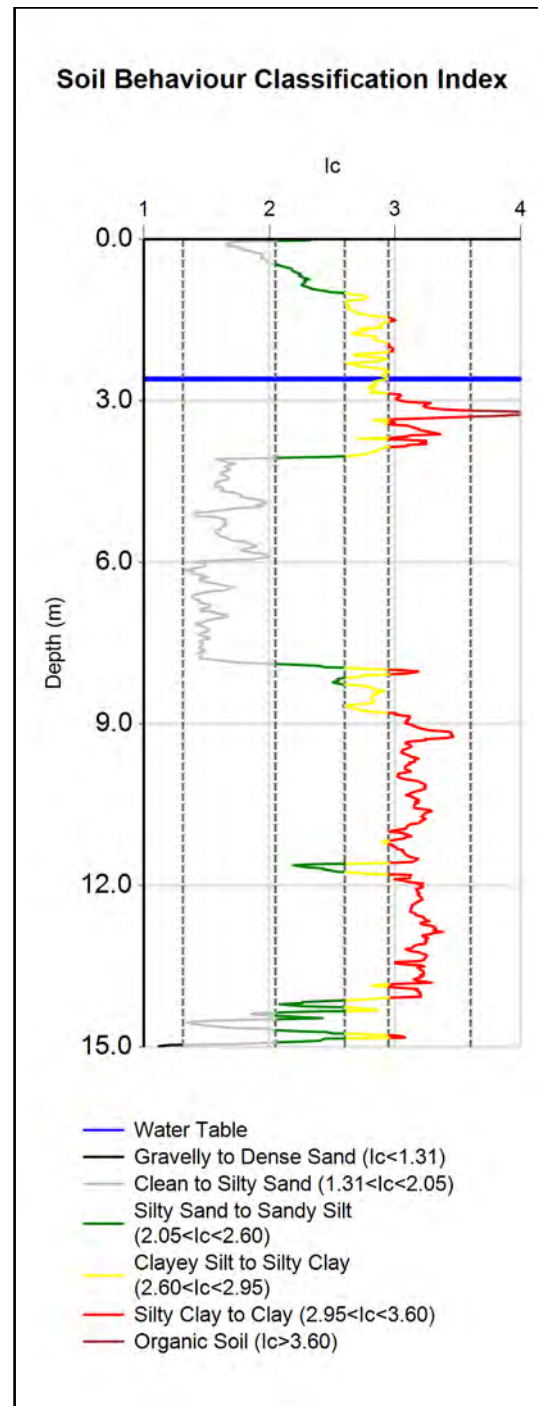
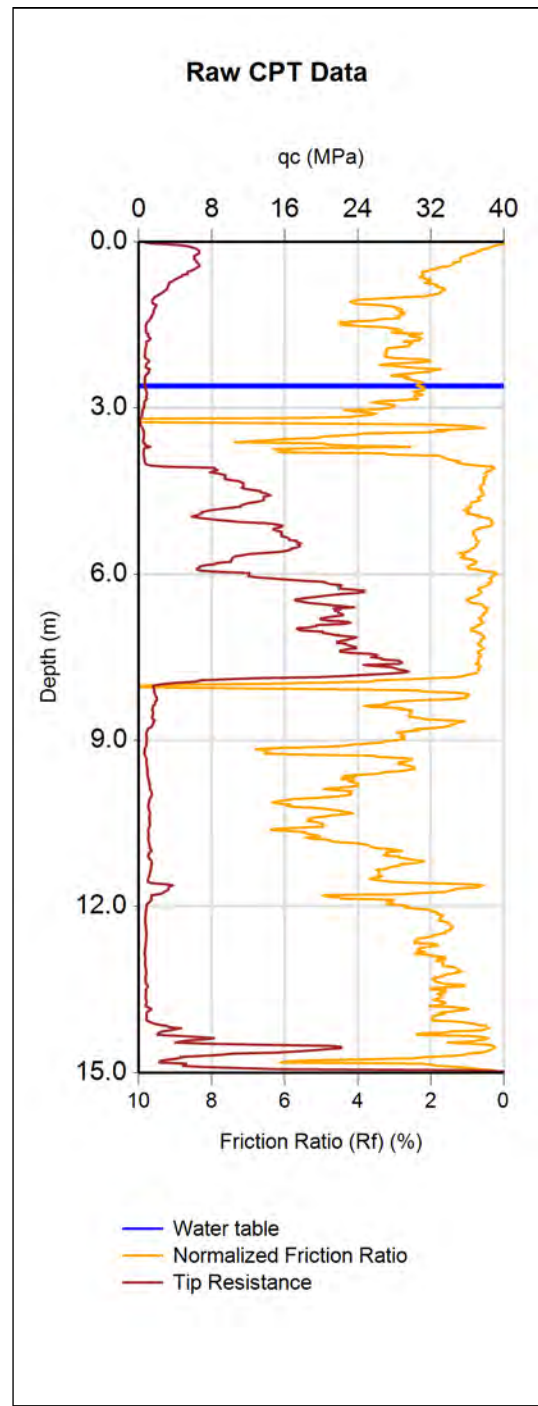


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CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE SLS Liquefaction Assessment CPT 9-12	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT12	60511	10/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	1	0	0	0	15	0						
	50%	0	0	0	0	15	0						
	85%	0	0	0	0	15	0						



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Exceptional thinking together
V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 9-12

LOCATION
Havelock Road / Howard Street

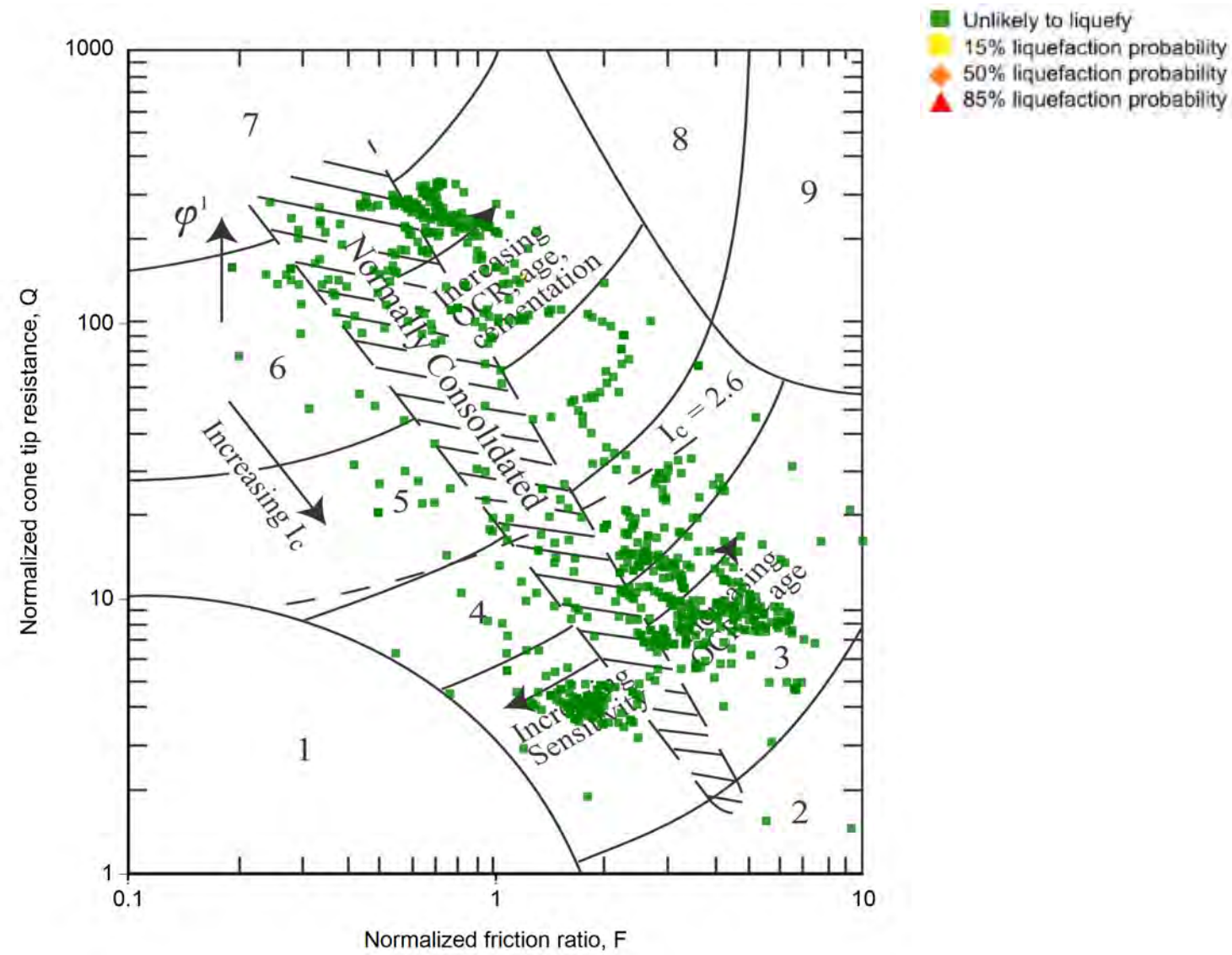
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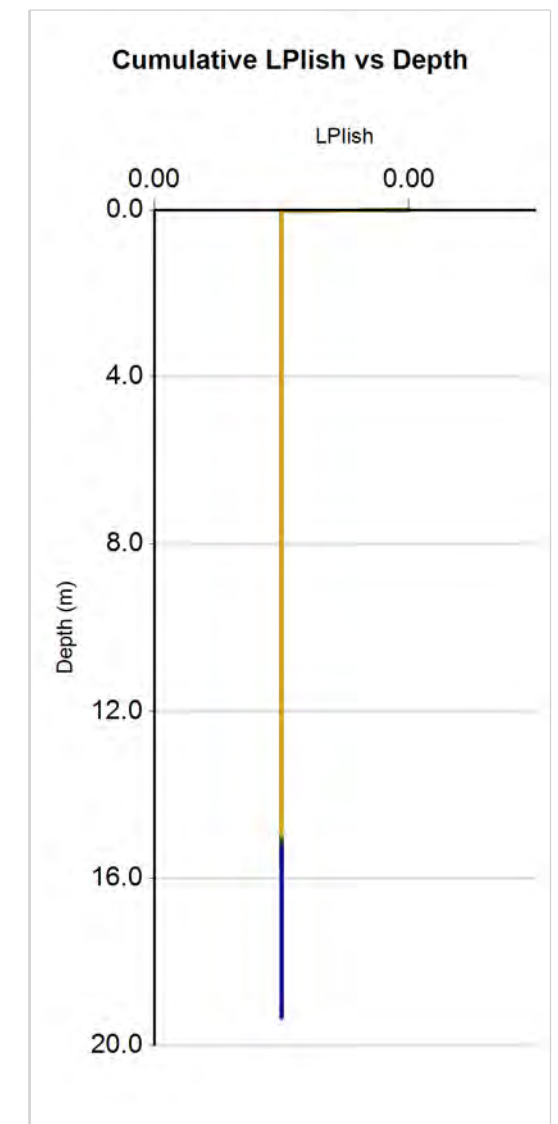
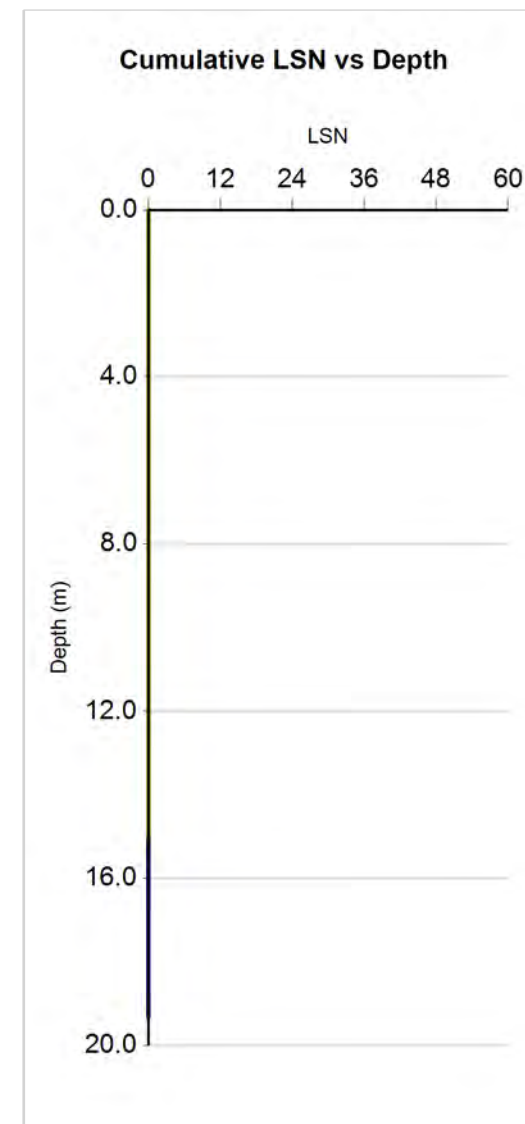
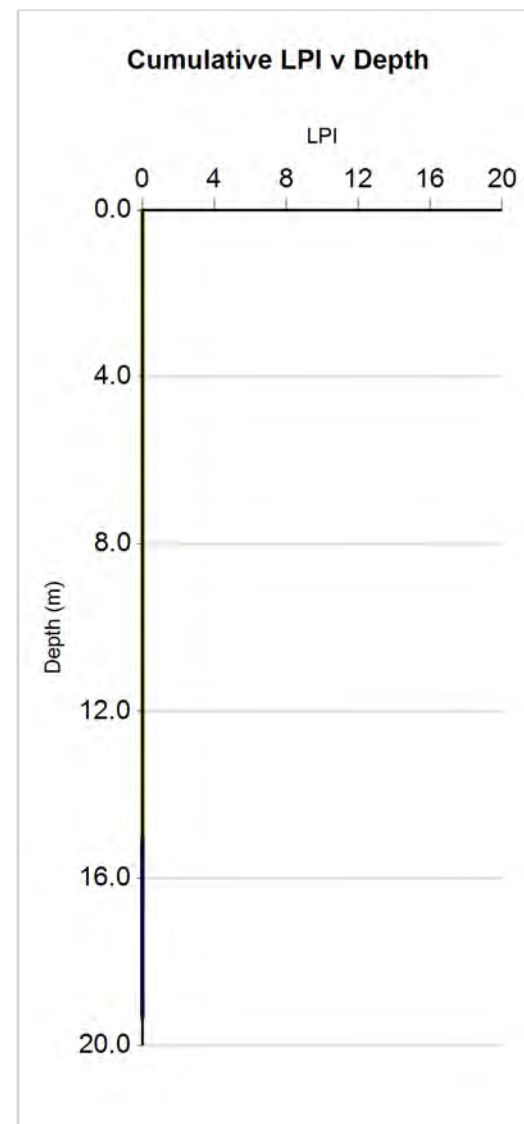
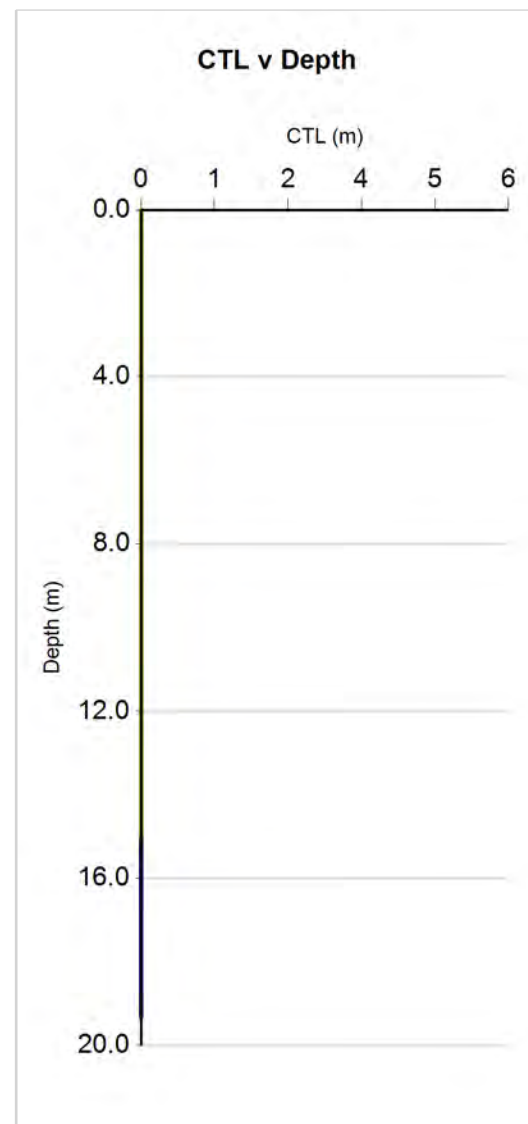
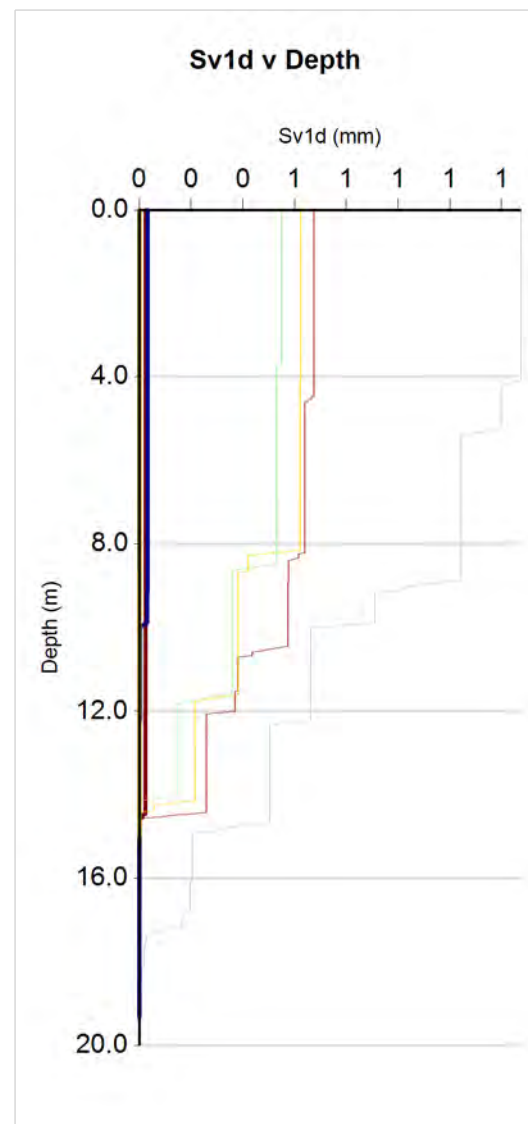


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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

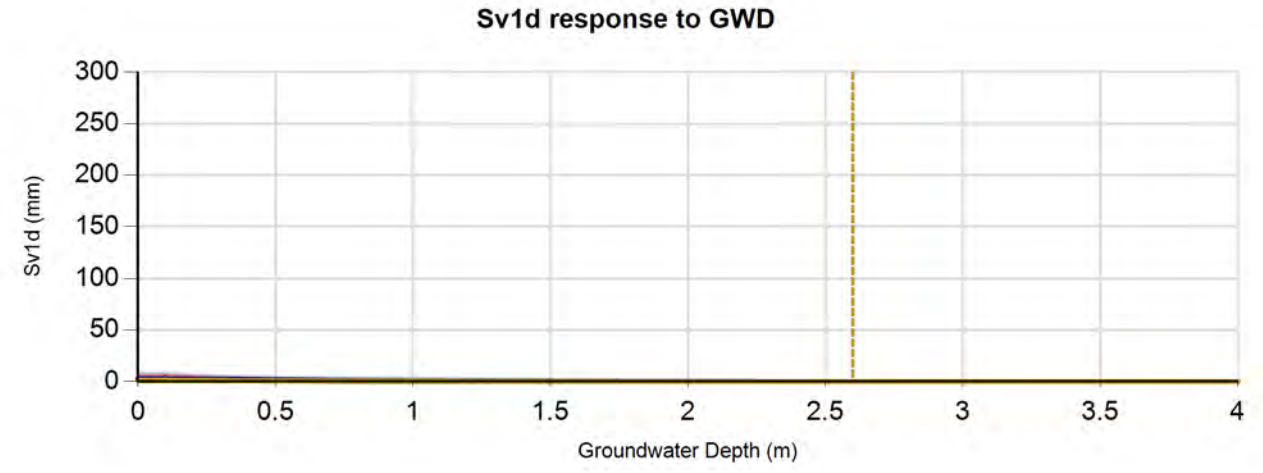
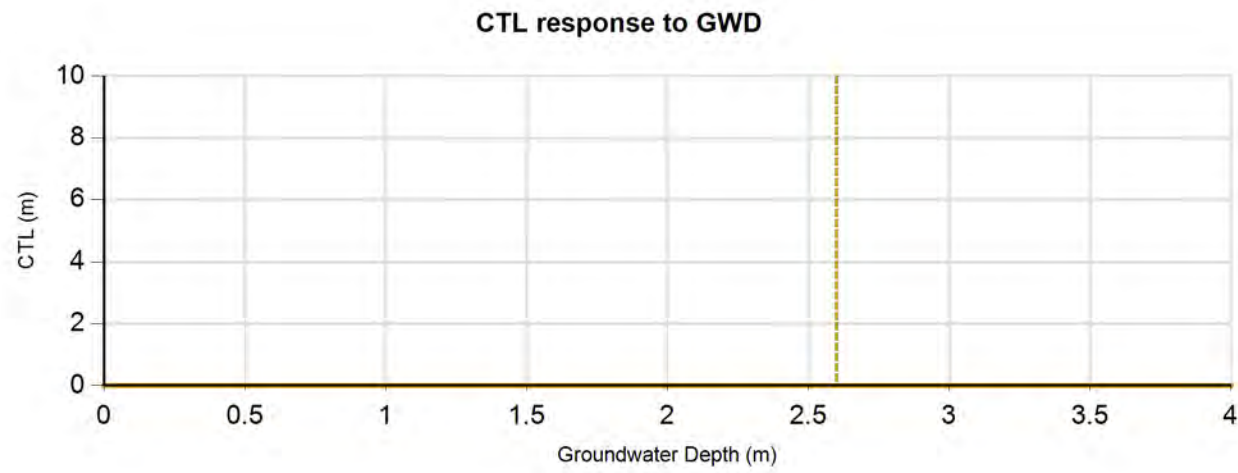
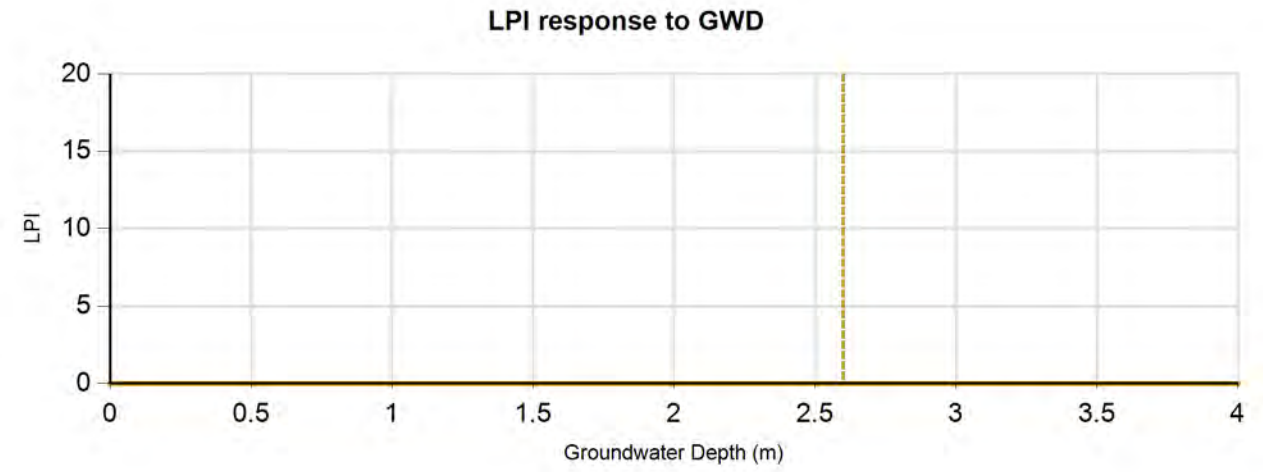
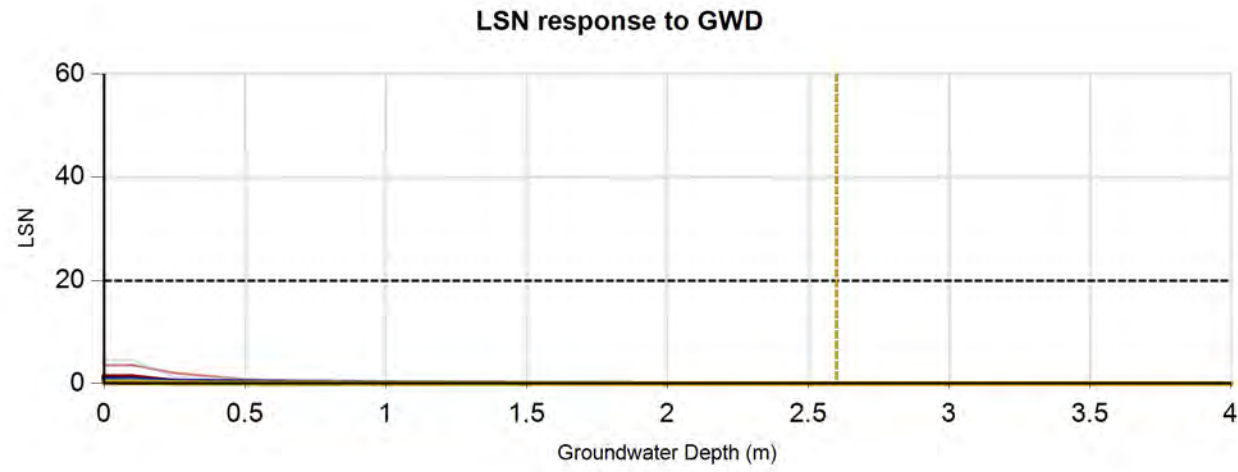
 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE SLS Liquefaction Assessment CPT 9-12	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT09	60507	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT10	60509	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT11	60510	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
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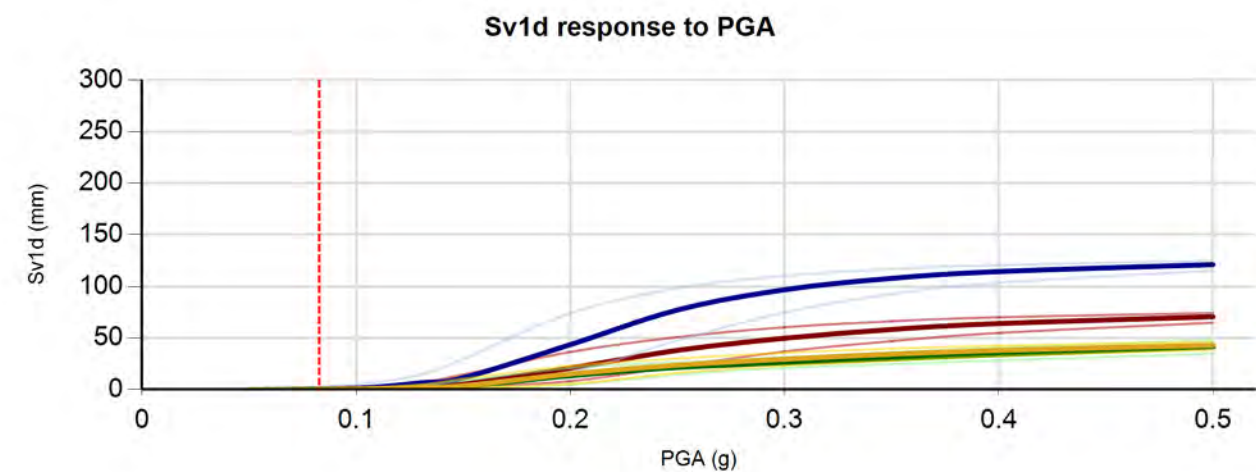
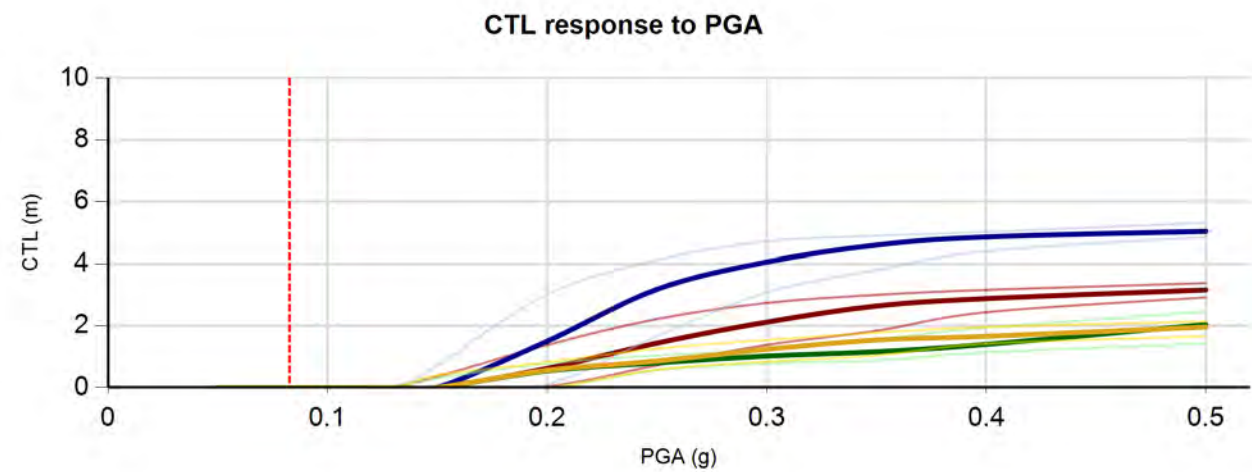
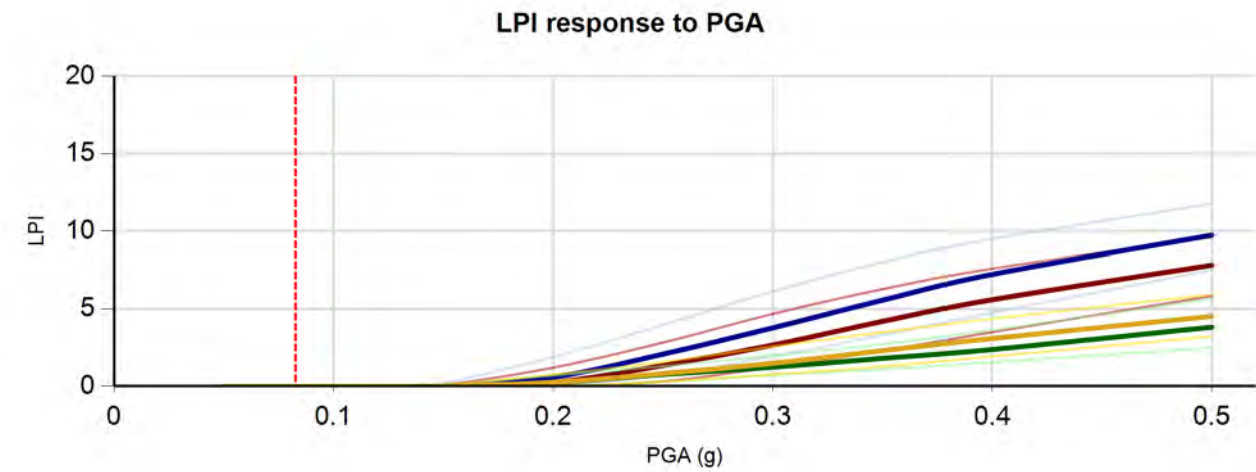
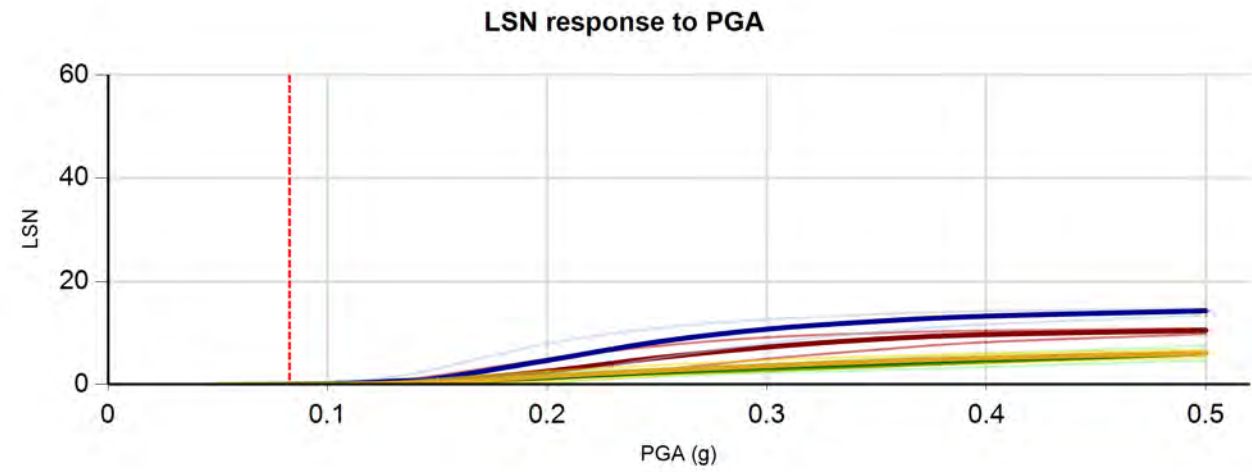
Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



Vertical dotted line/s indicate user specified GWD at the CPT locations. (actual GWD)

											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT09	60507	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT10	60509	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT11	60510	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT12	60511	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

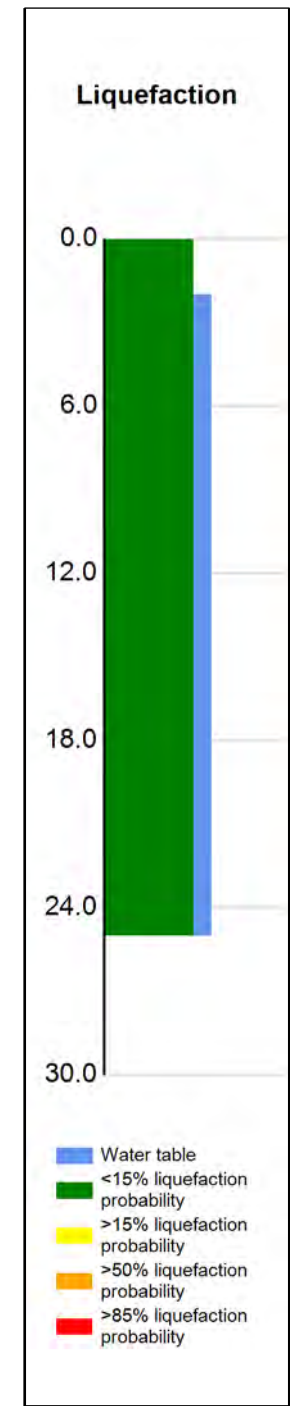
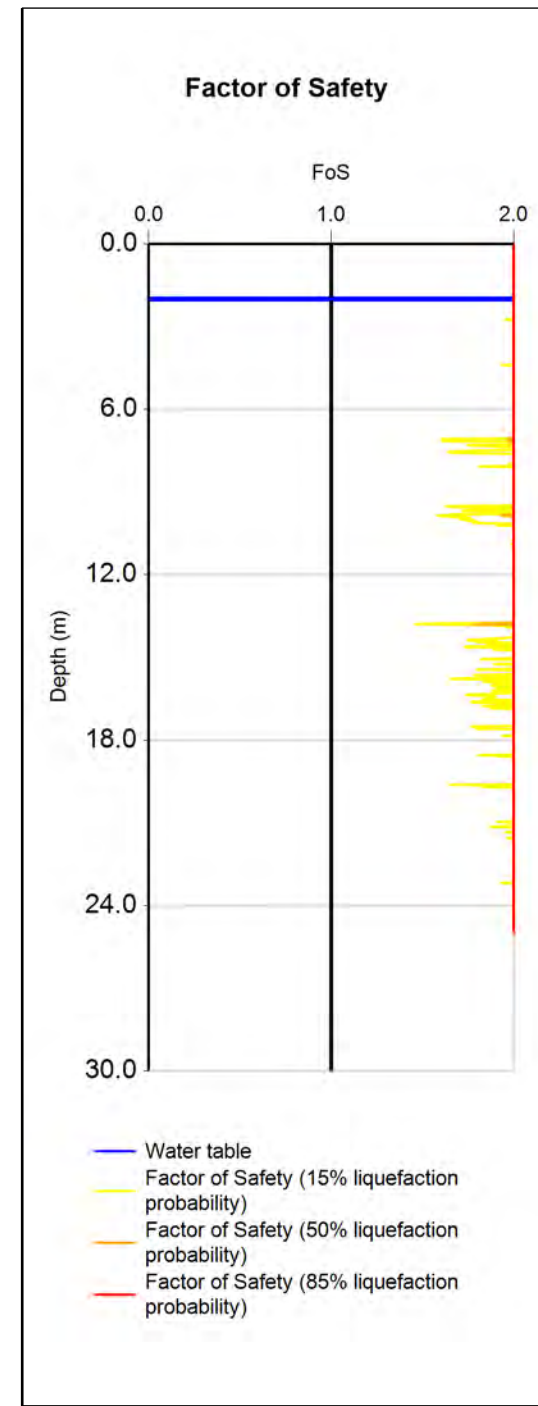
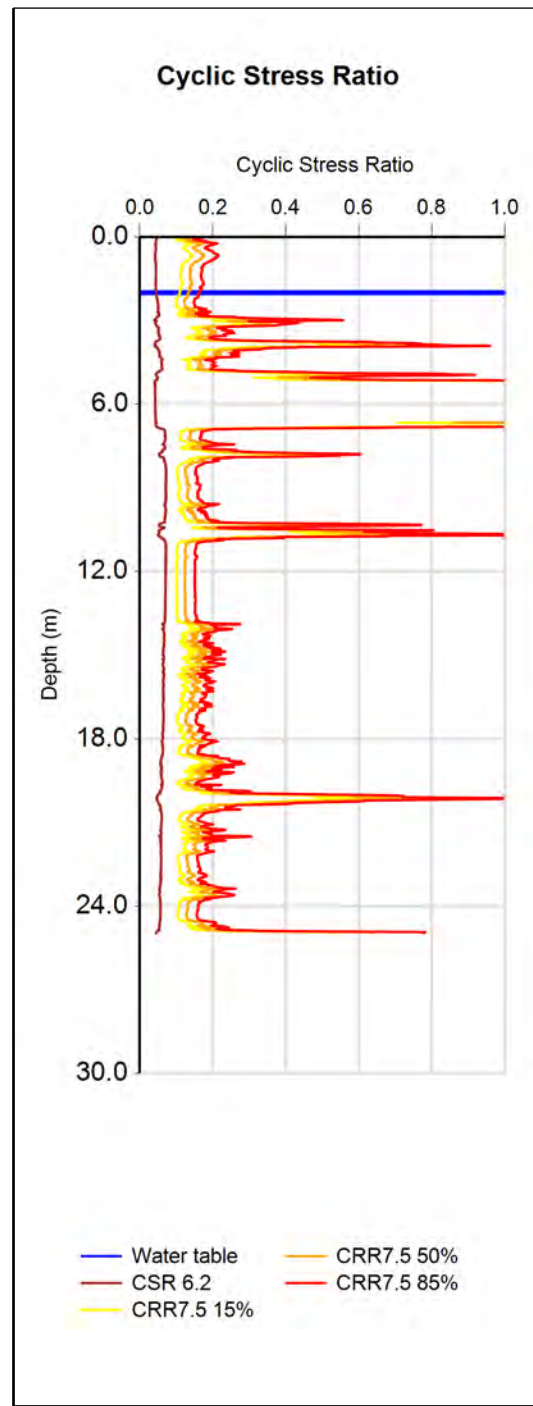
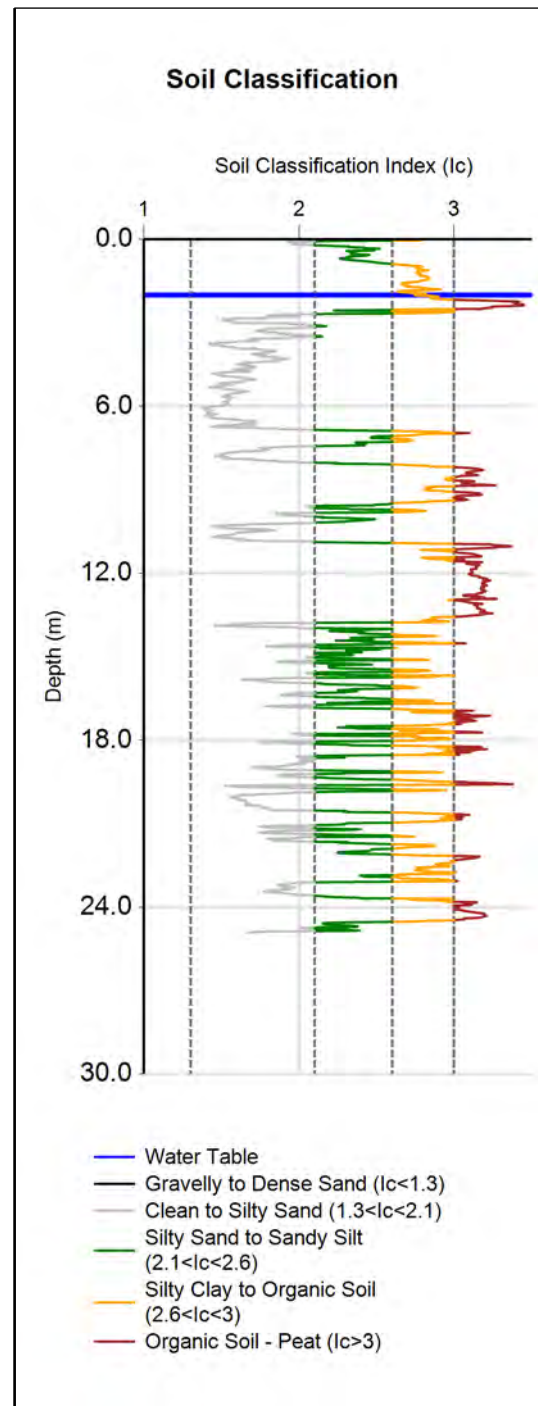
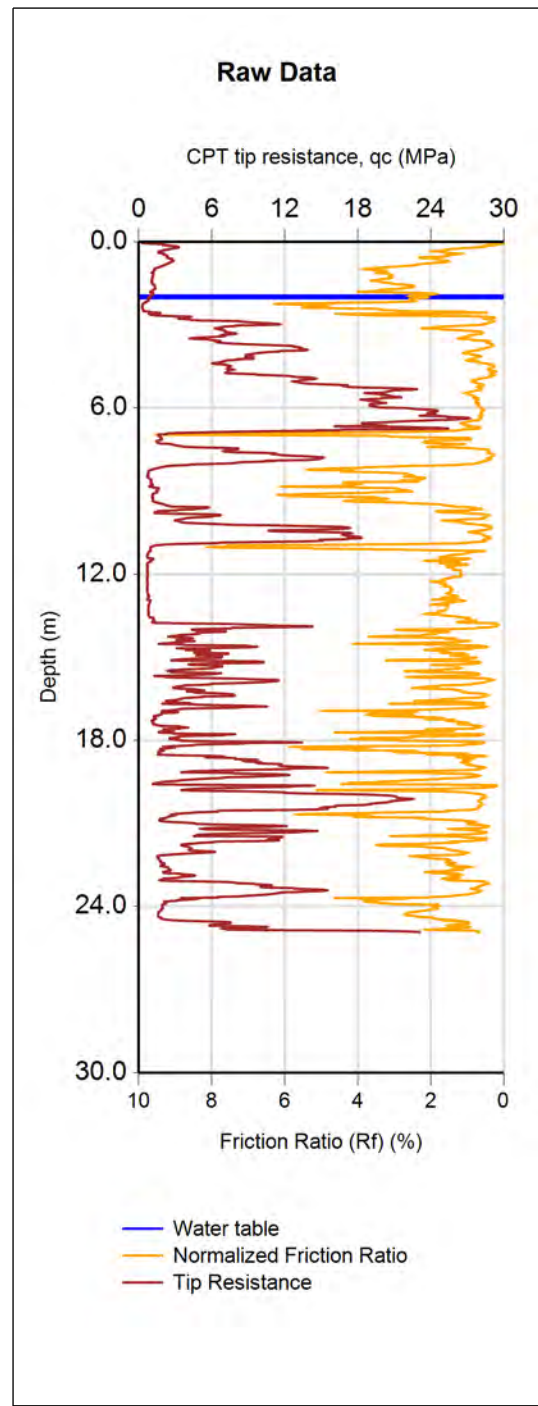
											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT09	60507	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT10	60509	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT11	60510	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT12	60511	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60507	60509	60510	60511
CPT Name	CPT09	CPT10	CPT11	CPT12
PGA	0.0827g	0.0827g	0.0827g	0.0827g
Magnitude	6.2	6.2	6.2	6.2
Depth to groundwater	2.6m	2.6m	2.6m	2.6m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	15.78m	19.34m	15.14m	14.98m
Maximum depth of analysis	15.78m	19.34m	15.14m	14.98m
RL	n/a	n/a	n/a	n/a



(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT13	60512	10/02/2016	User Specified	6.2	0.0827	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	2	0	0	0	25	0						
	50%	0	0	0	0	25	0						
	85%	0	0	0	0	25	0						



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CLIENT, PROJECT

Hastings District Council
Housing Rezone

TITLE

SLS Liquefaction Assessment CPT 13-16

LOCATION

Havelock Road/
Howard Street

JOB NUMBER

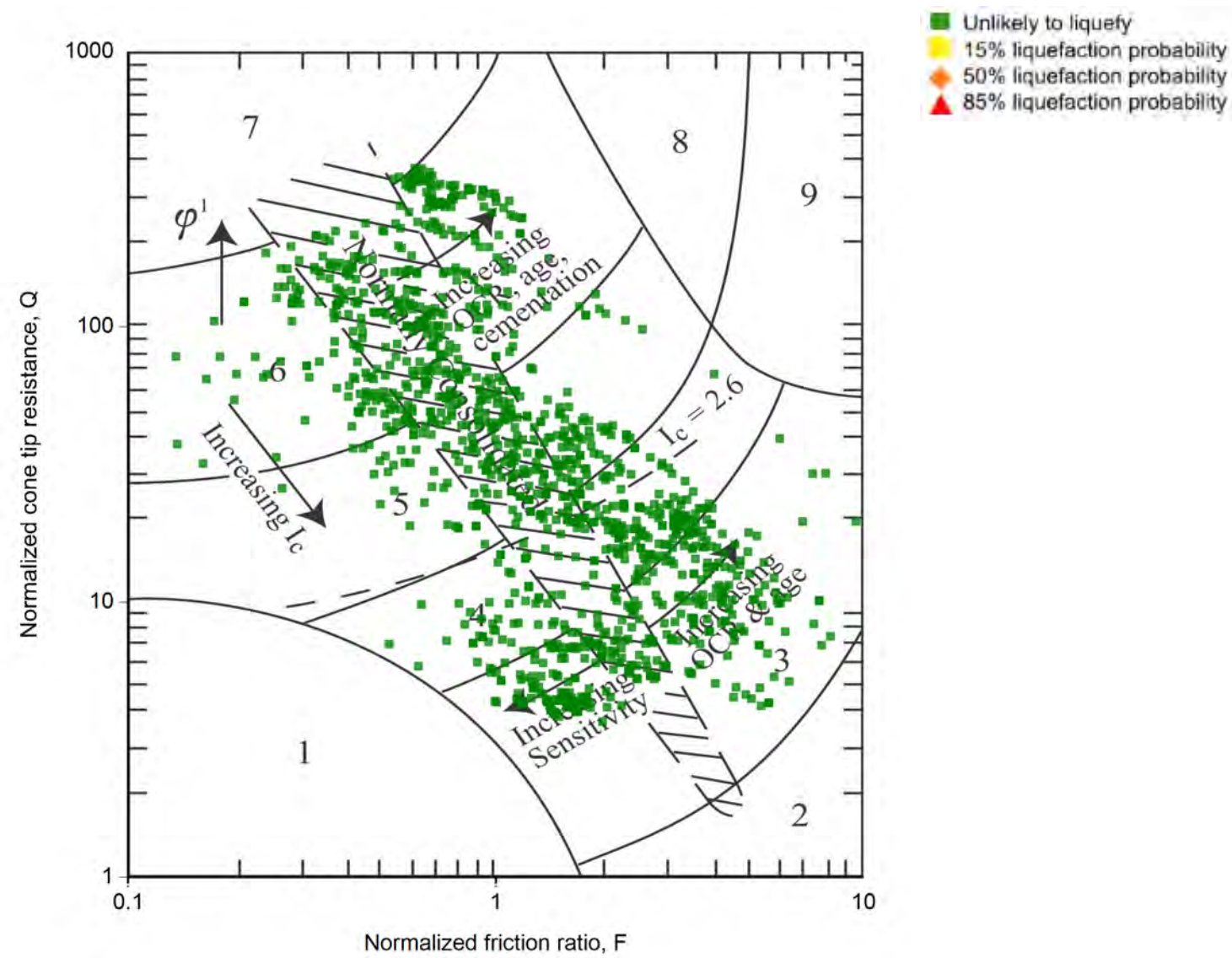
31464.1000

DATE 4/03/2016

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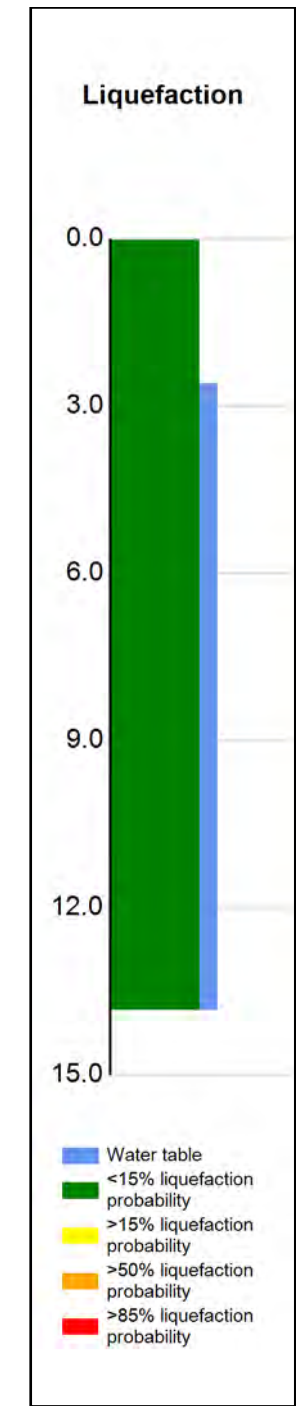
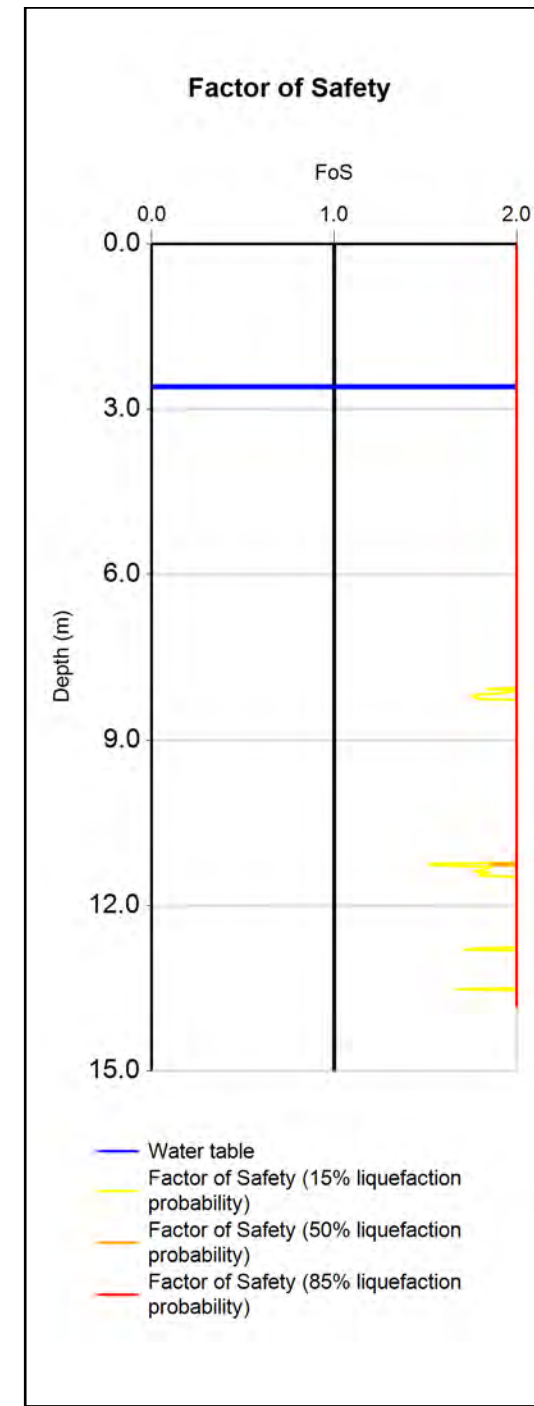
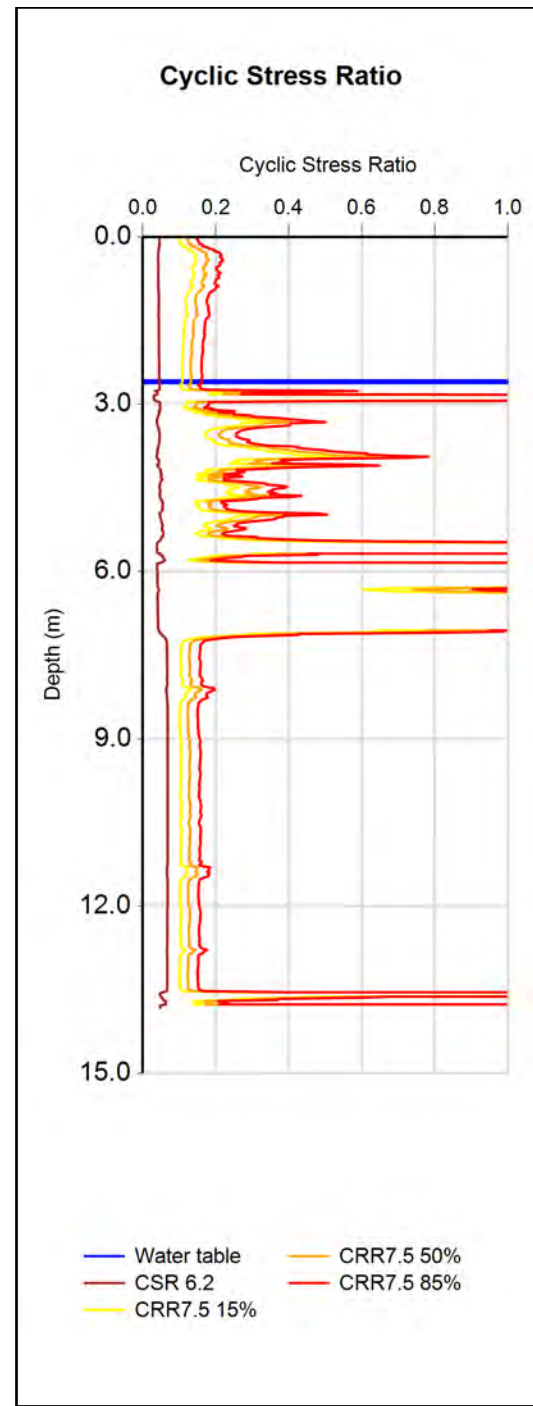
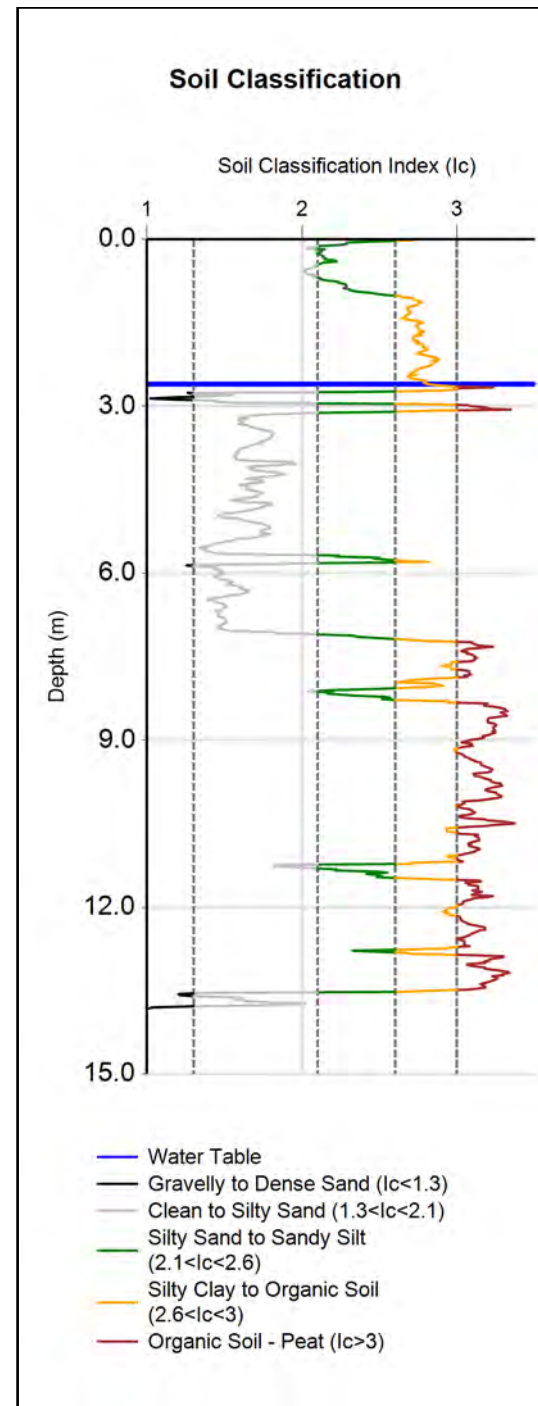
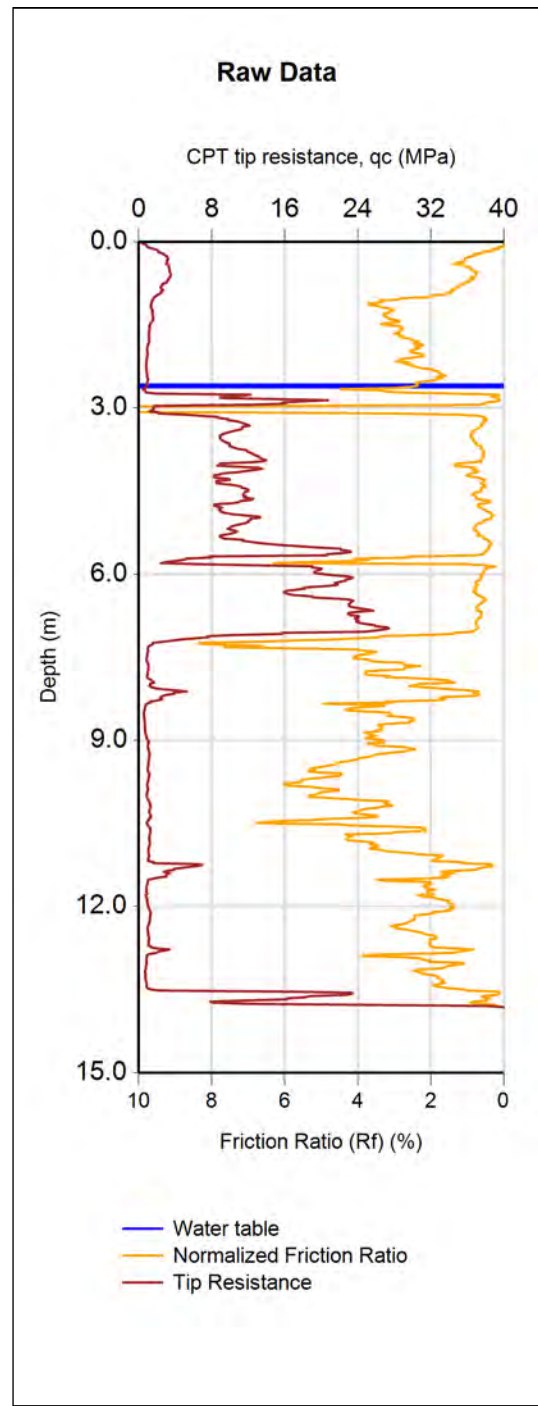


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
| 2. Organic soils - peats | 7. Gravelly sand to dense sand |
| 3. Clays - silty clay to clay | 8. Very stiff sand to clayey sand * |
| 4. Silt mixtures - clayey silt to silty clay | 9. Very stiff, fine grained * |
| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE SLS Liquefaction Assessment CPT 13-16	JOB NUMBER 31464.1000	ANALYSED khl



(Assumed pre-drill values)

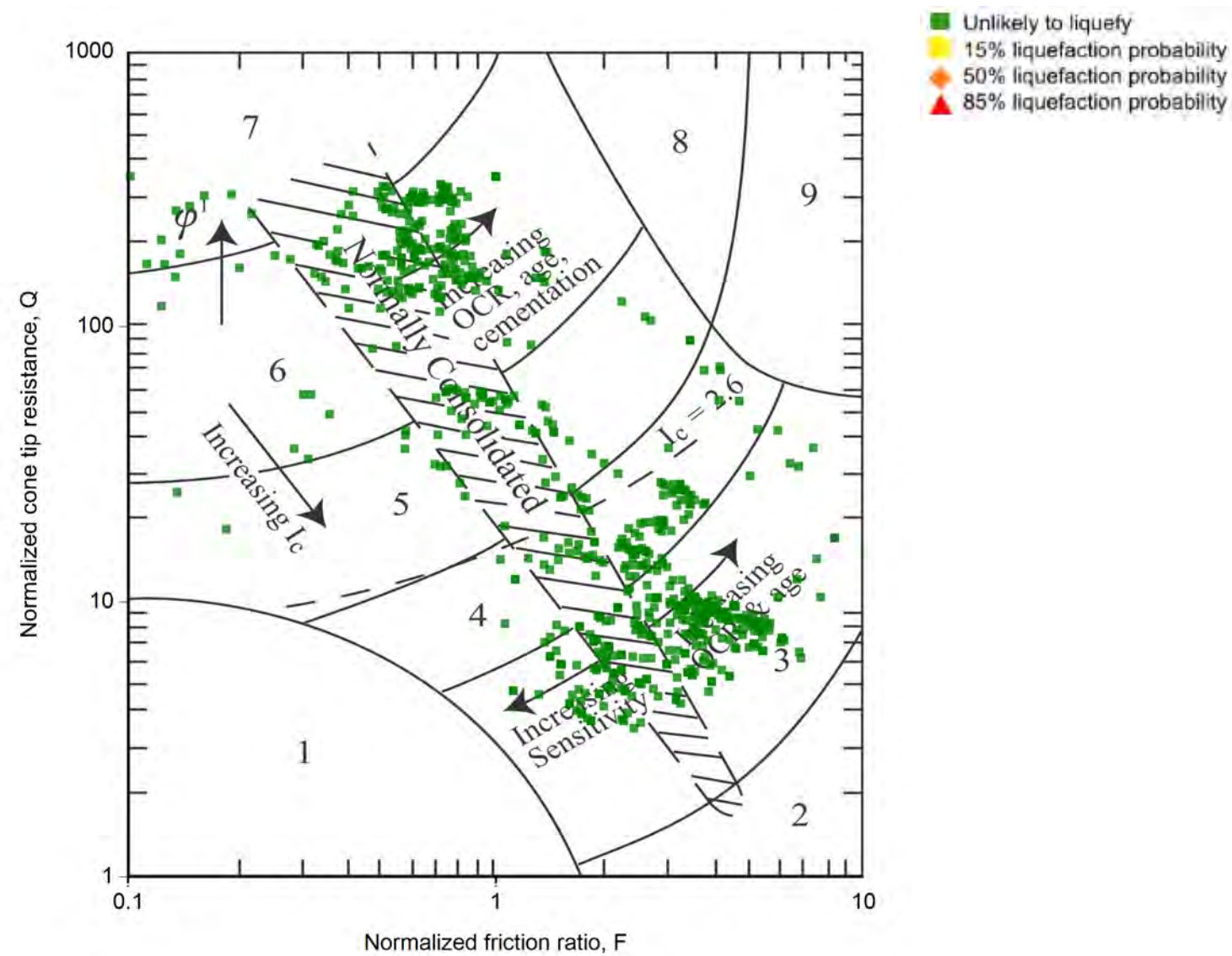
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT14	60514	9/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	1	0	0	0	13.8	0						
	50%	0	0	0	0	13.8	0						
	85%	0	0	0	0	13.8	0						



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Exceptional thinking together
V1.3

CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 13-16

LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
		CHECKED	
		PAGE	3 of 11 pages



- | | |
|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
| 2. Organic soils - peats | 7. Gravelly sand to dense sand |
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| 4. Silt mixtures - clayey silt to silty clay | 9. Very stiff, fine grained * |
| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

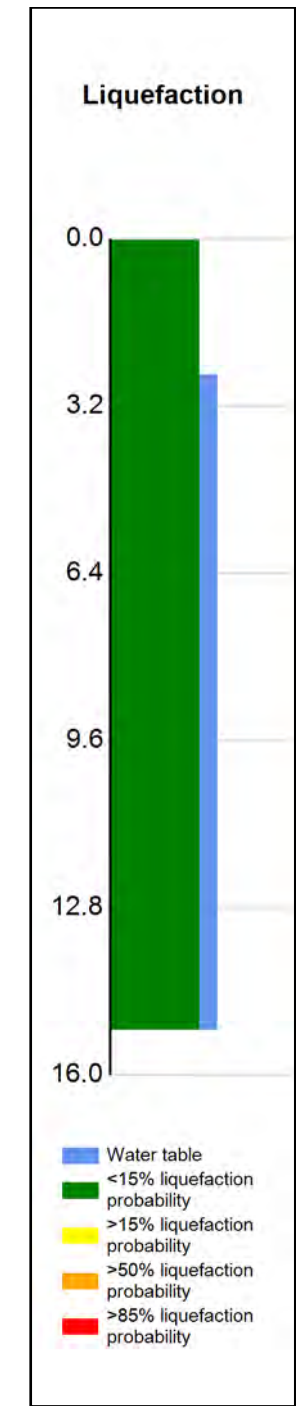
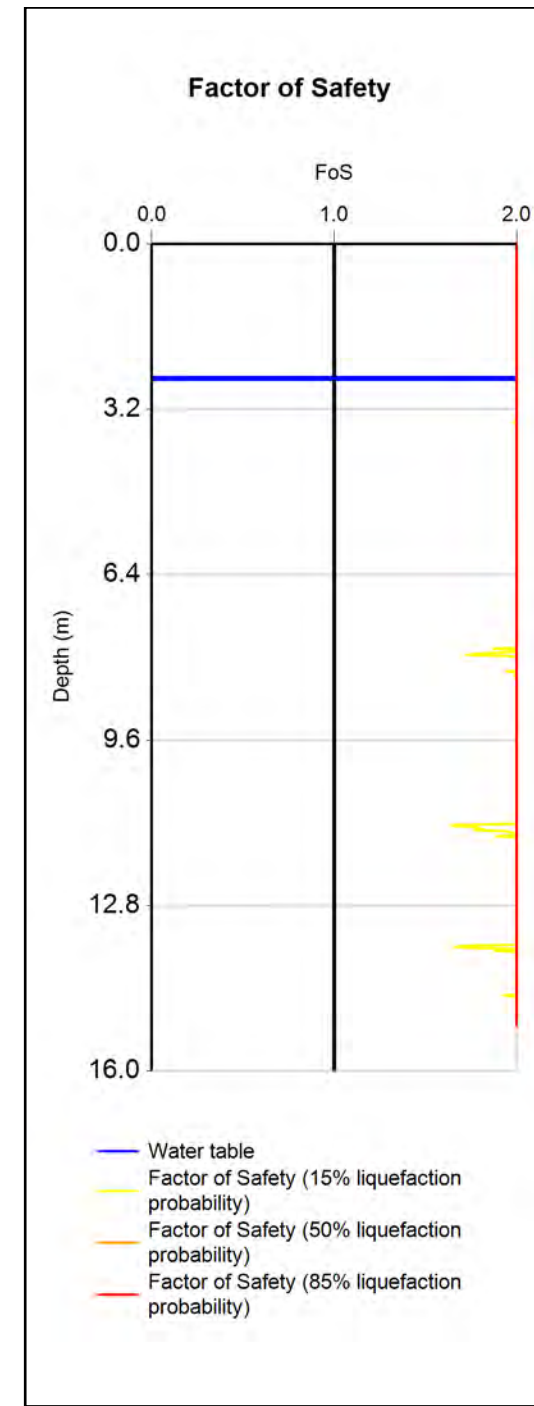
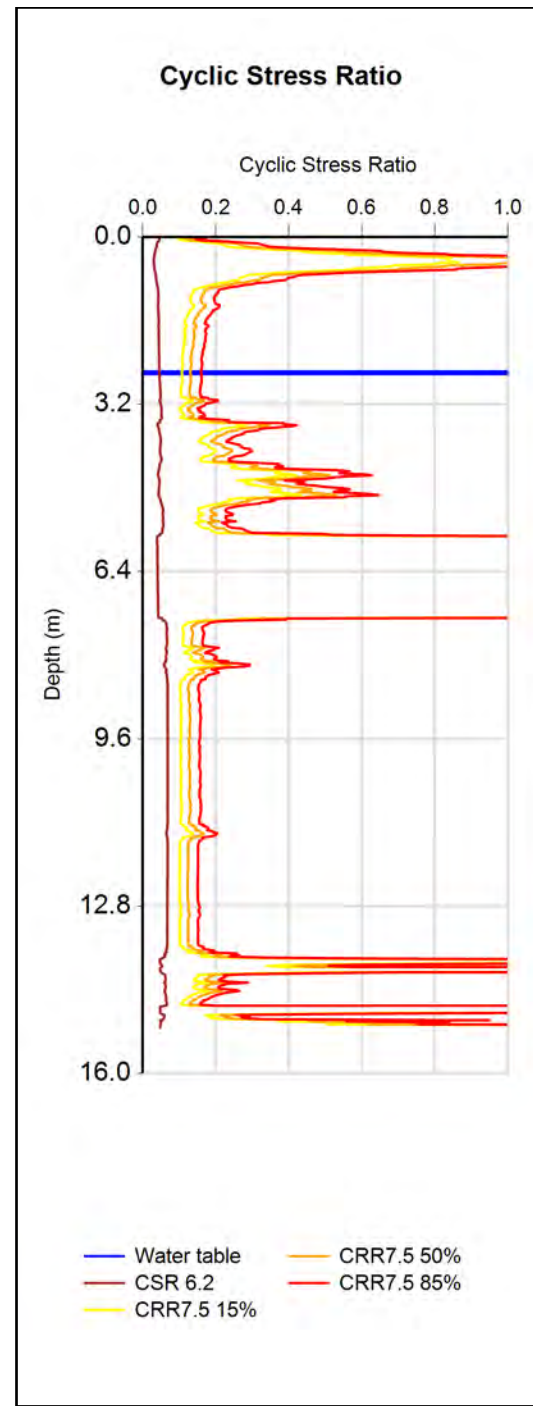
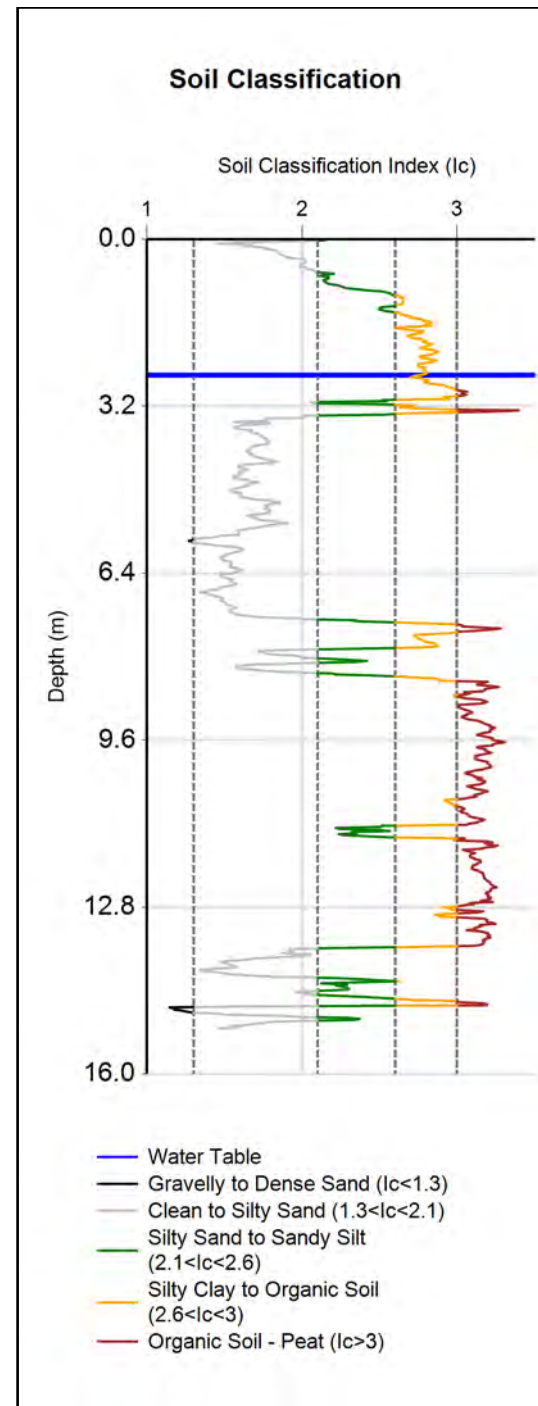
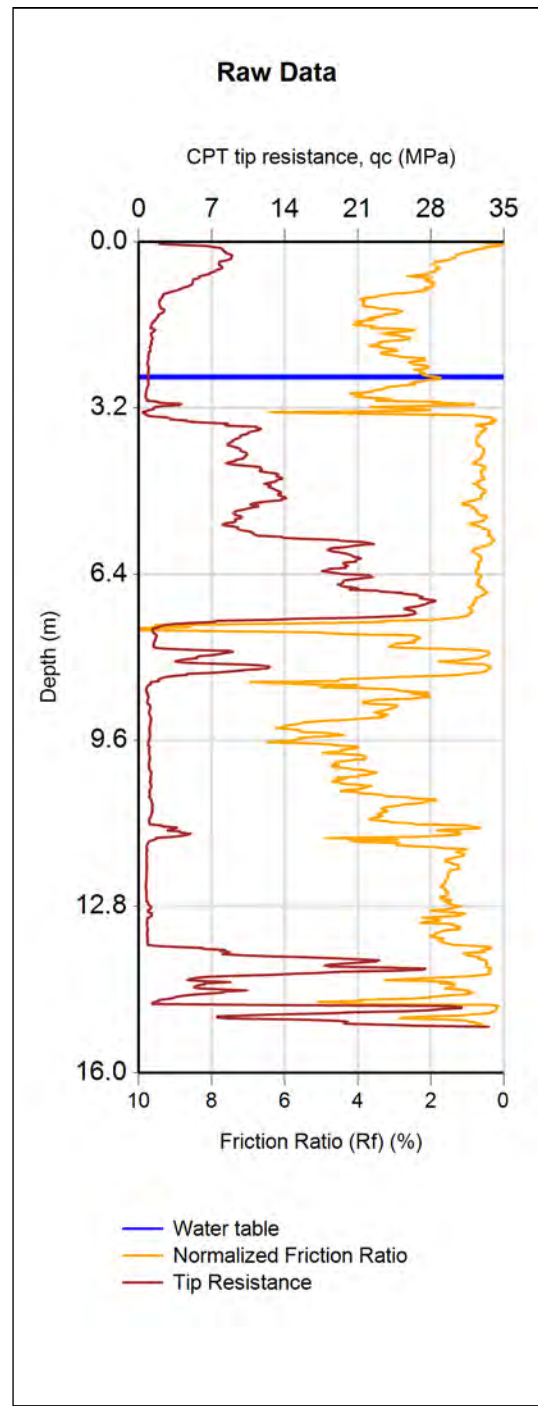
CPT-based soil behavior type classification chart by Robertson (1990)



Tonkin + Taylor
 Exceptional thinking
 together
 V1.3

CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 13-16

LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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		PAGE	4 of 11 pages



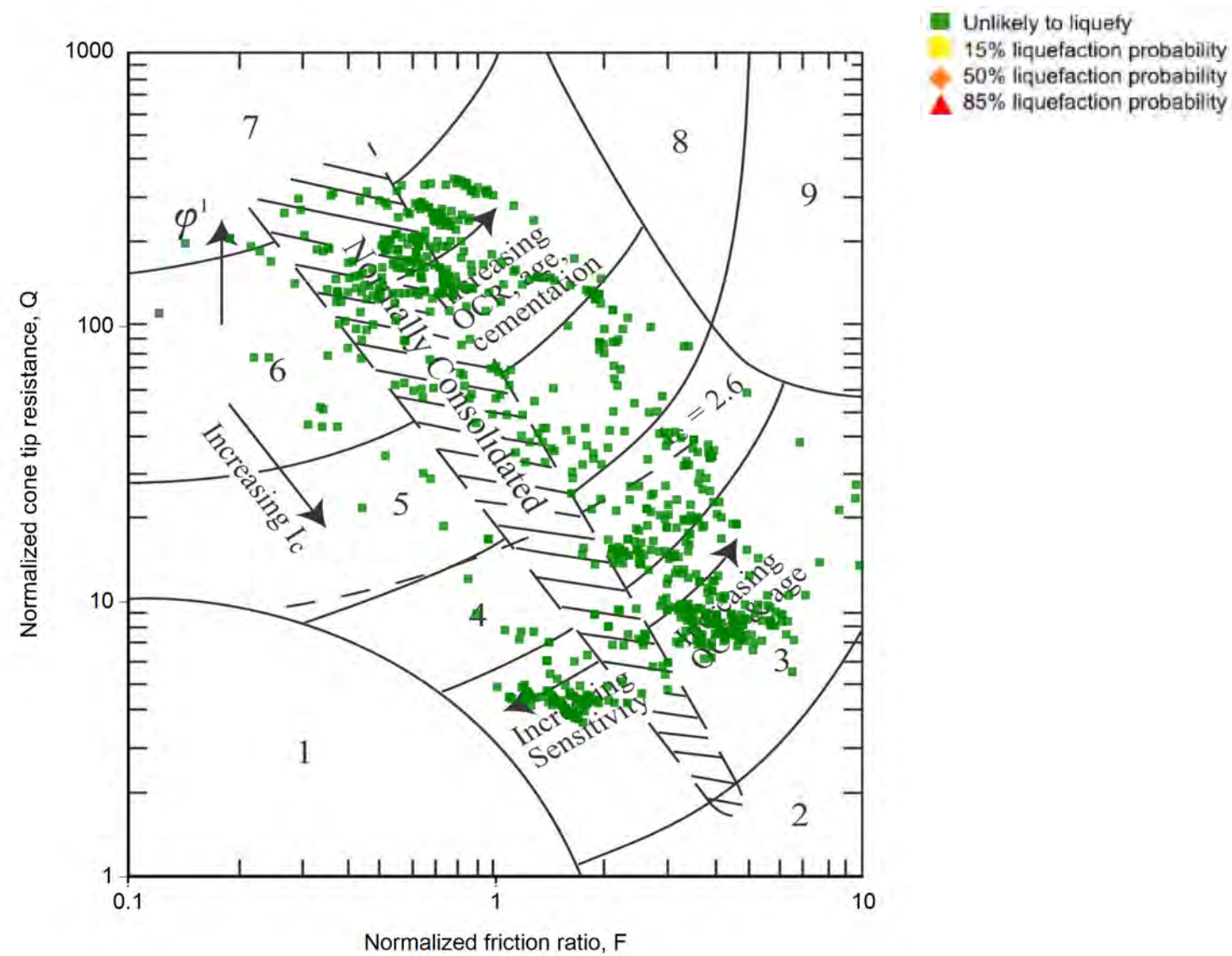
(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT15	60515	10/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	0	0	0	0	15.1	0						
	50%	0	0	0	0	15.1	0						
	85%	0	0	0	0	15.1	0						



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CLIENT, PROJECT	Hastings District Council Housing Rezone	LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
TITLE	SLS Liquefaction Assessment CPT 13-16	JOB NUMBER	31464.1000	ANALYSED	khl
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				PAGE	5 of 11 pages

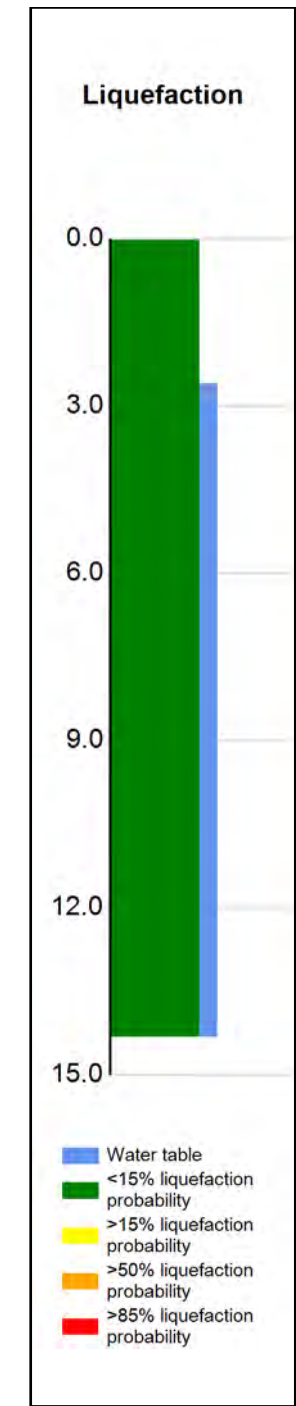
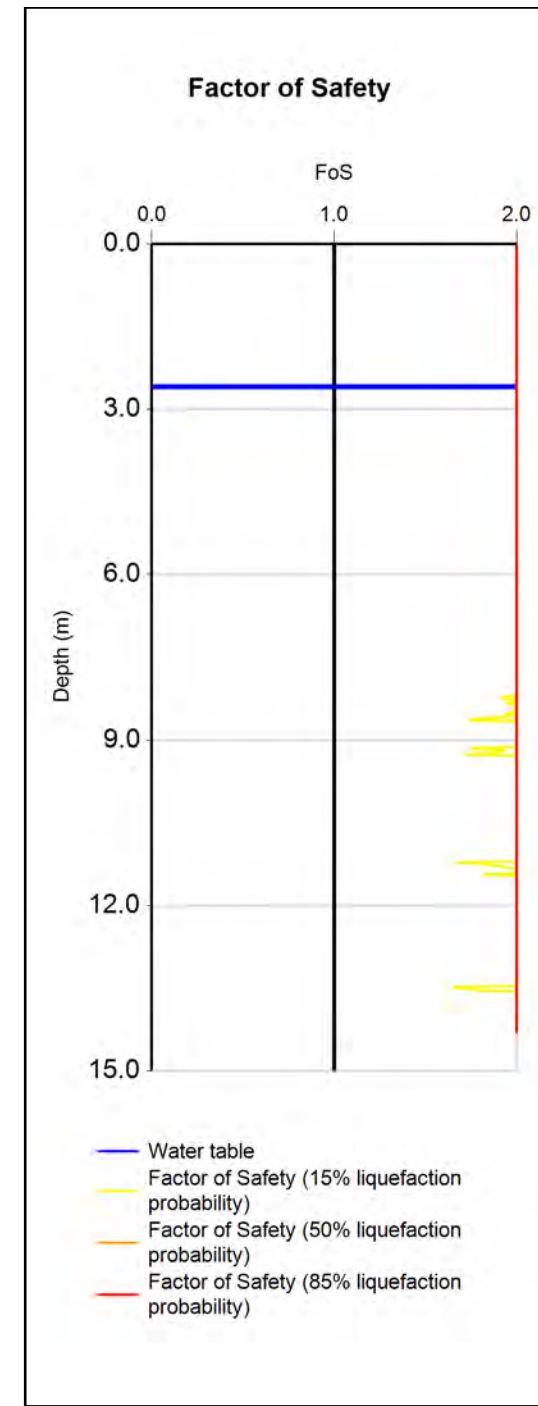
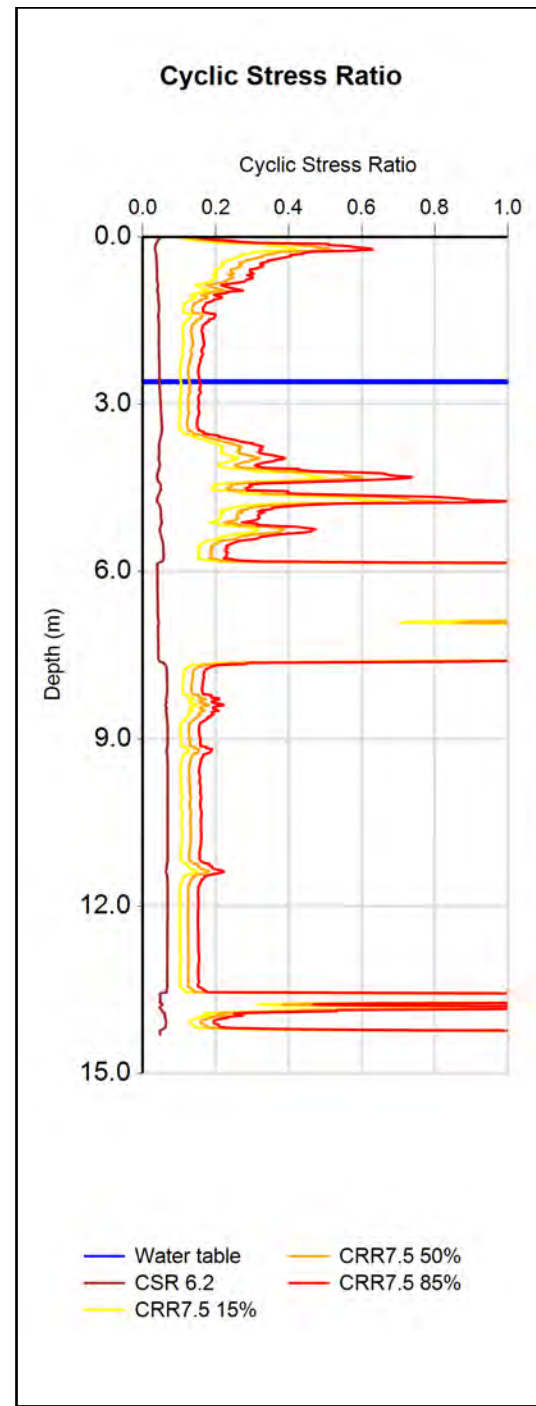
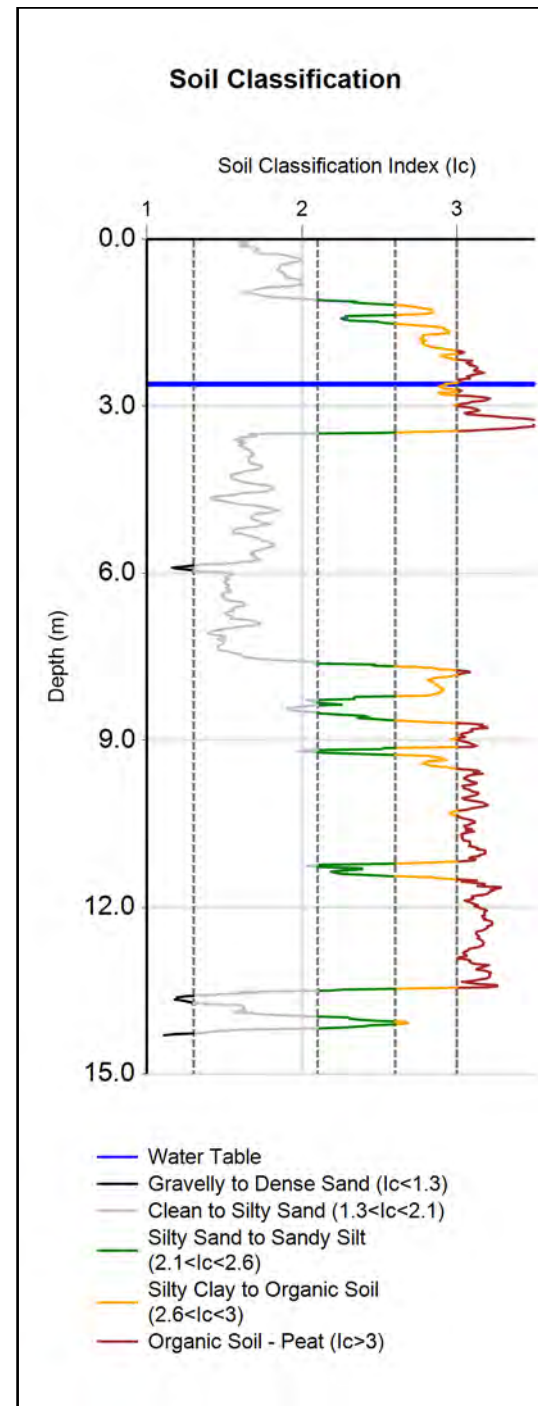
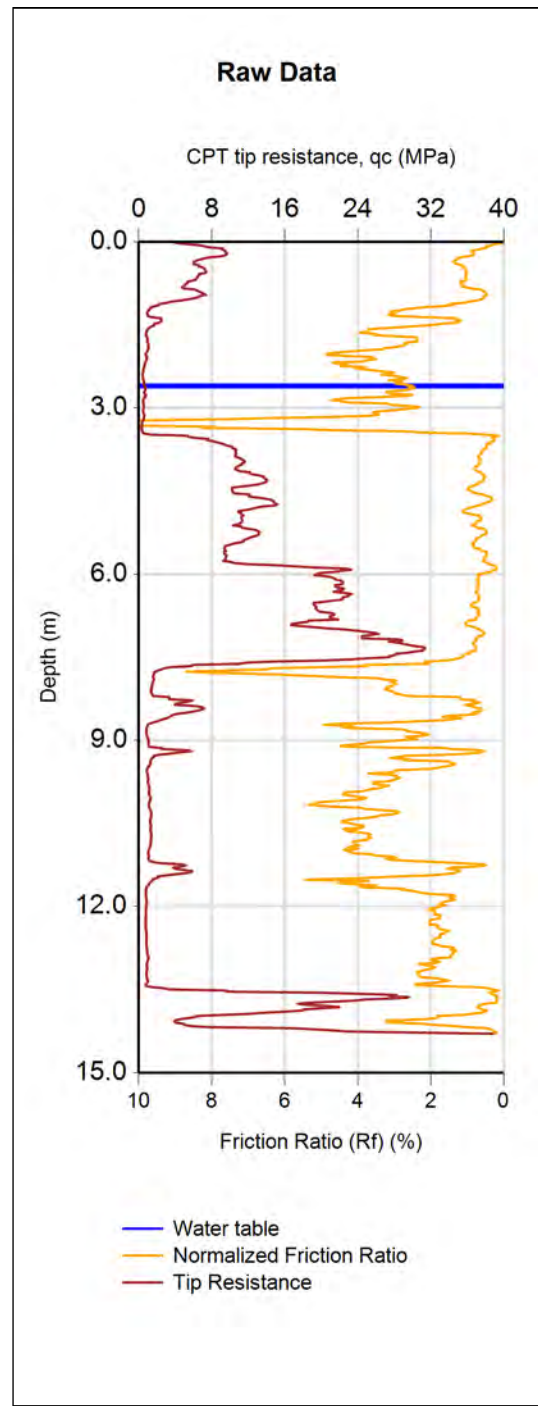


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE SLS Liquefaction Assessment CPT 13-16	JOB NUMBER 31464.1000	ANALYSED khl



(Assumed pre-drill values)

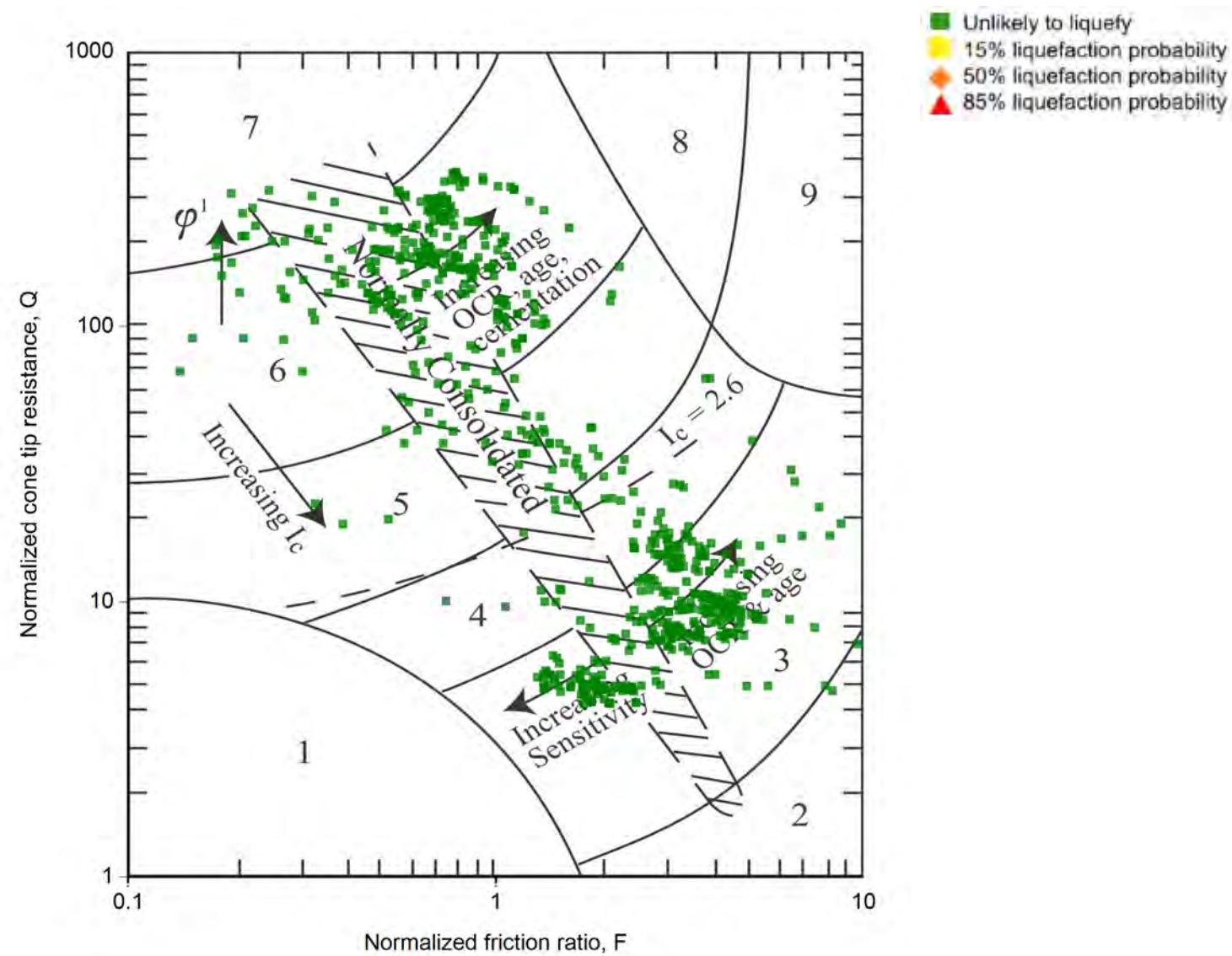
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT16	60516	10/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	0	0	0	0	14.3	0						
	50%	0	0	0	0	14.3	0						
	85%	0	0	0	0	14.3	0						



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V1.3

CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 13-16

LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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		PAGE	7 of 11 pages



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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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*Heavily overconsolidated or cemented

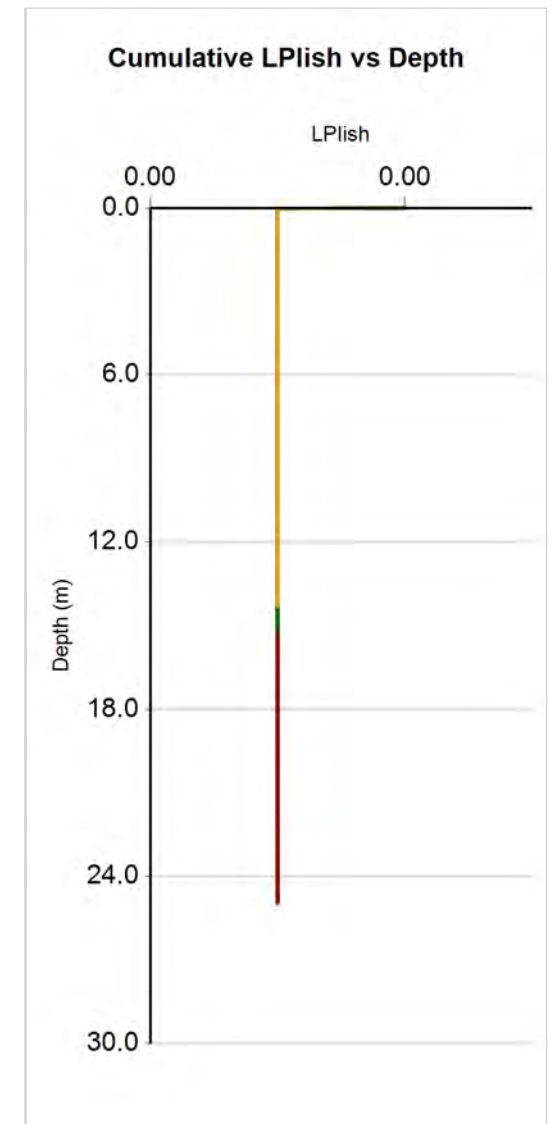
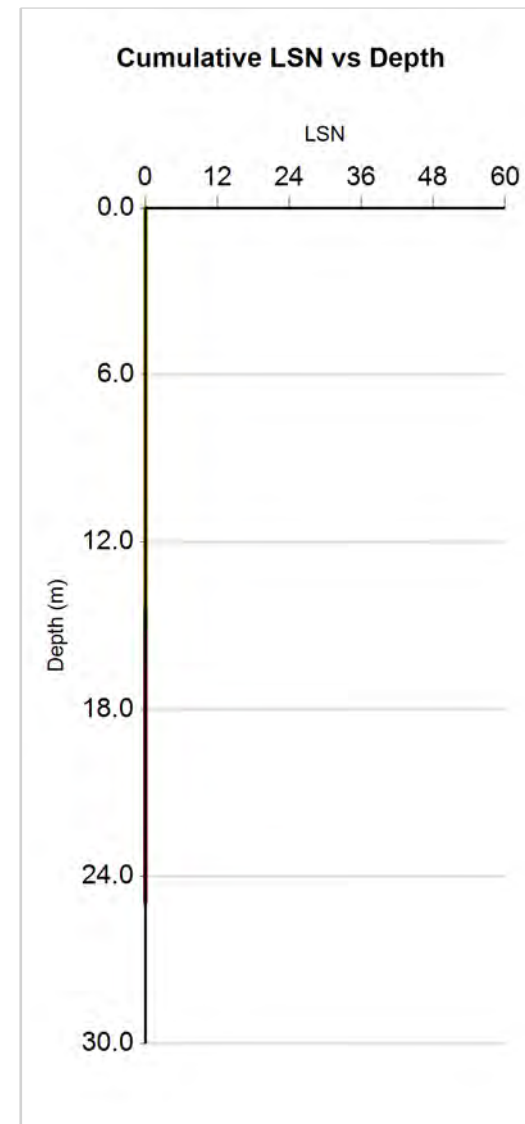
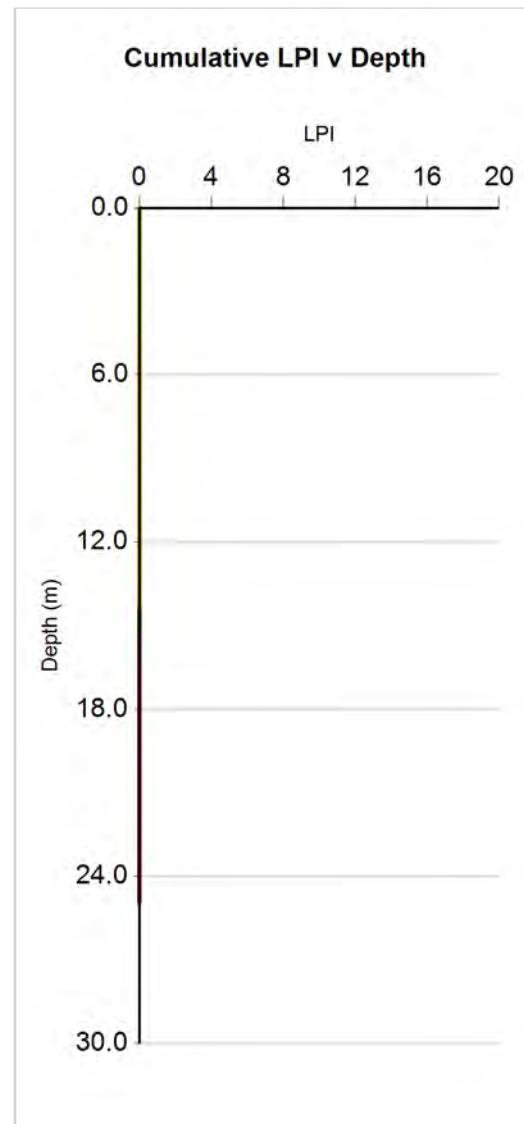
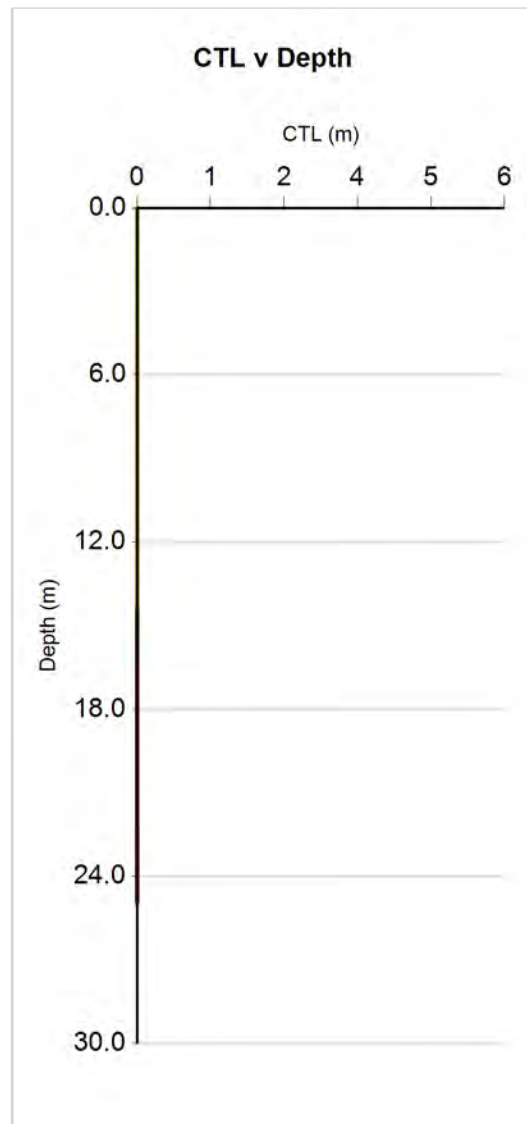
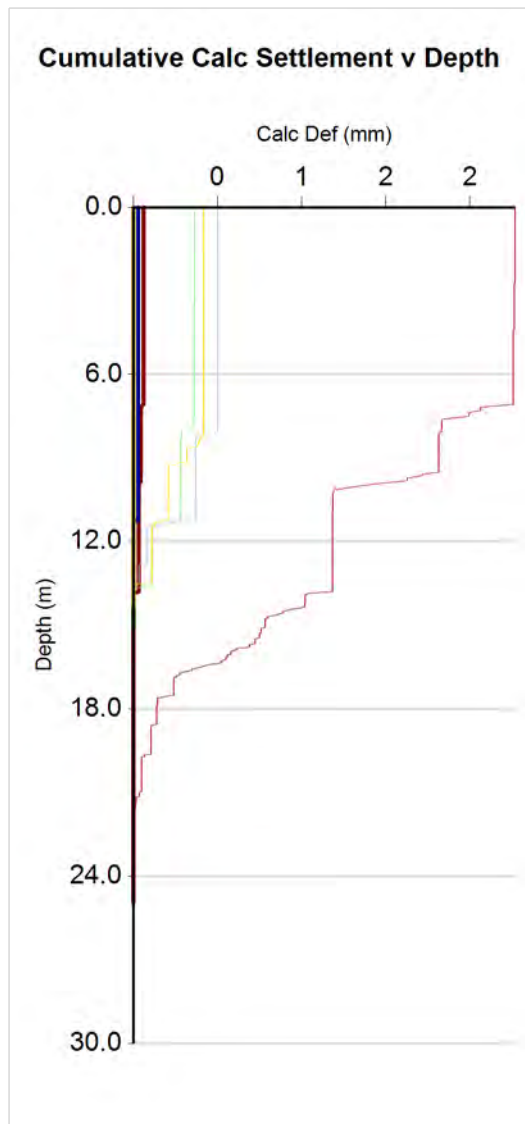
CPT-based soil behavior type classification chart by Robertson (1990)



Tonkin + Taylor
 Exceptional thinking
 together
 V1.3

CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 13-16

LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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		PAGE	8 of 11 pages

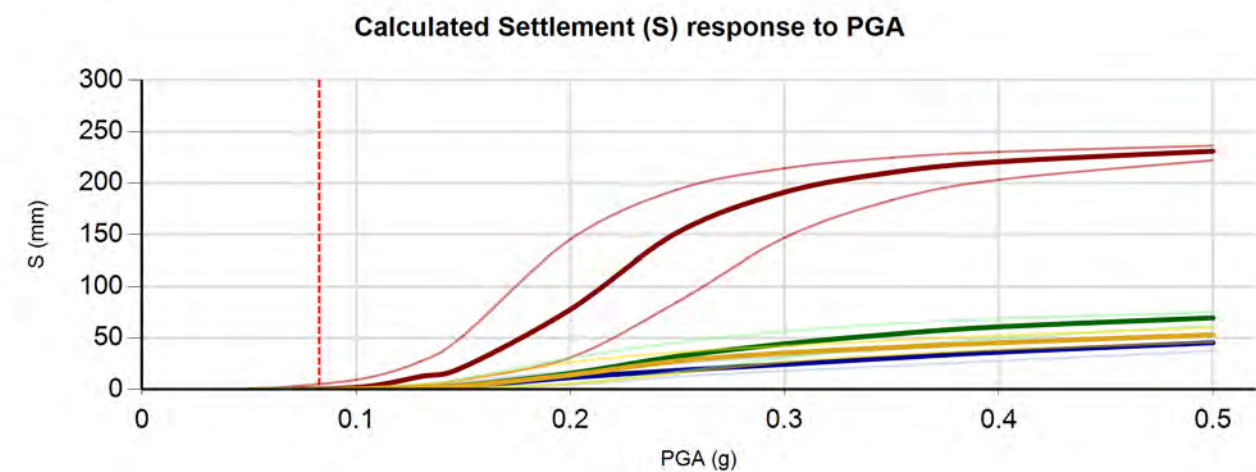
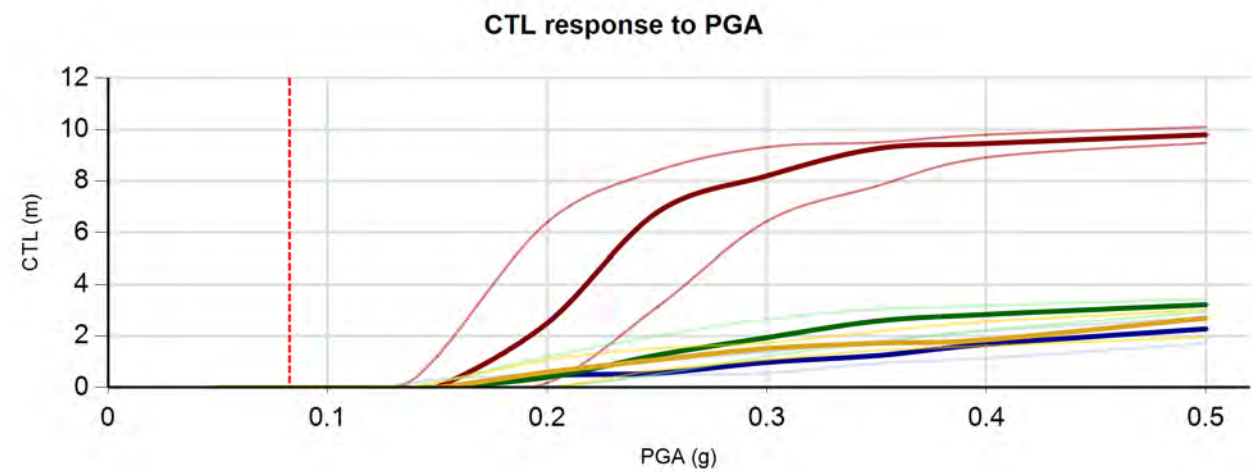
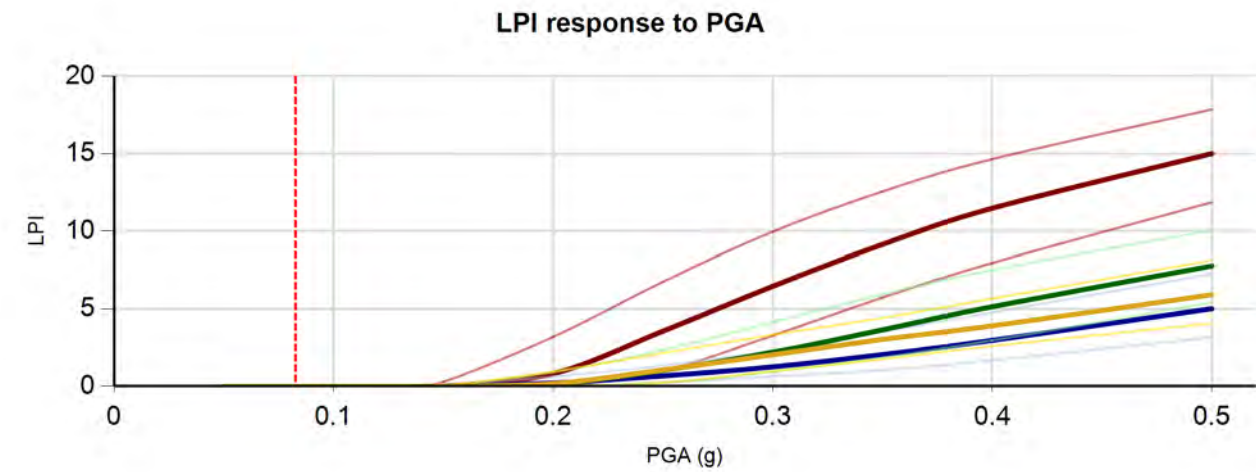
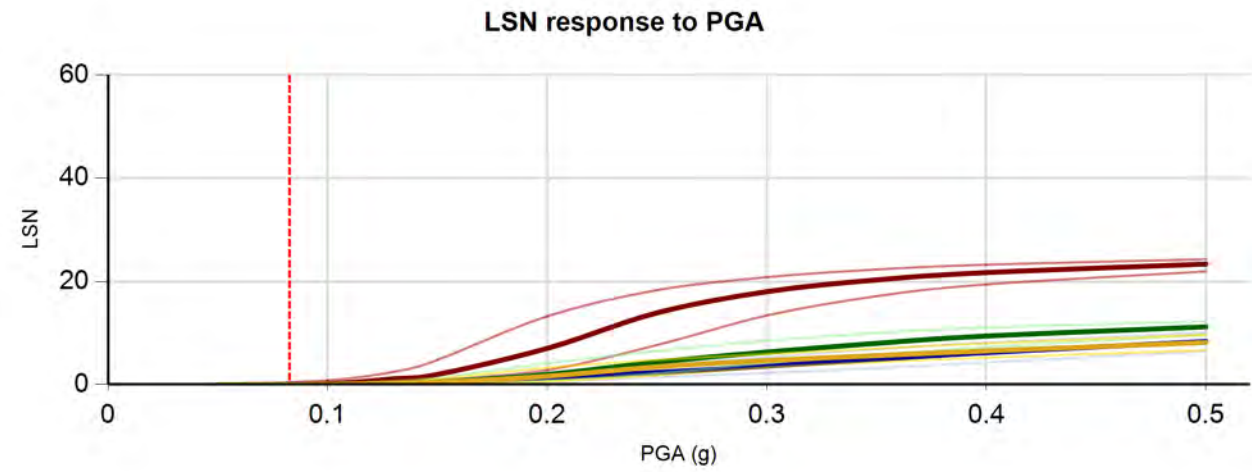


(Assumed pre-drill values)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m³)
CPT13	60512	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT14	60514	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT15	60515	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT16	60516	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

<p>Tonkin + Taylor Exceptional thinking together V1.3</p>	<p>CLIENT, PROJECT</p> <p>Hastings District Council Housing Rezone</p>	<p>LOCATION</p> <p>Havelock Road/ Howard Street</p>	<p>DATE</p> <p>4/03/2016</p>
	<p>TITLE</p> <p>SLS Liquefaction Assessment CPT 13-16</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>khl</p> <p>CHECKED</p> <p>PAGE</p> <p>9 of 11 pages</p>



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	É£ (kN/m³)
CPT13	60512	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT14	60514	9/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT15	60515	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT16	60516	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18

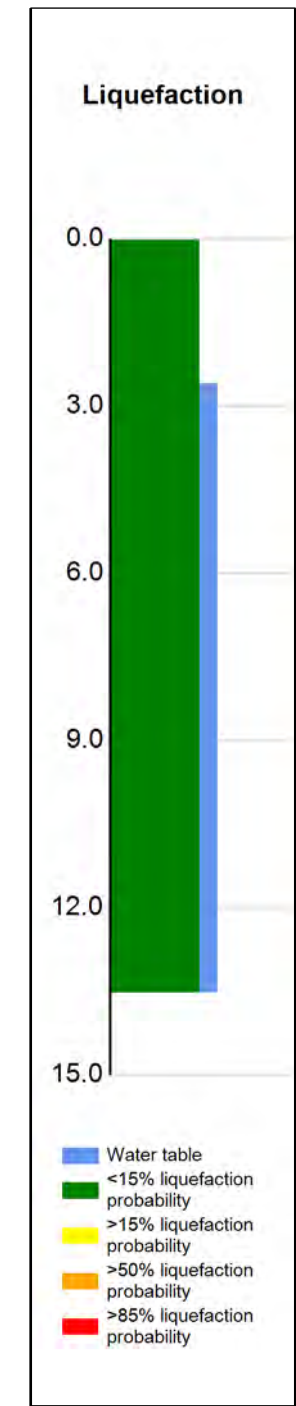
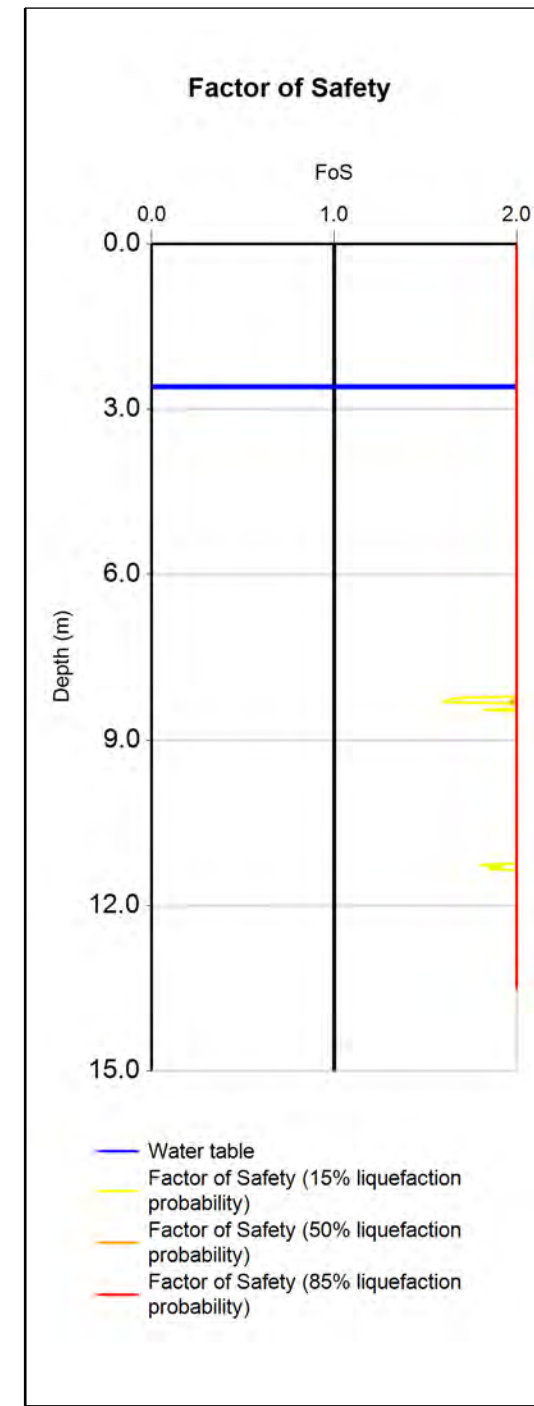
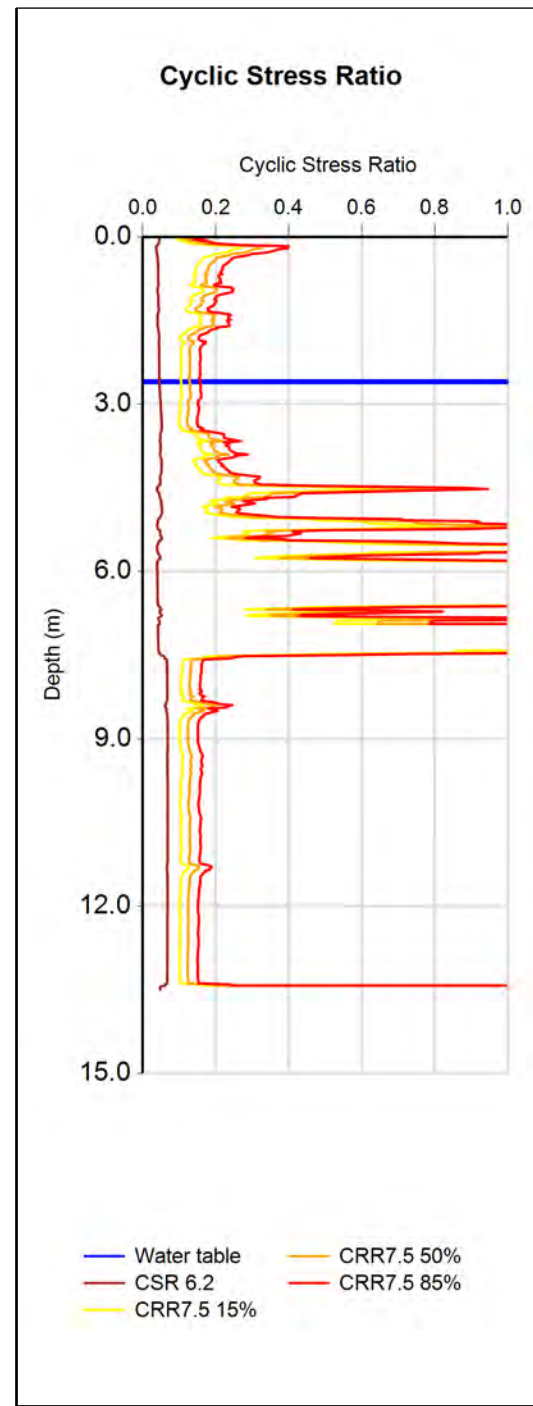
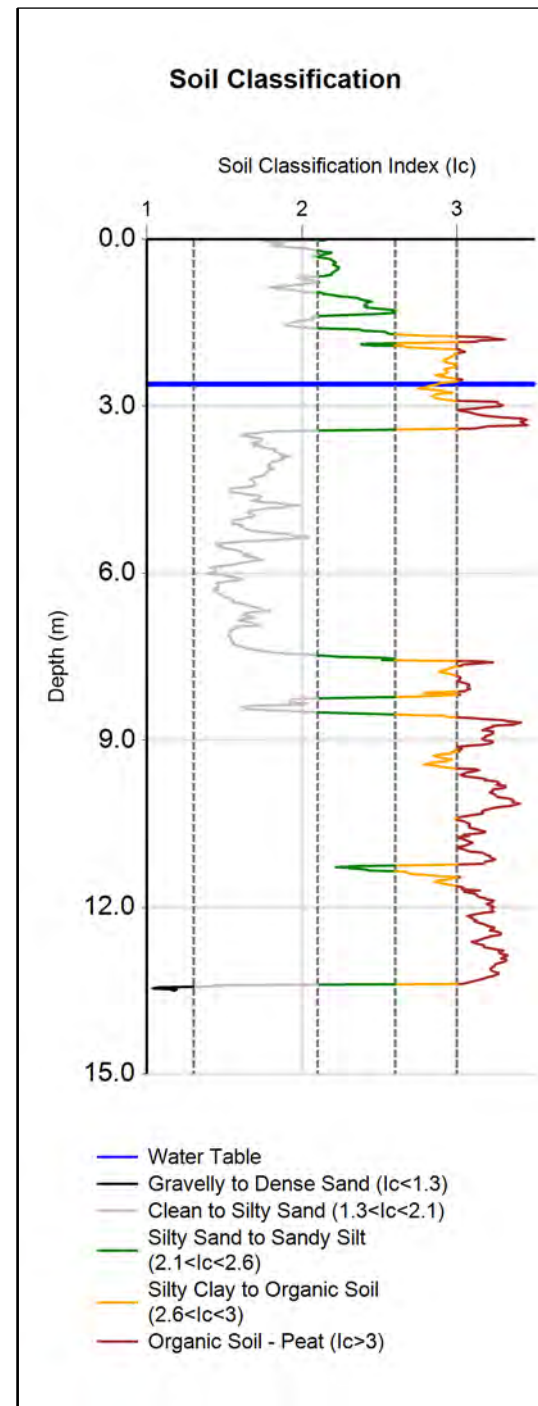
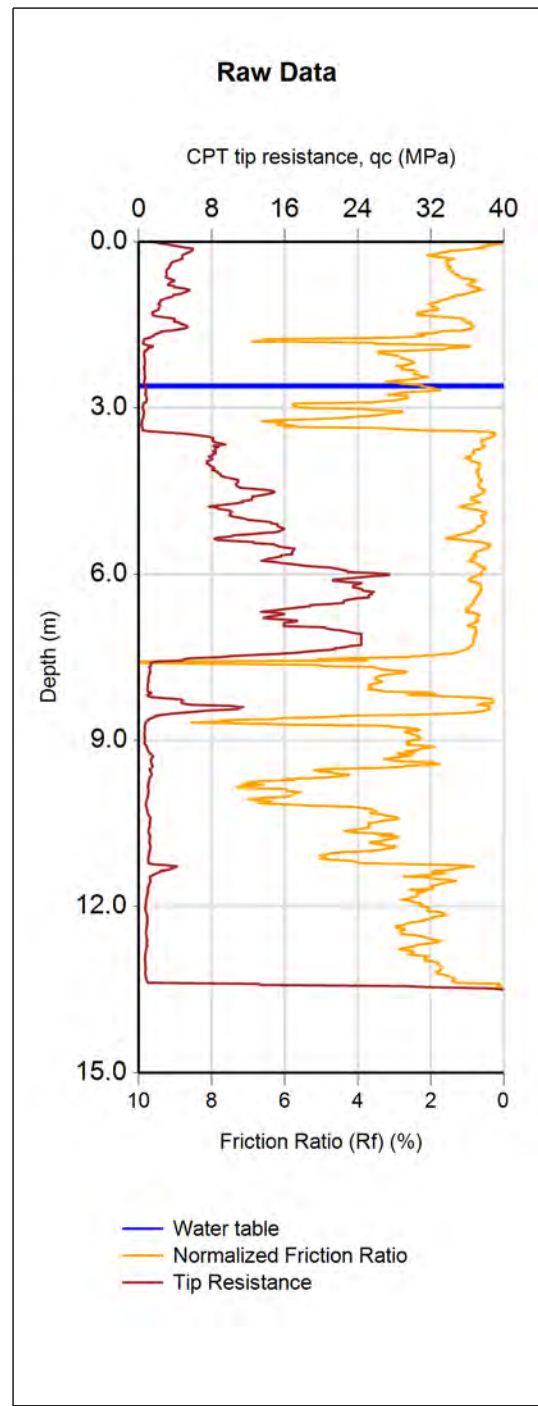
(Assumed pre-drill values)

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60512	60514	60515	60516
CPT Name	CPT13	CPT14	CPT15	CPT16
PGA	0.0827g	0.0827g	0.0827g	0.0827g
Magnitude	6.2	6.2	6.2	6.2
Depth to groundwater	2m	2.6m	2.6m	2.6m
Predrill depth	0.02m	0m	0.02m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	24.96m	13.82m	15.12m	14.3m
Maximum depth of analysis	24.96m	13.82m	15.12m	14.3m
RL	n/a	n/a	n/a	n/a



(Assumed pre-drill values)

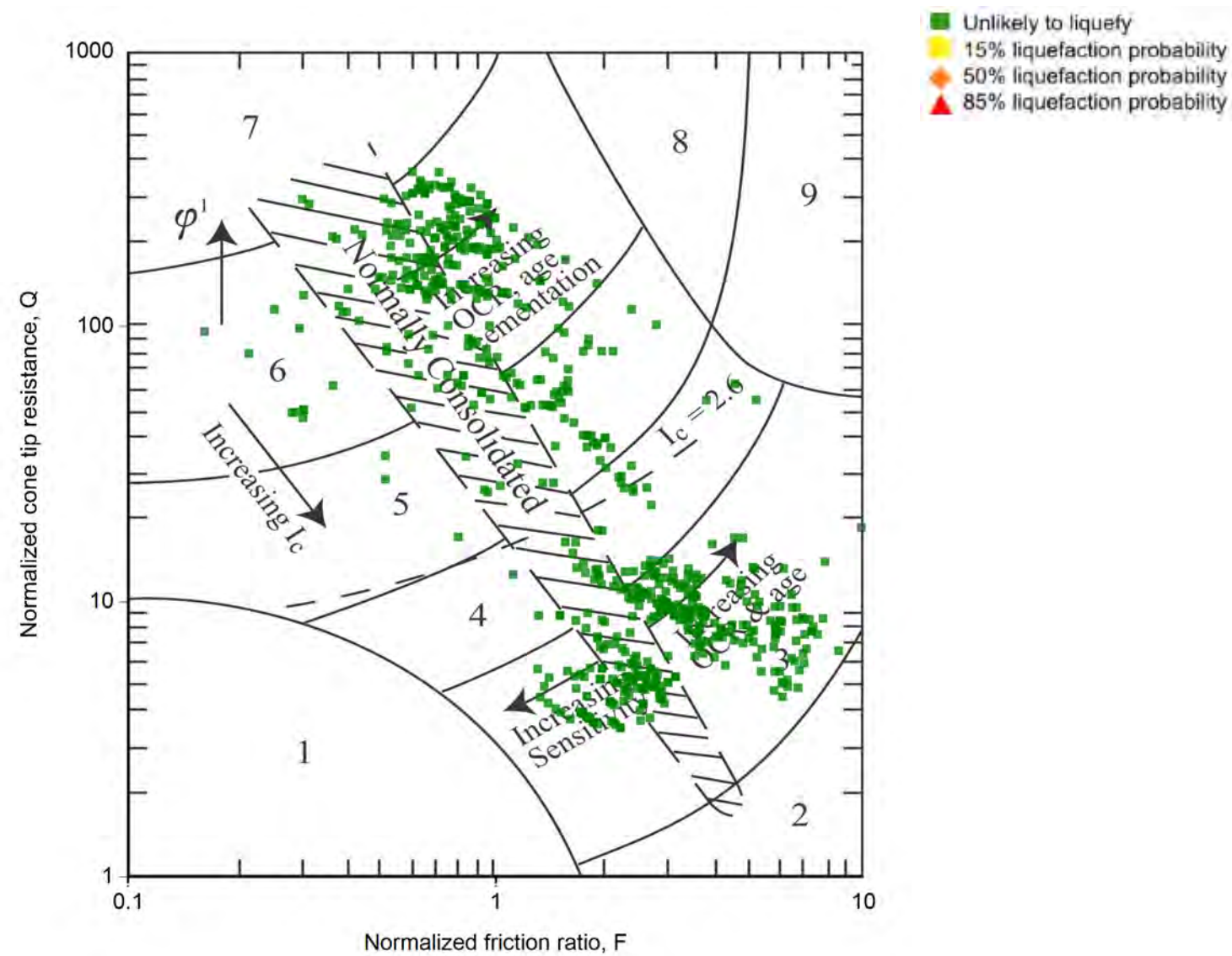
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT17	60517	10/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	0	0	0	0	13.5	0						
	50%	0	0	0	0	13.5	0						
	85%	0	0	0	0	13.5	0						



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 17-19


LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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		PAGE	1 of 9 pages

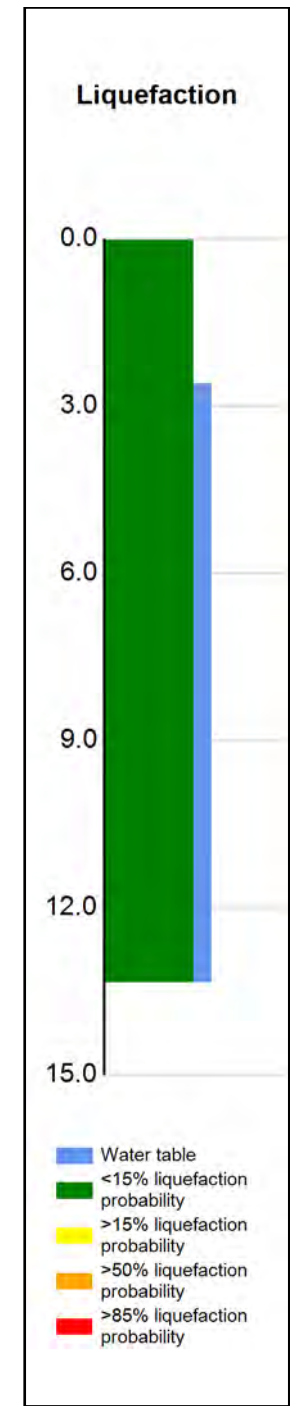
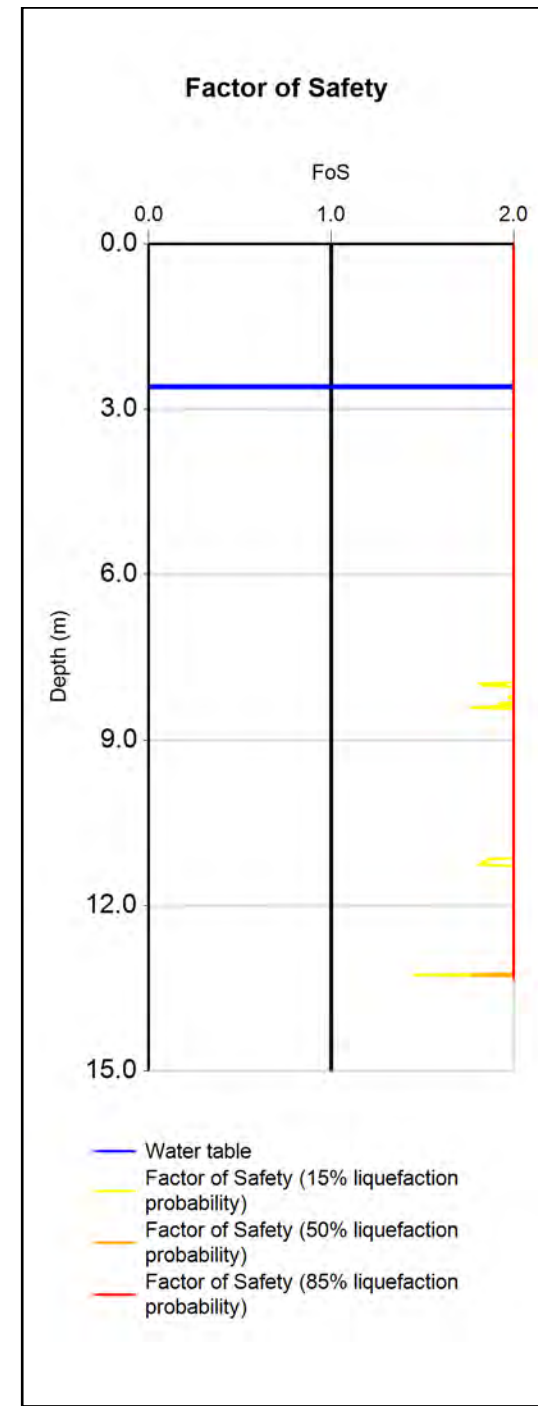
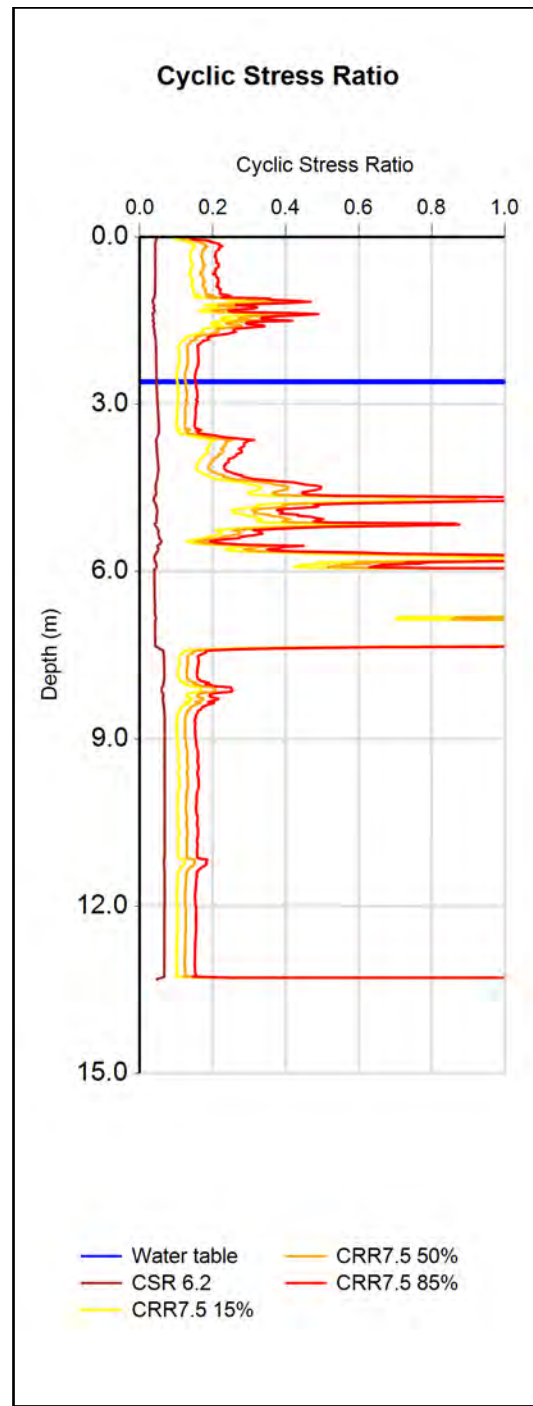
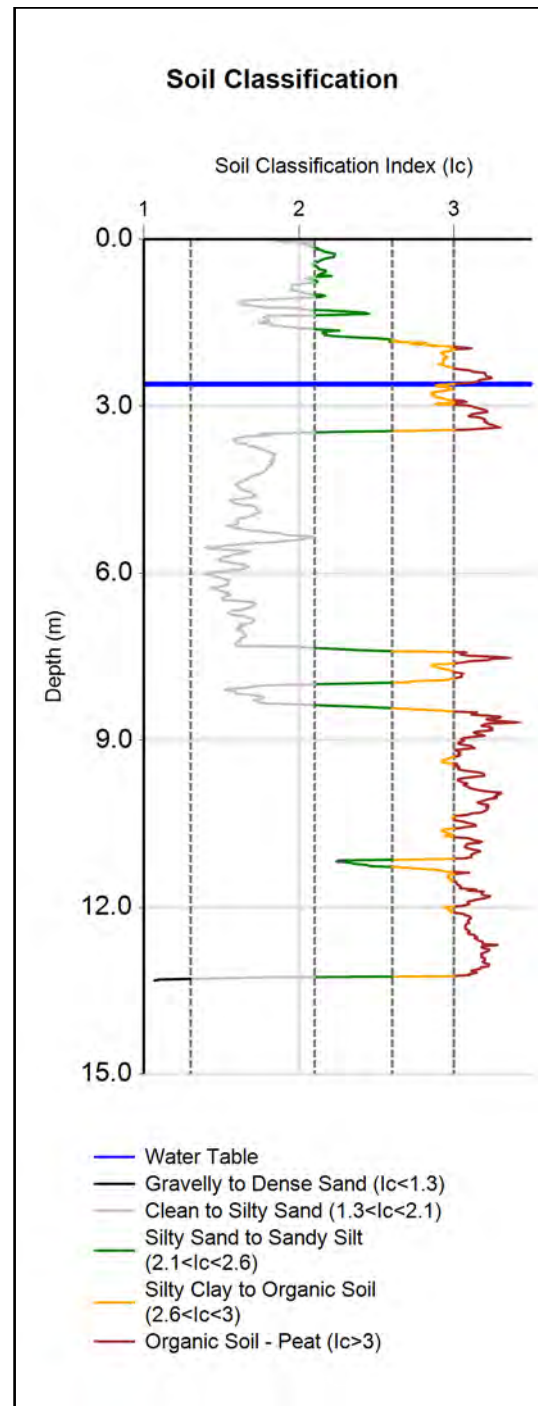
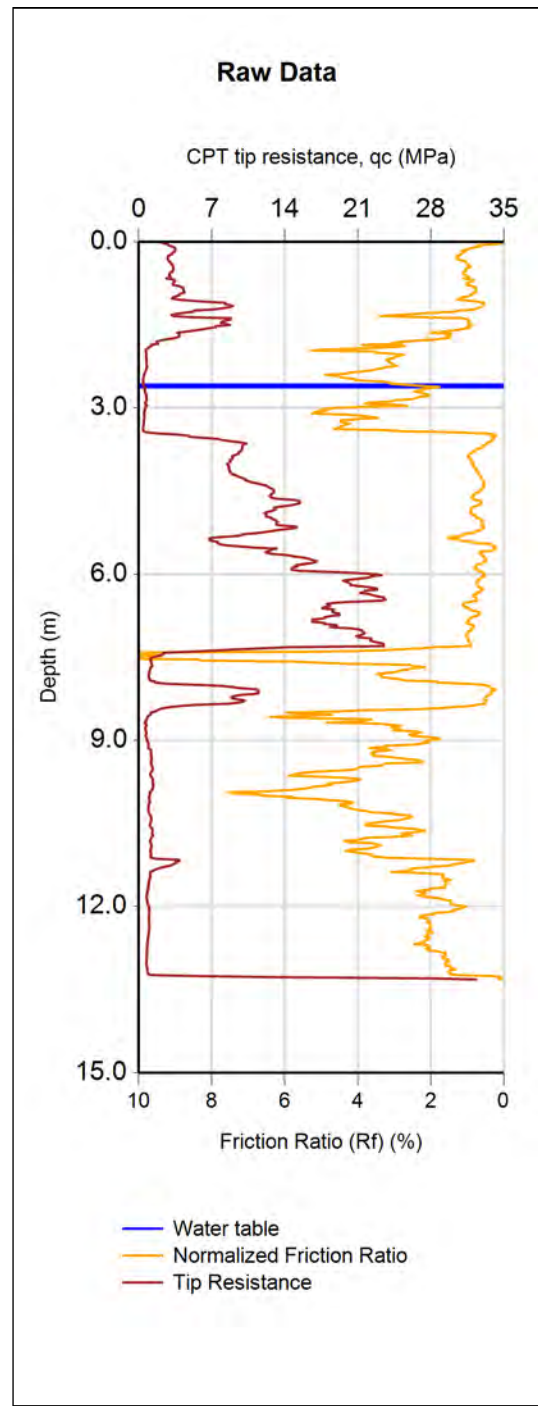


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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE SLS Liquefaction Assessment CPT 17-19	JOB NUMBER 31464.1000	ANALYSED khl



(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)		
INPUT	CPT18	60518	11/02/2016	User Specified	6.2	0.0827	2.6	BI-2014	ZRB-2002	0	2	0.01	18	
OUTPUT	Exceedance Probability	15%	S - Calculated Settlement (mm)	0	CTL - Cumulative Thickness of Liquefaction (m)	0	LPI - Liquefaction Potential Index	0	LSN - Liquefaction Severity Number	0	CT - Crust Thickness (m)	13.3	LPI Ishihara	0
		50%		0		0		0		0		13.3		0
		85%		0		0		0		0		13.3		0



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CLIENT, PROJECT

Hastings District Council
Housing Rezone

TITLE

SLS Liquefaction Assessment CPT 17-19

LOCATION

Havelock Road/
Howard Street

JOB NUMBER

31464.1000

DATE

4/03/2016

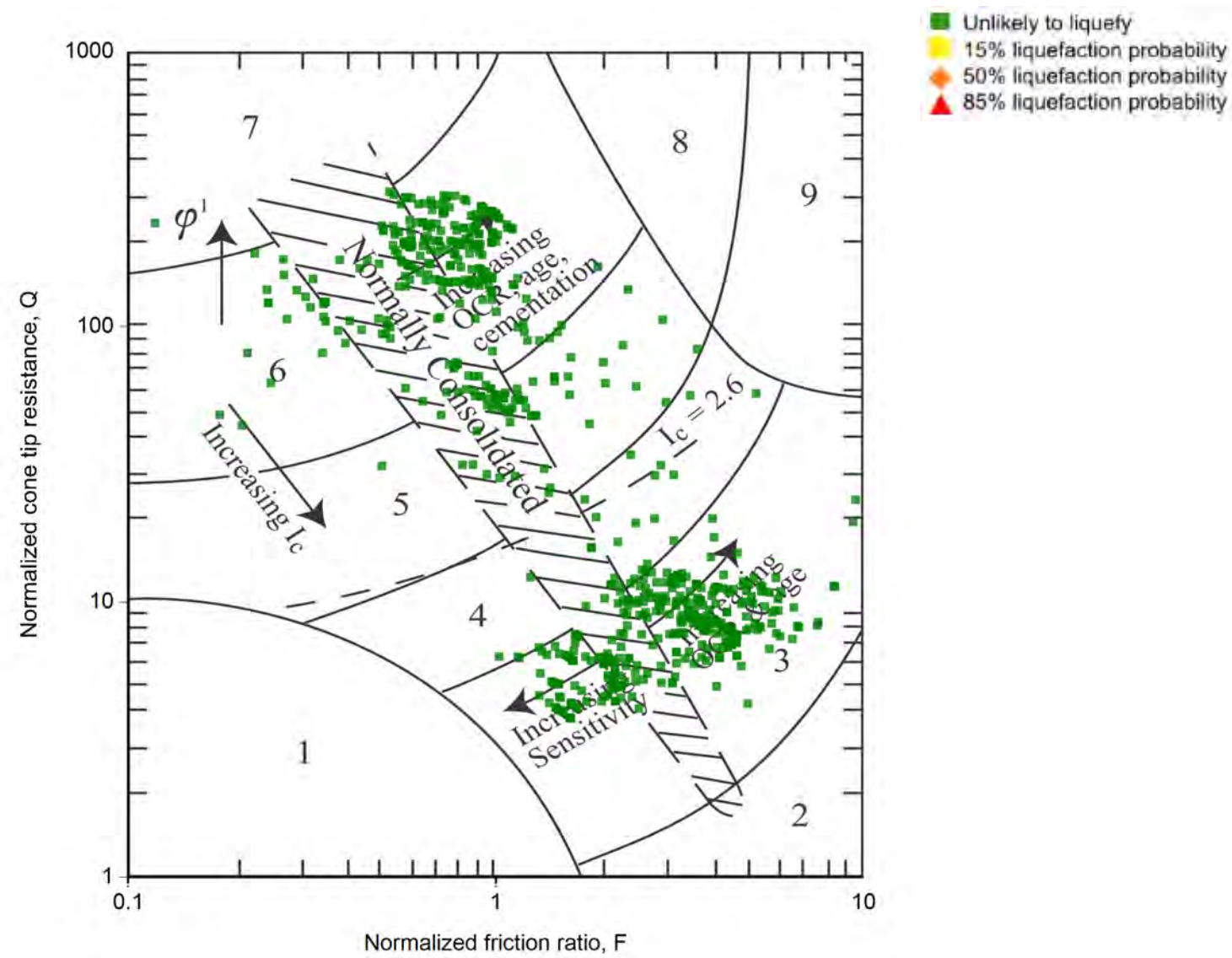
ANALYSED

khl

CHECKED

PAGE

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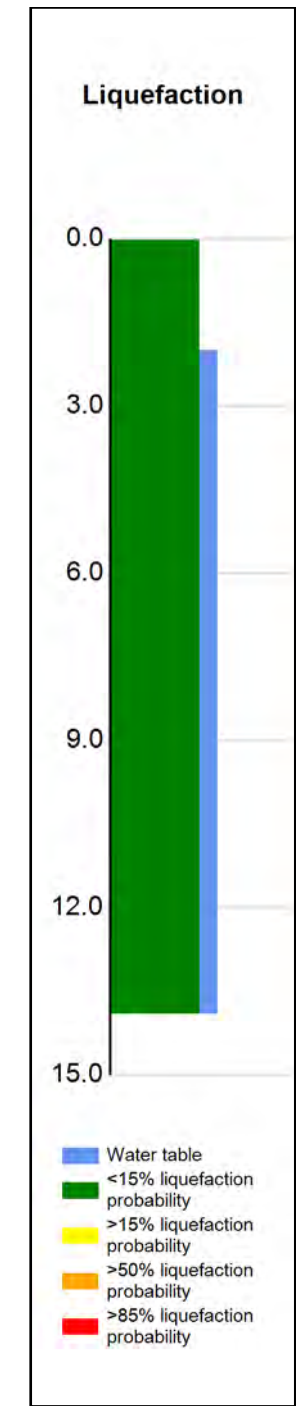
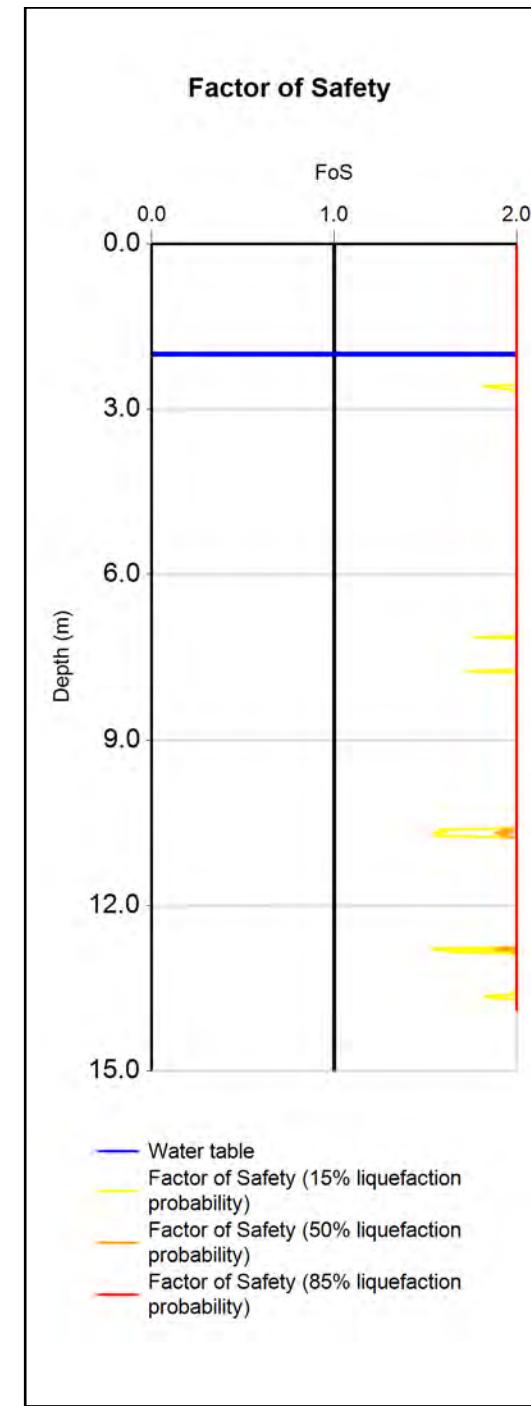
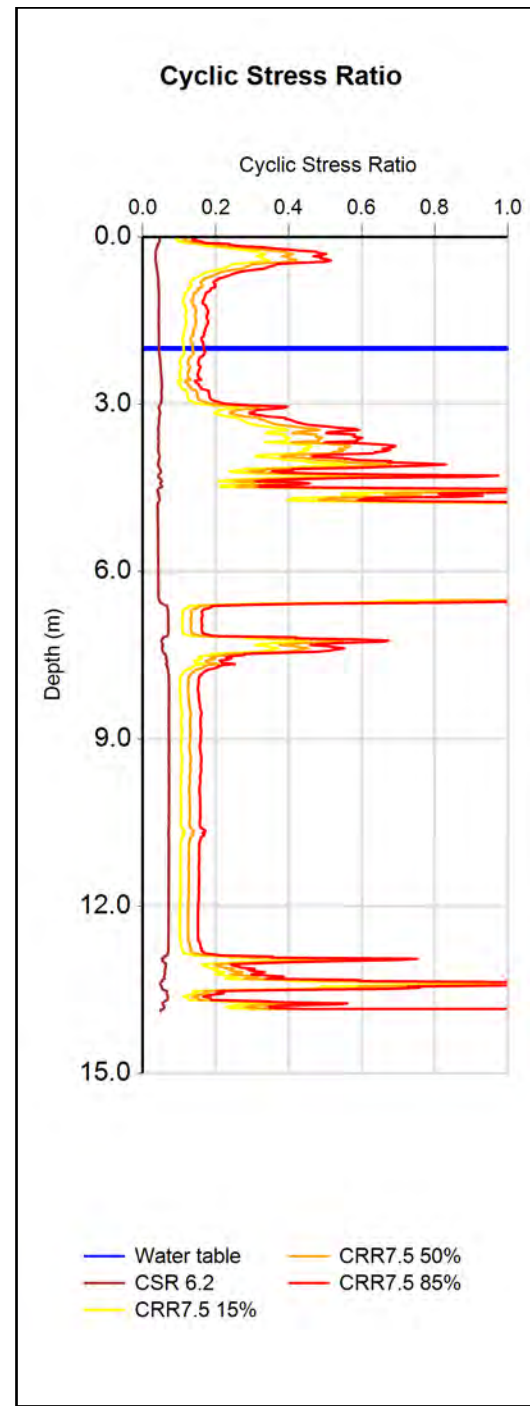
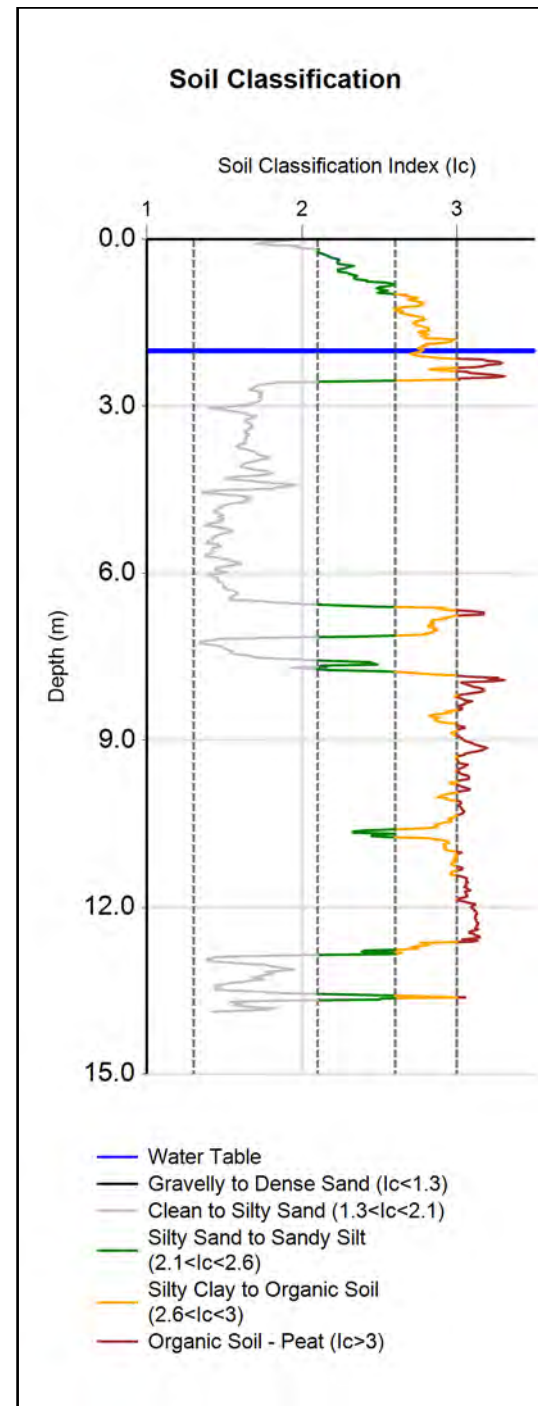
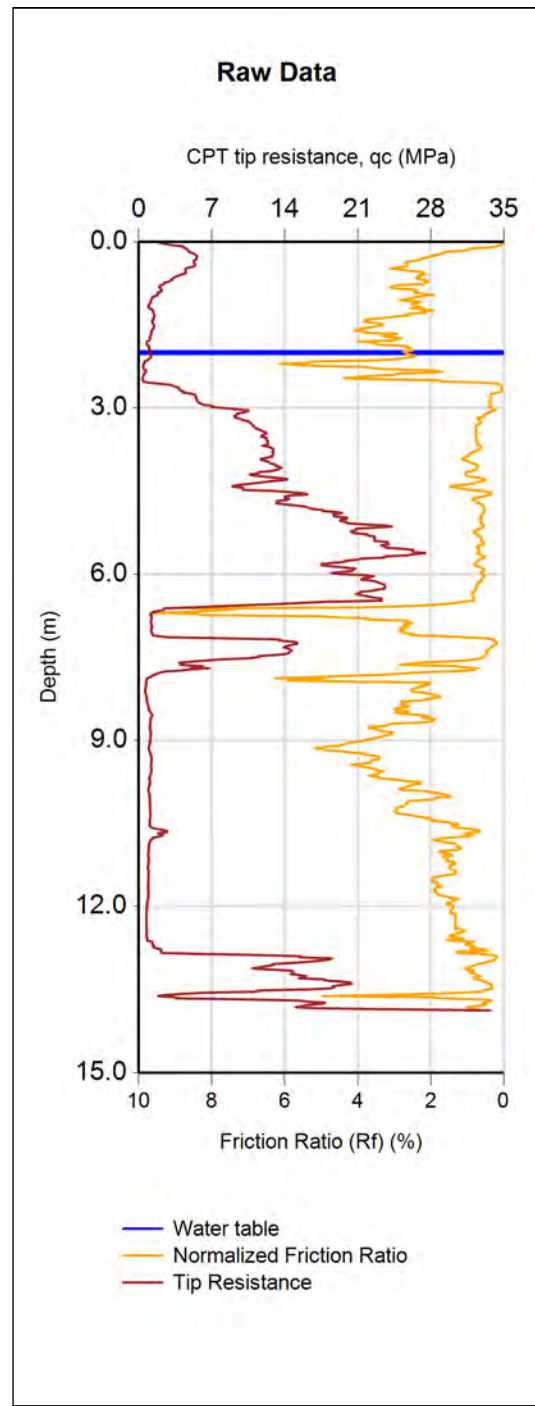
CPT-based soil behavior type classification chart by Robertson (1990)



Tonkin + Taylor
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 V1.3

CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 17-19

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		PAGE	4 of 9 pages



(Assumed pre-drill values)

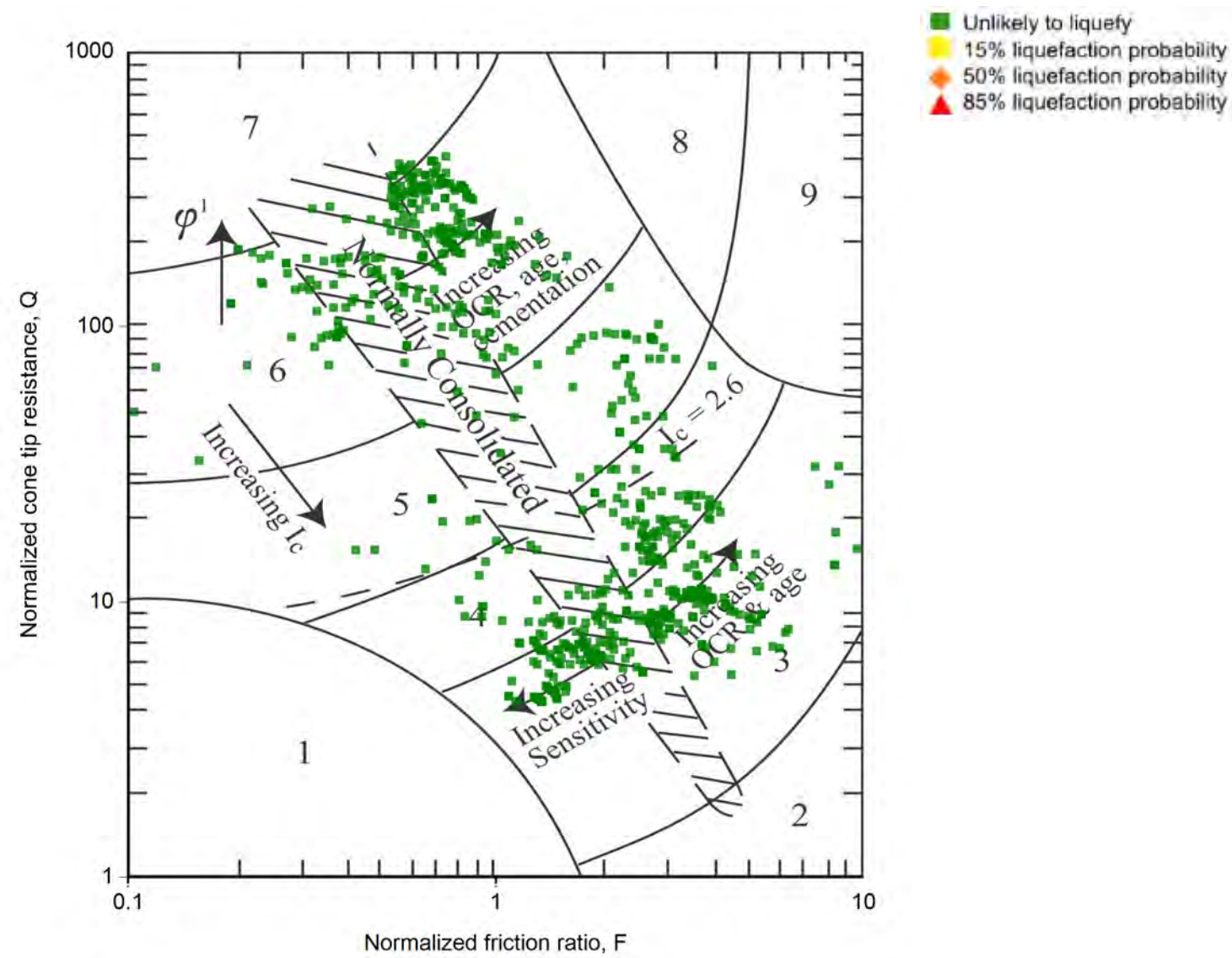
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT19	60519	11/02/2016	User Specified	6.2	0.0827	2.0	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	1	0	0	0	13.9	0						
	50%	0	0	0	0	13.9	0						
	85%	0	0	0	0	13.9	0						



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 17-19


LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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		PAGE	5 of 9 pages

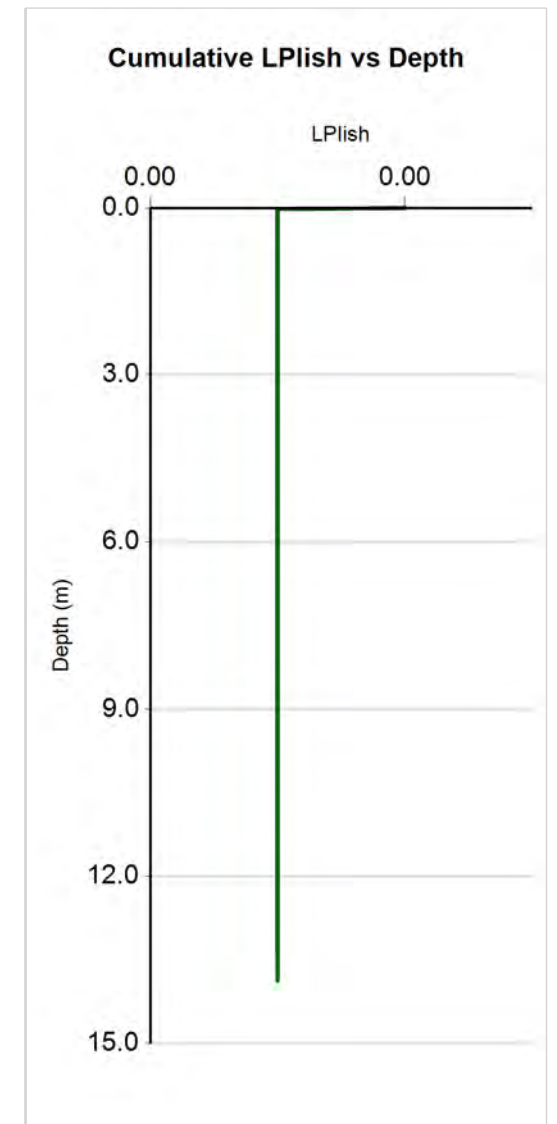
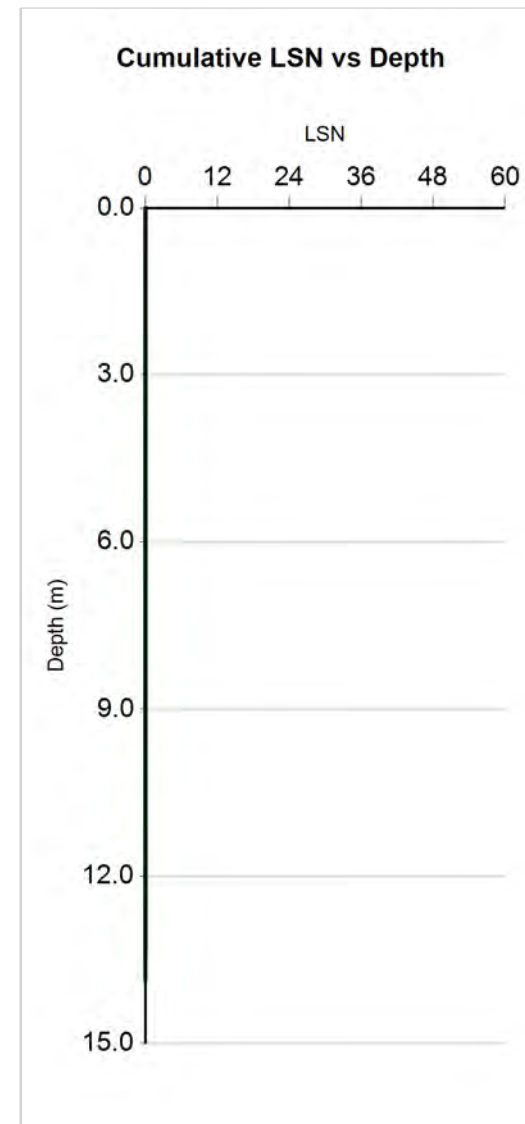
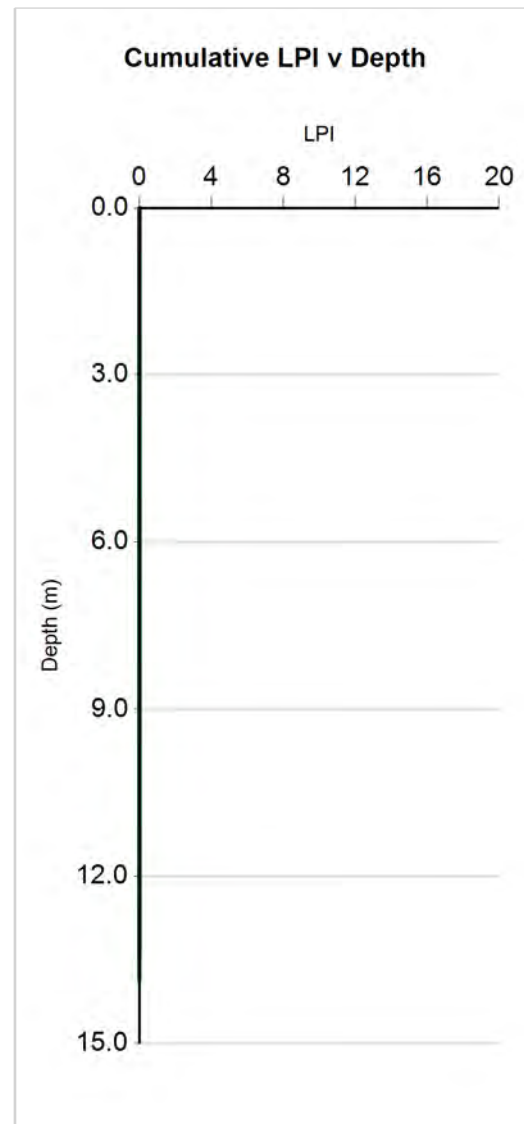
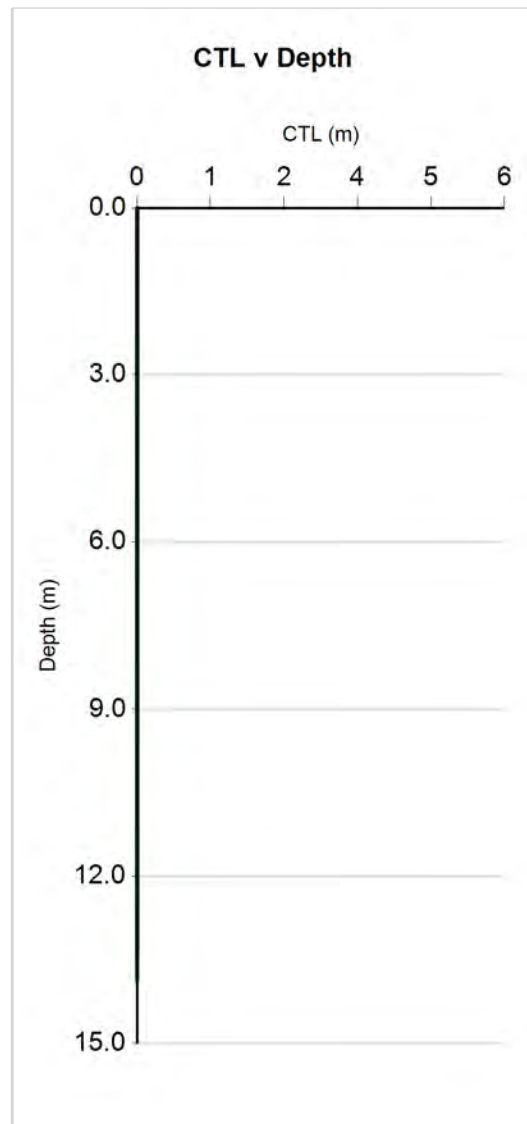
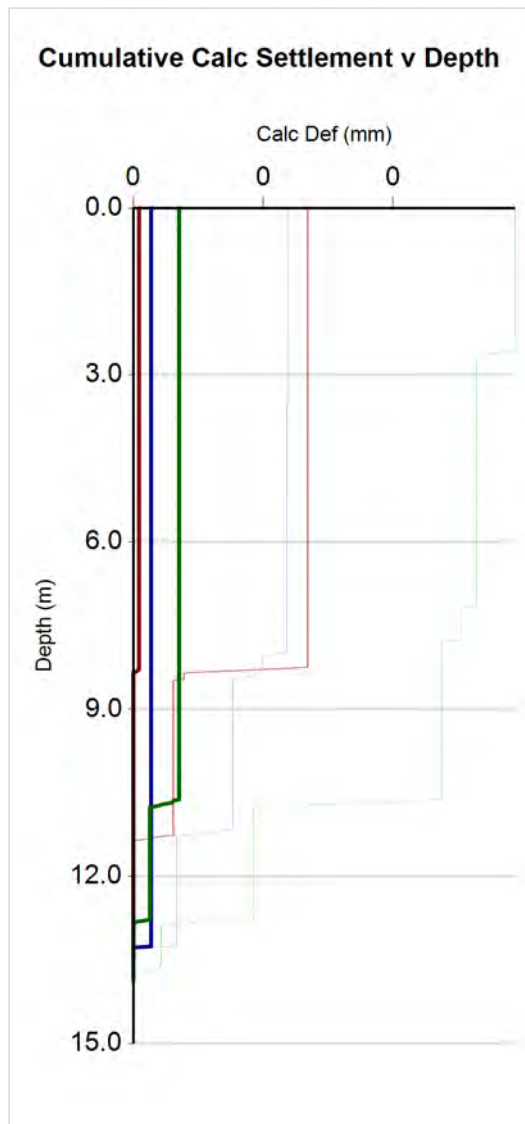


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CPT-based soil behavior type classification chart by Robertson (1990)


 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE SLS Liquefaction Assessment CPT 17-19	JOB NUMBER 31464.1000	ANALYSED khl

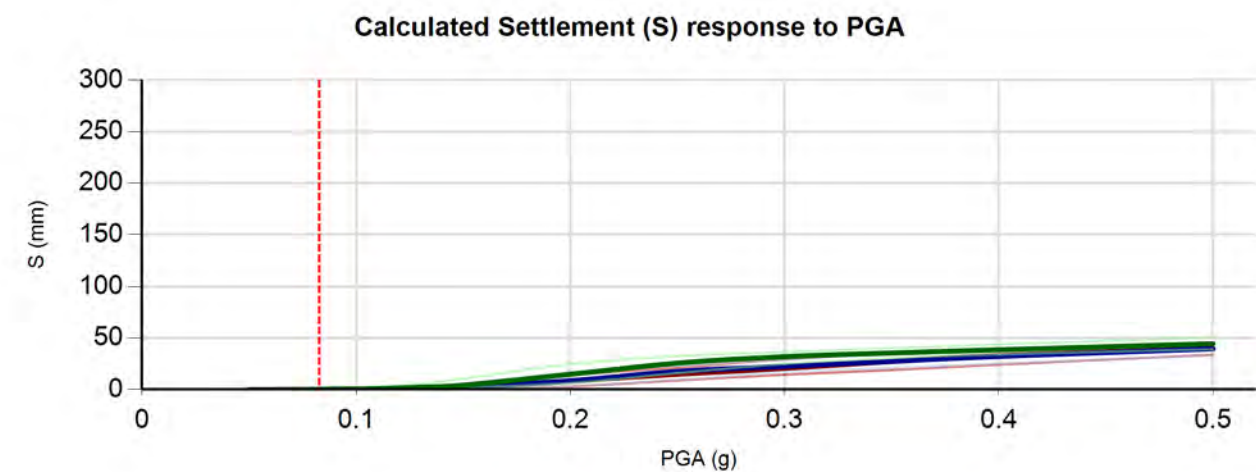
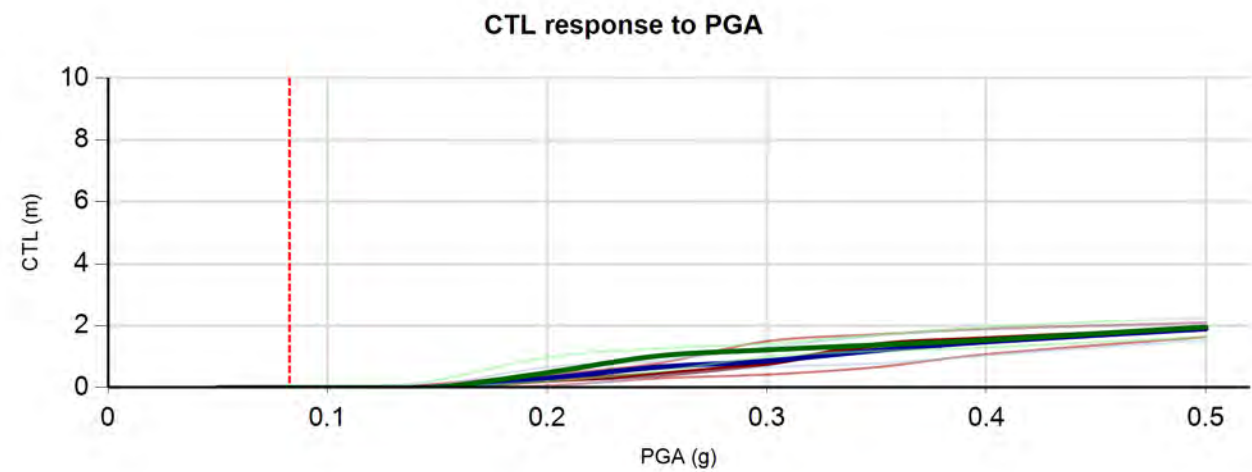
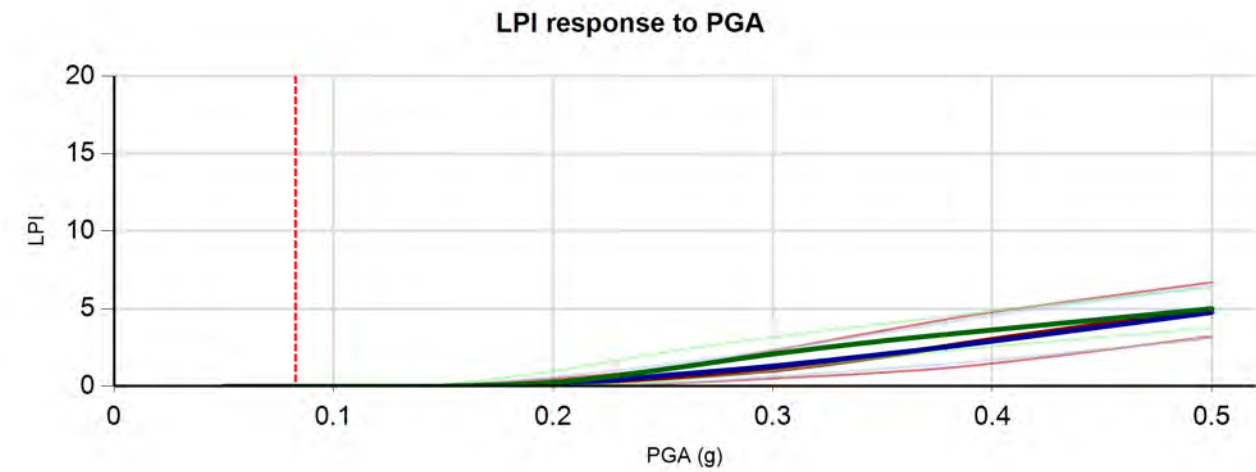
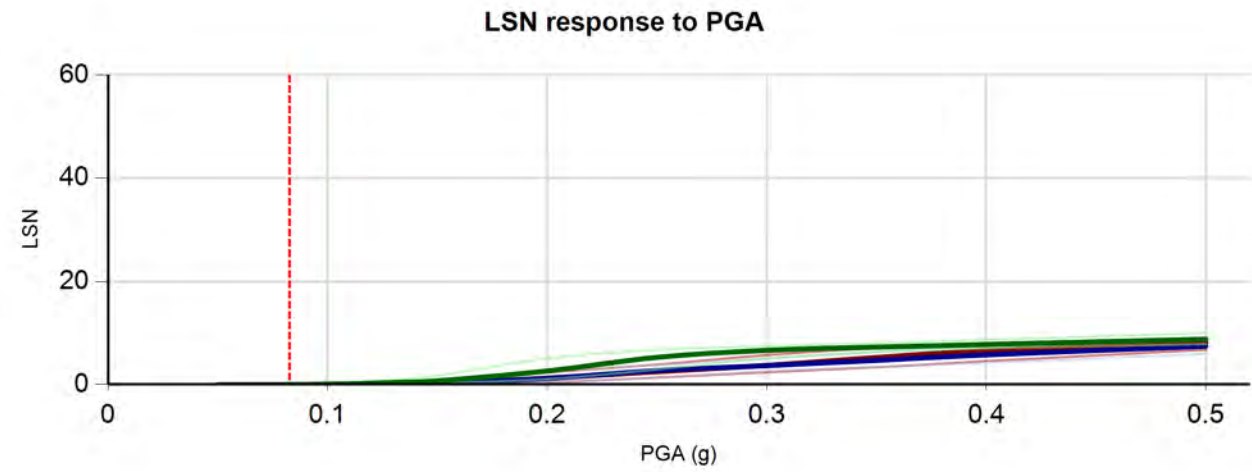


(Assumed pre-drill values)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT17	60517	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT18	60518	11/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT19	60519	11/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

 <p>Tonkin + Taylor Exceptional thinking together V1.3</p>	<p>CLIENT, PROJECT</p> <p>Hastings District Council Housing Rezone</p>	<p>LOCATION</p> <p>Havelock Road/ Howard Street</p>	<p>DATE</p> <p>4/03/2016</p>
	<p>TITLE</p> <p>SLS Liquefaction Assessment CPT 17-19</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>khl</p>
			<p>CHECKED</p> <p>PAGE</p> <p>7 of 9 pages</p>



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

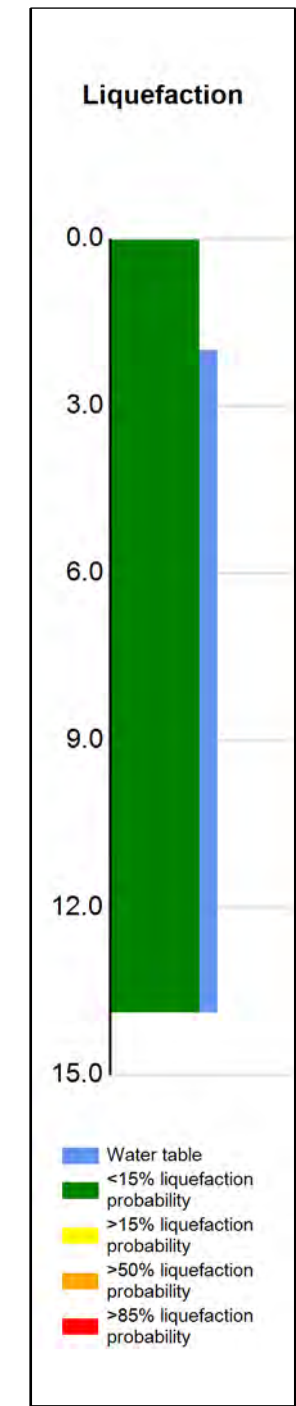
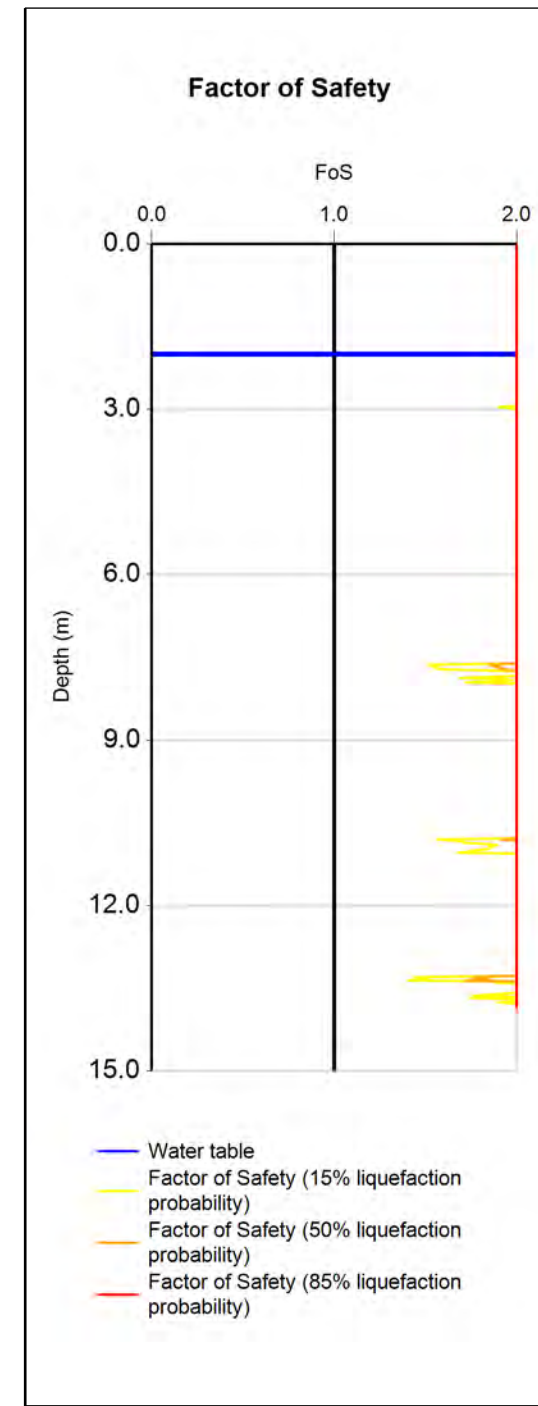
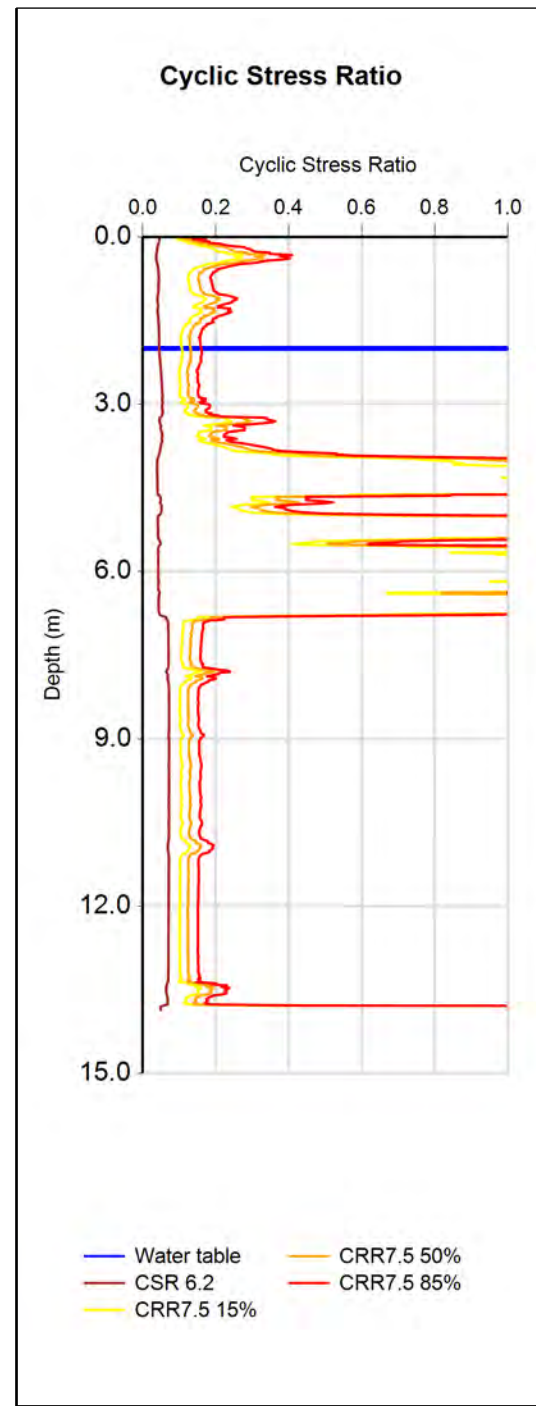
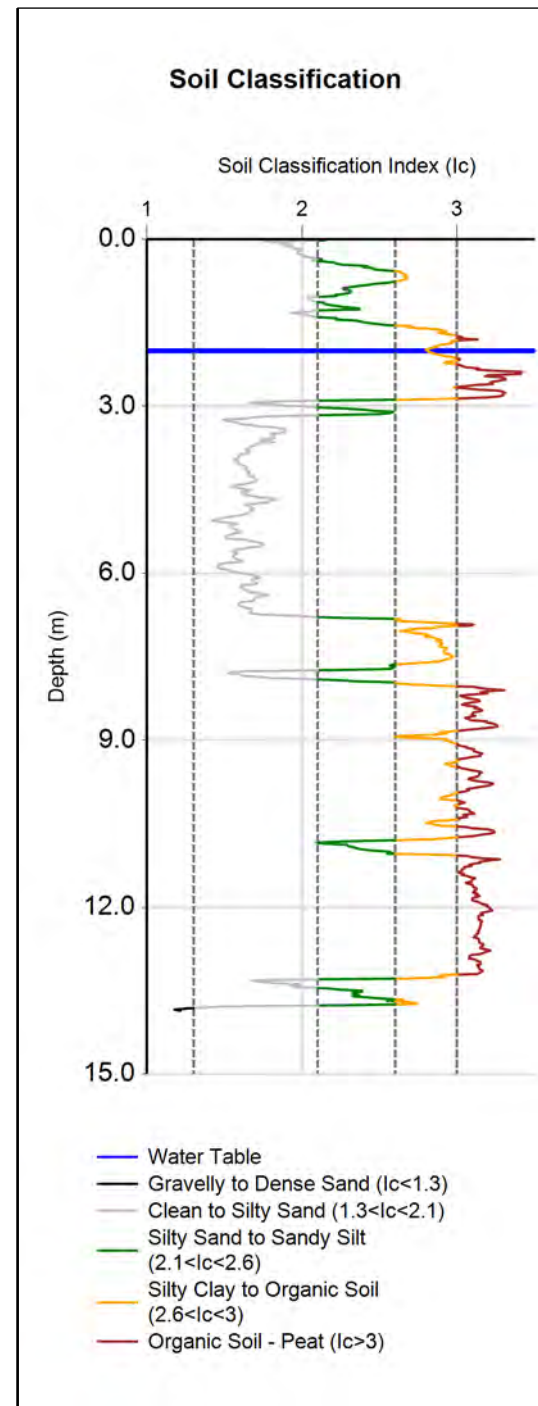
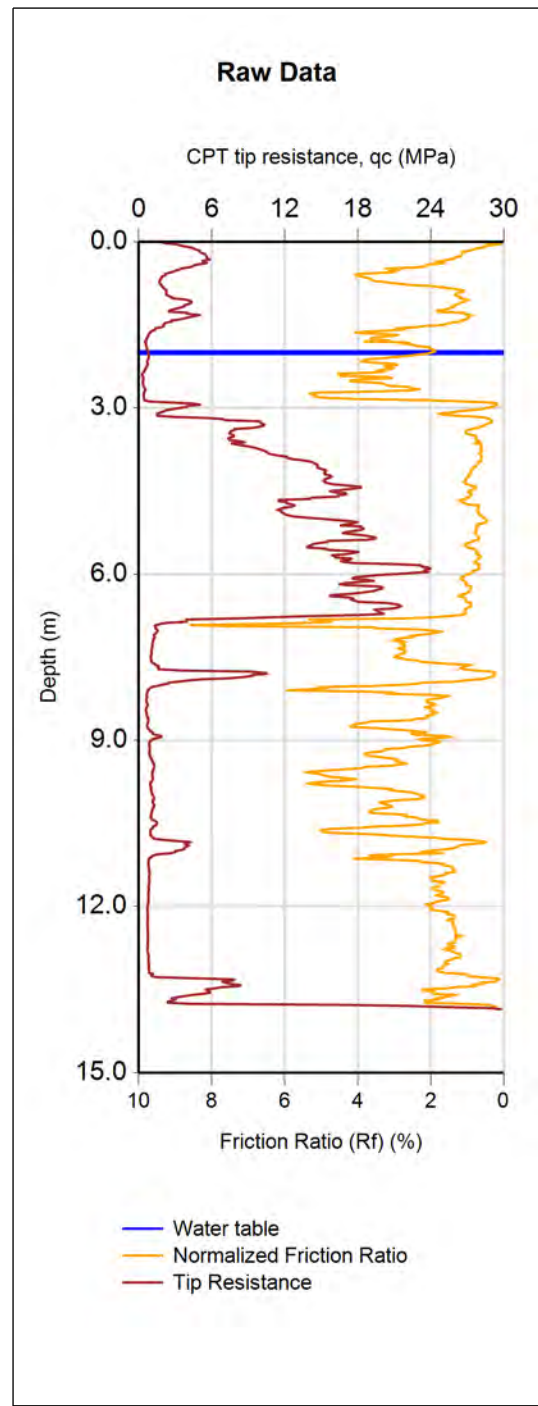
CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	(Assumed pre-drill values)		
										Qc (MPa)	Fs (MPa)	É£ (kN/m³)
CPT17	60517	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT18	60518	11/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT19	60519	11/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60517	60518	60519
CPT Name	CPT17	CPT18	CPT19
PGA	0.0827g	0.0827g	0.0827g
Magnitude	6.2	6.2	6.2
Depth to groundwater	2.6m	2.6m	2m
Predrill depth	0.02m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0
Total depth of CPT	13.5m	13.32m	13.88m
Maximum depth of analysis	13.5m	13.32m	13.88m
RL	n/a	n/a	n/a



(Assumed pre-drill values)

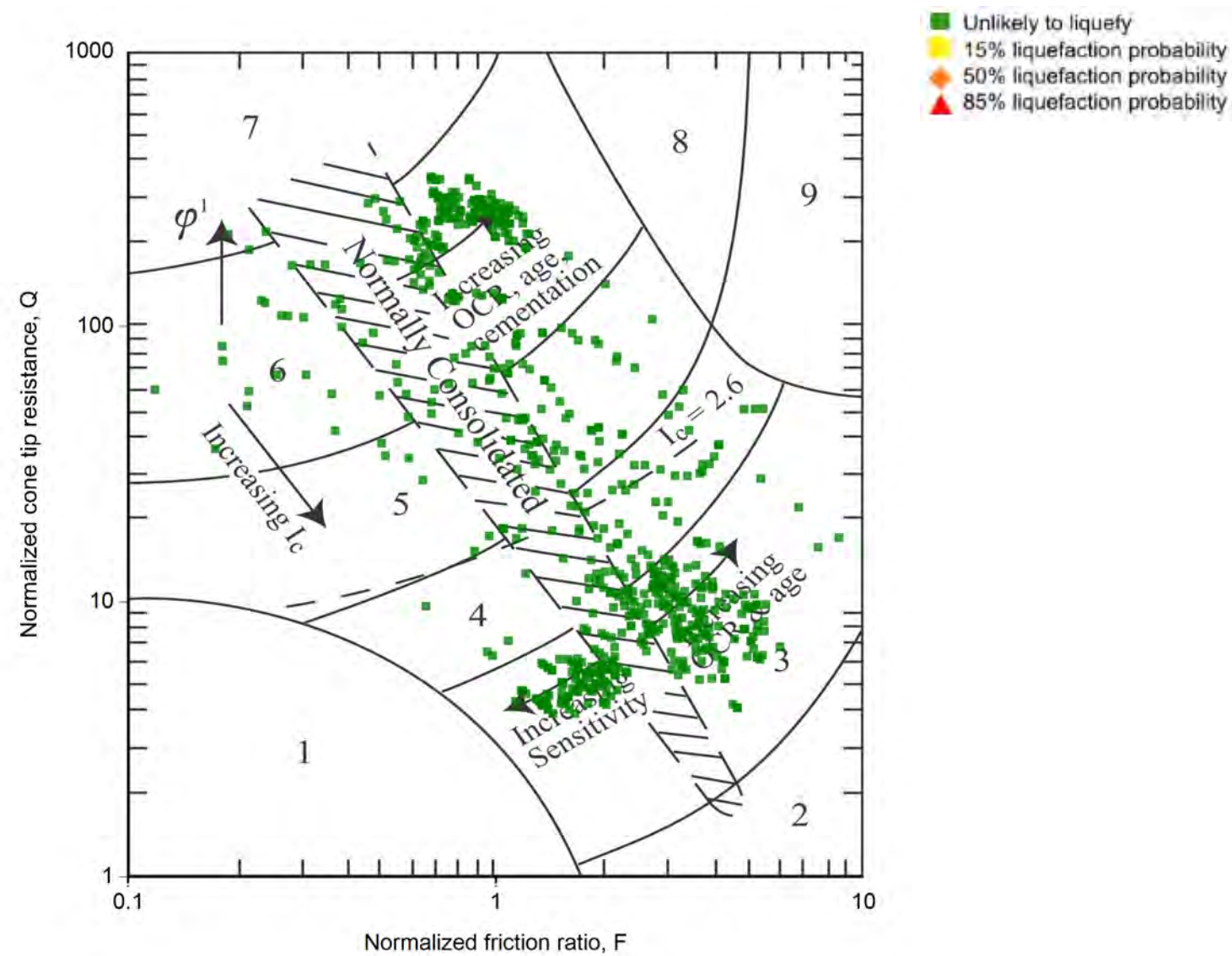
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT21	60520	11/02/2016	User Specified	6.2	0.0827	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
OUTPUT	15%	1	0	0	0	13.9	0						
	50%	0	0	0	0	13.9	0						
	85%	0	0	0	0	13.9	0						



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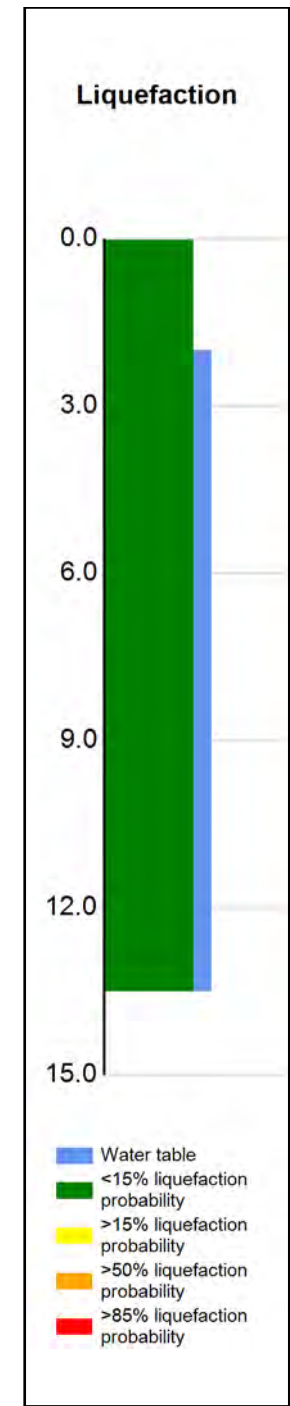
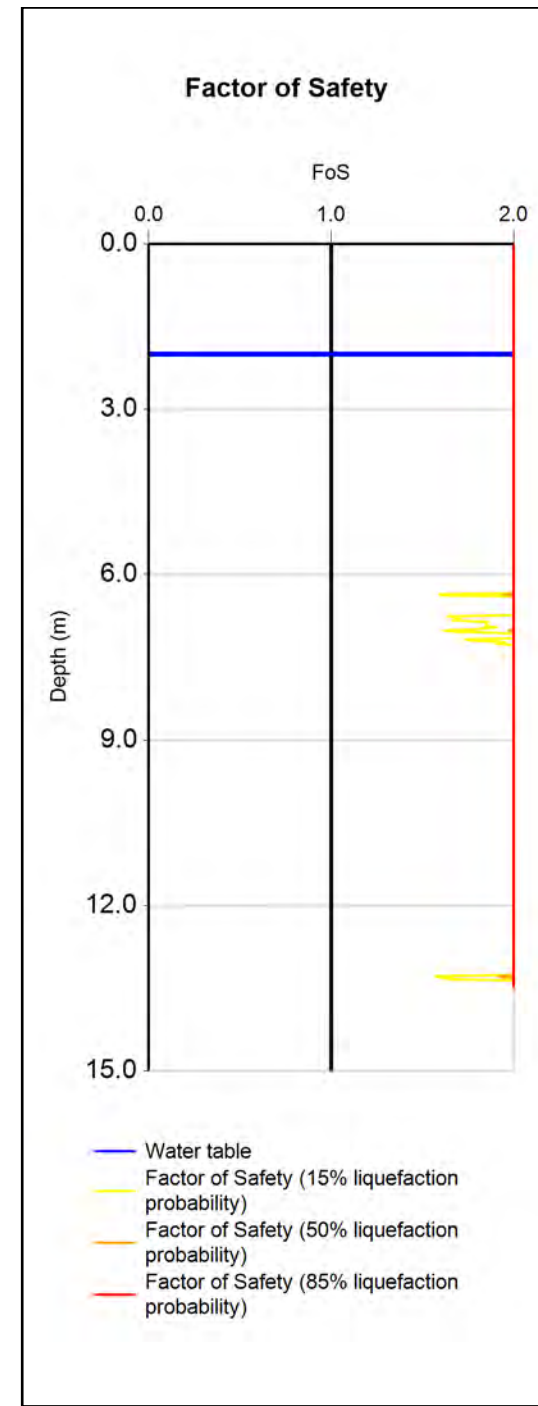
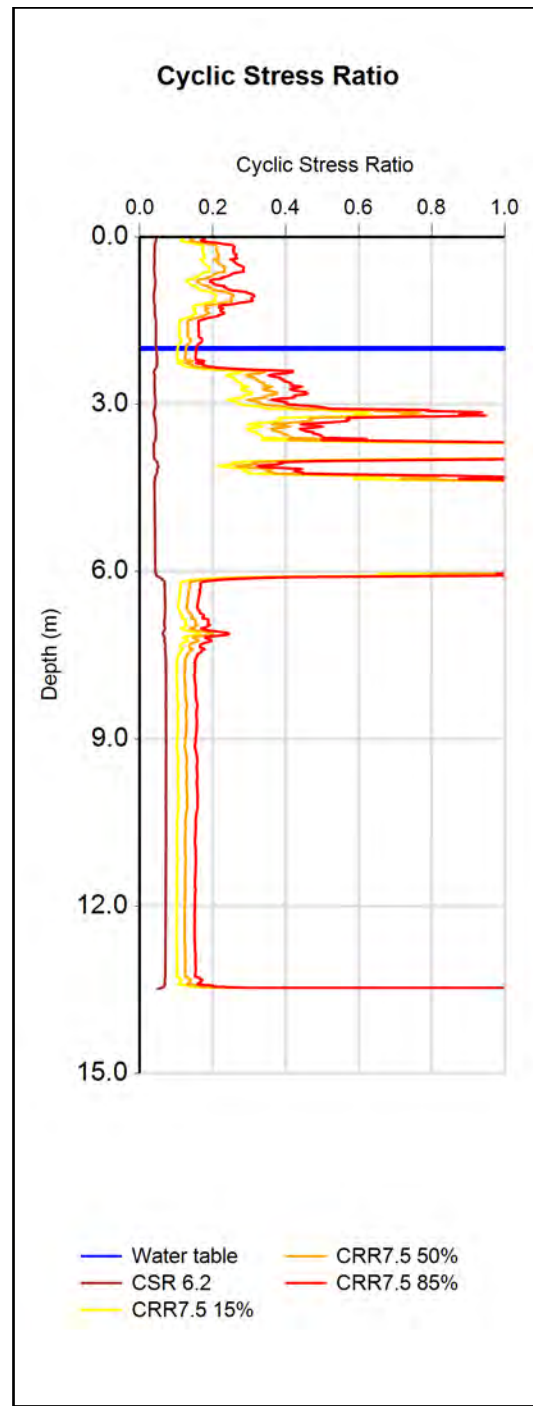
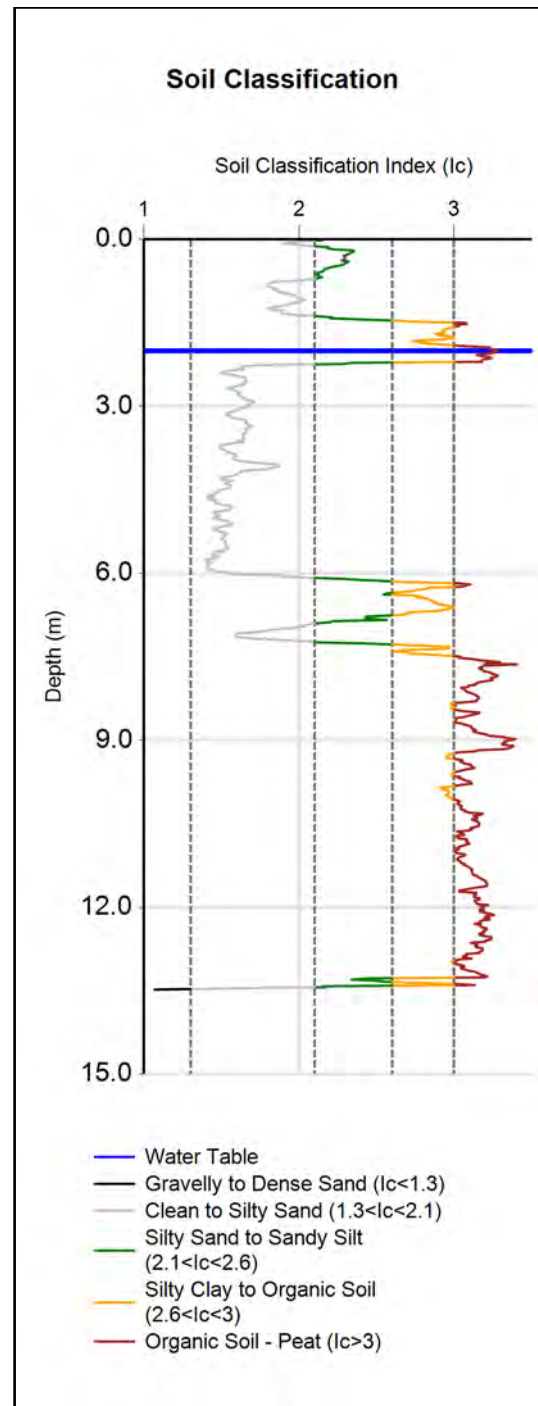
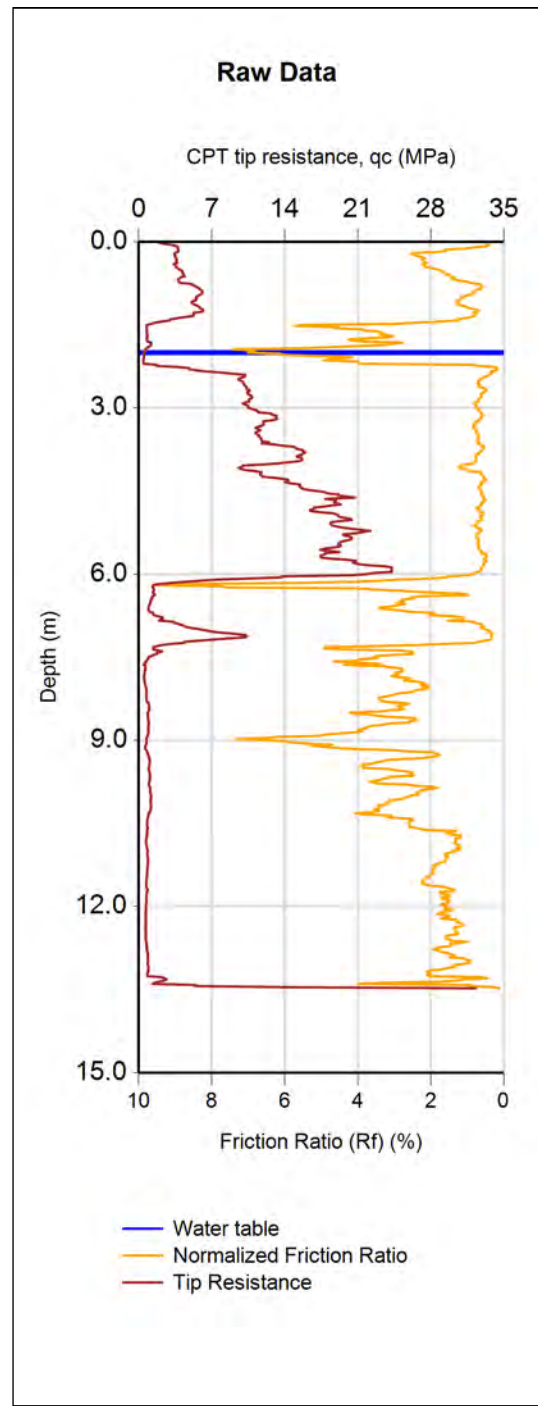
CPT-based soil behavior type classification chart by Robertson (1990)



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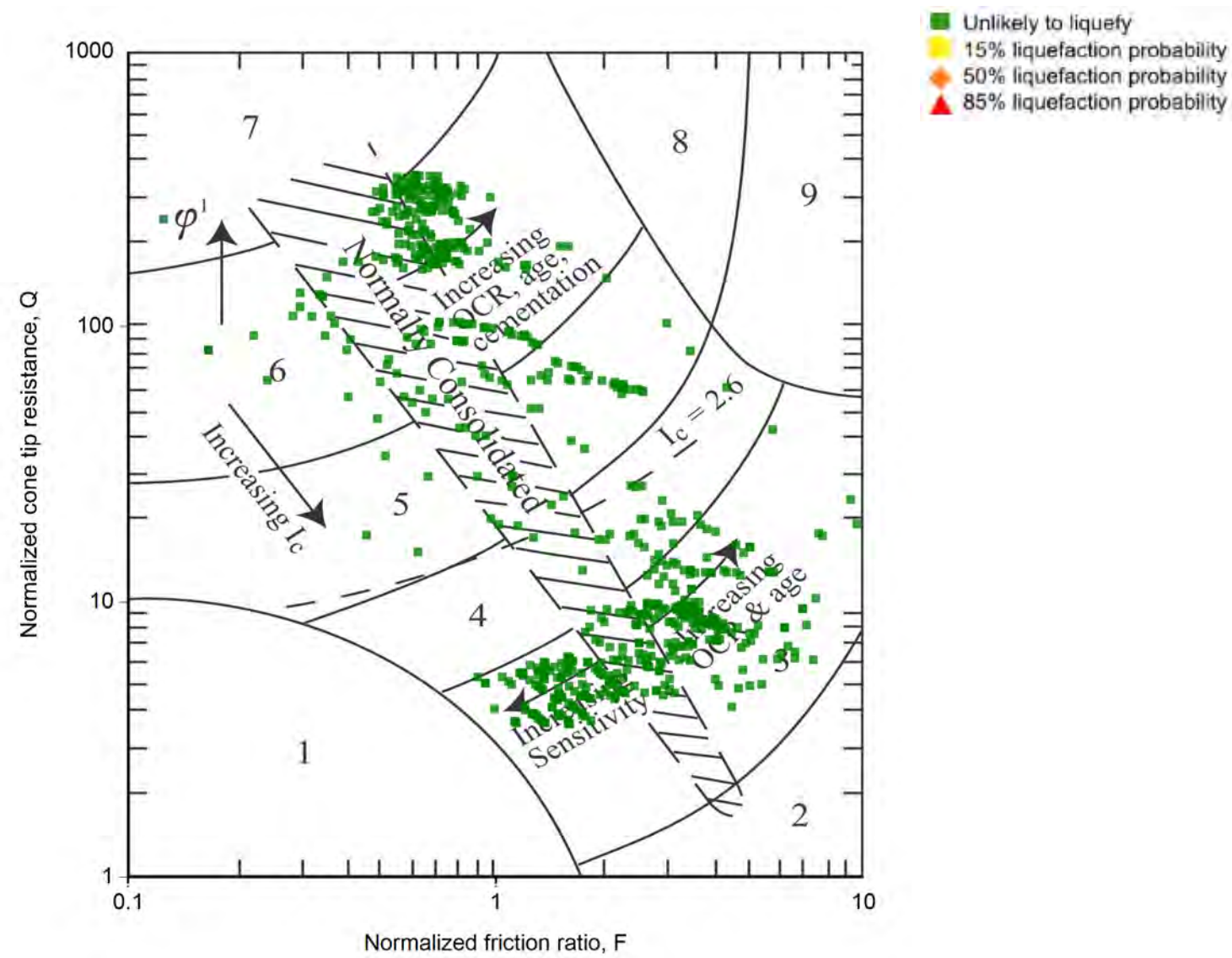
(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT22	60521	10/02/2016	User Specified	6.2	0.0827	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	1	0	0	0	13.5	0						
	50%	0	0	0	0	13.5	0						
	85%	0	0	0	0	13.5	0						



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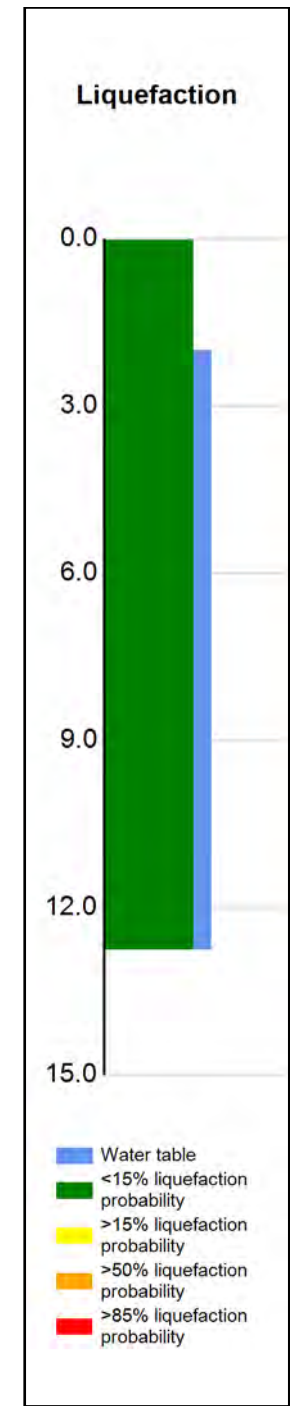
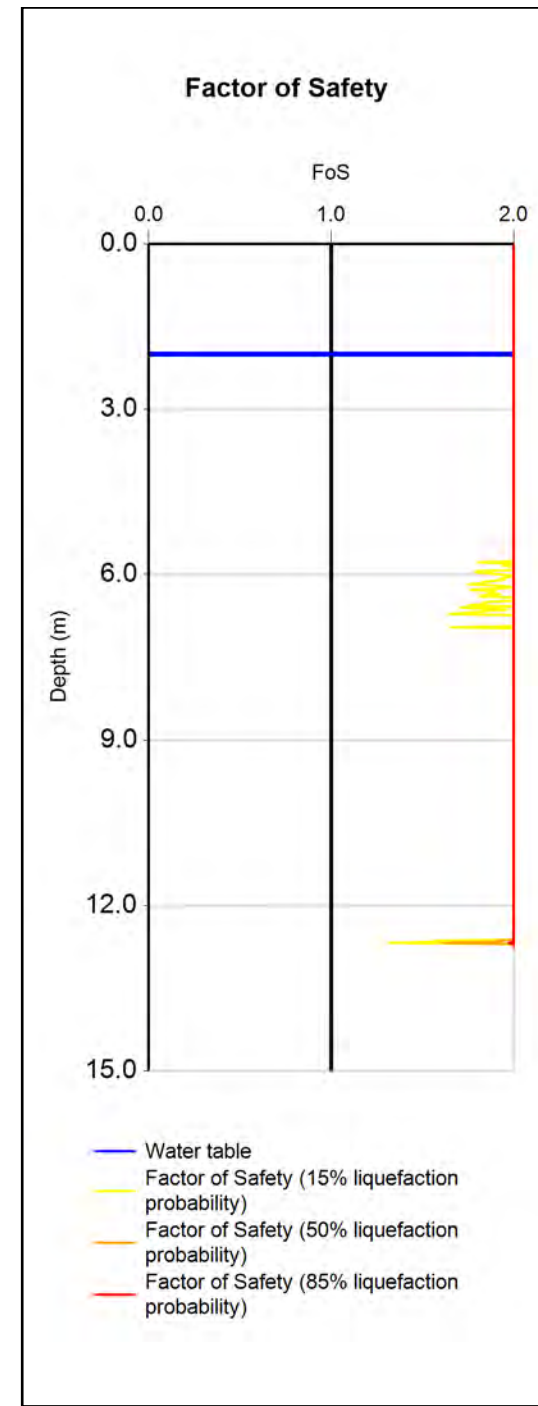
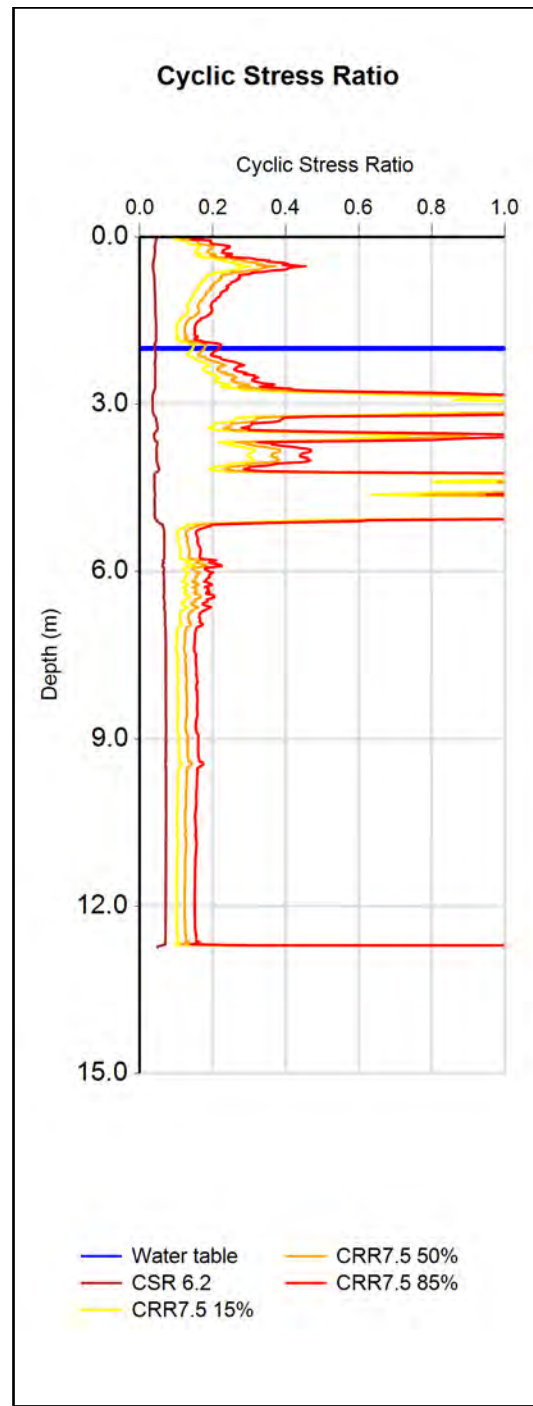
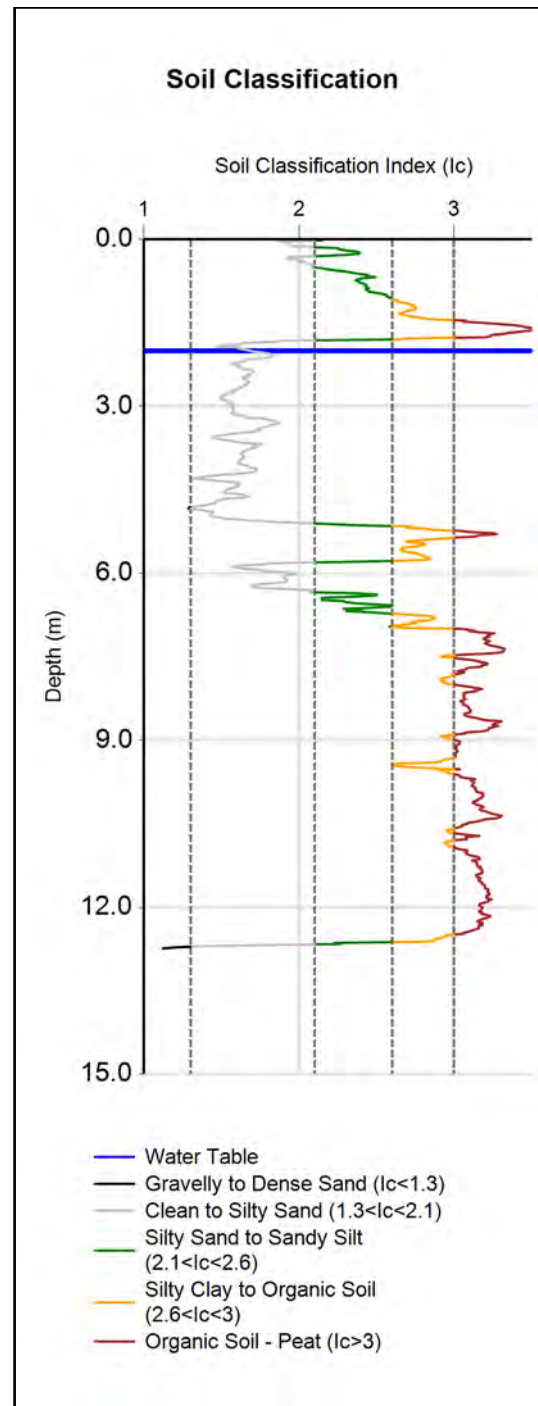
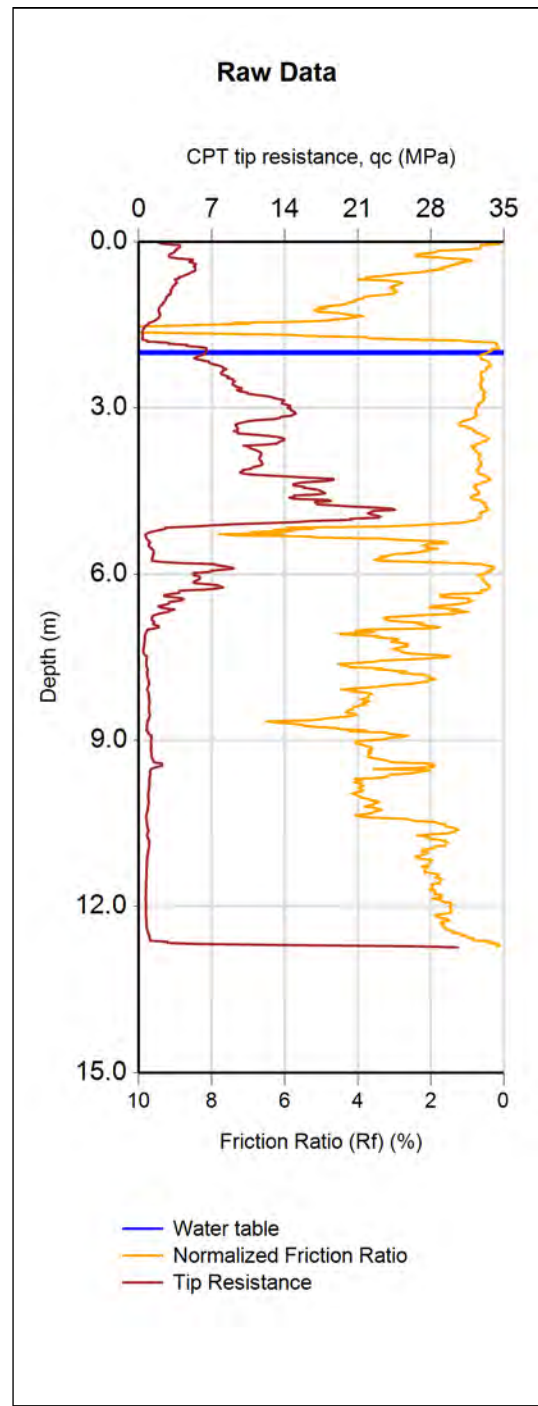
CPT-based soil behavior type classification chart by Robertson (1990)



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(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT23	60522	10/02/2016	User Specified	6.2	0.0827	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	1	0	0	0	12.7	0						
	50%	0	0	0	0	12.7	0						
	85%	0	0	0	0	12.7	0						



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CLIENT, PROJECT

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Housing Rezone

TITLE

SLS Liquefaction Assessment CPT 21-23

LOCATION

Havelock Road/
Howard Street

JOB NUMBER

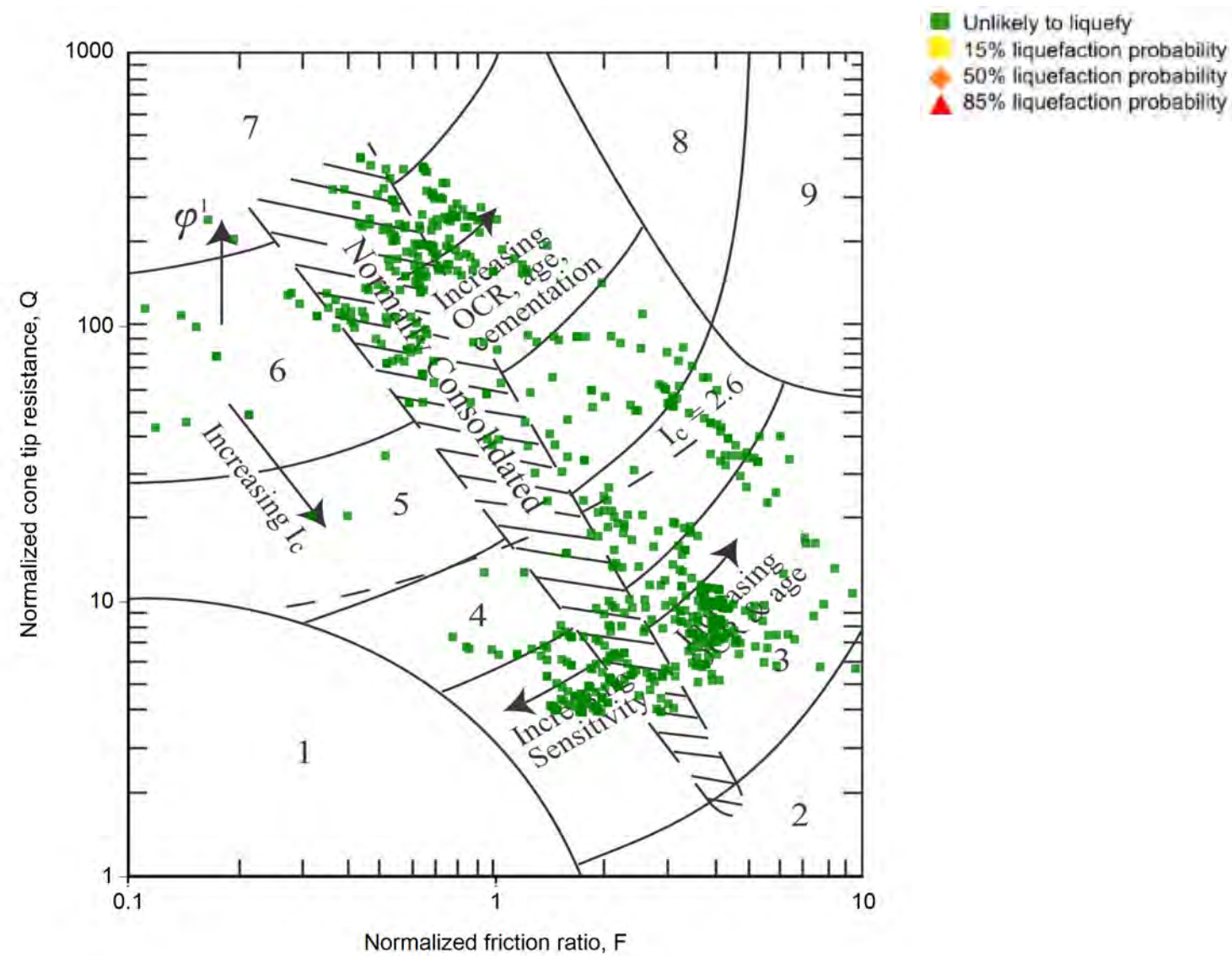
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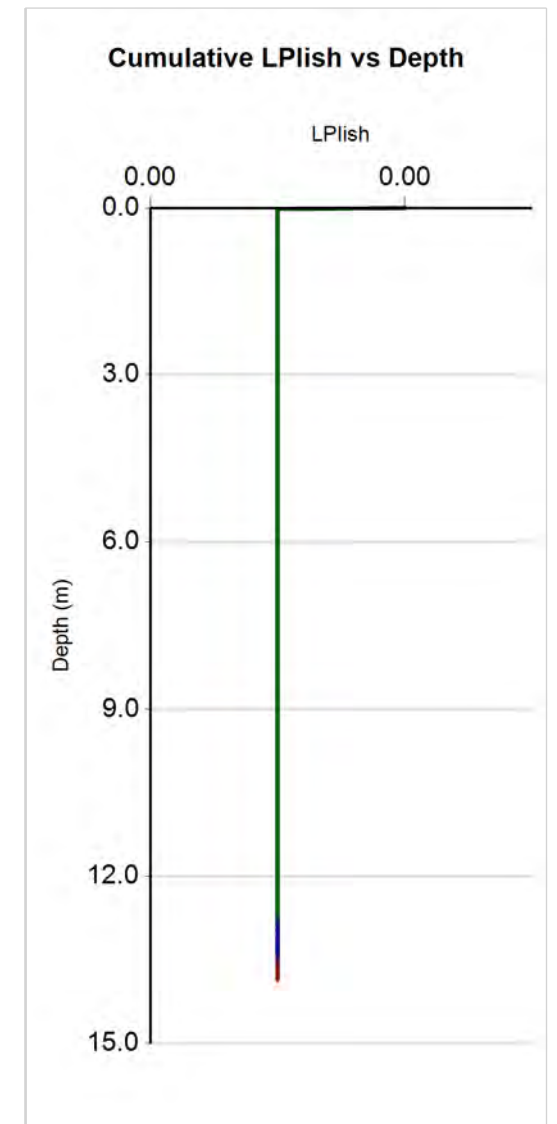
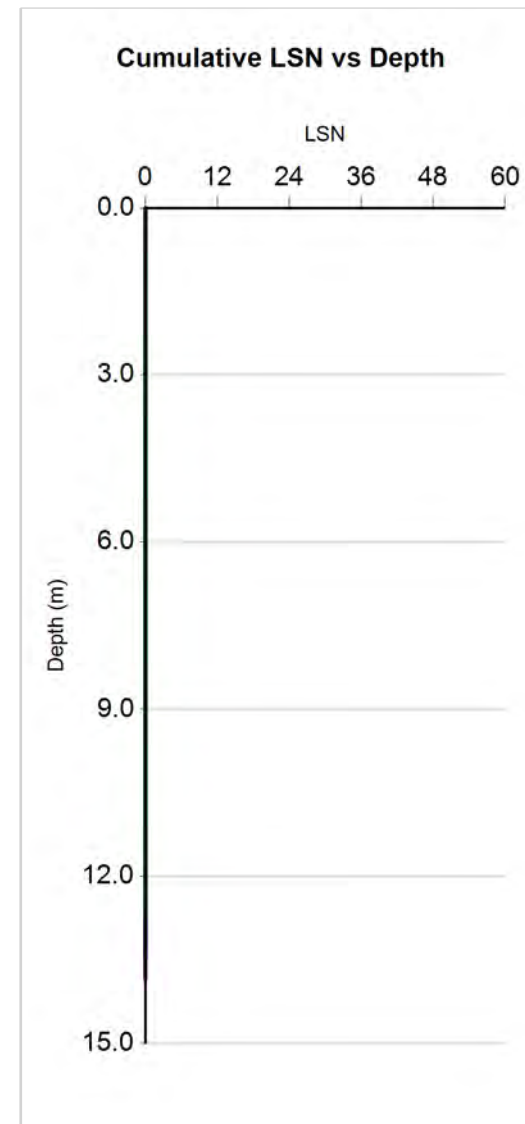
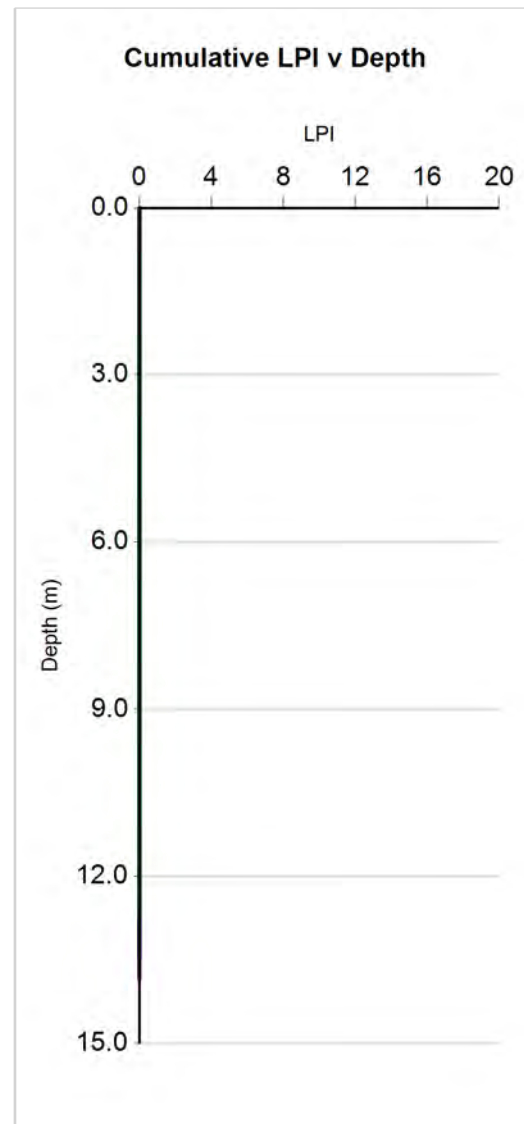
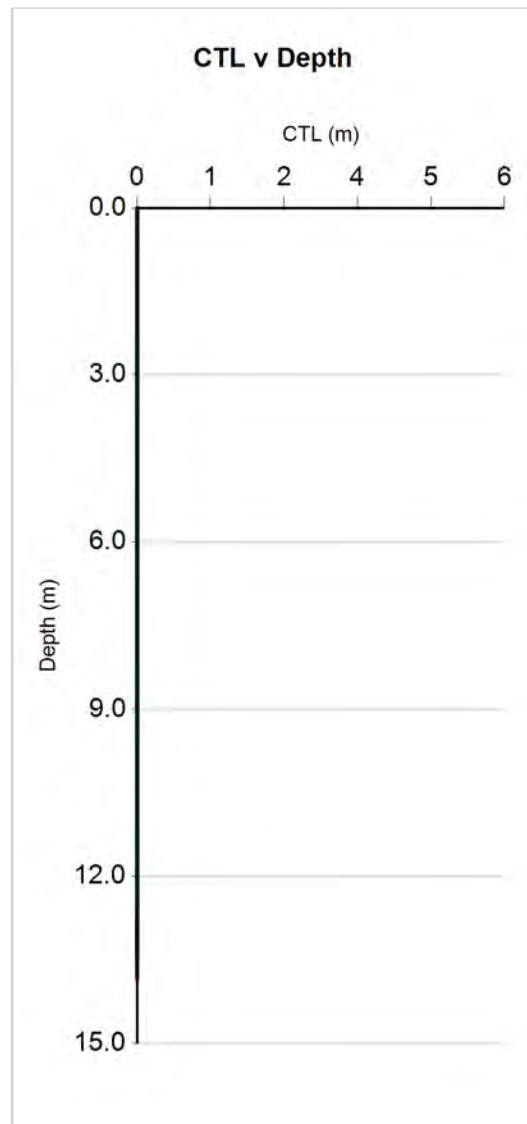
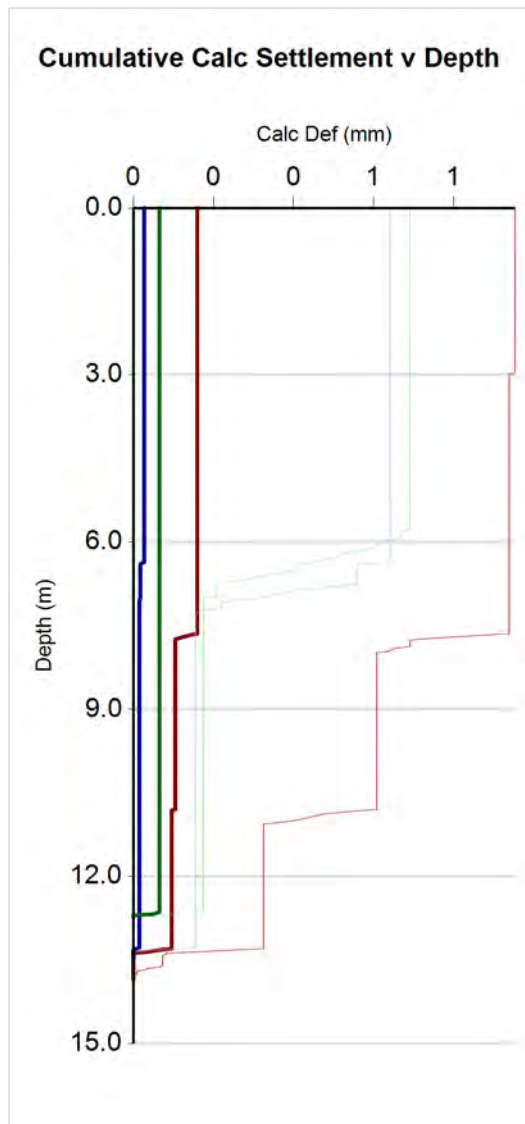
CPT-based soil behavior type classification chart by Robertson (1990)



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CLIENT, PROJECT	Hastings District Council Housing Rezone
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LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
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		PAGE	6 of 9 pages

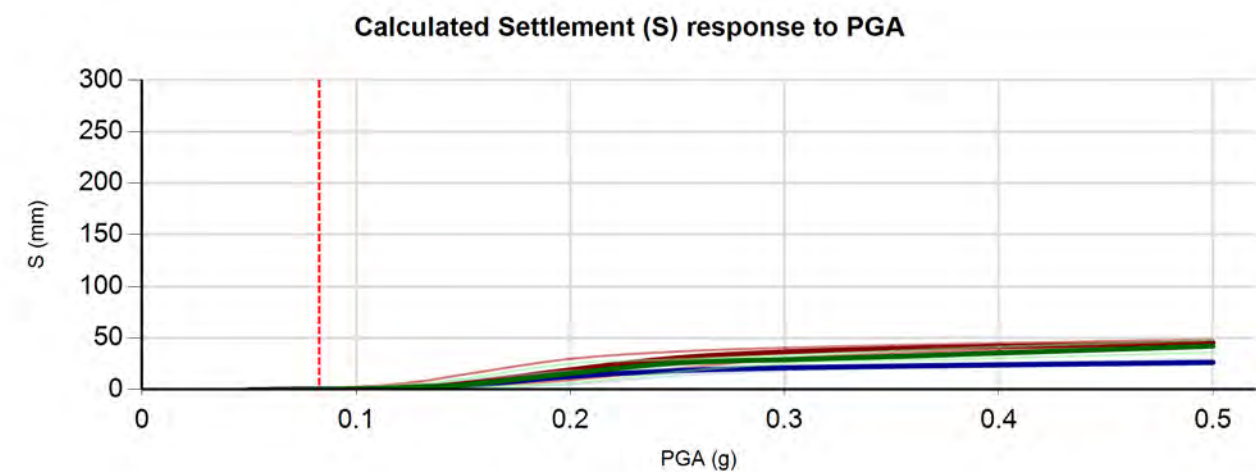
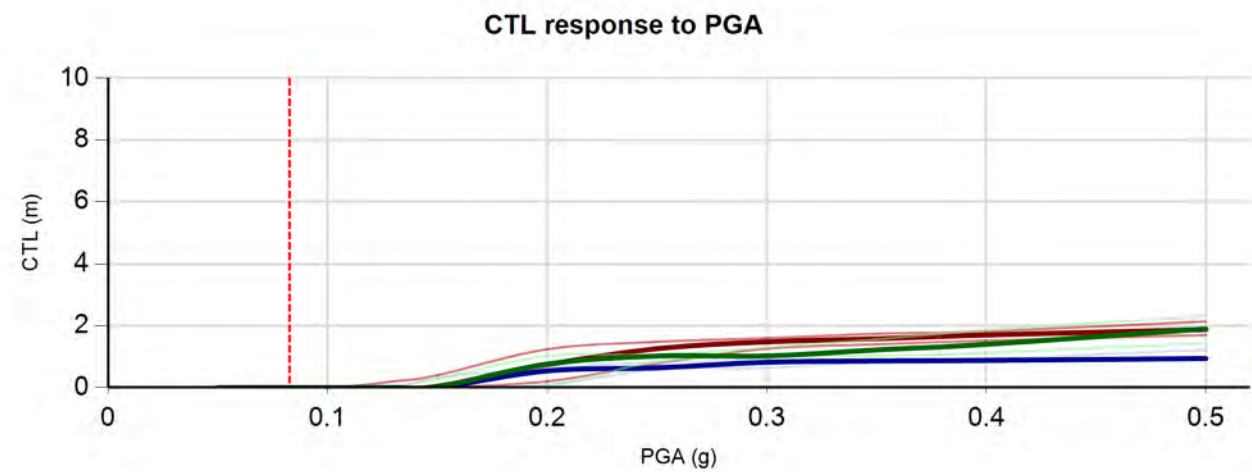
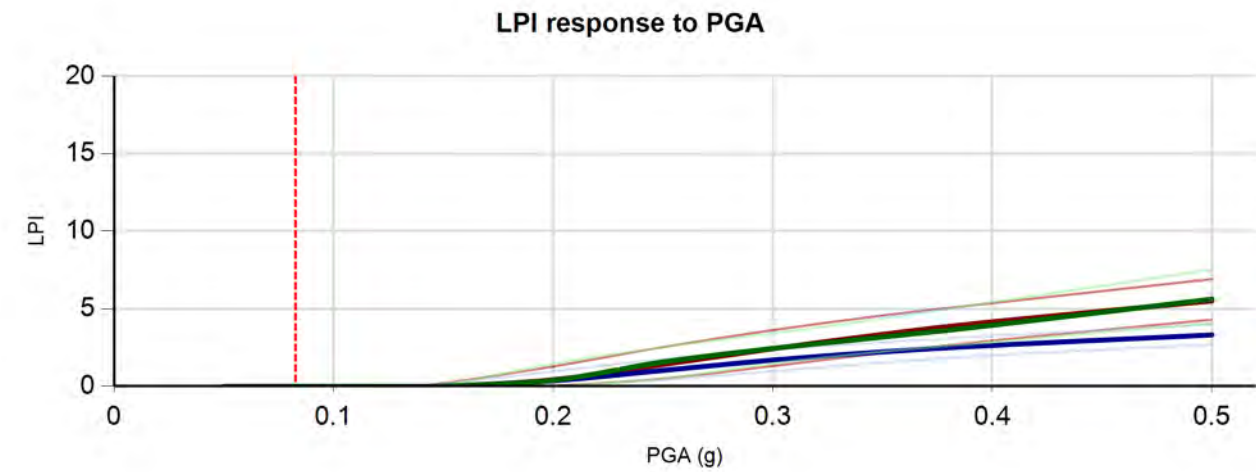
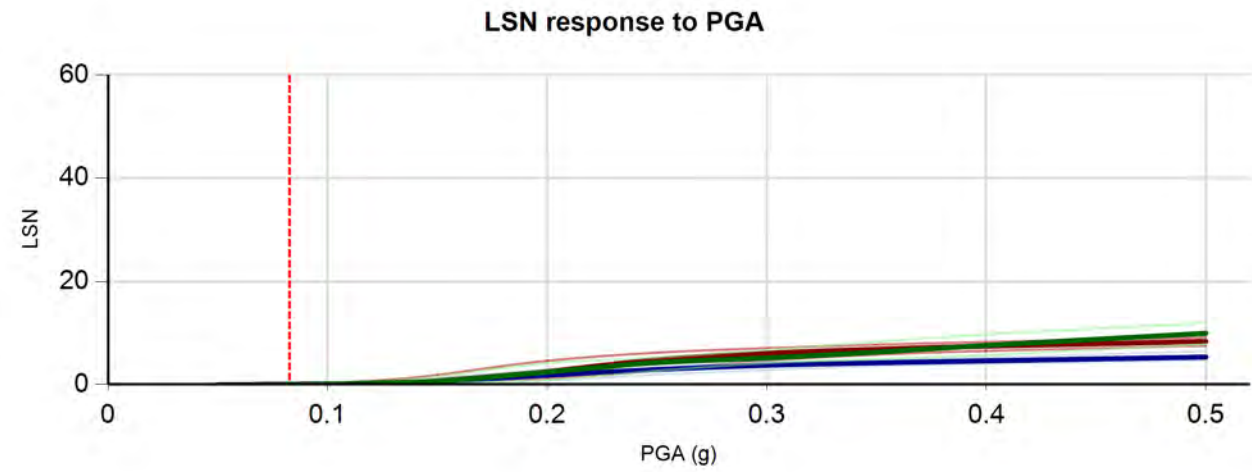


(Assumed pre-drill values)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m³)
CPT21	60520	11/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT22	60521	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT23	60522	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

 <p>Tonkin + Taylor Exceptional thinking together V1.3</p>	<p>CLIENT, PROJECT</p> <p>Hastings District Council Housing Rezone</p>	<p>LOCATION</p> <p>Havelock Road/ Howard Street</p>	<p>DATE</p> <p>4/03/2016</p>
	<p>TITLE</p> <p>SLS Liquefaction Assessment CPT 21-23</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>khl</p>
			<p>CHECKED</p> <p>PAGE</p> <p>7 of 9 pages</p>



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	ÉÉ (kN/m³)
CPT21	60520	11/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT22	60521	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT23	60522	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18

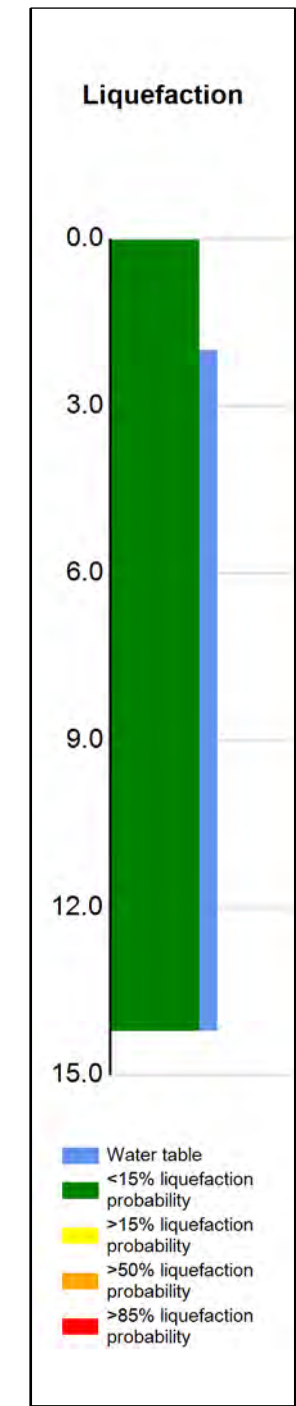
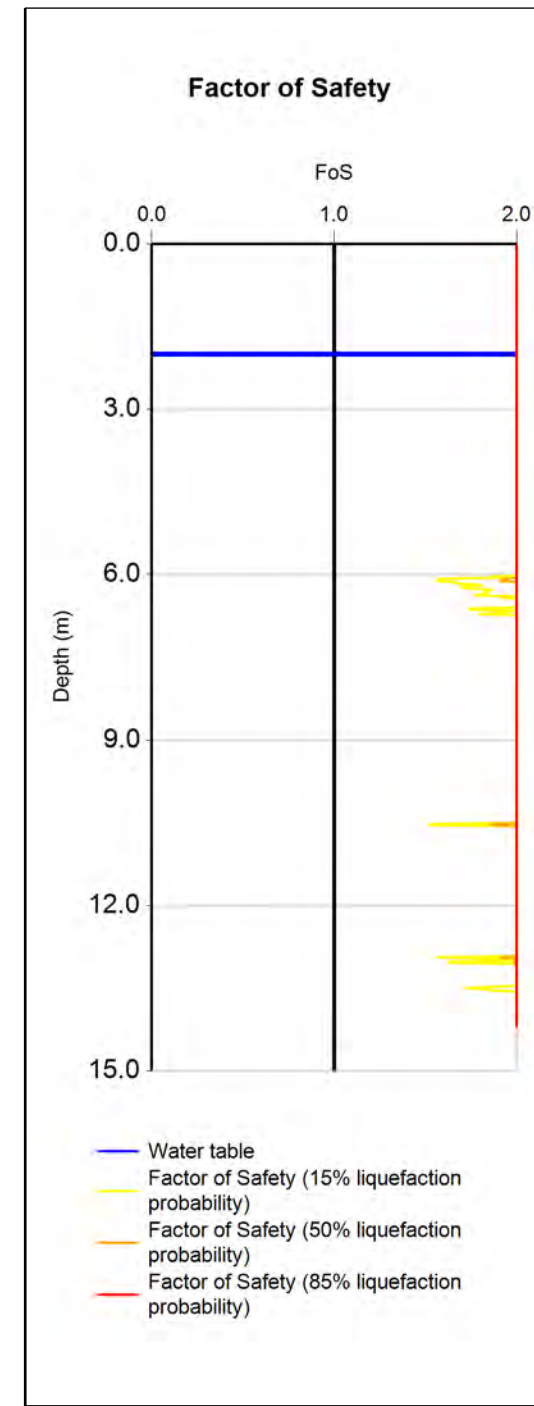
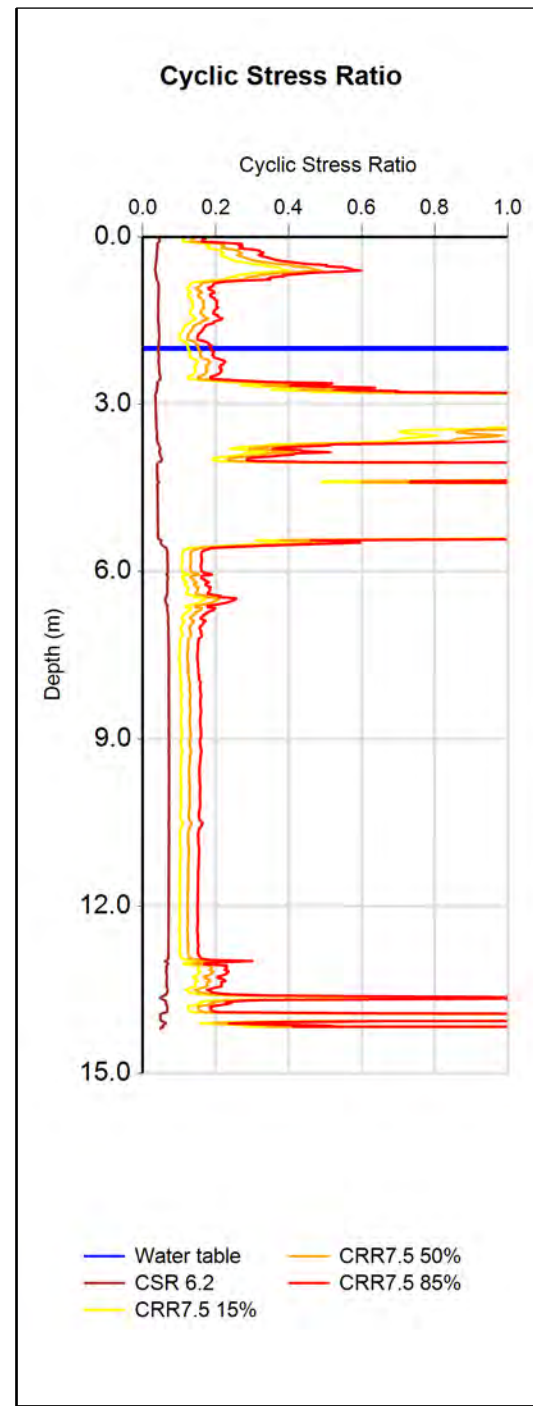
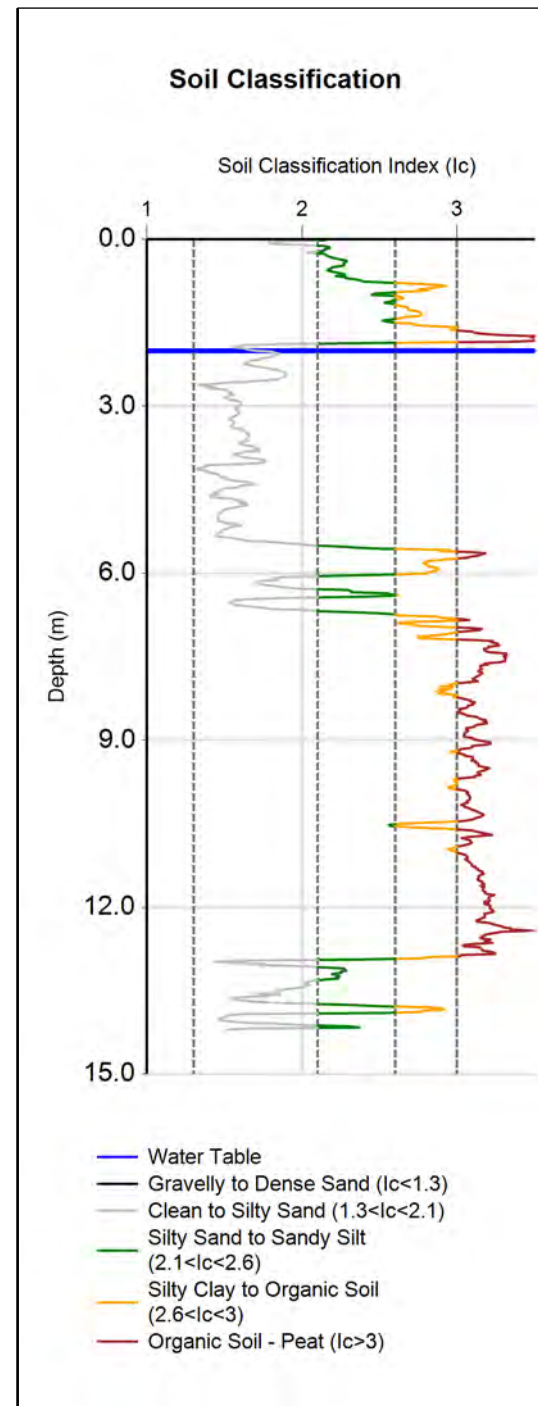
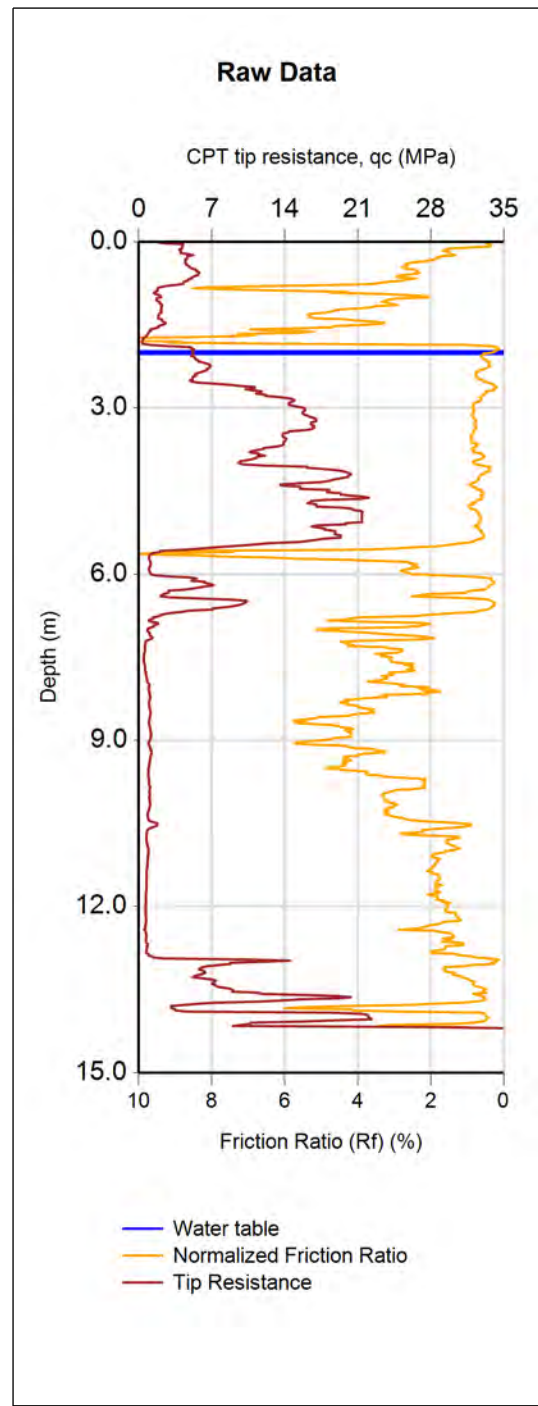
(Assumed pre-drill values)

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60520	60521	60522
CPT Name	CPT21	CPT22	CPT23
PGA	0.0827g	0.0827g	0.0827g
Magnitude	6.2	6.2	6.2
Depth to groundwater	2m	2m	2m
Predrill depth	0.02m	0.02m	0.02m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0
Total depth of CPT	13.86m	13.48m	12.74m
Maximum depth of analysis	13.86m	13.48m	12.74m
RL	n/a	n/a	n/a



(Assumed pre-drill values)

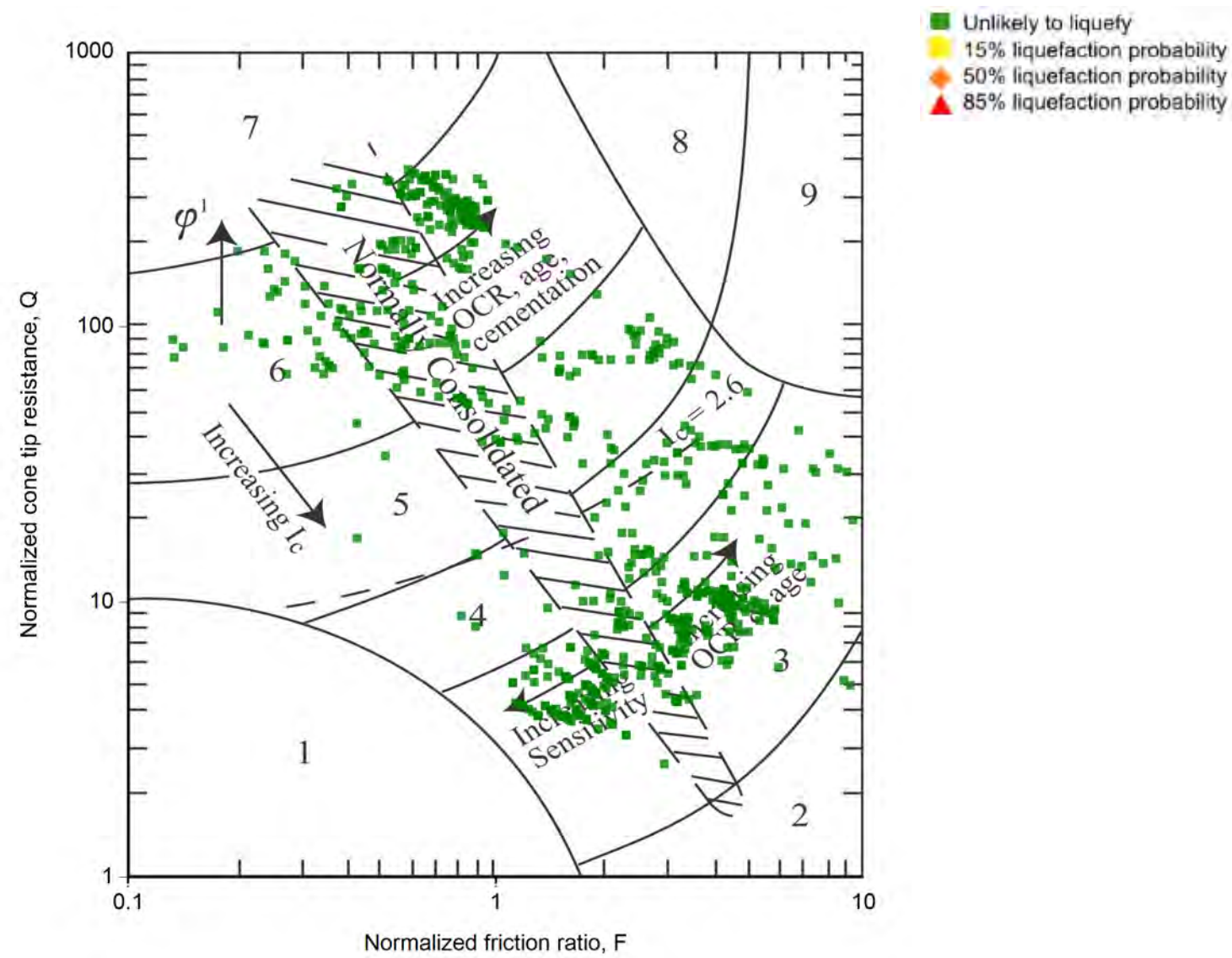
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT24	60523	10/02/2016	User Specified	6.2	0.0827	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	1	0	0	0	14.2	0						
	50%	0	0	0	0	14.2	0						
	85%	0	0	0	0	14.2	0						



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	SLS Liquefaction Assessment CPT 24-25


LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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		PAGE	1 of 10 pages

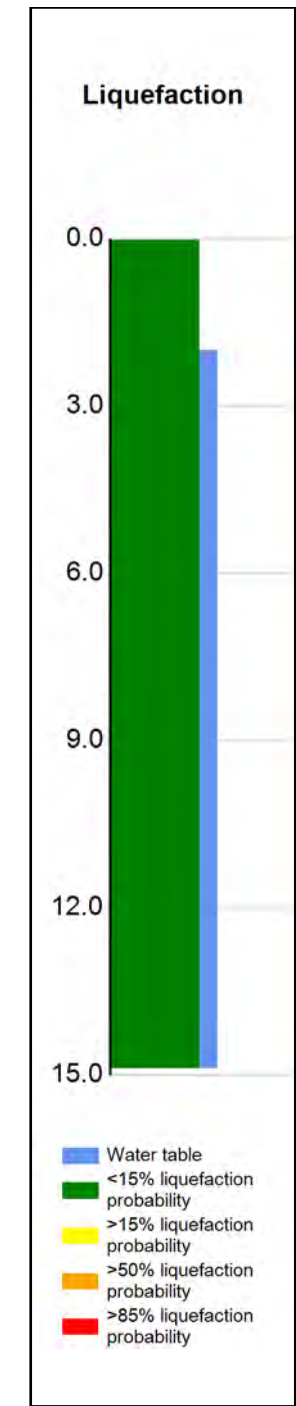
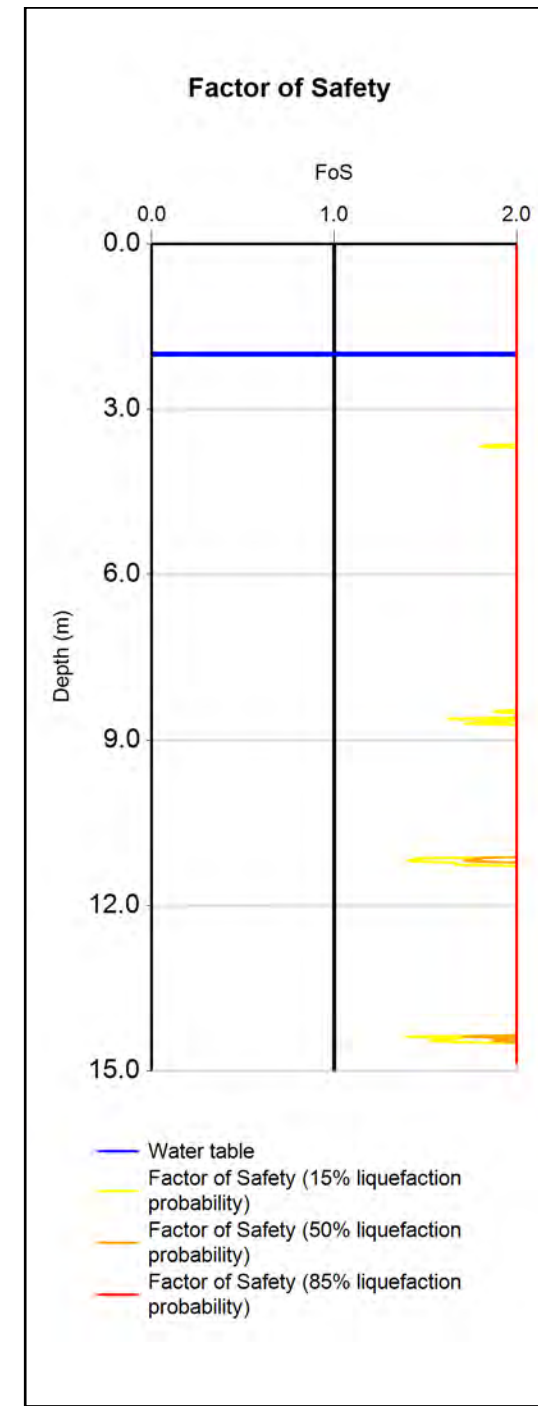
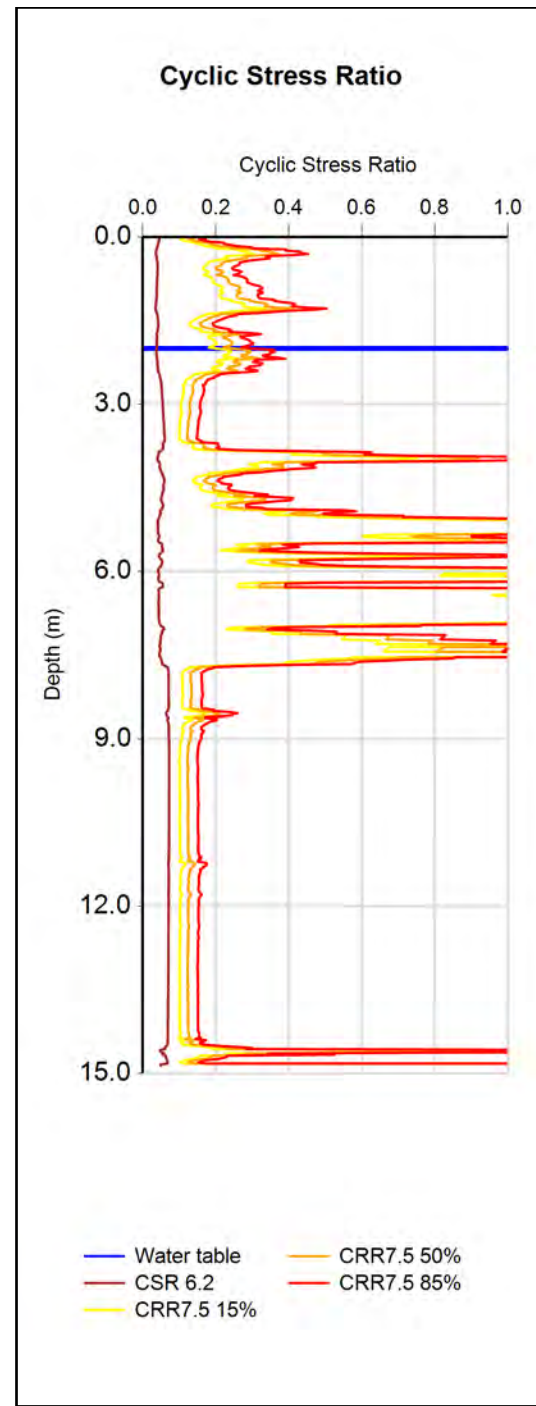
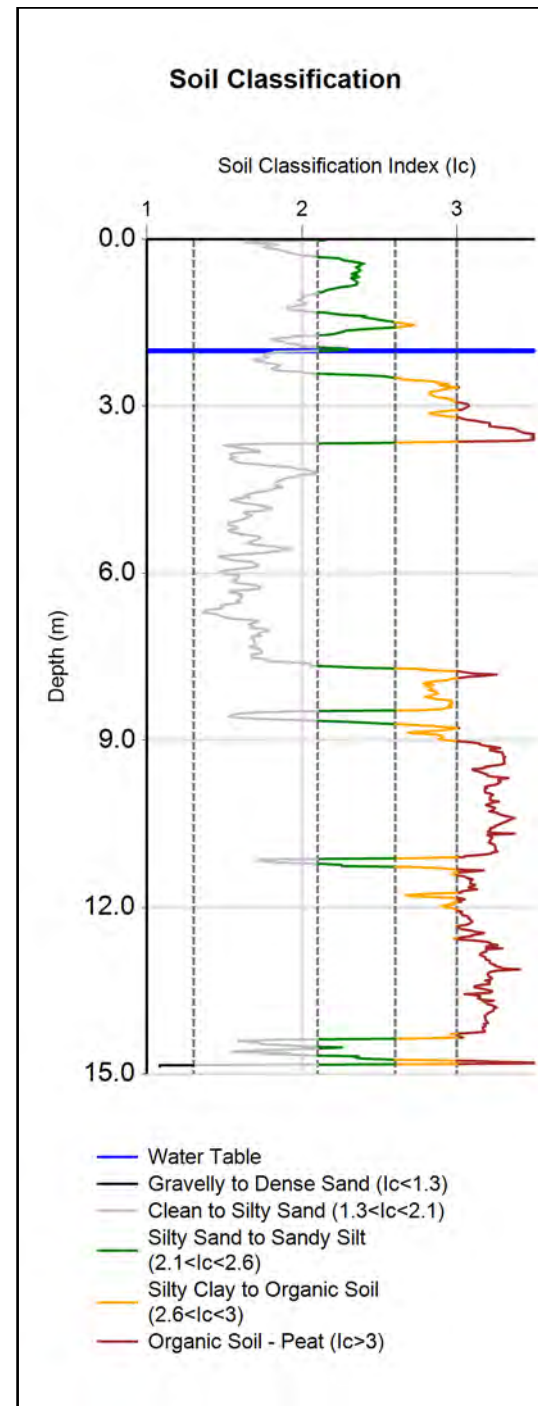
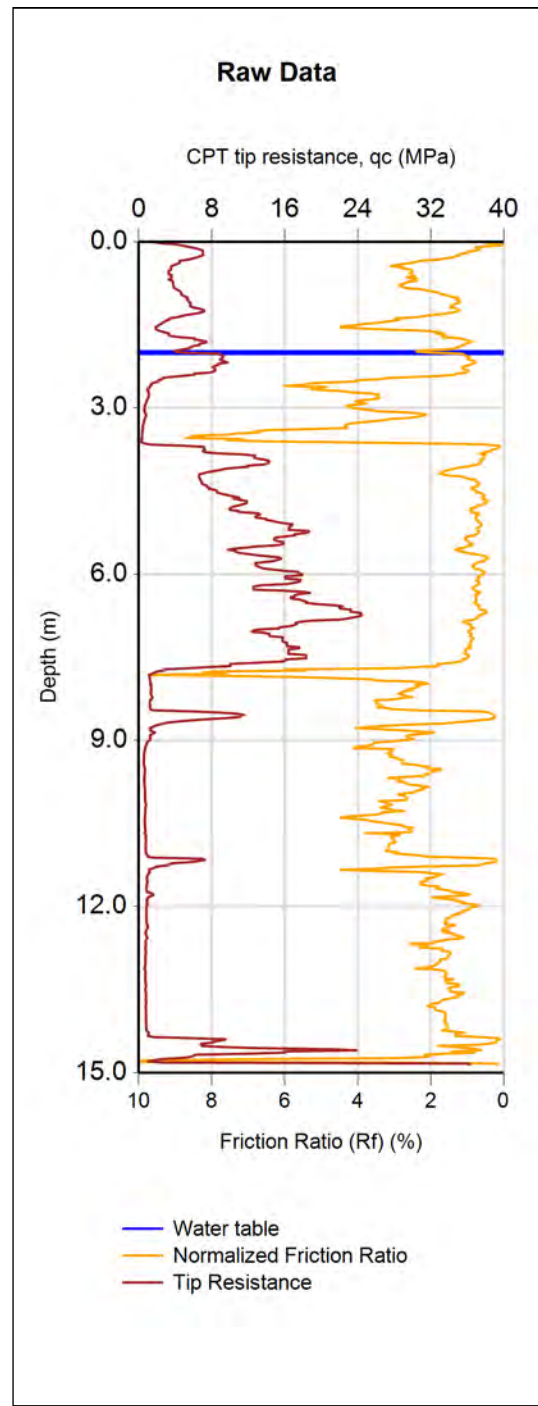


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE SLS Liquefaction Assessment CPT 24-25	JOB NUMBER 31464.1000	ANALYSED khl



(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT25	60524	10/02/2016	User Specified	6.2	0.0827	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
Exceedance Probability S - Calculated Settlement (mm) CTL - Cumulative Thickness of Liquefaction (m) LPI - Liquefaction Potential Index LSN - Liquefaction Severity Number CT - Crust Thickness (m) LPI Ishihara													
OUTPUT	15%	1	0	0	0	0	0	0	0	14.9	0	0	
	50%	0	0	0	0	0	0	0	0	14.9	0	0	
	85%	0	0	0	0	0	0	0	0	14.9	0	0	



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
SLS Liquefaction Assessment CPT 24-25

LOCATION
Havelock Road/
Howard Street

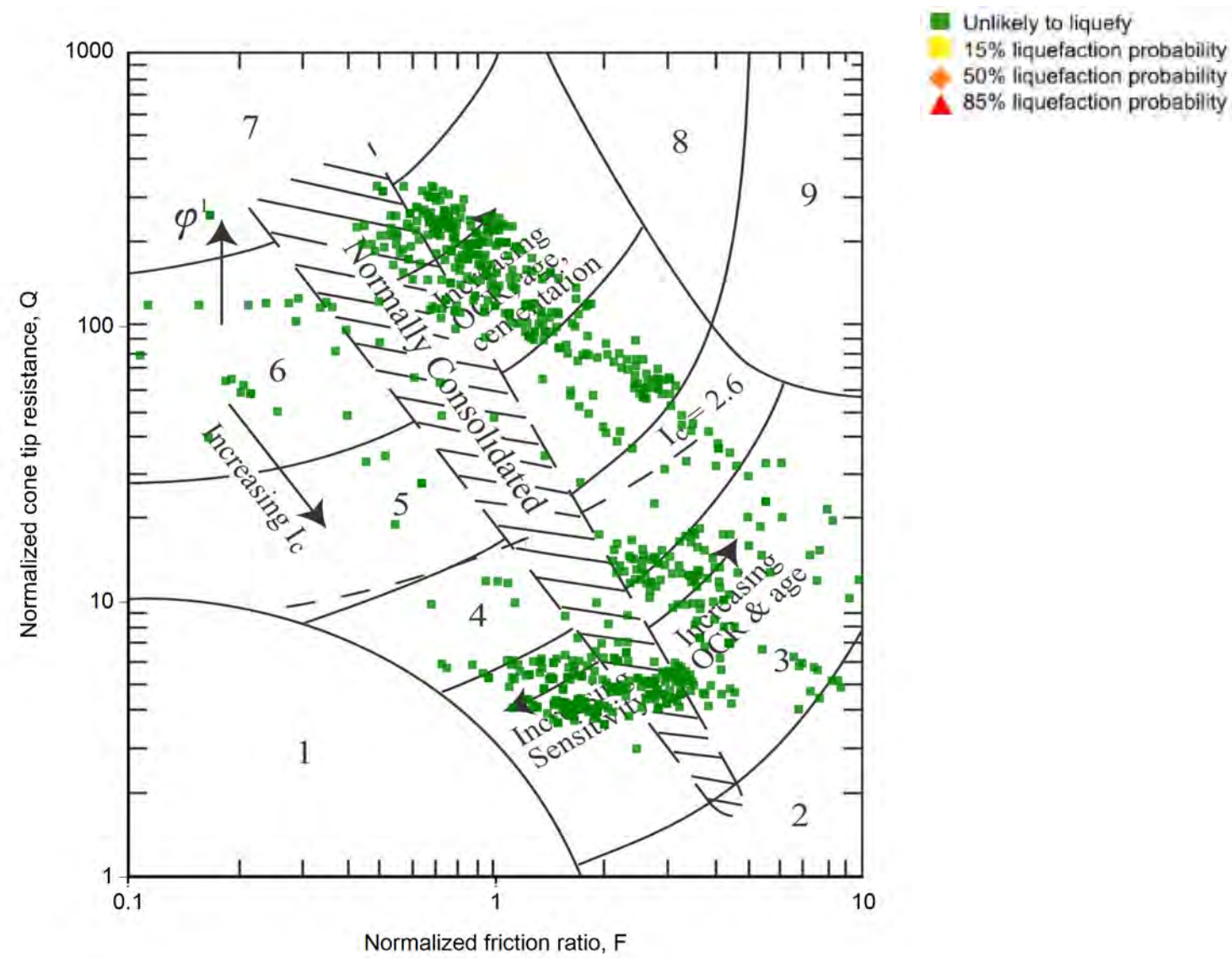
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4/03/2016

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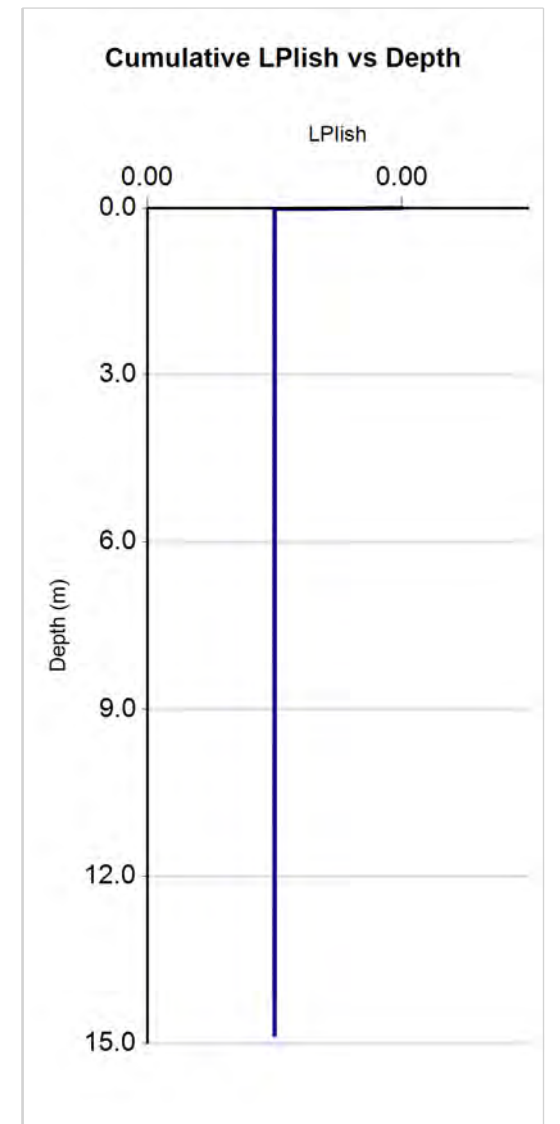
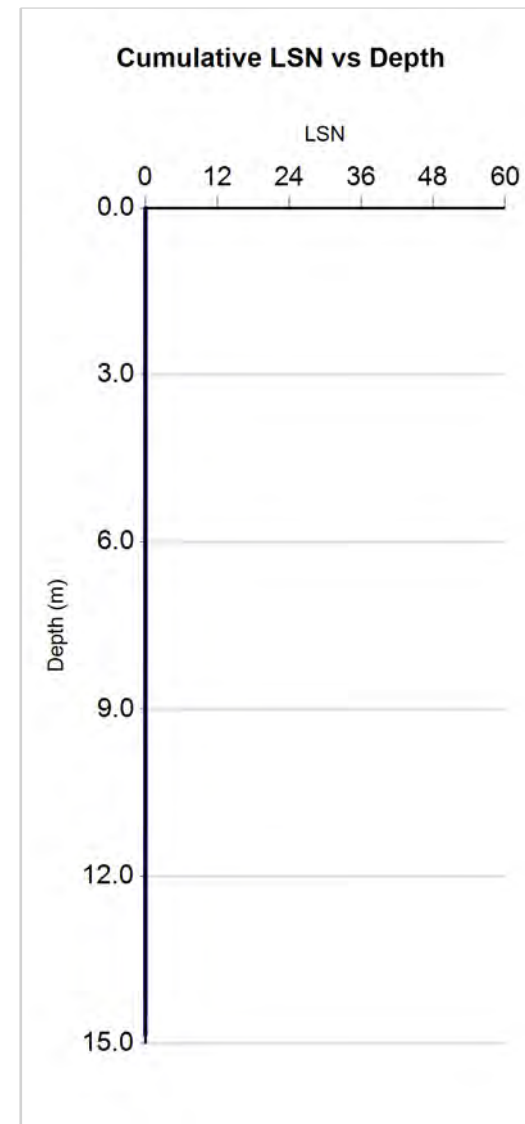
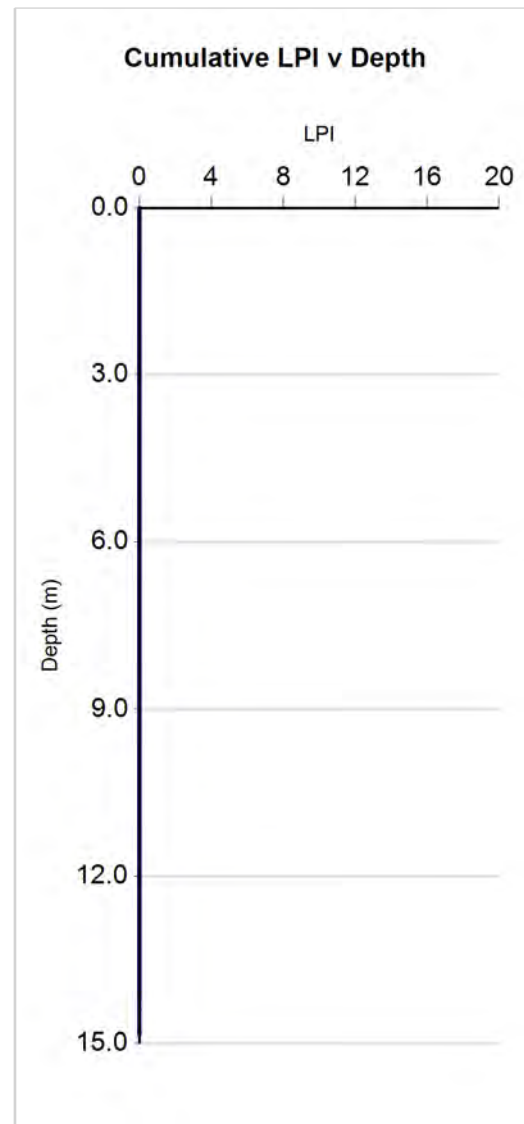
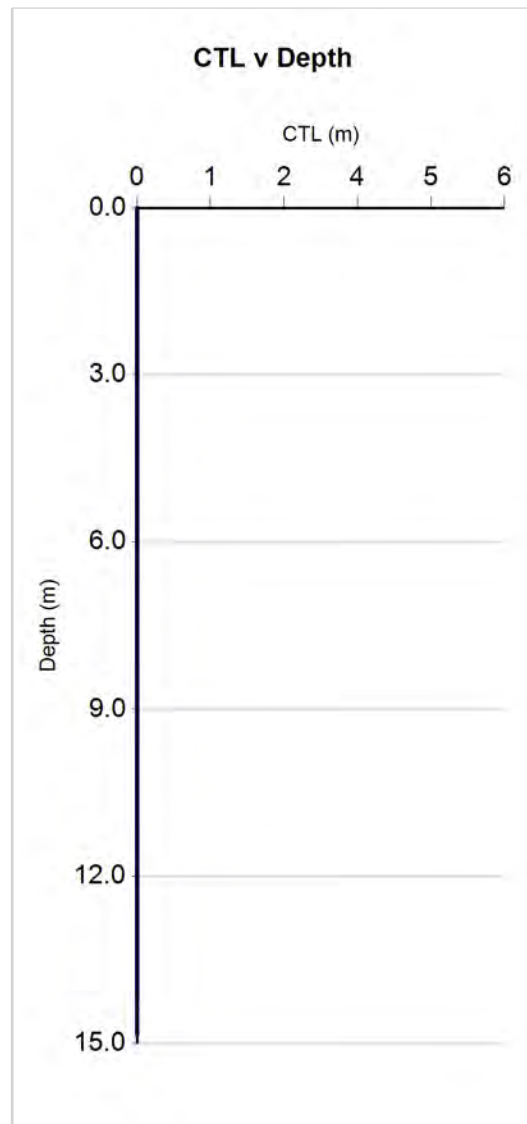
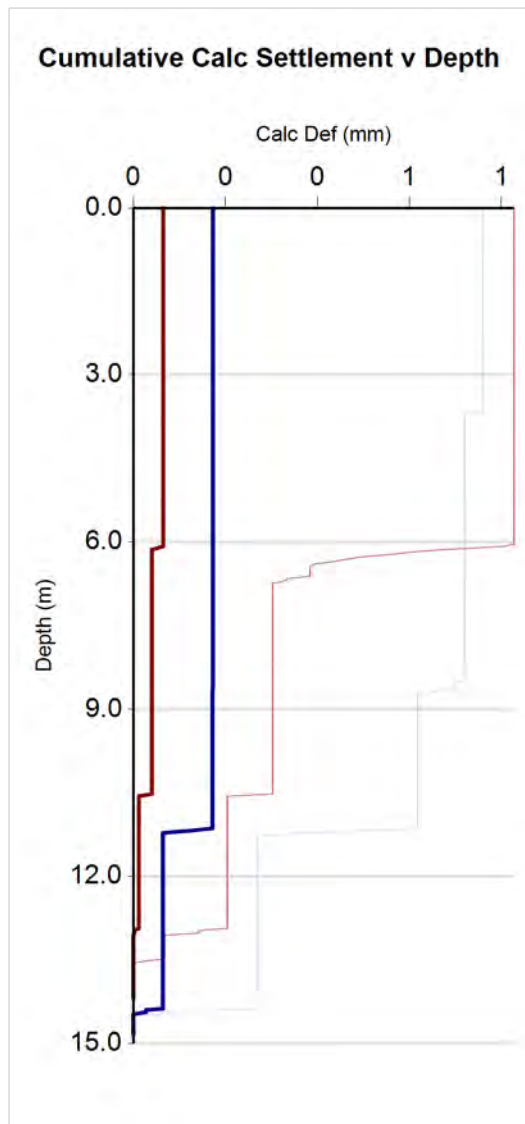


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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

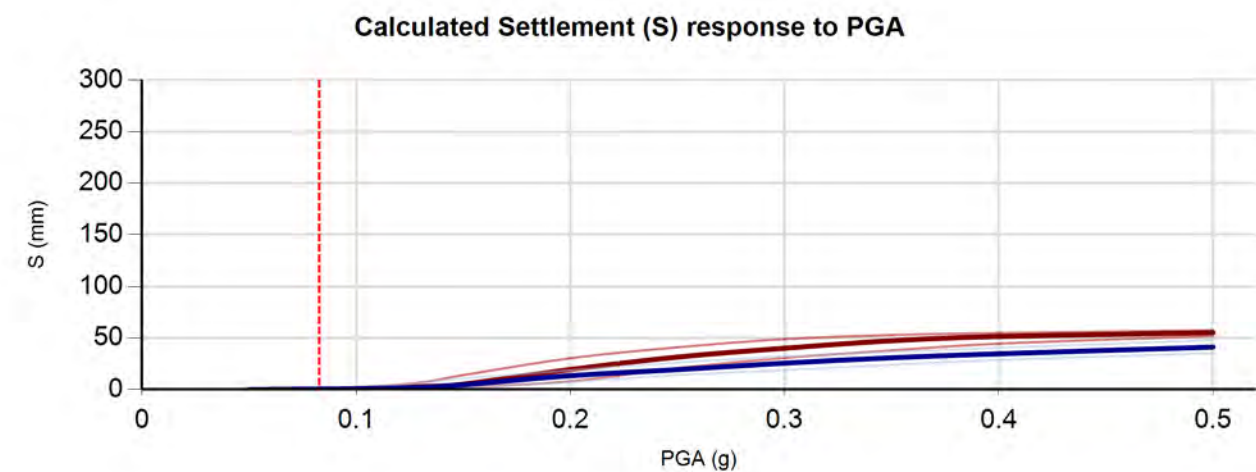
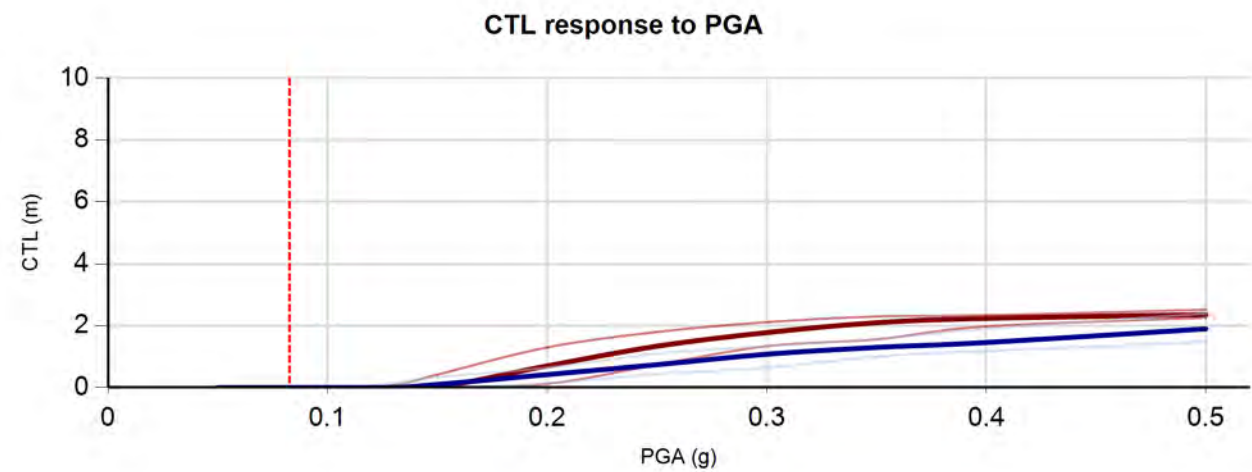
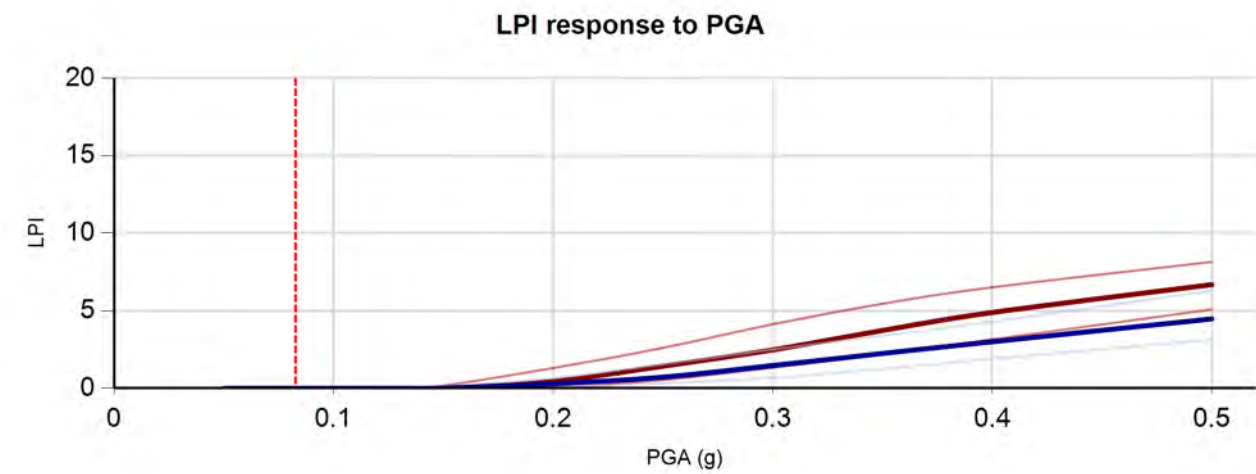
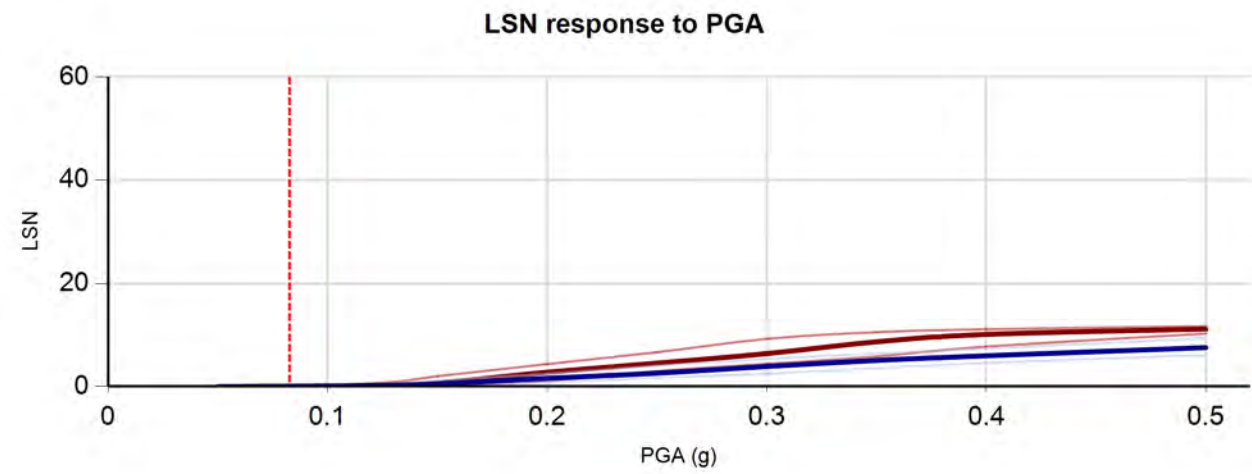
 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE SLS Liquefaction Assessment CPT 24-25	JOB NUMBER 31464.1000	ANALYSED khl



(Assumed pre-drill values)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT24	60523	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT25	60524	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	ÉÉ (kN/m³)
CPT24	60523	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT25	60524	10/02/2016	User Specified	6.2	0.0827	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18

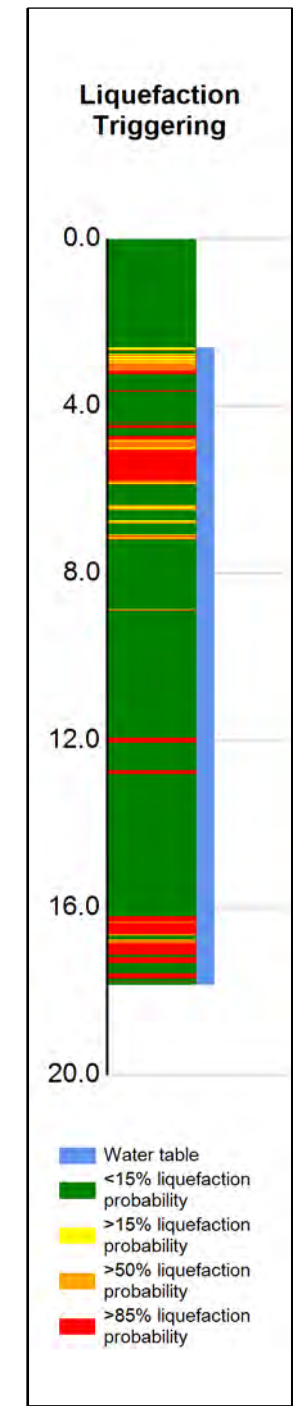
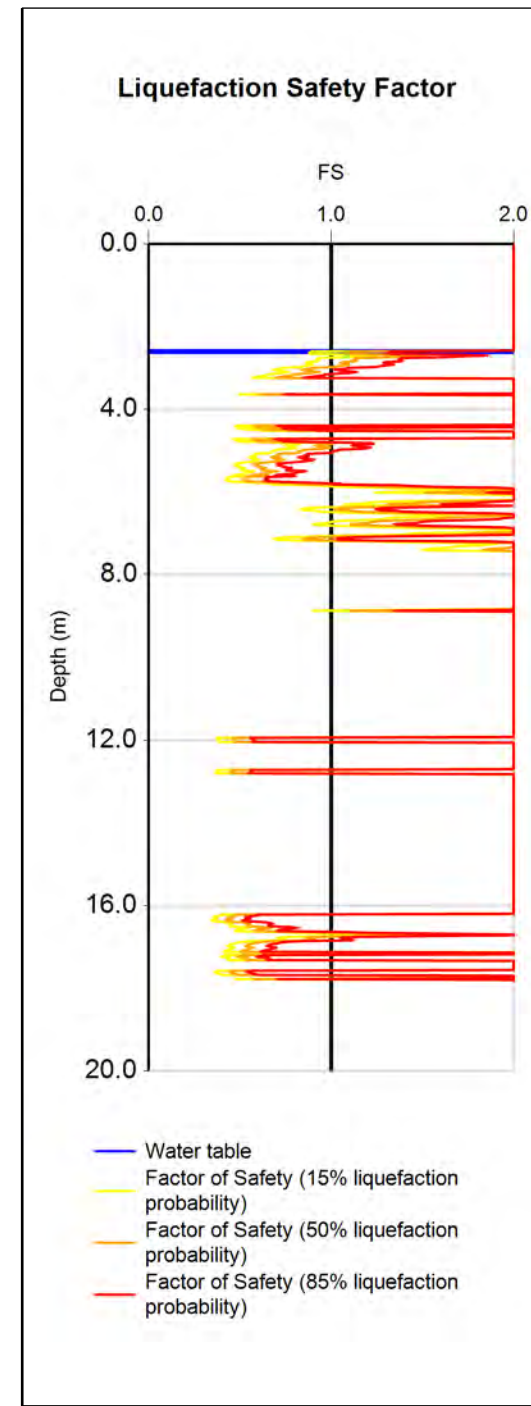
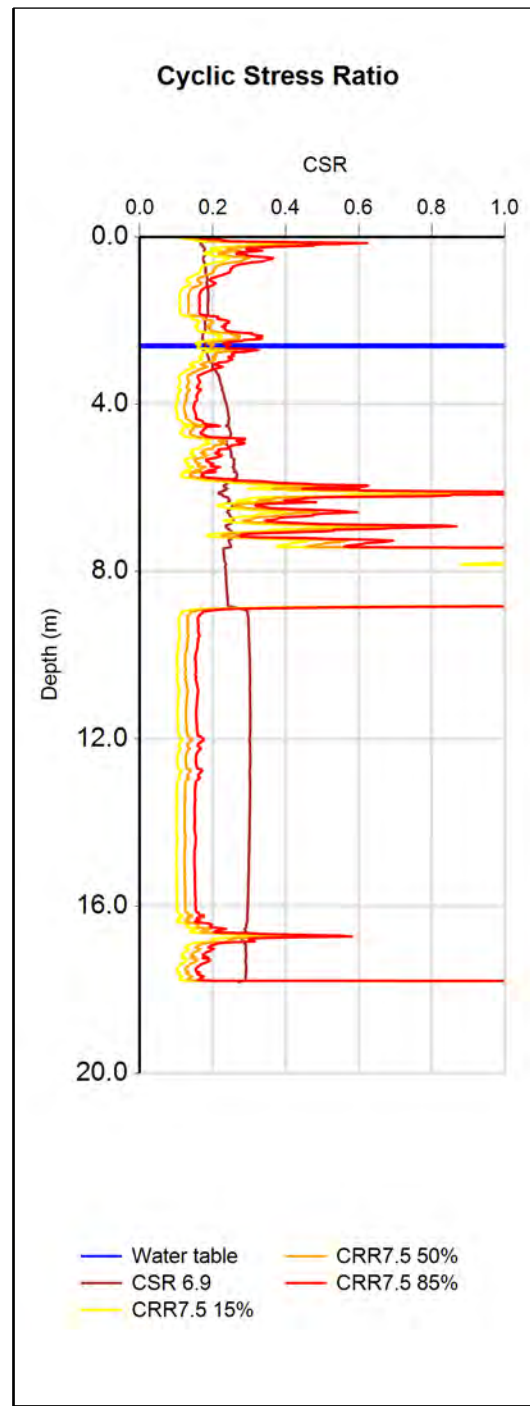
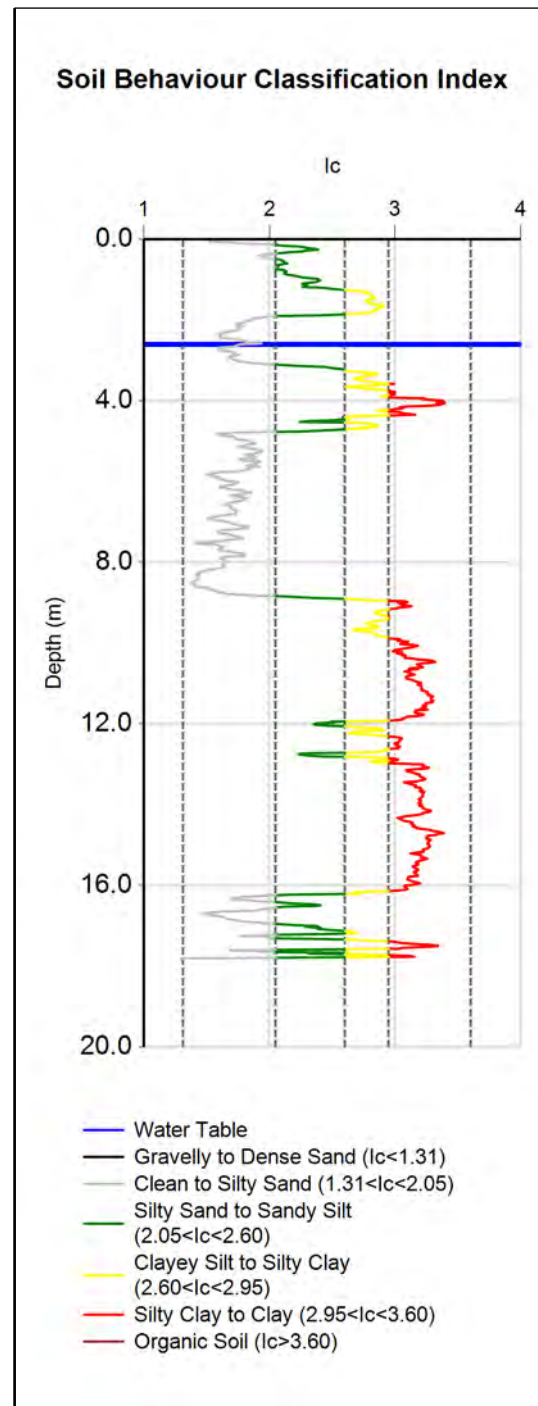
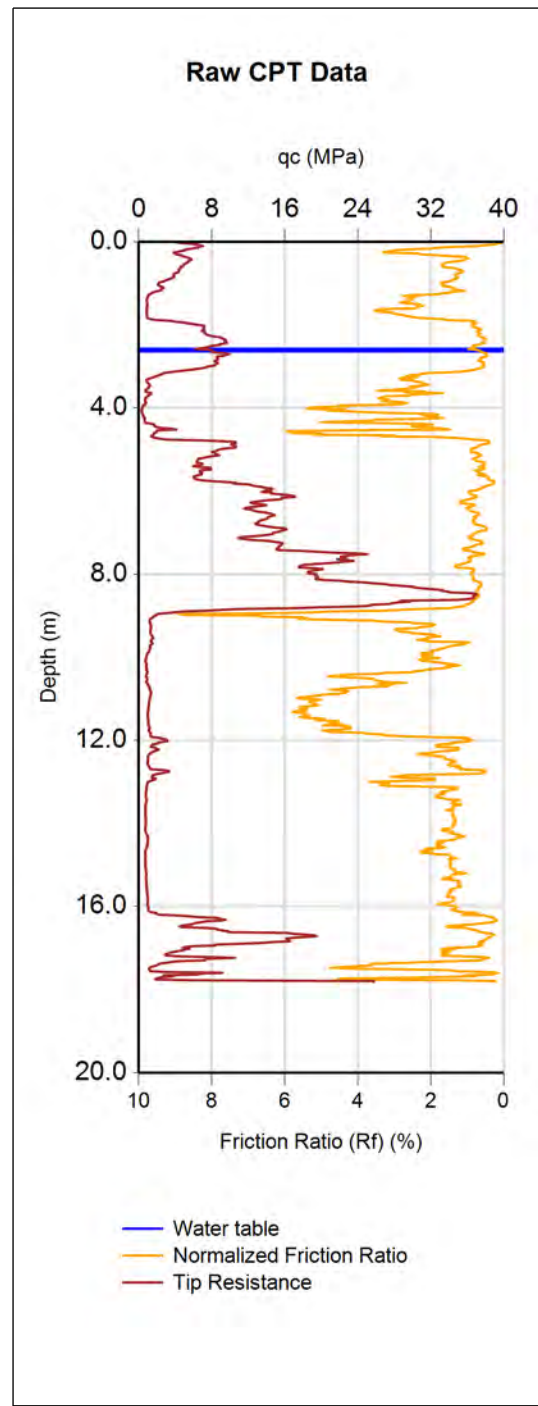
(Assumed pre-drill values)

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60523	60524
CPT Name	CPT24	CPT25
PGA	0.0827g	0.0827g
Magnitude	6.2	6.2
Depth to groundwater	2m	2m
Predrill depth	0.02m	0.02m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0
Total depth of CPT	14.2m	14.86m
Maximum depth of analysis	14.2m	14.86m
RL	n/a	n/a



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT01 - Coordina	60498	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	79	3.5	7	12	2.8	5						
	50%	70	2.9	4	10	3.1	3						
	85%	59	2.3	3	8	3.2	1						



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
ULS Liquefaction Assessment CPT 1-4

LOCATION
Havelock Road / Howard Street

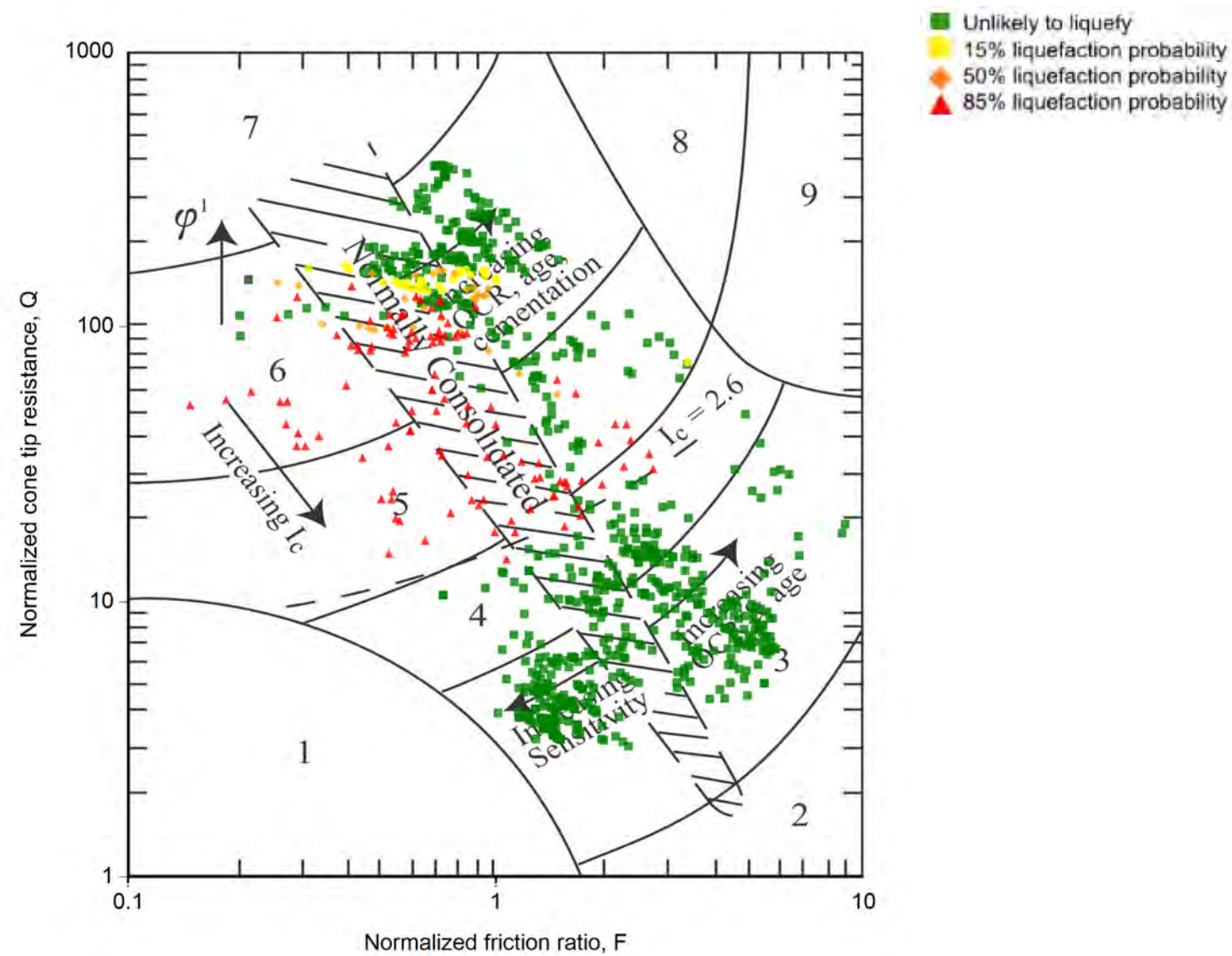
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DATE
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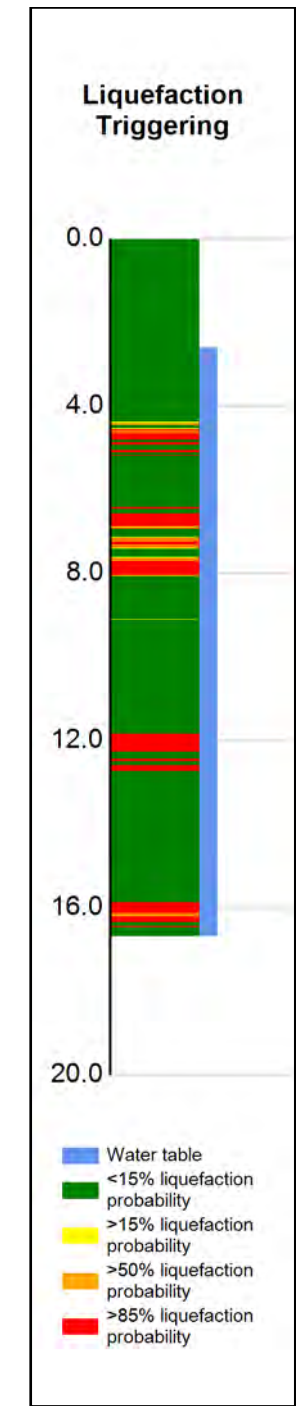
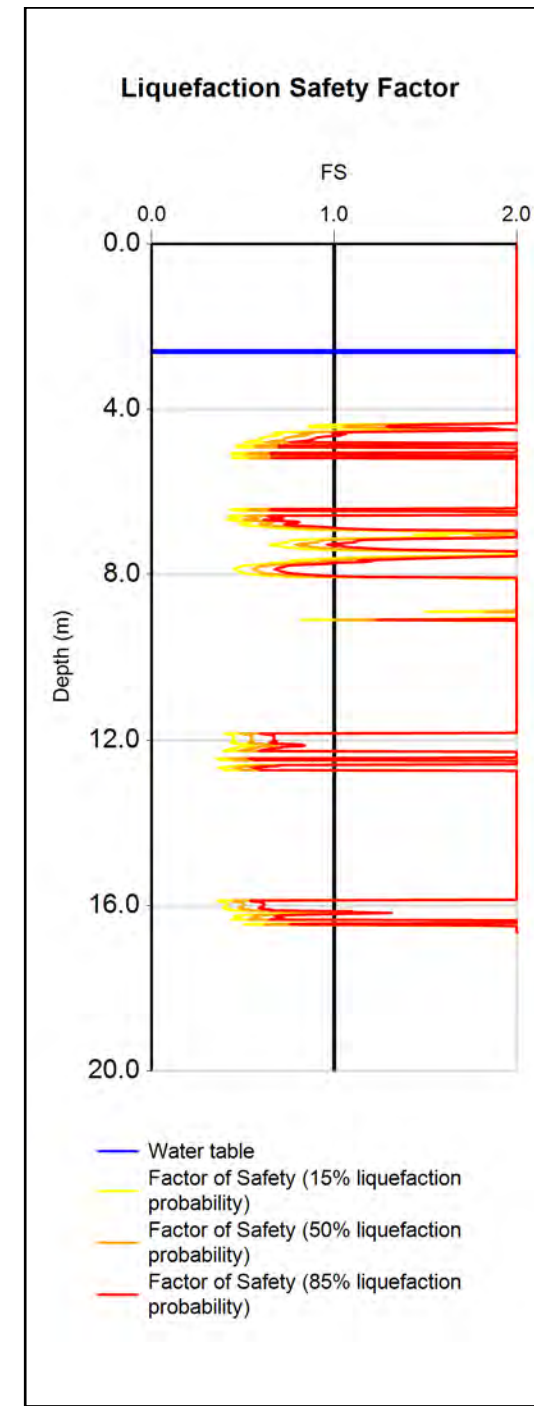
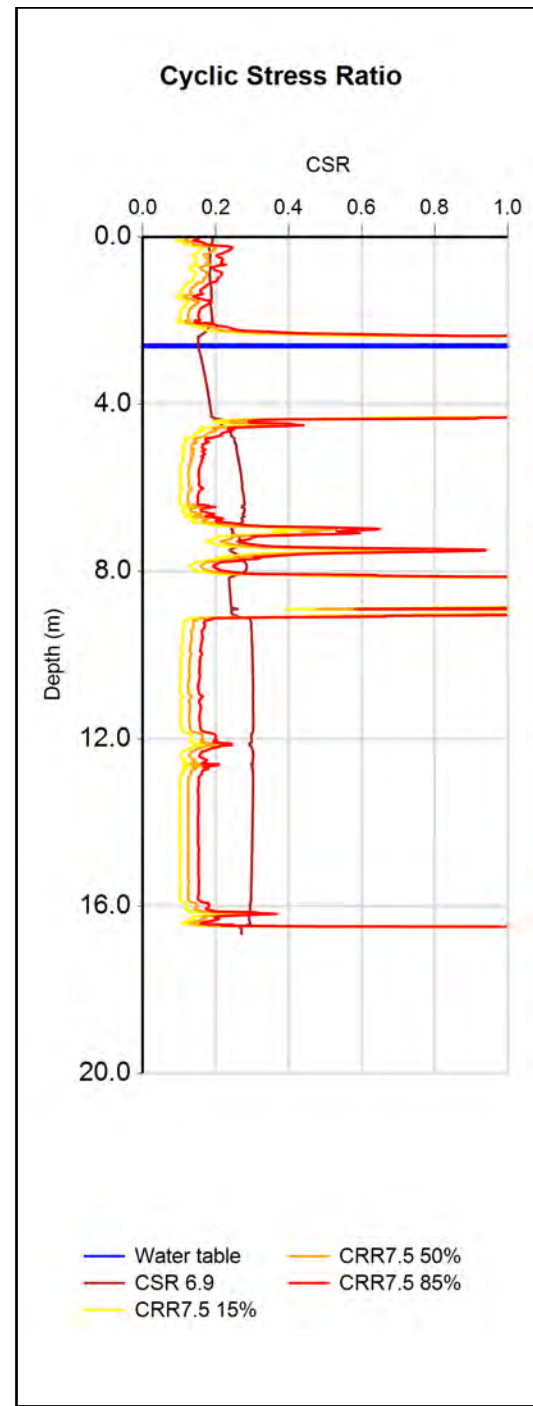
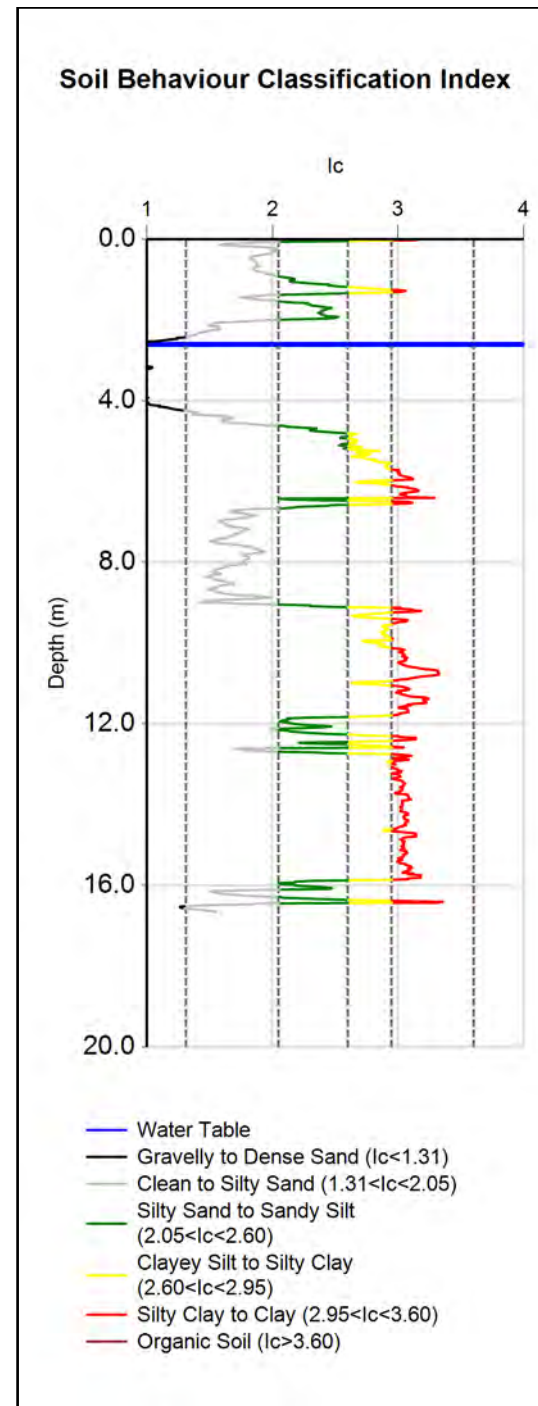
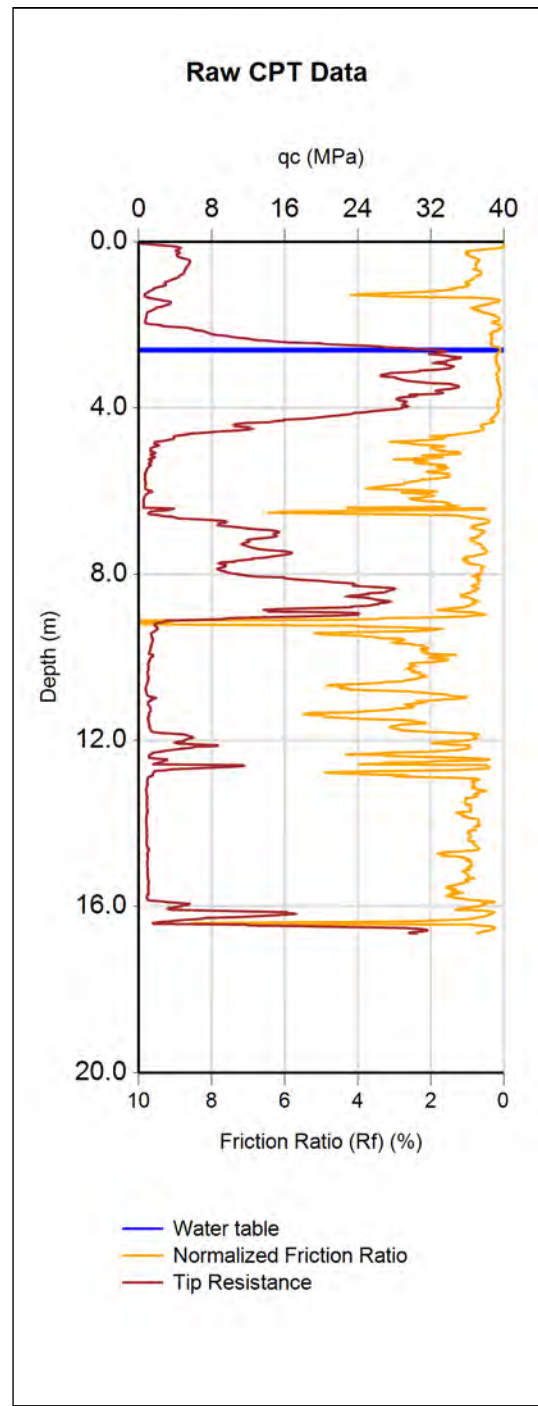


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|--|-------------------------------------|
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE ULS Liquefaction Assessment CPT 1-4	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT02	60500	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	63	2.8	6	8	4.5	3						
	50%	58	2.6	4	7	4.6	2						
	85%	51	2.1	3	6	4.7	1						



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
ULS Liquefaction Assessment CPT 1-4

LOCATION
Havelock Road / Howard Street

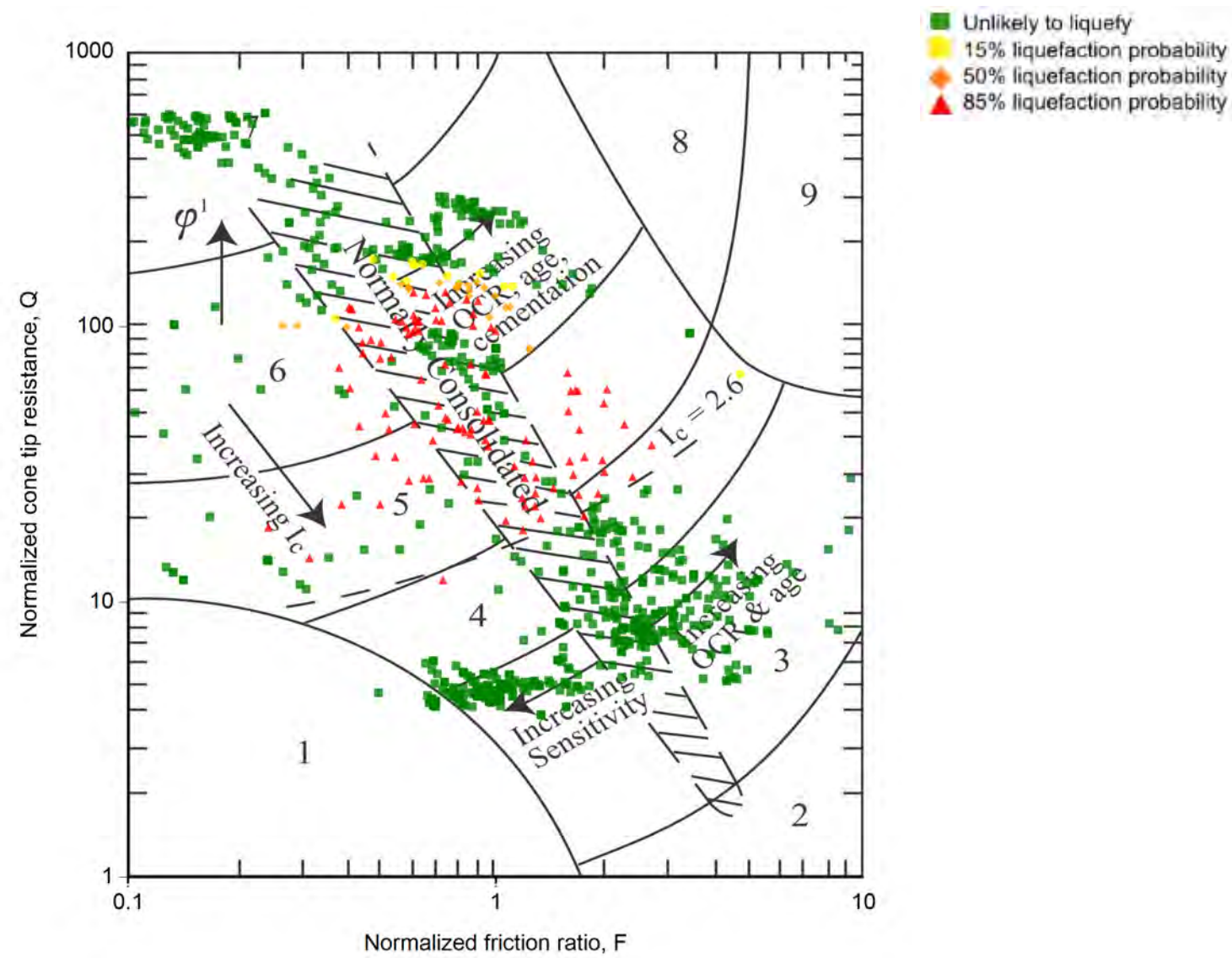
JOB NUMBER
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DATE
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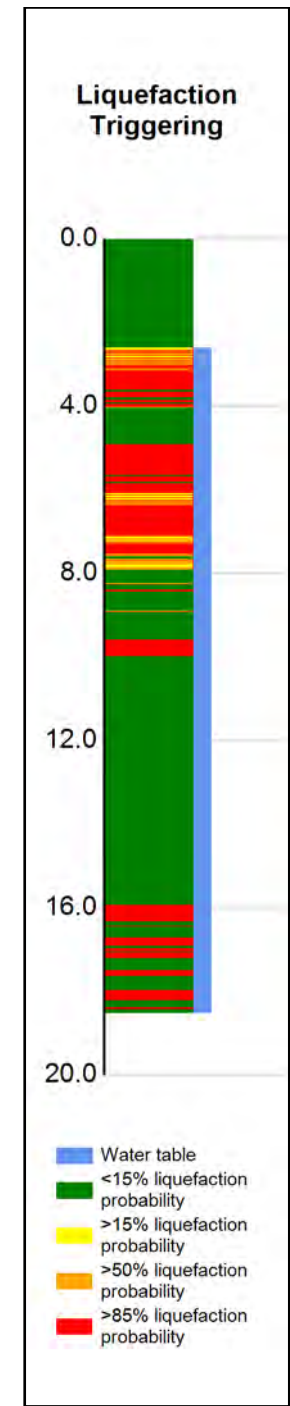
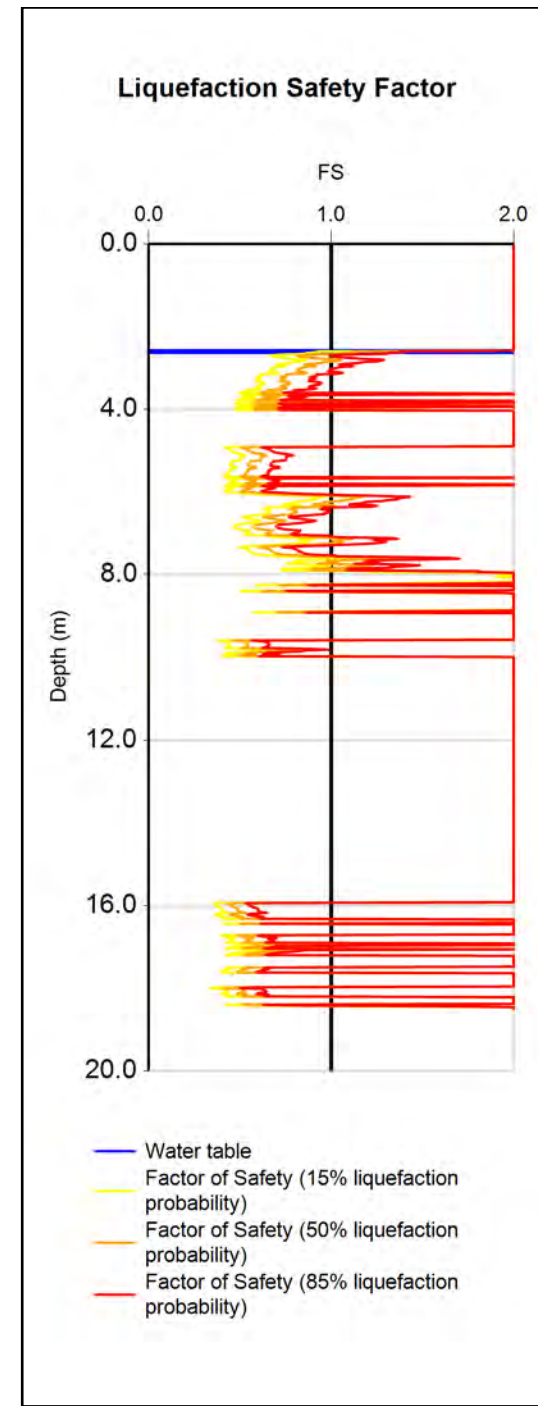
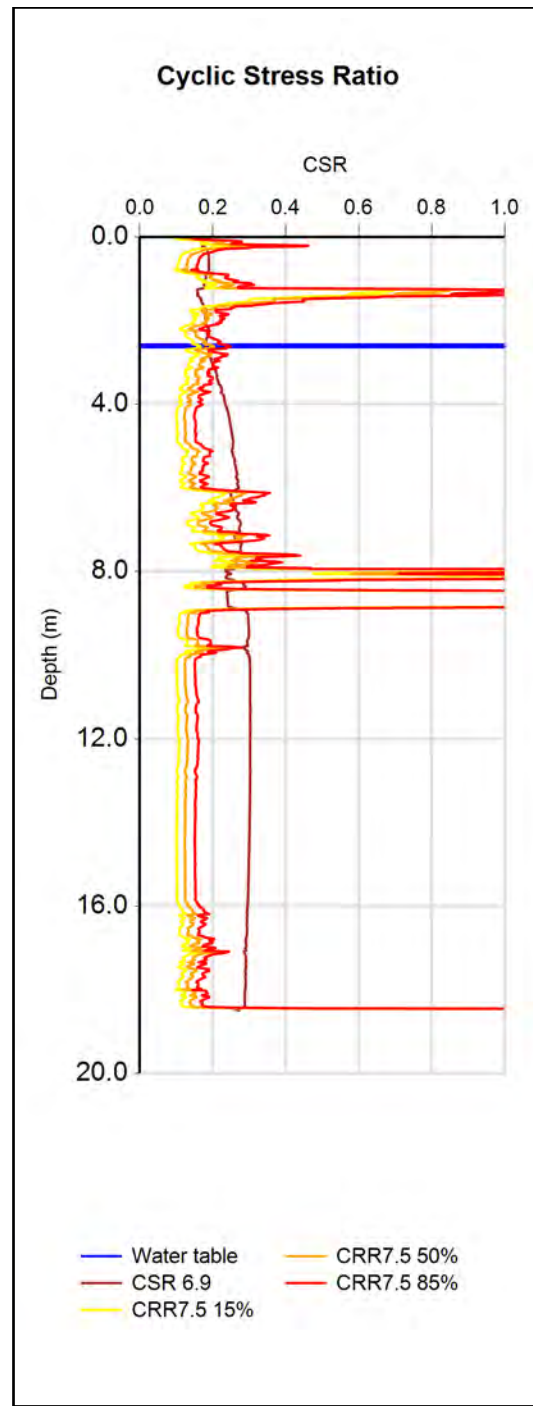
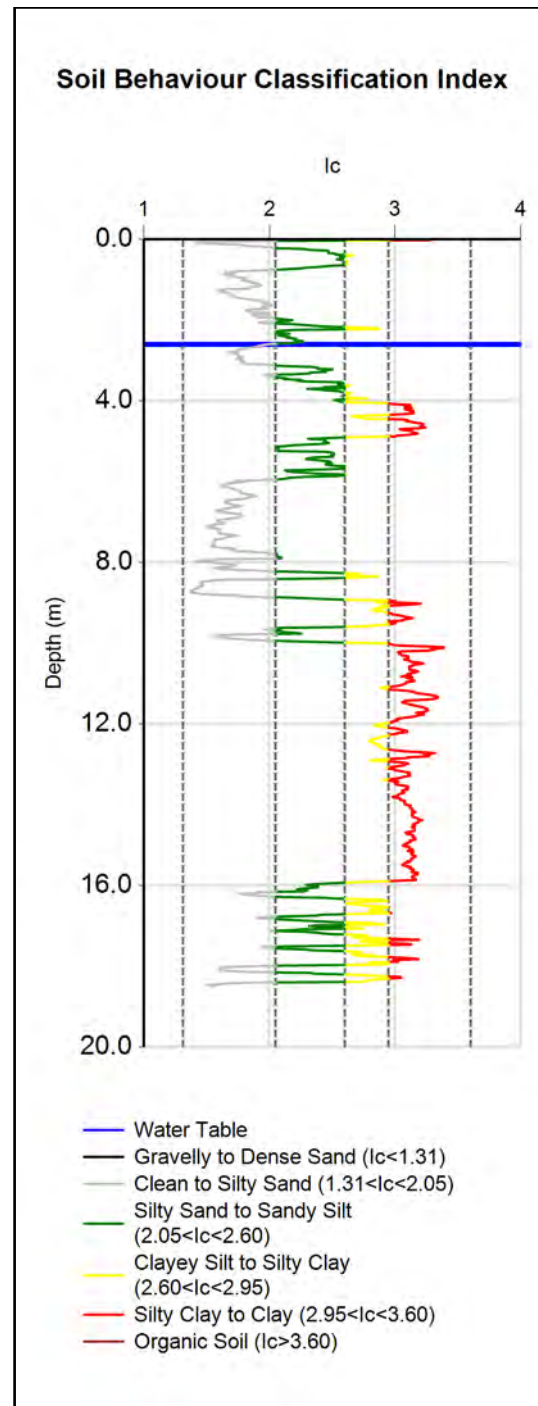
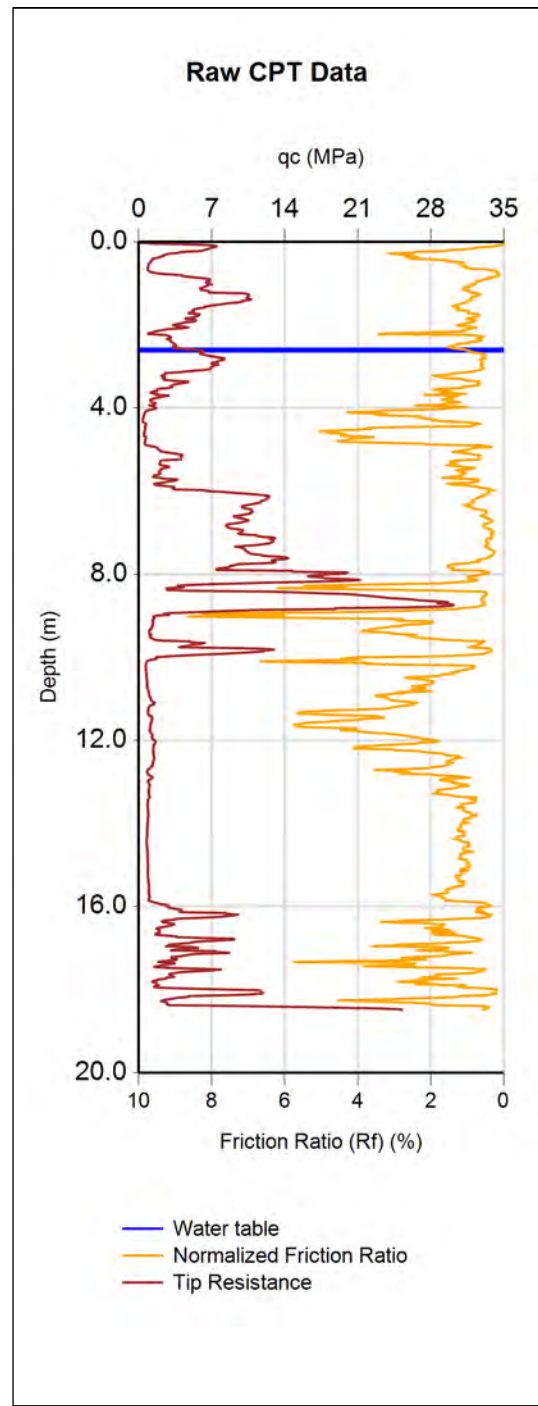


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|--|-------------------------------------|
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 <p>Tonkin + Taylor Exceptional thinking together V1.3</p>	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE ULS Liquefaction Assessment CPT 1-4	JOB NUMBER 31464.1000	ANALYSED cjc
		CHECKED	PAGE 4 of 12 pages



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT03	60501	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	137	6	14	23	2.7	10						
	50%	127	5.3	10	20	2.8	7						
	85%	110	4.6	6	17	3.2	4						



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT

Hastings District Council
Housing Rezone

TITLE

ULS Liquefaction Assessment CPT 1-4

LOCATION

Havelock Road / Howard Street

JOB NUMBER

31464.1000

DATE

17/02/2016

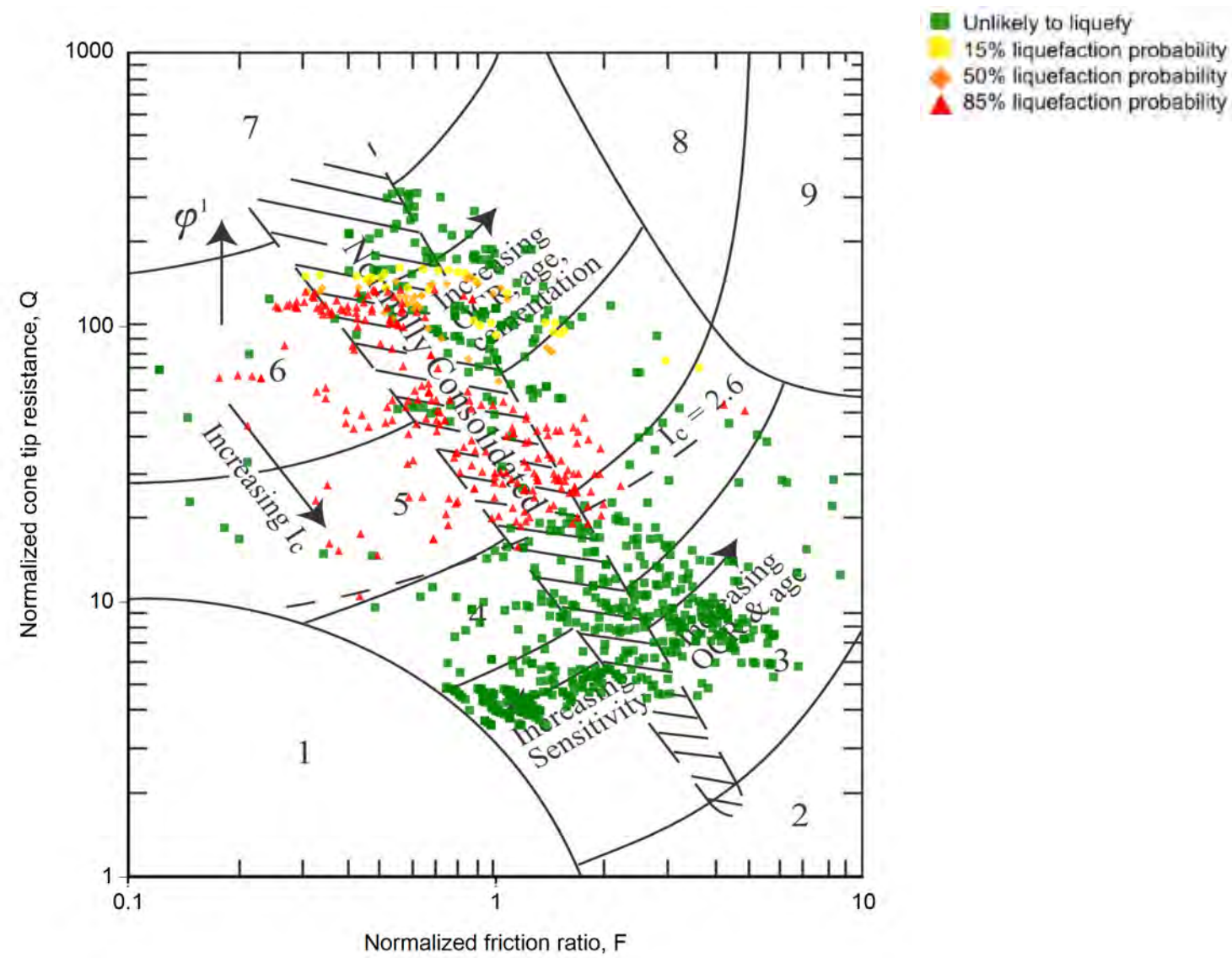
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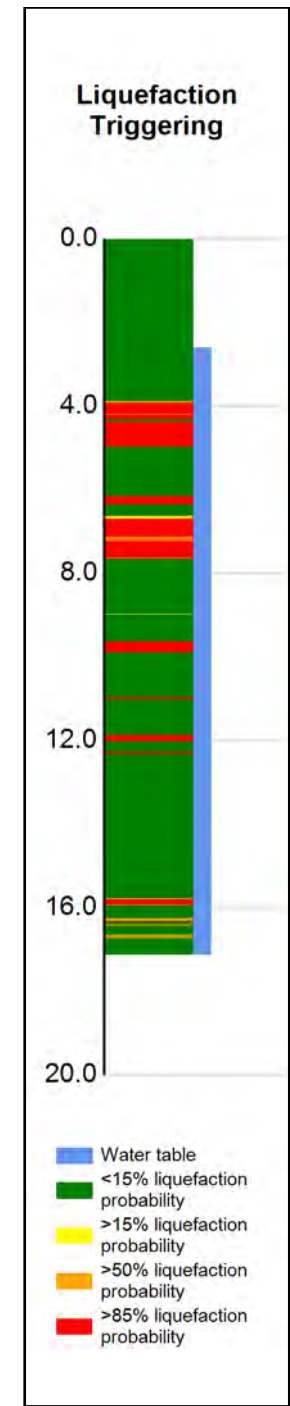
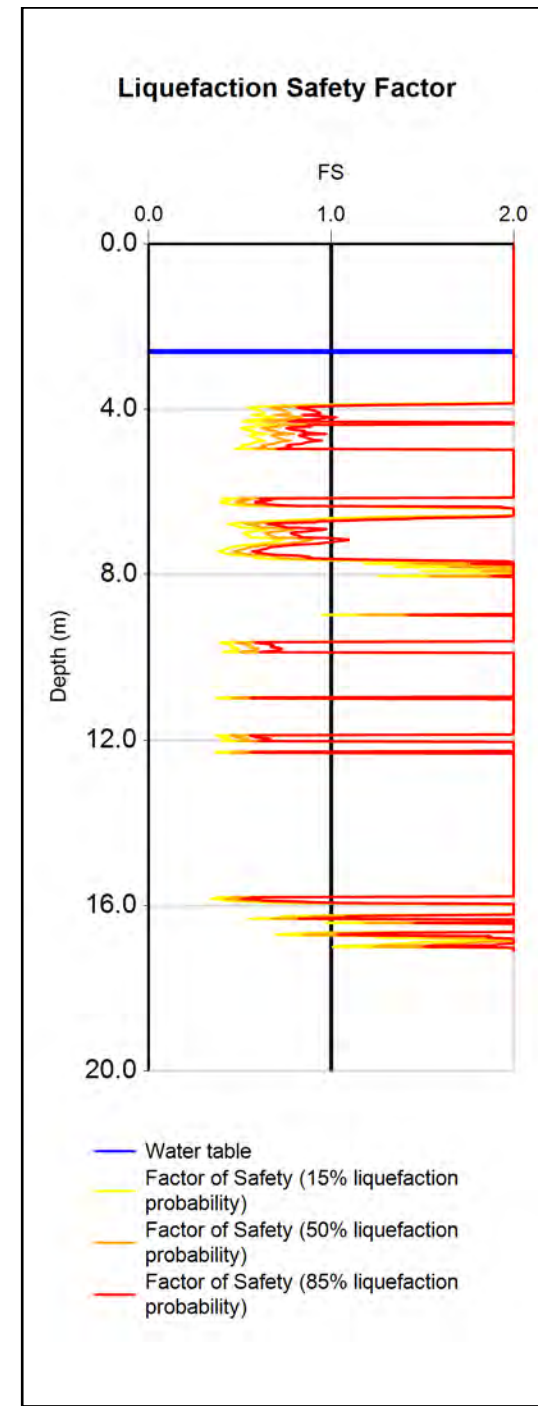
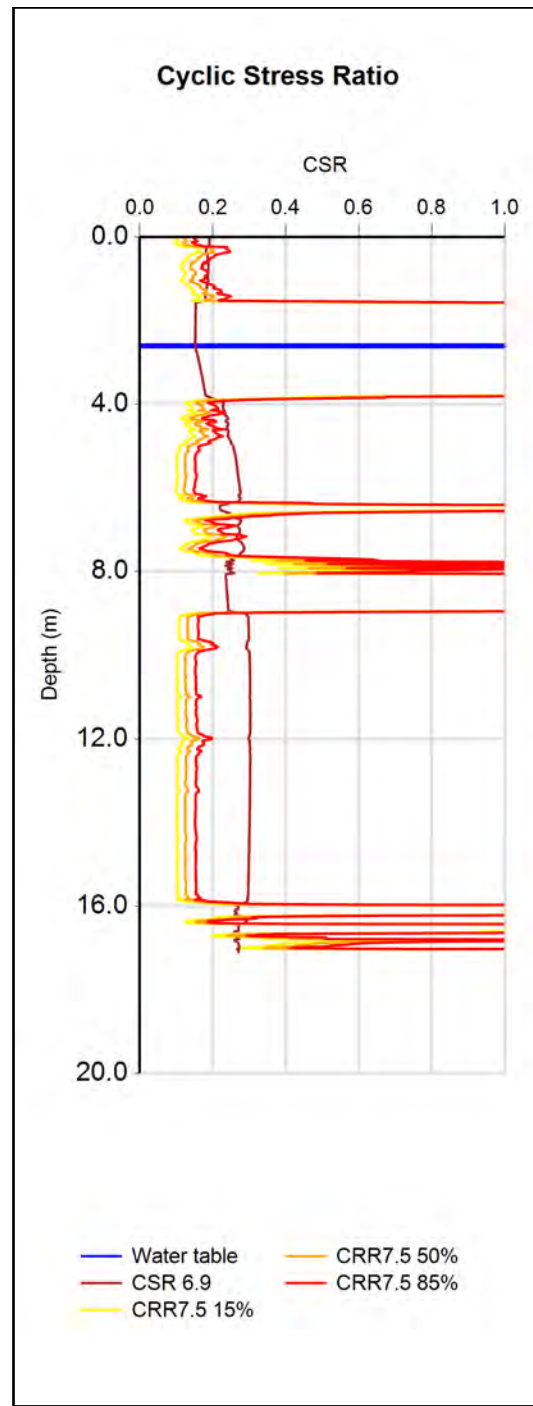
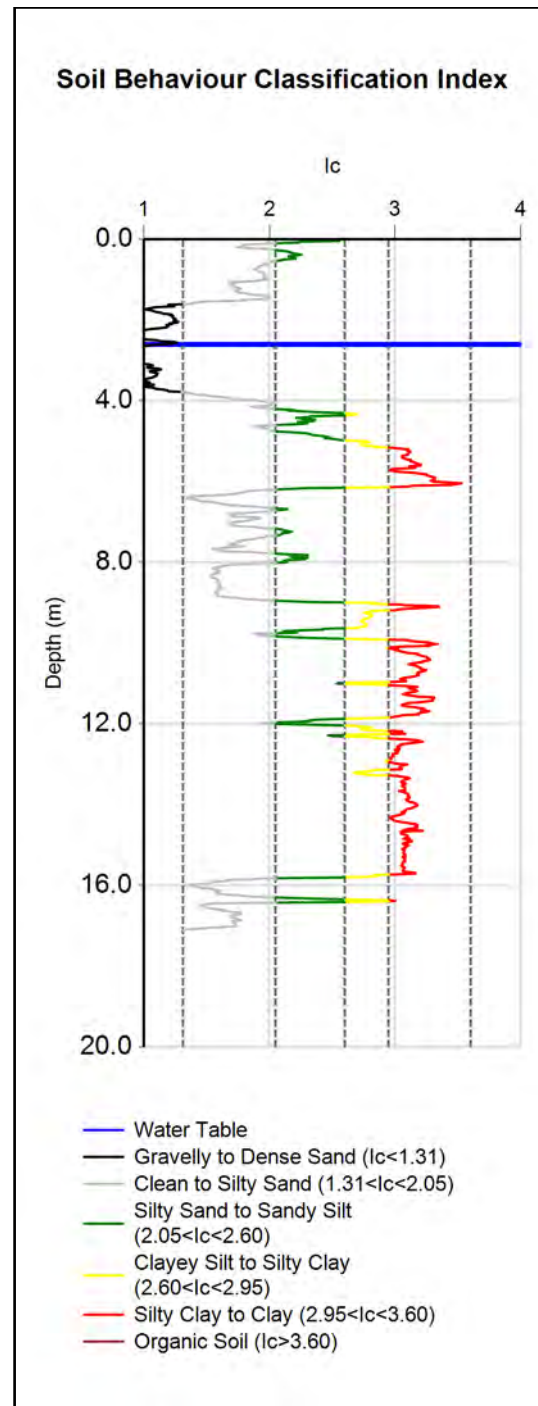
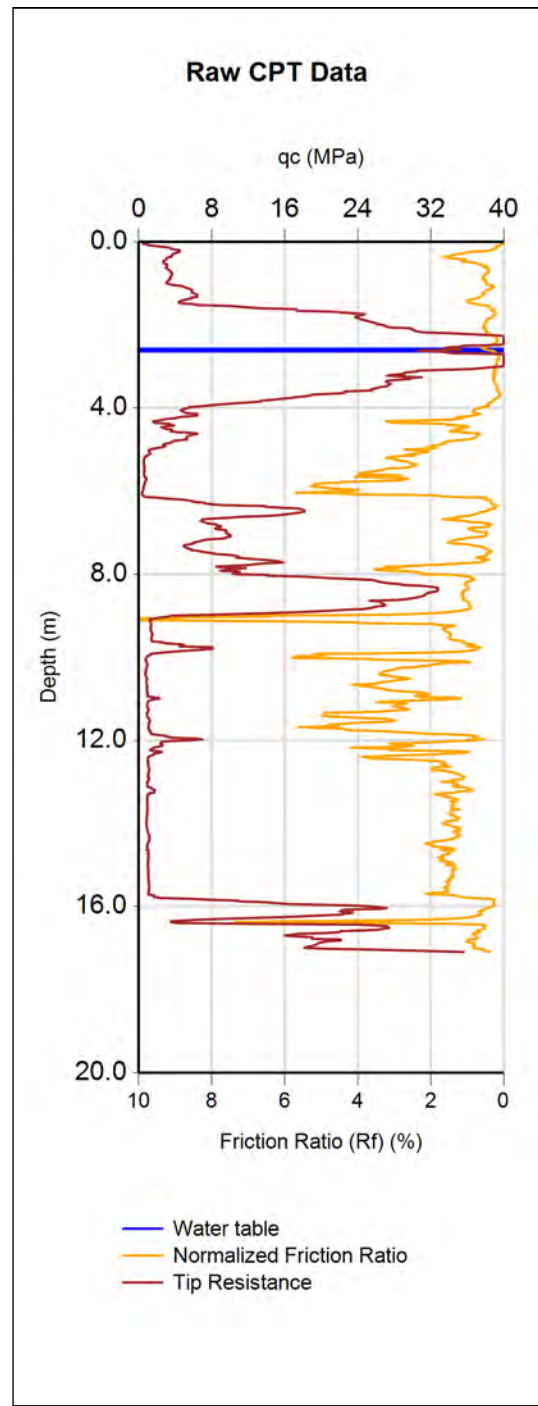


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 <p>Tonkin + Taylor Exceptional thinking together V1.3</p>	<p>CLIENT, PROJECT</p> <p>Hastings District Council Housing Rezone</p>	<p>LOCATION</p> <p>Havelock Road / Howard Street</p>	<p>DATE</p> <p>17/02/2016</p>
	<p>TITLE</p> <p>ULS Liquefaction Assessment CPT 1-4</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>cjc</p>
			<p>CHECKED</p> <p>PAGE</p> <p>6 of 12 pages</p>



(Assumed pre-drill values)

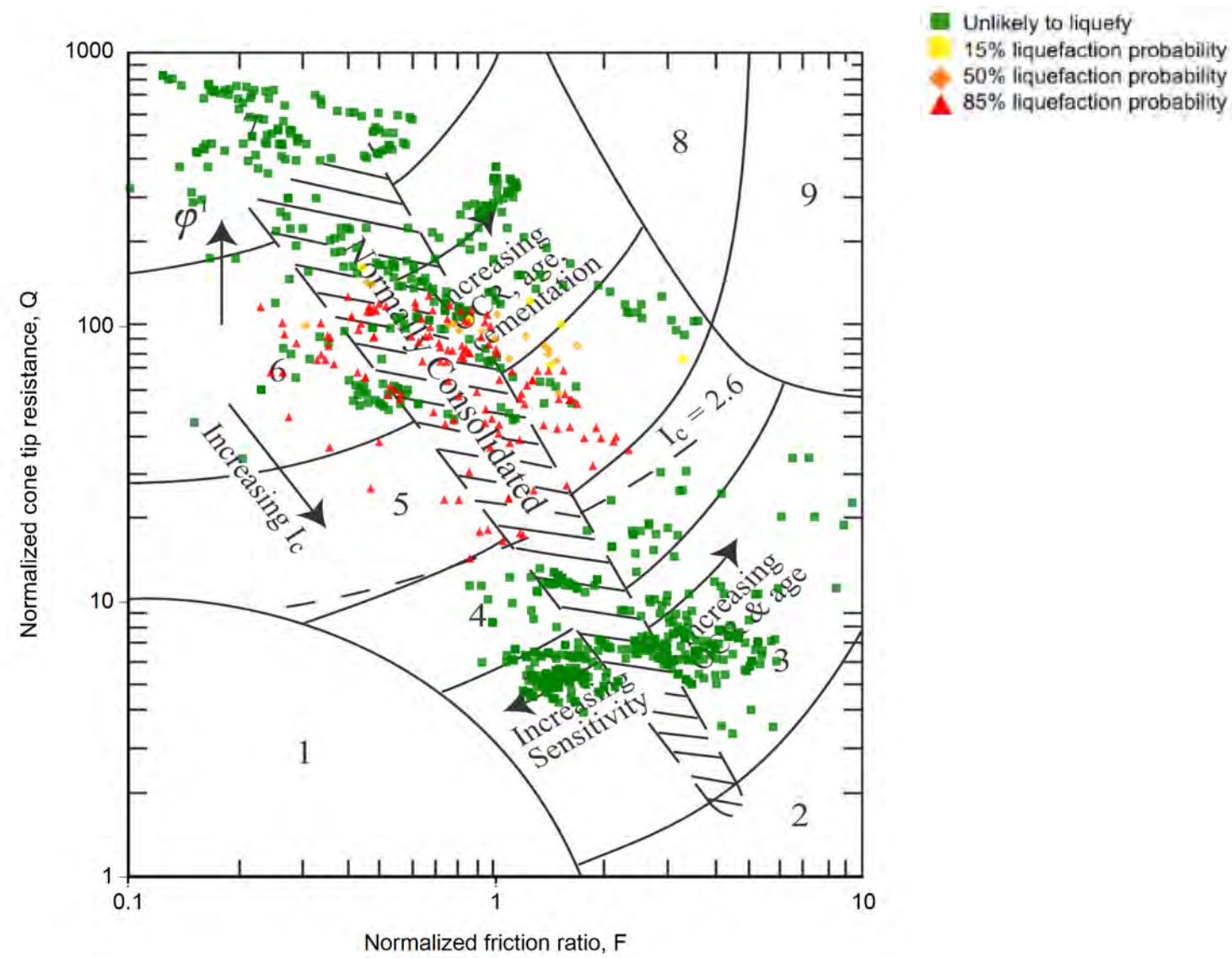
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INPUT	CPT04	60502	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	72	3.1	8	11	4	5						
	50%	68	3	6	10	4	3						
	85%	57	2.6	4	9	4	1						



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CLIENT, PROJECT
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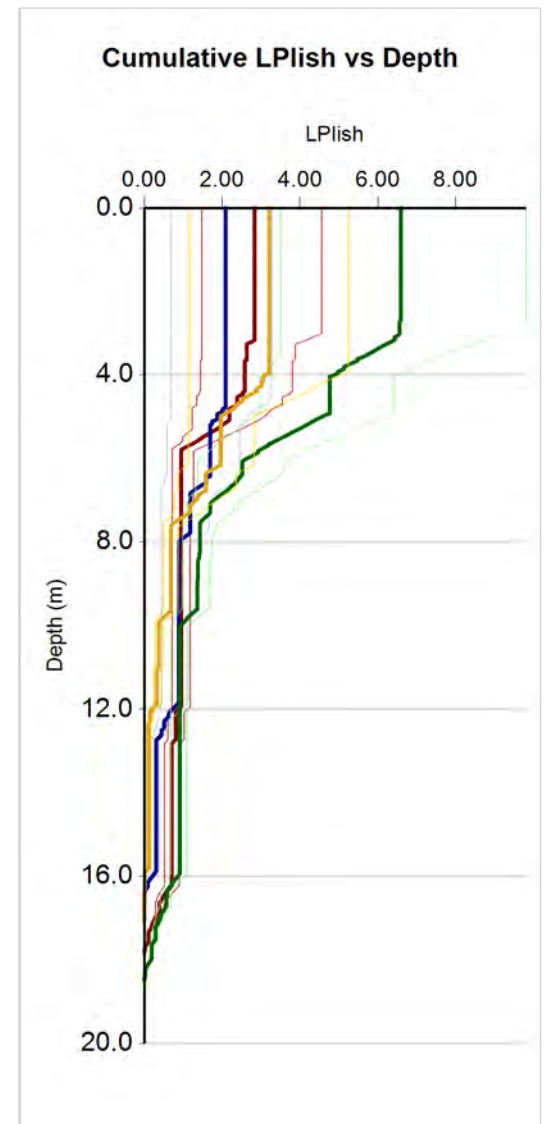
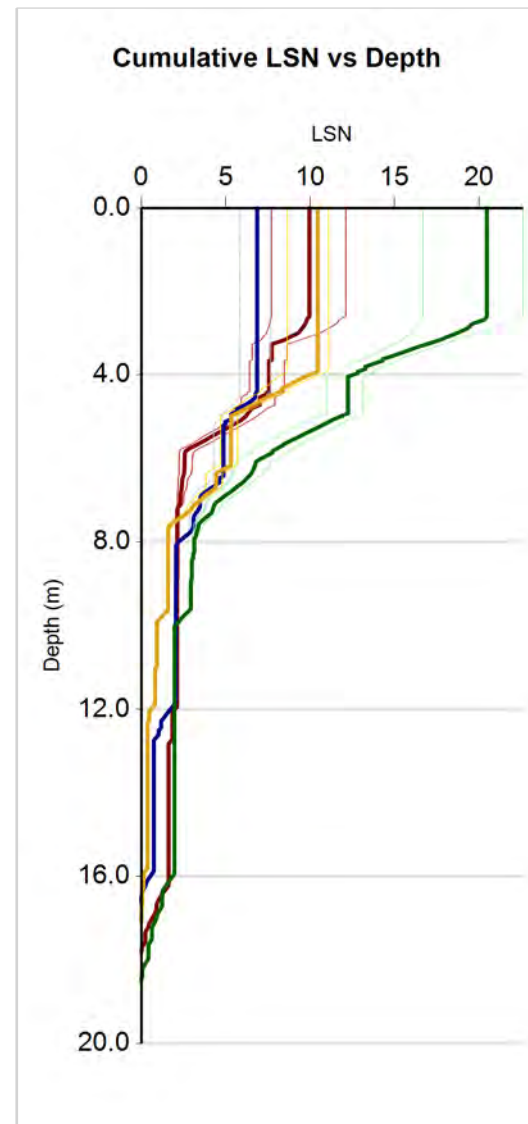
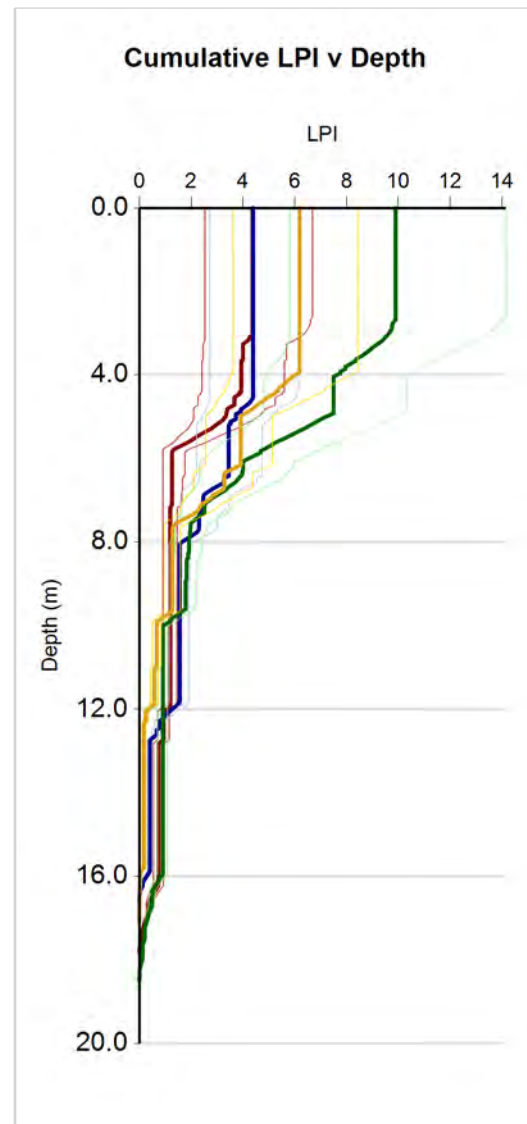
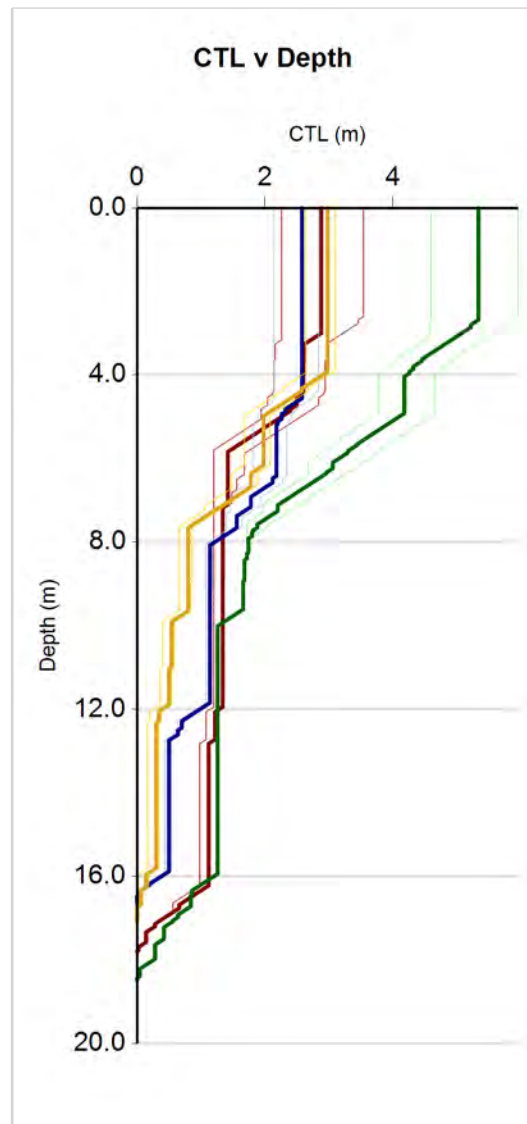
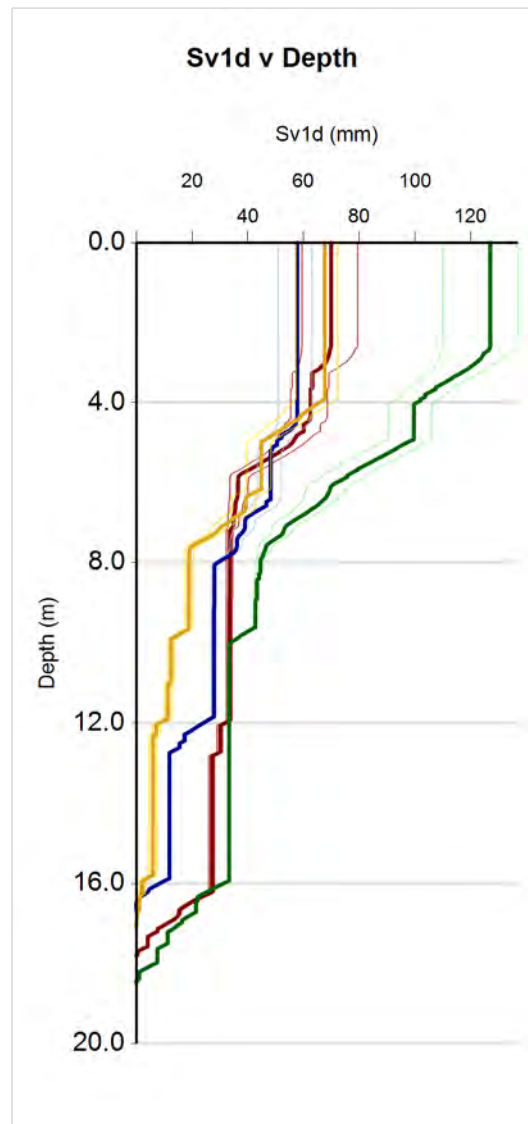


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 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE ULS Liquefaction Assessment CPT 1-4	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT01 - Coordina	60498	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT02	60500	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT03	60501	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT04	60502	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



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CLIENT, PROJECT

Hastings District Council
Housing Rezone

TITLE

ULS Liquefaction Assessment CPT 1-4

LOCATION

Havelock Road /
Howard Street

JOB NUMBER

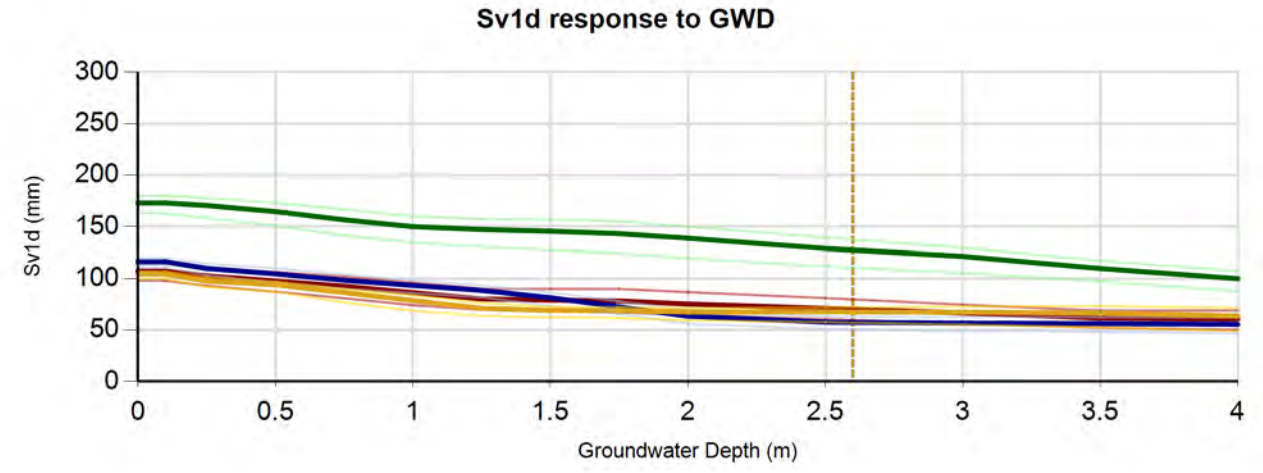
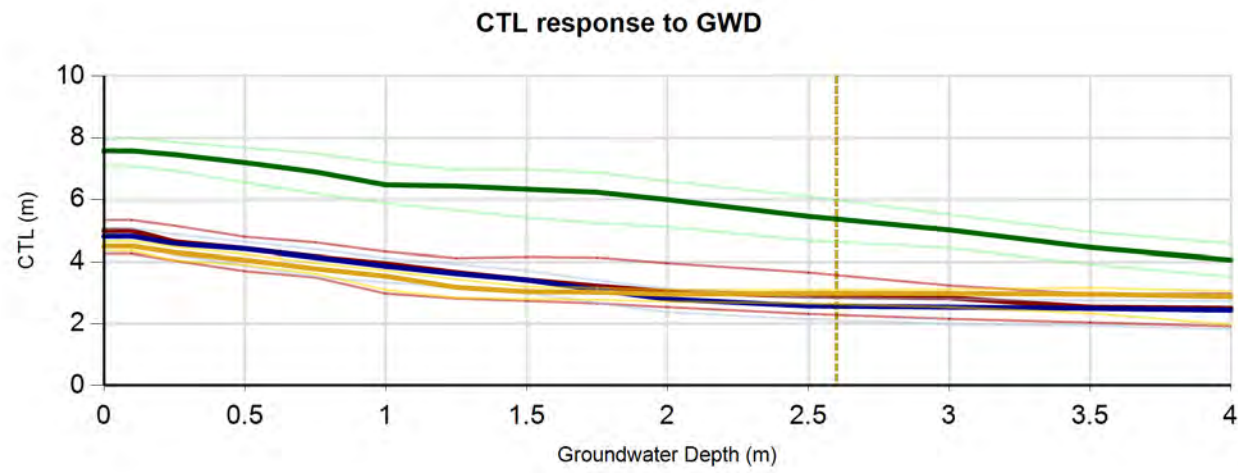
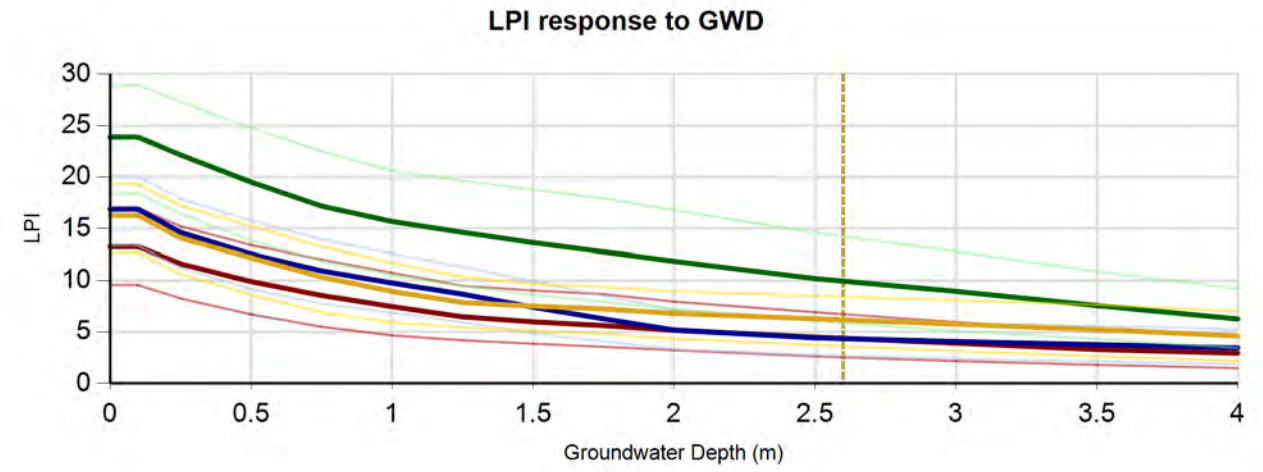
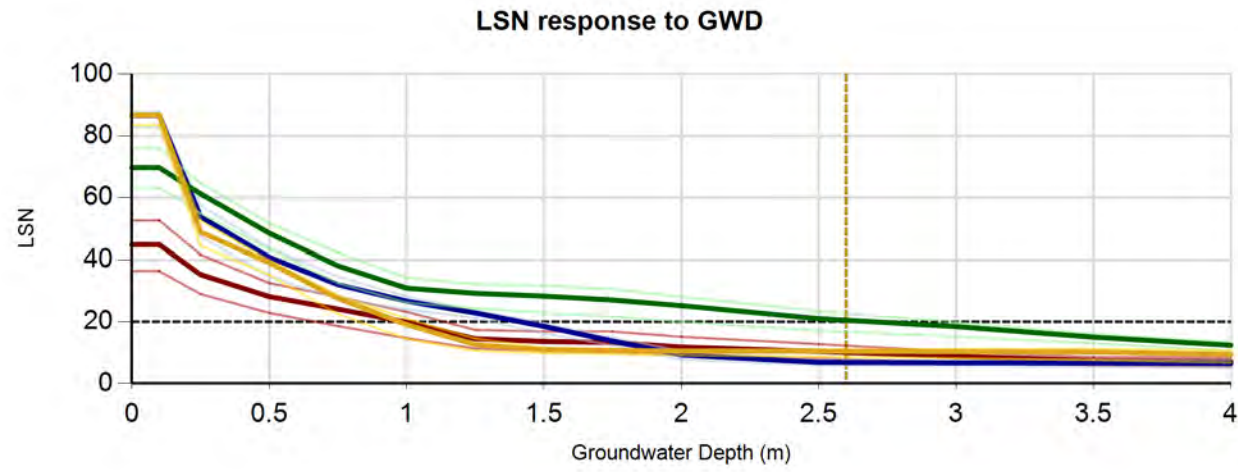
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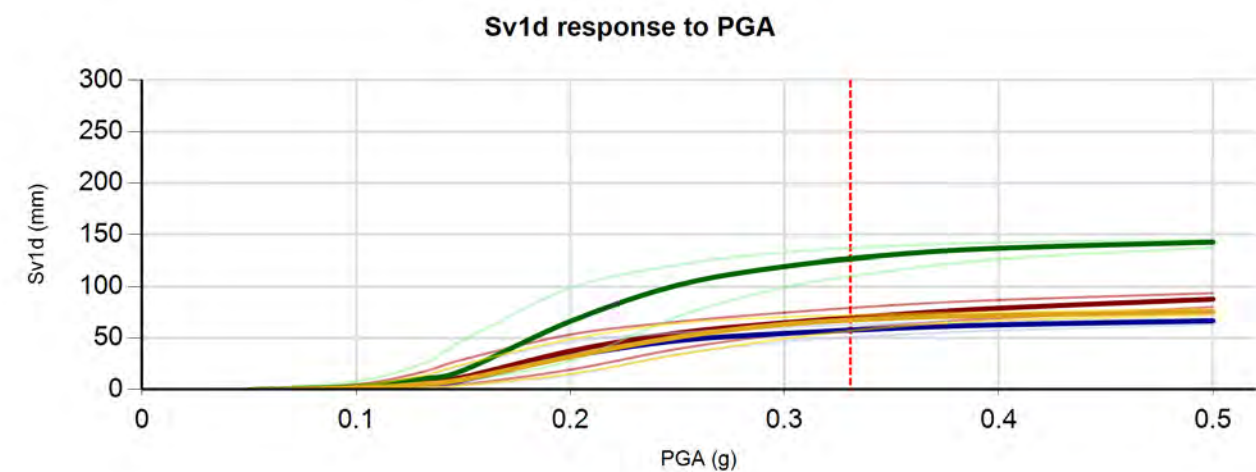
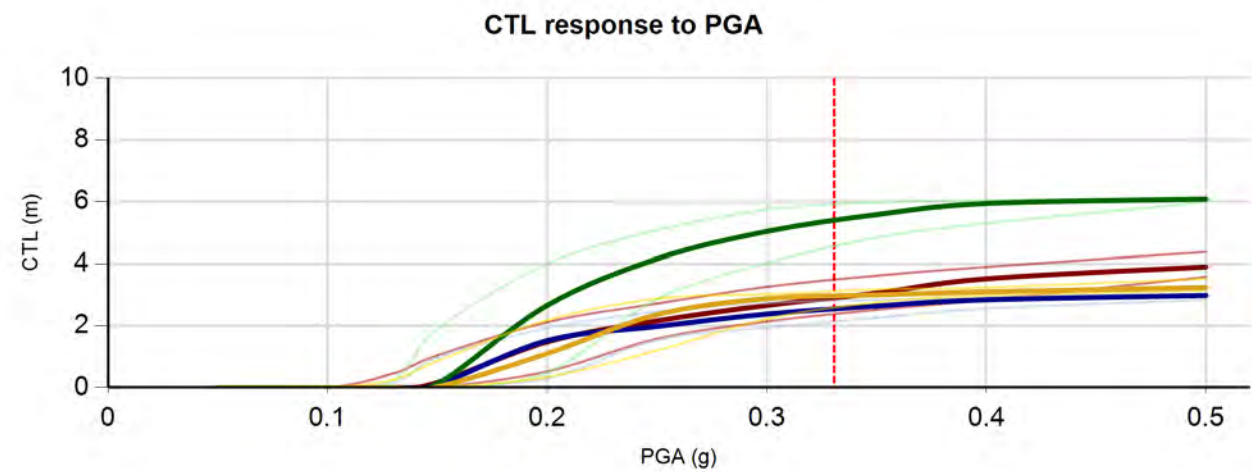
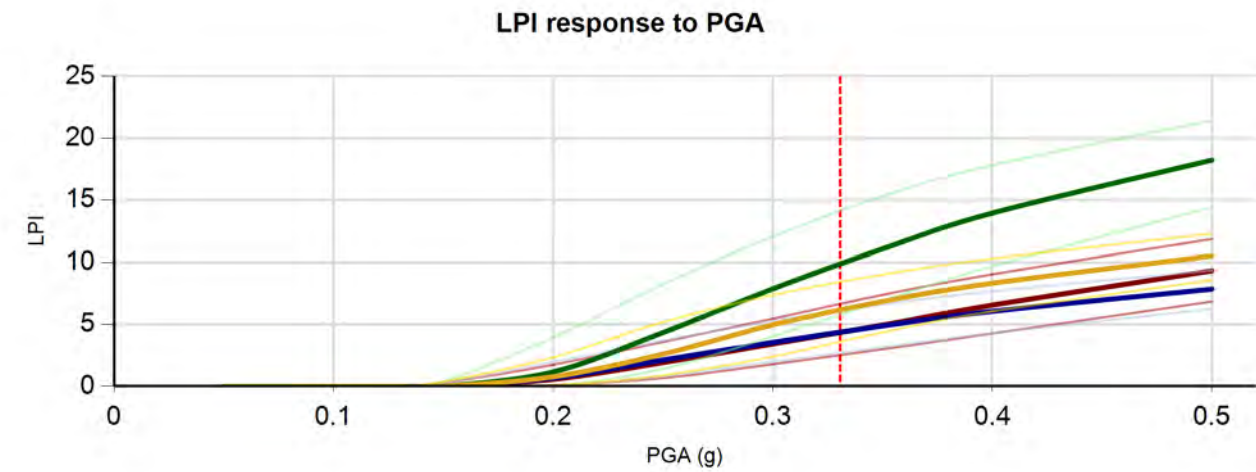
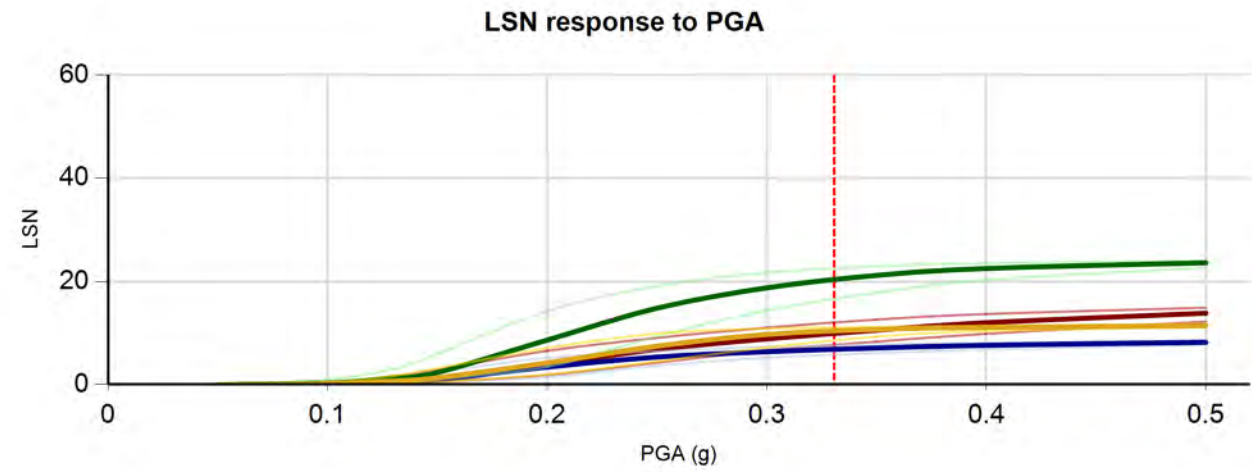
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Vertical dotted line/s indicate user specified GWD at the CPT locations. (actual GWD)

											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT01 - Coordina	60498	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT02	60500	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT03	60501	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT04	60502	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

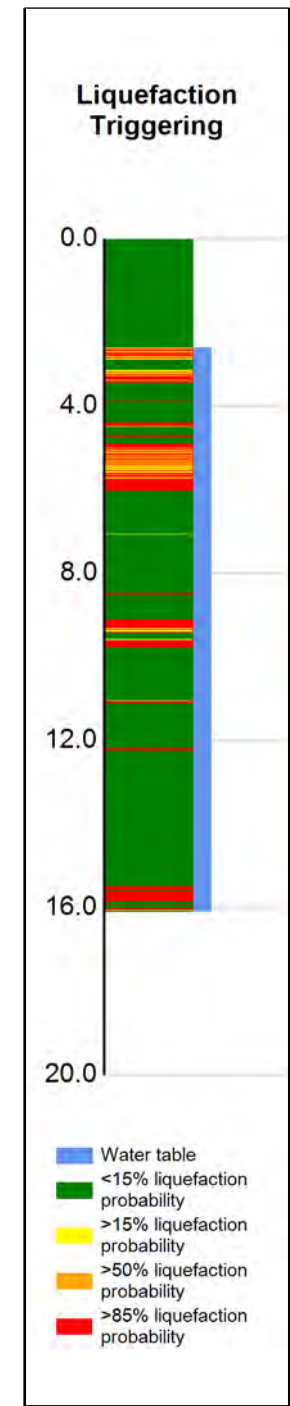
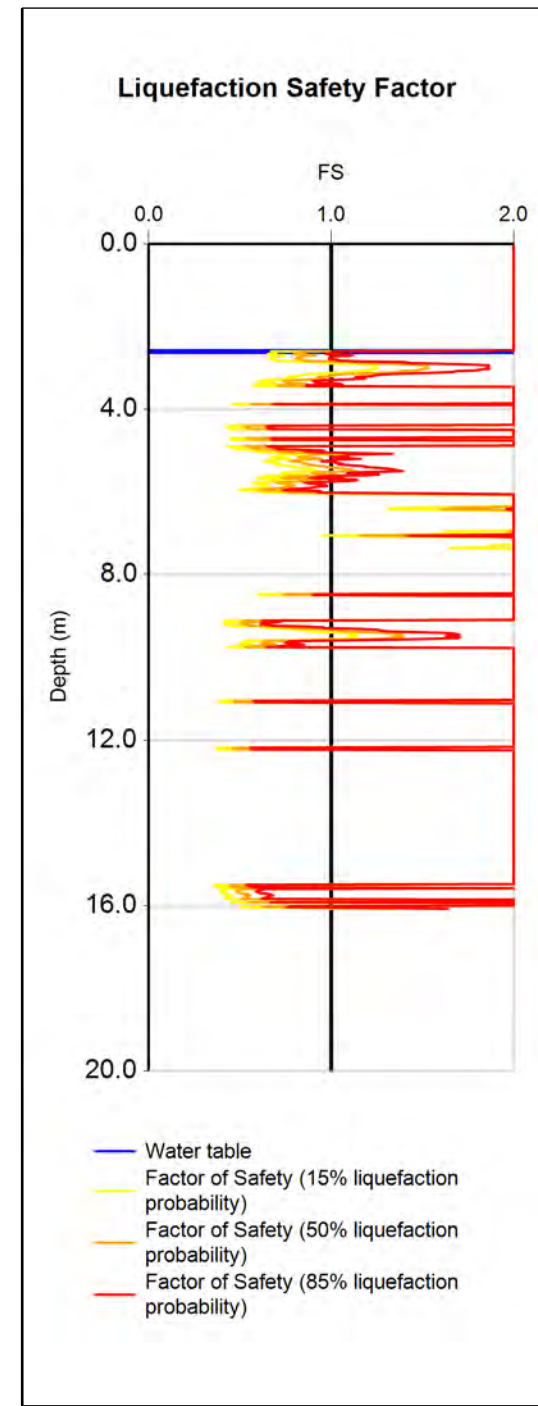
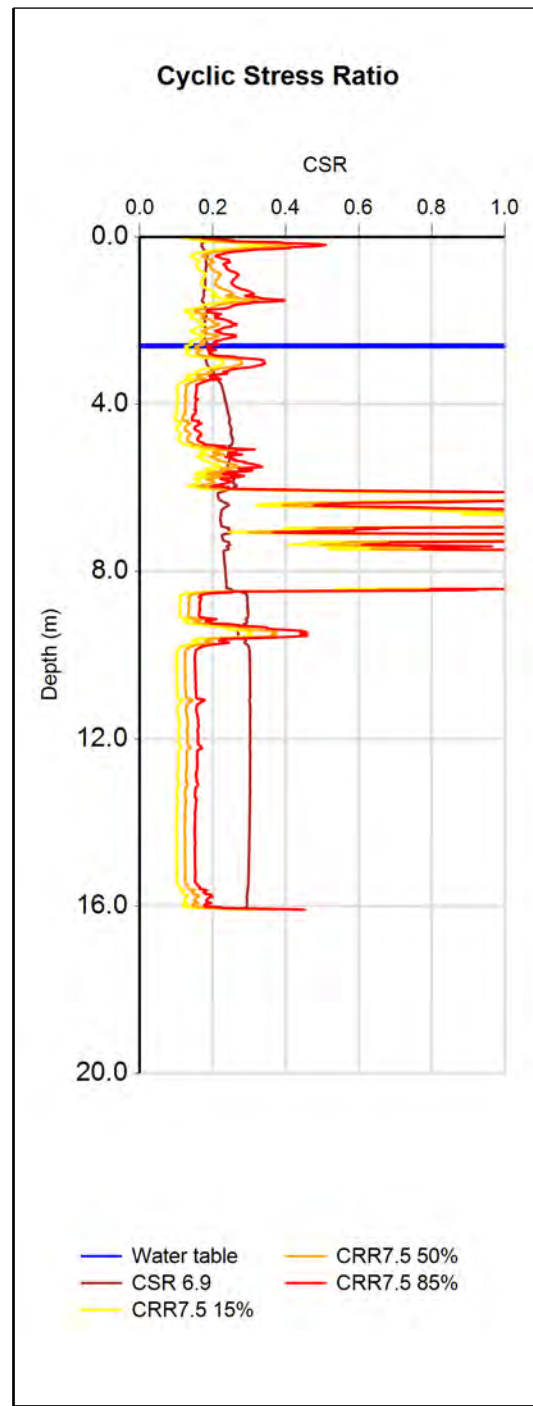
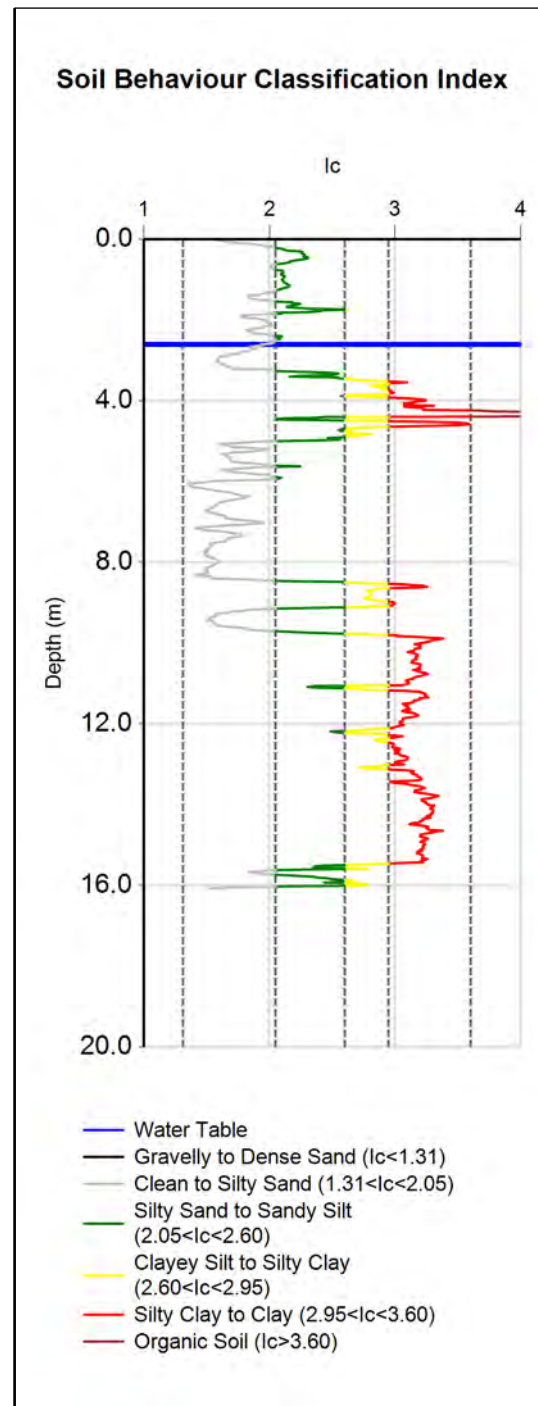
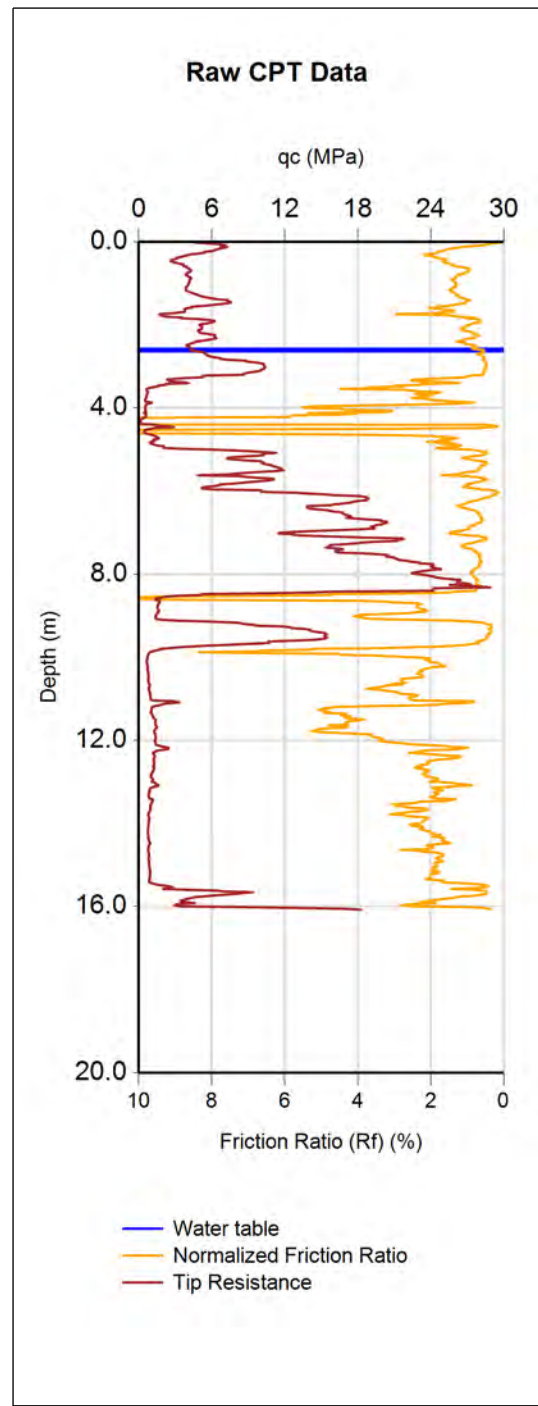
											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT01 - Coordina	60498	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT02	60500	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT03	60501	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT04	60502	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60498	60500	60501	60502
CPT Name	CPT01 - Coordinates	CPT02	CPT03	CPT04
PGA	0.33078g	0.33078g	0.33078g	0.33078g
Magnitude	6.9	6.9	6.9	6.9
Depth to groundwater	2.6m	2.6m	2.6m	2.6m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	17.82m	16.66m	18.5m	17.1m
Maximum depth of analysis	17.82m	16.66m	18.5m	17.1m
RL	n/a	n/a	n/a	n/a



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT05	60503	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	67	3	7	12	2.7	5						
	50%	57	2.6	4	10	2.7	2						
	85%	44	1.8	2	7	3.3	1						

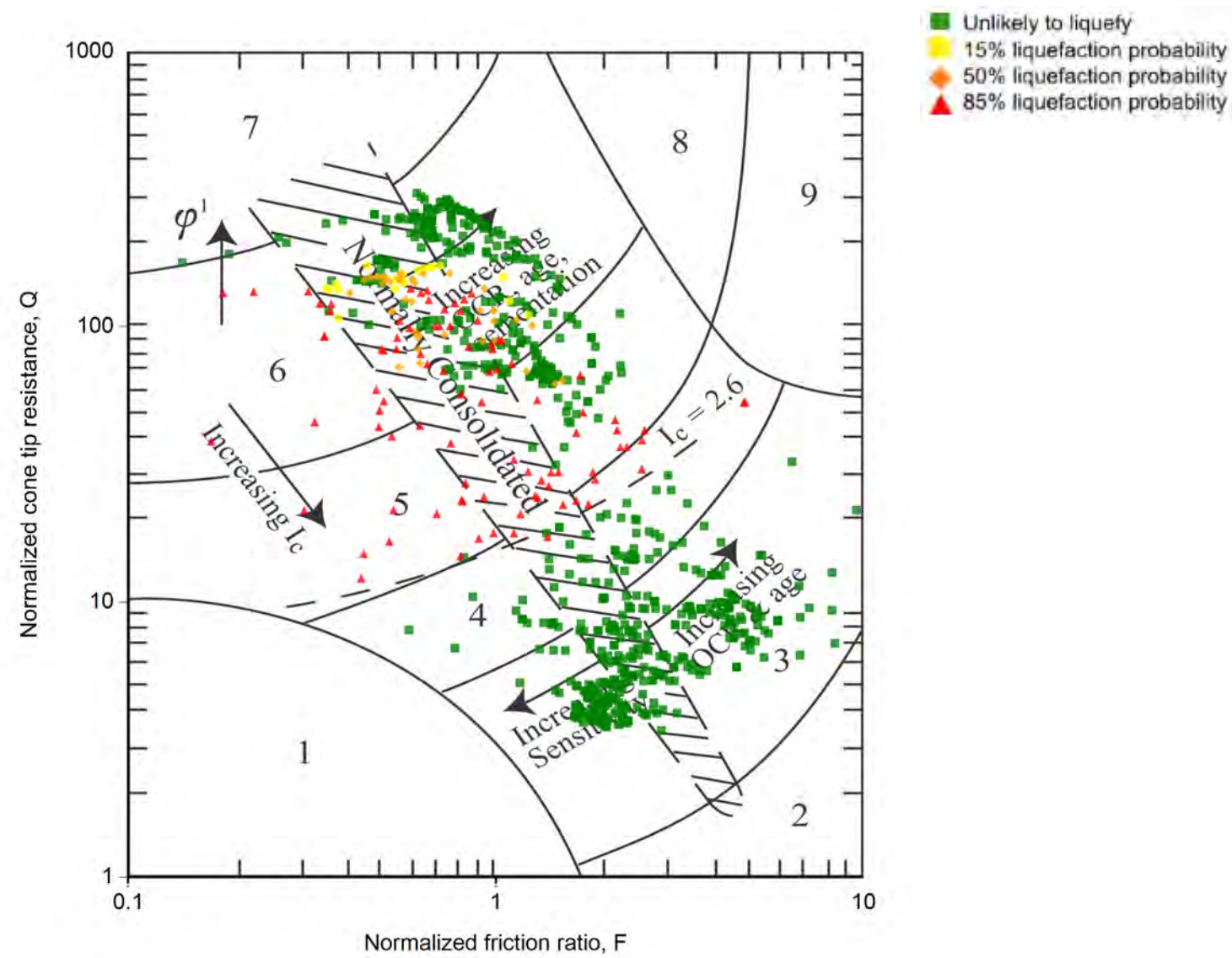


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CLIENT, PROJECT
Hastings District Council
Housing Rezone
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ULS Liquefaction Assessment CPT 5-8

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|--|-------------------------------------|
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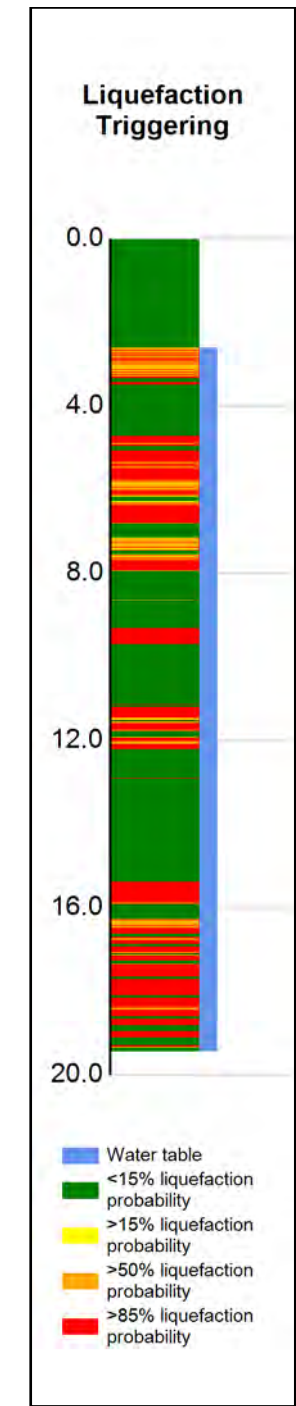
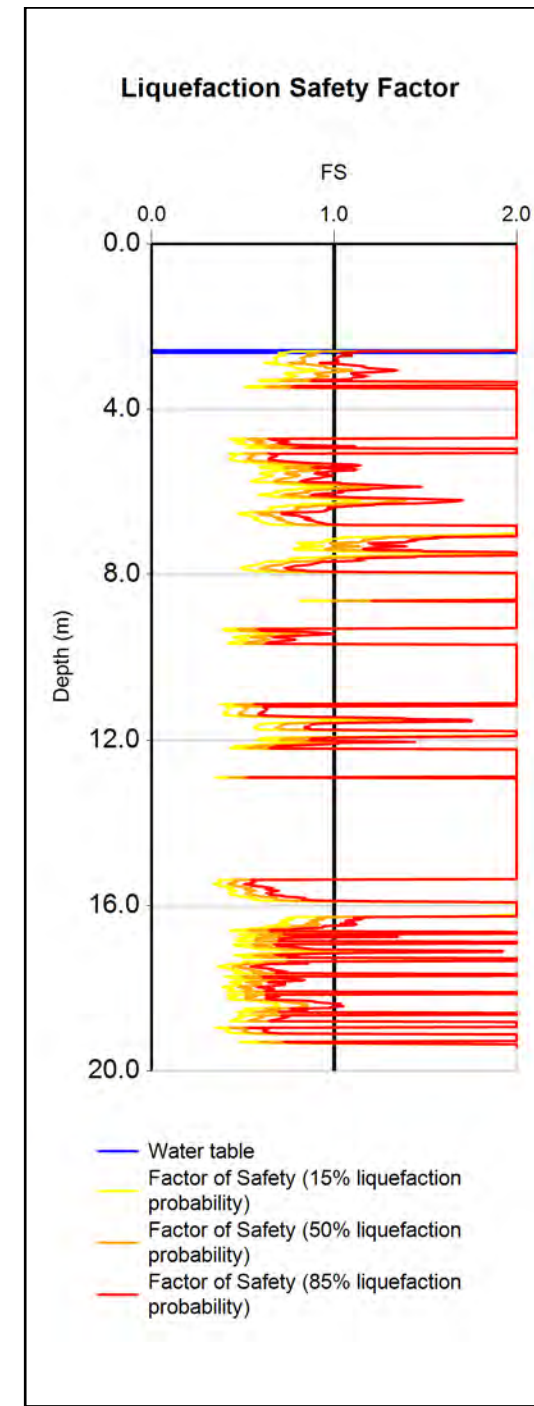
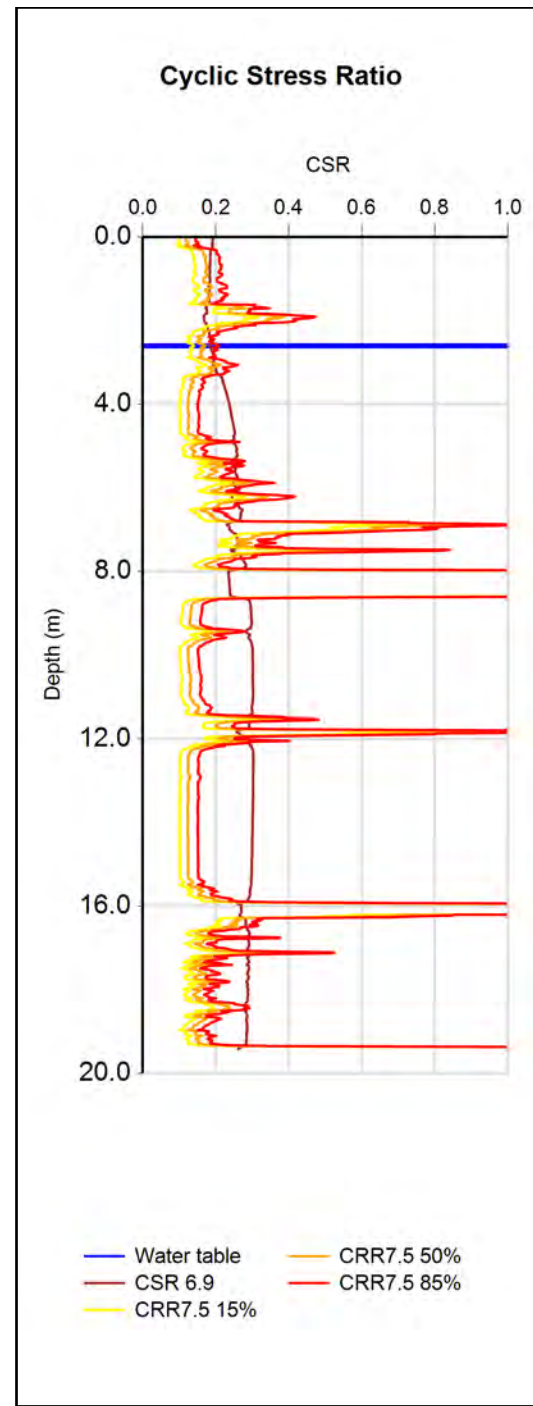
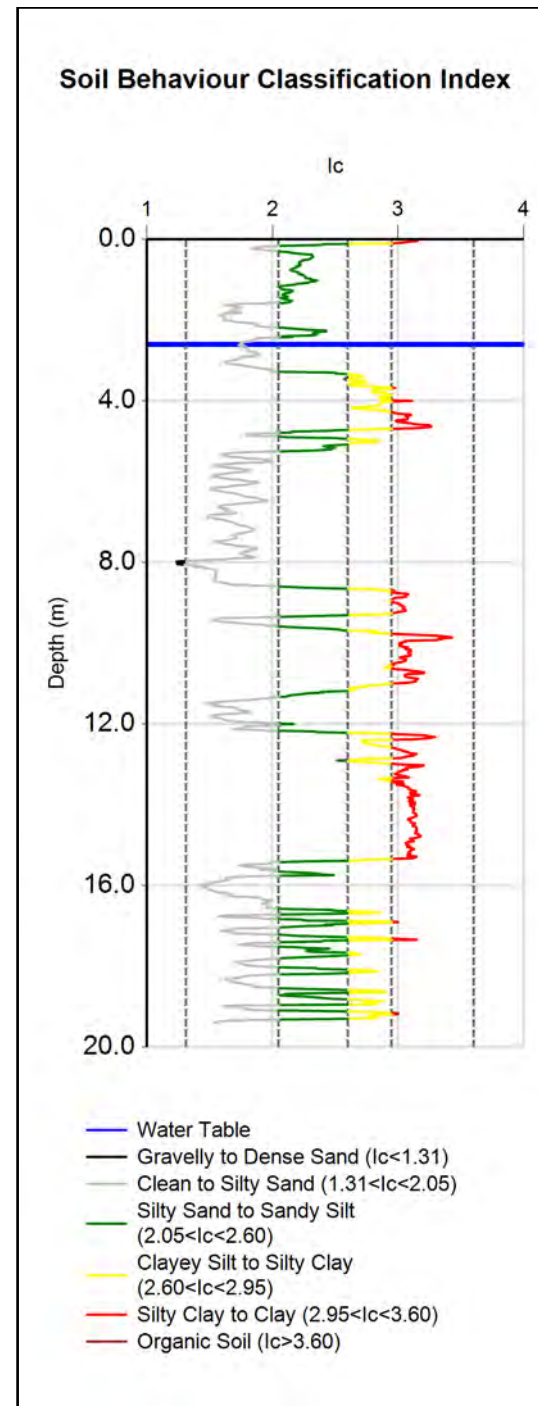
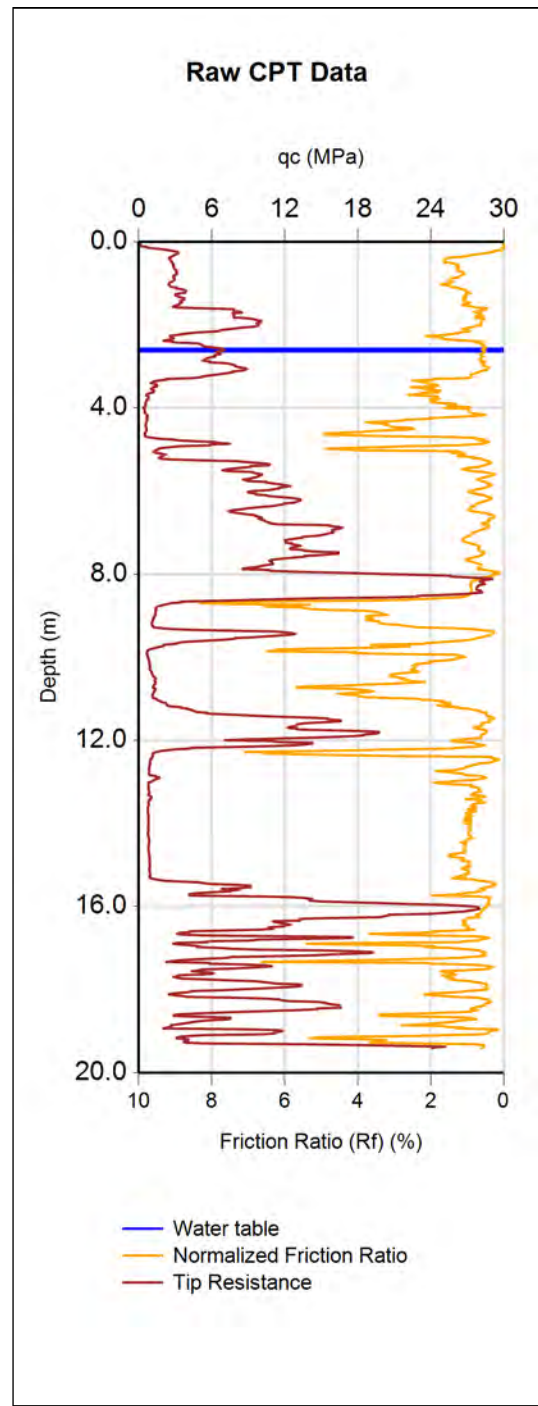
CPT-based soil behavior type classification chart by Robertson (1990)



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	ULS Liquefaction Assessment CPT 5-8

LOCATION	Havelock Road / Howard Street	DATE	17/02/2016
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(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT06	60504	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	160	7.5	12	21	2.7	9						
	50%	143	6.8	8	17	2.7	5						
	85%	117	5.2	4	13	3.3	2						



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LOCATION
Havelock Road / Howard Street

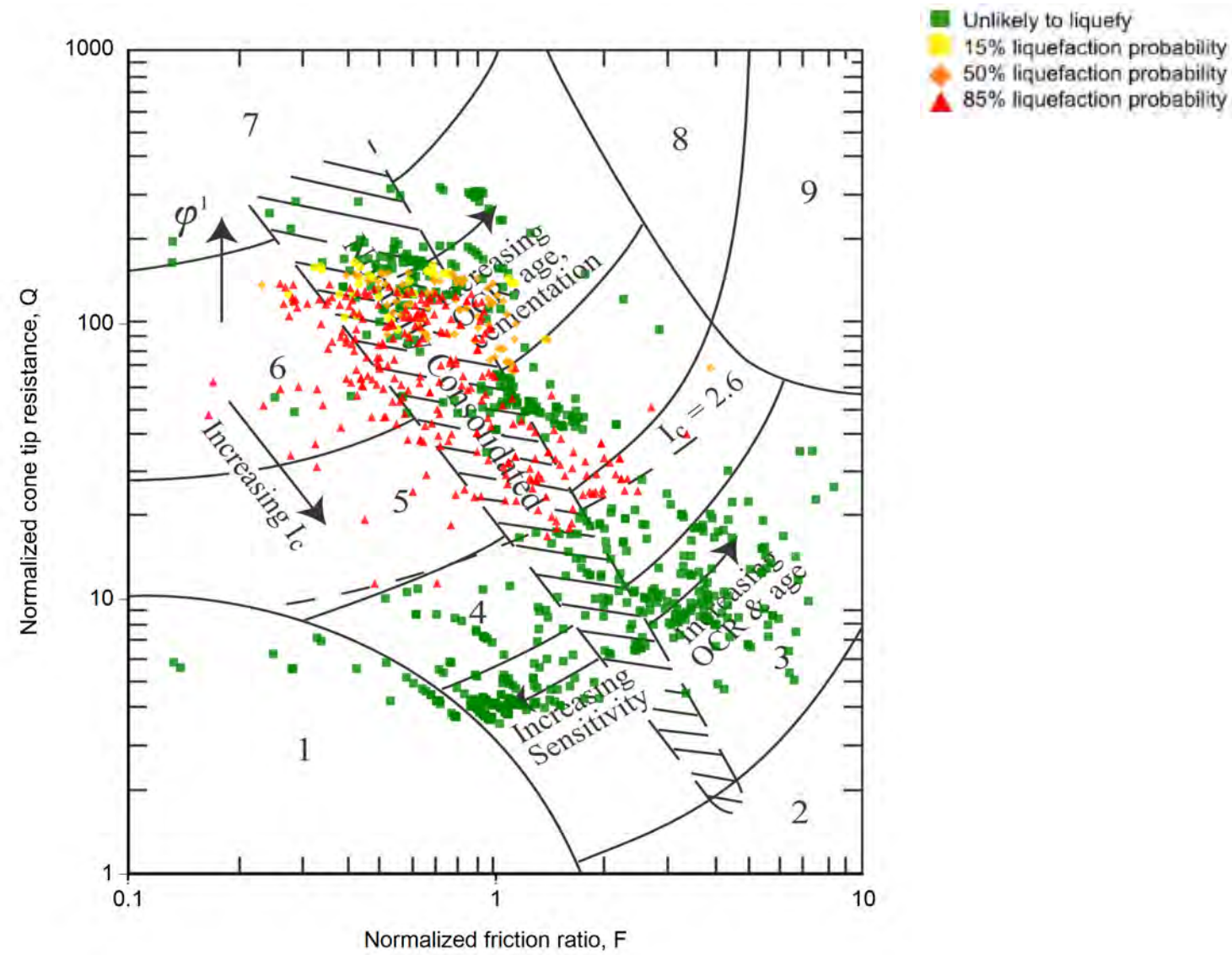
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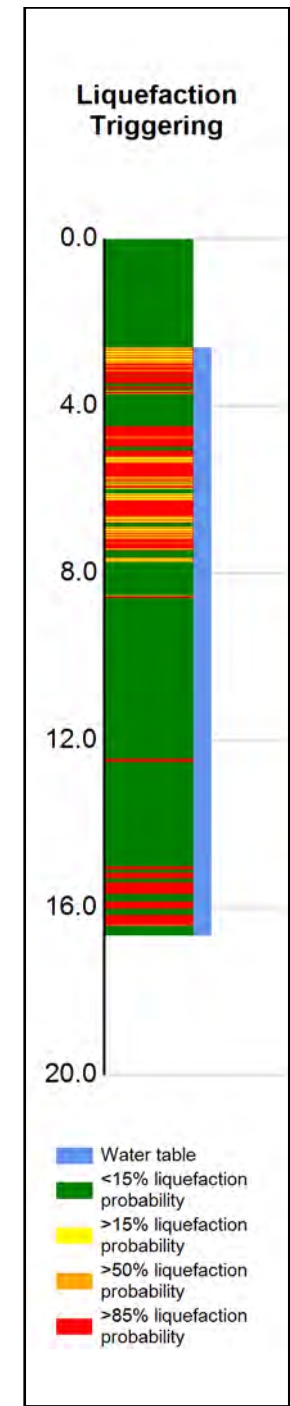
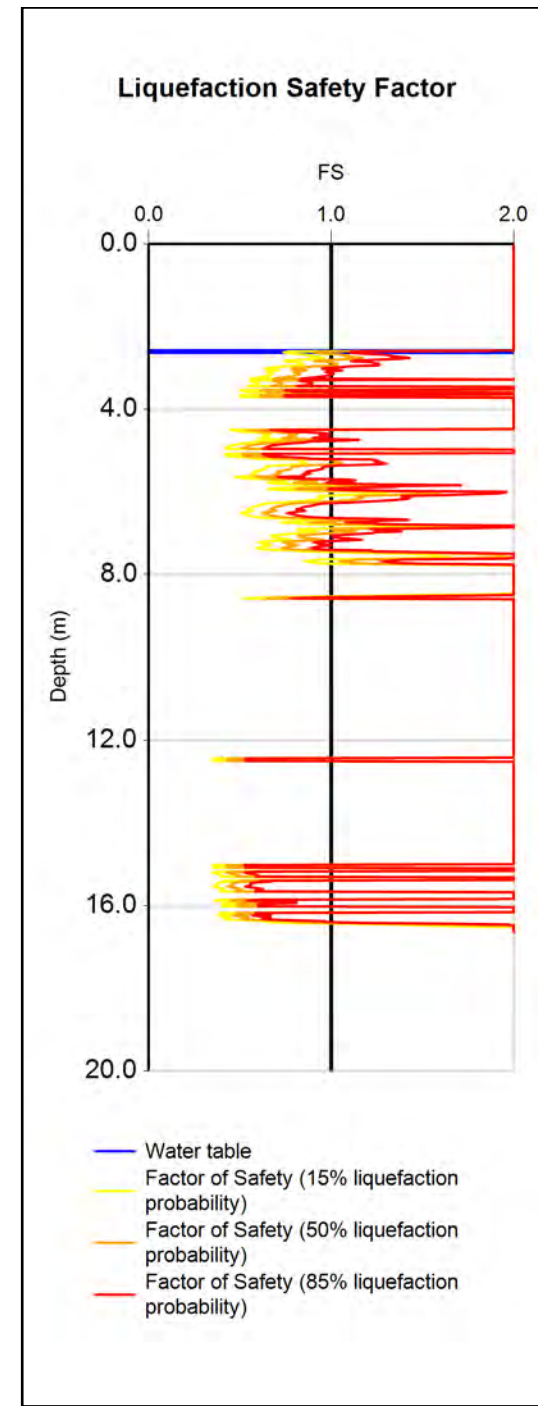
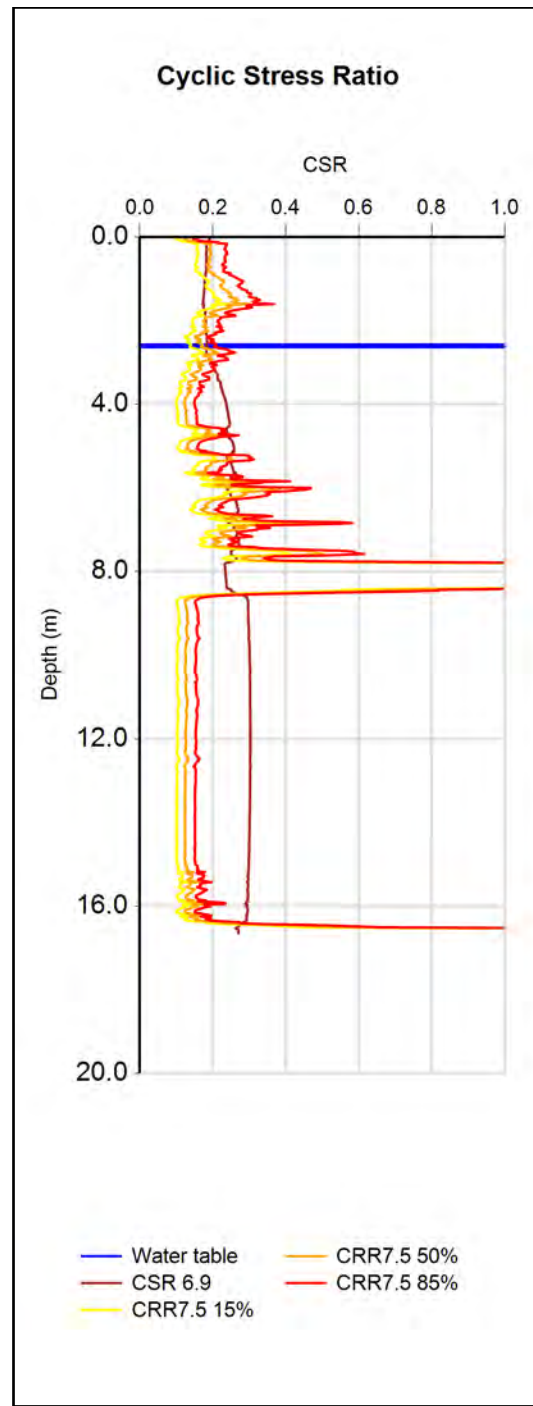
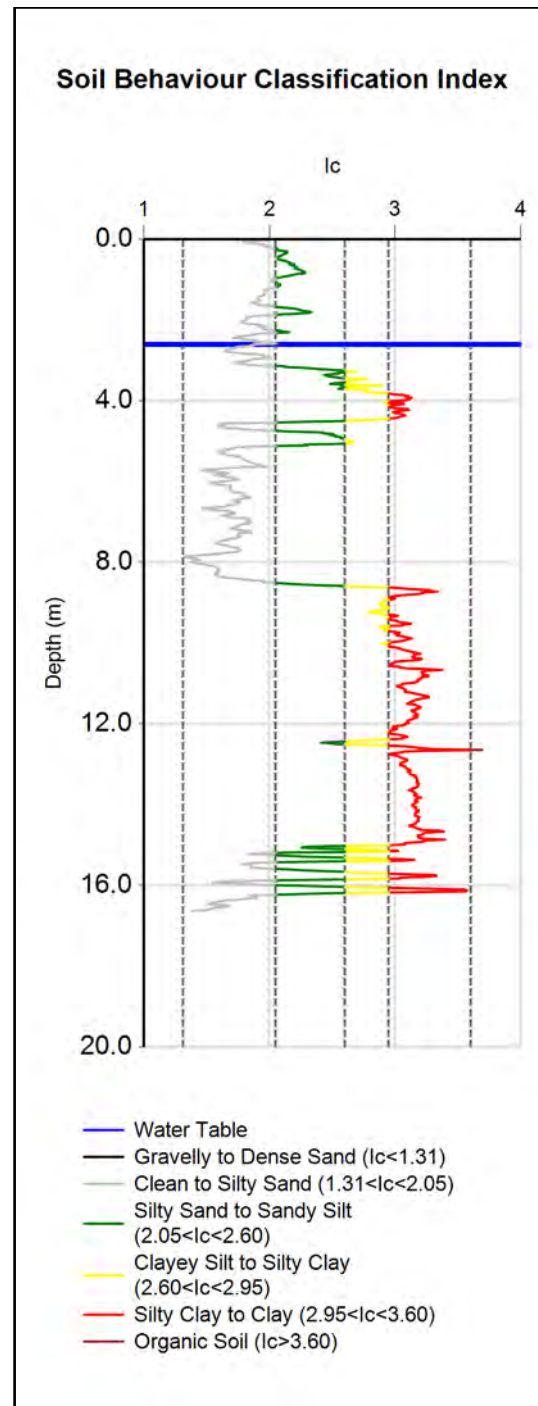
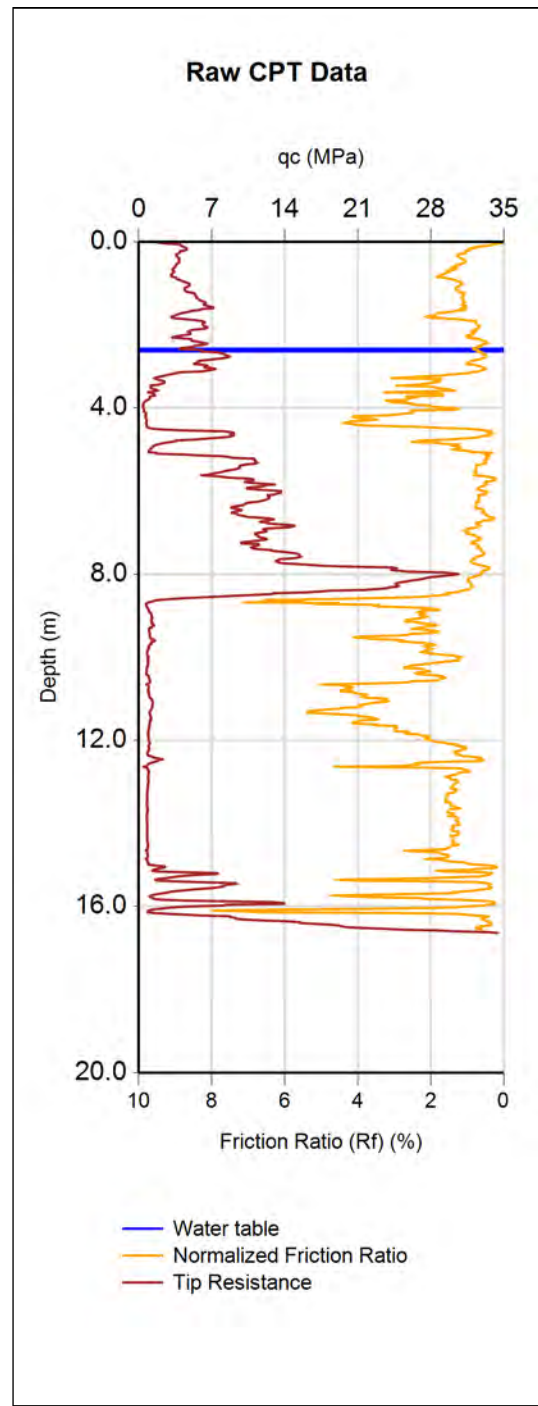


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CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
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(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT07	60505	10/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	102	4.8	10	18	2.7	7						
	50%	88	3.9	6	15	2.8	4						
	85%	69	3	3	11	3.1	1						



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CLIENT, PROJECT
Hastings District Council
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TITLE
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LOCATION
Havelock Road / Howard Street

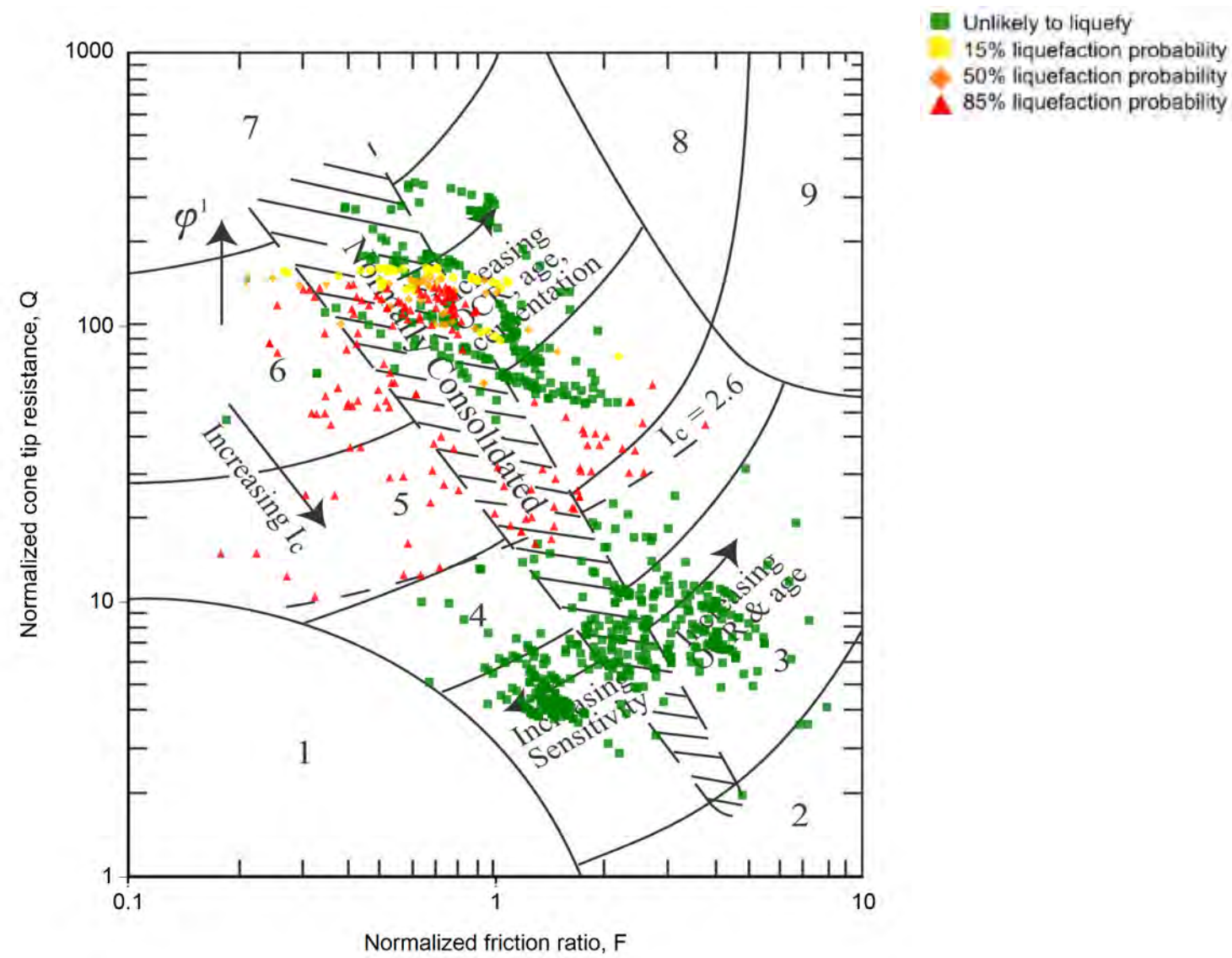
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17/02/2016

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cjc

JOB NUMBER
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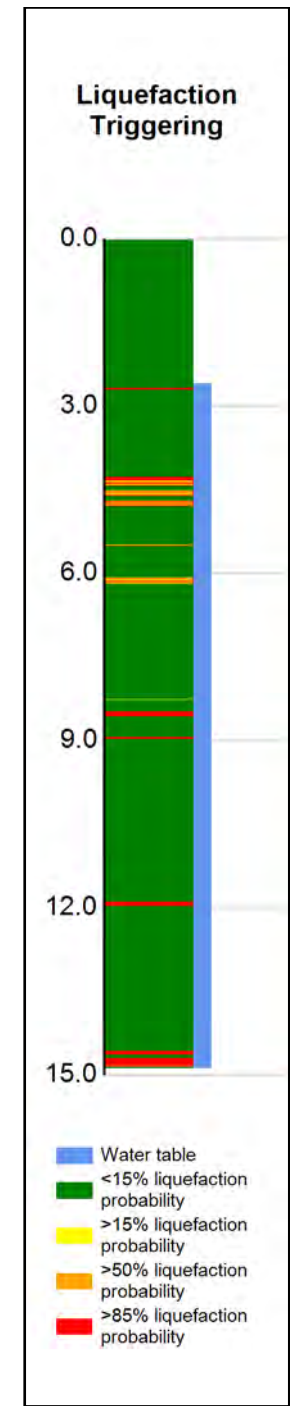
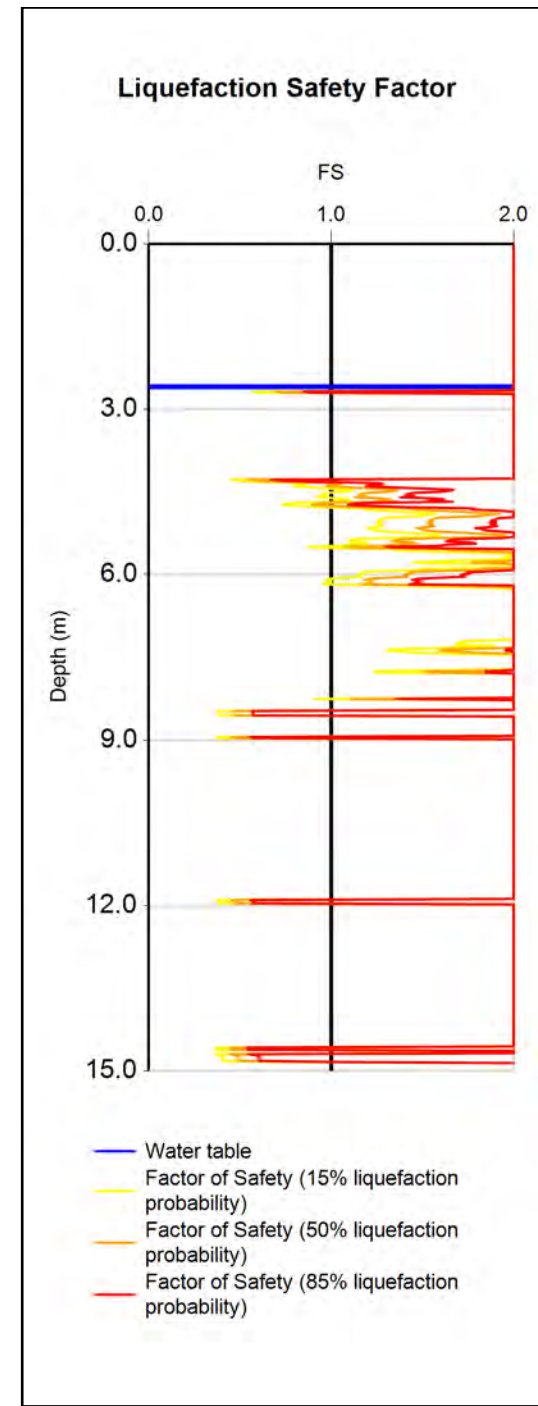
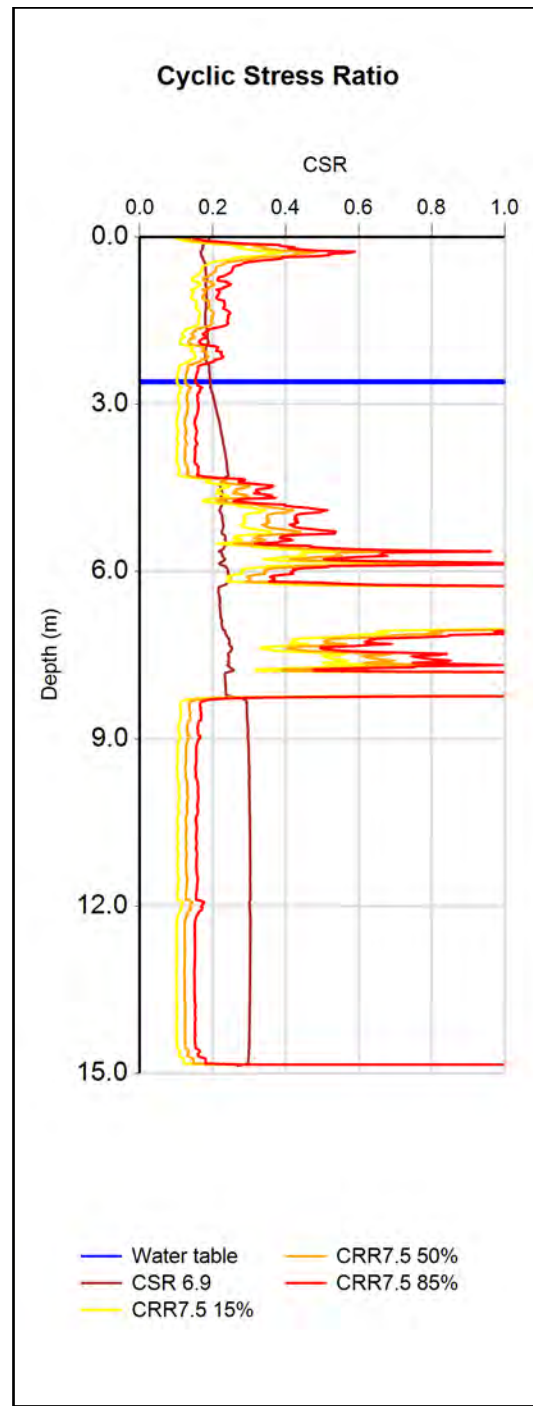
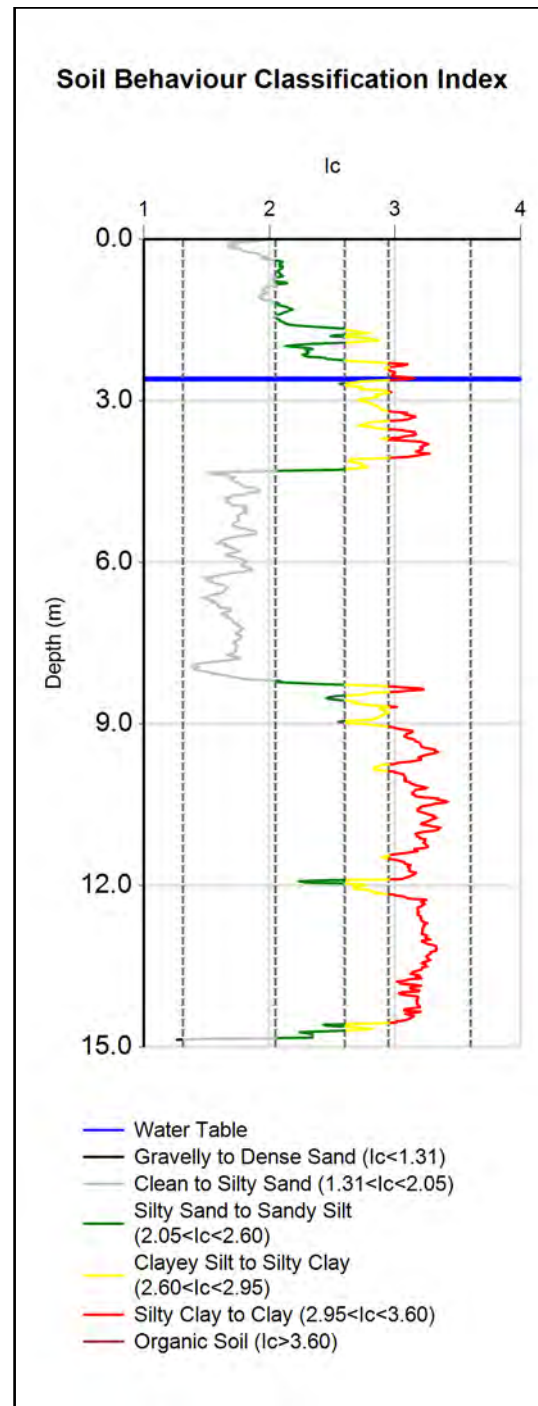
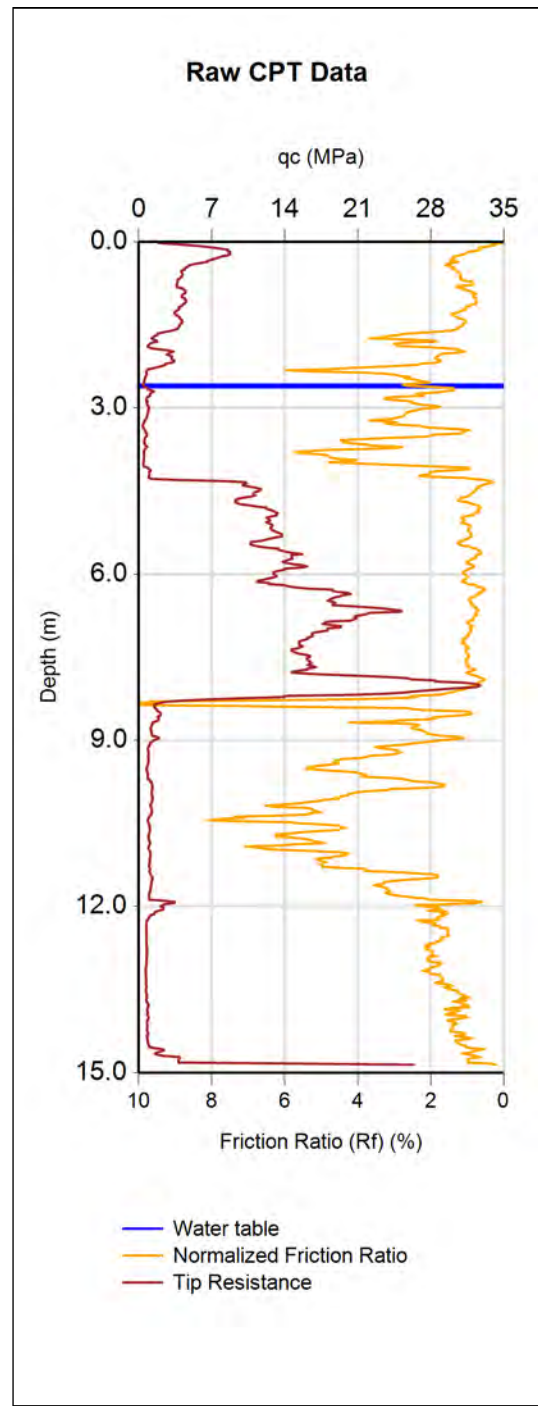


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CPT-based soil behavior type classification chart by Robertson (1990)

 <p>Tonkin + Taylor Exceptional thinking together V1.3</p>	<p>CLIENT, PROJECT</p> <p>Hastings District Council Housing Rezone</p>	<p>LOCATION</p> <p>Havelock Road / Howard Street</p>	<p>DATE</p> <p>17/02/2016</p>
	<p>TITLE</p> <p>ULS Liquefaction Assessment CPT 5-8</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>cjc</p>



(Assumed pre-drill values)

INPUT	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
	CPT08	60506	10/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	24	1	2	4	4.3	1						
	50%	19	0.6	1	3	4.3	1						
	85%	16	0.5	1	2	4.3	0						



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LOCATION
Havelock Road / Howard Street

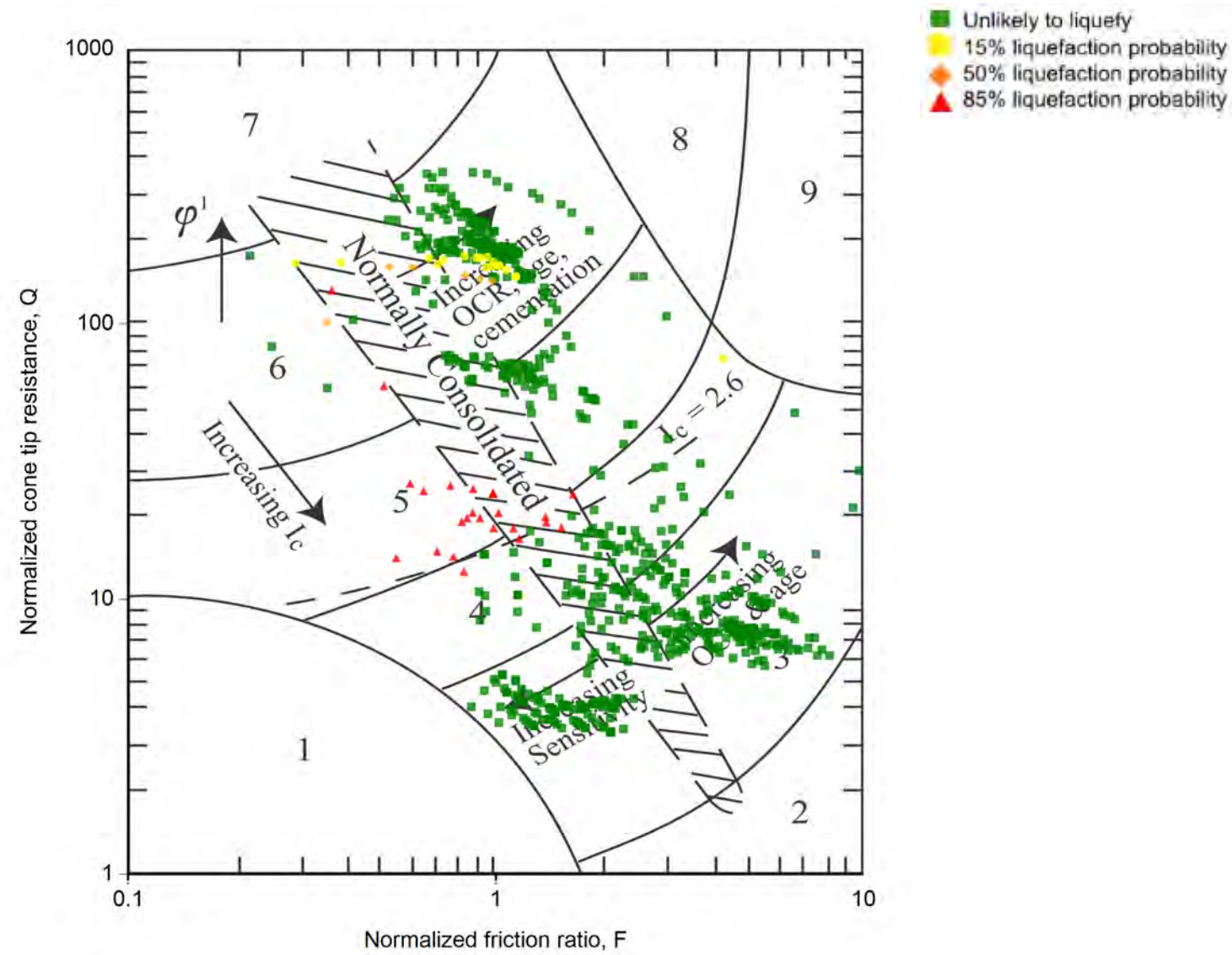
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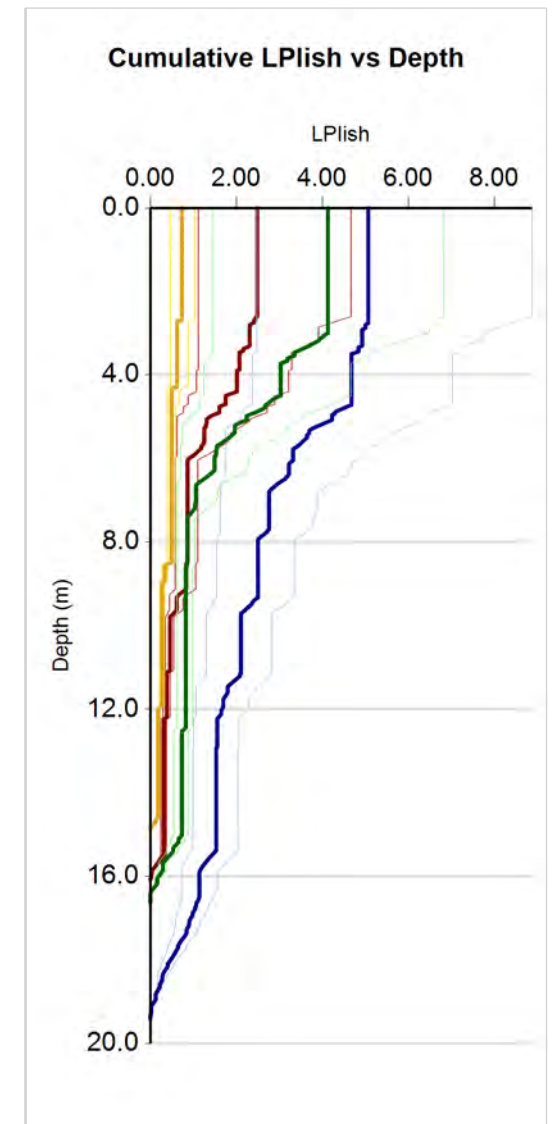
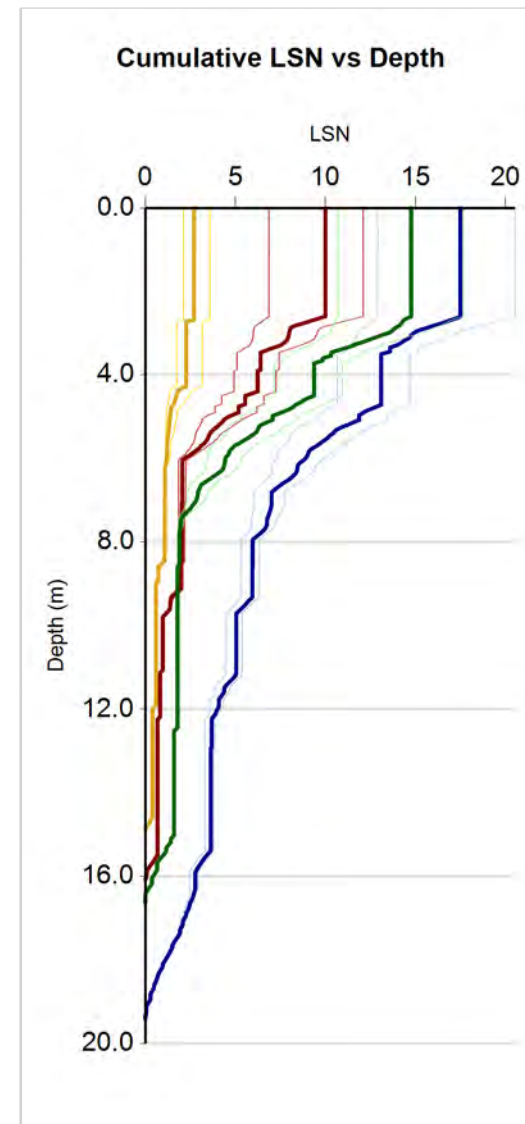
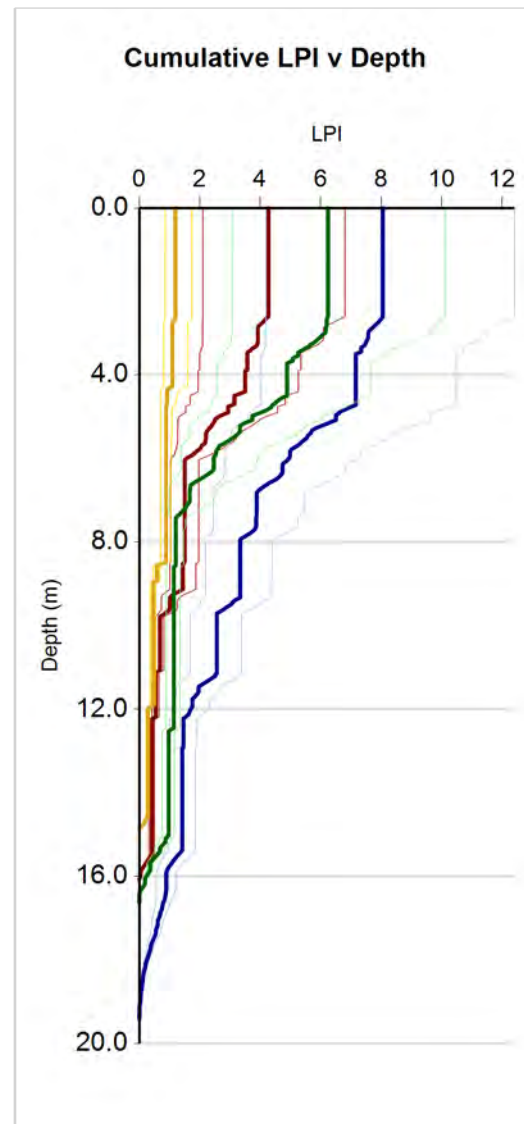
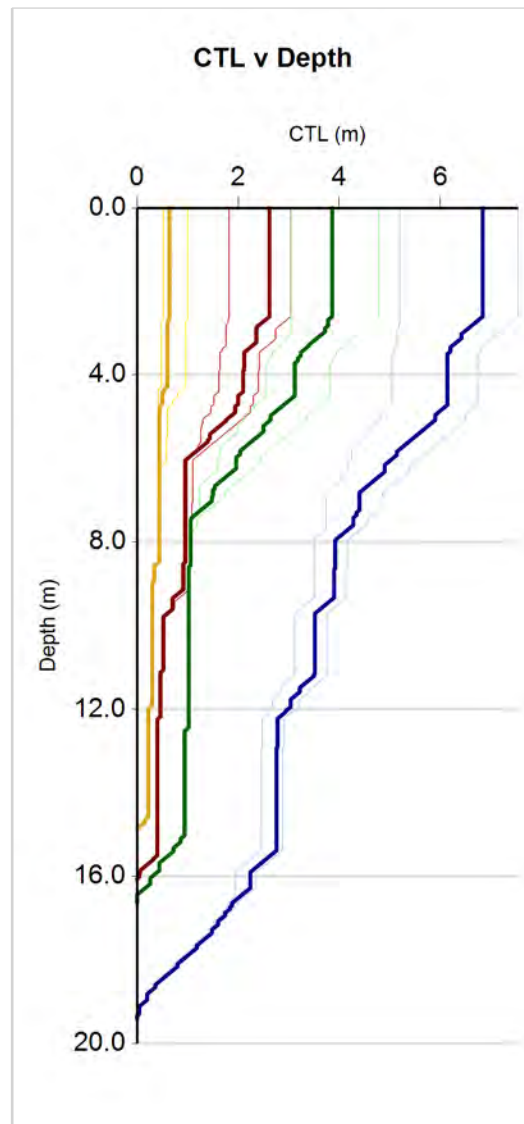
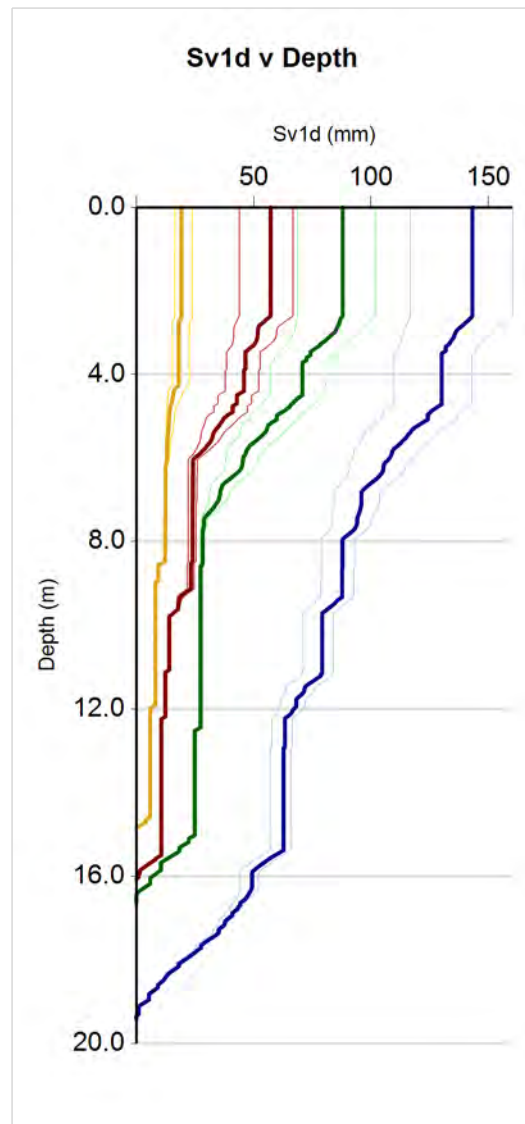


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road / Howard Street	DATE 17/02/2016
	TITLE ULS Liquefaction Assessment CPT 5-8	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT05	60503	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT06	60504	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT07	60505	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT08	60506	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



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ULS Liquefaction Assessment CPT 5-8

LOCATION

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Howard Street

JOB NUMBER

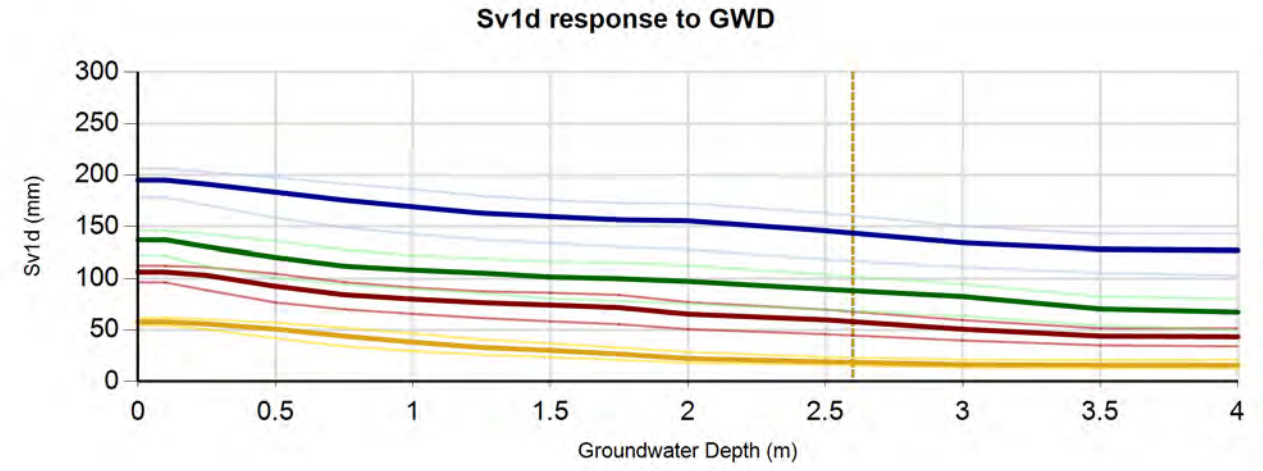
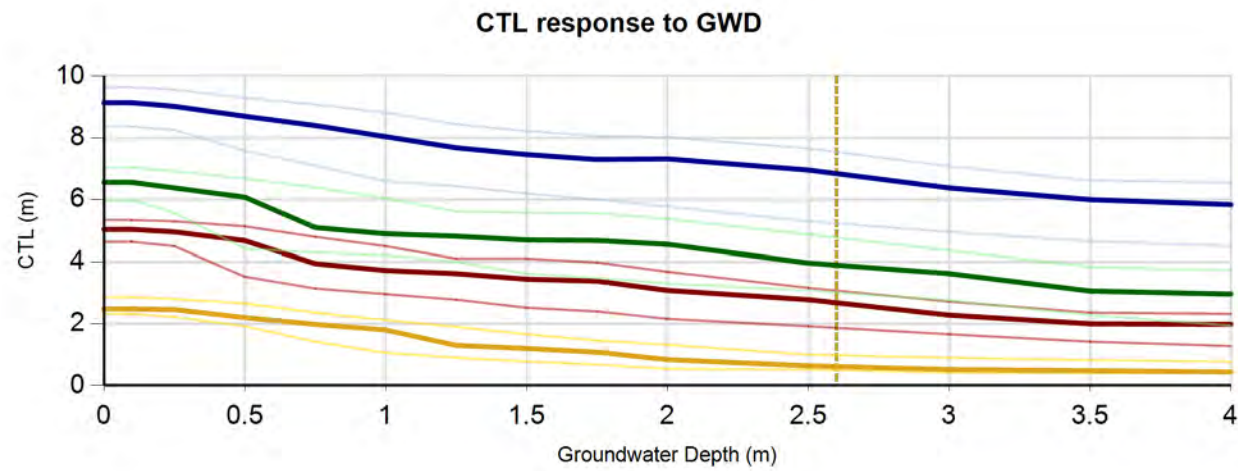
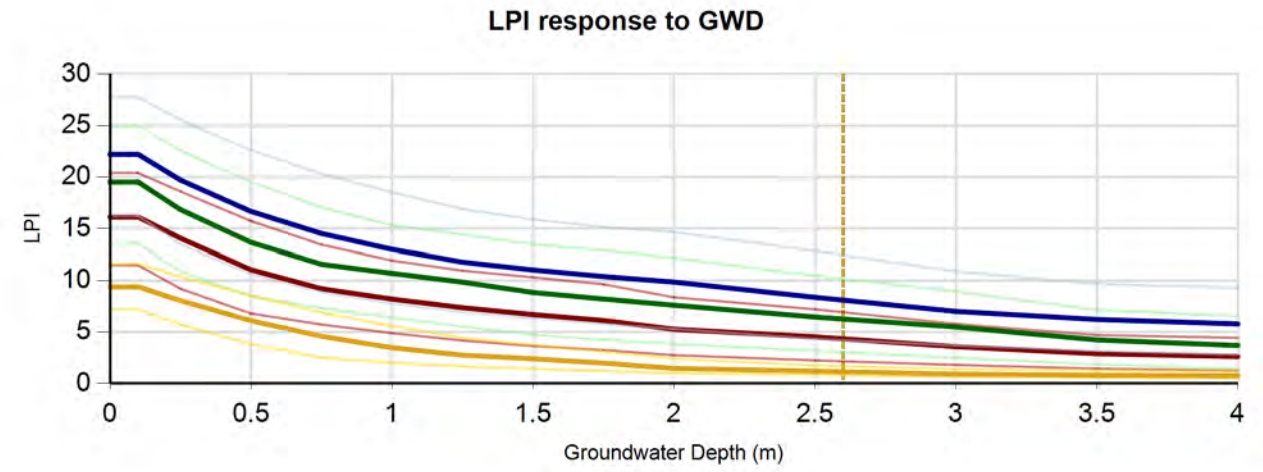
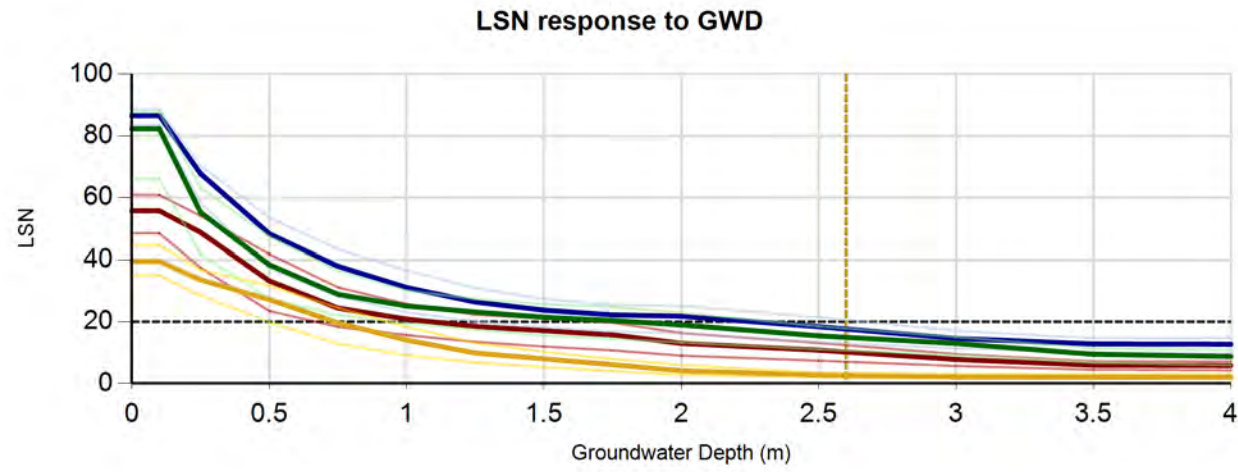
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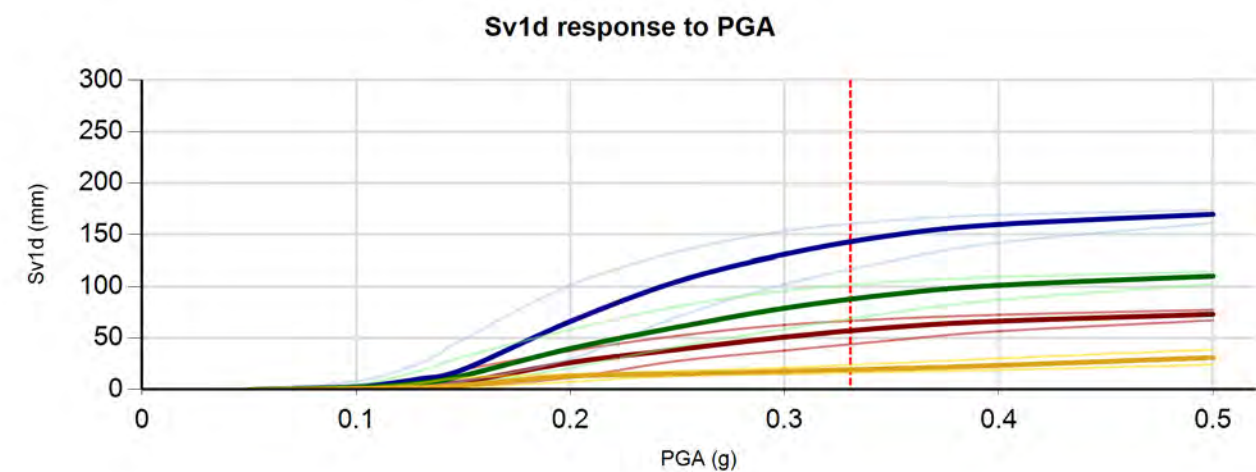
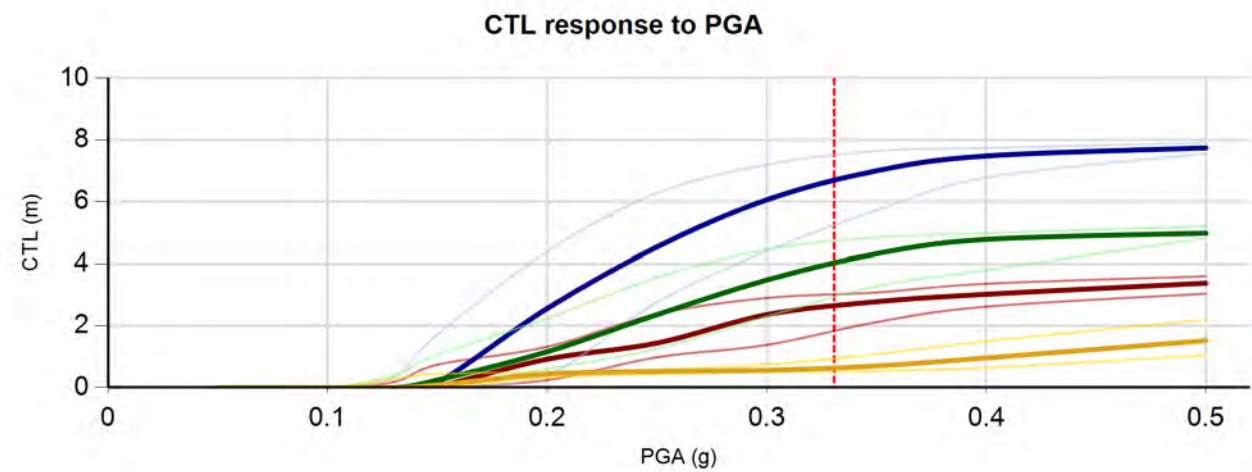
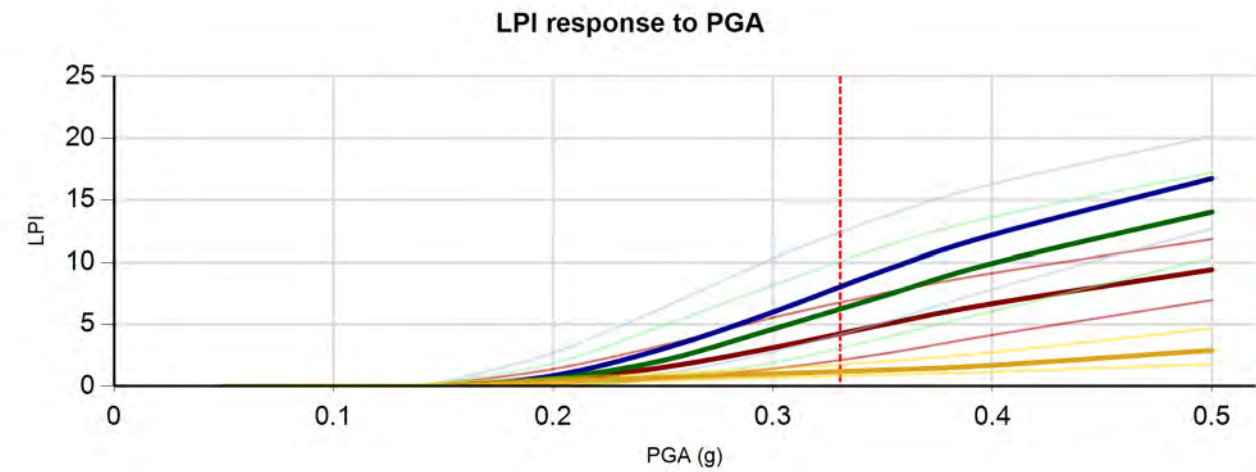
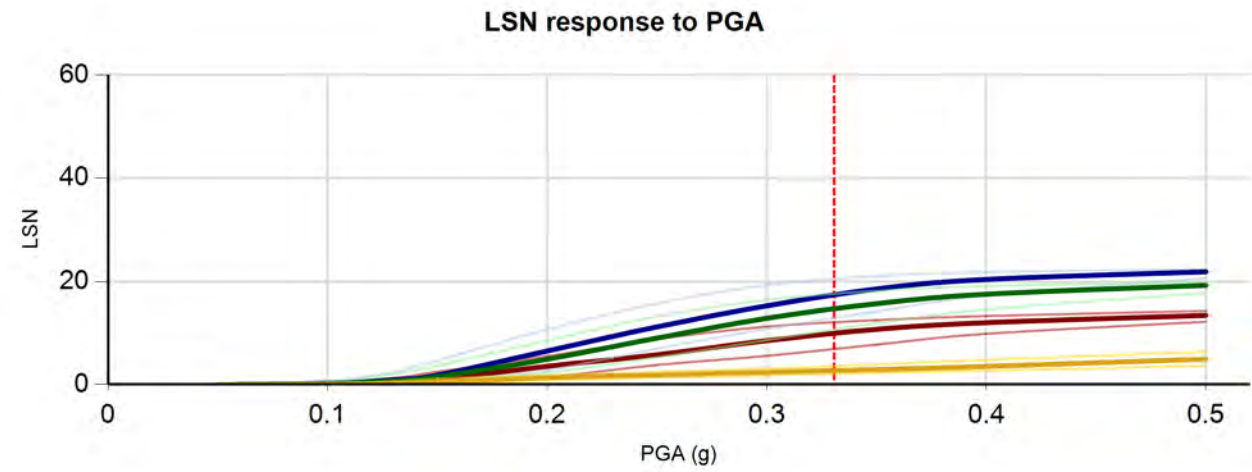
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Vertical dotted line/s indicate user specified GWD at the CPT locations. (actual GWD)

											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT05	60503	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT06	60504	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT07	60505	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT08	60506	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

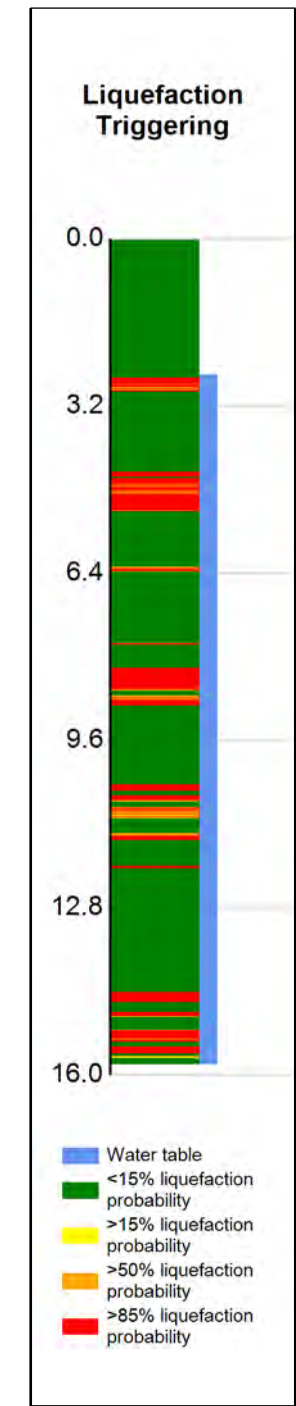
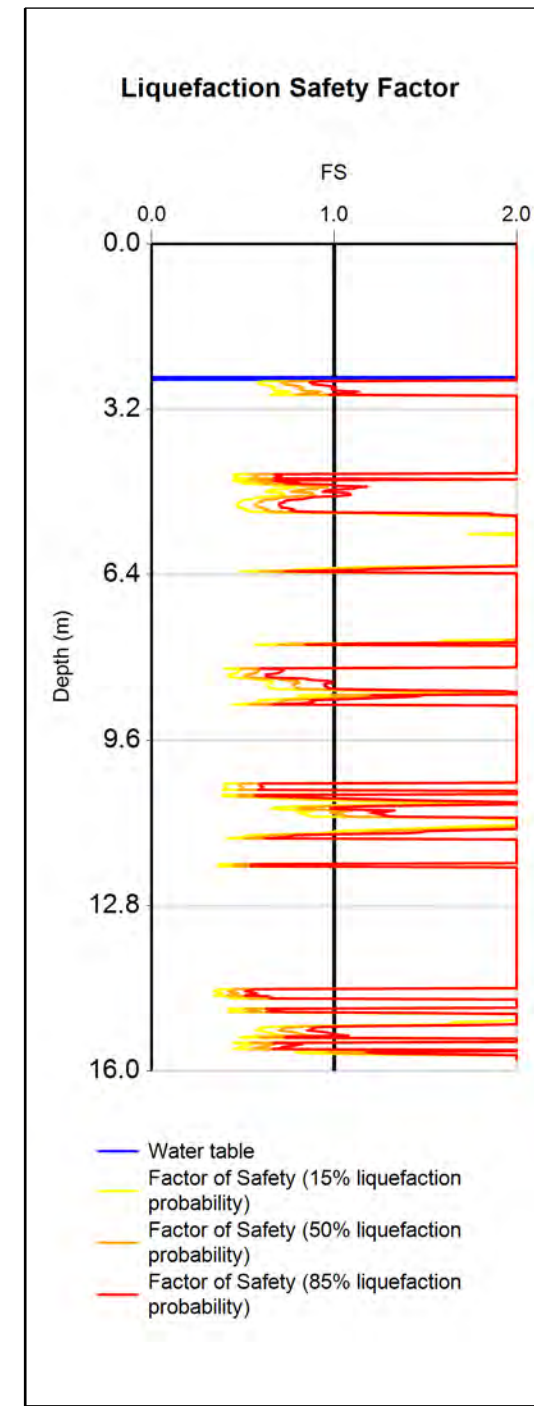
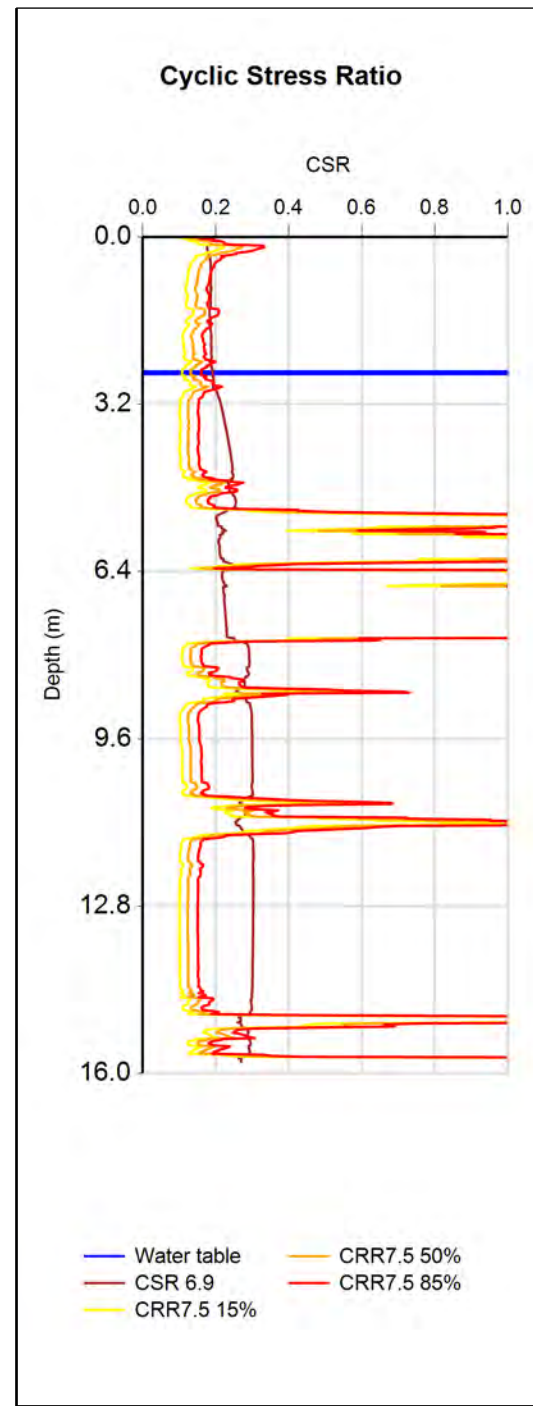
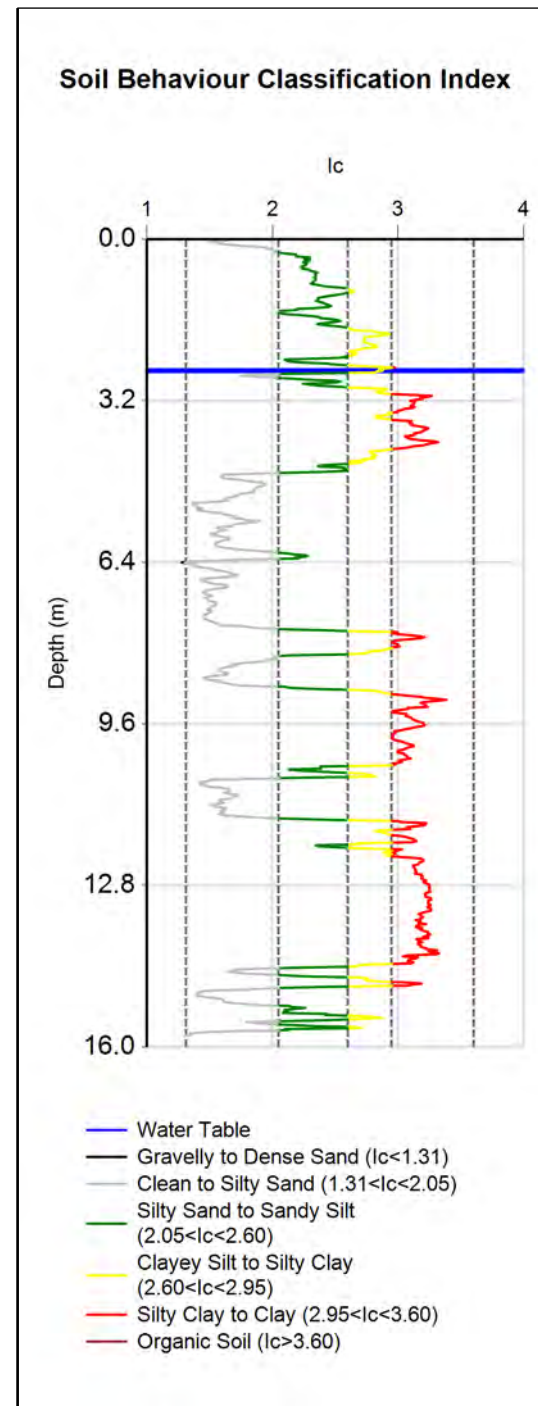
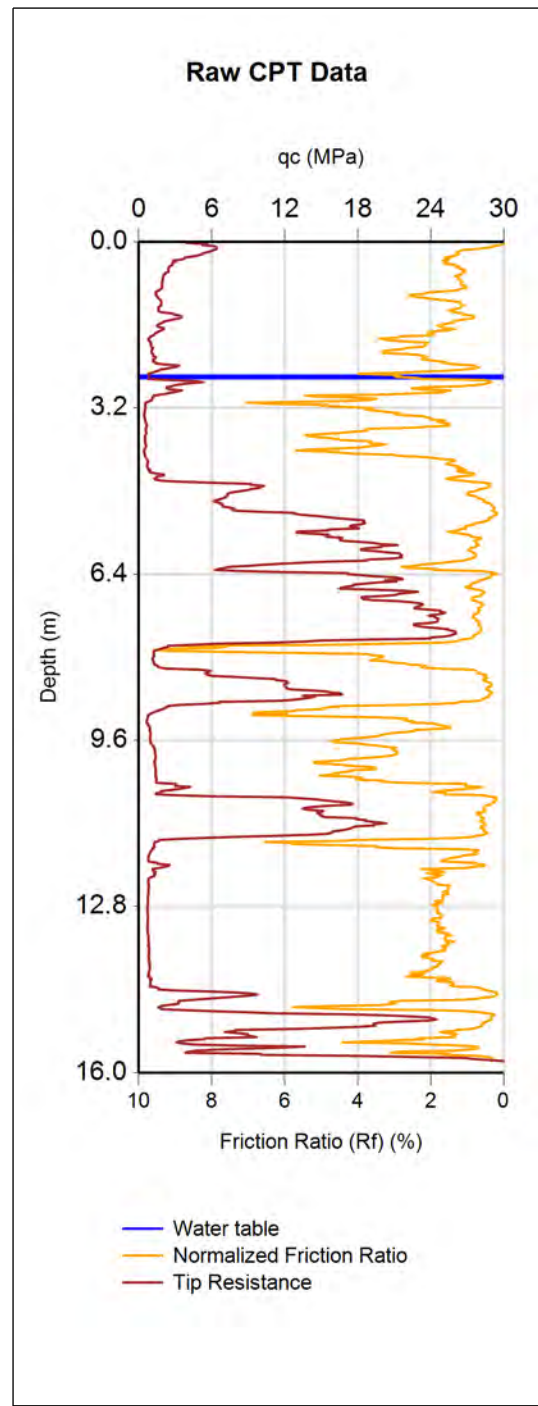
(Assumed pre-drill values)												
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT05	60503	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT06	60504	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT07	60505	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT08	60506	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60503	60504	60505	60506
CPT Name	CPT05	CPT06	CPT07	CPT08
PGA	0.33078g	0.33078g	0.33078g	0.33078g
Magnitude	6.9	6.9	6.9	6.9
Depth to groundwater	2.6m	2.6m	2.6m	2.6m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	16.08m	19.42m	16.64m	14.86m
Maximum depth of analysis	16.08m	19.42m	16.64m	14.86m
RL	n/a	n/a	n/a	n/a



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT09	60507	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
OUTPUT	15%	70	3.2	7	10	2.7	5						
	50%	63	2.9	5	9	2.7	3						
	85%	51	2.3	3	7	2.7	1						



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Housing Rezone

TITLE
ULS Liquefaction Assessment CPT 9-12

LOCATION
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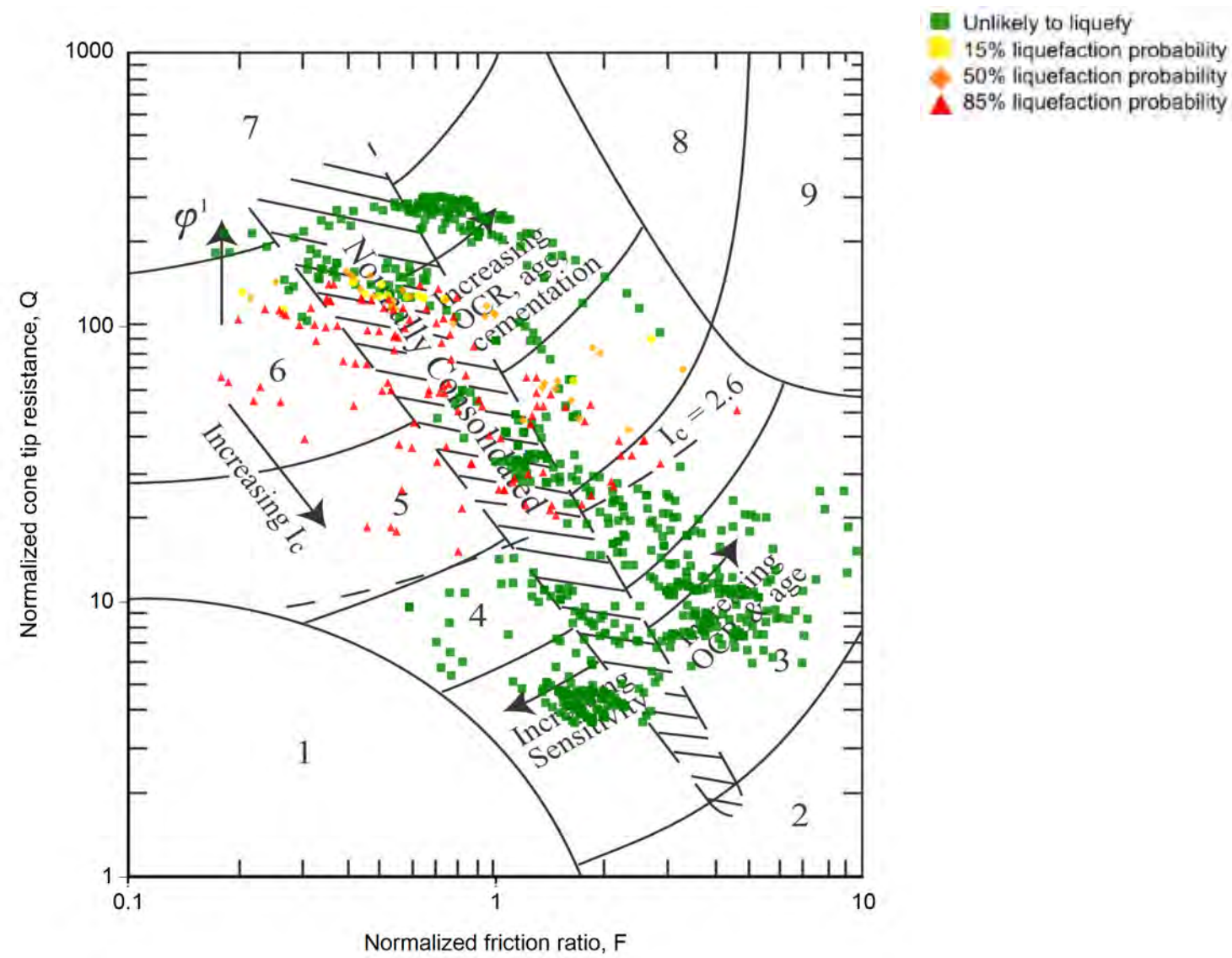
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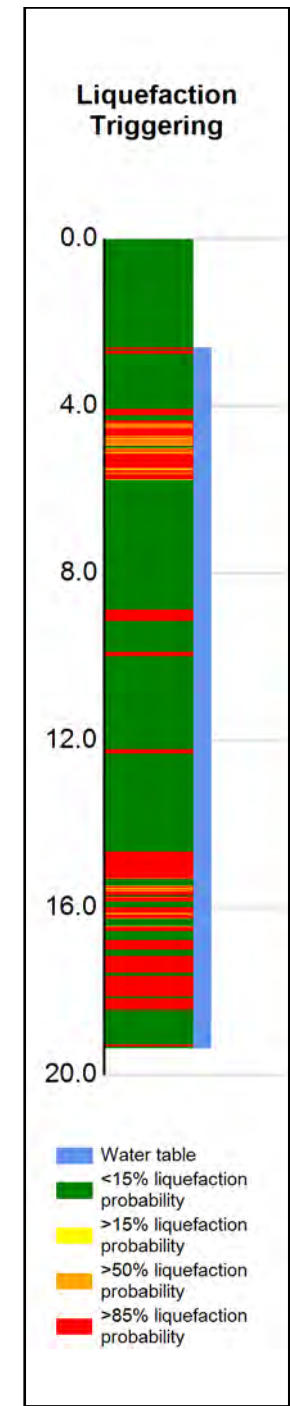
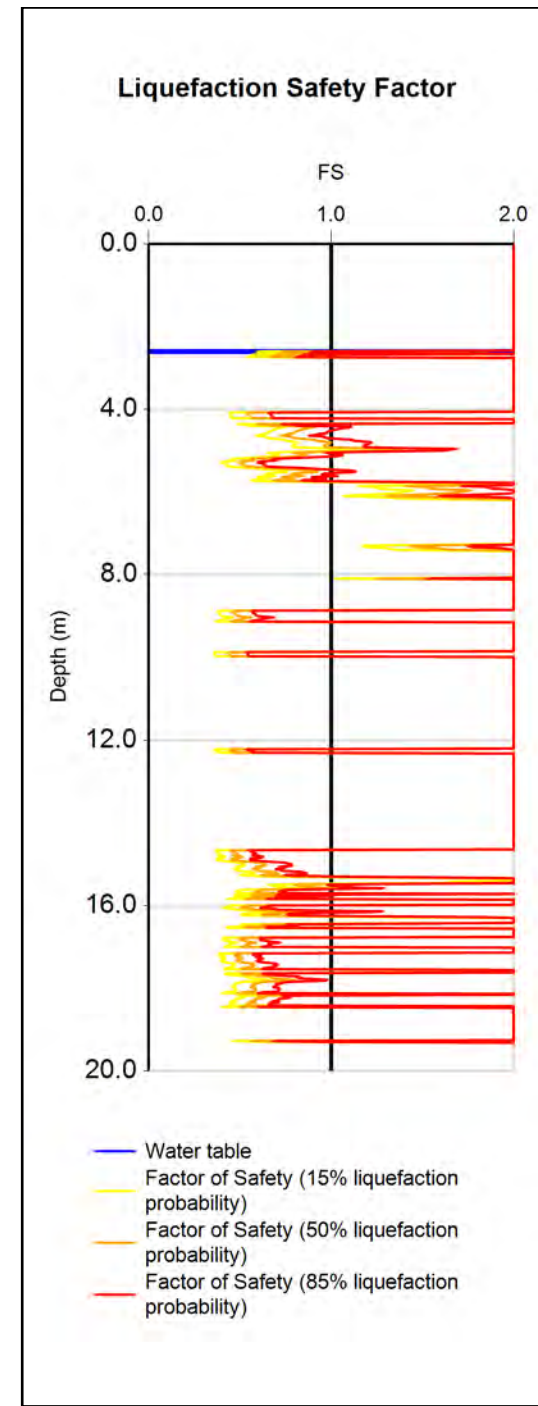
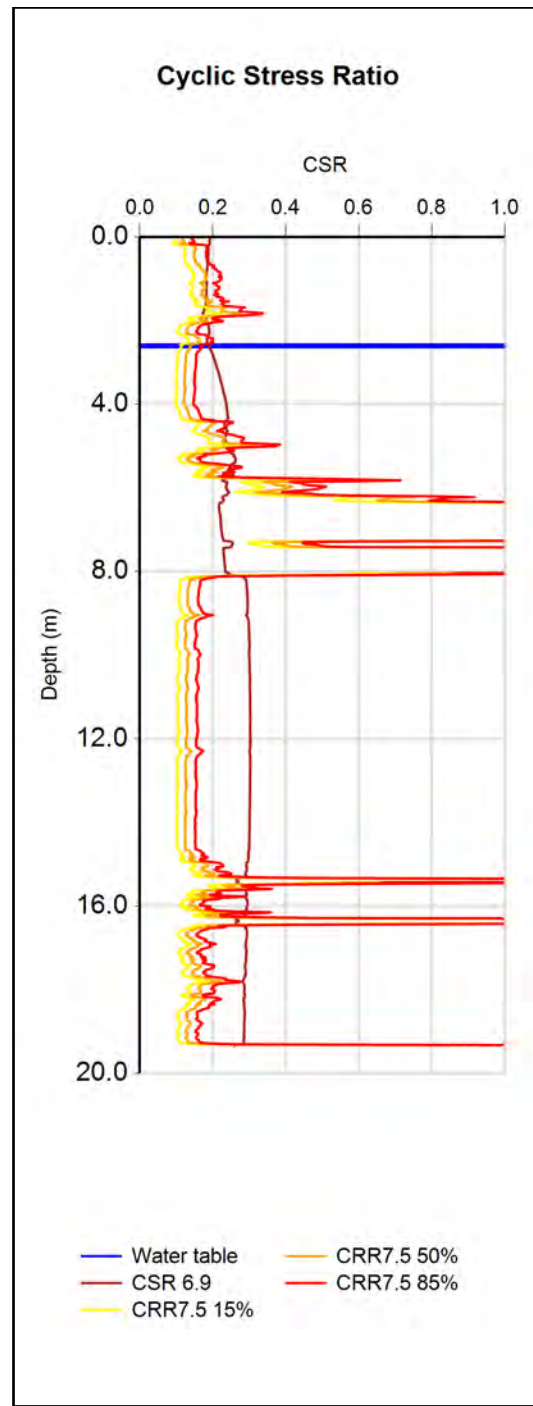
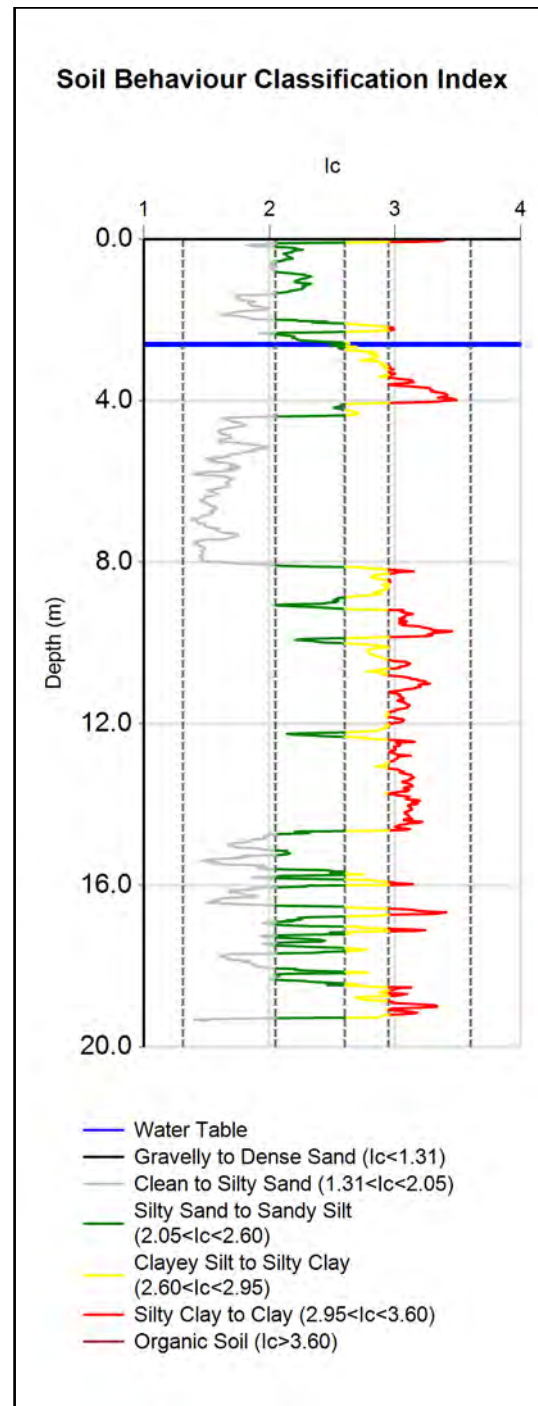
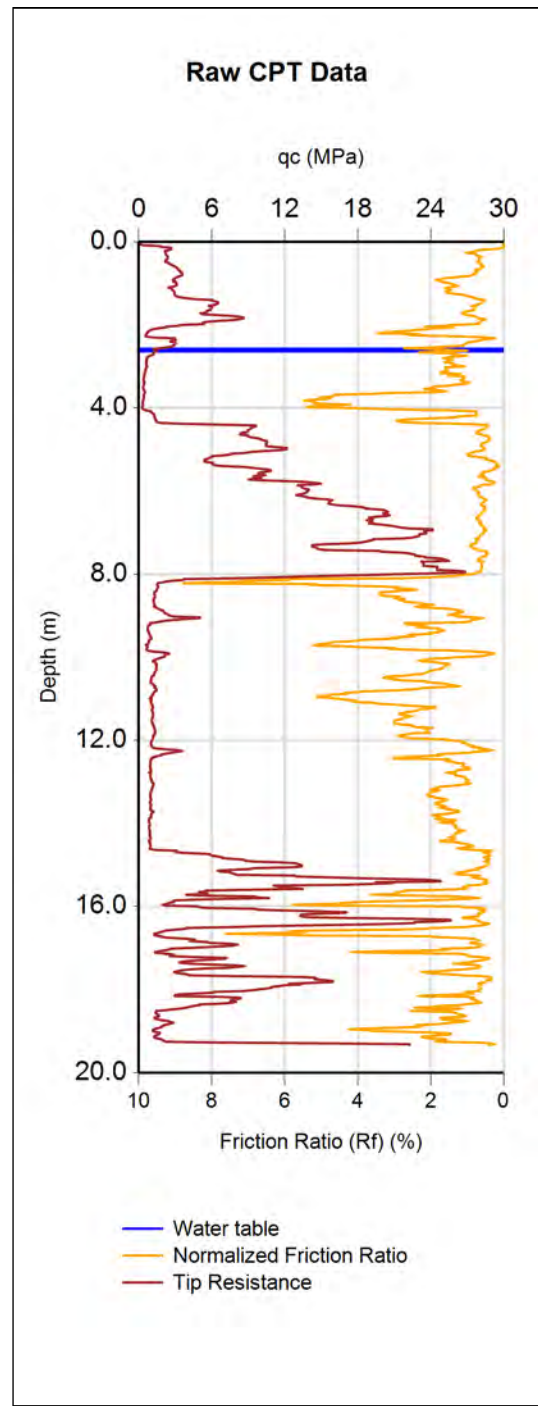
CPT-based soil behavior type classification chart by Robertson (1990)



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TITLE	ULS Liquefaction Assessment CPT 9-12

LOCATION	Havelock Road / Howard Street	DATE	17/02/2016
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(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT10	60509	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	120	5	9	14	2.7	7						
	50%	113	4.9	6	13	2.7	4						
	85%	101	4.2	4	11	2.7	3						



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ULS Liquefaction Assessment CPT 9-12

LOCATION

Havelock Road /
Howard Street

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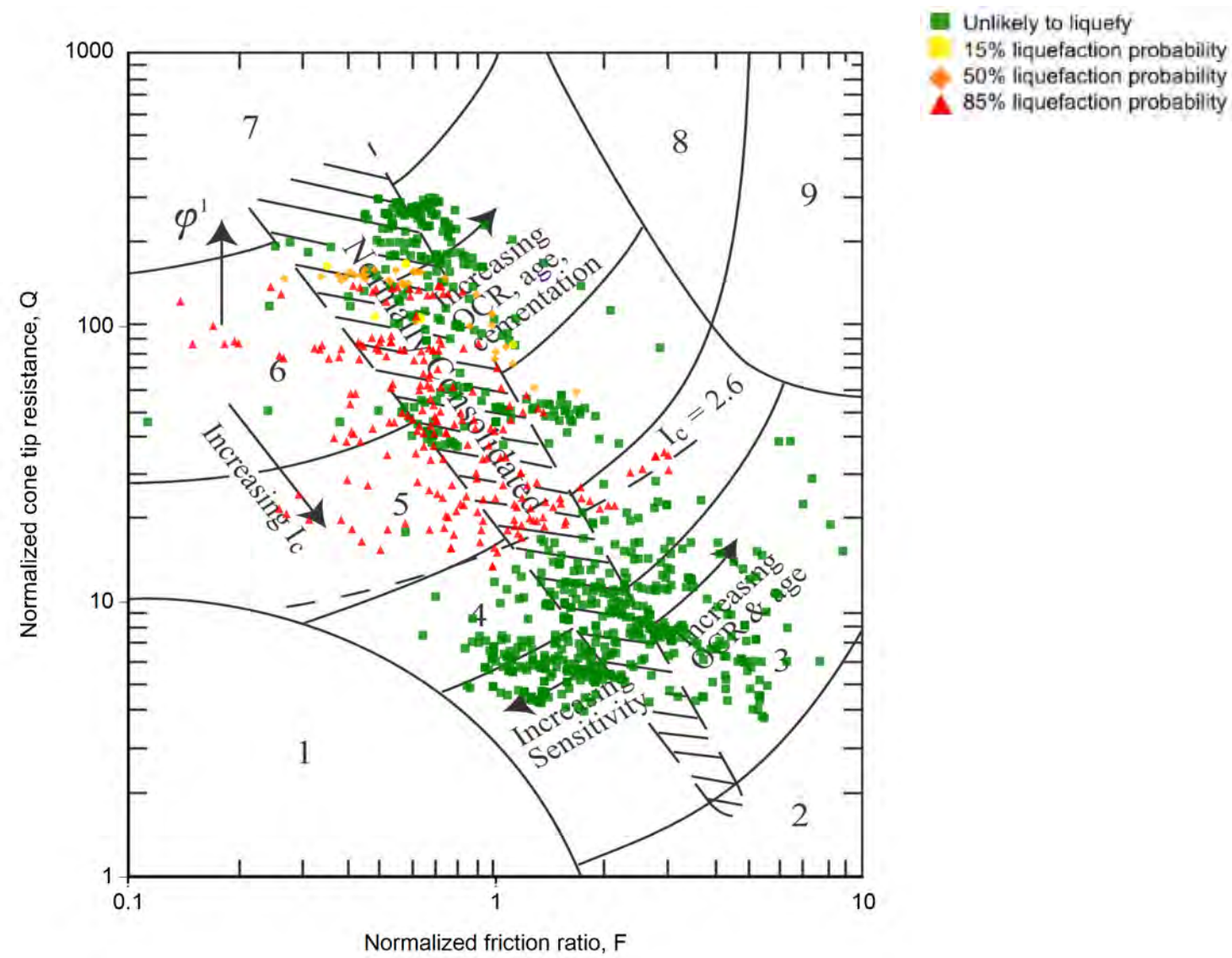
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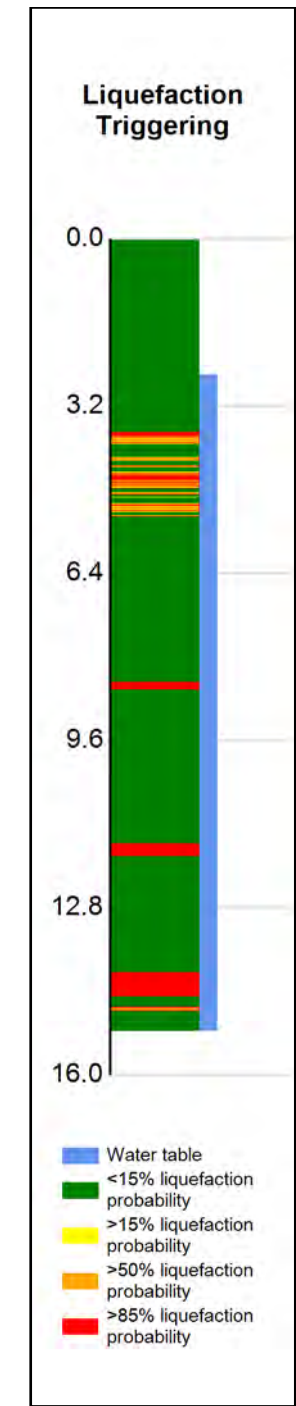
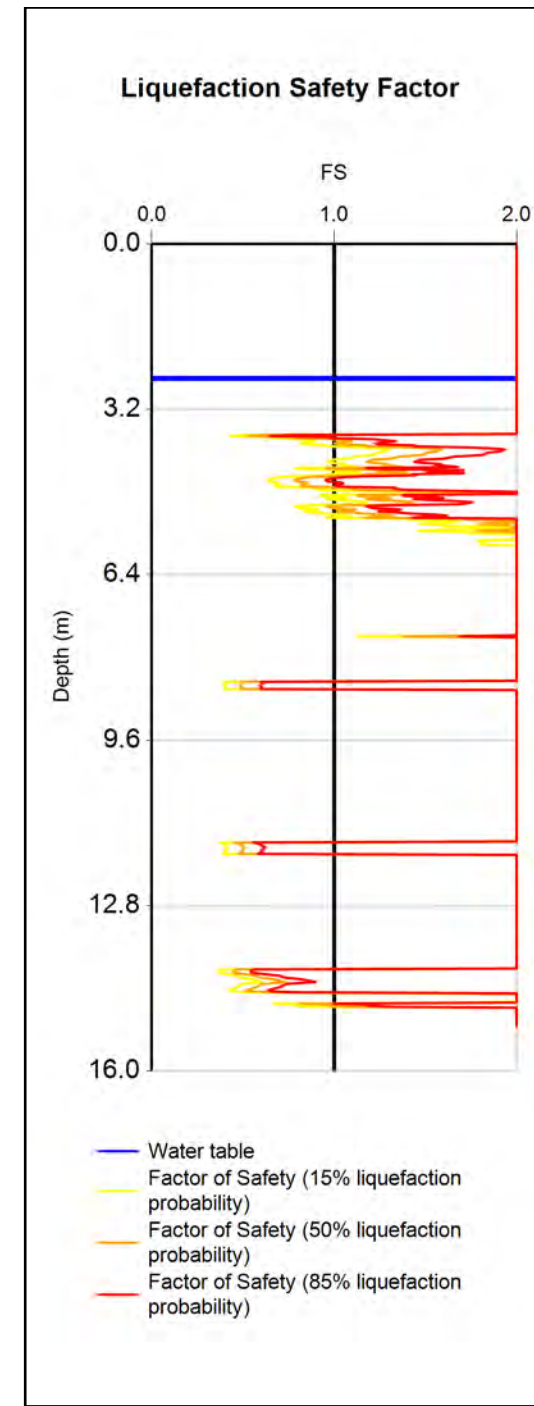
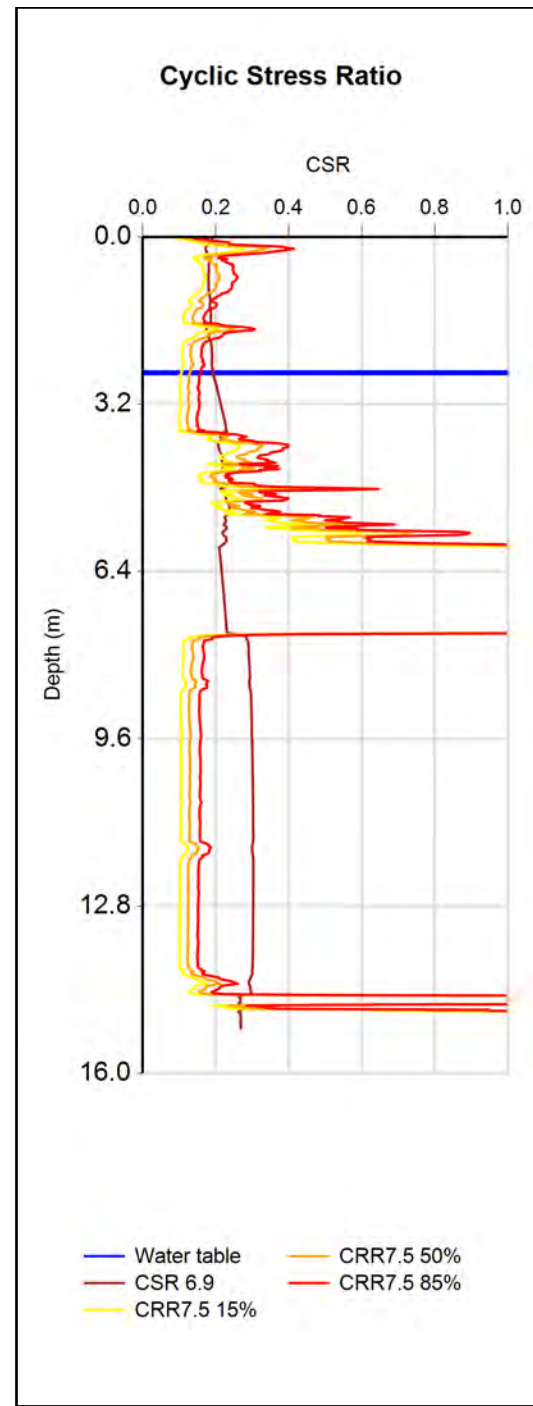
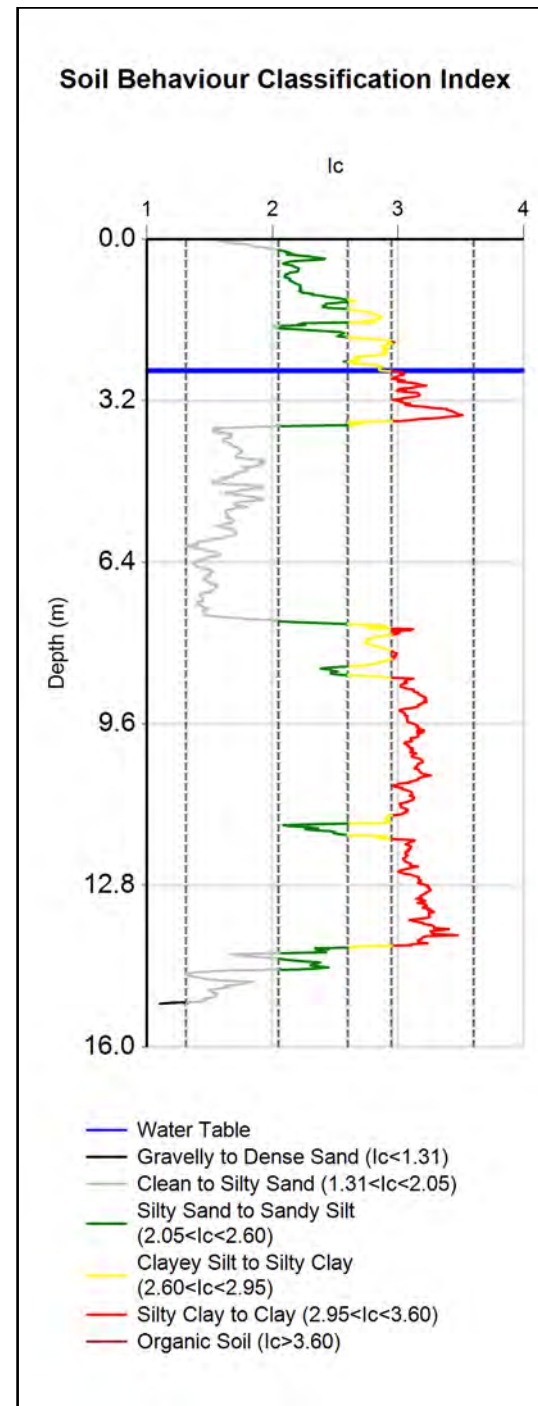
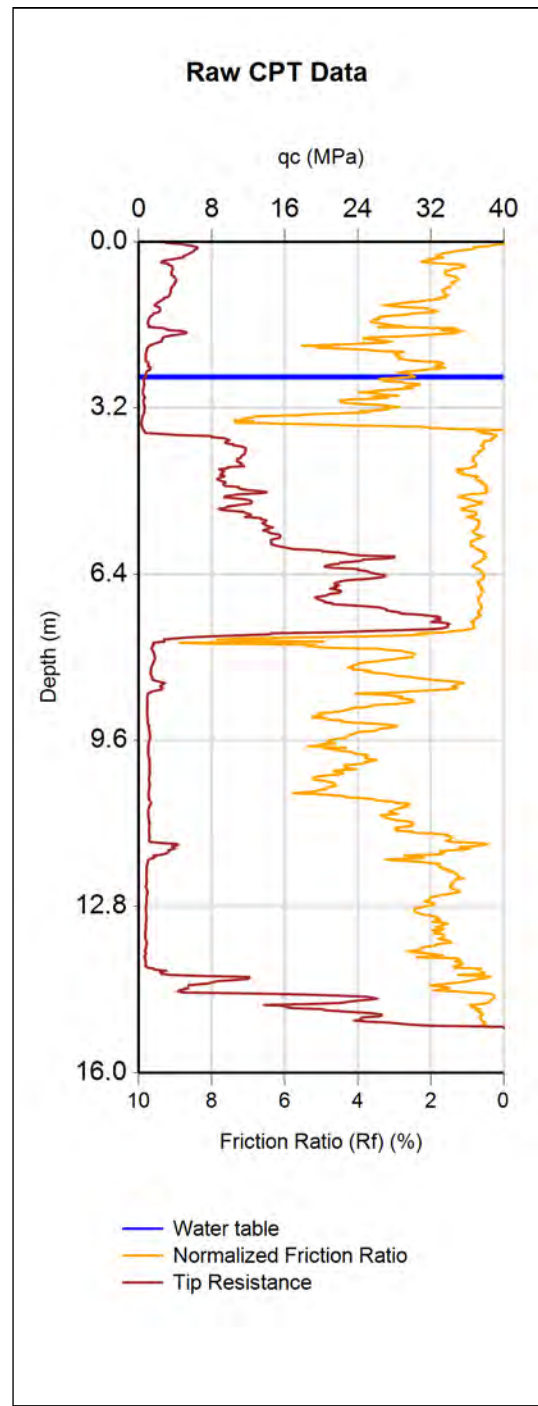


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CPT-based soil behavior type classification chart by Robertson (1990)

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	TITLE ULS Liquefaction Assessment CPT 9-12	JOB NUMBER 31464.1000	ANALYSED cjc



(Assumed pre-drill values)

INPUT	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
	CPT11	60510	10/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	39	1.9	3	6	3.8	2						
	50%	32	1.3	2	4	3.8	1						
	85%	27	1	1	3	4.5	1						



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ULS Liquefaction Assessment CPT 9-12

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JOB NUMBER

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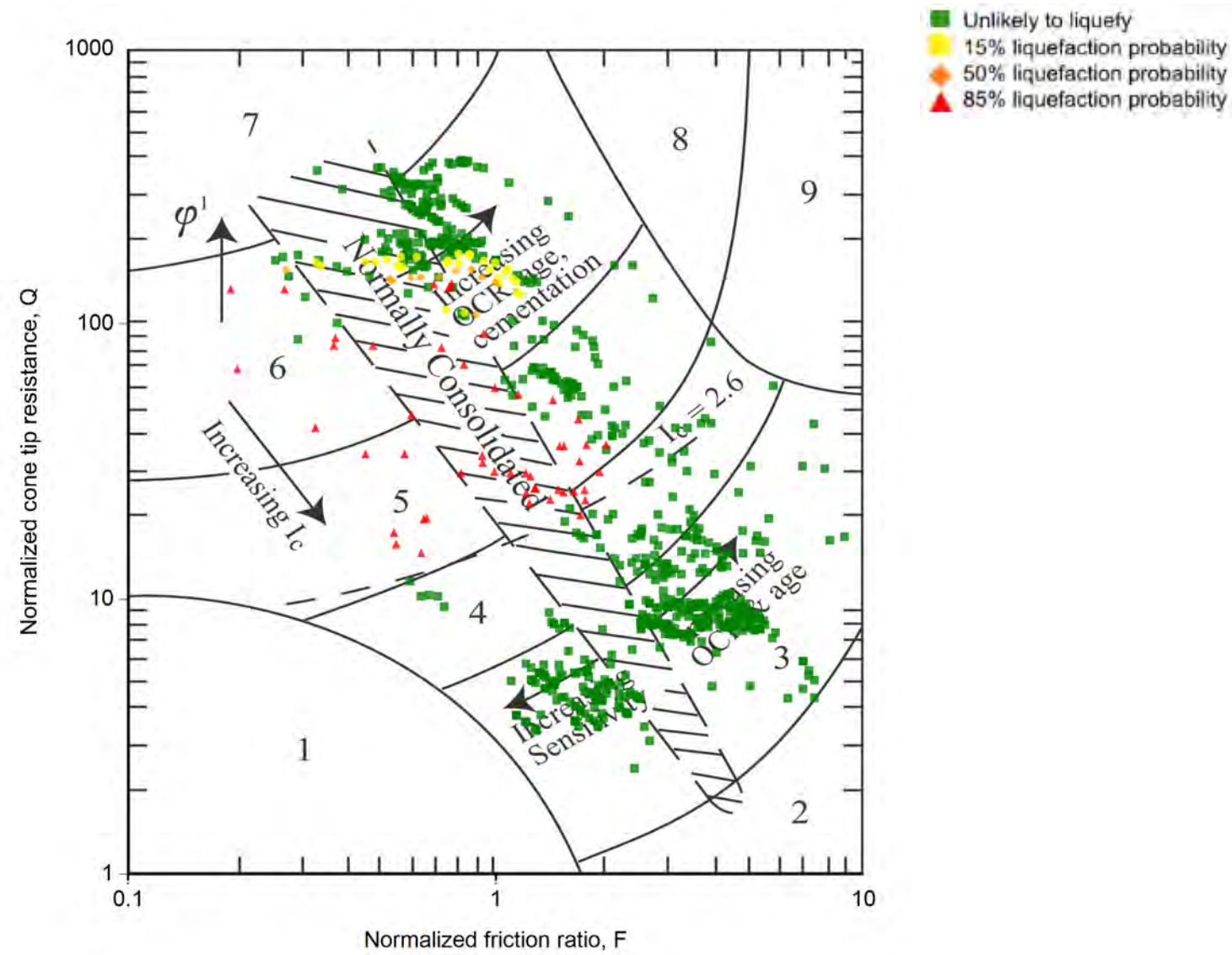
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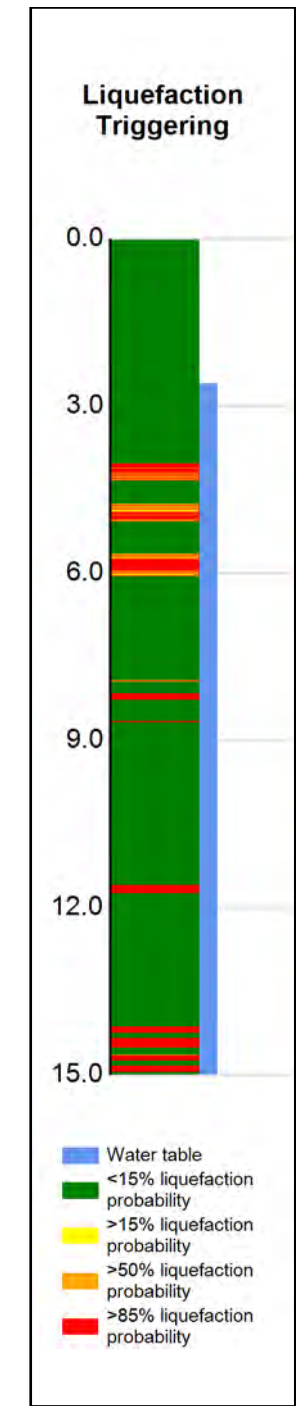
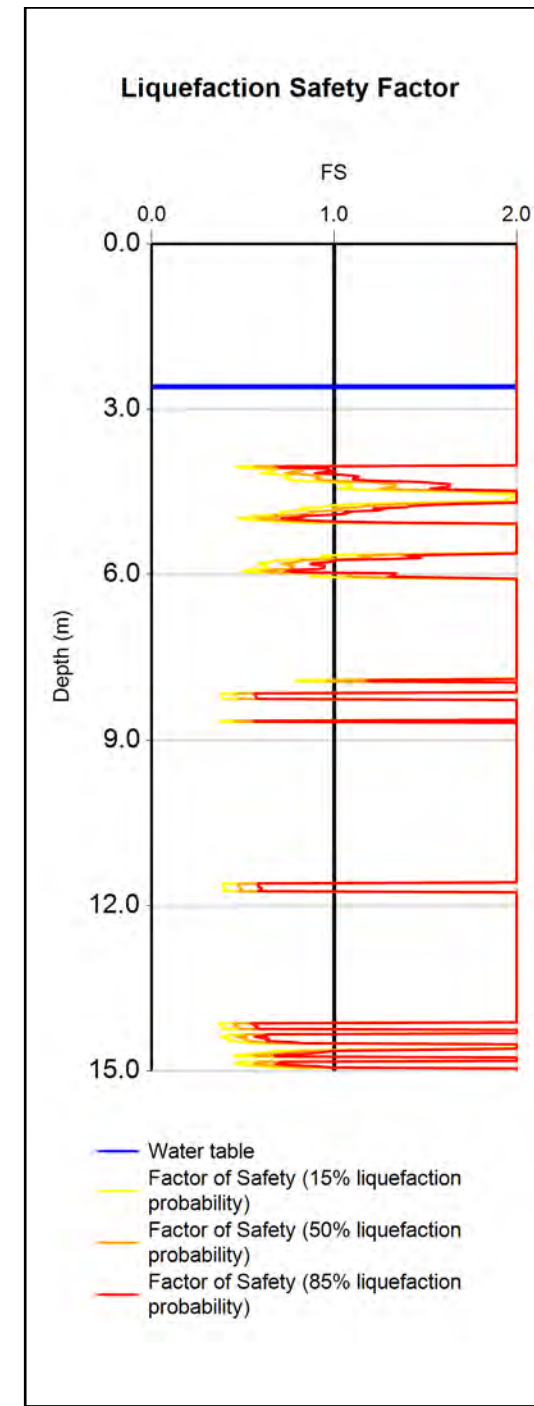
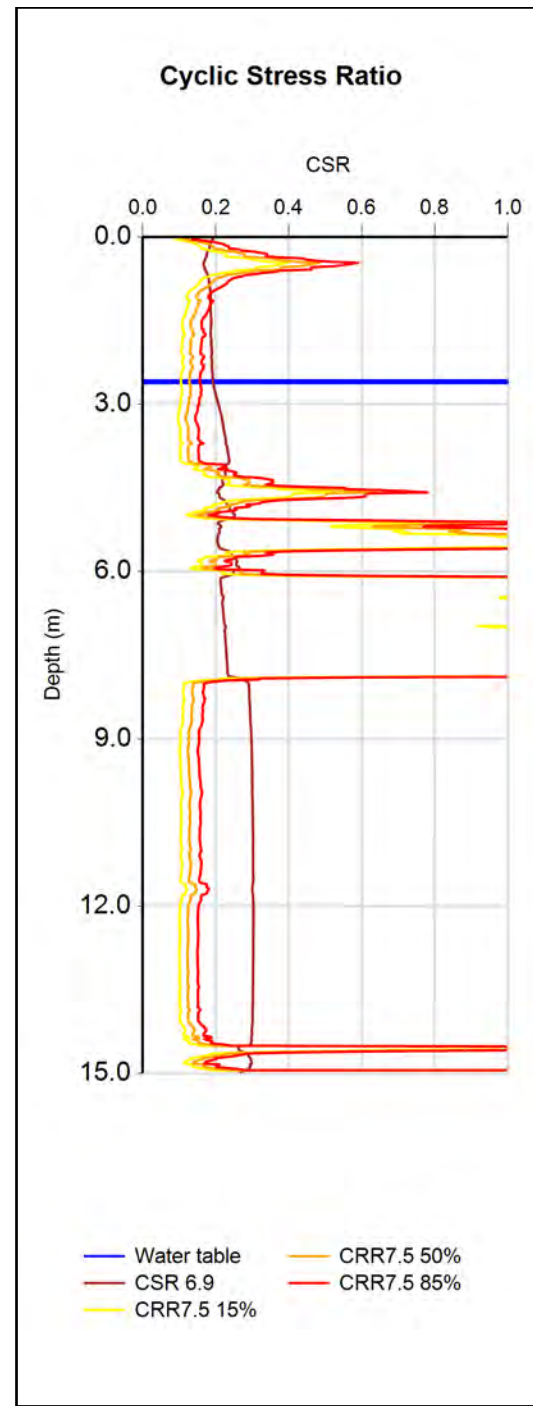
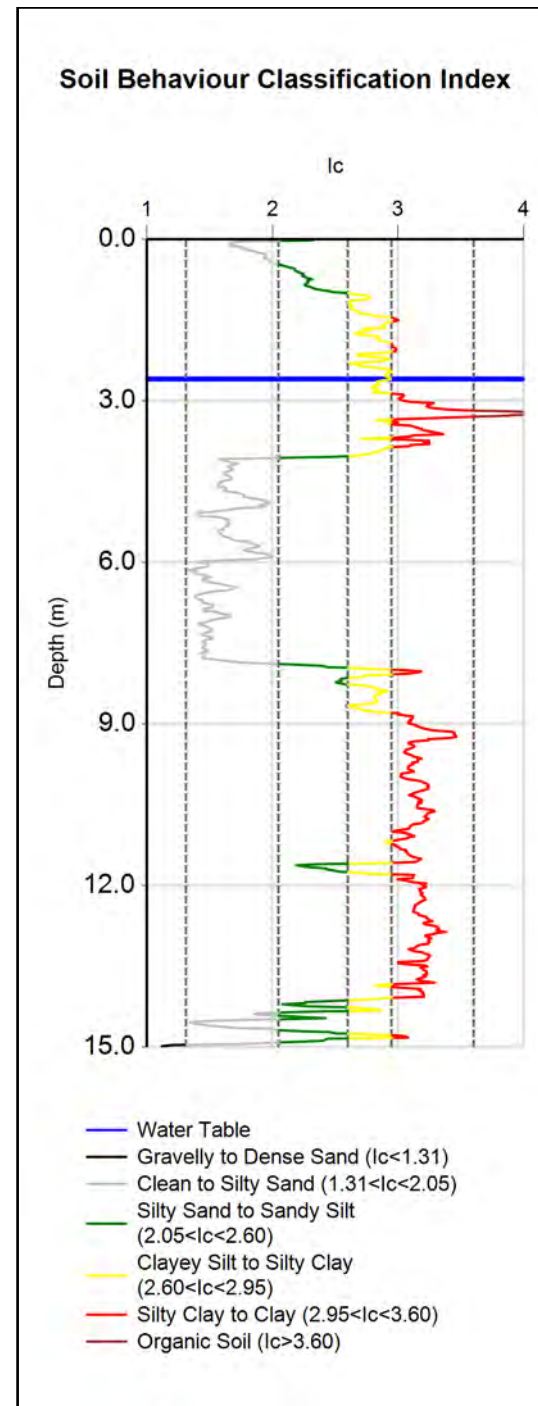
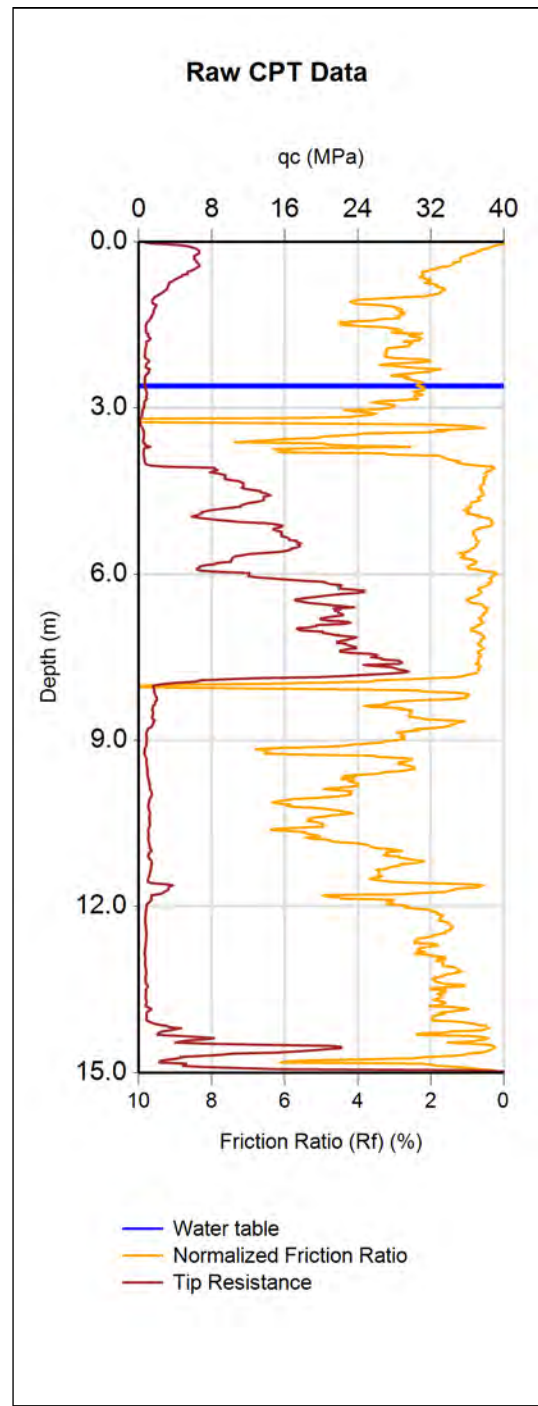
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CPT-based soil behavior type classification chart by Robertson (1990)



(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
INPUT	CPT12	60511	10/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish						
	15%	42	1.9	4	6	4.1	2						
	50%	37	1.6	3	5	4.1	1						
	85%	30	1.3	2	4	4.1	1						



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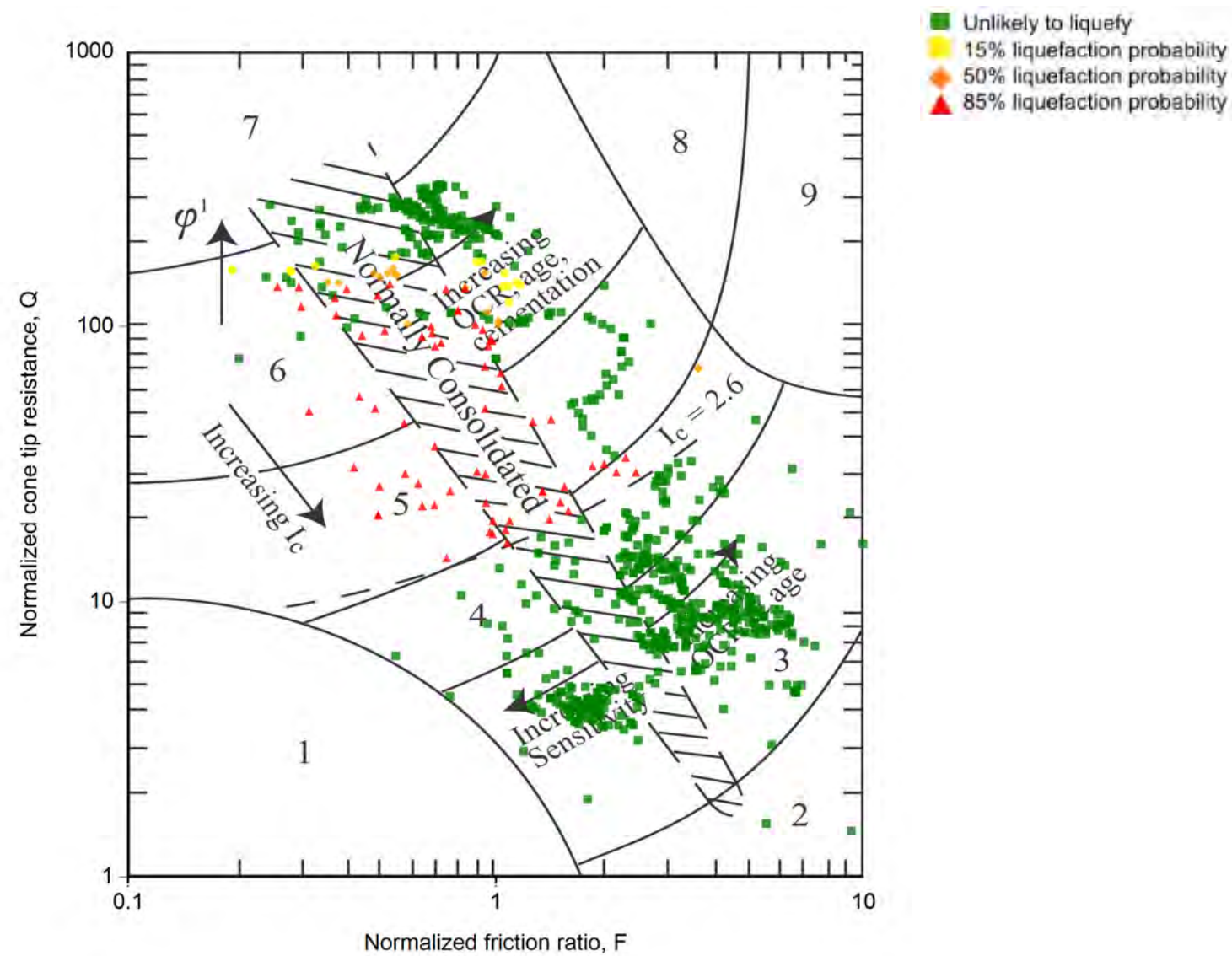
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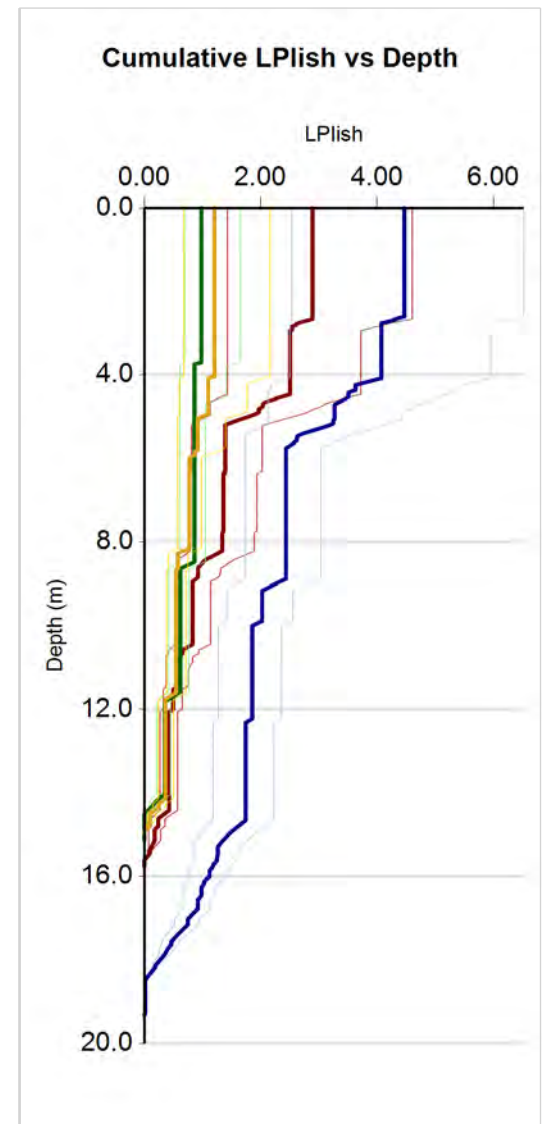
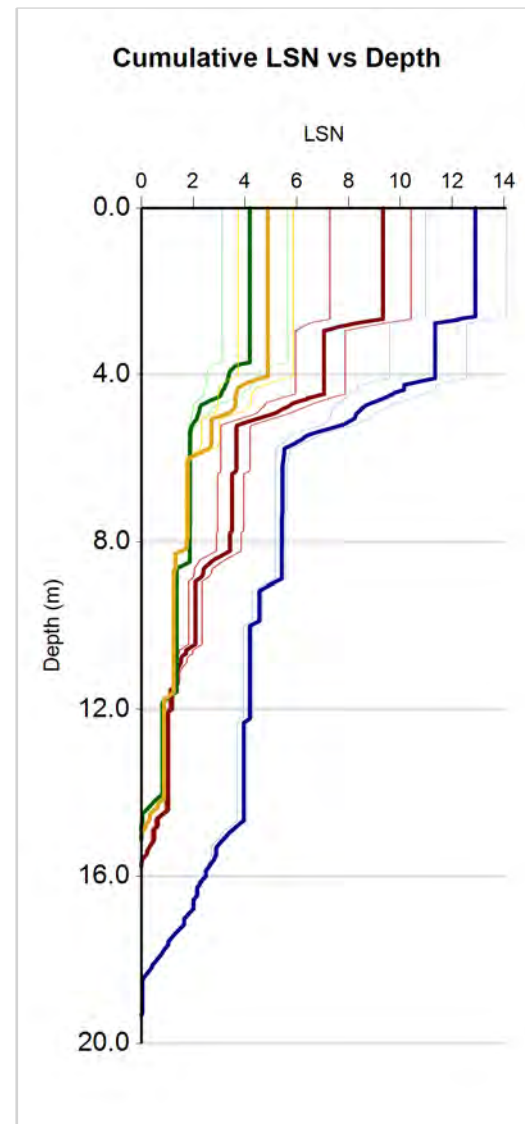
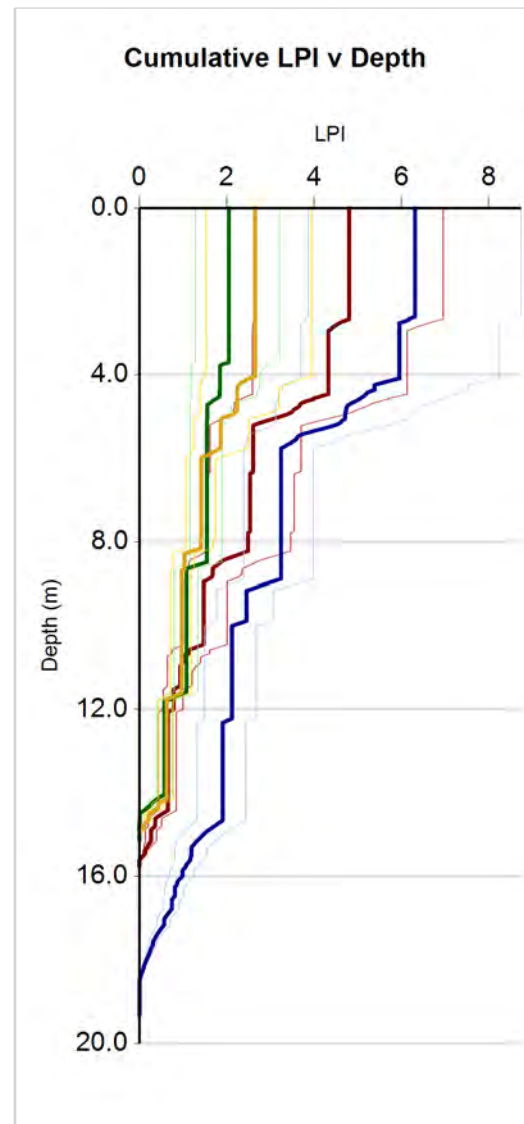
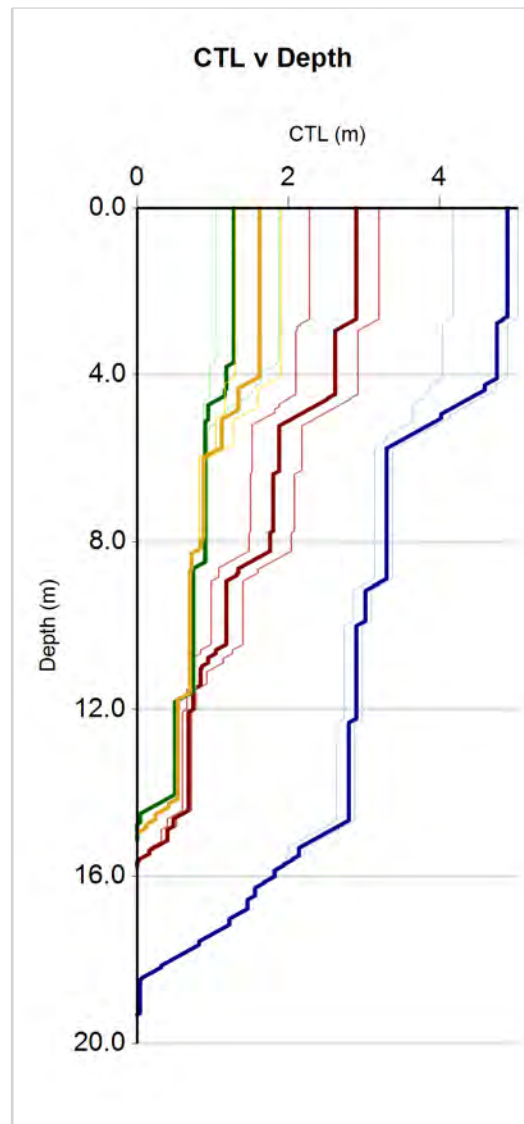
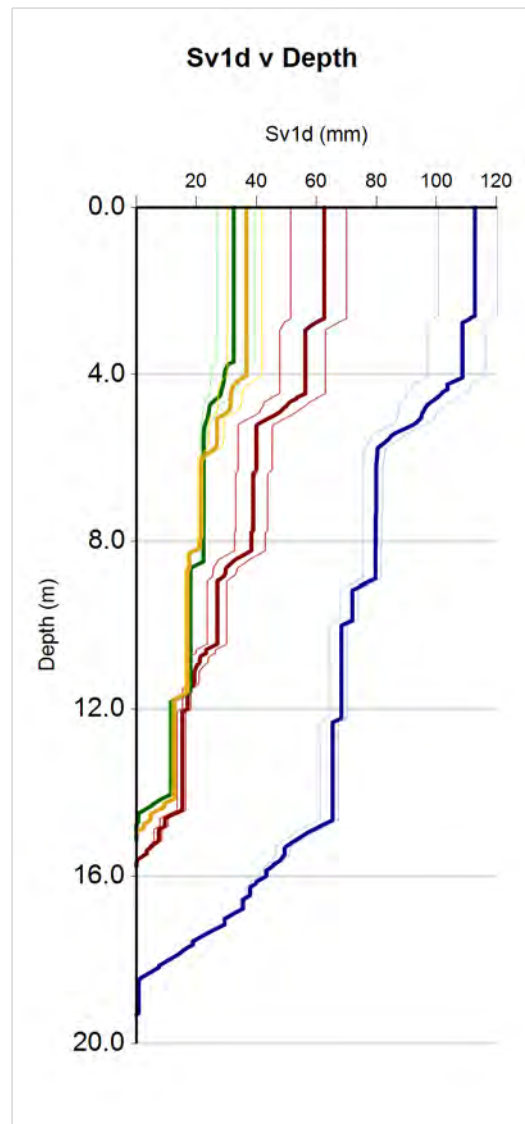
CPT-based soil behavior type classification chart by Robertson (1990)



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(Assumed pre-drill values)

CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT09	60507	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT10	60509	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT11	60510	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT12	60511	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



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Howard Street

JOB NUMBER

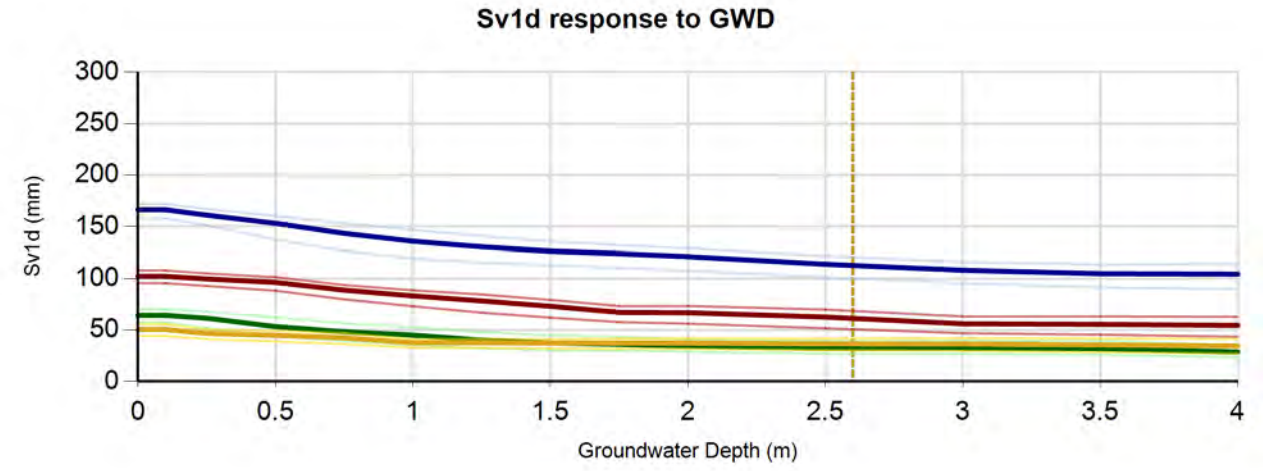
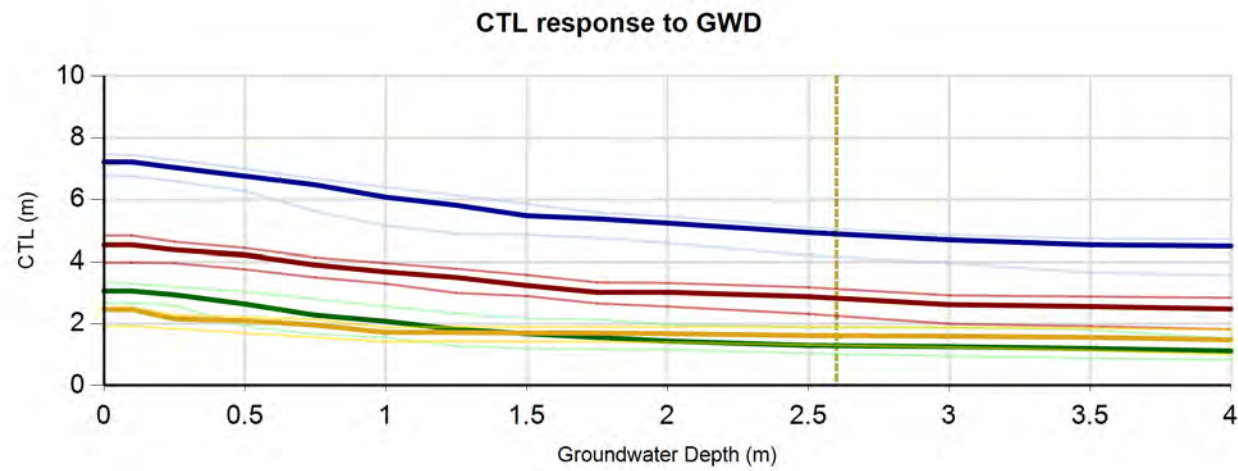
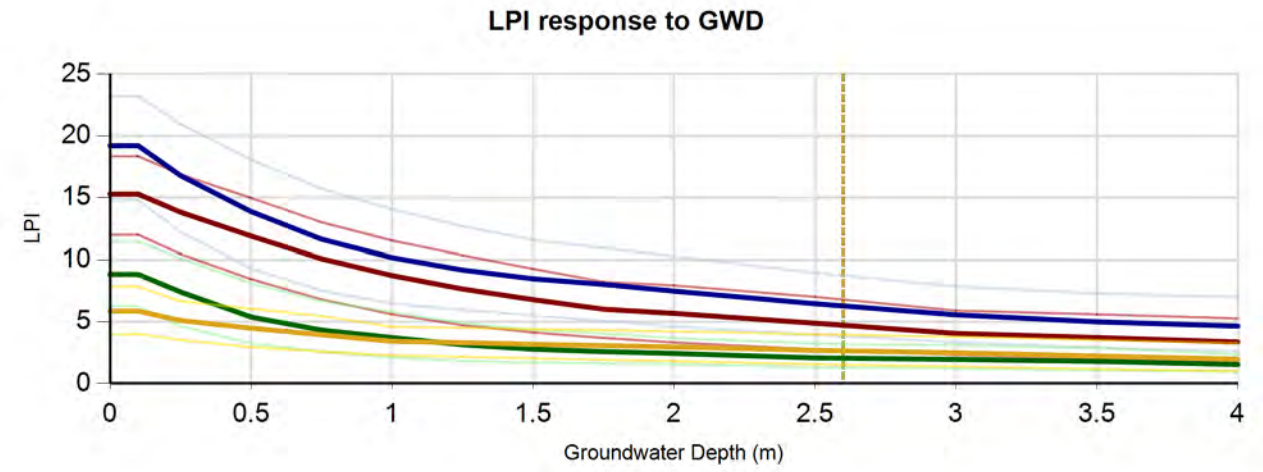
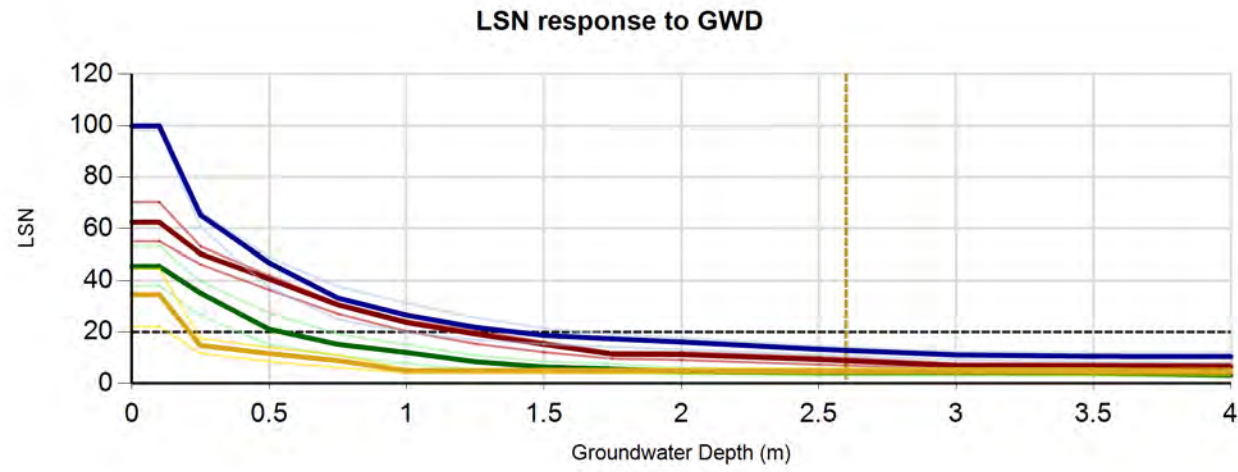
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DATE 17/02/2016

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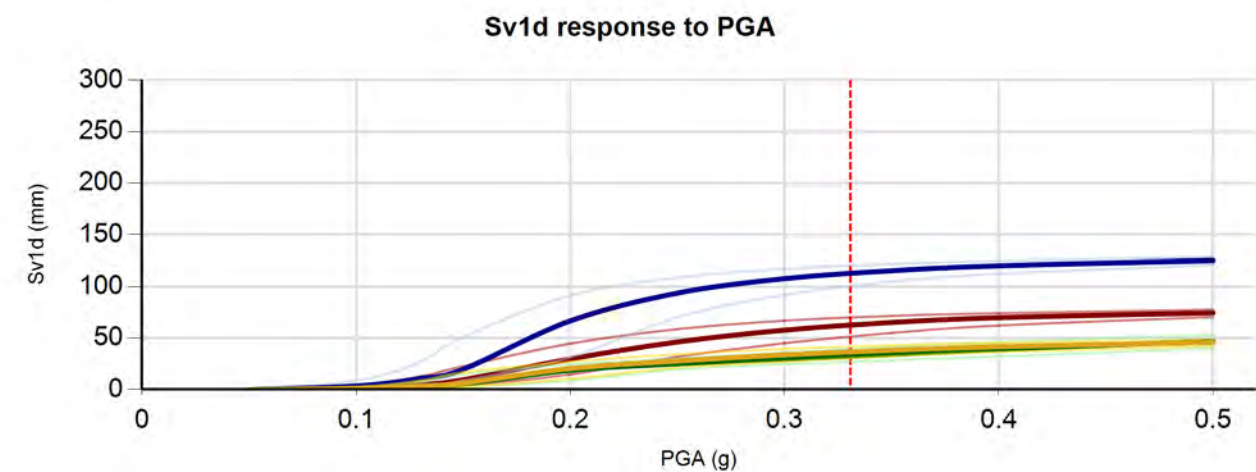
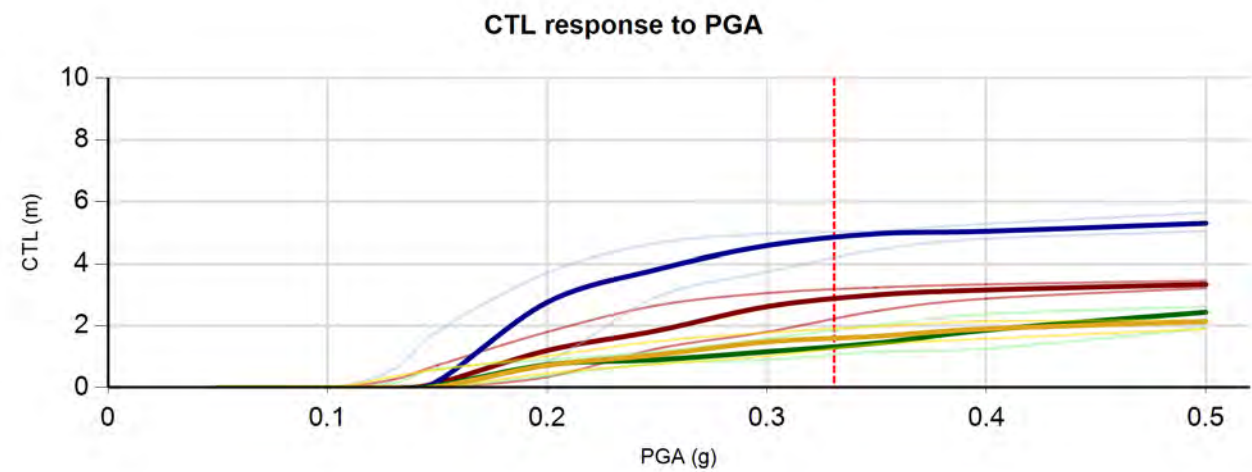
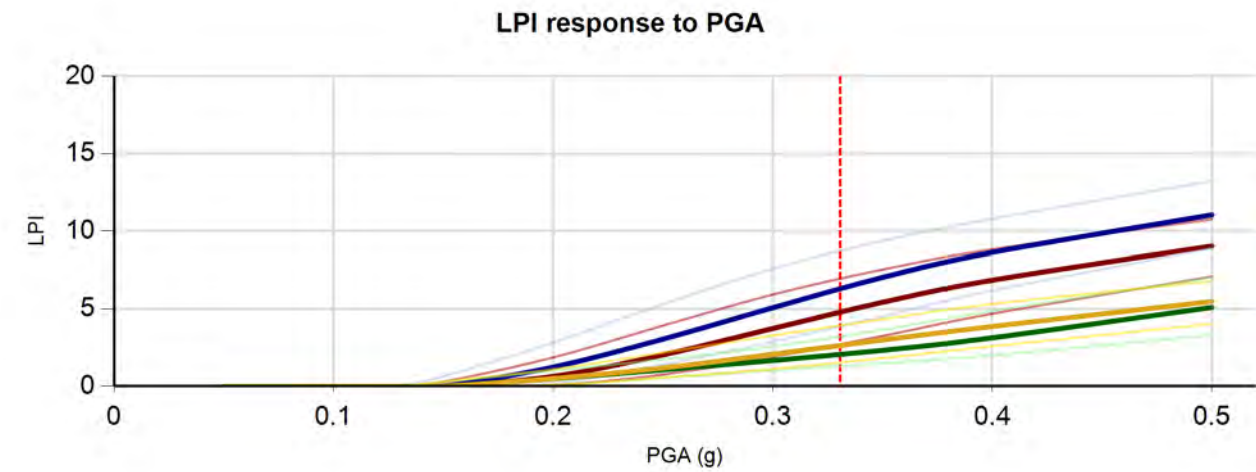
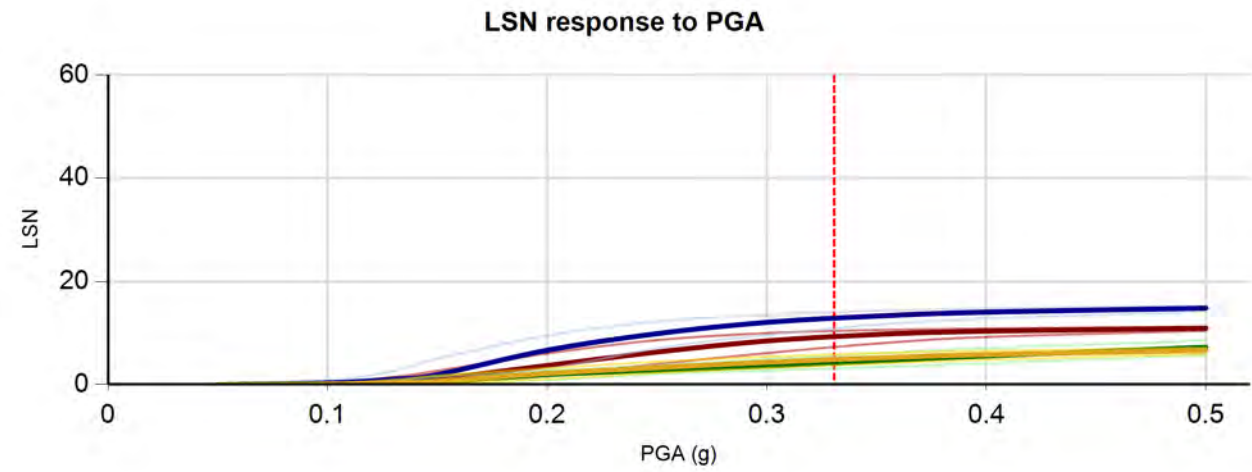
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Vertical dotted line/s indicate user specified GWD at the CPT locations. (actual GWD)

											(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT09	60507	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT10	60509	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT11	60510	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT12	60511	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

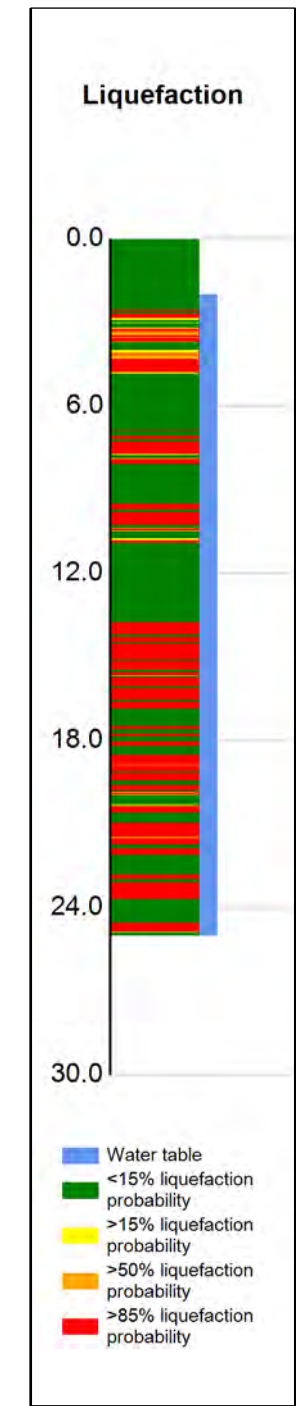
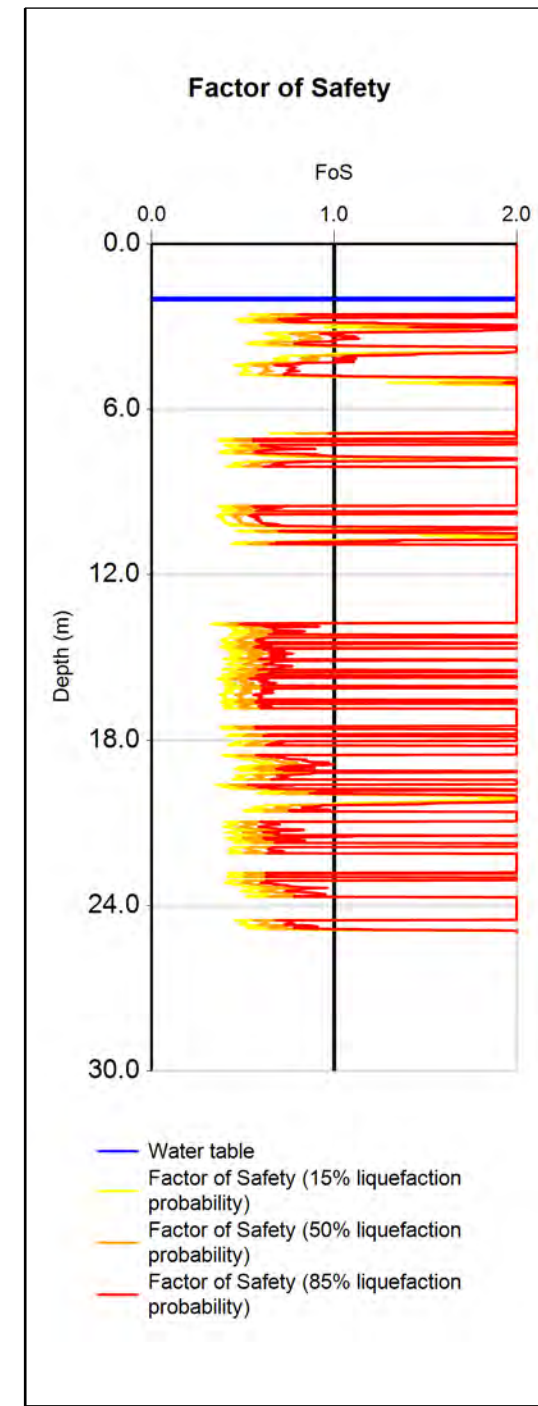
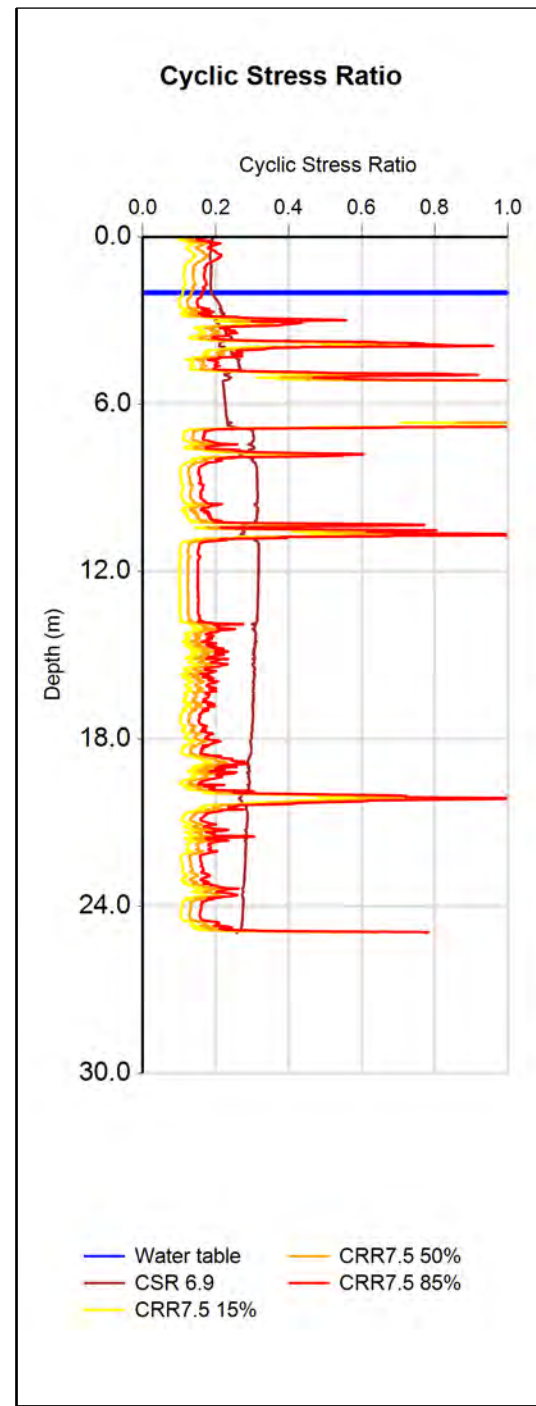
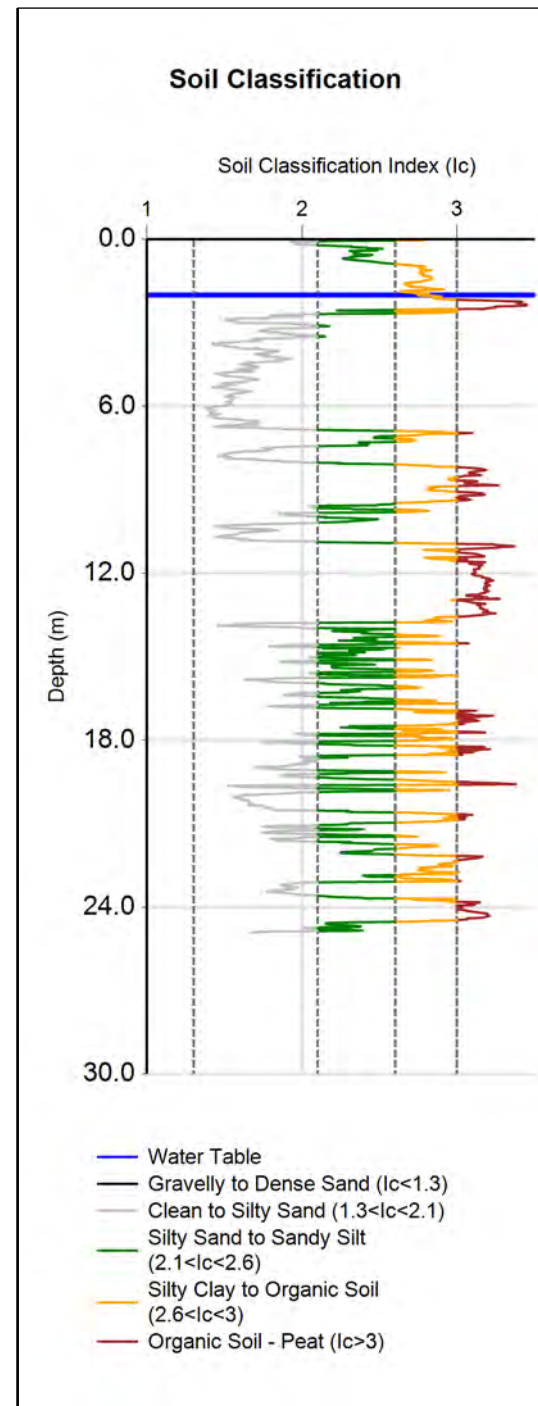
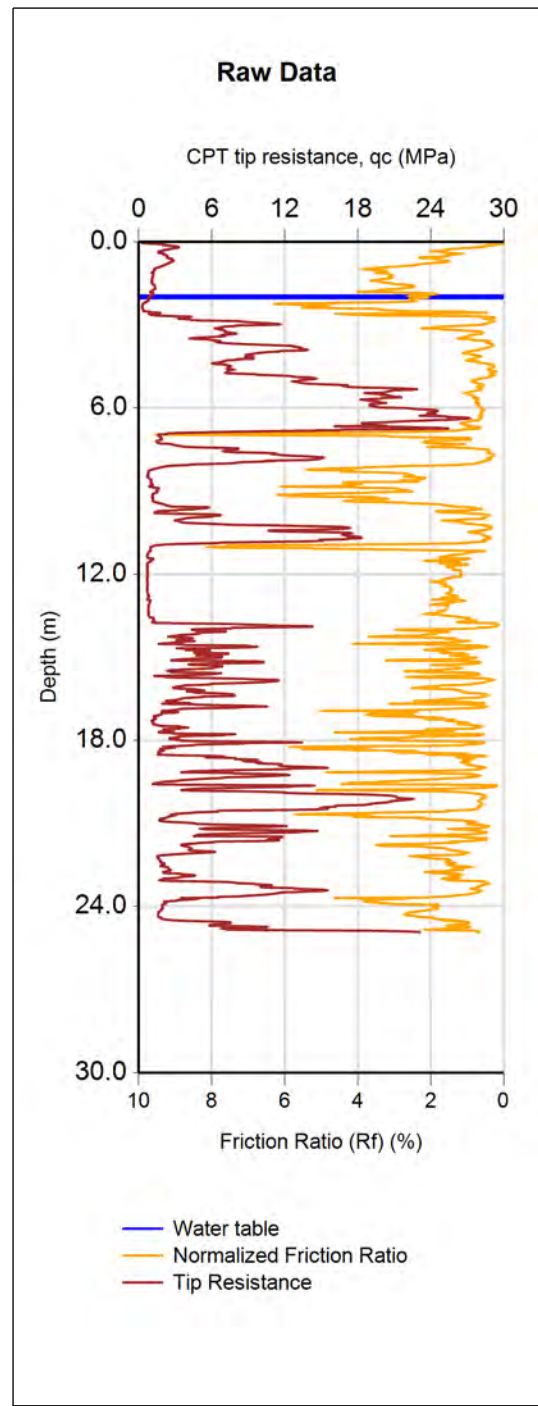
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CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m ³)	
CPT09	60507	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT10	60509	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT11	60510	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	
CPT12	60511	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18	

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedence cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60507	60509	60510	60511
CPT Name	CPT09	CPT10	CPT11	CPT12
PGA	0.33078g	0.33078g	0.33078g	0.33078g
Magnitude	6.9	6.9	6.9	6.9
Depth to groundwater	2.6m	2.6m	2.6m	2.6m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	15.78m	19.34m	15.14m	14.98m
Maximum depth of analysis	15.78m	19.34m	15.14m	14.98m
RL	n/a	n/a	n/a	n/a



(Assumed pre-drill values)

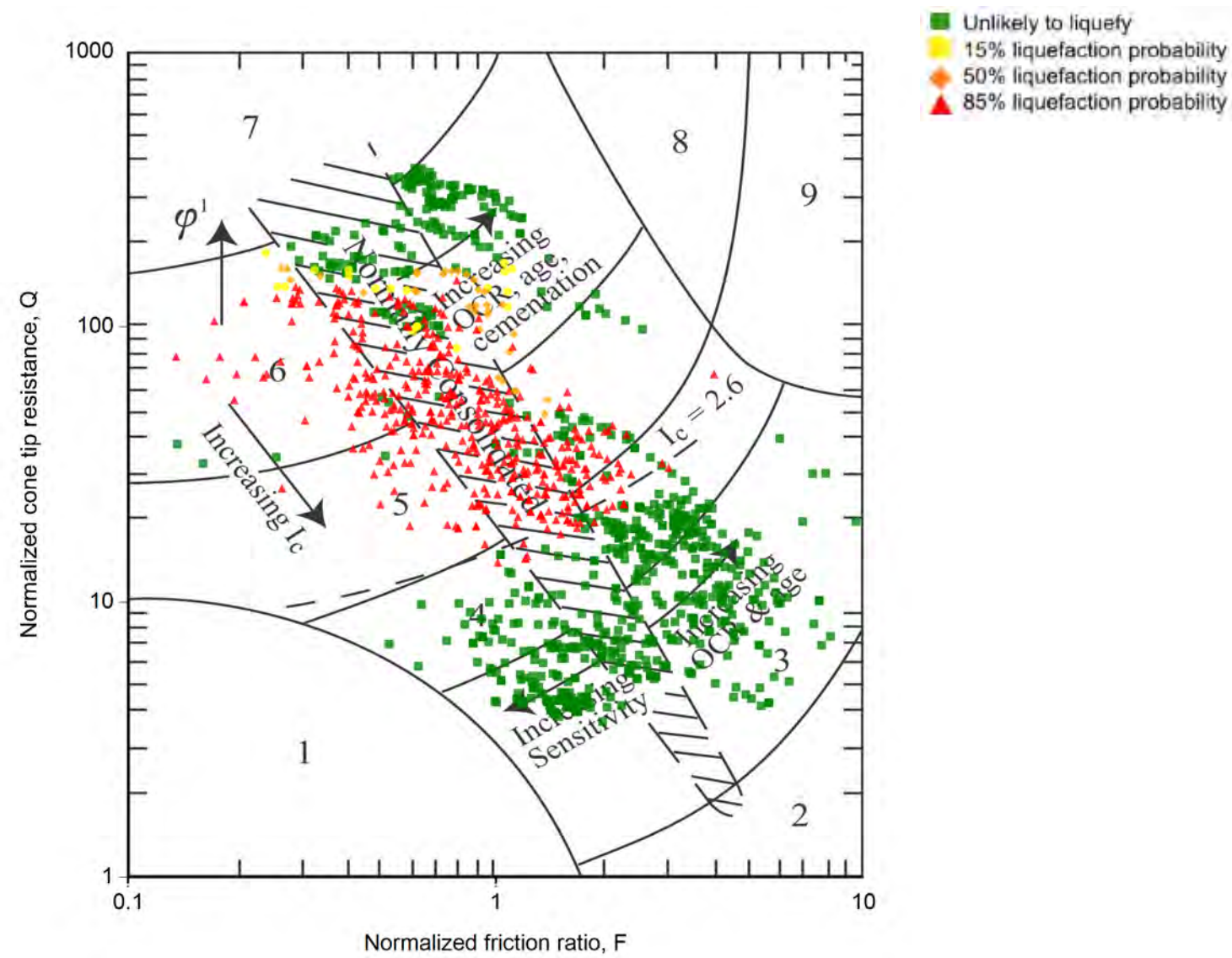
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT13	60512	10/02/2016	User Specified	6.9	0.3308	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	230	9.8	14	23	2.7	11						
	50%	220	9.4	10	21	2.7	8						
	85%	201	8.8	7	19	2.7	5						



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	ULS Liquefaction Assessment CPT 13-16

LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
		CHECKED	
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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
| 2. Organic soils - peats | 7. Gravelly sand to dense sand |
| 3. Clays - silty clay to clay | 8. Very stiff sand to clayey sand * |
| 4. Silt mixtures - clayey silt to silty clay | 9. Very stiff, fine grained * |
| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

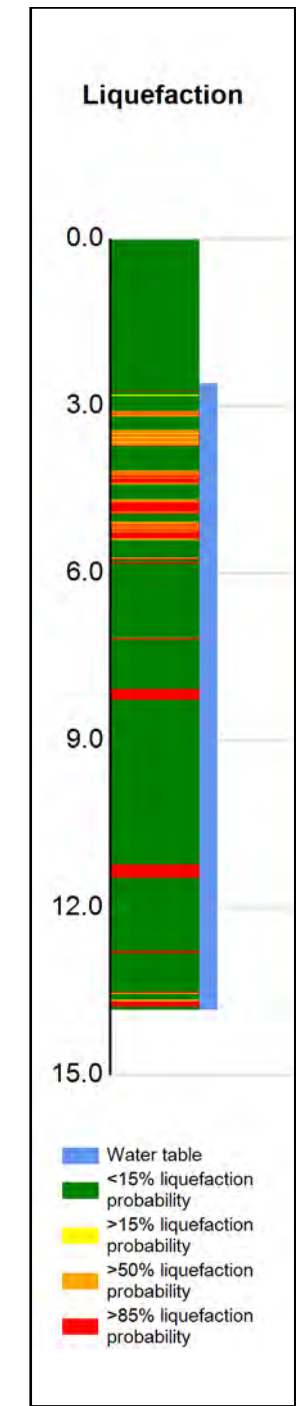
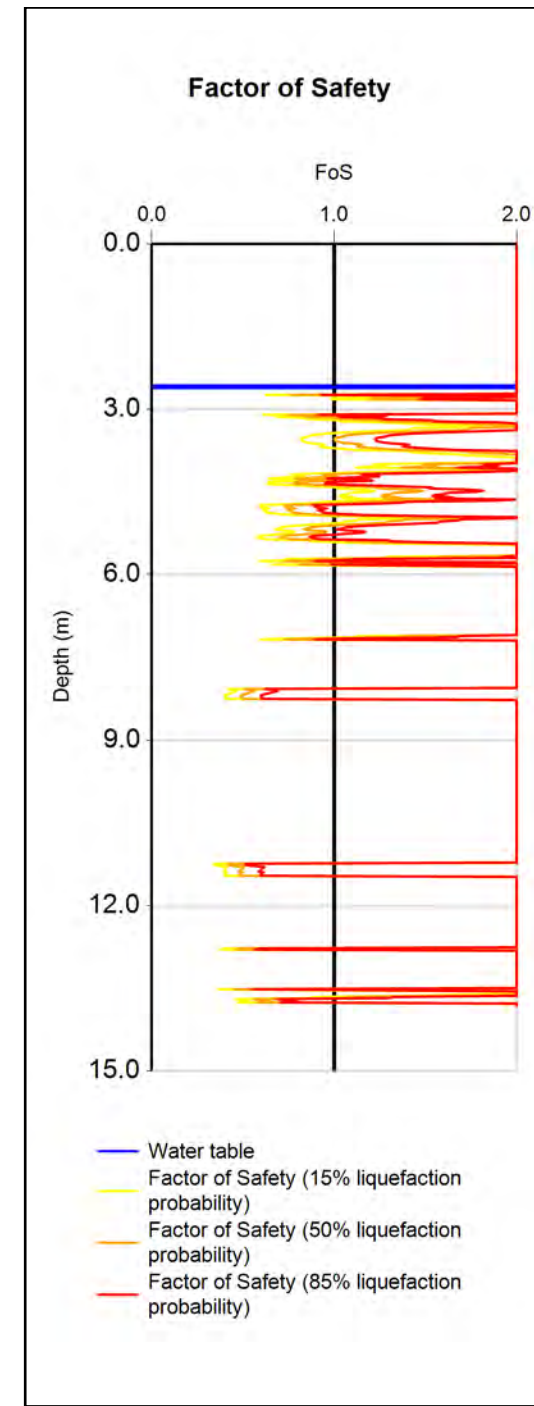
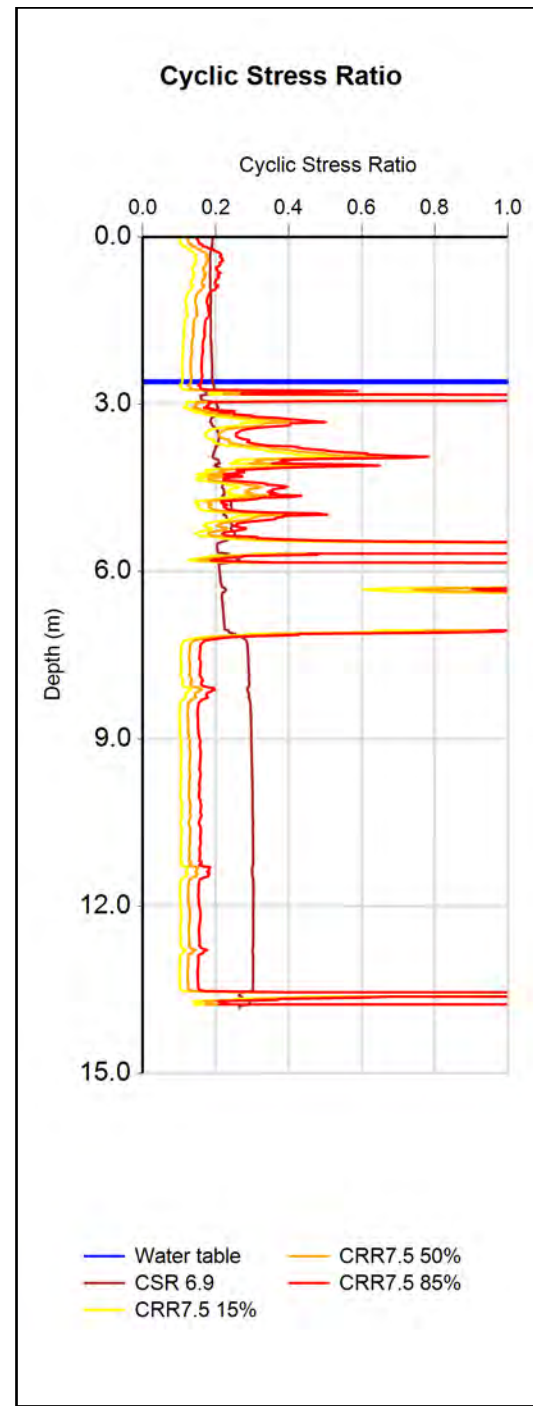
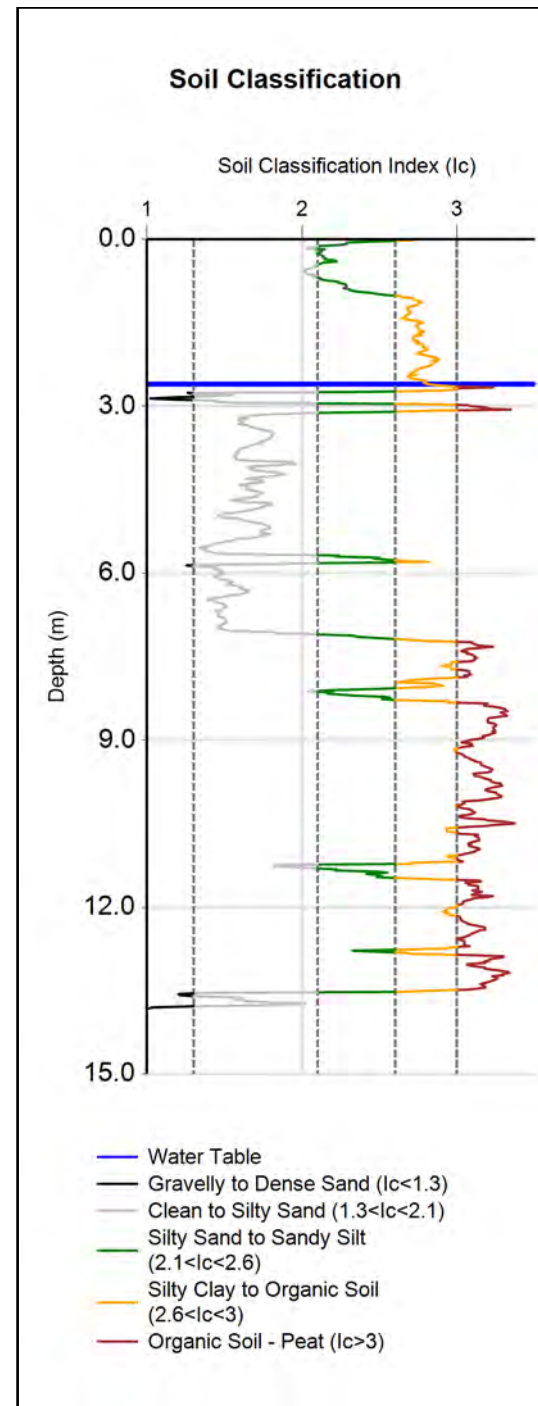
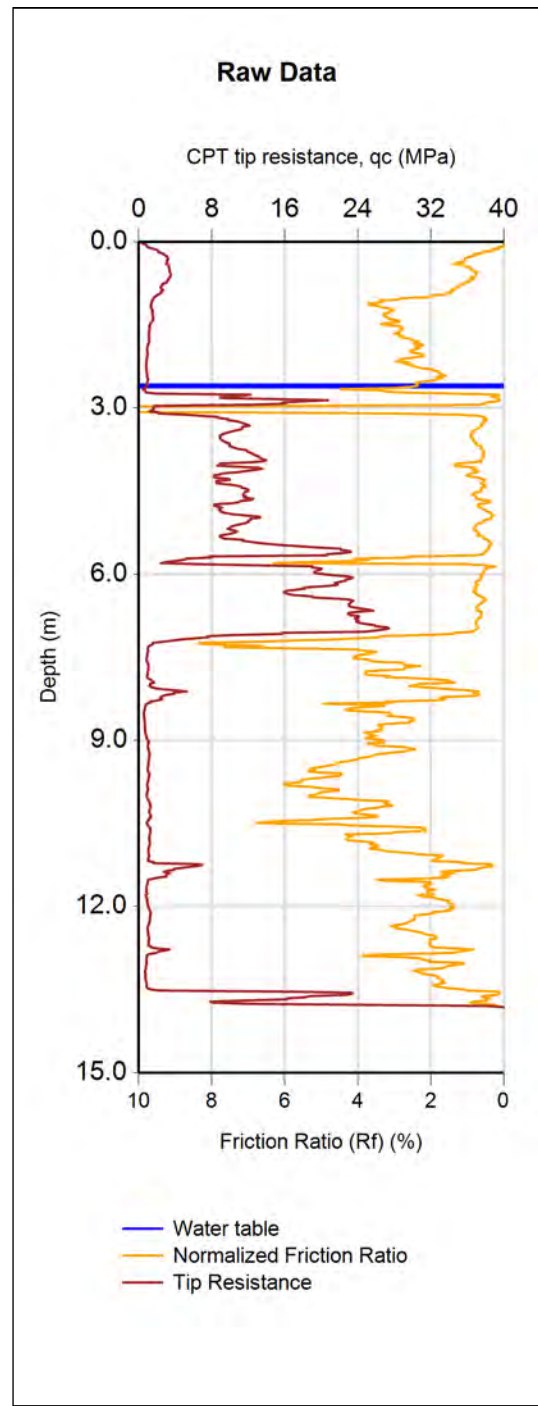
CPT-based soil behavior type classification chart by Robertson (1990)



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	ULS Liquefaction Assessment CPT 13-16

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(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT14	60514	9/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	43	2.1	4	8	3.1	2						
	50%	34	1.4	2	6	4.2	1						
	85%	25	1	1	4	4.3	1						



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CLIENT, PROJECT
Hastings District Council
Housing Rezone

TITLE
ULS Liquefaction Assessment CPT 13-16

LOCATION
Havelock Road/
Howard Street

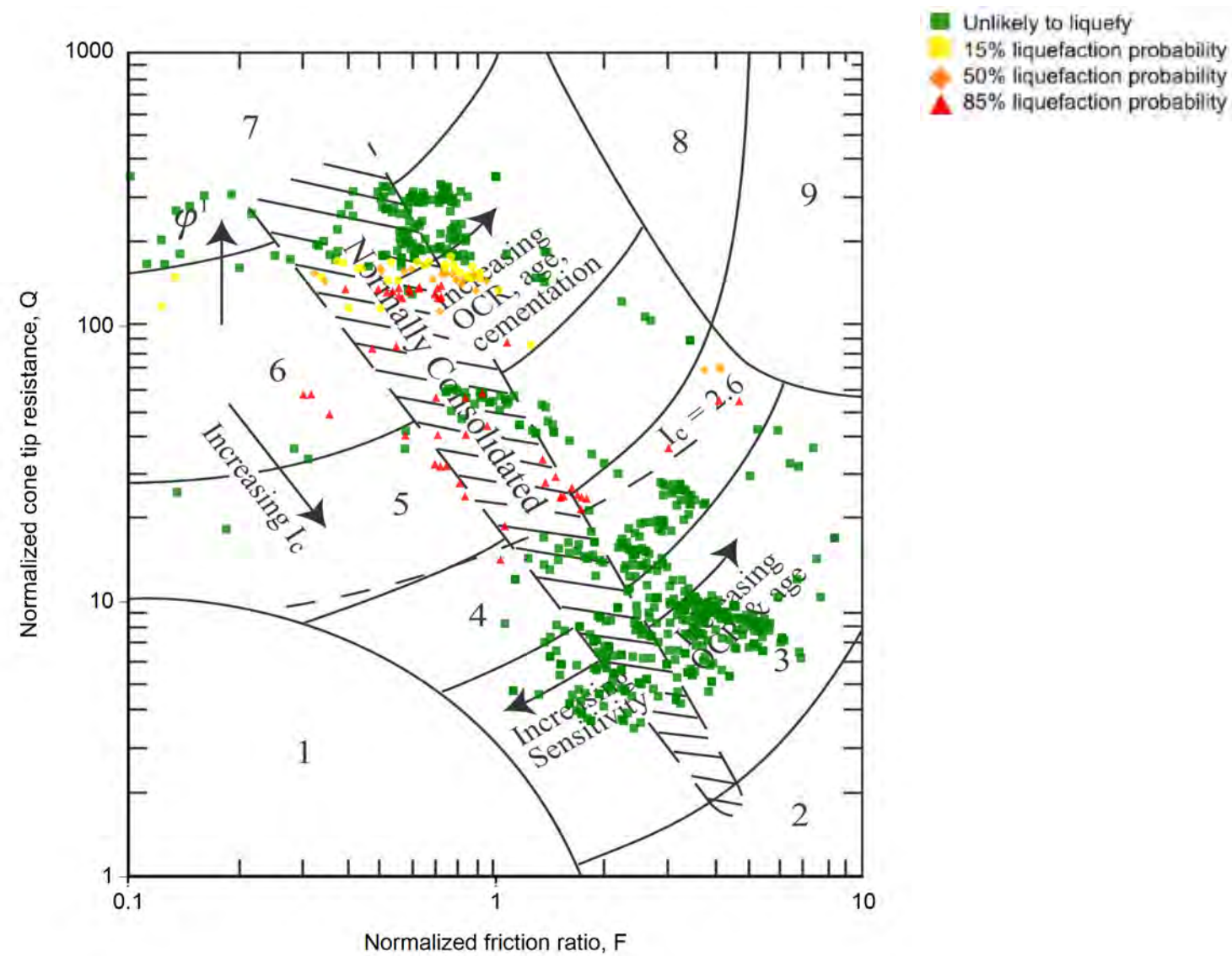
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31464.1000

DATE
4/03/2016

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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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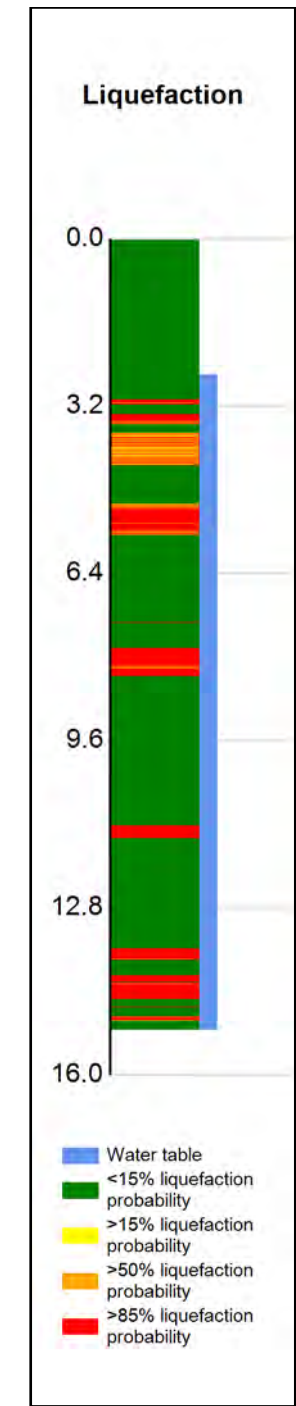
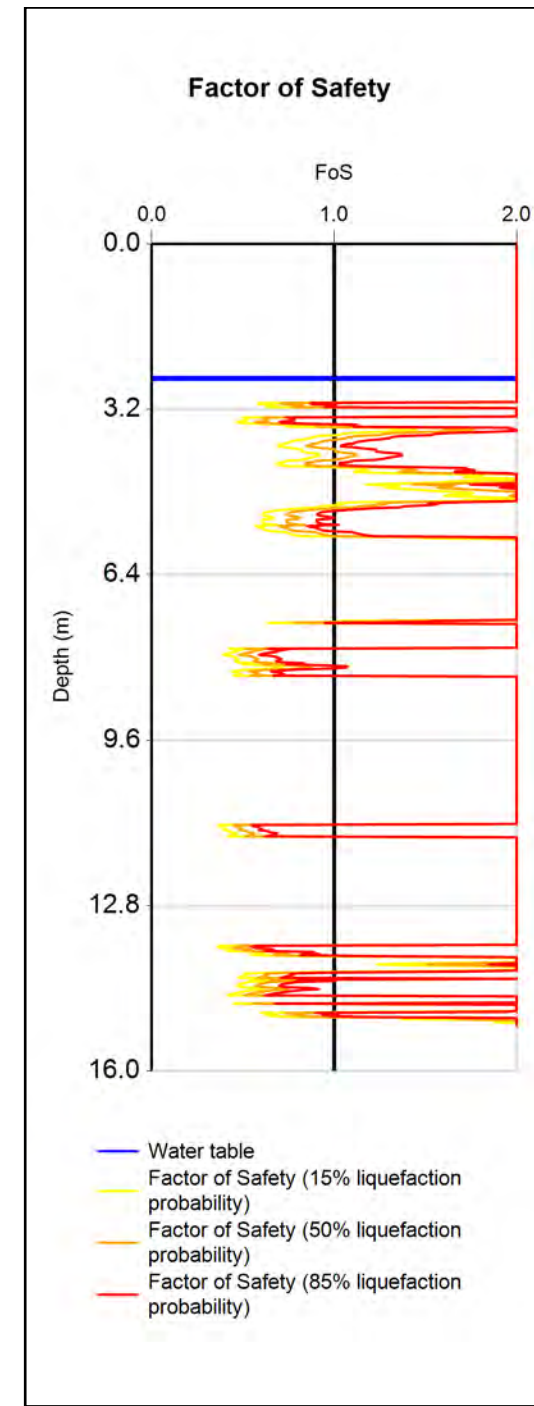
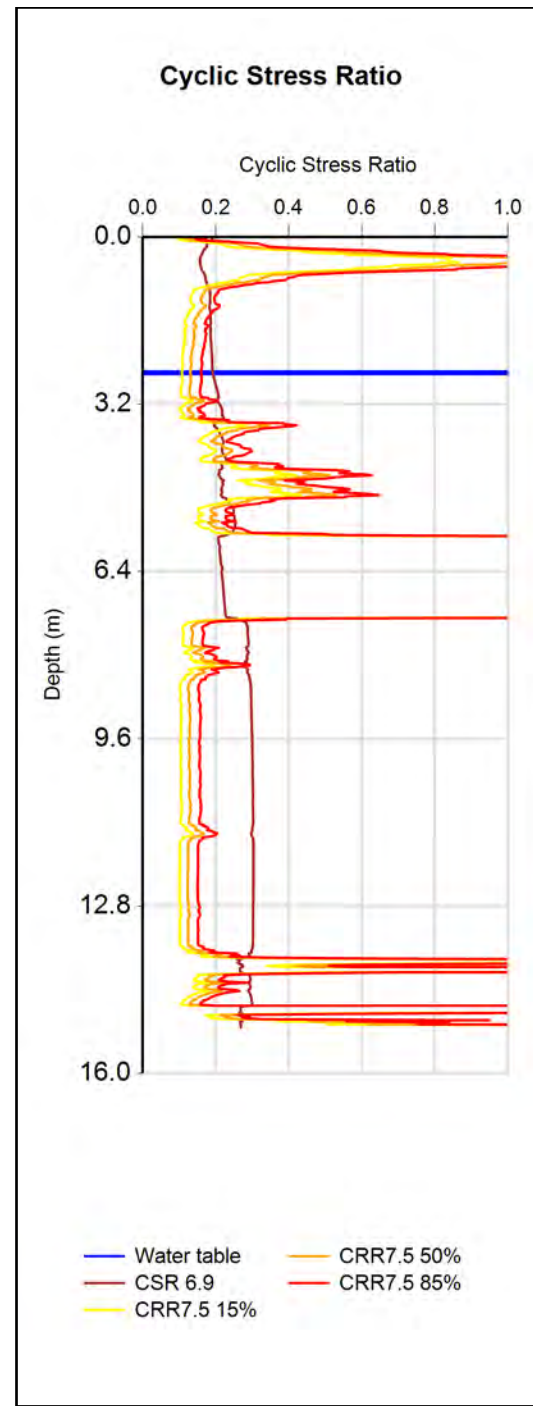
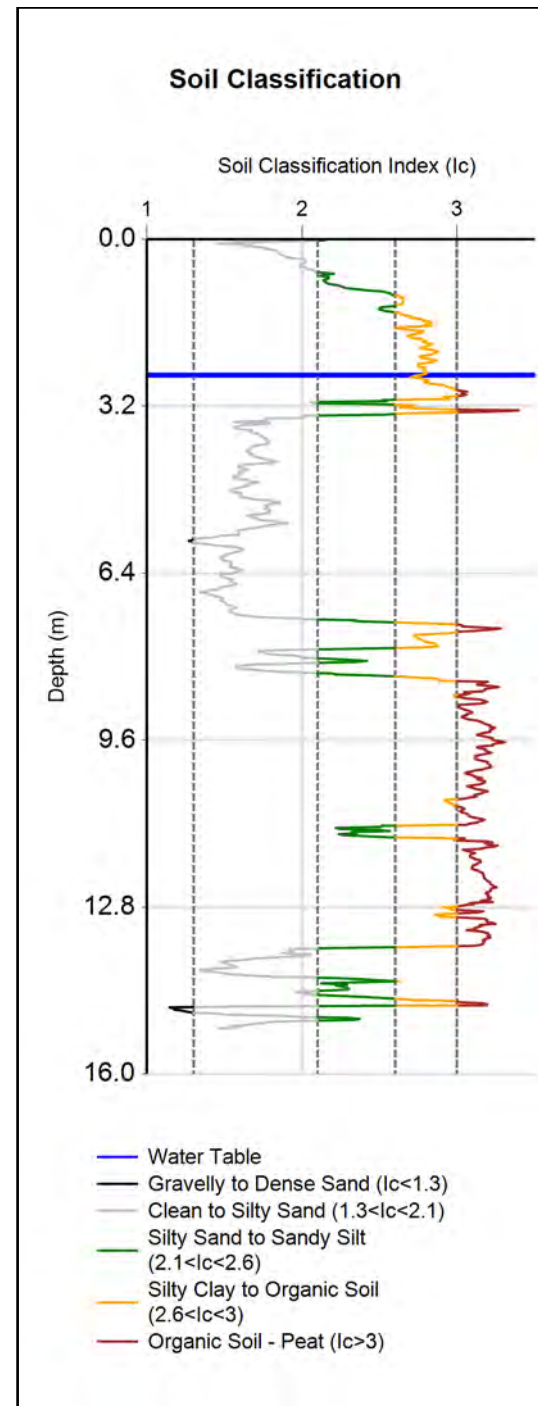
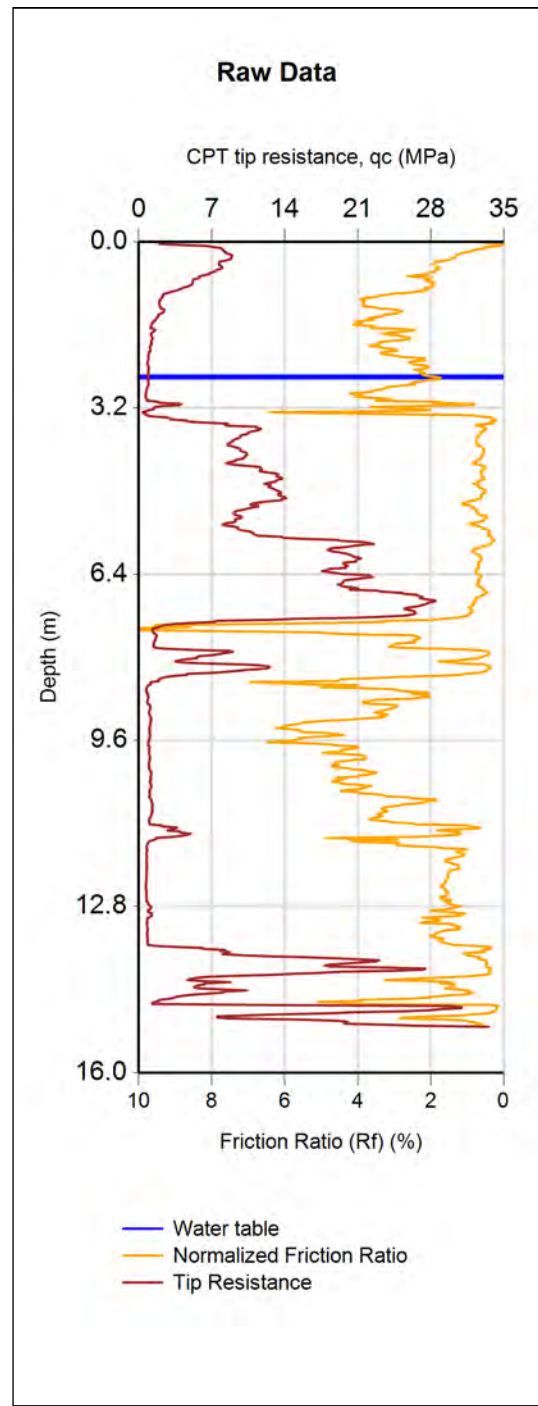
CPT-based soil behavior type classification chart by Robertson (1990)



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	ULS Liquefaction Assessment CPT 13-16

LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
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(Assumed pre-drill values)

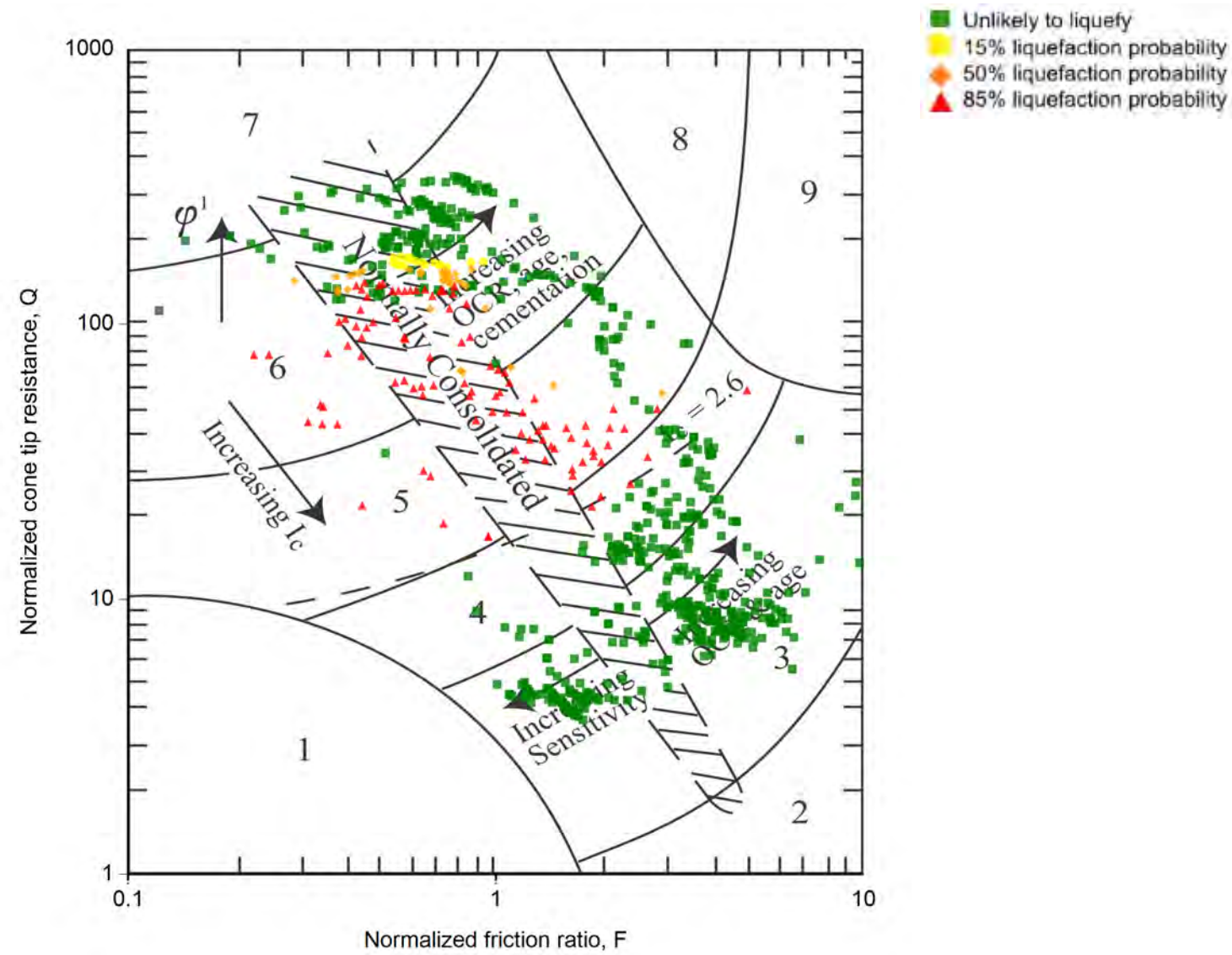
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT15	60515	10/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0.02	2	0.01	18
			Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara				
OUTPUT		15%	68	3.1	7	11	3.2	4					
		50%	58	2.7	4	9	3.2	2					
		85%	46	2	2	6	3.4	1					



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	ULS Liquefaction Assessment CPT 13-16


LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
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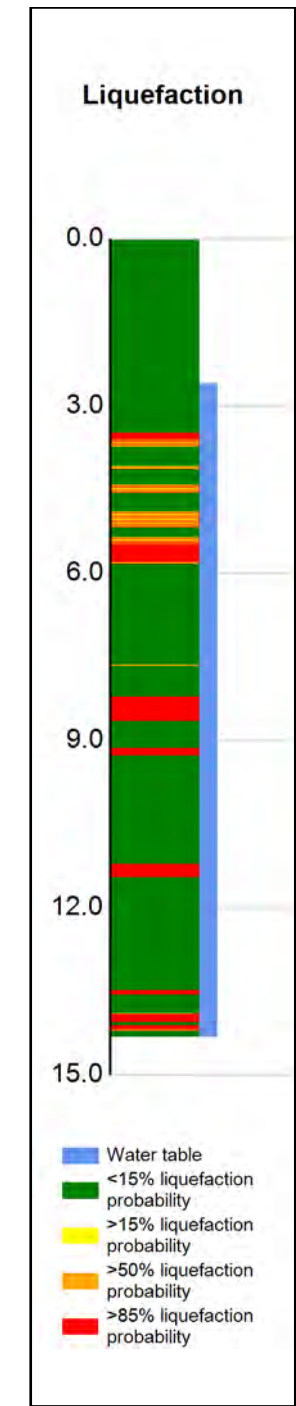
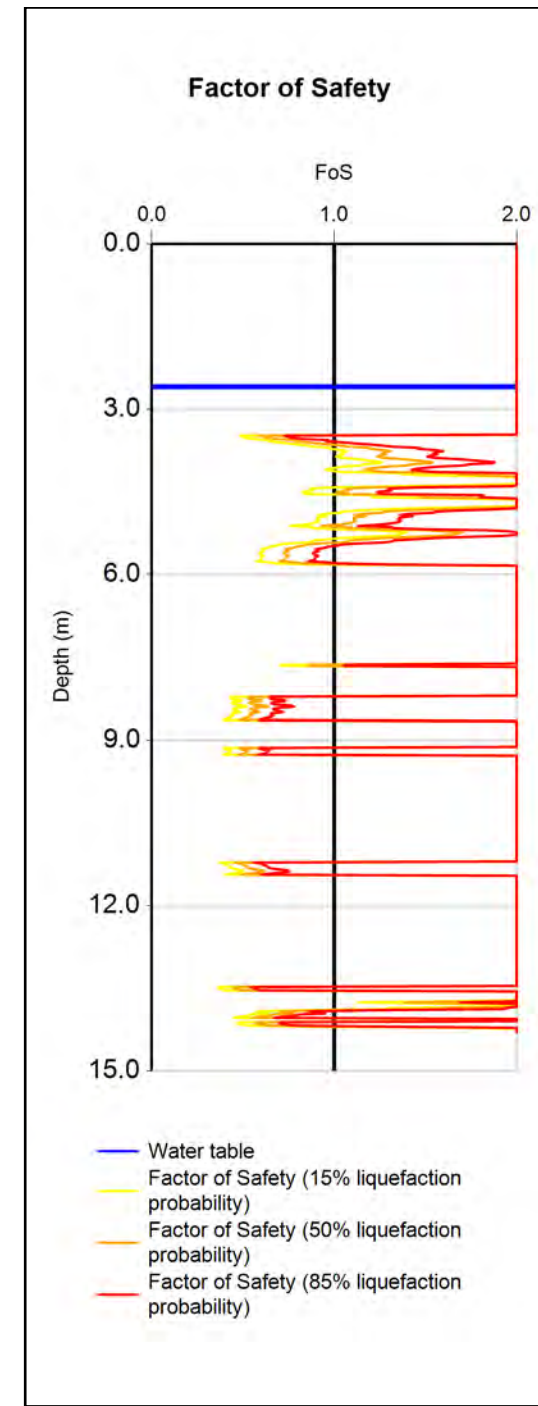
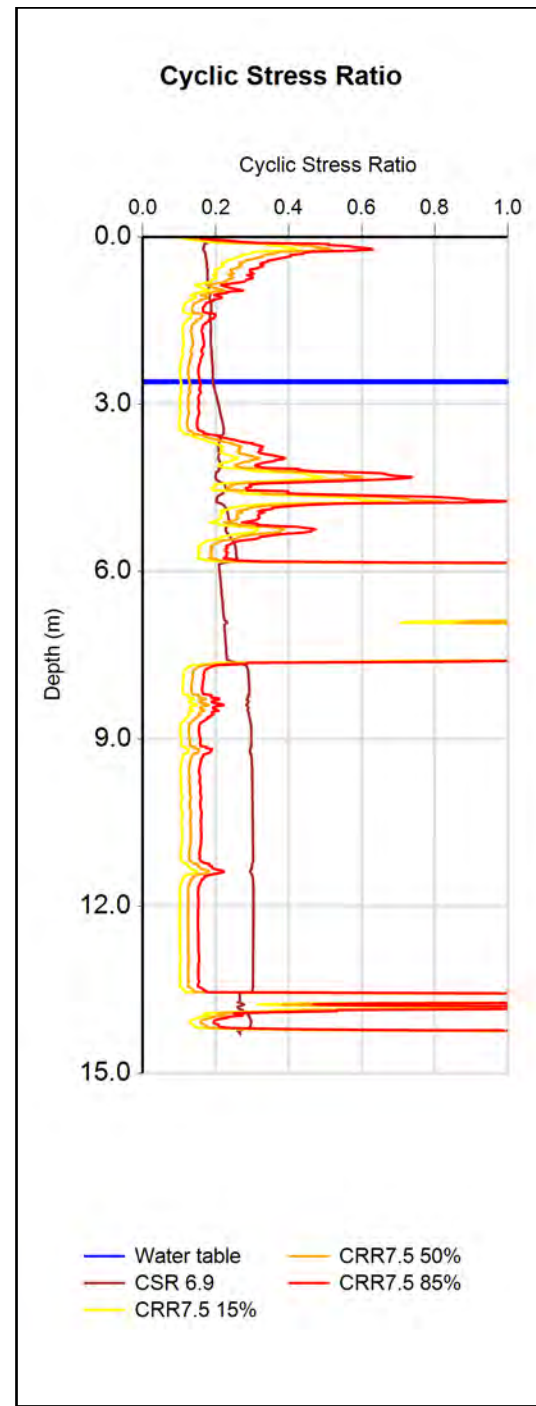
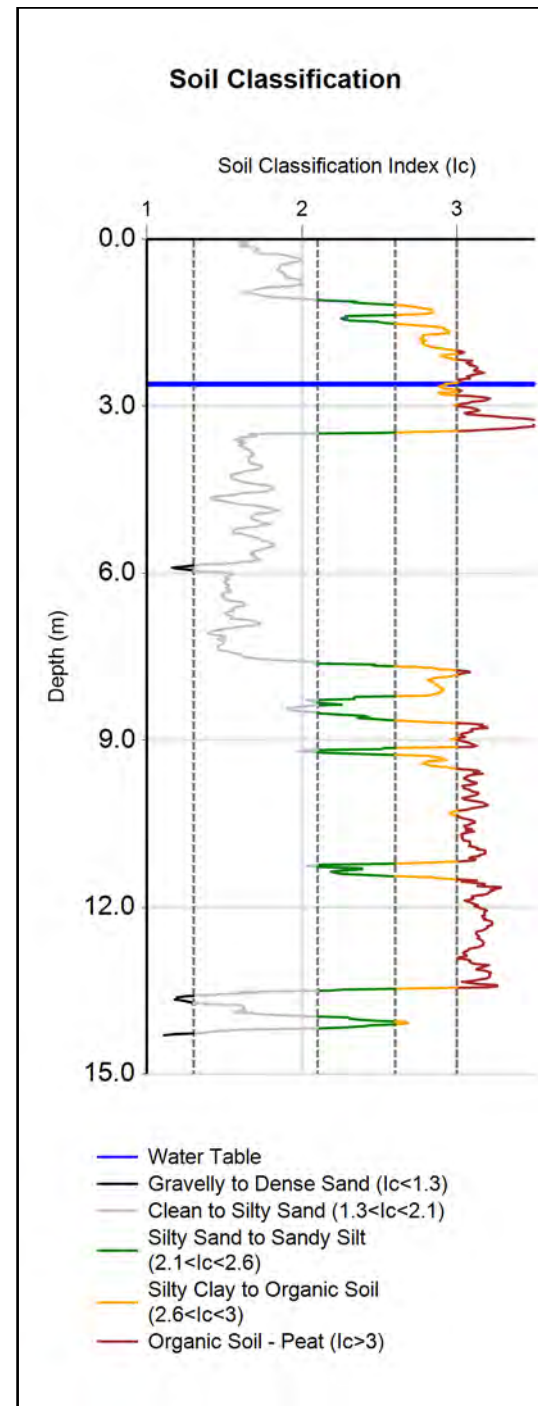
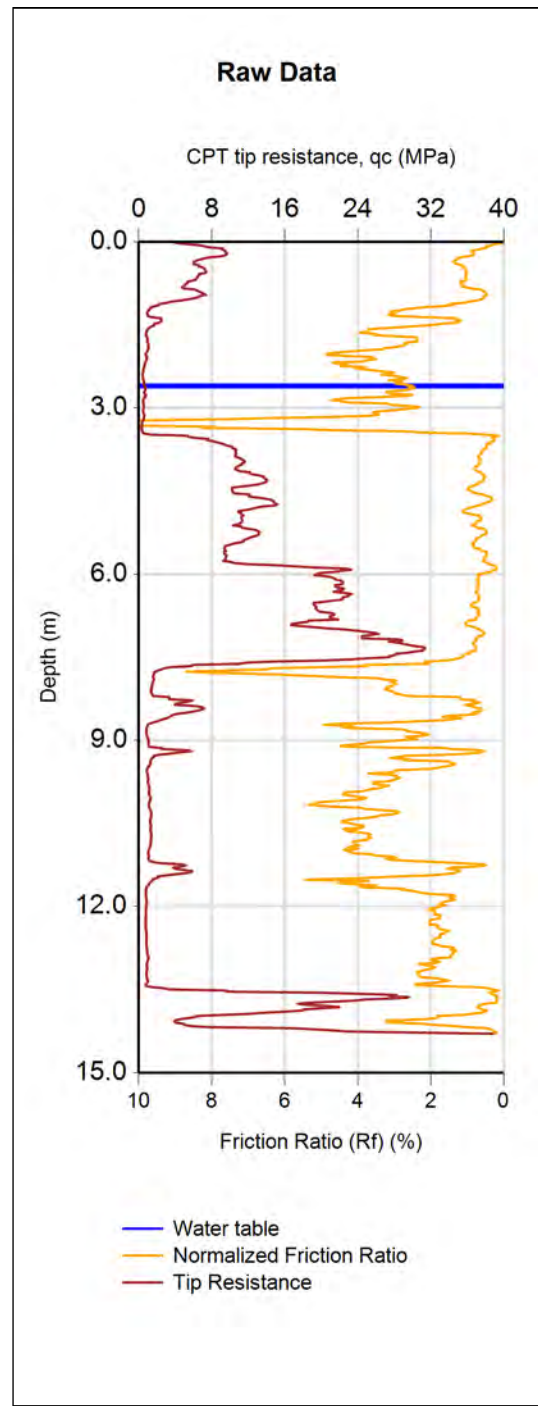


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|--|-------------------------------------|
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE ULS Liquefaction Assessment CPT 13-16	JOB NUMBER 31464.1000	ANALYSED khf



(Assumed pre-drill values)

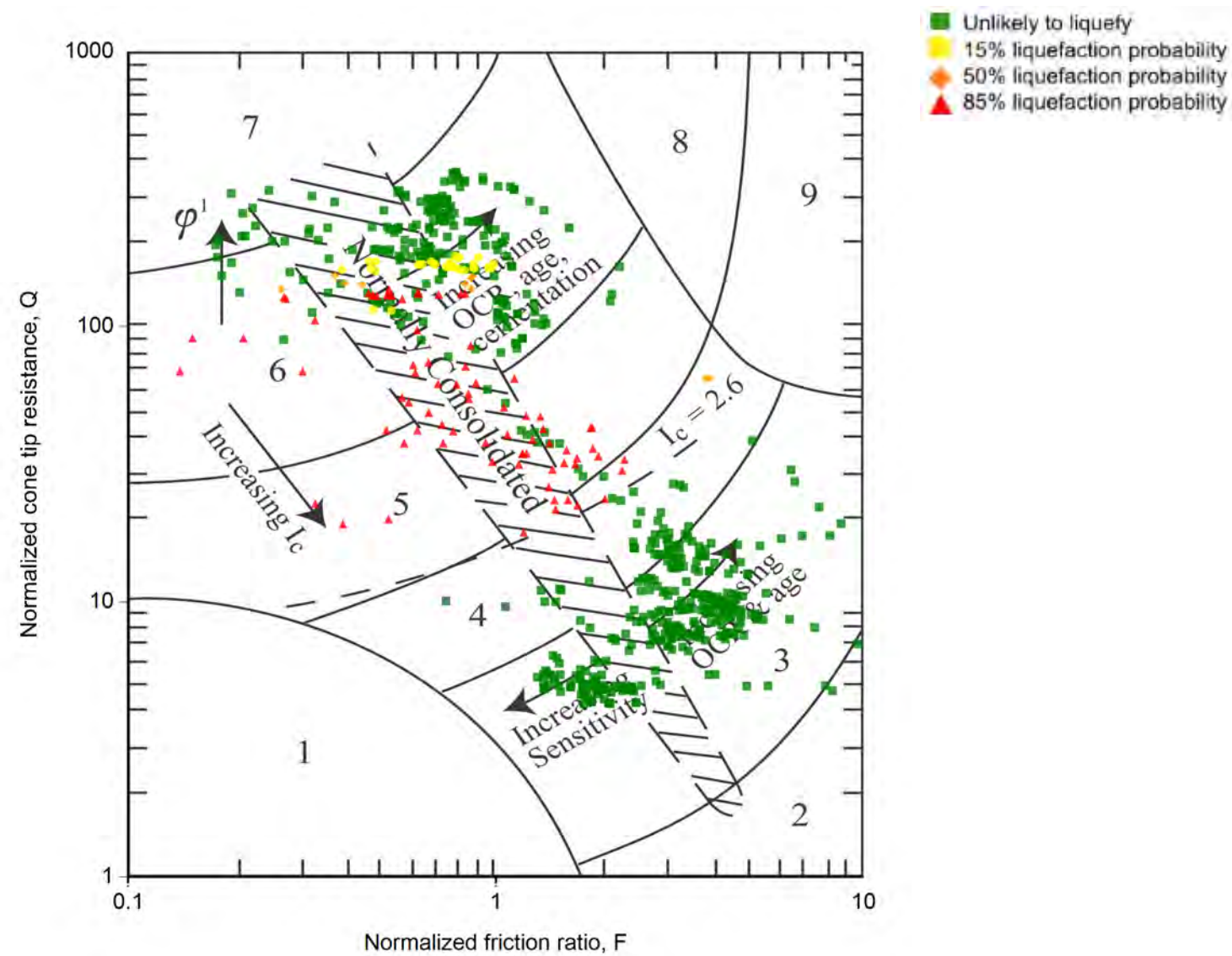
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT16	60516	10/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
Exceedance Probability S - Calculated Settlement (mm) CTL - Cumulative Thickness of Liquefaction (m) LPI - Liquefaction Potential Index LSN - Liquefaction Severity Number CT - Crust Thickness (m) LPI Ishihara													
OUTPUT	15%	51	2.4	5	8	3.6	3						
	50%	44	1.7	3	6	3.6	2						
	85%	37	1.5	2	5	3.6	1						



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CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	ULS Liquefaction Assessment CPT 13-16

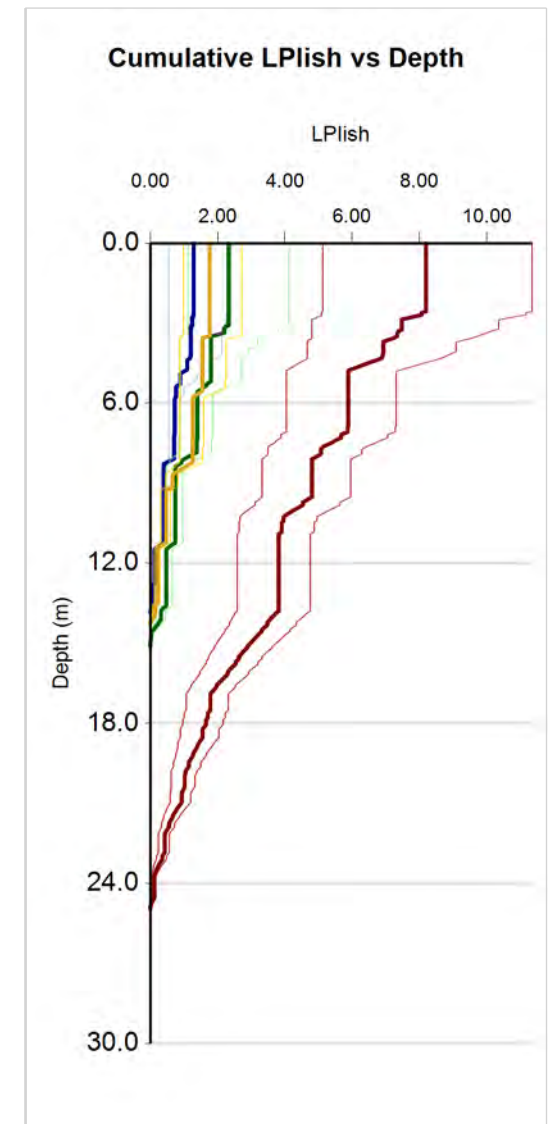
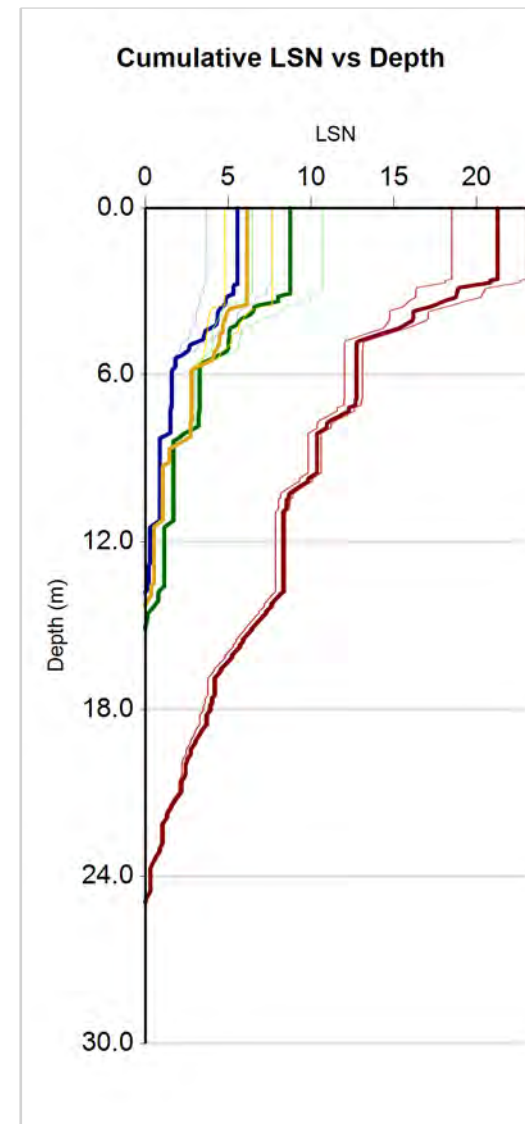
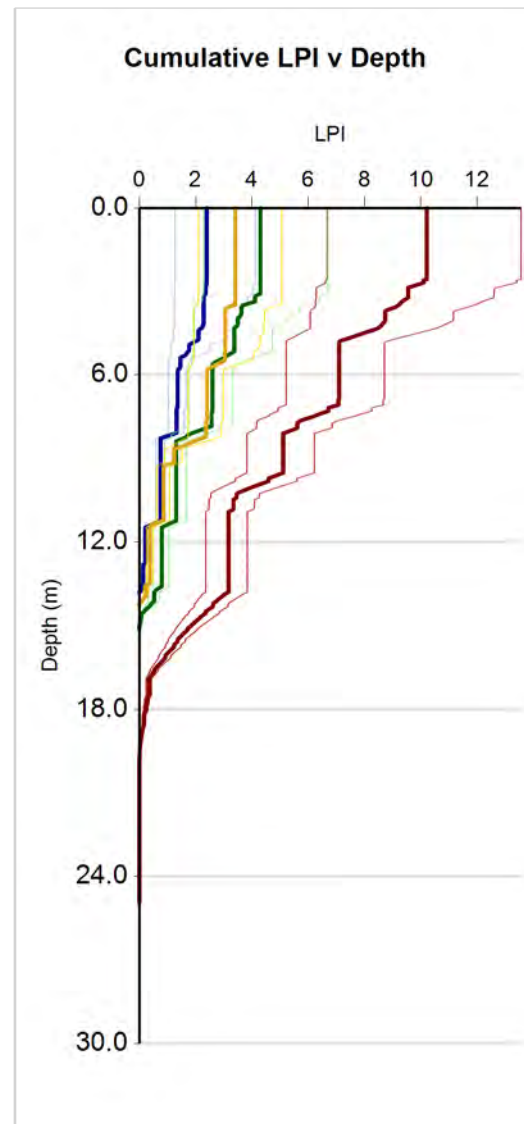
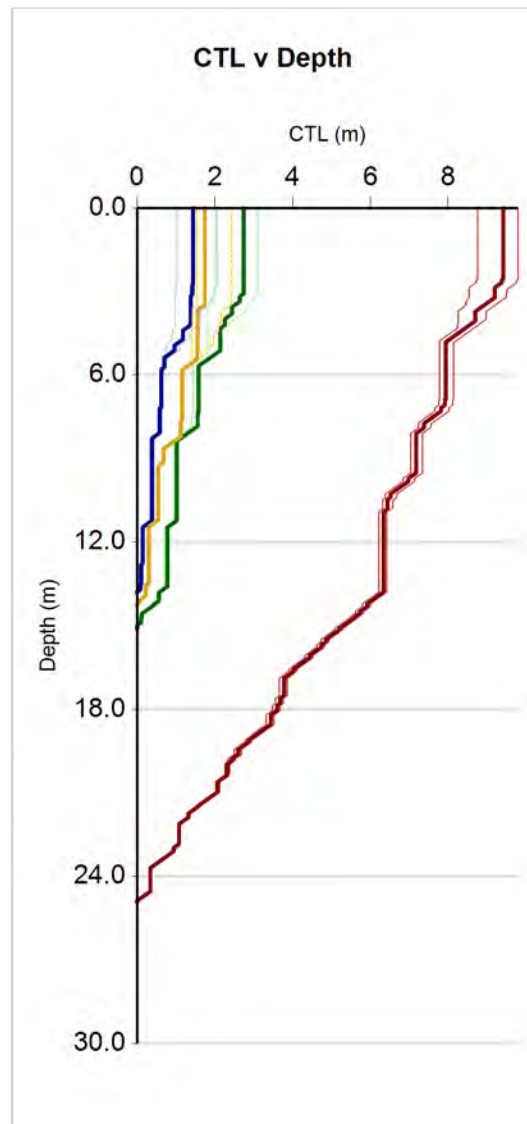
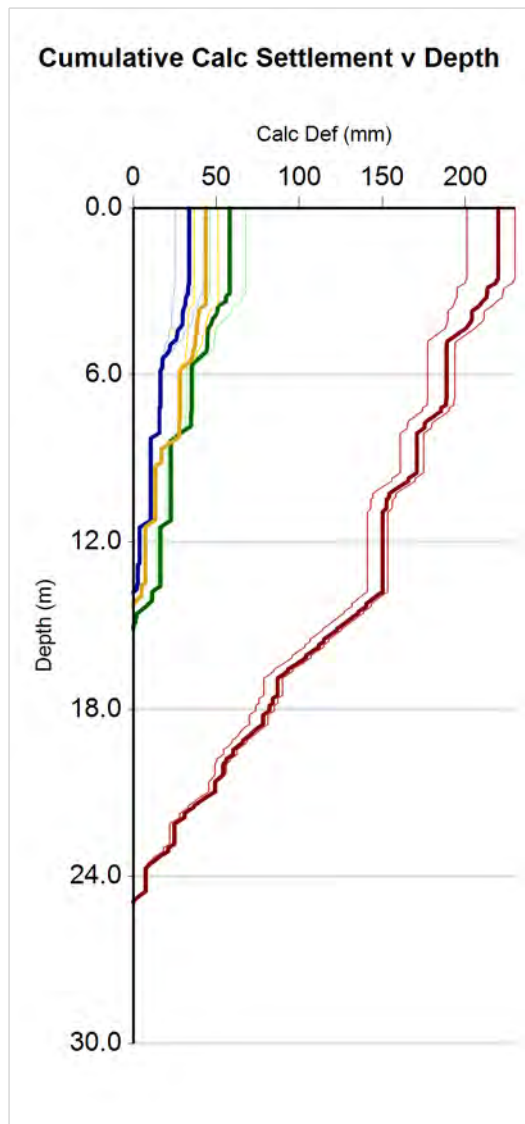
LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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|--|-------------------------------------|
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| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

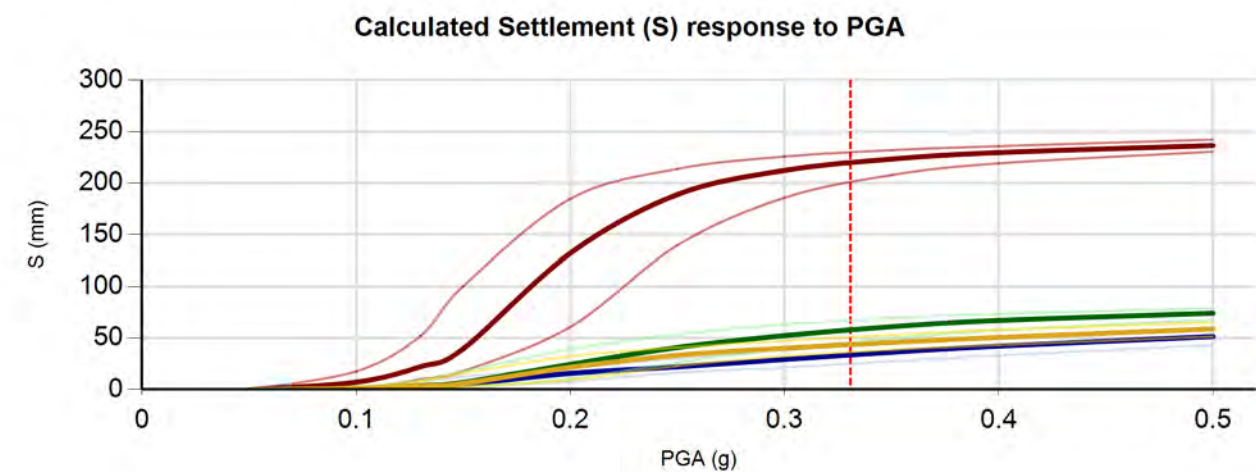
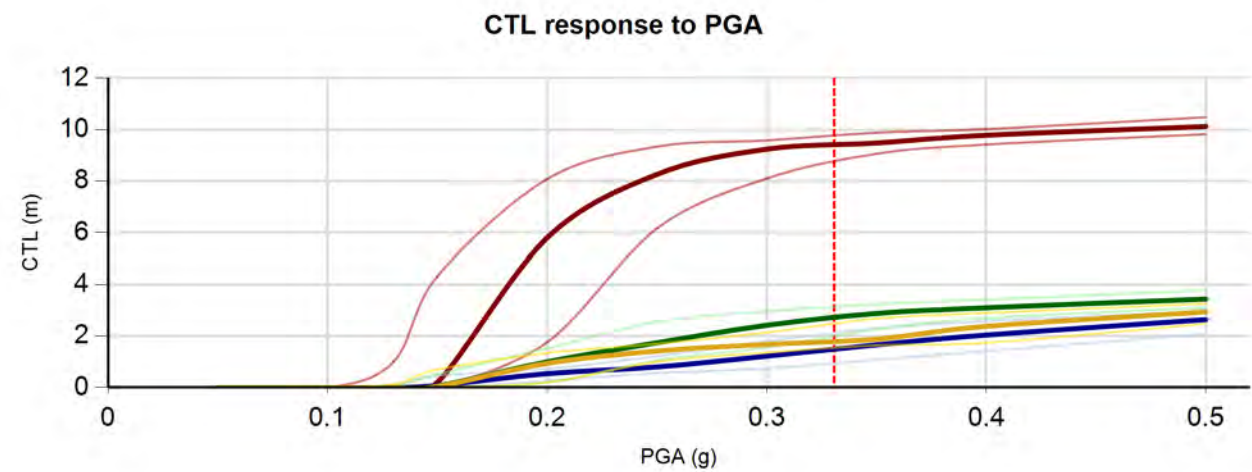
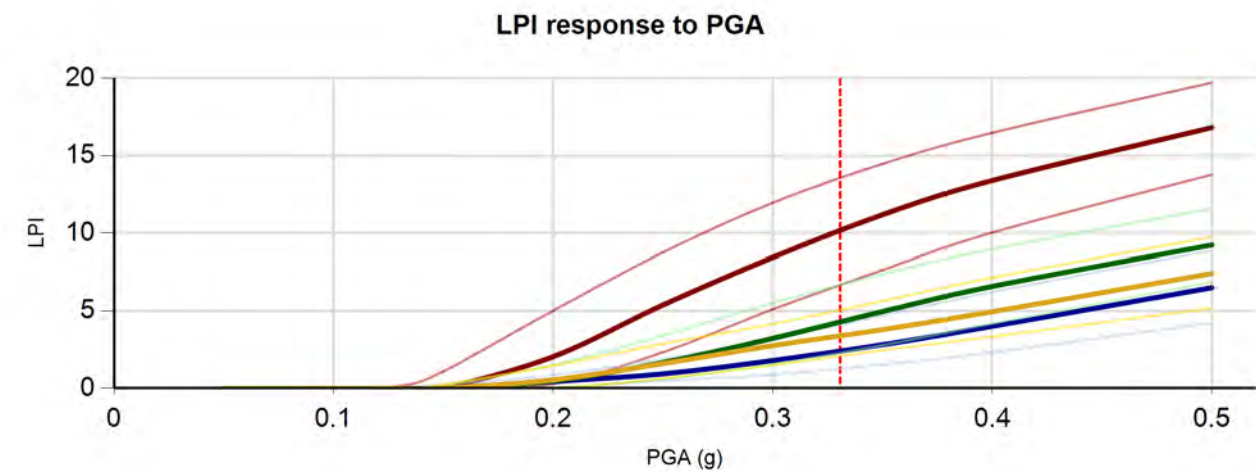
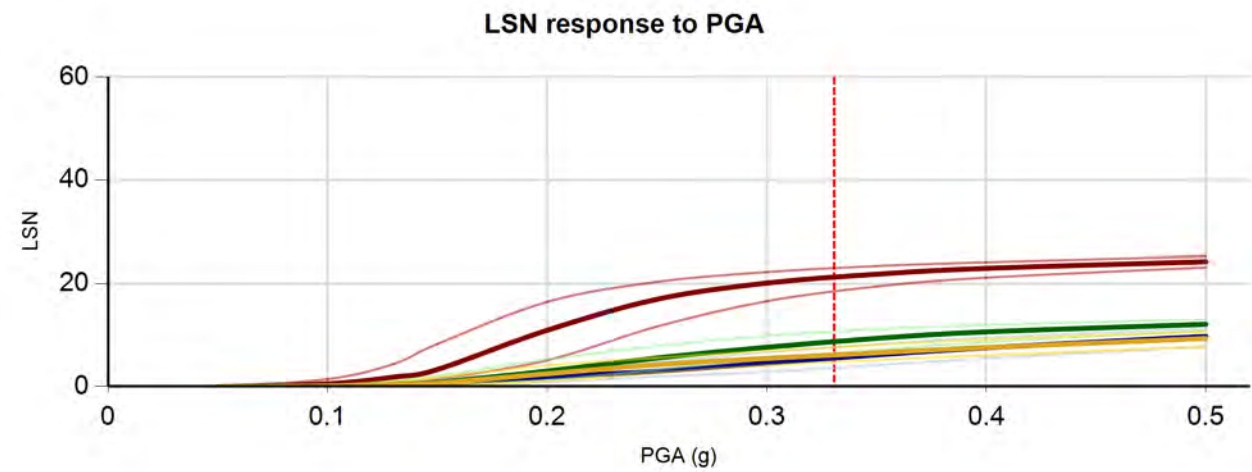
CPT-based soil behavior type classification chart by Robertson (1990)



(Assumed pre-drill values)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m³)
CPT13	60512	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT14	60514	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT15	60515	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT16	60516	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

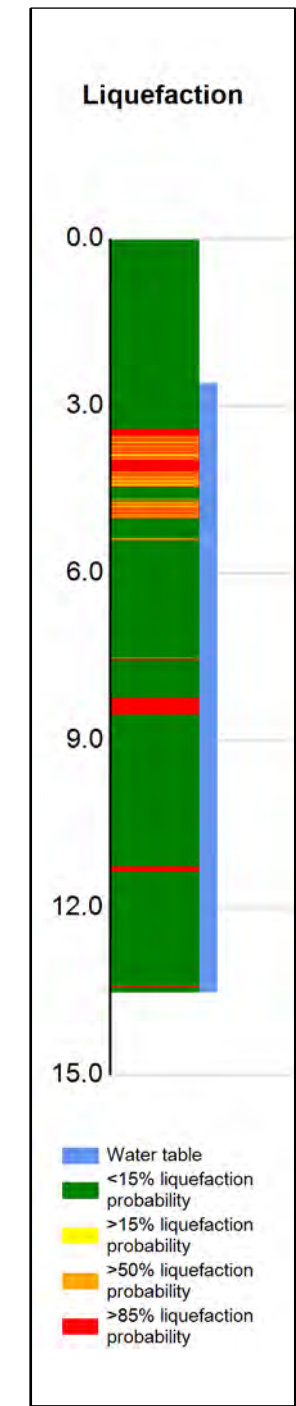
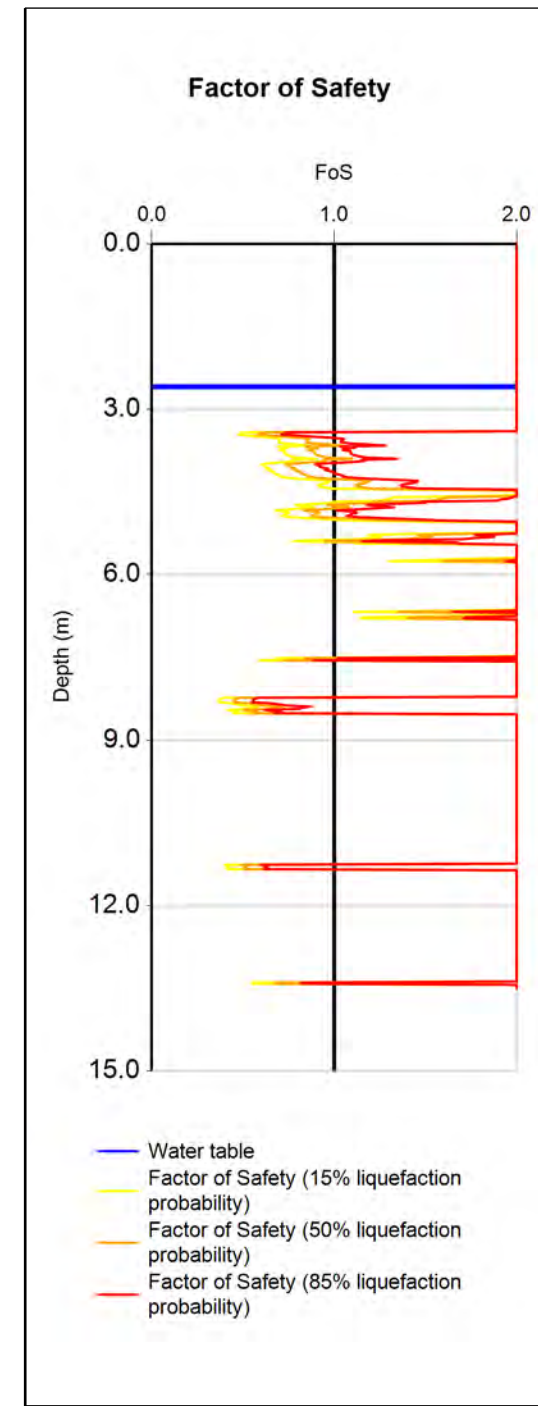
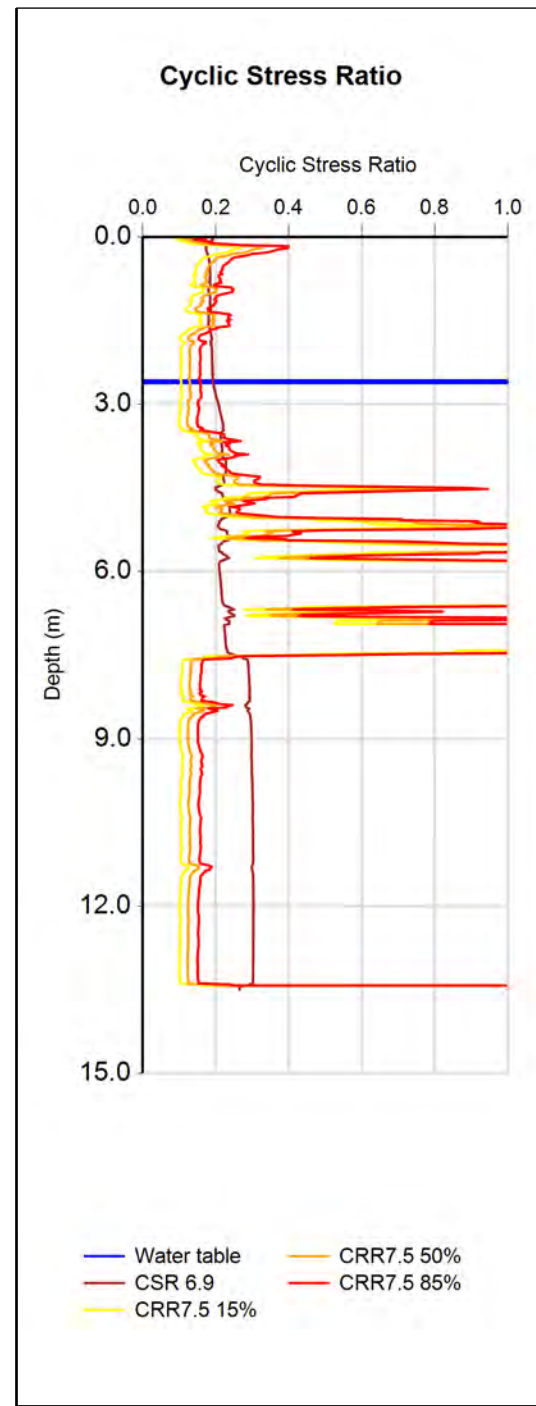
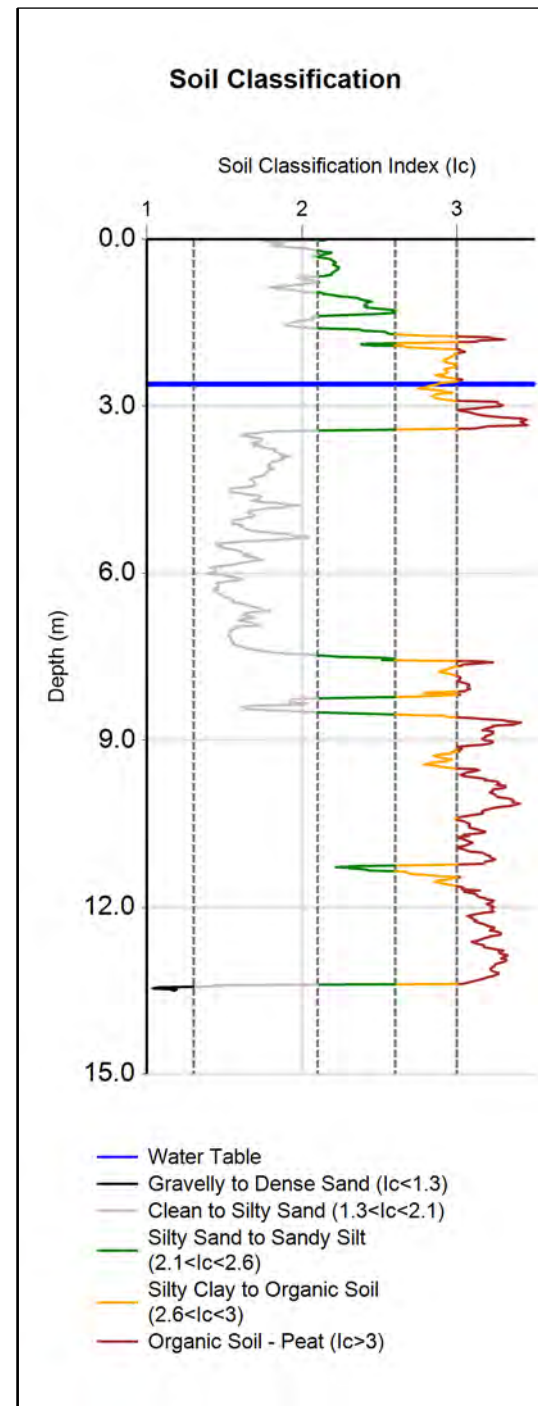
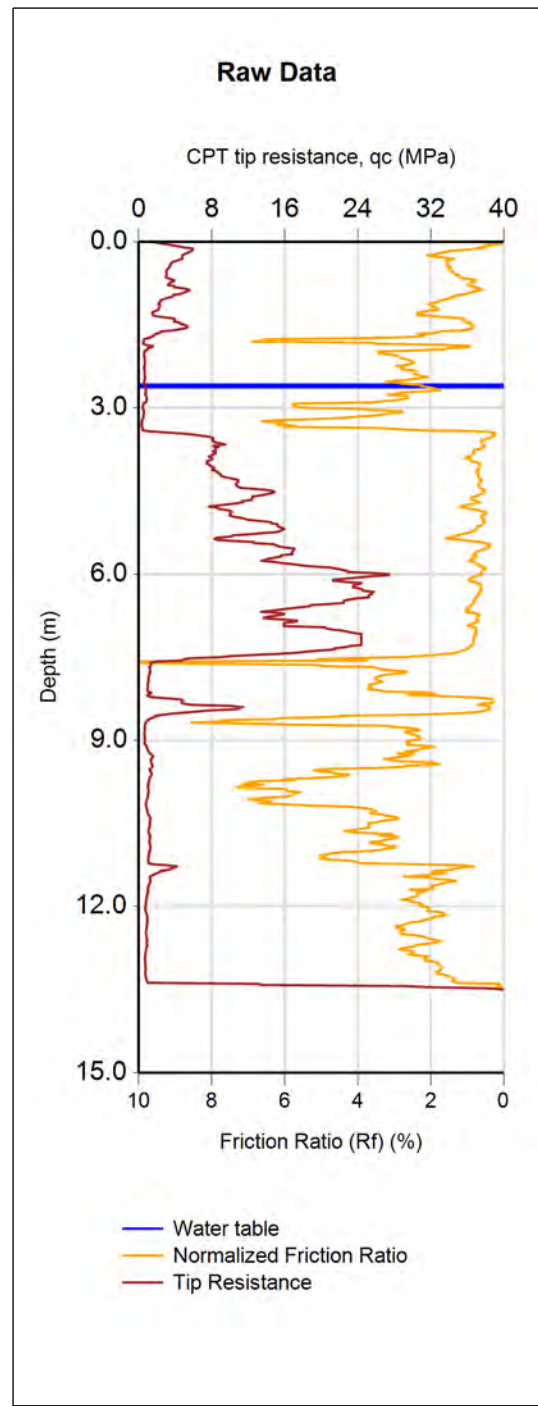
CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	(Assumed pre-drill values)		
										Qc (MPa)	Fs (MPa)	É£ (kN/m³)
CPT13	60512	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT14	60514	9/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT15	60515	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT16	60516	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60512	60514	60515	60516
CPT Name	CPT13	CPT14	CPT15	CPT16
PGA	0.3308g	0.3308g	0.3308g	0.3308g
Magnitude	6.9	6.9	6.9	6.9
Depth to groundwater	2m	2.6m	2.6m	2.6m
Predrill depth	0.02m	0m	0.02m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	24.96m	13.82m	15.12m	14.3m
Maximum depth of analysis	24.96m	13.82m	15.12m	14.3m
RL	n/a	n/a	n/a	n/a



(Assumed pre-drill values)

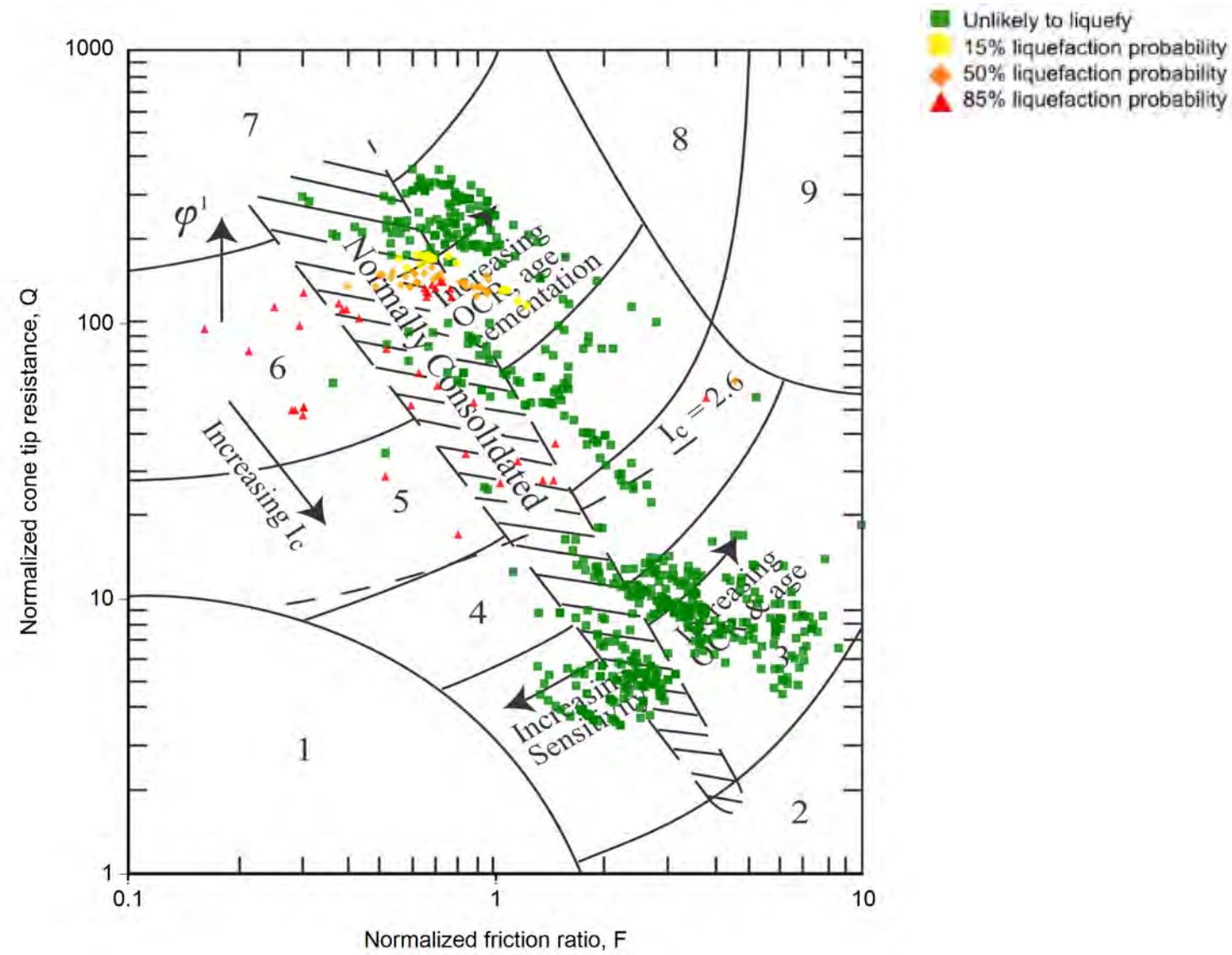
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT17	60517	10/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	38	1.9	4	8	3.5	3						
	50%	30	1.5	2	6	3.5	1						
	85%	21	0.8	1	4	3.5	0						



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CLIENT, PROJECT	Hastings District Council Housing Rezone
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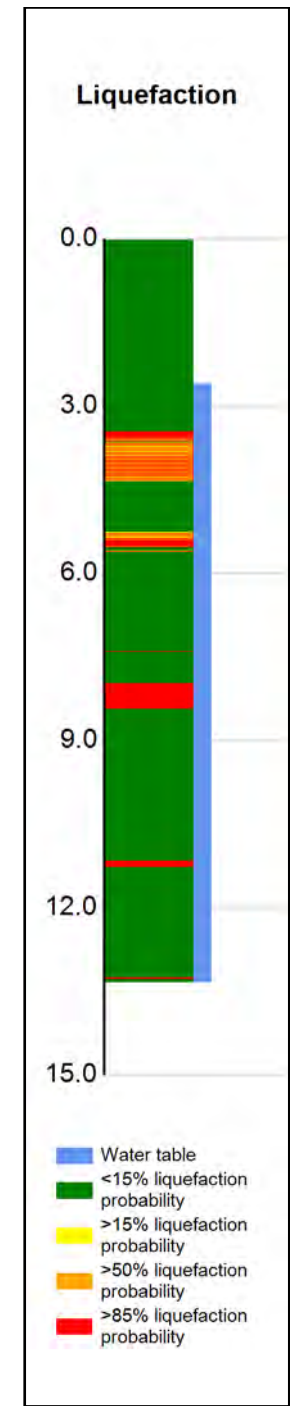
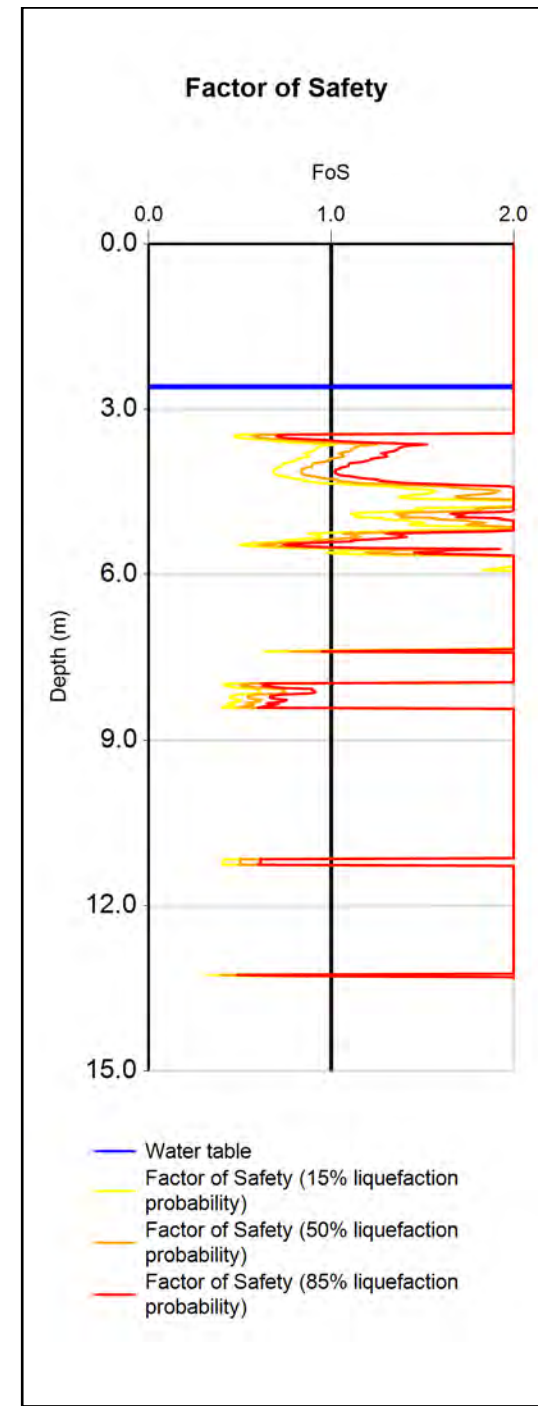
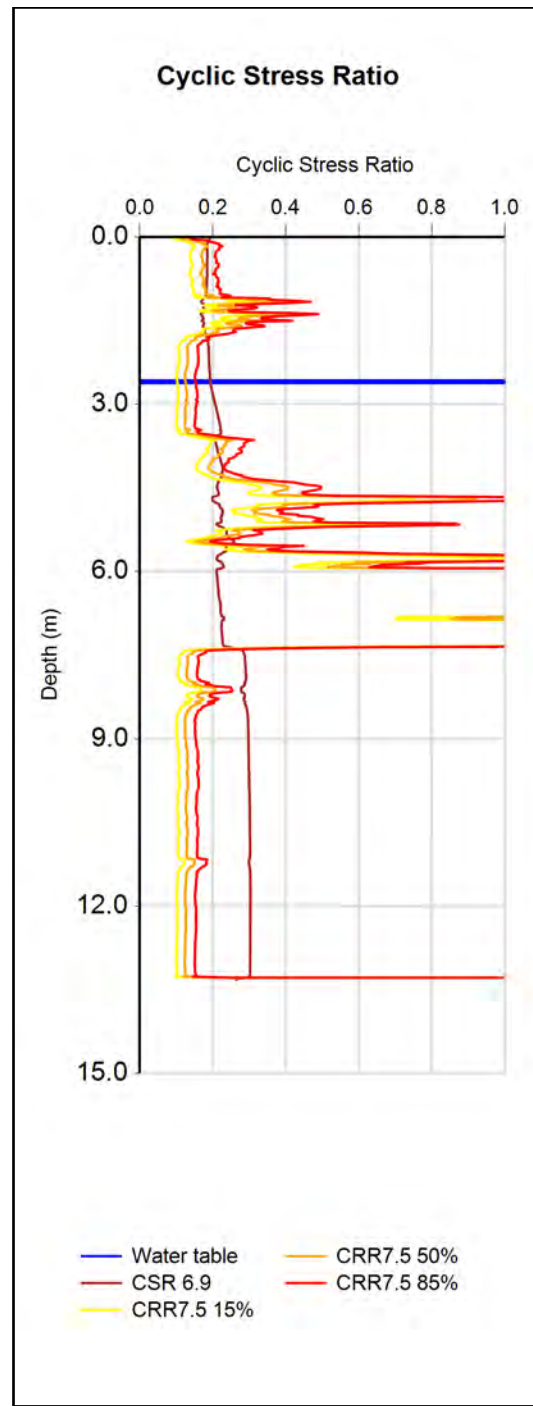
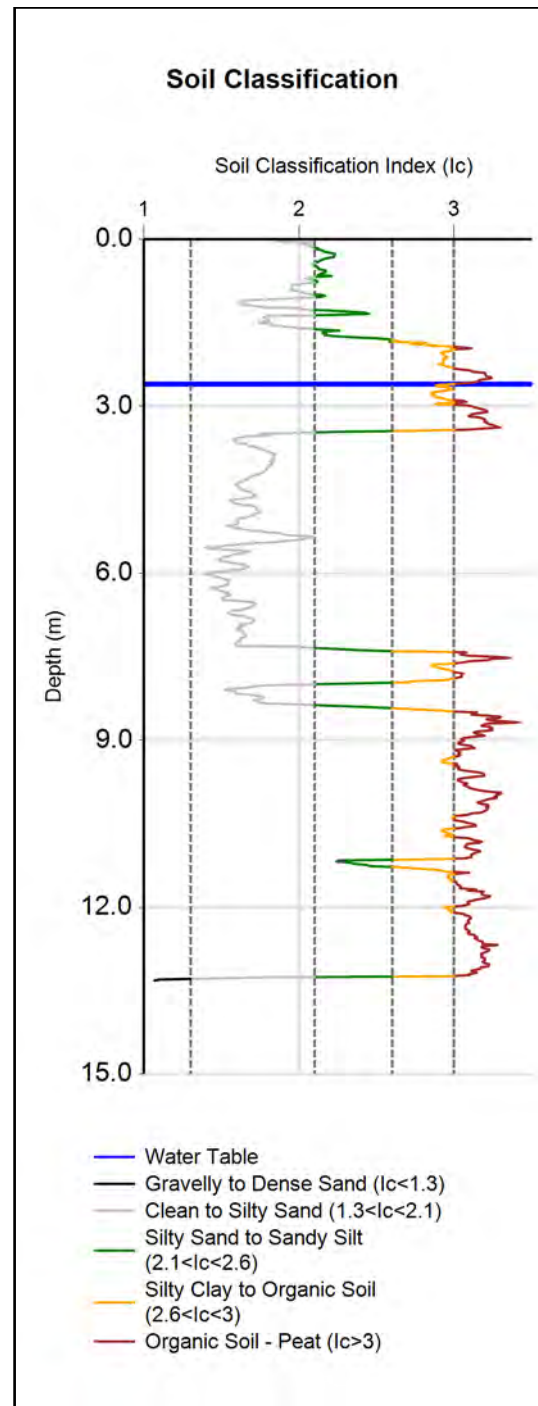
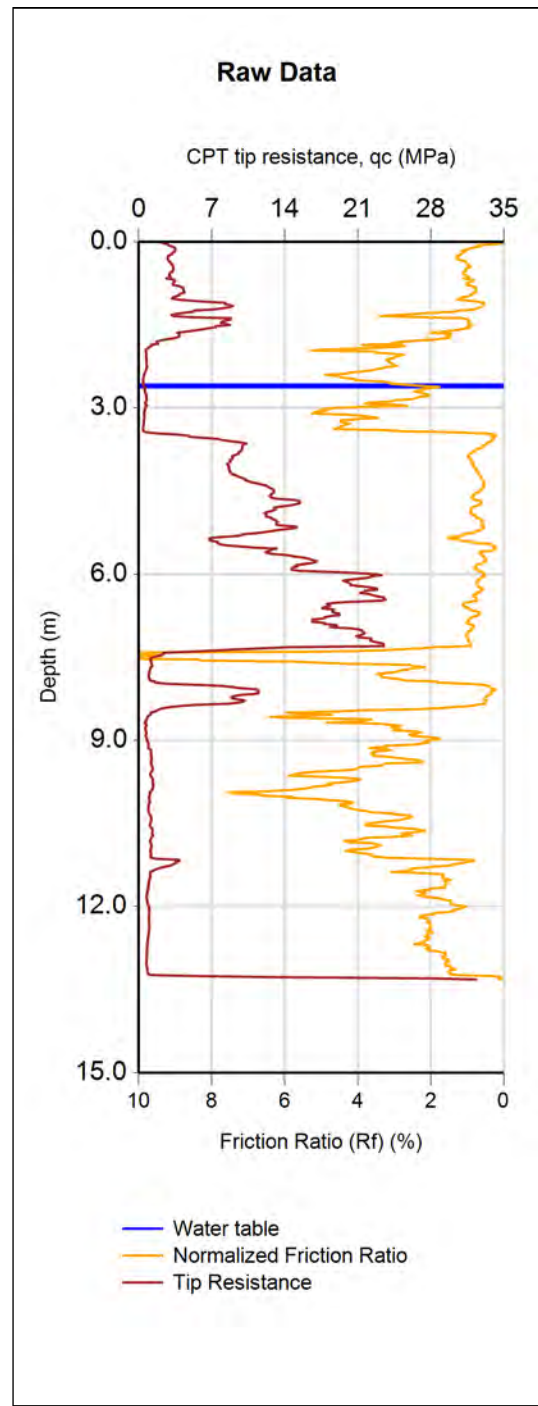
LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)



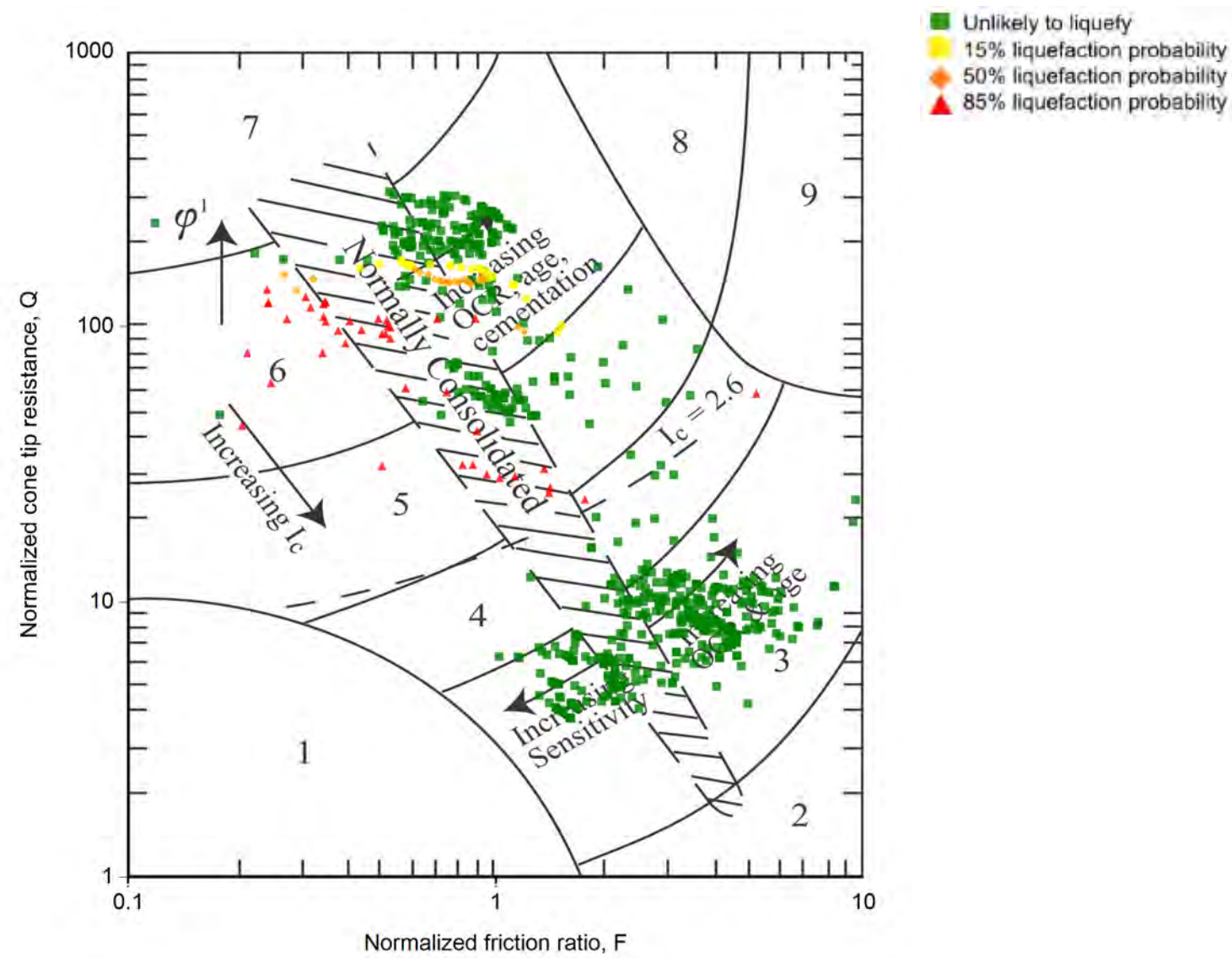
(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT18	60518	11/02/2016	User Specified	6.9	0.3308	2.6	BI-2014	ZRB-2002	0	2	0.01	18
Exceedance Probability S - Calculated Settlement (mm) CTL - Cumulative Thickness of Liquefaction (m) LPI - Liquefaction Potential Index LSN - Liquefaction Severity Number CT - Crust Thickness (m) LPI Ishihara													
OUTPUT	15%	37	1.8	4	7	3.5	2						
	50%	30	1.3	2	5	3.5	1						
	85%	23	0.9	1	4	3.5	1						



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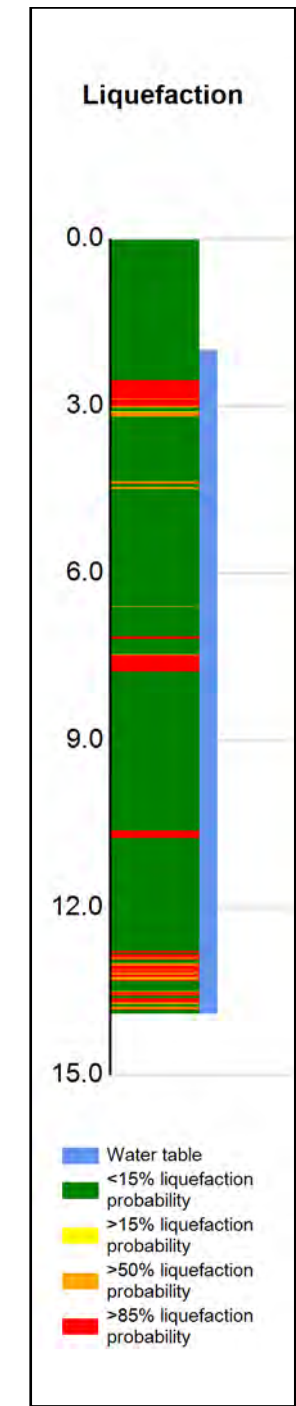
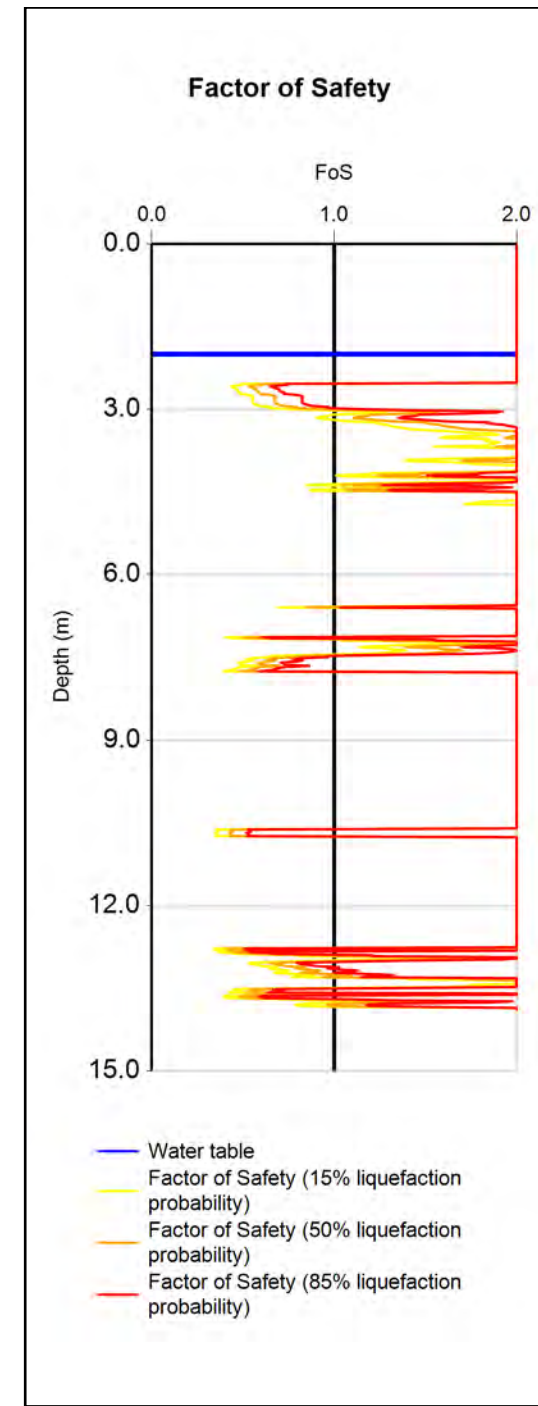
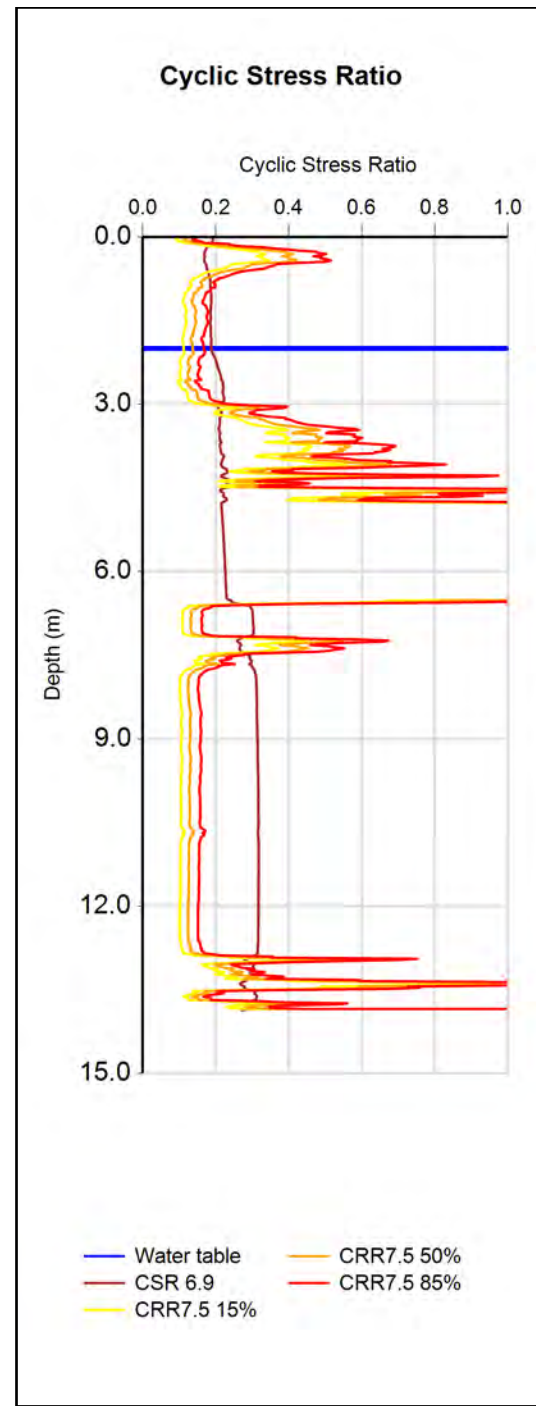
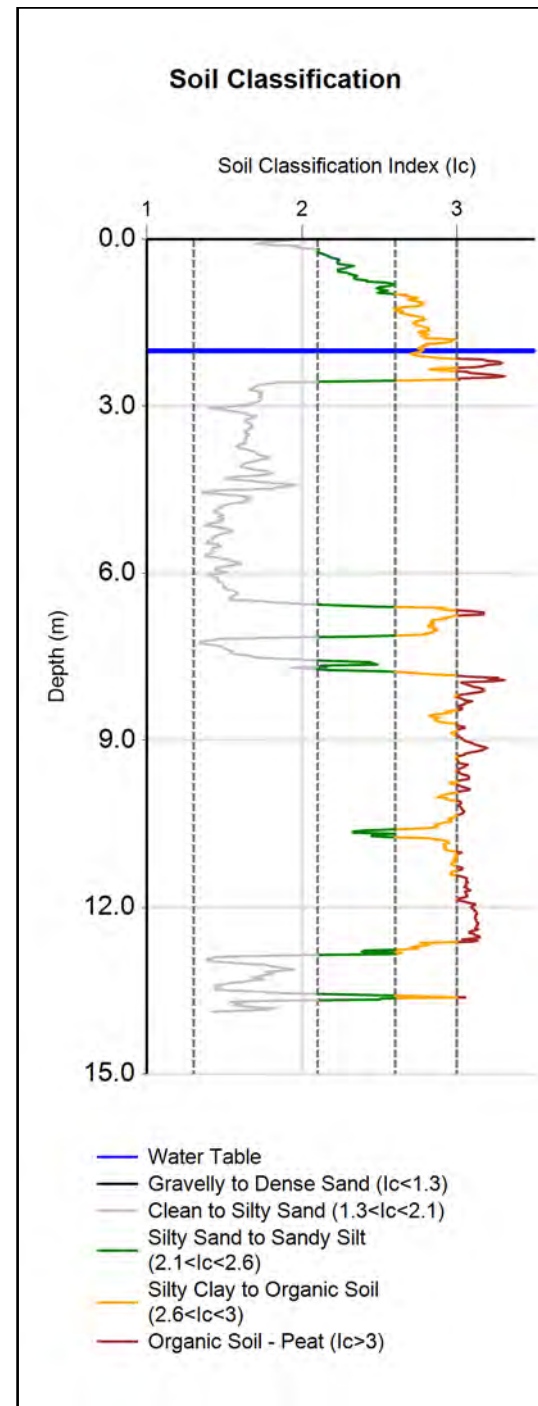
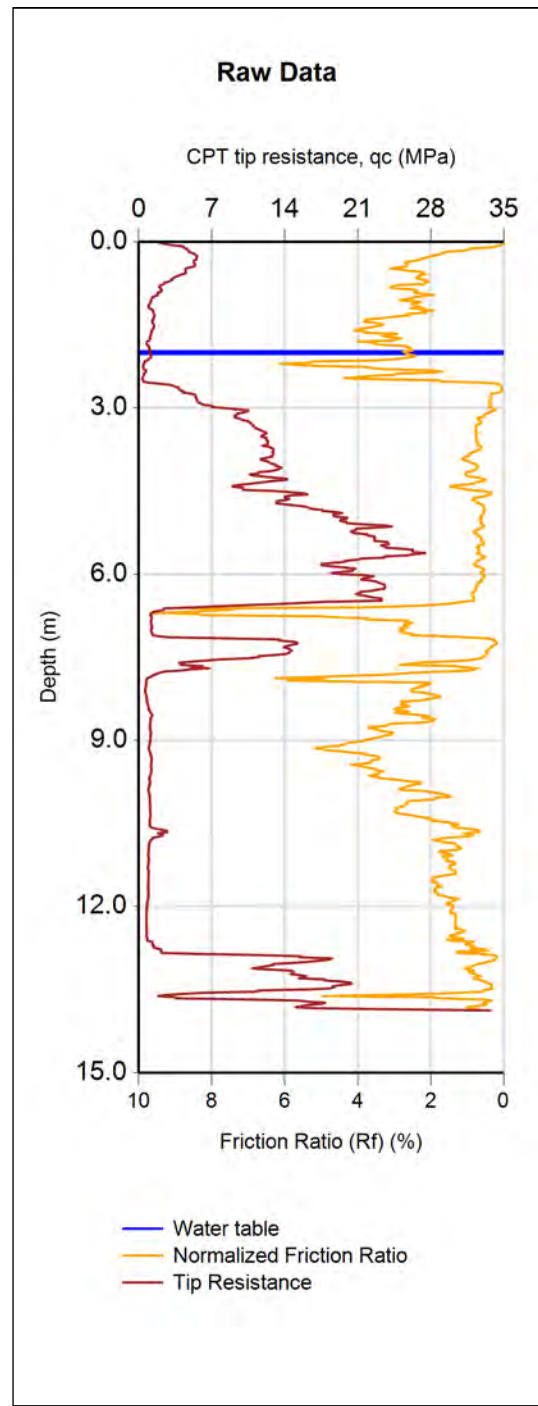
CPT-based soil behavior type classification chart by Robertson (1990)



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(Assumed pre-drill values)

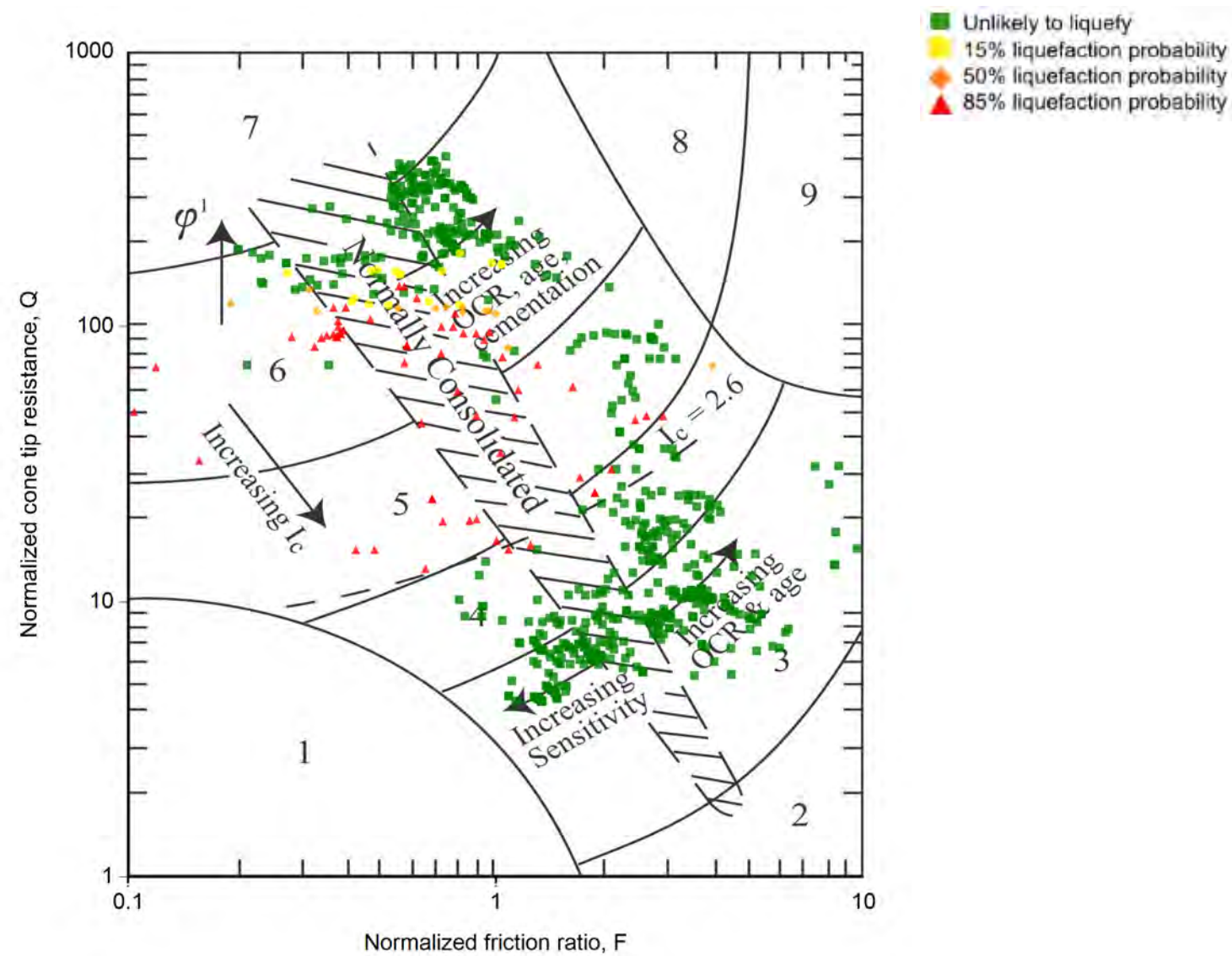
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT19	60519	11/02/2016	User Specified	6.9	0.3308	2.0	BI-2014	ZRB-2002	0	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	44	1.9	4	9	2.6	3						
	50%	38	1.6	3	8	2.6	2						
	85%	33	1.3	2	7	2.6	1						



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LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
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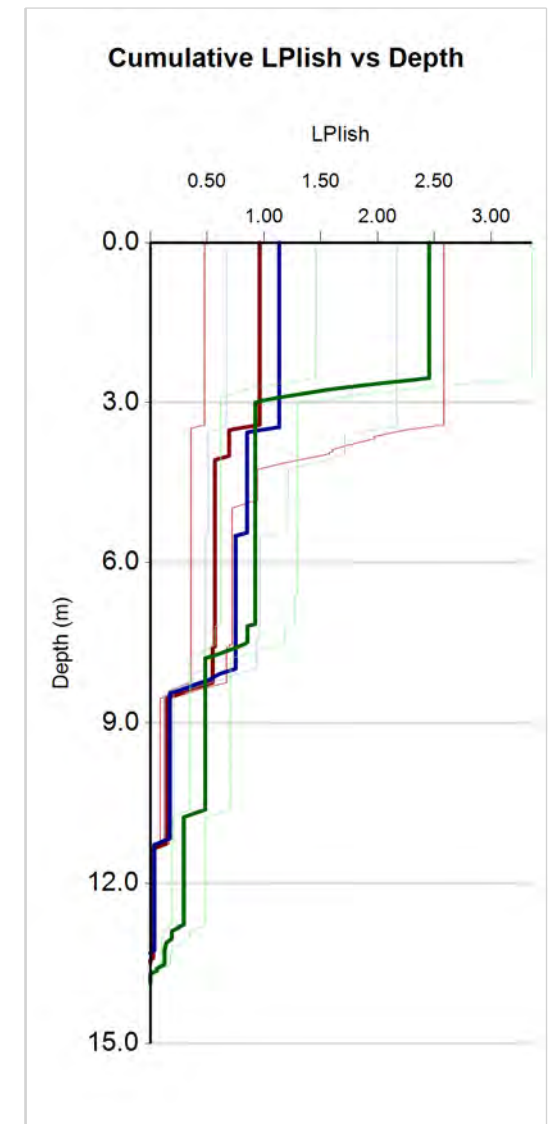
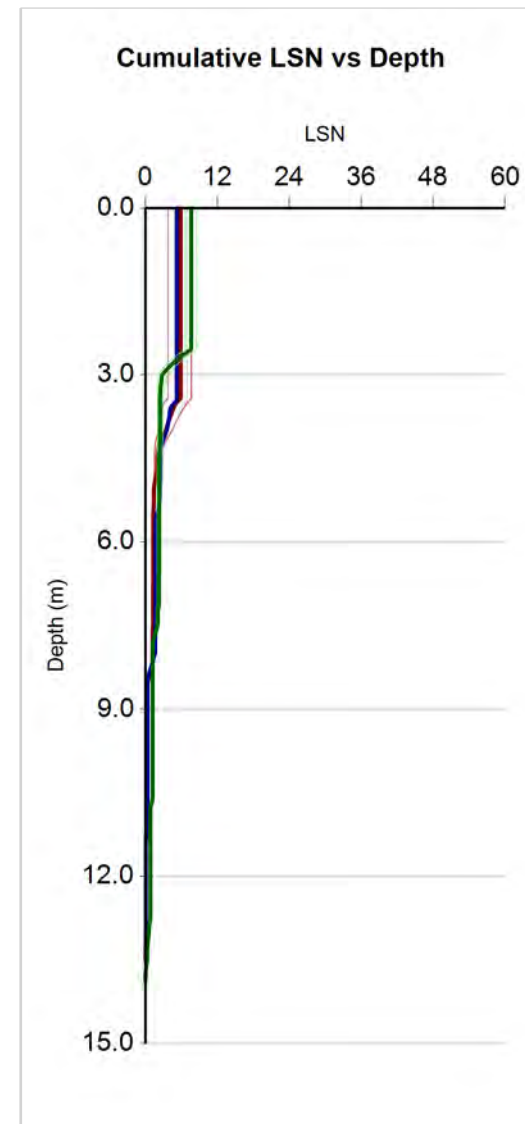
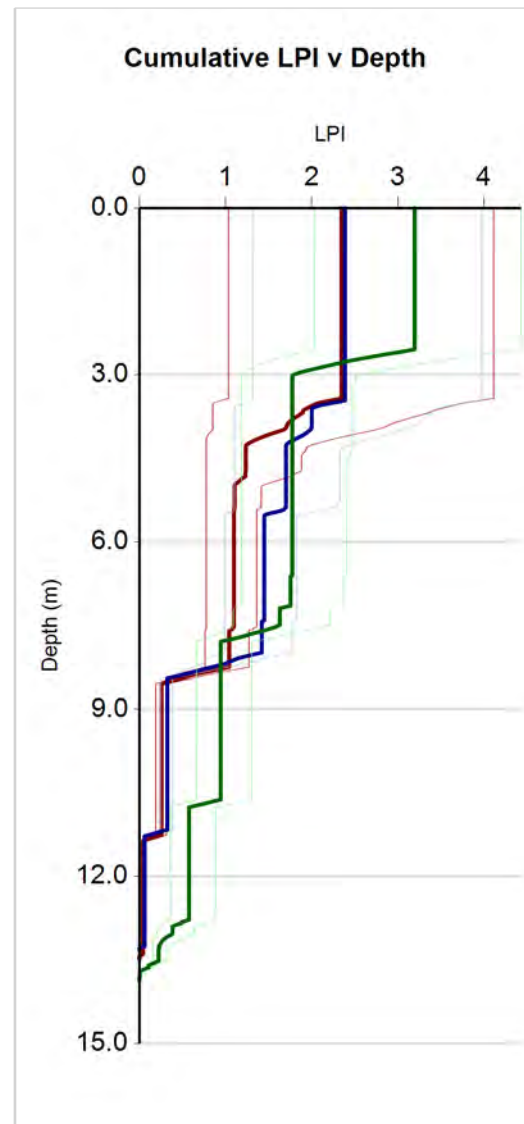
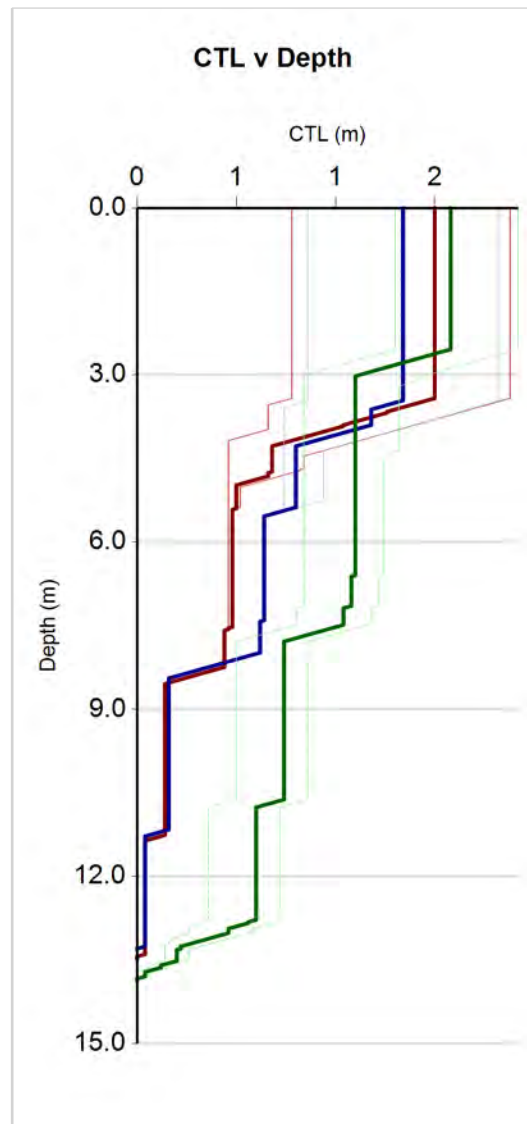
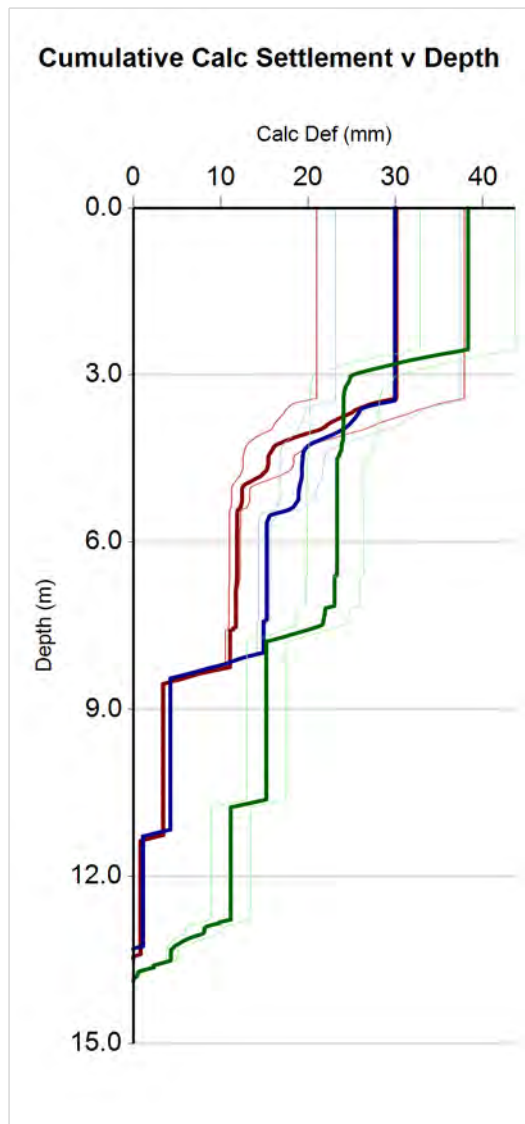


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE ULS Liquefaction Assessment CPT 17-19	JOB NUMBER 31464.1000	ANALYSED khl

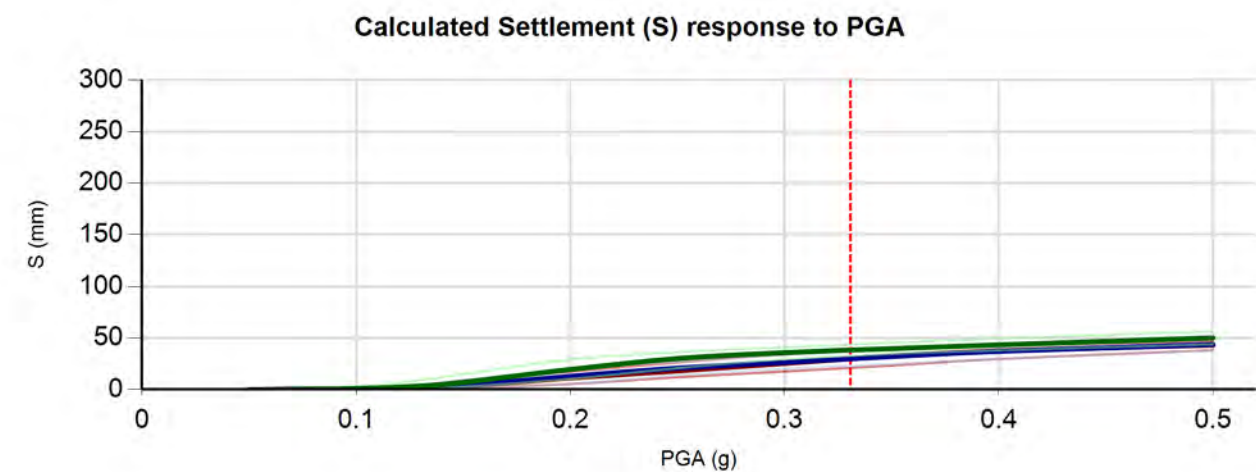
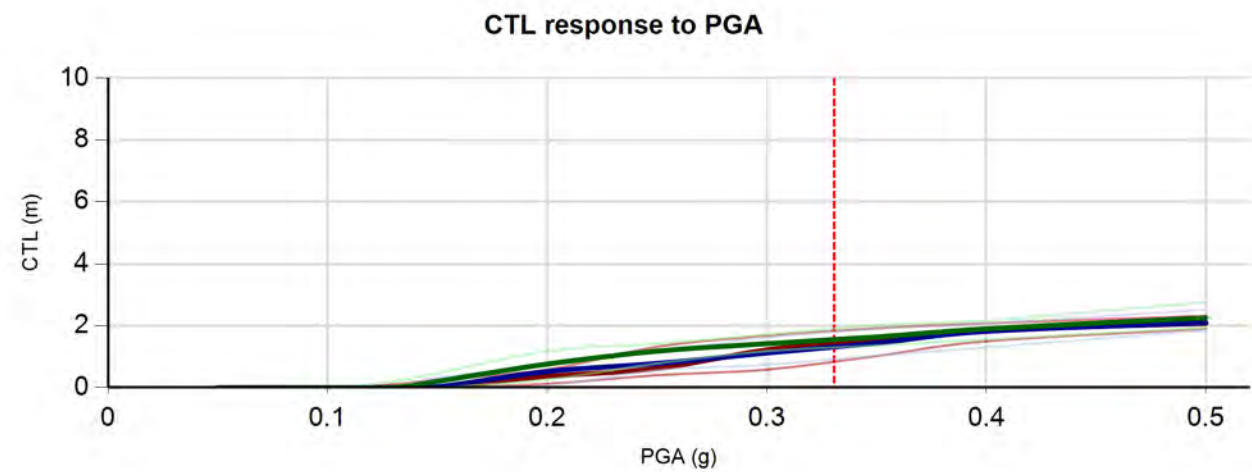
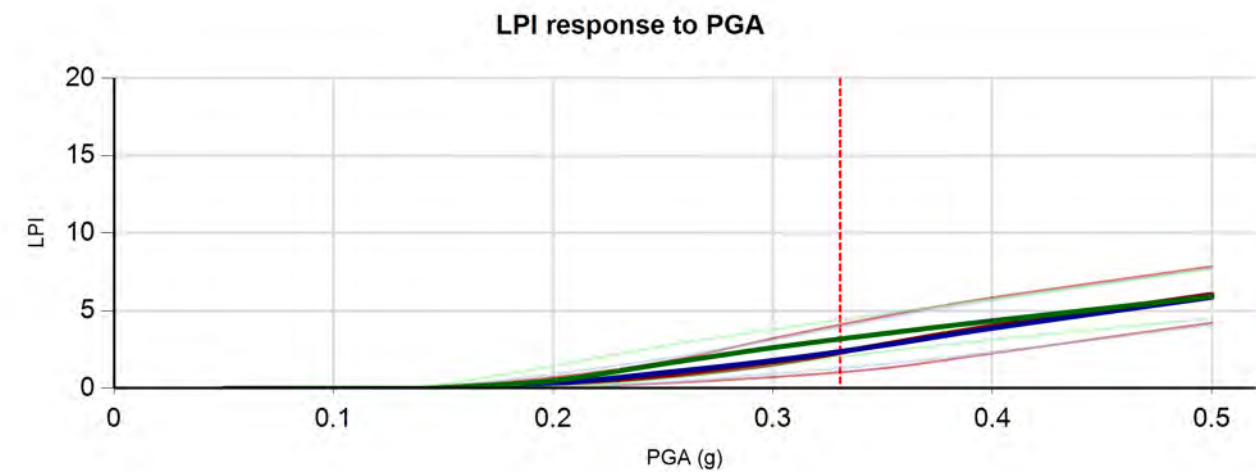
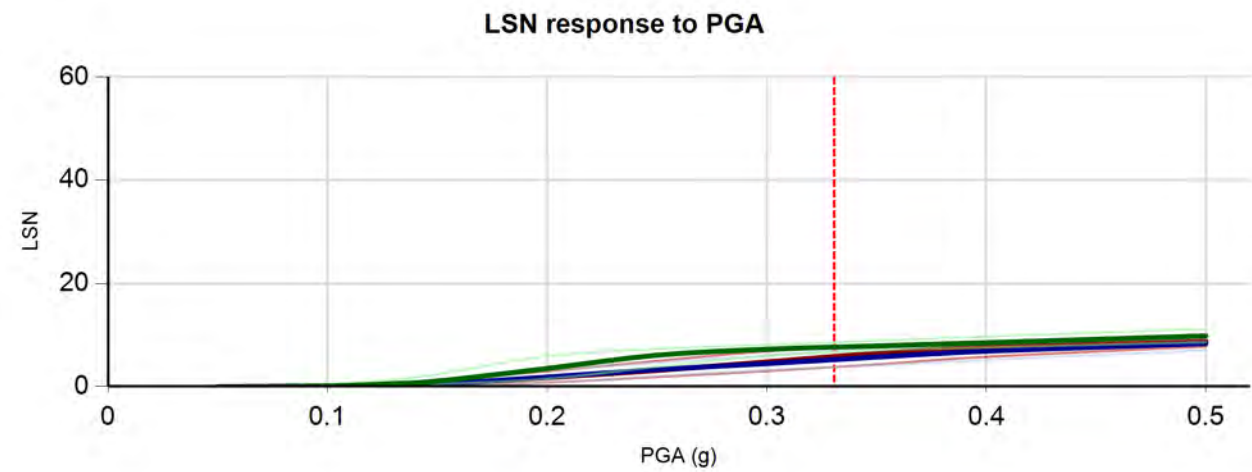


(Assumed pre-drill values)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT17	60517	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT18	60518	11/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT19	60519	11/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

<p>Tonkin + Taylor Exceptional thinking together V1.3</p>	<p>CLIENT, PROJECT</p> <p>Hastings District Council Housing Rezone</p>	<p>LOCATION</p> <p>Havelock Road/ Howard Street</p>	<p>DATE</p> <p>4/03/2016</p>
	<p>TITLE</p> <p>ULS Liquefaction Assessment CPT 17-19</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>khl</p>
			<p>CHECKED</p> <p>PAGE</p> <p>7 of 9 pages</p>



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

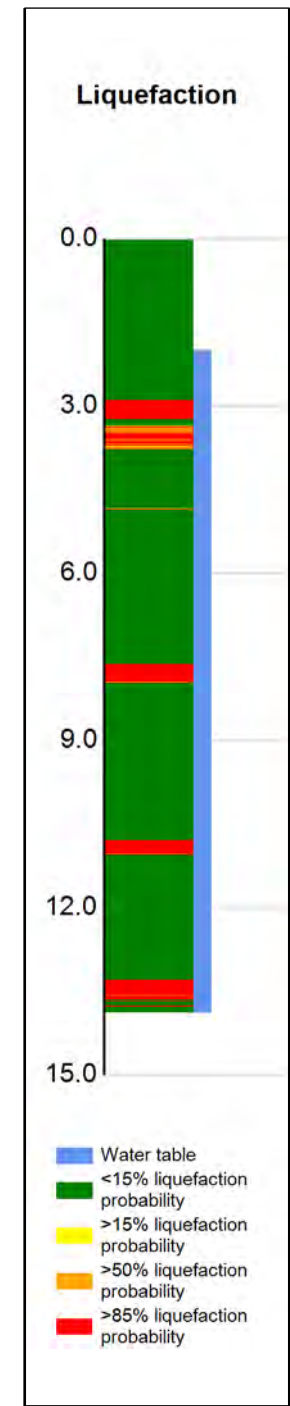
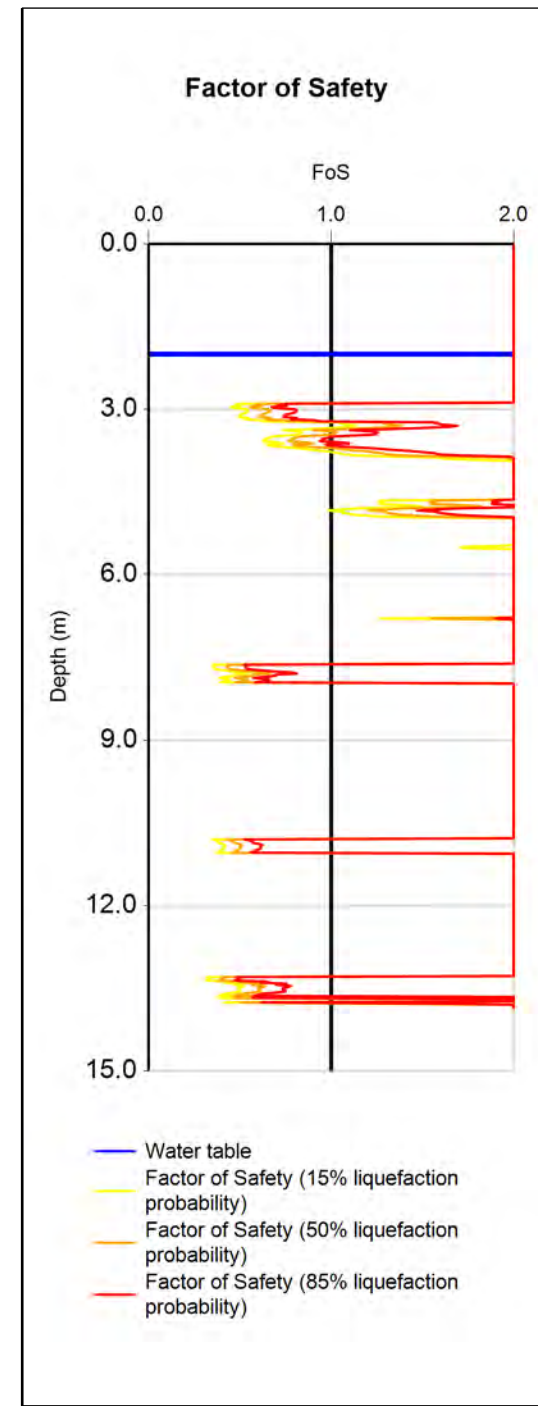
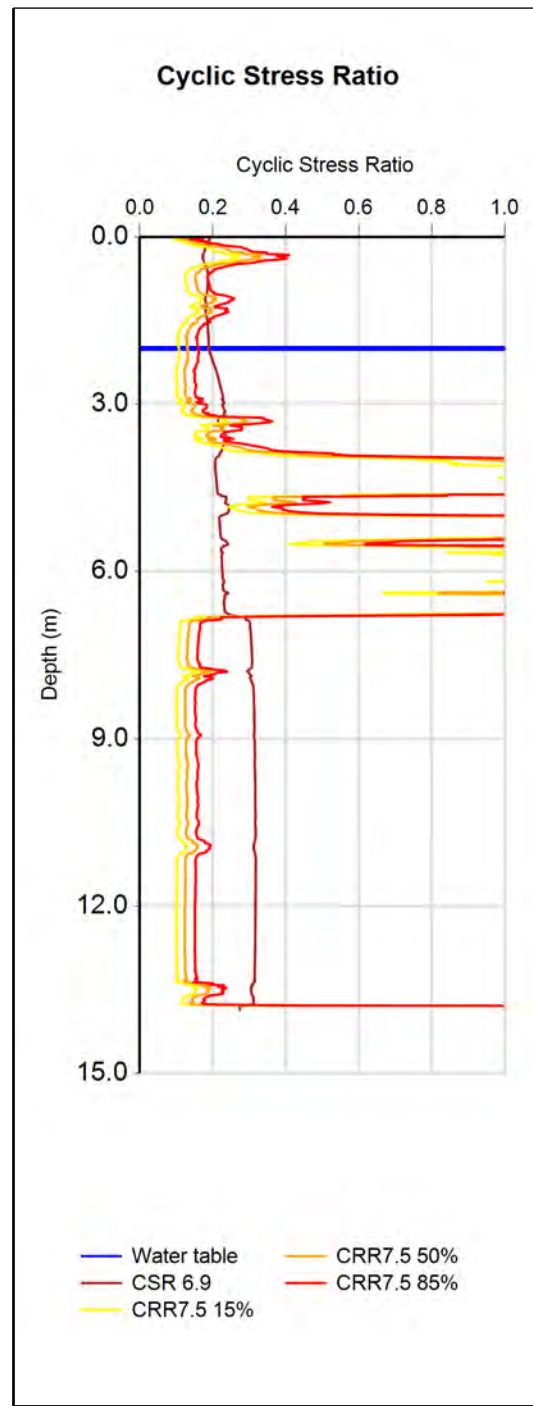
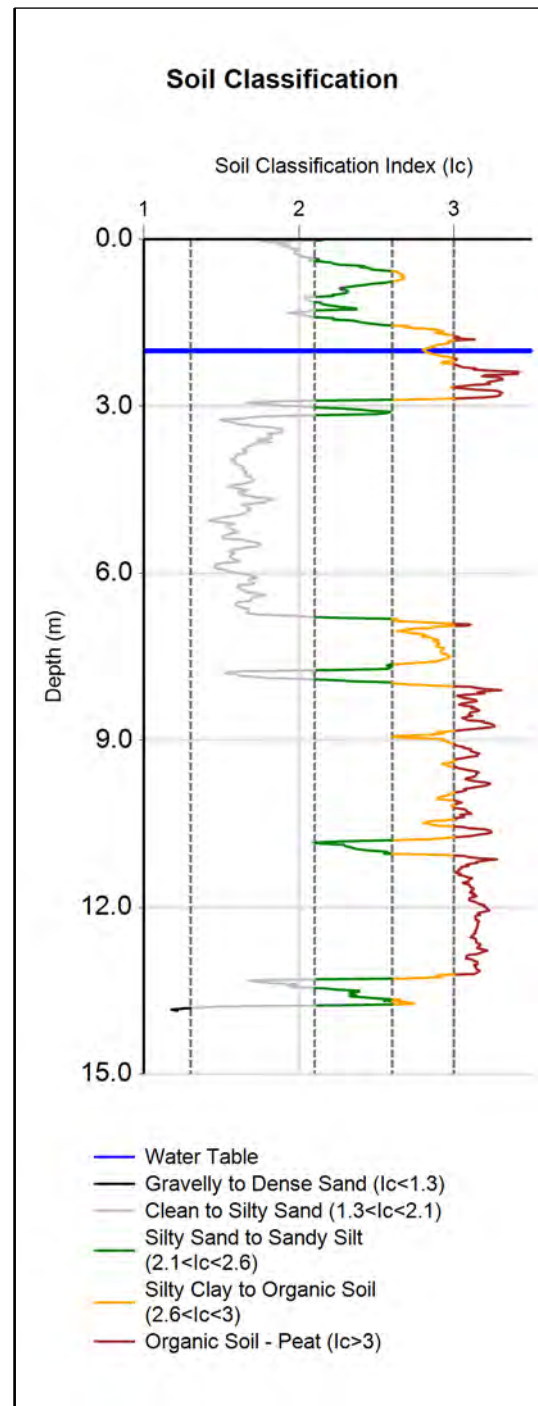
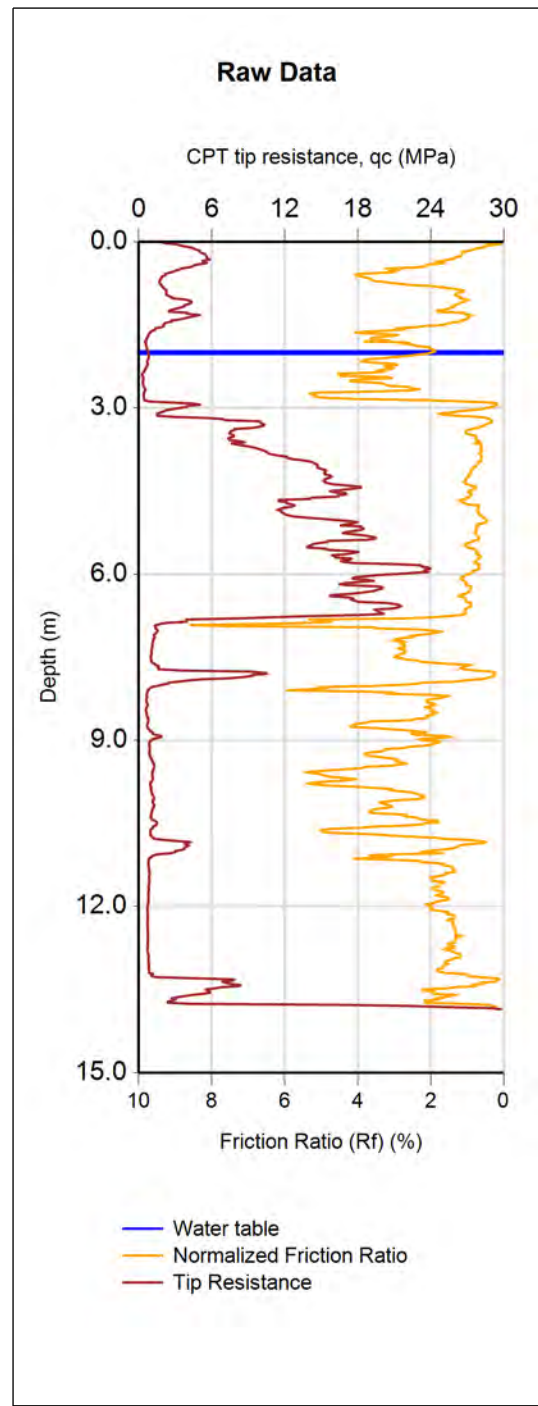
CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	(Assumed pre-drill values)		
										Qc (MPa)	Fs (MPa)	É£ (kN/m³)
CPT17	60517	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT18	60518	11/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18
CPT19	60519	11/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60517	60518	60519
CPT Name	CPT17	CPT18	CPT19
PGA	0.3308g	0.3308g	0.3308g
Magnitude	6.9	6.9	6.9
Depth to groundwater	2.6m	2.6m	2m
Predrill depth	0.02m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0
Total depth of CPT	13.5m	13.32m	13.88m
Maximum depth of analysis	13.5m	13.32m	13.88m
RL	n/a	n/a	n/a



(Assumed pre-drill values)

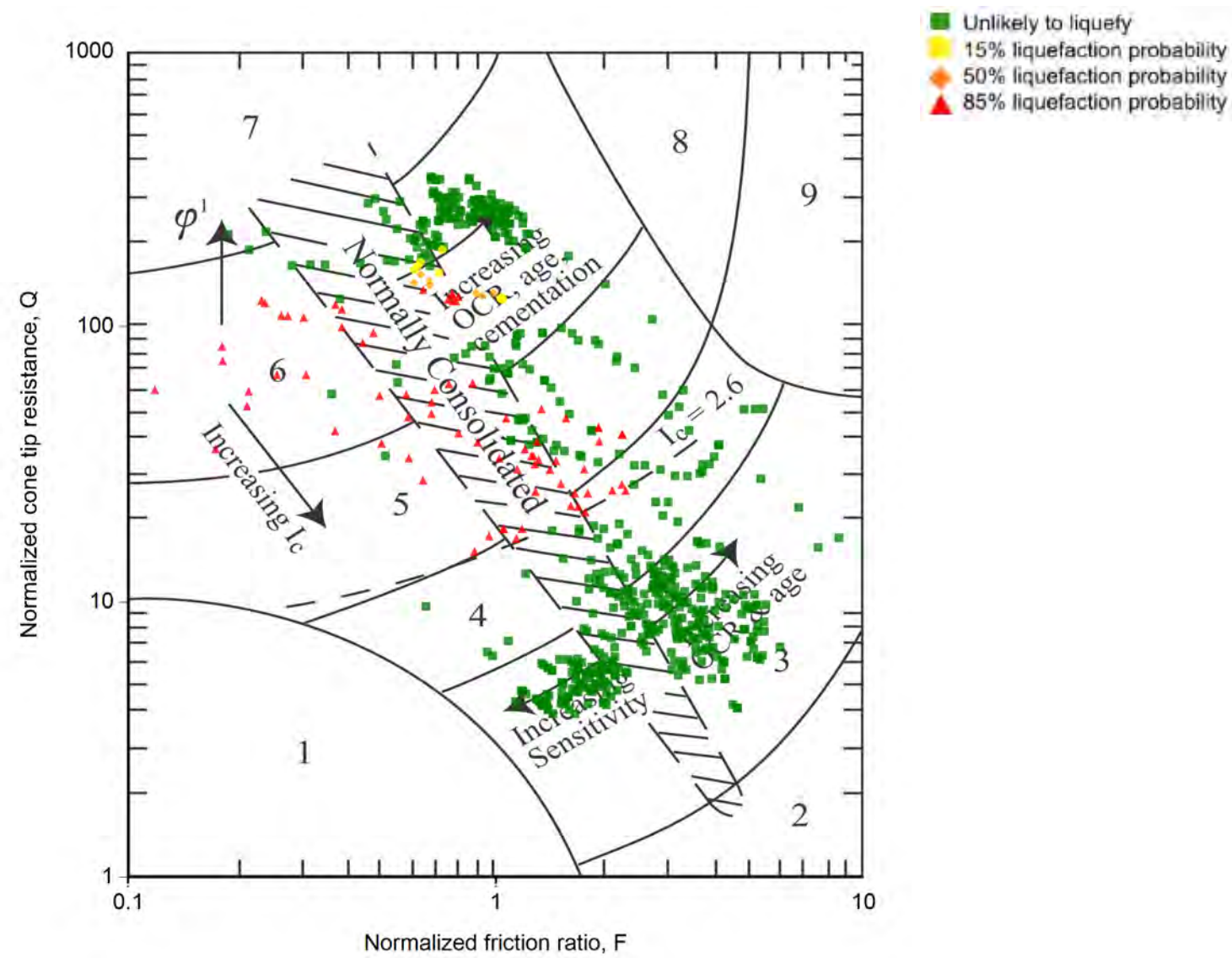
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT21	60520	11/02/2016	User Specified	6.9	0.3308	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
Exceedance Probability S - Calculated Settlement (mm) CTL - Cumulative Thickness of Liquefaction (m) LPI - Liquefaction Potential Index LSN - Liquefaction Severity Number CT - Crust Thickness (m) LPI Ishihara													
OUTPUT	15%	44	1.8	5	8	3	3						
	50%	41	1.6	4	7	3	2						
	85%	37	1.5	2	6	3	1						



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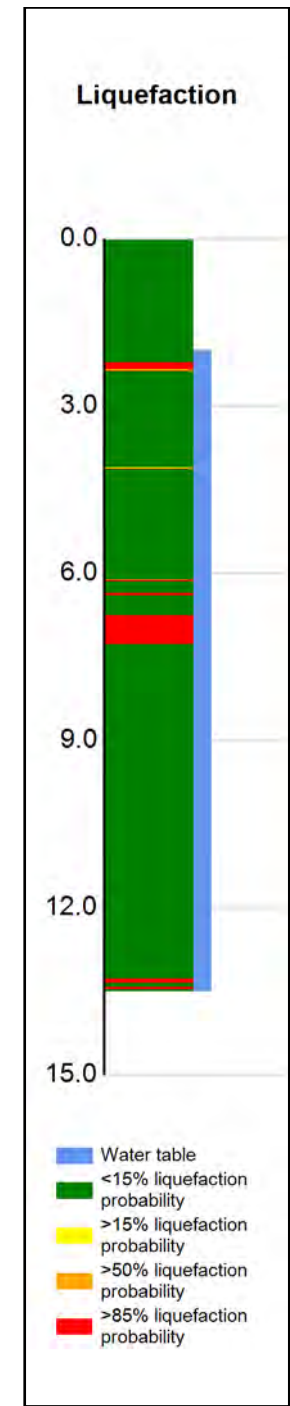
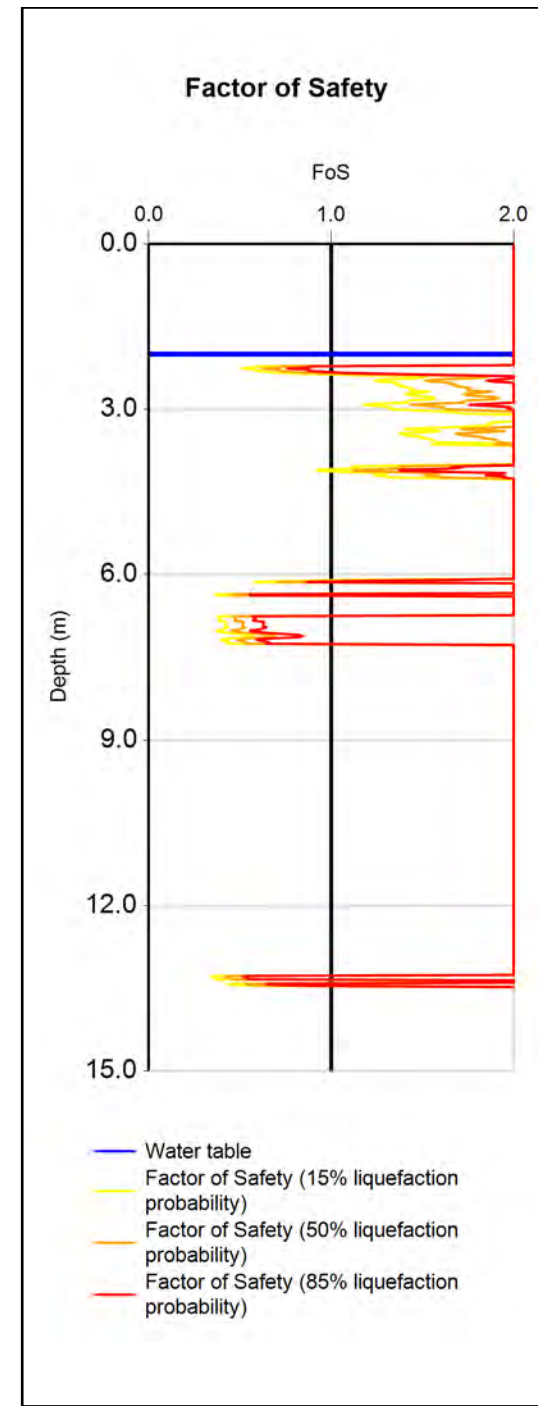
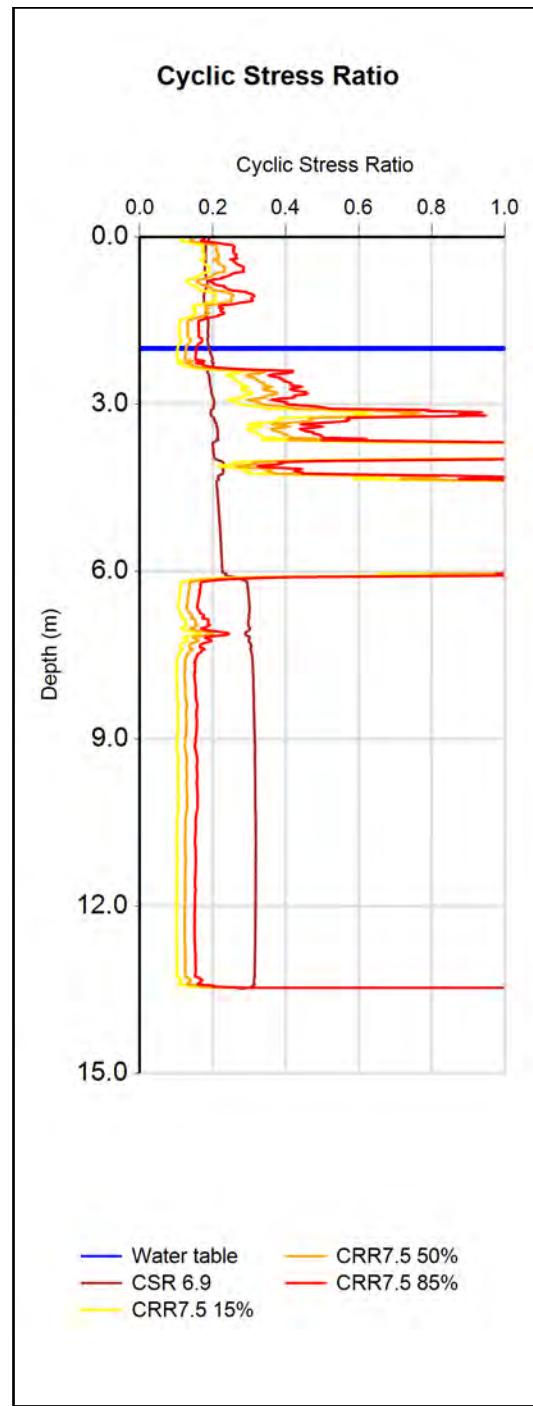
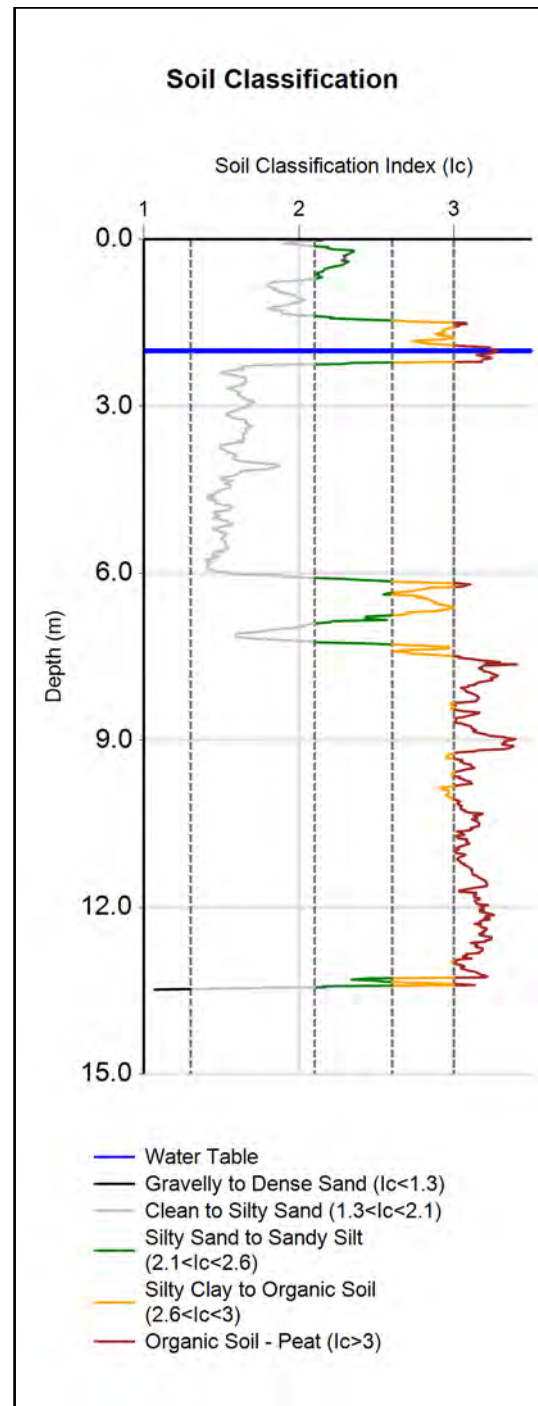
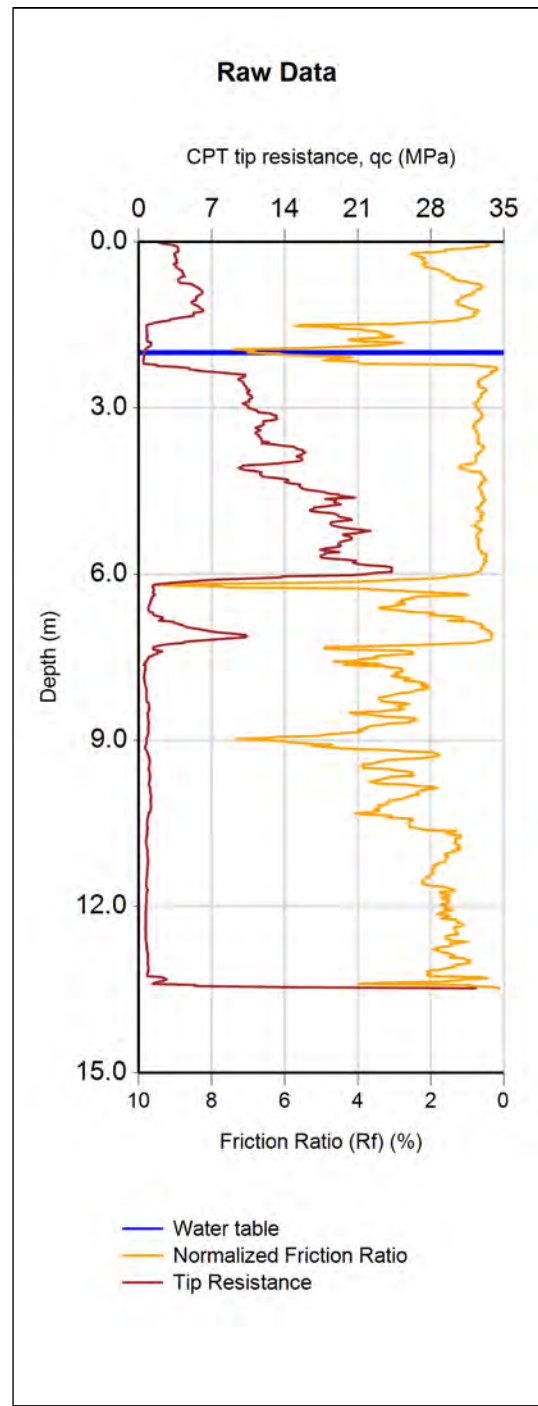
CPT-based soil behavior type classification chart by Robertson (1990)



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(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT22	60521	10/02/2016	User Specified	6.9	0.3308	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	26	0.9	3	5	2.3	2						
	50%	24	0.9	2	4	2.3	2						
	85%	21	0.8	2	4	2.3	1						



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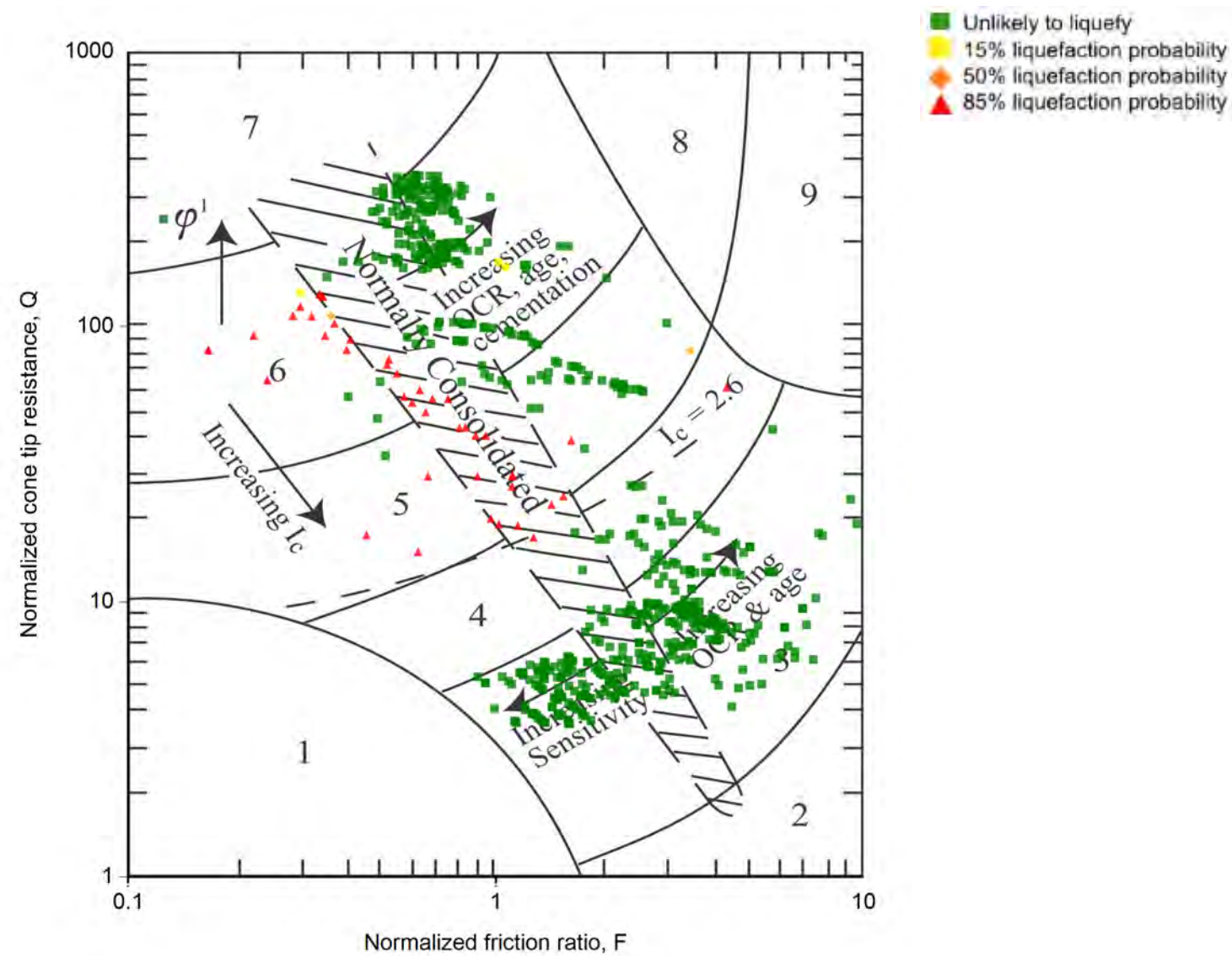
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*Heavily overconsolidated or cemented

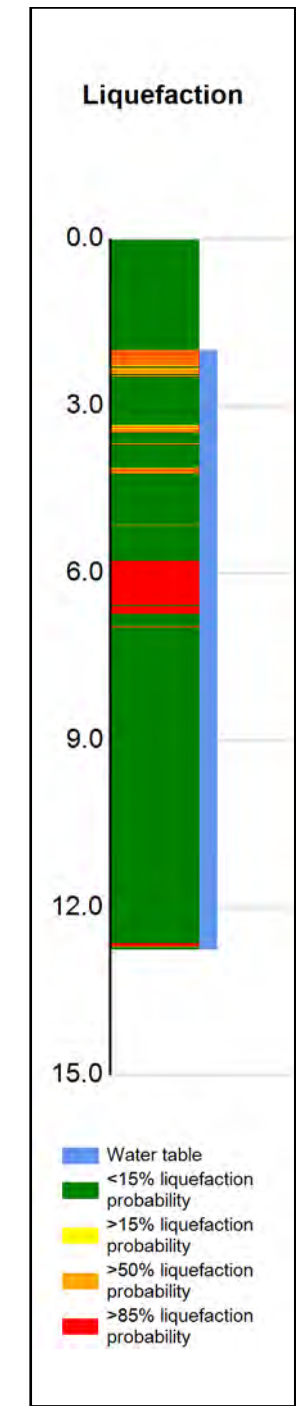
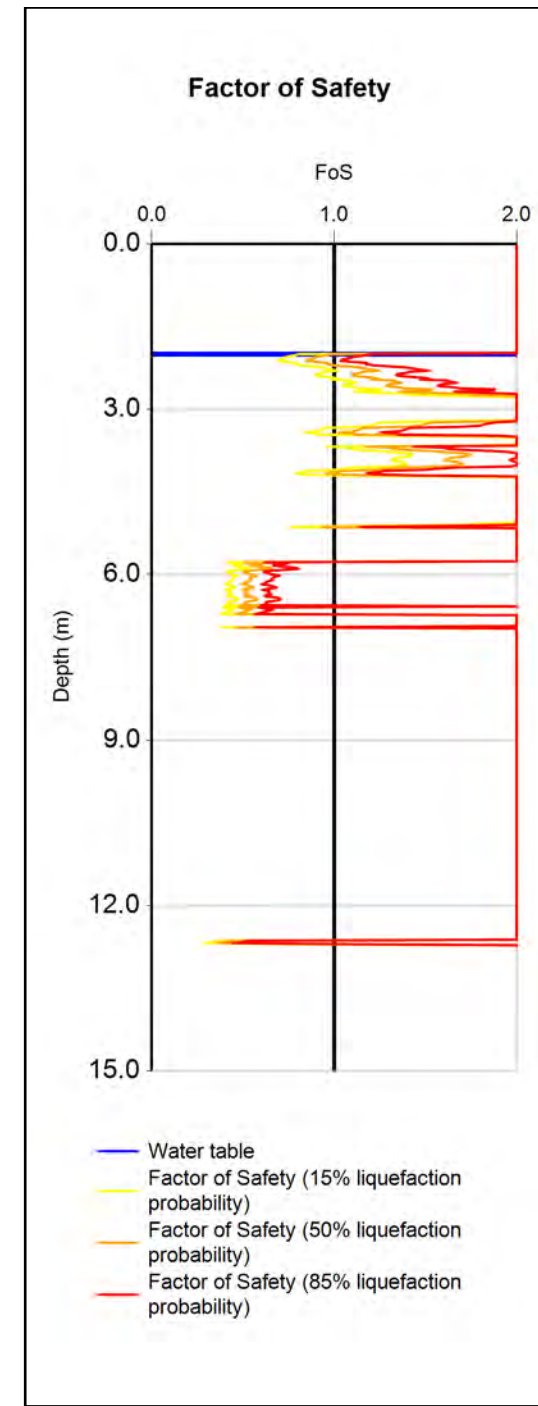
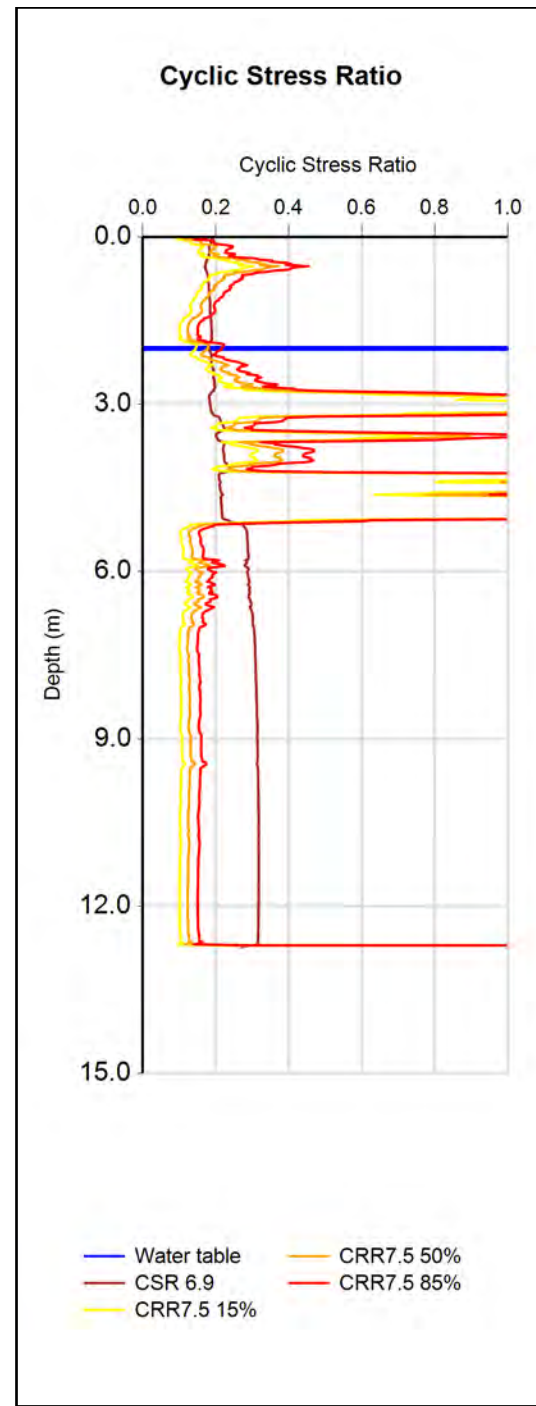
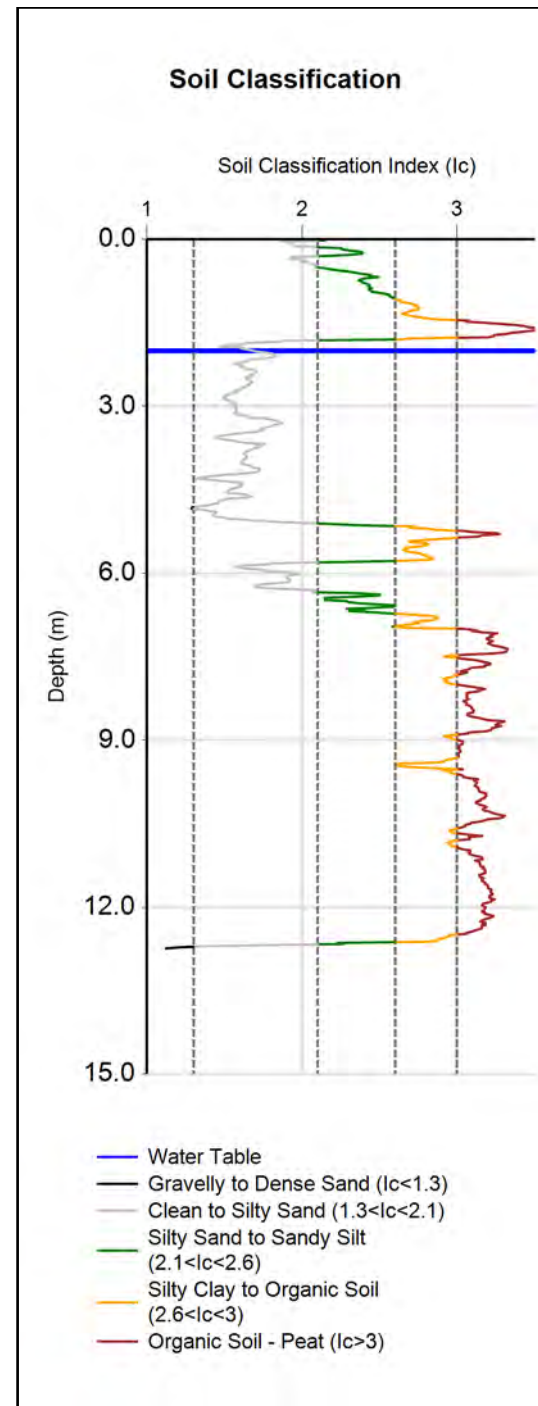
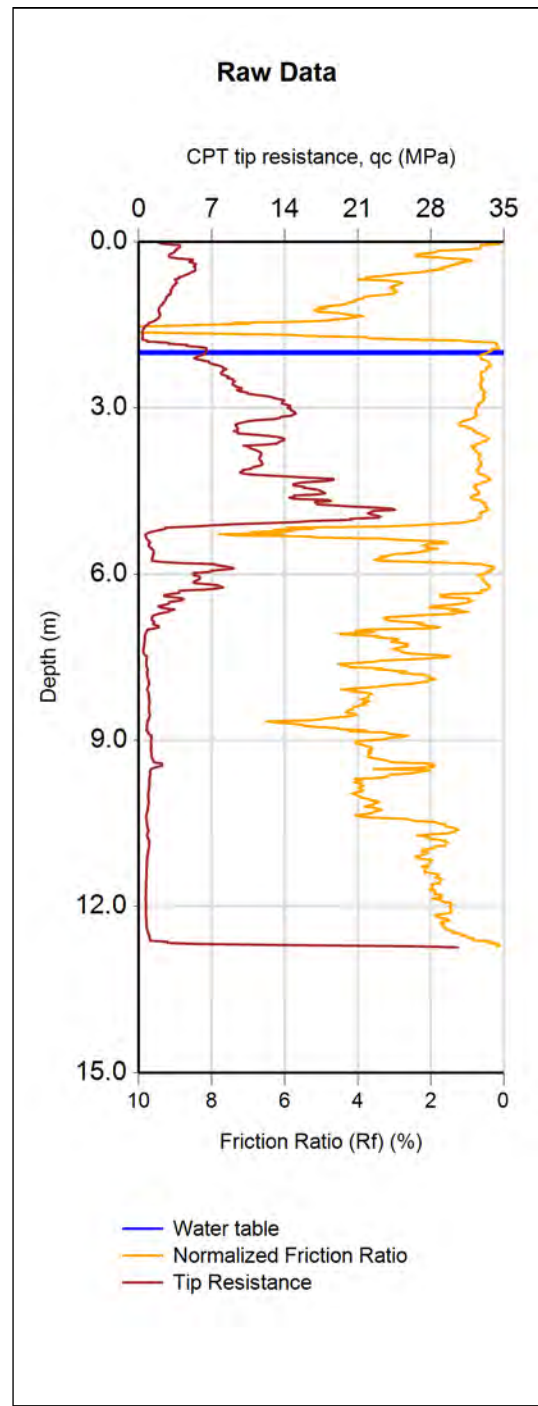
CPT-based soil behavior type classification chart by Robertson (1990)



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(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT23	60522	10/02/2016	User Specified	6.9	0.3308	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
OUTPUT	Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara						
	15%	40	1.8	5	9	2.1	3						
	50%	33	1.3	3	7	2.1	2						
	85%	29	1	2	5	5.9	0						



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ULS Liquefaction Assessment CPT 21-23

LOCATION
 Havelock Road/
 Howard Street

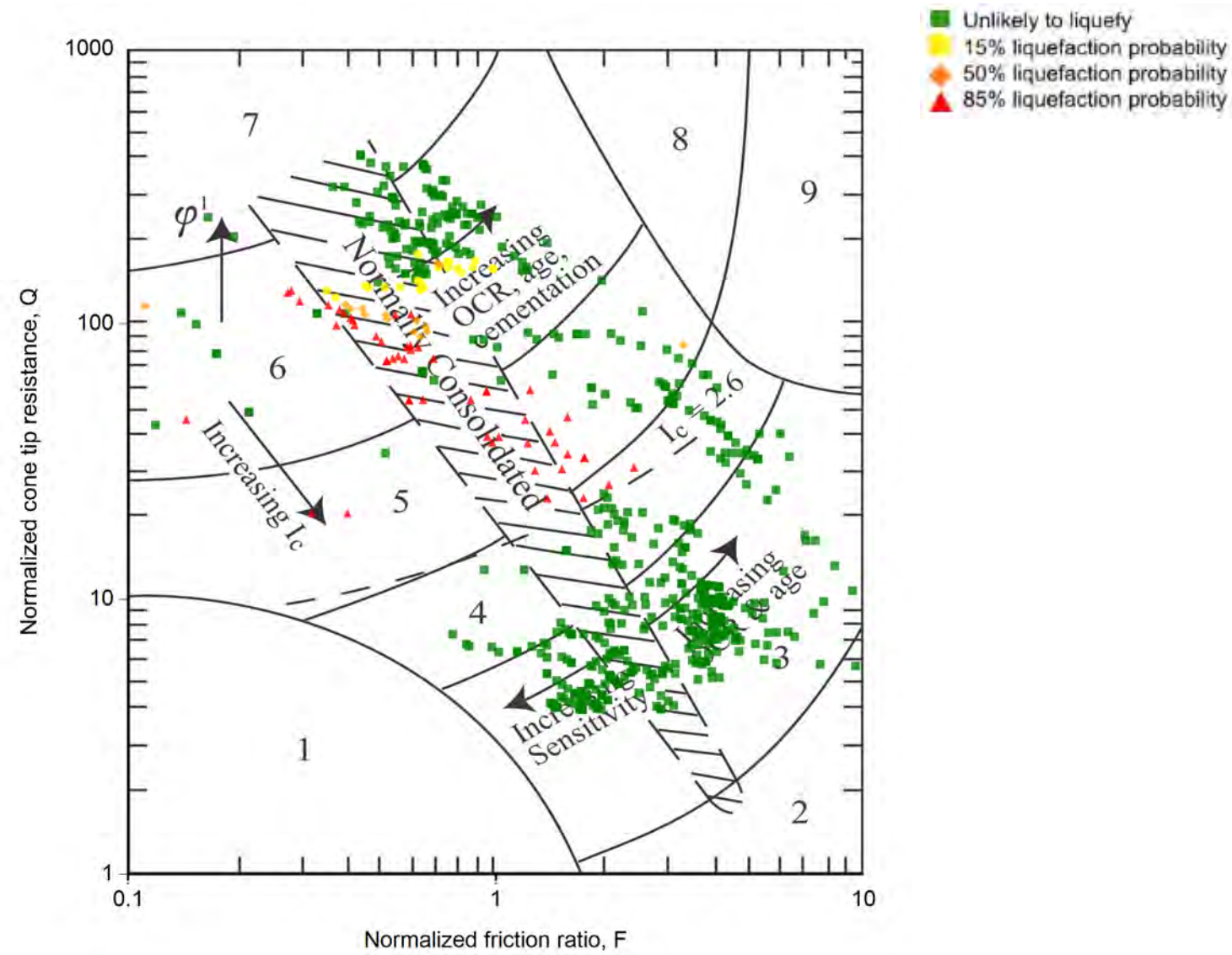
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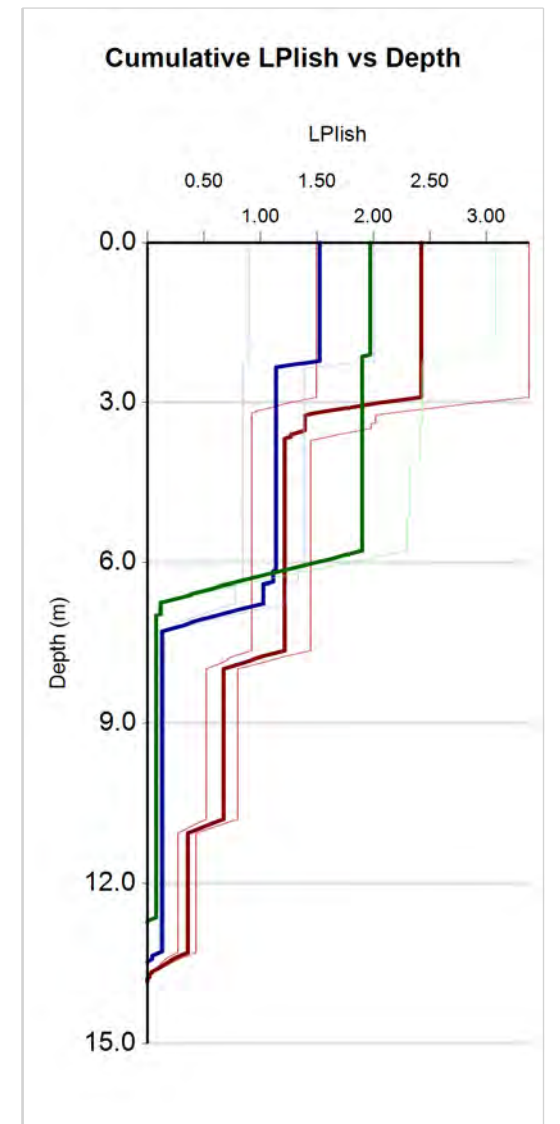
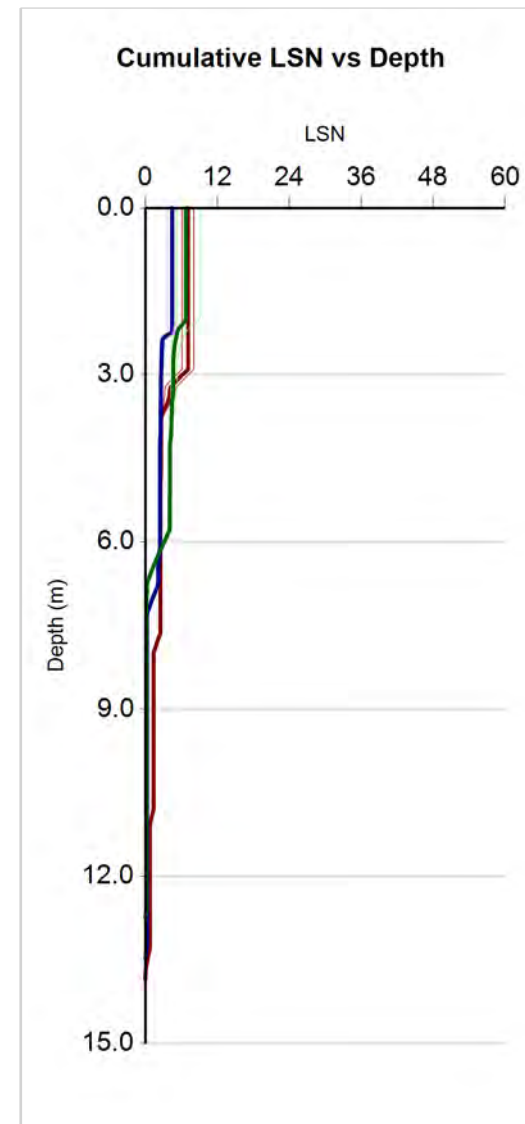
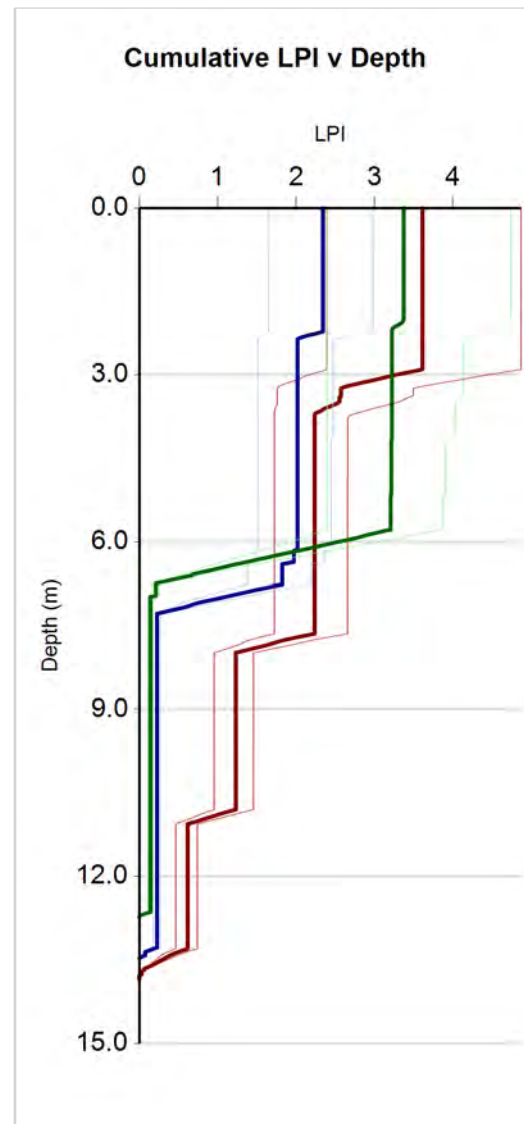
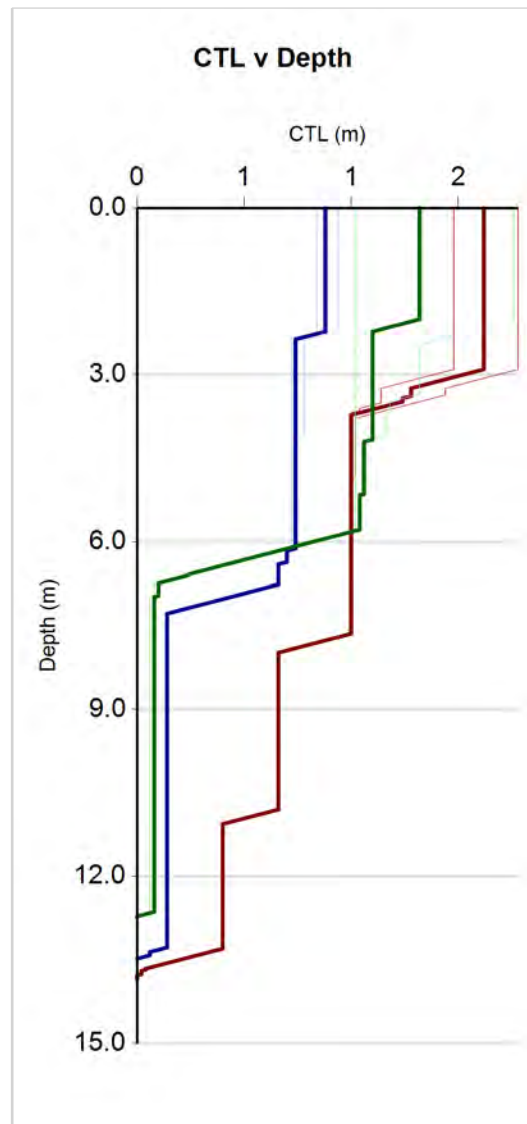
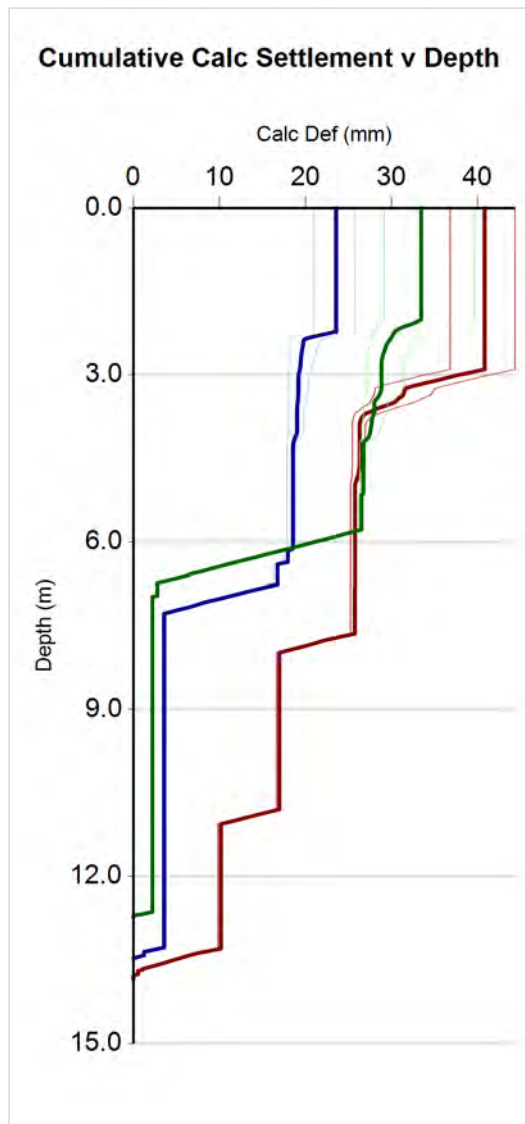


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|--|-------------------------------------|
| 1. Sensitive, fine grained | 6. Sands - clean sand to silty sand |
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| 3. Clays - silty clay to clay | 8. Very stiff sand to clayey sand * |
| 4. Silt mixtures - clayey silt to silty clay | 9. Very stiff, fine grained * |
| 5. Sand mixtures - silty sand to sandy silt | |

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

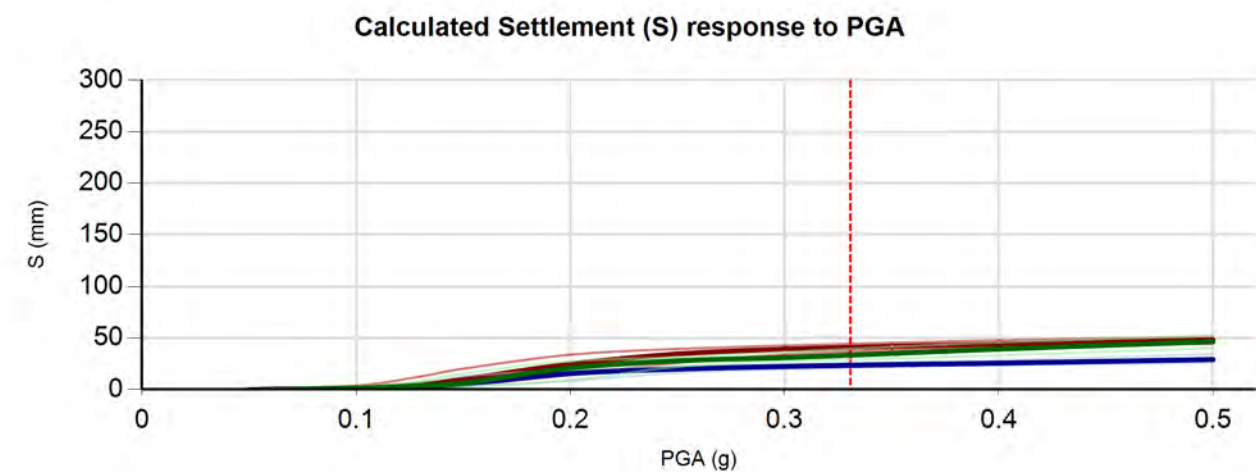
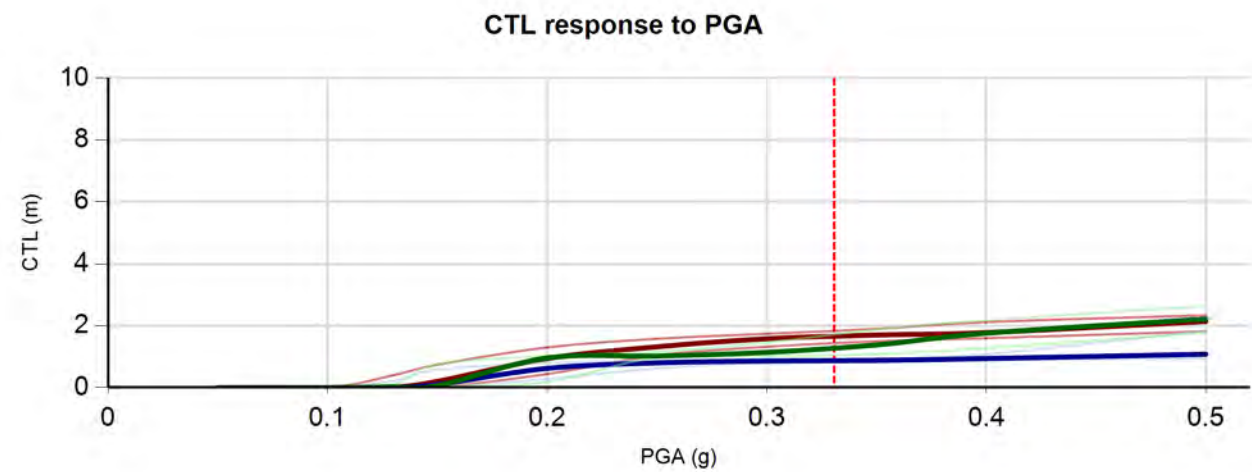
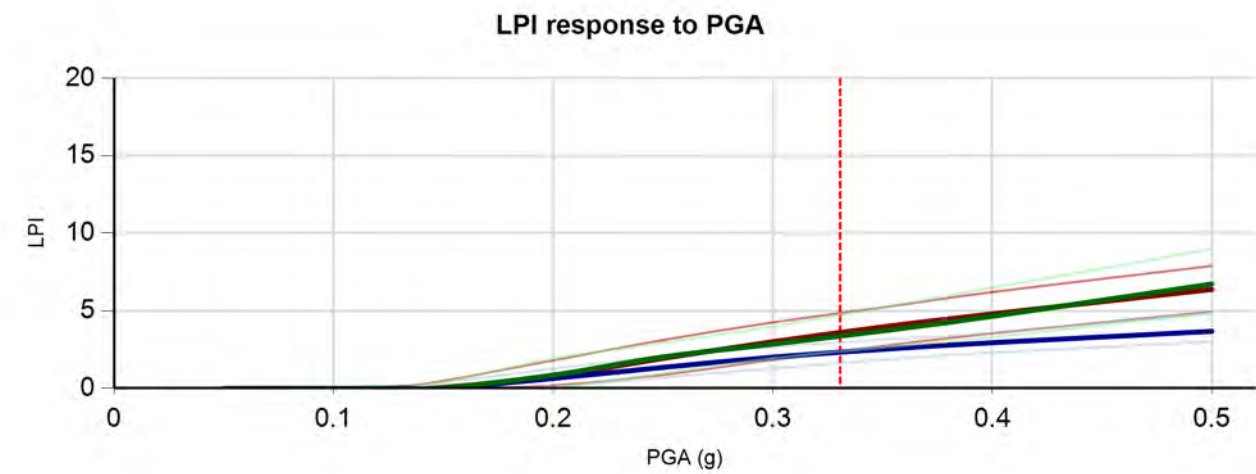
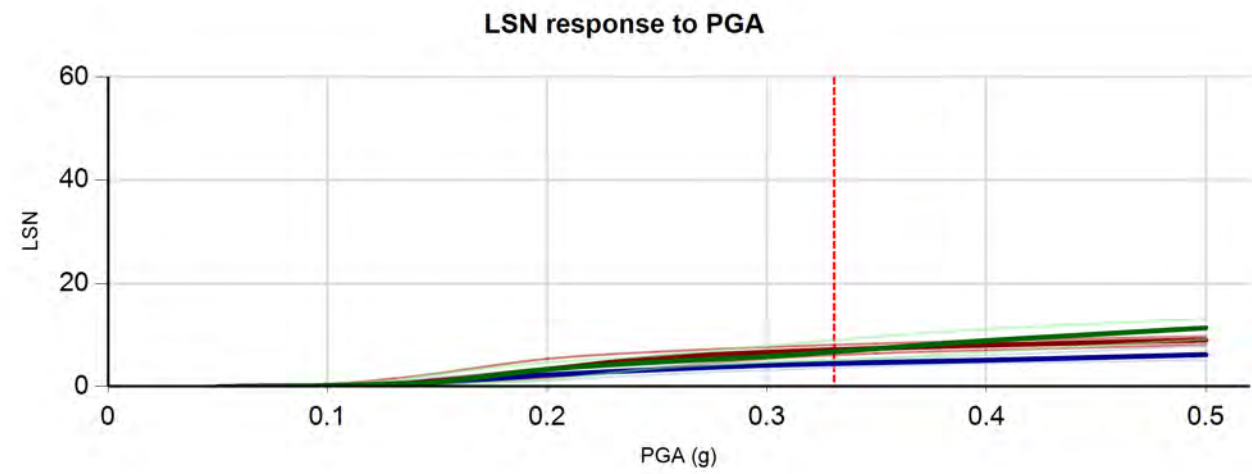
 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE ULS Liquefaction Assessment CPT 21-23	JOB NUMBER 31464.1000	ANALYSED khl



(Assumed pre-drill values)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m³)
CPT21	60520	11/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT22	60521	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT23	60522	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

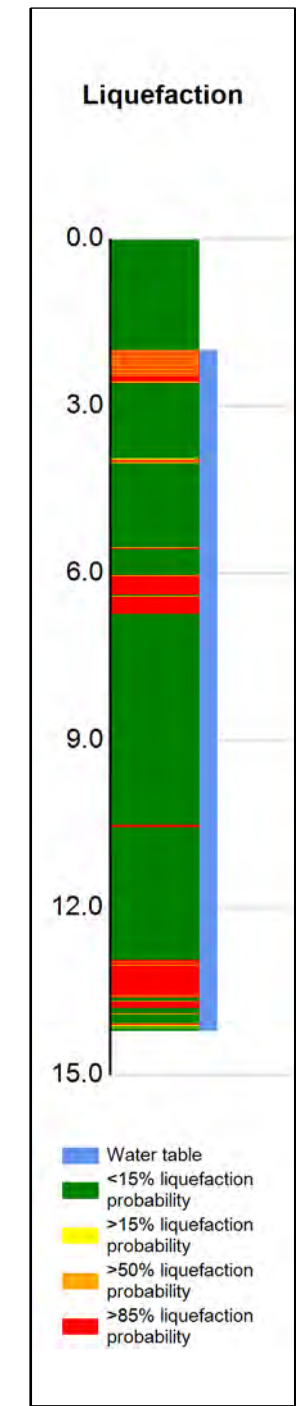
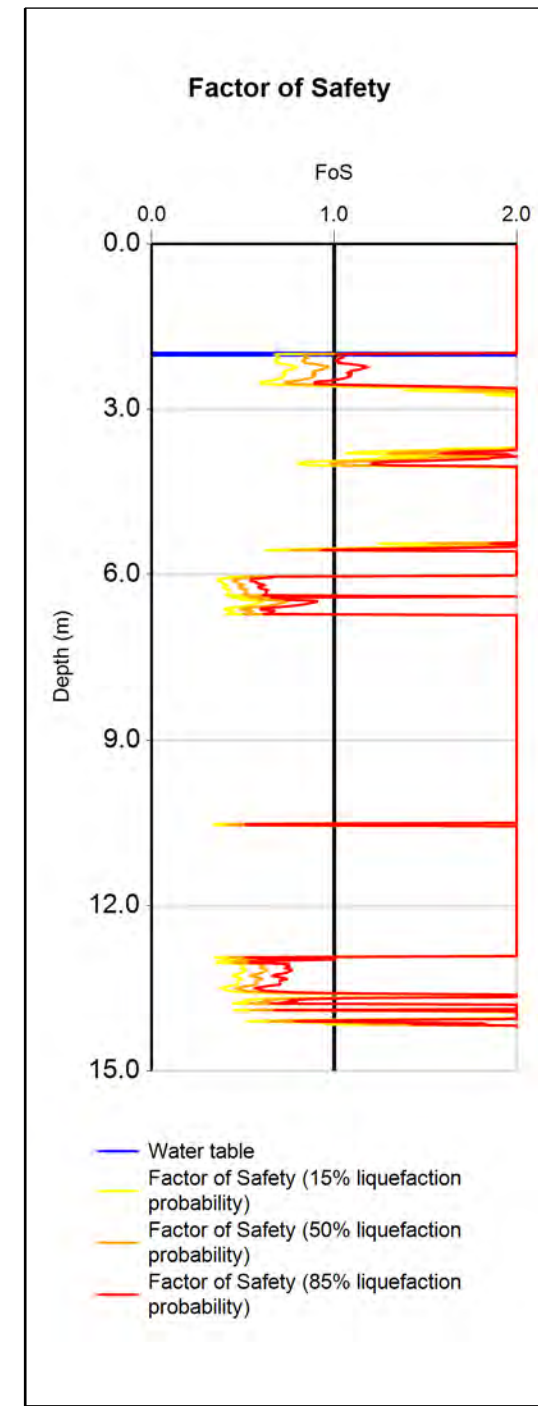
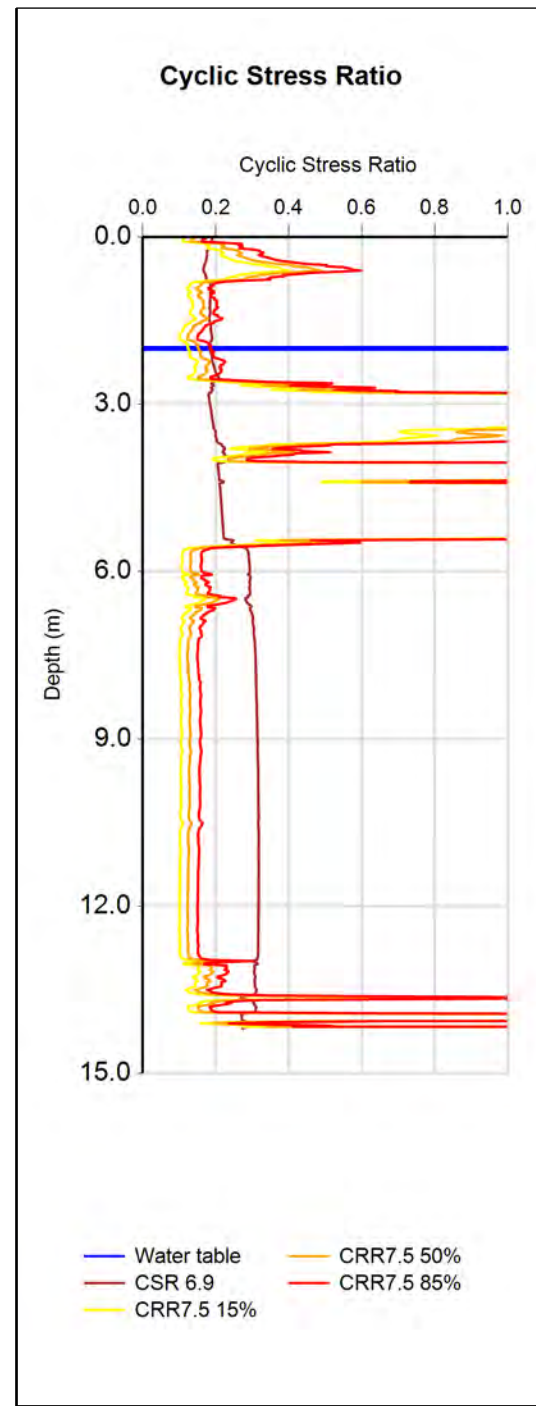
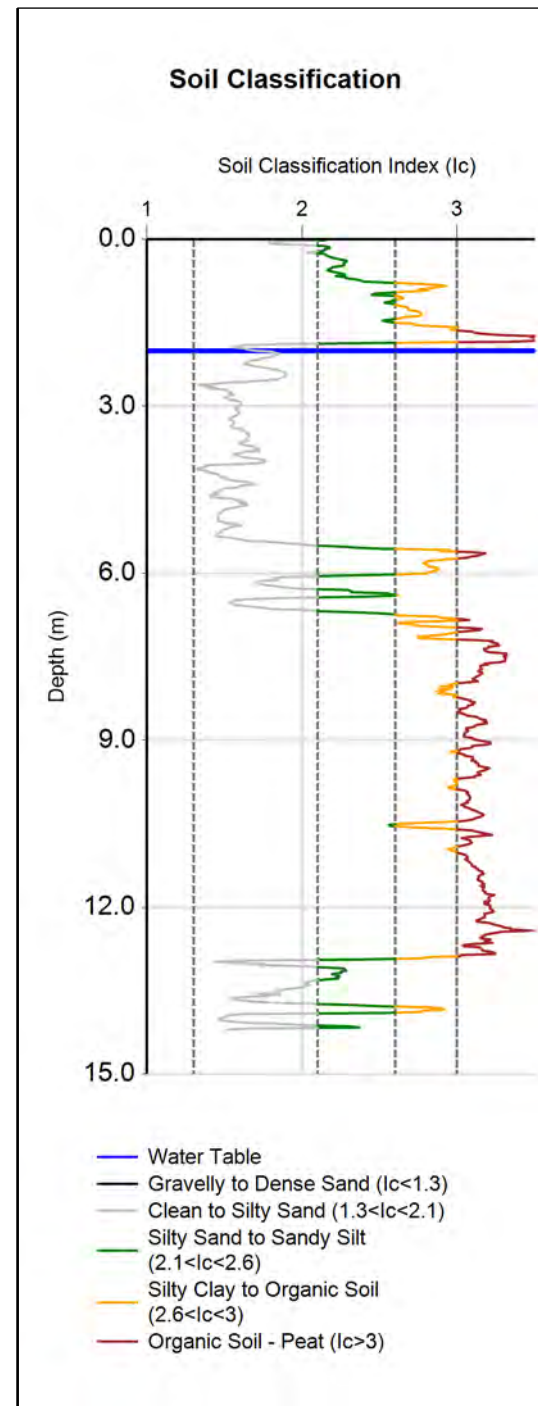
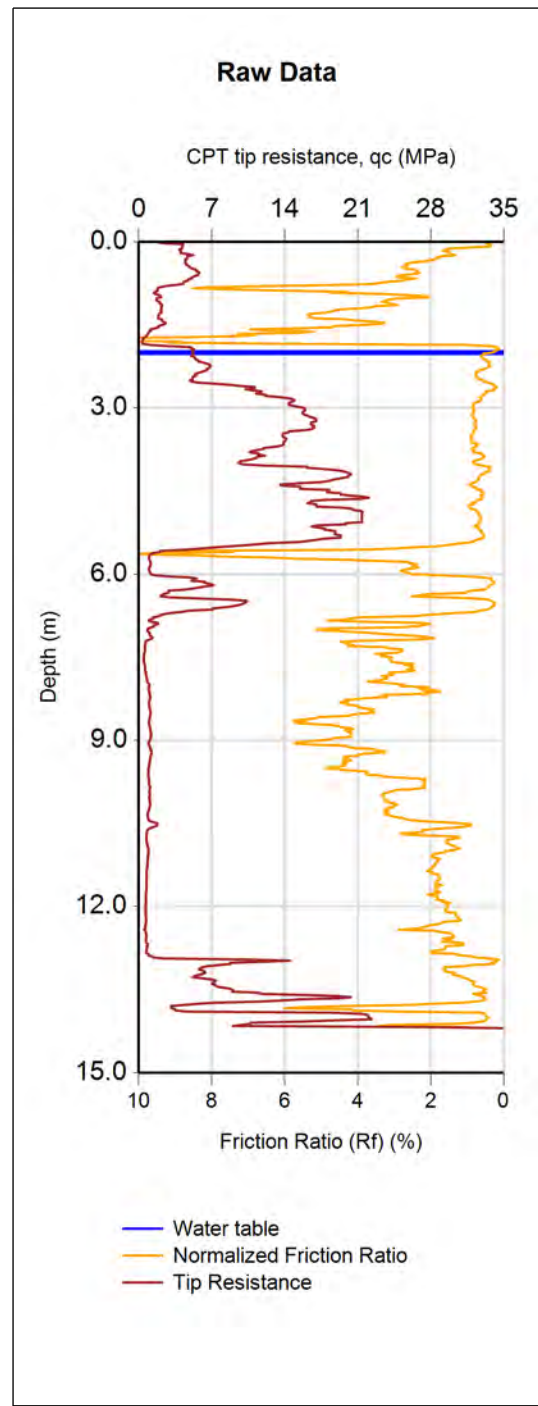
CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	(Assumed pre-drill values)		
										Qc (MPa)	Fs (MPa)	É£ (kN/m³)
CPT21	60520	11/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT22	60521	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT23	60522	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60520	60521	60522
CPT Name	CPT21	CPT22	CPT23
PGA	0.3308g	0.3308g	0.3308g
Magnitude	6.9	6.9	6.9
Depth to groundwater	2m	2m	2m
Predrill depth	0.02m	0.02m	0.02m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0
Total depth of CPT	13.86m	13.48m	12.74m
Maximum depth of analysis	13.86m	13.48m	12.74m
RL	n/a	n/a	n/a



(Assumed pre-drill values)

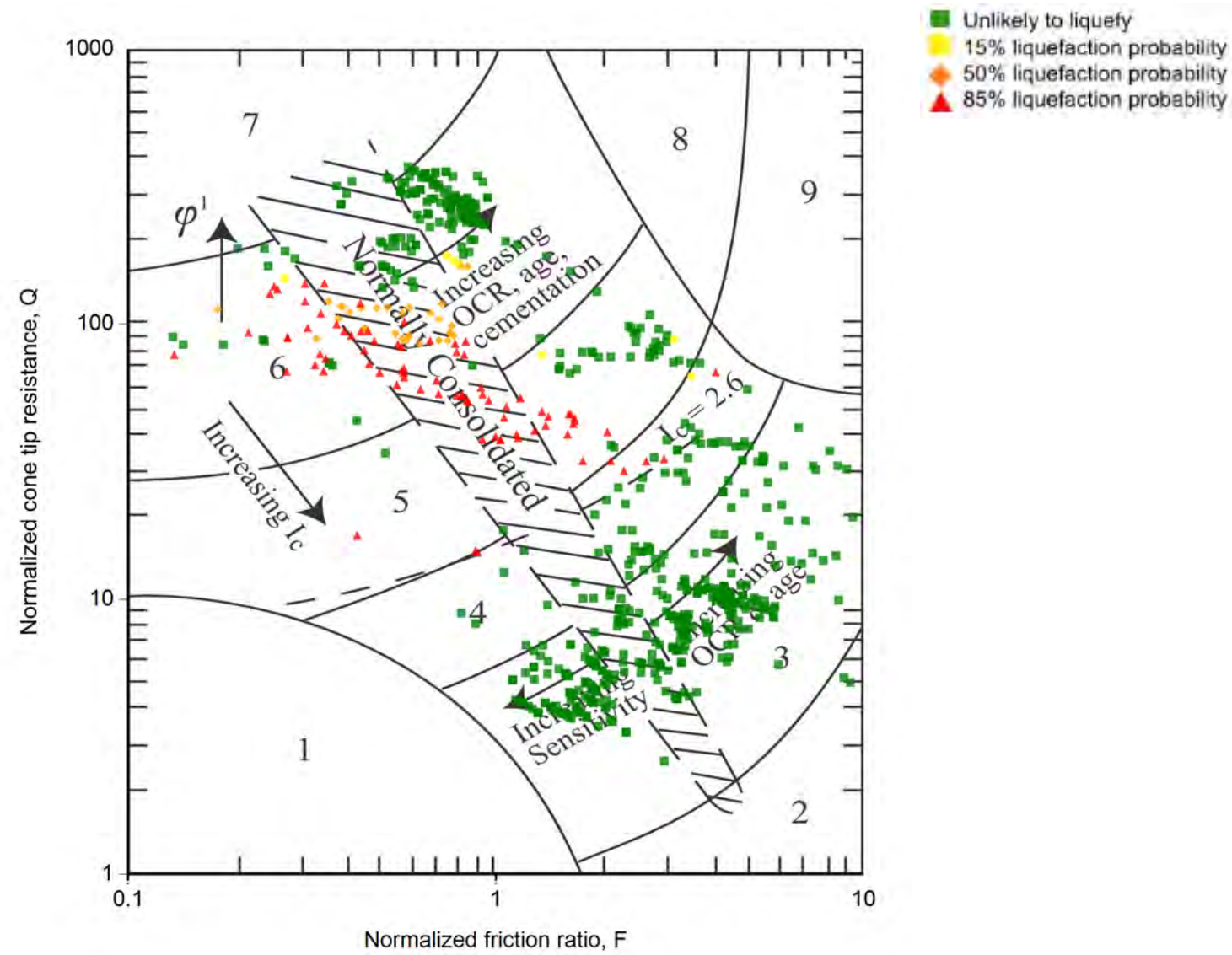
CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT24	60523	10/02/2016	User Specified	6.9	0.3308	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
Exceedance Probability S - Calculated Settlement (mm) CTL - Cumulative Thickness of Liquefaction (m) LPI - Liquefaction Potential Index LSN - Liquefaction Severity Number CT - Crust Thickness (m) LPI Ishihara													
OUTPUT	15%	54	2.4	6	11	2.1	4						
	50%	49	2.2	4	9	2.1	3						
	85%	41	1.6	3	6	5.6	1						



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V1.3

CLIENT, PROJECT	Hastings District Council Housing Rezone
TITLE	ULS Liquefaction Assessment CPT 24-25


LOCATION	Havelock Road/ Howard Street	DATE	4/03/2016
JOB NUMBER	31464.1000	ANALYSED	khl
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		PAGE	1 of 10 pages

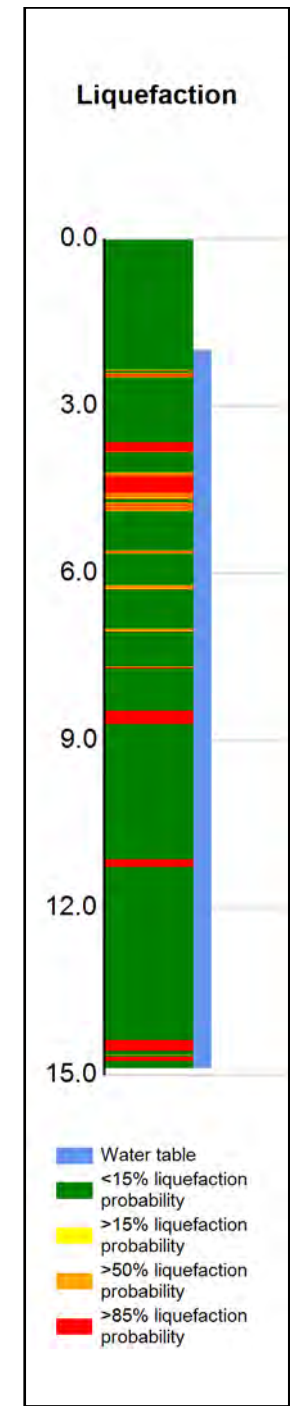
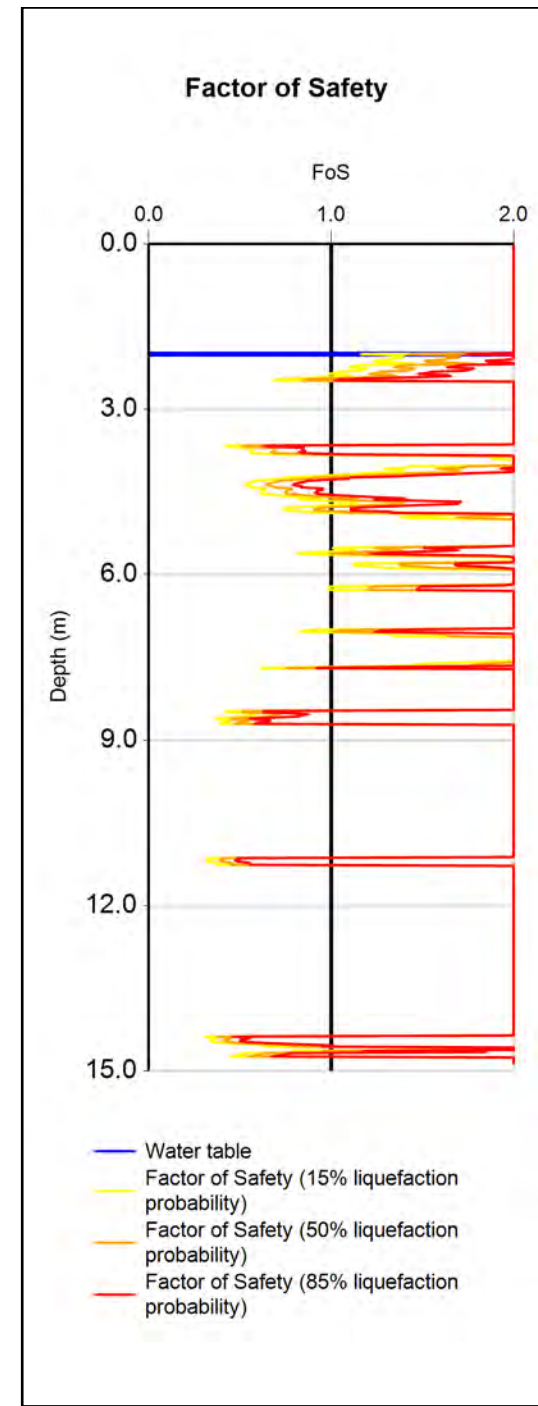
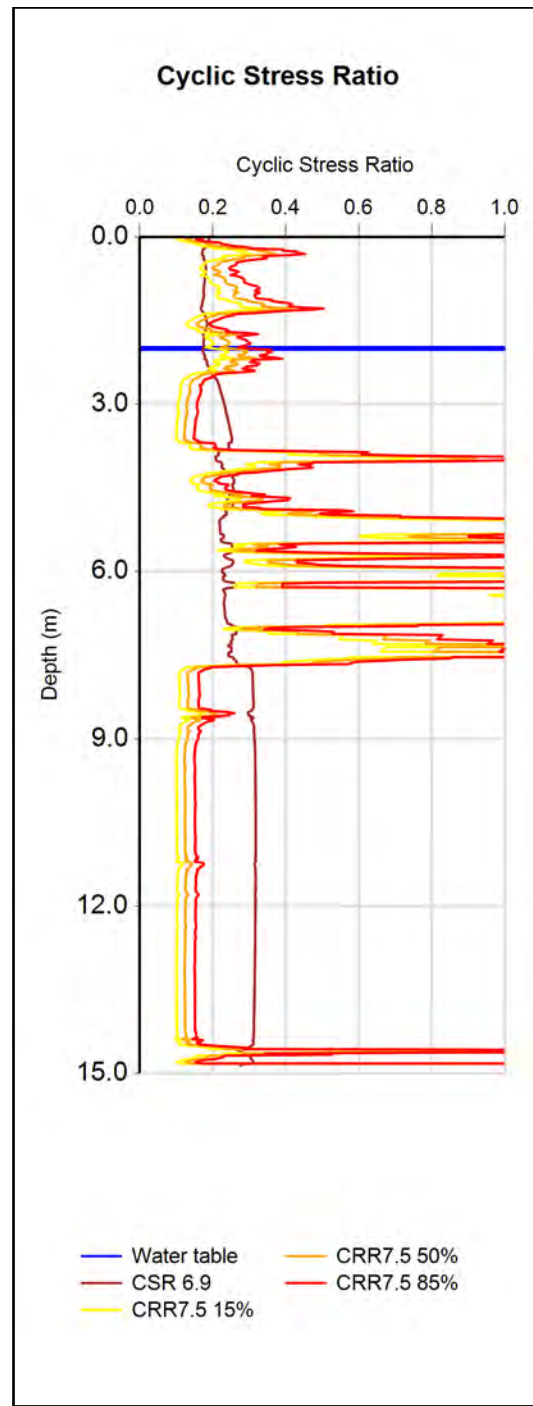
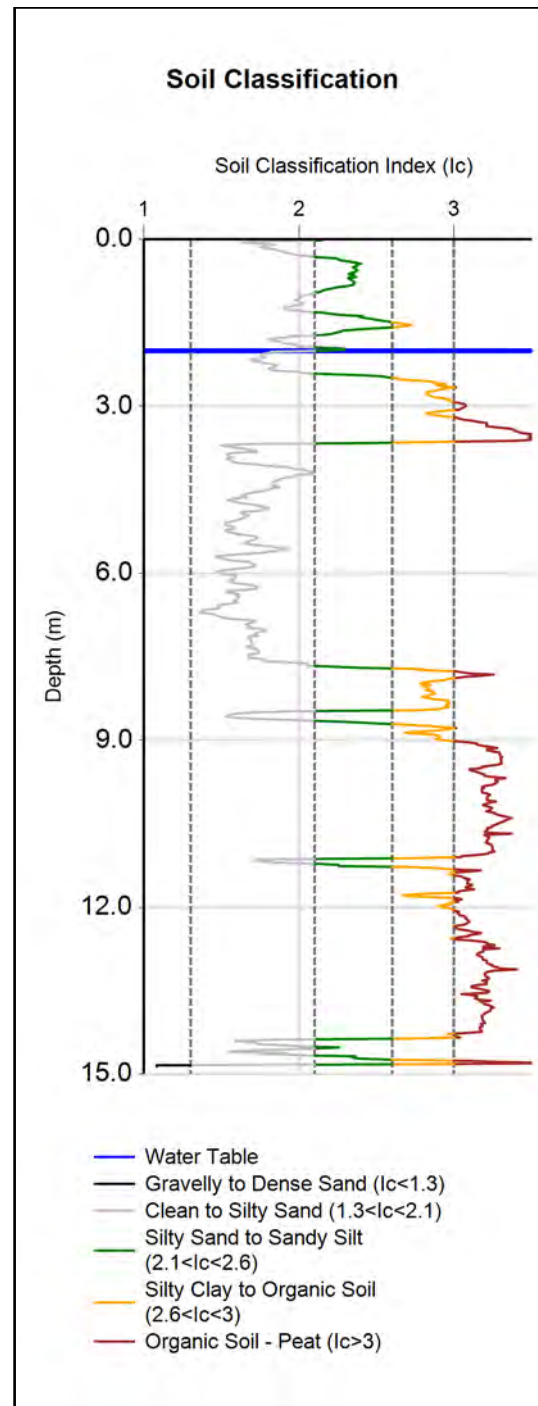
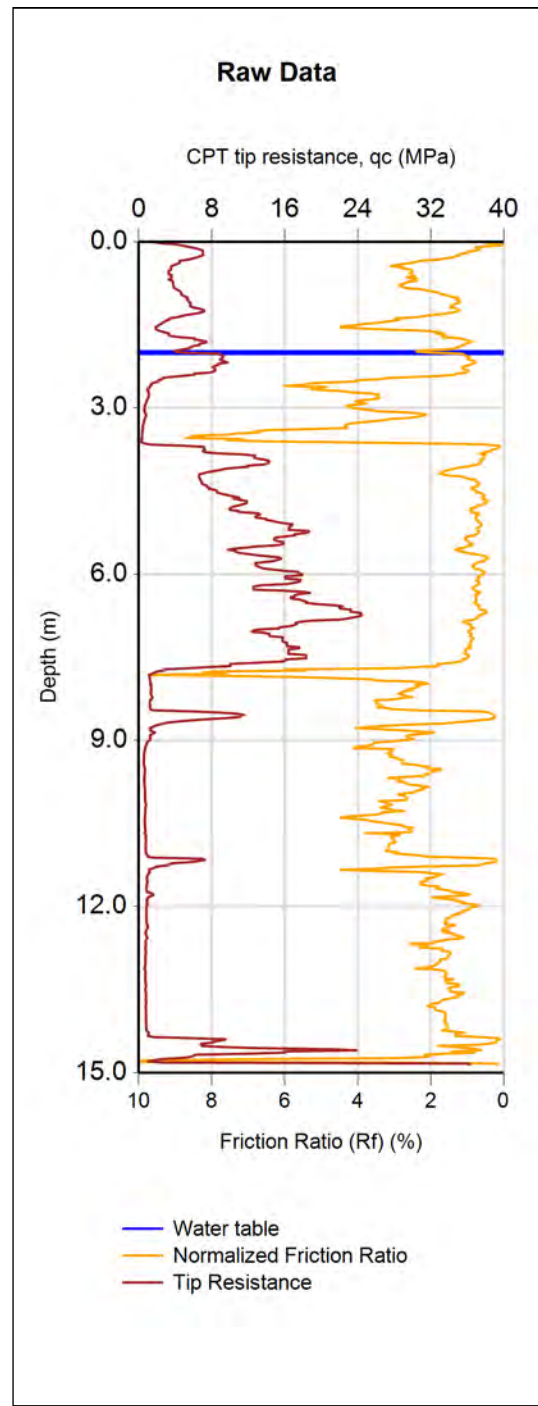


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*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

 Tonkin+Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Hastings District Council Housing Rezone	LOCATION Havelock Road/ Howard Street	DATE 4/03/2016
	TITLE ULS Liquefaction Assessment CPT 24-25	JOB NUMBER 31464.1000	ANALYSED khl



(Assumed pre-drill values)

CPT Name	Database ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)	
INPUT	CPT25	60524	10/02/2016	User Specified	6.9	0.3308	2.0	BI-2014	ZRB-2002	0.02	2	0.01	18
			Exceedance Probability	S - Calculated Settlement (mm)	CTL - Cumulative Thickness of Liquefaction (m)	LPI - Liquefaction Potential Index	LSN - Liquefaction Severity Number	CT - Crust Thickness (m)	LPI Ishihara				
OUTPUT	15%	40	1.8	4	7	2.5	3						
	50%	33	1.4	3	6	3.7	2						
	85%	26	1.1	1	4	3.7	1						



Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT

Hastings District Council
Housing Rezone

TITLE

ULS Liquefaction Assessment CPT 24-25

LOCATION

Havelock Road/
Howard Street

JOB NUMBER

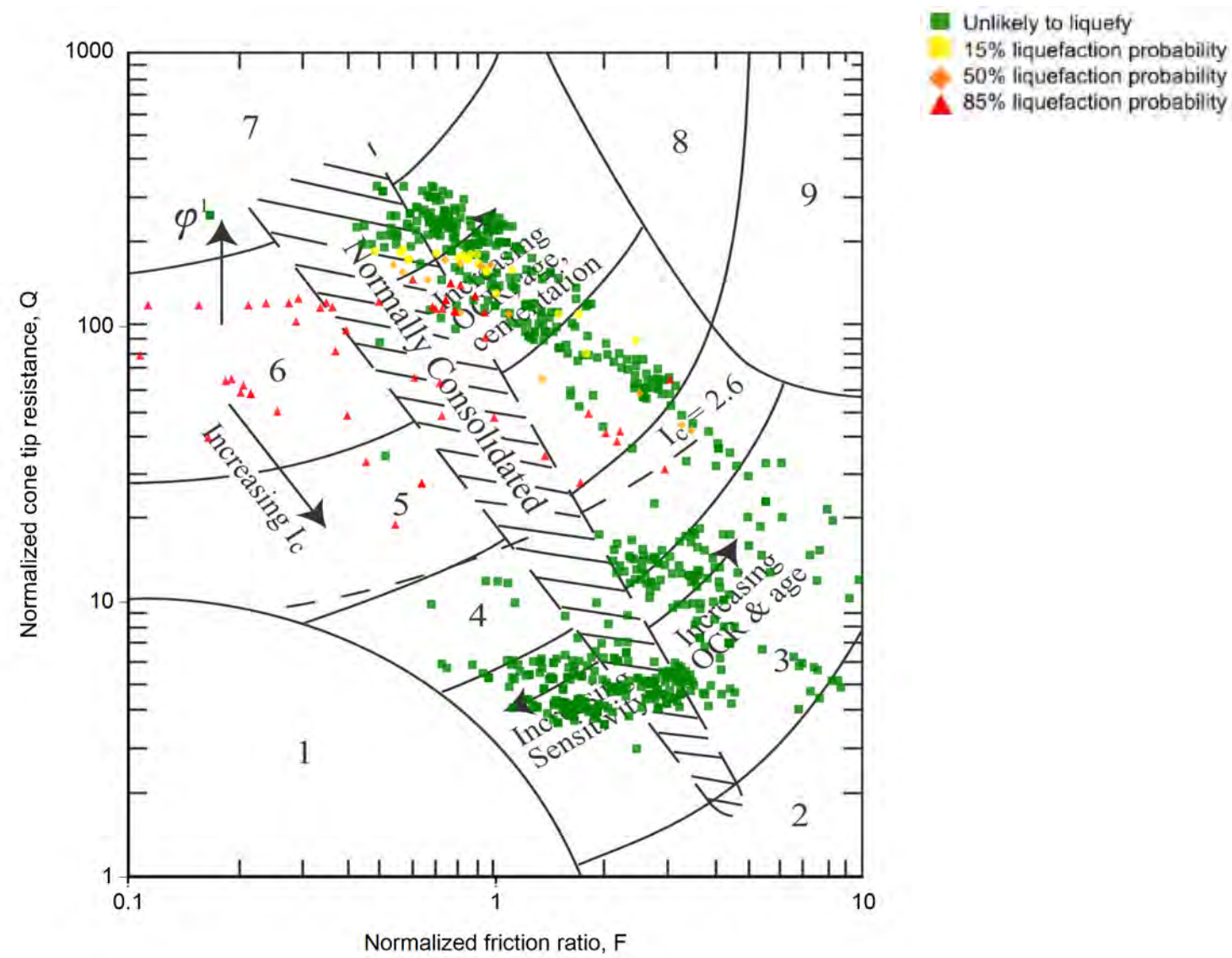
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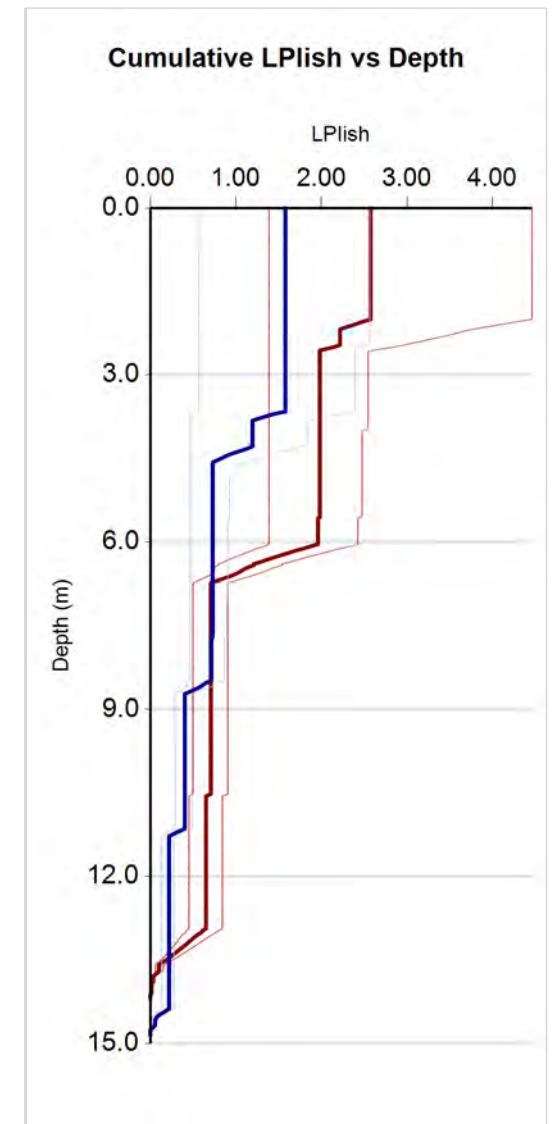
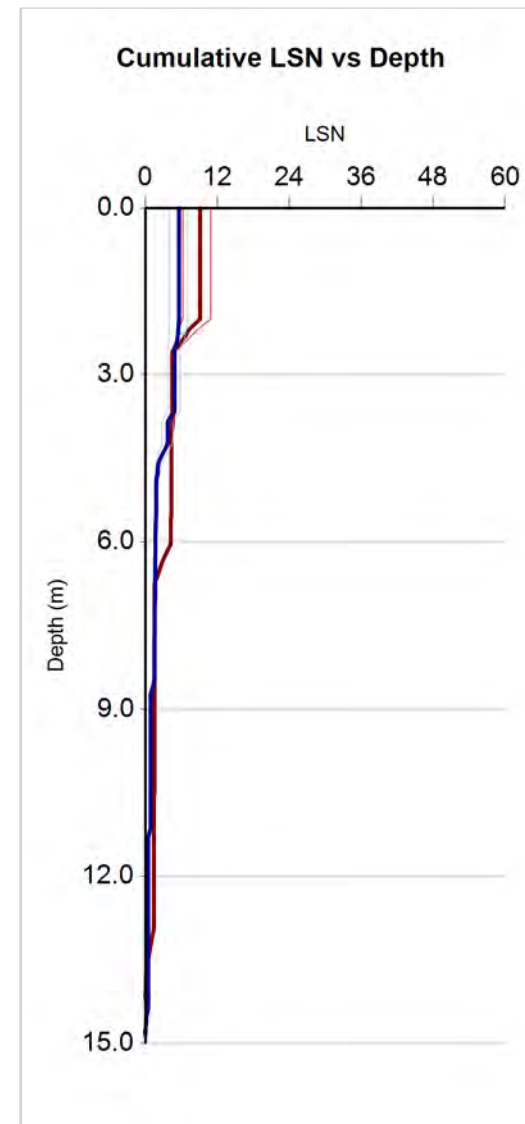
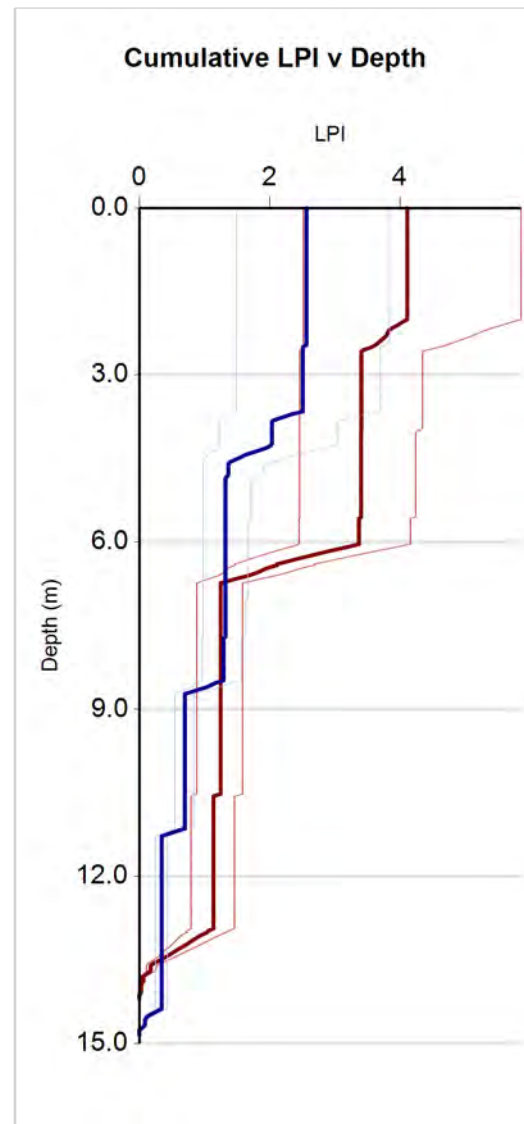
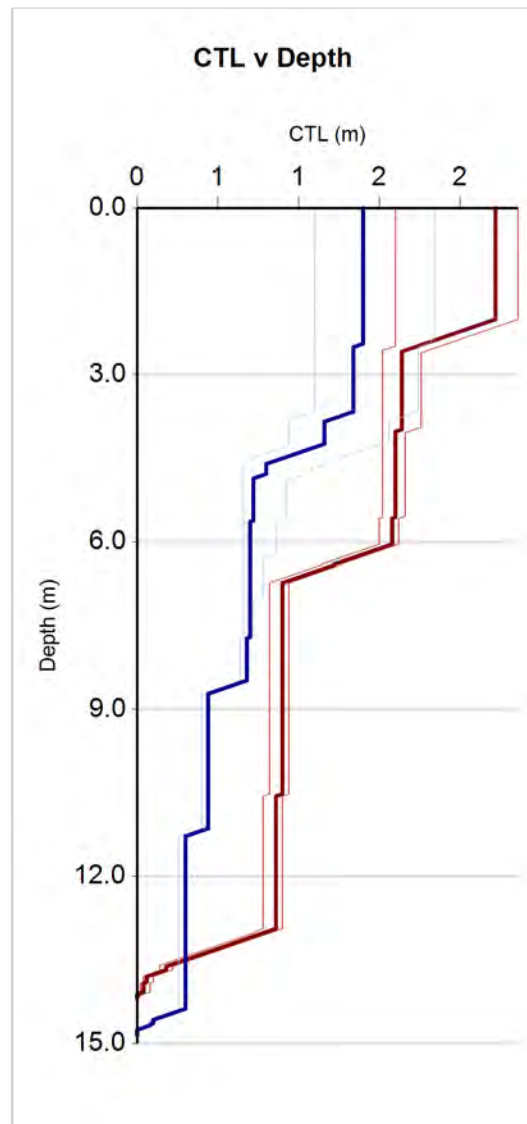
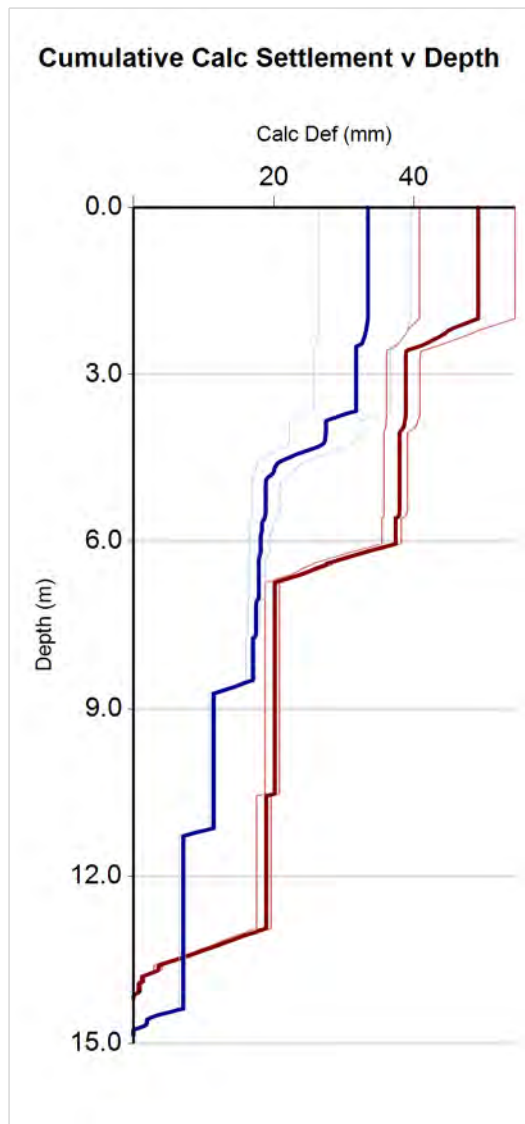


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CPT-based soil behavior type classification chart by Robertson (1990)

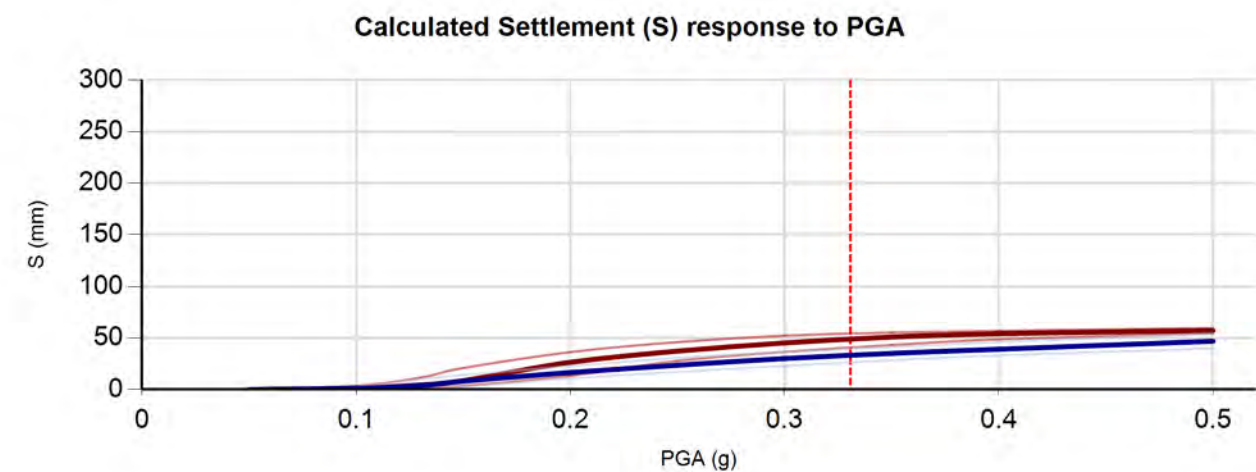
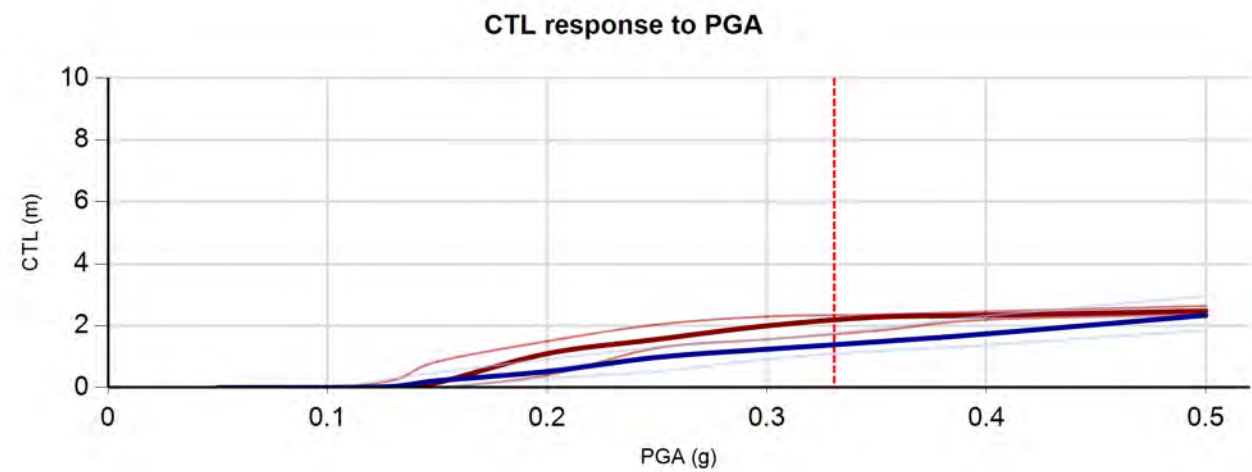
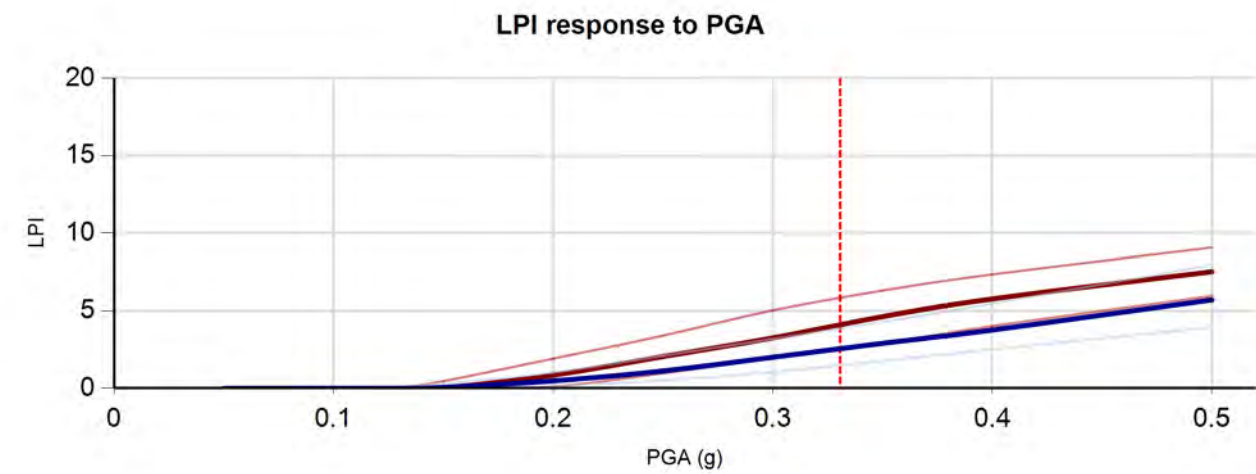
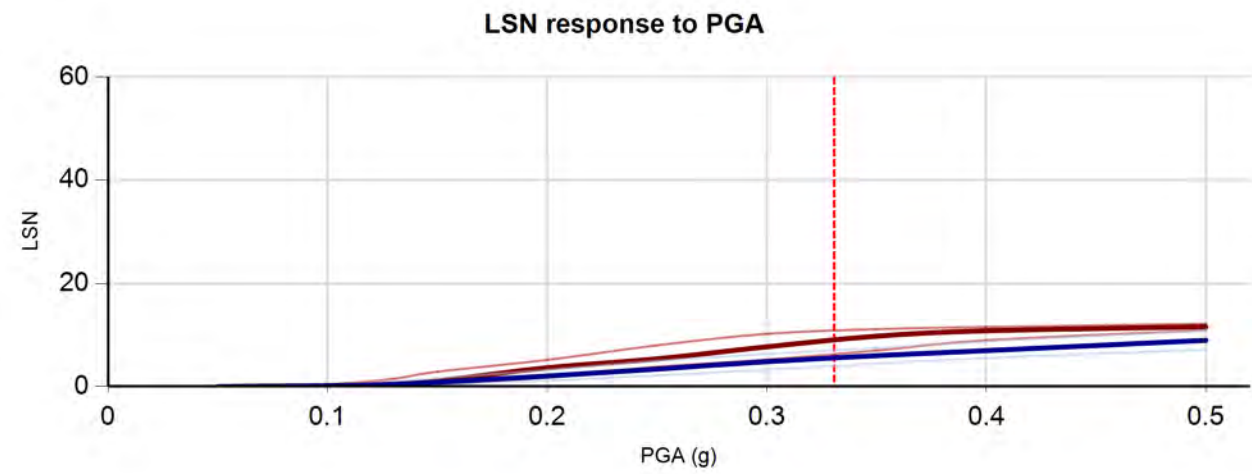
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	TITLE ULS Liquefaction Assessment CPT 24-25	JOB NUMBER 31464.1000	ANALYSED khl



(Assumed pre-drill values)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	γ (kN/m ³)
CPT24	60523	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT25	60524	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

CPT Name	ID	Investigation Date	Event and PGA	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	Qc (MPa)	Fs (MPa)	É£ (kN/m³)
CPT24	60523	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18
CPT25	60524	10/02/2016	User Specified	6.9	0.3308	Varies	BI-2014	ZRB-2002	0.02	2	0.01	18


(Assumed pre-drill values)

Thicker lines represent the 50% probability of exceedance case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	60523	60524
CPT Name	CPT24	CPT25
PGA	0.3308g	0.3308g
Magnitude	6.9	6.9
Depth to groundwater	2m	2m
Predrill depth	0.02m	0.02m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0
Total depth of CPT	14.2m	14.86m
Maximum depth of analysis	14.2m	14.86m
RL	n/a	n/a

 <p>Tonkin + Taylor Exceptional thinking together V1.3</p>	<p>CLIENT, PROJECT</p> <p>Hastings District Council Housing Rezone</p> <p>TITLE</p> <p>ULS Liquefaction Assessment CPT 24-25</p>	<p>LOCATION</p> <p>Havelock Road/ Howard Street</p>	<p>DATE</p> <p>4/03/2016</p>
		<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>khl</p> <p>CHECKED</p> <p>PAGE</p> <p>7 of 10 pages</p>

Liquefaction Assessment Notes

1.1 Liquefaction triggering analysis (Boulanger & Idriss, 2014)

This CPT based triggering analysis calculates a factor of safety (FOS) against liquefaction for each CPT data point. The factor of safety comparison uses the principles of the 'simplified procedure' developed by Seed & Idriss (1971), as set out in the Boulanger & Idriss (2014) publication, was used for this analysis. The simplified procedure compares the seismic demand imposed by an earthquake (referred to as the Cyclic Stress Ratio, or CSR) with the resistance of the soil to liquefaction (referred to as the Cyclic Resistance Ratio, or CRR).

The CSR varies with depth and is calculated as a function of the peak ground acceleration and earthquake magnitude. The CRR is a function of the normalised tip resistance of the CPT, corrected for fines content. The fines content in this calculation is based either on laboratory test results, or the apparent fines content assessed by Boulanger & Idriss (2014).

The CPT can be used to assess the behaviour of the soil, and whether it responds as a fine grained or coarse grained material. Robertson & Wride (1998) presented formulae to calculate a single index, the I_c , to represent the behaviour of the soils. The higher the I_c , the more fine grained the material behaviour is. The I_c is based on the normalised cone tip resistance and skin friction. For this calculation, the normalised values are based on the iterated results presented by Robertson & Wride (1998). Where the calculated I_c exceeds 2.6 the soil is assessed to be too fine grained to liquefy.

1.2 Assumptions

The following assumptions have been made in the liquefaction analyses:

1. The material is a standard material consistent with the empirical liquefaction databases. In other words, material is not welded, cemented or pumiceous in a manner that affects the penetration test results.
2. The pore pressure profile is hydrostatic unless specified in Table 1.1-1

1.3 Calculated volumetric strain and settlements (Zhang, Robertson & Brachman)

Soils that have liquefaction potential densify if subjected to cyclic shearing. This calculated volumetric densification has been investigated by Ishihara & Yoshimine (1992) and Zhang et al. (2002). Ishihara & Yoshimine (1992) presented a series of curves that calculate the volumetric densification of sand samples based on their relative density and factor of safety against liquefaction. The curves are based on samples of sand tested in a laboratory at different densities and undergoing cycles of shear strains. The factor of safety is based on the simplified method originally presented by Seed and Idriss (1971). The curves were updated by Zhang et al. (2002) and included the normalisation of CPT values in the correlations.

The outputs of the calculation are volumetric strains, which can be integrated through layers of potentially liquefiable materials to estimate settlements of the ground.

1.4 Calculated liquefaction vulnerability indicators

1.4.1 Crust thickness

This is the thickness of the non-liquefiable crust at the top of the CPT. It is at least the depth to saturated soil beneath the groundwater table, and can be deeper.

1.4.2 Cumulative Thickness of Liquefaction (CTL)

This parameter represents the sum of all layers within the CPT that have a calculated FoS < 1.0

1.4.3 Calculated settlement


The settlements have been calculated by integrating the calculated volumetric strains with depth. The volumetric strains are calculated using the Boulanger & Idriss (2014) and with the normalised CPT tip resistance based on Zhang, Robertson & Brachman (2002) (ZRB) (Recommended):

$$S = \int \varepsilon(z) dz$$

Note that the calculated settlements often do not correlate well with observed settlements but are better understood as a proxy for the likelihood of damage at the ground surface. As the calculated settlement increases, so does the risk of adverse effects at the ground surface.

1.4.4 Liquefaction Potential Index (LPI)

The vulnerability of sites to liquefaction was considered by Iwasaki et al. (1978) and Iwasaki et al. (1982). Iwasaki's Liquefaction Potential Index (LPI) is presented as a measure of the vulnerability of sites to liquefaction effects. The LPI is defined as:

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	<p>TITLE</p> <p>ULS Liquefaction Assessment CPT 24-25</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>khl</p> <p>CHECKED</p> <p>PAGE</p> <p>8 of 10 pages</p>

$$I_l = \int_0^{20} F_1 W(z) dz$$

Where $W(z) = 10 - 0.5z$, $F_1 = 1 - \text{FOS}$ for $\text{FOS} < 1.0$, $F_1 = 0$ for $\text{FOS} > 1.0$ and z is the depth below the ground surface. FS is the factor of safety calculated using the Boulanger & Idriss (2014) method.

The paper notes that the LPI values range from 0 to 100, with the following published indicators of liquefaction induced damage:

LPI range	Damage
LPI = 0	Liquefaction risk is very low
$0 < \text{LPI} \leq 5$	Liquefaction risk is low
$5 < \text{LPI} \leq 15$	Liquefaction risk is high
LPI > 15	Liquefaction risk is very high

Some researchers have subsequently updated the calculation and interpretation based on field mapping during earthquakes.

1.4.5 Liquefaction Severity Number (LSN)

The Liquefaction Severity Number (LSN) represents the more damaging effects of shallow liquefaction on residential land and foundations. The formula used to calculate LSN is presented below. LSN considers volumetric densification strain within layers as a proxy for severity of liquefaction.


$$LSN = \int \frac{\epsilon_v}{z} dz$$

Where ϵ_v is the calculated volumetric densification strain using Boulanger & Idriss (2014), and z is the depth to the layer of interest.

As the LSN increases, so does the risk of severe effects on the land and residential dwelling. In general, the following levels are reasonable for a typical groundwater table and using Boulanger & Idriss (2014) triggering:

LSN Effects

0-5	Negligible to Minor, no major effects expected
5-20	Minor, generally consistent with acceptable performance under SLS conditions (i.e. little settlement or permanent dwelling damage). Ejection of material can be expected at the ground surface, but likely to be localised in nature.
20-40	Moderate, liquefaction evidence possible and lateral spreading possible if free faces present. Generally consistent with acceptable performance under ULS conditions (i.e. settlement)
>40	Severe, high risk of substantial damage to the site and/or dwelling

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	<p>TITLE</p> <p>ULS Liquefaction Assessment CPT 24-25</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>ANALYSED</p> <p>khl</p> <p>CHECKED</p> <p>PAGE</p> <p>9 of 10 pages</p>

2.0 References

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Robertson, P.K. & Wride, C.E. (1998). *Evaluating cyclic liquefaction potential using the cone penetration test*, Canadian Geotechnical Journal, 35:442 – 459

Ishihara, K. & Yoshimine, M. (1992). *Evaluation of settlements in sand deposits following liquefaction during earthquakes*, Soils and Foundations, 32 (1), 173–188

Iwasaki, T., Tatsuoka, F., Tokida, K.-i. and Yasuda, S. (1978). A practical method for assessing soil liquefaction potential based on case studies at various sites in Japan, in Proceedings, 2nd International Conference on Microzonation, San Francisco, pp. 885–896.

Iwasaki, T., Arakawa, T. & Tokida, K. (1982). *Simplified Procedures for Assessing Soil Liquefaction During Earthquakes* Proc. Conference on Soil Dynamics and Earthquake Engineering. Southampton, 925-939

Boulanger, R.W. & Idriss, I.M. (2014). *CPT and SPT Liquefaction Triggering Procedures*, University of California

Zhang, G., Robertson, P. K. & Brachman, R. W. I. (2002). Estimating liquefaction-induced ground settlements from CPT for level ground, Canadian Geotechnical Journal, 39, 1168–80

Some other useful publications:


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 <p>Tonkin + Taylor Exceptional thinking together V1.3</p>	<p>CLIENT, PROJECT</p> <p>Hastings District Council Housing Rezone</p>	<p>LOCATION</p> <p>Havelock Road/ Howard Street</p>	<p>DATE</p> <p>4/03/2016</p>
	<p>TITLE</p> <p>ULS Liquefaction Assessment CPT 24-25</p>	<p>JOB NUMBER</p> <p>31464.1000</p>	<p>CHECKED</p> <p>PAGE</p> <p>10 of 10 pages</p>

