GEOTECHNICAL ASSESSMENT
PROPOSED PLAN CHANGE
RANGITIKEI LINE AND FLYGERS LINE
PALMERSTON NORTH

Engineers and Geologists

RILEY CONSULTANTS LTD
New Zealand
Email: riley@riley.co.nz
Email: rileychch@riley.co.nz
Web: www.riley.co.nz

AUCKLAND
4 Fred Thomas Drive, Takapuna, Auckland 0622
PO Box 100253, North Shore, Auckland 0745
Tel: +64 9 489 7872 Fax: +64 9 489 7873

CHRISTCHURCH
22 Moorhouse Avenue, Addington, Christchurch 8011
PO Box 4355, Christchurch 8140
Tel: +64 3 379 4402 Fax: +64 3 379 4403

GEOTECHNICAL ASSESSMENT
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RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH

Report prepared for: Flygers Line Investment Group Limited

Report prepared by: Laura Smith, Geotechnical Engineer

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Report reviewed and approved for issue by: Don Tate, Director, CPEng

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Copies to: Flygers Line Investment Group Limited Electronic copy

Riley Consultants Ltd 1 copy

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Contents

Appendices

RILEY CONSULTANTS LTD
New Zealand
Email: riley@riley.co.nz
Email: rileychch@riley.co.nz
Web: www.riley.co.nz

AUCKLAND
4 Fred Thomas Drive, Takapuna, Auckland 0622
PO Box 100253, North Shore, Auckland 0745
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1.0 Introduction

Riley Consultants Ltd (RILEY) has prepared the following report at the request of Resonant Consulting Limited (RCL) on behalf of Flygers Line Investment Group Limited. This geotechnical assessment has been prepared as part of an overall submission to Palmerston North City Council (PNCC) to rezone the existing rural site as residential land.

Our brief has not included potential flooding hazards. A ground contamination investigation has also been carried out on this site as part of the proposed plan change submission (RILEY Ref:170672-B, dated 13 February 2019).

2.0 Scope of Work

The scope of work has included the following main elements:

- Desktop review of historical aerial photographs, data available from the New Zealand Geotechnical Database (NZGD), and the GNS report for Palmerston North[1].
- Subsurface geotechnical investigations including 12 cone penetrometer tests (CPT), three machine boreholes, and three standpipe piezometers. Shallow hand auger boreholes, drilled as part of the ground contamination investigation, also give additional information.
- Laboratory testing of selected samples recovered from the machine boreholes to assist interpretation.
- Assess the extent of liquefaction susceptibility and associated risks to the proposed residential land.
- Comment on options for mitigation measures where required for future development.
- Assess any other geotechnical hazards that may have an impact on residential development.

3.0 Site Description

The site proposed for re-zoning, legally described as Lots 1 and 2 DP 389924, is located beyond the present northern urban limit of Palmerston North and is bordered by Flygers Line, Rangitikei Line, residential housing to the south-east, and rural farmland to the south-west. Aerial photography and LiDAR data show that the site is relatively flat with a stream running north to south through the middle of the site. The site is currently used as farmland and cropping.

[1] *Assessment of liquefaction and related ground failure hazards in Palmerston North, New Zealand. GNS Science Consultancy Report 2011/108 July 2011.*

4.0 Geology

From a review of the 1:250,000 Geological Map, together with our experience of the surrounding area, we infer that the site is underlain by Holocene river deposits comprising gravel, sand, silt, mud, and clay with local peat. A review of the New Zealand Geotechnical Database (NZGD) yielded no investigations within the site itself, but a few deep wells just outside the site boundaries are shown in the GNS report.

5.0 Geotechnical Investigations

To assess the subsurface conditions, 12 CPTs were carried out on 29 June 2018 to a maximum depth of 6.5m where practical refusal was reached in all tests. A tractor rig supplied and operated by Geotech Drilling Limited (Geotech Drilling) was used to push the CPTs.

Initial analyses of the shallow CPTs indicated moderate liquefaction potential, therefore, a further three machine holes (MH1 to MH3) were drilled on 16 January 2019 to depths of 10m to 15m where the target depth was reached. Material recovered from the boreholes were logged in accordance with the NZGS Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes. In-situ standard penetrometer testing (SPT) was carried out at 1.5m intervals. Standpipe piezometers were installed in each machine hole targeting depths between 6m and 15m. A sonic rig supplied and operated by Geotech Drilling was used to drill the machine holes.

14 hand auger boreholes were drilled to a maximum depth of 1m as part of the ground contamination investigation and are summarised in the Preliminary and Detailed Site Investigation Contaminated Land report (RILEY Ref:170672-B, dated 13 February 2019).

The machine hole, CPT, and hand auger borehole locations are shown on RILEY Dwg: 170672-1, attached, and machine hole, hand auger, and CPT logs are included within Appendix A.

6.0 Laboratory Testing

Laboratory testing was undertaken by Opus Laboratory on a sample selected from MH3. Atterburg Limit tests were carried out to provide a comparison to soil type from descriptions and inferred from CPT tests. Further testing was not considered necessary because the soil types from CPT and machine hole logs were consistent.

Results of the Atterburg Limit test gives a liquid limit of 69 and a plasticity Index of 42, which plots on the Casagrande Plasticity Chart as a highly plastic, inorganic, non-dilatant clay (CH). This soil can, therefore, be classified as non-liquefiable. Laboratory test results are presented within Appendix B.

7.0 Results of Subsurface Investigation

Subsoil conditions typically comprise firm sandy and clayey silts and sands from the surface to approximately 5m below ground level (bgl) to 7m bgl, where very dense gravels were encountered and on which the CPTs terminated. The machine boreholes below this depth largely encountered gravels with lenses of stiff clayey silt and very dense sandy gravel in places.

Subsoil conditions encountered at the test locations are summarised below and detailed descriptions of the soils encountered during drilling are given on the appended logs.

Table 1: Geological Model

Layer no.	Geological Unit	Description	Depth to top of layer (m)	Layer thickness (m)	Typical SPT 'N' value	Typical CPT tip resistance qc (MPa)
1	Topsoil	Brown, trace fine rootlets.	0	0.15 to 0.2	N/A	
2	Holocene River Deposits	Silt/sandy silt; dark grey. Firm, wet to saturated, moderately plastic.	0.15 to 0.2	4.3 to 4.35	18, 6, 3, 4	1 to 12
3	Holocene River Deposits	Silt/clayey silt; light bluish grey. Very soft, saturated, moderately plastic.	4.5	0.8 to 1.4	0, 1	0 to 2
4	Holocene River Deposits	Fine to medium gravel and fine to coarse sand; dark grey. Very dense, rounded, well graded.	5.3 to 5.9	4.1 to 6.0	50+	10 to 35, 20+, 10 to 30
5	Holocene River Deposits	Clayey silt/silt; grey. Stiff, slightly to moderately plastic.	9.4 to 11.9	1.6 to 2.1	15, 10, 15	
6	Holocene River Deposits	Silty sandy gravel; grey. Very dense, rounded.	11+ to 14	1.35+	50+	

The ground conditions encountered during the investigation are broadly consistent with published local geological maps. Groundwater was encountered between 3.0m and 4.2m bgl in the machine boreholes during January, and groundwater was measured after each CPT in June between 0.9m and 1.9m bgl. The shallow hand auger boreholes also encountered groundwater between 0.8m and 0.9m bgl.

8.0 Geotechnical Considerations

8.1 Depth to Groundwater

Groundwater was measured between 3.0m bgl and 4.2m bgl in the machine holes during January 2019 and between 0.8m and 1.9m bgl following each CPT and hand auger borehole carried out in June 2018. Groundwater levels are likely to vary seasonally and following rainfall events. A groundwater level of 4m bgl was mapped in the GNS report for Palmerston North.

8.2 Liquefaction Potential

8.2.1 Seismic Site Classification

The seismic loading induced on a structure will depend on, amongst other factors, the stiffness of the underlying soil/rock where the structure is located. Sites with low strength deep soils can amplify ground accelerations, requiring the structures built on them to resist a higher seismic coefficient. The New Zealand Structural Design code, NZS 1170.5:2004: Earthquake Actions, contains response spectra for structural design. Sites are categorised into five classes, Classes A to E. The site classes range from rock sites, Class A and B, to very soft or deep soil sites, Class E. These categories are used in structural design analysis.

A review of the machine hole logs and CPT data indicates that depths of firm to stiff sandy silts and very dense gravels encountered in the machine holes and CPTs did not exceed the maximum depth limits for site subsoil Class C (refer Table 3.2 in NZS 1170.5:2004), however, refusal in gravels does not discount the possibility of the site being classed as subsoil Class D. Therefore, the site is conservatively identified as category **Class D (deep soil sites)** for the purposes of our liquefaction assessment.

8.2.2 Methodology

Liquefaction can occur in saturated loose to medium dense cohesionless deposits (silts and sands) in moderate to severe ground shaking. Geologically, recent materials or very weak man-made fills are the most susceptible soils. Effects on structures and subdivision infrastructure such as roads and services include; lateral spreading, settlement, loss of support, and other effects such as flotation. The steps in the liquefaction assessment are as follows:

- Review the range of soils encountered for susceptibility on a qualitative basis.
- Analytical assessment of the CPT data using GeoLogismiki v.2.1.6.7.
- The methods are based on the latest methodology from the NZGS and Ministry of Business, Innovation and Employment (MBIE) Guidelines, developed after the Canterbury earthquake sequence, with the most up to date guidance published in 2016.
- The CPT is generally regarded within the industry as the most reliable method of testing potential liquefiable materials. The ground motion parameters are based on the following:
    - 500-year return period shaking for Ultimate Limit State (ULS).
    - Class D (deep soil).
    - Magnitude 6.9 earthquake (ULS), 6.1 Servicability Limit State (SLS).
- For the purposes of the liquefaction analyses presented in this report, a depth to groundwater of 1.0m bgl has been used.

The resulting peak ground acceleration for liquefaction analysis is 0.34g for ULS, and 0.09g for SLS using the latest MBIE guidance (2016), MBIE Module 1: Method 1, New Zealand Transport Agency Bridge Manual Addendum 6A.

8.2.3 Results

A qualitative assessment of each individual CPT investigation point has been made in terms of liquefaction susceptibility. Potentially liquefiable materials were identified within the upper 6.0m of the soil profile, comprising discrete layers of loose to medium dense sandy silt, or silty sand. The dense to very dense gravels encountered below 6m depth are not likely to liquefy. Table 2 shows the assessed thickness of any potentially liquefiable zones (i.e. saturated loose to medium dense materials) at each investigation location within alluvium and the corresponding settlement (for the SLS case of 0.09g and ULS case of 0.34g). Results from the liquefaction assessment are attached in Appendix C.

Table 2: Results of Liquefaction Assessment for ULS and SLS Event

CPT Location	CPT Depth (m)	Depth Interval of Potentially Liquefiable Soils (m)	SLS Vertical Settlement (mm)	ULS Vertical Settlement (mm)	Technical Category
1	4.8	1.0 to 1.1, 1.7 to 1.9, 2.1 to 3.4, and 3.7 to 4.5	2.5	94	TC2
2	6.1	1.0 to 2.4, 2.5 to 3.6, 3.7 to 4.3, and 4.8 to 5.7	1.5	119	TC2/3
3	5.7	1.3 to 1.5, 2.6 to 3.8, 4.2 to 4.6, and 5.5 to 5.6	2.5	80	TC2
4	4.1	1.0 to 2.2 and 2.6 to 2.9	0	39	TC2
5	5.6	1.0 to 1.2, 2.0 to 2.2, 2.6 to 3.2, 3.4 to 4.4, and 4.7 to 5.1	2.5	85	TC2
6	5.6	1.0 to 1.7, 2.0 to 2.2, 3.3 to 4.9, and 5.2 to 5.5	4	79	TC2
7	6	1.5 to 2.0, 4.2 to 4.9, and 5.2 to 6.0	2.5	71	TC2
8	5.3	3.4 to 3.7 and 4.0 to 4.4	0	24	TC2
9	5.7	2.2 to 3.7, 4.0 to 4.6, and 5.1 to 5.6	1.5	84	TC2
10	6.5	2.0 to 3.1, 4.5 to 5.2, and 5.7 to 6.5	2.5	92	TC2
11	5.7	1.0 to 1.5, 2.6 to 2.7, 3.2 to 3.3, 3.6 to 5.0, and 5.5 to 5.6	1	69	TC2
12	1.9	1.0 to 1.6 and 1.7 to 1.8	0	17	TC1

The assessed liquefied soils are within the upper Holocene River Deposits, typically described as loose to medium dense sandy silt, or silty sand. Overall, the thickness of liquefied soils for the SLS event is negligible, and several metres for the ULS event. Associated settlements are less than 15mm for the SLS event and less than 100mm (with one exception) for the ULS design seismic event. Liquefaction induced settlements in the order of 20mm to 100mm should be anticipated under the ULS event.

The liquefaction severity number (LSN) is a parameter based on investigation data, and considers the potential for liquefaction and the depth at which liquefaction occurs. This parameter has been correlated with evidence of surface ground damage in Christchurch. The LSN calculated for this site is typically between 20 and 30 (up to 45 in CPT2) and generally indicates moderate expression of liquefaction, sand boils, and minor damage to ground surface as well as minor differential settlement of structures.

The GNS Report for Palmerston North describes the low-lying materials of Holocene age, particularly saturated loose sands and silts, to be most likely to liquefy. The geological map categorises the site in the moderate to high liquefaction category for ground damage potential, however, it is noted that further subsurface information and assessment is required to determine material thicknesses and groundwater levels.

Based on the geotechnical investigation and the assessment undertaken for this site, in accordance with MBIE guidance, the site has a predicted future land performance **consistent with TC2**. We note that the MBIE guidance is for residential sites in Christchurch, however in the absence of any other available guidance, the MBIE guidelines are considered a suitable approach for this assessment.

Liquefaction presents a hazard to urban infrastructure in addition to dwellings (i.e. roads, buried services etc). This should be taken into account in infrastructure development.

8.3 Lateral Spreading

Lateral spreading may occur if a continuous horizon of liquefied soil is present. Free-face lateral spreading conditions may occur when liquefiable layers are continuous to a stream bank. The nearest free-face is adjacent to any of the streams or drainage ditches running through or close to the site. The main stream has an estimated free-face height of 2.5m located in the south-west area of the site and drainage ditches also just beyond the northern boundary (alongside Flyers Line) and in the centre of the site running approximately east to west. For conventional residential dwellings and land to be categorised as TC2 land for residential dwellings, up to 100mm of lateral stretch under the ULS event is considered acceptable and 50mm in the SLS event.

Empirical methods used to evaluate lateral spreading displacements for this site produced highly varying results with corresponding required setback distances exceeding 100m. As a comparison, MBIE have recommended various fallback setback distances from a free-face for TC3 sites in Christchurch (minor to moderate movement of less than 300mm). These distances range from 50m for typical watercourses to 100m to 200m for the Avon and Heathcote rivers. Given that the soil conditions at this site are in the TC2 category compared to the much more severe TC3 category, significantly less deformation would be expected, but this is balanced by the TC2 deformation limit of 100mm. Based on this approach, a setback distance in the order of 50m could be justified, but dwellings would need to be designed to a higher foundation standard of TC3. We note, however, such an approach may not be desirable for a new development. The options to mitigate the hazard include the following:

1. Ground improvement, which may be costly on a large-scale (allowing for a TC2 type foundation).
2. Utilise TC2 type foundations with appropriate setback i.e. without ground improvement (the setback distance requires refinement but could be considerable).
3. Utilise TC3 type foundations with a lesser setback than Option 2.

It should be noted that negligible liquefaction is predicted in the SLS event and the lateral spreading risk is correspondingly low. Also, there is a wide variability in seasonal groundwater levels, which also influences the lateral spreading risk. We recommend that further investigations surrounding stream banks and other free-faces are carried out to gain a more accurate prediction of lateral spreading displacements for this site and further develop options to mitigate the hazard.

9.0 Other Geotechnical Constraints

Land across the site is generally flat, therefore, the risk of slope instability is considered to be negligible.

Previously infilled streams will need to be investigated further to define the extent and nature of the material used for infilling. There may be a risk of settlement due to historic filling in these areas depending on the material used for infilling. The scale of these features is small relative to the size of the site and potentially only localised to these areas. It has been noted that none of the shallow hand augers encountered any obvious fill material.

10.0 Conclusions

From the site investigation, subsoil conditions comprise Holocene river deposits described as firm sandy and clayey silts and sands from the surface to approximately 5m bgl to 7m bgl, where very dense gravels were encountered.

An assessment of the site and subsoil conditions was carried out to determine the geotechnical risks present. These risks include liquefaction, lateral spreading, and slope instability. Since the site is generally flat, the risk of slope instability is considered to be negligible. However, the site is susceptible to liquefaction induced settlements and lateral spreading during future earthquake events.

Our liquefaction assessment predicts the upper loose river deposits to have negligible risk of liquefaction following an SLS event and 20mm to 100mm of liquefaction induced settlement under the ULS event. This corresponds to a predicted future land performance **consistent with TC2** and generally indicates moderate expression of liquefaction, sand boils, and minor damage to ground surface as well as minor differential settlement of structures. Foundations for new buildings in these areas are likely to be TC2 type foundations.

The risk of lateral spreading following an SLS event is considered to be negligible, however, under a ULS event the amount of lateral displacement varies significantly. Additional geotechnical investigations and assessments, tailored to the specific development, are recommended surrounding stream banks and other free-faces to gain a more accurate prediction of lateral spreading displacements for this site and further develop options to mitigate the hazard. In any event, we expect that with appropriate mitigation measures the site should be suitable for residential development from a geotechnical perspective, subject to the recommendations outlined in this report.

11.0 Limitation

This report has been prepared solely for the benefit of Flygers Line Investment Group Ltd as our client with respect to the brief and Palmerston North City Council in processing the plan change. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Recommendations and opinions in this report are based on data from limited test positions. The nature and continuity of subsoil conditions away from the test positions are inferred, and it must be appreciated that actual conditions could vary considerably from the assumed model.

During excavation and construction, the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation and the modification of the design based upon this report.

Riley Consultants Ltd would be pleased to provide this service to Flygers Line Investment Group Ltd and believes the project would benefit from such continuity. In any event, it is essential Riley Consultants Ltd is contacted if there is any variation in subsoil conditions from those described in the report as it may affect the design parameters recommended in the report.

APPENDIX A

CPT, MH, and HA Investigation Logs

RILEY CONSULTANTS

Christchurch:
22 Moorhouse Ave. Addington, Christchurch 8011
PO Box 4355, Christchurch 8140
Tel. 03 379 4402 Email: rileychch@riley.co.nz

Auckland:
4 Fred Thomas Drive, Takapuna, Auckland 0622
PO Box 100253, North Shore, Auckland 0745
Tel. 09 489 7872 Email: riley@riley.co.nz

GEOTECHNICAL AND GEOLOGICAL INFORMATION

SOIL TYPES AND SYMBOLS


FILL


TOPSOIL


SILT


SAND


GRAVEL


CLAY


PEAT


GROUNDWATER LEVEL

10,11,10
SCALA PENETROMETER
LAST 3 NUMBER OF BLOWS PER 50mm INCREMENT

ROCK TYPES AND SYMBOLS


SANDSTONE


SILTSTONE


MUDSTONE


LIMESTONE


BASALT


TUFF


IGNIMBRITE


GREYWACKE

SOIL STRENGTH CLASSIFICATION

FINE GRAINED COHESIVE SOILS

TERM	FIELD IDENTIFICATION	UNDRAINED SHEAR STRENGTH (KPa)
Very Soft (Vs)	Exudes between fingers when squeezed.	<12
Soft (S)	Easily indented by fingers.	12 – 25
Firm (F)	Indented only by strong finger pressure.	25 – 50
Stiff (St)	Indented by thumb pressure.	50 – 100
Very Stiff (VSt)	Indented by thumbnail.	100 – 200
Hard (H)	Difficult to indent by thumbnail.	200+

SPT & SCALA PENETROMETER RESULTS

TERM	SPT VALUE No. of BLOWS/300mm	SCALA PENETROMETER No. of BLOWS/100mm
very dense	>50	17+
dense	30 – 50	7 – 17
medium dense	10 – 30	3 – 7
loose	4 – 10	1 – 3
very loose	0 – 4	0 – 2

ROCK STRENGTH CLASSIFICATION

TERM		FIELD IDENTIFICATION	UNCONFINED UNIAXIAL COMPRESSIVE STRENGTH (MPa)
Extremely weak	(EW)	Indented by thumbnail.	< 1
Very weak	(VW)	Crumbles under firm blows with point of geological hammer. Can be peeled with pocket knife.	1 – 5
Weak	(W)	Difficult to peel with pocket knife.	5 – 20
Moderately strong	(MS)	Cannot be scraped or peeled with pocket knife.	20 – 50
Strong	(S)	More than one blow of geological hammer to fracture.	50 – 100
Very strong	(VS)	Many blows of geological hammer to break.	100 – 250
Extremely strong	(ES)	Can only be chipped with geological hammer.	250+

MOISTURE CONDITION

Dry (D)	Looks and feels dry; powdery and friable.
Moist (M)	Feels cool; darkened in colour; no free water when remoulded.
Wet (W)	Feels cool; darkened in colour; free water forms on hands.
Saturated (S)	Free water is present on sample.

SAMPLE TYPES


UNDISTURBED


MACHINE AUGER DISTURBED

D
HAND AUGER DISTURBED


STANDARD PENETRATION TEST (solid cone)


STANDARD PENETRATION TEST (hollow cone)

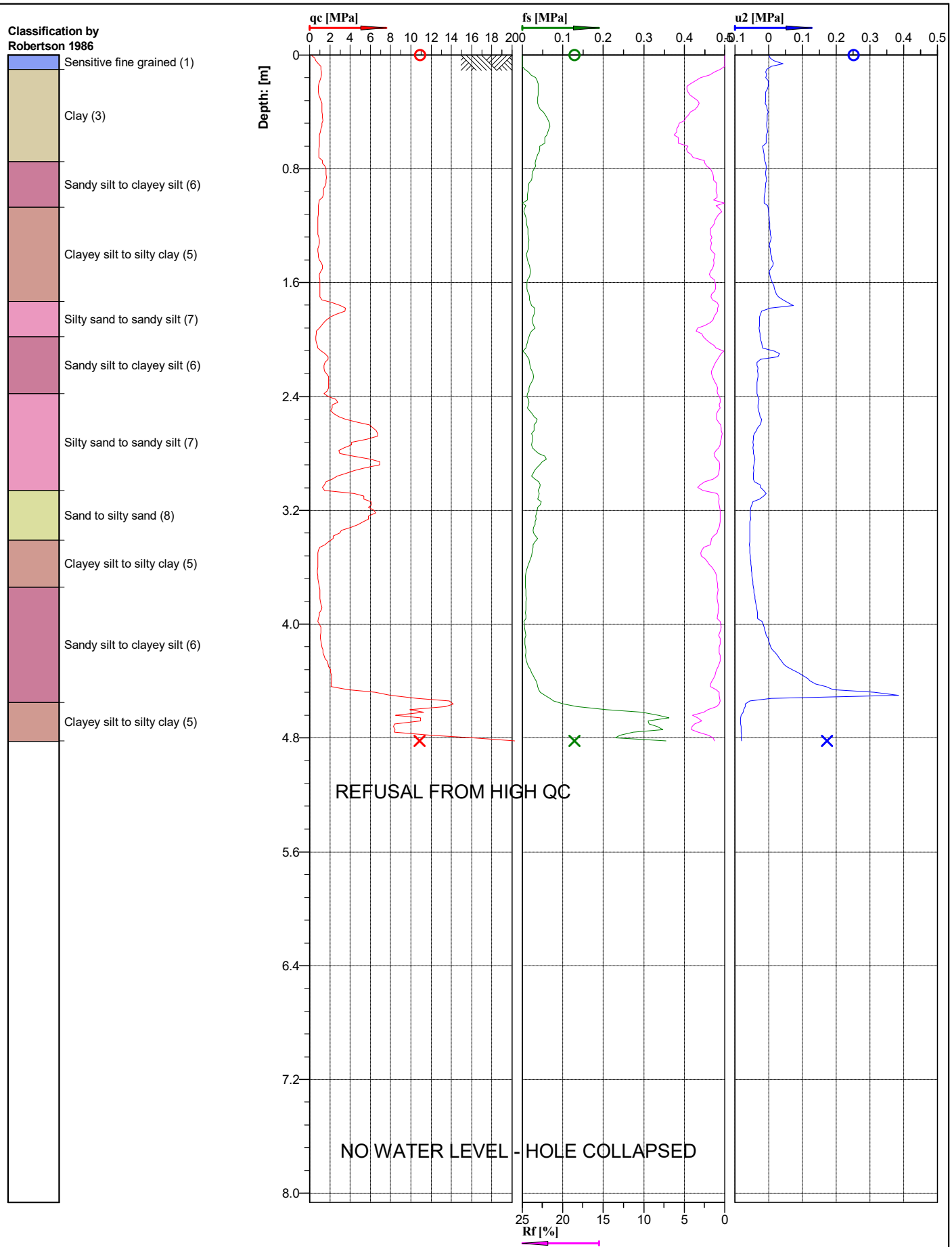
DRILLING METHOD

OB	OPEN BARREL
TT	TRIPLE TUBE
WB	WASH BORE
SH	UNDISTURBED SHELBY TUBE
RC	ROCK CORE
SPT	STANDARD PENETRATION TEST

FIELD TESTS

V	SHEAR VANE (corrected to BS:1377)
R	REMOULDED STRENGTH
P	POCKET PENETROMETER
CH	CLEGG HAMMER

INFORMATION BASED ON THE NZ GEOTECHNICAL SOCIETY INC. GUIDELINES FOR THE CLASSIFICATION AND DESCRIPTION OF SOIL AND ROCK FOR ENGINEERING PURPOSES

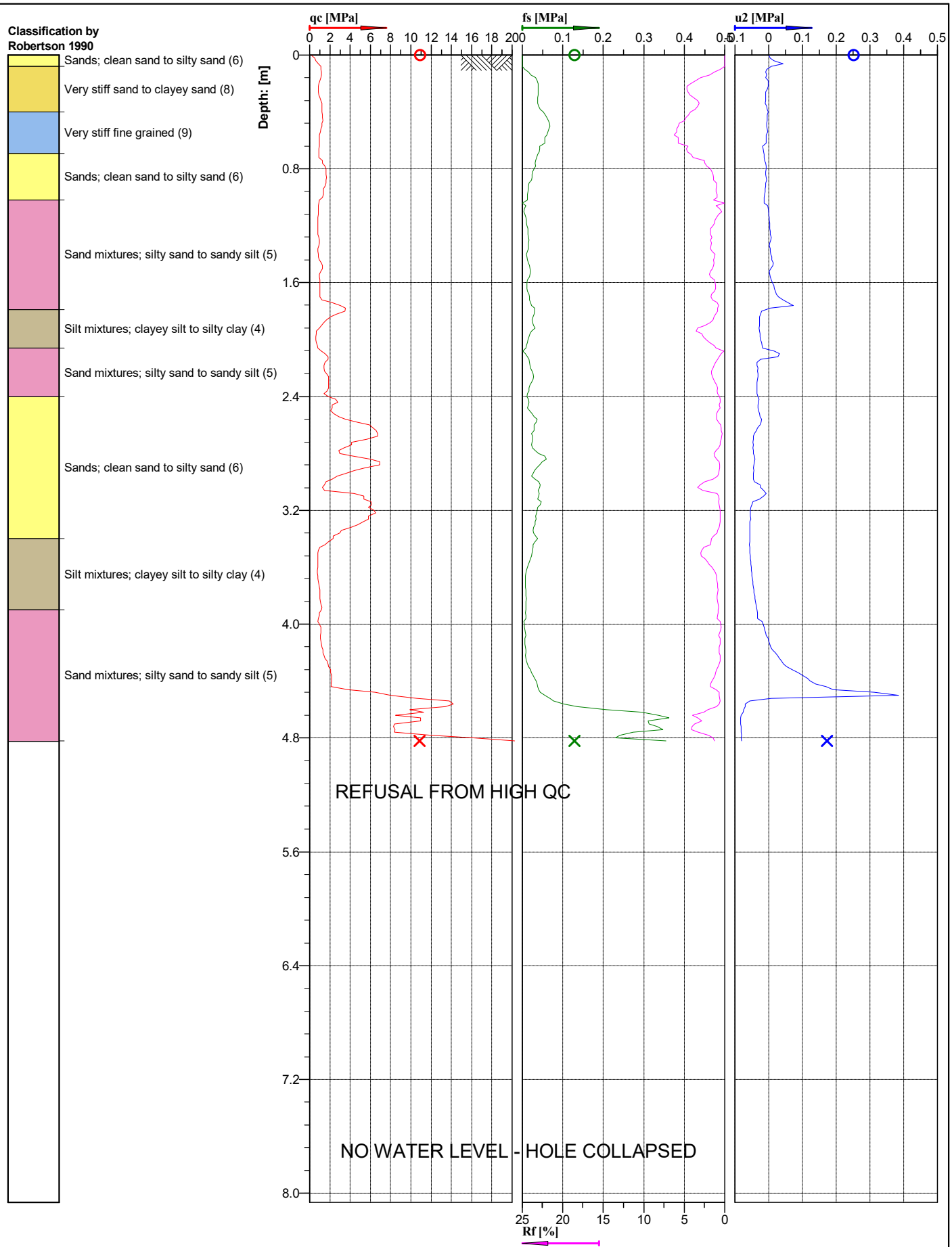


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT01
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33755, E 175.58424		File: CPT1A.cpt	



GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

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Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
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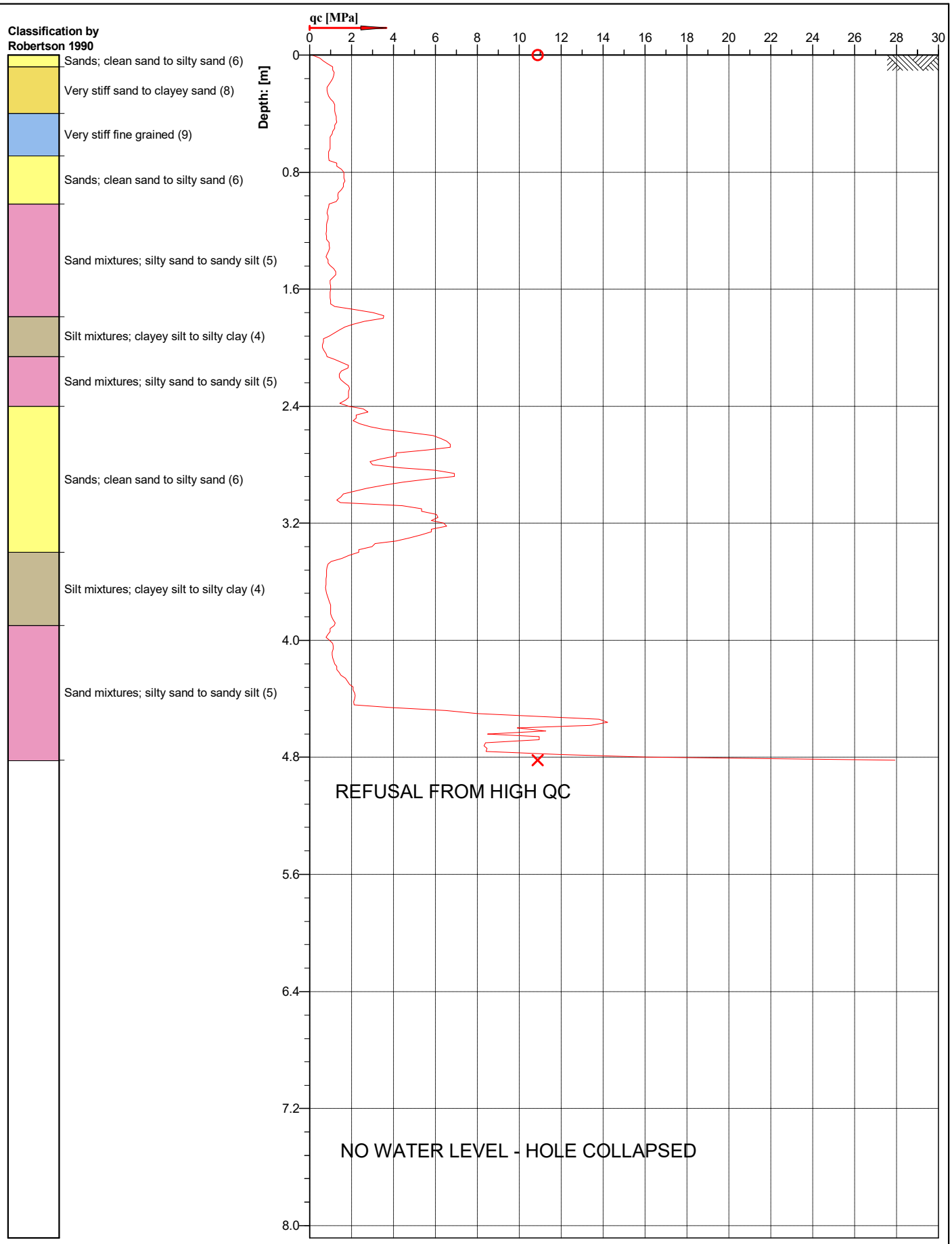

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT01
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
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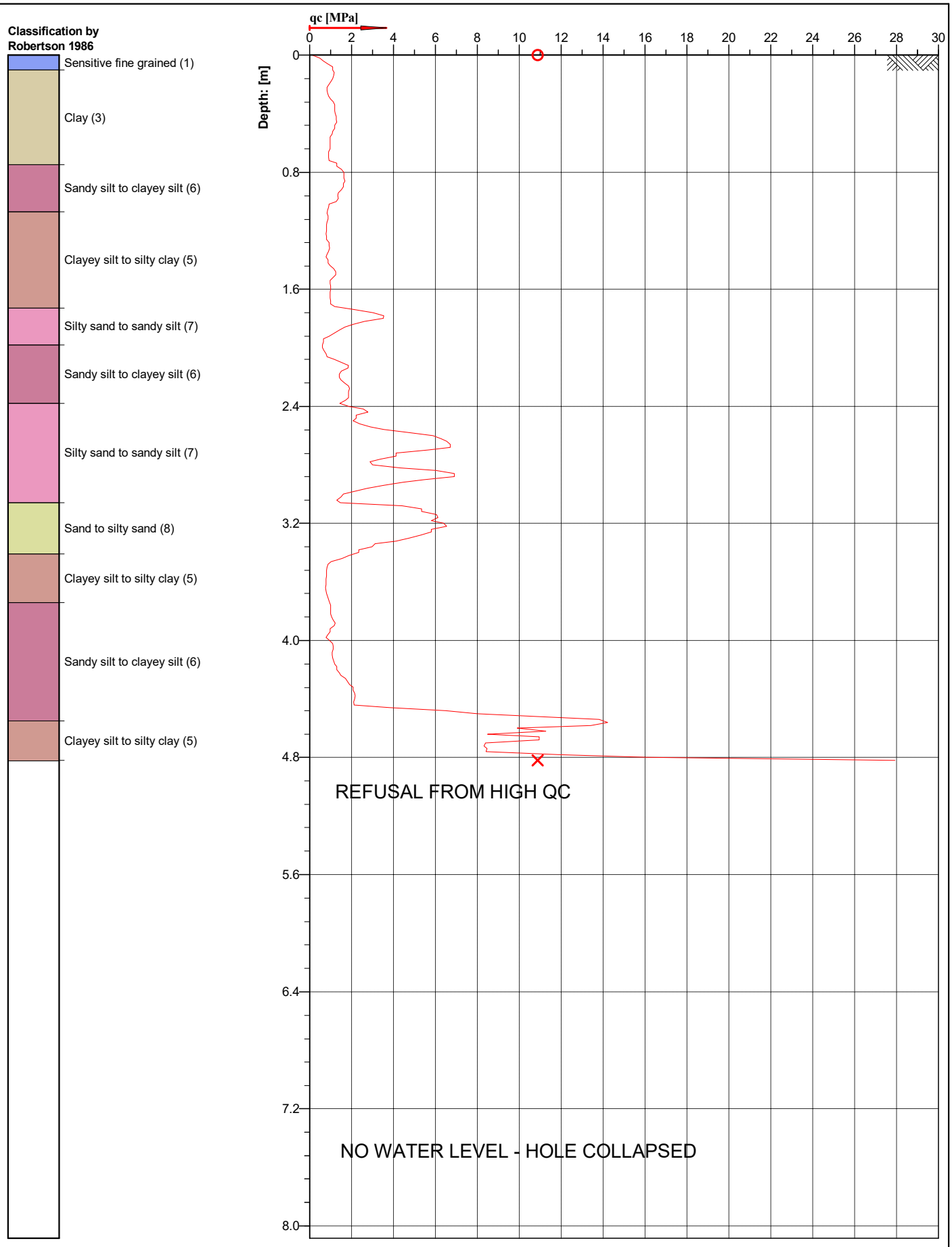

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT01
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
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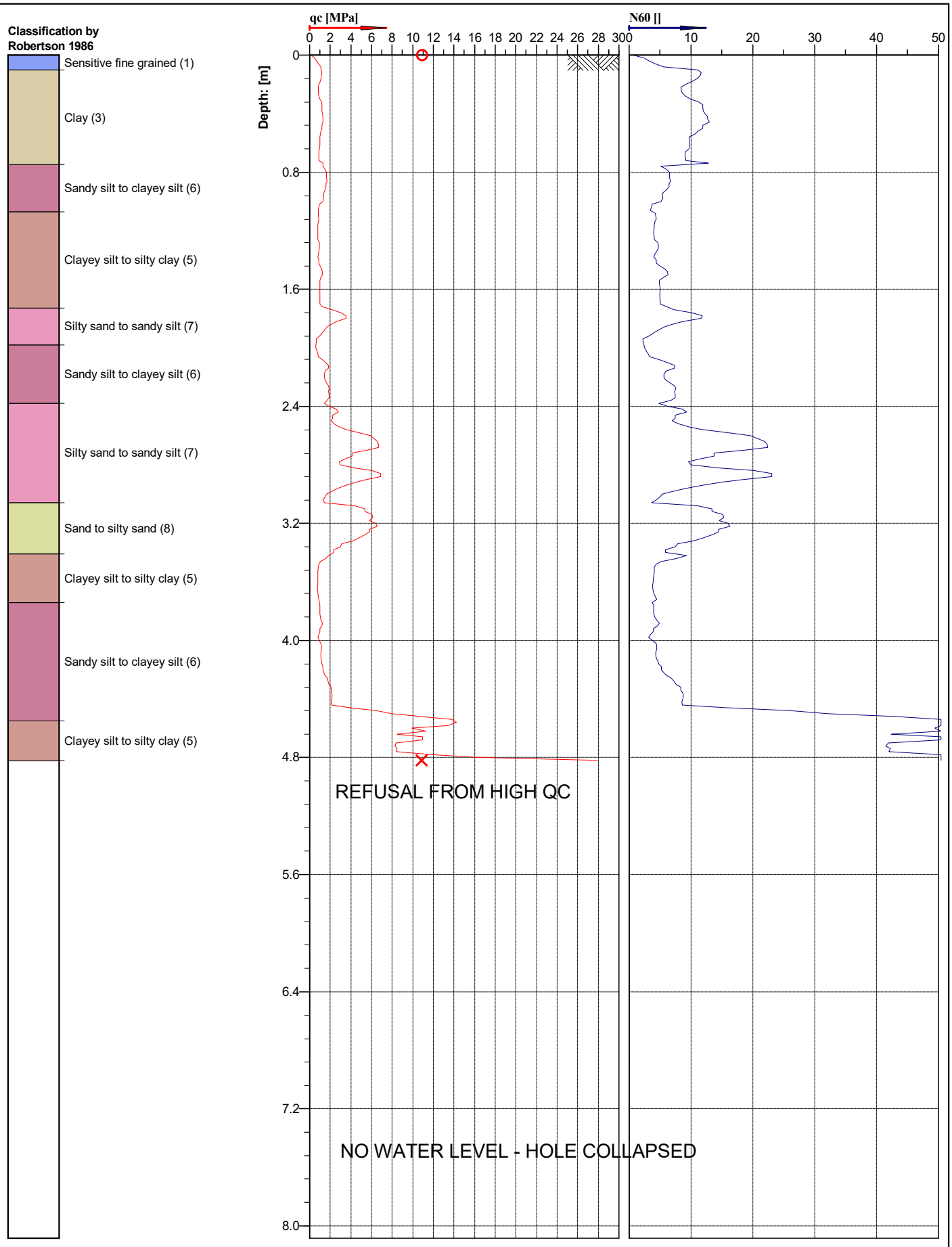

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

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Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
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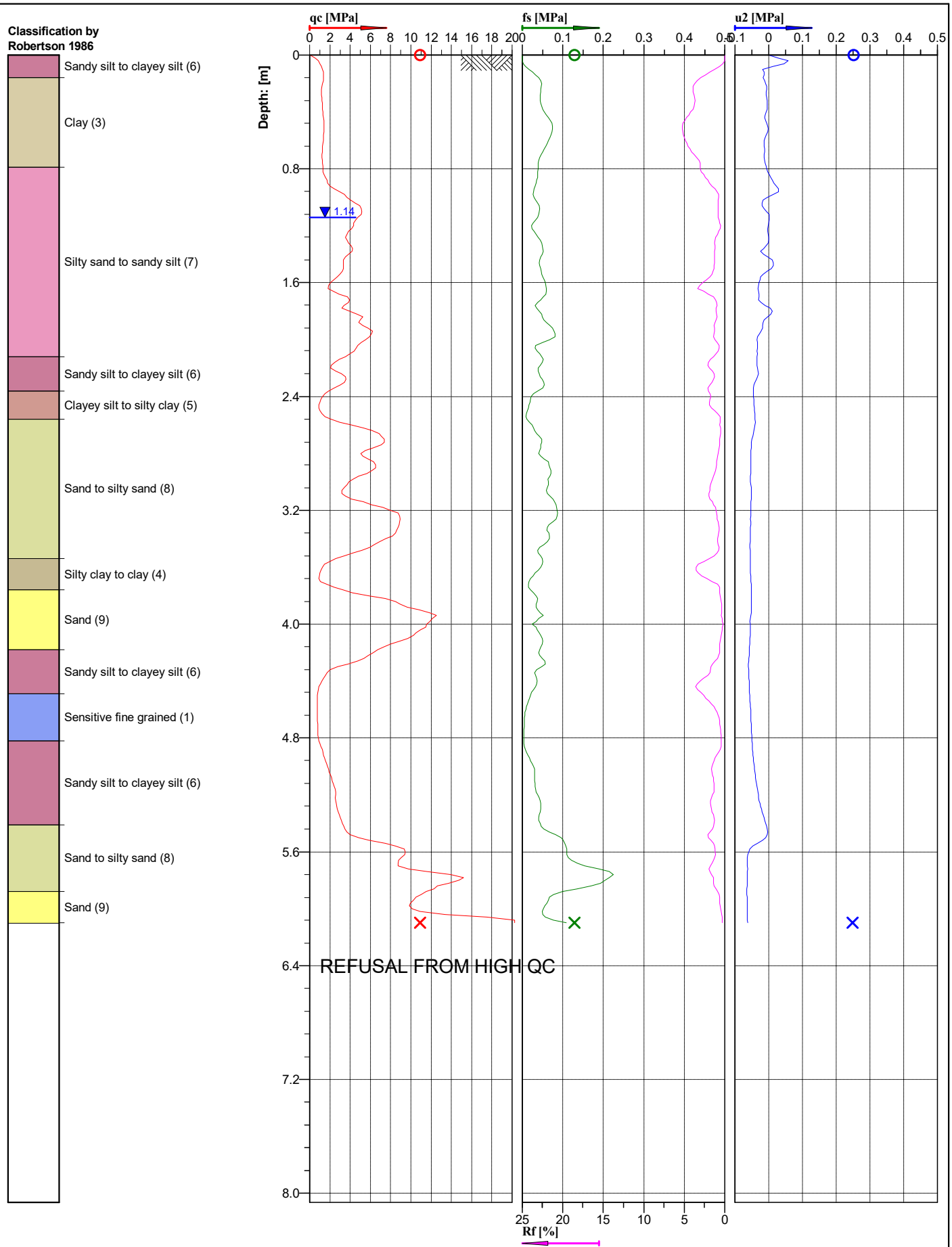

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Project: FLYGERS LINE		Page: 1/1	Fig.:
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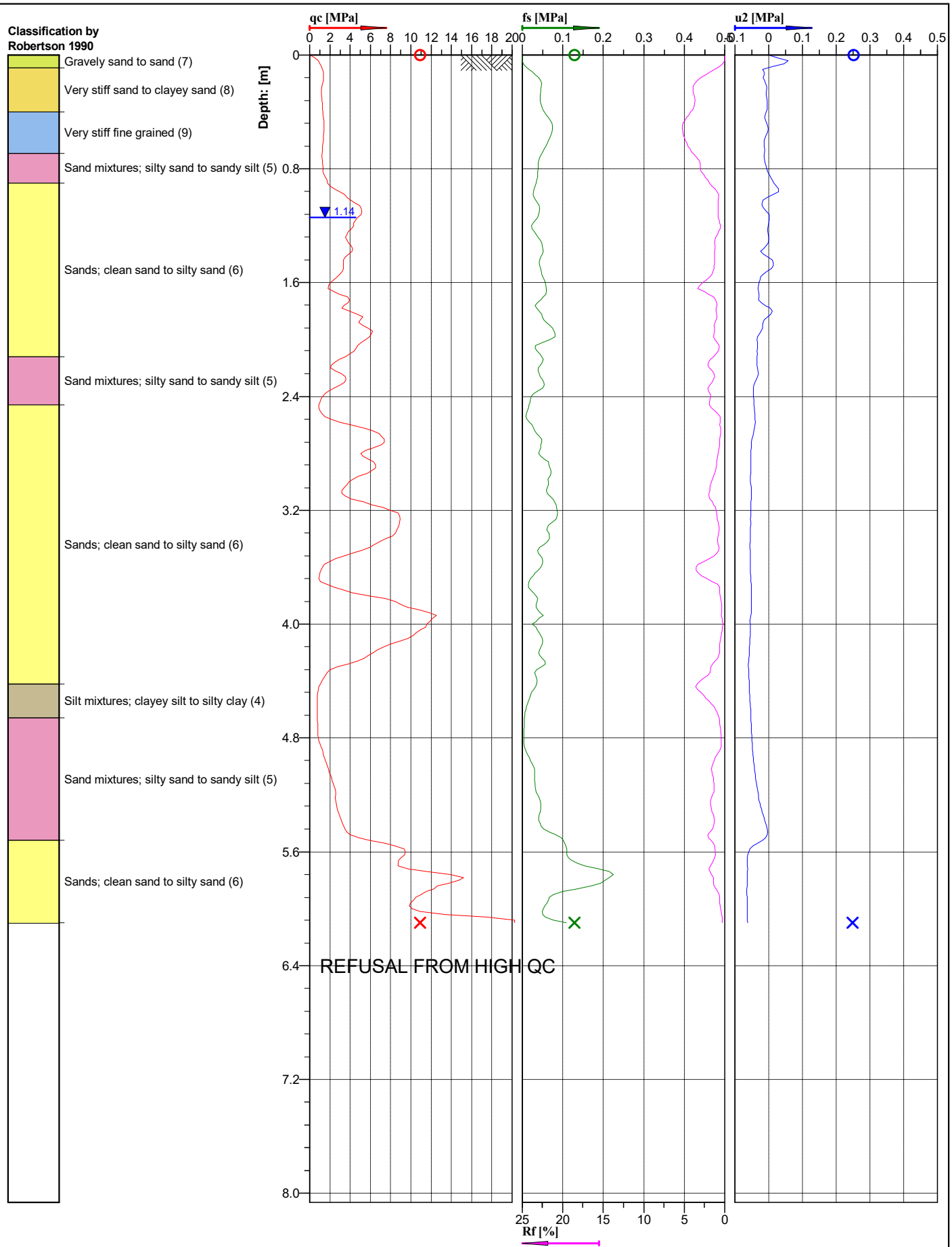
GEOTECH DRILLING

u2

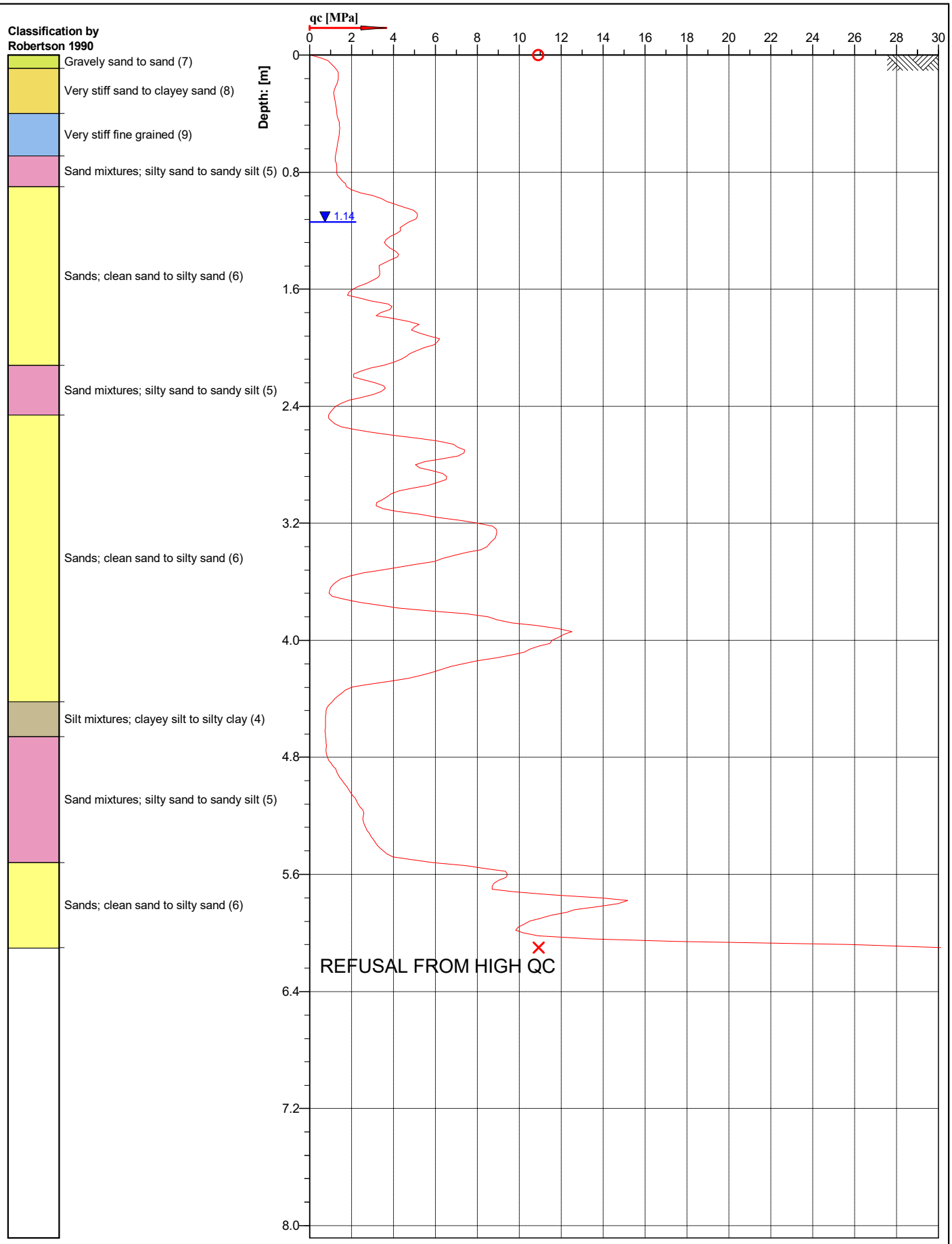
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150



Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT02
Project ID:	Client: RILEYS	Date: 28/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33923, E 175.58549		File: CPT02.cpt	

GEOTECH DRILLING

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

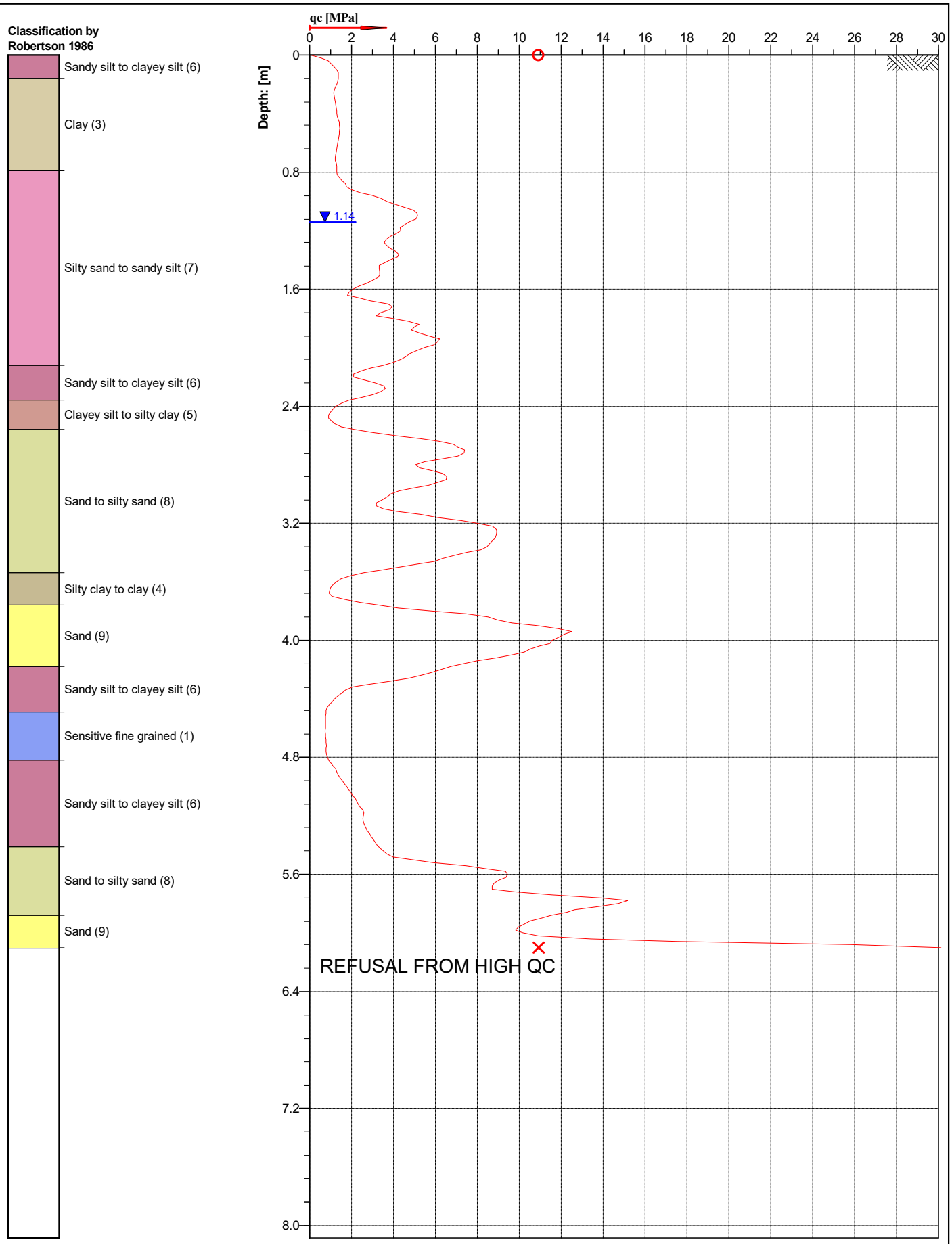


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT02
Project ID:	Client: RILEYS	Date: 28/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33923, E 175.58549		File: CPT02.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

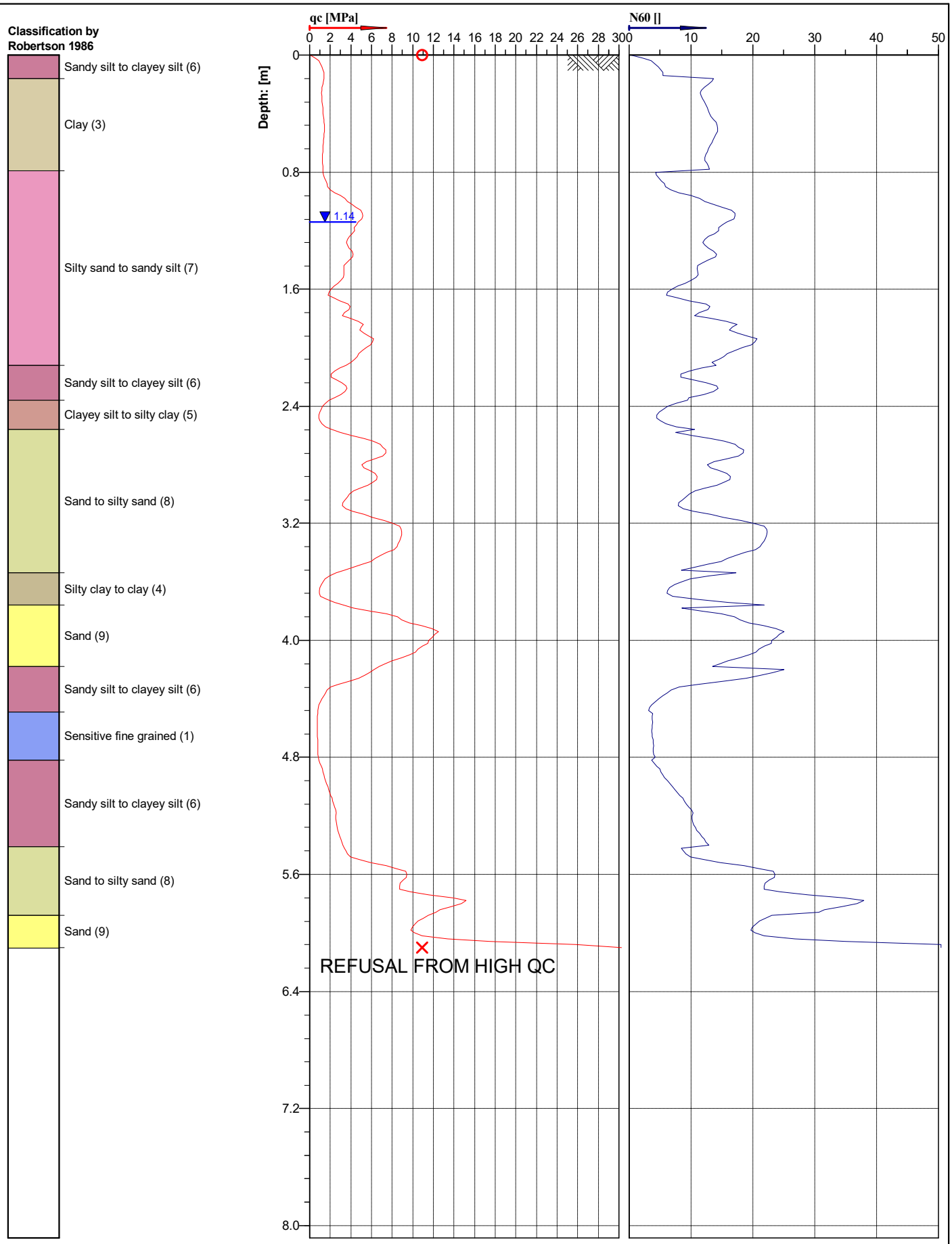


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT02
Project ID:	Client: RILEYS	Date: 28/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33923, E 175.58549		File: CPT02.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

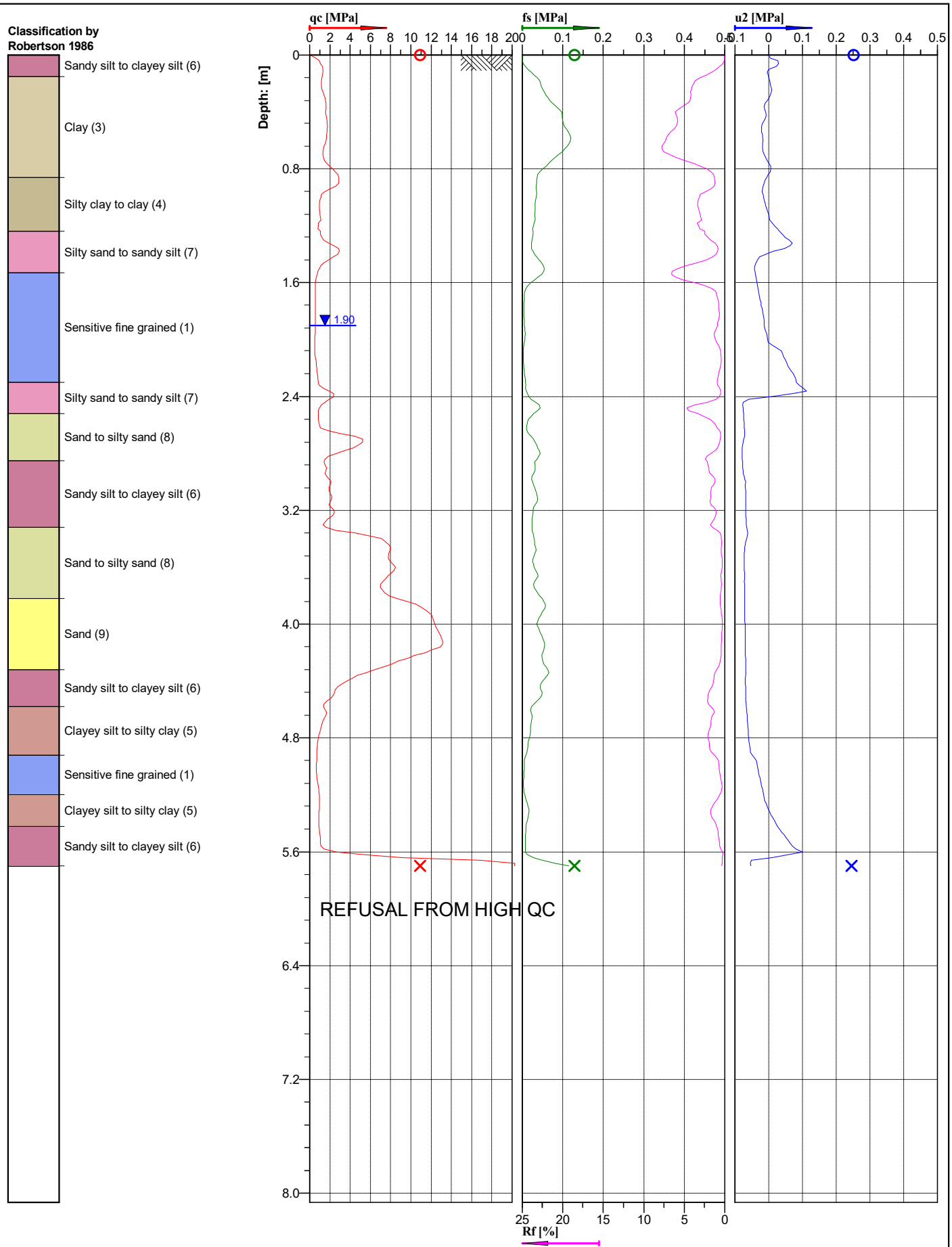


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT02
Project ID:	Client: RILEYS	Date: 28/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33923, E 175.58549		File: CPT02.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

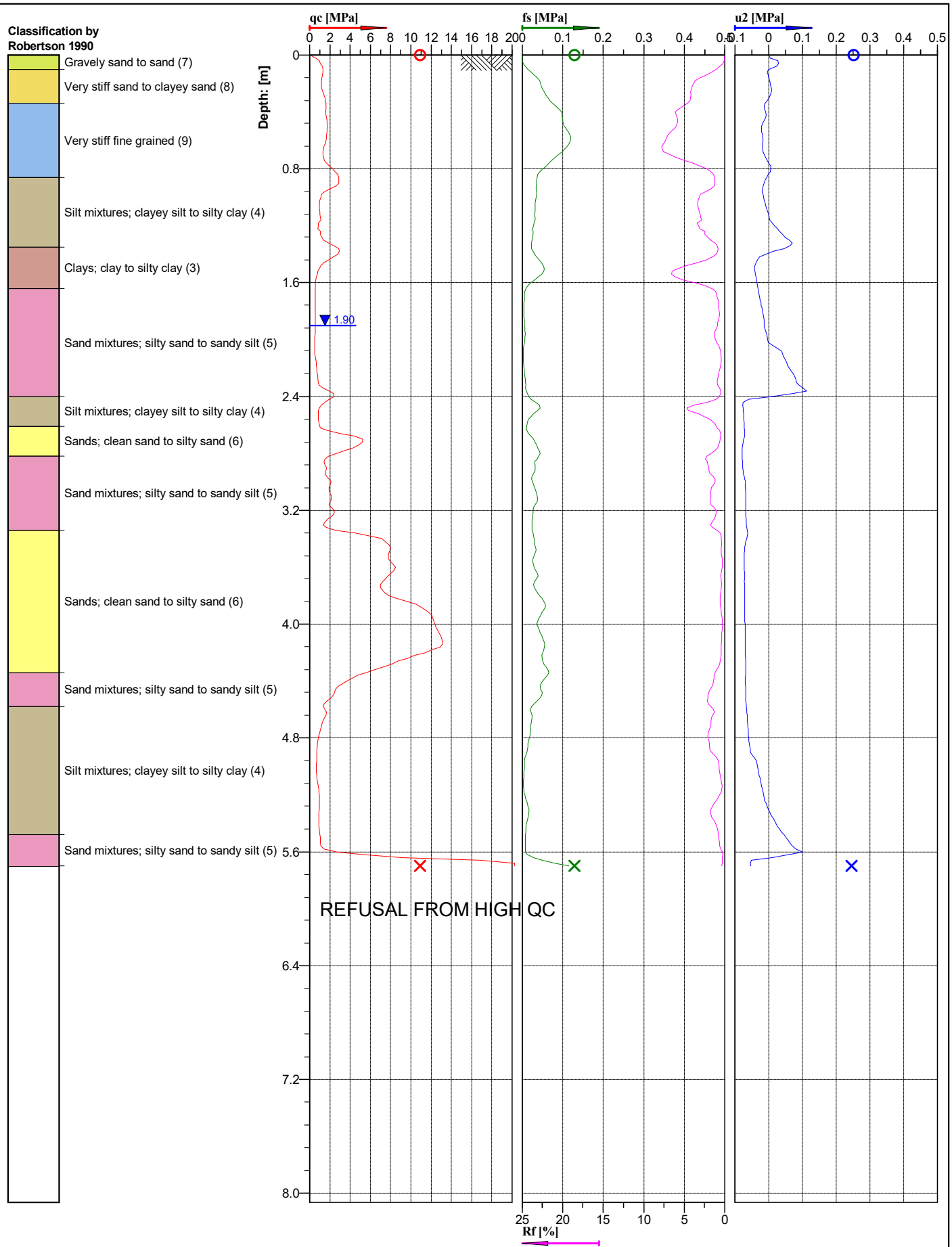


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT03
Project ID:	Client:	Date: 28/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33981, E 175.58708		File: CPT03.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

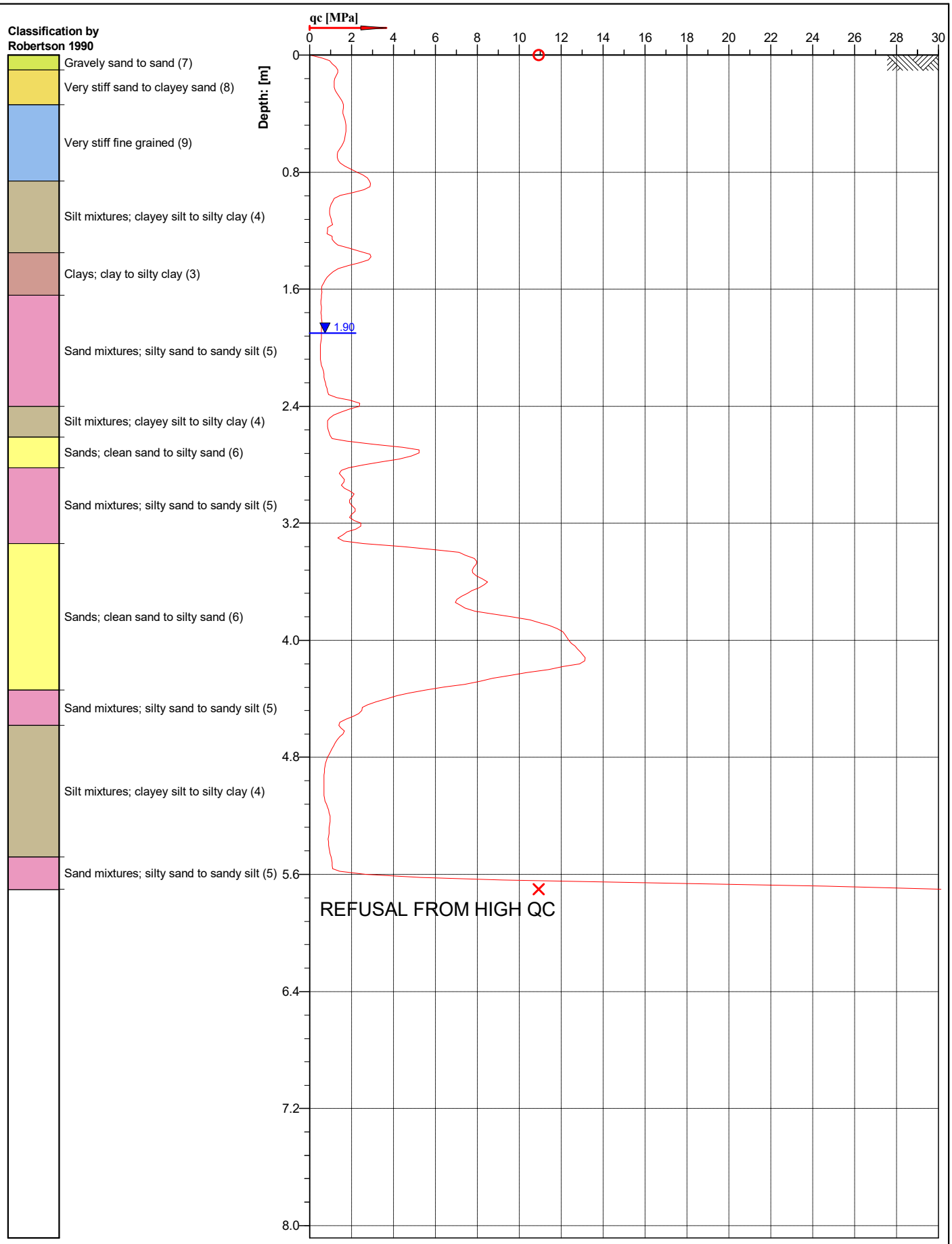


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT03
Project ID:	Client:	Date: 28/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33981, E 175.58708		File: CPT03.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

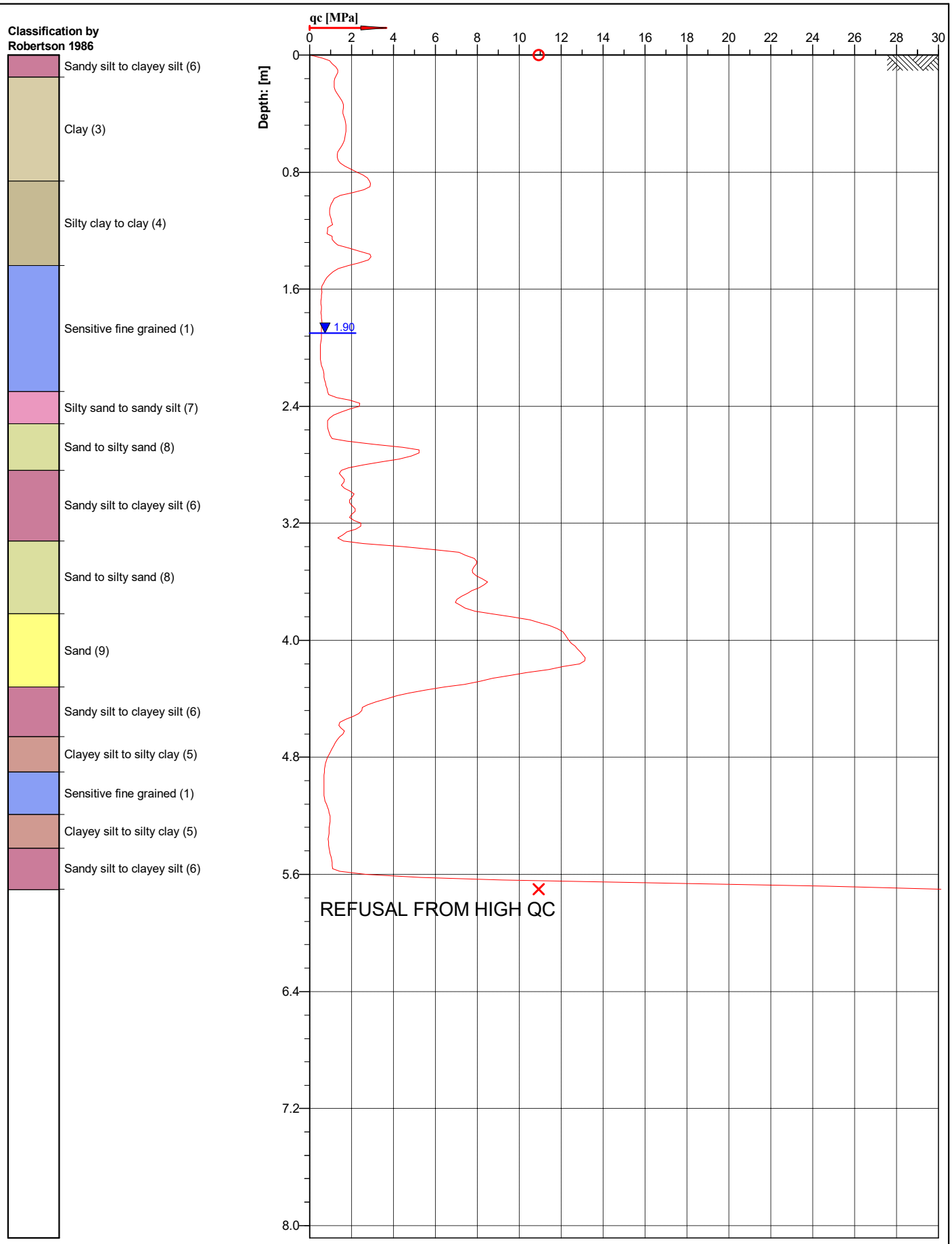


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT03
Project ID:	Client:	Date: 28/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33981, E 175.58708		File: CPT03.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

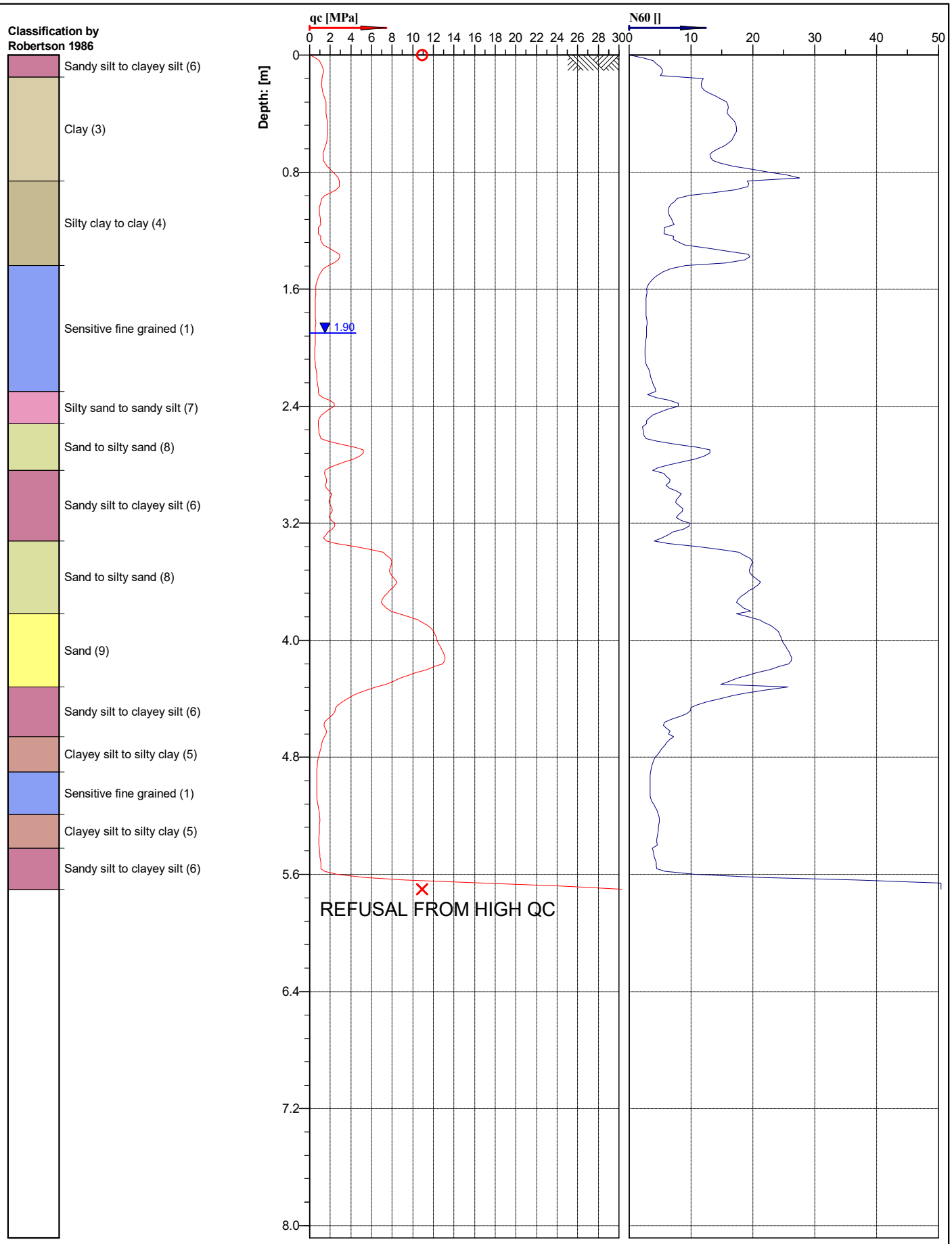


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT03
Project ID:	Client:	Date: 28/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33981, E 175.58708		File: CPT03.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

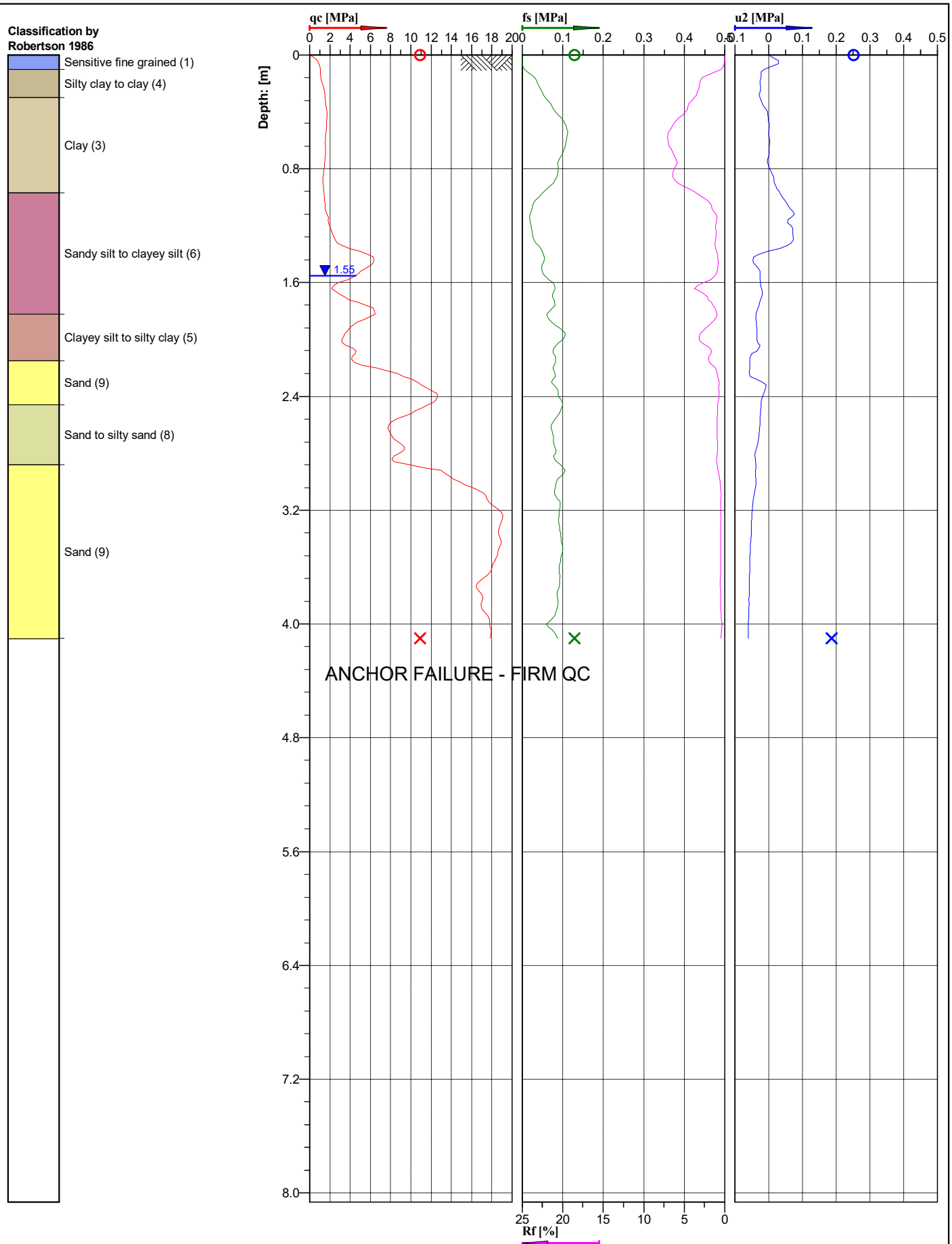


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT03
Project ID:	Client:	Date: 28/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33981, E 175.58708		File: CPT03.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

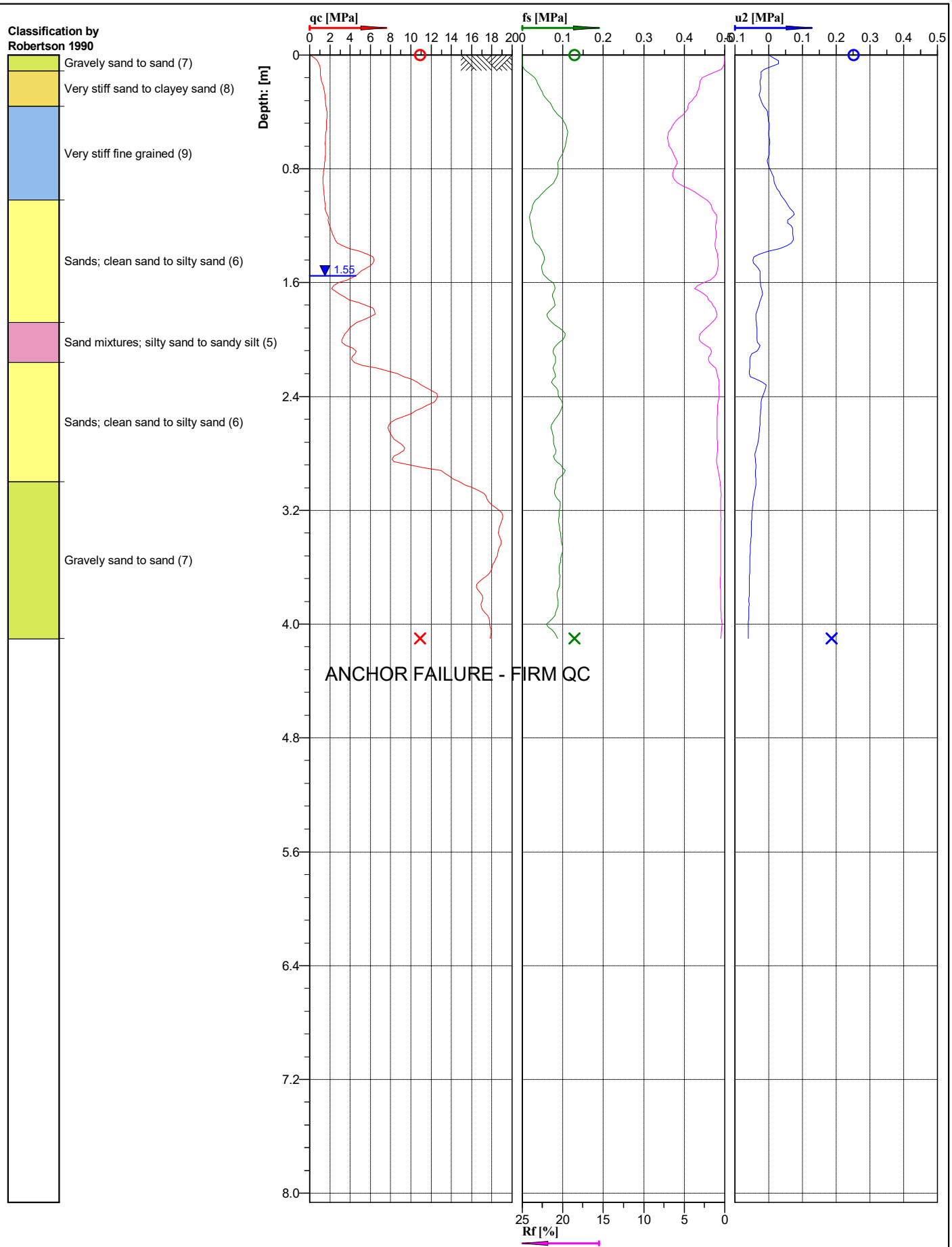


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT04
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33771, E 175.58850		File: CPT04.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

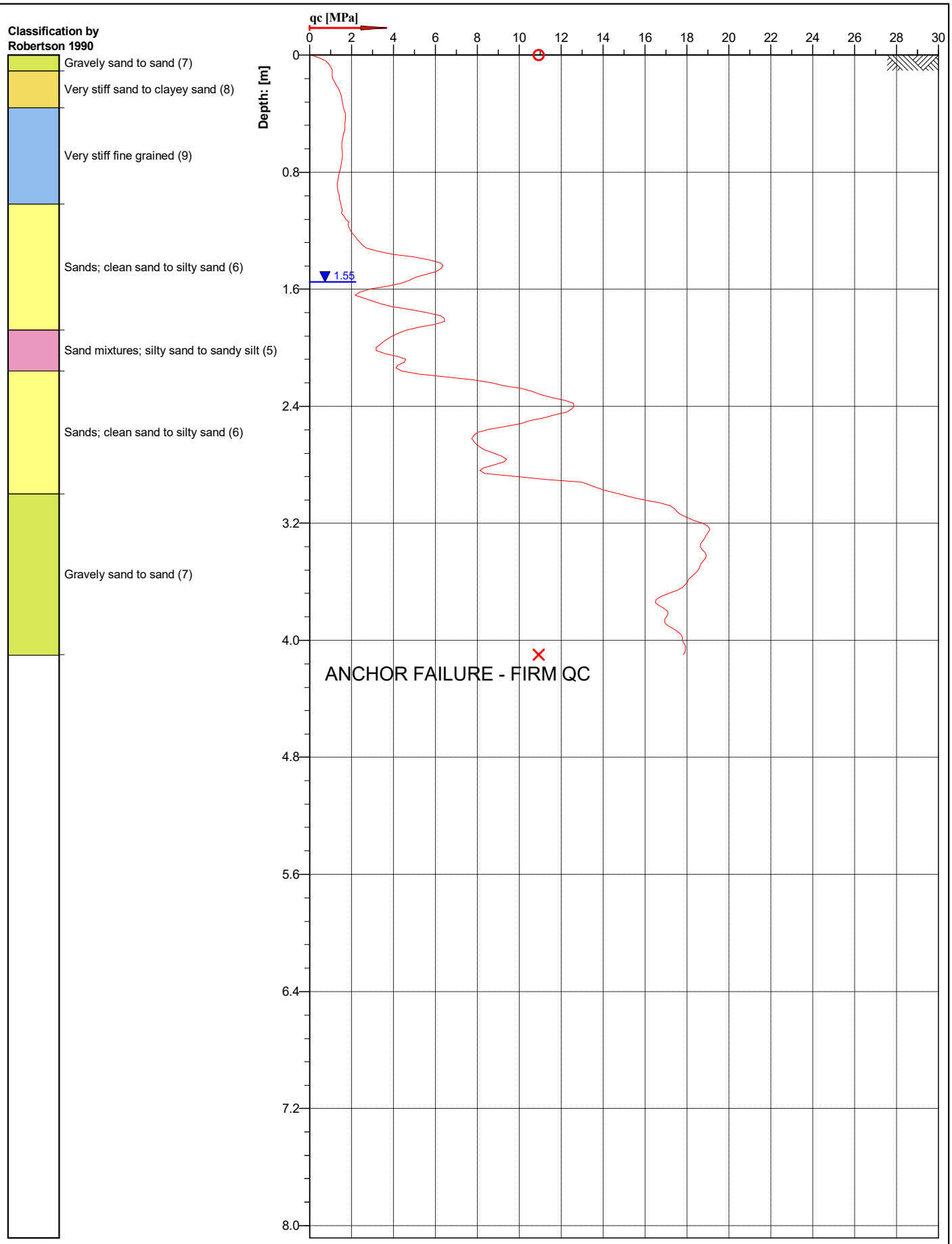


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT04
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33771, E 175.58850		File: CPT04.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

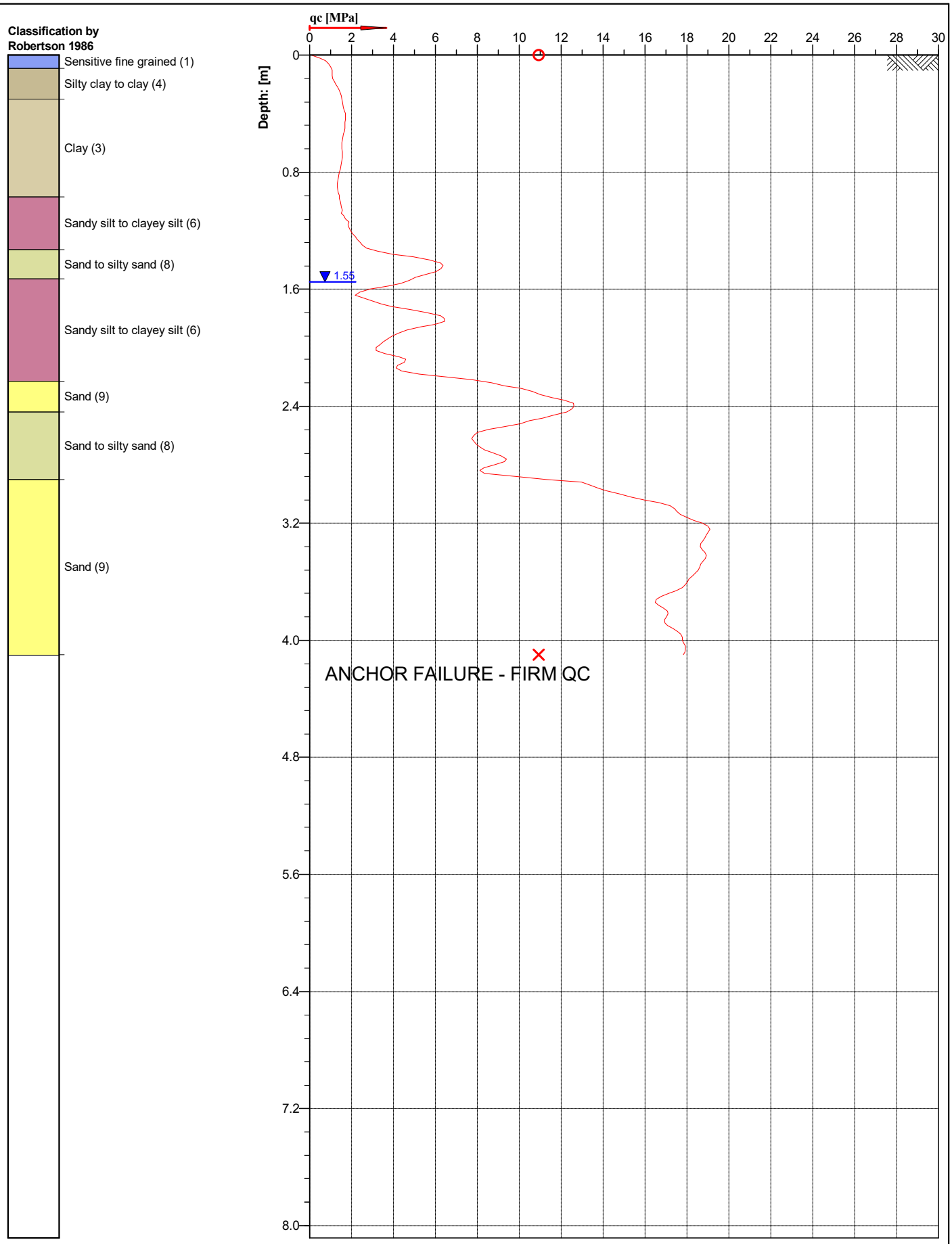


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT04
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33771, E 175.58850		File: CPT04.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

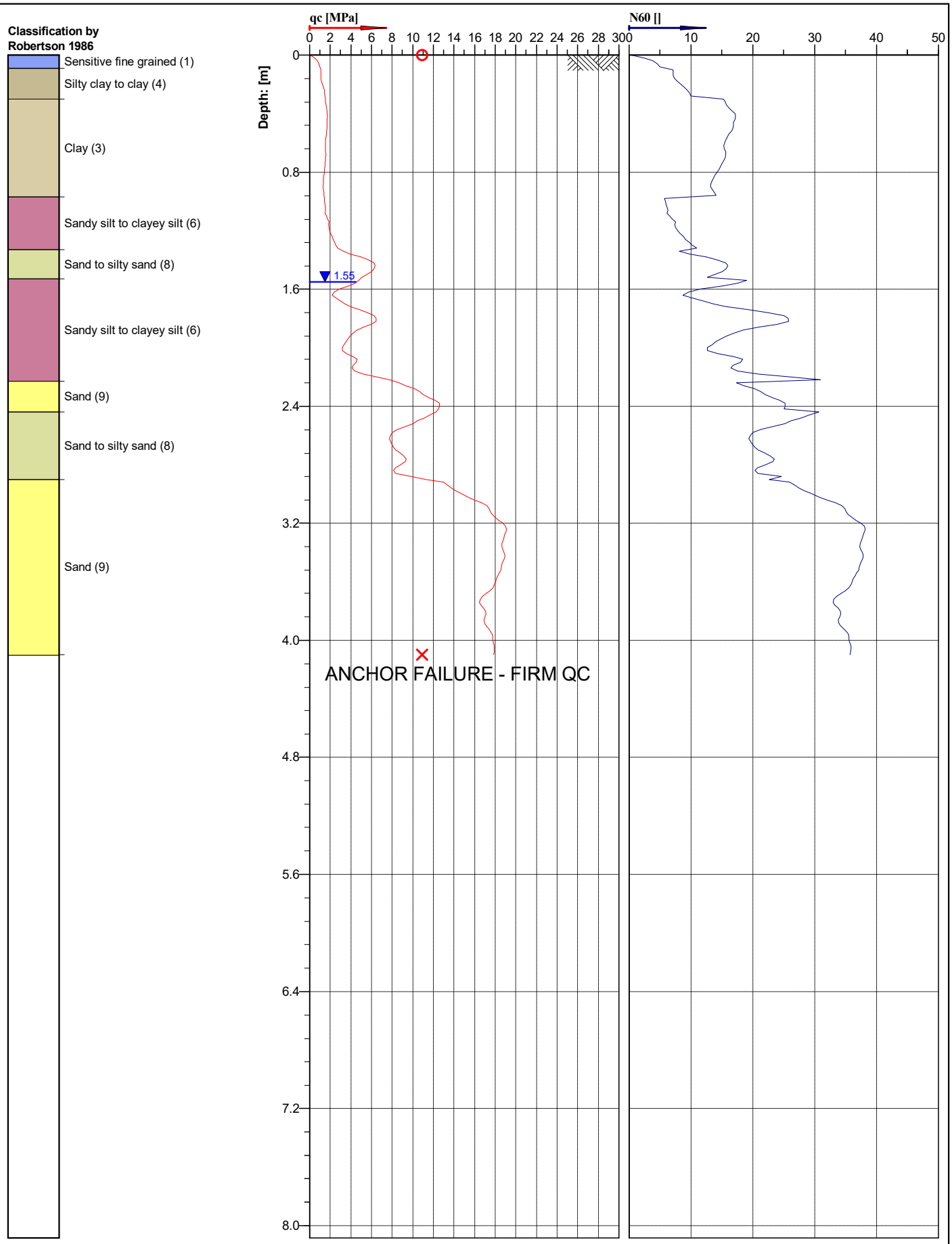


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT04
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33771, E 175.58850		File: CPT04.cpt	

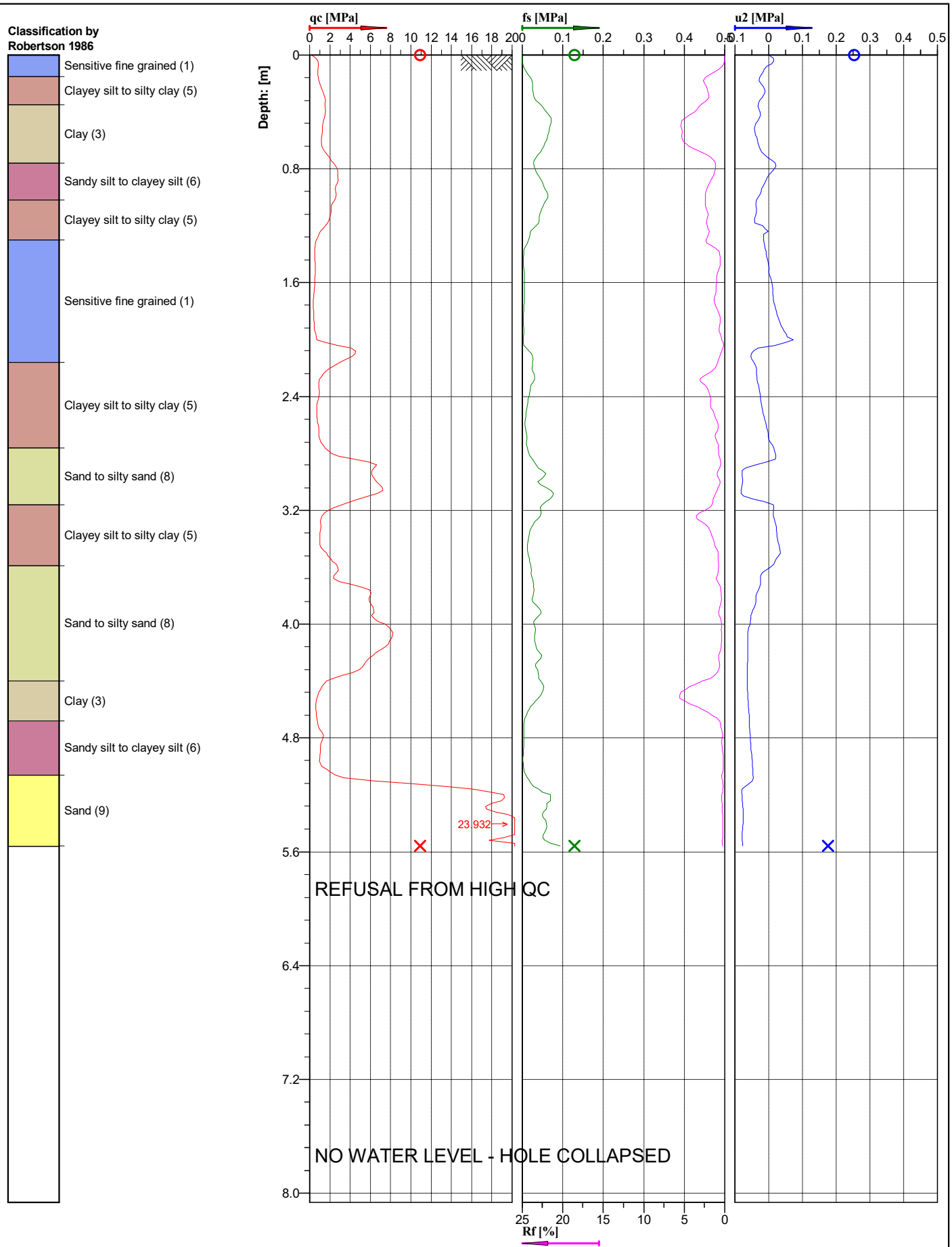


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT04
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33771, E 175.58850		File: CPT04.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

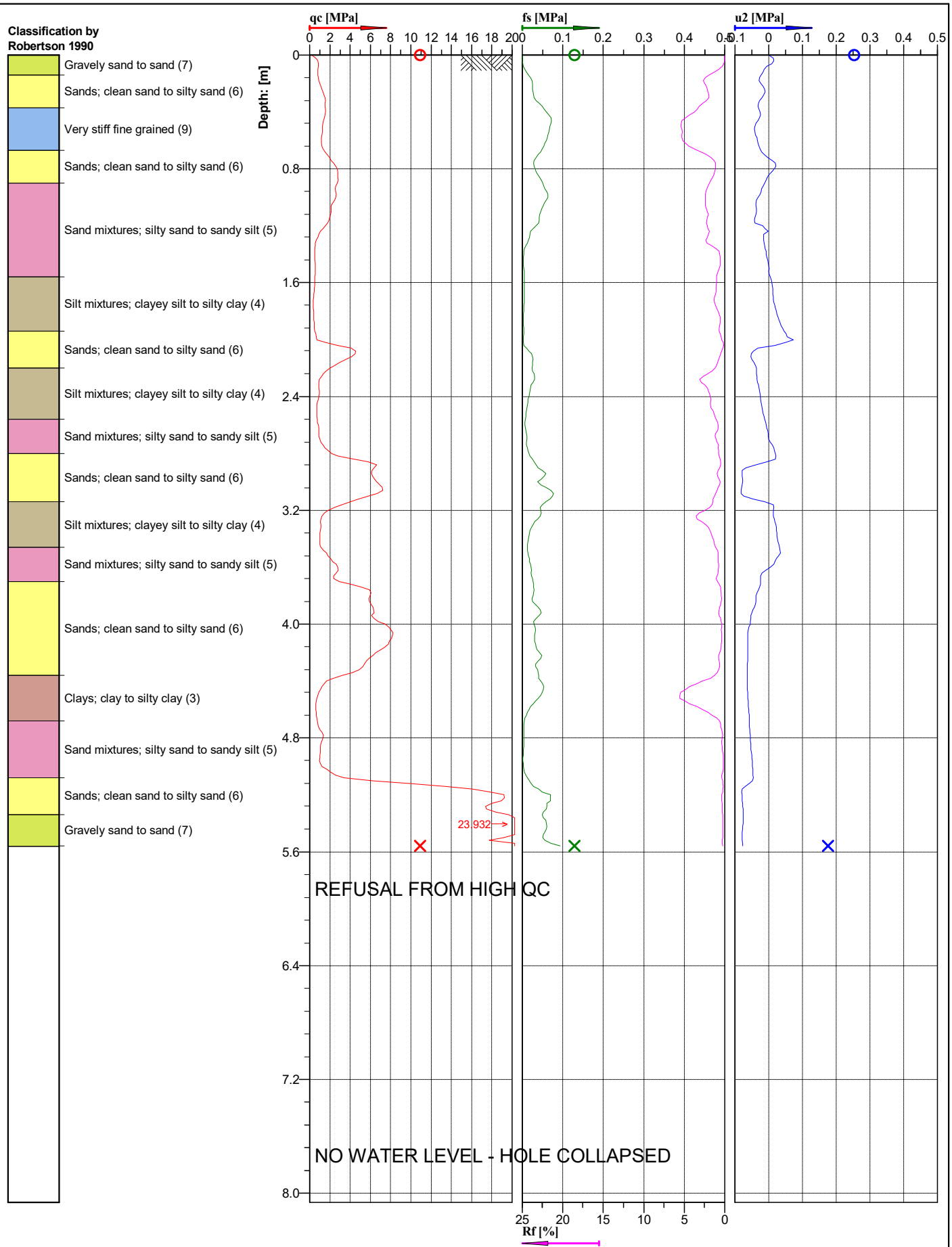


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT05
Project ID:	Client:	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33919, E 175.58945		File: CPT05.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

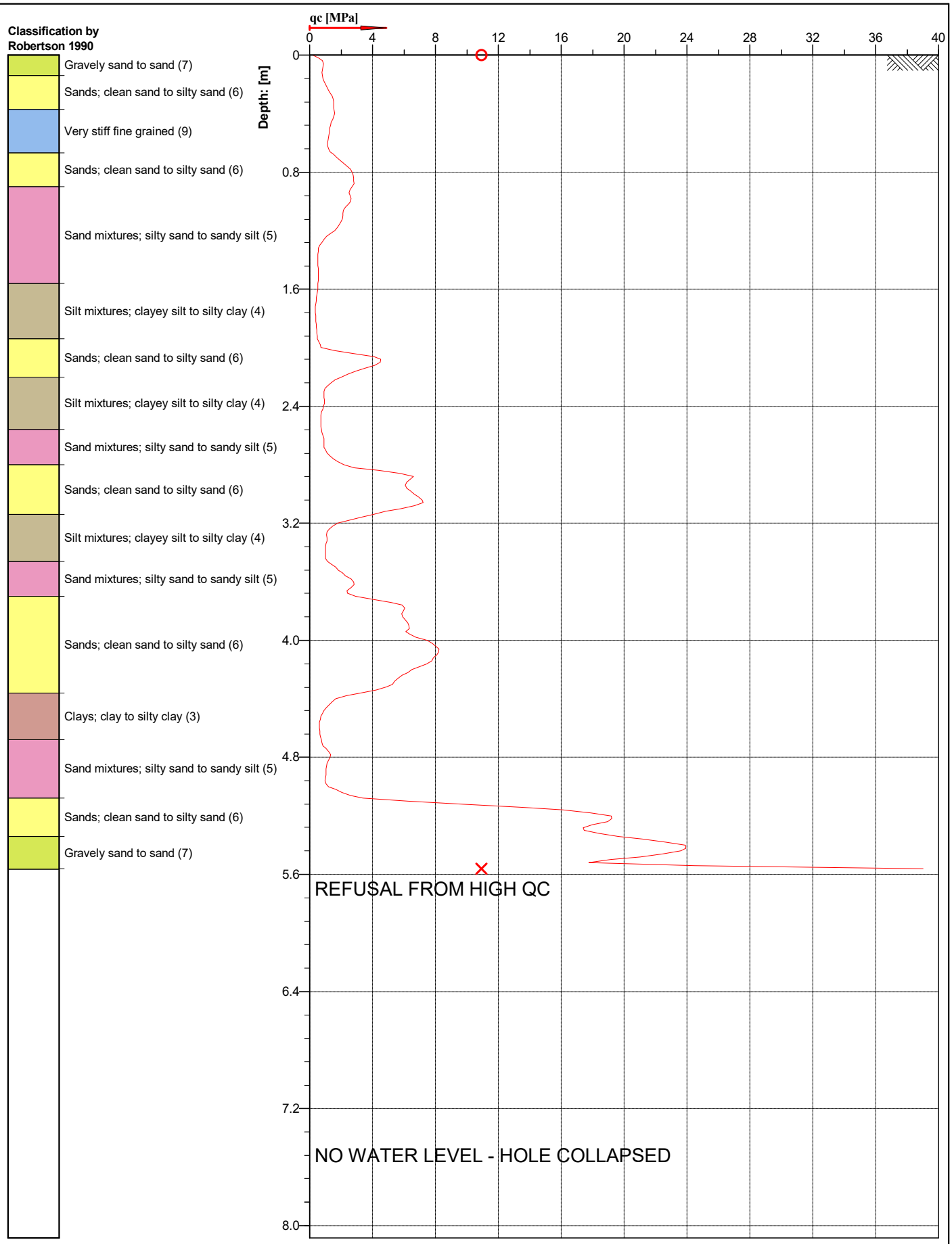


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT05
Project ID:	Client:	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33919, E 175.58945		File: CPT05.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

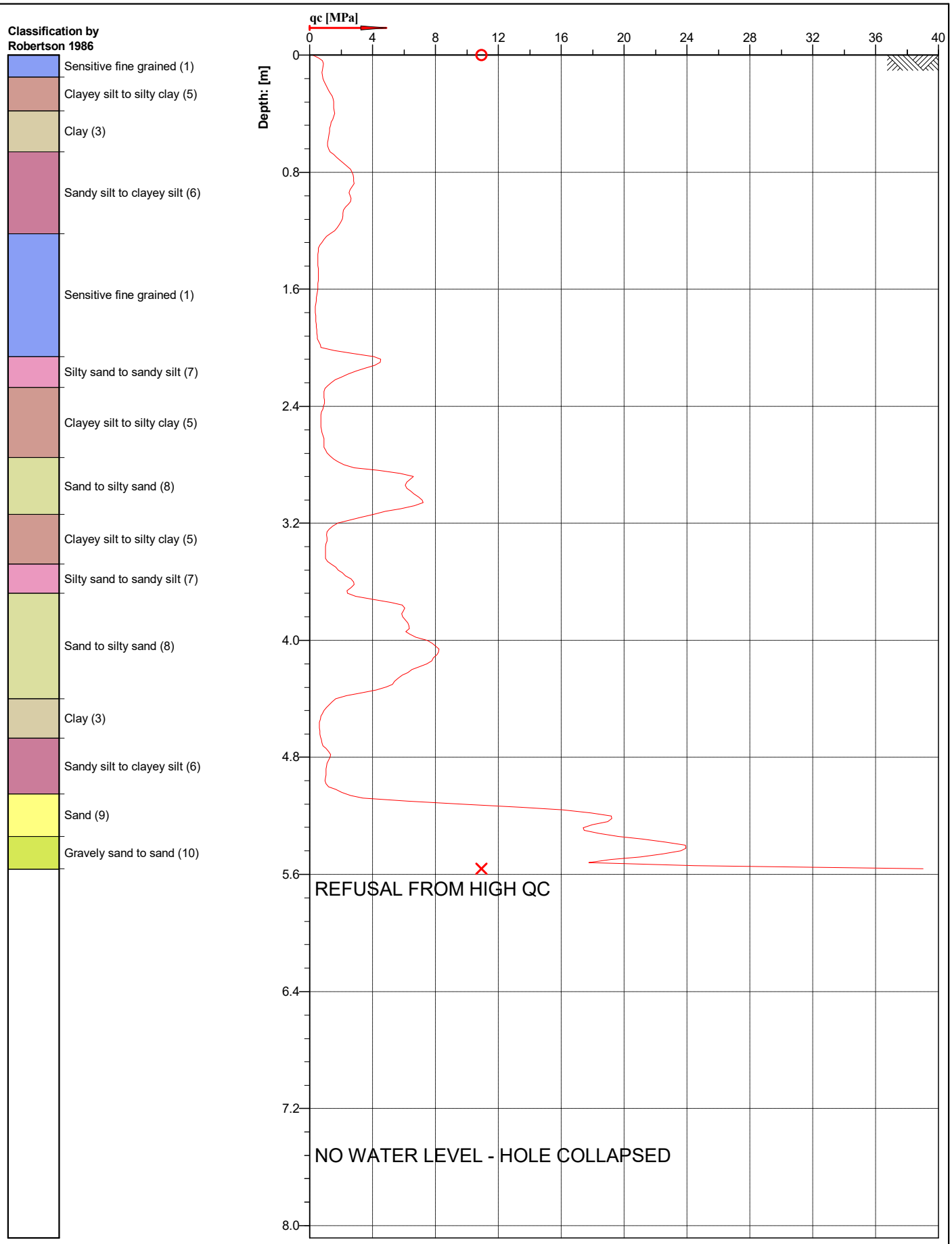


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT05
Project ID:	Client:	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33919, E 175.58945		File: CPT05.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

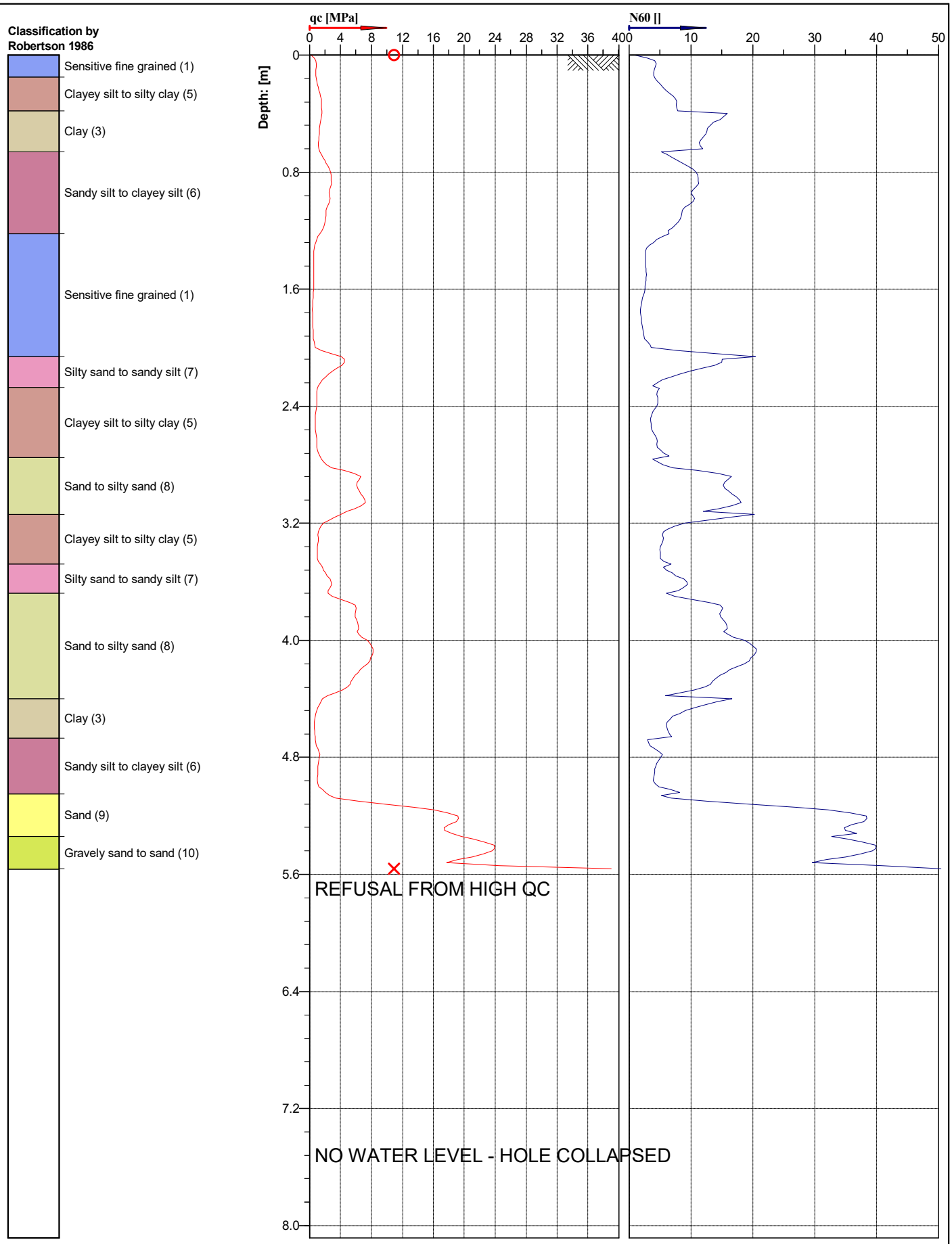


u2

GEOTECH DRILLING

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT05
Project ID:	Client:	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33919, E 175.58945		File: CPT05.cpt	

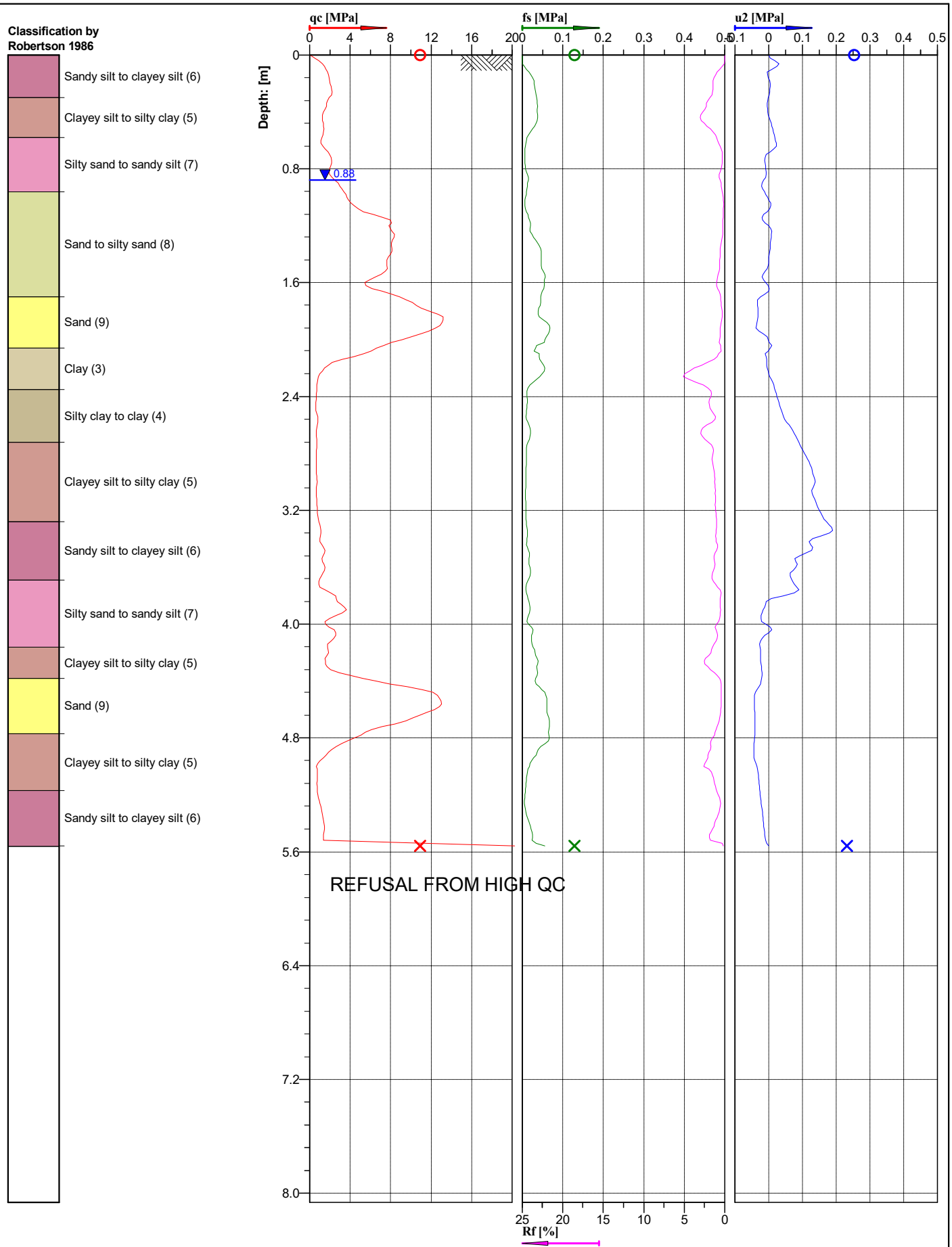


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT05
Project ID:	Client:	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33919, E 175.58945		File: CPT05.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

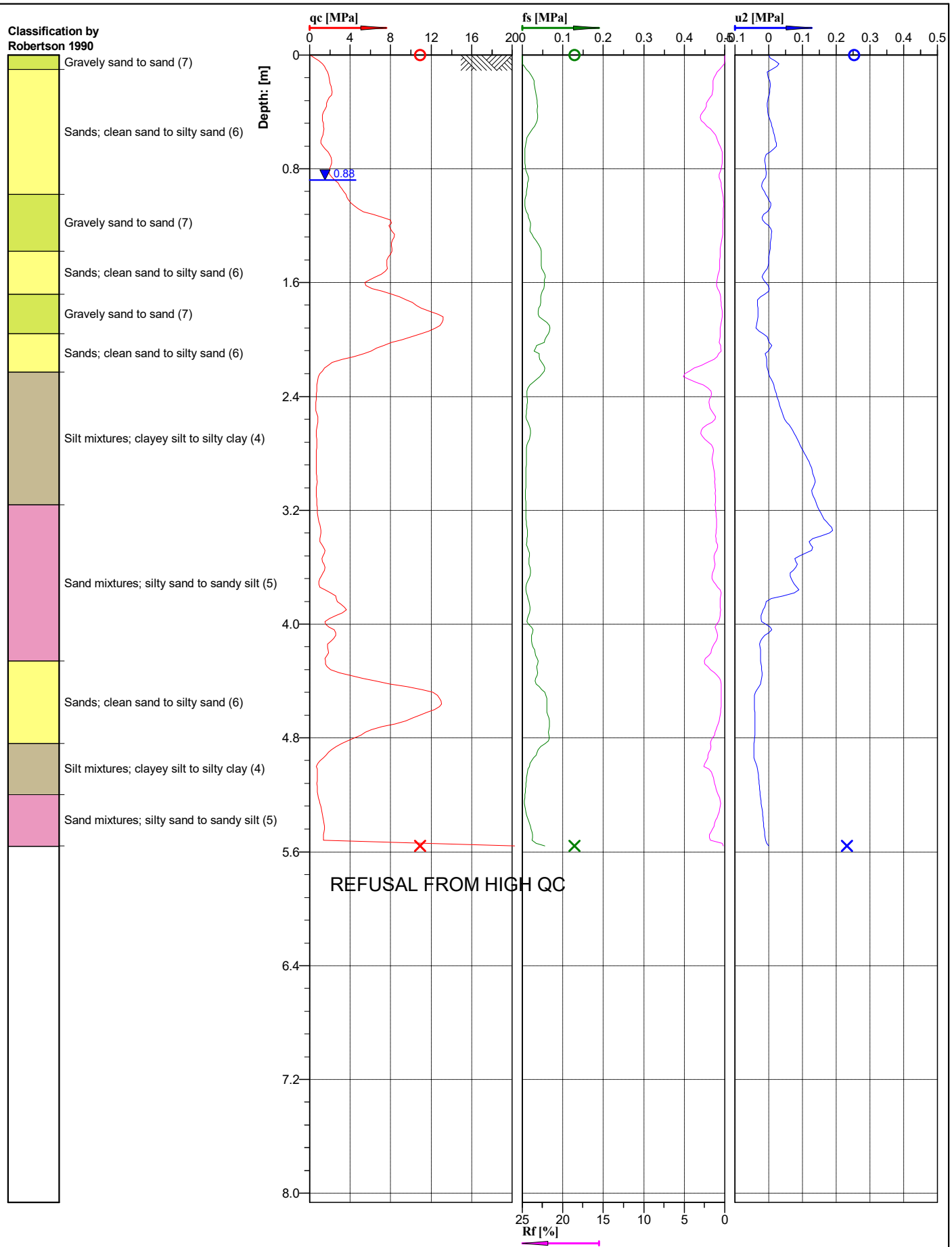


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT06
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33791, E 175.59085		File: CPT06.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

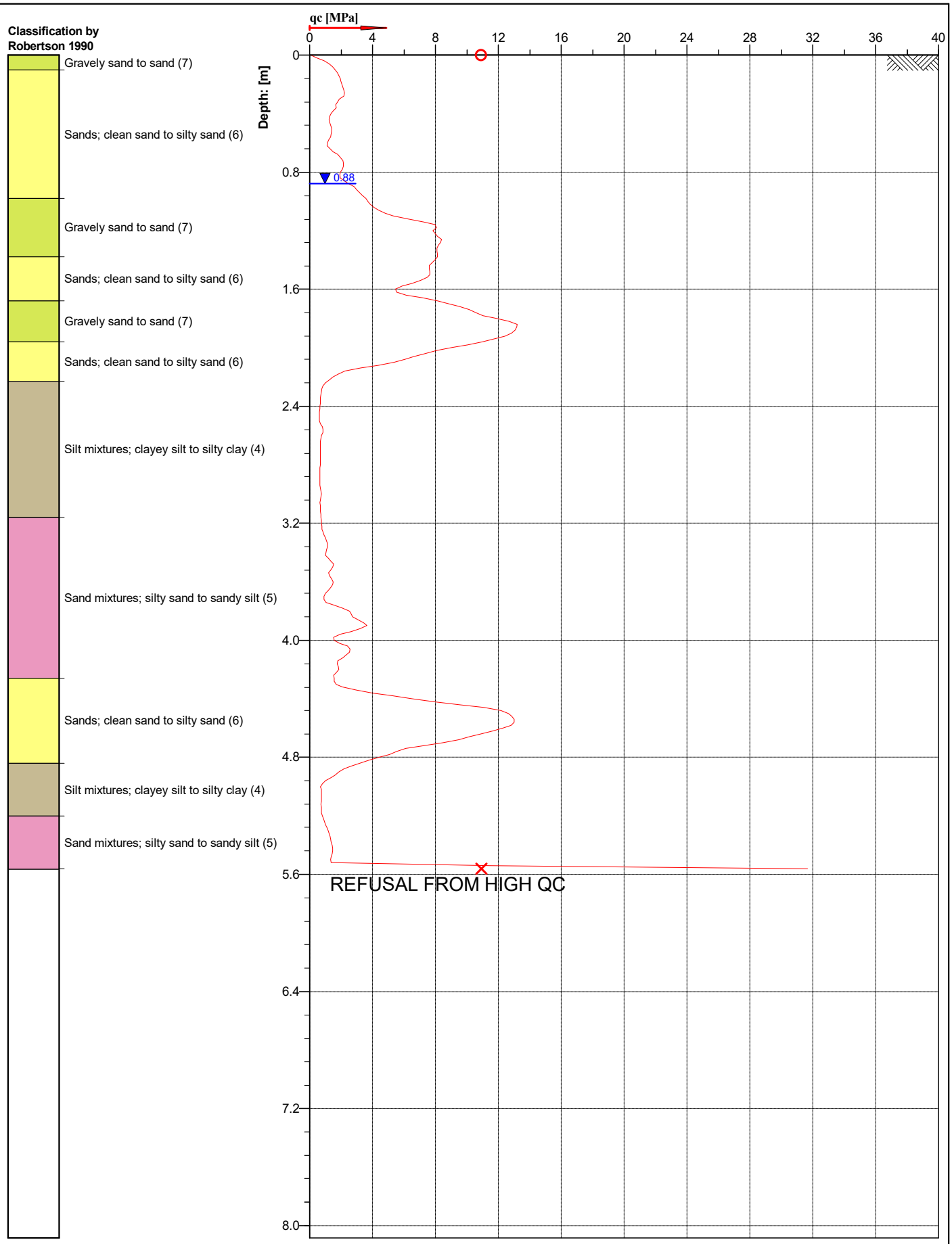


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT06
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33791, E 175.59085		File: CPT06.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

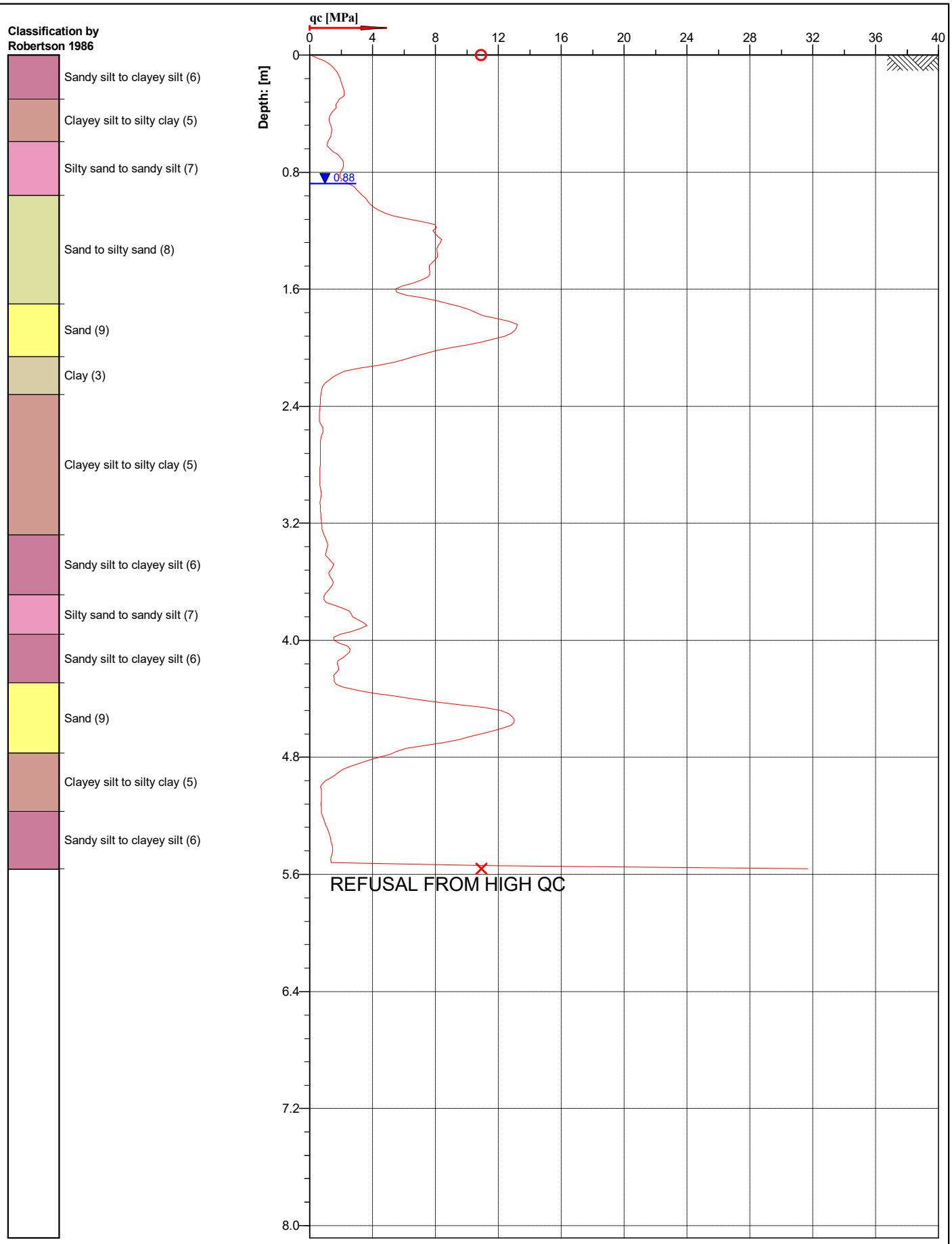


u2

GEOTECH DRILLING

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT06
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33791, E 175.59085		File: CPT06.cpt	

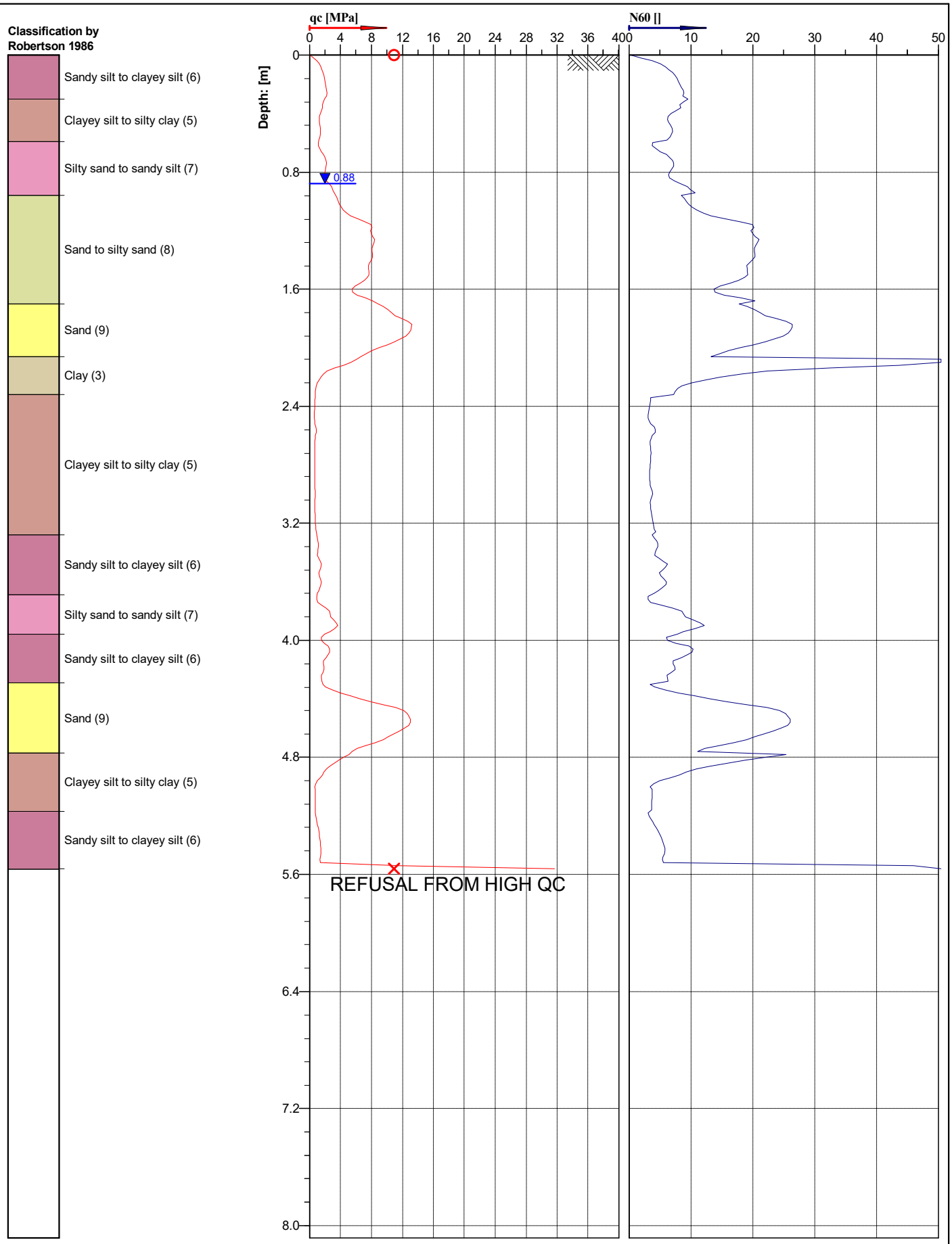


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT06
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33791, E 175.59085		File: CPT06.cpt	

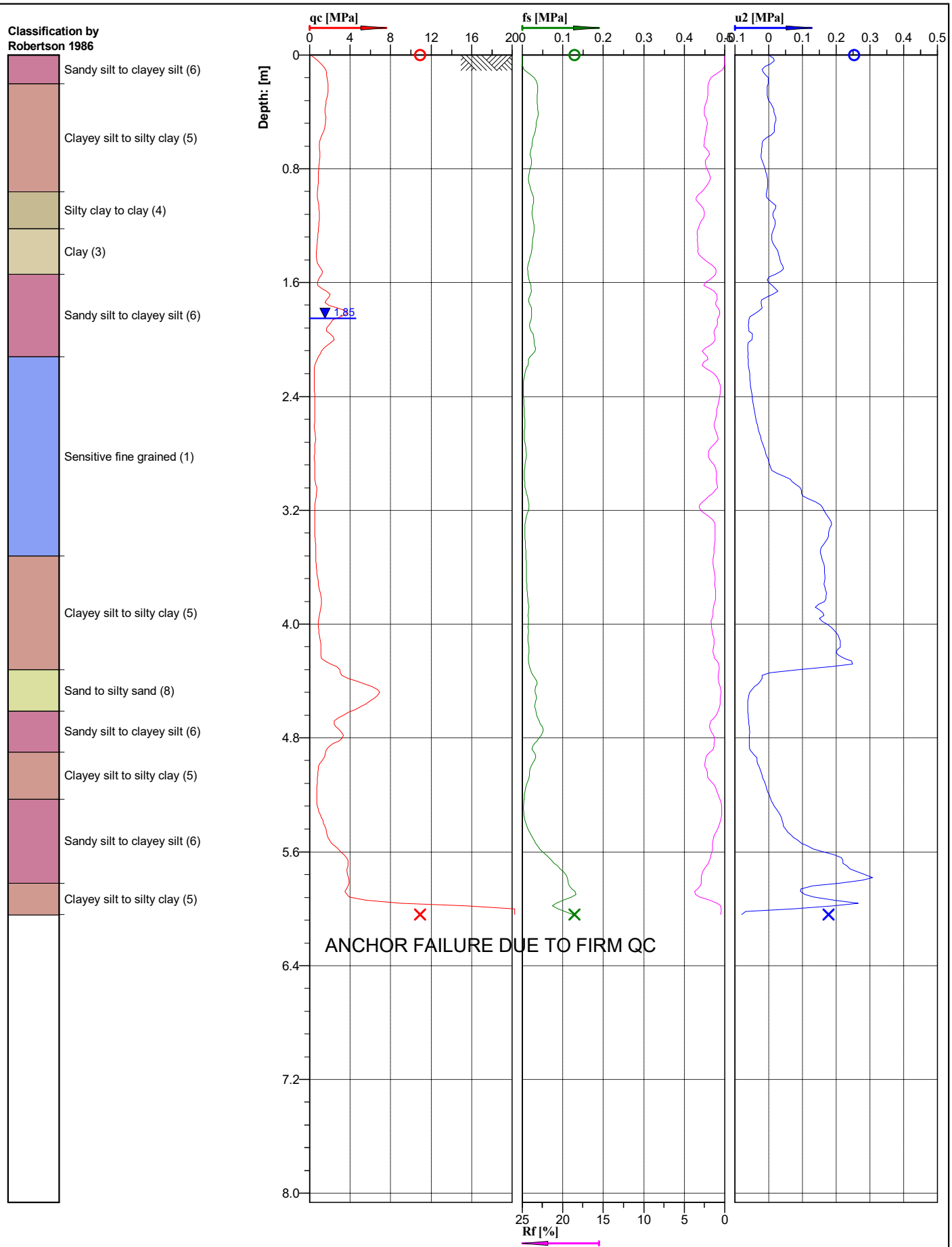


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT06
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33791, E 175.59085		File: CPT06.cpt	

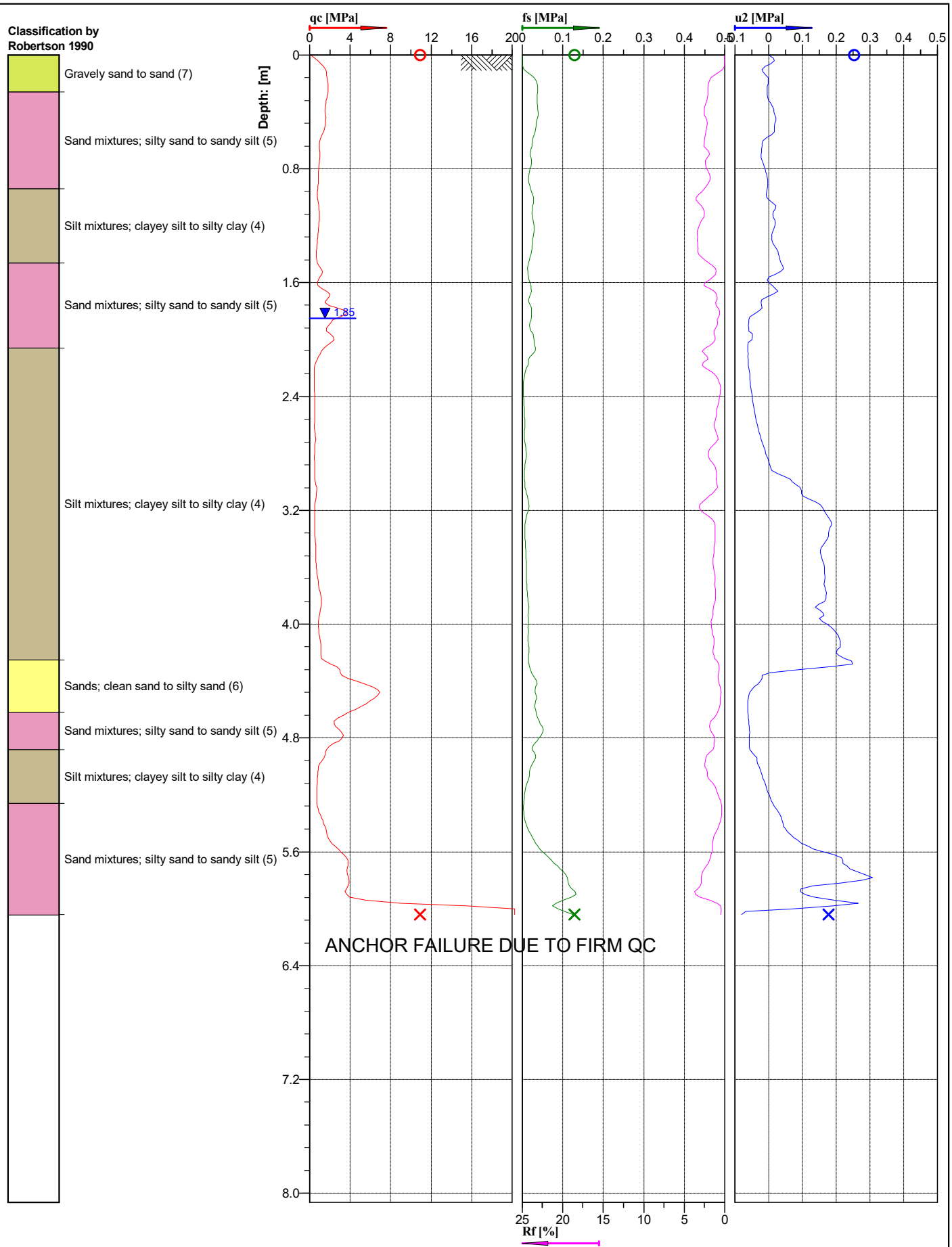


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT07
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33627, E 17559222		File: CPT07.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

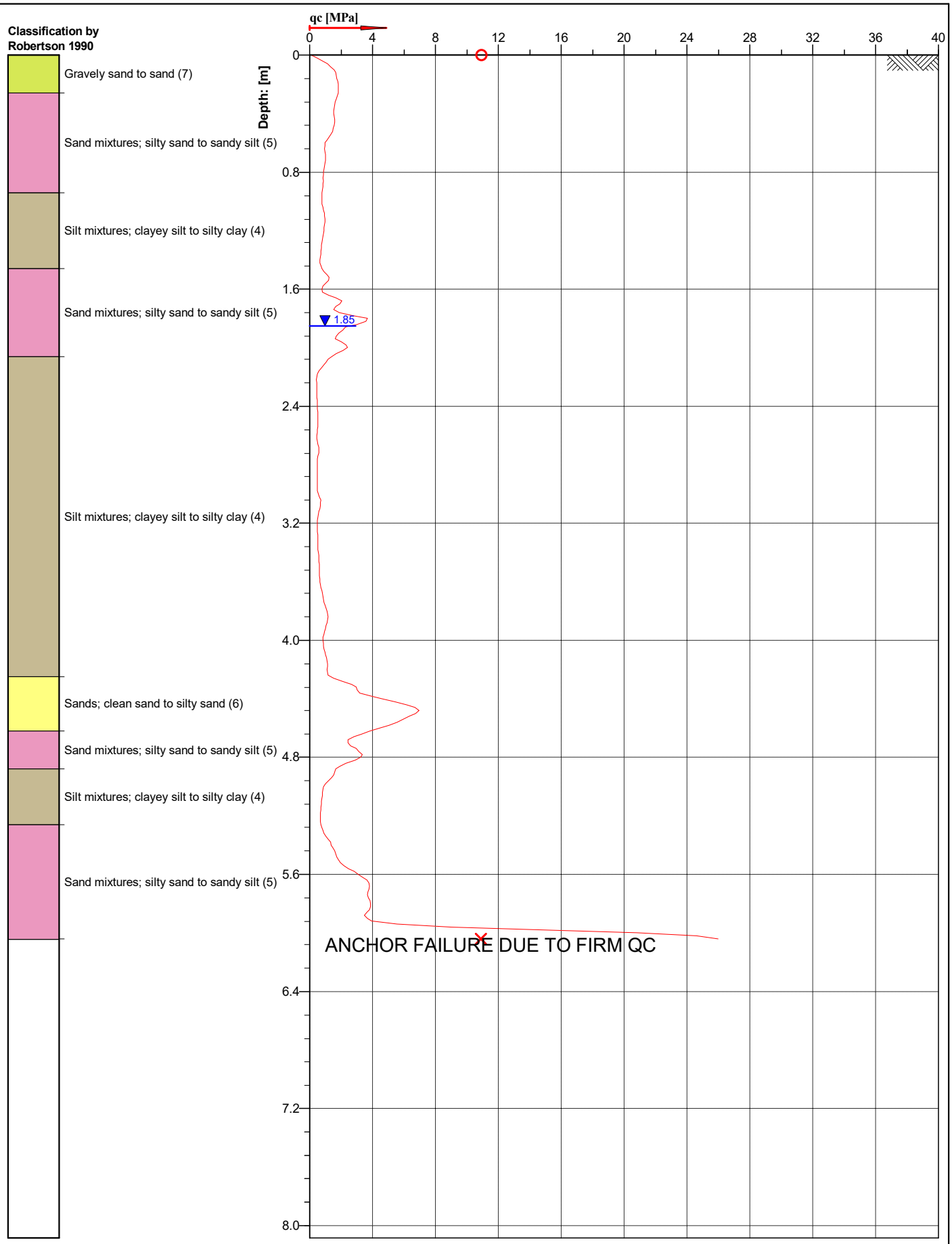


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT07
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33627, E 17559222		File: CPT07.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

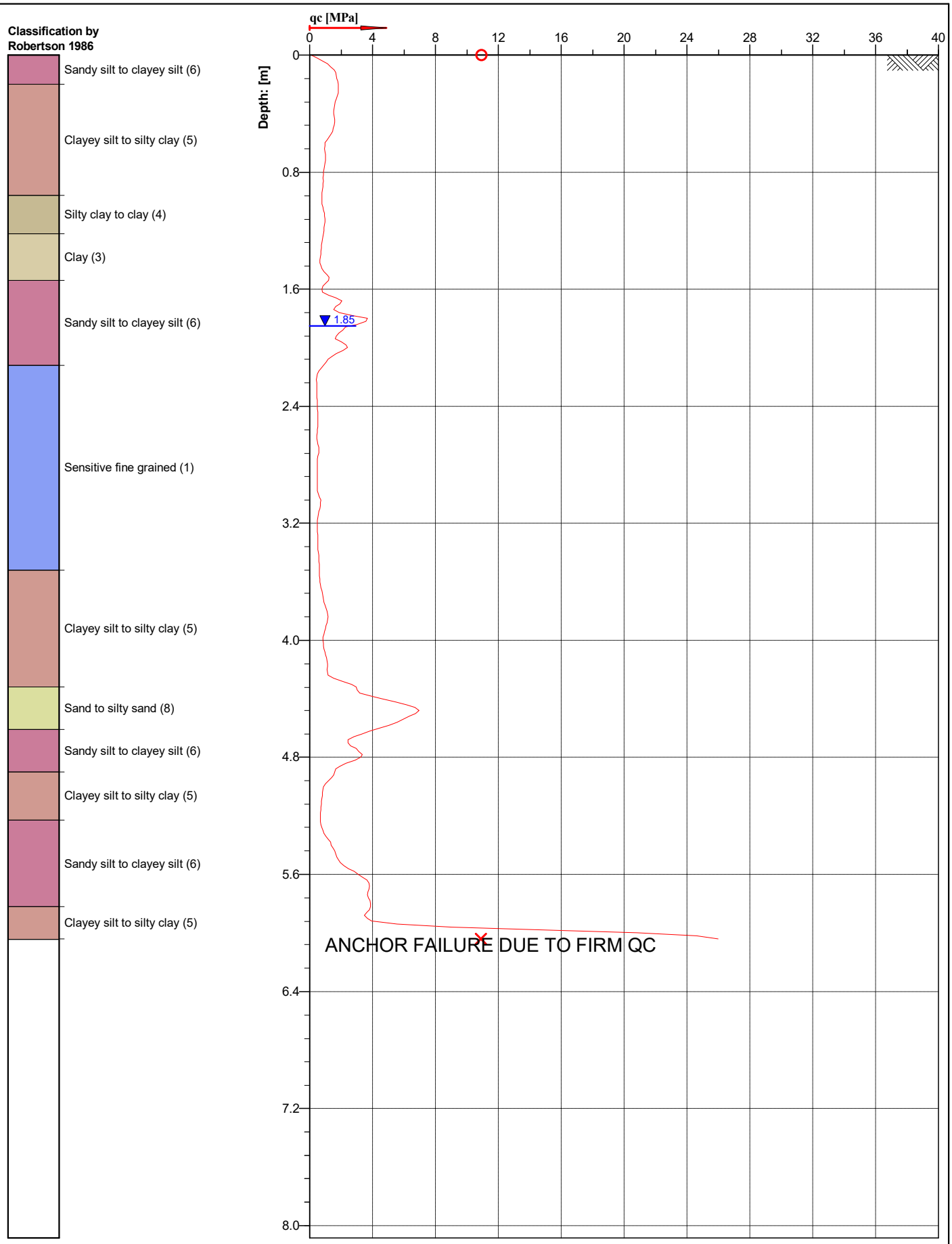


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT07
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33627, E 17559222		File: CPT07.cpt	

GEOTECH DRILLING

u2

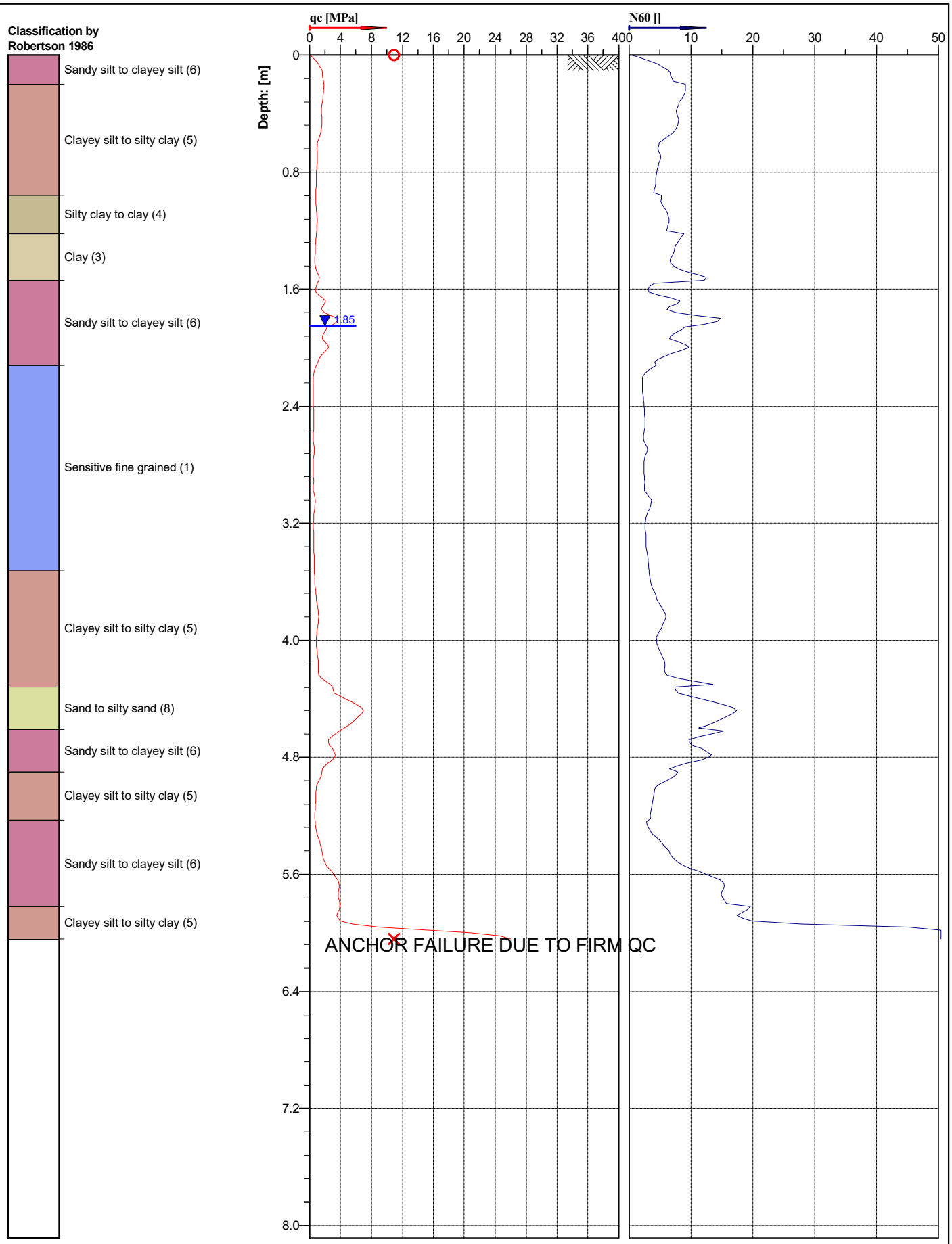
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150



u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT07
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33627, E 17559222		File: CPT07.cpt	

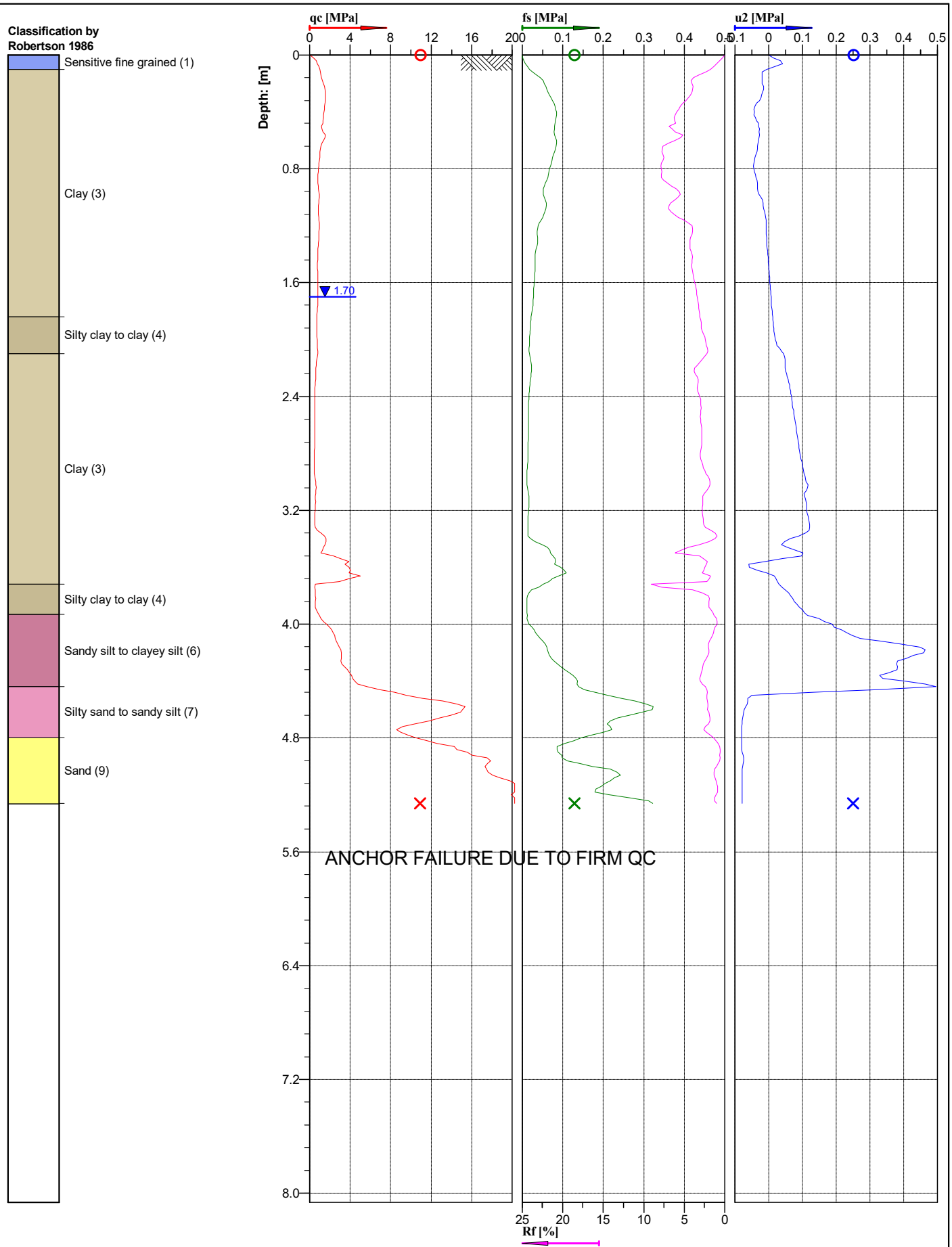


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT07
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33627, E 17559222		File: CPT07.cpt	

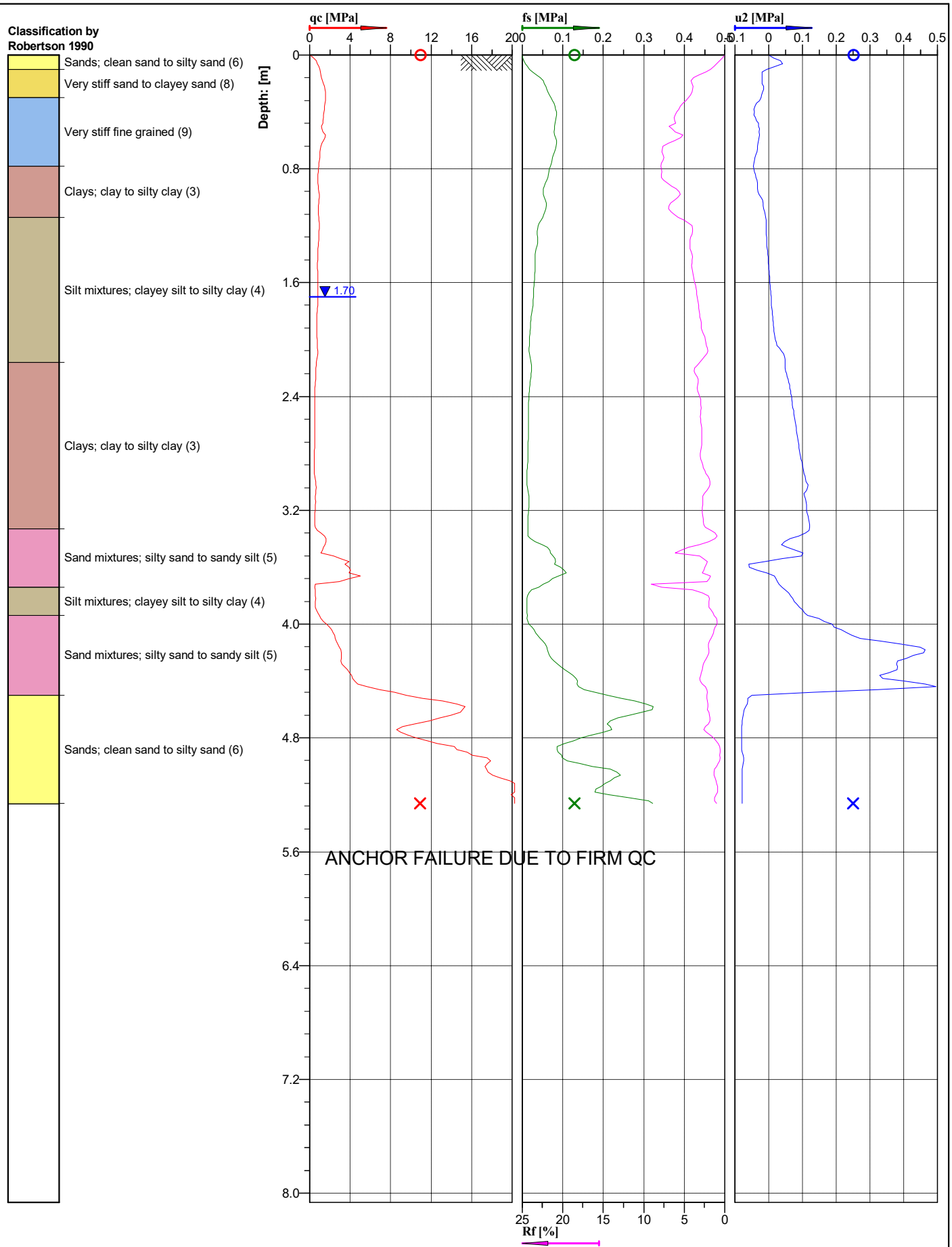


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT08
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33339, E 175.59032		File: CPT08.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

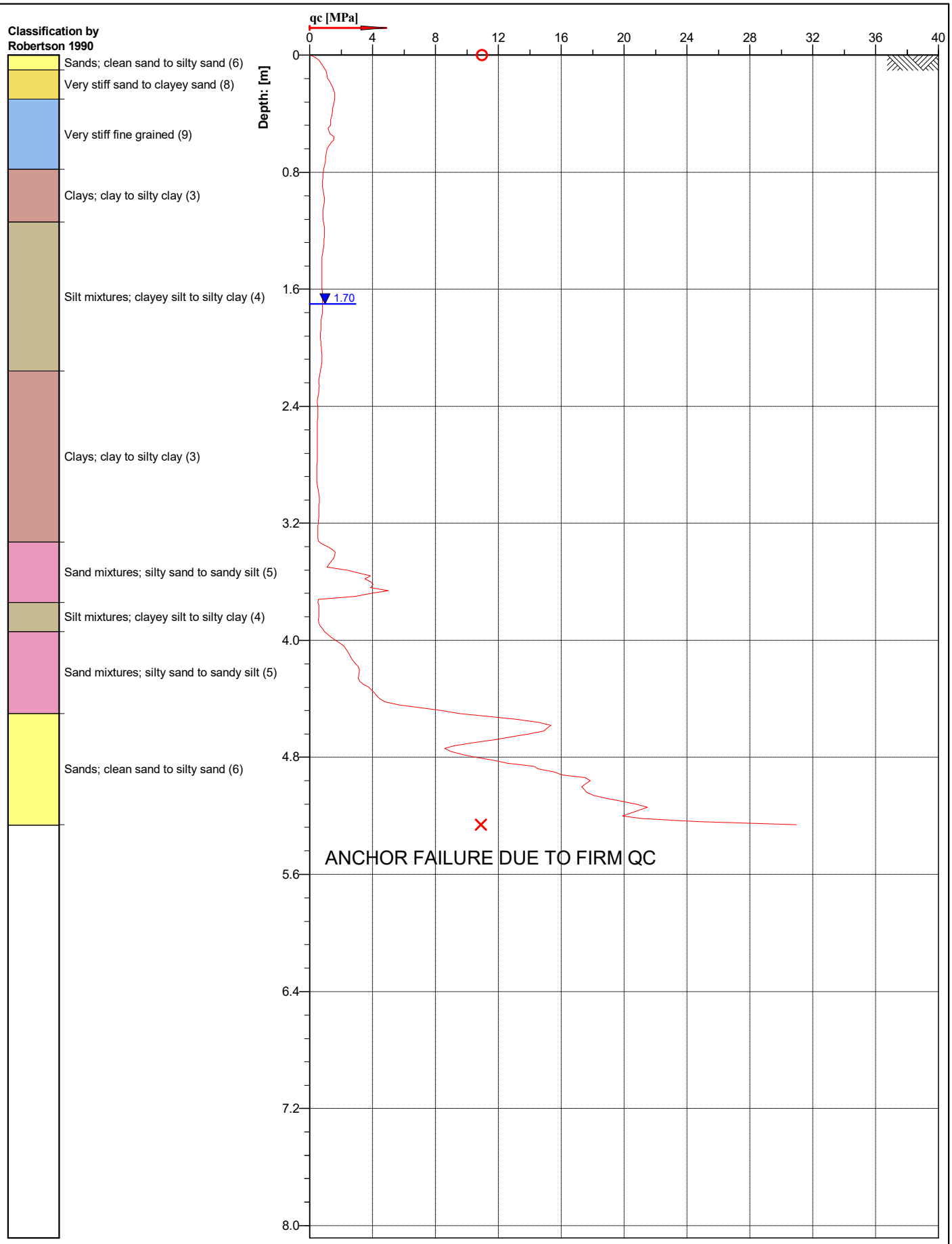


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT08
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33339, E 175.59032		File: CPT08.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

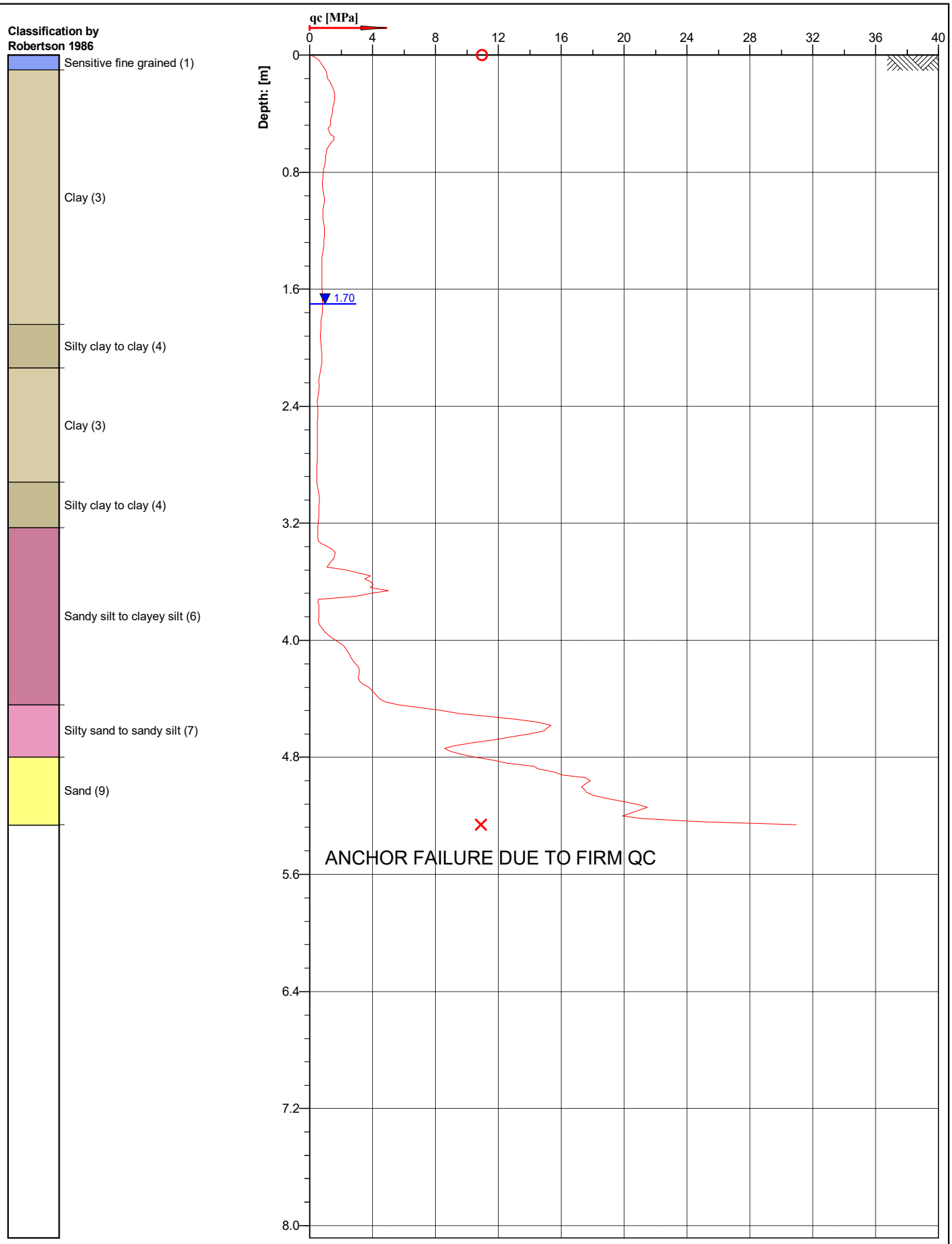


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT08
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33339, E 175.59032		File: CPT08.cpt	

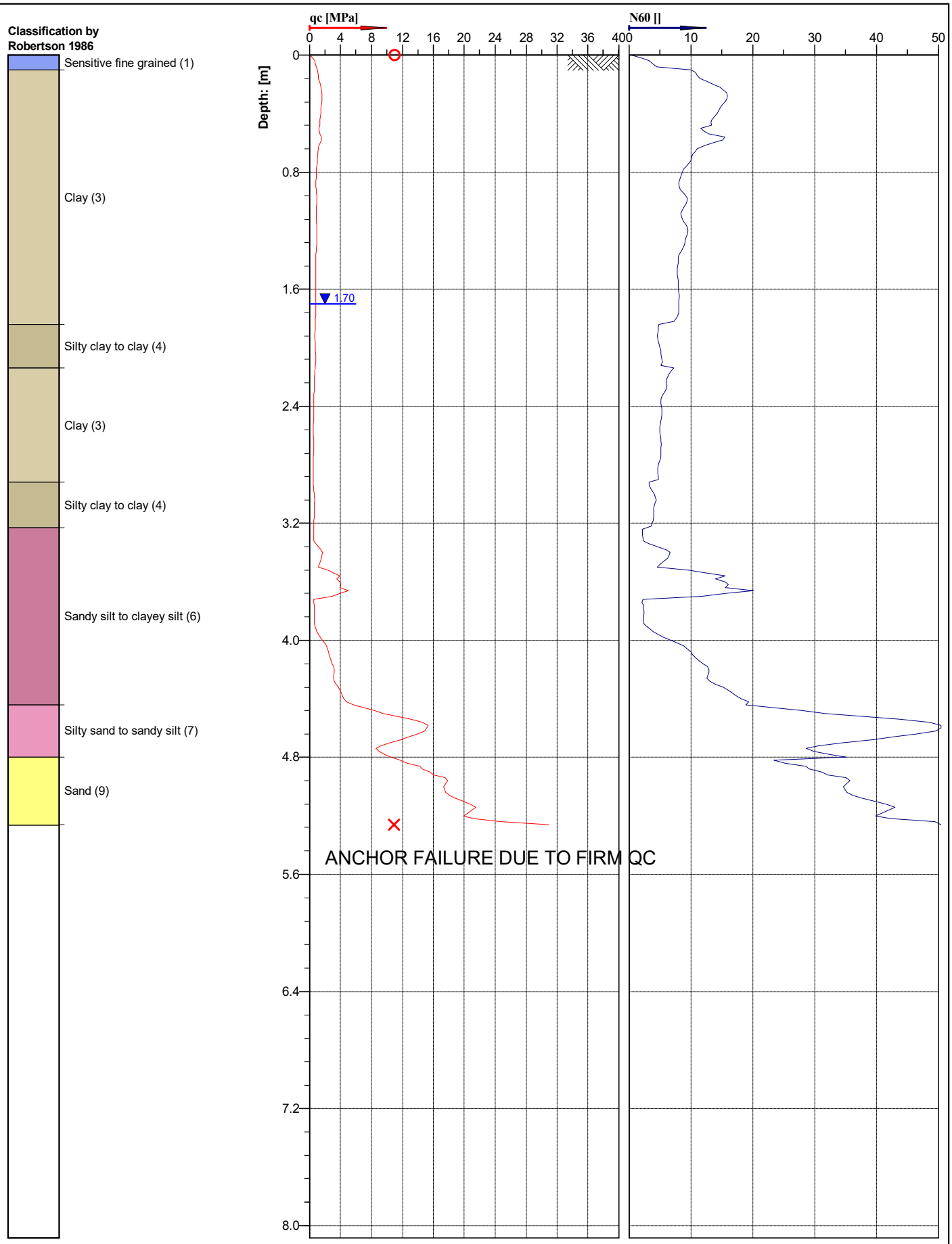


u2

GEOTECH DRILLING

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT08
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33339, E 175.59032		File: CPT08.cpt	

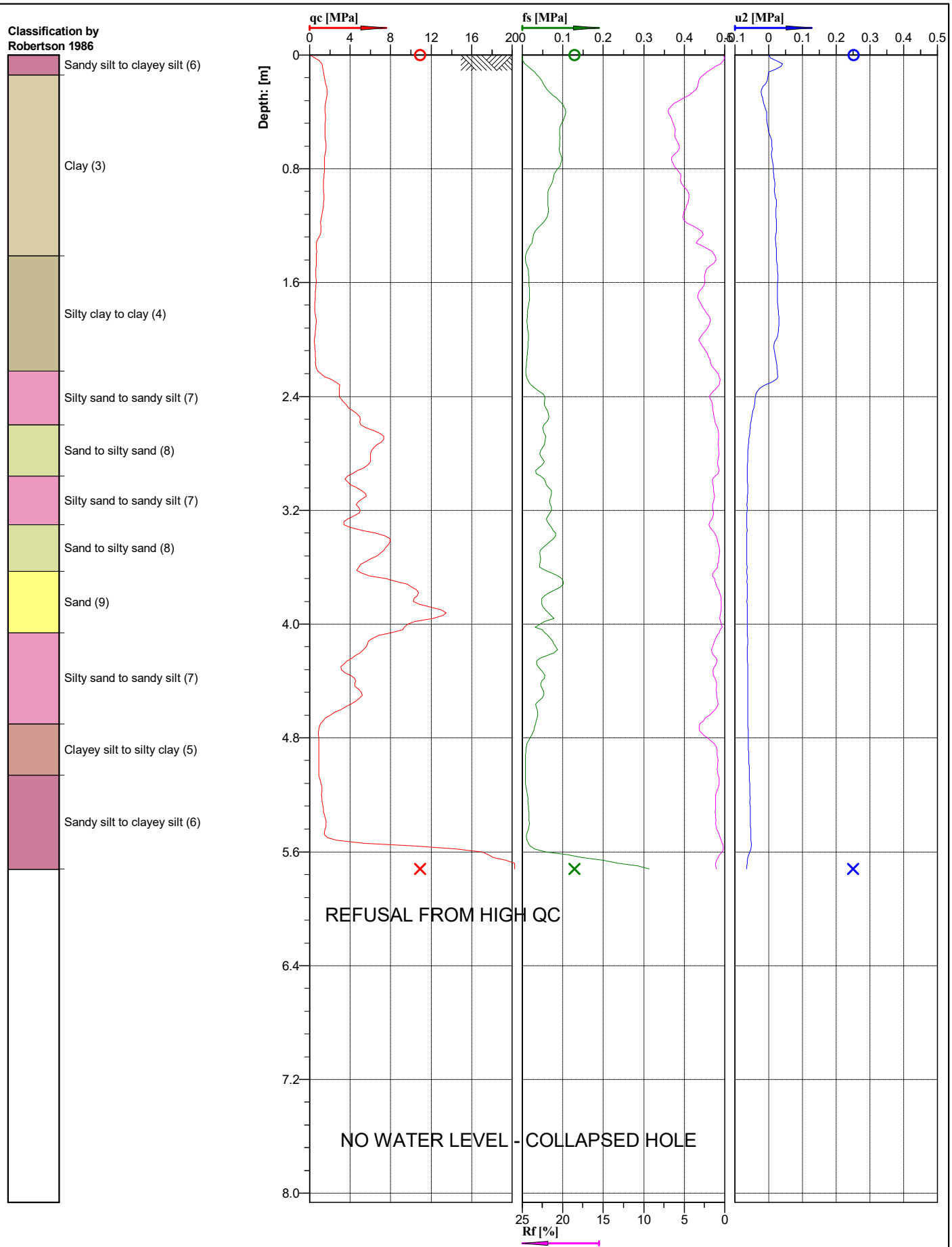


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT08
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33339, E 175.59032		File: CPT08.cpt	

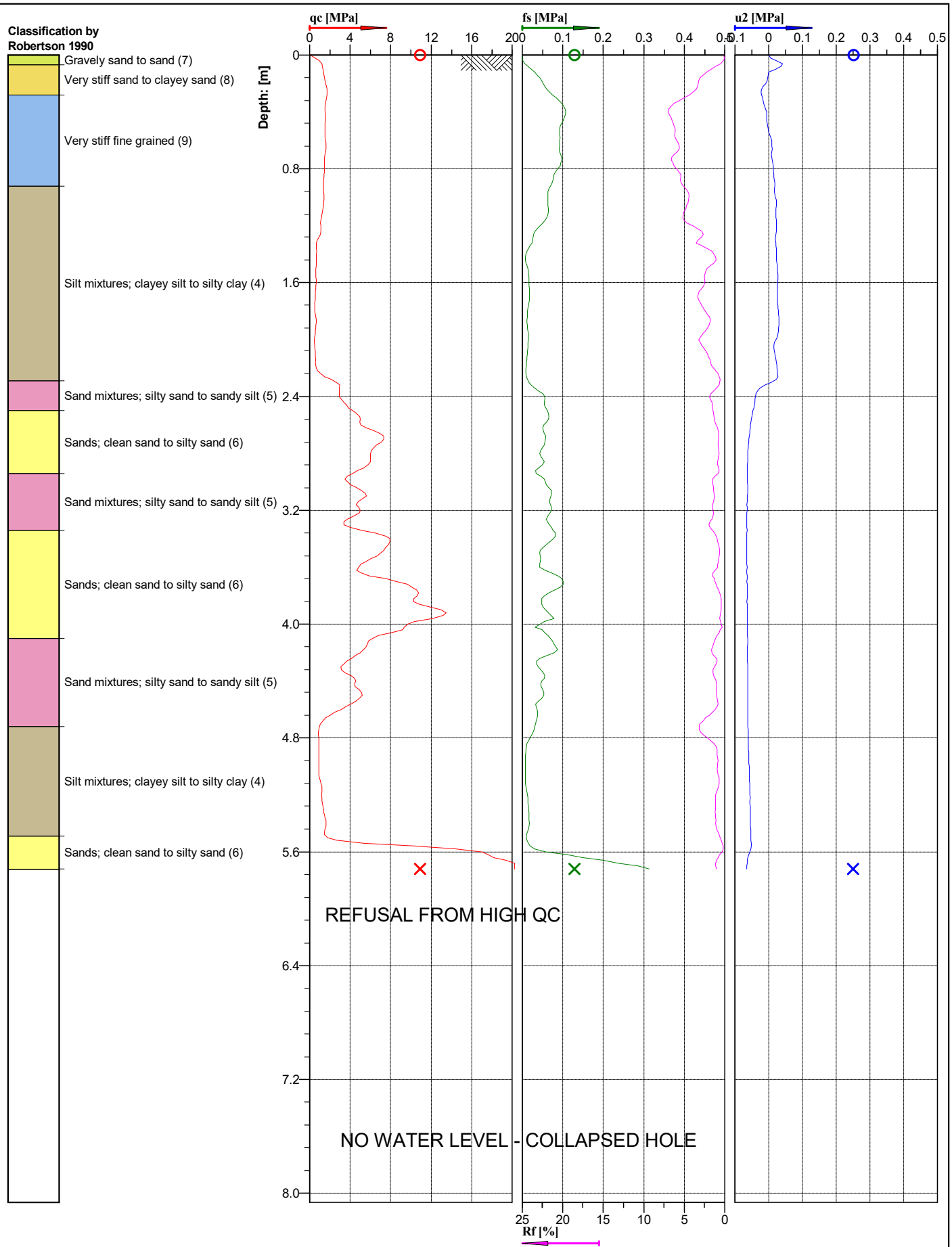


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT09
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33505, E 175.59158		File: CPT09.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

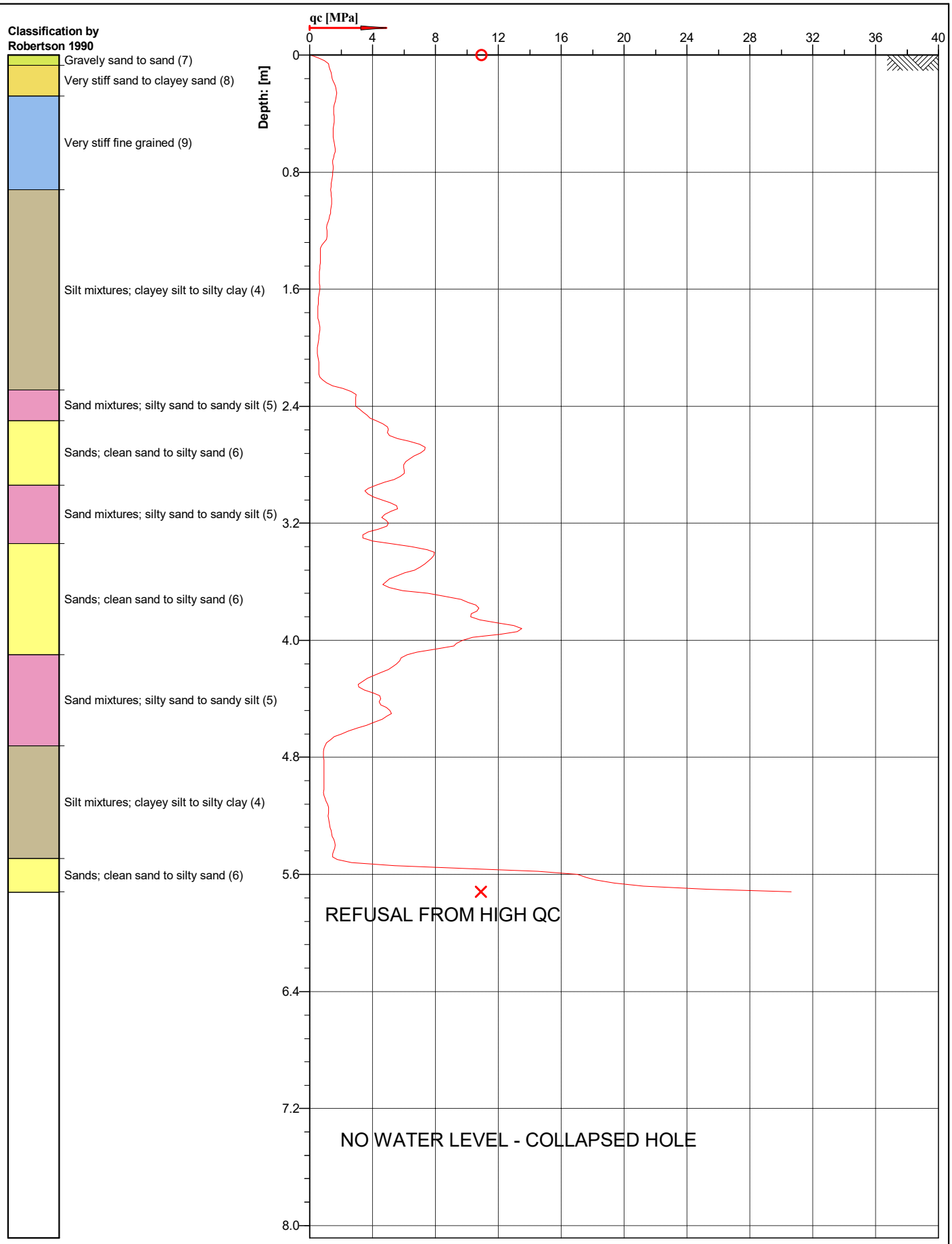


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT09
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33505, E 175.59158		File: CPT09.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

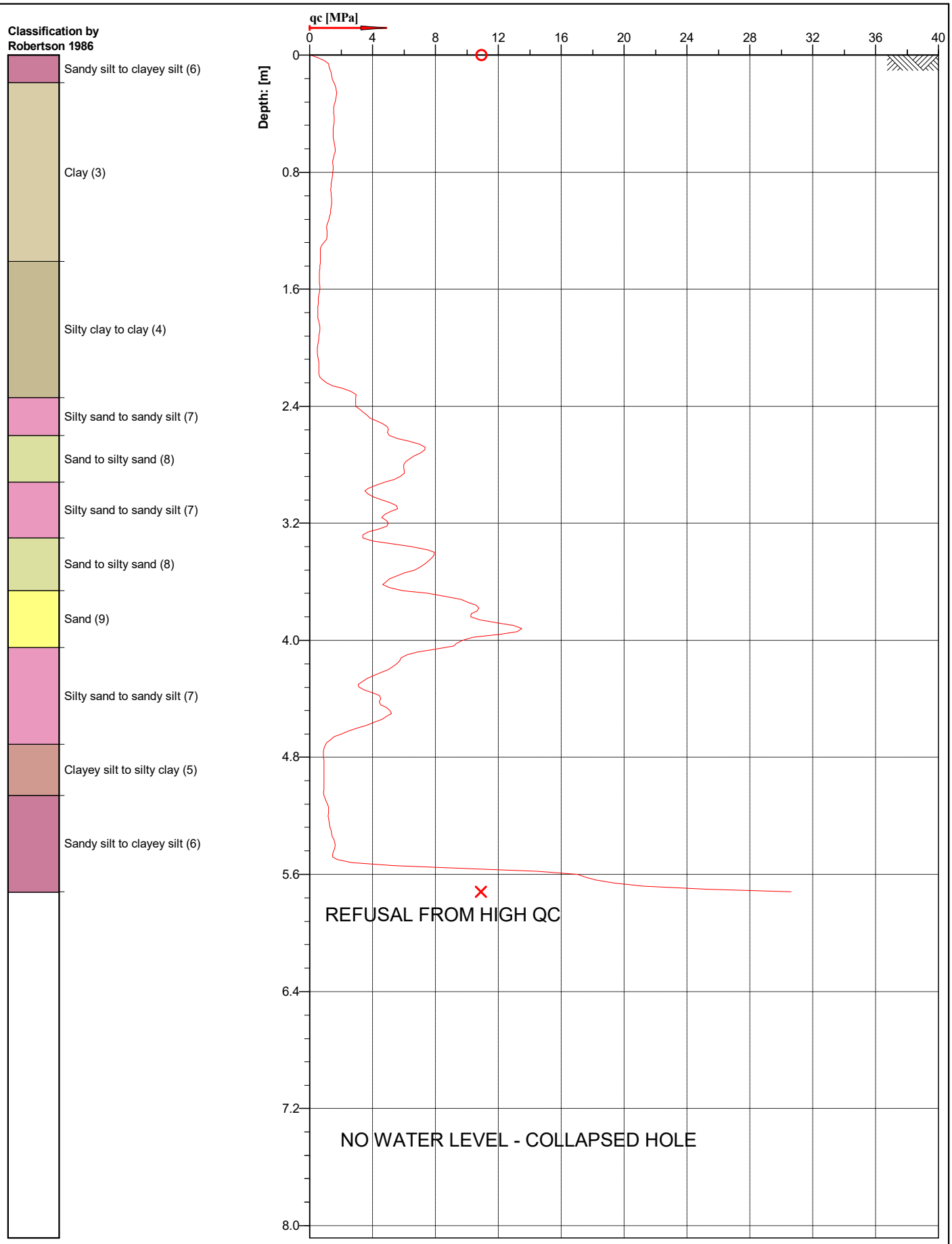


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT09
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33505, E 175.59158		File: CPT09.cpt	

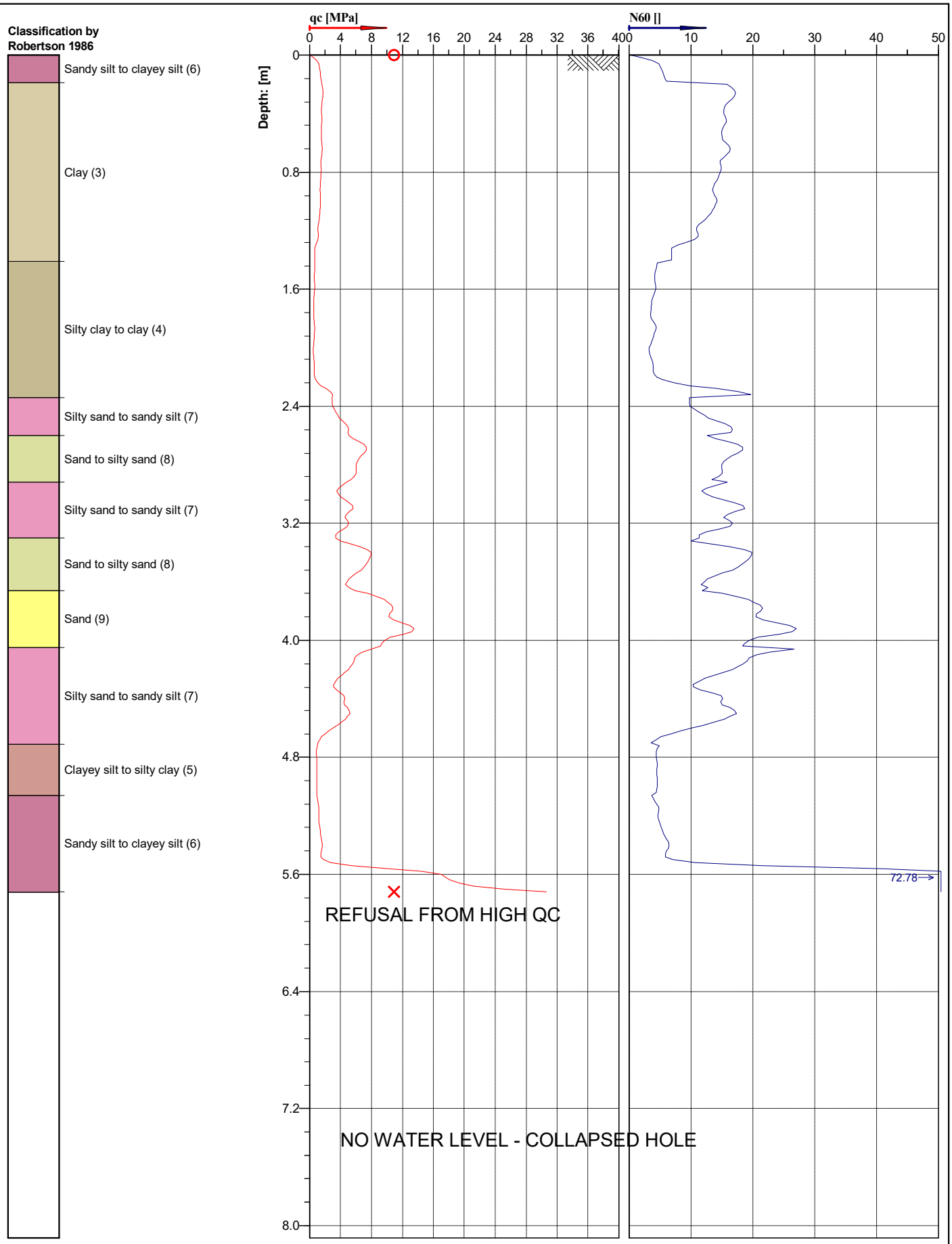


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT09
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33505, E 175.59158		File: CPT09.cpt	

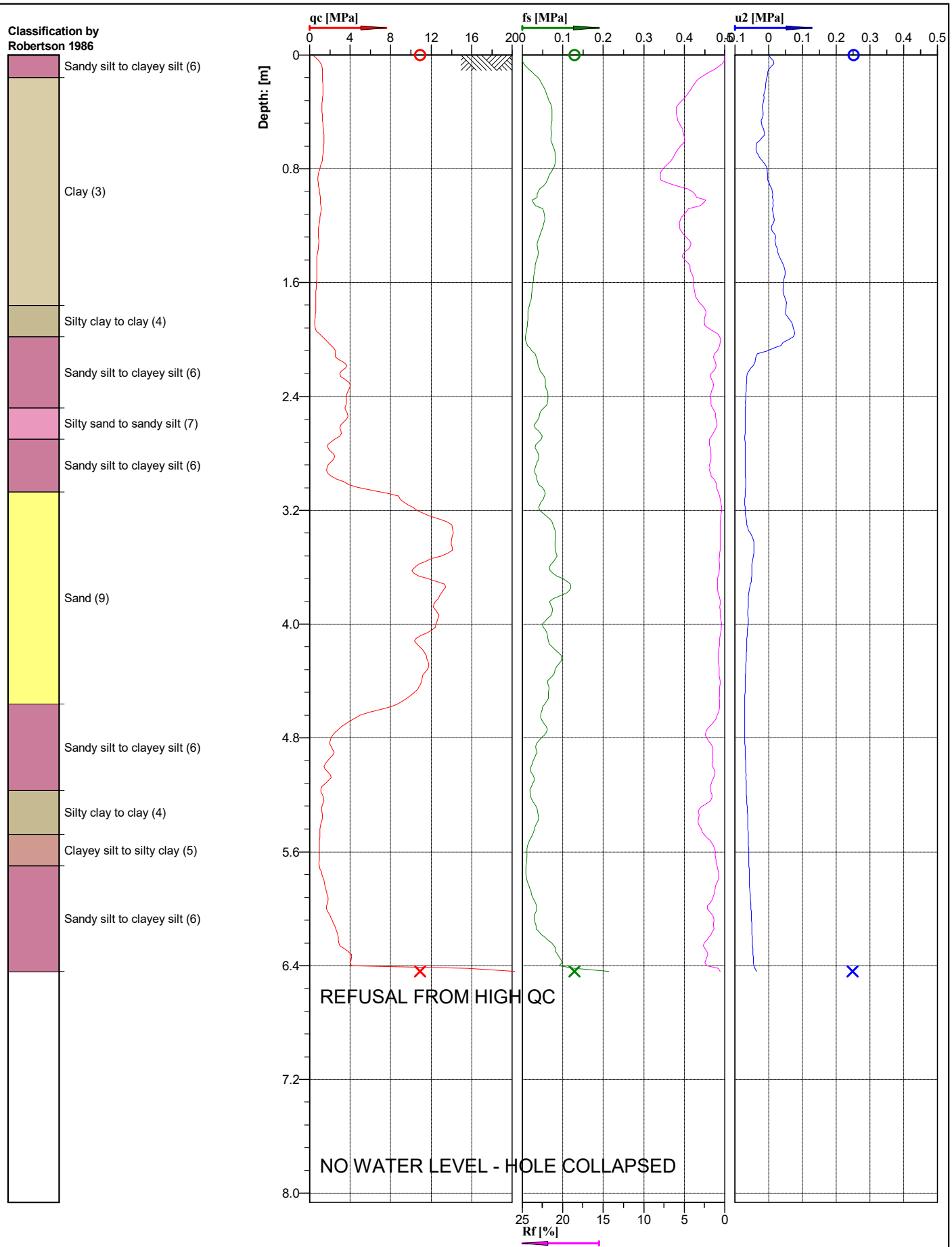


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT09
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33505, E 175.59158		File: CPT09.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

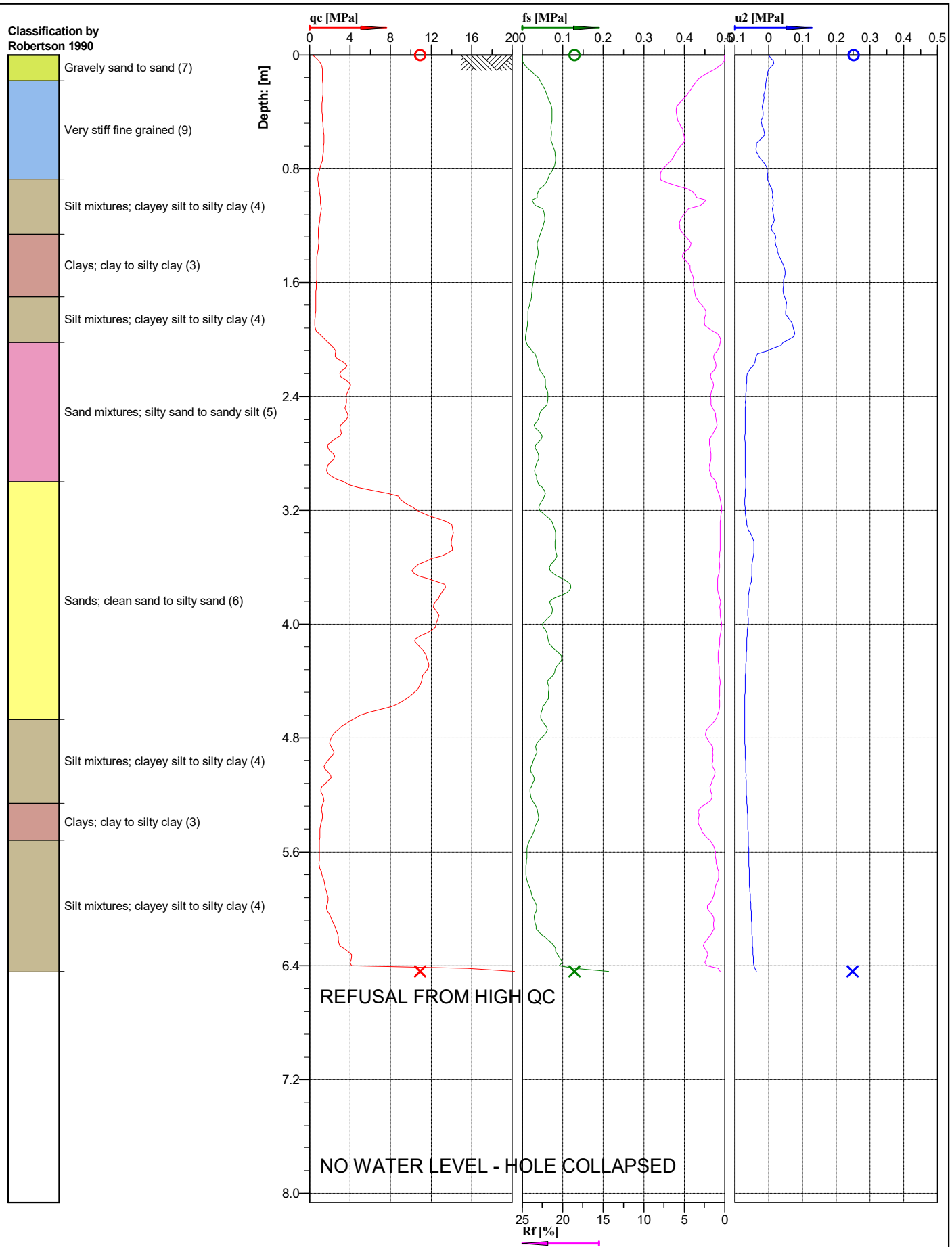


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT10
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33469, E 175.58904		File: CPT10.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

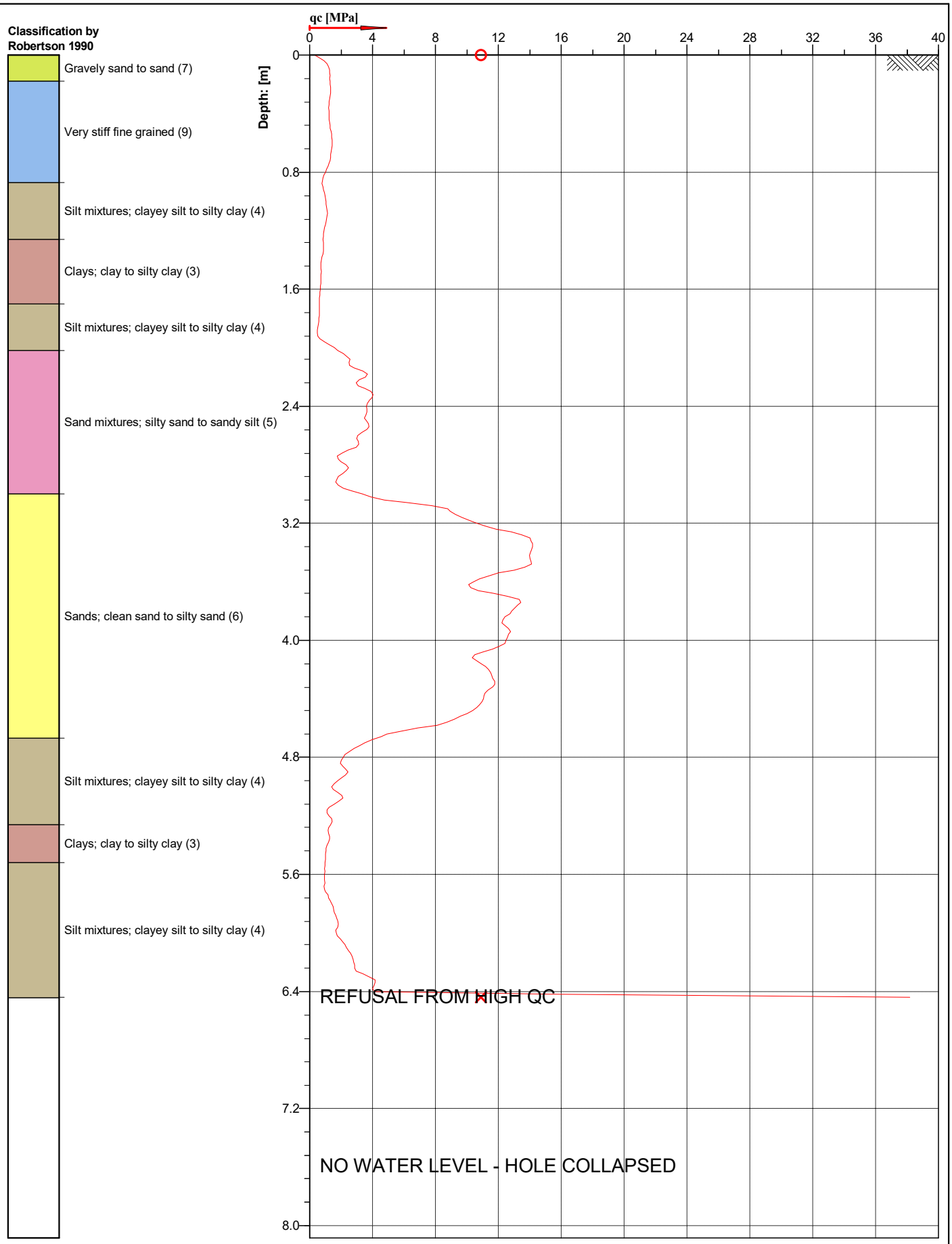


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT10
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33469, E 175.58904		File: CPT10.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

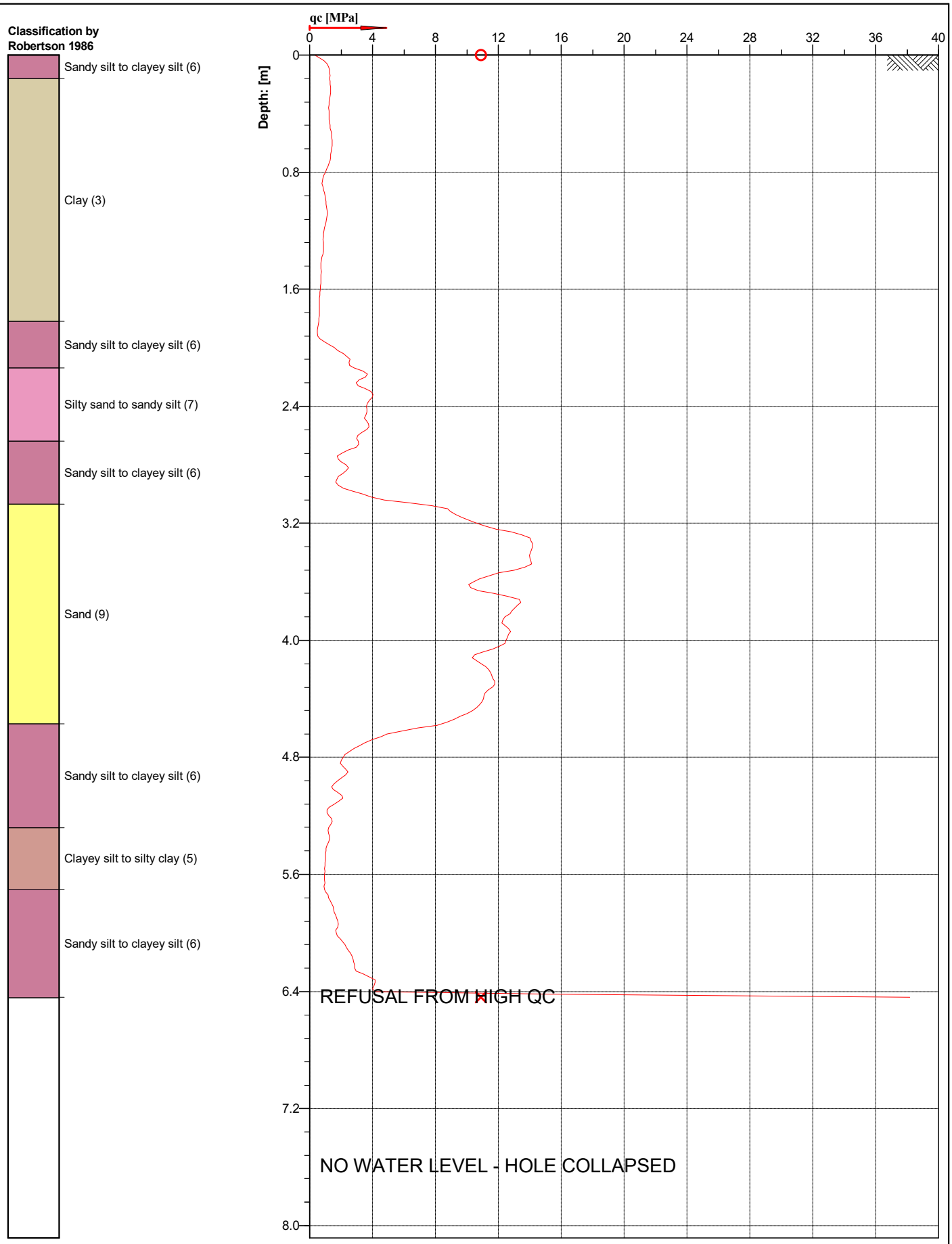


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT10
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33469, E 175.58904		File: CPT10.cpt	



GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT10
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
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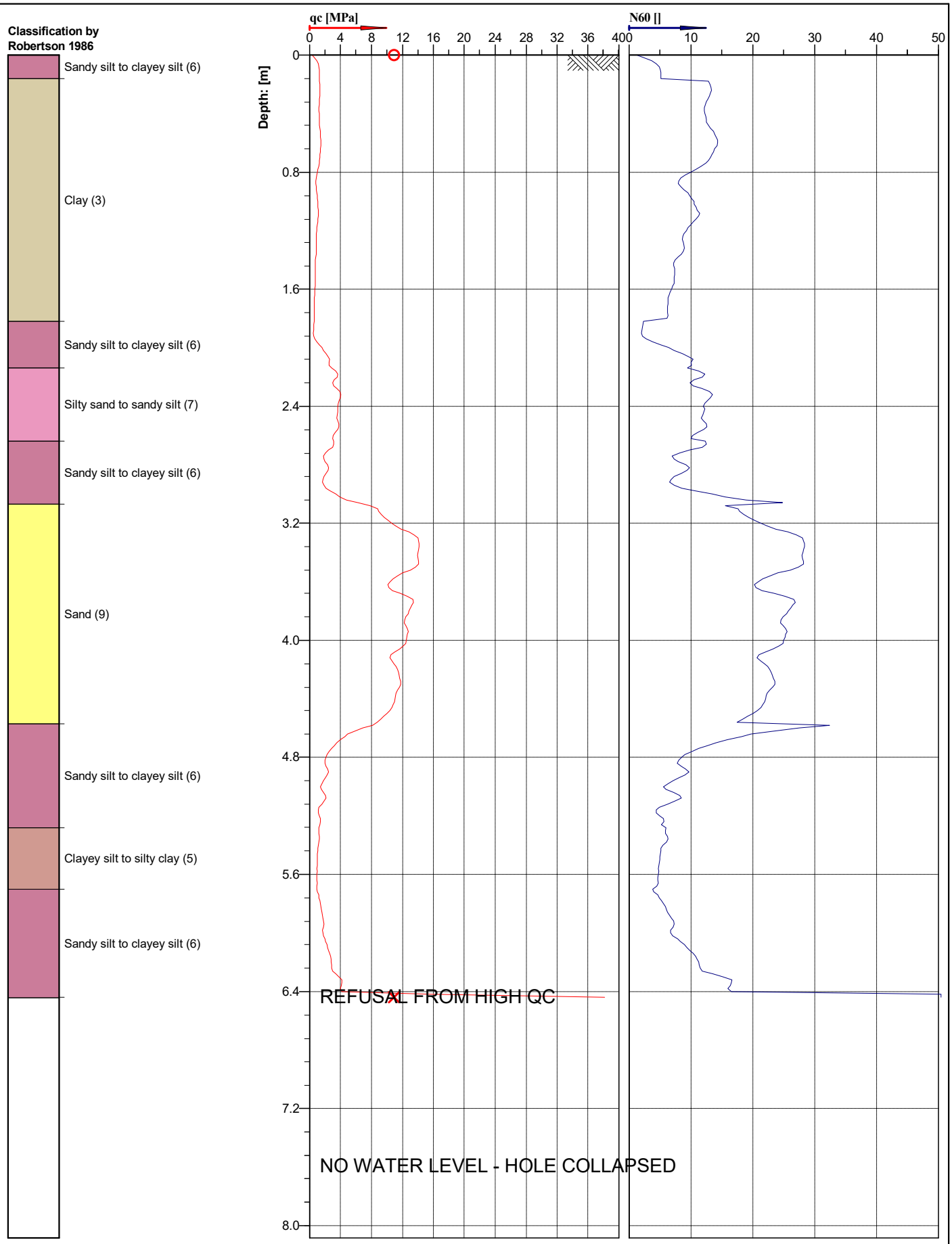
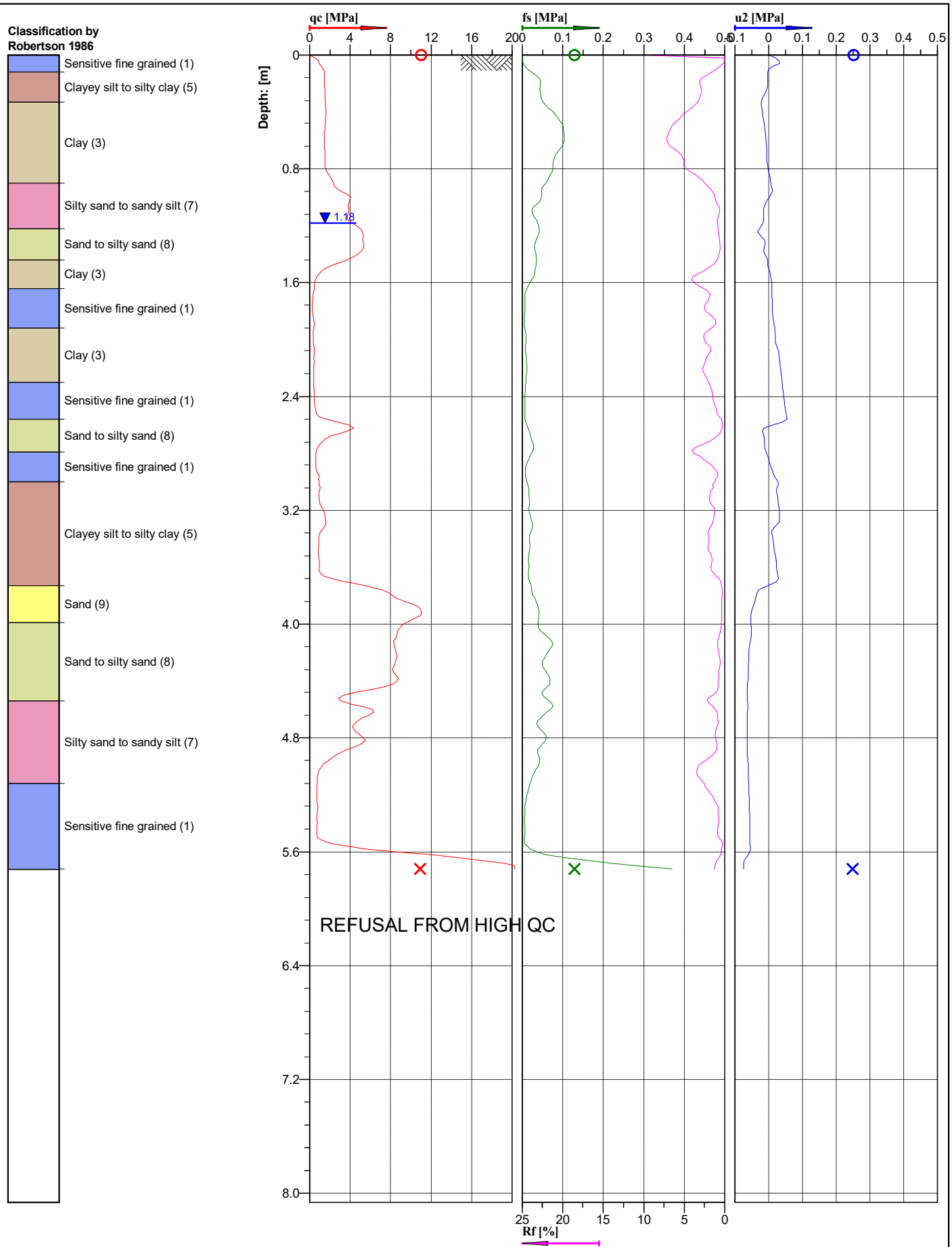


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT10
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33469, E 175.58904		File: CPT10.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

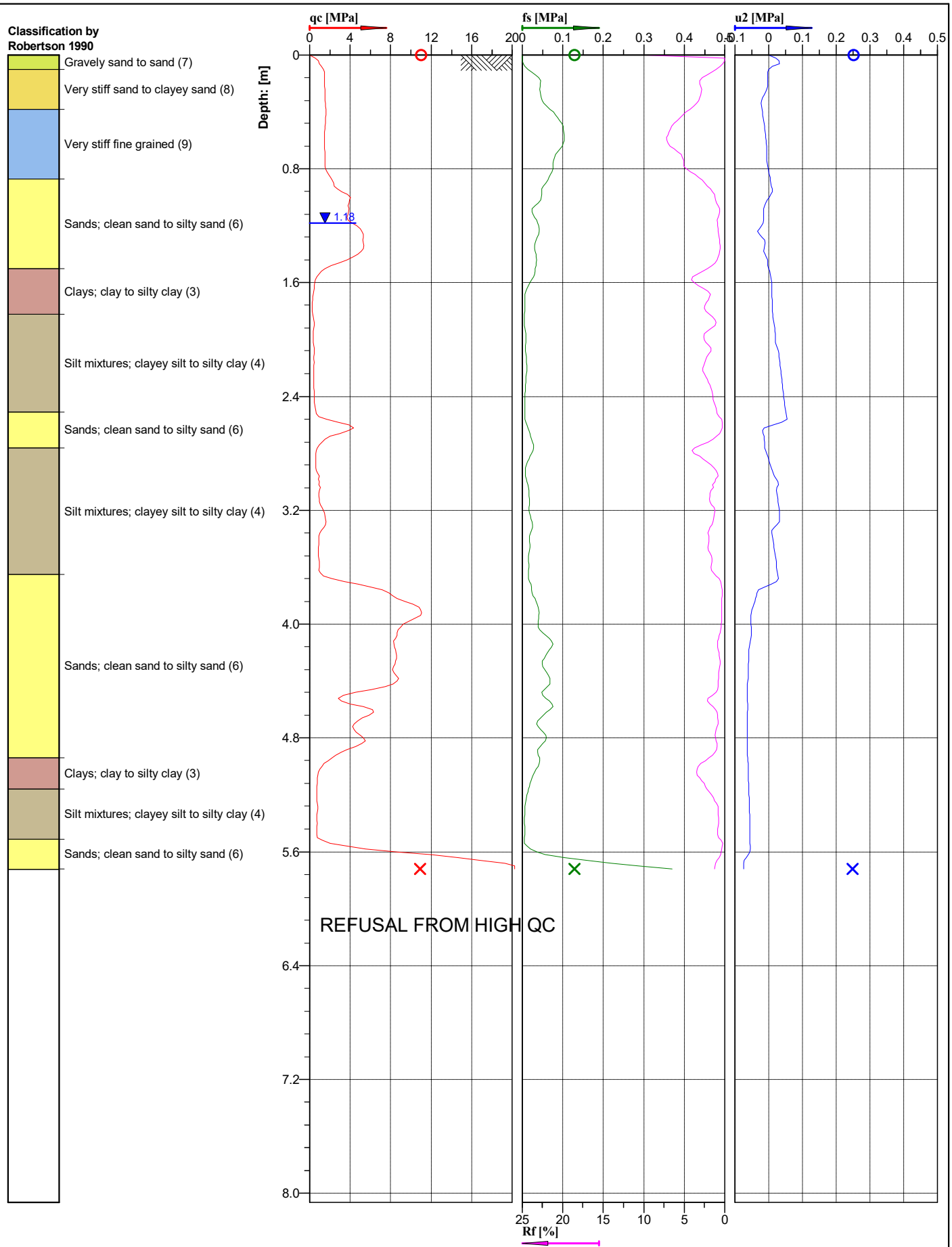


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT11
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33598, E 175.59033		File: CPT11.cpt	

GEOTECH DRILLING

u2

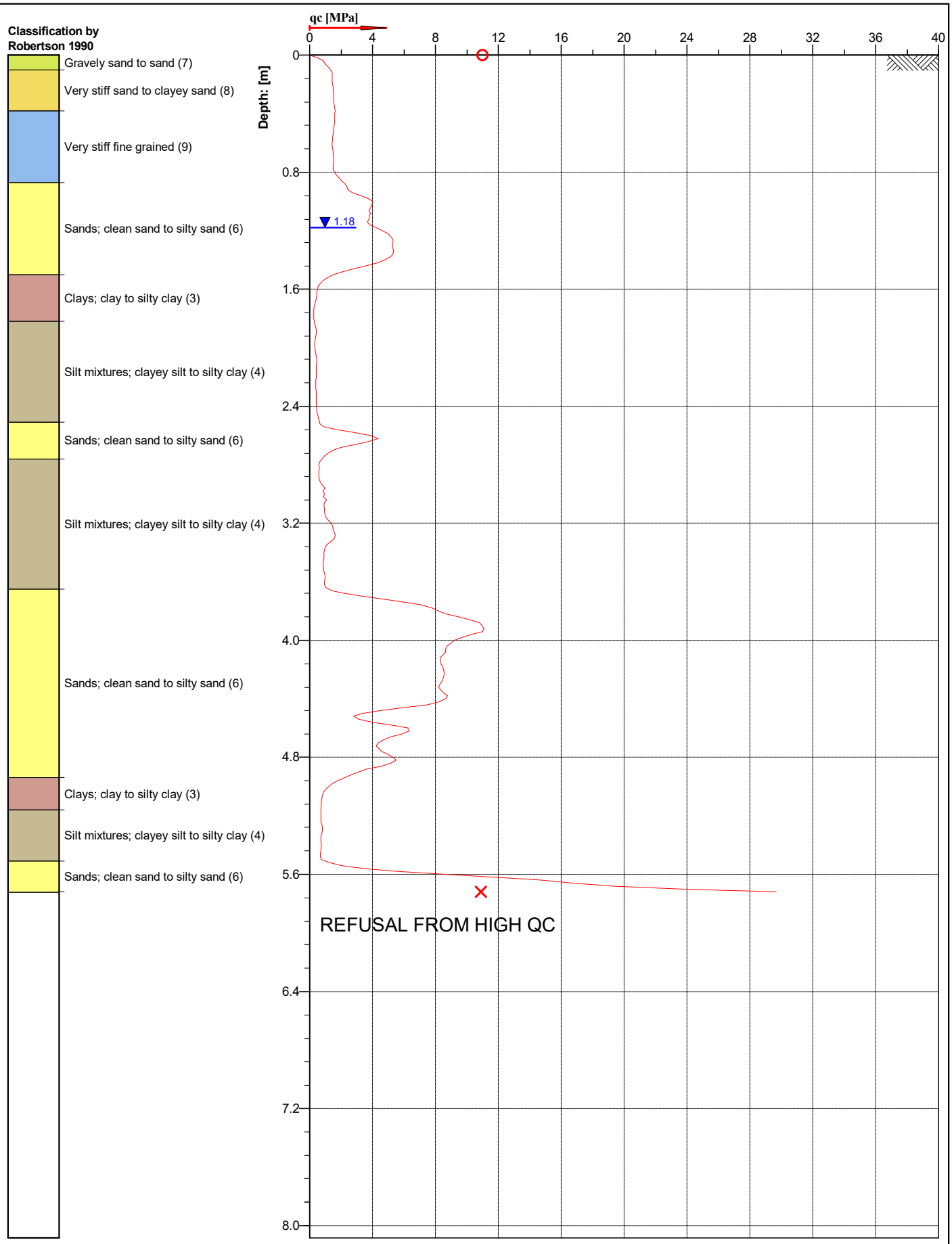
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150



Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT11
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33598, E 175.59033		File: CPT11.cpt	

GEOTECH DRILLING

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

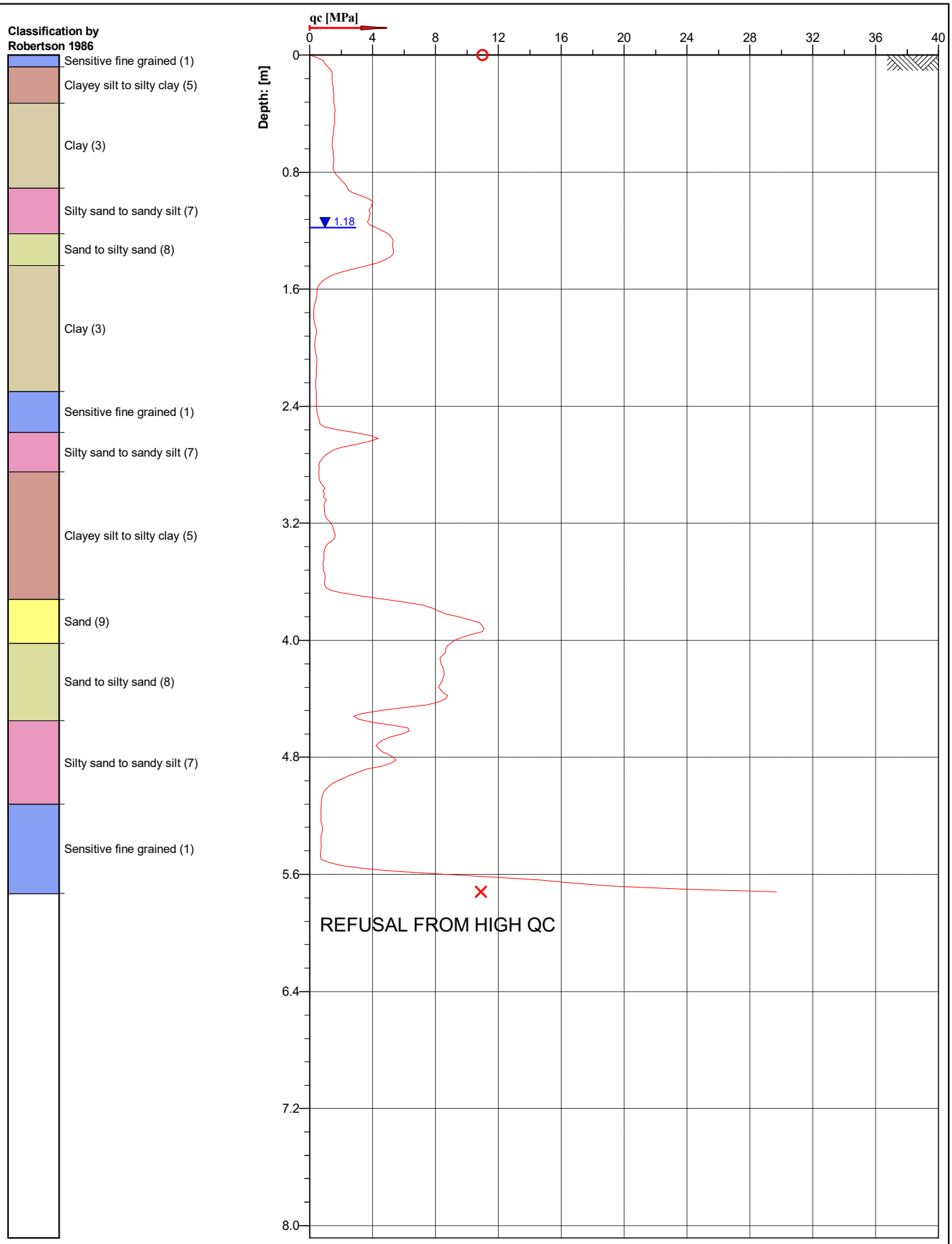


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT11
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33598, E 175.59033		File: CPT11.cpt	

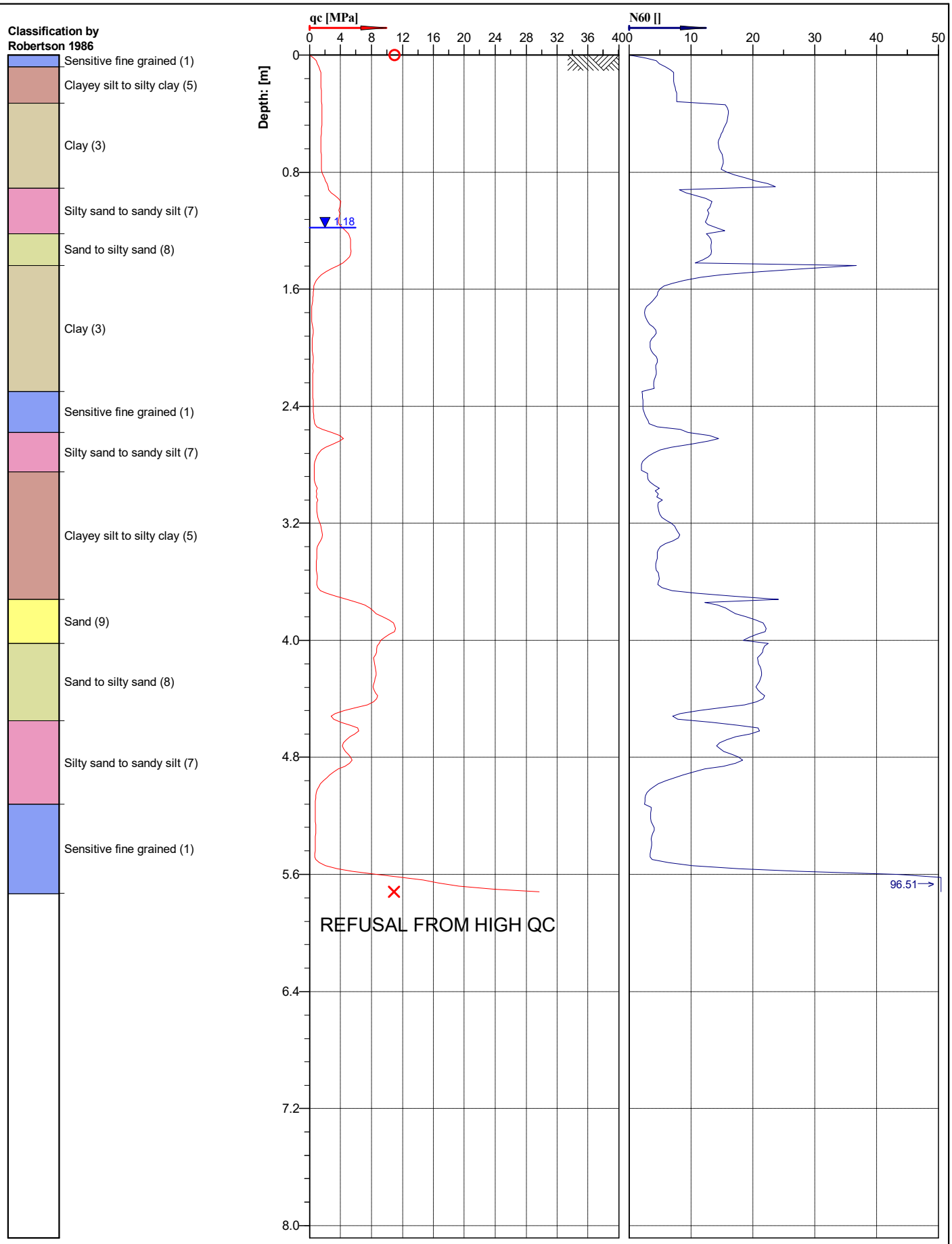


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT11
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33598, E 175.59033		File: CPT11.cpt	

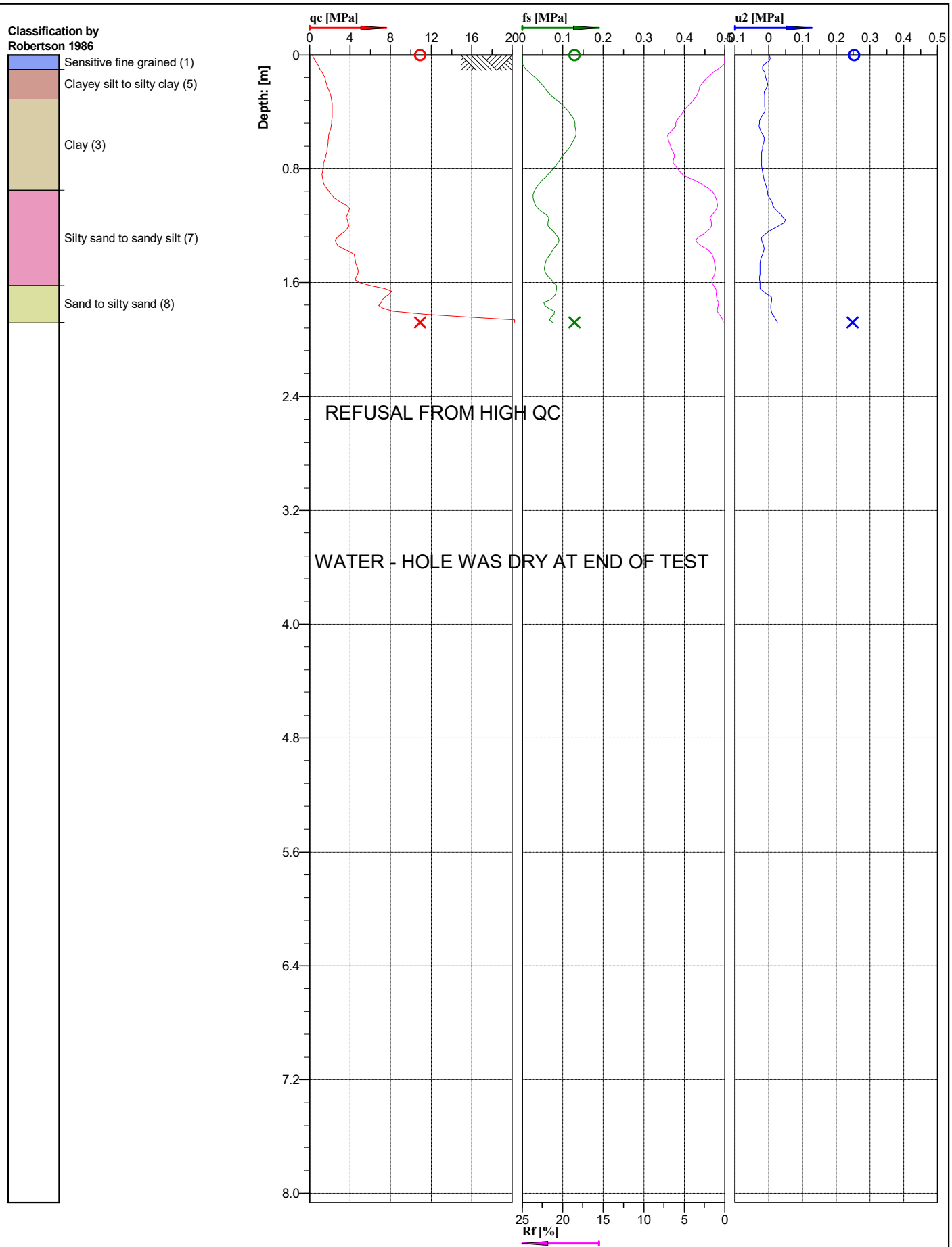


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT11
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33598, E 175.59033		File: CPT11.cpt	

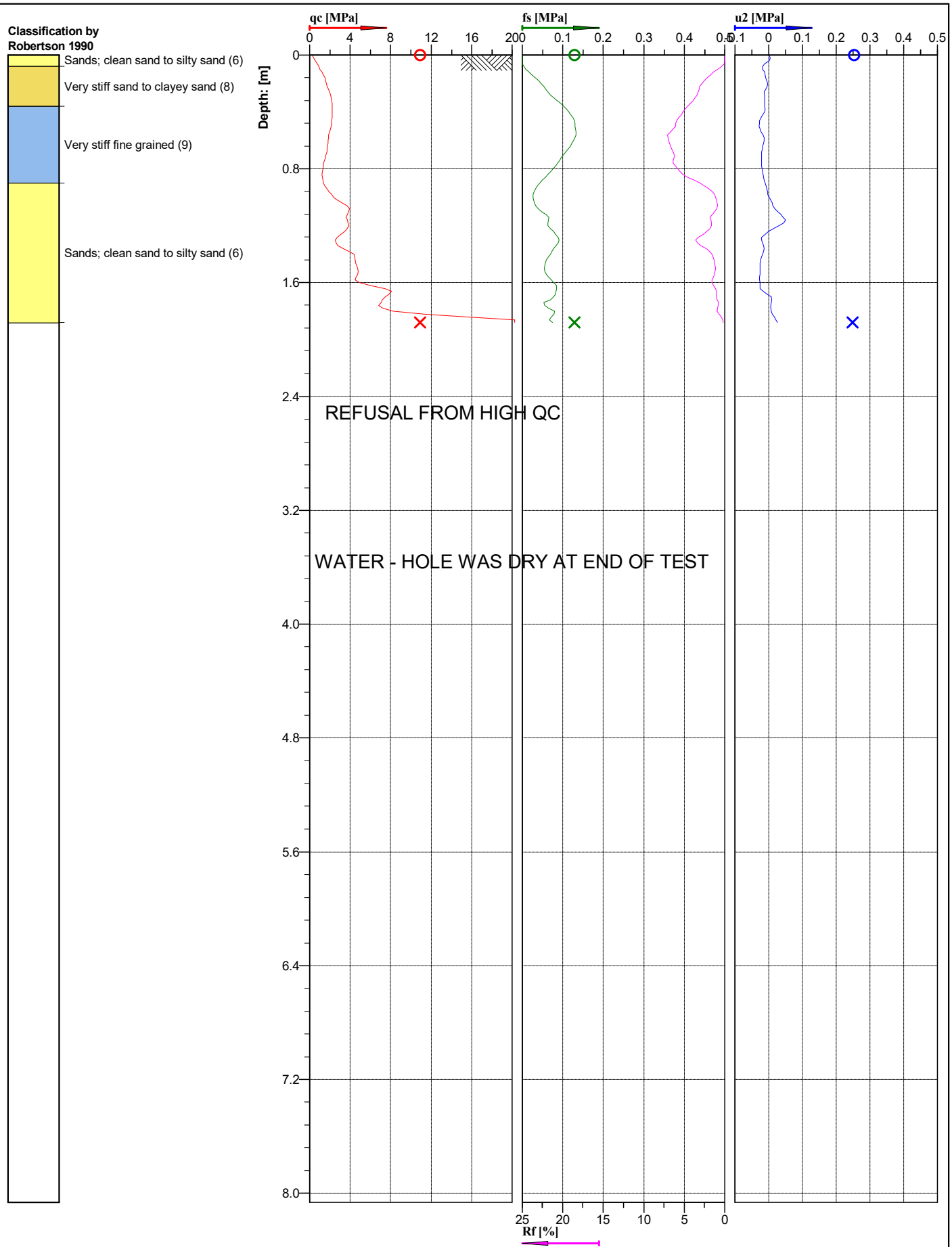


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT12
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33668, E 175.58669		File: CPT12.cpt	

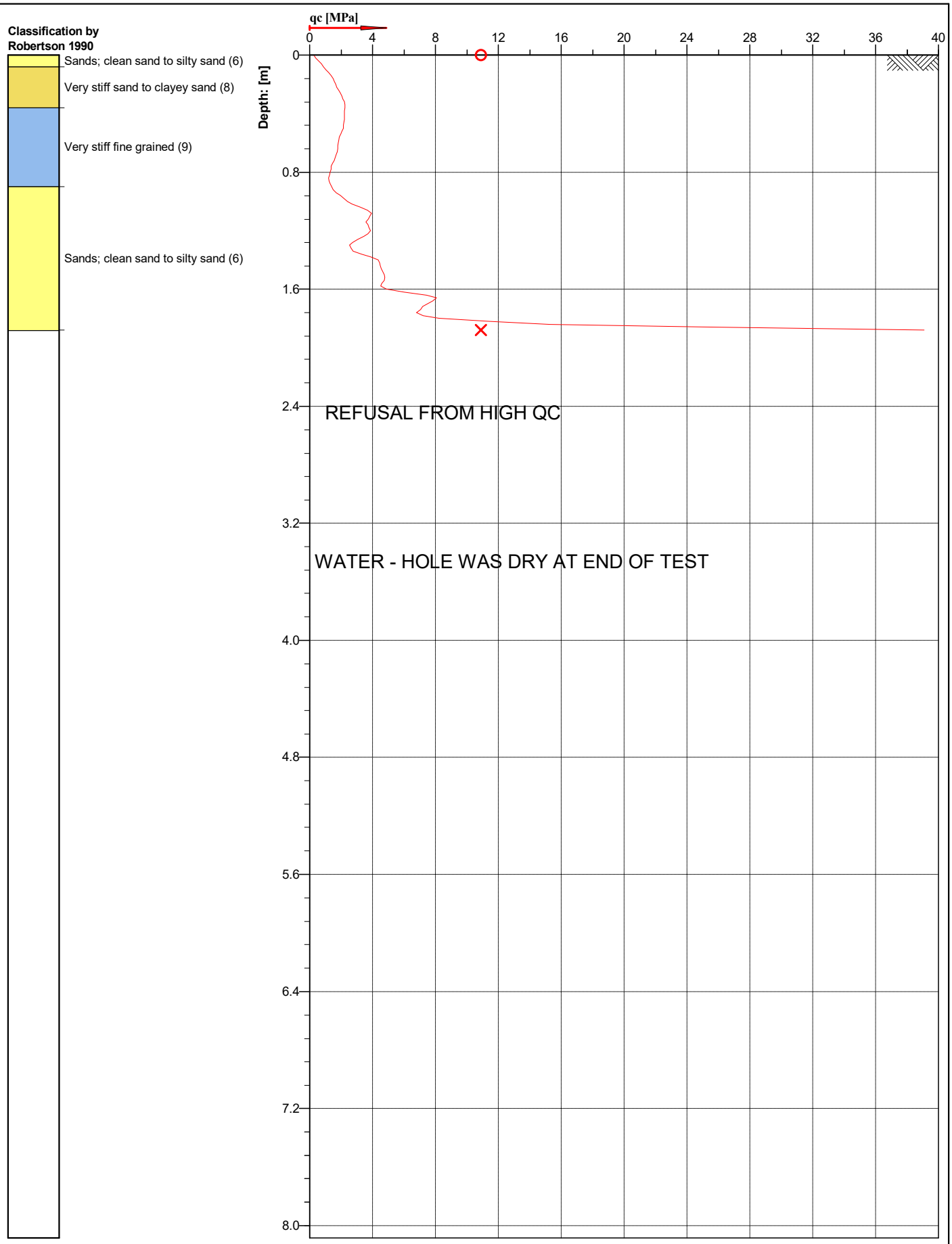


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT12
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 36
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33668, E 175.58669		File: CPT12.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

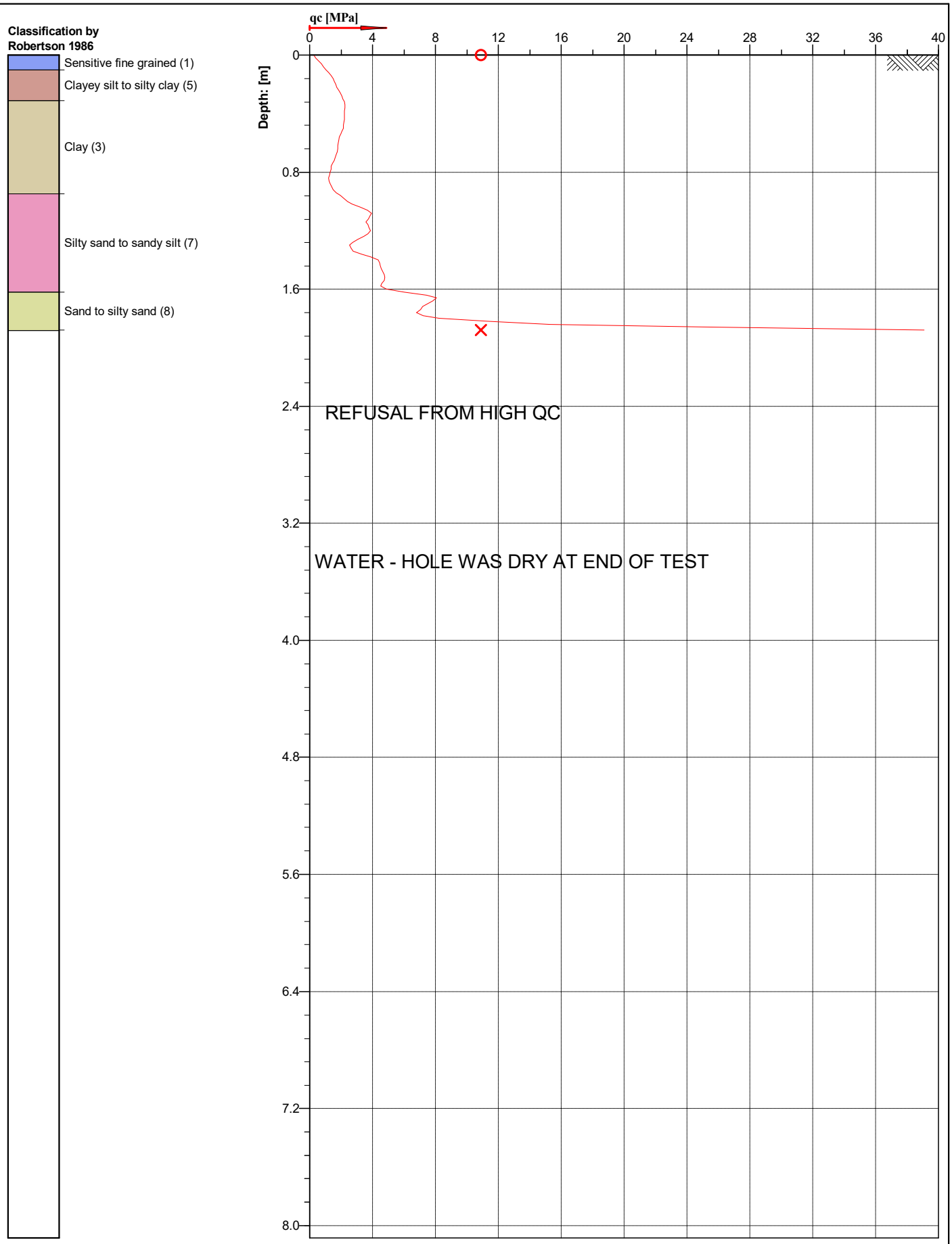


GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT12
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33668, E 175.58669		File: CPT12.cpt	

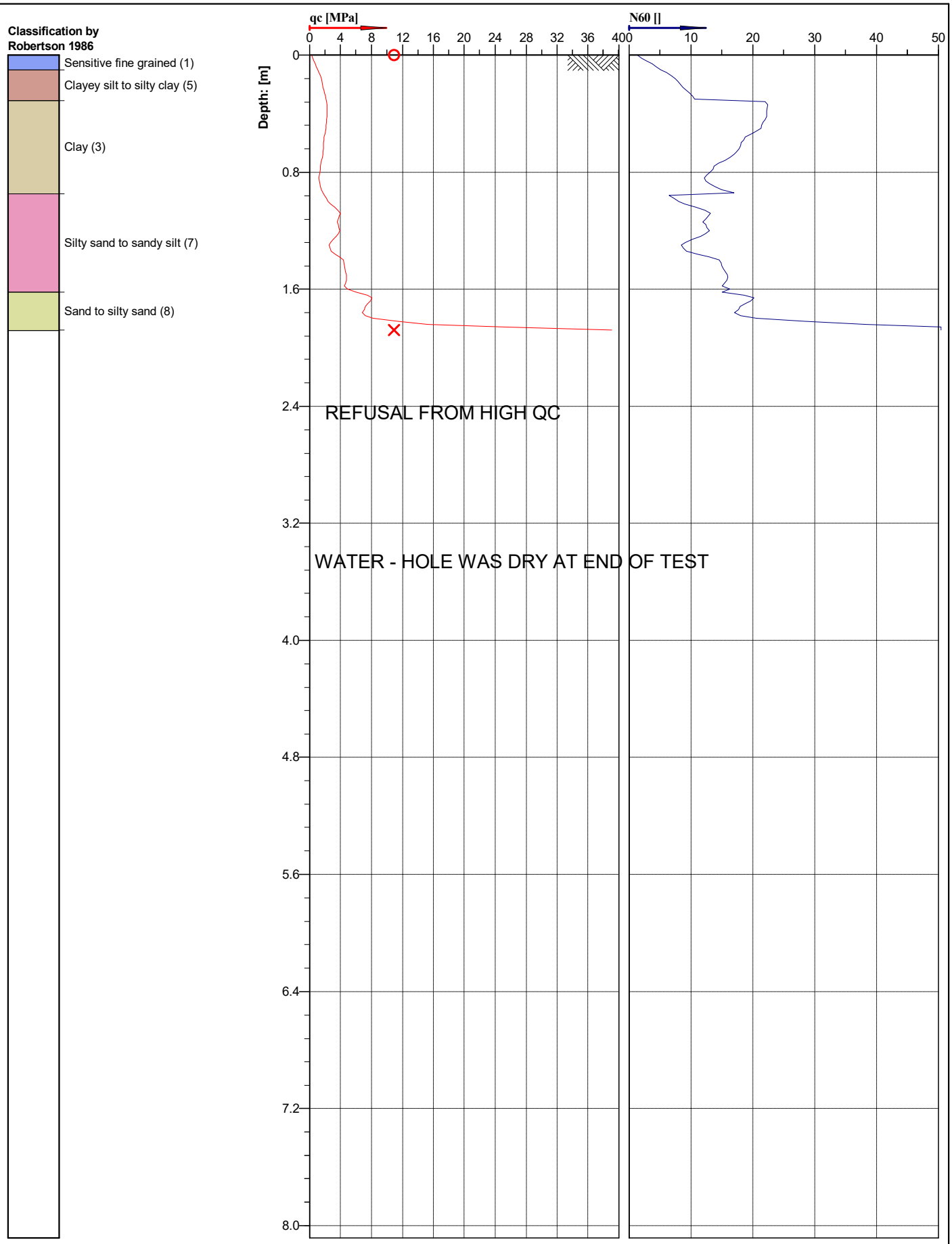


Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT12
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33668, E 175.58669		File: CPT12.cpt	

GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150



GEOTECH DRILLING

u2

Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: FLYGERS LINE, PALMERSTON NORTH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT12
Project ID:	Client: RILEYS	Date: 29/06/2018	Scale: 1 : 35
Project: FLYGERS LINE		Page: 1/1	Fig.:
S 40.33668, E 175.58669		File: CPT12.cpt	

RILEY CONSULTANTS
Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax:

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Near CPT 2 (Western Most MH)	**MH1**

Job No.:	Start Date: 16-01-19 Finish Date: 16-01-19	Ground Level (m):	Co-Ordinates ():
170672			E 175.6 N 40.3

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	15.34 m	1 of 2

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Drilling Method	Core Recovery (%)	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Air Voids (%)	Lab Testing: Density (t/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Tests/Comments	Field Testing
	0.20	Holocene Alluvial Deposits	TOPSOIL; light brown; fine rootlets.			Sonic	25 50 75			DM							
	1		SILT, trace to minor clay; mixed greyish orange. Moist, slightly plastic.							M							
	1.95		1.15 m - 1.95 m SILT, some fine sand; brown.														SPT 1.50 m 1, 1, 1, 1, 2, 2; N=6
	2		Sandy SILT; dark grey. Slightly cohesive; sand, fine to medium; slightly cohesive.							M							
	3		2.60 m - 3.45 m Fine sand with some silt; dark grey.								16/01/2019						SPT 3.00 m 1, 2, 2, 4, 6, 6; N=18
	3.70		3.45 m - 3.70 m Sandy SILT; dark grey; sand, fine.														
	3.90		SILT, minor to some clay; dark grey. Slight to moderate plasticity.							S							
	4.10		SILT; dark grey. Slightly plastic; trace organic inclusions.														SPT 4.50 m 0, 0, 0, 0, 0, 1; N=1
	4.40		Silty SAND; dark grey; sand, fine to medium.														
	4.95		SAND; dark grey; medium to fine.														
	5		Silty SAND; dark grey; slightly cohesive.														
	5.40		Clayey SILT; light bluish grey. Slight to moderate plasticity.														SPT 6.00 m 2, 2, 11, 19, 20, 0/0mm; N=50+
	5.90		SILT, minor clay, minor sand; light grey; sand, fine to medium.														
	6		SAND; dark bluish grey. Wet; sand, medium to coarse.														
	6.38		GRAVEL; rounded, well graded, fine to medium grain; <50mm diameter.														
	6.90		GRAVEL, some sand; rounded, well graded, fine to medium grain.														SPT 7.50 m 8, 10, 10, 11, 12, 17; N=50
	7		8.95 m Thin band of SILT with some clay.														
	8																
	9																
	9.45		Silty sandy GRAVEL; gravel, fine to medium grain; <70mm diameter; well graded.														SPT 9.00 m 7, 8, 11, 9, 14, 13; N=47
	10																
	11																SPT 10.50 m 11, 19, 20, 19, 11/30 mm; N=50+
	11.90																

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

- Scala Penetrometer - blows/50mm
- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Lugeon Test - Flow Type/Adopted Value
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP N
0 m
25 m
1:2,500
50 m

Remarks

All dimensions in metres Scale 1:70	Driller: Geotech Drilling	Rig Type: Sonic		Shear Vane No.:	Logged by: GJ	Checked by:

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Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax:

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Near CPT 2 (Western Most MH)	**MH1**

Job No.:	Start Date: 16-01-19 Finish Date: 16-01-19	Ground Level (m):	Co-Ordinates ():
170672			E 175.6 N 40.3

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	15.34 m	2 of 2

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Air Voids (%)	Lab Testing: Density (t/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Tests/Comments	Field Testing
	12.45	Holocene Alluvial Deposits	Clayey SILT, trace fine gravel and sand; light brownish orange. Slightly to moderately plastic. *(continued)*			Sonic											SPT 12.00 m 2, 2, 2, 3, 3, 3; N=11
	13.10		Silty SAND; light grey. Slightly cohesive; sand, fine.														
	14.00		SILT, minor clay, minor sand; light grey. Slightly plastic.														SPT 13.50 m 1, 2, 3, 4, 3, 5; N=15
	15.34		Silty sandy GRAVEL; grey; gravel, well graded, rounded <100mm diameter. 14.40 m Grades to light brown.														SPT 15.00 m 14, 14, 20, 20, 20, 10/35mm Nc=50+
			EOH @ 15.34 m														

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP N 0 m 25 m 1:2,500 50 m

Remarks

All dimensions in metres Scale 1:70	Driller: Geotech Drilling	Rig Type: Sonic		Shear Vane No.:	Logged by: GJ	Checked by: SRO

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Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax:

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Near CPT 4	**MH2**

Job No.:	Start Date: 15-01-19 Finish Date: 15-01-19	Ground Level (m):	Co-Ordinates ():
170672			E 175.6 N 40.3

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	10.64 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)
	0.20	Holocene Alluvial Deposits	TOPSOIL; light grey; slightly plastic; dry.
	1		SILT with some clay; mixed grey and orange. Dry to moist; moderately plastic.
	1.70		
	1.95		Sandy SILT; grey with trace brownish orange staining. Moist; non-plastic.
	2 2.10		Silty fine SAND; dark grey. Moist to wet.
	3		SAND with some silt; dark grey.
	3.45		Medium SAND; dark grey.
	4		
	5 5.00		SILT; dark grey. Non to slightly plastic.
	5.60		Clayey SILT; dark grey. Moderately to highly plastic.
	6 6.20		Gravelly SILT/silty GRAVEL with minor clay; dark greenish grey. Very dense; saturated. Well graded, rounded <50mm dia.
	6.50		Silty GRAVEL with minor sand. Rounded. <70mm dia.
	7		
	7.90		GRAVEL with some sand, minor silt. Well graded, rounded <50mm dia.
	8 8.30		Sandy fine GRAVEL; bluish grey. Sand, medium to coarse.
	8.45		GRAVEL with some sand and silt; greenish grey. Rounded gravel <60mm dia.
	9		
	10		
	10.64		EOH @ 10.64 m
	11		

Legend: Unified Symbol: Drilling Method: Sonic

Core Recovery (%): 25 50 75

RQD (%)

Piezometer

Soil Moisture: D, DM, M, MW, S

Groundwater: 15/01/2019

Samples

Lab Testing: Air Voids (%); Density (t/m3); Uniaxial Comp Strength (kPa); Tests/Comments

Field Testing:

- SPT 1.50 m 0, 2, 2, 1, 1, 2; N=6
- SPT 3.00 m 2, 4, 4, 4, 8, 6; N=22
- SPT 4.50 m 3, 6, 9, 9, 12, 15; N=45
- SPT 6.00 m 0, 2, 5, 13, 18, 14/70mm; N=50+
- SPT 7.50 m 9, 12, 15, 16, 7/40mm; N=50+
- SPT 9.00 m 19, 19, 16, 19, 15/65mm; N=50+
- SPT 10.50 m 22, 28/70mm; N=50+

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and
Rise Time (minutes)

MAP 0 m 25 m 1:2,500 50 m

Remarks

All dimensions in metres	Driller:	Rig Type:	Shear Vane No.:	Logged by:	Checked by:
Scale 1:70	Garry - Geotech Drilling	Sonic		GJ	SRO

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Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax:

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Near CPT 9	MH3

Job No.:	Start Date: 16-01-19 Finish Date: 16-01-19	Ground Level (m):	Co-Ordinates ():
170672			E 175.6 N 40.3

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	10.95 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Air Voids (%)	Lab Testing: Density (t/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Tests/Comments	Field Testing
	0.15	Holocene Alluvial Deposits	TOPSOIL; brown; trace fine rootlets.			Sonic				D DM							
	1		SILT, minor clay; light brown. Dry to moist, non to slightly plastic. 0.40 m Brownish orange staining. 1.20 m Grades to some Clay, moderate plasticity.														
	1.70																SPT 1.50 m 0, 0, 0, 1, 1, 1; N=3
	2		SILT, some clay, trace cemented clasts; dark grey with brown staining. Moderate plasticity.							MW							
	2.20									W							
	2.50		Clayey SILT; dark grey. Wet, moderate plasticity.							W	16/01/2019						
	2.60									W							
	3		SAND; grey; fine.														SPT 3.00 m 0, 0, 1, 1, 1, 1; N=4
	3.45																
	4		SILT, some sand; grey. Cohesive; sand, fine. 3.50 m Saturated							WS							
	4.70		Silty SAND; dark grey; sand, fine.														SPT 4.50 m 0, 1, 0, 0, 0, 0; N=0
	5		Clayey SILT; light bluish grey. Moderate to highly plastic. 5.10 m Grades to some medium Sand. 5.30 m Some gravel; rounded <50mm diameter.							WS							
	6																
	6.40		Gravel, minor sand, minor silt; well graded; fine to medium, rounded <60mm diameter; gravel, fine to medium.							WS							SPT 6.00 m 9, 15, 14, 15, 16, 5/15mm; N=50+
	7																
	8																SPT 7.50 m 10, 16, 16, 18, 16/50 mm; N=50+
	8.40		SAND; dark grey. Dense; sand, fine to coarse.							WS							
	9		8.90 m Grades to some fine Gravel.														
	9.40		Clayey SILT; bluish grey with brown staining. Highly plastic.							WS							SPT 9.00 m 8, 16, 12, 15, 16, 7/30mm; N=50+
	10		10.40 m Grades to some fine Sand.														
	10.95																SPT 10.50 m 2, 3, 2, 3, 4, 6; N=15
	11		EOH @ 10.95 m														

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and
Rise Time (minutes)

MAP 0 m 25 m 1:2,500 50 m

Remarks

All dimensions in metres Scale 1:70	Driller: Geotech Drilling	Rig Type: Sonic		Shear Vane No.:	Logged by: GJ	Checked by: SDO

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RILEY CONSULTANTS Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Northwestern corner of site	**HA1**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	28-06-18 / 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
		Holocene Alluvial Deposits	TOPSOIL; Silt; grey; roots; NVO.						D	1	
	0.35		SILT, some clay; light grey and orange. Wet, moderately plastic; NVO.						W	2	
	0.80		SILT, minor clay; light grey and orange mixed. Wet, slightly plastic.						W		
	0.90		Silty SAND; grey. Saturated, non plastic; NVO.					▼	S	3	
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- [ ] None
- [X] Slow Seep (depth 0.9 m)
- [ ] Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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RILEY CONSULTANTS Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Near western boundary	**HA2**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	28-06-18 / 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
		TOPSOIL; Silt; grey. Moist, non plastic; NVO.					D	4	
0.35	Holocene Alluvial Deposits	SILT, trace to minor clay; grey with orange staining. Moist to wet, slightly plastic; NVO.					MW	5	
0.50		SILT with minor clay; greyish orange. Moist to wet, slightly plastic; NVO.					MW		
0.80		SILT with trace fine sand; greyish orange. Wet, non plastic; NVO.					W		
0.95		Silty SAND; grey. Saturated, non plastic; NVO.					S	6	
1.00		EOH @ 1.00 m							

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- None
- Slow Seep (depth)
- Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Southwestern portion of site	**HA3**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	28-06-18 / 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey. Silt, rootlets. Moist, non plastic; NVO.						M	7	
	0.30	Holocene Alluvial Deposits	SILT, trace clay; light grey and orange mixed. Moist, slightly plastic; NVO.						M	8	
			0.70 m Wet.								
	0.90		Silty SAND; grey. Saturated; NVO.						S	9	
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

RILEY CONSULTANTS Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central portion of site	**HA4**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	28-06-18 / 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; light grey. Moist; NVO.						M		
	0.25	Holocene Alluvial Deposits	SILT, trace clay; light grey with orange staining. Moist, non to slightly plastic; NVO.						M		
	0.60		SILT, minor clay, minor sand; light grey and orange. Moist, slightly plastic; NVO.						M		
	0.90		SILT, minor fine sand, trace clay; grey. Wet, non to slightly plastic; NVO.						W		
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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RILEY CONSULTANTS Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central portion of site	HA5

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	28-06-18 / 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey, roots. Moist; NVO.						M		
	0.30	Holocene Alluvial Deposits	SILT, minor clay, trace sand; light grey with orange staining. Moist, slightly plastic; NVO.						M		
			0.90 m Grades to mixed grey and brown; wet.								
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- None
- Slow Seep (depth)
- Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central site near Flygers Line	HA7

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Unified Symbol	Soil Moisture
0.25	Holocene Alluvial Deposits	TOPSOIL; silt; grey. Moist, non plastic; NVO.		M
0.50		SILT, trace clay, trace sand; grey. Moist, non plastic; NVO.		M
1.00		SILT, minor clay; light greyish orange. Moist to wet, slightly plastic; NVO.		MW
1		EOH @ 1.00 m		

Soil Shear Strength (kPa): 50 100 150 200
Scala Penetrometer (blows / 50 mm): 3 6 9 12 15
Groundwater
Samples
Tests

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- None
- Slow Seep (depth)
- Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central site	**HA8**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
		TOPSOIL; grey. Moist; NVO.						M	10	
0.25	Holocene Alluvial Deposits	SILT, minor clay; light grey with light orange. Moist, slightly plastic; NVO.						M	11	
0.60		SILT, minor to some clay; greyish orange mixed. Moist to wet, slightly plastic.						MW		
0.85		SILT, minor sand, trace clay; light greyish orange. Wet; NVO.						W	12	
1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Southern portion of site	**HA9**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
0.25	Holocene Alluvial Deposits	TOPSOIL; grey. Moist, non plastic. NVO.						M	13	
0.70		SILT, trace sand; light grey with orange staining. Moist, non plastic; NVO.						M	14	
1.00		Silty SAND; grey. Saturated, non plastic; NVO.					▼	S	15	
		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- [ ] None
- [X] Slow Seep (depth 0.8 m)
- [ ] Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Northern corner of site	**HA10**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey. Moist, non plastic; NVO.						M		
	0.20										
		Holocene Alluvial Deposits	SILT, trace clay; Moist, slightly plastic; NVO.						M		
	0.60										
			SILT, minor clay, trace grit; grey and brownish orange mix. Moist, moderately plastic; NVO.						M		
	1.00										
	1		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

RILEYAKL.GLB Log RILEY HA (AKL) NO MAP 170672 - MACHINE HOLE LOGS.GPJ <<DrawingFile>> 22/02/2019 12:44 Produced by gINT Professional

Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central northeastern boundary	**HA11**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
		TOPSOIL; grey. Moist, non plastic.						M		
0.25										
	Holocene Alluvial Deposits	SILT, trace clay; light grey and orange. Moist, slightly plastic; NVO.						M		
0.70										
		SILT, some clay; greyish orange mixed. Moist to wet, moderately plastic; NVO.						MW		
1.00										
		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

RILEYAKL.GLB Log RILEY HA (AKL) NO MAP 170672 - MACHINE HOLE LOGS.GPJ <<DrawingFile>> 22/02/2019 12:44 Produced by gINT Professional

Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Eastern portion of site near sheds	HA12

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; dark grey. Moist, non plastic; NVO.						M		
	0.20										
		Holocene Alluvial Deposits	SILT, trace clay, trace sand; light grey. Moist, non plastic; NVO.						M		
	0.50										
			Sandy SILT; light grey. Wet, non plastic; NVO.						W		
	0.90										
			SILT, some clay; light grey. Saturated, moderately plastic; NVO.						S		
	1.00										
	1		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO:
Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

RILEYAKL.GLB Log RILEY HA (AKL) NO MAP 170672 - MACHINE HOLE LOGS.GPJ <<DrawingFile>> 22/02/2019 12:44 Produced by gINT Professional

RILEY CONSULTANTS Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central northern portion of site	**HA13**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey. Moist; NVO.						M	16	
	0.30	Holocene Alluvial Deposits	SILT, minor clay, trace sand; grey and orange mixed. Moist, slightly plastic; NVO.						M	17	
			0.80 m Grades to minor to some clay, trace grit; grey brownish orange mixed. Moist, slightly plastic; NVO.							18	
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central site	**HA14**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; NVO.							19	
	0.20								M		
		Holocene Alluvial Deposits	SILT, trace clay; light grey and orange. Moist, non plastic; NVO.							20	
	0.90								WS		
	1.00		Silty SAND; brownish orange grey. Wet to saturated; NVO.							21	
	1		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

APPENDIX B

Laboratory Test Results

PLASTICITY INDEX TEST REPORT

WSP OPUS

Project:	**Rangitikie Line**
Location:	**Rangitikie Line**
Client:	**Riley Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Not Stated**
Sampling method:	**Not Stated**
Sample description:	**Brownish Grey; silty CLAY**
Sample condition:	**As Received**
Sample reference:	**MH3**
Sample depth:	**2.1m**

Date sampled: **Not Stated**

Project number:	**1-LA014.00**
Lab ref number:	**AL3490/1**
Client ref number:	**170672**
Folder number:	**-**

Test Results

As rec'd water content:	**45.0%**
Liquid limit:	**69**
Plastic limit:	**27**
Plasticity Index:	**42**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	Sample descriptions are not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 05/02/19
Date reported: 08/02/2019

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
This report may only be reproduced in full

IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 08/02/2019

IANZ ACCREDITED LABORATORY
Tests indicated as not accredited are outside the scope of the laboratory's accreditation

WSP Opus
Auckland Laboratory
Quality Management Systems Certified to ISO 9001

7A Ride Way, Albany
Private Bag 101982, NS Mail Centre, North Shore City 0745, New Zealand

Telephone +64 9 415 4660
Website www.wsp-opus.co.nz

APPENDIX C

Liquefaction Outputs

TABLE OF CONTENTS

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

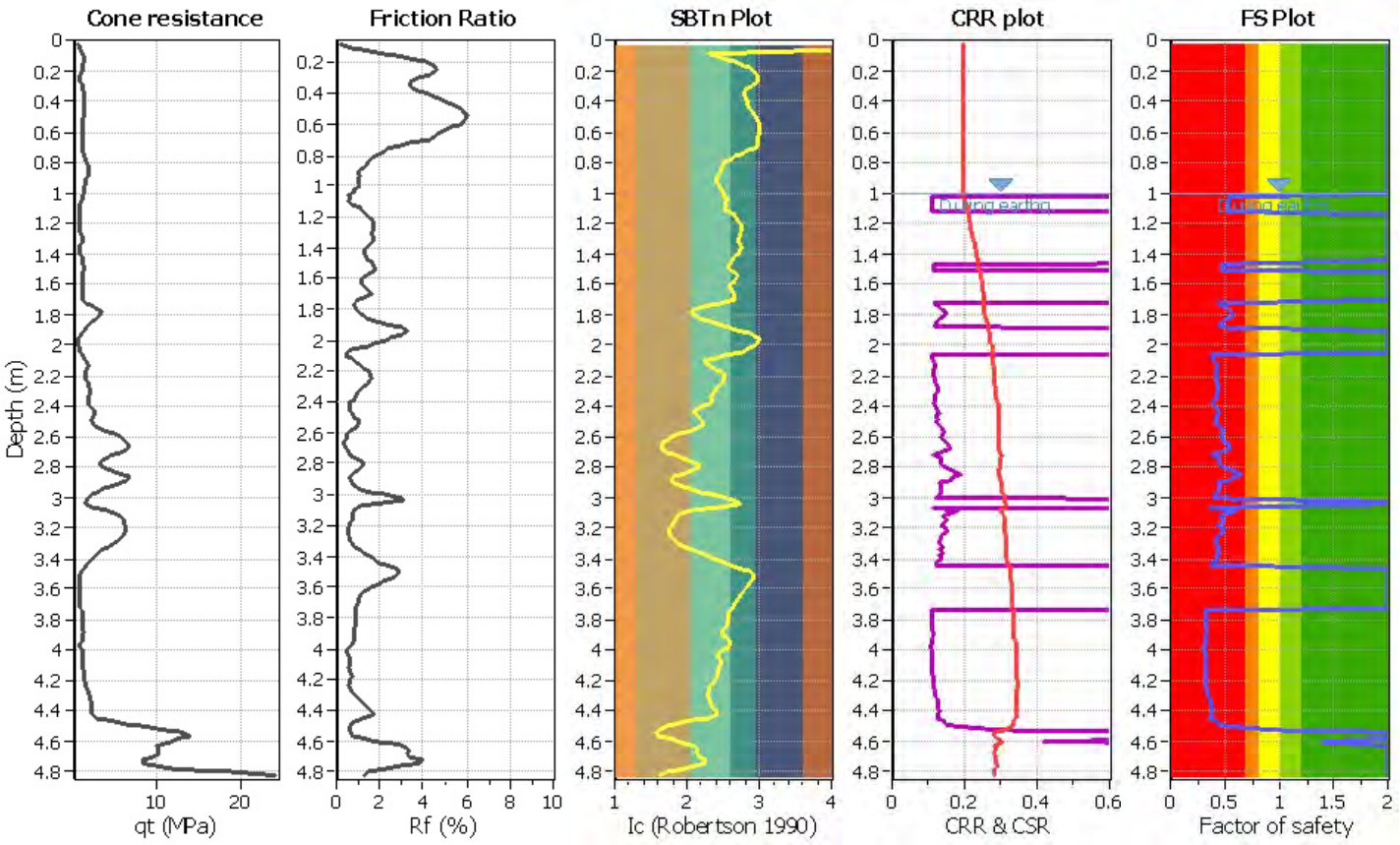
LIQUEFACTION ANALYSIS REPORT

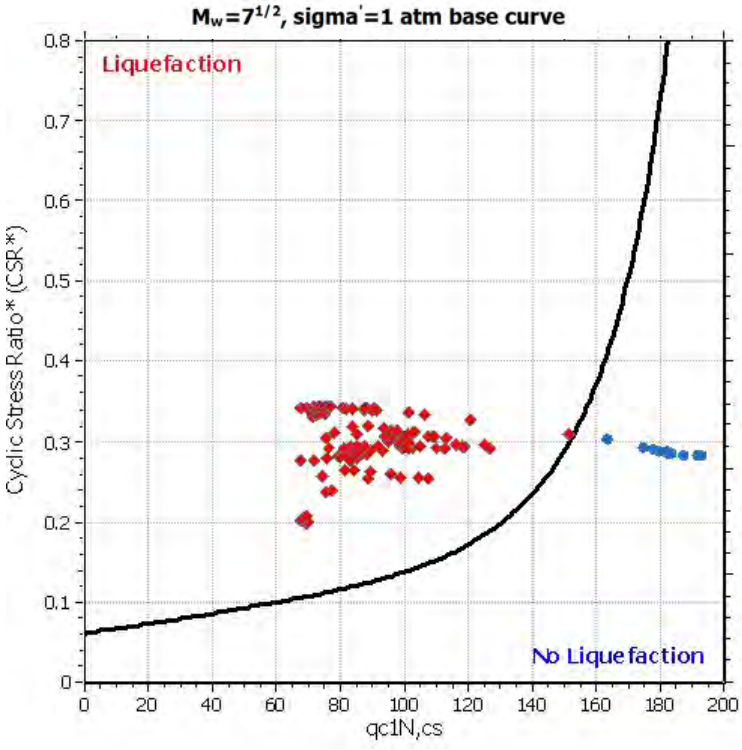
Project title : 170672 **Location : Flygers Line**

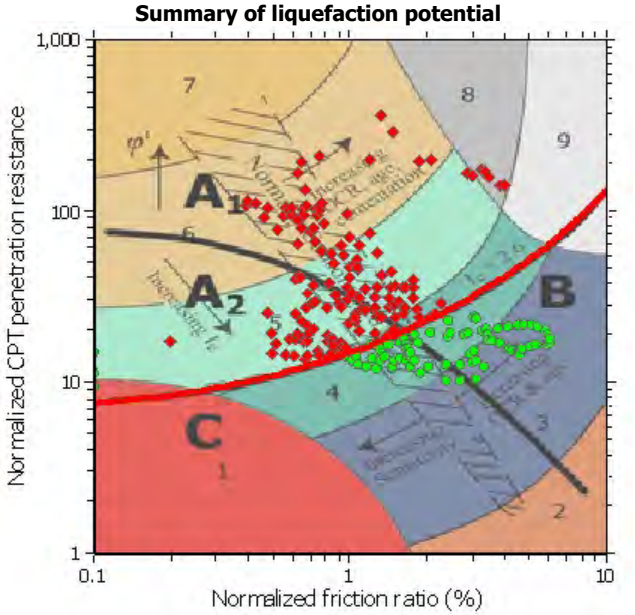
CPT file : CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

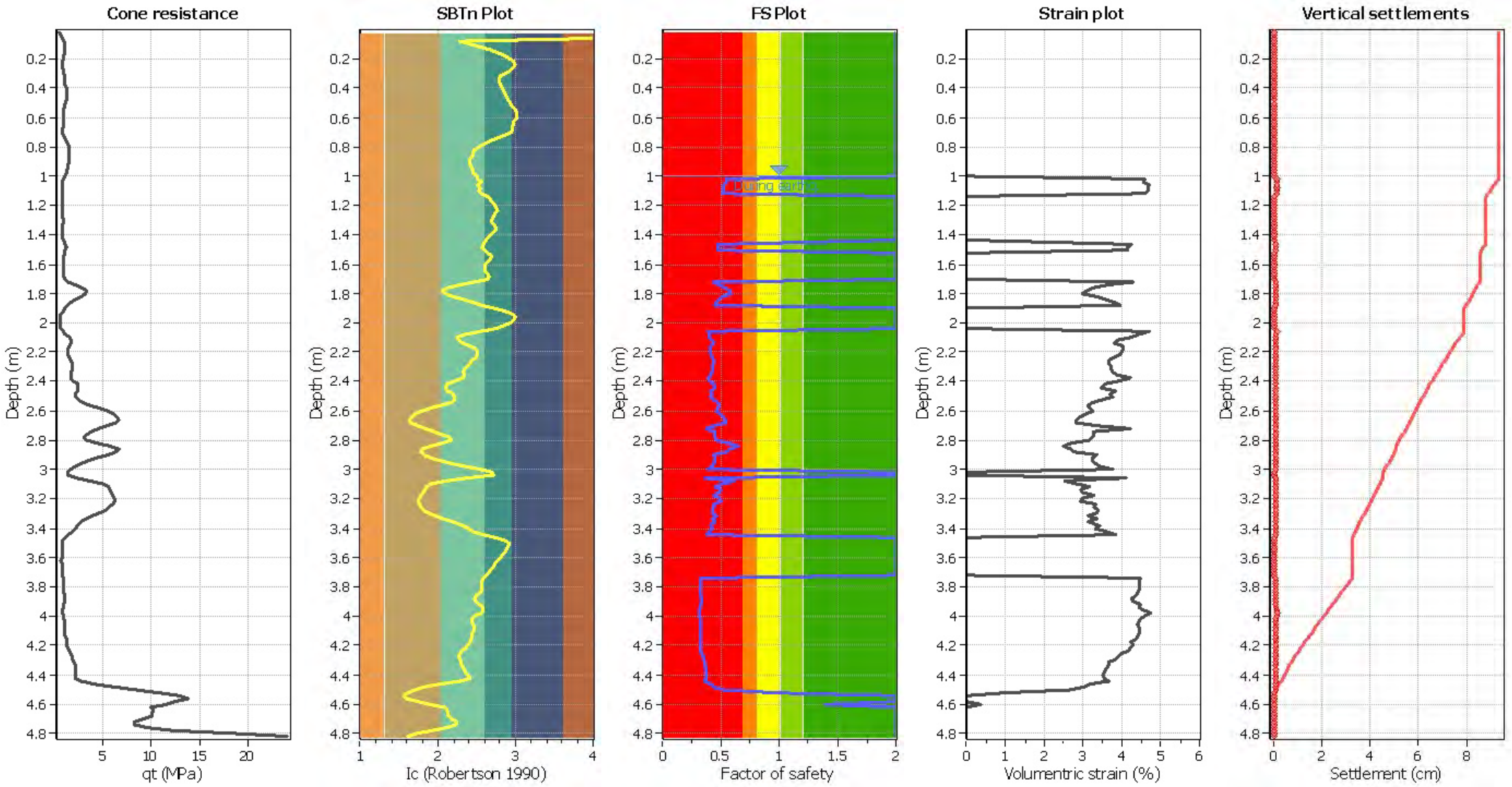






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

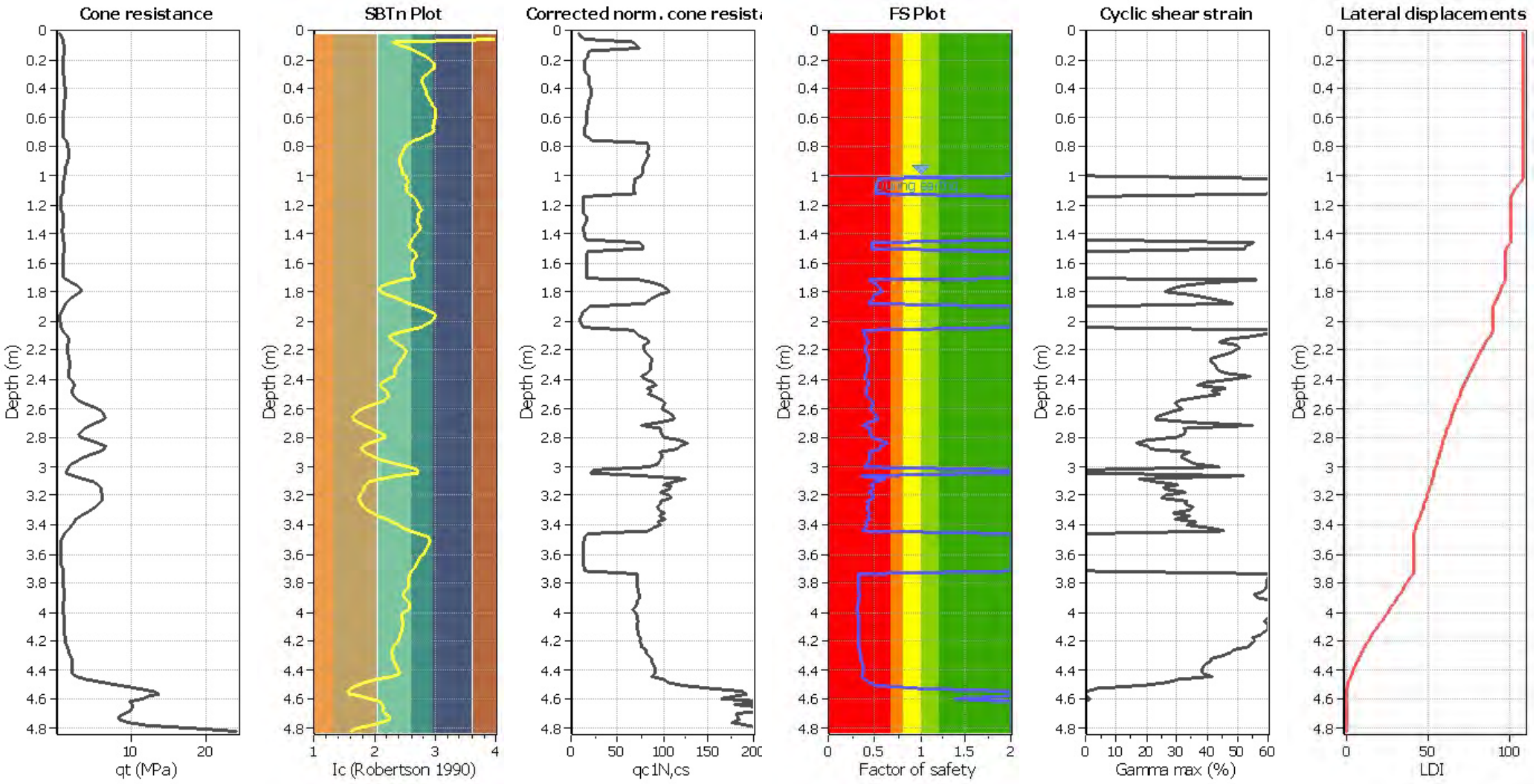
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

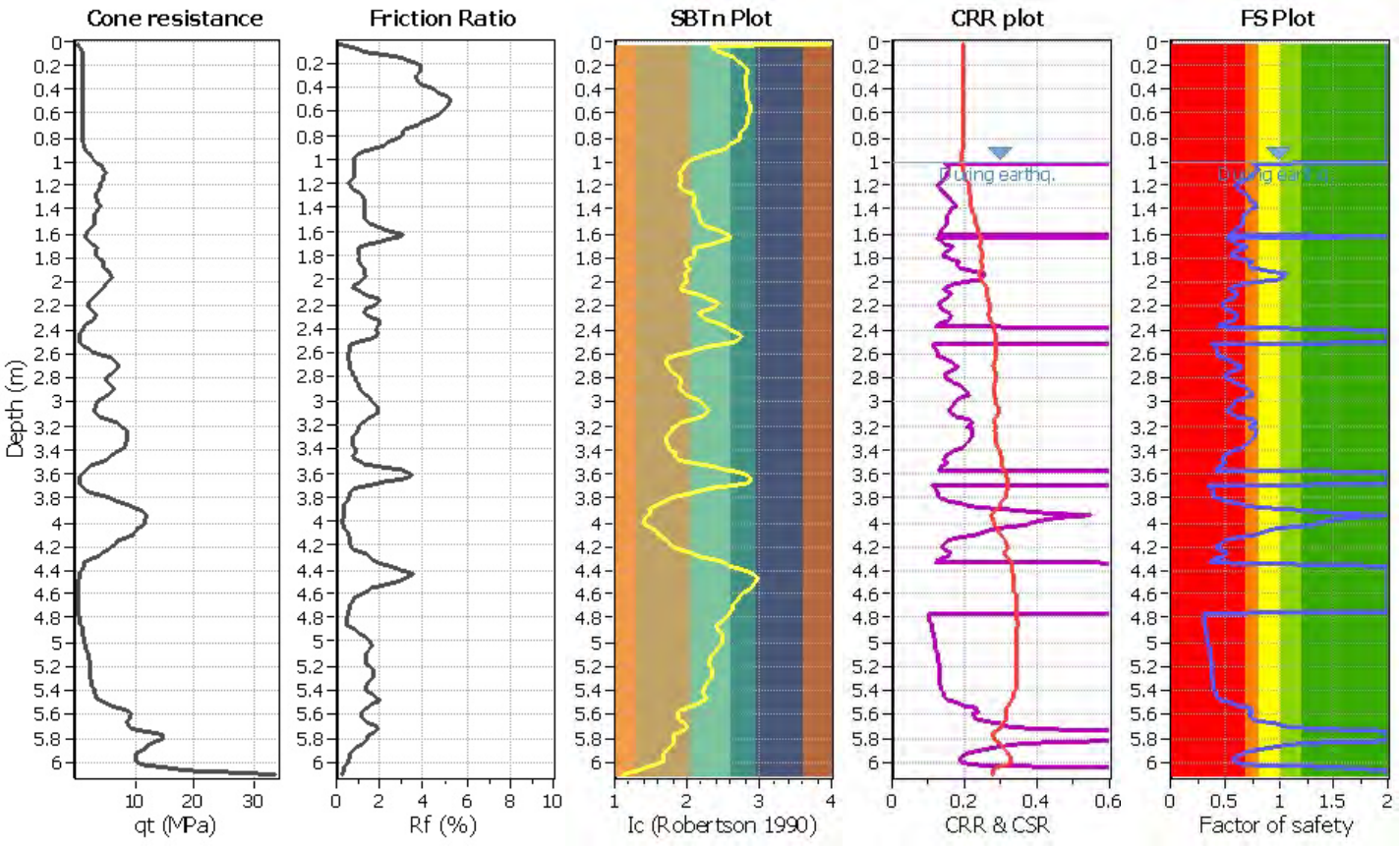
LIQUEFACTION ANALYSIS REPORT

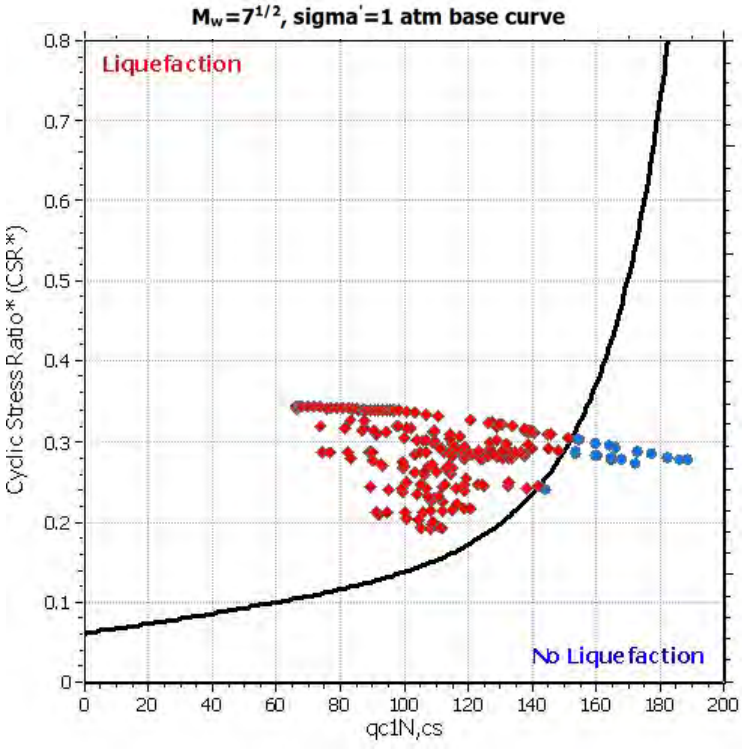
Project title : 170672 **Location : Flygers Line**

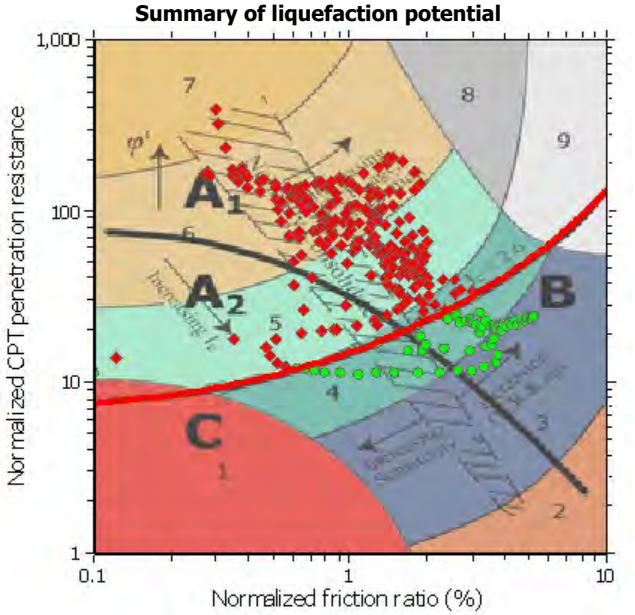
CPT file : CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

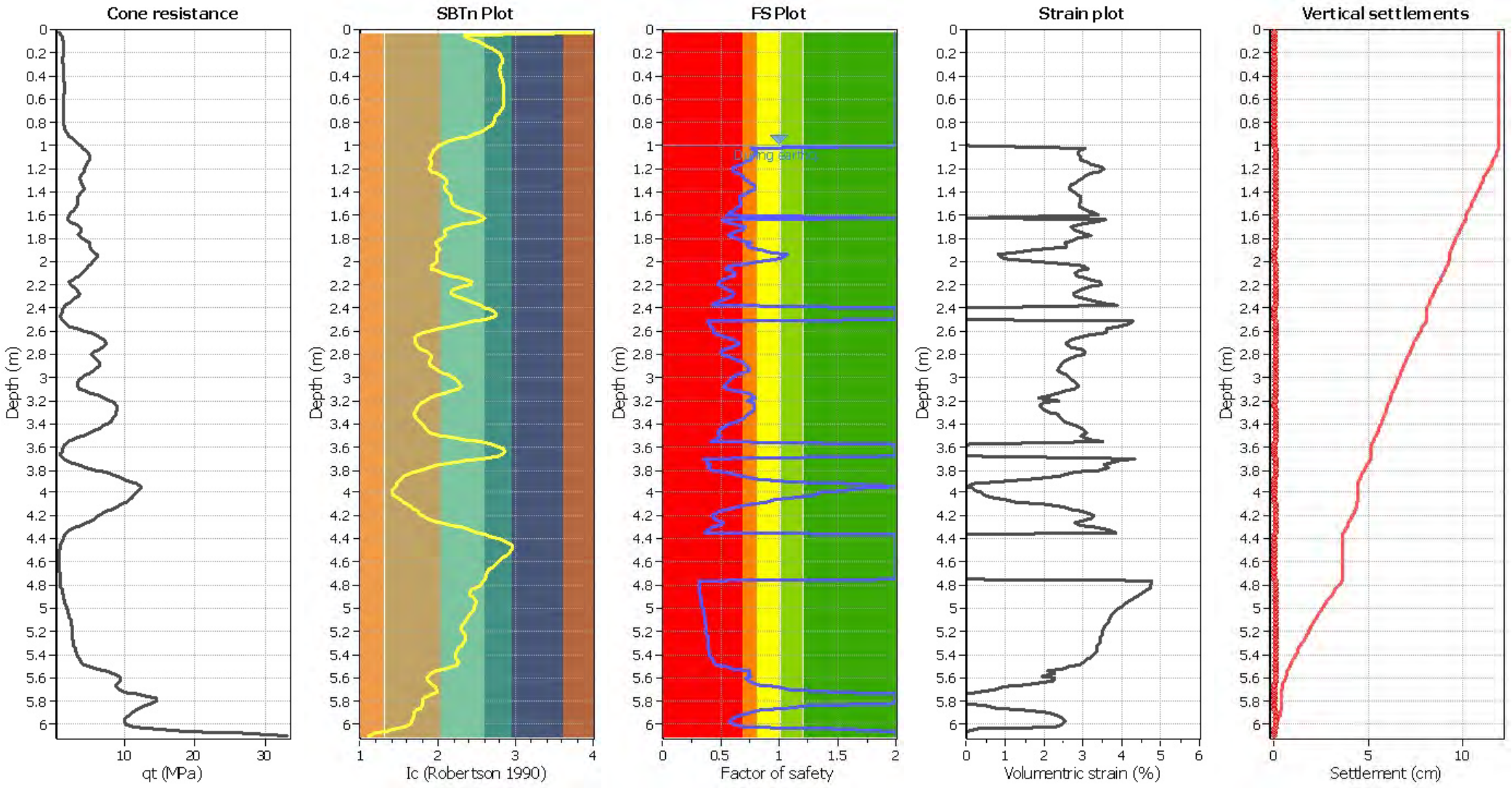






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

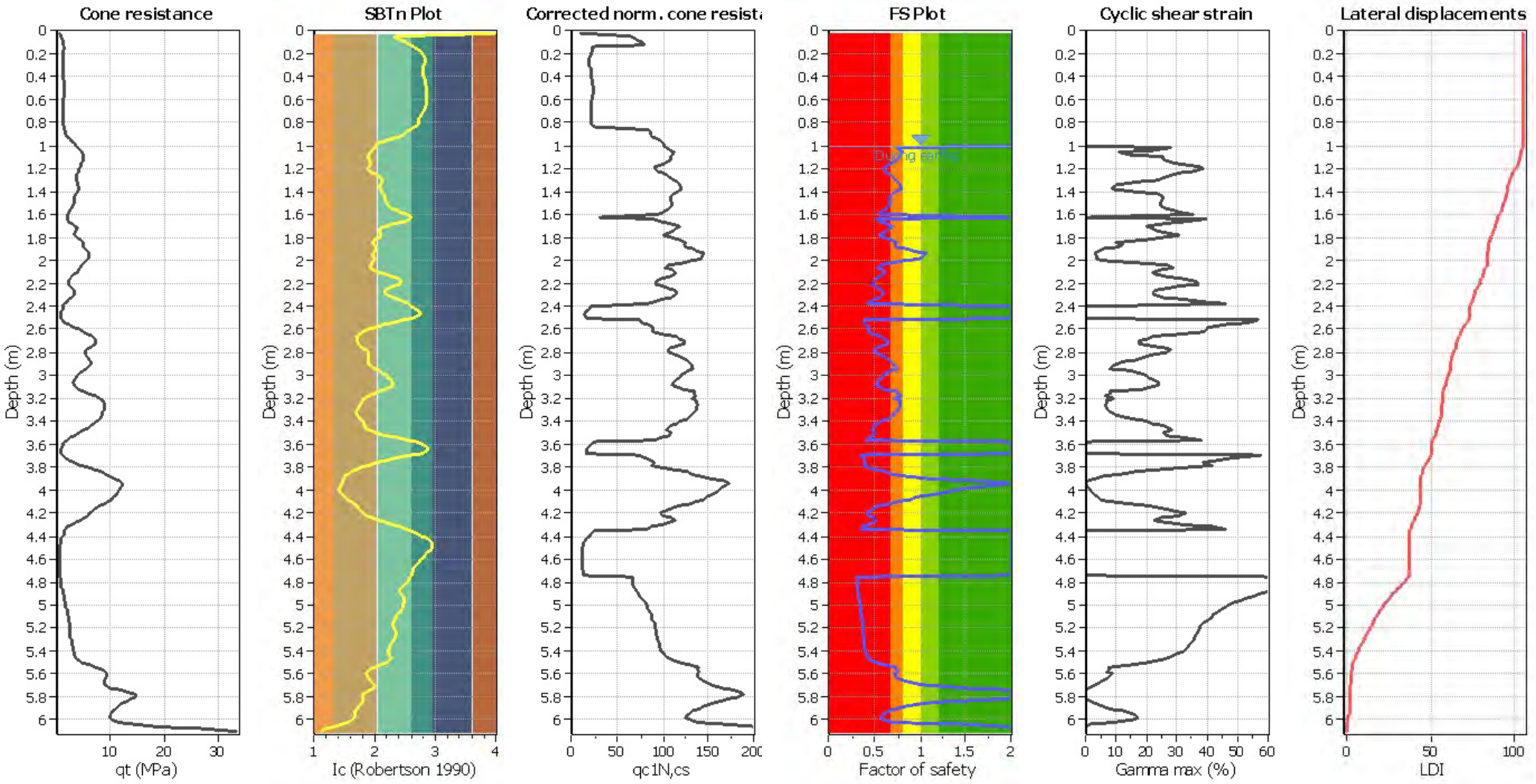
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

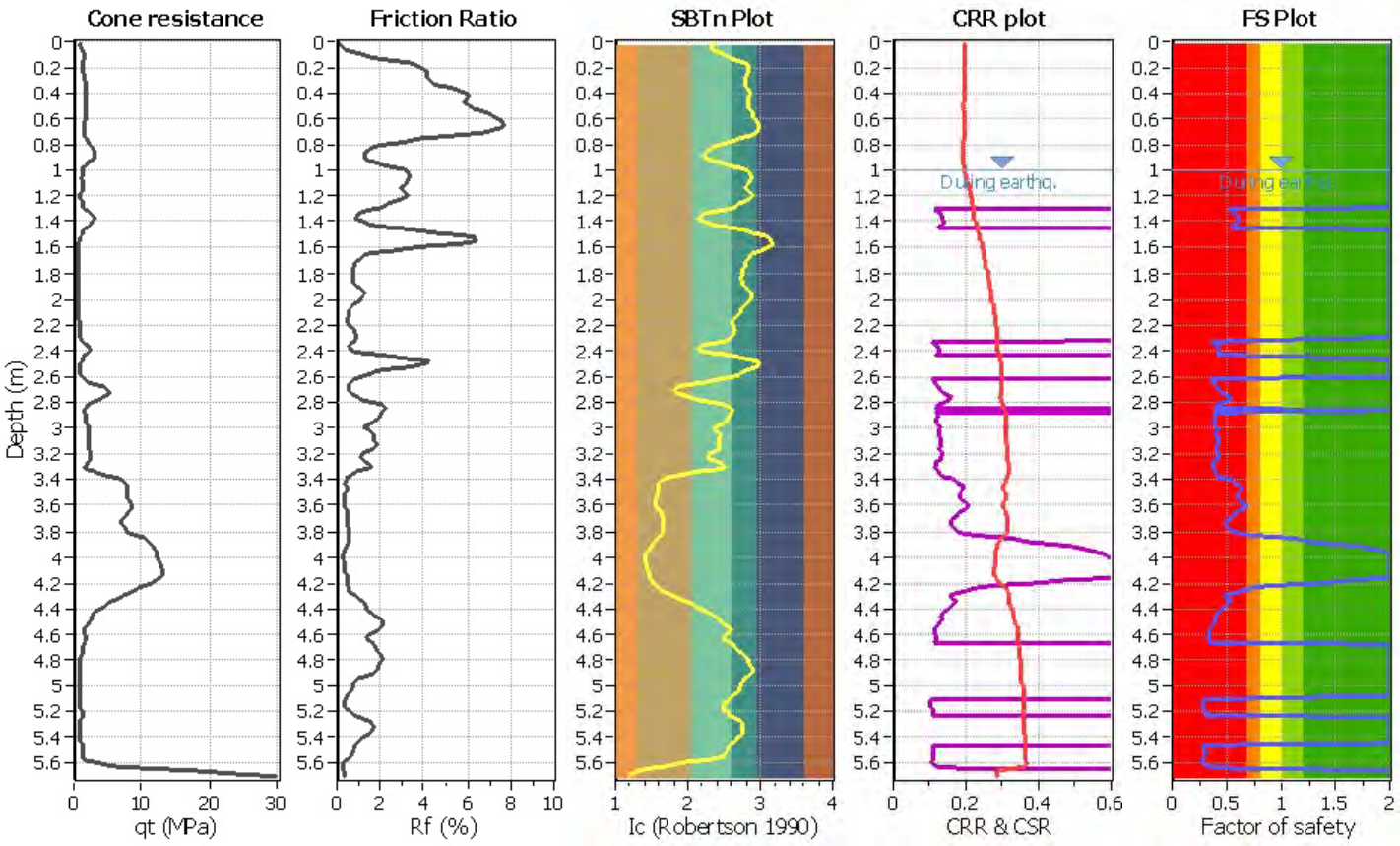
LIQUEFACTION ANALYSIS REPORT

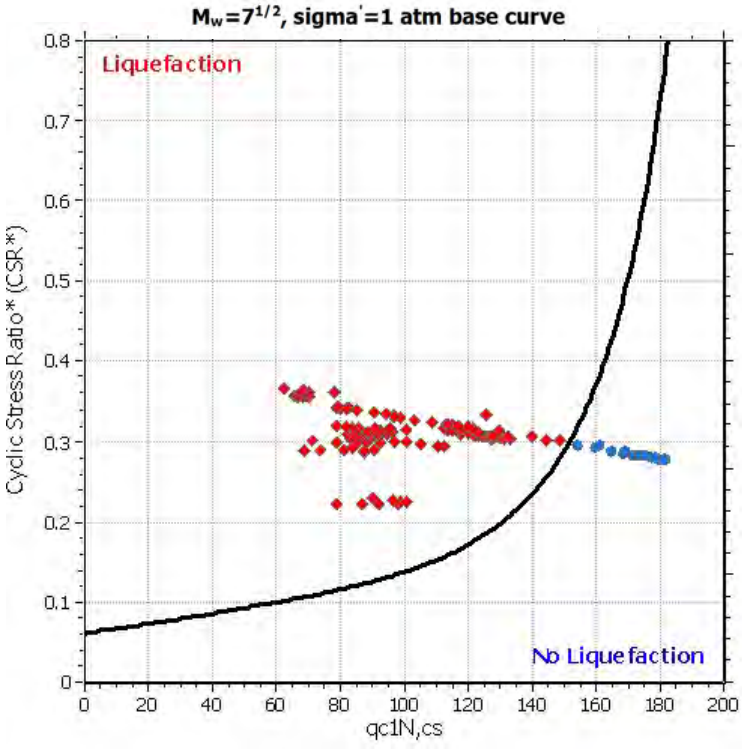
Project title : 170672 **Location : Flygers Line**

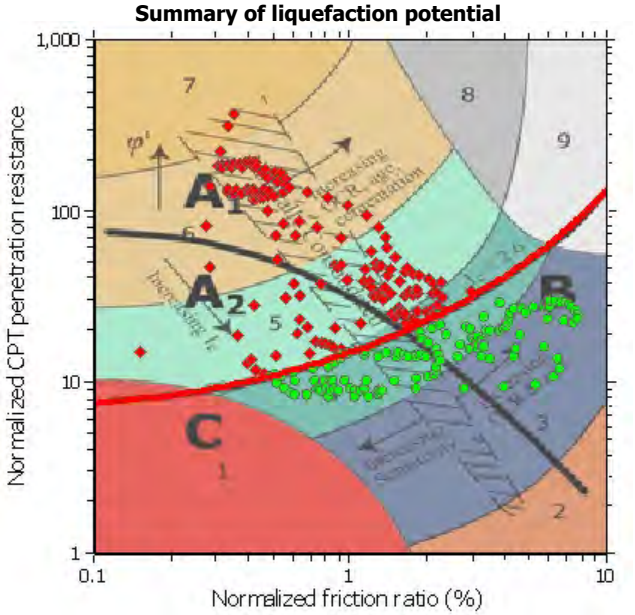
CPT file : CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

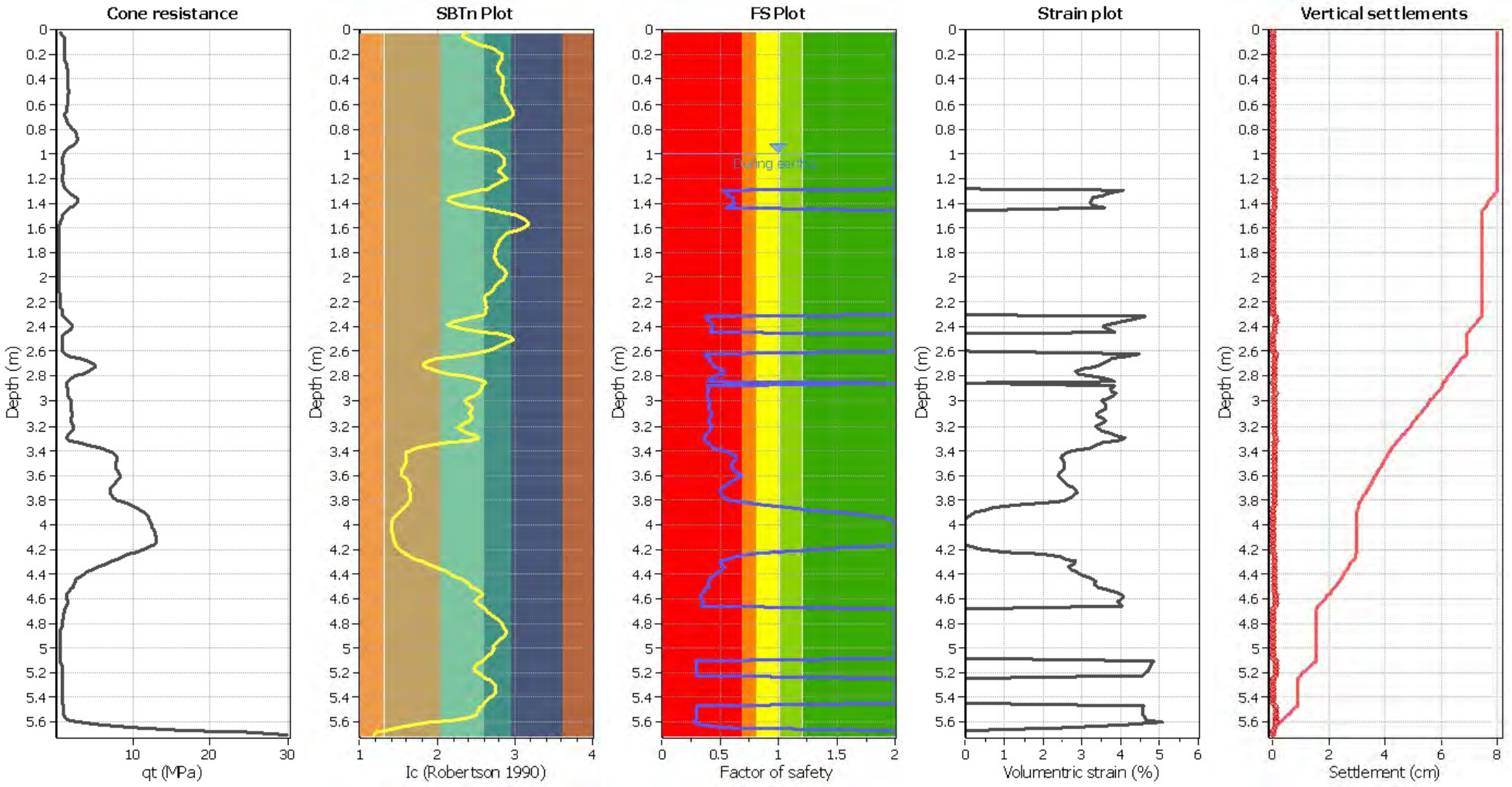






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

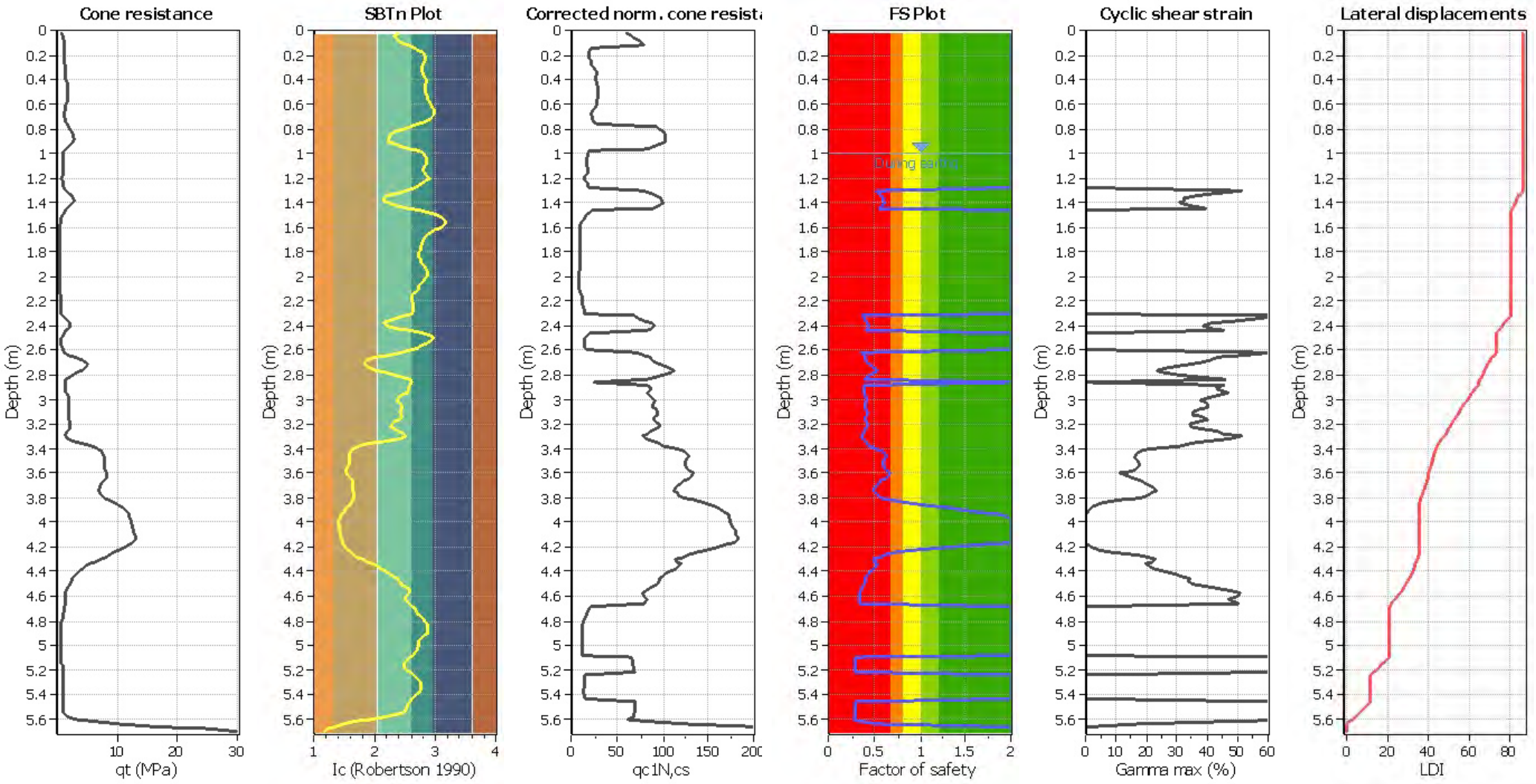
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

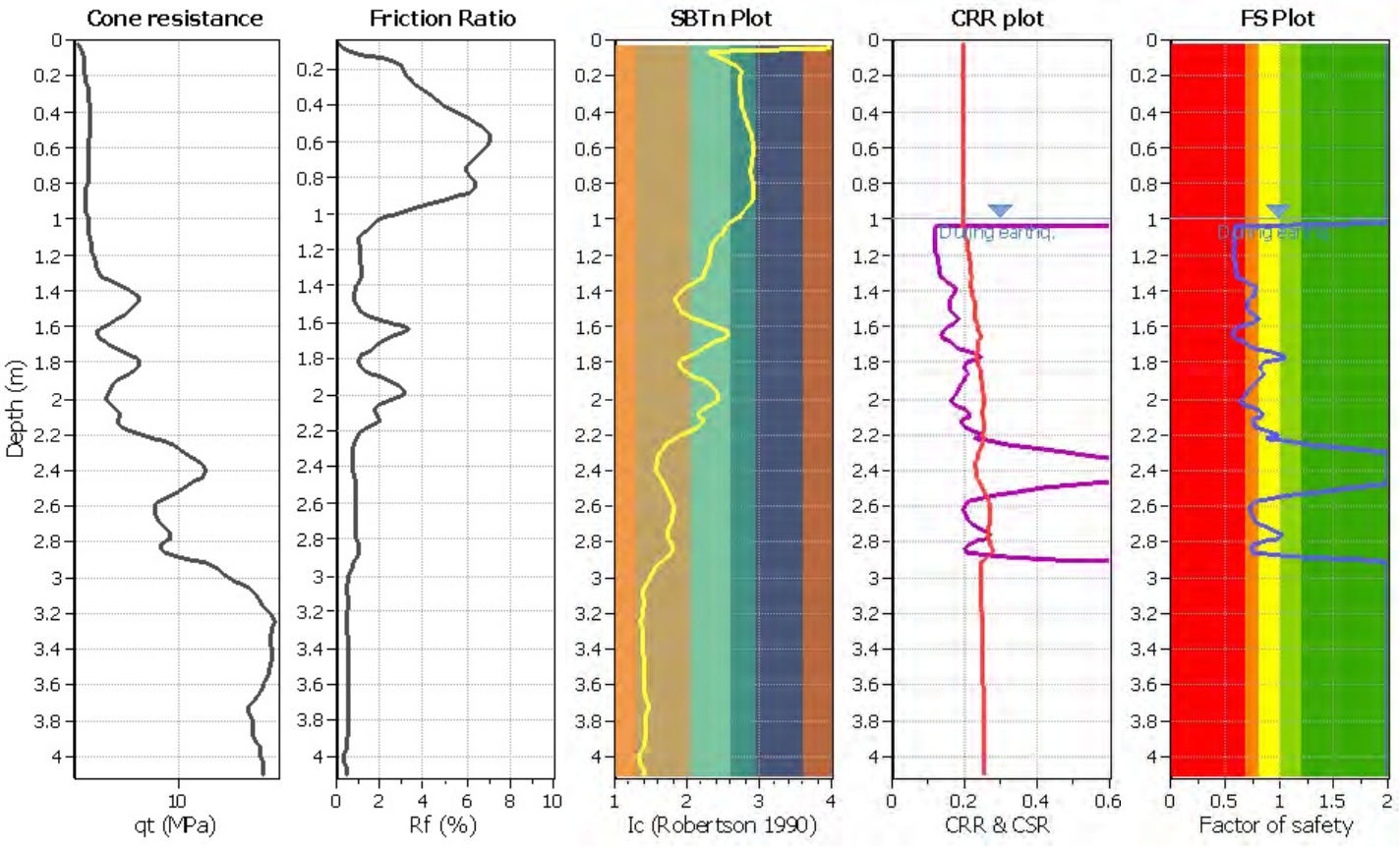
LIQUEFACTION ANALYSIS REPORT

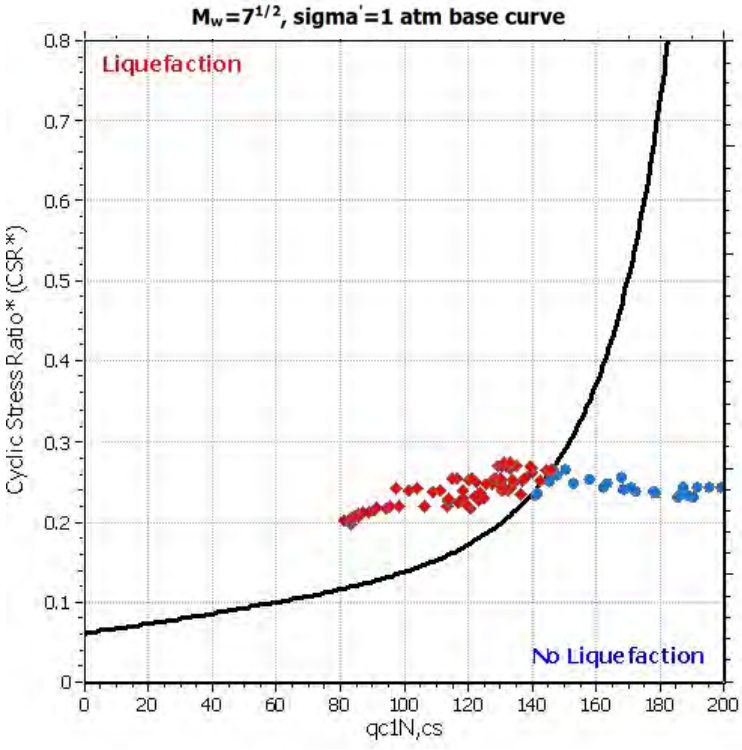
Project title : 170672 **Location : Flygers Line**

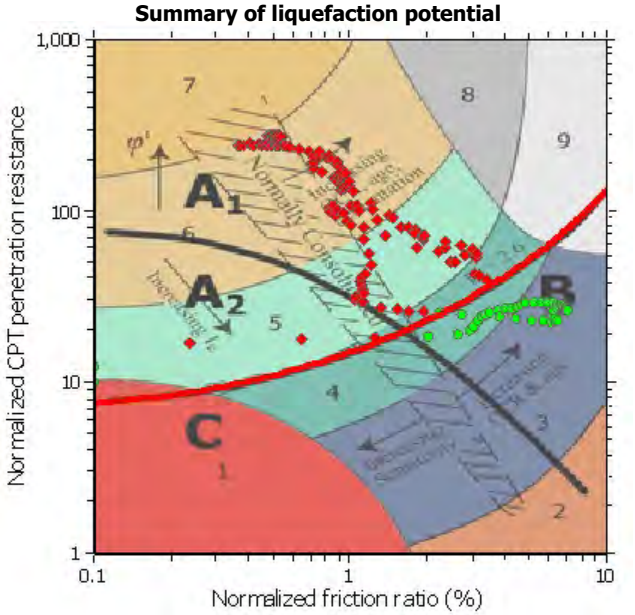
CPT file : CPT04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

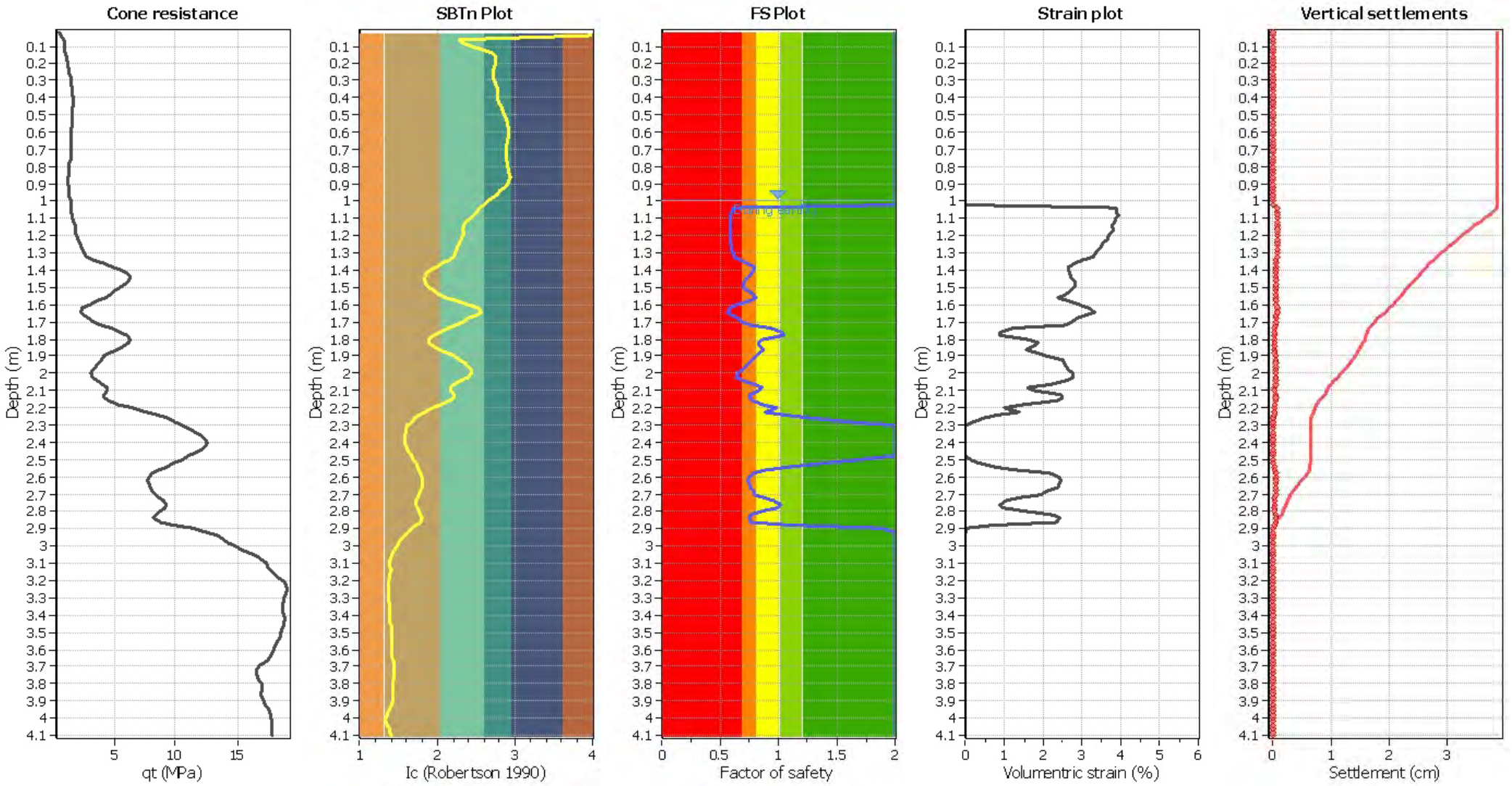






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

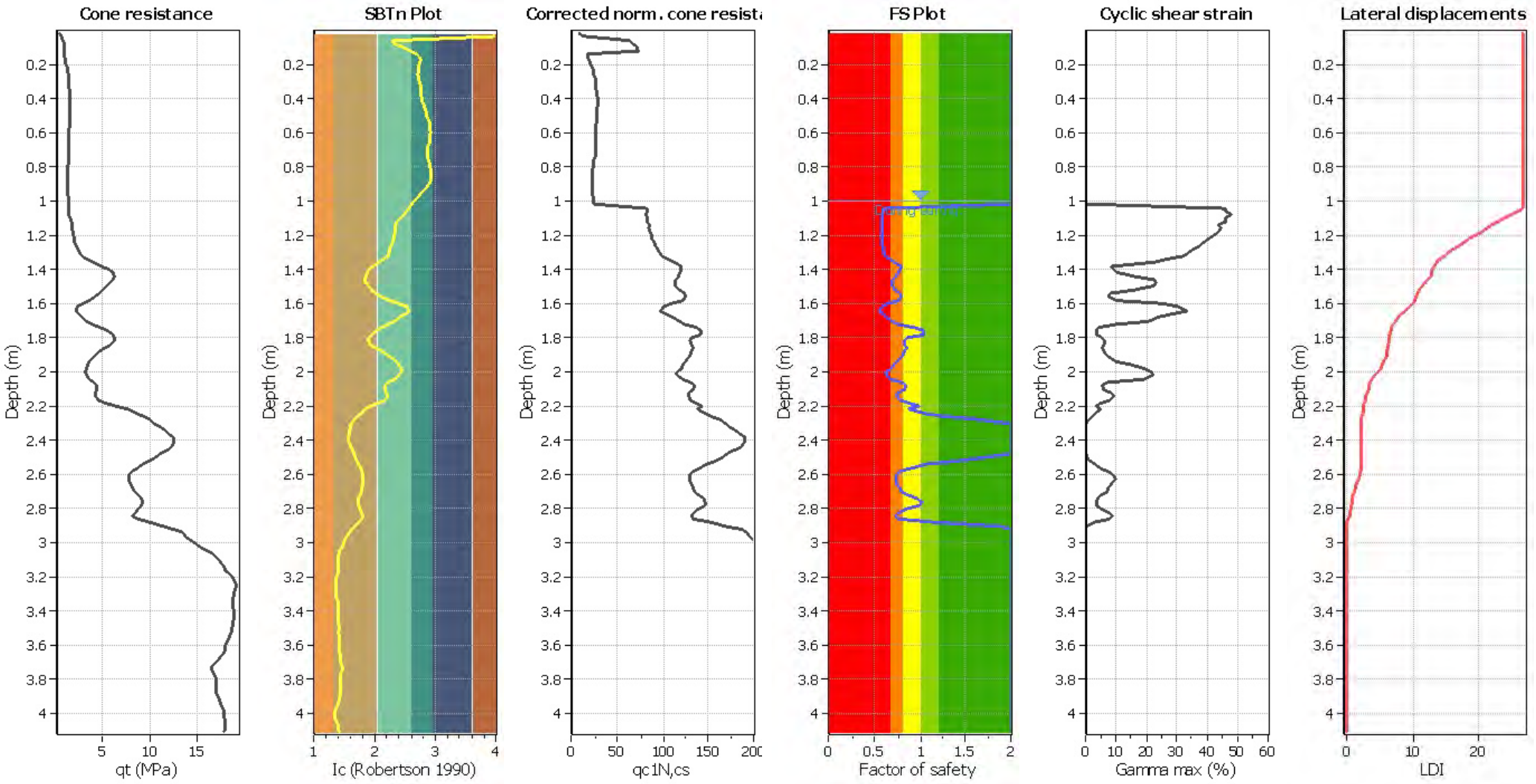
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

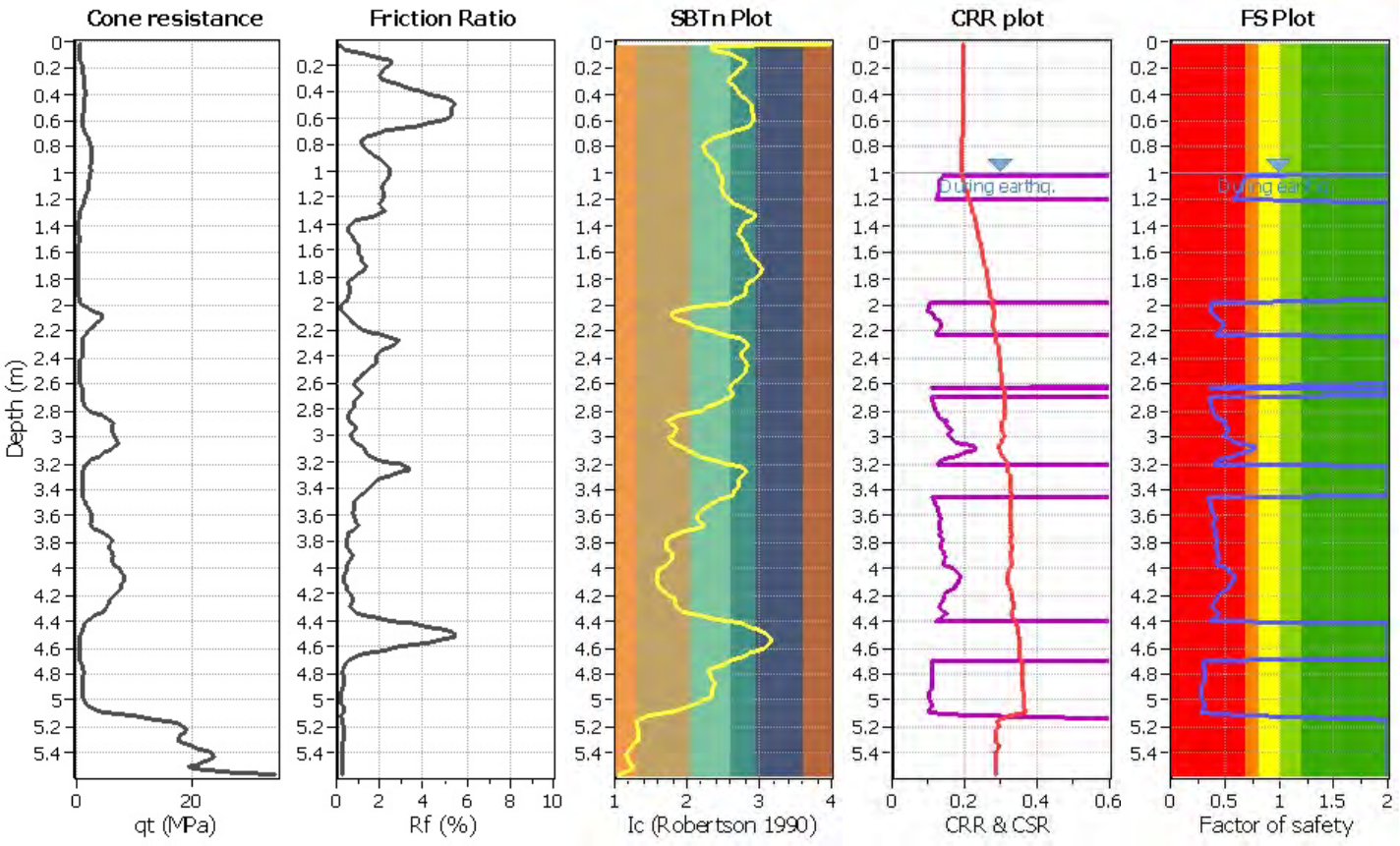
LIQUEFACTION ANALYSIS REPORT

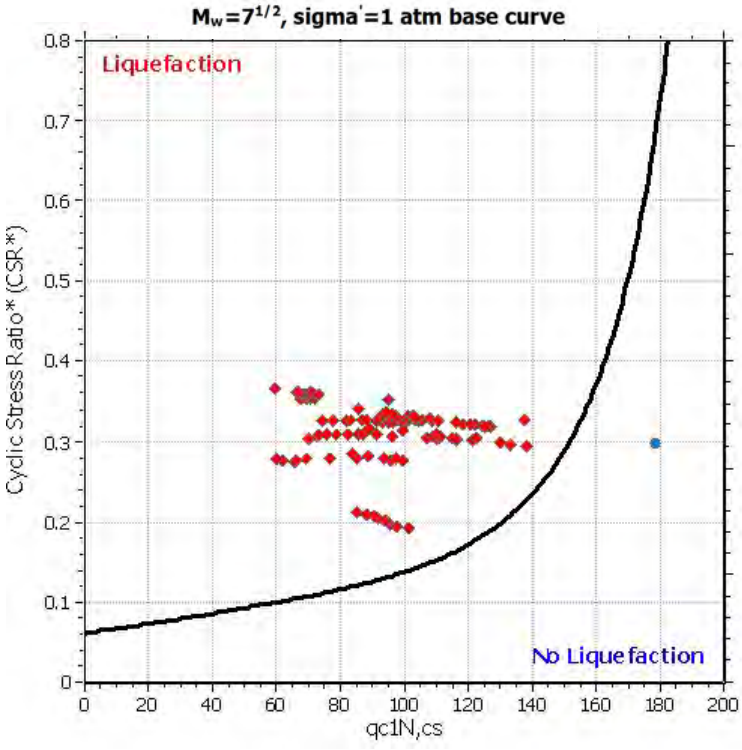
Project title : 170672 **Location : Flygers Line**

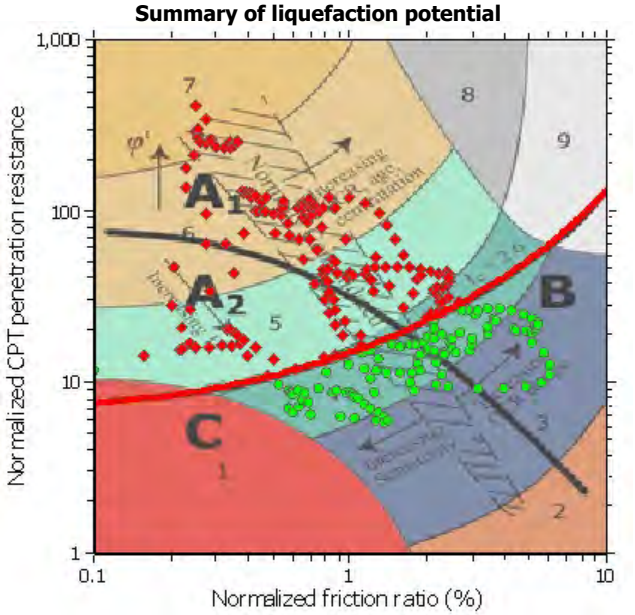
CPT file : CPT05

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

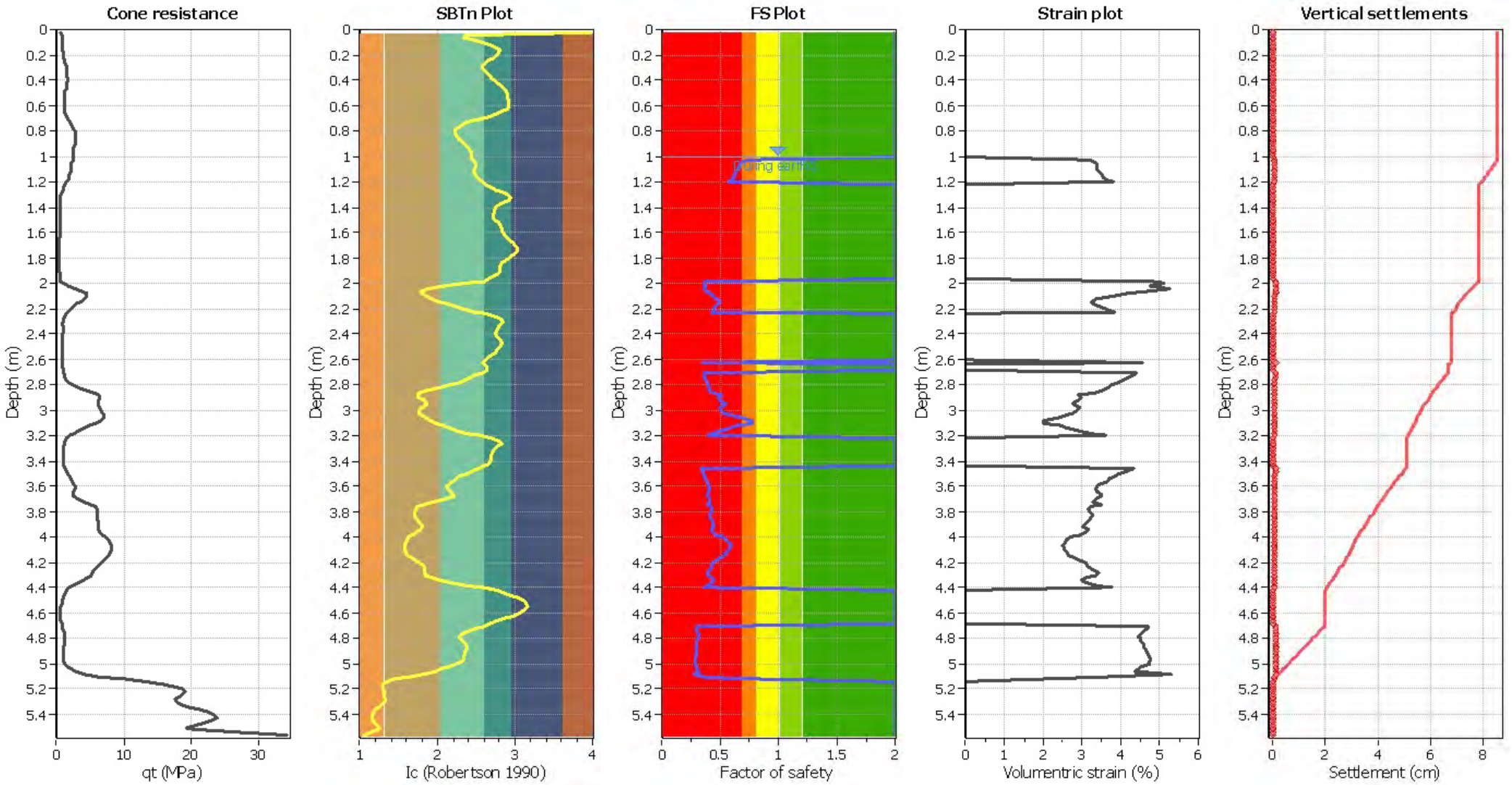






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

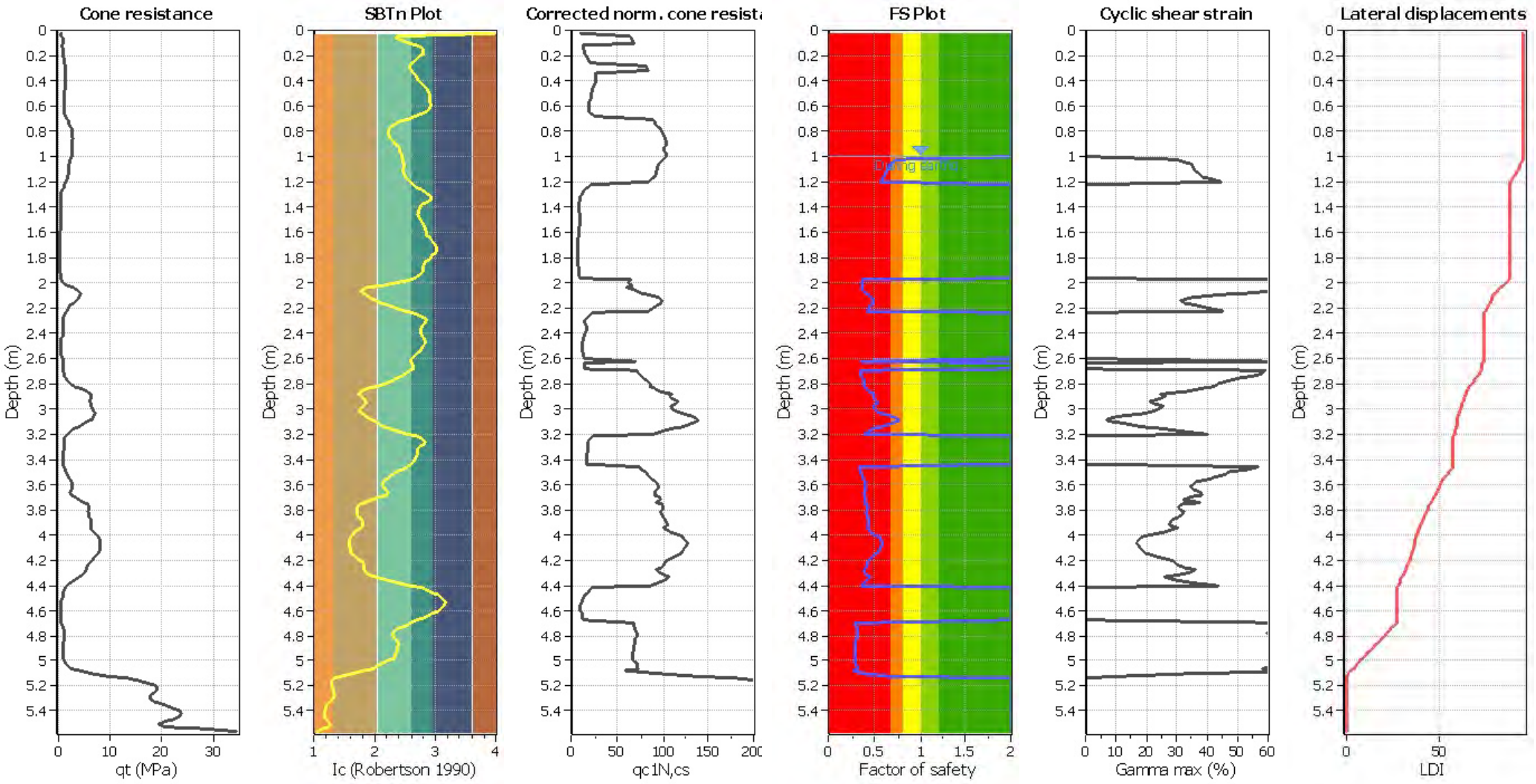
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
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$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

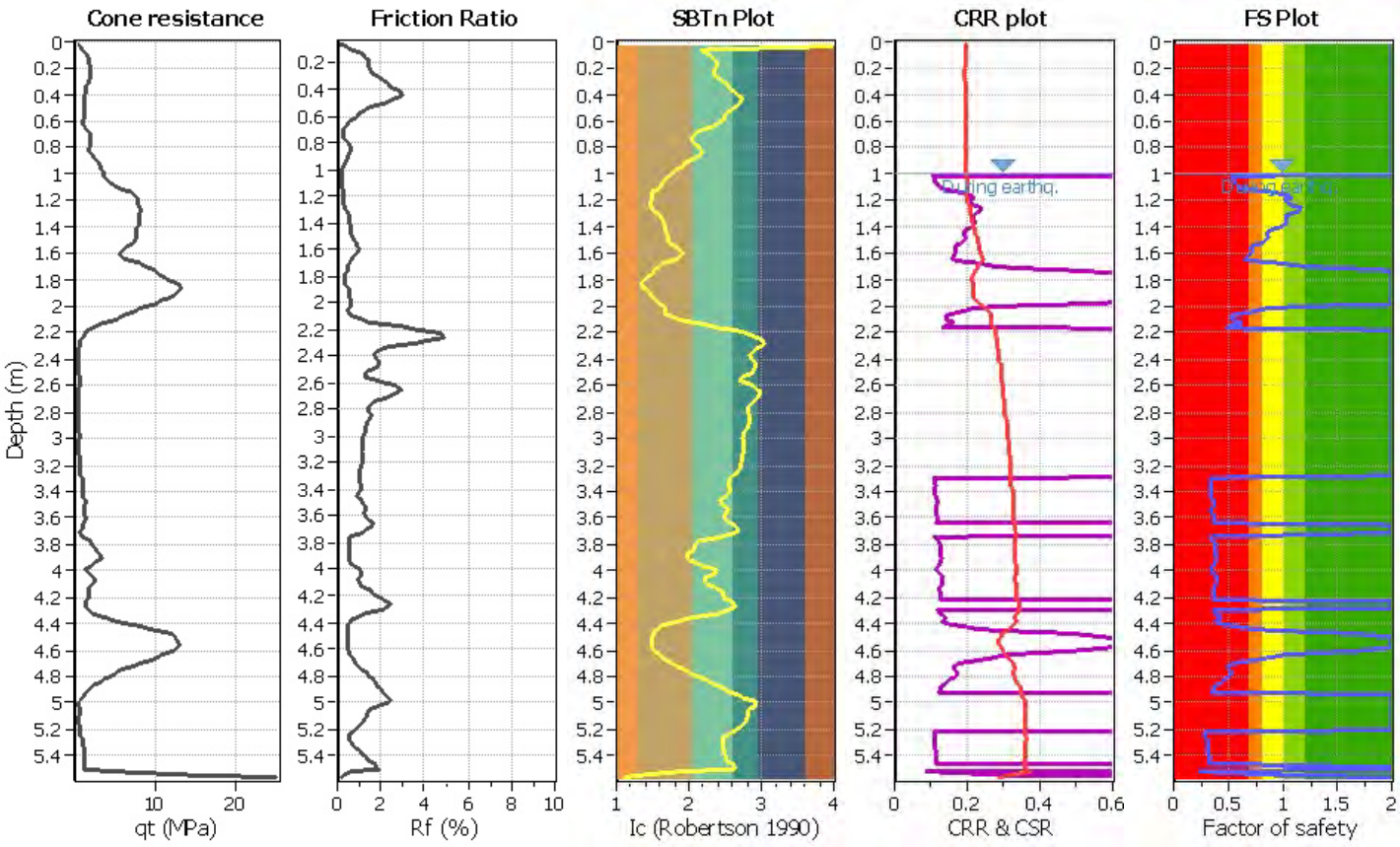
LIQUEFACTION ANALYSIS REPORT

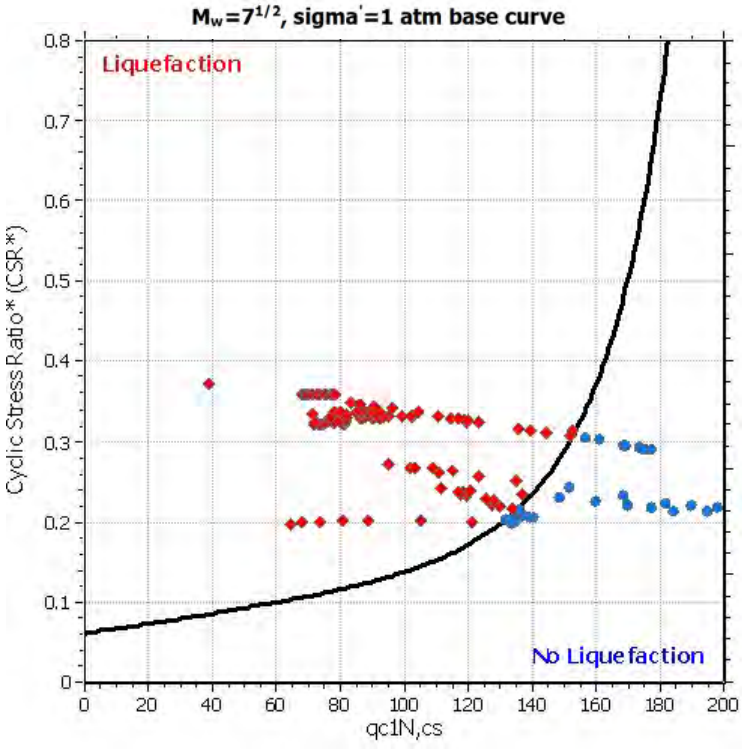
Project title : 170672 **Location : Flygers Line**

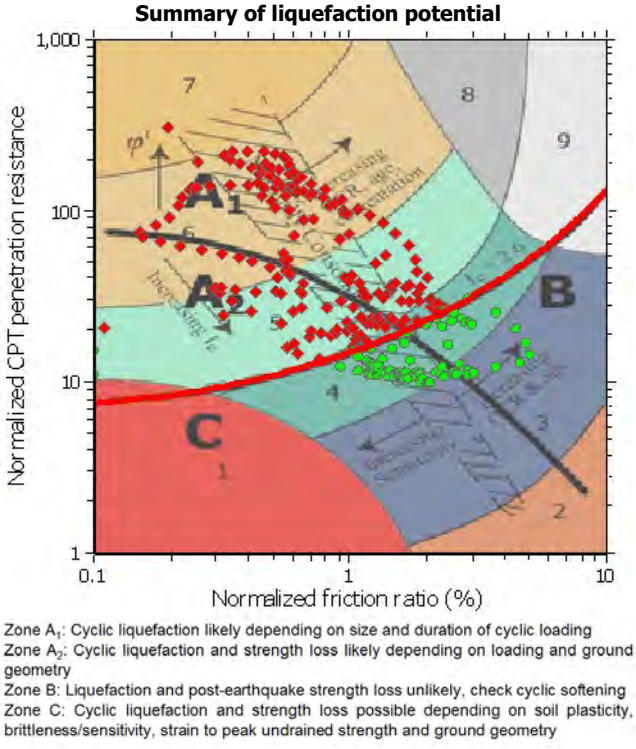
CPT file : CPT06

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

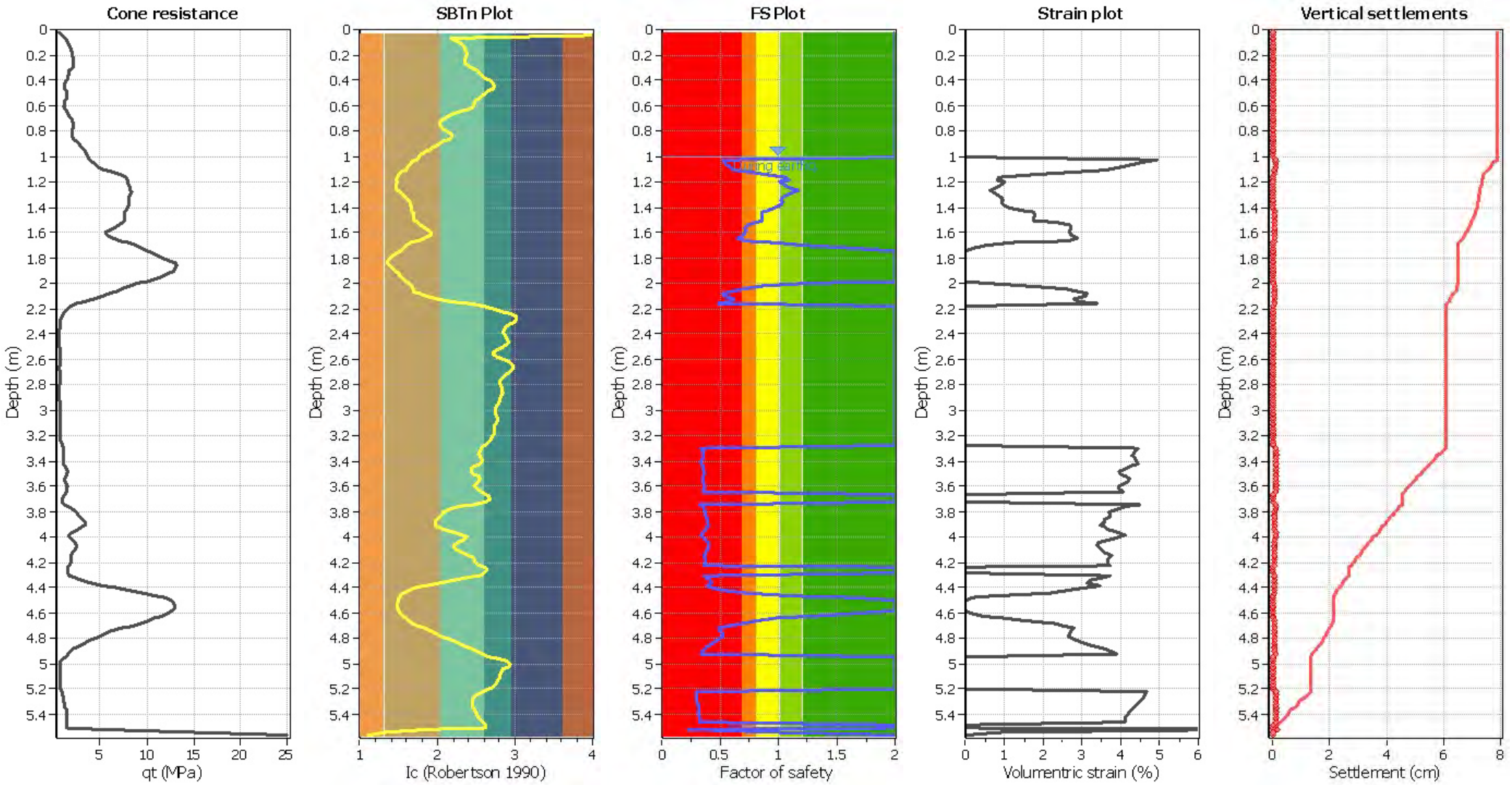






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

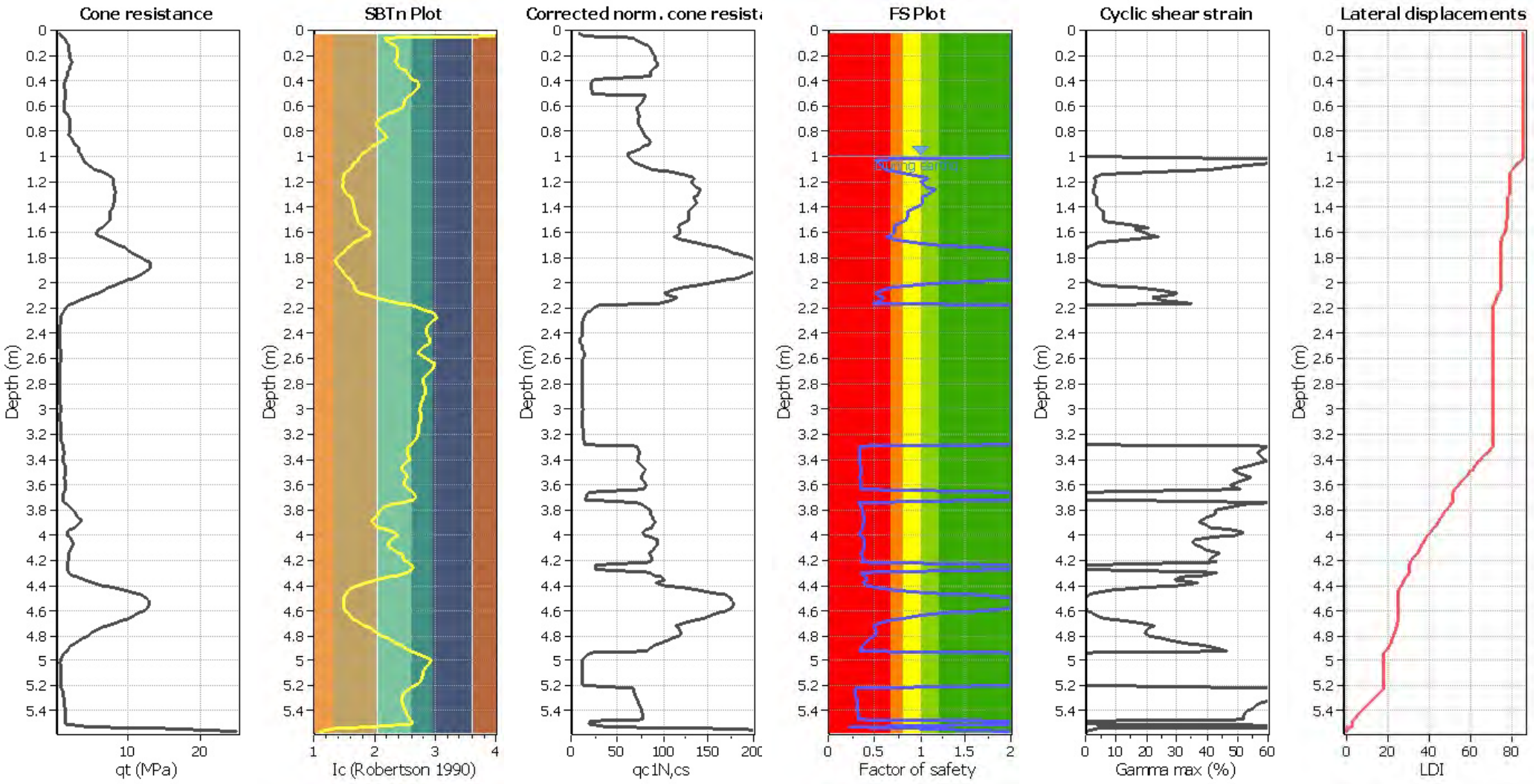
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

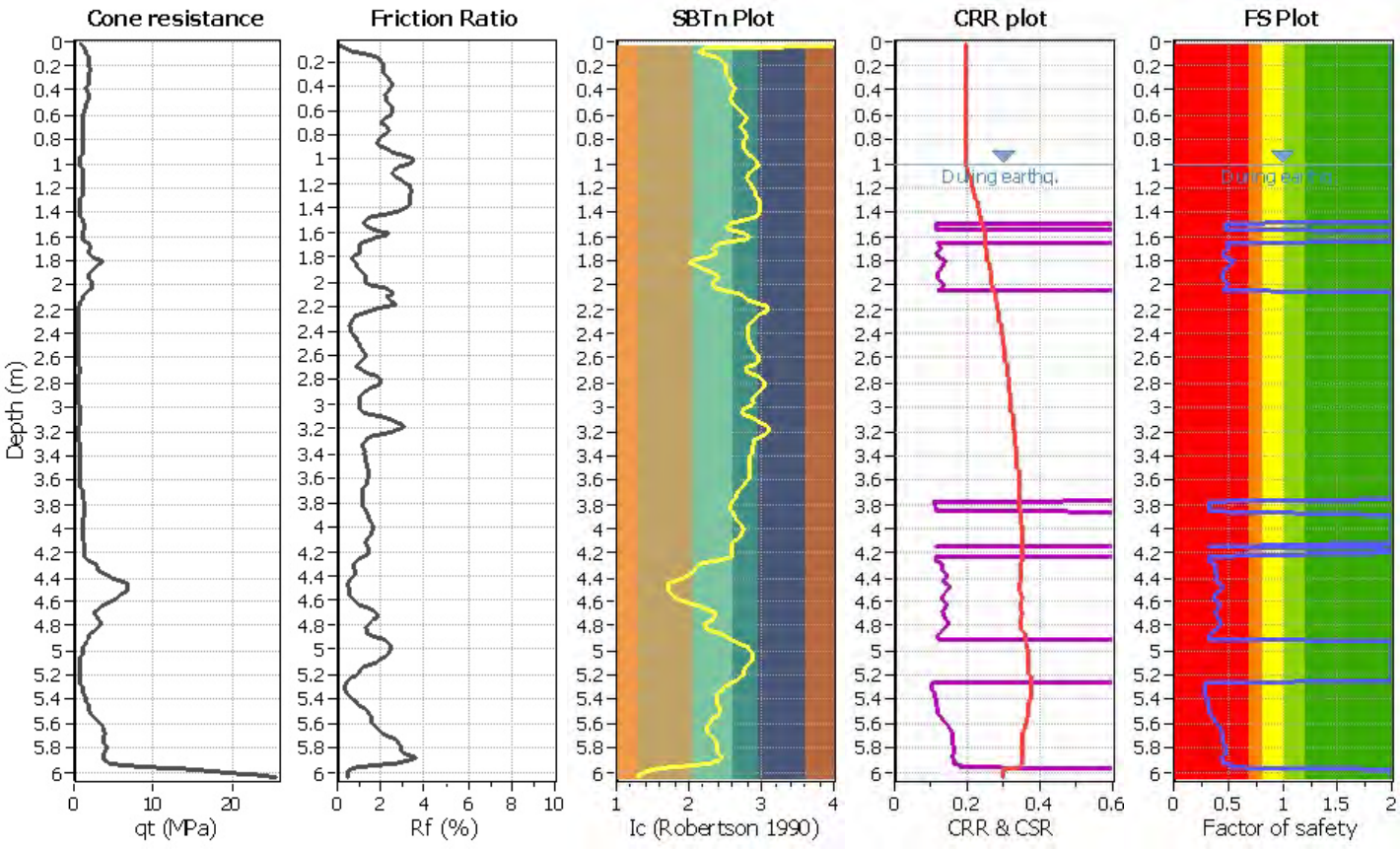
LIQUEFACTION ANALYSIS REPORT

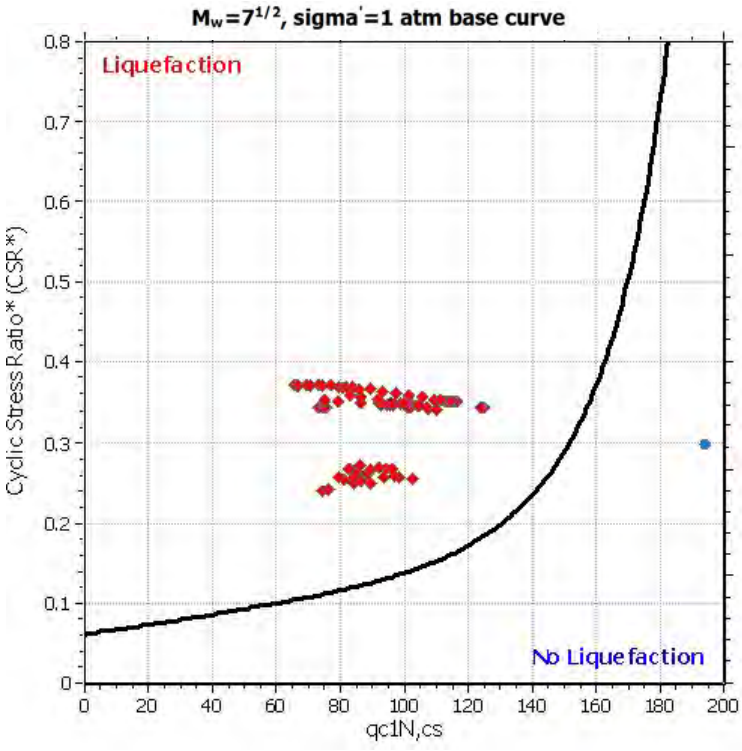
Project title : 170672 **Location : Flygers Line**

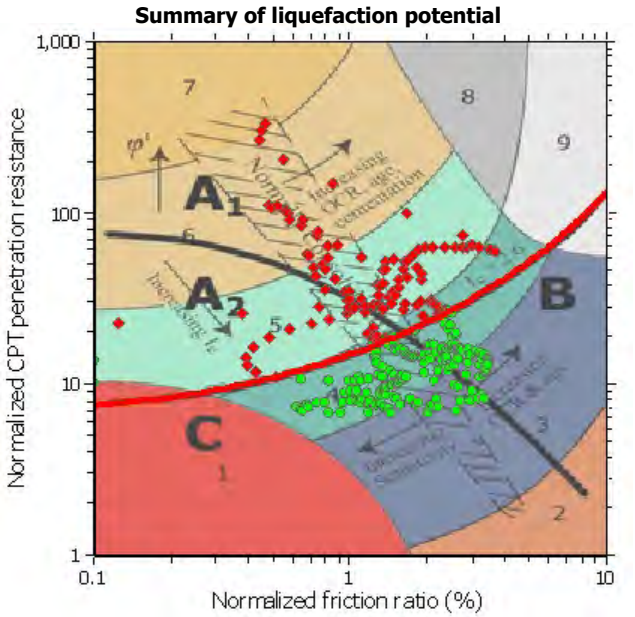
CPT file : CPT07

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

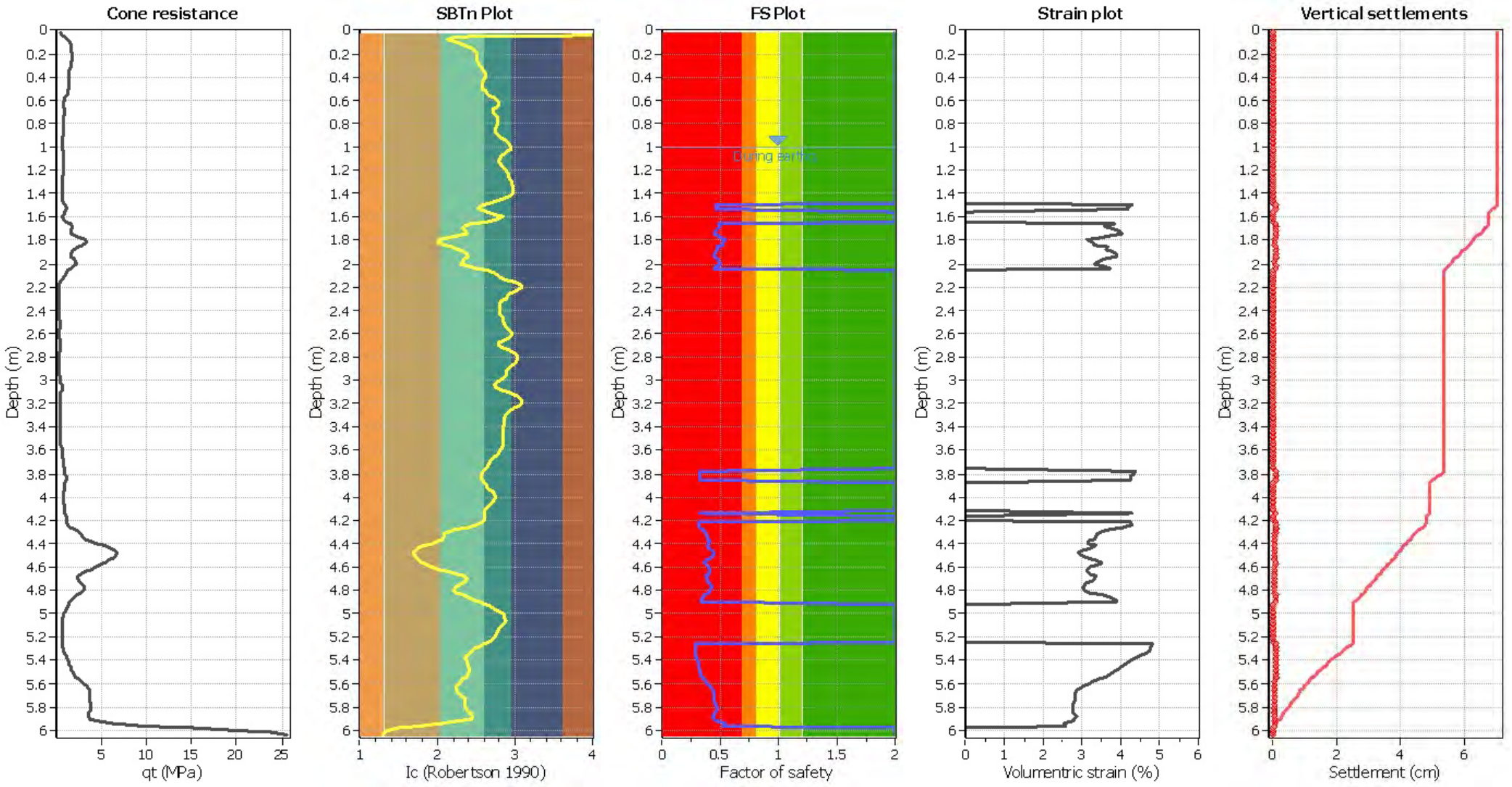






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

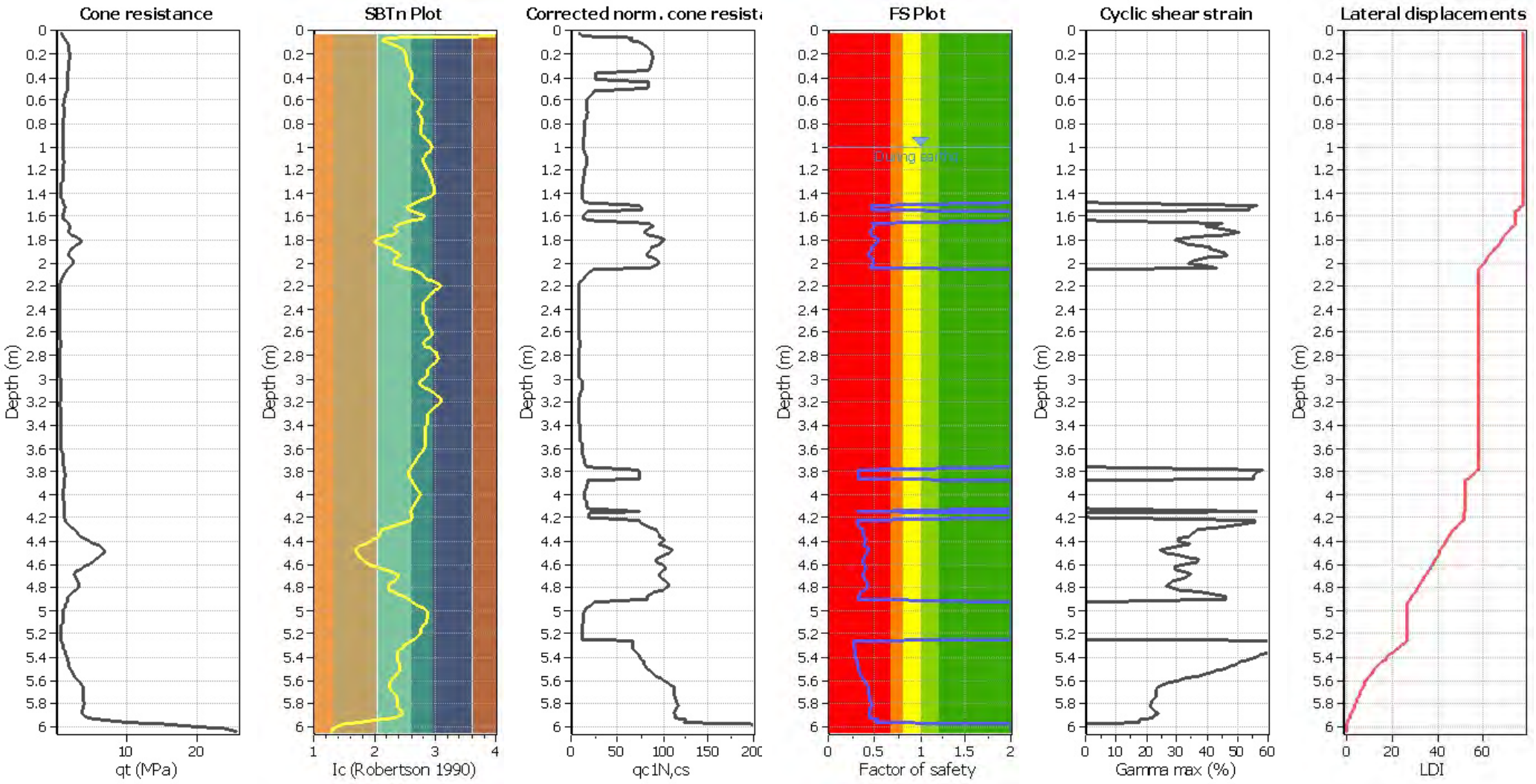
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

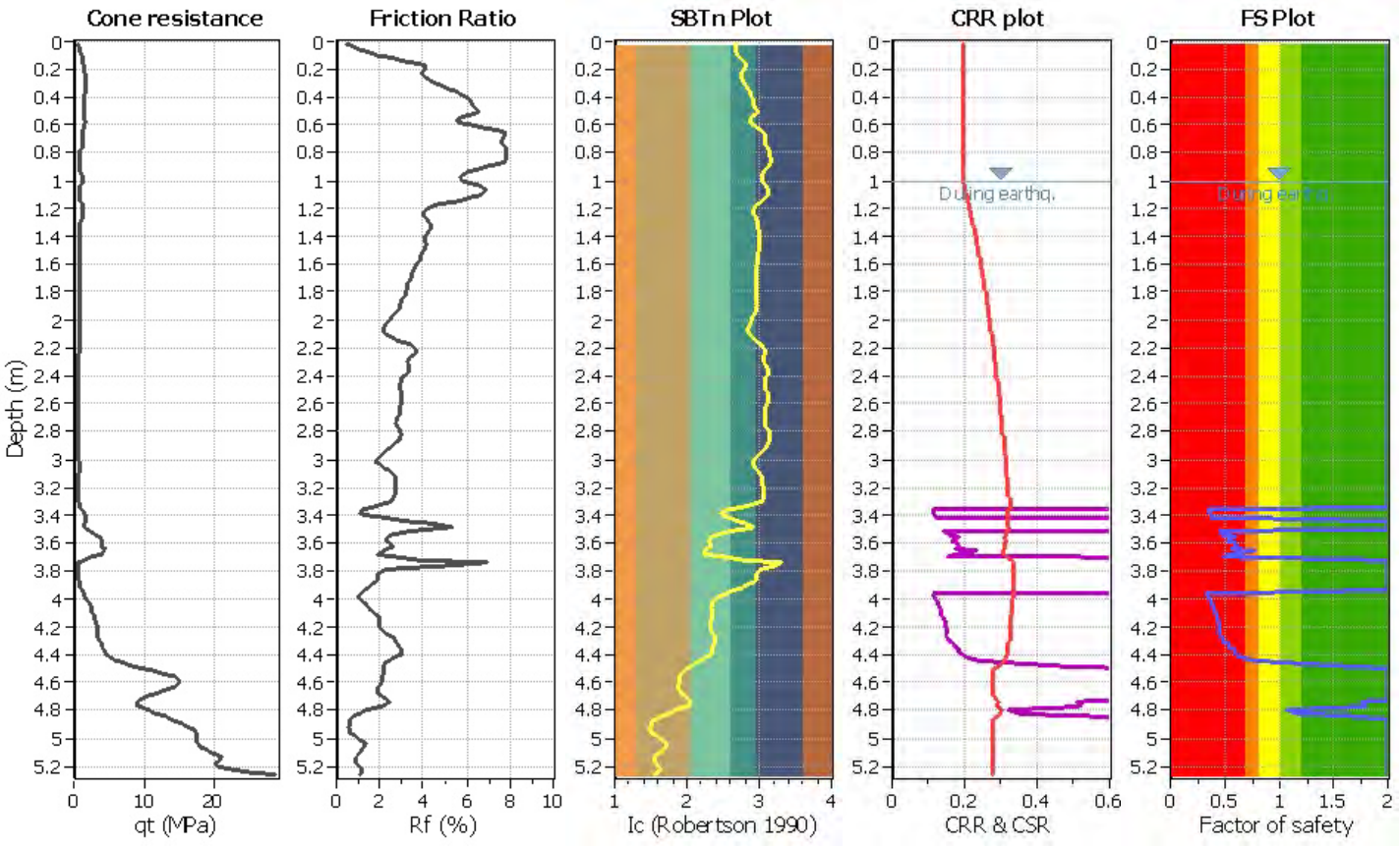
LIQUEFACTION ANALYSIS REPORT

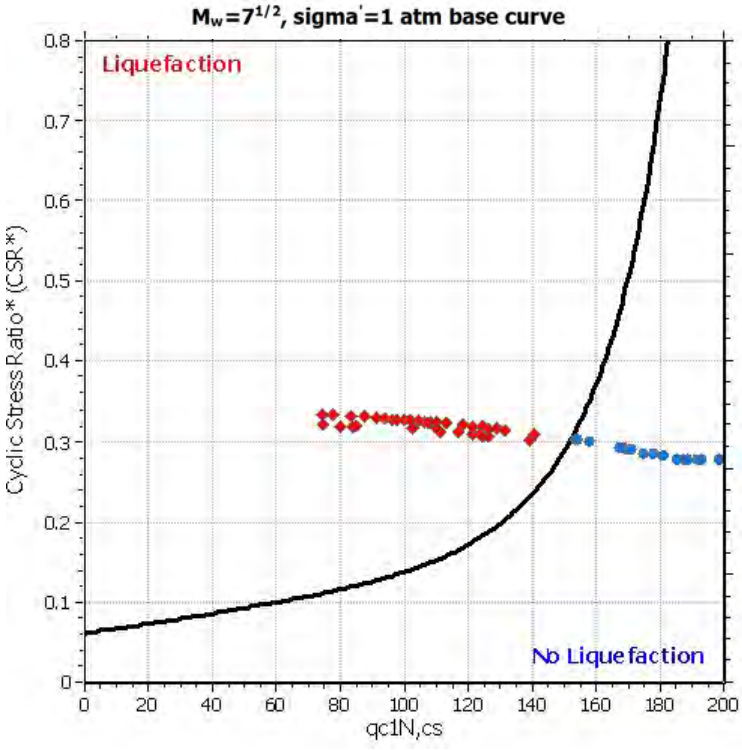
Project title : 170672 **Location : Flygers Line**

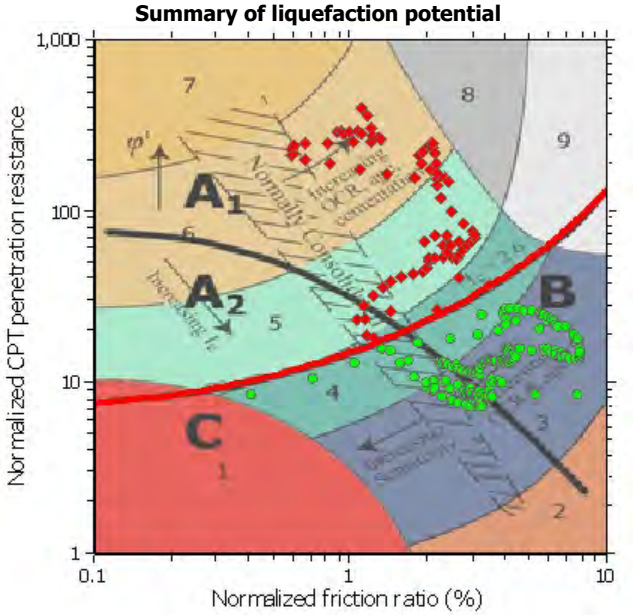
CPT file : CPT08

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

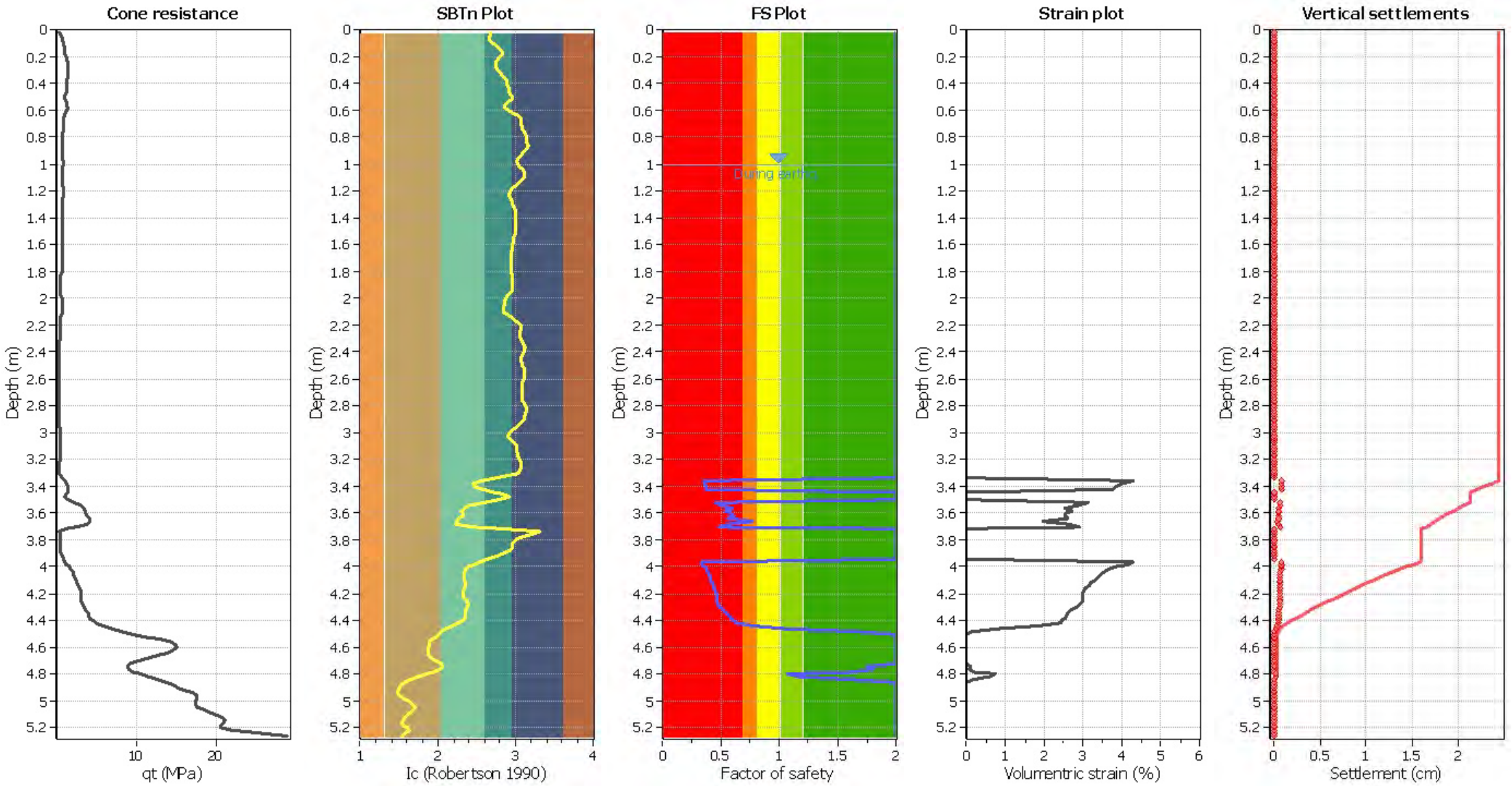






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

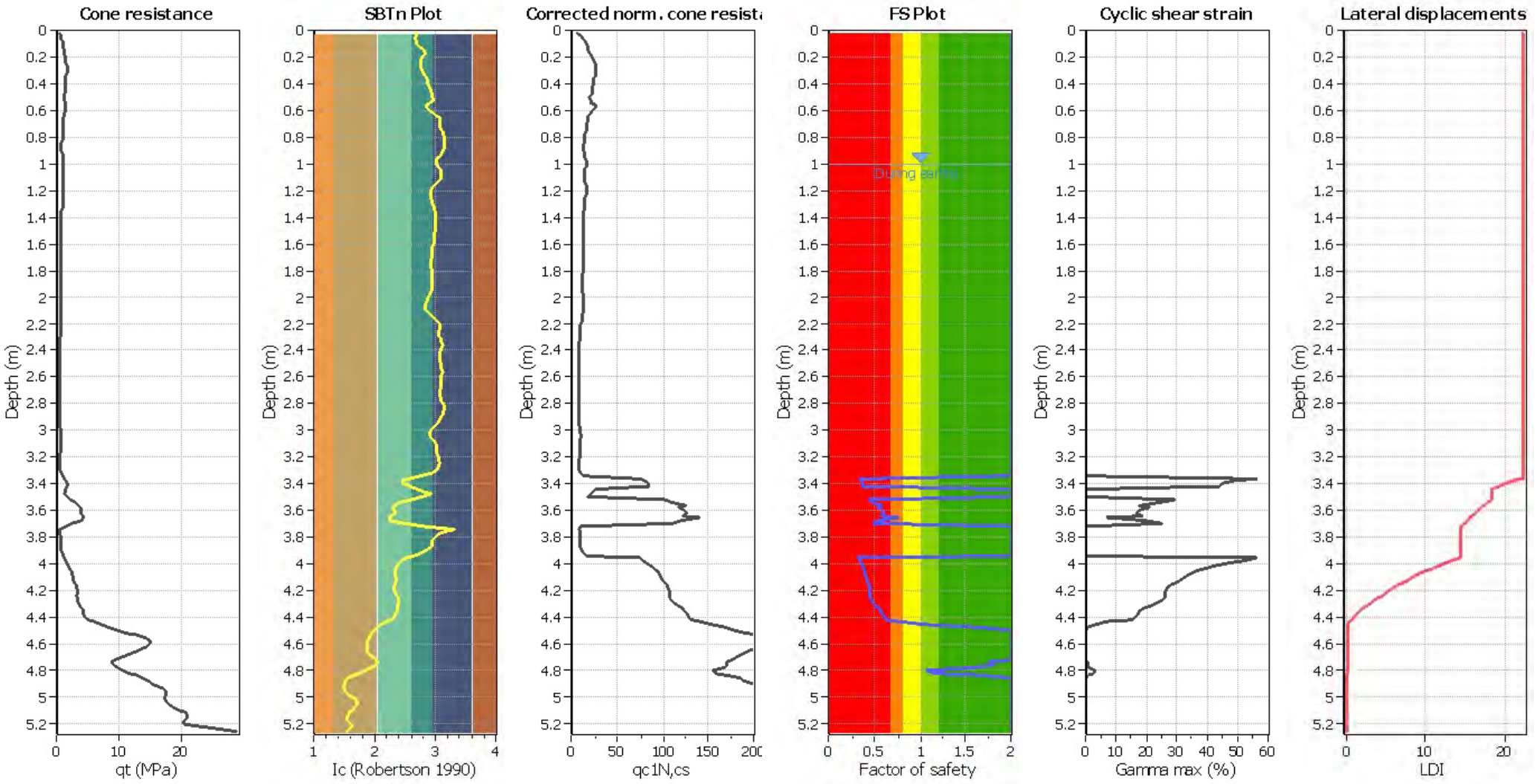
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

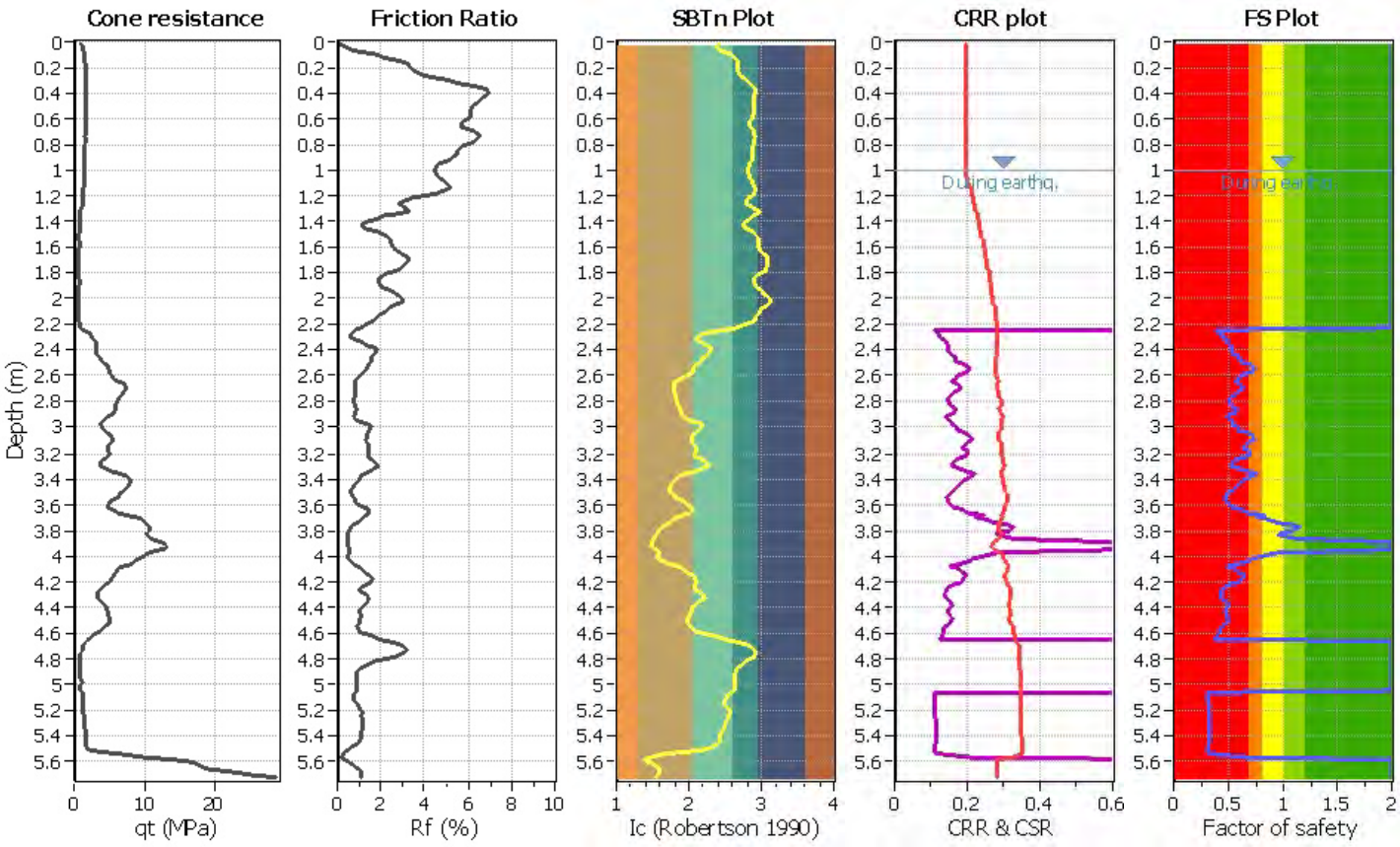
LIQUEFACTION ANALYSIS REPORT

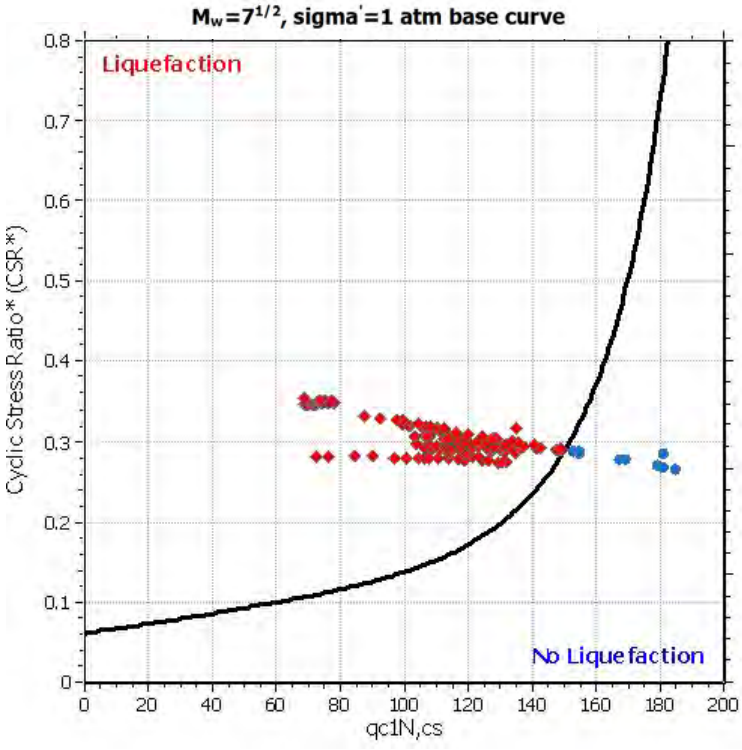
Project title : 170672 **Location : Flygers Line**

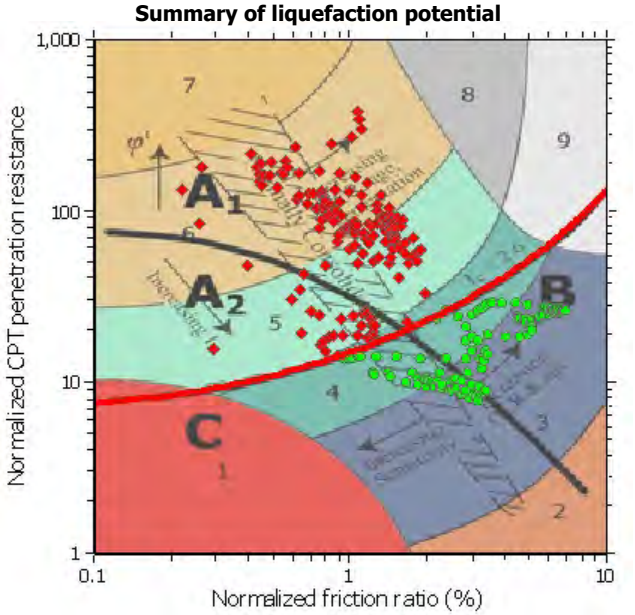
CPT file : CPT09

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

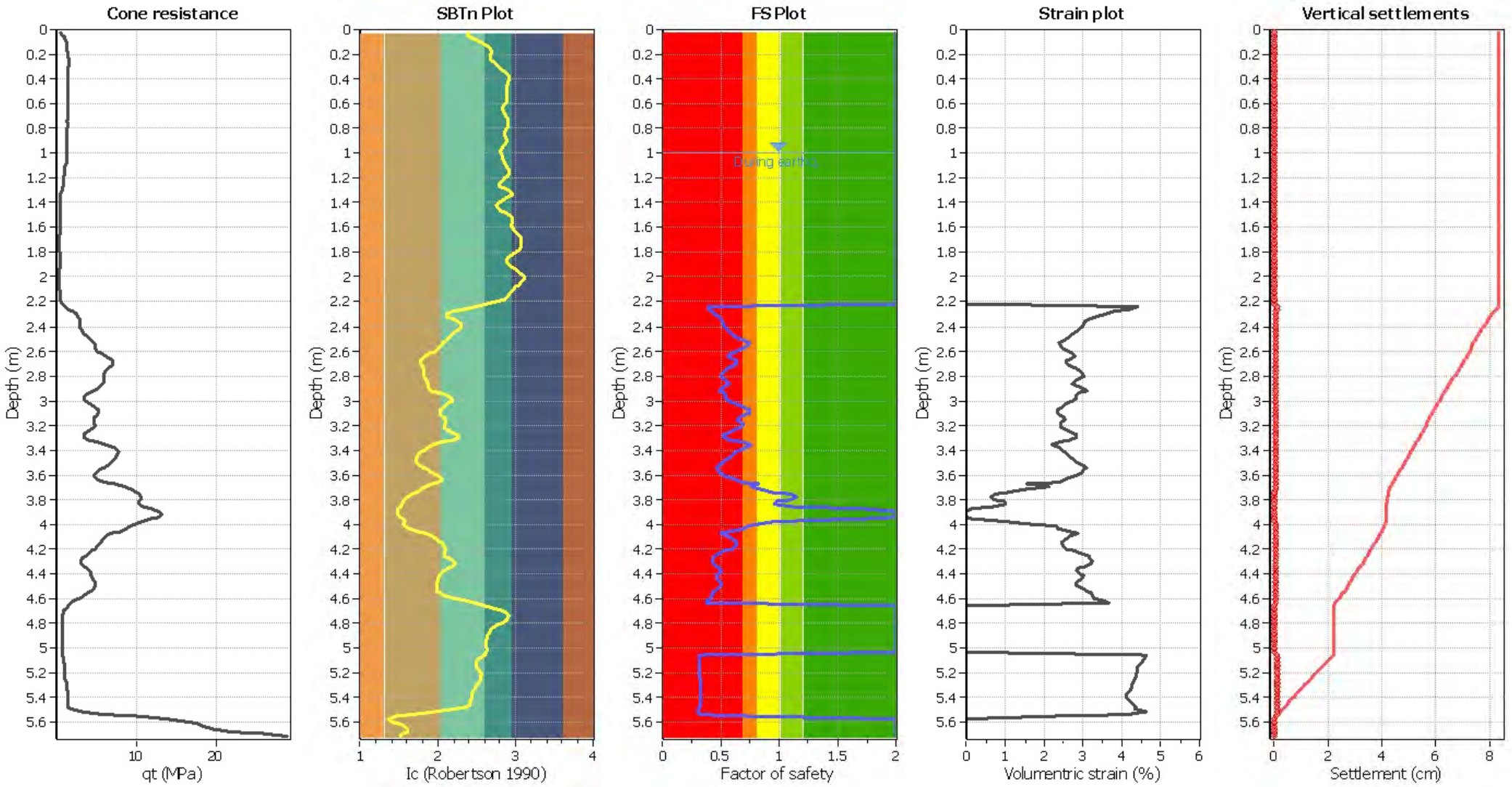






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

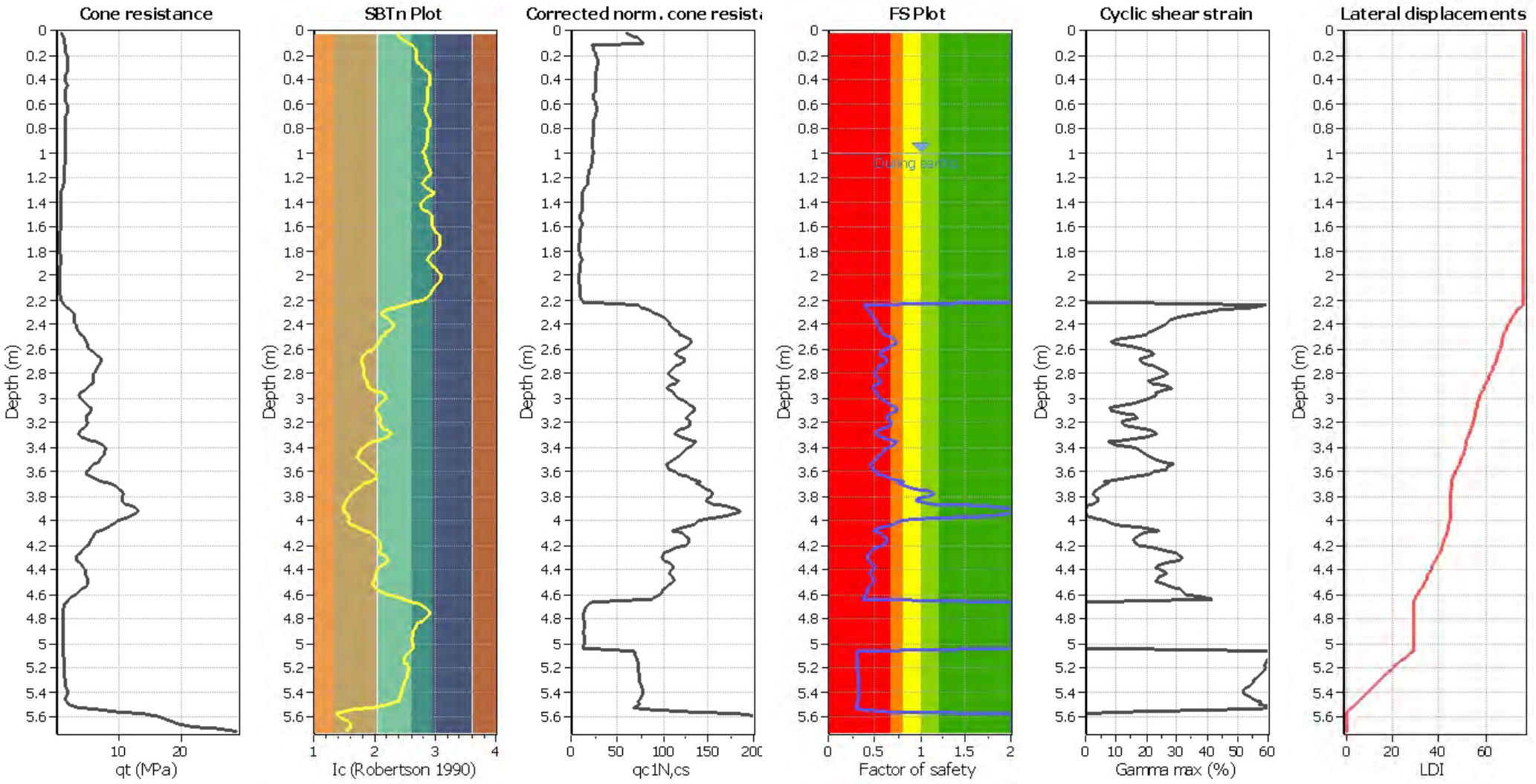
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
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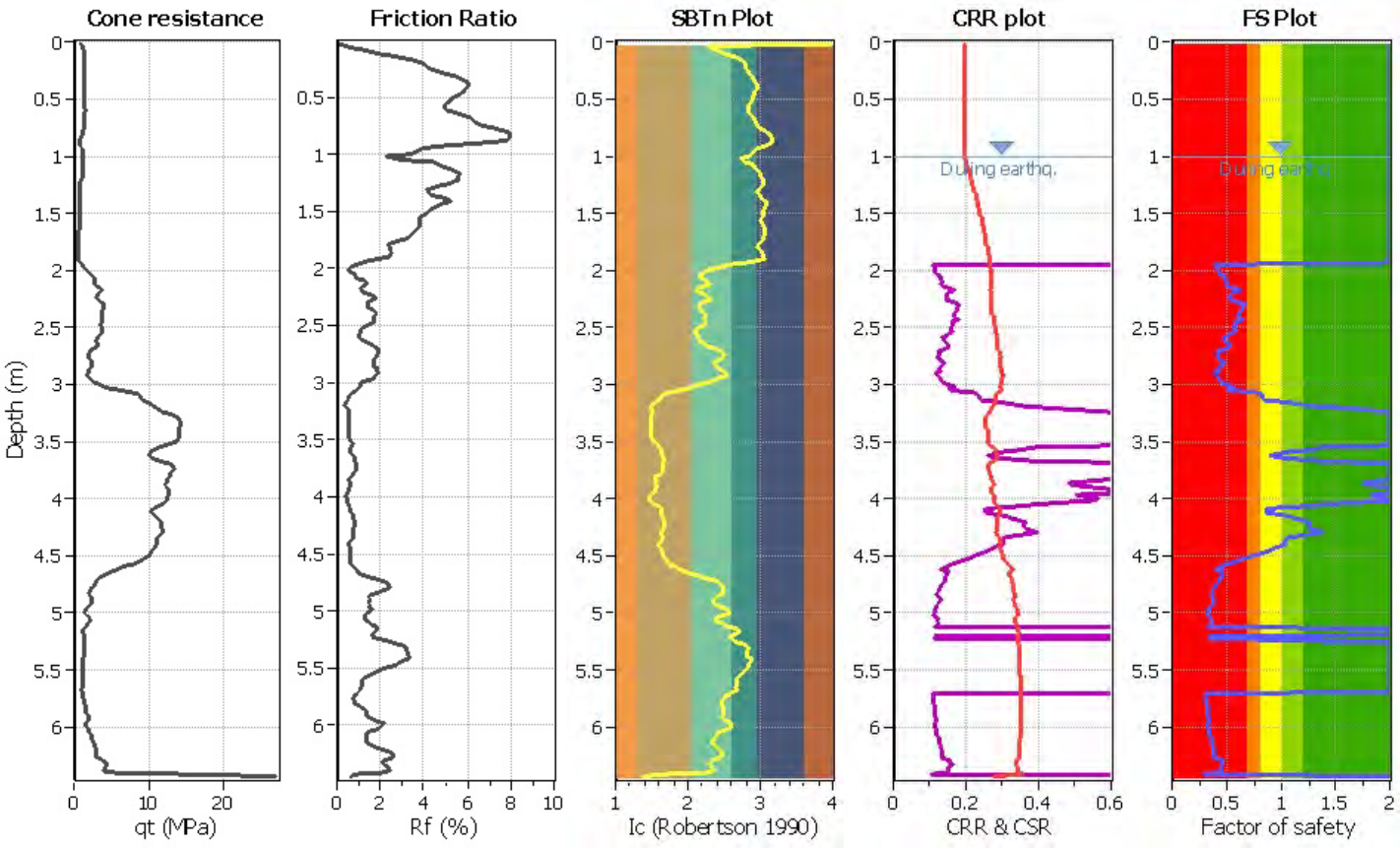
LIQUEFACTION ANALYSIS REPORT

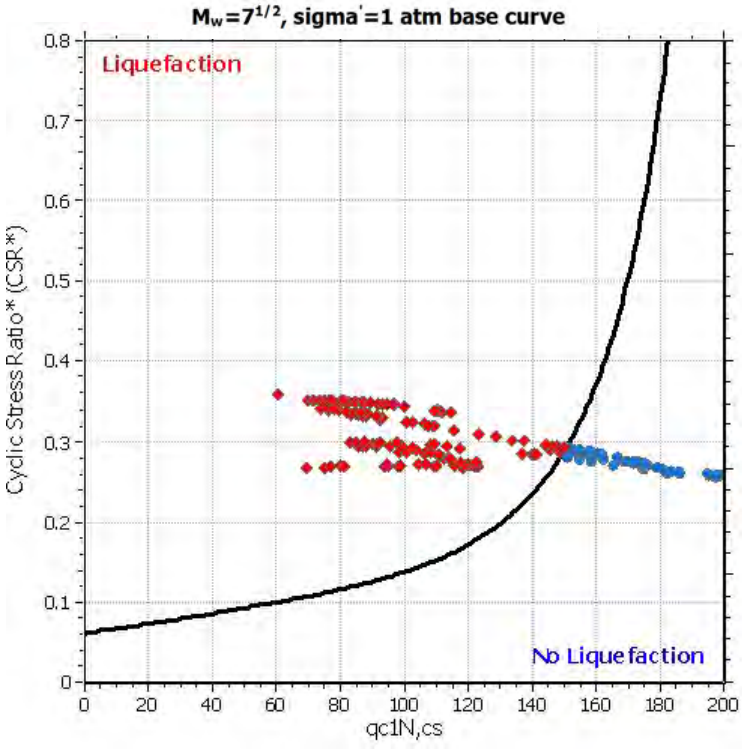
Project title : 170672 **Location : Flygers Line**

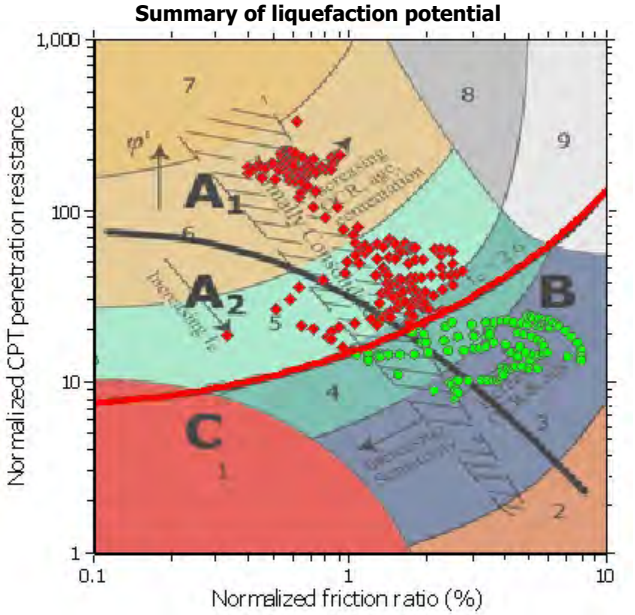
CPT file : CPT10

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

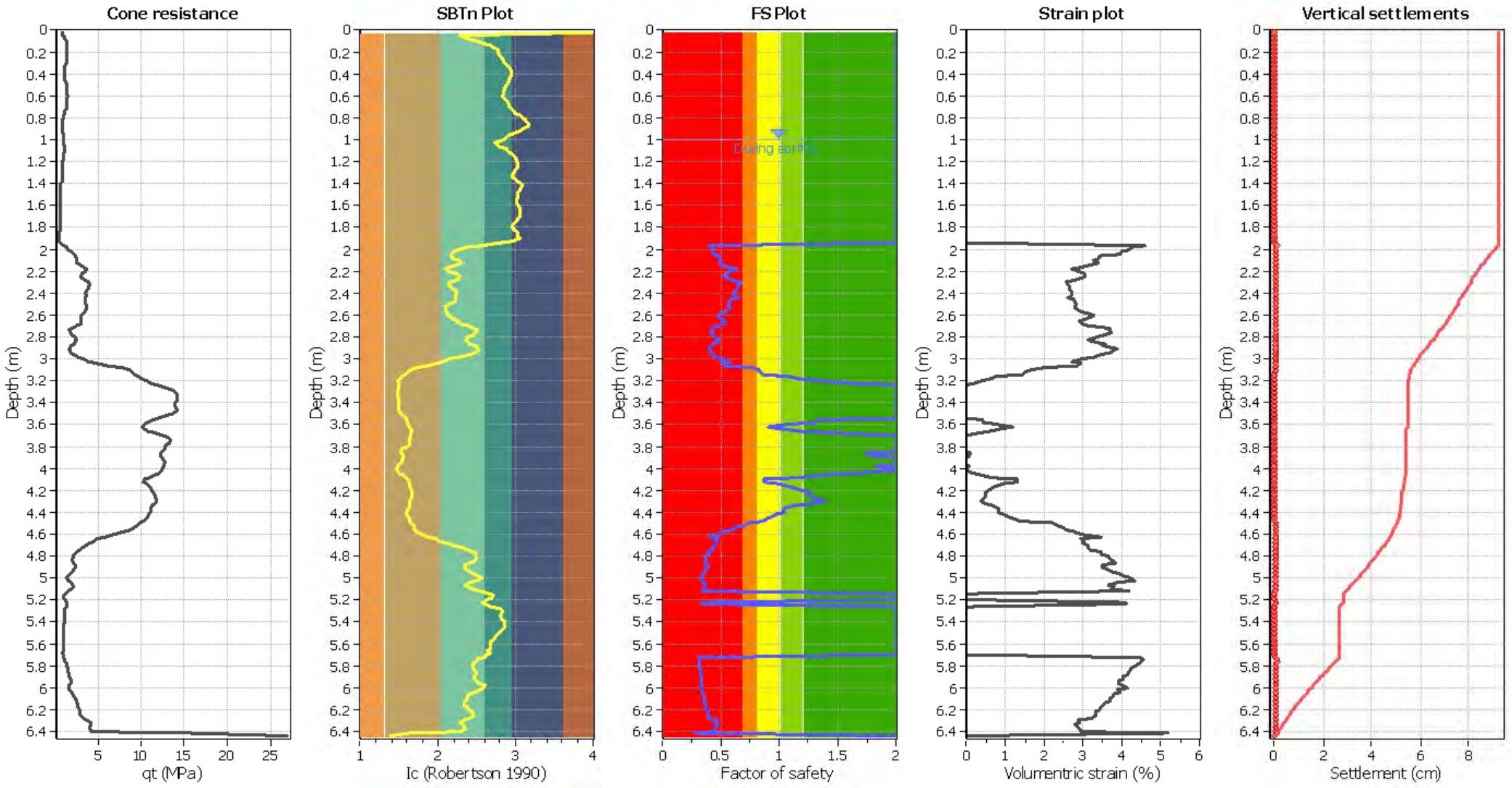






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

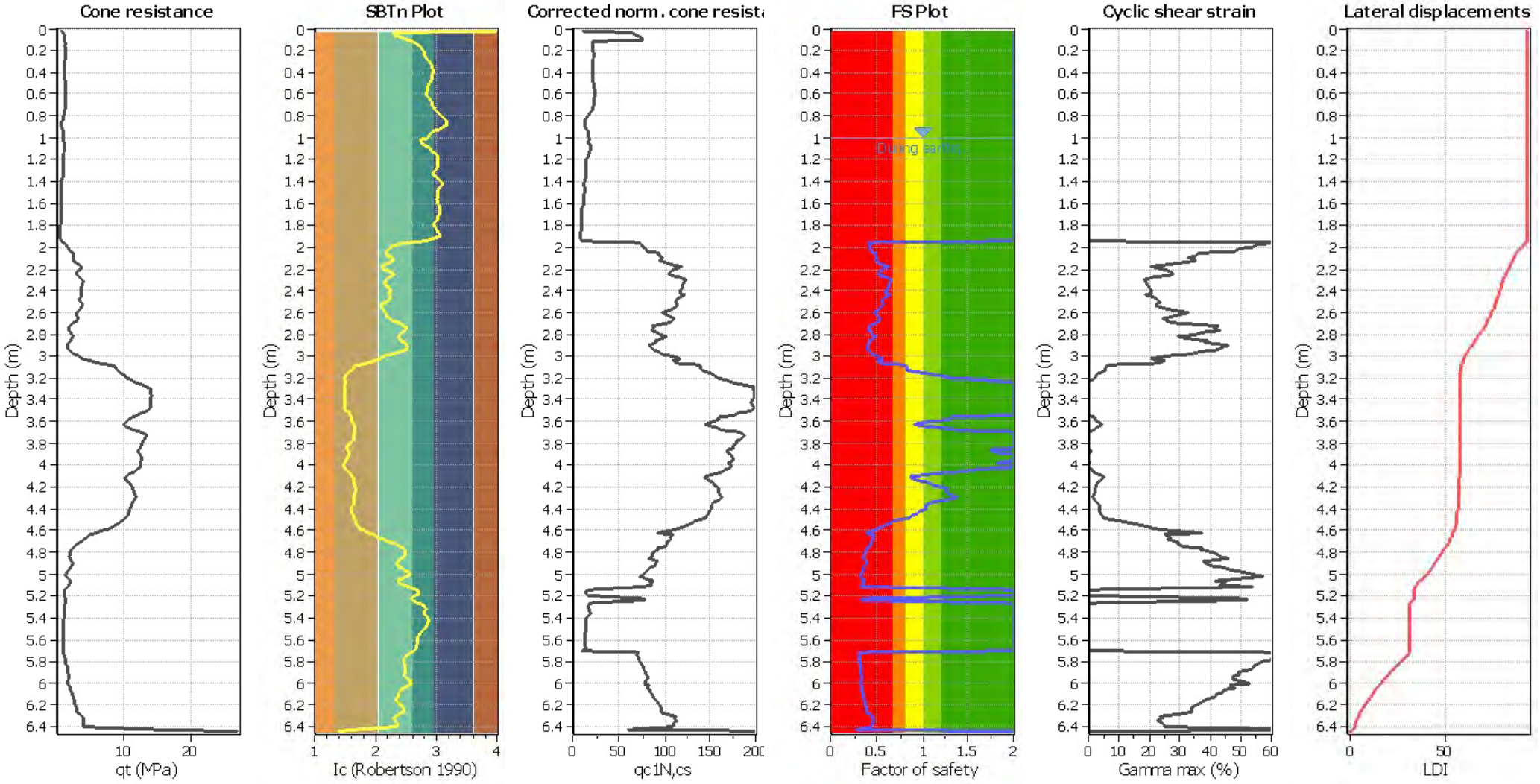
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
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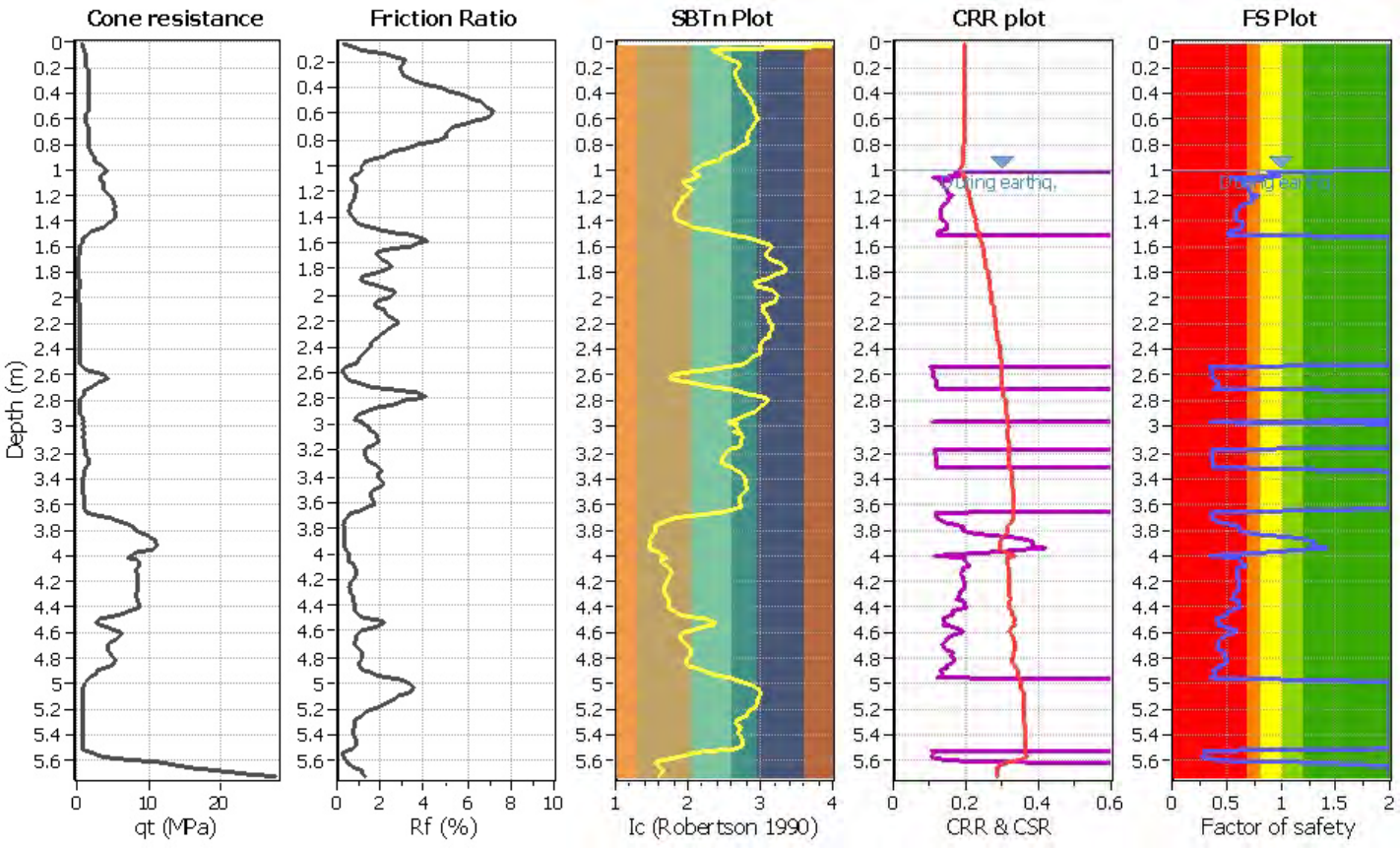
LIQUEFACTION ANALYSIS REPORT

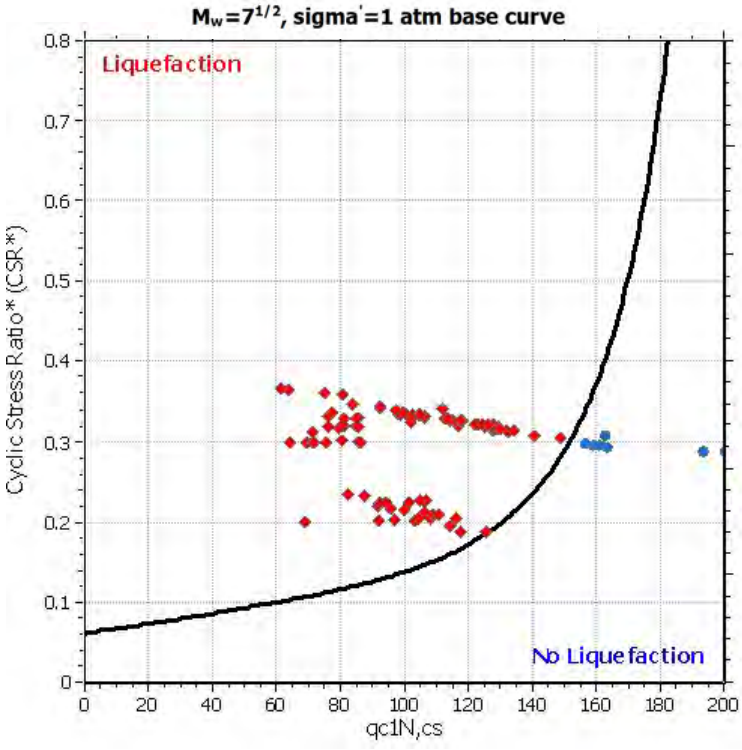
Project title : 170672 **Location : Flygers Line**

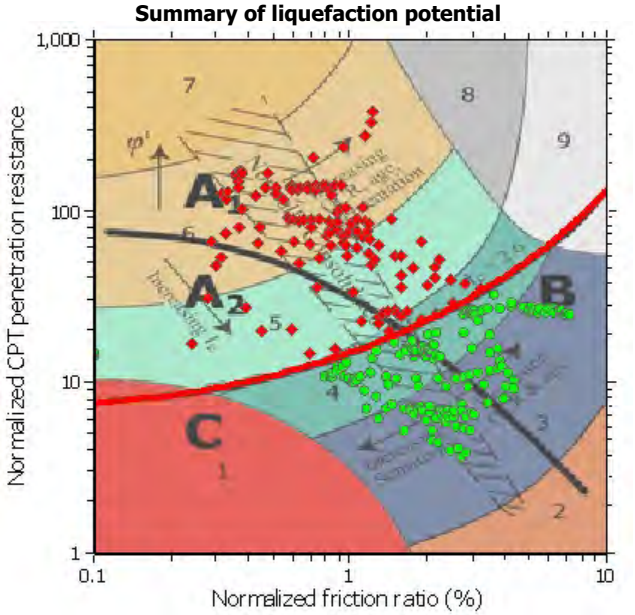
CPT file : CPT11

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

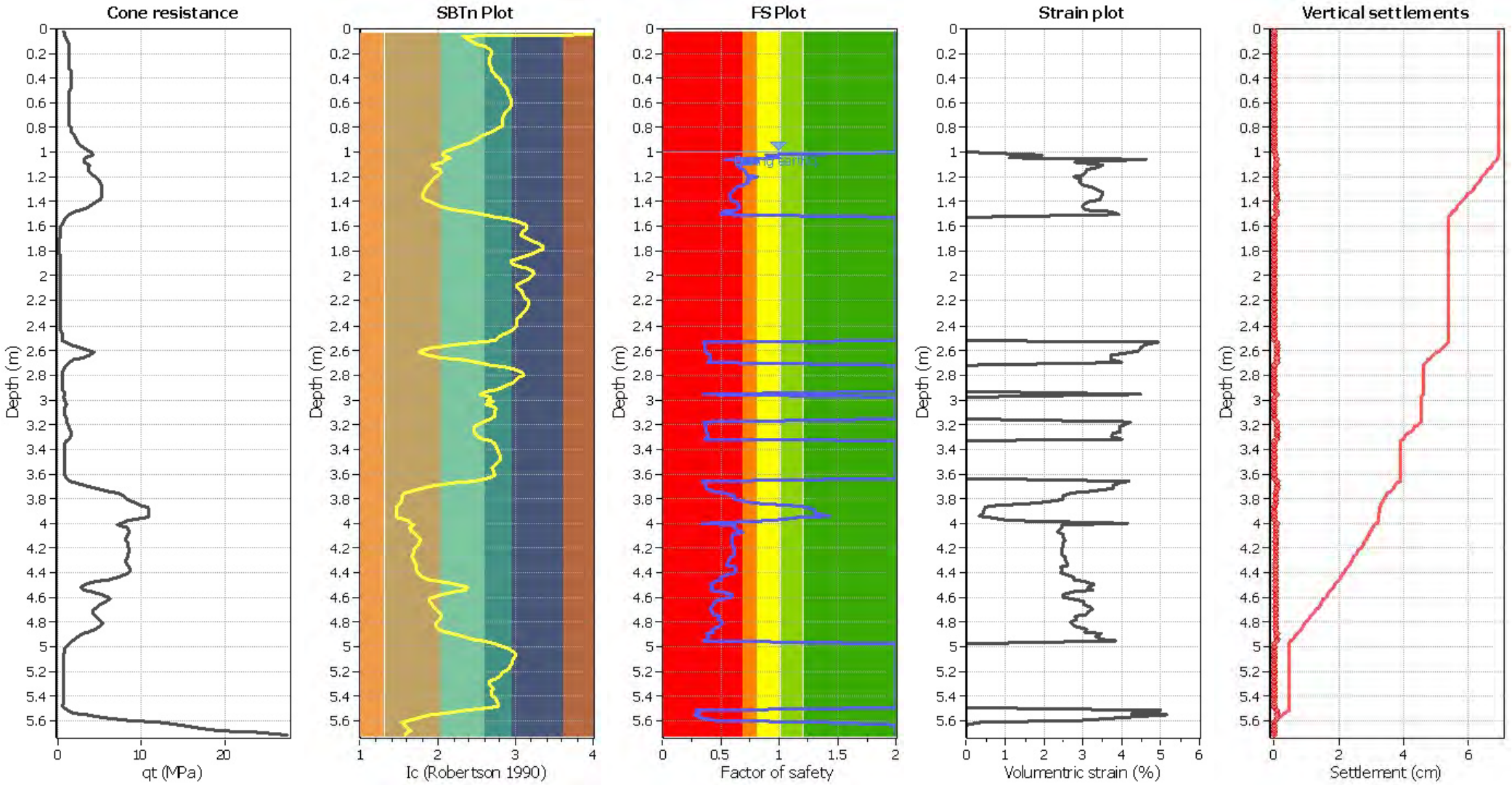






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

Estimation of post-earthquake settlements



Abbreviations

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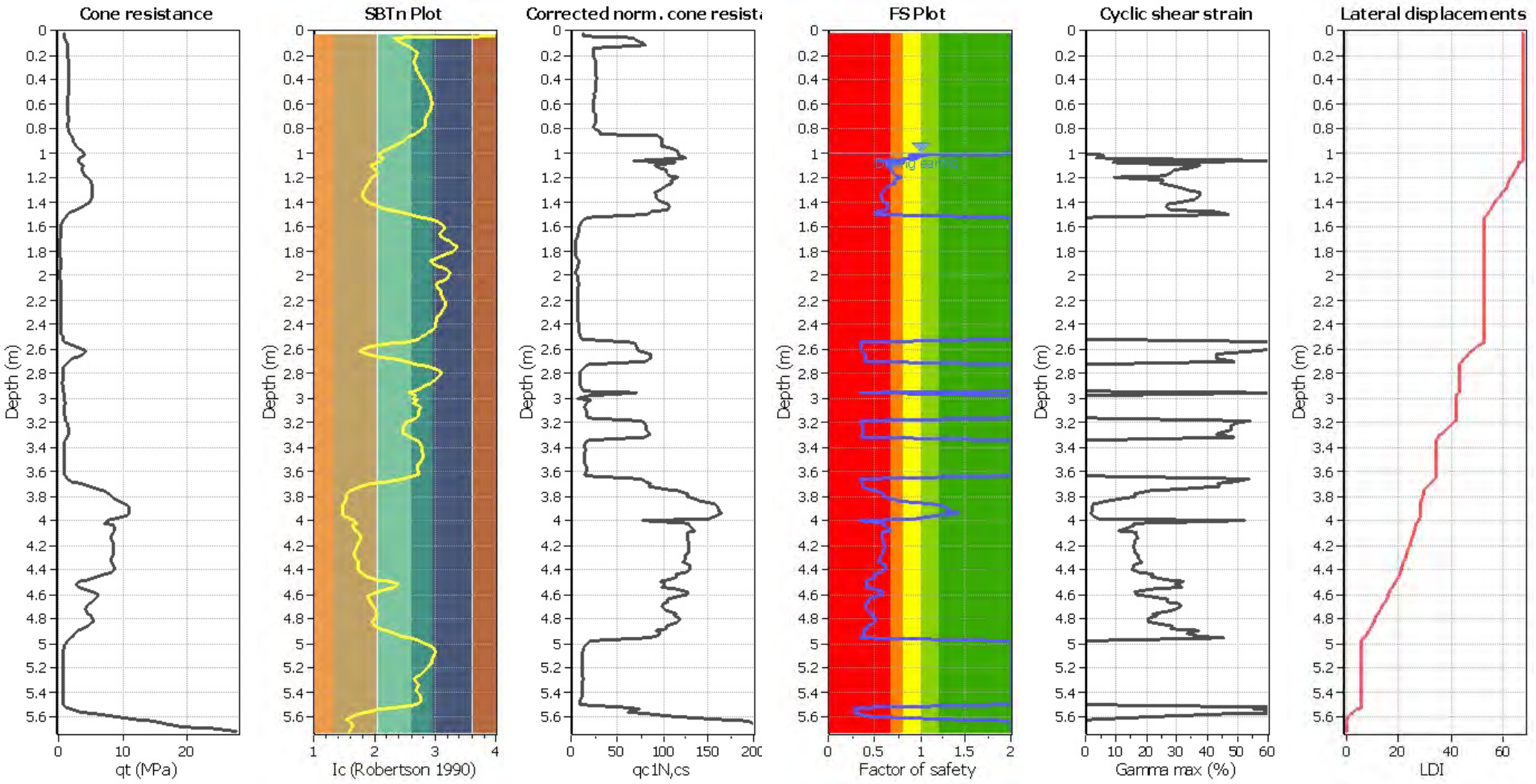
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Riley Consultants Ltd
4 Fred Thomas Drive, Takapuna
Ph: +64 9 489 7872
http://www.riley.co.nz

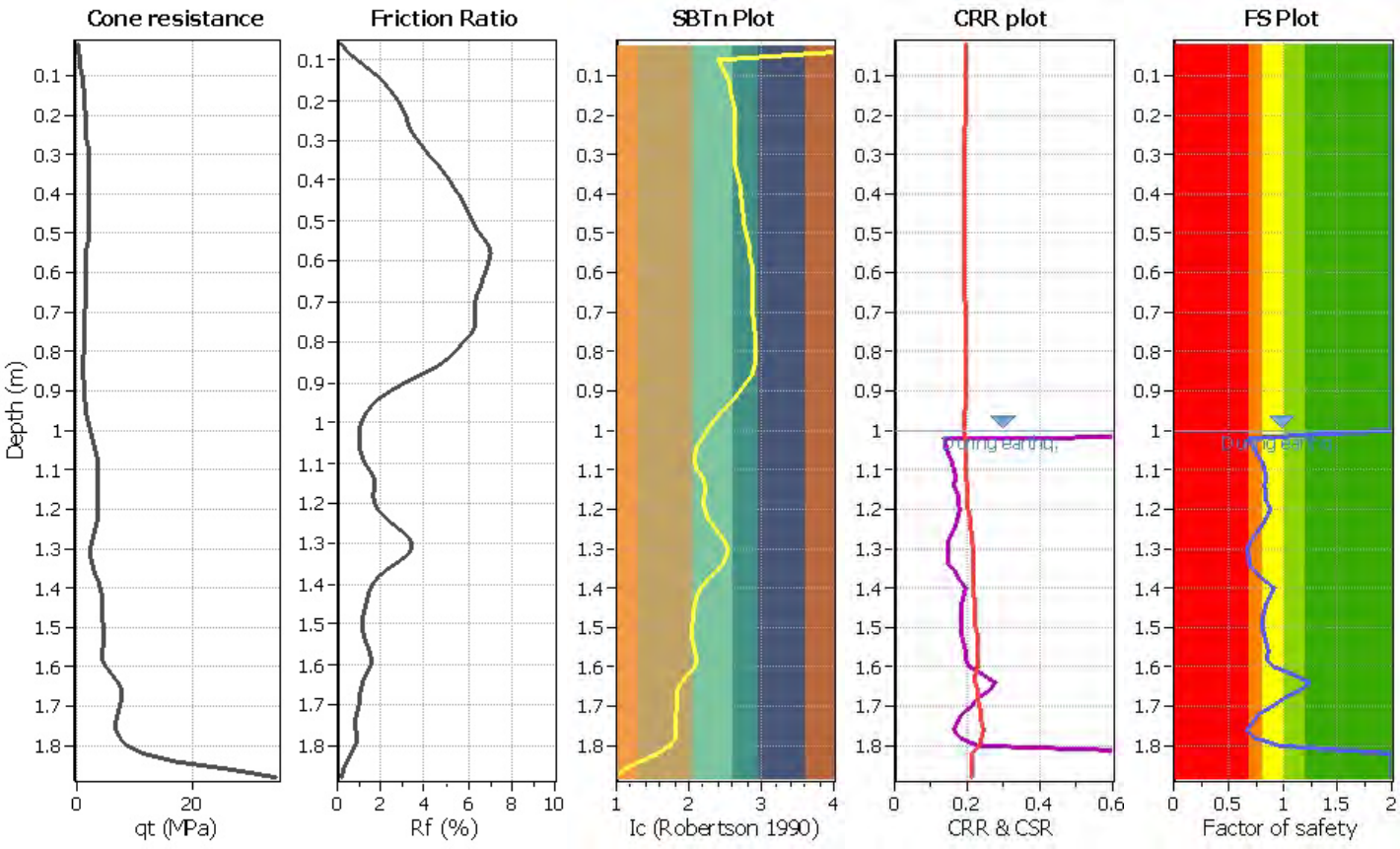
LIQUEFACTION ANALYSIS REPORT

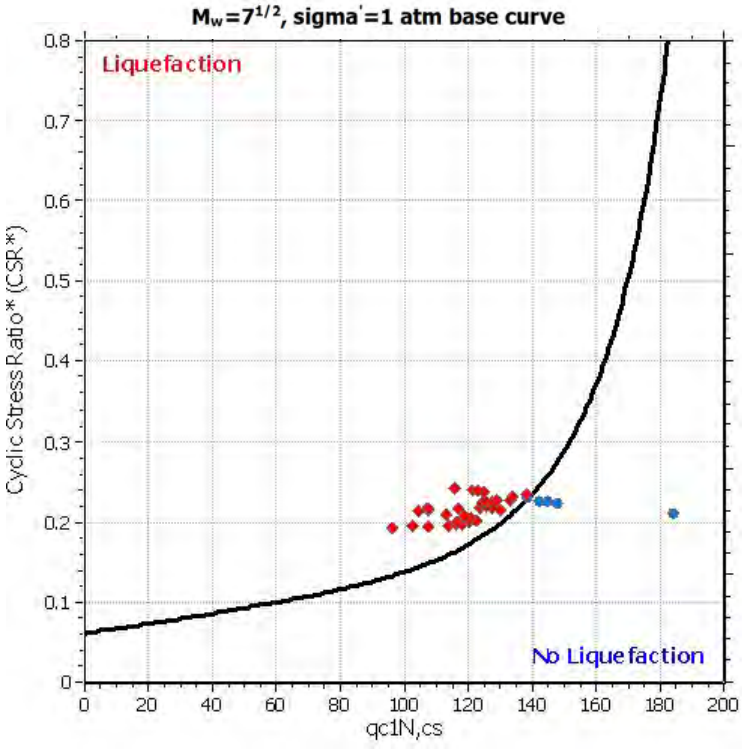
Project title : 170672 **Location : Flygers Line**

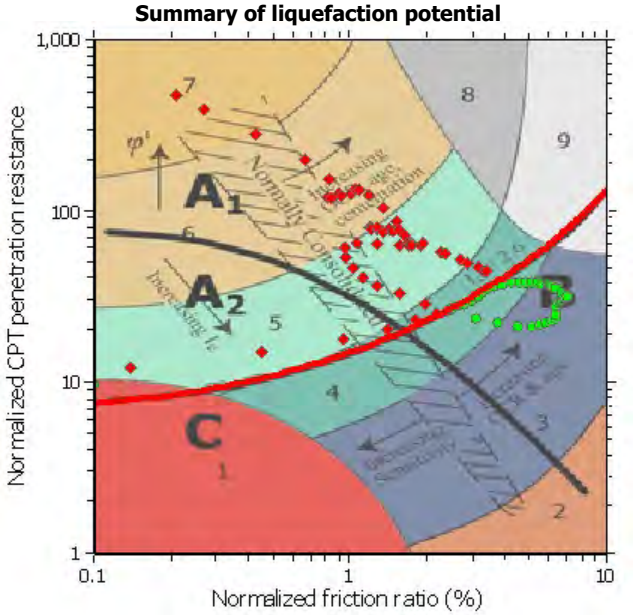
CPT file : CPT12

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

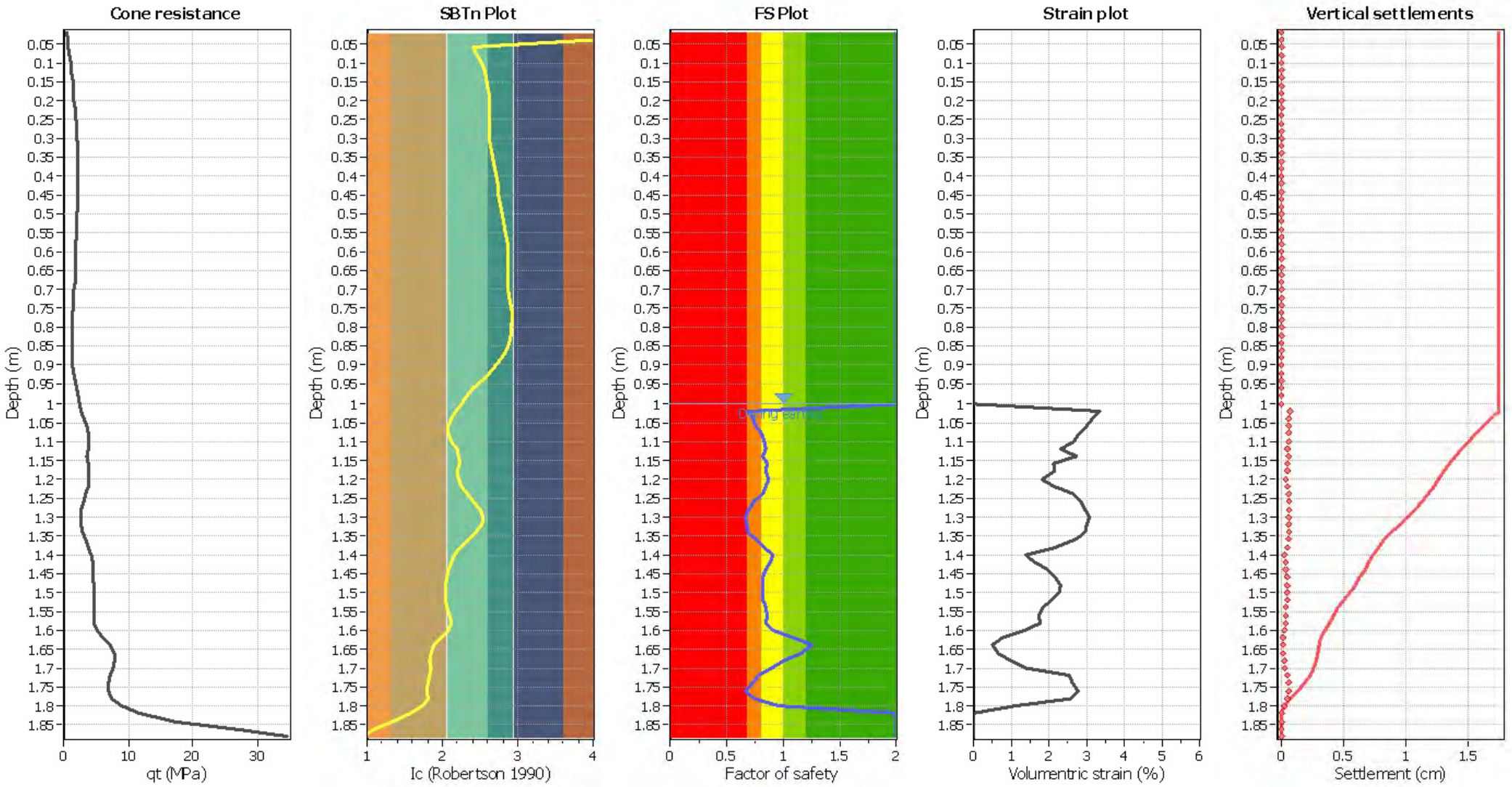






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

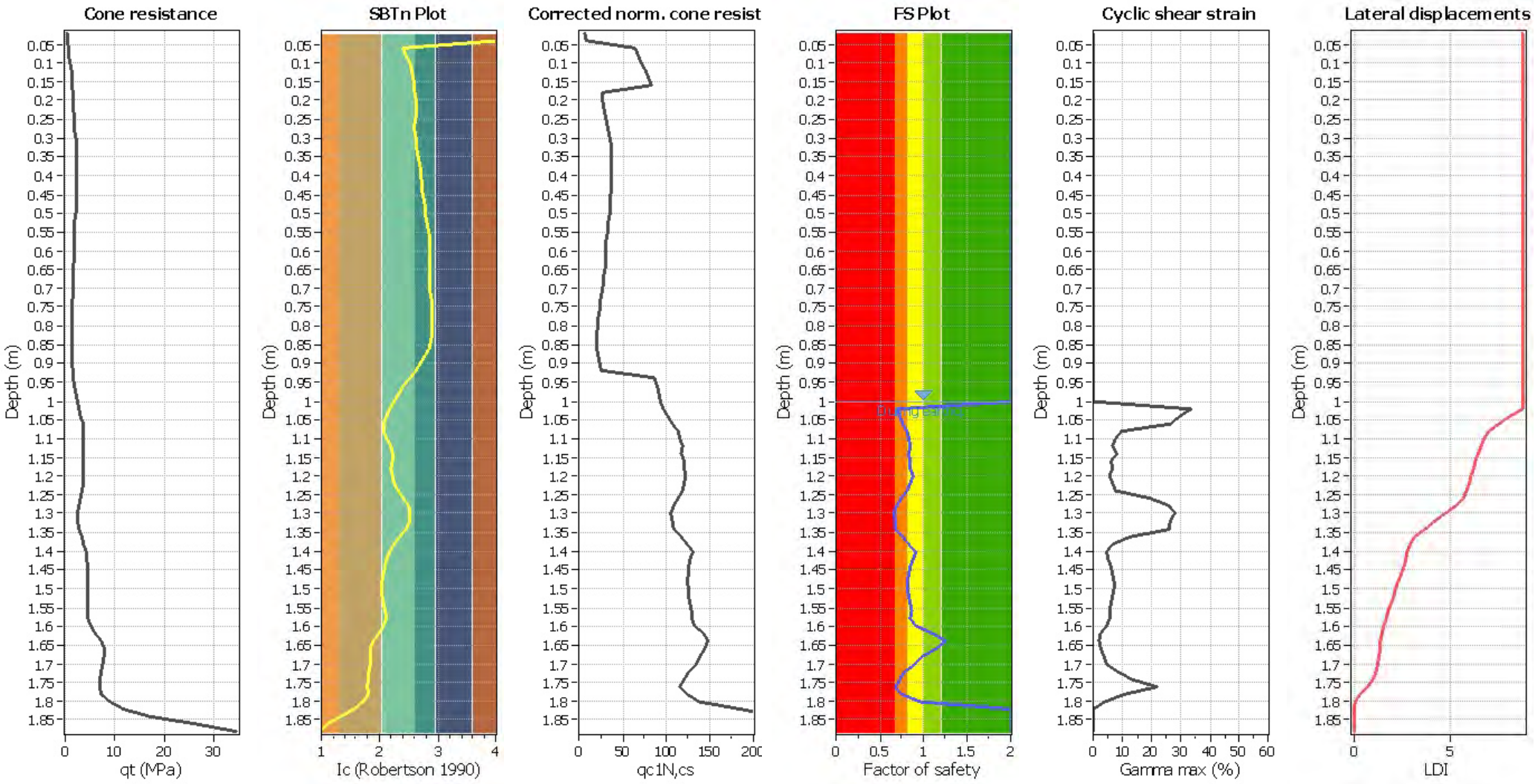
Estimation of post-earthquake settlements



Abbreviations

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

Estimation of post-earthquake lateral Displacements

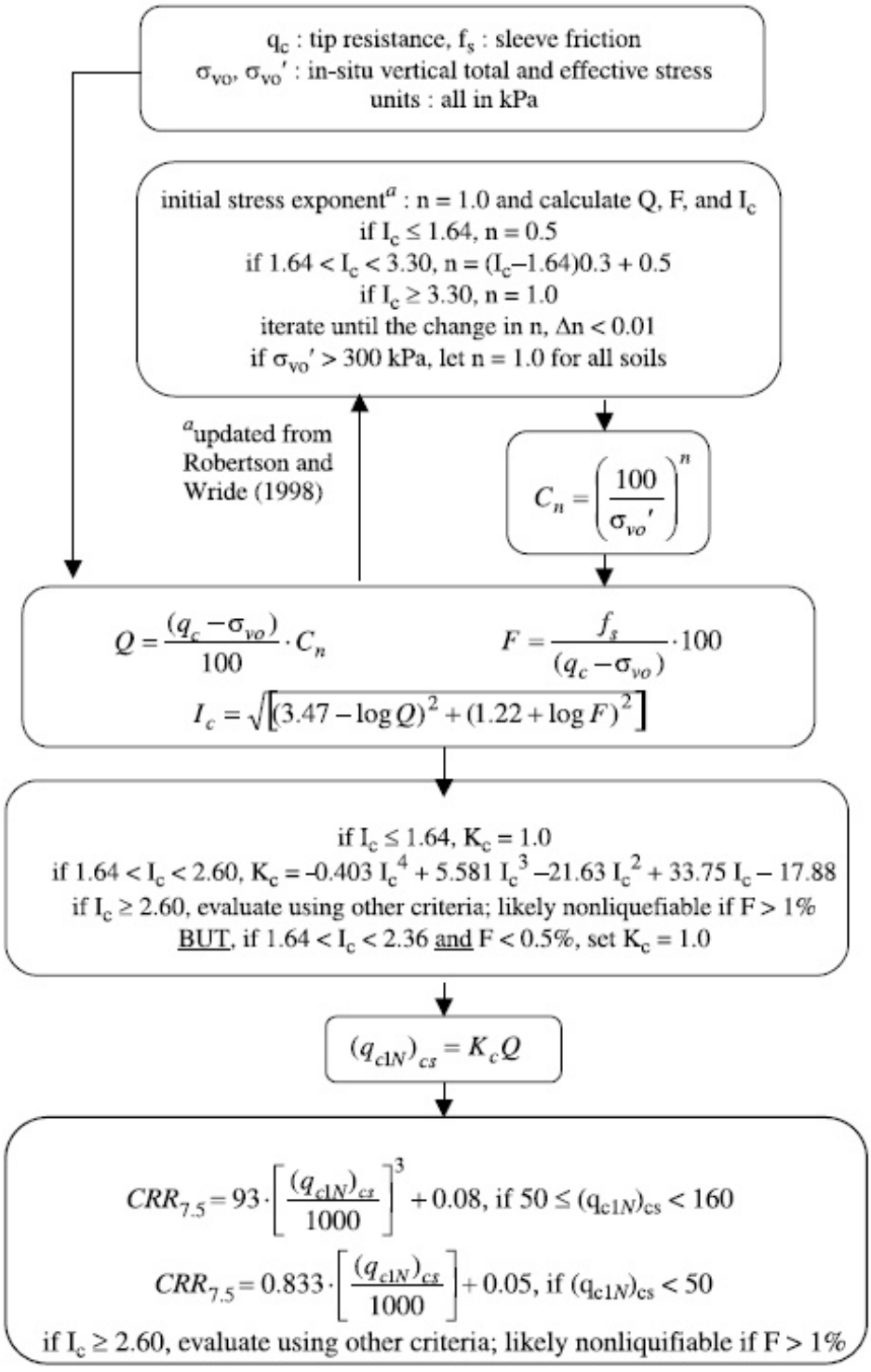


Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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

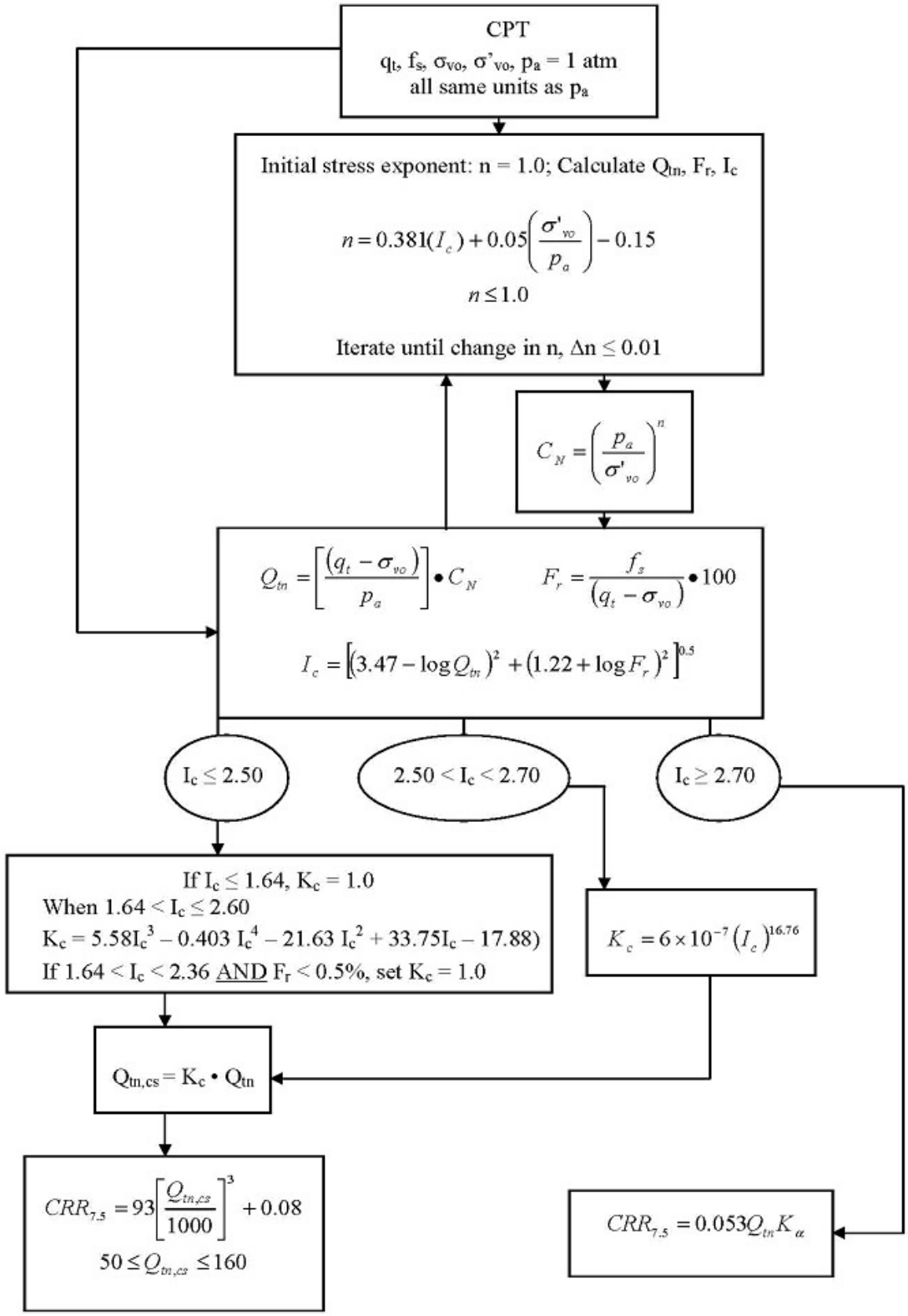
Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



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

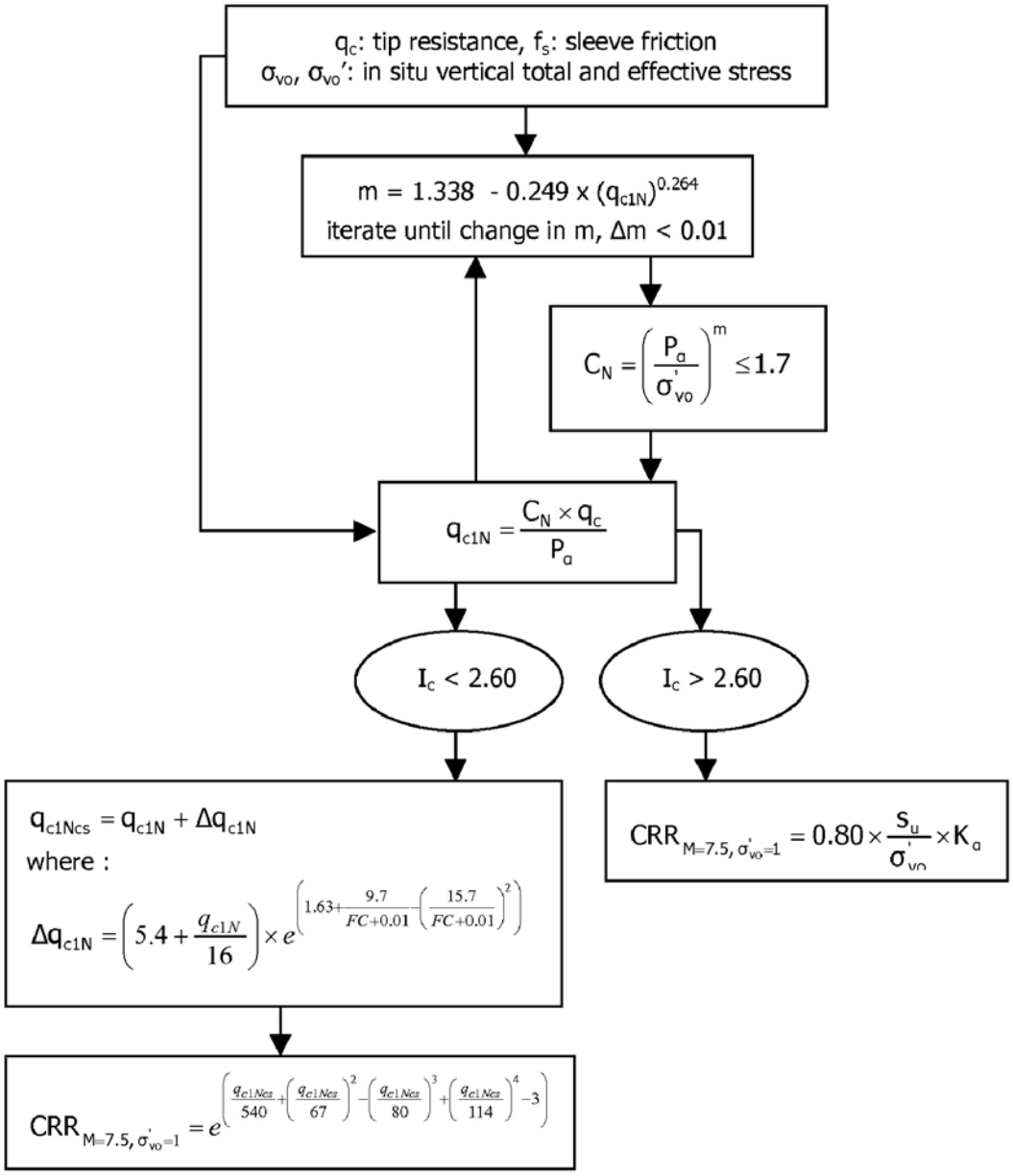
Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:

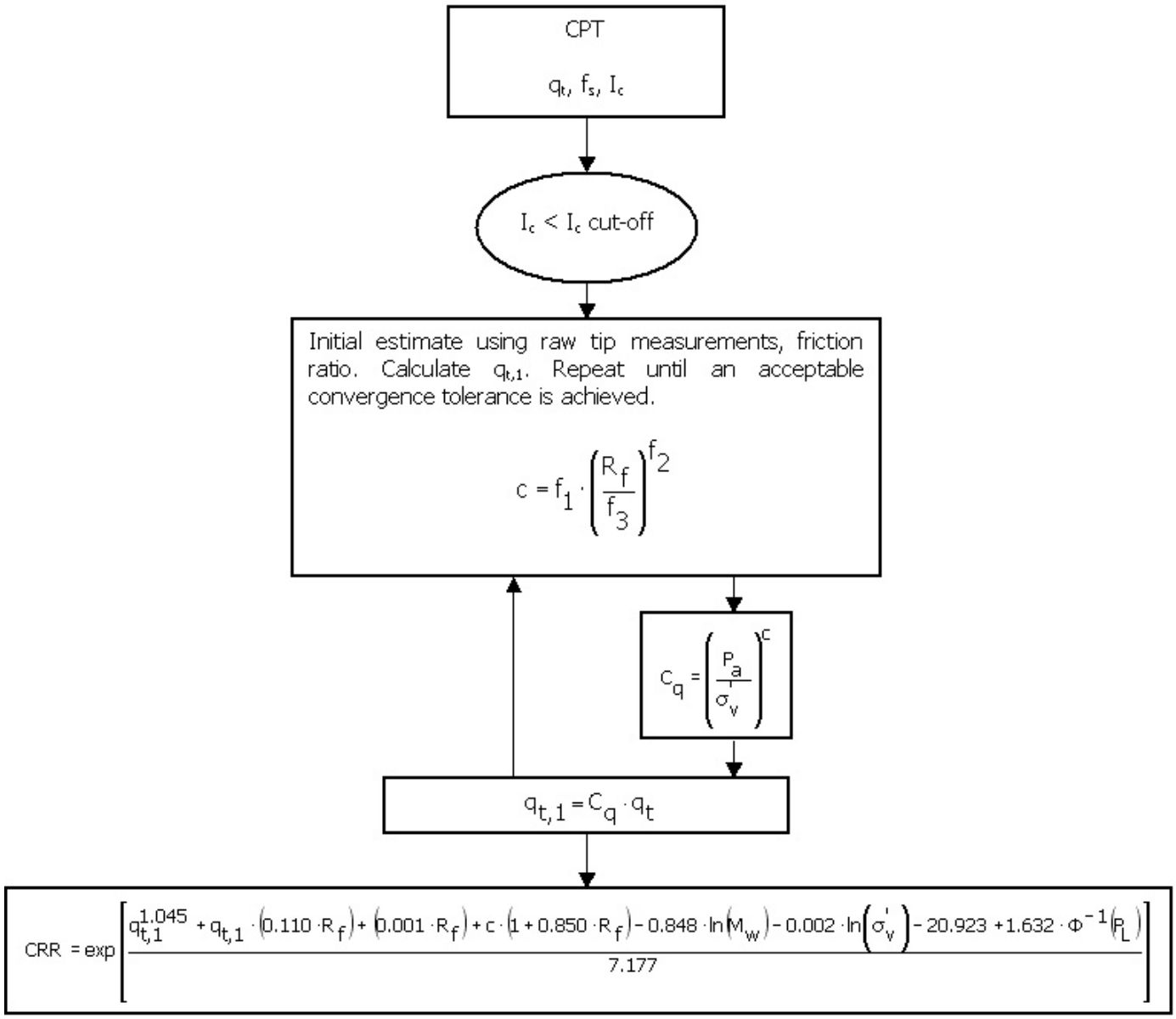


[1] P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

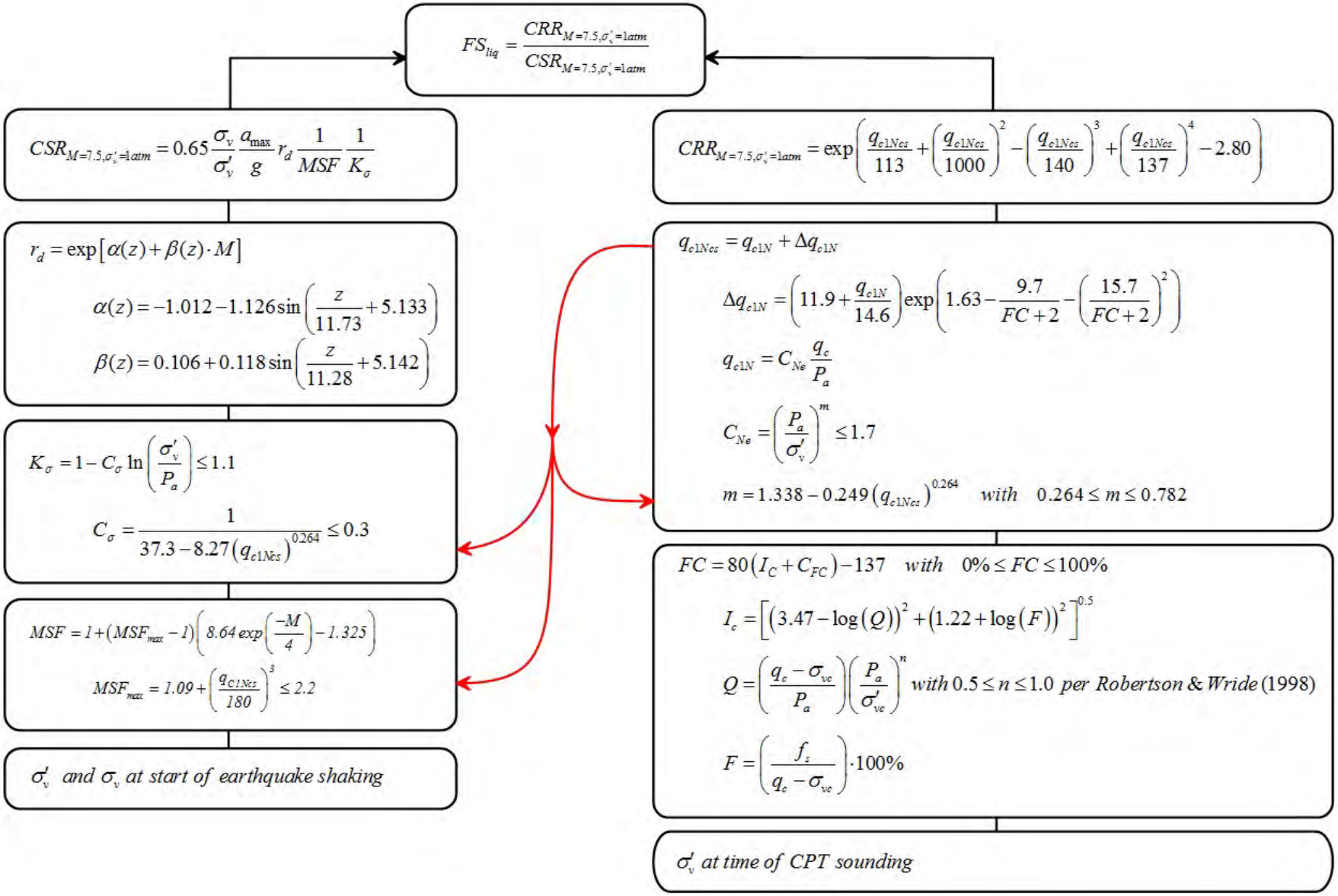
Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



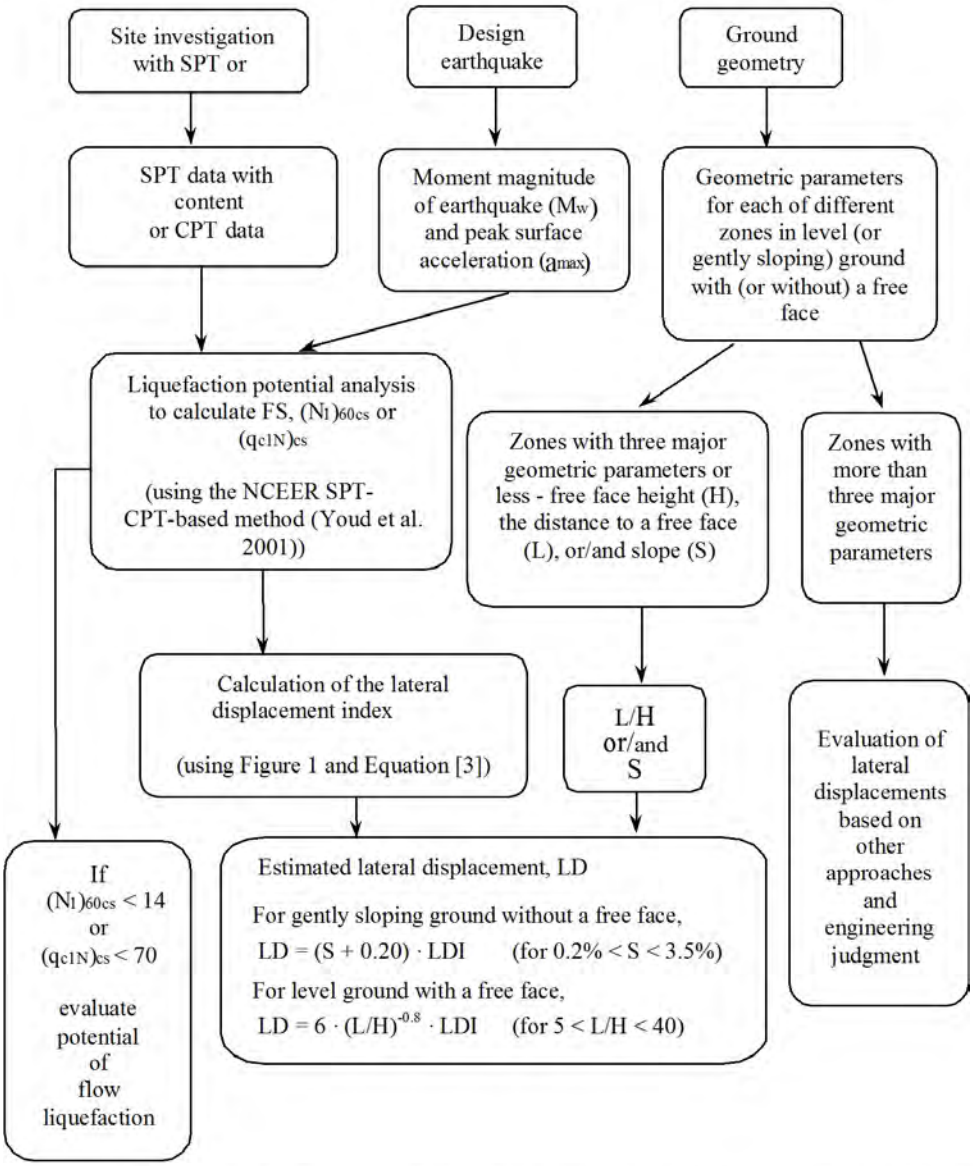
Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



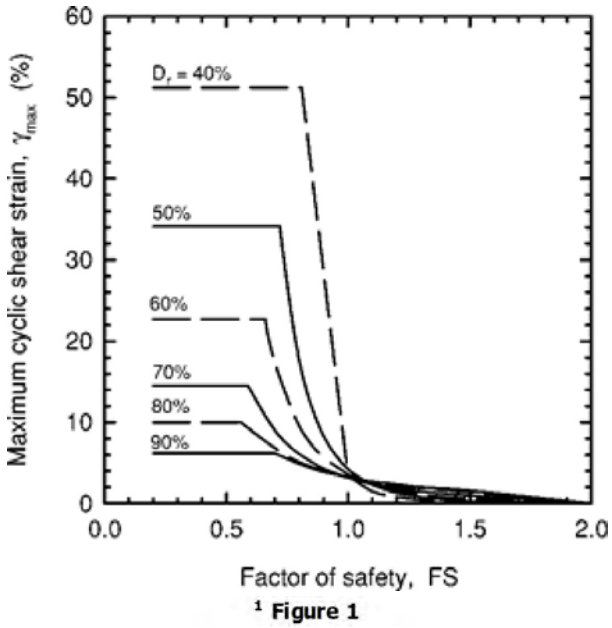
Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)



Procedure for the evaluation of liquefaction-induced lateral spreading displacements



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



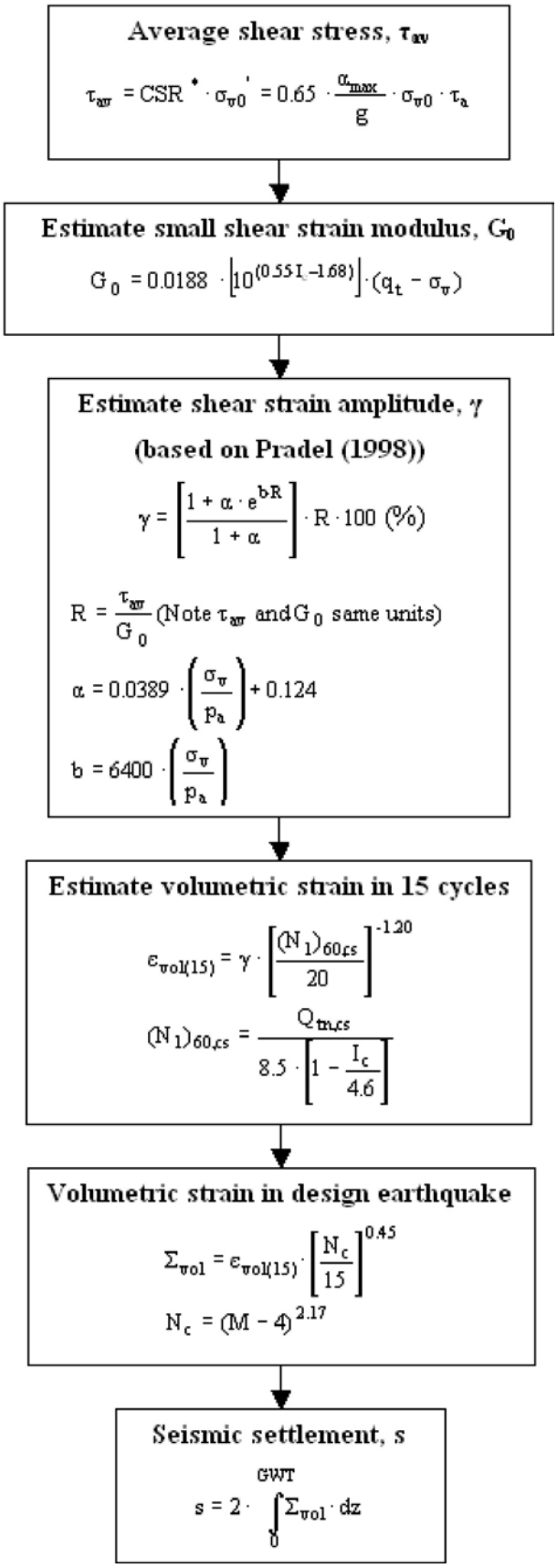
[1] **Figure 1**

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

[1] **Equation [3]**

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

Procedure for the estimation of seismic induced settlements in dry sands



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

Liquefaction Potential Index (LPI) calculation procedure

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

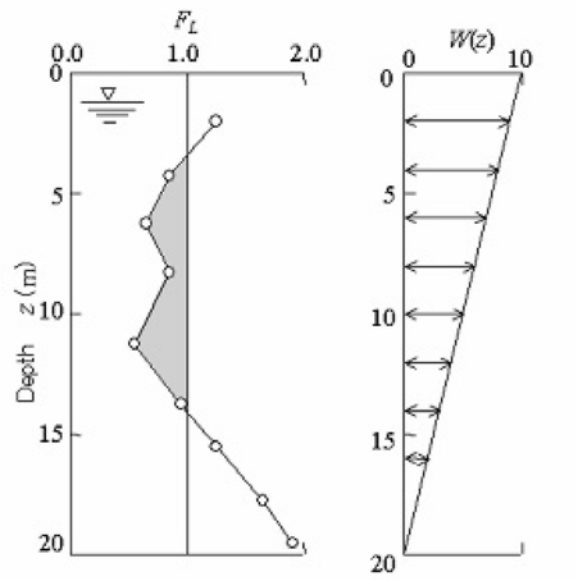
To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

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

where:
F_L = 1 - F.S. when F.S. less than 1
F_L = 0 when F.S. greater than 1
z depth of measurment in meters

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

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



Graphical presentation of the LPI calculation procedure

References

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

APPENDIX D

RILEY Dwgs:
170672-1 and -2

		DESIGN LES	CHECKED LES	APPROVED FOR ISSUE: D TATE	
		DRAWN GJ	CHECKED DT	DATE: 21/02/19	
1	FIRST ISSUE	WY	13.02.19	DATE DRAWN FEB 2019	
REV	DESCRIPTION	BY	DATE		

RILEY CONSULTANTS
P.O.BOX 100 253
NORTH SHORE
AUCKLAND 0745
TEL. 09-4897872
FAX. 09-4897873

TITLE

FLYGERS LINE INVESTMENT GROUP LIMITED

RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH

GEOTECHNICAL INVESTIGATION - SITE PLAN

CADFILE 170672-1		
SCALES (A3) 1:2500		
ACENZ	DRAWING No. 170672-1	REV. 1

LEGEND

CPT9 — CPT LOCATION

MH3 — MACHINE HOLE LOCATION

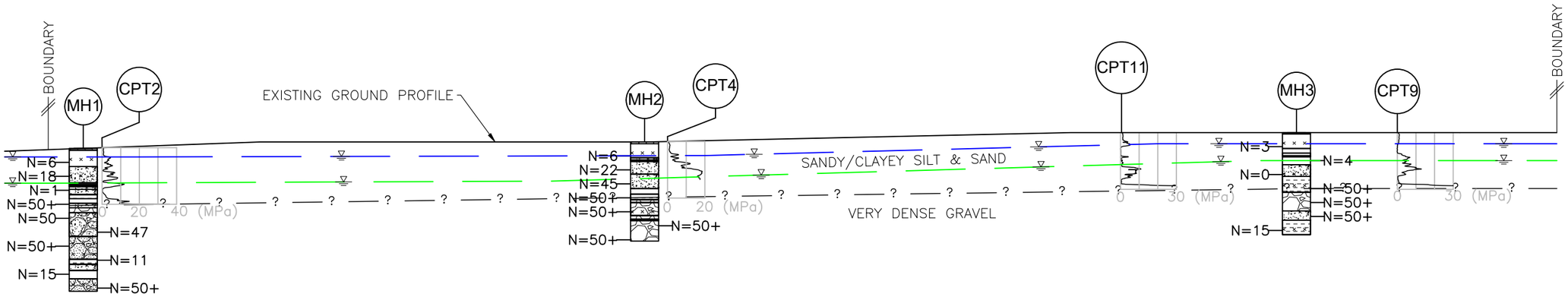
FILL | CLAY | ORGANICS

SILT | SAND | GRAVEL

N=15 SPT VALUE (RAW DATA)

WL — GROUNDWATER LEVEL (CPT, JUNE 2018)

WL — GROUNDWATER LEVEL (MH, JANUARY 2019)



CROSS SECTION A 1

HORIZONTAL SCALE 1:2500
VERTICAL SCALE 1:500

0 50 100 150 (m) SCALE 1:2500

0 5 10 15 20 30 (m) SCALE 1:500

FOR INFORMATION

REV	DESCRIPTION	BY	DATE
1	FIRST ISSUE	WY	13.02.19

DESIGN LES | CHECKED LES
DRAWN GJ | CHECKED JM
DATE DRAWN FEB 2019

APPROVED FOR ISSUE: D TATE
DATE: 21/02/19

RILEY CONSULTANTS
P.O.BOX 100 253
NORTH SHORE
AUCKLAND 0745
TEL. 09-4897872
FAX. 09-4897873

TITLE

FLYGERS LINE INVESTMENT GROUP LIMITED

RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH

GEOTECHNICAL INVESTIGATION - CROSS SECTION A

CADFILE 170672-2
SCALES (A3) AS SHOWN
ACENZ
DRAWING No. 170672-2
REV. 1