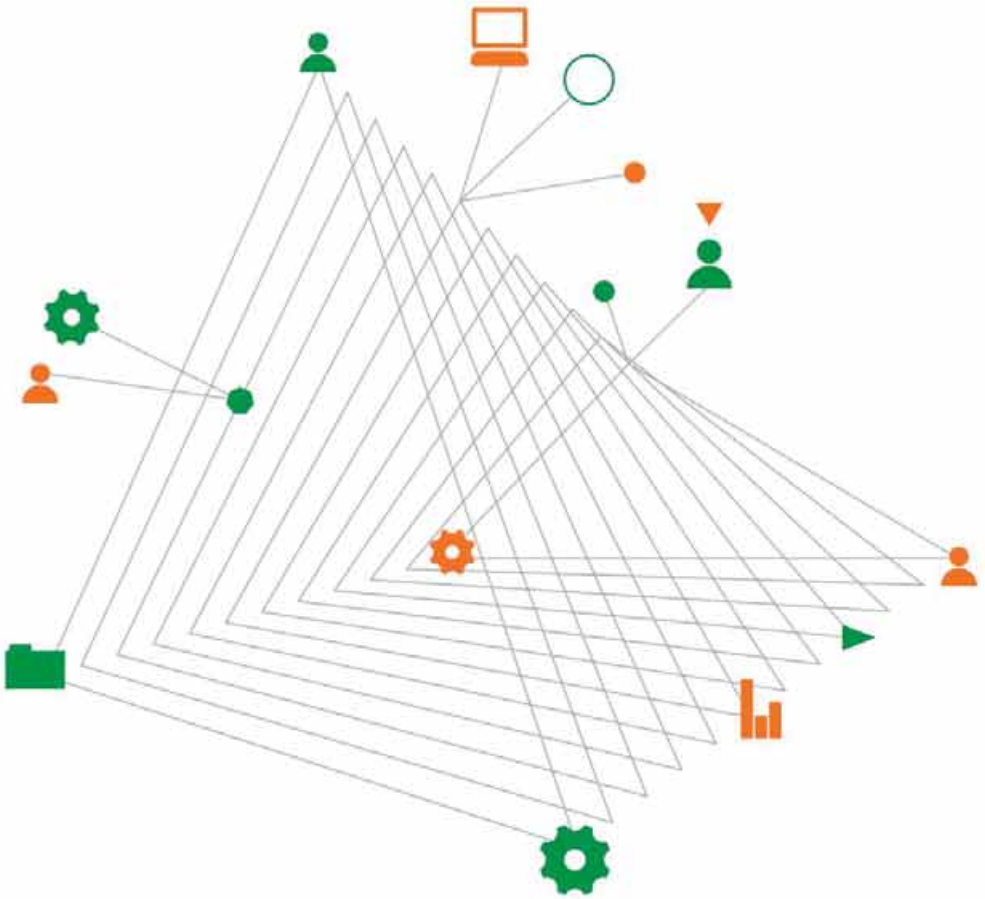
Christchurch City Council

Geotechnical Assessment Report

Review of the District Plan for R6 - East Belfast, Christchurch

12 June 2014



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12 June 2014

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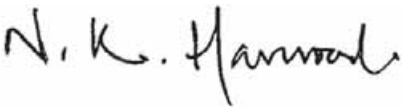
GEOTECHNICAL ASSESSMENT REPORT FOR THE PROPOSED REZONING OF REVIEW OF THE DISTRICT PLAN FOR R6-EAST BELFAST, CHRISTCHURCH

Please find attached our geotechnical report presenting the findings of our geotechnical investigation (Stage 2) for the 60 ha area of land known as R6 - East Belfast Christchurch.

Our investigation and reporting has been conducted in accordance with our proposal, dated 25 March 2014.

If you have queries or you require further clarification on any aspects of this report, please contact the undersigned.

For and on behalf of Coffey



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Distribution:	Christchurch City Council	1 Copy (electronic) 1 Hard Copy
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Appendices

EXECUTIVE SUMMARY

Coffey Geotechnics (NZ) Limited (Coffey) was commissioned by Christchurch City Council (CCC) to provide geotechnical reporting pertinent to the proposed rezoning of the 60 ha area of land known as R6 – East Belfast, Christchurch for future urban development.

This report should be read in conjunction with the December 2013 Preliminary Site Evaluation (PSE) and parallel Preliminary Site Investigation (PSI) that CCC commissioned Coffey to carry out to evaluate the geotechnical characteristics of the site and to assess potential environmental contamination and potential hazardous and harmful substances at the site.

The report provides a high-level overview of the ground in terms of its liquefaction hazard and discussion on issues associated with the proposed stormwater facilities. A *preliminary assessment* of liquefaction susceptibility and associated earthquake-induced ground deformations has been carried out with the expectation that further (more detailed) geotechnical evaluation would be required at the subdivision design and building consent stages of development.

Christchurch is noted for its complex ground conditions that can vary significantly both laterally and vertically over short distances. The larger the site area the greater the variability that can be expected. The investigation work at the site has confirmed complex and variable ground conditions that strongly influence liquefaction susceptibility, foundation engineering measures, and design of infrastructure.

Reference to the Canterbury Geotechnical Database and the Canterbury Earthquake Recovery Authorities' land zoning system confirms that the entire site is zoned Green. CERA states "Green zone areas are generally considered to be suitable for residential construction".

Our site-specific high-level overview of the site has found the following:

- No areas of the site are unfit for the proposed residential development.
- As expected, the 60 hectare area has a range of ground conditions and accordingly there is a range of predicted earthquake performance.
- A portion of land along the northern margin of the site is likely to be Technical Category (TC)2 equivalent. The remainder of the site is distributed in TC3 equivalent land with a patchwork of TC2 across the south east and south western areas of the site (see Figure 19).

The MBIE guidance (Appendix D) and the CCC Subdivision Bulletin (No. 23.2) recommend that residential lots in new subdivisions meet the performance criteria specified for TC1 or TC2 classified land. For the areas of R6 East Belfast with TC3 land equivalent classification ground improvement will be required. We anticipate that 'Stone Columns' or 'Deep Soil Mixing' will be the most suitable ground improvement methods for this site.

Land with an indicative TC2 equivalent classification does not mean the areas are free of foundation issues as is clear from the finding that soft ground including peat lenses are likely to be present across the site.

In regards to lateral spreading the Styx River margin is a high hazard area and we recommend as far as possible the margin of the Styx River be set aside as reserve land to minimise the need for engineering measures to protect buildings and infrastructure assets. Should stormwater facilities be needed to be placed at or close to the riverbank then specific engineering measures will need to be considered.

At this preliminary design stage, for residential dwellings, we have proposed a 50m set-back from the slope crest of the Styx River. The land beyond the set-back is deduced to fall within Technical Category TC2 or TC3. Within the set-back there is a heightened risk of lateral spread that warrants specific review at detailed design stage.

This report being a high-level overview requires all areas of the site to be subject to specific detailed investigation and engineering evaluation to confirm their indicative foundation categorisation and the ground conditions for foundation design.

Any development must be undertaken with an appropriate level of investigation and evaluation in accordance with MBIE guidance and satisfy CCC's regulatory requirements. The MBIE guidelines provide the *engineering criteria and means* by which the land may be developed to be Code compliant. It is a question of economics as to whether land is *economically viable* to develop.

1 INTRODUCTION

Coffey Geotechnics (NZ) Limited (Coffey) was commissioned by Christchurch City Council (CCC) to provide geotechnical reporting pertinent to a proposed rezoning of land known as R6 – East Belfast for future urban development. The R6 - East Belfast project is being led by CCC and covers a land area of 60 hectares (approx.) in the northern Christchurch suburb of East Belfast (Figure 1).

The CCC's scope and objectives for this report were set out in a brief dated 7 March 2014[1], the details of which are presented below.

Essentially, the work entails a high-level geotechnical overview of the ground in terms of its liquefaction and lateral spread hazard, a review of Section 106 Resource Management Act hazards and commentary on issues associated with the proposed stormwater facilities. A preliminary assessment of liquefaction susceptibility and associated earthquake-induced ground deformations has been carried out with the expectation that further (more detailed) geotechnical evaluation would be required at the subdivision design and building consent stages of development.

Figure 1: Site location plan (scale as shown)

[1] CCC's Brief Scope for Geotechnical Investigation of R6 – East Belfast area provided to Coffey on 7 March 2014.

2 OBJECTIVES

The Phase 2 geotechnical investigation is specifically required to advise on the geotechnical suitability of the land for residential and business activities and associated infrastructure. The investigation is to be sufficiently detailed to provide high-level advice on anticipated foundation types, infrastructure considerations and recommendations on ground improvement strategies where required[2].

The objectives of the Phase 2 geotechnical investigation are tailored to address the CCC's brief, and have been interpreted to include:

- Assess the ground conditions and develop a conceptual ground model for the site, defining geological transition areas, particularly the extent of the gravel layer;
- Determine indicative MBIE Technical Category (TC) equivalent boundaries;
- Assess the lateral spread hazard for the Styx River and Kaputone Creek margins;
- Comment on the impact of locating CCC stormwater assets in a high lateral spread hazard area (along the Styx River margin);
- Assess the geotechnical *natural hazard* risks in accordance with Section 106 of the Resource Management;
- Confirm the suitability of the land for residential and business development and/or provide recommendations on the type of ground-works/foundations needed for the intended use, and,
- Report in line with current MBIE requirements.

3 SCOPE OF WORKS

The following summarises our proposed scope of works developed to meet the objectives detailed above:

1. Geotechnical desktop study including a review of:
    - Preliminary Site Evaluation (PSE)[2] and Environmental Preliminary Site Investigation (PSI)[3] as part of Phase 1 of the investigation works;
    - Published geological records;
    - Canterbury Geotechnical Database;
    - MBIE Residential Foundation Technical Category maps;
    - ECan's wellcard database for relevant bore records in the site and environs; and,
    - Groundwater monitoring results for the area.
2. Geotechnical site walkover assessment to scope suitable testing locations and their access;

[2] Geotechnical Preliminary Site Evaluation R6 – East Belfast Christchurch prepared by Coffey for Christchurch City Council. Reference GENZCHRI15602AA, dated 9 December 2013.

[3] Coffey (2013) Environmental PSI R6 – East Belfast, Christchurch; Coffey, 9 December 2013.

3. Verification of on-site underground services as part of our Health & Safety management procedures;
4. Multi-phase deep ground investigation utilising CPTs and machine boreholes; and,
5. Geotechnical analyses and reporting to meet the objectives outlined in Section 2.

4 INDUSTRY GUIDANCE

Where relevant, reporting has been conducted in accordance with the current Ministry of Business, Innovation and Employment (MBIE)[4] Guidance and CCC Subdivision Bulletin No. 23.2[5].

5 EXISTING INFORMATION

The major landowner (Mr. Mundy acting for Lonestar Trust) has completed a geotechnical investigation and associated report[6] for much of the site area. Coffey has reviewed the report, however Coffey has not had access to the raw data files and only the CPT refusal depths have been considered in the preparation of this report.

Reference has been made to several Environment Canterbury (ECan) well borehole logs on site and in the site area which are available on the Canterbury Geotechnical Database (CGD)[7].

Relevant borehole information for the Northern Arterial investigation carried out by Opus along the eastern boundary of the R6 – East Belfast site has been referred to for the purpose of this investigation.

Other relevant reports reviewed for the purposes of the R6 – East Belfast report are noted below along with our summary comments on the report findings:

Styx Centre at 482 to 490 Main Road and 20 Radcliffe Road, Northwood, Christchurch. Stage 1 Preliminary Geotechnical Report prepared for Calco Development Limited; 30 April 2012. Coffey Reference GENZCHRI15084.

- The report is a detailed geotechnical and liquefaction hazard assessment to support subdivision design. The report pre-dates current guidelines.
- Conclusions as per Section 8 of the Coffey report:
    - No part of the site is precluded from development.

[4] Ministry of Business, Innovation and Employment, 2012: Repairing and rebuilding houses affected by the Canterbury earthquakes, December 2012. Particular reference to Part D: Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury region.

[5] Christchurch City Council Resource Consents and Building Policy Unit, Subdivision Bulletin No. 23.2, May 2013.

[6] Subdivision Geotechnical Report, Radcliffe Road, Northwood, Christchurch; Cook Costello, 10 October 2012. Revised 7 November 2013. Twenty-four cone penetrometer tests (CPTs) were completed as part of the work.

[7] Environment Canterbury well drilling logs published before the Sept 2010 earthquake and collated for the Earthquake Commission. Canterbury Geotechnical Database Map CGD0035 - 1 June 2012.

- In our opinion the characteristic land performance indicated by the investigation and analysis to date indicates the site falls within the CERA Green Zone with MBIE Technical Category TC2 to TC3 earthquake-induced land deformation.
- At the preliminary design stage Coffey proposed a 50m set-back from the slope crest of the Styx River. The land beyond the set-back is deduced to fall within Technical Category TC2 or TC3. Within the set-back there is a heightened risk of lateral spread that warrants specific review at detailed design stage.

Supa Centre. Coffey Reference GENZCHRI15325

- Conclusion as per the GENZCHRI15325 Coffey report: The report indicated that the Supa Centre site and environs were generally relatively resilient to earthquake-induced ground deformation. The site generally suffered minor damage when compared to other portions of Christchurch, but some areas were susceptible to liquefaction. The damage to the site was confined to a northern portion of the site and included differential building settlement in the order of 100mm. Sand boils affected asphalted car park surfaces in the northern area.

6 SITE DETAILS

6.1 Location

The 60ha of land known as R6 - East Belfast, Christchurch is located approximately 8km north of Christchurch City Centre. As shown on Figure 2 below, the site is bordered on its western side by the railway line heading north out of Christchurch. The Styx River flows through the southern portion of the site towards the east. The site consists of eighteen legal lots, which are associated with eleven physical addresses.

The northeast portion of the site is bounded by Thompsons Road to the north, with agricultural land to the north and east, and Kaputone Creek flowing along the north eastern boundary. The Redwood Conservation Area is located south of the Styx River, with residential land to the south of it; and industrial and agricultural land beyond the railway line on the western side of the site. The land use is predominantly intensive arable agricultural comprising cranberry, potato, lettuce, cabbage, pumpkin and grain crops. Farm buildings and roads and scrubland in the vicinity of the Styx River and Kaputone Creek constitute the remaining land use. Radcliffe Road cuts through the central portion of the site.

Two land parcels forming the southwest portion is bounded to the west by the Main North Road, to the north by the proposed Styx Centre, the east by the railway line, and to the south by existing residential development. The area is generally pasture land, with the Styx River flowing through it.

6.2 Site areas

For the purposes of reporting the site has been divided into four areas to aid in the description of the site, ground conditions and engineering matters. Figure 2 provides a plan of the site with the report areas marked.

The Redwood Conservation Area is not part of the site subject to our geotechnical assessment.

The two parcels of land to the south west (on the western side of the railway) have been under investigation and design for stormwater management by CCC in collaboration with the designer for the proposed Styx Centre site. These parcels are not part of the site subject to our geotechnical assessment.

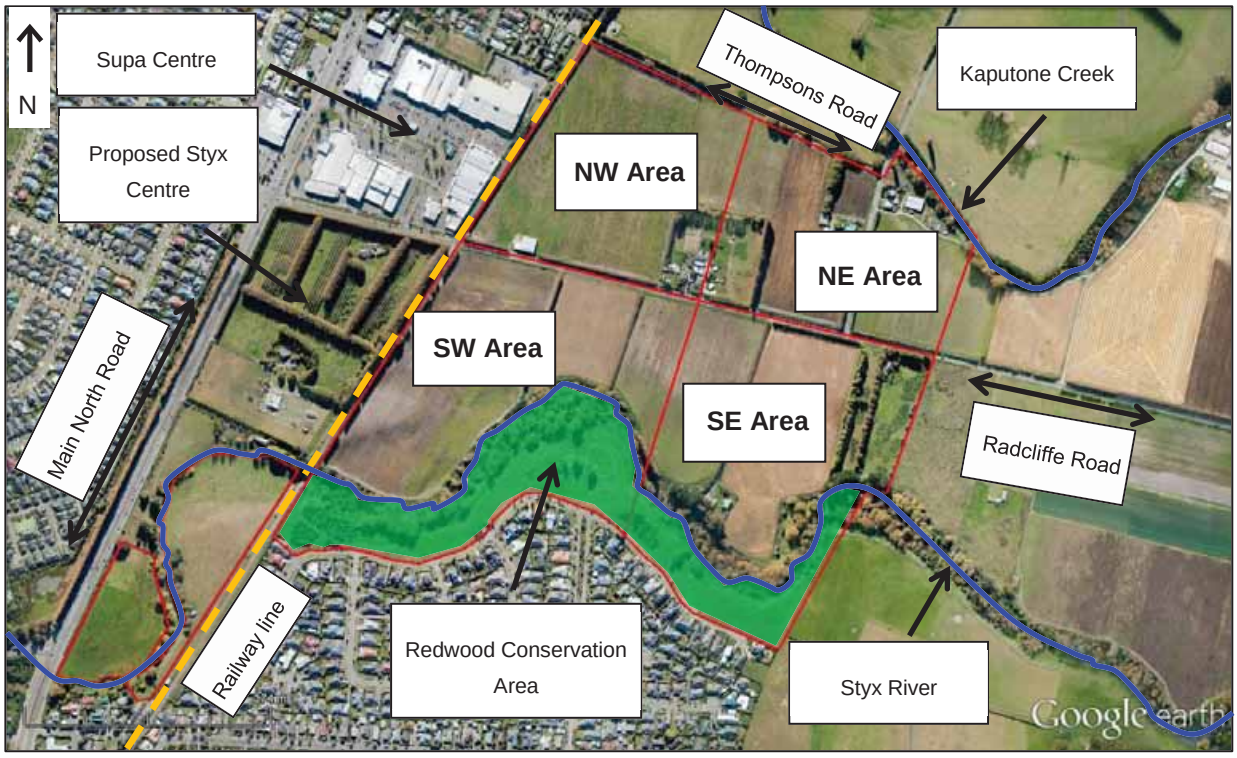

Figure 2: Site investigation areas (scale as shown)

6.3 Surface drainage

The only noticeable surface drainage across the site was that of shallow ditch drains (Figures 3 to 5), on the western side of the gravel access road to the property at 120 Radcliffe Road, which pipes under Radcliffe Road and joins the shallow drains capturing run-off from the properties and Blakes and Thompsons Roads. These ditch drains are typically in the order of 0.5m to 1.0m deep and are timber-lined and strutted only where access to properties in this area is required (refer to Figure 4).

6.4 Terrain

The land broadly undulates and has an overall dip towards the Styx River, with the exception of the land around Kaputone Creek.

The walkovers for the Phase 1 and Phase 2 investigations observed that the highest point of the site is to the northwest and the site broadly slopes to the south east towards the Styx River.

6.5 Styx River and Kaputone Creek

The Styx River bank runs along the southern boundary of the site, and Kaputone Creek is located across the northeast side of the site. The river banks of the Styx River undulate. We approximate that the height of these banks to between less than 1 and up to 4 metres higher than the current river level. These banks are in contrast to the banks of the Kaputone Creek which are significantly lower as the land gradually slopes towards this watercourse (bank height is generally less than 0.5 metre).

Figure 3: Viewing north along drain where it flows underneath Radcliffe Road at the entrance to 120 Radcliffe Road property. The drain invert is approximately 1 metre deep below existing ground level.

Figure 4: Viewing northwest along the north side of Radcliffe Road. The drain in on a slightly raised embankment, invert is approximately 0.5 metre deep below existing ground level, and is timber-lined and strutted to provide access to properties.

Figure 5: Viewing northwest along north side of Radcliffe Road. The drain invert is approximately 1 metre deep below existing ground level.

Recorded below are some approximate slope heights (from crest to river invert) and slope batters (see Figure 6 for the location of where the measurements were taken):

1. 1.4m high with a slope batter of 18°
2. 0.3m high with a slope batter of 30°
3. 2.0m high with a slope batter of 34°
4. 2.5m high with a slope batter of 37°
5. 3.4m high with slope batters varying between 10° to 35°
6. 1.5m high with a slope batter of 18°
7. 0.2m high with a low angle batter
8. 1.8m high with a slope batter of 36°
9. 0.5m high with a low angle batter
10. 0.5m high with a high angle slope batter

Figures 7 to 12 show the varying bank geometry observed and slope stability/erosion features.

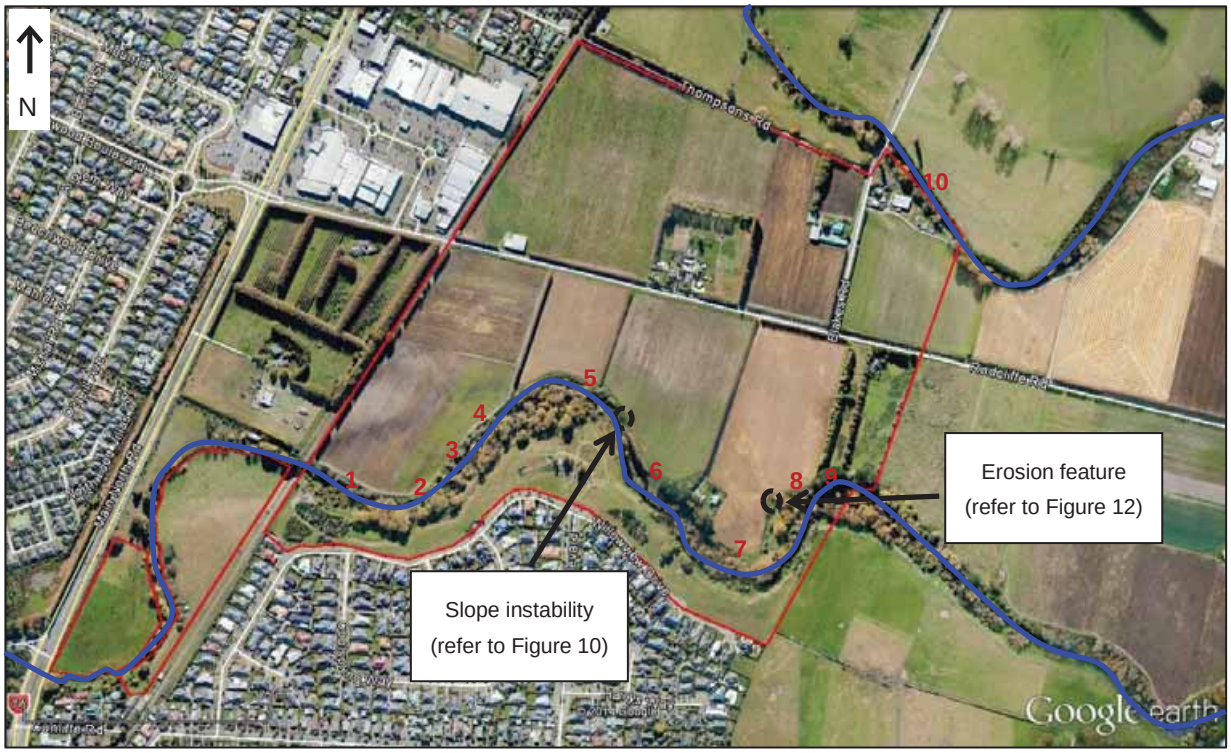

Figure 6: Site plan showing the approximate position of bank geometry observation points and location of observed slope instability and erosion features along the Styx River and Kaputone Creek.

Figure 7: The steep Styx riverbank geometry at Point 3. Similar steep geometries were observed at Points 2, 4, 5 and 8.

Figure 8: The shallow Styx riverbank geometry at Point 7. Similar shallow geometries were observed at Points 2 and 9.

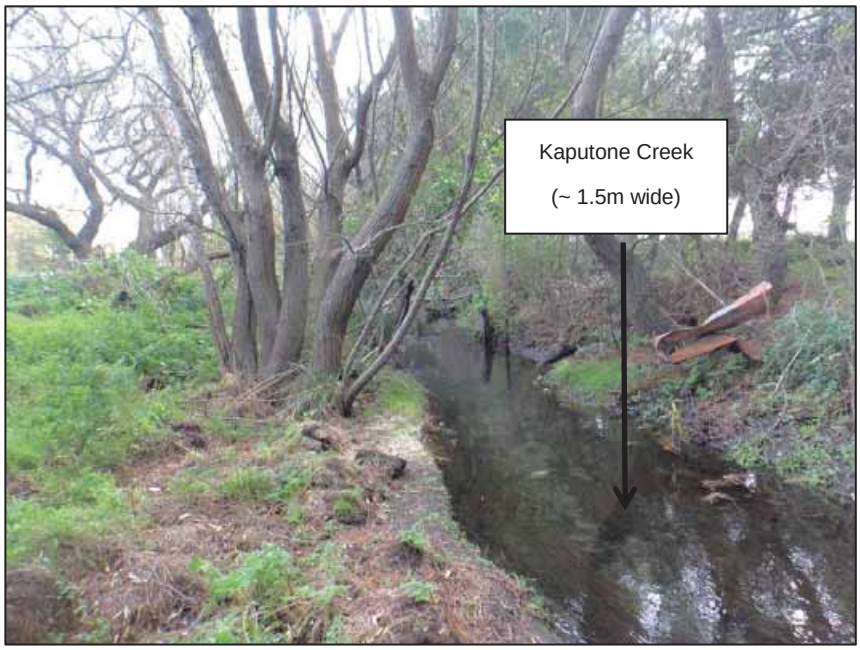

Figure 9: The shallow Kaputone Creek bank geometry at Point 10

Figure 10: Slope instability along the Styx River channel at the boundary of the SE and SW Areas

Generally, there is a strong impression of a mature slope and river terrace area along the Styx River. There is however evidence of minor slope instability at the riverbank at the approximate position indicated in Figure 6. The bank affected is approximately 1.2m high with a slope batter of 30° and is located 7.0m from the active river channel. The slip face created is approximately 3.7m in length and 0.6m deep with a crack in the order of 200mm to 400mm wide (refer to Figure 10).

The instability does not appear to be of significance to the land development.

Figure 11: Scattered sub-rounded to rounded gravel in a grey silty profile at the Styx riverbank where slope instability was noted.

Gravel is visible in the river bank of the Styx River at the above mentioned slip which is consistent with the watercourse's location in the bed of a former flood channel of the Waimakariri River.

Figure 12: Erosion feature in the SE Area (refer to Figure 6 for the approximate location of this feature).

The erosion does not appear to be of significance to the land development.

7 FIELDWORK SUMMARY

Coffey performed deep ground investigations at the site comprising:

- 44 Piezocone Penetrometer Test probes (CPTu) to approximately 20m depth or "effective refusal"[8] at depths ranging from 2.4m (CPT18) to 21.7m below ground level (bgl) (CPT12), using a track-mounted Pagani rig; and,
- 3 machine boreholes using a Comacchio MC-900 track-mounted sonic drilling rig to depths ranging from 15.45m to 19.95m bgl, with Standard Penetration Tests (SPTs) at approx. 1.5m intervals.
- Geotechnical logging of borehole core samples in accordance with the *NZGS's Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes* (December 2005).

Access to several paddocks of the site was restricted during the field work due to active crops. In addition, the central residential compound situated immediately north of Radcliffe Road was inaccessible during the field work.

No laboratory work was conducted for this high-level geotechnical overview exercise. We recognise the potential benefits of confirming fines content and plasticity in the evaluation of liquefaction susceptibility but the scale of drilling, sampling and testing required to reliably characterise these soil properties across the 60ha site area was beyond the scope of the report. Laboratory testing on soil samples should be considered for the more detailed geotechnical evaluations required at subdivision design stage and/or specific engineering design stages of the land development, as appropriate.

Appendix A contains the CPT and borehole locations plan for this investigation, including the position of the CPT and borehole data from existing information sources (see Section 5).

Appendix B contains the plan of indicative depths to inferred dense sand/gravel.

Appendix C contains the Soil Behaviour Type profiles (SBT) derived from CPTu data, and the machine borehole logs.

Appendix D contains the indication cross section location plan as well as Sections A-A' to E-E' which are cross-sections compiled using CPT records to give an overview of the soil conditions across the site area (A-A' and B-B') and also near the main watercourses i.e. Styx River and Kaputone Creek to assist with the lateral spread assessment (C-C' to E-E'). The cross sections pull together pairings of CPTs and boreholes to show how the cone resistance profiles correlate with the logged soil units. All of the pairings are for holes located at essentially the same location i.e. effectively zero distance between CPT and borehole.

The cross-sections are particularly useful in presenting a lot of relevant and useful information about the ground profile across the site. Understanding the structure of the ground and the relationship of the various soil units tells us a great deal about the liquefaction susceptibility and foundation engineering properties across the site. Reference should be made to these drawings as the following sections of the

[8] *Effective refusal* is the term used to describe where the cone resistance (q_c)[8] measured by the CPT rig reaches a high level and either (i) the rig operator considers further pushing would damage the equipment, and/or (ii) the rig's down-thrust capacity is reached, and/or the (iii) loss of cone verticality exceeds acceptable limits . For items (i) and (ii) refusal typically indicates competent ground at that depth but does not indicate the thickness of the hard ground encountered.

report relate specifically to information assembled from them. It should be noted that the vertical scale of the cross-sections are in elevation and not metres below ground level. In addition, there would appear to be an over-exaggeration of topography on Section A-A' and B-B' as we had to evenly space the test positions to incorporate all of the available information.

8 SITE GEOLOGY

8.1 Overview

The Christchurch Black Maps[9] indicate that the site was covered by "*Grass Land*" and "*Fern Tupaki and Grass*", Swamp areas were mapped immediately to the south and south east, and approximately 600m to the east of the site (refer to Figure 13).

Figure 13: The Christchurch Black Maps for R6 – East Belfast site and surroundings (scale as shown)

Christchurch is noted for its complex ground conditions that can vary significantly both laterally and vertically over short distances. The larger the site area the greater the variability that can be expected across the site. The investigation work at the R6 – East Belfast site has confirmed complex and variable ground conditions that strongly influence liquefaction susceptibility, foundation engineering measures, and design of stormwater facilities and other infrastructure.

The southernmost portion of the site lies on the Brown & Weeber (1992)[10] geological map, while the remainder of the site lies on the Sewell *et al*. (1992)[11] geological map. These maps indicate that the

[9] Waterways, Swamps and Vegetation Cover in 1856 Compiled from "Black Maps" Source: Christchurch City Council. Retrieved May 2014: http://resources.ccc.govt.nz/files/blackmap-environmentecology.pdf

[10] Brown, L.J.; Weeber, J.H. 1992: *Geology of the Christchurch urban area*. Scale 1:25 000. IGNS geological map 1.

majority of the site is underlain by Quaternary-aged river deposits belonging to the Yaldhurst Member of the Springston Formation. The Member consists of "*Dominantly alluvial sand and silt overbank deposits*".

In the area adjacent to the Styx River, the composition of the Yaldhurst Member changes to "*Alluvial gravel, sand, and silt of historic river flood channels"* associated with the Styx River. Springston Formation gravel is inter-bedded with fine sediments of the Christchurch Formation.

The Christchurch Formation can include beach, estuarine, lagoonal, dune, and coastal swamp deposits of gravel, sand, silt, clay, shell and peat. The formation extends inland as far as Kaiapoi, Belfast and Papanui. The site falls within the margin of this inland limit, and given the inter-bedding and similarity with the Springston Formation deposits it is not strictly definable where the Christchurch Formation ends and the Springston Formation begins.

The borehole logs and geological cross sections include question marks in the stratigraphic naming of the soil layers confirming the difficulty of distinguishing between the two units. For engineering purposes it is not strictly important that the stratigraphic unit name be identified. What is important is:

1. Recognition that the soils at the site can be very variable, both laterally and vertically, in terms of soil type (clay, silt, sand, gravel, peat) and strength/density (ranging from very soft, potentially organic fine-grained soil to dense sand and gravel); and,
2. The relative thickness and lateral distribution of the various deposits.

Map memoirs indicate that the Riccarton Gravel Formation is likely to be encountered at a depth of approximately 20m to 25m bgl; however the deep penetrating CPTs and some of the boreholes proved the head of the Riccarton Gravel at approximately 18m to 22m bgl. The Riccarton Gravel is typically described as well-graded gravel up to cobble size, and is brown or blue-grey in colour. The thickness of the Riccarton Gravel was not proven during the fieldwork for R6 – East Belfast. For liquefaction hazard assessment purposes at the site the Riccarton Gravel is assumed as non-liquefiable i.e. it is the base above which potentially liquefiable soil of the Christchurch and Springston Formations lie. However, for deep foundation engineering, for example piles that could be founded in end bearing in the head of the Riccarton Gravel, proving a depth of embedment and properties of the gravel is required by borehole drilling.

The site lies outside the CCC landfill map; therefore no data is available regarding commercial landfill areas on the site.

In the northeast corner of the site, borehole BH3 confirmed the presence of a 1.0m thick dark brown silty fill containing minor gravel and brick fragments as well as traces plastic fragments. CPT17 also in this area had to be pre-drilled to 0.8m due to the presence of this fill which is physically visible as mounds of soil dumped adjacent to Kaputone Creek.

Furthermore, during the Phase 1 PSE site walkover, soil and organic farming debris where observed down the river bank of the Styx River at several areas in the northeast portion of the site.

Aerial photographs (dating from 1941 to 2011, provided in the Appendix of the Phase 1 PSE) indicate the presence of paleo-channels and at least one in-filled former tributary of the Styx River. The majority

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[11] Sewell, R.J.; Weaver, S.D.; Reay, M.B. 1992: *The Geology of Banks Peninsula and the adjacent Canterbury Plains*. Scale 1:100 000. IGNS geological map 3.

landowner, Mr Mundy, confirmed that a paleo-channel once bisected the South West Area and drained land from the railway line into the Styx River. The Mundy's filled this channel using materials excavated to the south west during the 1970s. CPT records in the area of the in-filled channel did not confirm or refute the presence of the material. This could be because (i) the fill has similar properties to the natural soil or (ii) the CPTs were located outside the area of the fill. Refer to the yellow dashed line in Figure 14 for the approximate location of the historical paleo-channel.

Figure 14: Approximate location of in-filled paleo-channel (according to majority landowner interview during the Phase 1 PSE).

8.2 Ground models

Review of the published geological records, ECan well records and records from the fieldwork show the site to be underlain by the following soil sequence (also refer to the geological cross sections in Appendix D).

Table 1: Ground conditions summary table for the North West study area

Layer No.	Description	Depth to bottom of layer (m bgl)	Layer thickness (m)
-	Topsoil	0.4	0.4
1	Northern margin: Thinly inter-bedded, low to medium plasticity, firm sandy SILT/silty CLAY and loose fine to medium grained silty SAND (Springston Formation)	2.5 – 9.5	2.0 – 11.0
	Area approx. south of CPT7: ***As Springston Formation above, but frequency of very soft to soft CLAY/silty CLAY layers increases; containing occasional thin medium dense sand horizons.***	11.0 – 11.5	
2	Medium dense to dense gravelly SAND/sandy GRAVEL/GRAVEL & SAND, (colour is grey per BH1). Inter-beds of soft to firm SILT and sandy SILT, low plasticity, with few shell inclusions. (Springston/Christchurch Formation)	~ 19.0 – 20.0	7.8 – 9.5
3	Riccarton Gravel	Gravel head inferred from CPT4, CPT5 and CPT6	Not proven

Table 2: Ground conditions summary table for the North East study area

Layer No.	Description	Depth to bottom of layer (m bgl)	Layer thickness (m)
-	Topsoil (BH2)	0.4	0.4
-	Fill (BH3)	1.0	1.0
1	Northern margin (CPTs 9, 12, 13, 16, 17 & 18): Thinly inter-bedded, low plasticity, firm SILT/sandy SILT and loose fine to medium grained silty SAND (Springston Formation)	1.0 – 5.5	< 1.0 – 18.0
	Remainder of area: As Springston Formation above, but silts become stiff to very stiff; occasional thin medium dense sand/silty sand horizons. ***Frequency of very soft to soft CLAY/silty CLAY layers increases towards the south east.***	10.0 – 18.0	
2	Medium dense to dense gravelly SAND/sandy GRAVEL/GRAVEL, grey (not present at CPT14 & 15) (Springston/Christchurch Formation)	6.0 – 17.0	4.0 – 12.0
	Inter-beds of medium dense fine to medium grained SAND and firm to stiff SILT/sandy SILT, low plasticity, with some organic material/peat. (Springston/Christchurch Formation)	19.3 – > 20.0	At least 3.0 across NW portion of area
3	Fine sandy GRAVEL: grey, sub-rounded to rounded. (Riccarton Gravel)	Gravel head inferred from CPT15 and BH3 ~ 19.3	Not proven

Table 3: Ground conditions summary table for the South East study area

Layer No.	Description	Depth to bottom of layer (m bgl)	Layer thickness (m)
-	Topsoil	~ 0.5	0.5
1	Thinly inter-bedded, low plasticity, firm SILT/sandy SILT and loose fine to medium grained silty SAND; occasional thin medium dense sand/silty sand horizons. ***Soft CLAY/silty CLAY layers prevalent in upper 3.0 – 10.0m of the ground profile in this area*** (Springston Formation)	6.0 – 16.5	5.5 – 16.0
2	Medium dense to dense SAND/silty SAND Frequent inter-beds of stiff to very stiff SILT and sandy SILT (Springston/Christchurch Formation)	15 – >20.0 (max. tested CPT depth)	2.0 – 13.5 (thinning out towards Styx River)
	<u>CPT20 & CPT21 only</u> Inter-beds of soft silty CLAY possibly with organic material/peat. (Springston/Christchurch Formation)	17.0 – 19.5	3.1 – 4.5
3	Fine sandy GRAVEL: grey, sub-rounded to rounded. (Riccarton Gravel)	Gravel head inferred from Northern Arterial boreholes ~ 20.0 – 22.0	Not proven

Table 4: Ground conditions summary table for the South West study area

Layer No.	Description	Depth to bottom of layer (m bgl)	Layer thickness (m)
-	Topsoil	~ 0.5 – 1.5	0.5 – 1.5
-	Fill (in-filled paleo-channel; refer to Section 8.1)	Unknown	Unknown
1	Thinly inter-bedded soft to stiff SILT/sandy SILT/silty CLAY; occasional thin medium dense sand/silty sand horizons. Possibly with organic material/peat at variable depths (refer to CPT38 and CPT40 to CPT43) (Springston Formation)	12.0 – 13.0	10.5 – 11.5
2	Medium dense to dense SAND/silty SAND and possibly GRAVEL Thin inter-beds of firm to stiff SILT/sandy SILT (Springston/Christchurch Formation)	15.0 – 20.0 (max. tested CPT depth)	Up to 6.5
3	Riccarton Gravel	Gravel head inferred from CPT40 to 43 ~ 18.0	Not proven

8.3 Summary

The medium dense to dense sand and gravel channel deposits associated with Layer 2 play a very important role in the degree of liquefaction susceptibility a particular area of the site may be prone to. Where dense sand and gravel deposits are present and encountered at shallow depth over a depth of several metres, the performance of the ground is generally significantly better than those areas of the site where only soft/loose sediments exist down to the Riccarton Gravel unit.

9 GROUNDWATER REGIME

The CGD "*GNS Science Median Depth to Water Table*" map[12] indicates that the median long term groundwater level varies from approximately 1.0m – 2.0m bgl in the northwest corner of the site becoming progressively deeper (2.0m to 4.0m bgl) moving east across the site. These groundwater levels are however typically stated to have a low confidence level (with the exception of the northwest corner where there is a monitoring well in place) and are not consistent with the assessed information below, which indicates a complex hydrological environment.

[12] Canterbury Geotechnical Database (2013) "GNS Science Median Groundwater Surface Elevations", Map Layer CGD5160 - 7 Mar 2013, retrieved May 2014 from https://canterburygeotechnicaldatabase.projectorbit.com/

The groundwater regime at the site was assessed using the information below.

- Groundwater monitoring standpipes installed by Eliot Sinclair for the Styx Centre investigation with the following results:
    - September 2006 to May 2009 – Groundwater level (GWL) of between 1.0m to 5.1m bgl; and,
    - January 2012 – GWL of between 1.64m to 4.3m bgl.

It should be noted that this investigation was carried out during a particularly wet period. The Press reported on 6 May 2014 that *"In the last four months, Christchurch has received more than two thirds of the city's average annual rainfall, according to updated MetService data".*

- Groundwater was recorded during the borehole investigation conducted in April 2014 as follows:
    - BH1 – 0.9m bgl on 15 April 2014;
    - BH2 – 1.8m bgl on 16 April 2014; and,
    - BH3 – 2.3m bgl on 28 April 2014.

These results should be used with a certain degree of caution as sufficient time may not have been given to allow the groundwater to reach static conditions which can take some time particularly in a cohesive ground profile.

- Where applicable, groundwater was recorded during the CPT investigation as follows:

Table 5: Groundwater data from CPTu records (April & May 2014)

CPT No.	Depth of CPT (m bgl)	Water level (m bgl)	Date recorded
11	20.0	1.8	12 April 2014
20	17.15	0.9	1 May 2014
22	19.55	1.3	1 May 2014
24	14.96	0.0*	1 May 2014
26	18.55	1.1	24 April 2014
32	14.72	0.0*	12 April 2014
33	16.2	Artesian groundwater pressure	12 April 2014
35	19.43	0.8	12 April 2014
37	19.98	1.2	12 April 2014
44	15.99	Artesian groundwater pressure	17 April 2014

Note: CPT24 and CPT32 were located approximately 1.5 – 3.0m from the Styx River invert level, with bank heights of < 0.5m.

- A review of the ECan borehole data for two wells in the site area (M35_1657 and M35_17883; refer to Appendic A for the location of these wells) indicated minimum groundwater at approximately 1.0m bgl.

Based on the available on-site groundwater information and taking into account expected seasonal fluctuations in water levels, an in-situ groundwater level of 1.0 – 2.0m bgl and a design groundwater level of 1.0 – 1.5m bgl have been adopted for liquefaction hazard analysis.

10 EARTHQUAKE DAMAGE OBSERVATIONS

10.1 Performance of the site - observations from Phase 1 PSE

Coffey staff conducted a site walkover on 8 November 2013 as part of the Phase 1 PSE. The walkover included interviewing Mr Mundy, who grew up on site and is the majority land owner of the north eastern portion of the site. Mr Mundy indicated the following relating to his land:

- Minor amounts of liquefaction ejecta occurred towards the north western corner of the site following the February 2011 earthquake.
- Earthquake damage to his dwellings was limited to chimney damage and minor cracking to cladding and to perimeter foundation walls.

10.2 EQC mapped observations

It can be seen that the site was not specifically mapped as it is mostly rural land, whereas the mapping efforts concentrated in the dense residential areas. Aerial photographs taken during the Canterbury Earthquake Sequence were reviewed to assess liquefaction at the site.

Aerial photographs of the site following the February 2011 earthquake indicate that little or any liquefaction ejecta or lateral spread was evident at the site. Aerial photographs following the December 2011 earthquake only partially cover the site but do not indicate liquefaction ejecta or lateral spread. Aerial photographs following the September 2010 and June 2011 earthquakes were not available.

Information relating to liquefaction from the CGD "*EQC Liquefaction* and *Lateral Spreading Observations"* [13] did not sufficiently cover the site and provided limited information in relation to the site.

The ECan Liquefaction Assessment Area Map (2012) indicates that a liquefaction assessment is needed.

EQC Horizontal Ground Movements have not been given for the site; however, the land to the south of the site is indicated to have moved in a southerly direction, whereas the land to the north west of the site is indicated to have moved in a north-westerly direction.

EQC maps for *Vertical Ground Movements* and *Observed Ground Cracks* do not extend as far north as the site.

[13] Canterbury Geotechnical Database (2013) "Liquefaction and Lateral Spreading Observations", Map Layer CGD0300 - 11 Feb 2013, retrieved May 2014 from https://canterburygeotechnicaldatabase.projectorbit.com/

11 GROUND MOTION

Using the MBIE[4] and Bradley & Hughes (2012)[14] procedures we have found that the site was "not sufficiently tested" to the Serviceability Limit State (SLS) level of earthquake demand during the Canterbury earthquake sequence. However, following further statistical analysis it can be stated with an 84% degree of confidence that the site was tested to SLS during the 4 September 2010 earthquake.

Considering the geological setting and the terrain at the site, and taking into account the level of "test" experienced, an assessment has been made regarding predicted earthquake-induced deformation that may occur in a design earthquake event. It is considered that:

- An SLS earthquake event is likely to cause similar damage to the land than that experienced to date.
- A ULS earthquake event is likely to cause greater damage to the land than that experienced to date.

These considerations have been taken into account when assessing suitable founding options for the site.

12 CERA RESIDENTIAL ZONING

Reference to the Canterbury Earthquake Recovery Authorities' land zoning system confirms that the entire site is zoned "Green". CERA states "Green zone areas are generally considered to be suitable for residential construction"[15].

13 MBIE LAND ZONING

Figure 15 shows the MBIE (previously the Department of Building and Housing [DBH]) residential land Technical Category map for the area. It can be seen that site falls in *"N/A – Rural & Unmapped*" category and the existing residential land to the south, south west and west consists of MBIE Technical Categories TC2 and TC3. Land to the north of the site has been zoned for residential use but is not yet developed. Furthermore, land to the south east of the site is in the R7 Residential Priority Area, but has not yet been zoned.

In terms of engineering design standards, "small to medium sized earthquake" corresponds to a serviceability limit state (SLS) event with a nominal return period of 25 years, and "moderate to large earthquake" corresponds to an ultimate limit state (ULS) event with a nominal return period of 500 years[16].

[14] Bradley & Hughes (2012) *Conditional Peak Ground Accelerations in the Canterbury Earthquakes for Conventional Liquefaction Assessment*. Report for DBH (MBIE), April 2012.

[15] http://cera.govt.nz/land-information/land-zones

[16] Table C2.1 on page C2.2 of MBIE Guidance (December 2012).

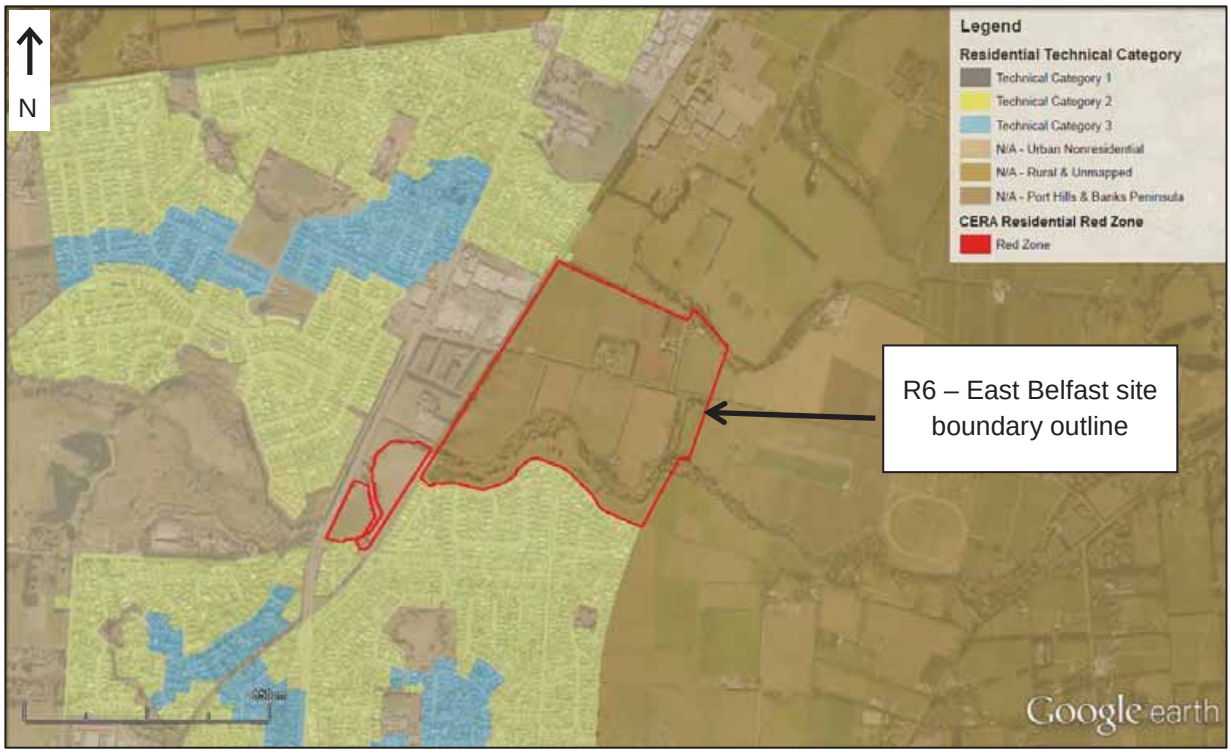


Figure 15: Site location plan showing MBIE Technical Categories (scale as shown)

14 LIQUEFACTION HAZARD ASSESSMENT

14.1 Introduction

The MBIE guidelines[4] state:

> *"In support of both plan change applications and subdivision consent applications, appropriate geotechnical investigations shall be carried out and stand-alone geotechnical reports prepared by a Chartered Professional Engineer (CPEng.) with competence in geotechnical engineering. The reports shall combine all relevant geotechnical information in both a factual and interpretive manner, provide justifiable statements about all pertinent geotechnical aspects and consider relevant RMA section 106 issues".*

14.2 Assessment method

Assessment of earthquake-induced ground deformation hazard at the site has generally been carried out in accordance with the latest MBIE Guidance that was published at the end of December 2012 and using proprietary liquefaction assessment software[17].

In accordance with NZS1170.5, Section 3.1.3, a site subsoil classification of "*Class D – Deep or soft soil sites"* may be assumed for this site.

[17] Geologismiki Geotechnical Software, Cliq v1.7.4.34 –CPT Liquefaction Assessment Software.

14.3 Additional evaluation tools

The guidance documents recognise that engineering judgement is required in considering the "sensibility" of analysis results, and therefore the methodologies should only be applied by those with a strong background in geotechnical engineering.

The MBIE's prescribed liquefaction susceptibility method does not recognise the need to evaluate the depth at which accumulating strains are occurring or the assessment of the potential for those strains to manifest as deformation at or near the ground surface where, for example, shallow foundations and buried services are located.

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

We refer to the LPI in our commentary on likelihood of vertical deformation being manifest at ground surface. LPI is a tool that provides a sensibility check on settlement values rather than simply summing vertical strains over the full ground profile and expecting these to manifest as surface deformation subsequently warranting engineering mitigation.

If we consider one of the fundamental principles of earthquake-resilient design promoted by the MBIE Guidance that is to build stiffer foundations and, where appropriate, improve the ground to stiffen it thus mitigating the severity of total and differential settlement of land and buildings, we see that non-liquefiable soil deposits in the ground impart a natural stiffening "raft" that can significantly mitigate liquefaction-induced vertical strains beneath that layer being manifest as surface deformation.

This scenario has been observed widely across Christchurch where land areas with shallow dense sand/gravel deposits have performed far better than those with deep deposits of liquefiable soil. Dense sand/gravel associated with Layer 2, which is present at relatively shallow depth across the northern margin of the R6 – East Belfast area, is such a deposit.

We consider that this line of thought is a good example of where sound engineering judgement coupled with an appreciation of the how the prescribed MBIE method calculates settlement can be applied to provide a sensibility check of the settlement values, and aid in the development of informed opinion on suitable engineering measures at the site.

So, we have two additional tools at our disposal: (i) consideration of the LPI value at a particular CPT location, and (ii) review of its settlement profile i.e. to review where is settlement actually accumulating in the ground profile. If it is at depth beneath a non-liquefiable (or a layer of distinctly lower liquefaction susceptibility) e.g. dense sand/gravel layer, then one would be inclined to down-rate the *practical significance* of settlements accumulating beneath that layer. Such a scenario occurs in some areas of the site where soil Layer 2 provides a rafting effect - for example, the northern margin of the North West and North East Areas (see later).

Reference should be made to Appendix E for the liquefaction analysis plots for CPT1 to CPT44 and BH1 to BH3.

15 NATURAL HAZARDS

Resource Management Act Section 106 issues relevant to this Plan Change assessment require an evaluation of whether:

(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.

15.1 Erosion

The potential for erosion has been assessed from the only viable sources, namely the Styx River and Kaputone Creek. We have walked the length of the northern bank of the Styx River between the railway line east to the edge of the R6 – East Belfast site. During this walkover an erosion feature was observed and is discussed in Section 6.5. This feature is expected to have developed as a result of surface flow from the up-slope agricultural land.

The overall erosive potential of the Styx River and the Kaputone Creek is expected to be low.

15.2 Falling debris

There are no sources of falling debris at the site.

15.3 Subsidence

This report specifically addresses the identification of subsidence that may occur due to construction on poor/soft/peat soil, and earthquake-induced ground deformation.

Founding in the dense sand/gravel associated with Layer 2 where possible will reduce the risk.

15.4 Slippage

We have discussed the potential for land slippage at the riverbank of the Styx River across the southern boundary of the site. Although the Styx River and associated channel (s) is typically a mature landscape feature, the potential for land slippage is present. Any development would typically be set back from the slope edge to accommodate a riparian margin, however we still consider the risk of slope failure or the risk to development should failure occur to be low.

The potential for lateral spread associated with the Styx River margin and stormwater facilities is commented on later in the report.

15.5 Inundation

The majority of the site is not within the CCC Flood Management Area (FMA)[18]. However, the river channel and the low-lying inward meanders of the Styx River are designated within the 50 year flood extent and floor level control area.

The majority landowner, Mr Mundy, indicated that immediately to the south of the area, work by the government during the 1920s straightened the current stream alignment of the Styx River. The river occasionally floods to its original position, resulting in boggy areas as shown in Figure 16 (highlighted in blue). An appropriate setback will mitigate this.

Observations on site reveal no major evidence of inundation associated with the Kaputone Creek.

Figure 16: Site plan showing an overlay of historic watercourses extracted from the 1856 Black Map[9] and indicative alignments of smaller watercourses.

With regard to stormwater inundation, it is recommended that stormwater design and management is dealt with by specialists in that field of work, and is beyond the scope of this report.

15.6 Subsequent use

The comments above relate to the current lay of the land. Proposed changes to the land (i.e. its subsequent use) that may potentially adversely affect future land and building performance include the development of stormwater facilities that requires the construction of drains and possibly swales and basins. These features provide a “free face” in the land requiring attention to address the potential for lateral spread. Stormwater design should have specialist geotechnical design input at the subdivision consent stage of development.

[18] http://maps.cera.govt.nz/advanced-viewer/?Viewer=Ccc-Floor-Levels

16 BROAD CLASSIFICATION OF LAND

16.1 Technical Categories

The site's liquefaction characteristics have been assessed against the deformation limits in the latest MBIE Guidance document as summarised below in Table 16.1.

Table 16.1: Liquefaction deformation limits and house foundation implications

Technical Category	Liquefaction deformation index limits				Likely implications for house foundation (subject to individual assessment)
	Vertical settlement		Lateral spread (across a house site)		
	SLS	ULS	SLS	ULS	
TC1	15 mm	25 mm	nil	nil	Standard NZS 3604 – like foundations with tied slabs*
TC2	50 mm	100 mm	50 mm	100 mm	The Ministry's enhanced foundation solutions (section 5.2) of the 2011 *Repairing and rebuilding houses affected by the Canterbury earthquakes*
TC3	>50 mm	>100 mm	>50 mm	>100 mm	The Ministry's TC3 foundation solutions, but preferably ground treatment to upgrade land to align with TC2 characteristics.

Note: Certain foundation details included in NZS 3604 are precluded from use (refer to Building Code Acceptable Solution B1/AS1 at www.dbh.govt.nz/compliance-documents#b1.

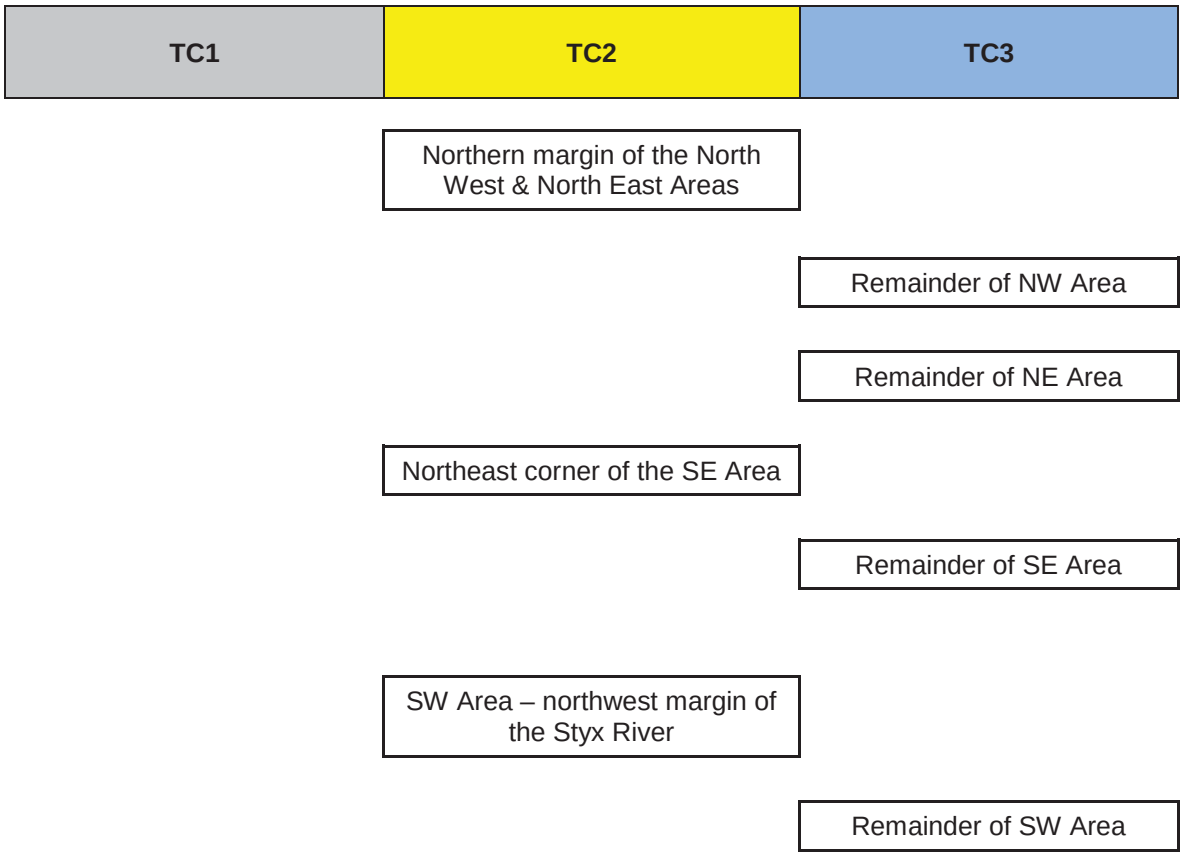
Indicative MBIE "free-field" settlement results and our assessment of appropriate foundation categories are displayed in Tables 6 to 8, and Figure 17 is a summary of the broad land foundation category areas for residential development of the site.

Figure 17: Summary of broad land zoning for residential development (in reference to MBIE residential foundation Technical Categories)

The Technical Categories presented below are high-level designations for the proposed rezoning of R6 – East Belfast for future urban development assessment purposes only. All areas require more detailed evaluation and confirmation of foundation design requirements for subdivision design and building consent purposes.

The natural continuum of ground properties and predicated earthquake performance

The Technical Categories



16.2 Indicative Technical Category equivalent map for R6 – East Belfast

No areas of the site are unfit for the proposed residential and business development.

As expected, the 60 ha area has a range of ground conditions and accordingly there is a range of predicted earthquake performance.

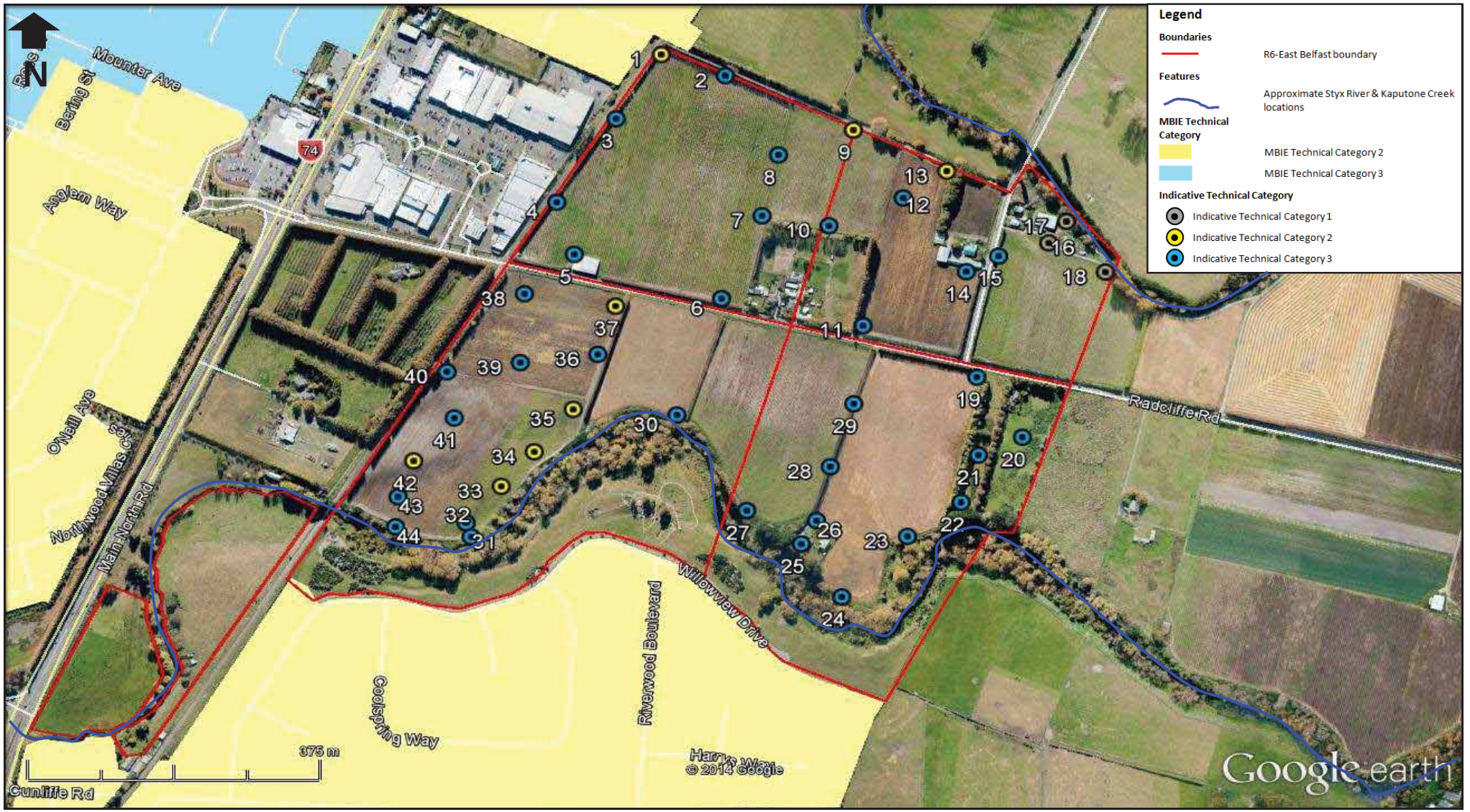
Figure 18 presents the indicative technical category map for R6 – East Belfast strictly reporting as per MBIE guidelines. However, using engineering judgement and the tools described in Section 14.3, we consider that the land is likely to be a patchwork of TC2 and TC3 equivalent land as per Figure 19.

A portion of land along the northern margin of the site is likely to be TC2. The remainder of the site is distributed in TC3 land with a patchwork of TC2equivalent land as indicated by clusters of CPTs with the same colour. Figure 18 presents a high-level overview of the land classification.

It is very important to recognise that the technical category system is purely a means of defining the *liquefaction-related issues* that may exist at a site. The ground conditions present at the site fall into a range, but are siloed into the technical categories on the basis of liquefaction-induced settlement and lateral spread deformation tolerances.

However, the complex ground conditions at the site present other potentially significant construction hazards including areas of soft compressible ground (e.g. soft silt, possible peat, organic soil). Awareness of these issues is very important when considering appropriate foundation engineering measures and ground improvement options for the site.

The ground conditions encountered at the site are comparable to the ground conditions present across much of Christchurch that are densely developed.



Revision	description	drawn	approved	Date					
	Revision 1			28/5/14	drawn	BR	coffey	client:	Christchurch City Council
					approved	NH		project:	Geotechnical Assessment for Review of the District Plan
					date	May 2014		title:	R6 – East Belfast, Christchurch Indicative MBIE Technical Categories
					scale	As shown			
					original size	A4		project no:	15602AB figure: 18

Table 6: North West & North East Areas CPTu data, indicative MBIE Technical Categories & indicative foundation categories for review of the district plan

Area	CPT No.	Refusal depth (m)	SLS1 MBIE "Index Value" (settlement in upper 10m) (mm)	ULSIL2 MBIE "Index Value (settlement in upper 10m) (mm)	Indicative MBIE Technical Category		Indicative foundation category	Comments
					SLS Ind.	ULS Ind.		
North West	**1**	3.9	38	53	TC2	TC2	TC2	-
	2	10.0	108	135	TC3	TC3	TC2	4.5m thick, non-liquefiable gravel at 2.5 – 7.0m bgl
	3	11.8	243	281	TC3	TC3	TC3	-
	4	19.2	73	103	TC3	TC3	TC3	-
	5	20.2	75	90	TC3	TC2	TC3	-
	6	10.6	108	123	TC3	TC3	TC3	-
	7	9.0	231	248	TC3	TC3	TC3	-
	8	5.0	135	168	TC3	TC3	TC3	-
North East	**9**	5.0	28	39	TC2	TC2	TC2	-
	10	-	192	215	TC3	TC3	TC3	-
	11	-	145	164	TC3	TC3	TC3	-
	12	-	212	236	TC3	TC3	TC3	-
	13	6.6	0	34	TC1	TC2	TC2	
	14	-	99	116	TC3	TC3	TC3	-
	15	19.4	72	85	TC3	TC2	TC3	-
	16	3.1	0	0	TC1	TC1	TC2	Due to proximity to Kaputone Creek
	17	2.8	0	2	TC1	TC1	TC2	Due to proximity to Kaputone Creek
	18	2.4	1	1	TC1	TC1	TC2	Due to proximity to Kaputone Creek

Table 7: South East Area CPTu data, indicative MBIE Technical Categories & indicative foundation categories for review of the district plan

Area	CPT No.	Refusal depth (m)	SLS1 MBIE "Index Value" (settlement in upper 10m) (mm)	ULSIL2 MBIE "Index Value (settlement in upper 10m) (mm)	Indicative MBIE Technical Category		Indicative foundation category	Comments
					SLS Ind.	ULS Ind.		
South East	**19**	-	74	84	TC3	TC2	TC2	Typically non-liquefiable clay-like profile between 1.5 – 8.5m bgl
	20	17.2	74	74	TC3	TC2	TC2	Typically non-liquefiable clay-like profile between 0.0 – 7.5m bgl
	21	-	118	123	TC3	TC3	TC3	-
	22	19.6	154	168	TC3	TC3	TC3	-
	23	19.4	181	187	TC3	TC3	TC3	-
	24	15.0	222	239	TC3	TC3	TC3	-
	25	18.6	73	85	TC3	TC2	TC3	Adjacent to Styx River, therefore lateral spread potential
	26	18.6	85	92	TC3	TC2	TC3	-
	27	18.0	62	82	TC3	TC2	TC3	Adjacent to Styx River, therefore lateral spread potential
	28	8.0	83	124	TC3	TC3	TC3	-
	29	-	93	110	TC3	TC3	TC3	-

Table 8: South West Area CPTu data, indicative MBIE Technical Categories & indicative foundation categories for review of the district plan

Area	CPT No.	Refusal depth (m)	SLS1 MBIE "Index Value" (settlement in upper 10m) (mm)	ULSIL2 MBIE "Index Value (settlement in upper 10m) (mm)	Indicative MBIE Technical Category		Indicative foundation category	Comments
					SLS Ind.	ULS Ind.		
South West	**30**	18.5	57	65	TC3	TC2	TC3	Adjacent to Styx River, therefore lateral spread potential
	31	11.8	55	91	TC3	TC2	TC3	Adjacent to Styx River, therefore lateral spread potential
	32	14.7	74	111	TC3	TC3	TC3	Adjacent to Styx River, therefore lateral spread potential
	33	16.2	39	48	TC2	TC2	TC3	Adjacent to Styx River, therefore lateral spread potential
	34	17.4	39	43	TC2	TC2	TC3	Adjacent to Styx River, therefore lateral spread potential
	35	19.4	27	37	TC2	TC2	TC3	Adjacent to Styx River, therefore lateral spread potential
	36	19.4	67	74	TC3	TC2	TC3	-
	37	20.0	18	21	TC2	TC1	TC2	-
	38	15.8	178	181	TC3	TC3	TC3	-
	39	13.8	57	71	TC3	TC2	TC2	Typically non-liquefiable profile between 0.0 – 5.0m bgl
	40	18.6	119	129	TC3	TC3	TC3	-
	41	18.0	100	103	TC3	TC3	TC3	-
	42	17.7	37	40	TC2	TC2	TC2	-
	43	17.8	88	97	TC3	TC2	TC3	-
	44	16.0	58	84	TC2	TC2	TC3	Adjacent to Styx River, therefore lateral spread potential

17 COMMENTS ON SPECIFIC LAND AREAS

Figure 19 presents a plan of specific areas that are discussed in detail below. This report being a high-level overview requires all areas of the site to be subject to specific detailed investigation and engineering evaluation to confirm indicative foundation categorisations and the ground conditions for foundation design.

17.1 Northern margin

There is an area of notable variability in the broad classification of the land where TC2 land is found to adjoin TC3 land with quite an abrupt transition between the two. The area of transition is marked on Figure 19 and is situated south of Thompsons Road along the northern margin of the site.

Review of the ground investigation works at borehole BH2 and CPT1, CPT2, CPT9 and CPT13 in this area indicate the area is underlain by a thick sandy gravel/gravel deposit associated with Layer 2 encountered at shallow depth (~ 2.0m bgl), whereas the adjoining land to the immediate south has no significant dense ground down to at least 20m bgl an example of which is indicated at CPT12 position.

We recommend further testing at the subdivision consent stage in this area to prove the transition between the TC2 and TC3 equivalent land.

Included in the northern margin is a small area adjacent to the Kaputone Creek. In this area the borehole (BH3) and CPT data indicates shallow gravel at approximately 2.0m to 3.0m bgl with an associated indicative TC1 categorisation, however, considering the close proximity of the Kaputone Creek, we consider that a land classification of TC2 should apply as TC1 land has ‘nil’ tolerance to lateral spread (as per MBIE table 16.1).

On confirmation of the boundary between the TC2 and TC3 equivalent land, no further earthworks are likely required to the “northern margin” area and this area would be ready for TC2 foundations for residential buildings. Standard methods of site specific verification testing of bearing capacities available will be required at the building consent stage of development.

17.2 Northeast corner of the South East Area

The CPT logs from CPT19 and CPT20 indicate the presence of a clay-like material that is less susceptible to liquefaction from existing ground level to depths of 7.5m to 8.5m bgl. Therefore, it can be the case that mitigation of poor/soft ground is a more dominant design issue than mitigation of liquefaction-related issues. In this regard, we believe that a foundation category of TC2 would be appropriate for this area but that specific detailed investigation and engineering evaluation is carried out to confirm available bearing capacities and ground conditions for foundation design.

17.3 South West Area - (northwest Styx River margin)

The north western margin of the Styx River in the South West Area presents a location of heightened potential for lateral spread. We have assessed the lateral spread hazard in this area and note the following:

- Geomorphologically this area of the site is located on a convex section of the Styx River and the height of the slope in this area is approximatley 2.0m – 4.0m;
- Analysis output shows that the CPTs encountered continuous deposits of liquefiable ground in proximity to the free-face (the Styx River).

Considering the above and the results of our lateral spread hazard assessment it is evident that the riverbank is susceptible to lateral spreading.

TC2 land has tolerance of less than 100mm as its lateral spread performance criteria and we consider that the risk of lateral spreading to be more consistant with TC3 classified land and have classified land located along the Styx River margin as TC3 equivalent.

As per the MBIE Guidance, in the absence of any evidence to the contrary, Table 12.3[19] provides a boundary condition of a 50m setback from the free-face[20] to work with beyond which "*Minor to Moderate"* global lateral movement (0mm to 200mm) can be assumed.

Furthermore, residential development may also be set-back a minimum distance to accommodate a riparian margin/reserve.

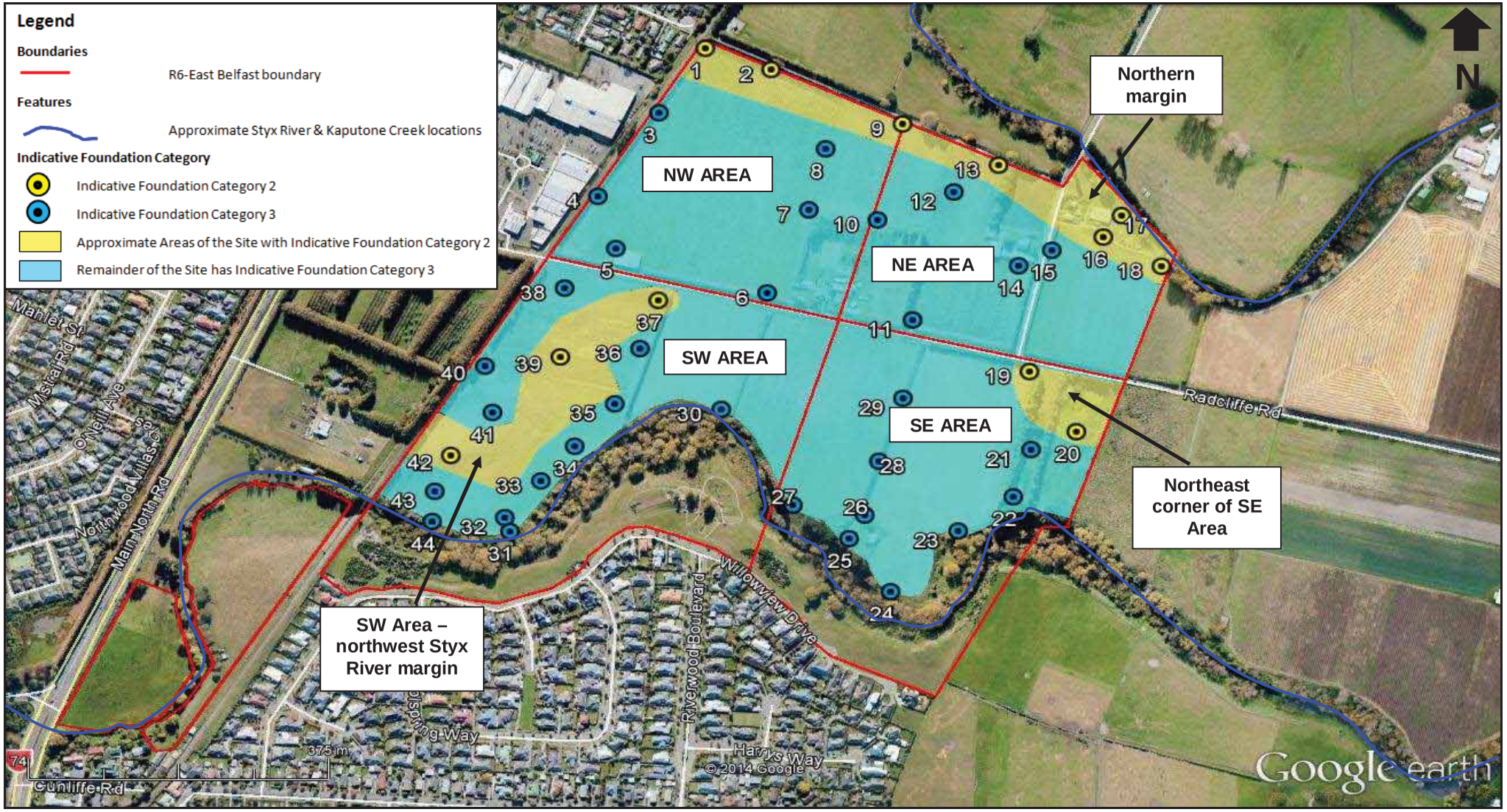
The area is subject to specific detailed investigation and engineering evaluation to confirm site specific ground conditions for foundation design.

17.4 Remainder of site

The remainder of the site is essentially classified as TC3 land. Recommendations regarding remediation of the land in line with TC2 land performance criteria are outlined in the following sections.

[19] Table 12.3: Distance from free-edge beyond which minor to moderate global lateral movement can be assumed in TC3, in the absence of any evidence to the contrary.

[20] The distance in analysis is usually the horizontal distance from the base of slope (i.e. invert level).



Revision	description	drawn	approved	Date				client:	Christchurch City Council	
	Revision 1			28/5/14	drawn	BR	coffey	project:	Geotechnical Assessment for Review of the District Plan	
					approved	NH		title:	R6 – East Belfast, Christchurch Indicative Foundation Categorization for Proposed Rezoning for Future Urban Development	
					date	May 2014				
					scale	As shown				
					original size	A4		project no:	15602AB	figure: 19

18 FOUNDATION RECOMMENDATIONS

18.1 Foundations on land classified TC2 equivalent

For TC2 equivalent areas shallow foundations as per Section 16.9 in Part D of the MBIE Guidance are considered likely to be appropriate foundations. Foundations in TC2 areas will likley be one of the MBIE TC2 “enhanced slab” Options 1 to 4 summarised under Section 5.3.1 of MBIE, and included below for ease of reference:

1. Option 1 – Excavation and replacement of the upper layers of the soil with compacted, well-graded gravels and construction of a reinforced NZS 3604 slab foundation.
2. Option 2 – Construct a thick slab foundation over the existing soil.
3. Option 3 – Construct a generic beam grid and slab foundation.
4. Option 4 – Construct a waffle slab over the existing soil.

Refer to the MBIE guidance for residential building development requirements. Foundation recommendations must have CPEng engineering involvement.

Site specific verification testing of bearing capacities available will be required at the building consent stage.

18.2 Foundations on land classified TC3 equivalent

For new foundations on TC3 land the MBIE Guidance recognise three broad types:

1. Deep piles
2. Site ground improvement
3. Surface structures/shallow foundations

Each have different capabilities to accommodate various levels of vertical settlement and lateral spreading, and require different constraints with respect to the configuration and weights of superstructure (e.g., deep piles will not be suited to areas of TC3 where global lateral movement or lateral stretch is major or severe).

Site specific assessment will be required to determine appropriate TC3 foundations. Refer to the MBIE guidance for residential building development requirements. Foundation recommendations must have CPEng engineering involvement.

19 SITE GROUND IMPROVEMENT TO MEET REQUIREMENTS OF TC1 / TC2 LAND CLASSIFICATION

19.1 Residential

Appendix D of the MBIE guidance and the CCC Subdivision Bulletin (No. 23.2) recommend that residential lots in new subdivisions meet the performance criteria specified for TC1 or TC2 classified land. For the areas of R6 East Belfast with TC3 land equivalent classification (see Figure 19) ground improvement will be required. We anticipate that ‘Stone Columns’ or ‘Deep Soil Mixing’ will be the most suitable ground improvement methods for this site. If ground improvement is to be undertaken at the specific engineering design will be required at the subdivision consent stage of development.

19.2 Infrastructure

The scope of ground improvement for infrastructure shall be in accordance with CCC Infrastructure Design Standard requirements.

Design of ground improvement necessary for infrastructure will be required at the subdivision consent stage of development.

20 STORMWATER FACILITIES

We have analysed the lateral spread hazard in regards to the proposed stormwater facilities on the margins of the Styx River. Prediction of lateral spread has been made using the method of Zhang et al. (2002)[21] and with reference to MBIE guidance December 2012.

Geomorphologically this area of the site is located on a convex section Styx River. Analysis output shows that the CPTs encountered continuous deposits of liquefiable ground in proximity to the free-face (the Styx River). Due to the height of the slope (2.0m – 4.0m), it is evident that the riverbank is at a high risk of lateral spreading. In addition, the soils are typically soft so can be prone to strain softening when subject to design earthquake shaking.

Accordingly the Styx River margin is a high hazard area and we recommend as far as possible the margin be set aside as reserve land to minimise the need for engineering measures to protect buildings and infrastructure assets. Should stormwater facilities be needed to be placed at or close to the riverbank then specific engineering measures will need to be considered.

21 CONCLUSIONS AND RECOMMENDATIONS

We confirm that that this review of the district plan has been conducted in accordance with the overview requirements appropriate for this high-level level assessment, and using CPTs and boreholes (both site-specific boreholes and existing borehole records) conducted to characterise the ground to the appropriate depth of at least 15 metres.

The work has been under the direction of a Chartered Professional Engineer (CPEng) with competence in geotechnical engineering. The fieldwork has provided a good picture of the geological depositional environment as discussed in the report, however our recommendations primarily relate to the need for additional investigation to refine the high-level overview presented in Figure 19.

A *preliminary assessment* of liquefaction susceptibility and associated earthquake-induced ground deformations has been carried out with the expectation that further (more detailed) geotechnical evaluation would be required at the subdivision design and building consent stages of development.

Further investigation and groundwater monitoring would help confirm the proposed TC2 land categorisation in these areas.

[21] Zhang, P. K. Robertson, and R. W. I. Brachman; *Estimating Liquefaction-Induced Lateral Displacements Using the Standard Penetration Test or Cone Penetration Test;* Journal of Geotechnical & Geo-environmental Engineering, Vol. 130, No. 8, 861-871.

Water levels adopted for detailed design will need to take in account any earthworks changes to ground levels.

We have found that the thicker the Layer 1 soil unit is, the more susceptible the ground is to earthquake-induced settlement. Hence, it is the depth to dense sand/gravel associated with Layer 2 that provides an index of the likely Technical Category. Multi-channel analysis of surface waves (MASW) geophysical survey provides a quick and cost-effective means of mapping the subsurface to determine the depth to competent strata that would be a very useful means of characterising the ground between boreholes and CPT locations across the site.

Any development across the site should be cognisant of the potential for the presence of fill that should be identified in the course of normal, good-practice ground investigation processes.

In regards to lateral spreading, the Styx River margin is a high hazard area and we recommend as far as possible the margin be set aside as reserve land to minimise the need for engineering measures to protect buildings and infrastructure assets. Should stormwater facilities be needed to be placed at or close to the riverbank then specific engineering measures will need to be considered.

At this preliminary design stage, for residential construction, we have proposed a 50m set-back from the slope crest of the Styx River. The land beyond the set-back is deduced to fall within Technical Category TC2 or TC3. Within the set-back there is a heightened risk of lateral spread that warrants specific review at detailed design stage.

Any development must be undertaken with an appropriate level of investigation and evaluation in accordance with MBIE guidance and satisfy CCC's regulatory requirements. The MBIE guidelines provide the *engineering criteria and means* by which the land may be developed to be Code compliant. It is a question of economics as to whether land is *economically viable* to develop.

We note that many greenfield areas across Christchurch with comparable ground conditions are being developed.

22 LIMITATIONS

This report has been prepared solely for the use of our client Christchurch City Council (CCC) and their professional advisers and in relation to the specific project described herein. No liability is accepted in respect of its use for any other purpose or by any other person or entity.

It is recommended that all other parties seek professional geotechnical advice to satisfy themselves as to its on-going suitability for their intended use.

Coffey Geotechnics (NZ) Ltd has not carried out a detailed structural inspection of any building(s) across the site nor has a topographical survey been undertaken. We had not visited the property prior to the earthquakes.

As subsurface information has been obtained from discrete investigation locations, which by their nature only provide information about a relatively small volume of subsoils, there may be special conditions pertaining to this site which have not been disclosed by the investigation and which have not been taken into account in the report. If variations in the subsoils occur from those described or assumed to exist then the matter should be referred back to us immediately.

Please also refer to the enclosed *Important Information about Your Coffey Report*.

23 CLOSURE

If you have any queries or you require any further clarification on any aspects of this report, please contact the undersigned.

For and on behalf of Coffey

Prepared by

Bjorn Raasch

Project Engineering Geologist

Prepared by

Bex Hawksworth

Project Engineering Geologist

Reviewed and approved by

Nick Harwood

BEng (Hons) MSc DIC MIPENZ CPEng

Principal Geotechnical Engineer

Attachments:

Important information about your Coffey Report

Appendix A: Testing Location Plan

Appendix B: Plan of indicative depth to inferred dense sand/gravel

Appendix C: Soil behaviour Type profiles (SBT) derived from CPTu data & Borehole Logs (BH1 – BH3)

Appendix D: Indicative Cross Section Location Plan

Geological cross sections (A-A' to E-E')

Appendix E: Liquefaction and Lateral Spread analyses for CPTs 1 – 44 and BHs 1 - 3

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Important information about your **Coffey** Report

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction,
speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Appendix A

Testing Location Plan


(sonic) position
osition* (existing data)
osition* (existing data)
l (East) and Styx Centre (West)
n* (existing data)
utone Creek & Styx River locations
ource
NW Area
NE Area
SW Area
SE Area
Kaputone Creek
BH1
BH2
BH3
BH7
BH11
BH12
1347
17842
17840
17883
35465
35470
1657
Brakes
Willowview Drive
Riverwood Boulevard
Coolspring Way
375 m
© 2014 Google

Appendix B

Plan of indicative depth to inferred dense sand/gravel soil

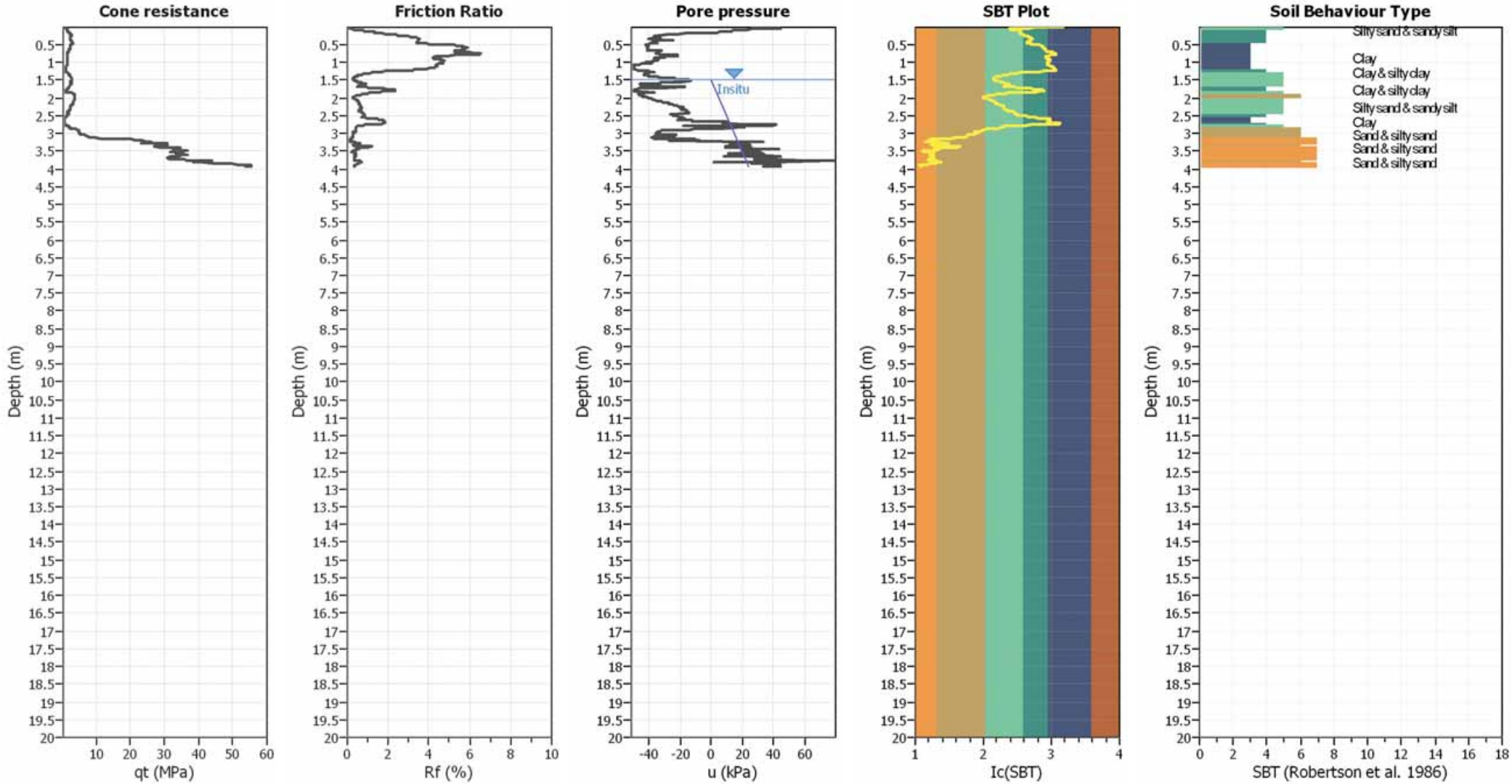

sand / gravel deposit)*
e (sonic) proven gravel depth
proven gravel depth*
efusal depth (inferred dense sand /
al (East) and Styx Centre (West)
n gravel depth
Blakes Rd
Willowview Drive
Riverwood Boulevard
Coolspring Way
375 m
© 2014 Google
UC
10.0
1.5
5.0
11.8
9.0
2.7
6.6
>9.1
19.3
10.6
>20.0
>20.0
>20.0
3.3
2.0
2.8
19.8
19.9
19.4
3.1
2.4
19.7
UC
20.2
>20.0
20.0
20.1
19.9
>20.0
18.8
19.4
18.6
UC
19.9
>20.0
3.0
14.8
18.0
18.0
19.4
18.5
17.8
19.9
17.2
22.0
17.4
>20.0
17.7
16.2
9.5
17.8
18.3
16.0
14.7
11.8
18.0
18.6
19.4
19.4
19.6
18.6
21.0
20.9
15.0
20.0

Appendix C

Soil Behaviour Type profiles (SBT) derived from CPTu data

Borehole logs (BH1 – BH3)

CPT basic interpretation plots



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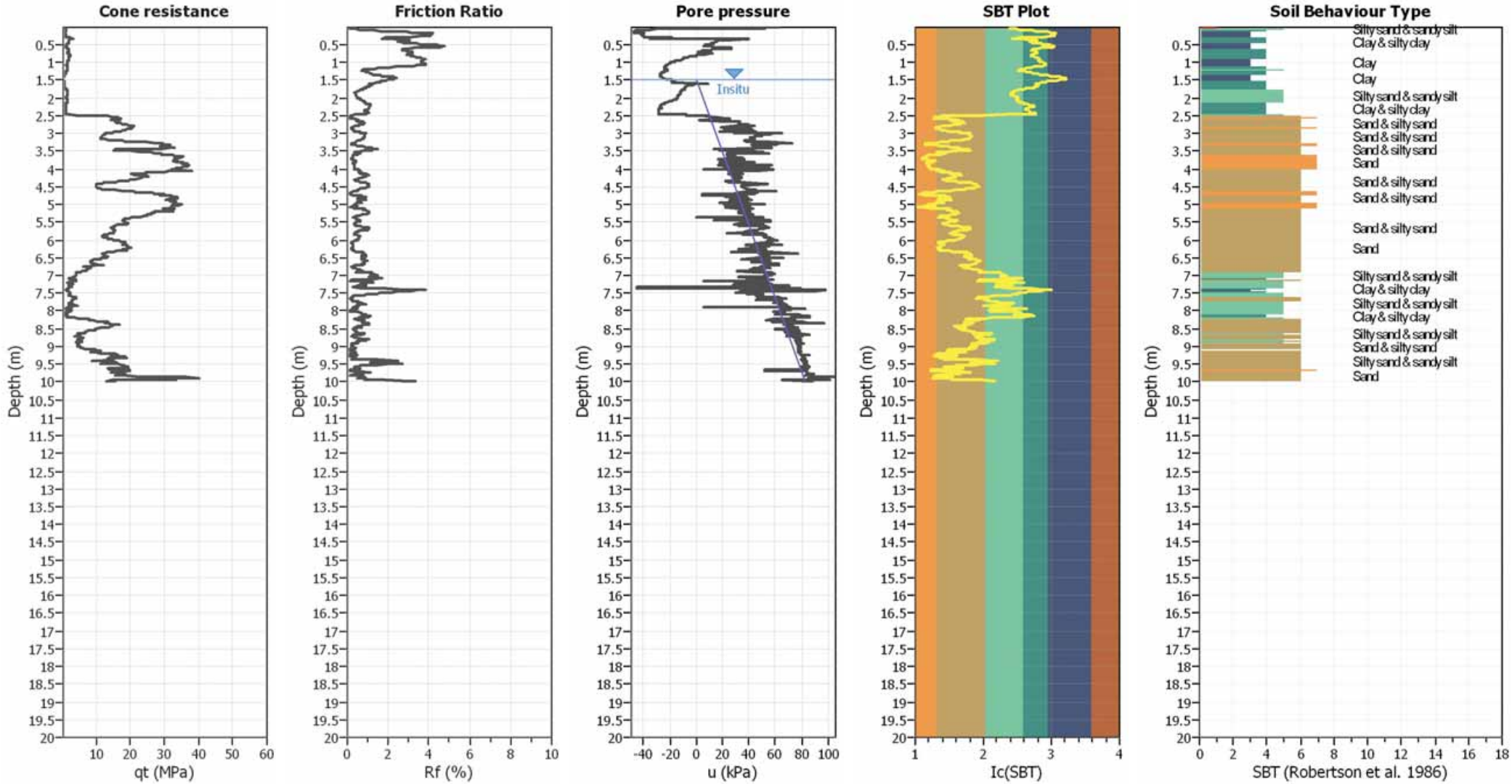
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



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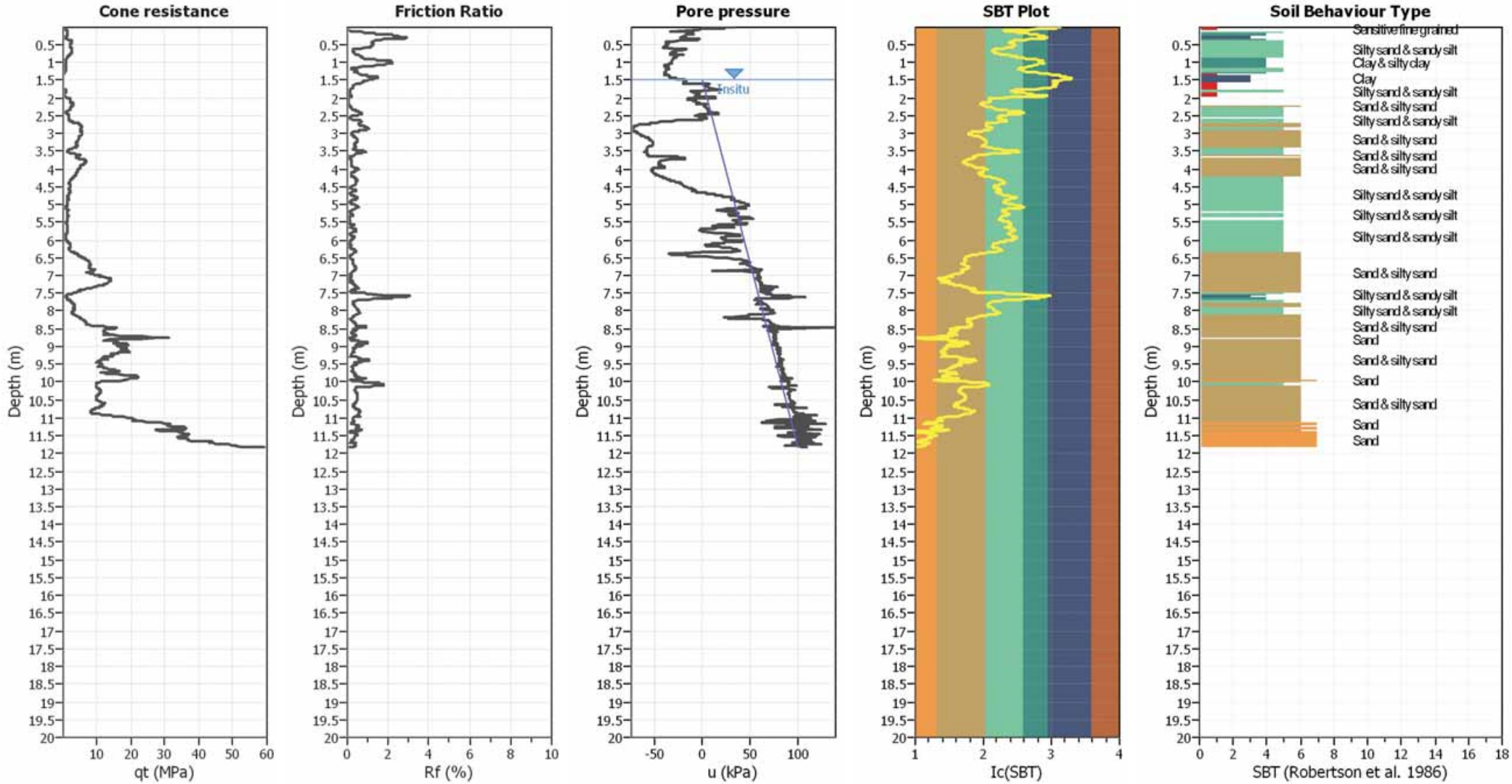
SBT legend

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



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3. Clay to silty clay
4. Clayey silt to silty
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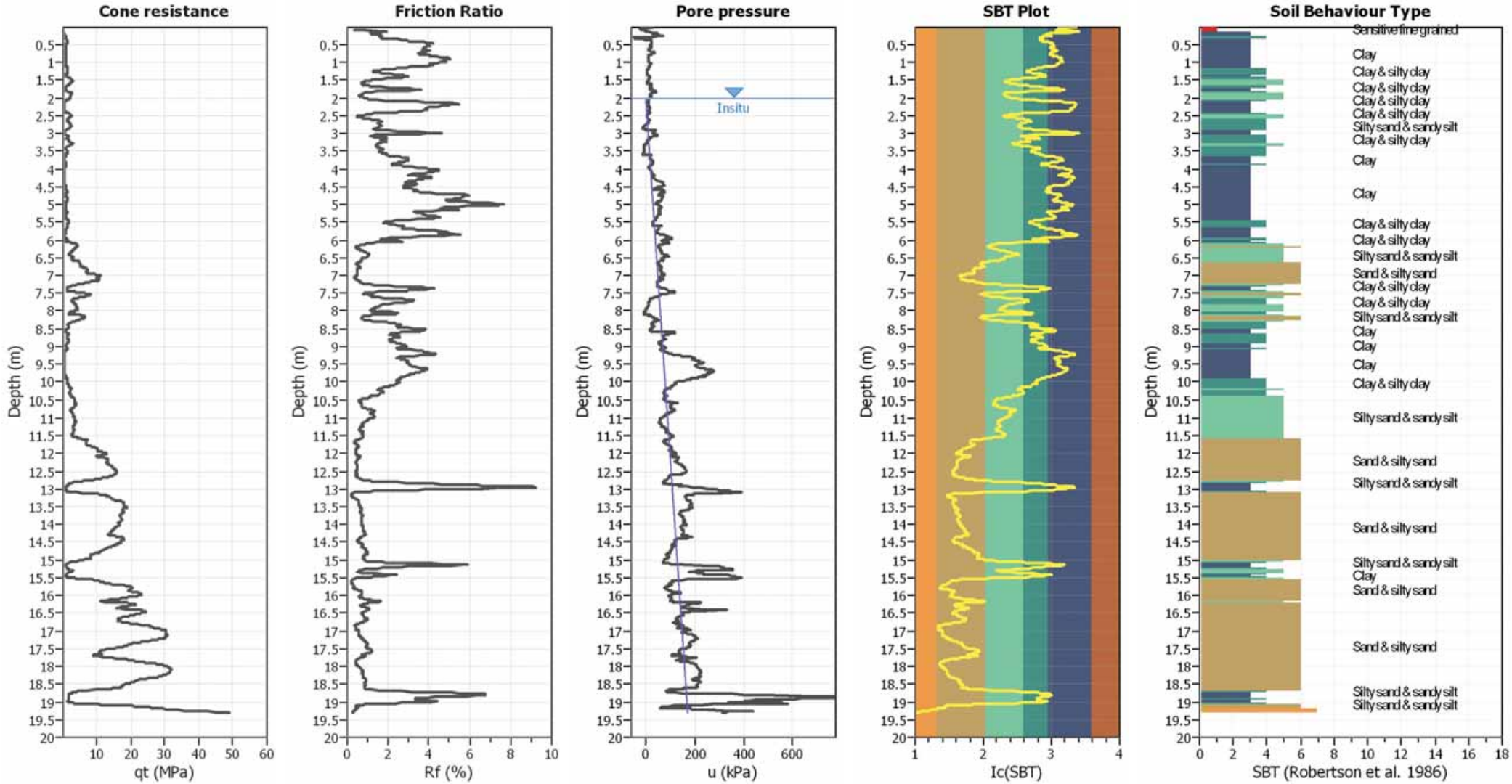
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots



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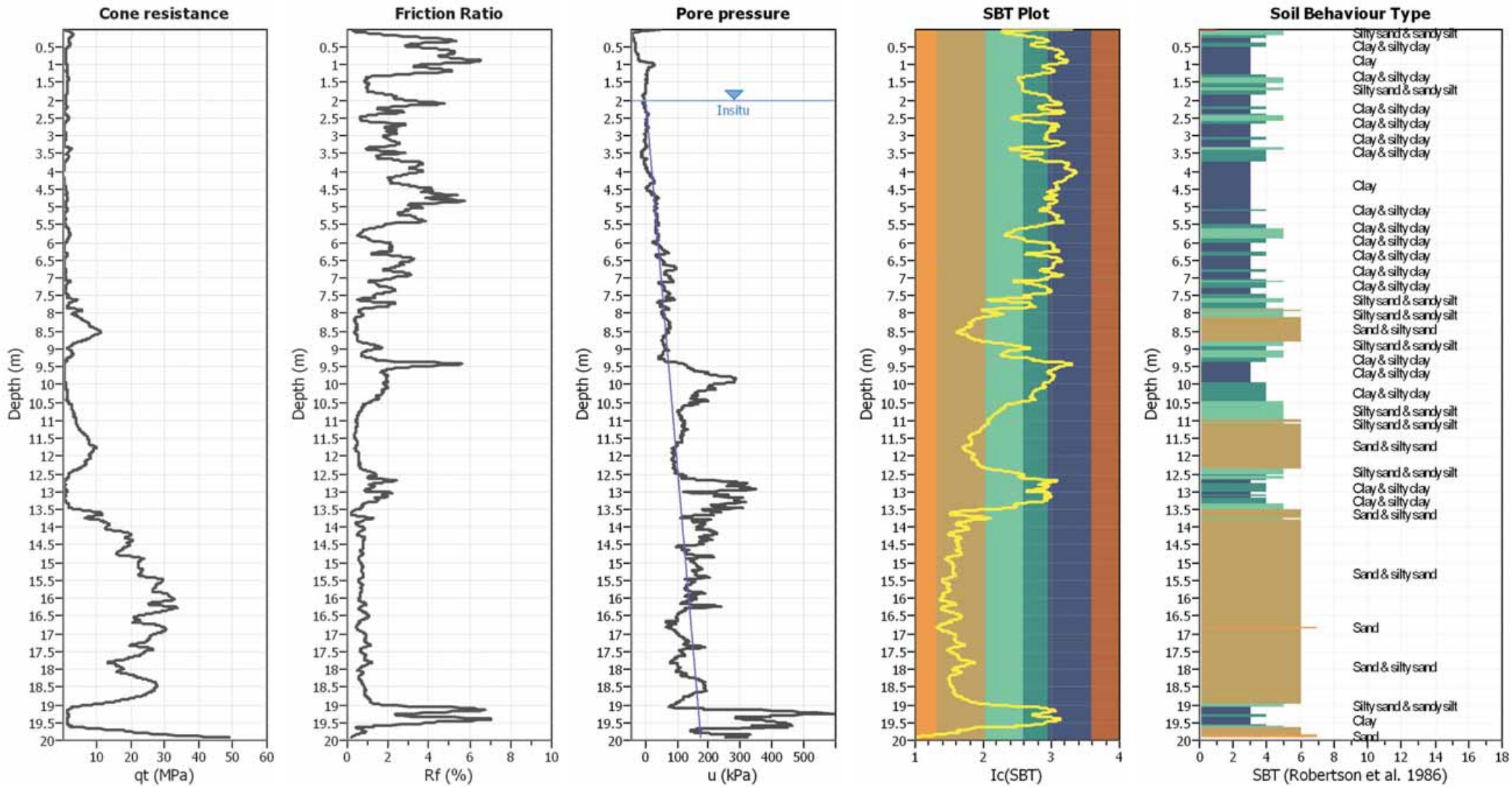
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots



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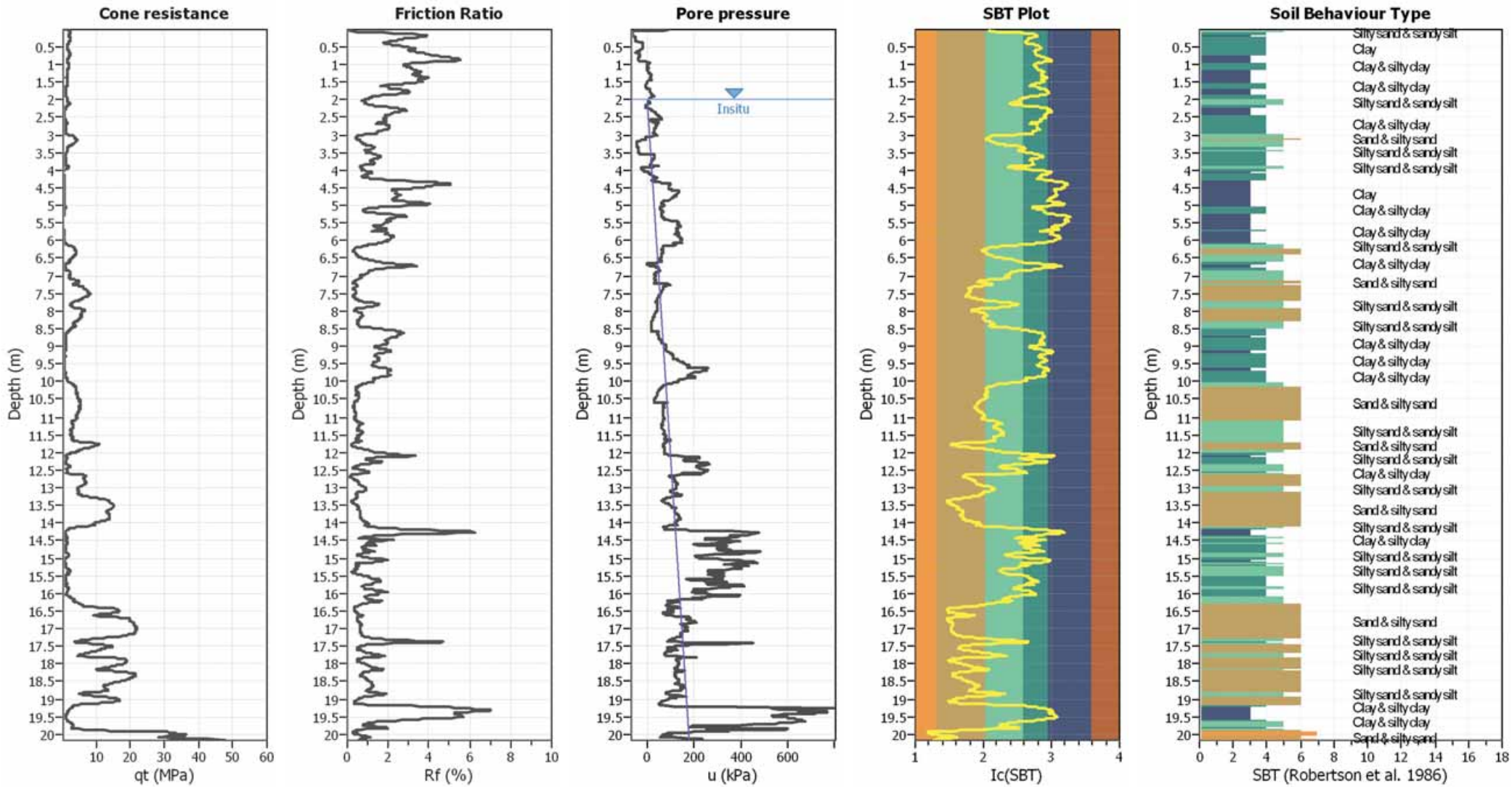
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots



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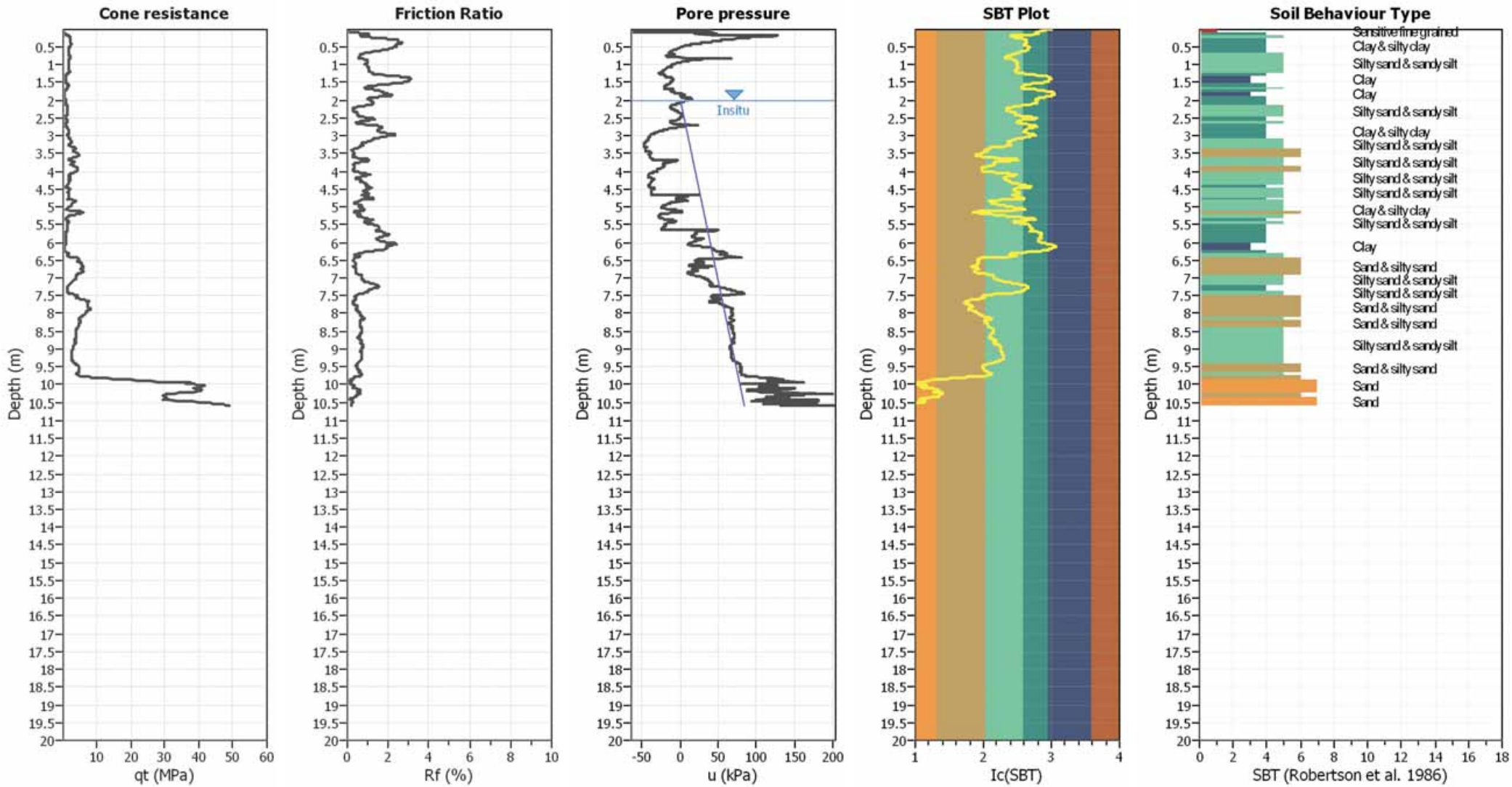
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots



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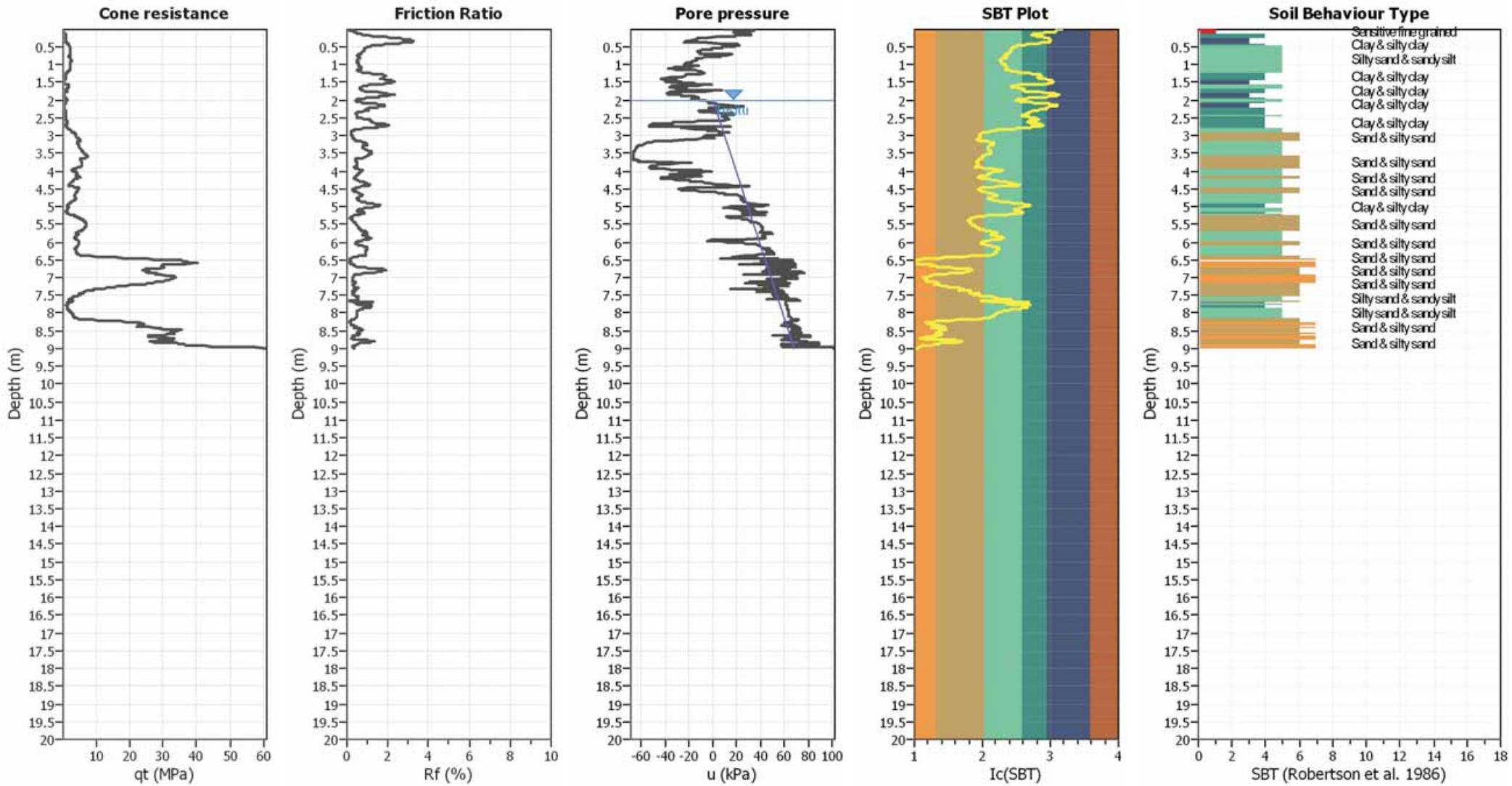
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots



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Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
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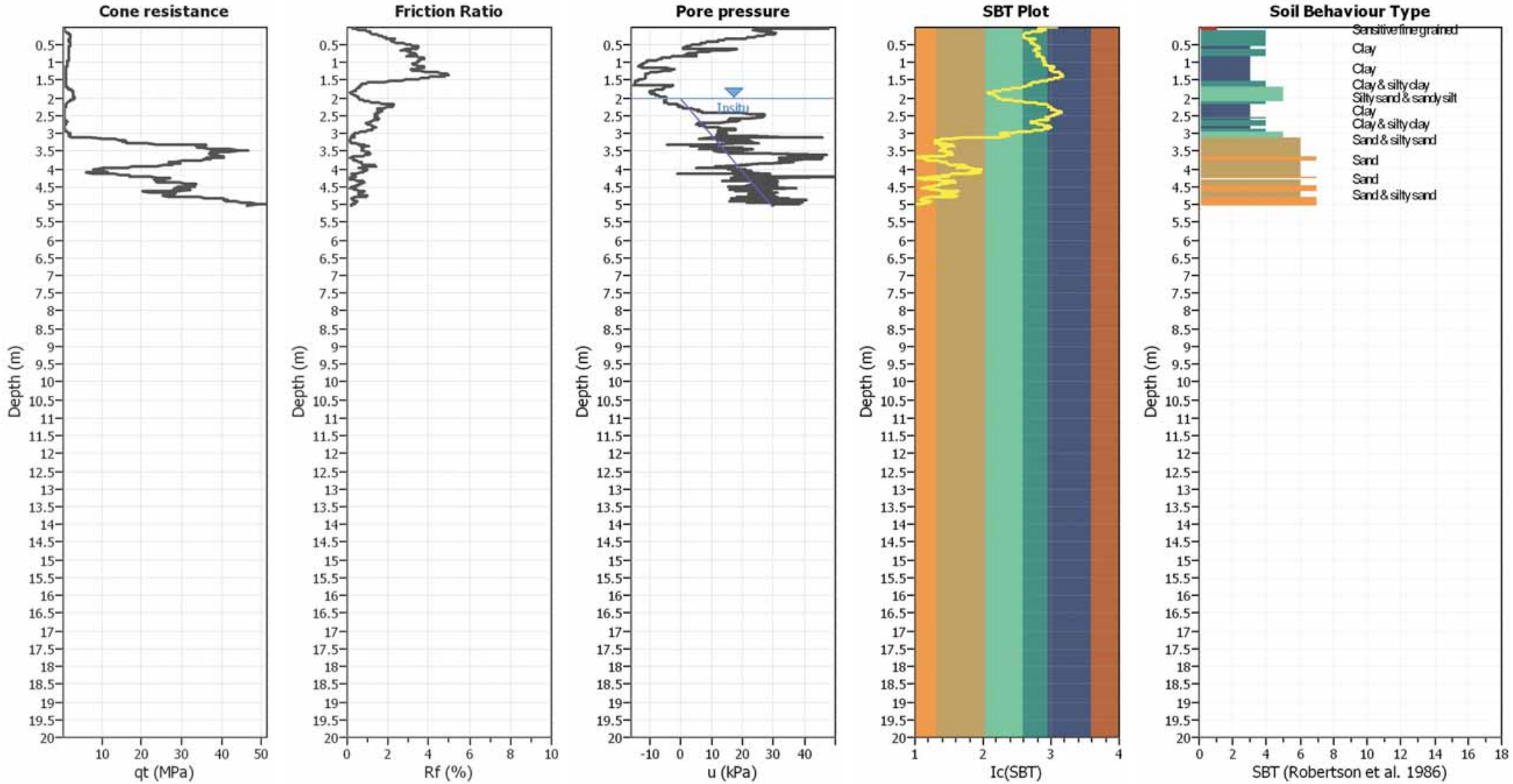
CPT basic interpretation plots



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SBT legend

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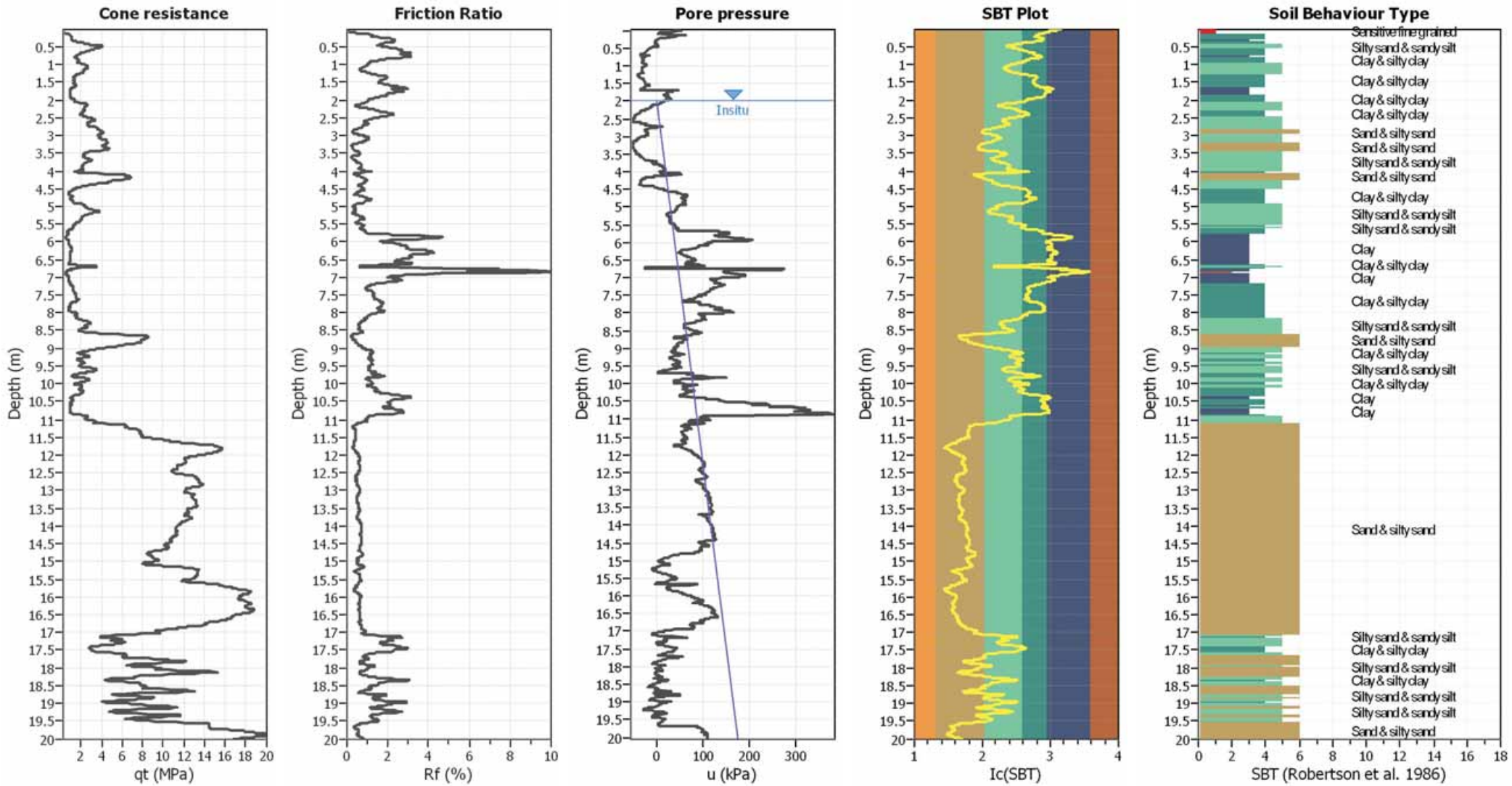
9. Very stiff fine grained

CPT basic interpretation plots



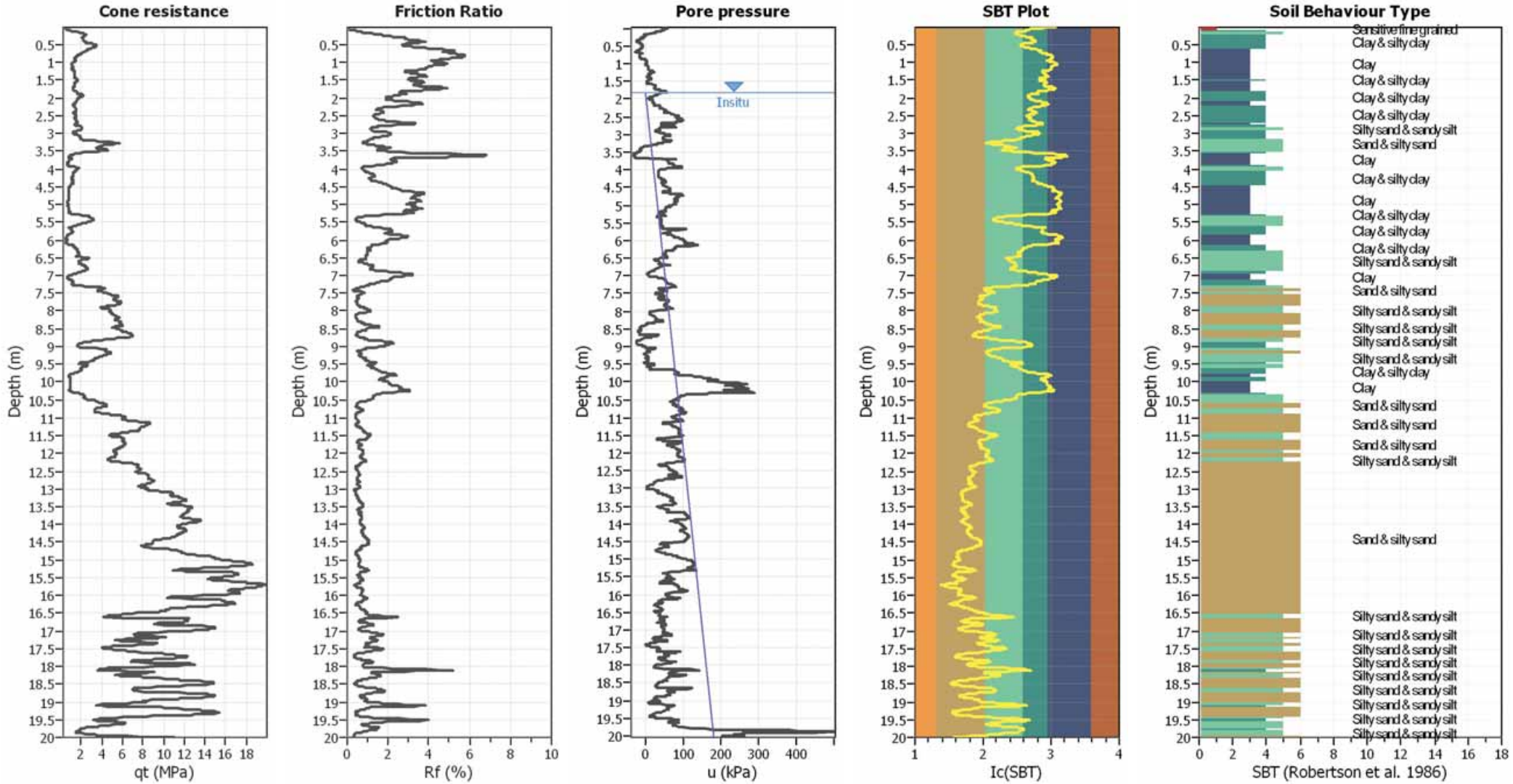
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



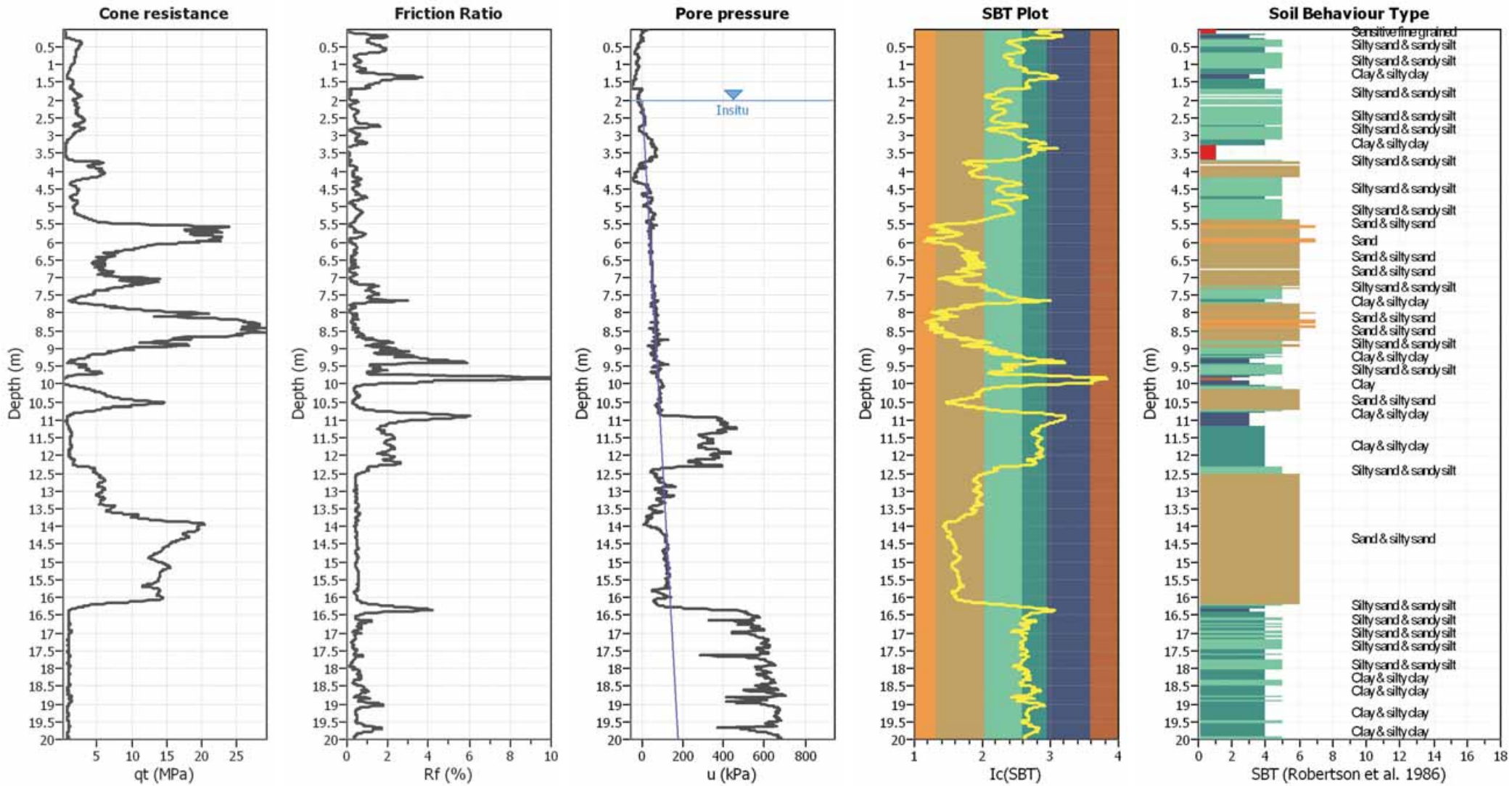
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.80 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



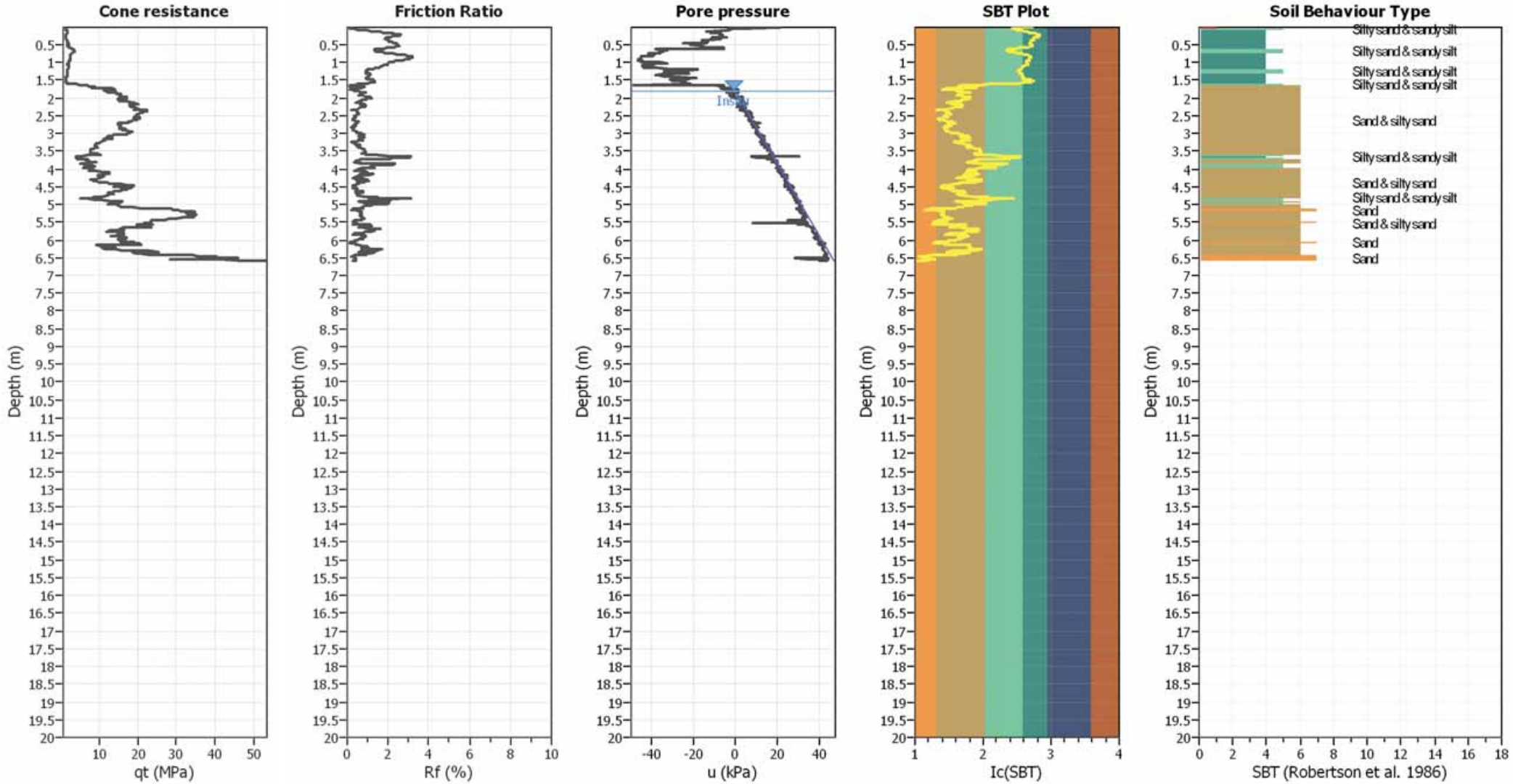
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



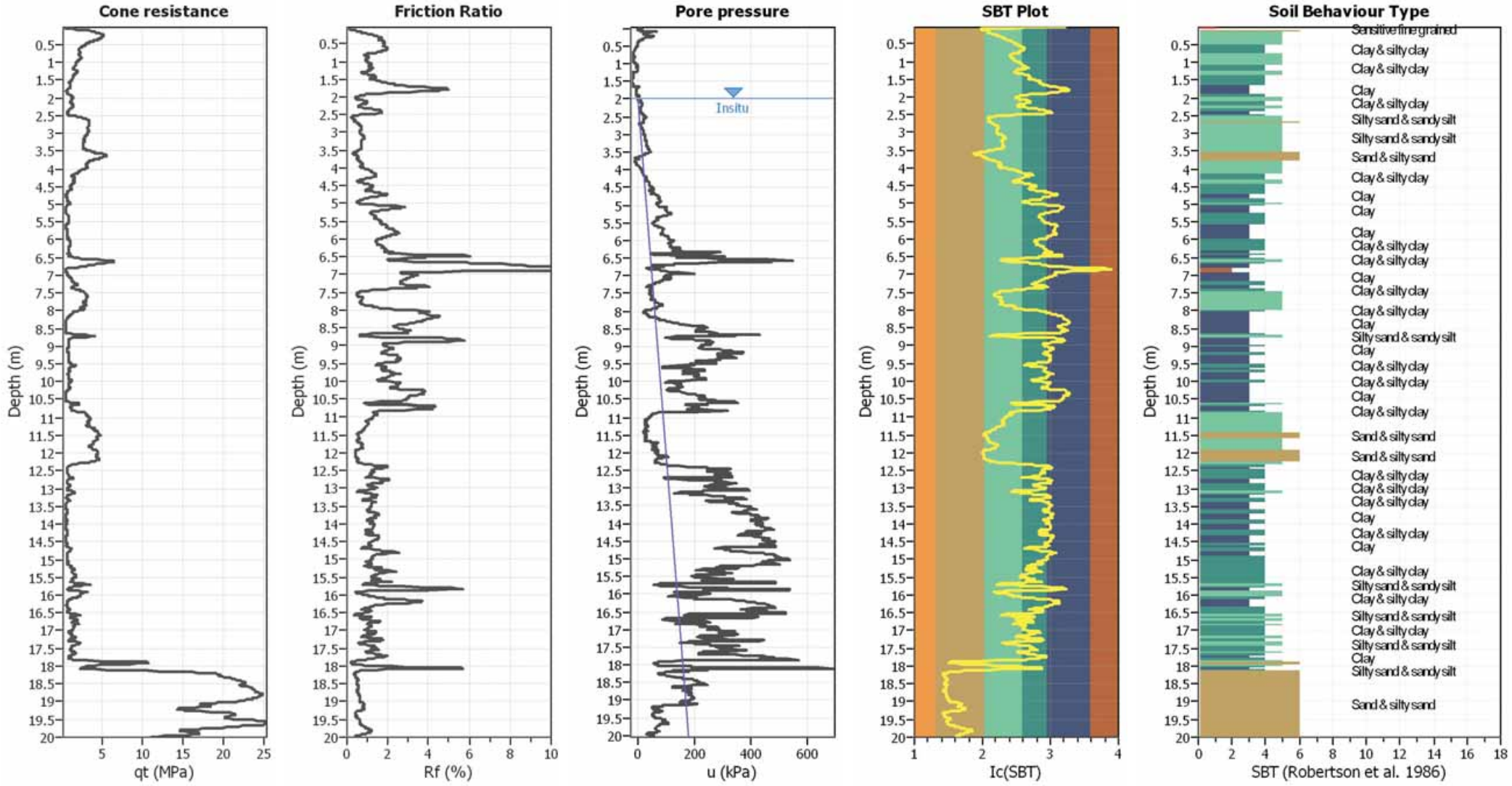
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.80 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



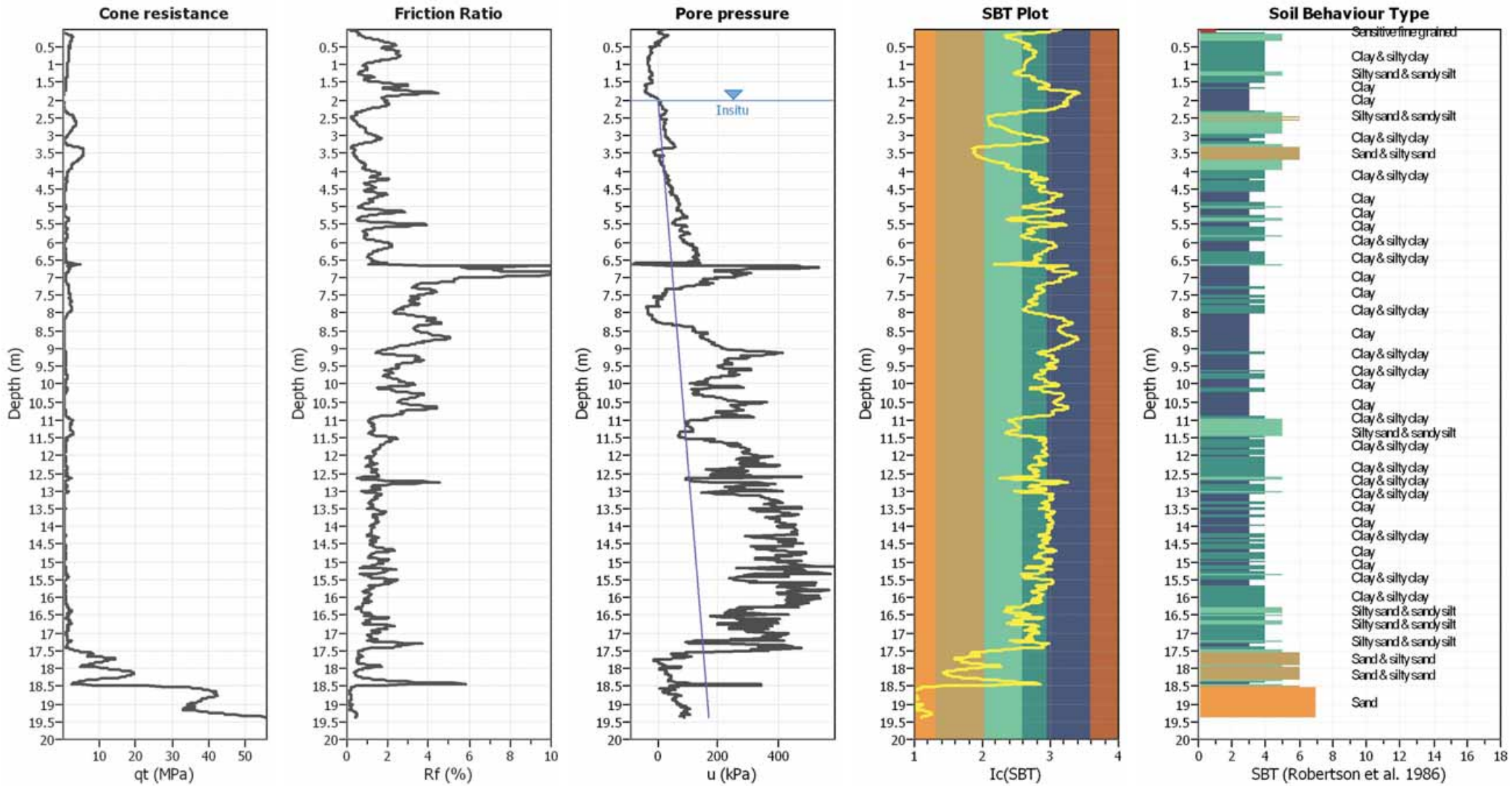
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



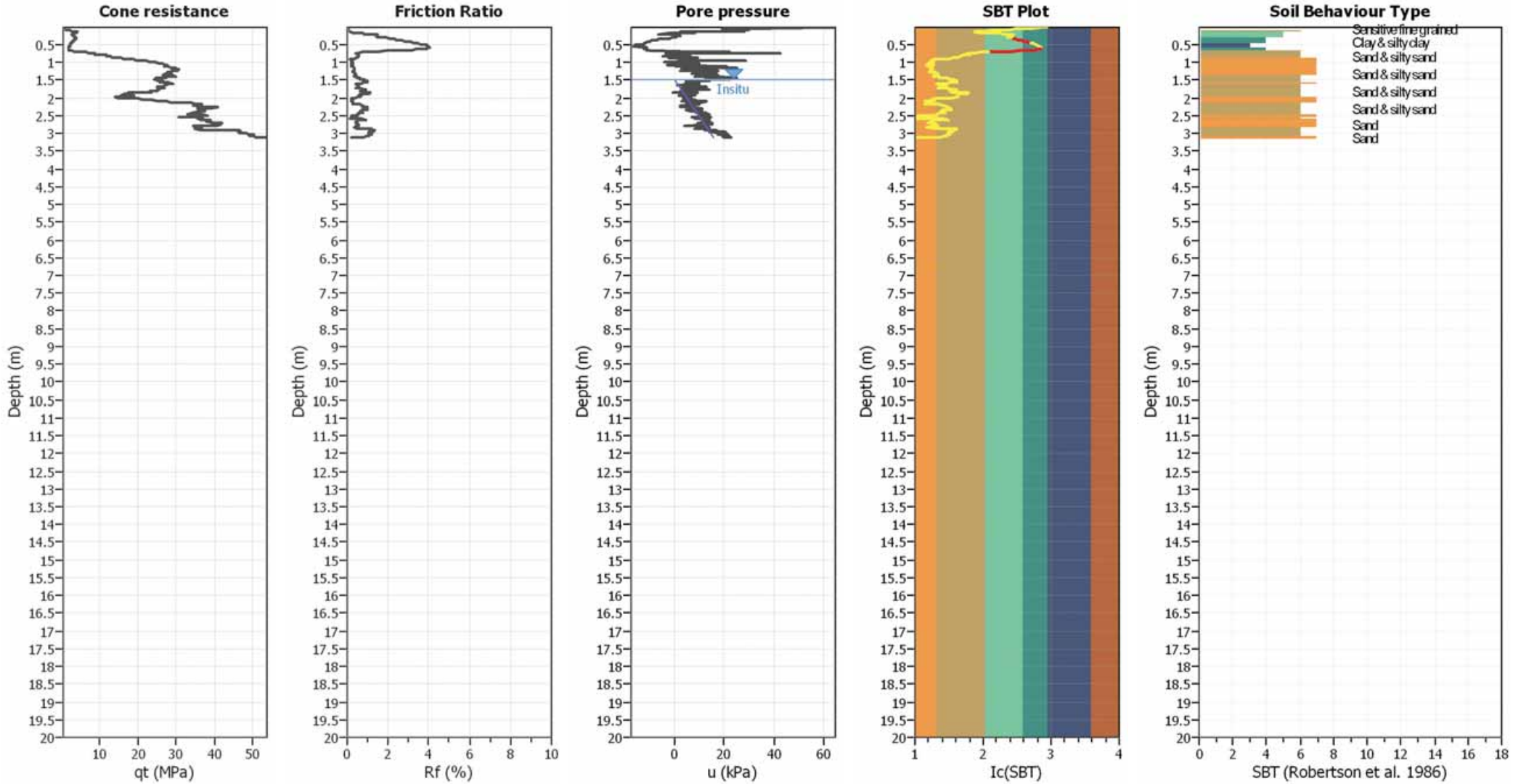
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



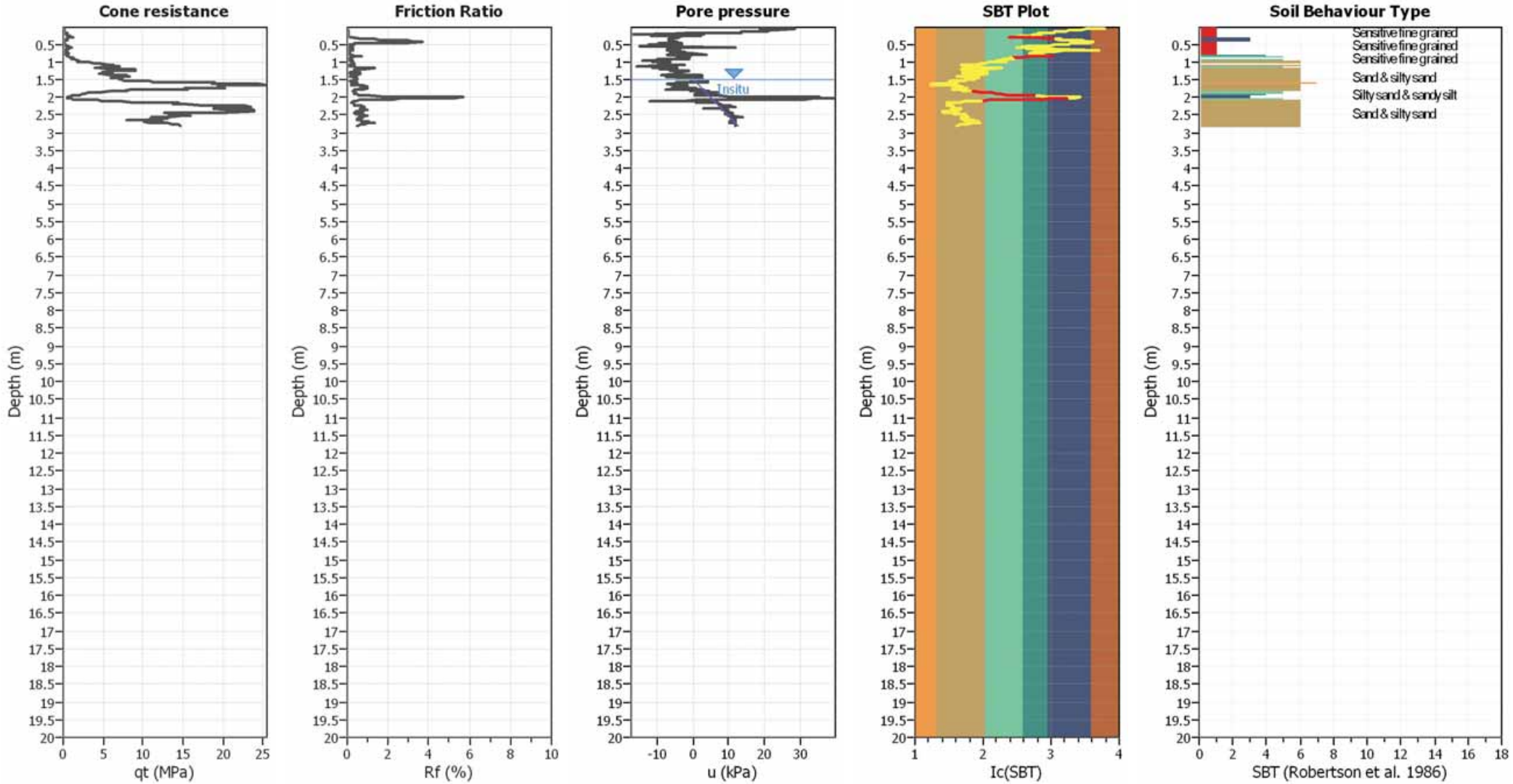
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



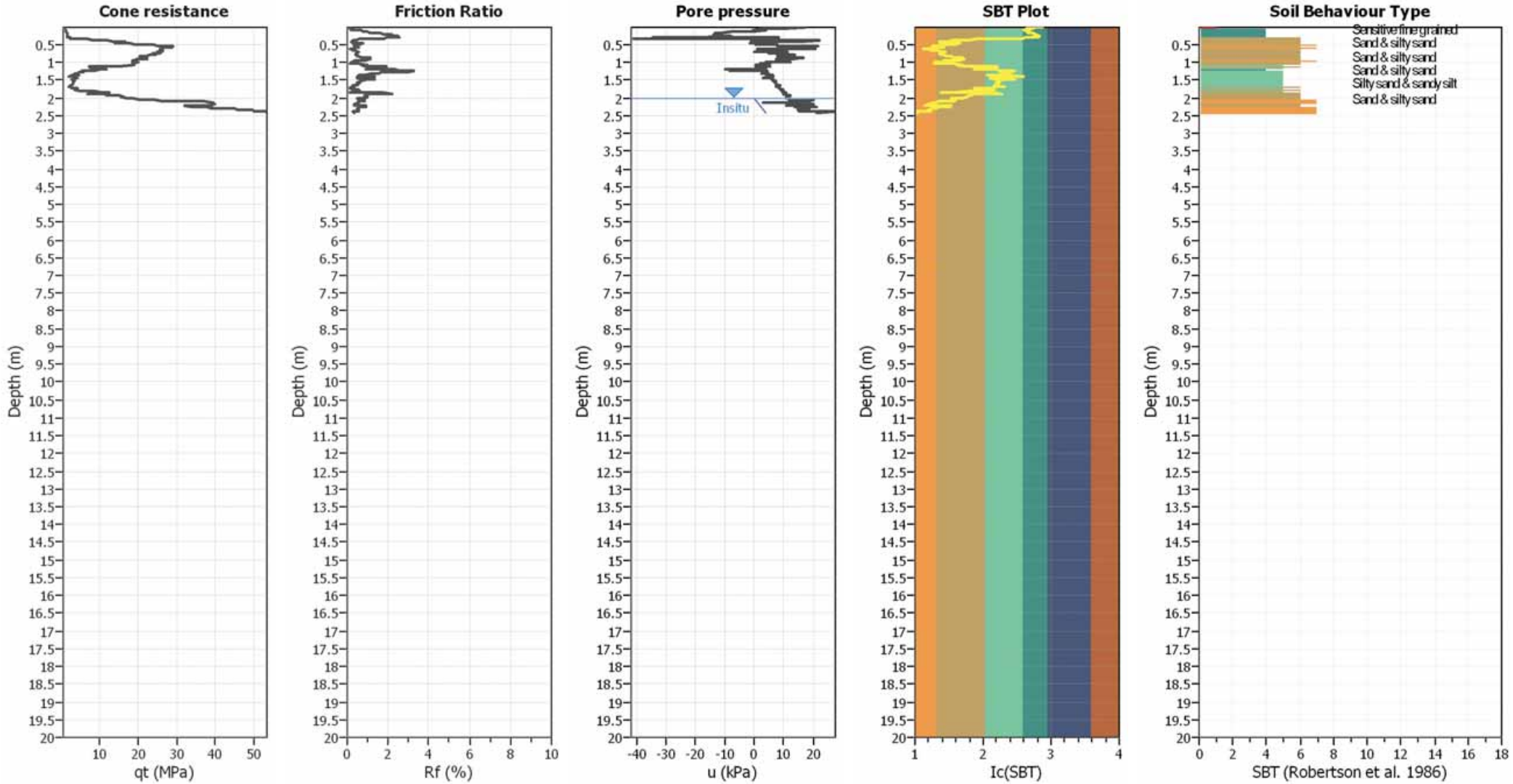
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



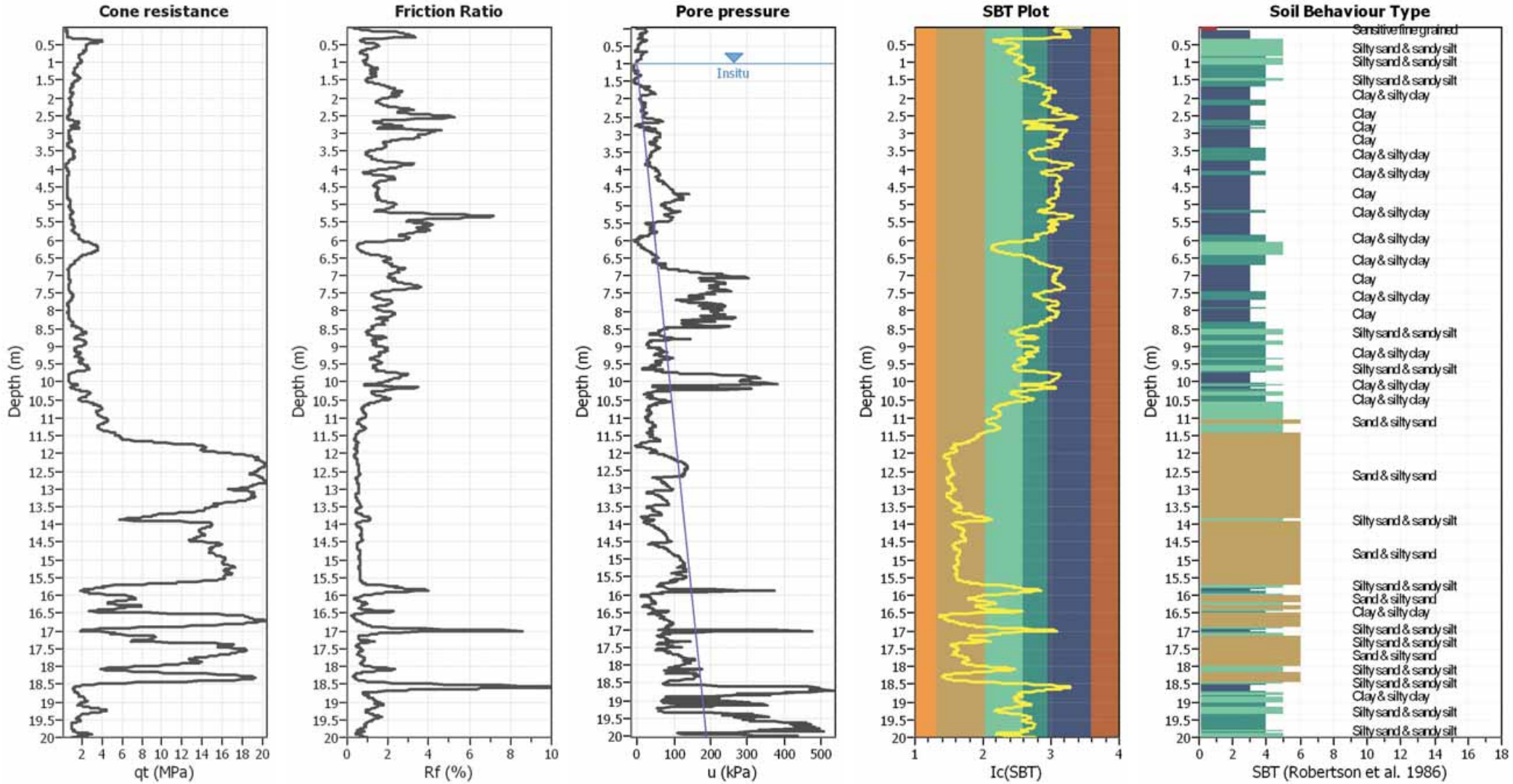
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



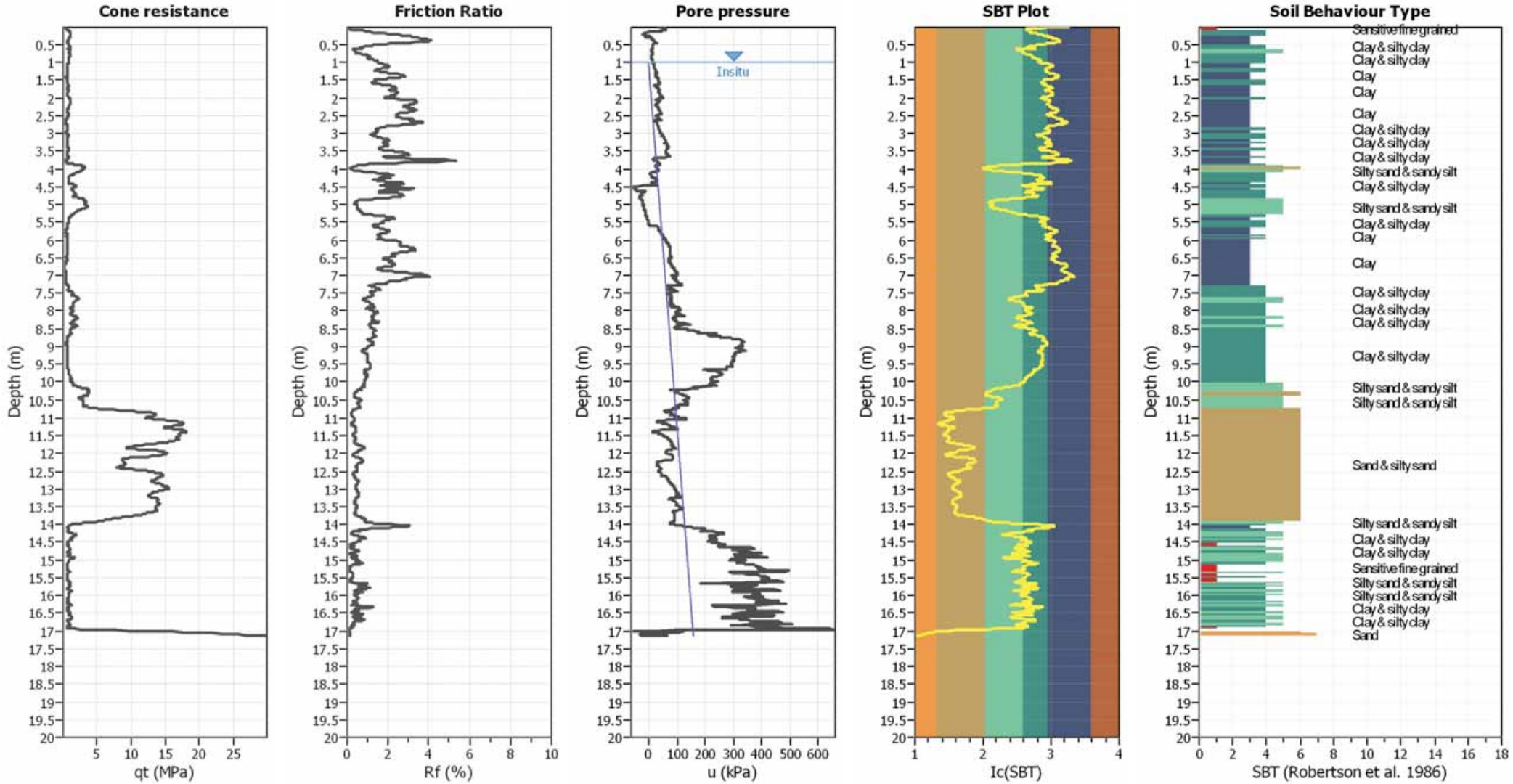
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



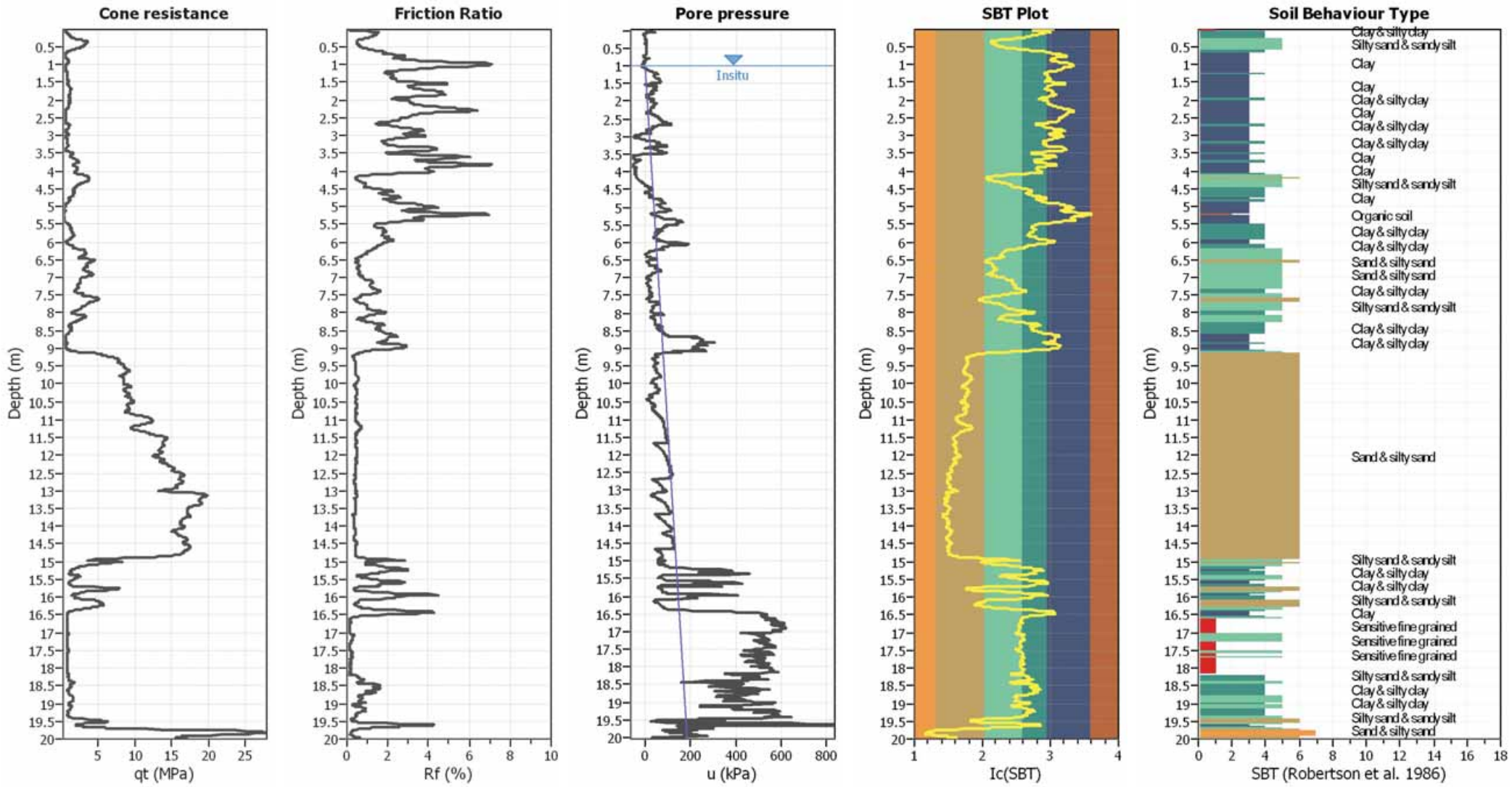
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



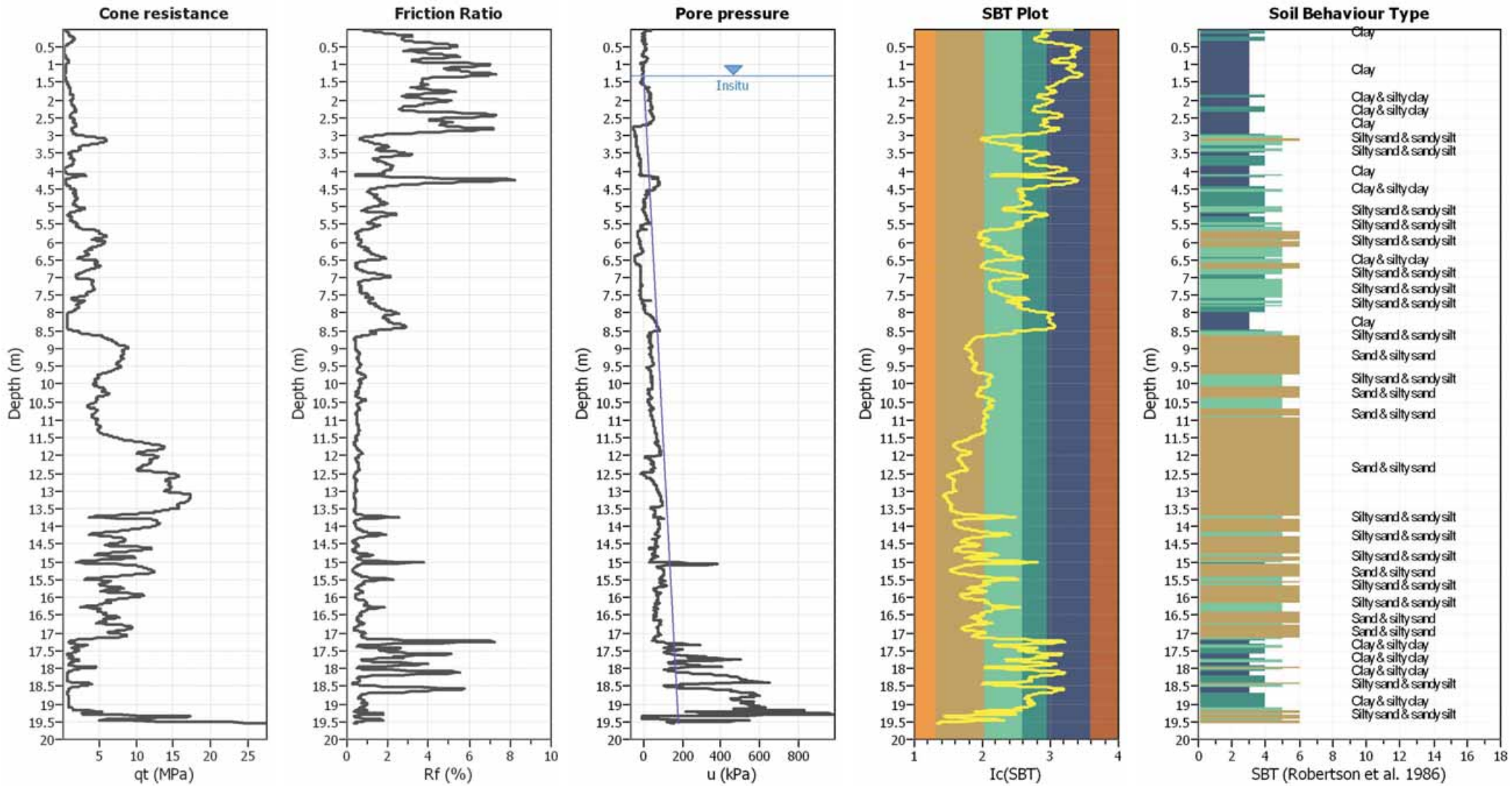
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



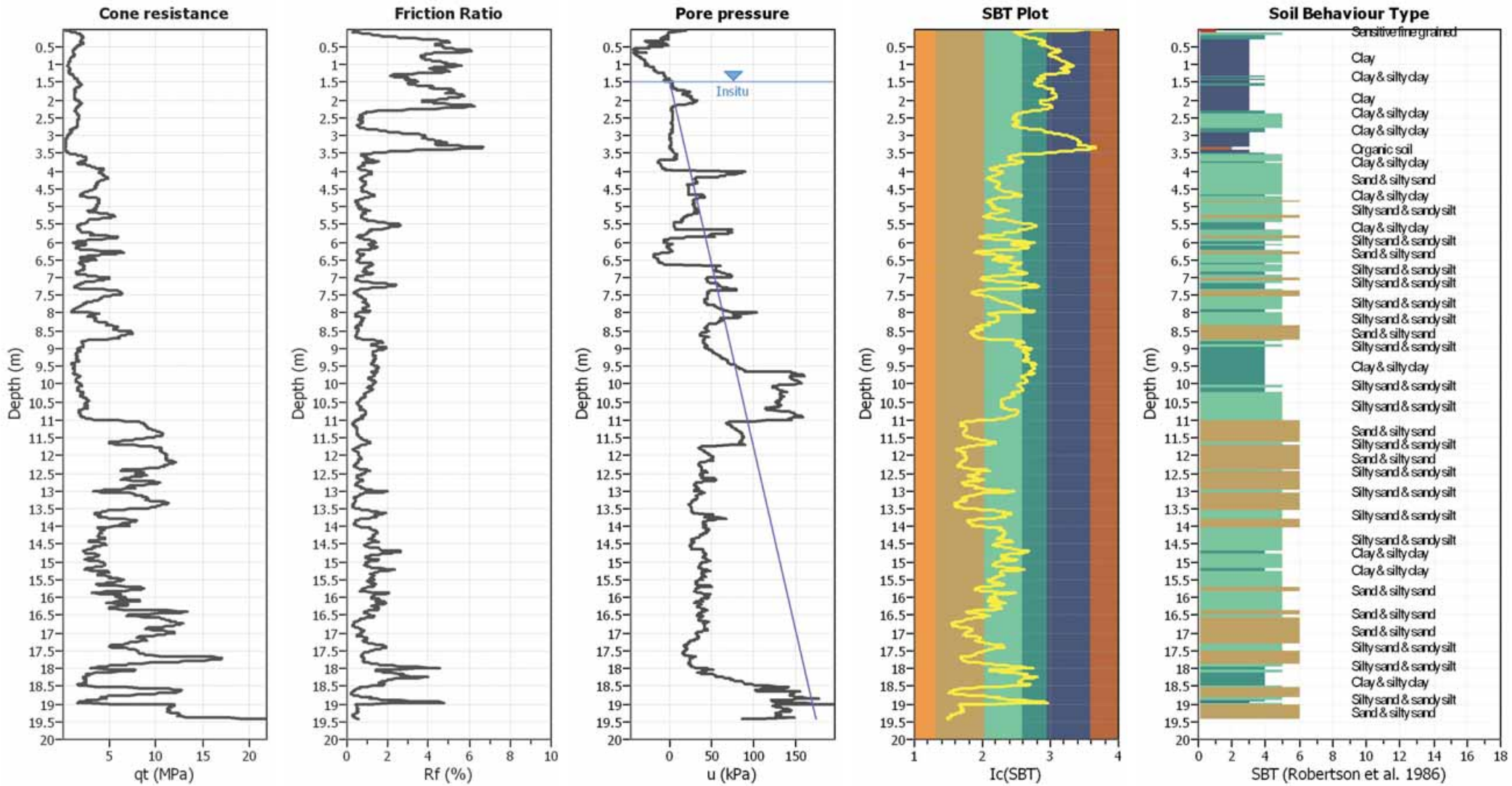
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.30 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



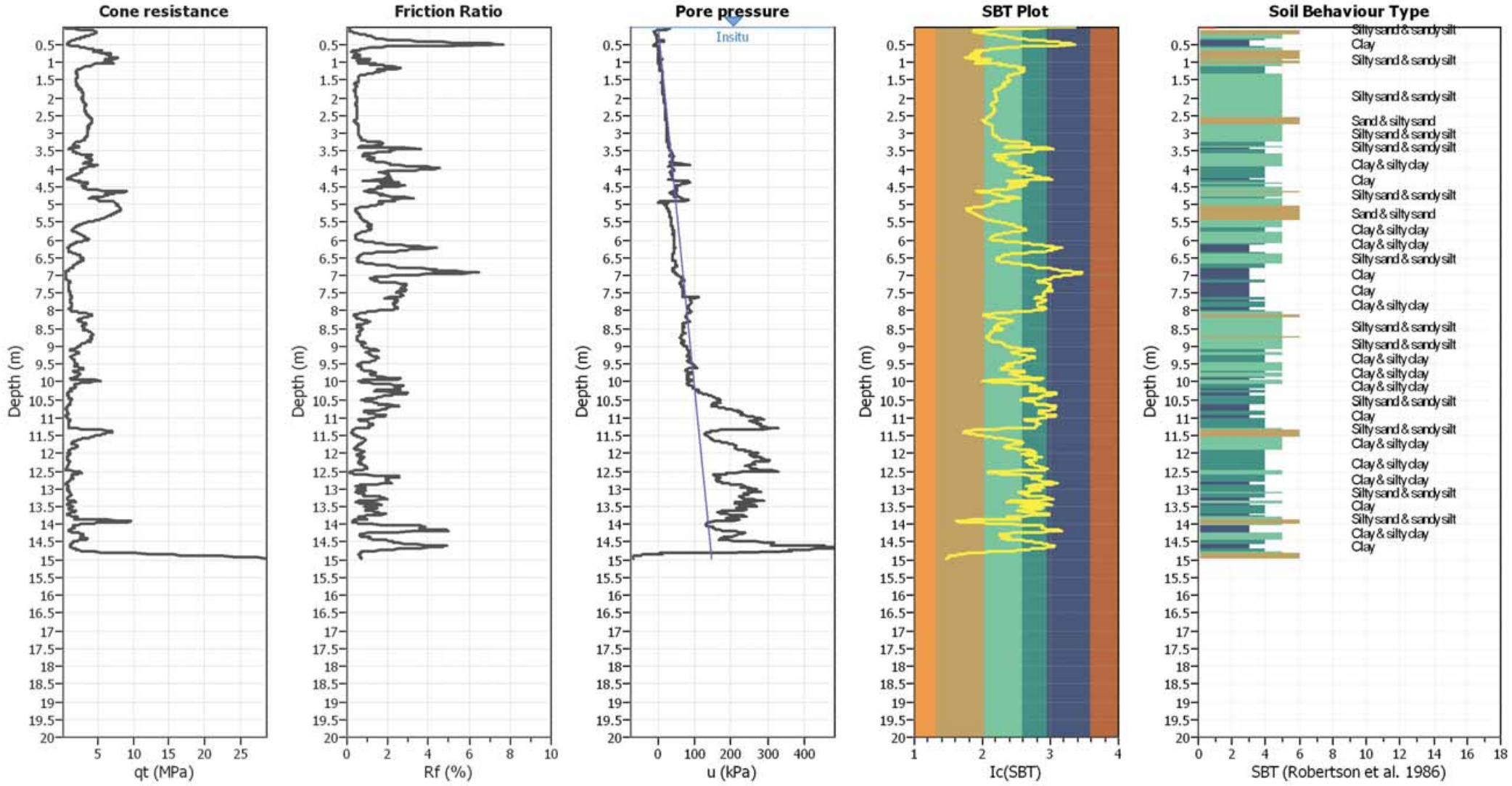
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



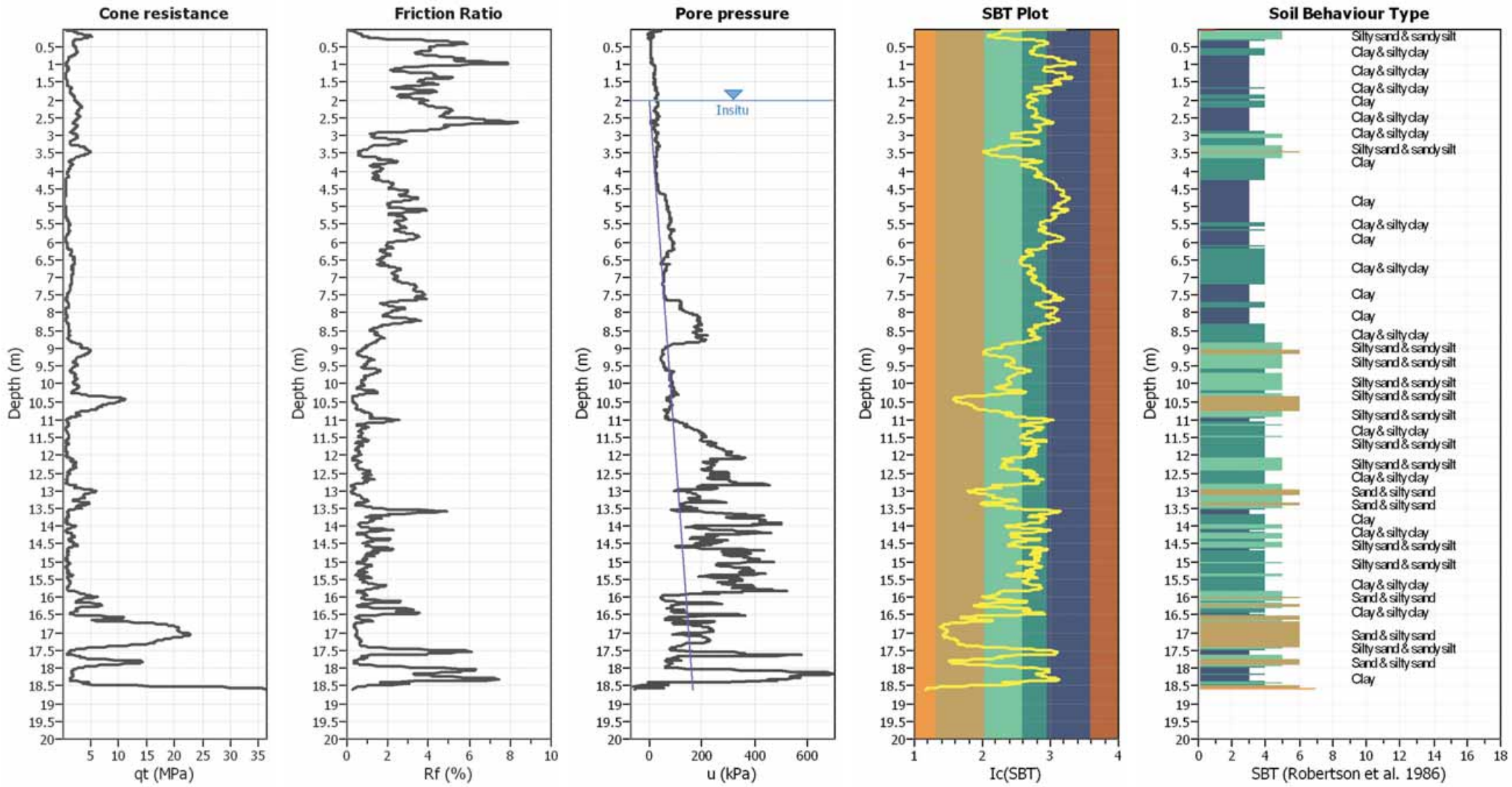
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	0.00 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



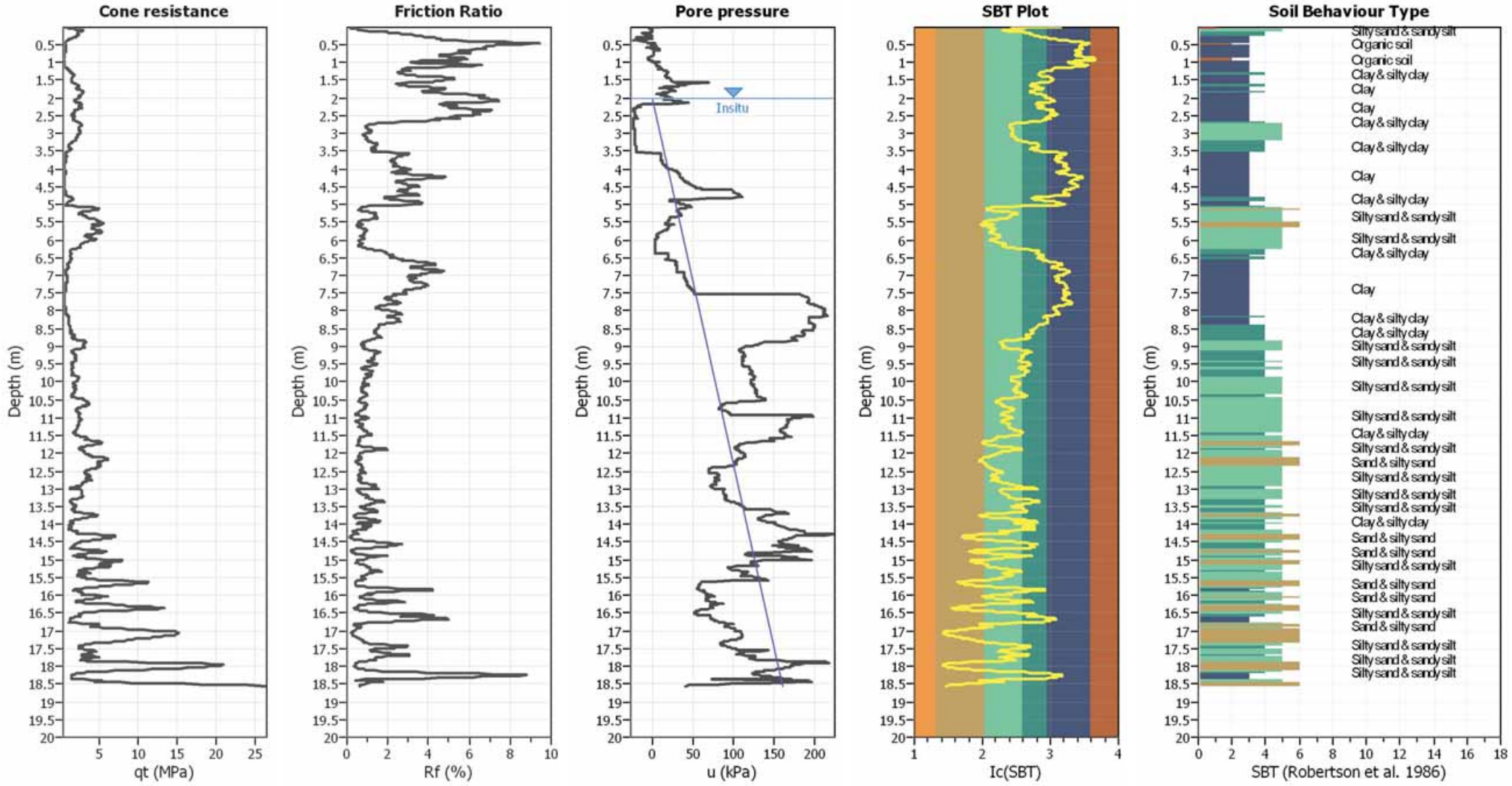
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



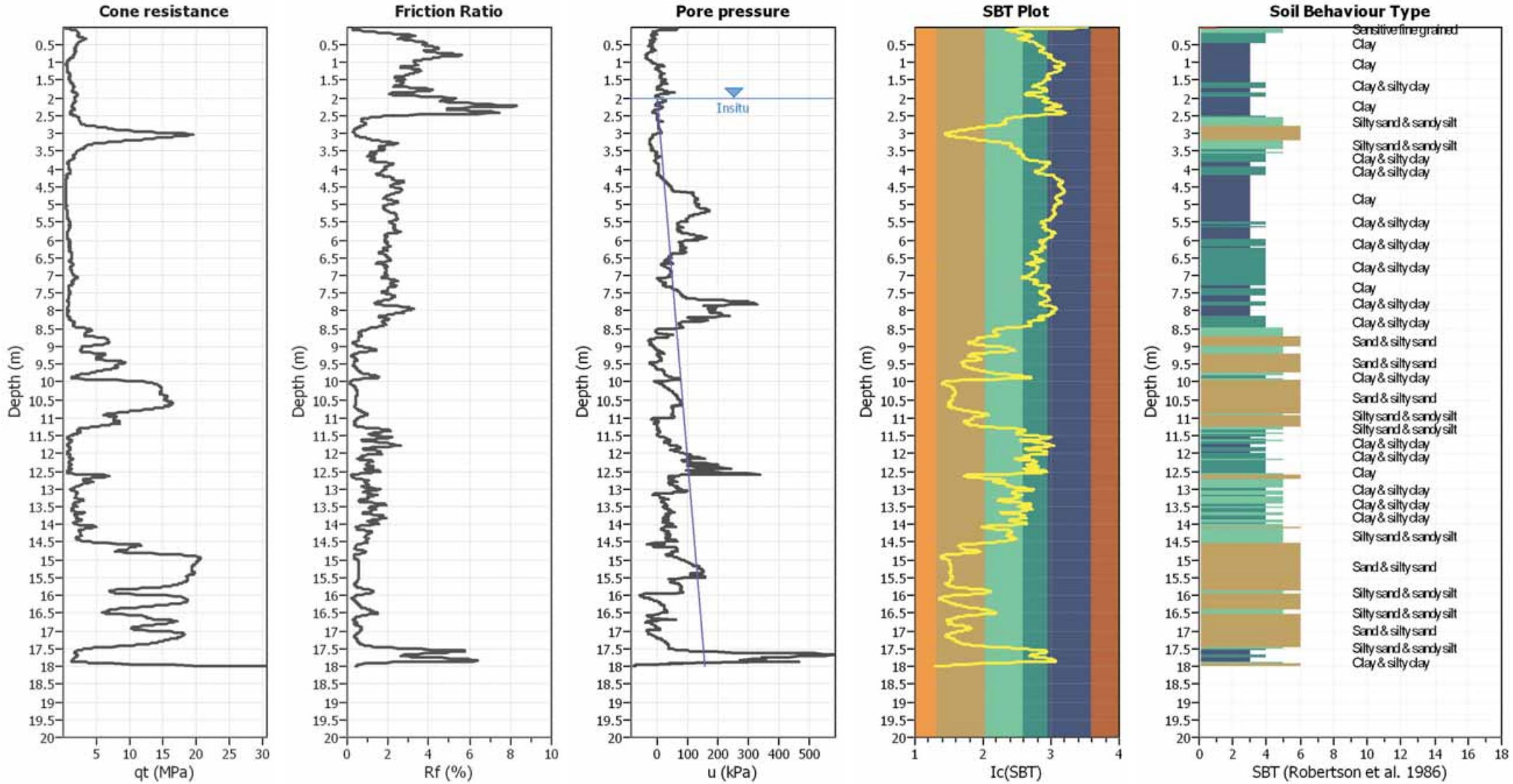
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



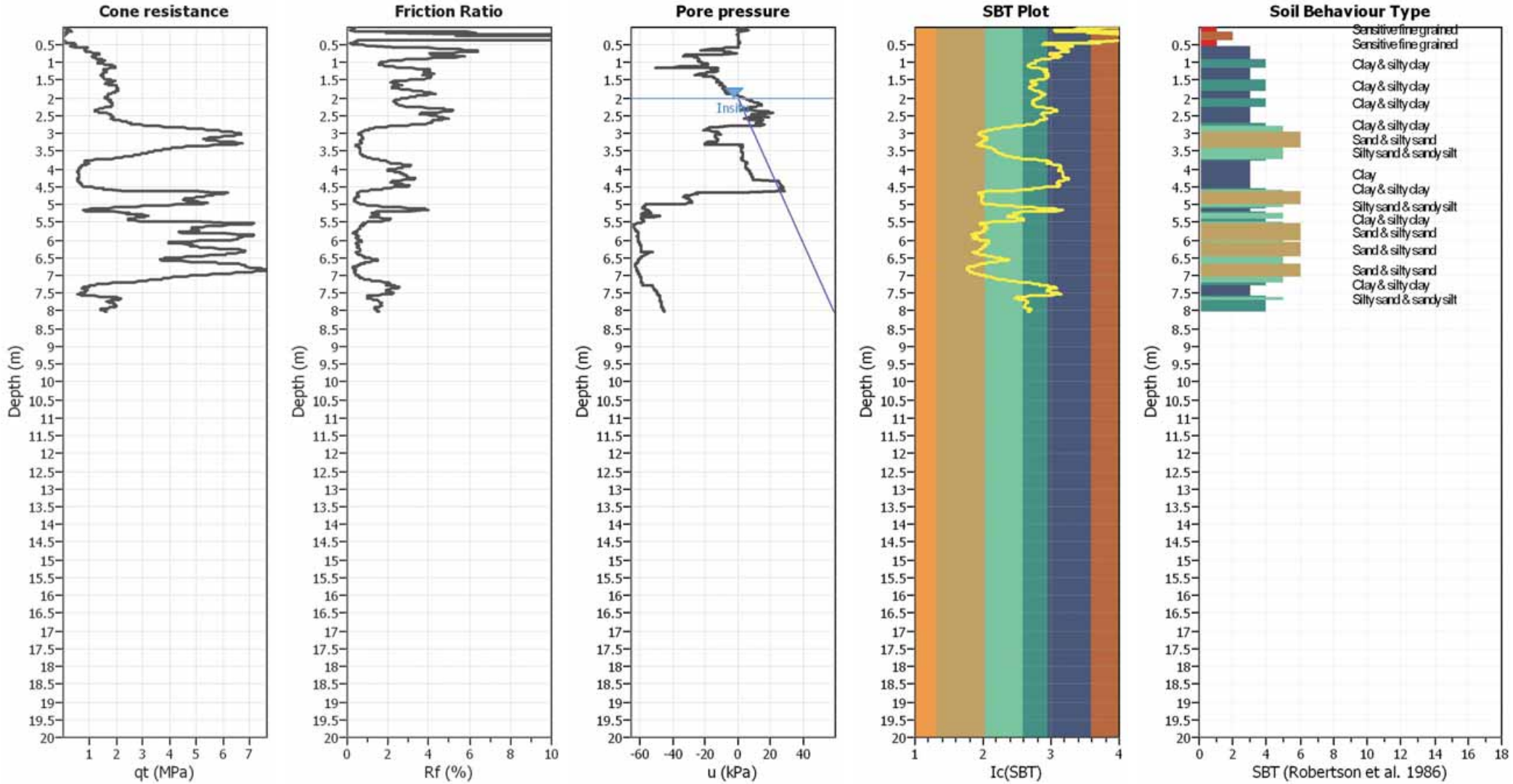
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



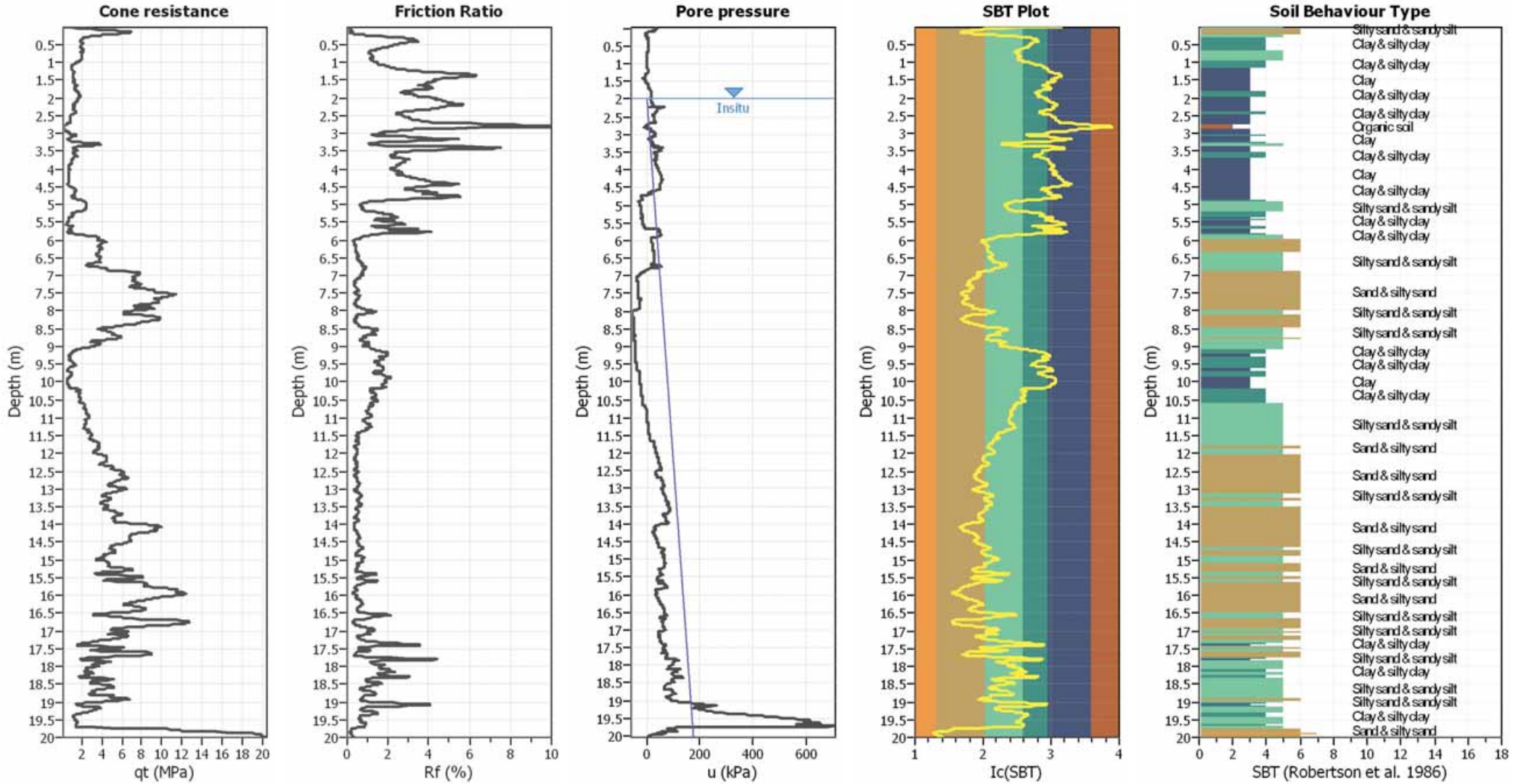
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



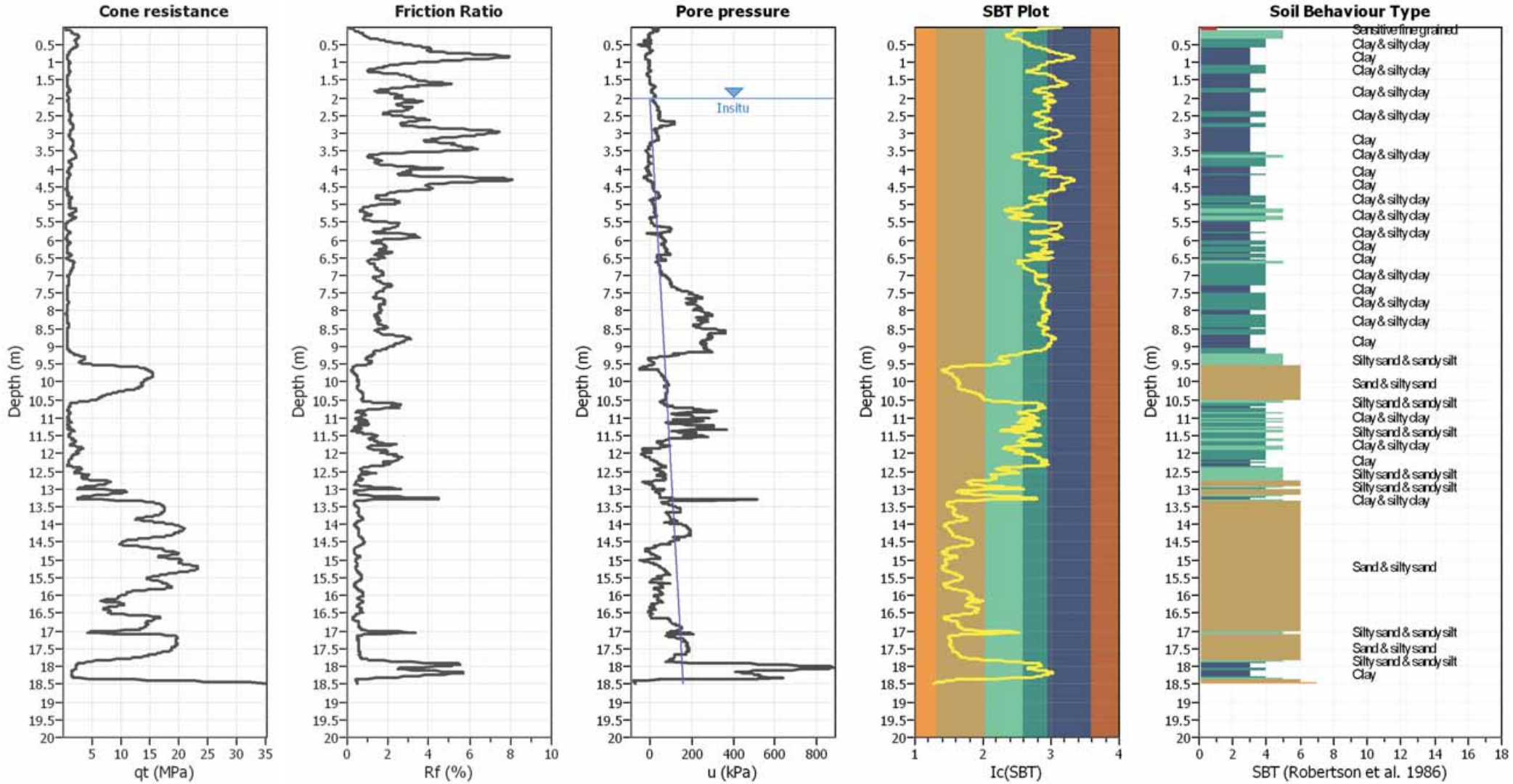
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



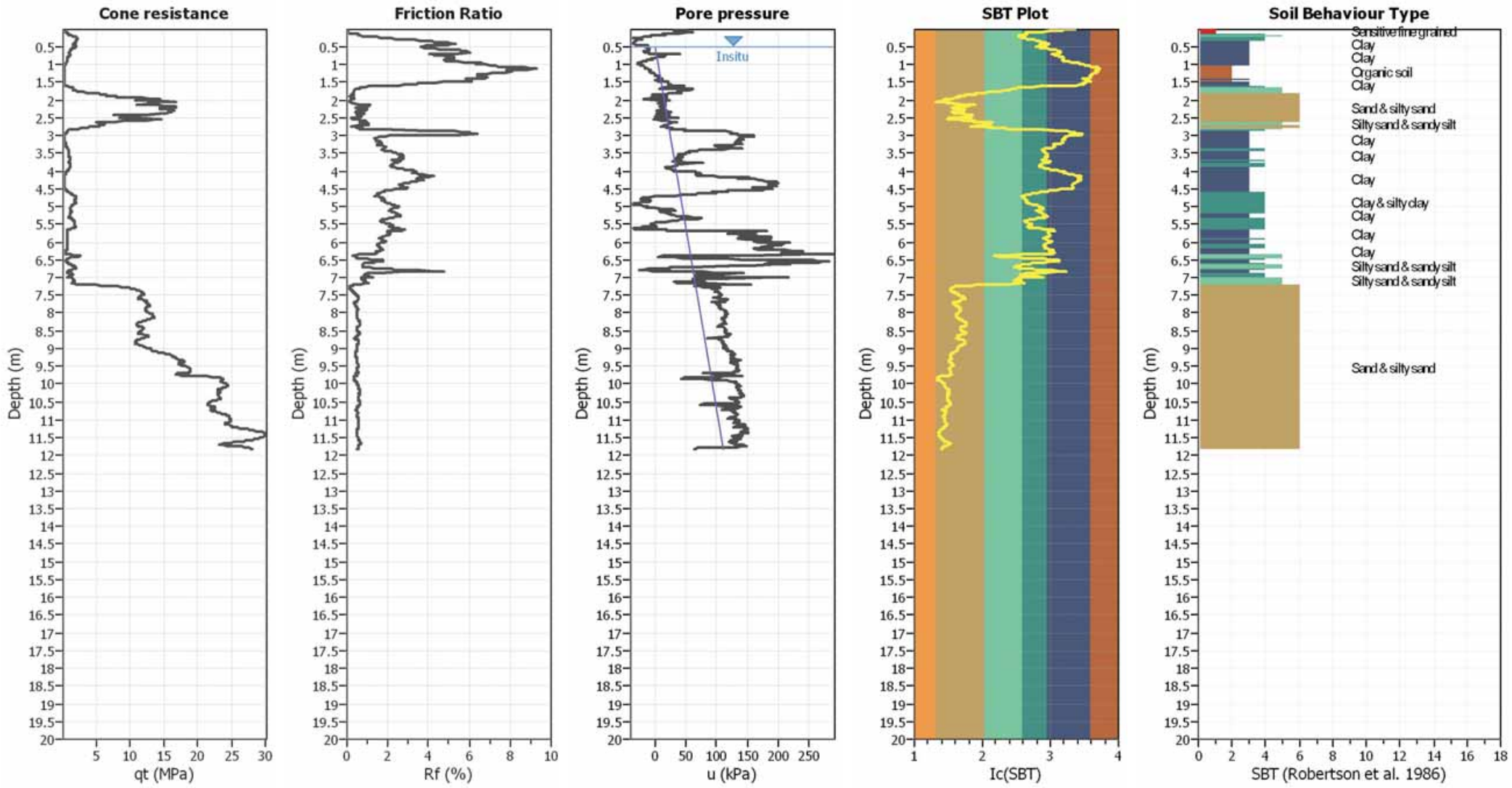
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



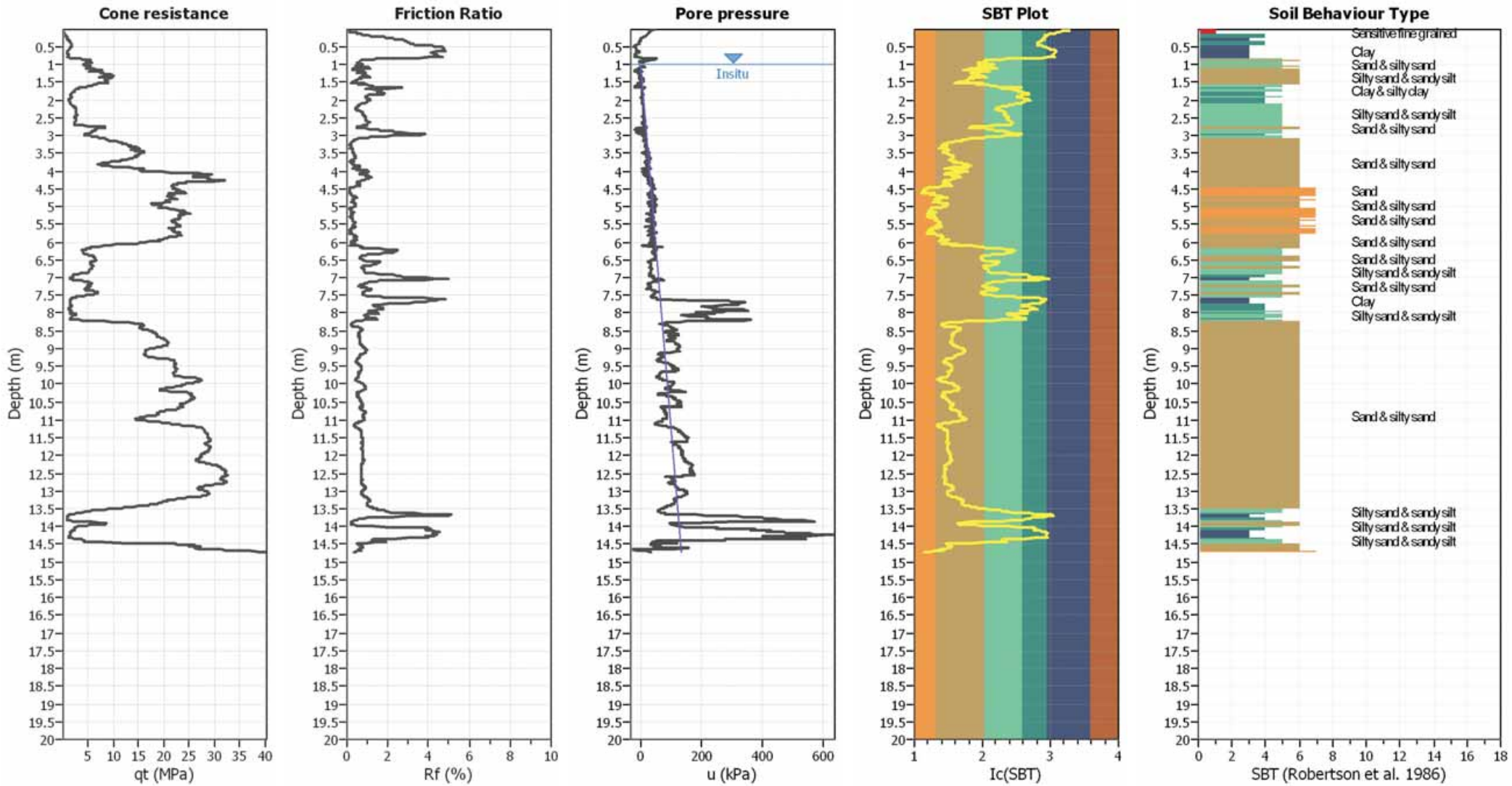
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	0.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



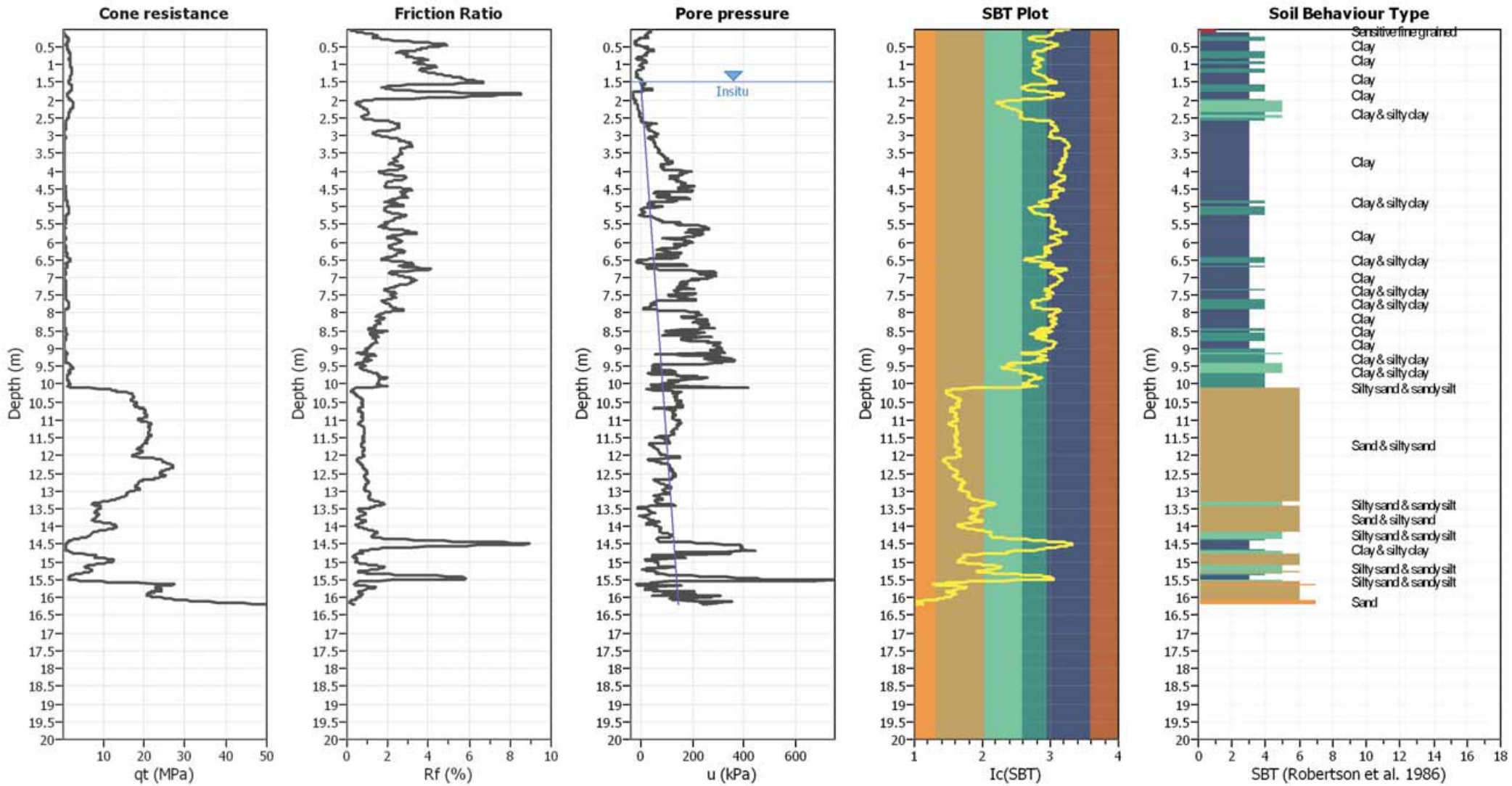
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



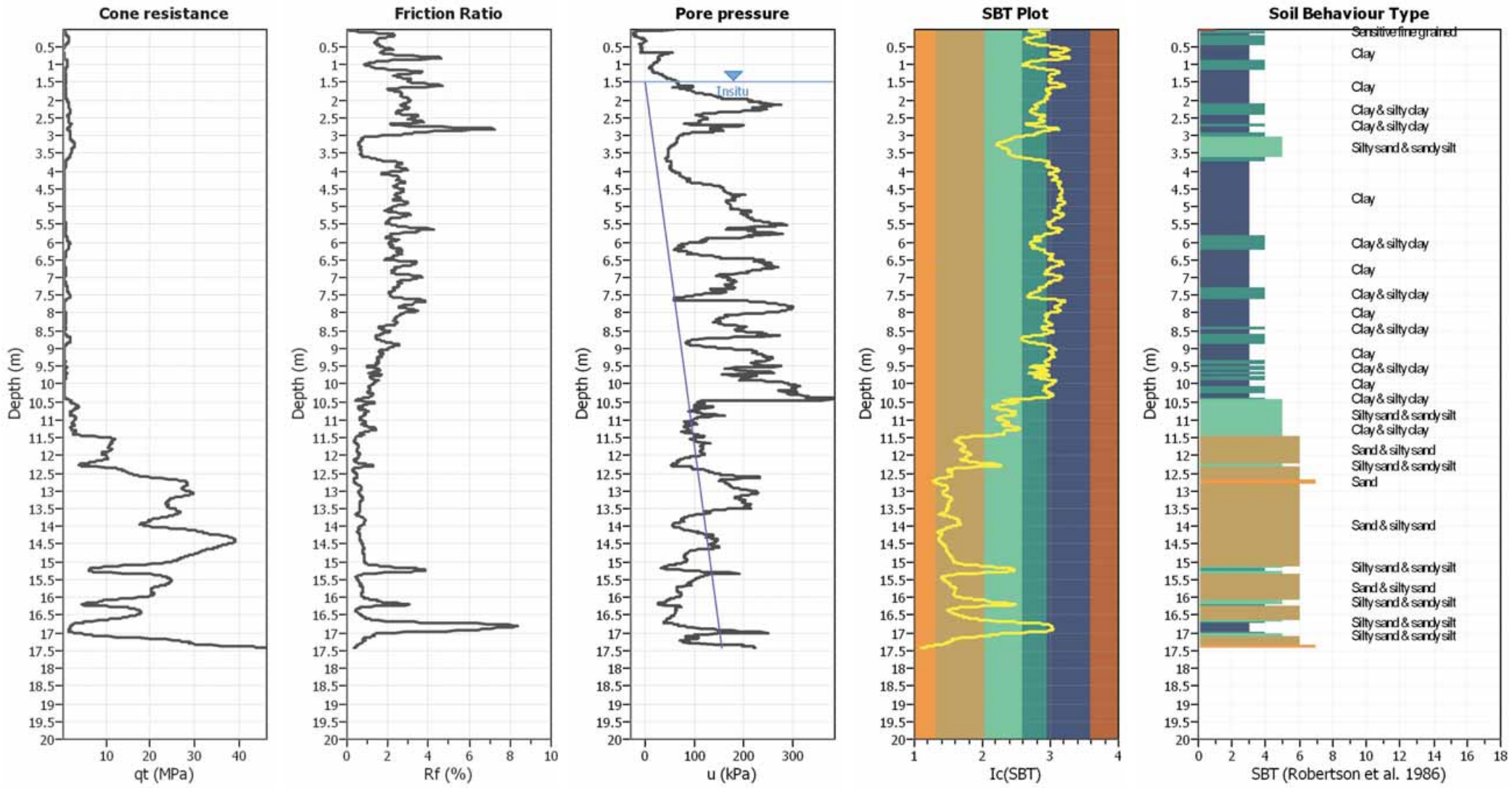
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



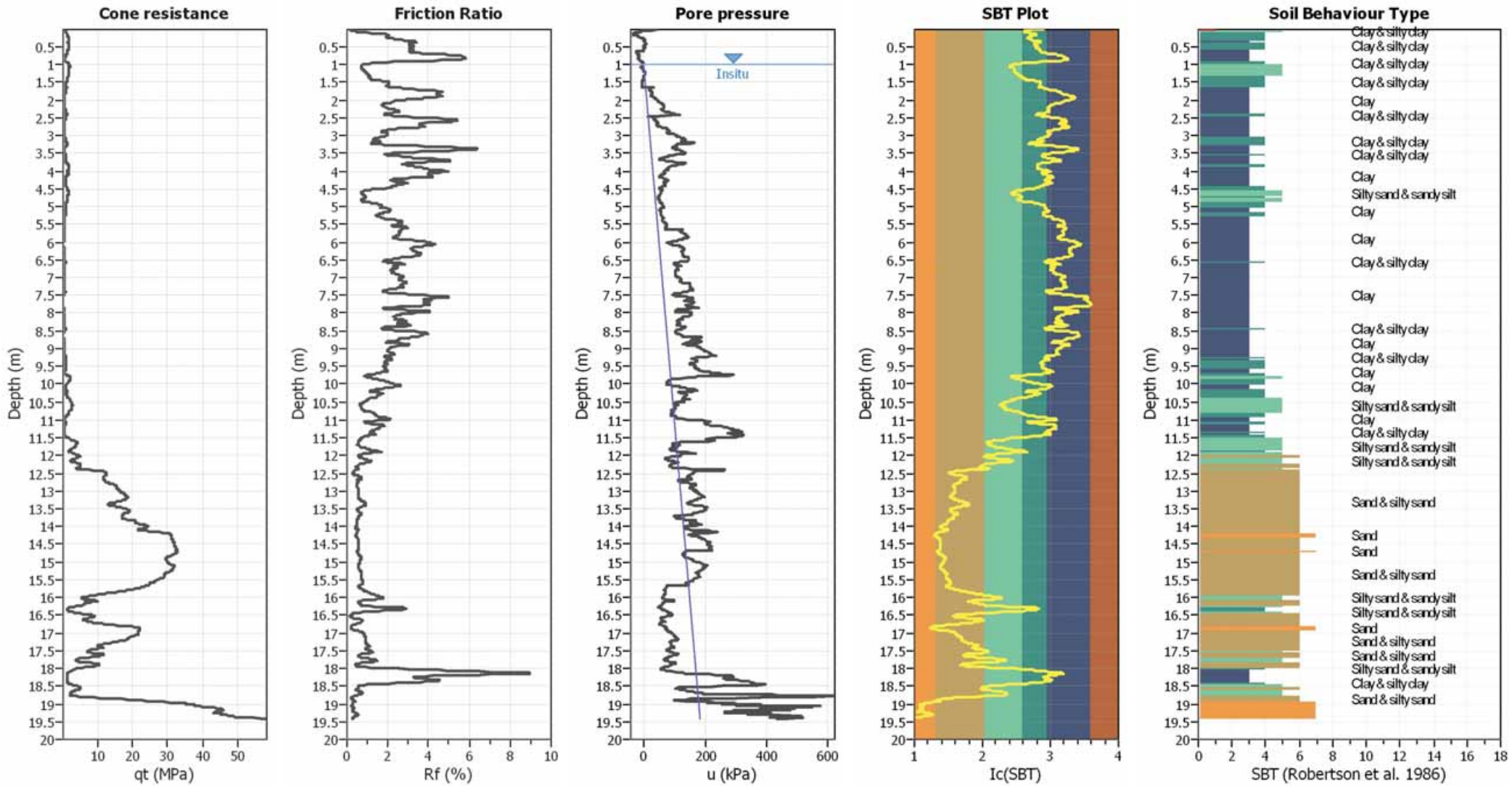
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



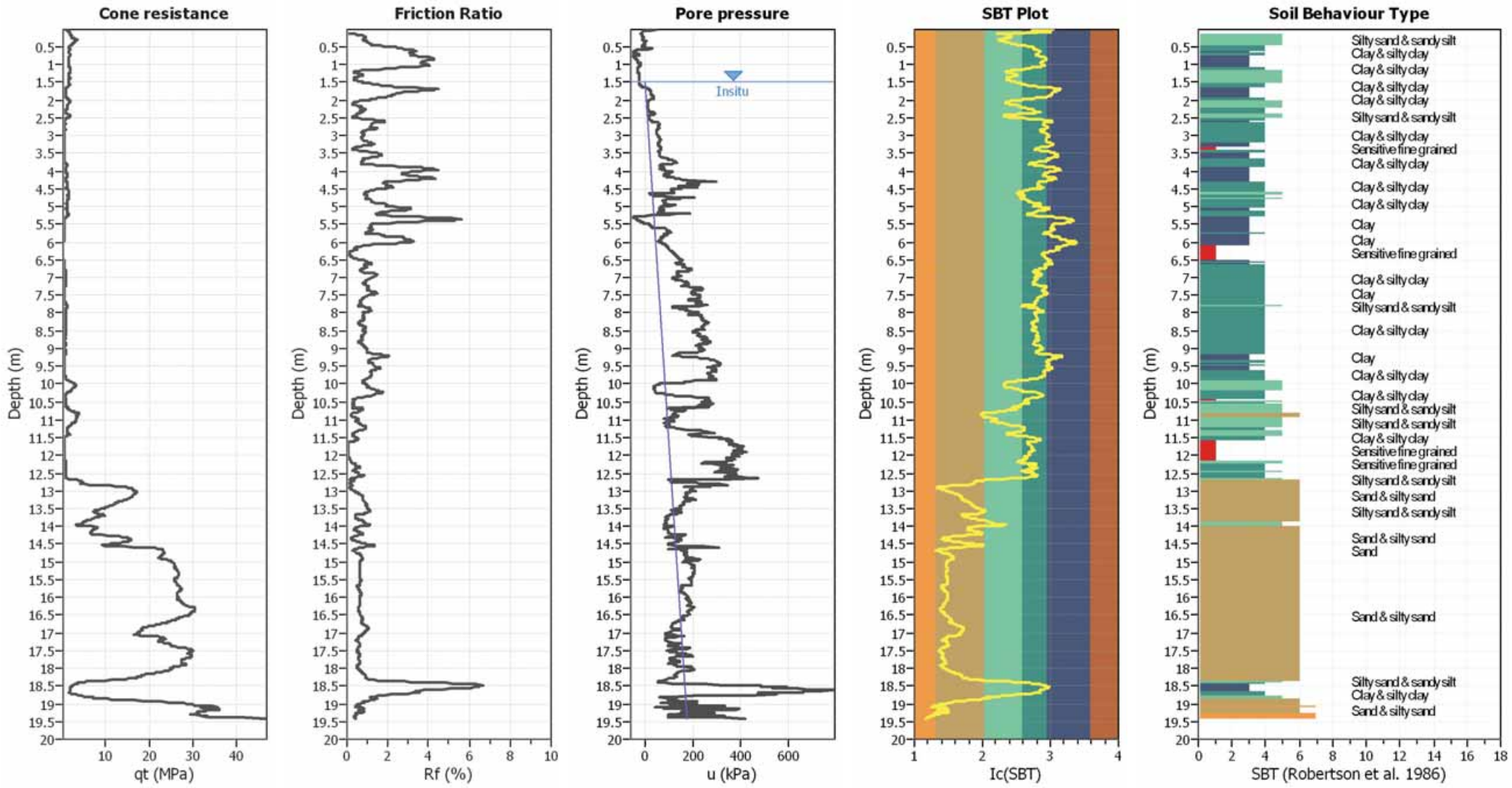
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.00 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



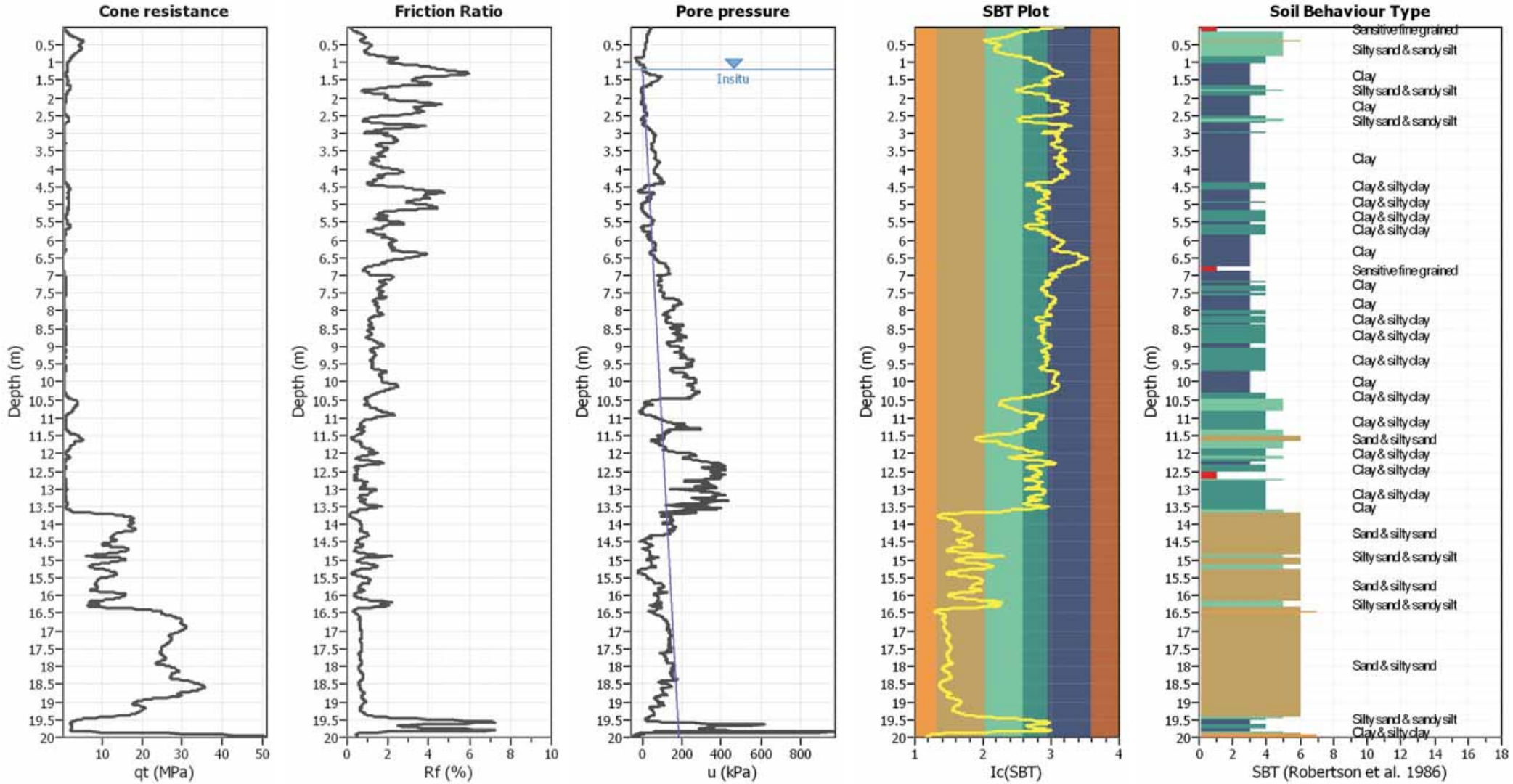
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



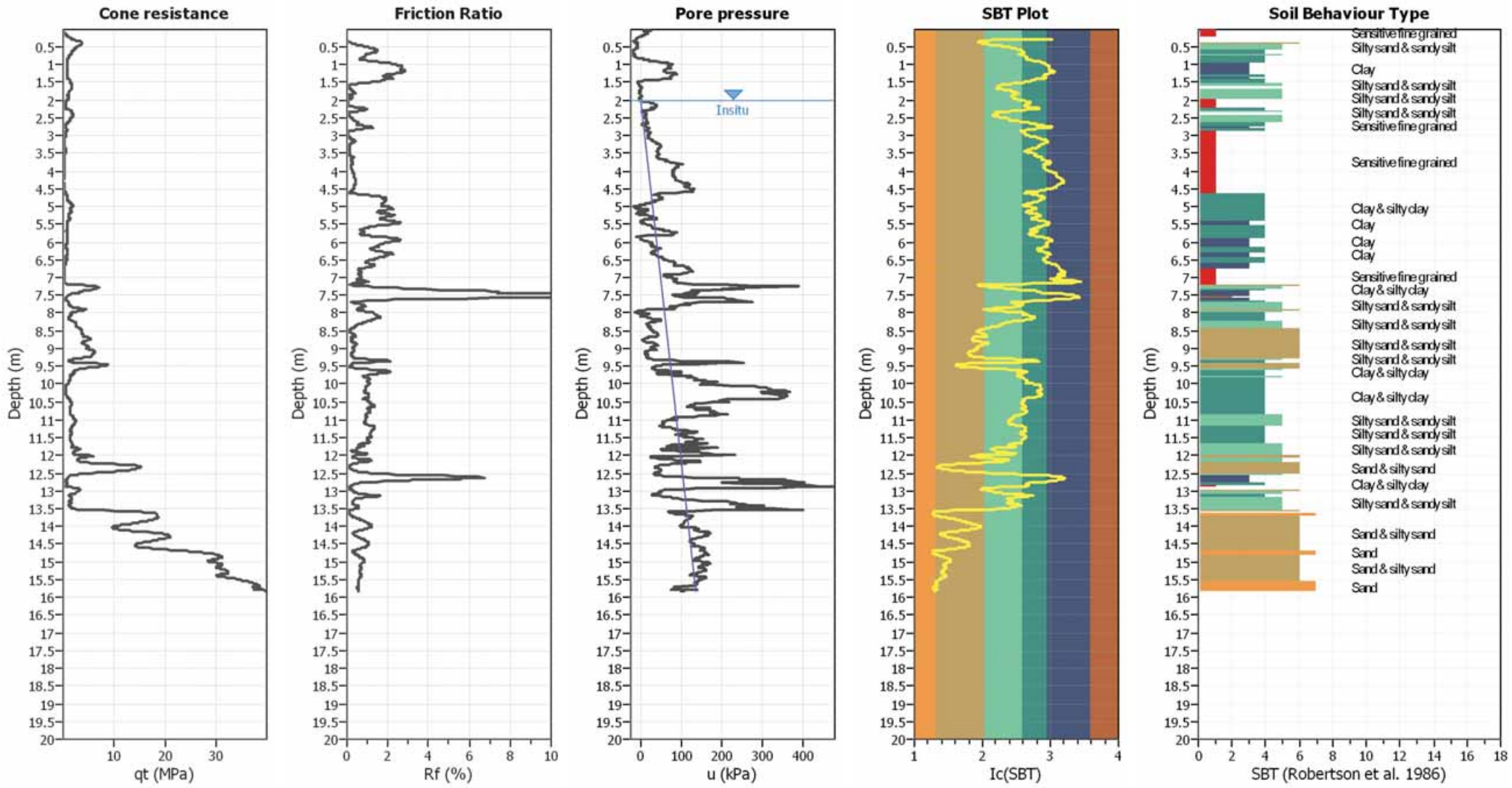
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.20 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



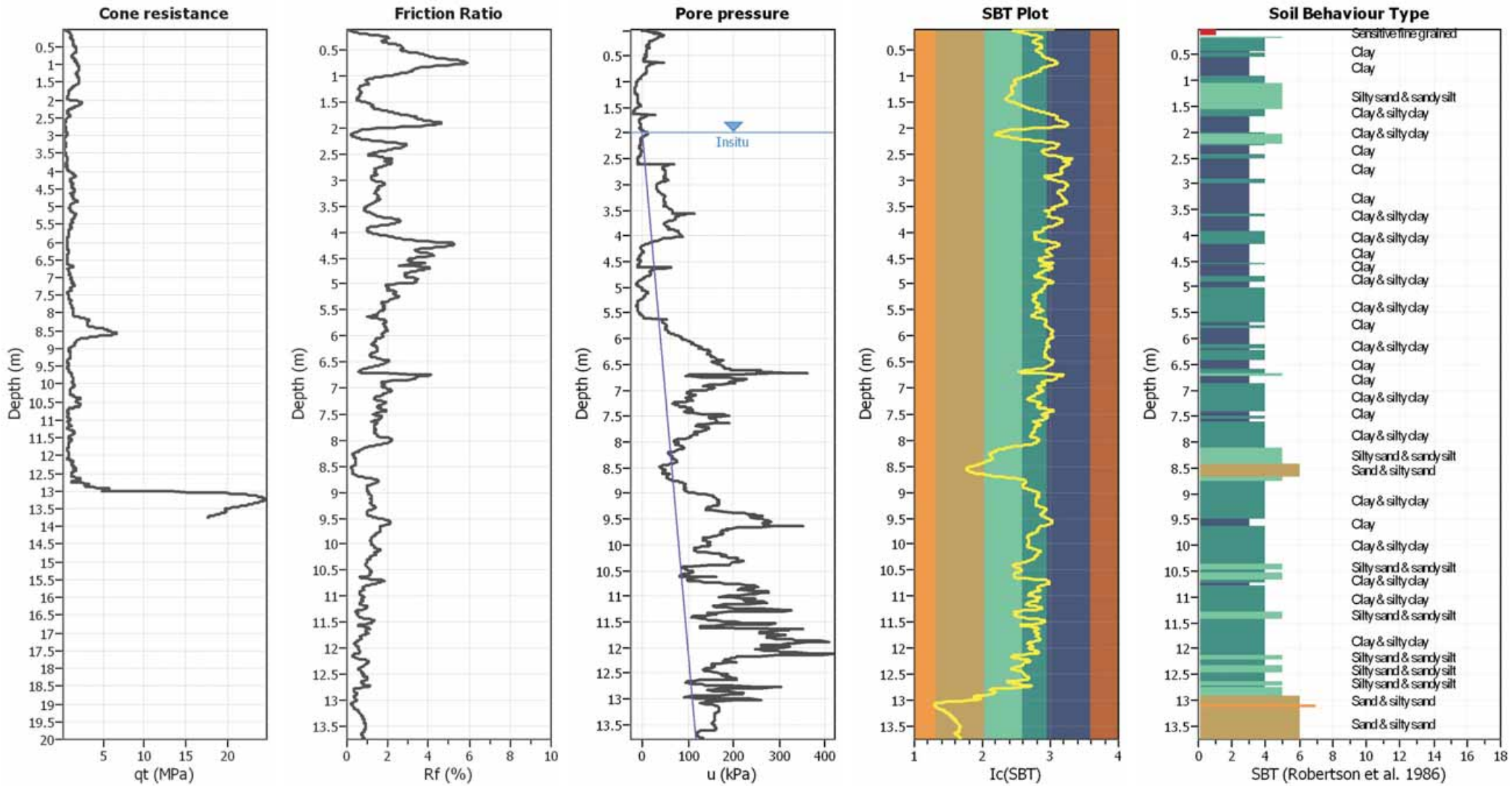
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



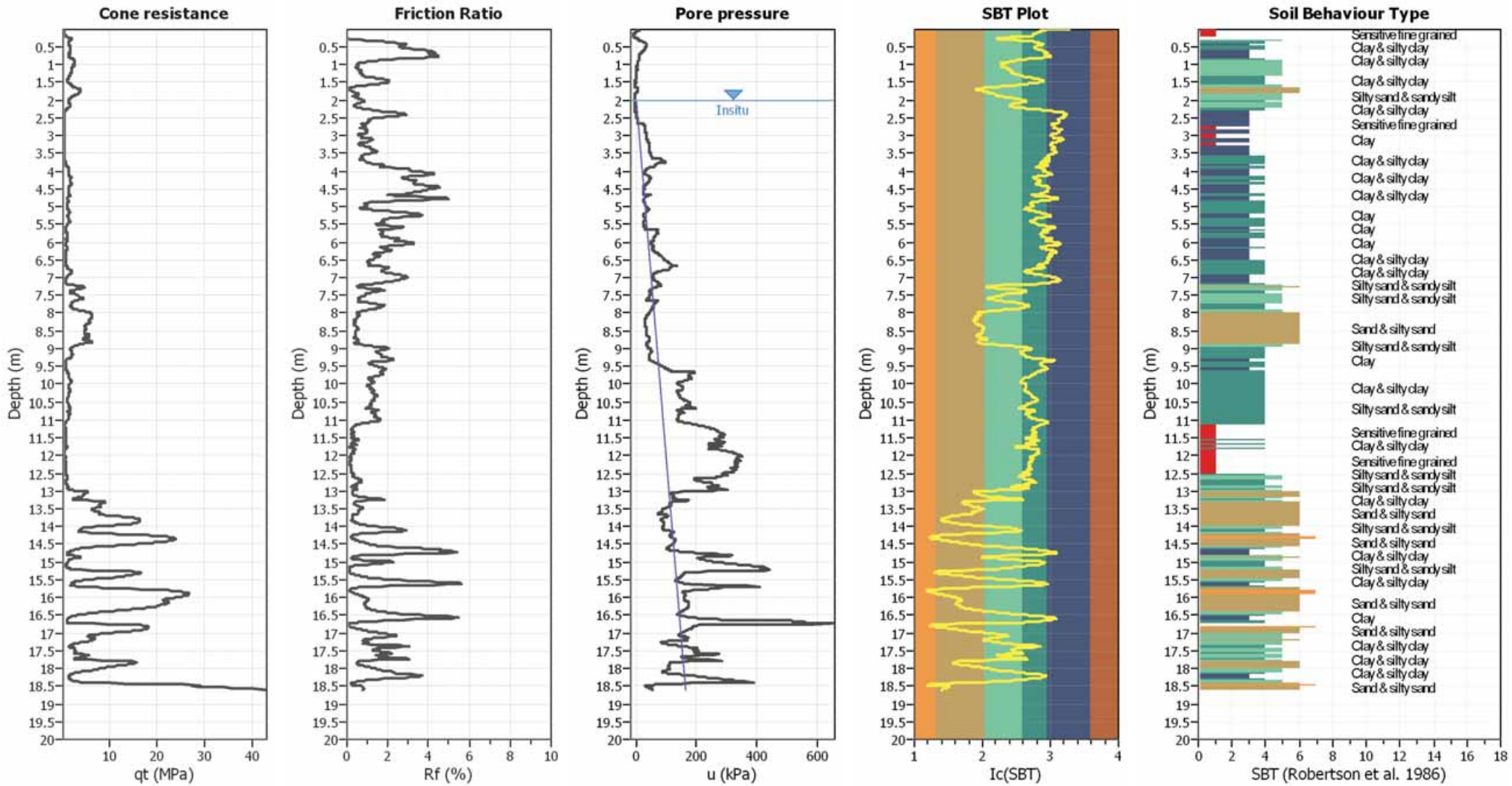
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



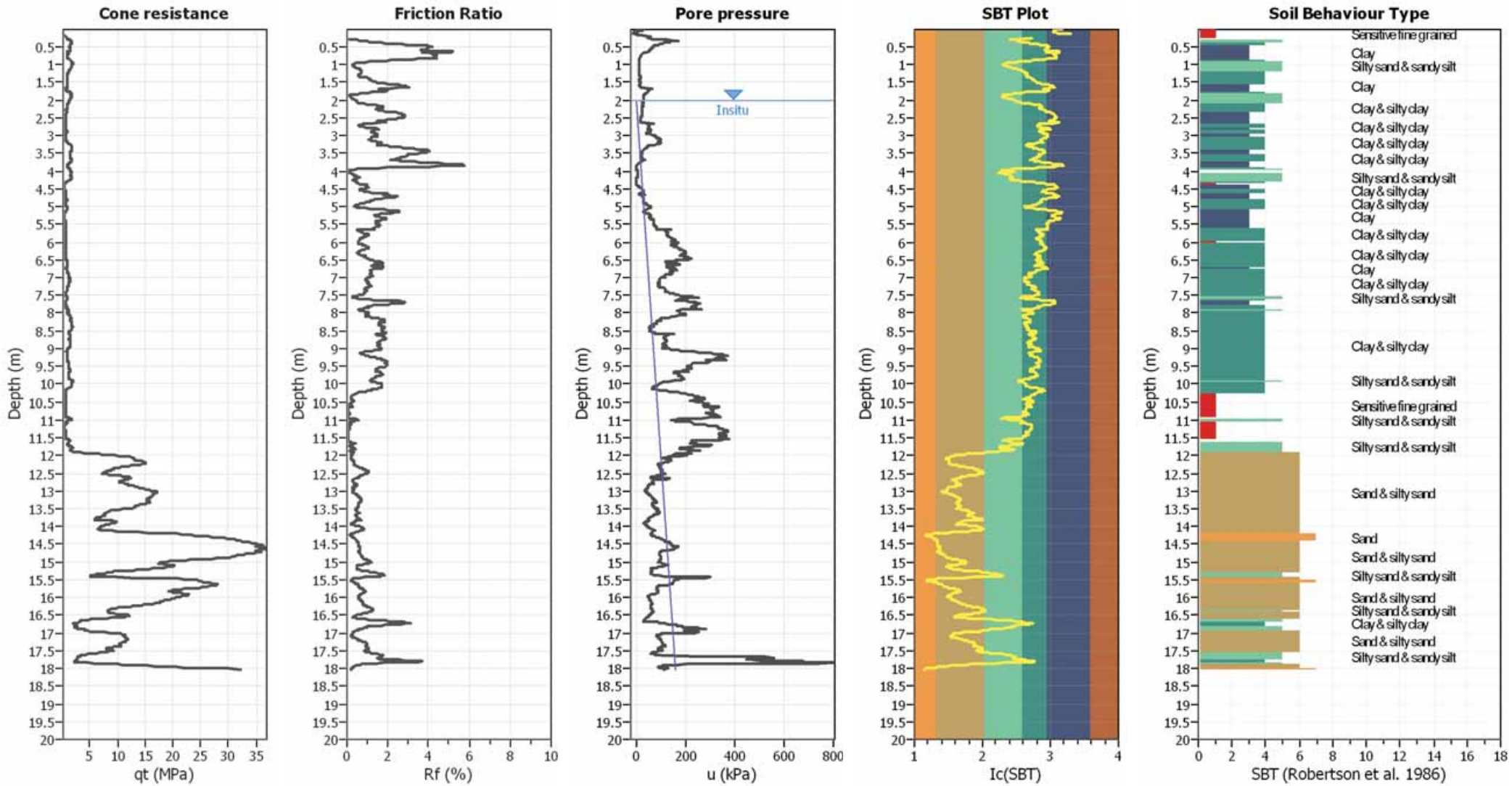
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



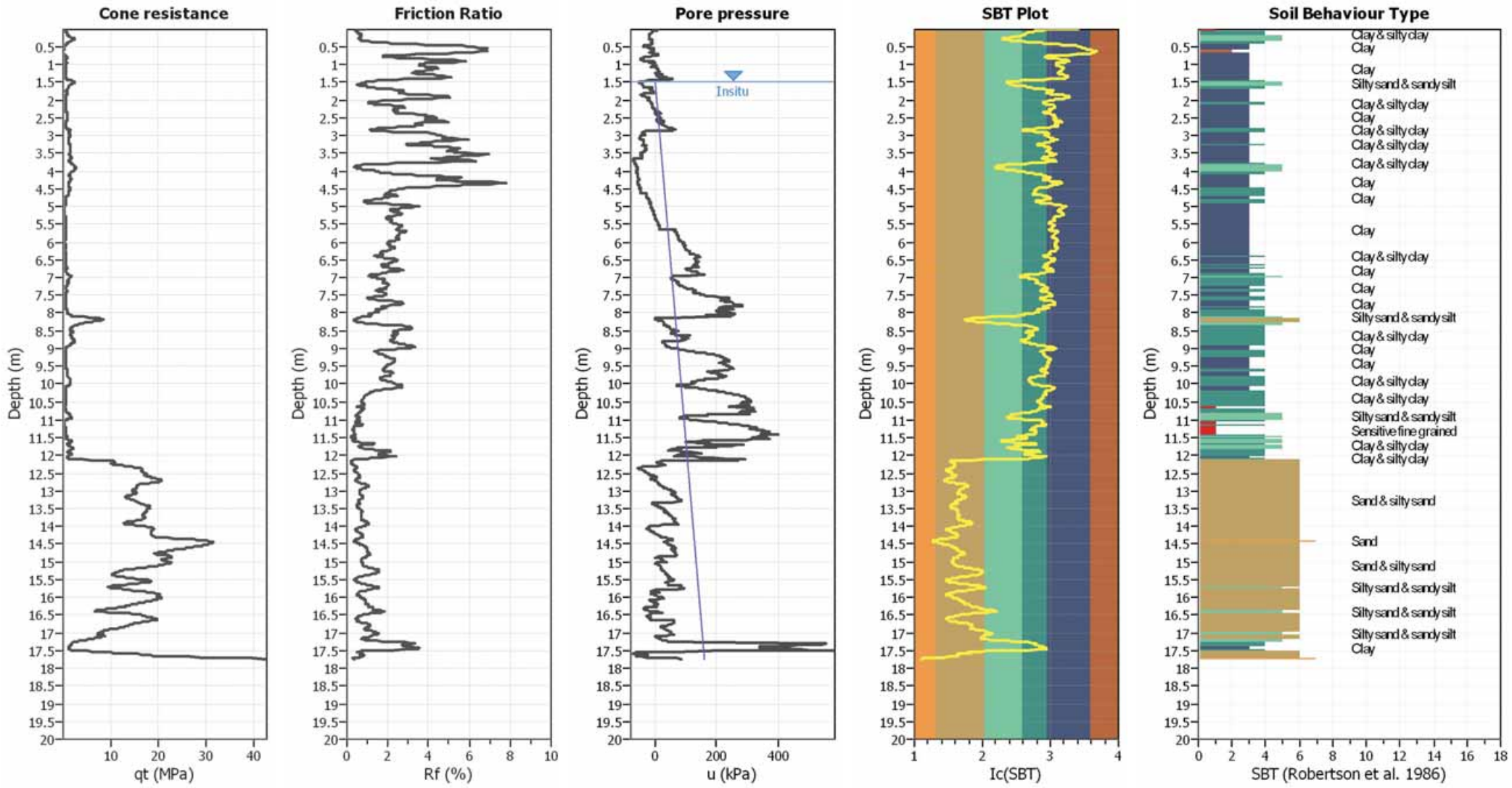
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

SBT 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



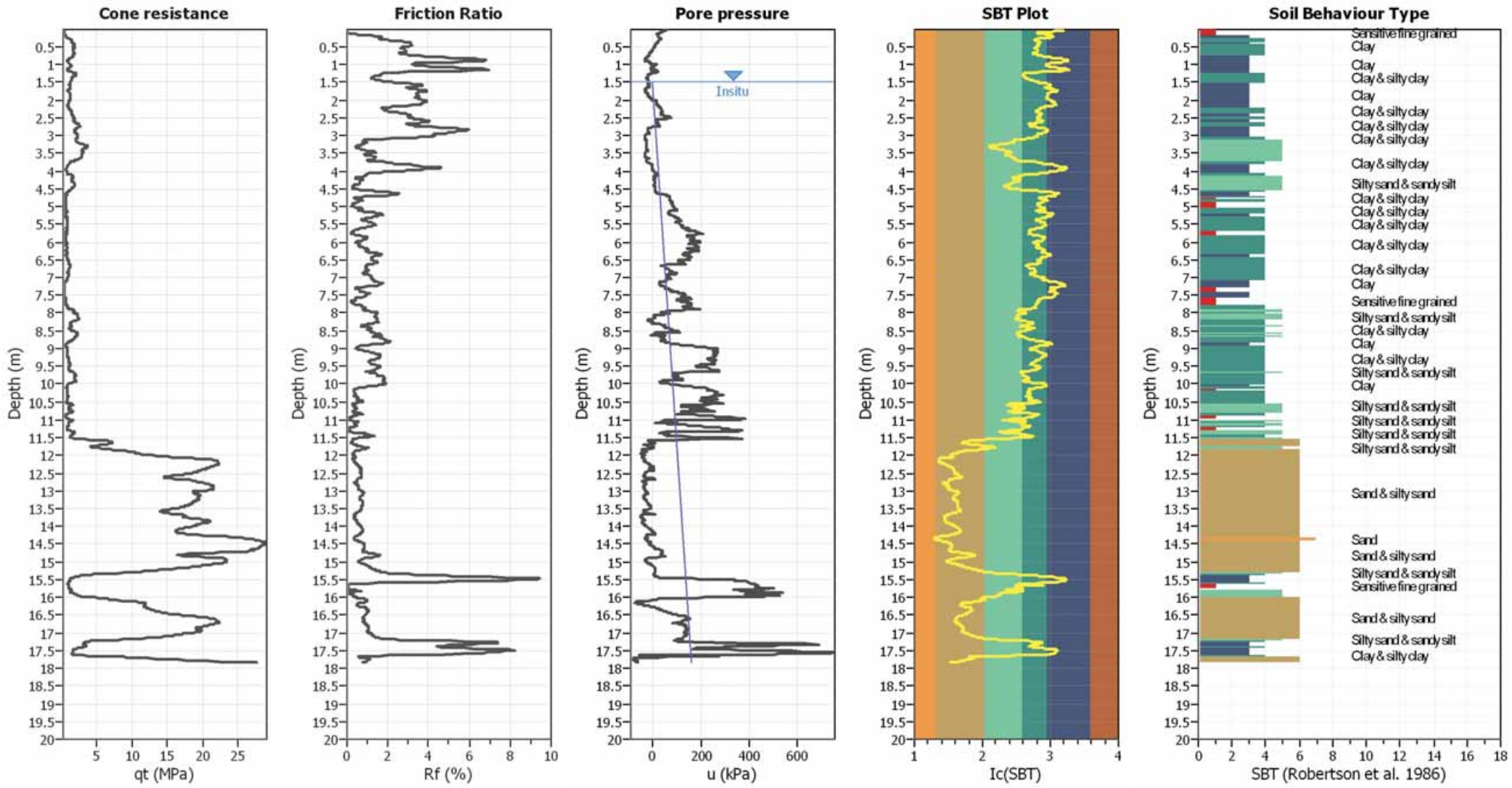
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



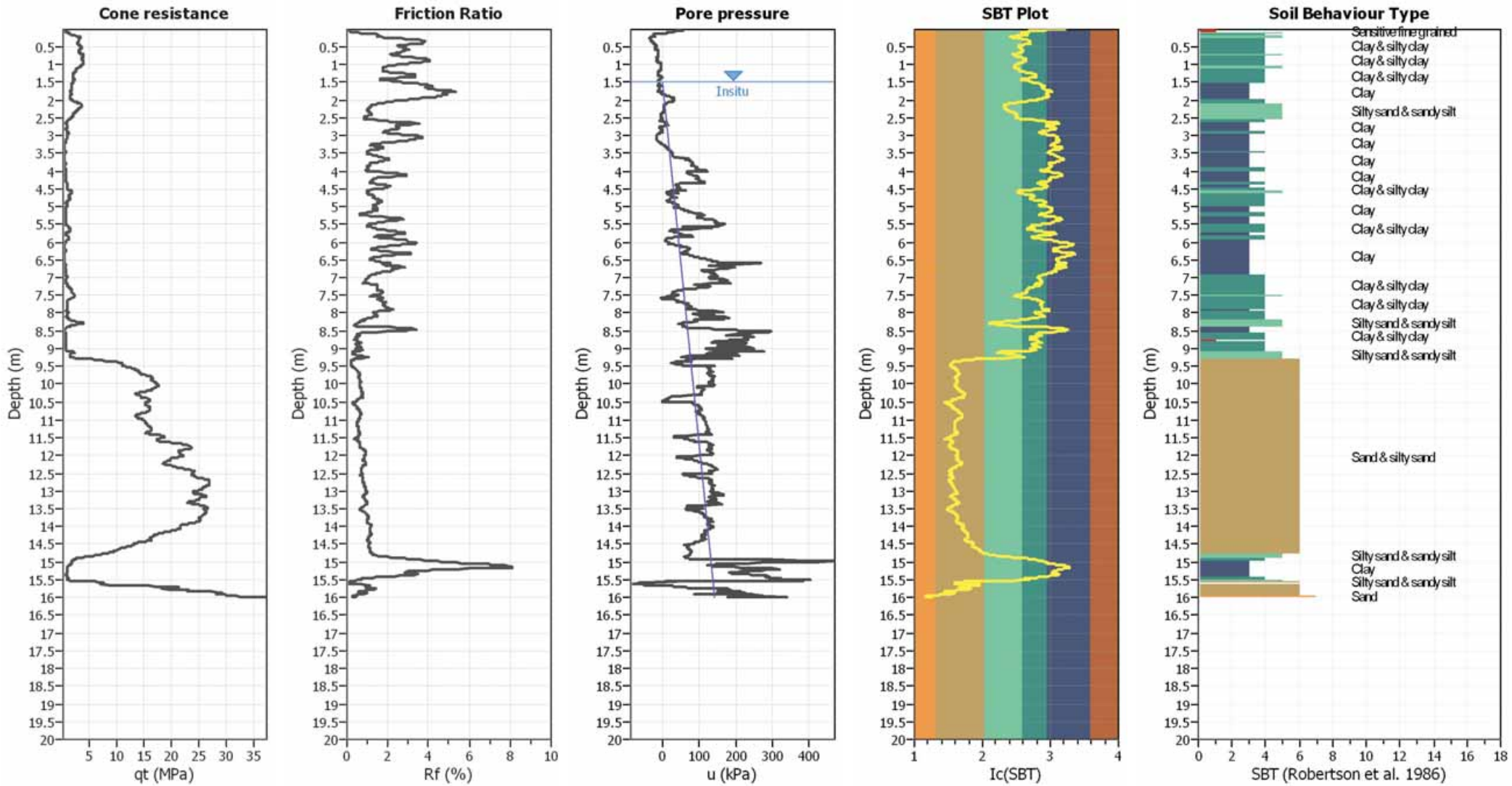
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

SBT 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

coffey

Engineering Log - Borehole

Borehole ID.	**BH1**
sheet:	1 of 2
project no.	**GENZCHRI15602AB**
client:	**Christchurch City Council**
date started:	**15 Apr 2014**
principal:	**-**
date completed:	**15 Apr 2014**
project:	**R6 - East Belfast Plan Change**
logged by:	**M. Houghton**
location:	**East Belfast**
checked by:	**B. Raasch**

position: E: 631,731; N: 5,186,968 (WGS84 Zone 59) surface elevation: 11.0 m (LYTTHT1937) angle from horizontal: 90°

drill model: Comacchio MC-900, Track mounted casing diameter : 150 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
SB		15/04/14 10:40		11			ML	**TOPSOIL: SILT**: low plasticity, dark brown, trace roots.	M	F		**TOPSOIL**
							MH	**Clayey SILT**: medium to high plasticity, yellow-grey mottled orange.		F / St		**SPRINGSTON FORMATION**
			SPT 0, 1, 2, 1, 2, 2 N*=7	10	1.0		SM	**Silty SAND**: fine to medium grained, grey.	S	L		
				9	2.0		ML	**Sandy SILT**: low plasticity, grey. 2.3 - 2.7m: trace of decomposed wood pieces		F		
							SP	**SAND**: fine to medium grained, grey, some silt; interbeds of clean sand and silt.		L / MD		
			SPT 2, 5, 6, 6, 6, 5 N*=23	8	3.0		GP	**Sandy GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey.		MD		**SPRINGSTON/CHRISTCHURCH FORMATION?** particles sorted by sonic drilling 3.45 - 4.5m
				7	4.0		GP	**GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey, some sand.		D		
			SPT 6, 9, 8, 11, 11, 12 Nc=42	6	5.0			5.0m: trace sand		MD		
			SPT 3, 6, 8, 6, 5, 4 Nc=23	5	6.0		GP	**GRAVEL**: medium to coarse grained, rounded to sub-rounded, grey, some sand.		D		particles sorted by sonic drilling 6.45 - 7.5m
			SPT 7, 10, 10, 10, 12, 9 Nc=41	4	7.0							

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED MACHINE BOREHOLES GINT.GPJ <<DrawingFile>> 15/05/2014 20:41

method
AD auger drilling*
AS auger screwing*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
* bit shown by suffix
e.g. AD/T

support
M mud
C casing
N nil

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey

Engineering Log - Borehole

Borehole ID.	**BH1**
sheet:	2 of 2
project no.	**GENZCHRI15602AB**
client:	**Christchurch City Council**
date started:	**15 Apr 2014**
principal:	**-**
date completed:	**15 Apr 2014**
project:	**R6 - East Belfast Plan Change**
logged by:	**M. Houghton**
location:	**East Belfast**
checked by:	**B. Raasch**

position: E: 631,731; N: 5,186,968 (WGS84 Zone 59) surface elevation: 11.0 m (LYTTHT1937) angle from horizontal: 90°

drill model: Comacchio MC-900, Track mounted casing diameter : 150 mm

drilling information						material substance						
method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
SB				3			GP	**GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey, trace sand. 8.5m: piece of wood, 70mm x 20mm	S	D		**SPRINGSTON/CHRISTCHURCH FORMATION?**
			SPT 1, 2, 3, 3, 2, 4 Nc=12	2	9.0		GP	**Sandy GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey.		MD		particles sorted by sonic drilling 9.45 - 10.5m
				1	10.0		GP	**GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey, trace sand.		D		
			SPT 5, 11, 12, 12, 10, 9 Nc=43	0	11.0		SP	**Gravelly SAND**: fine to medium grained, grey, gravel is fine to coarse grained, rounded to sub-rounded. 11.8m: slightly decomposed wood pieces up to 40mm diameter				
			SPT 6, 7, 8, 8, 9, 8 Nc=33	-1	12.0		ML	**SILT**: low plasticity, grey, minor sand.		S / F		
				-2	13.0							
			SPT 1, 1, 2, 1, 1, 3 N*=7	-3	14.0							
			SPT 1, 1, 0, 0, 1, 1 N*=2	-4	15.0		ML	**Sandy SILT**: low plasticity, grey, trace shell fragments. Interbeds of clean sand and silt.		VS		
								Borehole BH1 terminated at 15.45 m Target depth				

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED MACHINE BOREHOLES GINT.GPJ <<DrawingFile>> 15/05/2014 20:41

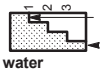
method

AD	auger drilling*
AS	auger screwing*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*	bit shown by suffix
e.g.	AD/T

support

M	mud
C	casing
N	nil

penetration



no resistance ranging to refusal

water

10-Oct-12 water level on date shown

water inflow

water outflow

samples & field tests

B	bulk disturbed sample
D	disturbed sample
E	environmental sample
SS	split spoon sample
U##	undisturbed sample ##mm diameter
HP	hand penetrometer (kPa)
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
VS	vane shear; peak/remouded (kPa)
R	refusal
HB	hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture

D	dry
M	moist
W	wet
S	saturated

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey

Engineering Log - Borehole

Borehole ID.	**BH2**
sheet:	1 of 3
project no.	**GENZCHRI15602AB**
client:	***Christchurch City Council***
date started:	***16 Apr 2014***
principal:	**-**
date completed:	***16 Apr 2014***
project:	***R6 - East Belfast Plan Change***
logged by:	***M. Houghton***
location:	***East Belfast***
checked by:	***B. Raasch***

position: E: 632,084; N: 5,186,797 (WGS84 Zone 59) surface elevation: 10.6 m (LYTTHT1937) angle from horizontal: 90°

drill model: Comacchio MC-900, Track mounted casing diameter : 150 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
SB		16/04/14 13:25, with casing in 16/04/14 14:20, with casing removed	SPT 1, 0, 1, 1, 1, 4 N*=7	10 9	1.0		ML	**TOPSOIL: SILT**: low plasticity, dark brown, minor sand.	M	F		**TOPSOIL**
							ML	**SILT**: low plasticity, grey mottled orange, some sand.	W	F / St		**SPRINGSTON FORMATION**
					2.0		ML	**Sandy SILT**: low plasticity, grey.		F		
				8			SM	**Silty SAND**: fine to medium grained, grey.	S	L / MD		
			SPT 5, 6, 8, 6, 5, 4 Nc=23		3.0		GP	**Sandy GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey.		MD		**SPRINGSTON/CHRISTCHURCH FORMATION?**
				7	4.0		GP	**GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey, trace sand.				
							SP	**SAND**: fine to medium grained, grey.				
			SPT 5, 7, 5, 4, 3, 3 N*=15	6	5.0		GP	**Gravelly SAND**: fine to medium grained, grey, gravel is fine to coarse grained, rounded to sub-rounded.				
				5			GP	**GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey, minor sand. 5.8 to 6.0m: wood pieces, >80mm diameter				
			SPT 3, 6, 4, 4, 3, 4 Nc=15		6.0							
				4				6.45 to 6.6m: wood pieces >80mm diameter 6.6m: trace sand				
					7.0							
			SPT 5, 4, 3, 3, 3, 3 Nc=12	3								

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED MACHINE BOREHOLES GINT.GPJ <<DrawingFile>> 15/05/2014 20:41

method
AD auger drilling*
AS auger screwing*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
* bit shown by suffix
e.g. AD/T

support
M mud
C casing
N nil

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey

Engineering Log - Borehole

Borehole ID.	**BH2**
sheet:	2 of 3
project no.	**GENZCHRI15602AB**
client:	***Christchurch City Council***
date started:	***16 Apr 2014***
principal:	**-**
date completed:	***16 Apr 2014***
project:	***R6 - East Belfast Plan Change***
logged by:	***M. Houghton***
location:	***East Belfast***
checked by:	***B. Raasch***

position: E: 632,084; N: 5,186,797 (WGS84 Zone 59) surface elevation: 10.6 m (LYTTHT1937) angle from horizontal: 90°

drill model: Comacchio MC-900, Track mounted casing diameter : 150 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
SB			SPT 7, 9, 8, 8, 8, 9 Nc=33	2 1 0	9.0 10.0		GP	**GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey, minor sand. *(continued)* 8.0m: wood pieces, 30mm diameter 9.45m: with minor cobbles up to 130mm	S	MD D VD		**SPRINGSTON/CHRISTCHURCH FORMATION?**
			SPT 13, 16, 13, 14, 13, 10/50mm Nc=R	-1	11.0					D		
			SPT 10, 15, 12, 12, 11, 10 Nc=45	-2	12.0		GP	**GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey, with 30 - 40% cobbles up to 80mm diameter. 14.0m: trace sand				
			SPT 12, 14, 16, 11, 10, 8 Nc=45	-3 -4	13.0 14.0							
			SPT 2, 2, 2, 3, 5, 6 Nc=16	-5	15.0		SP	**SAND**: fine to medium grained, grey, trace gravel. 15.6 to 15.7m: 60% cobbles up to 70mm		MD		
							Pt	**PEAT**: dark brown and dark orange, fibrous, some	M			

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED MACHINE BOREHOLES GINT.GPJ <<DrawingFile>> 15/05/2014 20:41

method
AD auger drilling*
AS auger screwing*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
* bit shown by suffix
e.g. AD/T

support
M mud
C casing
N nil

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remoulded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey

Engineering Log - Borehole

Borehole ID.	**BH2**
sheet:	3 of 3
project no.	**GENZCHRI15602AB**
client:	**Christchurch City Council**
date started:	**16 Apr 2014**
principal:	**-**
date completed:	**16 Apr 2014**
project:	**R6 - East Belfast Plan Change**
logged by:	**M. Houghton**
location:	**East Belfast**
checked by:	**B. Raasch**

position: E: 632,084; N: 5,186,797 (WGS84 Zone 59) surface elevation: 10.6 m (LYTTHT1937) angle from horizontal: 90°

drill model: Comacchio MC-900, Track mounted casing diameter : 150 mm

drilling information						material substance							
method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
SB							MH	decomposed wood pieces up to 40mm. **SILT**: medium to high plasticity, grey, minor interbeds of sandy silt.	M	F / St		**SPRINGSTON/CHRISTCHURCH FORMATION?**
			SPT 2, 3, 4, 3, 1, 2 N=10	-6	17.0		ML	**Sandy SILT**: low plasticity, grey, minor interbeds of clean sand and silt.	S			
				-7			ML	**SILT**: low to medium plasticity, grey, some sand.				
			SPT 2, 2, 4, 2, 3, 4 N*=13		18.0		SP	**SAND**: fine to medium grained, grey, some silt in interbeds up to 40mm thick.		MD		
				-8			ML	**Sandy SILT**: fine to medium grained, grey, interbeds of clean sand and silt up to 40mm thick.		F / St		
					19.0		SP	19.1m: 50mm layer of silt, medium to high plasticity, yellow-grey mottled orange	M	MD		
			SPT 1, 2, 4, 5, 9, 10 N*=28	-9				**SAND**: fine to medium grained, yellow-grey, some interbedded silt layers up to 50mm thick. 19.3m: silt absent	S			
					20.0			Borehole BH2 terminated at 19.95 m Target depth				
				-10								
					21.0							
				-11								
					22.0							
				-12								
					23.0							
				-13								

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED MACHINE BOREHOLES GINT.GPJ <<DrawingFile>> 15/05/2014 20:41

method
AD auger drilling*
AS auger screwing*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
* bit shown by suffix
e.g. AD/T

support
M mud N nil
C casing

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remoulded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey

Engineering Log - Borehole

Borehole ID.	**BH3**
sheet:	1 of 3
project no.	**GENZCHRI15602AB**
client:	***Christchurch City Council***
date started:	***28 Apr 2014***
principal:	**-**
date completed:	***28 Apr 2014***
project:	***R6 - East Belfast Plan Change***
logged by:	***N. Morgan***
location:	***East Belfast***
checked by:	***B. Raasch***

position: E: 632,212; N: 5,186,692 (WGS84 Zone 59) surface elevation: 9.6 m (LYTTHT1937) angle from horizontal: 90°

drill model: Comacchio MC-900, Track mounted casing diameter : 150 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
SB		28/04/14 14:25, with casing in		9				**FILL: SILT**: low plasticity, dark brown with minor fine rounded to sub-rounded gravel, trace rootlets. 0.20m: gravel becomes fine to medium grained with minor brick fragments (<20mm), rootlets become absent. 0.40m: yellow streaks become present with brick fragments absent.	S			**FILL**
					1.0		SP	0.80m: becoming fine to coarse gravel with trace plastic.	W	MD		**SPRINGSTON FORMATION**
							SW	0.90m: plastic becomes absent. **SAND**: fine to medium grained, yellow-brown, with some fine to medium, rounded to sub-rounded gravel.	S			
			SPT 6, 7, 6, 6, 5, 5 Nc=22	8	2.0		GP	**Gravelly SAND**: fine to coarse grained, yellow-brown, with fine to coarse, rounded to sub-rounded gravel. **NO CORE:** 0.45m (1.50-1.95) .				
				7				**GRAVEL**: fine to coarse grained, rounded to sub-angular, grey, with trace fine to coarse, yellow-brown sand.				
			SPT 3, 9, 9, 7, 6, 3 Nc=25		3.0			**NO CORE:** 0.45m (3.00-3.45) .				
				6			GP	**GRAVEL**: fine to coarse grained, rounded to sub-angular, grey, with minor fine to coarse, blue-grey sand.		D		
			SPT 6, 10, 9, 10, 10, 8 Nc=37	5	4.0			**NO CORE:** 0.45m (4.50-4.95) .				
				4	5.0		GP	**GRAVEL**: fine to coarse grained, rounded to sub-angular, grey, with minor fine to coarse, blue-grey sand.				
			SPT 5, 5, 3, 1, 1, 1 Nc=6		6.0			**NO CORE:** 0.45m (6.00-6.45) **INFERRED**: 0.2m thick chunk of wood followed by low plasticity dark brown organic silt with some wood fragments.	M to W	L VS		Received from top of next run. Retrieved 1.5m of sample from a 1.0m run.
				3			ML	**SILT**: low plasticity, blue-grey with trace brown streaks, trace clay. 6.60m: brown streaks become absent.		S		
					7.0					F		
								7.20m: becoming minor fine sand with minor rootlets.	S	VS		
			SPT 1, 0, 0, 0, 1, 1 N*=2	2				7.20m: becoming some brown mottling with minor decomposing wood fragments.				

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED MACHINE BOREHOLES GINT.GPJ <<DrawingFile>> 15/05/2014 20:41

method
AD auger drilling*
AS auger screwing*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
* bit shown by suffix
e.g. AD/T

support
M mud
C casing
N nil

penetration
no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remoulded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey

Engineering Log - Borehole

Borehole ID.	**BH3**
sheet:	2 of 3
project no.	**GENZCHRI15602AB**
client:	***Christchurch City Council***
principal:	**-**
project:	***R6 - East Belfast Plan Change***
location:	***East Belfast***
date started:	***28 Apr 2014***
date completed:	***28 Apr 2014***
logged by:	***N. Morgan***
checked by:	***B. Raasch***

position: E: 632,212; N: 5,186,692 (WGS84 Zone 59) surface elevation: 9.6 m (LYTTHT1937) angle from horizontal: 90°

drill model: Comacchio MC-900, Track mounted casing diameter : 150 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
SB							Pt	**PEAT**: dark brown, fibrous with minor pockets of low plasticity grey silt. *(continued)*	M	VS		**SPRINGSTON FORMATION**
							ML					
				1			Pt	**SILT**: low plasticity, grey with some fine rootlets and some pockets of dark brown organic matter and organic silt.				
							ML	**PEAT**: black with brown mottling, fibrous with minor low plasticity brown silt.	S			
			SPT 0, 0, 0, 1, 1, 0 N*=2		9.0			**SILT**: low plasticity, grey-brown with some fibrous organic matter and organic silt. 9.20m: becoming grey with minor fine organic matter and no organic silt. 9.35m: becoming trace organic matter. 9.45m: becoming streaked pale brown with some organic matter.				
				0								
					10.0			9.35m: becoming grey with minor fine sand, minor rootlets and no organic matter. 10.00m: becoming some fine sand with rootlets absent.				
			SPT 0, 0, 0, 0, 1, 0 N*=1	-1								
					11.0			11.00m: becoming trace fine rootlets.				
				-2			ML	**Sandy SILT**: low plasticity, blue-grey with fine sand.				
					12.0		ML	**SILT**: low plasticity, blue-grey with trace fine sand. 12.20m: becoming minor fine sand. 12.40m: becoming some fine sand.				
				-3								
			SPT 1, 0, 0, 0, 0, 0 N*=0		13.0			13.20m: becoming trace fine sand.				
				-4				13.60m: becoming some fine sand.				
					14.0		SM	**Silty SAND**: fine to coarse grained, blue-grey, with some shell fragments (bivalves).	W to S	MD		**CHRISTCHURCH FORMATION**
			SPT 1, 1, 0, 3, 5, 6 N*=14	-5				14.50m: becoming minor fine rounded to sub-angular gravel.				
					15.0		SP	**SAND**: fine to medium grained, yellow-brown, with some fine, rounded to sub-rounded gravel. 15.60m: becoming trace gravel. 15.60m: gravel becomes absent.		D		
			SPT 2, 2, 5, 9, 10, 11 N*=35	-6						MD		

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED MACHINE BOREHOLES GINT.GPJ <<DrawingFile>> 15/05/2014 20:41

method
AD auger drilling*
AS auger screwing*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
* bit shown by suffix
e.g. AD/T

support
M mud N nil
C casing

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remoulded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey

Engineering Log - Borehole

Borehole ID.	**BH3**
sheet:	3 of 3
project no.	**GENZCHRI15602AB**
client:	**Christchurch City Council**
date started:	**28 Apr 2014**
principal:	**-**
date completed:	**28 Apr 2014**
project:	**R6 - East Belfast Plan Change**
logged by:	**N. Morgan**
location:	**East Belfast**
checked by:	**B. Raasch**

position: E: 632,212; N: 5,186,692 (WGS84 Zone 59) surface elevation: 9.6 m (LYTTHT1937) angle from horizontal: 90°

drill model: Comacchio MC-900, Track mounted casing diameter : 150 mm

drilling information						material substance						
method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description **SOIL TYPE**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
SB			SPT 2, 2, 4, 5, 9, 10 N*=28	-7	17.0		SP	**SAND**: fine to medium grained, yellow-brown, with some fine, rounded to sub-rounded gravel. *(continued)* 16.20m: becoming some fine to medium, rounded to sub-rounded gravel. 16.95m: becoming trace fine to medium gravel.	W to S	MD		**CHRISTCHURCH FORMATION**
			SPT 1, 1, 3, 3, 7, 10 N*=23	-8 -9	18.0			17.80m: becoming some fine gravel. 18.10m: becoming trace fine gravel. 18.40m: becoming minor fine to medium gravel. 18.80m: gravel becomes absent. 19.00m: orange and brown streak present.				
			SPT 1, 2, 3, 5, 7, 12 N*=27	-10	19.0		GP	**Sandy GRAVEL**: fine grained, rounded to sub-rounded, grey, with fine to medium, yellow-brown sand.				**RICCARTON GRAVEL**
				-11 -12 -13 -14	20.0 21.0 22.0 23.0			Borehole BH3 terminated at 19.95 m Target depth				

method
AD auger drilling*
AS auger screwing*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
* bit shown by suffix
e.g. AD/T

support
M mud N nil
C casing

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Appendix D

Indicative Cross Section Location Plan

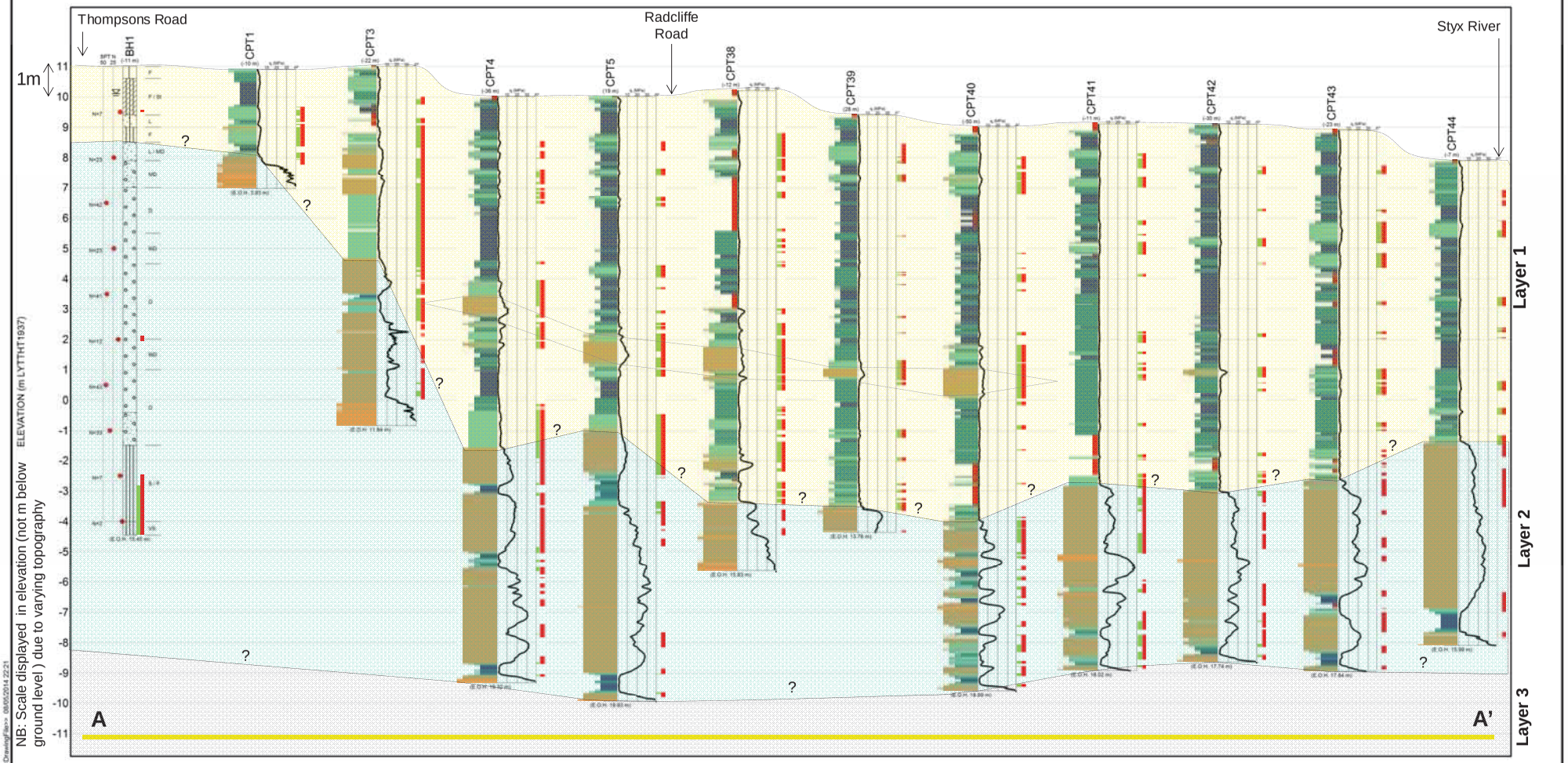
Geological cross sections (A-A' to E-E')


ve cross-section location
imate Kaputone Creek & Styx River locations
A
A'
B
B'
C
C'
D
D'
E
E'
BH2
BH3
Radcliffe Roa
Willowview Drive
Vaughan Way
Coolspring Way
© 2014 Google
300 m
59 G 631832.97 m E 5186520.54 m S elev 0 m

NORTH

Sub-surface Section A – A'

SOUTH



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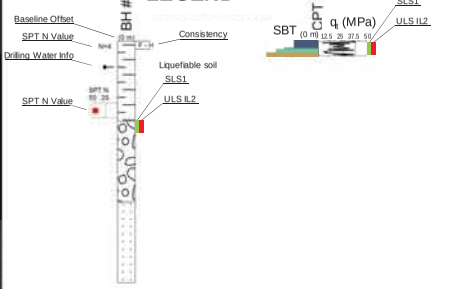


MATERIAL GRAPHIC

- TOPSOIL
- SANDY SILT
- GRAVEL
- CLAYEY SILT
- SAND
- GRAVELLY SAND
- SILTY SAND
- SANDY GRAVEL
- SILT

CPT SOIL BEHAVIOUR TYPE

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. GRAVELLY SAND TO SAND

NB: Not to scale horizontally

drawn	LRS & BH
approved	BR
date	26/05/2014
scale	V 1:130
original size	A3

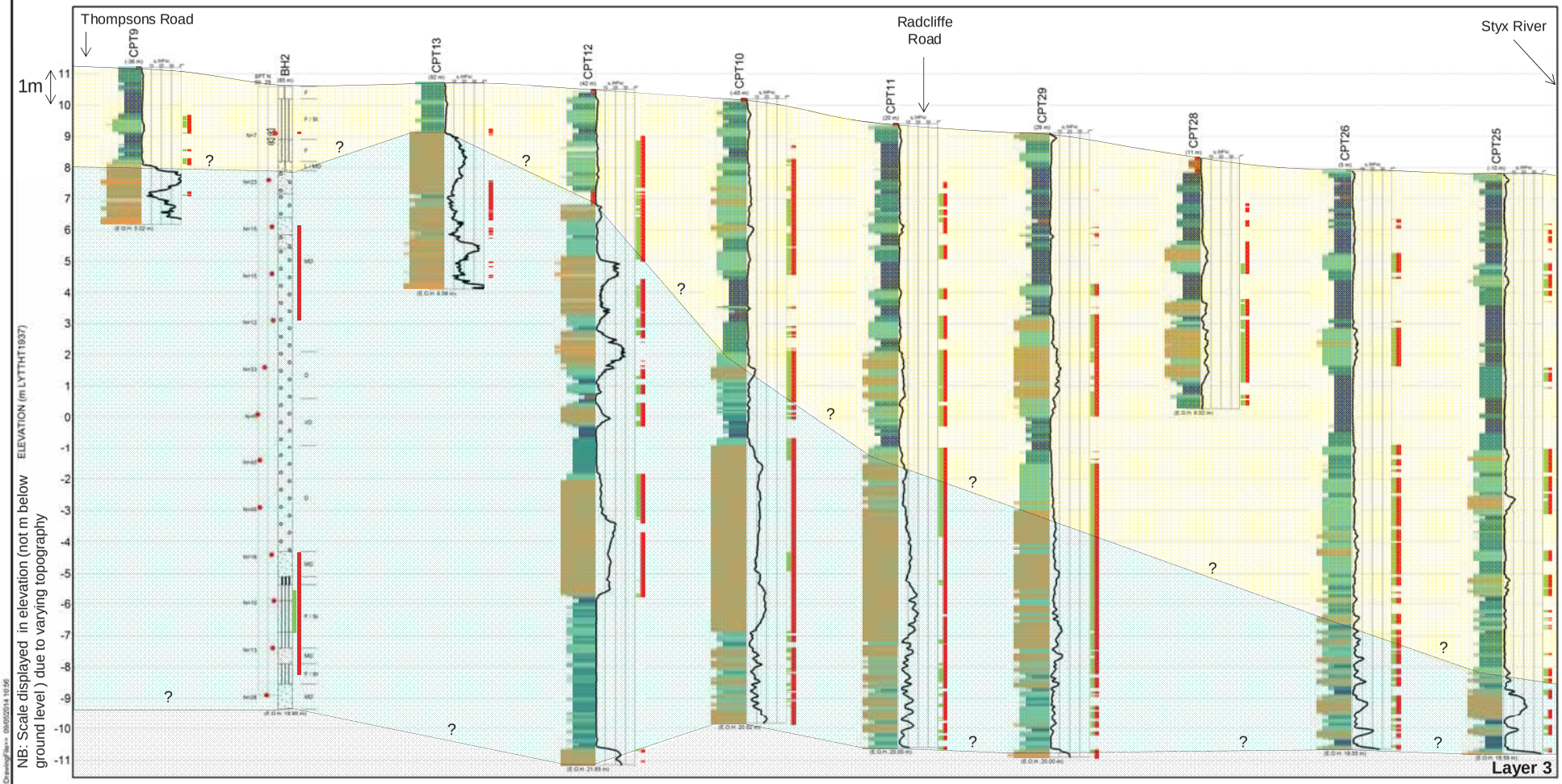
coffey

client:	Christchurch City Council
project:	R6 - East Belfast Review of the District Plan
title:	SUBSURFACE SECTION A-A'
project no:	GENZCHRI15602AB
appendix:	D
rev:	2

NORTH

Sub-surface Section B – B'

SOUTH



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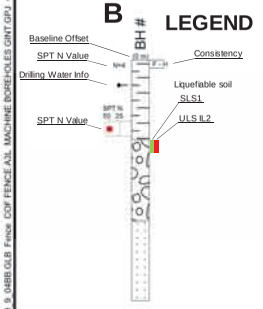


MATERIAL GRAPHIC

- TOPSOIL
- SILTY SAND
- SAND
- SILT
- SANDY GRAVEL
- GRAVELLY SAND
- SANDY SILT
- GRAVEL
- PEAT

CPT SOIL BEHAVIOUR TYPE

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. GRAVELLY SAND TO SAND

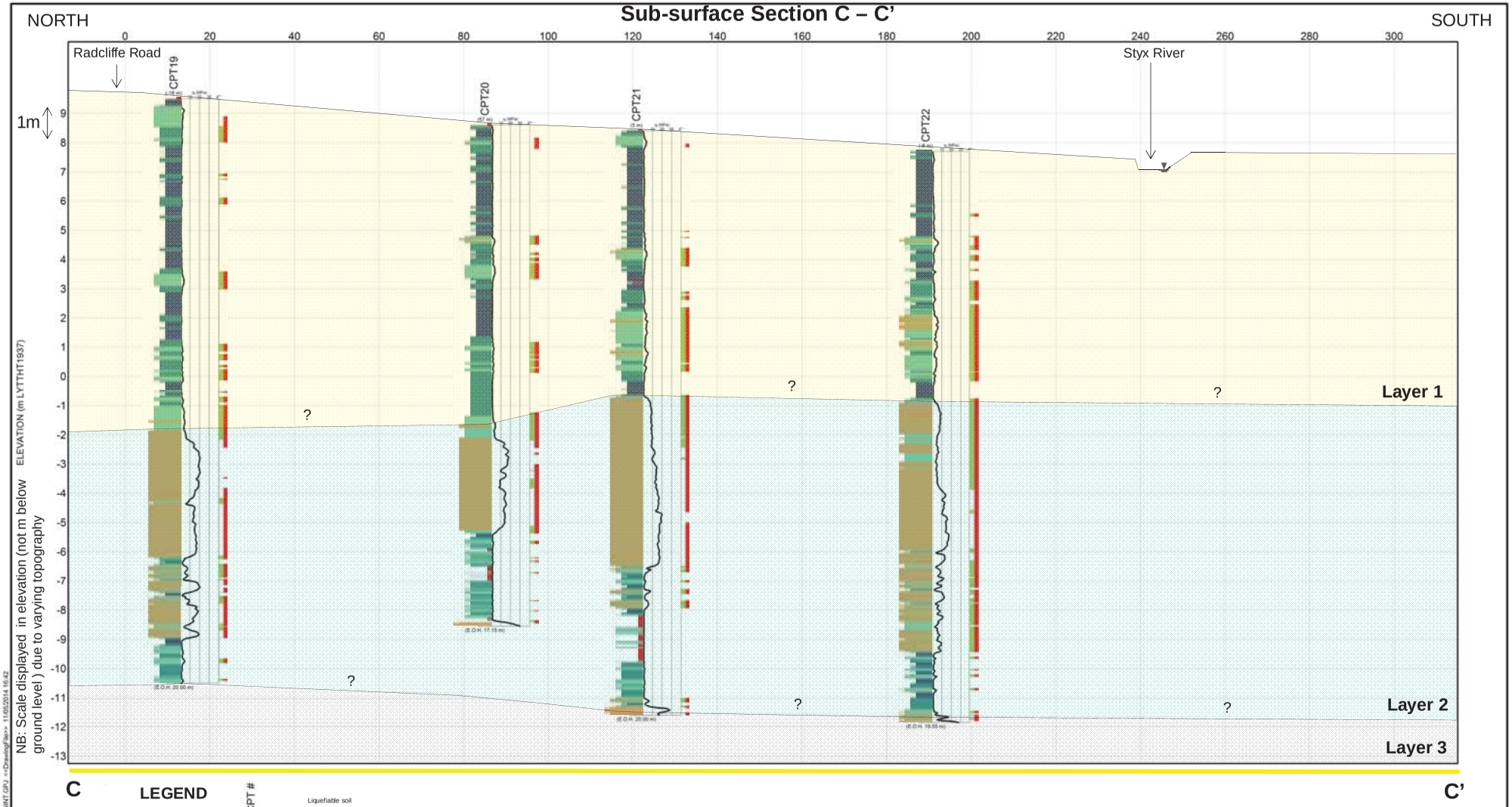
NB: Not to scale horizontally

drawn	LRS & BH
approved	BR
date	26/05/2014
scale	V 1:130
original size	A3

coffey

client:	Christchurch City Council
project:	R6 - East Belfast Review of the District Plan
title:	SUBSURFACE SECTION B-B'
project no:	GENZCHRI15602AB
appendix:	D
rev:	2

Sub-surface Section C – C’



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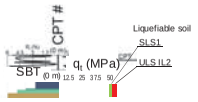


CPT SOIL BEHAVIOUR TYPE

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. GRAVELLY SAND TO SAND

H 1:900
0 10 20 30 40 50m
V 1:130
0 1 2 3 4 5m
Coord.System: WGS84 Zone 59 Height Datum: LYTTHT1937

drawn	LRS & BH
approved	BR
date	26/05/2014
scale	H 1:900 V 1:130
original size	A3

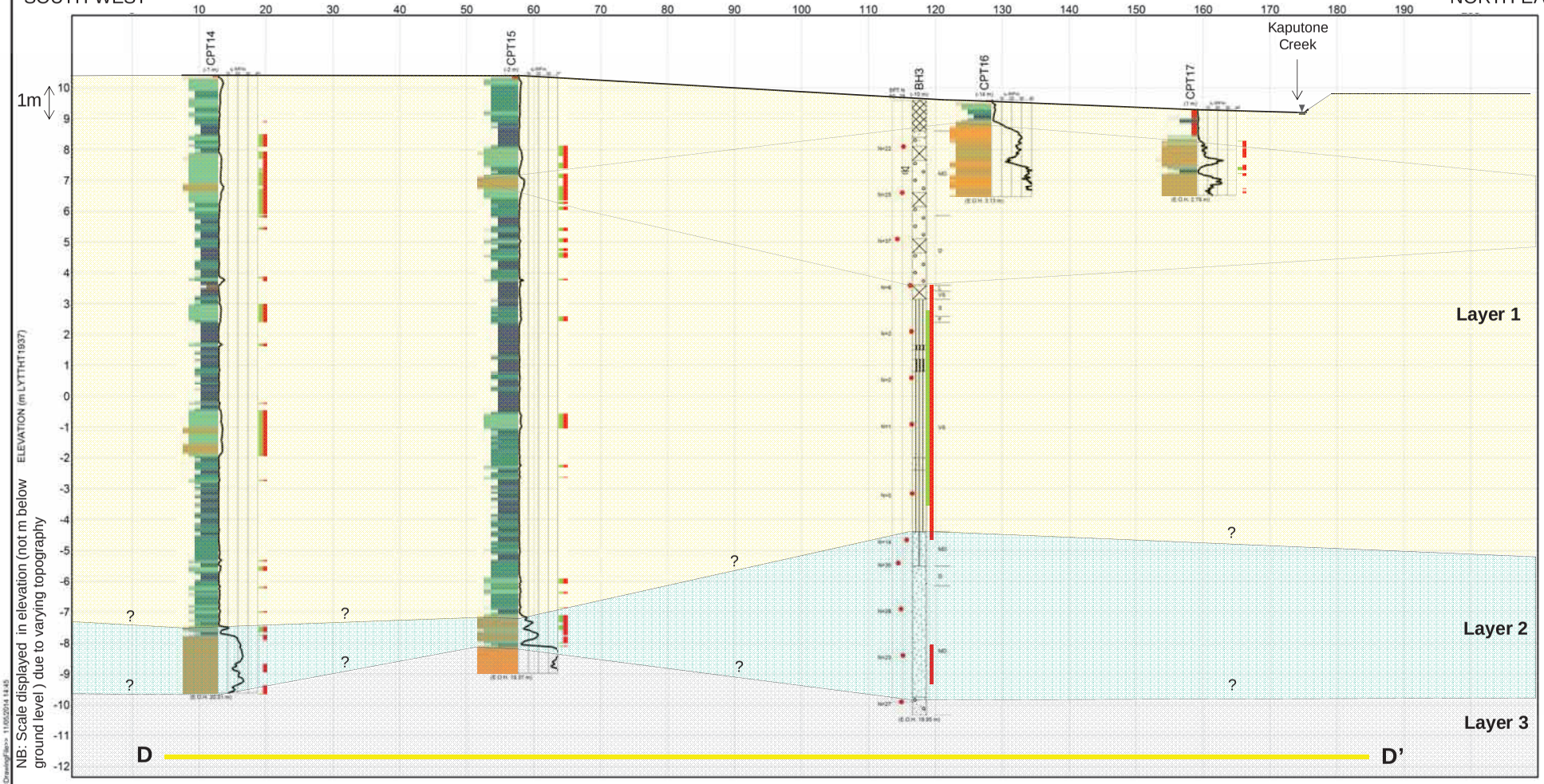
coffey

client: Christchurch City Council
project: R6 - East Belfast Review of the District Plan
title: SUBSURFACE SECTION C – C’
project no: GENZCHRI15602AB | appendix : D | rev: 2

Sub-surface Section D – D'

SOUTH-WEST

NORTH-EAST



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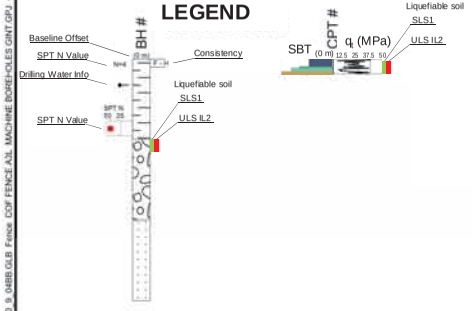


MATERIAL GRAPHIC

- FILL
- NO CORE
- PEAT
- SANDY GRAVEL
- SAND
- GRAVEL
- SANDY SILT
- GRAVELLY SAND
- SILT
- SILTY SAND

CPT SOIL BEHAVIOUR TYPE

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. GRAVELLY SAND TO SAND

H 1:600
0 5 10 15 20 25m

V 1:130
0 1 2 3 4 5m

Coord System: WGS84 Zone 59 Height Datum: LYTTHT1937

drawn	LRS & BH
approved	BR
date	26/05/2014
scale	H 1:600 V 1:130
original size	A3

coffey

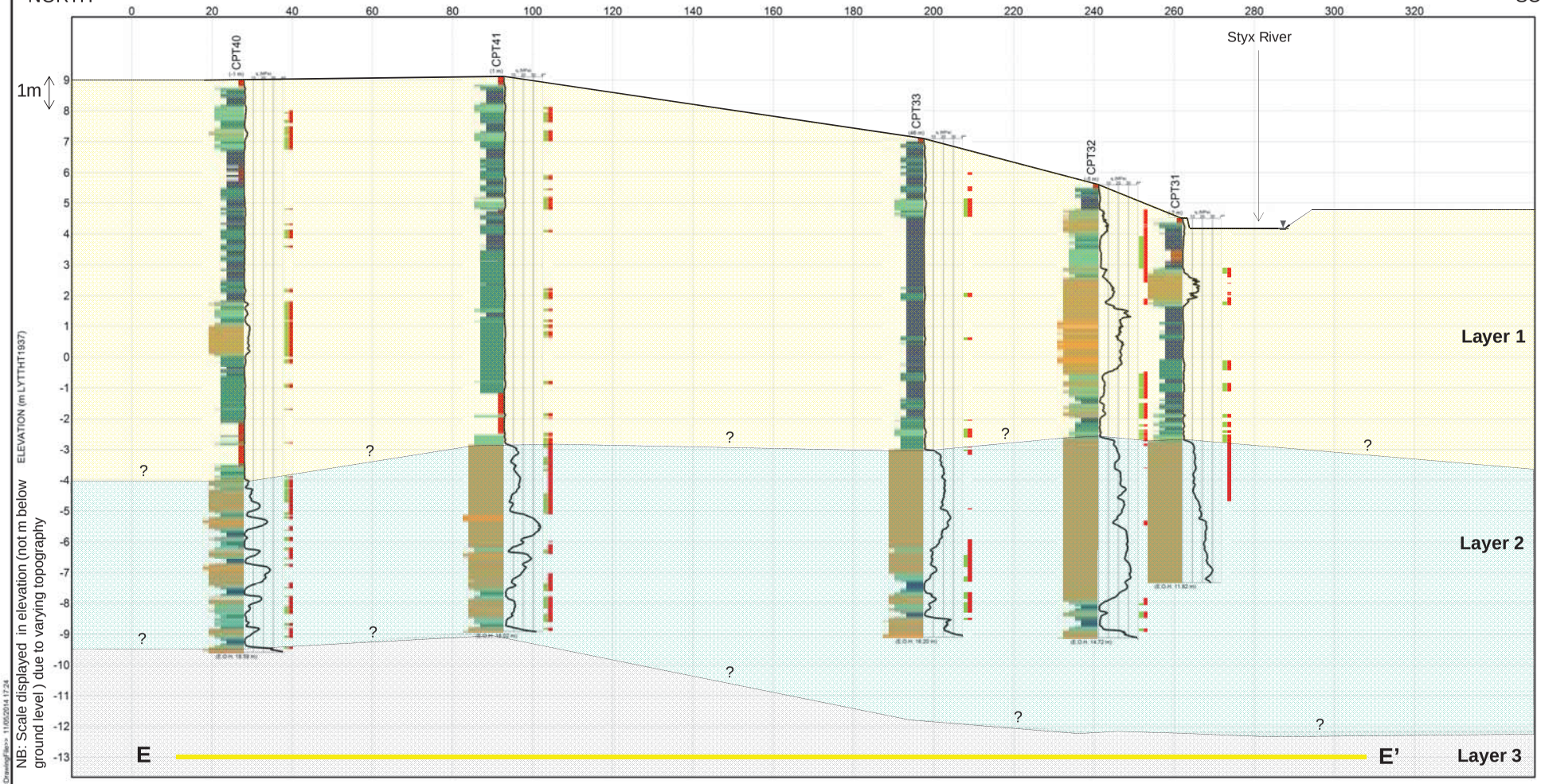
client: Christchurch City Council

project: R6 - East Belfast Review of the District Plan

title: SUBSURFACE SECTION D – D'

project no: GENZCHRI15602AB | appendix: D | rev: 2

Sub-surface Section E – E'



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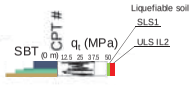

CPT SOIL BEHAVIOUR TYPE

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. GRAVELLY SAND TO SAND

H 1:1000
0 10 20 30 40 50m

V 1:130
0 1 2 3 4 5m

Coord System: WGS84 Zone 59 Height Datum: LYTTHT1937

drawn	LRS & BH
approved	BR
date	26/05/2014
scale	H 1:1000 V 1:130
original size	A3

coffey

client:	Christchurch City Council
project:	R6 - East Belfast Review of the District Plan
title:	SUBSURFACE SECTION E - E'
project no:	GENZCHRI15602AB
appendix:	D
rev:	2

Appendix E

Liquefaction and Lateral Spread Analyses for CPTs 1 – 44 and BHs 1 - 3

Coffey Geotechnics
PO Box 1872
Christchurch
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SPT BASED LIQUEFACTION ANALYSIS REPORT

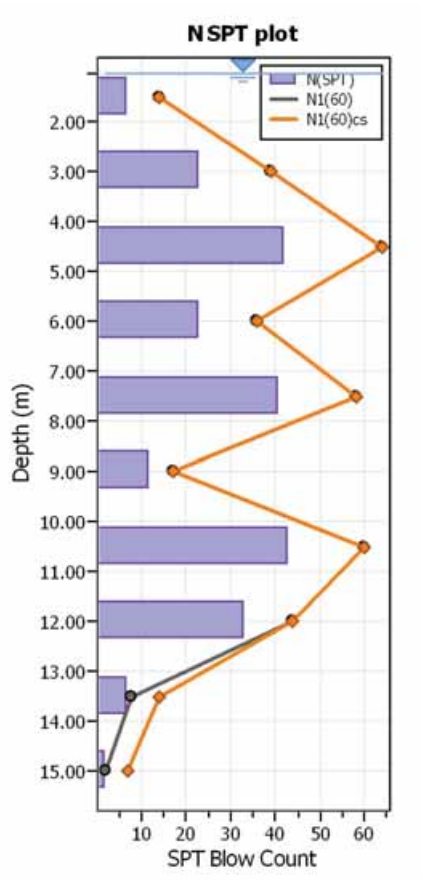
Project title : GENZCHRI15602AB

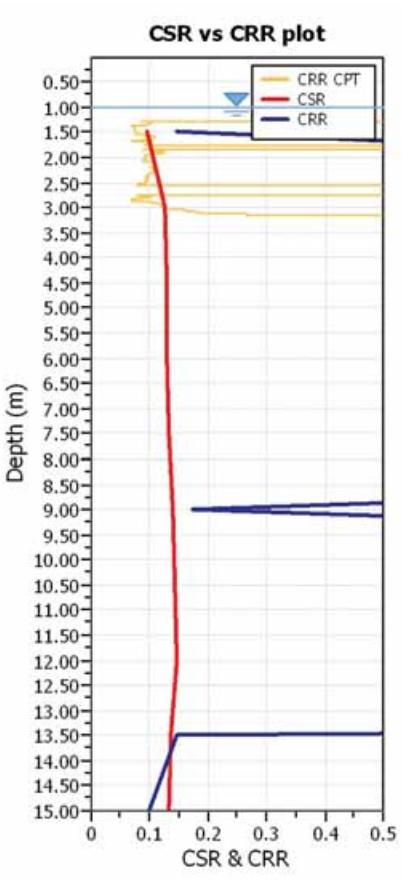
Location : R6 - East Belfast, Christchurch

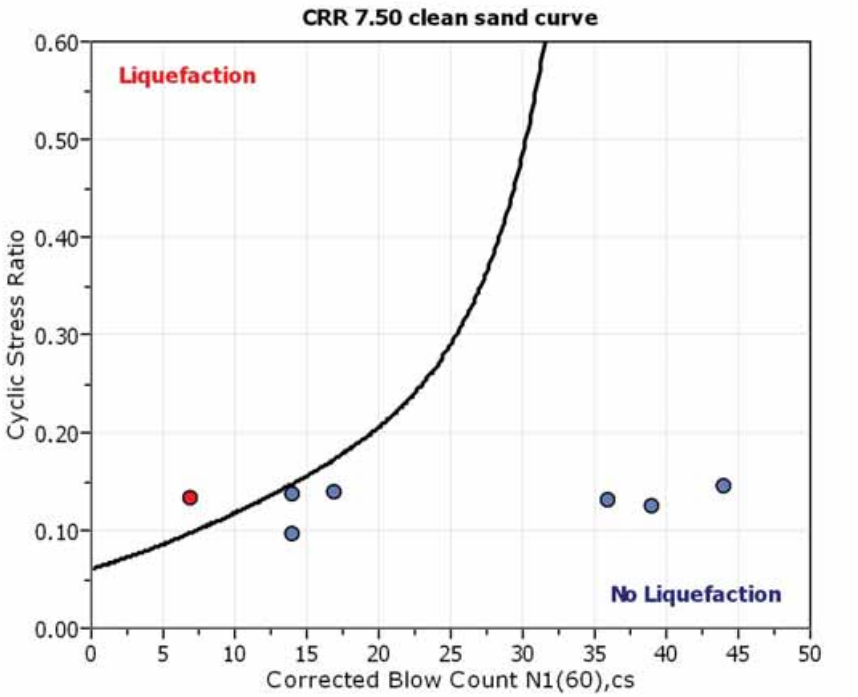
CPT file : BH1 - SLS

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss 2004	G.W.T. (in-situ):	1.50
Fines correction method:	Boulanger & Idriss 2004	G.W.T. (earthq.):	1.00
Sampling method:	Standard Sample	Earthquake magnitude M_w:	7.50
Borehole diameter:	65 mm to 11 5mm	Peak ground acceleration:	0.13
Rod length:	1.50	SPT results rounding mode:	Nearest
Hammer energy ratio:	1.43		







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SPT BASED LIQUEFACTION ANALYSIS REPORT

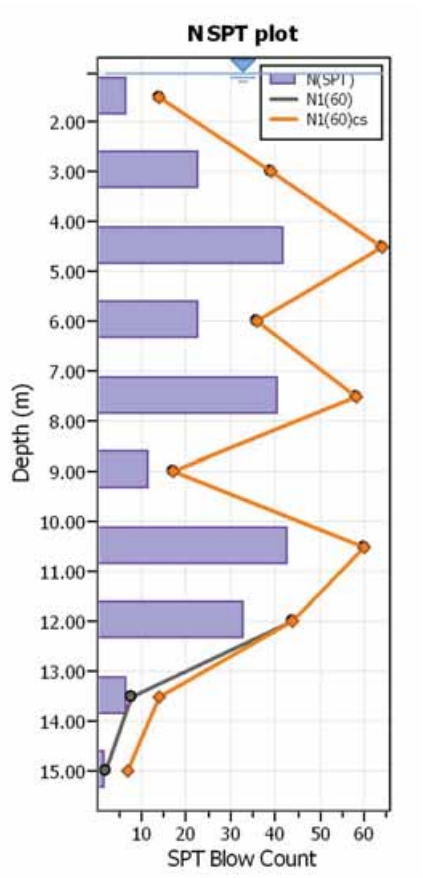
Project title : GENZCHRI15602AB

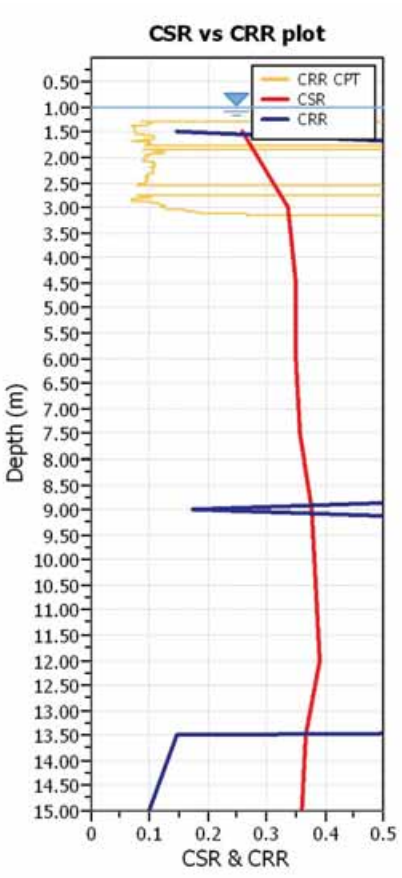
Location : R6 - East Belfast, Christchurch

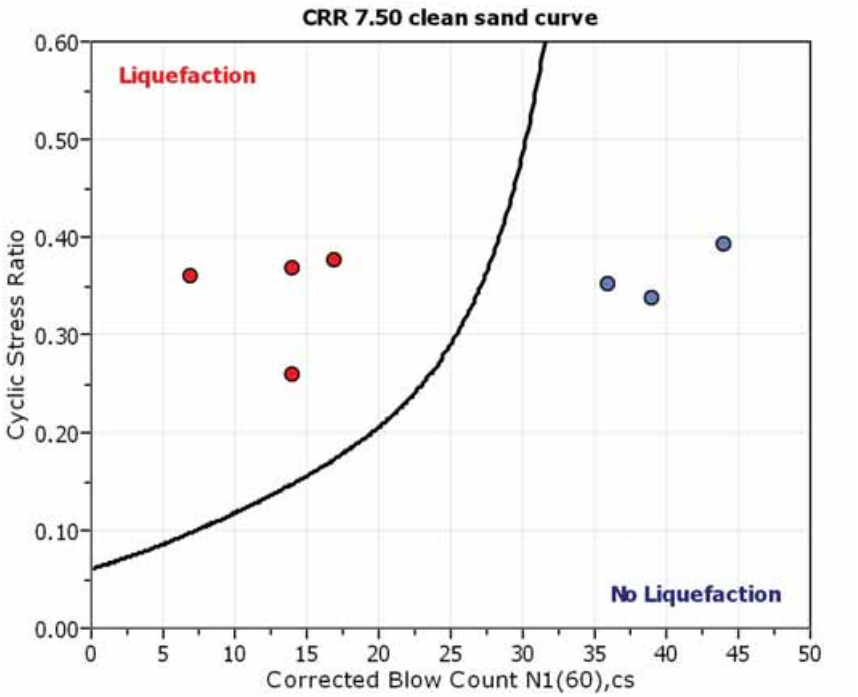
CPT file : BH1 - ULS

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss 2004	G.W.T. (in-situ):	1.50
Fines correction method:	Boulanger & Idriss 2004	G.W.T. (earthq.):	1.00
Sampling method:	Standard Sample	Earthquake magnitude M_w:	7.50
Borehole diameter:	65 mm to 11 5mm	Peak ground acceleration:	0.35
Rod length:	1.50	SPT results rounding mode:	Nearest
Hammer energy ratio:	1.43		







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SPT BASED LIQUEFACTION ANALYSIS REPORT

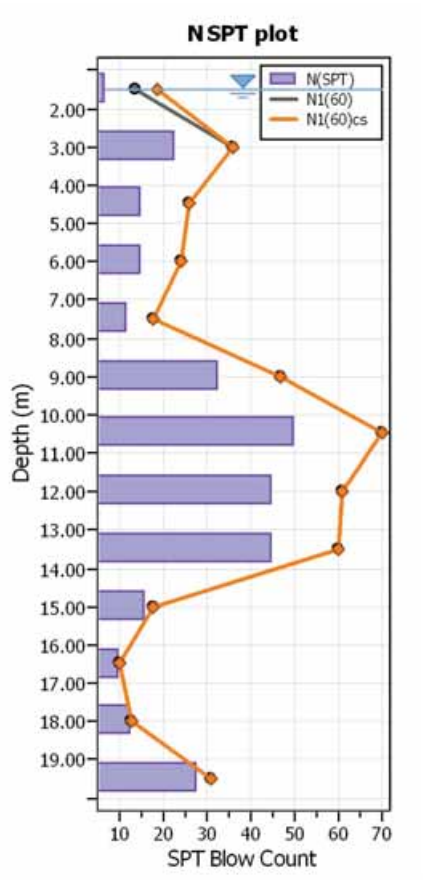
Project title : GENZCHRI15602AB

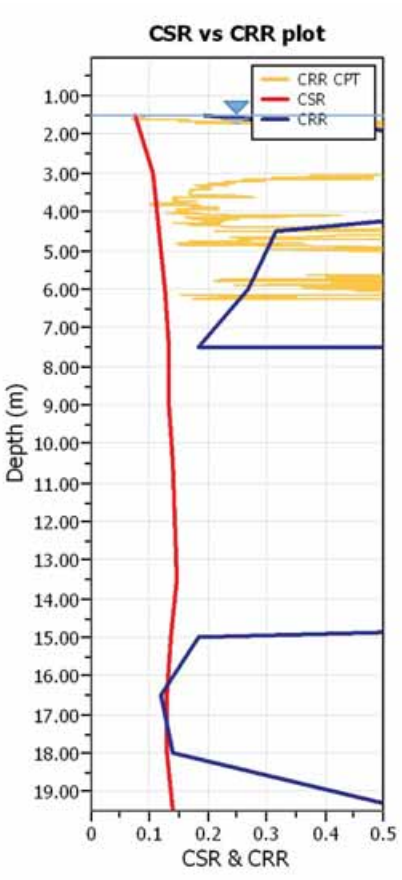
Location : R6 - East Belfast, Christchurch

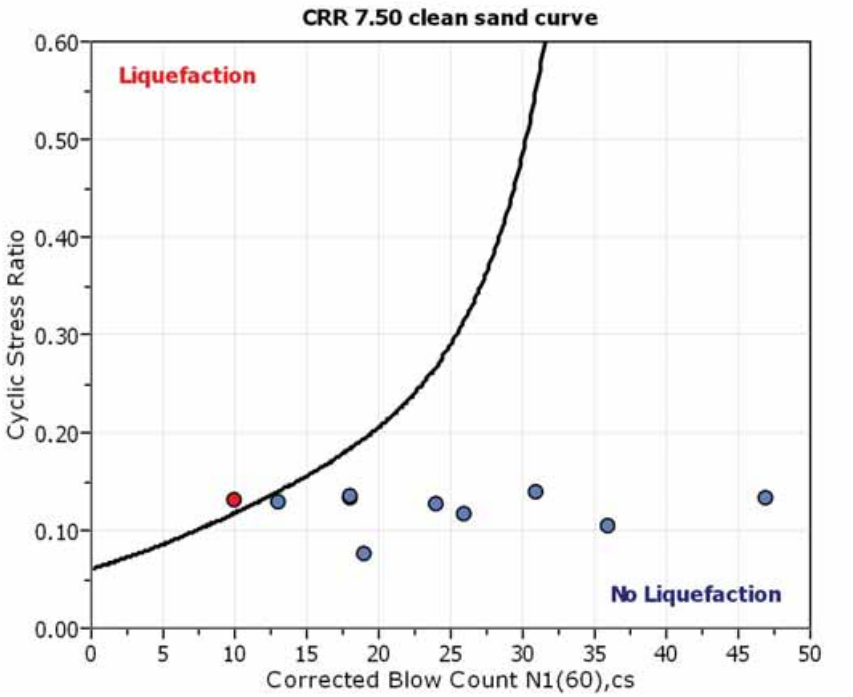
CPT file : BH2 - SLS

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss 2004	G.W.T. (in-situ):	2.00
Fines correction method:	Boulanger & Idriss 2004	G.W.T. (earthq.):	1.50
Sampling method:	Standard Sample	Earthquake magnitude M_w:	7.50
Borehole diameter:	65 mm to 11 5mm	Peak ground acceleration:	0.13
Rod length:	1.50	SPT results rounding mode:	Nearest
Hammer energy ratio:	1.43		







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PO Box 1872
Christchurch
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SPT BASED LIQUEFACTION ANALYSIS REPORT

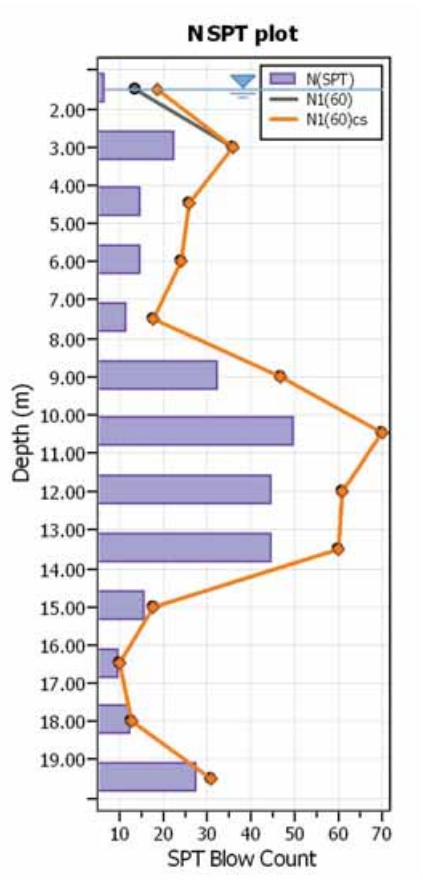
Project title : GENZCHRI15602AB

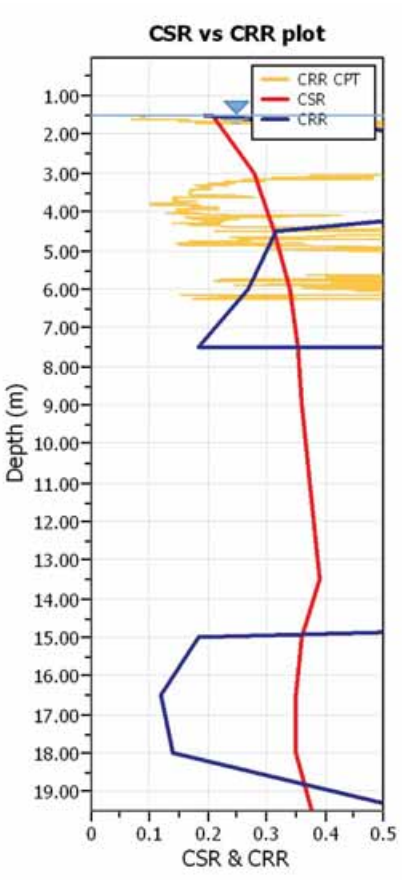
Location : R6 - East Belfast, Christchurch

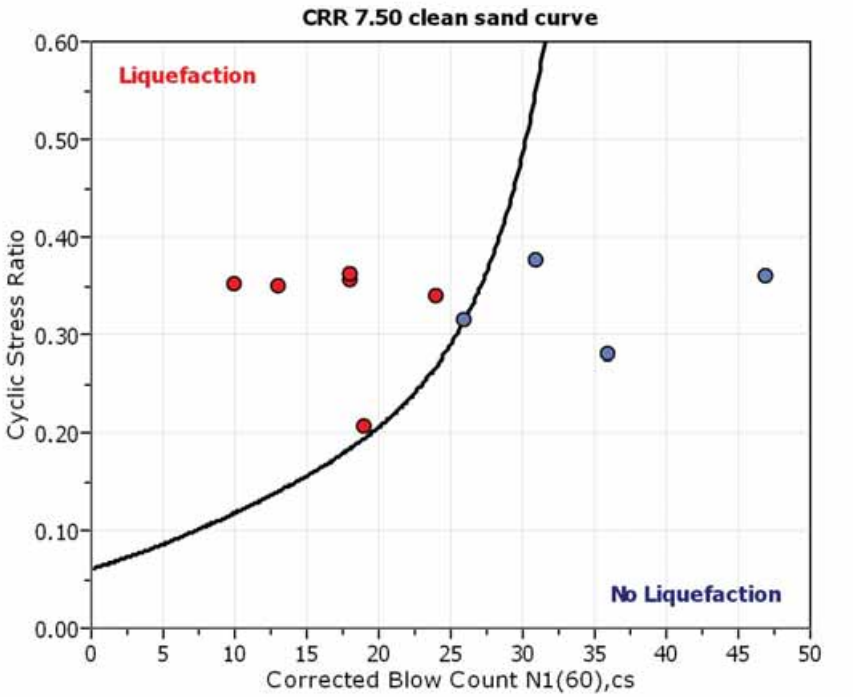
CPT file : BH2 - ULS

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss 2004	G.W.T. (in-situ):	2.00
Fines correction method:	Boulanger & Idriss 2004	G.W.T. (earthq.):	1.50
Sampling method:	Standard Sample	Earthquake magnitude M_w:	7.50
Borehole diameter:	65 mm to 11 5mm	Peak ground acceleration:	0.35
Rod length:	1.50	SPT results rounding mode:	Nearest
Hammer energy ratio:	1.43		







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Christchurch
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SPT BASED LIQUEFACTION ANALYSIS REPORT

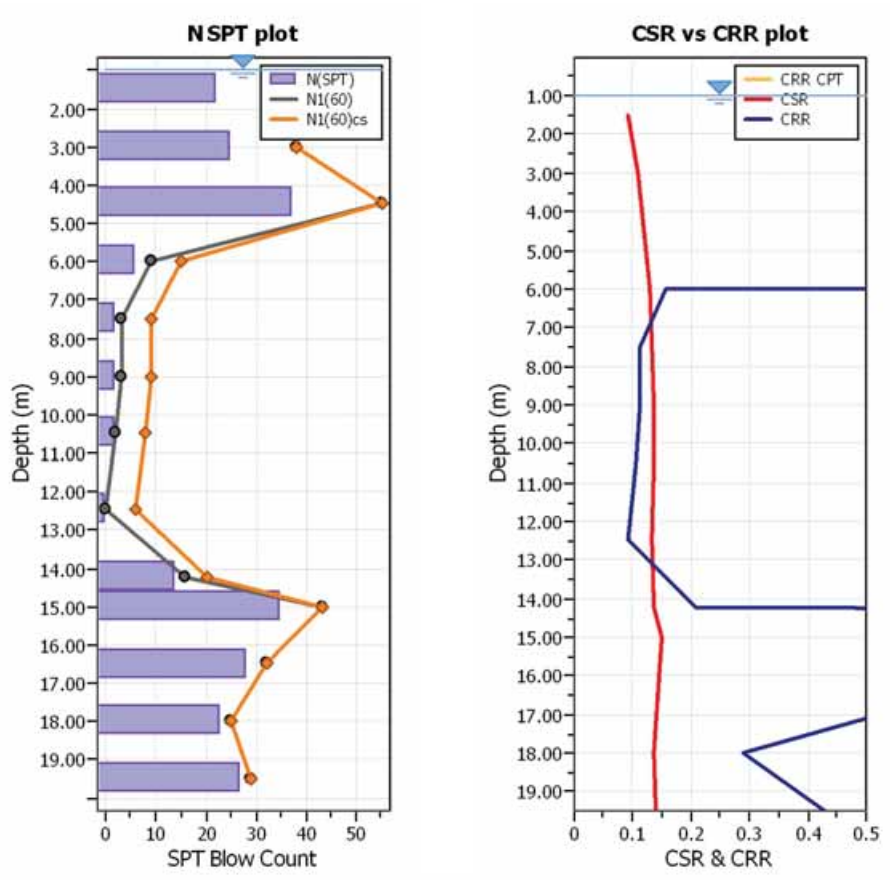
Project title : GENZCHRI15602AB

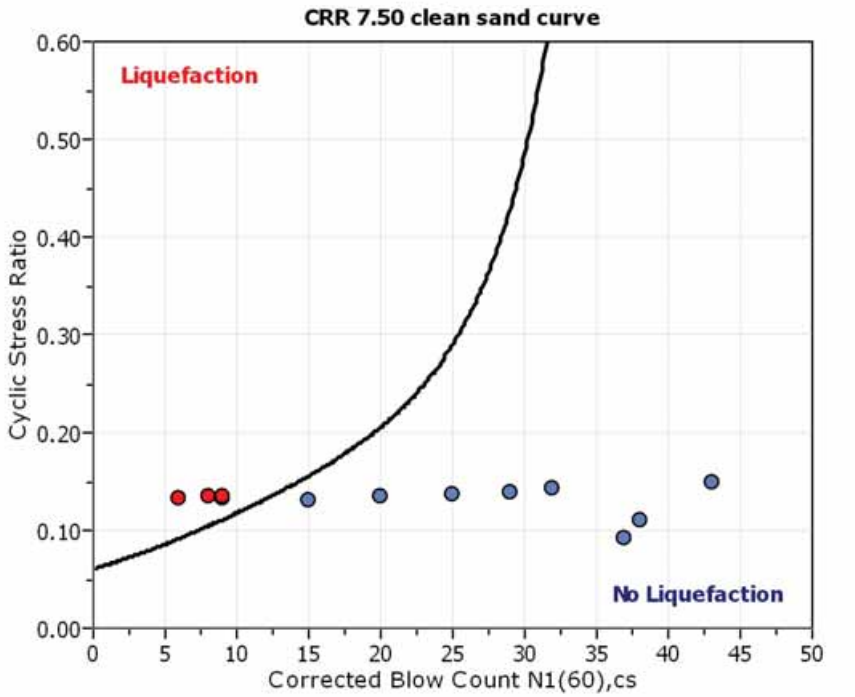
Location : R6 - East Belfast, Christchurch

CPT file : BH3 - SLS

:: Input parameters and analysis properties ::

Analysis method:	Boulanger & Idriss 2004	G.W.T. (in-situ):	1.50
Fines correction method:	Boulanger & Idriss 2004	G.W.T. (earthq.):	1.00
Sampling method:	Standard Sample	Earthquake magnitude M_w:	7.50
Borehole diameter:	65 mm to 11 5mm	Peak ground acceleration:	0.13
Rod length:	1.50	SPT results rounding mode:	Nearest
Hammer energy ratio:	1.43		





Coffey Geotechnics
PO Box 1872
Christchurch
8140

SPT BASED LIQUEFACTION ANALYSIS REPORT

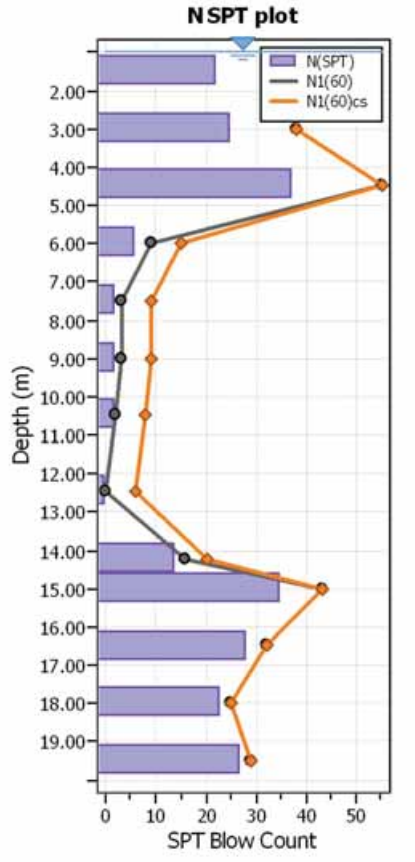
Project title : GENZCHRI15602AB

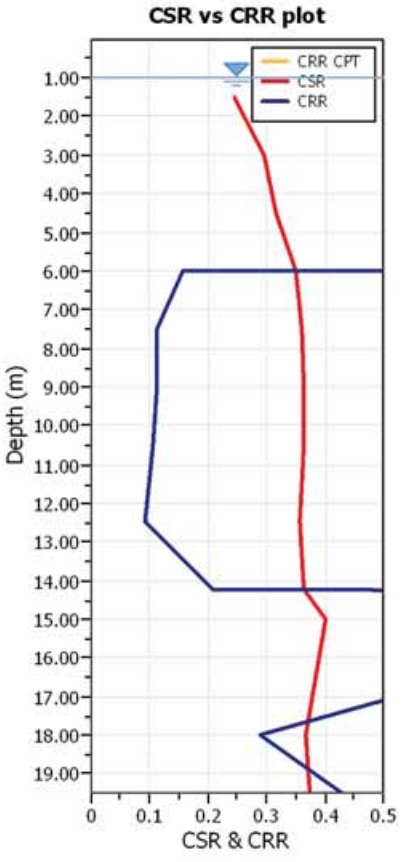
Location : R6 - East Belfast, Christchurch

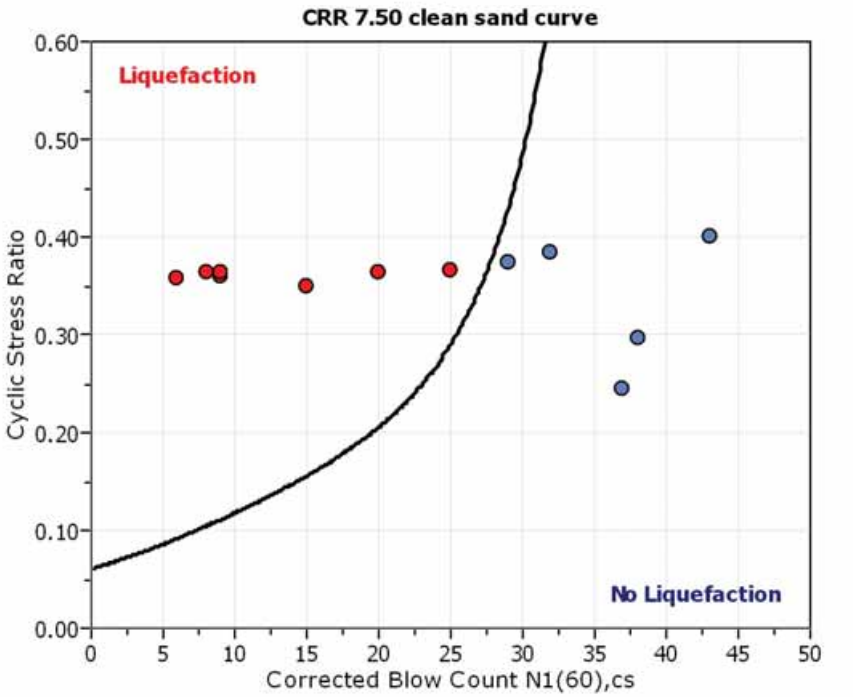
CPT file : BH3 - ULS

:: Input parameters and analysis properties ::

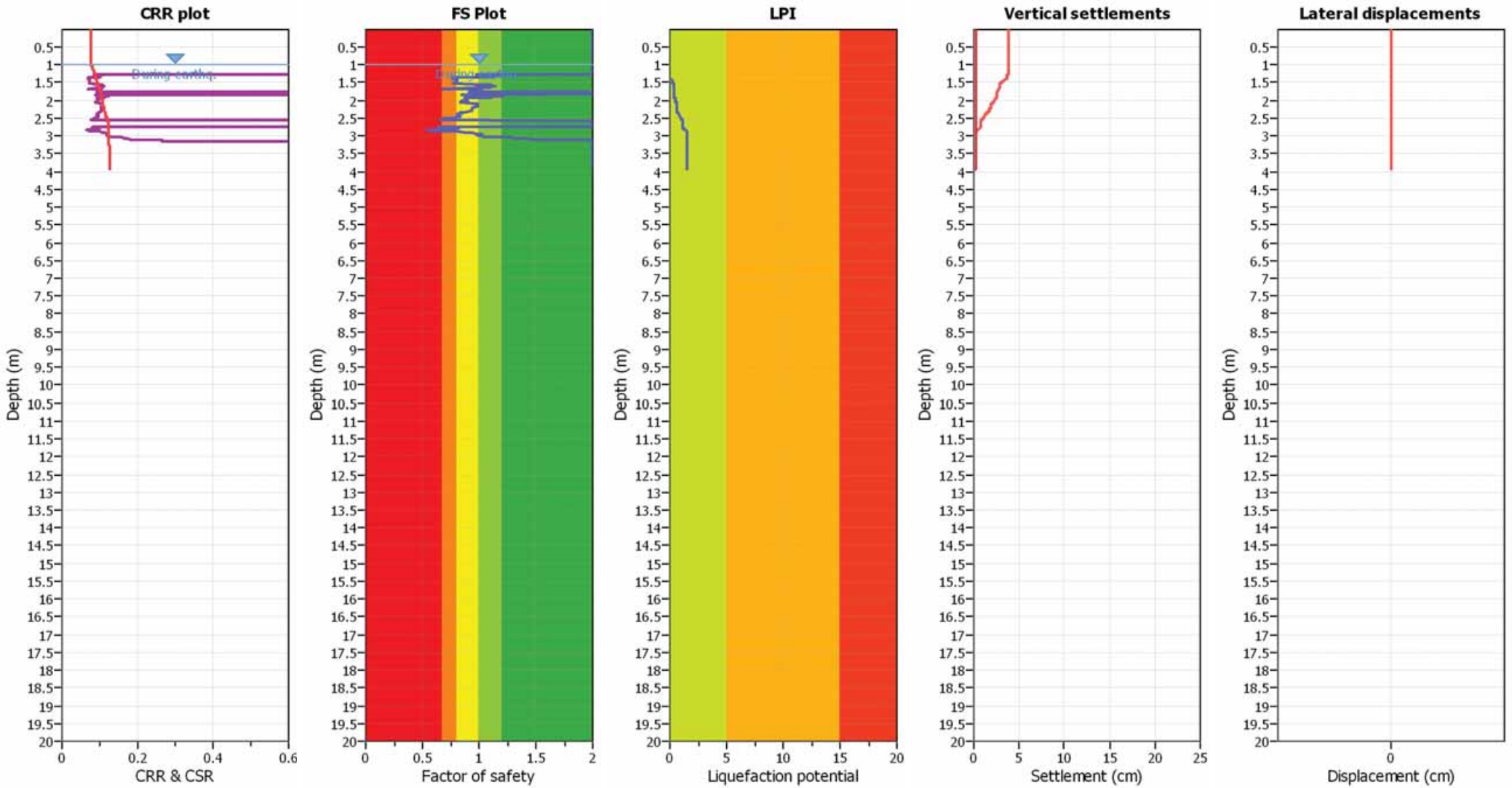
Analysis method:	Boulanger & Idriss 2004	G.W.T. (in-situ):	1.50
Fines correction method:	Boulanger & Idriss 2004	G.W.T. (earthq.):	1.00
Sampling method:	Standard Sample	Earthquake magnitude M_w:	7.50
Borehole diameter:	65 mm to 11 5mm	Peak ground acceleration:	0.35
Rod length:	1.50	SPT results rounding mode:	Nearest
Hammer energy ratio:	1.43		







Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

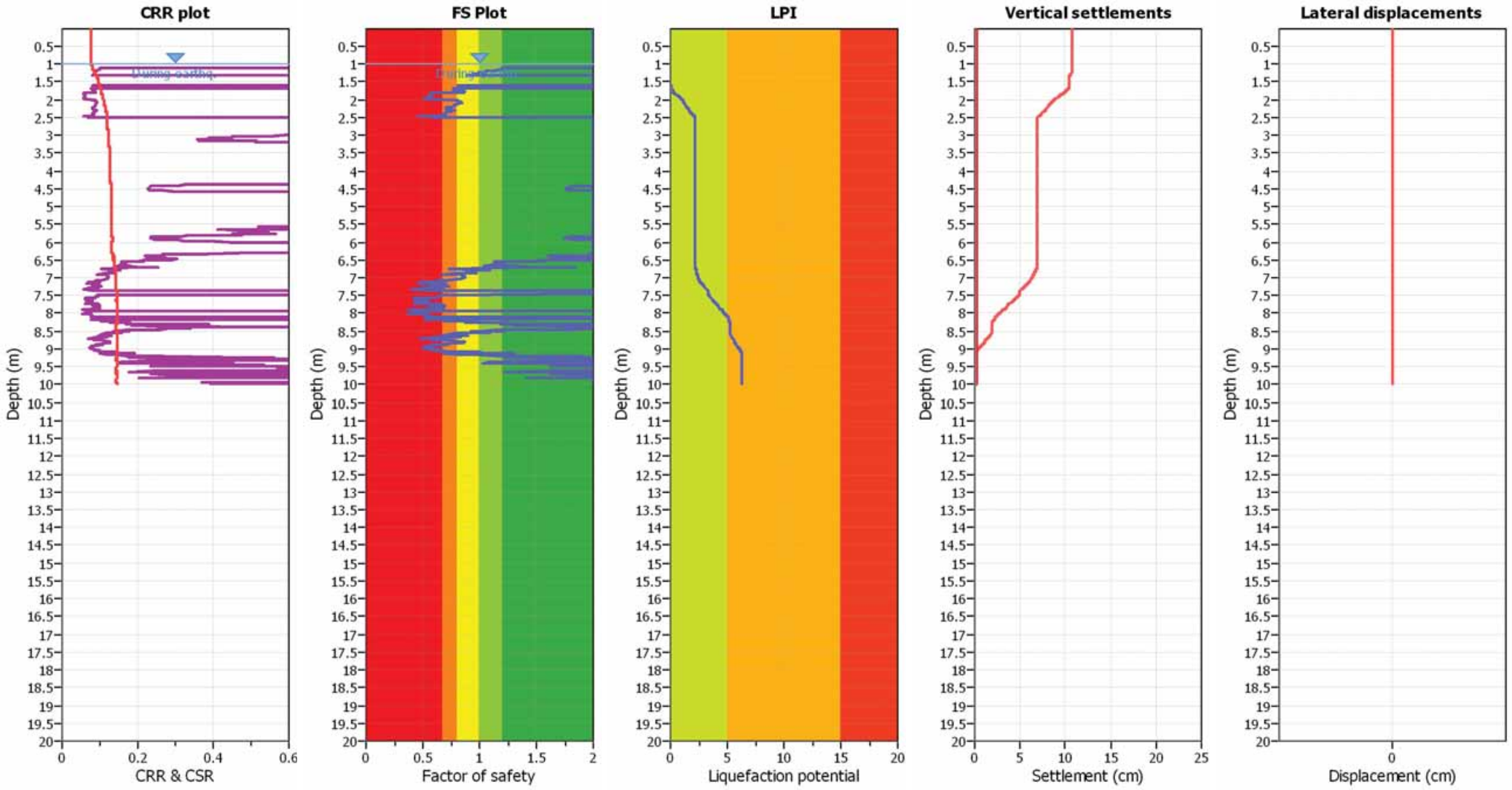
F.S. color scheme

- 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 plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

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- Very likely to liquefy
- Liquefaction and no liq. are equally likely
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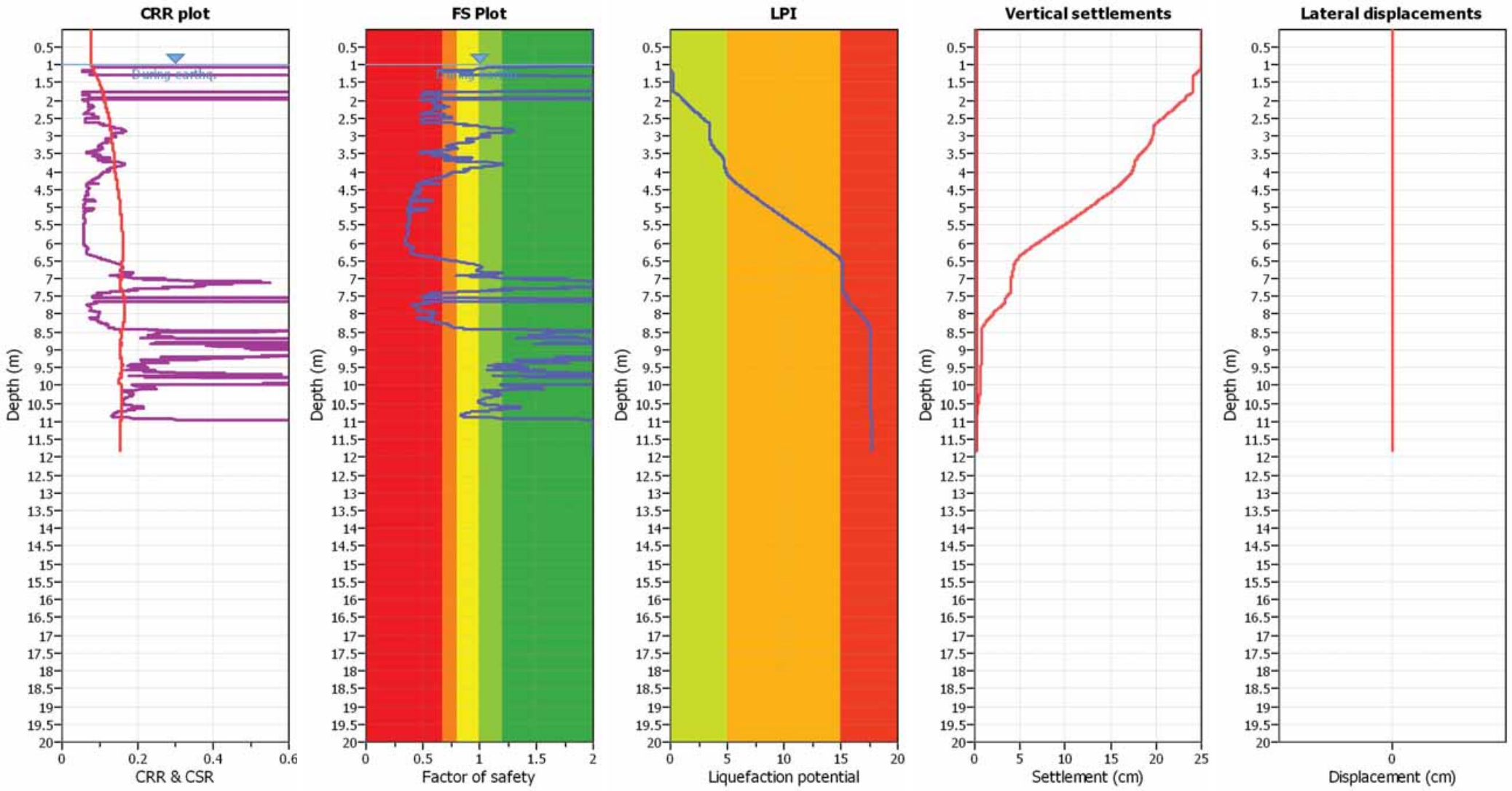
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

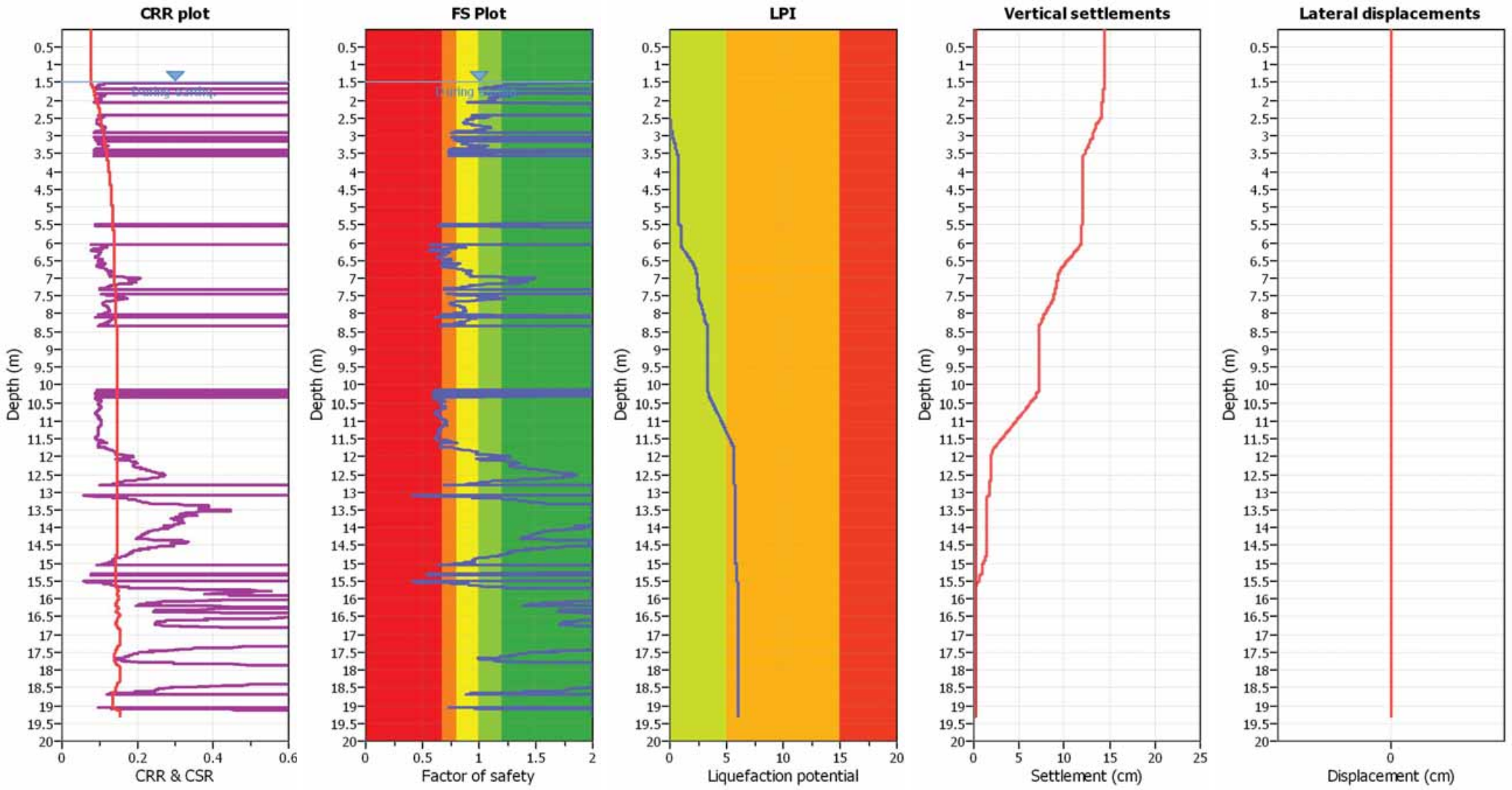
F.S. color scheme

- 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 plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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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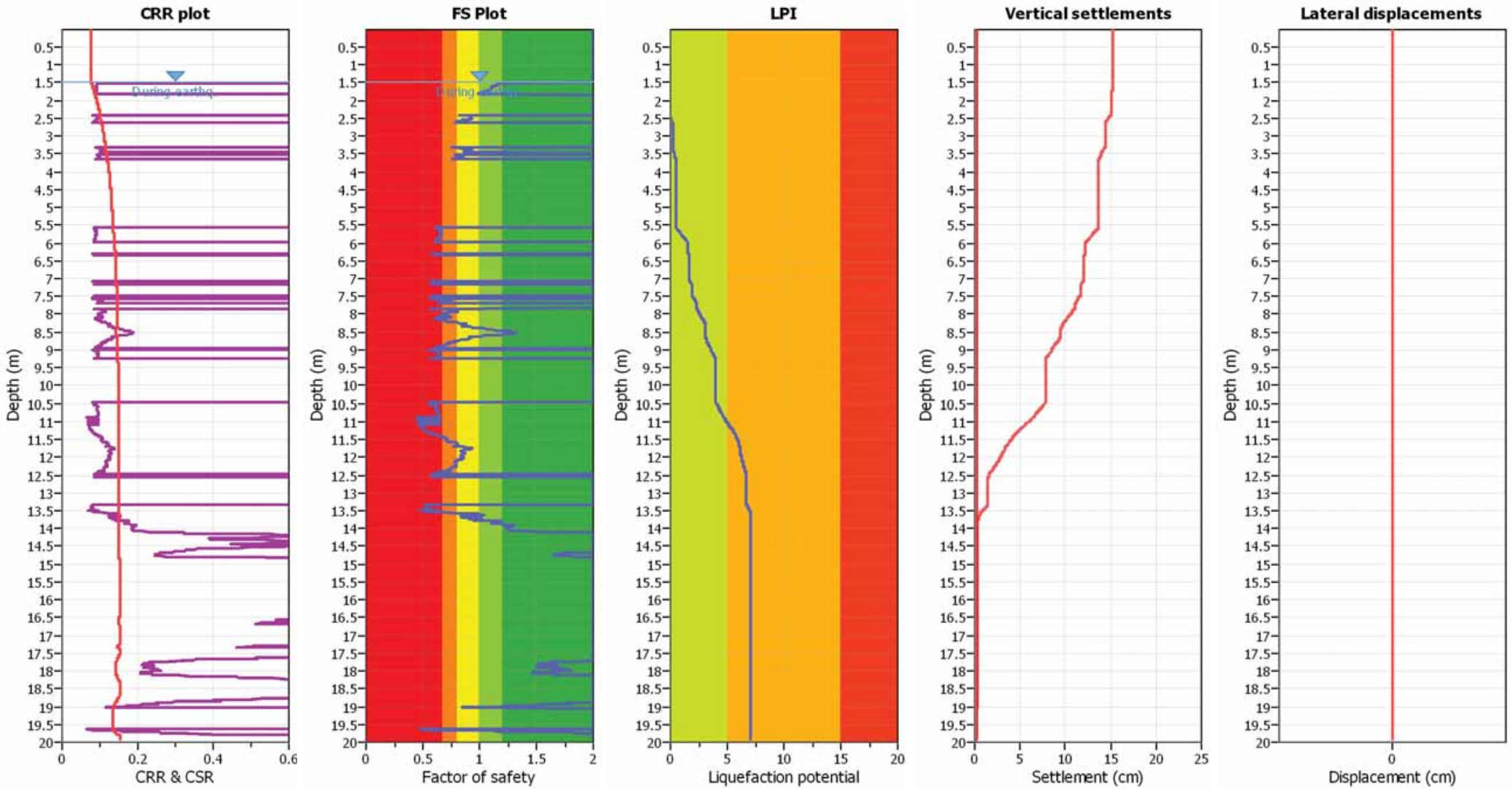
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

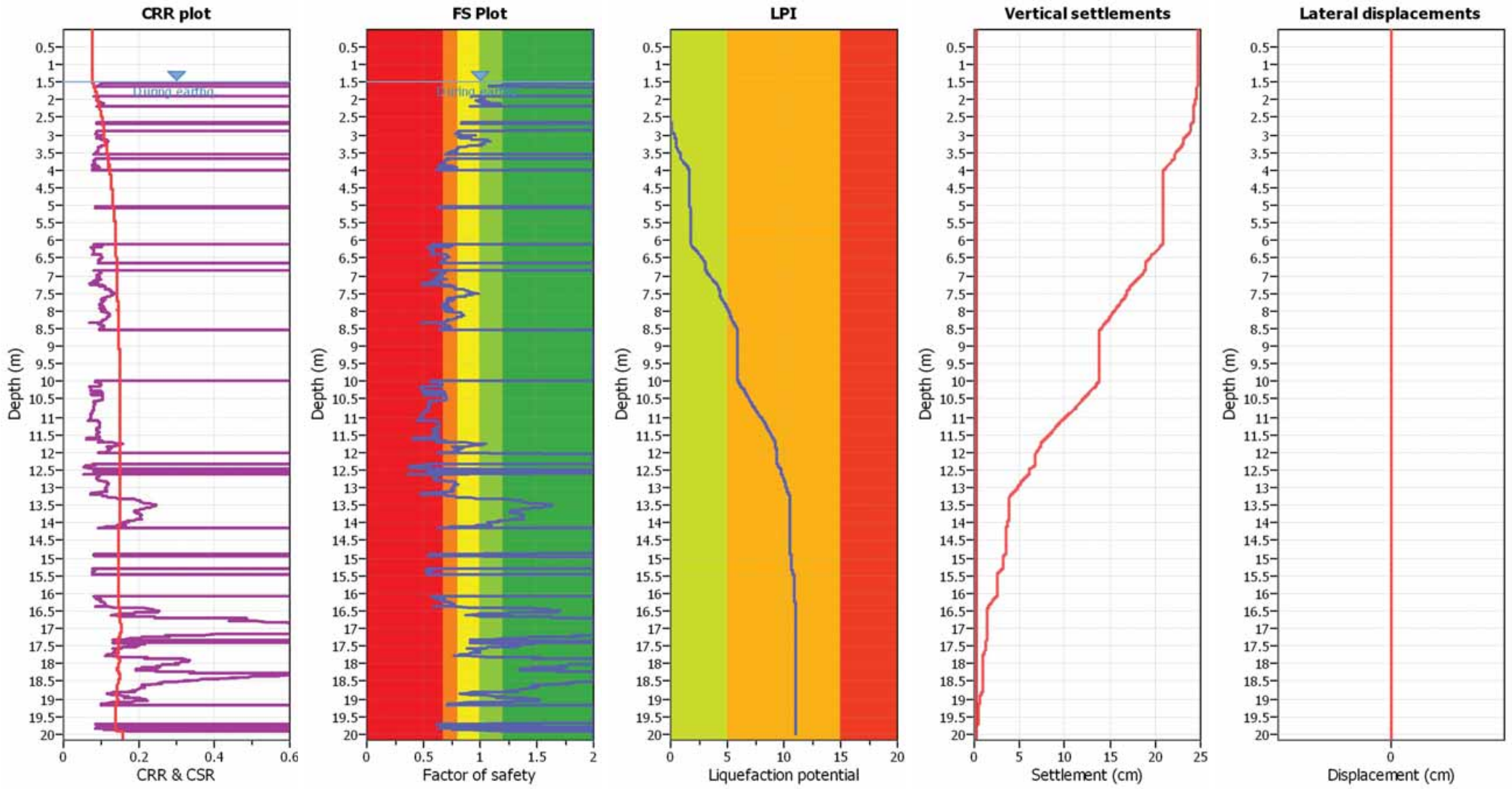
F.S. color scheme

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

LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis overall plots



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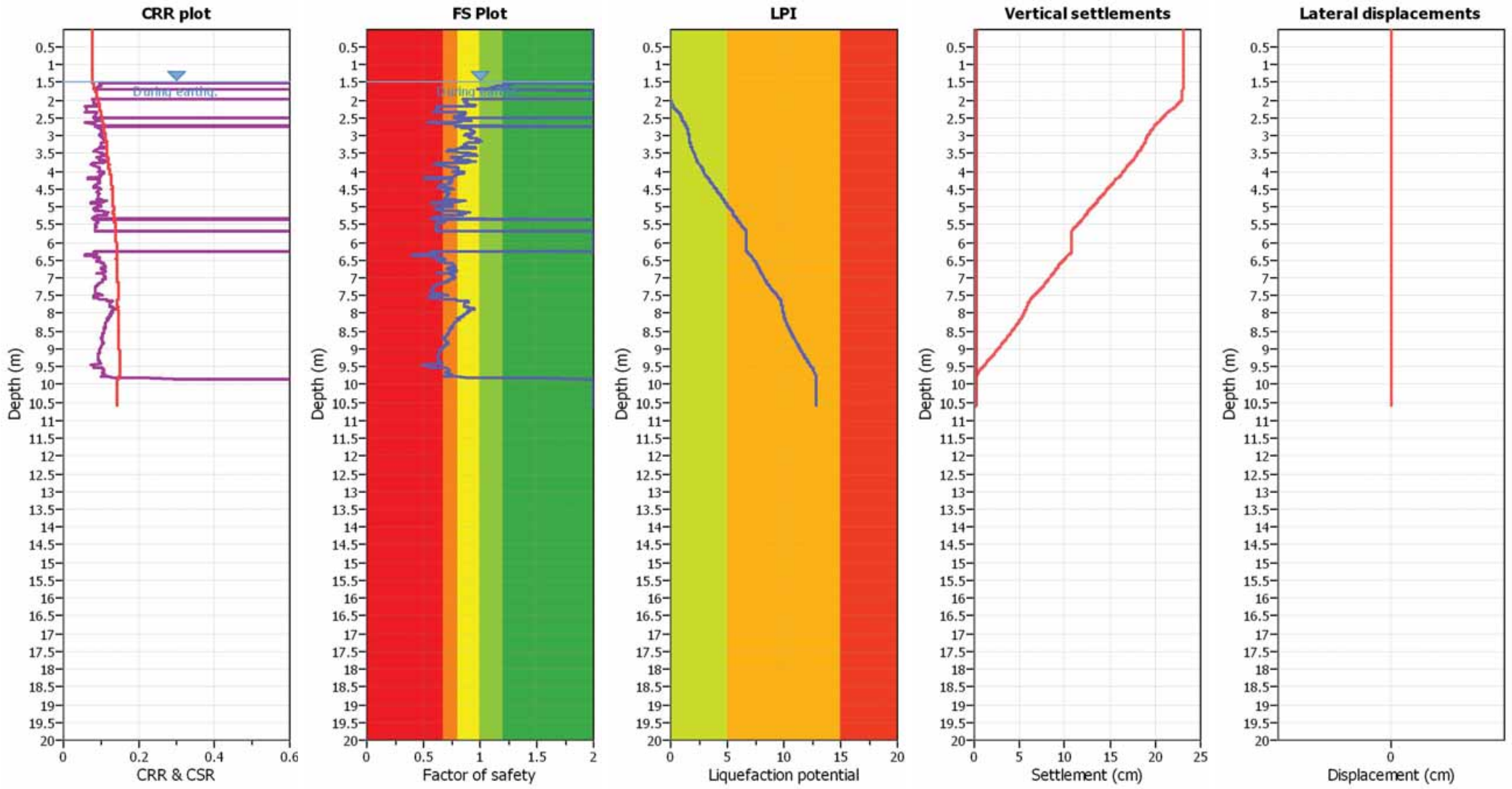

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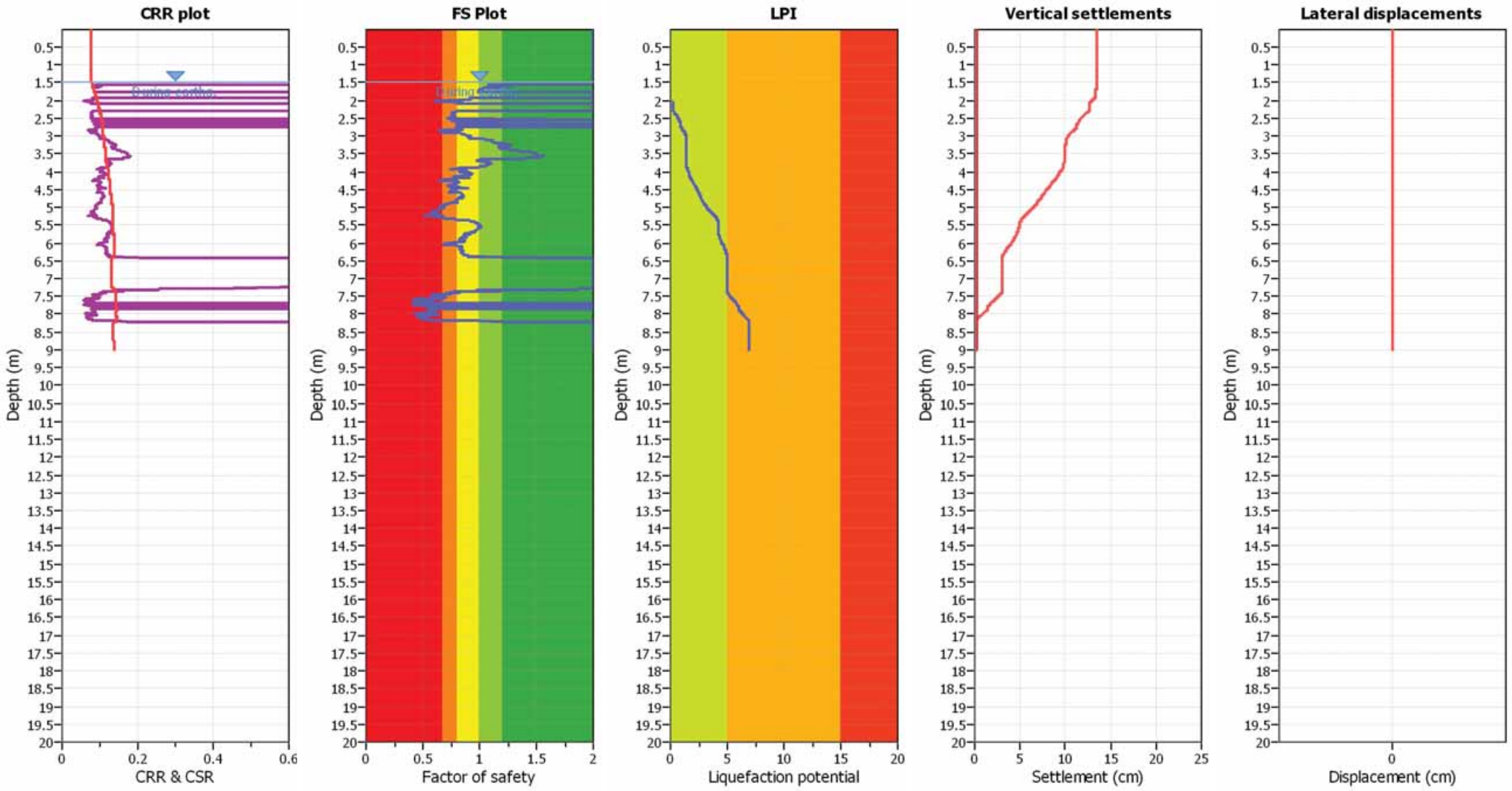

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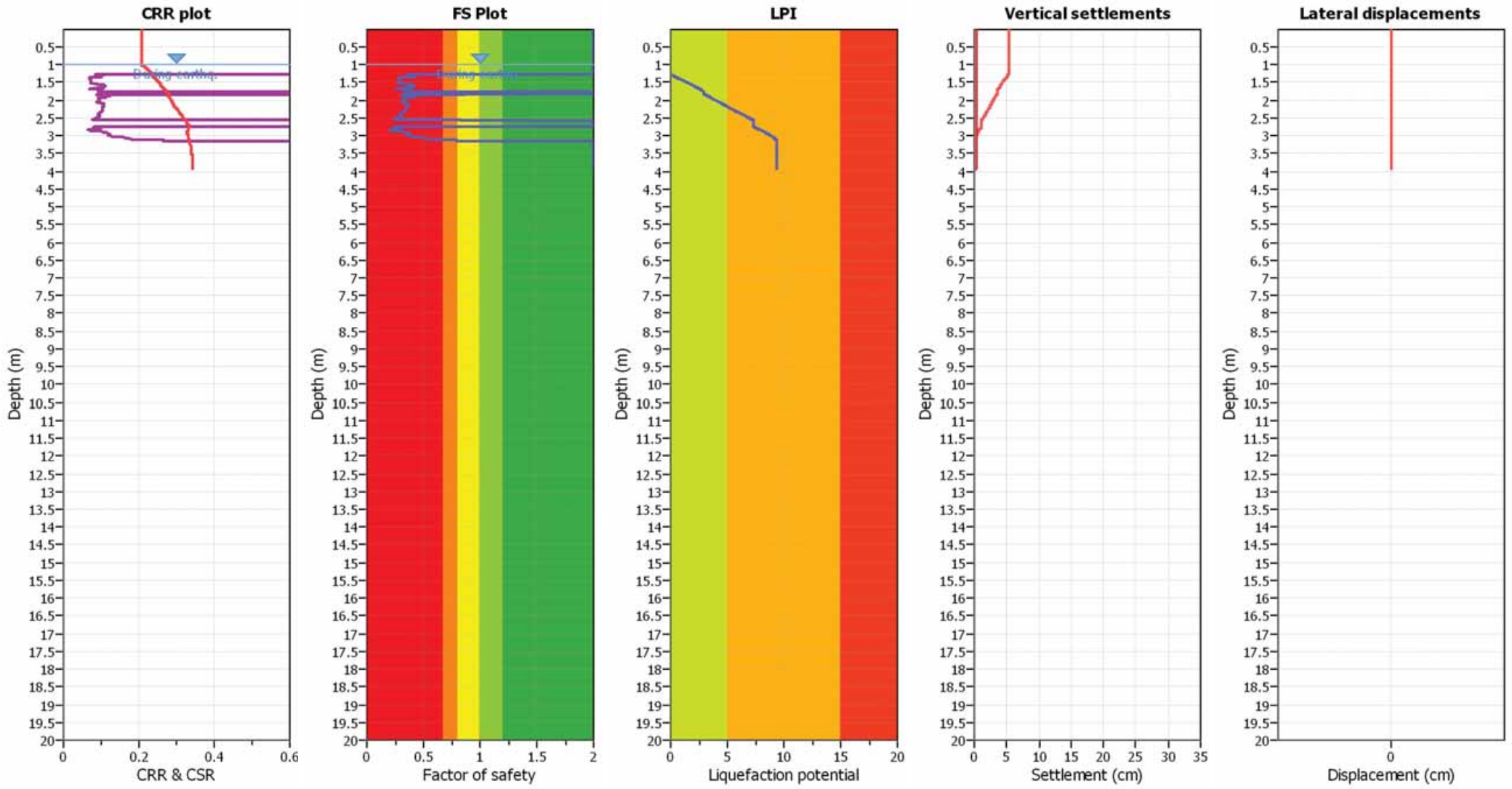

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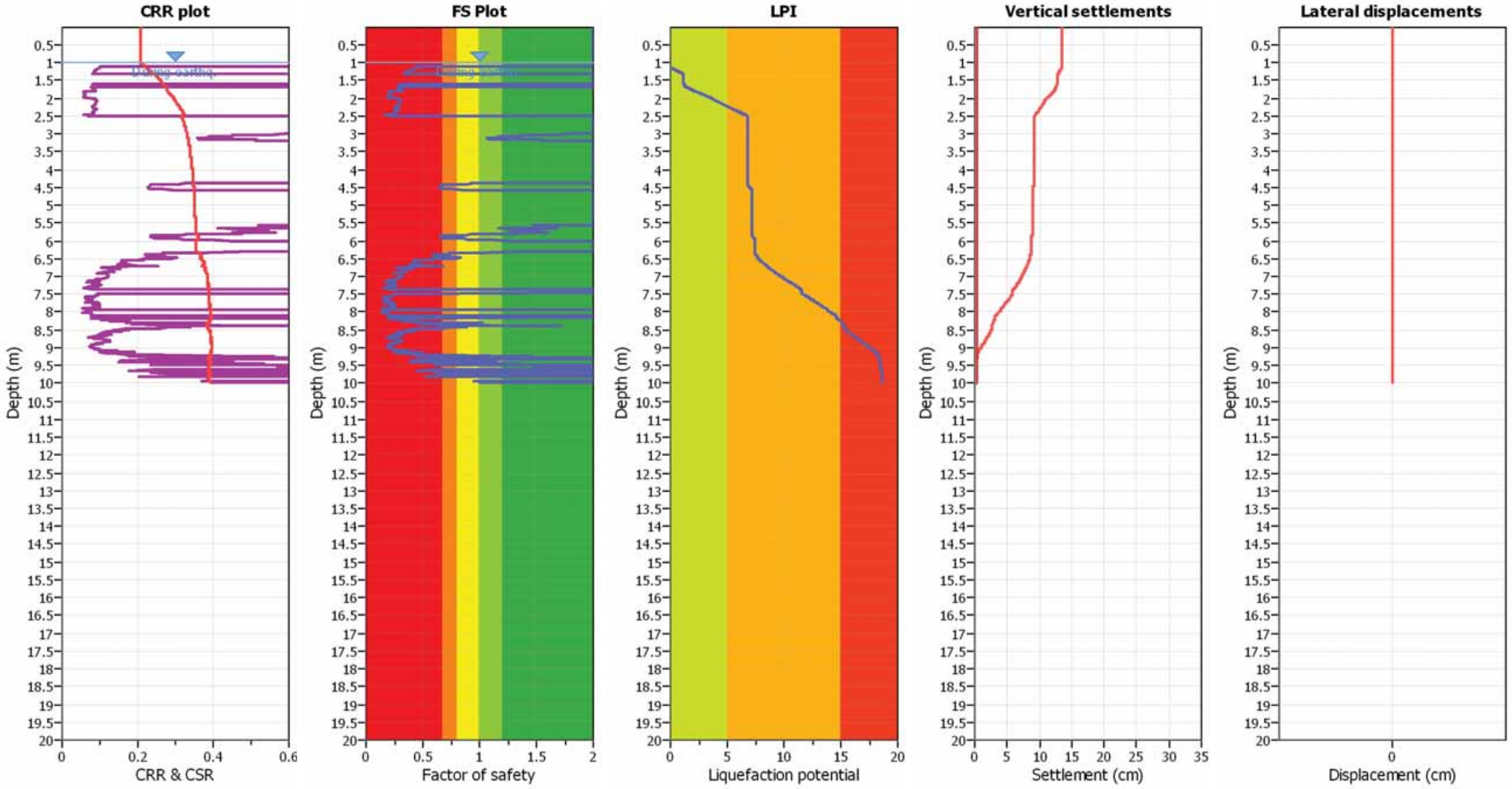

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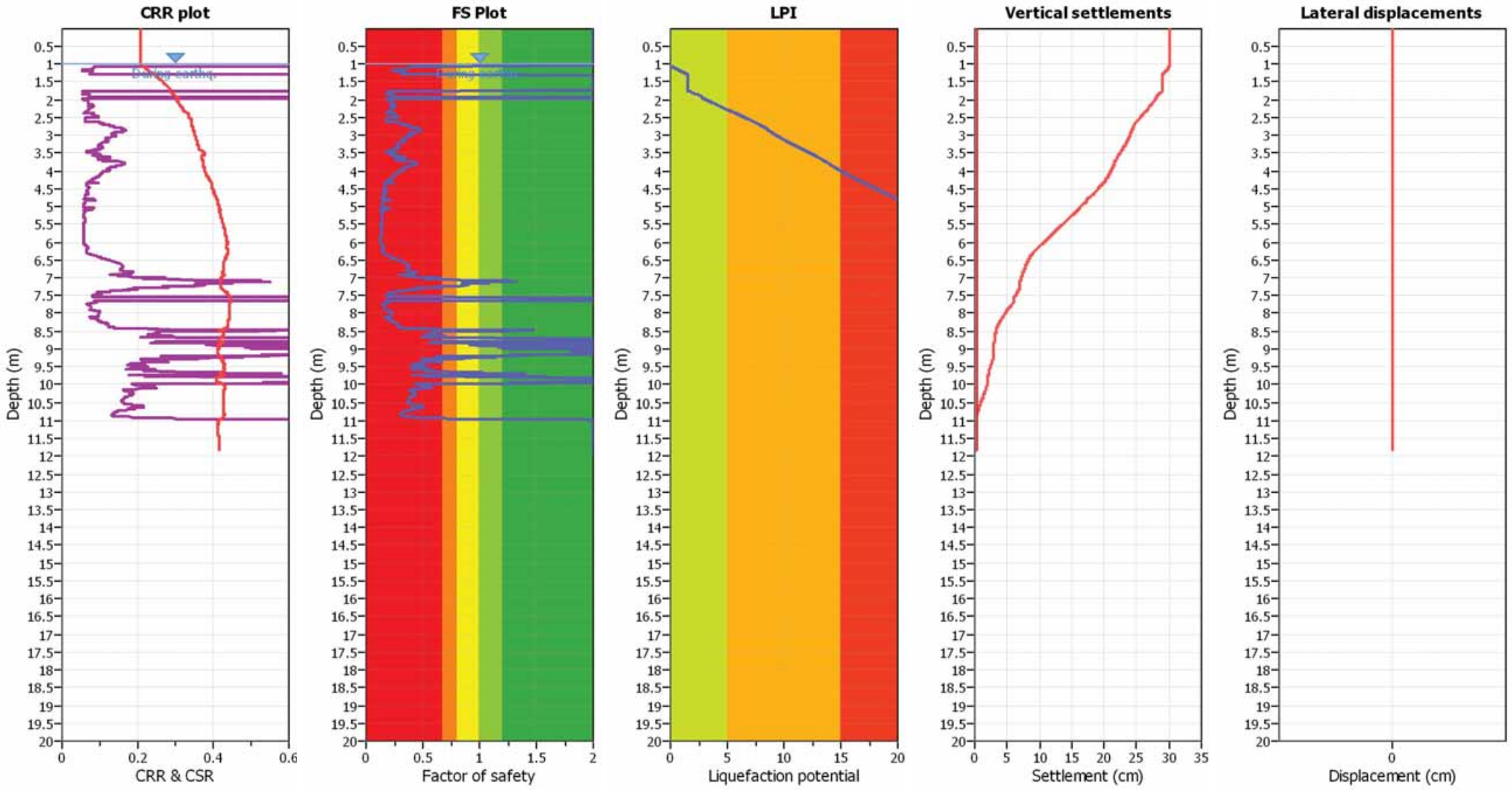

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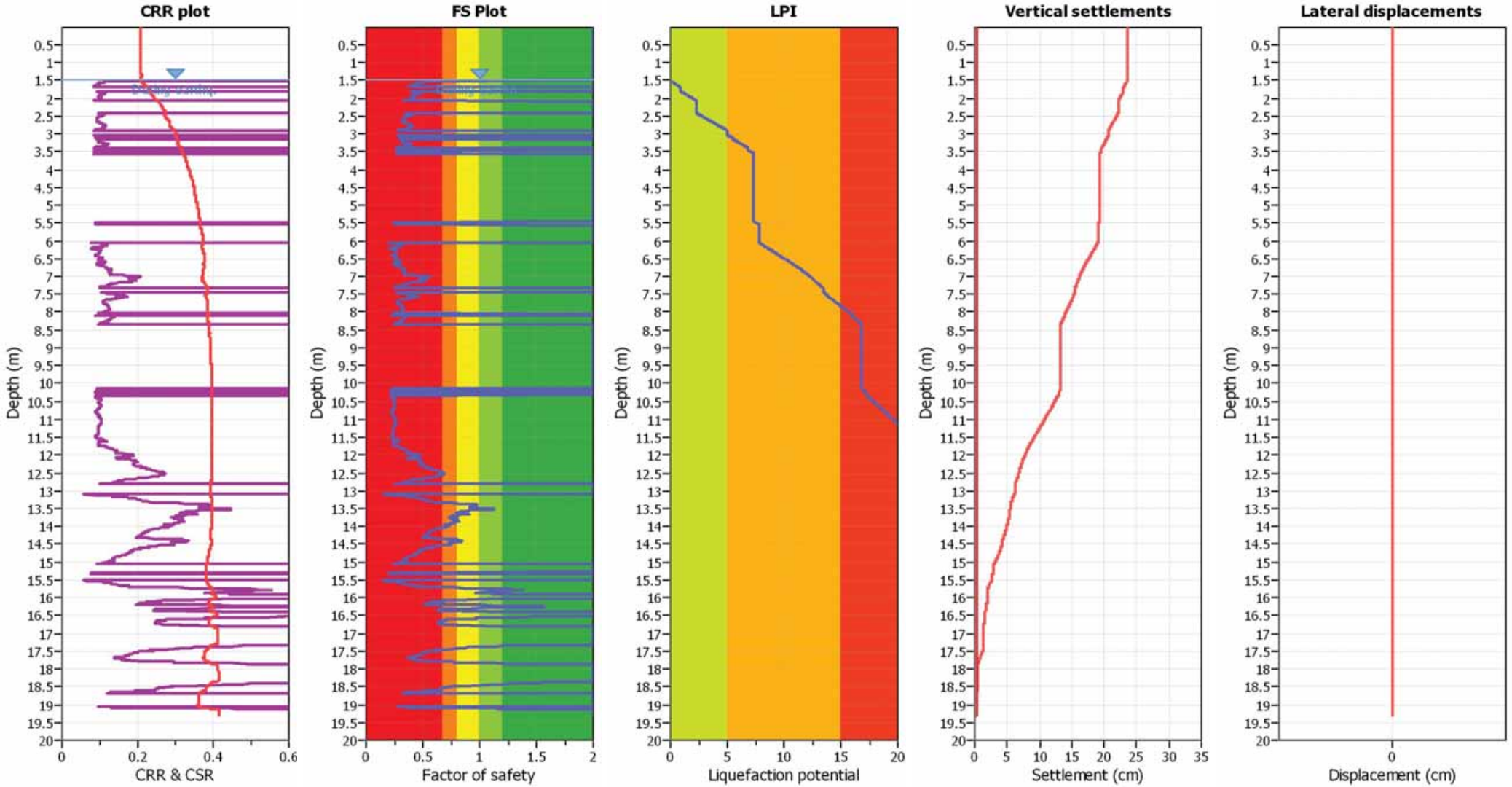

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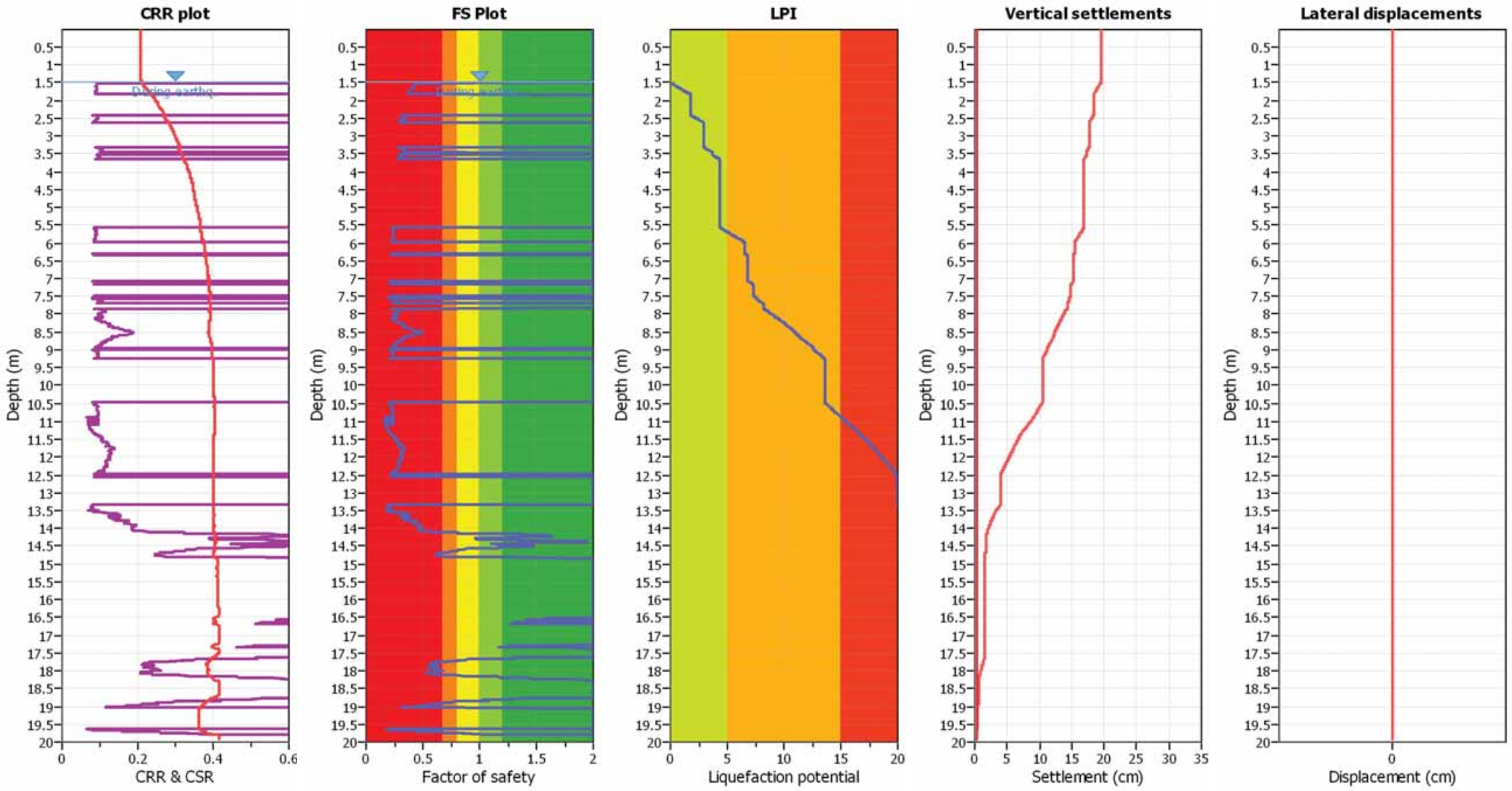

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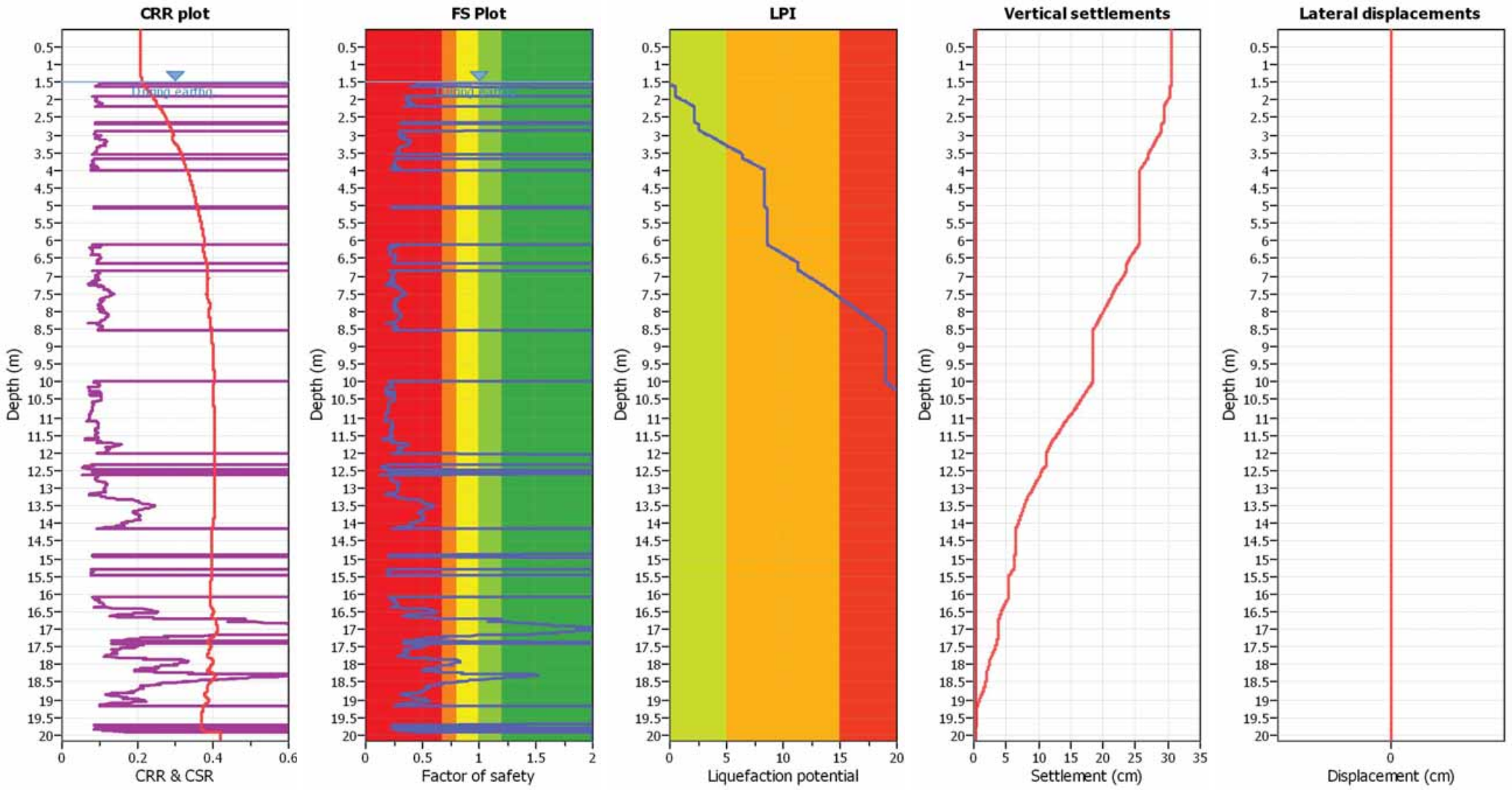

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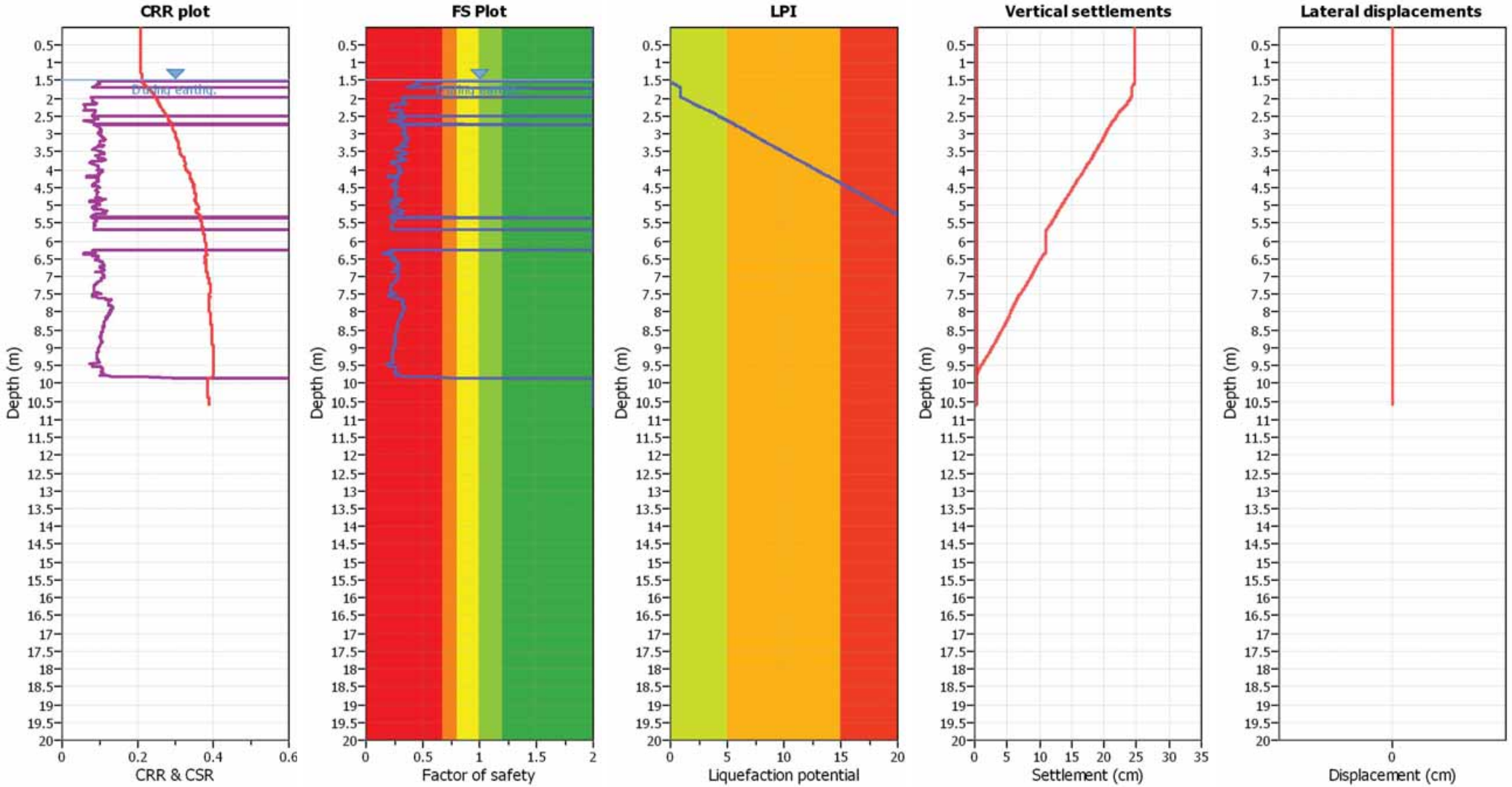

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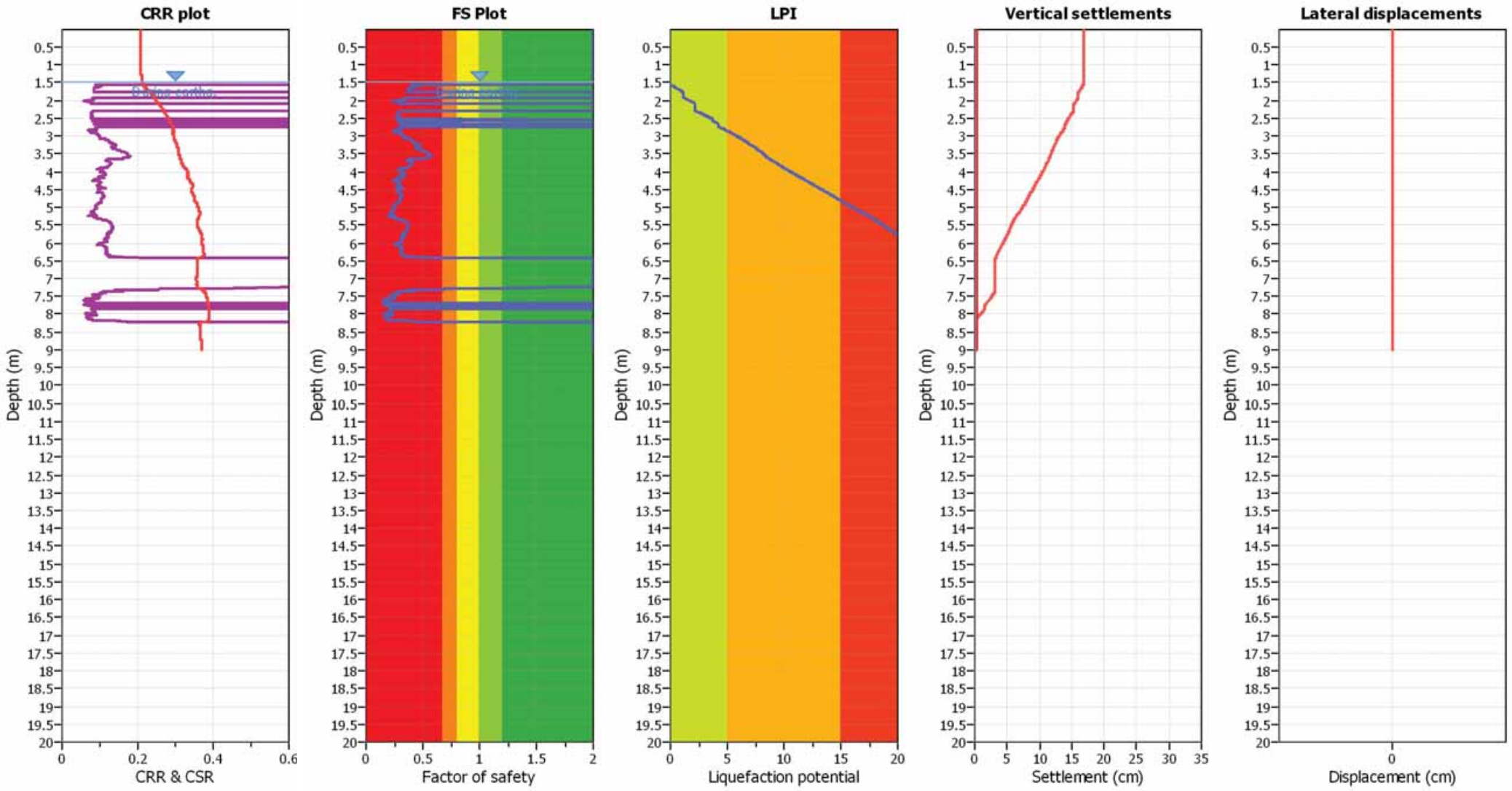

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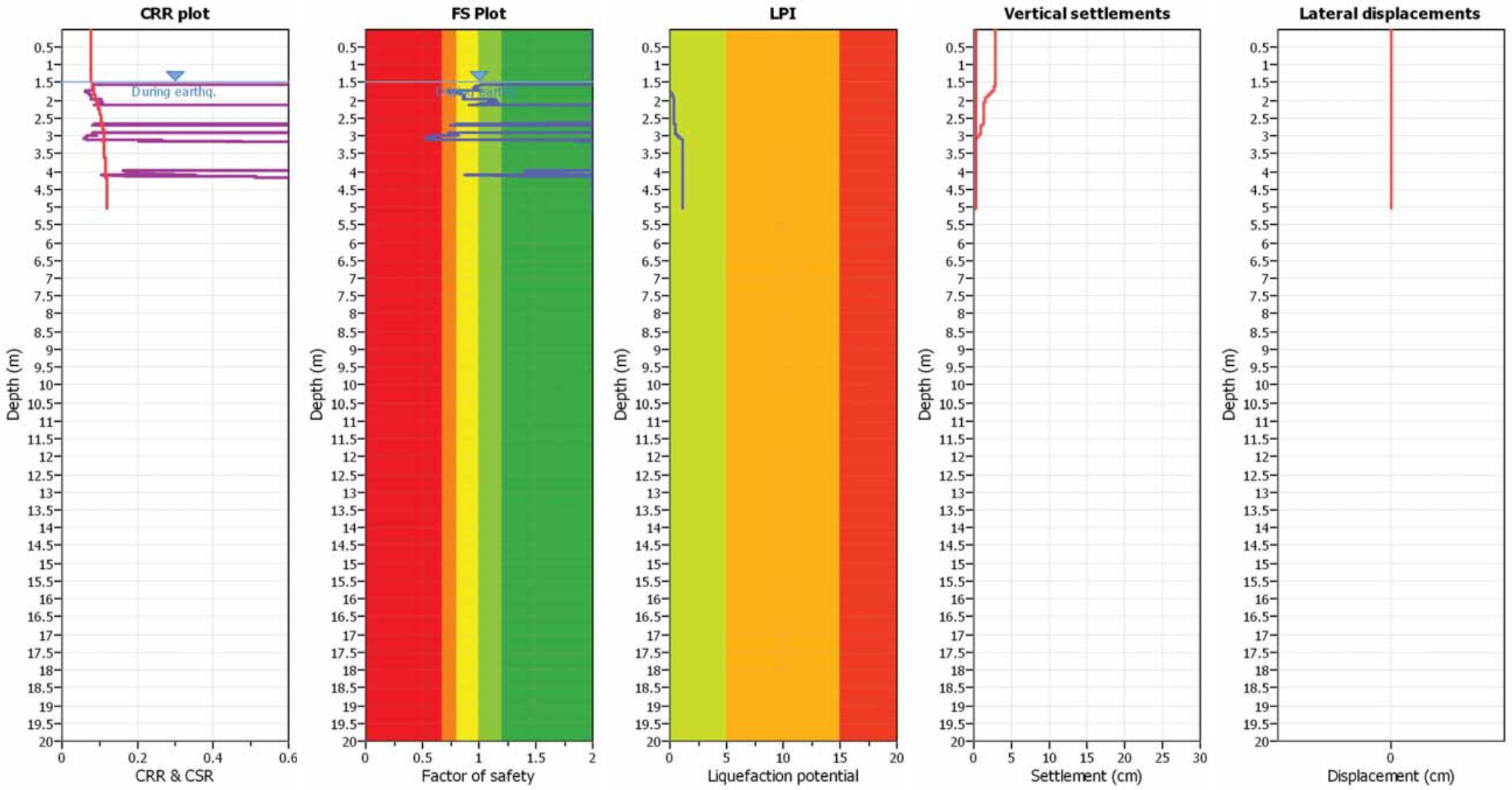

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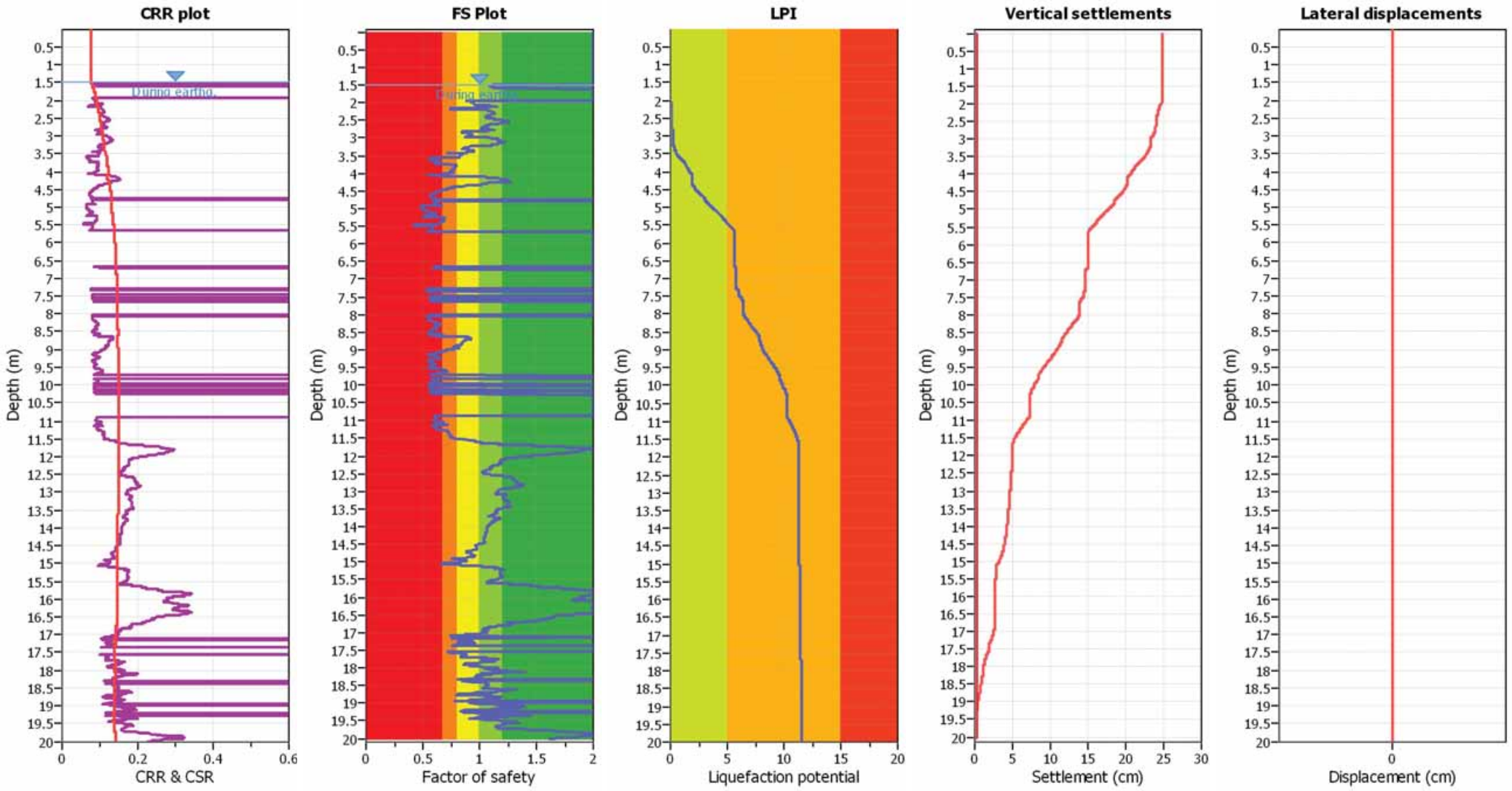

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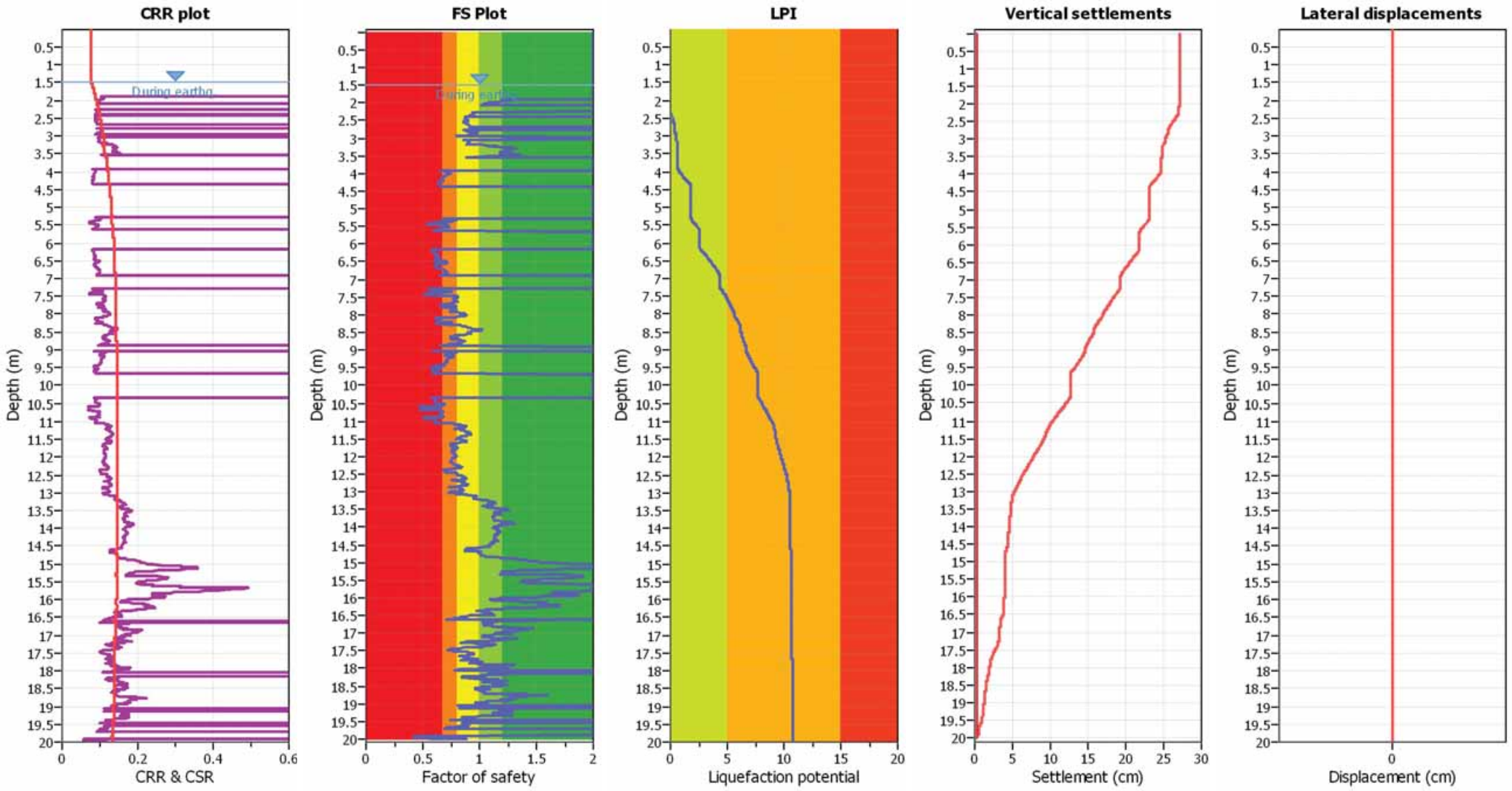

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Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

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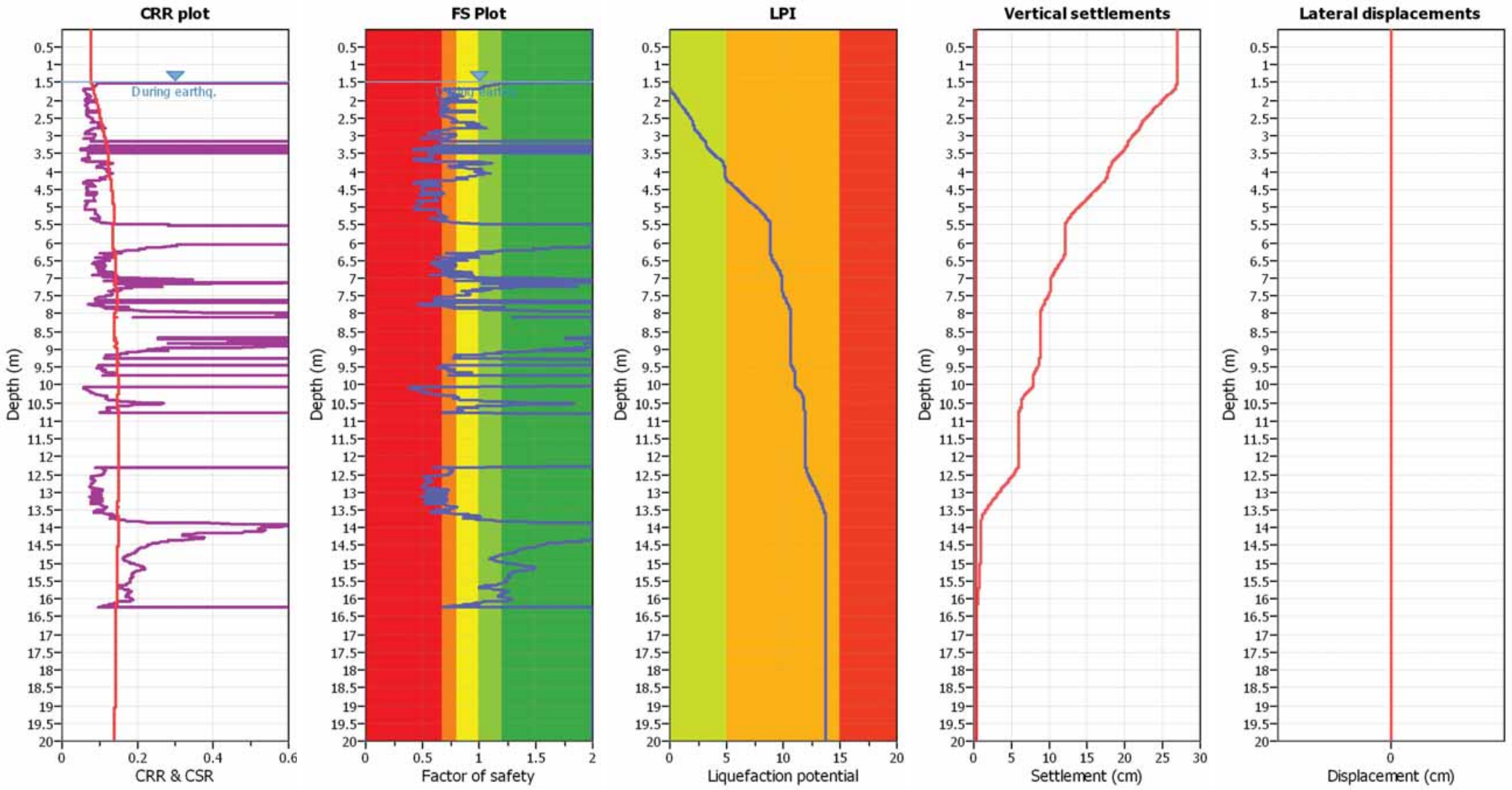

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Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

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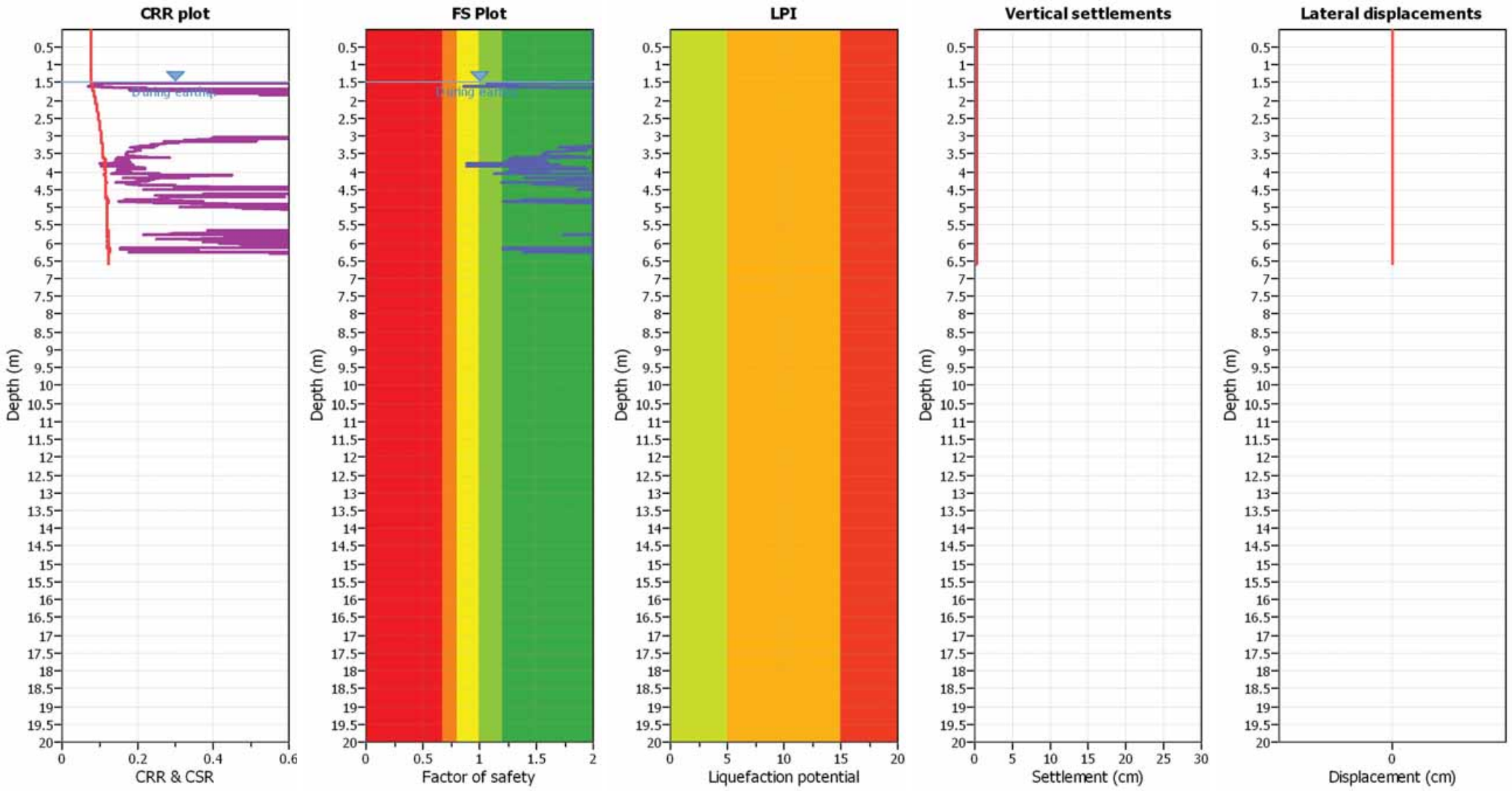

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Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

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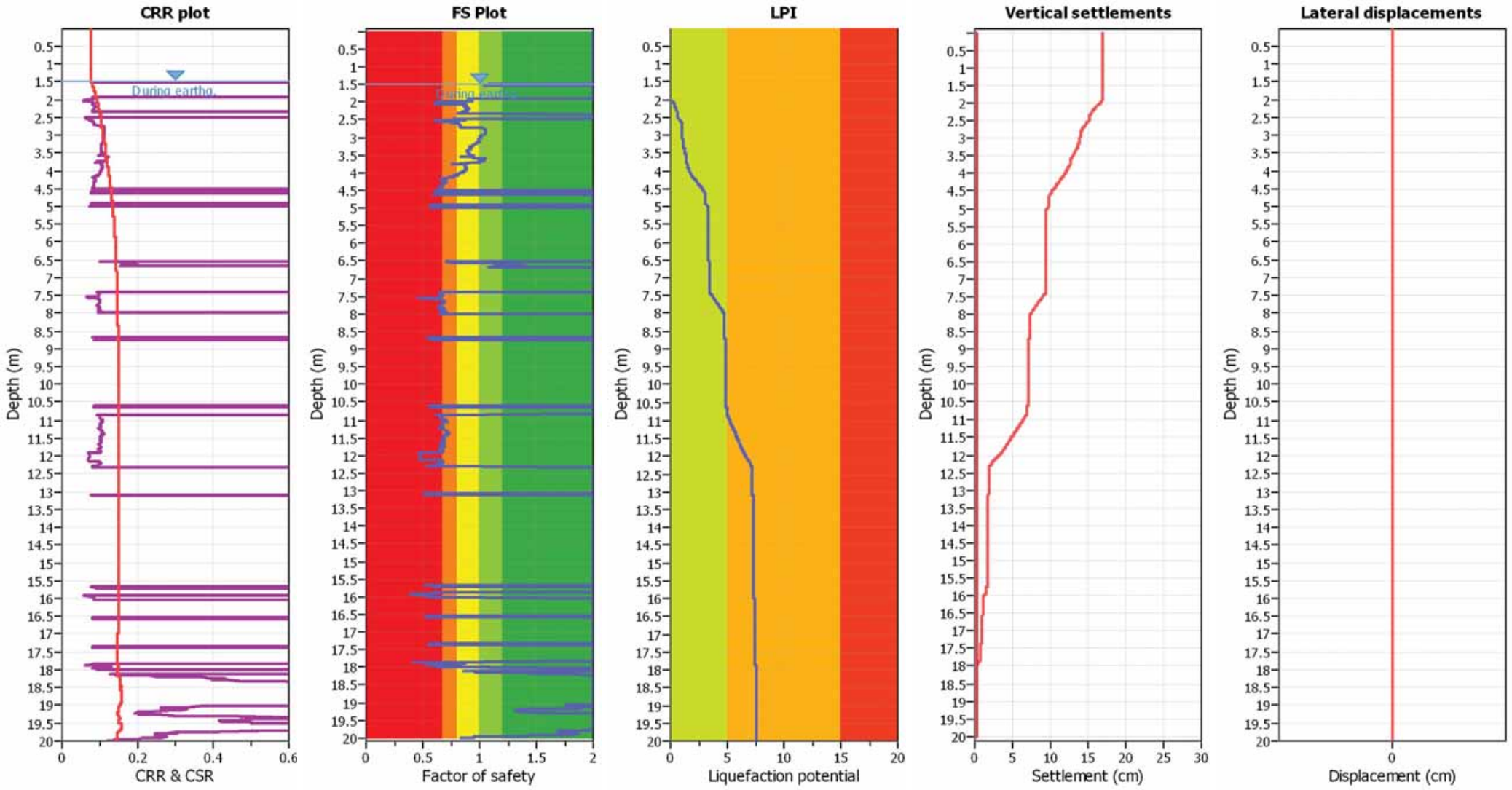

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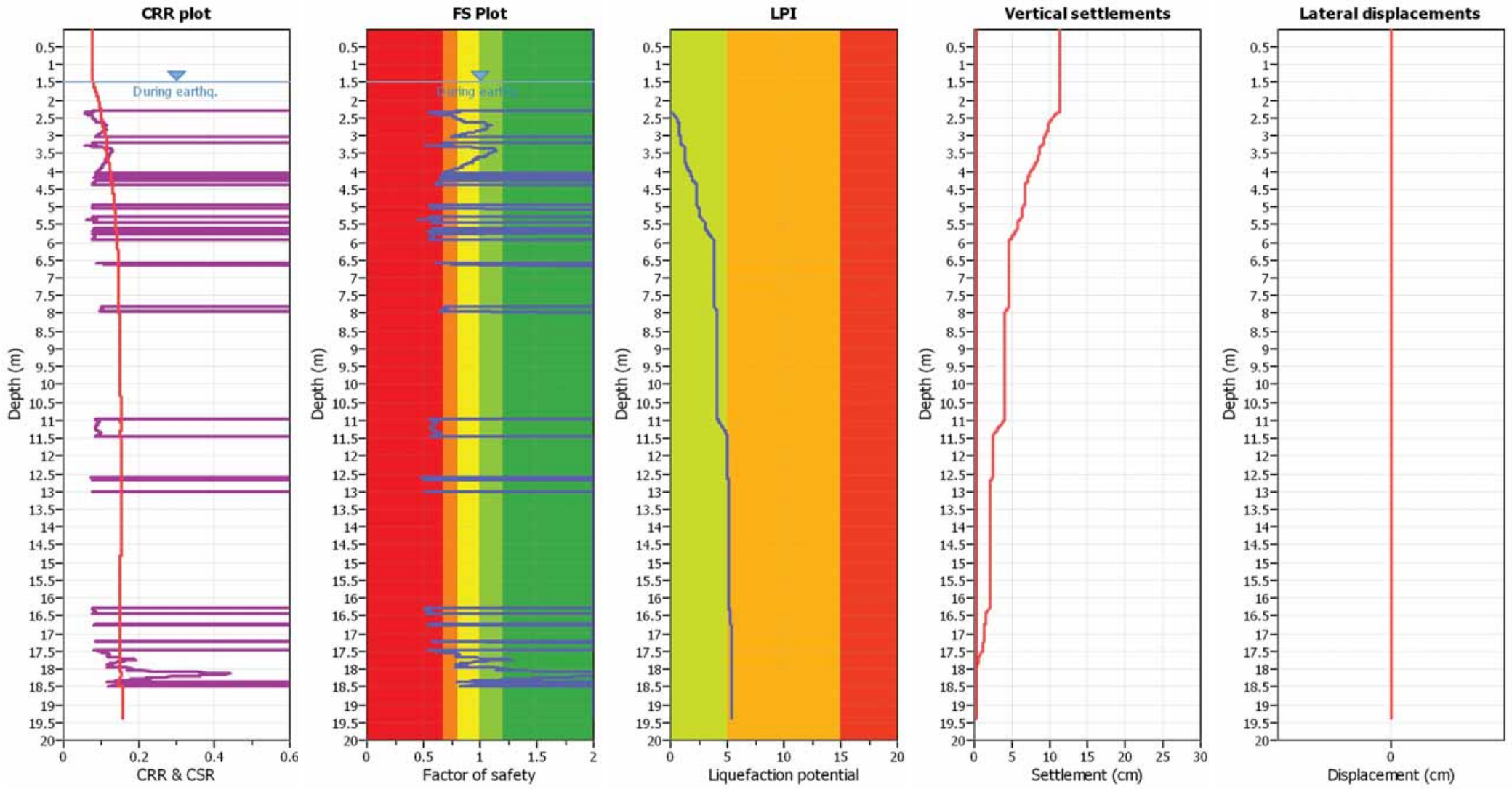

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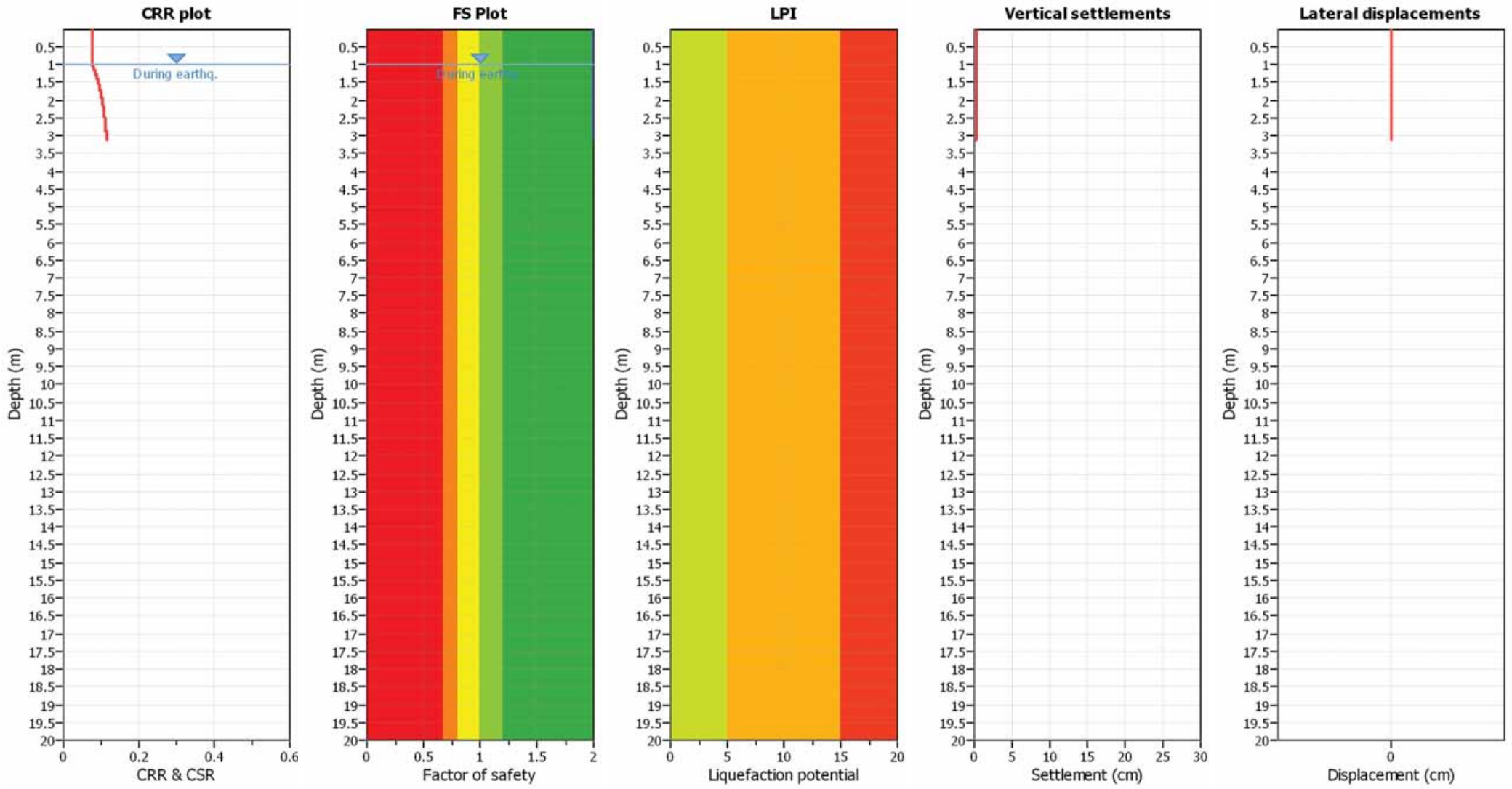

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Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

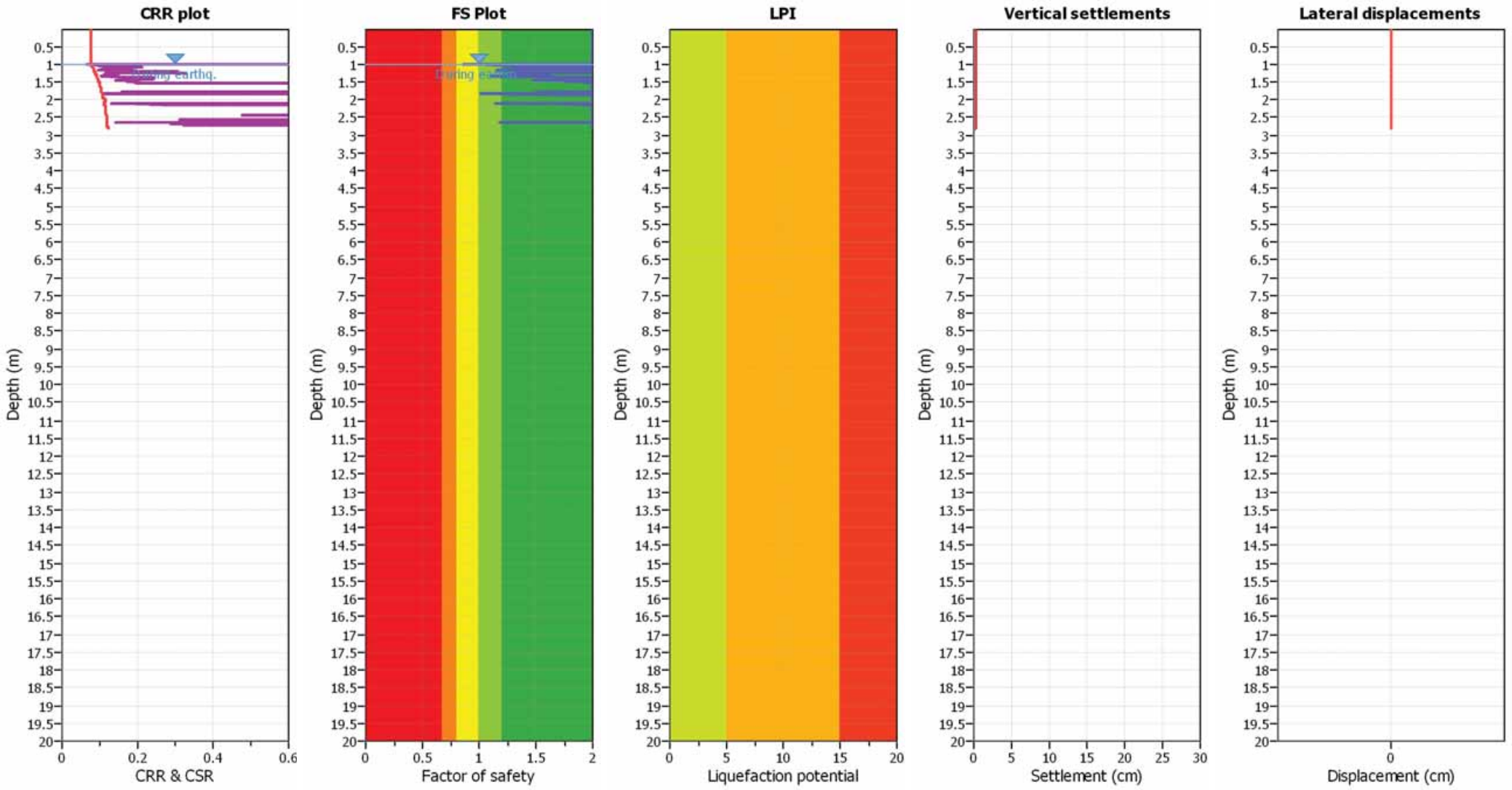
F.S. color scheme

- 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 plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

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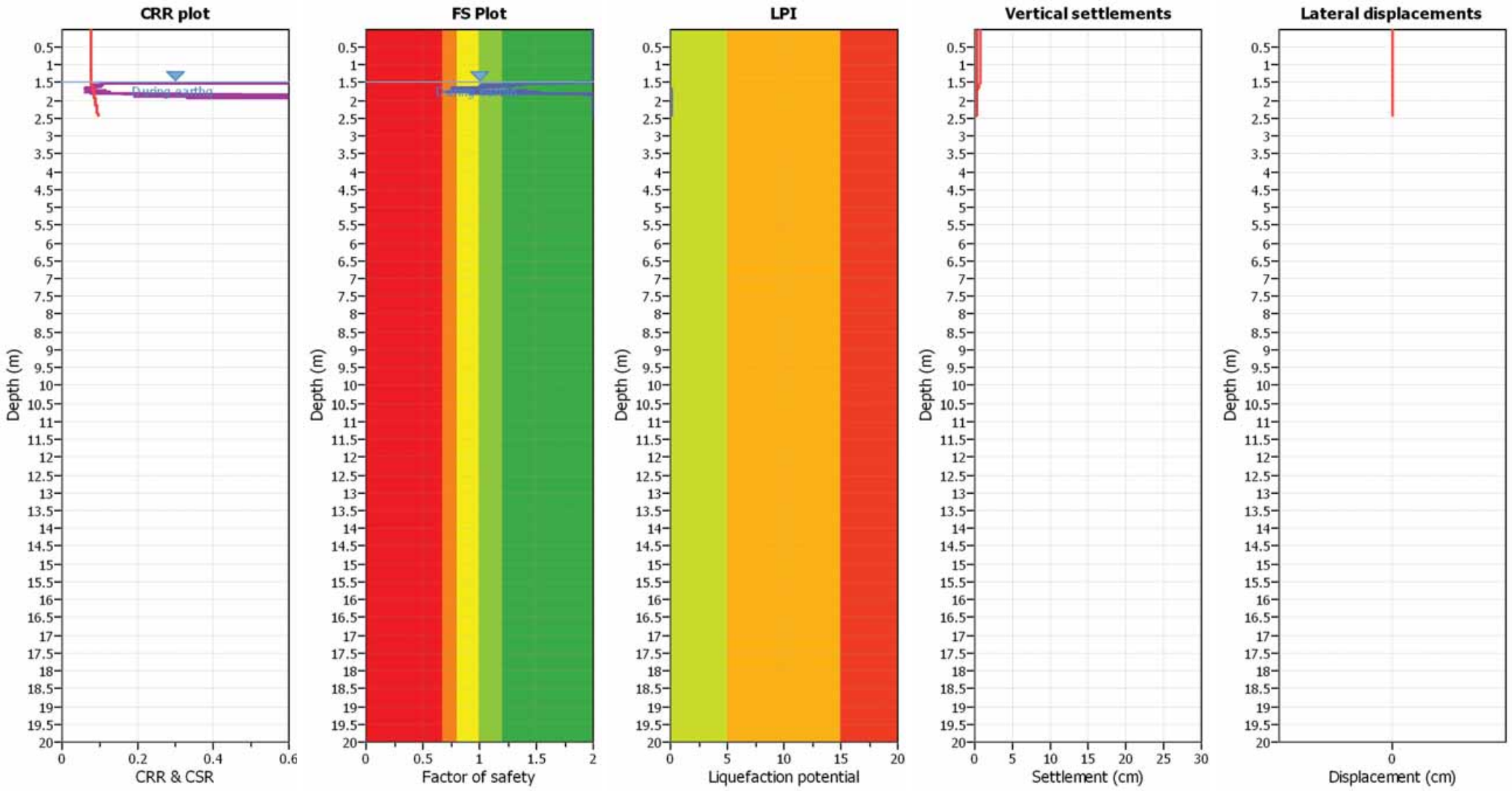

Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

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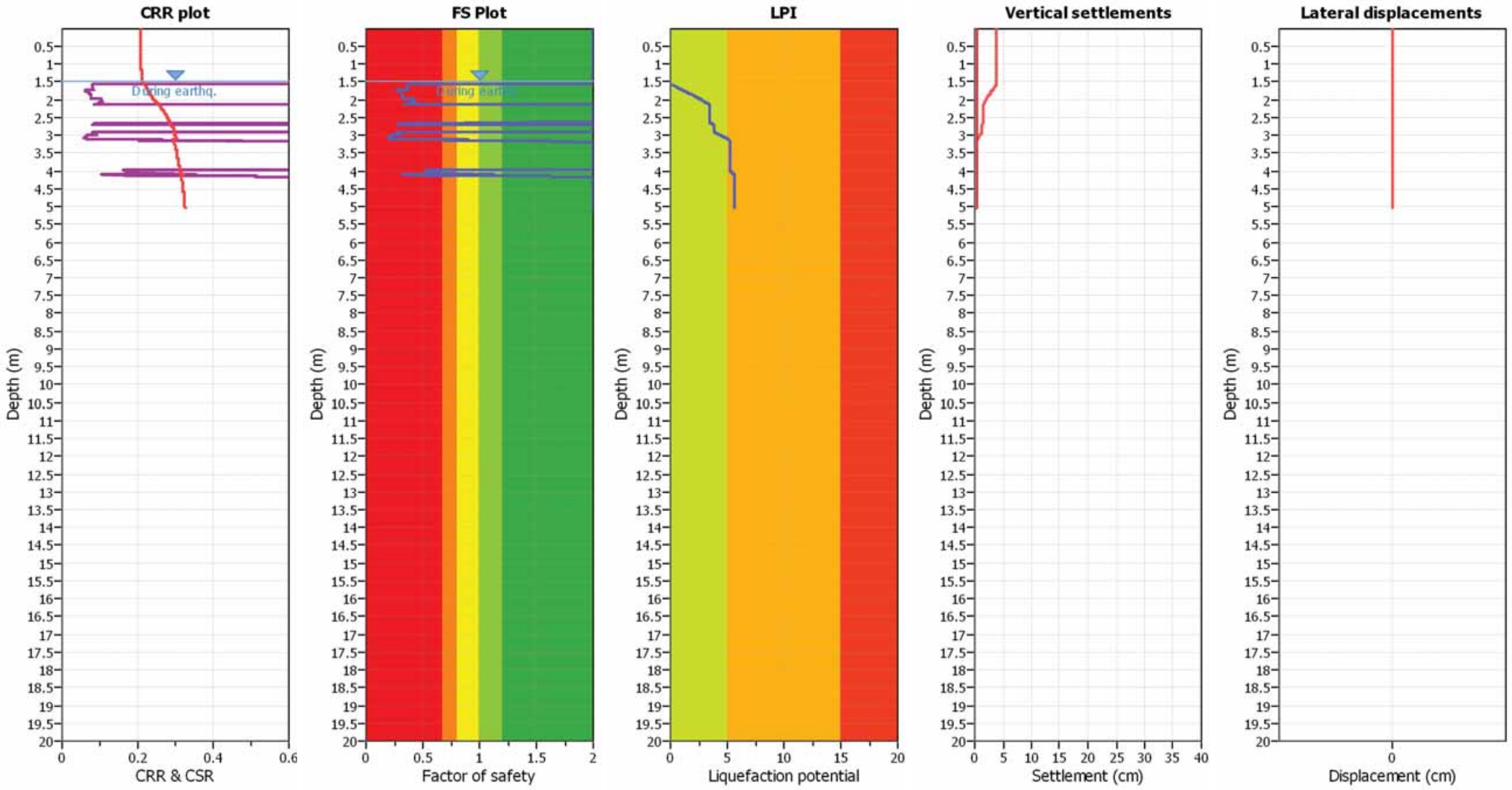

Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

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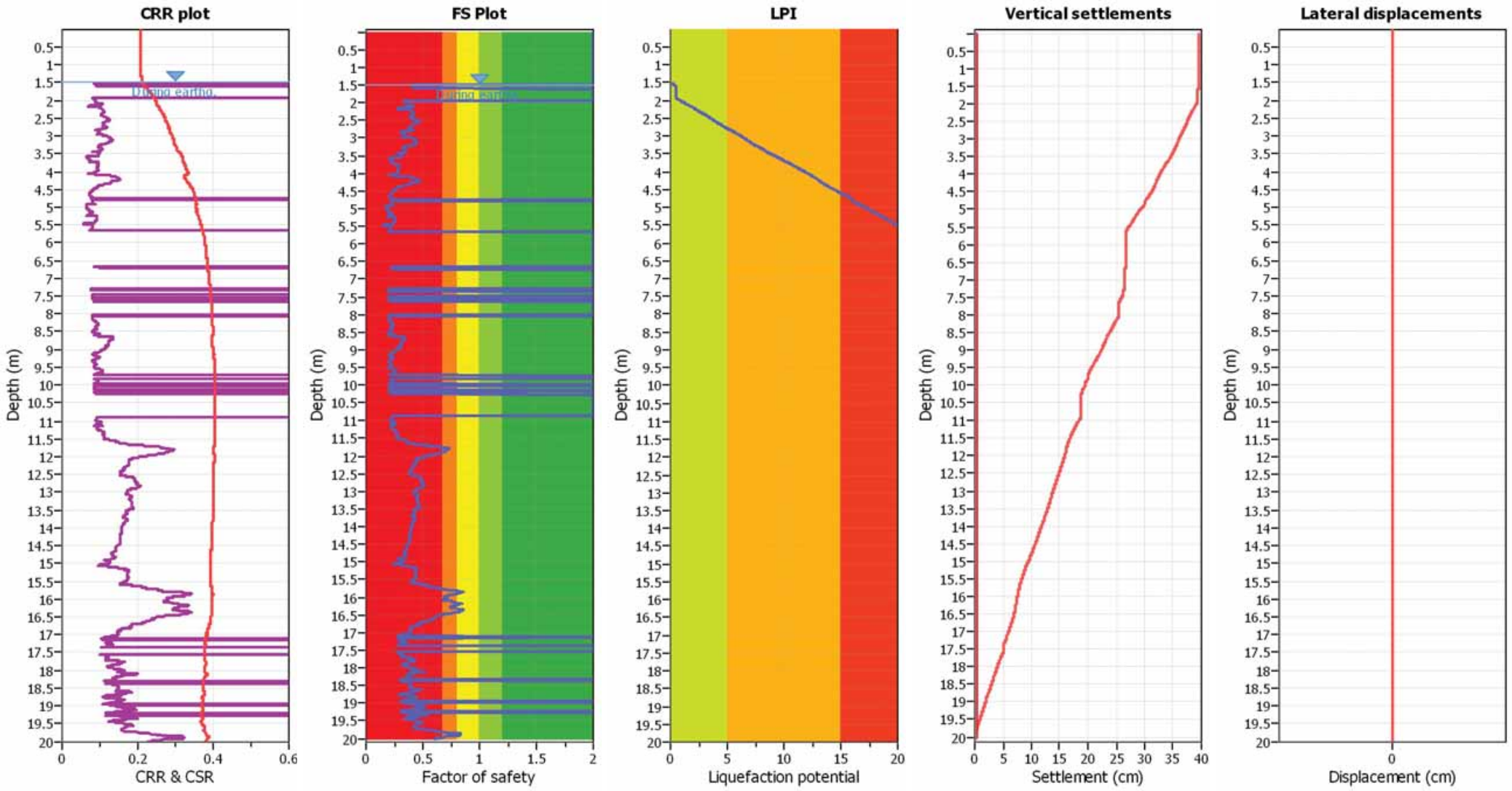
Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

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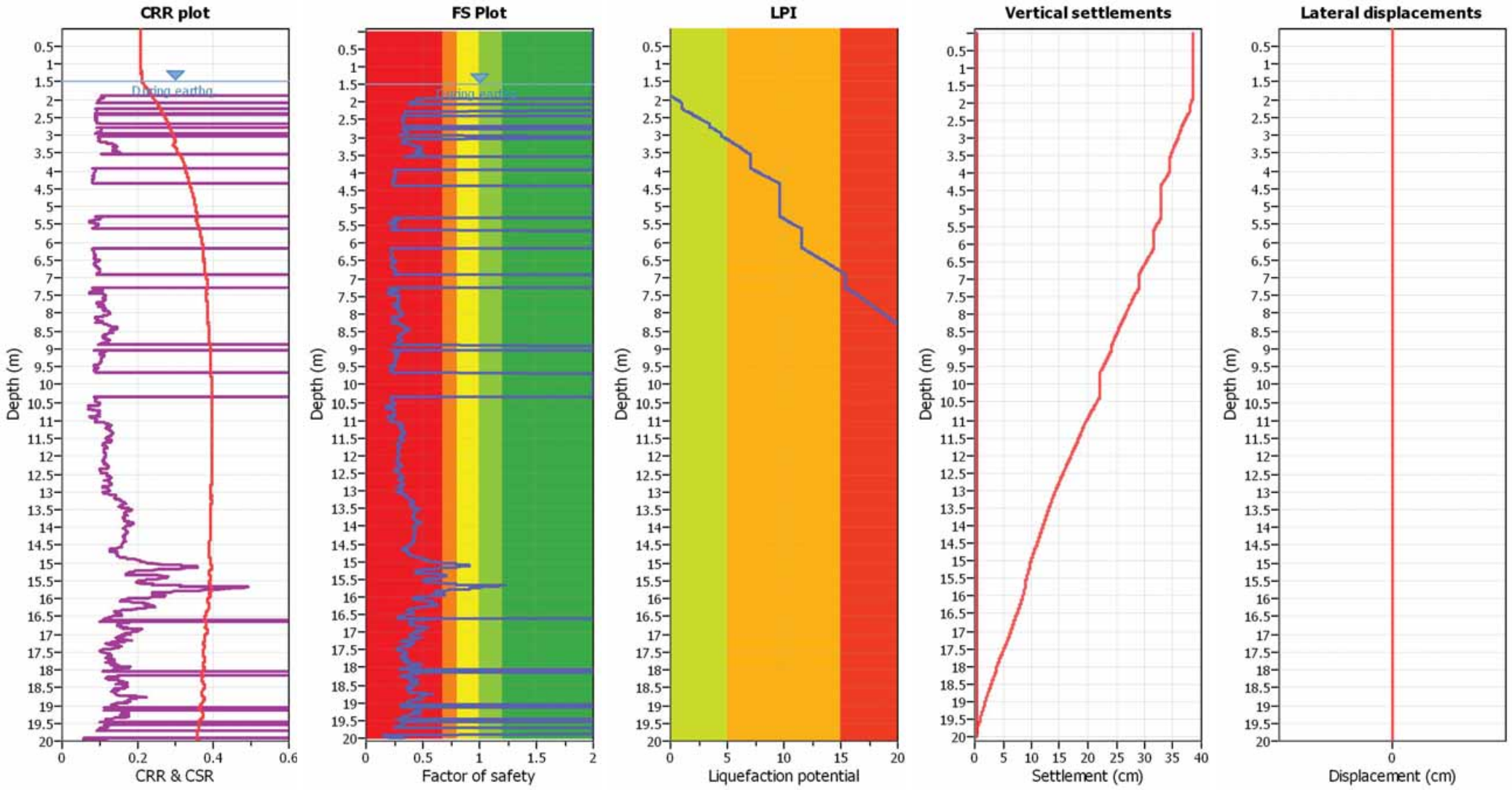
Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.80 m	Fill height:	N/A	Limit depth:	N/A

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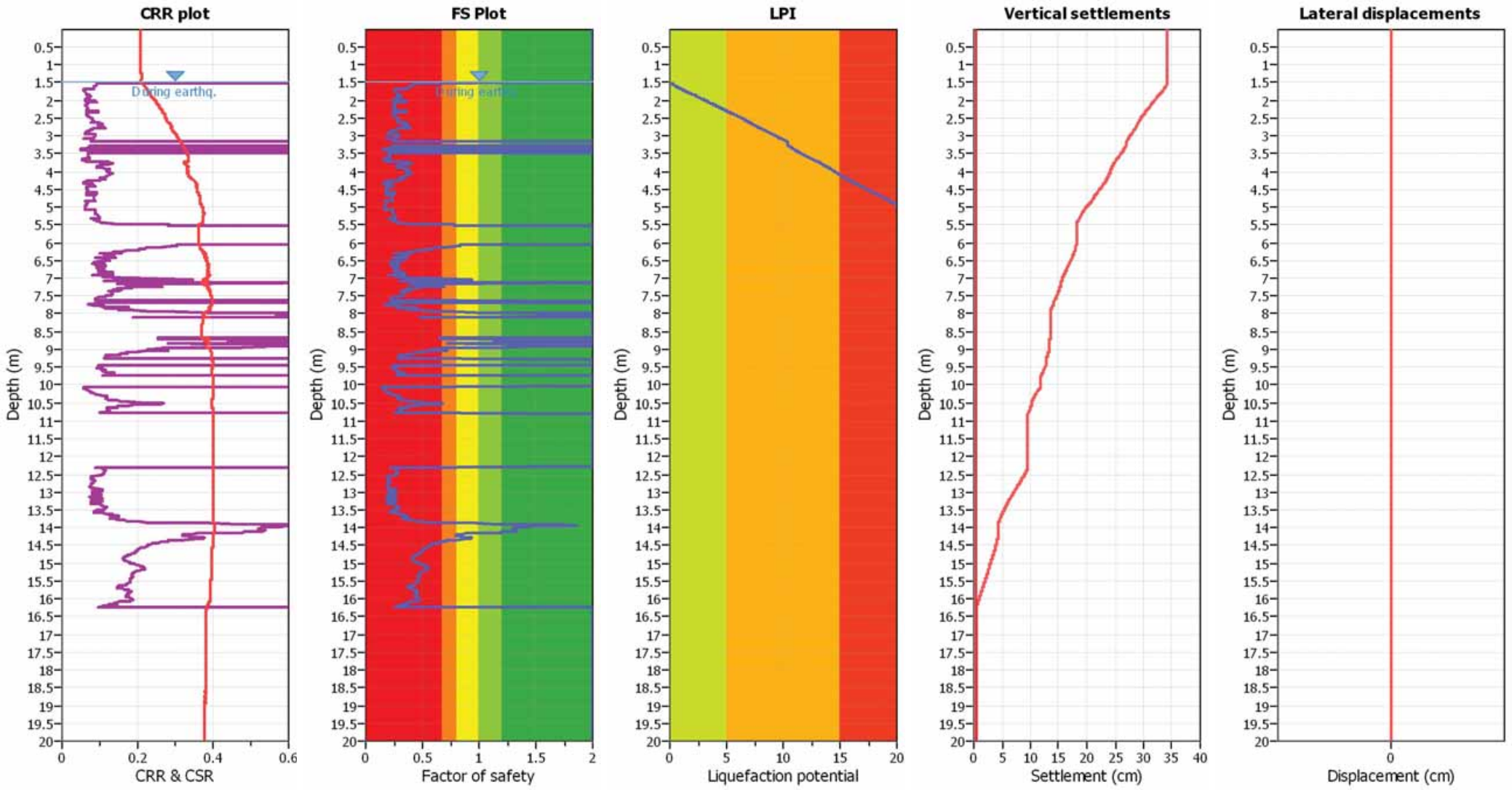

Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

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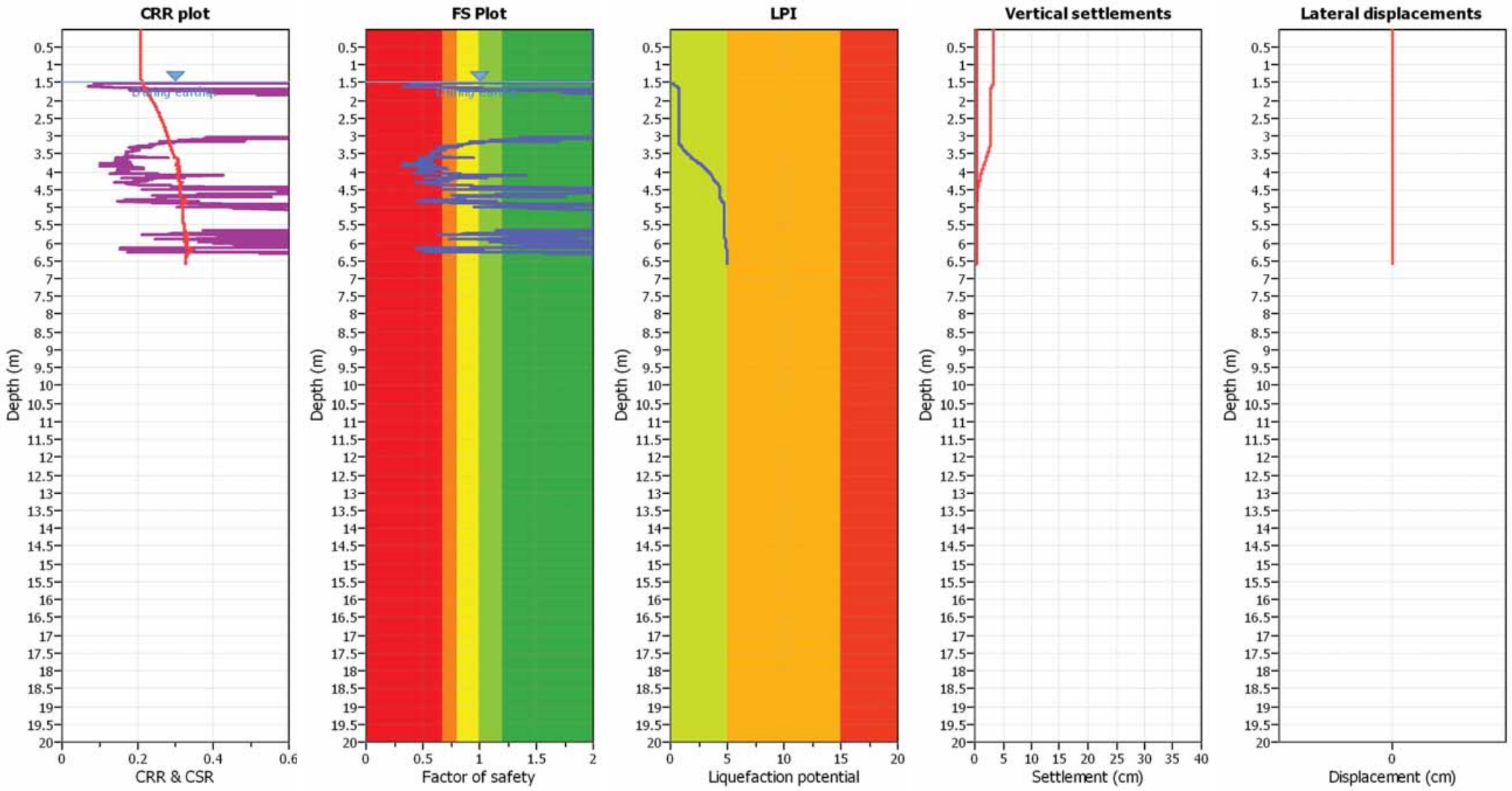

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Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake 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

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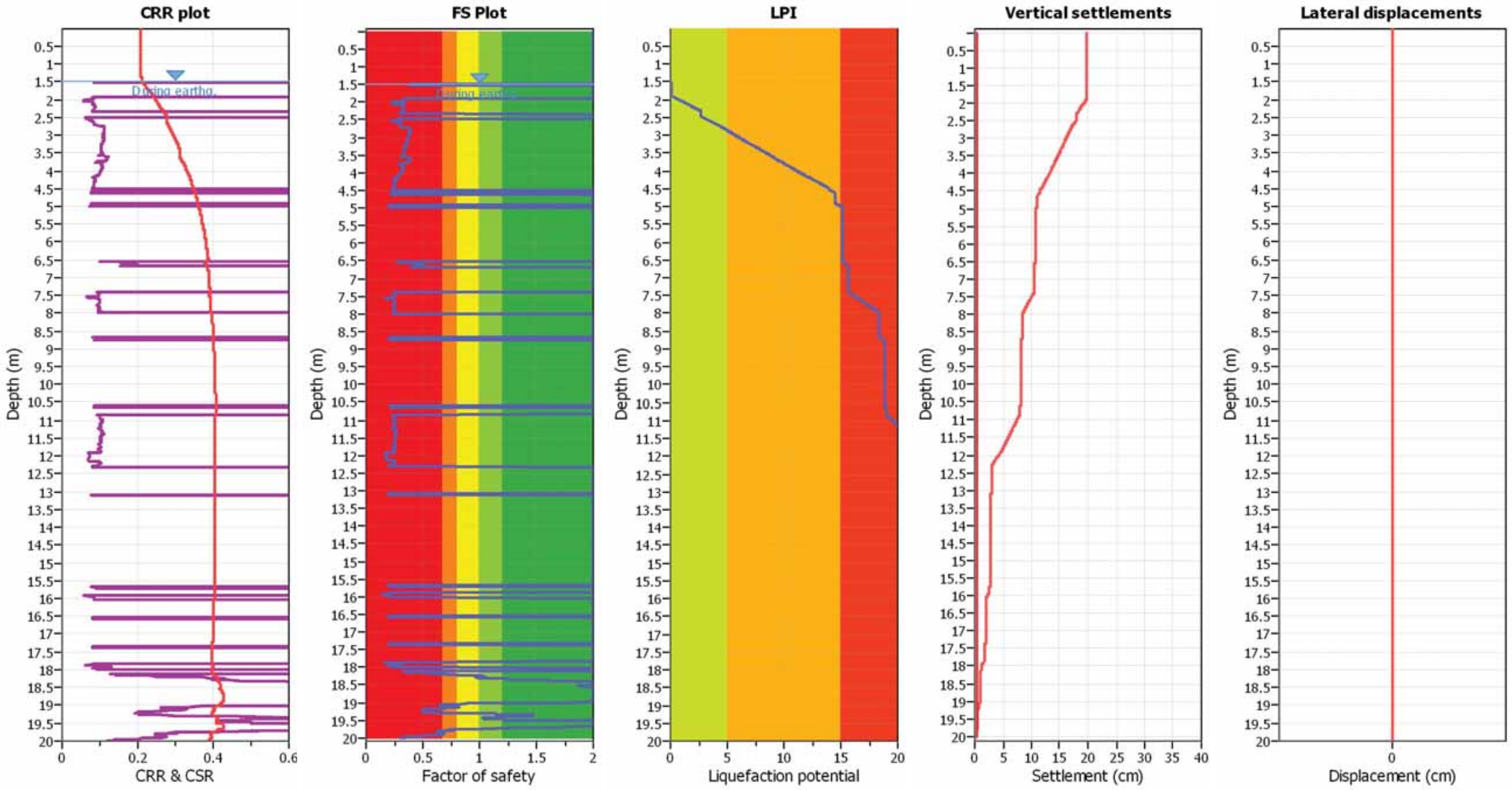

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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
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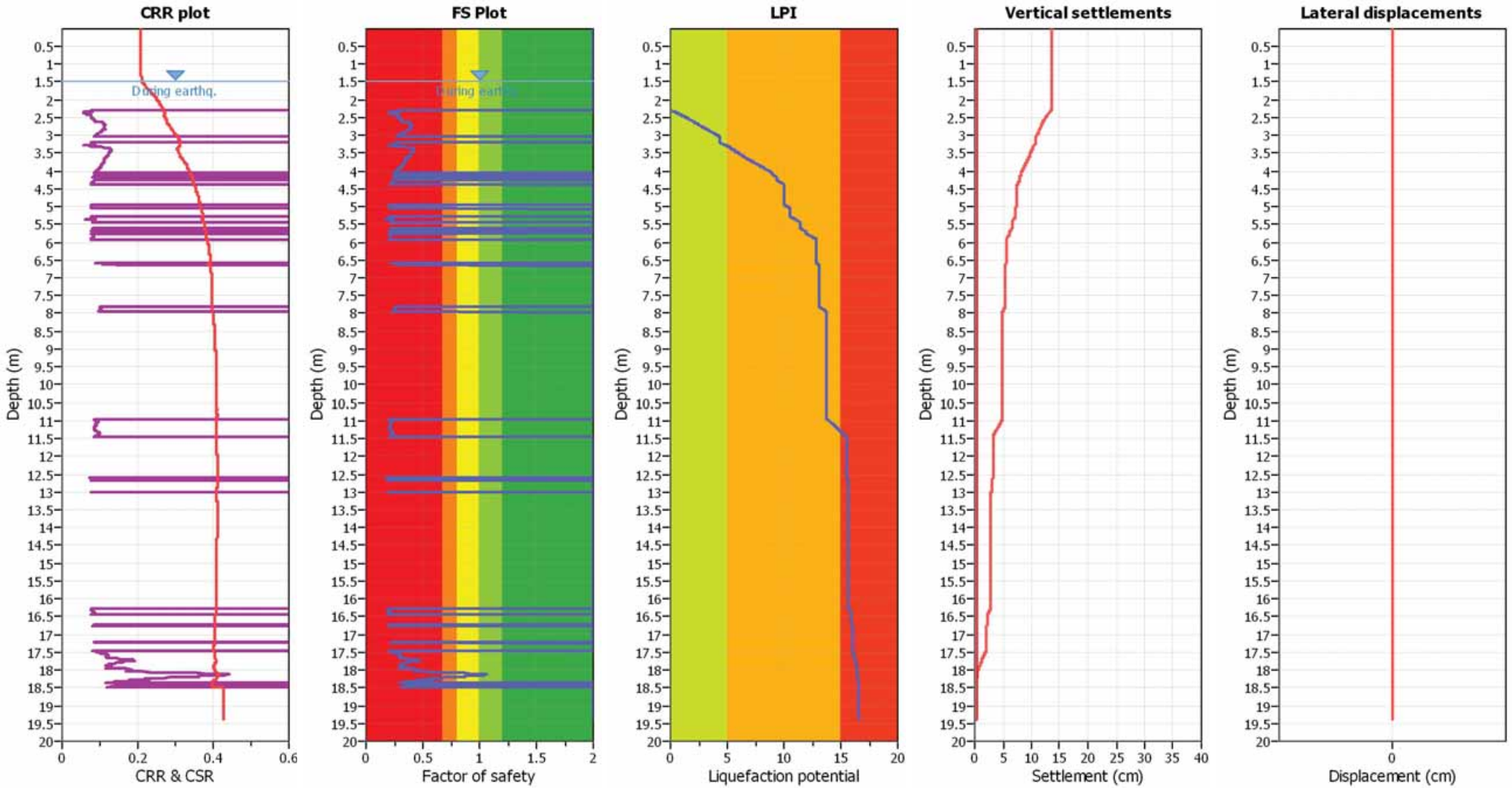

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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
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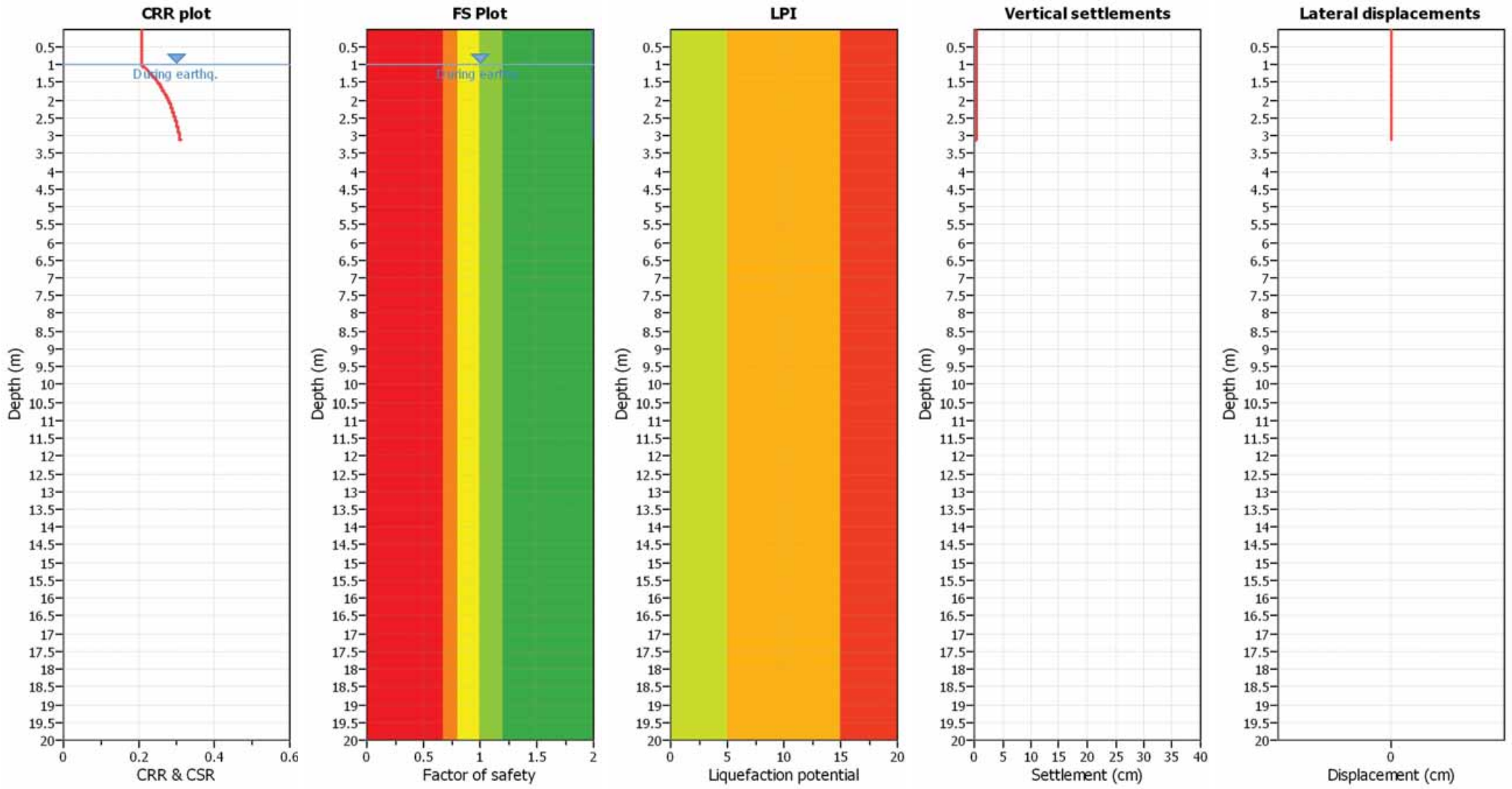

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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
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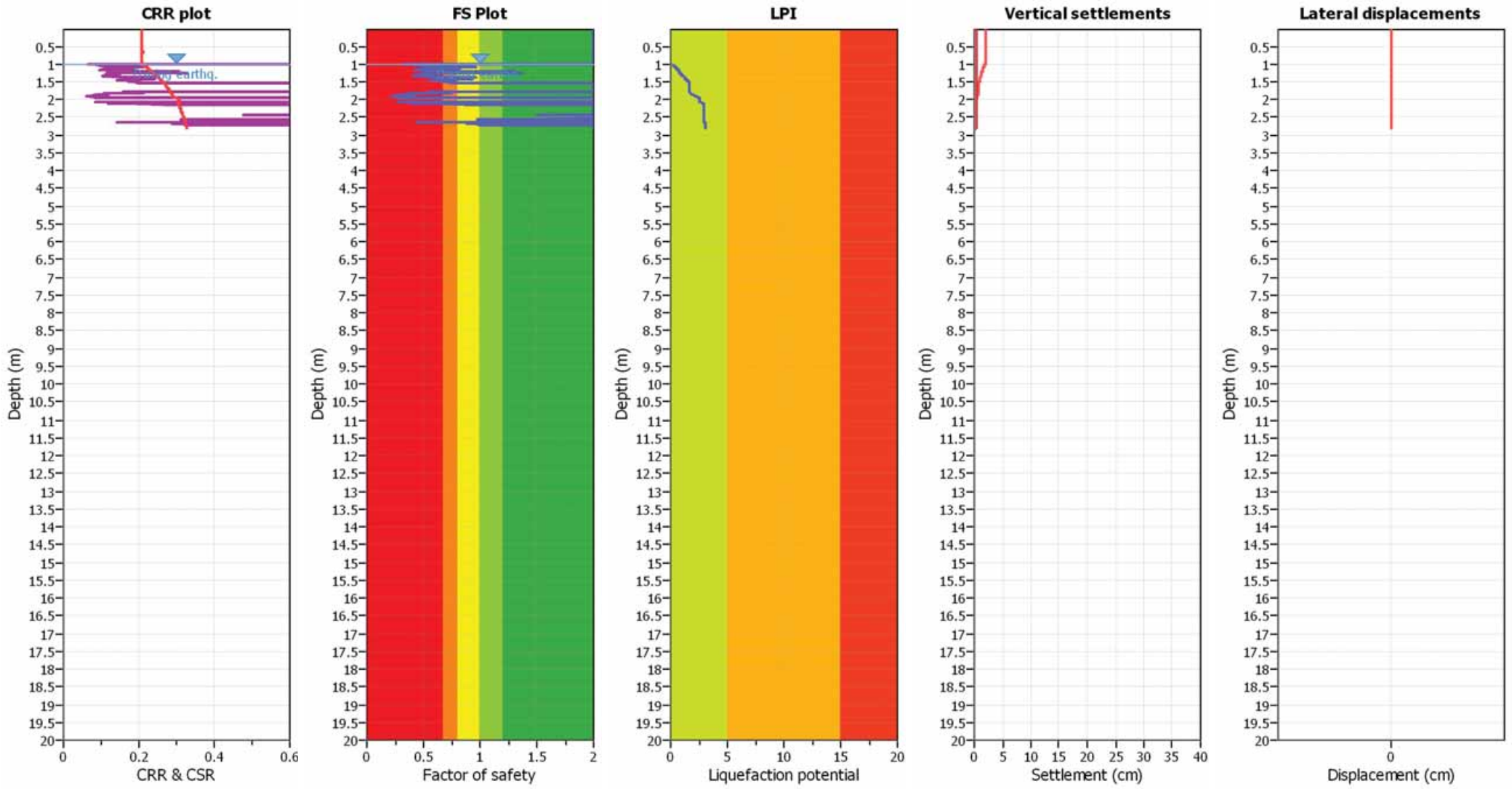

Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
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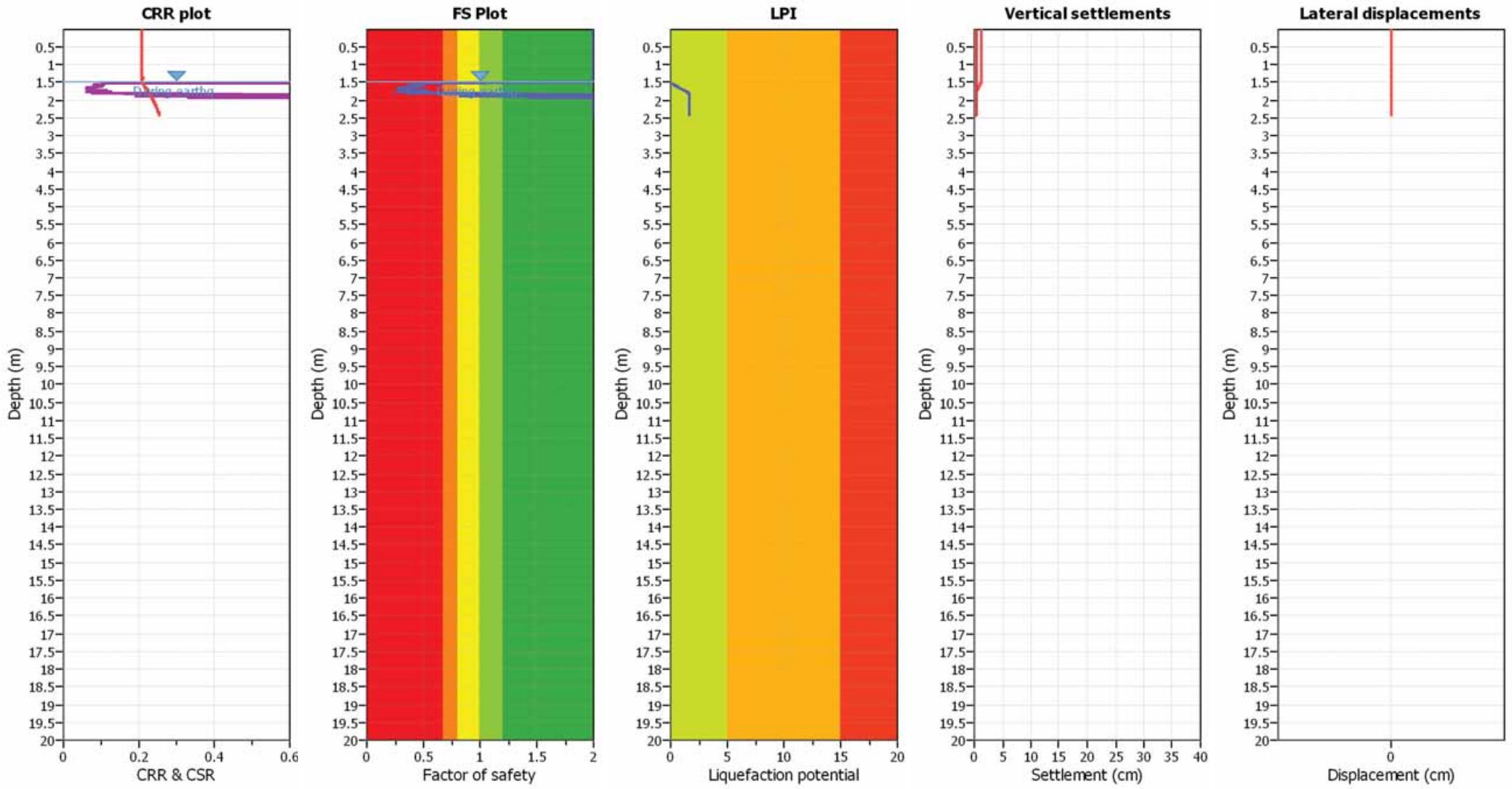

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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
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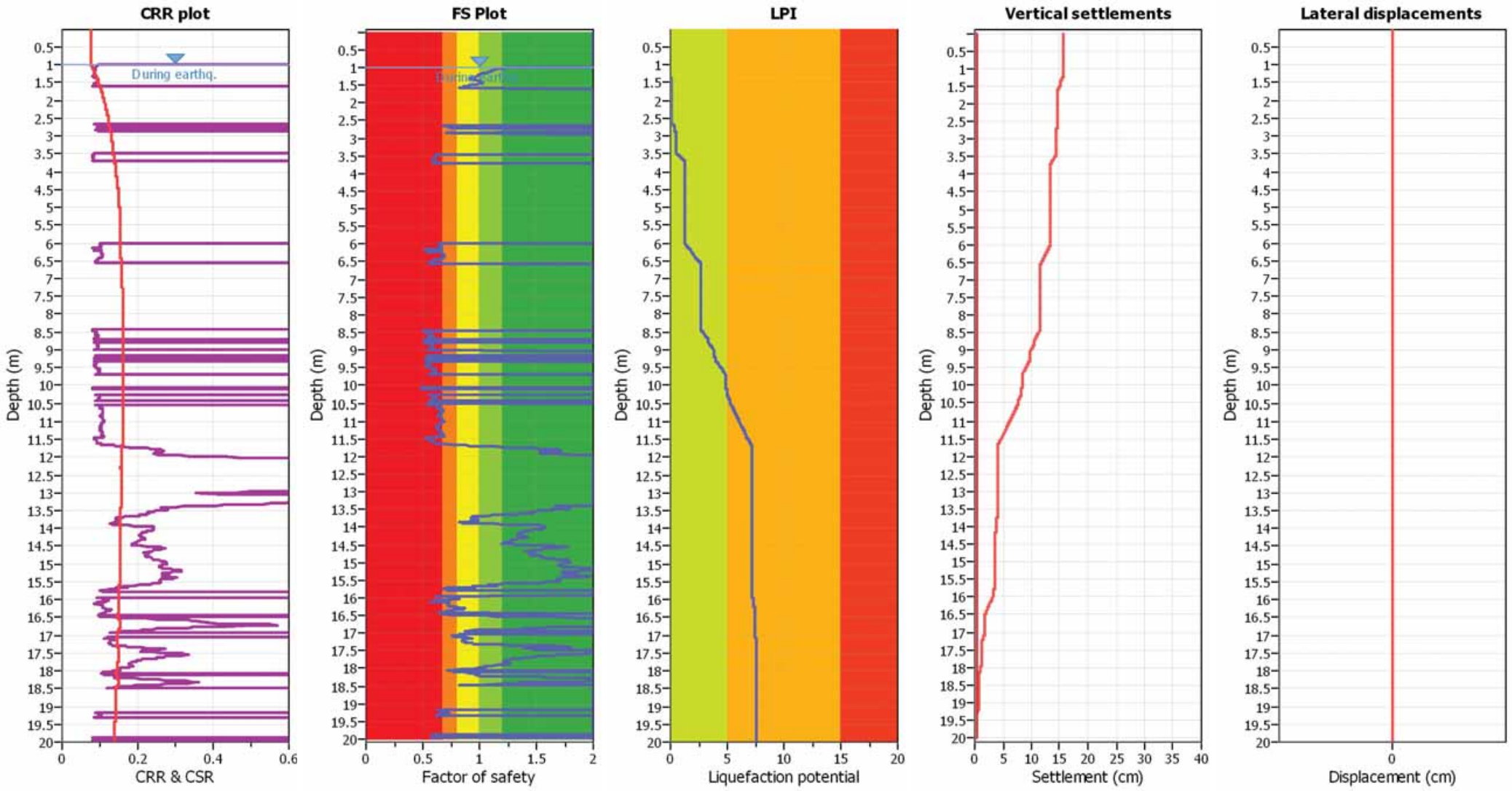

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Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake 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
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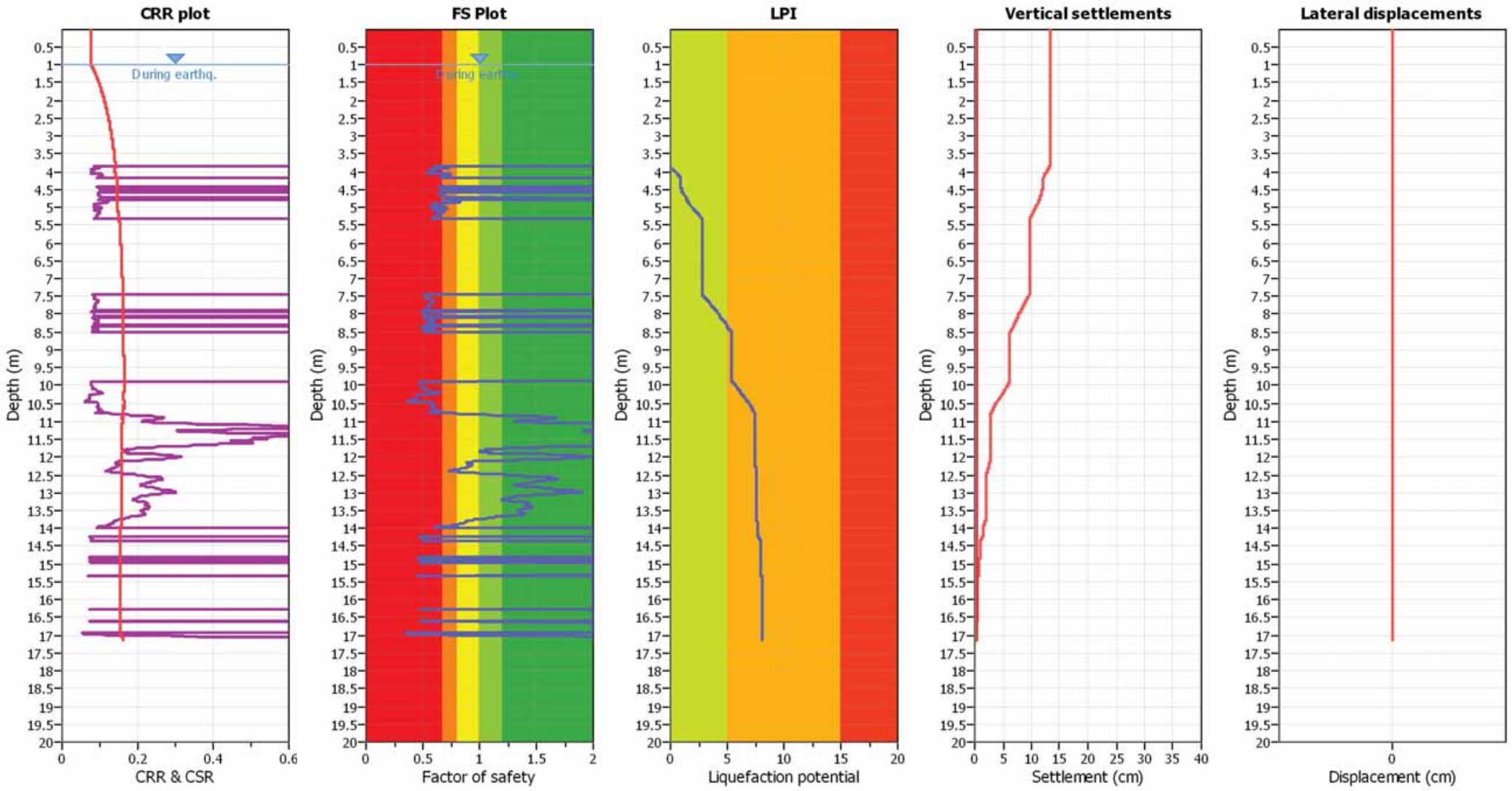

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Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake 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
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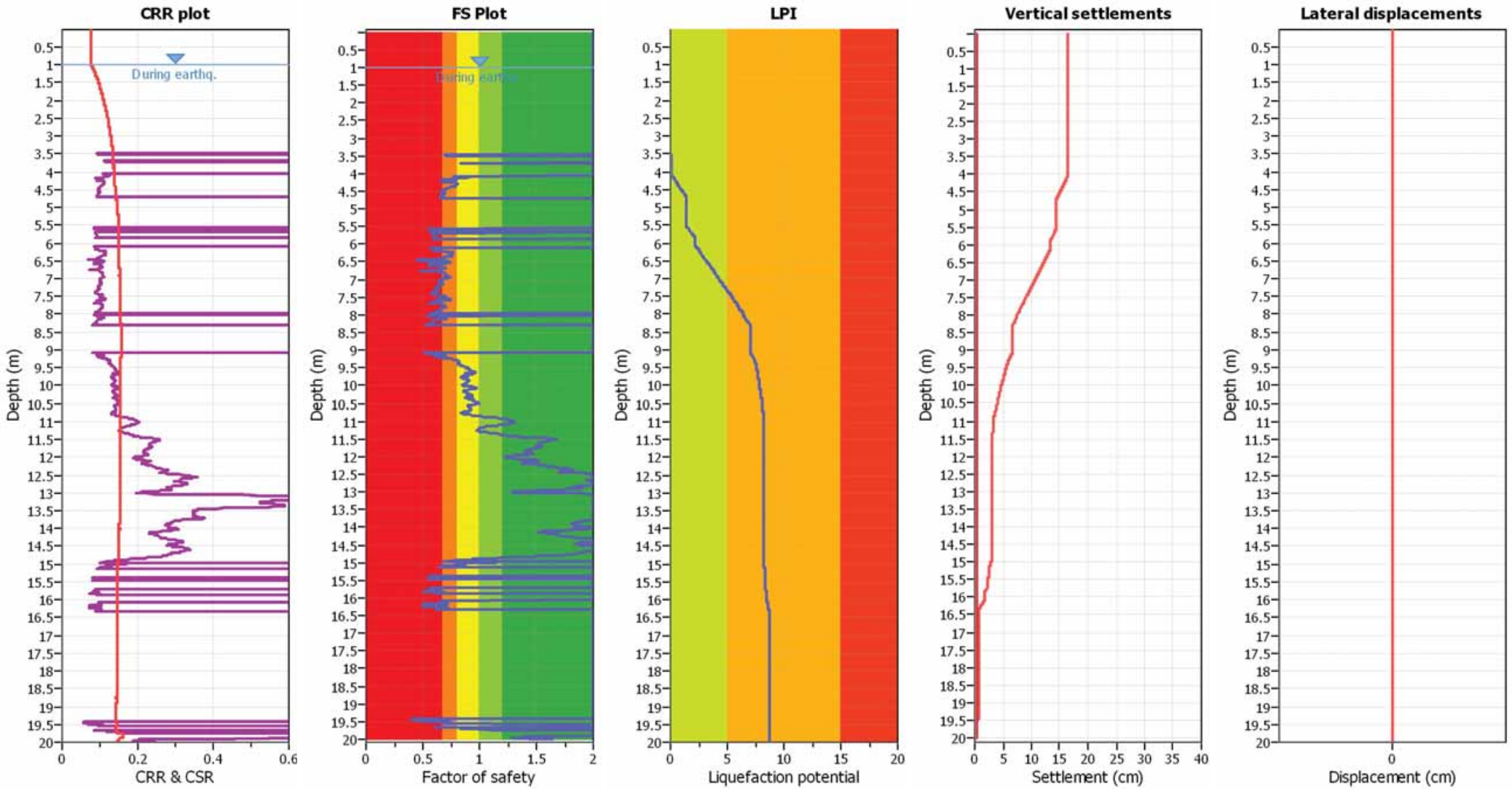

Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.00 m	Fill height:	N/A	Limit depth:	N/A

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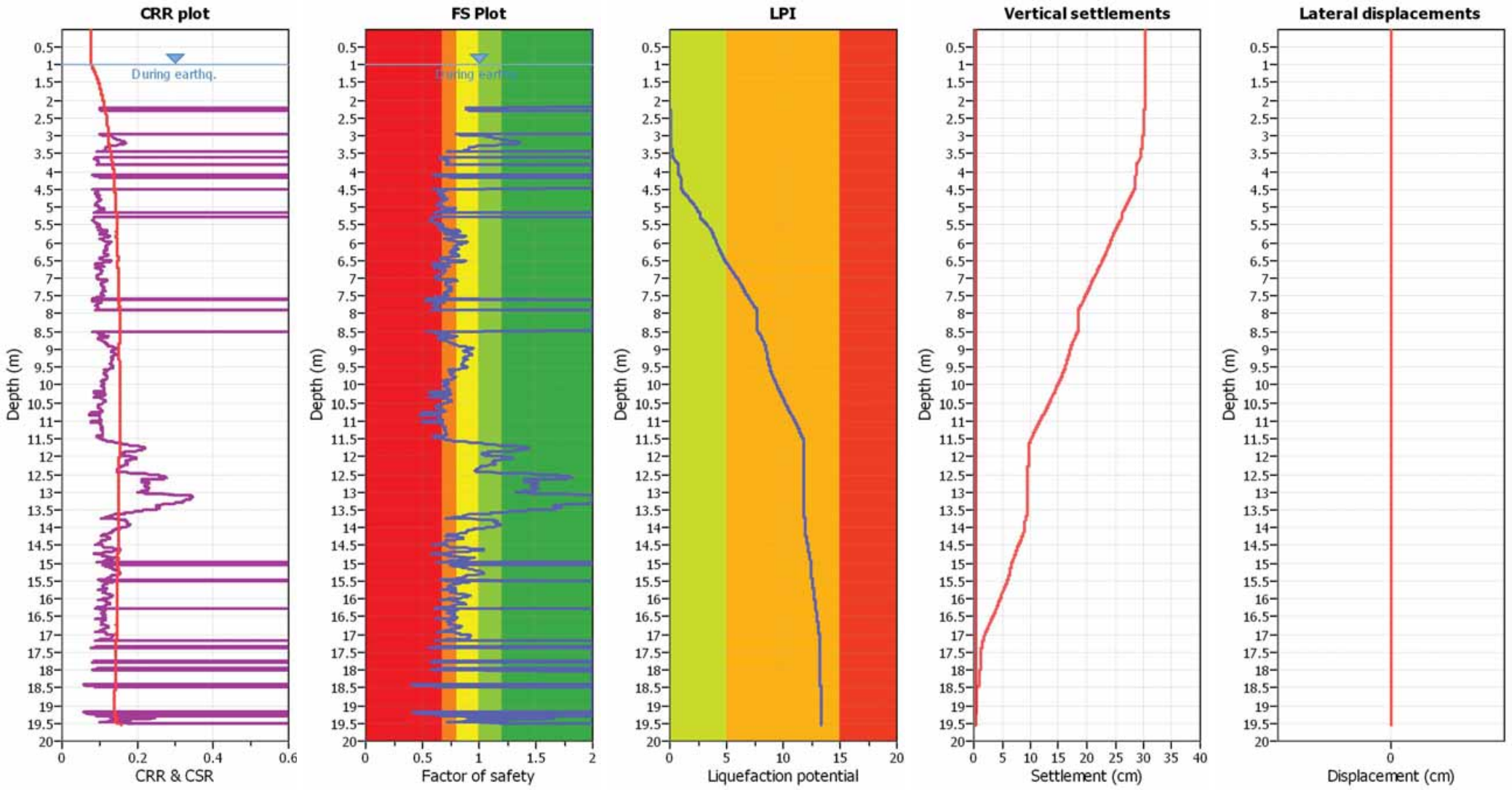

Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.30 m	Fill height:	N/A	Limit depth:	N/A

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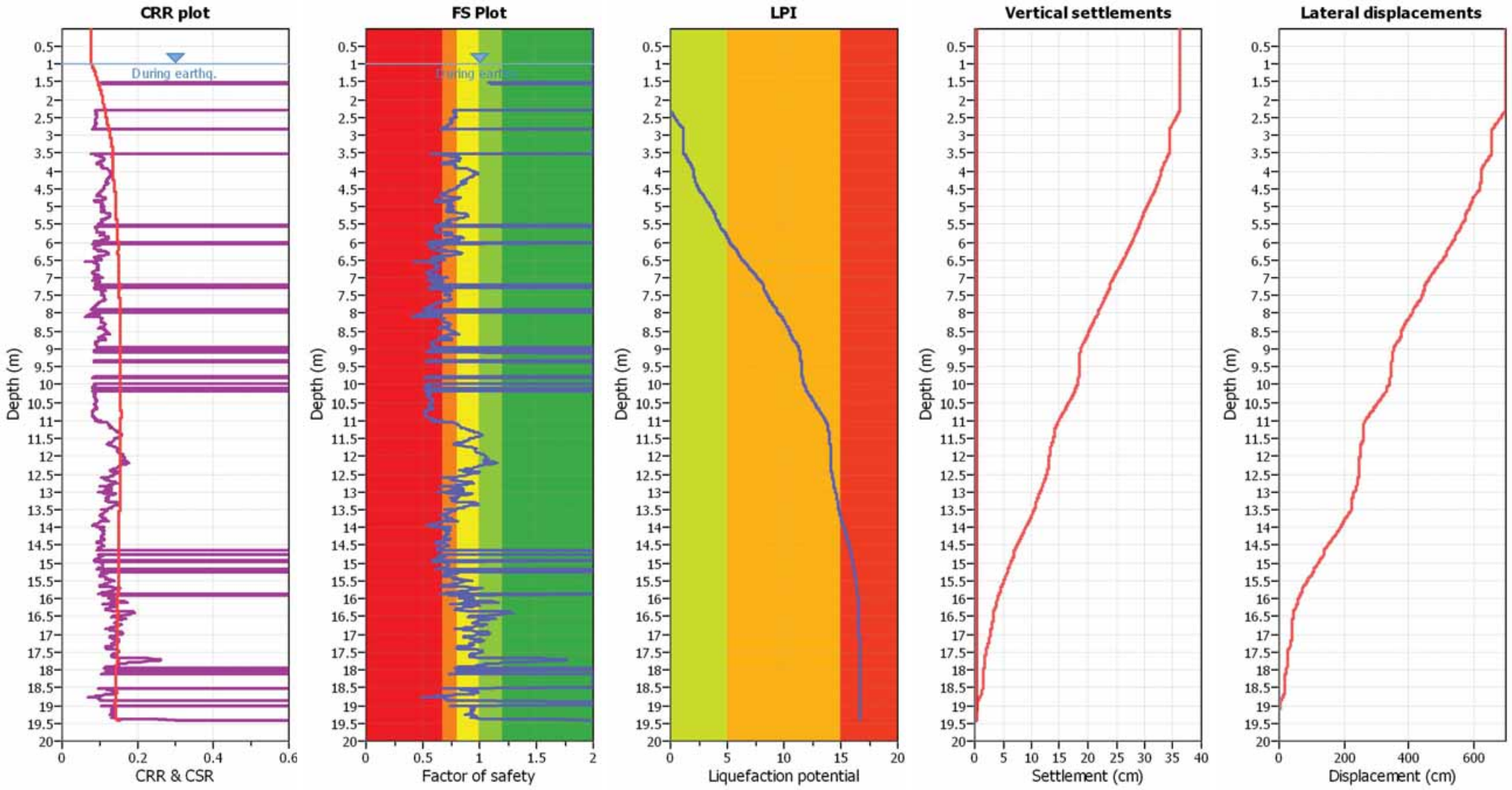
Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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):	1.50 m	Fill height:	N/A	Limit depth:	N/A

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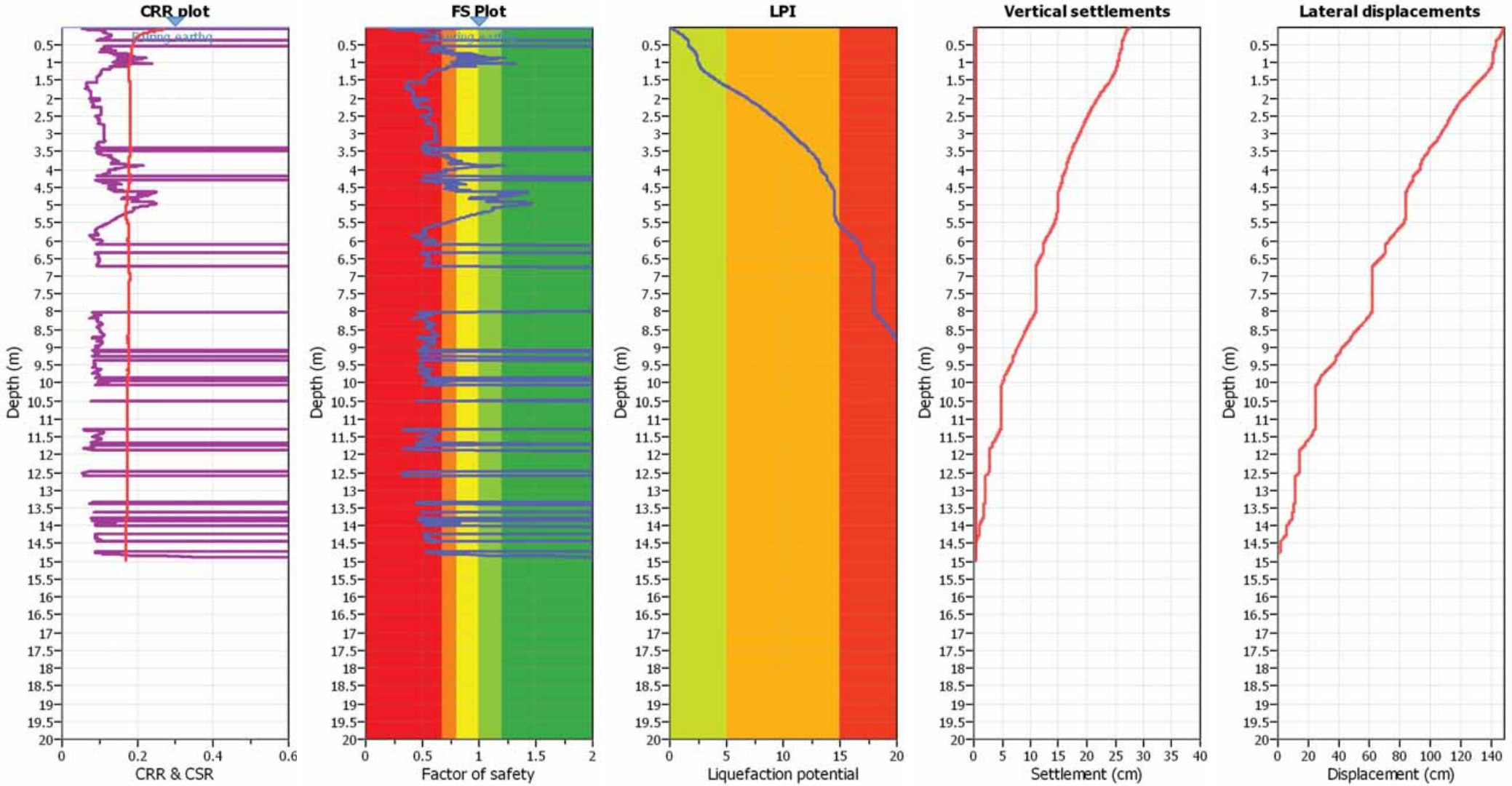

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Analysis method:	I&B (2008)	Depth to GWT (erthq.):	0.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
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Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
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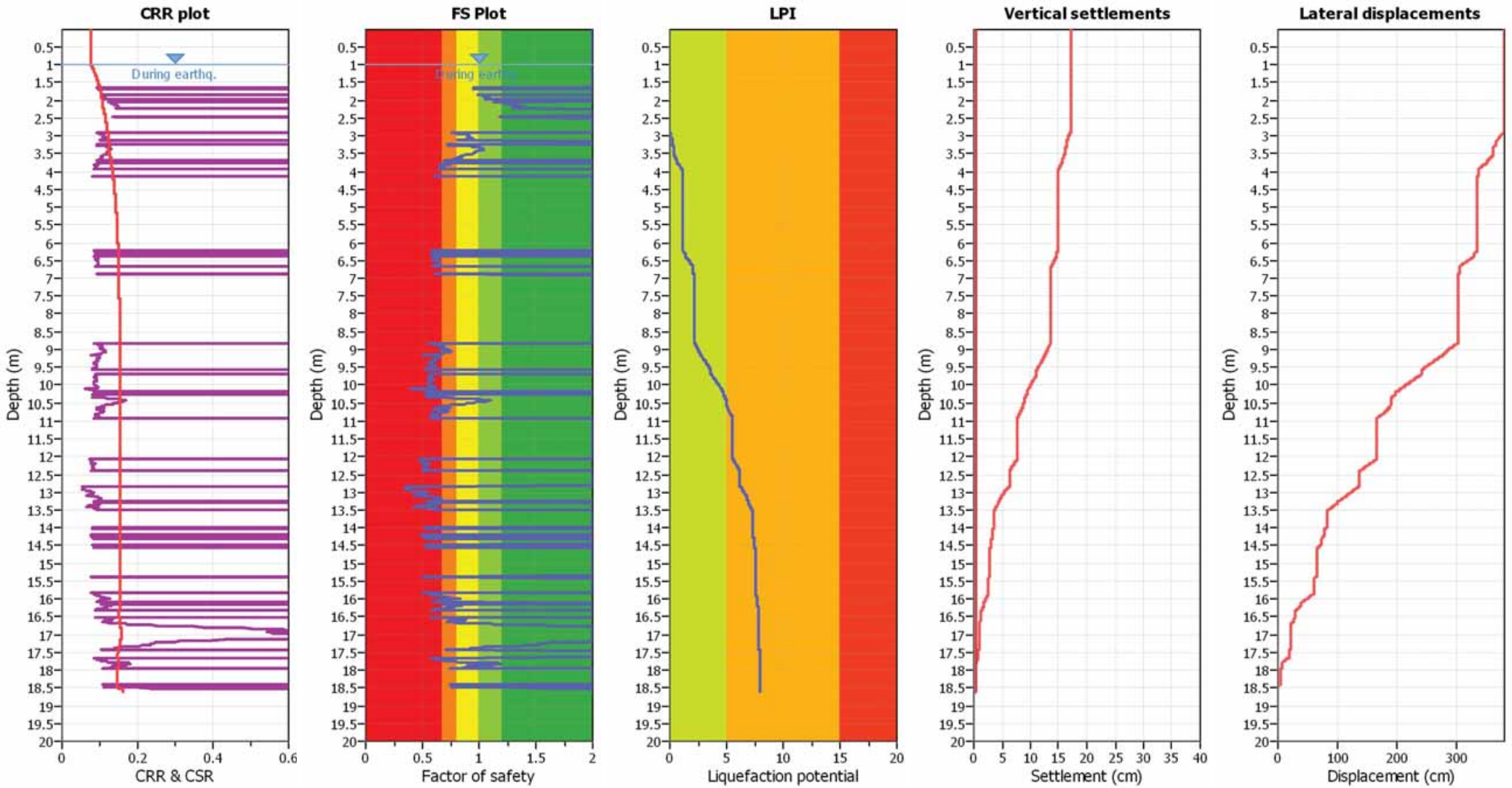

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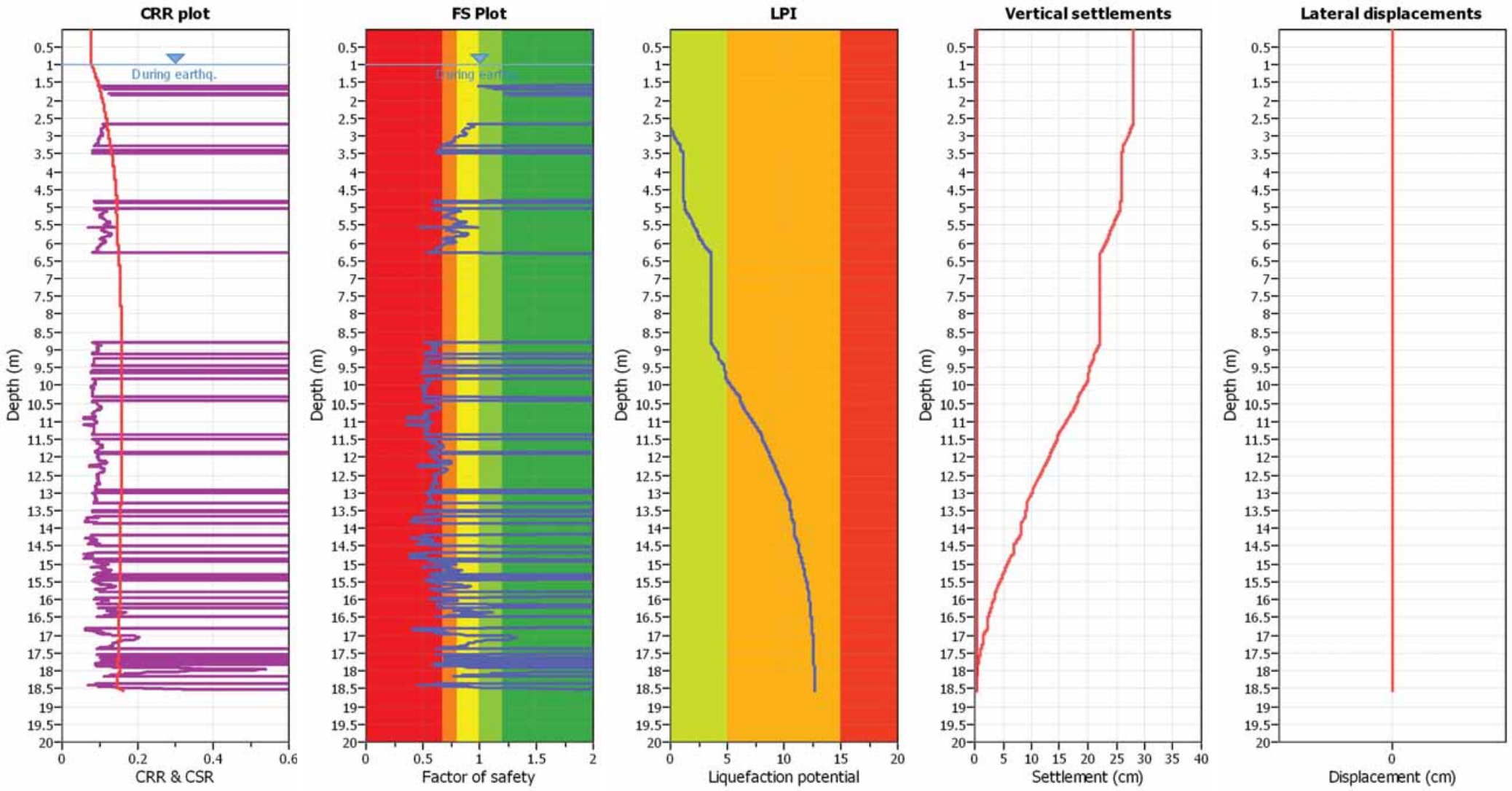

Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

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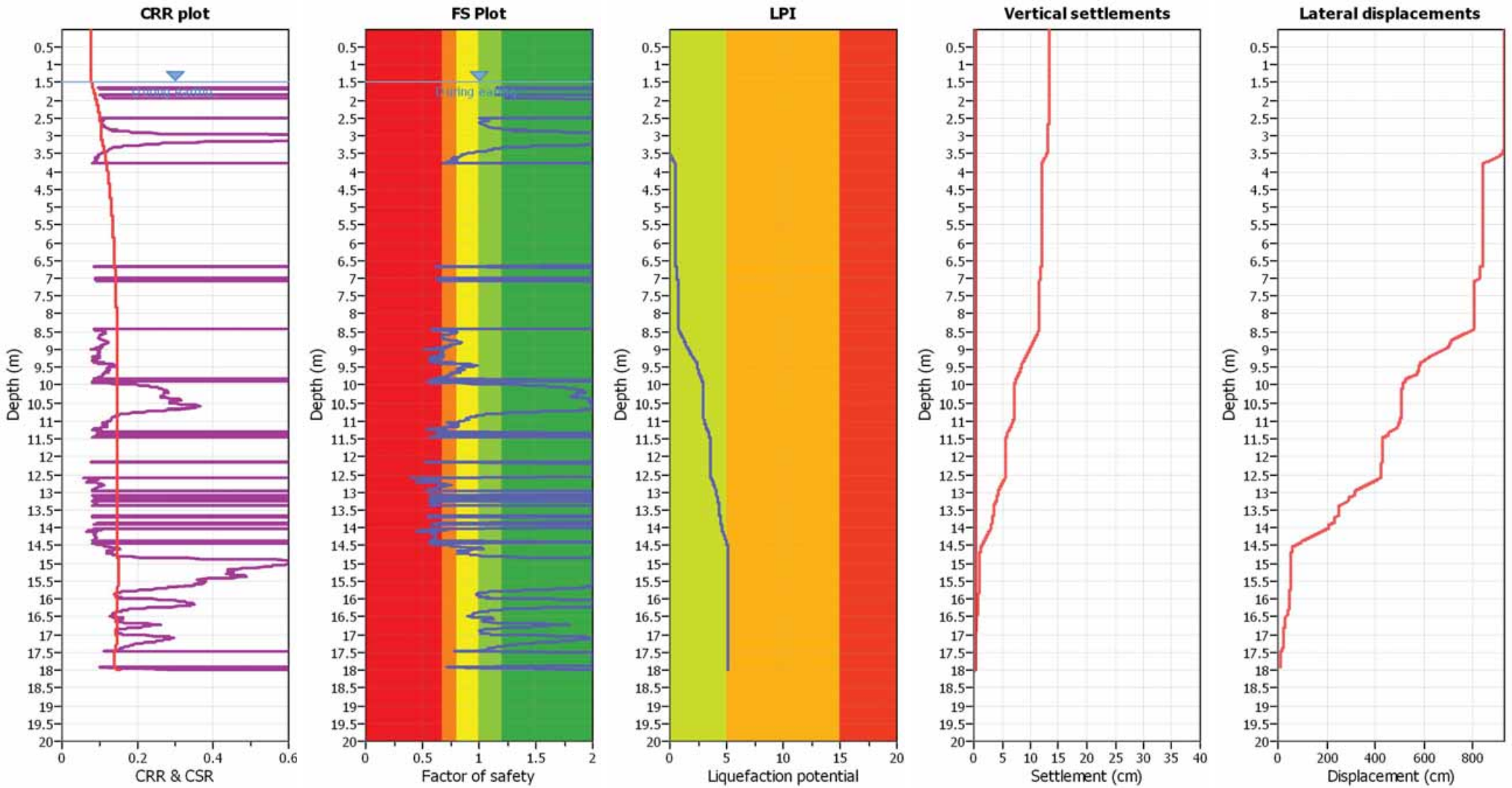

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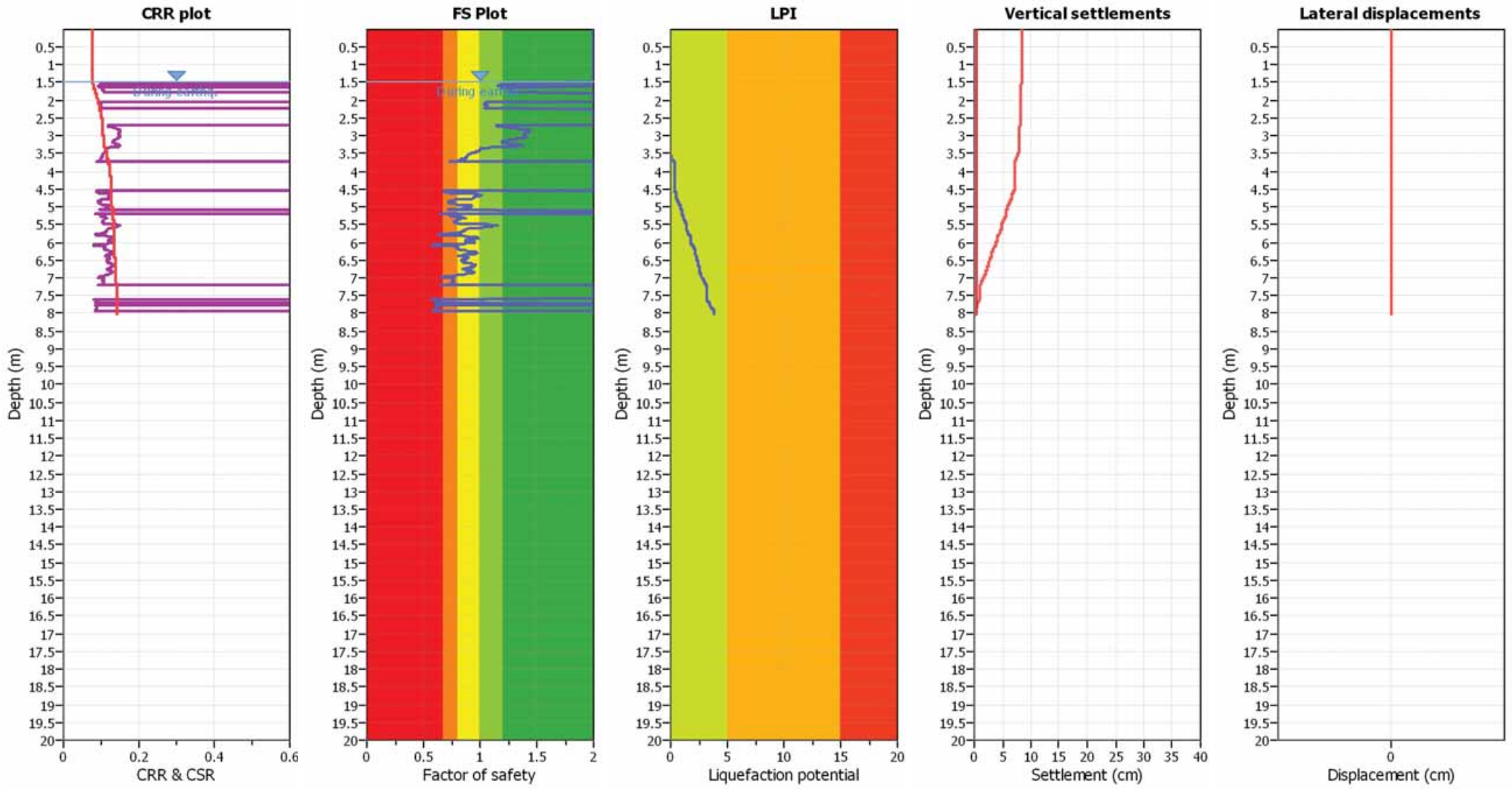

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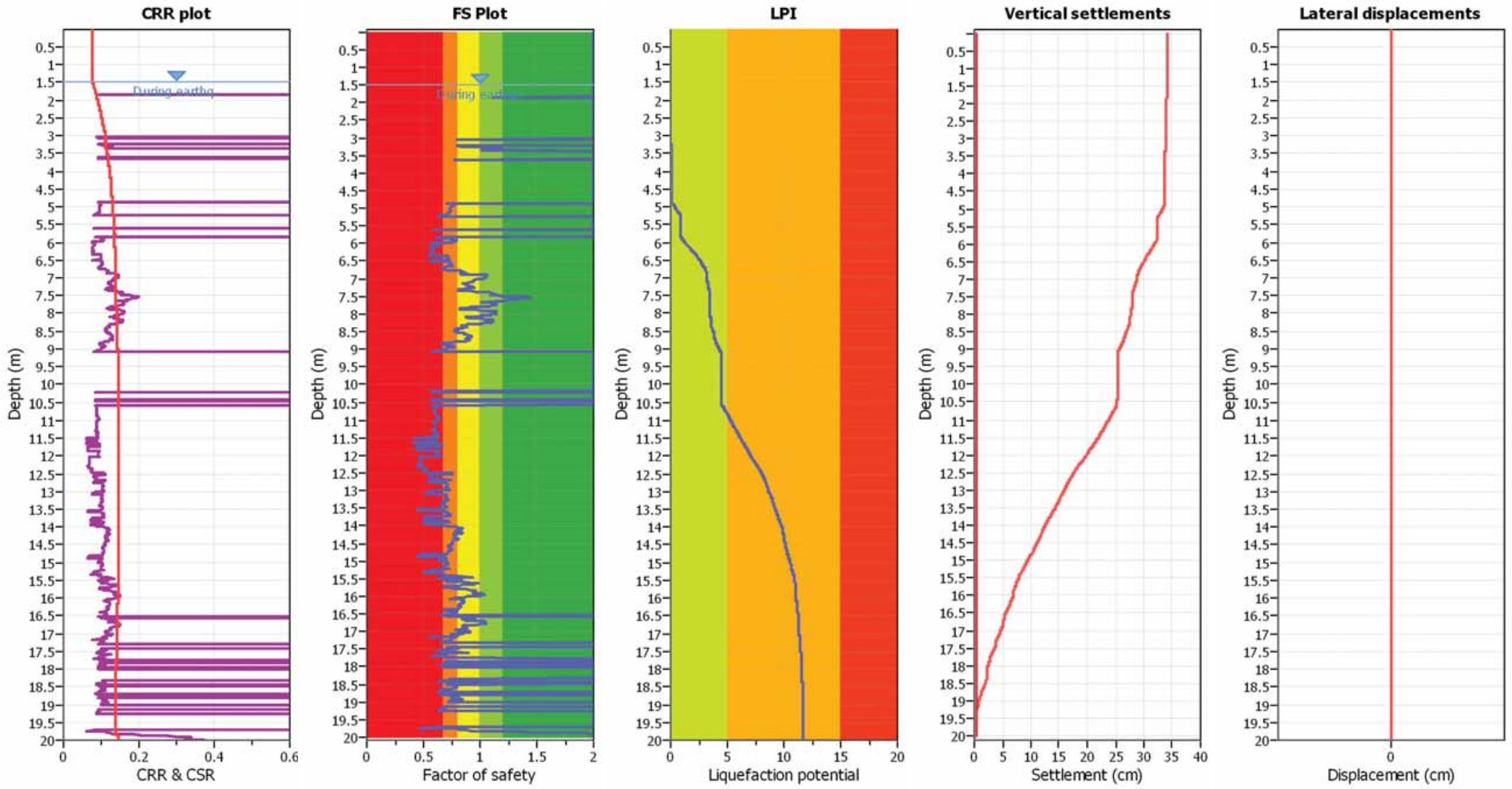

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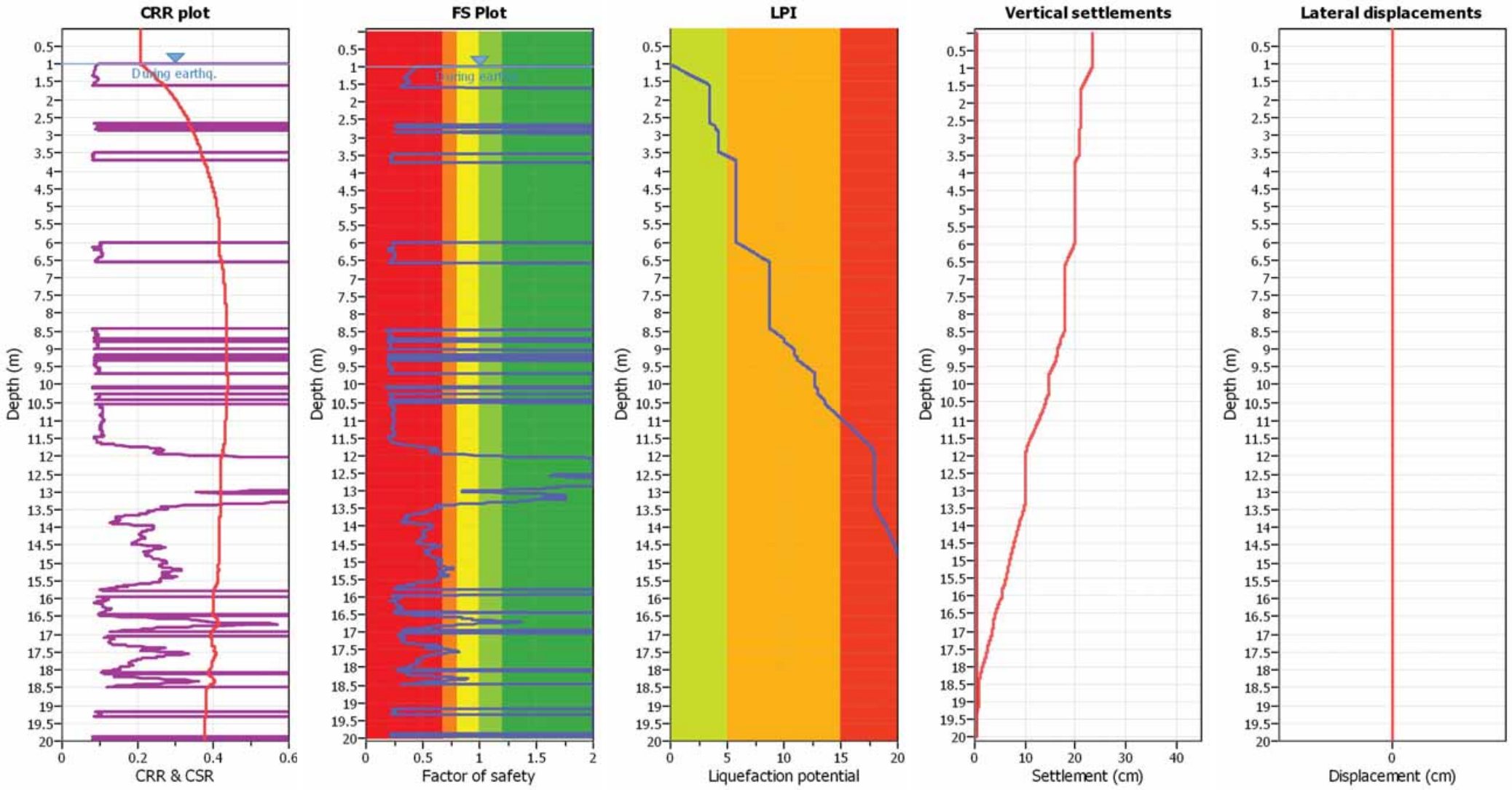

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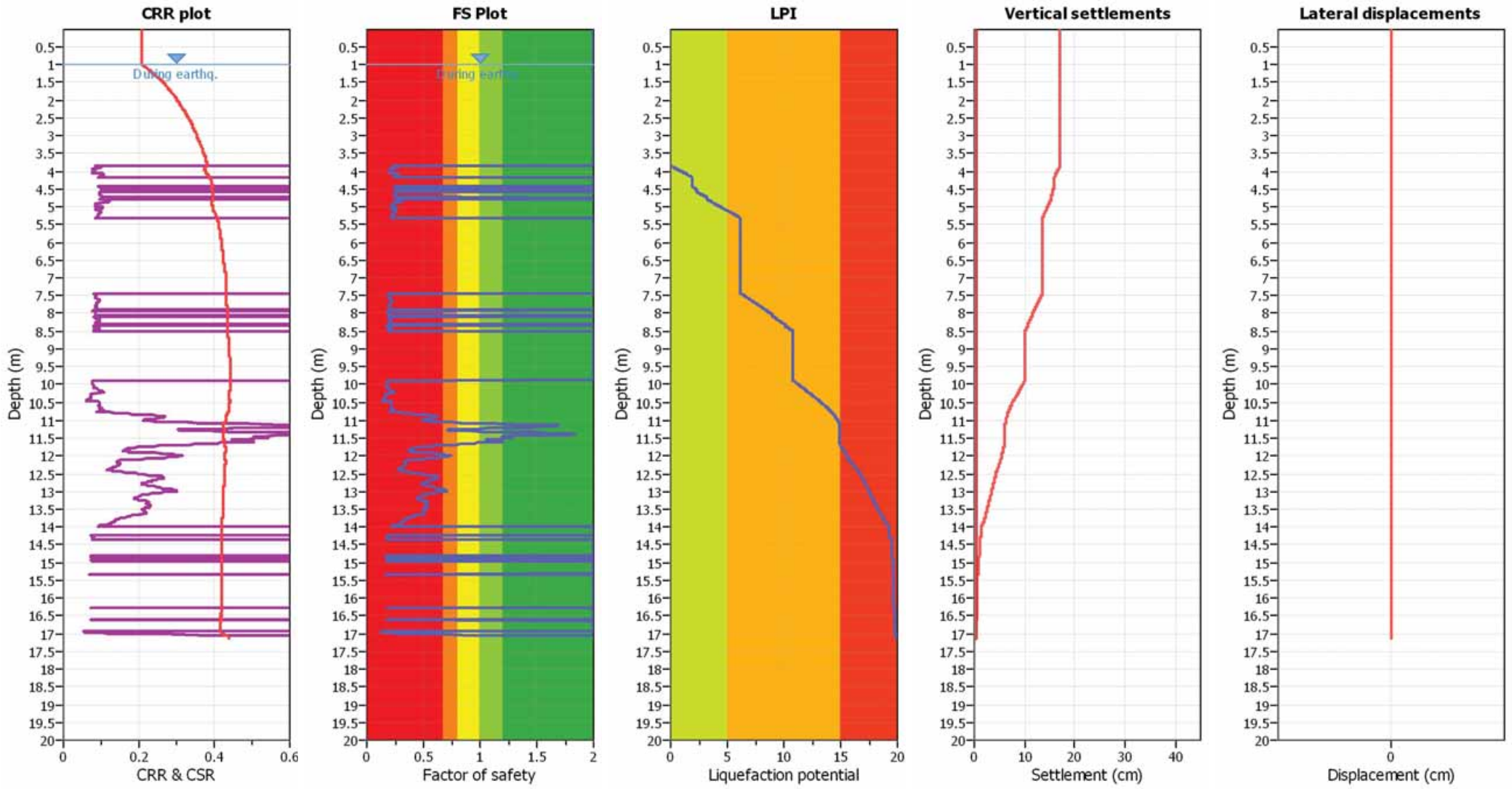

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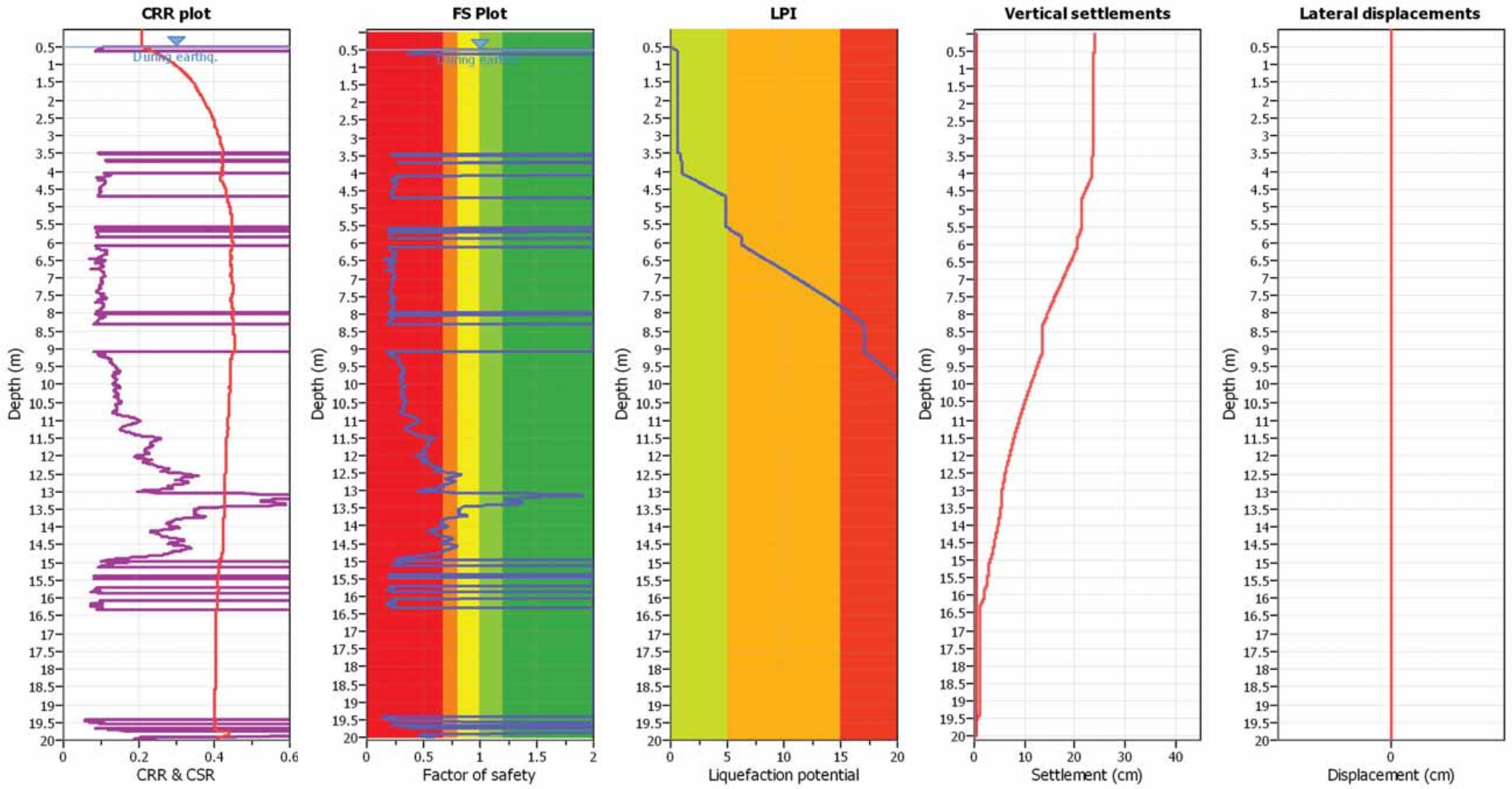

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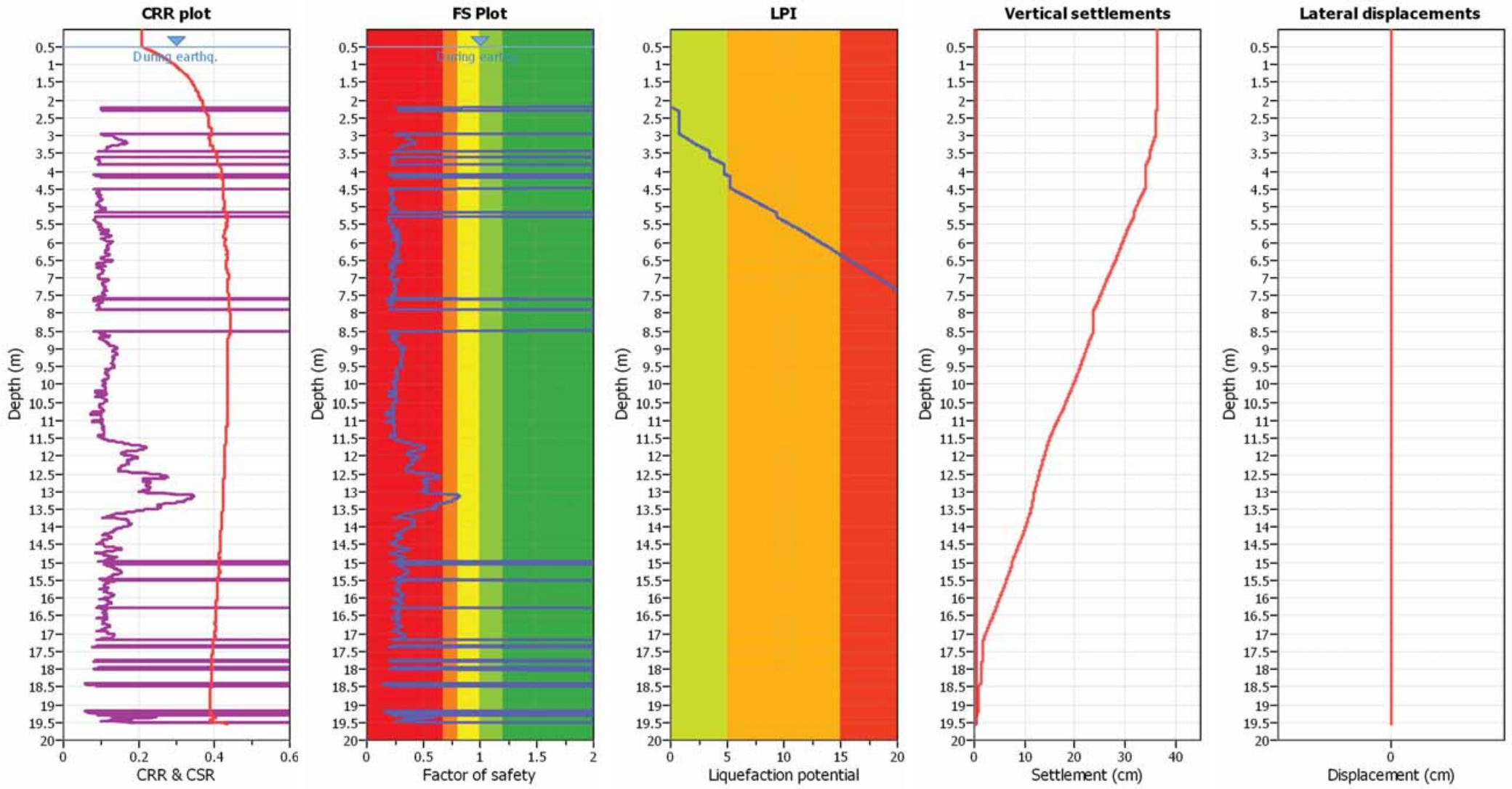

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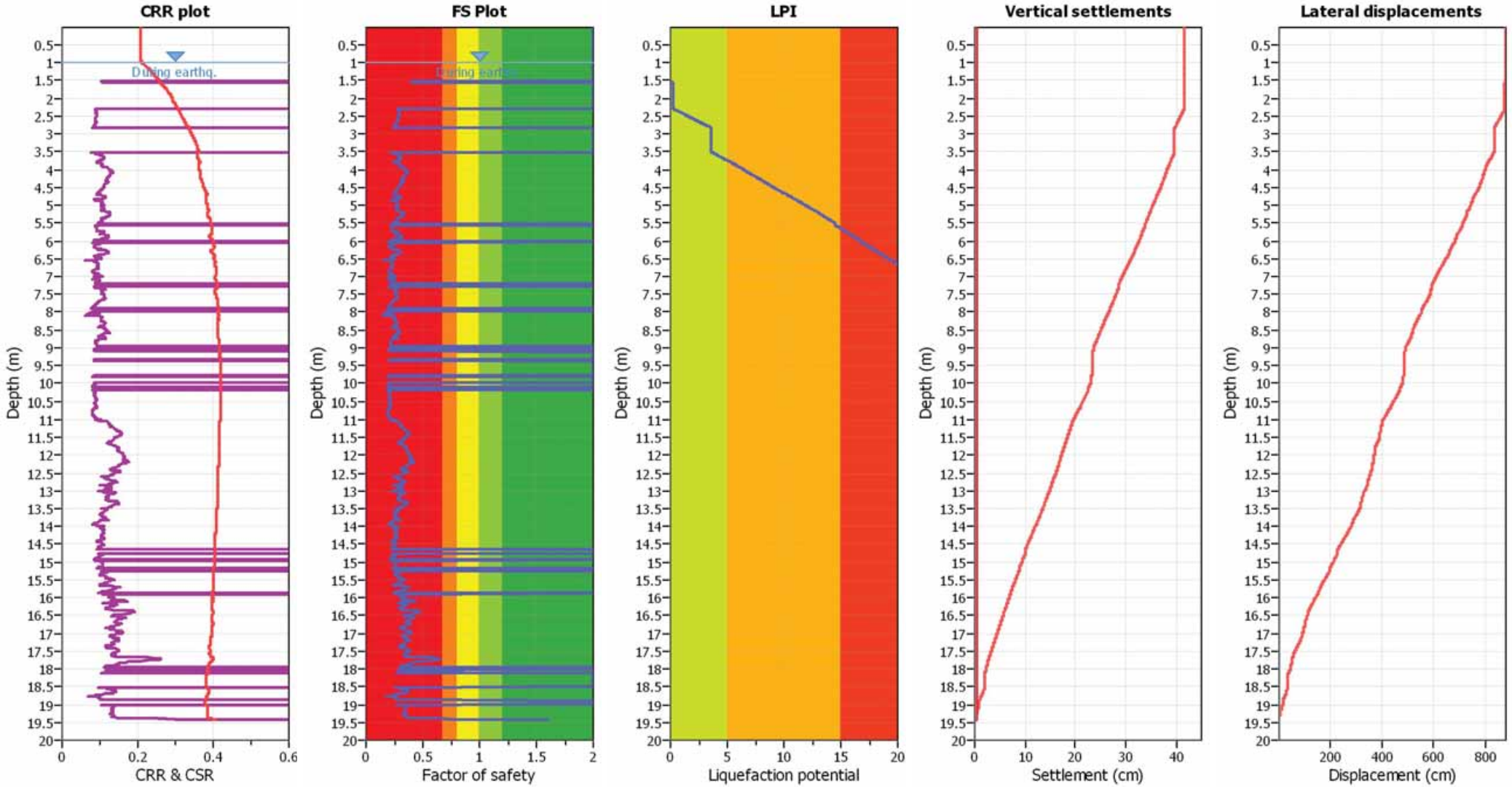

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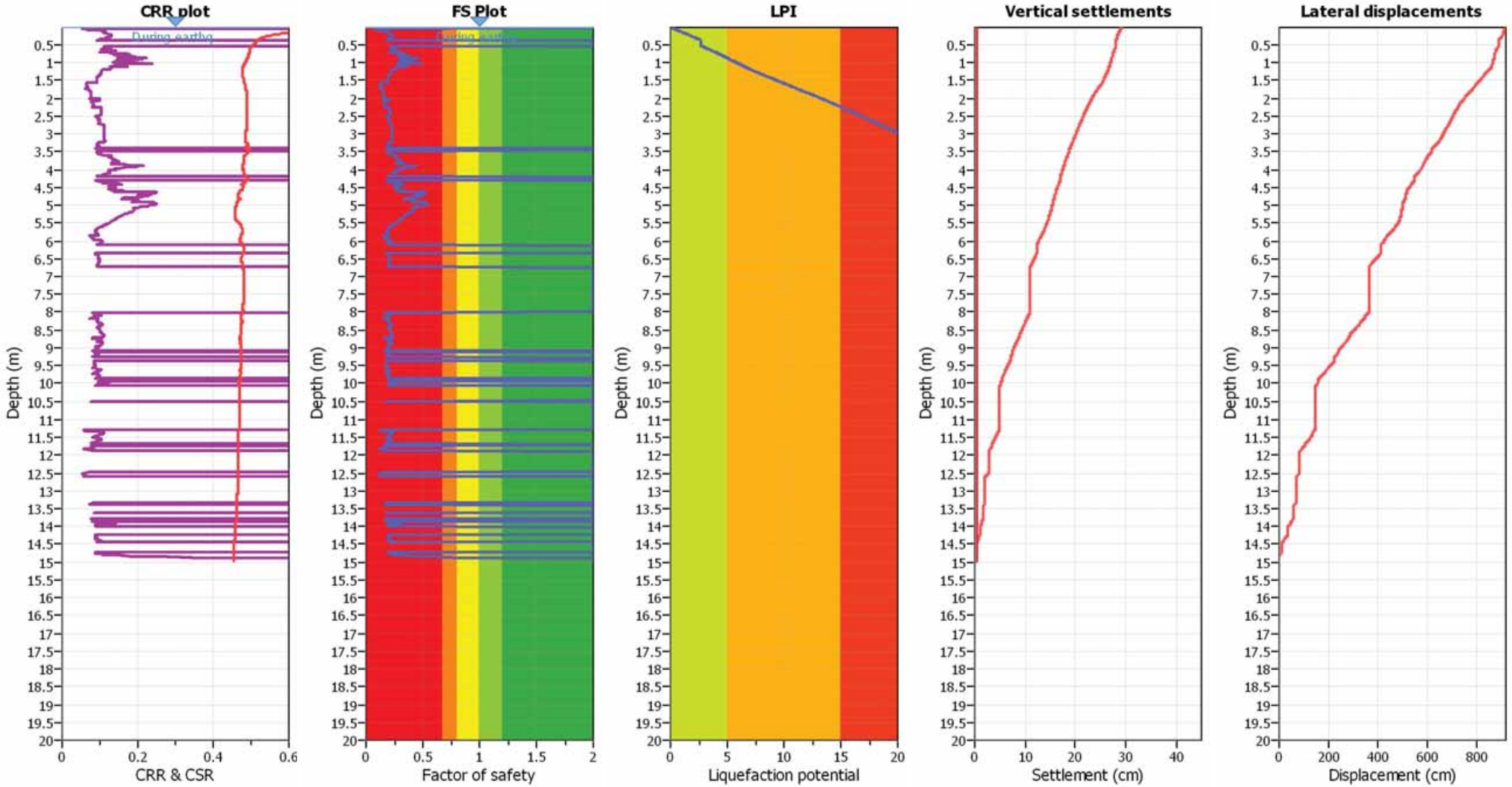

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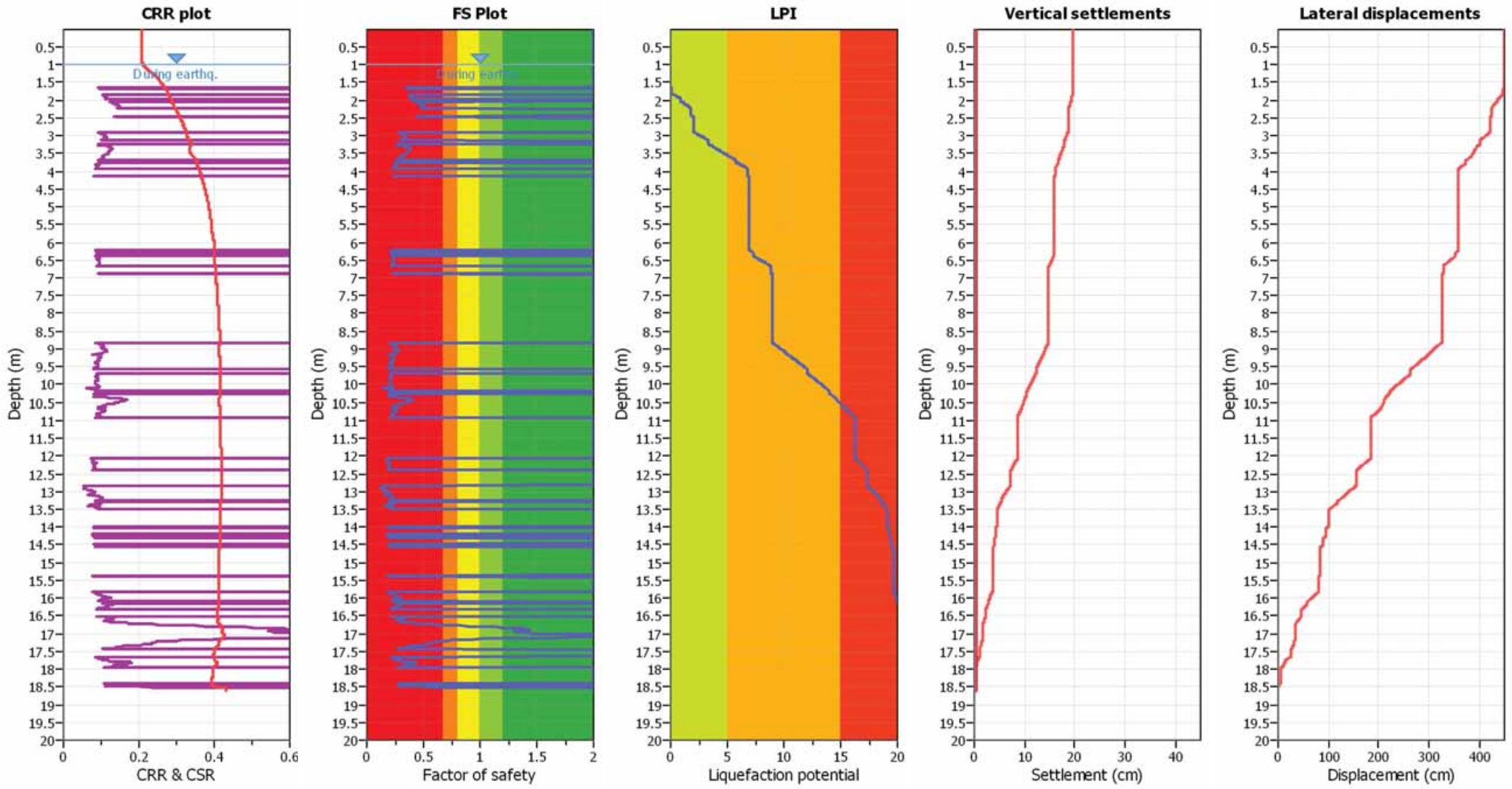

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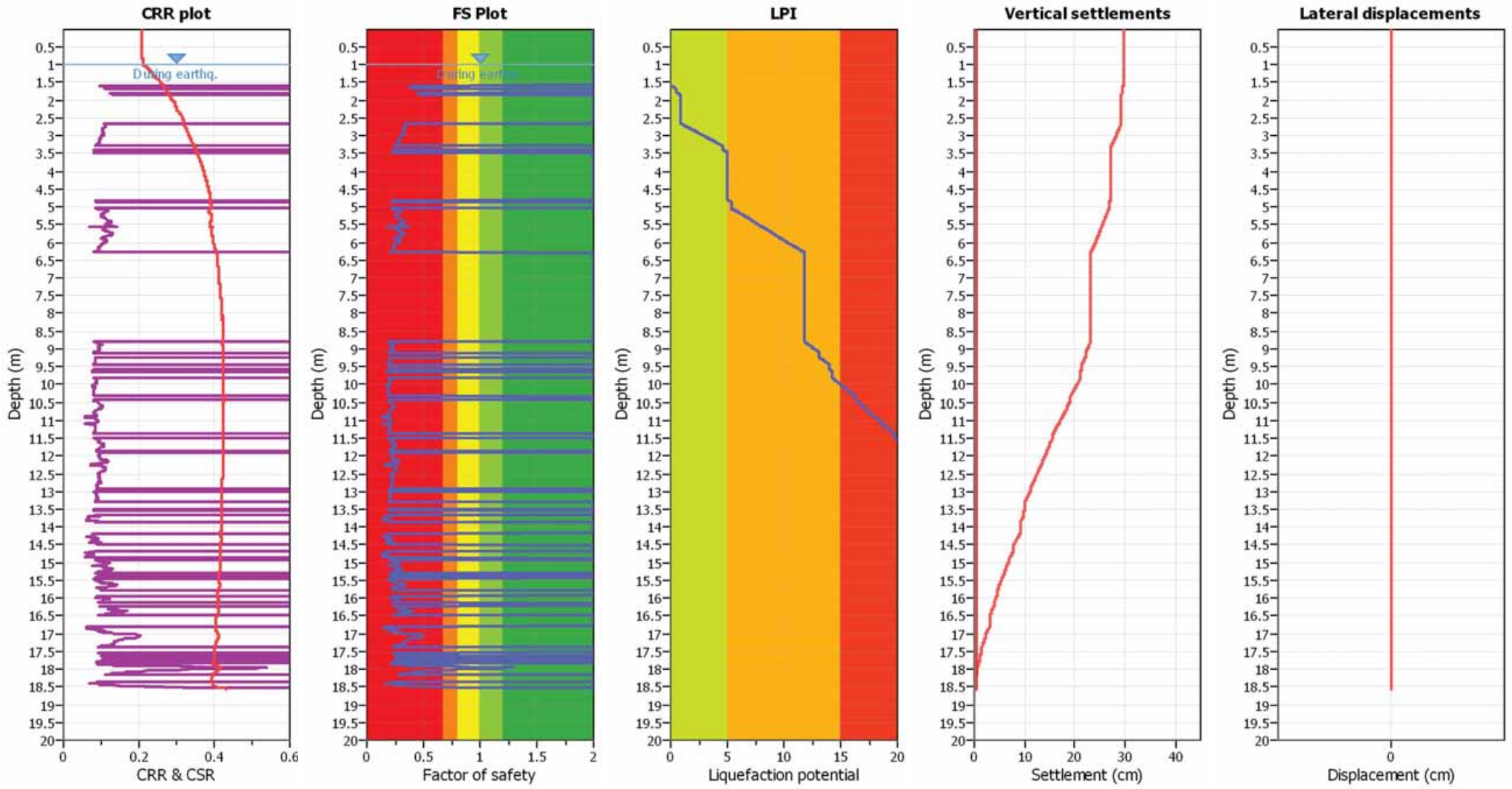

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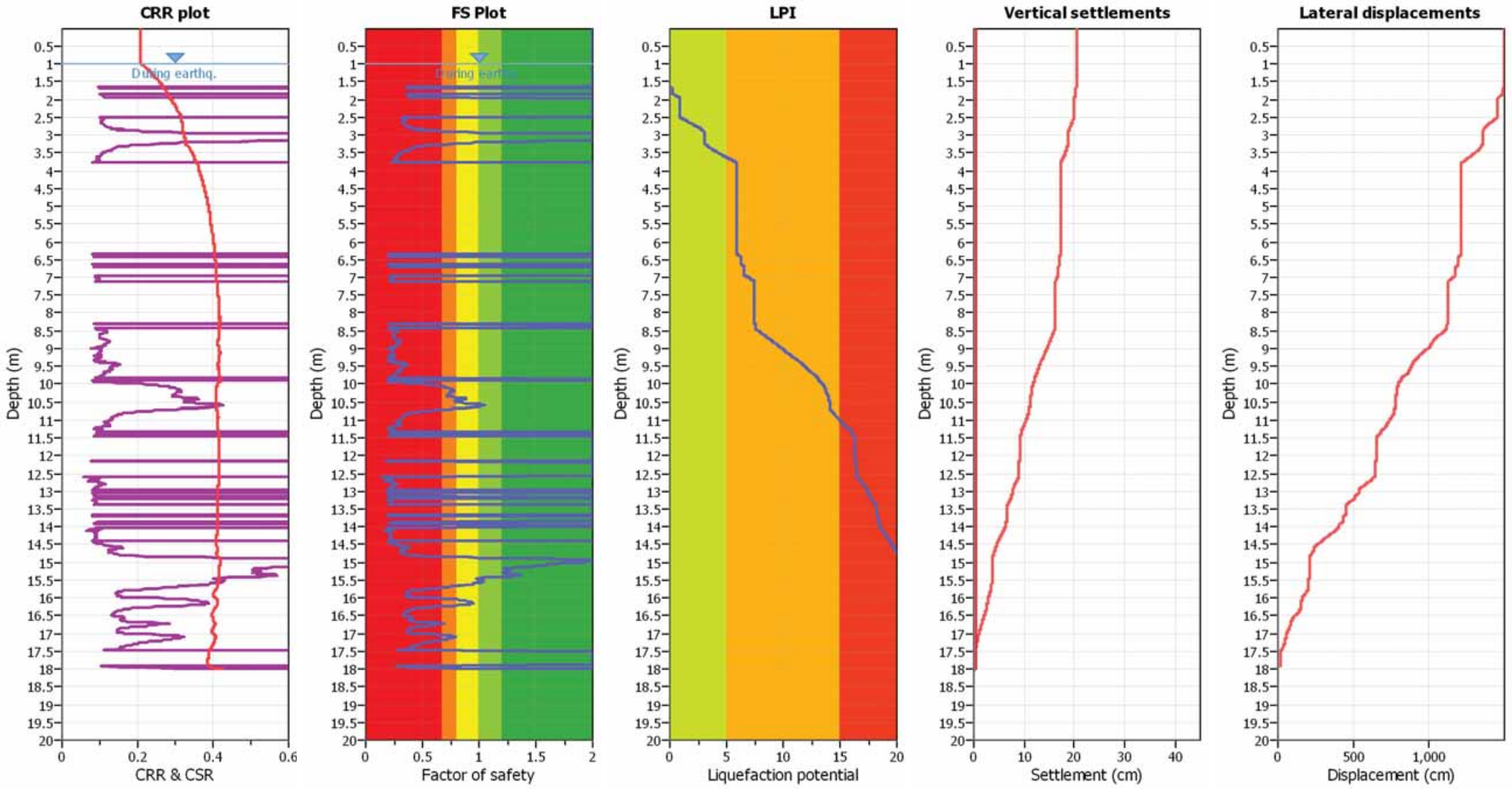

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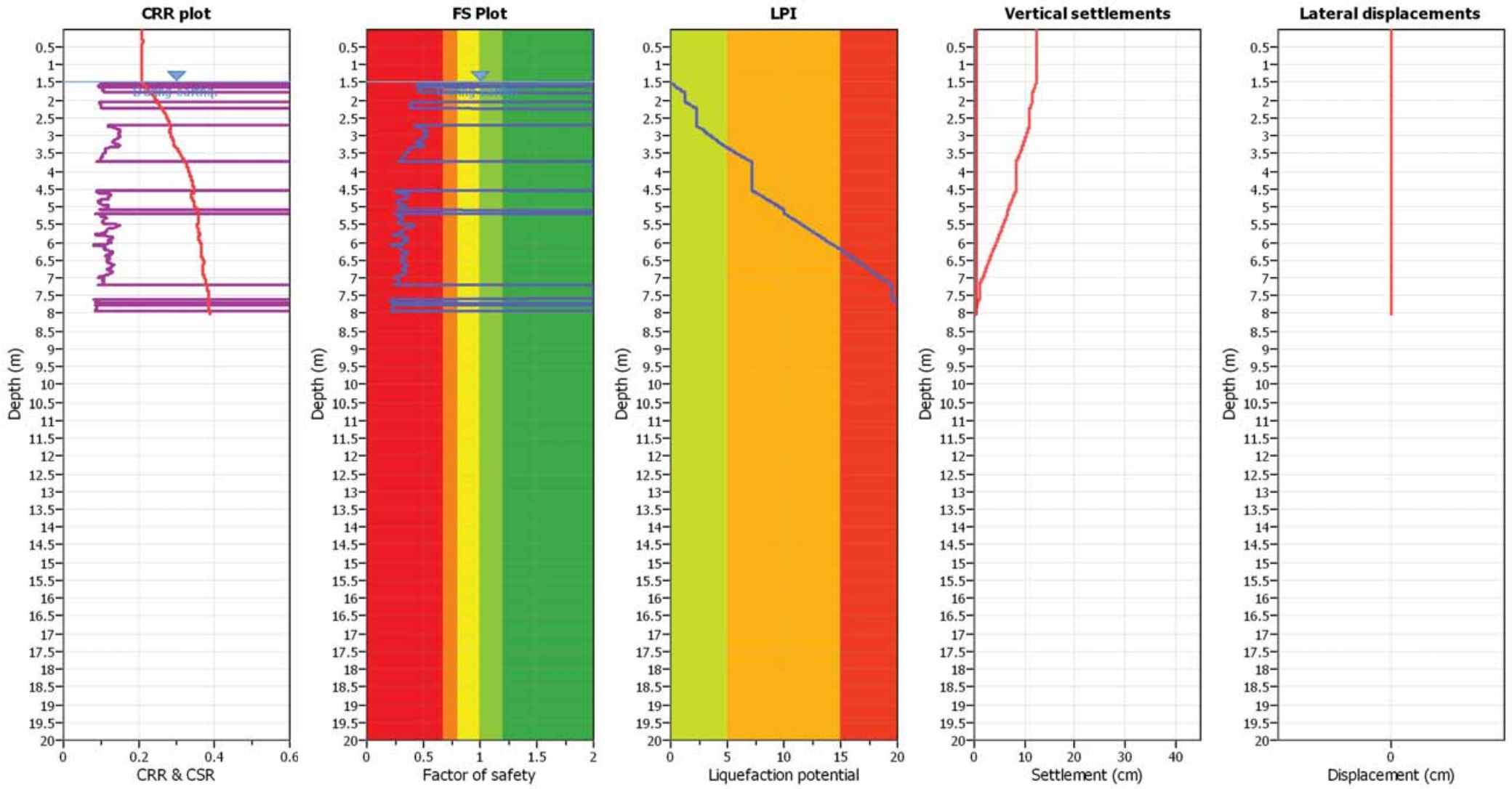

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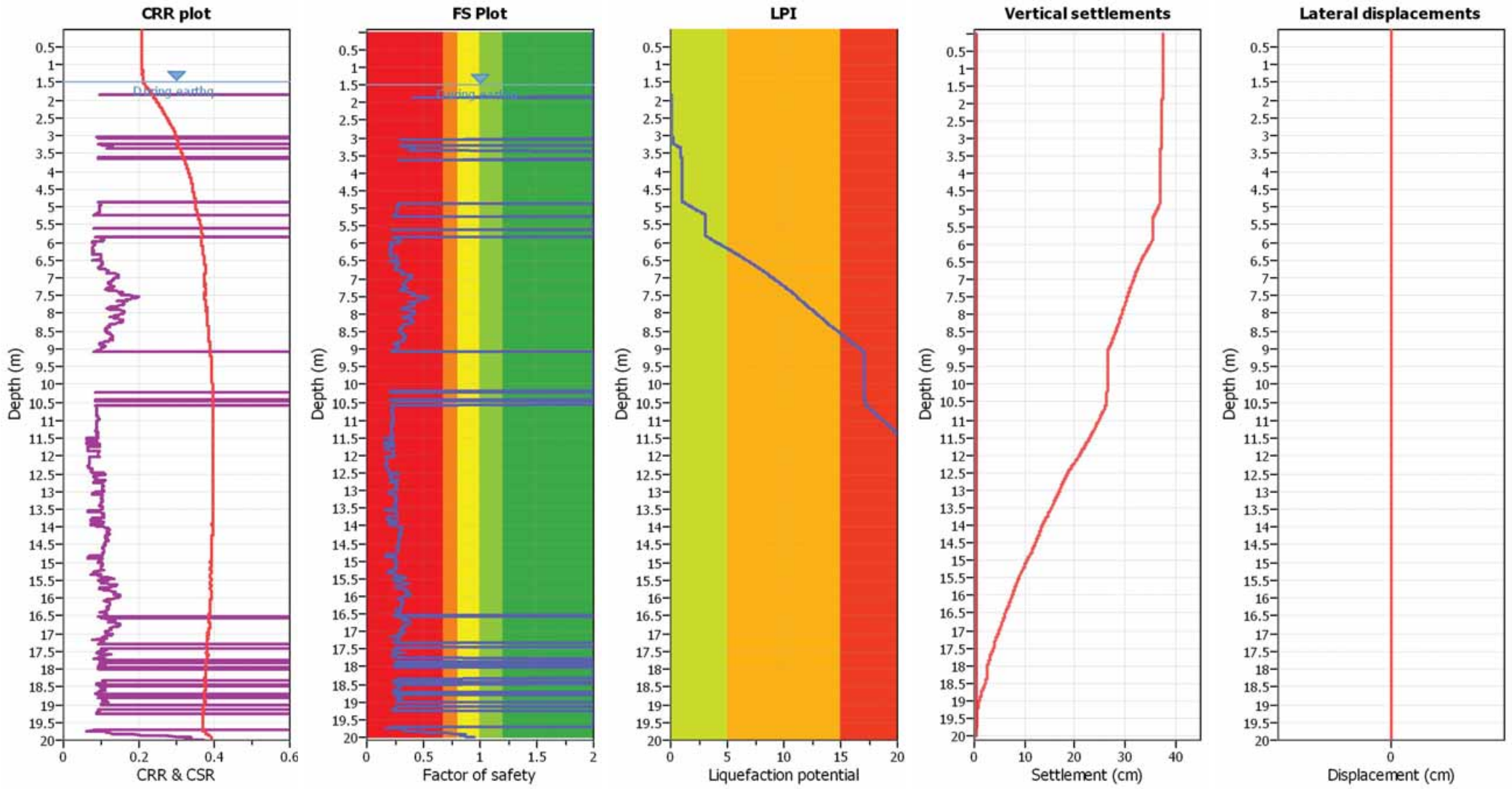

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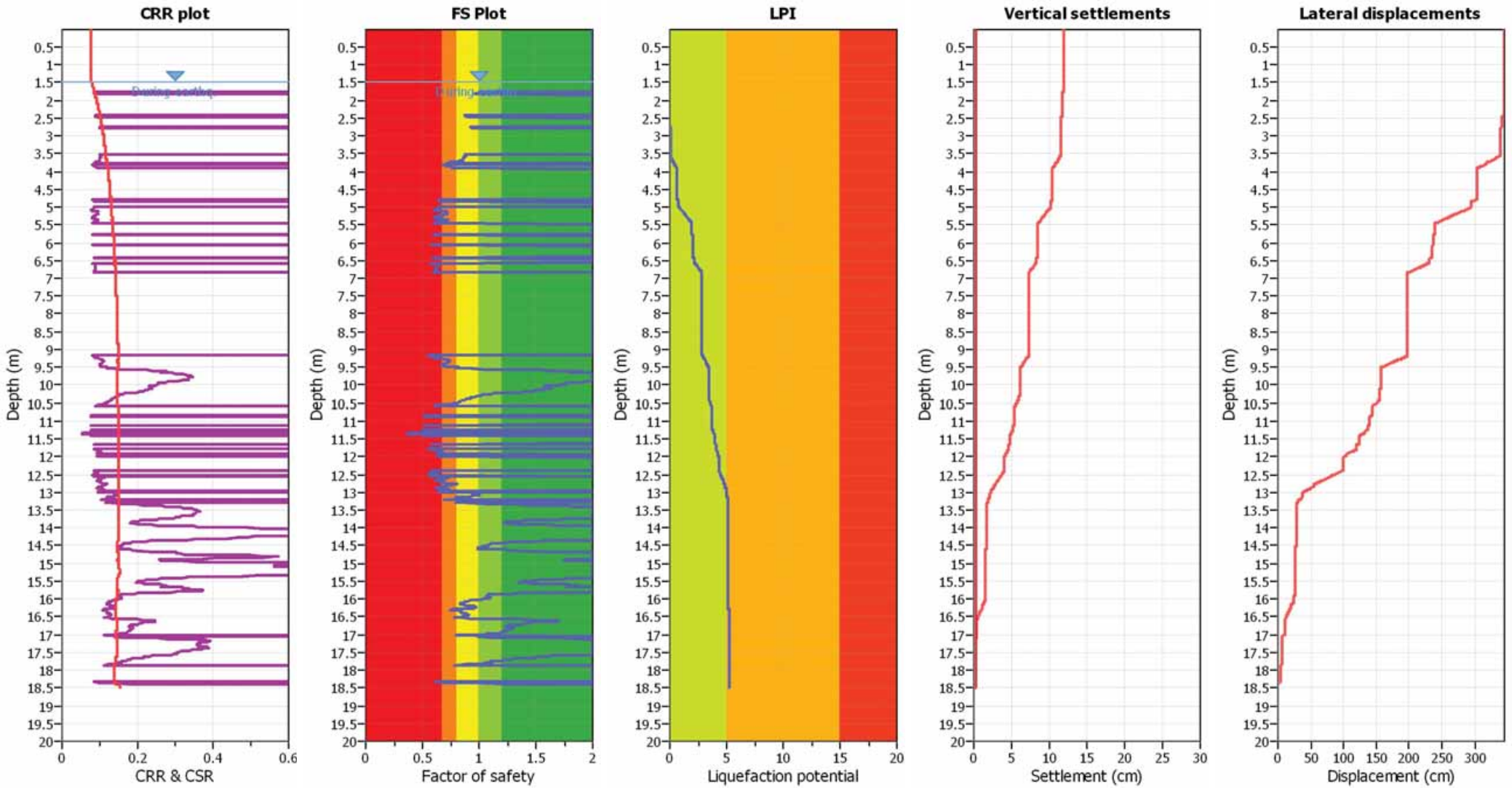

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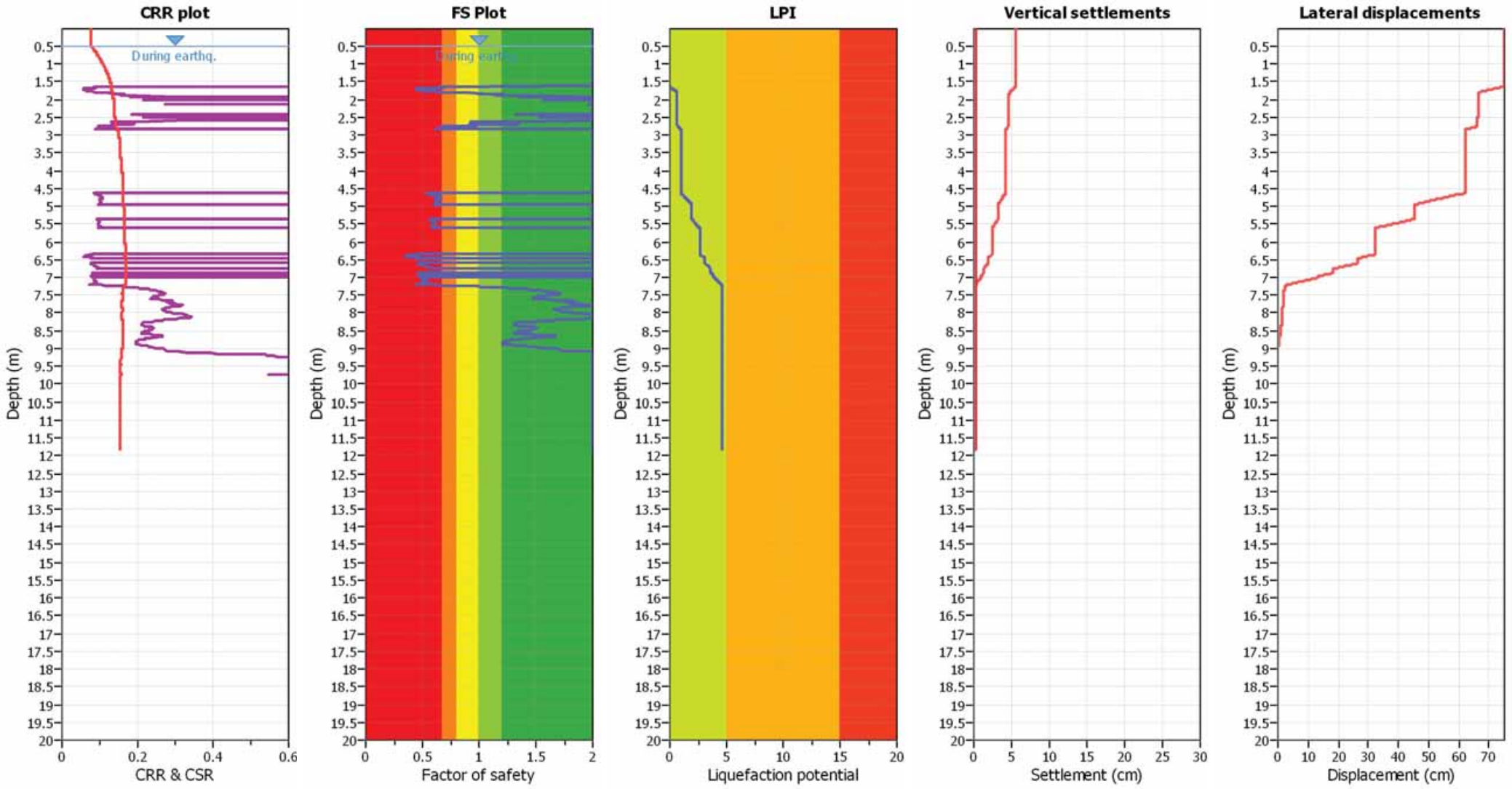

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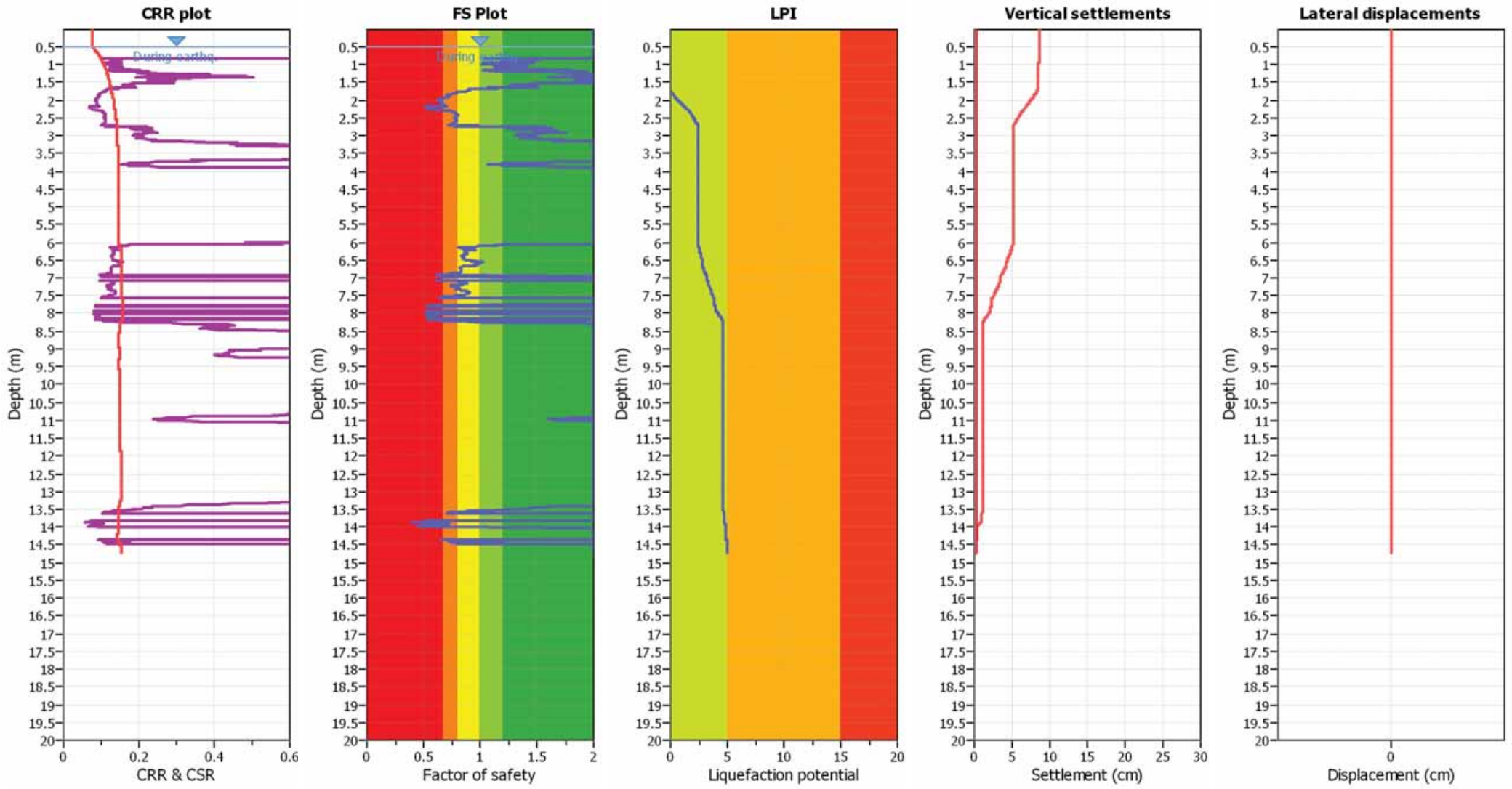

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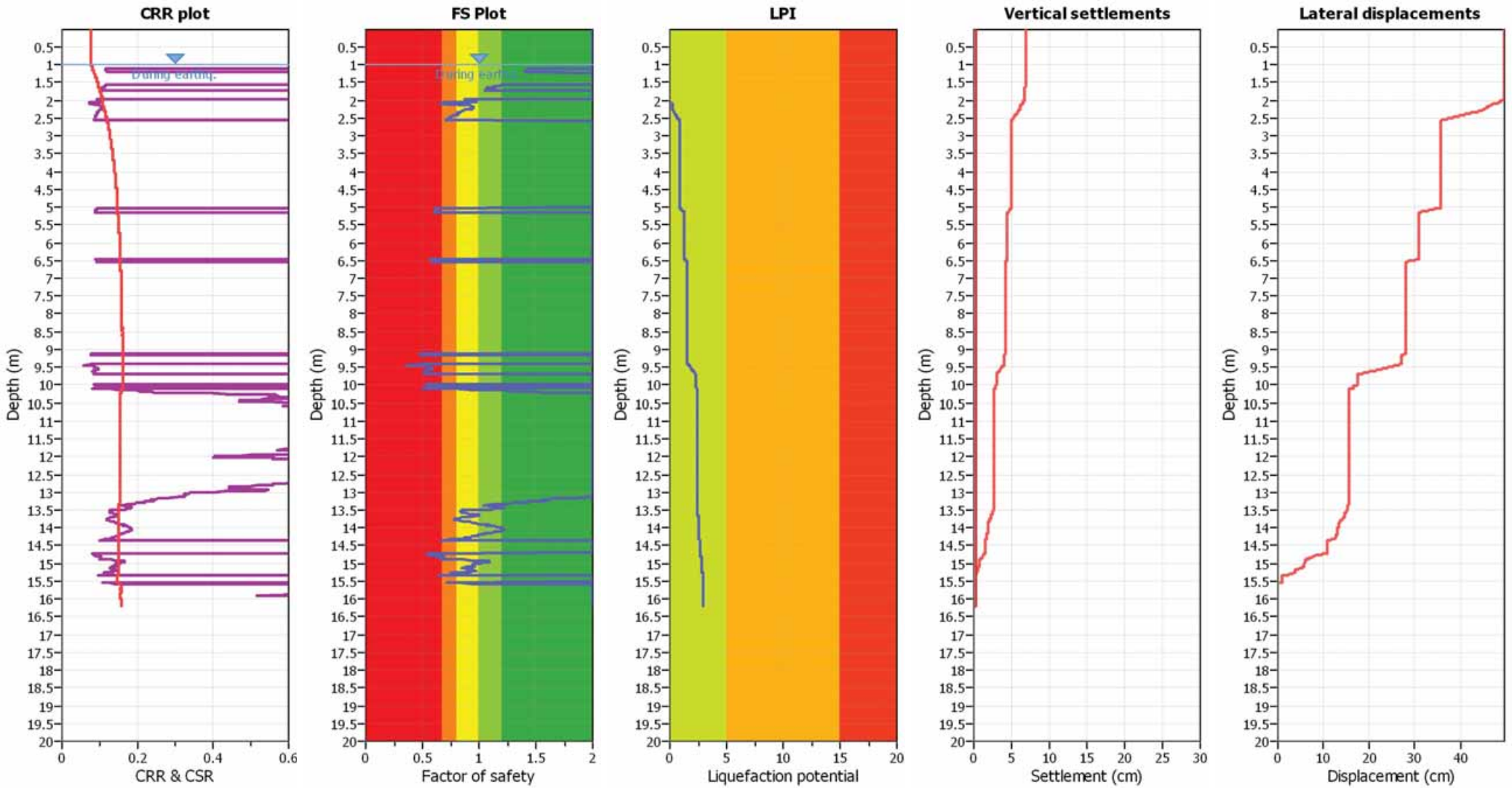

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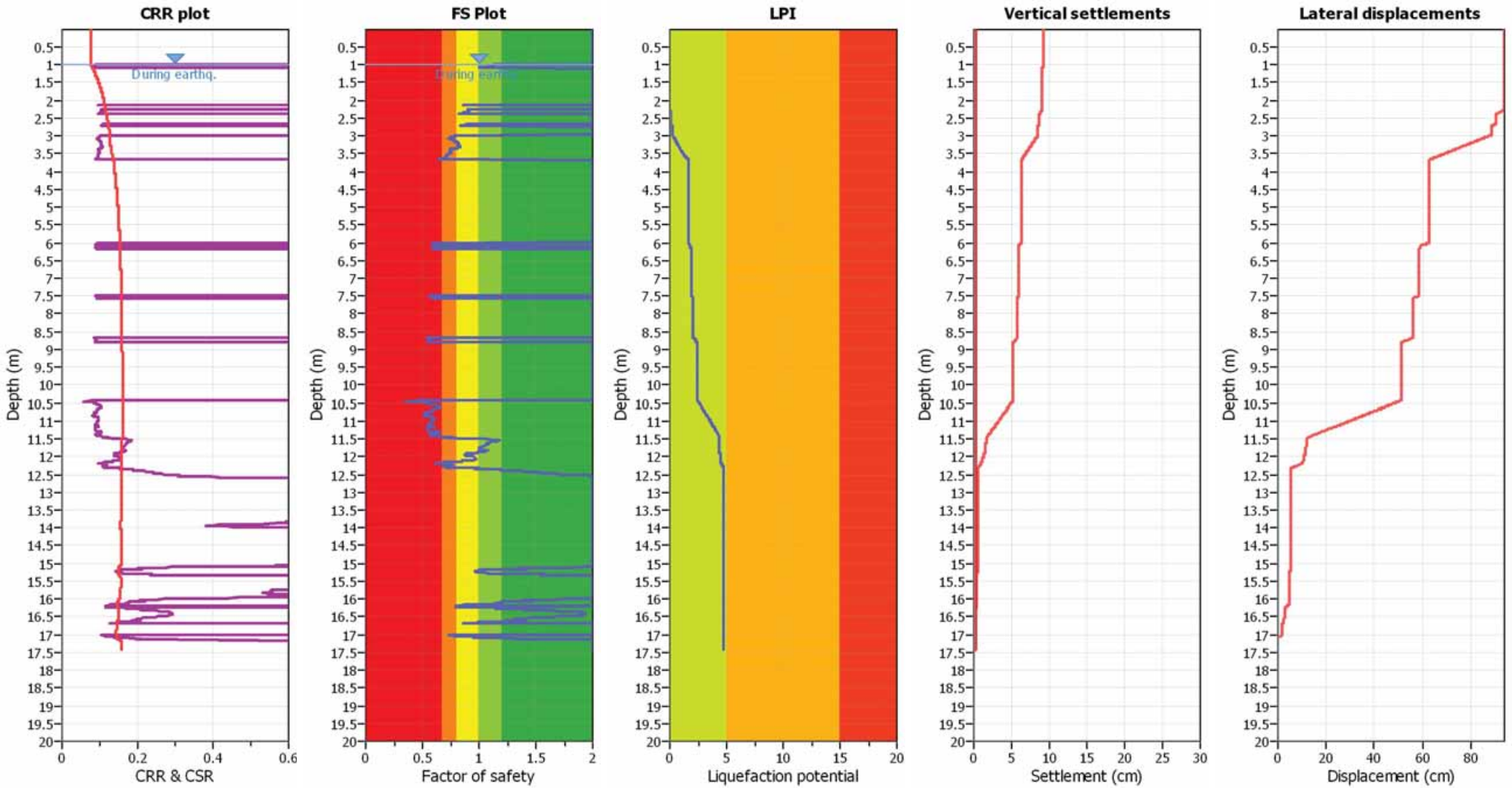

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Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

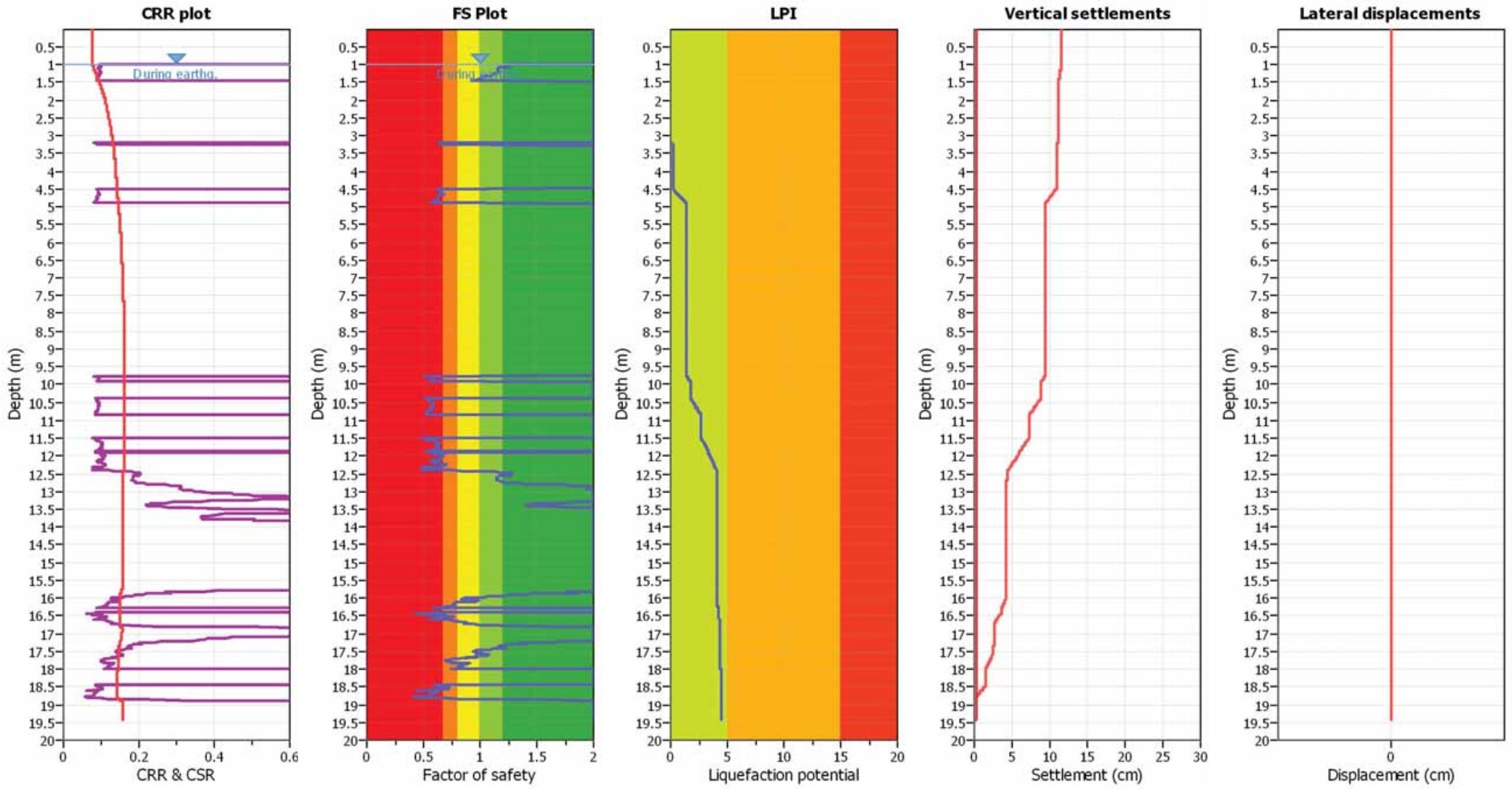
F.S. color scheme

- 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 plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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
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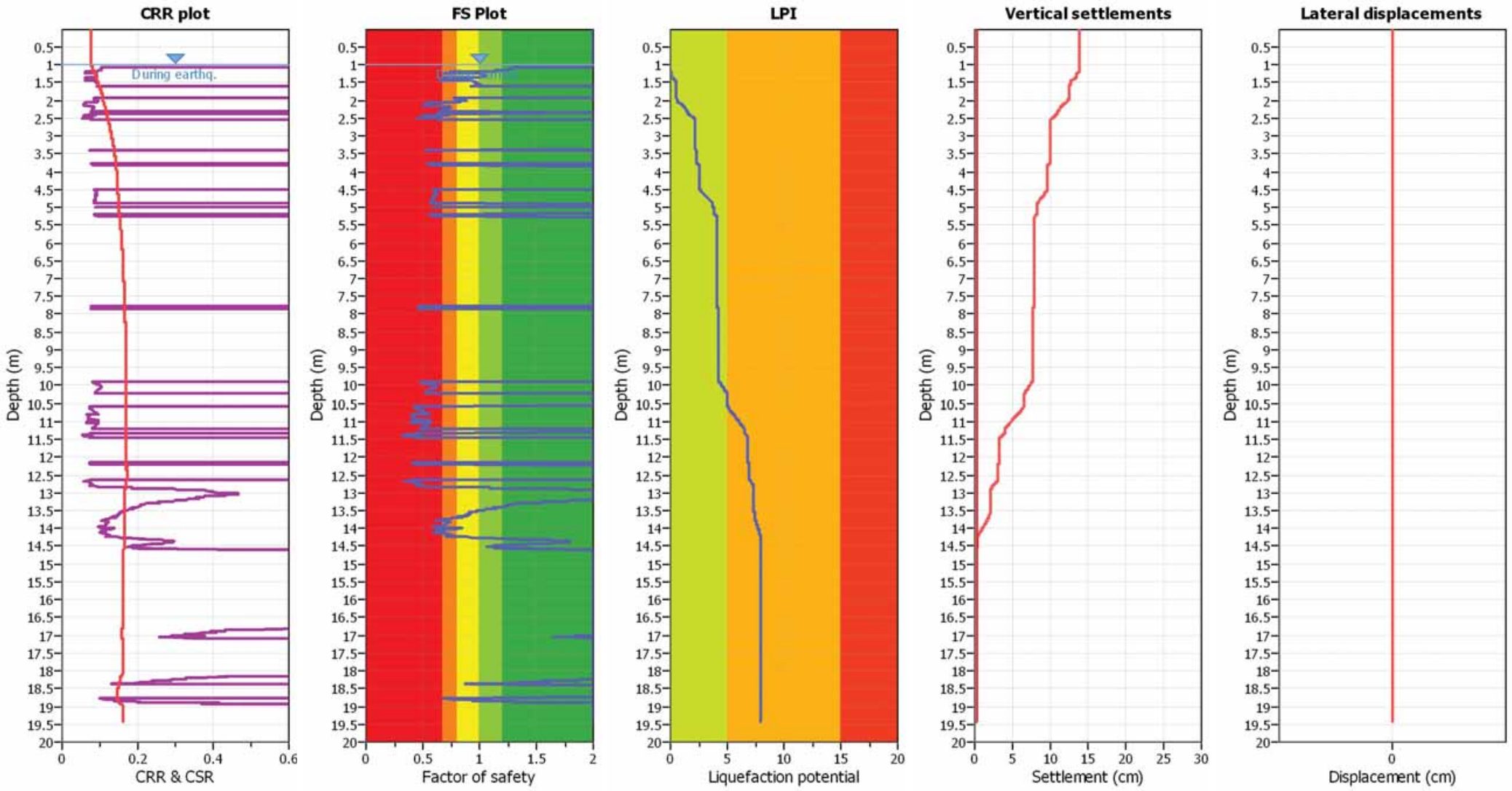

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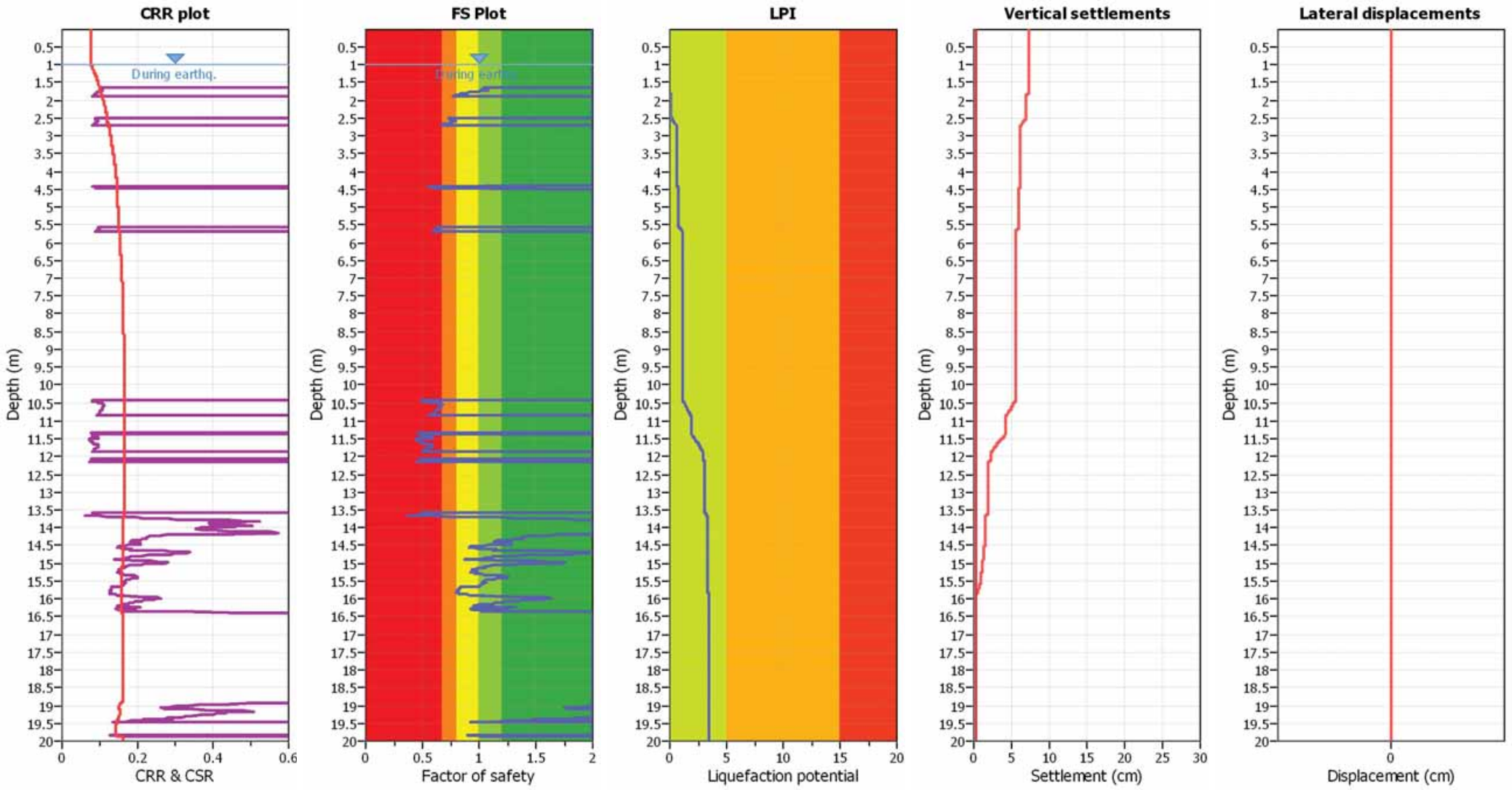

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Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	N/A

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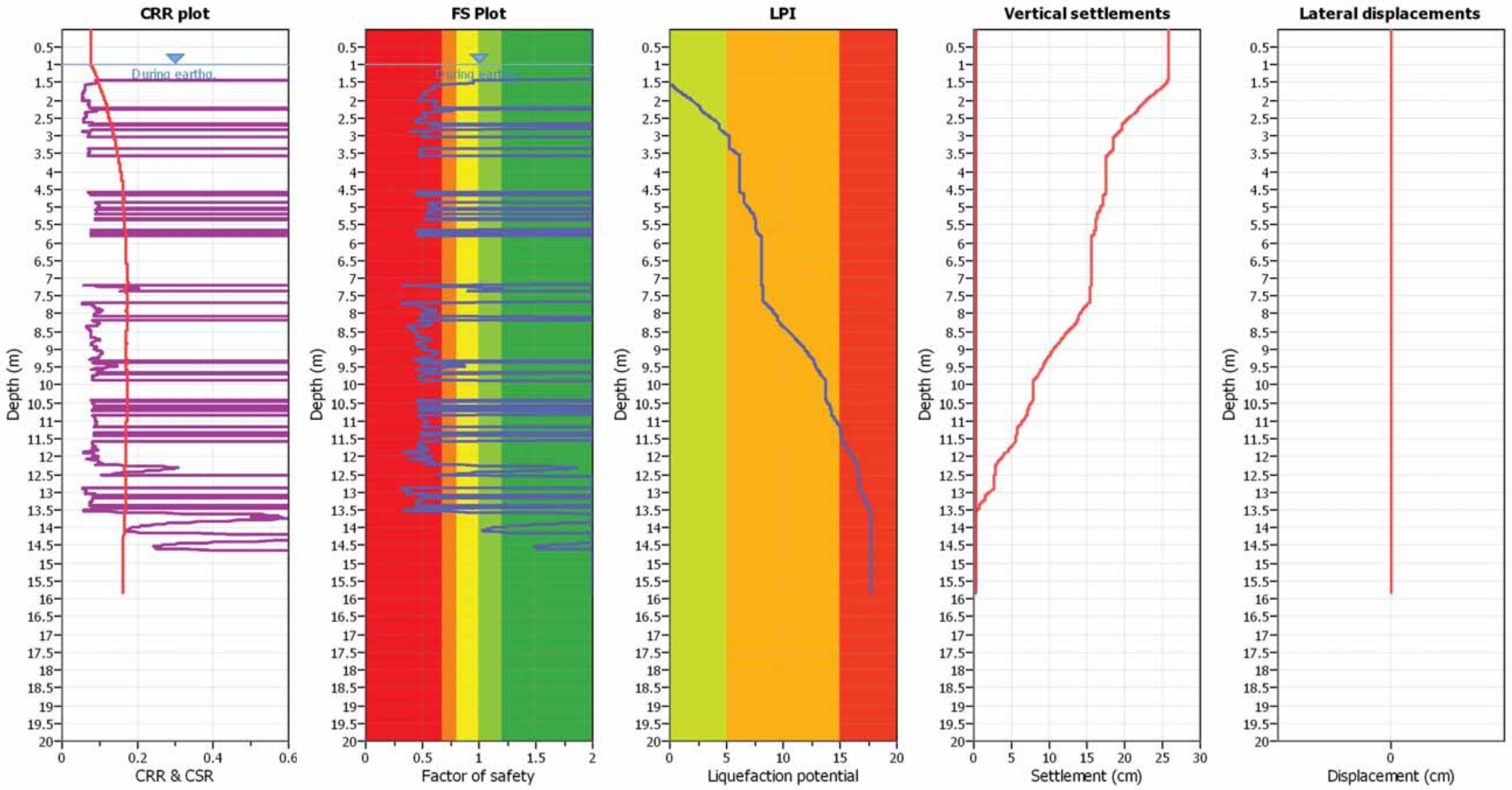

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Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

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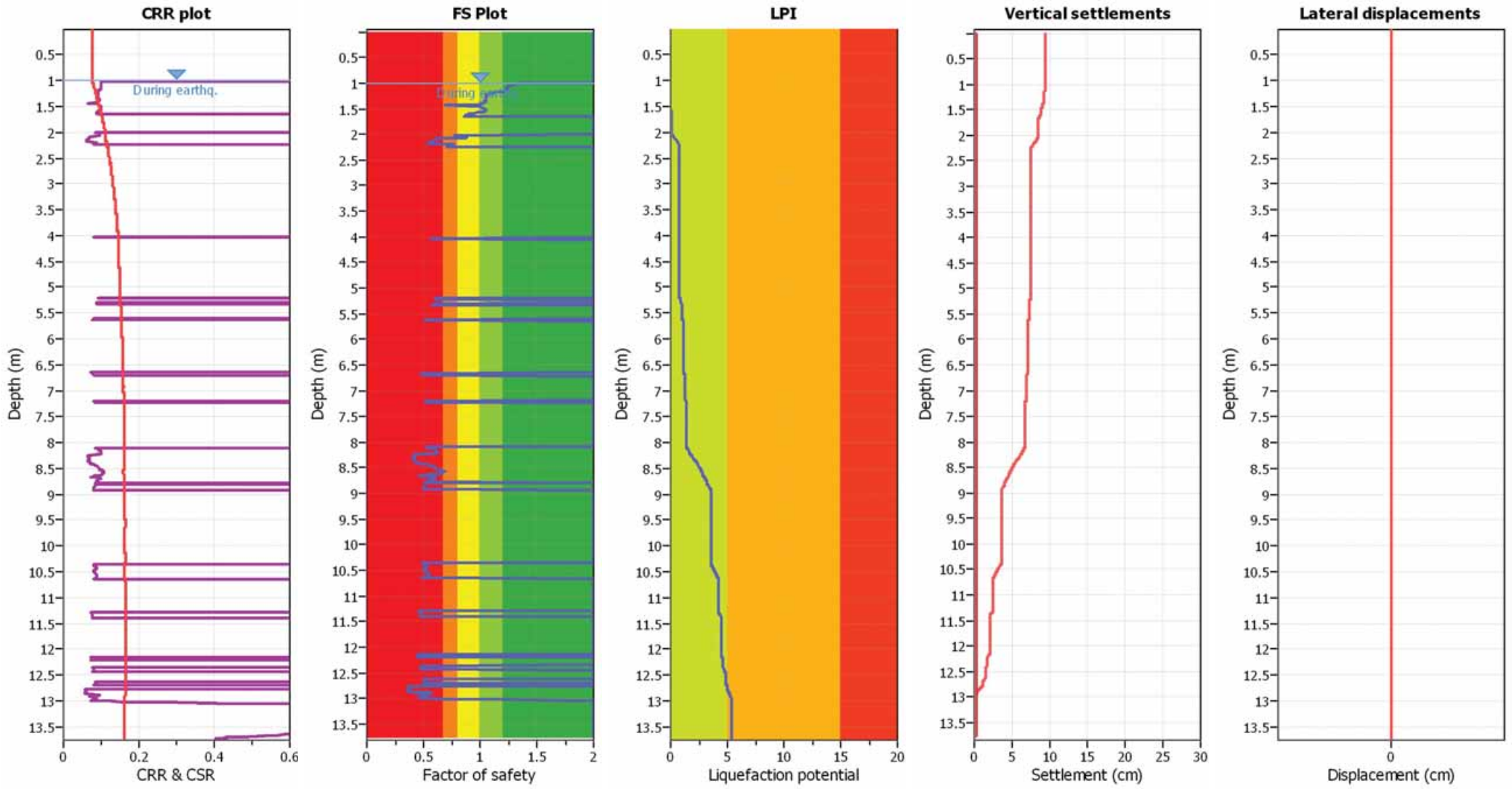

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Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

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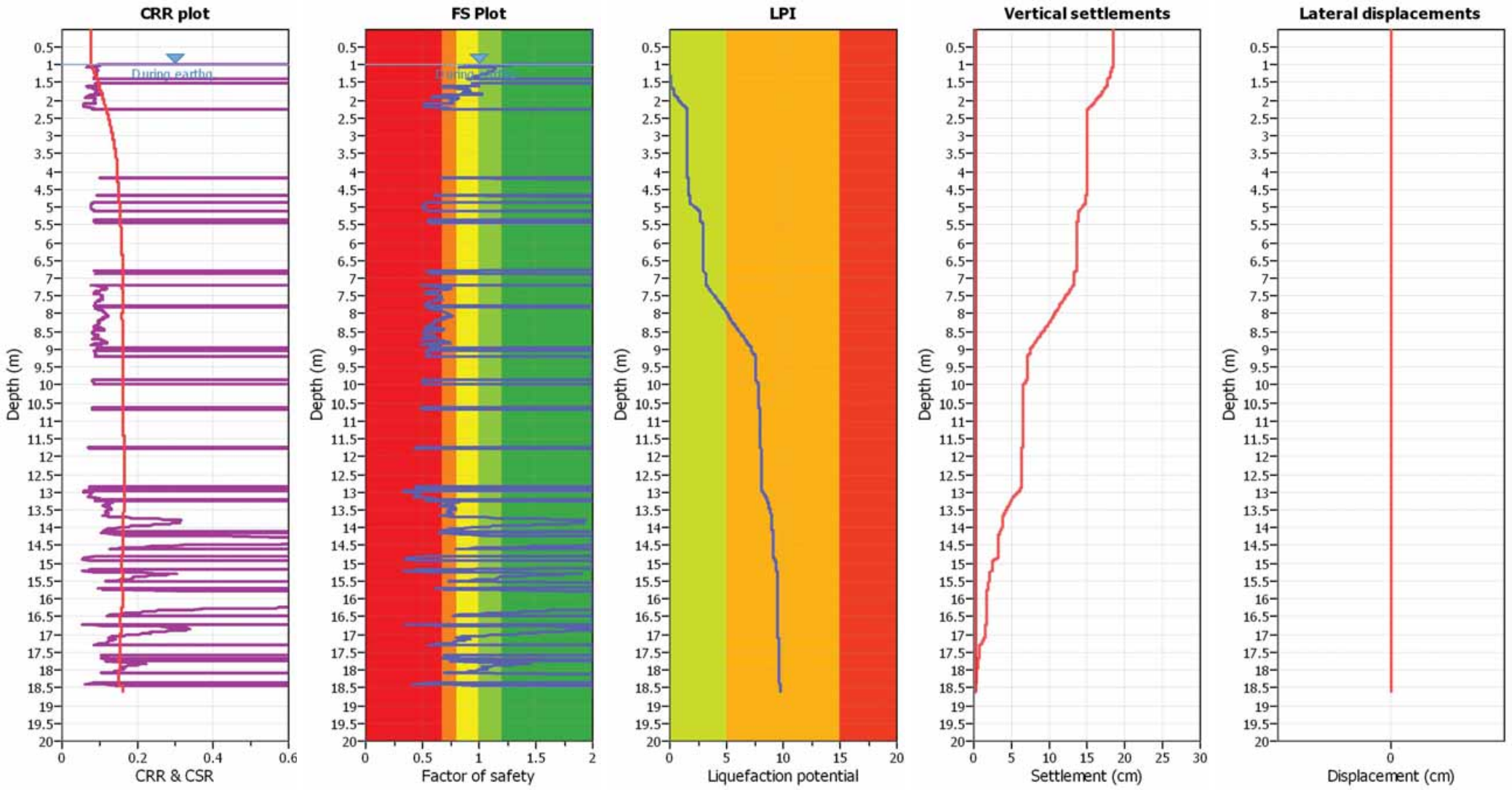

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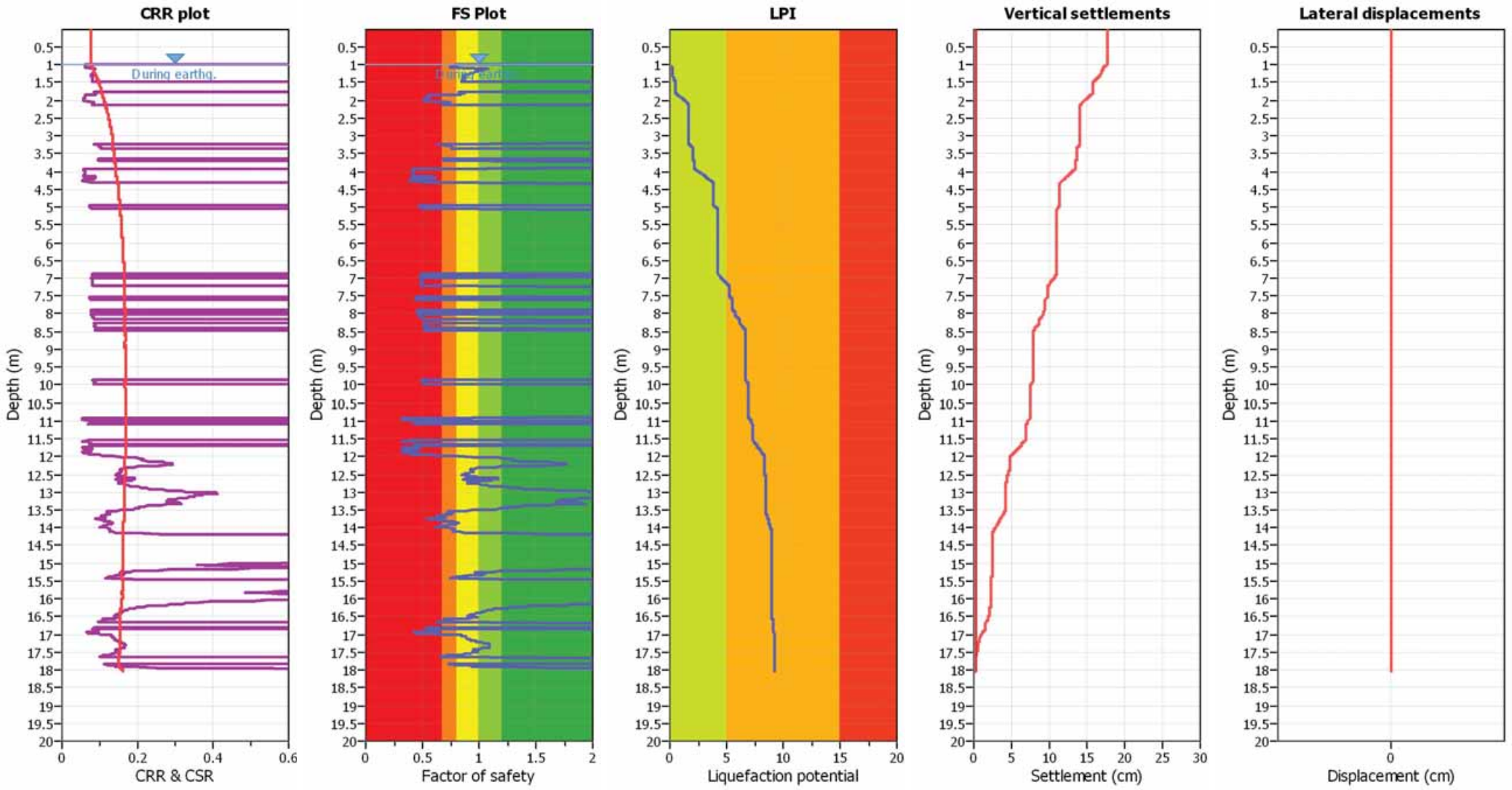

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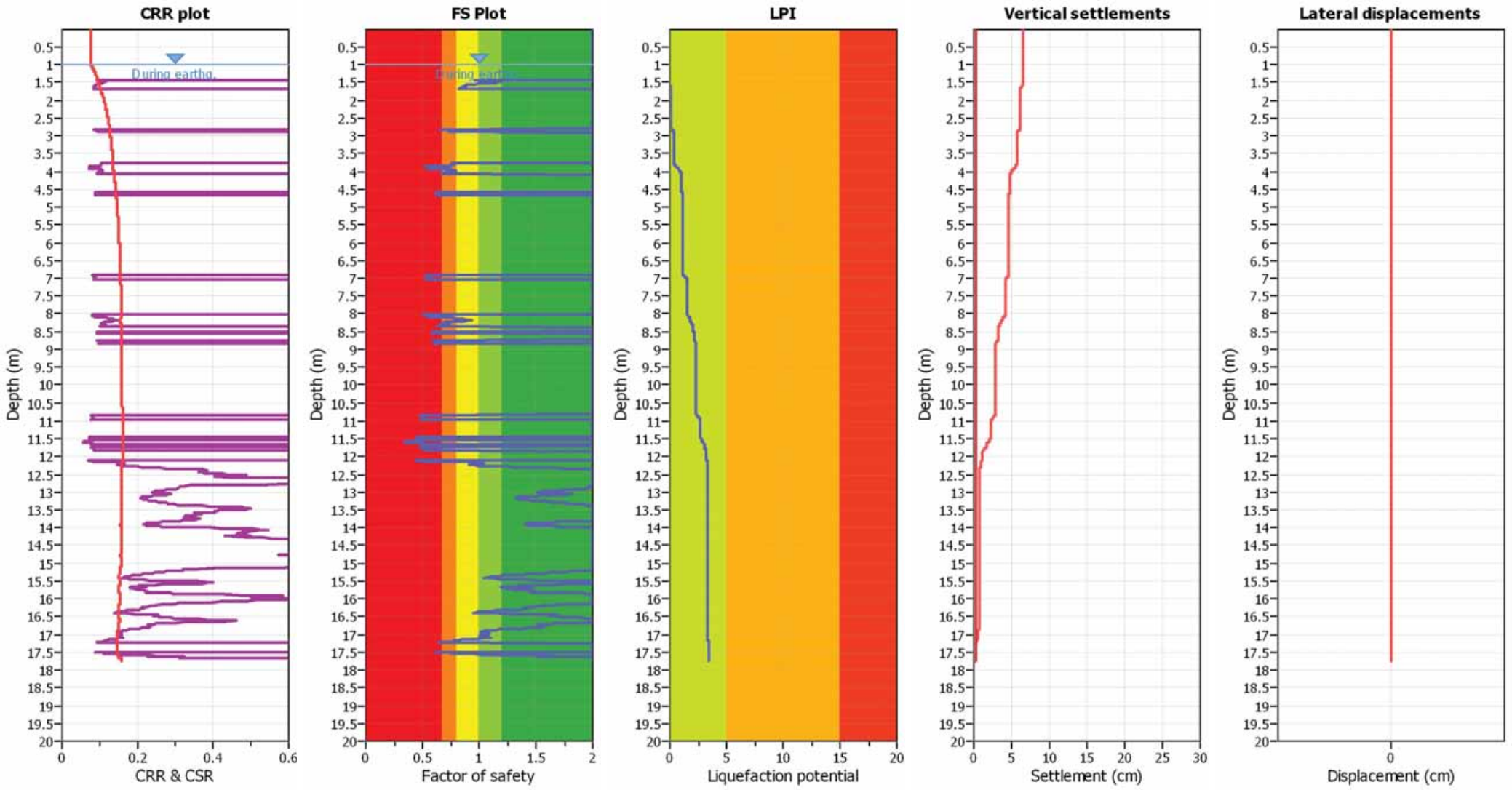

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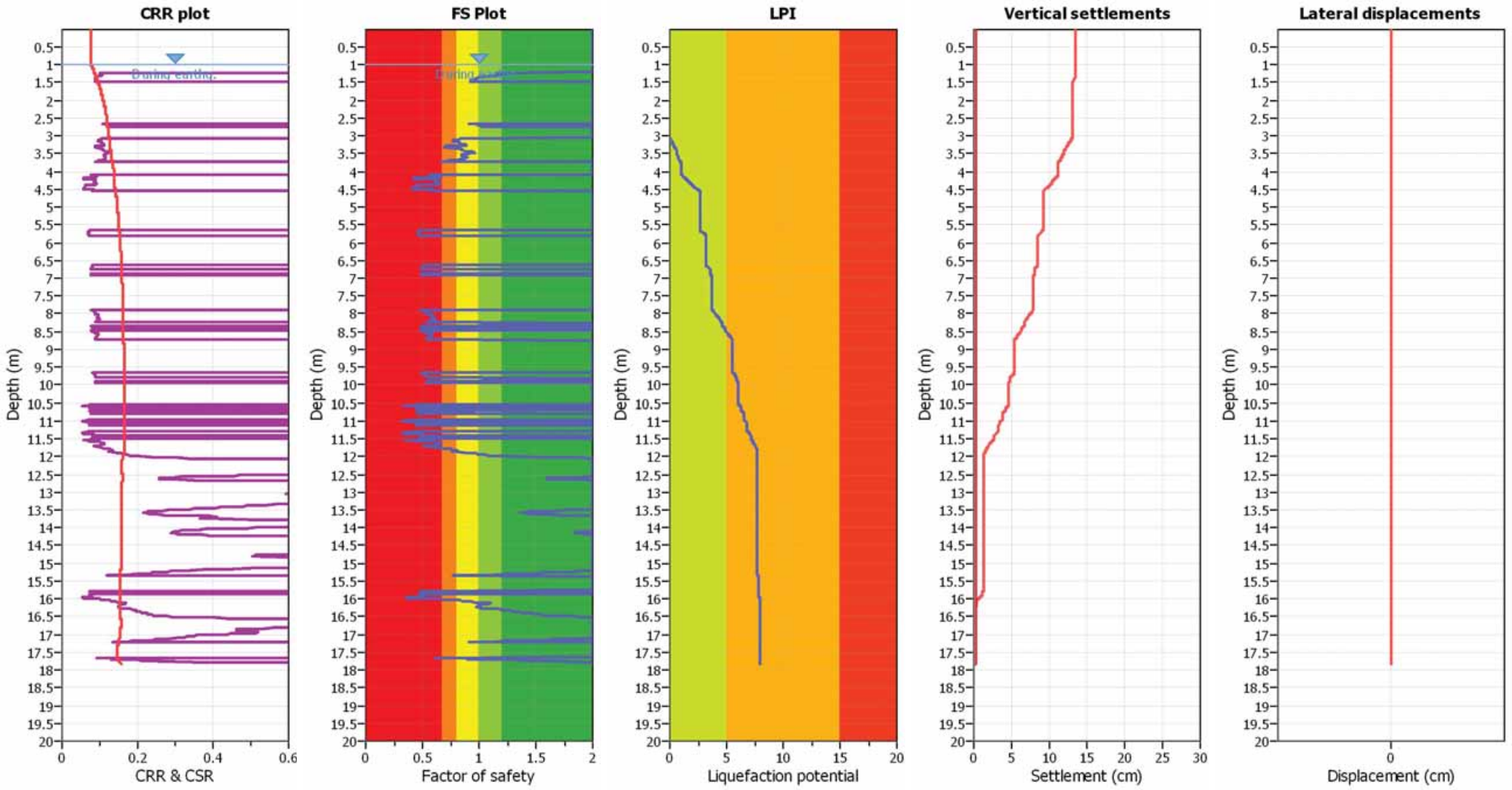

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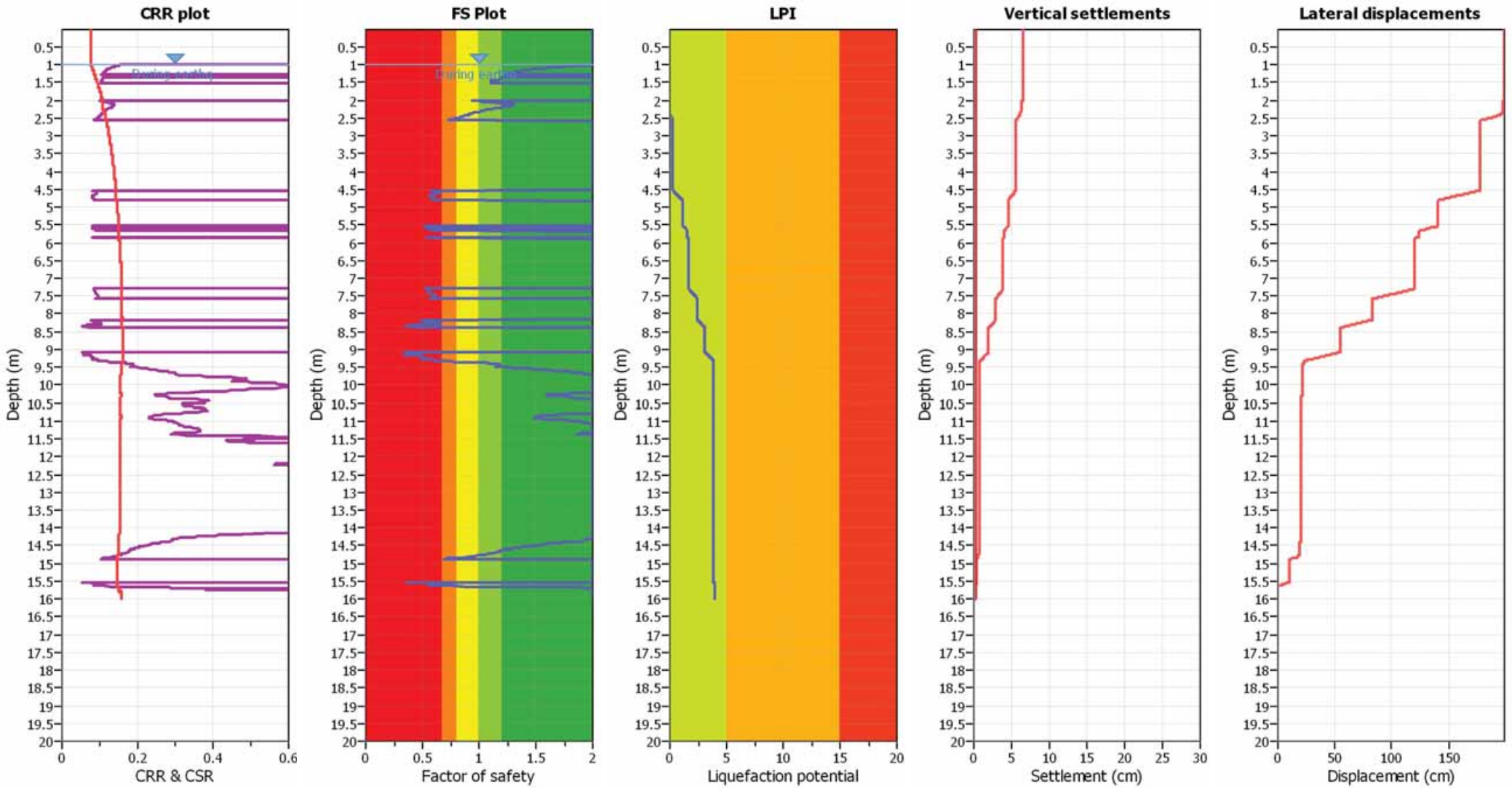

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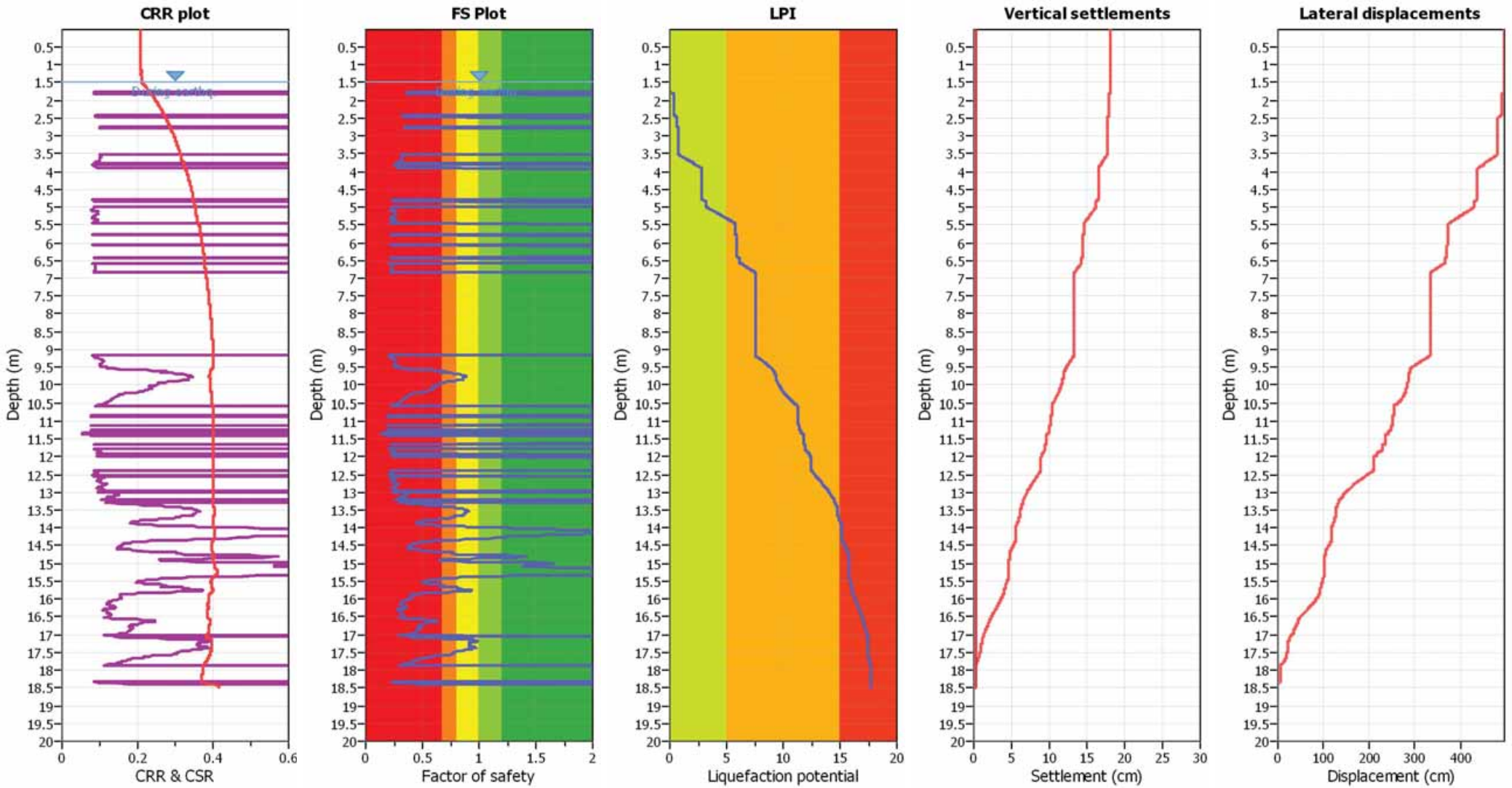

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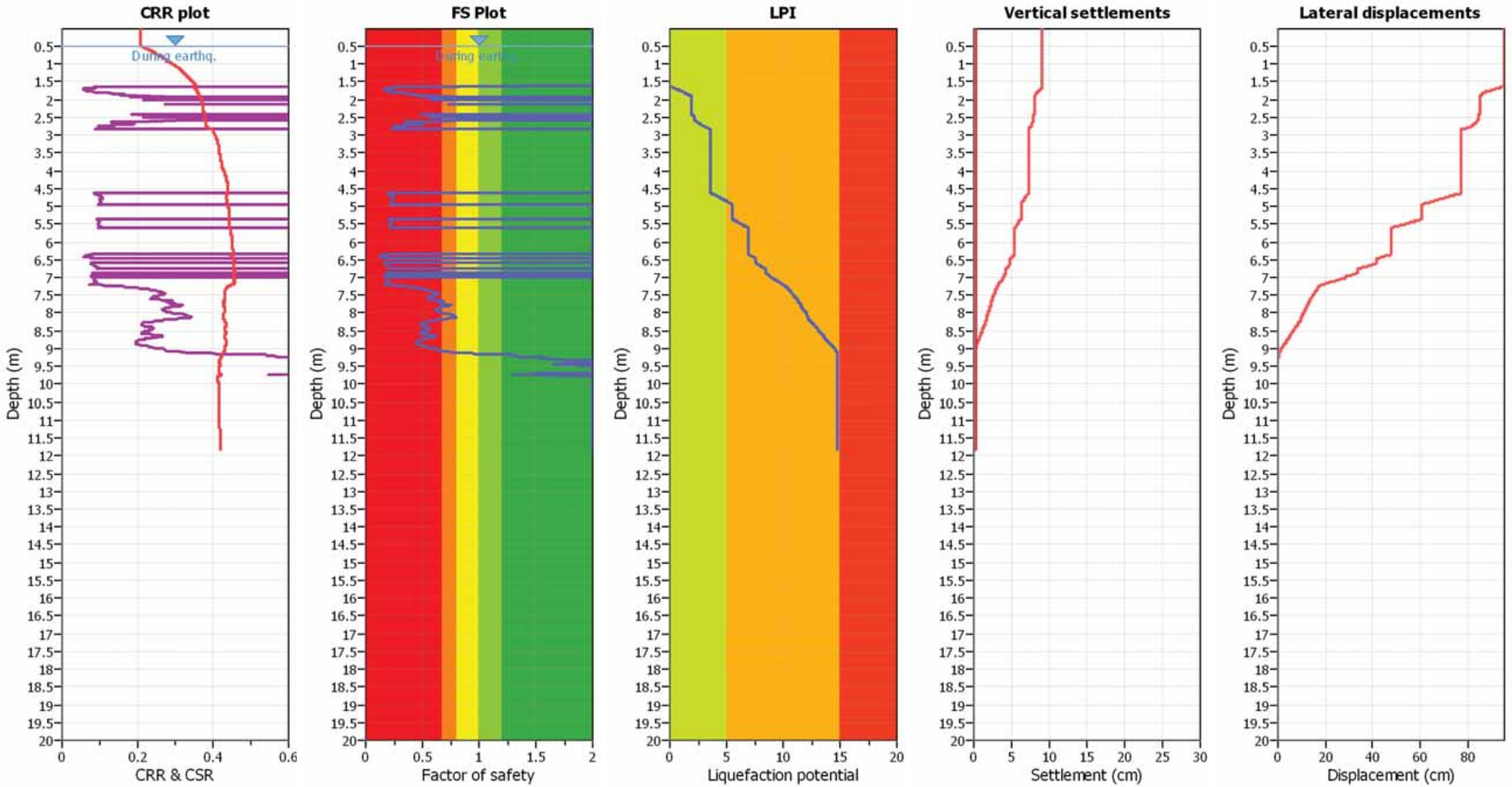

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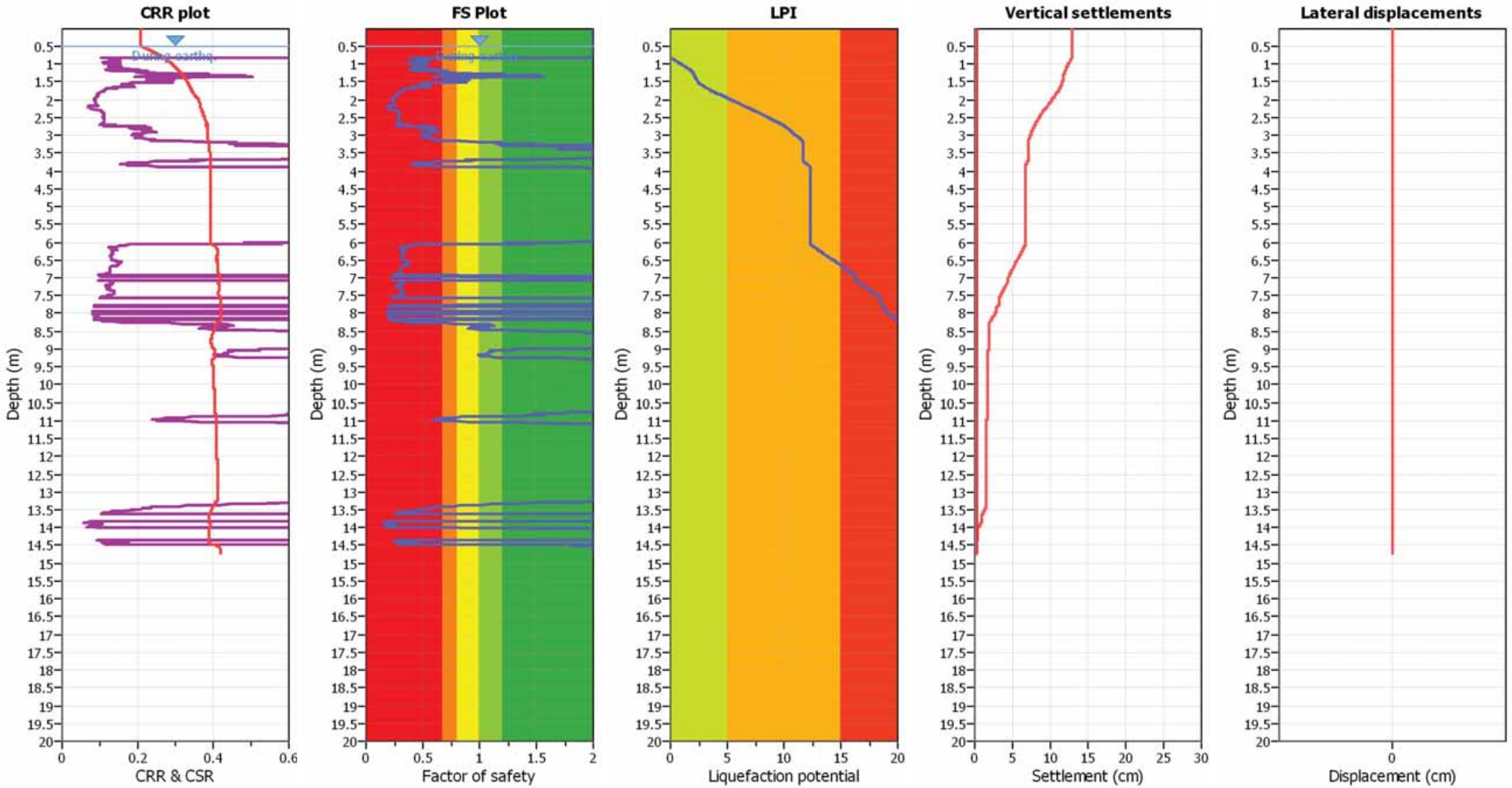

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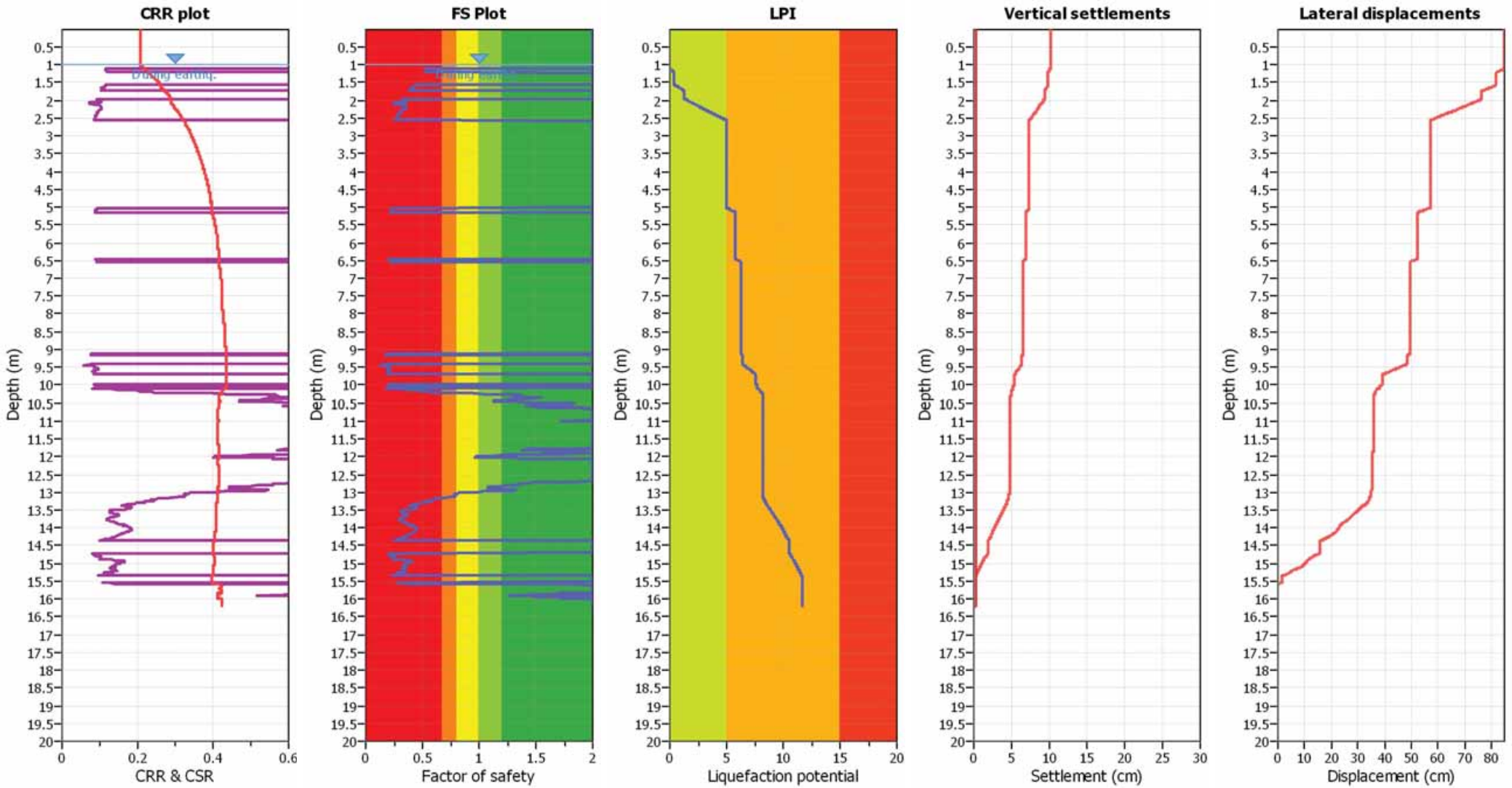

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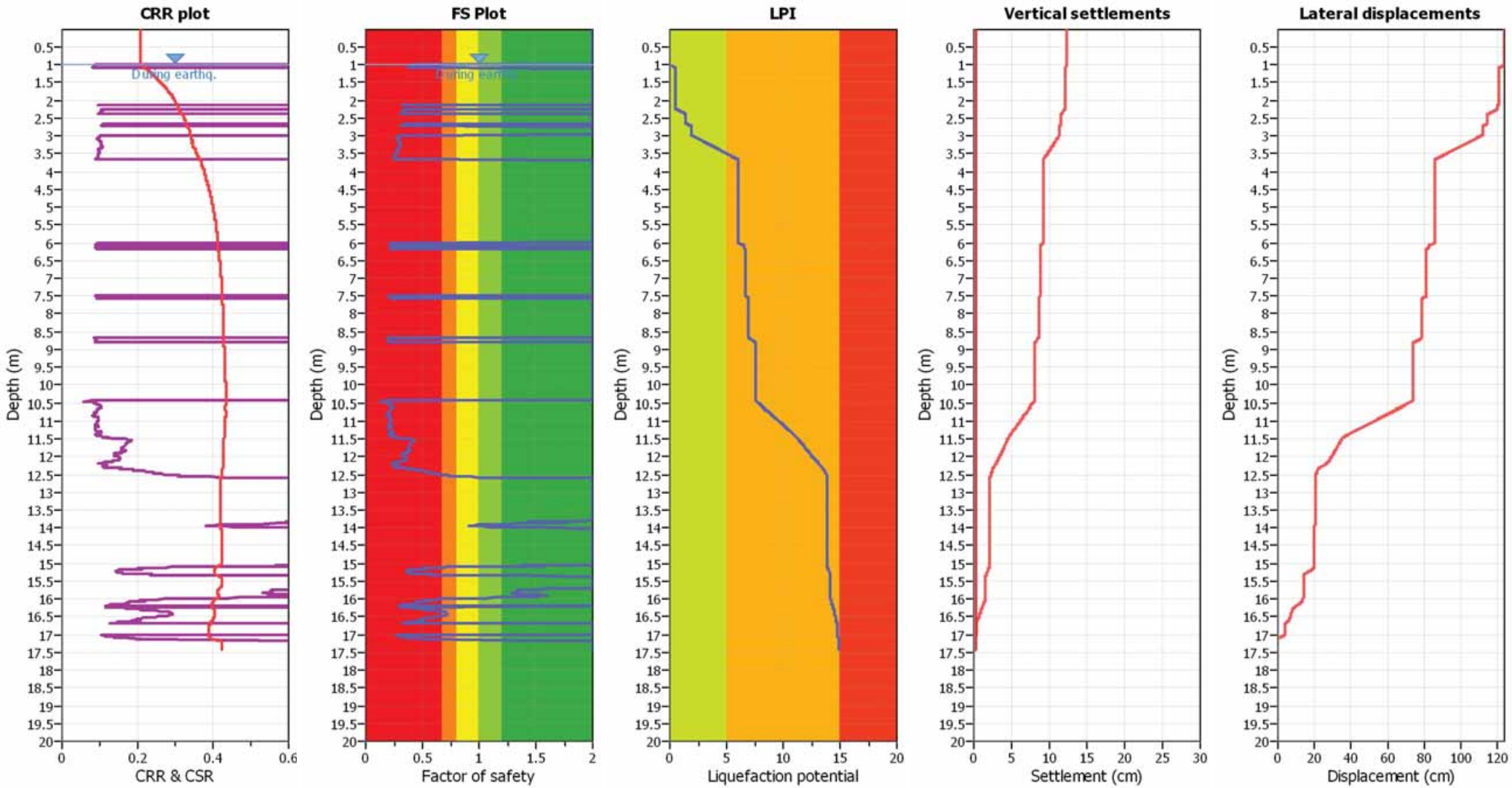

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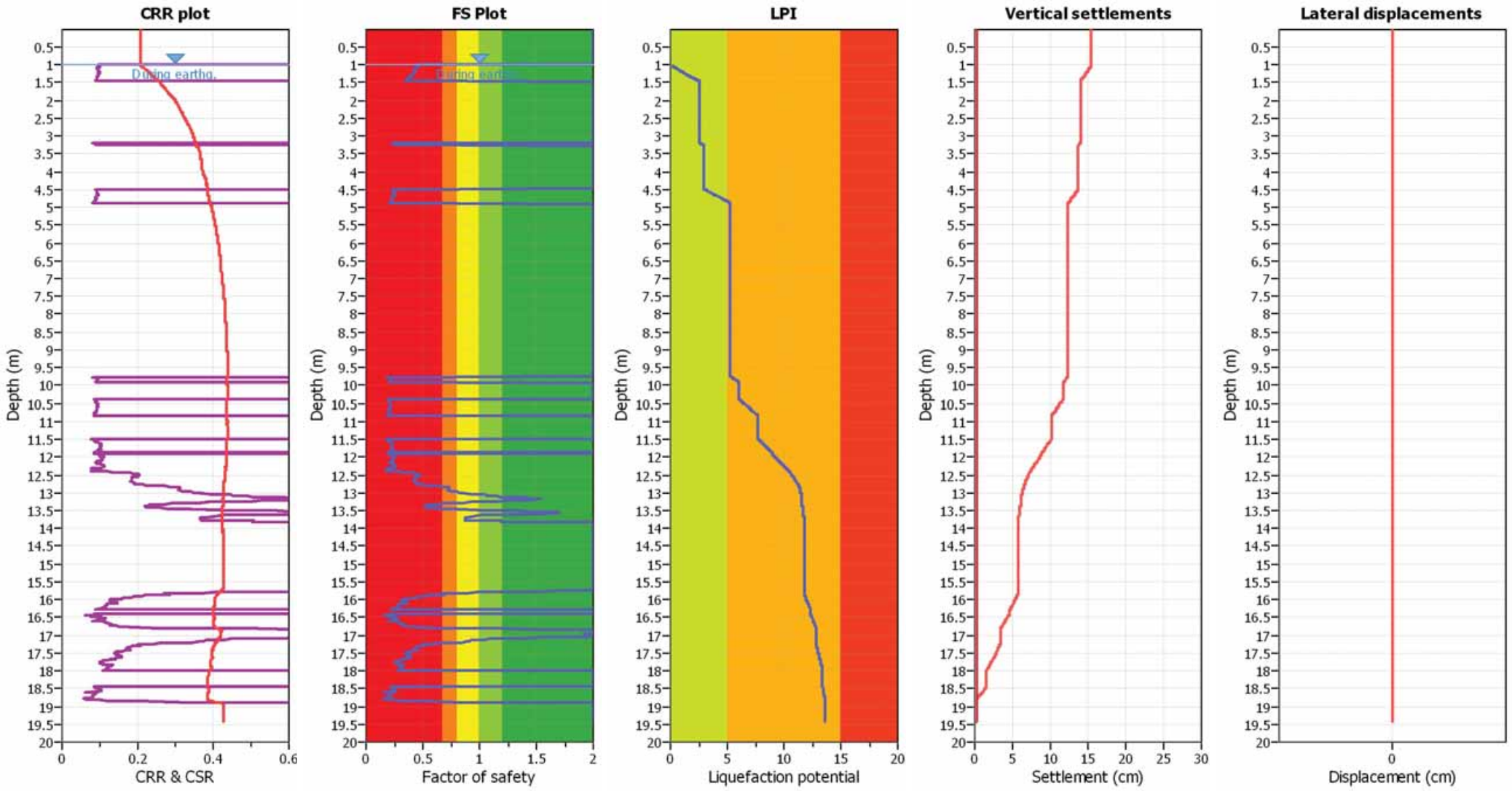

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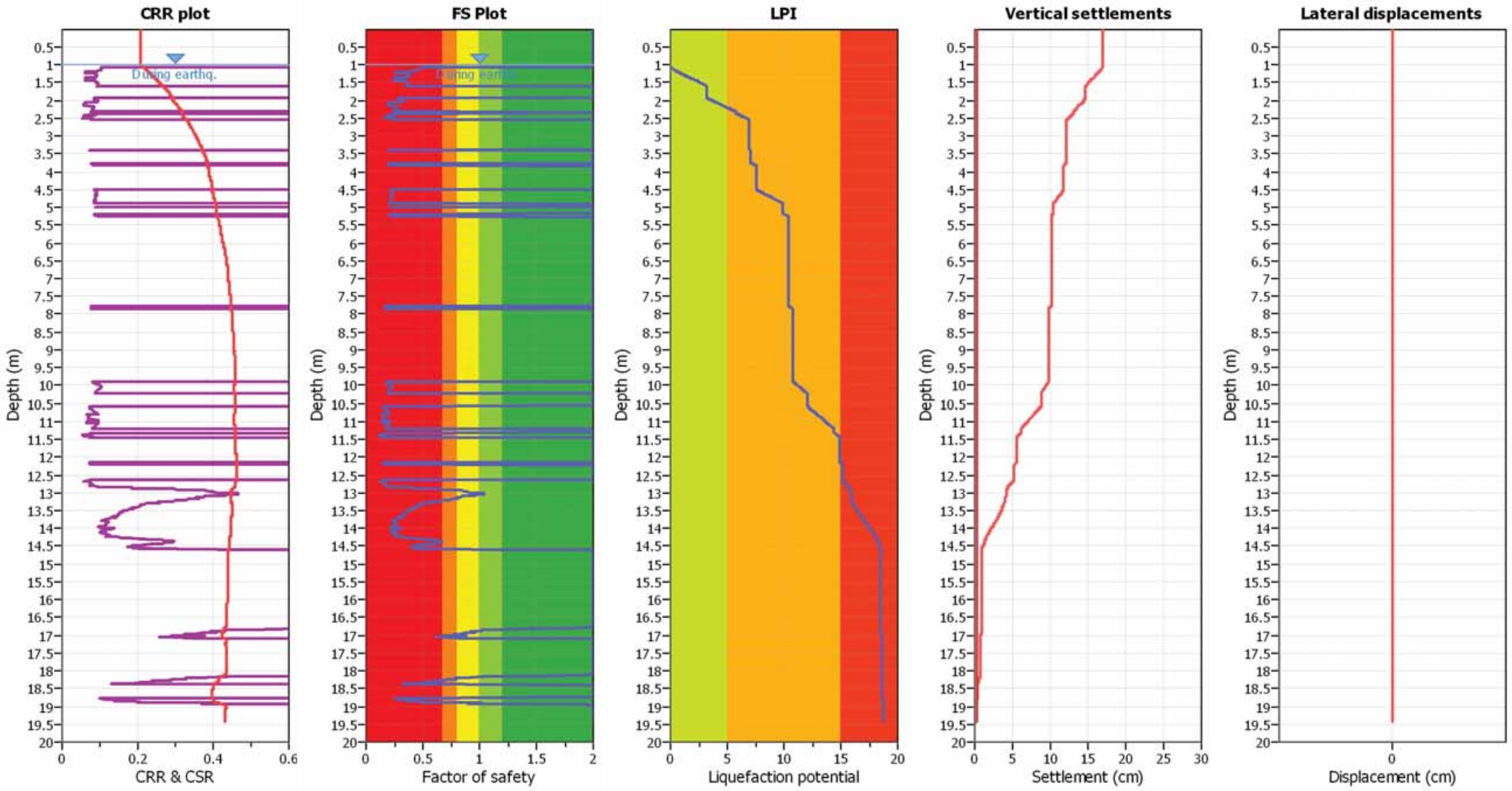

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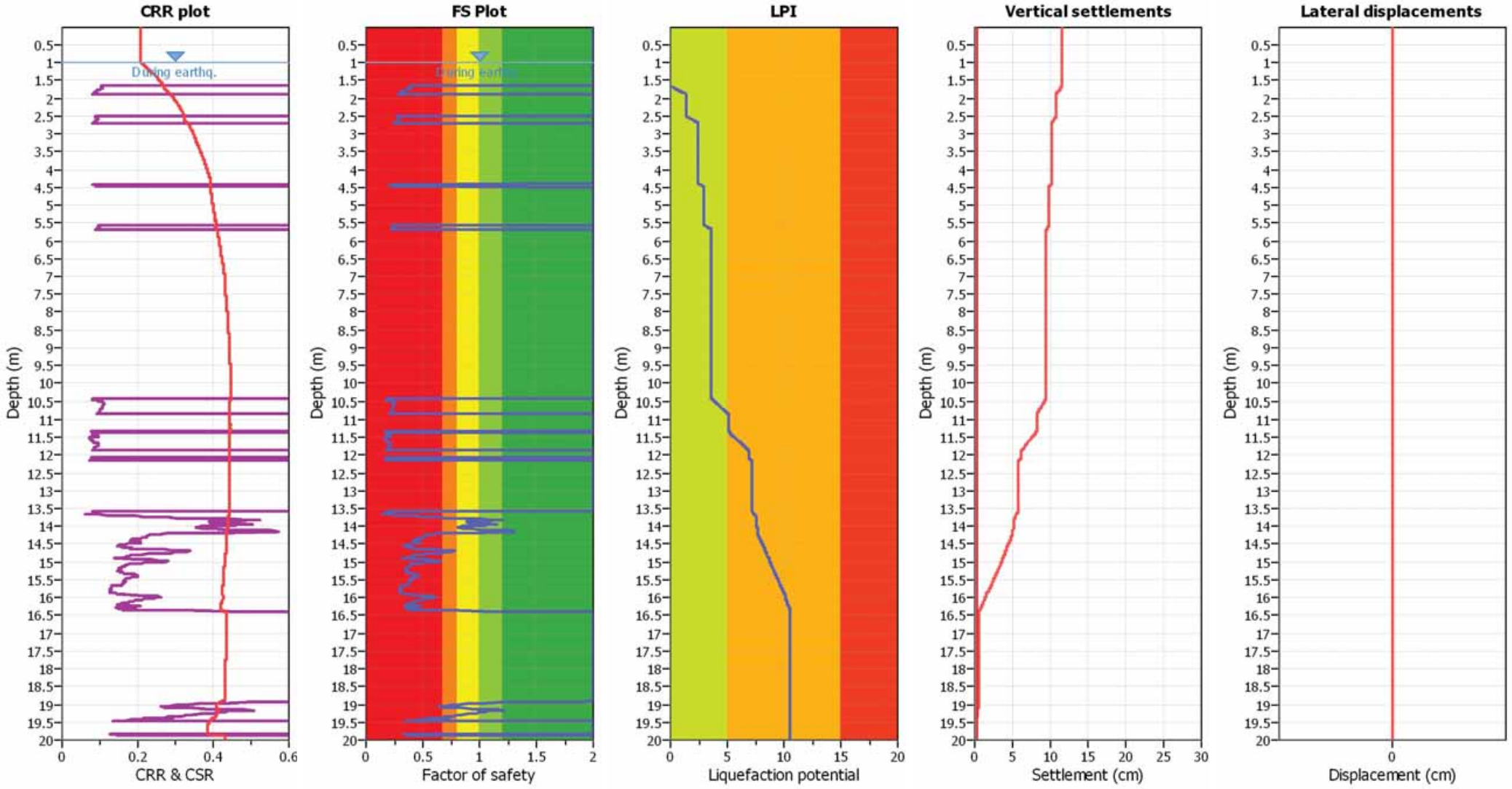

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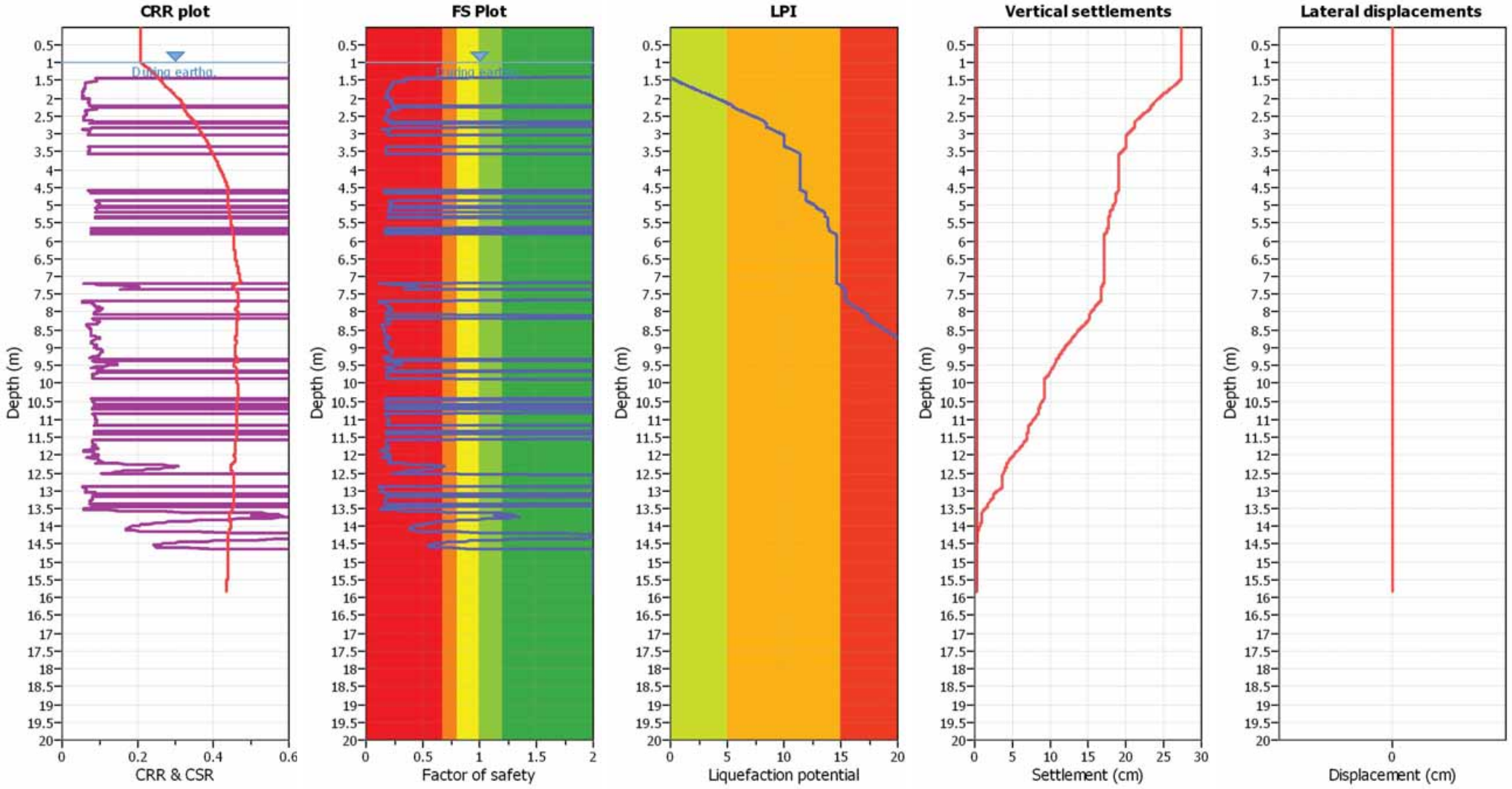

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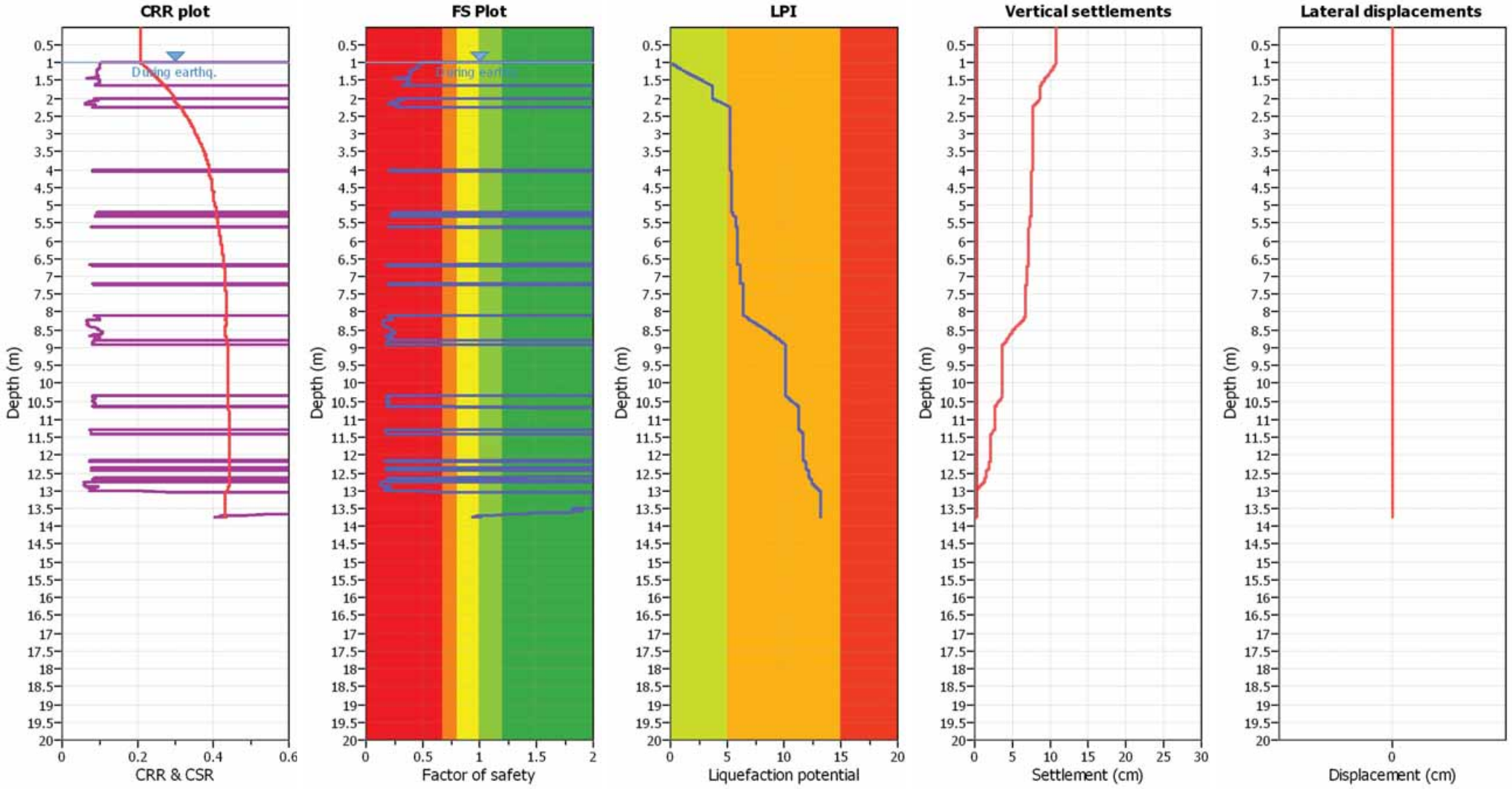


Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_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

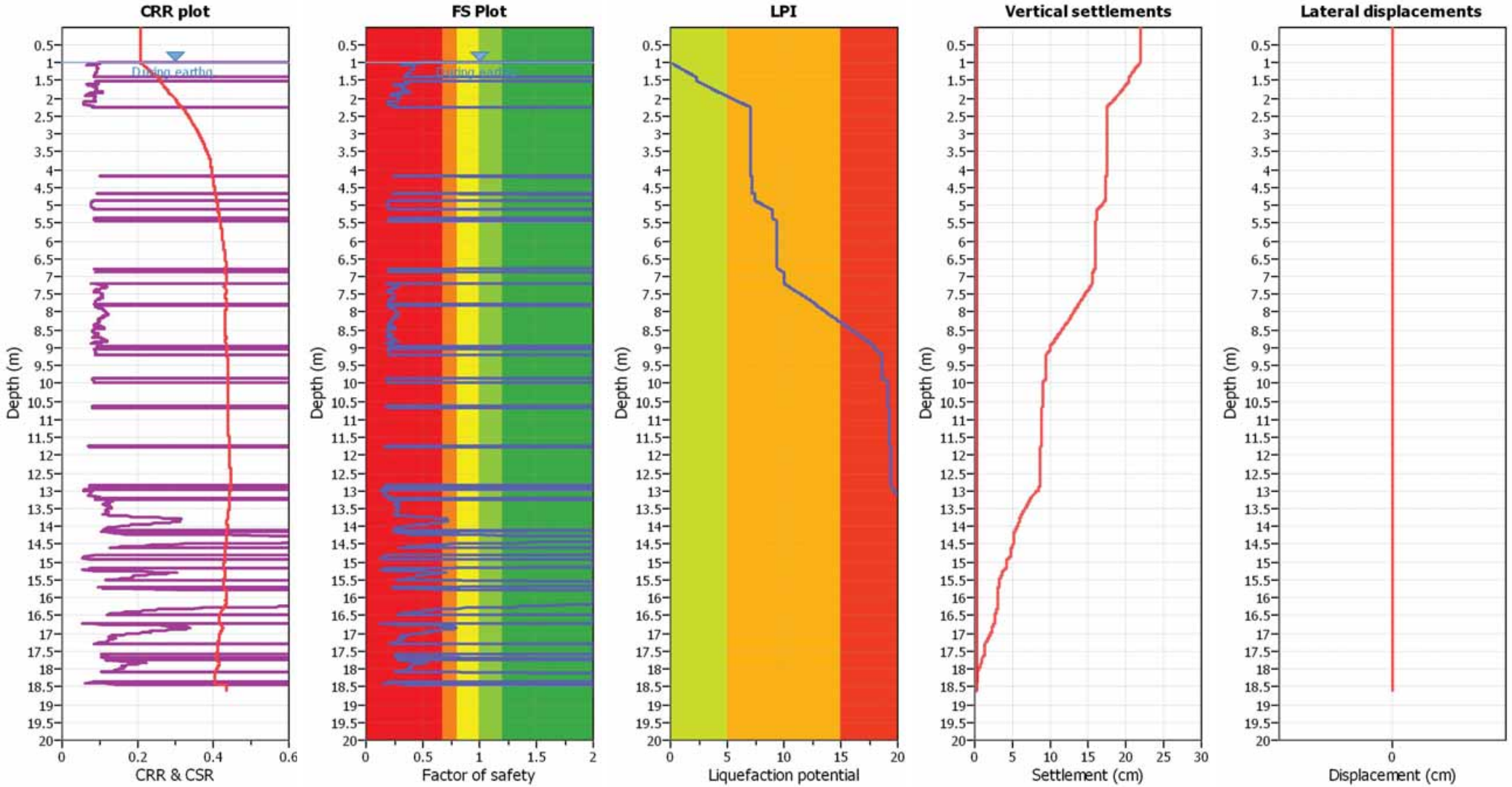
F.S. color scheme

- 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

Liquefaction analysis overall plots



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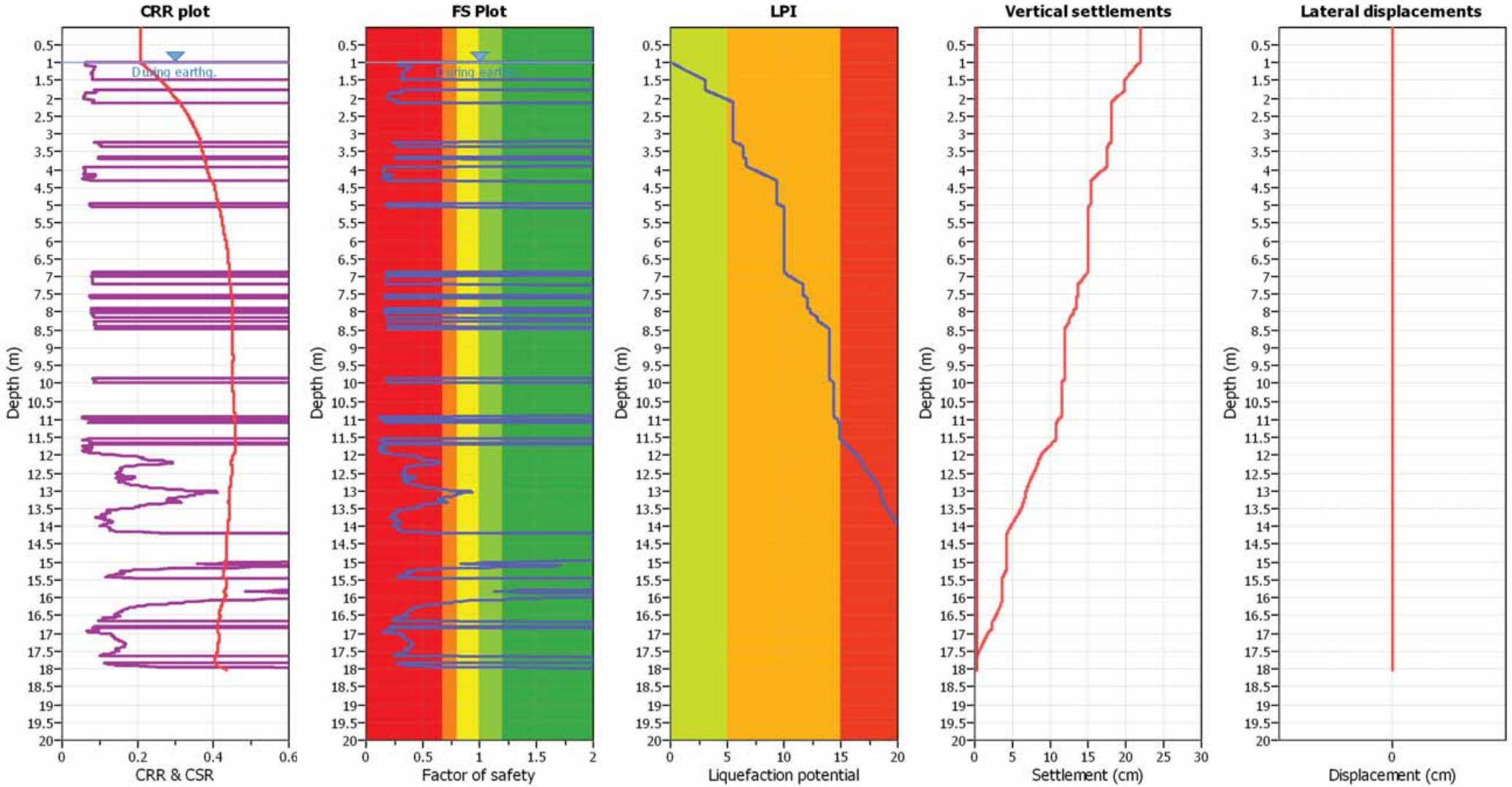

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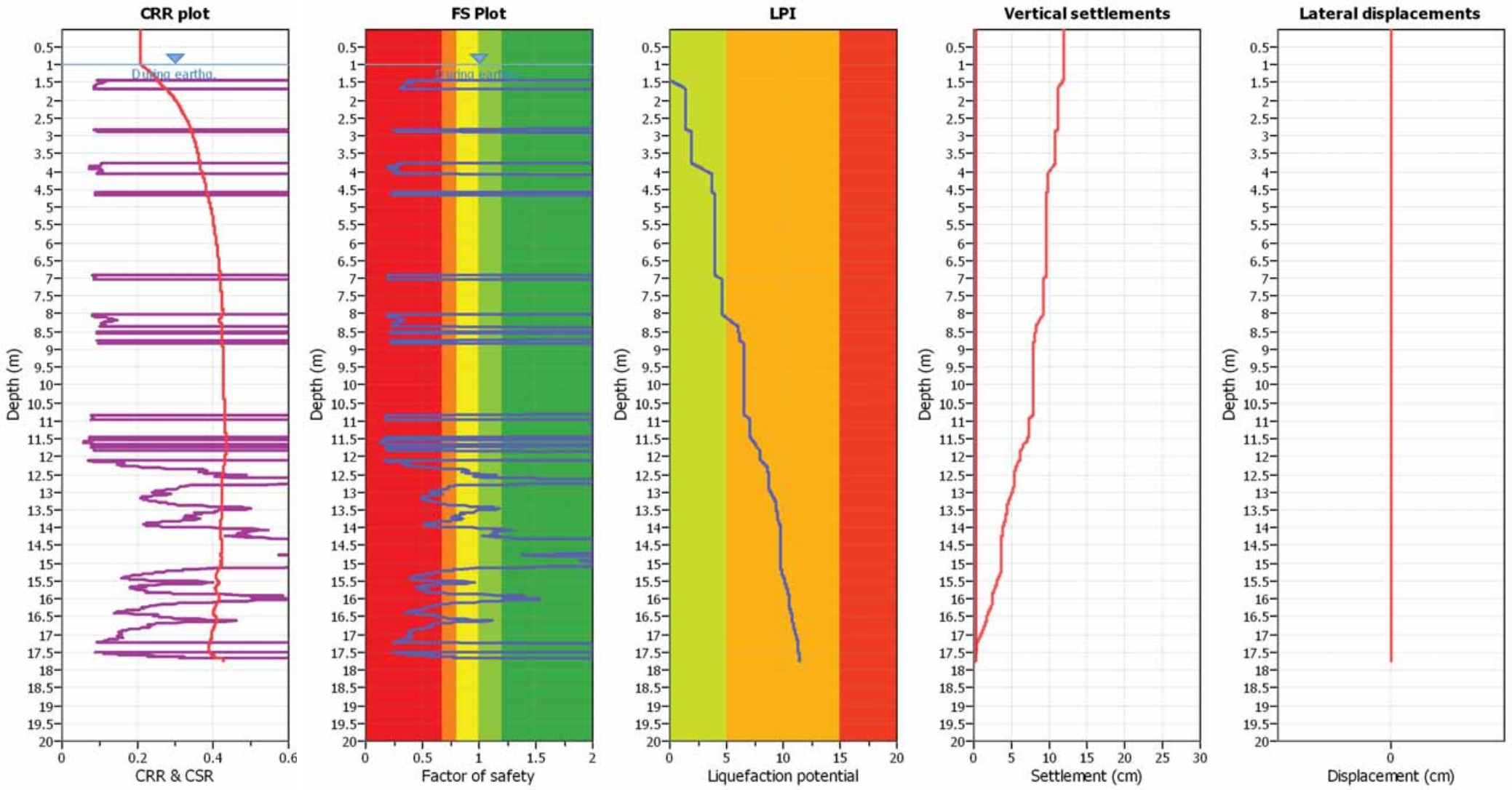

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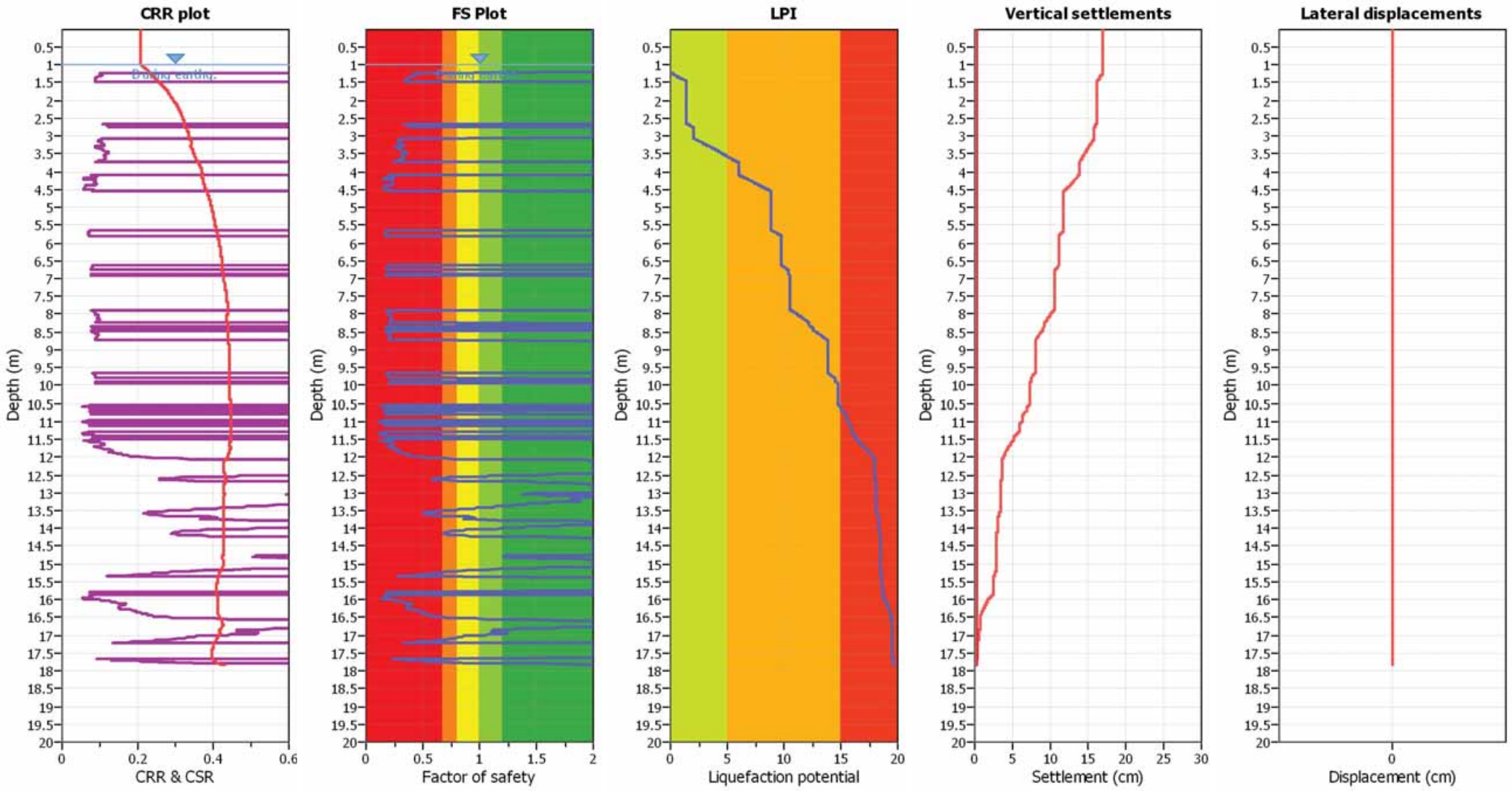

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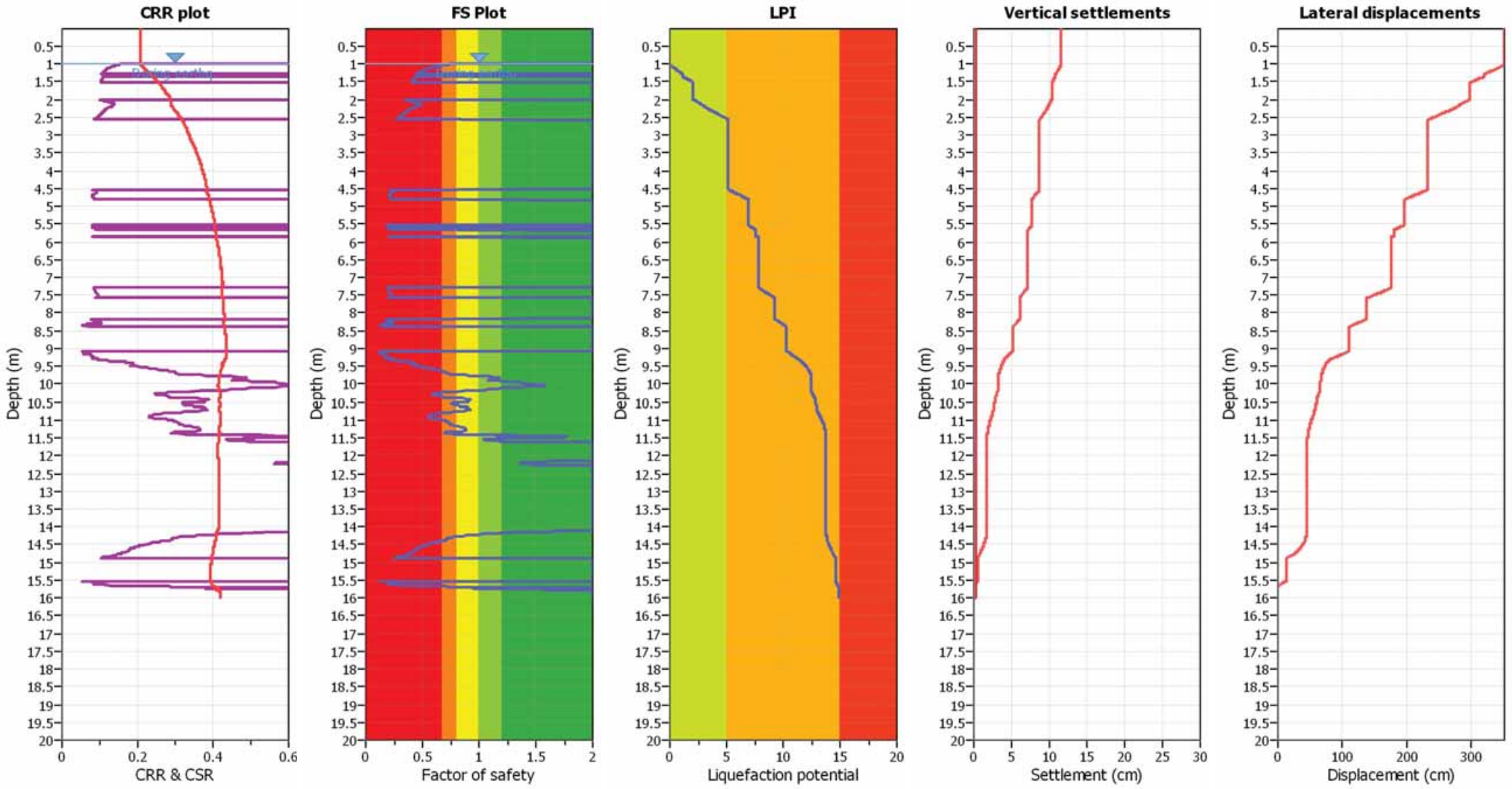

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