BEFORE THE HEARING PANEL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the Proposed Waikato District Plan

STATEMENT OF EVIDENCE OF KENNETH JOHN READ (GEOTECHNICAL)

Dated 17 February 2021

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INTRODUCTION

1. My full name is Kenneth John Read.

2. I hold the following qualifications:

   (a) Bachelor of Science (Geology) (2:1 Honours), 1982, from the University of Edinburgh;

   (b) Master of Science (Engineering Geology), 1984, from the University of Newcastle upon Tyne.

3. I am a Registered Chartered Professional Engineer (CPEng) with Engineering New Zealand. I am a Chartered Geologist with the Geological Society of London (UK).

4. I have 38 years' experience in engineering, geological, and geotechnical engineering consultancy, the last 14 of which have been in New Zealand. The previous 24 years were in the UK with much of that working in areas of historic coal mining (Central Scotland, North East England and the English Midlands) and metalliferous mining (South West England).

5. I have been engaged by Shand Properties Limited (**Shand**) to provide preliminary geotechnical investigation and assessment of its properties off Russell Road, Huntly and off Ralph Road/East Mine Road with respect to possible residential and industrial development respectively.

CODE OF CONDUCT

6. I have read the Environment Court Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014 and agree to comply with it. I confirm that the opinions expressed in this statement are within my area of expertise except where I state that I have relied on the

evidence of other persons. I have not omitted to consider materials or facts known to me that might alter or detract from the opinions I have expressed.

SCOPE OF EVIDENCE

7. My evidence will address the following:

   (a) The results of my high level, desk study assessment of mining risk for the proposed development, in particular the risk of unacceptable settlement of the ground surface due to collapse of abandoned mine workings at depth beneath the properties.

   (b) My evidence will also address the results of an intrusive ground investigation undertaken to identify and assess other potential geotechnical hazards and risks to the proposed developments.

   (c) I have prepared two reports, one on mining related issues and one on geotechnical issues to support a feasibility assessment for the proposed developments. My evidence summarises those two reports.

SUMMARY OF EVIDENCE

8. With respect to mining-associated risks to the development, my desk study of information in reports previously prepared by others for Waikato District Council concluded that there is a low risk of mining subsidence affecting the proposed developments. This is primarily based on the recorded methods of mining beneath the two areas, the depth at which mining occurred, the time since mining ceased and settlement records presented in the reports assessed.

9. With respect to geotechnical hazards and risks affecting the proposed developments, the findings presented in my Geotechnical Investigation Report (**GIR**) led me to conclude that there are no major geotechnical risks that cannot be managed and/or mitigated against at reasonable cost. The residential development proposed for the land immediately north of Russell Road is located across elevated moderately steep slopes formed in stiff clay soils. Potential instability of those slopes was considered the primary geotechnical risk for this development. The findings of the investigation undertaken indicate that the slopes have a satisfactory level of stability and development can be undertaken following conventional earthworks and construction practice.

10. The area being considered for proposed industrial development in the low-lying land north of East Mine Road is underlain by geologically younger sediments of a predominantly sandy nature. The investigation found that these soils have low shear strengths and there is a shallow groundwater level. Low foundation bearing strength, unacceptable foundation settlements and potential liquefaction are the primary geotechnical risks associated with development in this area. Analysis of the data obtained indicates that these risks can be effectively managed and mitigated.

11. Further detailed geotechnical investigation of these identified matters can be conducted at the subdivision stage of the future development, with suitable conditions imposed as part of any subdivision resource consent.

MINING-RELATED ISSUES

12. My assessment of mining risk relies heavily on data collated and presented in the reports prepared by others for Waikato District Council (**historic reports**) and listed in Section 2 of my letter report entitled "High Level Mining Risk Review, North Huntly Land Development (Areas 1, 2 and 3)"[1]

[1] Reference HAM2019-0082AD.

dated 10 February 2020 which is **Attachment 1**. This was supplemented by a review of historic aerial photography, old maps, and published geology as described in Section 3 of that report. I also carried out a walkover inspection of the proposed development area as described in Section 4 of that report.

13. It should be noted that the numbering of the development areas has been amended since preparation and issue of that report. The revised area numbers are shown on the appended Land Holding Plan prepared by BBO[2] which is **Attachment 2**. The relationship between the area numbers used in my report and the new numbering is shown on Table 1 below.

Table 1: Development Areas Numbering			
	Development Area(s)		
CMW Reports	1	2	3
BBO Land Holding Plan	1	2, 3 and 4	5 and 6

14. The study area has been mined for coal by Huntly East Mine with the last coal produced in October 2015. The area south of Russell Road was worked first in the early to mid-1980s. The geotechnical risks associated with the past mining activities are settlement and deformation of the ground surface caused by collapse of mine workings at depth, and migration of mine gases, (primarily methane) to the ground surface.

15. Settlement monitoring data collated and reported by others is limited to Russell Road and to areas to the south of Russell Road. Copies of selected figures showing recorded settlements in the vicinity of Russell Road taken from Ian R Brown Associates' March 2015 report are shown in **Attachment 3** to my evidence.

[2] Drawing No 144370-02-0141 Rev C dated 21 January 2020.

16. From data presented on Figures 2, 10 and 11 of **Attachment 3**, total settlements of the order to 75mm to 100mm have been recorded along Russell Road, the majority of which occurred pre-2009. In the case of monitoring point E10 settlement, this was mostly prior to 1998. Monitoring of those points that could still be found in 2014 suggests settlements of the order of 1 to 3mm may have occurred in that period. It is my opinion that those values are probably within the error of survey measurement.

17. Mine plans included in the historic reports show much of the land north of Russell Road, beneath the majority of the area of proposed residential development, is underlain by mine roadways that were formed to provide access to the mine as a whole. These roadways are usually highly engineered and designed to remain open. A small proportion of the western margin of the residential area is underlain by an area of fuller coal extraction. From my reading of the historic reports, I understand this area to have been worked by longwall mining techniques. This mining technique is known to result in ground settlement soon after coal extraction, with a low risk of long-term on-going settlement.

18. I am not aware of any settlement monitoring records for the land north of East Mine Road. There is reference in one of the historic reports, cited in my report (**Attachment 1**), to an earlier report by Pilbrow in 1988. That report is stated to describe about 1m of settlement affecting the ground surface to the north and east of the main mine entry.

19. A study of old maps and aerial photographs of the area north of East Mine Road shows development of the wetland west of Ralph Road sometime between 1984 and 1991 (in the aerial photographs) and 1989 and 1999 (in the old maps). I consider that development of this wetland and associated changes in stream courses seen over that period is most probably a

consequence of mining related surface settlement occurring soon after longwall mining of coals beneath that area. Survey contour data suggests that changes in ground level of the order of 1m may have occurred in the area of the wetland. Undulations in the road surface of East Mine Road also suggest localised mining related settlement over the longwall workings (see photograph 2 of **Attachment 1**).

20. There is a significant thickness of rock and soil above the mine workings. Beneath the residential area there is between approximately 77m and 190m of rock and soil above the mine workings. Beneath the industrial area there is of the order of 190m of rock and soil above the mine workings. The combined effect of this is to make the creation of any "crown" or "swallow" holes at the ground surface, generated by collapse of mine workings extremely unlikely and to 'smooth out' surface settlement over a large area.

21. In summary, I consider that the presence of the mine access ways beneath part of the area of proposed residential development and the use of longwall mining techniques beneath the remainder of both it, and all of the area of proposed industrial development, poses a low risk of on-going mining related surface settlements.

22. The thickness of rock and soils over the mine workings is such that, should any collapse occur in them, any resulting surface settlements should be spread over a wide area. I agree with the previous reporting that the risk of resulting differential surface settlements being unacceptable under the Building Code is very low.

23. There is a possibility that methane gas generated in the mine working may escape and migrate through the intervening strata to the ground surface. This is unlikely to pose a hazard unless it accumulates to hazardous levels in an enclosed space. There are a number of simple and easy to install

measures that mitigate this low risk. Examples include gas proof membranes in floor slabs, under slab venting, vent (gravel filled) trenches around buildings and vented covers to buried chambers.

GEOTECHNICAL ISSUES – RESIDENTIAL DEVELOPMENT NORTH OF RUSSELL ROAD

24. Details of the geotechnical investigation undertaken for this part of the proposed development area are presented in my report entitled "North Huntly Development, East Mine Road Huntly, Geotechnical Investigation Report" dated 13 July 2020[3] which is **Attachment 4** to my evidence. In that report, this land area is labelled "Area 3" but is now Area 6. This area comprises hill topography sloping down from Russell Road in the south to East Mine Road in the north. The hill is divided into two by an approximately north/south trending gully close to the midpoint of the area.

25. At the toe of the slope is generally flat-lying land with local springs and surface water ponding. The hill has been found to be formed from predominantly very stiff to hard clay strata with sub-ordinate thin silts and sands. The low-lying land is underlain by variably dense sands with shallow groundwater. The proposed development is confined to the hillside.

26. The liquefaction risk for the land beneath the proposed development as described in Sections 6.4 to 6.6 of my report has been assessed as very low. Slope stability analyses have been carried out for the existing landform as described in Section 6.8 of my report. These analyses have determined that the existing slopes have Factors of Safety against landslip in excess of those usually set as a minimum for prevailing site conditions, elevated groundwater conditions, and a 1 in 500-year seismic event. Foundation conditions in this area meet the criteria for 'good ground' with an ultimate geotechnical bearing capacity of 300kPa. The soils in this area are easily

[3] Reference HAM2019-0082AF Rev 0.

worked and earthworks in this area may be carried out by conventional means and equipment.

GEOTECHNICAL ISSUES NORTH OF EAST MINE ROAD

27. Details of the geotechnical investigation undertaken for this part of the proposed development area are presented in **Attachment 4**. In that report this area is labelled "Areas 1 and 2". The land in these areas is low-lying and gently undulating. Part of the area is occupied by a wetland designated a 'Significant Natural Area'. The low-lying land was found to be underlain by alluvial soils comprising interbedded sand, silt and clay as described in Section 5.2.1 of **Attachment 4**.

28. Of particular interest with respect to the possible future development of these areas is the presence of loose to medium dense sandy soils to approximately 5m depth, and medium dense sands below that to approximately 16m depth (Table 1 of **Attachment 4**). The shallow soils have poor foundation properties and are potentially liquefiable.

LIQUEFACTION POTENTIAL

29. The liquefaction risk has been assessed following current guidance in "Earthquake Engineering Practice, Module 3, Identification, assessment and mitigation of liquefaction hazards" from MBIE and the New Zealand Geotechnical Society (May 2016), as described in Section 6.4 of **Attachment 4**. Liquefaction analysis was undertaken on data obtained from each Cone Penetrometer Test (**CPT**) undertaken in the low-lying area. The analyses undertaken indicate that the soils present are at high risk of liquefaction for the Ultimate Limit State (**ULS**) seismic event modelled, a 1 in 500-year event.

30. Estimated liquefaction induced surface settlement arising from liquefaction in the upper 10m of soil ranges between 65mm and 105mm for the existing ground profile. To enable a qualitative comparison of this level of liquefaction and potential damage, it could cause I have referred to two widely used indices, the Liquefaction Potential Index (**LPI**) and Liquefaction Severity Number (**LSN**). Charts of the respective indices calculated for each CPT location are presented in Appendix E of **Attachment 4**. The LPI value ranges from 4 to 12 and are classified as "low" to "high risk" with the majority of values close to 5, the transition value between the two classifications. The LSN value ranges from 8 to 22 and classifies as "minor" to "moderate" expressions of liquefaction with the majority in the 'minor' expression of liquefaction. Comparison of these results to Table 5.1 of MBIE Module 3 previously referred to indicates the land may be considered to meet 'performance level L3'. This implies the effects of liquefaction may be 'high'.

31. I now understand that development may be restricted to Area 1 and the northwest of Area 2 (i.e. the west side of Area 2 on the appended BBO Land Holding Plan). The analyses of CPTs located in these areas (Nos 04, 06, 08, 09 and 010) gave LPI values of between 5.65 and 6.39, just above the low to high-risk threshold value of 5. Analyses of these same CPTs for LSN gave values of between 11.87 and 15.45, all within the 'minor expression of liquefaction' range. Comparison of these results to Table 5.1 of MBIE Module 3 previously referred to, indicates the land is marginal between performance levels L2 and L3. This implies the effects of liquefaction in this area may be 'moderate' to 'high'.

32. Subsequent to preparation of my report in **Attachment 4**, I have analysed the CPT data for a 1 in 100-year seismic event using a Peak Ground Acceleration of 0.11g and for a Magnitude 5.8 earthquake. No liquefaction was found to occur in the upper 10m of soils. After review of the above, I

consider that the land is of Medium Liquefaction Vulnerability as defined in Table 4.4 of "Planning and Engineering Guidance for Potentially Liquefaction-Prone Land" (MBIE September 2017).

33. Charts of the respective indices calculated for each CPT location with an additional metre of fill placed are presented in Appendix B of this submission. These show reduction in LSN value to between 4 and 15 (little to minor expression of liquefaction) and LPI to between 2 and 8 (still classifies low to high risk but generally reduced with a greater proportion of CPT locations classed as low risk). For those CPTS located in Area 1 and the northwest of Area 2 the LSN values range between 3.6 and 5.3, generally in the low-risk category with only one value over high-risk threshold value of 5. For those CPTs the LSN value determined range between 7.9 and 12.1 ranging between "little or no expression of liquefaction" to "minor expression of liquefaction".

34. Lateral spreading due to liquefaction can occur on sloping land or where a 'free face' is present. In this case the nearest free faces are the Waikato River and the wetlands near Ralph Road. I have qualitatively assessed the risk of lateral spread towards the Waikato River affecting the site to be low based on experience of more detailed assessments along the Waikato River side. The risk of spread towards the wetland near Ralph Road will be dependant of the final site layout adopted and will need to be assessed at the detailed design stage. However, if development is limited to the northwest part of Area 2, I expect, by inspection of the data, the risk of lateral spread towards the wetland affecting that area to be low.

FOUNDATION CONDITIONS

35. As stated in section 7.2 of **Attachment 4,** the foundation conditions beneath this area are highly variable, with ultimate geotechnical bearing capacities of less than 300kPa. There is also a significant risk of

unacceptable total and differential settlements without some form of ground improvement and/or specific engineer designed foundations to mitigate and manage settlement. Piled foundations are not recommended due to the liquefaction risk. Undercutting and replacing near surface loose /soft soils with engineered fill is a ground improvement option which should significantly improve foundation conditions.

GROUND IMPROVEMENT

36. Ground improvement measures that may be adopted in this area to mitigate settlements arising from foundation and fill loads, and the potential effects of liquefaction (settlement and lateral spread) are described in a Section 7.4 of **Attachment 4.**

CONCLUSION

37. I consider that with respect to the potential mining-related hazards of long term and on-going settlement, and of methane gas migration, the risks of detrimental effects to the possible development of the residential and industrial areas proposed are low and manageable using conventional engineering solutions as described above.

38. From my assessment of ground conditions beneath the proposed residential development off Russell Road I consider that the geotechnical hazards of slope instability and liquefaction are low risk and easily managed by conventional engineering practice. I also consider that the liquefaction hazard in the proposed industrial development area is moderate, and that associated risks and poor foundation conditions can be practically mitigated and managed.

39. I consider that the conventional and widely used ground improvement techniques described in my report should provide suitable means of doing so.

Kenneth John Read

17 February 2021

Attachment 1

CMW: High Level Mining Risk Review, North Huntly Land Development (Areas 1, 2 and 3)

10 February 2020 Document Ref: HAM2020-0082AD. Rev 0

Jackie Rodgers
Shand Properties Ltd.
PO Box 112, Huntly

Dear Jackie

RE: HIGH LEVEL MINING RISK REVIEW

NORTH HUNTLY LAND DEVELOPMENT (AREAS 1, 2, AND 3)

1 INTRODUCTION

CMW Geosciences (NZ) LP (CMW) was engaged by Shand Properties Ltd to carry out a 'high level' review of underground mining risk to 3 areas of land immediately north of the town of Huntly, Waikato, (Figure 1 below). We understand that Shand Properties have submitted on the District Plan to have these areas re-zoned from rural to industrial and residential land use.

The scope of work and associated terms and conditions of our engagement were detailed in Option 1 of our services proposal letter referenced HAM2019-0082AC, Rev0 dated 22 November 2019.

This scope comprised -

- Desktop study comprising a brief review of the conclusions of supplied reports,
- Review of publicly available historic aerial photography, old maps and geological maps to define the potential mining hazards affecting the site(s);
- Project management including any health and safety;
- Site walkover to assess the landform and geomorphology and meeting landowner/farmer of Area 2 if applicable;
- A geotechnical report for due diligence, outlining likely ground conditions, with commentary on likely mining associated risks such as surface settlement and gas migration, and outlining possible mitigation measures if considered necessary.

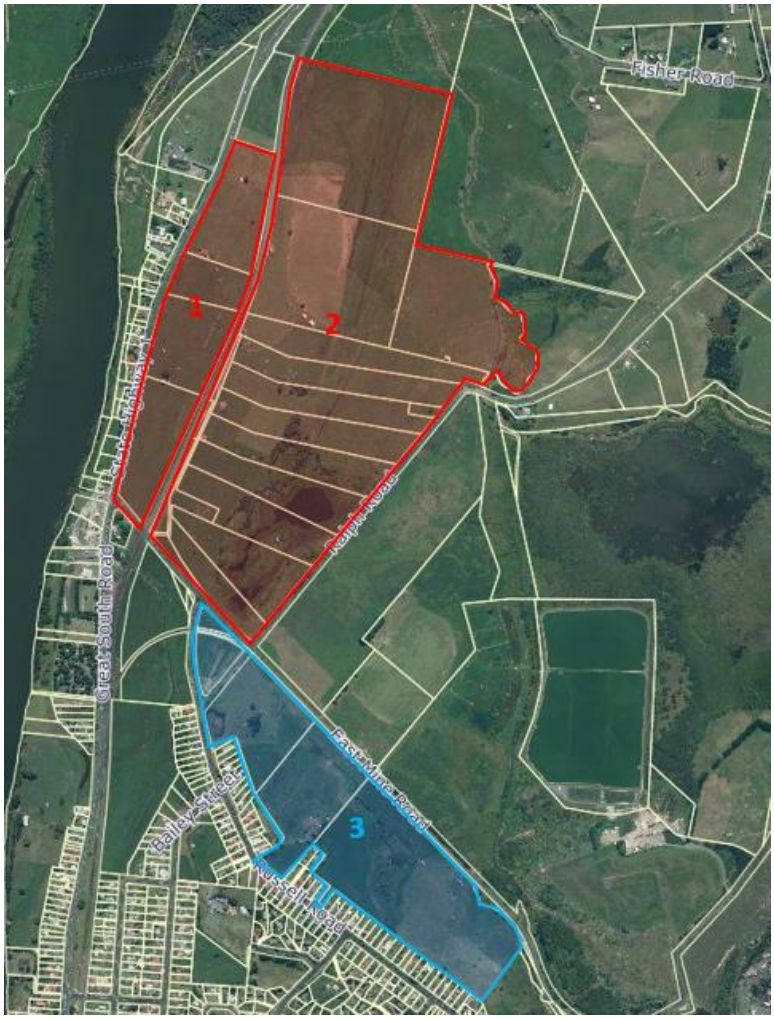


Figure 1: Land areas under consideration for re-zoning, red – industrial, blue - residential

2 REPORTS PROVIDED

The following reports and documents were supplied to us by Bloxham Burnet and Olliver Ltd (BBO) acting on behalf of Shand Properties:

- "Huntly East land subsidence due to coal mining – Investigation and analysis of potential hazard", IRBA Geological Engineering Consultants, Project ref 1003, dated March 2015
- "Huntly East Mine – issues arising from mine closure" paper copy of a power point presentation by IRBA dated March 2018
- "Report on hazards following mine closure, Huntly East", IRBA Geological Engineering Consultants, Project ref 1003, dated October 2018
- "Peer Review of Ian R Brown Associates report entitled -Report on hazards following mine closure, Huntly East", dated October 2018, Project 1003" TerraFirma Mining Limited, Project Ref TFM0096, dated January 2019*

- "Report on Risk Assessment for Urban Areas above the mine – Project: Huntly Mine East Closure Assessment" RDCL report ref R-357-01 dated 14 October 2019

3 DESK STUDY

3.1 Historic Aerial Photography

We have reviewed publicly available historic aerial photography from RetroLens NZ and Google Earth Pro specifically for evidence of mining related subsidence.

- RetroLens photographs from 1941, 1961, 1970, 1979, 1984 and 1991 were viewed. Annotated copies of those from 1961 to 1991 are presented in Appendix A.
- Google Earth Pro images from 2008 to 2019 were viewed and copies of images from January 2008, March 2010, September 2015 and February 2017 are presented in Appendix B.

Of particular interest is the development of a wetland in the southwest part of Area 2, in the corner between Ralph Road and East Mine Road. This is absent in all images up to and including the 1984 RetroLens image but is present in the 1991 RetroLens image and all subsequent Google Earth Pro images.

The 'pockmarked' appearance of the ground surface seen in Area 1 in the 1970 RetroLens image, and also the 2010 Google Earth Pro image (where it extends into the eastern side of Area 2) is likely to be related to archaeological features such as Māori sand pits and gardening, and not mining related. The New Zealand Archaeological Association web site shows 3 recorded sites within Areas 1 and 2.

3.2 Old Maps

We have reviewed publicly available historic maps from Mapspast.org.nz specifically for evidence of mining related subsidence.

Maps viewed were dated between 1929 and 2009.

Key changes between publication of the various maps are:

- The development of the wetland and a new stream in the southwest part of Area 2 between 1989 and 1999 as also observed from the aerial photographs.
- A 'new' water course/stream developing in the NE of Area 2 flowing across the area to the SW between publication of the 1989 and 1999 maps.
- A 'new' stream and pond developing in Area 3 south of East Mine Road between publication of the 1989 and 1999 maps.

Copies of the relevant maps are presented in Appendix C.

3.3 Published Geological Map

The published geological map of the area[1] shows the surface deposits to be alluvial soils ranging from recent river side alluvium and Holocene pumice alluvium in the low laying land to Late Miocene alluvial soils forming the higher ground north of Russell Road.

[1] Geology of the Auckland Area, 1:250,000 scale Map No 3, S W Edbrooke (ed) GNS 2001.

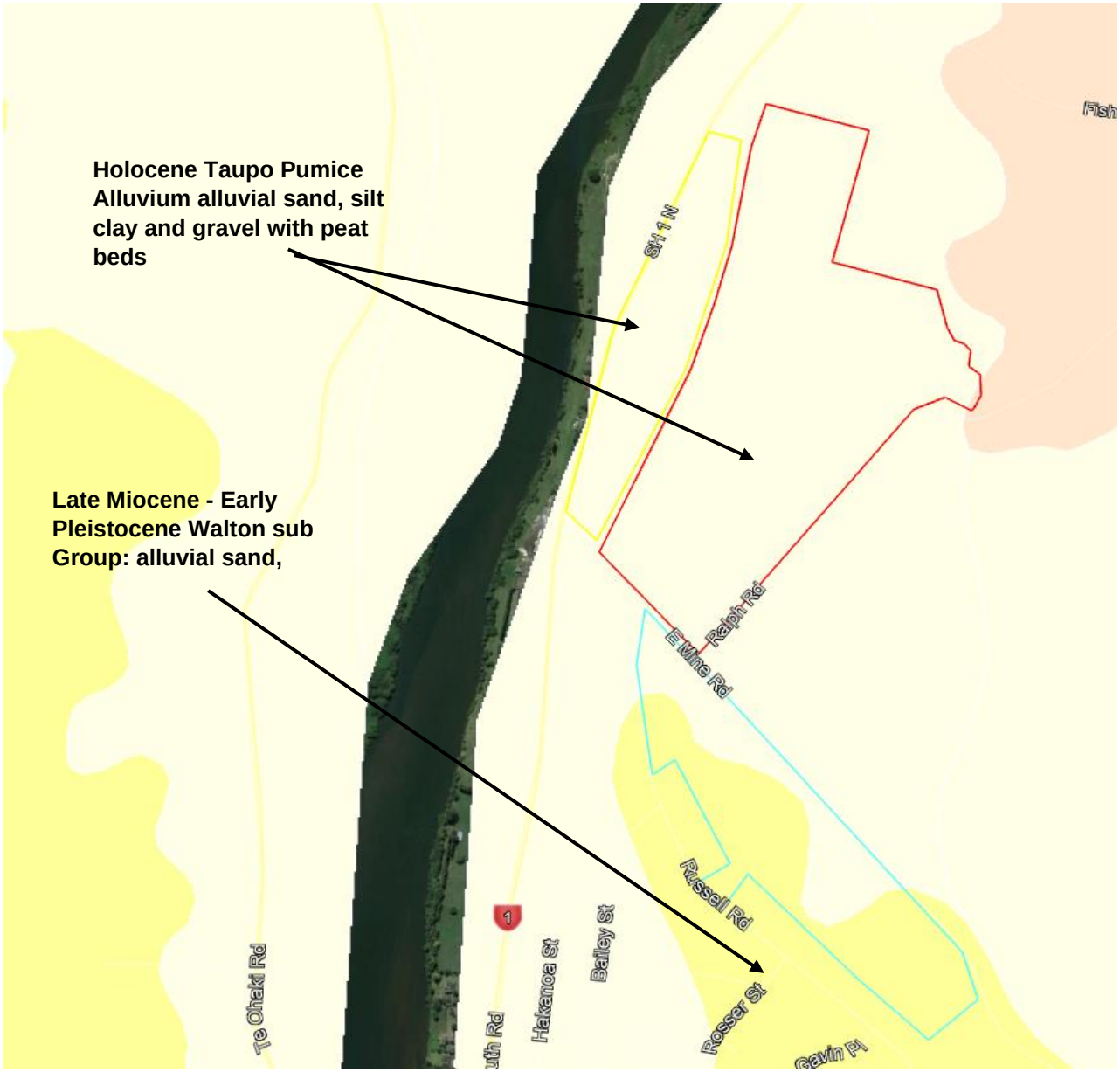


Figure 2: Published geology (Qmap series). (Areas outlined: Area 1- yellow, Area 2 - red, Area 3 - blue)

4 SITE VISIT AND WALKOVER

A site walkover was conducted by a CMW Geotechnical Engineer but was limited to inspection from public roadways.

The key observations are:

Areas 1 and 2: Essentially level but gently undulating topography, locally overgrown where not grazed. South eastern portion of Area 2 dominated by wet land area west of Ralph Road (Photo 1). Also of interest is a depression in East Mine Road between its junctions with Russell Road and Ralph Road, co-incident with the southern limits of the wetland (Photo 2).

Photo 1: Wetland viewed from Ralph Road.

Photo 2: Depression in East Mine Road, between Russell Road and Ralph Road, looking east.

Area 3: Area 3 is characterised by smooth rolling topography grading down to low lying land with locally wet areas adjacent to East Mine Road, Photos 3 and 4 below.

The primary possible evidence of mining related settlement is the uneven / undulating road surface evident on East Mine Road, coincident with the wet areas, Photo 5 below.

Photo 3: General composite view of western low-lying zone looking south into Area 3. Note reed/wetland vegetation to right of image – where 'new' pond is shown on the 1999 map.

Photo 4: View of eastern low-lying zone looking south into Area 3. Note more extensive wetland vegetation compared to western area.

Photo 5: Undulating road surface on East Mine Road next to Area 3.

5 SUMMARY AND DISCUSSION OF PREVIOUS ASSESSMENTS

5.1 Brief Overview

Much of the previous assessments have concentrated on the areas south of East Mine Road, with comparatively little discussion or assessment of underground mining risk north of East Mine Road.

Beneath Areas 1 and 2 the reduced level of the top of the worked coal seam is shown to increase from southeast to north west from approximately -185m RL to below -200m RL, however it is unclear what datum has been used. Ground level in these areas is approximately +9m RL to 10m RL (LINZ Lidar data – relative to mean sea level)[2]

Beneath Area 3 the equivalent levels fall from -60m RL in the east to -180m RL in the west. Ground level in Area 3 ranges between +28m RL on the hills in the south to approximately +9m RL in the low-lying areas immediately south of East Mine Road[2].

The IRBA reports describe all the workings north and south of the main mine roadways as 'room and pillar type' however the later RDCL report states those north of the main mine roadways (effectively the area north of Russell Road and all of Areas 1, 2 and 3) were mined by 'longwall' techniques.

Many of the reports recommend further monitoring of settlement, groundwater levels and gas levels. It is unclear if any of these recommendations were followed.

None of the reports discuss potential for seismic activity to cause ~~any potential~~ additional settlement due to fresh collapse of mine workings or consolidation of existing collapsed material.

[2] https://waikatomaps.waikatoregion.govt.nz/Viewer/?map=8d6d6fda779b4e59951953ae97d0ec4a

5.2 Settlement Risk

Beneath all areas there is a significant thickness of rock and alluvial soils above the mine workings which reduces the risk of 'swallow holes' developing from localised pillar collapse.

Figures 2 and 8 of the March 2015 IRBA report indicate that up to 75mm of settlement occurred at a monitoring location on Russell Road (Point E10 in Area 3) prior to 1998, and 1mm settlement at the same location between 2001 and 2014. However, this is not reflected in the maximum subsidence contour plans (Figure 10 of the same report) which do not show any significant settlement at that location.

The area over the mine roadways is stated by RDCL to be 'unlikely to exhibit any appreciable settlement due to their inherent cavern stability'.

With regard longwall mining RDCL also state that 'residual on-going settlement after a mine has closed is not a characteristic of this mining method'.

These two statements effectively imply a low risk of unacceptable on-going mining subsidence below the study areas, which RDCL describes as "rare to very rare".

However, there is no clear settlement monitoring data from within the Areas 1 and 2 presented in the reports assessed.

There has been no discussion of the risk of fresh or additional collapse of mining voids due to a seismic event.

5.3 Gas Risk

The risk of mine gas (primarily methane) accumulation and migration has been assessed in the previous reports.

The presentation prepared by IRBA for WDC shows potential "gas traps" close to Area 2 (just east of Ralph Road, at the southern end of Area 1 and between Russell Road and East Mine Road in Area 3.

There is various discussion of possible gas migration routes via groundwater, fractures in the bedrock and old boreholes, with some recommendations for monitoring.

The consensus of the working groups involved in the RDCL report was that the risk of gas migration and collection to hazardous levels in a structure over the workings is very low.

6 AREA 2 WETLAND AND LOWLYING LAND IN AREA 3

From our desk study we consider that the large wetland in Area 2 close to Ralph Road has most likely developed as a result of mining related settlement soon after longwall extraction of coal beneath this area.

It is less clear if the presence of wet low-lying land in Area 3 is entirely due to mining related settlement, however we consider that such settlement may have either generated or at least increased their development.

7 CONCLUSIONS AND POSSIBLE MITIGATION MEASURES

7.1 Conclusions

From the previous work it appears that Area 3 is largely over the Mine Roadways where settlement risk is considered to be low, and over areas of longwall workings where settement is usually evident soon after mining, with a low risk of longer term settlements.

Areas 1 and 2 are over areas of longwall workings where settement is usually evident soon after mining, with a low risk of longer term settlements.

The risk of localised crown holes developing is low and any settlement is likely to be spread over a wide area limiting differential settlement risk.

There is evidence of historic settlement affecting Areas 2 and 3. It is not known is if this settlement is continuing.

If further wide area regional settlement did occur, or is on-going then expansion of the wetlands, and creation of new ones is a possibility. A programme of regular surface level monitoring may help determine if settlement is continuing.

There is a very low risk that placing a significant thickness of fill and building loads across the land could promote additional mining settlement, particularly if the wetland in Area 2 were to be infilled.

There is a potential risk that fresh or re-activated mining related settlement could occur during or after a seismic event. Any such settlement would likely be widely distributed, again limiting differential settlement risk.

Gas risk is considered very low.

7.2 Mitigation

The greatest risk to the integrity of structures and infrastructure is differential settlement. This can be mitigated by the use of raft foundations, (possibly with ground treatment to provide a stiffened sub-grade raft which may be needed to increase foundation resilience against liquefaction effects), and flexible pipework, pavements and utilities.

Raising the ground level would also mitigate the risk of flooding if wide area regional settlement were to occur or if it is ongoing.

Although the risk of gas migration is considered to be low, passive protective measures such as vent trenches, and gas proof membranes in floor slabs are relatively low cost protective measures that may be adopted.

8 CLOSURE AND LIMITATIONS

This report has been prepared for use by our client, Shand Properties Limited and their consultants. Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

It should be noted that factual data for this report has been obtained from discrete sources and reports prepared by others which we have relied upon. There may be special conditions pertaining to this site which have not been disclosed by the assessment or observed on the day of our visit and which have not been taken into account in the report.

For and on behalf of CMW Geosciences

Prepared by:

Kenneth Read

Principal Geotechnical Engineer, CPEng, CMENZ

Reviewed and authorised by:

Andrew Linton

Principal Geotechnical Engineer, CPEng, CMENZ

Distribution: 1 electronic copy to Shand Properties via email
1 electronic copy to BBO via email
Original held at CMW Geosciences

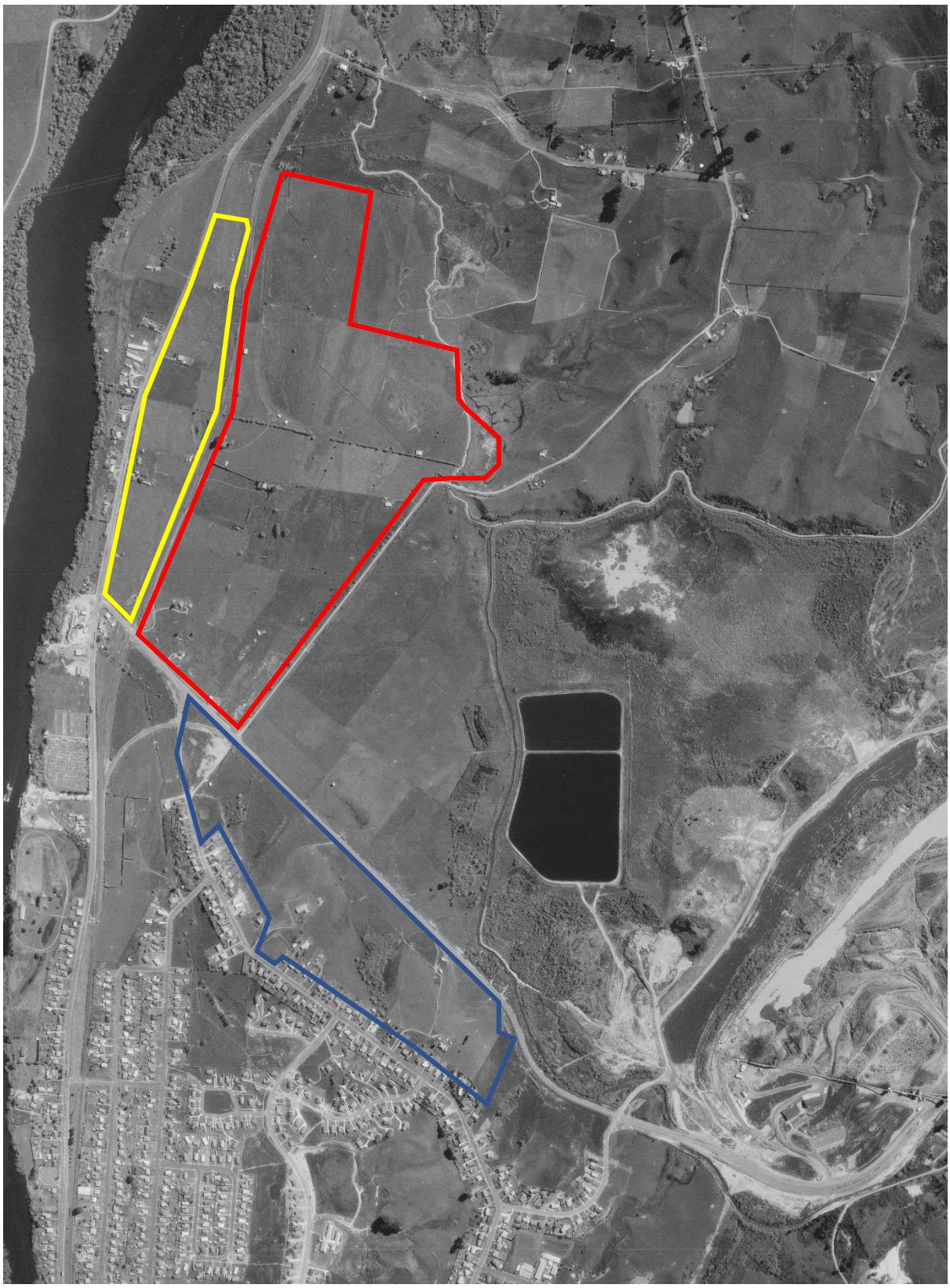
APPENDIX A
RETROLENS IMAGERY

October 1961

Area 1- Yellow
Area 2 - Red
Area 3 - Blue

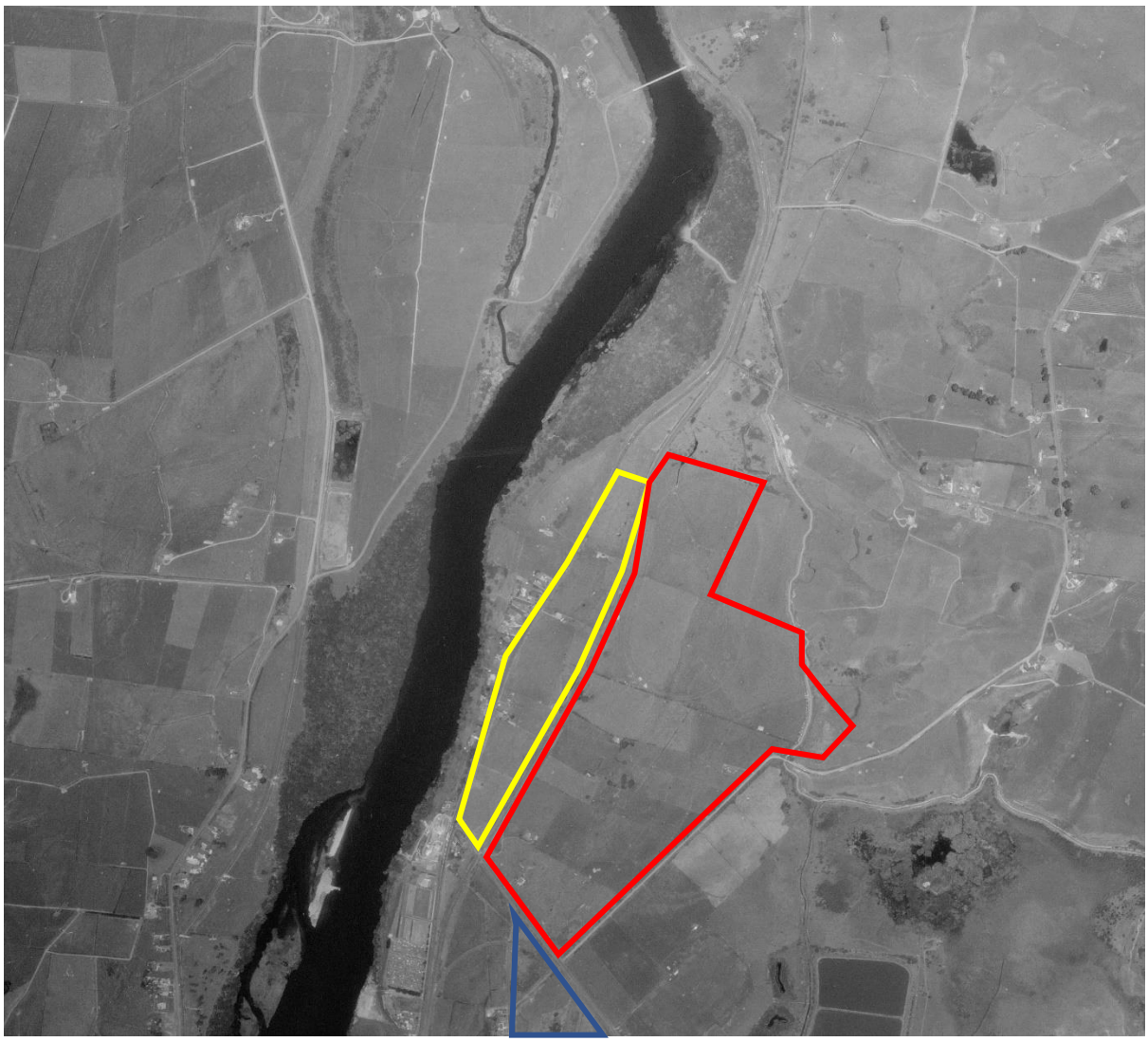
August 1970

Area 1- Yellow
Area 2 - Red
Area 3 - Blue



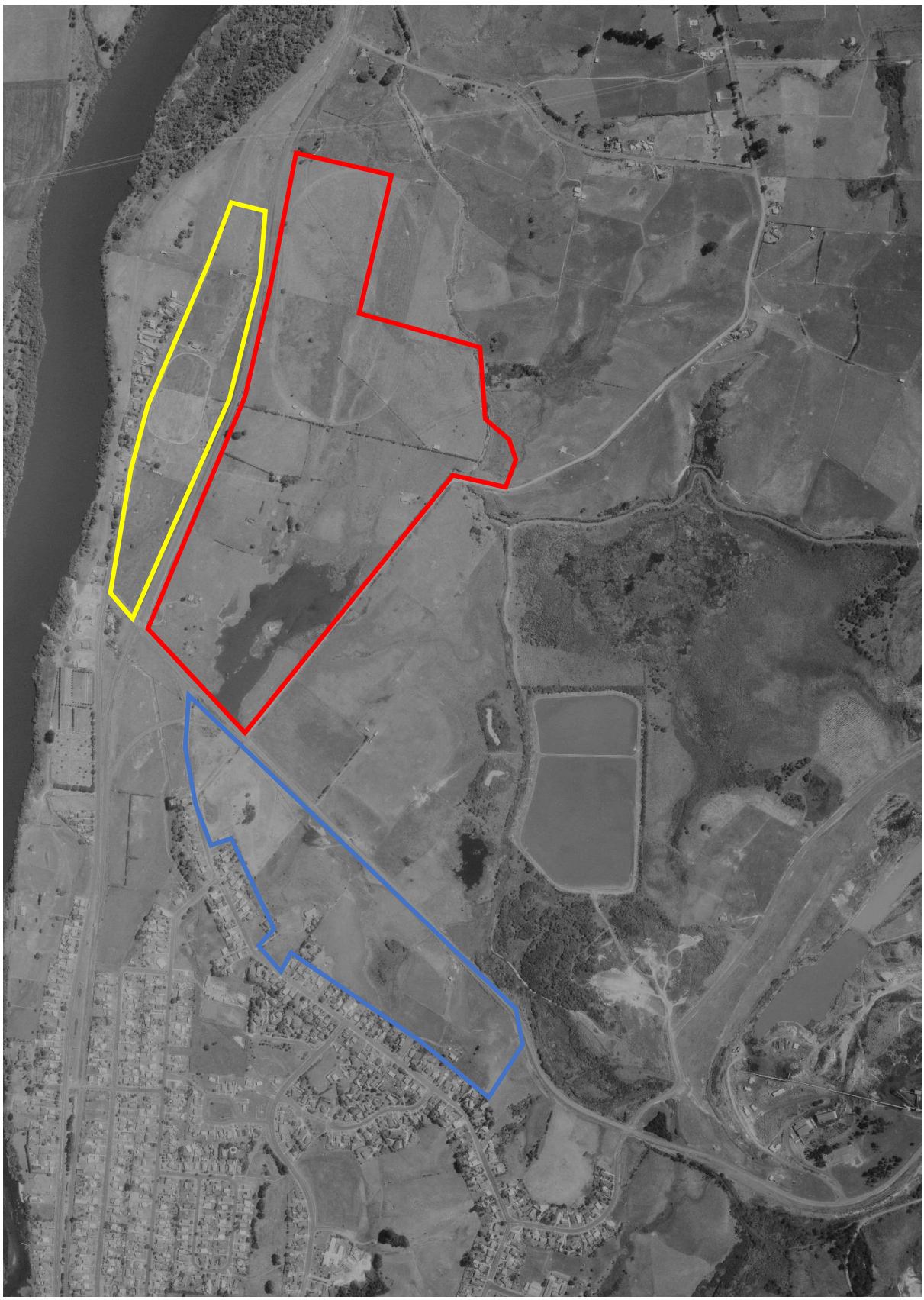
September 1979

Area 1- Yellow
Area 2 - Red
Area 3 - Blue



February 1984

Area 1- Yellow
Area 2 - Red
Area 3 - Blue



February 1991

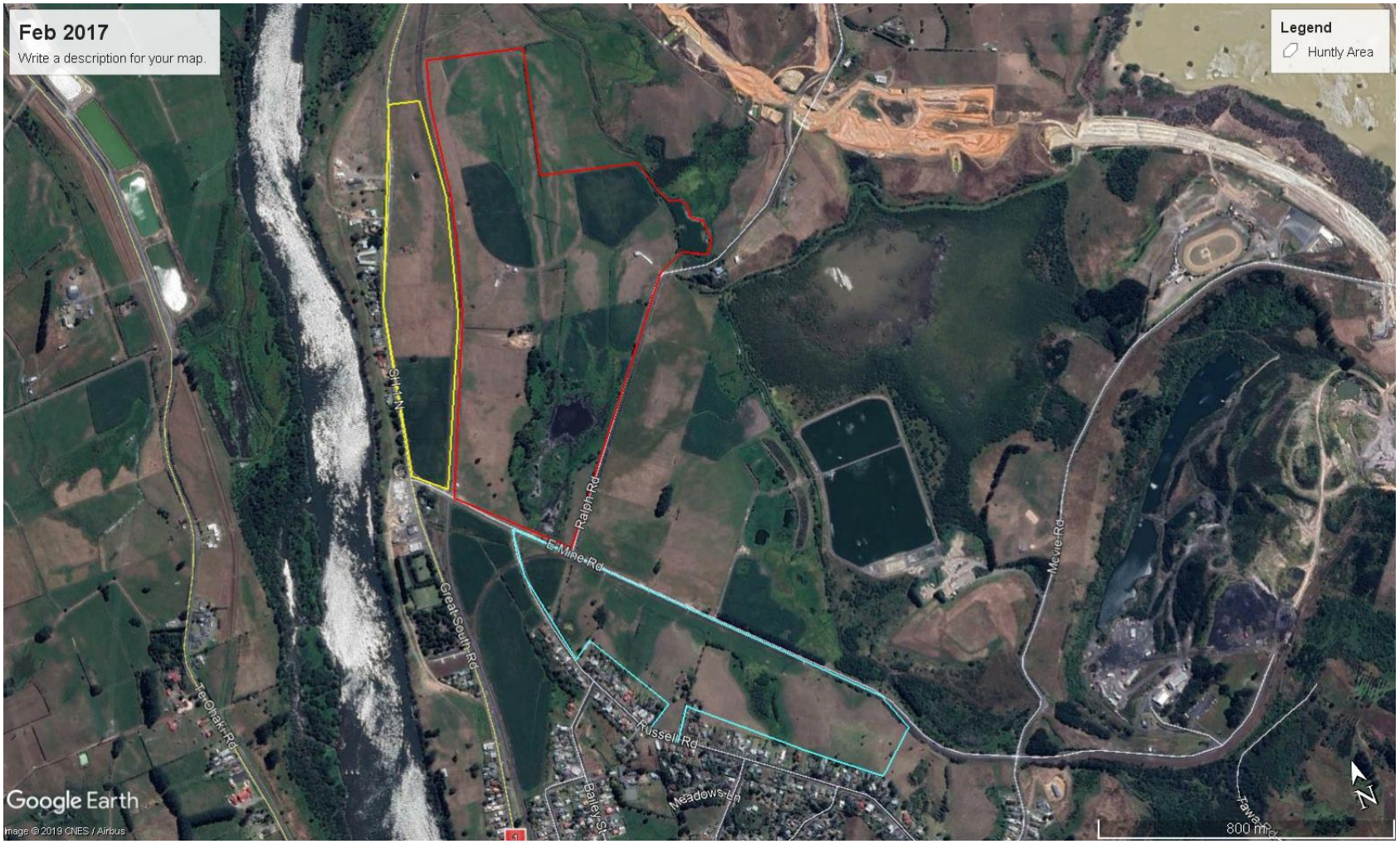
Area 1- Yellow
Area 2 - Red
Area 3 - Blue

APPENDIX B
GOOGLE EARTH IMAGERY

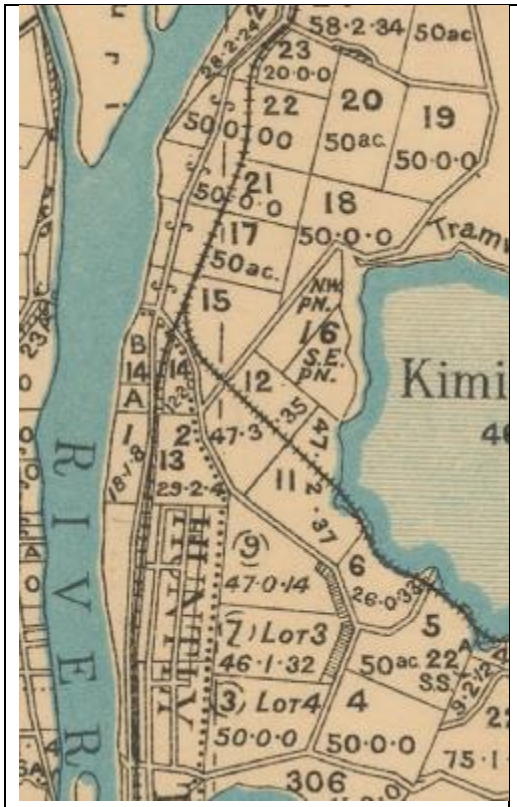
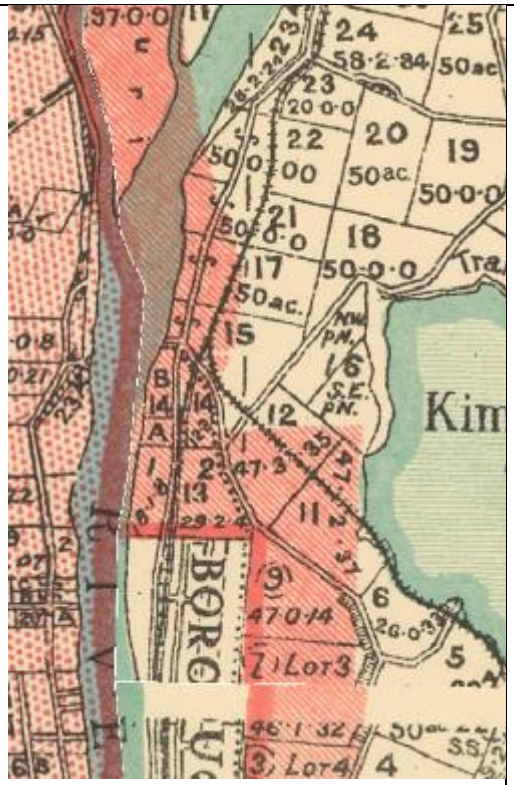
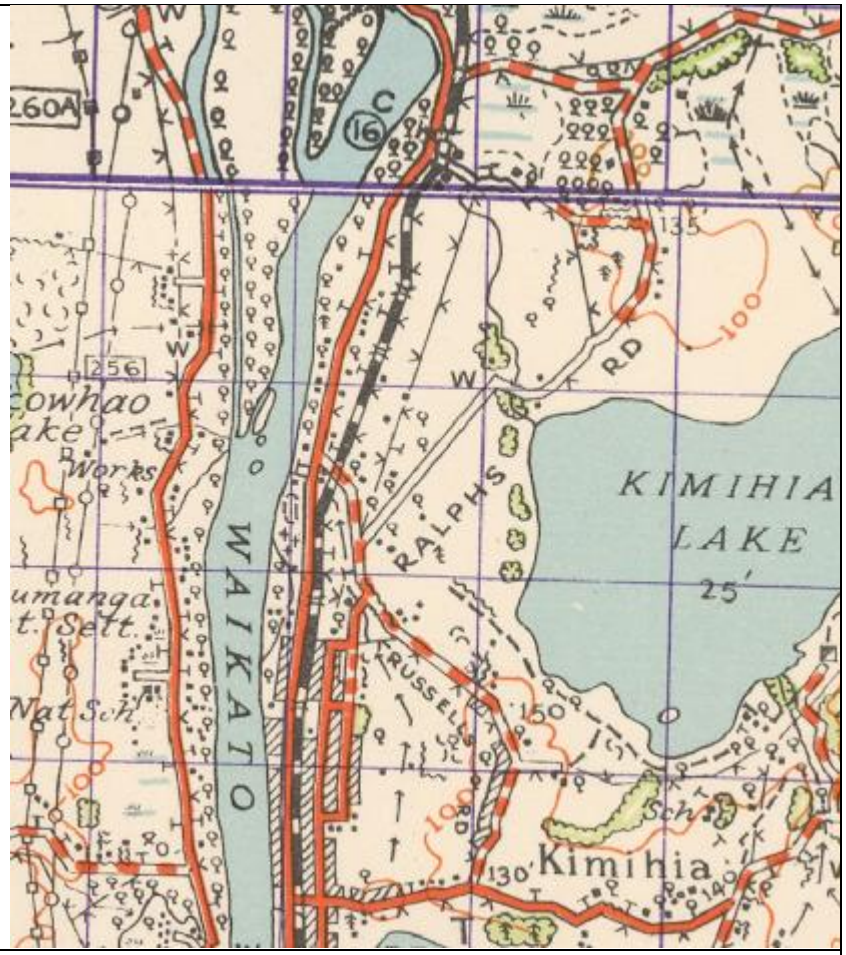

2008
Write a description for your map.
Legend
Huntly Area
Ralph Rd
E Mine Rd
Mcvie Rd
Russell Rd
Meadows Ln
Google Earth
800 m

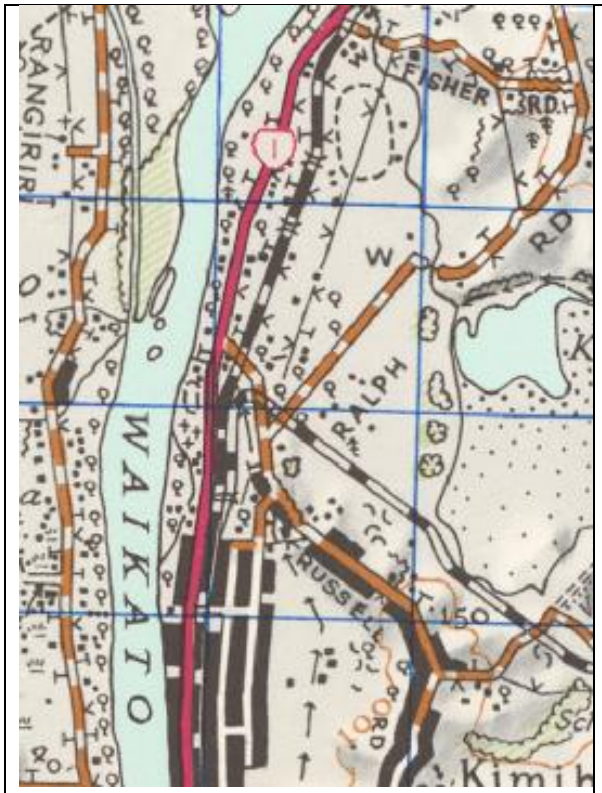
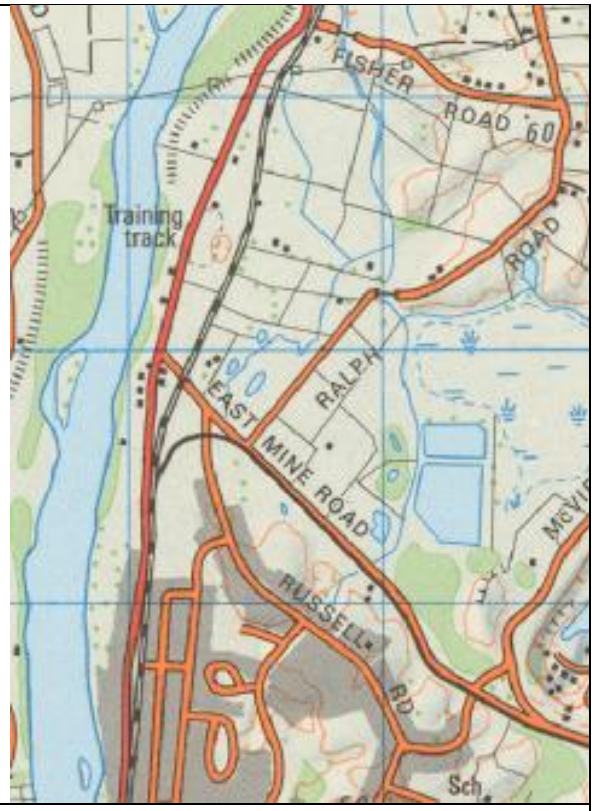

2010
Write a description for your map.
Legend
Huntly Area
SH 1N
Great South Rd
Ralph Rd
E Mine Rd
Mcvie Rd
Te Ohaki Rd
Russell Rd
Meadows Ln
Bailey St
Google Earth
Image © 2019 Maxar Technologies
800 m
N


2015
Write a description for your map.
Legend
Huntly Area
SH 1 N
Ralph Rd
E Mine Rd
Great South Rd
Te Ohaki Rd
Russell Rd
Meadows Ln
Mcvie Rd
Google Earth
Image © 2019 Maxar Technologies
800 m
N


Feb 2017
Write a description for your map.
Legend
Huntly Area
SH 1 N
Ralph Rd
E Mine Rd
Great South Rd
Te Onaki Rd
Russell Rd
Bailey St
Meadows Ln
Mevie Rd
Tawa Rd
800 m
N
Google Earth
Image © 2019 CNES / Airbus

APPENDIX C
HISOTRIC MAPS

		
1929 Railway follows what is now East Mine Road, with spur to north.	1949 Railway follows what is now East Mine Road with spur to north.	1959 Railway on East Mine Road not clearly shown.

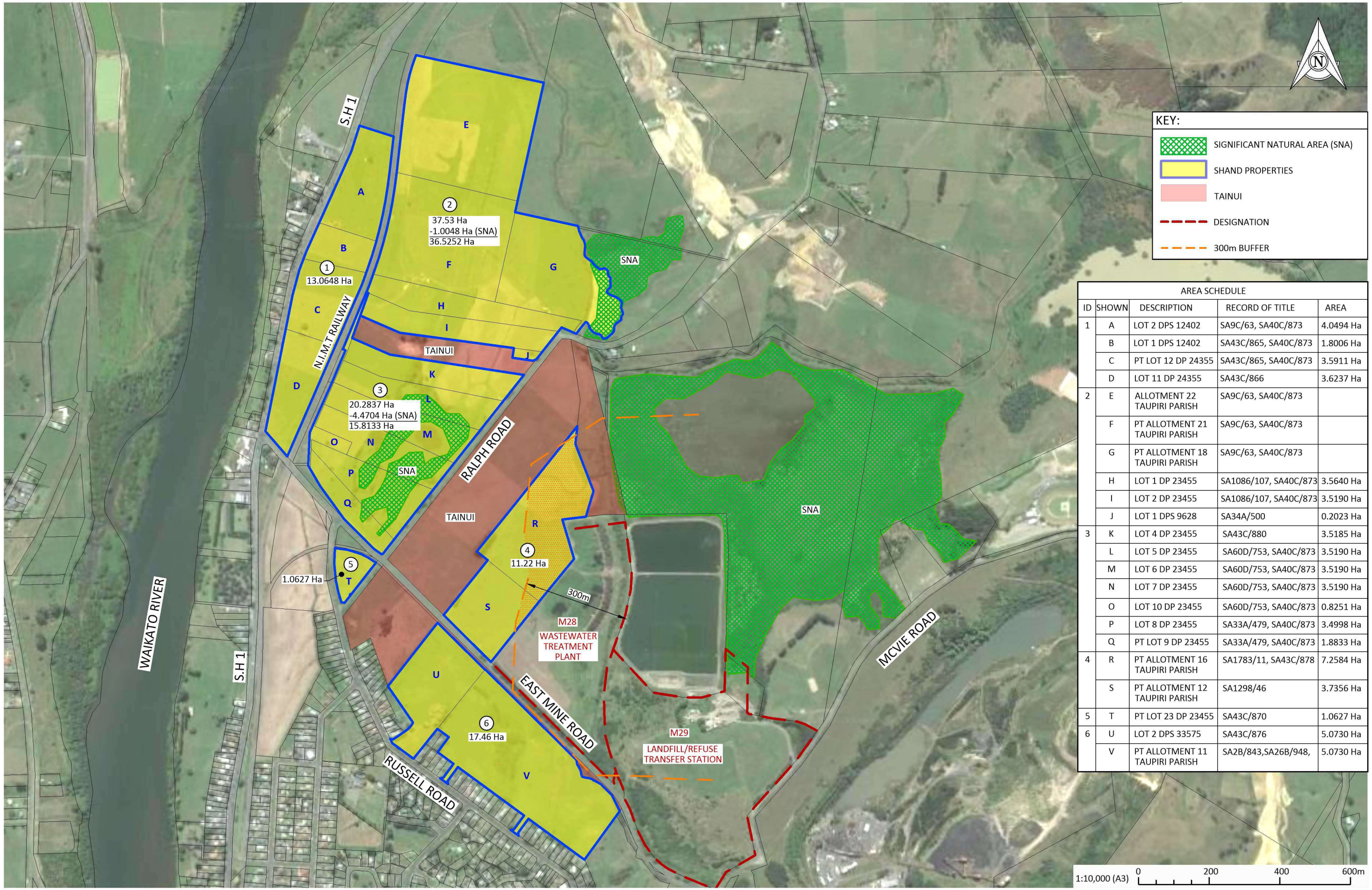
		
1979 Railway follows what is now East Mine Road with spur to south.	1989 Disused(?) railway follows south side of East Mine Road with spur to south	1999. • Disused(?) railway follows south side of East Mine Road with spur to south • Wetland shown between Ralph Road and East Mine Road in SW corner of Area 2 with new stream course. • New Stream in NE of Area 2, flowing to SW. • New Stream and possible pond south of East Mine Road in Area 3.

2009

- Disused(?) railway follows south side of East Mine Road with spur to south
- Stream and wetland in SW corner of Area 2, between Ralph Road and East Mine Road.
- Stream and pond south of East Mine Road

Attachment 2

“Land Holding Plan”, BBO Drawing No 144370-02-0141 Rev C



AREA SCHEDULE

ID	SHOWN	DESCRIPTION	RECORD OF TITLE	AREA
1	A	LOT 2 DPS 12402	SA9C/63, SA40C/873	4.0494 Ha
	B	LOT 1 DPS 12402	SA43C/865, SA40C/873	1.8006 Ha
	C	PT LOT 12 DP 24355	SA43C/865, SA40C/873	3.5911 Ha
	D	LOT 11 DP 24355	SA43C/866	3.6237 Ha
2	E	ALLOTMENT 22 TAUPIRI PARISH	SA9C/63, SA40C/873	
	F	PT ALLOTMENT 21 TAUPIRI PARISH	SA9C/63, SA40C/873	
	G	PT ALLOTMENT 18 TAUPIRI PARISH	SA9C/63, SA40C/873	
	H	LOT 1 DP 23455	SA1086/107, SA40C/873	3.5640 Ha
	I	LOT 2 DP 23455	SA1086/107, SA40C/873	3.5190 Ha
	J	LOT 1 DPS 9628	SA34A/500	0.2023 Ha
3	K	LOT 4 DP 23455	SA43C/880	3.5185 Ha
	L	LOT 5 DP 23455	SA60D/753, SA40C/873	3.5190 Ha
	M	LOT 6 DP 23455	SA60D/753, SA40C/873	3.5190 Ha
	N	LOT 7 DP 23455	SA60D/753, SA40C/873	3.5190 Ha
	O	LOT 10 DP 23455	SA60D/753, SA40C/873	0.8251 Ha
	P	LOT 8 DP 23455	SA33A/479, SA40C/873	3.4998 Ha
	Q	PT LOT 9 DP 23455	SA33A/479, SA40C/873	1.8833 Ha
4	R	PT ALLOTMENT 16 TAUPIRI PARISH	SA1783/11, SA43C/878	7.2584 Ha
	S	PT ALLOTMENT 12 TAUPIRI PARISH	SA1298/46	3.7356 Ha
5	T	PT LOT 23 DP 23455	SA43C/870	1.0627 Ha
6	U	LOT 2 DPS 33575	SA43C/876	5.0730 Ha
	V	PT ALLOTMENT 11 TAUPIRI PARISH	SA2B/843,SA26B/948,	5.0730 Ha

DATE	ISSUE/REVISION DETAIL	BY	CHK	APPR
-	-	-	-	-

DESIGNED: - | CHECKED: -
DRAWN: - | APPROVED: -
mx model version:

BLOXAM BURNETT OLLIVER
Phone +64-7-838 0144, Fax +64-7-839 0431

CLIENT: SHAND PROPERTIES

PROJECT: PROPOSED DISTRICT PLAN REZONING

DRAWING: LAND HOLDING PLAN

STATUS: PRELIMINARY
DATE: 21.01.2020
SCALE (ORIGINAL SIZE A3): 1:10,000
DRAWING NUMBER: 144370-02-0141
REVISION: A

Attachment 3

Figures 2, 10 and 11 from "Huntly East Land subsidence due to coal mining – Investigation and analysis of potential hazard", IRBA Geological Engineering Consultants, Project ref 1003

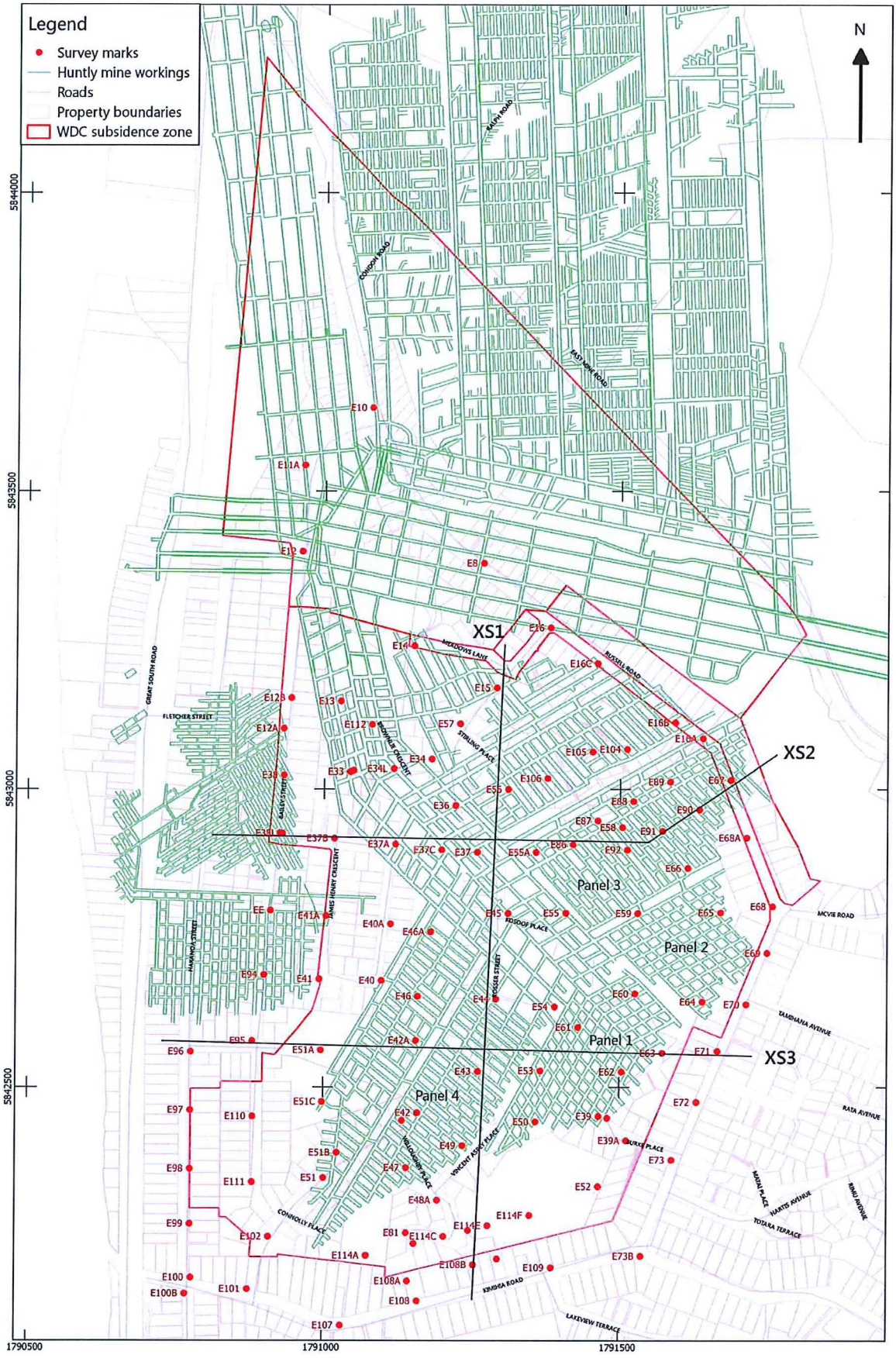


Figure 2. Site plan showing survey marks and mine workings.

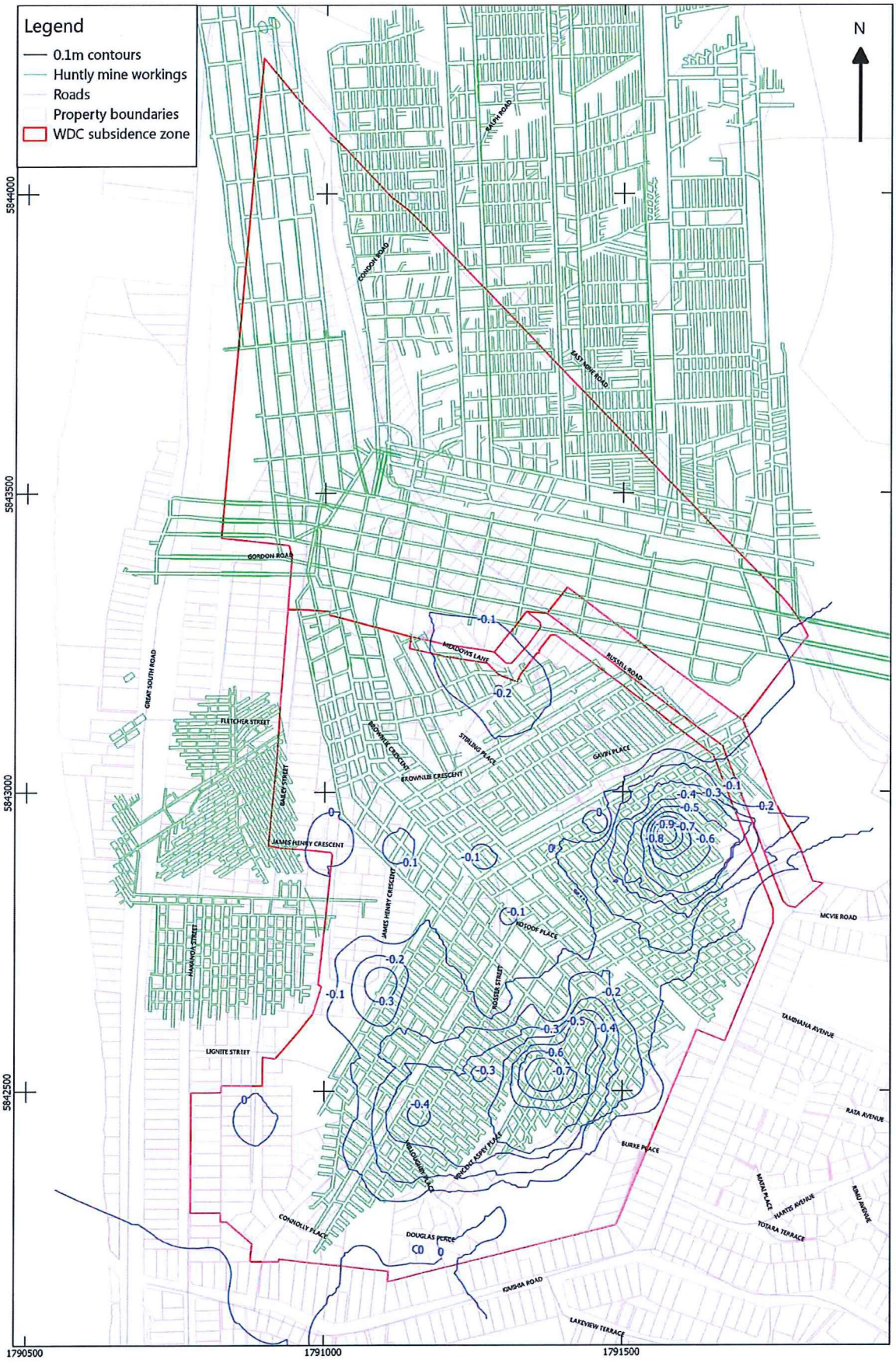


Figure 10. Maximum subsidence contours 1981-2014.

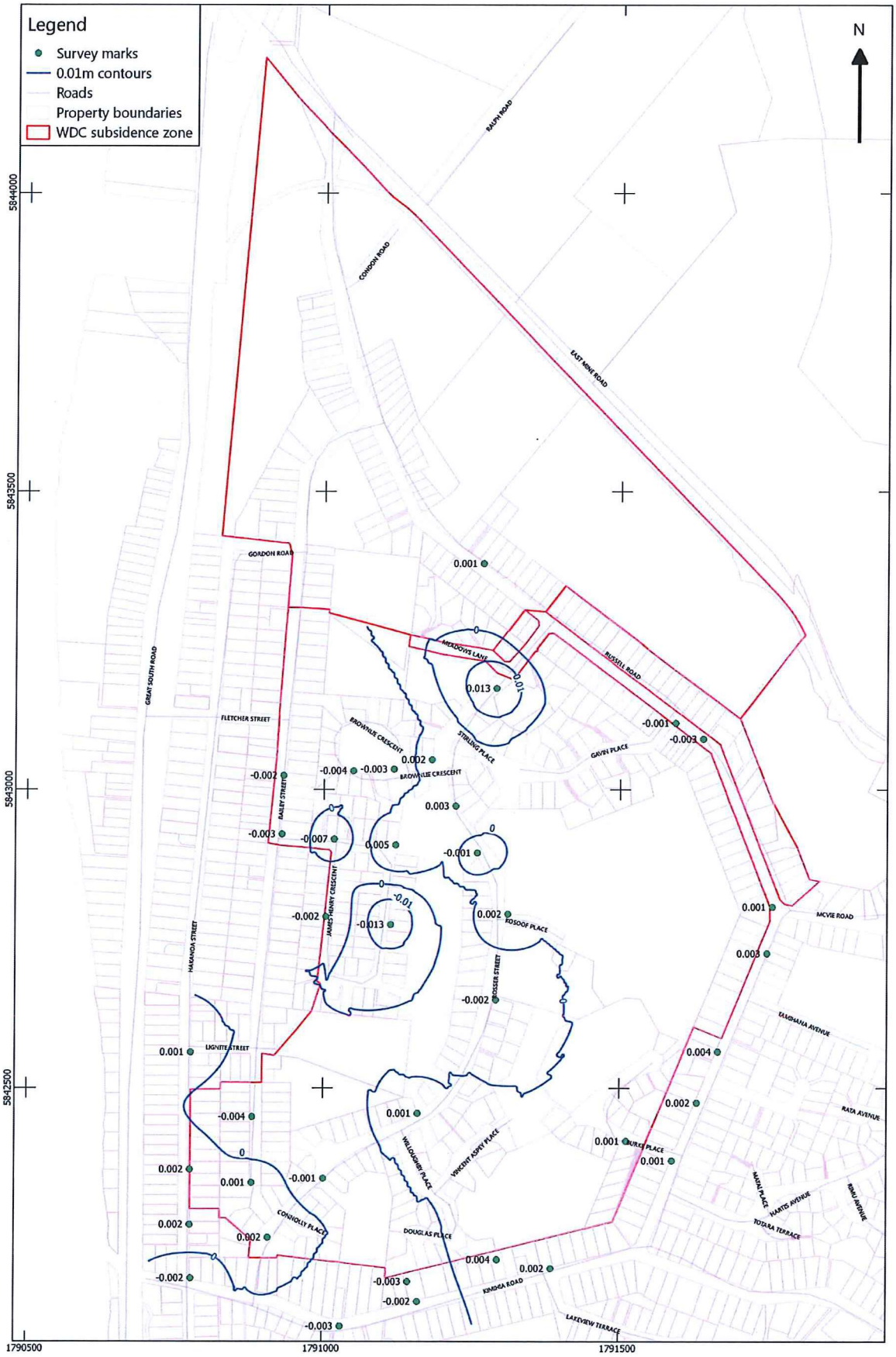


Figure 11. Subsidence contours 2009-2014 with subsidence values posted at each survey mark.

Attachment 4

CMW: North Huntly Development, East Mine Road Huntly, Geotechnical Investigation Report

13 July 2020

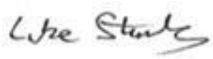
NORTH HUNTLY DEVELOPMENT
EAST MINE ROAD, HUNTLY

GEOTECHNICAL INVESTIGATION REPORT

Shand Properties Ltd

HAM2019-0082AF Rev 0

HAM2019-0082AF		
Date	**Revision**	**Comments**
16/06/2020	A	Initial draft for internal review
13/07/2020	0	Final issue to Client

	Name	**Signature**	**Position**
Prepared by	Luke Stanley		Engineering Geologist
Reviewed by	Ken Read		Principal Geotechnical Engineer
Authorised by	Andrew Linton		Principal Geotechnical Engineer

EXECUTIVE SUMMARY

CMW Geosciences (CMW) was engaged by Shand Properties Ltd (c/o BBO) to carry out a geotechnical investigation of land located off Old Mine Road, Huntly, which is being considered for the construction of industrial and residential sub-divisions.

This report is to support a feasibility assessment for the proposed residential and commercial/industrial development.

The study land under consideration has been divided into 3 areas.

Areas 1 and 2 are located on low lying land immediately north of East Mine Road, Huntly.

Area 3 is located on an elevated terrace off Russell Road, Huntly.

Our investigation has confirmed that the low lying Areas 1 and 2 are underlain by predominantly loose to medium dense sands of the Taupo Pumice Alluvium, with some near surface thin layers of silts and clays. Groundwater is relatively shallow beneath these areas.

Area 3 was found to be underlain by firm to stiff clays and silts of the Walton Subgroup with sandy soils about 14m below the top of the terrace.

Areas 1 and 2, North of East Mine Road

- The loose and medium dense sands beneath Areas 1 and 2 are potentially liquefiable and our preliminary assessment indicates total liquefaction induced settlements of between 90 and 150mm may occur in the ultimate limit state design event.
- The interbedded loose sand and firm clay soils near the surface do not generally have 300kPa geotechnical ultimate bearing pressures and engineered designed foundations will be needed to manage both bearing pressures and ensure settlement of foundations is within building tolerances.
- Ground improvement measures such as preloading and/or undercutting of the near surface soils may be required to manage static settlement.
- To protect structures from unacceptable liquefaction induced ground deformation further ground improvement measures may be needed. These can comprise incorporation of geogrid reinforcement into foundation preparation works, stone columns or rammed aggregate piers.

Area 3, North of Russell Road

- The firm and stiff silty soils forming the elevated terrace offer good foundation conditions, with generally over 300kPa ultimate bearing pressures.
- The slopes beneath the terrace have been analysed and found to be suitably stable.
- Localised areas of soil creep on the slopes beneath the terrace are unlikely to impact the development. This should be re-assessed at the detailed design stage.

Table of Contents

Drawings

Appendices

1 INTRODUCTION

1.1 Project Brief

CMW Geosciences (CMW) was engaged by Shand Properties Ltd (c/o BBO) to carry out a geotechnical investigation of land located off Old Mine Road, Huntly, which is being considered for the construction of commercial/industrial and residential sub-divisions.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal referenced HAM2019-0082AE, Rev0 dated 12 March 2020.

This report is to support a feasibility assessment for the proposed residential and commercial/industrial development.

1.2 Scope of Work

As detailed in our proposal, the agreed scope of work to be conducted by CMW was as follows:

- To carry out a desktop study comprising a review of publicly available historic aerial photography, old maps and geological maps to define the potential natural hazards affecting the site(s);
- A site walkover by an engineering geologist to assess the landform and geomorphology;
- To carry out sixteen hand augered boreholes with associated in situ shear vane and/or dynamic cone penetrometer testing to assess near surface ground conditions;
- To carry out ten cone penetration tests (CPTs) to target depths of 20m, including installation of 3 piezometers, to provide information on deeper ground and groundwater conditions, to aid liquefaction, settlement and stability assessments;
- Groundwater level monitoring (one visit);
- Presentation of a geotechnical investigation plan, 2 geological sections and site investigation records; and
- To prepare a geotechnical report to support a feasibility assessment, outlining ground conditions, covering settlement, liquefaction potential, bearing capacity, foundation suitability, slope stability and presenting results of a natural hazards risk assessment.

2 SITE DESCRIPTION

2.1 Site Location

The site is located on East Mine Road, Huntly, Waikato as shown on **Figure 1** below and has an area of approximately 110Ha.

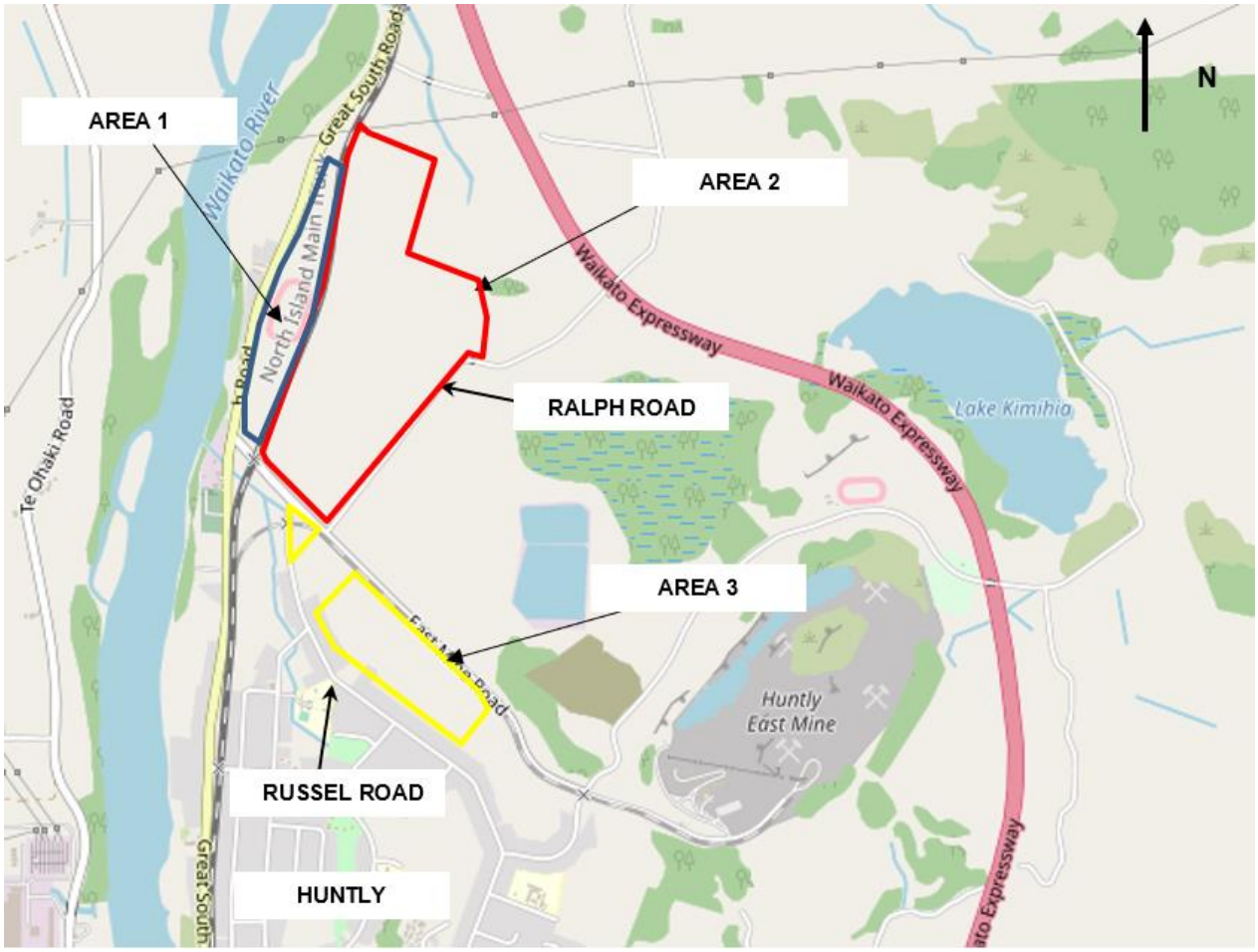


Figure 1: Site Location Plan (source openstreetmaps.org)

For ease of description due to the size of the site and the differing geology encountered during the ground investigation, we have split the site into 3 areas as per the High Level Mining Risk Review report produced by CMW Geosciences (HAM2019-0082AD Rev. 0).

Area 1 is approximately 13Ha and located to the west of the site between the railway (North Island Main Trunk Line) and Great South Road.

Area 2 is approximately 63Ha and makes up the main land mass of the site, located between the railway line and Ralph Road.

Area 3 is approximately 20Ha and is located to the south of East Mine Road, off Russel Road.

There are other smaller parcels of land which make up the whole site, however only the three areas referred to above were targeted during this ground investigation.

The approximate extent of the three areas which this report will refer to are shown on **Figure 1.**

2.2 Site Description

The current general landform, together with associated features located within and adjacent to the site is presented on the attached Geomorphological Plan, ***Drawing 01.***

Area 1 is a north - south orientated rectangular area of land located north of East Mine Road, between Great South Road to the west and the railway to the east. This area is essentially level with ground levels undulating between from RL11m[1] towards the western boundary and RL9m on the eastern boundary close to the railway. The area is used for grazing and pastureland. There are two small farm buildings present, the largest of which is approximately central to the area.

Area 2 is located north of East Mine Road, between the railway and Ralph Road. This area is also near level to gently undulating with ground levels generally ranging from RL9m to RL12m. In the south east corner of the area ground level is approximately RL8 where a significant wetland area is present. This is considered to have been formed through historic mining subsidence and subsequent flooding due to drainage into this topographically low area. It is now recorded as a Significant Natural Area (SNA). There is a linear depression trending north from this wetland at about RL9. There are no structures in this area and the land is given over to pasture and grazing.

Area 3, lies between East Mine Road and Russel Road and features two rolling hills grading down to a low-lying area with two north facing gullies dividing the site. The southern edge of the area is bordered by domestic housing off Russell Road, and the hillsides are grassed. The gully floors and low-lying land in the north of the area are wet and have typical wetland vegetation, ranging between RL 9m and RL 10m. The western hilltop within Area 3 peaks at RL 28m within the site boundary, falling to a low point of RL 10m. The eastern hilltop within Area 3 peaks at approximately RL 45m and falls to a low of RL 8m on the northern boundary next to East Mine Road.

Localised areas of soil creep are present in the north facing terrace slopes.

Historical maps show a railway used to run just inside the northern boundary next to East Mine Road.

The nearest major watercourse to the study area is the Waikato River, located approximately 80m west of Area 1's western boundary.

Approximately 480m east of Area 2 there are ponds associated with a waste-water treatment plant.

3 PROPOSED DEVELOPMENT

At the time of writing this report the project was in the early stages of planning and it was anticipated that the geotechnical investigation would provide information to aid assessment of feasibility and development of preliminary options for the site as a whole.

Limited development proposals have been provided for Areas 1 and 3. These plans indicate that Area 1 is being considered for industrial/commercial development and that Area 3 is being considered for a residential sub-division. There have been no development plans provided for Area 2, however we have been informed that it is being considered for industrial/commercial development.

Preliminary development proposals for Area 3 show a conceptual layout for a domestic housing sub-division. A copy of this is presented in **Appendix A**. Due to the sloping topography it is likely that this development will require cuts and fills to create level building platforms, with possible retaining walls.

We have prepared this report on the basis that a future development will broadly comprise minor cuts and fills to form a near level site supporting commercial and residential buildings with shallow strip and pad foundations, and, in the case of industrial units, assumed widespread floor loads of up to 12kPa.

[1] Waikato Regional Council LiDAR Contour Map

4 INVESTIGATION SCOPE

4.1 Desktop Study

We have reviewed publicly available historic aerial photography from Retrolens NZ and Google Earth Pro to identify any changes in landform and land use across the study area between 1941 and 2019

Historical maps[2] were also reviewed to identify any major changes in landform or land use between 1929 and 2009.

Publicly available geological maps were also studied to identify likely geology and help us assess any potential for natural hazards which may affect the site.

4.2 Field Investigation

The field work was carried out between 29 April 2020 and 15 May 2020 with a final groundwater monitoring visit undertaken on 05 June 2020.

All fieldwork was carried out under the direction of CMW Geosciences in general accordance with the NZGS specification[3] and soil logged by CMW geotechnical engineers in general accordance with NZGS guidance[4].

The fieldwork carried out was as follows:

- A walkover survey of the site to assess the general landform, site conditions and adjacent structures / infrastructure;
- Sixteen hand auger boreholes, denoted HA01 to HA16, were drilled using a 50mm diameter auger to target depths of up to 5.0m below existing ground levels to visually observe the near surface soil profile and to facilitate in-situ vane shear strength (VSS) testing. Engineering logs of the hand auger boreholes, together with peak and remoulded vane shear strengths are presented in **Appendix B**;
- Dynamic cone (Scala) penetrometer (DCP) tests were carried out adjacent to each relevant hand auger borehole to depths of up to 5m to provide soil density profiles, for use as a comparison with the CPT data and to provide a subgrade CBR value for pavement design purposes. Graphical results of the DCP testing are presented on the borehole logs in **Appendix B**;
- Ten Cone Penetrometer Tests (CPT), denoted CPT01 to CPT10, pushed to depths of up to 20m. The results of the CPT's, presented as traces of tip resistance (qc), friction resistance (fs) and friction ratio are presented in **Appendix C** Standpipe piezometers comprising 32mm diameter slotted uPVC pipe were installed to 6m depth in CPTS 04 and 08 respectively;
- Groundwater monitoring was undertaken during a visit to the site on 05 June 2020, some 21 days following the initial fieldwork, to measure the groundwater levels in the piezometers. The results of this monitoring are presented in Section 5.3;

The approximate locations of the respective CPTs, Hand augers and DCP tests referred to above are shown on the Site Plan, **Drawing 02.** Test locations were measured using hand-held GPS to an accuracy of +/- 10m. Elevations were inferred from publicly available topographic maps[5].

[2] Mapspast.org.nz.
[3] NZ Geotechnical Society (2017) NZ Ground Investigation Specification, Volume 1 – Master Specification
[4] NZ Geotechnical Society (2005), Field Description of Soil and Rock, Guideline for the field classification and description of soil and rock for engineering purposes.

[5] Waikato Regional Council Contours Map - https://waikatomaps.waikatoregion.govt.nz/Viewer/?map=8d6d6fda779b4e59951953ae97d0ec4a

5 GROUND MODEL

5.1 Published Geology

The published geological maps[6] for the area depict the regional geology as primarily comprising pumice sand, silt and gravel alluvium with charcoal fragments of the Holocene aged Taupo Pumice Alluvium, as illustrated in Figure 2 below.

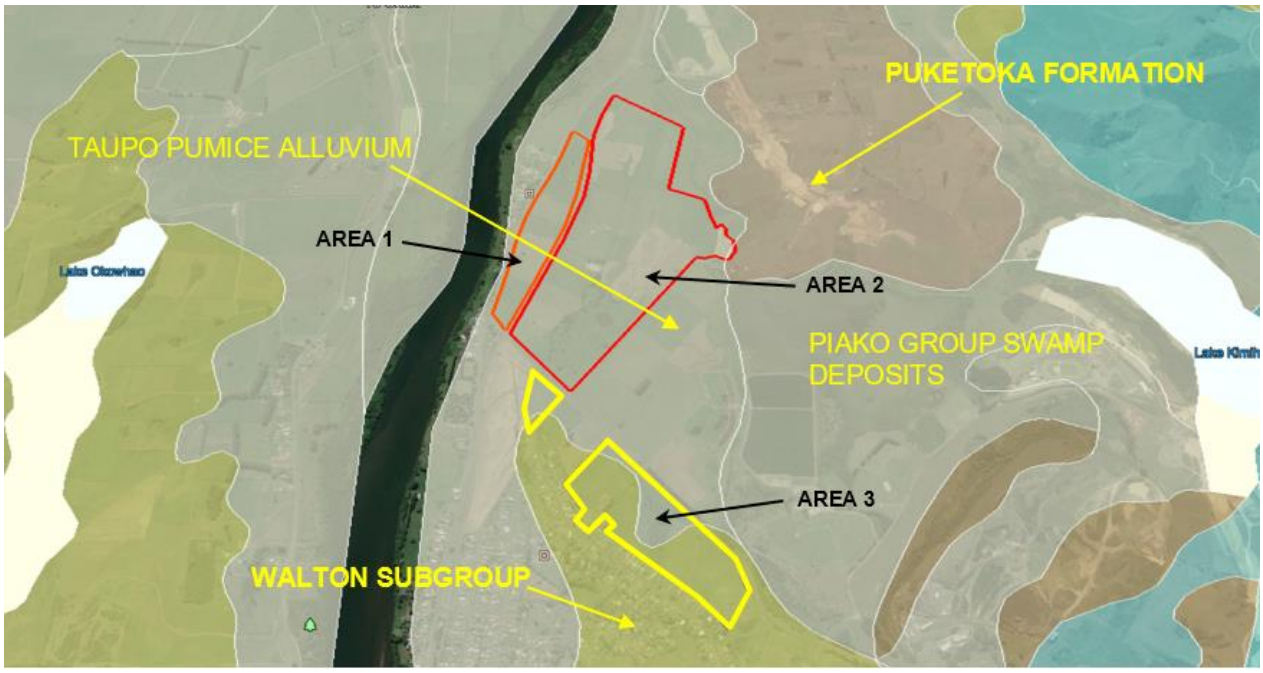


Figure 2: Regional Geology (GNS Q Map series)

To the immediate northeast of Area 2, pumiceous mud, sand and gravel with muddy peat and lignite of the Late Pliocene aged Puketoka Formation are shown to outcrop, with Piako Group swamp deposits noted further east of Area 2.

These soils are typically underlain by silts, sandy silts and clays of the Late Miocene aged Walton Subgroup which are shown to outcrop in Area 3, forming the higher rolling hills in the south of that area.

Beneath the upper soil layers, the deeper geological basement rocks are reported to comprise carbonaceous mudstone, claystone and coal seams of the Waikato Coal Measures Formation, which is expected to lie some 195m to 210m below existing ground levels.

Based on the known history of the site and surrounding land levels, some superficial depths of fill could be anticipated as a result of soft landscaping and general agricultural activity. Old plans show a former railway line immediately south of East Mine Road and fill materials associated with the railway including track ballast may be present.

5.2 Stratigraphy

The ground conditions encountered and inferred from the investigation are considered to be generally consistent with the published geology for the area.

[6] GNS Map No4, “Geology of the Waikato”, 1:250,000 scale, S. W. Edbrooke Compiler, 2005; and GNS Map No3 “Geology of the Auckland Area” 1:250,000 scale, S. W. Edbrooke Compiler, 2001

The distribution of the various strata encountered is presented in the appended Geological Sections (**Drawings 03 and 04**).

5.2.1 Areas 1 and 2

Topsoil was encountered across Areas 1 and 2 to a maximum depth of 0.40m.

A stiff orange brown silt, and some sandy silts up to 0.4m thick, locally underlies the topsoil over much of Area 1 (HA07, HA09, HA13, and HA15) and in the extreme north and south of Area 2 (HA06 and HA16).

Elsewhere beneath the topsoil and silts lie interbedded loose to medium dense sands and silts, becoming medium dense to dense with depth, generally from below 5m, and dense below 13m depth. There is significant lateral and vertical variation in soil composition and density/strength beneath the two areas as would be expected in alluvial soils.

Interbedded firm clay lenses are present at depth (below 16m) towards the north and east of Area 2 (CPTs 05, 07 and 10).

Firm clay was encountered by CPT06 between 9.4 and 20m depth. This is considered to possibly be the peak of a now buried landform comprising Walton Subgroup soils.

5.2.2 Area 3

Up to 0.5m of Topsoil was encountered across Area 3.

The hilltop and slopes in this area are underlain by very stiff to hard clays and silts of the Walton Subgroup. These were proved to 5m depth in HA01, HA02 and HA04.

From 3m depth CPT01 and CPT02 encountered 1.5m and 4m, respectively, of silty sands and sandy silts under the surface clays.

These sandy silt and silty sand layers are in turn underlain by stiff to very stiff clay to approximately 14m depth. These in turn are underlain by medium dense to dense sandy soils to the full 20m depth of the CPTs.

HA03 and HA05 located in the low lying area between East Mine Road and the hill encountered loose to medium dense sands of the Taupo Pumice Alluvium, as seen in Areas 1 and 2.

5.2.3 Summary

The distribution of the soils encountered within Areas 1 and 2 is illustrated on the appended Geological Section A (**Drawing 03**) and presented below in **Table** .

Table 1: Strata Encountered in Areas 1and 2

Strata	Depth to Top (m)		Thickness (m)	
	Min	Max	Min	Max
Topsoil	GL		0.2	0.4
Stiff Orange brown Silts and Sandy Silts* (TPA)	0.2	0.4	0.2	0.4
Interbedded Loose to Medium Dense Sands and Silts (TPA)	Varies ~ 5m		4.2	4.6
Medium Dense Sands (TPA)	Varies ~ 13m		Approx. 3m	
Interbedded Medium Dense to Dense Sand and Firm Clay (TPA)	Approx. 16m		> 4m	
Firm Clay/Silt (WS)***	9.4		>10.6	

Notes: TPA = Taupo Pumice Alluvium, WS = Walton sub-group
* Strata not encountered in HA08, HA10, HA12 and HA14
** Strata only encountered in HA08, HA10 and HA15
*** Strata only encountered in CPT06
Thickness is only recorded were base of strata has been confirmed.

The distribution of strata encountered within Area 3 is illustrated on the appended Geological Section B (**Drawing 04**) and presented below in **Table 2**.

Table 2: Strata Encountered in Area 3

Stratum	Depth to Top (m)		Thickness (m)**	
	Min	Max	Min	Max
Topsoil	GL		0.2	0.5
Very Stiff to Hard Clays and Silts (WS)	0.2	0.5	2.8	2.5
Medium Dense Sands (WS)	3	3	1.5	4
Stiff to Very Stiff Clay (WS)	4.5	7	7	9.5
Medium Dense Sand (WS)	14	14	>6	
Loose Sands* (TPA)	0.2	0.5	1.5	1.6
Medium Dense Sands* (TPA)	1.7*	-	>0.3	-

Notes: TPA = Taupo Pumice Alluvium, WS = Walton sub-group
* Strata encountered in HA03 and HA05
** Thickness is only recorded were base of strata has been confirmed.

5.3 Groundwater

During the investigation, which was carried out in autumn (May 2020), groundwater was encountered within the CPTs and boreholes at the depths provided in **Table 3**:

Table 3: Groundwater Levels Encountered and Measured in Boreholes

Location	Approx. Relative Level (m)	Hole Depth (mbgl)	Formation	May 2020		05 June 2020	
				Depth to GW (mbgl)	GW Level (m RL)	Depth to GW (mbgl)	GW Level (m RL)
HA01	20	5	WS	DRY	-	-	-
HA02	13	5	WS	2.8	10.2	-	-
HA03	8	2	TPA	1.1	7.9	-	-
HA04	21	5	WS	DRY	-	-	-
HA05	10	2	TPA	0.05	9.95	-	-
HA06	10	2.8	TPA	DRY	-	-	-
HA07	10	2.9	TPA	DRY	-	-	-
HA08	11	5	TPA	DRY	-	-	-
HA09	11	2.7	TPA	DRY	-	-	-
HA10	9	5	TPA	2.1	6.9	-	-
HA11	11	4	TPA	3.4	7.6	-	-
HA12	10	3.1	TPA	DRY	-	-	-
HA13	10	5	TPA	DRY	-	-	-
HA14	10	4.4	TPA	2.3	7.7	-	-
HA15	10	5	TPA	4.6	5.4	-	-
HA16	9	3.9	TPA	2	7	-	-
CPT01	23	20	WS	>4m	-	-	-
CPT02	24	20	WS	>10m	-	-	-
CPT03	10	20	TPA	6	4	-	-
CPT04	10	20	TPA	4.1	6.1	3.7	6.3
CPT05	10	20	TPA	2	8	-	-
CPT06	11	20	TPA	4	7	-	-
CPT07	9	20	TPA	1.7	7.3	-	-
CPT08	10	20	TPA	3.7	6.3	4.85	5.15
CPT09	10	20	TPA	5	5	-	-
CPT10	9	14.9	TPA	3.2	5.8	-	-

Groundwater was not encountered in all exploratory holes during our investigation. It should be noted that groundwater observations during and shortly after drilling are indicative only and may not reflect equilibrium levels. Some seasonal variation may also occur.

Further, given the presence of a variable soil profile it is possible that perched groundwater may occur during and following periods of rainfall.

Based on our review of the Waikato Regional Council water borehole database we consider that the regional groundwater table in the vicinity of the site lies at approximately RL 7m with anticipated groundwater flow towards the Waikato River located approximately 80m to the west of the site.

6 GEOHAZARDS ASSESSMENT

6.1 Context

Section 106 of the Resource Management Act[7] (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. Section 106 of the RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence).

The following sections of this report provide an assessment of the geohazards relevant to this site and provide the basis for the Natural Hazards Risk Assessment presented in **Appendix D.**

6.2 Seismicity

A seismic assessment has been carried out in general accordance with NZGS guidance[8] to calculate the peak horizontal ground acceleration or PGA (a_{max}) as follows:

$$a_{max} = C_{0,1000} \frac{R}{1.3} x\ f\ x\ g$$

Where: $C_{0,1000}$ = unweighted PGA coefficient (Subsoil Class D see section 7.1 for derivation)

R = return period factor given in NZS1170.5, Table 3.5

f = site response factor subject to subsoil class (Subsoil Class D)

g = acceleration due to gravity

The ultimate limit state (ULS) and serviceability limit state (SLS) PGAs were calculated based on a 50-year design life in accordance with the New Zealand Building Code[9] and importance level (IL) 2 structures. The PGA for the SLS and ULS earthquake scenarios is shown on Table 4:

Table 4: Design PGA for Various Limit States

Limit State	ARI	R	PGA(g)	$Magnitude_{eff}$
SLS	25	0.25	0.06	5.8
ULS	500	1.0	0.22	5.8
Note: SLS = serviceability limit state; ULS = ultimate limit state; ARI = annual return interval				

6.3 Fault Rupture

The nearest known active fault to the site is the Kerepehi fault located approximately 38km to the east.

This fault is recorded as having a recurrence interval of between 2000 and 3500 years.

The site is therefore considered to be at low risk of fault rupture.

[7] Resource Management Act (1991), as at 29 October 2019

[8] NZ Geotechnical Society publication "Earthquake geotechnical engineering practice, Module 1: Overview of the standards", (March 2016)

[9] Ministry of Business, Innovation and Employment (1992) NZ Building Code Handbook, Third Edition, Amendment 13 (effective from 14 February 2014)

6.4 Liquefaction

6.4.1 General

Soil liquefaction is a process where typically saturated, granular soils develop excess pore water pressures during cyclic (earthquake) loading that exceed the effective stress of the soil. In loose soils, some dilation can occur during this process, which can lead to individual soil grains moving into suspension. Following the onset of liquefaction, the shear strength and stiffness of the liquefied soil is effectively lost causing excessive differential settlement of the ground surface, bearing capacity failure and collapse of structures and low-angle lateral spreading of slopes in liquefiable soils.

In accordance with NZGS guidance[10] the liquefaction susceptibility of the soils at this site has been considered with respect to geological age, soil fabric and soil consistency / density.

6.4.2 Geological Age

The vast majority of case history data compiled in empirical charts for liquefaction evaluation come from Holocene deposits or man-made fills[11,12]. Pleistocene aged alluvium (>12,000 years) is also considered to have a very low to low risk of liquefaction[12.]

The Walton Subgroup clays and silts found within Area 3 of the site are of Pleistocene geological age and therefore not considered to have a high potential for liquefaction.

Elsewhere across the site, many of the soils below the water table comprise sands and silts of the Taupo Pumice Alluvium. These soils are of Holocene geological age. These deposits are therefore considered susceptible to liquefaction.

6.4.3 Soil Fabric

Soils are also classified with respect to their grain size and plasticity to assess liquefaction susceptibility. Based on more recent case histories, there is general agreement that sands, non-plastic silts, gravels and their mixtures form soils that are susceptible to liquefaction. Clays, although they may significantly soften under cyclic loading, do not exhibit liquefaction features, and therefore are not considered liquefiable.

The fines content of the sands beneath the site can also have a significant impact on their liquefaction susceptibility.

The loose sandy soils of the Taupo Pumice Alluvium beneath Areas 1 and 2 are therefore considered to be susceptible to liquefaction.

The stiff clay soils forming the high ground in Area 3 are considered unlikely to liquefy.

6.4.4 Specific Analyses

The clay soils of the Walton Subgroup in Area 3 are at low risk of liquefaction due to their stiff cohesive nature, age and deep groundwater level. However, for prudence a specific analysis of these soils was undertaken.

The loose sandy soils of the younger Taupo Pumice Alluvium which underlie Areas 1 and 2 are considered at risk of liquefaction and a specific analysis has therefore also been undertaken for these soils.

Specific liquefaction analyses were undertaken using the software package CLiq by comparing the cyclic stress ratio (CSR), being a function of the earthquake magnitude for the design return period event, to the cyclic resistance ratio (CRR), being a function of the CPT cone resistance (qc) and friction ratio.

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[10] Earthquake Geotechnical Engineering Practice, Module 3: Identification, assessment and mitigation of liquefaction hazards", (May 2016)

[11] Seed, H.B. and Idriss, I.M. (1971) *A simplified procedure for evaluating soil liquefaction potential*, Earthquake Engineering Research Centre, Report No. EERC 70-9, University of California

[12] Youd, T.L. and Perkins, D.M. (1978) Mapping liquefaction-induced ground failure potential, *Journal of the Geotechnical Engineering Division,* ASCE, Vol. 104, No. GT4, Proc Paper 13659, p. 433-446

No ageing of the soils was applied to the CLiq models.

A weighting factor (e_v)[13] has been applied against volumetric changes at depth.

Liquefaction analysis was undertaken for the SLS seismic event and found no liquefaction occurred.

Results for the ULS seismic event analyses are presented in **Appendices E and F**, and in Table 5 below.

Table 5: ULS Liquefaction Analyses Results

CPT No.	Estimated Settlement (Full depth Investigated) (mm)	Index Settlement* (mm)	LSN	Groundwater Level (mbgl)	Depth to top of Liquefied Layer (m)	Approx. Liquefaction Thickness (Full depth investigated) (m)
CPT01	<5	0	<1	4.0**	18	1.0
CPT02	<5	0	<1	4.0**	15.5	0.5
CPT03	110	65	8	6	6	12.5
CPT04	135	85	12	4.1	5	15.0
CPT05	130	105	22	2	3	11.5
CPT06	90	90	16	4	4	5.5
CPT07	110	90	18	1.7	2.5	9.0
CPT08	150	100	14	3.7	4.5	10.5
CPT09	120	80	12	5	5	11.0
CPT10	90	75	14	3.2	3.5	5.5
	Note: Settlements and depths are based on the current ground profile. * Index settlement – that derived from liquefaction down to 10m depth. ** Assumed conservative groundwater level					

6.5 Cyclic Softening

Clay and silt soils may be prone to cyclic softening and associated deformations. This process is related to both the size and duration of the cyclic loading and the plasticity of the soil.

In Areas 1 and 2 the key clay and silt soils are generally of low plasticity and have been considered potentially liquefiable in the above analyses.

The clay soils in Area 3 are highly plastic and considered unlikely to liquify. With the assumed conservative groundwater level of 4m below ground level the clay soils have a Factor of Safety against liquefaction of well over 1. Therefore cyclic softening is considered to be a low risk.

[13] Cetin et Al (2009) *Probabilistic Models for Cyclic Straining of Saturated Clean Sands, Journal of Geotechnical and Geoenvironmental Engineering*, Vol 135, Issue 3

6.6 Liquefaction Induced Settlement

6.6.1 Area 3

Analyses of CTP 01 and 02 indicates that the risk of unacceptable liquefaction induced settlement is very low.

6.6.2 Areas 1 and 2

Analyses of CPTs 03 to 10 demonstrates that the soils beneath these areas are potentially liquefiable in the ULS event.

Our estimated total potential liquefaction induced settlement is in the order of 90mm to 135mm in the ULS case for the total depth of soils investigated.

The published guidance notes states that liquefaction which induces surface effects is generally limited to the upper 10m of strata and an 'index' settlement based on this depth is used to assess liquefaction induced damage risk and determine the index value of the Liquefaction Severity Number and Liquefaction Potential Index.

Index settlements of 65mm to 105mm were calculated for the upper 10m of soil and LSN values of 8 to 18 and LPI values of 4 to 12 determined. Following NZGS guidance the LPI and LSN values indicate there is a high risk of liquefaction occurring with generally 'minor' to 'moderate' effects.

In areas where a crust of at least 5.0m of non-liquefiable material is present within the site there should be low risk of manifestation of liquefaction. However over much of these areas there is less than 5m of non-liquefiable crust material and there is a risk of surface manifestation of liquefaction.

Structure foundations in these areas will therefore require specific engineered design to accommodate the effects of liquefaction induced settlement and deformation.

It is noted that many larger warehouse facilities often include automated stacking systems that can be very sensitive to differential settlements.

6.7 Lateral Spread

Following the onset of liquefaction, the liquefied soils behave as a very weak undrained material, which can give rise to lateral spreading where a free face is present within the vicinity of the site or where proposed cut and fill batters are proposed over or within liquefied soils.

Areas 1 and 2 are relatively level and the nearest 'free face' is the Waikato riverbank approximately 80m west of Area 1. From local experience, lateral spread reaching in the order of 80m from the riverbank is possible but the degree of deformation on the site is expected to be low.

The risk of lateral spread and deformation associated with the riverbank, fill batters and any free faces generated by the development should be further assessed at the detailed design stage.

6.8 Area 3 Slope Stability

6.8.1 Design Criteria

The stability of cut batters and fill embankments under a range of design conditions is expressed in terms of a factor of safety (FoS), which is defined as the ratio of forces resisting failure to the forces causing failure. The following performance standards are recommended for slope stability assessment (Table 6):

Table 6: Slope Stability Factor of Safety Criteria	
Condition	**Minimum Factor of Safety**
Static long term conditions (drained soil conditions, normal groundwater)	1.5
Transient short term conditions (drained soil / elevated groundwater)	1.2
Ultimate Limit State (ULS) seismic condition (undrained soil conditions)	1.0*
Note*: Factor of safety < 1.0 acceptable where displacement-based approach is adopted.	

6.8.2 Shear Strength Parameters

Shear strength parameters for the various geological units that underlie the site were inferred from the field investigation and our experience of these soils, see Table 7 below.

Analyses were carried out for the 3 cases listed on Table 6. For the transient elevated groundwater case pore water pressure was modelled using a porewater pressure ratio (r_u) of 0.3 in the silt/clay soils to model raised pore water pressures due to intense or prolonged rainfall.

The soils below Area 3 comprise predominantly cohesive silts and clays. Undrained soil shear strengths (Su), used for assessing the stability of slopes during seismic loading, were taken from the hand-held shear vane results and inferred from the CPT data based on the following relationship:

$$Su = \frac{qc - \mathrm{s}}{Nk}$$

Where: qc = CPT cone resistance (kPa)

σ = total overburden pressure (kPa)

Nk = factor, typically between 10 and 20, 15 is typically adopted for silt and clay soils

Undrained shear strength correlations from the CPT data provide a range of values. Lower bound values used for preliminary seismic assessment, based on the hand-held shear vane and CPT results, are presented in Table 7 below.

Table 7: Shear Strength Parameters adopted				
Geological Unit	**Unit Weight (kN/m³)**	**Effective Stress Parameters**		**Undrained Shear Strength**
		c′ (kPa)	**Ø′ (deg)**	**Su (kPa)**
Silty Clays (WSG)	16	3	29	170
Clays- (WSG)	17	4	31	140
Silty Clays and Clayey Silts – (WSG)	16	3	29	60
Loose Sands – (TPA)	16	0	33	-
Silty Sands – (WSG)	17	2	33	-
Note: Where c' = effective cohesion, Ø′ = effective friction angle WSG = Walton Subgroup TPA = Taupo Pumice Alluvium				

6.8.3 Slope Stability Analyses

Two areas of soil creep were observed on the north facing slopes as shown on **Drawing 01**. These are believed to be related so localised topsoil creep under gravity during periods of saturation and not reflect any deep seated slope instability.

Global slope stability analyses were undertaken using the Morgenstern-Price method of slices under both circular and translational failure mechanisms using the proprietary software SLIDE Version 6.

Selected stability analyses printouts are attached in **Appendix G** and the results presented on Table 8.

Table 8: Slope Stability Analyses Results

Location	Factor of Safety		
	Prevailing	**Transient**	**Seismic**
Slope in Area 3 *(Geological Section B)*	2.53	2.46	1.34

Results show that the slope stability FoS criteria are met for the existing landform and assessed ground model conditions described above.

6.9 Erosion

Erosional features that are typically encountered within areas of land development tend to be driven by patterns and routes of surface water flow.

The nearest major watercourse to the site is the Waikato river located approximately 80m to the west and poses a very low risk of erosion to Areas 1 and 2. The low lying near level topography also serves to reduce the risk of surface erosion.

Area 3 features springs which may provide potential for erosion. The control of surface run-off in the post-development stages will be key to preventing erosional features from forming.

6.10 Load Induced Settlement

Introduction

Areas 1 and 2 are underlain by loose to medium dense sands which will pose a risk of settlement under applied loads from fills and foundations. Settlements are expected to be predominately immediate and to be effectively complete during or shortly after construction.

Area 3 is underlain by approximately 3m of near surface stiff clay and medium dense sands. Assuming minor fill thickness to achieve level building platforms and light weight domestic dwelling construction, load induced settlements on the clays and sands are expected to be nominal and immediate.

Estimated Settlements: Areas 1 and 2.

Preliminary estimated static settlements were calculated using the software CPeT-IT using CPT data gathered during the site investigation. CPeT-IT analysis reports are provided in **Appendix F**.

Analysis was undertaken in Area 1 and Area 2 assuming 1m of fill placed to raise ground levels. The results of this analysis are shown on Tables 9 and 10:

Table 2: Estimated Load Induced Static Settlements (1m fill only = 16kPa load)		
Location	**Construction Settlement (mm)**	**Post Construction Settlement (mm)**
CPT03	Up to 20mm	<10mm
CPT04	<10mm	Nominal
CPT05	Up to 50mm	<10mm
CPT06	Up to 100mm	<20mm
CPT07	Up to 60mm	<10mm
CPT08	<15mm	<5mm
CPT09	Up to 25mm	<10mm
CPT10	Up to 40mm	<10mm
Notes: Post construction settlements are made up of secondary creep + remaining 10% fill induced consolidation.		

Table 10: Estimated Load Induced Static Settlements (30 x 15m slab 12kPa load only)		
Location	**Construction Settlement (mm)**	**Post Construction Settlement (mm)**
CPT03	<10mm	Nominal
CPT04	<10mm	Nominal
CPT05	Up to 30mm	<10mm
CPT06	Up to 40mm	<20mm
CPT07	Up to 30mm	<10mm
CPT08	<10mm	<5mm
CPT09	< 25mm	<10mm
CPT10	< 25mm	<10mm
Notes: Post construction settlements are made up of secondary creep + remaining 10% floor load induced consolidation.		

6.11 Expansive Soils

Seasonal shrinking and swelling results in vertical surface ground movement which can cause significant cracking of floor slabs and walls. There have been instances of concrete floors and / or foundations that have been poured on dry, desiccated subgrades in summer months on expansive soils and have undergone heaving and cracking requiring extensive repairs or re-building once the soil moisture contents have returned to higher levels. This hazard is addressed by a combination of careful foundation design and site preparation.

In Areas 1 and 2 the fine soils are predominantly silt and therefore at low risk of being expansive. Furthermore, industrial commercial units are proposed which by their nature will have engineered specific design foundations. The risk of, and appropriate remediation measures for, expansive soils can be confirmed at the detailed design stage.

In Area 3, where domestic development is proposed, NZS 3604:2011[14] excludes from the definition of 'good ground', soils with a liquid limit of more than 50% and a linear shrinkage of more than 15% due to their potential to shrink and swell as a result of seasonal fluctuations in water content. For soils exceeding these limits, NZS 3604 has historically referenced AS 2870[15]. for foundation design advice. However the November 2019 update of Acceptable Solution B1/AS1[16] provides amendments to NZS 3604 that define a method for testing and classifying the soils and provides foundation designs for specific, simple house configurations across the range of expansive soil conditions.

The clays soils encountered within Area 3 have not been tested but are considered to be low risk. However for preliminary design purposes we recommend Class M conditions be assumed for foundation design.

Laboratory testing will be required to confirm this before progressing to the detailed design stage of development.

7 GEOTECHNICAL RECOMMENDATIONS

7.1 Seismic Site Subsoil Category

Based on the encountered ground conditions and the results of a specific study completed within the area surrounding East Mine Road, Huntly, by Ian R. Brown Associates Ltd[17] the seismic site subsoil category is assessed as being Class D (deep soil site) in accordance with NZS1170.5.

7.2 Area 1 and 2 Foundations

Foundation conditions across Areas 1 and 2 are highly variable. Near surface soils comprise interbedded, thin lenses of firm to very stiff silts and loose to medium dense sands with geotechnical ultimate bearing capacities of generally less than 300kPa for spread and shallow foundations.

The estimated settlements presented on Table 10 for a typical commercial /industrial slab show there is a significant risk of unacceptable total and differential settlements without some form of advanced ground improvement and/or engineer designed foundations to accommodate the settlements. This is particularly the case in a zone across the middle of Areas 1 and 2 (CPTs 05, 06 and 07).

Undercutting of the loose and variable near surface soils and replacement with well compacted engineered fill is likely to be required to improved bearing capacities, reduce the overall settlement risk and protect structures against liquefaction induced deformations.

Piled foundations are not recommended due to the liquefiable nature of the subsoils.

[14] Standards New Zealand (2011) Timber-framed buildings, NZS 3604:2011, NZ Standard
[15] Standards Australia Limited (2011) *Residential slabs and footings*, AS 2870-2011, Australian Standard, NSW
[16] Ministry of Business, Innovation and Employment (2019) *Acceptable Solutions and Verification Methods for NZ Building Code Clause B1 Structure,* B1/AS1, Amendment 19
[17] Ian R. Brown Associates Ltd (2015) *East Mine Road Subsidence Assessment*

7.3 Area 3 Foundations

The near surface stiff clays and medium dense sands are considered suitable for spread foundations to support domestic dwellings constructed in accordance with NZ3604 with a geotechnical ultimate bearing capacity of 300kPa anticipated in cut soils and suitably engineered fills in this area.

Some local undercutting and replacement of loose sandy soils may be required.

7.4 Ground Improvement in Areas 1 and 2

To manage static ground settlements within Area 1 and Area 2, a range of options may be considered, including the following:

- Construction of a temporary surcharge or pre-load fill embankment above design finished level, to consolidate the compressible soils and minimise post construction embankment settlements. Given the predominantly granular nature of the soils, settlements are expected to be rapid;
- Excavation and reworking of the loose sands within the near surface layers and recompaction to reach a typical earthworks specification standard.

To help manage possible liquefaction induced settlement and deformation options that may be considered, including the following:

- excavation to 1.5m and replacement with geogrid reinforced engineered fill (this may be incorporated into the overall ground improvement to manage static settlements)
- installation of deeper ground improvement measures such as vibro-stone columns and rammed aggregate piers.

7.5 Earthworks

7.5.1 General

All earthwork activities must be carried out in general accordance with the requirements of NZS 4431[18] and the requirements of the Waikato District Council Regional Infrastructure Technical Specifications (RITS) under the guidance of a Chartered Professional Geotechnical Engineer.

7.5.2 Excavatability

The sand and silts in Areas 1 and 2 and clays in Area 3 should be readily excavated with normal earthworks plant, such as scrapers and bulldozers.

Groundwater may be encountered in excavations at depths of 1.5m to 2m in Areas 1 and 2, possibly shallower in the east of Area 2 near the wetland.

7.5.3 Stockpiles

Careful consideration must be given to the location of temporary topsoil / unsuitable stockpiles to ensure that they are not located immediately above steep or unstable slopes, or that stockpile loads do not cause localised instability due to bearing capacity failure in areas of soft ground.

7.5.4 Underfill Drainage

No major infilling of gullies and streams is anticipated. Should this be undertaken, underfill drains will need to be installed beneath new fills within low lying tributaries and gully inverts, and outlet to appropriate discharge locations.

[18] Standards New Zealand (1989) Code of practice for earth fill for residential development, incorporating Amendment No. 1, NZS 4431:1989, NZ Standard

7.6 Civil Works

7.6.1 Subgrade CBR

Areas 1 and 2 are thought to require only minor cut and fill of surface strata prior to road construction. The reworking of these sands to engineered fill standard should achieve a CBR value of 5-10%.

Area 3 is predominantly in clay, with potential for some localised sand deposits, dependent on earthworks levels, and a long term CBR value of 3% is anticipated.

7.6.2 Service Trenches

Most of the materials to be exposed during the excavation of service trenches should be readily removed using an excavator.

In Areas 1 and 2, trench collapse is expected to pose problems in areas wherever excavations extend below the water table. Trench support is likely to be required together with temporary dewatering.

Services trenches may need to be backfilled with engineered fill.

7.6.3 Stormwater Soakage

Stormwater soakage relies heavily on the type of strata in which the soakage system is installed. Due to the differing soils identified in Areas 1 & 2 and Area 3, these will be discussed separately.

The investigation in Areas 1 and 2 largely encountered sandy soils which typically have a high permeability however it will be important to ensure that any soakage to ground penetrates the near surface silts in order to be fully efficient. Detailed design of soakage facilities must also take into account the relatively shallow groundwater table.

The investigation in Area 3 encountered near surface soils comprising predominantly clay soils of low permeability. We do not recommend soakage to the underlying deeper sands (approx. 3m below existing ground level) as this may result in seepage towards the adjacent slopes and possible detrimental effects on stability and erosion. We therefore recommend linkage to the local storm water reticulation.

8 FURTHER WORK

This site investigation was carried out prior to the development of formal drawings including any cut/fill earthworks and confirmed building layout plans. Once these have been prepared CMW should be offered the opportunity to review those plans against the recommendations in this report.

Further work should be carried out prior to detailed design of the development to further investigate the deep soil profile and confirm the extent of the liquefaction risk to the site. Investigation using seismic CPTs or seismic dilatometers should be considered to further refine the liquefaction susceptibility assessment in the pumice rich soils. (Conventional CPTs can underestimate the density of pumice rich soils, thereby over-estimating the liquefaction potential of the soils.) This would be supported by a ground water monitoring programme to assess groundwater level variability.

Detailed investigation will be required in all areas prior to development and to facilitate engineer designed foundations and ground improvement measures in Areas 1 and 2.

9 LIMITATIONS

This report has been prepared for use by our client, Shand Properties Limited and their consultants. Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

It should be noted that factual data for this report has been obtained from discrete locations using normal geotechnical investigation techniques. As such investigation methods 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 CMW Geosciences immediately.

USE OF THIS REPORT

Site subsurface conditions cause more construction problems than any other factor and therefore are generally the largest technical risk to a project. These notes have been prepared to help you understand the limitations of your geotechnical report.

Your geotechnical report is based on project specific criteria

Your geotechnical report has been developed on the basis of our understanding of your project specific requirements and applies only to the site area investigated. Project requirements could include the general nature of the project; its size and configuration; the location of any structures on or around the site; and the presence of underground utilities. If there are any subsequent changes to your project you should seek geotechnical advice as to how such changes affect your report's recommendations. Your geotechnical report should not be applied to a different project given the inherent differences between projects and sites.

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 investigation, the conditions may have changed, particularly when large periods of time have elapsed since the investigations were performed.

Interpretation of factual data

Site investigations identify actual subsurface conditions at points where samples are taken. Additional geotechnical information (e.g. literature and external data source review, laboratory testing on samples, etc) 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 exactly predict 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.

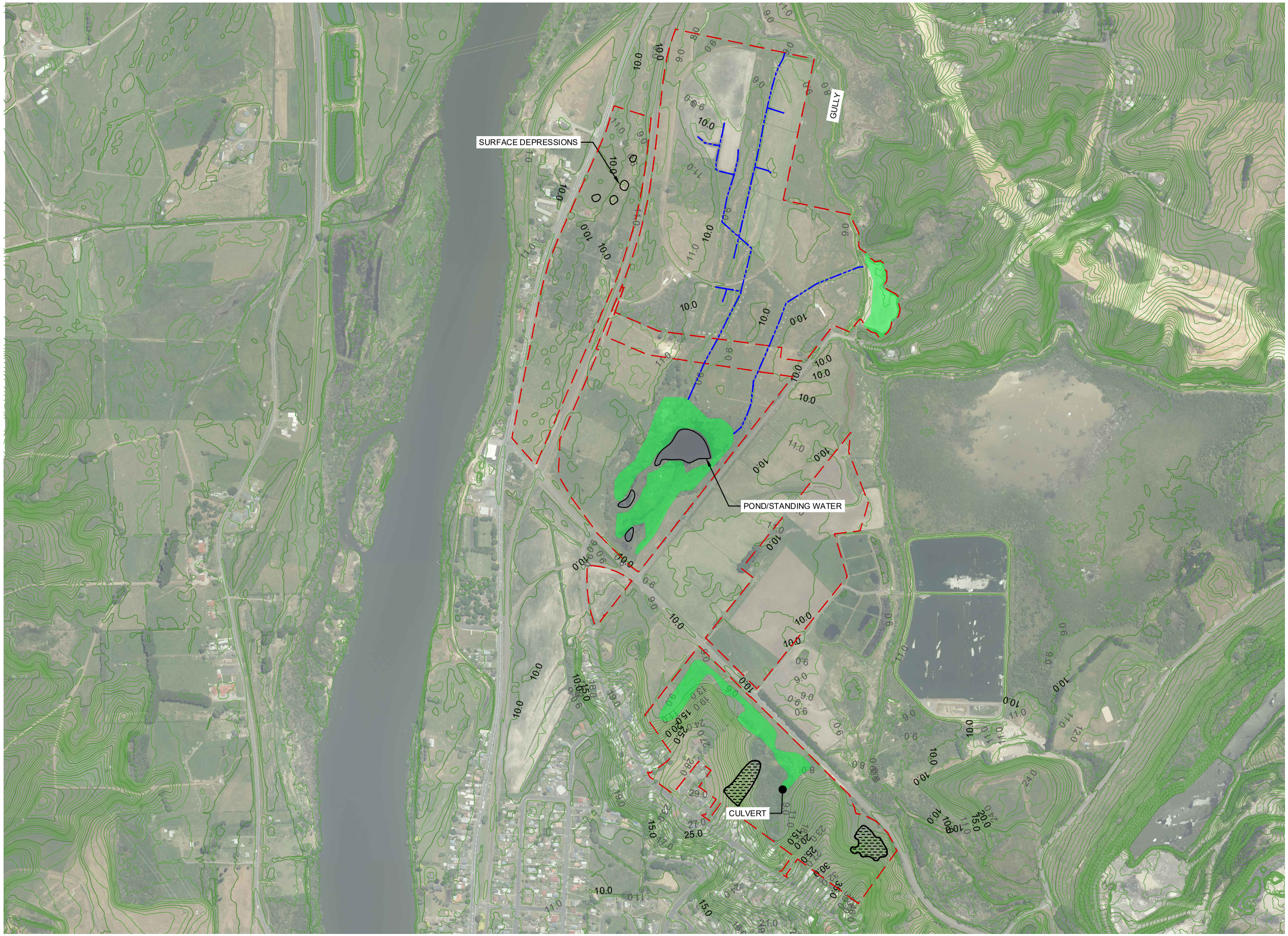
Your report's recommendations require confirmation during construction

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. For this reason, you should retain geotechnical services throughout the construction stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site. A geotechnical designer, who is fully familiar with the background information, is able to assess whether the report's recommendations are valid and whether changes should be considered as the project develops. An unfamiliar party using this report increases the risk that the report will be misinterpreted.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical report. Read all geotechnical documents closely and do not hesitate to ask any questions you may have. To help avoid misinterpretations, retain the assistance of geotechnical professionals familiar with the contents of the geotechnical report to work with other project design professionals who need to take account of the contents of the report. Have the report implications explained to design professionals who need to take account of them, and then have the design plans and specifications produced reviewed by a competent Geotechnical Engineer.

Drawings



LEGEND:

- DRAINAGE DITCH
- SITE BOUNDARY
- HYDROPHILIC VEGETATION
- SOIL CREEP

NOTES:

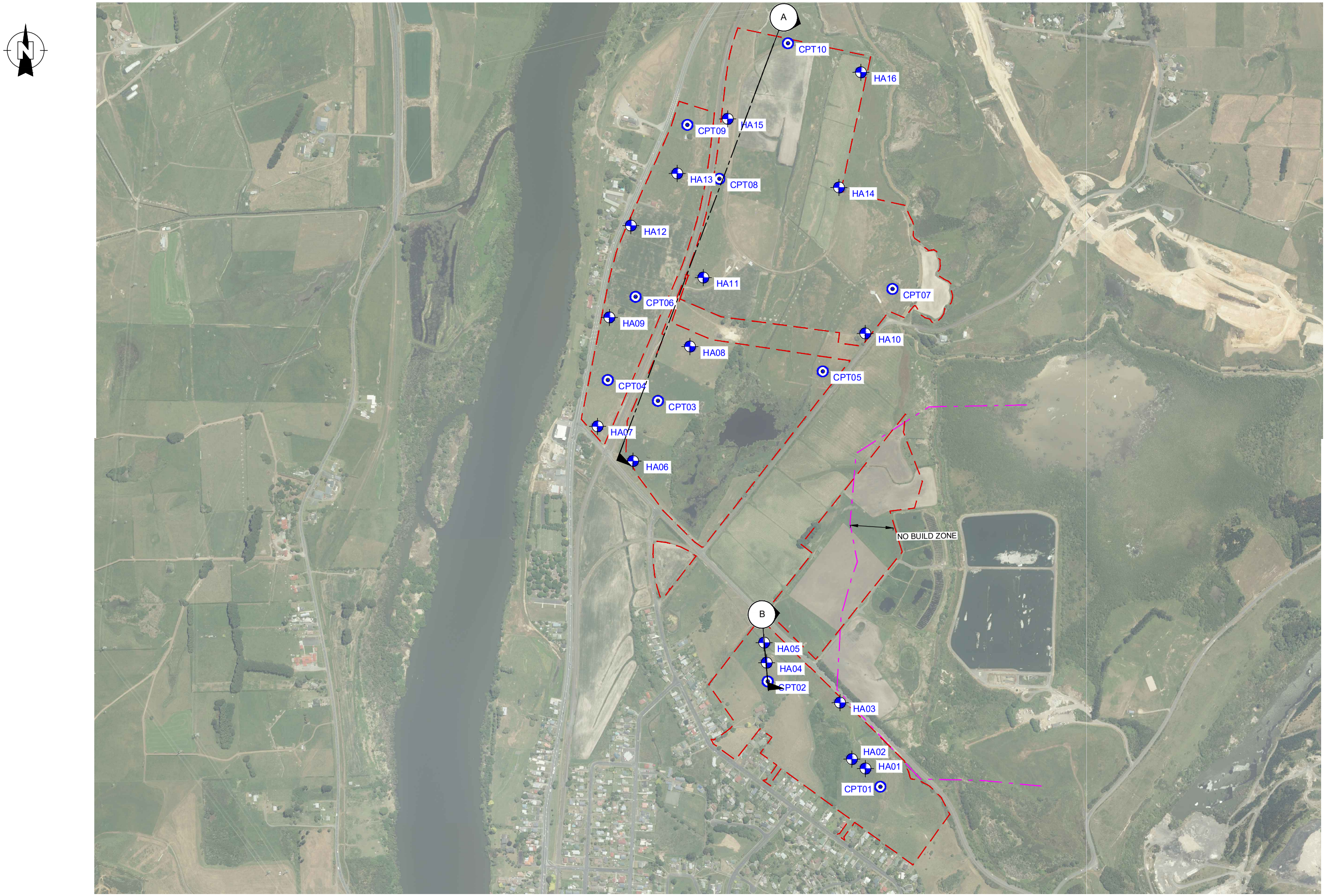
1. BASE PLAN ADAPTED FROM LINZ DATA SERVICE.
2. SITE BOUNDARIES ADAPTED FROM BBO DRAWING 'LAND HOLDING PLAN' REF. DRAWING NO.144370-02-0141 REV.A DATED 21.01.2020
3. EXISTING GROUND CONTOURS ARE SUPPLIED BY WAIKATO DISTRICT COUNCIL AND ARE AT 1.0m INTERVALS.

1:10 000 0 100 200 300 400 500 m

CMW Geosciences

CLIENT: SHAND PROPERTIES		DRAWN: WPJ	PROJECT No: HAM2019-0082
PROJECT: NORTH HUNTLY DEVELOPMENT, EAST MINE ROAD		CHECKED: LS	DRAWING: 01
		REVISION: 0	SCALE: 1:10000
TITLE: GEOMORPHOLOGY PLAN		DATE: 18/05/2020	SHEET: A3

C:\USERS\WINNIEPJ\CMW GEOSCIENCES PTY LTD\CMW CONNECT - HAM\2019\HAM2019-0082 NORTH HUNTLY DEVELOPMENT\DRAWINGS\SS\HAM2019-0082 GI PLAN.DWG



LEGEND:

- HA01 — HAND AUGER (HA) LOCATION
- CPT01 — CONE PENETROMETER TEST (CPT) LOCATION
- SITE BOUNDARY

NOTES:

1. BASE PLAN ADAPTED FROM LINZ DATA SERVICE.
2. SITE BOUNDARIES ADAPTED FROM BBO DRAWING 'LAND HOLDING PLAN' REF. DRAWING NO.144370-02-0141 REV.A DATED 21.01.2020

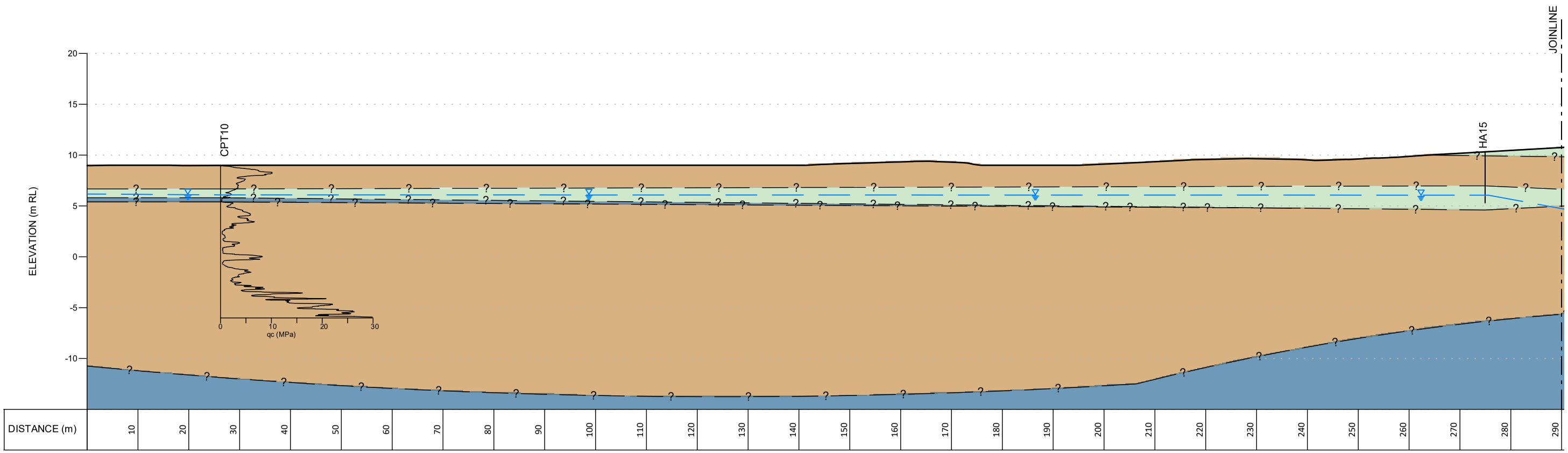
1:10 000 — 0 100 200 300 400 500 m

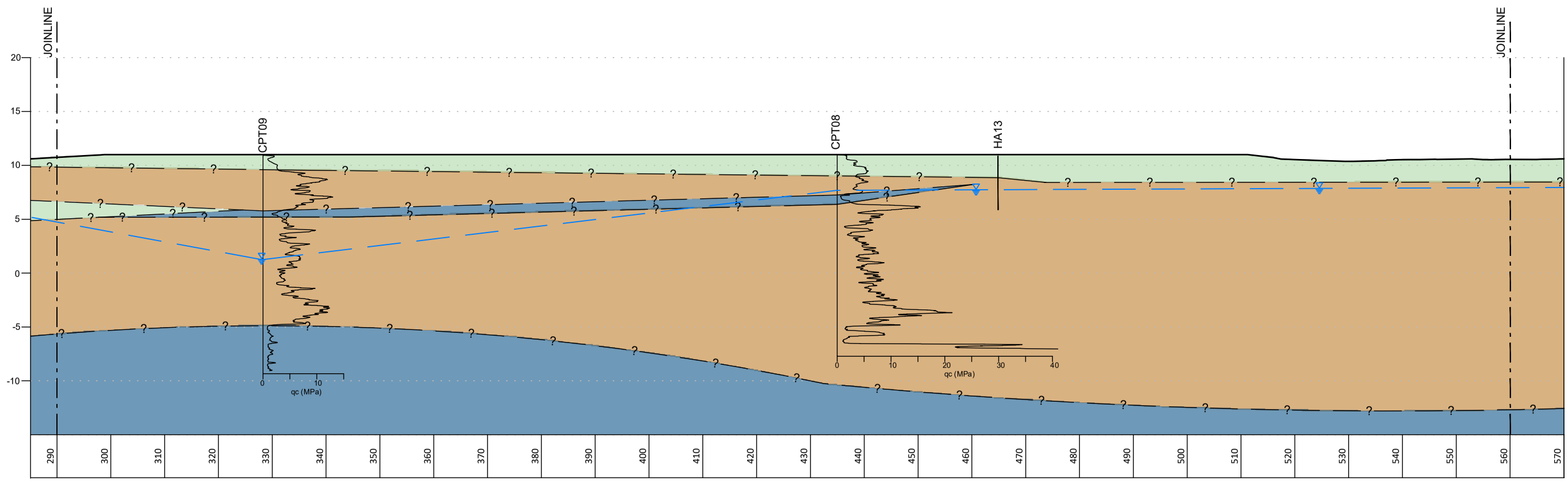
CMW Geosciences

CLIENT: SHAND PROPERTIES		DRAWN: WPJ	PROJECT No: HAM2019-0082
PROJECT: NORTH HUNTLY DEVELOPMENT, EAST MINE ROAD		CHECKED: LS	DRAWING: 02
		REVISION: 0	SCALE: 1:10000
TITLE: SITE PLAN		DATE: 10/06/2020	SHEET: A3

C:\USERS\WINNIEPJ\CMW GEOSCIENCES PTY LTD\CMW CONNECT - HAM\2019\HAM2019-0082 NORTH HUNTLY DEVELOPMENT\DRAWINGS\HAM2019-0082 GI PLAN.DWG

SECTION A





LEGEND:

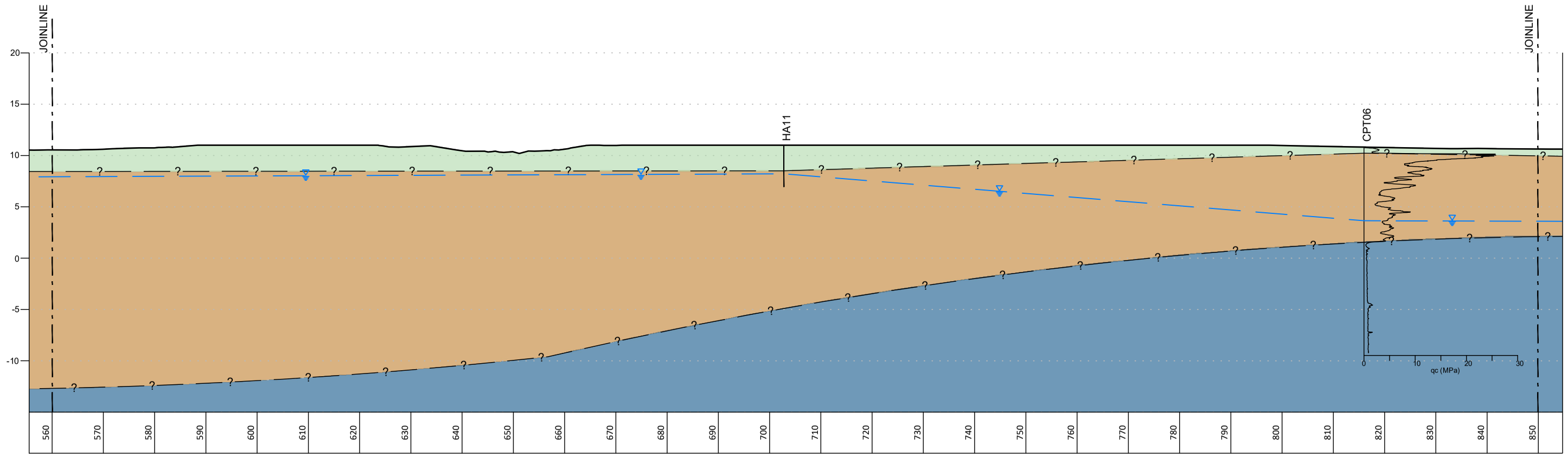
- EXISTING SLOPE PROFILE
- INFERRED GEOLOGICAL BOUNDARY
- APPROXIMATE GROUNDWATER TABLE
- INTERBEDDED SILTS AND SANDS **(TAUPO PUMICE ALLUVIUM)**
- LOOSE TO MEDIUM DENSE SANDS **(TAUPO PUMICE ALLUVIUM)**
- CLAY **(WALTON SUBGR OUP)**

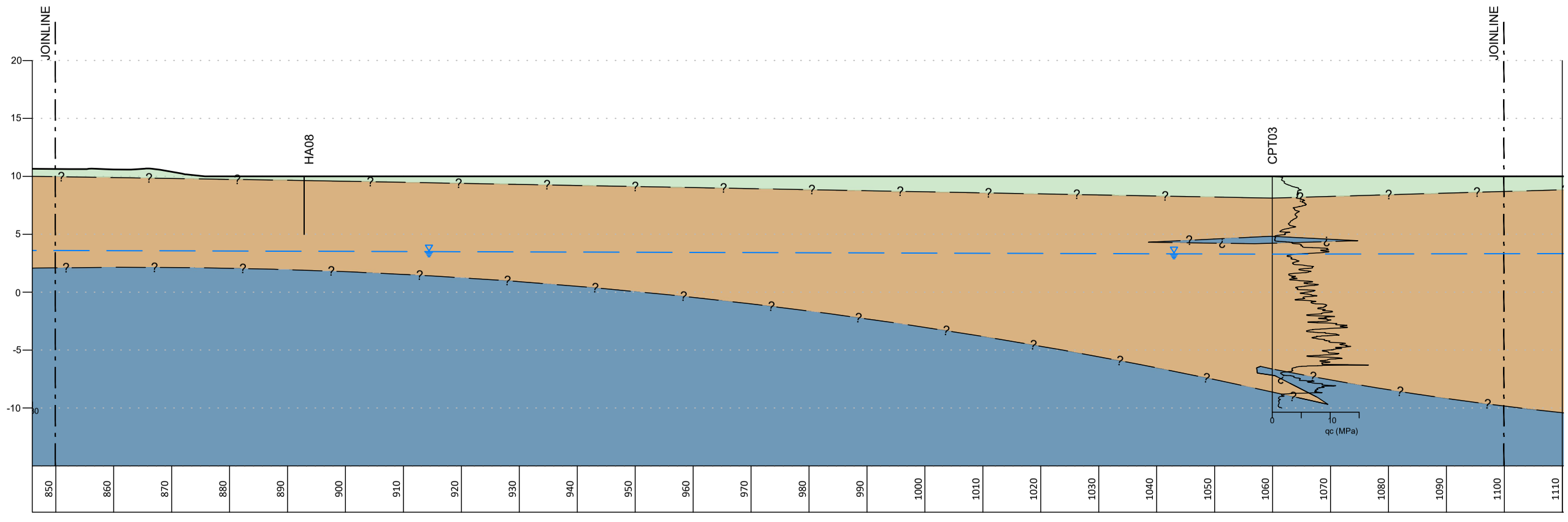
VERT: 1:400 — 0 4 8 12 16 20 m

HORI: 1:800 — 0 8 16 24 32 40 m

CMW Geosciences

CLIENT: **SHAND PROPERTIES**		DRAWN: WPJ	PROJECT No: HAM2019-0082
PROJECT: **NORTH HUNTLY DEVELOPMENT, EAST MINE ROAD**		CHECKED: LS	DRAWING: 03
		REVISION: 0	SCALE: AS SHOWN
TITLE: **GEOLOGICAL SECTION A - SHEET 1 OF 3**		DATE: 05/06/2020	SHEET: A3





LEGEND:

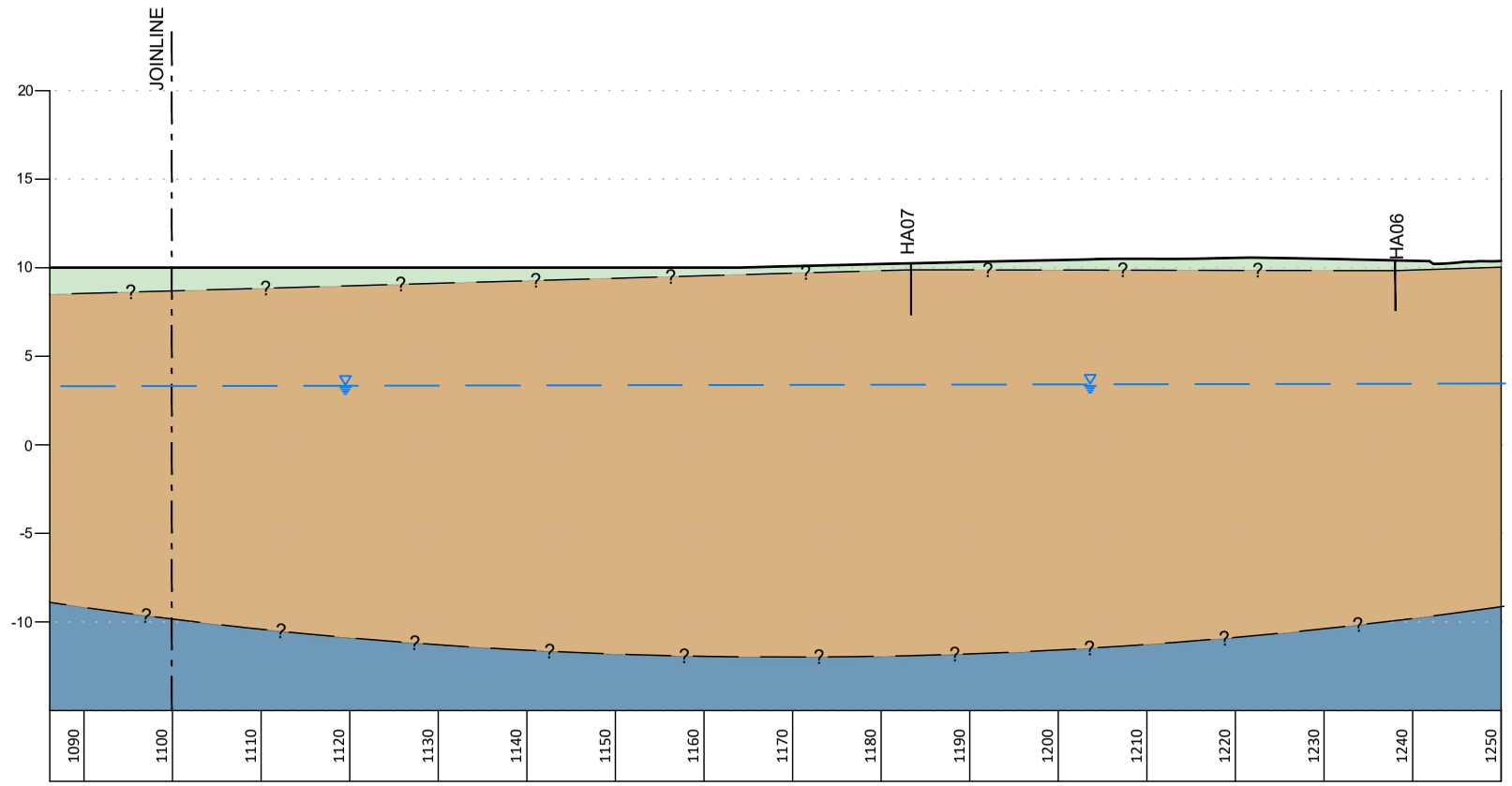
- EXISTING SLOPE PROFILE
- INFERRED GEOLOGICAL BOUNDARY
- APPROXIMATE GROUNDWATER TABLE
- INTERBEDDED SILTS AND SANDS (**TAUPO PUMICE ALLUVIUM**)
- LOOSE TO MEDIUM DENSE SANDS (**TAUPO PUMICE ALLUVIUM**)
- CLAY (**WALTON SUBGR OUP**)

VERT: 1:400 — 0 4 8 12 16 20 m

HORI: 1:800 — 0 8 16 24 32 40 m

CMW Geosciences

CLIENT: **SHAND PROPERTIES**		DRAWN: WPJ	PROJECT No: HAM2019-0082
PROJECT: **NORTH HUNTLY DEVELOPMENT, EAST MINE ROAD**		CHECKED: LS	DRAWING: 03
		REVISION: 0	SCALE: AS SHOWN
TITLE: **GEOLOGICAL SECTION A - SHEET 2 OF 3**		DATE: 05/06/2020	SHEET: A3



LEGEND:

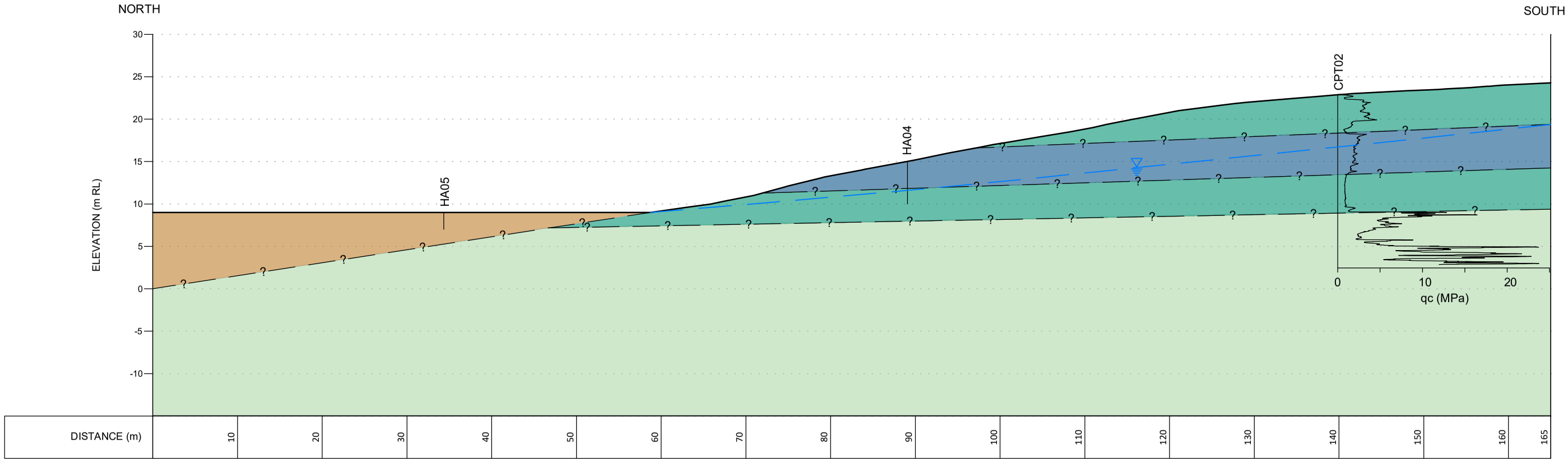
- EXISTING SLOPE PROFILE
- INFERRED GEOLOGICAL BOUNDARY
- APPROXIMATE GROUNDWATER TABLE
- INTERBEDDED SILTS AND SANDS **(TAUPO PUMICE ALLUVIUM)**
- LOOSE TO MEDIUM DENSE SANDS **(TAUPO PUMICE ALLUVIUM)**
- CLAY **(WALTON SUBGR OUP)**

VERT: 1:400 — 0 4 8 12 16 20 m

HORI: 1:800 — 0 8 16 24 32 40 m

CMW Geosciences

CLIENT: **SHAND PROPERTIES**		DRAWN: WPJ	PROJECT No: HAM2019-0082
PROJECT: **NORTH HUNTLY DEVELOPMENT, EAST MINE ROAD**		CHECKED: LS	DRAWING: 03
		REVISION: 0	SCALE: AS SHOWN
TITLE: **GEOLOGICAL SECTION A - SHEET 3 OF 3**		DATE: 05/06/2020	SHEET: A3



SECTION B

LEGEND:

- EXISTING SLOPE PROFILE
- INFERRED GEOLOGICAL BOUNDARY
- APPROXIMATE GROUNDWATER TABLE
- SILTY CLAY **(TAUPO PUMICE ALLUVIUM)**
- LOOSE TO MEDIUM DENSE SANDS **(TAUPO PUMICE ALLUVIUM)**
- CLAY **(TAUPO PUMICE ALLUVIUM)**
- INTERBEDDED SILTS AND SANDS **(TAUPO PUMICE ALLUVIUM)**

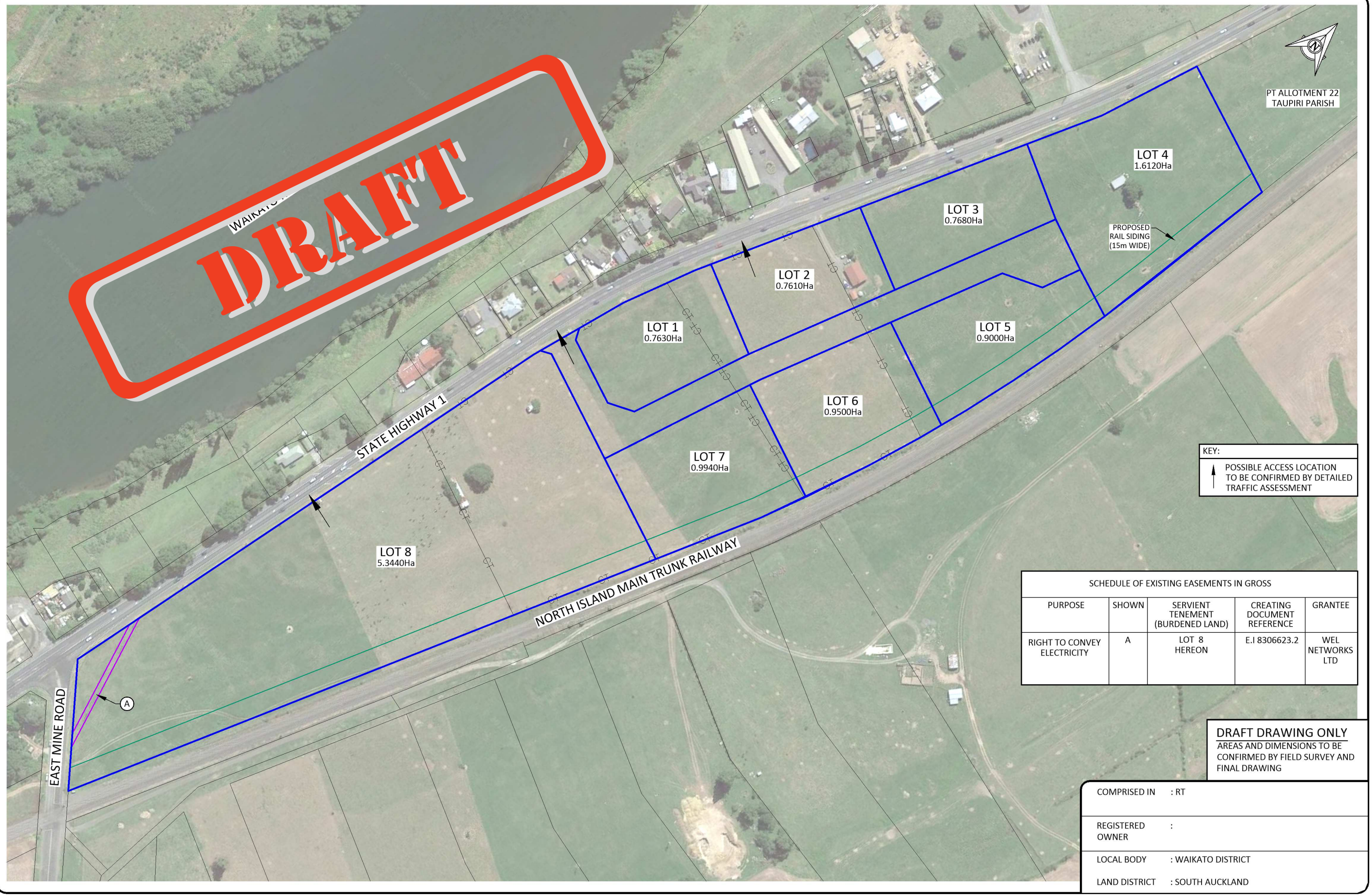
1:500 0 5 10 15 20 25 m

CMW Geosciences

CLIENT: **SHAND PROPERTIES**		DRAWN: WPJ	PROJECT No: HAM2019-0082
PROJECT: **NORTH HUNTLY DEVELOPMENT, EAST MINE ROAD**		CHECKED: LS	DRAWING: 04
		REVISION: 0	SCALE: 1:500
TITLE: **GEOLOGICAL SECTION B**		DATE: 05/06/2020	SHEET: A3

C:\USERS\WINNIEPJ\CMW GEOSCIENCES PTY LTD\CMW CONNECT - HAM\2019\HAM2019-0082 NORTH HUNTLY DEVELOPMENT\DRAWINGS\HAM2019-0082 SECTIONC REVB CAD LT.DWG

Appendix A: Development Plans Provided



SCHEDULE OF EXISTING EASEMENTS IN GROSS				
PURPOSE	SHOWN	SERVIENT TENEMENT (BURDENED LAND)	CREATING DOCUMENT REFERENCE	GRANTEE
RIGHT TO CONVEY ELECTRICITY	A	LOT 8 HEREON	E.I 8306623.2	WEL NETWORKS LTD

DRAFT DRAWING ONLY
AREAS AND DIMENSIONS TO BE CONFIRMED BY FIELD SURVEY AND FINAL DRAWING

COMPRISED IN	: RT
REGISTERED OWNER	:
LOCAL BODY	: WAIKATO DISTRICT
LAND DISTRICT	: SOUTH AUCKLAND

	DATE	ISSUE/REVISION DETAIL	BY	CHK	APPR
A	28.05.2019	INITIAL ISSUE	HW	BM	-

DESIGNED: - | CHECKED: -
DRAWN: - | APPROVED: -
mx model version:

BLOXAM BURNETT OLLIVER
Phone +64-7-838 0144, Fax +64-7-839 0431

CLIENT: SHAND PROPERTIES

PROJECT: INDUSTRIAL SITE

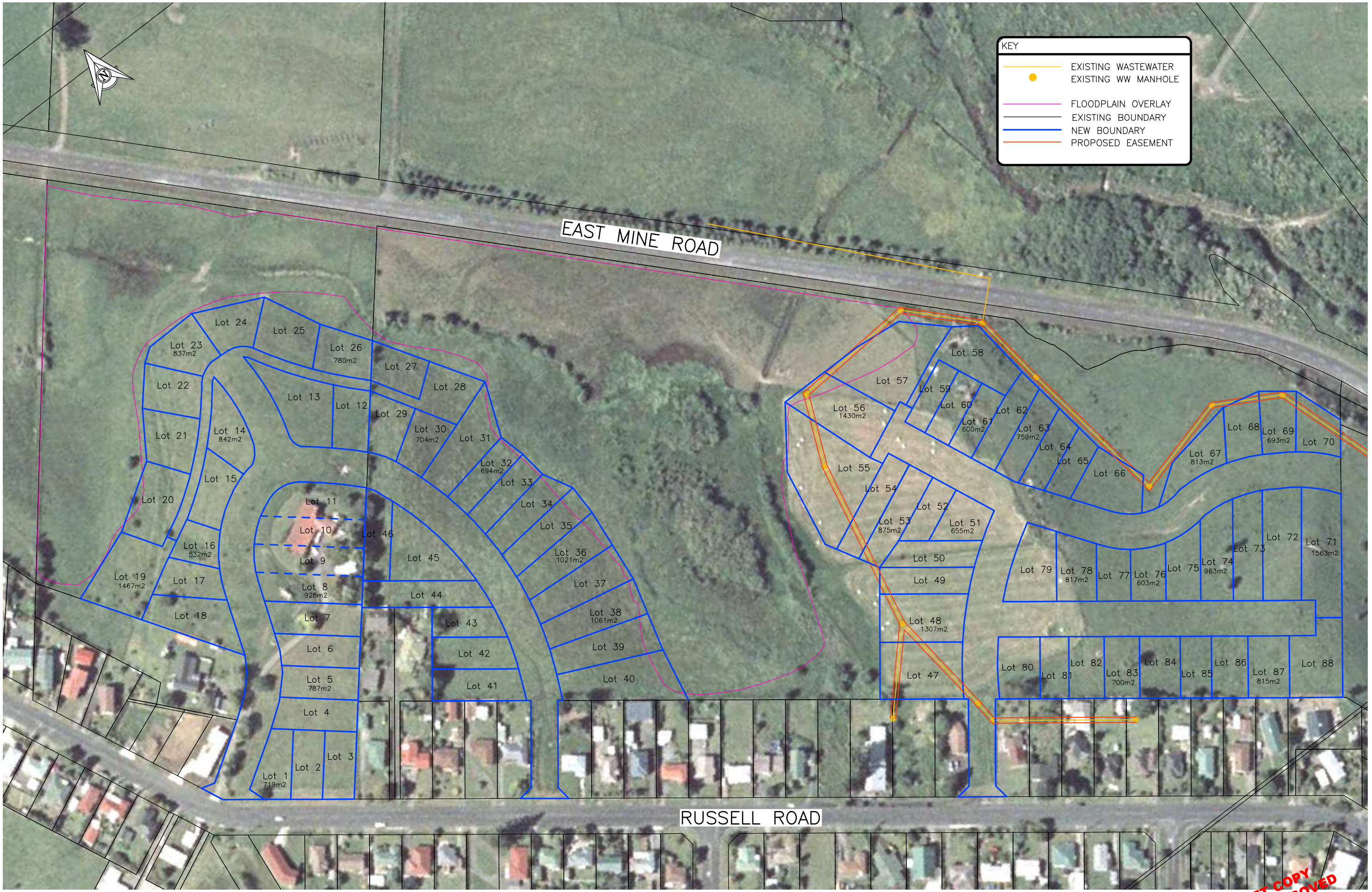
DRAWING: SITE LAYOUT PLAN
OPTION 2 - LARGER LOTS

STATUS: PRELIMINARY
DATE: 28.05.2019 | SCALE (ORIGINAL SIZE A3): 1:2500
DRAWING NUMBER: 144370_02_0102 | REVISION: A

100mm

SCALE FOR VALIDATING SIZE OF A3 PLOT ONLY

0



K:\144370 Shand Properties Rezoning\Drawings\144370_00_8001.dwg 25/8/2016 1:15 p.m. jdabney

	Date	Issue/revision detail	By	Chk	Appr
A	25.08.2016	initial issue	JD	BJM	

mx model version:

Version 2.04 – October 2013

Designed: JD | Checked: BJM
Drawn: JD | Approved:

BLOXAM BURNETT OLLIVER
Phone 64-7-838 0144, Fax 64-7-839 0431

Client: SHAND PROPERTIES LIMITED

Project: DEVELOPMENT SCOPING PLAN

Drawing: DRAFT SUBDIVISION CONCEPT

Status: PRELIMINARY
DRAFT COPY NOT APPROVED

Date: 25.08.2016
Scale (Original Size A3): 1:2000
Drawing Number: 144370/00 /– /8001
Revision: A

Appendix B: Hand Auger Borehole Logs

HAND AUGER BOREHOLE LOG - HA01

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 28/04/2020
Borehole Location: Refer to site plan. Logged by: LK Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435718.3mE; 727022.1mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: Black. Low plasticity. (Topsoil)	D		
	0.3	Peak = 191kPa				CH: CLAY with trace fine to coarse sand: Dark greyish brown. High plasticity.			
						CH: CLAY with trace fine to coarse sand: Greyish brown mottled orange. High plasticity.			
	0.6	Peak = UTP					M		
	0.9	Peak = UTP						H	
				1		CH: CLAY containing minor inclusions of clayey silt: Orange brown mottled pink. High plasticity.			
	1.2	Peak = UTP							
						MH: Clayey SILT: Orange brown mottled pink. High plasticity, sensitive.			
	1.6	Peak = 139kPa Residual = 16kPa						VSt	
	2.0	Peak = 150kPa Residual = 19kPa		2			W		
						CH: Silty CLAY: Reddish brown. High plasticity, moderately sensitive.			
	2.4	Peak = 191kPa Residual = 57kPa						VSt to H	
	2.8	Peak = UTP				CH: CLAY: White mottled light brown. High plasticity.			
						SM: Silty fine to medium SAND: Brown streaked orange. Poorly graded. Iron stained.	M	LP	
				3		MH: Clayey SILT: Brown mottled orange. High plasticity.			
	3.2	Peak = UTP							
						CH: Silty CLAY: Light brown mottled orange brown. High plasticity.		H	
	3.6	Peak = UTP					W		
	4.0	Peak = UTP		4					
						ML: Clayey SILT with trace fine sand, trace fine gravel and trace organic inclusions: Light brown mottled white and orange. High plasticity, sensitive.			
	4.4							VSt	
	4.8	Peak = 185kPa Residual = 33kPa					W to S		
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth reached.
Shear Vane No: 2560 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA02

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 28/04/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435681.4mE; 727047.9mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						CL: Silty CLAY with trace rootlets: Dark brown. Low plasticity. (Topsoil)			
	0.3	Peak = UTP				ML: SILT with trace clay: White streaked orange. No plasticity.	D	H	
	0.6	Peak = UTP				CH: CLAY: Grey streaked orange brown. High plasticity, insensitive to moderately sensitive.			
	0.9	Peak = >200kPa Residual = 112kPa		1		... at 0.90m, becomes orange brown.			
	1.2	Peak = >200kPa Residual = 102kPa							
	1.6	Peak = >200kPa Residual = 93kPa				... at 1.60m, with trace silt.	D to M	VSt to H	
	2.0	Peak = 170kPa Residual = 80kPa		2					
	2.4	Peak = 184kPa Residual = 80kPa							
▼	2.8	Peak = 108kPa Residual = 43kPa				ML: SILT with trace clay: Red streaked grey. High plasticity, moderately sensitive.	W	St to VSt	
	3.2	Peak = 77kPa Residual = 43kPa		3					
	3.6	Peak = 124kPa Residual = 72kPa				CH: Silty CLAY: Grey streaked orange brown. High plasticity, insensitive.	W to S	VSt	
	4.0	Peak = UTP		4		CH: Clay with some silt: Brown streaked grey. High plasticity, insensitive.			
	4.4	Peak = UTP						H	
	5.0	Peak = >200kPa Residual = 112kPa		5		Borehole terminated at 5.0 m			

Termination Reason: Target depth reached.
Shear Vane No: 2349 DCP No:
Remarks: Groundwater encountered at 2.8m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA03

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 30/04/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435649.4mE; 727201.5mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
				0		OL: Organic SILT with trace rootlets: Black. Low plasticity. (Topsoil)	M		1
						SW: Medium to coarse SAND: Orange brown. Well graded.	W	L	2
						SW: Fine to coarse SAND: Grey. Well graded.			2
									1
									2
									1
									1
									2
				1		GW: Fine to medium SAND: Light grey. Well graded.			2
						SP: Medium to coarse SAND with trace fine gravel: Grey. Poorly graded.	S		2
						... at 1.10m, very poor recovery.			2
									2
									1
									4
								L to MD	1
						... at 1.70m, hole beginning to collapse.			2
									3
				2		Borehole terminated at 2.0 m			4
									3
									4
									3
									3
									4
									4
									3
									3
									3
									3
				3					3
									5
									4
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									4
									4
									3
									4
									5
				4					4
									5
									4
									4
									4
									3
									3
									2
				5					3

Termination Reason: Hole collapsing below 2m.
Shear Vane No: DCP No: 13
Remarks: Groundwater encountered at 1.1m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA04

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 29/04/2020
Borehole Location: Refer to site plan. Logged by: LK Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435449.4mE; 727310.3mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS.

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Organic SILT: Black. Low plasticity. (Topsoil)			
	0.3	Peak = UTP				CH: CLAY: Orange brown mottled light grey. High plasticity	D		
	0.6	Peak = UTP							
	0.9	Peak = UTP		1					
						... at 1.00m, becoming light grey mottled orange.			
	1.2	Peak = UTP				... from 1.20m to 1.30m, contains trace slightly decomposed wood fragments around 5mm in diameter.	M		
	1.6	Peak = UTP				CH: CLAY: White mottled orange prink and red. High plasticity, moderately sensitive.			
	2.0	Peak = UTP		2		... from 2.00m to 2.40m, becoming orange brown mottled white.		H	
	2.4	Peak = UTP							
	2.8	Peak = UTP				... at 2.80m, becoming light brown mottled white and pink.			
				3					
	3.2	Peak = UTP				... from 3.20m to 3.80m, becoming orange brown.	W		
	3.6	Peak = UTP							
	4.0	Peak = 188kPa Residual = 82kPa		4		CH: Silty CLAY: Light orange brown mottled grey. High plasticity, moderately sensitive.			
	4.4	Peak = 150kPa Residual = 74kPa				CH: Silty CLAY: White mottled light brown. High plasticity, moderately sensitive.		VSt	
	4.8	Peak = 136kPa Residual = 60kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth reached.
Shear Vane No: 2560 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA05

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 29/04/2020
Borehole Location: Refer to site plan. Logged by: LK Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435442.5mE; 727364.6mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
▼	0.3	Peak = 19kPa Residual = 5kPa		0		OL: Organic SILT: Black. Moderately sensitive. (Topsoil)		S	1, 1
				1		SP: Fine to medium SAND: Grey. Poorly graded. Sand, pumiceous.	S	L to MD	2, 2, 2, 3, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 4, 2
				2		Borehole terminated at 2.0 m			1, 1, 2, 1, 2, 2, 1, 2, 2, 4, 4, 4, 4, 4, 5, 5, 5, 6, 6, 6, 6, 5, 6, 8, 8, 8, 9, 10, 10
				3					
				4					
				5					

Dynamic Cone Penetrometer (Blows/100mm): 5, 10, 15

Termination Reason: Hole collapsing below 2m.
Shear Vane No: 2560 DCP No: 13
Remarks: Groundwater encountered at 0.05m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA06

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 29/05/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435085.6mE; 727858.8mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
	0.3	Peak = 56kPa Residual = 40kPa				OL: Organic SILT with trace fine sand and trace fine gravel: Dark brown. Low plasticity, insensitive. (Topsoil)			2 2 1 1
	0.6	Peak = 77kPa Residual = 46kPa				ML: SILT with minor fine to medium sand: Orange brown. No plasticity, insensitive.		St	1 1 1 2 3
				1		SP: Medium to coarse SAND with trace fine gravel: Orange brown. Poorly graded.			3
						... at 1.00m, with some fine pumiceous gravel.	D		4 4 5
						... at 1.50m, with minor fine gravel.		L to MD	3 3 2 2
				2		SP: Fine to coarse SAND: Reddish brown. Poorly graded.			4 4 6 6
	2.2	Peak = 62kPa Residual = 21kPa				ML: Fine sandy SILT: Dark grey. Low plasticity, moderately sensitive.	M to W	St	2 3
						Fine to coarse SAND with minor fine to coarse gravel: Reddish brown. Poorly graded. *... at 2.30m, Very poor recovery and hole collapsing.*	D to M	MD	6 5 6 4 6
						Borehole terminated at 2.8 m			6 5
				3					5 5 6 5 7 5 4 5 5 3
				4					4 5 6 6 6 4 3 3 3
				5					

Termination Reason: Hole collapsing below 2.8m.
Shear Vane No: 2349 DCP No: 13
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA07

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 29/04/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 434989.4mE; 727953.1mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
				0		ML: Fine sandy SILT with trace rootlets: Dark brown. Low plasticity. (Topsoil)	D	L to MD	1
						ML: SILT with fine sand: Orange brown. Low plasticity, moderately sensitive.			3
						SP: Silty fine SAND: Light brownish grey. Uniformly graded.			2
						SP: Fine to coarse SAND with trace fine gravel: Dark reddish brown. Poorly graded.			2
									2
									2
									2
									2
									3
				1					2
									3
									3
						... from 1.30m to 1.40m, with medium to coarse gravel			4
									4
									3
									3
									3
									2
									3
									3
				2		... at 2.00m, with minor fine gravel.			4
						SW: Fine to medium SAND: Grey. Well graded.			3
						... at 2.20m, with some silt. Colour change to light grey.	M		6
						SP: Fine to coarse SAND with minor fine gravel: Dark reddish brown. Poorly graded	D to M	MD to D	10
									10
									6
									6
						... at 2.80m, with minor fine to coarse gravel			5
									4
						Borehole terminated at 2.9 m			6
				3					7
									6
									8
									8
									10
									8
									7
									7
									9
									9
				4					8
									15
									11
									9
									8
									6
									9
									9
									10
				5					

Termination Reason: Refusal on coarse gravel at 2.9m.
Shear Vane No: DCP No: 13
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA08

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 30/04/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435240.5mE; 728170.0mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
				0		OL: Fine sandy SILT with trace rootlets: Brown. No plasticity. (Topsoil)			1
						SP: Fine SAND with some silt: Brown. Uniformly graded.		L	2 1 2 1 1 1 3 2
				1		SP: Fine SAND: Whitish grey. Uniformly graded.	D	MD	3 5 4 5 4 4 3 5 5 6 6 7 6 7 6 6 5 5 6 6
				2		... at 2.80m, with trace silt.			
				3		... at 3.00m, colour change to grey.			
						SW: Fine to medium SAND with some silt: Dark grey. Well graded.	M to W		5 5 4 5 5 6 4 4 6 2
	4.2	Peak = 52kPa Residual = 43kPa		4		ML: SILT with minor fine to medium sand: Dark grey. No plasticity to low plasticity, insensitive.		St	
	4.6	Peak = 68kPa Residual = 34kPa				ML: SILT: Dark grey. Low plasticity, moderately sensitive.	W	St to VSt	
	5.0	Peak = 105kPa Residual = 49kPa		5		Borehole terminated at 5.0 m			

Termination Reason: Target depth reached.
Shear Vane No: 2349 DCP No: 13
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA09

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 29/04/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435021.5mE; 728249.4mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
				0		OL: Fine sandy SILT with trace rootlets: Dark brown. Low to no plasticity. (Topsoil)	D		1
									2
									2
						SM: SILT with some fine sand: Orange brown. Low to no plasticity, sensitive.			2
									2
									2
						SP: Fine SAND with minor silt: Light grey. Uniformly graded.		L	3
									3
									3
									3
				1		SP: Fine to coarse SAND with trace fine rounded gravel: Dark reddish brown. Poorly graded.			4
									8
									7
									9
									7
									4
									11
						... at 1.70m, trace mottled grey patches.		MD to D	6
									3
									6
				2					4
						... at 2.10m, minor fine to coarse gravel.	M		6
									7
									8
						... at 2.40m, minor fine gravel.			9
						... at 2.50m, minor fine to coarse gravel.			13
						... at 2.60m, minor fine gravel.			12
						Borehole terminated at 2.7 m			7
									6
				3					7
									7
									11
									10
									8
									11
									8
									10
									8
									6
									8
				4					10
									10
									10
									7
									8
									15
									13
									12
									6
				5					

Termination Reason: Hole collapsing below 2.8m.
Shear Vane No: DCP No: 13
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA10

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 11/05/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435717.8mE; 728205.8mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
				0		OL: Fine sandy SILT: Dark brown. Low plasticity. (Topsoil)			1, 3
						SW: Fine to medium SAND: Orange brown. Well graded.			2, 3, 4, 4, 4, 3
						... at 0.80m, colour change to brownish grey.	M		4, 4
				1		SP: Fine SAND: Grey. Uniformly graded.			4, 4, 3, 4, 3
						SP: Fine to coarse pumiceous SAND: Grey. Poorly graded.	W	MD	4, 5, 4, 6, 5
▼				2		SP: Medium to coarse pumiceous SAND: Grey. Poorly graded.	S		4, 4
						... at 2.30m, with trace fine gravel.			3, 3, 3
						... at 2.50m, with minor silt.			2
						SP: Silty medium to coarse SAND: Grey mottled white. Poorly graded.			3, 3, 3
	3.0	Peak = 43kPa Residual = 31kPa		3		ML: SILT with some medium to coarse sand: Dark grey streaked black. Low plasticity, insensitive.		F	
	3.4	Peak = 95kPa Residual = 46kPa				ML: SILT with minor fine to coarse sand: Dark grey. Low plasticity, moderately sensitive.		St	
						... from 3.40m to 3.44m, wood with minor decomposition.			
						... from 3.80m to 4.00m, Auger sinking under it's own weight, material seems to be very soft.			
	4.0	Peak = 90kPa Residual = 34kPa		4				St	
	4.4	Peak = 139kPa Residual = 59kPa				ML: Medium to coarse sandy SILT: Grey mottled white. Low to no plasticity, insensitive.		St to VSt	
	4.8	Peak = 86kPa Residual = 46kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth reached.
Shear Vane No: 2349 DCP No: 13
Remarks: Groundwater encountered at 2.1m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA11

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 06/05/2020 - 07/05/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1

Position: 435211.3mE; 728868.3mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						ML: SILT: with trace fine to medium sand, with trace rootlets; dark brown. Low plasticity.			2
						SILT: with minor fine to coarse sand, with trace fine gravel; orange brown. Low plasticity.			2
	0.3	Peak = 77kPa Residual = 28kPa							2
									2
	0.6	Peak = 124kPa Residual = 31kPa					D to M	St to VSt	2
									1
									1
									2
						Silty Fine SAND: orange brown. Uniformly graded.		MD	3
	1.0	Peak = >200kPa Residual = 43kPa		1		Sandy SILT: orange brown. Low plasticity.		H	4
									4
						Silty Fine SAND: light grey. Uniformly graded.			3
									3
	1.4	Peak = UTP					M	L	3
									3
									2
									3
									2
									2
						Gravelly Coarse SAND: white mottled reddish brown. Uniformly graded, subangular.	M…		4
				2		Sandy SILT: light grey streaked brown. Low plasticity.			3
	2.1	Peak = 126kPa Residual = 39kPa							3
									3
									4
	2.5	Peak = 93kPa Residual = 62kPa					W	MD	5
									4
									4
									5
									5
						Silty Fine SAND: light grey. Uniformly graded.			7
	3.0	Peak = UTP		3					7
								MD to D	8
									6
07-05-2020	3.4	Peak = Shear Vane Pushed Down to 3.7							8
						SILT: with some fine sand; brownish grey. Low plasticity.	W to S		6
								VS	1
									2
	3.7	Peak = 195kPa Residual = 62kPa				… at 3.70m, With minor fine to medium gravel			1
								VSt	2
									3
				4		Borehole terminated at 4.0 m			16
									6
									6
									5
									6
									5
									6
									8
									10
				5					

Termination Reason: Equipment refusal
Shear Vane No: 2349 DCP No: 13
Remarks: Groundwater encountered at 3.4m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA12

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 29/04/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435079.9mE; 728499.3mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
				0		OL: Fine sandy SILT: Dark brown. No plasticity. (Topsoil)			2 2 2
						SP: Fine SAND with some silt: Orange brown. Uniformly graded.			1
						SP: Fine SAND: Light grey. Uniformly graded.			2 2 2 3
				1		SP: Fine to coarse SAND: Reddish brown. Poorly graded.			2 2 6 3 3 4 4
						SW: Fine to coarse SAND: Grey. Well graded.	D	L to MD	5 4 5 7
				2		SP: Fine to coarse SAND with trace fine gravel: Reddish grey. Poorly graded.			5
						... at 2.00m, colour change to dark grey.			4 5 3 4
						... at 2.40m, colour change to reddish brown.			3 4 5 6
						... from 2.80m to 2.95m, with fine to coarse gravel.			5 4
				3		Borehole terminated at 3.1 m			6 5 6 5 5 5 5 6 5 5
				4					6 4 5 4 5 4 4 5
				5					6

Termination Reason: Refusal on coarse gravel at 3.1m.
Shear Vane No: DCP No: 13
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA13

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 30/04/2020
Borehole Location: Refer to site plan. Logged by: LS Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435206.1mE; 728641.0mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						OL: Fine sandy SILT with trace rootlets: Dark brown. No plasticity. (Topsoil)			
	0.3	Peak = 86kPa Residual = 34kPa				ML: Fine sandy SILT: Orange brown. No plasticity, moderately sensitive.			
	0.6	Peak = 120kPa Residual = 31kPa					D		
	0.9	Peak = 120kPa Residual = 31kPa		1		ML: Fine sandy SILT: Light grey. Low plasticity, moderately sensitive.			
	1.2	Peak = 148kPa Residual = 46kPa				ML: SILT with minor clay and minor fine sand: Light grey streaked brown. Low plasticity, moderately sensitive.		St to VSt	
	1.5	Peak = 74kPa Residual = 22kPa				ML: SILT: Light grey streaked orange brown. Low plasticity, moderate sensitivity.			
	2.0	Peak = 93kPa Residual = 77kPa		2		ML: SILT with trace fine sand: Light grey. Low plasticity, moderately sensitive.			
						SP: Silty fine SAND: Light grey. Uniformly graded.			3 4 8
						SW: Fine to coarse SAND: Light brownish grey. Well graded.			7 8
						... at 2.60m, becomes medium to coarse SAND.			6 3 4 5
				3		Medium to coarse SAND with trace fine gravel: Light whitish brown. Poorly graded.			6
						SP: Fine to coarse SAND with trace fine gravel: Light brownish grey. Poorly graded.	M		6 8 7 10
						SP: Fine to coarse SAND with trace fine gravel: Light reddish brown. Poorly graded.		MD to D	8 9 11 13
				4					9 7 8 8 10
						... at 4.50m, with minor fine to coarse gravel.			9 10 10
						... at 4.70m, with minor fine gravel.			9 7
				5		Borehole terminated at 5.0 m			

Termination Reason: Target depth reached.
Shear Vane No: 2349 DCP No: 13
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA14

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 06/05/2020
Borehole Location: Refer to site plan. Logged by: Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435646.0mE; 728602.7mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
						ML: Clayey SILT: dark brown. Low plasticity. (Topsoil)			1
						Fine SAND: with some silt; light grey streaked brown. Uniformly graded.	D to M		2 3 4 4 4 4 4 5
				1		... at 0.90m, With no silt.			5
						SW: Fine to medium SAND: grey. Well graded.	M to W	L to MD	4 4 4 5
						SW: Fine to coarse SAND: grey. Well graded.	W to S		4 4 2 3 4 4 4
				2		SP: Silty fine to coarse SAND: grey. Poorly graded.			3 3
07-05-2020	2.4	Peak = Shear Vane Pushed to 2.9m				SILT: with some fine to coarse sand; dark grey. Low plasticity.	S	VS	3 2 2 2 1 3
	2.9	Peak = UTP				MH: SILT: grey mottled bluish black. High plasticity.		VSt to H	4 3 4 3 3 2 5 6 5
	3.4	Peak = 80kPa Residual = 46kPa		3		... at 3.70m, With minor coarse sand.			
	3.9	Peak = UTP				SP: Silty medium to coarse SAND: dark grey. Poorly graded, sand, subangular.		MD to D	7 8 7 10 7 8
				4		... at 4.00m, Very poor to no recovery.			
						Borehole terminated at 4.4 m			7 7 10 8 8
				5					

Termination Reason: Equipment refusal
Shear Vane No: 2349 DCP No: 13
Remarks: Groundwater encountered at 2.3m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA15

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 07/05/2020
Borehole Location: Refer to site plan. Logged by: Checked by: DMM Scale: 1:25 Sheet 1 of 1
Position: 435343.5mE; 728789.5mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
				0		OL: Sandy SILT: with trace rootlets; dark brown. Low plasticity. (Topsoil)			1
						SW: Fine to medium SAND: with some silt; orange brown. Well graded.			2, 2, 3, 2, 2, 2, 2, 2, 2
				1		SW: Fine to medium SAND: light greyish white. Well graded.			3, 3, 3, 3, 2, 3, 3, 3, 3, 4
				2		Fine SAND: light grey. Uniformly graded.	D to M	L to MD	3, 4, 4, 3, 3, 3, 4, 3, 3, 3
				3		... at 2.90m, With minor silt.	M		4, 4, 2, 3, 2, 3, 2, 3, 4
						SP: Silty Fine SAND: light grey. Uniformly graded.	W		1
	4.0	Peak = 93kPa Residual = 43kPa		4		ML: SILT: with some fine to medium sand; grey. Low plasticity.		St to VSt	
07-05-2020	4.4	Peak = 102kPa Residual = 43kPa					S		
				5		GP: Silty Fine to coarse GRAVEL: greyish white mottled brownish red. Poorly graded. Sand, subangular. Borehole terminated at 5.0 m			

Termination Reason: Equipment refusal
Shear Vane No: 2349 DCP No: 13
Remarks: Groundwater encountered at 4.6m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA16

Client: Shand Properties Limited
Project: North Huntly Development
Site Location: East Mine Road, Huntly
Project No.: HAM2019-0082
Date: 06/05/2020
Borehole Location: Refer to site plan. Logged by: Checked by: DMM Scale: 1:25 Sheet 1 of 1

Position: 435706.0mE; 728915.9mN Projection: Mt Eden 2000
Datum: NZVD2016 Survey Source: Hand held GPS

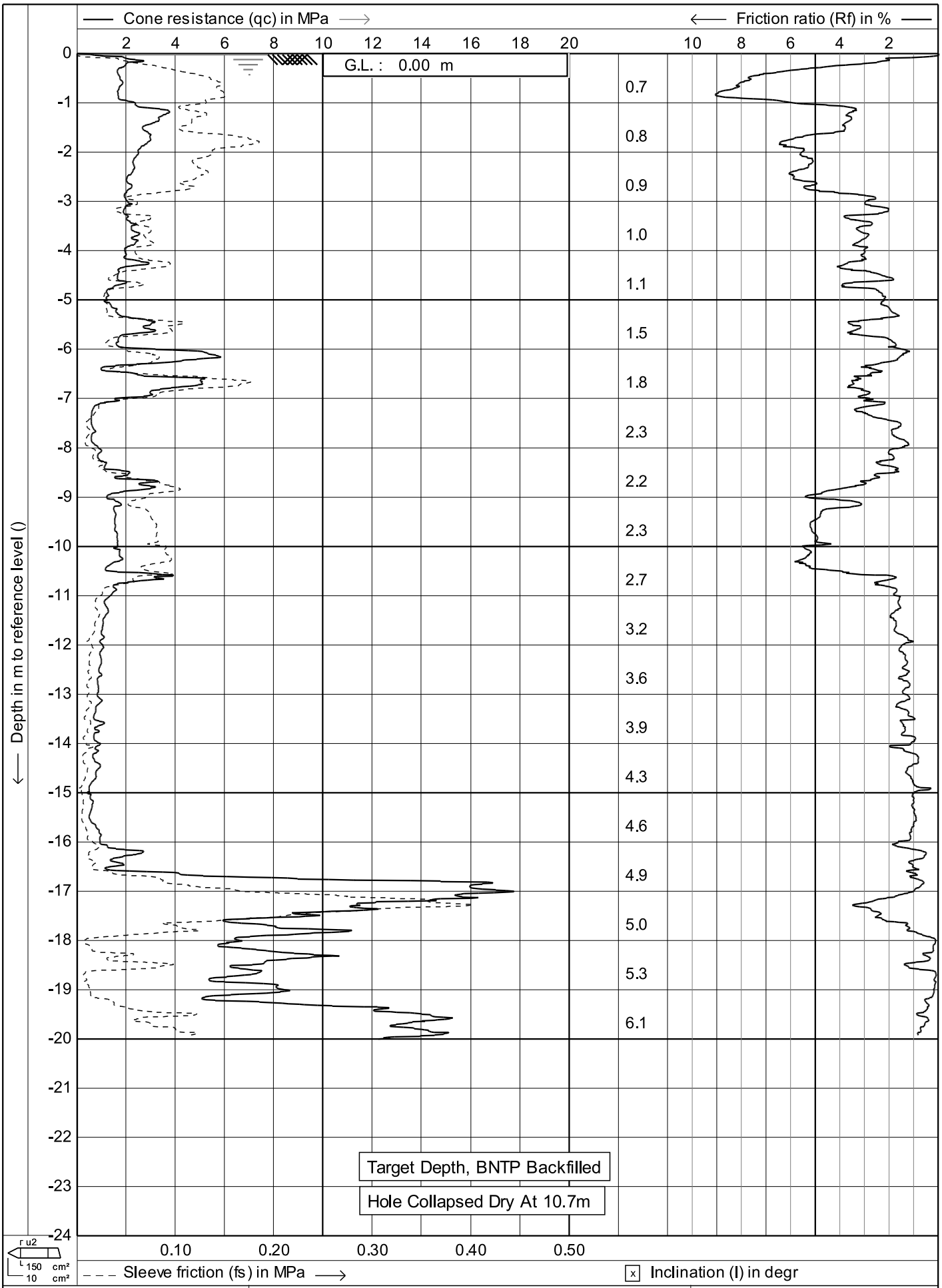
Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
				0		ML: Clayey SILT: dark brown. High plasticity. (Topsoil)			1, 2, 3
	0.3	Peak = 146kPa Residual = 56kPa				MH: Silty CLAY: light greyish white. High plasticity.		VSt	4
				1		SP: Fine SAND: with minor silt; light grey. Uniformly graded.		MD to D	6, 6, 8, 9, 6, 7, 6, 5, 6, 6, 5, 5, 3, 5, 5, 4
						... at 1.70m, With some silt			
	2.2	Peak = 62kPa Residual = 31kPa		2		ML: SILT: with minor fine sand; dark grey. Low plasticity.		L to MD	2, 4, 3, 2, 3, 2, 2, 3, 6, 6
	2.6	Peak = Pushed down to 3m then UTP		3		SM: Silty Fine SAND: grey. Uniformly graded.		MD to D	8, 9, 6, 8, 5, 5, 7, 7, 5
				4		Borehole terminated at 3.9 m			6, 6, 7, 6, 6, 5, 4, 6, 7, 6
				5					

07-05-2020

Termination Reason: Equipment refusal
Shear Vane No: 2349 DCP No: 13
Remarks: Groundwater encountered at 2m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

Appendix C: CPT Investigation Results



PERRY GEOTECH

ASTM D5778-12

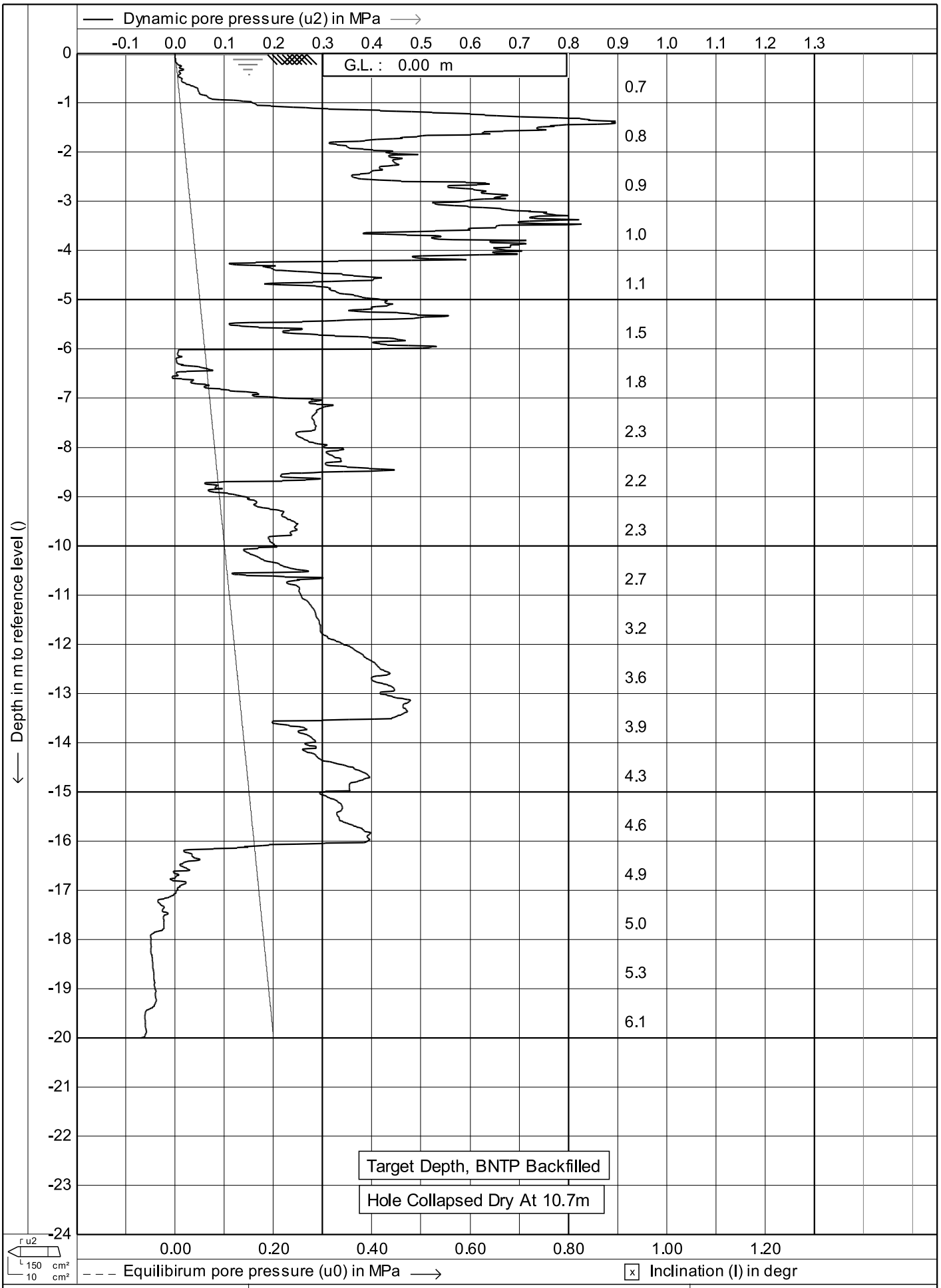
Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **13/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **01**

1.48



PERRY GEOTECH

ASTM D5778-12

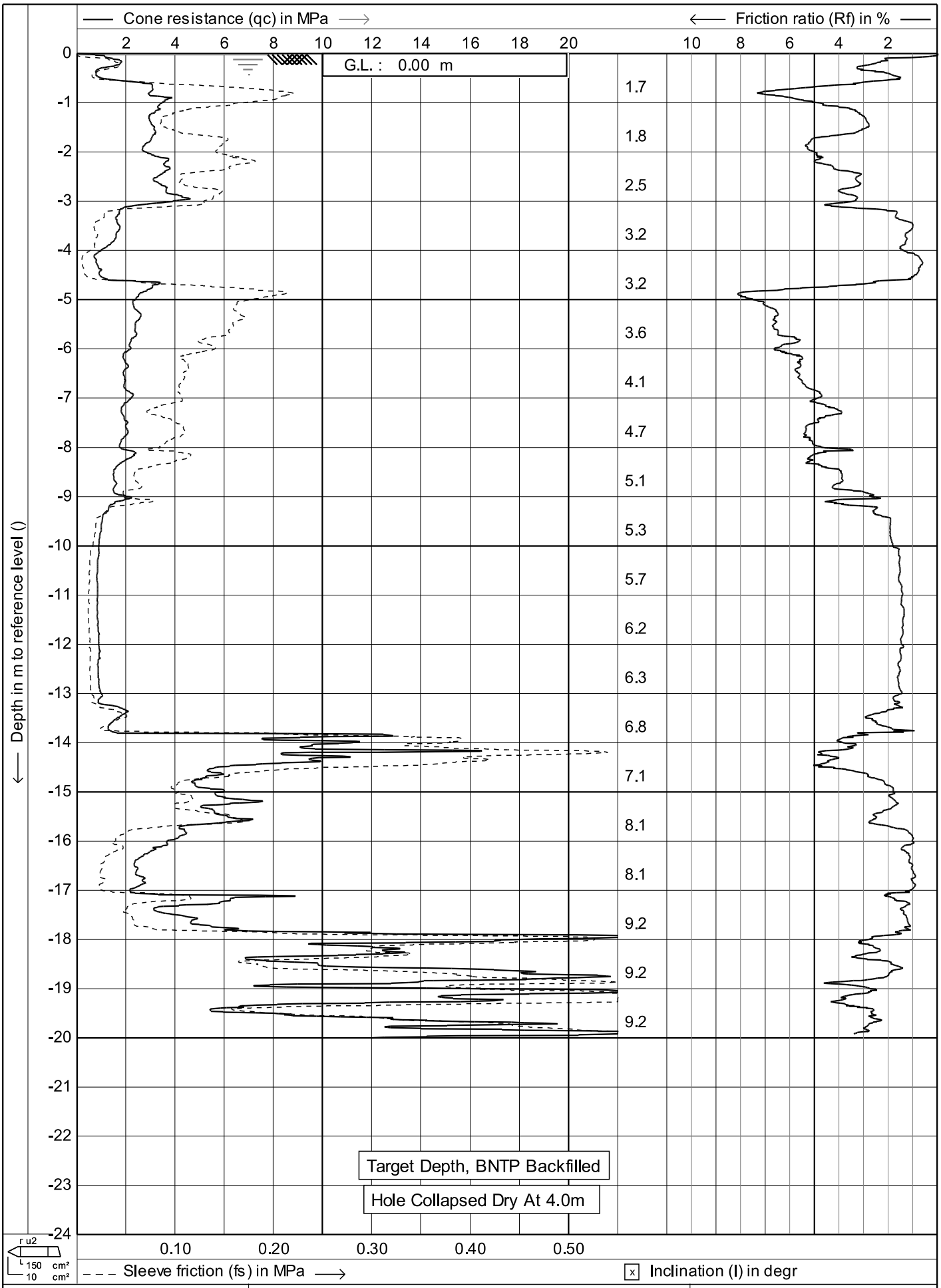
Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **13/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **01**

1.48



ASTM D5778-12

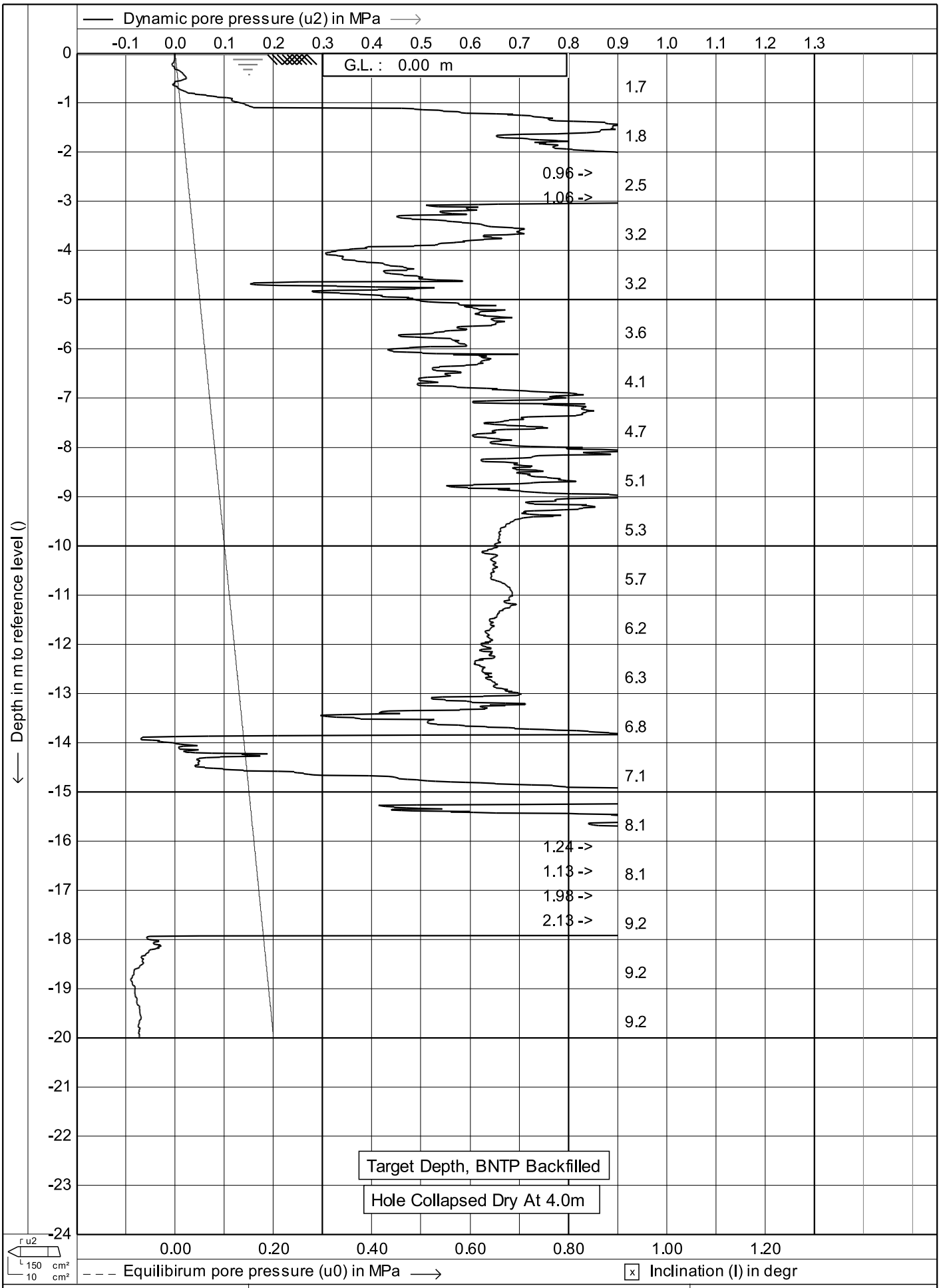
PERRY GEOTECH

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **13/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **02**



PERRY GEOTECH

ASTM D5778-12

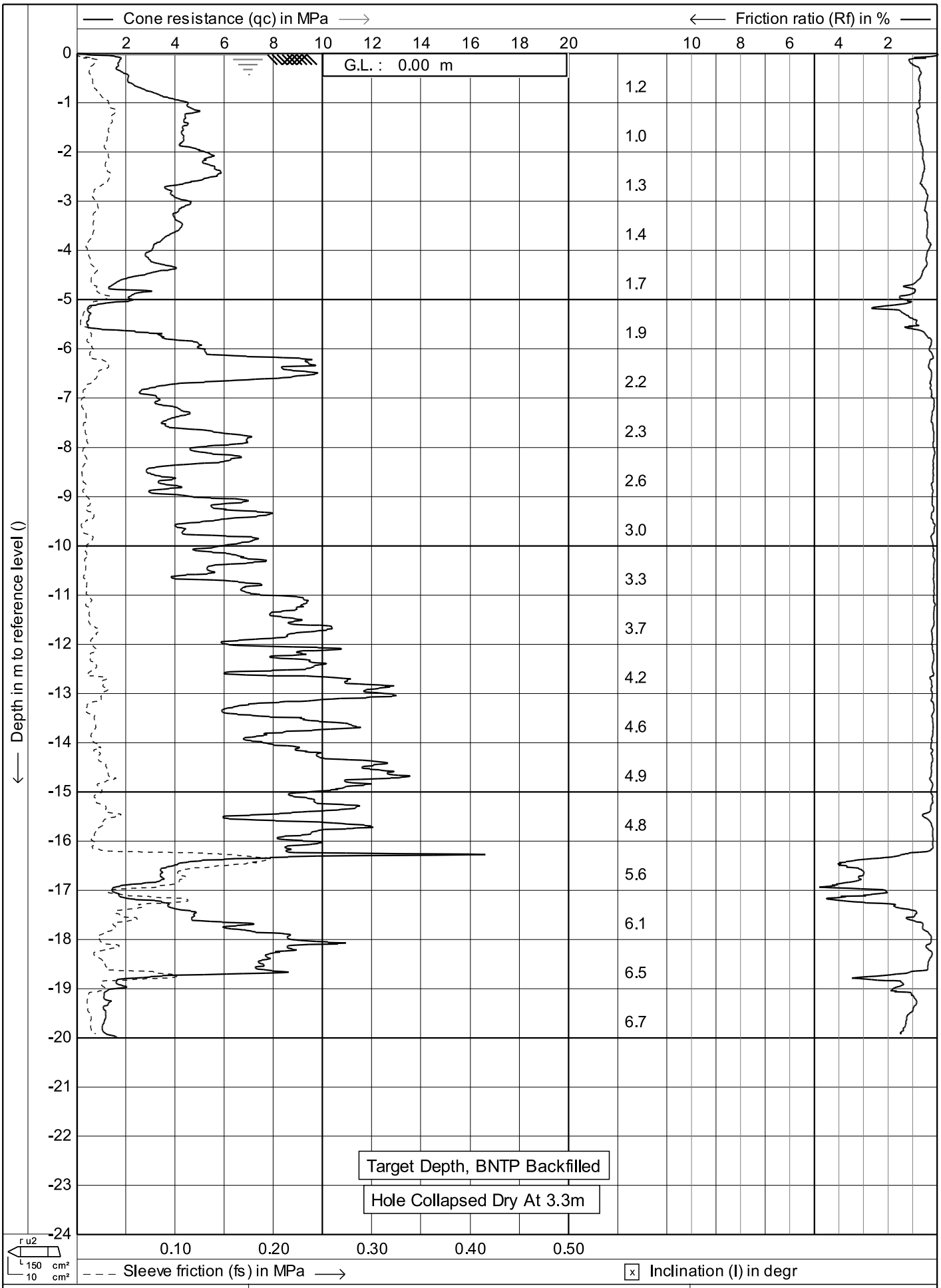
Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **13/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **02**

1.48



ASTM D5778-12

PERRY GEOTECH

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

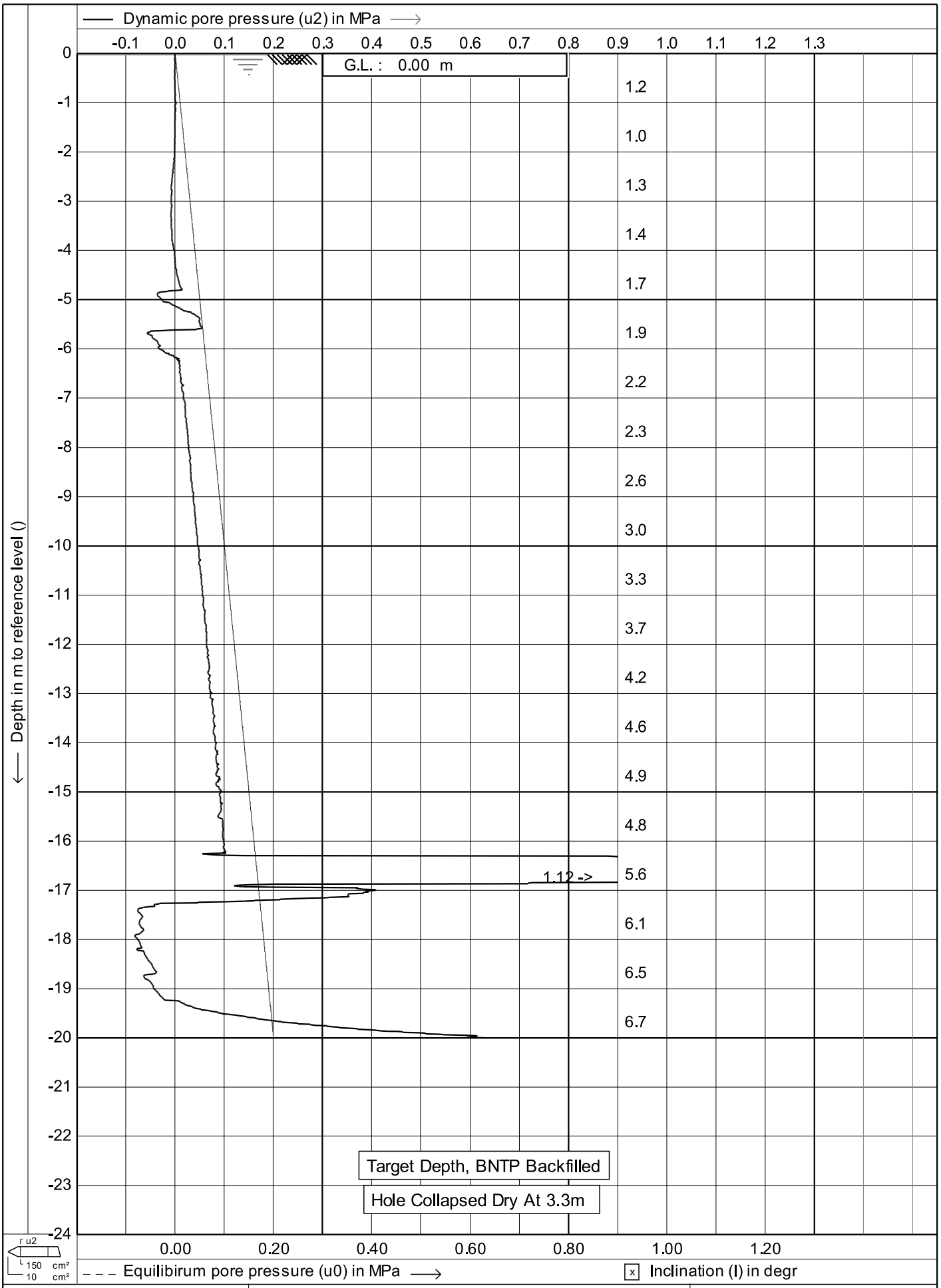
Date : **12/05/2020**

Cone no. : **C10CFIIP.C13081**

Project no. : **02CMW01**

CPT no. : **03**

1/14



PERRY GEOTECH

ASTM D5778-12

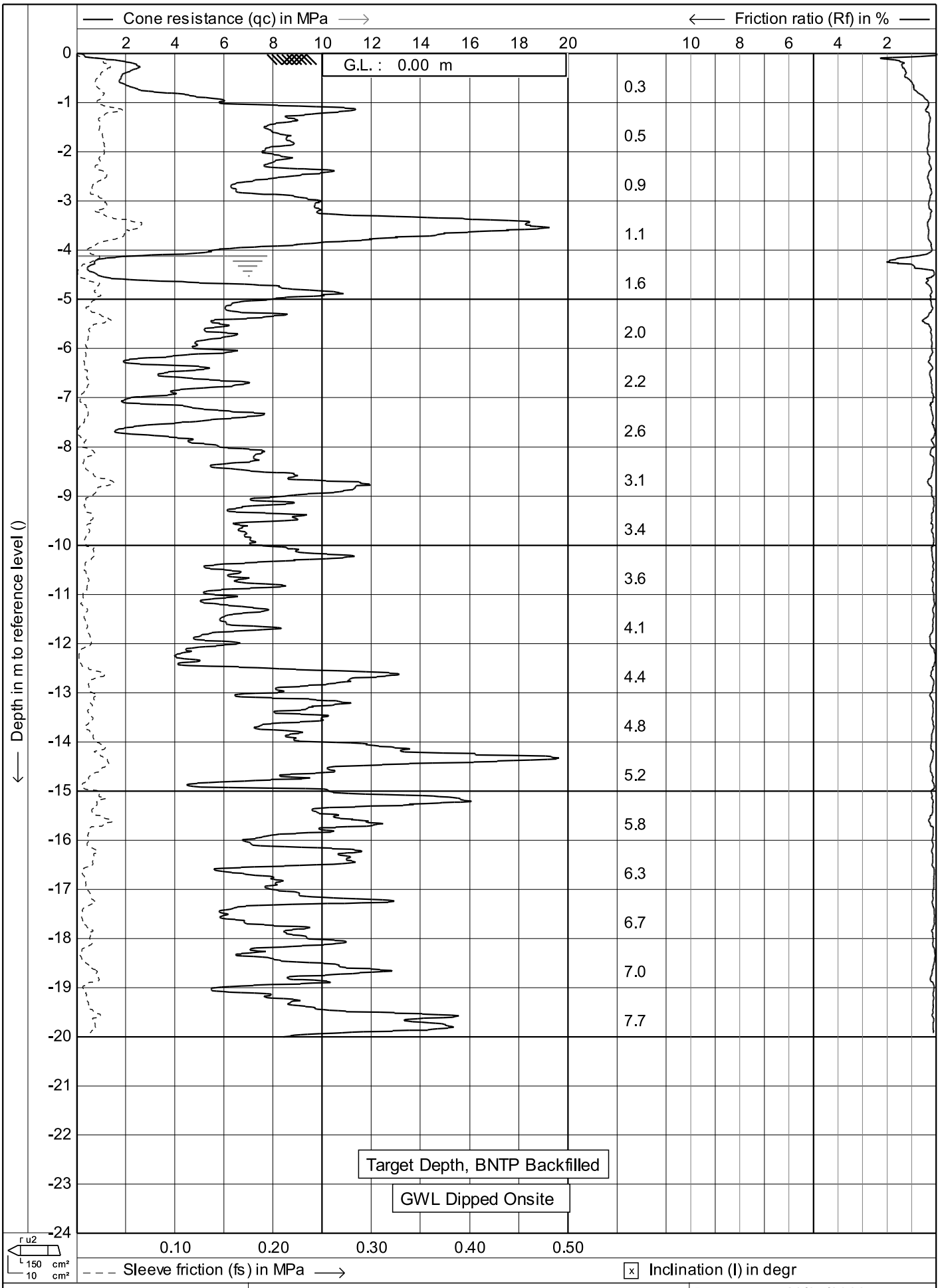
Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **12/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **03**

1.48



PERRY GEOTECH

ASTM D5778-12

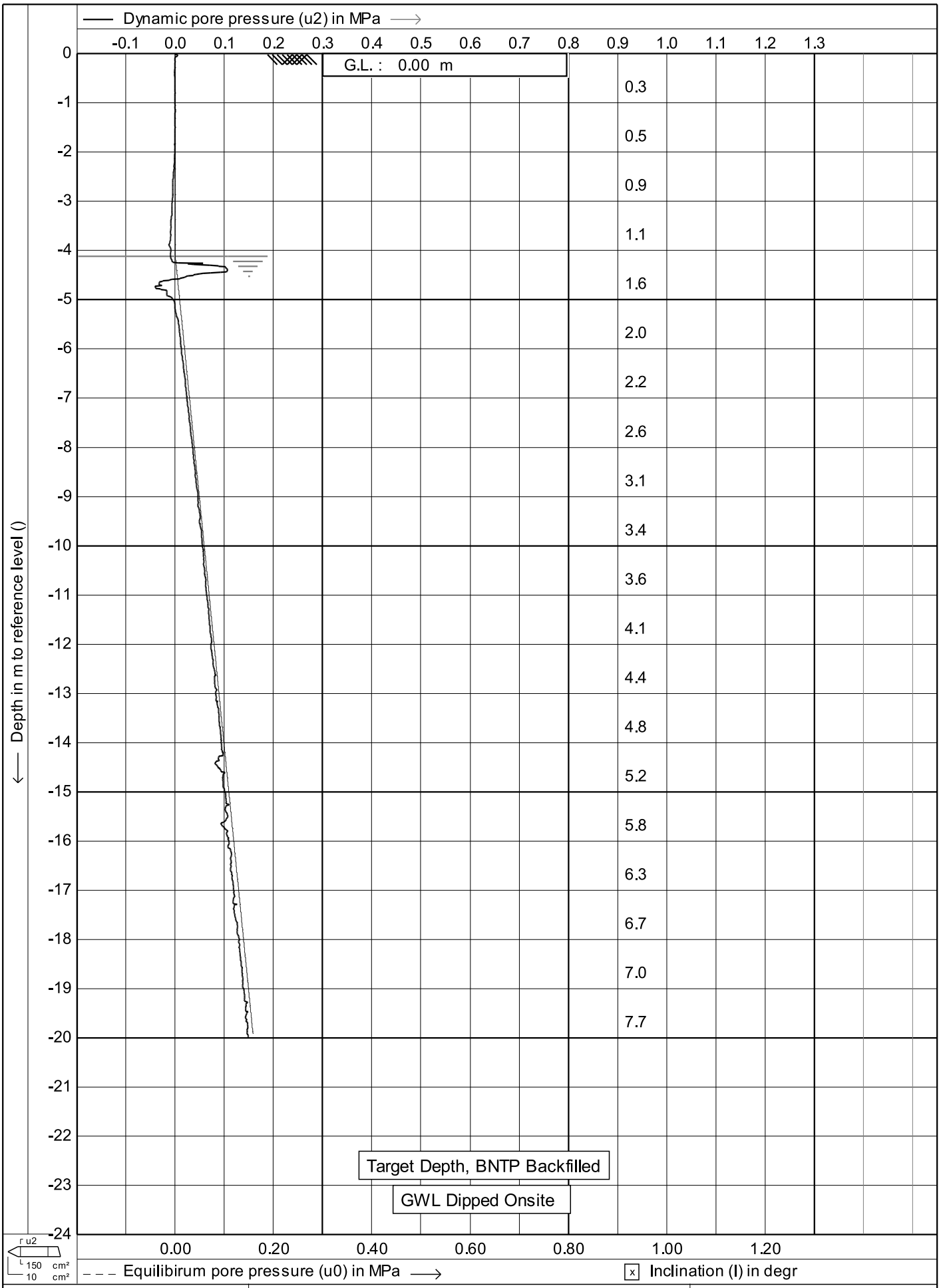
Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **12/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **04**

1.48



PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **12/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **04**

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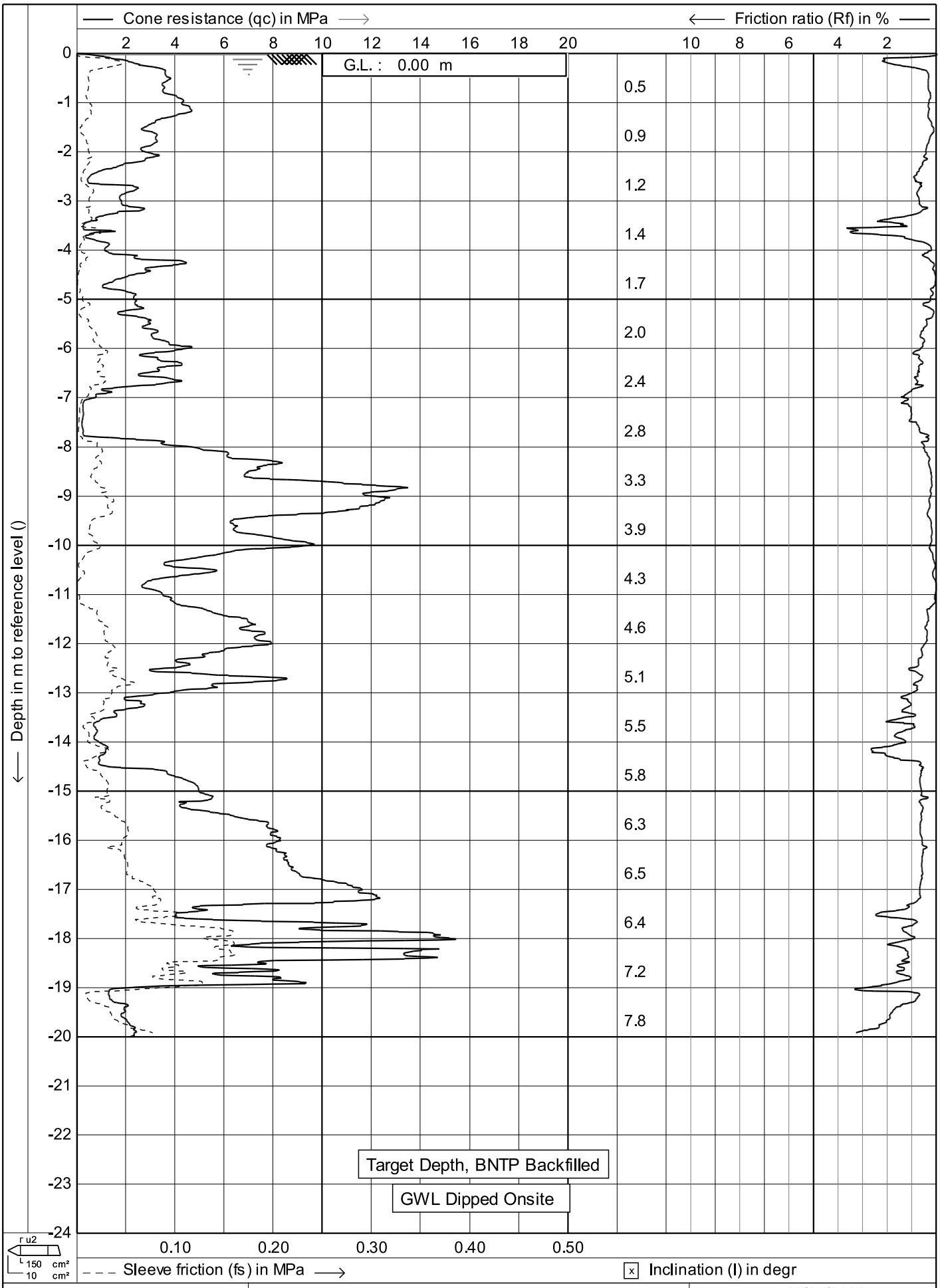

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date : **13/05/2020**

Cone no. : **C10CFIIP.C13081**

Project no. : **02CMW01**

CPT no. : **05**

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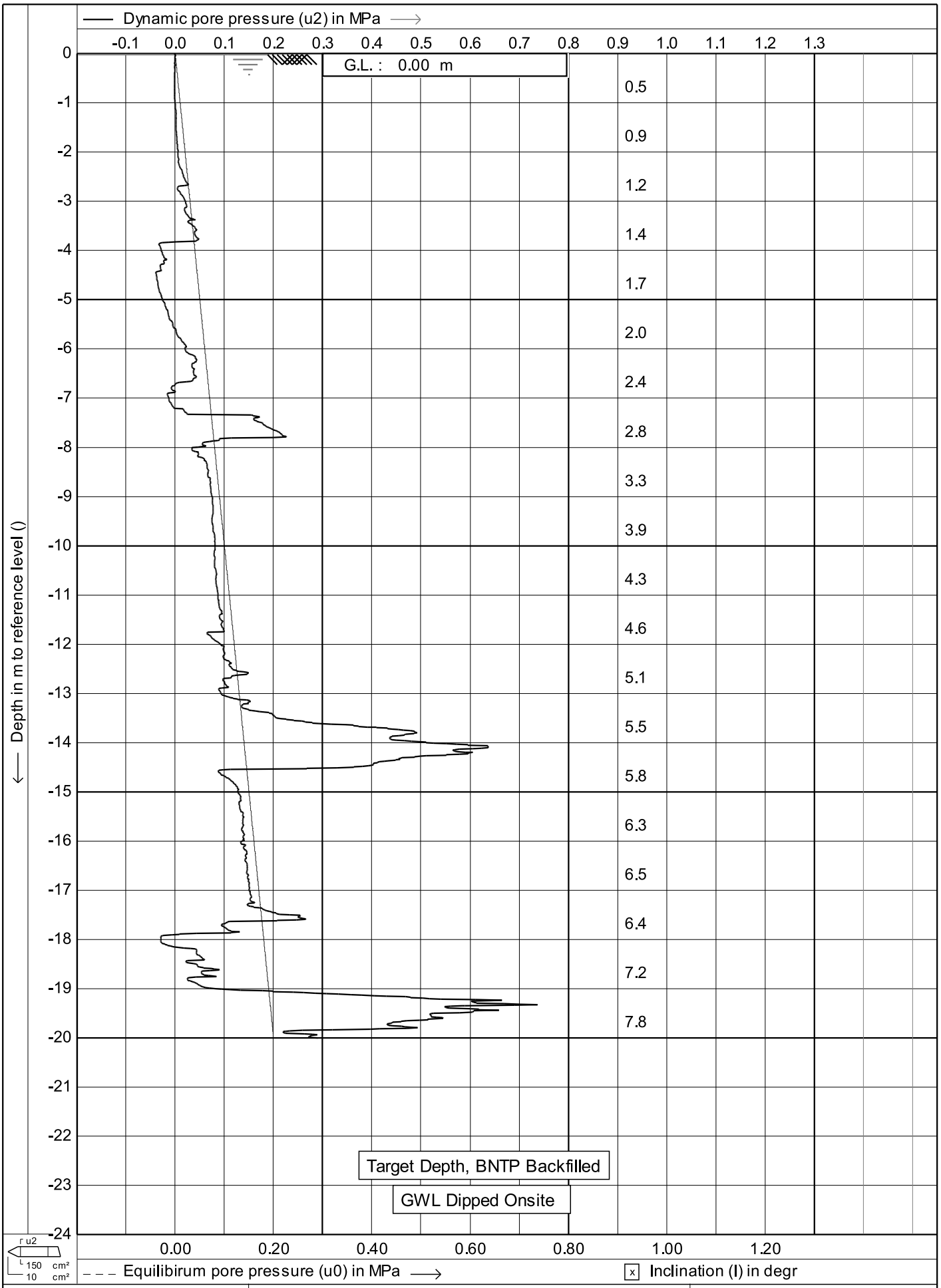

PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **13/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **05**

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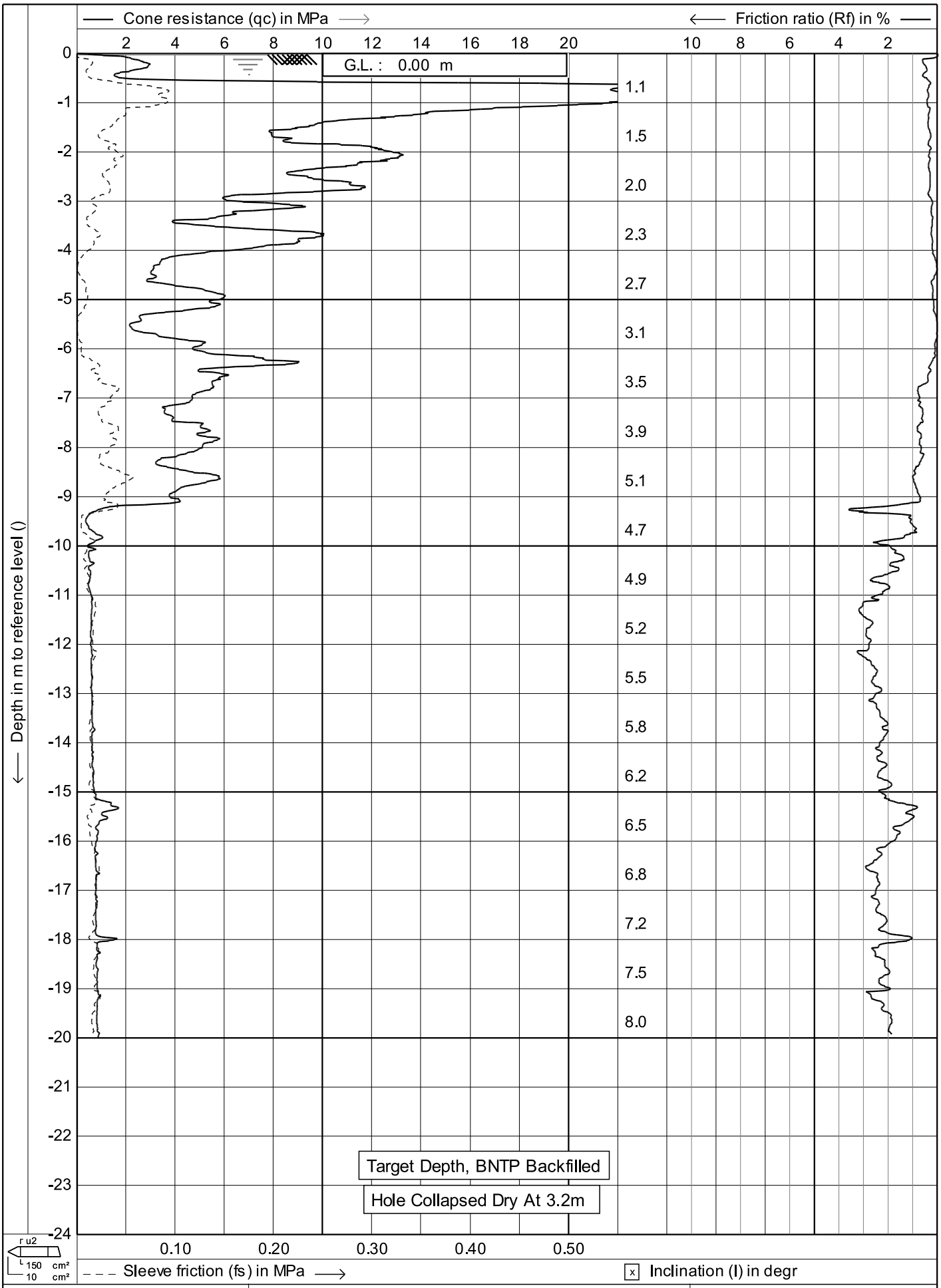

PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **12/05/2020**
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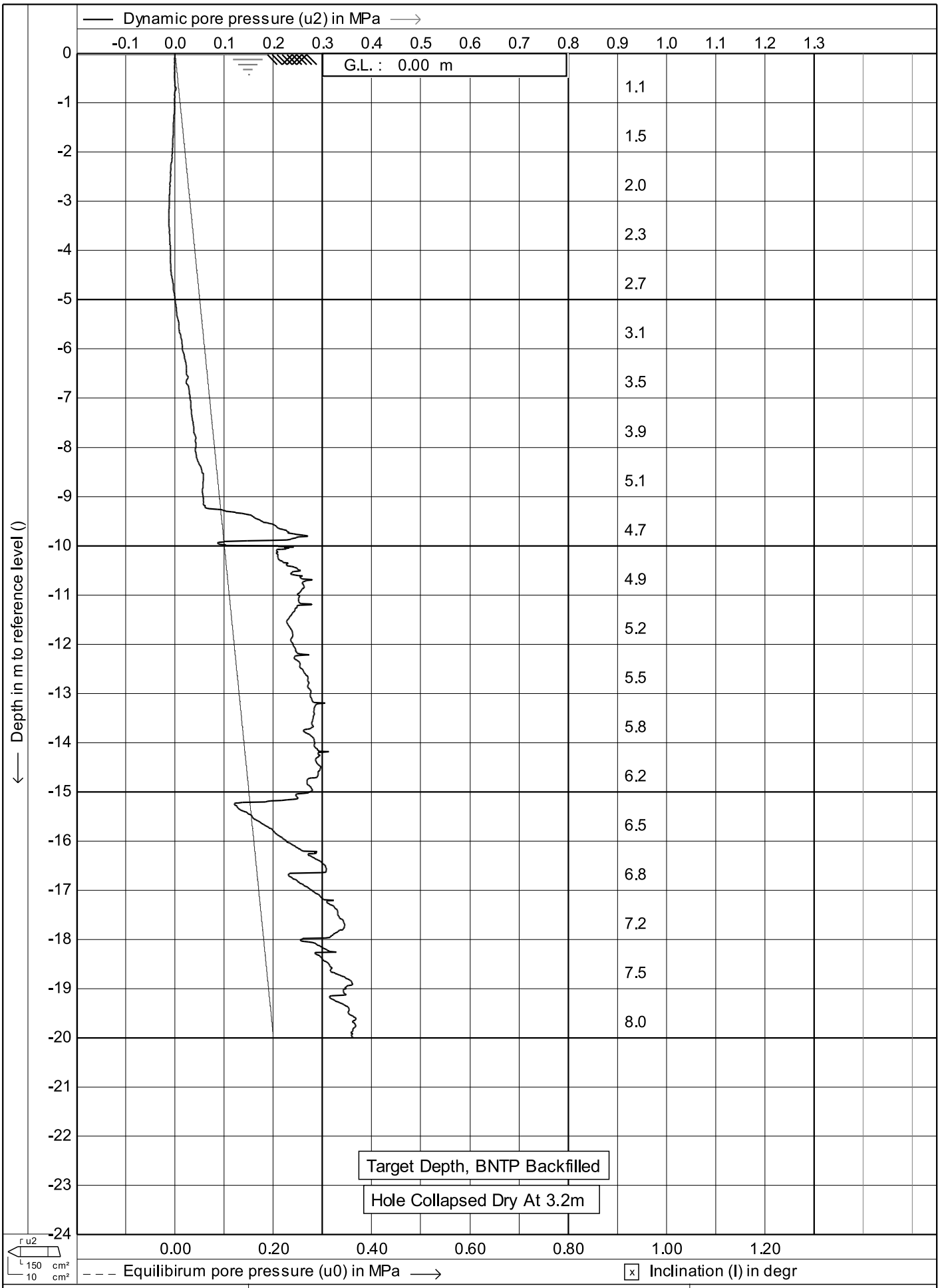
Project no.	: **02CMW01**
CPT no.	: **06**

1/14



PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **12/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **06**

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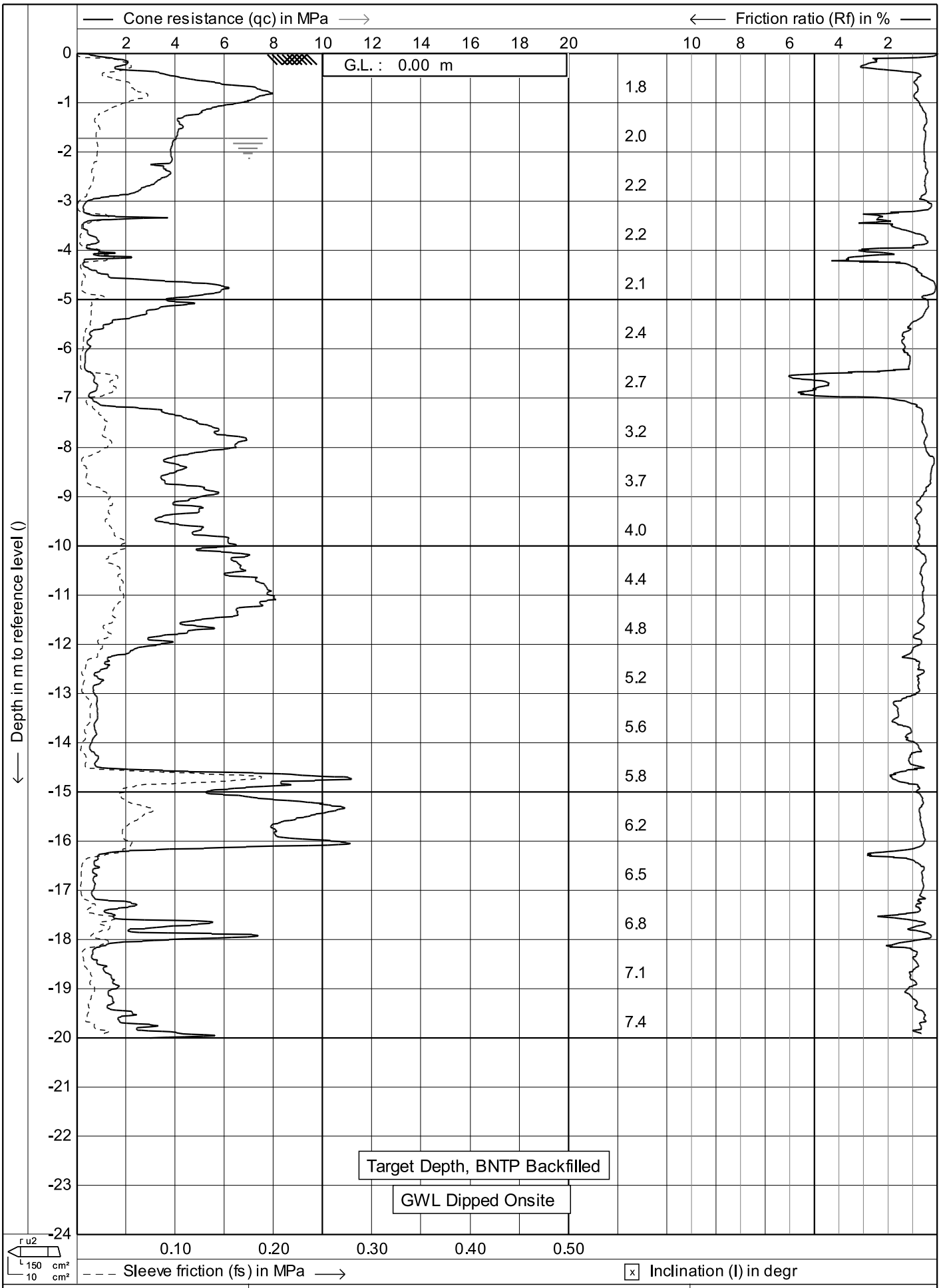

PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **13/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **07**

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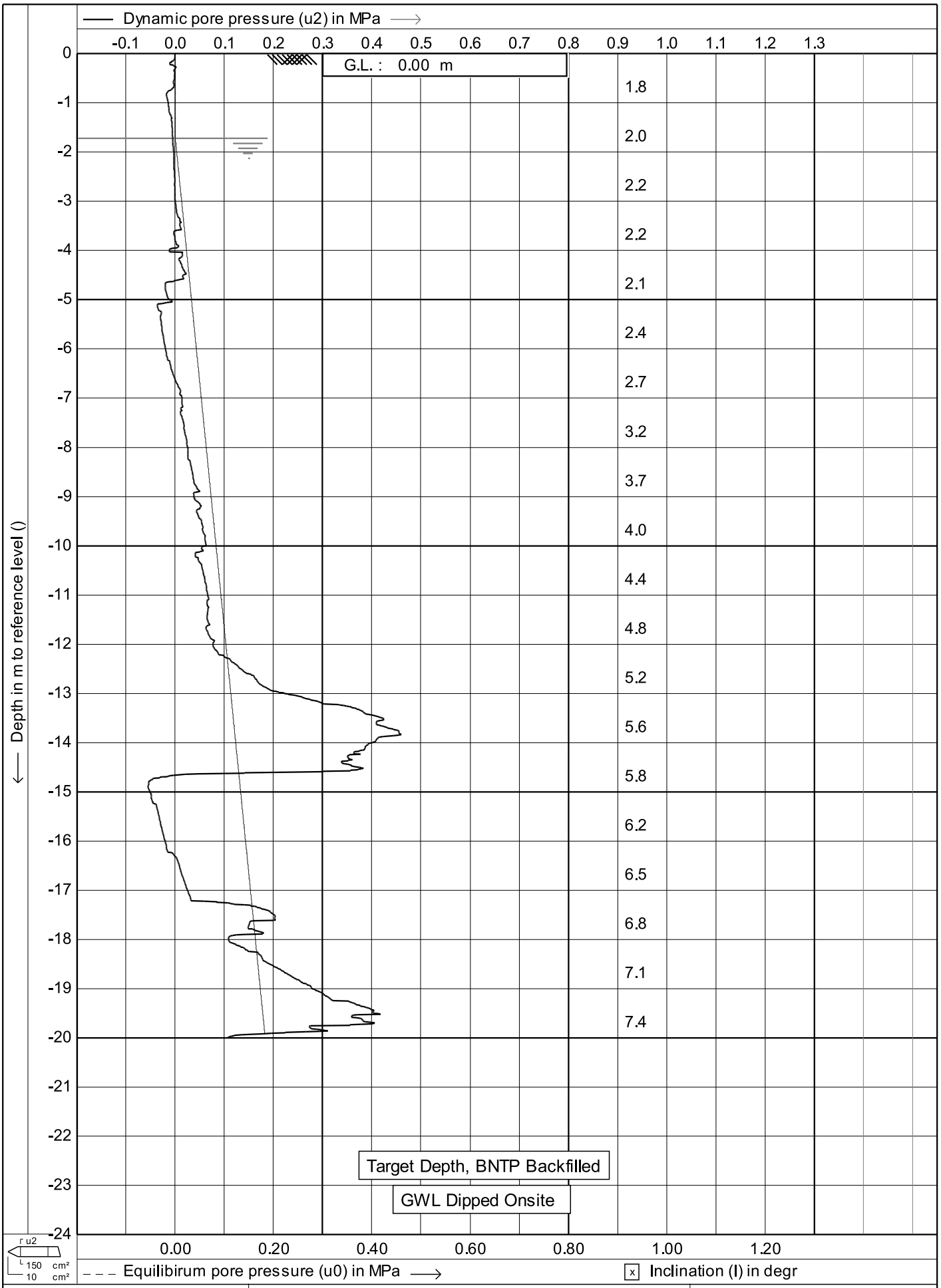

PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **13/05/2020**
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Project no.	: **02CMW01**
CPT no.	: **07**

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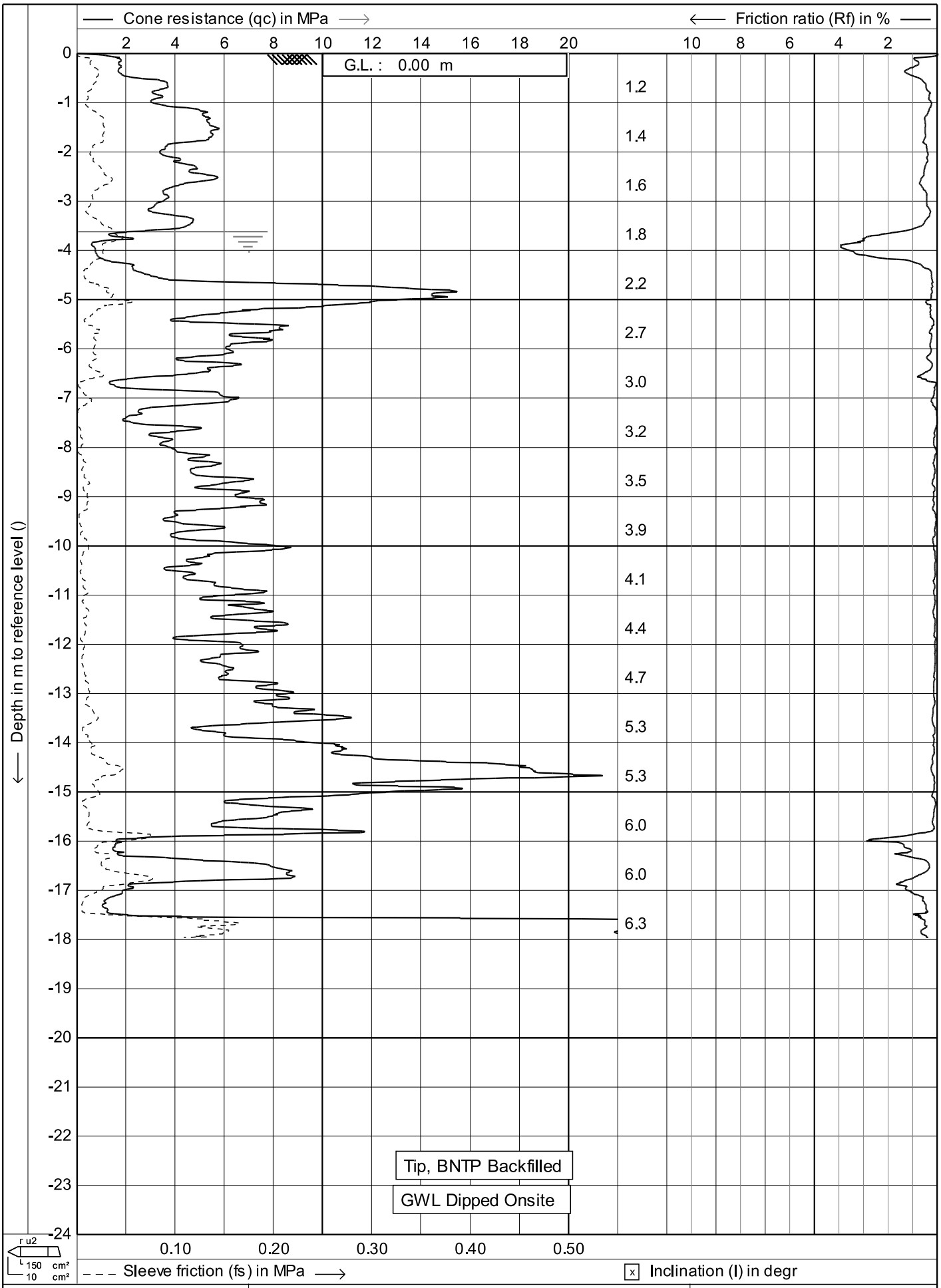
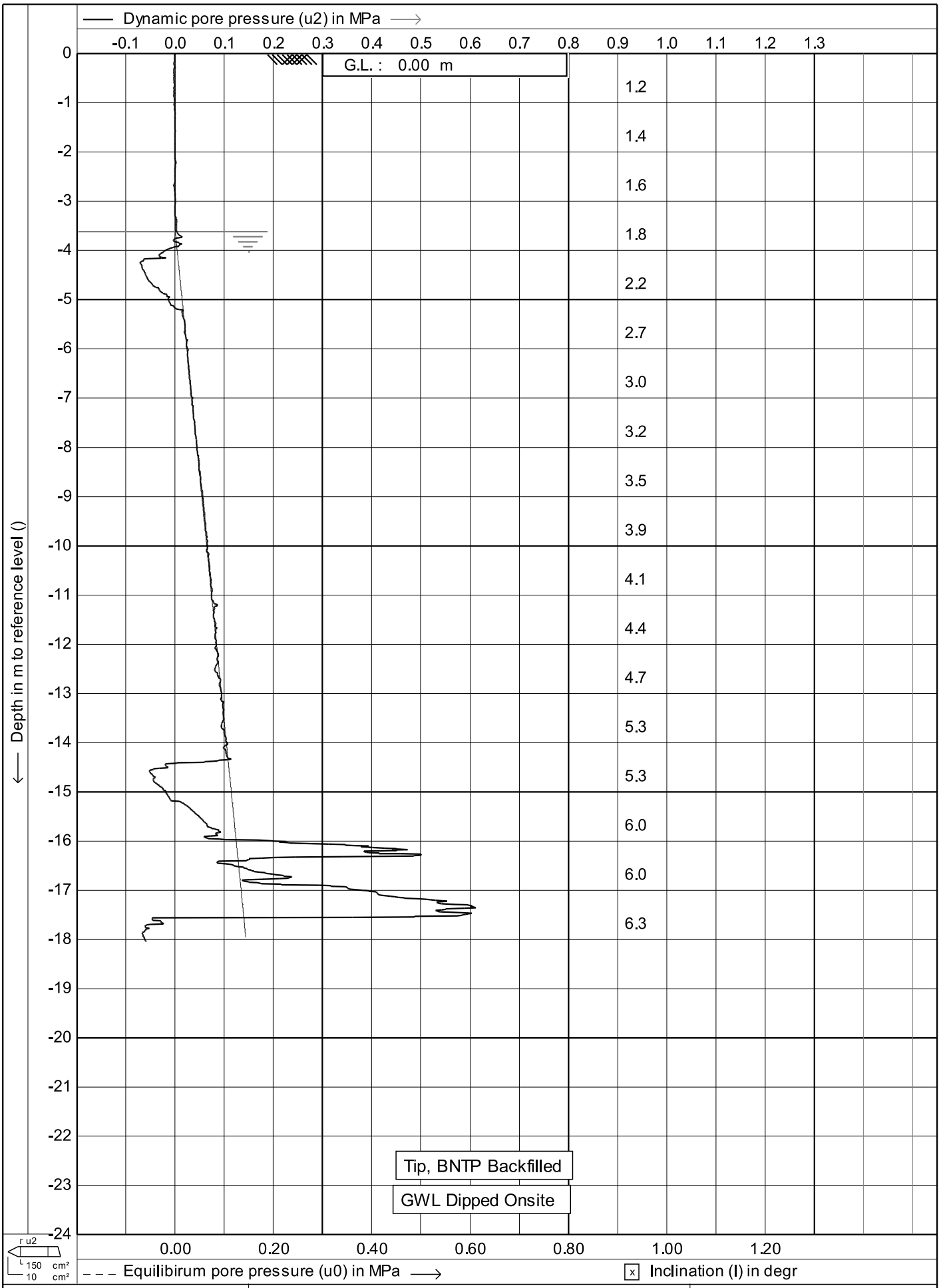


PERRY GEOTECH	ASTM D5778-12	Date : **12/05/2020**
	Project :	Cone no. : **C10CFIIP.C13081**
	Location: **East Mine Rd - Huntly**	Project no. : **02CMW01**
	Position: **0, 0**	CPT no. : **08** 1/14

1.48



PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **12/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **08**

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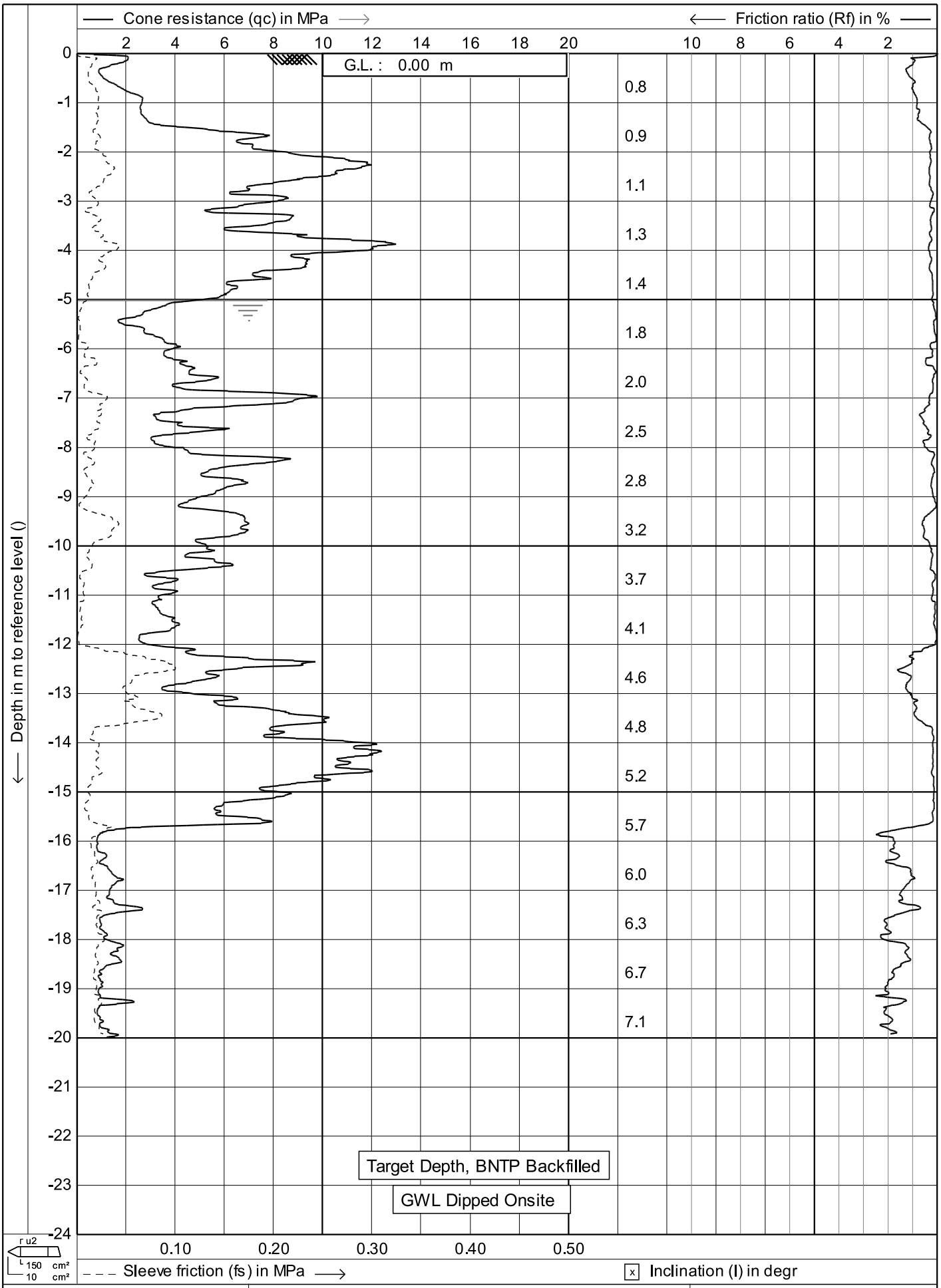


PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

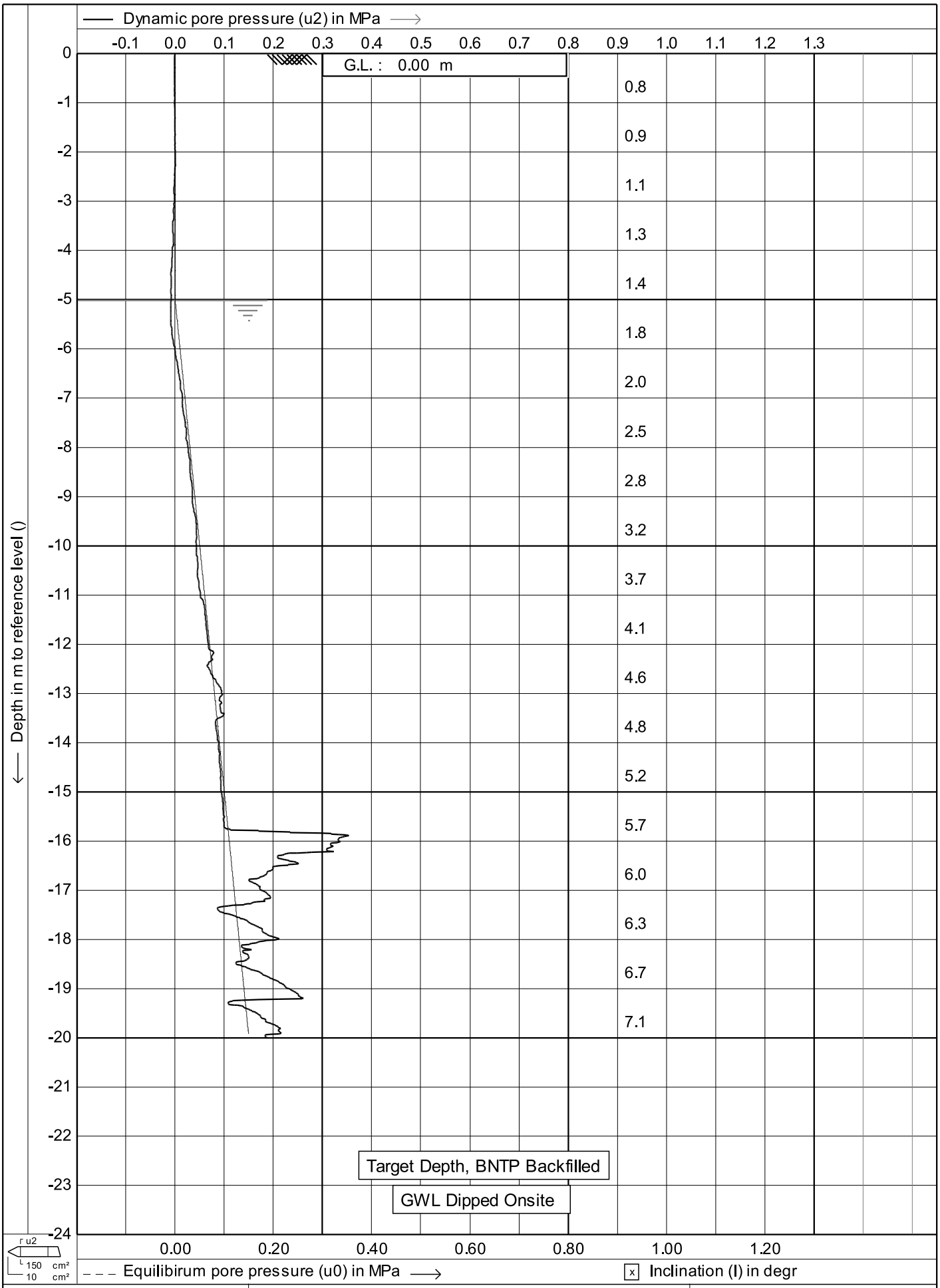
Date : **12/05/2020**

Cone no. : **C10CFIIP.C13081**

Project no. : **02CMW01**

CPT no. : **09**

1.48



PERRY GEOTECH

ASTM D5778-12

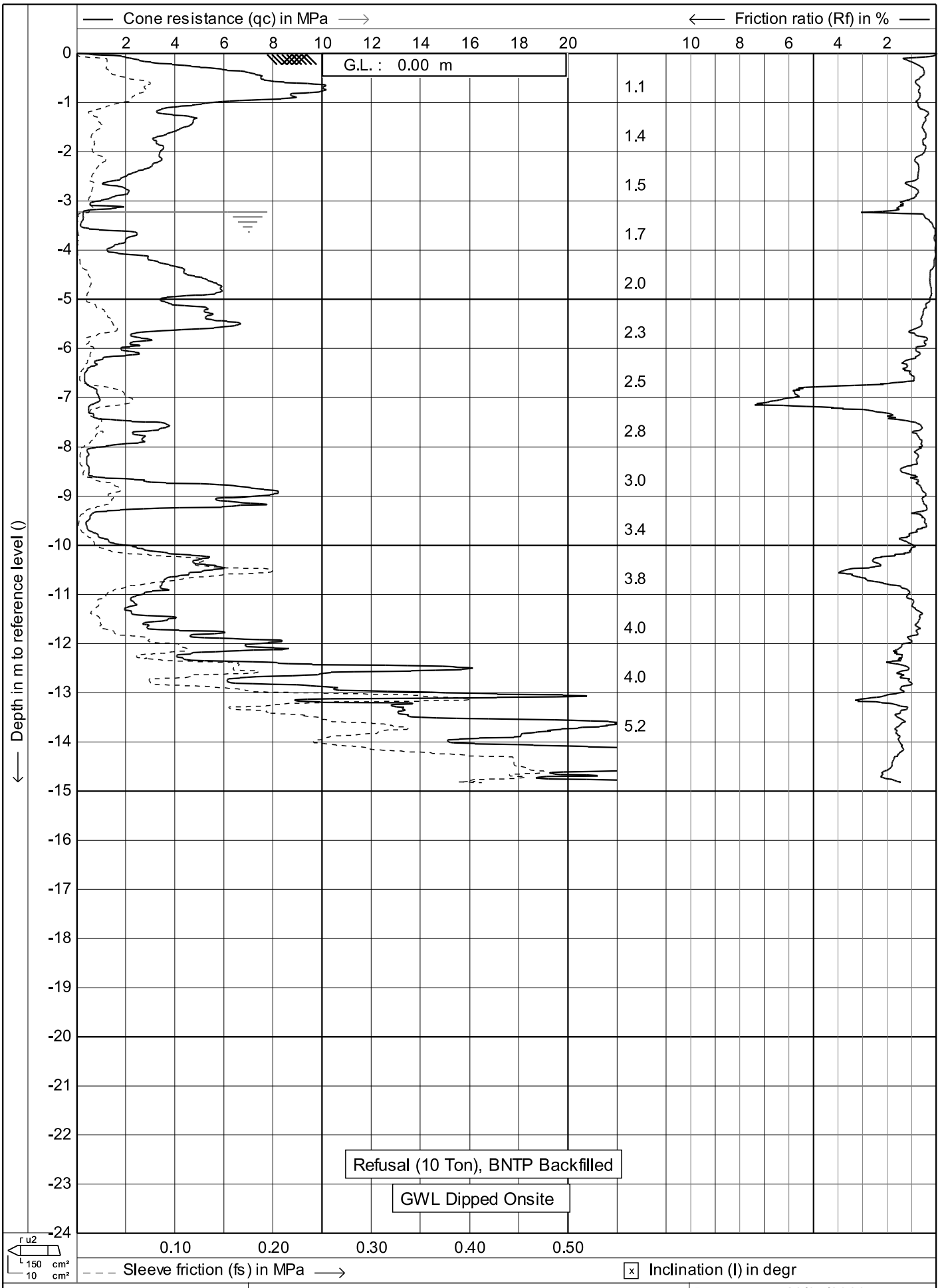
Project :

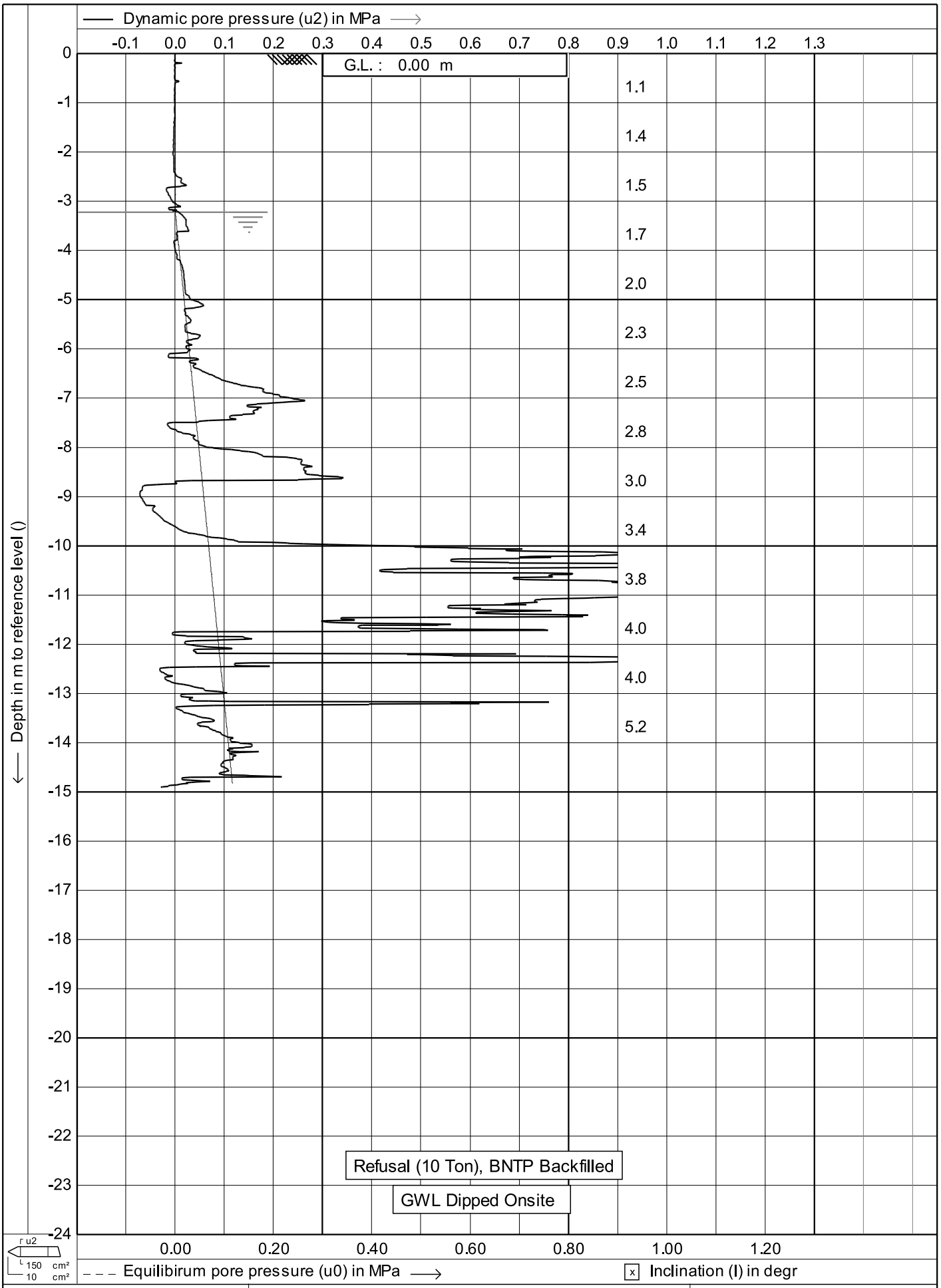
Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **12/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **09**

1.48


Cone resistance (qc) in MPa
Friction ratio (Rf) in %
G.L. : 0.00 m
Depth in m to reference level ()
Refusal (10 Ton), BNTP Backfilled
GWL Dipped Onsite
Sleeve friction (fs) in MPa
Inclination (I) in degr
ASTM D5778-12
PERRY GEOTECH
Project :
Location: East Mine Rd - Huntly
Position: 0, 0
Date : 12/05/2020
Cone no. : C10CFIIP.C13081
Project no. : 02CMW01
CPT no. : 10
1/14



PERRY GEOTECH

ASTM D5778-12

Project :

Location: **East Mine Rd - Huntly**

Position: **0, 0**

Date	: **12/05/2020**
Cone no.	: **C10CFIIP.C13081**
Project no.	: **02CMW01**
CPT no.	: **10**

1.48

Appendix D: Natural Hazards Risk Assessment

NATURAL HAZARDS RISK ASSESSMENT FOR LAND SUBDIVISION EAST MINE ROAD, HUNTLY

A. CONTEXT

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land, other land or structures (consequence).

Section 2 of the RMA defines natural hazards as any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding) the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment.

This appendix to CMW report reference HAM2019-0082AF Rev.0 sets out the criteria for and presents the results of an assessment of the geotechnical-related natural hazards associated with this proposed subdivision development. The remaining hazards, i.e. tsunami, wind, drought, fire and flooding hazards are not covered by this assessment.

B. BASIS OF ASSESSMENT

B1. Risk Classification

The occurrence of natural hazards and their potential impacts on the proposed subdivision development is assessed in terms of risk significance, which is based on likelihood and consequence factors. A risk table is used to help assess the likelihood and consequence factors, the form of which used by CMW for this project is presented in Table B1.

Table B1: Natural Hazard Risk Classification

		Consequence				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	Almost Certain 5	Medium 5	High 10	Very high 15	Extreme 20	Extreme 25
	Likely 4	Low 4	Medium 8	High 12	Very high 16	Extreme 20
	Moderate 3	Low 3	Medium 6	Medium 9	High 12	Very high 15
	Unlikely 2	Very low 2	Low 4	Medium 6	Medium 8	High 10
	Rare 1	Very low 1	Very low 2	Low 3	Low 4	Medium 5

B2. Likelihood

With respect to assessing the likelihood or chance of the risk occurring, the qualitative definitions used by CMW for this project are provided in Table B2 for each likelihood classification.

Table B2: Qualitative Natural Hazard Likelihood Definitions		
1	Rare	The natural hazard is not expected to occur during the design life of the project
2	Unlikely	The natural hazard is unlikely, but may occur during the design life
3	Moderate	The natural hazard will probably occur at some time during the life of the project
4	Likely	The natural hazard is expected to occur during the design life of the project
5	Almost Certain	The natural hazard will almost definitely occur during the design life of the project

B3. Consequence

In terms of determining the consequence or severity of the natural hazard occurring, the qualitative definitions used by CMW for this project are provided in Table B3 for each consequence classification.

Table B3: Qualitative Natural Hazard Consequence Definitions		
1	Insignificant	Very minor to no damage, not requiring any repair, no people at risk, no economic effect to landowners.
2	Minor	Minor damage to land only, any repairs can be considered normal property maintenance no people at risk, very minor economic effect.
3	Moderate	Some damage to land requiring repair to reinstate within few months, minor cosmetic damage to buildings being within relevant code tolerances, does not require immediate repair, no people at risk, minor economic effect.
4	Major	Significant damage to land requiring immediate repair, damage to buildings beyond serviceable limits requiring repair, no collapse of structures, perceptible effect to people, no risk to life, considerable economic effect.
5	Catastrophic	Major damage to land and buildings, possible structure collapse requiring replacement, risk to life, major economic effect or possible site abandonment.

B4. Risk Acceptance

It is recognised that the natural hazard risk assessment provided herein is qualitative and, due to the wide range of possible geohazards that could occur, is somewhat subjective. Other methods are available to quantitatively assess an acceptable level of geotechnical related natural hazard risk, such as defining an acceptable factor of safety with respect to slope stability or acceptable differential ground settlements with respect to recommended building code limits.

Therefore, to give this qualitative natural hazard risk assessment some relevance to more commonly adopted numerical or quantitative geotechnical assessment techniques, a residual risk rating of very low to medium (risk value = 1 to 9 inclusive) is considered an acceptable result for the proposed subdivision development.

A risk rating of high to extreme (risk value ≥ 10) is considered an unacceptable result for the proposed subdivision development.

C. RISK ASSESSMENT

The natural hazards relevant to this proposed subdivision development and adjacent, potentially affected land have been assessed with respect to the criteria outlined above.

Assessment is based on proposed post development ground conditions with and without any geotechnical controls. The latent risk was first assessed with the site in its proposed developed state to consider the risks to the development and surrounding land, including assessment of land modifications from the pre-existing natural state, without any implemented geotechnical controls. The specific geotechnical mitigation measures and engineering design solutions outlined in the table below and CMW report, where relevant, were then considered to determine the natural hazard residual risk remaining after the proposed controls have been implemented.

Results of this assessment are presented in Table C1 below.

Table C1: Natural Hazard Risk Assessment Results

RMA S2 Hazard	Description	Proposed Site Latent Risk of Damage to Land / Structures			Comments and Geotechnical Control	Proposed Site Residual Risk of Damage to Land / Structures OR Acceleration/ Worsening of Hazard with Geotechnical Controls Implemented		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Earthquake	Fault Rupture	1	4	Low 4	Low proximity to active faults.	1	4	Low 4
	Liquefaction Induced Flooding and/ or Subsidence	1	5	Medium 5	Ground improvement of the near surface soils of Areas 1 and 2	1	4	Low 4
	Lateral Spread	1	5	Medium 5	Ground improvement of the near surface soils of Areas 1 and 2.	1	3	Low 3

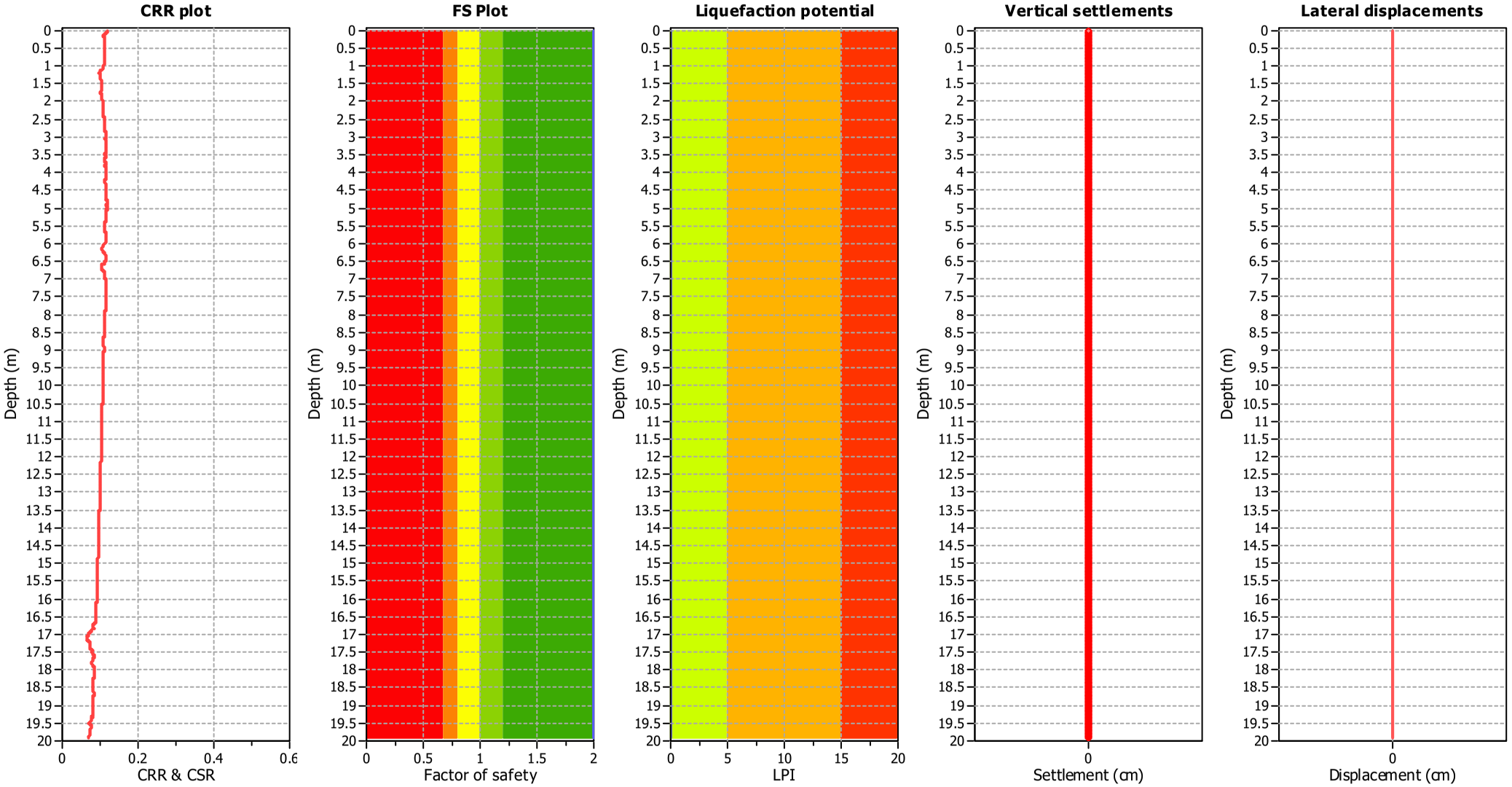
Volcanic Activity	Ash & Pyroclastic Falls	1	4	Low 4	Very low risk of occurrence	1	4	Low 4
	Lava flows & Lahars	1	4	Low 4	Very low risk of occurrence	1	4	Low 4
Geothermal Activity	Formation of geysers, hot springs, fumaroles, mud pools	1	4	Low 4	Very low risk of occurrence	1	4	Low 4
Erosion	Cut Batters	2	3	Medium 6	Max 1:3 gradient in cut batters. Grassing	1	3	Low 3
	Fill Batters	2	3	Medium 8	Max 1:3 gradient in cut batters. Grassing	1	3	Low 3
Landslip	Soil Creep	2	4	Medium 8	Set backs and regrading	1	3	Low 3
Subsidence	Soft or compressible soils	3	4	High 12	Ground improvement of the near surface soils in Areas 1 and 2. Preloading.	1	4	Low 4

Notes:

- Assessments include the impact of the proposed subdivision works on adjacent properties.
- The following reference(s) contain information on the hazards contained in this assessment and the non-geotechnical hazards that have not been included:
    - **Waikato** https://waikatoregion.maps.arcgis.com/apps/MapSeries/index.html?appid=f2b48398f93146e8a5cf0aa3fddce92c

Appendix E: Liquefaction Assessment Results

Liquefaction analysis overall plots



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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:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	30.00 m	Fill height:	N/A	Limit depth:	20.00 m

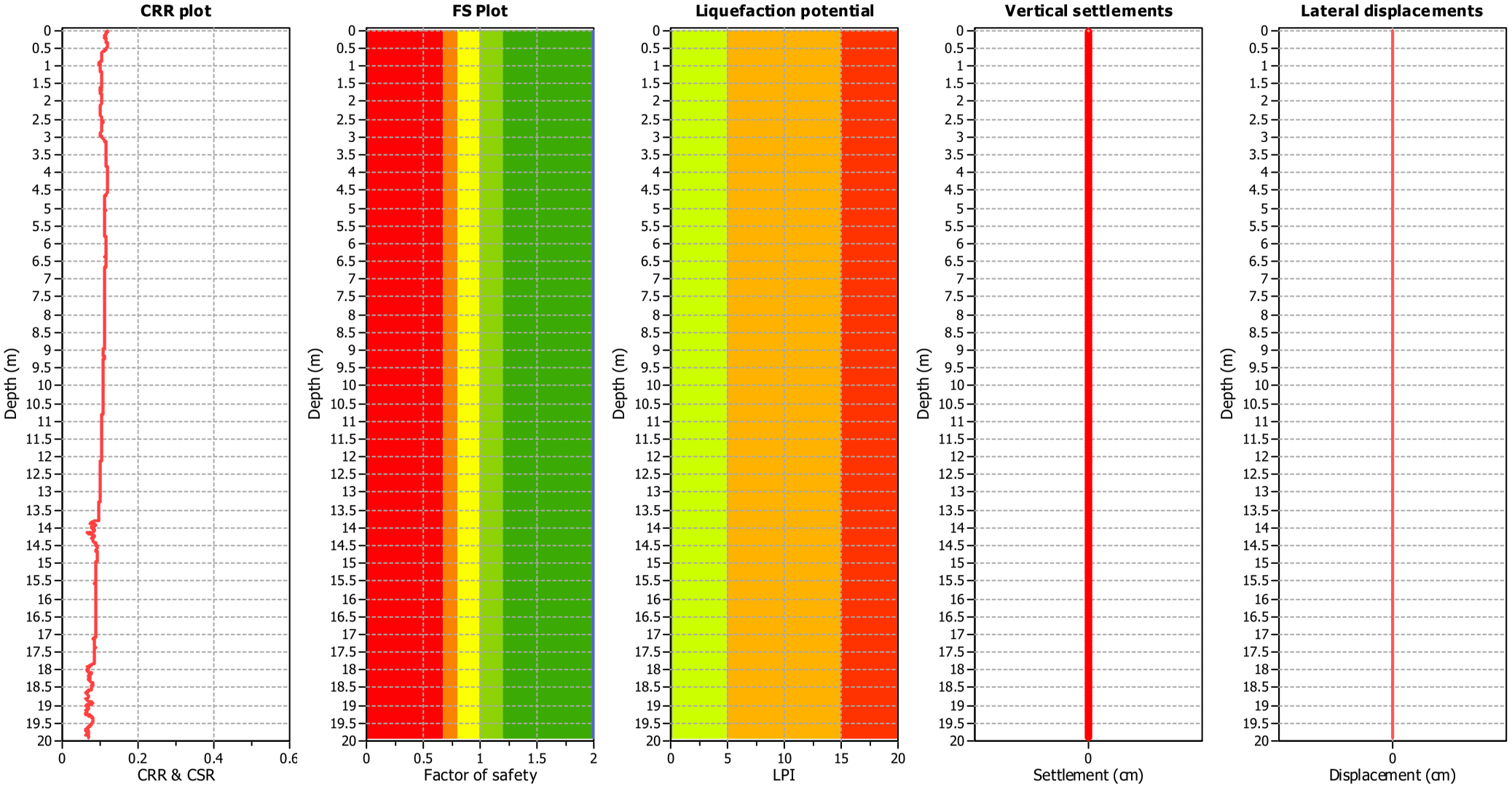
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	30.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	30.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

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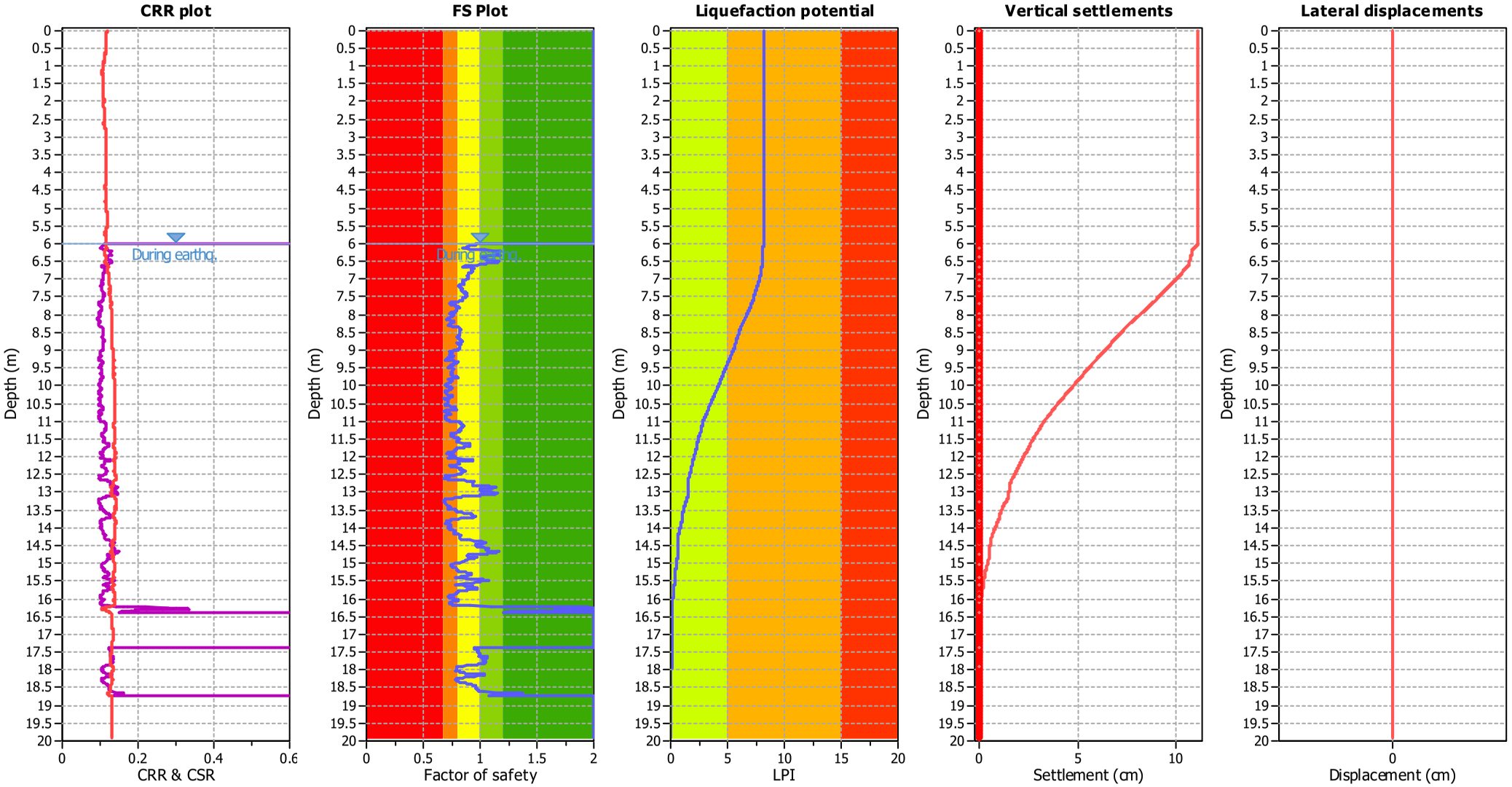
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis overall plots



Input parameters and analysis data

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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:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	6.00 m	Fill height:	N/A	Limit depth:	20.00 m

F.S. color scheme

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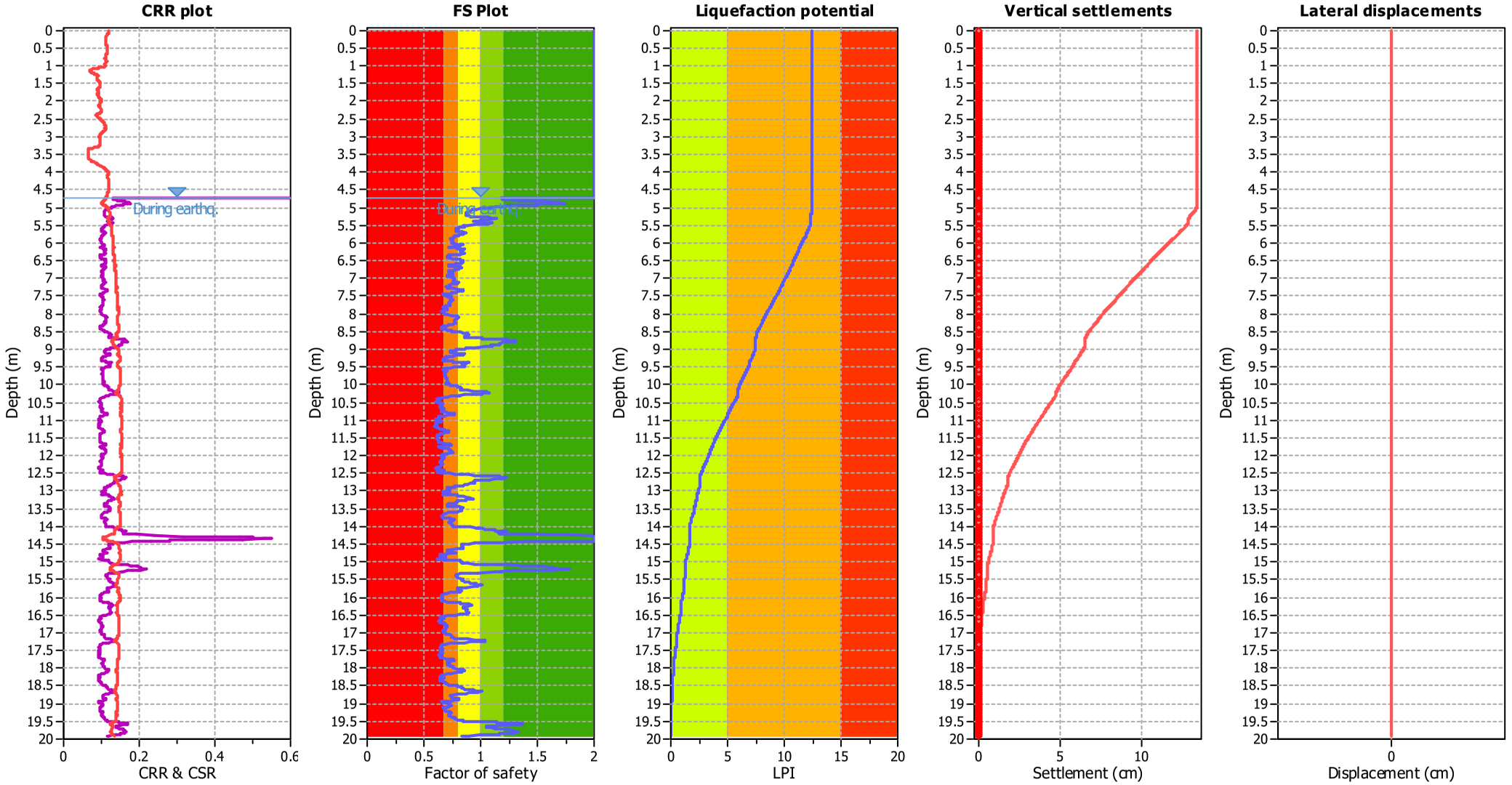
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis overall plots



Input parameters and analysis data

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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:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.10 m	Fill height:	N/A	Limit depth:	20.00 m

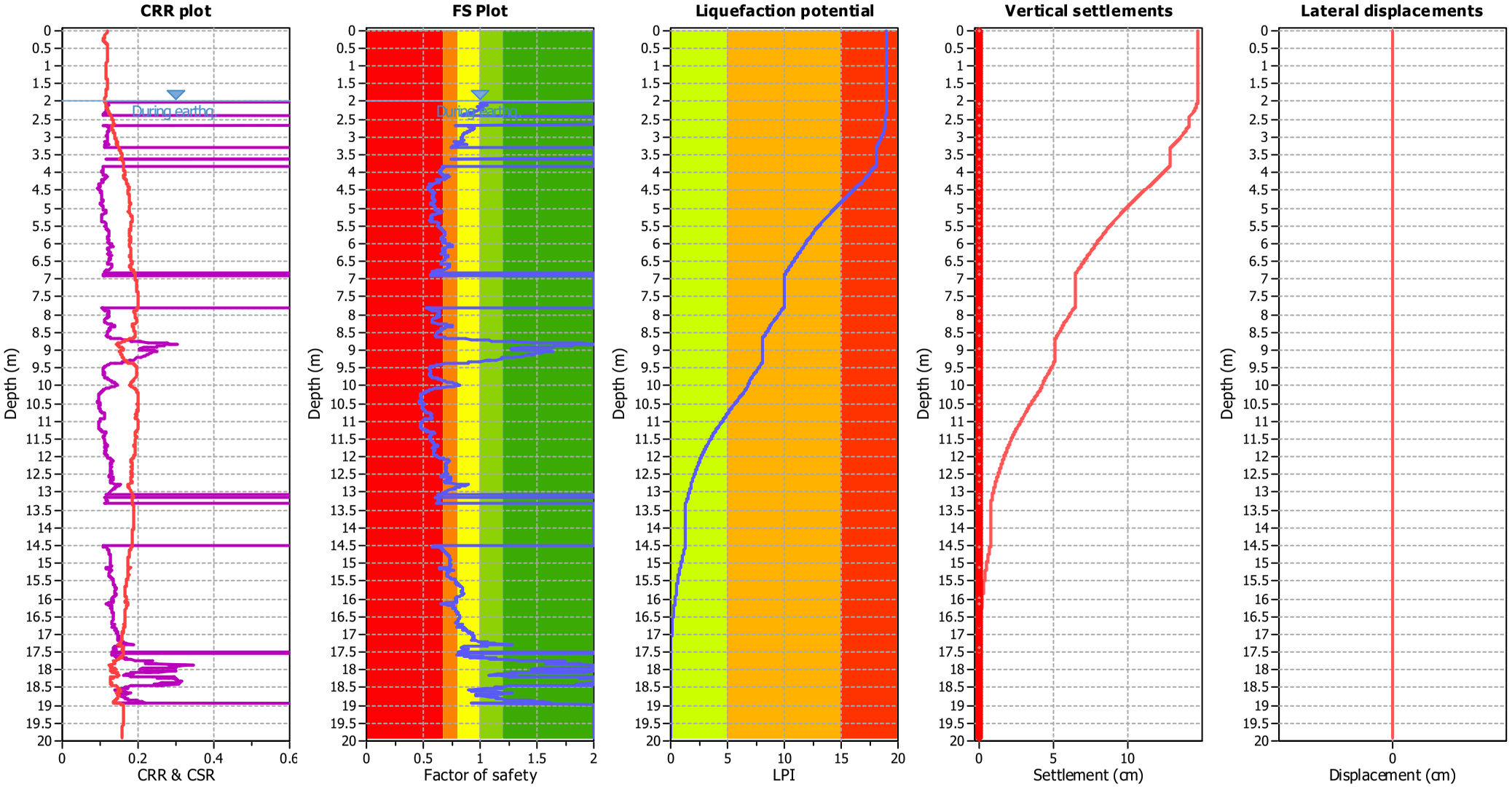
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

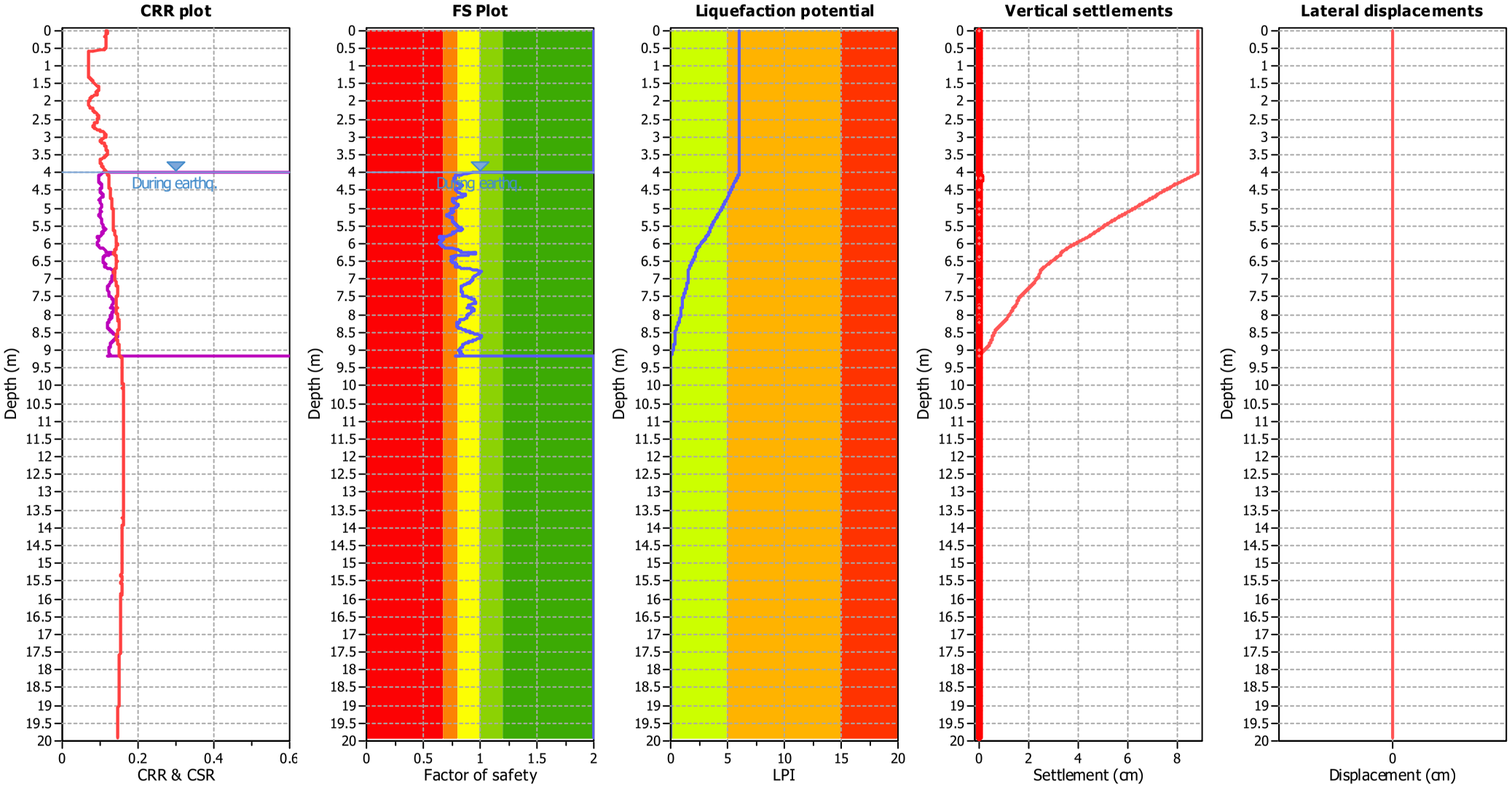
F.S. color scheme

- 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

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Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	20.00 m

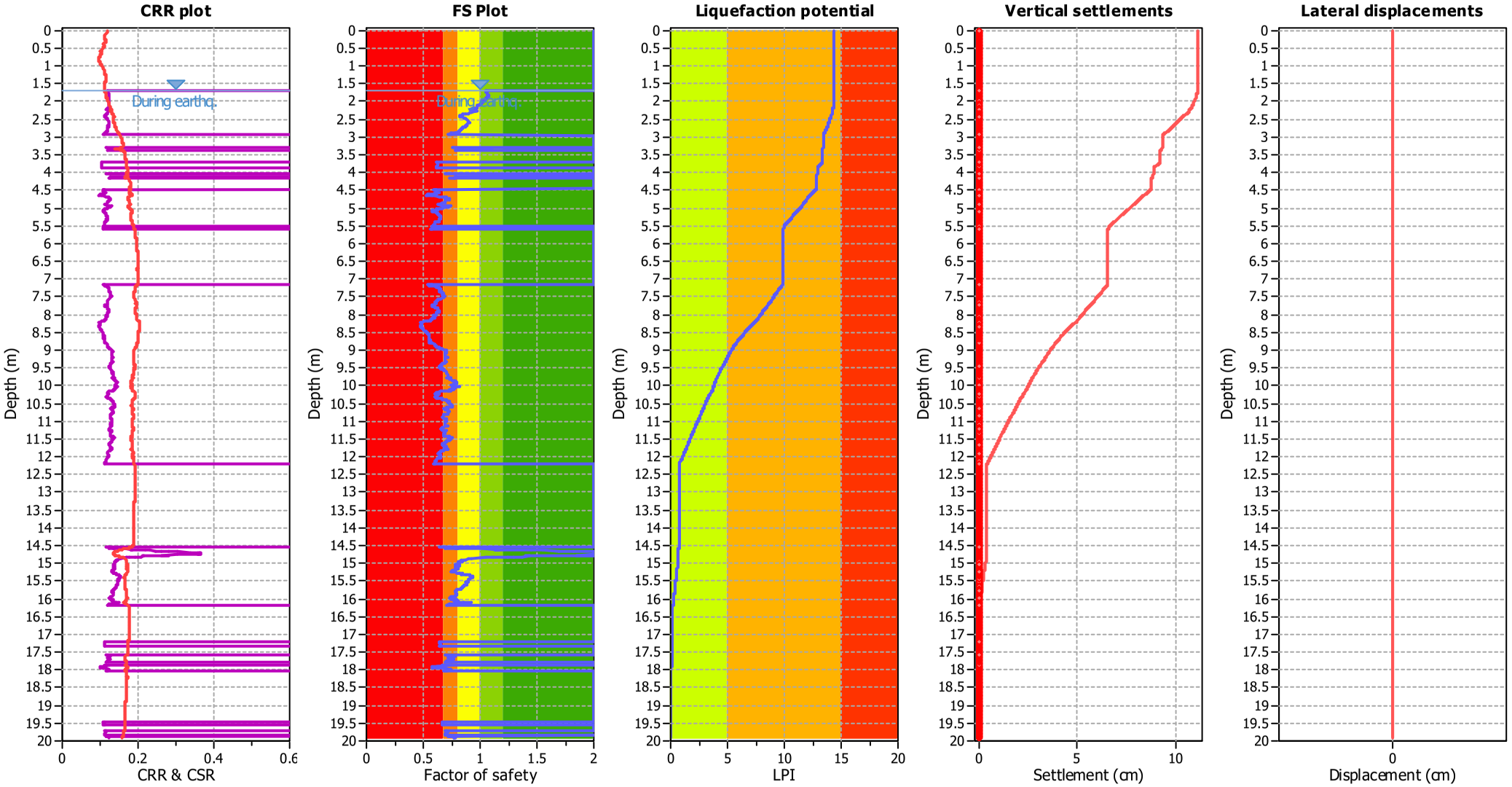
F.S. color scheme

- 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

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Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.70 m	Fill height:	N/A	Limit depth:	20.00 m

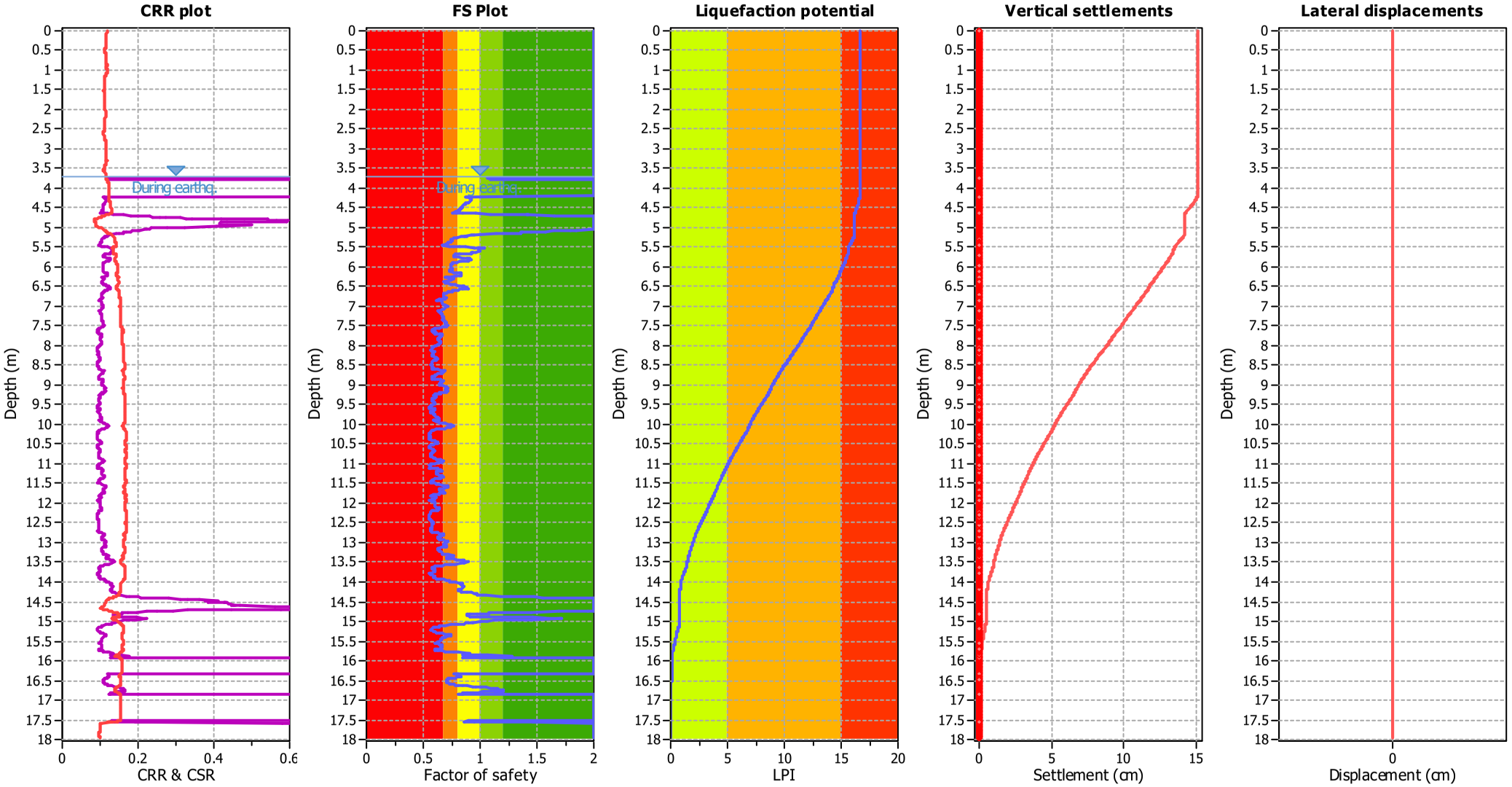
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	3.70 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.70 m	Fill height:	N/A	Limit depth:	20.00 m

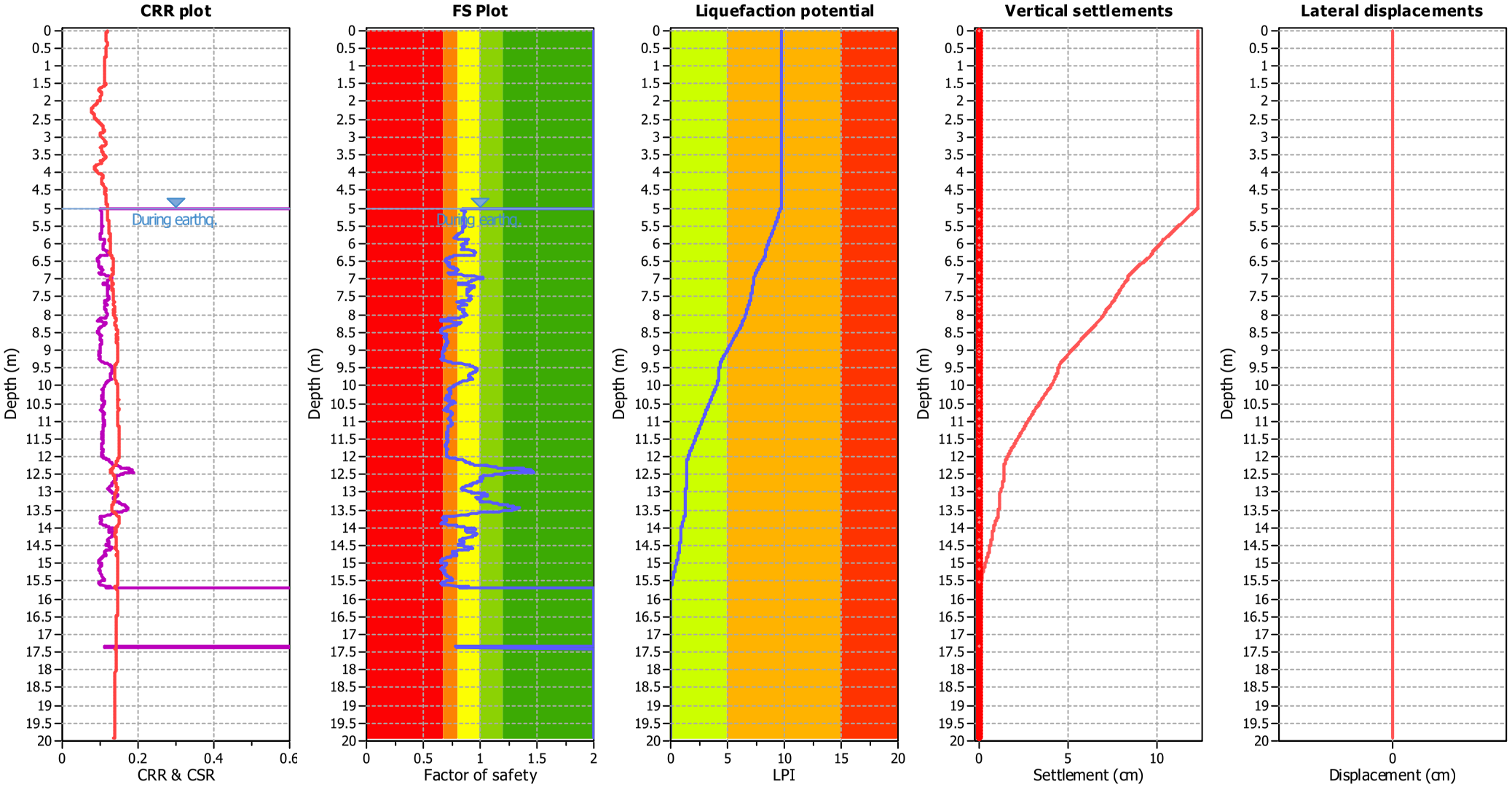
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	5.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	6.00 m	Fill height:	N/A	Limit depth:	20.00 m

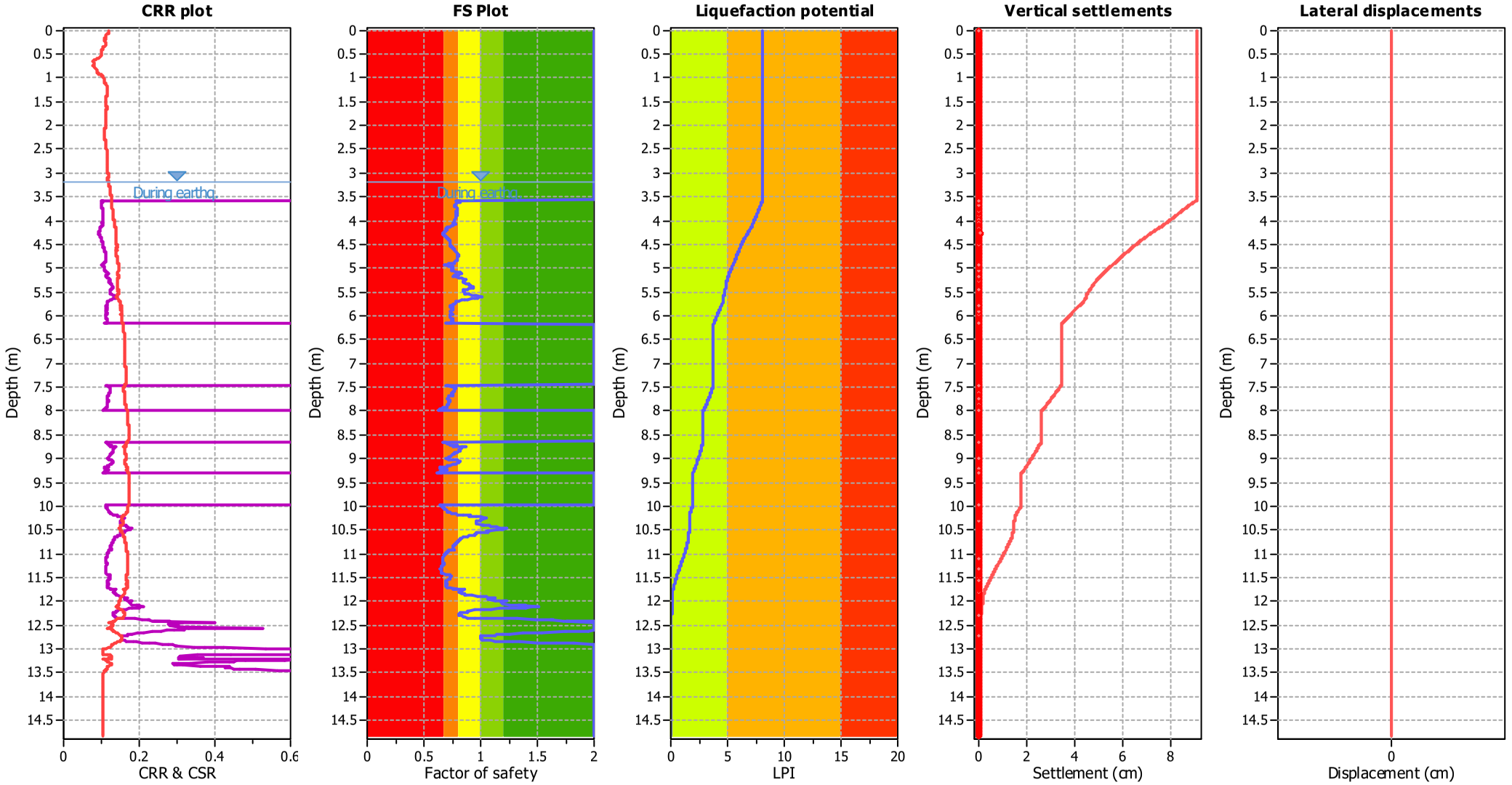
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	3.20 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.20 m	Fill height:	N/A	Limit depth:	20.00 m

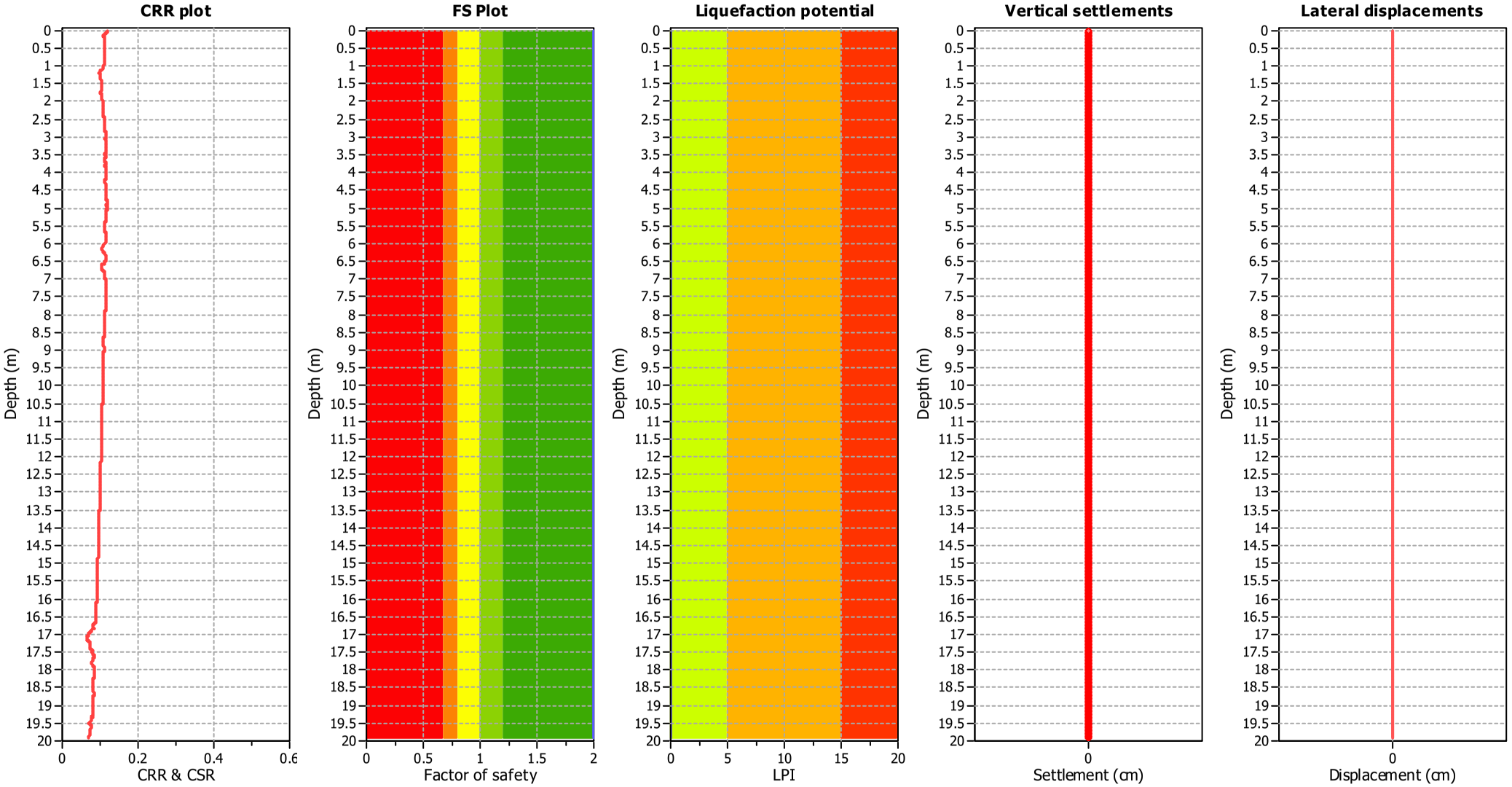
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	30.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	30.00 m	Fill height:	N/A	Limit depth:	10.00 m

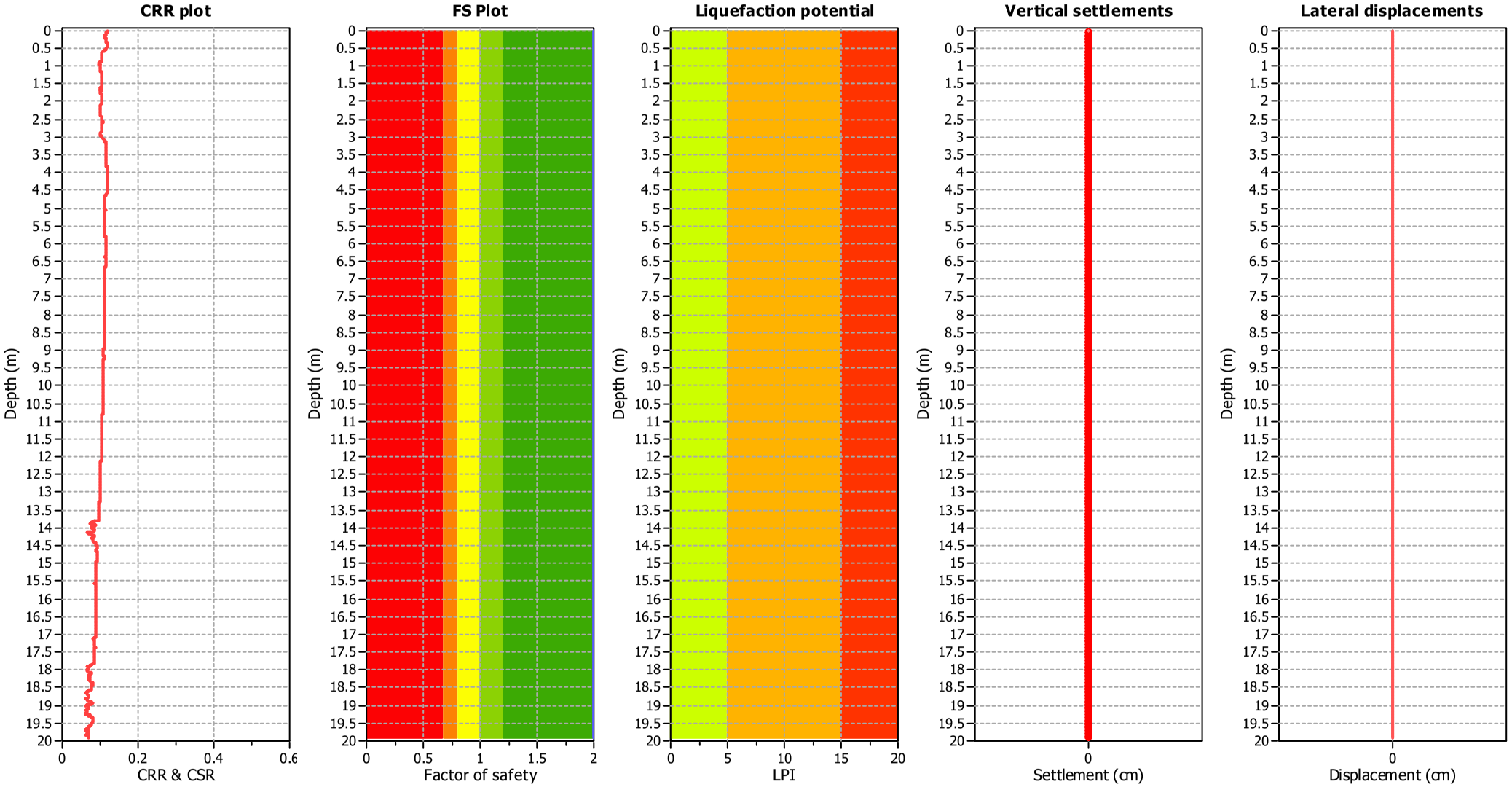
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	30.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	30.00 m	Fill height:	N/A	Limit depth:	10.00 m

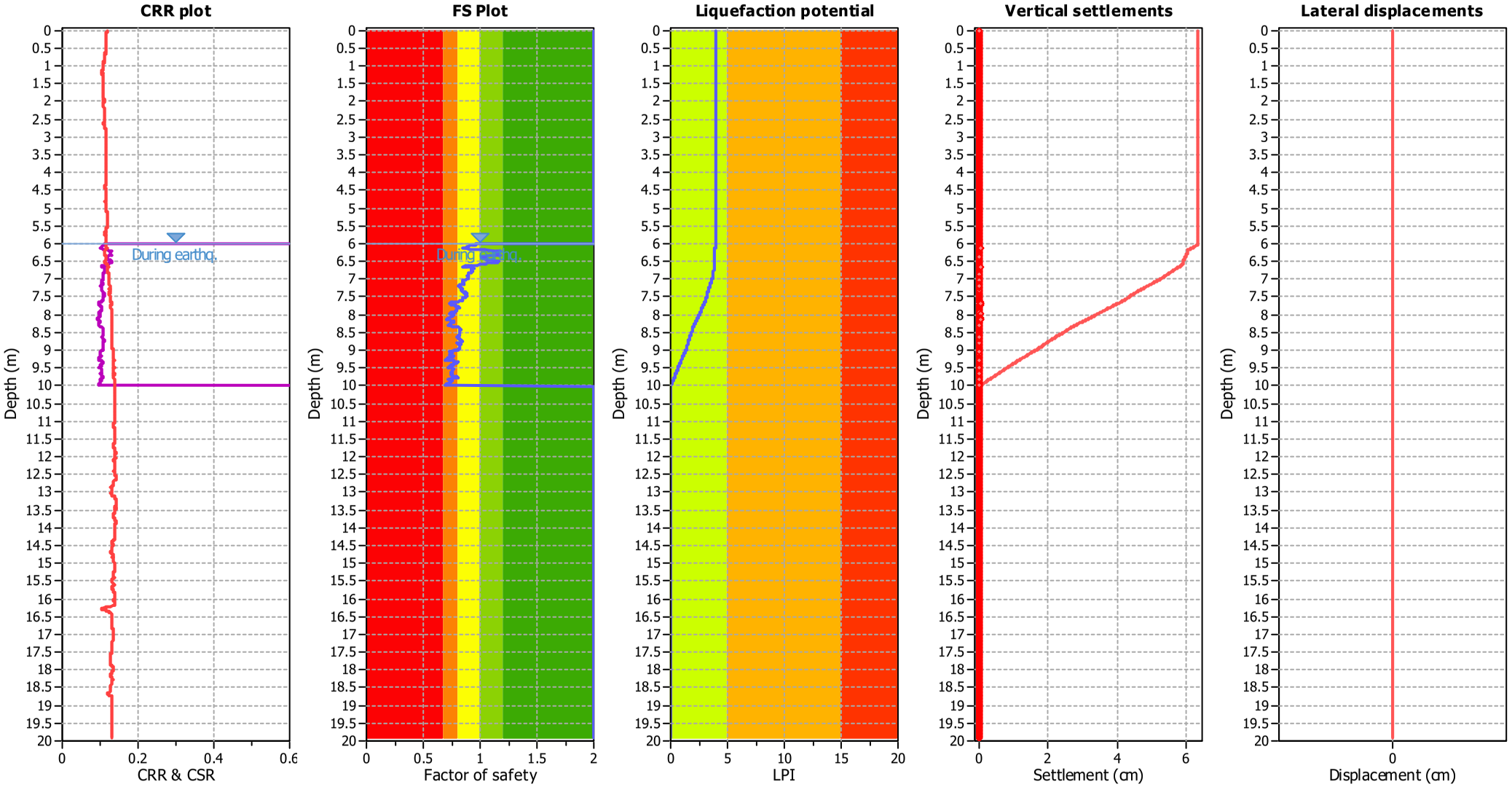
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	6.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	6.00 m	Fill height:	N/A	Limit depth:	10.00 m

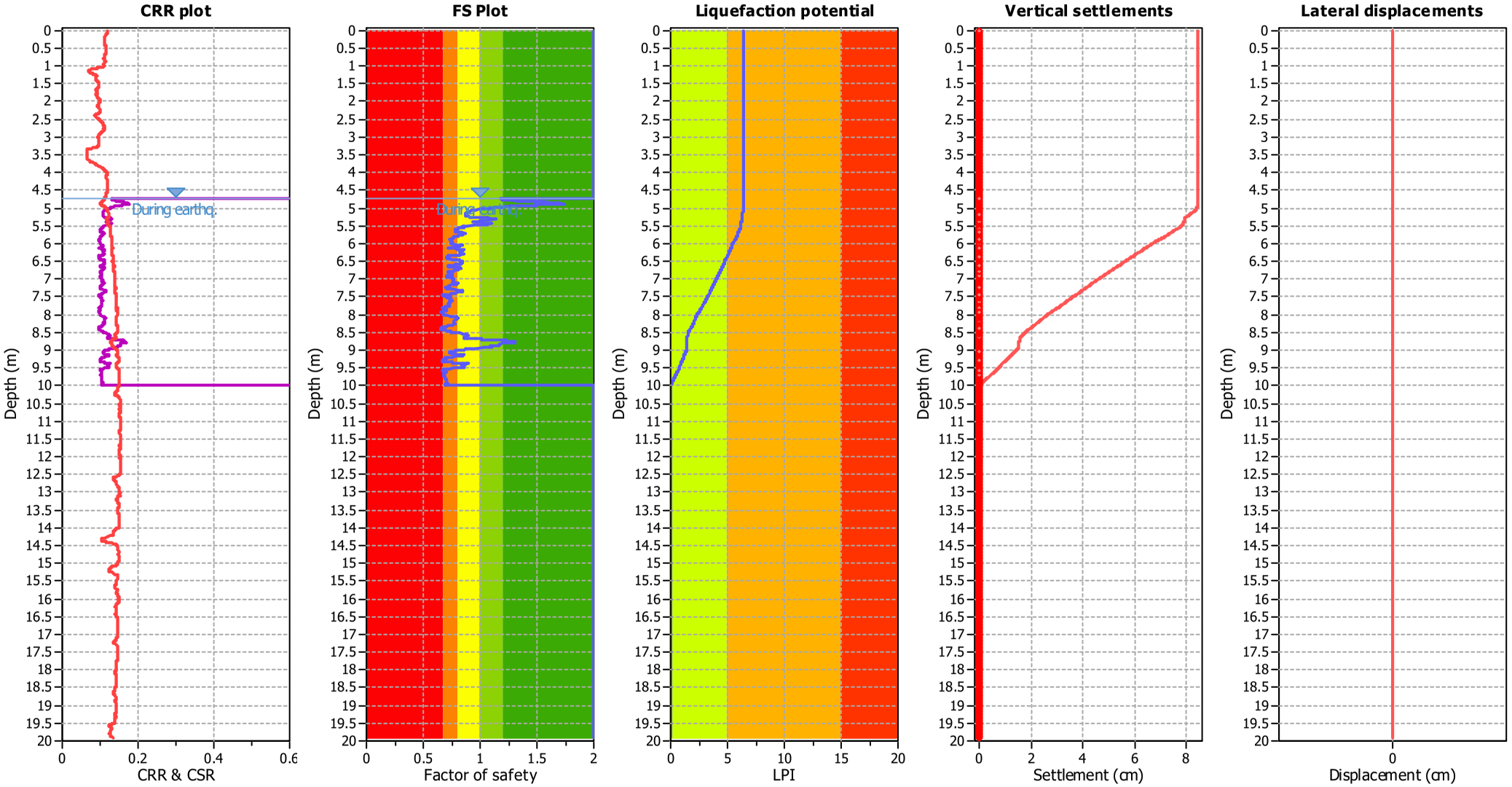
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	4.73 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	4.10 m	Fill height:	N/A	Limit depth:	10.00 m

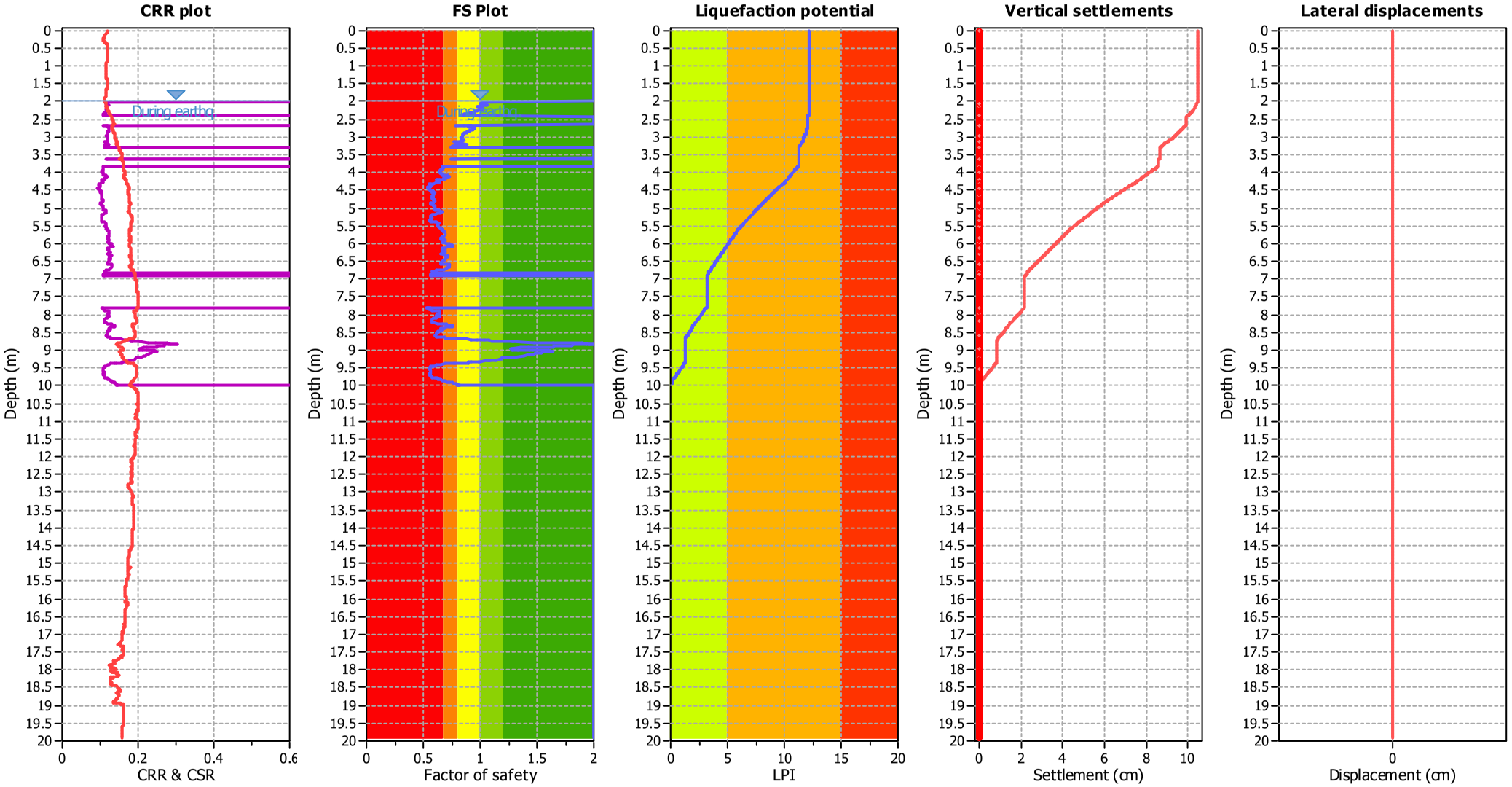
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	2.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	10.00 m

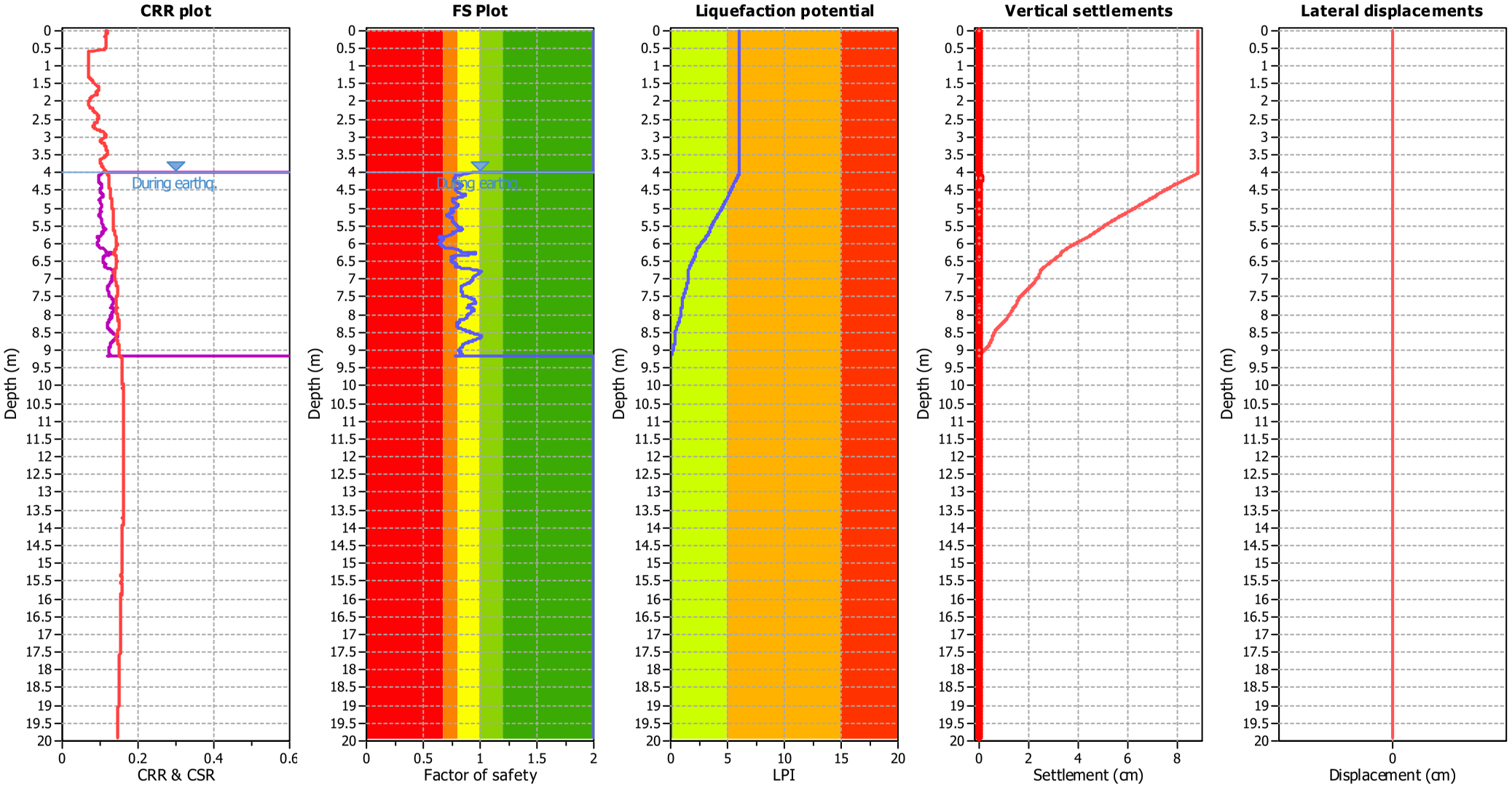
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	5.00 m	Fill height:	N/A	Limit depth:	10.00 m

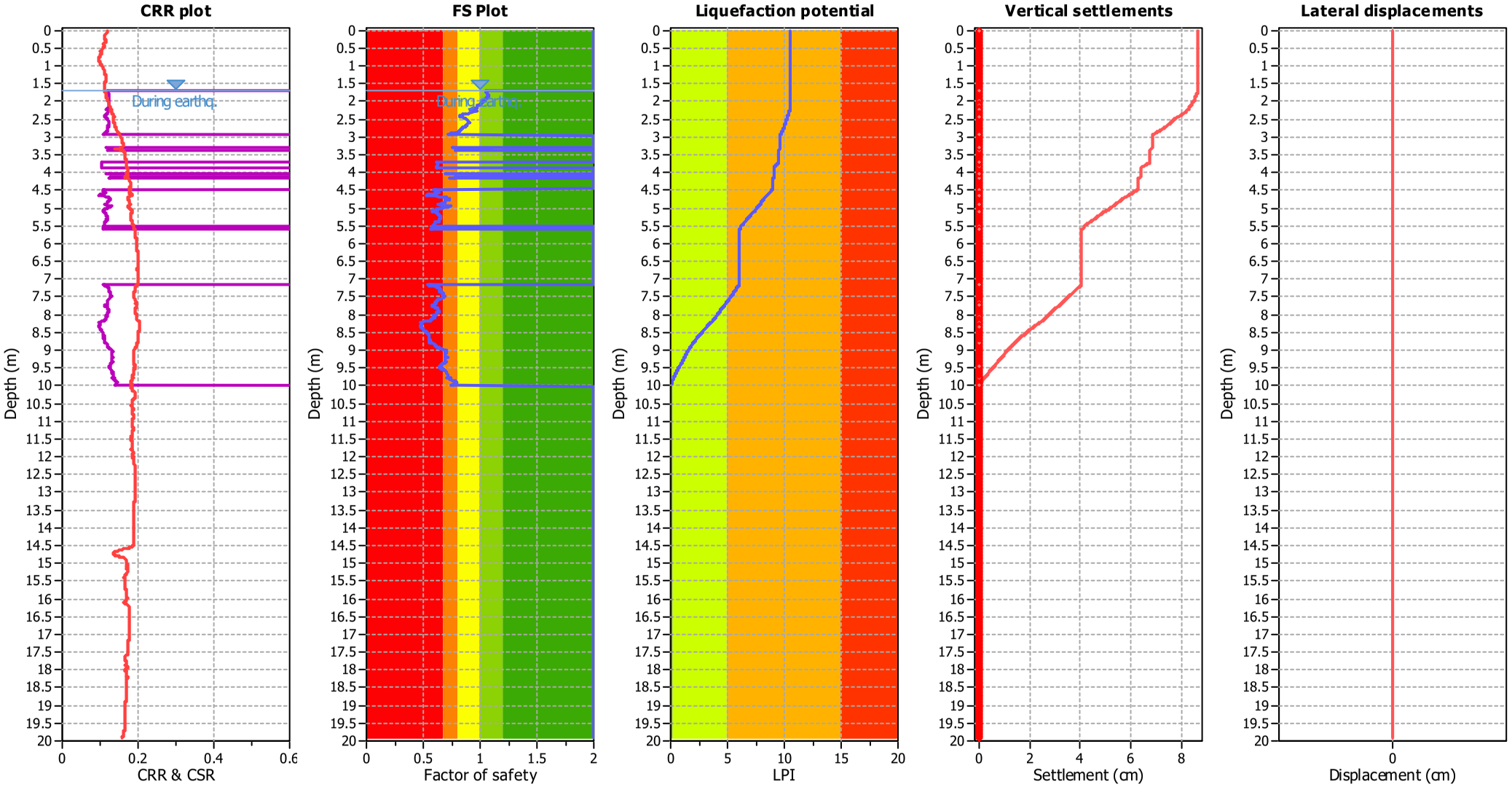
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	1.70 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.70 m	Fill height:	N/A	Limit depth:	10.00 m

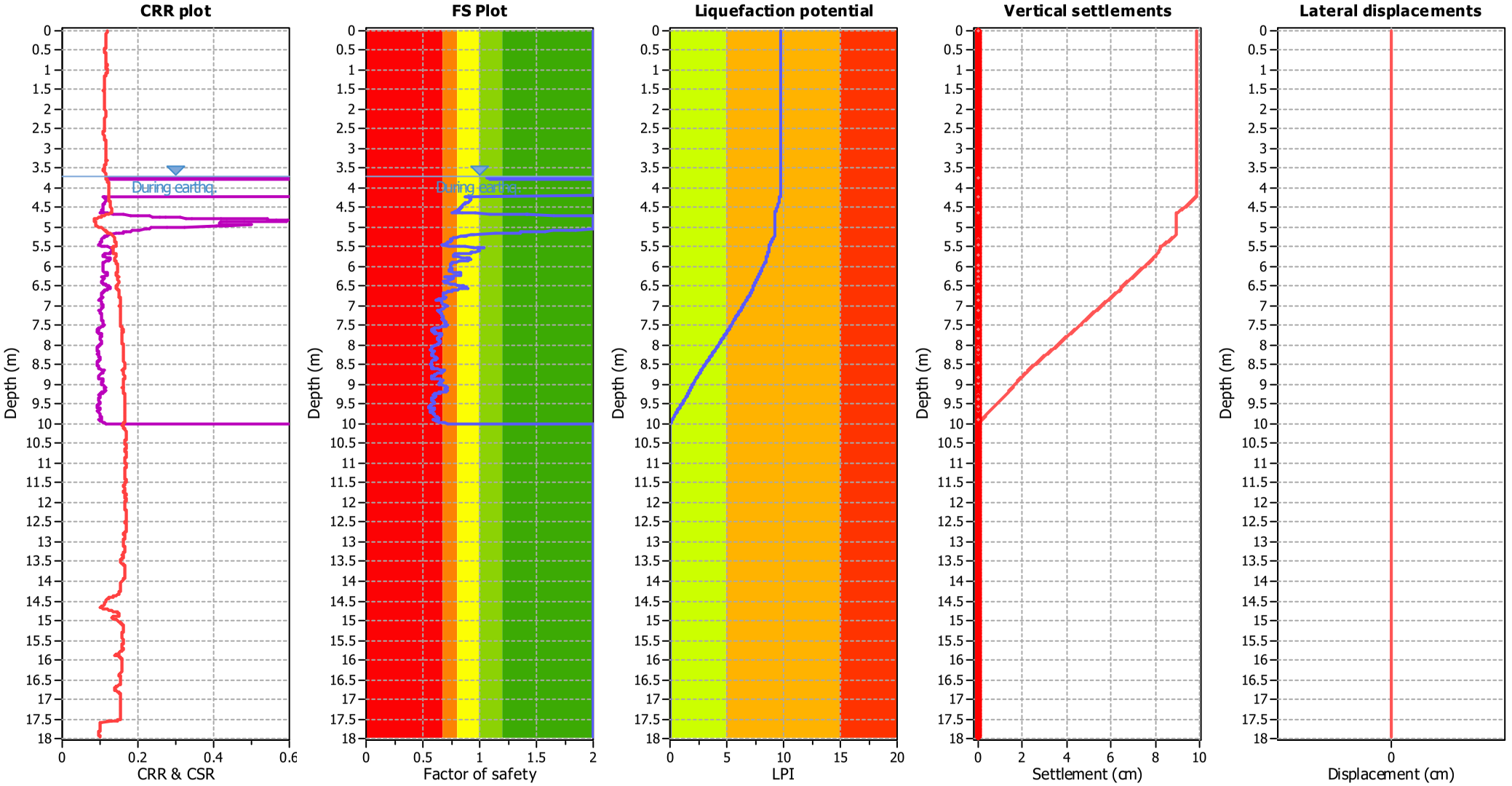
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	3.70 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.70 m	Fill height:	N/A	Limit depth:	10.00 m

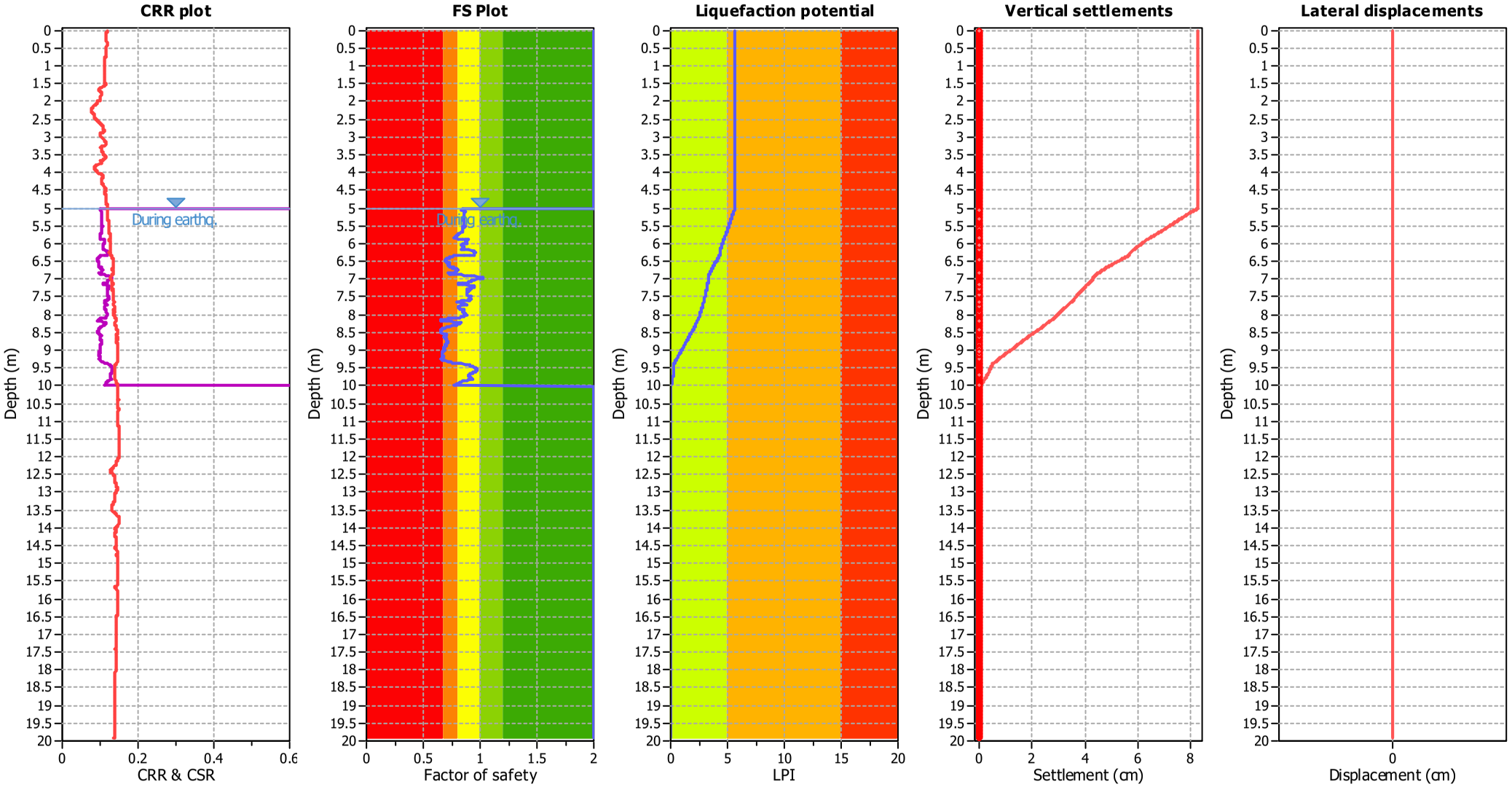
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	5.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	6.00 m	Fill height:	N/A	Limit depth:	10.00 m

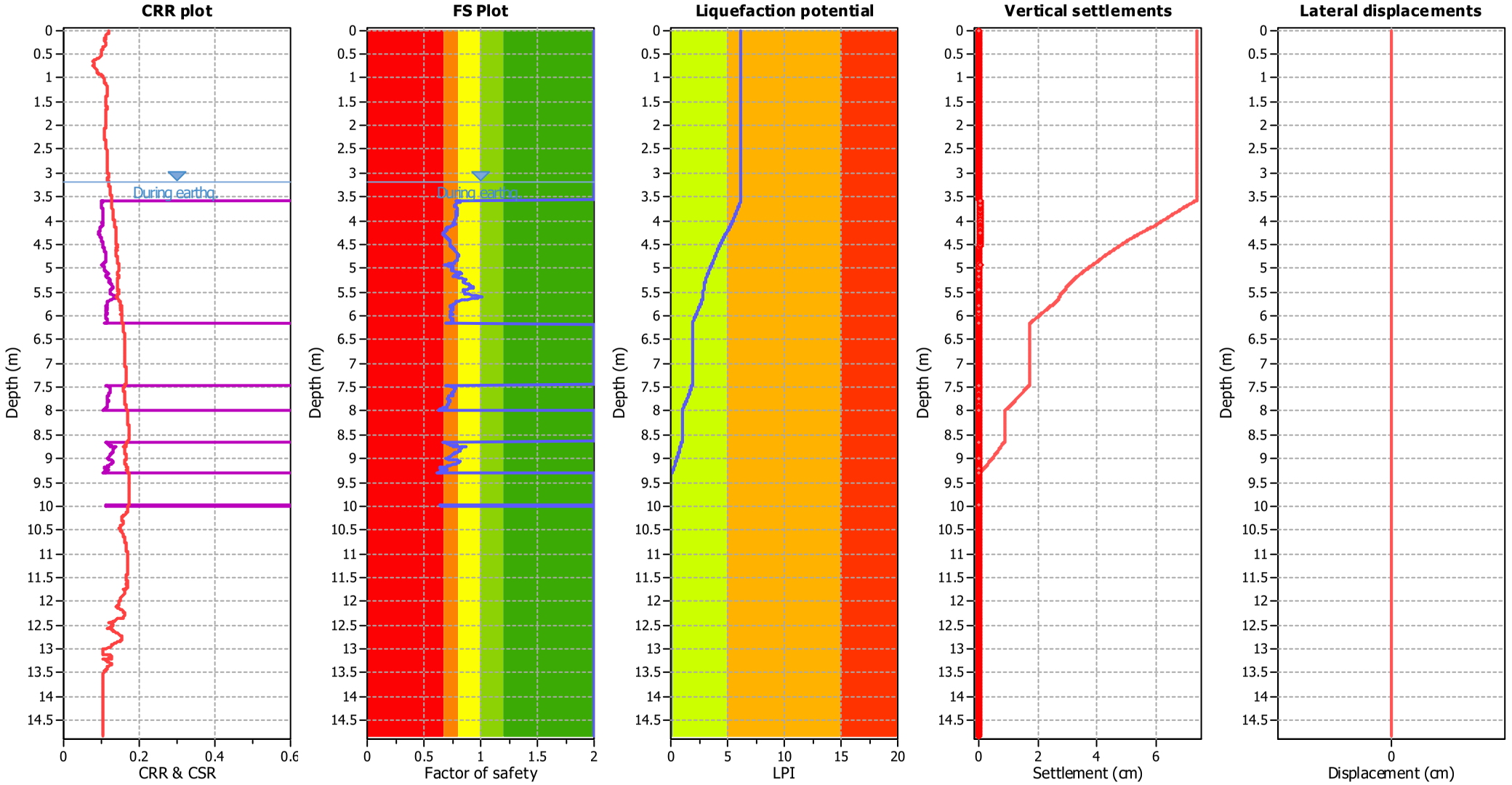
F.S. color scheme

- 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:	B&I (2014)	Depth to GWT (erthq.):	3.20 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	5.80	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.20 m	Fill height:	N/A	Limit depth:	10.00 m

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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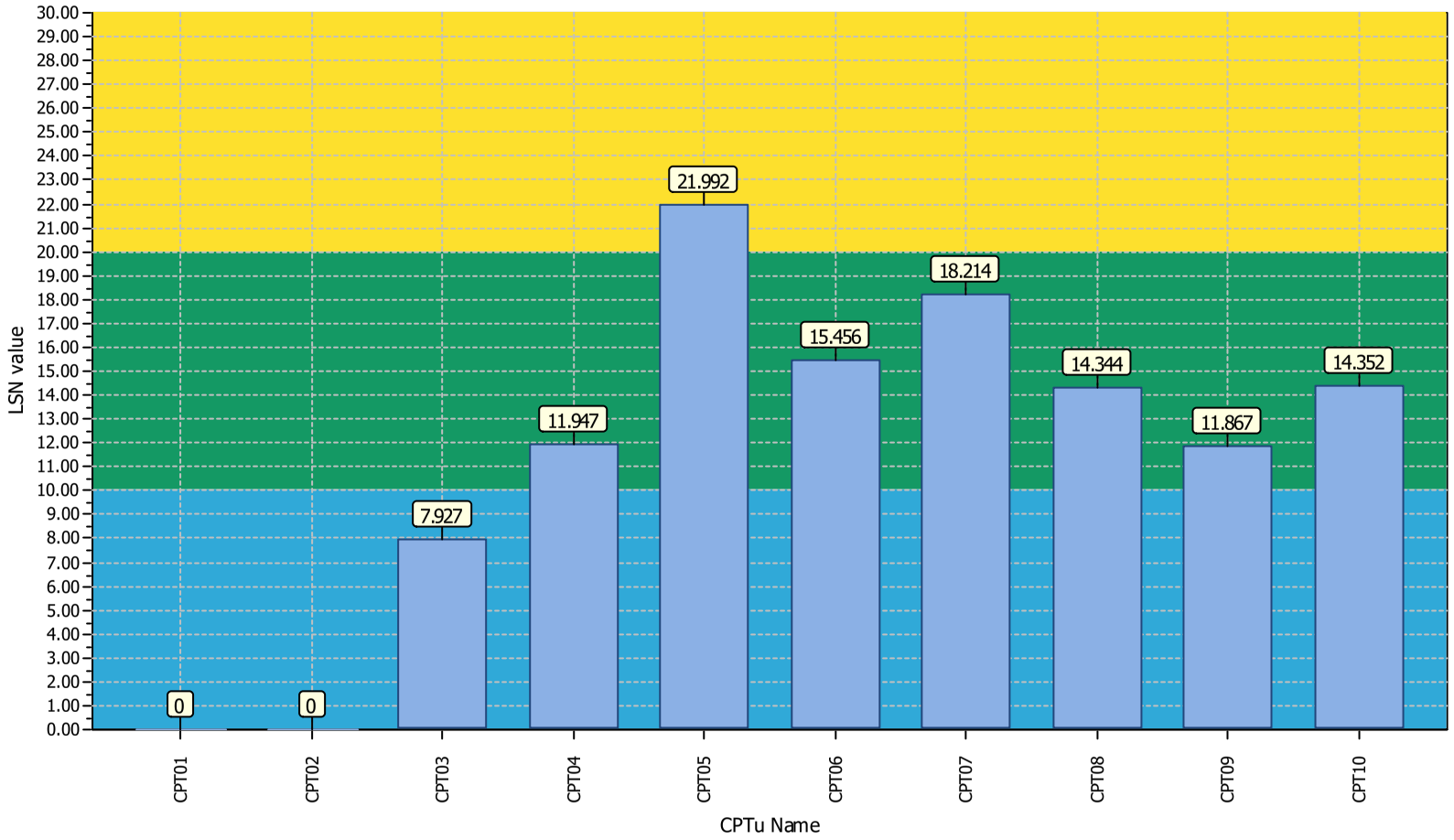
Merarhias 56
http://www.geologismiki.gr

Project title :

Location :

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 10

30% little liquefaction

60% minor liquefaction

10% moderate liquefaction

0% moderate to major liquefaction

0% major liquefaction

0% severe liquefaction

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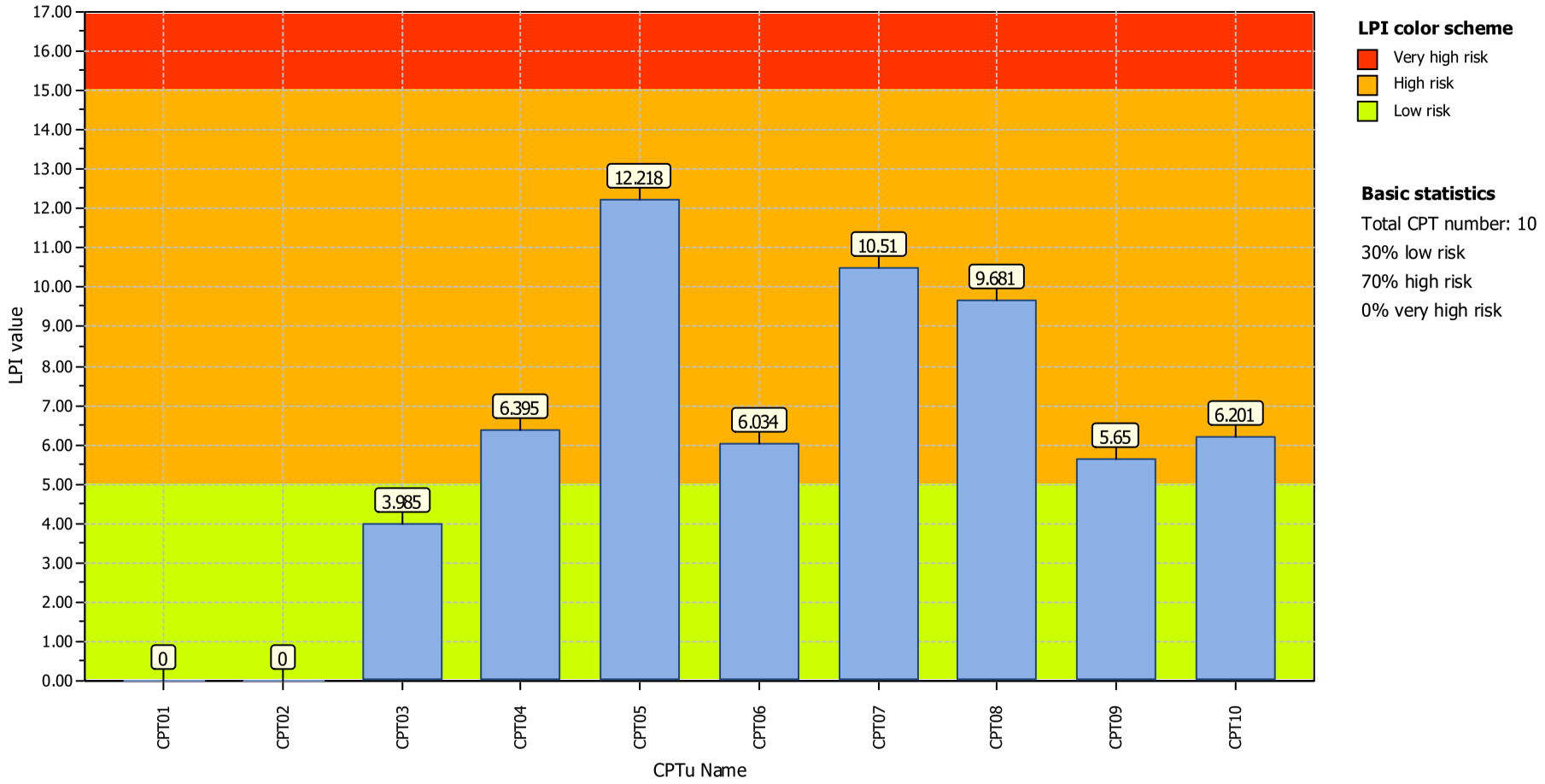
Project title :

Location :

Overall Liquefaction Potential Index report



Appendix F: Settlement Assessment Outputs

Estimated Settlement Areas 1 and 2 under 1m of Fill

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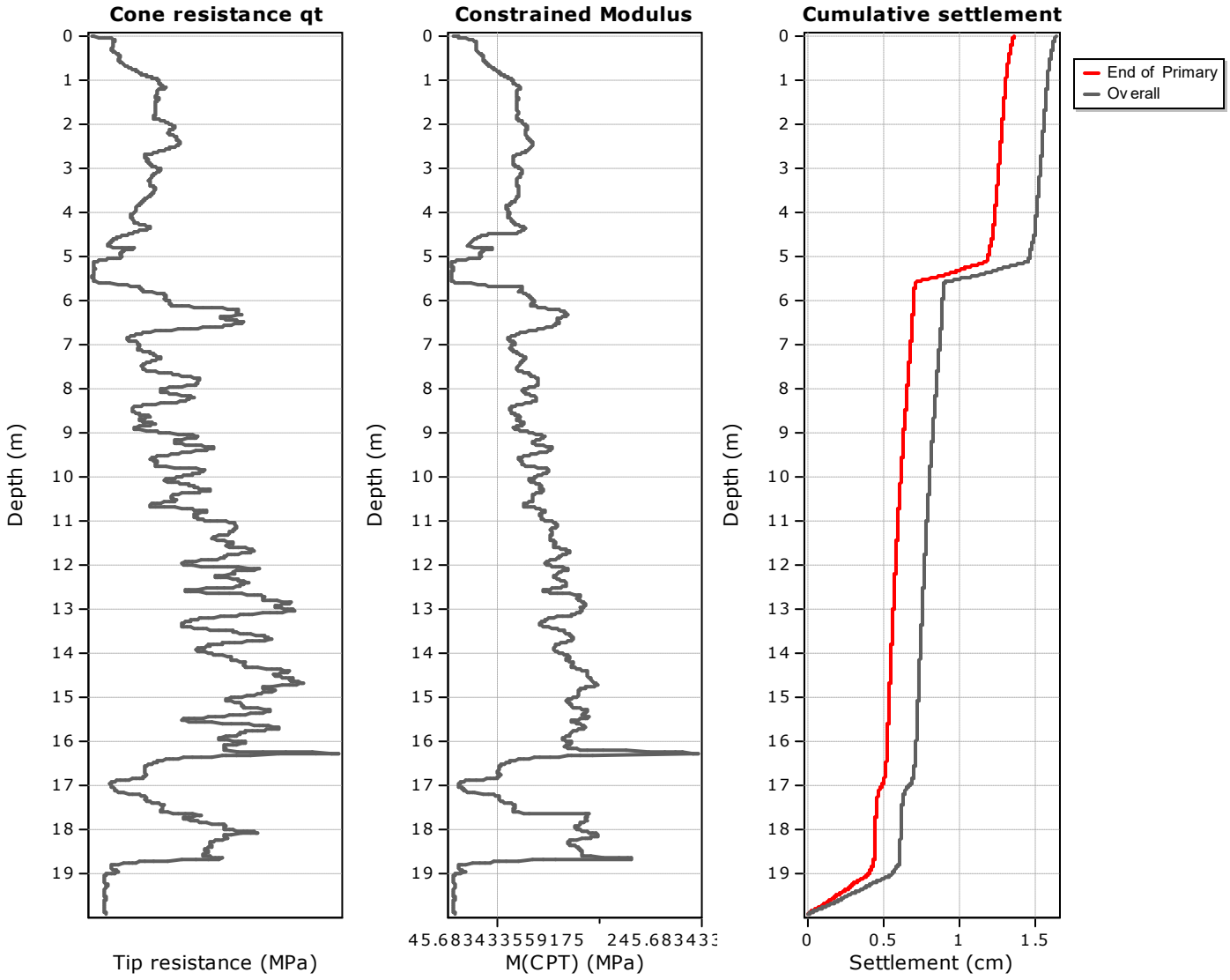
CPT: CPT03
Total depth: 19.92 m, Date: 5/06/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.00 (m)
L/B: 1.0
Footing pressure: 16.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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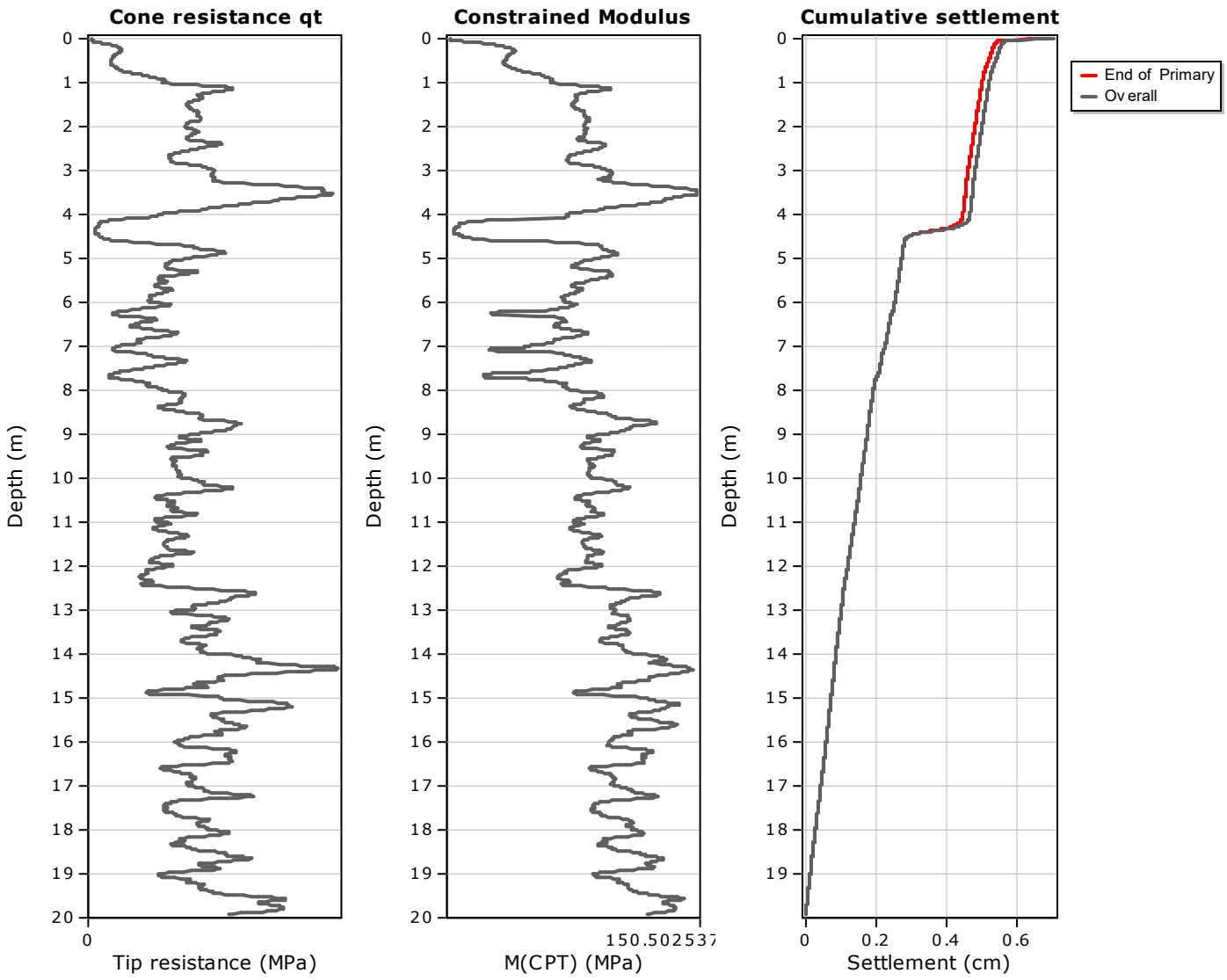
CPT: CPT04
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.00 (m)
L/B: 1.0
Footing pressure: 16.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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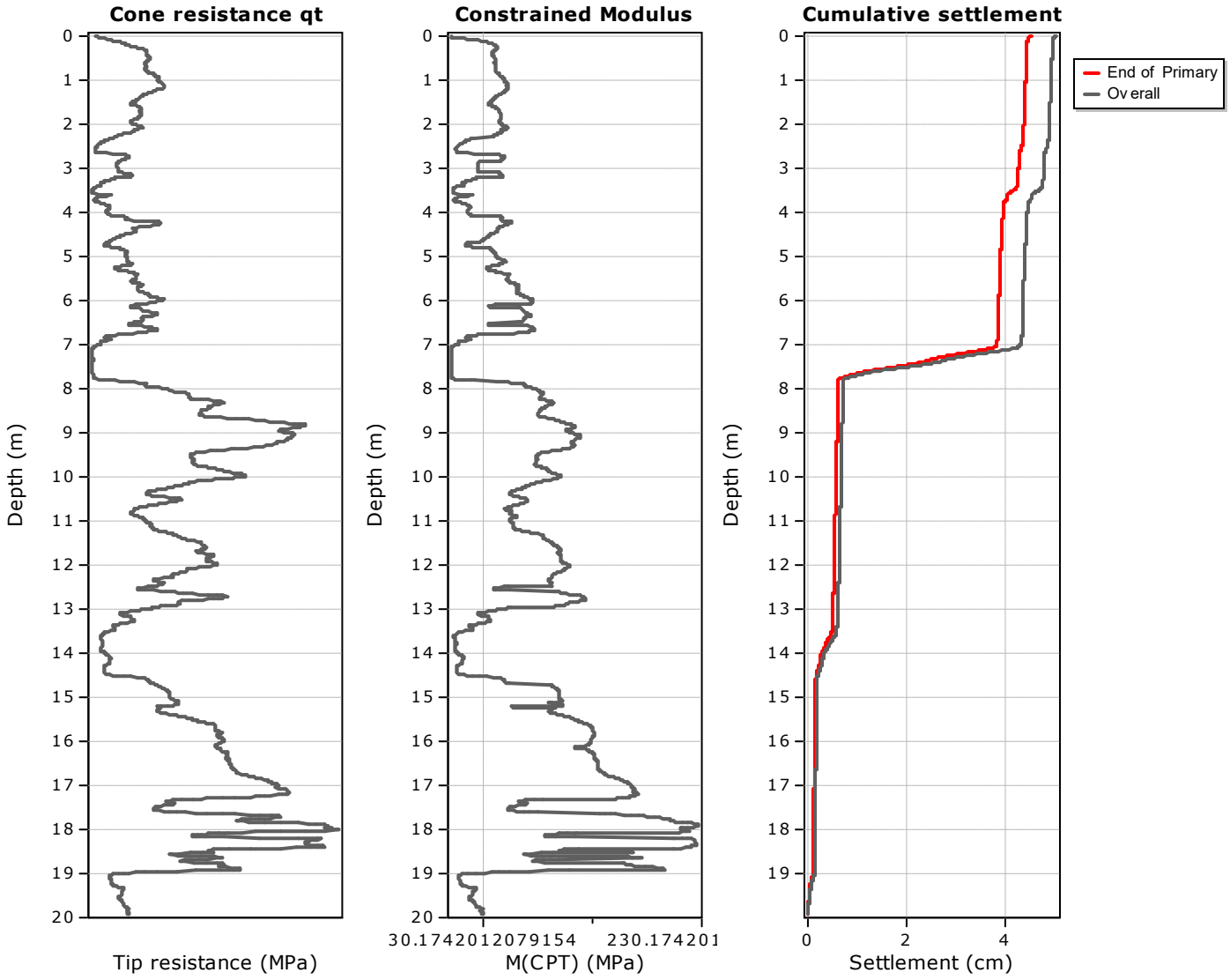
CPT: CPT05
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.00 (m)
L/B: 1.0
Footing pressure: 16.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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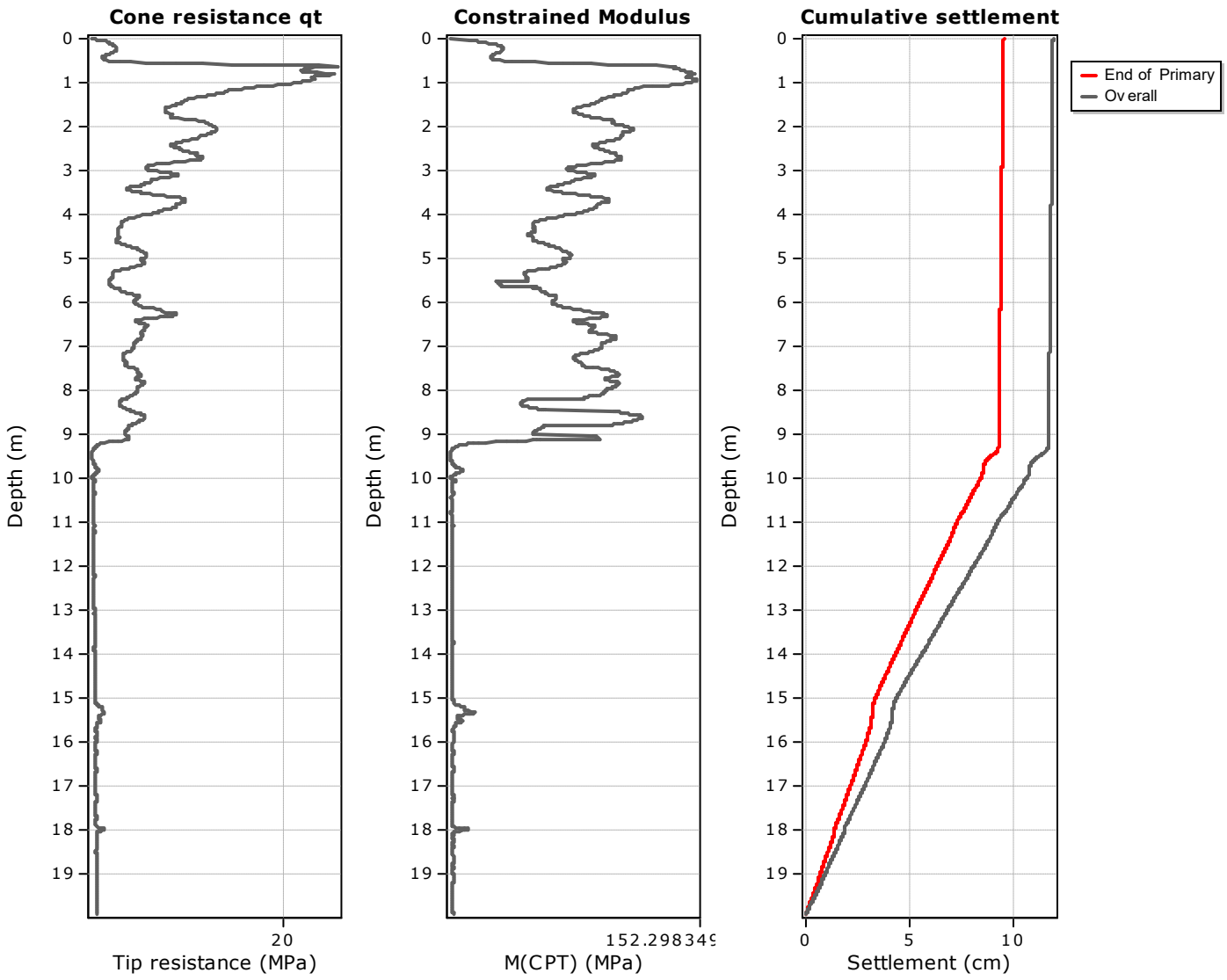
CPT: CPT06
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.00 (m)
L/B: 1.0
Footing pressure: 16.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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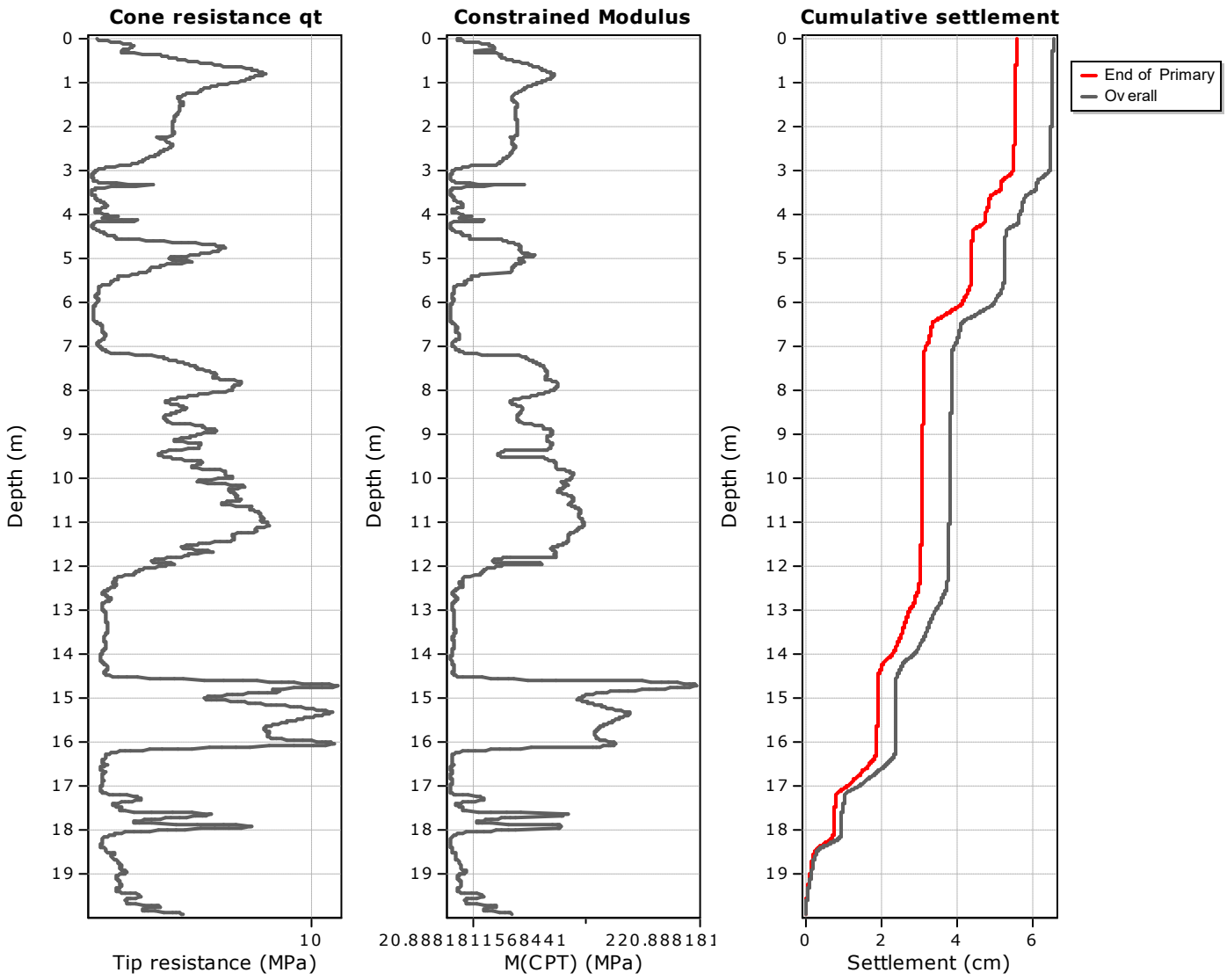
CPT: CPT07
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.00 (m)
L/B: 1.0
Footing pressure: 16.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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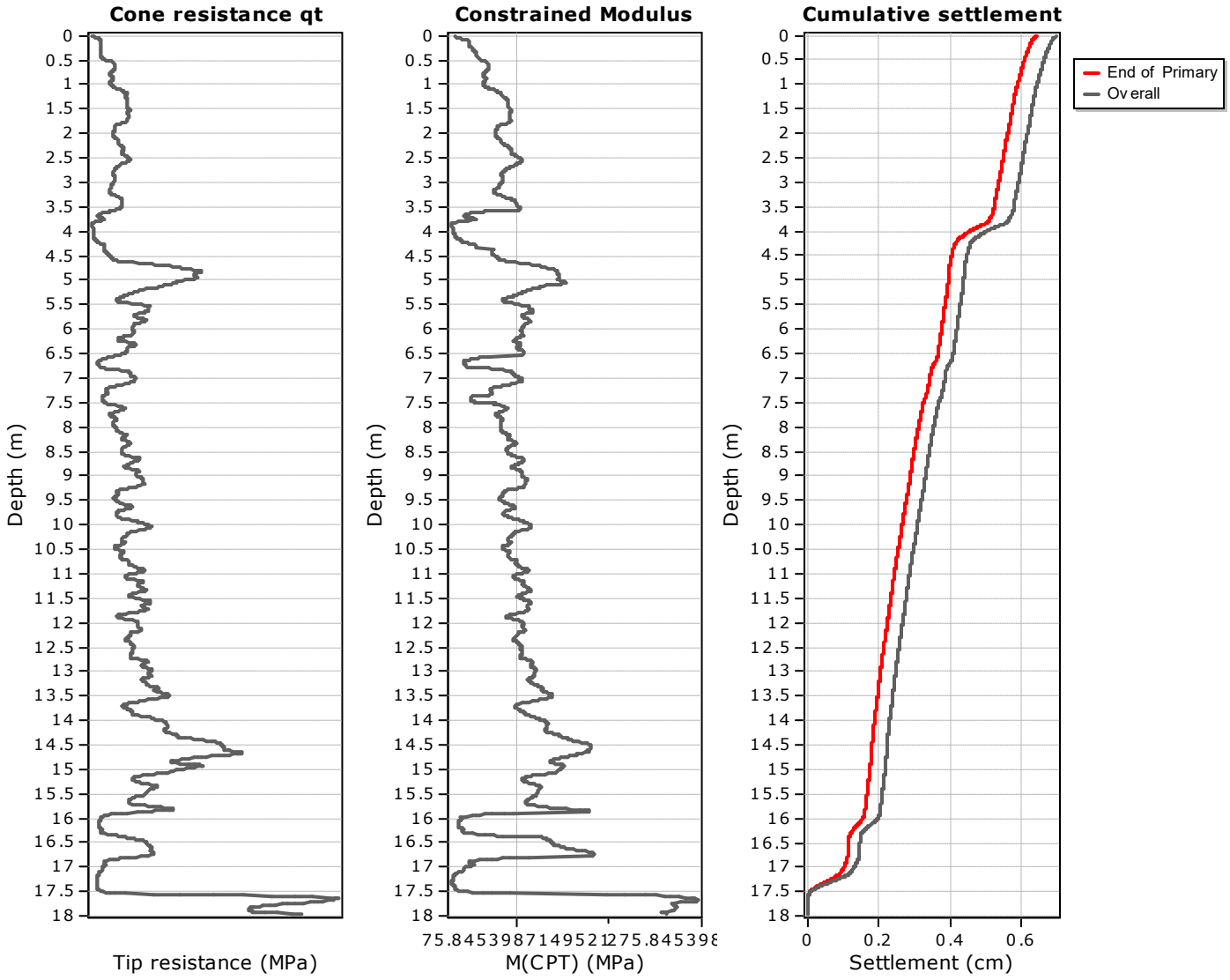
CPT: CPT08
Total depth: 17.96 m, Date: 5/06/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.00 (m)
L/B: 1.0
Footing pressure: 16.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

GeoLogismiki
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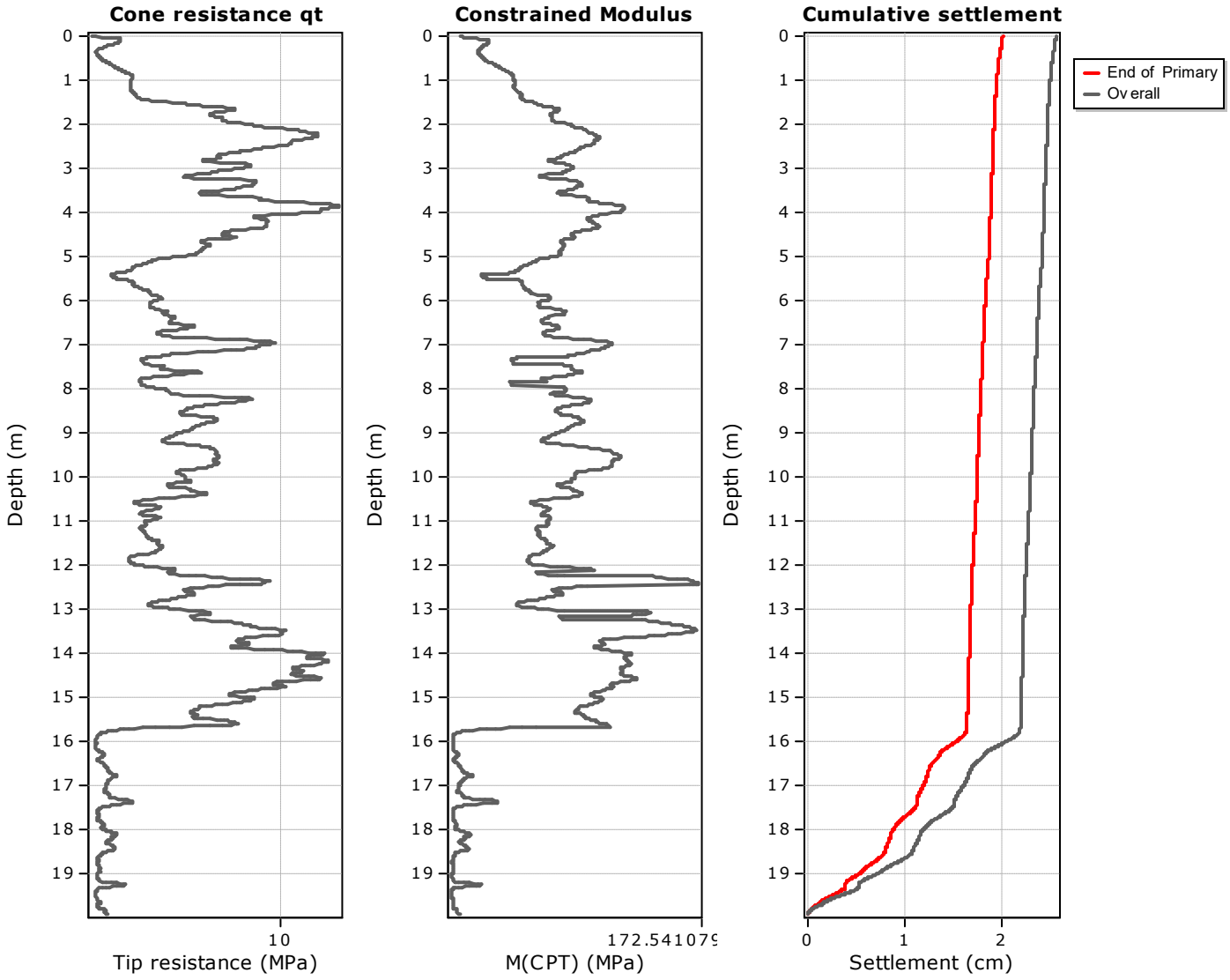
CPT: CPT09
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.00 (m)
L/B: 1.0
Footing pressure: 16.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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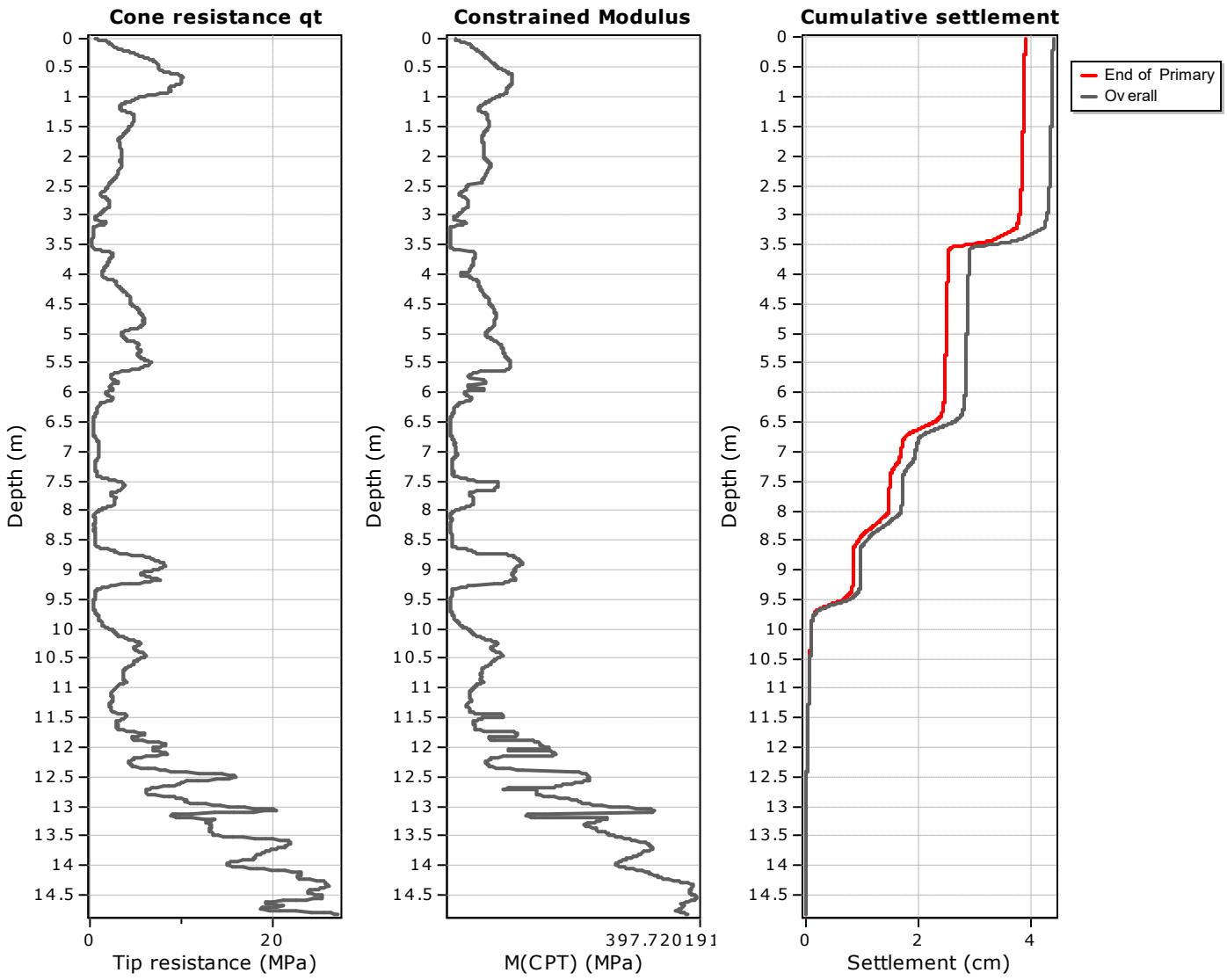
CPT: CPT10
Total depth: 14.83 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.00 (m)
L/B: 1.0
Footing pressure: 16.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

Estimated Settlement Areas 1 and 2 under floor slab 15m x 30m and 12kPa uniform load.

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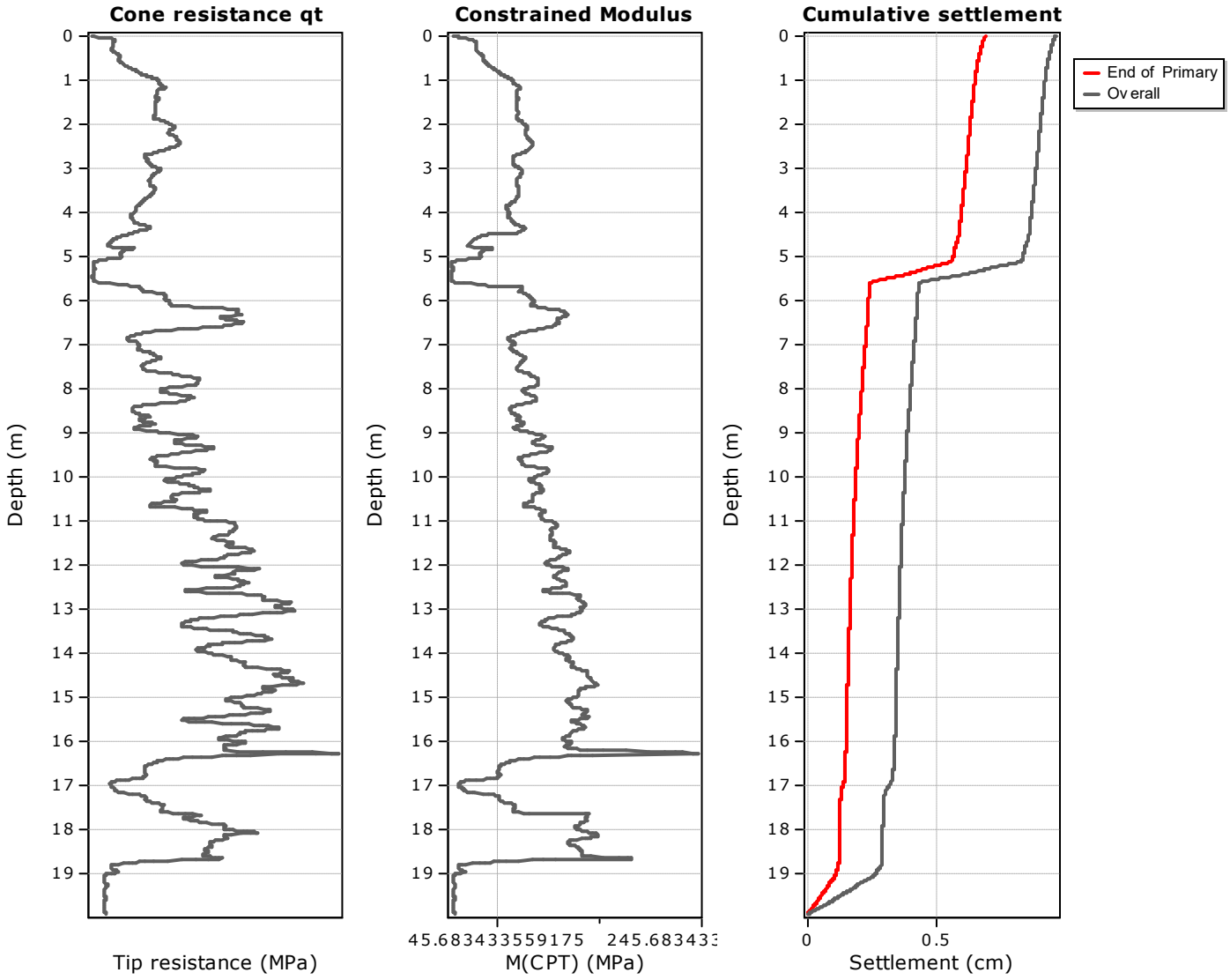
CPT: CPT03
Total depth: 19.92 m, Date: 5/06/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 15.00 (m)
L/B: 2.0
Footing pressure: 12.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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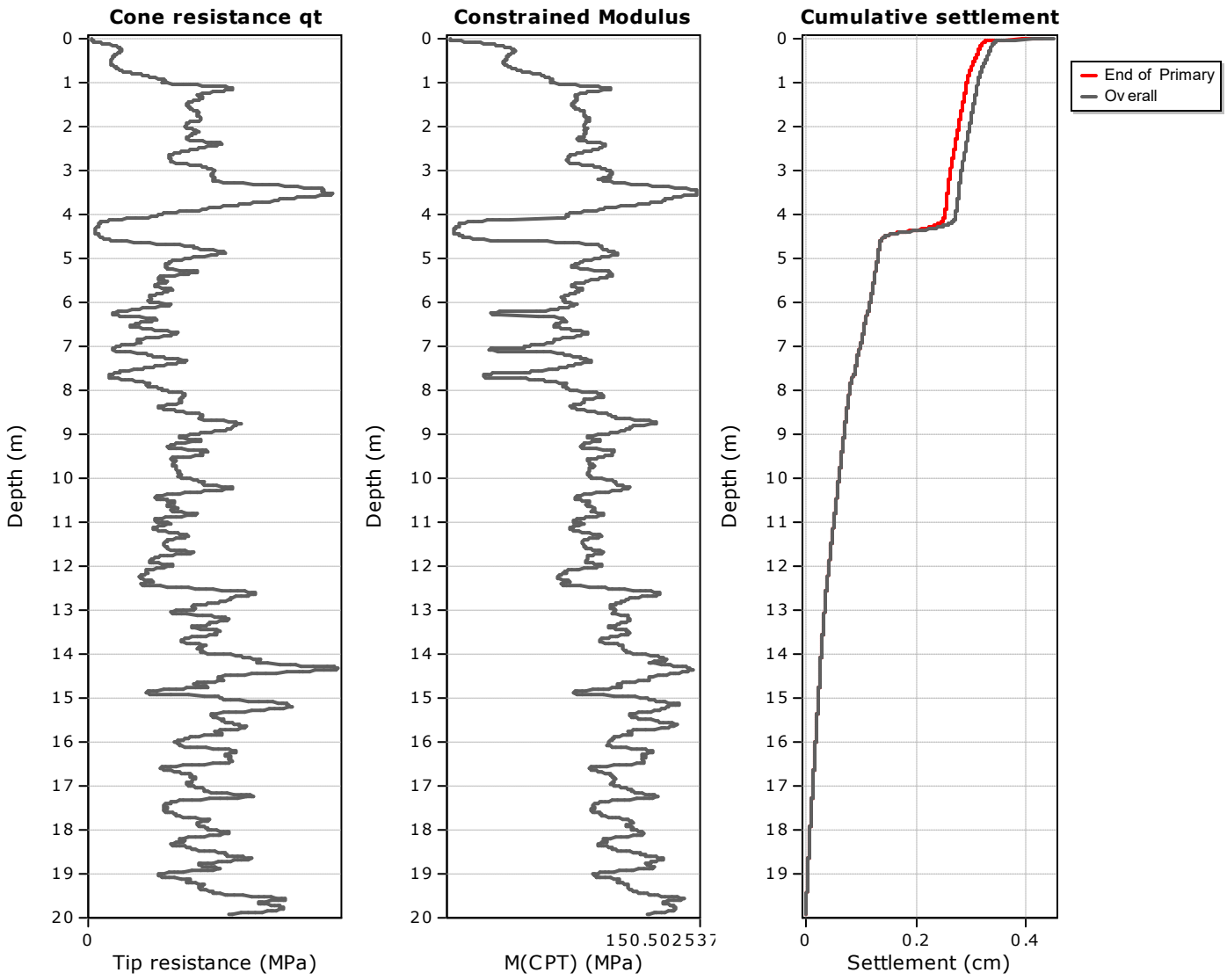
CPT: CPT04
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 15.00 (m)
L/B: 2.0
Footing pressure: 12.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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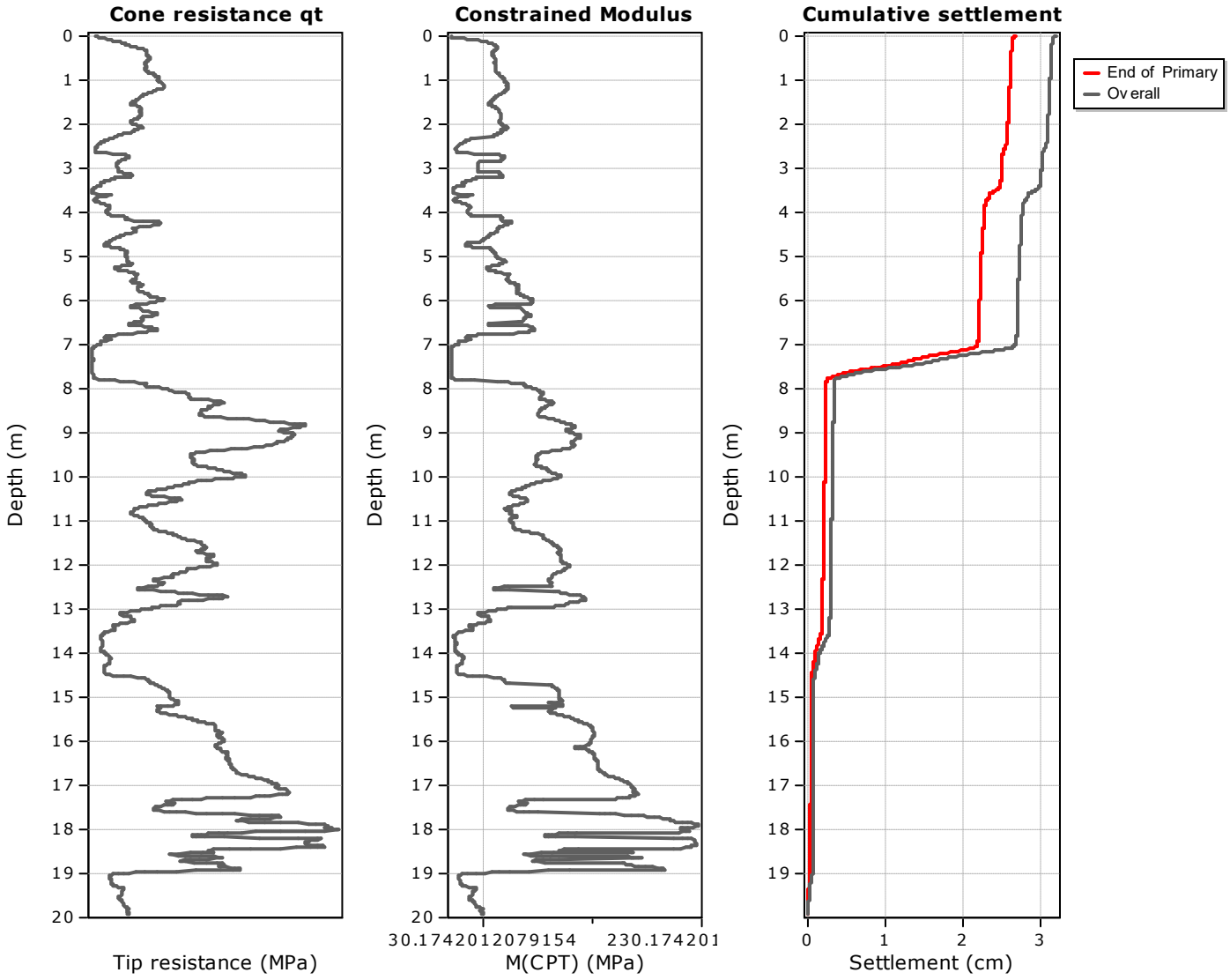
CPT: CPT05
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 15.00 (m)
L/B: 2.0
Footing pressure: 12.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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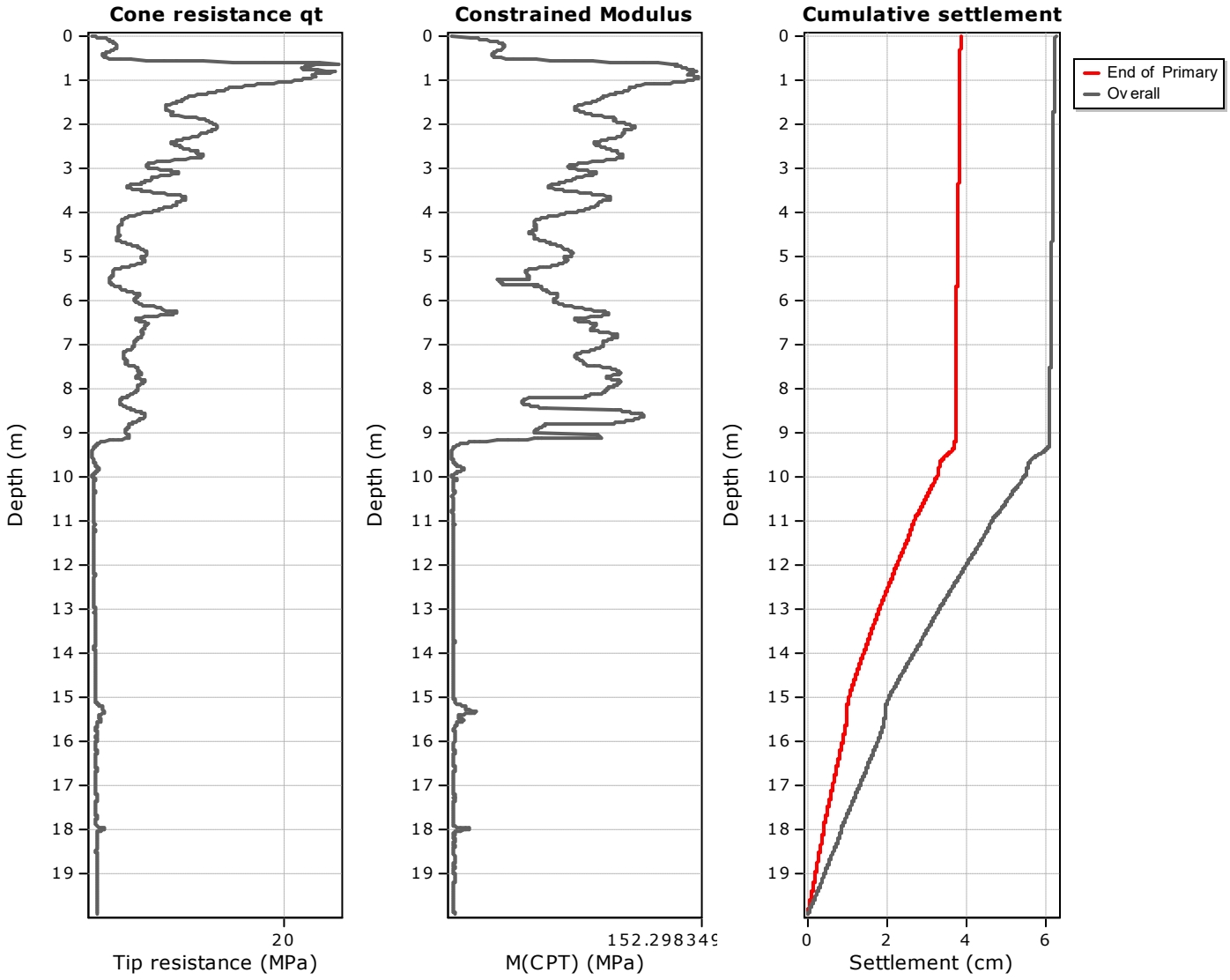
CPT: CPT06
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 15.00 (m)
L/B: 2.0
Footing pressure: 12.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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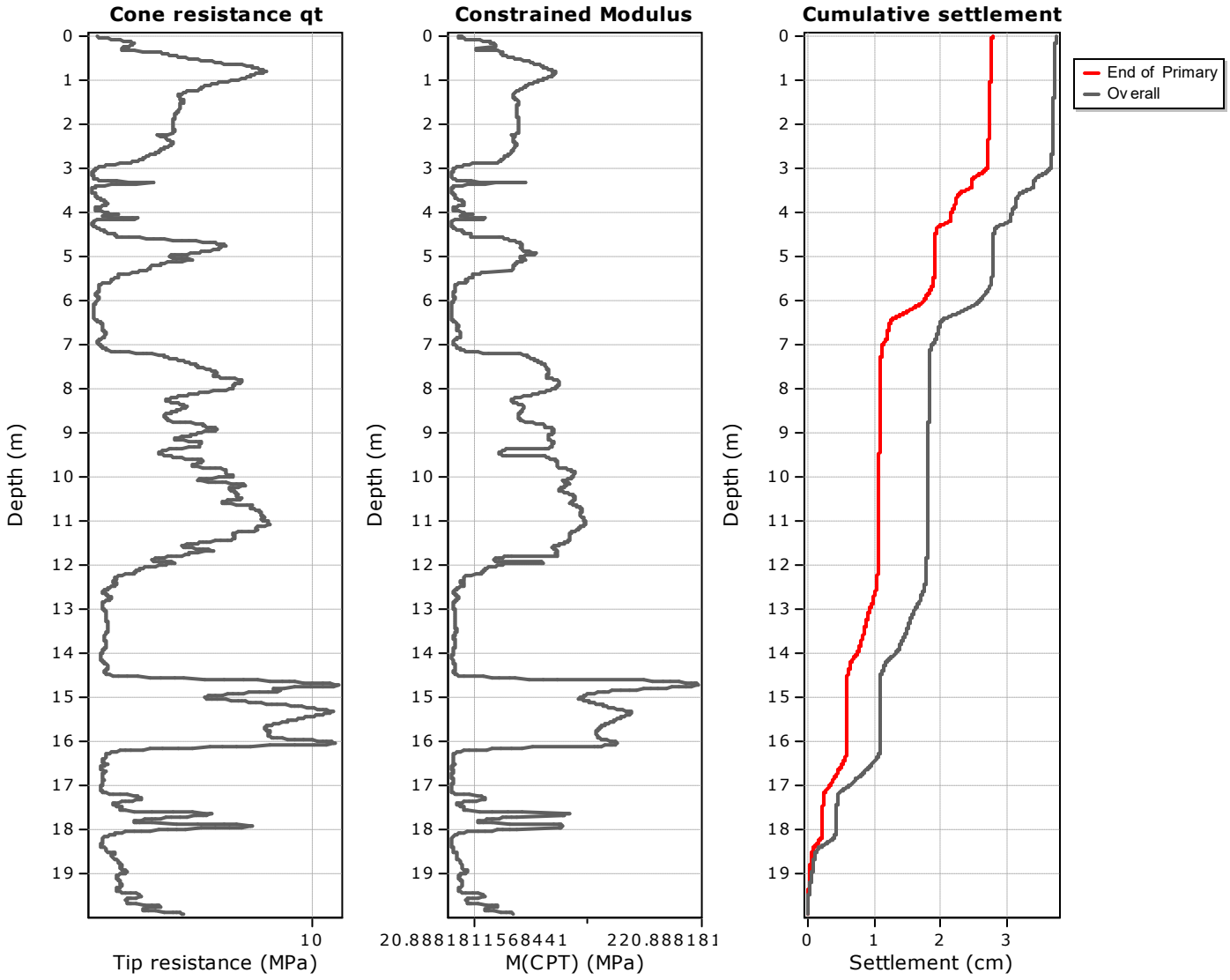
CPT: CPT07
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 15.00 (m)
L/B: 2.0
Footing pressure: 12.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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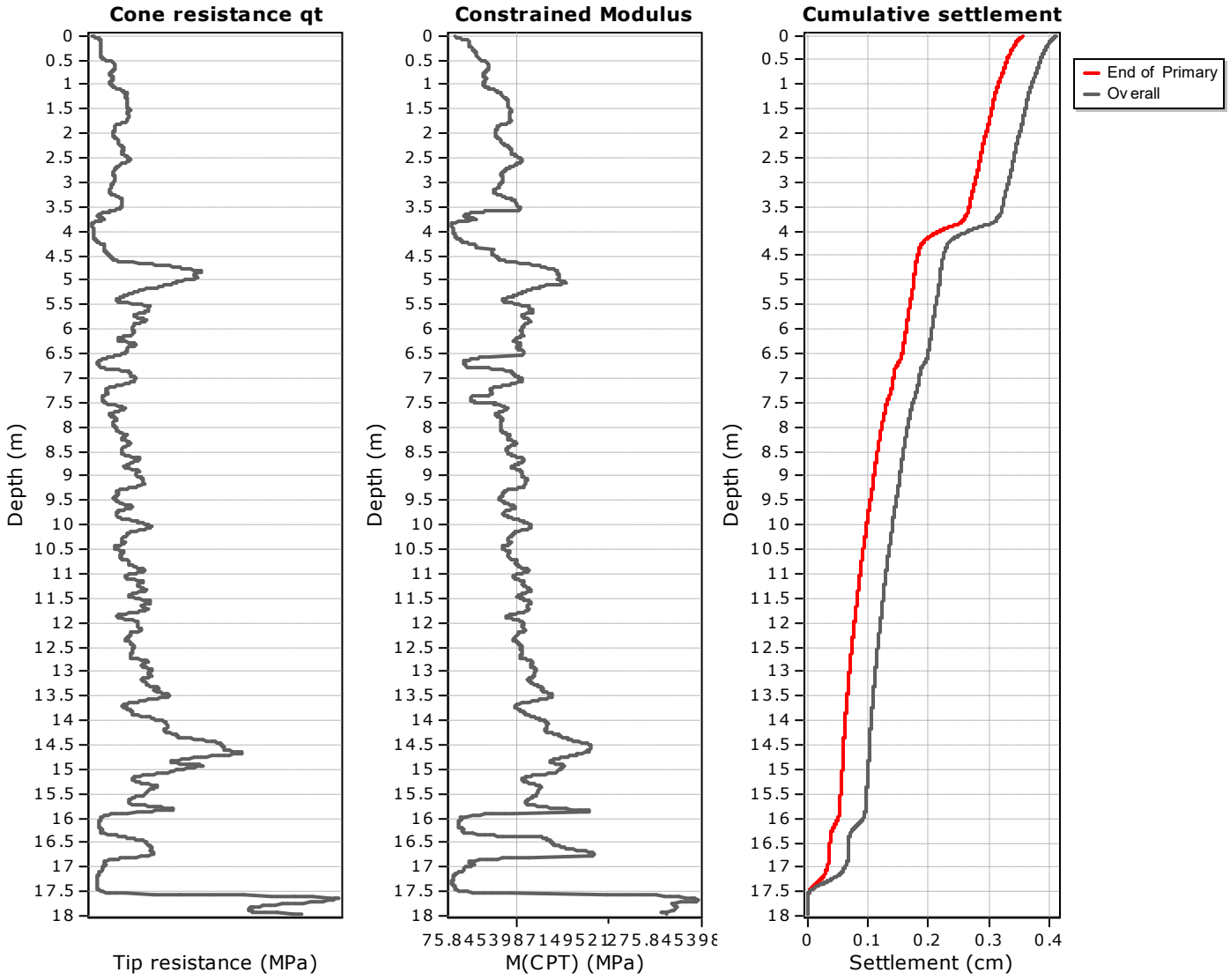
CPT: CPT08
Total depth: 17.96 m, Date: 5/06/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 15.00 (m)
L/B: 2.0
Footing pressure: 12.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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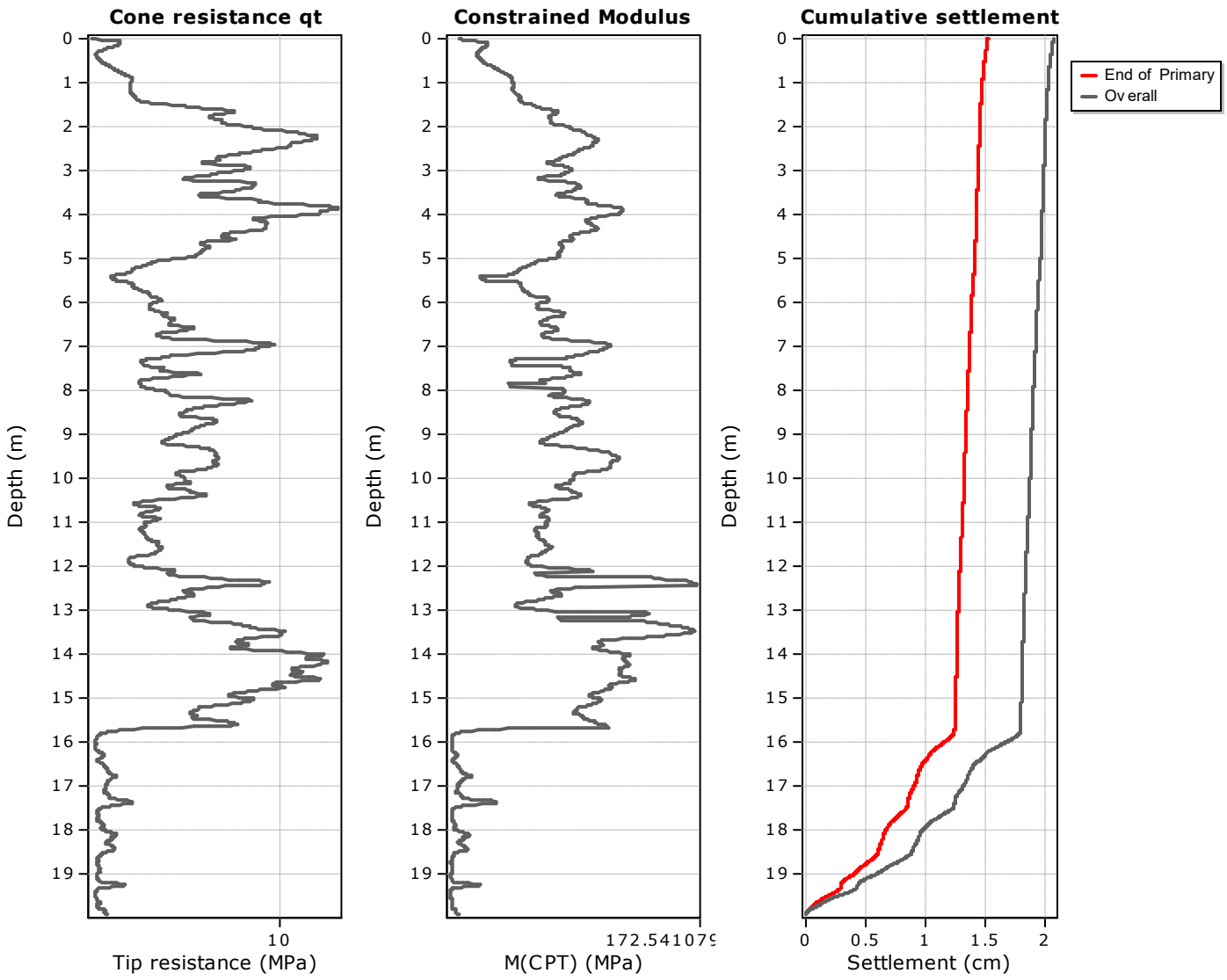
CPT: CPT09
Total depth: 19.92 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 100.15 (m)
L/B: 2.0
Footing pressure: 12.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

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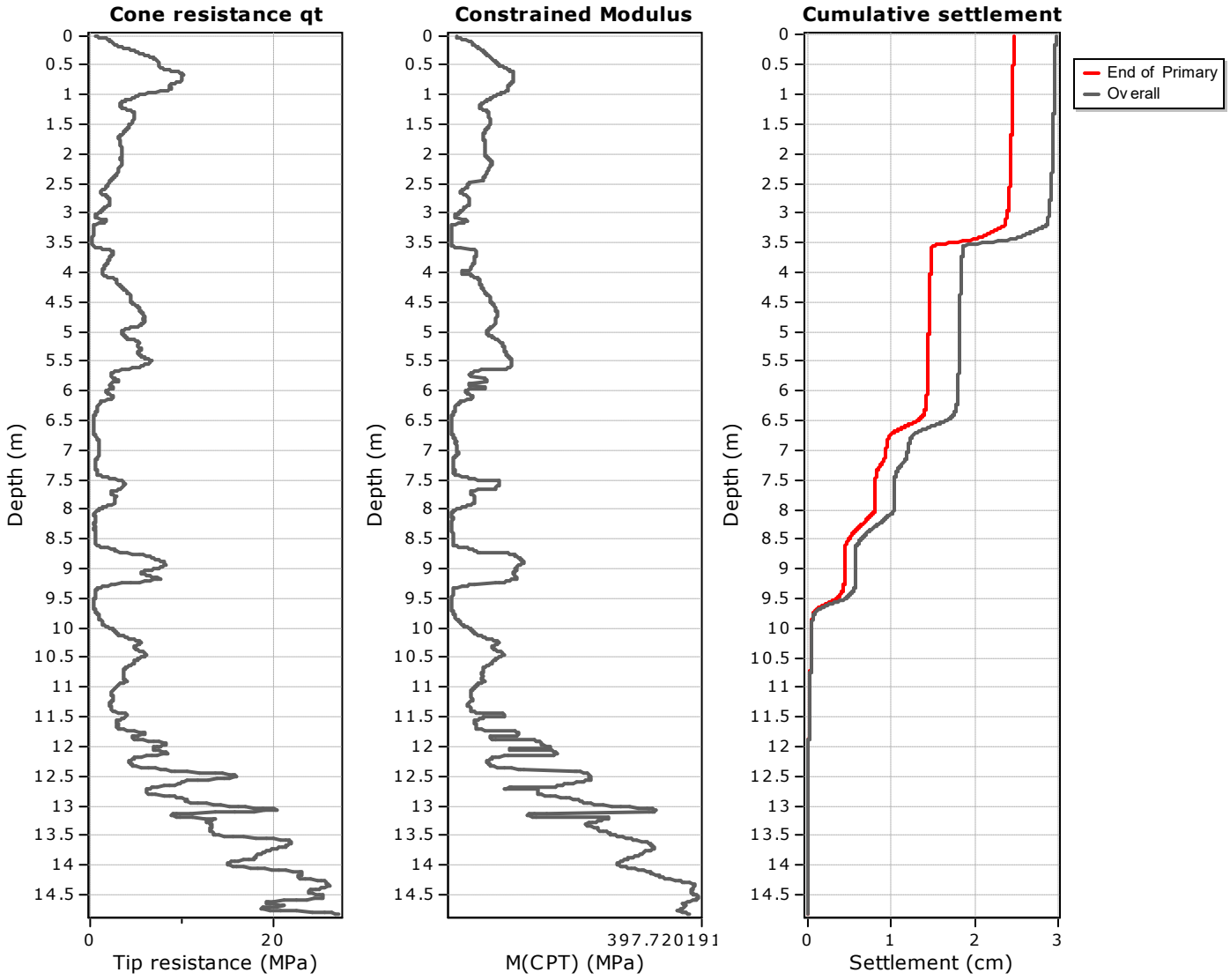
CPT: CPT10
Total depth: 14.83 m, Date: 14/05/2020
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project:
Location:

Settlements calculation according to theory of elasticity*



Calculation properties

Footing type: Rectangular
Footing width: 15.00 (m)
L/B: 2.0
Footing pressure: 12.00 (kPa)
Embedment depth: 0.00 (m)
Footing is rigid: No
Remove excavation load: No
Apply 20% rule: No
Calculate secondary settlements: Yes
Time period for primary consolidation: 6 months
Time period for second. settlements: 12 months

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta \sigma_v}{M_{CPT}} \Delta z$$

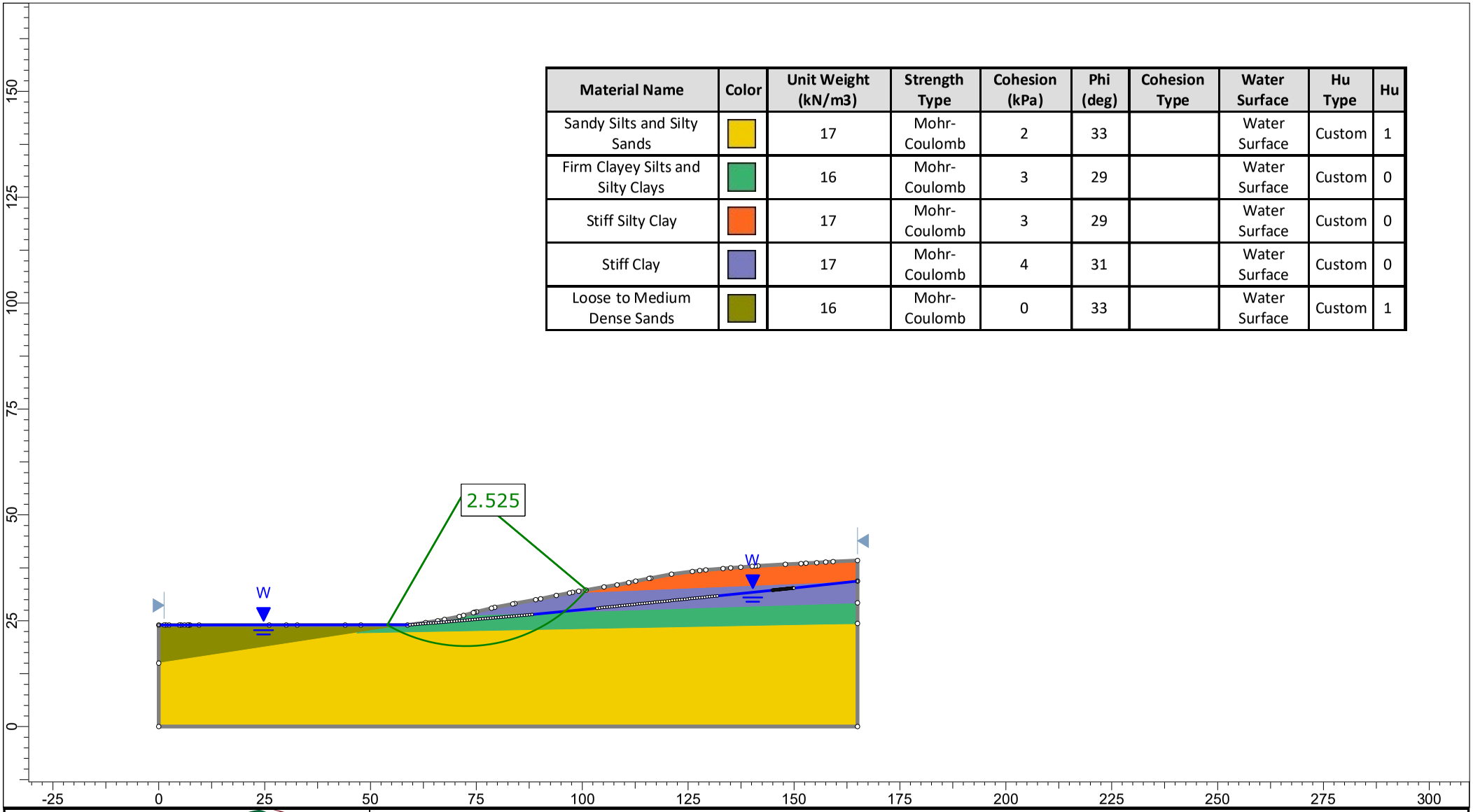
* Secondary (creep) settlements calculation is performed according to the following formula:

$$S = C_\alpha \cdot \Delta z \cdot \log(t/t_p)$$

where t_p is the duration of primary consolidation

Appendix G: Slope Stability Outputs

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Sandy Silts and Silty Sands		17	Mohr-Coulomb	2	33		Water Surface	Custom	1
Firm Clayey Silts and Silty Clays		16	Mohr-Coulomb	3	29		Water Surface	Custom	0
Stiff Silty Clay		17	Mohr-Coulomb	3	29		Water Surface	Custom	0
Stiff Clay		17	Mohr-Coulomb	4	31		Water Surface	Custom	0
Loose to Medium Dense Sands		16	Mohr-Coulomb	0	33		Water Surface	Custom	1

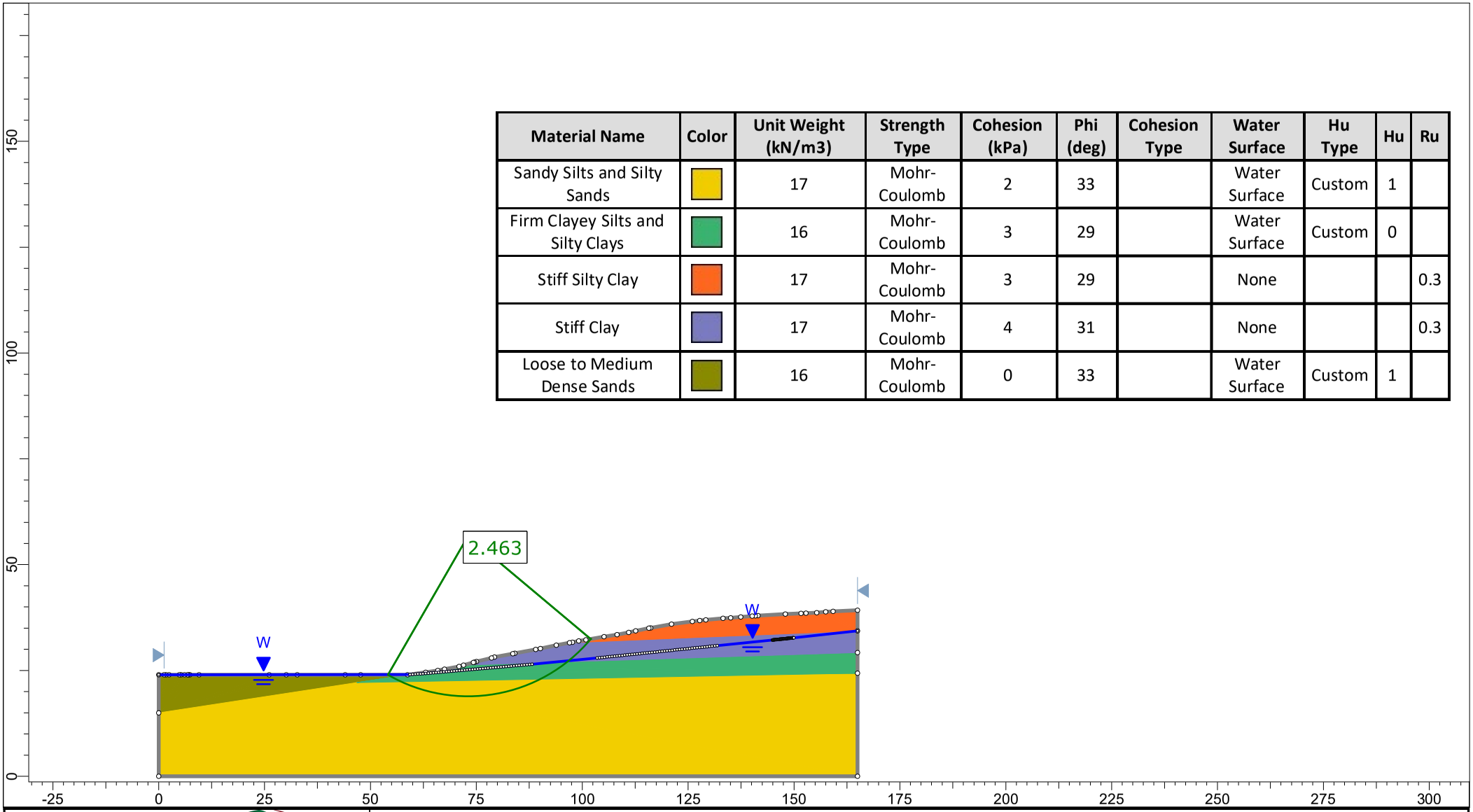


CMW Geosciences

SLIDEIN... 9.001

Project	North Huntly Development, East Mine Road		
Analysis Description	Geological Section B - Prevailing Groundwater Case. Minimum FoS Displayed.		
Drawn By: LS	Date: 13/07/2020	Scale: 1:1250	Company: Shand Properties Ltd
Figure No	Job No: HAM2019-0082		File Name: HAM2019-0082AF Section B

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu	Ru
Sandy Silts and Silty Sands		17	Mohr-Coulomb	2	33		Water Surface	Custom	1	
Firm Clayey Silts and Silty Clays		16	Mohr-Coulomb	3	29		Water Surface	Custom	0	
Stiff Silty Clay		17	Mohr-Coulomb	3	29		None			0.3
Stiff Clay		17	Mohr-Coulomb	4	31		None			0.3
Loose to Medium Dense Sands		16	Mohr-Coulomb	0	33		Water Surface	Custom	1	

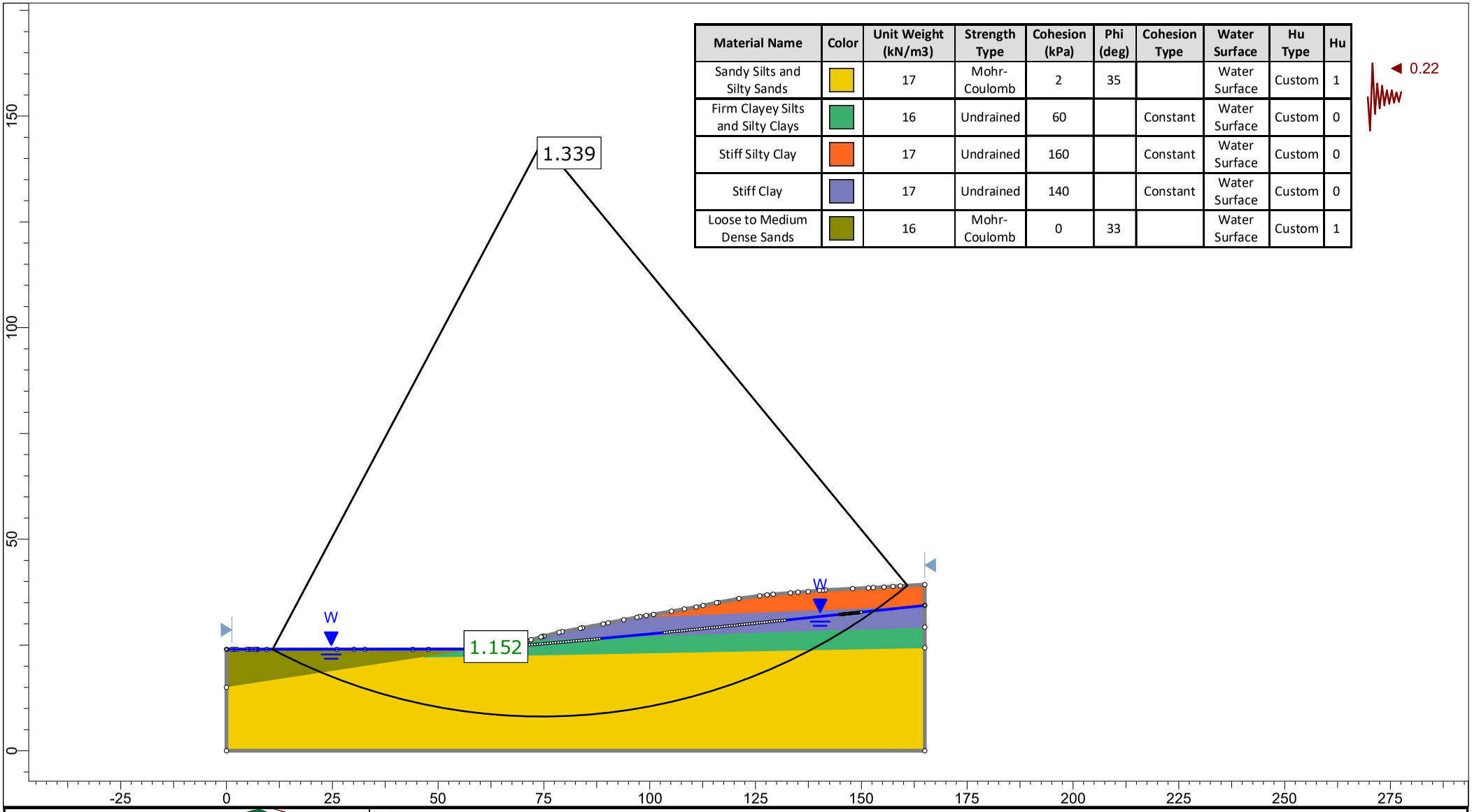


CMW Geosciences

SLIDEIN... 9.001

Project	North Huntly Development, East Mine Road			
Analysis Description	Geological Section B - Elevated Groundwater Case. Minimum FoS Displayed.			
Drawn By: LS	Date: 13/07/2020	Scale: 1:1250	Company: Shand Properties Ltd	
Figure No	Job No: HAM2019-0082	File Name: HAM2019-0082AF Section B		

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Sandy Silts and Silty Sands		17	Mohr-Coulomb	2	35		Water Surface	Custom	1
Firm Clayey Silts and Silty Clays		16	Undrained	60		Constant	Water Surface	Custom	0
Stiff Silty Clay		17	Undrained	160		Constant	Water Surface	Custom	0
Stiff Clay		17	Undrained	140		Constant	Water Surface	Custom	0
Loose to Medium Dense Sands		16	Mohr-Coulomb	0	33		Water Surface	Custom	1



CMW Geosciences

SLIDEINTERPRET 9.001

Project	North Huntly Development, East Mine Road		
Analysis Description	Geological Section B - ULS Seismic Case. Minimum FoS and Critical FoS Displayed.		
Drawn By: LS	Date: 7/07/2020	Scale 1:1250	Company Shand Properties Ltd
Figure No	Job No HAM2019-0082		File Name HAM2019-0082AF Section B