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PRIVATE PLAN CHANGE, OCEAN
RIDGE DEVELOPMENT AREA –
KAIKŌURA



GEOTECHNICAL
INVESTIGATION
REPORT

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PRIVATE PLAN CHANGE, OCEAN
RIDGE DEVELOPMENT AREA –
KAIKŌURA

GEOTECHNICAL INVESTIGATION REPORT

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SUMMARY

This report presents the results of a geotechnical investigation and appraisal undertaken for the proposed plan change request to the operative Kaikōura District Plan for the subject site located at Ocean Ridge Subdivision, Kaikōura.

The subject site comprises multiple titles and development areas (some outside of the scope of this Plan Change report), and the subject development area is best broken down into four separate ‘neighbourhood’ designations for the purpose of this report. These ‘neighbourhood’ area designations are described in Section 1.0 of this report.

The plan change is seeking to alter the anticipated land use activities of various areas within the Ocean Ridge Outline Development Plan (see Section 1.0 of this report).

The approximate location and extent of the subject site, and the various development ‘neighbourhood’ area designations, are shown on the appended Fraser Thomas Ltd drawing CH01912-G-01. The overall masterplan for the proposed development is shown on drawing CH01912-G-02.

The subsoil information, presented in Appendix A of this report, indicate that the surficial soils underlying the site are likely to comprise the following:

- (1) Holocene aged marine sediments (on the lower elevation, southern parts of the site),
- (2) Holocene aged alluvial sediments (on the lower elevation, western parts of the site),
- (3) Colluvial and landslide deposits (on the middle to upper sloping parts of the site) inferred to be of Holocene age.

The middle and upper sloping parts of the site are also generally underlain by a layer of residual soils, which are inferred to be weathering products of the underlying sandstone and limestone rock, inferred to be of the Seymour Group of Cretaceous age.

Reference has been made to the Kaikōura District Council- Digital District Plan. The District Plan indicates that the following geotechnical hazards affect some parts of the subject site:

- (1) *“Liquefaction Assessment Overlay”*, and the
- (2) *“Debris Inundation Overlay”*.

The approximate locations and extents of these hazard overlays, as they affect the subject site, are shown on the appended Fraser Thomas Ltd drawing CH01912-G-04. These hazards are addressed in Sections 8.0, 9.0, 10.0, 11.0 and 14.0 of this report.

Earthworks design recommendations are provided in Sections 18.0 and 19.0 of this report.

Likely suitable foundation solutions for the various proposed development areas are discussed in Section 15.0 of this report.

In general terms and within the limits of the investigation as outlined and reported herein, except for the slope stability issues, no unusual problems, from a geotechnical perspective, are anticipated with future residential, small-scale commercial activities and community facilities developments at the subject site.

We confirm that this report includes recommendations which will appropriately avoid, remedy or mitigate potential geotechnical hazards on the land subject to the plan change request, in accordance with the provisions of Section 106 of the Resource Management Act.

The site is, in general, considered suitable for its intended use, with satisfactory conditions for future residential and small-scale commercial activities and community facilities developments, subject to the recommendations and qualifications reported herein, and provided the design and inspection of foundations are carried out as would be done under normal circumstances in accordance with the requirements of the relevant New Zealand Standard Codes of Practice.

PRIVATE PLAN CHANGE

OCEAN RIDGE DEVELOPMENT AREA

KAIKŌURA

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TABLE OF CONTENTS

SUMMARY

1.0	INTRODUCTION	1
2.0	PREVIOUS REPORTS	2
2.1	URS, “ENGINEERING GEOLOGICAL AND GEOTECHNICAL ASSESSMENT OF THE OCEAN RIDGE DEVELOPMENT”, DATED JUNE 2005	2
2.2	AURECON NEW ZEALAND LTD, “GEOTECHNICAL INTERPRETIVE REPORT OCEAN RIDGE – PLAN CHANGE PROPOSAL”, DATED JANUARY 2010	3
2.3	GOLDER ASSOCIATES (NZ) LTD, “LIQUEFACTION STUDY FOR KAIKOURA DISTRICT”, DATED SEPTEMBER 2019	4
2.4	KAIKOURA DISTRICT COUNCIL- DIGITAL DISTRICT PLAN- HAZARD MAPS	5
2.4.1	General	5
2.4.2	Liquefaction Assessment Overlay	5
2.4.3	Debris Inundation Overlay	5
3.0	AERIAL PHOTOGRAPHS	6
3.1	GENERAL	6
3.2	1942 AERIAL PHOTOGRAPHY	6
3.3	1960S AERIAL PHOTOGRAPHY	7
3.4	1970S AERIAL PHOTOGRAPHY	7
3.5	2000S AERIAL PHOTOGRAPHY	7
4.0	GEOLOGY	8
5.0	PROPOSED PLAN CHANGE DEVELOPMENT	9
6.0	FIELD INVESTIGATION	10
6.1	GENERAL	10
6.2	RESULTS OF VISUAL APPRAISAL	11
6.2.1	General	11
6.2.2	Area H (Southern Part of the Site)	11
6.2.3	Area F (South-Western Part of the Site)	12
6.2.4	Area C (South-Western Part of the Site)	12
6.2.5	Area G (Northern and North-Western Parts of the Site)	12
6.3	MACHINE BOREHOLE INVESTIGATION	14
6.4	MACHINE EXCAVATED TEST PIT INVESTIGATION	14
6.5	CPT INVESTIGATION	15
6.6	HAND AUGERED BOREHOLE INVESTIGATION	15

7.0	SUBSURFACE CONDITIONS	15
7.1	GENERAL	15
7.2	TOPSOIL	16
7.3	NON-ENGINEERED FILL	16
7.4	ALLUVIAL SEDIMENTS	16
	7.4.1 Upper Silts and Sandy Silts	16
	7.4.2 Sandy Gravels	17
	7.4.3 Lower Silts, Clayey Silts, Gravelly Silts, Silty Sands and Sandy Silts	17
7.5	MARINE SEDIMENTS	17
7.6	COLLUVIUM AND LANDSLIDE DEBRIS	18
7.7	SEYMOUR GROUP ROCK	18
	7.7.1 Residual Soils	18
	7.7.2 Weathered Sandstone and Siltstone	19
	7.7.3 Highly Weathered Limestone	19
7.8	GROUNDWATER	20
8.0	SLOPE STABILITY APPRAISAL	21
8.1	GENERAL	21
8.2	METHOD OF ANALYSIS	21
8.3	RISK CATEGORIES	22
8.4	RESULTS AND DISCUSSION	24
	8.4.1 Results for Slope Stability Analyses	24
	8.4.2 Discussion of Results for Slope Stability Analyses	25
9.0	COMMENTS REGARDING THE KDC “DEBRIS INUNDATION OVERLAY”	25
10.0	LIQUEFACTION POTENTIAL ASSESSMENT	26
10.1	GENERAL	26
10.2	METHOD OF ANALYSIS	27
10.3	ASSESSMENT OF LIQUEFACTION SUSCEPTIBILITY	28
10.4	TRIGGERING OF LIQUEFACTION	29
10.5	CONSEQUENCES OF LIQUEFACTION	29
11.0	THEORETICAL ANALYSES OF LIQUEFACTION TRIGGERING POTENTIAL AND EXPECTED GROUND SETTLEMENTS	30
11.1	GENERAL	30
11.2	PEAK GROUND ACCELERATION (PGA) VALUES ASSUMED FOR ANALYSES	30
11.3	METHOD OF ANALYSES	32
	11.3.1 General	32
	11.3.2 Thin Sand Layer “Transition Zones”	32
	11.3.3 Summary	32
11.4	RESULTS OF ANALYSES	33
12.0	LIQUEFACTION SEVERITY NUMBER (LSN)	37
13.0	FOUNDATION TECHNICAL CATEGORY FOR THE SITE	42
14.0	COMMENTS REGARDING THE KDC “LIQUEFACTION ASSESSMENT OVERLAY”	44
15.0	LIKELY SUITABLE FOUNDATION DESIGN SOLUTIONS	44
16.0	ALLOWABLE FOUNDATION BEARING PRESSURES	46
16.1	GENERAL	46
16.2	SHALLOW PAD OR BEAM FOUNDATIONS	46

17.0	EXISTING SERVICE LINES	47
18.0	EARTHWORKS CONSIDERATIONS	47
18.1	GENERAL	47
18.2	PROPOSED FILL AREAS	48
18.3	PROPOSED CUT AREAS	49
18.4	SITE PREPARATION	49
18.5	COMPACTION CRITERIA	49
19.0	DEVELOPMENTAL EARTHWORKS	49
20.0	CONCLUSIONS AND RECOMMENDATIONS	50
20.1	CONCLUSIONS	50
20.2	RECOMMENDATIONS	54
21.0	LIMITATIONS	55

TABLES:

1	ASSUMED GROUNDWATER LEVELS FOR ANALYSIS PURPOSES	20
2	ACCEPTABLE FACTORS OF SAFETY FOR VARIOUS CATEGORIES OF RISK AS PROPOSED BY BRAND (1982)	23
3	RISK OF FAILURE OCCURRING FOR VARIOUS FACTORS OF SAFETY	23
4	DESIGN PEAK HORIZONTAL GROUND ACCELERATION (a_{max}) AND CORRESPONDING EARTHQUAKE MOMENT MAGNITUDES (M_w) VALUES FOR ASSUMED DESIGN CONDITIONS	31
5	INPUT PARAMETERS FOR LIQUEFACTION ANALYSES	33
6	THEORETICAL EXPECTED GROUND SETTLEMENTS FOR SERVICEABILITY LIMIT STATE (SLS) DESIGN EARTHQUAKE EVENT	34
7	THEORETICAL EXPECTED GROUND SETTLEMENTS FOR INTERMEDIATE LIMIT STATE (ILS) DESIGN EARTHQUAKE EVENT	35
8	THEORETICAL EXPECTED GROUND SETTLEMENTS FOR ULTIMATE LIMIT STATE (ULS) DESIGN EARTHQUAKE EVENT	36
9	LSN RANGES - CORRESPONDING TO EXPECTED LIQUEFACTION-INDUCED GROUND DAMAGE	38
10	MEAN LSN VALUE - FOR SERVICEABILITY LIMIT STATE (SLS) DESIGN EARTHQUAKE EVENT	39
11	MEAN LSN VALUE - FOR INTERMEDIATE LIMIT STATE (ILS) DESIGN EARTHQUAKE EVENT	40
12	MEAN LSN VALUE - FOR ULTIMATE LIMIT STATE (ULS) DESIGN EARTHQUAKE EVENT	41
13	EXPECTED FUTURE LAND PERFORMANCE FOR VARIOUS FOUNDATION TECHNICAL CATEGORIES	42

14	LIKELY SUITABLE FOUNDATION DESIGN SOLUTIONS	45
15	ALLOWABLE FOUNDATION BEARING PRESSURES FOR SHALLOW CONCRETE PADS OR FOUNDATION BEAMS FOUNDED IN THE UNDERLYING NATURAL GROUND OR ENGINEERED FILL	47

APPENDICES:

A	FIELD INVESTIGATION RESULTS
B	CLIQ ANALYSES RESULTS
C	SLOPE STABILITY ANALYSES RESULTS
D	DRAWINGS

DRAWINGS:

CH01912-G-01	SITE PLAN (CONTEXT)
CH01912-G-02	PROPOSED OVERALL MASTERPLAN
CH01912-G-03	SITE PLAN – FRASER THOMAS TEST LOCATIONS
CH01912-G-04	SITE PLAN – KAIKOURA DISTRICT COUNCIL HAZARD OVERLAY
CH01912-G-05	SITE PLAN – GEOMORPHOLOGICAL MAP
CH01912-G-06	SITE PLAN – PREVIOUS CONSULTANTS TEST LOCATIONS
CH01912-G-07	CROSS SECTIONS A-A' AND B-B'
CH01912-G-08	CROSS SECTIONS C-C' AND D-D'
CH01912-G-09	CROSS SECTION E-E'

PRIVATE PLAN CHANGE

OCEAN RIDGE DEVELOPMENT AREA KAIKŌURA

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation and appraisal undertaken for the proposed plan change request to the operative Kaikōura District Plan for the subject site located at Ocean Ridge Subdivision, Kaikōura.

The subject site comprises multiple titles and development areas (some outside of the scope of this Plan Change report), and the subject development area is best broken down into four separate 'neighbourhood' designations for the purpose of this report. These 'neighbourhood' area designations being:

- | | | |
|-------|-----------|--|
| (i) | Area 'H'- | Located at the toe of side slopes associated an existing (central) north-east to south-west trending ridgeline, and extending to a low lying area, adjacent to State Highway 1. Located in the southern part of the site (approximately 5.4 ha), |
| (ii) | Area 'F'- | the low-lying area adjacent to the existing golf course, located in the south-western part of the site (approximately 16.6 ha), |
| (iii) | Area 'C'- | slightly elevated area located in the south-western part of the site (approximately 4.0 ha), |
| (iv) | Area 'G'- | adjacent to the existing railway line, located in the north-western part of the site. The area encompasses the western side slopes and the ridge associated with a northeast-southwest trending ridgeline (approximately 32.0 ha). |

The plan change is seeking to alter the anticipated land use activities of various areas within the Ocean Ridge Outline Development Plan, namely:

- Areas 'C' and 'G' will be retained for residential purposes but with an overall increase in residential density;
- portions of Area 'H' and Kekenō Park will be repurposed from their respective low density residential and utility uses to enable an overall increase in the land identified on the Outline Development Plan as 'Mixed Use Area';
- portions of Area 'F' identified on the Outline Development Plan as 'Open Space / Grazing' will be repurposed for residential, community and commercial uses.

The approximate location and extent of the subject site, and the various development 'neighbourhood' area designations, are shown on the appended Fraser Thomas Ltd drawing CH01912-G-01. The overall masterplan for the proposed development is shown on drawing CH01912-G-02.

There are also existing areas within the Ocean Ridge development, identified as Areas A, B D(i) and E, which have been previously subject to subdivisional development. These areas are outside of the scope of the Plan Change. These areas are also indicated on drawings CH01912-G-01 and CH01912-G-02.

The subsurface conditions underlying the subject site have been investigated by means of three machine boreholes, fourteen Cone Penetration Test soundings, sixteen machine excavated test pits, and twelve hand augered boreholes with associated Dynamic Cone Penetrometer (DCP) scale tests. A visual appraisal of the site and a study of geological maps have also been undertaken.

The purpose of the geotechnical investigation reported herein was to determine the subsoil conditions beneath the subject site as they may affect future residential and potentially light commercial development, with particular regard to foundation design considerations, and to determine the suitability of the subject site for residential and potentially light commercial development, in support of a plan change.

2.0 PREVIOUS REPORTS

2.1 URS, "ENGINEERING GEOLOGICAL AND GEOTECHNICAL ASSESSMENT OF THE OCEAN RIDGE DEVELOPMENT", DATED JUNE 2005

A previous report, titled *"Engineering Geological and Geotechnical Assessment for the Ocean Ridge Development"*, dated June 2005, has been prepared by URS for the Ocean Ridge subdivision.

Geotechnical investigations were undertaken for the June 2005 report, which comprised 34 Test Pits and 6 Dynamic Cone Penetrometer Tests. The approximate inferred locations of the URS test positions are presented on the appended Fraser Thomas Ltd drawing CH01912-G-06.

The 2005 report states the following, regarding soils encountered onsite:

"Colluvial soil appears to overlie the majority of the proposed development site. The soil can be broadly described as an unweathered, compact, yellowish-brown, massive silt/clay that occasionally contains sand. The soil colour suggests the presence of wind deposited loess, which has been subsequently been transported downhill after deposition and mixed with the products of weathered rock."

The June 2005 report states the following, with regard to the liquefaction potential at the then proposed subdivision:

"Alluvial sediments are present in a small part of the west of the proposed subdivision. None of the test pits in this area (TP1, 2 & 3) had sediments susceptible to liquefaction. The intrinsically variable nature of alluvial deposits suggests that liquefaction will not impede development of the subdivision."

The June 2005 report states the following, with regard to slope instability at the site:

“In the eastern part of the proposed subdivision, where the topography is relatively steep, at least twenty shallow slips have occurred. These range from large, 100 m long landslips that have exposed soil, to more subtle hummocky or bulging ground where material has not moved more than a metre or two. According to the previous landowner, many of these occurred in 1975 during Cyclone Alison, an extreme rainfall event. Subsequent planting of trees in some of these areas for slope stabilisation purposes has meant that many slips can be readily identified on aerial photographs... Most slips appear to be located in gullies or concave parts of the slope. They are generally shallow features, and probably have a failure plane depth of between 1 and 4 m beneath the ground surface and occur on slopes of between approximately 25 – 55° above the horizontal plane. The previous landowner has noted a single episode of land instability in the last 19 years. In approximately 1993 unusually heavy rain caused a reactivation of the lowest part of the ‘Big Slip’. This slip was 10 m wide and 20 m long and travelled approximately 2 m downhill.”

and that:

“The distribution of slips is relatively uniform and does not appear to be controlled by the orientation of the rock strata beneath the surface. Instead slips appear to be failing along a soft layer of clay a few metres beneath the surface.”

The URS 2005 report included a site plan of with observations of “*landslides or hummocky, unstable ground*”. The approximate inferred locations of the URS “*landslides or hummocky, unstable ground*” is presented on the appended Fraser Thomas Ltd drawing CH01912-G-05.

2.2 AURECON NEW ZEALAND LTD, “GEOTECHNICAL INTERPRETIVE REPORT OCEAN RIDGE – PLAN CHANGE PROPOSAL”, DATED JANUARY 2010

A previous report, titled “*Geotechnical Interpretive Report Ocean Ridge- Plan Change Proposal*”, dated 27 January 2010, was previously prepared by Aurecon New Zealand Ltd for the Ocean Ridge subdivision site.

Geotechnical investigations were undertaken for the January 2010 report, which comprised 7 Test Pits. The approximate inferred locations of the Aurecon test positions are presented on the appended Fraser Thomas Ltd drawing CH01912-G-06.

The January 2010 report states the following with regard to the suitability of the site, for the then proposed plan change:

“Based on our observations, investigations and review of published data, we determined that there are no geotechnical reasons to prevent the proposed plan change of the northern area and the proposed subdivision and plan change of the south eastern area. We also conclude that both the proposed development areas discussed in this report comply with the intent of clauses (a) and (b) of Section 106 of the RMA, provided the suitable mitigation measures are put in place as described in this report, required by consent conditions and determined at the subdivision engineering design stage.”

The January 2010 report states the following, with regard to slope instability at the site:

“There are potentially two historic landslips on the site affecting the future buildable areas. These slips were already reported by URS in their report. TP3 was excavated in the centre of the larger slip, however no evidence of the slip surface was found. The second slip area was walked over and mapped. Both slipped areas lie within the proposed buildable areas of the northern development area, they should both be investigated further in detail during the detailed design process, to determine what remediation will be required to enable the site to be built on.

We note that these areas of potential instability form only a small part of the overall site, but should both be investigated further during the detailed design process, to determine what remediation (if any) is required. Mitigation measures that were used successfully on similar areas of instability in the already developed part of the greater Ocean Ridge Development include; geogrid reinforced soil retention; gabion retaining walls; herring drainage systems; cut, removal and landscaping; and avoidance of the hazard. We recommend that a chartered geotechnical engineer should undertake the investigations, make recommendations for potential remediation and finalise the positioning of the buildable areas.”

2.3 GOLDER ASSOCIATES (NZ) LTD, “LIQUEFACTION STUDY FOR KAIKOURA DISTRICT”, DATED SEPTEMBER 2019

A previous report titled *“Liquefaction study for Kaikoura District”*, dated September 2019, was prepared by Golder Associates (NZ) Ltd for Environment Canterbury and Kaikoura District Council.

The September 2019 report was prepared in order to determine the parts of the Kaikoura area which may be susceptible to the damaging effects of liquefaction induced ground deformations and areas where liquefaction induced damage is unlikely to occur.

Figure B10, presented in the September 2019 report, indicates that the majority of the subject site (i.e. north-west, north and central portions) is sited in the zone where the September 2019 report indicates that damaging liquefaction induced ground deformation is considered to be *“unlikely”*.

The September 2019 report goes on to state the following with regard to this zone:

“Liquefaction damage is possible (as defined in MBIE 2017) in some areas within this zone but unlikely. This zone is dominated by alluvial deposits older than Holocene age and river plains and fans far away from the coastal margins. Liquefaction potential should be discussed/confirmed by a suitably qualified engineer or engineering geologist.”

Figure 2.1 presented in the September 2019 report, indicates that the southern and western portions of the subject site is sited within the zone where the September 2019 report indicates that liquefaction damage is *“possible”*. The September 2019 report goes on to state the following with regard to this zone:

“Liquefaction damage is possible (as defined by MBIE 2017) in this zone... Input from a suitably qualified geotechnical engineer or engineering geologist is required for adequate ground characterisation regarding liquefaction potential. Deep investigations, such as cone penetration testing or borehole drilling with standard penetration tests, are required unless in specific cases where the geotechnical engineer or engineering geologist can justify that they are not necessary.”

The approximate location and extent of the area of the subject site, which have been identified by the September 2019 report as being classified as “liquefaction damage is possible” are shown on the appended Fraser Thomas drawing CH01912-G-04.

2.4 KAIKOURA DISTRICT COUNCIL - DIGITAL DISTRICT PLAN- HAZARD MAPS

2.4.1 General

Reference has been made to the Kaikoura District Council- Digital District Plan. The District Plan indicates that the following geotechnical hazards affect some parts of the subject site:

- (3) “*Liquefaction Assessment Overlay*”, and the
- (4) “*Debris Inundation Overlay*”.

The approximate locations and extents of these hazard overlays, as they affect the subject site, are shown on the appended Fraser Thomas Ltd drawing CH01912-G-04.

2.4.2 Liquefaction Assessment Overlay

As shown on drawing CH019121-G-03 the “*Liquefaction Assessment Overlay*” affects the following areas of the site:

- (i) The low lying area in the south and south-western parts of the site, affecting parts of Area F and Area H
- (ii) The low lying area abutting the railway line, adjacent to the north-western site boundary, affecting a small part of Area G.

The Kaikoura District Council Digital Plan “*Liquefaction Assessment Overlay*” states the following, with regard to this mapped area:

“Liquefaction damage is possible. Input from geotech engineer needed for ground characterisation regarding liquefaction potential. Deep investigations as per section 3.4 of MBIE 2017. Inv. Level C or D (depending on scope) per Table 3.2 of MBIE 2017 N.B. Data for Ocean Ridge was amended during the 2021-22 natural hazards plan change notification and consultation process prior to adoption into the district plan in October 2022 - see HITS ticket GIS-2786 & earlier related tickets.”

It is noted that the District Plan “*Liquefaction Assessment Overlay*” does not quite align with the September 2019 “*Liquefaction study for Kaikoura District*” report, discussed in Section 2.3 of this report. A part of the proposed Area G development area is mapped in the “*Liquefaction Assessment Overlay*” as “liquefaction is possible”, but is mapped as “*Liquefaction Damage is unlikely*” in the September 2019 “*Liquefaction study for Kaikoura District*” report.

2.4.3 Debris Inundation Overlay

As shown on drawing CH01912-G-04 the “*Debris Inundation Overlay*” is primarily mapped in the parts of the Ocean Ridge subdivision site which are outside the scope of the proposed plan change. However, an area in the southern part of Area G has this hazard overlay.

The Kaikoura District Council Digital Plan “*Debris Inundation Overlay*” states the following, with regard to this mapped area:

“Debris inundation overlay from the KDC natural hazards plan change 3 as adopted in October 2022. Merges landslide debris and alluvial fan debris inundation under scenario 4 - see HITS ticket GIS-2786 and preceding tickets for background, with the original scenario 4 data being provided on October 22nd 2021 by Saskia de Vilder of GNS Science and explained by Nick Griffiths of ECan on October 27th 2021.”

The Kaikoura District Council District Plan states the following, with regard to subdivision activity within areas mapped as a “*Debris Inundation Overlay*”:

“may be subject to damage by erosion, subsidence, fault rupture, liquefaction, flooding, landslide debris inundation, debris flow fan or flooding”:

and goes on to state:

“13.2.1 Objective 1 To avoid subdivision in localities where it is likely to increase risk to people or property from erosion, sea level rise, subsidence, fault rupture, liquefaction, flooding, landslide debris inundation and debris flow fans slippage or inundation from any source, unless this risk can be remedied, avoided or mitigated without significant adverse effects on the environment.”

3.0 AERIAL PHOTOGRAPHS

3.1 GENERAL

A range of historic aerial photography of the site, ranging from 1942 to 2018, has been examined, as part of the site appreciation.

3.2 1942 AERIAL PHOTOGRAPHY

Aerial photography, captured on 10 December 1942, shows at the time of capture, the subject site generally comprised pastoral farmland. The site was surrounded by paddocks of a similar nature, and the present-day railway line, running along the northern-western edge of the site, appears to be undergoing construction at this time.

A large historic landslide/area of instability (referred to hereafter as the “pre-1940’s landslide”), is present in Area G. This landslide appears to have occurred (evident by significant scalloping and hummocks in the hillside) some time prior to the date, as there is no obvious ‘fresh’ scarping visible in the aerial photography. It also appears that successive landslide events have occurred in this area, based on the ‘different’ hummocky and slumped areas appearing to overlie one another. The footprint of the landslide is vegetated with grass (i.e. no shrubs/trees), along with the rest of the slopes in the site.

It also appears, at the time of this capture, that recent landslides (referred to hereafter as the “Big Slip”) had occurred on the slopes above Area H, contemporaneously with the date of capture, but appear to have occurred more recently than the large landslide within Area G (due to the apparent ‘freshness’ of the landslide head scarps). It appears the debris from these landslides (based on the apparent ‘bulging’ at the toe of these slopes) partially encroached into the northern portion of Area H. It also appears that a pond is present in Area H, near the toe of these south-facing side slopes.

3.3 1960s AERIAL PHOTOGRAPHY

A review of aerial photography, dated 8 October 1961, indicates that, in the decades prior to this capture, a planting effort had been undertaken in the area of the “pre-1940’s landslide” in Area G, inferred to be an attempt to stabilise this landslide with trees. It appears that, prior to the date of capture, reactivation of the existing displaced landslide material occurred, as indicated by the formation of a head scarp, located roughly centrally within the “pre-1940’s landslide” footprint area. It appears that some of the landslide runout debris has deposited on the slopes below this reactivated head scarp.

This capture also indicates widespread surficial slippage had occurred on the hillsides in the vicinity of the site, suggesting there may have been contemporaneous inclement weather causing widespread instability on the slopes, in the area, at that time.

Aerial photography, captured on 28 September 1962, also provides a clearer image of the pond in the Area H, (in particular in the vicinity of No 1 Ludley Drive), and also more clarity on the areas of instability above Area H.

3.4 1970s AERIAL PHOTOGRAPHY

A review of aerial photography, captured on 29 September 1975, indicates widespread surficial slippage had occurred on the hillsides in the vicinity of the site, inferred to be as a result of Cyclone Alison (1975), as discussed in Section 2.1 of this report. It is noted that this imagery does not quite capture the area of the site.

Aerial photography, captured on 15 March 1976, indicates that, prior to this date, a series of shallow landslides had occurred in Area G. In particular, three seemingly shallow translational type landslides, are observed on the west-facing side slopes associated with the ridgeline extending through Area G. These landslides appear to have occurred within the surficial soils, and are inferred to be related to overland stormwater flow associated with Cyclone Alison (1975).

This aerial imagery also shows, in the area to the north of the “pre-1940’s landslide”, an area of bulging in the hillside, inferred to be indicative of ongoing slope movement, in the surficial soils.

3.5 2000s AERIAL PHOTOGRAPHY

A review of aerial photography, captured on 13 January 2000, indicates that a shallow landslide occurred in the area of ‘bulging’ observed for the west-facing side slopes, in the area to the north of the “pre-1940’s landslide”, at some point between 1976 and 2000. This landslide feature appears to be ‘fresh’, and likely occurred sometime not long prior to the 2000 capture. This landslide is referred to herein, as the “2000’s landslide”.

It also appears that generally the slopes previously exhibiting instability, in proximity to Area H, have been vegetated, sometime between 1976 and 2000, which is inferred to have been undertaken as a slope stabilisation measure.

Aerial photography, captured on 24 March 2007, indicates that the subdivisional earthworks and infrastructure for parts of the Ocean Ridge subdivision (Areas A, B, H and part of D(i)) had been completed prior to this date.

It is not obvious, based on the aerial photography, when the previously existing pond within Area H was infilled. It is understood, based on anecdotal information from the then development engineer in the 2000s, that this area was not subject to any significant bulk earthworks.

4.0 GEOLOGY

In assessing the geology of the site, reference has been made to the Institute of Geological & Nuclear Sciences Geological Map 13, scale 1:250,000, “Kaikoura”. An excerpt from this map is presented in Figure 1.

The geological map indicates that the site is likely underlain by various geological units, comprising:

- “Undifferentiated well-sorted fine-grained sandstone, commonly sulphurous muddy siltstone, conglomerate, micritic limestone and turbidites” of the Seymour Group of Late Cretaceous age (Ky),
- “Marine sand and gravel beneath lower coastal terraces” marine sediments of middle Pleistocene age (Q5b),
- “River gravel, sand with minor silt, and fan deposits” alluvial sediments of Pleistocene age (Q2a),
- “Postglacial deposits, including river gravel and sand, fan deposits” alluvial sediments of Holocene age (Q1a),
- Beach sand and gravel, underlying present day coastal plain” marine sediments of Holocene age (Q1b).



Figure 1: Excerpt from Geological & Nuclear Sciences Geological Map 13, scale 1:250,000, “Kaikoura”. The development areas of the site are roughly outlined in red line.

The results of the investigations reported herein, in general, indicate that the surficial soils underlying the site are likely to comprise:

- (a) Holocene aged marine sediments (on the lower elevation, southern parts, of the site),
- (b) Holocene aged alluvial sediments (on the lower elevation, southern and south-western, parts of the site),
- (c) colluvial and landslide deposits (on the side slopes of the site) inferred to be of Holocene age.

The upper sloping parts of the site are also generally underlain by a layer of residual soils, which are inferred to be weathering products of the underlying sandstone and limestone rock, inferred to be of the Seymour Group of Cretaceous age.

The closest mapped active fault, as indicated by the GNS Active Fault Database, is the Hope Fault, located a distance of approximately 7 km north of the site.

The published recurrence interval class of the Hope Fault is identified as “I” (i.e. >0 to <2000 years), with a slip rate identified as “Very High” (i.e. >10mm/year).

5.0 PROPOSED PLAN CHANGE DEVELOPMENT

As discussed in Section 1.0 of this report, the subject site comprises multiple titles and development areas (some outside of the scope of this Plan Change report), and the subject development area is best broken down into four separate ‘neighbourhood’ designations for the purpose of this report.

These ‘neighbourhood’ area designations being:

- (i) Area ‘H’- Located at the toe of side slopes associated with an existing (central) north-east to south-west trending ridgeline, and extending to a low lying area, adjacent to State Highway 1. Located in the southern part of the site (approximately 5.4 ha),
- (ii) Area ‘F’- the low-lying area adjacent to the existing golf course, located in the south-western part of the site (approximately 16.6 ha),
- (iii) Area ‘C’- slightly elevated area located in the south-western part of the site (approximately 4.0 ha),
- (iv) Area ‘G’- adjacent to the existing railway line, located in the north-western part of the site. The area encompasses the western side slopes and the ridge associated with a northeast-southwest trending ridgeline (approximately 32.0 ha).

The approximate location and extent of the subject site, and the various development ‘neighbourhood’ area designations, are shown on the appended Fraser Thomas Ltd drawing CH01912-G-01. The overall masterplan for the proposed development is shown on drawing CH01912-G-02.

There are also existing areas within the Ocean Ridge development, identified as Areas A, B D(i) and E, which have been previously subject to subdivisional development. These areas are outside of the scope of the Plan Change. These areas are also indicated on drawings CH01912-G-01 and CH01912-G-02.

Based on our understanding of the overall masterplan, the future development in the various areas will generally comprise the following:

- | | |
|--------|--|
| Area H | Provision of new roading and infrastructure for the development of a multi-use area, including residential, small-scale commercial activities and community facility buildings. Fill earthworks to be undertaken to backfill existing dry basin at Keken Park, subject to future reserve exchange. Excavation earthworks to be undertaken to create a new dry basin, as part of the stormwater management system. |
| Area F | Provision of new roading and infrastructure for the development of a new residential area. Bulk fill earthworks to be undertaken to form a 'raised' level building platform on the flood plain (adjacent to the Kowhai River and the golf course). |
| Area C | Provision of new roading and infrastructure for the development of a new residential area. Cut and fill earthworks to be undertaken to form an access road for this area. |
| Area G | Provision of new roading and infrastructure for the development of a new residential area. Ocean Ridge Drive extension will be constructed through the western part of this area. Cut and fill earthworks to be undertaken to form suitable carriageways for the Ocean Ridge Drive extension and other access roads. In general, the cut earthworks will be undertaken along the ridgeline within this area, and the filling will be undertaken along the toe of an existing landslide feature, in order to provide toe buttress support in this area. |
- Excavation earthworks to be undertaken to create a new dry basin, and to form a stormwater channel, along the western site boundary (as part of the stormwater management system).

6.0 FIELD INVESTIGATION

6.1 GENERAL

The field investigation comprised a visual appraisal, 3 machine boreholes, 14 Cone Penetration Test (CPT) soundings, 16 machine excavated test pits, and 12 hand augered boreholes with associated Dynamic Cone Penetrometer (DCP) scale tests.

The approximate locations of the investigation test positions associated with Fraser Thomas Ltd investigations are shown on Fraser Thomas Ltd drawing CH01912-G-03.

As discussed in Section 2.0 of this report, previous geotechnical investigations, including two machine boreholes, have been undertaken at the subject site by other consultants. The results of these investigations have also been used as part of our site appreciation works. These test locations are presented on the appended Fraser Thomas Ltd drawing CH01912-G-06.

6.2 RESULTS OF VISUAL APPRAISAL

6.2.1 General

Visual appraisals of the various development areas of the subject site were undertaken by a Fraser Thomas Ltd engineering geologist on 7 to 10 October 2024.

The approximate location and extent of the subject site, development areas and site features are shown on the appended Fraser Thomas Ltd drawings CH01912-G-01 and CH01912-G-05.

The results of the visual appraisals are detailed in the following sections.

6.2.2 Area H (Southern Part of the Site)

The Area H development area is located in the southern part of the Ocean Ridge subdivision, generally between State Highway 1 (to the south), and Ingles Drive (to the north). This area has been previously developed with some roading infrastructure (Kersage Drive, Ludley Drive and Fidele Lane).

The topography within Area H area, south of Ludley Drive, is predominantly flat (with localised slope angles of between approximately 6° to 9° to the horizontal). This part of the site was generally vegetated with grass, at time of the investigation reported herein.

The topography, north of Ludley Drive, generally slopes gently to moderately with a southerly aspect, at slope angles ranging between approximately 2° and 16° to the horizontal. These slopes are generally vegetated with grass.

The south facing slopes, abutting Area H, exhibit, in places, hummocky and undulating landforms. It is understood that historic landslides have occurred on these south facing side slopes, as discussed in Sections 2.1 and 3.0 of this report. The 2005 URS report describes a “Big Slip” in this area, which is understood to have reactivated in 1993. The approximate inferred location and extent of this landslide is shown on drawing CH01912-G-05.

The surficial soils in the northern part of Area H are inferred to comprise landslide debris (colluvium material).

The upper parts of the side slopes, in this area, are currently densely vegetated with trees, and it appears that slope stability remediation works have been undertaken, in the vicinity of the “Big Slip”, as part of the previous Ocean Ridge subdivisional development works, these works included:

- (i) Construction of a gabion basket retaining wall system,
- (ii) Planting of trees to re-vegetate the side slopes,
- (iii) Construction of Ingles Drive along the crest of the ridgeline, with the provision of kerb and channel and reticulated stormwater collection, which prevents the concentration of overland stormwater onto the south-facing side slopes.

No obvious signs of any significant ground deformation, that could be attributed to liquefaction induced ground movement, were observed within the subject site, at the time of the investigation reported herein.

6.2.3 Area F (South-Western Part of the Site)

The Area F development area is located in the south-western part of Ocean Ridge subdivision, adjacent to the Kaikōura Golf Club golf course and the Kowhai River, and on the southern side of an existing railway embankment. An existing river access track, trending east to west, roughly bisects this development area.

The topography within the Area F development area, south of the river access track, is generally flat pastoral farmland, and is vegetated with paddock grass. An existing shallow watercourse, with an associated swampy margin, is located along the eastern edge of this development area. Water was observed ponding in the 'swampy area', at the time of the investigation reported herein.

The topography within Area F, north of the access track, generally slopes with a southerly aspect at slope angles of between approximately 6° and 12° to the horizontal. This area is also pastoral farmland, and is vegetated with paddock grass. Several localised ephemeral streams and drains appear to have been cut into the slopes in this area, and appear to be draining towards an existing pond/swamp, located in the eastern part of Area F.

Signs of surficial soil creep and shallow-seated slope instability were observed on the steeper south-facing side slopes within Area F.

No obvious signs of any significant ground deformation, that could be attributed to liquefaction induced ground movement, were observed within the subject site, at the time of the investigation reported herein.

6.2.4 Area C (South-Western Part of the Site)

The Area C development area is located in the south-western part of Ocean Ridge subdivision, abutting Area F. Area C is generally sited on the crest of a north-west to south-east trending ridgeline. The proposed development area is located to the west of Ocean Ridge Drive, and is located to south side of the existing railway line.

The topography within Area C generally comprises a roughly flat plateau, bordered on the south-western side by a steep (up to approximately 38°) side slope, and on the north-eastern side by gentle to moderately sloping slopes, of between approximately 9° and 18°. An existing incised gully, with shallow creek, is located at the toe of the north-east facing side slope.

Completely weathered fine grained sandstone rock was observed in the existing railway cut, located along the northern site boundary.

Signs of surficial soil creep and shallow-seated slope instability were observed on the steeper slopes within Area C.

No obvious signs of any significant ground deformation, that could be attributed to liquefaction induced ground movement, were observed within the subject site, at the time of the investigation reported herein.

6.2.5 Area G (Northern and North-Western Parts of the Site)

The Area G development area is located in the north-western and northern parts of Ocean Ridge subdivision, and is generally sited on the flank and crest of a north-east to south-west trending ridgeline. The existing railway line generally extends along the western boundary of Area G.

The side slopes associated with the ridgeline generally slope at slope angles ranging between approximately 15° and 28° to the horizontal. The area between the toe of the side slopes and the western site boundary is generally flatter, and slopes at between approximately 2° and 7° to the horizontal.

Signs of surficial soil creep and shallow-seated slope instability were observed on the steeper side slopes within Area G.

As discussed in Section 3.2 of this report, an area of historic instability (referred to as the “pre-1940’s landslide”) is sited within Area G. The historic landslide occurred on the western flank of the ridgeline feature, at the northern end of the site. The side slopes, in the vicinity of the historic instability, generally slope at between approximately 13° and 16° to the horizontal. The historic head scarp of the original landslide is not easily identified, due to vegetative cover and likely erosion effects.

A reactivation ‘mid scarp’, inferred to be associated with a translational landslide within the footprint of the historic landslide feature, was observed approximately centrally within the footprint of the historic landslide feature. The head scarp is between approximately 0.6 m and 0.8 m in vertical height. The debris lobe positioned below the “pre-1940’s landslide” is vegetated with several mature poplar trees (discussed in Section 3.3), and smaller manuka and broom shrubs. At the toe of the zone of depletion a pond was observed, approximately 0.5 m in depth. It is possible that the landslide movement has resulted in a change to the hydrological conditions of the surficial soils in this area, which has prevented the normal flow of groundwater, which has resulted in the manifestation of groundwater locally at the ground surface (see drawing CH01912-G-07, Cross Section B-B’).

As discussed in Section 3.5 of this report, a review of aerial photography, captured on 13 January 2000, indicates that a landslide also occurred on the western flank of the northeast-southwest trending ridgeline. The side slopes in the vicinity of the “2000’s landslide” generally slope at between approximately 13° and 16°. This landslide appears to be a rotational landslide and likely occurred as a result of the concentration of overland stormwater flow at the north-western end of the existing ridgeline at the site, during a severe weather event. The head scarp is approximately 1.0 m in vertical height (see drawing CH01912-G-08, Cross Section C-C’).

As discussed in Section 3.4 of this report, aerial photography, captured on 15 March 1976, indicates that, prior to this date, a series of landslides had occurred within Area G. In particular, three translational type landslides occurred on the west-facing side slopes associated with the ridge which extends through Area G. These landslides are evident today by localised depressions in the steeper hummocky flanks of the ridgeline, generally sloping at between approximately 15° and 28° to the horizontal.

The approximate inferred locations of the various landslide head scarps, and the inferred extents of the landslide debris run-out areas are shown on drawing CH01912-G-05.

No obvious signs of any significant ground deformation, that could be attributed to liquefaction induced ground movement, were observed within the subject site, at the time of the investigation reported herein.

6.3 MACHINE BOREHOLE INVESTIGATION

Three “sonic” cored machine boreholes, numbered M1, M2 and M3, were put down at the site on 27 to 31 January 2025, in order to investigate the shallow subsurface conditions beneath the subject site.

The machine boreholes were conducted under the supervision of a qualified Fraser Thomas Ltd engineering geologist.

As discussed in Section 6.1 of this report, two existing machine boreholes, understood to have been put down under the direction of other consultants, are also located on the site. Subsoil information has been obtained from the previous machine boreholes and has been used for appraisal purposes in this report.

The existing machine boreholes are identified as Machine Boreholes BH01 and BH02.

The machine boreholes were terminated at depths of between approximately 15.2 m and 21.3 m below the existing ground surface.

Standard Penetration Tests (SPT) were carried out, in order to quantify the properties of the soils.

The logs of Machine Boreholes M1, M2 and M3 and BH01 and BH02 are presented in Appendix A of this report.

The approximate locations of the test positions are shown on the appended drawings CH01912-G-03 and CH01912-G-06.

A standpipe piezometer was installed in Machine Borehole M2, in order to measure and monitor the groundwater level underlying the subject site.

6.4 MACHINE EXCAVATED TEST PIT INVESTIGATION

Sixteen machine excavated test pits, numbered TP1 to TP16 inclusive, were put down at the site on 9 and 10 October 2024, in order to investigate the shallow subsurface conditions beneath the subject site.

The test pits were excavated under the supervision of a qualified Fraser Thomas Ltd engineering geologist.

The test pits were terminated at depths ranging between approximately 2.2 m and 3.3 m below the ground surface existing at the time of the investigation reported herein (the existing ground surface).

All soils in the test pits were carefully logged.

In situ undrained shear strength measurements were carried out, where possible, within the cohesive materials encountered in the test pits, using hand held field shear vane equipment.

Dynamic Cone Penetrometer (DCP) scala tests were performed from the ground surface, adjacent to Test Pits TP1 and TP3.

The approximate locations of the test positions are shown on the appended drawing CH01912-G-03.

6.5 CPT INVESTIGATION

Fourteen Cone Penetration Test (CPT) soundings, numbered CPT1 to CPT14 inclusive, were carried out at the site on 14 and 15 October 2024, under the direction of Fraser Thomas Ltd. The CPT soundings were pushed in order to obtain continuous strength profiles for the subsoils, and for the purpose of determining the theoretical liquefaction potential of the soils.

The CPT soundings were terminated at depths of between approximately 1.9 m and 10.4 m below the existing ground surface.

The CPT data has been interpreted using the computer program CPeT-IT. The results of the interpretation of the CPT data are presented in Appendix A of this report.

The approximate locations of the CPT soundings are shown on drawing CH01912-G-03.

6.6 HAND AUGERED BOREHOLE INVESTIGATION

Twelve hand augered boreholes, numbered H1 to H12 inclusive, were put down at the site between 7 and 10 October 2024, in order to determine the nature and consistency of the subsoils underlying the site.

The boreholes were put down by a qualified Fraser Thomas Ltd engineering geologist. The logs of the boreholes are presented in Appendix A of this report.

The boreholes were terminated, when soils became too difficult to auger, at depths of between approximately 0.5 m and 2.5 m below the existing ground surface.

All soils in the boreholes were carefully logged.

In situ undrained shear strength measurements were carried out, where possible, within the cohesive materials encountered in the boreholes, using hand held field shear vane equipment.

Dynamic Cone Penetrometer (DCP) scala testing was undertaken from the ground surface adjacent to Boreholes H1, H2, H11 and H12, and from the bases of Boreholes H2 and H4.

The results of the DCP scala testing are also presented in Appendix A of this report.

The approximate locations of Boreholes H1 to H12 inclusive are shown on drawing CH01912-G-03.

7.0 SUBSURFACE CONDITIONS

7.1 GENERAL

The subsoil information, presented in Appendix A of this report, indicate that the surficial soils underlying the site are likely to comprise the following:

- (1) Holocene aged marine sediments (on the lower elevation, southern parts of the site),
- (2) Holocene aged alluvial sediments (on the lower elevation, western parts of the site),
- (3) Colluvial and landslide deposits (on the middle to upper sloping parts of the site) inferred to be of Holocene age.

The middle and upper sloping parts of the site are also generally underlain by a layer of residual soils, which are inferred to be weathering products of the underlying sandstone and limestone rock, inferred to be of the Seymour Group of Cretaceous age.

It has been assumed that even though the various subsoil strata (depths, thicknesses, and locations of groundwater levels) have been determined only at the locations and within the depths of the various test positions recorded herein, these various subsurface features can be projected between the various test positions. Even though such inference is made, no guarantee can be given as to the validity of this inference or of the nature and continuity of these various subsurface features.

7.2 TOPSOIL

A surficial layer of topsoil, generally comprising silts, was encountered to depths of between approximately 0.1 m and 0.4 m below the existing ground surface, at the locations of the test positions. Generally, the surficial topsoil layer is no thicker than approximately 0.3 m.

7.3 NON-ENGINEERED FILL

As discussed in Section 3.5 of this report, aerial photography, captured on 24 March 2007, indicates that prior to this date the developmental earthworks and infrastructure for some parts of the Ocean Ridge subdivision had been completed.

The aerial photography appears to indicate the presence of a pond within Area H. This pond is no longer evident at the site, so it appears that, at some time between 2007 and the present, it was backfilled.

A layer of fill material, generally comprising clayey silts, cobbly gravels and gravelly silts, was encountered at the location of Test Pit 3, put down in the vicinity of the inferred location of the backfilled pond. The fill was encountered to a depth of approximately 1.5 m below the existing ground surface, at the location of this test pit.

In situ undrained shear strength values in excess of 200 kPa were generally measured in the cohesive fill material, using hand held shear vane equipment, corresponding to a hard consistency. It is our opinion that the fill material encountered at the location of Test Pit 3 is likely to be fill material associated with the backfilling of the previously existing pond at the site.

It is not known if the backfill material was subject to specific placement and compaction, however, due to the nature of the fill encountered, it is our opinion that the fill should be considered to be non-engineered.

The approximate inferred location of the previously existing pond, is shown on drawing CH01912-G-05.

7.4 ALLUVIAL SEDIMENTS

7.4.1 Upper Silts and Sandy Silts

The results of the CPT soundings, boreholes and machine excavated test pit investigations reported herein indicate that the surficial layer of topsoil, at the locations of Test Pit TP4, and Cone Penetration Test soundings CPT1, CPT2, CPT3, CPT4 and CPT6 (located in the western, lower parts of Area F), is underlain by a layer of material comprising sandy silts and silts, inferred to be alluvial sediments of Holocene age. These sediments were encountered to depths of between approximately 1.7 m and 3.3 m below the existing ground surface, at locations of Test Pit TP4, and Cone Penetration Test soundings CPT1, CPT2, CPT3 and CPT4.

In situ undrained shear strength values of between approximately 69 kPa and 78 kPa were generally measured in these cohesive sediments, using hand held shear vane equipment, corresponding to a stiff consistency.

The CPT soundings generally obtained cone resistance (q_t) values of between approximately 0.4 MPa and 4.3 MPa in the alluvial sediments, corresponding to in situ undrained shear strength values of between approximately 30 kPa and in excess of 200 kPa, corresponding to a firm to hard consistency.

7.4.2 Sandy Gravels

The results of the CPT soundings, hand augered boreholes and machine excavated test pit investigation reported herein indicate that the surficial soils, at the locations of Test Pit TP4, and Cone Penetration Test soundings CPT1, CPT2 and CPT4 (located in the western, lower parts of Area F), is underlain by a layer of material comprising sandy gravels, inferred to be alluvial sediments of Holocene age.

These sediments were encountered at depths of between approximately 1.7 m and 3.3 m approximately, and encountered to depths of between 1.9 m and 4.5 m below ground level. The sandy gravels were encountered to the extents of the test positions. These CPT soundings were unable to be progressed through the sandy gravels.

These CPT soundings obtained cone resistance (q_t) values of generally greater than 20 MPa in these sediments, corresponding to very dense consistency.

This layer of sandy gravels was also encountered at a depth of approximately 1.5 m below the existing ground surface, at the locations of Machine Boreholes M1 and M2. These sediments were generally encountered to the extent of M2, i.e. to a depth of at least approximately 15.2 m below the existing ground surface. Machine Borehole M2 was terminated in the sandy gravels, so the vertical extent of this layer of sandy gravels was unable to be determined, at the location of M2.

These sediments were generally encountered to a depth of approximately 5.0 m below the existing ground surface, at the location of Machine Borehole M1.

SPT 'N' values measured in these soils generally ranged between 33 and greater than 50, corresponding to a dense to very dense consistency.

7.4.3 Lower Silts, Clayey Silts, Gravelly Silts, Silty Sands and Sandy Silts

The results of the machine borehole investigations reported herein indicate that the surficial soil layers, at the location of Borehole M1 (i.e. below the upper 5.0 m), is underlain by a layer of material comprising a mixture of firm to stiff silts, clayey silts, gravelly silts, silty sand and sandy silts, inferred to be alluvial sediments of Holocene age. These sediments were encountered to the extent of M1, i.e. to a depth of at least approximately 15.2 m below the existing ground surface.

7.5 MARINE SEDIMENTS

The results of the CPT soundings, hand augered boreholes and machine excavated test pit investigation reported herein indicate that the surficial layers of topsoil, at the locations of Test Pits TP1, TP3, hand augered Boreholes H1 and H11, and Cone Penetration Test soundings CPT12 to CPT14 inclusive (located in the southern, lower parts of Area H), is underlain by a layer of material comprising gravelly sands and gravels, inferred to be marine sediments of Holocene age. These sediments were encountered to the extents of Test Pits TP1, TP3, Borehole H1, and Cone Penetration Test soundings CPT12, CPT13 and CPT14.

The results of the DCP tests undertaken in the sandy gravels generally obtained DCP blow counts of between approximately 4 and greater than 15 blows per 100 mm penetration, generally corresponding to SPT 'N' values of between 21 and greater than 50, corresponding to a medium dense to very dense consistency.

The CPT soundings obtained cone resistance (q_t) values of generally greater than 20 MPa in these sediments, corresponding to very dense consistency.

7.6 COLLUVIUM AND LANDSLIDE DEBRIS

The results of the field investigation presented herein indicate the 'sloping' parts of the site are generally mantled by a surficial layer material inferred to be loess derived colluvium and landslide debris. This material generally comprised silts, clayey silts, gravelly silts and silty gravels. This colluvium and landslide debris was encountered at the locations of Test Pits TP2, TP5, TP7 to TP12 inclusive, and TP16, hand augered Boreholes H2, H3, H5, H6, H7, H10 and H11, and Cone Penetration Test soundings CPT5 to CPT11 inclusive.

These soils were encountered at depths of between approximately 0.2 m and 1.3 m below the existing ground surface, and to depths of between approximately 0.3 m and 6.3 m below the existing ground surface, at the locations of these test positions. These soils were encountered to the extents of Test Pit TP2, and Boreholes H2, H3, H10 and H11.

In situ undrained shear strength values ranging between approximately 90 kPa and in excess of 200 kPa were measured in these soils, corresponding to a stiff to hard consistency.

The CPT soundings obtained cone resistance (q_t) values of between approximately 0.6 MPa and 21.0 MPa (but generally around approximately 3.5 MPa) in these soils, corresponding to in situ undrained shear strength values of between approximately 40 kPa and in excess of 200 kPa (generally in excess of 200 kPa), corresponding to a firm to hard consistency.

7.7 SEYMOUR GROUP ROCK

7.7.1 Residual Soils

Residual soils, inferred to be weathering products of the underlying Seymour Group bedrock, generally comprising clayey silts, were encountered at the locations of Machine Boreholes M3 and BH01 and BH02, Test Pits TP2, TP5, TP7 to TP12 inclusive and TP16, hand augered Boreholes H4 to H9 inclusive and H12, and Cone Penetration Test soundings CPT5 to CPT11 inclusive.

These soils were encountered at depths of between approximately 0.2 m and 6.2 m below the existing ground surface, and to depths of between approximately 0.8 m and 10.2 m below the existing ground surface, at the locations of these test positions. These soils were encountered to the extents of Test Pits TP5, TP6, TP9, and Boreholes H5, H6, H7, and Cone Penetration Test sounding CPT7.

In situ undrained shear strength values ranging between approximately 102 kPa and in excess of 200 kPa were measured in these soils, corresponding to a very stiff to hard consistency.

These CPT soundings obtained cone resistance (q_t) values of between approximately 1.7 MPa and 30.0 MPa in the inferred residual soils, corresponding to in situ undrained shear strength values of between approximately 120 kPa and in excess of 200 kPa, corresponding to a very stiff to hard consistency.

7.7.2 Weathered Sandstone and Siltstone

The surficial residual soils at the site are inferred to be underlain by a layer of completely weathered sandstone and siltstone of the Seymour Group, of Late Cretaceous age.

This material contains some “rock fabric”, but is considered to generally have the characteristics of a hard soil, and is considered to be an extremely weak rock.

This material was encountered at depths of between approximately 0.1 m and 3.5 m below the existing ground surface, and to depths of between approximately 2.2 m and 10.4 m below the existing ground surface, at the locations of these test positions. These soils were encountered to the extents of Test Pits TP7, TP8, TP10 to TP16 inclusive, hand augered Boreholes H8, H9 and H12, and Cone Penetration Test soundings CPT3, CPT5, CPT6, CPT8 to CPT11 inclusive.

This sandstone was also encountered at the locations of Machine Boreholes M3, BH01 and BH02, at depths of between approximately 1.4 m and 14.3 m below the existing ground surface.

A full description of the sandstone and siltstone is shown on the logs for Machine Boreholes M3, BH01 and BH02. The vertical extent of the rock was not determined at the locations of the machine boreholes.

It is inferred that, due to the weakness of the rock, the high intensity vibrations associated with the sonic drilling method are likely to have caused some damage/disturbance to the retrieved core.

Due to the core disturbance, it is difficult to determine the strength of the rock (and intact rock parameters), using typical field logging techniques, however, individual clasts of undisturbed sandstone were identified to be extremely weak to very weak.

SPT testing undertaken within the sandstone rock obtained SPT ‘N’ values of between approximately 29 and greater than 60.

Based on the foregoing, the fine grained sandstone and siltstone is generally inferred to be completely to moderately weathered, extremely weak to very weak.

7.7.3 Highly Weathered Limestone

The surficial residual soils beneath the crest of the ridgeline extending through Area G are inferred to be underlain by a layer of material comprising highly weathered limestone inferred to be of the Seymour Group.

This layer was inferred to be encountered at a depth of approximately 0.8 m below the existing ground surface, at the location of hand augered Borehole H4, and as encountered to the extent of this test position.

The highly weathered limestone rock is inferred to be weak to moderately strong.

7.8 GROUNDWATER

Groundwater was not encountered at the location of Machine Borehole M3, and generally not encountered at the locations of the hand augered boreholes and machine excavated test pits, at the time of the investigations reported herein, except at the following test locations:

- (i) TP3 (Area H) - 2.9 m below existing ground surface,
- (ii) TP4 (Area F) - 2.8 m below the existing ground surface.

Groundwater was encountered at the locations of the following machine boreholes, at the time of the investigations reported herein:

- (i) M1 (Area F) - 3.4 m below existing ground surface,
- (ii) M2 (Area F) - 3.0 m below existing ground surface (with piezometer).

It should be noted that following the completion of the CPT sounding investigations, the CPT contractor dipped the holes using a water level meter. The measured depths of 'saturation' measured at the locations of the CPT soundings are provided below:

- (i) CPT2 (Area F) - 0.9 m below existing ground surface (likely perched),
- (ii) CPT3 (Area F) - 5.1 m below existing ground surface,
- (iii) CPT5 (Area F) - 6.2 m below existing ground surface,
- (iv) CPT7 (Area C) - 5.2 m below existing ground surface.

Based on the groundwater levels measured during the investigations reported herein, and allowing for possible wet winter and climate change induced groundwater level increases over the next 100 years, conservative groundwater levels, for analysis purposes, have been adopted for the following areas. These are presented in Table 1.

TABLE 1: ASSUMED GROUNDWATER LEVELS FOR ANALYSIS PURPOSES

Development Area	Inferred Groundwater Depth (below the existing ground surface)
Area F (low-lying part)	2.0 m
Area F (higher elevations)	4.5 m
Area C	4.5 m
Area G	4.5 m
Area H	2.2 m

8.0 SLOPE STABILITY APPRAISAL

8.1 GENERAL

As discussed in Sections 2.0, 3.0 and 6.2 of this report, there is evidence of past slope instability affecting some of the slopes at the subject site.

In order to assess the landslide hazard at the site, slope stability analyses have been undertaken for the soil veneer materials, located in the vicinity of observed historic land instability, at the following locations:

- (1) West-facing side slope in the vicinity of the '2000's landslide' feature in Area G (represented by Cross Section C-C')
- (2) West-facing side slope through the 'pre-1940's landslide' feature in Area G (represented by Cross Section B-B')
- (3) West-facing side slope at the southern end of the ridgeline extending through Area G (represented by Cross Section A-A')
- (4) South-facing side slope in the vicinity of the 'Big Slip' landslide feature, identified for the 2005 URS report, abutting Area H (represented by Cross Section E-E').

The locations of Cross Sections A-A', B-B', C-C', and E-E' are shown on drawing CH01912-G-05.

8.2 METHOD OF ANALYSIS

The stability of the moderately sloping slopes within the site have been analysed using the computer programme Slope/W, for critical circular slip surfaces.

Slope/W is a computer programme that uses the limit equilibrium theory to solve for the theoretical factor of safety of earth and rock slopes. The comprehensive formulation of Slope/W makes it possible to select a variety of methods for computing the factor of safety, and to analyse both simple and complex geometric, stratigraphic, and loading conditions. Slope/W allows slope stability to be analysed by up to nine methods, including the more mathematically rigorous Morgenstern-Price and Generalised Limit Equilibrium (GLE) methods. For the purpose of the analyses reported herein, the theoretical factor of safety values derived from the Morgenstern-Price method of analysis have been adopted for the potential slip surfaces.

As discussed in Section 2.1 of this report, it was speculated by URS Ltd that the various slips at the site *"appear to be failing along a soft layer of clay a few metres beneath the surface"*, inferred to be a layer in the vicinity of the soil and rock interface.

Back Analyses

It has been assumed that the 'pre-1940's landslide' feature is the result of historical translational and rotational landslides in this area. The assumed slope profiles (based on adjacent topography), prior to these landslides occurring, have been back analysed for a defined potential slope movement under assumed extreme transient groundwater conditions, which were based on the conservative assumption of a groundwater level which could possibly occur after long periods of prolonged intense rainfall.

Back analyses undertaken for the slope failures yielded effective design parameters of 26° friction angle and 1 kPa effective cohesion for the veneer soils (colluvium), based on the assumption that the phreatic surface was coincident with the ground surface at the time of failure, in order to obtain a theoretical factor of safety value of 1.0 (i.e. an assumed failure condition).

Forward Analyses

Testing undertaken in the vicinity of the landslides did not indicate any obvious soft clay layers that may be serving as a failure plane (though they may exist as disparate units). Accordingly, forward analyses have been undertaken for the moderate sloping slopes at the site for a circular slip surface, as appropriate to the slope geometry and stratigraphy, using the computer programme Slope/W for critical circular slip surfaces, and assuming the design effective strength parameters (yielded by back analyses of the “pre-1940s landslide”) of 26° friction angle and 1 kPa cohesion for the surficial colluvium soils, and assuming design effective strength parameters of 28° friction angle and 3 kPa cohesion, for the residual soils, and 32° friction angle and 25 kPa cohesion, for the completely weathered extremely weak sandstone and limestone.

The analyses were undertaken under two different inferred groundwater conditions, estimated to represent wet winter and extreme transient groundwater conditions. Wet winter groundwater conditions were based on raised groundwater levels. Extreme transient groundwater conditions were generally based on the conservative assumption that the slope will become partially saturated during periods of prolonged intense rainfall.

8.3 RISK CATEGORIES

Traditionally, if a theoretical factor of safety value of 1.5 can be achieved by analysis, then the slope is considered to be stable. The problem arises in determining the correct parameters to use and the influence of subsurface conditions on the form of analysis, and which is consequently dependent on the nature and level of investigation.

Cumulating experience suggests that the proper selection of a theoretical factor of safety value for slope stability purposes is dependent upon a proper assessment of the level of risk.

The risk category of a particular slope is governed by the consequences of failure in terms of loss of life, property damage, or destruction of communications and services.

Typical high risk slopes are those where there is a likelihood of loss of life should the slope fail, e.g. schools or apartments below cut slopes. A low risk slope, for example, is one which will only threaten a secondary road.

Brand (1982) cites design theoretical factor of safety values for residual soils for a 1 in 10 year return period storm for various risk categories as shown in Table 2 of this report.

TABLE 2: ACCEPTABLE FACTORS OF SAFETY FOR VARIOUS CATEGORIES OF RISK AS PROPOSED BY BRAND (1982)

Risk Category	Minimum Factor of Safety for Transient Conditions (e.g. a 1 in 10 Year Storm)
Low	1.2
Significant	1.3
High	1.4

Factors of safety have been adopted in geotechnical design to cover the uncertainties in slope geology, soil data, the method of analysis adopted and the validity of assumptions made.

For these reasons, it is customary to adopt a theoretical factor of safety value of 1.5 for subdivisions or housing development. This factor of safety does not in every case assure safety from instability or slope movement. Based on published literature, the average risk of failure, or the probability of failure occurring, for different adopted factors of safety, is given in Table 3.

TABLE 3: RISK OF FAILURE OCCURRING FOR VARIOUS FACTORS OF SAFETY

Factor of Safety	Risk of Failure Per Annum
1.1	1:10
1.3	1:50
1.5	1:200
1.7	1:1000

It is our opinion that the slopes on the subject site fall into the low to possibly significant risk category. It is, therefore, concluded that while the conventionally accepted minimum value of approximately 1.5 should be adopted for the conventional stability analyses relating to groundwater levels "raised" for wet winter conditions, a lower acceptable theoretical factor of safety value of between 1.2 and 1.3 could be adopted for the transient groundwater condition for saturation states that could occur during a period of prolonged intense rainfall, such as a 1 in 10 year return period storm.

8.4 RESULTS AND DISCUSSION

8.4.1 Results for Slope Stability Analyses

(a) Cross Section A-A'

The side slopes, represented by Cross Section A-A', generally slope at between approximately 20° to the horizontal (1V:2.74H) and 28° to the horizontal (1V:1.88H), with a vertical height of approximately 40 m between the crest and the toe.

Slope/W yielded a theoretical factor of safety value of 1.52 and 1.31 for the inferred wet winter and extreme transient groundwater levels, respectively. These values are considered to be satisfactory, being equivalent to the limiting values of 1.5 and 1.2 to 1.3, for the assumed wet winter and extreme transient groundwater conditions respectively.

(b) Cross Section B-B'

The side slopes, represented by Cross Section B-B', within the footprint of the existing landslide feature, generally slope at between approximately 16° to the horizontal (1V:3.48H) and 25° to the horizontal (1V:2.14H), with a vertical height of approximately 35 m between the crest and the toe.

Slope/W yielded theoretical factor of safety values of 1.6 and 1.0 for the inferred wet winter and extreme transient groundwater conditions respectively. The wet winter value is considered to be satisfactory, being greater than the limiting values of 1.5 and 1.3. The extreme transient value is considered to be unsatisfactory, being less than the limiting 1.2, for the extreme transient groundwater conditions.

(c) Cross Section C-C'

The side slopes, represented by Cross Section C-C', generally slope at between approximately 16° to the horizontal (1V:3.48H) and 25° to the horizontal (1V:2.14H), with a vertical height of approximately 35 m between the crest and the toe.

Slope/W yielded a theoretical factor of safety value of 2.38 and 2.17 for the inferred wet winter and extreme transient groundwater levels, respectively. These values are considered to be satisfactory, being greater than the limiting values of 1.5 and 1.2 to 1.3, for the assumed wet winter and extreme transient groundwater conditions respectively.

(d) Cross Section E-E'

The south-facing side slopes, represented by Cross Section E-E', generally slope at between approximately 15° to the horizontal (1V:3.73) and 22° to the horizontal (1V:2.47H), with a vertical height of approximately 38 m between the Ingles Drive and the toe.

Slope/W yielded a theoretical factor of safety value of 1.88 and 1.64 for the inferred wet winter and extreme transient groundwater levels, respectively. These values are considered to be satisfactory, being greater than the limiting values of 1.5 and 1.2 to 1.3, for the assumed wet winter and extreme transient groundwater conditions respectively.

8.4.2 Discussion of Results for Slope Stability Analyses

The results of the slope stability analyses reported herein, generally indicate that the side slopes at the site have satisfactory theoretical factor of safety values against deep-seated instability of the veneer soils.

There is a risk of re-activation of the landslide in the vicinity of the 'pre-1940's landslide' located within Area G, particularly under extent transient groundwater conditions. It is recommended that buttress trench drains be installed within this area, in order to control the groundwater levels within the slope and to mitigate against the risk of groundwater levels rising to a level which may result in slope instability.

As discussed in Section 5.0 of this report, the proposed development within Area G will involve cut earthworks along the ridgeline, and filling, along the toe of the existing landslide feature. These works will further improve the stability of the landslide affected area by:

- (i) Reducing the driving force at the top of a potential slip circle
- (ii) Providing toe buttress support to the toe of any potential slip circle.

It is anticipated that these works can be addressed at the detailed design stage associated with any subdivisional development in this area.

9.0 COMMENTS REGARDING THE KDC "DEBRIS INUNDATION OVERLAY"

As discussed in Section 2.4.3 of this report, Kaikōura District Council have produced 'hazard overlays' for the subject site, which includes a "*Debris Inundation Overlay*".

As shown on drawing CH019121-G-04 the "*Debris Inundation Overlay*" is primarily mapped in the parts of the Ocean Ridge subdivision site which are outside the scope of the proposed plan change. However, an area in the southern part of Area G has this hazard overlay.

The Kaikoura District Council District Plan states the following, with regard to subdivision activity within areas mapped as a "*Debris Inundation Overlay*":

"may be subject to damage by erosion, subsidence, fault rupture, liquefaction, flooding, landslide debris inundation, debris flow fan or flooding":

and goes on to state:

"13.2.1 Objective 1 To avoid subdivision in localities where it is likely to increase risk to people or property from erosion, sea level rise, subsidence, fault rupture, liquefaction, flooding, landslide debris inundation and debris flow fans slippage or inundation from any source, unless this risk can be remedied, avoided or mitigated without significant adverse effects on the environment."

Based on the results of our site-specific investigation and appraisal of this area, we comment as follows:

- (1) The results of the slope stability analyses reported herein, for Cross Section A-A' (in the vicinity of the mapped hazard overlay), generally indicate that the side slopes in this area have satisfactory theoretical factor of safety values against deep-seated instability of the veneer soils.
- (2) The proposed development works will involve cut earthworks along the ridgeline and the construction of roading and infrastructure at the crest of the side slope. These works will further improve the stability of the west-facing slopes in this area by:
 - (i) Reducing the driving force at the top of a potential slip circle
 - (ii) Intercepting and directing any potential overland stormwater flows away from the crest of the slope, so as to prevent the concentration of stormwater onto the side slopes.
- (3) Based on the foregoing, it is our opinion that the risk of any deep-seated instability of the side slopes in the southern part of Area G (in the area affected by the "*Debris Inundation Overlay*") is low, and that future residential development in this area should not be restricted due to potential geotechnical hazards associated with slope instability.

We confirm that this report includes recommendations which will appropriately avoid, remedy or mitigate potential geotechnical hazards on the land subject to the plan change request, in accordance with the provisions of Section 106 of the Resource Management Act.

Given the steepness of some of the side slopes, there is a risk of some slopes being affected by shallow soil creep. This is a common mechanism of shallow surficial soil movement for slopes typically steeper than 18° to the horizontal and will be addressed at the subdivision stage, and for any site-specific geotechnical reports prepared for specific building developments (in support of an application for building consent). Foundations can be designed for the effects of surficial soils creep, so as to meet the performance requirements of the New Zealand Building Code.

10.0 LIQUEFACTION POTENTIAL ASSESSMENT

10.1 GENERAL

Liquefaction is defined as the phenomenon that occurs when soils are subject to a sudden loss in shear stiffness and strength associated with a reduction in effective stress due to cyclic loading (i.e. ground shaking associated with an earthquake).

The two main effects of liquefaction on soils are:

- (a) Consolidation of the liquefied soils,
- (b) Reduction in shear strength within the liquefied soils.

Liquefaction is considered to occur when the soils reach a condition of "zero effective stress". It is considered that only "sand like" soils can reach a condition of "zero effective stress" and therefore only "sand like" soils are considered to be liquefiable.

An indication that the underlying soils have been subject to liquefaction is the surface expression of ejected sand and water. This occurs as a result of the dissipation of excess pore water pressures generated within the liquefied soils as a result of the cyclic loading.

It should be noted that cohesive type materials or “clay like” soils are unlikely to be subject to liquefaction, as these soils (due to their nature) are unlikely to develop sufficient excess pore water pressures during cyclic loading to reach a condition of zero effective stress, i.e. the point of liquefaction.

However, “clay like” soils do develop some excess pore water pressures during cyclic loading which can result in consolidation settlement and a temporary reduction of the shear strength (i.e. softening) of the soils. Sensitive “clay like” soils are in particular susceptible to softening as a result of cyclic loading.

A liquefaction potential assessment has been undertaken for the soils underlying the subject site.

10.2 METHOD OF ANALYSIS

The New Zealand Geotechnical Society released Guidelines, in 2016 (revised in November 2021), with the objective of summarising current best practice in earthquake geotechnical engineering with a focus on New Zealand conditions. The main purpose of the Guidelines is to promote consistency of approach to everyday engineering practice in New Zealand and, thus, improve geotechnical earthquake aspects of the performance of the built environment.

The Guidelines consists of six modules (identified as Modules 1 to 6 inclusive).

“Module 3: Identification Assessment and Mitigation of Liquefaction Hazards” of the Guidelines provides guidance on the identification of liquefaction hazards, and also provides details regarding different methodologies for determining theoretical liquefaction triggering.

The Module 3 guideline suggests a three step process for the liquefaction assessment of sites, generally being:

- (i) Step 1: Assessment of liquefaction susceptibility,
- (ii) Step 2: Triggering of liquefaction,
- (iii) Step 3: Consequences of liquefaction.

The Module 3 guideline refers to the methods suggested by “Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils”, dated October 2001. The guideline, among others, also refers to papers by Youd et al; Seed; Idriss; Boulanger; Robertson and Bray.

A liquefaction potential assessment of the soils underlying the subject site has been undertaken using the methods suggested by the Module 3 guideline.

10.3 ASSESSMENT OF LIQUEFACTION SUSCEPTIBILITY

The following soils are generally considered to be susceptible to liquefaction:

- (a) Young (typically Holocene age) alluvial sediments (typically fluvial deposits laid down in a low energy environment) or man-made fills,
- (b) Poorly consolidated/compacted sands and silty sands,
- (c) Areas with a high groundwater level.

As discussed in Section 4.0 of this report, the geological map indicates that the site is likely underlain by various geological units, comprising:

- *“Undifferentiated well-sorted fine-grained sandstone, commonly sulphurous muddy siltstone, conglomerate, micritic limestone and turbidites”* of the Seymour Group of Late Cretaceous age (Ky),
- *“Marine sand and gravel beneath lower coastal terraces”* marine sediments of mid Pleistocene age (Q5b),
- *“River gravel, sand with minor silt, and fan deposits”* alluvial sediments of Pleistocene age (Q2a),
- *“Postglacial deposits, including river gravel and sand, fan deposits”* alluvial sediments of Holocene age (Q1a),
- *Beach sand and gravel, underlying present day coastal plain”* marine sediments of Holocene age (Q1b).

As discussed in Section 7.0 of this report, the results of the investigations reported herein, in general, indicate that the surficial soils underlying the site are likely to comprise Holocene aged marine sediments (on the lower elevation, southern parts of the site), Holocene aged alluvial sediments (on the lower elevation, western parts of the site), and colluvial and landslide deposits (on the middle to upper sloping parts of the site) inferred to be of Holocene age.

As discussed in Section 7.8 of this report, groundwater levels of between approximately 2.0 m and 2.2 m have been adopted, for analysis purposes, for the low lying parts of the subject site.

Based on the foregoing, it is our opinion that some soils underlying the site could be susceptible to liquefaction. It is understood that no obvious ejection of silt and sand, inferred to be associated with liquefaction of the underlying soil layers, was observed at or in the vicinity of the site immediately following the Kaikōura 2016 earthquake event.

10.4 TRIGGERING OF LIQUEFACTION

The NCEER report, dated October 2001, suggests the triggering of liquefaction within soils be assessed using the methods suggested by Seed and Idriss (1971), which states that:

$$FL = CRR/CSR$$

-where FL = Liquefaction Triggering Factor

CRR = Cyclic Resistance Ratio (ability of soils to resist liquefaction)

CSR = Cyclic Stress Ratio (seismic demand on soil caused by earthquake)

When $FL \leq 1.0$ - Liquefaction is assumed to occur within the soil layer.

Generally, the calculation of the CRR value for a certain soil is determined taking into account the soil type, density and the depth (confinement) of the soil layer.

Generally, the calculation of the CSR value for a certain soil is determined taking into account the theoretical PGA resulting from an earthquake and the depth (confinement) of the soil layer.

Computer programs are available which can compute the CRR and CSR values for soils using the data obtained from the CPT soundings.

The CRR and CSR values, and the theoretical triggering of liquefaction within the soils underlying the site, have been assessed using the computer program CLiq using the data obtained from the CPT sounding investigation discussed in Section 6.5 of this report.

CLiq is a computer program that uses the methods suggested by the NCEER report (October 2001) and which also applies amended calibration/methodology procedures suggested by Zhang, Idriss and Boulanger, Robertson et al.

The results of the analyses to determine the theoretical liquefaction triggering potential of the site soils are presented in Section 11.4 of this report.

10.5 CONSEQUENCES OF LIQUEFACTION

The possible consequences of liquefaction of the soils beneath a site may include:

- (i) Ground settlement,
- (ii) Ejection of sand at the surface,
- (iii) Differential building foundation settlement as a result of differential ground settlement,
- (iv) Foundation settlement as a result of bearing capacity failure of the soils (both “sand like” and “clay like”),
- (v) Lateral displacement of the ground as a result of “lateral spread”.

Theoretical analyses have been undertaken using the computer program CLiq to determine the theoretical ground settlements expected to occur as a result of liquefaction of soil layers. The analyses have been undertaken using the CPT sounding data obtained from the site.

CLiq uses the methods suggested by Zhang et al (2002 and 2004) to predict ground settlements expected to occur as a result of liquefaction of “sand like” soil layers.

The results of the analyses to determine the theoretical ground settlements as a result of liquefaction of the subsoils are presented in Section 11.4 of this report.

11.0 THEORETICAL ANALYSES OF LIQUEFACTION TRIGGERING POTENTIAL AND EXPECTED GROUND SETTLEMENTS

11.1 GENERAL

Analyses have been undertaken using the computer programme CLiq to assess the theoretical liquefaction triggering potential and expected ground settlements for the soils underlying the subject site.

The analyses have been undertaken for the subsoil profile obtained at the locations of CPT1 to CPT14 inclusive.

11.2 PEAK GROUND ACCELERATION (PGA) VALUES ASSUMED FOR ANALYSES

The following design earthquake events have been assessed for the site for the purposes of the analyses reported herein:

- (a) Serviceability Limit State (SLS) – 25 year return period,
- (b) Intermediate Limit State (ILS) – 100 year return period,
- (c) Ultimate Limit State (ULS) – 500 year return period.

Module 4: Earthquake resistant foundation design, provides some discussion regarding the use of the Intermediate Limit State (ILS) design earthquake event in liquefaction triggering assessments. Module 4 states the following:

“Under verification method B1/NVM1 and NZS 1170.0-2002, there is no requirement to consider earthquake events intermediate between the SLS and ULS levels of shaking, the assumption being that there would be a continuum of performance of the structure between the SLS and ULS limit states (except SLS for IL4 buildings). With liquefaction triggering at a site, however, there may be a pronounced degradation in foundation performance and this is likely to happen at a shaking level which is intermediate between the SLS and ULS earthquakes. Where liquefaction triggering is likely at modest, intermediate return period (eg less than 100 year return period for a building of normal importance) the resulting level of damage may be excessive and inappropriate for such a high likelihood of occurrence.”

Module 4, goes on to state:

“Tolerable impact limits for these intermediate cases will depend on the return period. The return period for earthquake shaking required to trigger consequential liquefaction at a site should be calculated, and design measures taken to limit building damage to an appropriate level for that return period”.

Based on the foregoing, in addition to the SLS and ULS design earthquake events, we have also undertaken analyses for an “intermediate” design strength earthquake (ILS – 100 year return period).

In order to provide for a robust foundation solution, it is our opinion that the ‘index’ theoretical ground settlement and LSN values, calculated using the earthquake loading parameters for the ILS design earthquake event, should also be considered when assessing the theoretical liquefaction potential for sites.

Table A1 of *Module 1: Overview of the Guidelines*, provides Peak Ground Acceleration and Earthquake Magnitude values for use in liquefaction triggering analyses. These design seismic values presented in Table A1 of *Module 1*, are shown in Table 4 of this report, for the Kaikōura region.

TABLE 4: DESIGN PEAK HORIZONTAL GROUND ACCELERATION (a_{max}) AND CORRESPONDING EARTHQUAKE MOMENT MAGNITUDES (M_w) VALUES FOR ASSUMED DESIGN CONDITIONS

Design Condition	Design Peak Ground Acceleration (pga) (proportion of gravity acceleration (m/s^2))	Earthquake Moment Magnitude (M_w)
SLS	0.14g	6.1
ILS	0.28g	6.1
ULS	0.56g	6.7

11.3 METHOD OF ANALYSES

11.3.1 General

Module 3 guidelines recommends using the Boulanger & Idriss (2014) methodology, for determining theoretical liquefaction triggering.

Because the deterministic methodology, suggested by B&I (2014), takes into account additional case history data obtained from sites in Christchurch, it is our opinion that the 2014 methodology will likely provide more reliable predictions of liquefaction triggering and associated ground settlements than the 2008 methodology. For this reason, we have adopted the methodology suggested by Boulanger & Idriss (2014) for the analyses reported herein.

For the purposes of this report, analyses have been undertaken to determine the theoretical free-field “*index*” ground settlement values of the site soils and also the Liquefaction Severity Number (LSN).

11.3.2 Thin Sand Layer “Transition Zones”

Robertson, Idriss and Boulanger et al recognise that the reliability of CPT based theoretical liquefaction triggering analyses, can be affected by an effect known as the “thin sand layer” transition zone. This occurs because the CPT sounding provides readings from a soil influence zone, which is located some distance in front of the cone tip (the influence zone varies with soil types), which can underestimate the cone resistance of sand layers (particularly when sandwiched between soft cohesive soil layers), which can consequently incorrectly estimate liquefaction triggering for some layered sandy soils.

PK Robertson (2009) provides a method for adjusting for this effect in the CLiq program. The adjustment is based on the rate of change of the Soil Behaviour Type Index (I_c).

It should be noted, however, that recent research has shown that there is currently no reliable method for dealing with the problem of thin sand layer ‘transition zones’, and that Geoprofessionals should therefore be prudent when attempting to allow for the “thin sand layer” transition zone, in their analyses.

In order to provide some allowance for the ‘thin sand layer’ issue, we have undertaken liquefaction triggering analyses using the thin sand layer adjustment methodology or “transition zone” adjustment methodology, suggested by PK Robertson, and have also undertaken the analyses allowing for no thin sand layer adjustment. The results of the two analyses have been averaged, in order to more reliably determine the theoretical liquefaction triggering potential of the soils, by allowing for some ‘thin sand layer’ influence.

11.3.3 Summary

The input parameters used for the theoretical liquefaction triggering analyses reported herein are summarised in Table 5.

TABLE 5: INPUT PARAMETERS FOR LIQUEFACTION ANALYSES

Input parameter	Value adopted	Comments
Design Seismic Loading	See Table 4	See Section 11.2
I_c cut-off	2.6	Recommended value for simplified procedure
Probability of Liquefaction (P_L)	16%	Deterministic value - in accordance with B&I (2014)
FC Fitting Parameter C_{FC}	Assume 0.0	Recommended value for simplified procedure, for soils in the Kaikoura region

11.4 RESULTS OF ANALYSES

The results of the liquefaction analyses undertaken for the site for the SLS, ILS and ULS design earthquake events are summarised in Tables 6, 7 and 8 respectively.

TABLE 6: THEORETICAL EXPECTED GROUND SETTLEMENTS FOR SERVICEABILITY LIMIT STATE (SLS) DESIGN EARTHQUAKE EVENT

CPT Sounding	Theoretical expected ground settlement (mm)
1	0*
2	0*
3	0*
4	0*
5	0*
6	1*
7	2
8	0*
9	0*
10	2
11	0
12	0*
13	0*
14	0*

TABLE 7: THEORETICAL EXPECTED GROUND SETTLEMENTS FOR INTERMEDIATE LIMIT STATE (ILS) DESIGN EARTHQUAKE EVENT

CPT Sounding	Theoretical expected ground settlement (mm)
1	0*
2	8*
3	0*
4	0*
5	7*
6	22*
7	40
8	9*
9	12*
10	30
11	11
12	0*
13	0*
14	0*

TABLE 8: THEORETICAL EXPECTED GROUND SETTLEMENTS FOR ULTIMATE LIMIT STATE (ULS) DESIGN EARTHQUAKE EVENT

CPT Sounding	Theoretical expected ground settlement (mm)
1	0*
2	13*
3	0*
4	0*
5	21*
6	38*
7	54
8	15*
9	18*
10	40
11	50
12	0*
13	0*
14	0*

The results of the analyses are presented in Appendix B of this report.

It should be noted that the theoretical liquefaction induced ground settlements presented in Tables 6, 7 and 8, for the soils encountered at the locations of the CPT soundings (when denoted by an asterisk), have only been obtained for the analyses of the upper 1.9 m to 8.2 m depth of the subsoils, due to the CPT soundings being unable to be progressed through the underlying dense substrate.

It is conventionally acceptable to analyse the upper 10 m of the subsoils when assessing the potential liquefaction induced ground settlements that could be expected to affect a site, in accordance with the MBIE guidelines. It is possible that liquefiable soils are located beneath the upper 1.9 m to 8.2 m depth of the subsoils, which could increase the theoretical liquefaction induced ground settlements for the site. For this reason, some of the theoretical settlement values presented in Tables 6, 7 and 8, could be considered to be conservatively low.

That been said, it is unlikely, in our opinion, that any significant liquefaction induced ground settlement would occur as a result of liquefaction of the dense to very dense sandy gravels, or cohesive soils (i.e. the layer located below the upper 1.9 m to 8.2 m of soils), as these soils, due to their nature, are generally not expected to be liquefiable. It should also be noted, as discussed in Section 7.4.2 of this report, the sandy gravels were encountered to a depth of at least 15.2 m below the existing ground surface, at the location of M2.

12.0 LIQUEFACTION SEVERITY NUMBER (LSN)

Following the Canterbury Earthquake Sequence (CES), S. van Ballegooy, et al (2013) developed an unweighted assessment methodology, to assess the vulnerability of land to liquefaction-induced damage. The methodology suggests the use of a dimensionless number termed the Liquefaction Severity Number (LSN).

The LSN, is defined as:

$$LSN = 1000 \int \frac{\varepsilon_v}{z} dz$$

- where ε_v is the calculated post-liquefaction volumetric reconsolidation strain, and z is the depth below the ground surface in metres. The LSN is calculated over the upper 10 m depth profile of the subsoil.

The theoretical value of LSN varies from 0 (representing no liquefaction vulnerability) to more than 100 (representing very high liquefaction vulnerability).

S. van Ballegooy, et al (2013) suggest a range of LSN values, which relate to three categories of expected degree of liquefaction-induced ground damage, namely:

- (i) None to minor,
- (ii) Minor to moderate,
- (iii) Moderate to severe.

The original LSN 'boundary' values, suggested by Ballegooy (2013), have been amended by more up-to-date studies. The suggested range of LSN values for each ground damage category, are presented in Table 9.

TABLE 9: LSN RANGES - CORRESPONDING TO EXPECTED LIQUEFACTION-INDUCED GROUND DAMAGE

LSN	Expected liquefaction-induced ground damage category
< 13	None to minor
13 – 18	Minor to moderate
18+	Moderate to severe

The typical consequences at the ground surface, for the various categories presented in Table 8 are described in Table 2.2 of the MBIE guidance document, titled “Planning and Engineering Guidance for Potentially Liquefaction Prone Land”, dated September 2017.

The results of the analyses to determine the LSN values are presented in Tables 10, 11 and 12.

TABLE 10: LSN VALUE - FOR SERVICEABILITY LIMIT STATE (SLS) DESIGN EARTHQUAKE EVENT

CPT	LSN value	Expected liquefaction-induced ground damage category
1	0	None to minor
2	0	None to minor
3	0	None to minor
4	0	None to minor
5	0	None to minor
6	0	None to minor
7	0	None to minor
8	0	None to minor
9	0	None to minor
10	0	None to minor
11	0	None to minor
12	0	None to minor
13	0	None to minor
14	0	None to minor

TABLE 11: LSN VALUE - FOR INTERMEDIATE LIMIT STATE (ILS) DESIGN EARTHQUAKE EVENT

CPT	LSN value	Expected liquefaction-induced ground damage category
1	0	None to minor
2	3	None to minor
3	0	None to minor
4	0	None to minor
5	1	None to minor
6	3	None to minor
7	6	None to minor
8	2	None to minor
9	2	None to minor
10	4	None to minor
11	2	None to minor
12	0	None to minor
13	0	None to minor
14	0	None to minor

TABLE 12: LSN VALUE - FOR ULTIMATE LIMIT STATE (ULS) DESIGN EARTHQUAKE EVENT

CPT	LSN value	Expected liquefaction-induced ground damage category
1	0	None to minor
2	5	None to minor
3	0	None to minor
4	0	None to minor
5	4	None to minor
6	7	None to minor
7	8	None to minor
8	3	None to minor
9	4	None to minor
10	6	None to minor
11	7	None to minor
12	0	None to minor
13	0	None to minor
14	0	None to minor

Based on the results of the investigation and appraisal reported herein (and as indicated in Tables 10 and 11 of this report), it is our opinion that the liquefaction-induced ground damage expected to occur at the site, in response to a SLS design earthquake event, is considered to be none to minor.

Based on the results of the investigation and appraisal reported herein (and as indicated in Table 12 of this report), it is our opinion that the liquefaction-induced ground damage expected to occur at the site, in response to a ULS design earthquake event, is also considered to be none to minor.

It should be noted that the foregoing LSN values for the site are consistent with the observed performance of the site during the 2016 Kaikoura earthquake event. The 2016 Kaikoura earthquake event is understood to have imposed a seismic loading at the subject site, which was greater than the SLS and ILS design loadings. However, no obvious liquefaction ejecta was observed at the subject site, in response to these earthquake events, which is consistent with the behaviour, as predicted by the calculated LSN values.

13.0 FOUNDATION TECHNICAL CATEGORY FOR THE SITE

The Ministry of Business, Innovation & Employment (MBIE) released a document entitled “Repairing and rebuilding houses affected by the Canterbury earthquakes”; Version 3, dated December 2012.

The principal objective of the MBIE Canterbury guidance document is to provide building repair and reconstruction solutions and options that:

- (i) are appropriate to the level of land and building damage experienced;
- (ii) take account of the likely future performance of the ground;
- (iii) meet Building Act and Building Code requirements; and
- (iv) are acceptable to insurers and property owners.

The document also divides the previous CERA "Green Zone" on flat land, into three technical categories that reflect both the liquefaction experienced to date, and future performance expectations. The Foundation Technical Categories are identified as TC1, TC2 and TC3.

Table 3.1 of the MBIE Canterbury guidance document provides expected future land performance for the various Foundation Technical Categories. These are summarised in Table 13 of this report.

TABLE 13: EXPECTED FUTURE LAND PERFORMANCE FOR VARIOUS FOUNDATION TECHNICAL CATEGORIES

Foundation Technical Category	Future Land Performance Expectation in Response to Liquefaction	Expected Ground Settlement in Response to an SLS Strength Earthquake	Expected Ground Settlement in Response to a ULS Strength Earthquake
TC1 (where confirmed)	Liquefaction damage is unlikely in a future large earthquake	0 – 15 mm	0 – 25 mm
TC2 (where confirmed)	Liquefaction damage is possible in a future large earthquake	0 – 50 mm	0 – 100 mm
TC3 (where confirmed)	Liquefaction damage is possible in a future large earthquake	>50 mm	>100 mm

The results of the CLiq analyses are presented in Appendix B of this report.

Table 12.5 of the guidance document provides categories of vertical land settlement, for the calculated “index number” theoretical ground settlement. The guidance document suggests that for sites with SLS “index number” theoretical ground settlements of less than 100 mm the land settlement should be assumed to be “minor to moderate”. For sites with SLS “index number” theoretical ground settlements of greater than 100 mm the land settlement should be assumed to be “potentially significant”.

Although the MBIE Canterbury guidance document has been prepared for sites in the Canterbury region. The methodology used to categorise the liquefaction triggering potential characteristics of sites is considered to be useful for sites outside of Canterbury also, and has been used, in this report, to determine the liquefaction triggering potential characteristics of the subject site.

Using the methodology recommended by the MBIE guidance document and described in Section 11.3 of this report, “index number” theoretical ground settlement values of between 0 mm and 2 mm have been calculated for the site soils under the assumed SLS seismic loading, and between 0 mm and 40 mm, under the assumed ILS seismic load conditions.

Under the assumed ULS load conditions, “index number” theoretical ground settlement values of between 0 mm and 50 mm have been calculated for the site soils.

As discussed in Section 13.0 of this report, the results of our analyses to determine LSN values for the site soils indicates that the liquefaction-induced ground damage, expected to occur at the site, in response to a SLS or ILS design earthquake event, is generally considered to be none to minor. The liquefaction-induced ground damage, expected to occur at the site, in response to an ULS design earthquake event, is also considered to be none to minor. The LSN value provides an unweighted assessment methodology, to assess the vulnerability of land to liquefaction-induced damage.

It should be noted that the LSN values for the site are consistent with the observed performance of the site during the 2016 Kaikoura earthquake event. The 2016 Kaikoura earthquake event is understood to have imposed a seismic loading at the subject site, which was greater than the SLS and ILS design loadings. However, no obvious liquefaction ejecta was observed at the subject site, in response to these earthquake events, which is consistent with the behaviour, as predicted by the calculated LSN values.

Based on the foregoing, given the observed performance of the site in response to seismic loading associated with the 2016 Kaikōura earthquake, and given the depth of the potentially liquefiable layers beneath the ground surface (generally no shallower than approximately 4.5 m below the existing ground surface), it is our opinion that the subject site, for foundation design purposes, should be assumed to be within Foundation Technical Category 1 (TC1), as defined by the MBIE Canterbury guidelines, and that it is unlikely that liquefaction induced ground deformation could occur at the site in response to a large earthquake event, and that the ground settlements at the site in response to seismic loading should be considered to be “within normally accepted tolerances”, as defined by the MBIE Canterbury guidance document.

14.0 COMMENTS REGARDING THE KDC “LIQUEFACTION ASSESSMENT OVERLAY”

As discussed in Section 2.4.2 of this report, Kaikōura District Council have produced ‘hazard overlays’ for the subject site, which includes a “*Liquefaction Assessment Overlay*”.

As shown on drawing CH019121-G-04 the “*Liquefaction Assessment Overlay*” affects the following areas of the site:

- (i) The low lying area in the south and south-western parts of the site, affecting parts of Area F and Area H,
- (ii) The low lying area abutting the railway line, adjacent to the north-western site boundary, affecting a small part of Area G.

As reported herein, we have undertaken site-specific field investigation works and detailed theoretical liquefaction triggering analyses to address the potential liquefaction hazard at the subject site.

As discussed in Section 13.0 of this report, the results of our analyses indicate that it is unlikely that liquefaction induced ground deformation could occur at the site in response to a large earthquake event, and that the ground settlements at the site in response to seismic loading should be considered to be “within normally accepted tolerances”, as defined by the MBIE Canterbury guidance document.

15.0 LIKELY SUITABLE FOUNDATION DESIGN SOLUTIONS

Providing any subdivisional earthworks are undertaken in accordance with the relevant New Zealand Standard Codes of Practice, and in accordance with any recommendations provided by Fraser Thomas Ltd, it is our opinion that suitable building platforms should be available at the site, which would be suitable for future residential, small-scale commercial activities and community facilities developments (Area H).

Subject to the results of any further specific geotechnical investigation and appraisal works undertaken in support of any future subdivision consent application and any geotechnical completion reporting (associated with bulk earthworks), the likely suitable foundation solutions for each proposed development area are presented in Table 14.

TABLE 14: LIKELY SUITABLE FOUNDATION DESIGN SOLUTIONS

Development Area	Likely Suitable Foundation Design Solutions
Area C	Slightly elevated area located in the south-western part of the site. Cut and fill earthworks to be undertaken to form an access road for this area. Some sections may be slightly sloping and may require excavation works to form a level building platform. An appropriate foundation solution for the site conditions would likely be a shallow foundation system designed in accordance with the requirements of NZS 3604: 2011, New Zealand Standard, Timber Framed Buildings, founded in competent soils.
Area F	Low-lying area adjacent to the existing golf course, located in the south-western part of the site. Bulk fill earthworks to be undertaken to form a 'raised' level building platform on the flood plain. An appropriate foundation solution for the site conditions, following bulk earthworks, would likely be a shallow foundation system designed in accordance with the requirements of NZS 3604: 2011, New Zealand Standard, Timber Framed Buildings, founded in competent soils.
Area G	Located adjacent to the existing railway line, located in the north-western part of the site. The area encompasses the western side slopes and the ridge associated with a northeast-southwest trending ridgeline. Cut and fill earthworks to be undertaken to form suitable carriageways for the Ocean Ridge Drive extension and other access roads. In general, the cut earthworks will be undertaken along the ridgeline within this area, and the filling will be undertaken along the toe of an existing landslide feature, in order to provide toe buttress support in this area. Some sections may be slightly sloping and may require excavation works to form a level building platform. An appropriate foundation solution for the site conditions would likely be a shallow foundation system designed in accordance with the requirements of NZS 3604: 2011, New Zealand Standard, Timber Framed Buildings, founded in competent soils. Some sections, located on the west-facing side slopes, may be moderately sloping and may require excavation works to form a level building platform. The surficial soils on these sections may be subject to soil creep. The sections located on the moderately sloping west-facing side slopes will likely be designated to be in a 'specific building foundation design zone', in which the foundations of any proposed residential building should be subject to specific design with particular regard to slope stability (soil creep) with the assistance of an engineer experienced in geotechnical engineering.

Area H	Located at the toe of side slopes associated an existing (central) north-east to south-west trending ridgeline, and extending to a low lying area, adjacent to State Highway 1. Located in the southern part of the site. Provision of new roading and infrastructure for the development of a multi-use area, including residential small-scale commercial activities and community facility buildings. Fill earthworks to be undertaken to backfill existing dry basin at Keken Park, subject to future reserve exchange. Excavation earthworks to be undertaken to create a new dry basin, as part of the stormwater management system. Some sections may be slightly sloping and may require excavation works to form a level building platform. An appropriate foundation solution for the site conditions would likely be a shallow foundation system designed in accordance with the requirements of NZS 3604: 2011, New Zealand Standard, Timber Framed Buildings, founded in competent soils (for residential structures) and shallow foundations designed in accordance with the relevant New Zealand Standard Codes of Practice (for light commercial structures). In order to avoid removing toe buttress support to the south-facing side slopes, located upslope of the northern part of Area H, controls/restrictions will be recommended for excavation work for the northern most sections, in order to mitigate this hazard.
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16.0 ALLOWABLE FOUNDATION BEARING PRESSURES

16.1 GENERAL

In this section of the report, ultimate bearing capacity values and strength reduction factors are provided in order to allow calculation of design (dependable) foundation bearing capacities, in accordance with the limit state design methods outlined in AS/NZS 1170: 2002, Structural Design Actions, by applying the appropriate strength reduction factors, as provided in this report, and the factored load combinations required by AS/NZS 1170. Allowable foundation bearing pressures are also provided, based on conventional factors of safety, for cases where unfactored load combinations are being considered.

16.2 SHALLOW PAD OR BEAM FOUNDATIONS

A minimum ultimate static bearing capacity value for vertical loading of 300 kPa is recommended for shallow concrete pads or beam foundations, founded in the underlying natural ground or engineered fill. It is recommended that a strength reduction factor (Φ_{bc}) of 0.5 be adopted for limit state design in accordance with the requirements of AS/NZS 1170, resulting in a design (dependable) bearing capacity value of 150 kPa.

If unfactored load combinations are to be considered, the allowable foundation bearing pressures presented in Table 15 are recommended for shallow concrete pads or beam foundations, founded in the underlying natural ground or engineered fill.

TABLE 15: ALLOWABLE FOUNDATION BEARING PRESSURES FOR SHALLOW CONCRETE PADS OR FOUNDATION BEAMS FOUNDED IN THE UNDERLYING NATURAL GROUND OR ENGINEERED FILL

Load Case	Factor of Safety	Allowable Bearing Pressure (kPa)
Dead Load and Permanent Live Load	3.0	100
Dead plus Live plus Transient Load	2.0	150

17.0 EXISTING SERVICE LINES

It is recommended that the location and depth of any buried services should be verified at the site prior to the commencement of foundation construction.

It is expected that any service line trenches would have been backfilled by conventionally acceptable means, which did not involve specific compaction. It would therefore be expected that some consolidation settlement of the service trench backfill could occur, which could result in lateral and vertical deformation of the undisturbed ground on each side of the trench backfill. The deformation is caused by the soil wedge behind the side wall of the trench moving downwards and inwards with time, towards the trench backfill as the backfill consolidates. The geometry of the soil wedge defines the theoretical zone of influence of the service trench backfill.

Due to the risk of consolidation settlement of the trench backfill occurring, it is recommended that, if any foundations of any proposed new building are located within the zone of influence of any existing service line, either the trench backfill be excavated and replaced with compacted hardfill or the foundations and floor of the proposed new building be designed to span across the trench backfill and the adjacent zone of influence.

The zone of influence is defined by a theoretical line projecting upwards in both directions from the centreline of the pipeline at the invert level of the pipeline at an angle of 45° to the vertical. The zone of influence is defined by the zone between the intersection point of the theoretical line and the ground surface on each side of the pipeline.

18.0 EARTHWORKS CONSIDERATIONS

18.1 GENERAL

It is understood that any future subdivisional development at the site will likely involve cut and fill earthworks, in order form suitable building platforms, roading infrastructure and to provide for the construction of suitable gravity wastewater and stormwater reticulation systems.

In particular, we note the following proposed earthworks for the various Development Areas:

- | | |
|--------|--|
| Area H | Fill earthworks to be undertaken to backfill existing dry basin at Kekeno Park, subject to future reserve exchange. Excavation earthworks to be undertaken to create a new dry basin, as part of the stormwater management system. |
| Area F | Bulk fill earthworks to be undertaken to form a 'raised' level building platform on the flood plain (adjacent to the Kowhai River and the golf course). |
| Area C | Cut and fill earthworks to be undertaken to form an access road for this area. |
| Area G | Cut and fill earthworks to be undertaken to form suitable carriageways for the Ocean Ridge Drive extension and other access roads. In general, the cut earthworks will be undertaken along the ridgeline within this area, and the filling will be undertaken along the toe of an existing landslide feature, in order to provide toe buttress support in this area. |
- Excavation earthworks to be undertaken to create a new dry basin, and to form a stormwater channel, along the western site boundary (as part of the stormwater management system).

18.2 PROPOSED FILL AREAS

The maximum depth of filling anticipated for Area F (to form a raised building platform) is approximately 1.5 m. The maximum depth of filling anticipated for Area H (to backfill the existing dry basin) is between approximately 2.0 m and 3.0 m. These works in Area H are subject to future reserve exchange.

It is our opinion that the natural soils underlying the site, after the removal of the topsoil or non-engineered fill layers, will exhibit only a low compressibility under the proposed fill loadings and relatively light static foundation loads associated with the proposed new buildings. It is recommended that Fraser Thomas Ltd be engaged to inspect any stripped subgrades, prior to placement of any bulk engineered fill, to confirm the suitability of the stripped subgrade.

It is recommended, prior to placement of any bulk fill material, that appropriate laboratory testing be undertaken, for any proposed borrow fill material (either 'site won' or imported), in order to determine the compaction parameter/characteristics of the proposed fill material (i.e compaction curves).

It is possible that some of the materials may require to be wetted to increase the water content of the fill material, in order to obtain the minimum compaction standards as presented in Section 18.5 of this report.

Any proposed 'engineered fill' will need to be subject to appropriate observation and testing, by a suitably qualified CPEng engineer, so as to confirm that the fill is suitable for its intended purpose.

It should be anticipated that some of the soils encountered in the proposed fill and cut areas will be sensitive to disturbance by earthworks plant and inclement weather. These two factors together could result in plant trafficability problems, and which may result in the artificial creation, by virtue of ill-conceived construction efforts, of excessive quantities of unsuitable (i.e. unworkable) materials, unless earthworks construction activities and the nature of the earthmoving plant used in the site development are selected and controlled in cognisance of the particular characteristics of the site materials.

18.3 PROPOSED CUT AREAS

It is understood that the majority of the 'site won' cut material will be sourced from excavation works to construct the proposed stormwater management systems at the site, and 'lowering' and 'flattening' of the ridgeline within Area G.

It is understood that the base of the proposed stormwater management basins will range between approximately 3.0 m and 4.0 m below the 'finished' (post bulk earthworks) ground surface, and that cuts associated with the 'lowering' and 'flattening' of the Area G ridgeline will result in excavations of generally between approximately 3.0 m and 4.0 m depth.

It is anticipated that the proposed cut materials, will consist of material generally comprising clayey silts, sandy silts and sandy gravels.

The undrained shear strength values in the proposed cut materials, as determined from the borehole logs of Appendix A, are expected to generally be between 70 kPa and in excess of 100 kPa, corresponding to a stiff to very stiff consistency.

18.4 SITE PREPARATION

Preparation prior to placing and compacting fill should involve the stripping of topsoil and non-engineered fill, as directed by the Engineer, to stockpile and all "unsuitable" soils to stockpile or waste.

18.5 COMPACTION CRITERIA

It is recommended that any cohesive fill material placed at the site be placed in accordance with the general requirements described in NZS 4431:2022; Engineered fill construction for lightweight structures, and in accordance with the recommended fill specification, and should be constructed so as to obtain the following:

- (1) an average in situ undrained shear strength value of not less than 120 kPa, and any one test site value of not less than 100 kPa.
- (2) an average air voids value of not more than 10% and any one test site value of not more than 12%.

It is recommended that Fraser Thomas Ltd be engaged to observe the placement and compaction of the proposed fill material to confirm that the fill has been placed in accordance with the recommended fill specification.

19.0 DEVELOPMENTAL EARTHWORKS

It is recommended that, unless the stability of any developmental earthworks (i.e. constructed for an access driveway, building platform or landscaping) is considered in detail by a chartered professional engineer experienced in geotechnical engineering, and particularly slope stability considerations, permanent fill end and cut slopes should be constructed to a maximum batter slope of 26° (1V:2H) with maximum batter heights of approximately 2.5 m. Any proposed higher permanent batter slopes should be subject to specific stability appreciation so as to determine stable limiting batter slopes.

It is recommended that any temporary excavated slopes be constructed to a maximum batter slope of 45° (1V:1H), with a maximum batter height of approximately one meter. It is recommended that any temporary excavation slopes not be left unsupported for a period exceeding one month. It is also recommended that stormwater run-off be diverted away from the crest of any proposed temporary excavation slopes.

20.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations should be read together and not be taken in isolation.

20.1 CONCLUSIONS

Our conclusions based on the field data obtained from the site and as presented in this report, our visual appraisal of the site, our study of the geological maps relating to the area and our professional judgement and opinions, are as follows:

- (a) In general terms and within the limits of the investigation as outlined and reported herein, except for the slope stability issues, no unusual problems, from a geotechnical perspective, are anticipated with future residential, small-scale commercial activities and community facility developments at the subject site.

We confirm that this report includes recommendations which will appropriately avoid, remedy or mitigate potential geotechnical hazards on the land subject to the plan change request, in accordance with the provisions of Section 106 of the Resource Management Act.

The site is, in general, considered suitable for its intended use, with satisfactory conditions for future residential and small-scale commercial activities and community facility building developments, subject to the recommendations and qualifications reported herein, and provided the design and inspection of foundations are carried out as would be done under normal circumstances in accordance with the requirements of the relevant New Zealand Standard Codes of Practice.

In arriving at this conclusion and expressing this opinion, reliance has been based on the various topographical data as discussed herein and on subsoil information which has only been obtained at the locations and within the depths of the test positions reported herein. It has been assumed that this subsoil information can be projected between the various test positions. Even though such inference is made and forms the basis of the conclusions and opinions expressed herein, no guarantee can be given as to the validity of this inference or of the nature and continuity of the subsoils underlying the proposed subdivision.

- (b) The subsoil information, presented in Appendix A of this report, indicate that the surficial soils underlying the site are likely to comprise the following:
 - (1) Holocene aged marine sediments (on the lower elevation, southern parts of the site),
 - (2) Holocene aged alluvial sediments (on the lower elevation, western parts of the site),
 - (3) Colluvial and landslide deposits (on the middle to upper sloping parts of the site) inferred to be of Holocene age.

The middle and upper sloping parts of the site are also generally underlain by a layer of residual soils, which are inferred to be weathering products of the underlying sandstone and limestone rock, inferred to be of the Seymour Group of Cretaceous age.

- (c) Based on the groundwater levels measured during the investigations reported herein, and allowing for possible wet winter and climate change induced groundwater level increases over the next 100 years, conservative groundwater levels, for analysis purposes, have been adopted for the following areas. These are presented in Table 1.
- (d) As discussed in Sections 2.0, 3.0 and 6.2 of this report, there is evidence of past slope instability affecting some of the slopes at the subject site. In order to assess the landslide hazard at the site, slope stability analyses have been undertaken for the soil veneer materials, located in the vicinity of observed historic land instability, at the following locations:
 - (1) West-facing side slope in the vicinity of the '2000's landslide' feature in Area G (represented by Cross Section C-C')
 - (2) West-facing side slope through the 'pre-1940's landslide' feature in Area G (represented by Cross Section B-B')
 - (3) West-facing side slope at the southern end of the ridgeline extending through Area G (represented by Cross Section A-A')
 - (4) South-facing side slope in the vicinity of the 'Big Slip' landslide feature, identified for the 2005 URS report, abutting Area H (represented by Cross Section E-E').

The locations of Cross Sections A-A', B-B', C-C', and E-E' are shown on drawing CH01912-G-05.

- (e) Back analyses undertaken for the slope failures yielded effective design parameters of 26° friction angle and 1 kPa effective cohesion for the veneer soils (colluvium), based on the assumption that the phreatic surface was coincident with the ground surface at the time of failure, in order to obtain a theoretical factor of safety value of 1.0 (i.e. an assumed failure condition).
- (f) The results of the slope stability analyses reported herein, generally indicate that the side slopes at the site have satisfactory theoretical factor of safety values against deep-seated instability of the veneer soils.

There is a risk of re-activation of the landslide in the vicinity of the 'pre-1940's landslide' located within Area G, particularly under extent transient groundwater conditions. It is recommended that buttress trench drains be installed within this area, in order to control the groundwater levels within the slope and to mitigate against the risk of groundwater levels rising to a level which may result in slope instability.

As discussed in Section 5.0 of this report, the proposed development within Area G will involve cut earthworks along the ridgeline, and filling, along the toe of the existing landslide feature. These works will further improve the stability of the landslide affected area by:

- (i) Reducing the driving force at the top of a potential slip circle
- (ii) Providing toe buttress support to the toe of any potential slip circle.

It is anticipated that these works can be addressed at the detailed design stage associated with any subdivisional development in this area.

- (g) As discussed in Section 2.4.3 of this report, Kaikōura District Council have produced 'hazard overlays' for the subject site, which includes a "Debris Inundation Overlay".

As shown on drawing CH019121-G-04 the "Debris Inundation Overlay" is primarily mapped in the parts of the Ocean Ridge subdivision site which are outside the scope of the proposed plan change. However, an area in the southern part of Area G has this hazard overlay.

Based on the results of our site-specific investigation and appraisal of this area, we comment as follows:

- (1) The results of the slope stability analyses reported herein, for Cross Section A-A' (in the vicinity of the mapped hazard overlay), generally indicate that the side slopes in this area have satisfactory theoretical factor of safety values against deep-seated instability of the veneer soils.
- (2) The proposed development works will involve cut earthworks along the ridgeline and the construction of roading and infrastructure at the crest of the side slope. These works will further improve the stability of the west-facing slopes in this area by:
 - (i) Reducing the driving force at the top of a potential slip circle,
 - (ii) Intercepting and directing any potential overland stormwater flows away from the crest of the slope, so as to prevent the concentration of stormwater onto the side slopes.
- (3) Based on the foregoing, it is our opinion that the risk of any deep-seated instability of the side slopes in the southern part of Area G (in the area affected by the "Debris Inundation Overlay") is low, and that future residential development in this area should not be restricted due to potential geotechnical hazards associated with slope instability.

We confirm that this report includes recommendations which will appropriately avoid, remedy or mitigate potential geotechnical hazards on the land subject to the plan change request, in accordance with the provisions of Section 106 of the Resource Management Act.

- (h) Given the steepness of some of the side slopes, there is a risk of some slopes being affected by shallow soil creep. This is a common mechanism of shallow surficial soil movement for slopes typically steeper than 18° to the horizontal and will be addressed at the subdivision stage, and for any site-specific geotechnical reports prepared for specific building developments (in support of an application for building consent). Foundations can be designed for the effects of surficial soils creep, so as to meet the performance requirements of the New Zealand Building Code.
- (i) A liquefaction potential assessment has been undertaken for the soils underlying the subject site.

Based on the results of the site-specific geotechnical investigation and appraisal works reported herein, given the observed performance of the site in response to seismic loading associated with the 2016 Kaikōura earthquake, and given the depth of the potentially liquefiable layers beneath the ground surface (generally no shallower than approximately 4.5 m below the existing ground surface), it is our opinion that the subject site, for foundation design purposes, should be assumed to be within Foundation Technical Category 1 (TC1), as defined by the MBIE Canterbury guidelines, and that it is unlikely that liquefaction induced ground deformation could occur at the site in response to a large earthquake event, and that the ground settlements at the site in response to seismic loading should be considered to be “within normally accepted tolerances”, as defined by the MBIE Canterbury guidance document.

- (j) As discussed in Section 2.4.2 of this report, Kaikōura District Council have produced ‘hazard overlays’ for the subject site, which includes a “Liquefaction Assessment Overlay”. As shown on drawing CH019121-G-04 the “*Liquefaction Assessment Overlay*” affects the following areas of the site:

- (1) The low lying area in the south and south-western parts of the site, affecting parts of Area F and Area H,
- (2) The low lying area abutting the railway line, adjacent to the north-western site boundary, affecting a small part of Area G.

As reported herein, we have undertaken site-specific field investigation works and detailed theoretical liquefaction triggering analyses to address the potential liquefaction hazard at the subject site.

As discussed in Section 13.0 of this report, the results of our analyses indicate that it is unlikely that liquefaction induced ground deformation could occur at the site in response to a large earthquake event, and that the ground settlements at the site in response to seismic loading should be considered to be “within normally accepted tolerances”, as defined by the MBIE Canterbury guidance document.

- (k) Providing any subdivisional earthworks are undertaken in accordance with the relevant New Zealand Standard Codes of Practice, and in accordance with any recommendations provided by Fraser Thomas Ltd, it is our opinion that suitable building platforms should be available at the site, which would be suitable for future residential, small-scale commercial activities and community facility developments (Area H).
- (l) The maximum depth of filling anticipated for Area F (to from a raised building platform) is approximately 1.5 m. The maximum depth of filling anticipated for Area H (to backfill the existing dry basin) is between approximately 2.0 m and 3.0 m. These works in Area H are subject to future reserve exchange.

It is our opinion that the natural soils underlying the site, after the removal of the topsoil or non-engineered fill layers, will exhibit only a low compressibility under the proposed fill loadings and relatively light static foundation loads associated with the proposed new buildings. It is recommended that Fraser Thomas Ltd be engaged to inspect any stripped subgrades, prior to placement of any bulk engineered fill, to confirm the suitability of the stripped subgrade.

- (m) It is understood that the majority of the 'site won' cut material will be sourced from excavation works to construct the proposed stormwater management systems at the site, and 'lowering' and 'flattening' of the ridgeline within Area G. It is anticipated that the proposed cut materials, will consist of material generally comprising clayey silts, sandy silts and sandy gravels.

20.2 RECOMMENDATIONS

Our recommendations based on the field data obtained from the site and as presented in this report, our visual appraisal of the site, our study of the geological maps relating to the area and our professional judgement and opinions, are as follows:

- (a) Subject to the results of any further specific geotechnical investigation and appraisal works undertaken in support of any future subdivision consent application and any geotechnical completion reporting (associated with bulk earthworks), the likely suitable foundation solutions for each proposed development area are presented in Table 14.
- (b) A minimum ultimate static bearing capacity value for vertical loading of 300 kPa is recommended for shallow concrete pads or beam foundations, founded in the underlying natural ground or engineered fill. It is recommended that a strength reduction factor (Φ_{bc}) of 0.5 be adopted for limit state design in accordance with the requirements of AS/NZS 1170, resulting in a design (dependable) bearing capacity value of 150 kPa.
- (c) Due to the risk of consolidation settlement of the trench backfill occurring, it is recommended that, if any foundations of any proposed new building are located within the zone of influence of any existing service line, either the trench backfill be excavated and replaced with compacted hardfill or the foundations and floor of the proposed new building be designed to span across the trench backfill and the adjacent zone of influence.

The zone of influence is defined by a theoretical line projecting upwards in both directions from the centreline of the pipeline at the invert level of the pipeline at an angle of 45° to the vertical. The zone of influence is defined by the zone between the intersection point of the theoretical line and the ground surface on each side of the pipeline.

- (d) It is recommended, prior to placement of any bulk fill material, that appropriate laboratory testing be undertaken, for any proposed borrow fill material (either 'site won' or imported), in order to determine the compaction parameter/characteristics of the proposed fill material (i.e compaction curves).
- (e) Any proposed 'engineered fill' will need to be subject to appropriate observation and testing, by a suitably qualified CPEng engineer, so as to confirm that the fill is suitable for its intended purpose.
- (f) Preparation prior to placing and compacting fill should involve the stripping of topsoil and non-engineered fill, as directed by the Engineer, to stockpile and all "unsuitable" soils to stockpile or waste.

- (g) It is recommended that any cohesive fill material placed at the site be placed in accordance with the general requirements described in NZS 4431:2022; Engineered fill construction for lightweight structures, and in accordance with the recommended fill specification, and should be constructed so as to obtain the following:
 - (1) an average in situ undrained shear strength value of not less than 120 kPa, and any one test site value of not less than 100 kPa.
 - (2) an average air voids value of not more than 10% and any one test site value of not more than 12%.
- (h) It is recommended that Fraser Thomas Ltd be engaged to observe the placement and compaction of the proposed fill material to confirm that the fill has been placed in accordance with the recommended fill specification.
- (i) It is recommended that, unless the stability of any developmental earthworks (i.e. constructed for an access driveway, building platform or landscaping) is considered in detail by a chartered professional engineer experienced in geotechnical engineering, and particularly slope stability considerations, permanent fill end and cut slopes should be constructed to a maximum batter slope of 26° (1V:2H) with maximum batter heights of approximately 2.5 m. Any proposed higher permanent batter slopes should be subject to specific stability appreciation so as to determine stable limiting batter slopes.

It is recommended that any temporary excavated slopes be constructed to a maximum batter slope of 45° (1V:1H), with a maximum batter height of approximately one meter. It is recommended that any temporary excavation slopes not be left unsupported for a period exceeding one month. It is also recommended that stormwater run-off be diverted away from the crest of any proposed temporary excavation slopes.

21.0 LIMITATIONS

The professional opinion expressed herein has been prepared solely for, and is furnished to our client, Cargill Station Ltd, and their professional advisers, and Kaikōura District Council for their purposes only with respect to the particular brief given to us, on the express condition that it will not be relied upon by any other person or for any other purposes without our prior written agreement, and relates to the conditions that exist up to and at the time of this report.

No liability is accepted by this firm or by any principal, or director, or any servant or agent of this firm, in respect of the use of this report by any other person, and any other person who relies upon any matter contained in this report does so entirely at its own risk. This disclaimer shall apply notwithstanding that this report may be made available to any person by any person in connection with any application for permission or approval, or pursuant to any requirement of law.

This report does not comment on stormwater management, flooding, root effects and land uses outside the specific site, which may be required to be assessed to complete a foundation design for building consent application purposes.

Notwithstanding the foregoing, if the circumstances at the subject site change with respect to topography or the proposed development concept, or the buildings are subject to further damaging earthquakes, or if a period of more than three years has elapsed since the date of this report, this report should not be used without our prior review and written agreement.

Notwithstanding the foregoing conclusions and recommendations, any proposed building development should be designed to satisfy the relevant requirements of the Building Code, so as to ensure compliance with the Building Act.

The conclusions and recommendations expressed herein should be read in conjunction with the remainder of this report and should not be referred to out of context with the remainder of this report.

Report prepared by:
FRASER THOMAS LTD.



K E TWOHILL
Senior Engineering Geologist

Report reviewed and approved by:



M V REED
Director
Chartered Professional Engineer

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Appendix A

Field Investigation Results



BOREHOLE AND TEST PIT LOGS SYMBOLS AND TERMS

SYMBOLS AND ABBREVIATIONS

RL	Reduced Level
EOH	End of Hole
•	Shear vane test result
UTP	Unable to Penetrate
TDTA	Too Difficult to Auger
SPT	Standard Penetration Test
N	SPT blows per 300mm penetration
35/90	35 blows per 90mm penetration after seating for SPT
(s)	Inclusive of seating blow count for SPT
GWL	Ground Water Level
PL	Planar Discontinuity Surface
R	Rough Discontinuity Surface

U	Undulating Discontinuity Surface
SR	Slightly Rough Discontinuity Surface
S	Smooth Discontinuity Surface
Fe	Iron Oxide Staining
QV	Quartz Vein
F	Fracture
ST	Stepped Discontinuity Surface
J	Jointing
RQD	Rock Quality Designation
CZ	Crush Zone
SZ	Shear Zone
Fo	Foliation
SL	Slickenside Discontinuity Surface

SOIL

	TOPSOIL		COBBLES
	CLAY		BOULDERS
	SILT		PEAT
	SAND		FILL
	GRAVEL		

CONSISTENCY TERMS

Cohesive Description	Undrained Shear Strength (kPa)
Very Soft	<12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very Stiff	100 - 200
Hard	>200

RELATIVE DENSITY

Non-cohesive Description	SPT "N" Value
Very Loose	<4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

ROCK

	LIMESTONE		RYHOLITE
	MUDSTONE		ANDESITE
	SANDSTONE		BASALT
	CONGLOMERATE		
	BRECCIA		

STRENGTH

Description	Unconfined Compressive Strength MPa
Extremely Weak	< 1
Very Weak	1 - 5
Weak	5 - 20
Moderately Strong	20 - 50
Strong	50 - 100
Very Strong	100 - 250
Extremely Strong	> 250

WEATHERING

UW - Unweathered (fresh rock)
SW - Slightly Weathered
MW - Moderately Weathered
HW - Highly Weathered
CW - Completely Weathered
RS - Residual Soil

SPACING OF DISCONTINUITIES

Term	Aperture (mm)
Very widely spaced	>2000
Widely spaced	600 - 2000
Moderately widely spaced	200 - 600
Closely spaced	60 - 200
Very closely spaced	20 - 60
Extremely closely spaced	<20

Notes

1. Based on New Zealand Geotechnical Society "Field Description of Soil and Rock, Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes" December 2005
2. Composite soil types are signified by combined symbols

Machine Excavated Test Pits



INVESTIGATION LOG

Hole No:
TP1

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane:	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa) Vane readings corrected as per BS 1377 ● Shear Vane ○ Residual Shear Vane	Depth (m)	Dynamic Cone Penetrometer Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 100mm)	Groundwater
0.2	SILT, gravelly (fine to medium, rounded, greywacke); dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S			0.2	2	GWNE
0.4	SAND (fine to coarse), gravelly (fine to coarse, rounded, greywacke); dark grey. linterbedded with: GRAVEL (fine to medium, subrounded, greywacke), some sand (fine to coarse), trace cobbles; grey. Medium dense to very dense, moist [MARINE SEDIMENTS]	Holocene Beach Deposits			0.4	4	
0.6					0.6	4	
0.8					0.8	6	
1.0					1.0	13	
1.2					1.2	10	
1.4					1.4	5	
1.6					1.6	10	
1.8					1.8	8	
2.0					2.0	9	
2.2					2.2	10	
2.4					2.4	15	
2.6					2.6	14	
2.8					2.8	15	
3.0					3.0	16	
3.2	EOTP: 3.10 m DIGGER REACH				3.2	17	
3.4					3.4		
3.6					3.6		
3.8					3.8		
4.0					4.0		
4.2					4.2		
4.4					4.4		
4.6					4.6		
4.8					4.8		

Profile:		Excavation Method:
		Remarks: Groundwater not encountered on 9/10/2024. Minor instability in upper 1.0 m.
		Datum:
		Coordinates:



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INVESTIGATION LOG

Hole No:
TP2

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer											Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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0.2	SILT, gravelly (fine to medium, rounded, greywacke); dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S									0.2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

Profile:	Excavation Method:
	Remarks: Groundwater not encountered on 9/10/2024. Stable throughout.
	Datum:
	Coordinates:



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INVESTIGATION LOG

Hole No:

TP3

Project No:
CH01912

Project: Cargill Station Ltd
Ocean Ridge, Kaikoura

Shear Vane:
2512

Date Excavated:
09/10/2024

Logged By:
KT

Checked By:

Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)		Depth (m)	Dynamic Cone Penetrometer										Groundwater		
				Vane readings corrected as per BS 1377			Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 100mm)												
				● Shear Vane	○ Residual Shear Vane		2	4	6	8	10	12	14	16					
0.2	SILT, gravelly (fine to medium, rounded, greywacke); dark brown. Moist, non plastic, rootlets [TOPSOIL/FILL]	Fill					1												
0.4	Clayey SILT; yellowish brown mottled dark brown. Hard, moist, low plasticity [FILL]						1												
0.6							2												
0.8	Cobbly GRAVEL (fine, subrounded to subangular, greywacke), some sand (coarse); grey. Wet.					●	>200	2											
1.0							3									20 >>			
1.2	SILT, gravelly (fine to coarse, subrounded greywacke); dark grey. Hard, moist, non plastic, seemingly cemented			●	UTP											23 >>			
1.4																19 >>			
1.6	SILT; dark brown. Moist, non plastic [BURIED TOPSOIL]	T/ S		●	UTP														
1.8																			
2.0	Silty GRAVEL; greyish brown. Medium dense to very dense, wet [MARINE SEDIMENTS]	Holocene Beach Deposits																	
2.2																			
2.4	GRAVEL (fine to coarse, predominantly fine, subrounded to rounded, greywacke), some sand and silt; greyish brown. Medium dense to very dense, wet																		
2.6																			
3.0	EOTP: 3.00 m TDTE - SATURATED GRAVEL																		
3.2																			
3.4																			
3.6																			
3.8																			
4.0																			
4.2																			
4.4																			
4.6																			
4.8																			

09/10/2024

09/10/2024

Profile:



Excavation Method:

Remarks:

Groundwater encountered at a depth of approximately 2.9 m below ground level, on 9/10/2024.
Unstable from approximately 2.0 m below ground level.

Datum:

Coordinates:



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INVESTIGATION LOG

Hole No:
TP4

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Depth (m)	Dynamic Cone Penetrometer								Groundwater			
				Vane readings corrected as per BS 1377						Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)											
				● Shear Vane	○ Residual Shear Vane			Values		2	4	6	8	10	12	14	16				
0.2	Sandy (fine) SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S								0.2											
0.4	Sandy (fine) SILT, trace gravel (fine to medium, subrounded); greyish brown mottled orangey brown. Stiff, moist to wet, low plasticity [ALLUVIAL DEPOSITS]	Holocene Alluvial Deposits								0.4											
0.6												0.6									
0.8					●					69	0.8										
1.0	Sandy (fine to coarse) GRAVEL (fine to coarse, subrounded, greywacke); greyish brown. Moist										1.0										
1.2	Sandy (fine) SILT, trace gravel (fine to medium, subrounded); greyish brown mottled orangey brown. Stiff, moist to wet, low plasticity				●					72	1.2										
1.4										78	1.4										
1.6					●						1.6										
1.8	Sandy (fine to coarse) GRAVEL (fine to coarse, subrounded, greywacke); greyish brown. Moist to wet										1.8										
2.0											2.0										
2.2											2.2										
2.4											2.4										
2.6											2.6										
2.8											2.8										
3.0	EOTP: 2.90 m TDTE - SATURATED GRAVEL								3.0												
3.2									3.2												
3.4									3.4												
3.6									3.6												
3.8									3.8												
4.0									4.0												
4.2									4.2												
4.4									4.4												
4.6									4.6												
4.8									4.8												

09/10/2024

09/10/2024

Profile:		Excavation Method:
		Remarks: Groundwater encountered at a depth of approximately 2.8 m below ground level, on 9/10/2024. Stable throughout.
		Datum:
		Coordinates:



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INVESTIGATION LOG

Hole No:
TP5

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Depth (m)	Dynamic Cone Penetrometer											Groundwater
				Vane readings corrected as per BS 1377						Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)											
				● Shear Vane	○ Residual Shear Vane																
				50	100	150	200	Values		2	4	6	8	10	12	14	16				
0.2	Sandy (fine) SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S								0.2											
0.4										0.4											
0.6	Clayey SILT; light brownish grey. Very stiff, wet, low plasticity [COLLUVIAL DEPOSITS]	Colluvial Deposits								0.6											
0.8										0.8											
1.0	Clayey SILT; light grey mottled orangey brown. Stiff to hard, wet, moderate plasticity [RESIDUAL SOILS - SEYMOUR GROUP]	Seymour Group								1.0											
1.2											1.2										
1.4											1.4										
1.6											1.6										
1.8											1.8										
2.0											2.0										
2.2											2.2										
2.4											2.4										
2.6	2.6 m: Increasing rock fabric										2.6										
2.8	EOTP: 2.80 m DIGGER REACH										2.8										
3.0										3.0											
3.2										3.2											
3.4										3.4											
3.6										3.6											
3.8										3.8											
4.0										4.0											
4.2										4.2											
4.4										4.4											
4.6										4.6											
4.8										4.8											

Profile:		Excavation Method:
		Remarks: Groundwater not encountered on 9/10/2024. Stable throughout.
		Datum:
		Coordinates:



INVESTIGATION LOG

Hole No:
TP6

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer											Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
				Vane readings corrected as per BS 1377							Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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0.2	Sandy (fine) SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S									0.2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

Profile:		Excavation Method:
		Remarks: Groundwater not encountered on 9/10/2024. Stable throughout.
		Datum:
		Coordinates:



INVESTIGATION LOG

Hole No:
TP7

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Depth (m)	Dynamic Cone Penetrometer											Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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0.2	Sandy (fine) SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S								0.2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

Profile:		Excavation Method:
		Remarks: Groundwater not encountered on 9/10/2024. Stable throughout.
		Datum:
		Coordinates:



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INVESTIGATION LOG

Hole No:
TP8

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)		Values	Depth (m)	Dynamic Cone Penetrometer								Groundwater			
				Vane readings corrected as per BS 1377				Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)											
				● Shear Vane	○ Residual Shear Vane			2	4	6	8	10	12	14	16				
0.2	Sandy (fine) SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S					0.2												
0.4	Clayey SILT; greyish brown. Very stiff, moist, moderate plasticity [COLLUVIUM]	Colluvial Deposits					0.4												
0.6																			
0.8	Clayey SILT; light grey mottled orangey brown. Very stiff to hard, moist, moderate plasticity [RESIDUAL SOILS - SEYMOUR GROUP]	Seymour Group					0.6												
1.0																			
1.2																			
1.4																			
1.6	Clayey SILT, trace gravels (rounded, limestone); light grey mottled orangey brown and black. Very stiff to hard, moist, moderate plasticity, iron nodules						1.2												
1.8																			
2.0	Completely weathered, light grey and orangey brown, fine grained, SANDSTONE, extremely weak						1.6												
2.2																			
2.4	EOTP: 2.20 m TDTA - ROCK						1.8												
2.6																			
2.8							2.0												
3.0																			
3.2																			
3.4																			
3.6																			
3.8																			
4.0																			
4.2																			
4.4																			
4.6																			
4.8																			

Profile:		Excavation Method:
		Remarks: Groundwater not encountered on 9/10/2024. Stable throughout.
		Datum:
		Coordinates:



INVESTIGATION LOG

Hole No:
TP9

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer											Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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0.2	Sandy (fine) SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S								0.2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

Profile:	Excavation Method:
	Remarks: Groundwater not encountered on 9/10/2024. Stable throughout.
	Datum:
	Coordinates:



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INVESTIGATION LOG

Hole No:
TP10

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)			Depth (m)	Dynamic Cone Penetrometer								Groundwater		
				Vane readings corrected as per BS 1377				Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)										
				● Shear Vane	○ Residual Shear Vane	Values		2	4	6	8	10	12	14	16			
0.2	Sandy (fine) SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/ S																
0.4	Clayey SILT; brownish grey mottled orangey brown. Moist, moderate plasticity [COLLUVIUM]	Seymour Group																
0.6	Clayey SILT; brown to orangey brown. Very stiff to hard, moist, low to moderate plasticity, increasing lithification with depth [RESIDUAL SOILS - SEYMOUR GROUP]																	
0.8																		
1.0																		
1.2																		
1.4																		
1.6																		
1.8			1.7 m: Iron oxide nodules															
2.0																		
2.2																		
2.4																		
2.6	2.6 m: Becomes light grey with orange mottles. Increasing rock fabric																	
2.8																		
3.0																		
3.2	Completely weathered, light grey and orangey brown, fine grained, SANDSTONE, extremely weak																	
3.4	EOTP: 3.10 m TDTE - ROCK																	
3.6																		
3.8																		
4.0																		
4.2																		
4.4																		
4.6																		
4.8																		

Profile:	Excavation Method:
	Remarks: Groundwater not encountered on 9/10/2024. Stable throughout.
	Datum:
	Coordinates:



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INVESTIGATION LOG

Hole No:
TP11

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 10/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)	Depth (m)	Dynamic Cone Penetrometer	Groundwater
				Vane readings corrected as per BS 1377 ● Shear Vane ○ Residual Shear Vane		Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)	
				50 100 150 200 Values		2 4 6 8 10 12 14 16	
0.2	Sandy (fine) SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S			0.2		
0.4	Clayey SILT; brownish grey mottled orangey brown. Very stiff, moist, moderate plasticity [COLLUVIUM]			● 100	0.4		
0.6					0.6		
0.8	Clayey SILT; brown to orangey brown. Very stiff to hard, moist, low to moderate plasticity, increasing lithification with depth [RESIDUAL SOILS - SEYMOUR GROUP]			● 150	0.8		
1.0				● 180	1.0		
1.2					1.2		
1.4					1.4		
1.6				● 220	1.6		
1.8	DOWNHILL SIDE OF PIT: Clayey SAND (fine to coarse), trace gravel (fine, rounded); orange. UPHILL SIDE OF PIT: Clayey SILT; brown to orangey brown unit continues	Seymour Group			1.8		
2.0					2.0		
2.2					2.2		
2.4					2.4		
2.6					2.6		
2.8					2.8		
3.0					3.0		
3.2	Completely weathered, light grey mottled orangey brown, fine grained, SANDSTONE, extremely weak to very weak, calcite veins [SEYMOUR GROUP]				3.2		
3.4					3.4		
3.6	EOTP: 3.20 m TDTE - ROCK				3.6		
3.8					3.8		
4.0					4.0		
4.2					4.2		
4.4					4.4		
4.6					4.6		
4.8					4.8		

Profile:	Excavation Method:
	Remarks: Groundwater not encountered on 10/10/2024. Stable throughout.
	Datum:
	Coordinates:



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INVESTIGATION LOG

Hole No:
TP12

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 10/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer											Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
				Vane readings corrected as per BS 1377							Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				● Shear Vane	○ Residual Shear Vane																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
0.2	SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S									0.2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

Profile: 	Excavation Method:
	Remarks: Groundwater not encountered on 10/10/2024. Stable throughout.
	Datum: Coordinates:



INVESTIGATION LOG

Hole No:

TP13

Project No:
CH01912

Project: Cargill Station Ltd
Ocean Ridge, Kaikoura

Shear Vane:
2512

Date Excavated:
10/10/2024

Logged By:
KT

Checked By:

Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)				Values	Depth (m)	Dynamic Cone Penetrometer								Groundwater		
				Vane readings corrected as per BS 1377						Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)										
				● Shear Vane	○ Residual Shear Vane															
				50	100	50	200			2	4	6	8	10	12	14	16			
0.2	SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S								0.2										
0.4	Clayey SILT; light grey mottled orangey brown. Very stiff to hard, moist, moderate plasticity, occasional completely weathered white gravel (limestone?) [RESIDUAL SOILS - SEYMOUR GROUP]	Seymour Group								0.4										
0.6											0.6									
0.8											0.8									
1.0											1.0									
1.2	Completely weathered, light grey mottled orangey brown, fine grained, SANDSTONE, extremely weak to very weak, occasional concretions (cobble sized), readily excavatable [SEYMOUR GROUP]	Seymour Group								1.2										
1.4											1.4									
1.6											1.6									
1.8											1.8									
2.0	2.2 m: Excavation more difficult, recovered material more platy, no obvious bedding	Seymour Group								2.0										
2.2											2.2									
2.4											2.4									
2.6											2.6									
2.8	EOTP: 2.30 m TDTE - ROCK									2.8										
3.0											3.0									
3.2											3.2									
3.4											3.4									
3.6											3.6									
3.8											3.8									
4.0											4.0									
4.2											4.2									
4.4											4.4									
4.6											4.6									
4.8											4.8									

Profile:



Excavation Method:

Remarks:

Groundwater not encountered on 10/10/2024.
Stable throughout.

Datum:

Coordinates:



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INVESTIGATION LOG

Hole No:

TP14

Project No:
CH01912

Project: Cargill Station Ltd
Ocean Ridge, Kaikoura

Shear Vane:

Date Excavated:

10/10/2024

Logged By:

KT

Checked By:

Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Depth (m)	Dynamic Cone Penetrometer								Groundwater		
				Vane readings corrected as per BS 1377						Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)										
				● Shear Vane	○ Residual Shear Vane			Values		2	4	6	8	10	12	14	16			
0.2	SILT, some gravel (fine to coarse, angular, siltstone) ; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S							0.2											
0.4	Highly weathered, brown, fractured, fine grained, SANDSTONE, moderately strong to strong, moderate excavatability [SEYMOUR GROUP] 0.7 m: Colour change to light grey mottled orangey brown 1.0 m: Excavation more difficult, recovered material more platy, no obvious bedding	Seymour Group							0.4											
0.6																				
0.8																				
1.0									1.0											
1.2									1.2											
1.4	EOTP: 1.30 m TDTE - ROCK								1.4											
1.6									1.6											
1.8									1.8											
2.0									2.0											
2.2									2.2											
2.4									2.4											
2.6									2.6											
2.8									2.8											
3.0									3.0											
3.2									3.2											
3.4									3.4											
3.6									3.6											
3.8									3.8											
4.0									4.0											
4.2									4.2											
4.4									4.4											
4.6									4.6											
4.8									4.8											

Profile:



Excavation Method:

Remarks:

Groundwater not encountered on 10/10/2024.
Stable throughout.

Datum:

Coordinates:



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INVESTIGATION LOG

Hole No:
TP15

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane:	Date Excavated: 10/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer											Groundwater	
				Vane readings corrected as per BS 1377							Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)												
				● Shear Vane	○ Residual Shear Vane						2	4	6	8	10	12	14	16					
0.2	SILT, some gravel (fine to coarse, angular, siltstone) ; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S								0.2											GWNE		
0.4	Highly weathered, brown, fractured, fine grained, SANDSTONE, moderately strong to strong, moderate excavatability, occasional concretions (cobble sized) [SEYMOUR GROUP] 0.5 m: Colour change to light grey, trace orangey brown mottles. Excavation more difficult, recovered material more platy, no obvious bedding	Seymour Group								0.4													
0.6																							
0.8													0.8										
1.0													1.0										
1.2													1.2										
1.4													1.4										
1.6													1.6										
1.8													1.8										
2.0													2.0										
2.2													2.2										
2.4													2.4										
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3.4													3.4										
3.6													3.6										
3.8													3.8										
4.0													4.0										
4.2													4.2										
4.4													4.4										
4.6													4.6										
4.8	EOTP: 0.80 m TDTE - ROCK									4.8													

Profile:		Excavation Method:
		Remarks: Groundwater not encountered on 10/10/2024. Stable throughout.
		Datum:
		Coordinates:



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INVESTIGATION LOG

Hole No:
TP16

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Excavated: 10/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Depth (m)	Dynamic Cone Penetrometer											Groundwater								
				Vane readings corrected as per BS 1377						Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 0mm)																			
				● Shear Vane	○ Residual Shear Vane			Values		2	4	6	8	10	12	14	16												
0.2	SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S								0.2																			
0.4	Clayey SILT; chaotic greyish brown and orangey brown. Very stiff, moist, low plasticity, rootlets throughout, flaky [INFERRED LANDSLIDE DEPOSITS]	Colluvial Deposits								0.4																			
0.6																													
0.8	Clayey SILT, minor gravels (fine to medium, subangular, extremely weak to very strong limestone); grey mottled orangey brown. Very stiff to hard, wet, moderate plasticity [COLLUVIUM]	Colluvial Deposits								0.8																			
1.0																													
1.2	Clayey SILT; light grey mottled orangey brown. Hard, moist, moderate plasticity [RESIDUAL SOILS - SEYMOUR GROUP]	Seymour Group								1.2																			
1.4																													
1.6													1.6																
1.8													1.8																
2.0													2.0																
2.2													2.2																
2.4													2.4																
2.6													2.6																
2.8													2.8																
3.0													3.0																
3.2	Completely weathered, light grey mottled orangey brown, fine grained, SANDSTONE, extremely weak to very weak, calcite veins [SEYMOUR GROUP]									3.2																			
3.4													3.4																
3.6	EOTP: 3.30 m DIGGER REACH									3.6																			
3.8													3.8																
4.0													4.0																
4.2													4.2																
4.4													4.4																
4.6													4.6																
4.8													4.8																

Profile: 	Excavation Method:
	Remarks: Groundwater not encountered on 10/10/2024. Stable throughout.
	Datum:
	Coordinates:



HAND AUGER LOG

H1



Fraser
Thomas

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HAND AUGER LOG

Hole No:
H2

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 07/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Depth (m)	Dynamic Cone Penetrometer										Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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Fraser
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HAND AUGER LOG

Hole No:
H3

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 07/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer												Groundwater	
				Vane readings corrected as per BS 1377							Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 100 mm)													
				● Shear Vane	○ Residual Shear Vane						2	4	6	8	10	12	14	16						
0.2	SILT, trace sand (fine); dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S	TS TS <																					



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HAND AUGER LOG

Hole No:
H4

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 07/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)		Depth (m)	Dynamic Cone Penetrometer										Groundwater
				Vane readings corrected as per BS 1377			Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 100 mm)										
				● Shear Vane	○ Residual Shear Vane		2	4	6	8	10	12	14	16			
0.2	SILT, trace sand (fine); dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S															
0.4	Silty CLAY, trace sand (fine); yellowish brown. Very stiff to hard, moist, moderate plasticity [RESIDUAL SOILS]	Seymour Group				111											GWNE
0.6						>200											
0.8	Silty CLAY, trace sand (fine) and gravel (fine, angular limestone); yellowish brown. Very stiff to hard, moist, moderate plasticity					>200											
1.0	LIMESTONE recovered as: Sandy (fine to coarse) GRAVEL (fine to coarse, angular); white. [LIMESTONE - SEYMOUR GROUP]					UTP										21 >>	
1.2	EOH: 0.90 m TDTA - LIMESTONE ROCK															25 >>	
																30 >>	
1.4																	
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4.4																	
4.6																	
4.8																	
Remarks: Groundwater not encountered on 7/10/2024.						Datum:											
						Coordinates:											



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HAND AUGER LOG

Hole No:
H5

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 07/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer										Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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Fraser
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HAND AUGER LOG

Hole No:
H6

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 07/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Depth (m)	Dynamic Cone Penetrometer										Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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HAND AUGER LOG

H7

Checked By:

Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer												Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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Fraser
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HAND AUGER LOG

Hole No:
H8

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 08/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer												Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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HAND AUGER LOG

Hole No:
H9

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 08/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)			Depth (m)	Dynamic Cone Penetrometer								Groundwater		
				Vane readings corrected as per BS 1377				Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 100 mm)										
				● Shear Vane	○ Residual Shear Vane	Values		2	4	6	8	10	12	14	16			
0.2	SILT, trace sand (fine); dark brown. Wet, non plastic, rootlets [TOPSOIL]	T/S																
0.4	Silty CLAY; orangey brown mottled pinkish brown. Very stiff to hard, moist, moderate plasticity, twinkly (micaceous or calcite) [RESIDUAL SOILS - SEYMOUR GROUP] 0.8 m: Colour change to light grey mottled orangey brown and pinkish brown, trace gravel (fine, siltstone)	Seymour Group			●		111											
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0.8					●		>200											
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4.6																		
4.8																		
Remarks: Groundwater not encountered on 8/10/2024.							Datum:											
							Coordinates:											



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HAND AUGER LOG

Hole No:
H10

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 09/10/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer											Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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HAND AUGER LOG

Hole No:
H11

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 05/11/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer												Groundwater																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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Fraser
Thomas

ENGINEERS • RESOURCE MANAGERS • SURVEYORS

HAND AUGER LOG

Hole No:
H12

Project No: CH01912	Project: Cargill Station Ltd Ocean Ridge, Kaikoura	Shear Vane: 2512	Date Drilled: 05/11/2024	Logged By: KT	Checked By:
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Depth (m)	Description of Strata	Geological Unit	Graphic Log	Undrained Shear Strength (kPa)					Values	Depth (m)	Dynamic Cone Penetrometer																Groundwater
				Vane readings corrected as per BS 1377							Test Method: NZS 4402:1988, Test 6.5.2 (Blows / 100 mm)																
				● Shear Vane	○ Residual Shear Vane																						
0.2	SILT; dark brown. Moist, non plastic, rootlets [TOPSOIL]	T/S								1														GWNE			
0.4	Clayey SILT; light grey mottled orangey brown. Hard, moist, moderate plasticity [RESIDUAL SOILS - SEYMOUR GROUP]	Seymour Group								2																	
0.6											8																
0.8	Clayey SILT, trace sand (fine); light grey mottled orangey brown. Hard, moist, moderate plasticity										8																
1.0	0.9 m: Iron nodules, becomes wet and orangey brown									8																	
1.2	EOH: 1.20 m TDTA - INFERRED ROCK																										
1.4																											
1.6																											
1.8																											
2.0																											
2.2																											
2.4																											
2.6																											
2.8																											
3.0																											
3.2																											
3.4																											
3.6																											
3.8																											
4.0																											
4.2																											
4.4																											
4.6																											
4.8																											
Remarks: Groundwater not encountered on 5/11/2024.										Datum:																	
										Coordinates:																	

Machine Borehole

M1



BOREHOLE AND TEST PIT LOGS SYMBOLS AND TERMS

SYMBOLS AND ABBREVIATIONS

RL	Reduced Level
EOH	End of Hole
•	Shear vane test result
UTP	Unable to Penetrate
TDTA	Too Difficult to Auger
SPT	Standard Penetration Test
N	SPT blows per 300mm penetration
35/90	35 blows per 90mm penetration after seating for SPT
(s)	Inclusive of seating blow count for SPT
GWL	Ground Water Level
PL	Planar Discontinuity Surface
R	Rough Discontinuity Surface

U	Undulating Discontinuity Surface
SR	Slightly Rough Discontinuity Surface
S	Smooth Discontinuity Surface
Fe	Iron Oxide Staining
QV	Quartz Vein
F	Fracture
ST	Stepped Discontinuity Surface
J	Jointing
RQD	Rock Quality Designation
CZ	Crush Zone
SZ	Shear Zone
Fo	Foliation
SL	Slickenside Discontinuity Surface

SOIL

	TOPSOIL		COBBLES
	CLAY		BOULDERS
	SILT		PEAT
	SAND		FILL
	GRAVEL		

CONSISTENCY TERMS

Cohesive Description	Undrained Shear Strength (kPa)
Very Soft	<12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very Stiff	100 - 200
Hard	>200

RELATIVE DENSITY

Non-cohesive Description	SPT "N" Value
Very Loose	<4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

ROCK

	LIMESTONE		RYHOLITE
	MUDSTONE		ANDESITE
	SANDSTONE		BASALT
	CONGLOMERATE		
	BRECCIA		

STRENGTH

Description	Unconfined Compressive Strength MPa
Extremely Weak	< 1
Very Weak	1 - 5
Weak	5 - 20
Moderately Strong	20 - 50
Strong	50 - 100
Very Strong	100 - 250
Extremely Strong	> 250

WEATHERING

UW - Unweathered (fresh rock)
SW - Slightly Weathered
MW - Moderately Weathered
HW - Highly Weathered
CW - Completely Weathered
RS - Residual Soil

SPACING OF DISCONTINUITIES

Term	Aperture (mm)
Very widely spaced	>2000
Widely spaced	600 - 2000
Moderately widely spaced	200 - 600
Closely spaced	60 - 200
Very closely spaced	20 - 60
Extremely closely spaced	<20

Notes

1. Based on New Zealand Geotechnical Society "Field Description of Soil and Rock, Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes" December 2005
2. Composite soil types are signified by combined symbols



BOREHOLE INFORMATION		CO-ORDINATES:		Date Started: 29/01/2025		Logged By: KT	
Method: Sonic		Easting:		Date Completed:		Input By: KT	
Equipment: Tracked rig		Northing:		Inclination: -90°		Reviewed By:	
Contractor: McMillans		Reduced Level:		Azimuth: N/A			
Datum:							

R.L. (m)	Depth (m)	Material Description	Geological Unit	Graphic Log	Weathering / USCS	Testing	TCR (%)	RQD (%)	Installation
		0.00m: Sandy SILT with minor gravel (fine to coarse, subrounded greywacke); dark brown. Soft, low plasticity, containing rootlets and grass [TOPSOIL]	T/S						
		0.40m: Sandy (fine to coarse) GRAVEL (fine to coarse, subrounded greywacke), trace silt; greyish brown. Dense. [ALLUVIAL SEDIMENTS]	Alluvial Sediments				100	-	
		0.75m: Sandy (fine) SILT; greyish brown. Soft, non plastic.							
-1	1	1.00m: Sandy (fine) SILT, trace clay; greyish brown. Stiff, low to moderate plasticity.							
		1.20m: SILT, trace clay and sand (fine); light brown. Hard, low plasticity.							
		1.50m: Sandy (fine to coarse) GRAVEL (fine to coarse, subrounded greywacke), some silt; greyish brown. Very dense, saturated				1.50m: SPT 11,24//26,23,11 for 55mm N=60+			
-2	2		Alluvial Sediments				100	-	
-3	3		Alluvial Sediments						
-4	4	4.00m: ...Iron oxide staining	Alluvial Sediments						
		4.10m: Sandy (fine to coarse) GRAVEL (fine to coarse, subrounded greywacke); bluish grey. Very dense, saturated							
		4.70m: Gravelly (fine to coarse, subrounded greywacke) SAND (fine to coarse); bluish grey. Saturated					100	-	

REMARKS
Groundwater dipped at a depth of approximately 3.6 m, on 29/01/2025.



BOREHOLE INFORMATION		CO-ORDINATES:		Date Started: 29/01/2025		Logged By: KT	
Method: Sonic		Easting:		Date Completed:		Input By: KT	
Equipment: Tracked rig		Northing:		Inclination: -90°		Reviewed By:	
Contractor: McMillans		Reduced Level:		Azimuth: N/A			
Datum:							

R.L. (m)	Depth (m)	Material Description	Geological Unit	Graphic Log	Weathering / USCS	Testing	TCR (%)	RQD (%)	Installation
		5.00m: Silty SAND (fine); bluish grey to grey. Saturated, occasional lenses of 'clean' fine sand, trace decomposed organics, dilatant	Alluvial Sediments				100	-	
		5.20 to 5.22m: ...Semi decomposed fibrous wood inclusion							
		5.80 to 5.82m: ...Semi decomposed fibrous wood inclusion							
		6.00m: Sandy (fine) SILT; grey. 'Stiff', saturated, non plastic, trace decomposed organics, occasional lenses of fine sand							
-6	6		Alluvial Sediments				100	-	
		8.00m: SILT, trace fine sand; dark grey to grey. 'Stiff', saturated, low plasticity, trace decomposed organics							
		8.60m: SILT, some clay; dark grey. 'Very stiff', moderate plasticity, minor decomposed organics							
		8.80 to 8.81m: ...Organic silt lens, black							
		8.80m: Clayey SILT; grey. 'Hard', moderate plasticity	Alluvial Sediments				100	-	
		8.90m: SILT, some clay; dark grey. 'Stiff', moderate plasticity, minor decomposed organics in bands							
-9	9	9.20m: Clayey SILT; grey. 'Soft to stiff', moderate plasticity					80	-	

REMARKS

Groundwater dipped at a depth of approximately 3.6 m, on 29/01/2025.



BOREHOLE INFORMATION Method: Sonic Equipment: Tracked rig Contractor: McMillans		CO-ORDINATES: Easting: Northing: Reduced Level: Datum:		Date Started: 29/01/2025 Date Completed: Inclination: -90° Azimuth: N/A		Logged By: KT Input By: KT Reviewed By:	
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R.L. (m)	Depth (m)	Material Description	Geological Unit	Graphic Log	Weathering / USCS	Testing	TCR (%)	RQD (%)	Installation
		[CONT] 9.20m: Clayey SILT; grey. 'Soft to stiff', moderate plasticity							
		10.30m: Sandy (fine) SILT; grey. 'Firm', containing occasional decomposed sticks					80	-	
		10.34m: CORE LOSS							
		10.64m: SILT, some clay and sand (fine); greenish light blue banded light blue. 'Hard', low plasticity, micaceous, occasional lenses of sandy silt							
-11	11		Alluvial Sediments				100	-	
		12.00m: Gravelly (fine to coarse, subangular to subrounded greywacke) SILT, trace cobbles; light blue. 'Hard', low plasticity.							
-12	12						100	-	
		13.10m: SILT, minor gravel (fine to medium, subrounded to subangular greywacke and chert), trace cobbles; light greyish brown mottled orangey brown. 'Hard', low plasticity.							
-13	13								
		13.70m: SILT, some gravel (fine subrounded greywacke), trace sand (coarse); light brown mottled orangey brown. 'Hard', non plastic.							
-14	14								
		14.80m: Gravelly (fine to coarse, subangular to subrounded greywacke) SILT; light brown. 'Hard', dry (driller ran out of water), low plasticity.	Alluvial Sedi				100	-	

REMARKS Groundwater dipped at a depth of approximately 3.6 m, on 29/01/2025.
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Client: Cargill Station Ltd
Project: Ocean Ridge, Kaikoura
Location: Ocean Ridge, Kaikoura
Project Reference: CH01912

Sheet 4 of 4

Method: Sonic
Equipment: Tracked rig
Contractor: McMillans

Easting:
Northing:
Reduced Level:
Datum:

Date Started: 20/05/2016
Date Completed: 20/05/2016
Inclination: -90°
Azimuth: N/A

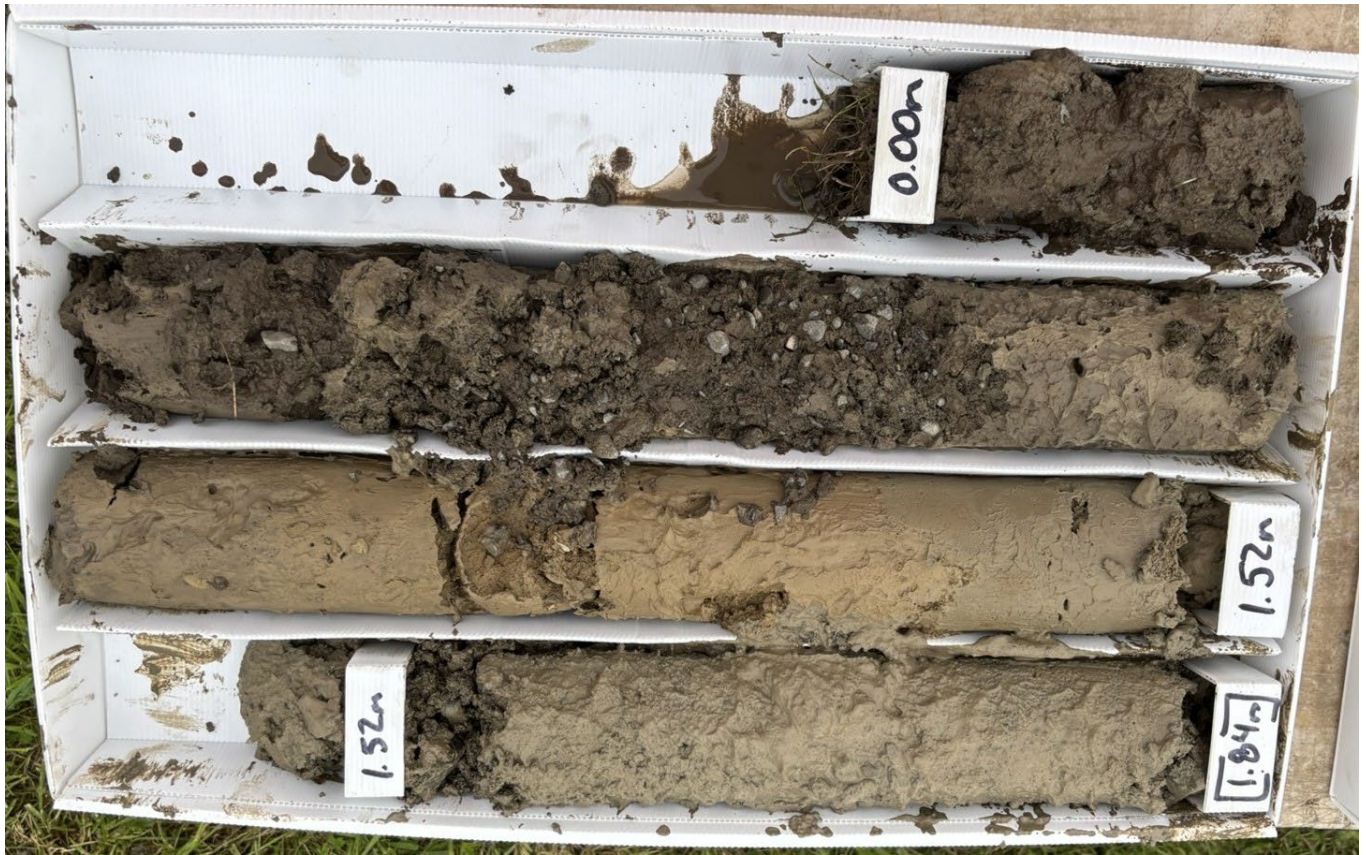
Logged By: KT
 Input By: KT
 Reviewed By:

REMARKS									
Groundwater dipped at a depth of approximately 3.6 m, on 29/01/2025.									

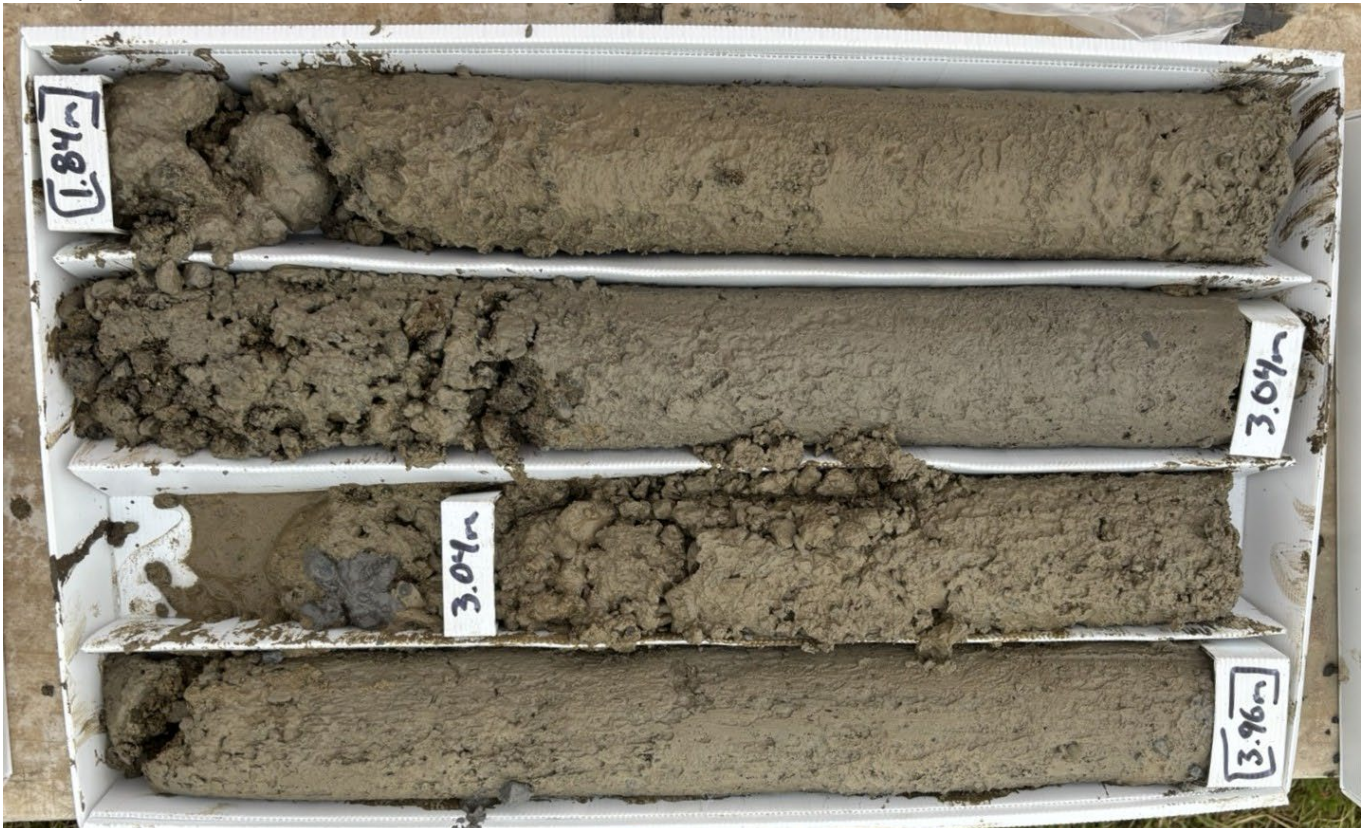
GEOTECHNICAL SERVICES

Machine Borehole Reference: M1
Photographed by: K. Twohill

Date Drilled: 29/01/2025
Date Photographed: 29/01/2025



Box 1: Depth 0.0m to 1.84m



Box 2: Depth 1.84m to 3.96m

GEOTECHNICAL SERVICES

Machine Borehole Reference:
Photographed by:

M1
K. Twohill

Date Drilled:
Date Photographed:

29/01/2025
29/01/2025



Box 3: Depth 3.96m to 6.08m



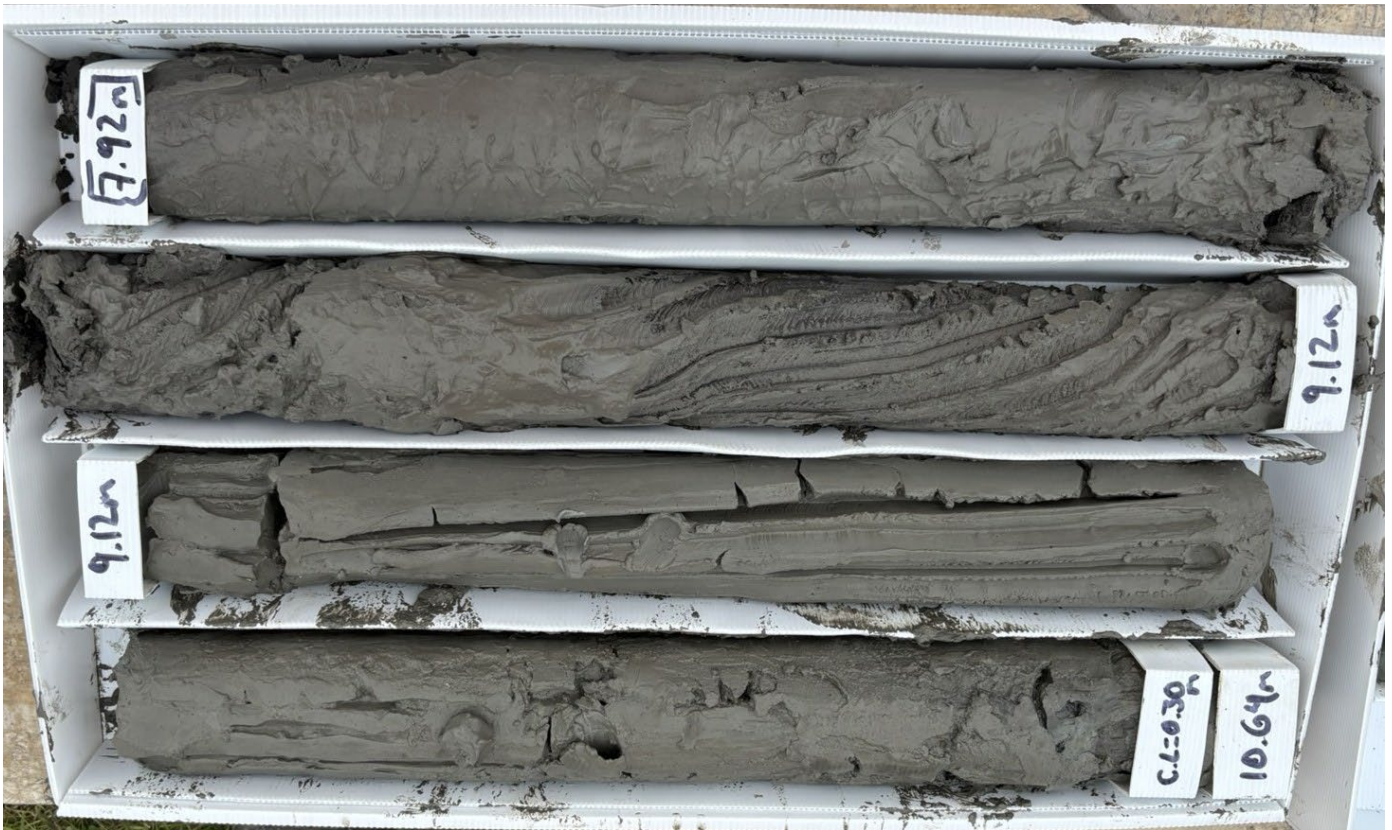
Box 4: Depth 6.08m to 7.92m

Machine Borehole Reference:
Photographed by:

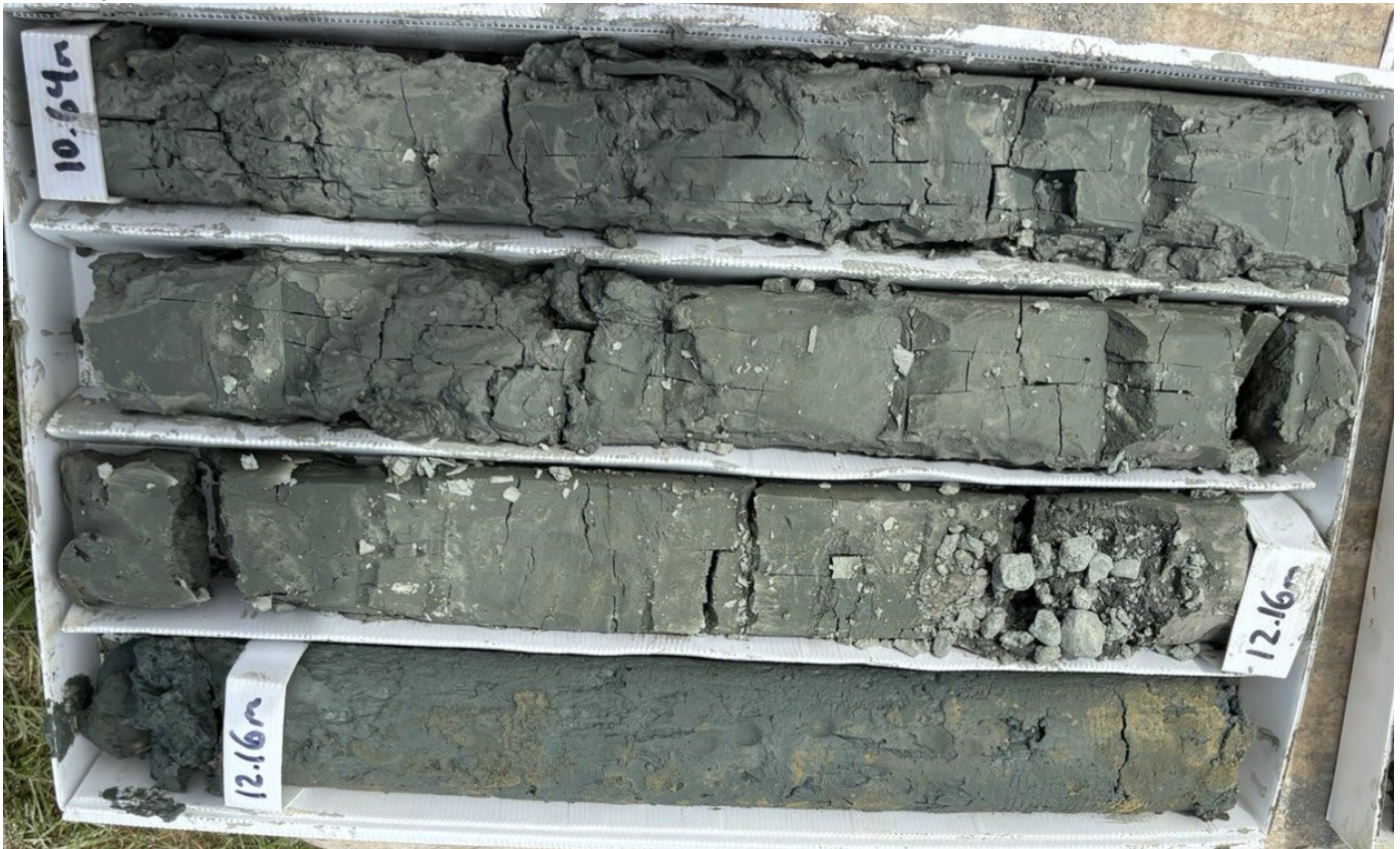
M1
K. Twohill

Date Drilled:
Date Photographed:

29/01/2025
29/01/2025



Box 5: Depth 7.92m to 10.64m



Box 6: Depth 10.64m to 12.48m

GEOTECHNICAL SERVICES

Machine Borehole Reference:
Photographed by:

M1
K. Twohill

Date Drilled:
Date Photographed:

29/01/2025
29/01/2025



Box 7: Depth 12.5m to 14.6m



Box 8: Depth 14.6m to 15.2m

M2



BOREHOLE AND TEST PIT LOGS SYMBOLS AND TERMS

SYMBOLS AND ABBREVIATIONS

RL	Reduced Level
EOH	End of Hole
•	Shear vane test result
UTP	Unable to Penetrate
TDTA	Too Difficult to Auger
SPT	Standard Penetration Test
N	SPT blows per 300mm penetration
35/90	35 blows per 90mm penetration after seating for SPT
(s)	Inclusive of seating blow count for SPT
GWL	Ground Water Level
PL	Planar Discontinuity Surface
R	Rough Discontinuity Surface

U	Undulating Discontinuity Surface
SR	Slightly Rough Discontinuity Surface
S	Smooth Discontinuity Surface
Fe	Iron Oxide Staining
QV	Quartz Vein
F	Fracture
ST	Stepped Discontinuity Surface
J	Jointing
RQD	Rock Quality Designation
CZ	Crush Zone
SZ	Shear Zone
Fo	Foliation
SL	Slickenside Discontinuity Surface

SOIL

	TOPSOIL		COBBLES
	CLAY		BOULDERS
	SILT		PEAT
	SAND		FILL
	GRAVEL		

CONSISTENCY TERMS

Cohesive Description	Undrained Shear Strength (kPa)
Very Soft	<12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very Stiff	100 - 200
Hard	>200

RELATIVE DENSITY

Non-cohesive Description	SPT "N" Value
Very Loose	<4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

ROCK

	LIMESTONE		RYHOLITE
	MUDSTONE		ANDESITE
	SANDSTONE		BASALT
	CONGLOMERATE		
	BRECCIA		

STRENGTH

Description	Unconfined Compressive Strength MPa
Extremely Weak	< 1
Very Weak	1 - 5
Weak	5 - 20
Moderately Strong	20 - 50
Strong	50 - 100
Very Strong	100 - 250
Extremely Strong	> 250

WEATHERING

UW	- Unweathered (fresh rock)
SW	- Slightly Weathered
MW	- Moderately Weathered
HW	- Highly Weathered
CW	- Completely Weathered
RS	- Residual Soil

SPACING OF DISCONTINUITIES

Term	Aperture (mm)
Very widely spaced	>2000
Widely spaced	600 - 2000
Moderately widely spaced	200 - 600
Closely spaced	60 - 200
Very closely spaced	20 - 60
Extremely closely spaced	<20

Notes

1. Based on New Zealand Geotechnical Society "Field Description of Soil and Rock, Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes" December 2005
2. Composite soil types are signified by combined symbols



BOREHOLE INFORMATION Method: Sonic Equipment: Tracked rig Contractor: McMillans		CO-ORDINATES: Easting: Northing: Reduced Level: Datum:	Date Started: 28/01/2025 Date Completed: Inclination: -90° Azimuth: N/A	Logged By: KT Input By: KT Reviewed By:
--	--	---	--	--

R.L. (m)	Depth (m)	Material Description	Geological Unit	Graphic Log	Weathering / USCS	Testing	TCR (%)	RQD (%)	Installation
		0.00m: Sandy SILT with minor gravel (fine to coarse, subrounded greywacke); dark brown. Soft, low plasticity, containing rootlets and grass [TOPSOIL]	T/S						
		0.30m: SILT, some sand (fine), trace gravels (fine to coarse) and cobbles; light greyish brown. Moist, non plastic [ALLUVIAL SEDIMENTS]							
		0.50m: CORE LOSS - BARREL BLOCKED BY COBBLE					33	-	
		1.52m: Silty GRAVEL (fine to coarse, subrounded greywacke), some sand (fine to coarse); greyish brown. Dense, loosely packed				1.50m: SPT 5,7//10,9,7,8 N=34			
		2.40m: Sandy (fine to coarse) GRAVEL (fine to coarse, subrounded greywacke), some silt, trace cobbles; greyish brown. Dense, densely packed	Alluvial Sediments				100	-	
		3.14m: Silty CLAY; orangey brown. Stiff, low to moderate plasticity				3.00m: SPT 1,5//9,10,10,10 N=39			
		3.30m: Gravelly (fine, subrounded greywacke) SILT; greyish brown. Soft, non plastic							
		3.60m: Silty GRAVEL (fine, subrounded greywacke); greyish brown. Dense, densely packed.					100	-	
		4.56m: Silty sandy GRAVEL (fine to medium, subrounded to subangular greywacke); orangey greyish brown. Dense				4.50m: SPT 6,11//10,14,11,11 N=46			

REMARKS Groundwater dipped at a depth of approximately 3.0 m, on 28/01/2025.
--



**Fraser
Thomas**

ENGINEERS • RESOURCE MANAGERS • SURVEYORS

Client: Kaikōura District Council
Project: Ocean Ridge Area F
Location: Ocean Ridge Area F
Project Reference: CH02248

M2

Sheet 2 of 4

BOREHOLE INFORMATION Method: Sonic Equipment: Tracked rig Contractor: McMillans		CO-ORDINATES: Easting: Northing: Reduced Level: Datum:	Date Started: 28/01/2025 Date Completed: Inclination: -90° Azimuth: N/A	Logged By: KT Input By: KT Reviewed By:
--	--	---	--	--

R.L. (m)	Depth (m)	Material Description	Geological Unit	Graphic Log	Weathering / USCS	Testing	TCR (%)	RQD (%)	Installation
		[CONT] 4.56m: Silty sandy GRAVEL (fine to medium, subrounded to subangular greywacke); orangey greyish brown. Dense	Alluvial Sediments			6.00m: SPT 1,1//1,3,4,6 N=14	100	-	
		5.70m: GRAVEL (fine to coarse, subrounded, greywacke), trace sand and silt; bluish grey. Medium dense							
		6.50m: Sandy (coarse) GRAVEL (fine, subrounded, greywacke); bluish grey.							
		6.65m: GRAVEL (fine to coarse, subrounded, greywacke), trace sand and silt; bluish grey. Densely packed.							
		7.00m: Gravelly (medium to coarse, subrounded, greywacke and chert) CLAY; brownish grey. Hard, low plasticity							
		7.60m: Silty sandy GRAVEL (fine to coarse, subrounded greywacke); greyish brown. Dense to very dense	Alluvial Sediments			7.50m: SPT 7,8//8,8,8,9 N=33	100	-	
		8.82m: CORE LOSS							
		9.12m: Silty sandy GRAVEL (fine to coarse, subrounded greywacke); greyish brown. Dense to very dense							
						9.00m: SPT 9,14//15,18,18, 9 for 40mm N= 60+			

REMARKS Groundwater dipped at a depth of approximately 3.0 m, on 28/01/2025.
--



BOREHOLE INFORMATION Method: Sonic Equipment: Tracked rig Contractor: McMillans		CO-ORDINATES: Easting: Northing: Reduced Level: Datum:		Date Started: 28/01/2025 Date Completed: Inclination: -90° Azimuth: N/A		Logged By: KT Input By: KT Reviewed By:	
---	--	---	--	--	--	--	--

R.L. (m)	Depth (m)	Material Description	Geological Unit	Graphic Log	Weathering / USCS	Testing	TCR (%)	RQD (%)	Installation
-11	11	[CONT] 9.12m: Silty sandy GRAVEL (fine to coarse, subrounded greywacke); greyish brown. Dense to very dense	Alluvial Sediments			10.50m: SPT 20,27//33,27 for 70mm N= 60+	100	-	
-12	12	12.16m: Silty sandy GRAVEL (fine to coarse, subrounded greywacke and chert), some cobbles; orangey greyish brown. Very dense				12.00m: SPT 25,35 for 10mm N=60+	100	-	
-13	13	13.48m: CORE LOSS				13.50m: SPT 20,40 for 25mm N=60+	87	-	
-14	14	13.68m: Silty sandy GRAVEL (fine to coarse, subrounded greywacke and chert), some cobbles; orangey greyish brown. Very dense					100	-	

REMARKS Groundwater dipped at a depth of approximately 3.0 m, on 28/01/2025.
--



Client: Kaikōura District Council
Project: Ocean Ridge Area F
Location: Ocean Ridge Area F
Project Reference: CH02248

Sheet 4 of 4

Method: Sonic
Equipment: Tracked rig
Contractor: McMillans

Easting:
Northing:
Reduced Level:
Datum:

Date Started: 20/05/2017
Date Completed: 20/05/2017
Inclination: -90°
Azimuth: N/A

Logged By: KT
 Input By: KT
 Reviewed By:

REMARKS	
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Groundwater dipped at a depth of approximately 3.0 m. on 28/01/2025.

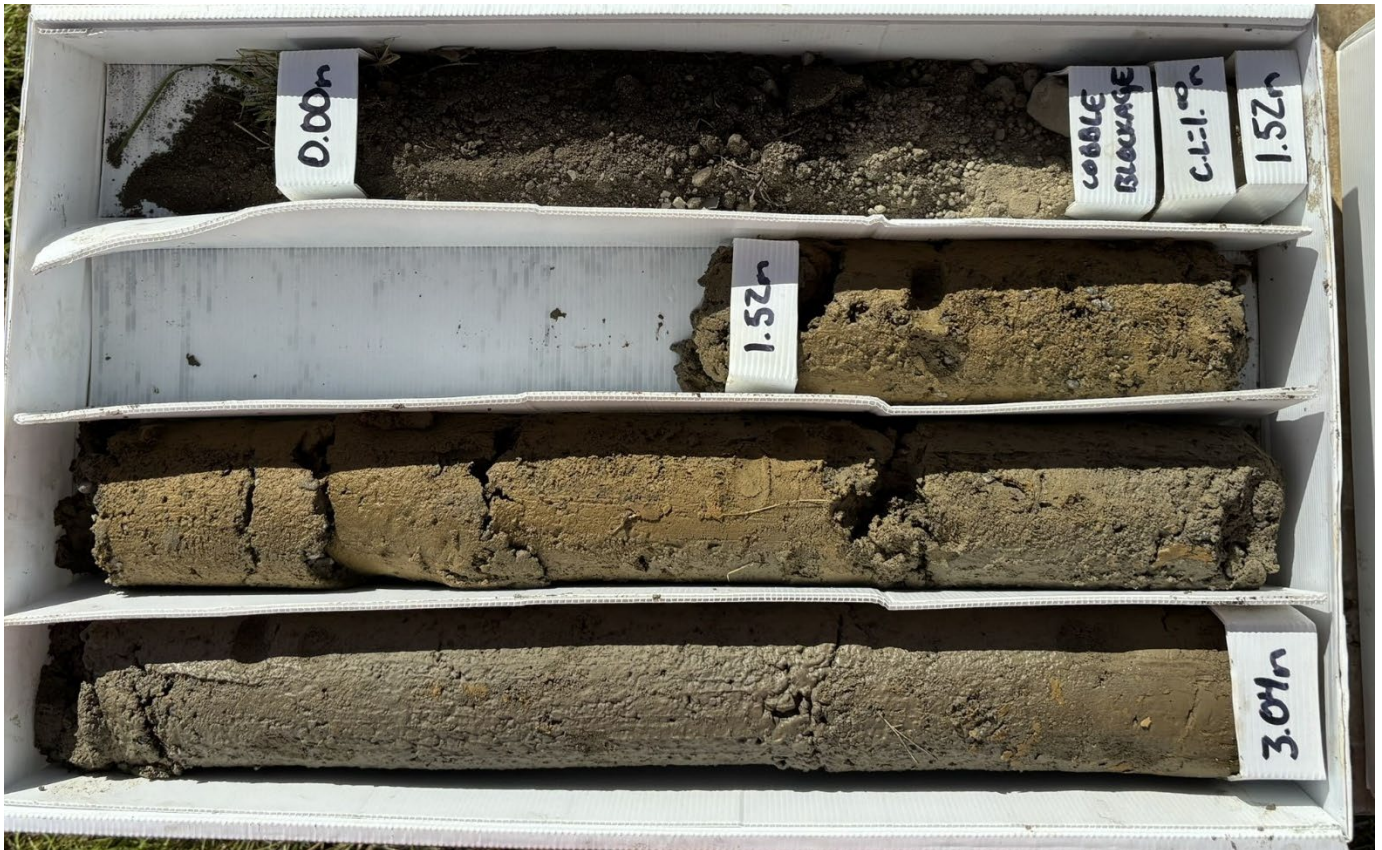
GEOTECHNICAL SERVICES

Machine Borehole Reference:
Photographed by:

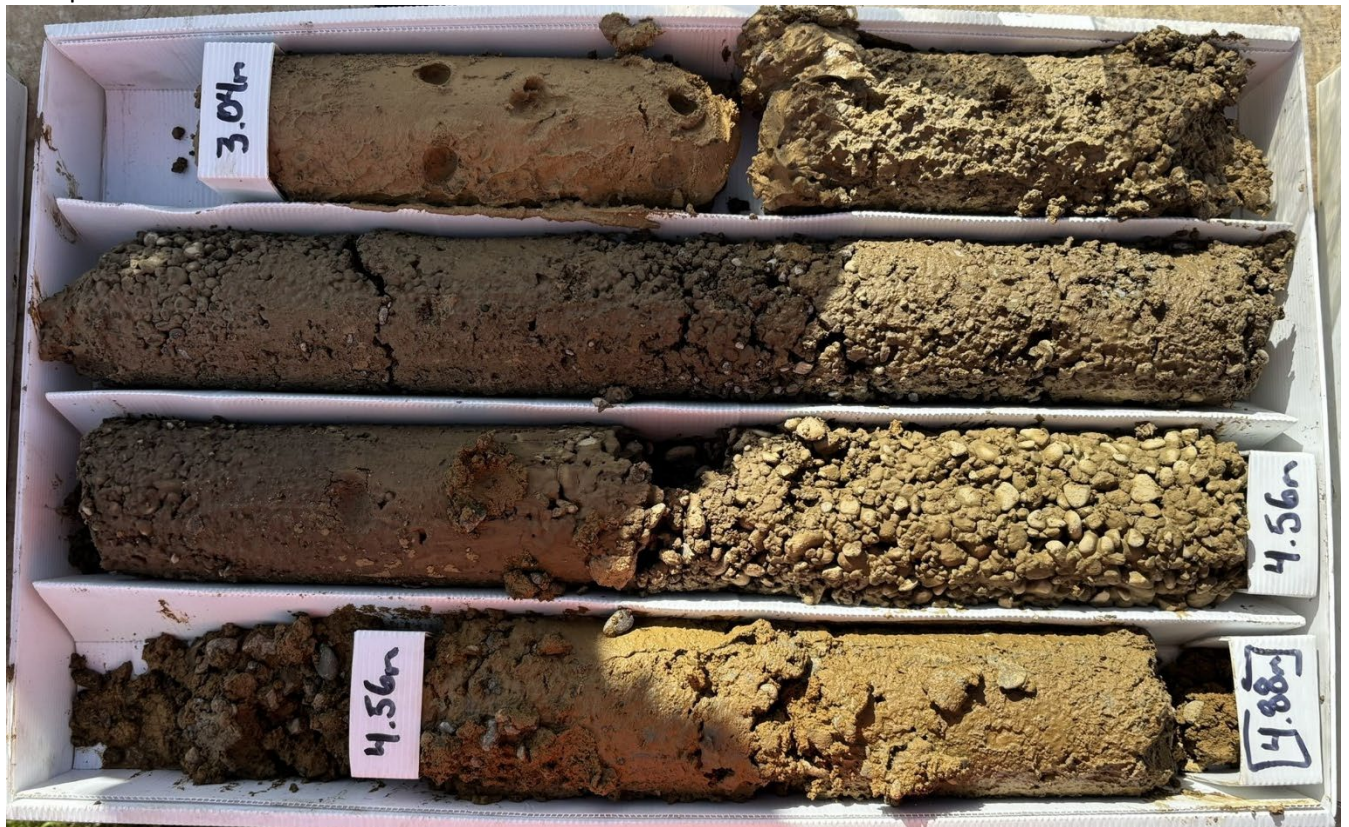
M2
K. Twohill

Date Drilled:
Date Photographed:

28/01/2025
28/01/2025



Box 1: Depth 0.0m to 3.04m



Box 2: Depth 3.04m to 4.88m

Machine Borehole Reference:
Photographed by:

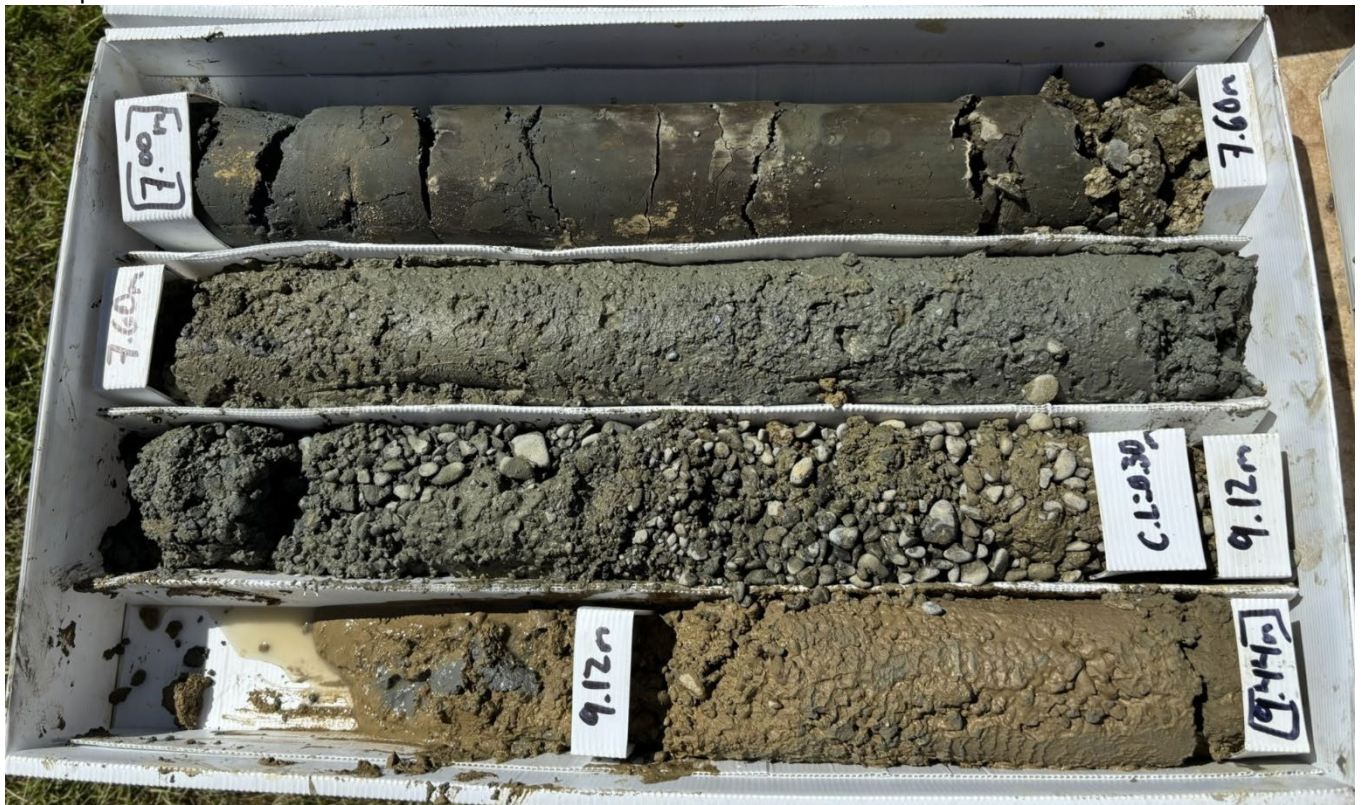
M2
K. Twohill

Date Drilled:
Date Photographed:

28/01/2025
28/01/2025



Box 3: Depth 4.88m to 7.0m



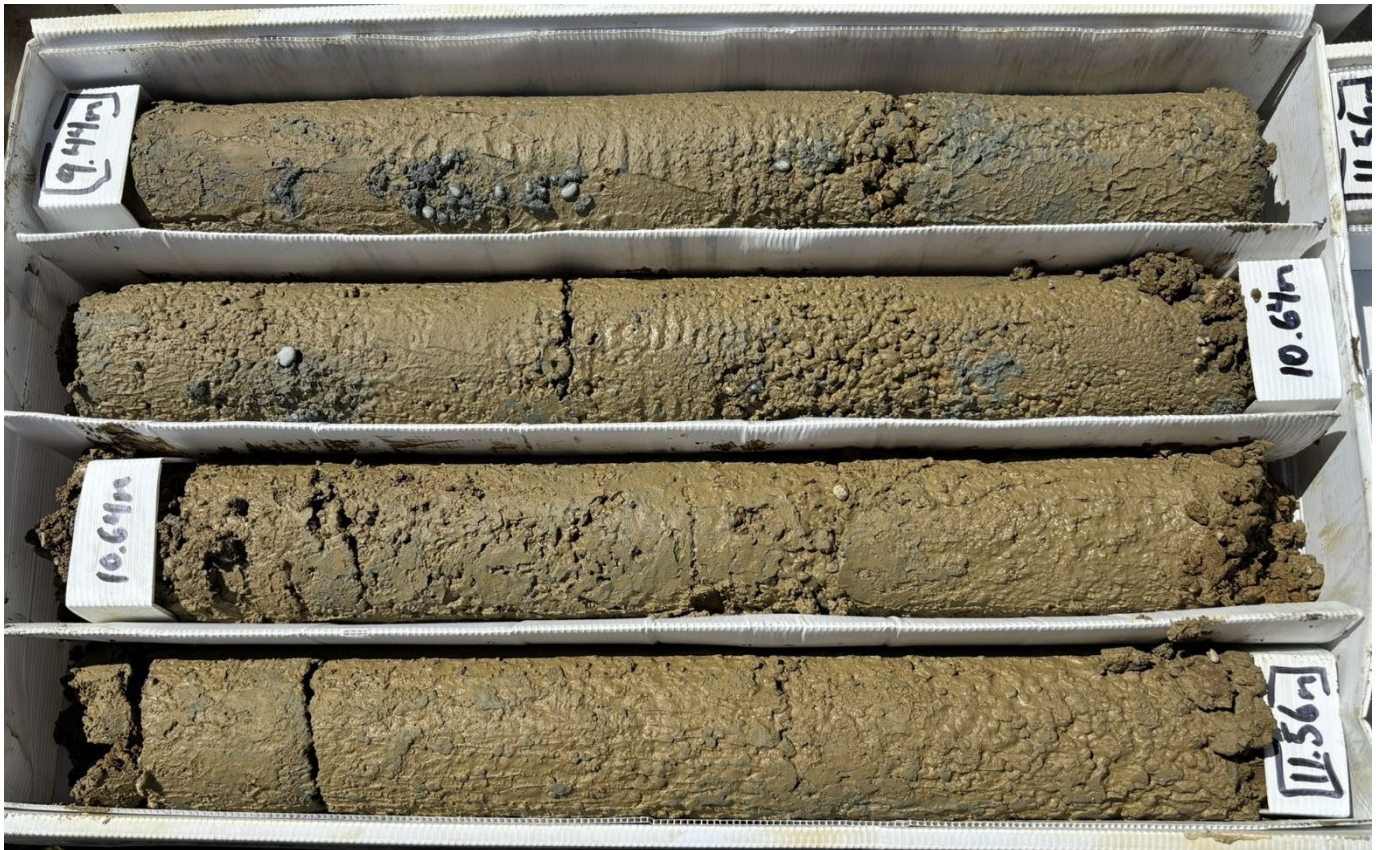
Box 4: Depth 7.0m to 9.44m

Machine Borehole Reference:
Photographed by:

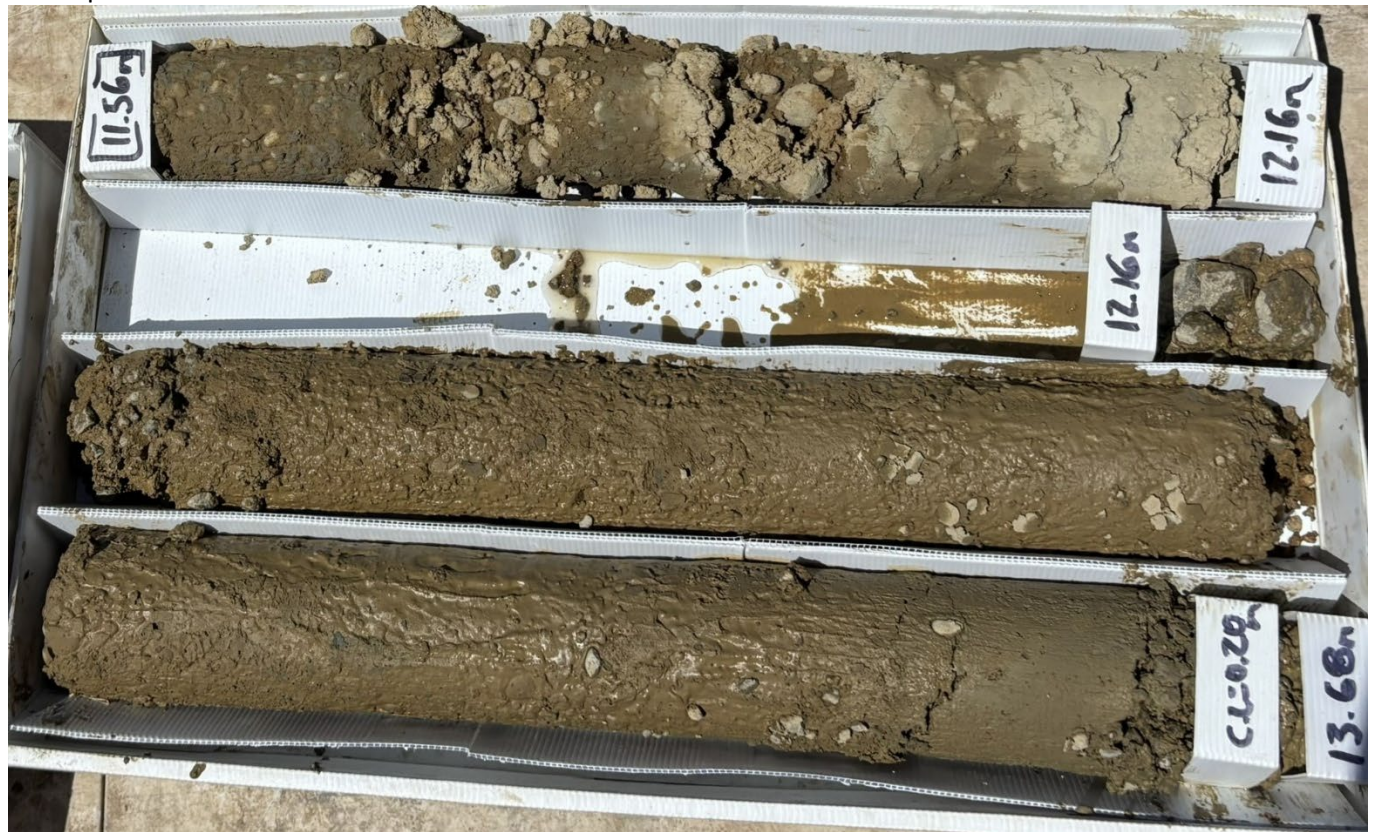
M2
K. Twohill

Date Drilled:
Date Photographed:

28/01/2025
28/01/2025



Box 5: Depth 9.44m to 11.56m



Box 6: Depth 11.56m to 13.68m

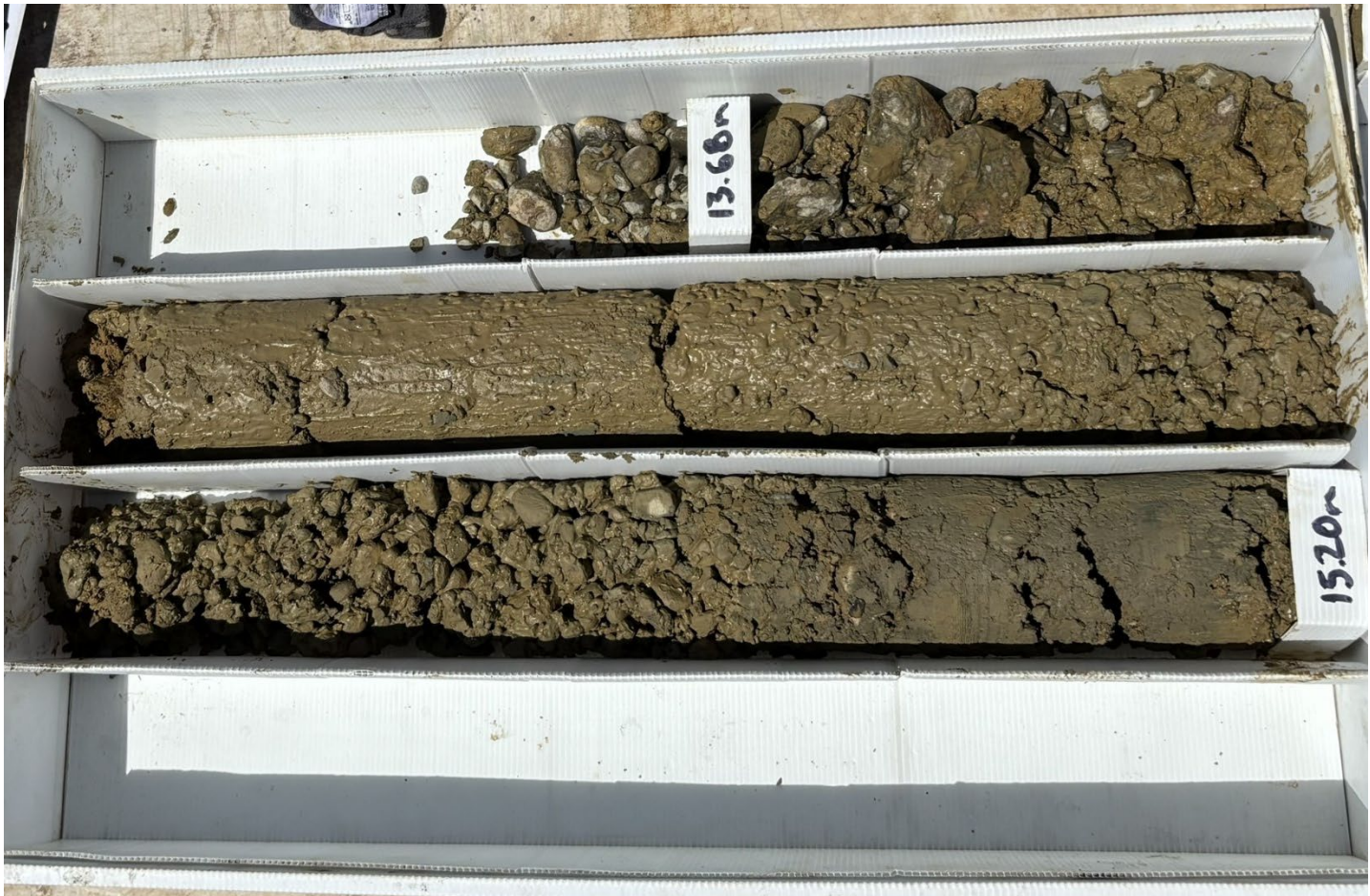
GEOTECHNICAL SERVICES

Machine Borehole Reference:
Photographed by:

M2
K. Twohill

Date Drilled:
Date Photographed:

28/01/2025
28/01/2025



Box 7: Depth 13.68m to 15.2m

M3



BOREHOLE AND TEST PIT LOGS SYMBOLS AND TERMS

SYMBOLS AND ABBREVIATIONS

RL	Reduced Level
EOH	End of Hole
•	Shear vane test result
UTP	Unable to Penetrate
TDTA	Too Difficult to Auger
SPT	Standard Penetration Test
N	SPT blows per 300mm penetration
35/90	35 blows per 90mm penetration after seating for SPT
(s)	Inclusive of seating blow count for SPT
GWL	Ground Water Level
PL	Planar Discontinuity Surface
R	Rough Discontinuity Surface

U	Undulating Discontinuity Surface
SR	Slightly Rough Discontinuity Surface
S	Smooth Discontinuity Surface
Fe	Iron Oxide Staining
QV	Quartz Vein
F	Fracture
ST	Stepped Discontinuity Surface
J	Jointing
RQD	Rock Quality Designation
CZ	Crush Zone
SZ	Shear Zone
Fo	Foliation
SL	Slickenside Discontinuity Surface

SOIL

	TOPSOIL		COBBLES
	CLAY		BOULDERS
	SILT		PEAT
	SAND		FILL
	GRAVEL		

CONSISTENCY TERMS

Cohesive Description	Undrained Shear Strength (kPa)
Very Soft	<12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very Stiff	100 - 200
Hard	>200

RELATIVE DENSITY

Non-cohesive Description	SPT "N" Value
Very Loose	<4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

ROCK

	LIMESTONE		RYHOLITE
	MUDSTONE		ANDESITE
	SANDSTONE		BASALT
	CONGLOMERATE		
	BRECCIA		

STRENGTH

Description	Unconfined Compressive Strength MPa
Extremely Weak	< 1
Very Weak	1 - 5
Weak	5 - 20
Moderately Strong	20 - 50
Strong	50 - 100
Very Strong	100 - 250
Extremely Strong	> 250

WEATHERING

UW - Unweathered (fresh rock)
SW - Slightly Weathered
MW - Moderately Weathered
HW - Highly Weathered
CW - Completely Weathered
RS - Residual Soil

SPACING OF DISCONTINUITIES

Term	Aperture (mm)
Very widely spaced	>2000
Widely spaced	600 - 2000
Moderately widely spaced	200 - 600
Closely spaced	60 - 200
Very closely spaced	20 - 60
Extremely closely spaced	<20

Notes

1. Based on New Zealand Geotechnical Society "Field Description of Soil and Rock, Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes" December 2005
2. Composite soil types are signified by combined symbols



BOREHOLE INFORMATION

Method: Sonic
Equipment: Tracked rig
Contractor: McMillans

CO-ORDINATES:

Easting:
Northing:
Reduced Level:
Datum:

Date Started: 30/01/2025

Date Completed:
Inclination: -90°
Azimuth: N/A

Logged By: KT
Input By: KT
Reviewed By:

R.L. (m)	Depth (m)	Material Description	Geological Unit	Graphic Log	Weathering / USCS	Testing	TCR (%)	RQD (%)	Installation
		0.00m: SILT, trace clay; dark brown. Soft, low plasticity, containing rootlets [TOPSOIL] 0.10m: SILT, some sand (fine) and clay; light grey mottled orangey brown. Hard, low plasticity [RESIDUAL SOILS - SEYMOUR GROUP]	T/S						
		0.90m: SILT, minor clay; light grey mottled orangey brown. Stiff, low plasticity					100	-	
		1.10m: Sandy SILT; light grey mottled orangey brown. Hard, non plastic.							
		1.30m: ...Iron oxide band with nodules (grainy - fine gravel sized)							
		1.40m: Completely weathered, light grey mottled orangey brown, fine grained, SANDSTONE, extremely weak [SANDSTONE - SEYMOUR GROUP] 1.50m: Sandy SILT; grey. Stiff, low to moderate plasticity 1.52m: Completely weathered, light grey mottled orangey brown, fine grained, SANDSTONE, extremely weak to very weak				1.50m: SPT 5,6//7,8,8 N=31			
		2.50m: CORE LOSS					66	-	
		3.00m: Completely weathered, orangey grey, massive and fine grained, SANDSTONE, extremely weak, occasional bands of iron oxide staining 3.30m: ...Colour change to light grey mottled orangey brown	Seymour Group			3.00m: SPT 5,5//6,7,8 N=29			
		4.10m: ...J,5° Fe				4.50m: SPT 7,11//10,6,10,25 N=51	100	-	
							27	-	

REMARKS

Groundwater not encountered on 30/01/2025.



BOREHOLE INFORMATION Method: Sonic Equipment: Tracked rig Contractor: McMillans		CO-ORDINATES: Easting: Northing: Reduced Level: Datum:		Date Started: 30/01/2025 Date Completed: Inclination: -90° Azimuth: N/A		Logged By: KT Input By: KT Reviewed By:	
--	--	---	--	--	--	--	--

R.L. (m)	Depth (m)	Material Description	Geological Unit	Graphic Log	Weathering / USCS	Testing	TCR (%)	RQD (%)	Installation
		4.98m: CORE LOSS							
							27	-	
-6	6	6.08m: Moderately weathered, dark greyish brown, massive and fine grained, SANDSTONE, extremely weak to very weak, micaceous, trace angular gravels				6.00m: SPT 11,19//16,20,24 for 40mm N= 60+			
-7	7						100	-	
		7.60m: ...Until end of bore: Most of recovered rock is highly fractured due to drilling methodology and weakness of rock.	Seymour Group			7.50m: SPT 16,28//25,20,15 for 60mm N= 60+			
-8	8						100	-	
-9	9					9.00m: SPT 8,11//11,11,10,11 N= 43			
							100	-	

REMARKS

Groundwater not encountered on 30/01/2025.



Client: Kaikōura District Council
Project: Ocean Ridge Area G
Location: Ocean Ridge Area G
Project Reference: CH02181

Sheet 3 of 4

Method: Sonic
Equipment: Tracked rig
Contractor: McMillans

Easting:
Northing:
Reduced Level:
Datum:

Date Started: 30/06/2017
Date Completed: 01/07/2017
Inclination: -90°
Azimuth: N/A

Logged By: KT
 Input By: KT
 Reviewed By:

REMARKS	
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Groundwater not encountered on 30/01/2025.



Client: Kaikōura District Council
Project: Ocean Ridge Area G
Location: Ocean Ridge Area G
Project Reference: CH02181

Sheet 4 of 4

Method: Sonic
Equipment: Tracked rig
Contractor: McMillans

Easting:
Northing:
Reduced Level:
Datum:

Date Started: 09/09
Date Completed: 09/09
Inclination: -90°
Azimuth: N/A

Logged By: KT
 Input By: KT
 Reviewed By:

REMARKS

Groundwater not encountered on 30/01/2025.

GEOTECHNICAL SERVICES

Machine Borehole Reference:
Photographed by:

M3
K. Twohill

Date Drilled:
Date Photographed:

30/01/2025
30/01/2025



Box 1: Depth 0.00m to 2.44m



Box 2: Depth 2.44m to 4.56m

Machine Borehole Reference:
Photographed by:

M3
K. Twohill

Date Drilled:
Date Photographed:

30/01/2025
30/01/2025



Box 3: Depth 4.56m to 7.6m



Box 4: Depth 7.6m to 9.44m

Machine Borehole Reference:
Photographed by:

M3
K. Twohill

Date Drilled:
Date Photographed:

30/01/2025
30/01/2025



Box 5: Depth 9.44m to 11.56m



Box 6: Depth 11.56m to 14.00m

GEOTECHNICAL SERVICES

Machine Borehole Reference:
Photographed by:

M3
K. Twohill

Date Drilled:
Date Photographed:

30/01/2025
30/01/2025



Box 7: Depth 14.0m to 15.2m

BH01



LOG OF BORING BH01

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 28.05.2024
Hole Depth : 21.28 m
Drilling Method : Rotasonic
Drilling Contractor : McMillan Drilling Group Ltd

Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39657667
Longitude : 173.64760061

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
												25 50 75	
	FILL			[FILL] Sandy SILT, minor gravel; brownish grey, saturated, non plastic, saturated; sand is fine to coarse, gravel is fine angular to subrounded.				S					
0.5	TOPSOIL			[FILL] Gravelly fine to coarse SAND, some silt; brownish grey; gravel is fine to medium angular to subrounded.									
			ML	[TOPSOIL] SILT, some gravel, trace sand; dark brown with white speckles, moist, non plastic; gravel is fine to coarse angular to subrounded, sand is fine to coarse. 0.45 m - Minor gravel encountered. 0.5 m - Trace gravel encountered.				St					
1.0				[TOPSOIL] SILT, minor sand, trace gravel; dark brownish black with white speckles, non plastic; sand is fine, gravel is fine angular to subrounded.									
1.5	LOESS		ML	[LOESS] SILT, minor clay; light brown with orange brown mottles, low plasticity. 0.9 m - Becomes light brownish grey with orange brown mottles. 1.3 m - Trace clay encountered; becomes brown with light grey inclusions.						3,4,5,6,7,8 N=26			
2.0				Core Loss									
			CH	1.52 m - Minor clay encountered; becomes brown with black speckles, trace limonite modules. 1.8 m - Some clay encountered; moderate plasticity.				VSt					
2.5				[ALLUVIUM] Silty CLAY; brown with black speckles, high plasticity, trace limonite nodules 2.2 m - 3.0 m.									
3.0				2.8 m - Becomes light brown.				M					
				3.0 m - Becomes light grey and light brown intermixed. No limonite.						2,2,3,3,4,5 N=15			
3.5	ALLUVIUM												
4.0									St				
4.5													
								F		1,2,2,2,3,3 N=10			
5.0				4.9 m - Becomes light grey with orange brown									
Borehole met target depth				Standing water was measured at 2.7 mbgl one day after drilling									
Consistency/density inferred based on SPTs and tactile assessments				(level likely influenced by drilling fluid)									



LOG OF BORING BH01

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 28.05.2024
Hole Depth : 21.28 m
Drilling Method : Rotasonic
Drilling Contractor : McMillan Drilling Group Ltd

Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39657667
Longitude : 173.64760061

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
5.5			CH	mottles. [ALLUVIUM] Silty CLAY; brown with black speckles, high plasticity, trace limonite nodules 2.2 m - 3.0 m. 5.15 m - 50mm of heavy orange staining and some limonite nodules 5.15 m - 6.0 m.									
6.0				6.0 m - Becomes light brownish grey with orange brown mottles.					F	0,0,2,1,2,3 N=8			
6.5													
7.0			ML	Sandy clayey SILT; light brown with orange brown mottles, low plasticity; sand is fine.									
7.5			CH	Silty CLAY; light brown with orange brown mottles, high plasticity. 7.6 m - Becomes light greyish brown with orange brown mottles.				M		1,2,2,2,4,4, N=12			
8.0									St				
8.5													
9.0													
9.5				9.07 m - Trace fine, rounded gravel or coarse sand; light brown with brownish grey streaks.					F	2,1,2,2,3,3 N=10			
10.0			ML										

ALLUVIUM

Borehole met target depth

Consistency/density inferred based on SPTs and tactile assessments

Standing water was measured at 2.7 mbgl one day after drilling (level likely influenced by drilling fluid)



LOG OF BORING BH01

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 28.05.2024
Hole Depth : 21.28 m
Drilling Method : Rotasonic
Drilling Contractor : McMillan Drilling Group Ltd

Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39657667
Longitude : 173.64760061

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
10.5			ML	Sandy SILT, minor clay; greyish brown with orange brown streaks, moderate plasticity; sand is fine to medium. 10.24 m - 50mm CLAY inclusion, grey. 10.29 m - Becomes brown with dark brown streaks.					F				
11.0				10.64 m - Trace clay encountered.						6,6,6,9,9,10 N=34			
11.5				Core Loss					VSt				
12.0	ALLUVIUM		ML	12.16 m - Dark brown streaks absent.						6,7,8,11,12,15 N=46			
12.5				12.78 m - 50mm reddish brown staining.				M					
13.0				Core Loss					H				
13.5			ML	14.08 m - SILT, minor clay; light brown with orange brown mottles, low plasticity.						6,11,15,15,18,12 N=60+			
14.0			ML	[RESIDUAL SANDSTONE/SILTSTONE] SILT, trace fine sand; dark grey, low plasticity.									
14.5				14.5 m - 14.7 m Becomes stained orange brown.									
15.0			SW	14.8 m - 50mm CLAY lens.				D					

GEOTECH MACHINE BORING GINT LOGS.GPJ NZ DATA TEMPLATE 2.GDT 26/6/24

Borehole met target depth

Consistency/density inferred based on SPTs and tactile assessments

Standing water was measured at 2.7 mbgl one day after drilling
(level likely influenced by drilling fluid)



LOG OF BORING BH01

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 28.05.2024
Hole Depth : 21.28 m
Drilling Method : Rotasonic
Drilling Contractor : McMillan Drilling Group Ltd
Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39657667
Longitude : 173.64760061

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
			SW	Fine to medium SAND, some silt; greyish brown with orange brown mottles. Completely weathered SANDSTONE; extremely weak to very weak.				D		7,12,12,12,17,17 N=58			
			ML	SILT, minor clay; dark grey with orange brown mottles, low plasticity. 15.25 m - Clay absent. 15.7 m - Orange brown mottles absent.									
15.5													
16.0													
16.5													
17.0				17 m - Minor clay encountered. 17.1 m - Trace clay encountered.						8,10,16,19,18,7 N=60+			
17.5								M	H				
18.0			ML	Sandy SILT; light brown with orange staining, low plasticity; sand is fine to medium.									
				Core Loss									
			ML	SILT, trace clay; dark grey, low plasticity.						25,25,17,21,22 N=60+			
18.5													
19.0			SM	Silty fine to coarse SAND; grey, coarser sand is green and reddish brown.									
				Core Loss									
19.5													
20.0			SM	Silty fine to coarse SAND; grey, coarser sand is green and reddish brown.						15,23,30,24,6 N=60+			
Borehole met target depth Consistency/density inferred based on SPTs and tactile assessments													
Standing water was measured at 2.7 mbgl one day after drilling (level likely influenced by drilling fluid)													



LOG OF BORING BH01

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 28.05.2024
Hole Depth : 21.28 m
Drilling Method : Rotosonic
Drilling Contractor : McMillan Drilling Group Ltd

Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39657667
Longitude : 173.64760061

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
			SM	Silty fine to coarse SAND; grey, coarser sand is green and reddish brown.								25 50 75	
20.5			ML	SILT; dark grey, residual rock fabric. Completely weathered dark grey SILTSTONE; extremely weak to very weak.				M	H				
21.0													
End of Hole Depth: 21.28 m Termination: Target depth										42.60 N=60+			

Borehole met target depth

Consistency/density inferred based on SPTs and tactile assessments (level likely influenced by drilling fluid)

Standing water was measured at 2.7 mbgl one day after drilling



BH01 0.0m – 1.84m



BH01 1.84m – 3.96m



BH01 3.96m – 6.08m



BH01 6.08m – 7.92m



BH01 7.92m – 10.04m



BH01 10.04m – 13.08m



BH01 13.08m – 15.20m



BH01 15.20m – 17.04m



BH01 17.04m – 19.76m



BH01 19.76m – 21.28m

BH02



LOG OF BORING BH02

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 29.05.2024
Hole Depth : 19.76 m
Drilling Method : Rotasonic
Drilling Contractor : McMillan Drilling Group Ltd

Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39693782
Longitude : 173.64782278

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
	TS			[TOPSOIL] SILT, trace rootlets; blackish brown, non plastic.								25 50 75	
0.5			ML	[LOESS] SILT, trace fine sand, trace rootlets; light greyish brown with orange brown mottles, non plastic.									
1.0				0.6 m - Minor clay encountered; becomes light brownish grey with orange brown mottles, low plasticity. 0.75 m - Trace clay encountered; becomes brown with grey streaks.					F				
1.5			ML	[LOESS] Clayey SILT; light brown with grey streaks, moderate plasticity.				M		1,3,3,3,4,3 N=13			
2.0				1.7 m - Becomes light greyish brown.									
2.5			CH	[ALLUVIUM] Silty CLAY, trace 6 mm diameter roots; light greyish brown, high plasticity.									
3.0			ML	SILT, some sand; greyish brown with orange brown mottles, non-plastic; sand is fine to medium.					St				
3.5			CH	Silty CLAY; light brown with grey streaks, high plasticity. 3.1 m - Becomes grey with orange brown mottles. 3.35 m - Becomes grey with orange brown streaks.						1,2,2,3,4,6 N=15			
4.0				3.96 m - Minor limonite nodules encountered.				W					
4.5			ML	SILT, minor clay; brownish grey with heavy orange brown mottling, Low plasticity. 4.45 m - Trace clay encountered. 4.56 m - Some clay encountered; becomes light grey with light brown streaks and orange brown mottles, moderate plasticity. 4.76 m - Minor fine sand, trace clay encountered; becomes light greyish brown, low					VSt	2,5,6,9,9,10 N=34			
5.0													

Borehole met target depth

Consistency/density inferred based on SPTs and tactile assessment

Standing water measured 0.0 mbgl immediately after drilling (drilling fluid). Standing water measured at 7.3 mbgl 20 days after drilling and was likely still influenced by drilling fluid



LOG OF BORING BH02

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 29.05.2024
Hole Depth : 19.76 m
Drilling Method : Rotasonic
Drilling Contractor : McMillan Drilling Group Ltd

Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39693782
Longitude : 173.64782278

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
5.5			ML	plasticity. SILT, minor clay; brownish grey with heavy orange brown mottling, Low plasticity. 5.2 m - Some clay encountered; becomes light brownish grey, moderate plasticity. 5.4 m - Trace sand encountered, clay absent; becomes greyish brown, non-plastic; sand is fine to medium.				W					
6.0			ML	Core Loss									
6.5			ML	6.08 m - Minor clay encountered; becomes light greyish brown, low plasticity. 6.25 m - Some fine sand, trace clay encountered 6.25 m - 6.4 m.						5,5,10,14,16,17 N=57			
7.0				6.8 m - Becomes brownish grey with orange brown streaks. 7.0 m - Becomes grey with orange brown streaks.									
7.5													
8.0				7.6 m - Minor clay, minor fine sand encountered. 7.92 m - Some fine sand encountered, clay absent.				M		5,11,13,17,20,10 N=60+			
8.5									H				
9.0			ML	[RESIDUAL SANDSTONE/SILTSTONE] SILT, some fine sand; dark grey with orange brown streaks. non-plastic. 9.12 m - Trace clay encountered, low plasticity.						6,10,14,14,20,12 N=60+			
9.5													
10.0													

ALLUVIUM

Standing water measured 0.0 mbgl immediately after drilling (drilling fluid). Standing water measured at 7.3 mbgl 20 days after drilling and was likely still influenced by drilling fluid

Borehole met target depth

Consistency/density inferred based on SPTs and tactile assessment



LOG OF BORING BH02

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 29.05.2024
Hole Depth : 19.76 m
Drilling Method : Rotasonic
Drilling Contractor : McMillan Drilling Group Ltd

Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39693782
Longitude : 173.64782278

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
10.5			ML	[RESIDUAL SANDSTONE/SILTSTONE] SILT, some fine sand; dark grey with orange brown streaks. non-plastic.					H				
11.0				10.64 m - Minor clay encountered; becomes mottled orange brown 10.64 m - 10.85 m.						5,9,10,9,9,11 N=39			
11.5				11.5 m - Becomes mottled orange brown.				M					
12.0			ML	Sandy SILT, minor clay; dark grey with orange brown mottles, low plasticity; sand is fine to medium.					VSt				
12.5				12.16 m - Becomes grey with light brown inclusions.						3,4,5,7,8,10, N=30			
13.0			SM	Silty SAND; light brown; sand is fine to coarse.				W					
13.5			ML	[FRACTURED SANDSTONE] GRAVEL; grey with orange brown staining; gravel is fine to coarse angular. Highly weathered SANDSTONE; weak.									
14.0			ML	[RESIDUAL SANDSTONE/SILTSTONE] Sandy SILT, trace clay; grey, non-plastic; sand is fine to coarse.									
14.5				[FRACTURED SANDSTONE] GRAVEL; grey with orange brown staining; gravel is fine to coarse angular. Highly weathered SANDSTONE; weak.									
15.0				[RESIDUAL SILTSTONE] Sandy SILT, trace clay; grey, non-plastic; sand is fine to coarse. 13.5 m - 13.65 m Some fine to medium sand encountered. 13.65 m - Minor clay encountered; low plasticity. 13.9 m - Some fine to medium sand encountered. 14.0 m - Becomes sandy, non-plastic; sand is fine to coarse. 14.4 m - Trace fine, rounded gravel encountered, trace green mineral. 14.6 m - Gravel absent.				M		8,12,15,15,20,10 N=60+			
15.0									H				

RESIDUAL SANDSTONE/SILTSTONE

GEOTECH MACHINE BORING GINT LOGS.GPJ NZ DATA TEMPLATE 2.GDT 26/6/24

Borehole met target depth

Consistency/density inferred based on SPTs and tactile assessment

Standing water measured 0.0 mbgl immediately after drilling (drilling fluid). Standing water measured at 7.3 mbgl 20 days after drilling and was likely still influenced by drilling fluid



LOG OF BORING BH02

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 29.05.2024
Hole Depth : 19.76 m
Drilling Method : Rotosonic
Drilling Contractor : McMillan Drilling Group Ltd

Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39693782
Longitude : 173.64782278

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
15.5			ML	[RESIDUAL SILTSTONE] Sandy SILT, trace clay; grey, non-plastic; sand is fine to coarse.						8,14,20,20,20 N=60+			
16.0				16.02 m - Minor fine sand, trace fine, 16.02 m - 16.12 m rounded gravel encountered.									
16.5				16.72 m - Becomes sandy; sand is fine to coarse.						15,20,12,30,18 N=60+			
17.0								M	H				
17.5													
18.0			ML	SILT, trace fine sand; dark grey, residual rock fabric. Completely weathered dark grey SILTSTONE; extremely weak to very weak.						8,24,30,30 N=60+			
18.5													
19.0													
19.5													
				End of Hole Depth: 19.76 m Termination: Target depth						9,15,25,20,15 N=60+			
Borehole met target depth Consistency/density inferred based on SPTs and tactile assessment					Standing water measured 0.0 mbgl immediately after drilling (drilling fluid). Standing water measured at 7.3 mbgl 20 days after drilling and was likely still influenced by drilling fluid								



LOG OF BORING BH02

Geotechnical Investigation
Green Lane
Kaikoura
25930.000.001

Client : Vitruvius
Date : 29.05.2024
Hole Depth : 19.76 m
Drilling Method : Rotosonic
Drilling Contractor : McMillan Drilling Group Ltd
Core Diameter : 83 mm
Energy Transfer Ratio : 84.3%
Logged By/Reviewed By : CN / JC
Latitude : -42.39693782
Longitude : 173.64782278

Depth (m BGL)	Material	Sample Type	USCS Symbol	DESCRIPTION	Log Symbol	Elevation (mRL)	Water Level	Moisture	Consistency/ Density Index	SPT N-Value	Torvane Shear (kPa)	Total Core Recovery (%)	Notes
												25 50 75	
Borehole met target depth													
Consistency/density inferred based on SPTs and tactile assessment													
Standing water measured 0.0 mbgl immediately after drilling (drilling fluid). Standing water measured at 7.3 mbgl 20 days after drilling and was likely still influenced by drilling fluid													



BH02 0.0m – 1.84m



BH02 1.84m – 3.96m



BH02 3.96m – 6.08m



BH02 6.08m – 7.92m



BH02 7.92m – 10.04m



BH02 10.04m – 12.16m



BH02 12.16m – 14.00m



BH02 14.00m – 16.12m



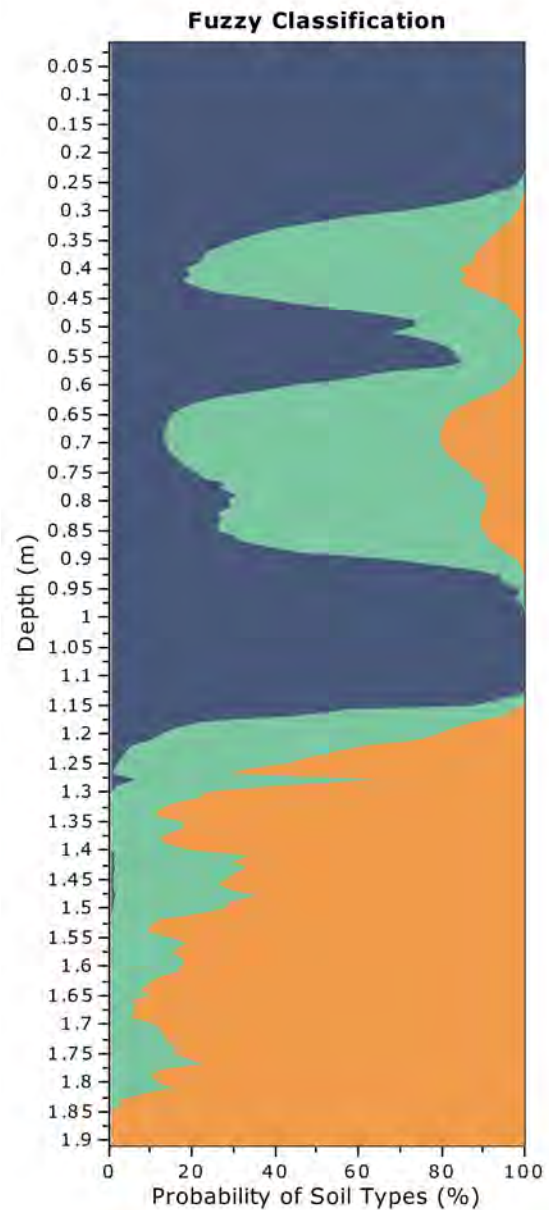
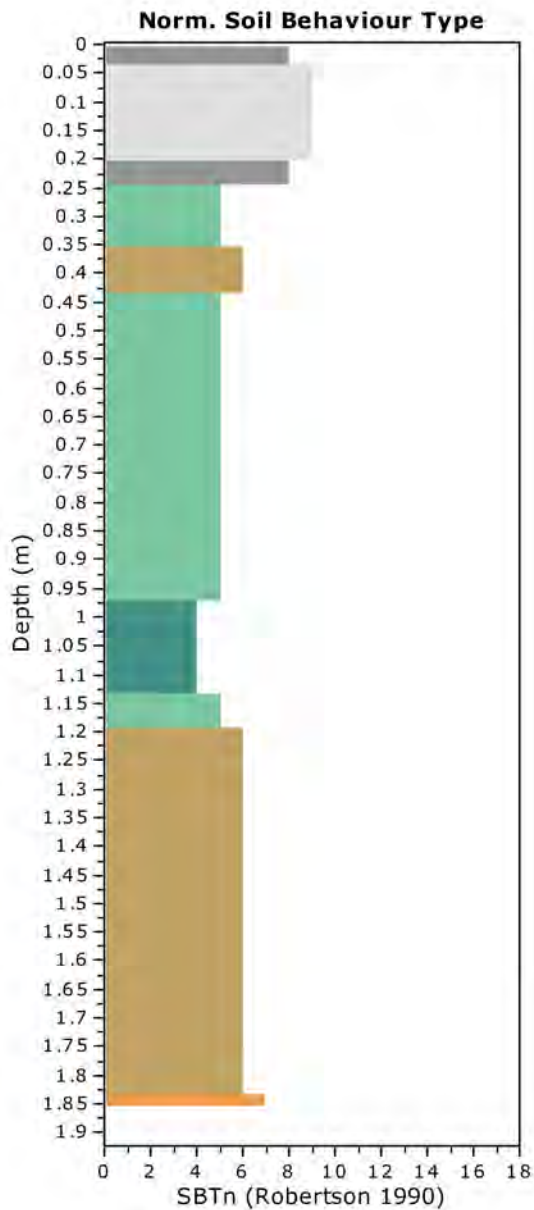
BH02 16.12m – 18.24m



BH02 18.24m – 19.76m

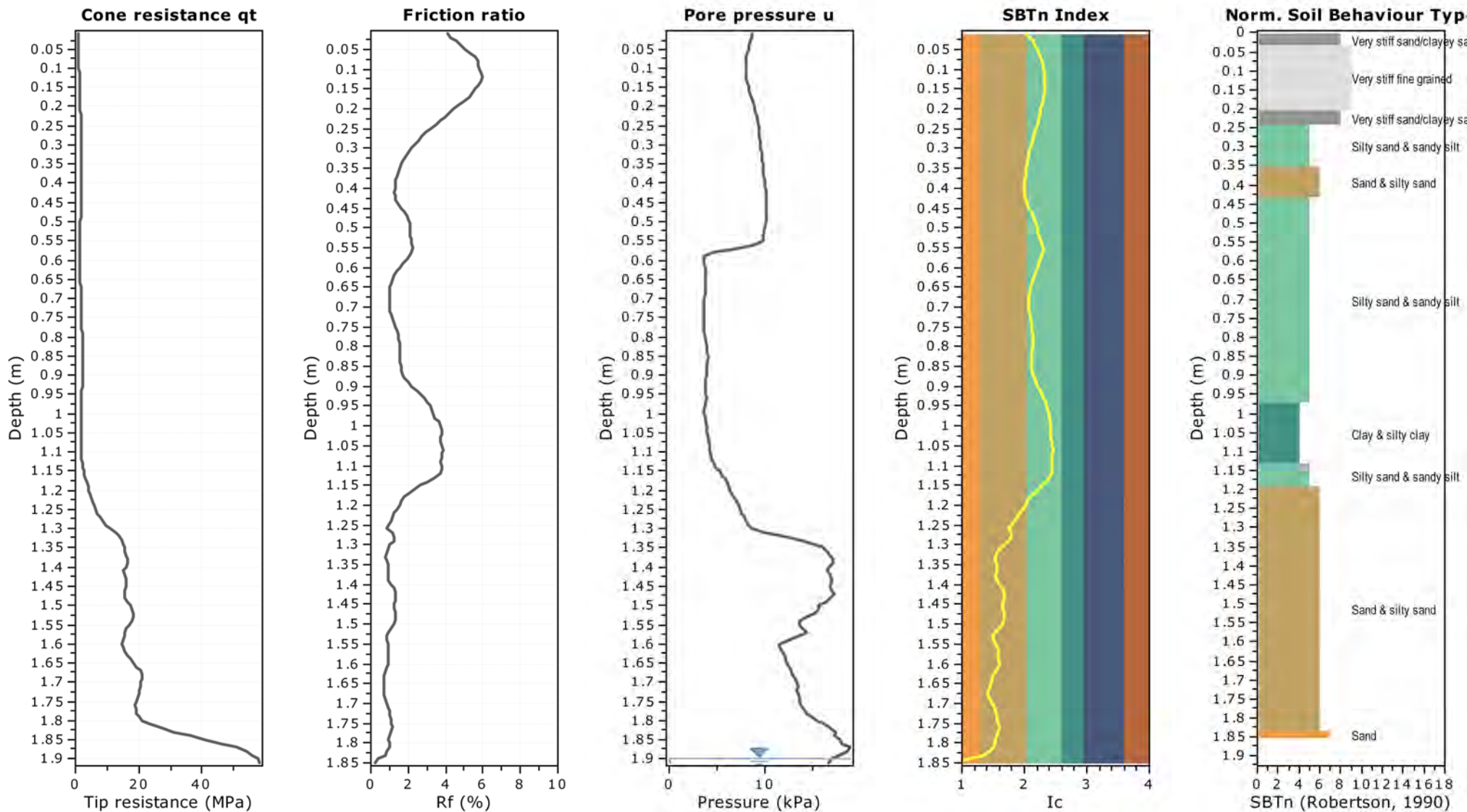
Cone Penetration Test (CPT) Results

CPT1

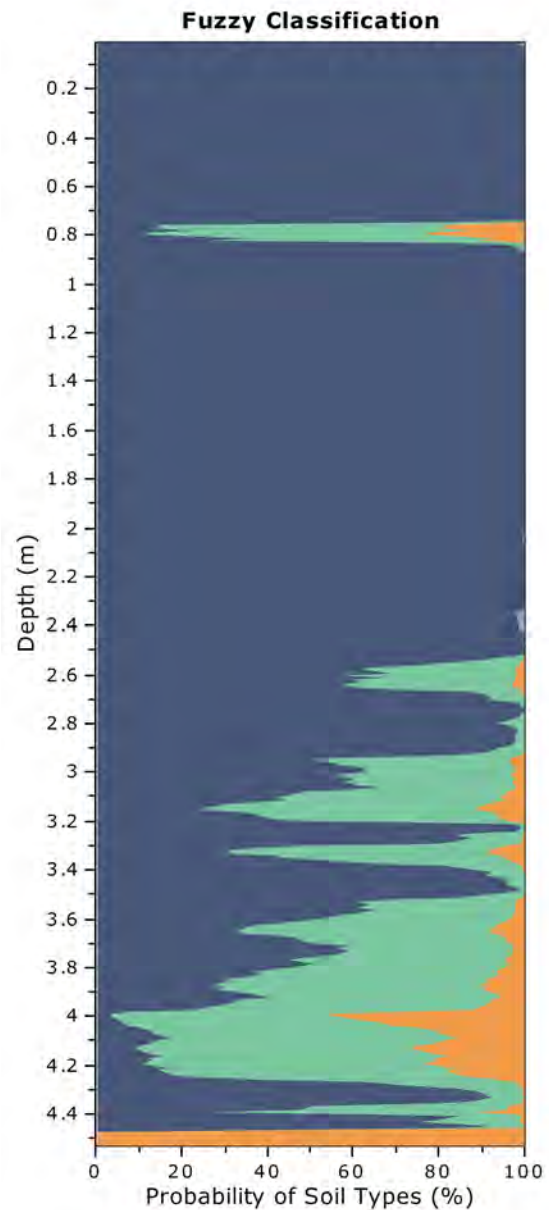
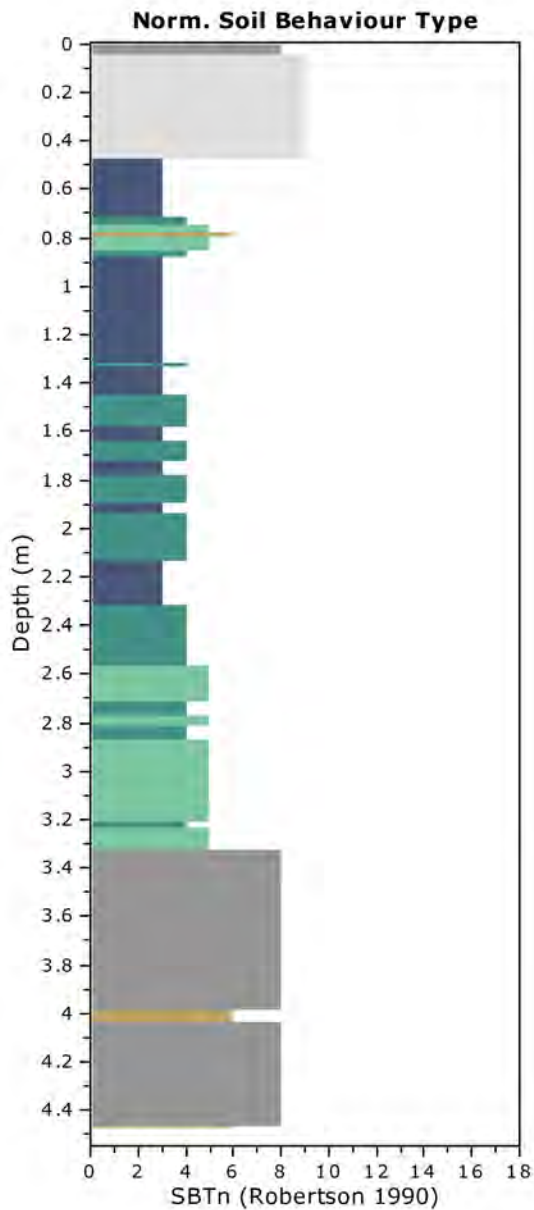


Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

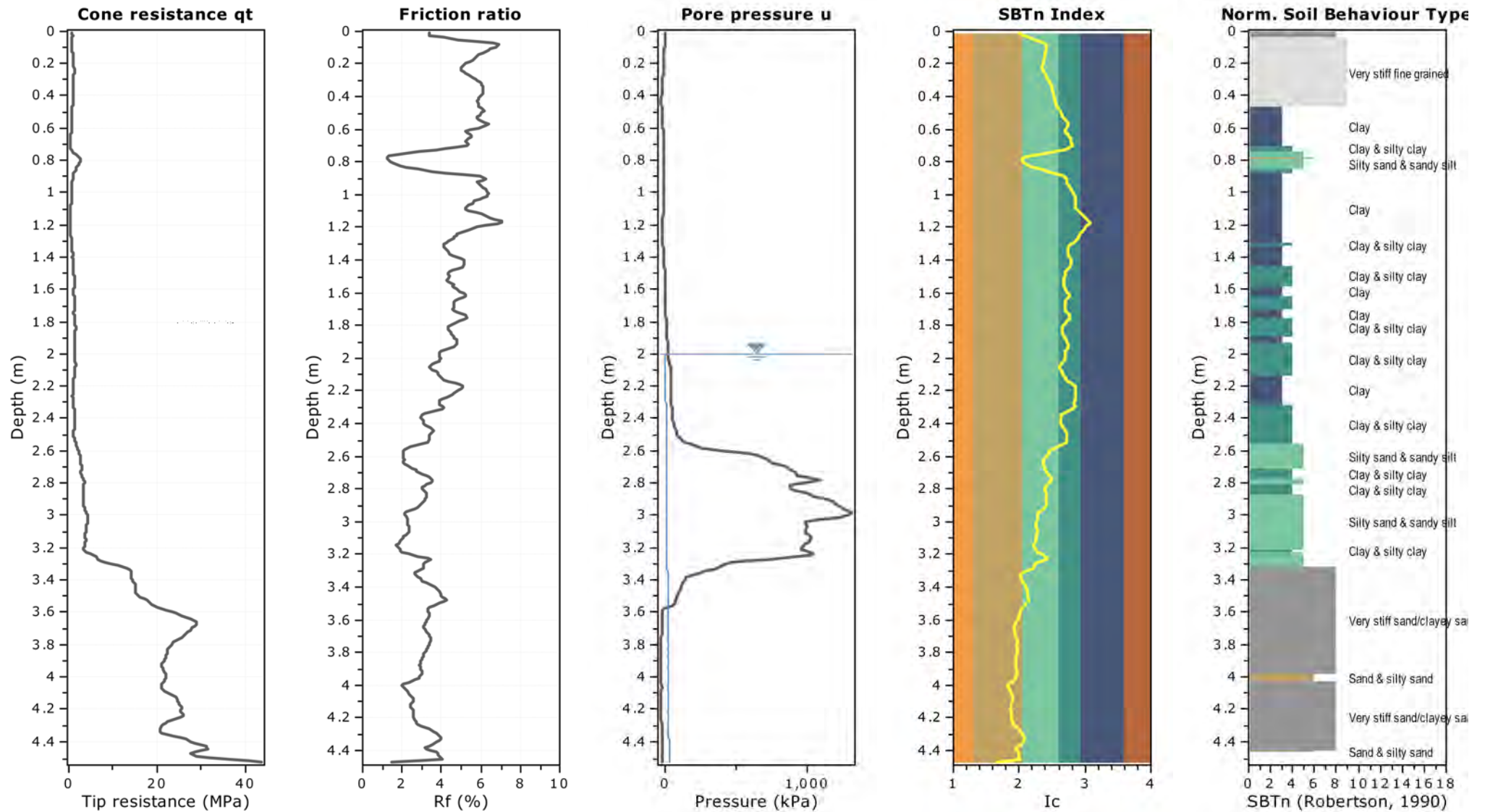


CPT2



Fuzzy classification legend

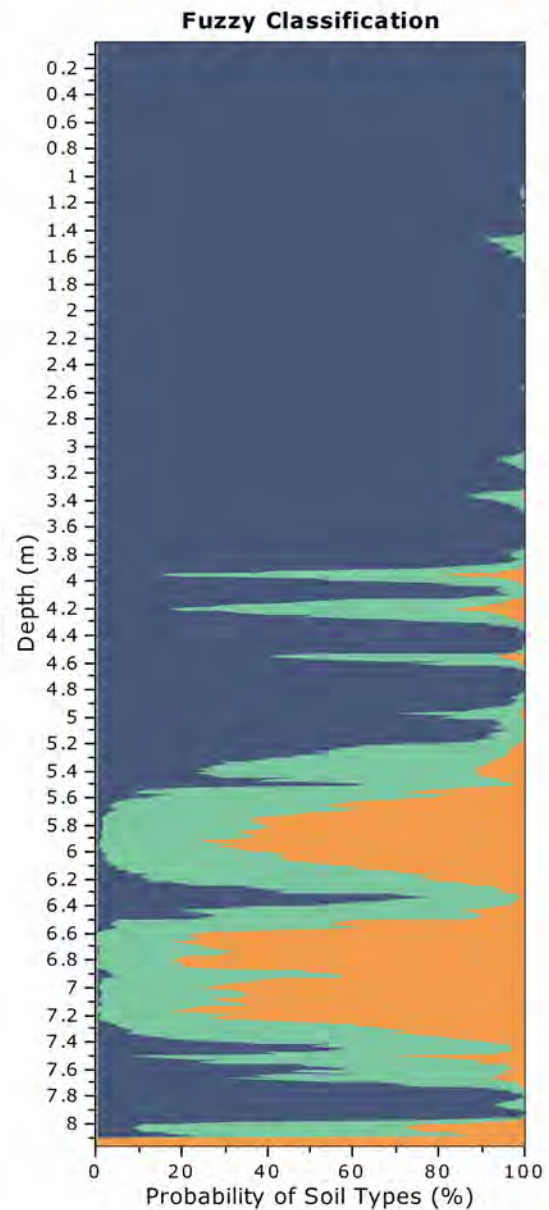
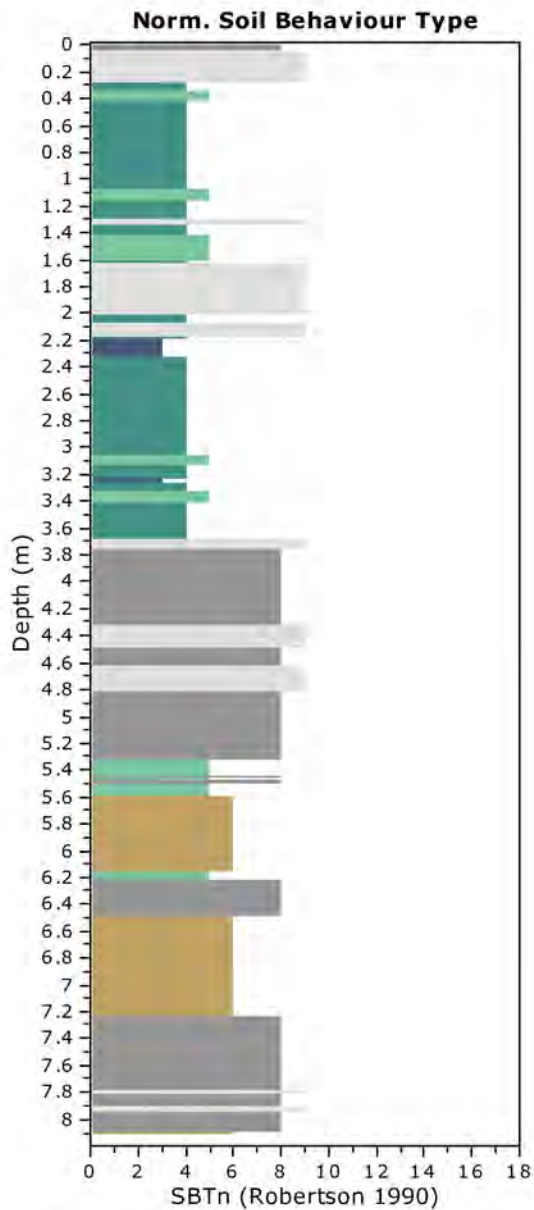
- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil



CPT3

Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura

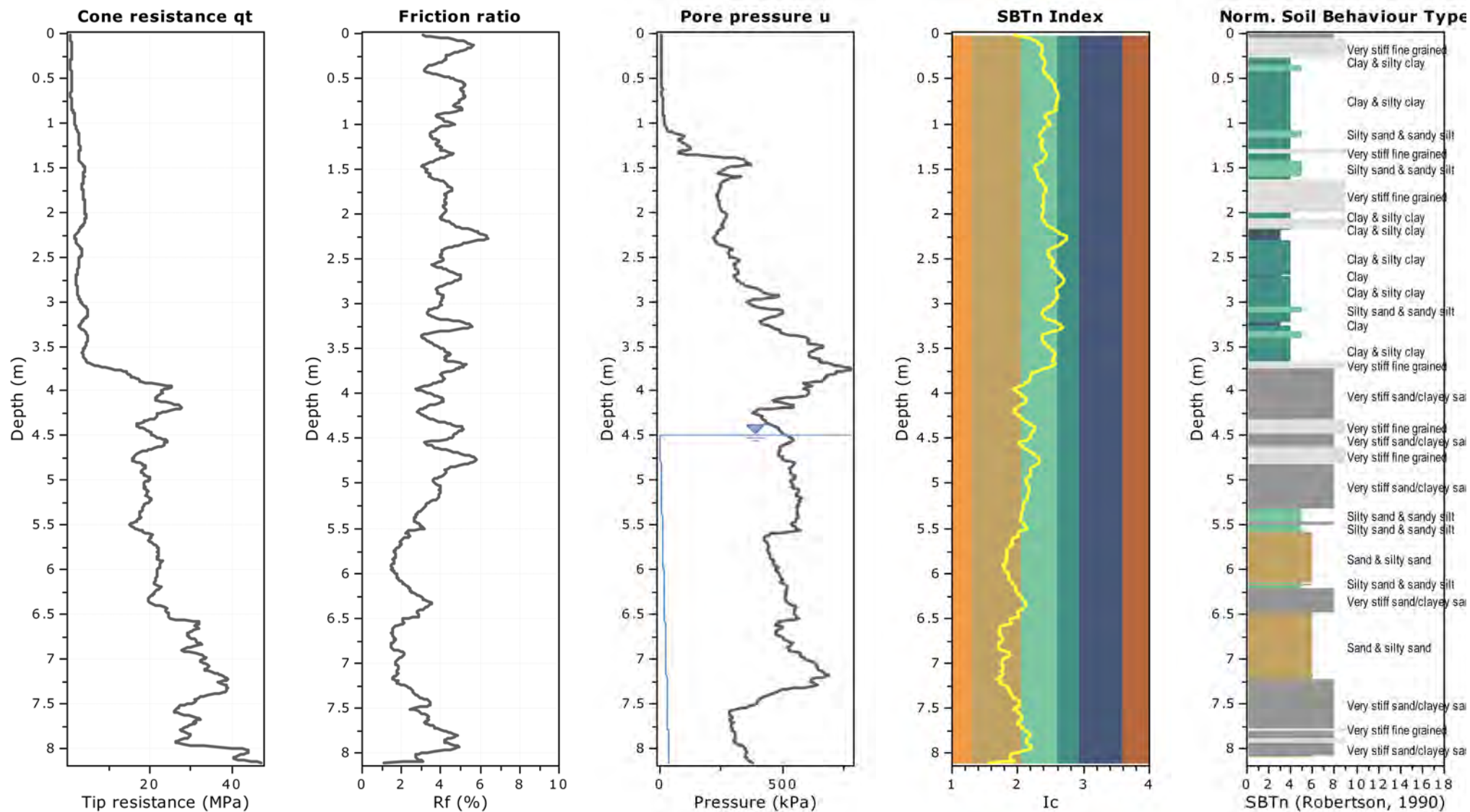


Fuzzy classification legend

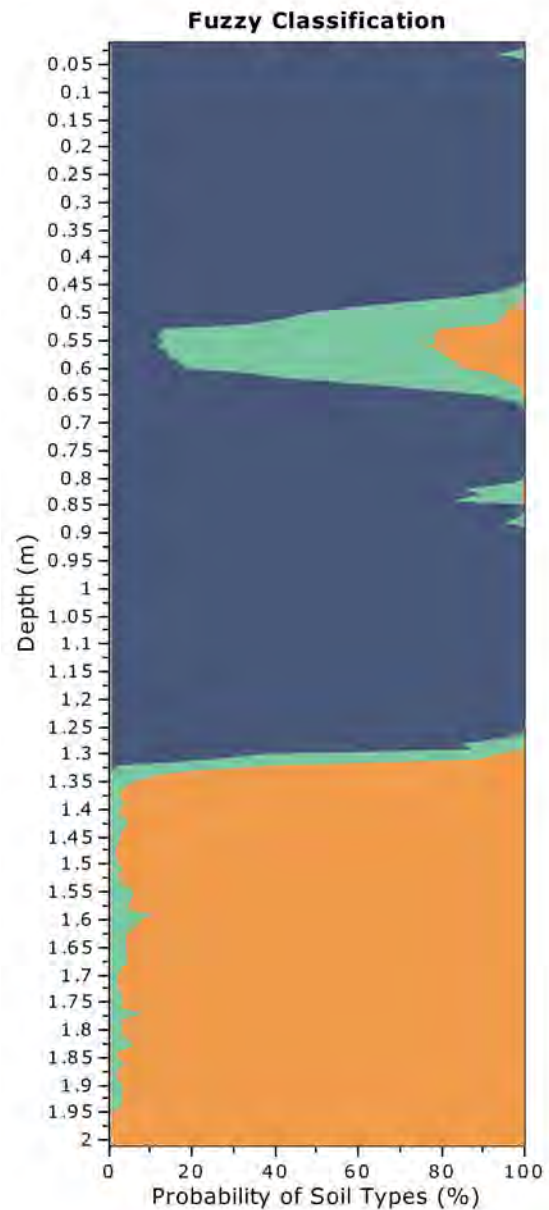
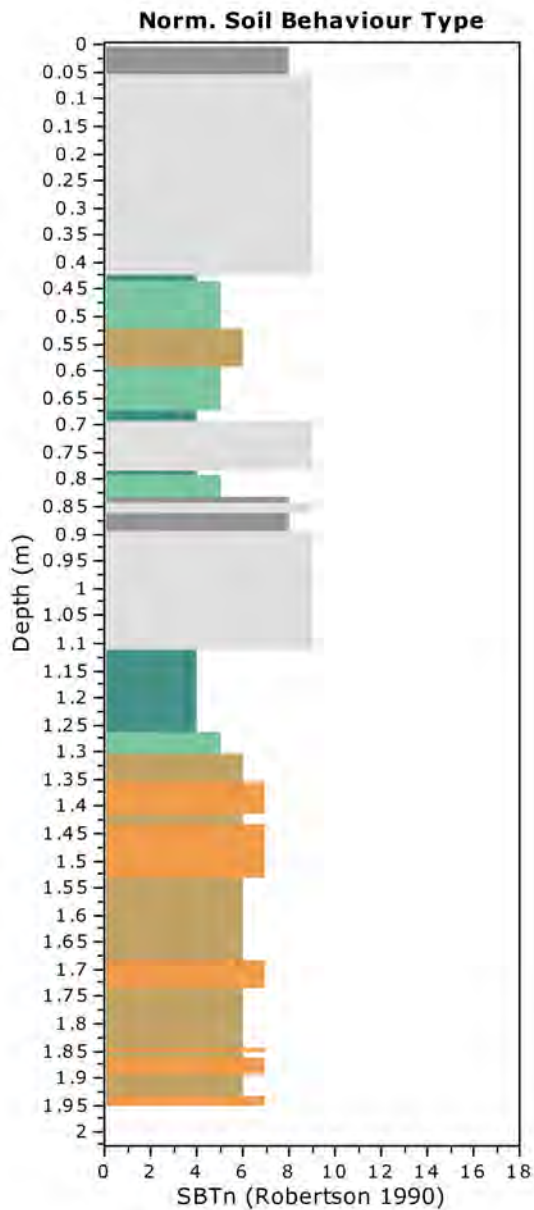
- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura



CPT4

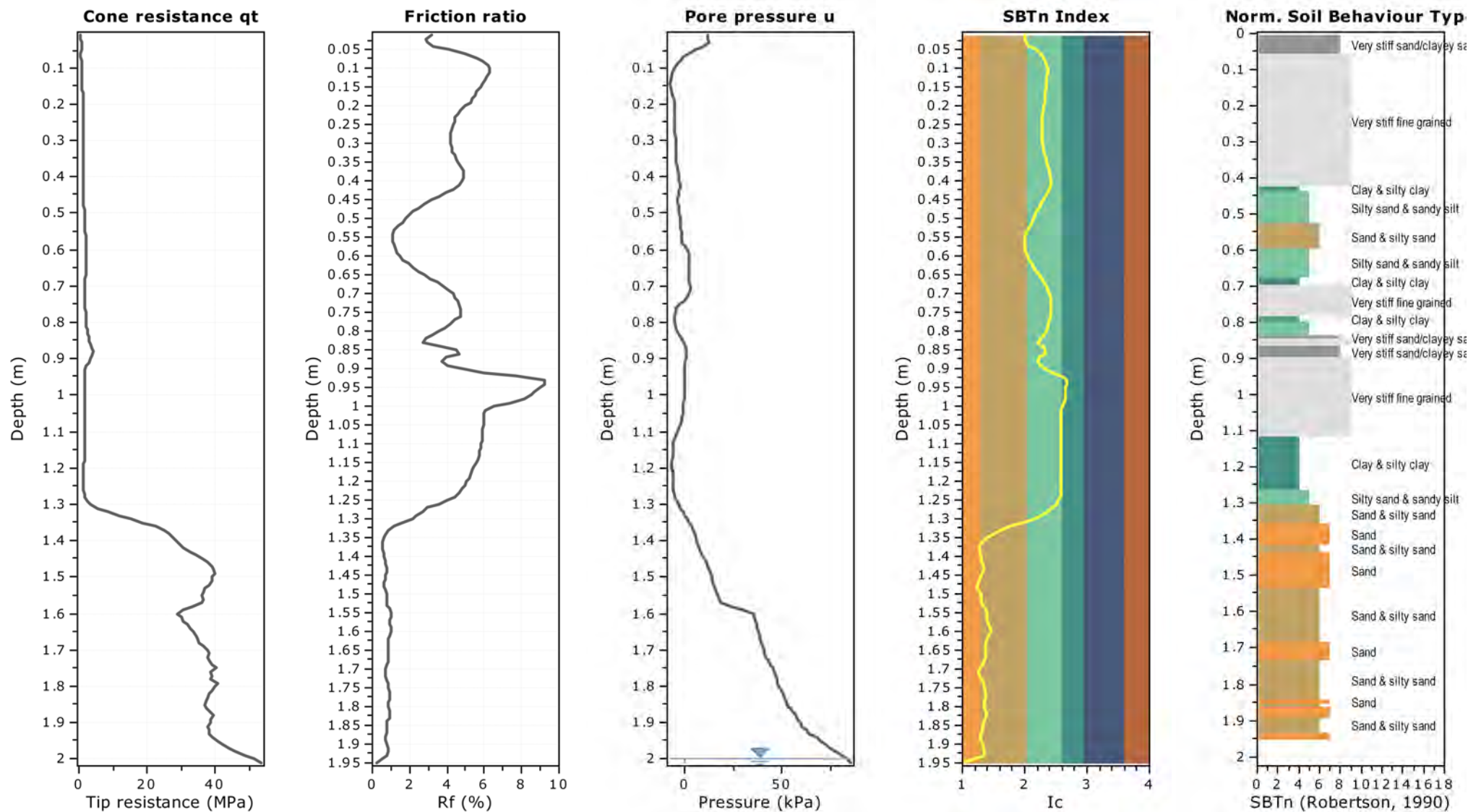


Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

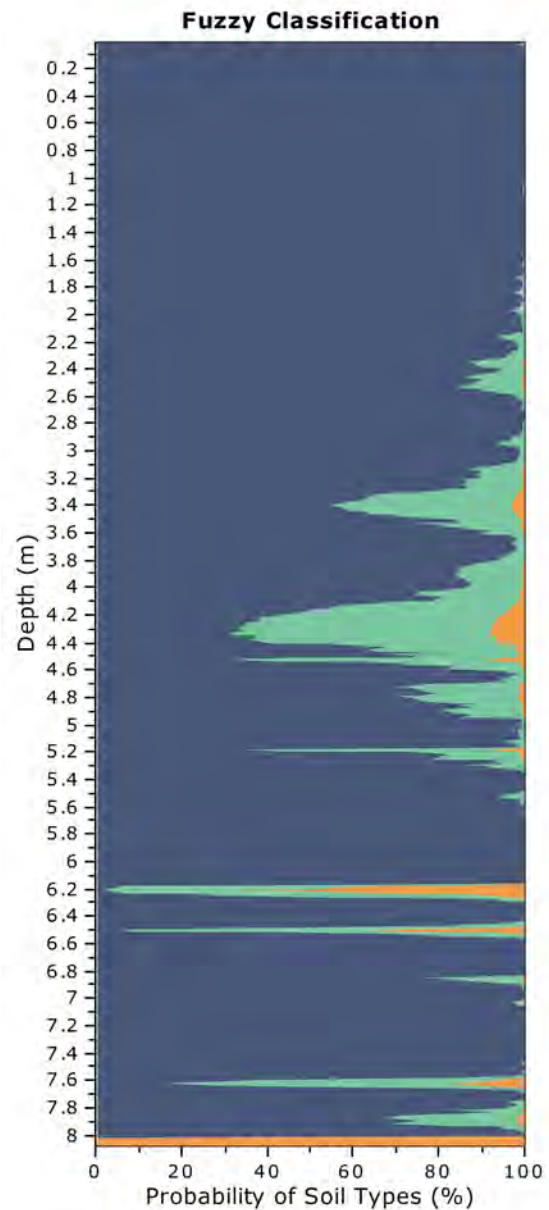
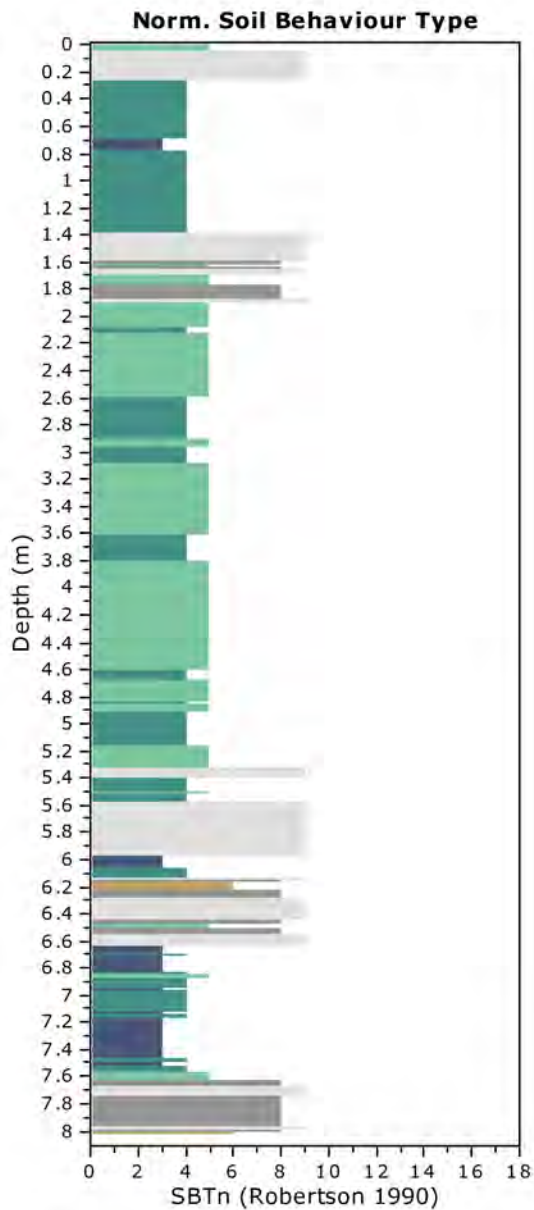
Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura



CPT5

Project: Cargill Station Ltd
Location: Ocean Ridge, Kaikoura

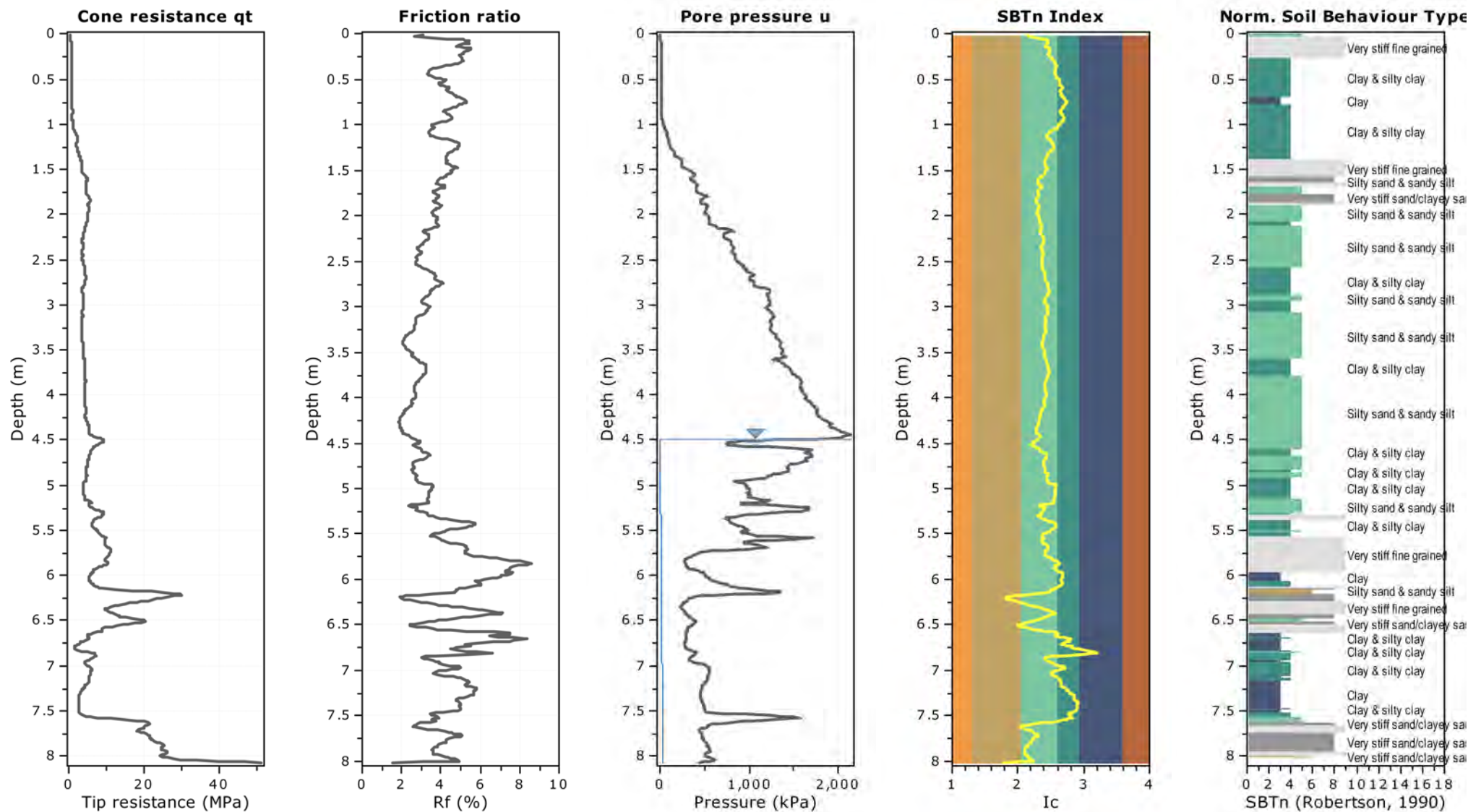


Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

Project: Cargill Station Ltd

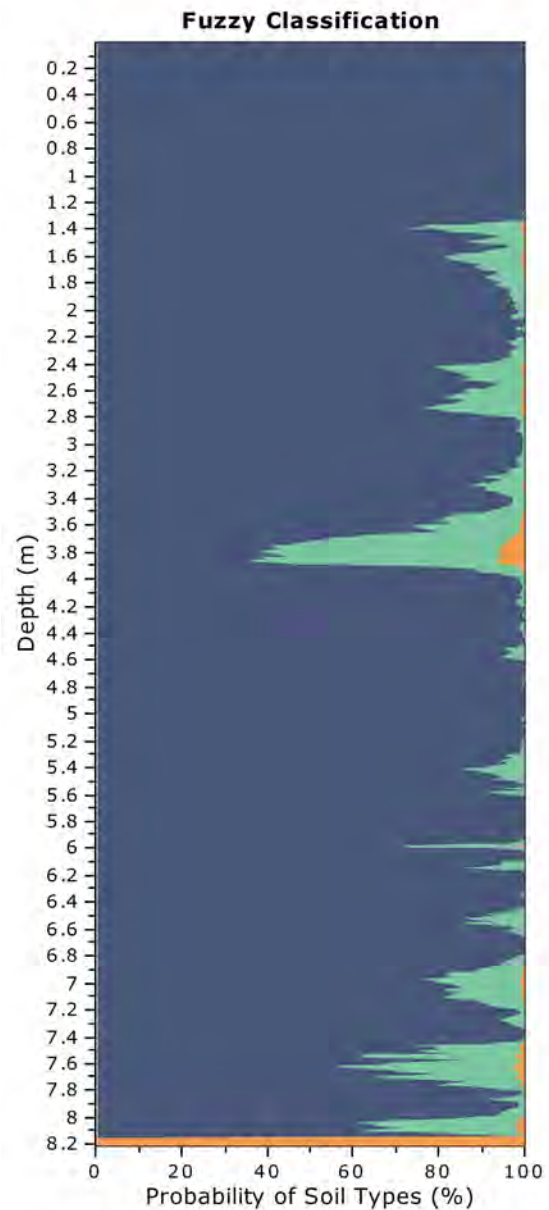
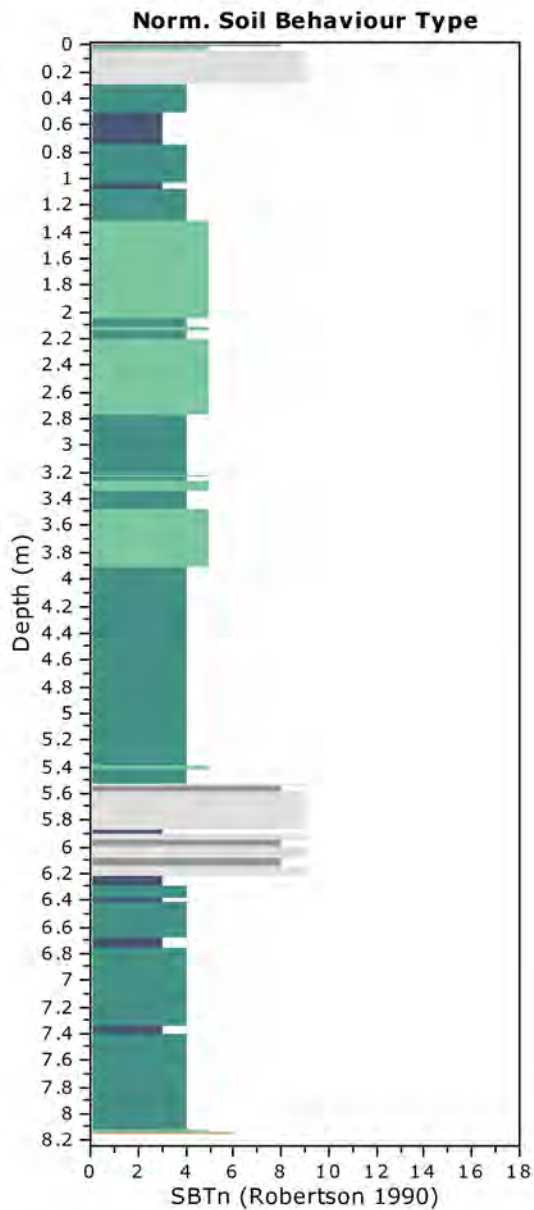
Location: Ocean Ridge, Kaikoura



CPT6

Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura

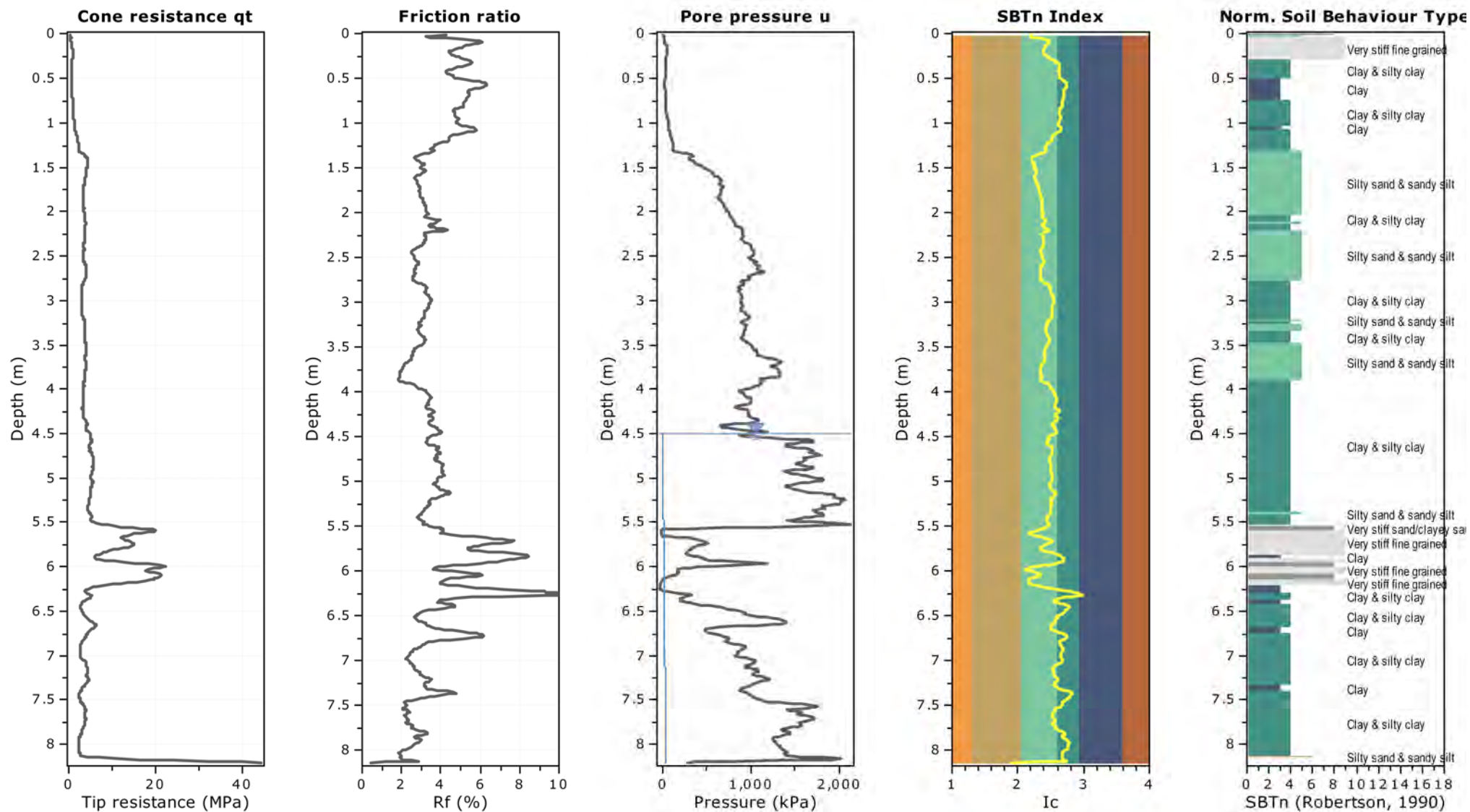


Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

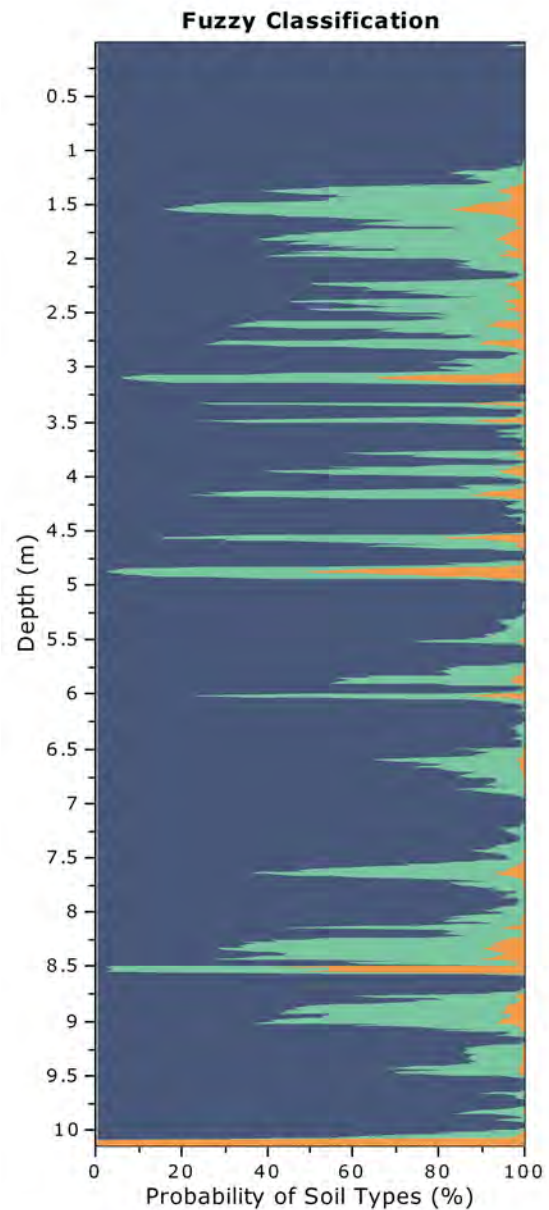
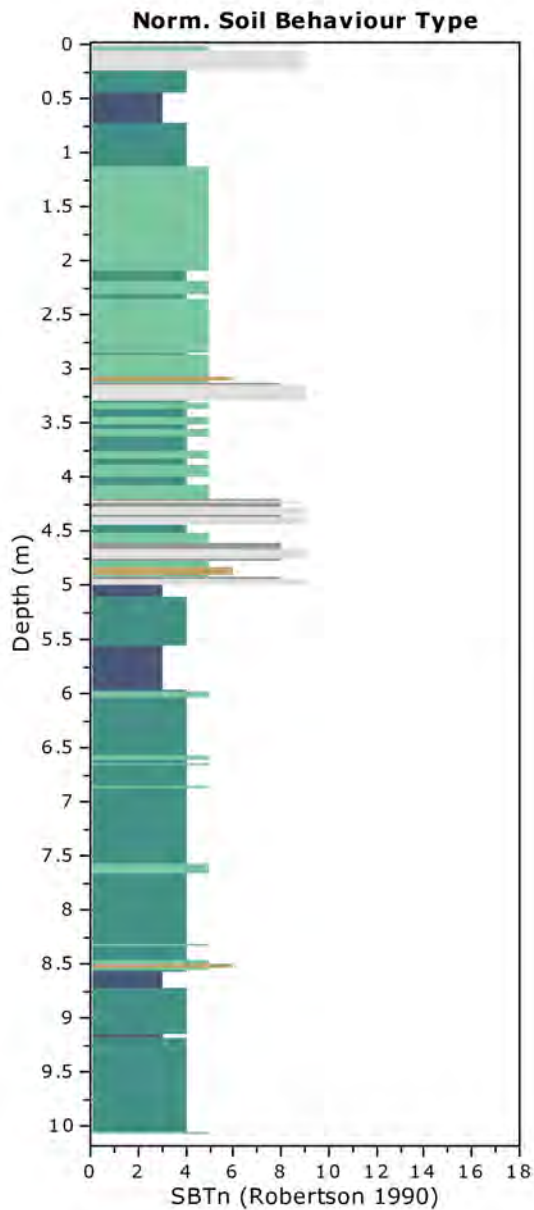
Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura



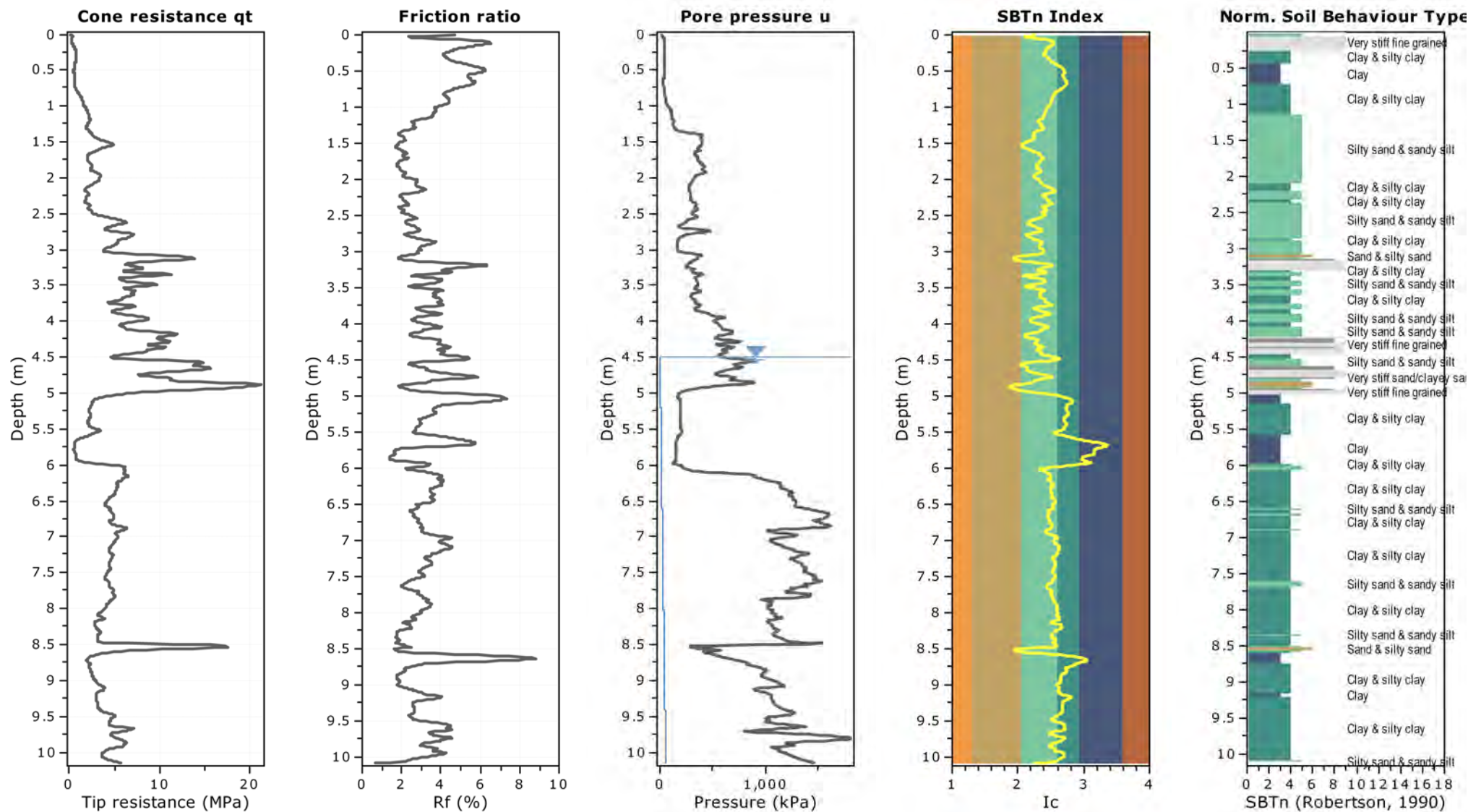
CPT7

Project: Cargill Station Ltd
Location: Ocean Ridge, Kaikoura



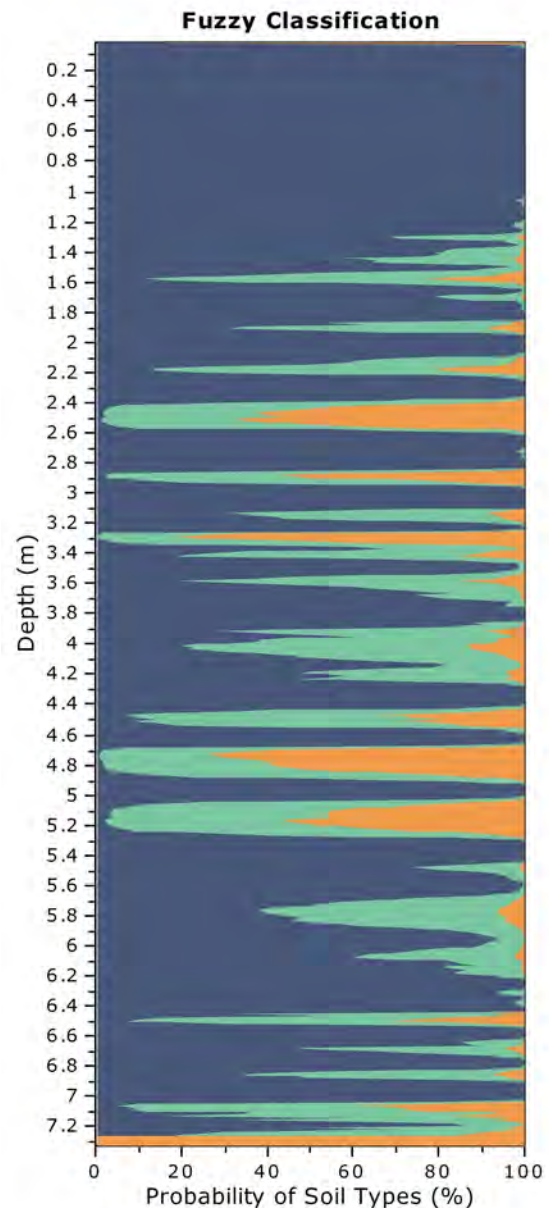
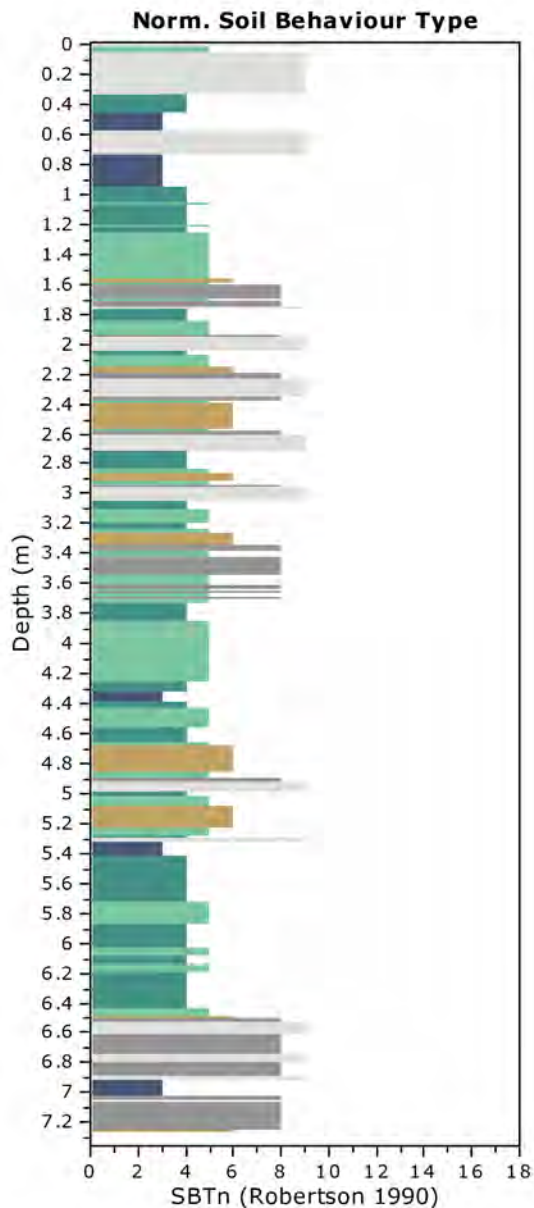
Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil



CPT8

Project: Cargill Station Ltd
Location: Ocean Ridge, Kaikoura

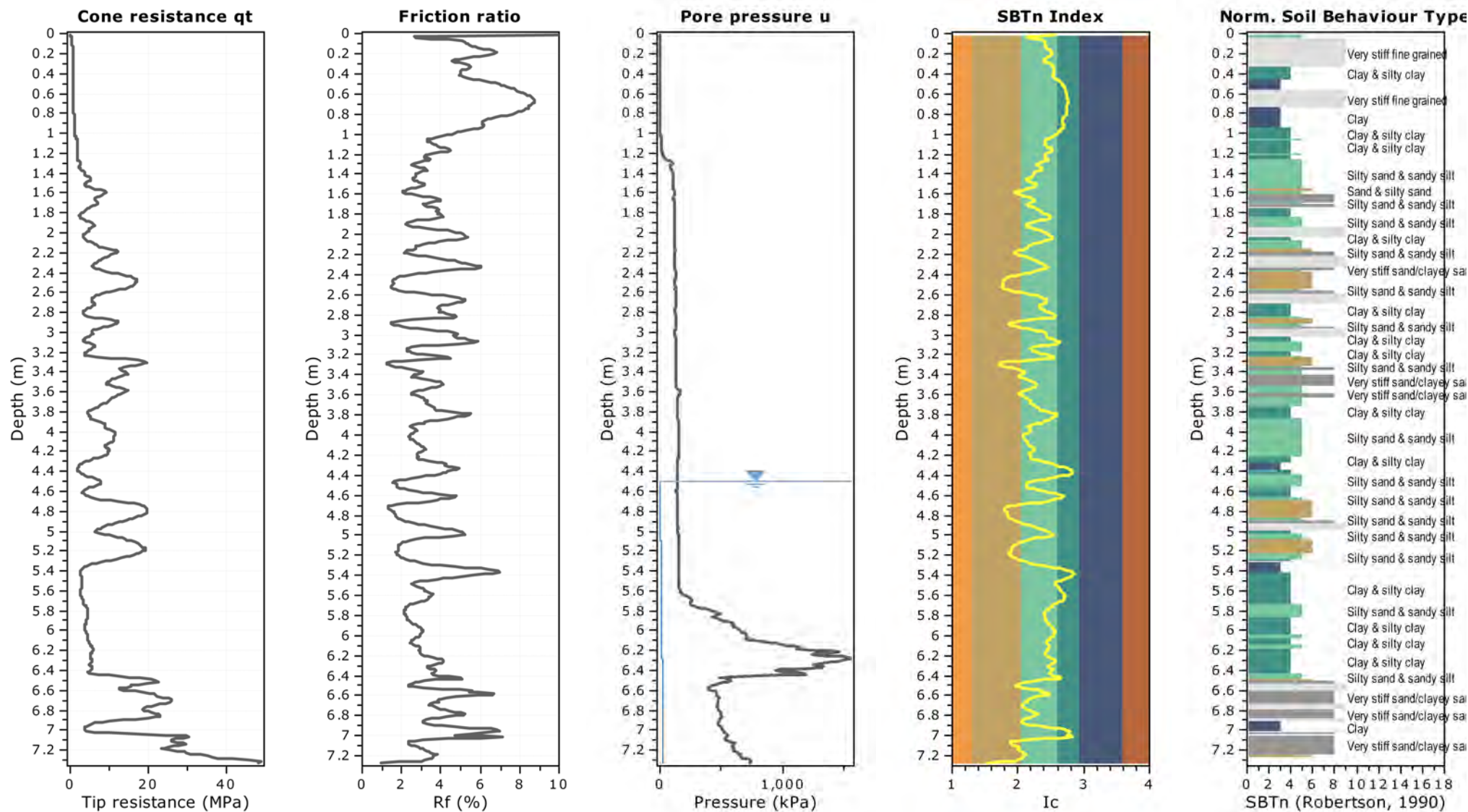


Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

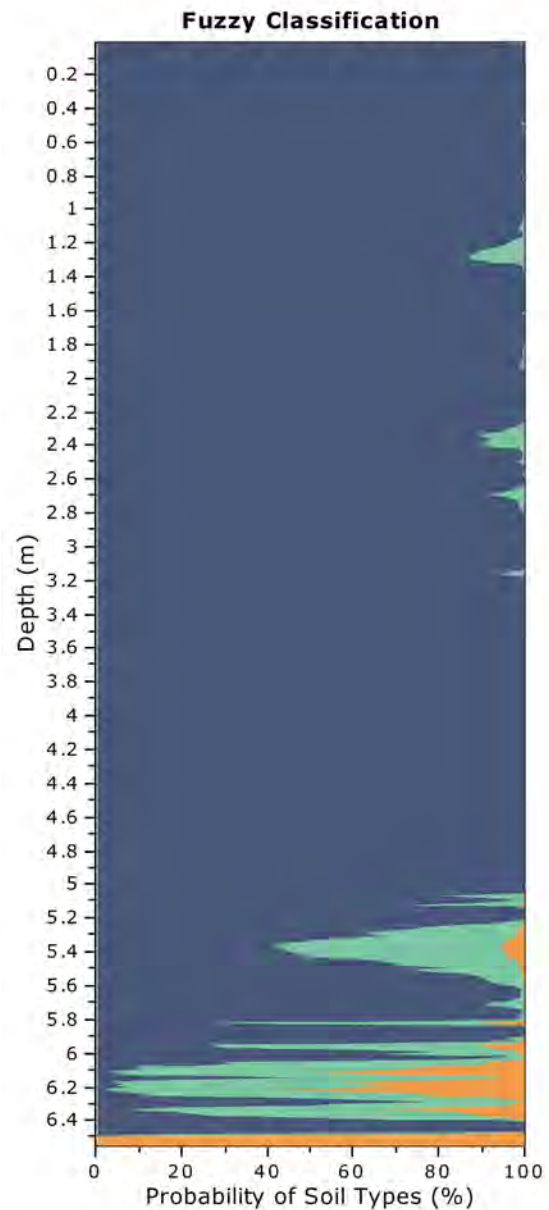
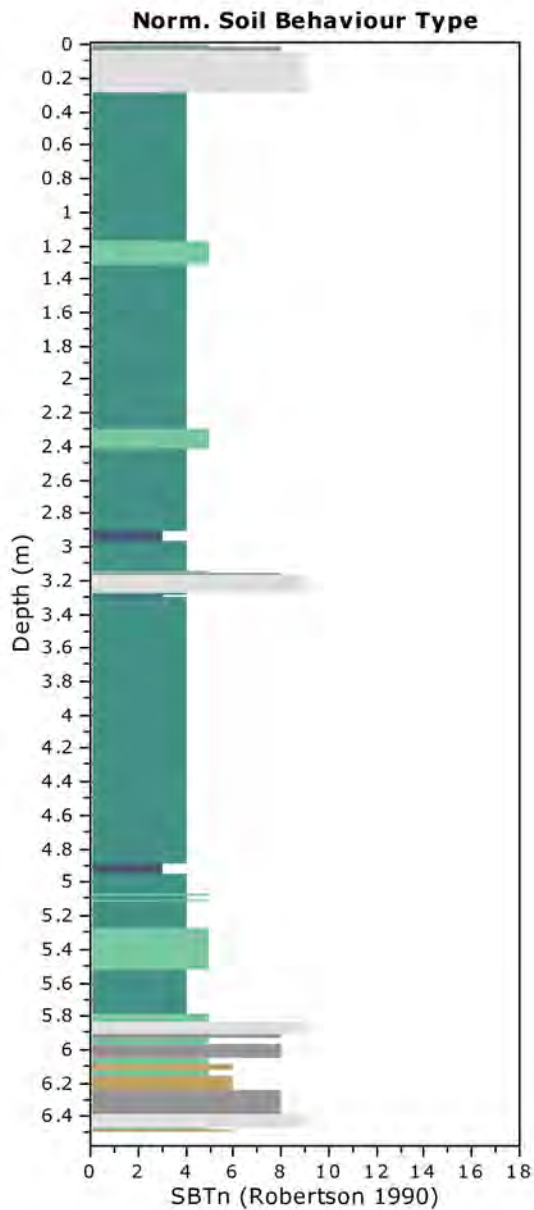
Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura



CPT9

Project: Cargill Station Ltd
Location: Ocean Ridge, Kaikoura

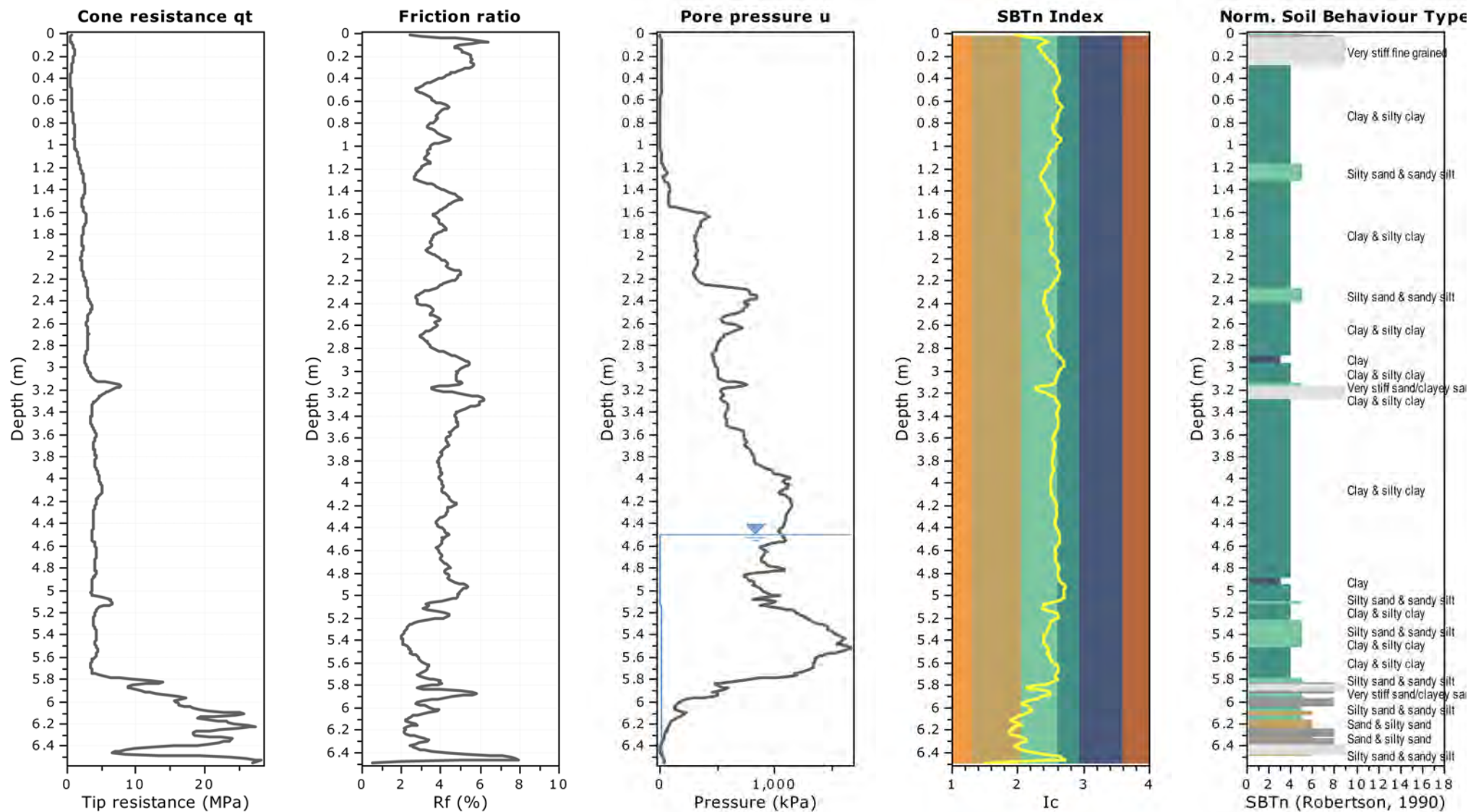


Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

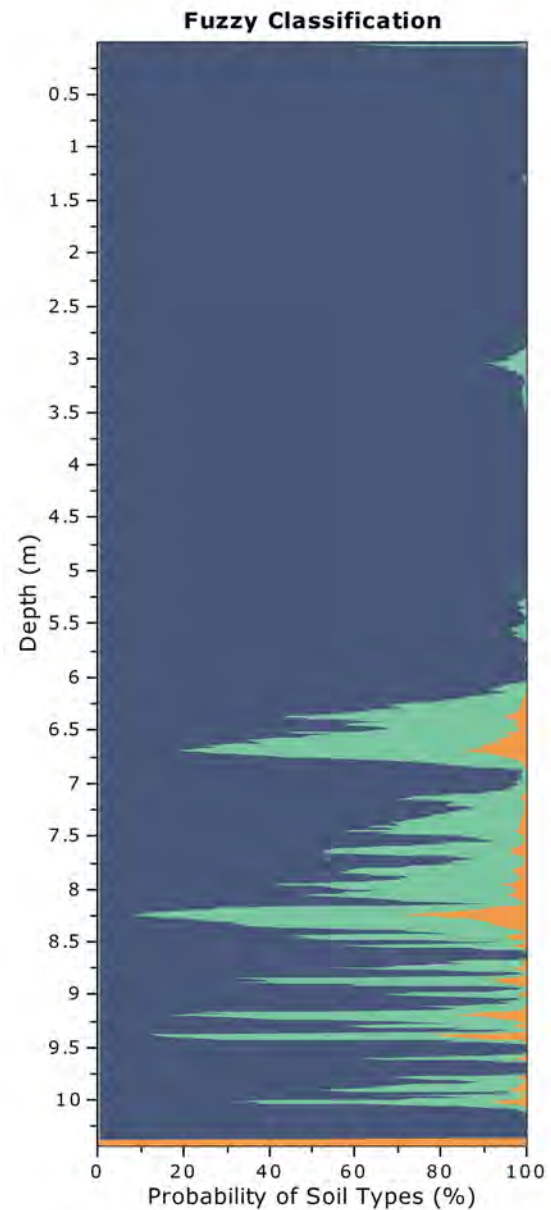
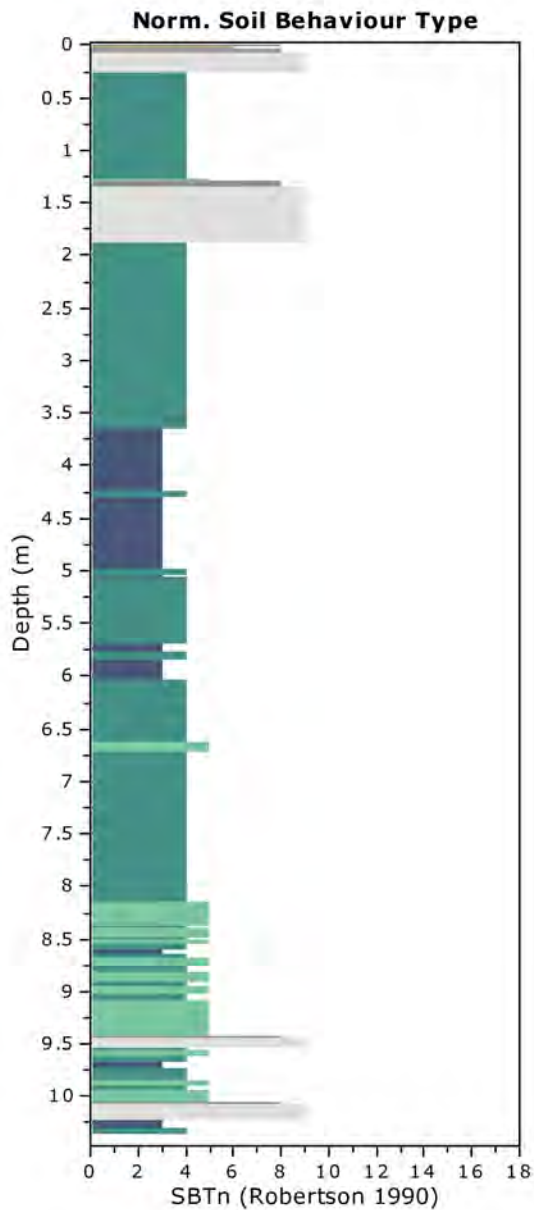
Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura



CPT10

Project: Cargill Station Ltd
Location: Ocean Ridge, Kaikoura

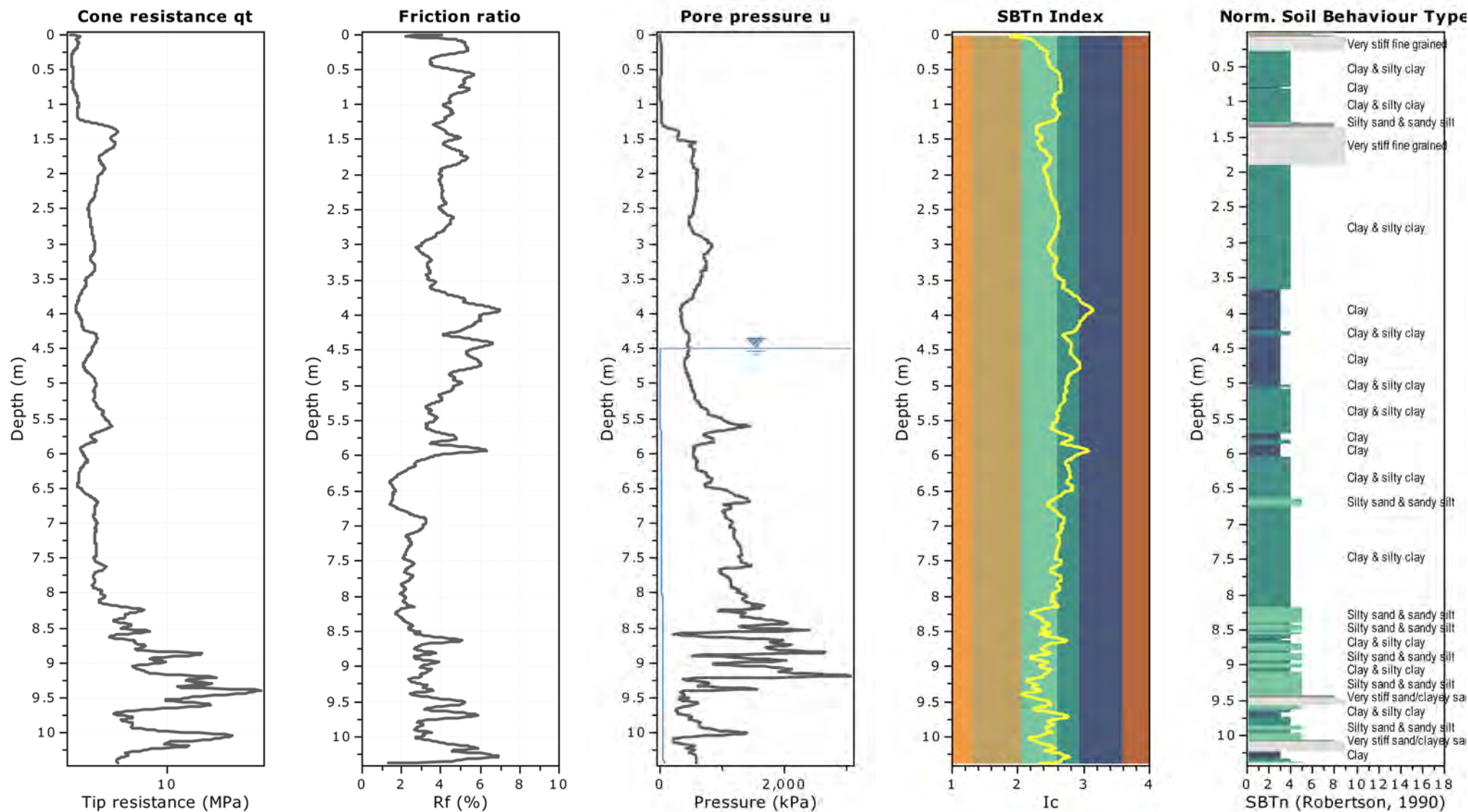


Fuzzy classification legend

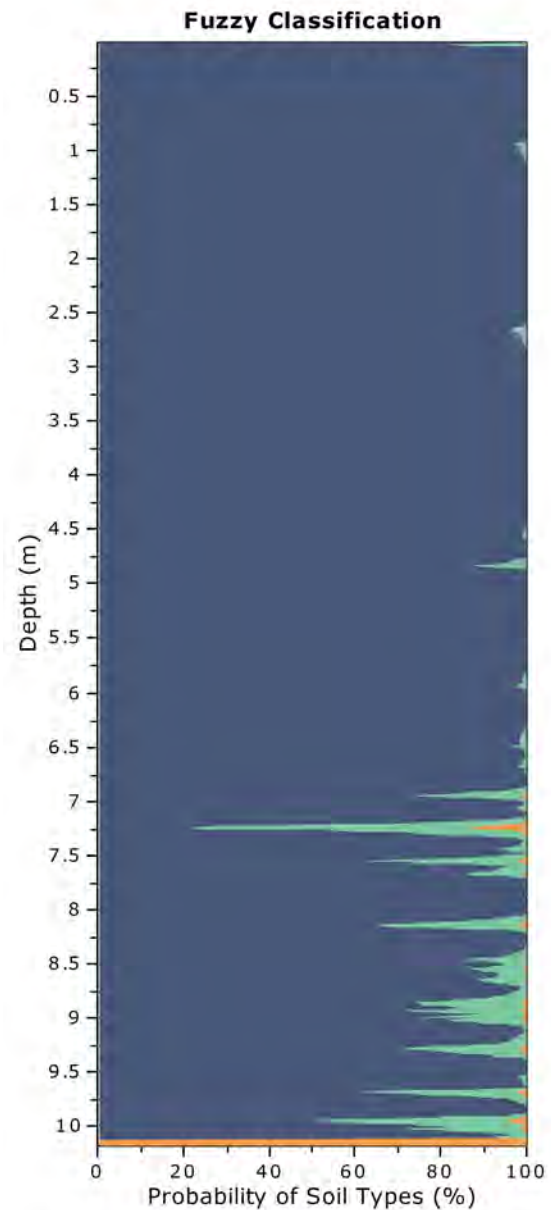
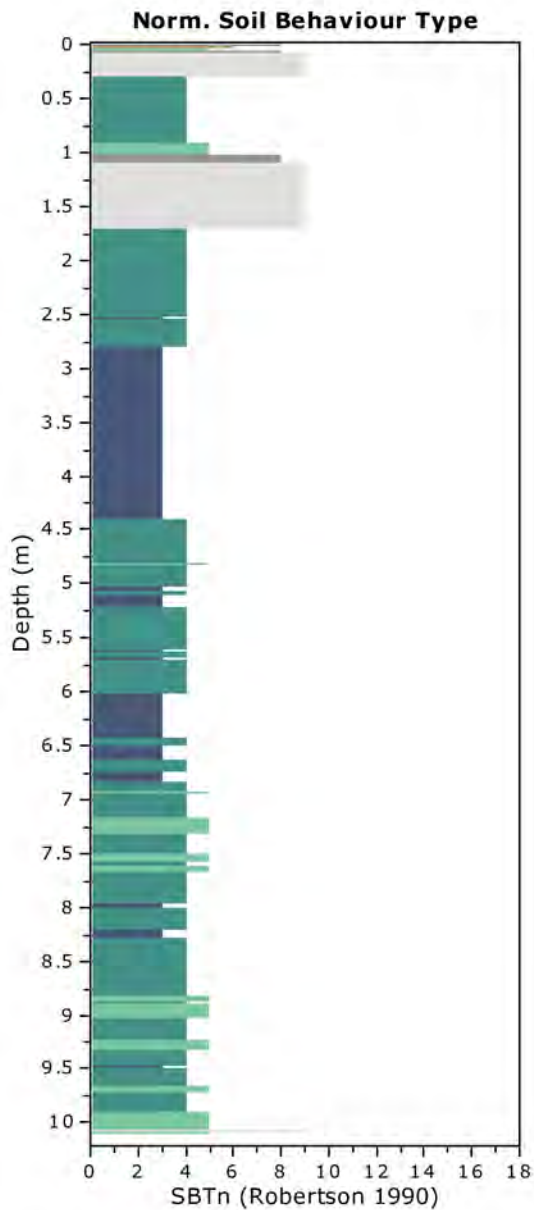
- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura

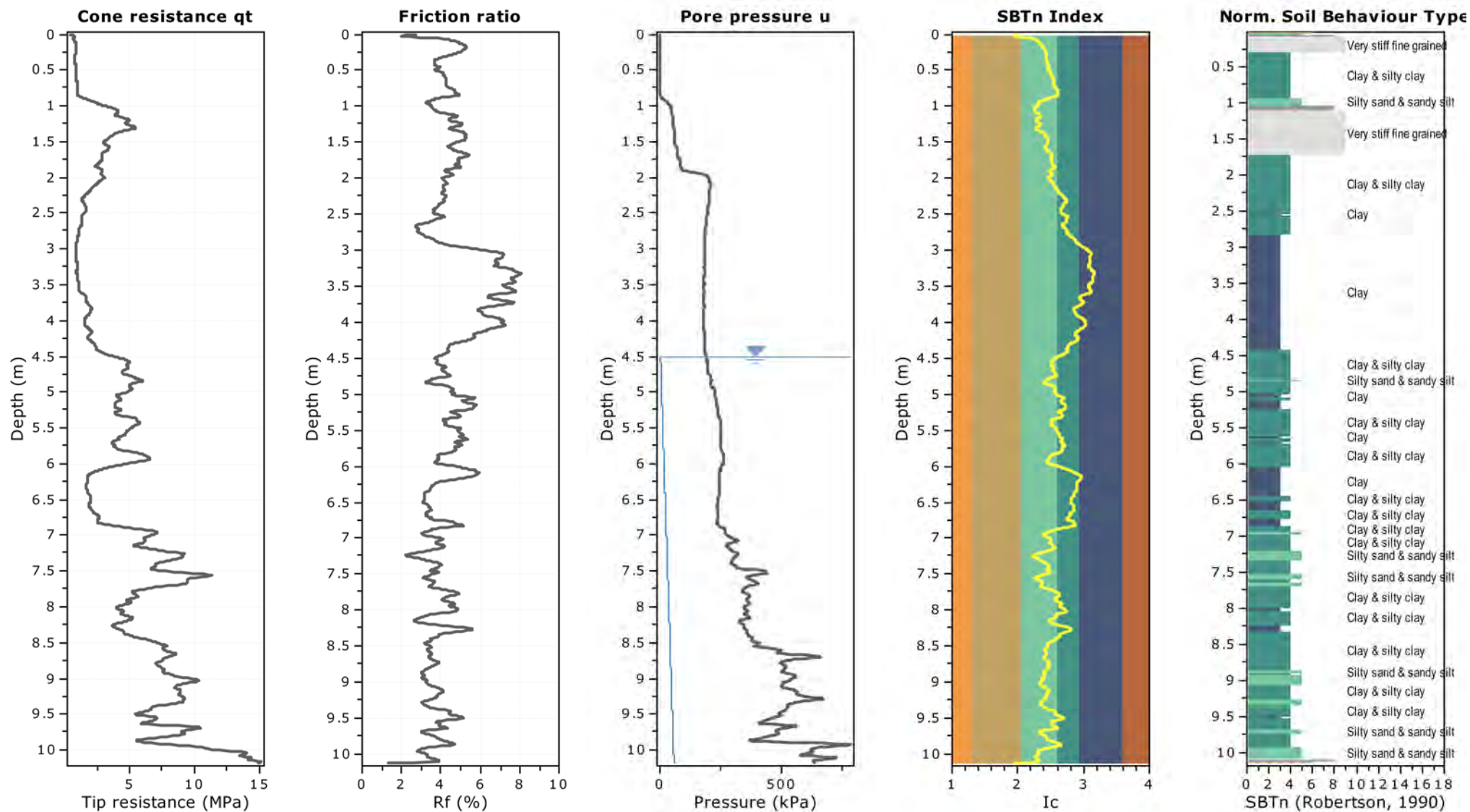


CPT11



Fuzzy classification legend

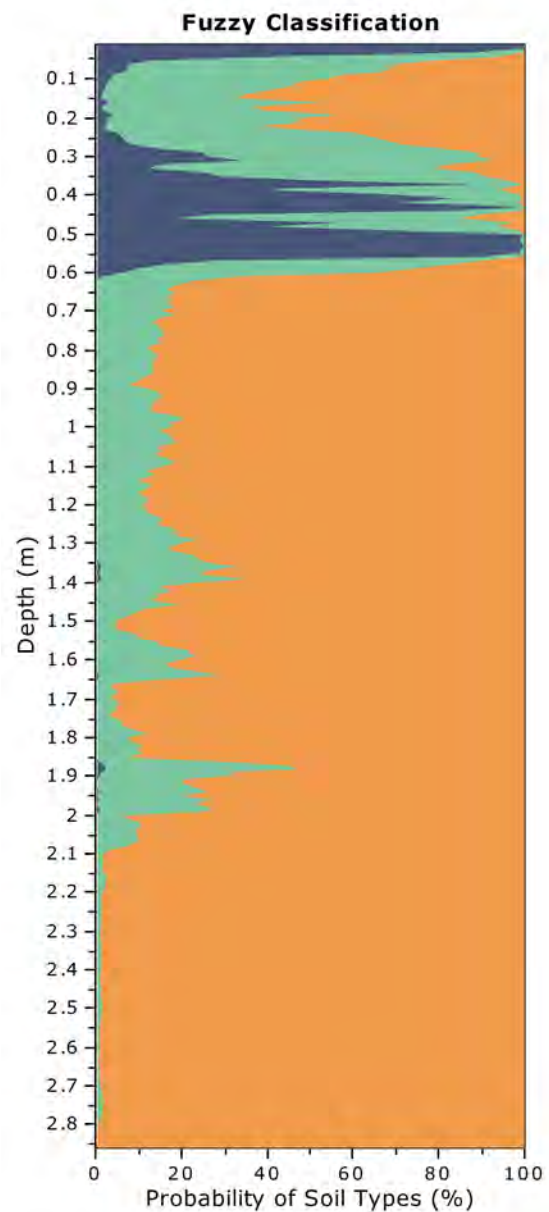
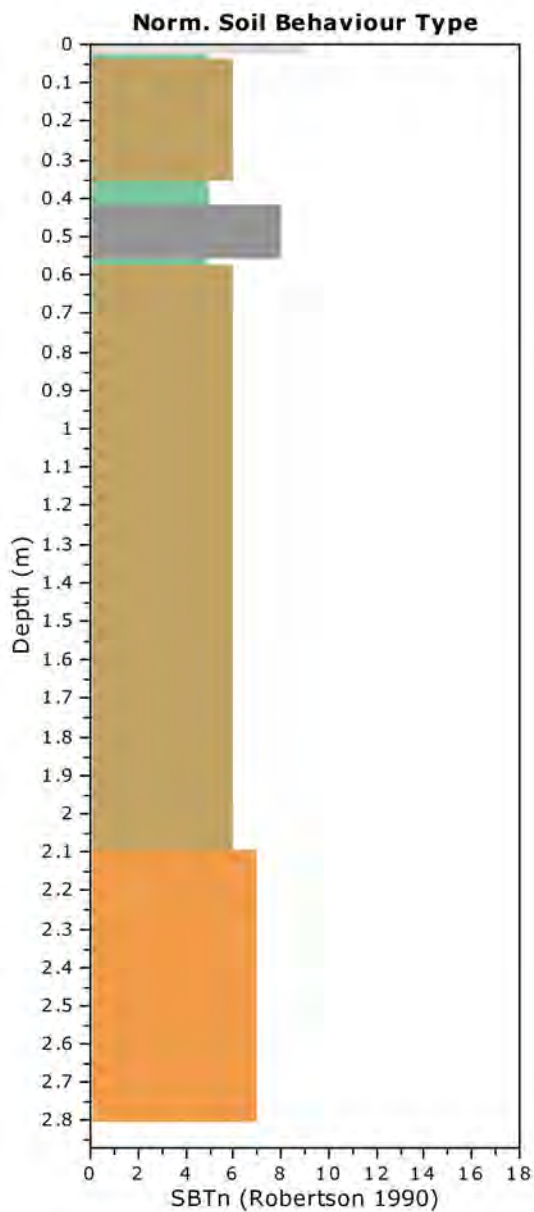
- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil



CPT12

Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura

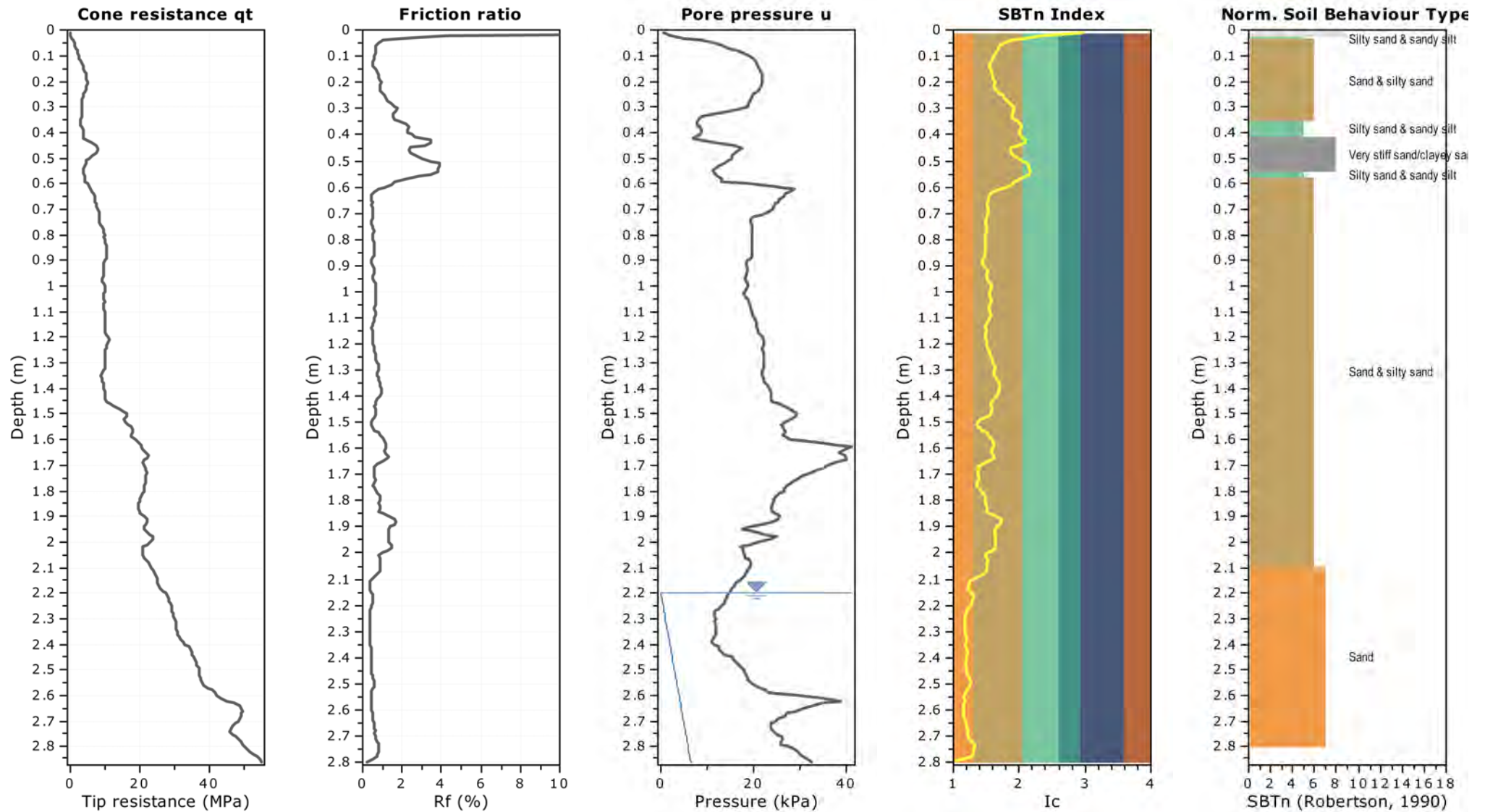


Fuzzy classification legend

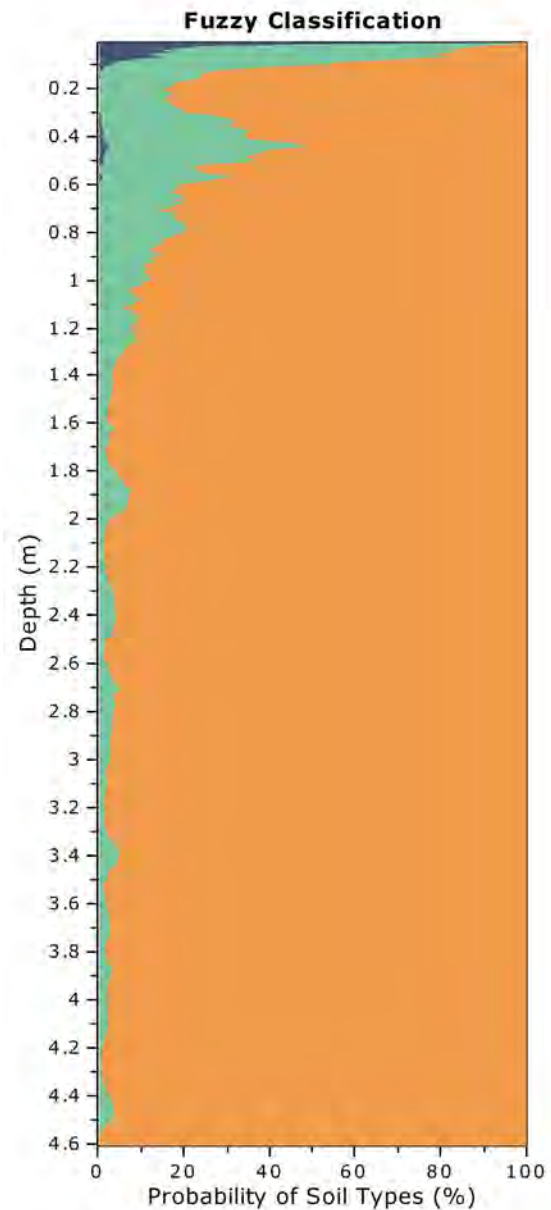
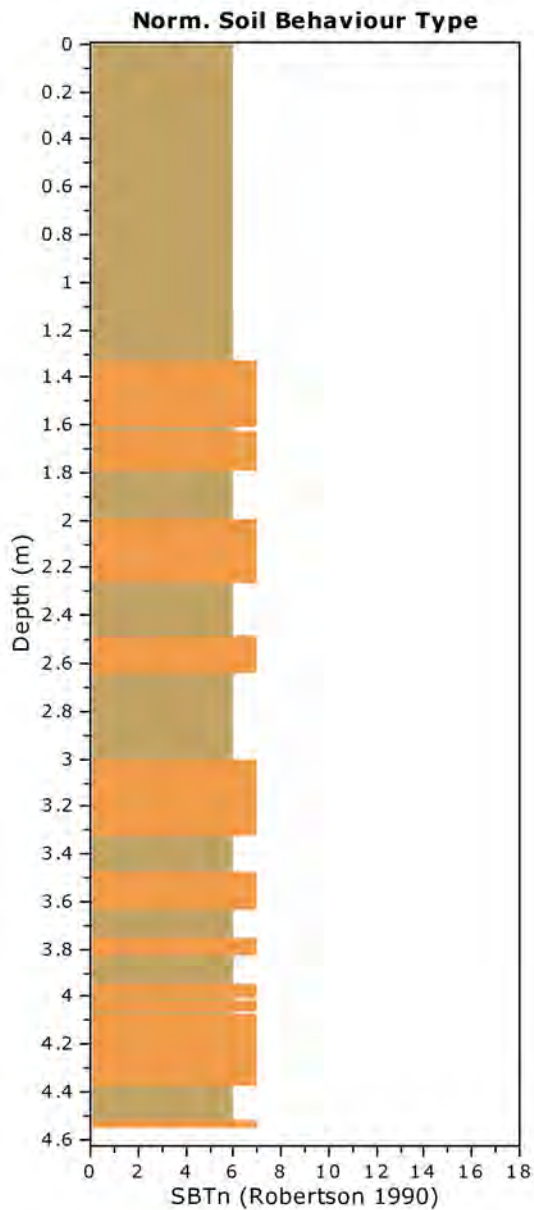
- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura



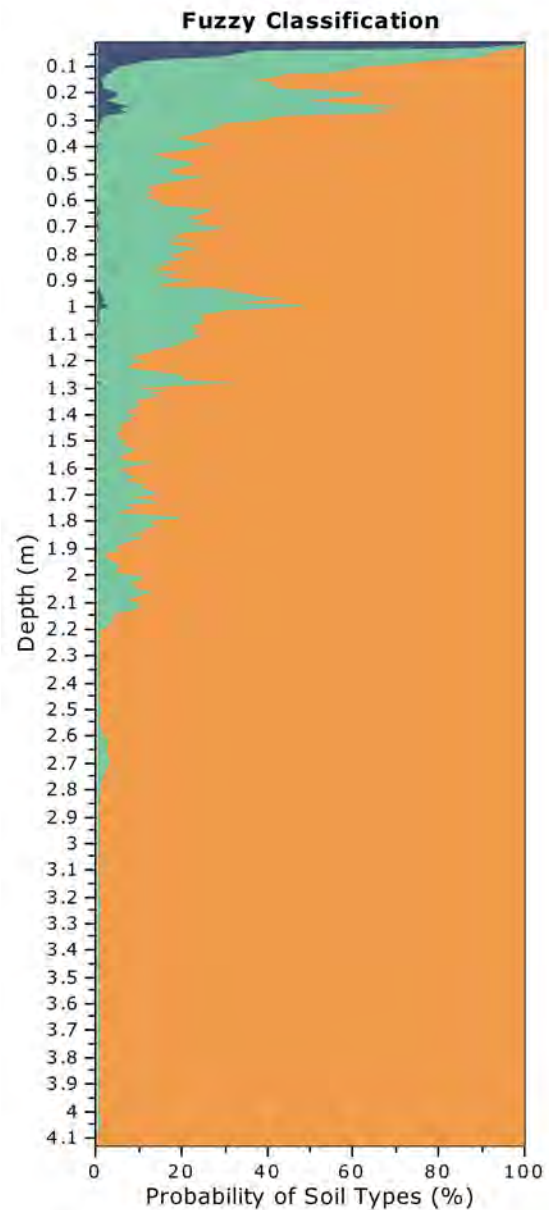
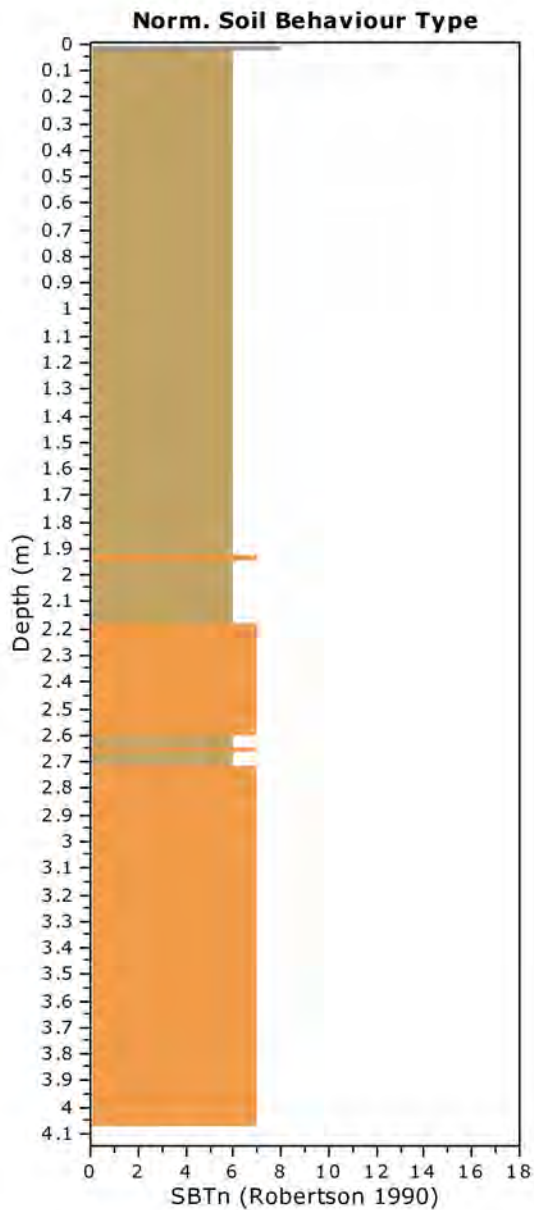
CPT13



Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

CPT14

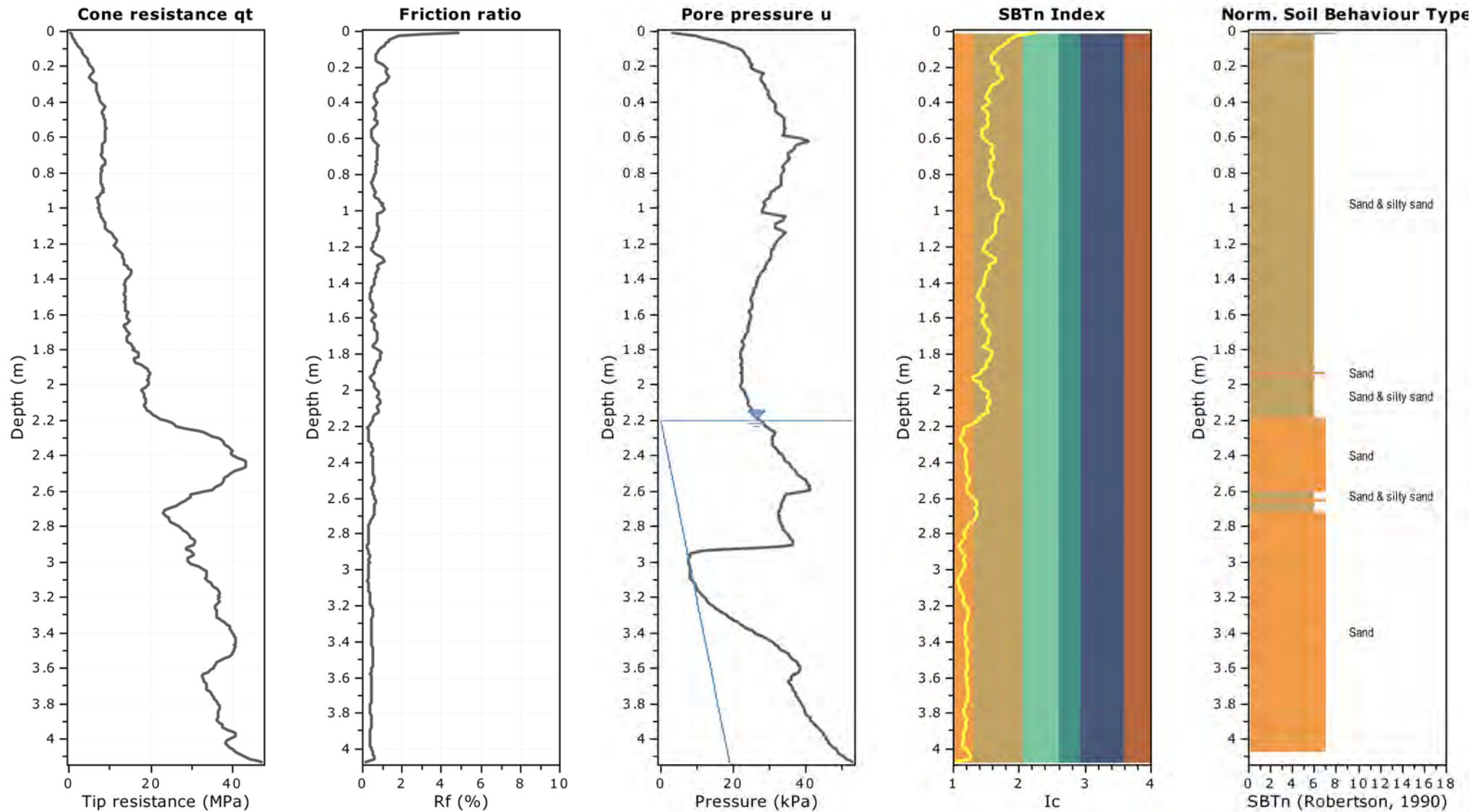


Fuzzy classification legend

- Highly probable clayey soil
- Highly probable mixture soil
- Highly probable sandy soil

Project: Cargill Station Ltd

Location: Ocean Ridge, Kaikoura



Appendix B

CLiq Analyses Results

***Serviceability Limit State (SLS) Design
Earthquake Event***

CPT1

LIQUEFACTION ANALYSIS REPORT

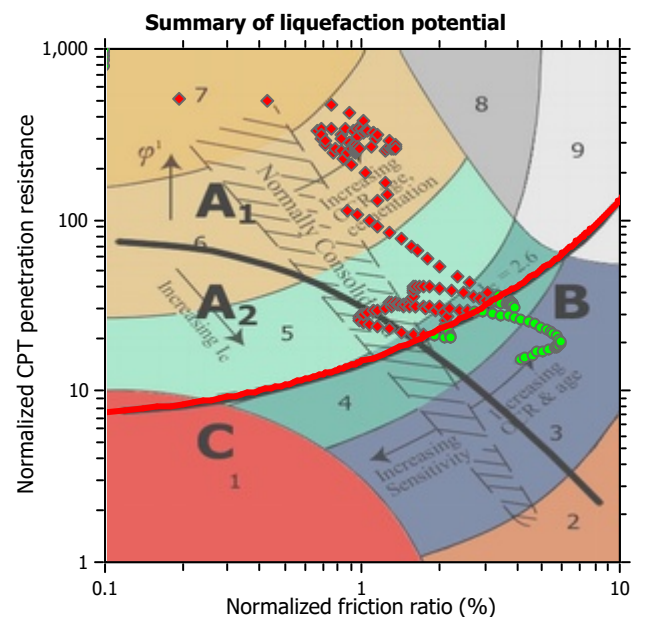
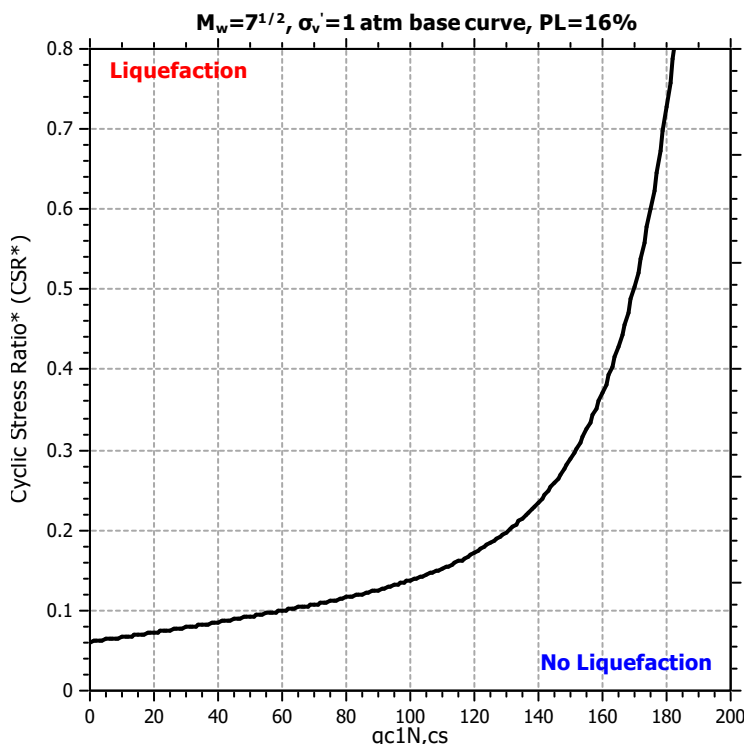
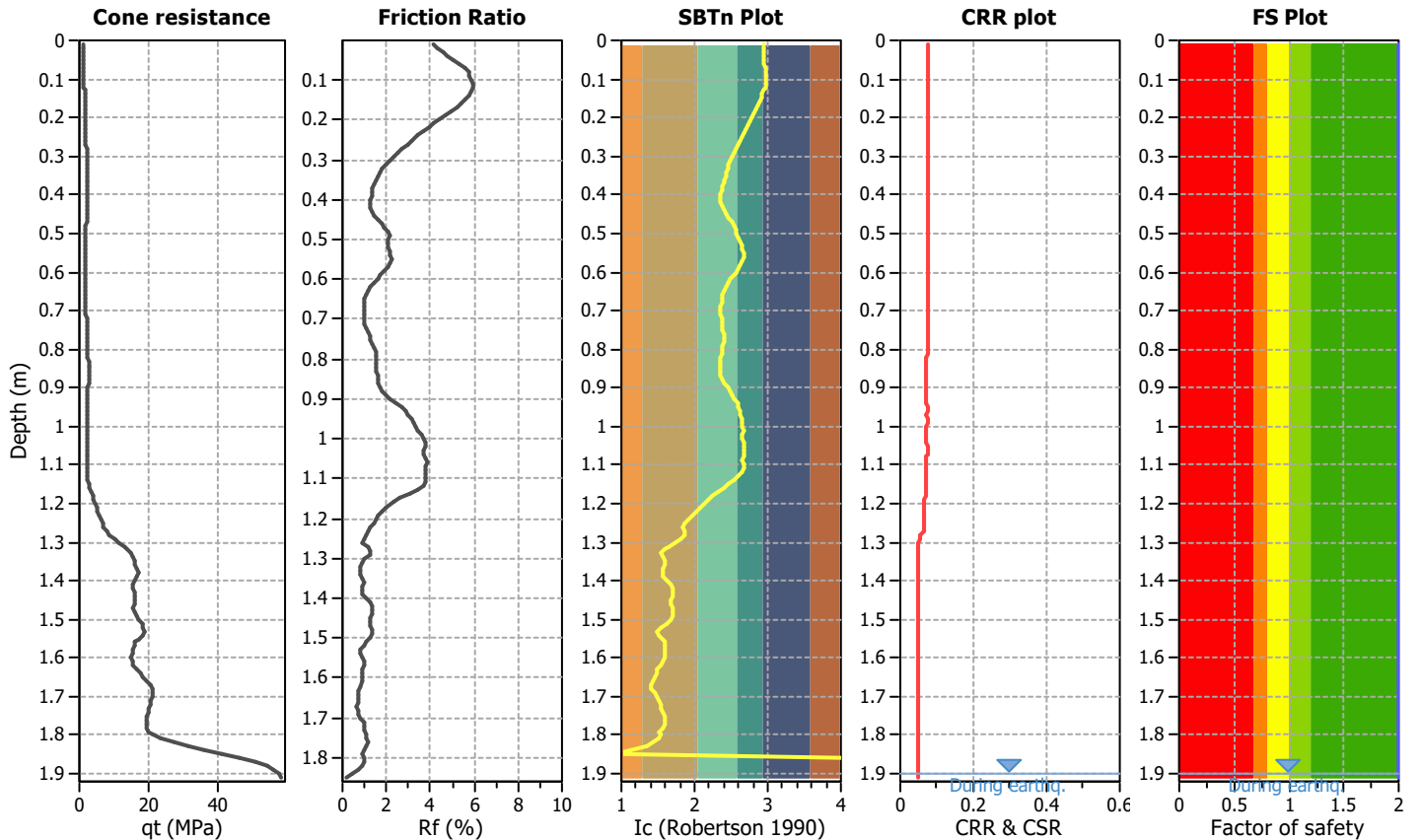
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 1

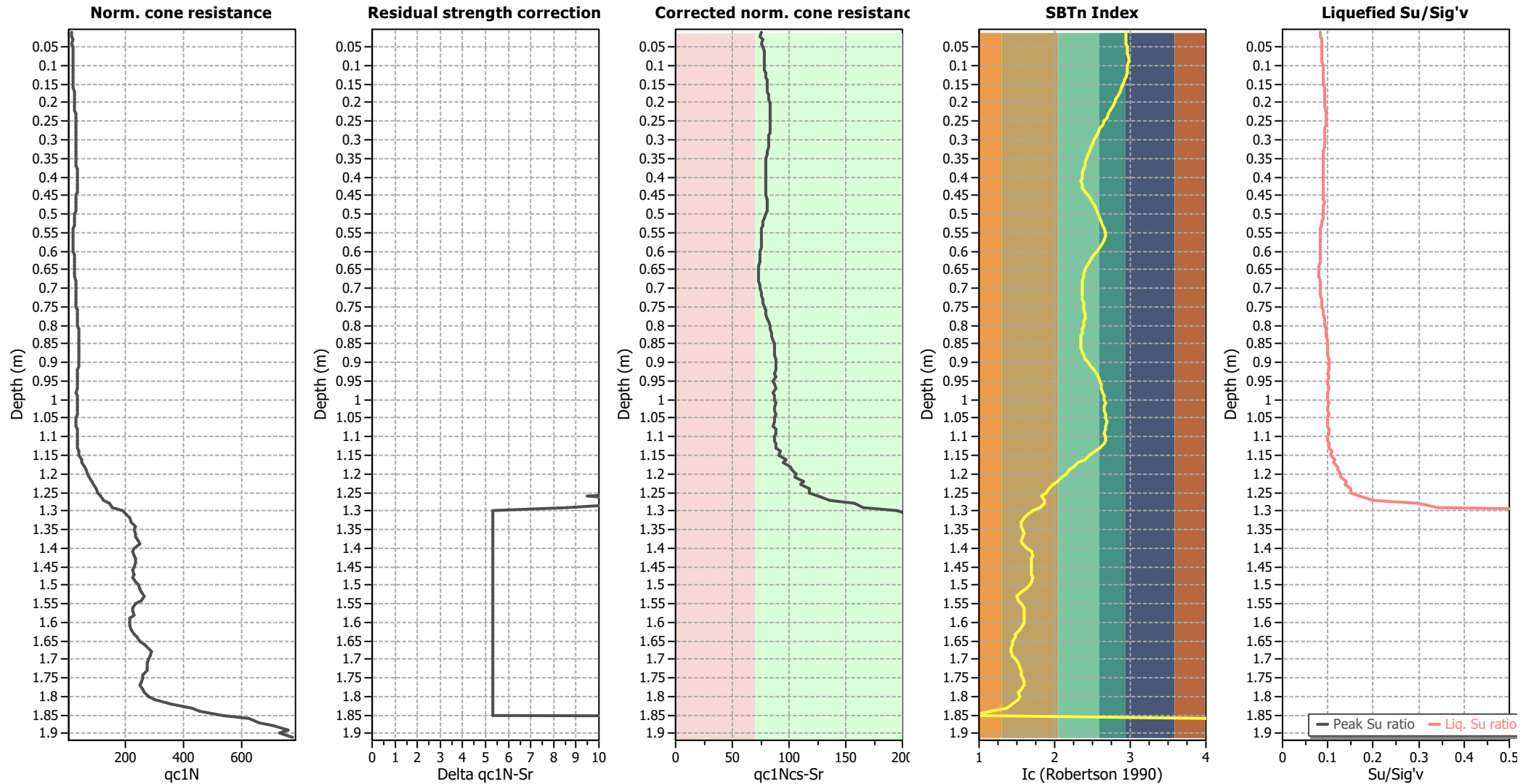
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.90 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.90 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

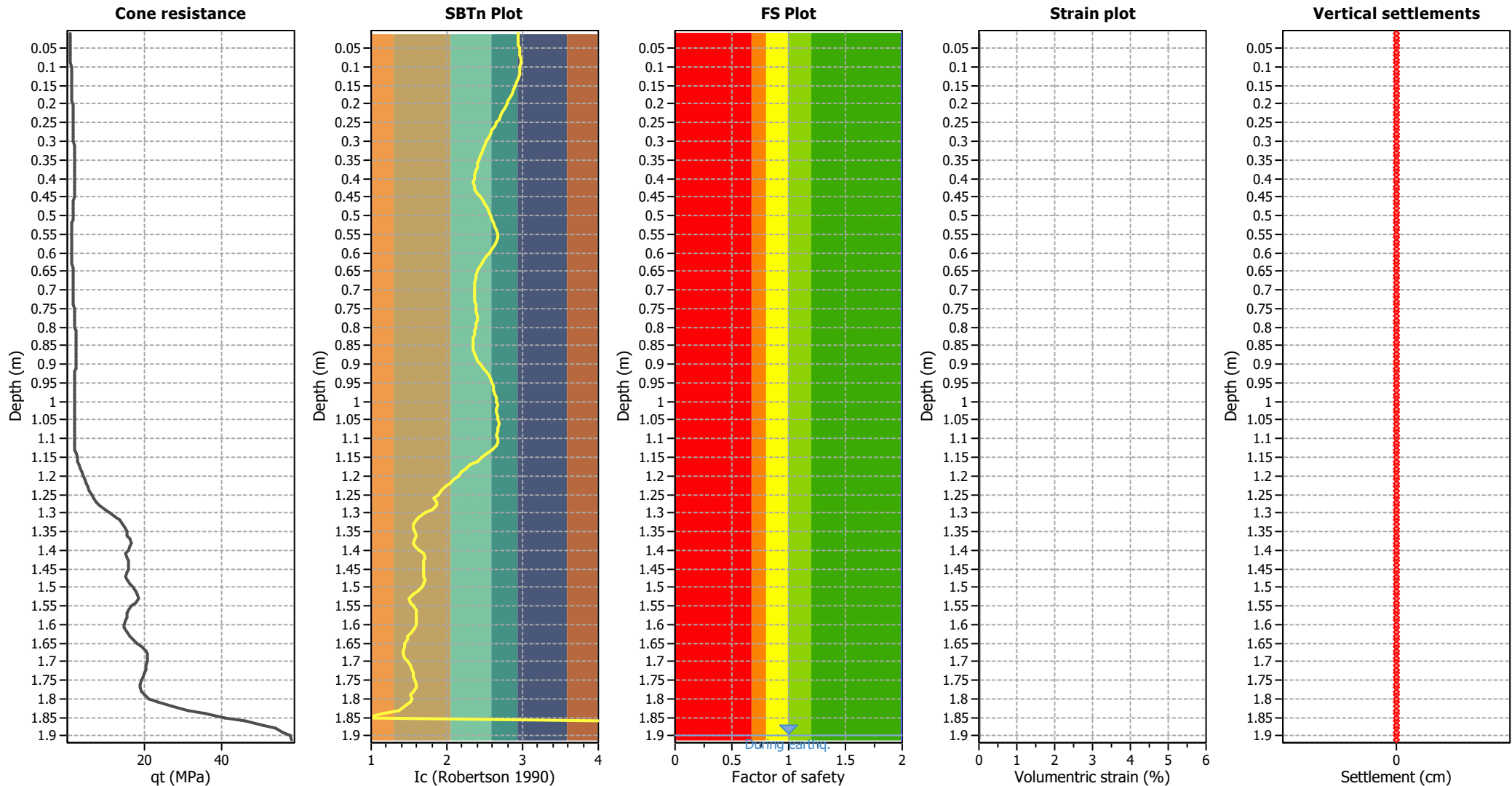
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.90 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.90 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements

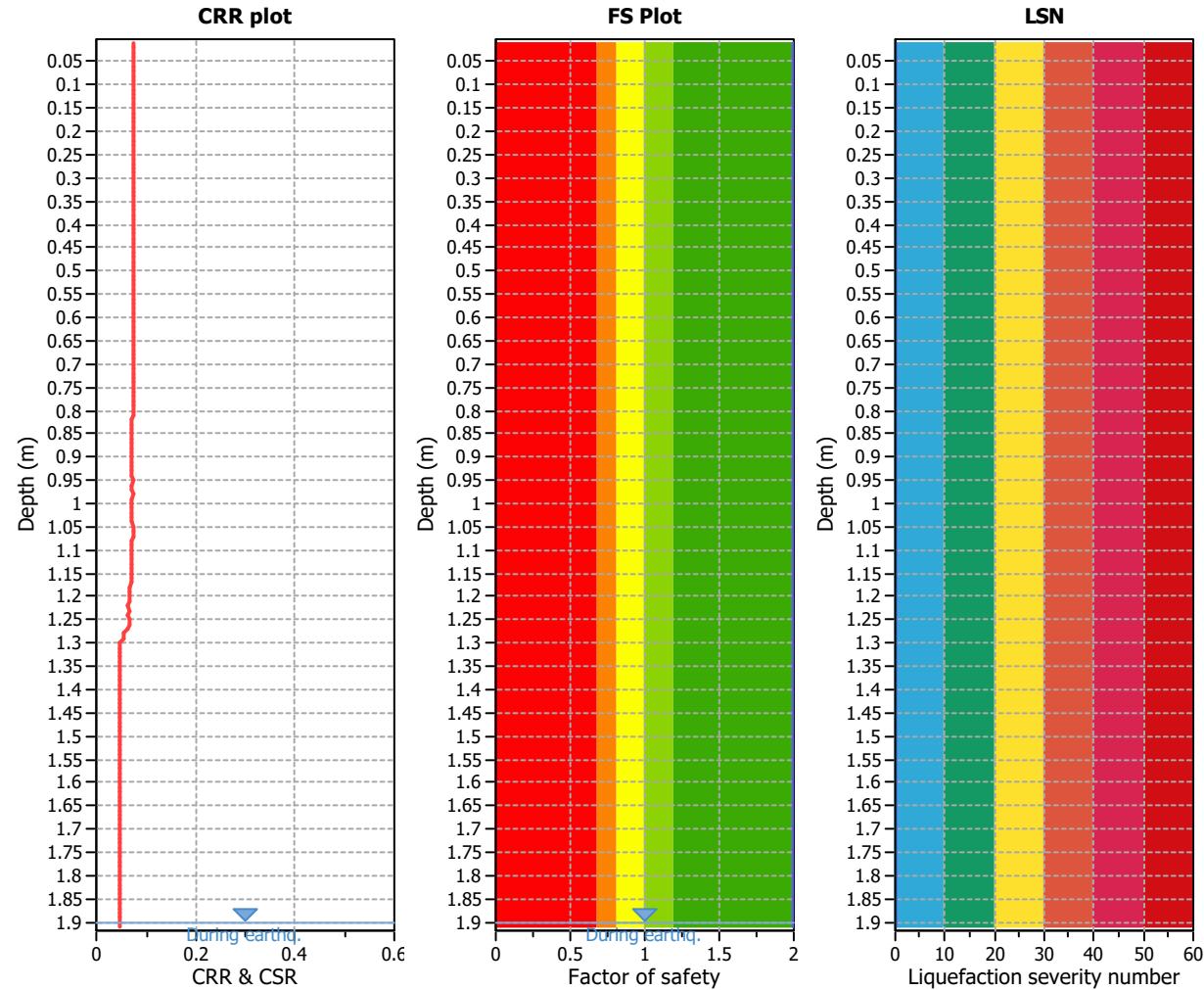


Abbreviations

- q_c: 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
Volumetric strain: Post-liquefaction volumetric strain

Project: Cargill Station Ltd
Location: Ocean Ridge, Kaikoura

CPT: CPT 1
Total depth: 1.91 m



Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.90 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.90 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT2

LIQUEFACTION ANALYSIS REPORT

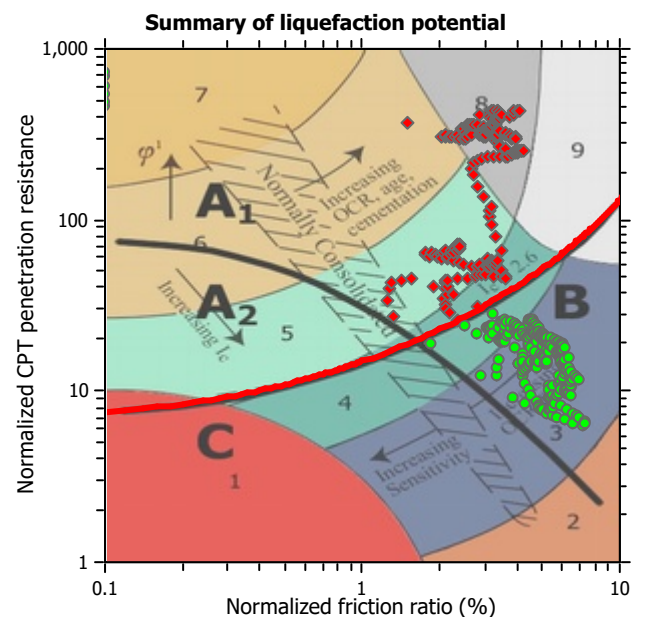
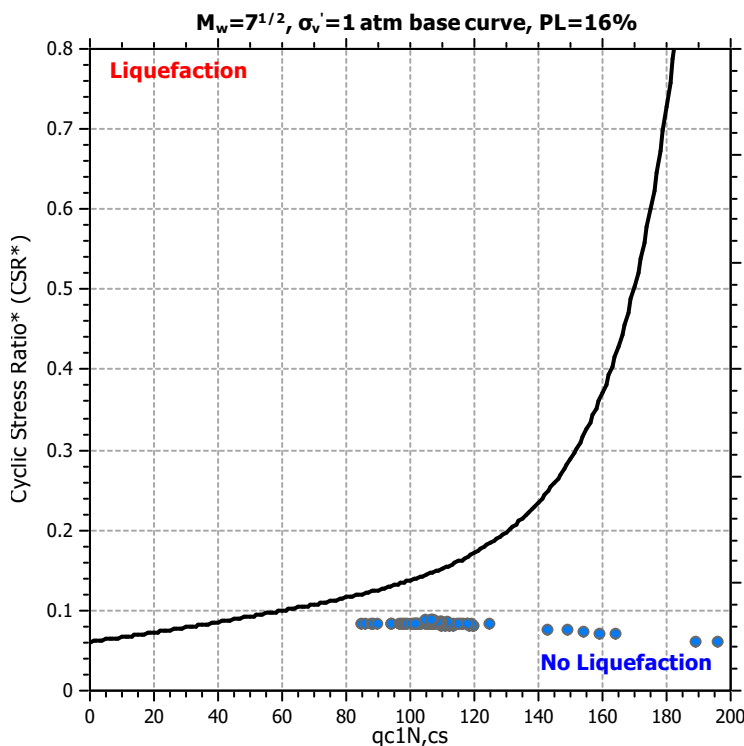
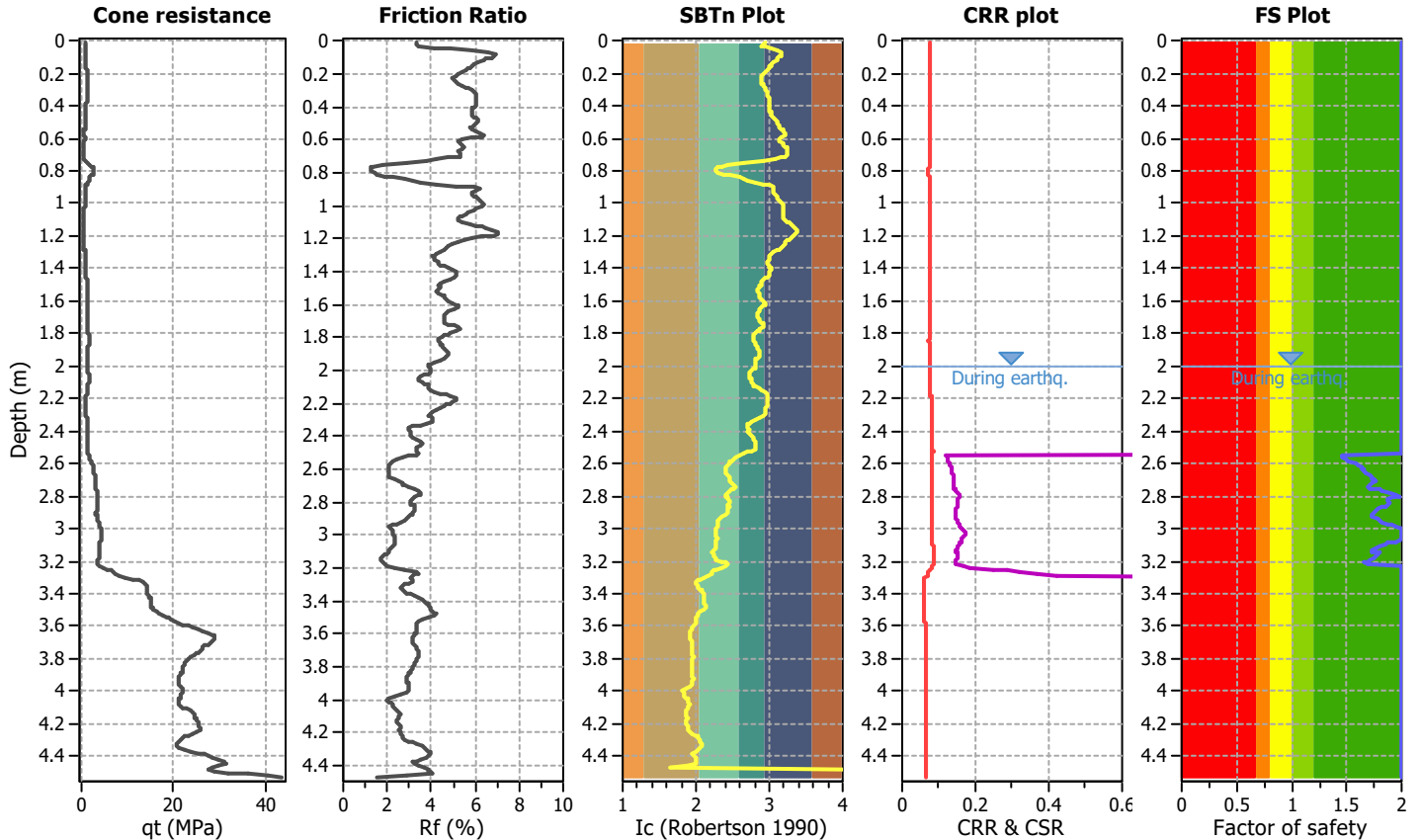
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 2

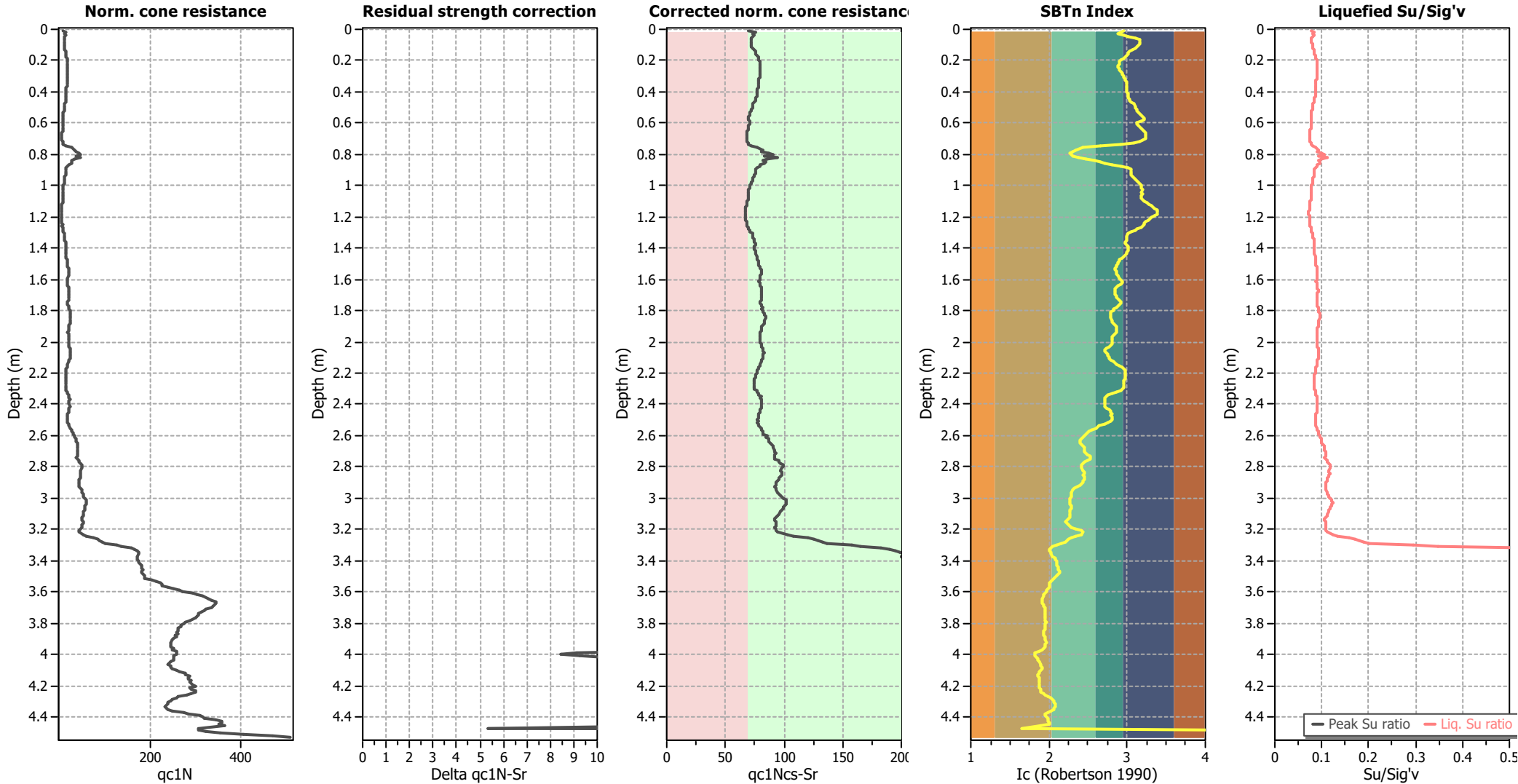
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

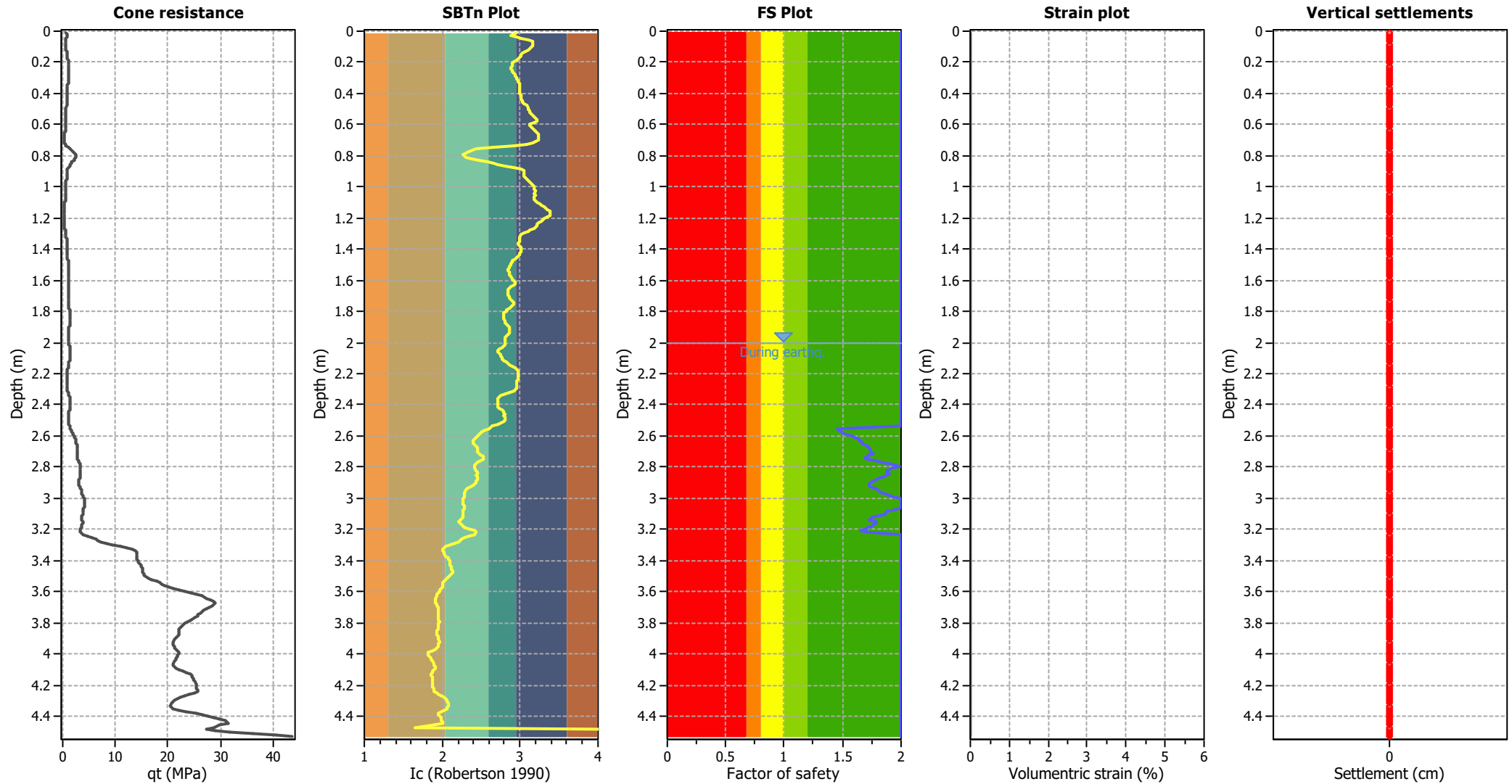
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

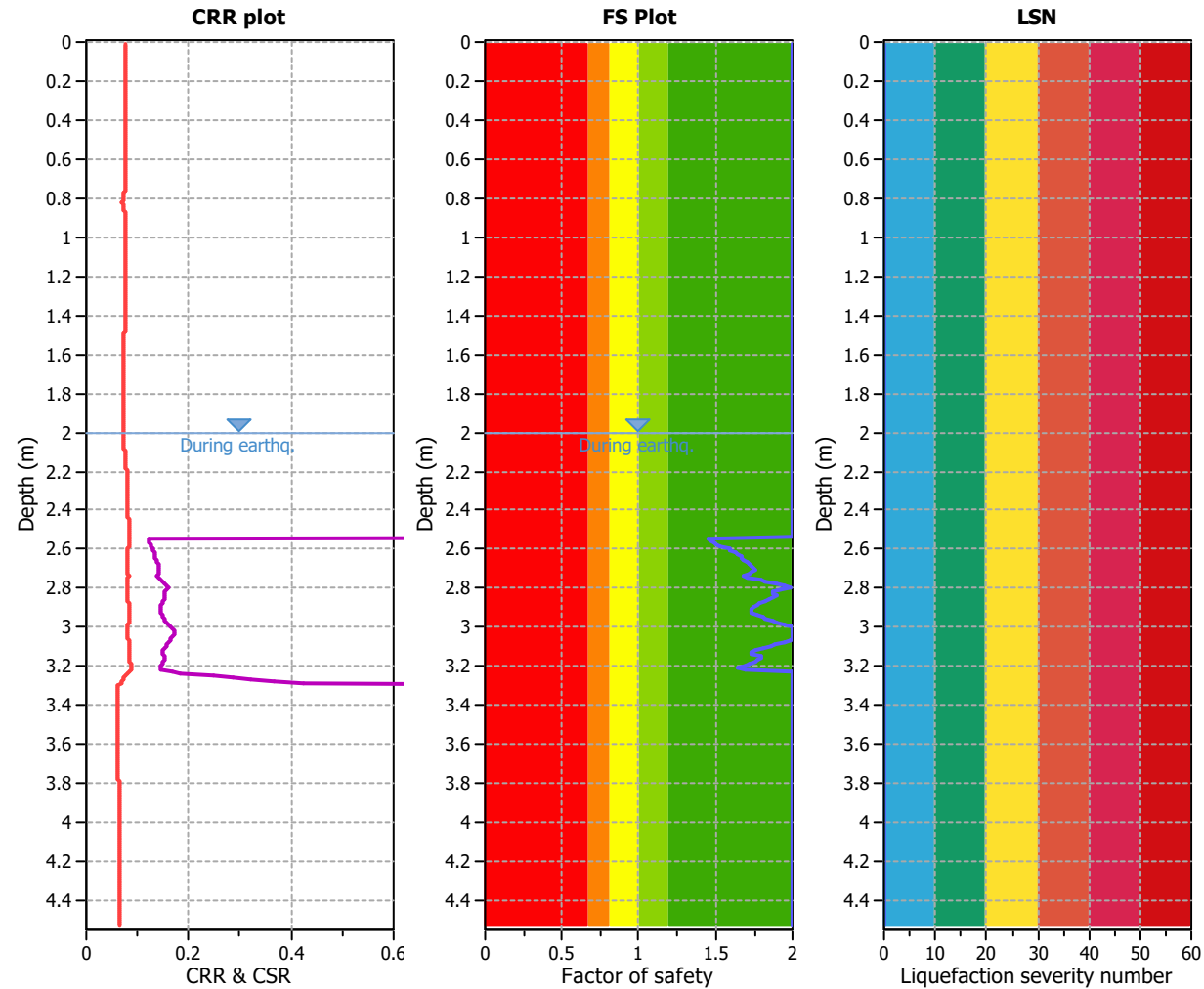
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

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
 Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT3

LIQUEFACTION ANALYSIS REPORT

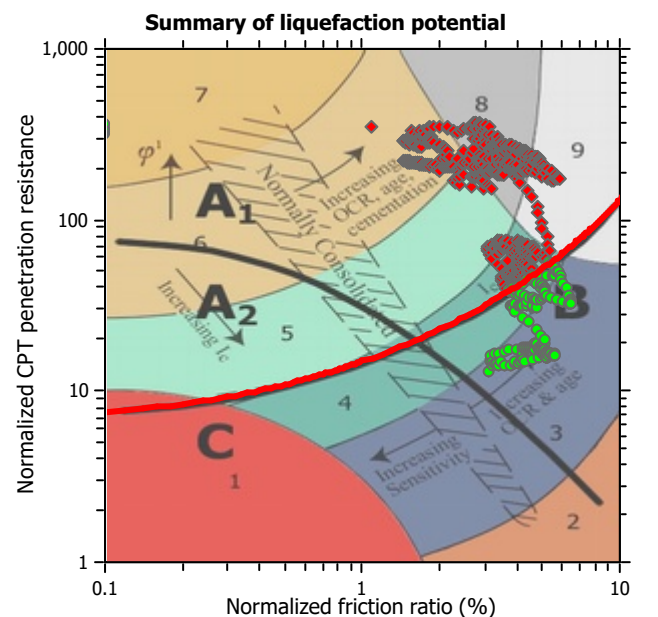
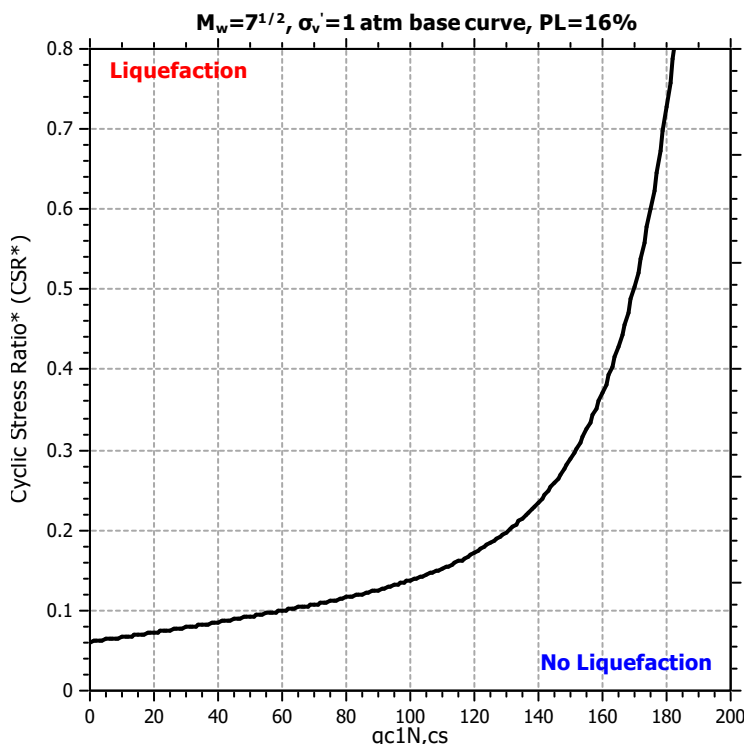
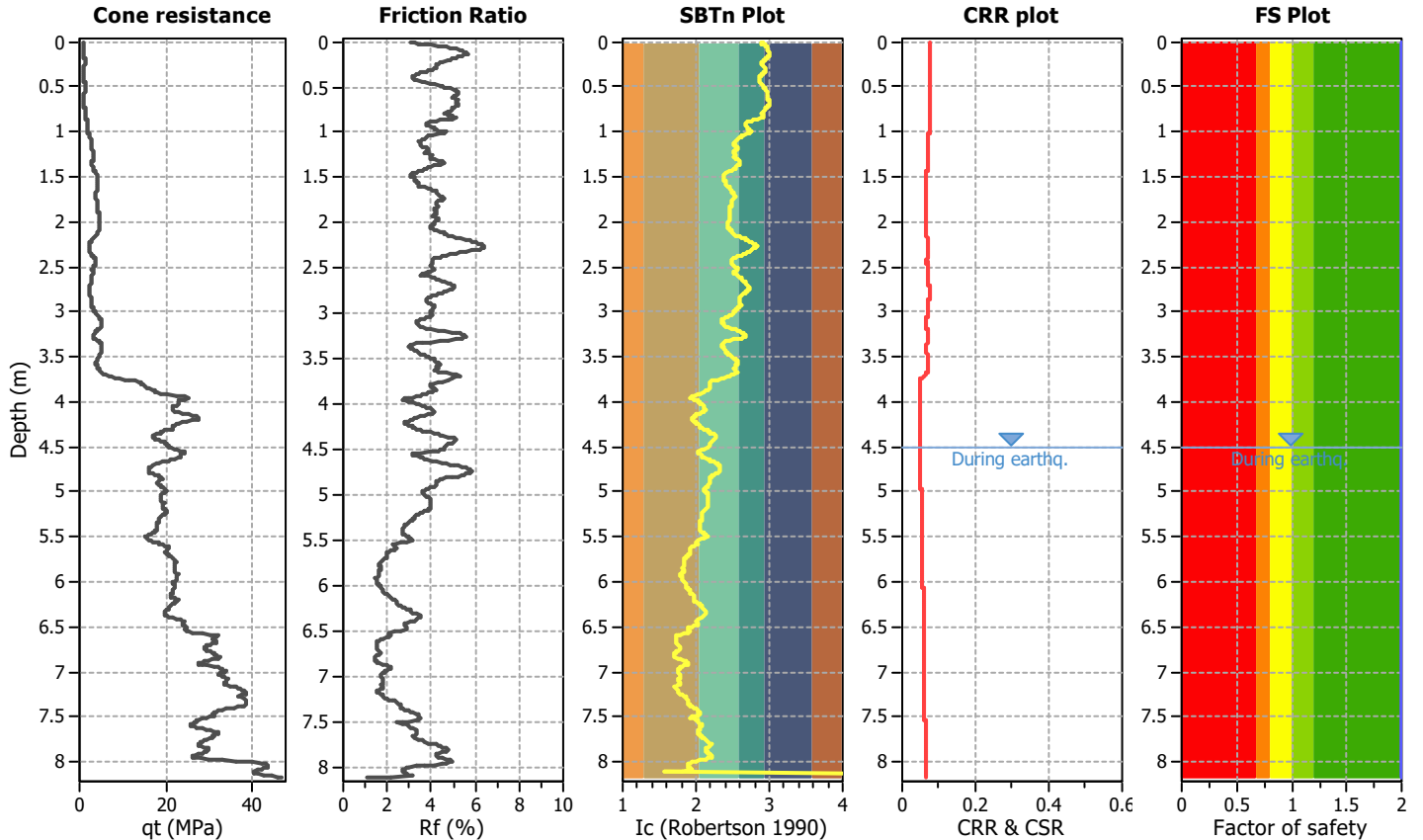
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 3

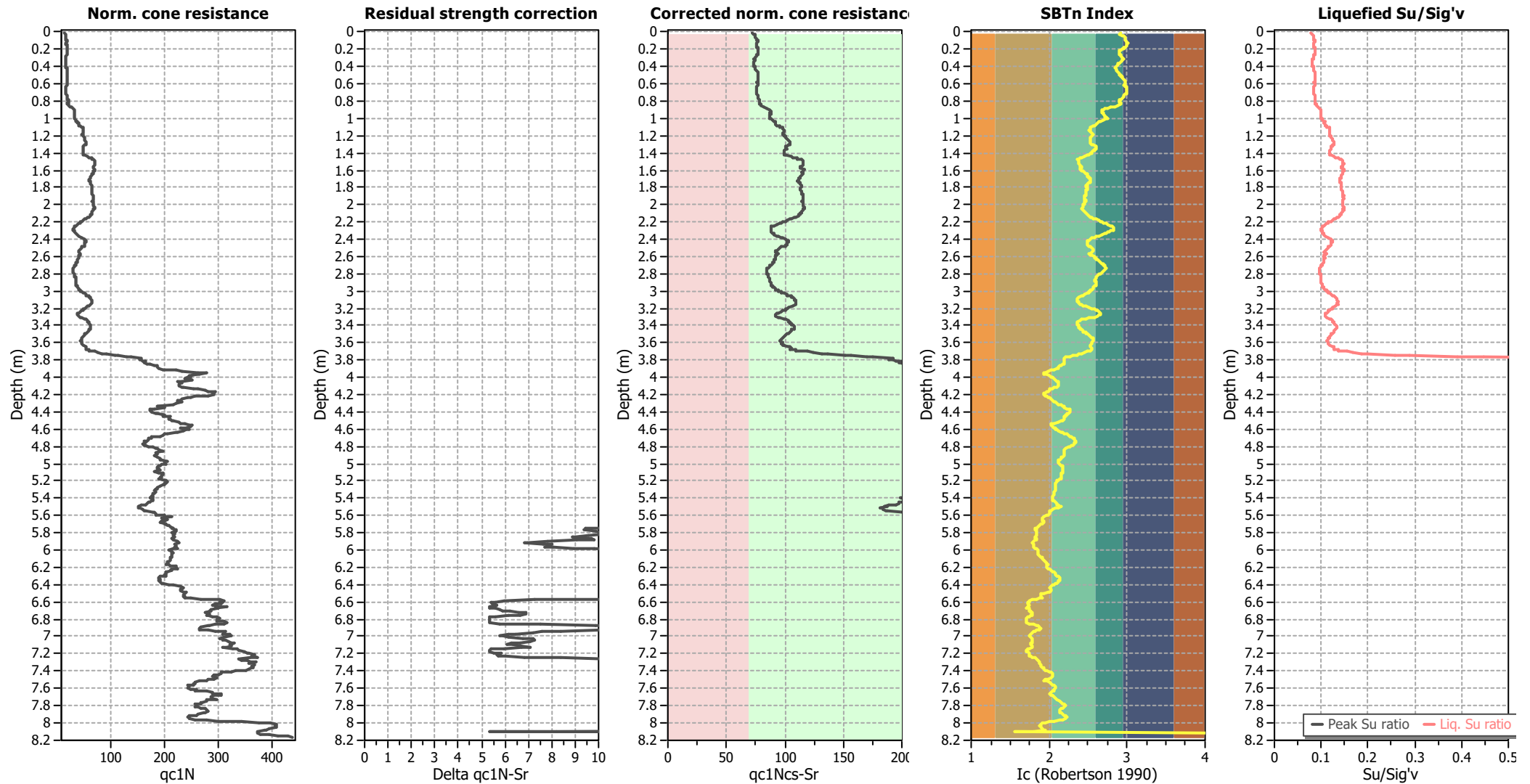
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A₂: 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

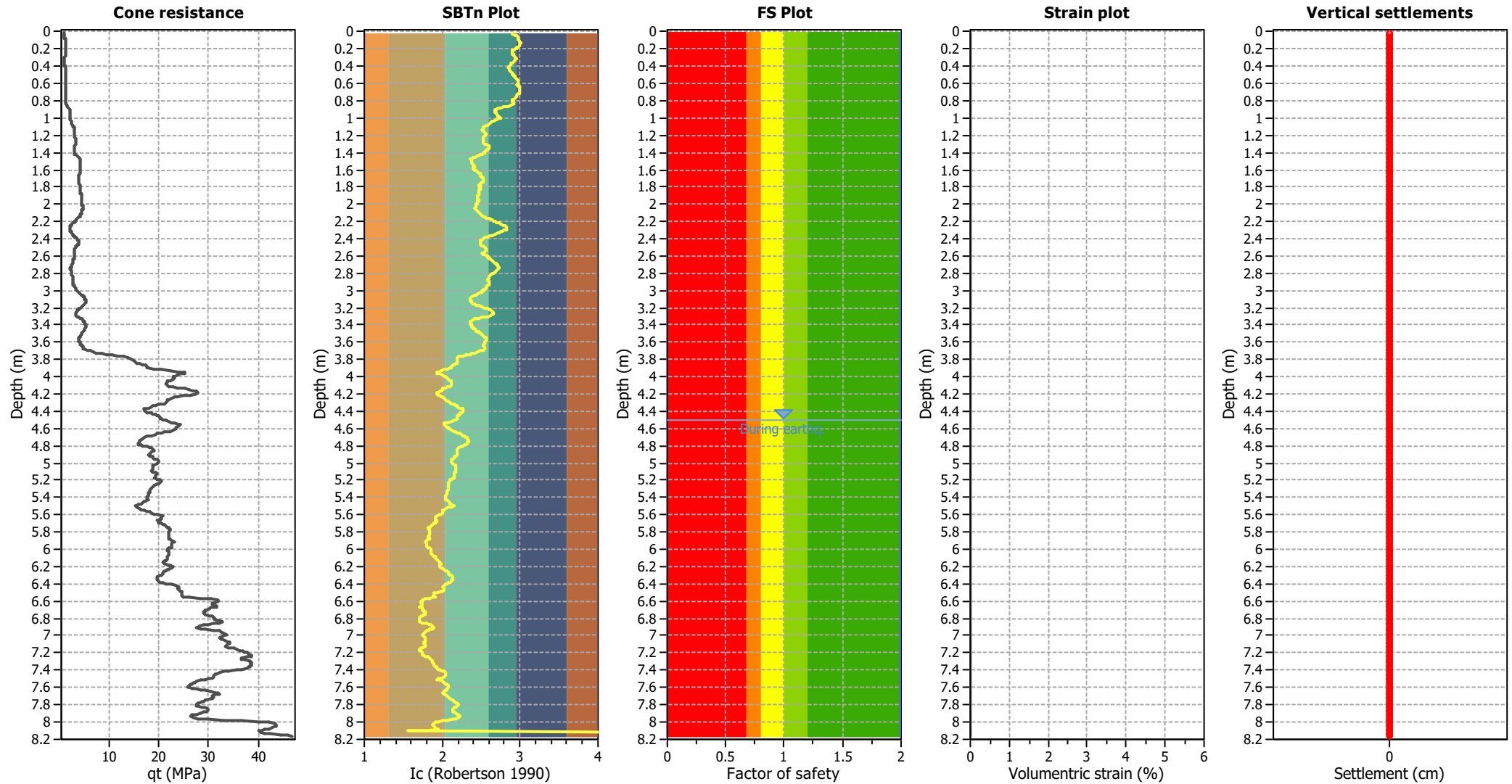
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

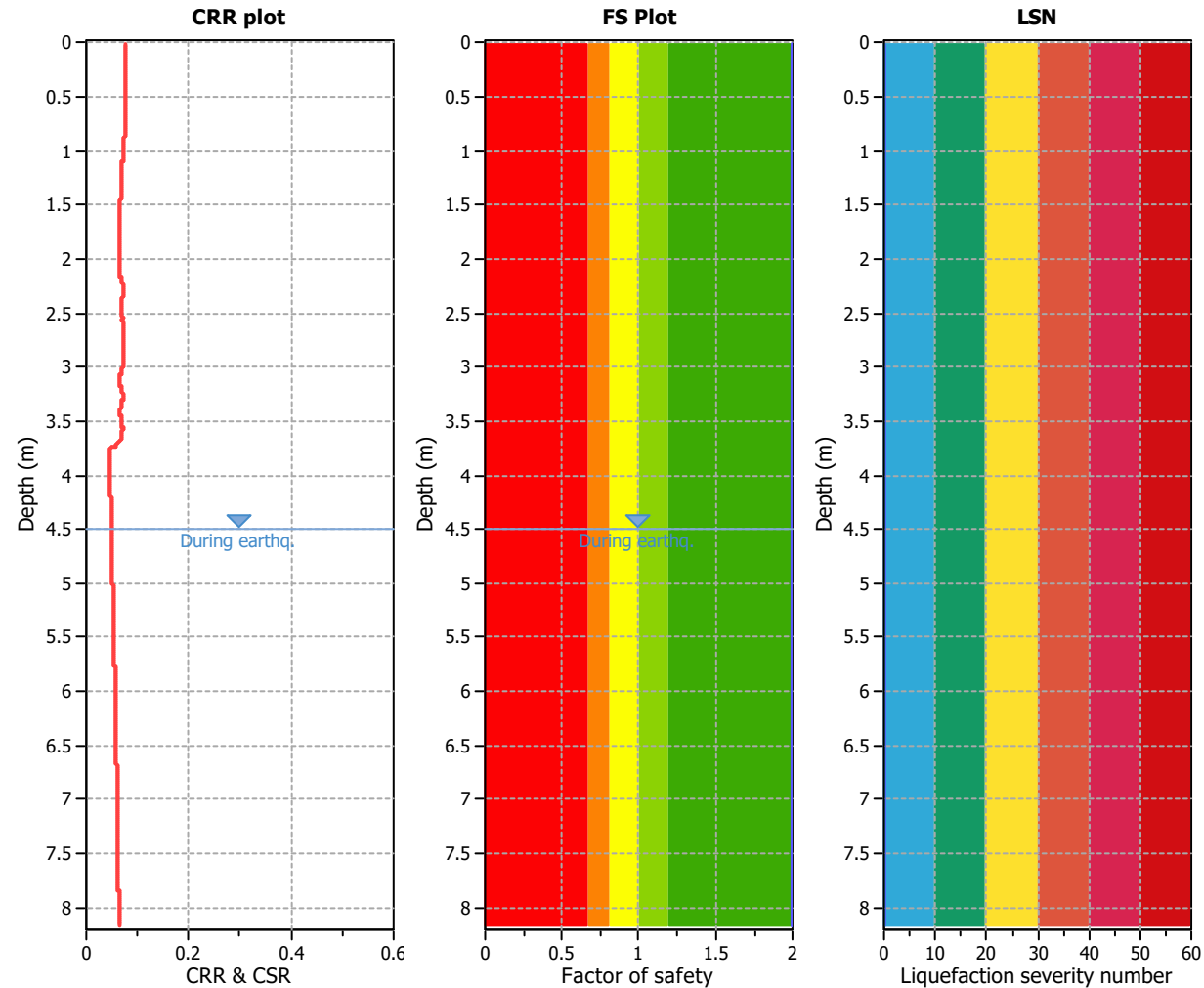
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
 Volumetric strain: Post-liquefaction volumetric strain



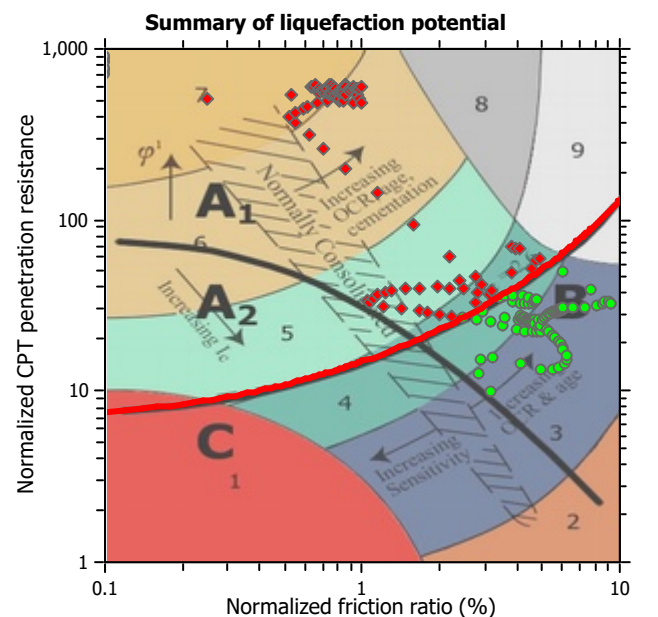
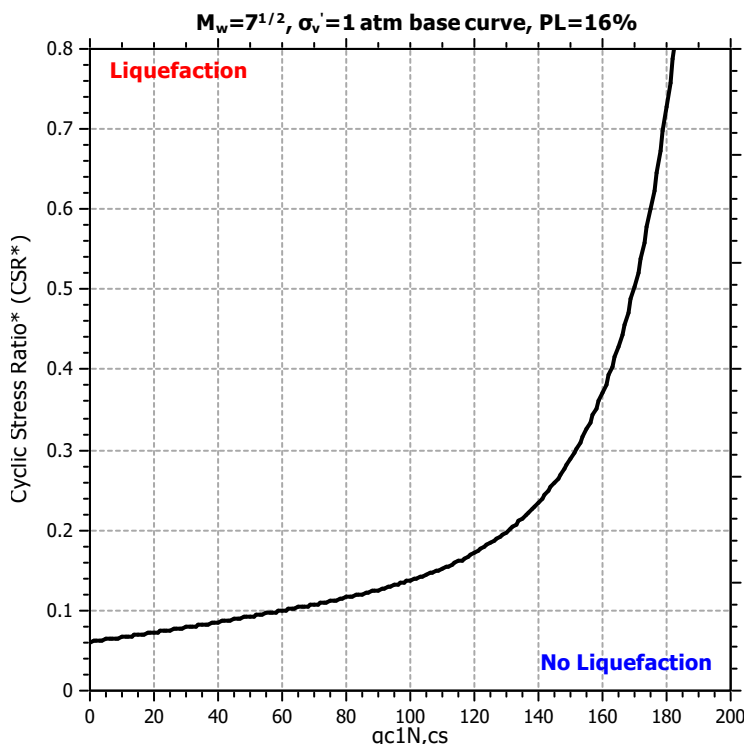
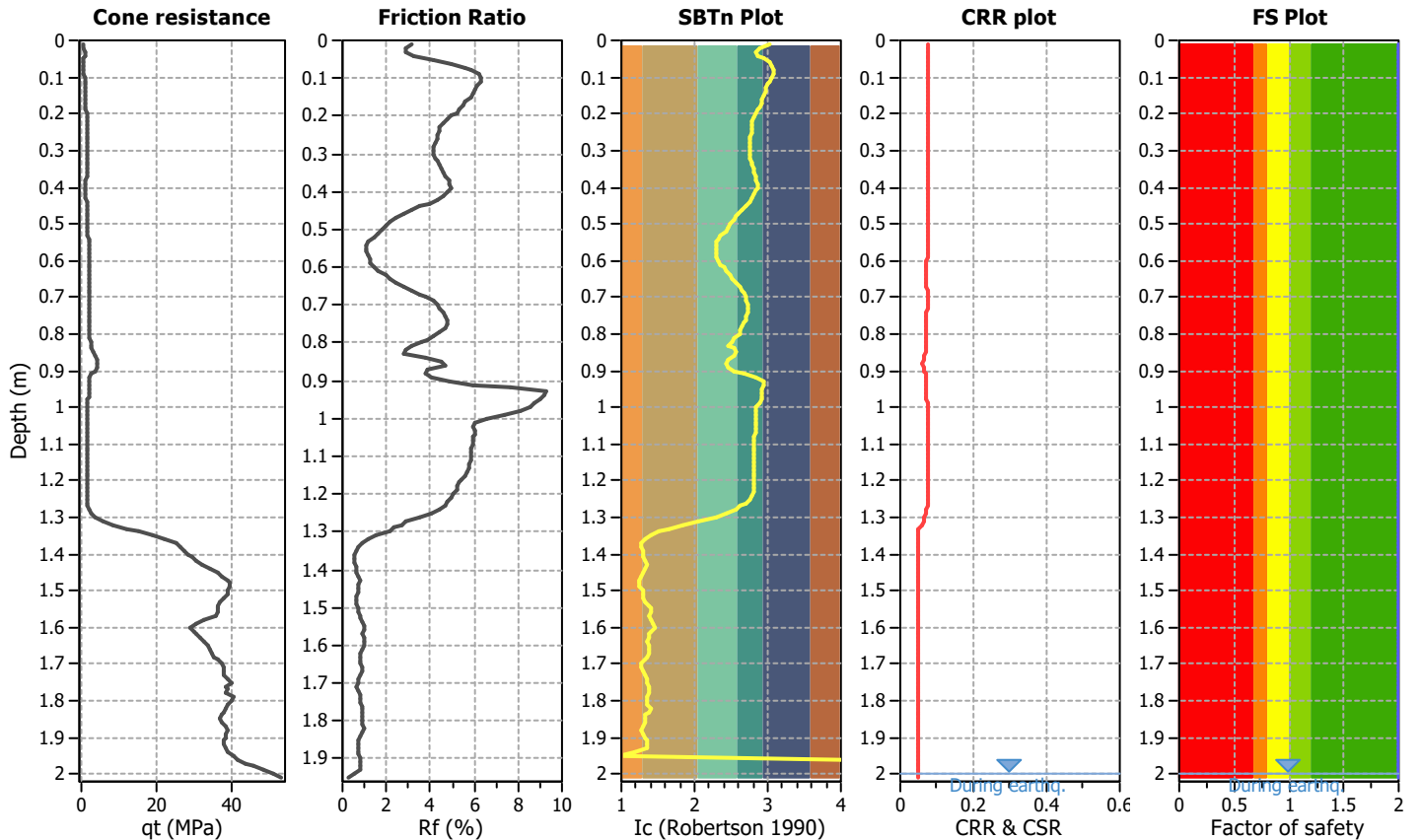
Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT4

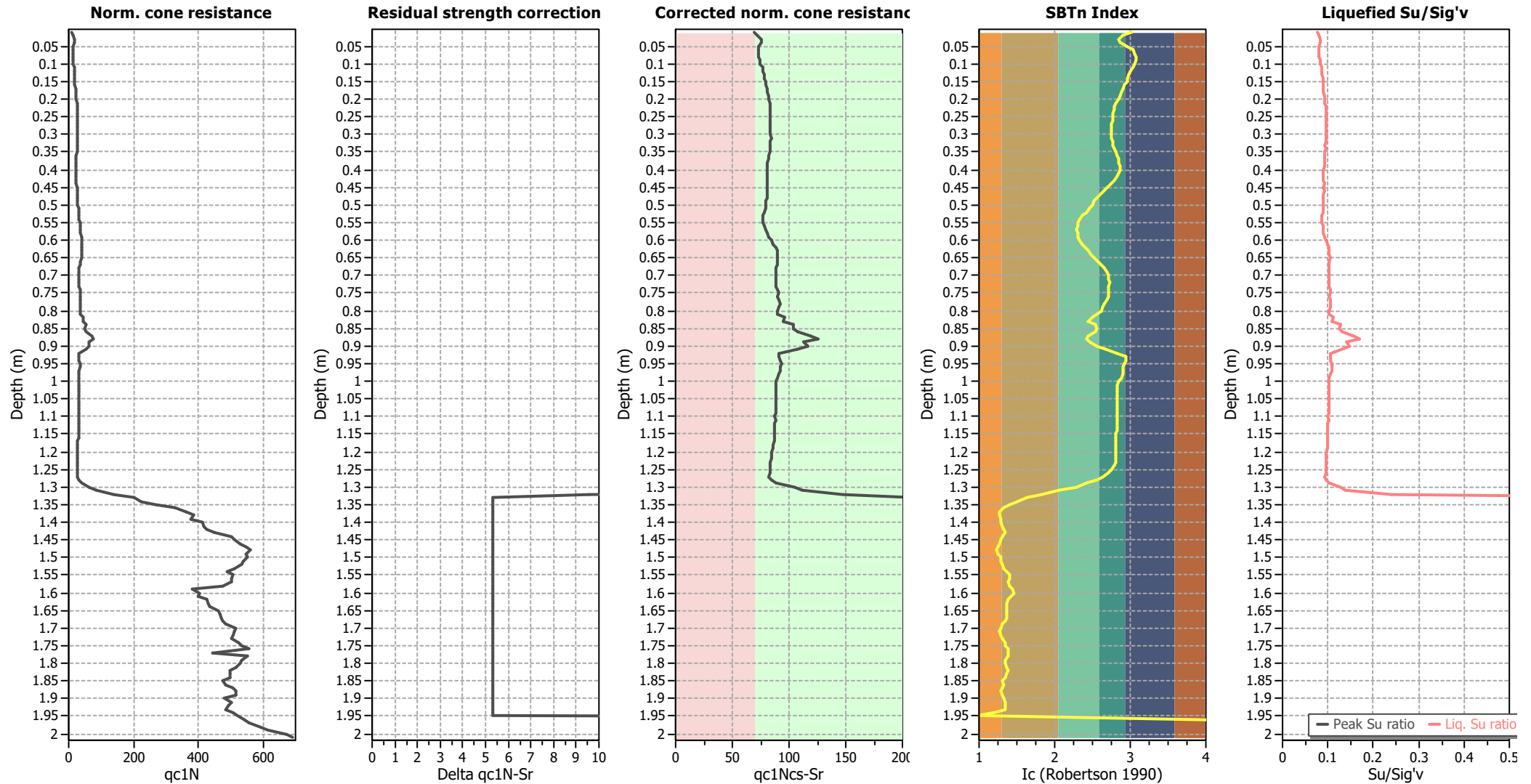
LIQUEFACTION ANALYSIS REPORT

Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 4
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



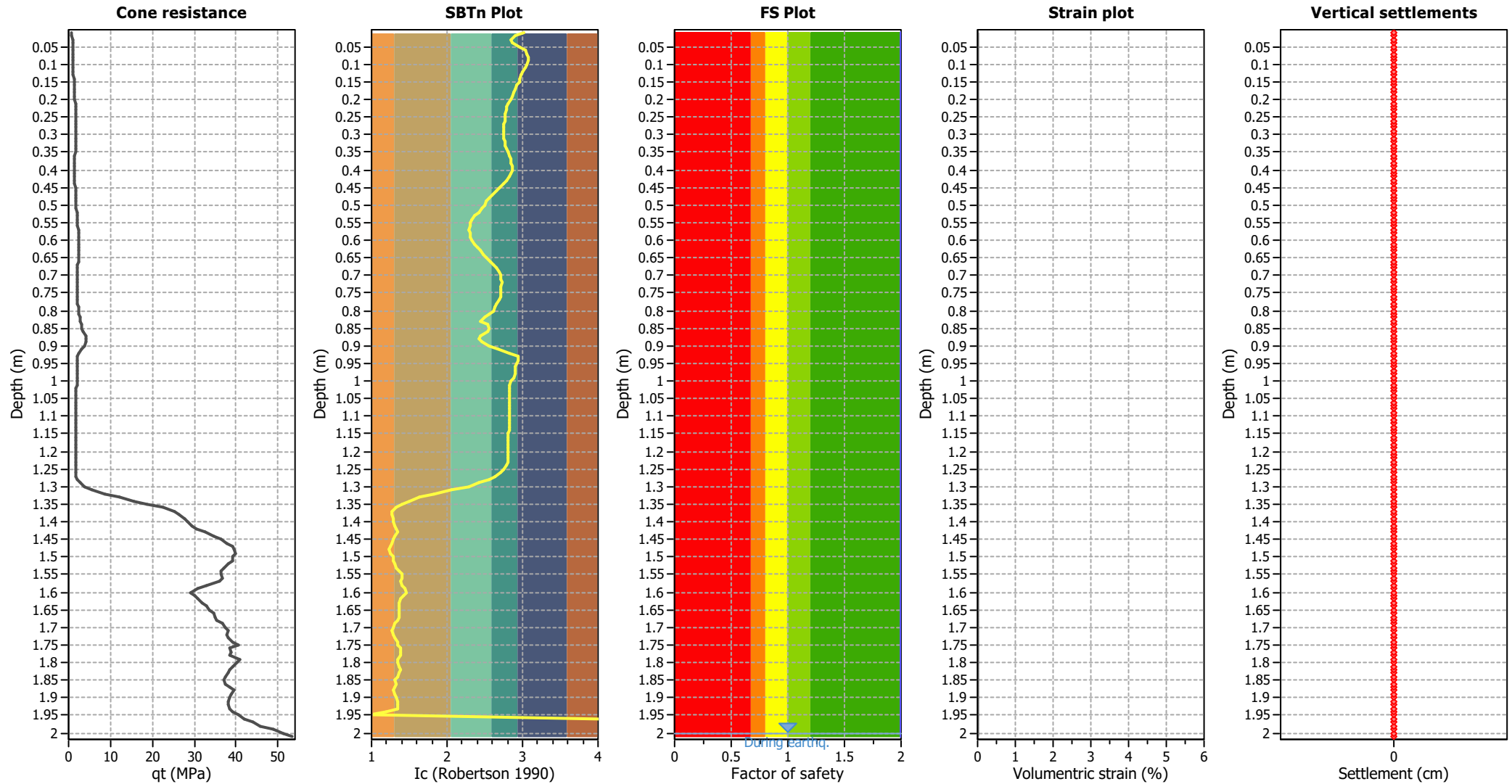
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

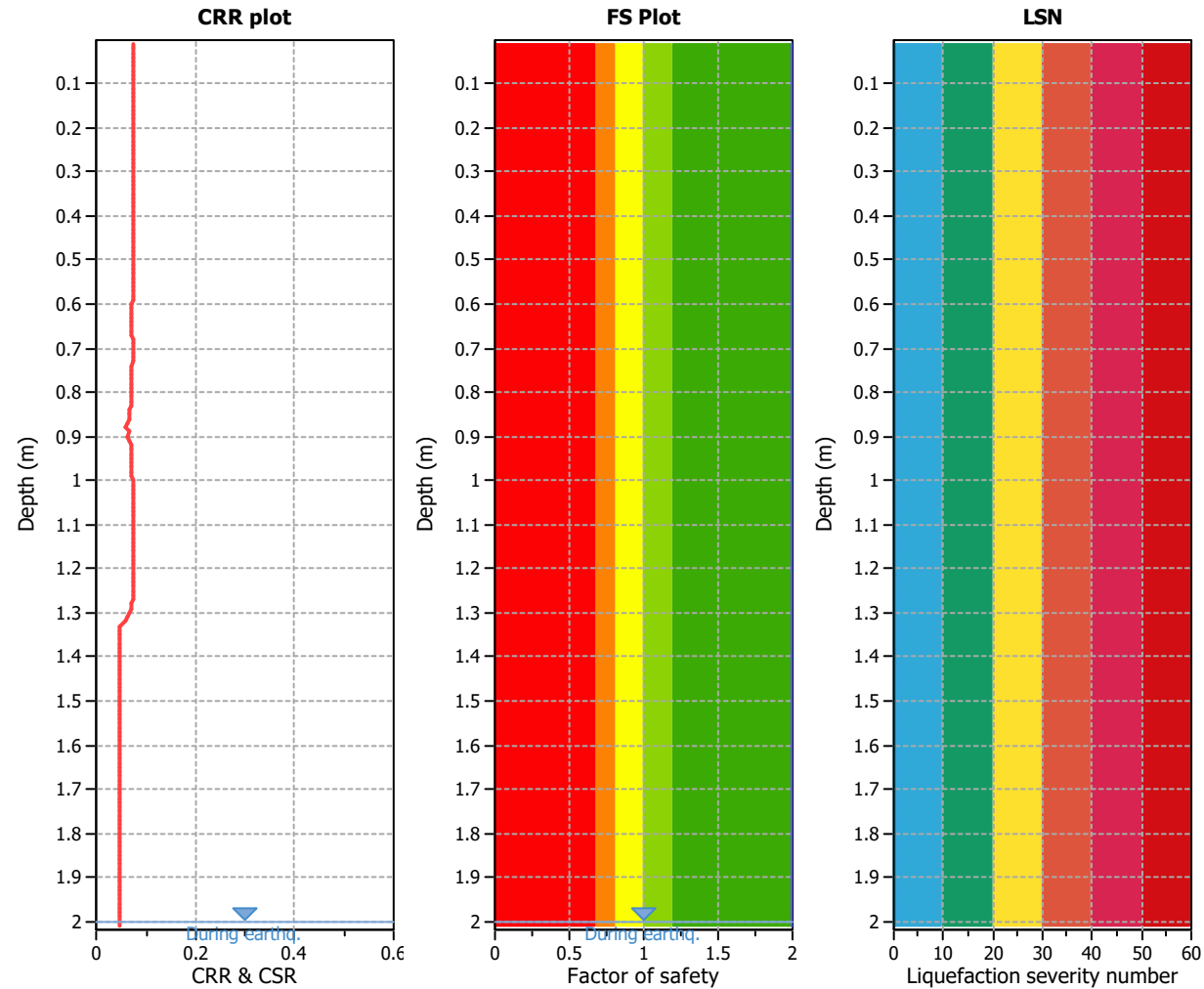
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_g applied:	Yes
Earthquake magnitude M_w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

q_c : 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
 Volumetric strain: Post-liquefaction volumetric strain



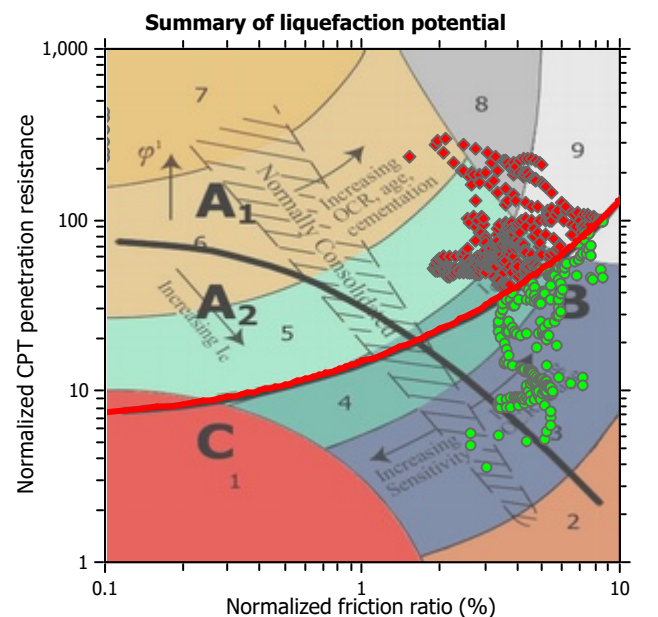
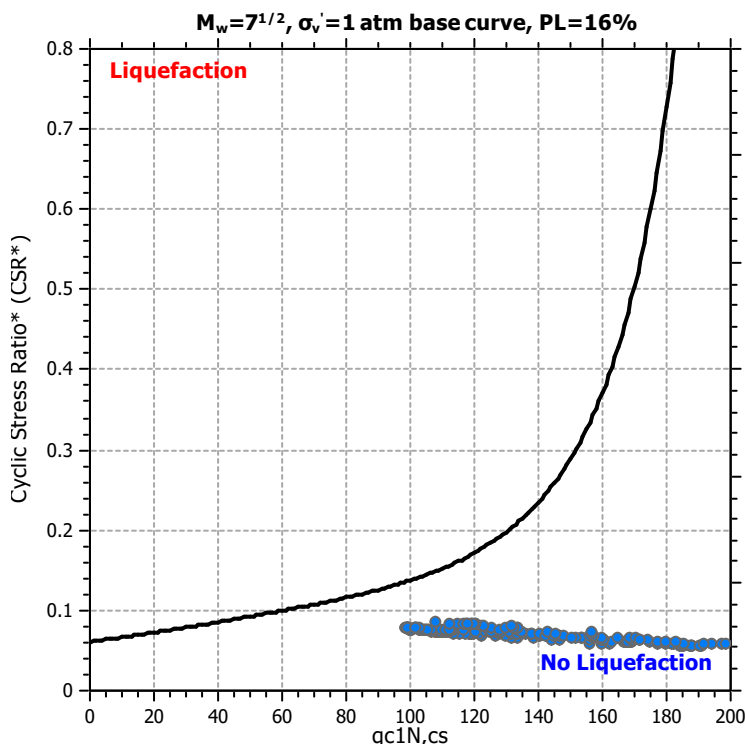
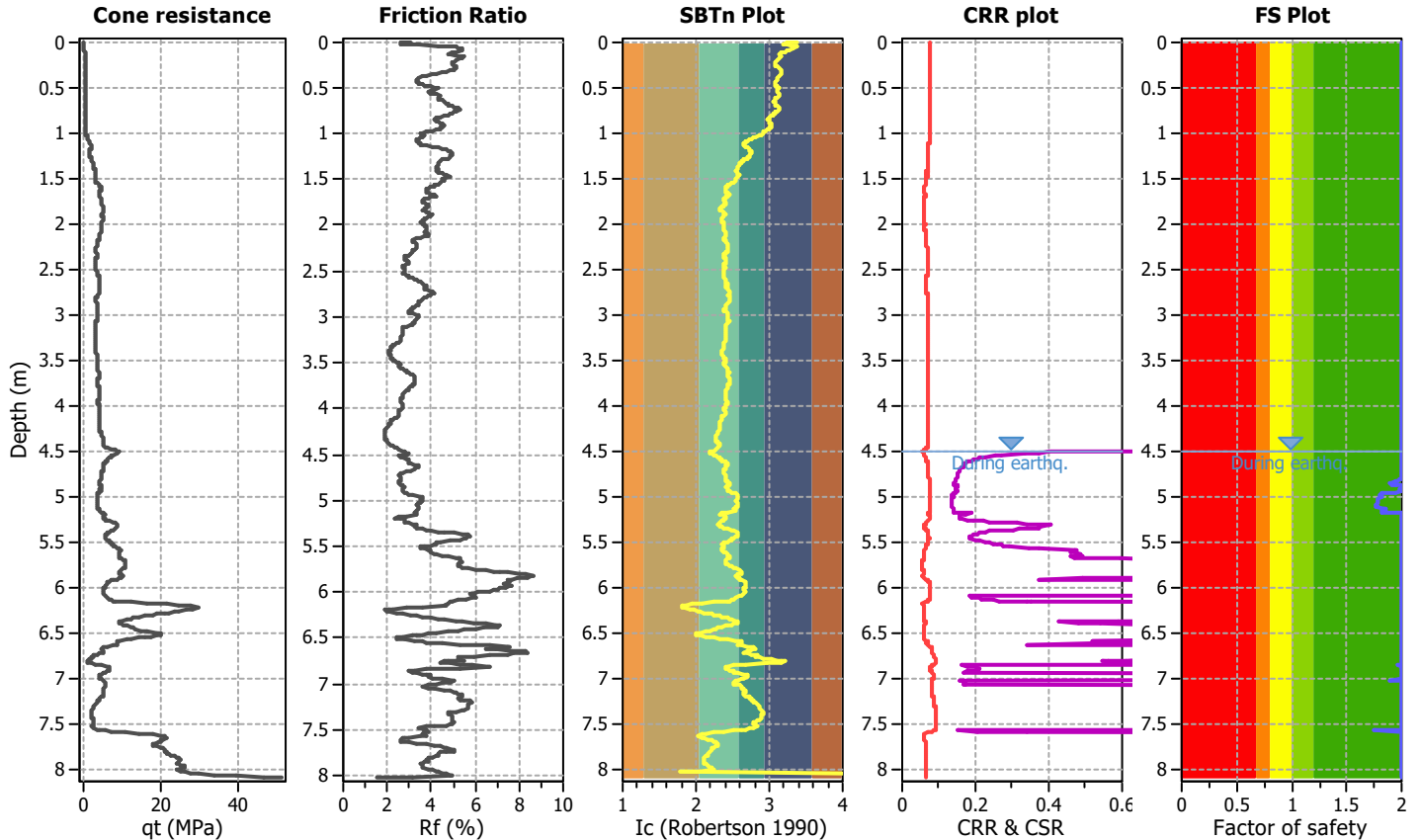
Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT5

LIQUEFACTION ANALYSIS REPORT

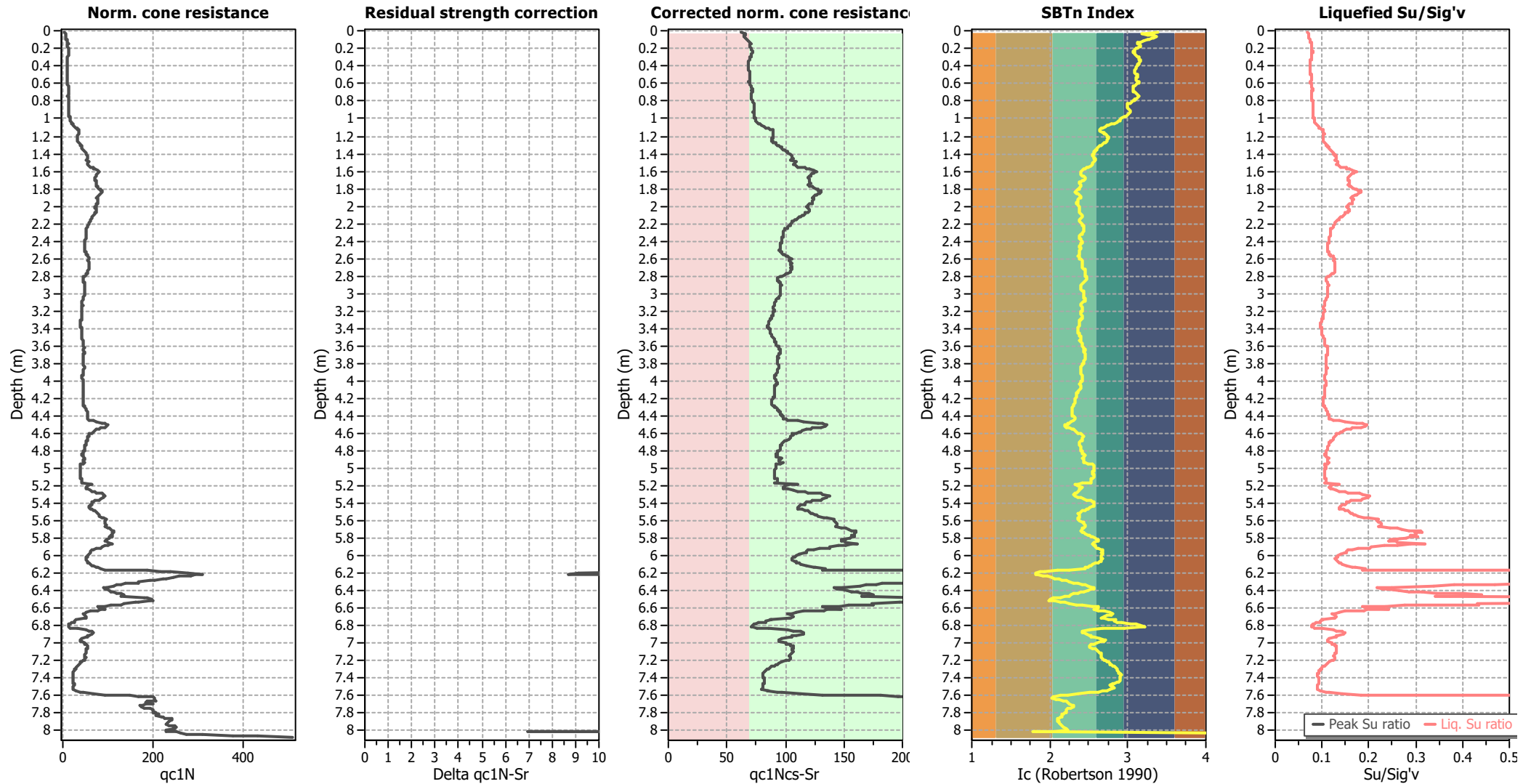
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 5
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

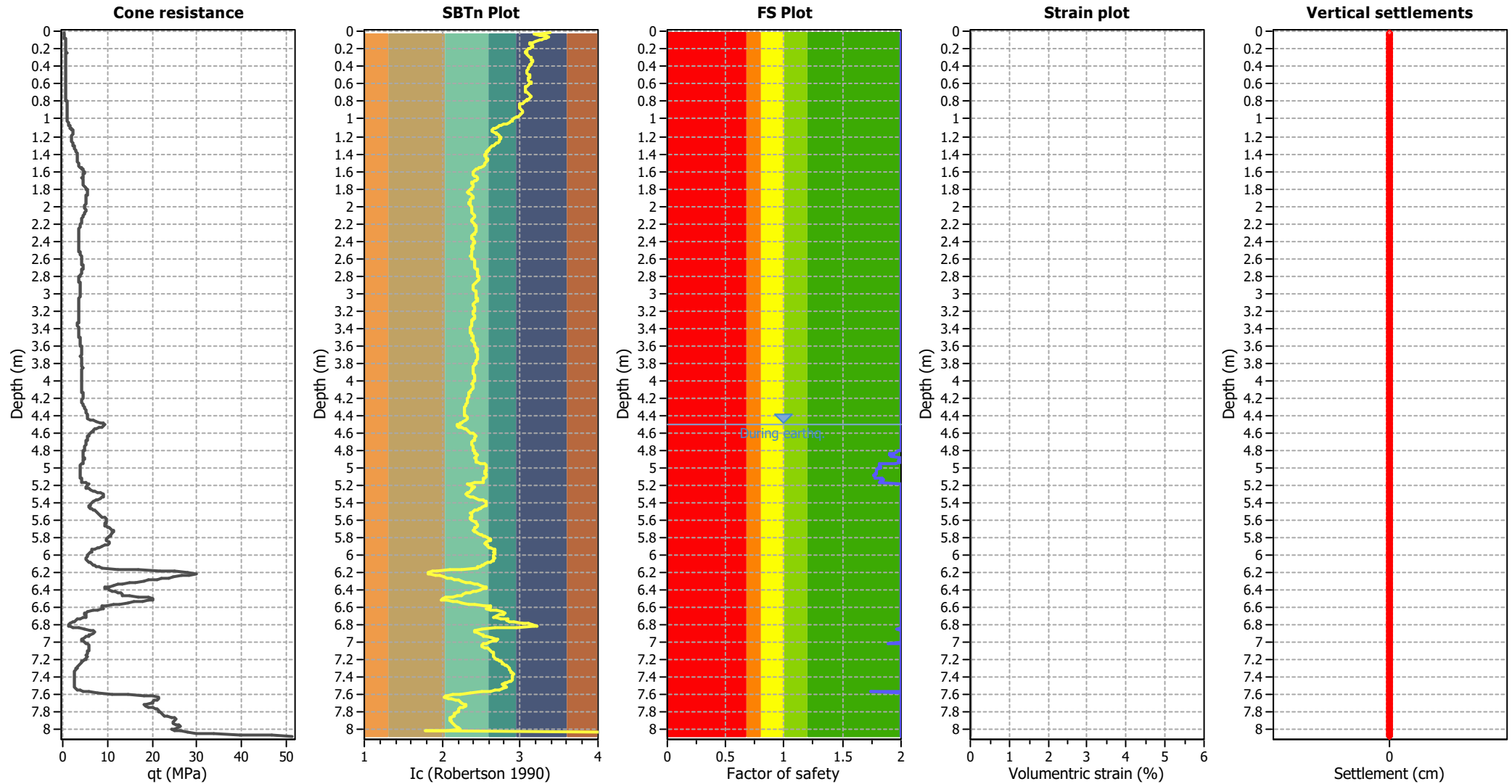
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

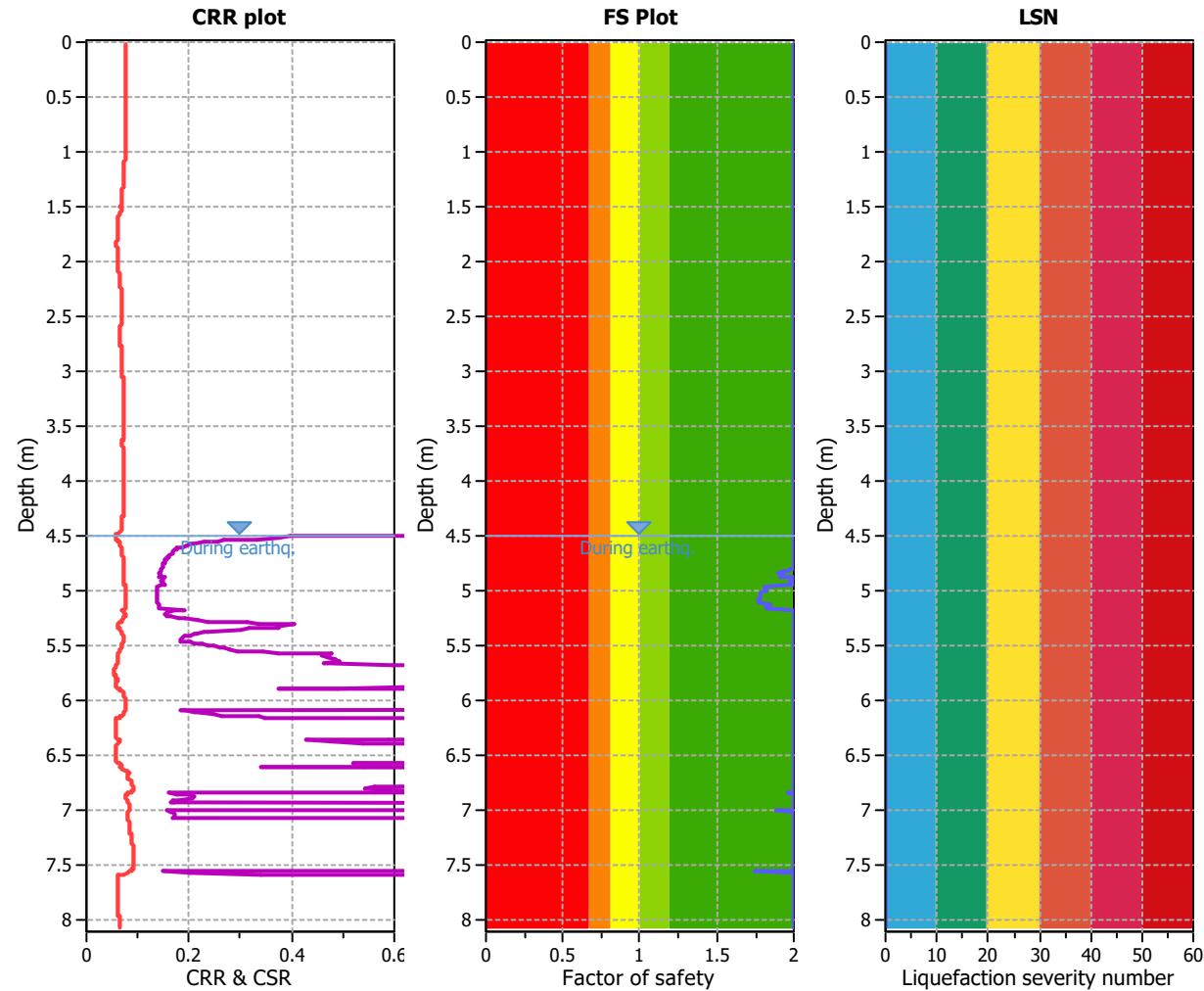
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
 Volumetric strain: Post-liquefaction volumetric strain



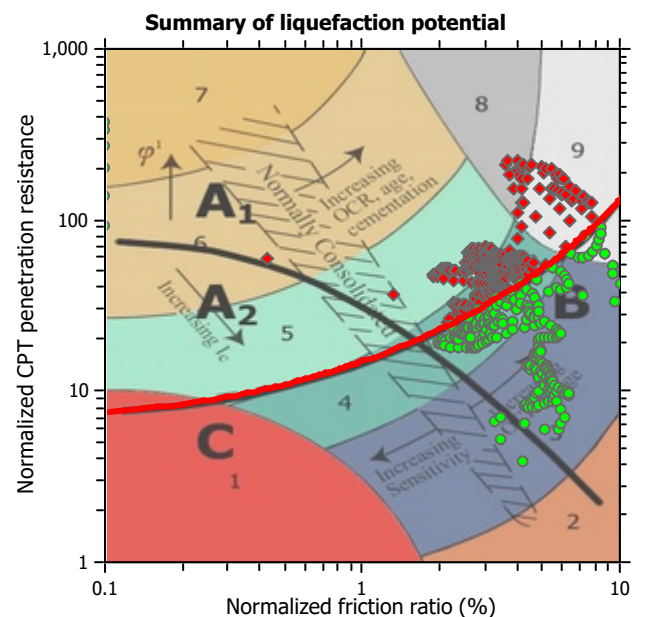
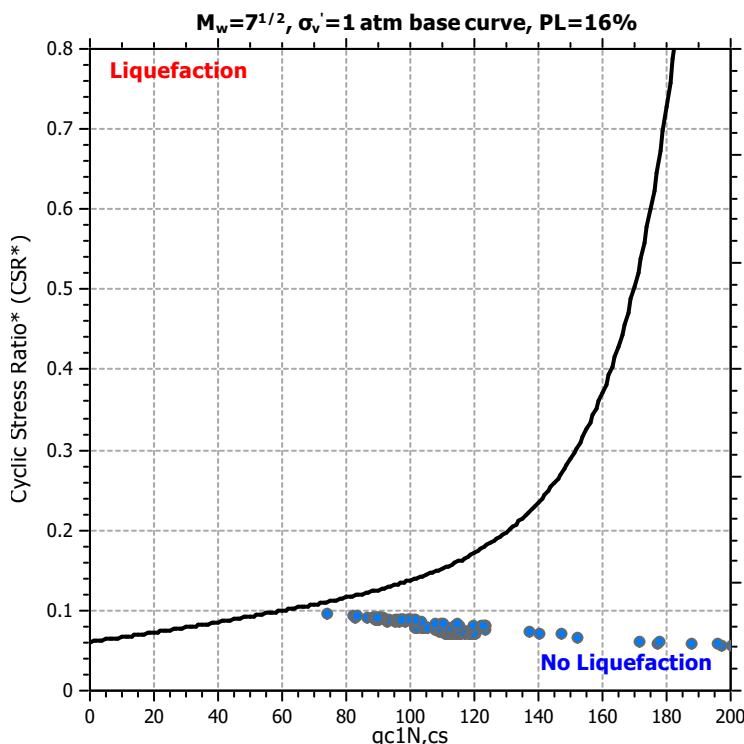
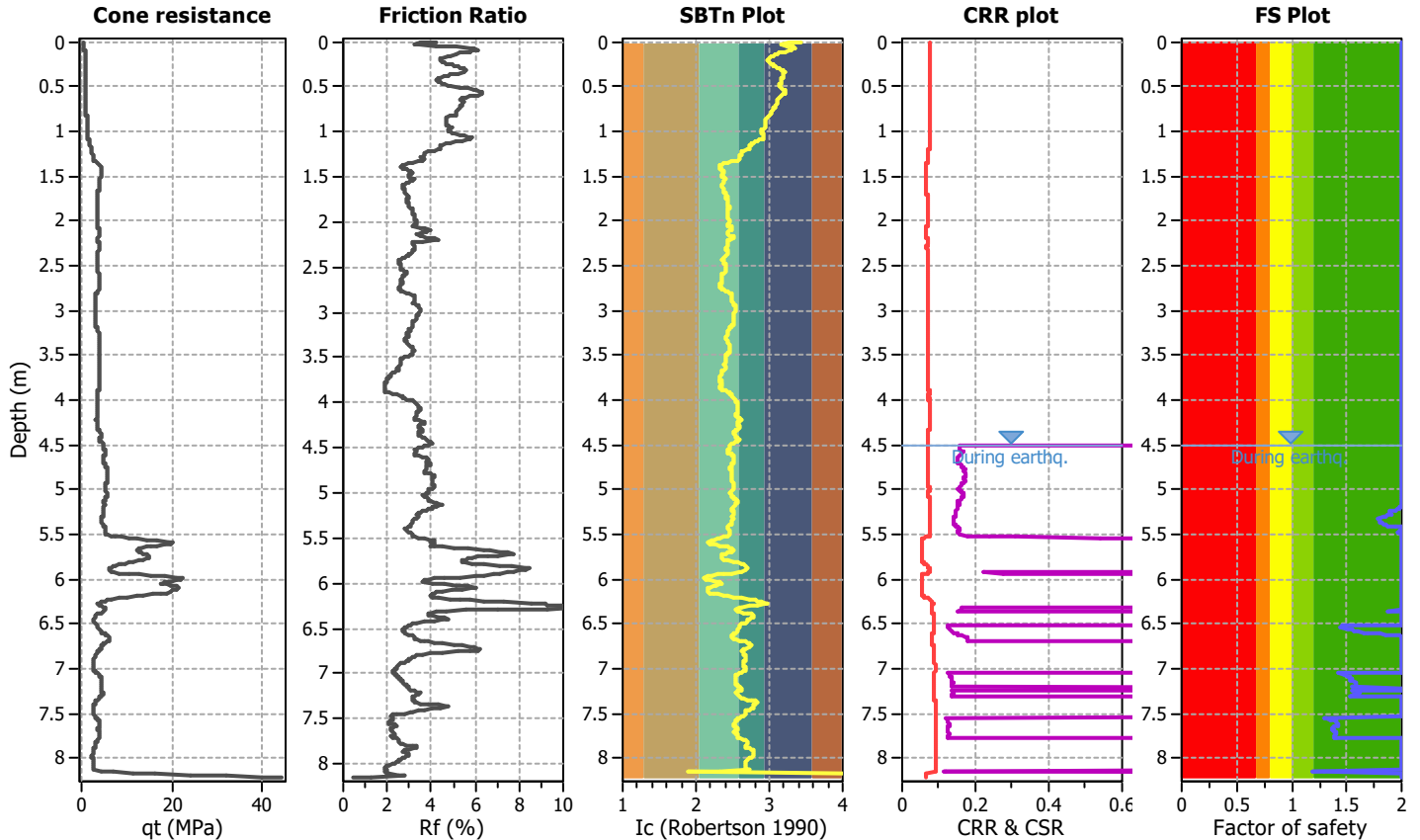
Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT6

LIQUEFACTION ANALYSIS REPORT

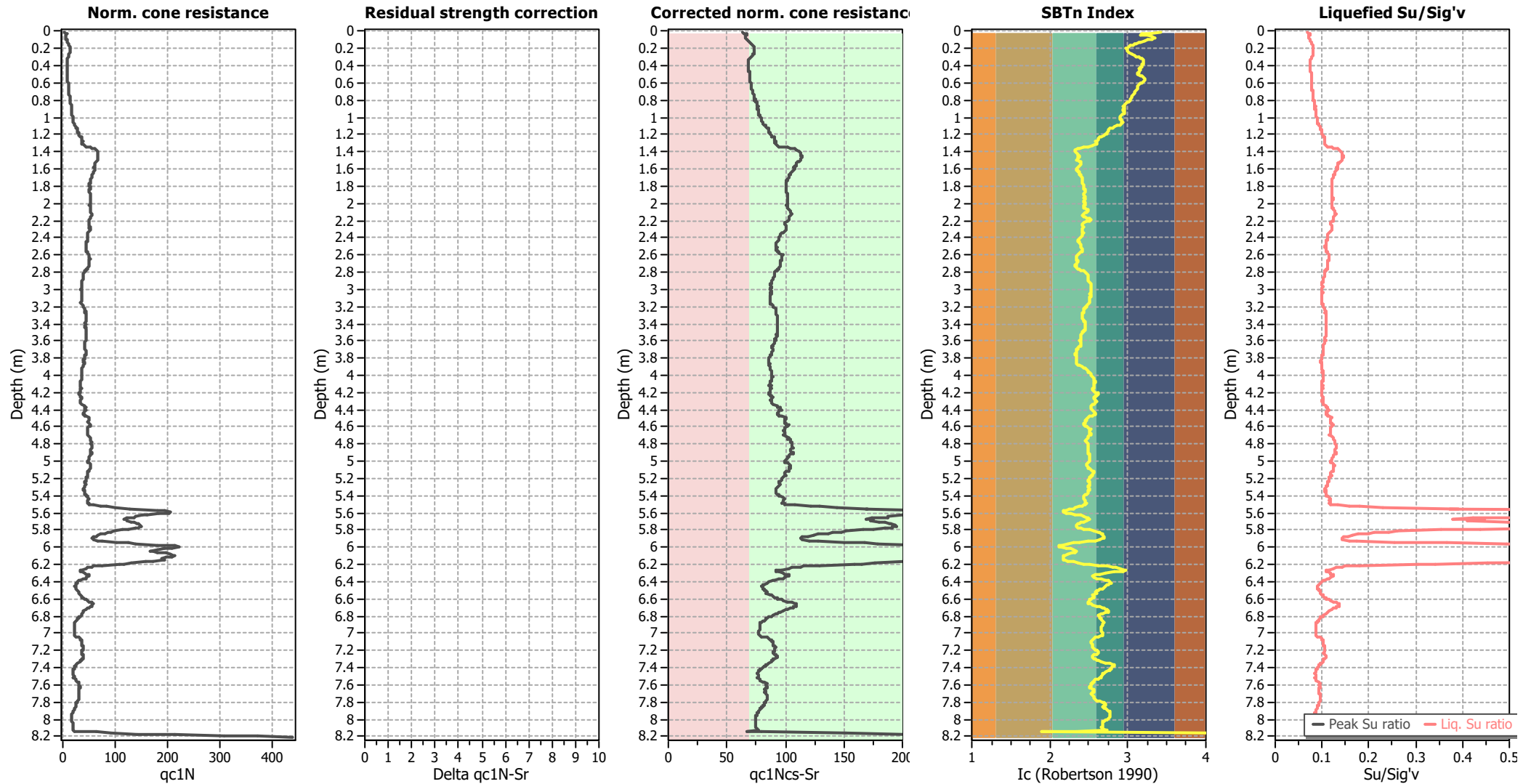
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 6
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A2: 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

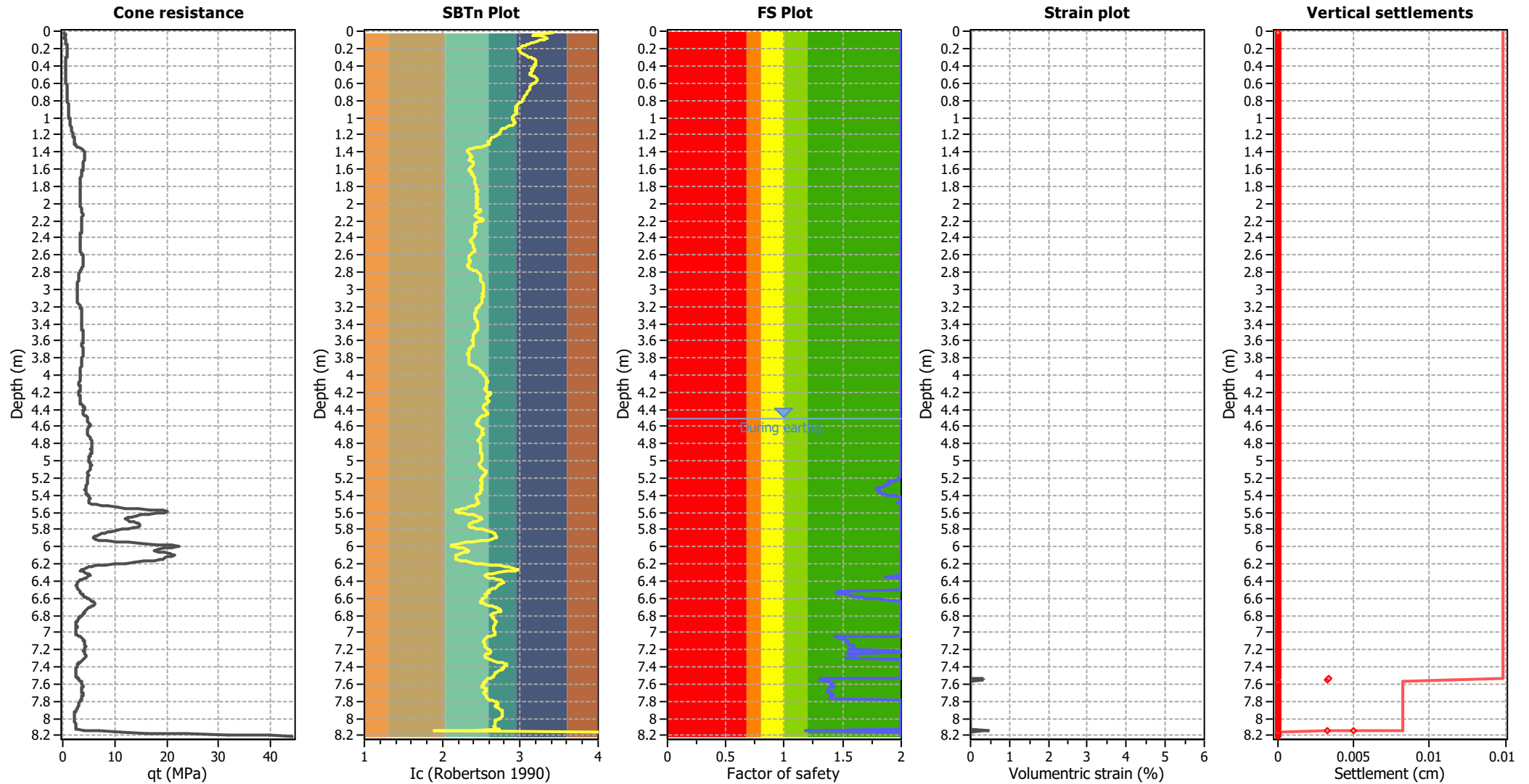
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

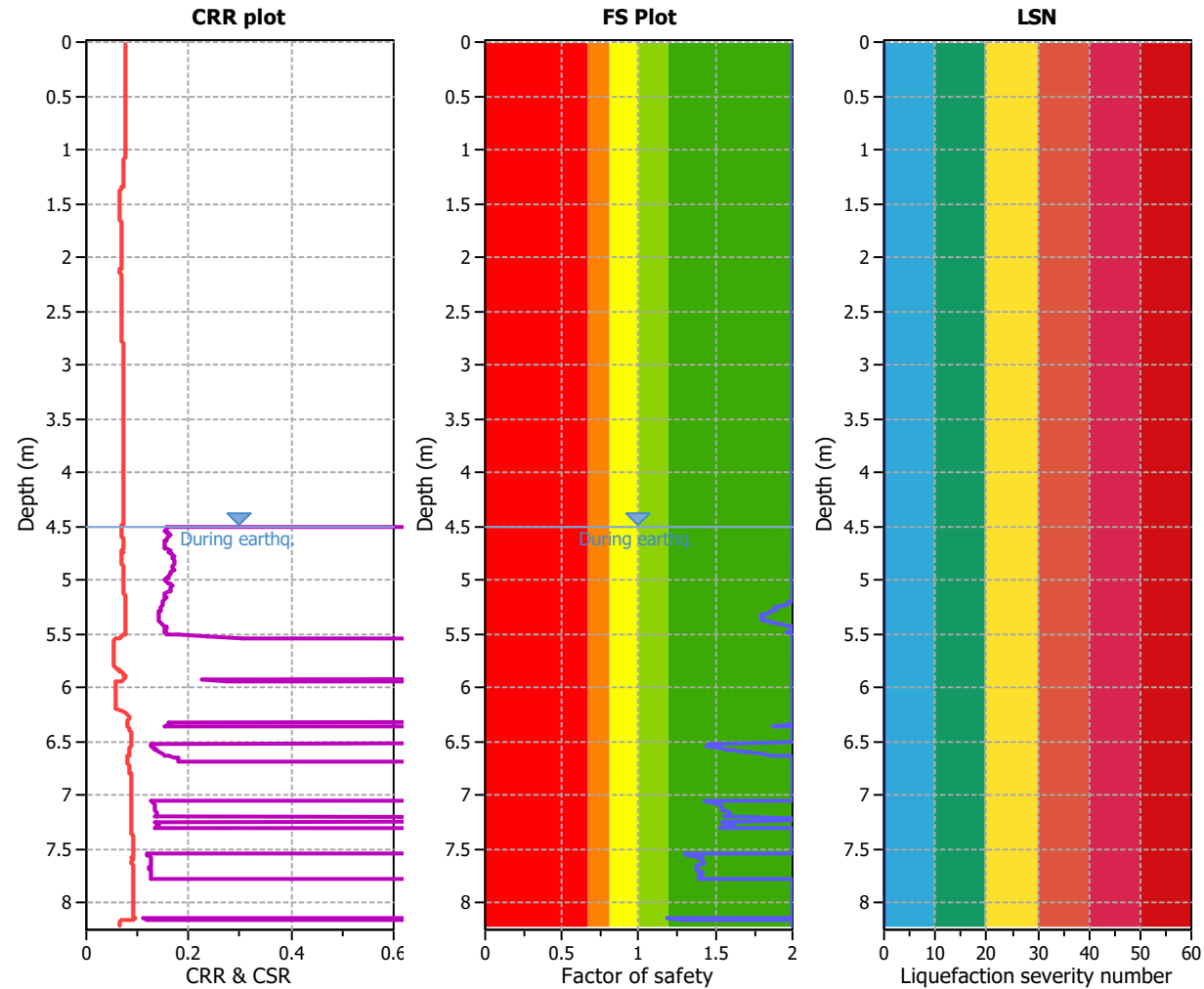
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _o applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
 Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT7

LIQUEFACTION ANALYSIS REPORT

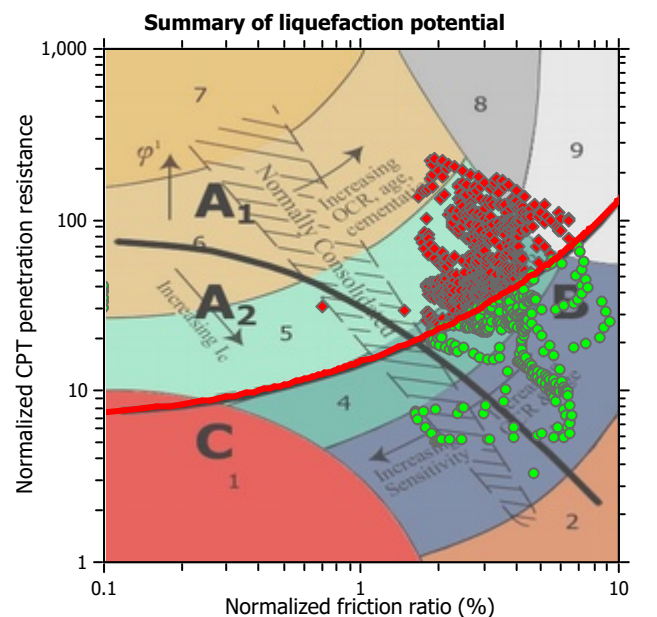
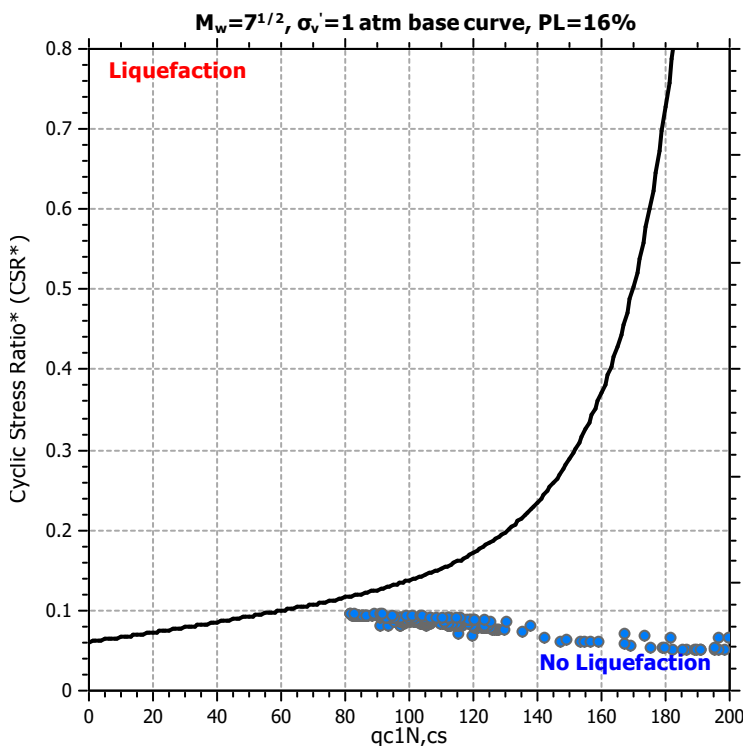
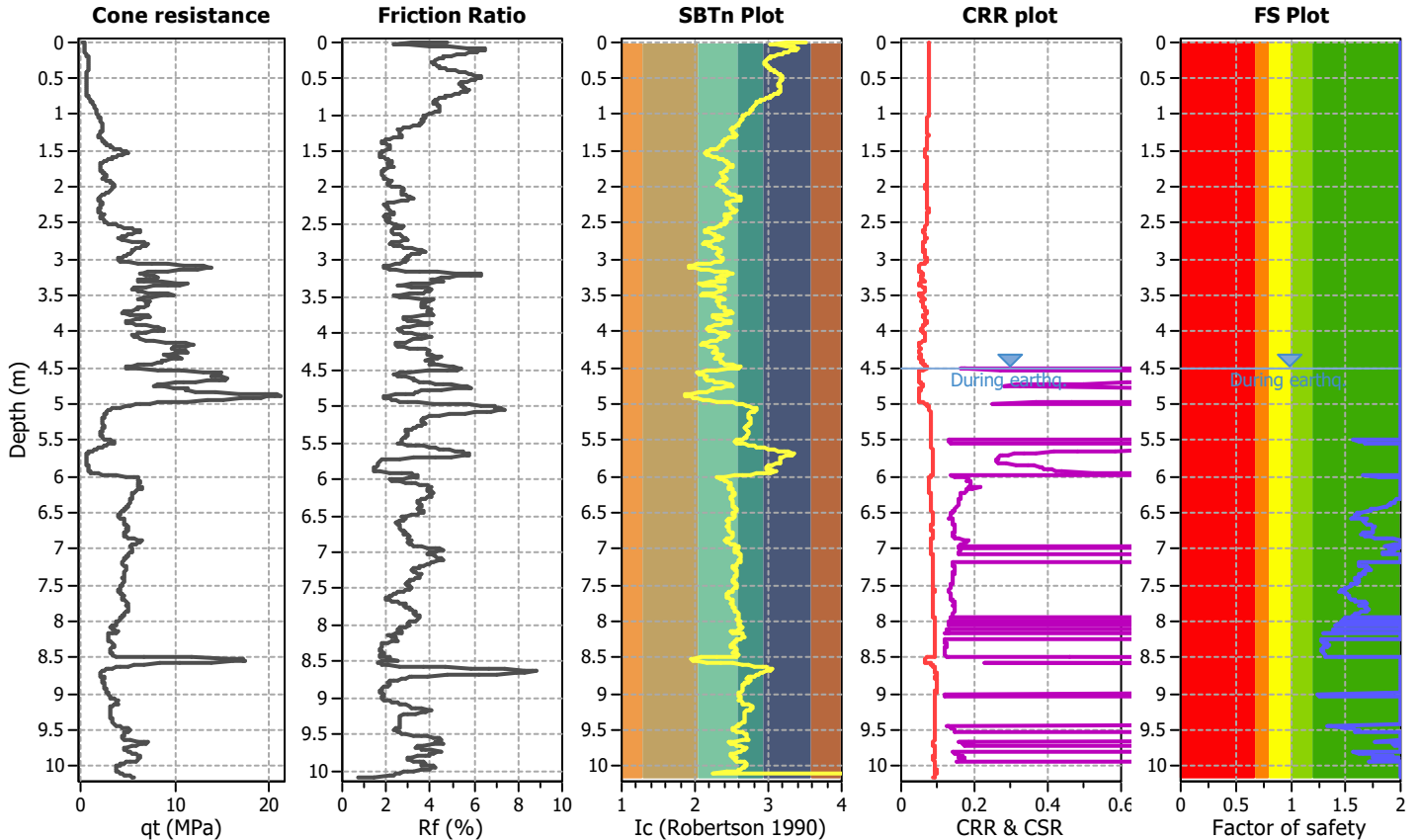
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 7

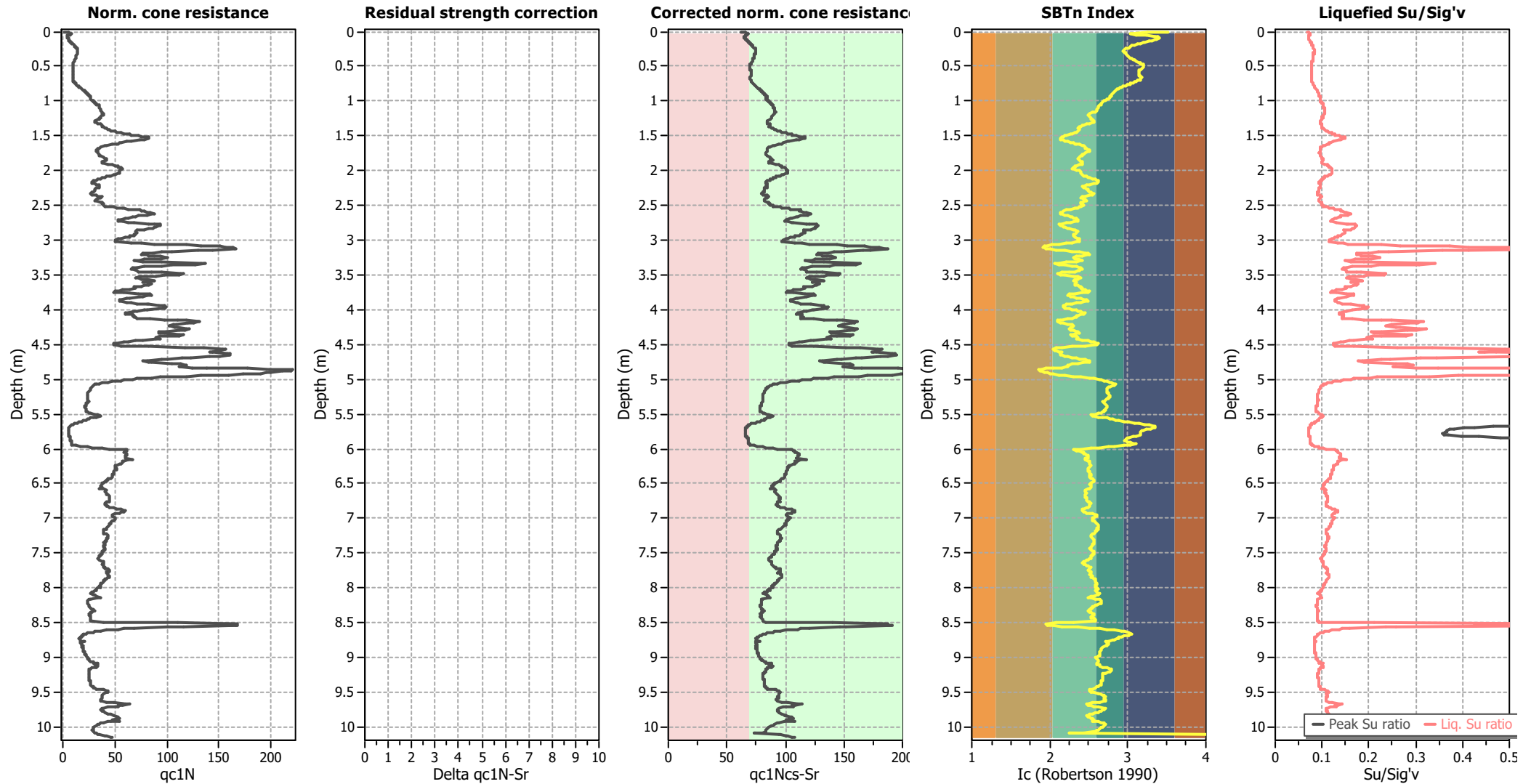
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

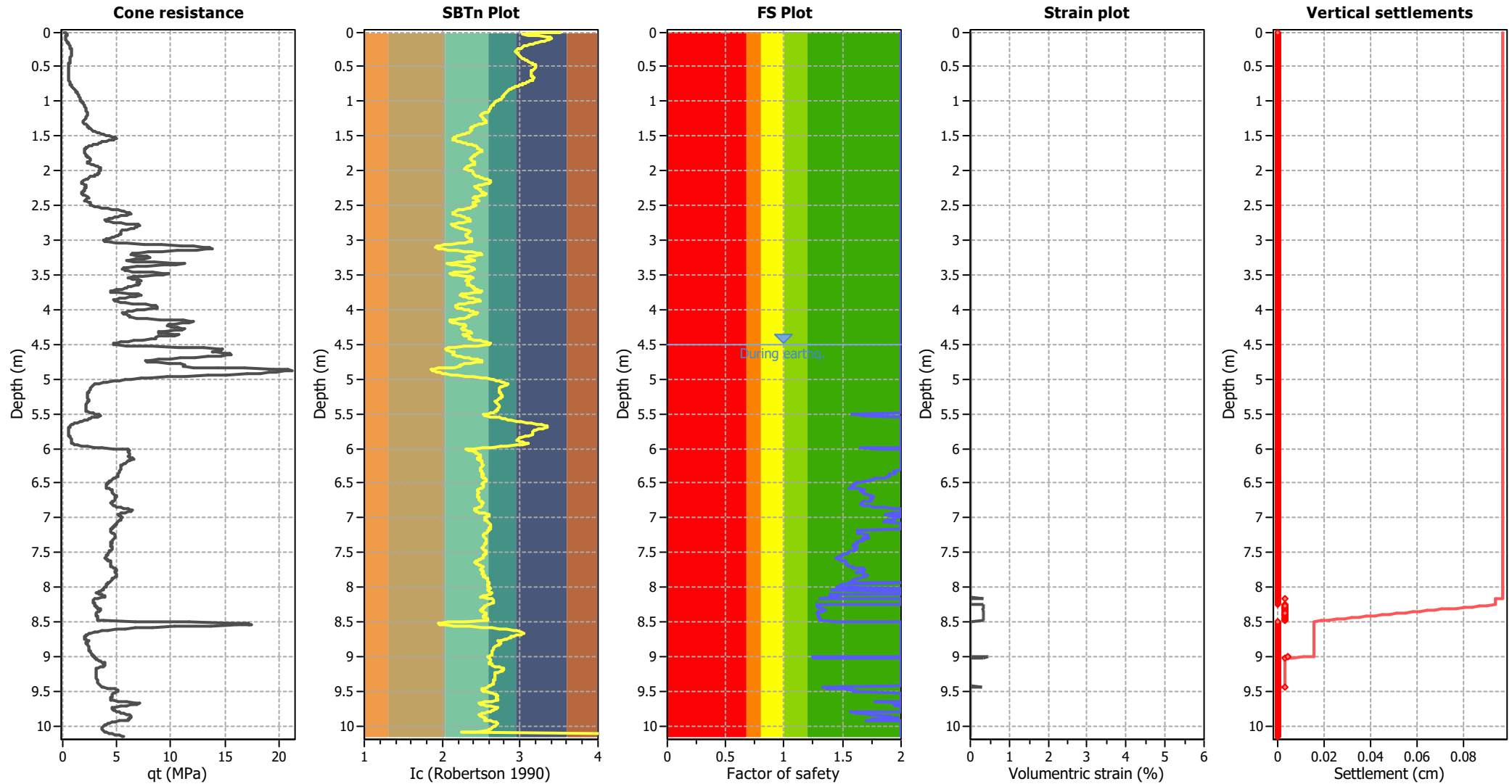
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

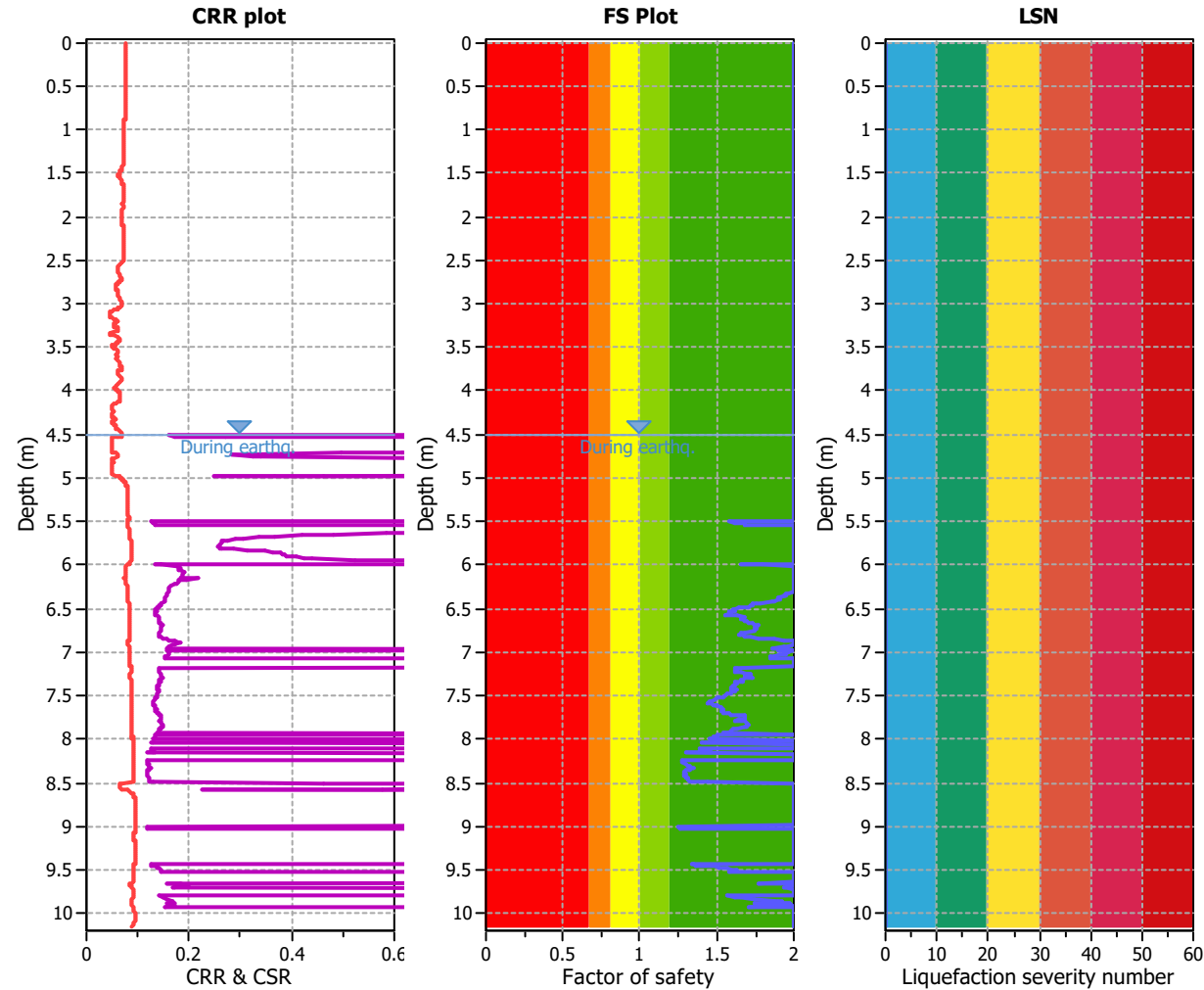
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

q_c : 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
 Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT8

LIQUEFACTION ANALYSIS REPORT

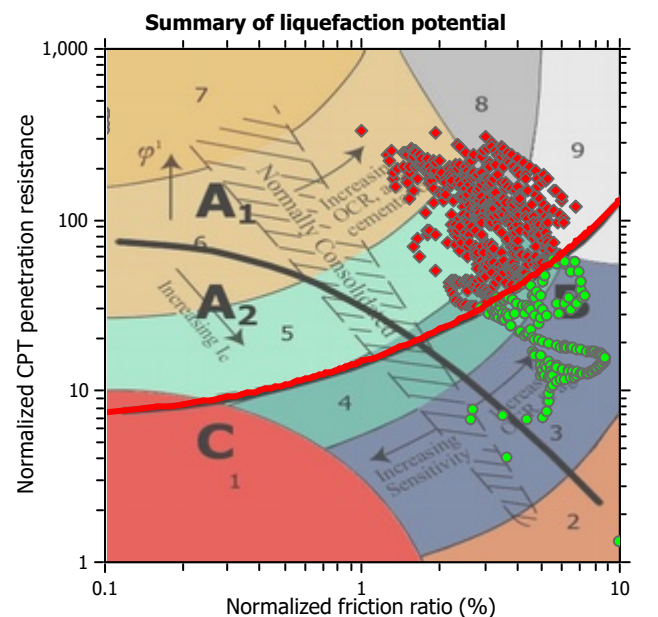
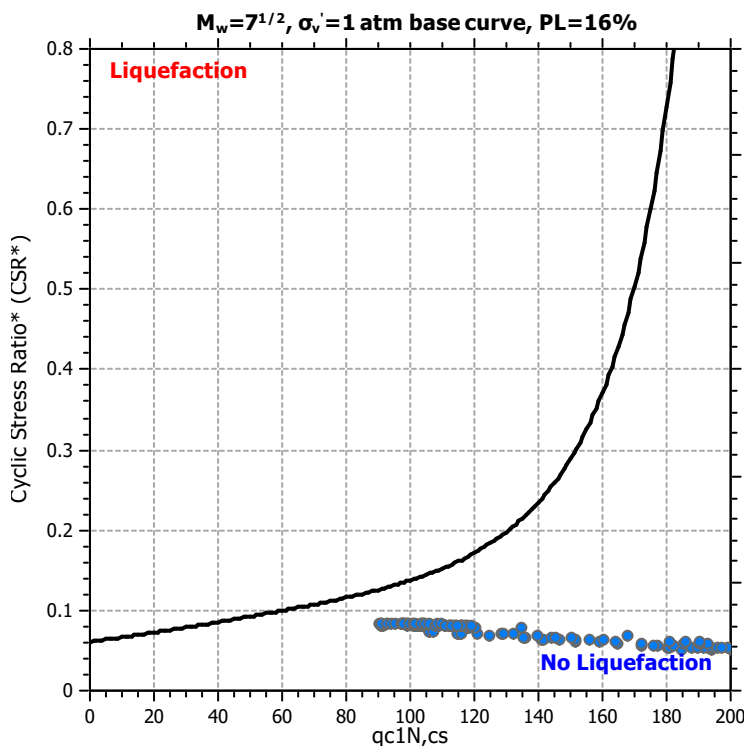
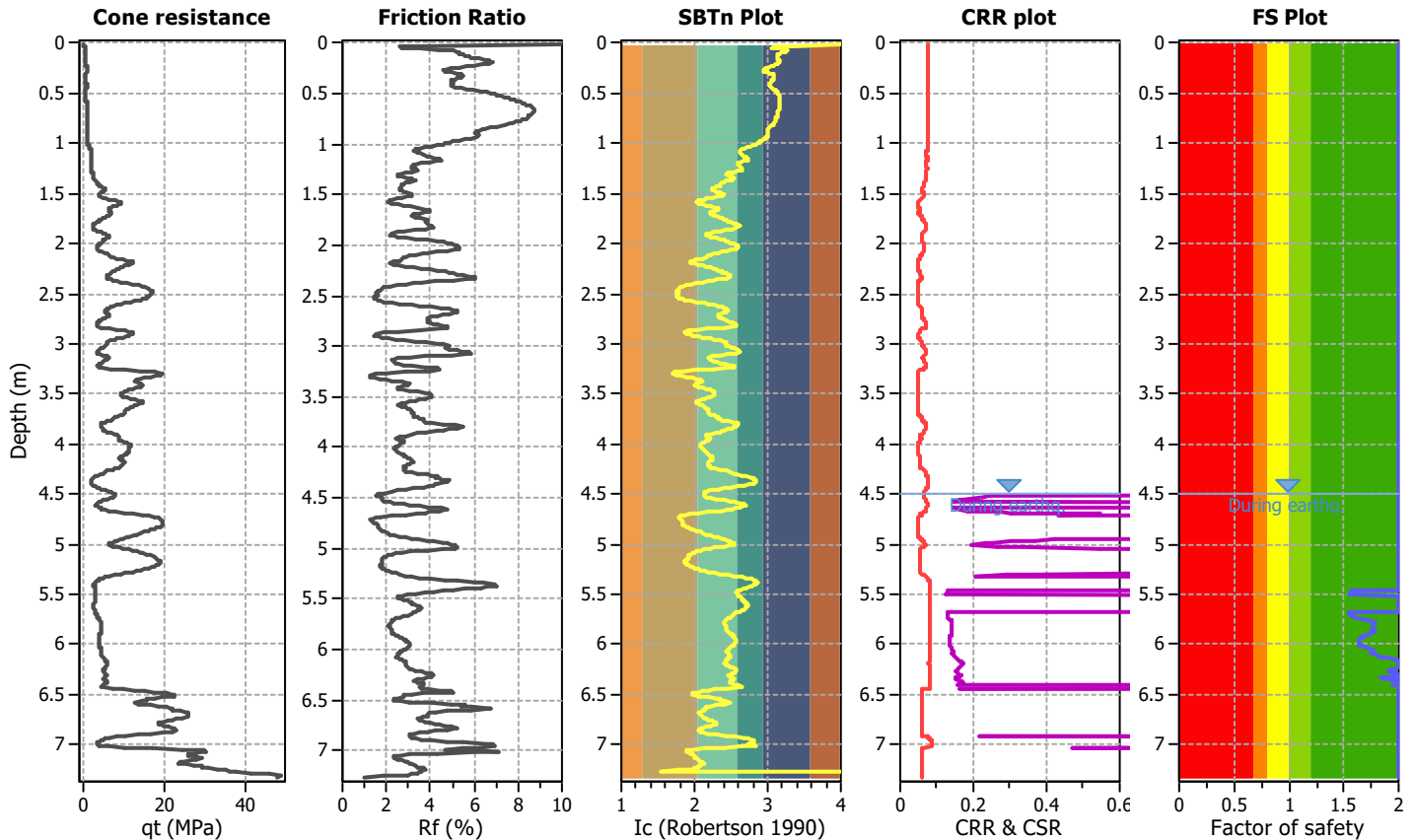
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 8

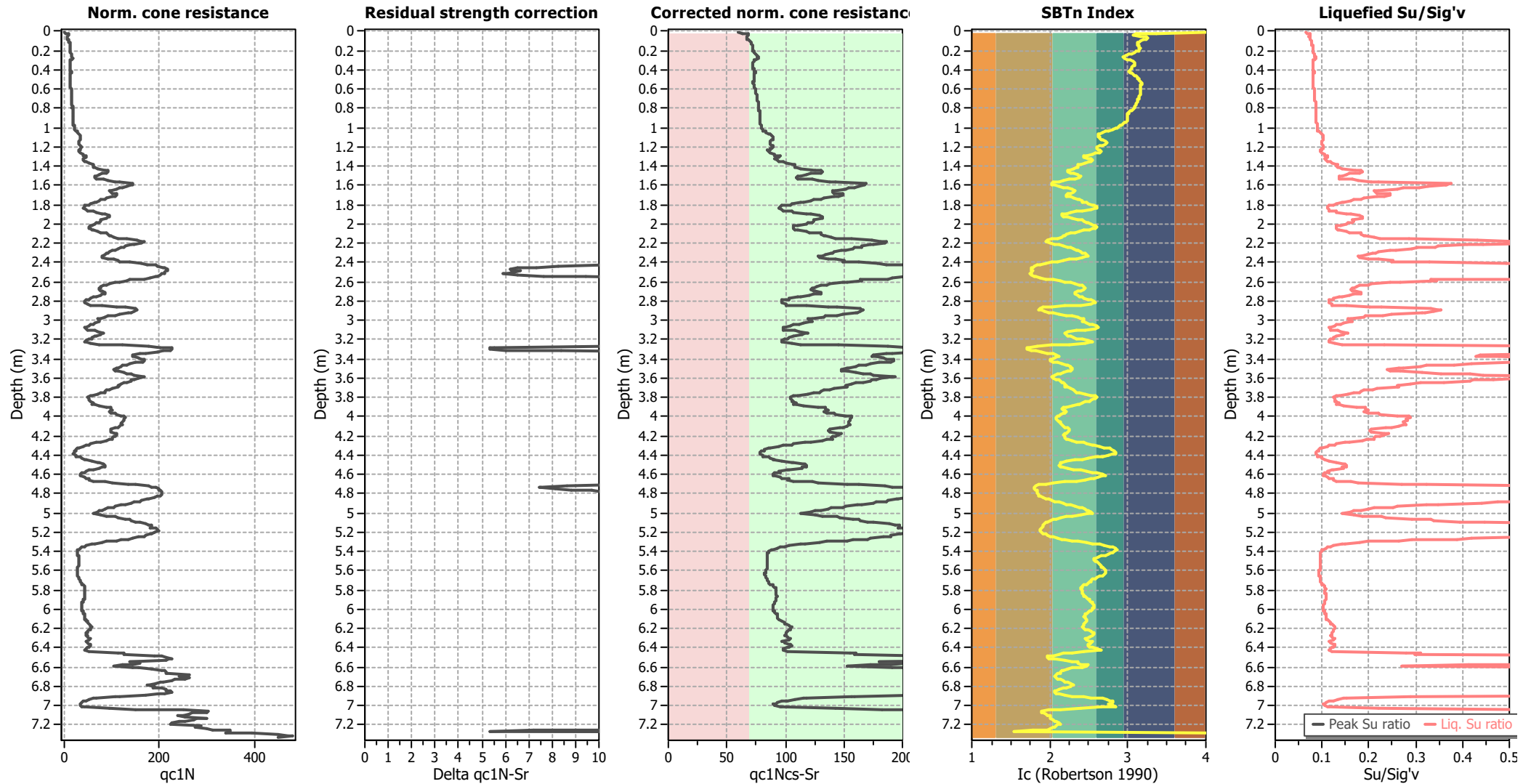
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

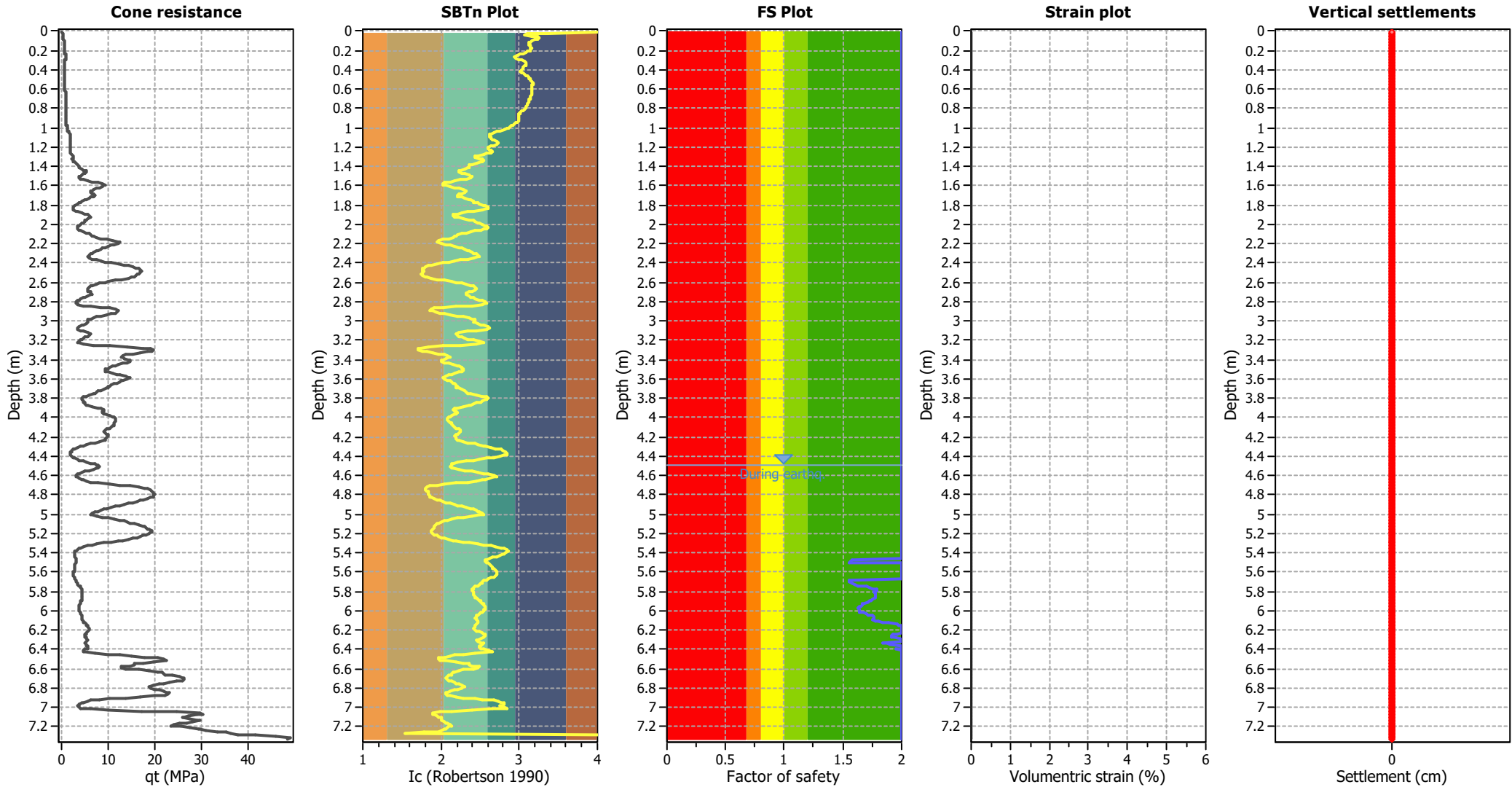
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

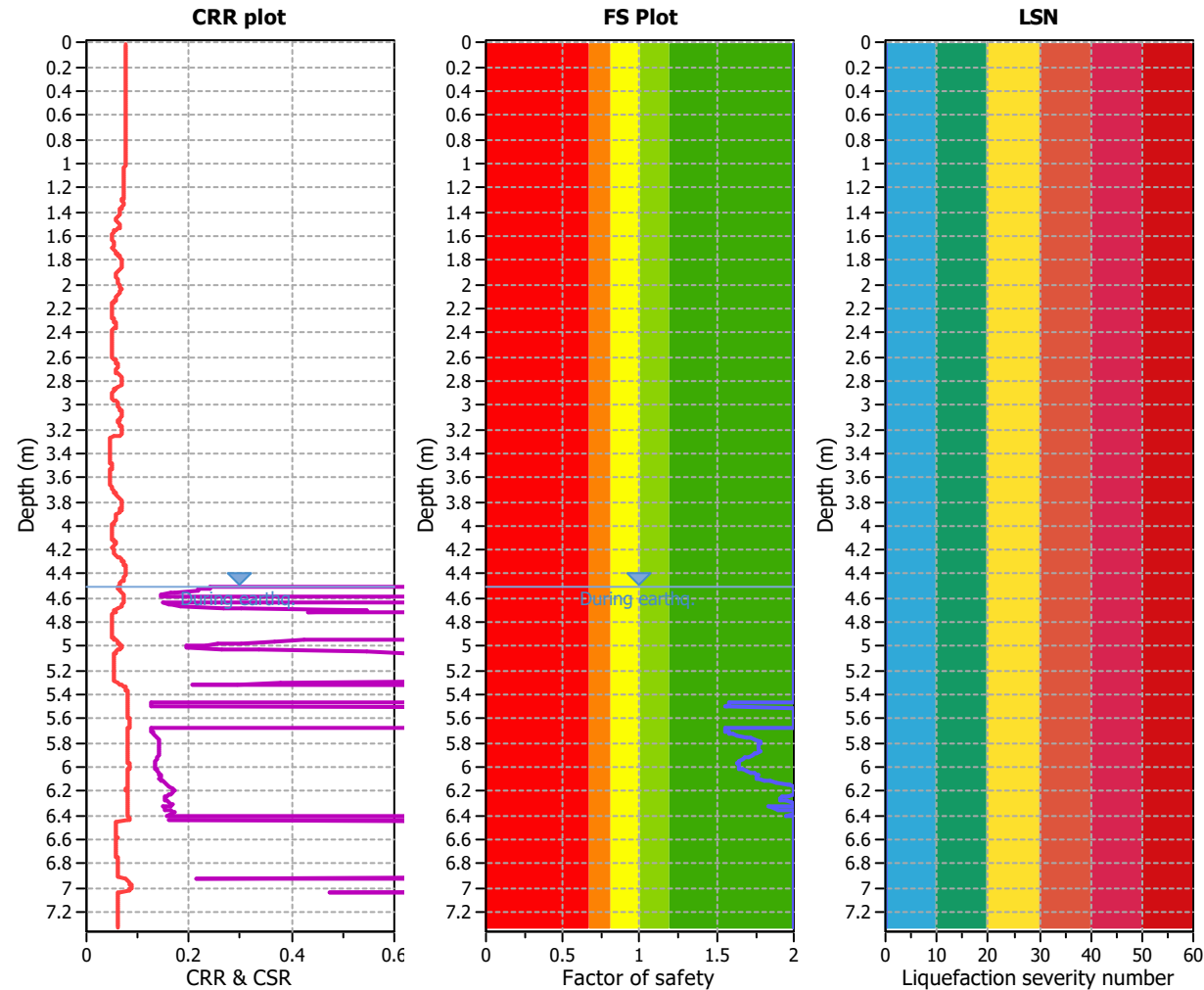
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _o applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

- q_c : 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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT9

LIQUEFACTION ANALYSIS REPORT

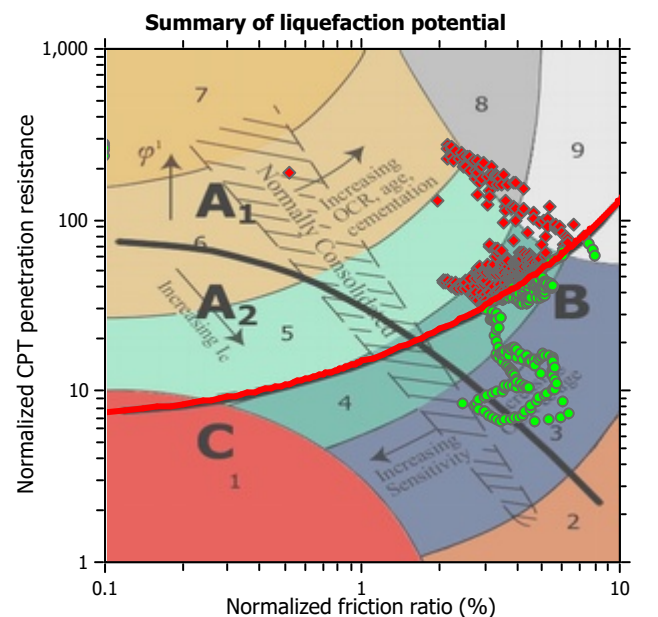
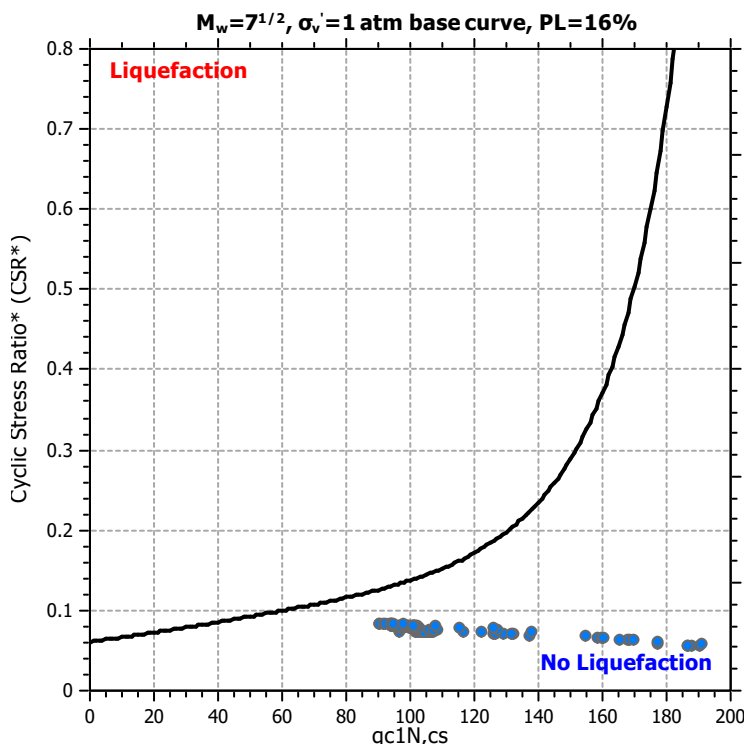
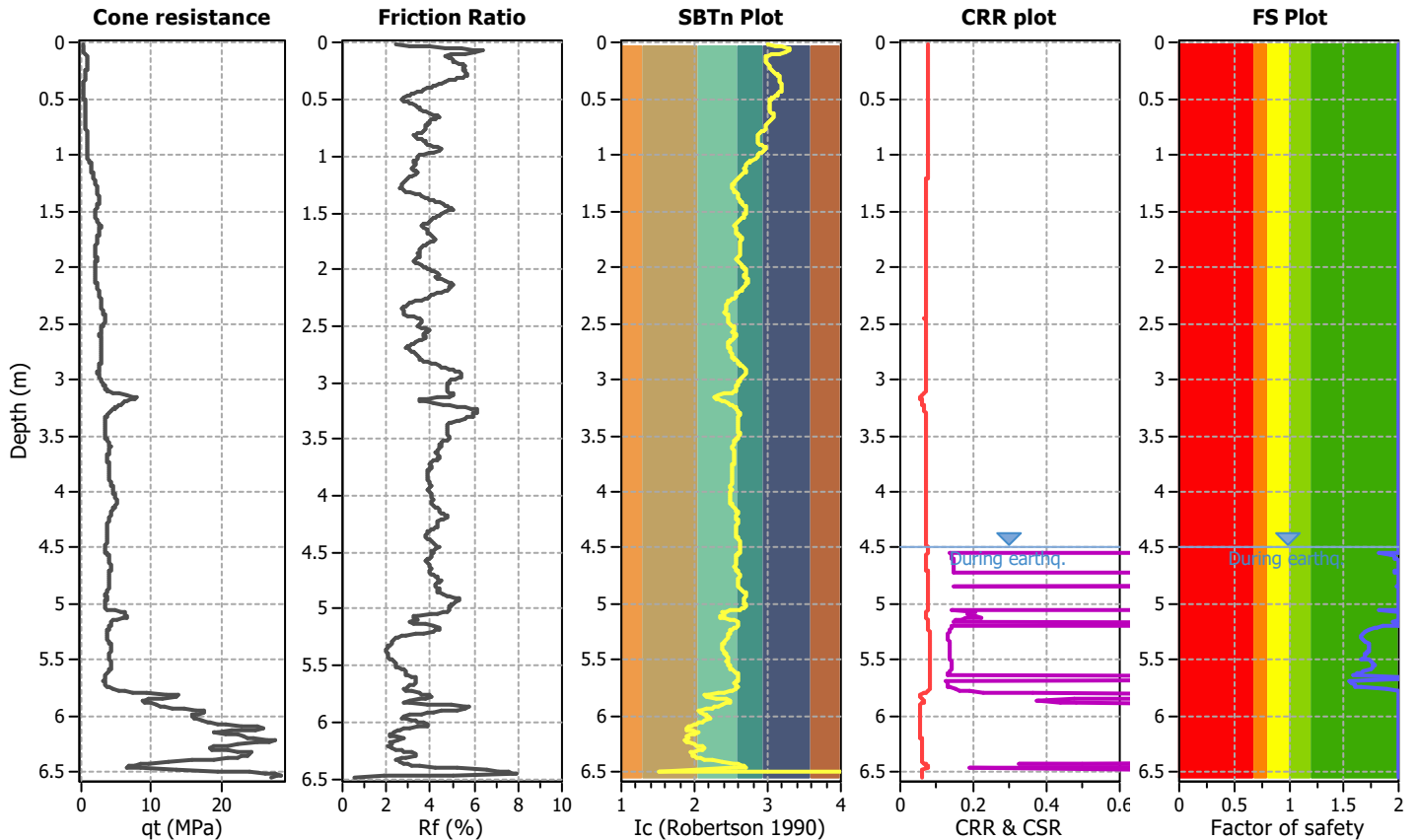
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 9

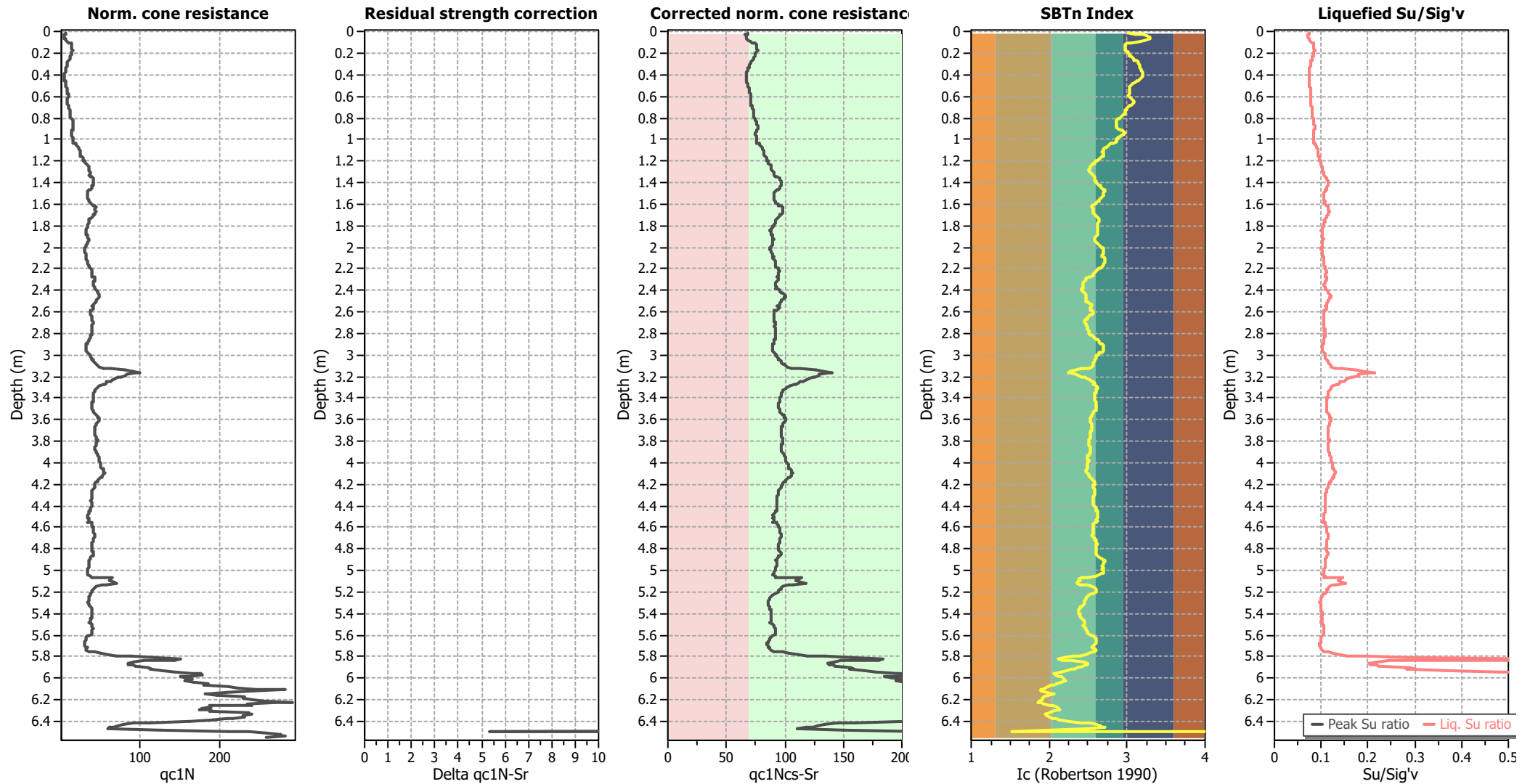
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

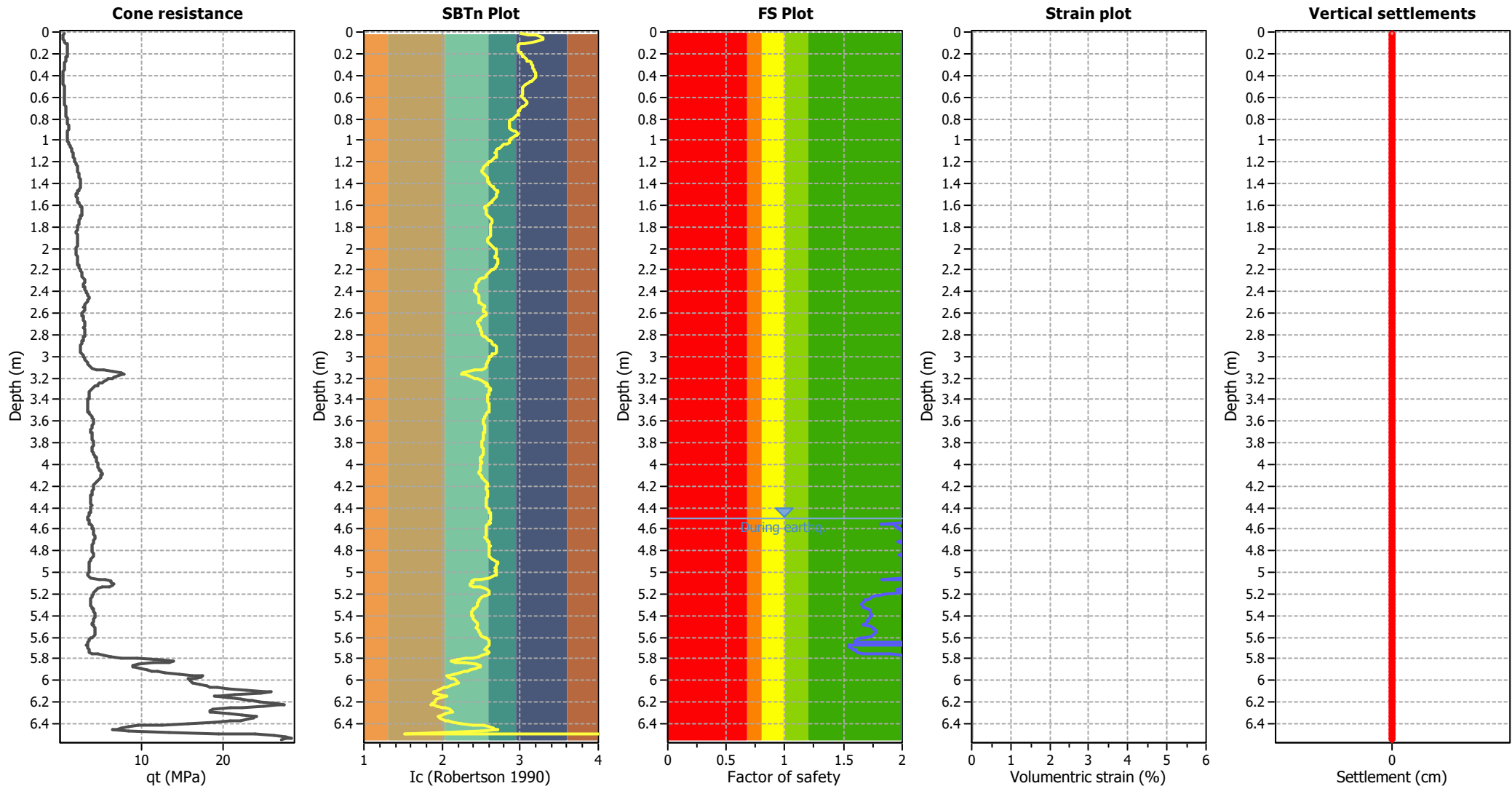
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

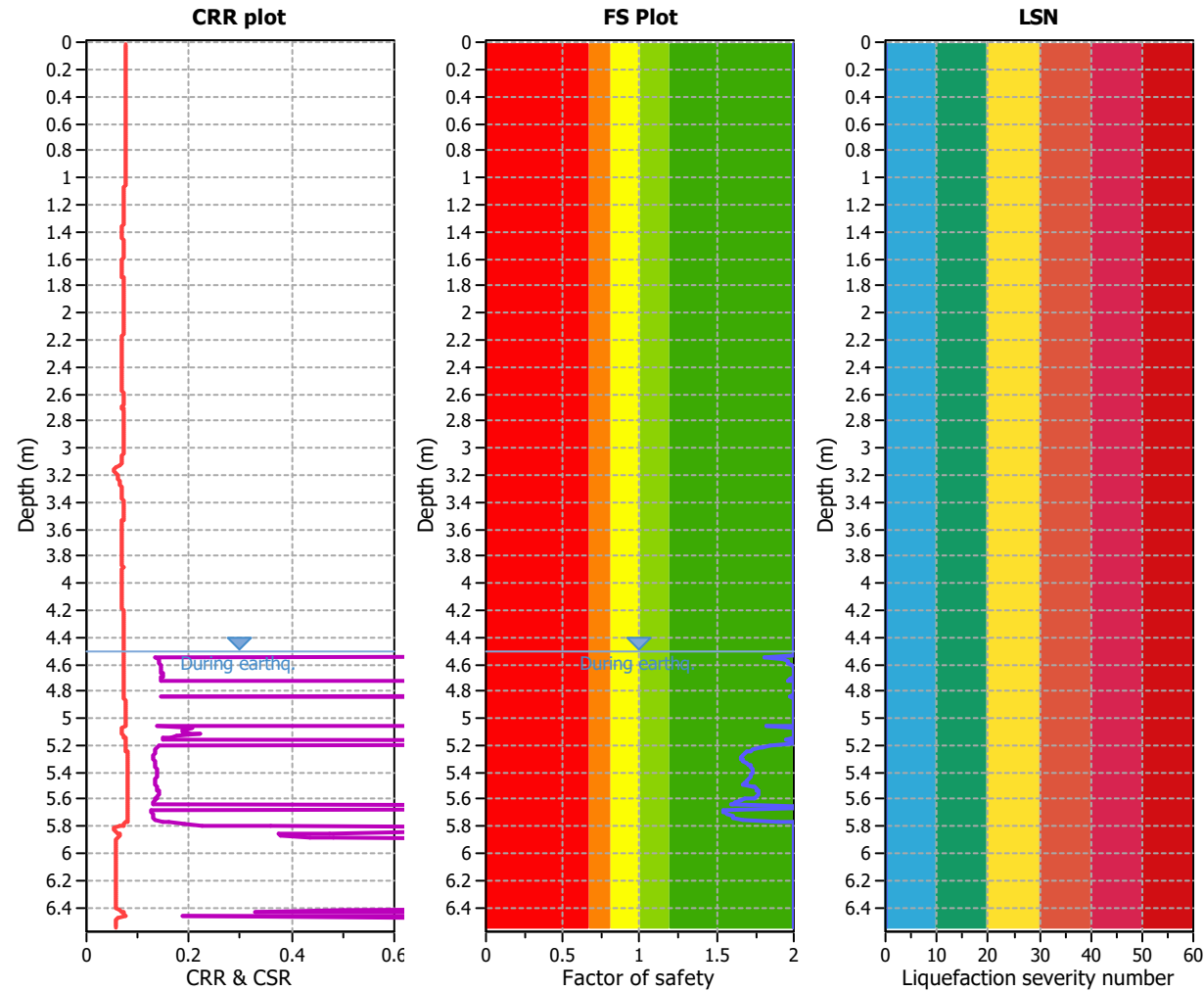
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_g applied:	Yes
Earthquake magnitude M_w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT10

LIQUEFACTION ANALYSIS REPORT

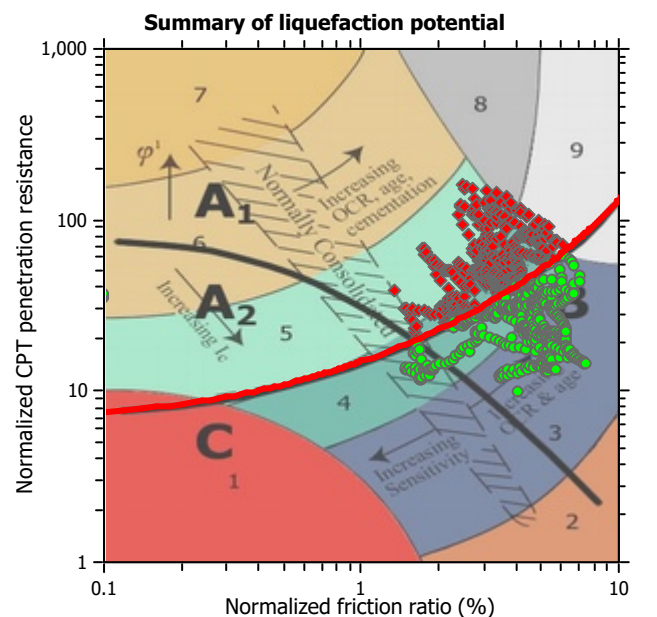
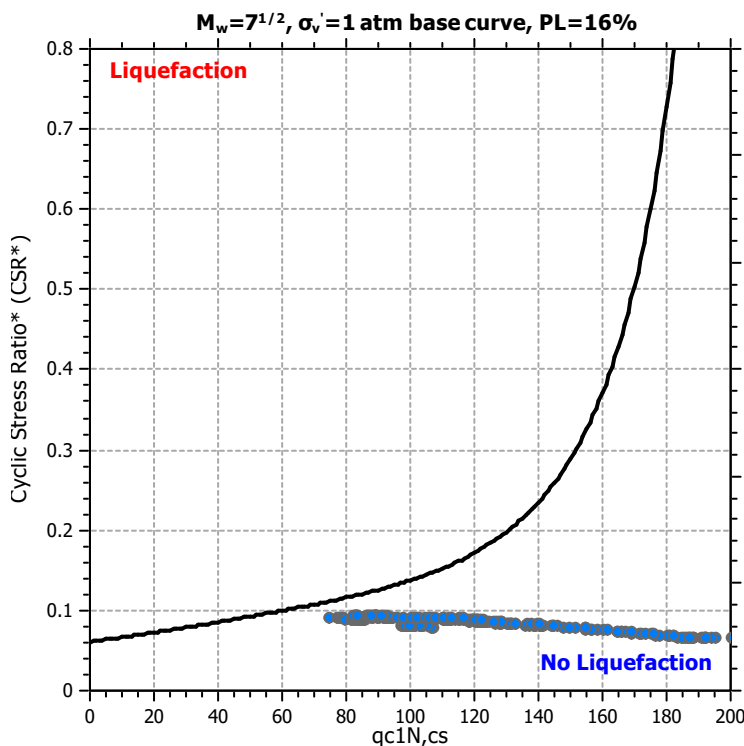
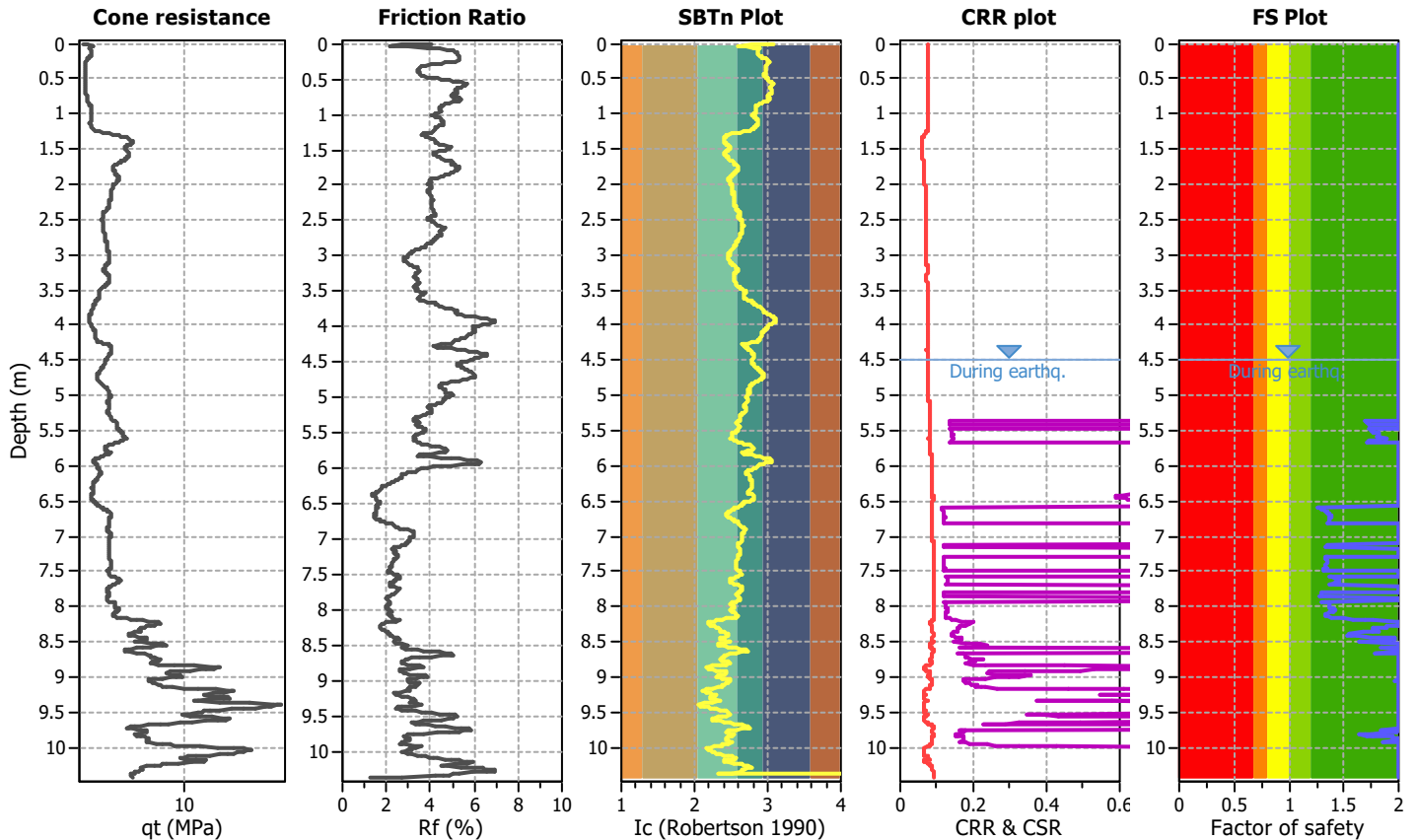
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 10

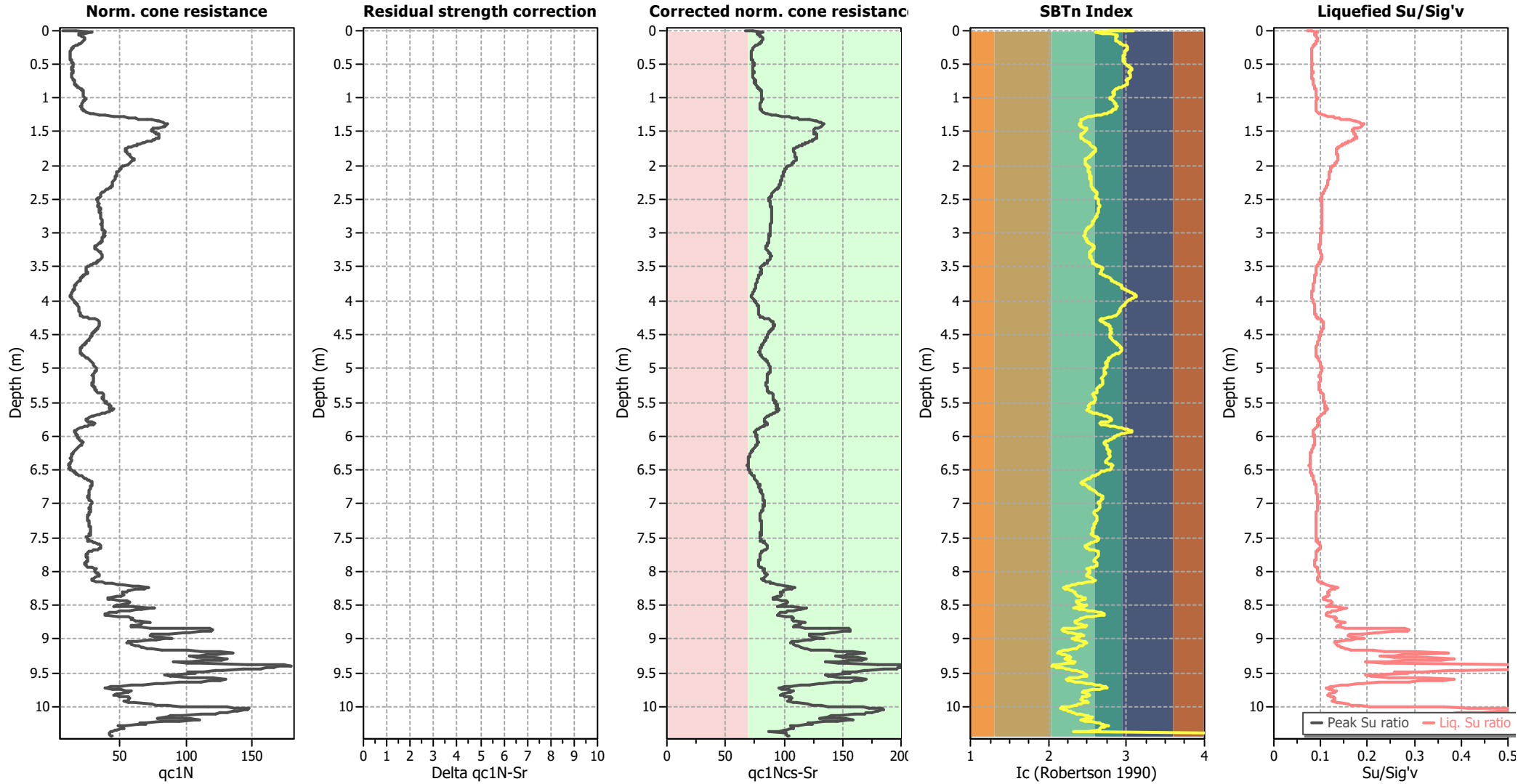
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

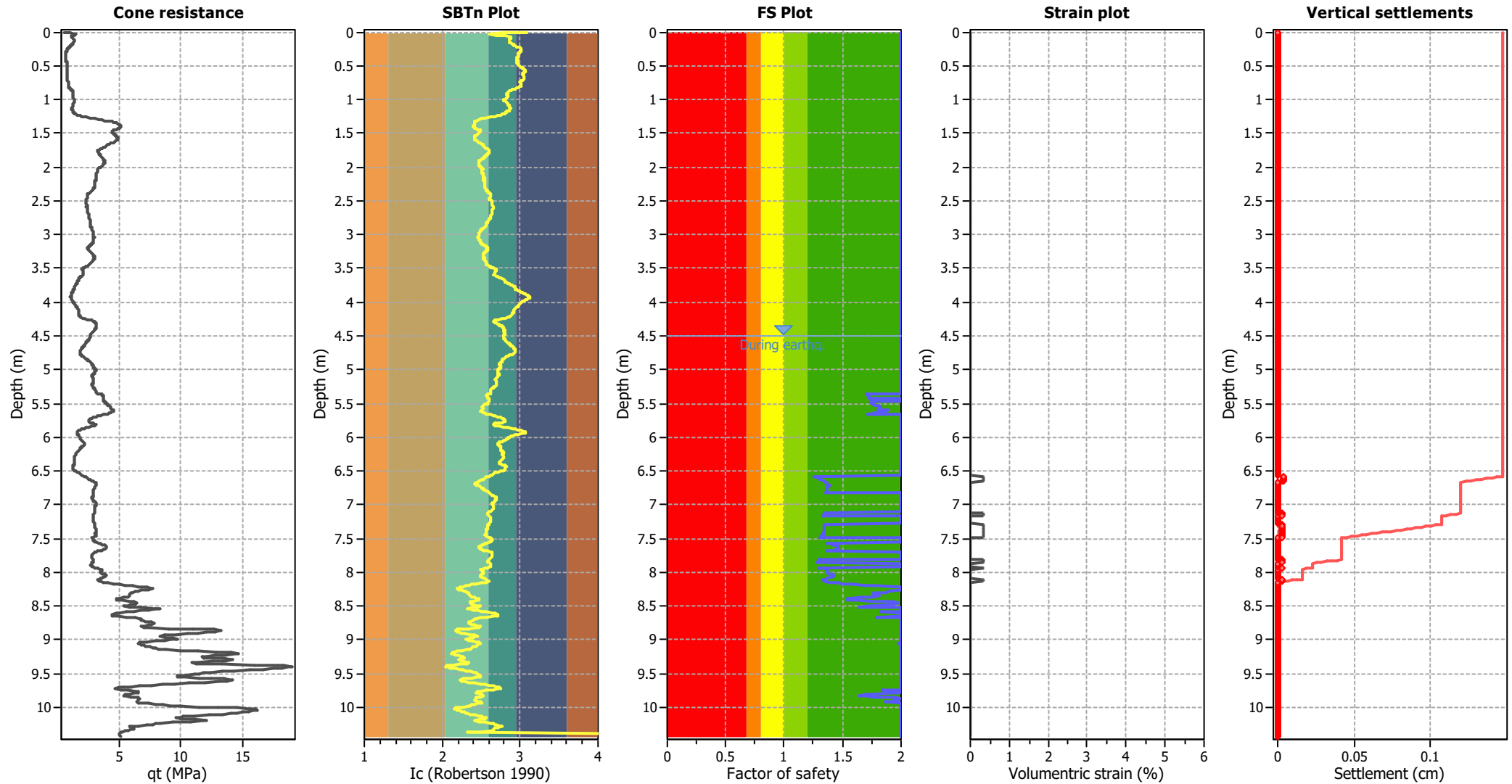
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

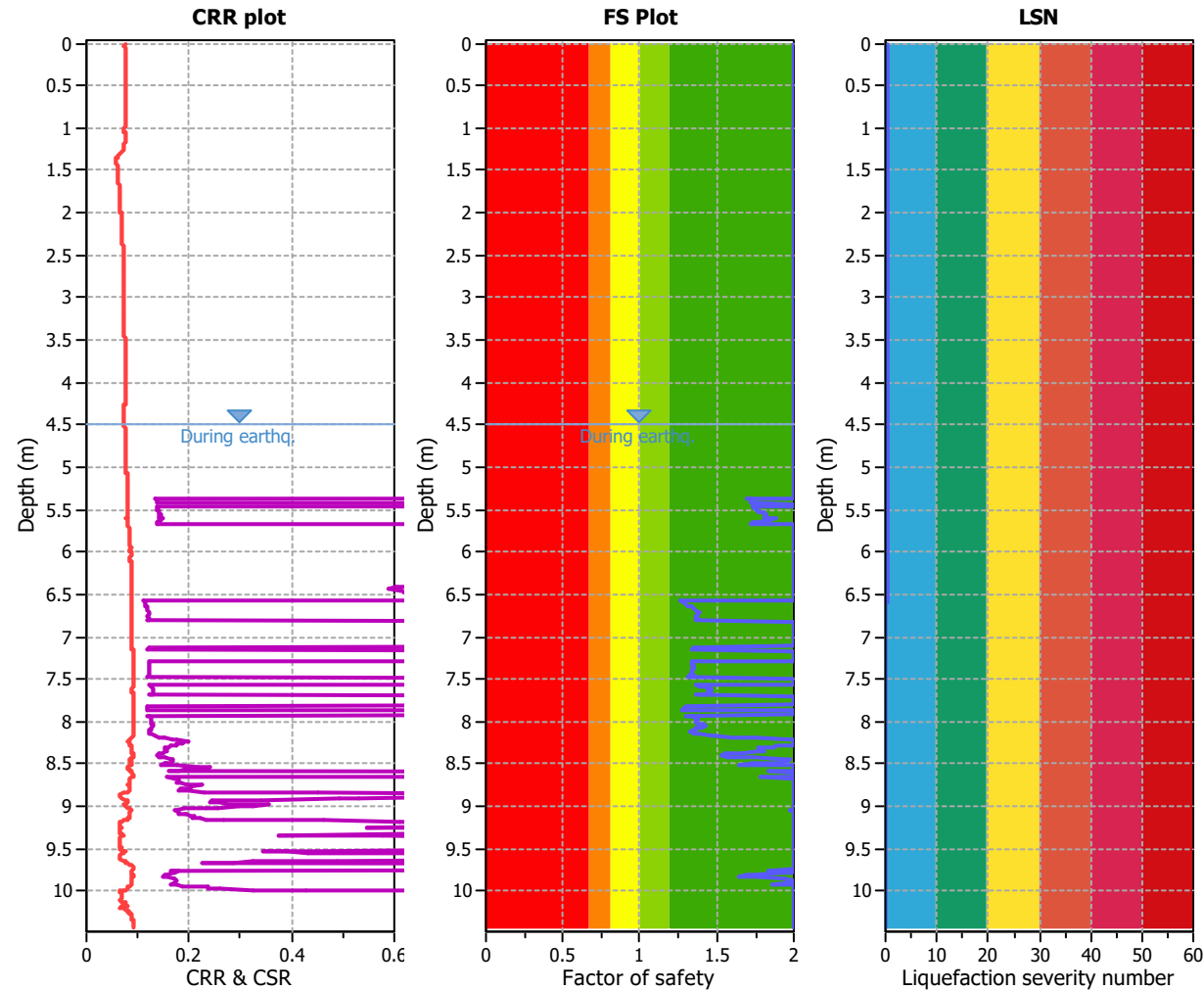
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _o applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

q_c : 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
 Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT11

LIQUEFACTION ANALYSIS REPORT

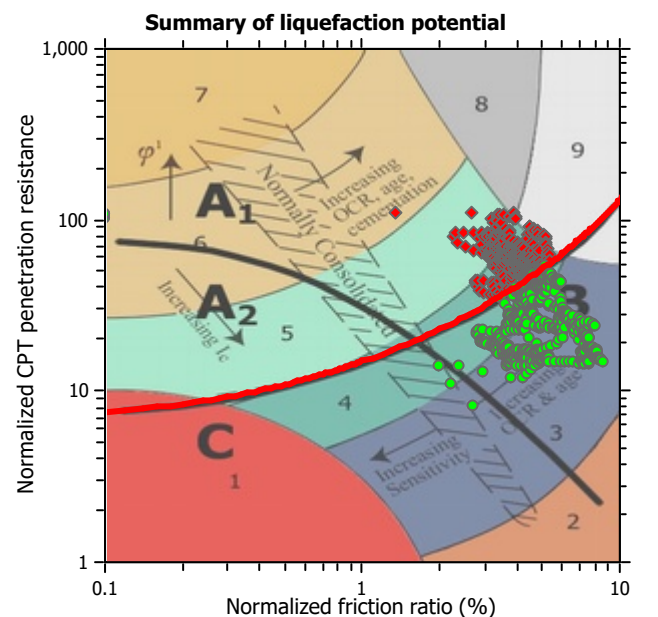
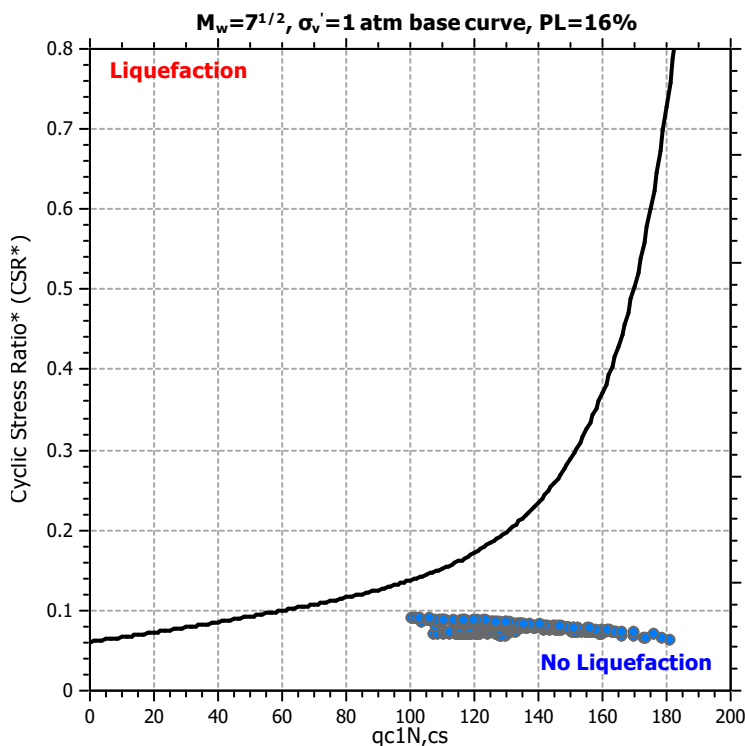
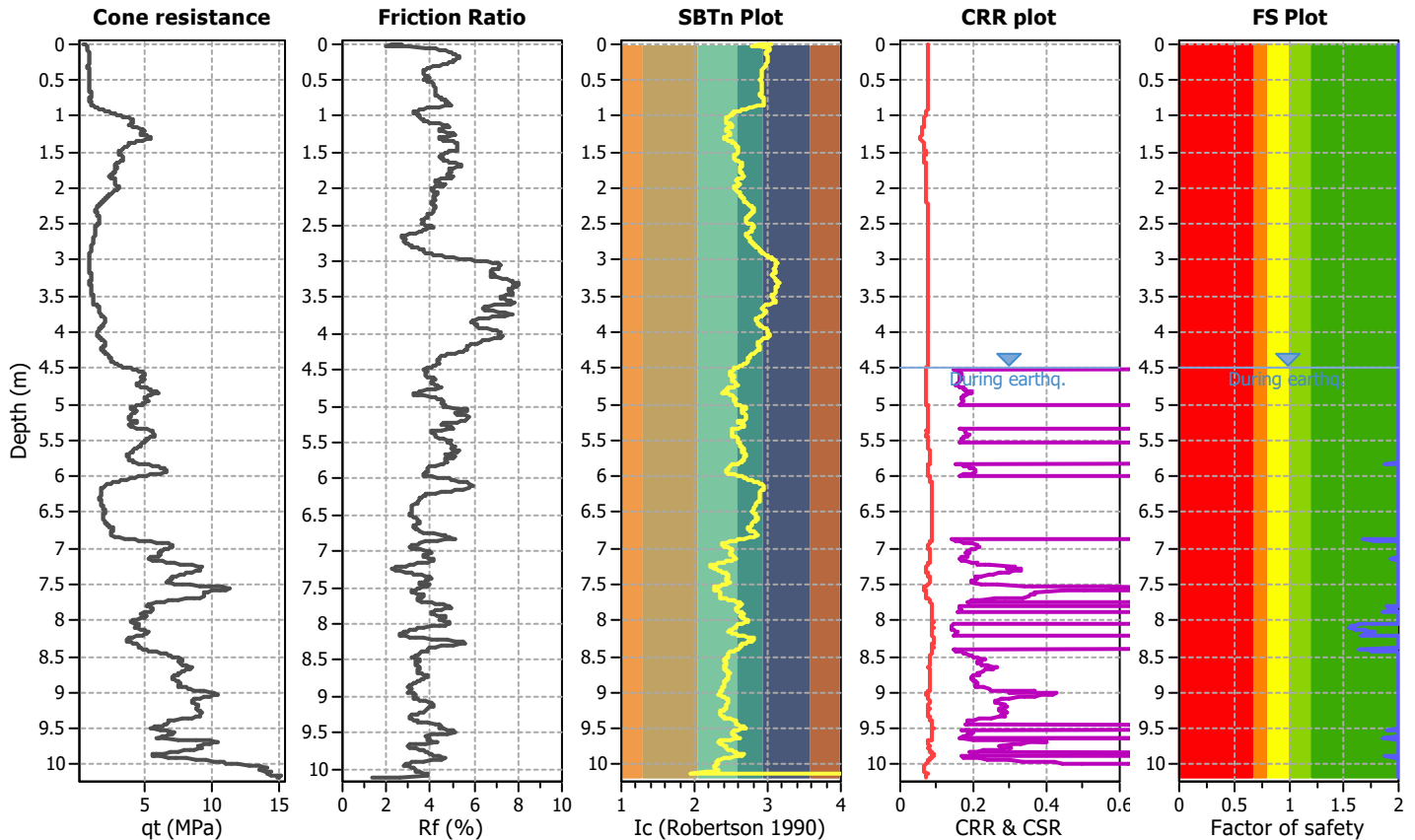
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 11

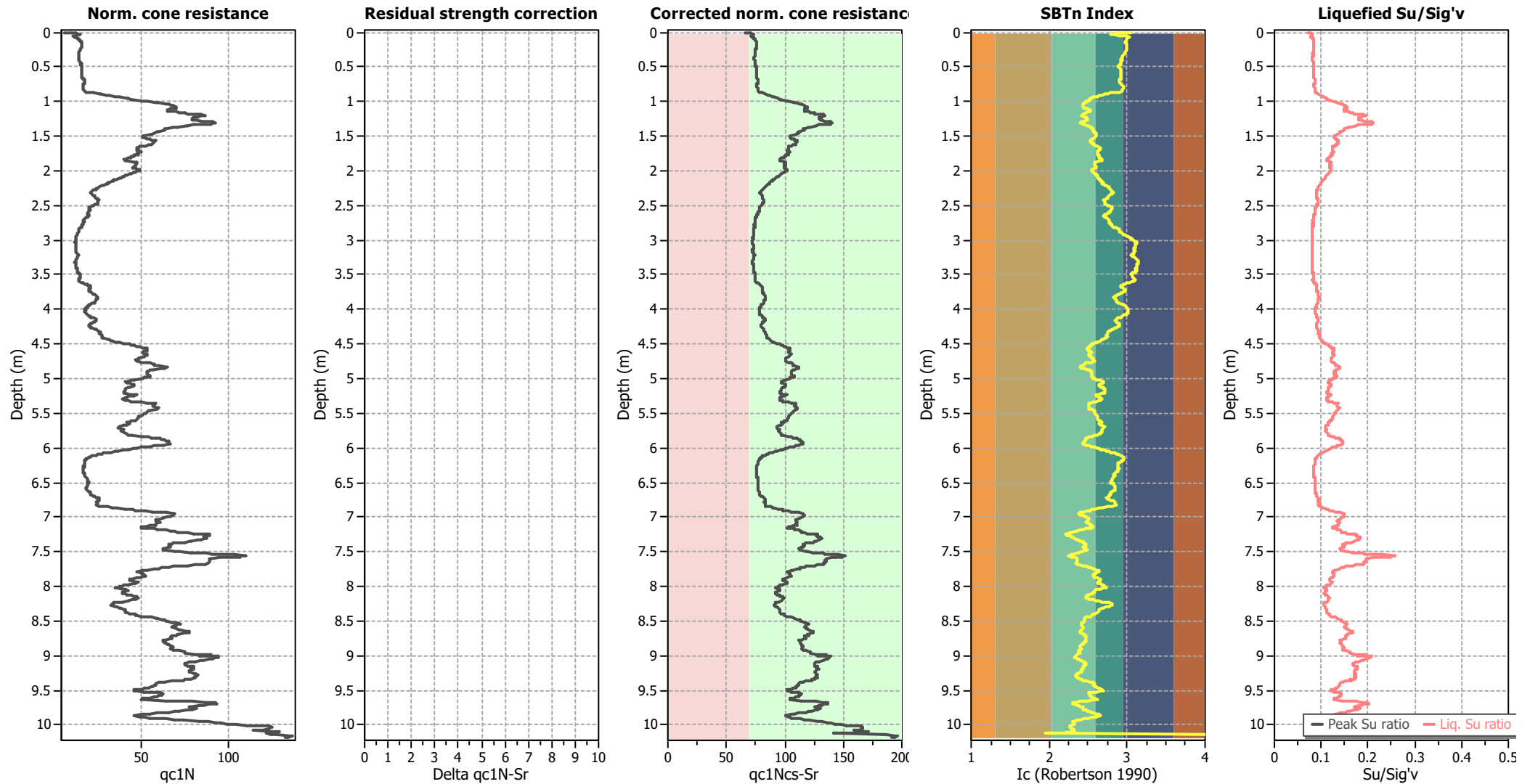
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

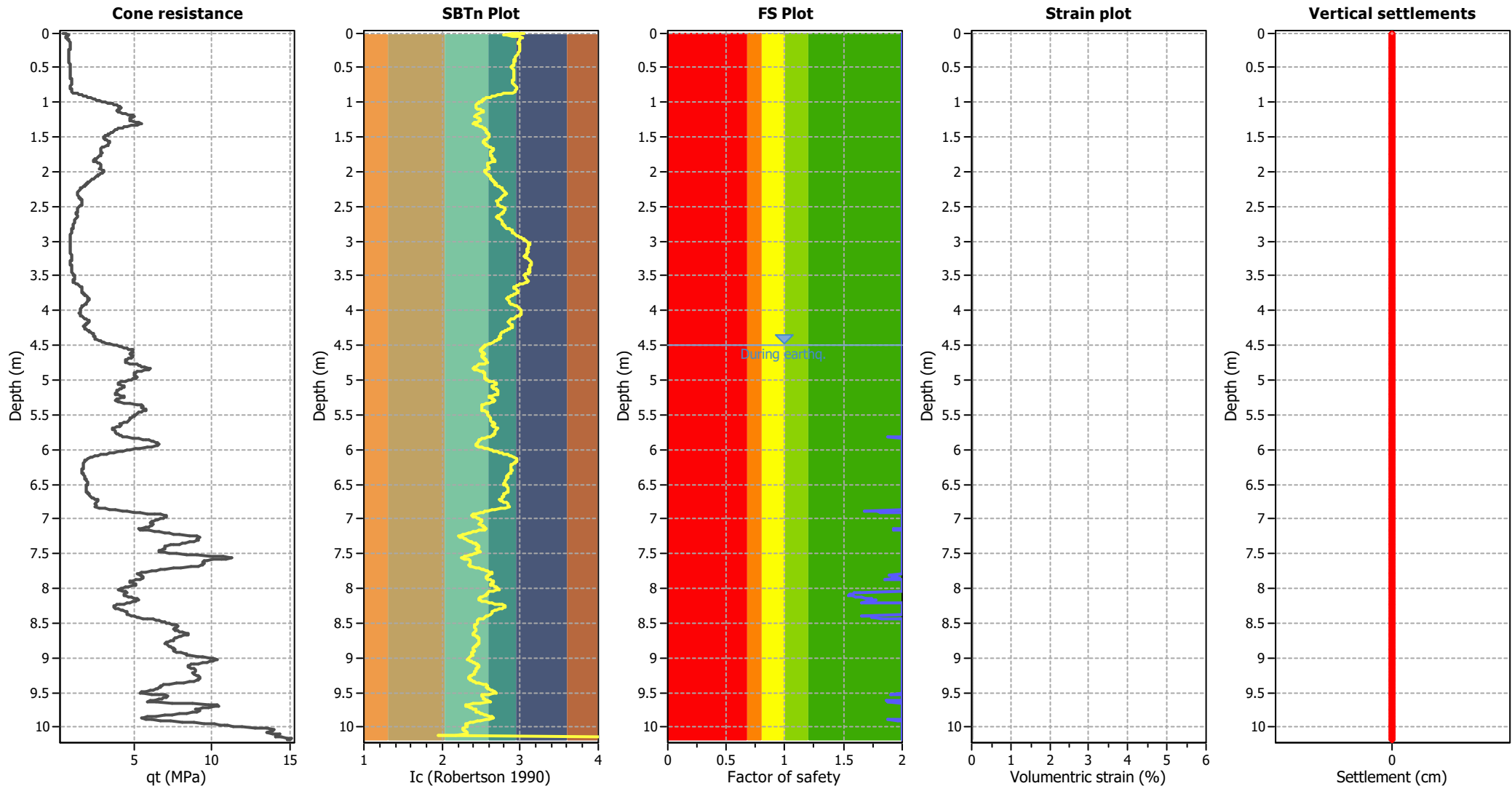
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

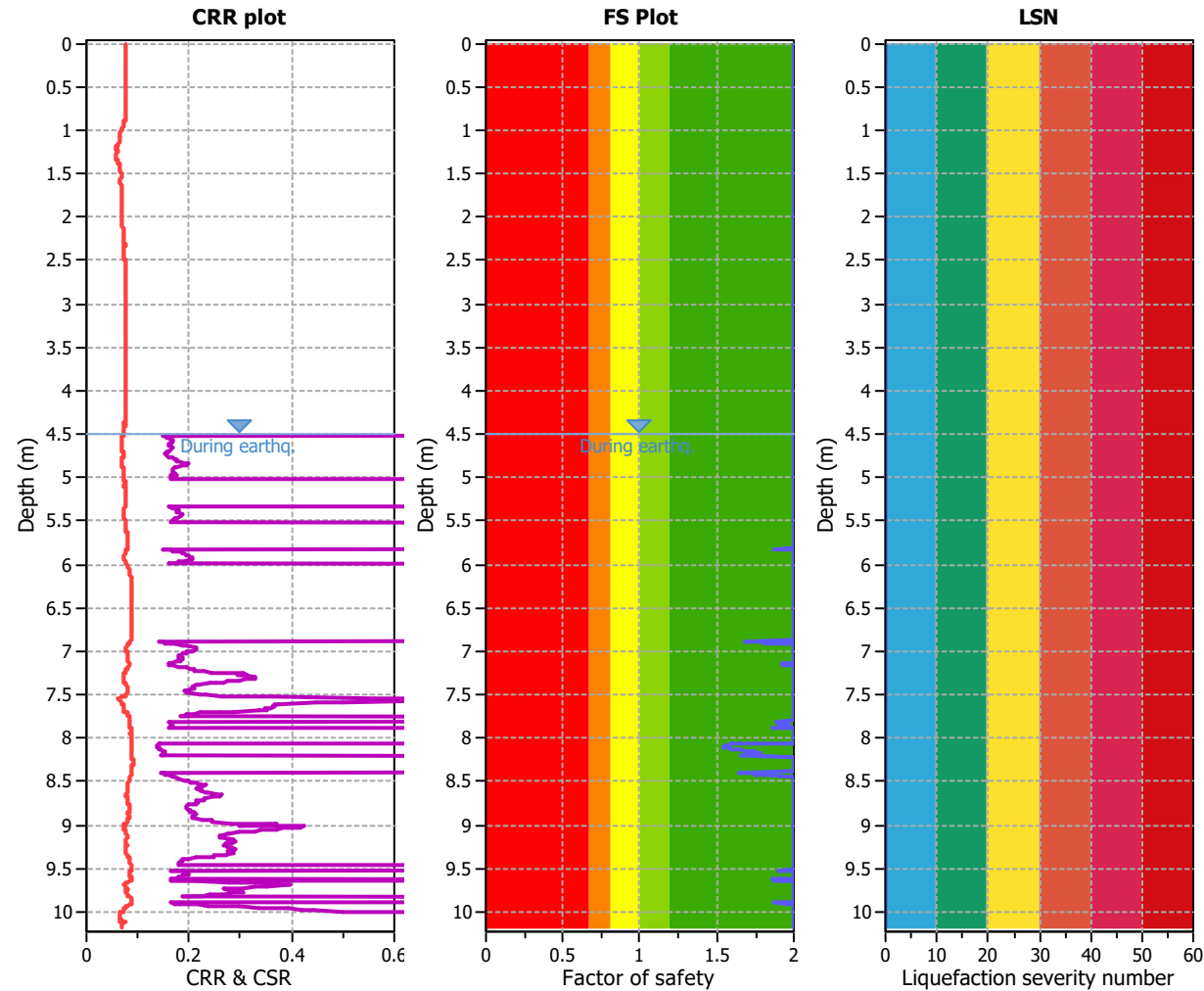
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

- q_c: 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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT12

LIQUEFACTION ANALYSIS REPORT

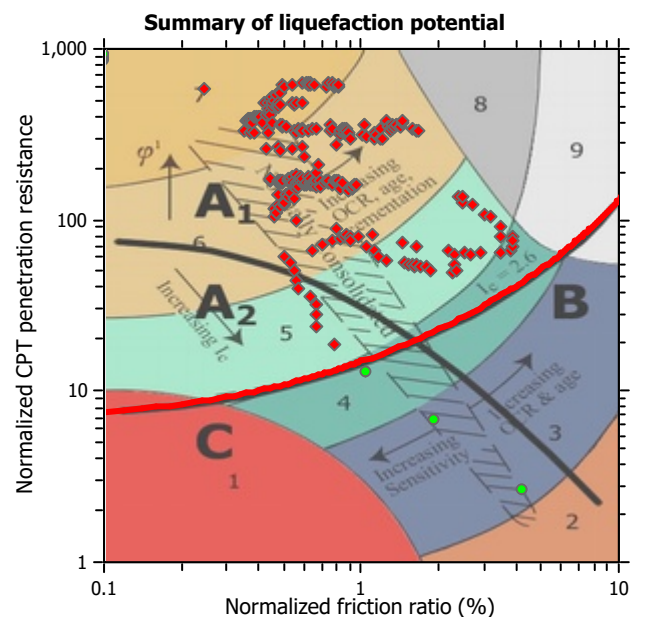
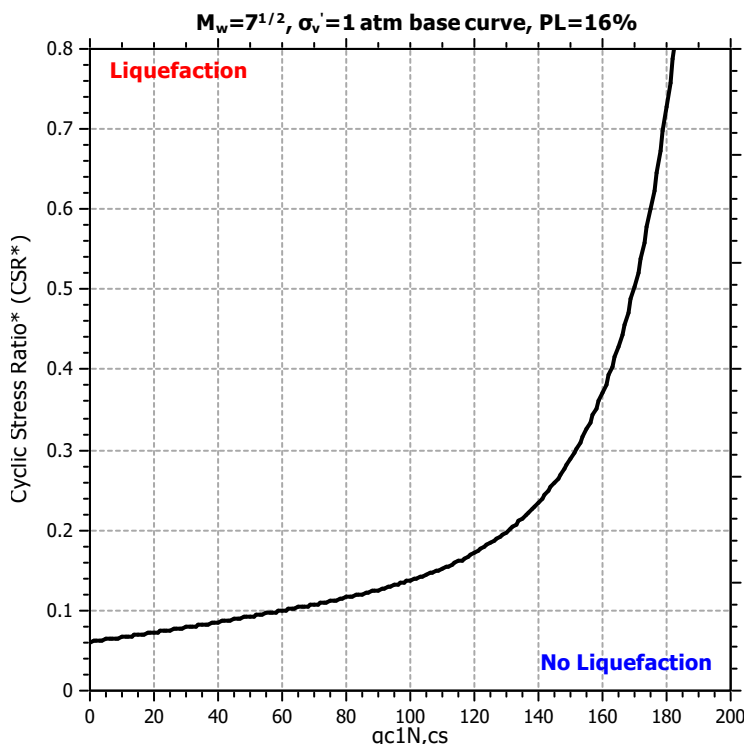
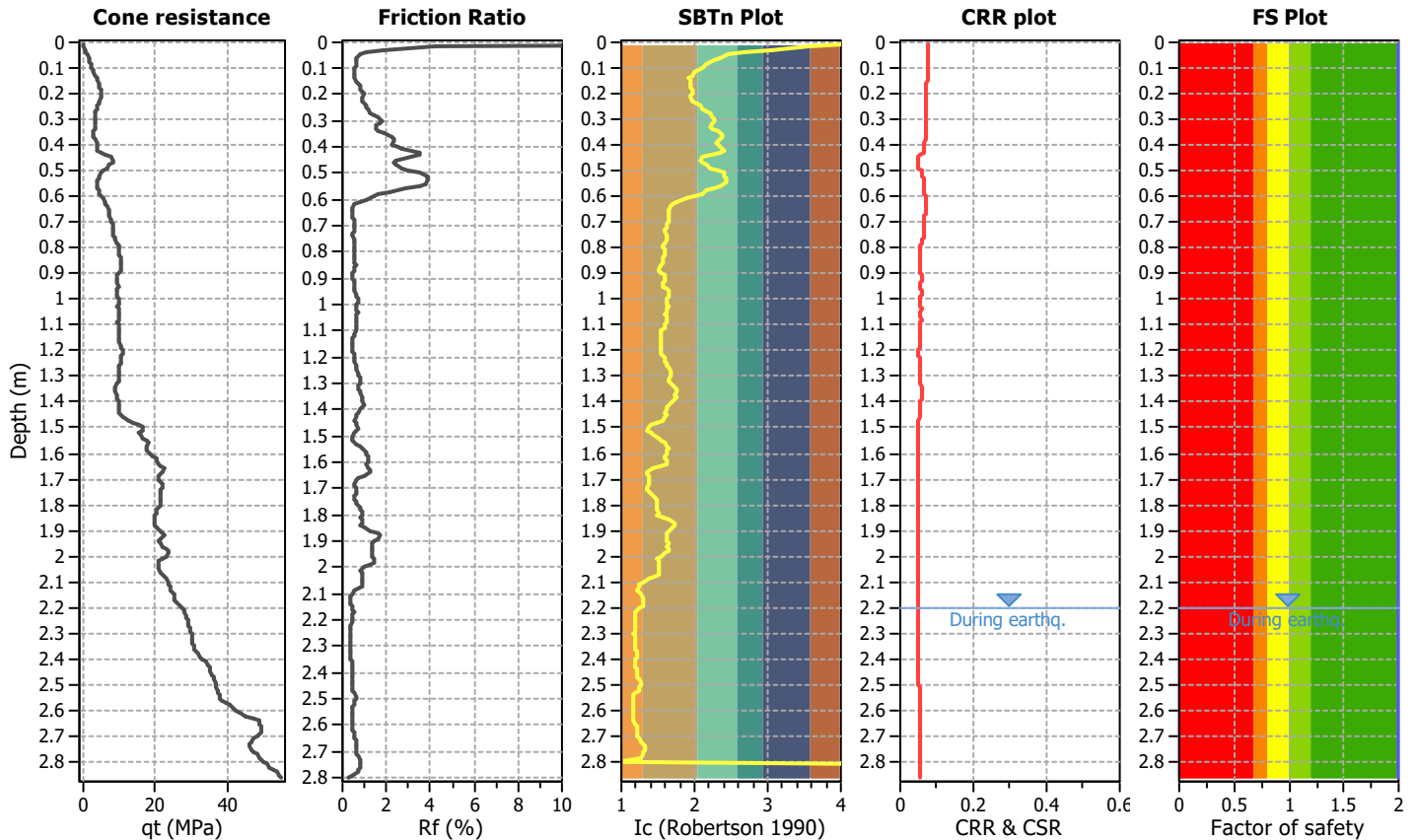
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 12

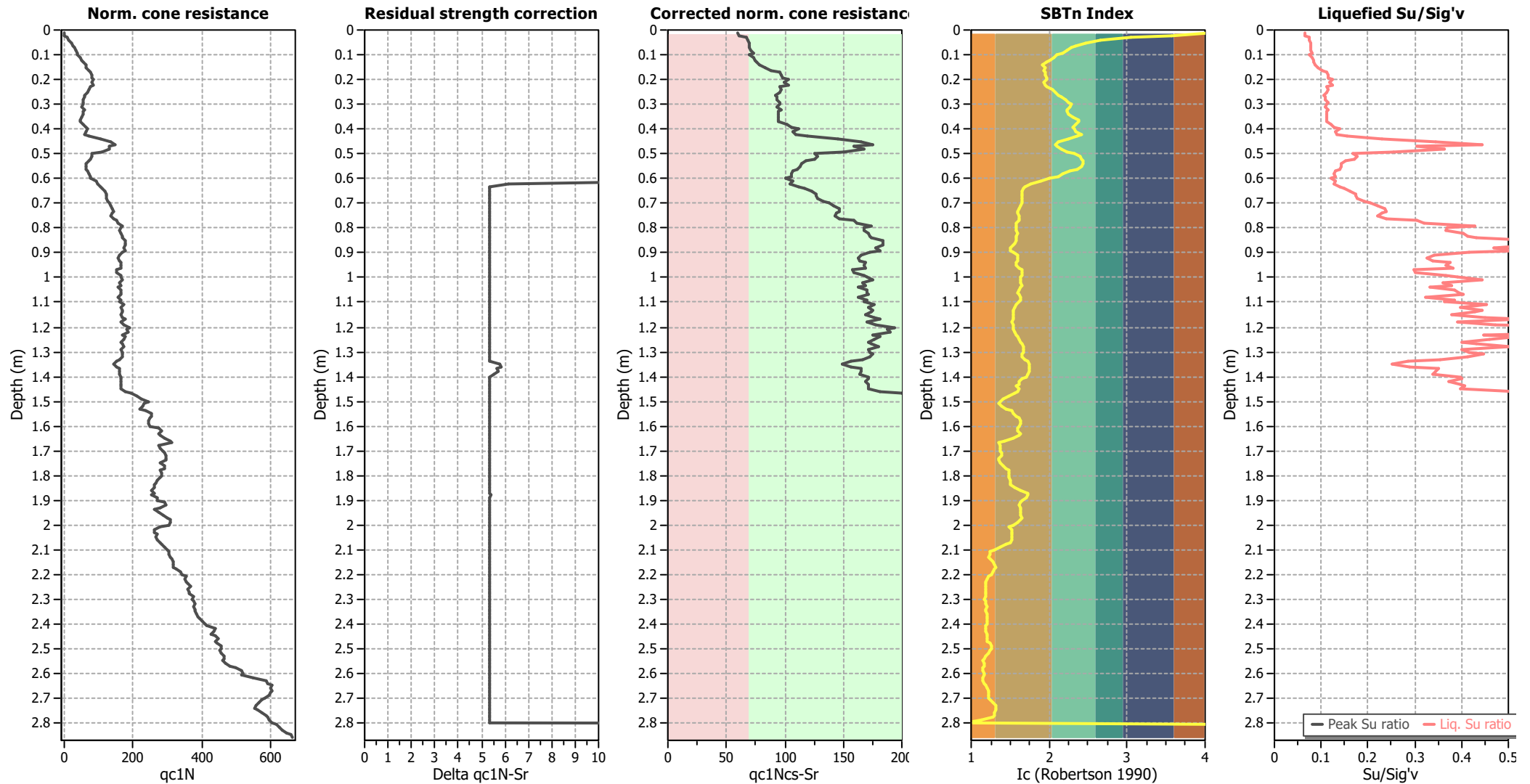
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

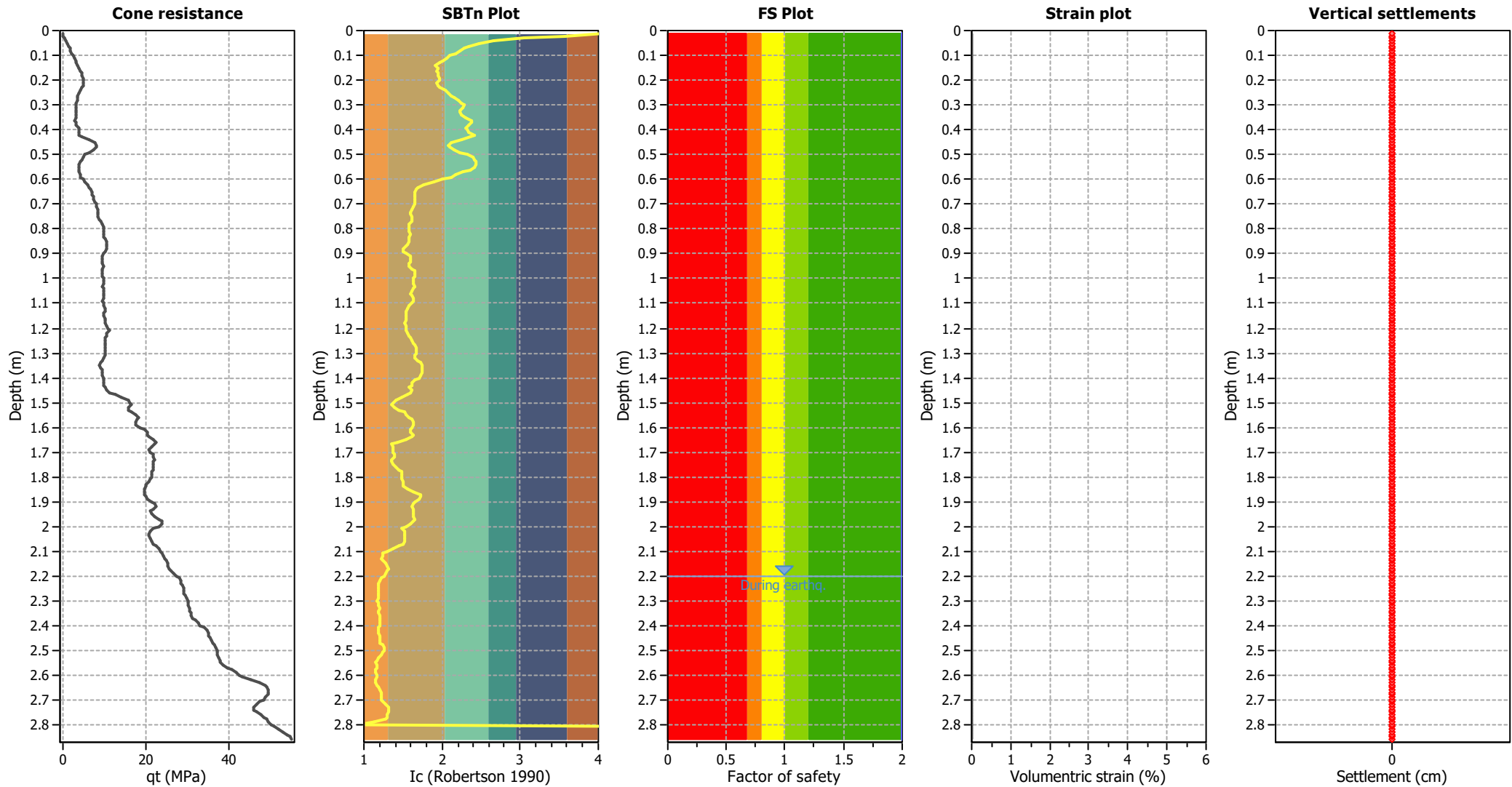
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

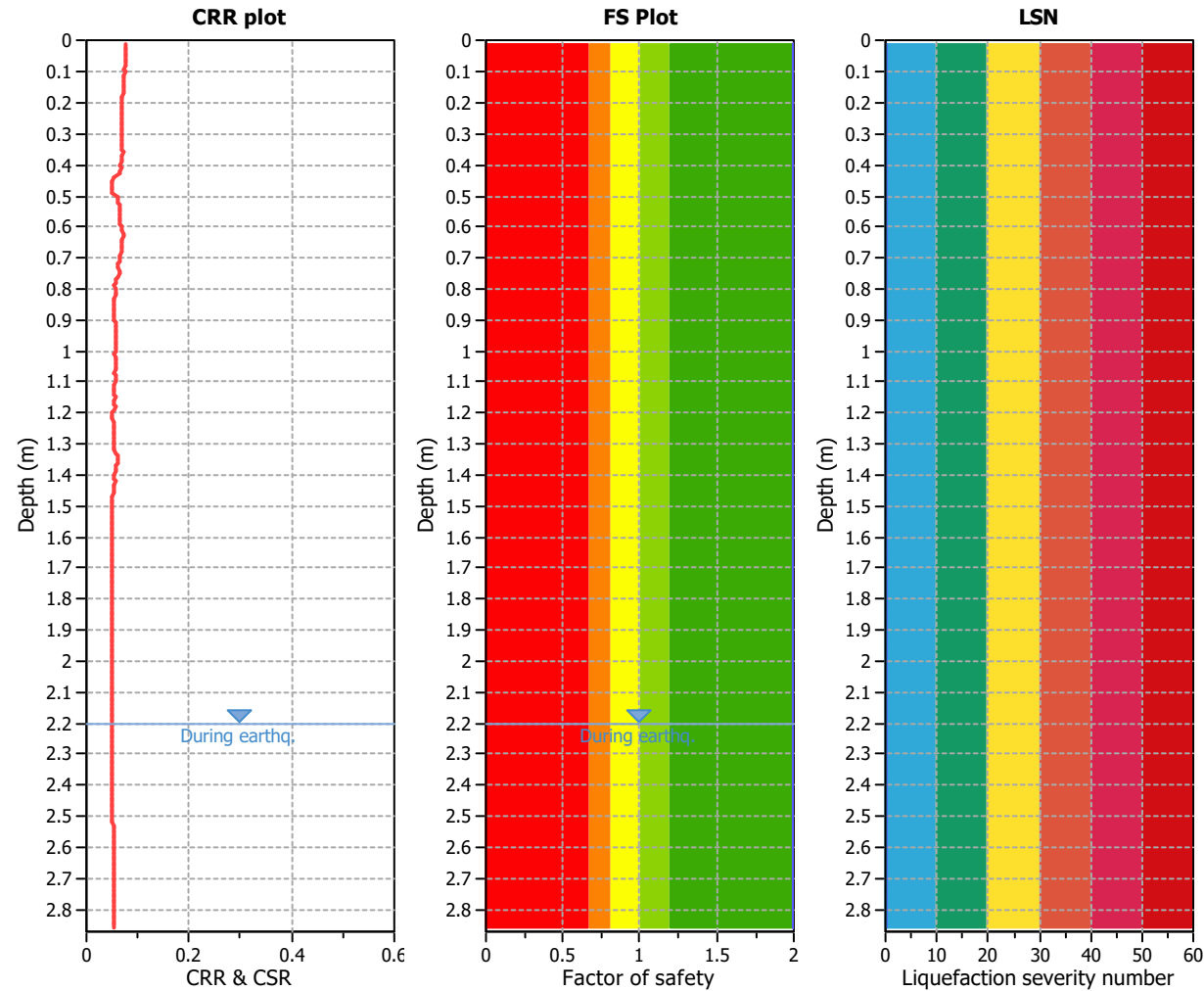
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.20 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_0 applied:	Yes
Earthquake magnitude M_w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.20 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

- q_c : 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
- Volumetric strain: Post-liquefaction volumetric strain



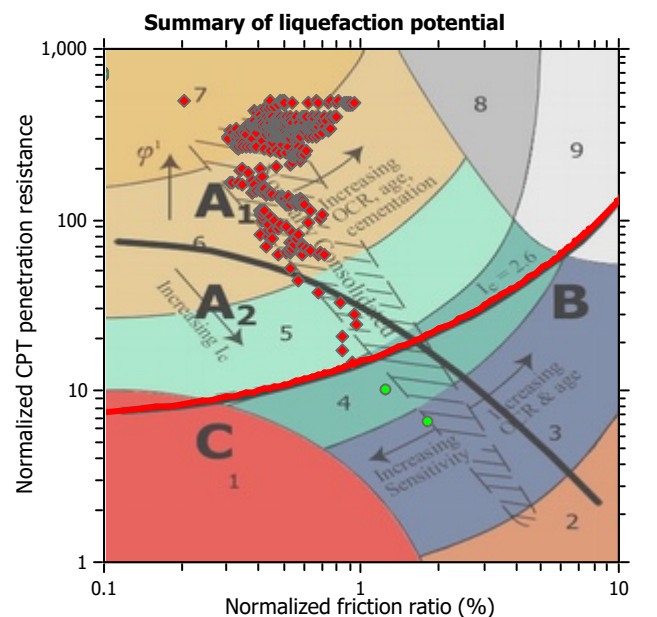
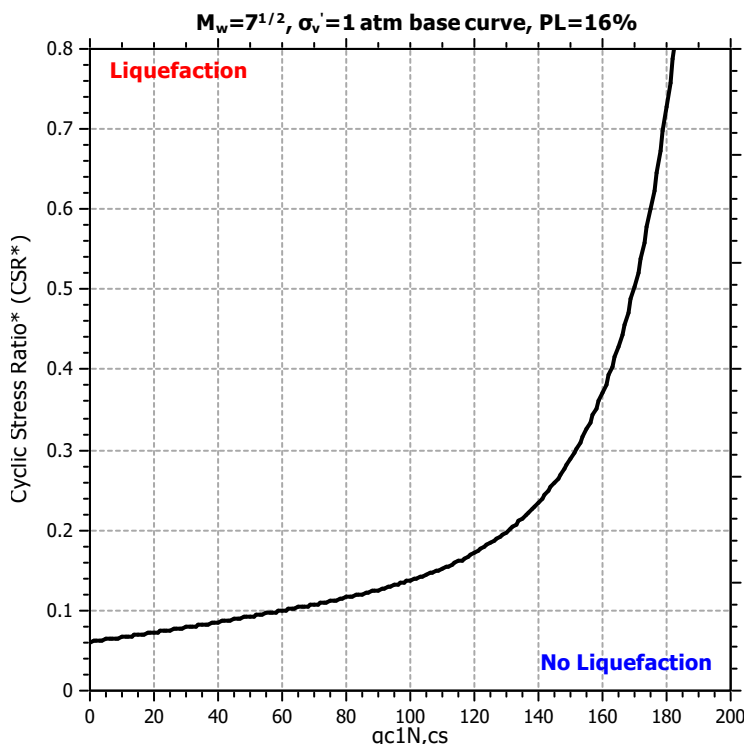
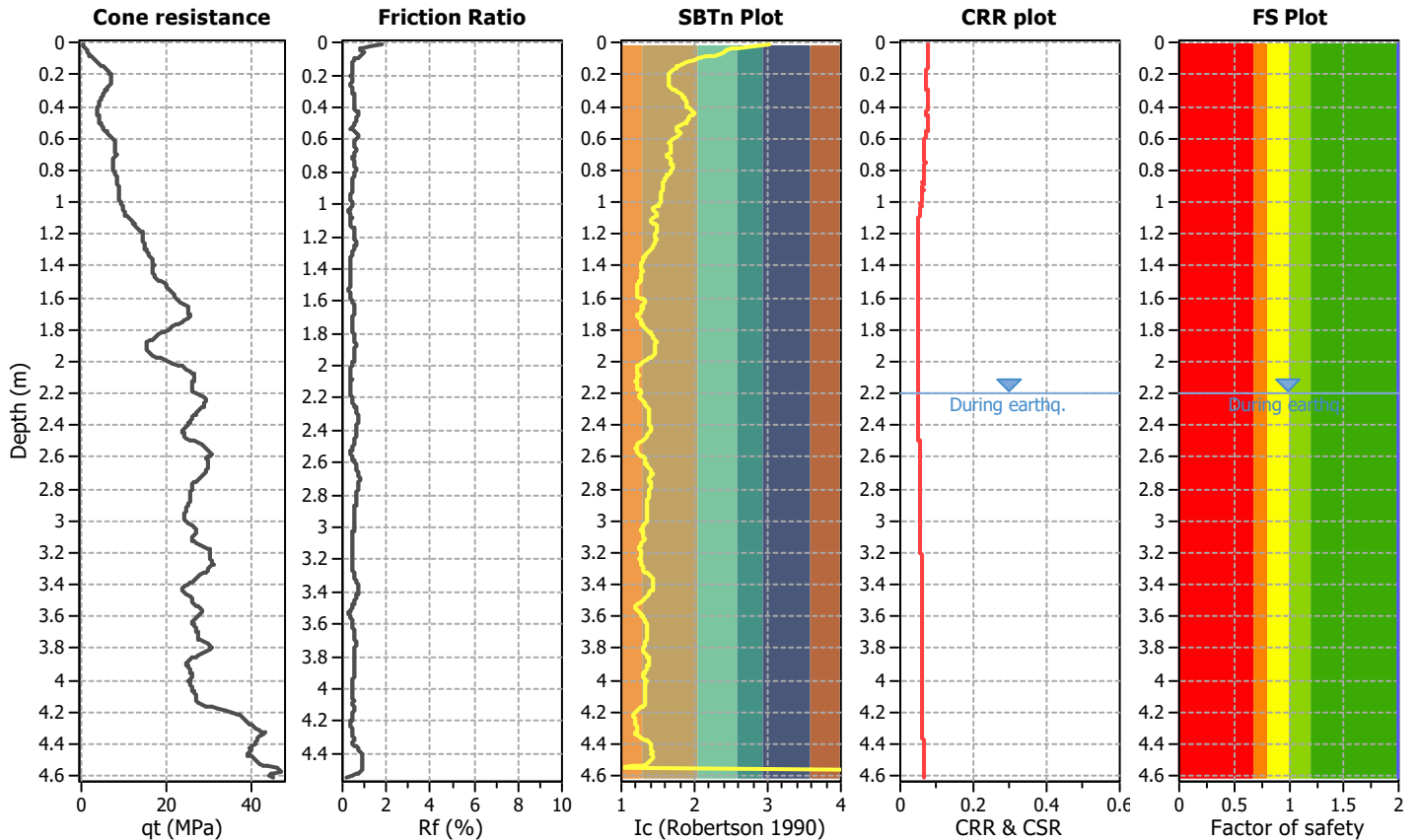
Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT13

LIQUEFACTION ANALYSIS REPORT

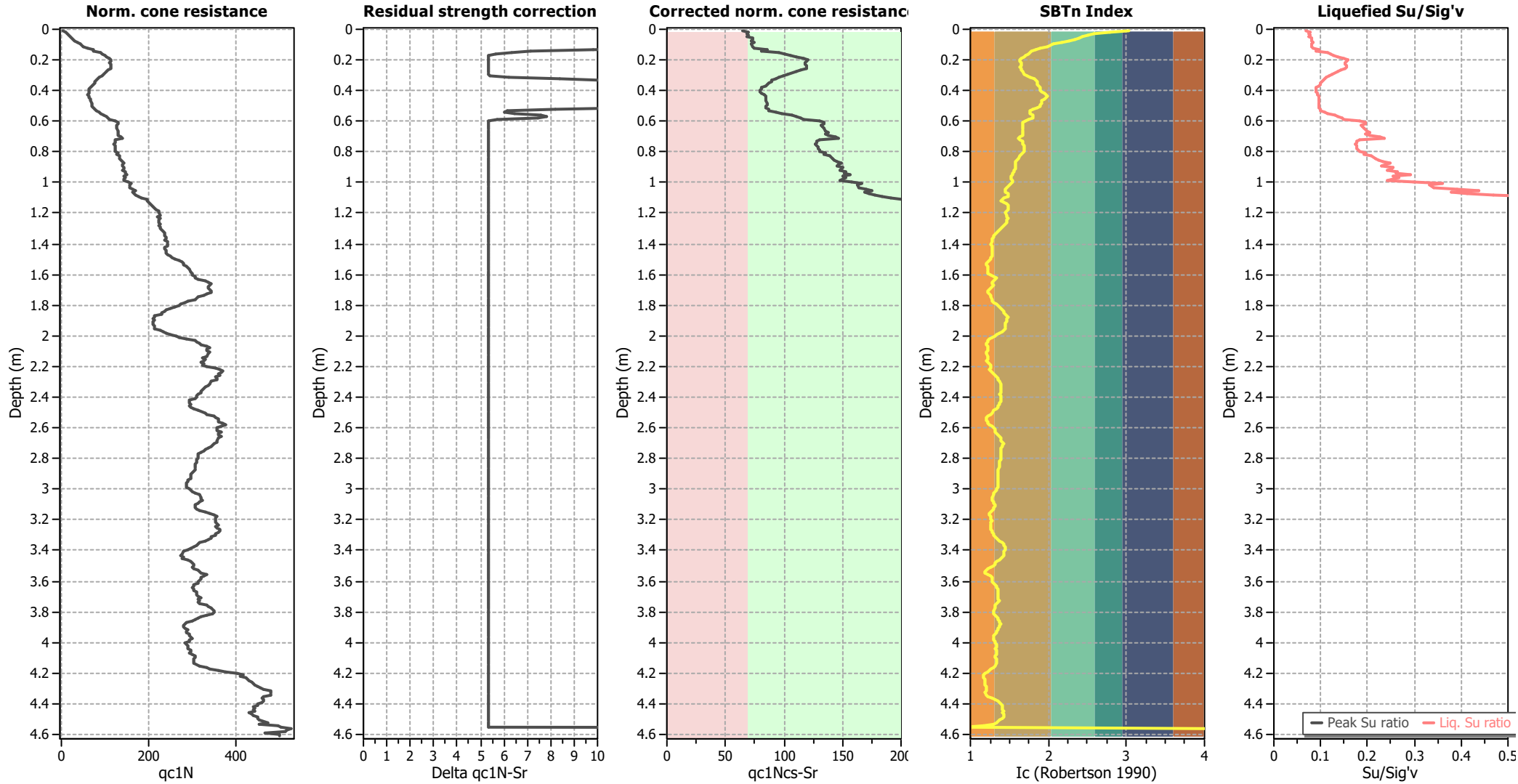
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 13
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

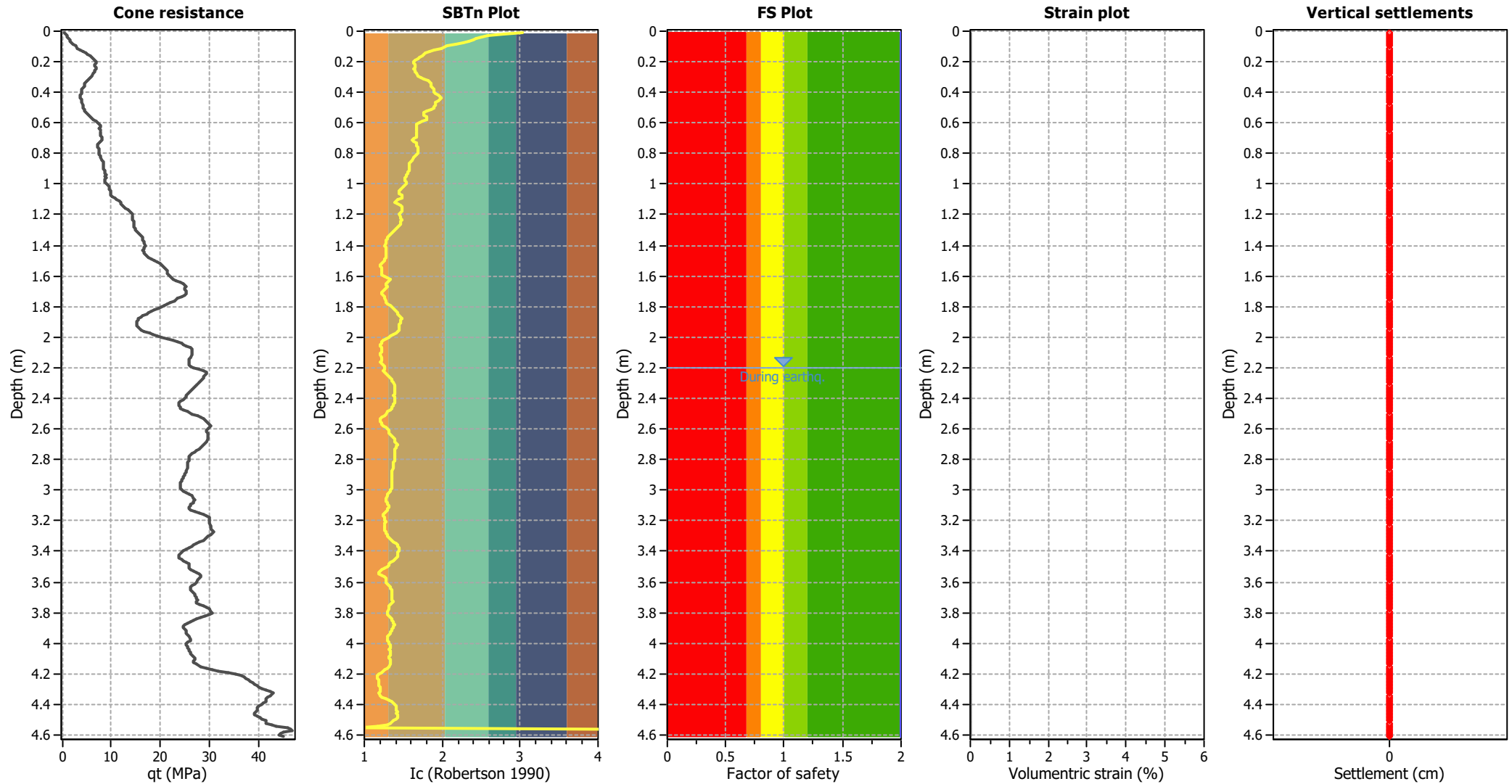
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

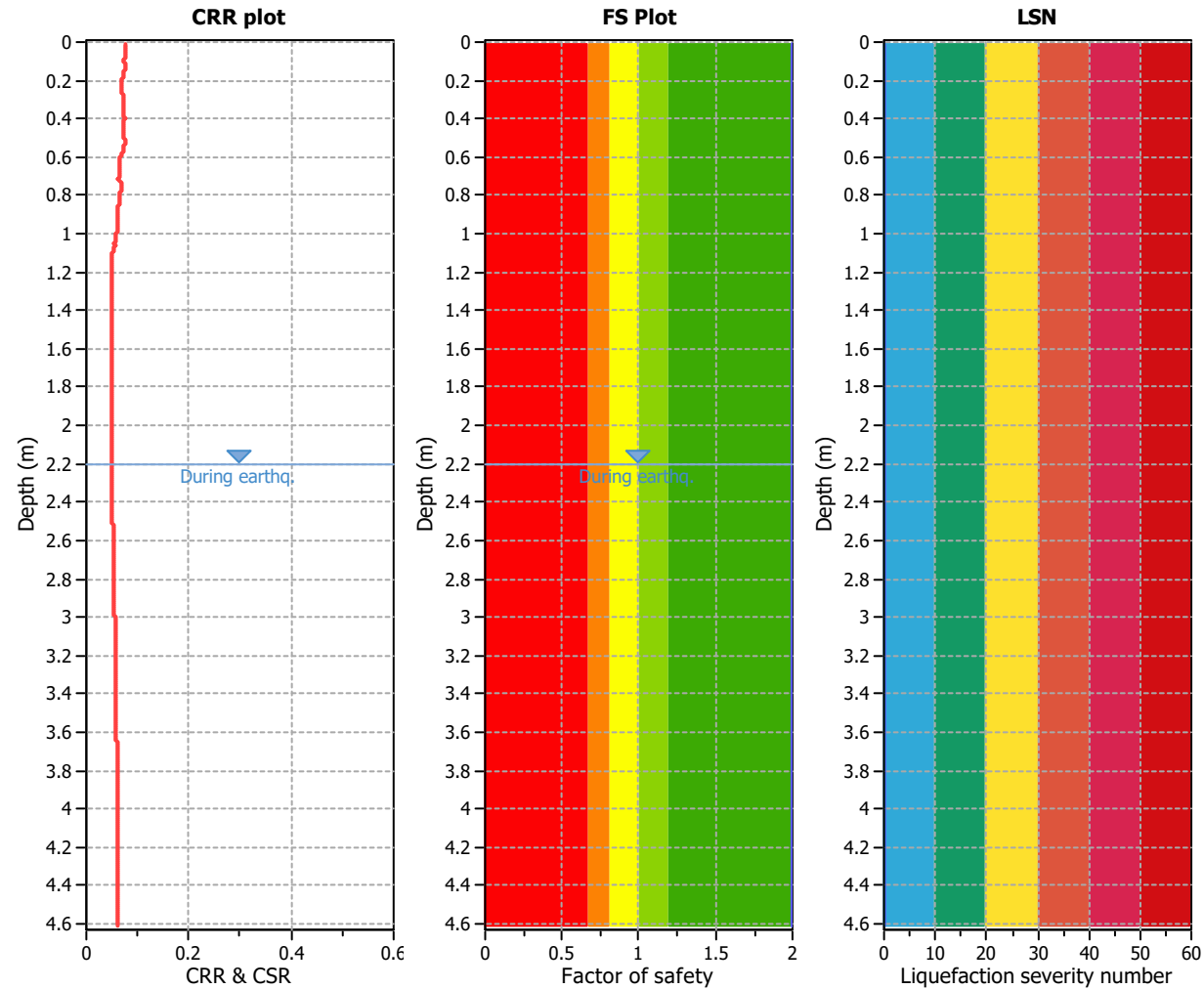
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.20 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _o applied:	Yes
Earthquake magnitude M _w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.20 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

q_c : 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
 Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT14

LIQUEFACTION ANALYSIS REPORT

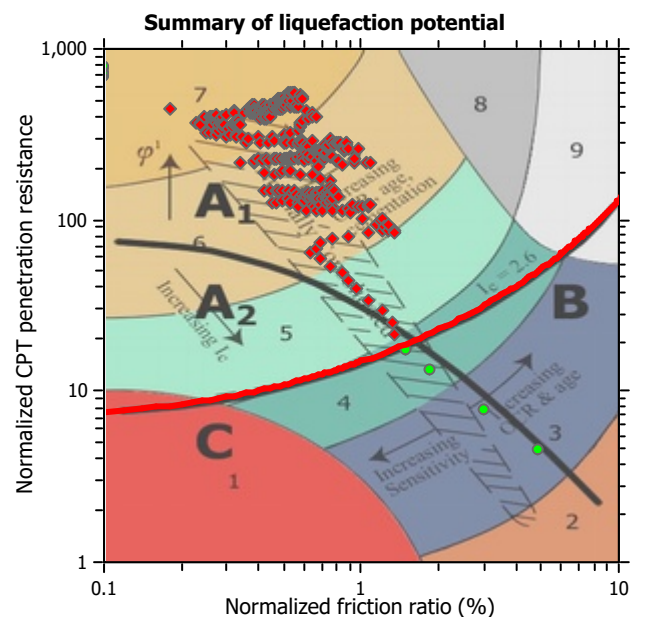
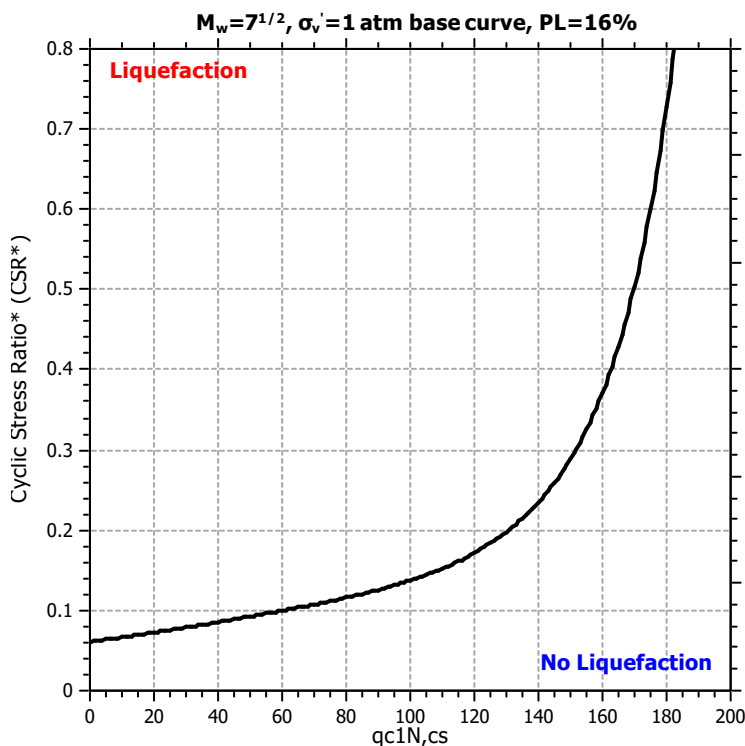
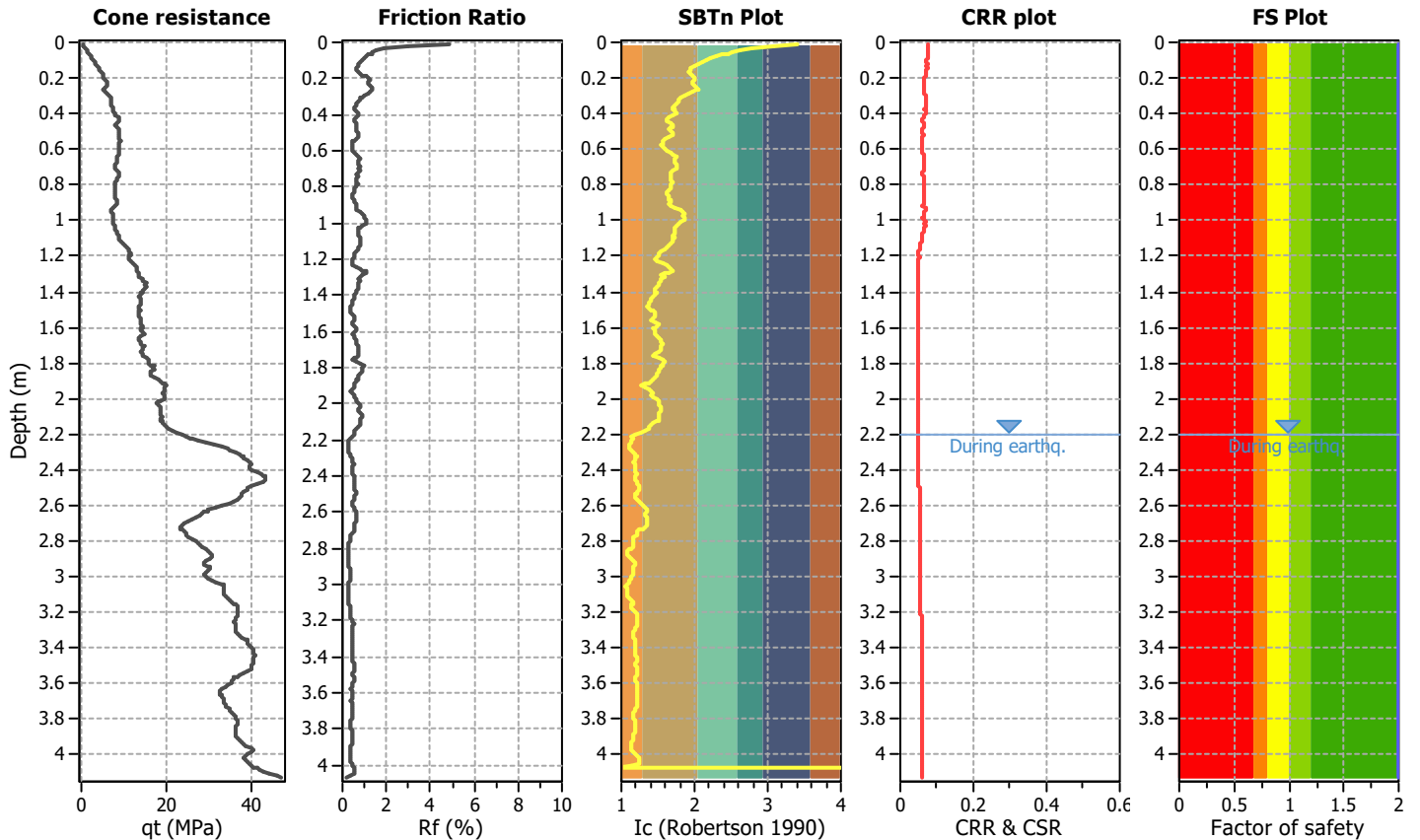
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 14

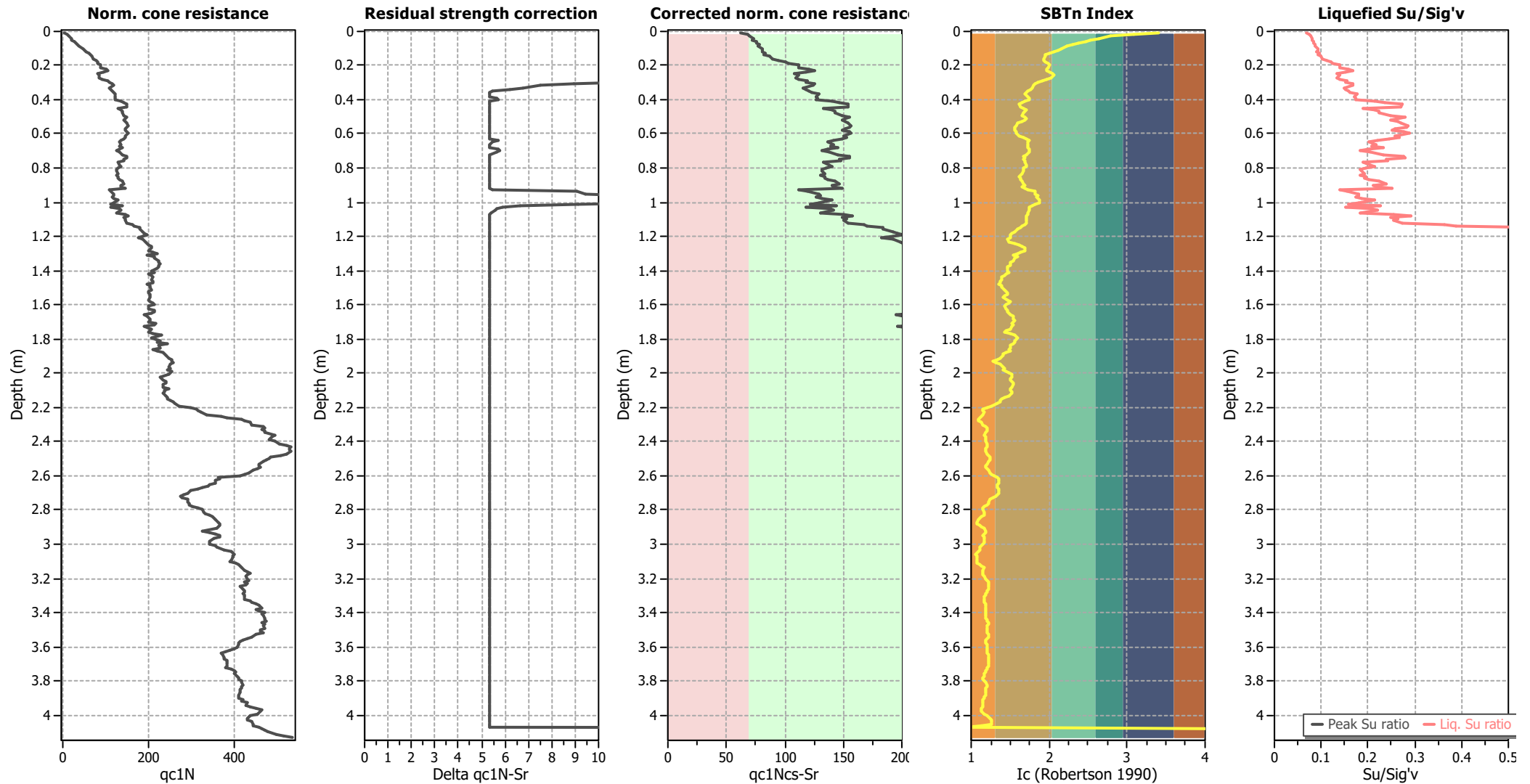
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

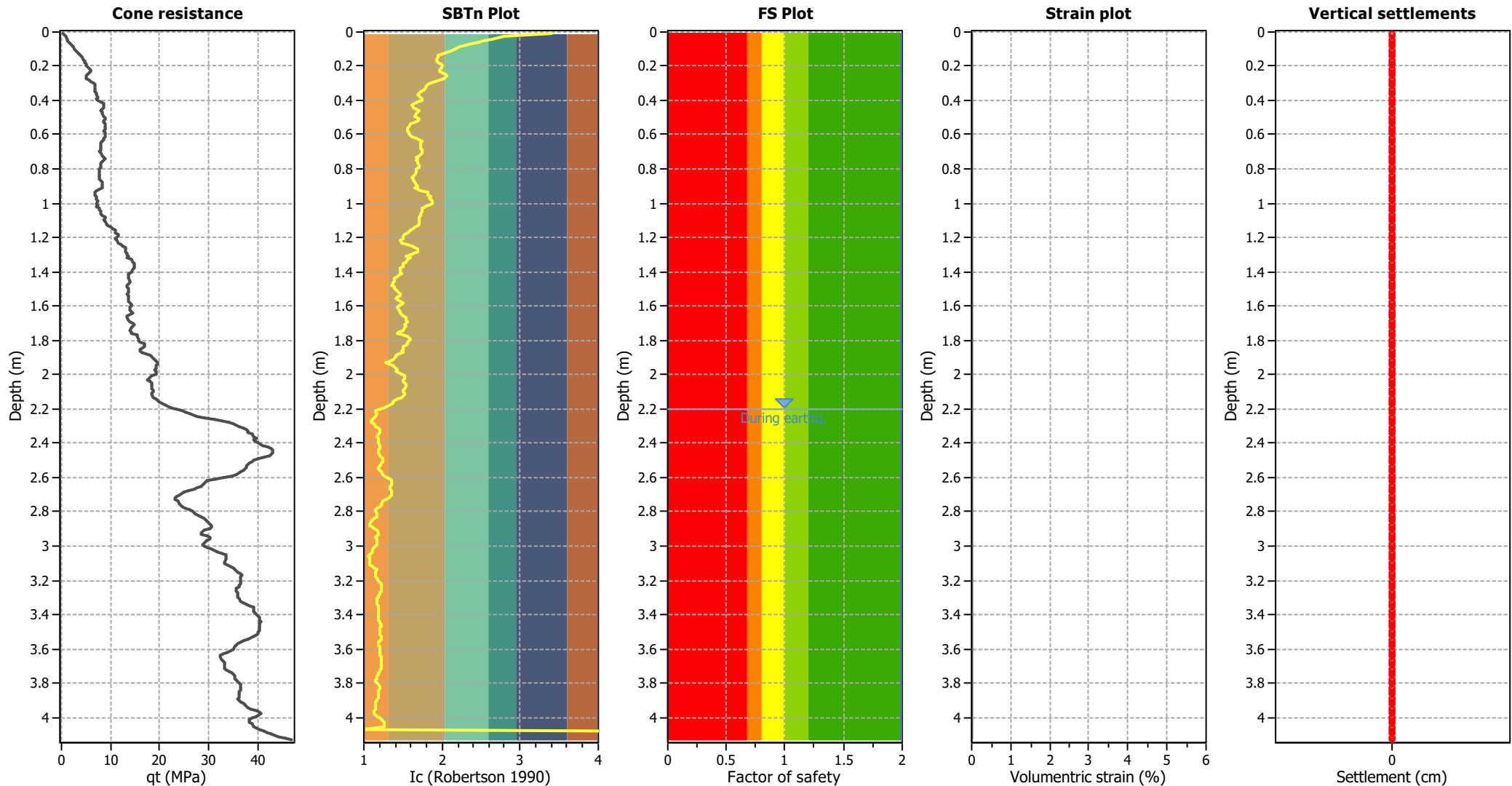
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

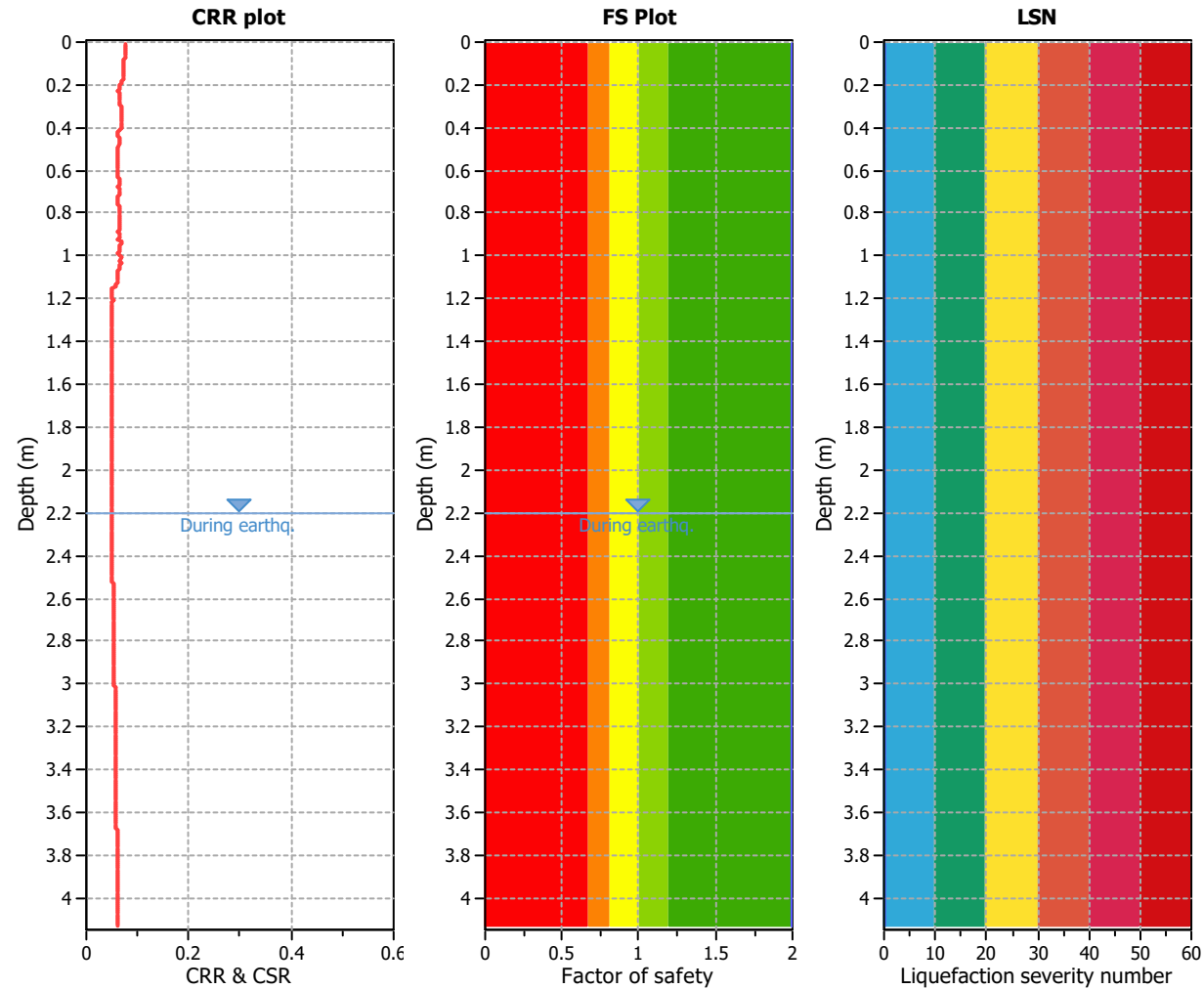
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.20 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_o applied:	Yes
Earthquake magnitude M_w :	6.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.14	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.20 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.10	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.14	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

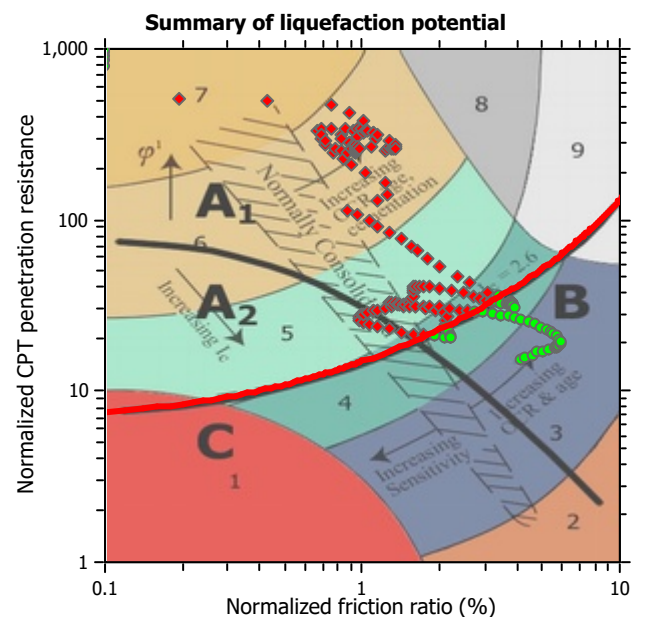
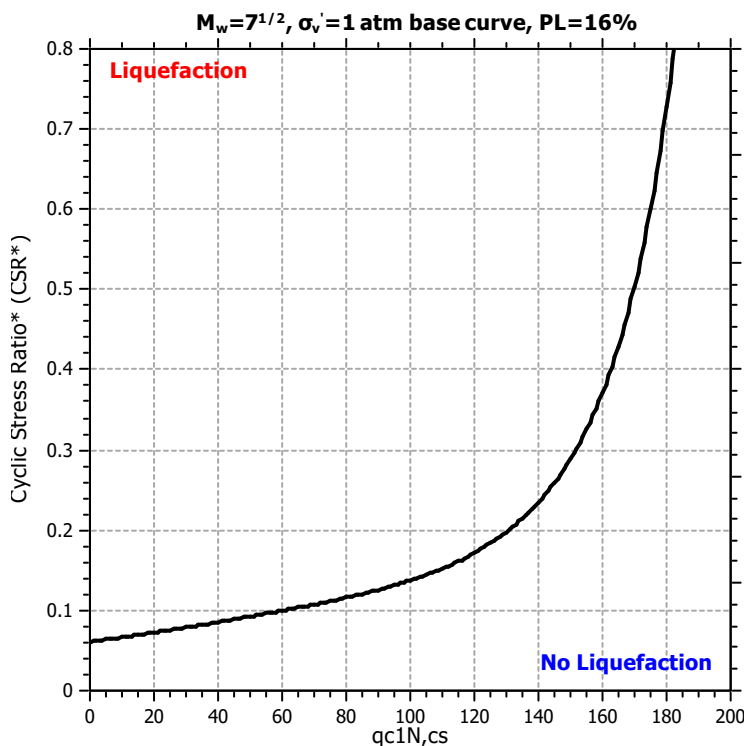
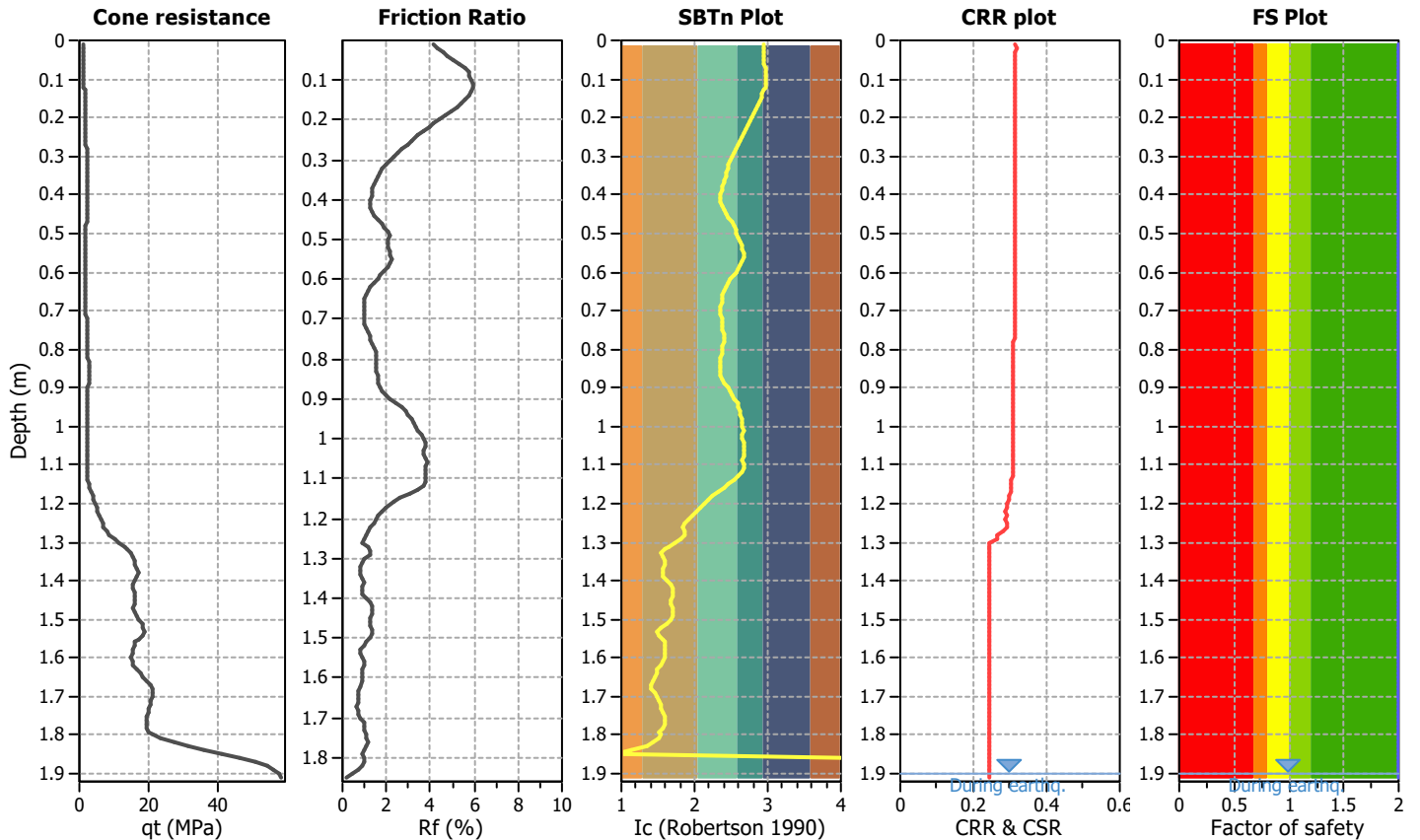
***Ultimate Limit State (ULS) Design
Earthquake Event***

CPT1

LIQUEFACTION ANALYSIS REPORT

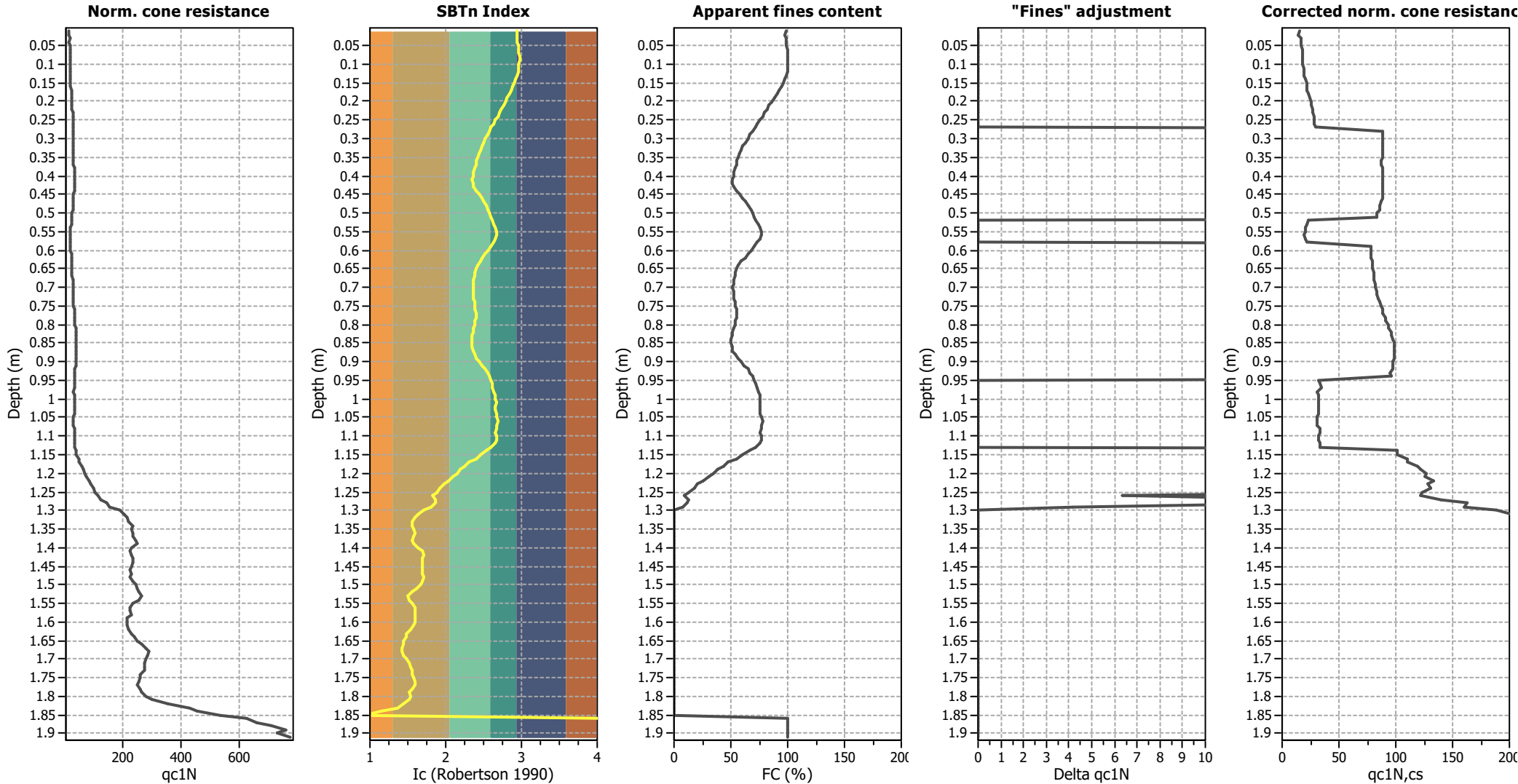
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 1
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.90 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.90 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

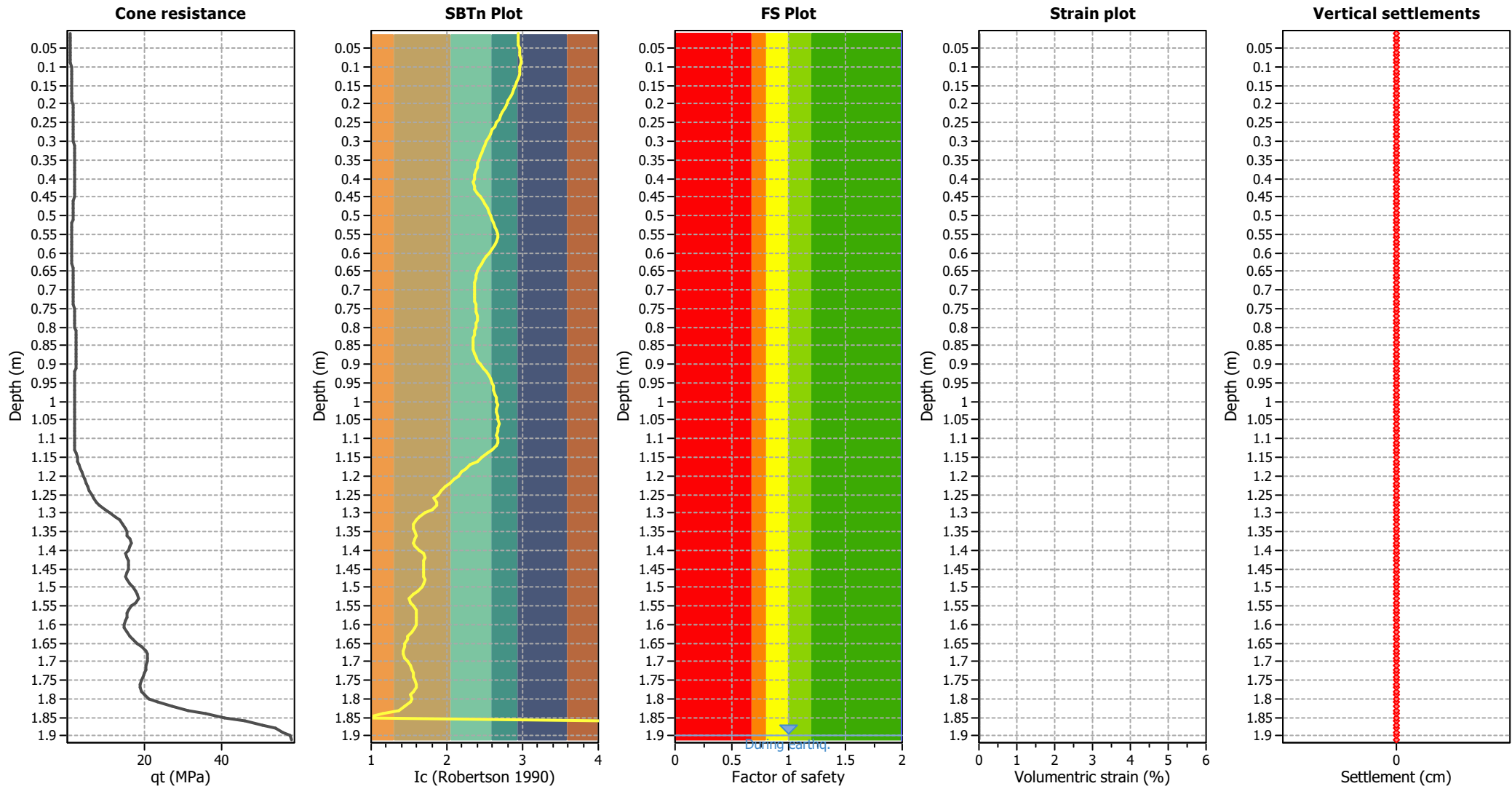
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.90 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.90 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements

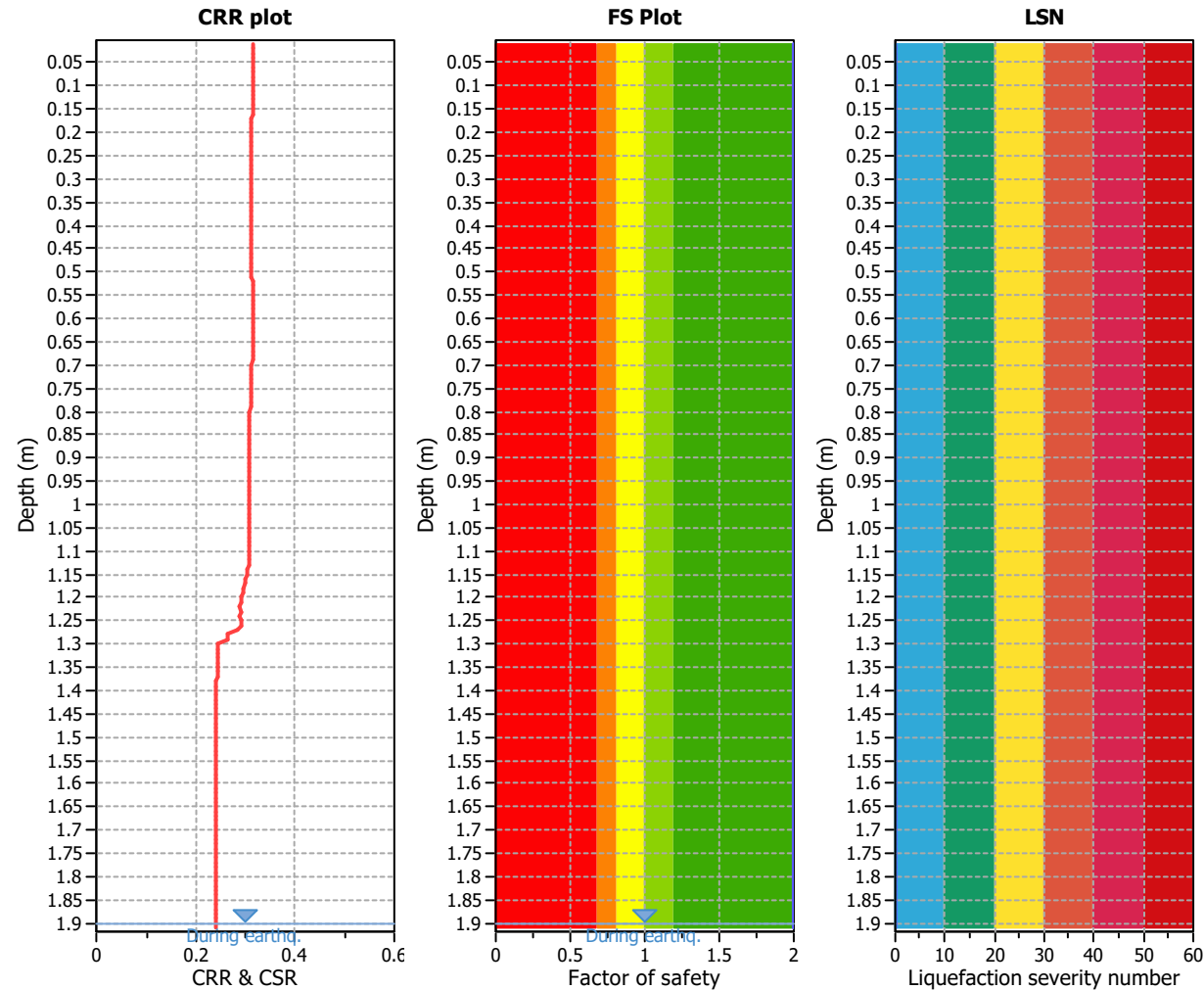


Abbreviations

- q_c: 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
- Volumetric strain: Post-liquefaction volumetric strain

Project: Cargill Station Ltd
Location: Ocean Ridge, Kaikoura

CPT: CPT 1
Total depth: 1.91 m



Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.90 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.90 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT2

LIQUEFACTION ANALYSIS REPORT

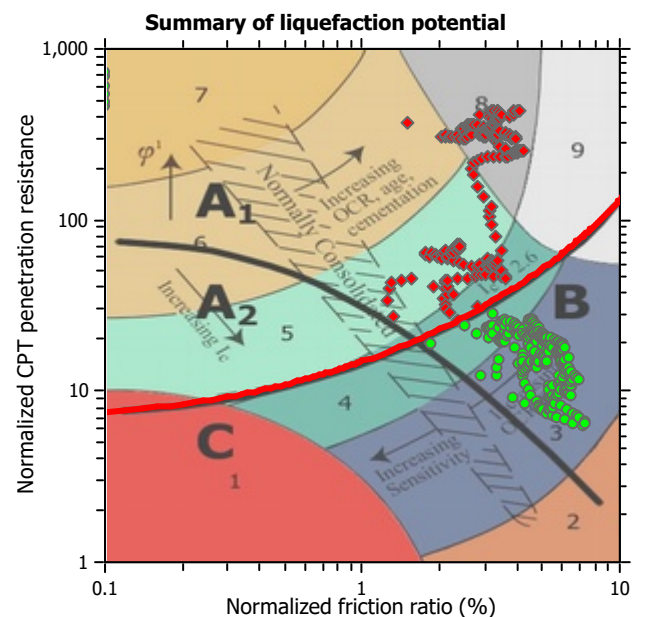
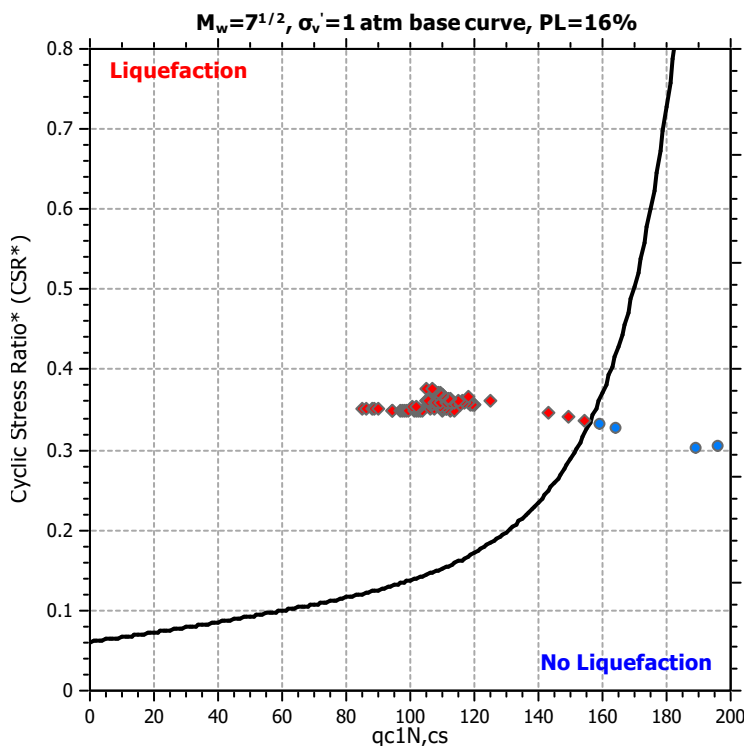
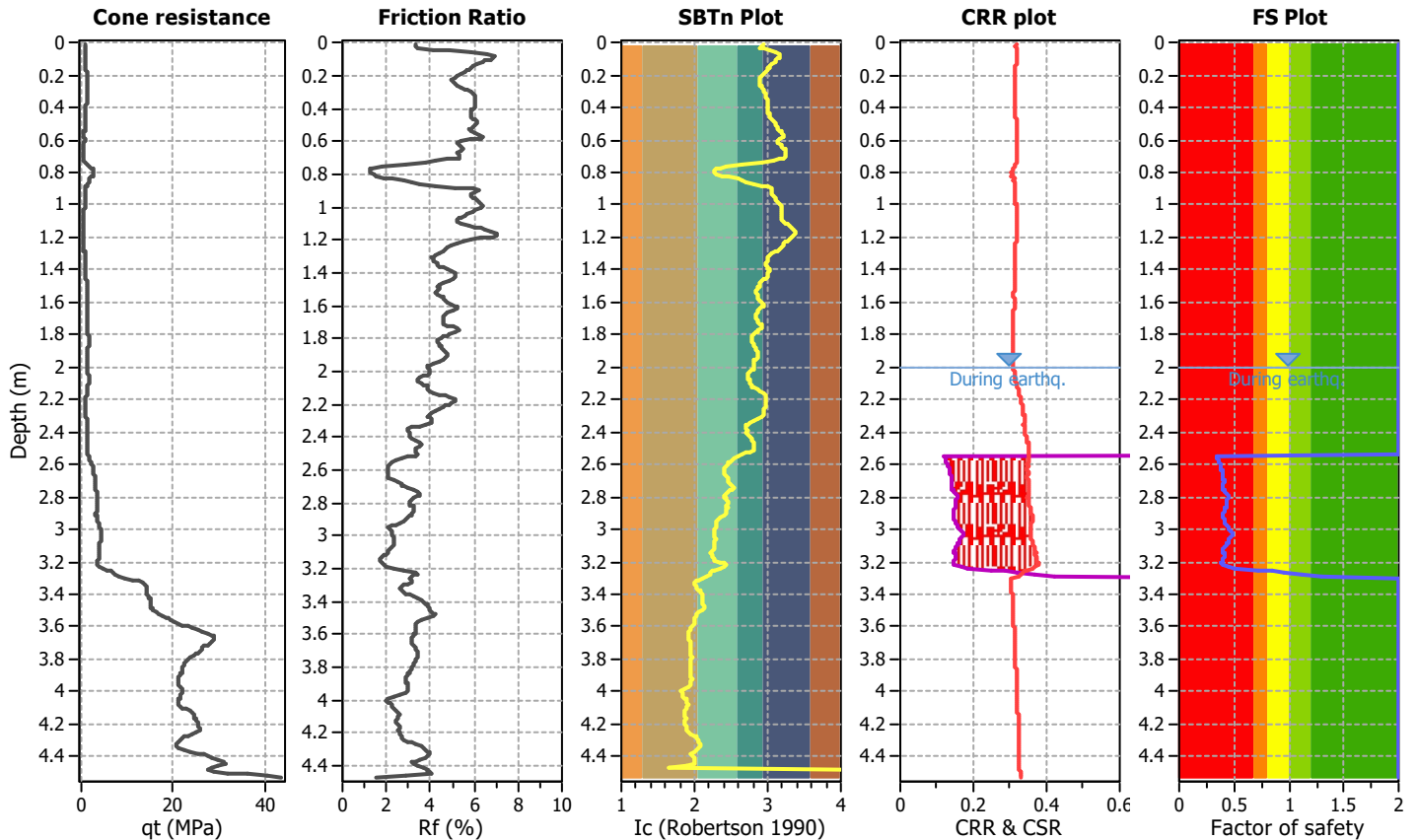
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 2

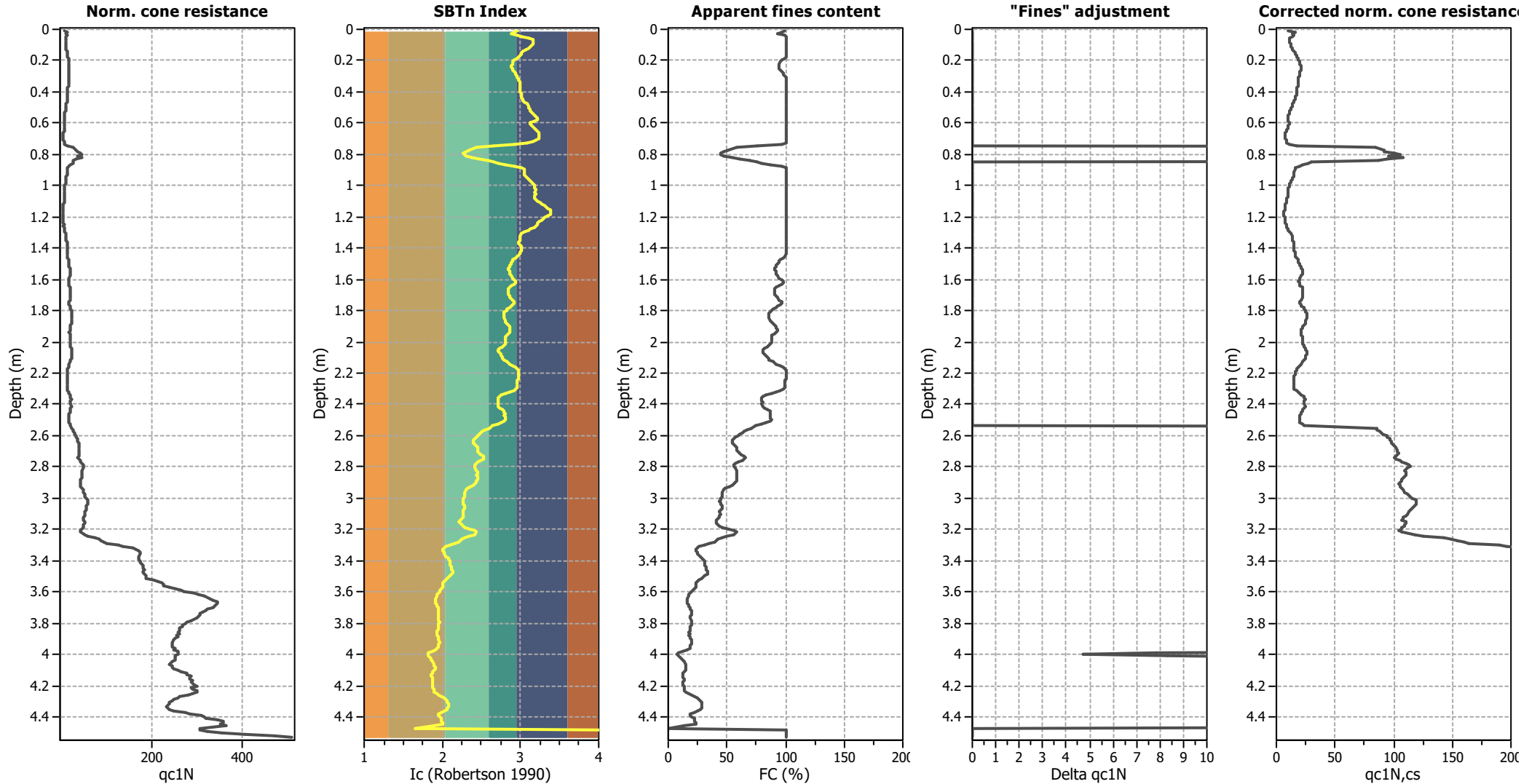
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

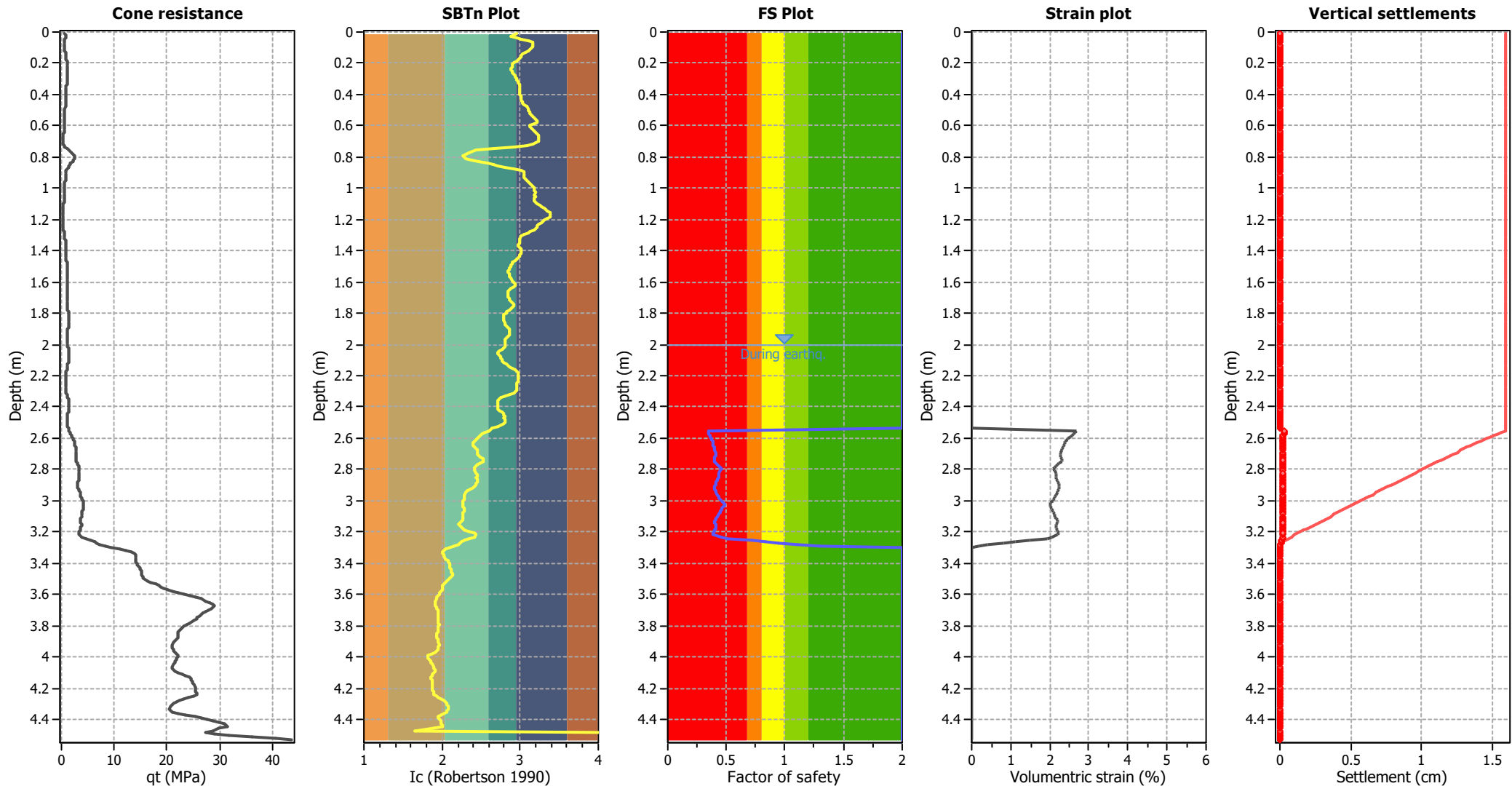
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

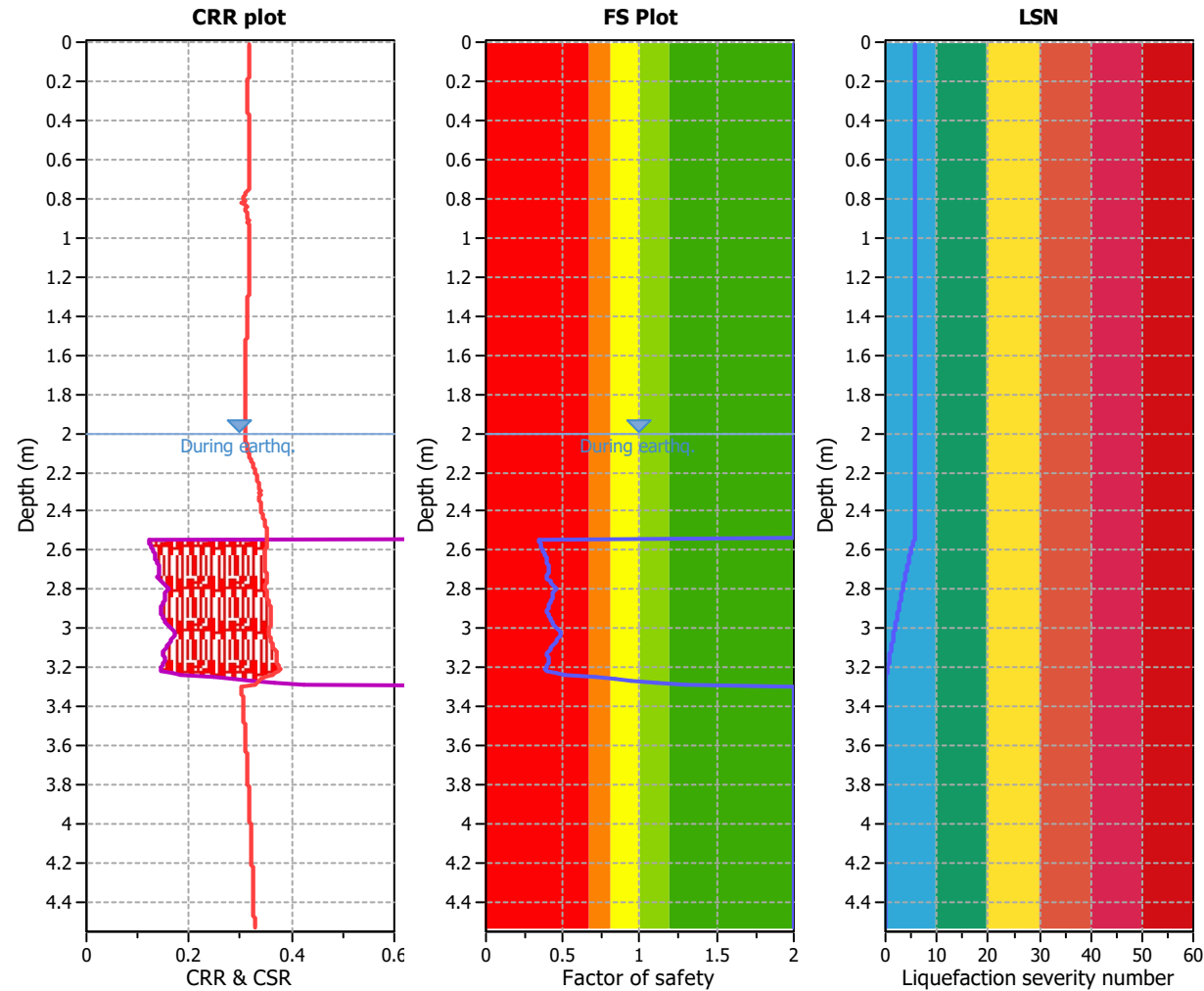
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT3

LIQUEFACTION ANALYSIS REPORT

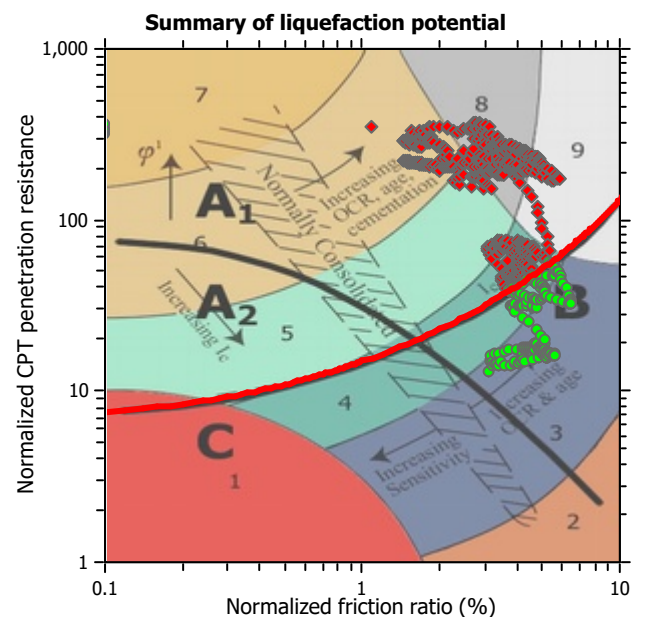
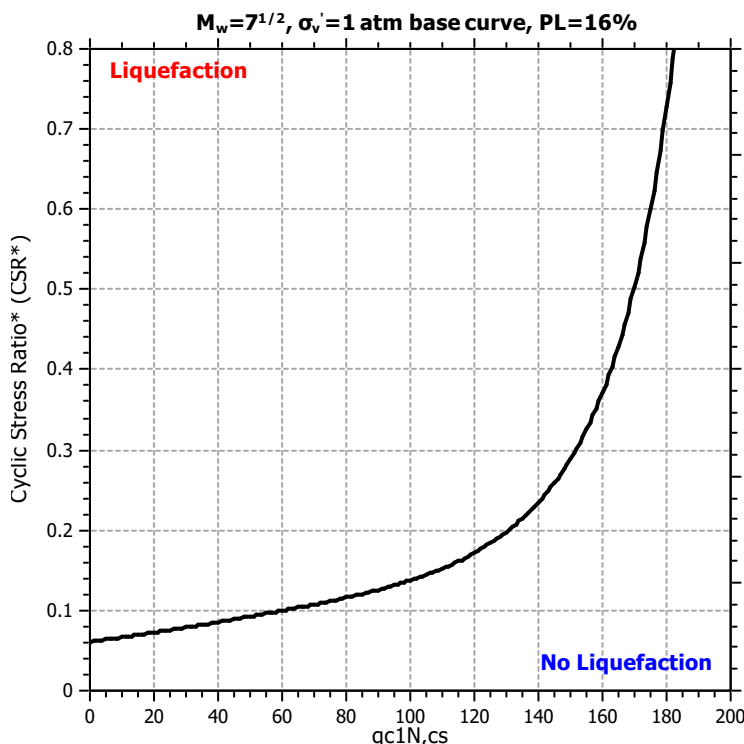
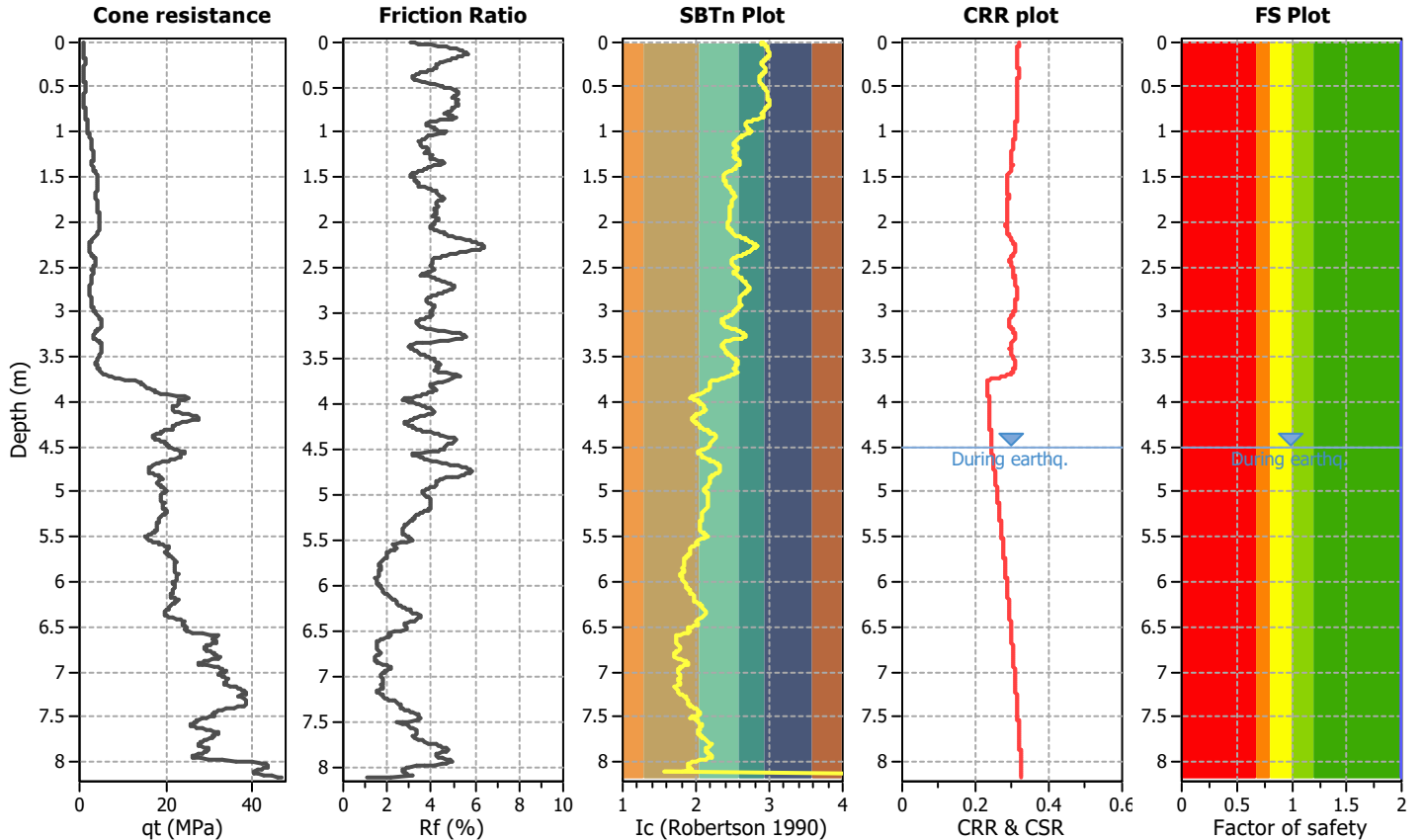
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 3

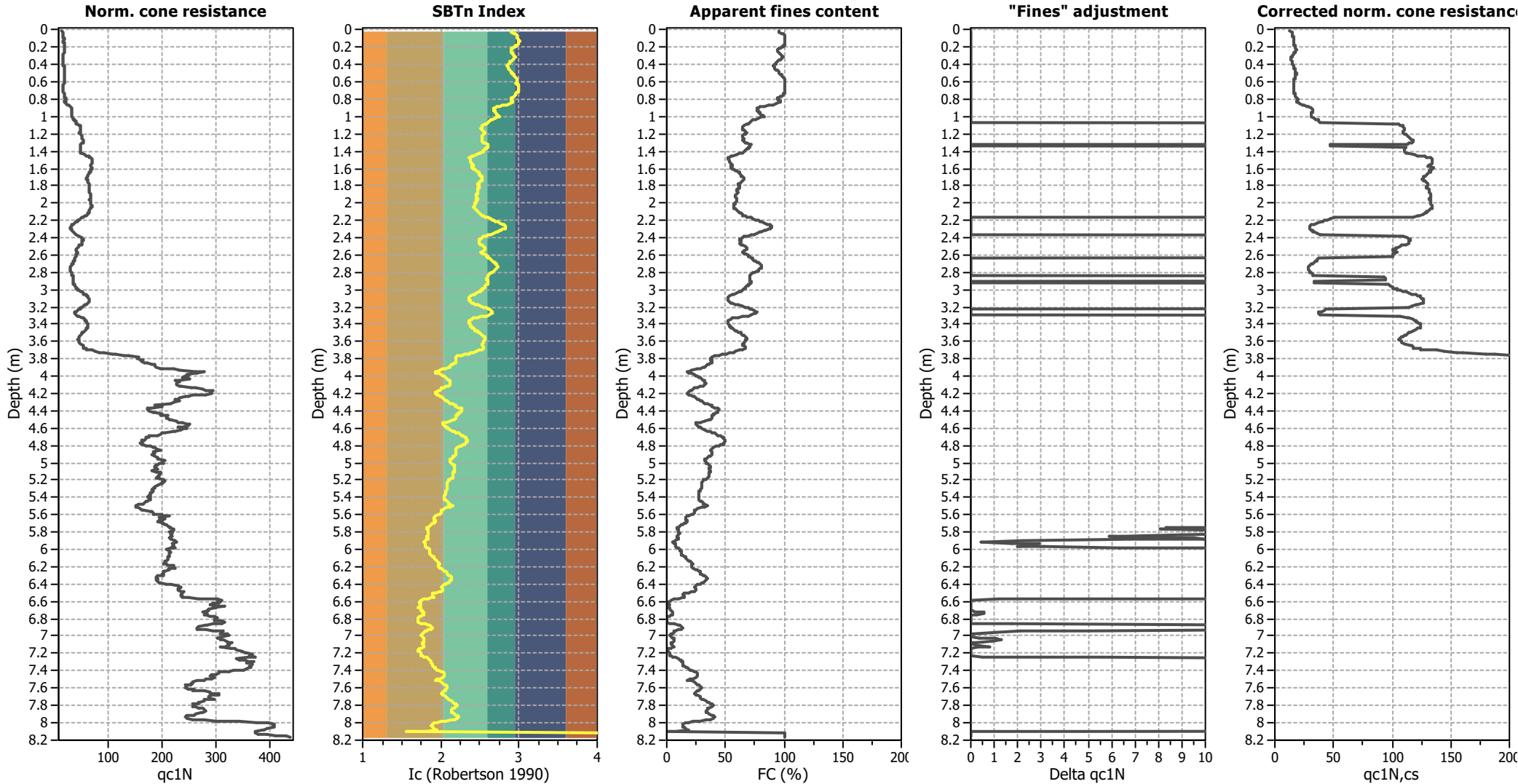
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A₂: 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

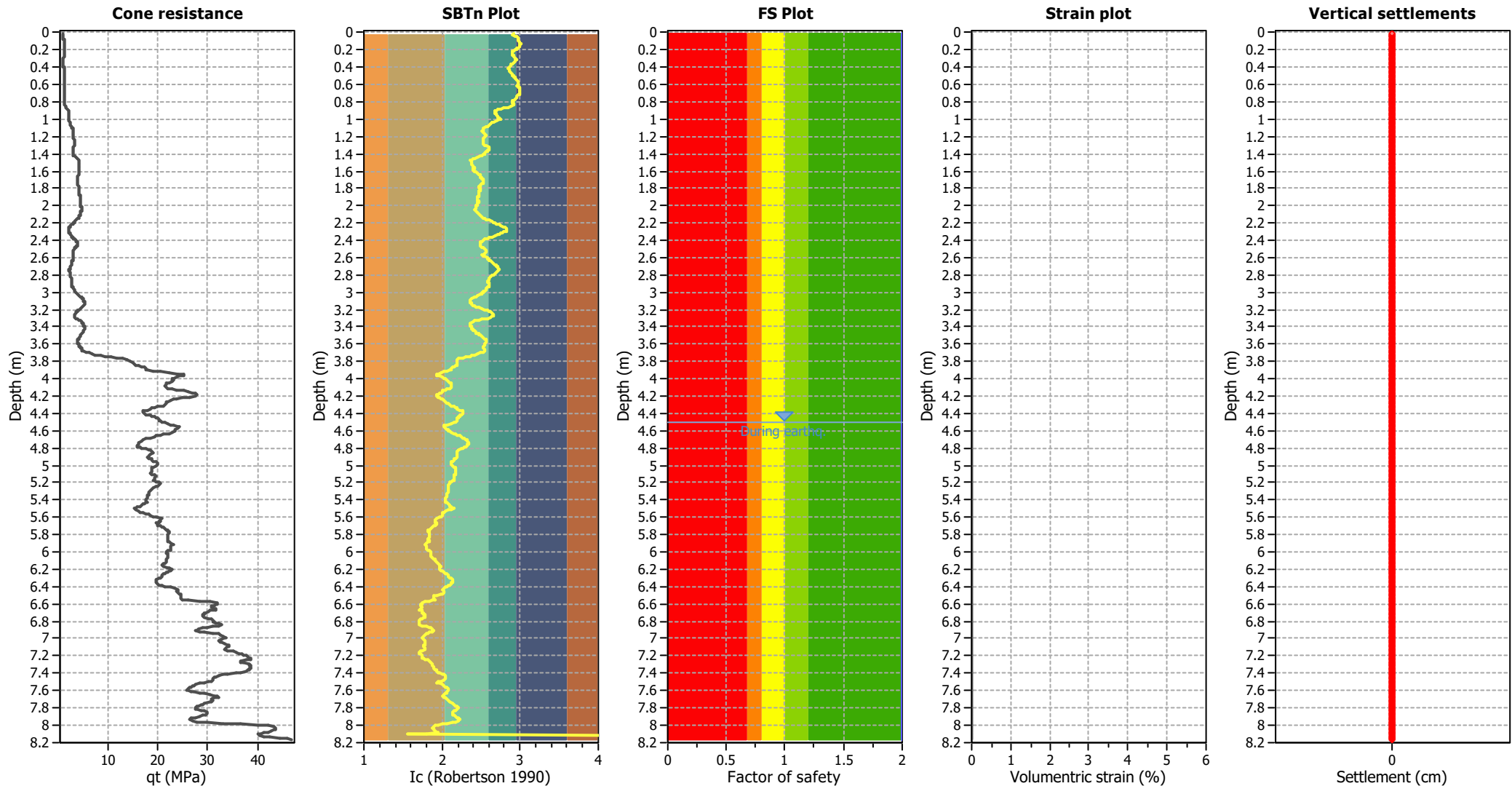
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

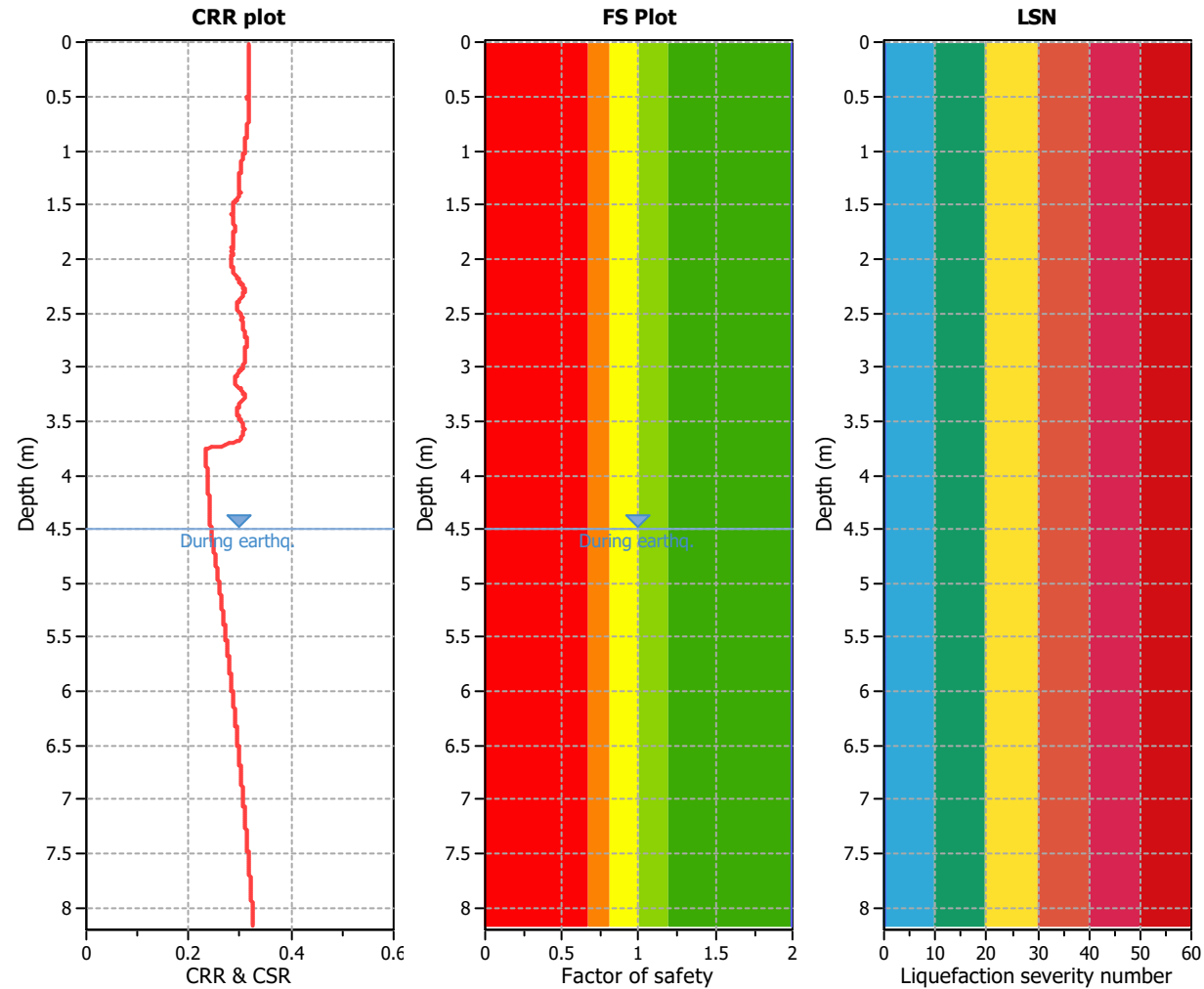
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

- q_c: 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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT4

LIQUEFACTION ANALYSIS REPORT

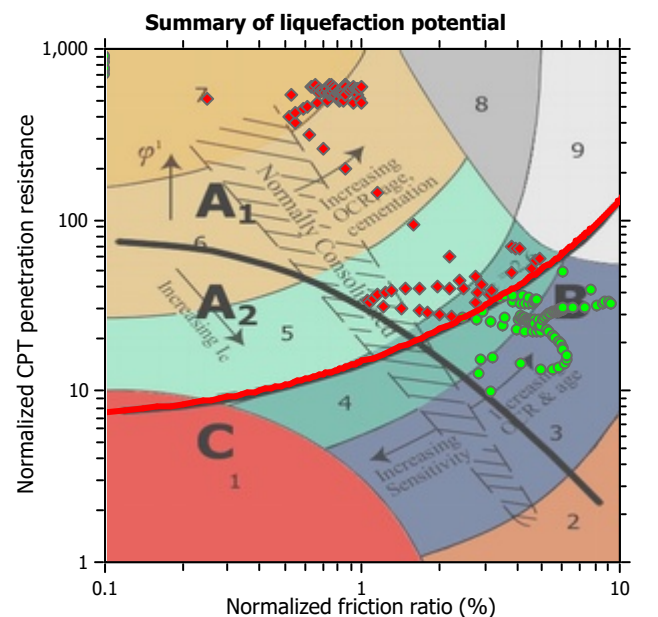
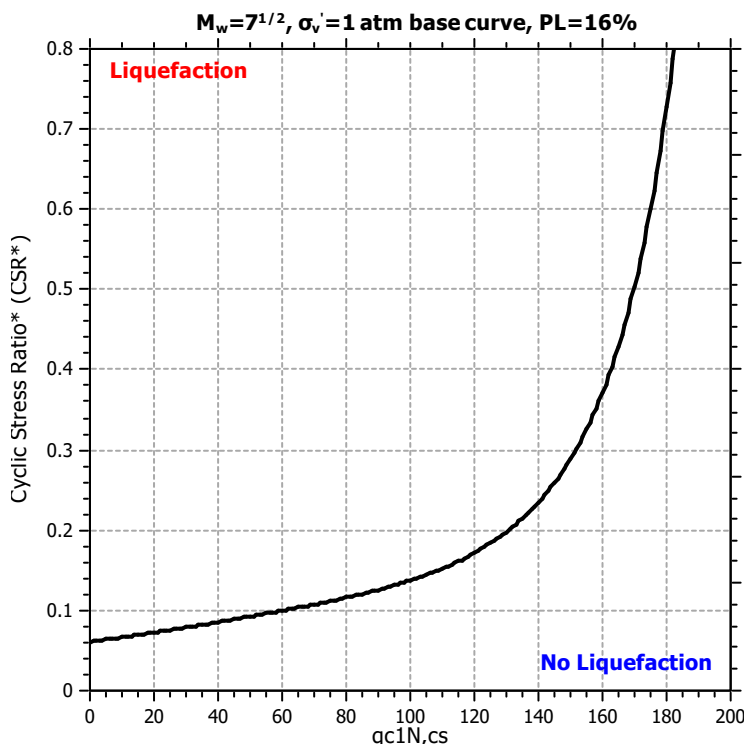
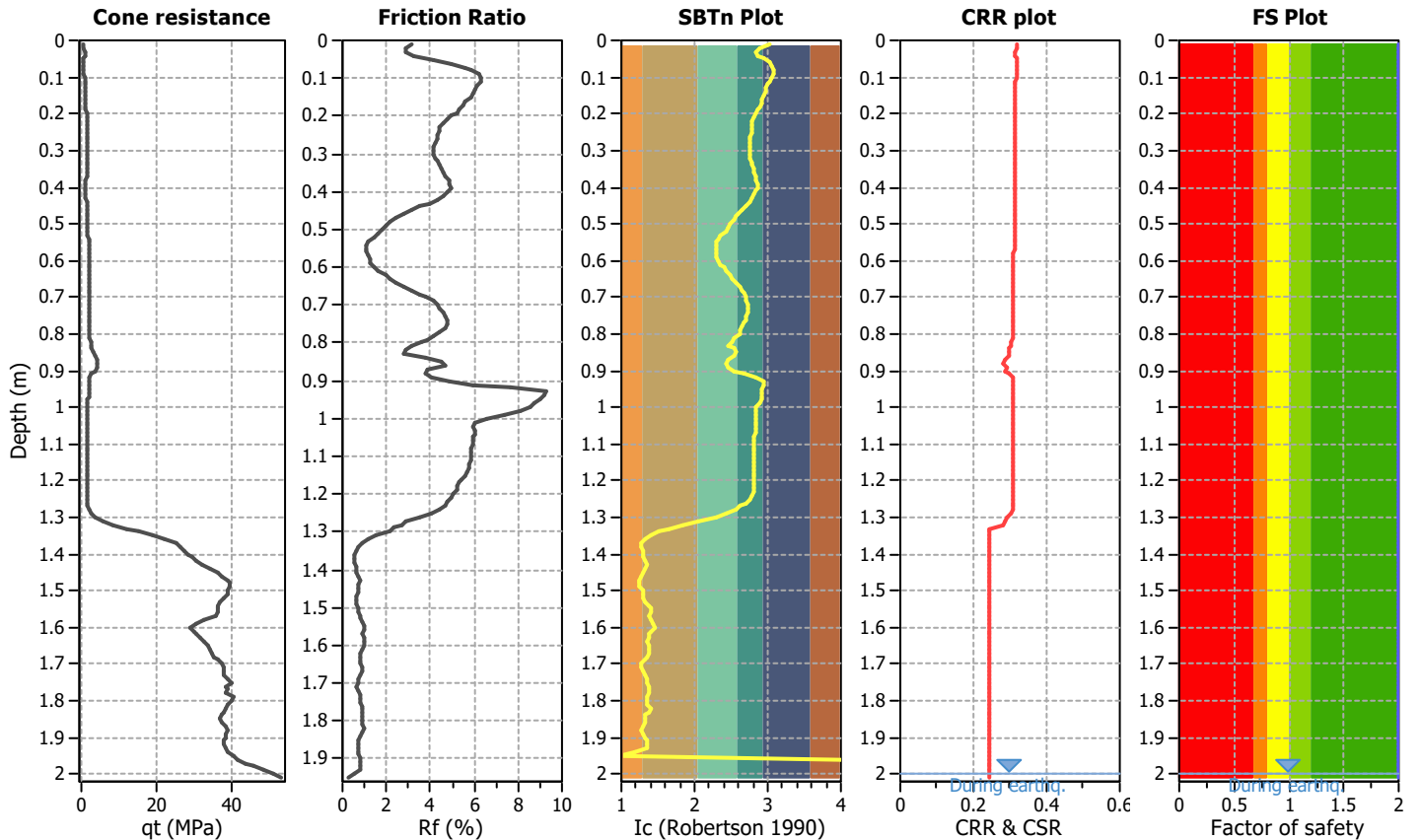
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 4

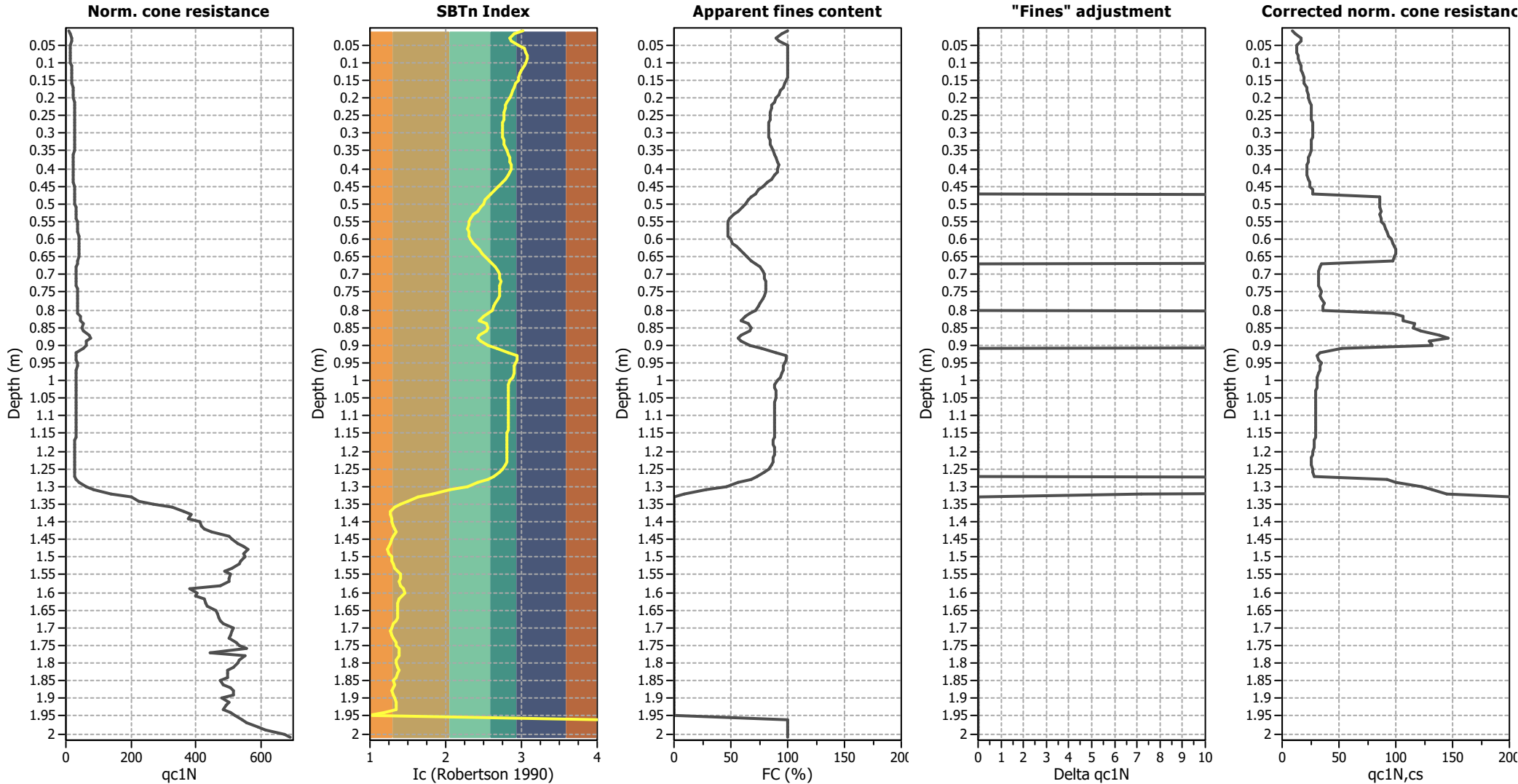
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

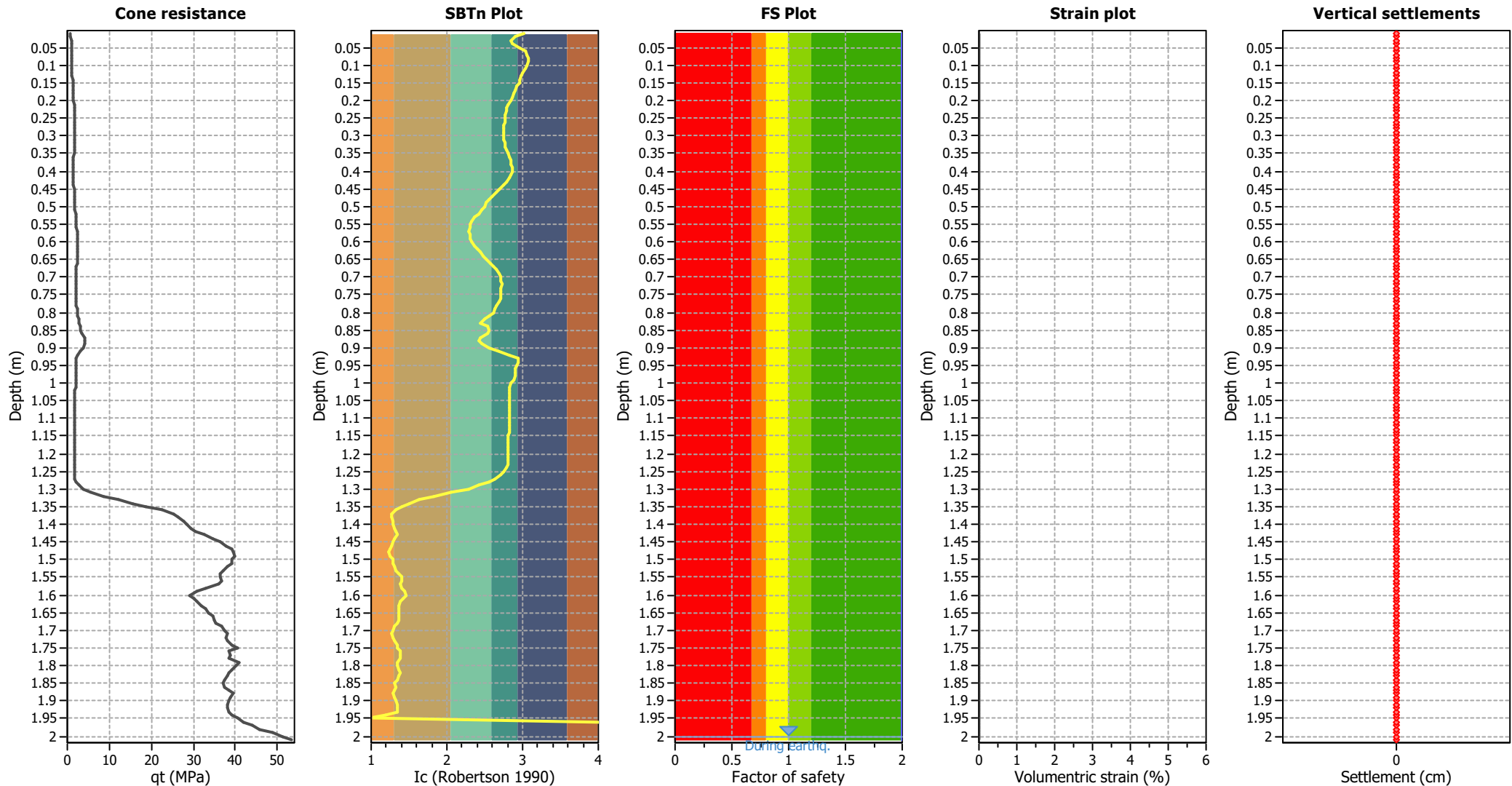
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

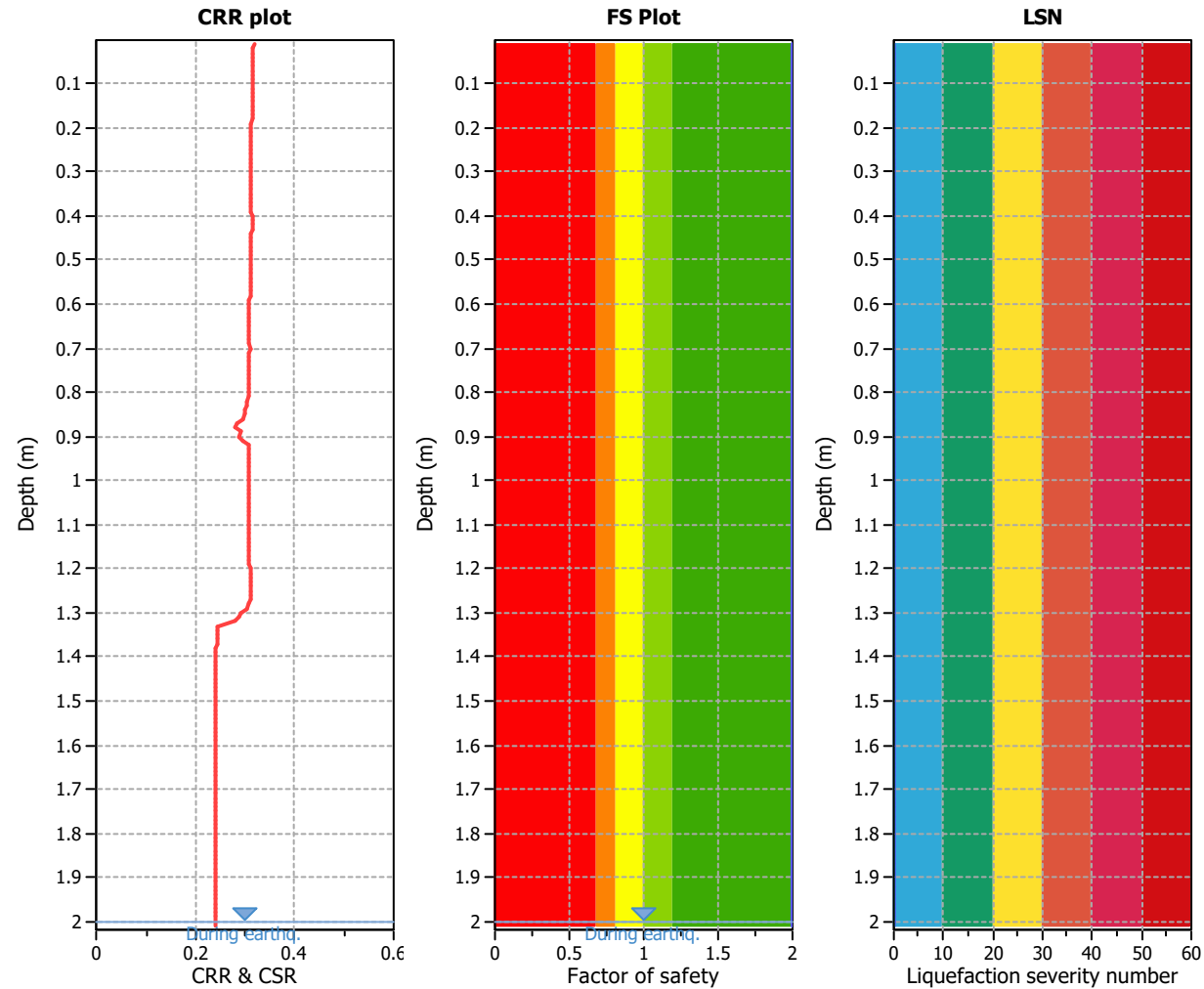
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _g applied:	Yes
Earthquake magnitude M _w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

- q_c: 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
- Volumetric strain: Post-liquefaction volumetric strain



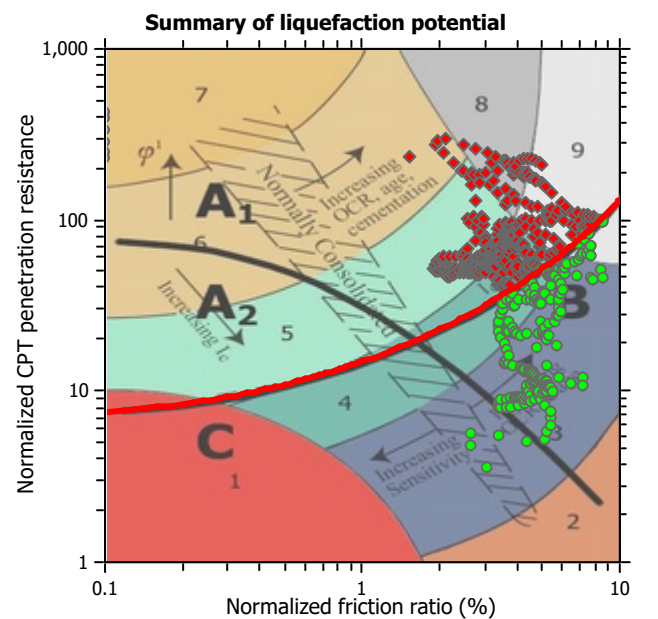
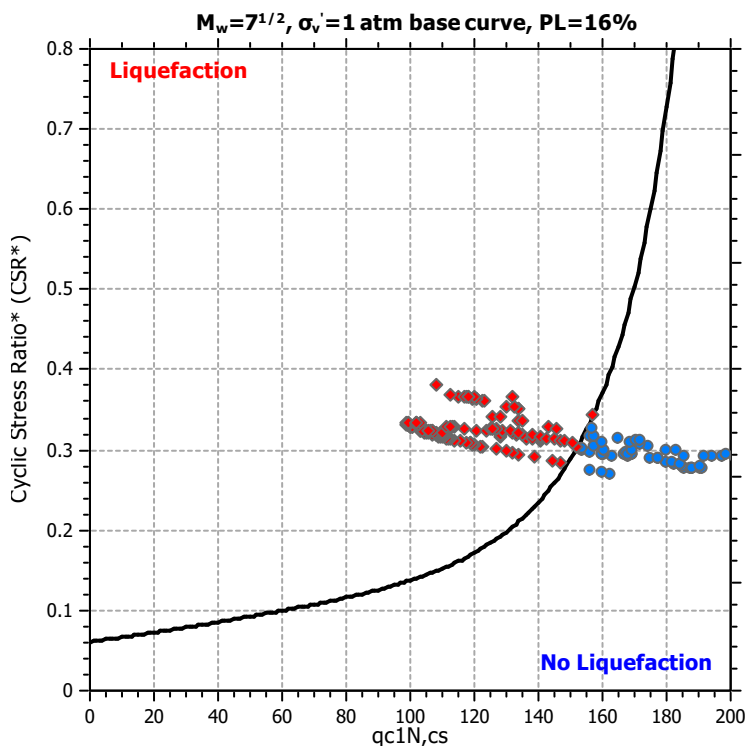
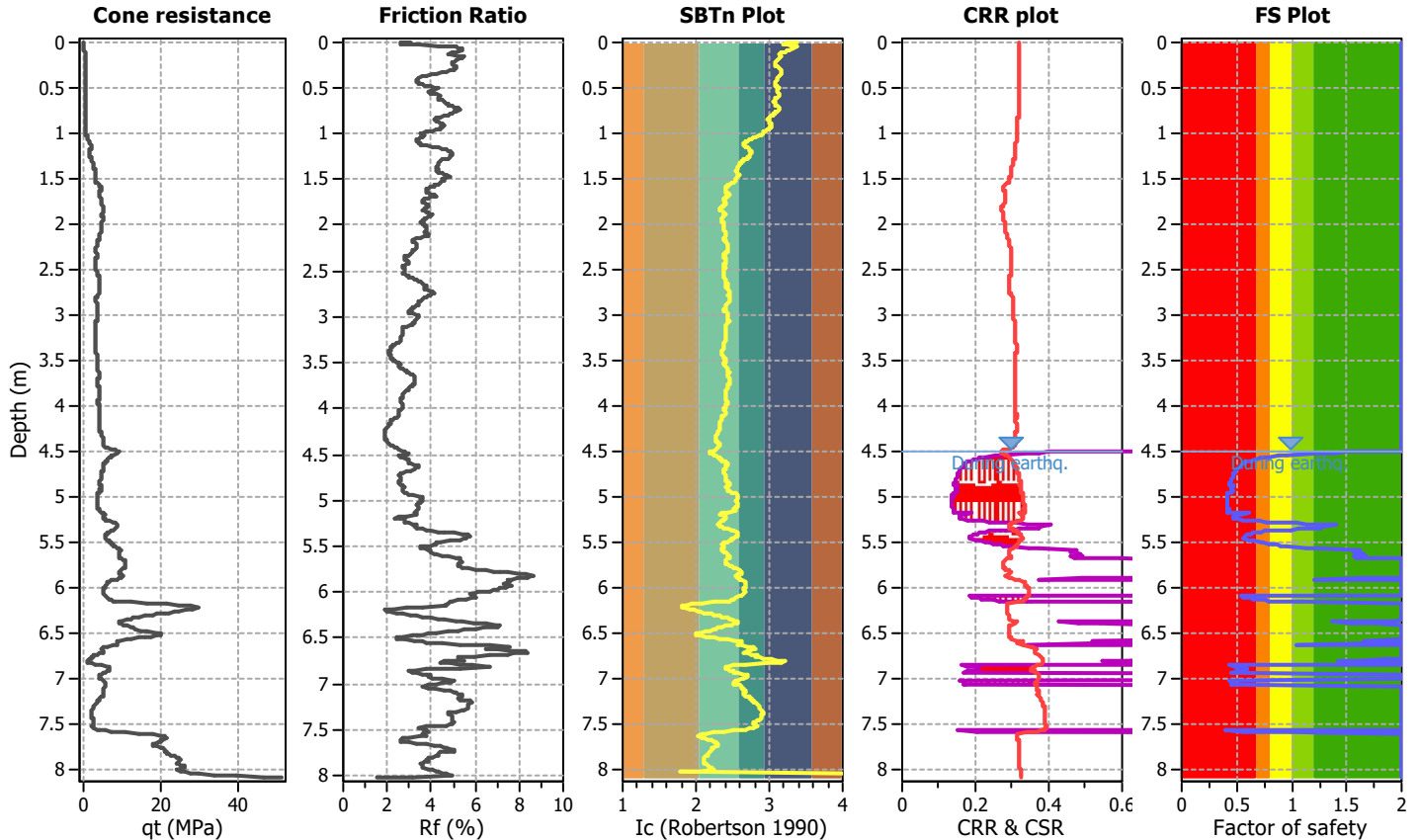
Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.00 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT5

LIQUEFACTION ANALYSIS REPORT

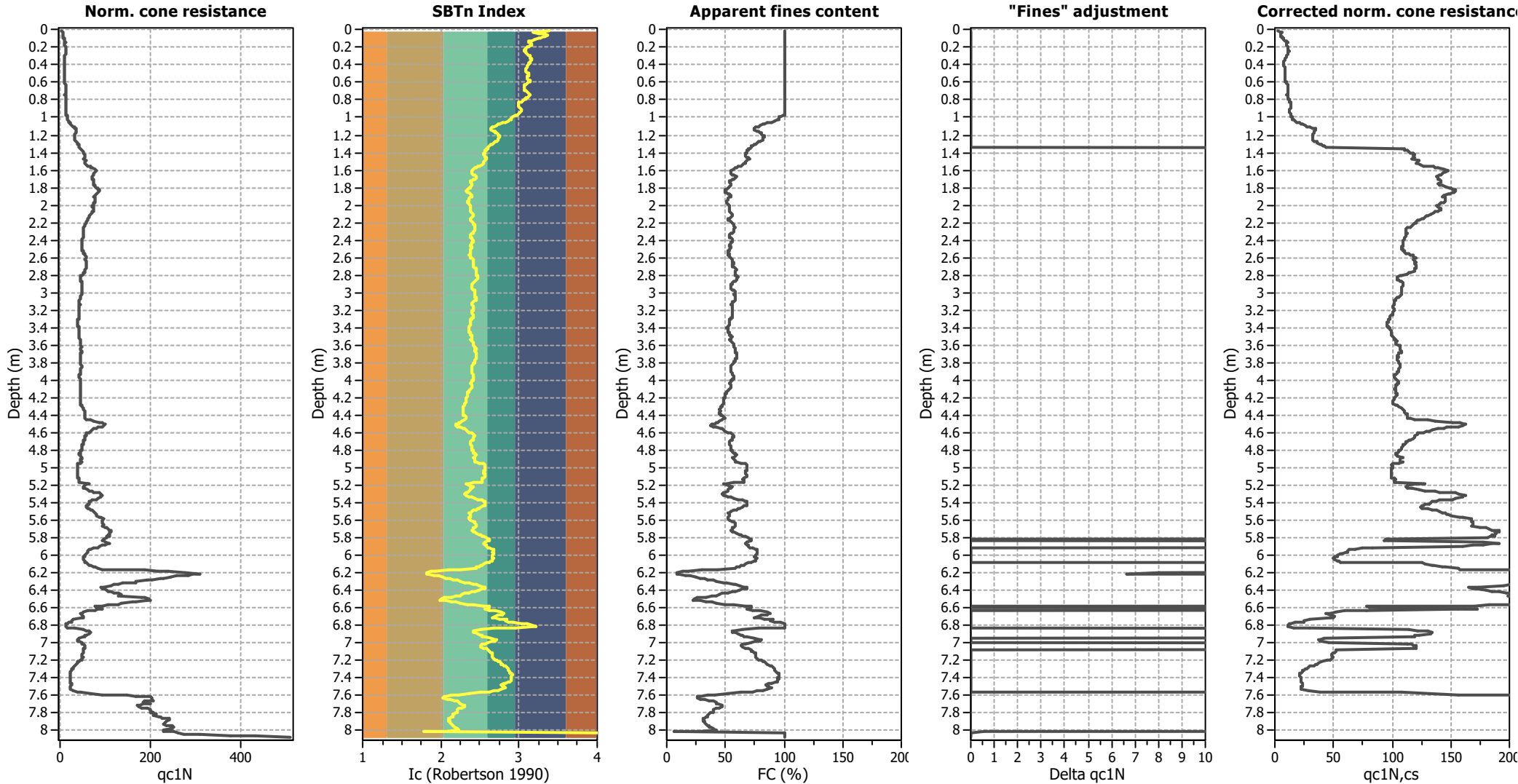
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 5
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A2: 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

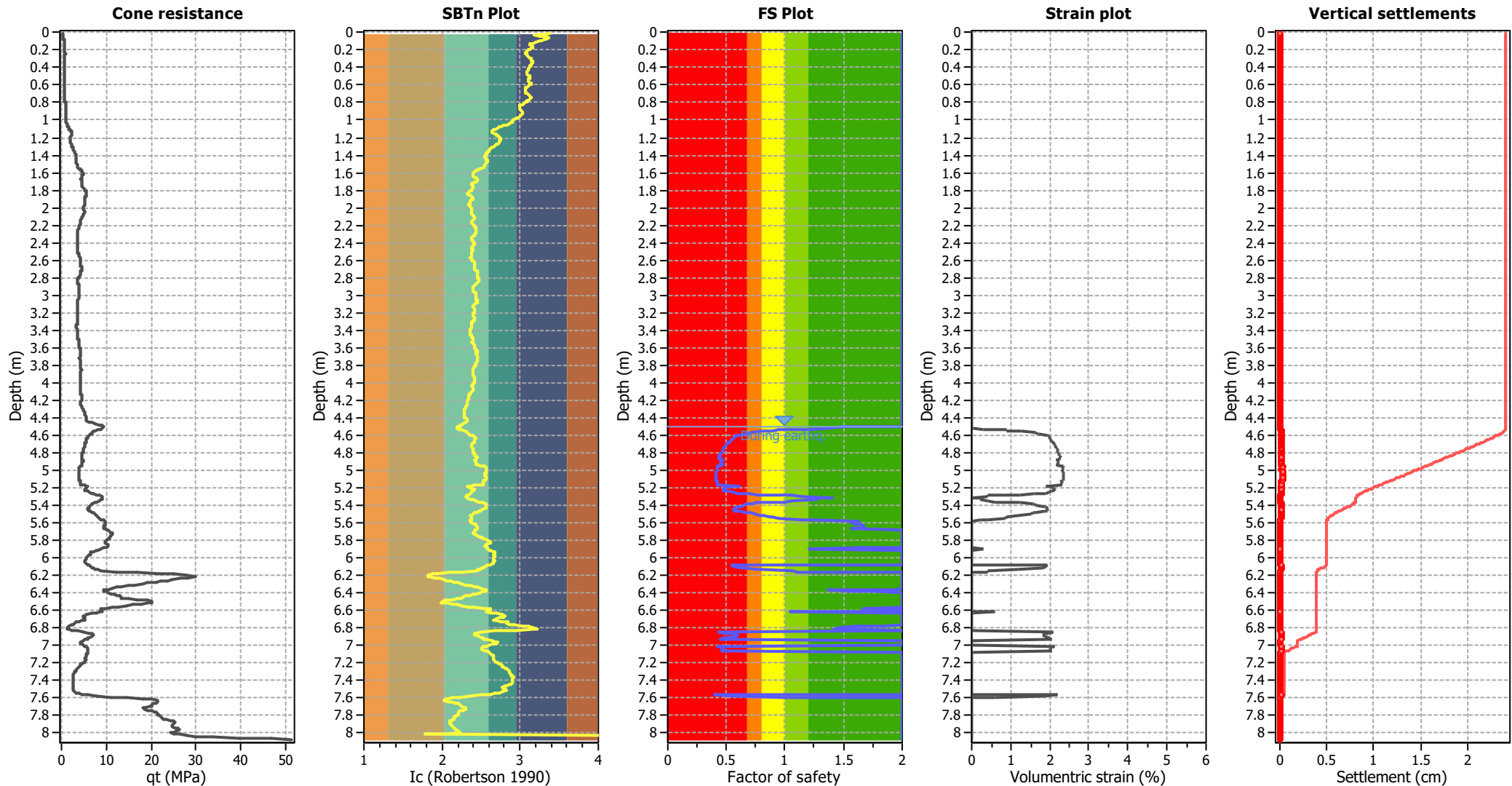
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

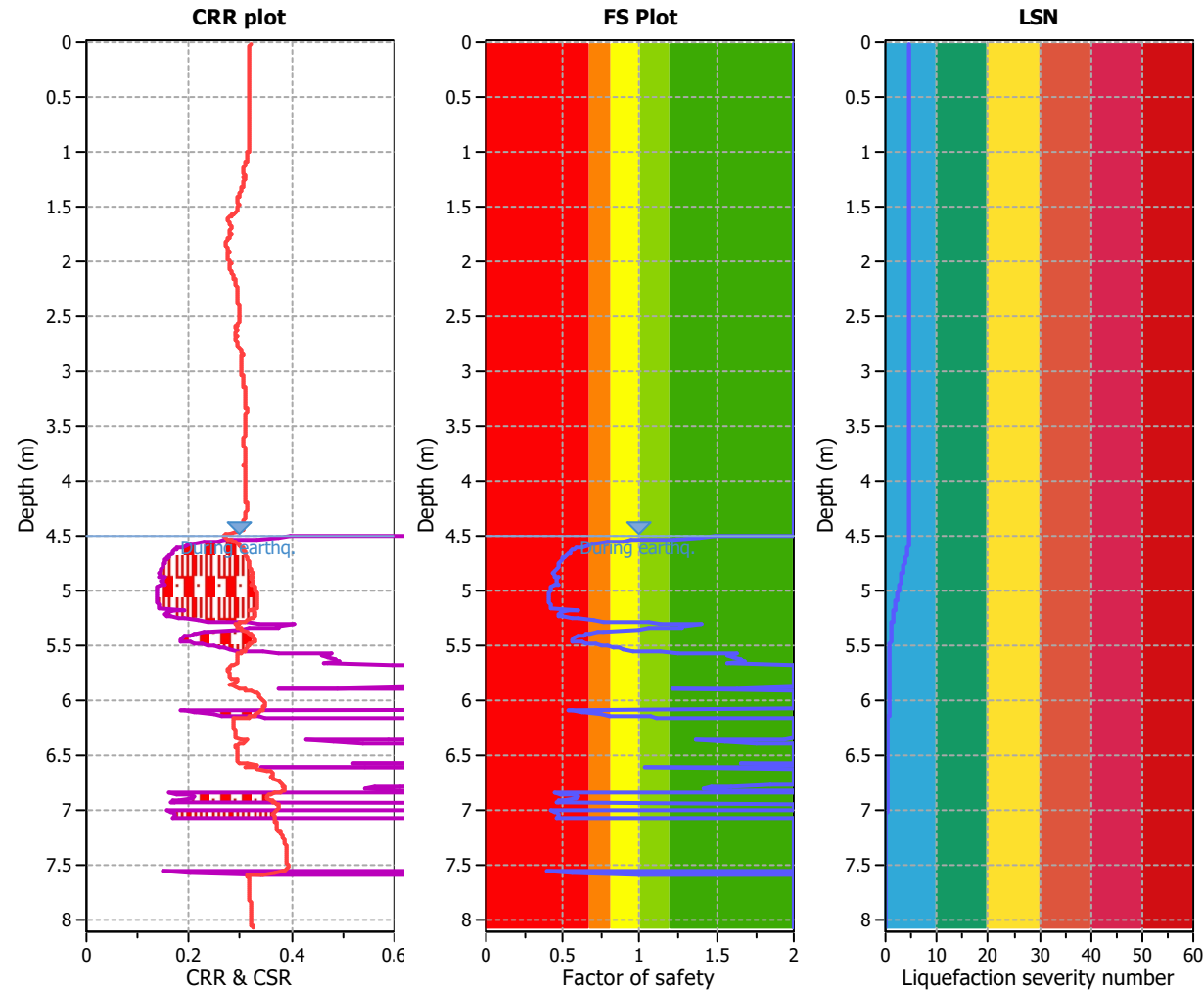
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_o applied:	Yes
Earthquake magnitude M_w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT6

LIQUEFACTION ANALYSIS REPORT

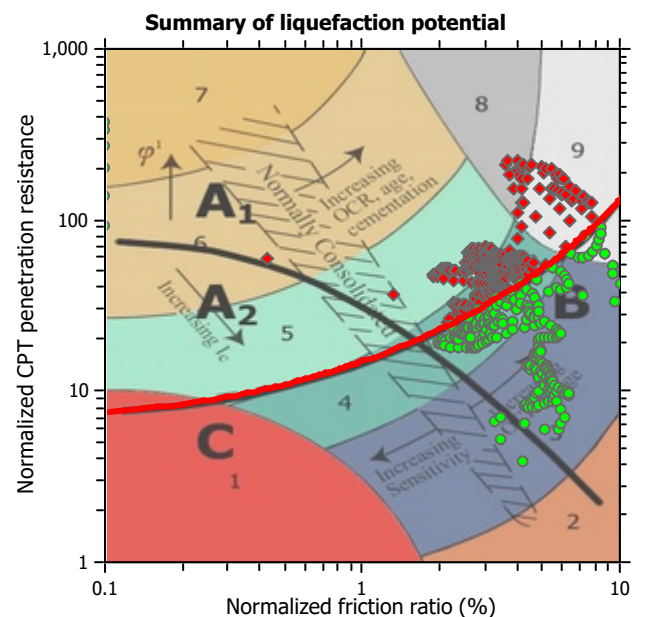
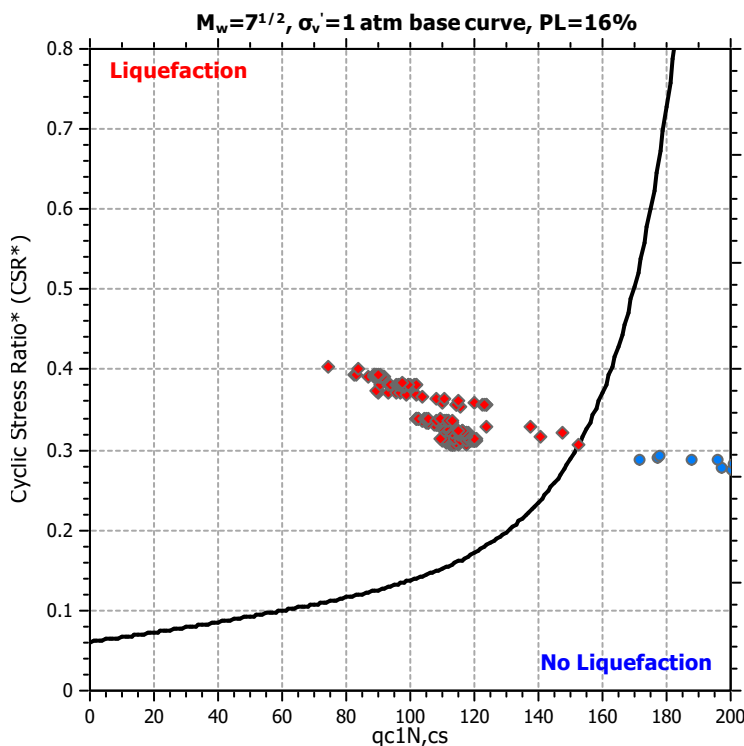
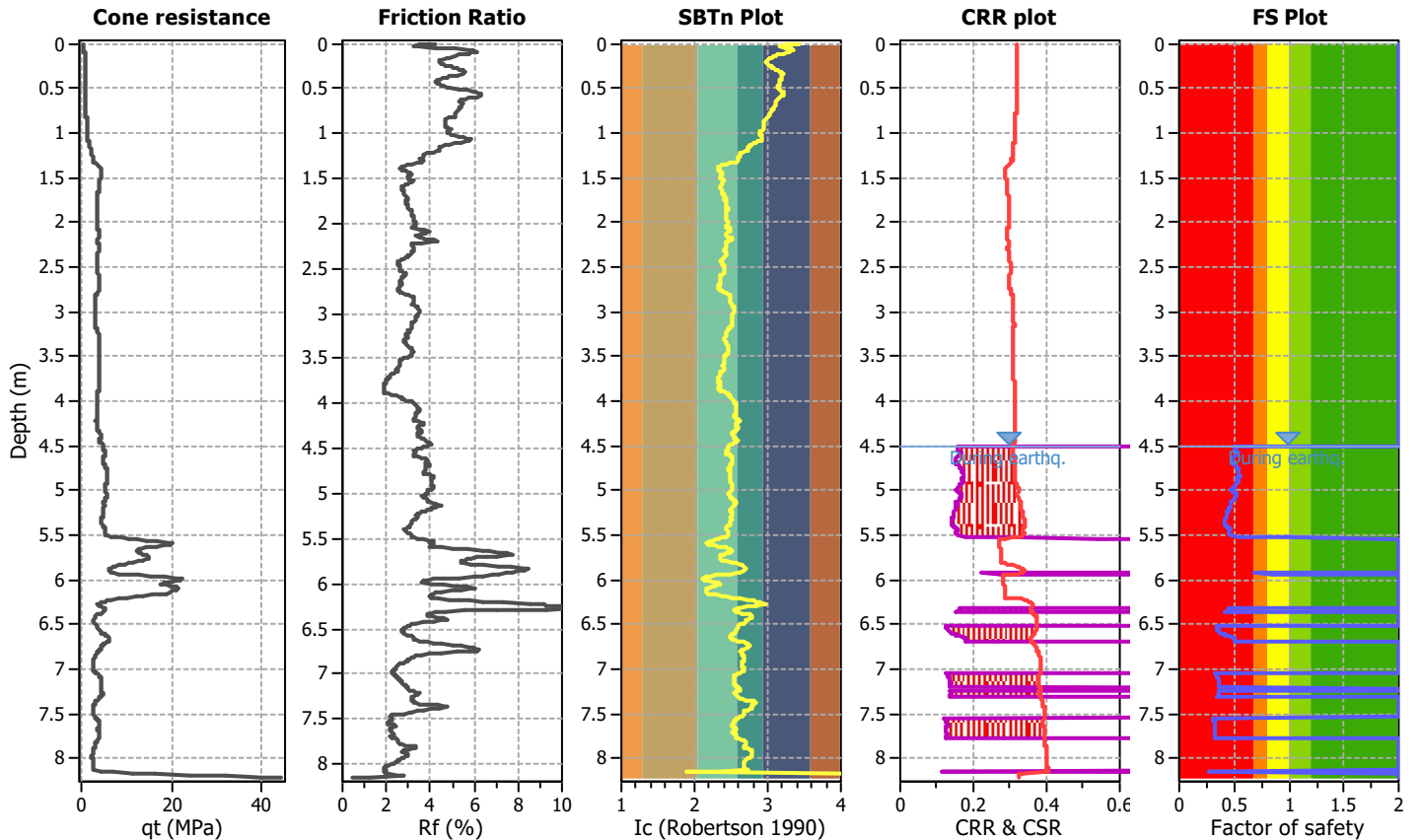
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 6

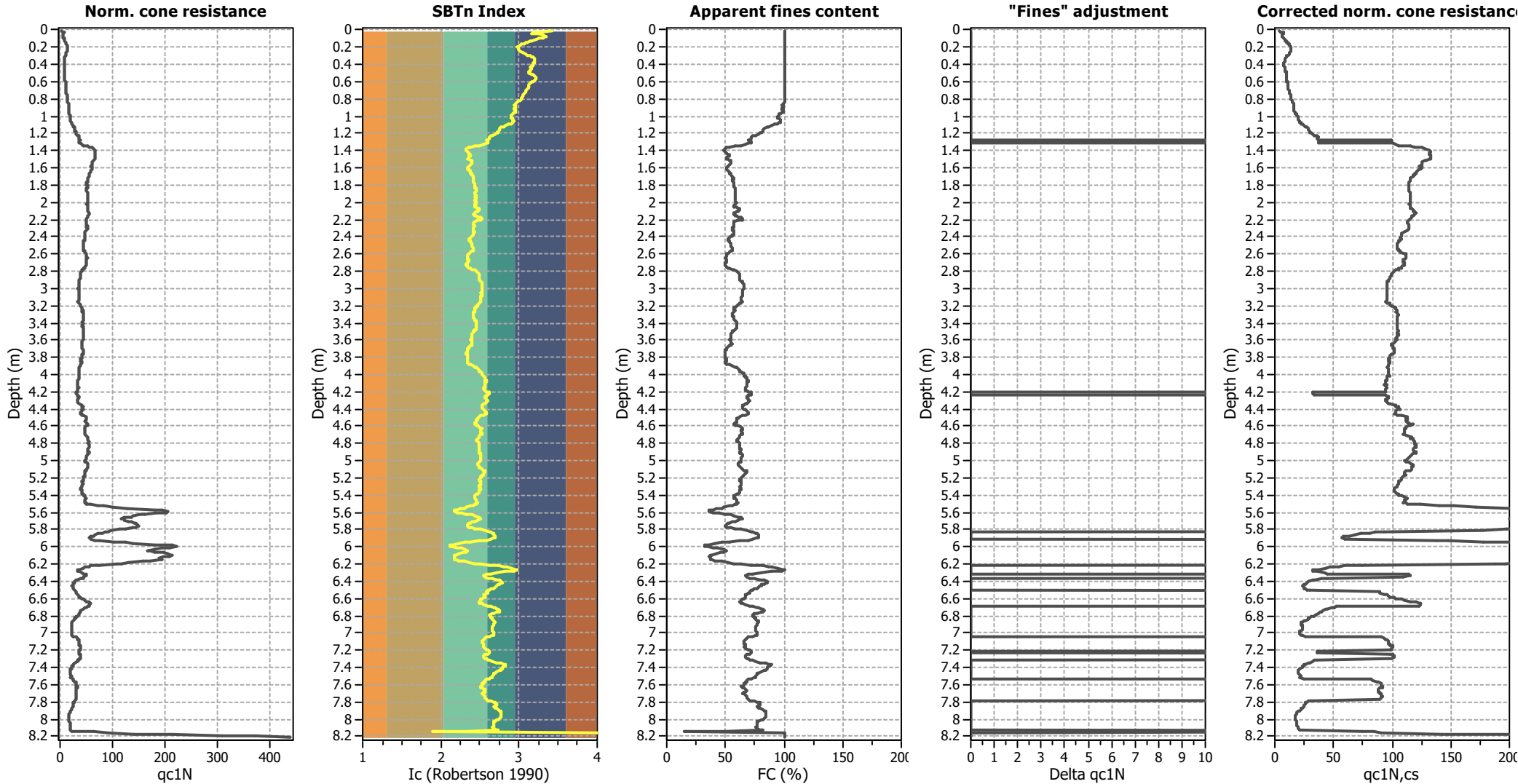
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

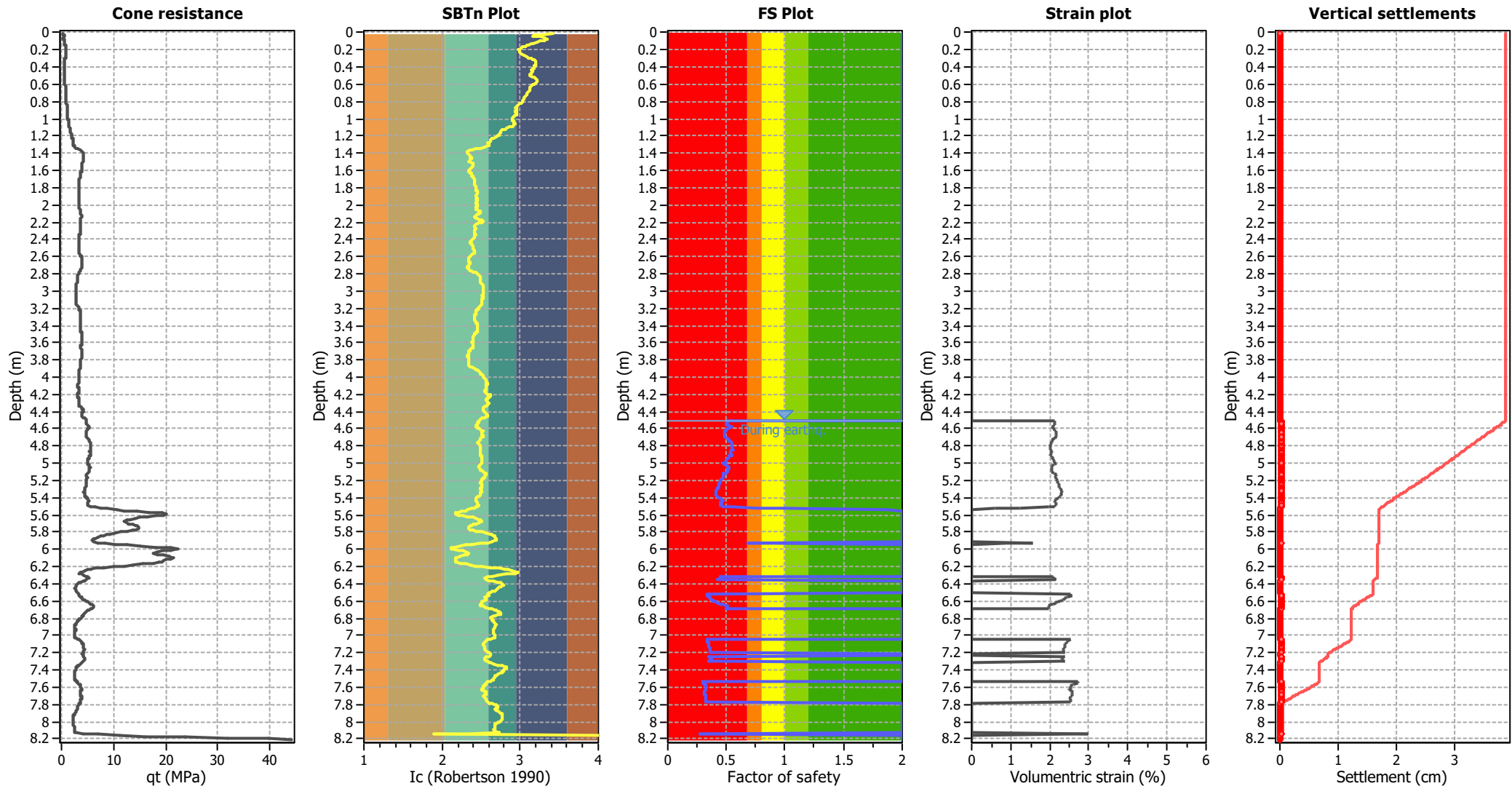
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

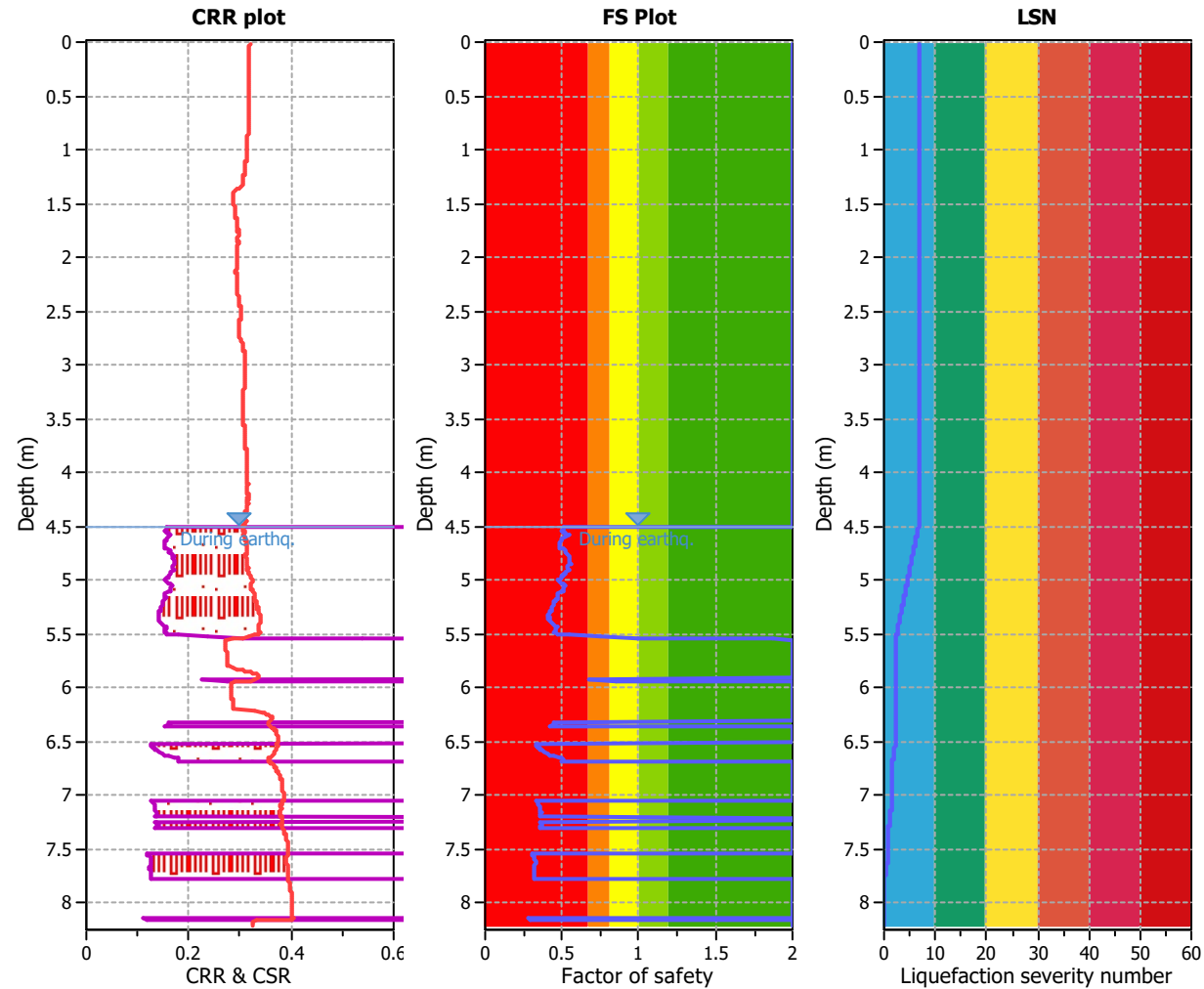
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _o applied:	Yes
Earthquake magnitude M _w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT7

LIQUEFACTION ANALYSIS REPORT

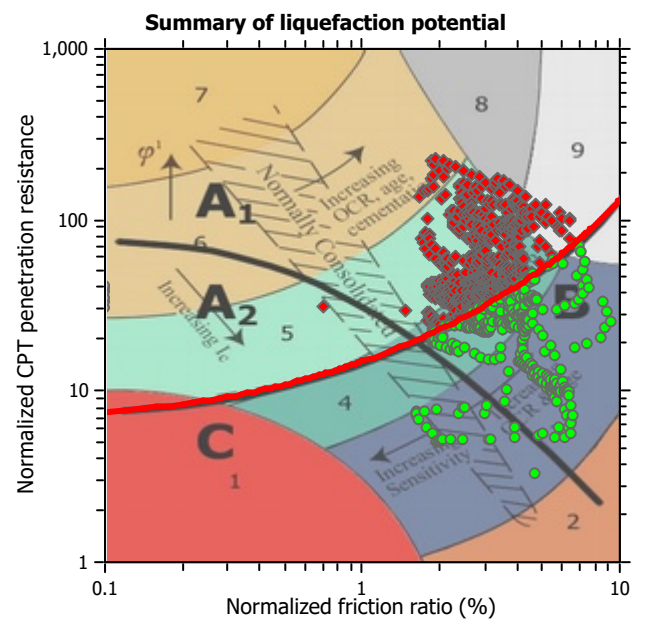
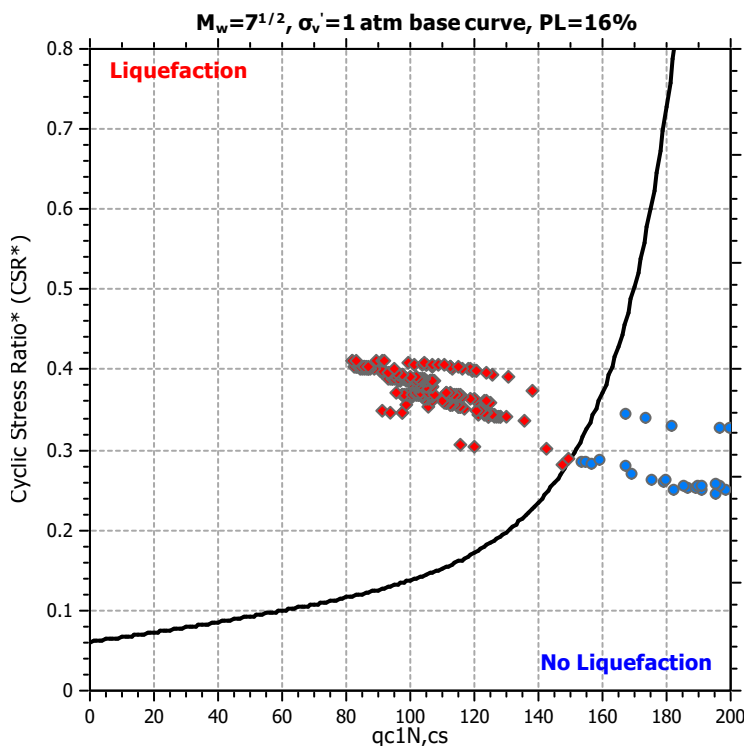
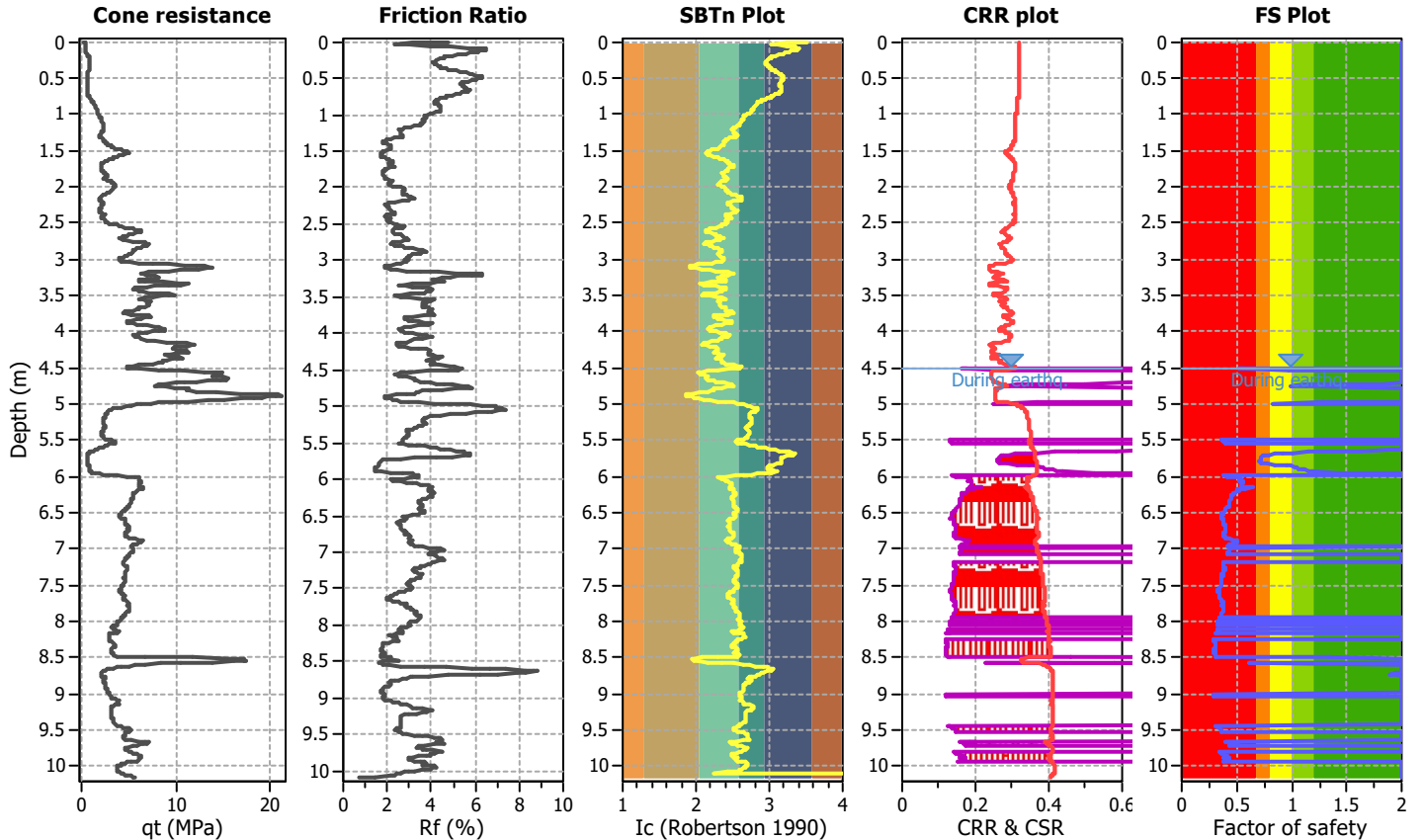
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 7

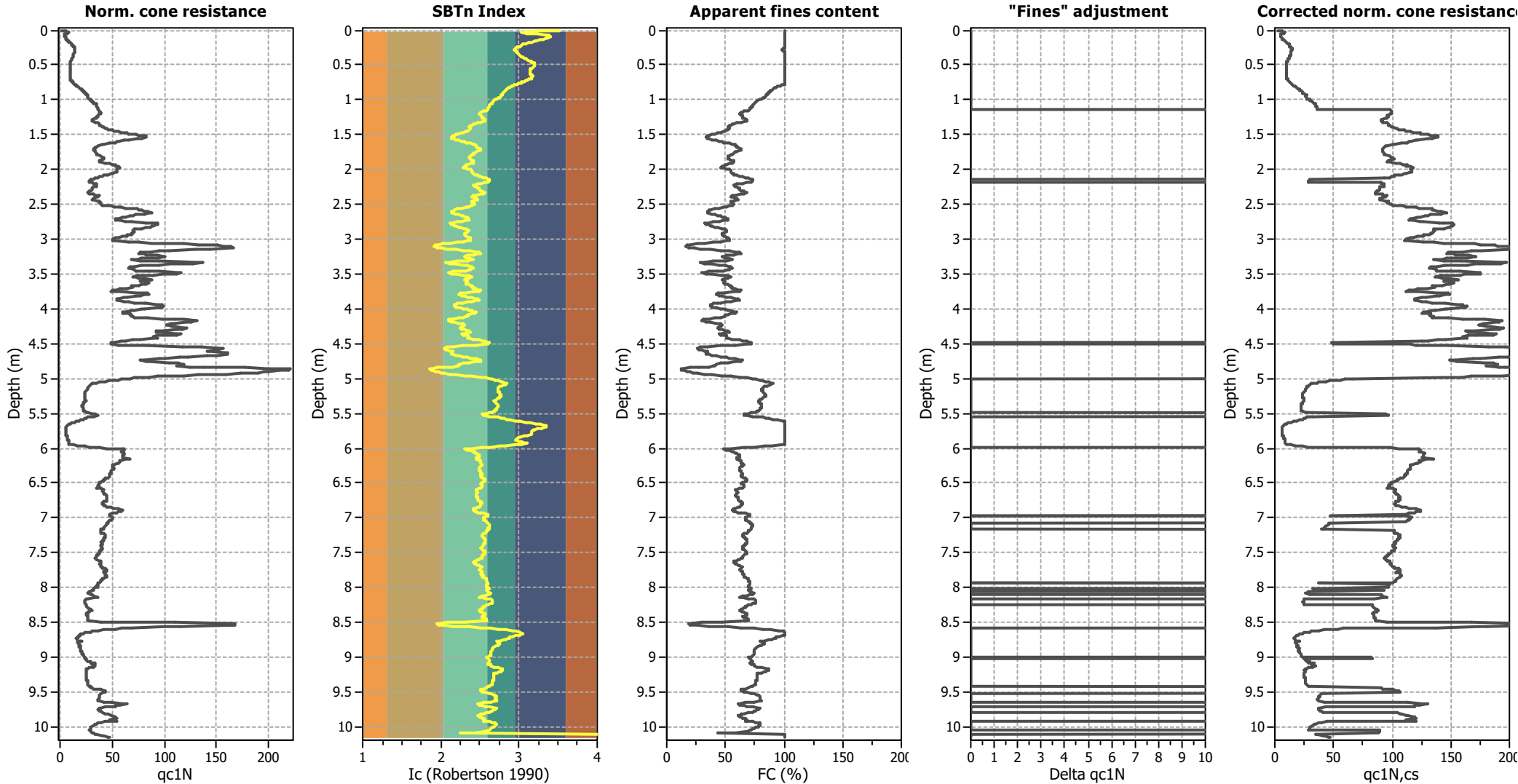
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

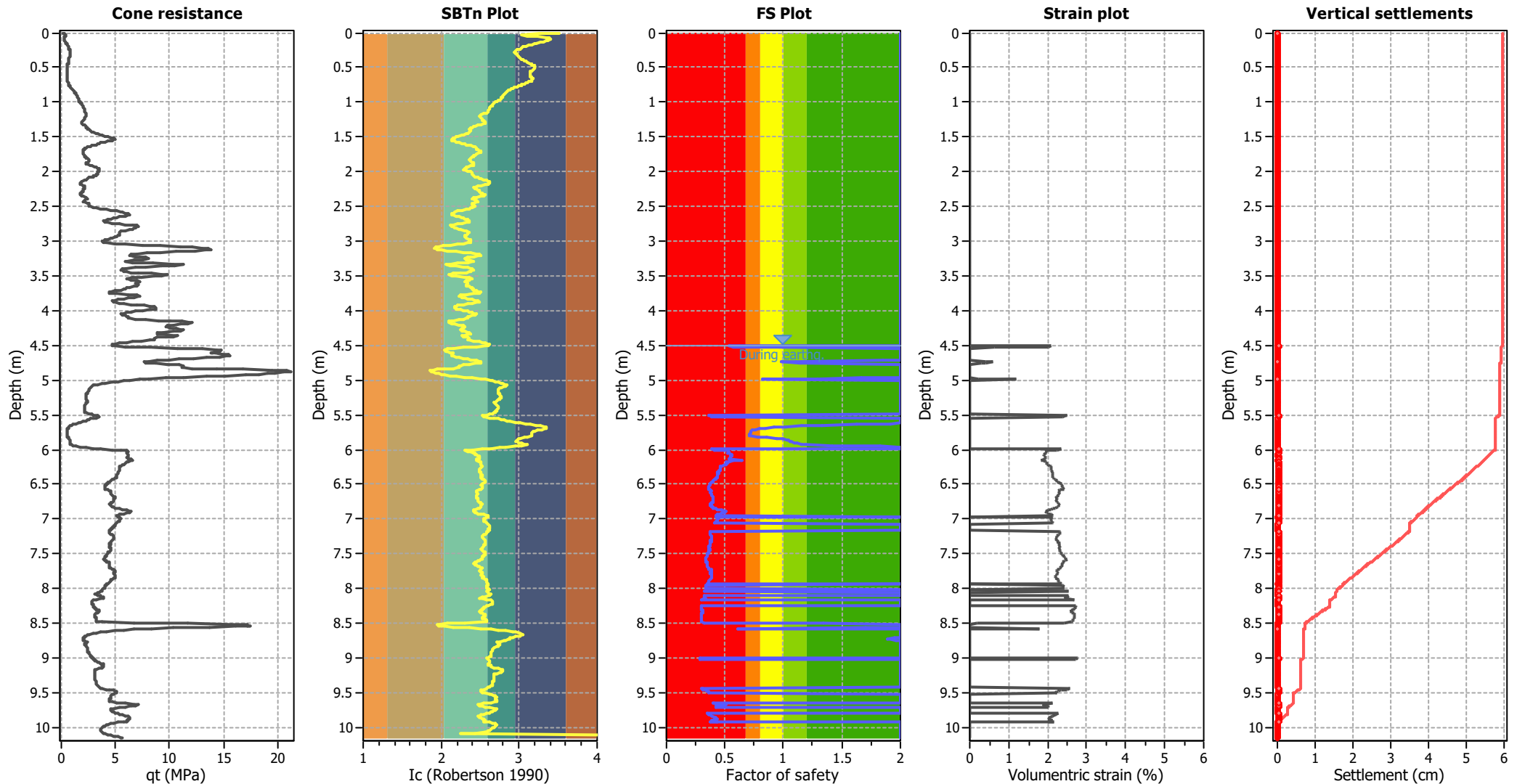
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

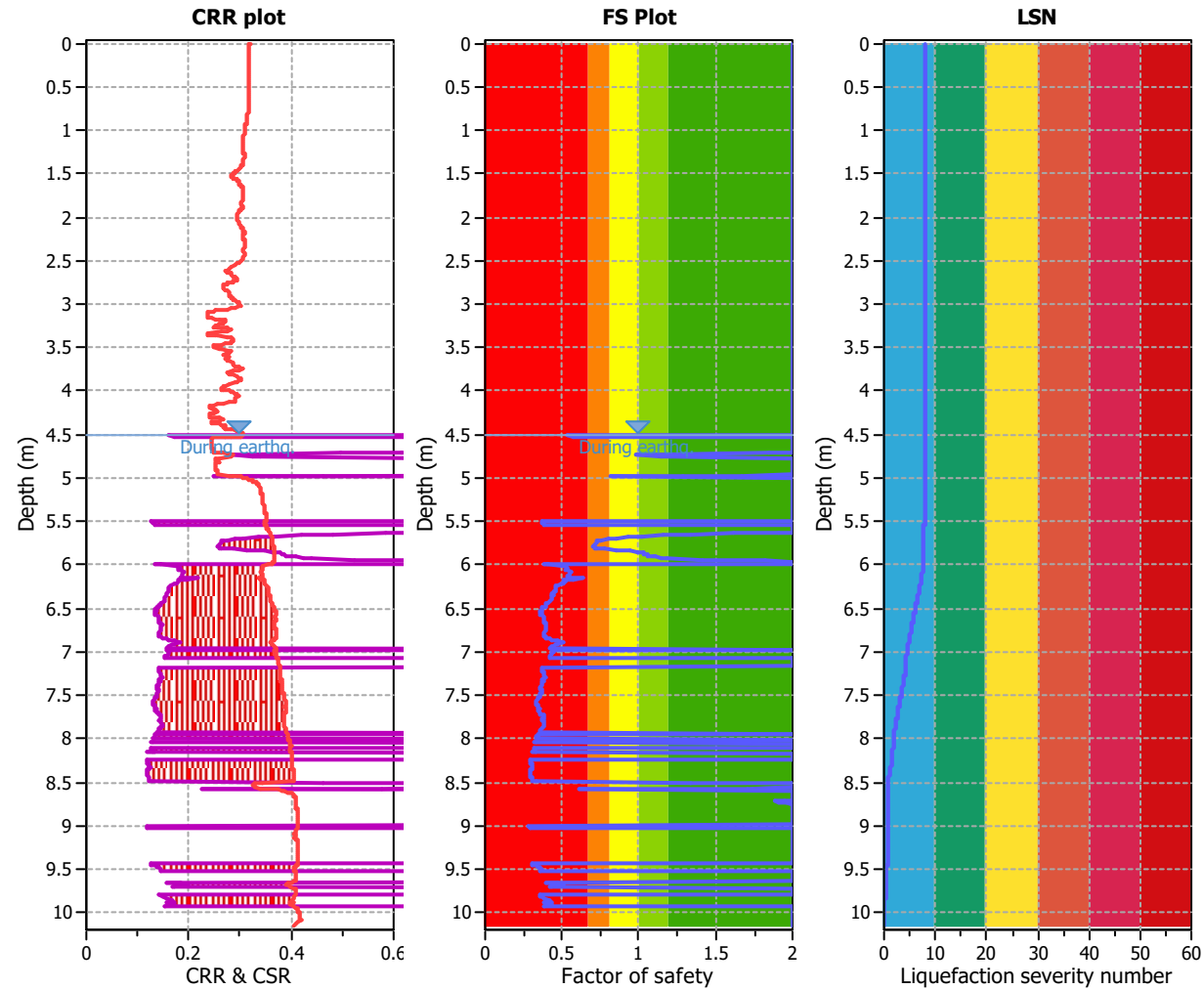
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _o applied:	Yes
Earthquake magnitude M _w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT8

LIQUEFACTION ANALYSIS REPORT

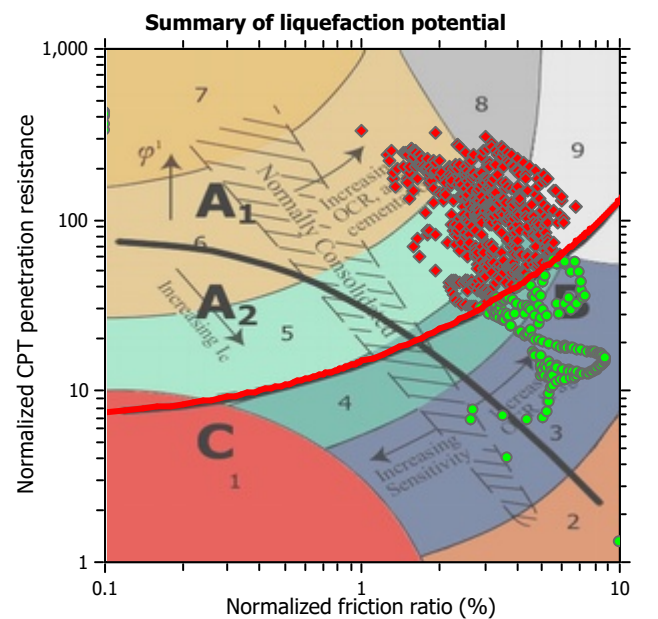
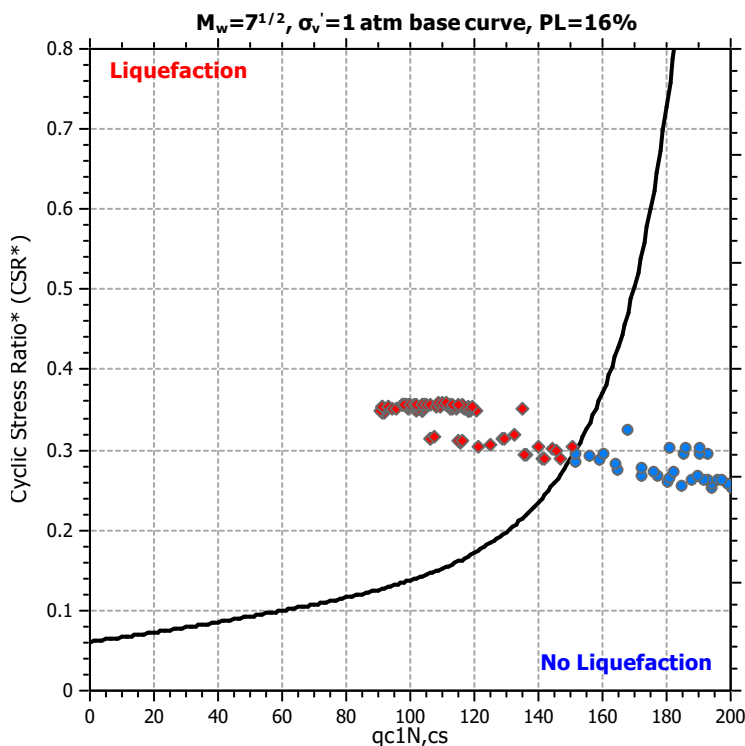
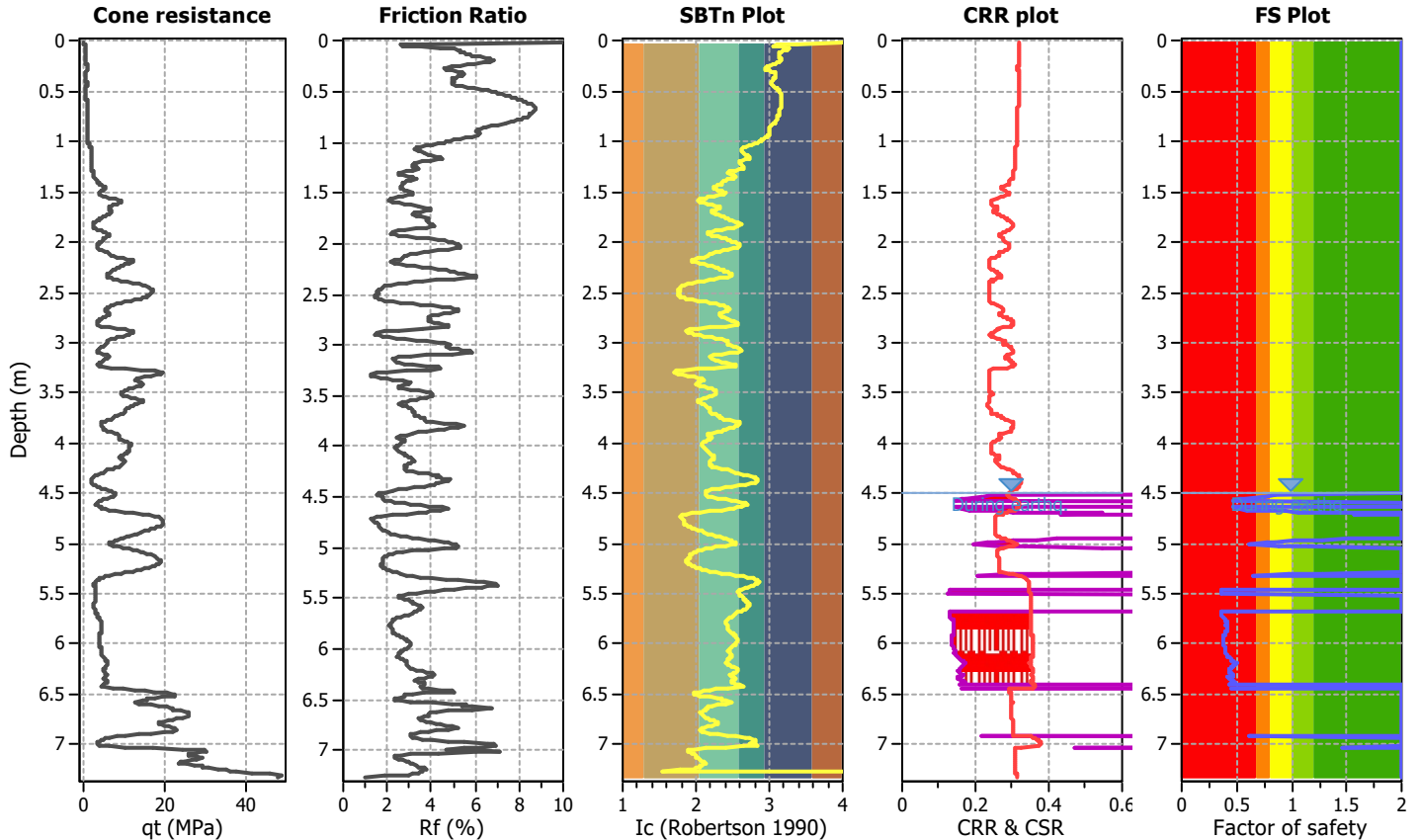
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 8

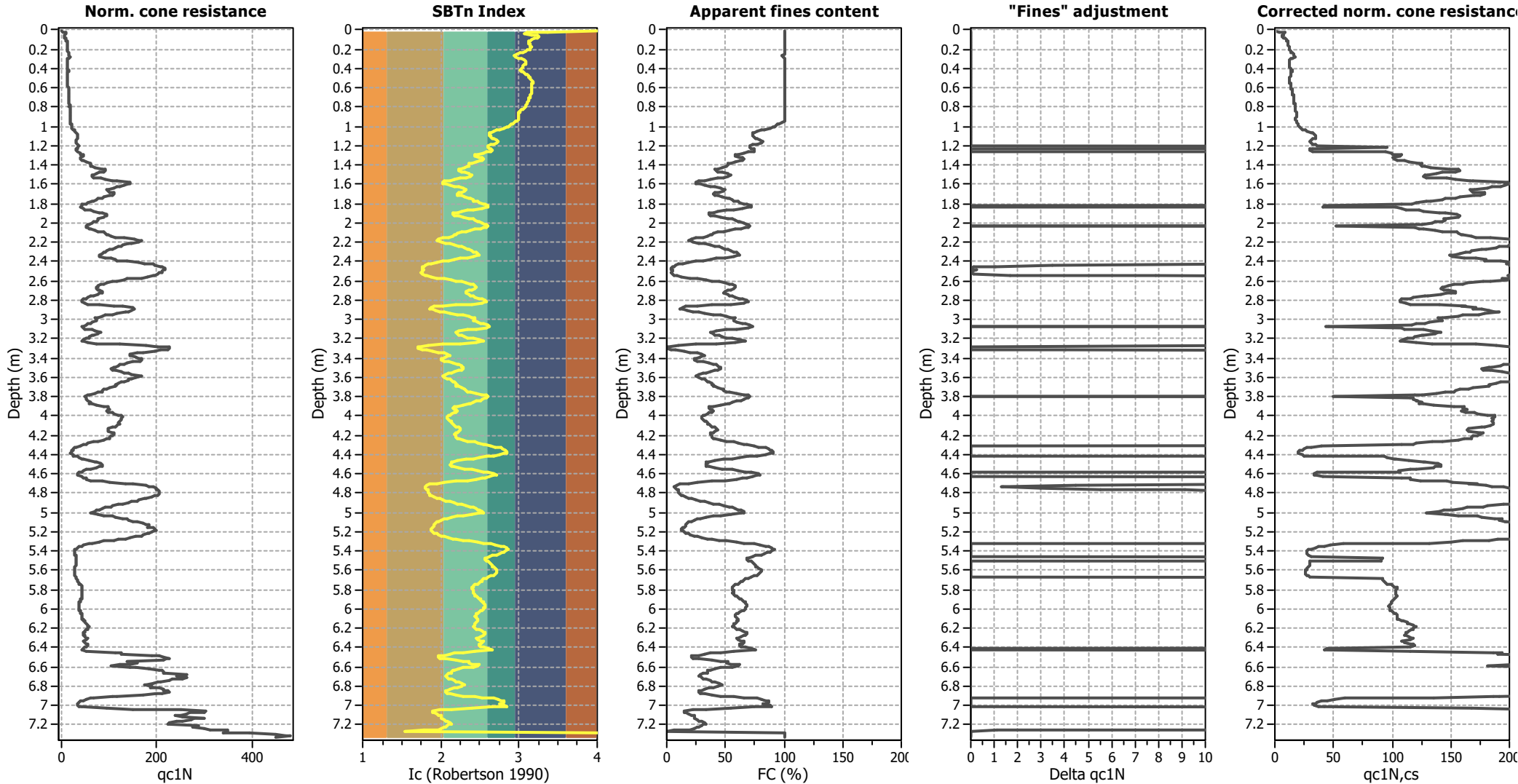
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

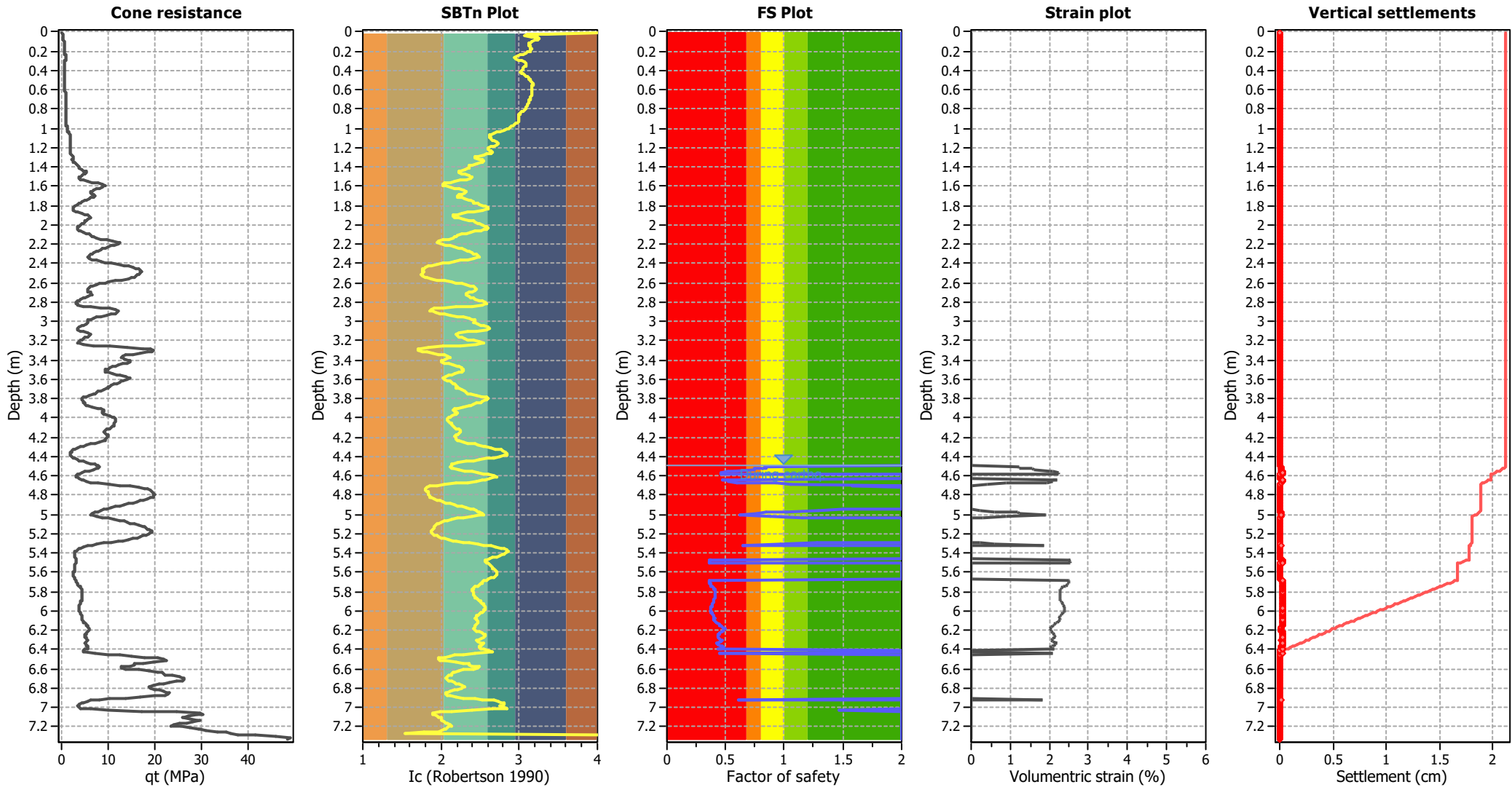
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

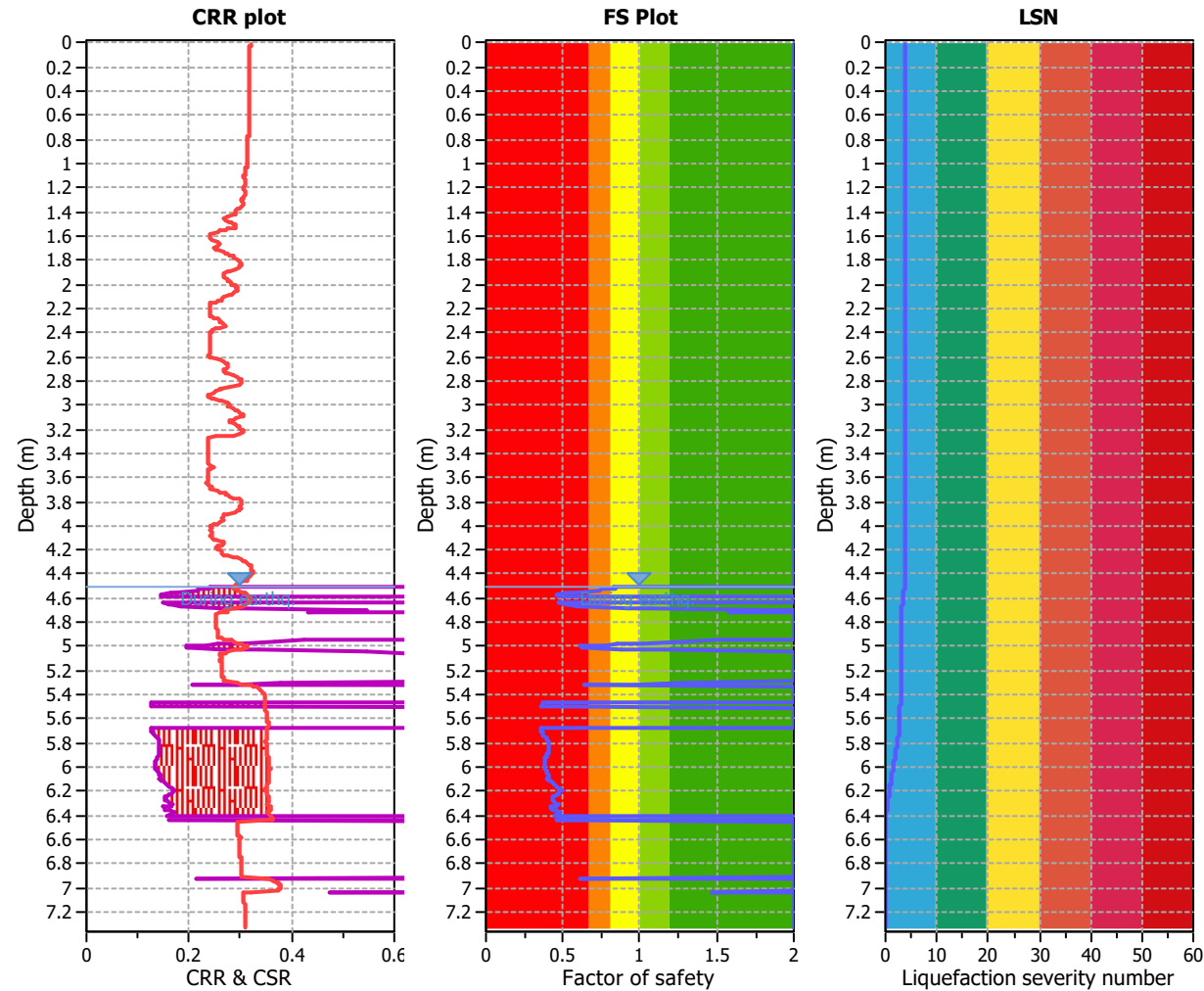
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K ₀ applied:	Yes
Earthquake magnitude M _w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

- q_c: 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
- Volumetric strain: Post-liquefaction volumetric strain



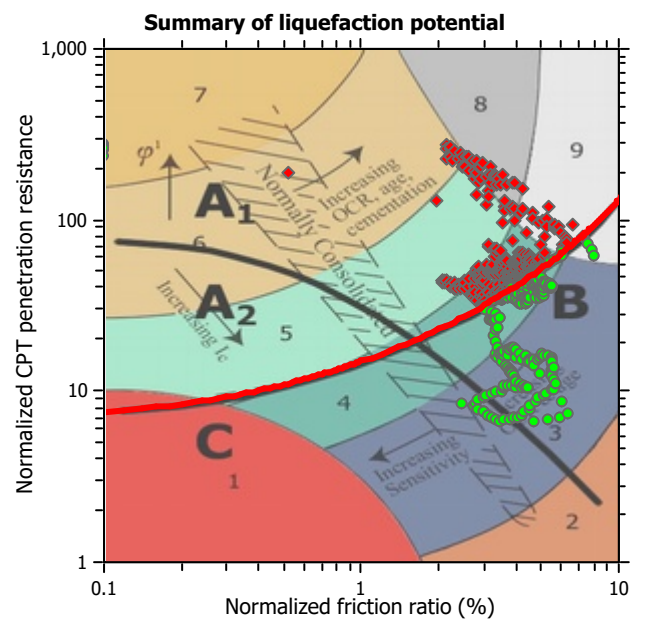
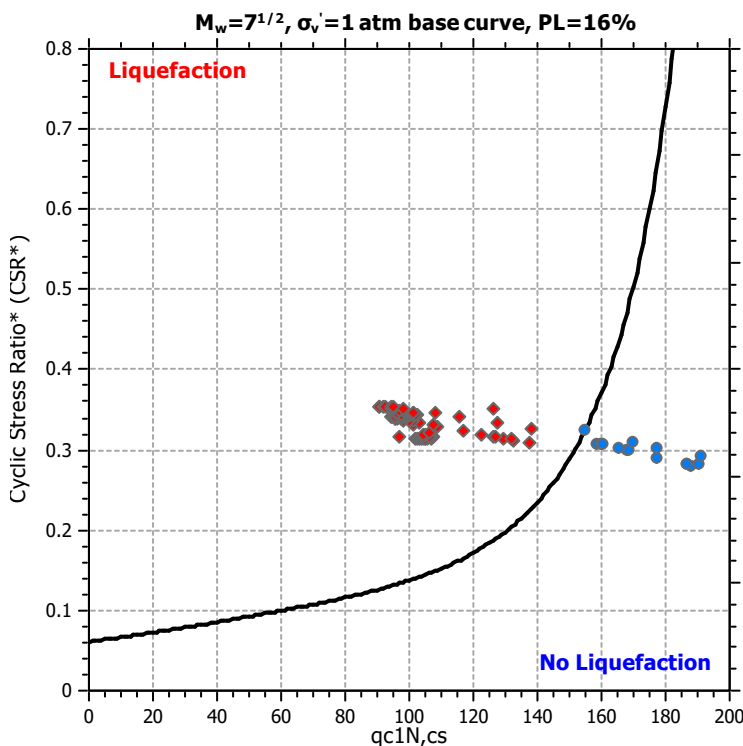
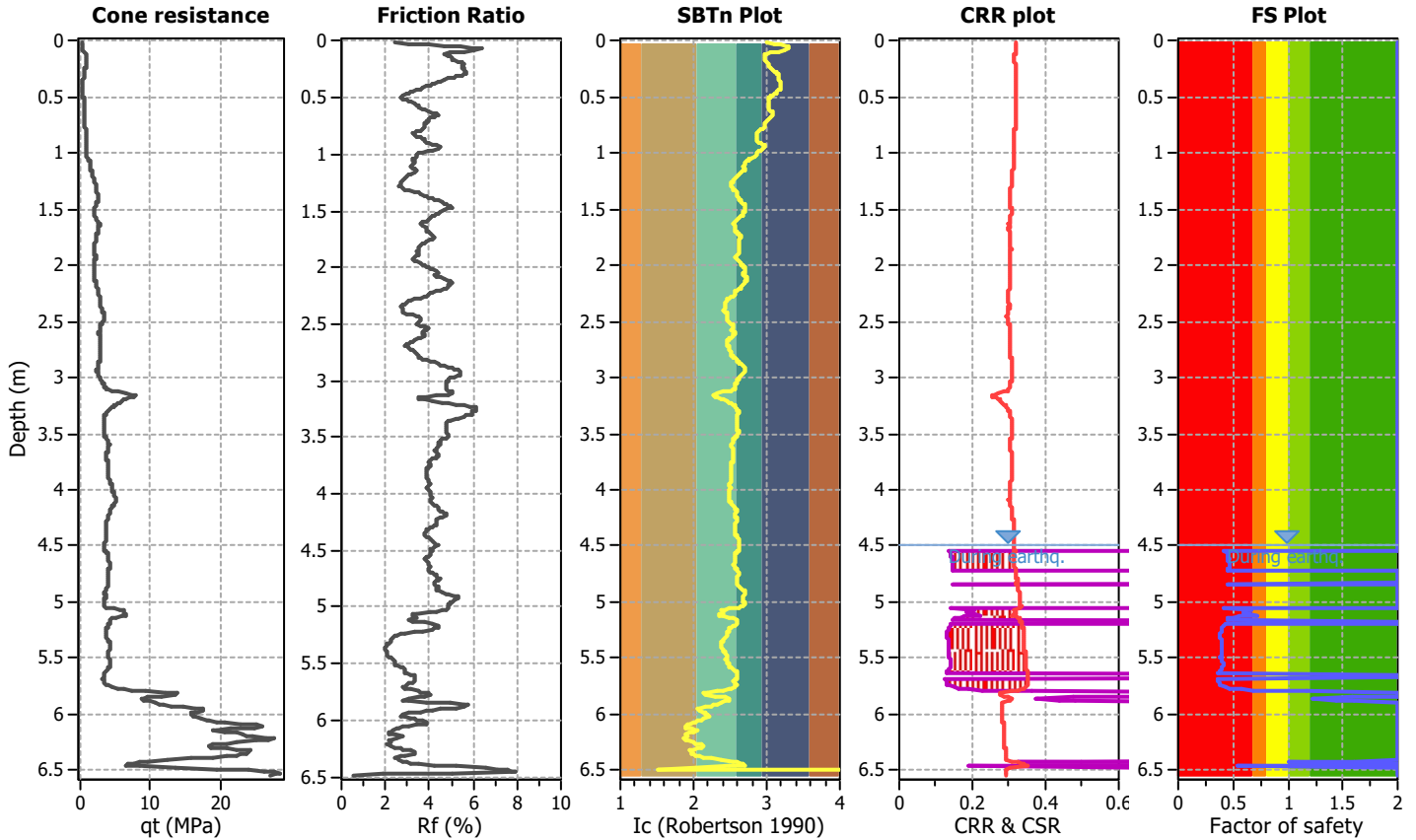
Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT9

LIQUEFACTION ANALYSIS REPORT

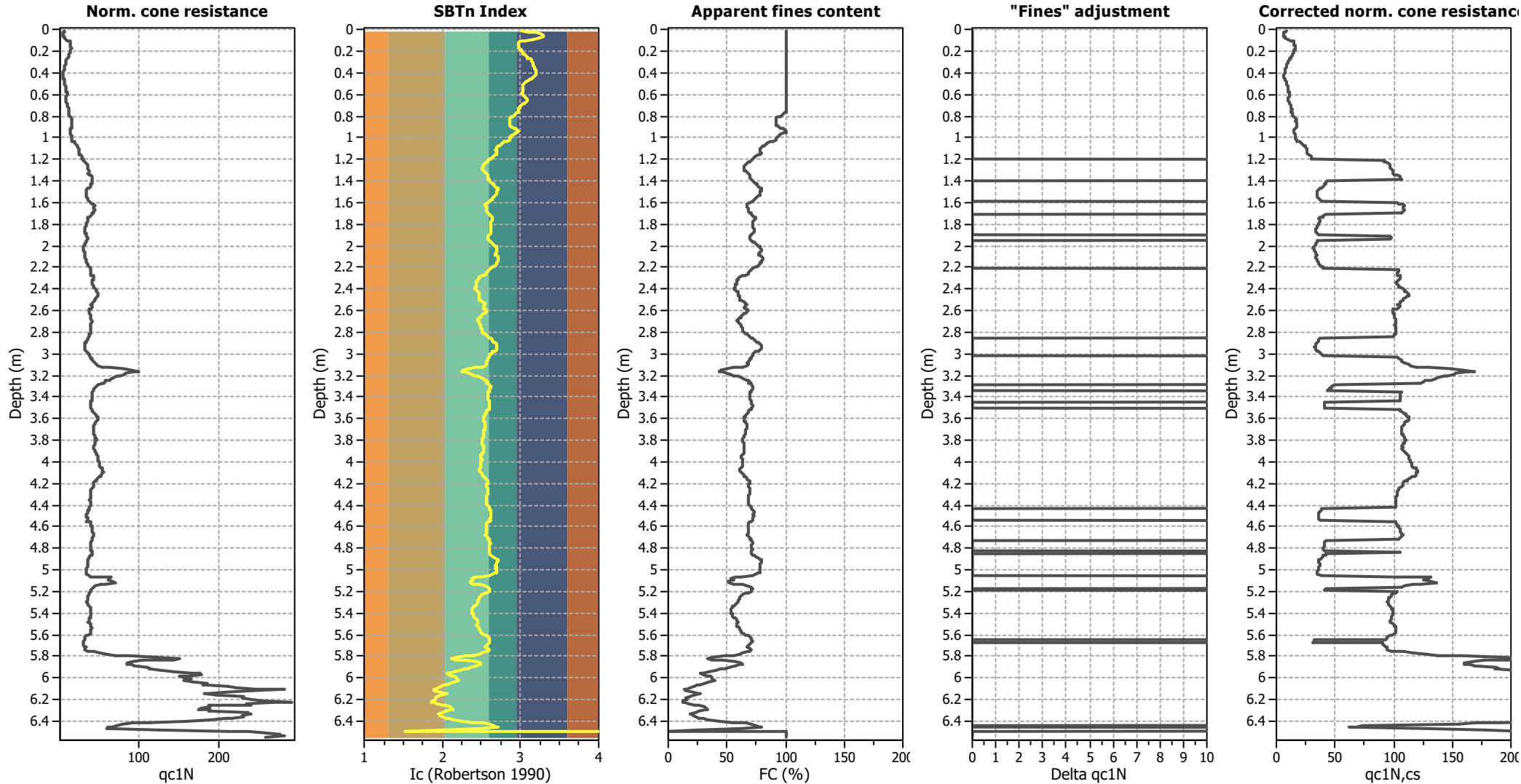
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 9
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

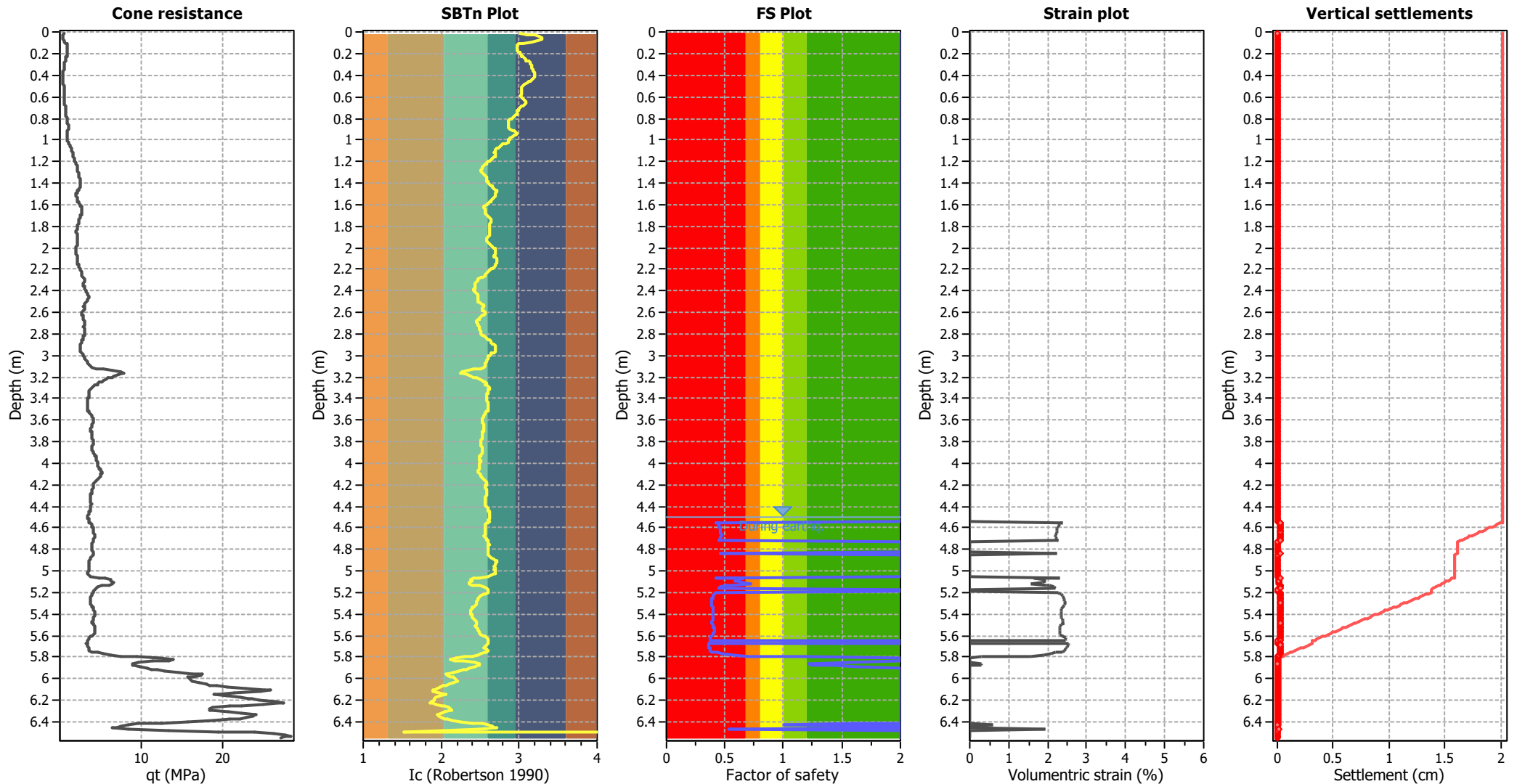
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

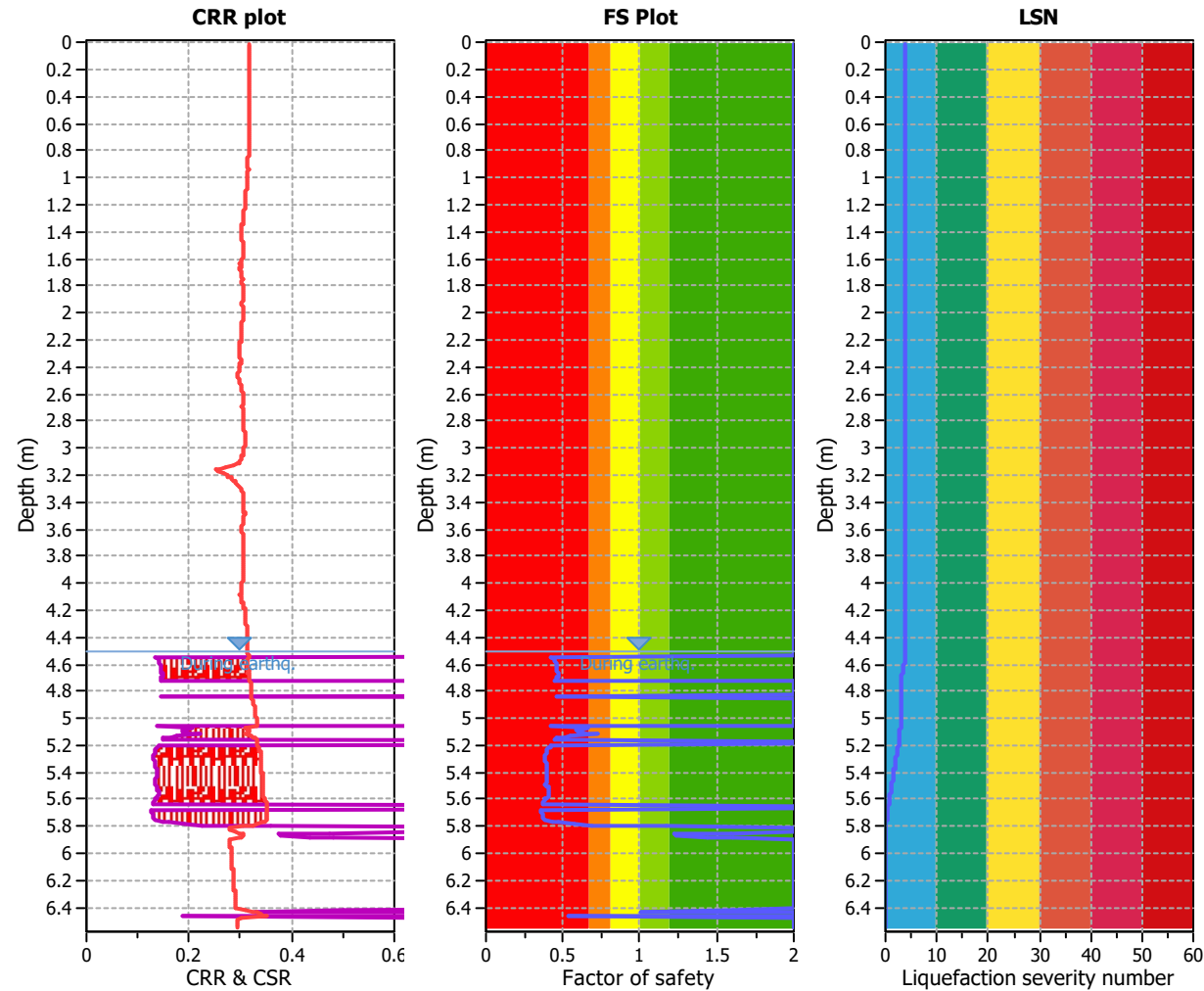
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT10

LIQUEFACTION ANALYSIS REPORT

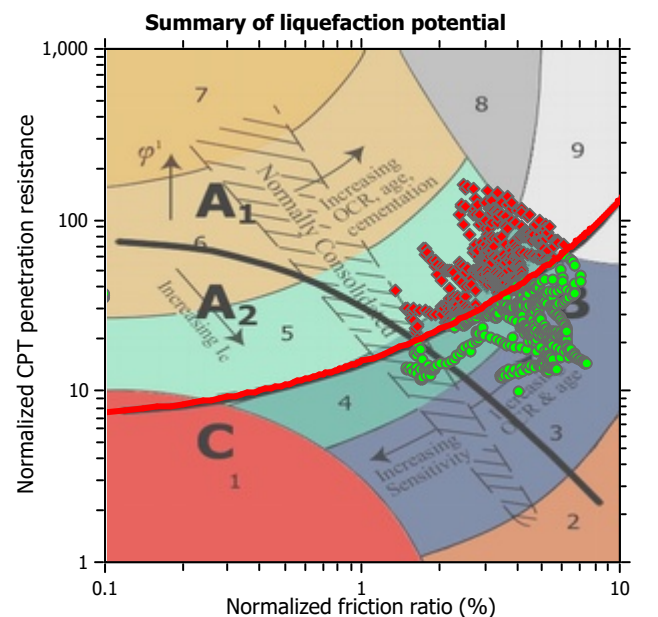
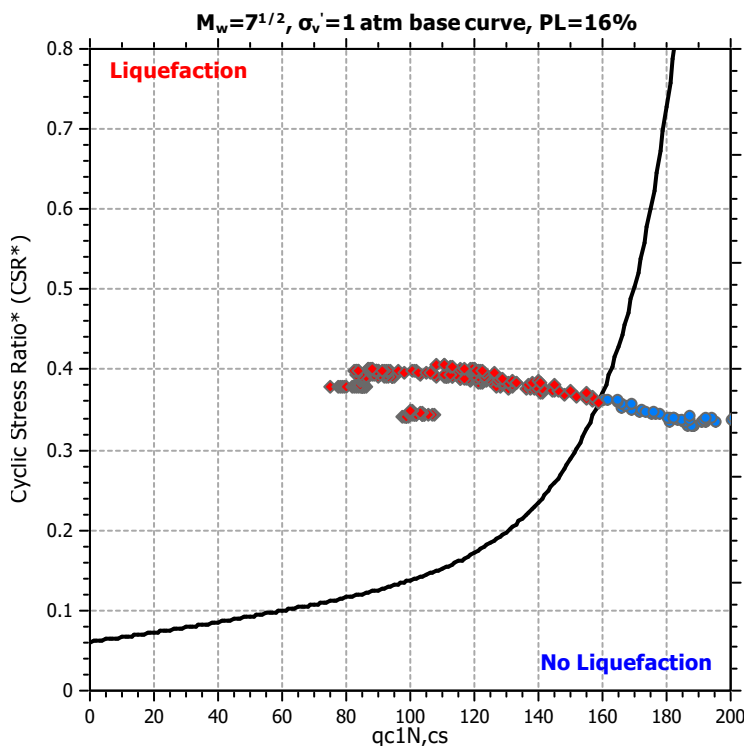
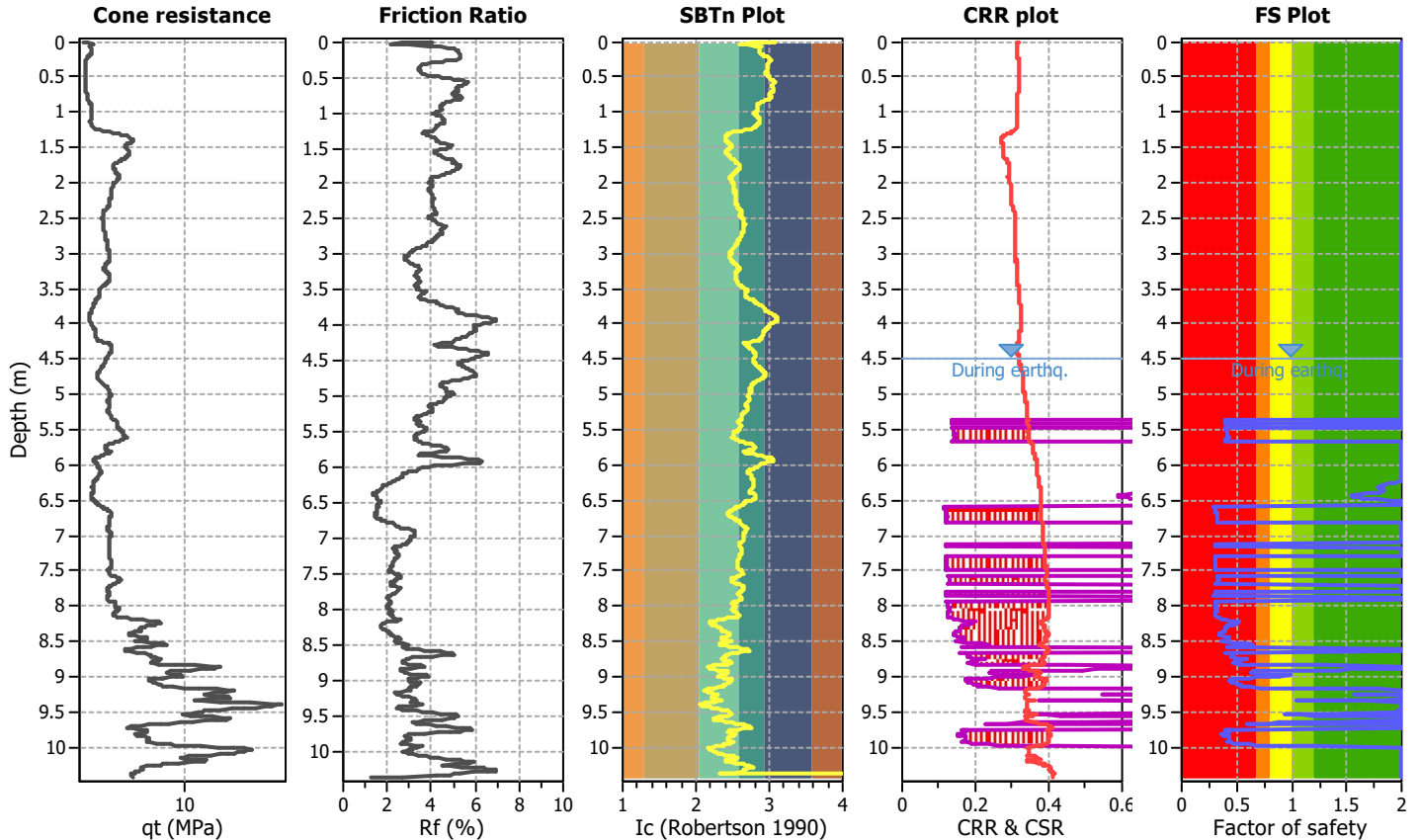
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 10

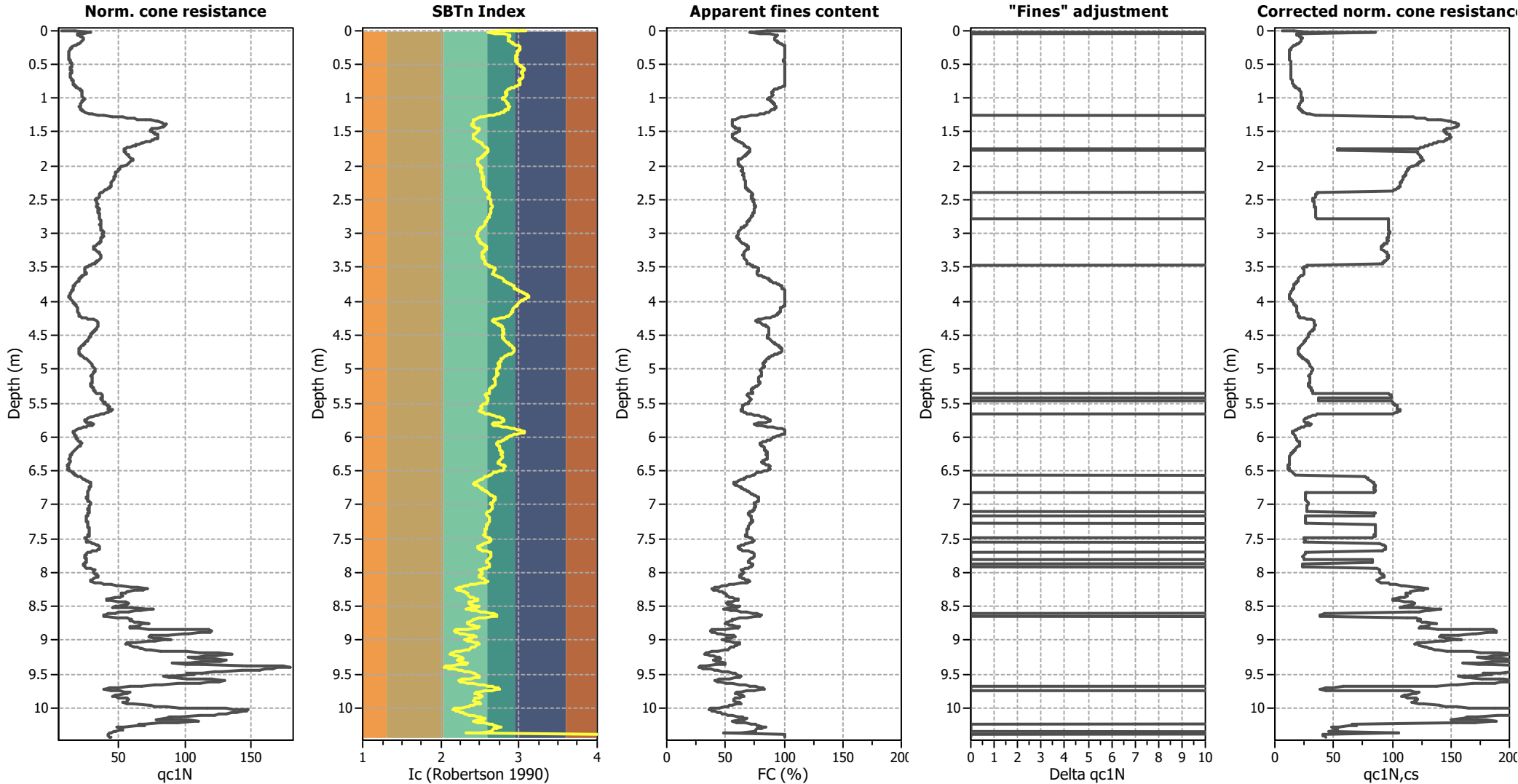
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

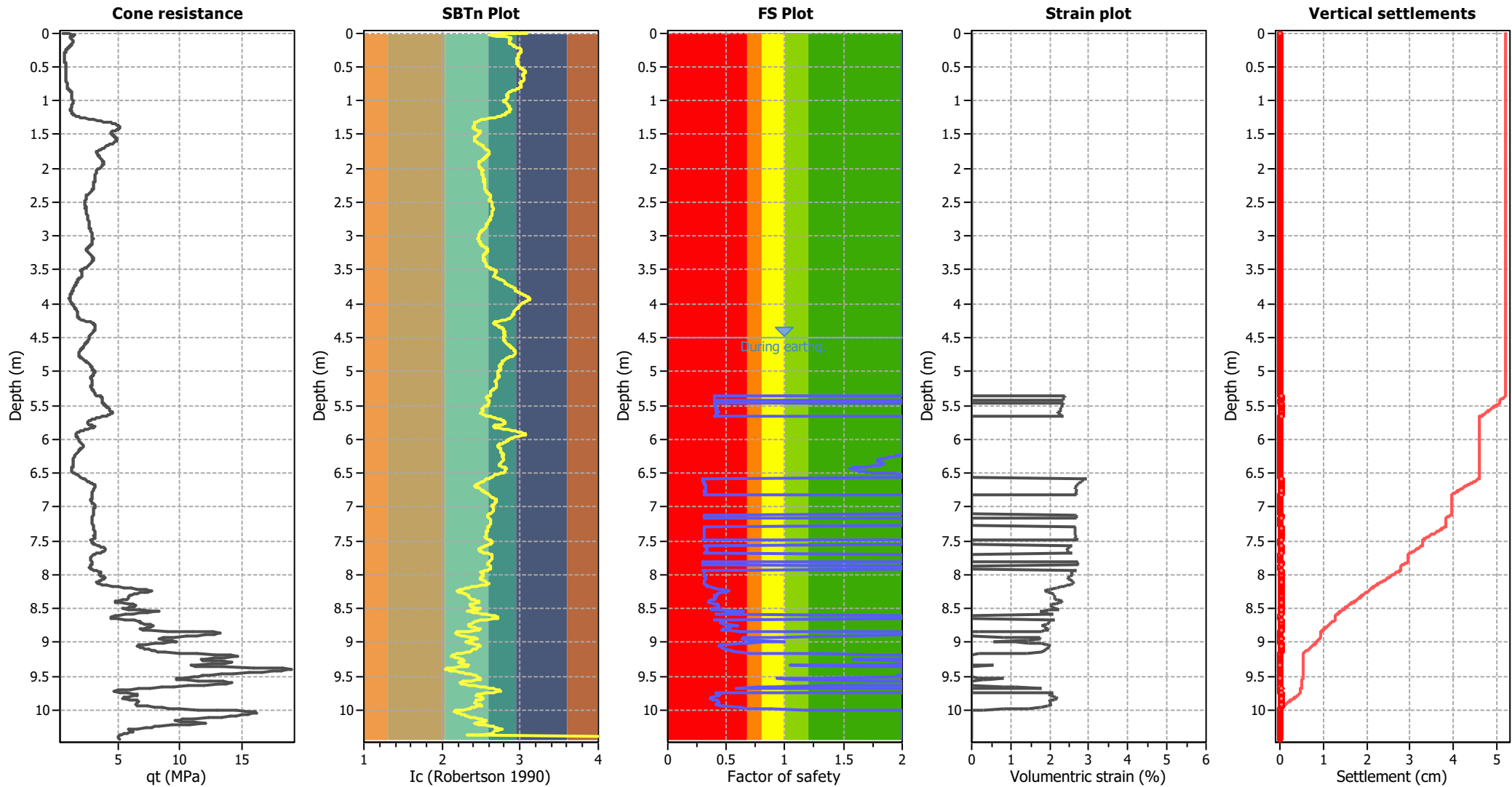
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

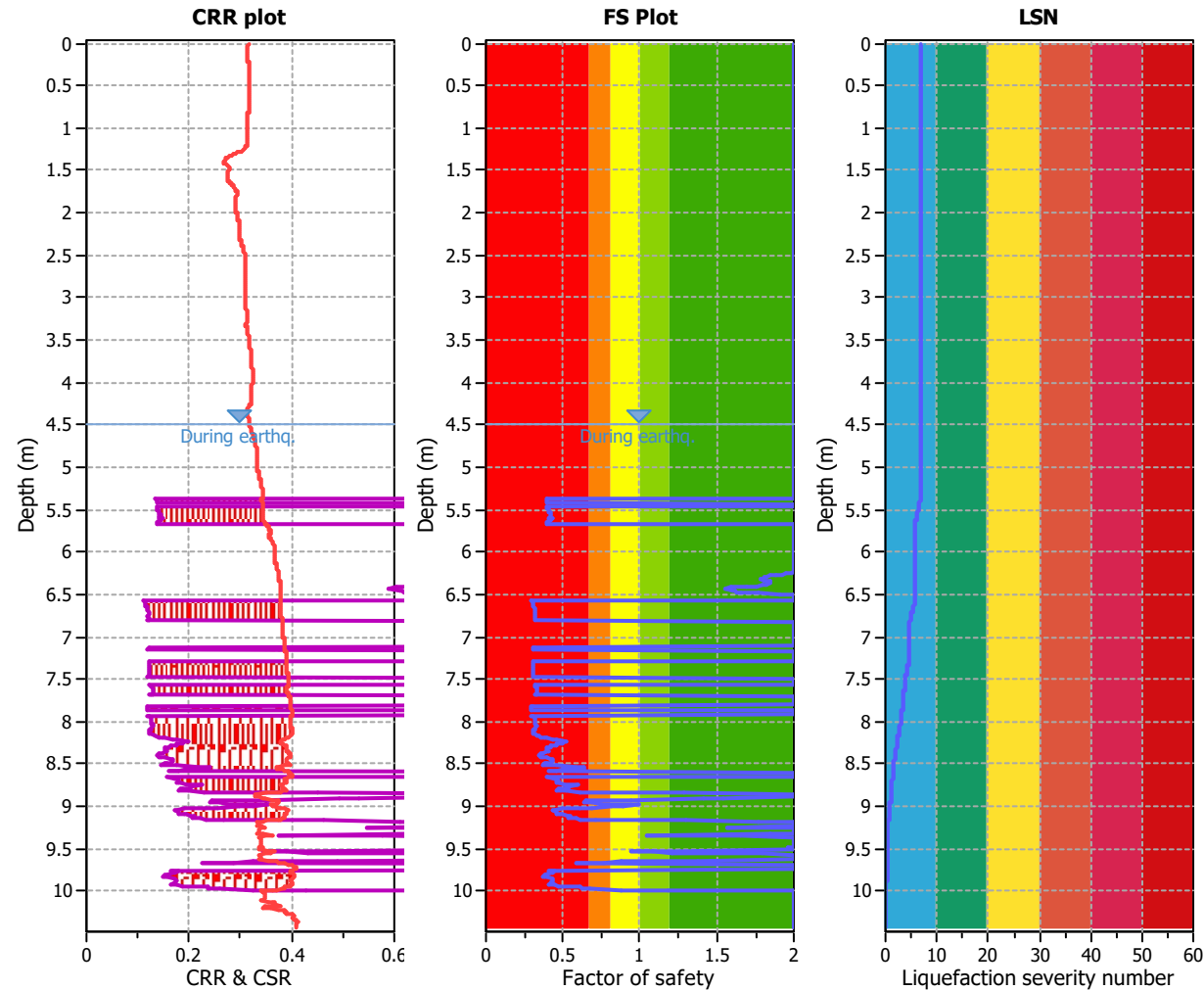
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

- q_c: 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
Volumetric strain: Post-liquefaction volumetric strain



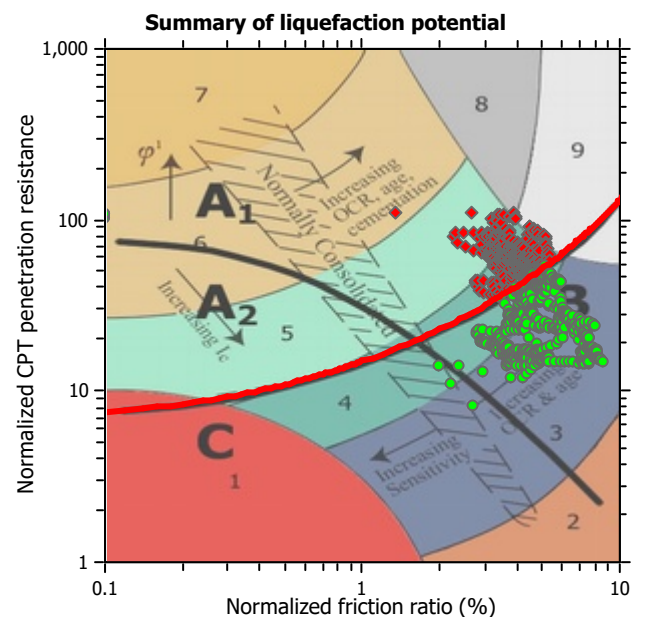
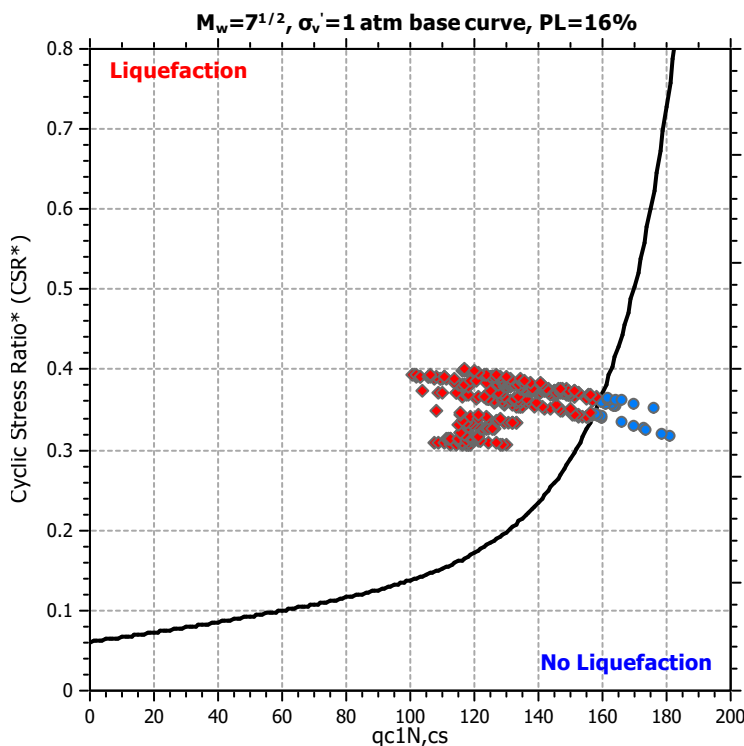
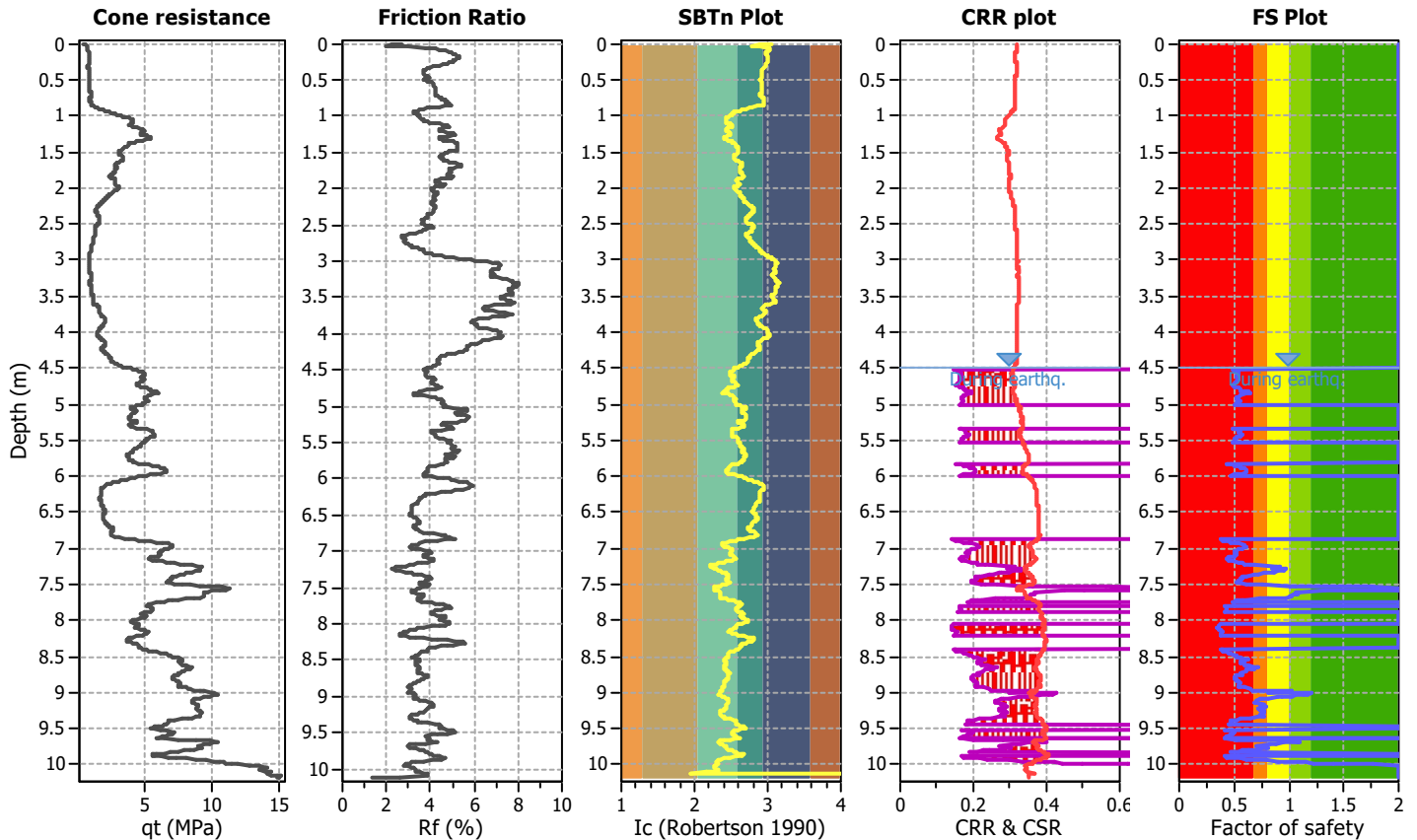
Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

CPT11

LIQUEFACTION ANALYSIS REPORT

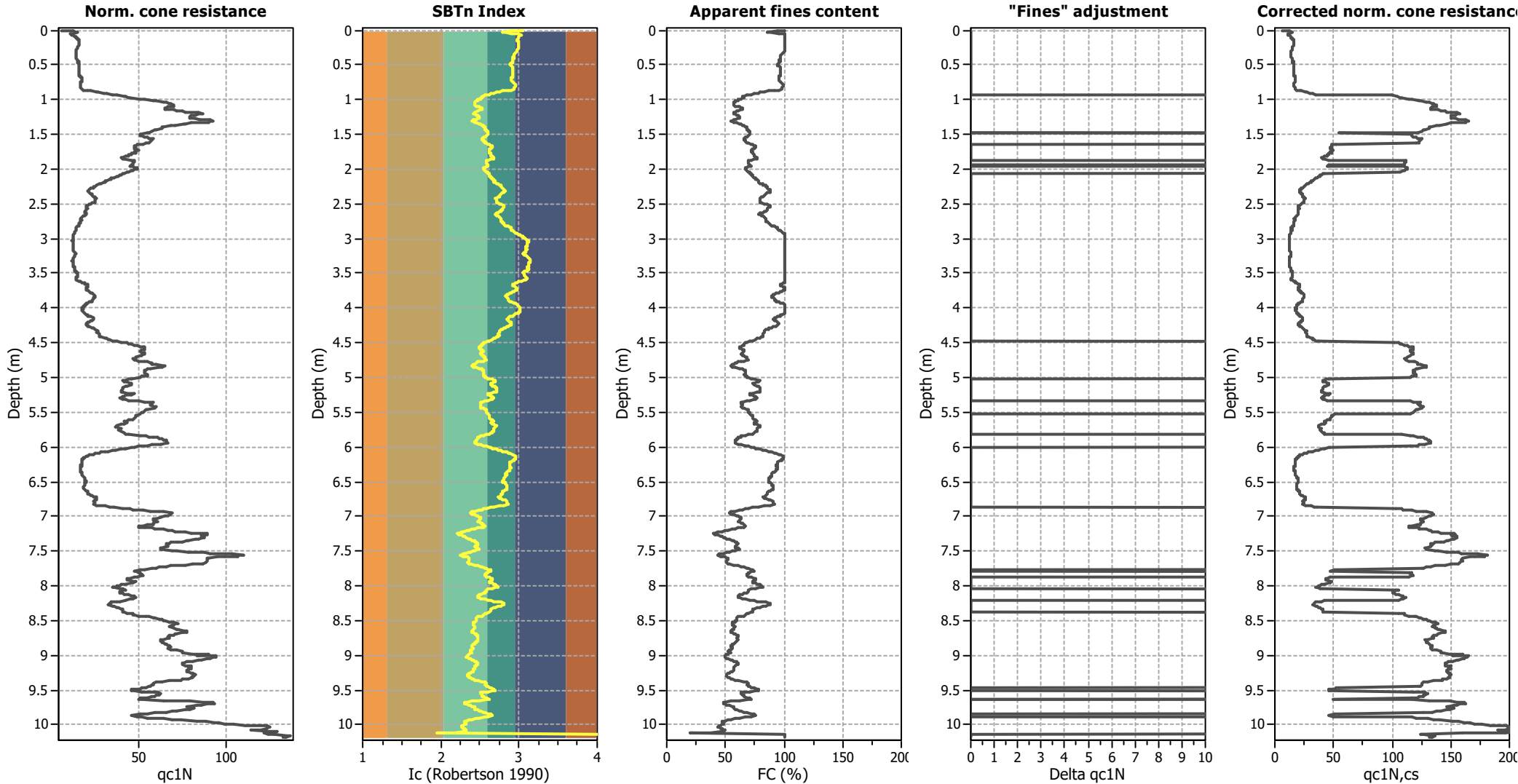
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 11
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

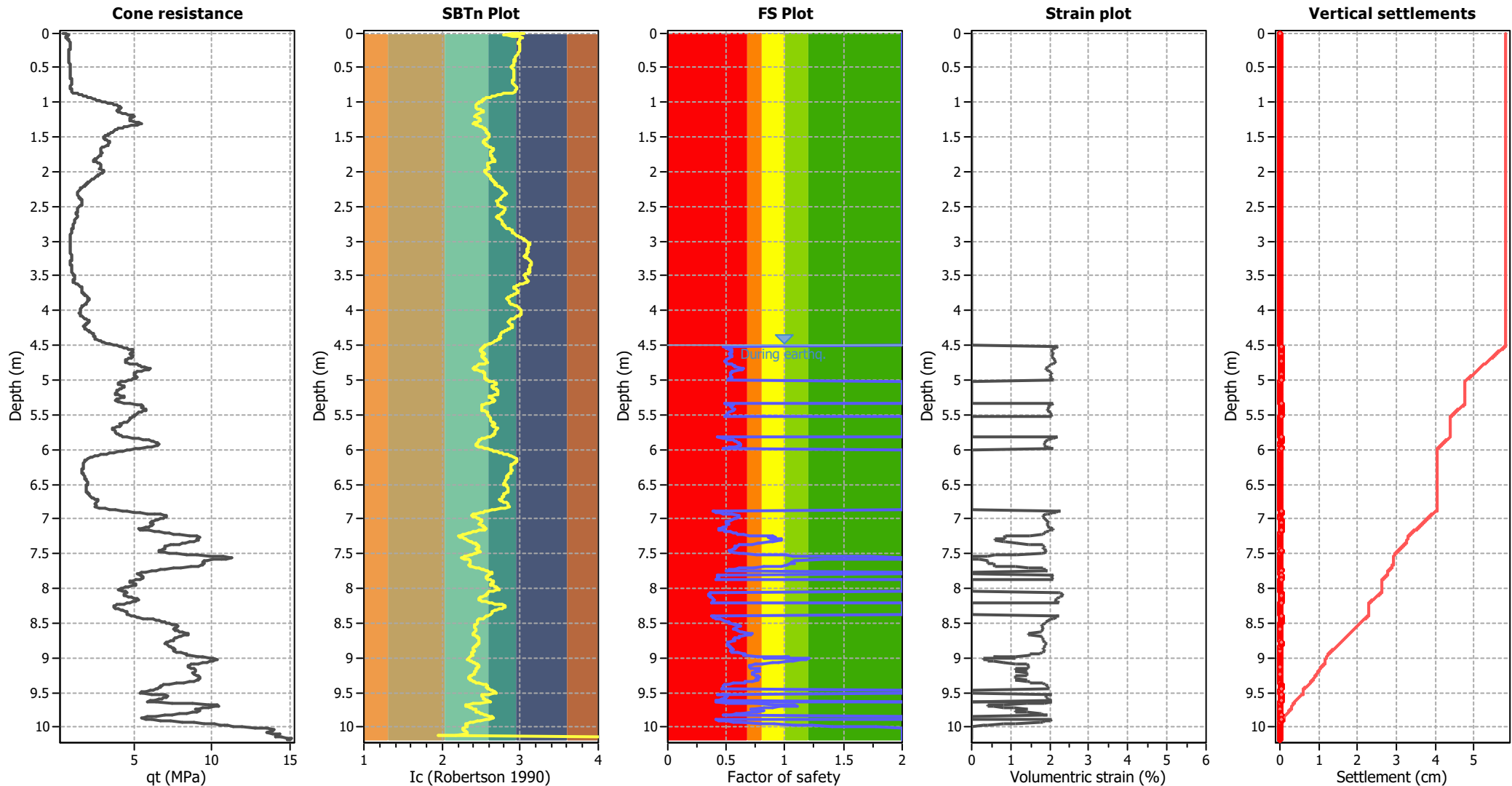
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

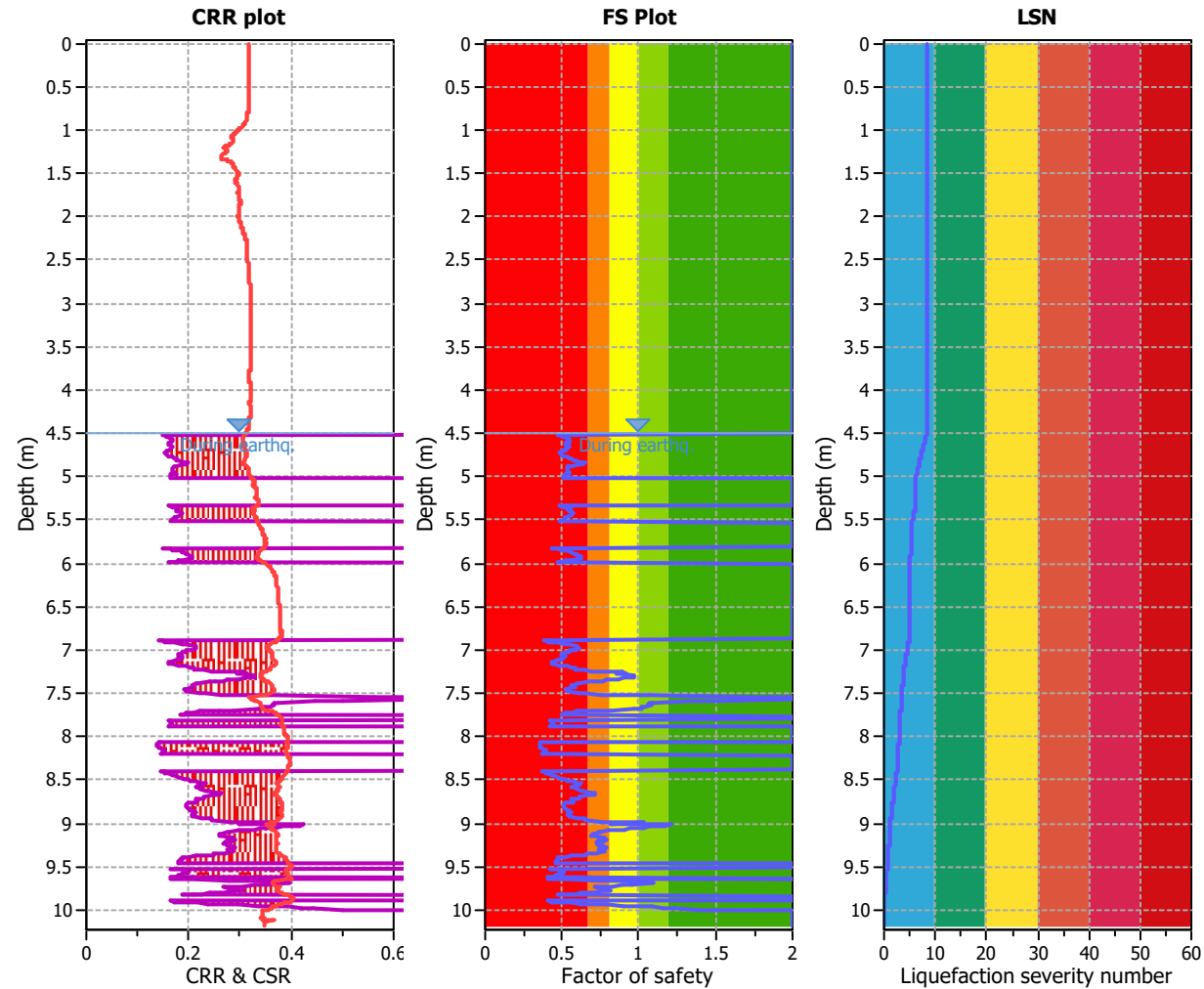
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.50 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.50 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



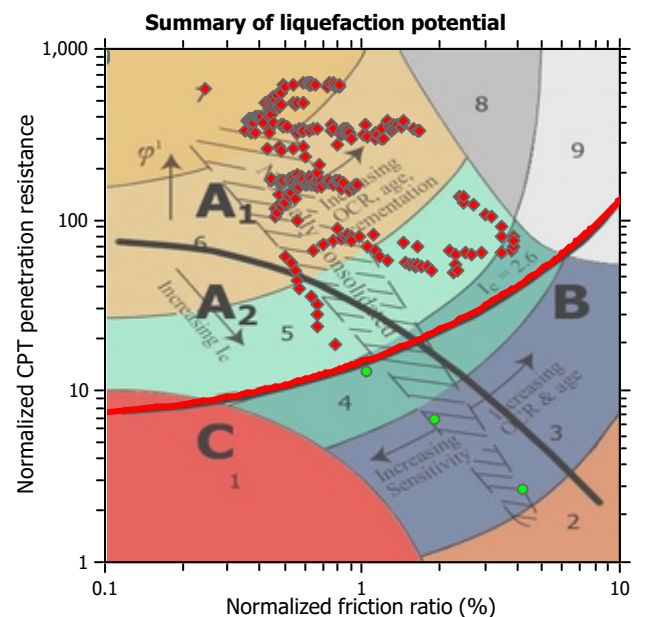
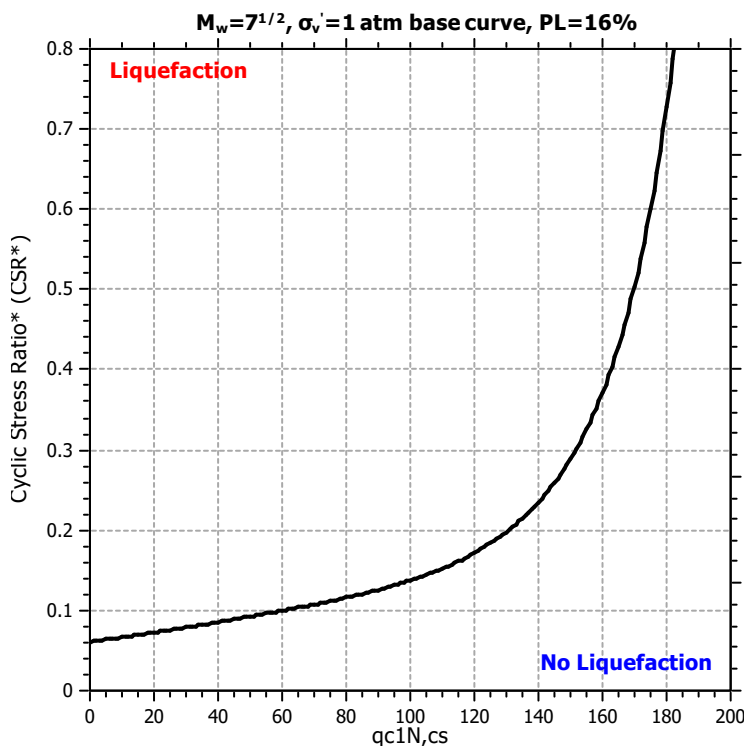
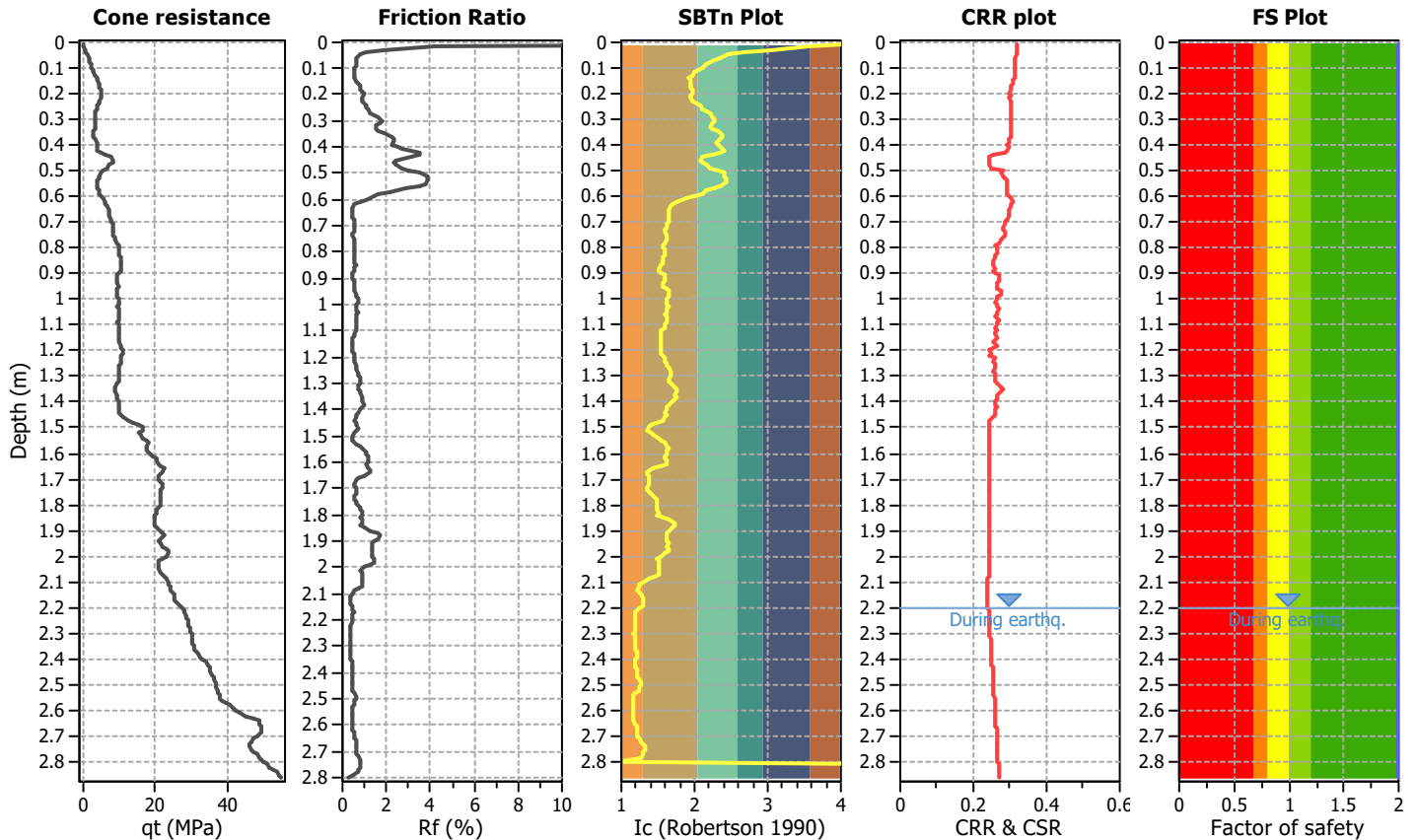
Analysis method:	B&I (2014)	G.W.T. (in-situ):	4.50 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	4.50 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT12

LIQUEFACTION ANALYSIS REPORT

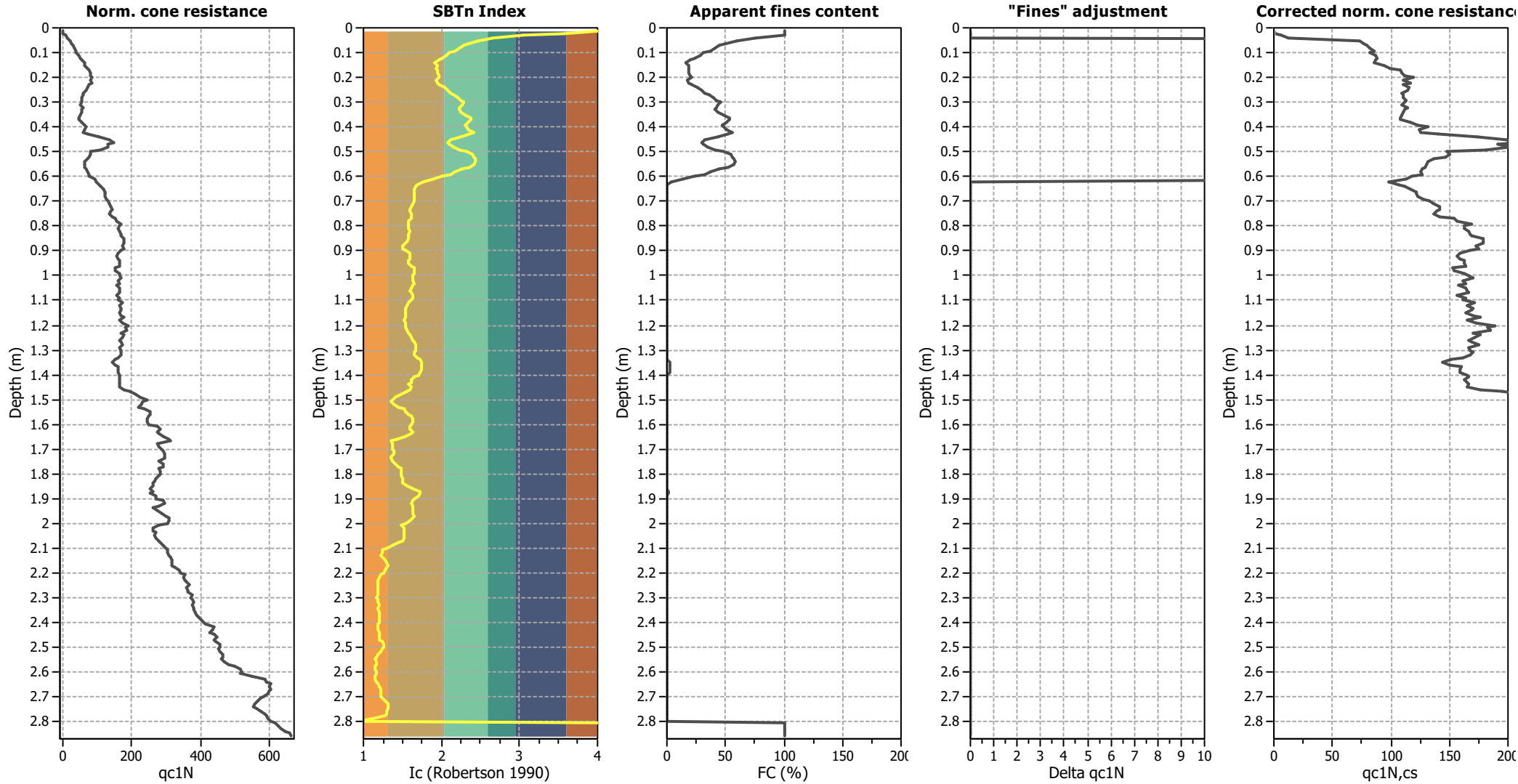
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 12
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

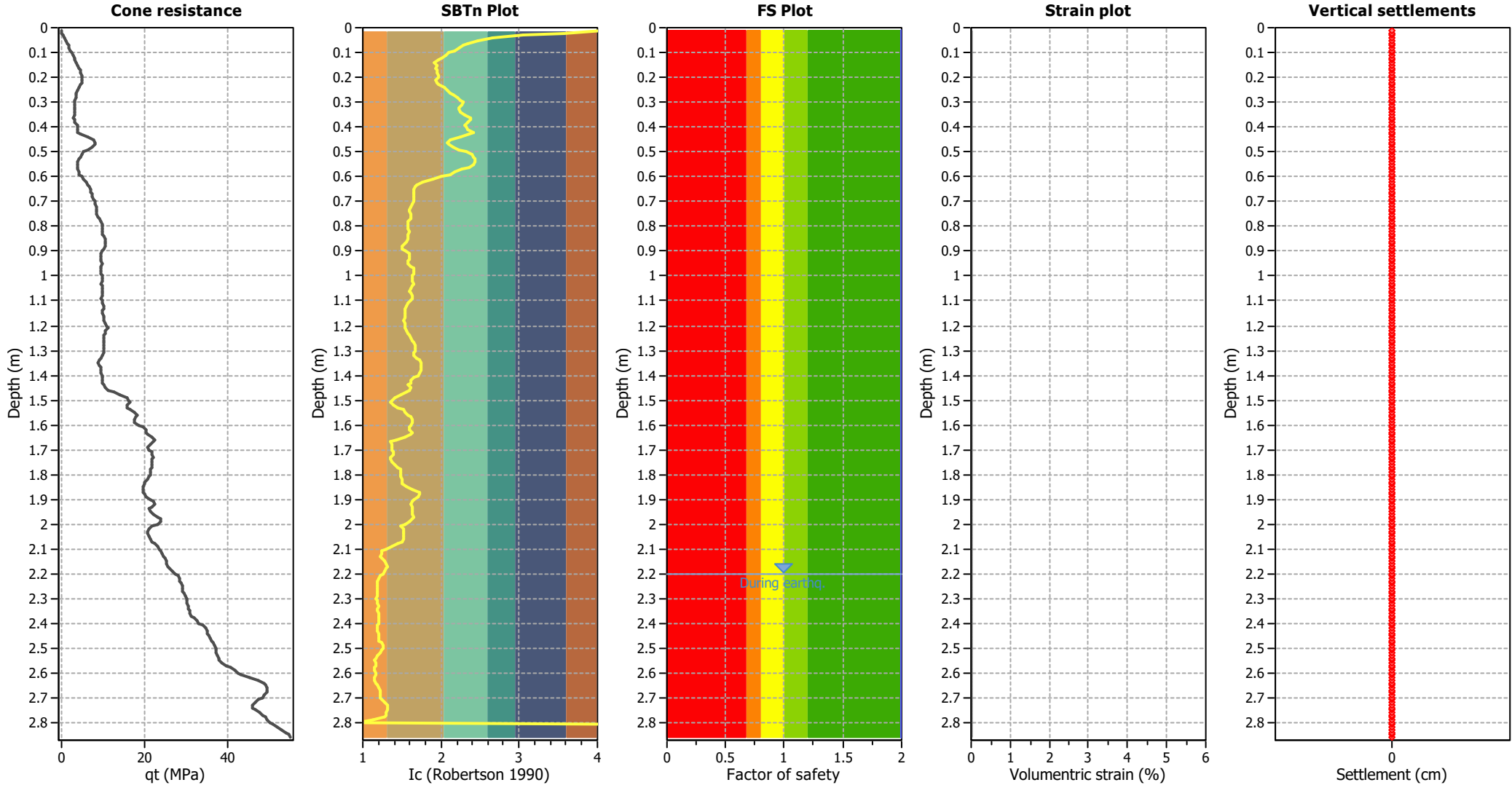
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

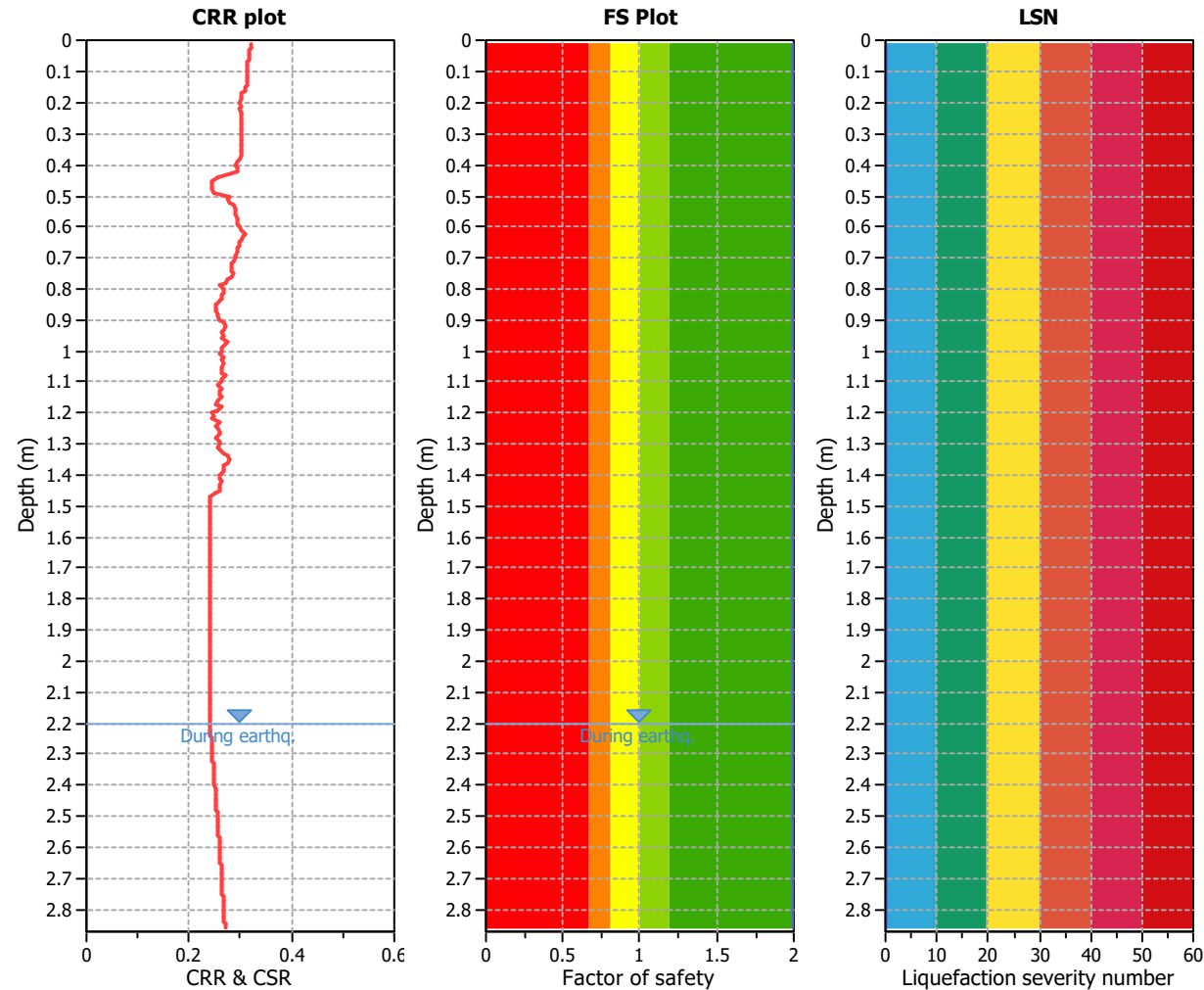
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.20 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_g applied:	Yes
Earthquake magnitude M_w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.20 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain



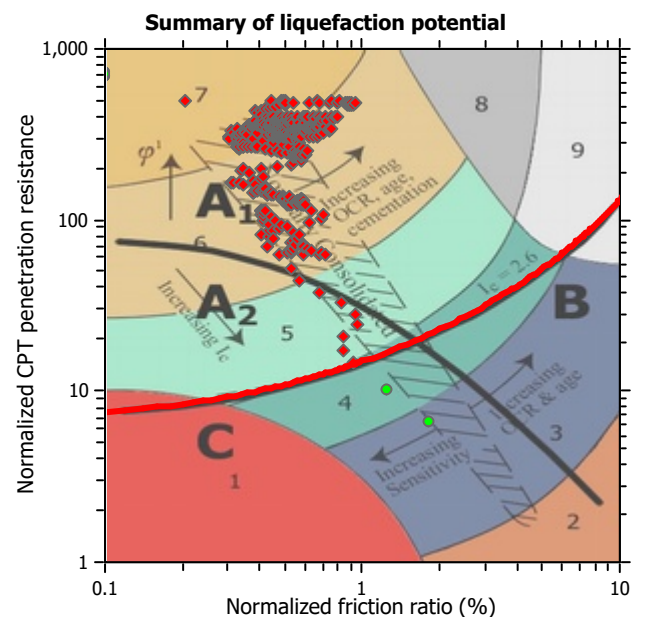
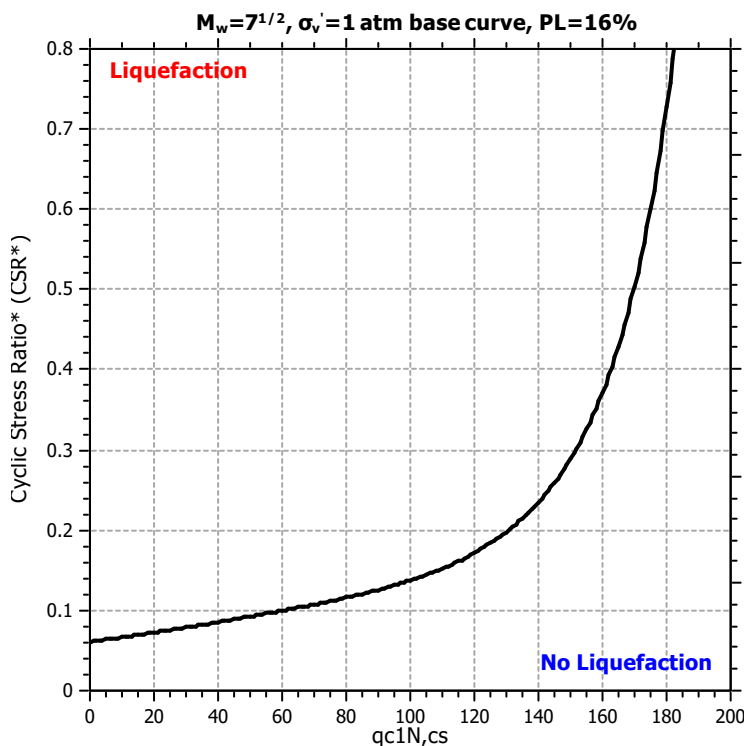
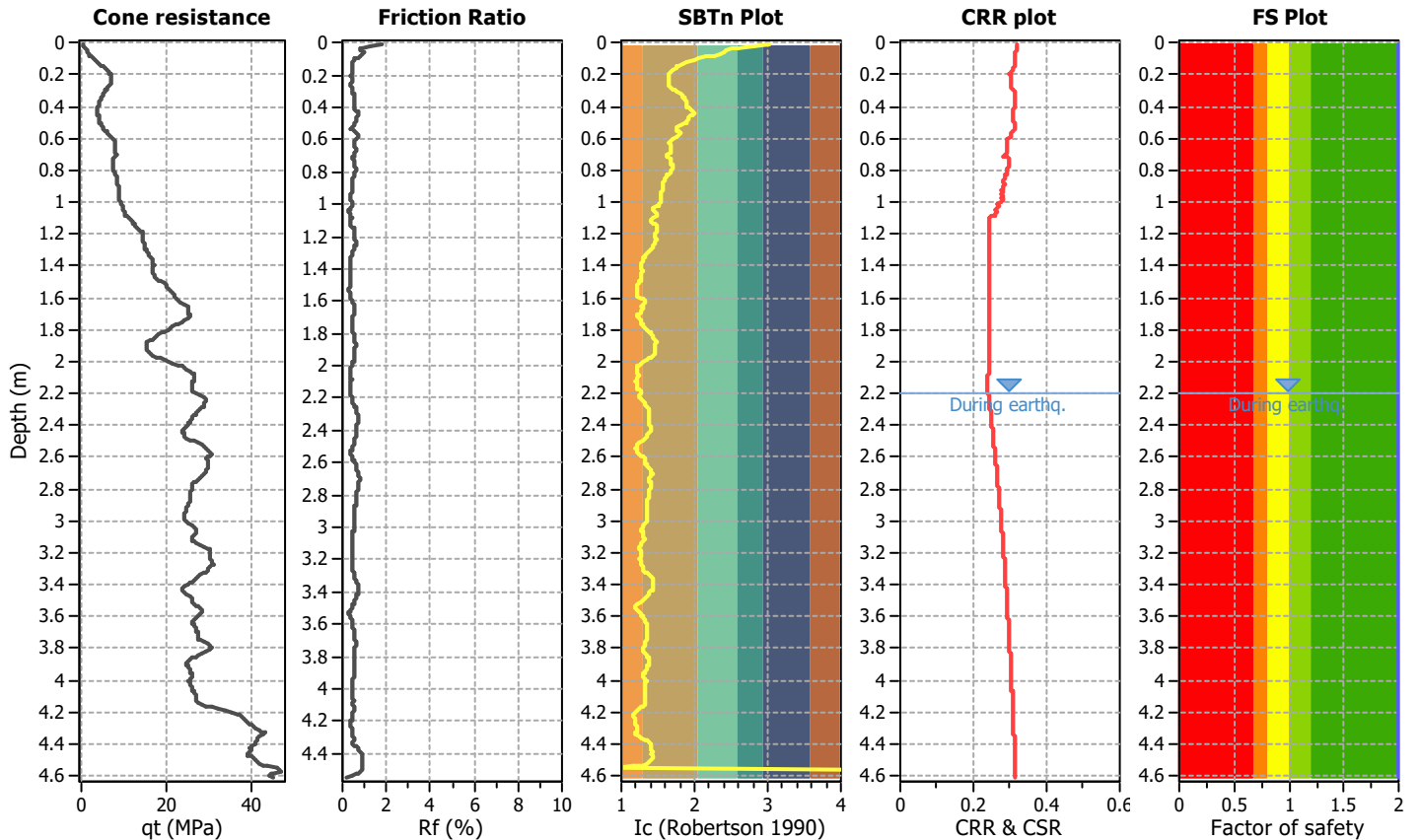
Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT13

LIQUEFACTION ANALYSIS REPORT

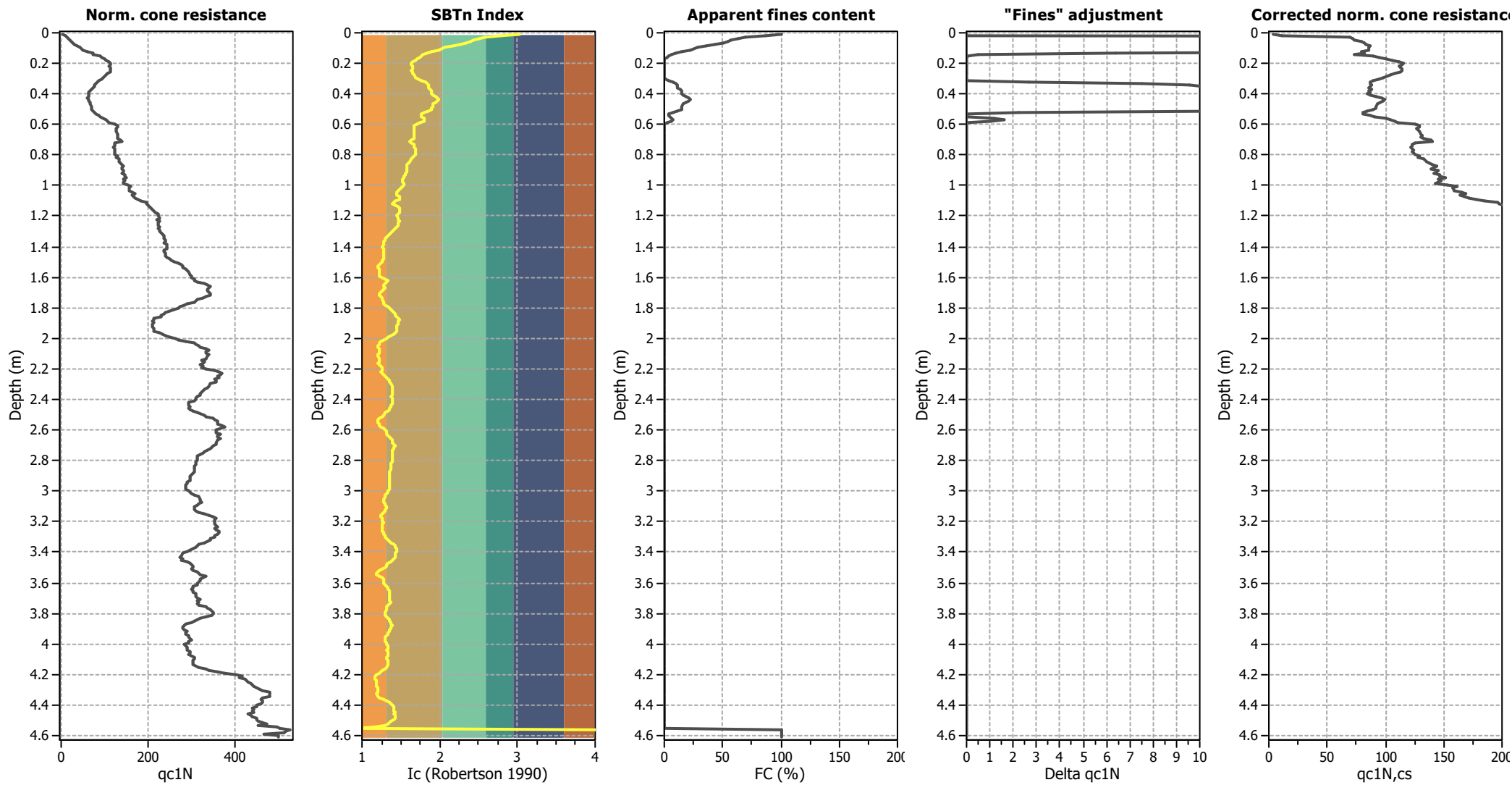
Project title : Cargill Station Ltd
Location : Ocean Ridge, Kaikoura
CPT file : CPT 13
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

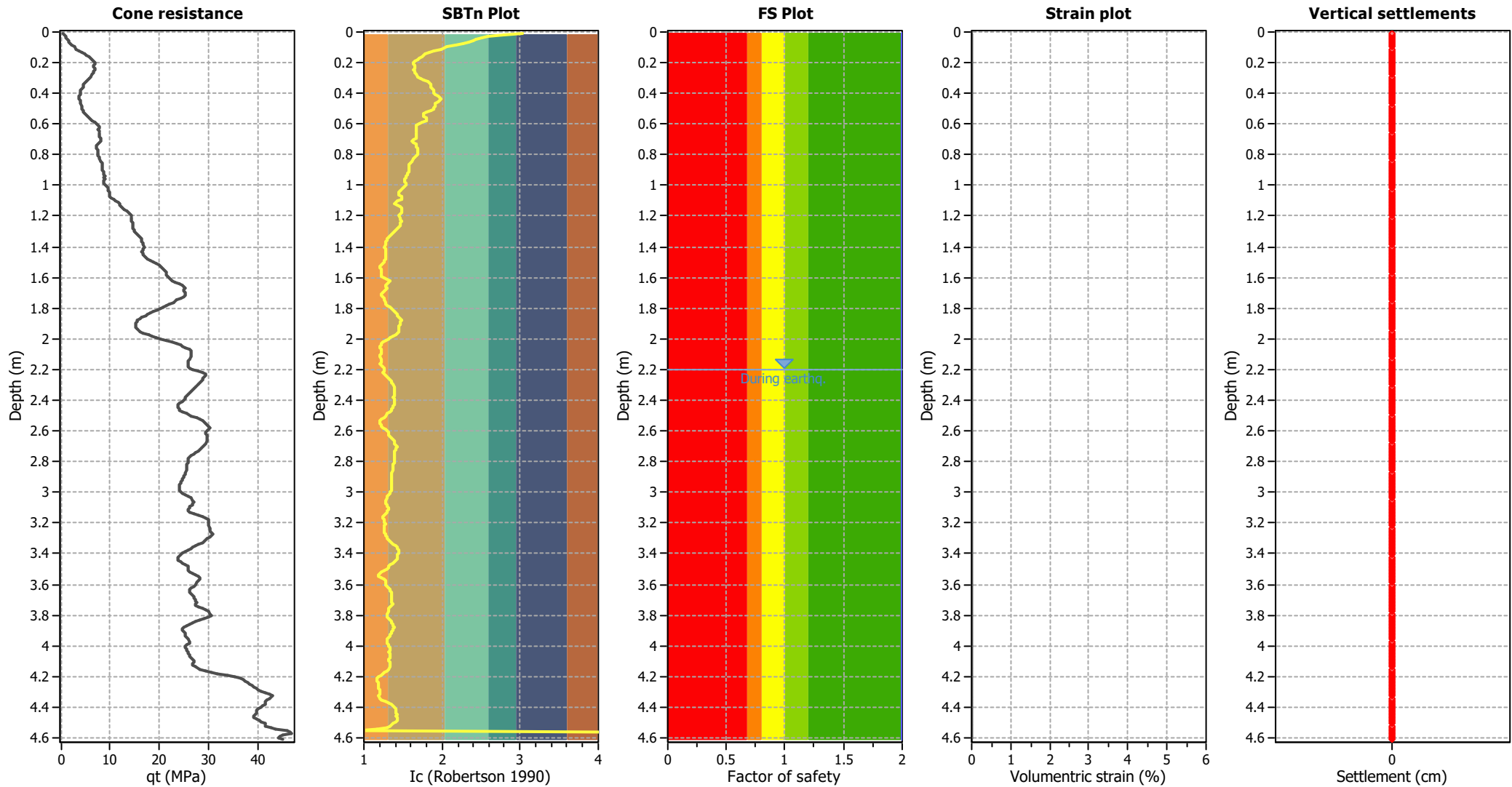
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

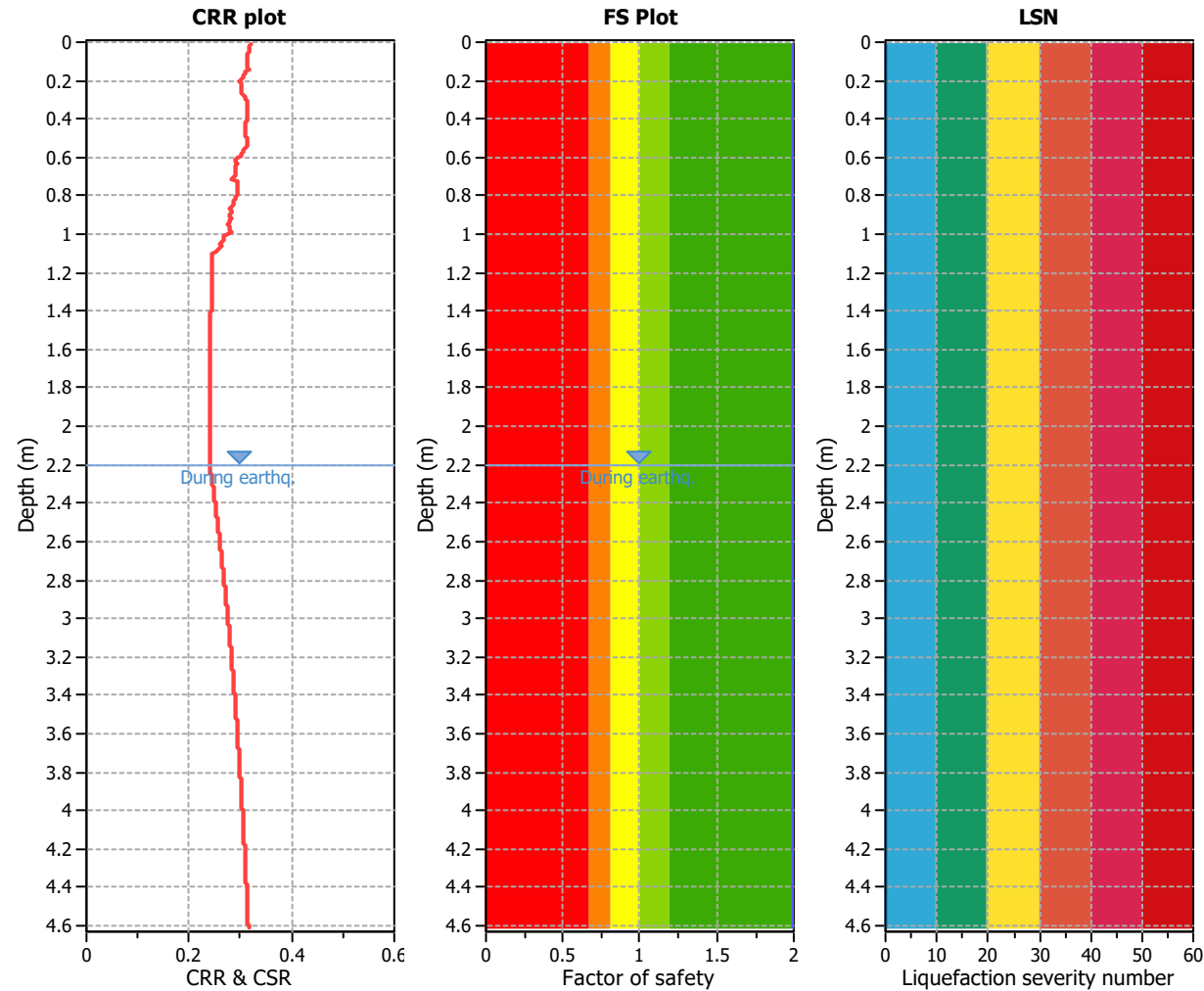
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.20 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I_c value	I_c cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.20 m	Fill height:	N/A	Limit depth:	10.00 m

Estimation of post-earthquake settlements



Abbreviations

- q_c : 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
- Volumetric strain: Post-liquefaction volumetric strain



Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied: Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth: 10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method: Method based

CPT14

LIQUEFACTION ANALYSIS REPORT

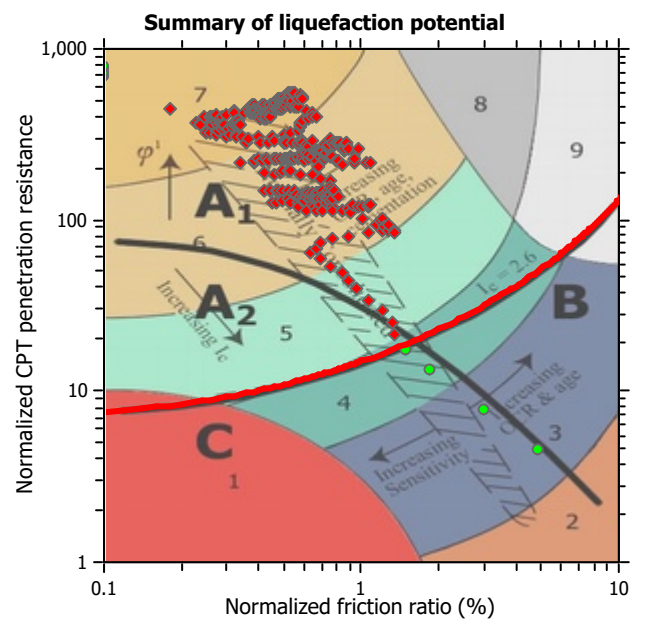
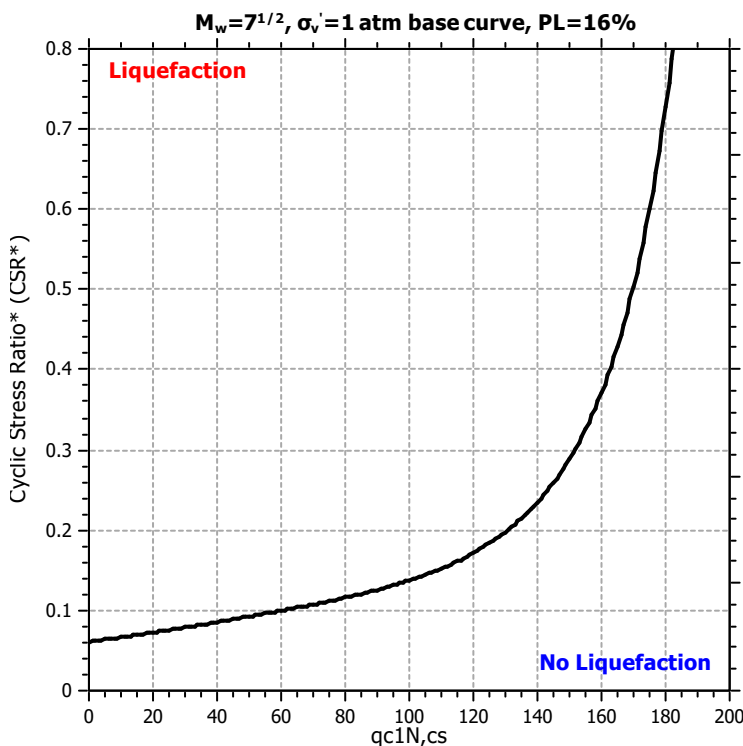
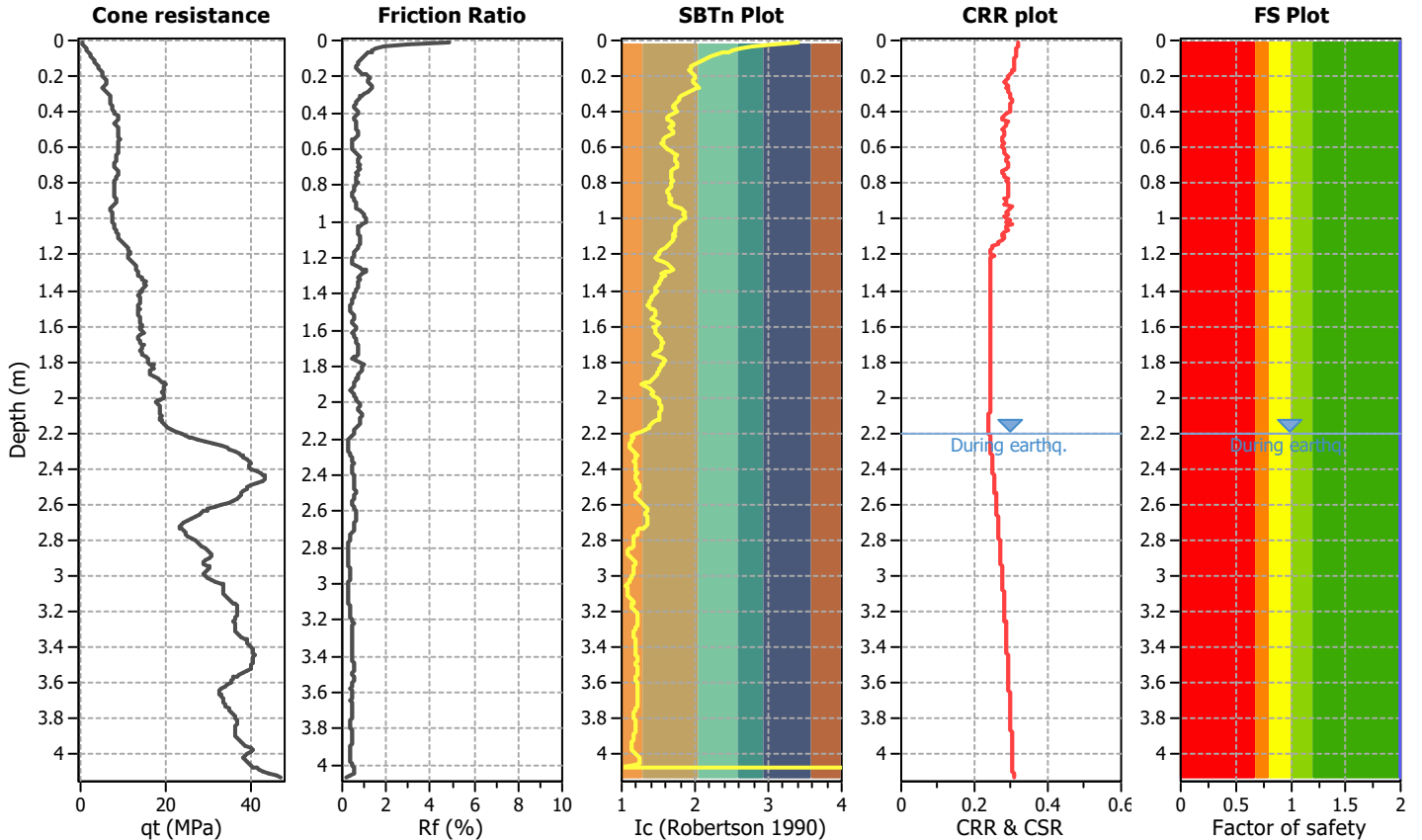
Project title : Cargill Station Ltd

Location : Ocean Ridge, Kaikoura

CPT file : CPT 14

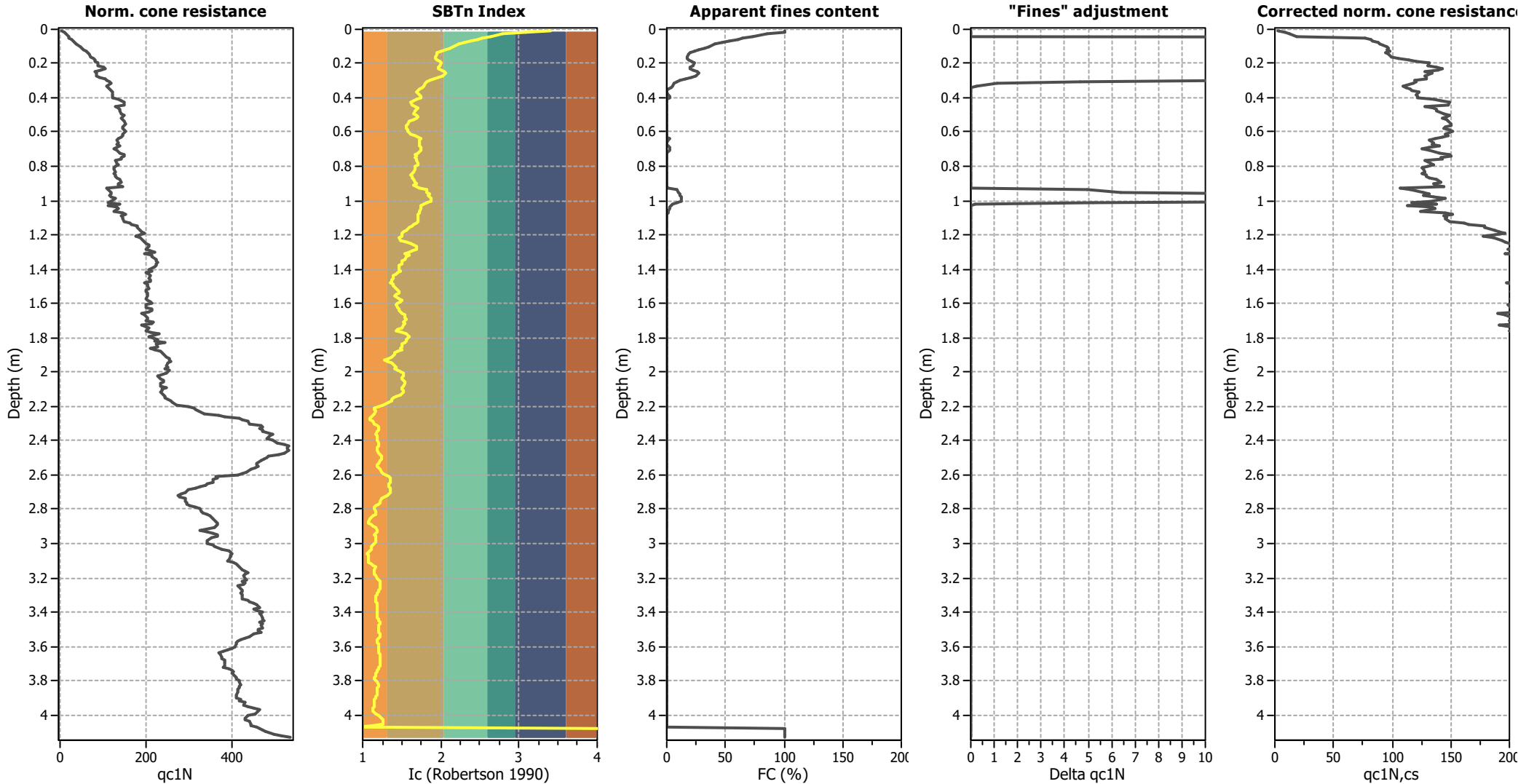
Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior	
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:	Sand & Clay
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	10.00 m
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



Zone A₁: Cyclic liquefaction likely depending on size and duration of cyclic loading
 Zone A₂: 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

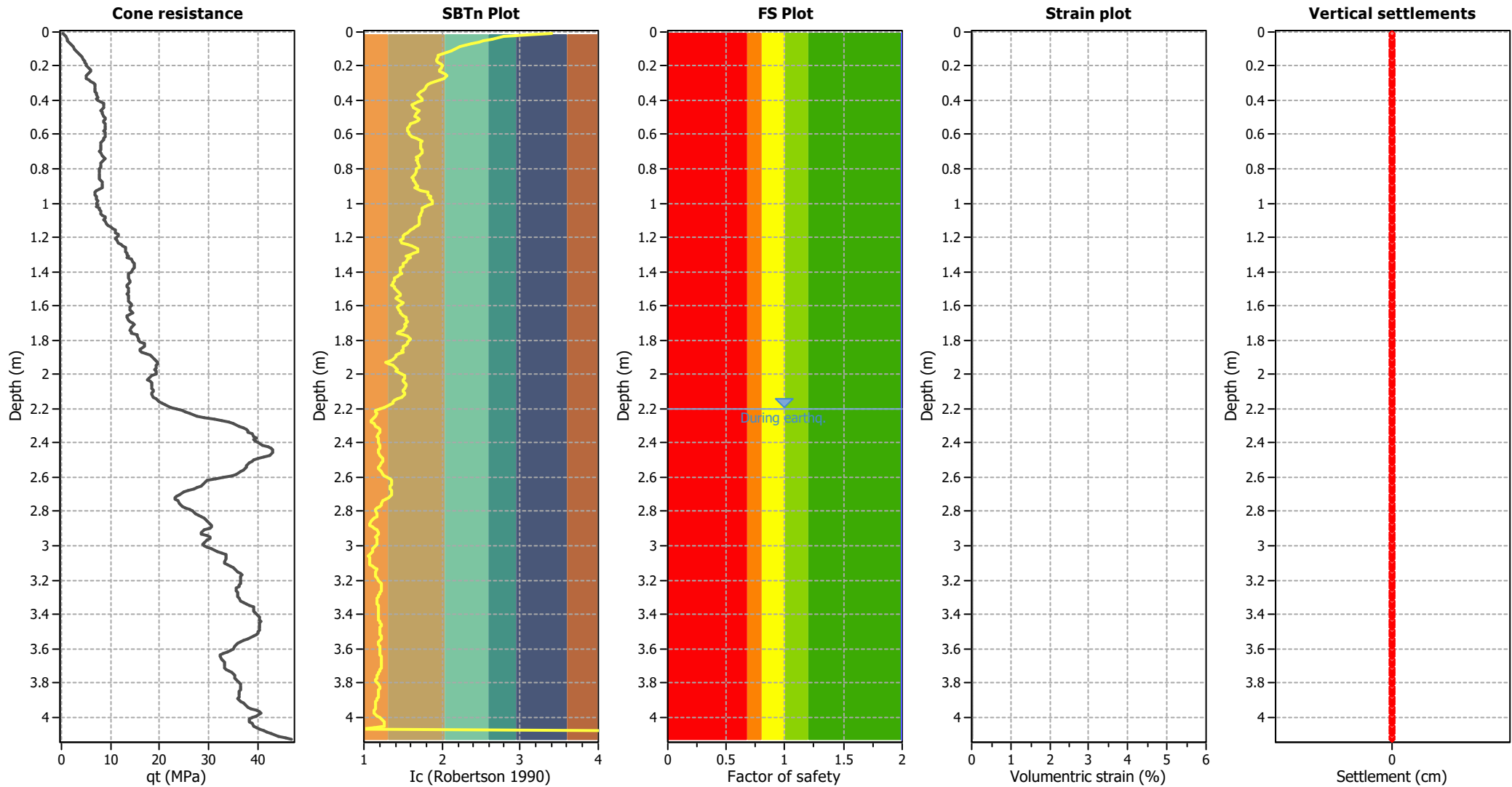
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

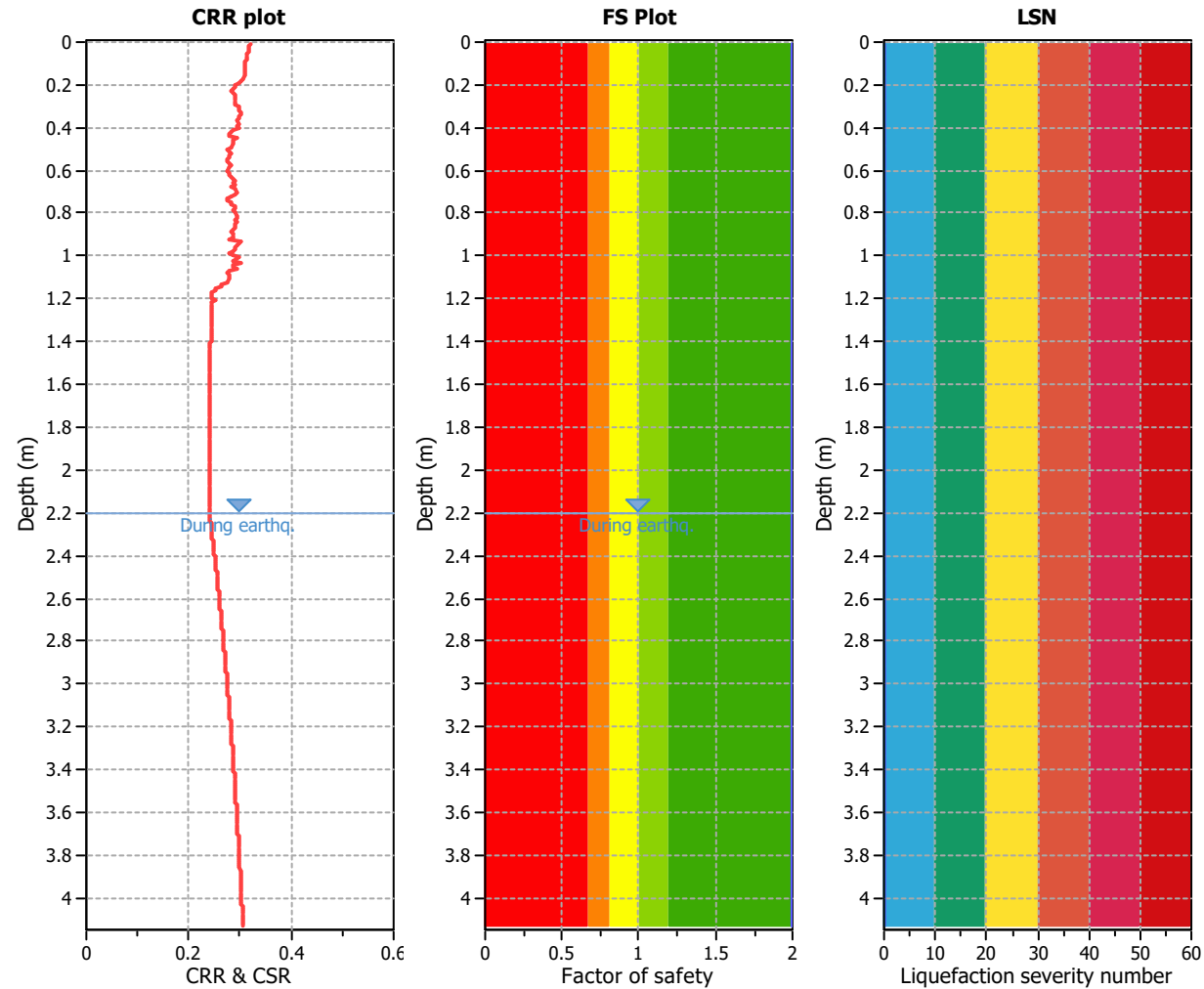
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.20 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K _o applied:	Yes
Earthquake magnitude M _w :	6.70	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.56	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.20 m	Fill height:	N/A	Limit depth:	10.00 m

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
- Volumetric strain: Post-liquefaction volumetric strain

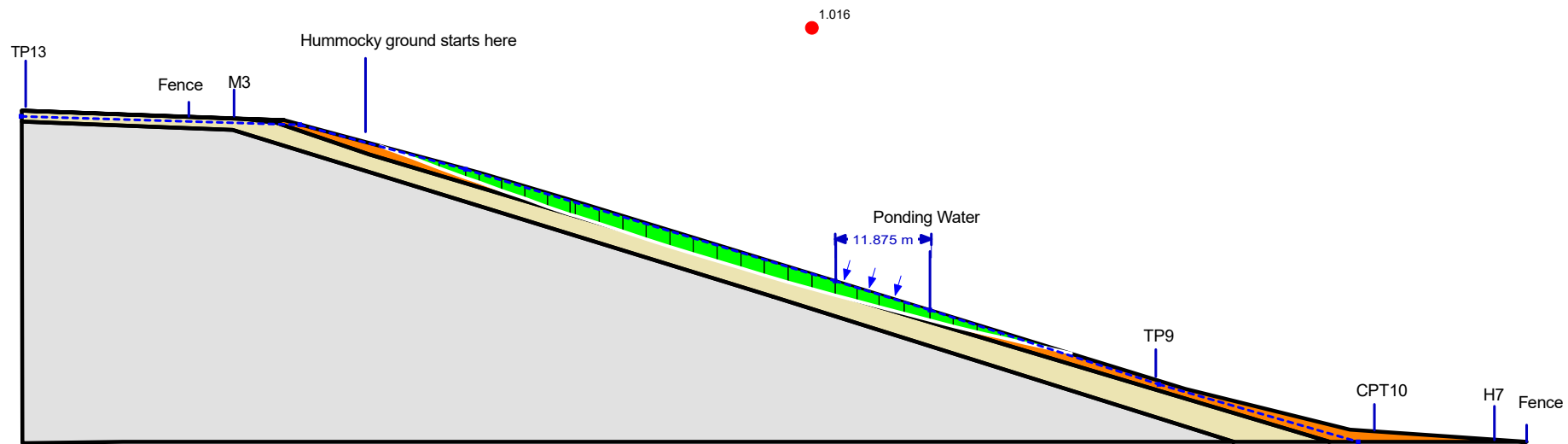


Analysis method:	B&I (2014)	G.W.T. (in-situ):	2.20 m	Use fill:	No	Clay like behavior
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	2.20 m	Fill height:	N/A	applied:
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:
Earthquake magnitude M_w :	6.70	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:
Peak ground acceleration:	0.56	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:
						Method based

Appendix C

Slope Stability Analyses Results

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Colluvium	Mohr-Coulomb	18	1	26
	Residual soils	Mohr-Coulomb	18	3	28
	Rock CW	Mohr-Coulomb	20	25	32



Ocean Ridge Cross Section B-B' Back Analysis

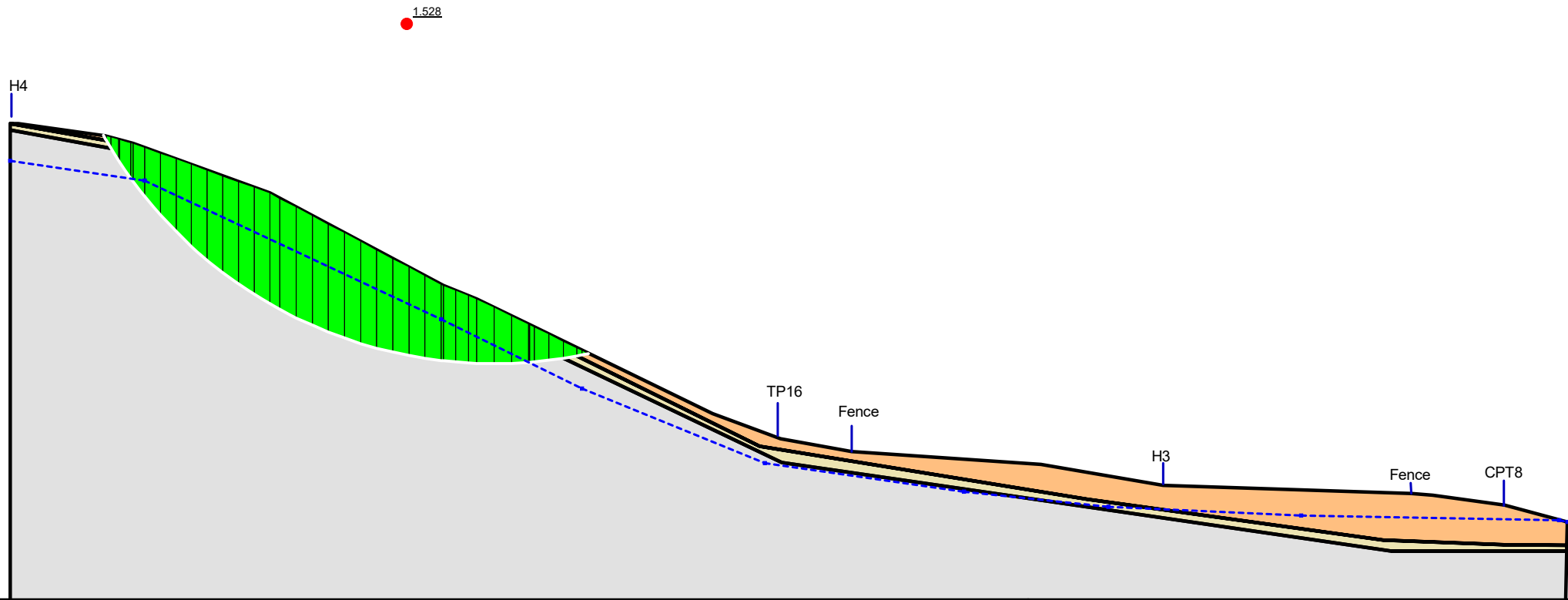


**Fraser
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PROJECT NO: CH01912
ANALYSED BY: K. Twohill
SCALE: 1:800 (A4)
DATE: 11/03/2025

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Colluvium (Limestone)	Mohr-Coulomb	18	3	28
	Residual soils	Mohr-Coulomb	18	3	28
	Rock CW	Mohr-Coulomb	20	25	32

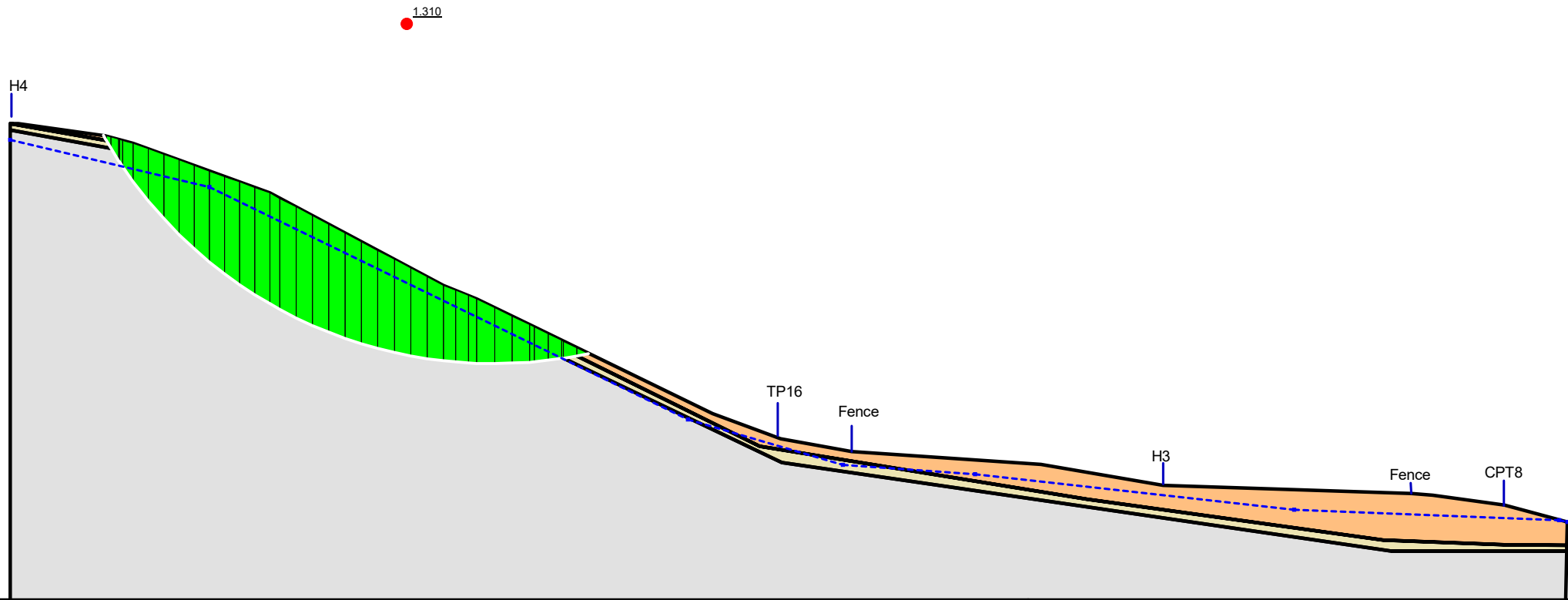


Ocean Ridge Cross Section A-A' Forward Analysis - Wet Winter



PROJECT NO: CH01912
 ANALYSED BY: K. Twohill
 SCALE: 1:800 (A4)
 DATE: 11/03/2025

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Colluvium (Limestone)	Mohr-Coulomb	18	3	28
	Residual soils	Mohr-Coulomb	18	3	28
	Rock CW	Mohr-Coulomb	20	25	32



Ocean Ridge Cross Section A-A'
Forward Analysis - Extreme Transient

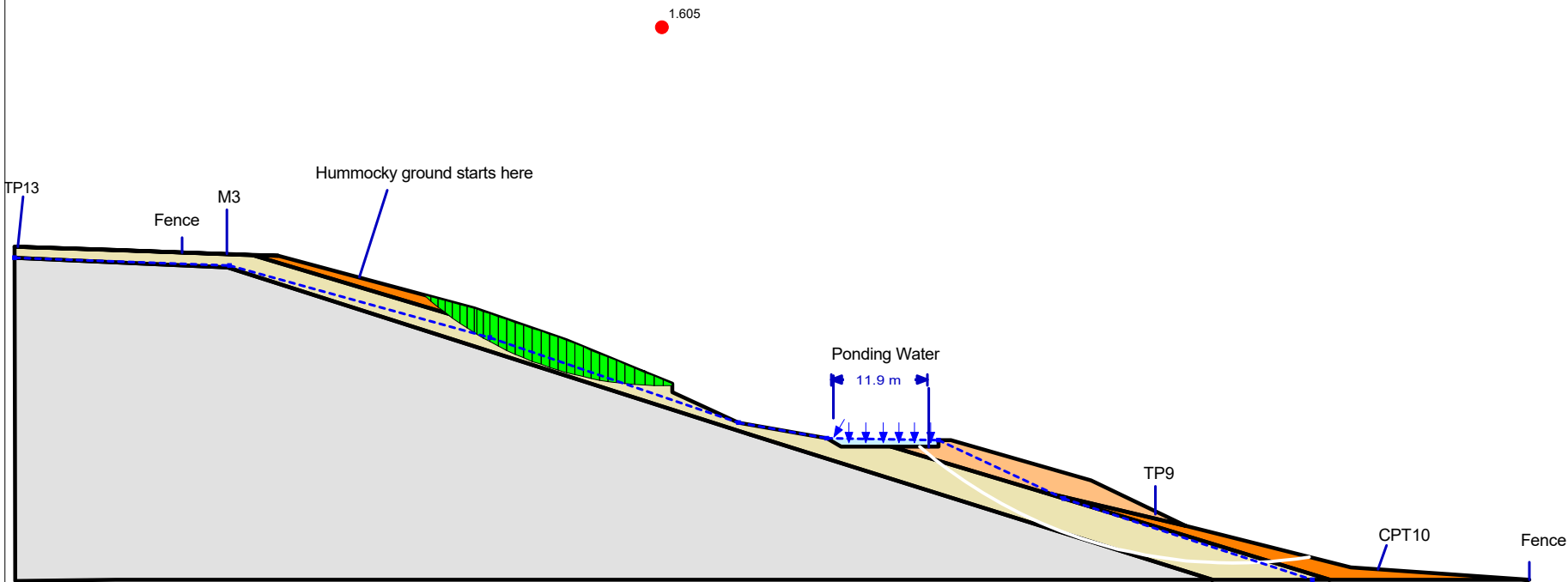


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PROJECT NO: CH01912
ANALYSED BY: K. Twohill
SCALE: 1:800 (A4)
DATE: 11/03/2025

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
Orange	Colluvium	Mohr-Coulomb	18	1	26
Light Orange	landslide debris	Mohr-Coulomb	18	1	26
Yellow	Residual soils	Mohr-Coulomb	18	3	28
Grey	Rock CW	Mohr-Coulomb	20	25	32



Ocean Ridge Cross Section B-B' Forward Analysis - Wet Winter

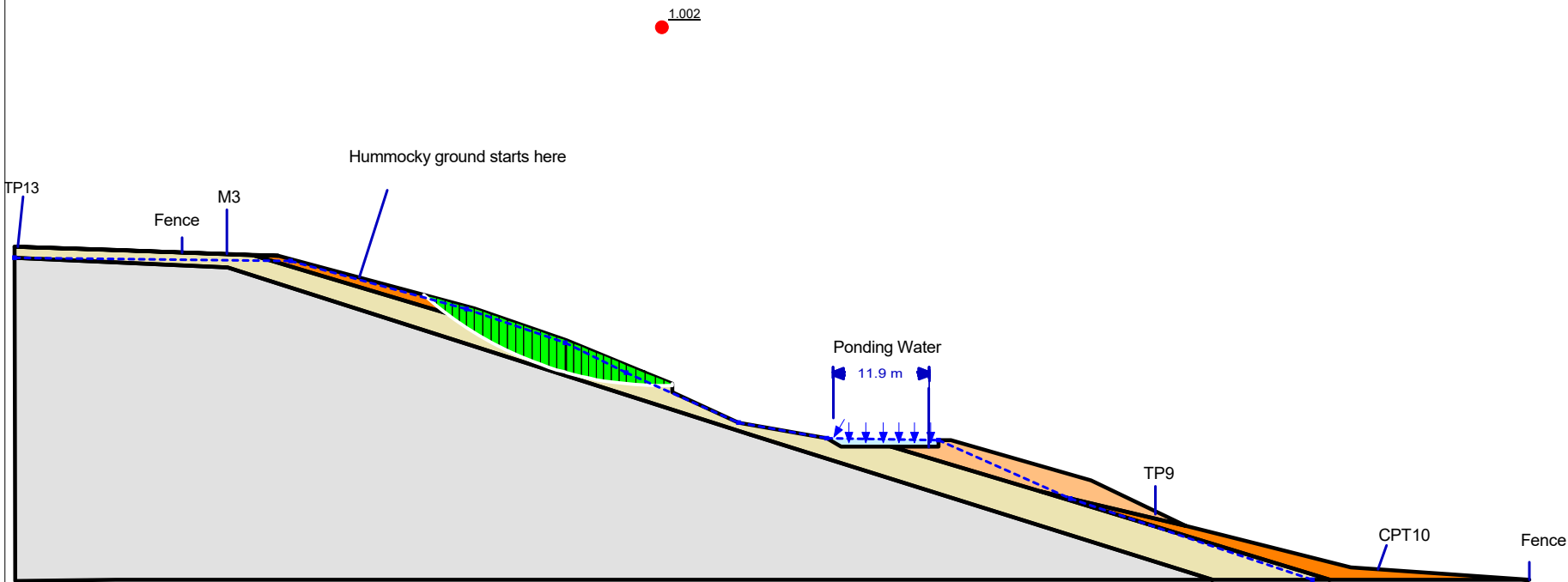


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PROJECT NO: CH01912
ANALYSED BY: K. Twohill
SCALE: 1:800 (A4)
DATE: 13/03/2025

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Colluvium	Mohr-Coulomb	18	1	26
	landslide debris	Mohr-Coulomb	18	1	26
	Residual soils	Mohr-Coulomb	18	3	28
	Rock CW	Mohr-Coulomb	20	25	32



Ocean Ridge Cross Section B-B' Forward Analysis - Extreme Transient

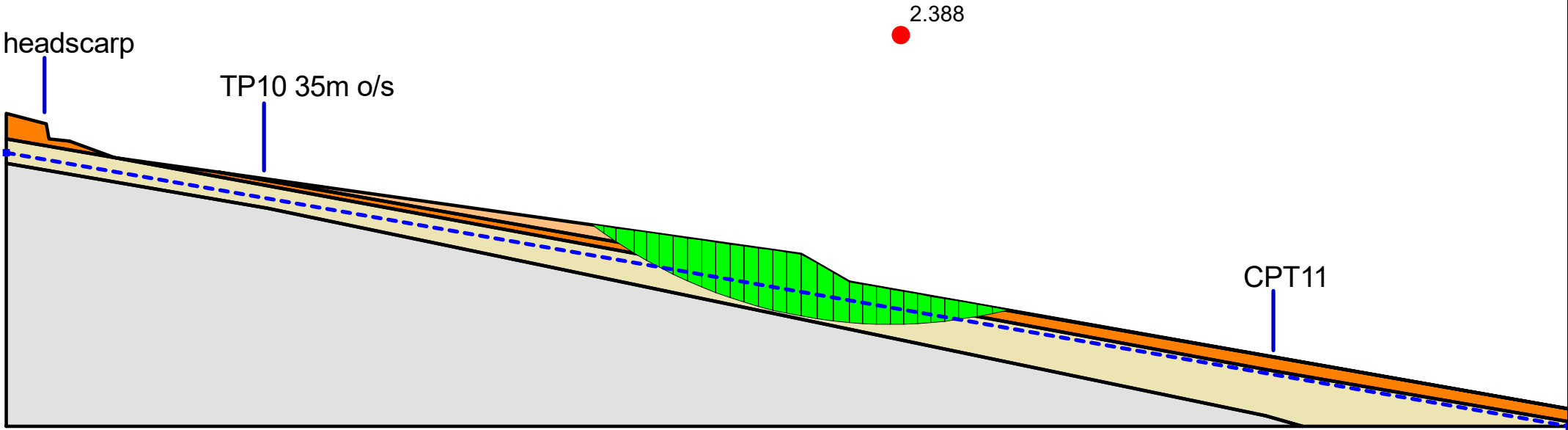


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PROJECT NO: CH01912
 ANALYSED BY: K. Twohill
 SCALE: 1:800 (A4)
 DATE: 13/03/2025

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Colluvium	Mohr-Coulomb	18	1	26
	landslide debris	Mohr-Coulomb	18	1	26
	Residual soils	Mohr-Coulomb	18	3	28
	Rock CW	Mohr-Coulomb	20	25	32



Ocean Ridge Cross Section C-C'
Forward Analysis - Wet Winter

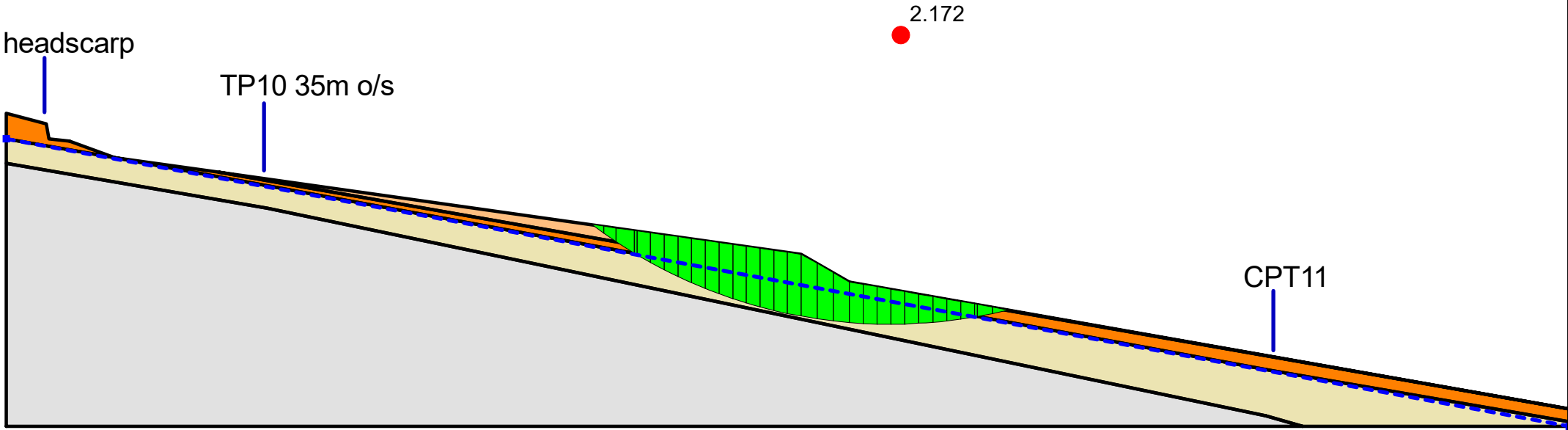


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PROJECT NO: CH01912
ANALYSED BY: K. Twohill
SCALE: 1:400 (A4)
DATE: 11/03/2025

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Colluvium	Mohr-Coulomb	18	1	26
	landslide debris	Mohr-Coulomb	18	1	26
	Residual soils	Mohr-Coulomb	18	3	28
	Rock CW	Mohr-Coulomb	20	25	32

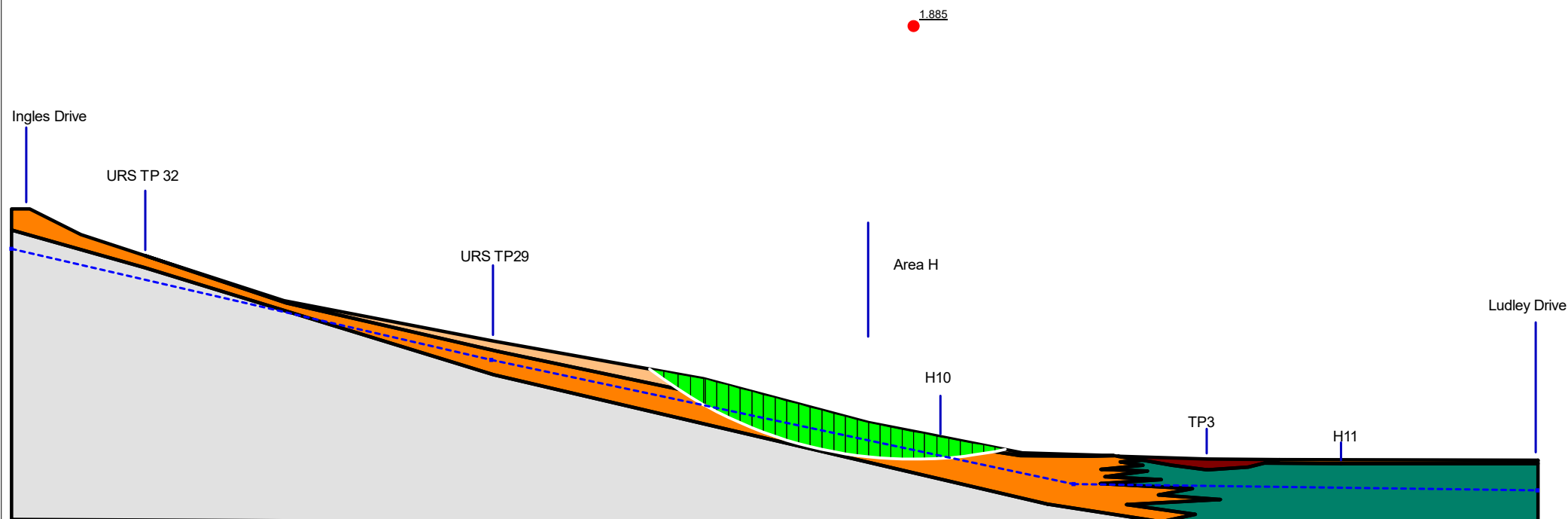


Ocean Ridge Cross Section C-C'
Forward Analysis - Extreme Transient



PROJECT NO: CH01912
ANALYSED BY: K. Twohill
SCALE: 1:400 (A4)
DATE: 11/03/2025

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Colluvium	Mohr-Coulomb	18	1	26
	landslide debris	Mohr-Coulomb	18	1	26
	Marine sediments	Mohr-Coulomb	20	0	30
	Non-Engineered Fill / Topsoil	Mohr-Coulomb	17	0	22
	Rock CW	Mohr-Coulomb	20	25	32



Ocean Ridge Cross Section E-E'

Forward Analysis - Wet Winter

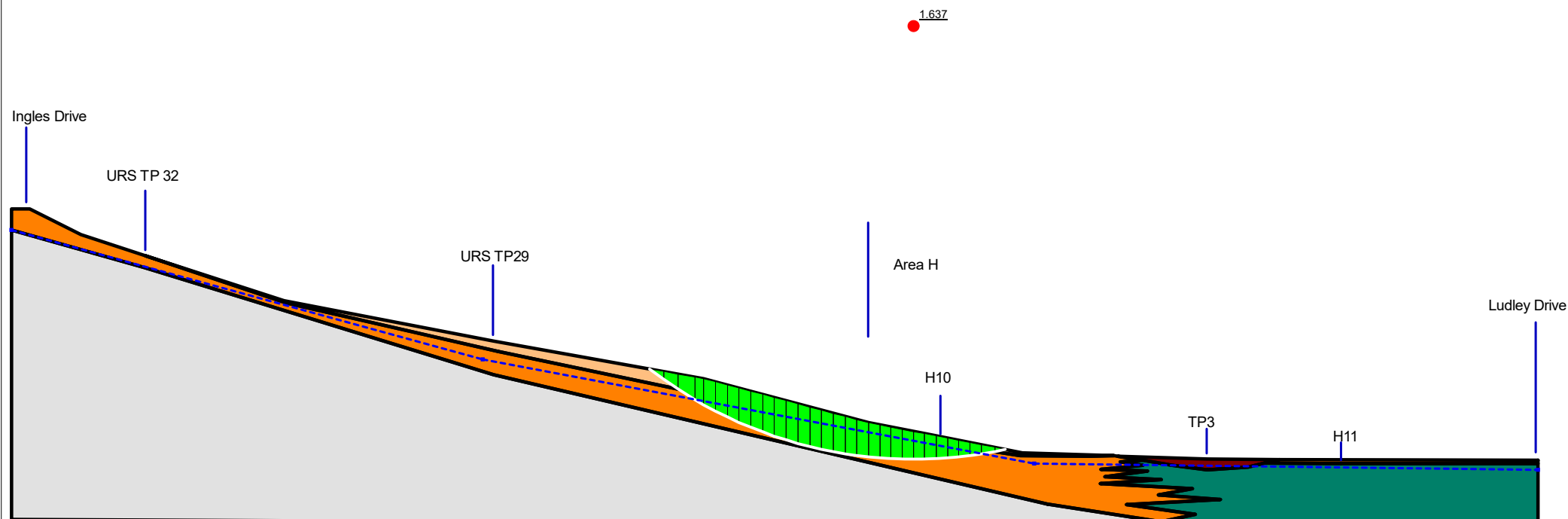


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PROJECT NO: CH01912
ANALYSED BY: K. Twohill
SCALE: 1:800 (A4)
DATE: 11/03/2025

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Colluvium	Mohr-Coulomb	18	1	26
	landslide debris	Mohr-Coulomb	18	1	26
	Marine sediments	Mohr-Coulomb	20	0	30
	Non-Engineered Fill / Topsoil	Mohr-Coulomb	17	0	22
	Rock CW	Mohr-Coulomb	20	25	32



Ocean Ridge Cross Section E-E'

Forward Analysis - Extreme Transient



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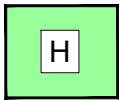
PROJECT NO: CH01912
ANALYSED BY: K. Twohill
SCALE: 1:800 (A4)
DATE: 11/03/2025

Appendix D

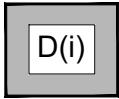
Drawings

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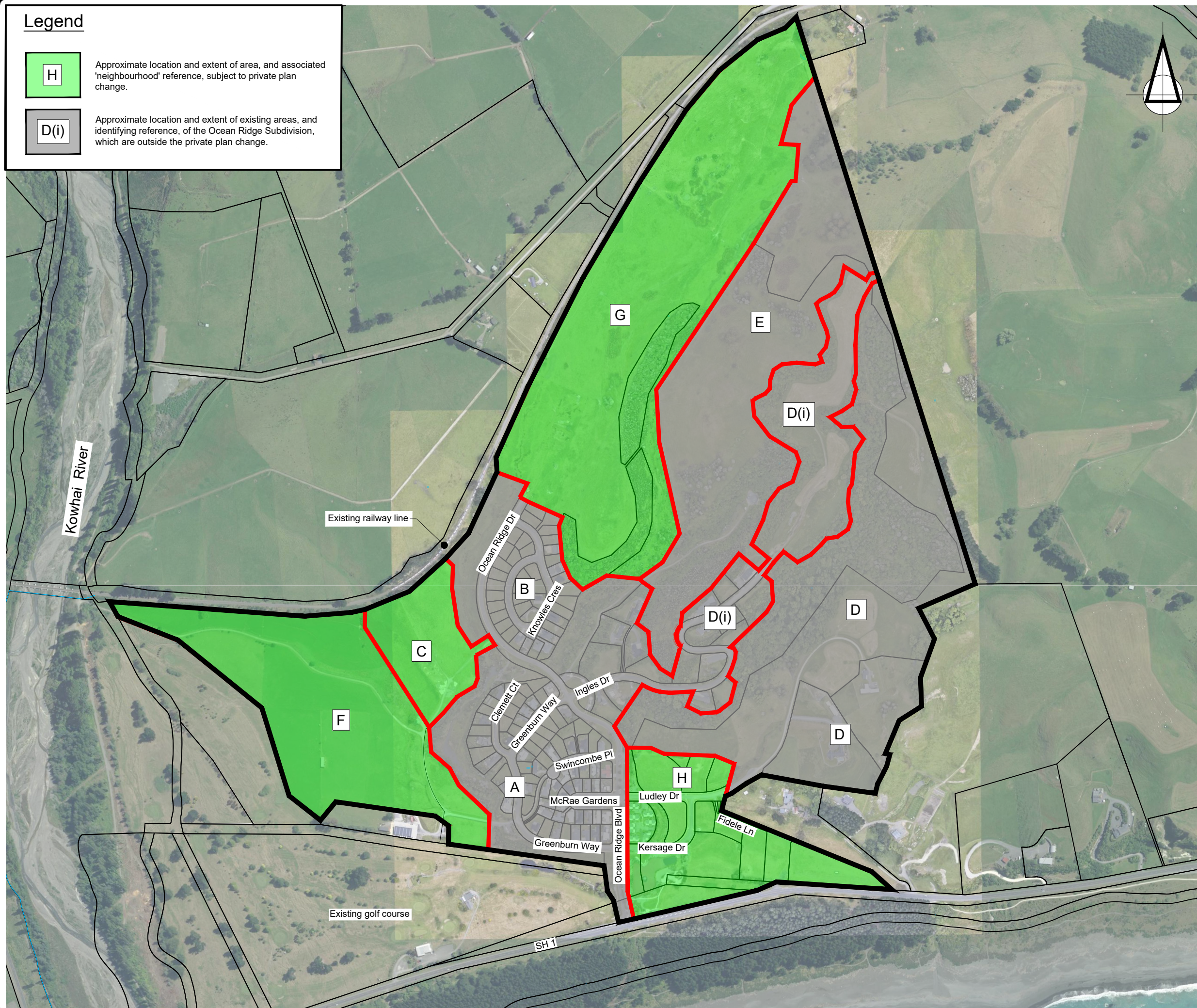
Legend



Approximate location and extent of area, and associated 'neighbourhood' reference, subject to private plan change.



Approximate location and extent of existing areas, and identifying reference, of the Ocean Ridge Subdivision, which are outside the private plan change.



SURVEYED			APPROVED	MVR	DATE
DESIGNED					
DRAWN	GN	13/03/25			
CHECKED	KT	13/03/25			
REVISION	CHANGES			CHECKED	DATE

- NOTES
1. This plan has been adopted from Grip map. The location and extent of the site boundaries and site features are therefore considered to be approximate only.
 2. The location and extent of the site neighbourhood designations locations have been adopted from the Novo Group "Overall MasterPlan", project number 132001, dated 24-01-2025.

CLIENT
CARGILL STATION LTD

PROJECT
PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA

TITLE
SITE PLAN
(CONTEXT)



Fraser Thomas

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AUCKLAND	09 278 7078
HAWKE'S BAY	06 211 2766
CHRISTCHURCH	03 358 5936
BLenheim	03 428 3292
NELSON	03 222 1132
TAURANGA	07 220 9277

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STATUS
Construction shall begin only on receipt of and in accordance with the Council or CCO stamped approved drawings, unless otherwise indicated.

SCALE 1:7500 (A3)

DRAWING No CH01912-G-01 REVISION

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SURVEYED			APPROVED	DATE
DESIGNED			MVR	
DRAWN	GN	13/03/25		
CHECKED	KT	13/03/25		
REVISION	CHANGES		CHECKED	DATE

NOTES

1. This plan has been adopted from the Novo Group Overall Masterplan, project number 132001, revision C, dated 03/03/2025.

CLIENT

CARGILL STATION LTD

PROJECT

PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA

TITLE

OVERALL MASTER PLAN
(NOVO GROUP)



Fraser

Thomas

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AUCKLAND

HAWKE'S BAY

CHRISTCHURCH

BLenheim

NELSON

TAURANGA

09 278 7078

06 211 2766

03 358 5936

03 428 3292

03 222 1132

07 220 9277

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Construction shall begin only on receipt of and in accordance with the Council or CCO stamped approved drawings, unless otherwise indicated.

SCALE 1:7500 (A3)

DRAWING No CH01912-G-02 REVISION

Legend

- M1

Approximate location and number of machine borehole, put down under the direction of Fraser Thomas Ltd.
- H1

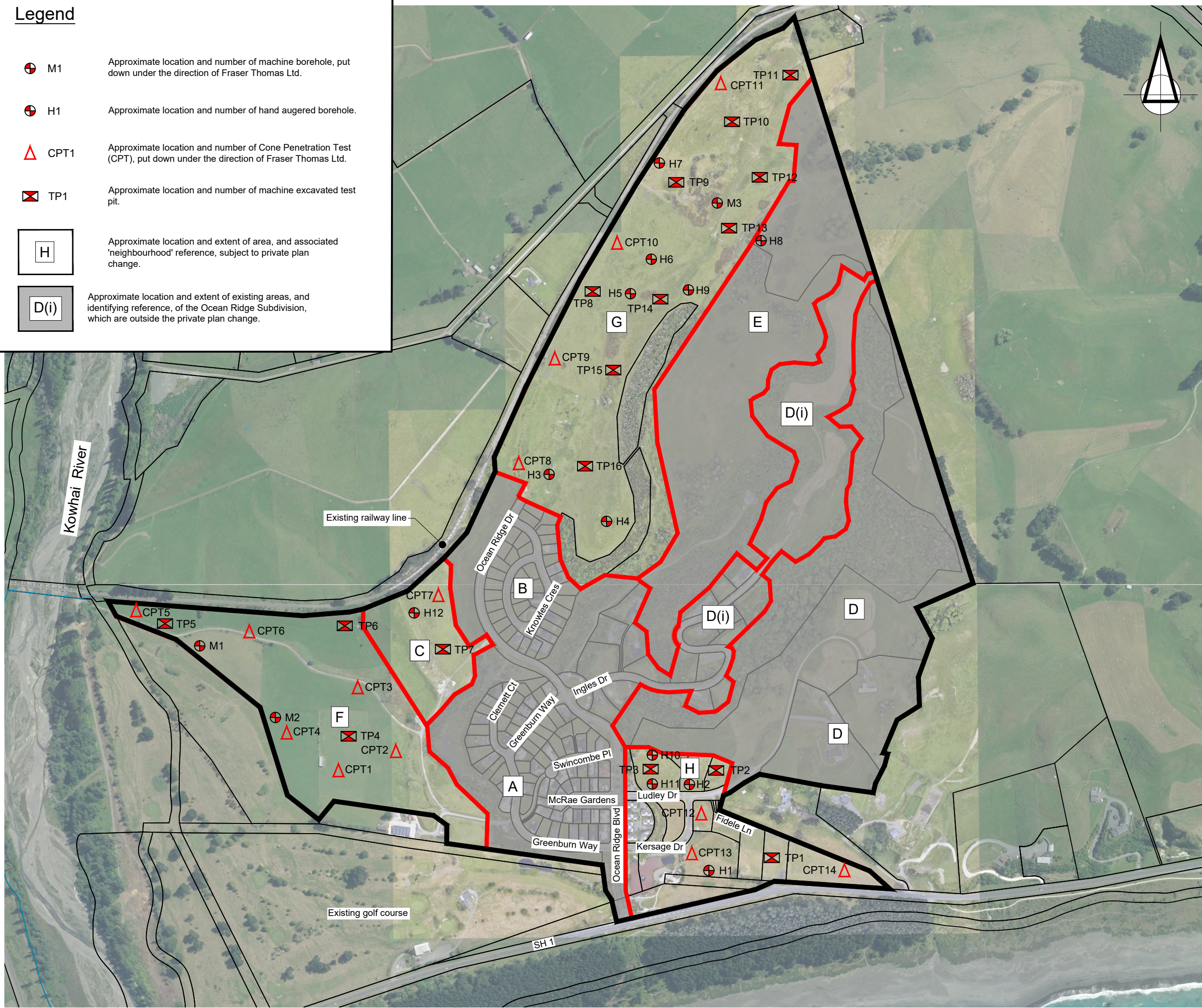
Approximate location and number of hand augered borehole.
- CPT1

Approximate location and number of Cone Penetration Test (CPT), put down under the direction of Fraser Thomas Ltd.
- TP1

Approximate location and number of machine excavated test pit.
- H

Approximate location and extent of area, and associated 'neighbourhood' reference, subject to private plan change.
- D(i)

Approximate location and extent of existing areas, and identifying reference, of the Ocean Ridge Subdivision, which are outside the private plan change.



SURVEYED			APPROVED	DATE
DESIGNED			MVR	
DRAWN	GN	13/03/25		
CHECKED	KT	13/03/25		
REVISION	CHANGES		CHECKED	DATE

NOTES

1. The location and extent of the site boundaries and neighbourhood designations locations have been adopted from the Novo Group survey plan project number 1322001, dated 24-04-2024.

CLIENT

CARGILL STATION LTD

PROJECT

PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA

TITLE

SITE PLAN
FRASER THOMAS TEST
LOCATIONS

Fraser Thomas

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AUCKLAND	09 278 7078
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BLenheim	03 428 3292
NELSON	03 222 1132
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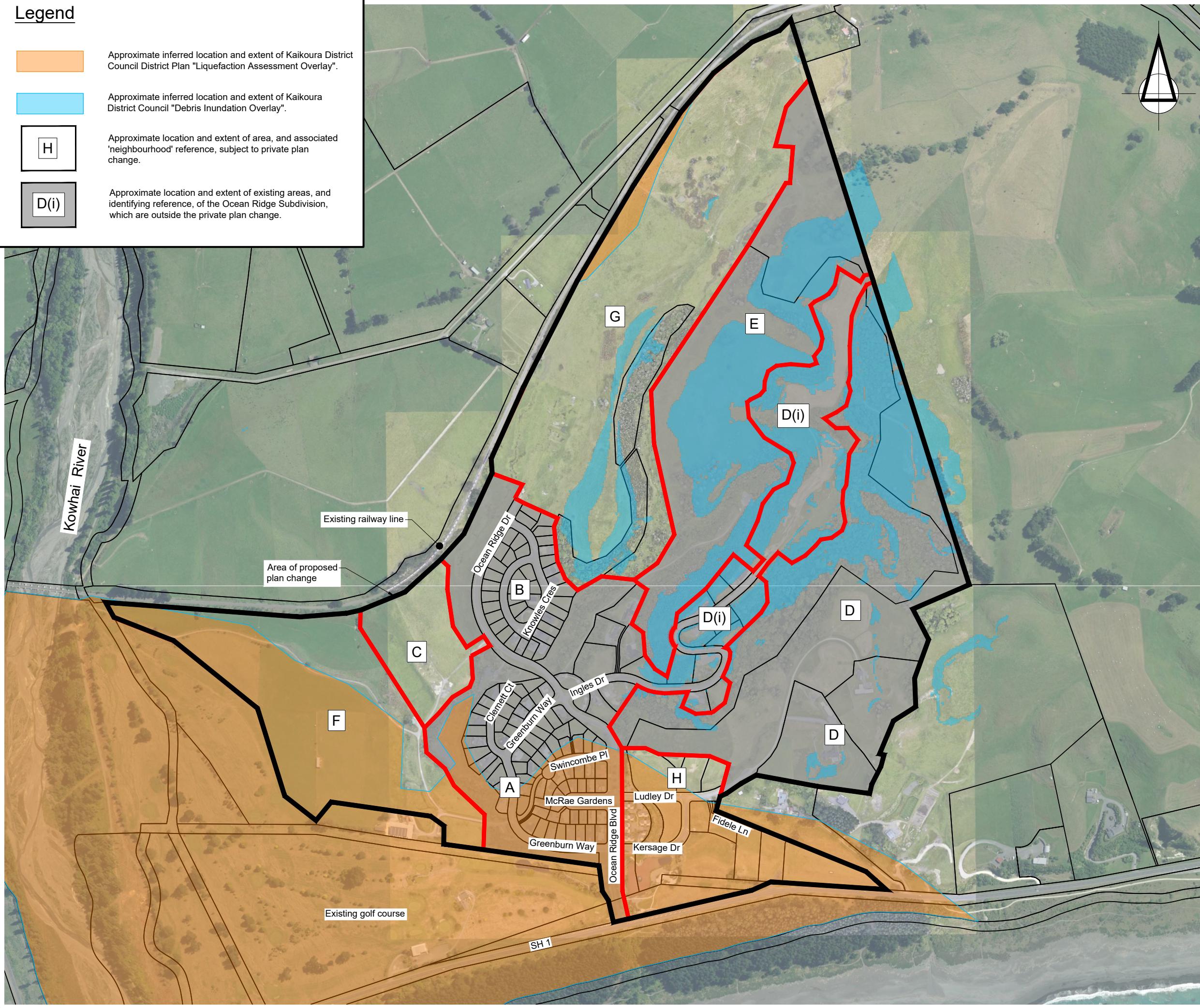
STATUS	
Construction shall begin only on receipt of and in accordance with the Council or CCO stamped approved drawings, unless otherwise indicated.	
SCALE	1:7500 (A3)
DRAWING No	CH01912-G-03
REVISION	

Legend

- Approximate inferred location and extent of Kaikoura District Council District Plan "Liquefaction Assessment Overlay".
- Approximate inferred location and extent of Kaikoura District Council "Debris Inundation Overlay".
- H

Approximate location and extent of area, and associated 'neighbourhood' reference, subject to private plan change.
- D(i)

Approximate location and extent of existing areas, and identifying reference, of the Ocean Ridge Subdivision, which are outside the private plan change.



SURVEYED			APPROVED	MVR	DATE
DESIGNED					
DRAWN	GN	13/03/25			
CHECKED	KT	13/03/25			
REVISION	CHANGES			CHECKED	DATE

- NOTES
- The location and extent of the site boundaries and neighbourhood designations locations have been adopted from the Novo Group survey plan project number 1322001, dated 24-04-2024.
 - Kaikoura District Council development areas from Kaikoura District Council Outline Development Plan.

CLIENT

CARGILL STATION LTD

PROJECT

PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA

TITLE

SITE PLAN
KAIKOURA DISTRICT COUNCIL
HAZARD OVERLAY



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CHRISTCHURCH

BLenheim

NELSON

TAURANGA

09 278 7078

06 211 2766

03 358 5936

03 428 3292

03 222 1132

07 220 9277

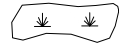
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STATUS	
Construction shall begin only on receipt of and in accordance with the Council or CCO stamped approved drawings, unless otherwise indicated.	
SCALE	1:7500 (A3)
DRAWING No	CH01912-G-04
REVISION	

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Legend



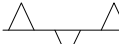
Approximate inferred location and extent of swampy ground.



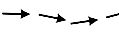
Approximate inferred location and extent of historic infilled pond.



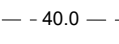
Approximate inferred location and extent of headscarp.



Approximate inferred location and extent of ridgeline.



Approximate inferred location and extent of waterway.



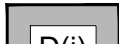
Existing ground surface contour (RL) (m).



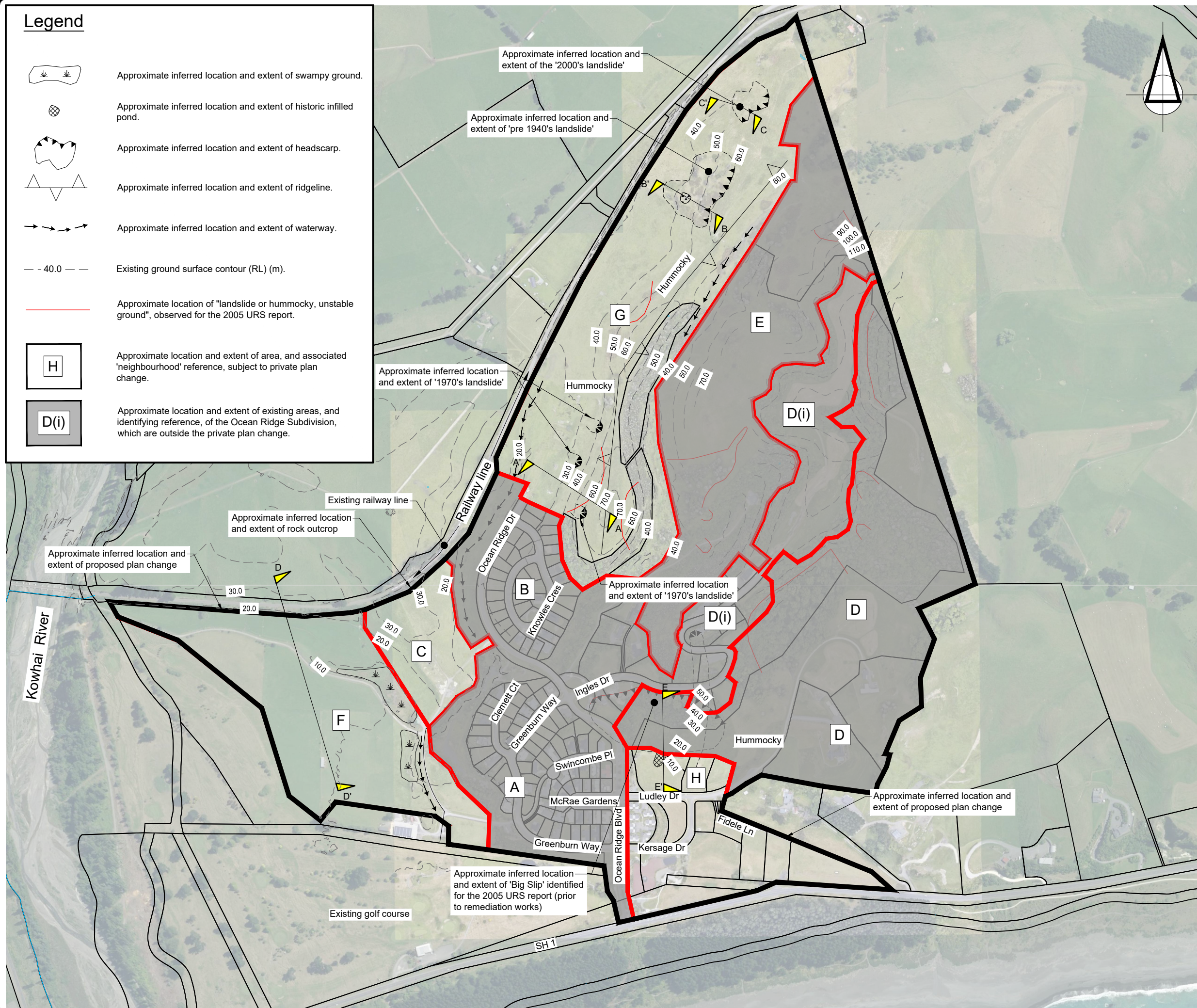
Approximate location of "landslide or hummocky, unstable ground", observed for the 2005 URS report.



Approximate location and extent of area, and associated 'neighbourhood' reference, subject to private plan change.



Approximate location and extent of existing areas, and identifying reference, of the Ocean Ridge Subdivision, which are outside the private plan change.



SURVEYED			APPROVED	DATE
DESIGNED			MVR	
DRAWN	GN	13/03/25		
CHECKED	KT	13/03/25		
REVISION	CHANGES		CHECKED	DATE

- NOTES
1. The location and extent of the site boundaries and neighbourhood designations have been adopted from the Novo Group survey plan project number 1322001, dated 24-04-2024.
 2. Contours shown on this plan have been sourced from LINZ. Coordinates are in terms of Marlborough circuit. Vertical datum in terms of NZVD 2016.

CLIENT
CARGILL STATION LTD

PROJECT
PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA

TITLE
SITE PLAN
GEOMORPHOLOGY

 **Fraser Thomas**

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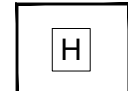
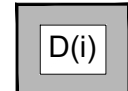
AUCKLAND	09 278 7078
HAWKE'S BAY	06 211 2766
CHRISTCHURCH	03 358 5936
BLenheim	03 428 3292
NELSON	03 222 1132
TAURANGA	07 220 9277

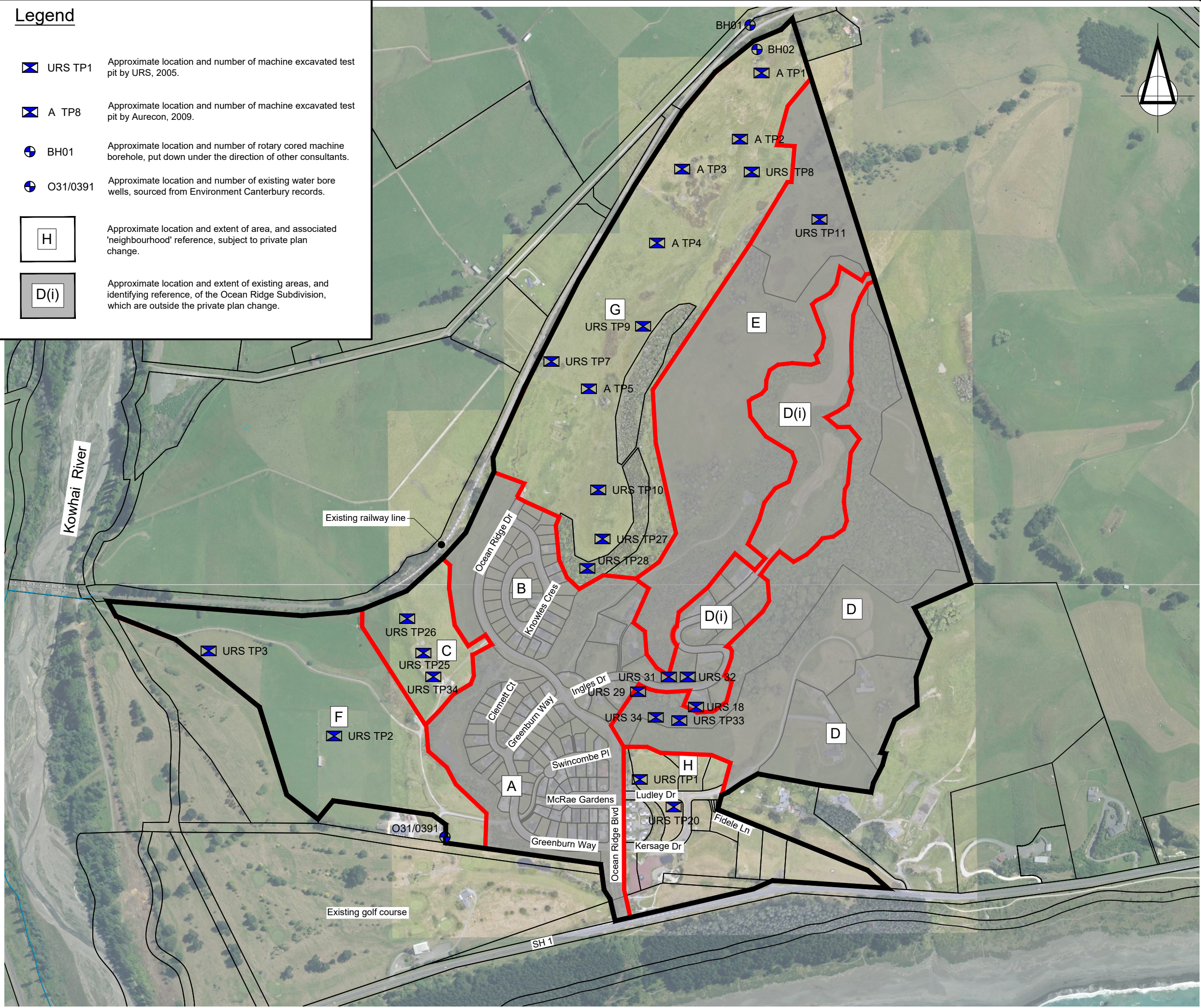
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STATUS	
Construction shall begin only on receipt of and in accordance with the Council or CCO stamped approved drawings, unless otherwise indicated.	
SCALE	1:7500 (A3)
DRAWING No	CH01912-G-05
REVISION	

Legend

-  URS TP1
- Approximate location and number of machine excavated test pit by URS, 2005.
-  A TP8
- Approximate location and number of machine excavated test pit by Aurecon, 2009.
-  BH01
- Approximate location and number of rotary cored machine borehole, put down under the direction of other consultants.
-  O31/0391
- Approximate location and number of existing water bore wells, sourced from Environment Canterbury records.
-  H
- Approximate location and extent of area, and associated 'neighbourhood' reference, subject to private plan change.
-  D(i)
- Approximate location and extent of existing areas, and identifying reference, of the Ocean Ridge Subdivision, which are outside the private plan change.



SURVEYED			APPROVED	DATE
DESIGNED			MVR	
DRAWN	GN	13/03/25		
CHECKED	KT	13/03/25		
REVISION	CHANGES		CHECKED	DATE

- NOTES
1. The location and extent of the site boundaries and neighbourhood designations have been adopted from the Novo Group survey plan project number 1322001, dated 24-04-2024.

CLIENT

CARGILL STATION LTD

PROJECT

PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA

TITLE

SITE PLAN
PREVIOUS CONSULTANTS
TEST LOCATIONS

 **Fraser
Thomas**

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HAWKE'S BAY 06 211 2766

CHRISTCHURCH 03 358 5936

BLenheim 03 428 3292

NELSON 03 222 1132

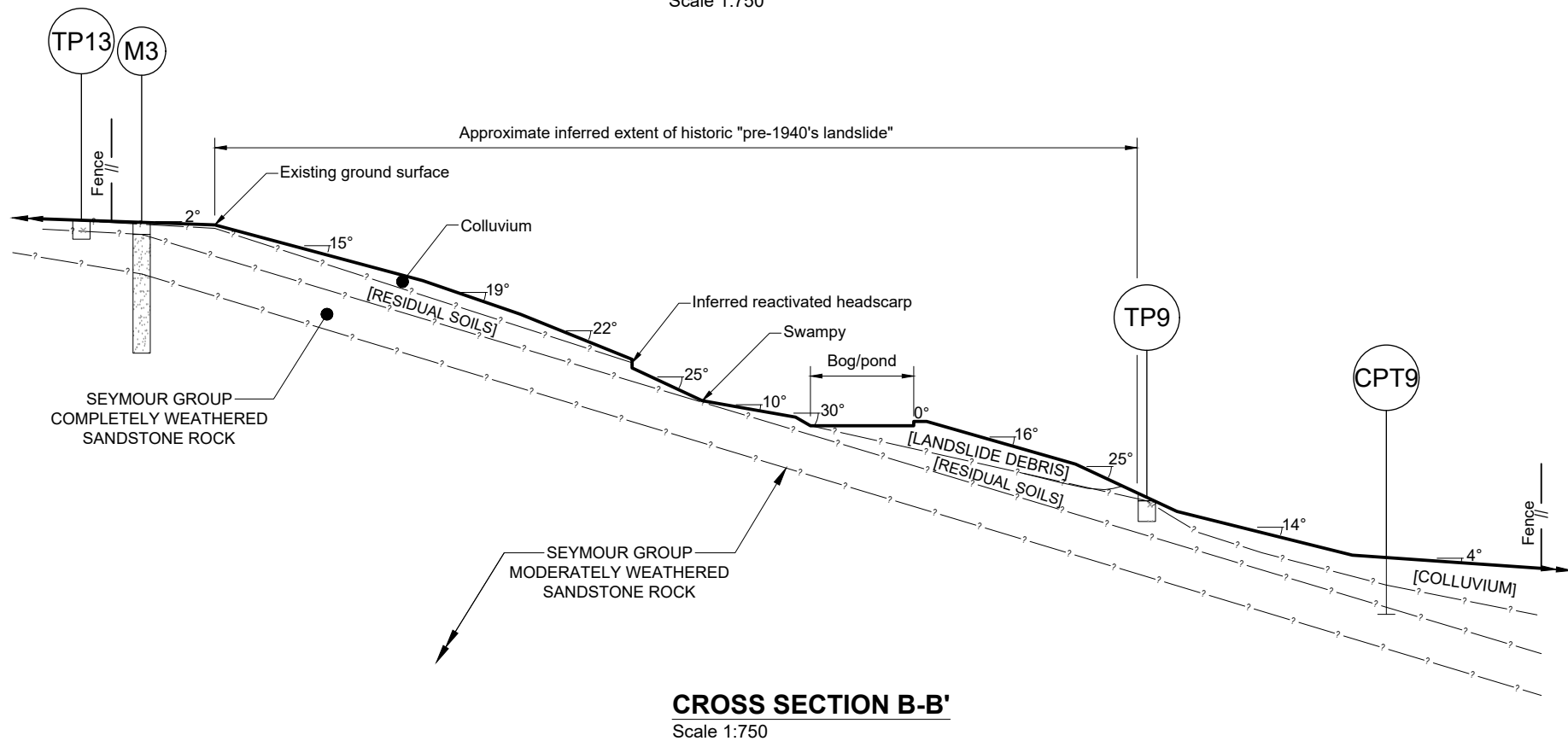
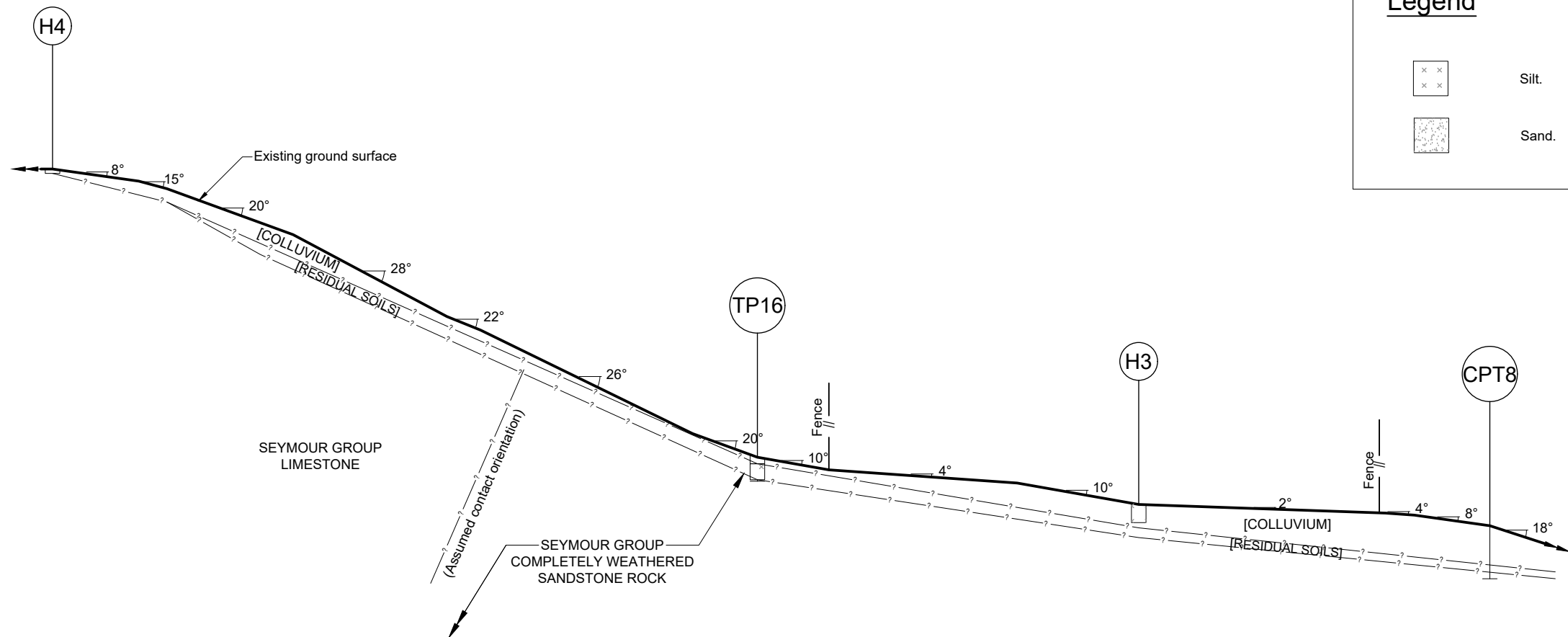
TAURANGA 07 220 9277

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SCALE	1:7500 (A3)
DRAWING No	CH01912-G-06
REVISION	

P:_CH Series\CH01912 - Ocean Ridge\Cad\03 Drawings\CH01912-G-01.dwg, gnaulls, 13/03/2025 1:14:06 pm



SURVEYED			APPROVED	DATE
DESIGNED			MVR	
DRAWN	GN	13/03/25		
CHECKED	KT	13/03/25		
REVISION	CHANGES		CHECKED	DATE

- NOTES
- The subsurface conditions as shown on this drawing have been determined only at the locations and within the depths of the various shown.
 - The subsurface conditions have been projected between the test positions and represent a rational assessment based on all available data.
 - No guarantee can be given as to the validity of, and the nature and continuity of the various subsurface features shown.
 - The soil descriptions on this drawing have been simplified for this presentation. For detailed descriptions refer to the logs of the test positions as presented in the related Fraser Thomas Report No. CH01912.

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PROJECT

PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA

TITLE

CROSS SECTIONS
A-A' AND B-B'



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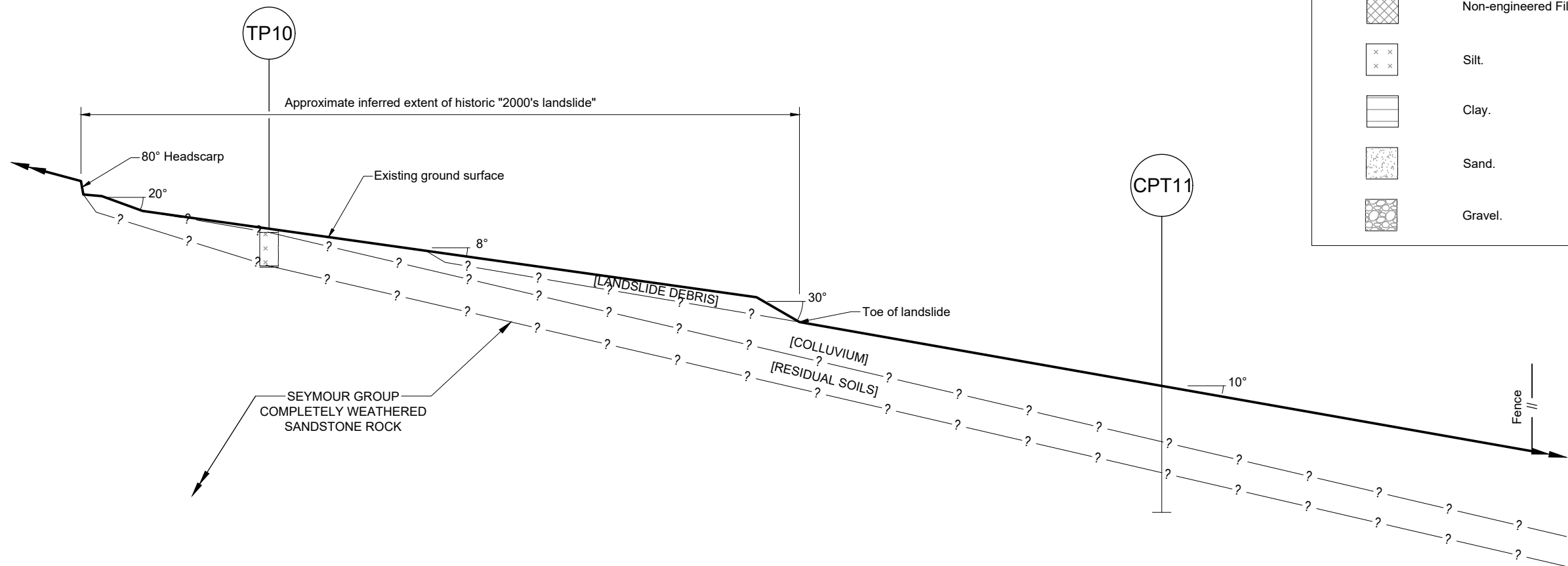
AUCKLAND	09 278 7078
HAWKE'S BAY	06 211 2766
CHRISTCHURCH	03 358 5936
BLenheim	03 428 3292
NELSON	03 222 1132
TAURANGA	07 220 9277

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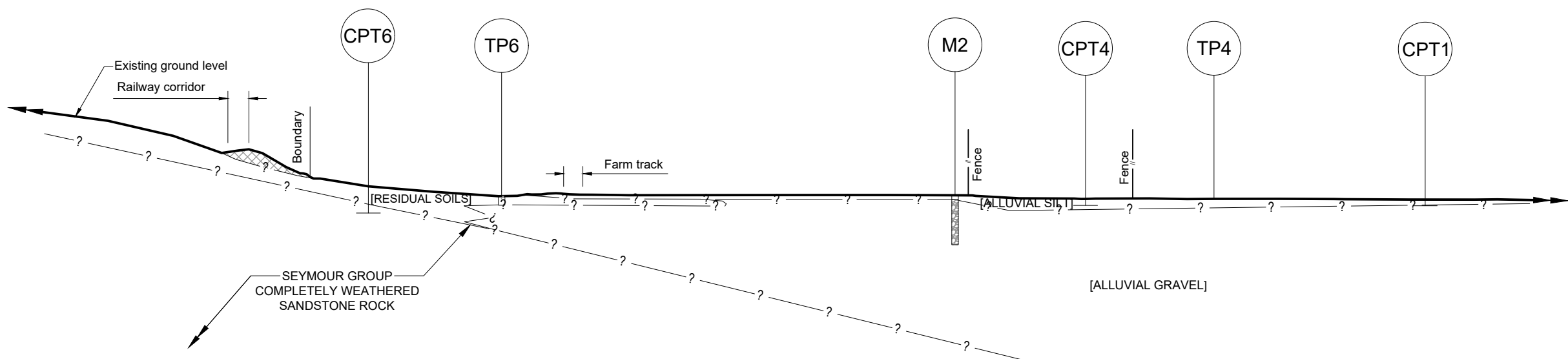
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SCALE	1:750 (A3)
DRAWING No	CH01912-G-07
REVISION	

P:_CH Series\CH01912 - Ocean Ridge\Cad\03 Drawings\CH01912-G-01.dwg, gnaulls, 13/03/2025 1:35:58 pm



CROSS SECTION C-C'
Scale 1:400



CROSS SECTION D-D'
Scale 1:1500

Legend



Non-engineered Fill.



Silt.



Clay.



Sand.



Gravel.

SURVEYED			APPROVED	DATE
DESIGNED			MVR	
DRAWN	GN	13/03/25		
CHECKED	KT	13/03/25		
REVISION	CHANGES		CHECKED	DATE

- NOTES
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 3. No guarantee can be given as to the validity of, and the nature and continuity of the various subsurface features shown.
 4. The soil descriptions on this drawing have been simplified for this presentation. For detailed descriptions refer to the logs of the test positions as presented in the related Fraser Thomas Report No. CH01912.

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**PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA**

TITLE
**CROSS SECTIONS
C-C' AND D-D'**

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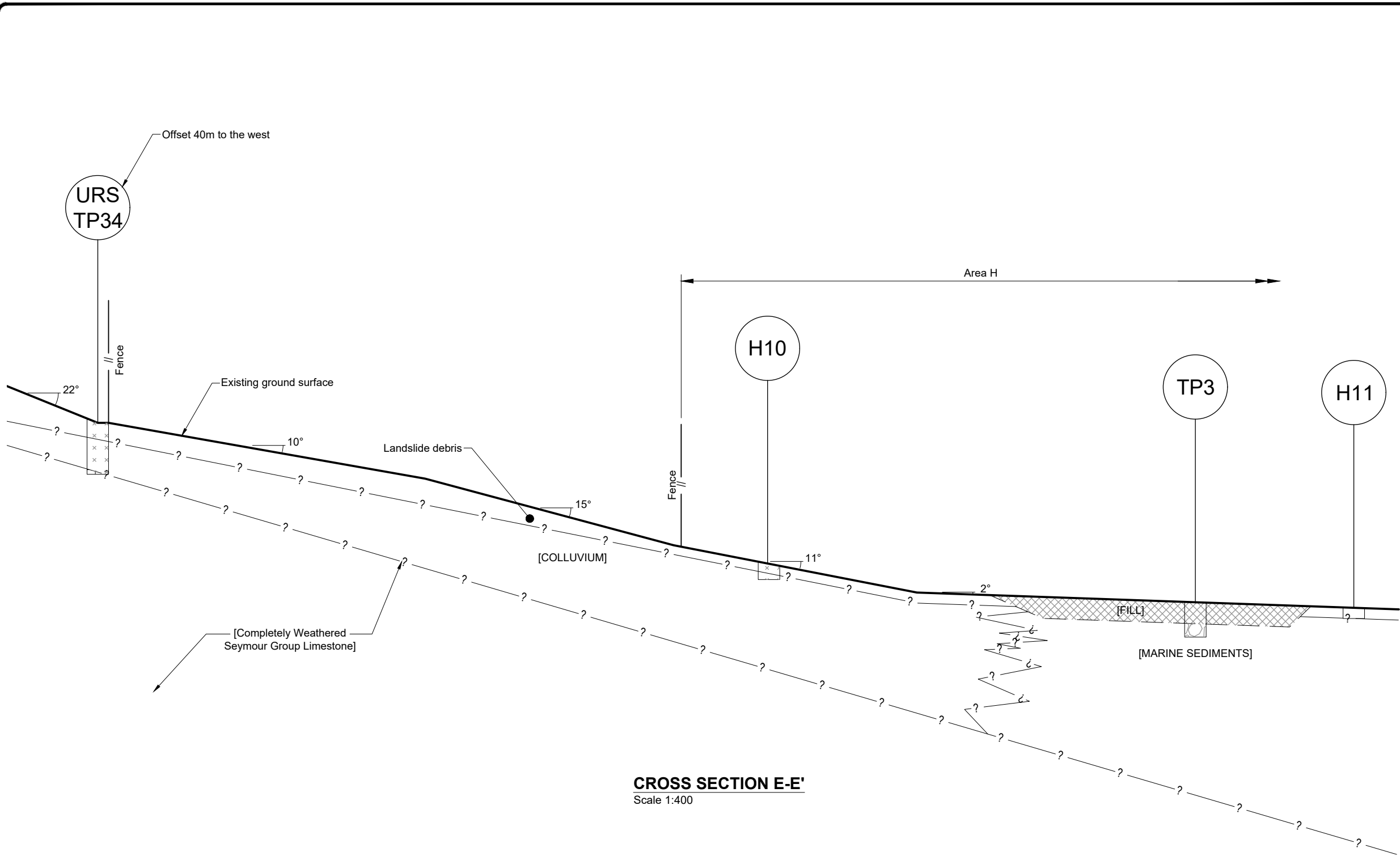
AUCKLAND	09 278 7078
HAWKE'S BAY	06 211 2766
CHRISTCHURCH	03 358 5936
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SCALE	AS SHOWN (A3)
DRAWING No	REVISION
CH01912-G-08	

P:_CH Series\CH01912 - Ocean Ridge\Cad\03 Drawings\CH01912-G-01.dwg, gnaulls,13/03/2025 3:11:18 pm



CROSS SECTION E-E'
Scale 1:400

Legend

- | | |
|--|----------------------|
| | Non-engineered Fill. |
| | Silt. |
| | Limestone. |
| | Sand. |
| | Gravel. |

SURVEYED			APPROVED	DATE
DESIGNED			MVR	
DRAWN	GN	13/03/25		
CHECKED	KT	13/03/25		
REVISION	CHANGES		CHECKED	DATE

- NOTES
1. The subsurface conditions as shown on this drawing have been determined only at the locations and within the depths of the various shown.
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PROJECT

PRIVATE PLAN CHANGE,
OCEAN RIDGE,
KAIKOURA

TITLE

CROSS SECTION
E-E'



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SCALE 1:400 (A3)

DRAWING No CH01912-G-09 REVISION