Geotechnical Investigation Report

115 Halswell Junction Road, Halswell, Christchurch

Suburban Estates Limited

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1. Introduction

CGW Consulting Engineers have been engaged by Suburban Estates Ltd (Client) to undertake a geotechnical investigation and report for a proposed development at 115 Halswell Junction Road, Halswell. We understand the client is proposing to subdivide the site and ultimately develop it into residential allotments. As part of our geotechnical investigations and reporting, we will assess the liquefaction risk of the site and a correlated MBIE prescribed Technical Category.

CGW geotechnical engineers are extensively involved in the geotechnical analysis and assessment of the neighbouring Country Palms Subdivision towards the south east of the site. We have undertaken an in-depth geotechnical analysis of this neighbouring subdivision and will reference any related information relevant to the current assessed site. The following reports have been referred to in compiling this report.

Soil & Rock Consultants Geotechnical Investigation Report, Proposed Residential Subdivision Country Palms Drive, Halswell; Ref C16073; dated 3 June 2016 Rev A.

Soil & Rock Consultants Geotechnical Investigation Report, Proposed Residential Subdivision 103 Halswell Junction Road, Halswell; Ref C16073.3; dated 19 July 2016 Rev A.

Beca Interpretive Report of Preliminary Geotechnical Investigation – CCC Halswell ODP dated 20 June 2014 Rev 3.

This report has been prepared in accordance with the Ministry of Building, Innovation and Employment (MBIE) document "Revised Guidance on Repairing and Rebuilding Houses Affected by the Canterbury Earthquake Sequence", version 3, dated December 2012, and subsequent updates, hereafter referred to as the MBIE Guidance. Our geotechnical limitations are attached in Appendix A.

2. Scope of Works

Our scope of works as per our short form agreement dated 25 February 2019 includes the following:

- Deep investigations including at least six Cone Penetration Tests (CPT) to a target death of 15m below ground level (bgl).
- Three test pit excavations undertaken across the site to interpret the shallow bearing soils to a target depth of 4 m depth.
- Geotechnical analysis of the site specific and nearby information gathered to confirm a more accurate liquefaction hazard and risk for the site.
- Assessment against RMA Section 106/ Building Act 2004 Section 71.

- Statement of Professional Opinion.
- Compile this geotechnical investigation report providing guidance on the liquefaction risk and any geological aspects that may need to be considered for the development of the site.

3. Desktop Study

3.1 Site Description

The site, located off 115 Halswell Junction Road, Halswell, Christchurch, is situated approximately 8.5km south-west of Central Christchurch and is legally described as Lot 2 DP 23163 covering a total area of 2.1 hectares. Access to the site is via Halswell Junction Road.

The site is bound to the north by a residential property, to the east by Country Palms Subdivision and to the south and west by farmland. The site is currently categorised by the Canterbury Earthquake Recovery Authority (CERA) as Rural & Unmapped. The Beca Geotechnical Investigation Report assessed the site as consistent with a Technical Category TC3 classification (R15 area).

The adjacent Country Palms subdivision is classified as being consistent with Technical Category 2 (TC2) land.

Figure 1: Site Location (Taken from Google Earth Imagery)

3.2 MBIE Technical Category

The site is located within a classified MBIE N/A – Urban Non-Residential area (Brown). MBIE designated Technical Category TC3 (Blue) land is located approximately 300m north and west of the site. As mentioned the site is bordering the recently developed Country Palms subdivision which was assessed as being consistent with a Technical Category TC2 area (Yellow).

3.3 EQC Land Damage Information

The NZGD information for the site indicates no land damage occurred at the site following the 22 February 2011 earthquake which was the only earthquake event of the Christchurch Earthquake Sequence (CES) mapped.

3.4 Vertical Land Movement

Cumulative vertical ground settlement (excluding tectonic movement) approximated via LiDAR surveys undertaken by EQC following all recent significant earthquake sequences indicates the site has undergone approximately 200mm of vertical settlement in the north-west portion of the site with an average of approximately 100mm of vertical settlement across the site. The vertical deformation data provided by the EQC is based on LiDAR observations, which are considered approximate only, with a likely error of +/- 0.1m.

3.5 Horizontal Land Movement

LiDAR survey data indicates cumulative local horizontal movement (excluding tectonic movement) of the site and surrounding area for all events of approximately 200mm to the north-west. The site is not located within an area considered susceptible to major global lateral movement (Tables 12.2, MBIE Guidelines). The horizontal deformation data provided by the EQC is based on LiDAR observations, which are considered approximate only, with a likely error of +/- 0.4m.

3.6 Scaled Conditional Peak Ground Acceleration

Conditional Peak Ground Acceleration (PGA) values, developed by Bradley Seismic Ltd and the University of Canterbury, are available on the NZGD. These values have been scaled (Table 1) to match a design earthquake moment magnitude (Mw) of 7.5 in accordance with Idriss/Boulanger (2008/2014), as recommended by Bradley and Hughes (2012).

Table 1 - Scaled Conditional PGA Values for the Site						
Earthquake Event	**Moment Magnitude (M_w)**	**Average PGA (g)**	**Standard Deviation σ**	**PGA M = 7.5 (g)**	**10th Percentile PGA M = 7.5 (g)**	**Sufficiently tested**
4th September 2010	7.1	0.30	0.39	0.27	0.16	Yes
22nd February 2011	6.2	0.35	0.42	0.25	0.14	Yes
13th June 2011	6.0	0.14	0.46	0.09	0.05	No
23rd December 2011	5.9	0.13	0.37	0.09	0.05	No

3.7 Site Performance

Using guidance from the MBIE and Bradley & Hughes (2012) 'Conditional Peak Ground Accelerations in the Canterbury Earthquakes for Conventional Liquefaction Assessment', we consider the site was "sufficiently tested" to a Serviceability Limit State SLS Level of earthquake demand during the 4 September 2010 and 22nd February 2011 earthquake events of the CES.

3.8 Published Geology

The soils across the Canterbury Plains comprise interbedded alluvial formations deposited by eastward flowing rivers emanating from the Southern Alps and draining towards the coast along Pegasus Bay. These alluvial soils, interlayered with marine deposits associated with previous fluctuations of sea level, comprise variable gravels, sand, silts and occasional peat, and can change markedly over relatively short distances, both horizontally and vertically. The sandy and silty soil types are considered susceptible to liquefaction, dependent upon grain size distribution, saturation and in-situ density.

The 1:25,000 scale geological map 'Geology of the Christchurch Urban Area' (Brown and Weeber, 1992), indicates the near surface geology at the site is the Christchurch Formation. The Christchurch Formation is described as typically up to 40 m thick, less than 10,000 years in age, and comprises marine beach and dune sands.

In this area the Christchurch Formation is likely to be underlain by the Riccarton Gravel. The Riccarton Gravel is described as typically 20 m thick, between 14,000

and 70,000 years in age, and comprises alluvial gravels with sand and silt deposited by rivers on outwash fans during the most recent glacial period. This formation is the upper most confined gravel aquifer in Canterbury.

3.9 Site Subsoil Classification

We consider that the site subsoil category in terms of NZS 1170.5 Clause 3.1.3 is Class D (deep or soft soil sites) based on the following:

- Forsyth et al (2008) indicates that rock in this area of Christchurch is likely to be in the order of several hundred metres.
- Investigations indicate approximately 20 m of interbedded silt, sand and clay, which is likely overlying predominately gravels to at least 200 m depth.
- Clause 3.1.3 and Table 3.2 of NZS 1170.5:2004

4. Geotechnical Investigation Information

In this section we will present both our site specific investigation information as well as nearby information.

4.1 Site Specific Investigations

We have undertaken six CPTs to a target depth of 15m and three test pit excavations to a target depth of 4m below ground level (bgl). The site specific testing is summarised in Table 2.

We have also relied upon the neighbouring geotechnical investigation information for 43 Country Palms Drive & 103 Halswell Junction Road where we have previously completed a comprehensive liquefaction back-analysis and sensitivity analysis for the Country Palms subdivision. We will refer to the available Cone Penetration Tests (CPT), Machine Boreholes (MB), Laboratory testing and piezometer monitoring of groundwater levels to supplement our site specific investigations.

A visual-tactile field classification of the subsoils encountered during machine drilling was carried out in accordance with 'Guidelines for the Field Classification and Description of Soil and Rock for Engineering Purposes' (NZGS, 2005). All test locations are presented on drawing 18594/1 in Appendix B. The test locations for each test was recorded by handheld GPS and reduced levels interpolated from LiDAR and are therefore approximate only.

CPT results showing cone resistance and soil behaviour type presented in Appendix C, Test Pit logs presented in Appendix D, nearby borehole logs presented in Appendix E and the associated laboratory test results presented in Appendix G.

Table 2: Site Specific Investigation Information			
Test No.	Elevation (RL)	Termination Depth (m) bgl	Further Information (Groundwater, piezometer, etc.)
TP01	13.6	3.9	No groundwater encountered
TP02	14.1	3.9	No groundwater encountered
TP03	14.7	4.0	No groundwater encountered
CPT01	14.0	9.67	Groundwater not measured
CPT02	14.0	7.57	Groundwater measured at 1.4m
CPT03	14.0	10	Groundwater measured at 1.8m
CPT04	14.0	6.9	Groundwater measured at 0.9m
CPT05	14.0	7.51	Groundwater measured at 1.1m
CPT06	14.0	9.37	Groundwater measured at 0.9m

4.2 Nearby Investigations Referenced

We have referred to the nearby machine borehole (MB01) which was undertaken within the 103 Halswell Junction Road property as part of the Country Palms Subdivision investigations. We have also referred to the laboratory testing information which was undertaken on predetermined layers of soil that exhibited a propensity to being susceptible to seismically induced liquefaction.

The machine borehole logs are presented in Appendix E and the test location is given in the test location plan in Appendix B.

A site ground model has been tabulated below in Table 3, summarising the site specific testing data encountered.

4.3 Site Ground Model

Table 3: Ground Model			
Soil Type	**Depth to bottom of layer (m)**	**Layer Thickness (m)**	**Relative Density / Consistency**
SILT (Topsoil/Fill)	0.1 – 0.4	0.1 – 0.4	Firm to Stiff
Sandy SILT interbedded with SILT and SAND, fine, minor silt, greyish brown	5.5 – 9.6	4.2 – 11.2	Loose to Medium Dense
Sandy GRAVEL, well graded, light brownish grey, subangular to subrounded	5.5+ - 9.6+	Not Confirmed	Dense to Very dense

4.4 Laboratory Test Results

The majority of the soils tested comprised silt with fine soils inferred to be fine grained sand ranging in percentage of the total sample tested of between 58% and 98%. The laboratory results are presented in Appendix F.

Table 4: Laboratory Test Results

Test No.	Depth (m)	Particle Size Distribution						PL	PI	USC
		Fines		Sand			Gravel (%)			
		Clay (%)	Silt (%)	Fine (%)	Medium (%)	Coarse (%)				
MB01 (103 Halswell Junction Rd)	2.2 – 2.5	0	58	41	1	0	0	NP	NP	ML
	3.2 – 3.5	0	63	37	0	0	0	NP	NP	ML
	8.2 – 8.5	11	87	2	0	0	0	26	5	ML

4.5 Groundwater

Groundwater was recorded between at 0.9m and 1.4m bgl within the CPT tests, however, standing groundwater was not encountered within the test pit excavations which extended to 4m depth. Groundwater measurements from the piezometer installed within machine borehole MB01, indicated a depth to groundwater of 2.85m bgl. (See Appendix H for the piezometer logs and a summary of the piezometer readings).

5. Geotechnical Assessment

5.1 Liquefaction Analysis Methodology

As mentioned, we have relied on the nearby geotechnical investigation information including laboratory testing and back analysis of similar soils in order to better quantify the liquefaction risk of the site. The geotechnical investigation and analysis for the Country Palms Subdivision undertook a comprehensive liquefaction back-analysis and sensitivity analysis of the neighbouring site (43 Country Palms Drive & 103 Halswell Junction Road). The methodology included an initial liquefaction analysis of the CPT results using the standard CPT based liquefaction analyses using the CLiq software (v1.7.6.49) and Boulanger & Idriss (2014) for liquefaction triggering and fines correction, and Zhang et al (2002) for post liquefaction induced ground subsidence, as prescribed by MBIE. From this initial analysis the CPTs exhibiting the greatest liquefaction induced settlement were identified and a machine borehole was drilled in close proximity to these identified CPTs. From the

initial liquefaction analysis, identified specific liquefiable layers that exhibited a possibility of fines (silt) being present were sampled within the boreholes and sent to a laboratory for specific testing of the fines content within the sampled soils. These are summarised and tabulated below.

5.2 Laboratory Results and Probability Consideration Analysis

The laboratory results (Table 4), indicate a 'fines content' of between 48% to 60% from a depth of between 2.0m to 4.0m bgl and up to 100% at a depth of between 4.5m to 5m and 8.2m to 8.5m bgl.

Table 5: Average Fines Content based on CPT07/11 Interpretations

Fitting Parameter C_{FC}	Fines content (%)		
	2.0 – 2.5m	3.0 – 3.5m	8.0 – 10m
0.00	20	30	30
0.07	25	35	40
0.29	45	55	80

According to B&I 2014, it suggests that the behaviour soil type index (Ic) can be calibrated as follows:

$$I_C = \frac{(FC + 137)}{80} - C_{FC}$$

Where: FC = fines content

C_{FC} = fitting parameter

Therefore, we consider the fitting parameter (C_{FC}) of 0.29) and an Ic value of 2.4 are considered appropriate for this site as they correlate well with the laboratory testing fines contents for the specific liquefiable layers assessed.

In addition, we also consider that the higher threshold probability of liquefaction P_L of 50% is appropriate due to the site being 'well tested' and in-line with nearby topography survey measurements which was considered in the back analysis.

Assessment of liquefaction potential has been undertaken using CPT001 to CPT006 to determine possible ground subsidence at the site during future design seismic events. Acceleration values for Design Level events and liquefaction analysis methodologies are taken from the MBIE Guidelines and MBIE October 2014 clarifications.

Liquefaction analyses have considered the following Serviceability Limit State (SLS) (1:25 year return period) and Ultimate Limit State (ULS) (1:500 year return period) Design Levels:

- SLS1 Mw 7.5, PGA 0.13g;
- SLS2 (sensitivity analysis at SLS) Mw 6.0, PGA 0.19g; and
- ULS Mw 7.5, PGA 0.35g.

CPT based liquefaction analyses were undertaken in CLiq software (v2.2.0.28) using Boulanger & Idriss (2014) for liquefaction triggering and fines correction, and Zhang et al (2002) for post liquefaction induced ground subsidence.

A conservative groundwater level of 2.0 m has been used for in-situ conditions and 2.0 m for the Design Level events for the analyses. Analysis outputs are presented in Appendix I.

5.3 Liquefaction Induced Settlement

Table 6: CPT based Liquefaction Analysis Results for Design Events

Test No. (Termination Depth)	Predicted Liquefaction Induced Settlement (mm)					
	Limited to 10 m (Index Value)			Full Depth of Testing (Depth)		
	SLS1	SLS2	ULS	SLS1	SLS2	ULS
CPT001	<5	<5	25	<5	<5	25
CPT002	<5	<5	45	<5	<5	45
CPT03	<5	20	54	<5	20	54
CPT04	<5	<5	35	<5	<5	35
CPT05	<5	<5	40	<5	<5	40
CPT06	<5	<5	45	<5	<5	45

5.4 Lateral Displacement

5.4.1 Global Lateral Movement

The site is not located within an area of known major global lateral ground movement (Table 12.2, MBIE December 2012 Guidelines) and no evidence of major global lateral movement was noted on the site or within the surrounding area. Therefore, we consider the site should be designated as 'minor to moderate' for global lateral movement (i.e. <300mm at ULS levels of shaking) in accordance with the MBIE Guidelines.

5.4.2 Lateral Stretch

Based on the previous performance of the site, and it's location, we consider the site should be designated as minor for lateral stretch (i.e. <50mm at ULS levels of shaking) in accordance with the MBIE Guidelines.

5.4.3 Expected Future Land Performance

The MBIE Guidelines provide broad classification of land for future land performance based on index values of expected settlements. Calculation of index values has been limited to the upper 10m of the soil profile as specified in the MBIE Guidelines, and the expected future land performance Technical Category, based on average values obtained, is shown below in Table 7 with a summary of the liquefaction analysis presented in Appendix I.

Table 7: Expected Future Land Performance Categories

Technical Category	Expected SLS Land Settlement (mm)		Expected ULS Land Settlement (mm)		Expected ULS Global Lateral Movement (mm)		Expected ULS Lateral Stretch (mm)	
TC1	0 - 15		0 – 25		Nil		Nil	
TC2	0 -50	✓	0 – 100	✓	<300 (Minor to Moderate	✓	<50 (Minor)	✓
TC3	>50		>100		300 – 500 (Major)		0 – 200 (Minor to Moderate) Or 200-500 (Major)	

Our liquefaction and lateral spreading assessment and analysis indicates that liquefaction-induced ground subsidence is consistent with a current Technical Category TC2 land performance designation. Similarly LSN values and corresponding damage classifications obtained for the site reflect TC2 land performance at SLS and ULS levels of shaking.

6. Assessment Against RMA Section 106

Section 106 of the Resource Management Act (RMA) states "… a consent authority may refuse to grant a subdivision consent, or may grant a subdivision consent subject to conditions, if it considers that:

a) the land in respect of which a consent is sought, or any structure on the land, is or is likely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source; or

b) any subsequent use that is likely to be made of the land is likely to accelerate, worsen, or result in material damage to the land, other land, or structure by erosion, falling debris, subsidence, slippage, or inundation from any source; or

c) sufficient provision has not been made for legal and physical access to each allotment to be created by the subdivision."

No erosion was observed on the site, however there is the potential for erosion to occur if the soils are left sparse of vegetation and exposed. The site is unlikely to be susceptible to falling debris or slippage due to its topography and the surrounding ground.

Due to the potential for seismically induced liquefaction, the site is currently susceptible to varying degrees of subsidence and inundation from liquefaction. However, if the appropriate liquefaction mitigation measures are undertaken the risk of subsidence and inundation from liquefaction is significantly reduced. With the appropriate liquefaction mitigation measures in place the risk of "subsidence" will be minimised. The proposed subdivision development therefore generally complies with the intent of Section 106 (a).

Due to the presence of fine grained soils at the site, the potential for erosion and rilling is present if soils are exposed to weathering for prolonged periods, Forms of weathering may include wind, precipitation and inadequately discharged stormwater runoff. The susceptibility of soils to erosion can be minimised by undertaking appropriate industry standard design measures during construction. The site has been identified as being susceptible to seismically induced liquefaction and therefore has the potential for "subsidence", "and "inundation." Provided that appropriate liquefaction mitigation measures are implemented, subsequent use of the land following development is unlikely to accelerate, worsen, or result in material damage to the land, other land, or structures. In our opinion therefore, the development will comply with the intent of section 106 (b).

Section 106 (c) is not directly relevant to a geotechnical appraisal and therefore has not been considered in detail in this report.

Thus in our opinion, under Section 106 of the RMA, there are no geotechnical reasons preventing the development, provided the developer takes the appropriate measures as recommended in this report and follows appropriate industry standards for erosion control.

7. Foundation Recommendations

We consider new dwelling foundations should comprise TC2 type foundations as given within Section A of the MBIE guidelines. For the given site, we consider 'Options 2 or 4' (enhanced foundation slab) are both suitable for the support of concrete flooring.

8. Construction Considerations

8.1 Site Formation Works

All earthworks should be carried out to the requirements of NZS 4431:1989, 'Code of Practice for Earthfilling for Residential Development'. All unsuitable materials (vegetation, organic or deleterious material, topsoil and non-engineered fill etc.) should be stripped from any areas of earthworks and stockpiled well clear of earthwork operations or carted from the site. Compaction of non-cohesive fill should be carried out using pad foot compaction plant of a minimum 10tonne static weight, in loose layers no greater than 200mm thickness. All fill materials should be clear of unsuitable materials as described above.

Prior to commencing earthworks, a sediment control system should be constructed to ensure Council requirements are met.

8.2 Excavations and Dewatering

Temporary excavation sidewalls should be battered no steeper than 1V:1H and where this cannot be safely achieved due to proximity to site boundaries then temporary retaining will be required.

We recommend construction be undertaken during the drier summer months and that groundwater levels be investigated just prior to excavations to determine whether dewatering or a drainage blanket is required. Site wide dewatering may be required if measured groundwater levels are within or close to depths of excavation. Isolated sumps and pumps may provide a sufficiently dry excavation base which to work from, however well points or more extensive dewatering may be required dependent on the groundwater depth at the time of excavation. If significant groundwater inflow is experienced into the excavation a 200mm thick drainage blanket of geotextile (Terratex 180N or equivalent) wrapped railway ballast may need to be installed in the base of the excavation to provide a free-draining platform from which to conduct fill placement and compaction.

Dewatering and excavation side-wall retention are the responsibility of the contractor.

8.3 Local Soft / Organic Ground

Soft soils or those rich in organic matter should be treated as unsuitable. If encountered during excavations these materials should be placed in a designated unsuitable stockpile for removal and disposal off site.

8.4 Fill and Backfill

We consider engineered fill should be placed on a suitable subgrade in layers not exceeding 200mm thickness and each layer compacted to achieve a Maximum Dry Density Ratio of at least 95%. A geotechnical engineer should be engaged to assist in assessing suitable subgrade and excavations.

8.5 Stormwater Control

Concentrated stormwater flows from all impermeable areas must be collected and carried in sealed pipes to the Council system. Uncontrolled stormwater must not be allowed to saturate the ground as this will potentially affect foundation performance both statically and during future seismic activity (liquefaction potential and liquefaction induced settlement are both increased with a higher groundwater table which can result from uncontrolled disposal of stormwater).

8.6 Pavement Areas

Vegetation, any organic or deleterious material, topsoil and non-engineered fill should be removed from the site under pavement areas prior to aggregate placement. Based on our observations during testing we consider the natural ground at the site should provide an adequate subgrade for the proposed pavement areas. We recommend for preliminary design a CBR value of 3% or a modulus of subgrade reaction of 20kPa/mm, for flexible or rigid pavements respectively.

The thickness of the basecourse would depend on the final CBR/modulus of subgrade reaction used for the subgrade and the traffic loads anticipated. The compaction of the basecourse should be carried out with a vibratory roller of appropriate static weight and energy.

8.7 Underground Services

Flexible connections should be constructed where all service drains and ducts enter/exit either concrete floor slabs or areas of ground improvement. Service trench backfill should comprise well graded crushed stone aggregate (i.e. GAP 65) treated with 3% cement by weight.

The contractor is responsible for ascertaining whether any major services are present within the site. This should be confirmed prior to any earth-working.

9. Further Geotechnical Involvement

9.1 Geotechnical Drawing Review

A geotechnical engineer familiar with the findings of this report should be engaged to review the final working drawings of the proposed development prior to submission to the Building Consent Authority, to ensure the geotechnical recommendations of this report have been implemented correctly. Further geotechnical analysis may be warranted at this stage subject to the specifics of the development proposal.

9.2 Construction Observations

A Geotechnical Engineer familiar with the findings of this report should be engaged to carry out observations during foundation excavations to confirm soil and foundation conditions are consistent with those adopted within this report. Inspections will not be carried out prior to Council issuing the required Resource and/or Building Consents, and unconsented works will not be inspected.

The recommendations given in this report are based on limited site data from discrete locations. Variations in ground conditions could exist across the site. It is in the interests of all parties that we be retained to observe excavations and foundation conditions exposed during construction, so that ground conditions can be compared with those assumed in formulating this report. In any event, we should be notified of any variations in ground conditions from those described or assumed to exist.

Without sufficient observations during the subgrade preparation prior to placement of fill or concrete, CGW Consulting Engineers will not be in a position to provide engineering signoff (i.e. Earthworks Completion Report, Professional Opinion or Producer Statement PS4). We recommend once a Resource and/or Building Consent be issued it be forwarded to us for review. We will then on-forward a schedule of inspections required by us in order to meet the consent conditions. Areas where concrete or fill are placed without prior geotechnical observation will be specifically excluded from completion documentation.

10. Statement of Professional Opinion

A statement of professional opinion with regards to the proposed development is provided in Appendix J.

Appendix A: Limitations

CGW CONSULTING ENGINEERS - LIMITATIONS

The professional services and this document provided by CGW Consulting Engineers Ltd ("CGW") are subject to the following limitations:

Reliance: This document has been prepared solely for the benefit of our client, as per our brief and an agreed consultancy agreement. The document is confidential and reliance by any other parties on the information or opinions contained in this document shall, without our prior agreement in writing, be at such parties' sole risk. CGW accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this document.

Our Brief: This document has been prepared solely to address the issues raised in our brief, and shall not be relied on for any other purpose. The scope and the period of CGW's services are as described in CGW's proposal, and are subject to restrictions and limitations. CGW did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by CGW in regards to it.

Unforeseen Ground Conditions: The conclusions and recommendations contained within this document are based on the ground conditions indicated from published sources, site inspections and subsurface investigations described in this document based on accepted normal methods of site investigation. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this document does not purport to completely describe all the site characteristics and properties. The nature and continuity of ground and groundwater conditions are inferred using experience and judgement and it must be appreciated that actual conditions could vary considerably from the assumed model. Defects and unforeseen ground conditions may remain undetected which might adversely affect the stability of the site and the recommendations made herein.

Third Party Data: In the event that external third party investigation data has been utilised or provided to us, the client acknowledges that we have placed reliance on this information to produce our document and CGW will accept no liability resulting from any errors or defect in the external third party data.

Ground Investigation Data: The Client grants permission to CGW to upload any factual data collected during the works to the National Geotechnical Database (or other similar database) as appropriate.

Warranty: Any assessments made in this document are based on the conditions indicated from published sources and the investigations described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this document.

Time: In addition, it is recognised that the passage of time affects the information and assessment provided in this document. CGW's opinions are based upon information that existed at the time of the production of the document. It is understood that the services provided allowed CGW to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality or features of the site, or its surroundings, or any laws or guidance or regulations.

Construction Issues: It is common that not all site issues will necessarily be dealt with at site assessment stage. As the project progresses through design towards construction, if issues arise, allow CGW to develop alternative solutions to problems, that will be of benefit both in time and cost. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. Contractors should perform any additional tests as necessary for their own purposes.

Geoenvironmental: Unless specifically stated the document will not relate any findings, conclusions or recommendations about the potential for hazardous or contaminated materials existing at the site. Specialist equipment, techniques, laboratory testing and personnel are required to perform geoenvironmental (ie. HAIL) assessments.

Sub-Contractors and Staff: CGW may have retained sub-consultants or sub-contractors to provide services for the benefit of CGW. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, CGW's sub-consultant or sub-contractor companies, and CGW's employees, officers and directors.

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Intellectual Property Rights: All intellectual property (IP), designs and documents created or provided by CGW in the provision of the services shall remain the property of CGW. Subject to the Client complying with its obligations under the agreed consultancy agreement, the Client shall upon payment own all deliverables provided to it in the provision of the Services, and CGW grants to the Client a nonexclusive, non-transferable license to use the IP for the purposes described in the Proposal. The Client shall not use, or make copies of, the deliverables in connection with any work not included in the Proposal without prior written consent from CGW. If the Client is in breach of any obligation to make a payment to CGW, then CGW may revoke the license to use the IP and the Client shall return to CGW all originals of deliverables provided under the services and any copies thereof.

Assignment: Neither party and their respective successors may assign, transfer, or sublet any obligation under this Agreement without the prior written consent of the other party. Unless stated in writing to the contrary, no assignment, transfer, novation or sublet shall release the assignor from any obligation under this Agreement.

Standard Terms: These Limitations should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement as per our proposal and agreed consultancy agreement.

Appendix B: Test Location Plan

N

Approximate True North

Legend:

- CPT — Cone Penetration Test Locations
- TP — Test Pit Location
- MB — Nearby Machine Borehole Test

Notes:

1. CGW Consulting Engineers Test Location Plan adapted from Ecan or Google maps.
2. It should be borne in mind that locations of features are approximate only.
3. Original plan size A4.

CGW Consulting Engineers

Civil Structural Environmental Geotechnical

Nelson Ph: 548 - 8259
Christchurch Ph: 348 - 1000

DATE:	March 2019
DRAWN:	JF
SCALE:	NTS
CAD REF:	18594

Test Location Plan

115 Halswell Junction Road
Halswell
Christchurch

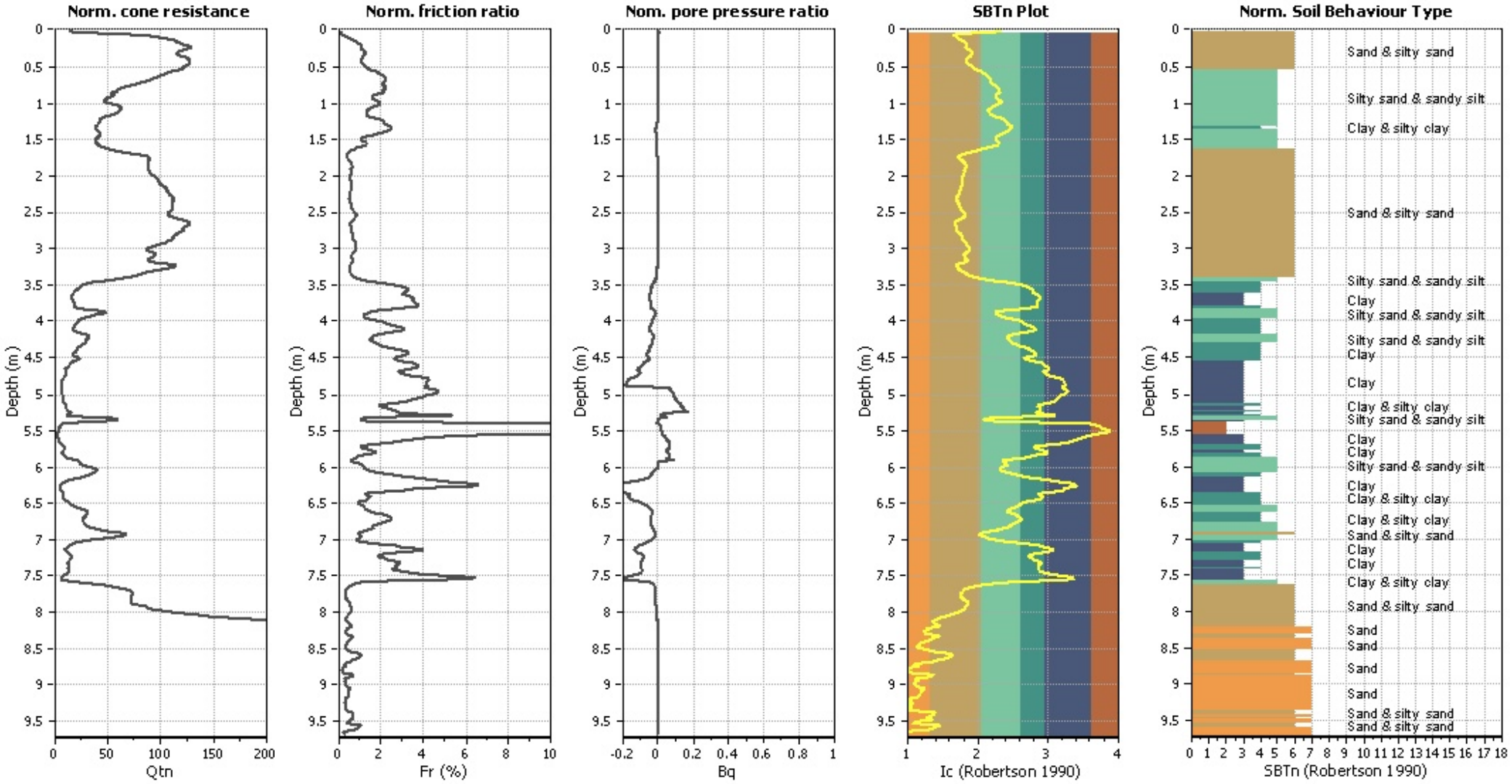
DRAWING NO:

18594/1

SHEET 1 OF 1

Appendix C: Cone Penetration Test Logs

CPT basic interpretation plots (normaliz



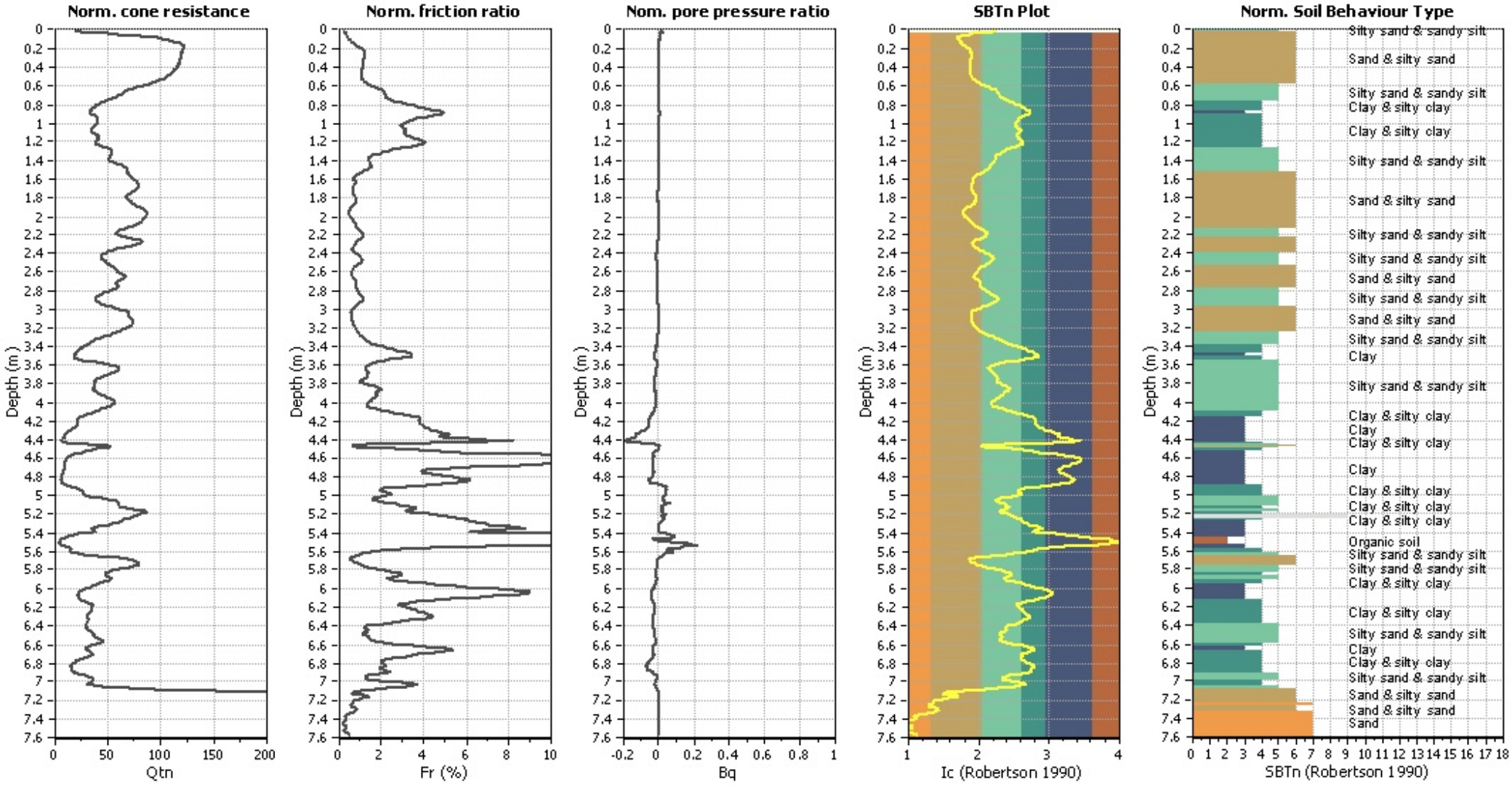
Input parameters and analysis data

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:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

CPT basic interpretation plots (normaliz



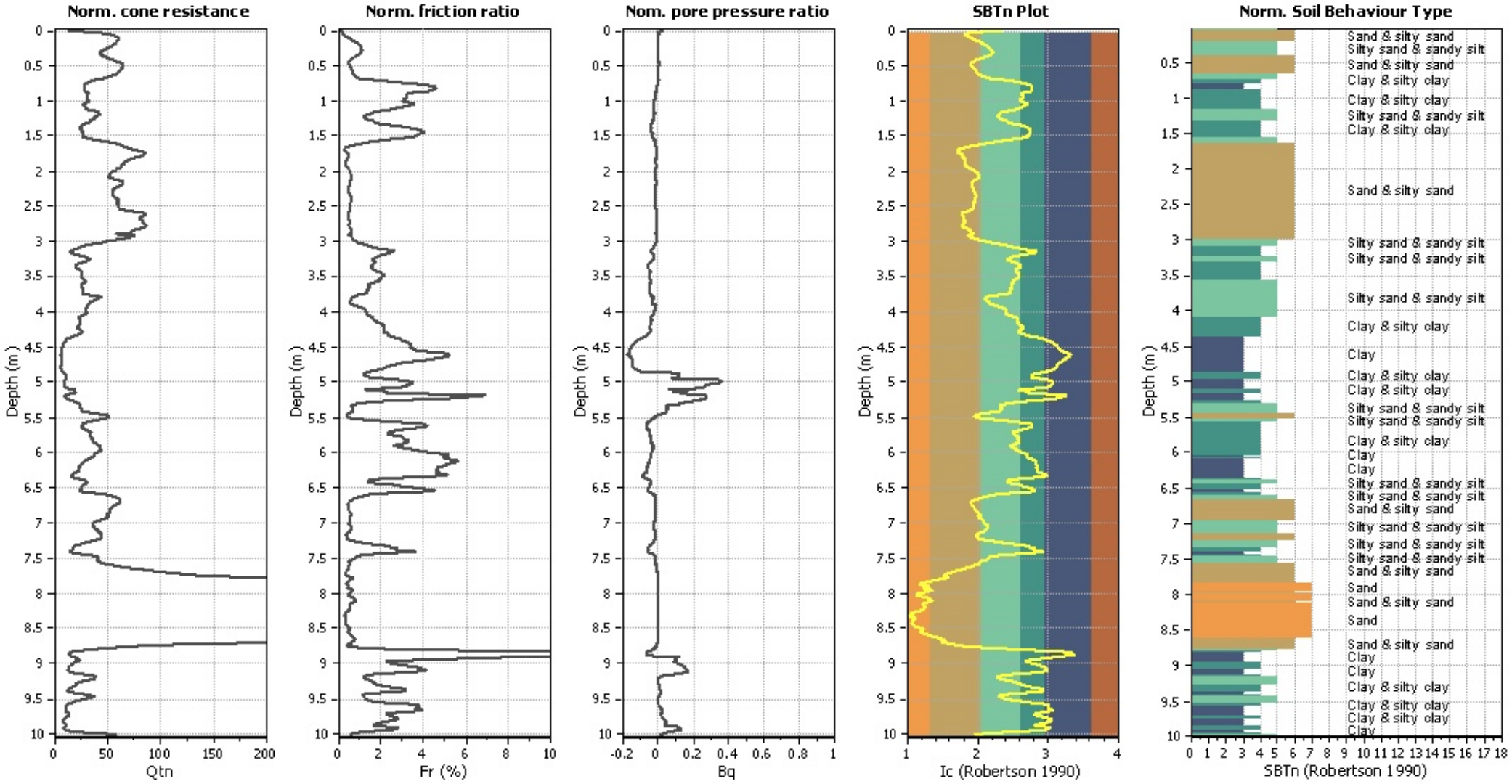
Input parameters and analysis data

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:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

CPT basic interpretation plots (normaliz



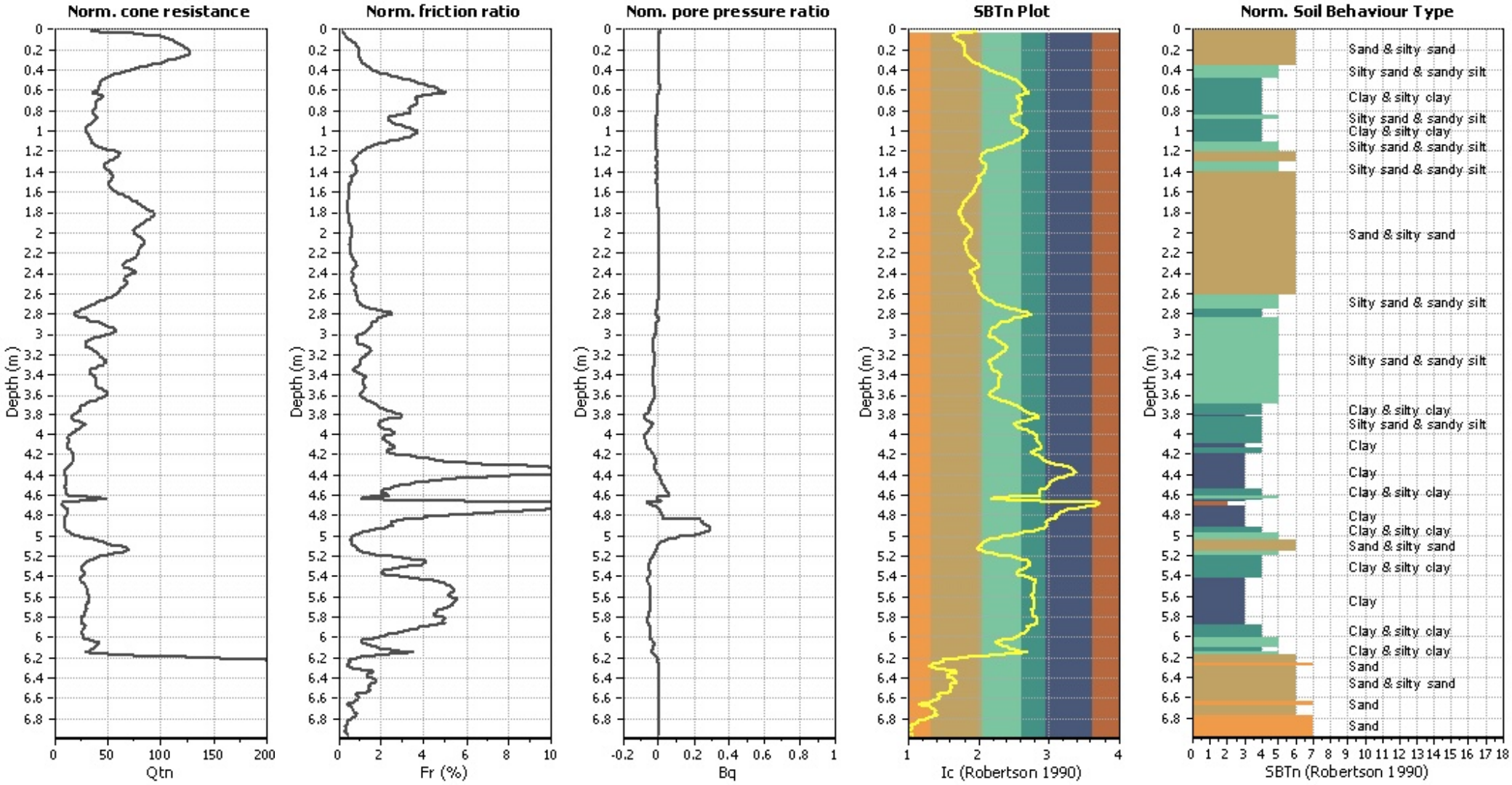
Input parameters and analysis data

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:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

CPT basic interpretation plots (normaliz



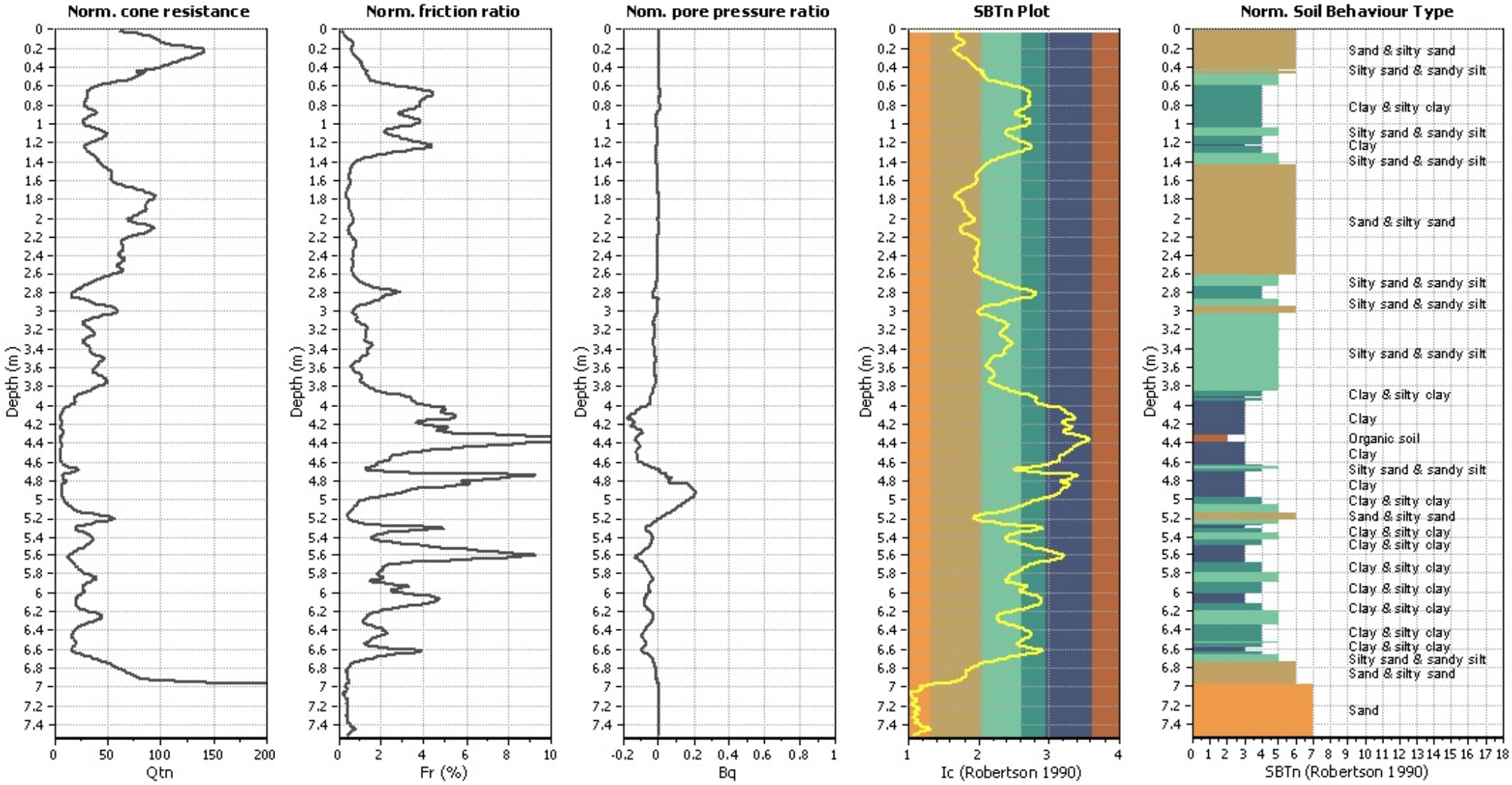
Input parameters and analysis data

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:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

CPT basic interpretation plots (normaliz



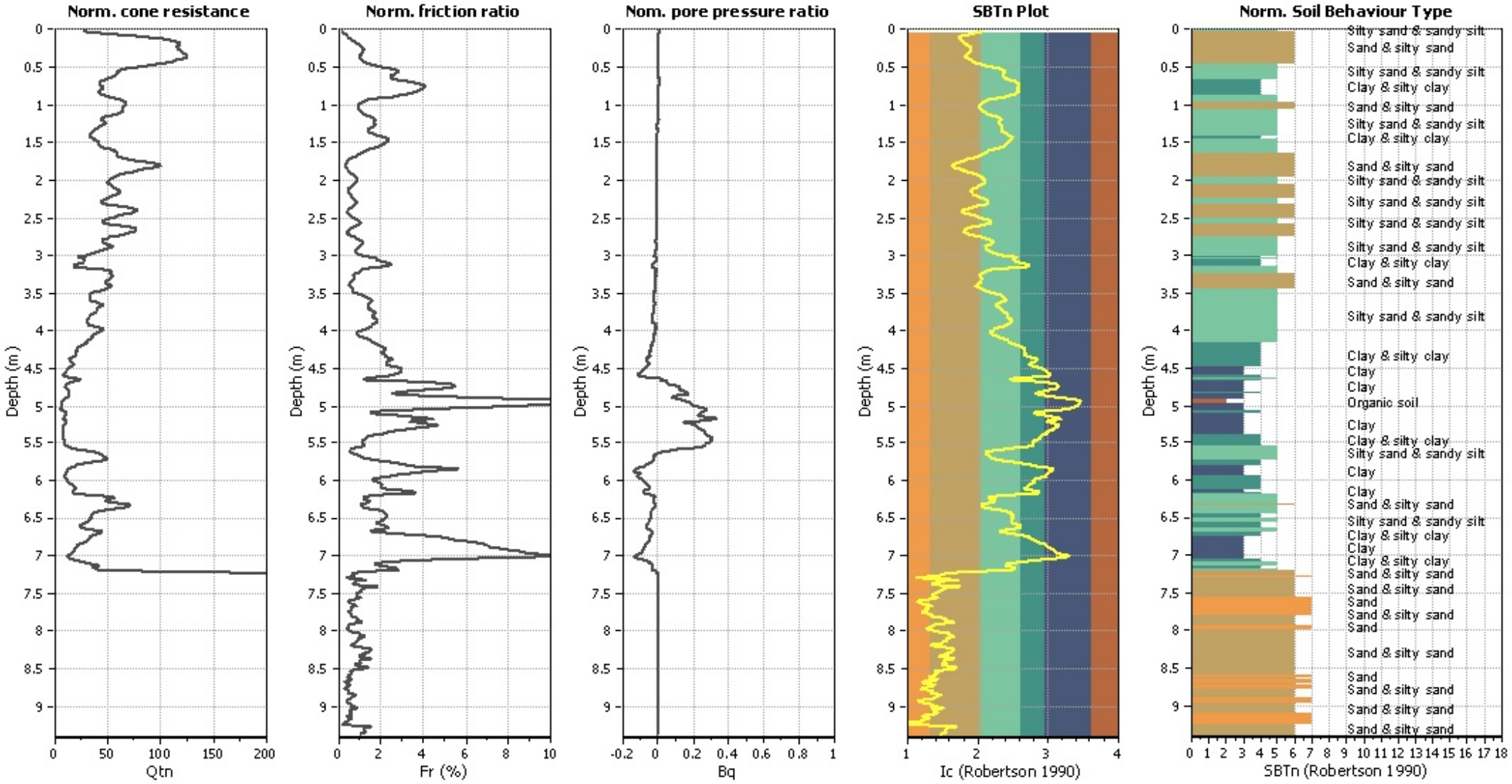
Input parameters and analysis data

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:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

CPT basic interpretation plots (normaliz



Input parameters and analysis data

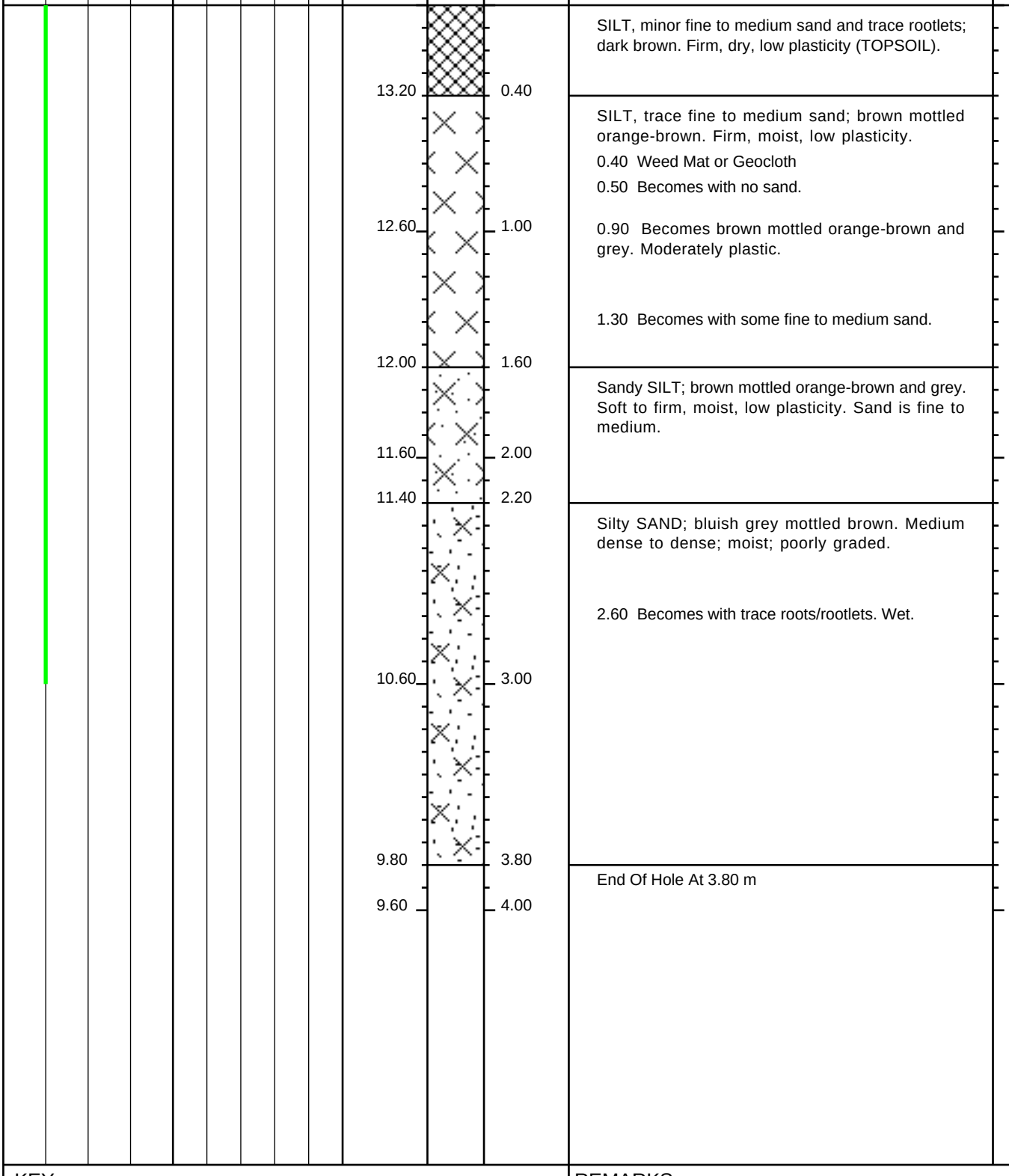
Analysis method:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

SBTn legend

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

Appendix D: Test Pit Logs

CGW Consulting Engineers	Project Title: 115 Halswell Junction Road, Halswell, Christchurch		TP01
	Project Number: 18594	Client: Suburban Estates Ltd	
	GL (mAOD): 13.60	N Coord: -43.583847	E Coord: 172.558536
Date: 19/03/2019	Method: Digger	Logged By: JF	Scale: 1:25 Sheet 1 Of 1



Description	Water
SILT, minor fine to medium sand and trace rootlets; dark brown. Firm, dry, low plasticity (TOPSOIL).	
SILT, trace fine to medium sand; brown mottled orange-brown. Firm, moist, low plasticity. 0.40 Weed Mat or Geocloth 0.50 Becomes with no sand. 0.90 Becomes brown mottled orange-brown and grey. Moderately plastic. 1.30 Becomes with some fine to medium sand.	
Sandy SILT; brown mottled orange-brown and grey. Soft to firm, moist, low plasticity. Sand is fine to medium.	
Silty SAND; bluish grey mottled brown. Medium dense to dense; moist; poorly graded. 2.60 Becomes with trace roots/rootlets. Wet.	
End Of Hole At 3.80 m	

KEY

D - Disturbed Sample
B - Bulk Sample
W - Water Sample
V - Hand Shear Vane kPa

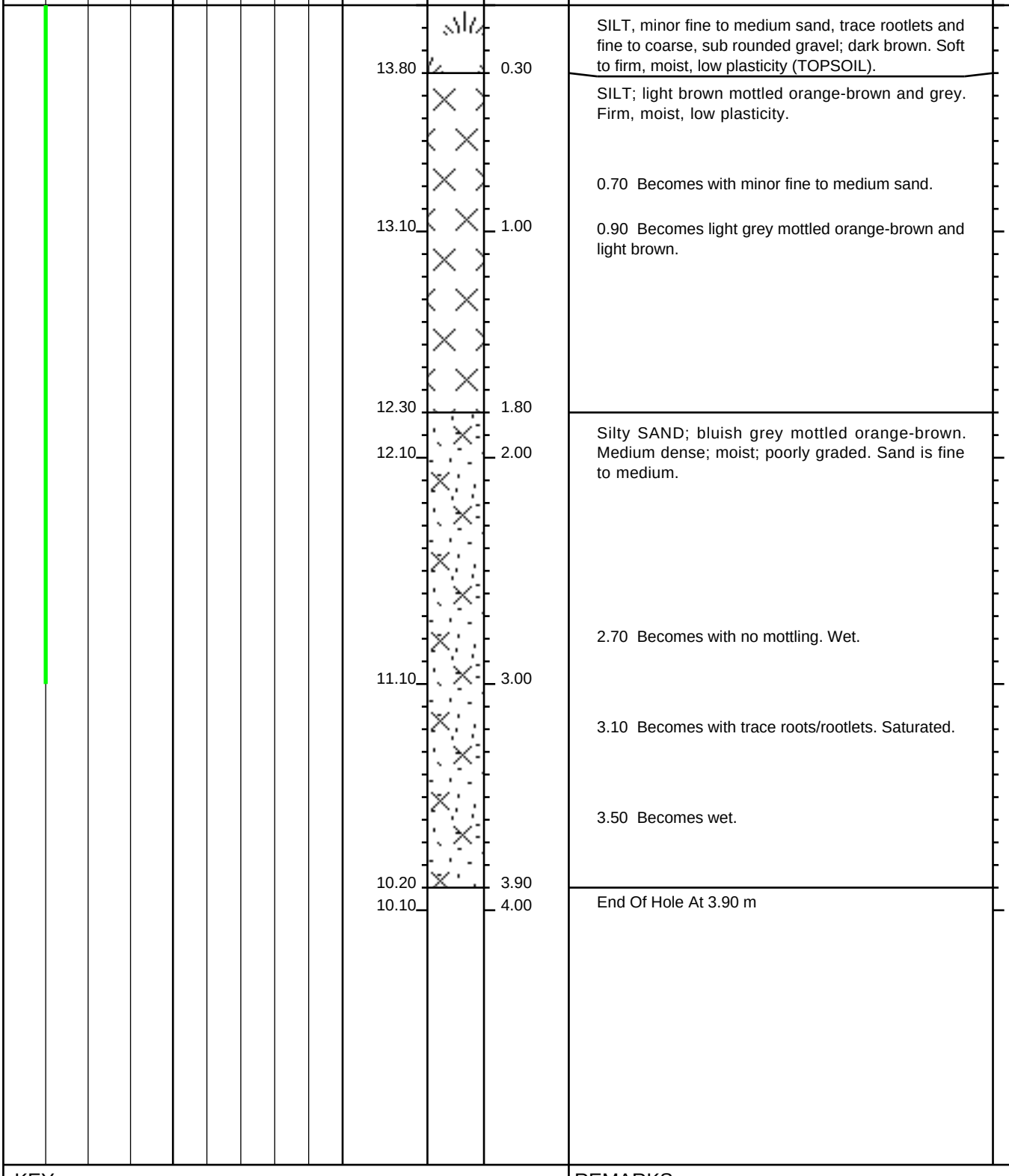
▽ - Groundwater Strike
▼ - Groundwater Level

AGS

REMARKS

No Groundwater Encountered
End of Hole at 3.8 m.
Target Depth Reached.

CGW Consulting Engineers	Project Title: 115 Halswell Junction Road, Halswell, Christchurch		TP02
	Project Number: 18594	Client: Suburban Estates Ltd	
	GL (mAOD): 14.10	N Coord: -43.583279	E Coord: 172.55911
Date: 19/03/2019	Method: Digger	Logged By: JF	Scale: 1:25 Sheet 1 Of 1



Level	Depth (m)	Description	Water
		SILT, minor fine to medium sand, trace rootlets and fine to coarse, sub rounded gravel; dark brown. Soft to firm, moist, low plasticity (TOPSOIL).	
13.80	0.30	SILT; light brown mottled orange-brown and grey. Firm, moist, low plasticity.	
		0.70 Becomes with minor fine to medium sand.	
13.10	1.00	0.90 Becomes light grey mottled orange-brown and light brown.	
12.30	1.80		
12.10	2.00	Silty SAND; bluish grey mottled orange-brown. Medium dense; moist; poorly graded. Sand is fine to medium.	
		2.70 Becomes with no mottling. Wet.	
11.10	3.00	3.10 Becomes with trace roots/rootlets. Saturated.	
		3.50 Becomes wet.	
10.20	3.90		
10.10	4.00	End Of Hole At 3.90 m	

KEY

D - Disturbed Sample
B - Bulk Sample
W - Water Sample
V - Hand Shear Vane kPa

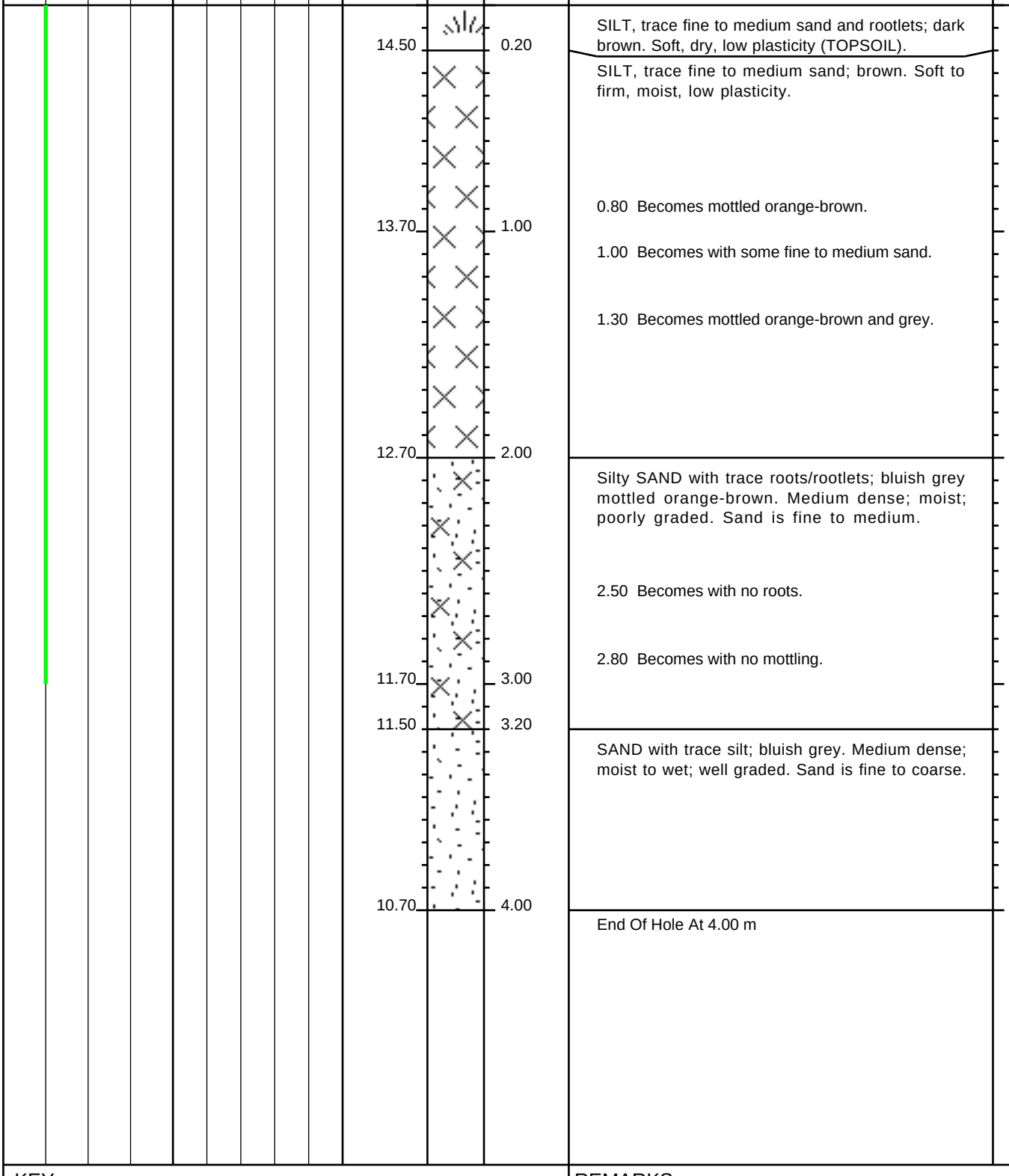
▽ - Groundwater Strike
▼ - Groundwater Level

AGS

REMARKS

No Groundwater Encountered
End of Hole at 3.8 m.
Target Depth Reached.

CGW Consulting Engineers	Project Title: 115 Halswell Junction Road, Halswell, Christchurch		TP03
	Project Number: 18594	Client: Suburban Estates Ltd	
	GL (mAOD): 14.70	N Coord: -43.582937	E Coord: 172.559641
Date: 19/03/2019	Method: Digger	Logged By: JF	Scale: 1:25 Sheet 1 Of 1



Description	Water
SILT, trace fine to medium sand and rootlets; dark brown. Soft, dry, low plasticity (TOPSOIL).	
SILT, trace fine to medium sand; brown. Soft to firm, moist, low plasticity.	
0.80 Becomes mottled orange-brown.	
1.00 Becomes with some fine to medium sand.	
1.30 Becomes mottled orange-brown and grey.	
Silty SAND with trace roots/rootlets; bluish grey mottled orange-brown. Medium dense; moist; poorly graded. Sand is fine to medium.	
2.50 Becomes with no roots.	
2.80 Becomes with no mottling.	
SAND with trace silt; bluish grey. Medium dense; moist to wet; well graded. Sand is fine to coarse.	
End Of Hole At 4.00 m	

KEY

D - Disturbed Sample
B - Bulk Sample
W - Water Sample
V - Hand Shear Vane kPa

▽ - Groundwater Strike
▼ - Groundwater Level

AGS

REMARKS

No Groundwater Encountered
End of Hole at 4.0 m.
Target Depth Reached.

Appendix E: Nearby Borehole Logs

Soil&Rock Consultants
For well-grounded solutions

CLIENT: Suburban Estates Ltd

PROJECT: 103 Halswell Junction Road, Halswell

Machine Borehole No: MB01

Sheet 1 of 2

Drill Type:	Sonic	Project No:	C16073.1	Logged By:	JW
Drilled By:	Landtest	Coordinates:	1564527.41 E, 5174222.02 N	Reviewed By:	RS
Date Started:	20/6/16	Ground Elevation:	15m LYTTHT1937	Surface Conditions:	Near level grass
Date Finished:	20/6/16	Water Level:	3.0m Groundwater	Shear Vane Number:	N/A

STRATIGRAPHY	GRAPHIC LOG	Soil description in accordance with the NZ Geotechnical Society Inc 2005 "Guidelines for Field Description of Soil and Rock in Engineering Use"	WATER LEVEL (m)	DEPTH (m)	SAMPLE TYPE	SPT / c_u (kPa) (blows/300mm)	DRILLING METHOD	RECOVERY (%)	TCR SCR RQD	If	WATER CONTENT	OTHER
TOPSOIL		SILT, trace fine sand, dark brown. Moist, non-plastic, trace rootlet inclusions (TOPSOIL).		0.0								
SPRINGSTON FORMATION		Fine SAND, trace to minor silt, light brown. "Tightly packed", moist (SPRINGSTON FORMATION).		0.5								
		Becomes silty, greyish brown.										
		Trace to minor silt.		1.0								
		Minor silt, light brownish grey with brownish orange mottles, moist to wet.										
		Minor to some silt.		1.5								
		Fine sandy SILT, grey with reddish orange mottles. "Firm", wet, non-plastic.		2.0								
		Fine to medium SAND, trace silt, grey. "Tightly packed", wet.										
		Fine sand, some silt to silty.		2.5								
		Minor silt.										
		Trace silt.	Groundwater									
		Fine to medium SAND, saturated (dilatent).		3.0								
		Minor silt.										
		Fine sandy SILT, grey. "Firm to stiff", saturated, non-plastic.		3.5								
		Fine to medium SAND, minor silt, grey. "Tightly packed", saturated.										
		Fine SAND.		4.0								
		Trace to minor silt.										
		Minor to some silt.										
		SILT, trace fine sand, grey. "Firm to stiff", saturated, non-plastic.		4.5								
		Trace fibrous wood inclusions.										
		Minor fine sand.		5.0								
		Trace fine sand.										
		Amorphous PEAT, trace to minor silt, trace fibrous wood inclusions, dark brown. "Firm", saturted, non-plastic.		5.5								
		Organic SILT, minor fibrous wood inclusions, trace amorphous peat inclusions, grey and brown intermixed. "Firm to stiff", saturated, non-plastic, organic odour.										
		Fibrous wood inclusion (100mm).		6.0								
		SILT, trace clay, trace fibrous wood inclusions, light grey. "Stiff", saturated, non-plastic to slightly plastic.		6.5								
				7.0								

Dual Tube

MACHINE LOG-BAK C16073.1_MB01_20-06-2016.GPJ S+R_2012-AGS - REVISED.GDT 21/6/16

Soil&Rock Consultants
For well-grounded solutions

CLIENT: Suburban Estates Ltd

PROJECT: 103 Halswell Junction Road, Halswell

Machine Borehole No: MB01

Sheet 2 of 2

Drill Type:	Sonic	Project No:	C16073.1	Logged By:	JW
Drilled By:	Landtest	Coordinates:	1564527.41 E, 5174222.02 N	Reviewed By:	RS
Date Started:	20/6/16	Ground Elevation:	15m LYTTHT1937	Surface Conditions:	Near level grass
Date Finished:	20/6/16	Water Level:	3.0m Groundwater	Shear Vane Number:	N/A

STRATIGRAPHY	GRAPHIC LOG	Soil description in accordance with the NZ Geotechnical Society Inc 2005 "Guidelines for Field Description of Soil and Rock in Engineering Use"	WATER LEVEL (m)	DEPTH (m)	SAMPLE TYPE	SPT / c_u (kPa) (blows/300mm)	DRILLING METHOD	RECOVERY (%)	TCR SCR RQD	If	WATER CONTENT	OTHER
SPRINGSTON FORMATION		SILT, trace clay, trace fibrous wood inclusions, light grey. "Stiff", saturated, non-plastic to slightly plastic.		7.0			Dual Tube					
		Fine to coarse SAND, trace silt, dark brown. "Tightly packed", saturated.		7.5								
		SILT, trace fine sand, grey. "Stiff to very stiff", saturated, non-plastic.		8.0								
		Trace to minor fibrous wood inclusions, organic odour.		8.5								
		No fibrous wood inclusions.		9.0								
		Organic SILT, trace fine sand, trace fibrous wood inclusions, grey. "Stiff", saturated, non-plastic.		9.5								
		Amorphous PEAT, minor silt, minor fibrous wood inclusions, dark brown. "Firm", saturated.		10.0								
		END OF BORE. 10.10 METRES. Target Depth		10.5								
				11.0								
				11.5								
				12.0								
				12.5								
				13.0								
				13.5								
				14.0								

MACHINE LOG-BAK C16073.1_MB01_20-06-2016.GPJ S+R_2012-AGS - REVISED.GDT 21/6/16

Appendix G: Laboratory Results

Central Testing Services
18 Ngapara Street, P.O. Box 397, Alexandra, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: 16/1480

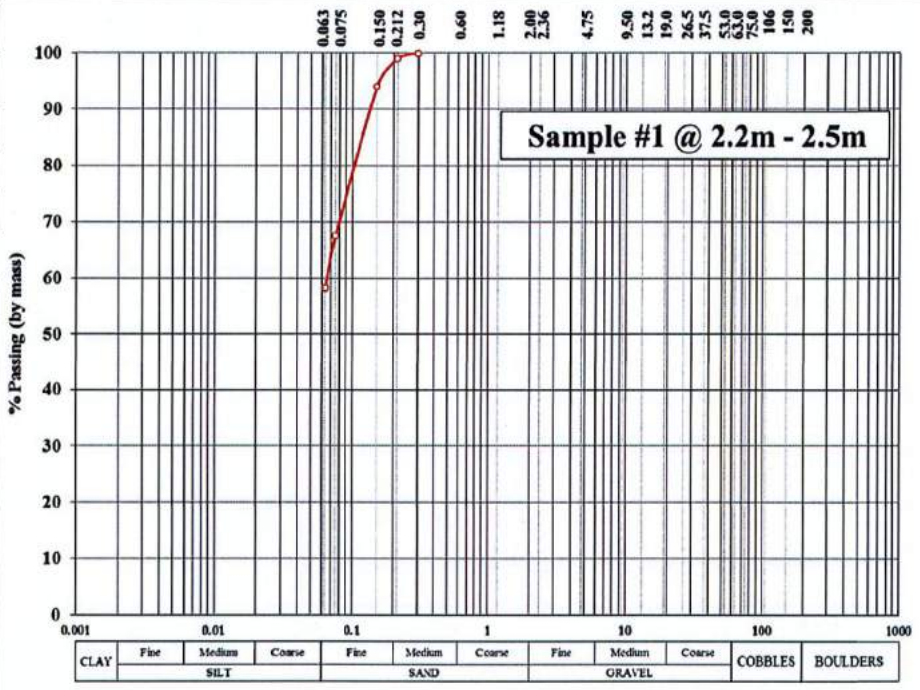
Date: 30 June 2016

TEST REPORT – 103 COUNTRY PALMS DRIVE, HALSWELL

Client Details:	Soil & Rock Consultants, P.O. Box 10 212, Phillipstown, Christchurch	**Attention:**	R. Smith
Job Description:	103 Country Palms Drive, Halswell - Investigations		
Sample Description:	Sandy SILT	**Client Order No:**	C16073.1
Sample Source:	Machine Borehole # 1; Sample #1 @ 2.2m - 2.5m	**Sample Label No:**	N/A
Date & Time Sampled:	Unknown	**Sampled By:**	Unknown
Sample Method:	Borehole	**Date Received:**	23-Jun-16
Sample Specification:	Not Applicable		

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
37.5	
26.5	
19.0	
13.2	
9.50	
4.75	
2.36	
2.00	
1.18	
0.60	
0.30	100
0.212	99
0.150	94
0.075	68
0.063	58



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & PLASTICITY INDEX RESULTS - NZS 4402:1986, Test 2.1, 2.3, 2.4 & 2.5	
Water Content: (As Received)	25.5 %
Cone Penetration Limit: (CPL)	28
Plastic Limit: (PL)	Non-plastic
Plasticity Index: (PI)	Non-plastic
Note: The sample was received in a natural state. The plasticity index material tested was whole soil.	

Note:

- *Information contained in this report which is Not IANZ Accredited relates to the sample descriptions based on NZ Geotechnical Society Guidelines 2005 and sampling.*
- *This report may not be reproduced except in full.*

Tested By: L.T. Smith **Date:** 25 to 30-Jun-16

Checked By:

Tests indicated as Not Accredited are outside the laboratory's scope of accreditation

IANZ ACCREDITED LABORATORY Accreditation No: 434

Central Testing Services
18 Ngapara Street, P.O. Box 397, Alexandra, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: Info@centraltesting.co.nz

Reference No: 16/1480

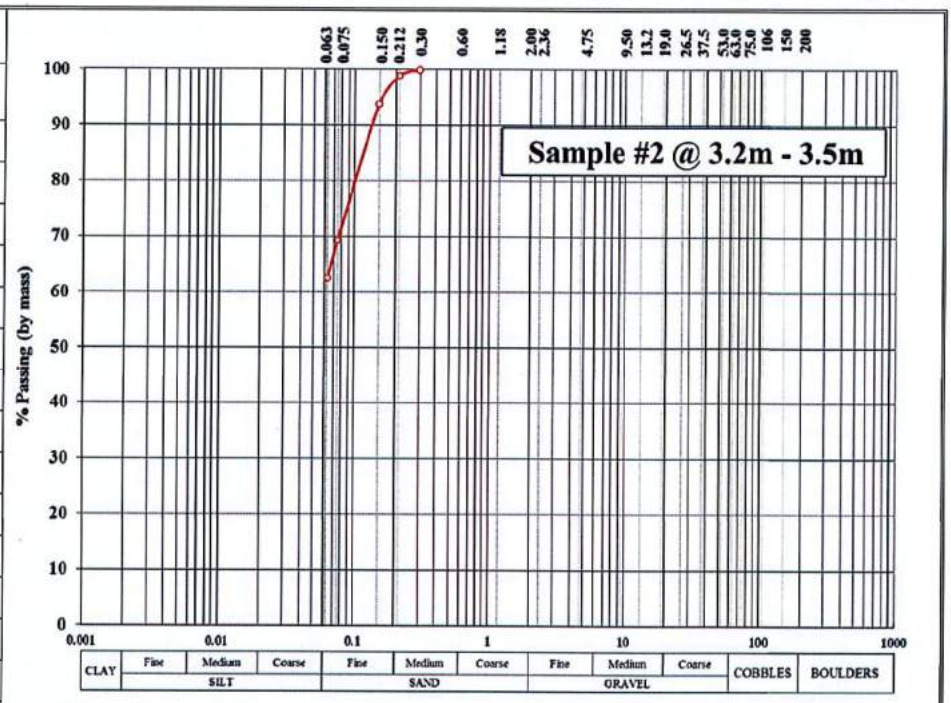
Date: 30 June 2016

TEST REPORT – 103 COUNTRY PALMS DRIVE, HALSWELL

Client Details:	Soil & Rock Consultants, P.O. Box 10 212, Phillipstown, Christchurch	Attention:	R. Smith
Job Description:	103 Country Palms Drive, Halswell - Investigations		
Sample Description:	Sandy SILT	Client Order No:	C16073.1
Sample Source:	Machine Borehole # 1; Sample #2 @ 3.2m - 3.5m	Sample Label No:	N/A
Date & Time Sampled:	Unknown	Sampled By:	Unknown
Sample Method:	Borehole	Date Received:	23-Jun-16
Sample Specification:	Not Applicable		

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
37.5	
26.5	
19.0	
13.2	
9.50	
4.75	
2.36	
2.00	
1.18	
0.60	
0.30	100
0.212	99
0.150	94
0.075	69
0.063	63



The sample was received in a natural state. The percentage passing the 63μm test sieve was obtained by difference.

WATER CONTENT & PLASTICITY INDEX RESULTS - NZS 4402:1986, Test 2.1, 2.3, 2.4 & 2.5	
Water Content: (As Received)	27.9 %
Cone Penetration Limit: (CPL)	28
Plastic Limit: (PL)	Non-plastic
Plasticity Index: (PI)	Non-plastic
Note: The sample was received in a natural state. The plasticity index material tested was whole soil.	

Note:

- *Information contained in this report which is Not IANZ Accredited relates to the sample descriptions based on NZ Geotechnical Society Guidelines 2005 and sampling.*
- *This report may not be reproduced except in full.*

Tested By: L.T. Smith Date: 25 to 30-Jun-16

Checked By:

Tests indicated as Not Accredited are outside the laboratory's scope of accreditation

IANZ ACCREDITED LABORATORY Accreditation No: 434

Central Testing Services
18 Ngapara Street, P.O. Box 397, Alexandra, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: 16/1480

Date: 30 June 2016

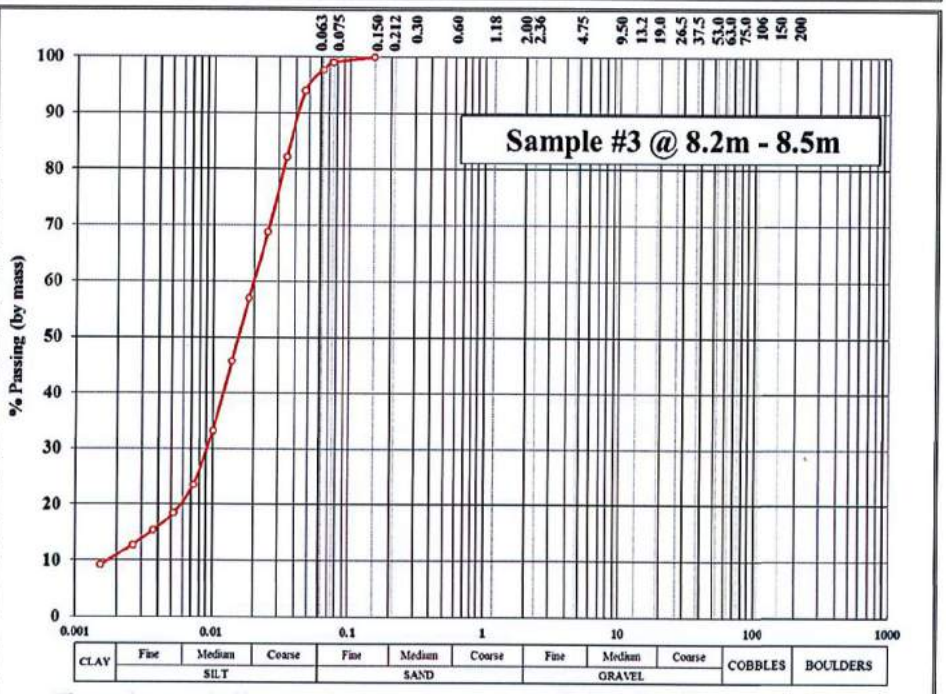
TEST REPORT – 103 COUNTRY PALMS DRIVE, HALSWELL

Client Details:	Soil & Rock Consultants, P.O. Box 10 212, Phillipstown, Christchurch	**Attention:**	R. Smith
Job Description:	103 Country Palms Drive, Halswell - Investigations		
Sample Description:	SILT with minor clay and trace of sand	**Client Order No:**	C16073.1
Sample Source:	Machine Borehole # 1; Sample #3 @ 8.2m - 8.5m	**Sample Label No:**	N/A
Date & Time Sampled:	Unknown	**Sampled By:**	Unknown
Sample Method:	Borehole	**Date Received:**	23-Jun-16
Sample Specification:	Not Applicable		

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1 & 2.8.4)

Test Sieve (mm)	% Passing (by mass)
26.5	
19.0	
13.2	
9.50	
4.75	
2.36	
2.00	
1.18	
0.60	
0.30	
0.212	
0.150	100
0.075	99
0.063	98

Fraction Size	Interpolated % Passing
60 µm	97
20 µm	60
6 µm	21
2 µm	11



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference. The pH of the hydrometer suspension was 9.5. Sodium hexametaphosphate was used as a dispersant.

PARTICLE SIZE ANALYSIS & HYDROMETER ANALYSIS RESULTS - NZS 4402:1986, Test 2.8.1 & 2.8.4

Description	Fraction Range	% Within Range	Description	Fraction Range	% Within Range
Coarse Gravel	60.0mm to 20.0mm	-	Fine Sand	200 µm to 60 µm	3
Medium Gravel	20.0mm to 6.0mm	-	Coarse Silt	60 µm to 20 µm	37
Fine Gravel	6.0mm to 2.00 mm	-	Medium Silt	20 µm to 6 µm	39
Coarse Sand	2.00mm to 600 µm	-	Fine Silt	6 µm to 2 µm	10
Medium Sand	600 µm to 200 µm	-	Clay	< 2 µm	11

WATER CONTENT & PLASTICITY INDEX RESULTS - NZS 4402:1986, Test 2.1, 2.3, 2.4 & 2.5

Water Content: (As Received)	30.0 %
Cone Penetration Limit: (CPL)	31
Plastic Limit: (PL)	26
Plasticity Index: (PI)	5
Note: The sample was received in a natural state. The plasticity index material tested was whole soil.	

Note:

- *Information contained in this report which is Not IANZ Accredited relates to the sample descriptions based on NZ Geotechnical Society Guidelines 2005 and sampling.*
- *This report may not be reproduced except in full.*

Tested By: L.T. Smith **Date:** 25 to 30-Jun-16

Checked By:

Approved Signatory

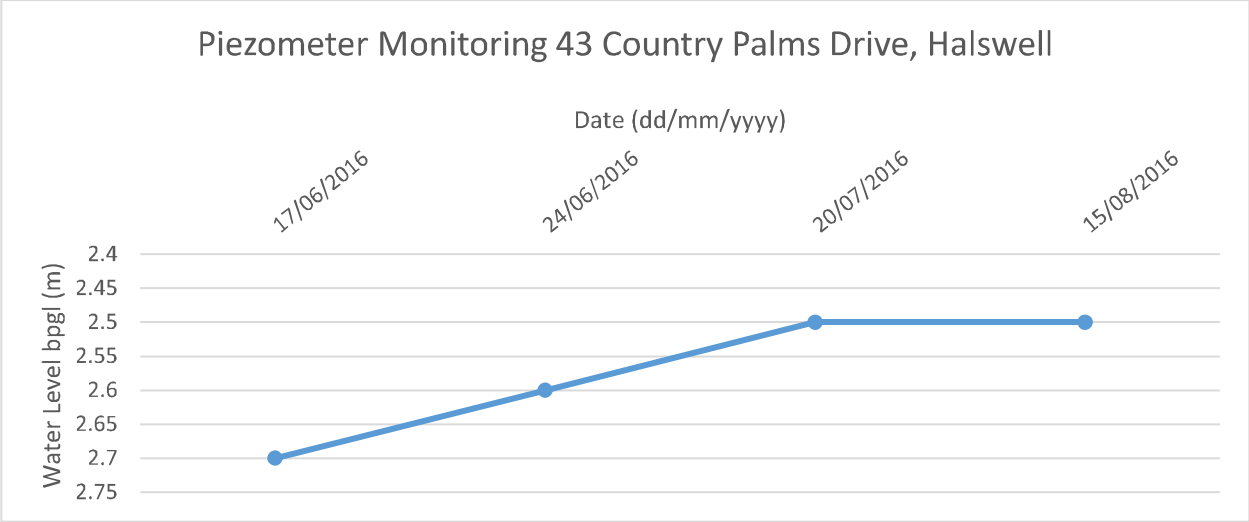
A.P. Julius
Laboratory Manager

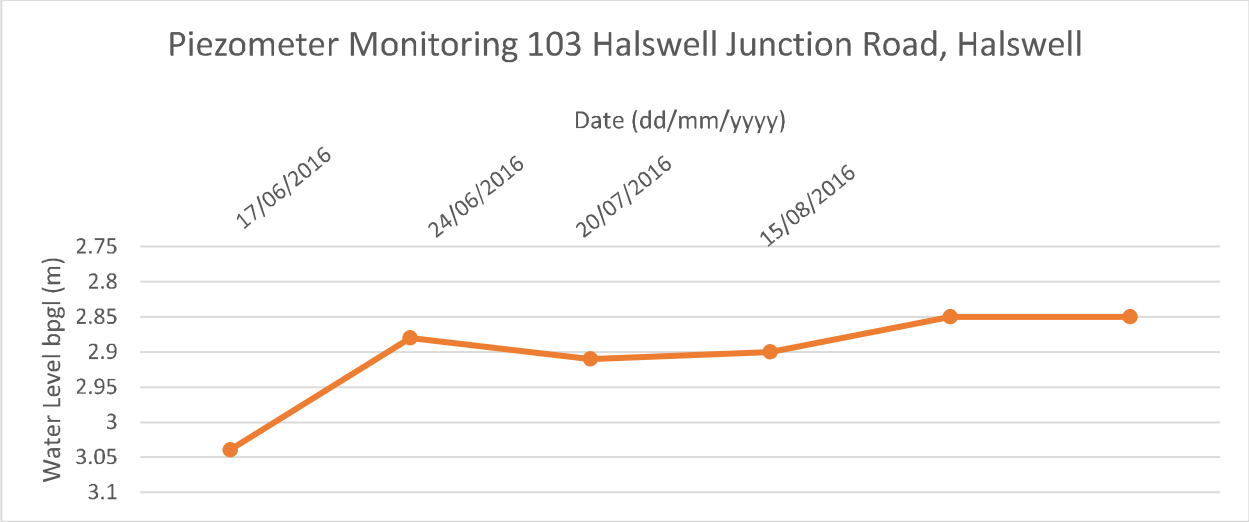
Tests indicated as Not Accredited are outside the laboratory's scope of accreditation

IANZ ACCREDITED LABORATORY Accreditation No: 434

Appendix H: Groundwater Monitoring Data

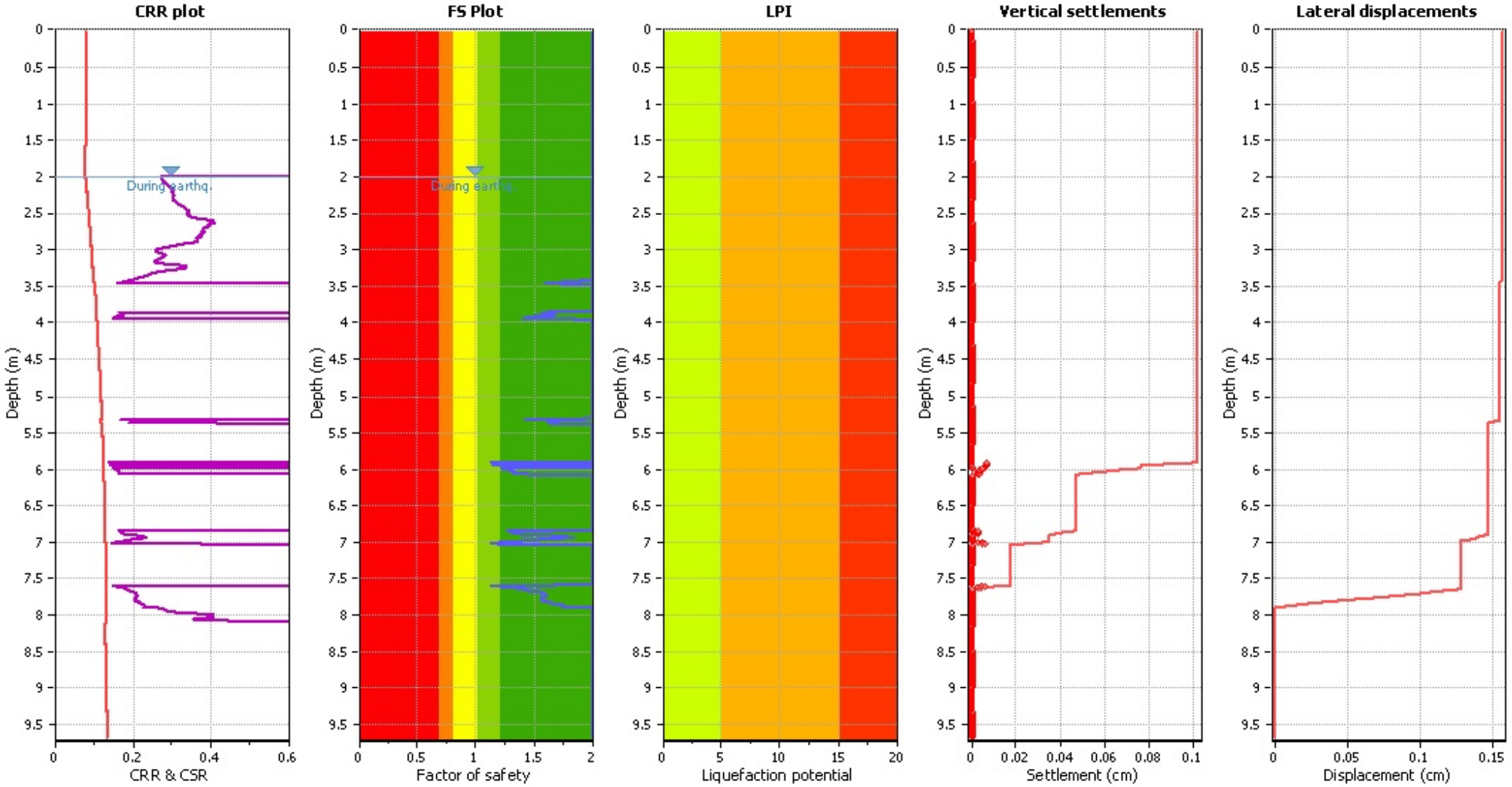
Piezometer Monitoring Information





Appendix I: Liquefaction Analysis Results

Liquefaction analysis overall plot



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:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
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LPI color scheme

- Very high risk
- High risk
- Low risk

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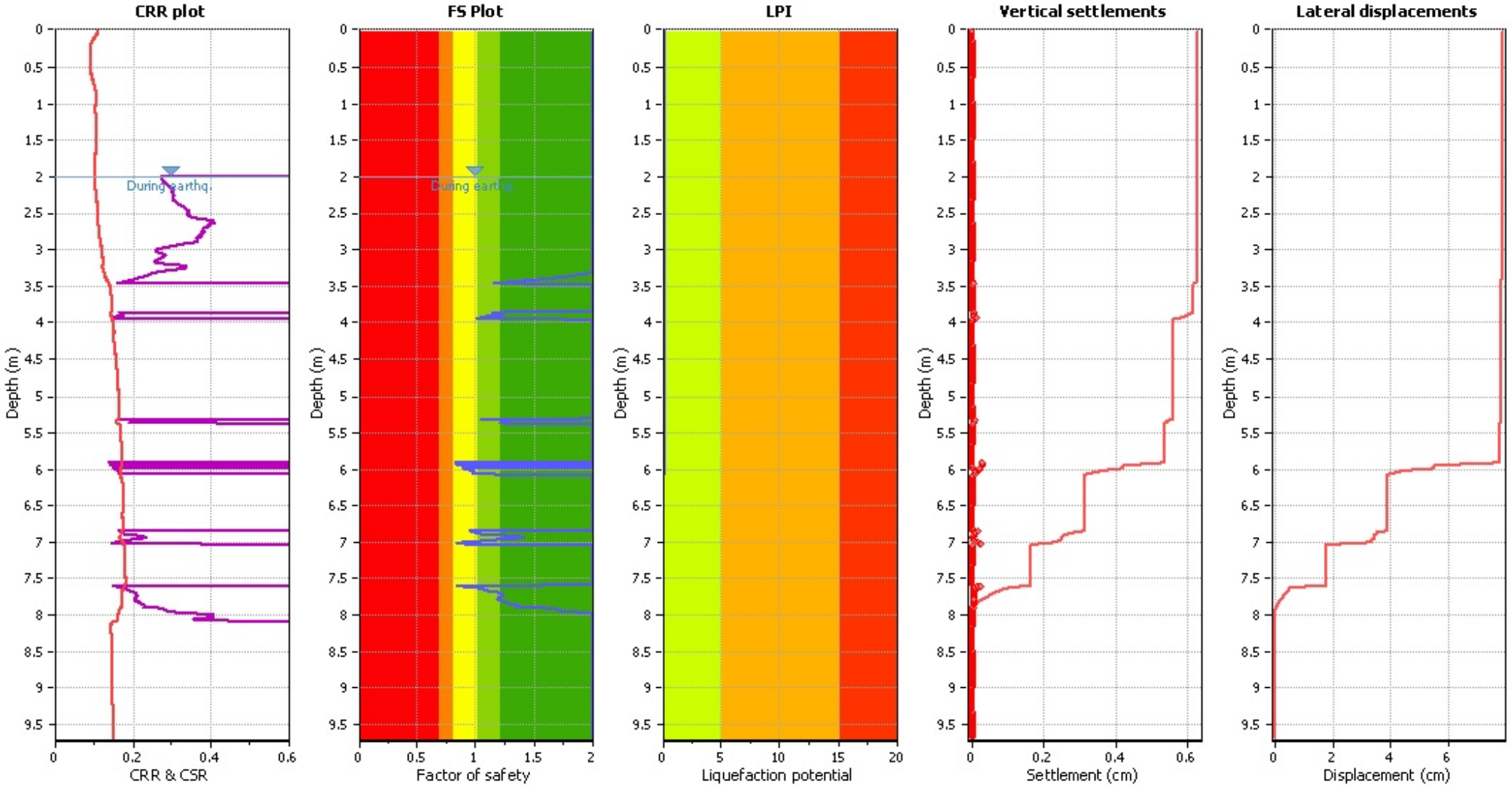

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Peak ground acceleration:	0.19	Use fill:	No	Limit depth applied:	No
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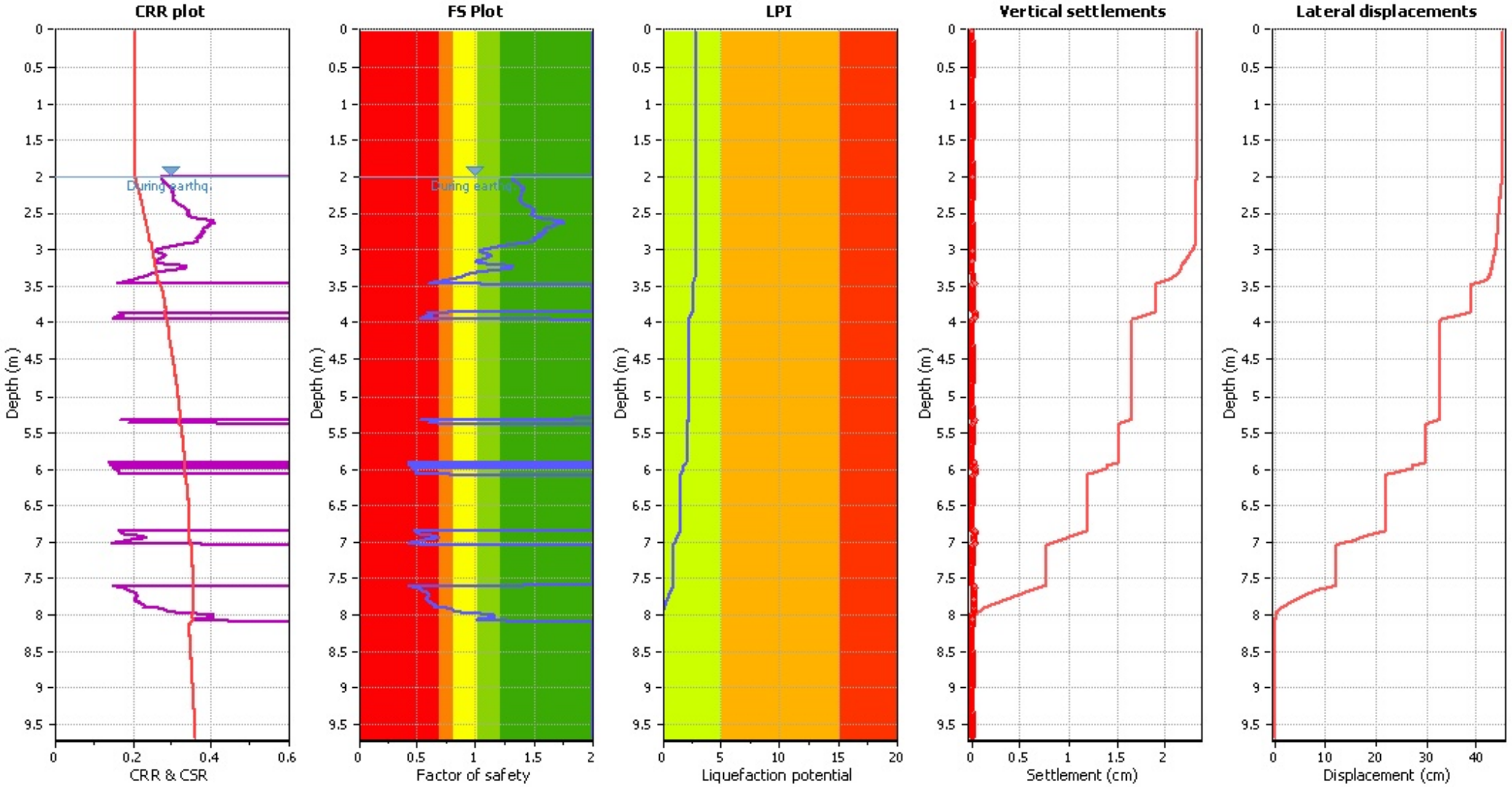

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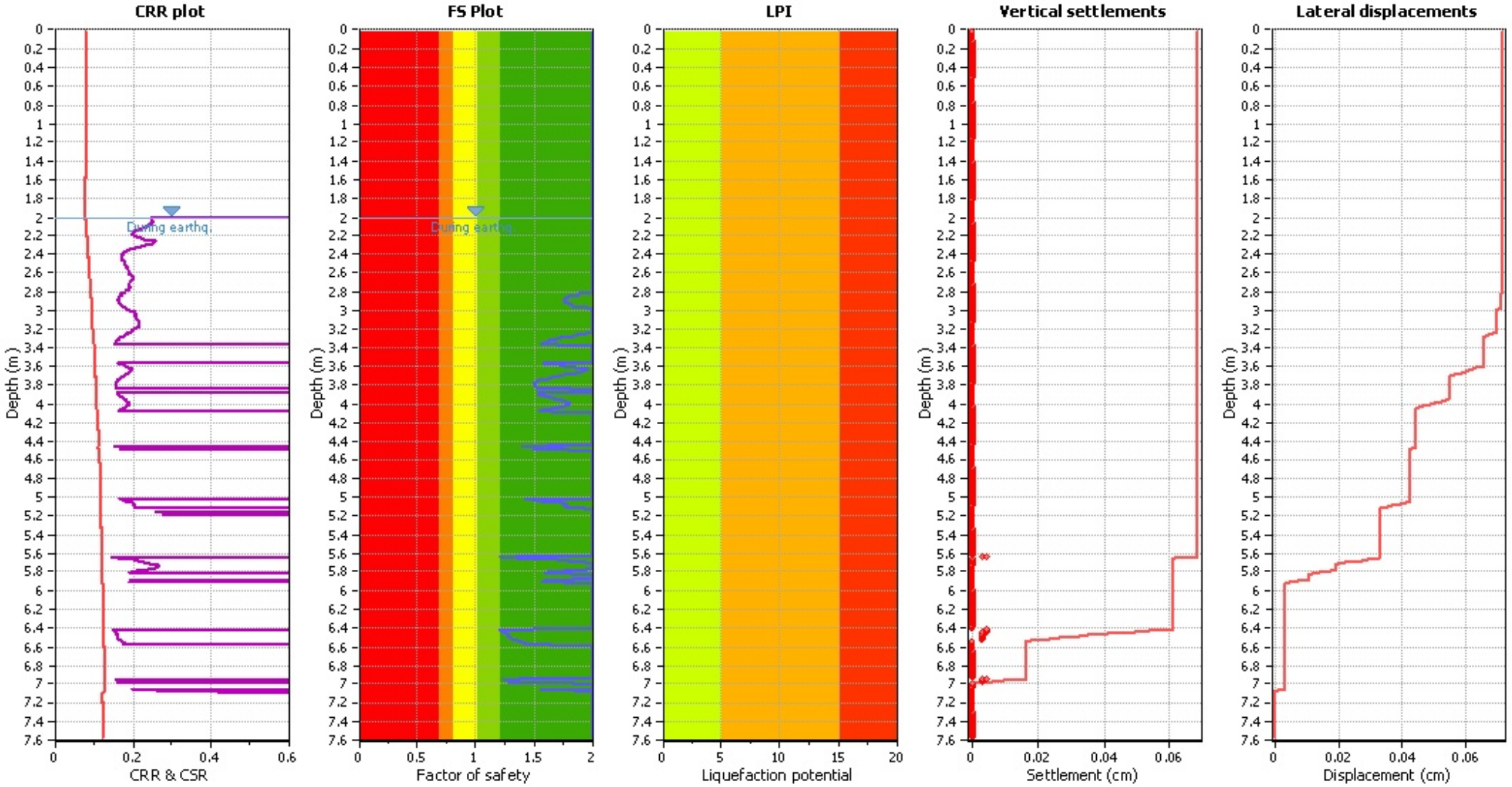

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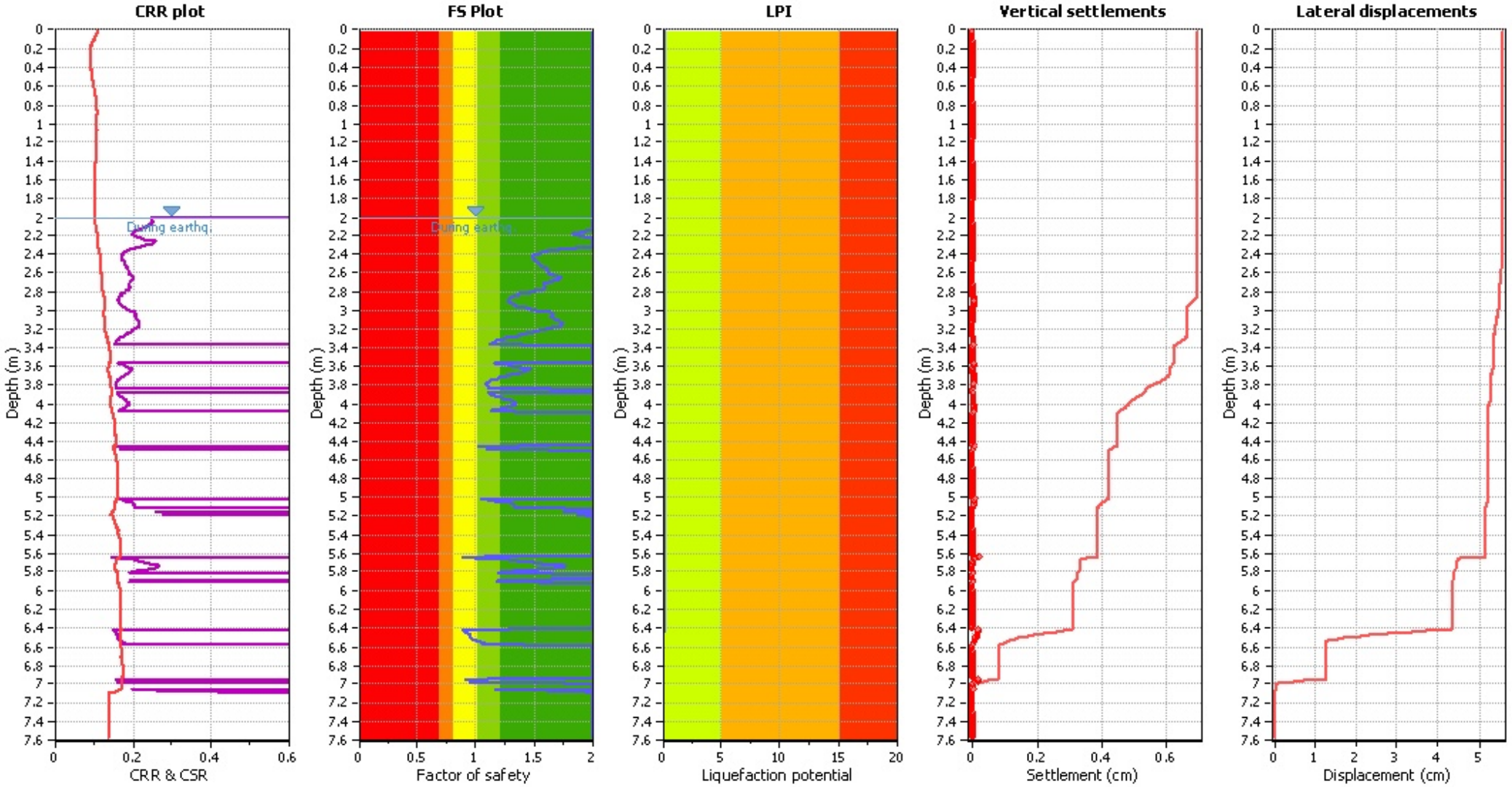

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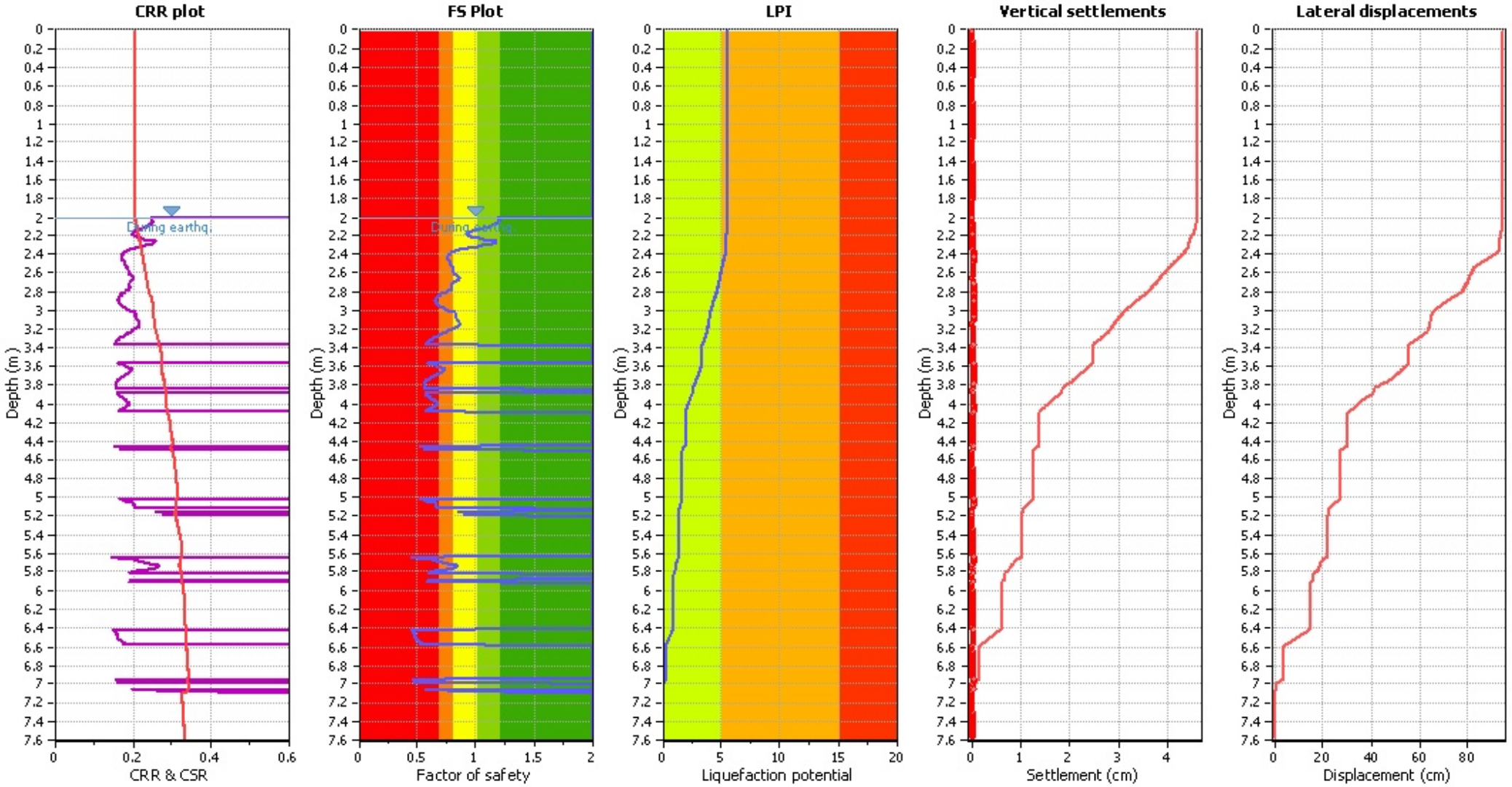

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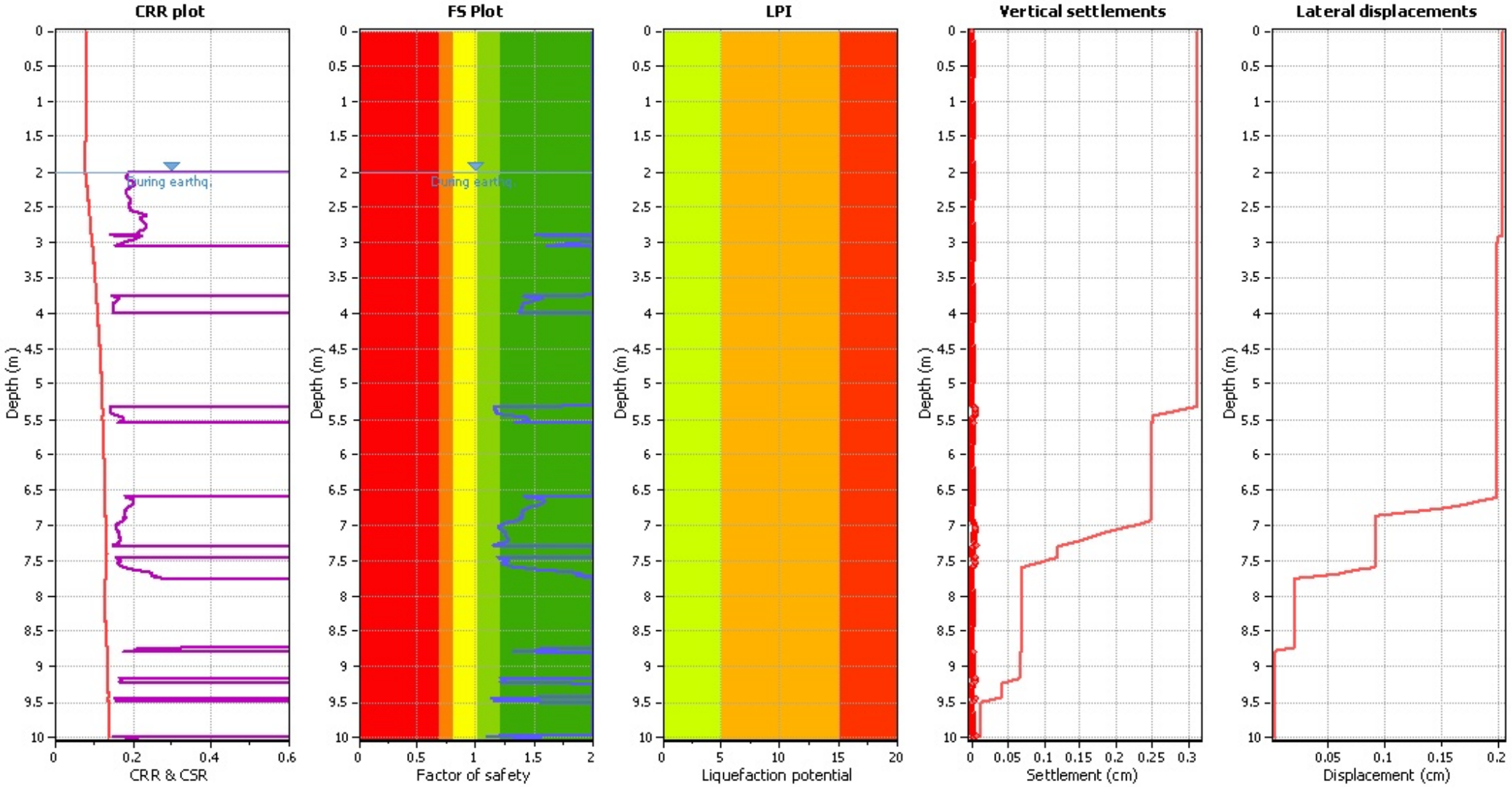

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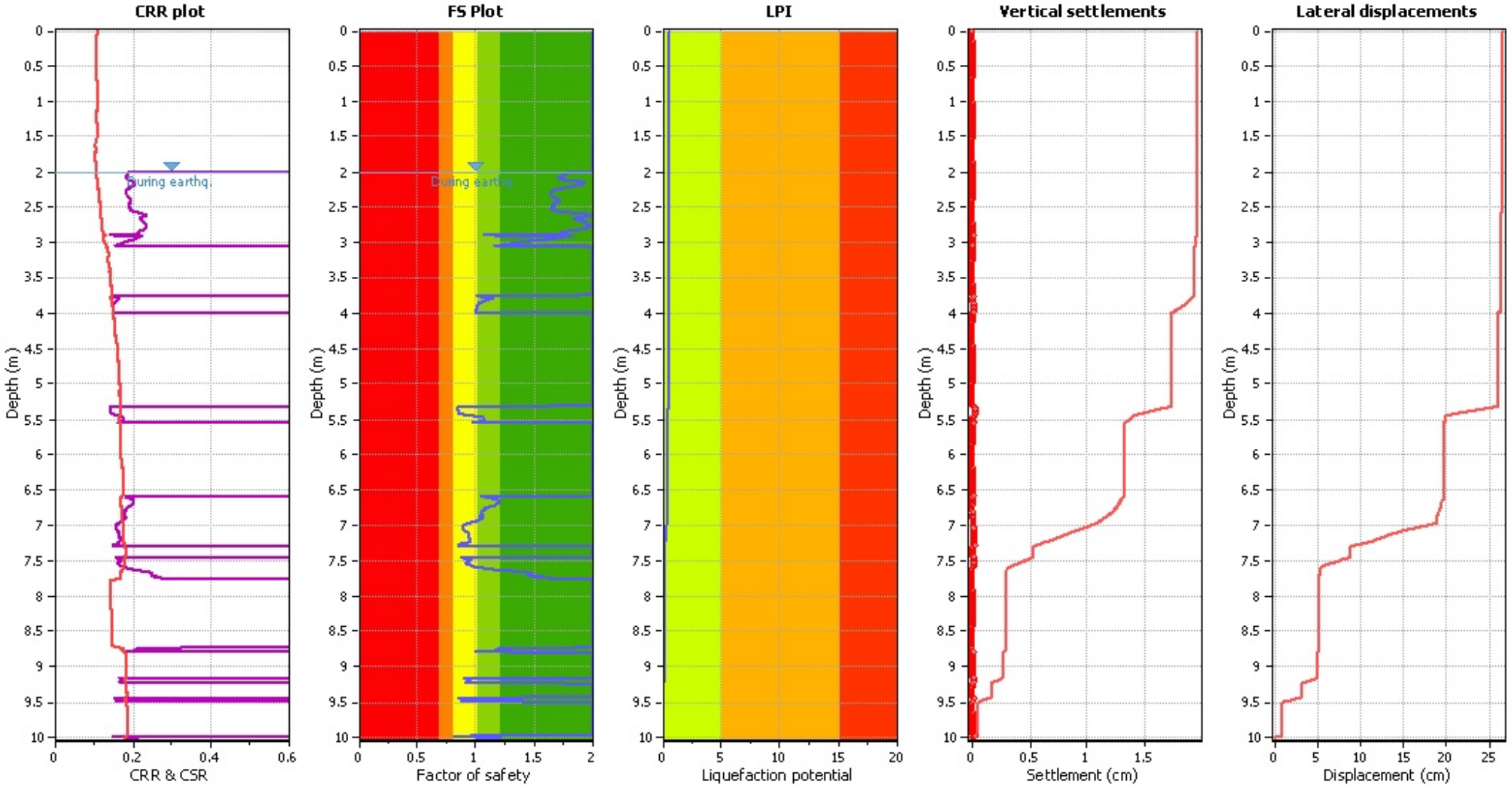

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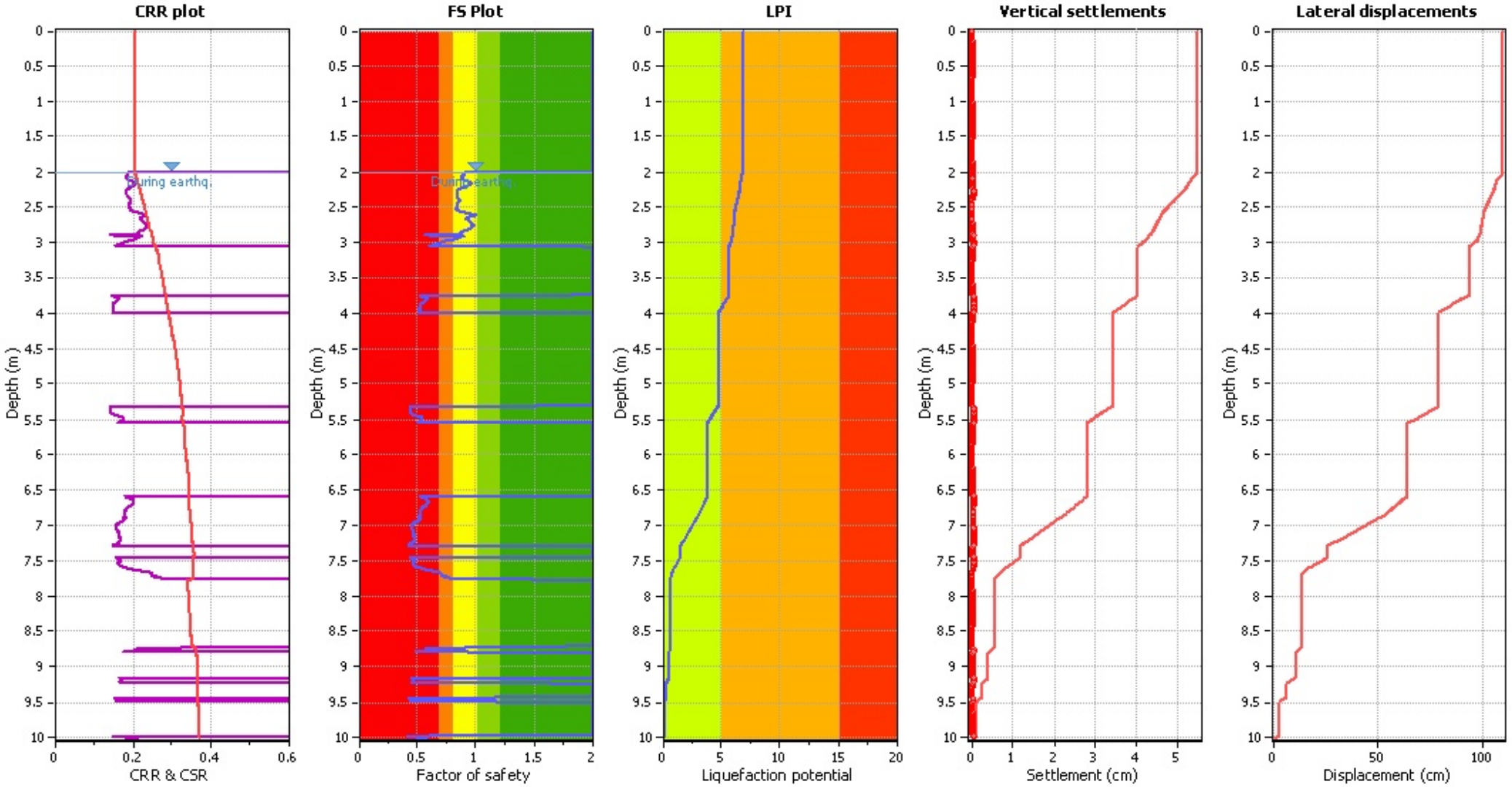

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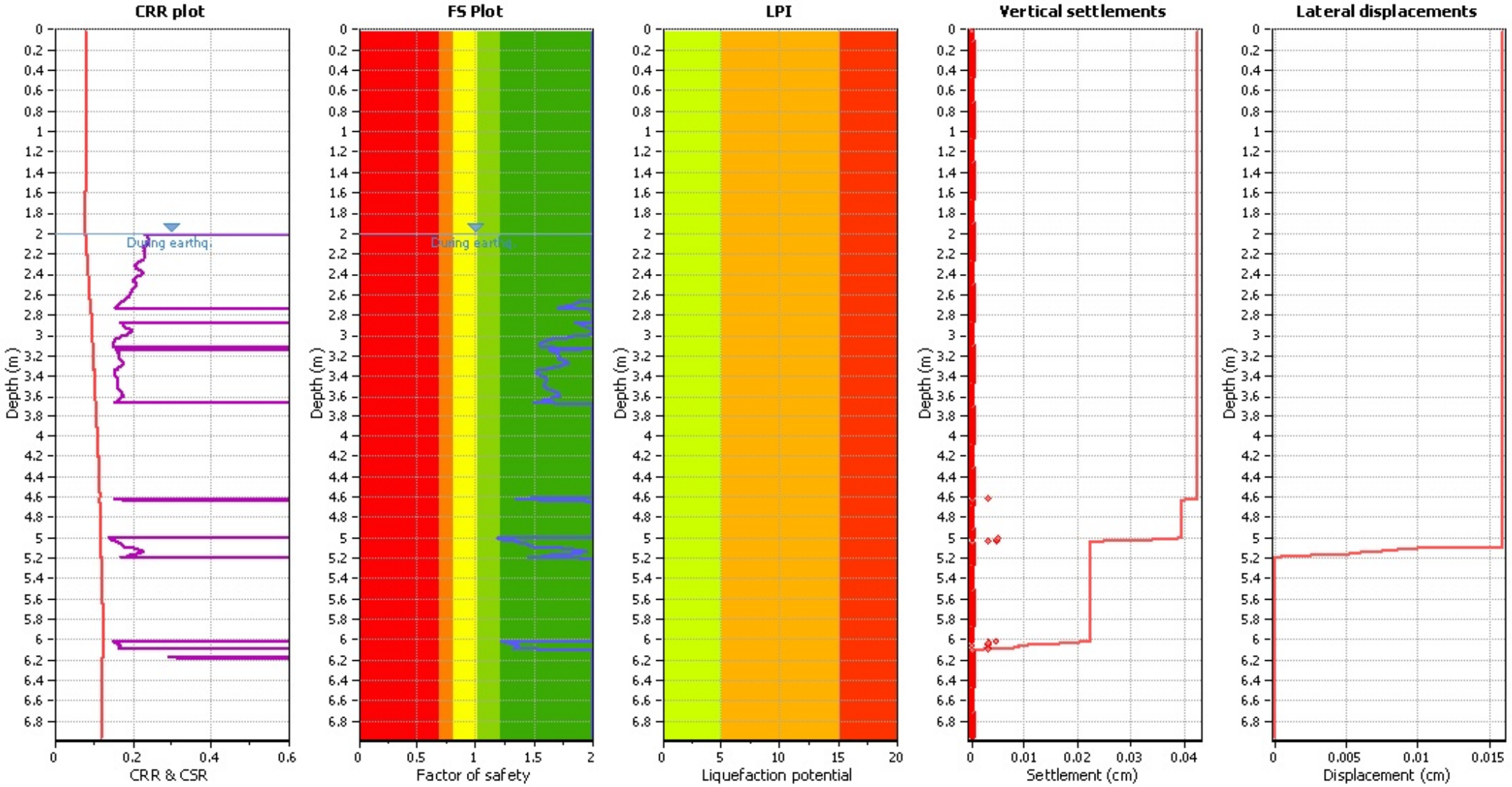

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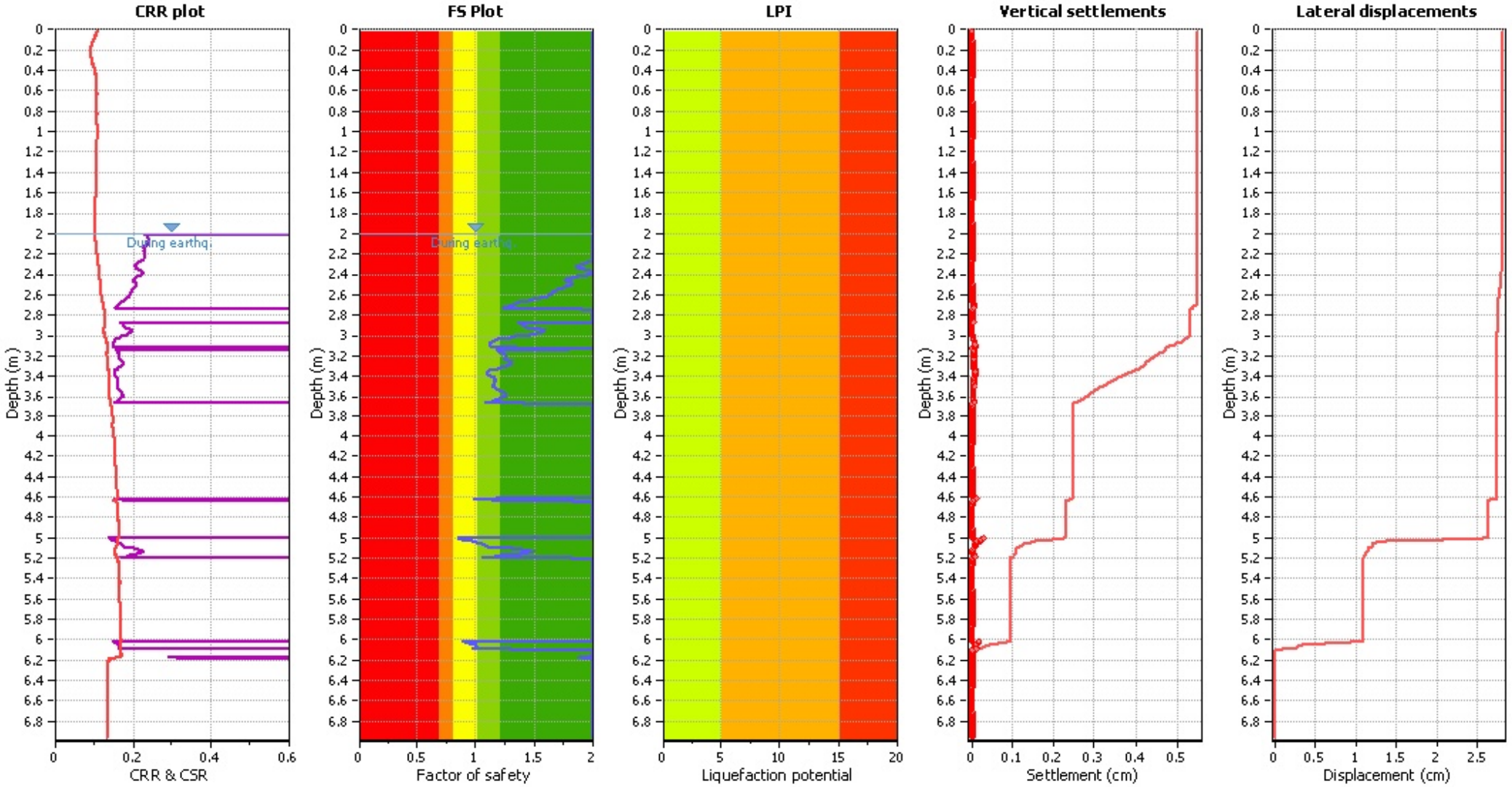

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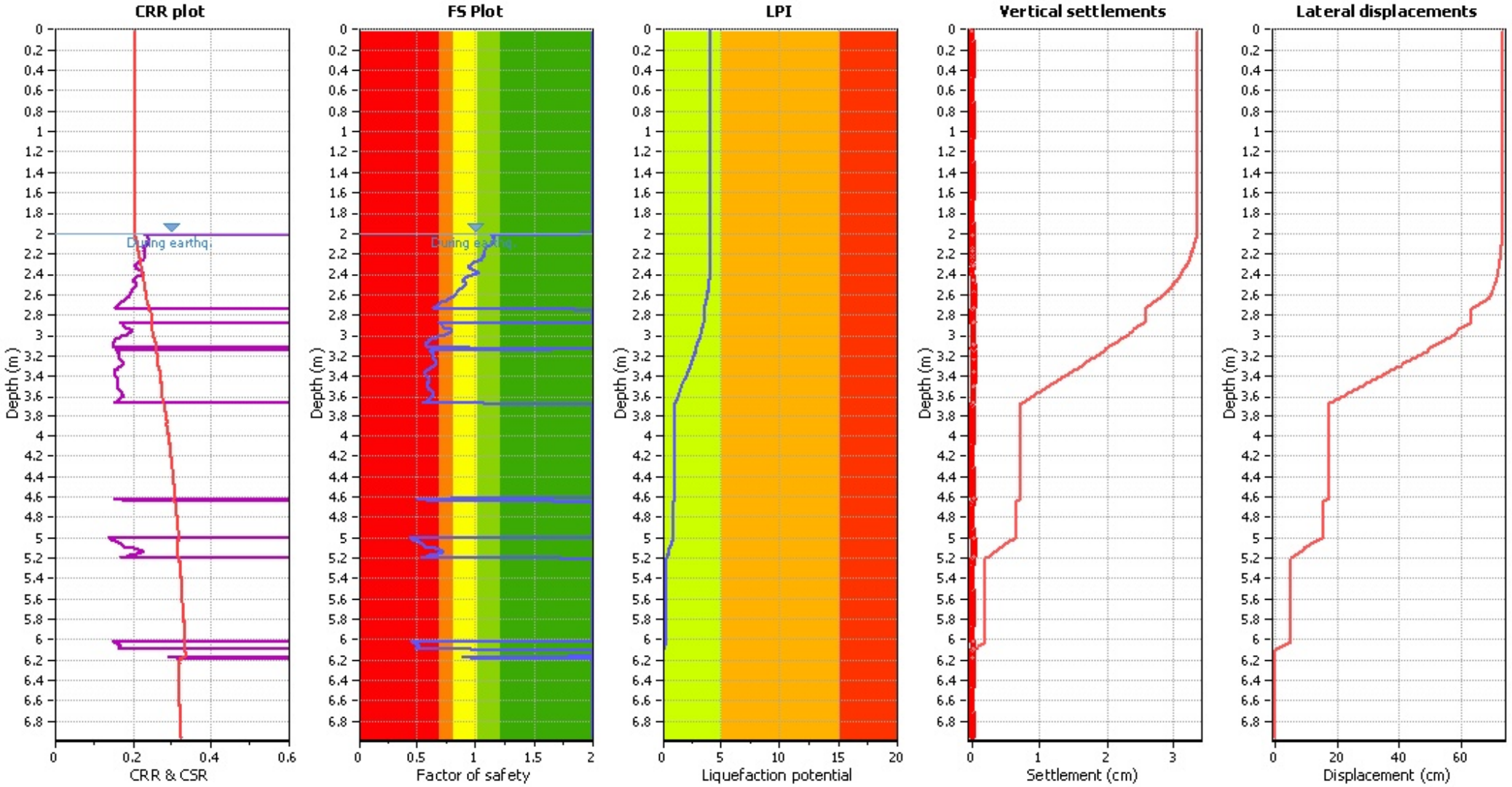

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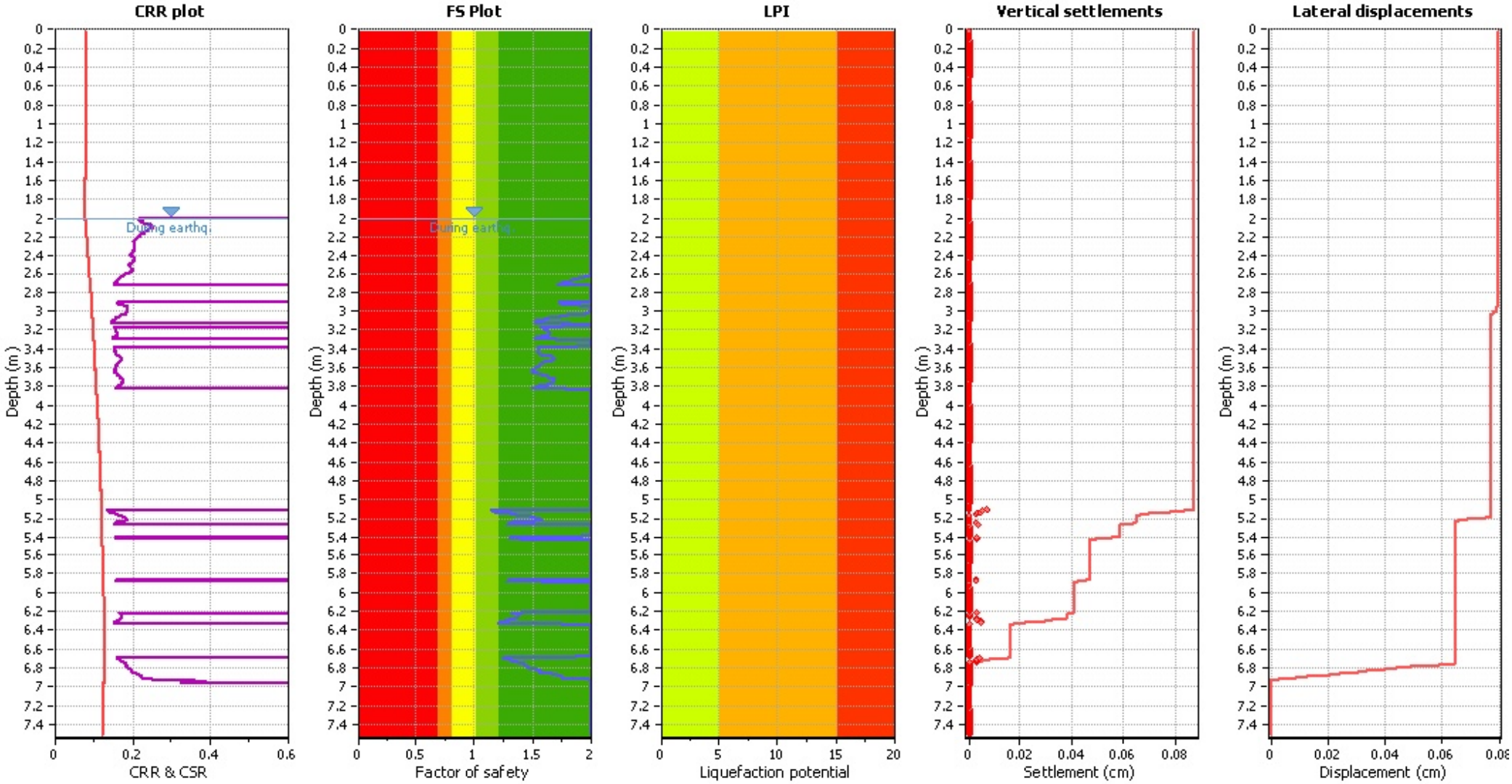

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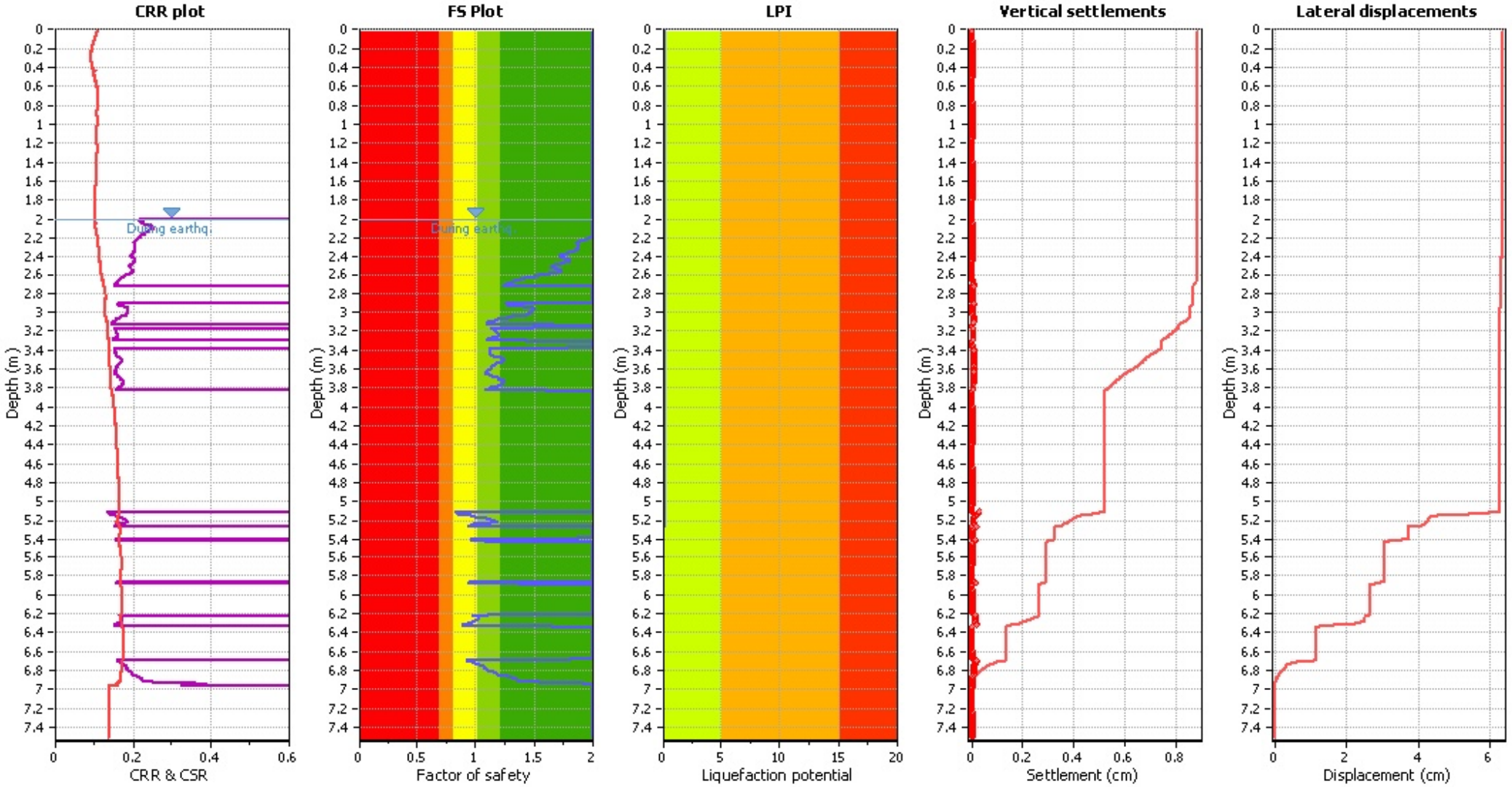

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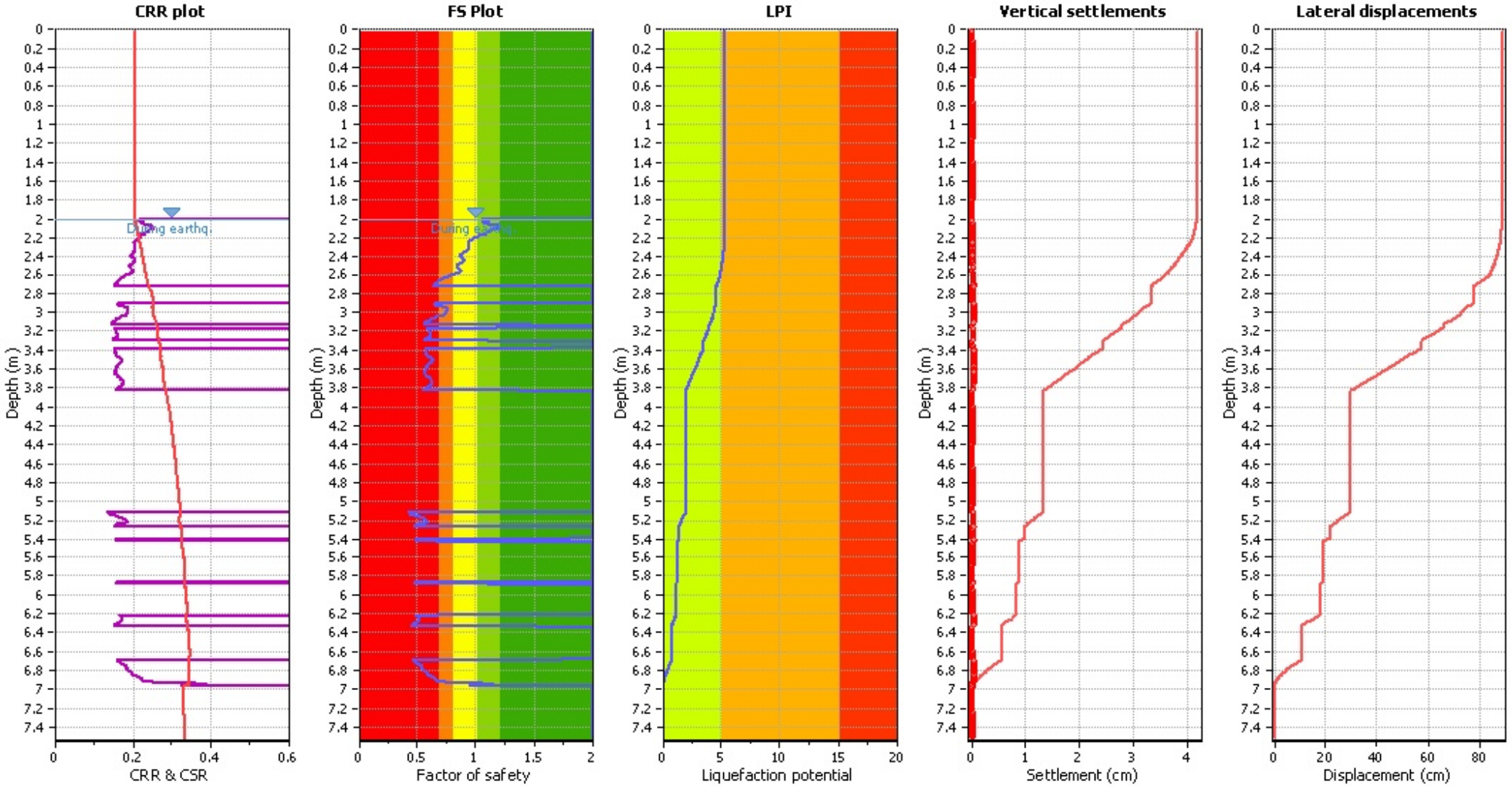

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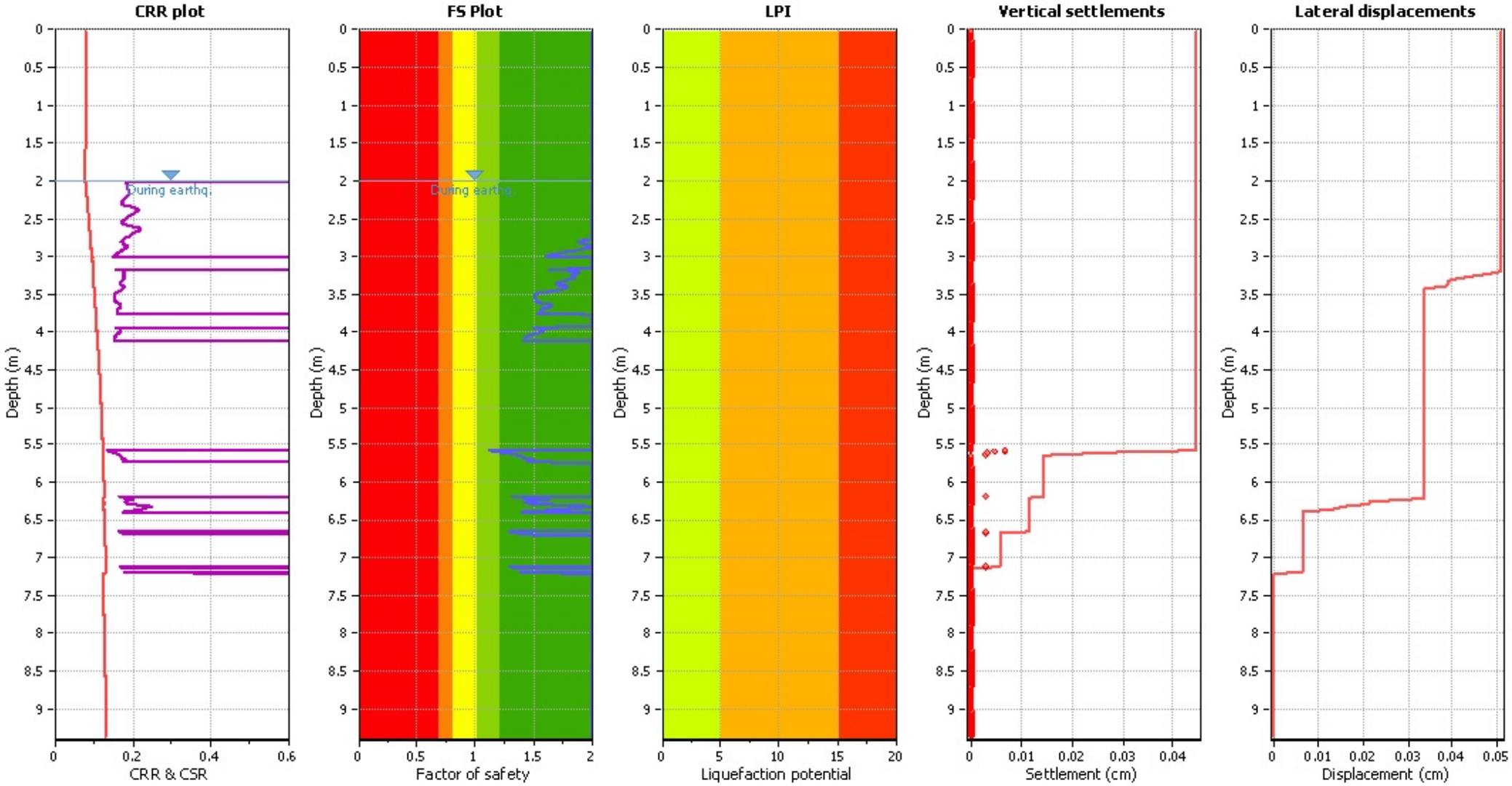

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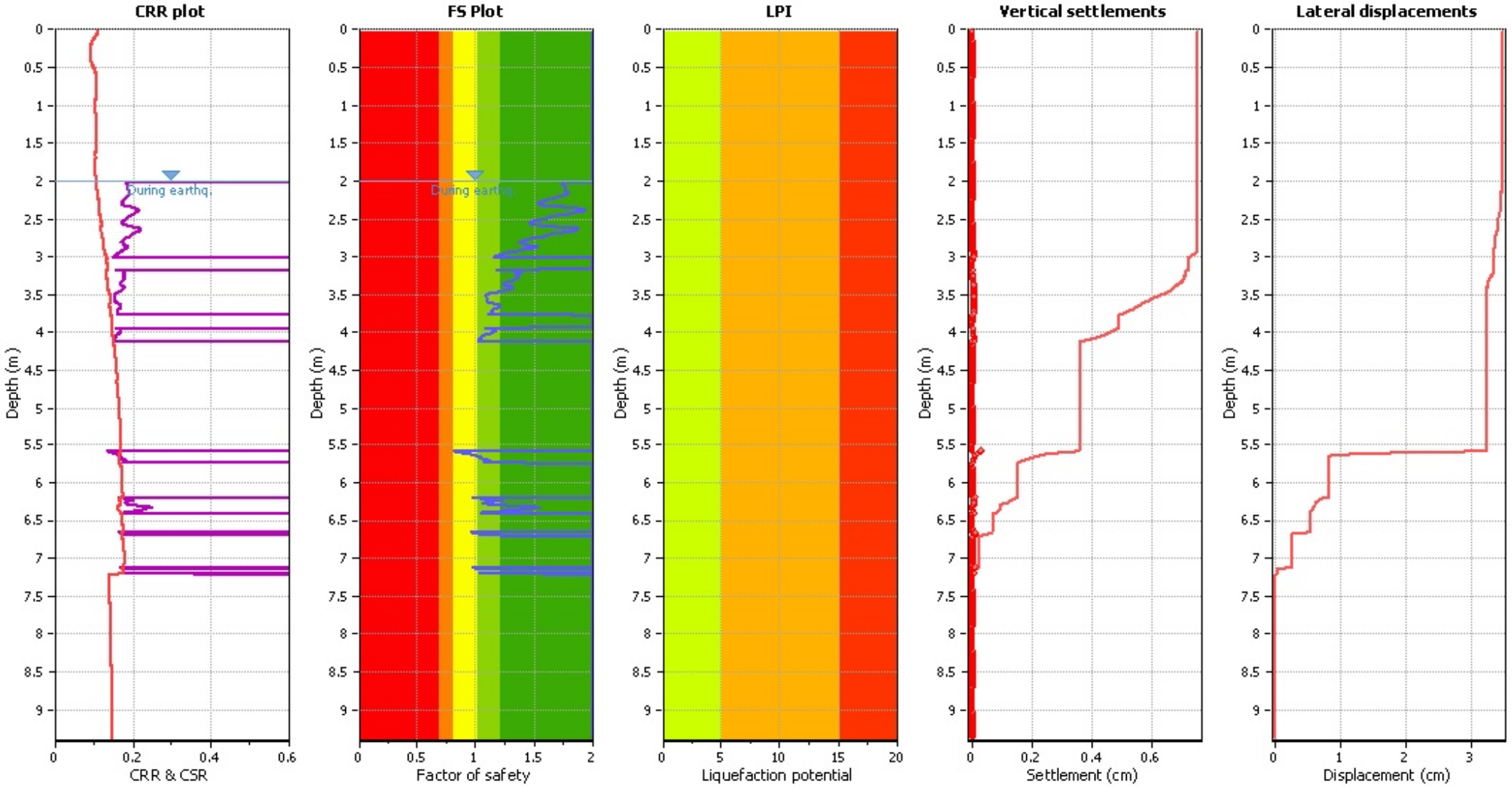

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Points to test:	Based on Ic value	Ic cut-off value:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	6.90	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.19	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

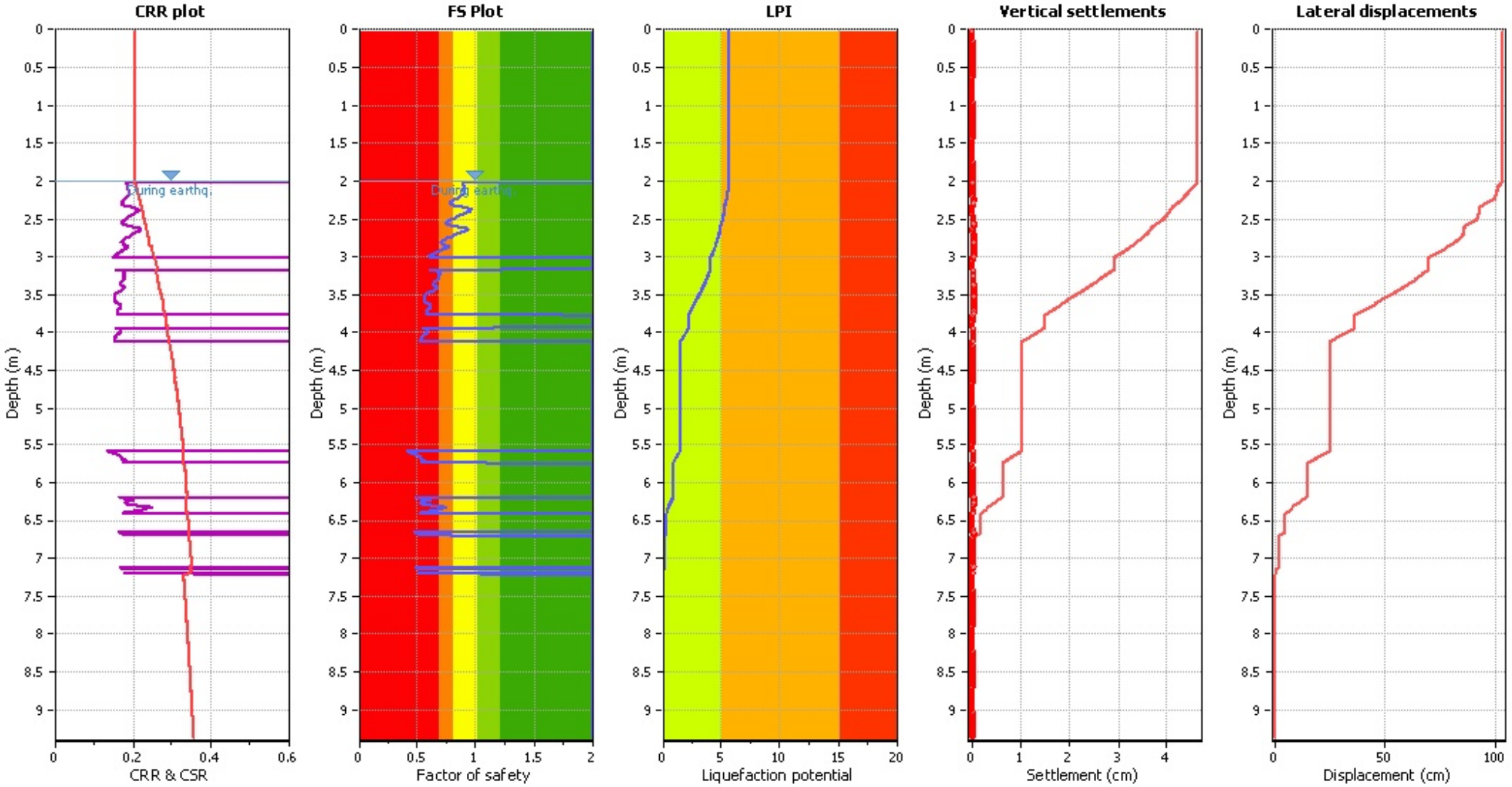
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis overall plot



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:	2.40	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

Appendix J: Statement of Professional Opinion

Statement of Professional Opinion on the Suitability of Land for Subdivision

(Appendix I to the Infrastructure Design Standard)

Issued by: *CGW Consulting Engineers*
(Geotechnical engineering firm or suitably qualified engineer)

To: *Suburban Estates Limited*
(Owner/Developer)

To be supplied to: *Christchurch City Council*
(Territorial authority)

In respect of: *Proposed Residential Subdivision*
(Description of proposed infrastructure/land development)

At: *115 Halswell Juction Road, Halswell, Christchurch*
(Address)

I *(Geotechnical engineer)* *Ferry Haryono* on behalf of *(Geotechnical engineering firm)* *CGW Consulting Engineers*

hereby confirm:

1. I am a suitably qualified and experienced geotechnical engineer and was retained by the owner/developer as the geotechnical engineer on the above proposed development.

2. My/the geotechnical assessment report, dated *28 March 2019* has been carried out in accordance with the Department of Building and Housing *Guidelines for geotechnical investigation and assessment of subdivisions* and includes:
   (i) Details of and the results of my/the site investigations.
   (ii) A liquefaction assessment.
   (iii) An assessment of rockfall and slippage, including hazards resulting from seismic activity.
   (iv) An assessment of the slope stability and ground bearing capacity confirming the location and appropriateness of building sites.
   (v) Recommendations proposing measures to avoid, remedy or mitigate any potential hazards on the land subject to the application, in accordance with the provisions of Section 106 of the Resource Management Act 1991.

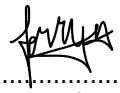
3. In my professional opinion, I consider that Council is justified in granting consent incorporating the following conditions:

   The original ground is suitable for the construction of a development/subdivision and is not subject to erosion, subsidence or slippage provided that the recommendations made in the CGW Consulting Engineers Geotechnical Investigation Report; Geotechnical Investigation Report, 115 Halswell Junction Road, Halswell, Christchurch; Suburban Estates Ltd; dated 28 March 2019 are followed.

4. This professional opinion is furnished to the territorial authority and the owner/developer for their purposes alone, on the express condition that it will not be relied upon by any other person and does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any building.

5. This certificate shall be read in conjunction with my/the geotechnical report referred to in Clause 2 above, and shall not be copied or reproduced except in conjunction with the full geotechnical completion report.

6. The geotechnical engineering firm issuing this statement holds a current policy of professional indemnity insurance of no less than $ *1 million dollars*
(Minimum amount of insurance shall be commensurate with the current amounts recommended by IPENZ, ACENZ, TNZ, INGENIUM.)



.....
(Signature of Engineer)

Date: *28 March 2019*

Qualifications and experience: *CPEng, CMEngNZ, IntPE(NZ)*