Resource Consent Application

Assessment of Environmental Effects

Discharge of Wastewater into Land

Prepared for

Te Pirangi Developments

Prepared by

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June 2024

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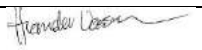
Prepared by:	Henry van der Vossen and Eise Venter	
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INTRODUCTION

Overview

Te Pirangi Developments (TPD) own two land parcels side by side on Turitea Road, Palmerston North (Figure 0.1). TPD is seeking subdivision consent from Palmerston North City Council to subdivide both properties into eight (8) lots. The site is legally described as Lot 3 DP 67730 and Lot 4 DP 30170.

Figure 0.1: Turitea Rd Subdivisions with Reference to Massey University

The subdivision will create 8 individual lots, of which 3 (Lots 2, 14 and 16) will have land areas under the specified 5,000 m^2 as detailed in the Horizon's One Plan permitted activity rule for onsite wastewater discharges. Therefore, resource consents are being sought to discharge treated wastewater into land from Lots 2, 14 and 16.

This report provides an assessment of environmental effects to accompany a resource consent application for each of those undersized lots.

Purpose

Te Pirangi Developments (TPD) has engaged Lowe Environmental Impact (LEI) to apply for resource consent for the discharge of treated wastewater into the land.

The resource consent application has been prepared in accordance with the requirements of the Resource Management Act 1991 (RMA) and considers the actual and potential adverse environmental effects of the proposed discharges from Lots 2, 14, and 16. Only these three lots,

being under 5,000 m^2, are being considered. This report is to provide an assessment of environmental effects accompanying the consent application, being the completion of Horizons Regional Council's (HRC's) standard Form 9 application documents.

DESCRIPTION OF THE ENVIRONMENT

Site Location

The subdivision is at 158 - 164 Turitea Road, Palmerston North (Lat: -40.40144 and Long: 175.64397). It will comprise eight lots ranging between 3,500 m^2 and 9,491 m^2. However, only Lots 2, 14, and 16 are being considered here. Figure 0.1 depicts the existing parcels before subdivision. Figure 0.2 illustrates each of the proposed lots and Table 0.1 provides a description of the site and surrounding land use. Appendix A shows the Certificates of Title.

Figure 0.1: Existing Parcels Before Subdivision

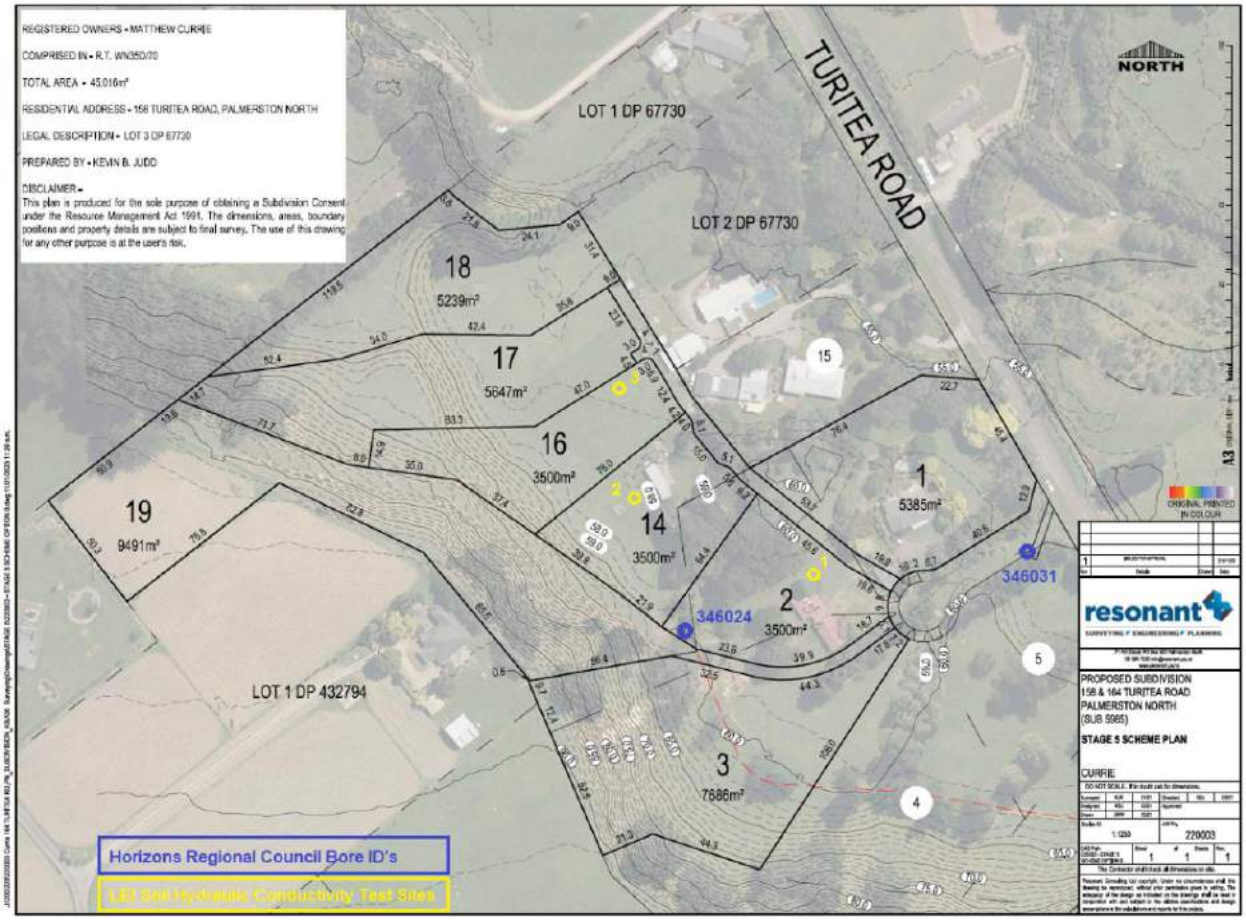


Figure 0.2: Outline of Proposed Lots in Turitea Rd Subdivision, indicating LEI Hydraulic Conductivity Test Sites and Local HRC Bore Locations

Table 0.1: Site Description and Surrounding Land Use

Parameter	Description
Owner	Te Pirangi Developments
Locality	Palmerston North
Site Address	158 - 164 Turitea Road, Palmerston North
Legal Description	LOT 3 DP 67730 and LOT 4 DP 30170 SEC 1 SO 37477
Map Reference	Lat: -40.381 and Long: 175.609
Valuation Number	14440 04000 and 14440 04100
Regional Council Area	Horizons Regional Council
District Council Area	Palmerston North City Council
Total Land Area (ha)	3.205 and 5.916 (Total subdivided 4.57 ha)
Land Area of Proposed Lots	Lots 2, 14 and 16 - 3,500 m^2
Existing Land Use	Pasture
Surrounding Land Use	Consists of lifestyle blocks
Slope	Flat to undulating
Properties Primary Water Source	Reticulated

Climate

Rainfall and evaporative data have been obtained from the National Institute of Water and Atmospheric Research (NIWA) data website. The closest and most appropriate weather station was combined monthly rainfall and potential evapotranspiration (PET) data from Palmerston North Ews.

The Palmerston North Ews station is approximately 4 km from the property. The data sets consisted of 23 years of monthly rainfalls and PET data. Table 0.2 below presents averaged climate data provided by NIWA.

The PET values vary significantly over the year, with the highest value in January of 148 mm and the lowest in June of 17 mm. Rainfall is fairly consistent over the year with no significant variation. The highest average rainfall was in June, at 98 mm, and the lowest was in January at 57 mm. This would indicate that soils will be wettest during winter months due to high rainfall and low evaporative losses. The rainfall at the property is expected to be slightly higher than that of the airport location due to the proximity to the Tararua Ranges, which is approximately 2.5 km southeast of the property.

Table 0.2: Rainfall and Evaporation Palmerston North Ews

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Rainfall	57	71	56	76	86	98	90	88	89	93	80	96
PET	148	120	96	52	27	17	20	33	58	85	113	135
Deficit/ Surplus	-91	-49	-40	24	59	81	69	54	31	8	-34	-38

The mean annual rainfall at the site is 980 mm/year.

The following link details the wind speed and direction recorded at Palmerston North Airport: https://www.windfinder.com/windstatistics/palmerston_north. This monitoring station is the closest for wind direction and speed data, which has been averaged over a period from 2009 to 2020. It shows that the dominant average annual wind direction is WNW, with an average of 9 knots. Monthly records are also available on the website, and they show that in the winter months, North Westerlies are the dominant wind direction, and during the summer, Westerly winds dominate.

Soils, Geology and Topography

Geology and Geomorphology

Geological information (IGNS 2000—http://data.gns.cri.nz/geology) indicates that the subdivision site is underlain by river deposits of Late Pleistocene age, including gravel, minor sand, and silt underlaying terraces with minor fan deposits and loess. Young terrace alluvial deposits are likely to originate from the Turitea River.

Soil Investigation

The soil assessment was assisted using a geotechnical investigation report prepared by Resource Development Consultants Ltd (RDCL). RDCL undertook a geotechnical investigation and assessment on 17 & 18 January 2024, and LEI used the soil logs for the assessment of the soil. A total of 12 test pits (TPs) were dug. The location of each test pit is shown on the map in Figure 0.3.

LEI used the information from the test pit logs to assess the soil categories based on classification from Table 2.1 of the Horizons Regional Council Manual for On-site Wastewater Systems. This uses the soil category system based on the Auckland Regional Council TP58 2004.

LEI conducted a second soil investigation on 13 June 2024 to determine the topsoil's hydraulic conductivity and potential wastewater discharge rates. Topsoil depth at all locations observed was between 200 and 400 mm. These observations were made in Lots 2, 14 and 16, shown in

Figure 0.2. RDCL described the topsoil as light brown silt topsoil with minor sand in some instances.

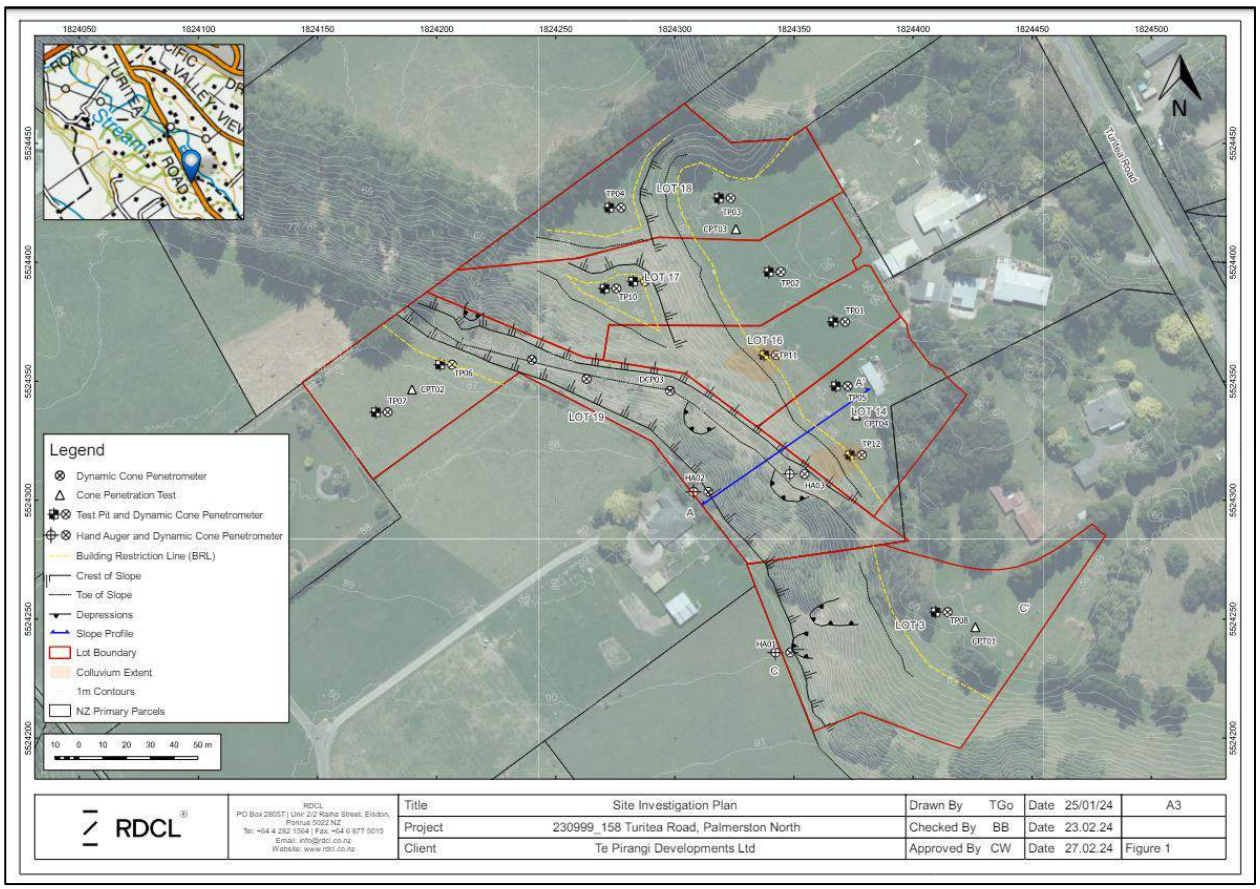


Figure 0.3: Location of test pits within Turitea Road Subdivision

Our soil textural observations suggested the topsoil is predominantly silt loam (Category 4) over the proposed subdivision. The respective soil horizons, soil types and categories for Lots 1, 14 and 16 are detailed in Table 0.3.

Table 0.3: Soil Horizons, Soil Types and Categories for Lots Lot 2, 14 and 16

Soil Horizon	Lot 2 (Lot 3) (TP08)	Lot 14 (TP05)	Lot 14 (TP12)	Lot 16 (TP01)	Lot 16 (TP11)
Topsoil	0- 200 mm **Silt Category 4**	0-500 mm **Sandy Silt Category 4**	0-200 mm **Silty Sand Category 4**	0-400 mm **Silt Loam Category 4**	0-200 mm **Silty Sand Category 4**
B1	200-1,500 mm **Clayey Silt Category 5**	500-2,700 mm **Sandy Gravel Category 2**	200-1,700 mm **Silty Sand Category 4**	400-1,400 mm **Silty Gravelly Sand Category 4**	200-1,800 mm **Silty Sand Category 4**
B2	1,500-3,250 mm **Sandy Gravel - Category 2**		1,700-2,700 mm **Sandy Gravel Category 2**	1,400-3,200 mm **Sandy Gravel Category 2**	1,800-2,900 mm **Sandy Gravel Category 2**
Limiting Layer	Category 5	Category 4			
Drainage of Limiting Soil Layer	Imperfectly Drained	Moderate Drainage			

The test pit logs can be seen in Appendix B.

The second lower horizon (B1), detailed by RDCL over most of the lower terrace, was described as silty sand or gravel covering Lots 14 and 16. Our soil textural analysis at Lots 14 and 16 again indicated the soil type to be a silt loam (Category 4). Our soil assessment for Lot 2, where no test pits were completed, has concluded that the B horizon will likely be clay loam (Category 5) (similar to Lot 3), as detailed in Table 0.3.

Much of the third horizon (B2) consisted of Sandy Gravel (Category 2) for Lots 3 (Lot 2), 14, and 16. These were present at depths ranging between approximately 500 mm and 3,200 mm across these lots.

Based on the results of the soil investigation, the most limiting soil layer on proposed Lots 14 and 16 have been assigned a soil Category of 4 and Lot 2 has been assigned a soil Category 5, which is silty sand to loam and clayey silt with moderate drainage.

Land Use, Vegetation and Topography

Google Earth historical photos dating back to early 2000 show that the existing buildings on the property are the only development that has occurred on the land over this time. Images indicate that the property may have been used for cropping and general farming purposes. The vegetation at the time of the visit consisted of lush green pasture.

The site's topography consists of relatively flat ground at the toe of a 30 m high northeast-facing slope (~ 35°), as illustrated in Figure 0.2. Lot 2, most of Lot 14 and the eastern half of Lot 16 are located on relatively flat ground. The southwestern perimeter of Lot 14 lies at the toe of the ~ 30 m high northeast-facing slope. The western half of Lot 16 reaches about halfway up the 30 m high slope. Photos of the LEI soil infiltration test sites on Lots 2 and 14 can be seen in Figure 0.4 and Figure 0.5.

Figure 0.4: Photo of Lot 2 Looking South-East

Figure 0.5: Photo Taken from Lot 14 and Looking North-West Towards Lots 16, 17 and 19.

Figure 0.5 shows the expected overland flow path along the foot of the terrace towards the north-west as discussed in Section 0.

Groundwater

LAWA describes the groundwater in this area as being in the Manawatu Groundwater Zone. It is described as moving in the general direction towards the coast through Quaternary sediments. However, due to the elevation change, it is understood that shallow groundwater will enter surface water in the Turitea Stream or Manawatu River.

Bore ID 346031 drilled to a depth of 47 m deep, is a flowing artesian bore with a water level of 12.11 m above ground level as recorded in July 2019. The bore is currently being used for stock watering. Bore logs obtained from HRC indicate that the bore penetrates gravels between -2.13 m and -3.05 m, sand between -3.05 m and -7.63 m, peat and clay between -7.63 m and -8.85 m, and sand again between -8.85 m and 22.26 m. The peat and clay layer in Bore ID 346031 confines the deep groundwater and suggests limited vertical movement in silts and clays, with higher water movement occurring horizontally in some lenses of sands and gravels.

The bore (HRC ID 346031) is located 15 m outside the southern boundary of Lot 1, on the shoulder of the new shared accessway road. See Figure 2.2.

HRC records indicate that bore ID 346024 located on Lot 2 was drilled in ~ 1954 to a depth of 20 m. No additional information related to static water level or lithology has been documented, and no further information was recorded since it was drilled. It is believed that bore ID 346024 has been decommissioned as the landowner is not aware of the existence of the bore.

A 3 km radius bore search from the property indicates groundwater uses associated with farm supply, small scale irrigation, domestic and light industrial purposes.

No data was found to indicate groundwater flow direction, but it is assumed that shallow groundwater is predominantly influenced by slope and the Turitea Stream. It would flow down the slope in a northeast to an easterly direction parallel to and potentially converge on the stream.

During the RDCL geotechnical investigation on 17 & 18 January 2024, no groundwater was encountered in the twelve Test Pits dug to between 2.7 m and 3.4 m bgl. Mottling was found in

TP08, suggesting intermittent moisture from 0.3 m bgl, which is expected to be due to this being the restricting layer.

Surface Water

The Turitea Stream flows approximately 90 m northeast of the property at its closest point (see Figure 2.6). This point of the Turitea Stream is approximately 4 km downstream from the Turitea Dam, which supplies water to Palmerston North. The headwaters of the Turitea Stream are located in the Northern end of the Tararua Ranges. The Turitea Stream runs mainly through farmland before its confluence with the Manawatu River 4.1 km north-west of the property and is described on the LAWA website as being a valuable local amenity, used for water supply, a food supply source, trout spawning and flood control.

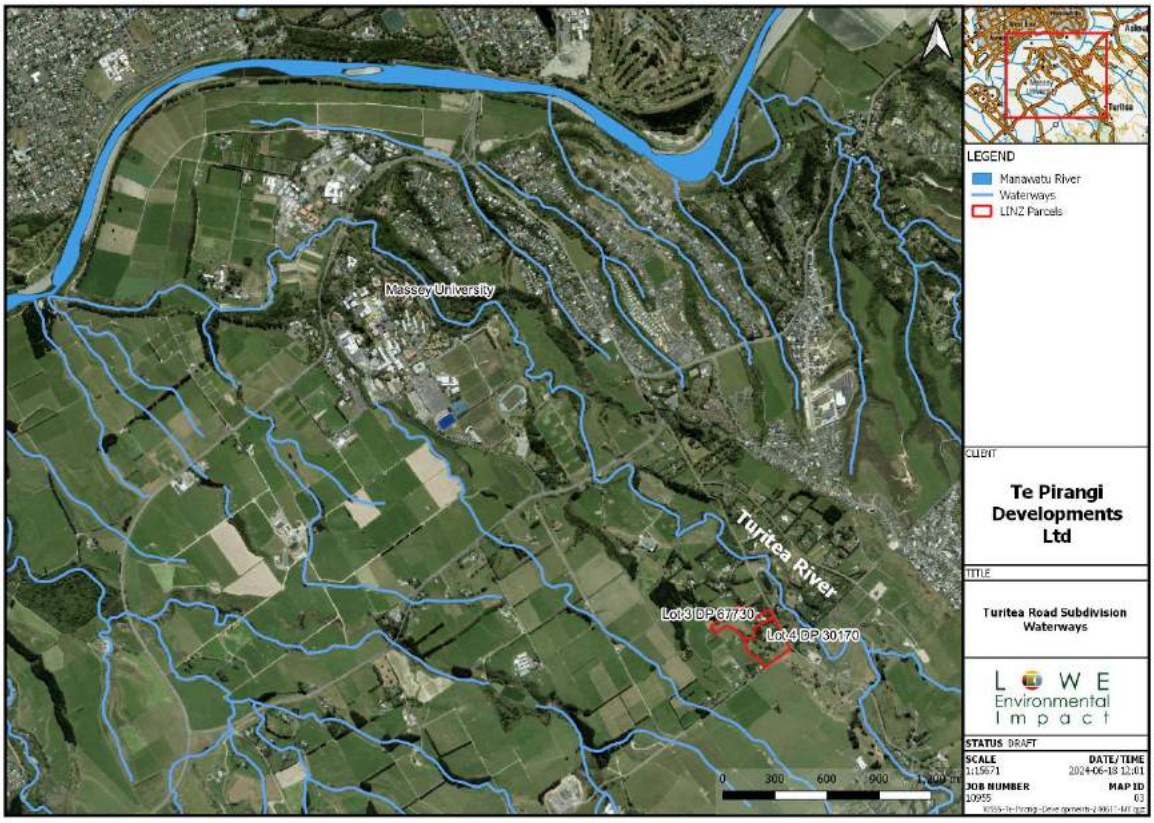


Figure 0.6: Turitea Road Subdivision with Surrounding Waterways

There are no surface water abstractions for the local community's water supply downstream of the proposed subdivision. The nearest abstraction is from the Turitea Dam, approximately 4 km upstream of the property.

DESCRIPTION OF THE PROPOSED ACTIVITY

General

The proposed activity is to discharge secondary treated wastewater to land from households on Lots 2, 14 and 16.

This section will clarify the following:

- Size of the Lots in the subdivision which are under 5,000 m^2;
- Wastewater design flows for typical house size;
- Effluent treatment and quality; and
- Possible land treatment locations on each of the undersized lots.

Size of Proposed Lots

The size of each of the lots are provided in Table 0.1 and shown in Figure 0.1.

Table 0.1: Areas of Proposed Lots

Lot Number	Lot Size (m^2)
Lot 1	5,385
Lot 2	**3,500**
Lot 3	7,686
Lot 14	**3,500**
Lot 16	**3,500**
Lot 17	5,647
Lot 18	5,239
Lot 19	9,491

This application is just for Lot 2, 14 and 16, as these lots are under the permitted activity area of 5,000 m^2.

Figure 0.1: Lots 2, 14, and 16 – Turitea Road Subdivision

Wastewater Design Flows

Design flow rates have been calculated using Tables 3.1 and 3.2 of the Horizons Manual for On-site Wastewater Design and Management (2007), which states that a four-bedroom house has a design occupancy rate of 6 people. The typical flow allowance per person per day is 200 litres for a household with standard fixtures on a reticulated community or bore water supply. Therefore, the design flow rate of 1,200 L/p/day or 1.2 m^3/day has been used for each of the wastewater systems.

Treatment and Effluent Quality

The permitted activity rule from the Rule LF-LW-R22 Horizons Regional Council One Plan sets out effluent quality. This is summarised in Table 0.2.

Table 0.2: Expected Secondary Treated Effluent Quality

Parameter	Expected concentration (g/m^3)
Suspended Solids	30
BOD_5	20
Total Nitrogen	60

Table 3.3 provides the details of secondary treatment systems that have been tested in trials and can meet these parameters.

Table 0.3: Treatment Systems Achieving Secondary Treated Effluent

Manufacturer/ Supplier	Treatment System	System Type
Hynds	Hynds Lifestyle	Submerged Aerated Filter
Oasis	Oasis Clearwater 3000 series	Submerged Aerated Filter
Innoflow	Advantex AX20	Textile Recirculating Packed Bed Reactor

One of these systems should be chosen for treatment, or one similar with proven performance based on rigorous Water NZ testing trials.

Land Treatment Areas

Soil Investigation

During the LEI soil investigation, replicated saturated hydraulic conductivity tests were undertaken on each of the three lots on the topsoil using double-ring infiltrometers. Table 0.4 presents the saturated hydraulic conductivity (total flow through the soil, including macropores, such as roots and wormholes) for the sites. The testing locations are shown in Figure 0.2.

Table 0.4: Soil Saturated Hydraulic Conductivity (K_{sat})

Site	Topsoil Average K_{sat} (mm/hr)	Topsoil Average K_{sat} (mm/day)
Lot 2 (LEI Test 1)	25 ± 14	600 ± 336
Lot 14 (LEI Test 2)	57 ± 6	1,368 ± 144
Lot 16 (LEI Test 3)	40 ± 15	960 ± 360

The average saturated hydraulic conductivity for the topsoil was 41 mm/hr (984 mm/d).

Field measurements typically only observe clean water effects, but the impact of wastewater constituents must also be considered. Organic material, solids and nutrients in the wastewater can allow the development of microbial growth, commonly referred to as biofilm, which in turn can result in a 'clogging' effect of the soil pores, particularly near the irrigation line outlets. This can reduce the soil's infiltration capacity. In addition, the salt concentration will influence the soil

wetting by altering the water tension. Crites and Tchobanoglous (1998) recommend a value of 10 - 30% of the K_{sat} to provide a Design Irrigation Rate (DIR). LEI has conservatively adopted a value of 10% of the K_{sat} to provide a DIR seen in Table 0.5.

Table 0.5: Design Application Rate

	Saturated (K_{sat})
Field Measurement Low Permeability Topsoil(mm/day)	984
Adjustment (%)	10
DIR (mm/day)	98

These high infiltration results confirm that soils will be able to assimilate the rates reported in the Horizons On-Site Design Manual, which specifies a DIR for Lot 14 and 16 of 4 - 5 mm/day for Category 4 soils and a DIR for Lot 2 of 3 – 4 mm/day for Category 5 soils.

Irrigation Design

Based on the soil categories outlined in Section 2.3.2 above, with respect to the moderately draining nature of the soils and the local weather conditions at the site, the most appropriate land treatment method for secondary treated effluent is Pressure Compensating Drip Irrigation (PCDI).

The areal loading rate is based on soil categories as provided in Horizons On-Site Design Manual (Table 6.2). In addition to this, Table 2.3 of Horizons Regional Council Manual for On-site Wastewater System sets out the reserve Land Application Area requirements for PCDI. A minimum reserve area of 50% of the calculated area is needed.

The size of the land treatment areas has been determined based on the areal loading rate of Category 4 and 5 of 3-5 mm and a flow rate of 1.2 m^3/d. Table 0.6 outlines the size of the land treatment areas for each of the lots.

Table 0.6: Land Treatment Areas Sizes

Lot No	**Limiting Soil Type**	**Soil Category**	**Areal Loading Rate**	**LTA Size Required (m^2)***	**LTA Area with reserve (m^2)**
Lot 2	Clayey Silt	5	3-4 mm/d	300 - 400	450-600
Lot 14	Silty Sand	4	4-5 mm/d	240 - 300	360-450
Lot 16	Silty Sand	4	4-5 mm/d	240 - 300	360-450

* Based on DIR of 4 mm/day

However, for simplicity and consistency across the sites, the DIR of 4 mm/d has been selected as the upper end of the scale for Category 5 soil on Lot 2 and the lower end of the scale for Category 4 soil on Lots 14 and 16. Therefore, the total area required for Lots 2, 14 and 16 is 450 m^2 (including the reserve area, at the low slope sites proposed).

Location of Land Treatment Areas

The proposed land treatment areas are illustrated in Figure 0.2. These locations have been chosen to maximise land space for building platforms and ensure appropriate buffer distances to the waterway (>20 m), active groundwater bore (> 20 m), property boundaries (1.5 m), buildings (> 1.5 m) and from retaining wall and embankments (> 3.0 m) (under AS/NZS 1547), these are the minimum separation distances recommended in Table 2.2 of the Manual for On-Site Wastewater Systems Design and Management. There has been no buffer given for the Lot 2 bore (ID 346024) as this is understood to have been decommissioned.

Figure 0.2: Proposed Land Treatment Areas for Lots 2, 14 and 16

STATUTORY ASSESSMENT

The Resource Management Act (RMA) 1991 sets out a statutory framework for consideration of resource consent applications which includes National Environmental Standards, National Policy Statements, Regional Policy Statements, Regional and District Plans.

The site is located in the Horizons region, therefore, the operative plan is the Horizons One Plan which incorporates the Regional Policy Statement. The One Plan defines how the natural and physical resources of the Region, including fresh water, air, productive land and natural ecosystems, will be cared for and managed by the Regional Council in partnership with Territorial Authorities and the community.

An assessment of the proposed activity against the relevant rules in the One Plan is given below. An evaluation of the objectives and policies of the NPS-FM, Horizons' Regional Policy Statement and Horizons' Regional One Plan will be provided later in this document.

Table 4.1 outlines the rules relating to the discharge of wastewater into land.

Table 0.1: Summary of Rules in the Horizons One Plan

Rule	Detail	Comment
LF-LW-R21 Existing discharges* of domestic wastewater*.	1. The design flow as specified in section 3 of the Manual for On-Site Wastewater Systems Design and Management (Horizons Regional Council, 2010) must be no greater than 2 m^3/d (2,000 litres per day). 2. The flow allowance used to calculate the system design flow must be no less than 145 litres per person per day where the water supply is provided by roof water collection, or no less than 180 litres per person per day for other sources of water supply. 3. The discharge must consist only of contaminants normally associated with domestic sewage and greywater. 4. There must be no direct discharge of wastewater to groundwater. 5. The discharge must comply with the following separation distances: (i) at least 20 m from any bore used for drinking water supply (ii) at least 20 m from surface water bodies, artificial watercourses and the coastal marine area. 6. The discharge must not cause any offensive or objectionable odour beyond the property boundary. 7. There must be no increase in the concentration of pathogenic organisms in any surface water body as a result of the discharge.	Can comply with the requirements of this rule but does not apply as the discharge is new.
LF-LW-R22 The discharge of domestic wastewater onto or into land pursuant to ss15(1) or15(2A) RMA and any	1. The activity must comply with conditions (1) to (7) of Rule LF-LW-R21. 2. All aspects of the wastewater treatment and land application system, including soil assessment, design, installation and operation, must be in accordance with the Manual for On-	1. Complies as detailed above. 2. Complies - The manual has been used to assess the design parameters.

Rule	Detail	Comment
ancillary discharge of contaminants into air pursuant to ss15(1)or 15(2A) RMA from a new or upgraded onsite wastewater treatment and land application system which either:(a) is newly established after this rule becomes operative, or(b) involves the upgrade of a system that existed at the date that this rule becomes operative.	Site Wastewater Systems Design and Management (Horizons Regional Council, 2010). 3. … 4. … 5. Where the property within which the discharge occurs is less than 4 ha: (a) the property must cover an area of at least either 5,000 m^2 for properties created by subdivision after this rule becomes operative, or 2,500 m² for properties that existed at the date that this rule becomes operative; (b) the wastewater treatment system must include secondary treatment which must achieve, as a minimum, the following discharge quality standards: 20 g/m³ Biochemical Oxygen Demand, 30 g/m³ Suspended Solids, and 60 g/m³ Total Nitrogen; (c) the land application system must be via pumping to dose load pressure compensating dripper irrigation lines; (d) the areal loading rate within the wastewater land application area must be no greater than 3 mm/d (3 litres per m² per day) or lesser rate in accordance with that prescribed in Table 6.2 in the Manual for On-Site Wastewater Systems Design and Management (Horizons Regional Council, 2010). 6. Separation distances to water bodies and property boundaries must be in accordance with those specified in Table 2.2 in the Manual for On-Site Wastewater Systems Design and Management (Horizons Regional Council, 2010). 7. The placement, burial, covering and exclusion of the land application area must be as specified in section 6 in the Manual for On-Site Wastewater Systems Design and Management (Horizons Regional Council, 2010). 8. For secondary treatment systems there must be at least a 50% reserve disposal area allocation. For primary treatment systems this reserve area allocation must be not less than 100%. 9. The activity must not take place in any rare habitat, threatened habitat or at-risk habitat. 10. The activity must not be to any historic heritage identified in any district plan or regional plan. 11. The wastewater treatment and land application system must be maintained by a manufacturer approved contractor in accordance with the supplier's specifications or the requirements of the Manual for On-Site Wastewater Systems Design and Management (Horizons Regional Council, 2010), whichever are the more stringent. All records of each maintenance action must be retained and made available for inspection by the Regional Council or	3. N/A 4. N/A 5. (a) **Does not comply** – Lots 2, 14 and 16 are <5,000 m^2. (b) Complies - The wastewater will be secondary treated to meet the expected discharge quality standards. (c) Complies - The discharge will be via pumping to dosing lines – PCDI. (d) **Does not comply** - The areal loading rate of 4 mm/d is higher than 3mm/d. 6. Complies – Separation distances will be met. 7. Complies – The discharge area will be kept isolated from the placement of soil during building and placement of other materials. 8. Complies – The designated land treatment areas have more than enough room for reserve area too. 9. Complies – The proposed activity does not occur in rare or threatened habitat 10. Complies – The proposed activity is not located in a heritage area. 11. Complies – Only approved contractors will be used to maintain the systems.

Rule	Detail	Comment
	its available for inspection by the Regional Council or its agents upon request. 12. The discharge must not cause any offensive or objectionable odour beyond the property boundary.	12. Complies – There will be no odour beyond the property boundary.
LF-LW-R24 Discharges* of domestic wastewater* not complying with LF-LW-R21 and LF-LW-R22	1. The design flow must not exceed 6 m^3/d. 2. The flow allowance used to calculate the system design flow must be no less than 145 litres per person per day where the water supply is provided by roof water collection, or no less than 180 litres per person per day for other sources of water supply. 3. The discharge must consist only of contaminants normally associated with domestic sewage and greywater. 4. The activity must not take place in any rare habitat, threatened habitat or at-risk habitat. 5. The activity must not be to any historic heritage identified in any district plan or regional plan.	1. Complies as detailed above.

Discretion is restricted to:

1. The volume of wastewater and design of the treatment system;
2. Compliance with the Manual for On-Site Wastewater Systems Design and Management (Horizons Regional Council, 2010);
3. The design of the disposal system, the disposal method, and the rate of land application;
4. The discharge quality, and allowable level of contamination;
5. Environmental effects arising from the location and method of disposal;
6. The reserve application area;
7. Duration of consent; and
8. Review of consent conditions

The discharge of wastewater to land is assessed as being a Restricted Discretionary Activity under **LF-LW-R24** as it does not comply with 5(a) and 5 (d) as Lots 2, 14 and 16 will be less than 5,000 m^2, and the proposed areal application rate is 4 mm/day. It should be noted that when the total subdivision area is average over the number of lots, the average lot area is 5,710 m^2 which would comply with the PA rules.

Matters of discretion Item 1 to 4 and 7 have been addressed in Section 3, the outstanding Items will be addressed below.

ALTERNATIVES ASSESSMENT

Multiple options could be considered for the treatment and disposal of wastewater from the proposed development. These are as follows:

- Individual on-site primary wastewater treatment and Low Pressure Effluent Dosing (LPED) discharge;
- Individual on-site primary wastewater treatment and PCDI discharge;
- Individual on-site secondary wastewater treatment and LPED discharge;
- Individual on-site secondary wastewater treatment and PCDI discharge (as proposed);
- Communal wastewater treatment and LTA; and
- Discharge to a community network.

These options and their appropriateness and efficiency at the applicants' site are discussed below.

Individual on-site primary wastewater treatment and Low Pressure Effluent Dosing (LPED) discharge is not considered appropriate for the management of environmental effects.

Individual on-site primary wastewater treatment and PCDI discharge or secondary wastewater treatment and LPED discharge; can be achieved successfully and is considered standard practice in some communities around New Zealand.

We have proposed the option of individual on-site secondary wastewater treatment and PCDI discharge to align with the permitted activity and manage environmental effects.

Discharge to a community network is not available at this time.

ASSESSMENT OF ENVIRONMENTAL EFFECTS

General

This assessment has been prepared in accordance with the requirements of Section 88(2)(b) and the Fourth Schedule of the Resource Management Act 1991 ("the Act"). Section 88 requires an application for resource consent to include an assessment of environmental effects in such detail as corresponds with the scale and significance of the effects that the activity may have on the environment.

This is a proposal to discharge secondary treated wastewater to land via drip irrigation, as such, soil, groundwater and surface water are the primary receptors to receive the contaminants. If the wastewater has not been treated to an acceptable standard, the concentration of contaminants will be beyond what the soil can assimilate which can result in leaching into groundwater. If the rate at which the wastewater is applied is too high, the soils can become saturated which can lead to ponding and potentially runoff into nearby watercourses. An appropriate rate of discharge and level of treatment will ensure that effects on the soil, groundwater and surface water are less than minor.

To address the matter of discretion, the following main areas of potential environmental effects from the proposed wastewater system have been assessed:

- Effects on Soils and Plants;
- Effects on Groundwater;
- Effects on Surface Water;
- Effects on Amenity, Community, Cultural and Heritage Values; and
- Cumulative Effects

Effects on Soils and Plants

The proposed application rate is 4 mm/day, which is also the same as the permitted activity rule provision for the discharge of treated wastewater on site. This application rate will ensure that the soil and vegetation health will remain in suitable condition. The proposed effluent quality will assist in ensuring that the organic, solids and nitrogen loading is adequate for the soil and vegetation to utilise and will not cause the soil to become anaerobic.

The proposed rate of application meets the recommended loading rates specified in Table 6.2 of Manual for On-Site Wastewater Systems Design and Management (Horizons Regional Council, 2010), and onsite testing confirms the soil can assimilate the proposed application rate.

It is proposed that the land treatment area is managed to ensure that no livestock and vehicles have access to it. Livestock and/or vehicles could damage the drip irrigation lines and adversely affect soil surface porosity and vegetation cover by pugging or compaction.

Therefore, the adverse effects on soils and plants are considered to be less than minor, and consistent with permitted activity provisions.

Effects on Groundwater

Ensuring that the contaminants from the discharge remain in the topsoil will assist in the prevention of migration of these contaminants through the soil profile and then into groundwater. Given the discharge option sought is pressure compensating drip irrigation (PCDI), only the topsoil profile will receive the contaminants. PCDI is the most favourable land treatment option type for

protection of groundwater in comparison to trenches and other sub-surface land treatment systems.

The productive groundwater level accessed in Bore ID 346031 is under pressure with an artesian pressure of >12 m. The strong confining layers creating the artesian pressure protects the deeper groundwater from contaminants entering.

Shallow unconfined groundwater was not encountered in the soil test pits to a depth of 2.7 m and 3.4 m bgl. These test pits confirm that a groundwater minimum separation distance of more than 600 mm will be maintained, a depth considered necessary to limit effects.

The HRC mapped Bore ID 346024 on Lot 2 has not been located onsite and is not used. There are no springs or wet areas indicating that the bore does not penetrate the deeper confined aquifer or that if it does, it is well sealed. A proposed condition is included that if this bore is located within the LTA area, it will be plugged with a bentonite seal.

Nitrate

Nitrate-nitrogen is formed by the chemical change of nitrogen compounds in the wastewater, particularly the breakdown of ammonium by nitrification processes during treatment and biological processes in the soil. Nitrate can then be readily leached through the soil to groundwater. The amount of nitrate leached depends on the types of plants/crops that utilise the nitrate, soil conditions (particularly how saturated the soils are) and drainage systems.

If nitrate drains into groundwater and is in a high enough concentration, it can have a detrimental effect on human health, especially if the groundwater system is used for drinking water supplies.

Due to a low application rate and a more than 600 mm separation distance between the land application system and groundwater, nitrogen will be attenuated in the soil by microbial, chemical, and physical processes. This will assist in reducing the contaminant concentration before it reaches groundwater.

Biological Oxygen Demand

The organic loading measured by biological oxygen demand (BOD) in the effluent can be detrimental if it reaches groundwater and can affect the oxygen levels in the groundwater. This can cause the groundwater to become anaerobic, which can create issues such as poor-tasting water and odours. If contaminated groundwater enters surface water through ground seepage, the organic loading can be detrimental to aquatic life.

Due to secondary treated effluent and low loading rates, the potential effects of BOD on the discharge are expected to be less than minor and consistent with the permitted activity provisions.

Escherichia coli

Escherichia coli (E. coli) in the effluent is an indicator of the presence of pathogens. Pathogens can cause sickness if they reach groundwater. Due to the nature of the upper soil profile, pathogens are unlikely to migrate through the soil profile into the groundwater. *E. coli* and pathogens are treated in the soil via natural attrition and other physical, chemical, and biological processes.

While the large depth of unsaturated soil is expected to remove all bacteria, the presence of a confining layer prevents any land surface drainage from entering the deeper aquifer.

The potential adverse effects from the discharge to land on groundwater are considered to be less than minor.

Effects on Surface Water

The Turitea Stream flows approximately 90 m northeast of the property at its closest point. Lots 2, 14 and 16 look to have an overland flow path at the foot of the terrace that is likely to flow into the Turitea Stream during high-intensity or long rainfall events. Contaminants can enter surface water either by ground seepage or runoff.

The location of the proposed land treatment areas is just outside of this flow path. The application rate is conservative, ensuring no ponding or runoff occurs. Due to the low application rate, land seepage from groundwater to surface water should also be minimal.

Nutrients such as ammoniacal nitrogen and phosphorus would be deemed as contaminants of concern, these can be detrimental to surface water courses as they can promote algal growth which leads to a poor aquatic environment. However, these contaminants are likely to be utilised in the upper soil profile, so migration or leaching into groundwater, and therefore seepage to surface water, is highly unlikely.

Organic matter can also be a contaminant of concern from wastewater discharges whereby the organic material increases the biological oxygen demand of the receiving watercourse and reduces the vital oxygen levels in the aquatic environment, sparing very little for the support of aquatic life. Due to the low levels of BOD in the secondary level quality of the effluent proposed, this will ensure that no organics from the effluent will enter surface water bodies.

The potential adverse effects from the discharge on surface water bodies is considered to be less than minor.

Effects on Amenity, Community, Cultural and Heritage Values

The discharges from proposed sites are considered to have less than minor effects on amenity, community, cultural and heritage values. They are well away from surface water bodies which may be of importance to local iwi, and because most of the discharge activity meets the permitted activity rule for the discharge of onsite wastewater to land (apart from the lot size), the activity will not be impacting on these values.

Cumulative Effects

Comparison with On-site Permitted Activity Rule

The subdivision is 4.57 ha (or 45,700 m^2) in area, and if the 8 lots were of equal size (5,710 m^2), they would all meet the permitted activity rule. However, a layout refinement has resulted in 3 of the 8 lots being less than 5,000 m^2, which is the minimum size for the discharge to be considered a permitted activity.

The cumulative impact of the proposed on-site wastewater systems at Lots 2, 14 and 16 is the same as if the lots were all equal in size. It is noted that the smaller lots are still at a size that will not cause any adverse impact, particularly as there will still be plenty of land for the land treatment areas outside the building platforms.

Cumulative Effects - Nitrogen

It is important to assess the cumulative effects of contaminants when developing multiple lot developments. The main contaminant of concern is nitrate-nitrogen and its impact on groundwater.

For conservatism, this assessment has assumed that all nitrogen emanating from the treatment plants is being leached, irrespective of its form (i.e., all nitrogen discharged from the land treatment system enters groundwater, and there is no soil attenuation). Table 0.1 below shows the calculated nitrogen loading (how much is applied to land) over the entire subdivision.

The areal loading rate selected earlier has been used to calculate the possible nitrogen loadings along with various nitrogen concentrations (the varying concentrations allow for differing treatment plant performance). The table indicates that with a concentration of 40 g N/m^3, the flows from 8 households would give a loading of 31 kg N/ha-yr. The mass actually leached to groundwater is expected to be considerably lower.

Table 0.1: The Cumulative Nitrogen Loading Over the Total Subdivision Area

Flow (m^3/household/d)	Concentration of Nitrogen (g/m^3)	Annual Mass for all 8 lots (kg N/yr)	Total Area-discharge for total of all - 8 lots (ha)	Total N loading over total subdivision area (4.57 ha) (kg N/ha-yr)
1.2	15	52	0.36	11
1.2	30	105	0.36	23
1.2	40	140	0.36	31

Table 0.1 above calculates the mass of nitrogen potentially discharged by all 8 lots under different treatment plant performances (i.e. different levels of treatment). This mass is then divided by the larger combined lot area to identify a worse-case annual leaching rate to groundwater.

The flows from each house are unlikely to be as high as they are in Table 0.1 every day; given these design flows are based on having six people at each residence full-time. Some onsite wastewater systems would produce flows less than 500 L/household/d for a family of four, and some properties may have fewer or more people. In addition to this, nitrogen concentrations from a secondary onsite system are likely to be in the order of less than 15 g/m^3 of total nitrogen and not the higher 40 g/m^3 as indicated for comparative purposes in Table 0.1.

The average loading rate is low, and with natural attenuation, the cumulative effect of all the lots' discharges is assessed to be less than minor.

MAINTENANCE AND MITIGATION

Suggested Maintenance

The proposed secondary wastewater treatment and land application systems will have a maintenance programme and contact that must be a certified servicing agent. This will be dependent on the chosen system, but it is expected that all pumps, aeration equipment, and the overall integrity of the treatment system must be checked on a regular basis. The land treatment system will also need to be checked regularly. Routine flushing of lines at the time of inspection will ensure no build-up or blockages of slimes occur in the lines.

The LTA area's proposed included a 50% additional area as a reserve area of 150 m^2.

OBJECTIVES AND POLICIES

National Policy Statement Freshwater Management (NPS-FM 2020)

The National Policy Statement for Freshwater Management 2020 (Freshwater NPS 2020) directs how freshwater resources, and activities that affect those resources, are to be managed under the Resource Management Act 1991. It came into force on 3 September 2020. Included within the document are directions to regional councils to amend regional plans to incorporate specific provisions from the NPSFM 2020.

The following sub-section provides an assessment of the activity against the objectives and policies of the NPSFM.

Objective 1
The objective of this National Policy Statement is to ensure that natural and physical resources are managed in a way that prioritises:
(a) first, the health and well-being of water bodies and freshwater ecosystems
(b) second, the health needs of people (such as drinking water)
(c) third, the ability of people and communities to provide for their social, economic, and cultural well-being, now and in the future.

(a) The discharge of treated domestic wastewater into land is protecting the well-being of water bodies and freshwater ecosystems. As outlined in Section 3 the wastewater will be secondary treated prior to discharge out of PCDI. Also, adequate separation distances will be maintained between the land treatment area and ground and surface water;
(b) The discharge of wastewater into land, provides essential sanitary services for the proposed dwellings. The subdivision is located approximately 4 km from the nearest drinking water source.
(c) The proposed subdivision will provide for the social well-being of the local community by providing housing.

Policy 1 – Freshwater is managed in a way that gives effect to Te Mana o te Wai.
As outlined in (a), (b) and (c) above the discharge of treated wastewater into land protects the health of freshwater while providing for the health and well-being of the community, it also ensures the mauri of the wai is protected by utilising Papatūānuku to cleanse the wastewater.

Policy 3 – Freshwater is managed in an integrated way that considers the effects of the use and development of land on a whole-of-catchment basis, including the effects on receiving environments.

Regional Policy Statement

The policies from Chapter 5 (Water) of the Horizons One Plan that are relevant to the discharge of on-site wastewater to land area:

Policy 5-10: Point source discharges to land

Discharges of contaminants onto or into land must be managed in a manner which:
a. does not result in pathogens or other toxic substances accumulating in soil or pasture to levels that would render the soil unsafe for agricultural, domestic or recreational use;
b. has regard to the strategies for surface water quality management set out in Policies 5-3, 5-4 and 5-5, and the strategy for groundwater management set out in Policy 5-6;

c. *maximises the reuse of nutrients and water contained in the discharge to the extent reasonably practicable;*
d. *results in any discharge of liquid to land generally not exceeding the available water storage capacity of the soil (deferred irrigation);*
e. *ensures that adverse effects on rare habitats, threatened habitats and at-risk habitats are avoided, remedied or mitigated.*

The discharge of treated wastewater to land upholds all provisions detailed in Policy 5-10 a – e. No contaminants or pathogens will accumulate in the soil due to the low application rate and the proposed level of secondary treatment of the wastewater. The discharge meets the surface water quality and groundwater management practices outlined in the policies. The soil will not be saturated due to the conservative application rate. There are no rare habitats, threatened habitats or at-risk habitats that will be adversely affected by the proposed discharges.

Regional Plan

The following Objectives and Policies are detailed in Chapter 14 of the One Plan and are relevant to this application.

Objective 14-1: Management of discharges to land and water and land uses affecting groundwater and surface water quality.

The management of discharges onto or into land (including those that enter water) or directly into water and land use activities affecting groundwater and surface water quality in a manner that:

a. *safeguards the life supporting capacity of water and recognises and provides for the values and management objectives in **Schedule B**,*
b. *provides for the objectives and policies of **Chapter 5** as they relate to surface water and groundwater quality, and*
c. *where a discharge is onto or into land, avoids, remedies or mitigates adverse effects on surface water or groundwater.*

The discharge of treated wastewater to land from the proposed lots will meet the provisions of Objective 14-1 by ensuring that surface waterways and groundwater quality are protected by ensuring that adequate separation distances are maintained. Treatment of the wastewater will be to secondary standard, which will reduce the level of contaminants potentially reaching ground or surface water. The conservative application rate will also ensure that there is no ponding or runoff to surface water.

Policy 14-2: Consent decision-making for discharges to land

When making decisions on resource consent applications, and setting consent conditions, for discharges of contaminants onto or into land the Regional Council must have regard to:

a. *the objectives and policies of **Chapter 5** regarding the management of groundwater quality and discharges,*
b. *where the discharge may enter surface water or have an adverse effect on surface water quality, the degree of compliance with the approach for managing surface water quality set out in **Chapter 5**,*
c. *avoiding as far as reasonably practicable any adverse effects on any sensitive receiving environment or potentially incompatible land uses, in particular any residential buildings,*

*educational facilities, churches, marae, public areas, infrastructure and other physical resources of regional or national importance identified in **Policy 3-1**, wetlands, surface water bodies and the coastal marine area,*

d. *the appropriateness of adopting the best practicable option to prevent or minimise adverse effects in circumstances where:*
    i. *it is difficult to establish discharge parameters for a particular discharge that give effect to the management approaches for water quality and discharges set out in **Chapter 5**,*
    ii. *the potential adverse effects are likely to be minor, and the costs associated with adopting the best practicable option are small in comparison to the costs of investigating the likely effects on land and water,*
e. *Avoiding discharges which contain any persistent contaminants that are likely to accumulate in the soil or groundwater, and*
f. *the objectives and policies of Chapters **2**, **3**, **6**, **9** and **12**, extent that they are relevant to the discharge.*

Policy 14-4: Options for discharges to surface water and land

When applying for consents and making decisions on consent applications for discharges of contaminants into water or onto or into land, the opportunity to utilise alternative discharge options, or a mix of discharge regimes, for the purpose of mitigating adverse effects, applying the best practicable option, must be considered, including but not limited to:

a. *discharging contaminants onto or into land as an alternative to discharging contaminants into water,*
b. *withholding from discharging contaminants into surface water at times of low flow, and*
c. *adopting different treatment and discharge options for different receiving environments or at different times (including different flow regimes or levels in surface water bodies).*

Policy 14-9: Consent decision making requirements from the National Policy Statement for Freshwater Management

a. *This policy applies to any application for the following discharges^ (including a diffuse discharge by any person or animal):*
    i. *a new discharge; or*
    ii. *a change or increase in any discharge of any contaminant into fresh water, or onto or into land^ in circumstances that may result in that contaminant (or, as a result of any natural process from the discharge of that contaminant, any other contaminant) entering fresh water.*
b. *When considering any application for a discharge the Regional Council must have regard to the following matters:*
    i. *the extent to which the discharge would avoid contamination that will have an adverse effect on the life-supporting capacity of fresh water including on any ecosystem associated with fresh water; and*
    ii. *the extent to which it is feasible and dependable that any more than minor adverse effect on fresh water, and on any ecosystem associated with fresh water, resulting from the discharge would be avoided.*

This clause of the policy does not apply to any application for consent first lodged before the National Policy Statement for Freshwater Management 2011 took effect on 1 July 2011.

c. *When considering any application for a discharge the Regional Council must have regard to the following matters:*
    i. *the extent to which the discharge would avoid contamination that will have an adverse effect on the health of people and communities as affected by their secondary contact with fresh water; and*
    ii. *the extent to which it is feasible and dependable that any more than minor adverse effect on the health of people and communities as affected by their secondary contact with fresh water resulting from the discharge would be avoided.*

    This clause of the policy does not apply to any application for consent first lodged before the National Policy Statement for Freshwater Management 2014 took effect on 4 July 2014.

The activity is consistent with the relevant provisions outlined in the Regional Plan. The proposed activity of discharging treated onsite wastewater to land will not cause adverse effects to people's health and communities as it is 4 km away from any drinking water sources. Additionally, adequate separation distances from property boundaries, housing, groundwater and surface water will be instated. Ecosystems will not be threatened, due to the low level of contaminants in the resulting wastewater discharged. All discharges are to be to land, as opposed to water, and will undergo further treatment in the soil. If the effluent was to be discharged to water, the contaminants may adversely affect the aquatic environment. All steps have been made to ensure that the best option for discharge has been chosen, based on the receiving environment, ensuring the discharges meet permitted activity rule provisions for treatment, application rate and separation distances.

NATIONAL ENVIRONMENTAL STANDARDS

NES - Sources of Human Drinking Water

The Turitea Stream flows approximately 90 m northeast of the property at its closest point. This point of the Turitea Stream is approximately 4 km downstream from the Turitea Dam. Palmerston North City Council's drinking water comes from a combination of sources, including the Turitea Dam and several bores around the city. About two-thirds of the drinking water supplied comes from the Turitea Dam.

Due to the distant proximity to the water supply locations, the discharges from the proposed on-site wastewater treatment systems will not have any effect on local water supplies.

PART II OF THE RESOURCE MANAGEMENT ACT

Section 104 of the RMA sets out the matters to be considered when assessing an application for a resource consent. These matters are subject to Part 2, the purpose and principles, which are set out in Sections 5 to 8 of the Act. Those matters that are considered for this application are as follows.

b. Section 5 - Purpose

The purpose of the Resource Management Act 1991 is to promote the sustainable management of natural and physical resources.

In the Act, sustainable management means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while –

- *Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
- *Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and*
- *Avoiding, remedying or mitigating any adverse effects of activities on the environment.*

As outlined in Section 5 above, the proposed on-site wastewater systems will safeguard the life-supporting capacity of the soil and water, while avoiding or mitigating any potential adverse effects on the environment.

c. Part 6 – Matters of National Importance

In achieving the purpose of the RMA, it is necessary to recognise and provide for the following matters of national importance:

a) the preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development;
b) the protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development;
c) the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna;
d) the maintenance and enhancement of public access to and along the coastal marine area, lakes, and rivers;
e) the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga;
f) the protection of historic heritage from inappropriate subdivision, use, and development;
g) the protection of protected customary rights.

The proposal is consistent with the matters of national importance in the Act in that it discharges wastewater into land.

d. Part 7 – Other Matters

In achieving the purpose of RMA it is also necessary for all persons exercising functions and powers under it to have particular regard to –

(a) kaitiakitanga;
(aa) the ethic of stewardship;

(b) the efficient use and development of natural and physical resources;
(ba) the efficiency of the end use of energy;
(c) the maintenance and enhancement of amenity values;
(d) intrinsic values of ecosystems;
(e) [Repealed]
(f) maintenance and enhancement of the quality of the environment;
(g) any finite characteristics of natural and physical resources;
(h) the protection of the habitat of trout and salmon;
(i) the effects of climate change;
(j) the benefits to be derived from the use and development of renewable energy.

The proposal is consistent with the other matters of the Act outlined above in that it makes good use of the available natural resources and maintains the quality of the environment.

e. Part 8 – Treaty of Waitangi

Part 8 of the Act requires all persons exercising functions and powers under it in relation to managing the use, development, and protection of natural and physical resources, to take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).

A significant cause of concern for the runanga is the degradation of freshwater sources and the protection of sites of cultural significance such as Nohoanga sites (traditional camping sites associated with mahinga kai – food gathering), sites of Wahi, Taonga and Tapu (sacred and treasured sites) and "silent files" which are unidentified areas of cultural and spiritual significance.

There have been no sites identified as having cultural significance within the vicinity of the proposed activity.

PROPOSED CONSENT CONDITIONS

The consent duration of 35 years is being proposed to align with the expected lifetime of the wastewater treatment plant.

1. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimise any actual or likely adverse effect on the environment associated with the discharge.

2. The effluent shall be discharged over a land area of no less than 300 m^2 (with 50 % reserve).

3. The volume of effluent discharged shall not exceed 2 m^3/day.

4. There shall be no discharge within 20 metres of any surface waterbody.

5. The consent holder shall ensure that there is a point where the treated effluent can be sampled before it is discharged to the effluent land application area. The consent holder shall provide access to enable a sample to be taken as required.

6. There shall be no surface run-off, ponding, or contamination of surface water resulting from the discharge of treated wastewater to land.

7. The wastewater treatment system shall be operated and maintained according to the manufacturer's guidelines.

8. The disposal field shall be located within the boundaries of the subject property in accordance with the information submitted in support of this application, and as far as is reasonably practicable, the discharge shall be contained within the boundaries of the subject property.

9. The consent holder shall ensure that there will be no noxious, dangerous, offensive or objectionable odour at or beyond the boundaries of the subject property.

CONCLUSIONS AND RECOMMENDATIONS

The subdivision on Turitea Road will create 8 individual lots. Of the 8 lots, 3 will have land areas under the 5,000 m^2 as specified in the One Plan permitted activity rule, LF-LW-R22. When averaged over the entire subdivision, the average lot area is 5,710 m^2, and at a subdivision level the 5,000 m^2 provision would be met. However, on an individual lot basis, three of the lots require resource consent purely based on land area requirements. The proposed LTA area is 450 m^2 (including the 50% reserve area).

The wastewater will be treated to meet secondary treatment standards; meaning it will have low concentrations of BOD, suspended solids and nitrogen. Suitable buffer distances from sensitive areas such as groundwater and surface water will be in place, with wet areas being avoided.

The proposed lots will have a generous area of flat land to allow for building, as well as garden and land treatment areas. Assuming a total land treatment area of 450 m^2 is required, there is more than sufficient land area remaining for other activities, including the house, driveway, sheds and landscaping.

Given the above, it is considered that it is appropriate to grant consent to this application in terms of the Resource Management Act 1991 for the following reasons:

- There will be less than minor adverse effects associated with the discharge of wastewater into land; and
- The proposal is not contrary to the objectives and policies of the relevant planning documents.

Overall, it is concluded that the proposal will continue to promote the sustainable management of natural and physical resources while avoiding, remedying or mitigating adverse effects on the environment.

REFERENCES

Crites, R., & Tchobanoglous, G. (1998). Small and decentralized wastewater management systems. Boston: WCB/McGraw-Hill.

Horizons Regional Council (2007) Manual for On-Site Wastewater Design and Management

Horizons Regional Council (2014) One Plan (updated June 2024)

APPENDICES

Appendix A Certificates of Title
Appendix B RDCL Geotechnical Report

APPENDIX A

Certificates of Title

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier	**WN35D/790**
Land Registration District	**Wellington**
Date Issued	30 January 1990

Prior References
WN7C/683

Estate	Fee Simple
Area	3.2050 hectares more or less
Legal Description	Lot 3 Deposited Plan 67730

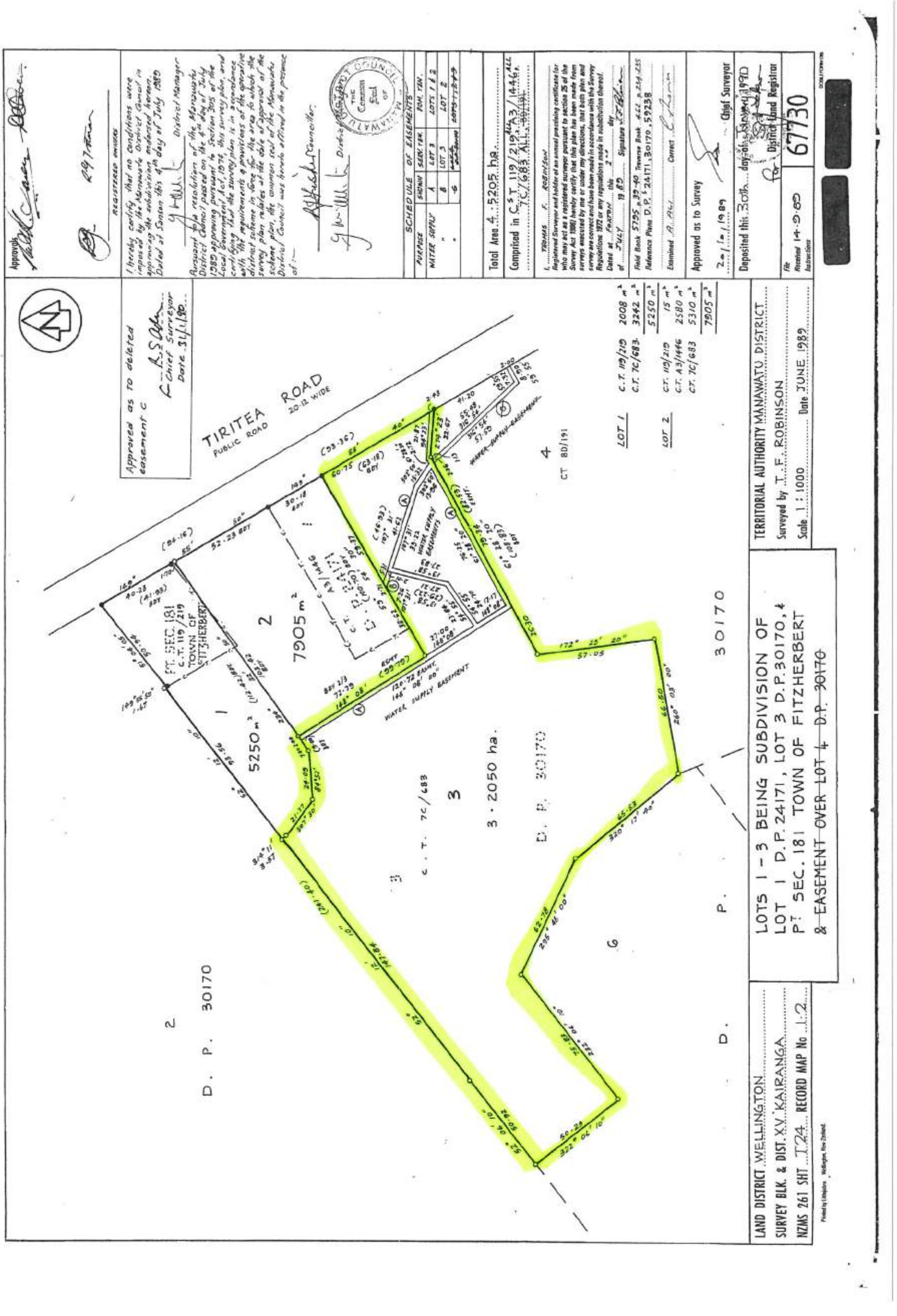
Registered Owners

Nathan John Donaldson and Bernadette Ellen Donaldson

Interests

Subject to a right to convey water over parts marked A and B on DP 67730 specified in Easement Certificate B058606.7 - 30.1.1990 at 2.41 pm

10657611.2 Mortgage to TSB Bank Limited - 16.12.2016 at 4:16 pm


TIRITEA ROAD
LOTS 1 - 3 BEING SUBDIVISION OF
LOT 1 D.P. 24171, LOT 3 D.P. 30170, &
PT SEC. 181 TOWN OF FITZHERBERT
& EASEMENT OVER LOT 4 D.P. 30170
TERRITORIAL AUTHORITY MANAWATU DISTRICT
Surveyed by T.F. ROBINSON
Scale 1:1000
Date JUNE 1989
LAND DISTRICT WELLINGTON
SURVEY BLK. & DIST. XV KAIRANGA
NZMS 261 SHT T24 RECORD MAP No 1-2
Total Area 4.5205 ha
67730

COMPUTER FREEHOLD REGISTER
UNDER LAND TRANSFER ACT 1952

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier	**WN51C/979**
Land Registration District	**Wellington**
Date Issued	01 April 1997

Prior References
WN47D/402

Estate	Freehold for Life
Area	5.9159 hectares more or less
Legal Description	Lot 4 Deposited Plan 30170 and Section 1 Survey Office Plan 37477

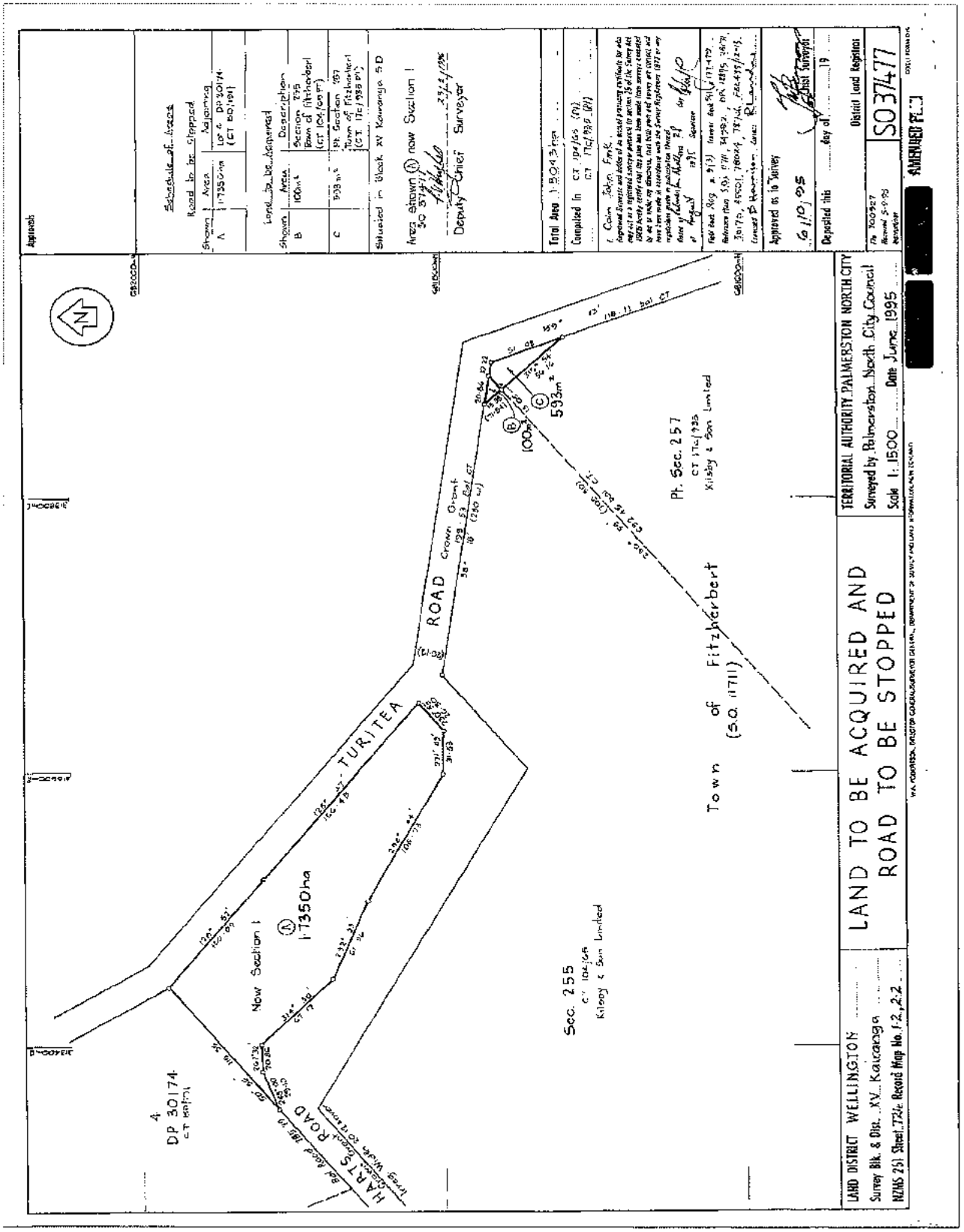
Proprietors
Colin William Holmes and Dorothy Anne Holmes

Estate	Remainder in Fee Simple
Area	5.9159 hectares more or less
Legal Description	Lot 4 Deposited Plan 30170 and Section 1 Survey Office Plan 37477

Proprietors
Colin William Holmes and Dorothy Anne Holmes

Interests
Subject to a right to water conveyance over part created by Transfer 852228.1 (affects Lot 4 DP 30170)

Identifier **WN51C/979**



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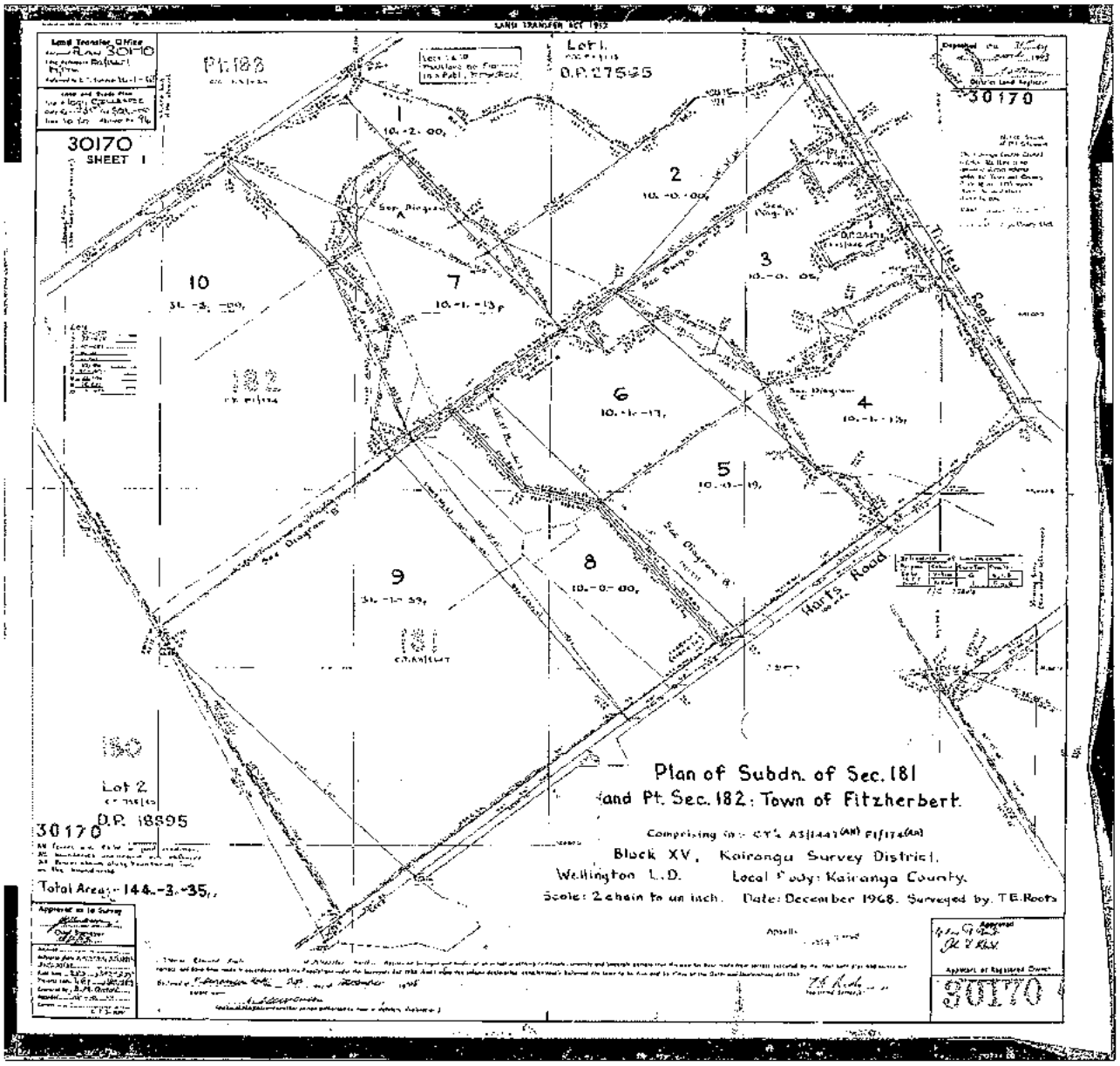
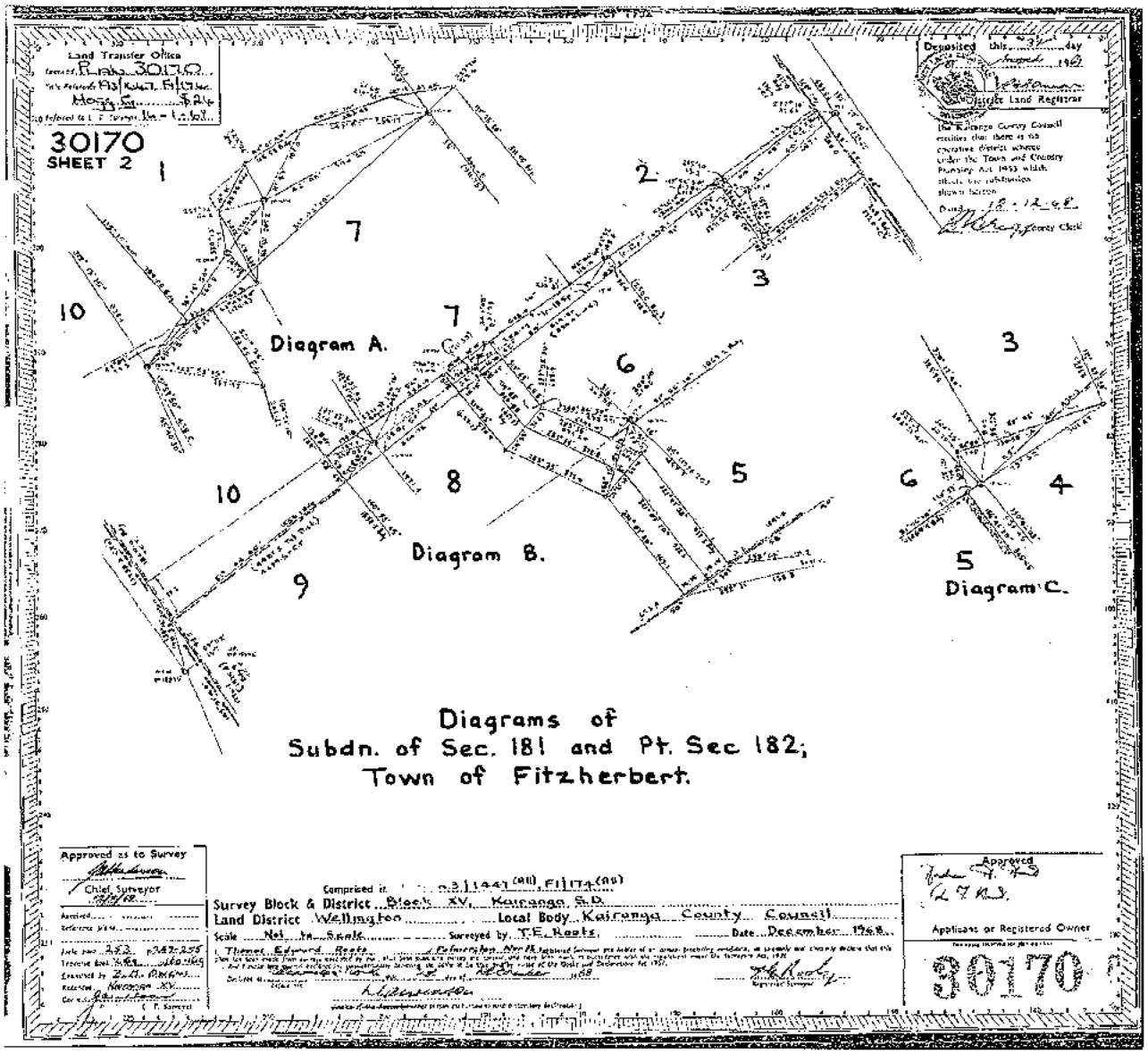


Identifier **WN51C/979**



APPENDIX B

RDCL Geotechnical Report

GEOTECHNICAL ASSESSMENT REPORT

PROJECT:

158 TURITEA ROAD, PALMERSTON NORTH

CLIENT: TE PIRANGI DEVELOPMENT LTD

REVISION TABLE

Revision	Description	Date	Signature
R230999_A_01	Geotechnical Report		

REPORT REVIEW TABLE

Report	Author	Date	Signature
Written by	T Goettler	21.02.24	
Checked by	B Bistouni	23.02.24	
Approved by	C Wylie	27.02.24	

Reference	Compliance achieved
Hazards (Active Faults, Flood, Liquefaction, Slope Stability)	✓
Shallow Bearing Capacity Assessment	✓
Seismic Site Class in accordance with NZS 1170.5 Amendment 1	✓
In accordance with Section 106, RMA	✓
In accordance with Building Code B1	✓
In accordance with MBIE (2012) Part A&B Technical Guidance	✓

CONTENTS

FIGURES

TABLES

APPENDICES

1 OVERVIEW

Resonant, on behalf of Te Pirangi Development Limited (The Client), engaged Resource Development Consultants Ltd (RDCL) to complete a geotechnical investigation and assessment for a multi-lot subdivision at 158 Turitea Road, Palmerston North (Legal Description: Lot 2 & 3 DP 67730 & Lot 4 DP 30170).

1.1 UNDERSTANDING THE PROJECT

We understand the client intent is to subdivide the existing properties at 158 &164 Turitea Road into Ten (10) Lots for Stage 5 of Turitea Road development:

- New Lots comprises of:
  - Lots 3, 14, 16, 17, 18 and 19.
  - Existing dwellings on Lots 1, 2 and 15 will remain.

A Geotechnical assessment is required to:

- Assess ground conditions;
- Assess natural hazards in accordance with section 106 of Resource Management Act (1991) relevant to future residential development and each lot; and
- Submit with subdivision consent application.

The client supplied RDCL with:

- Scheme Plan prepared by Resonant (Project: Proposed Development 158 & 164 Turitea Road, Palmerston North, Job number: 220003, Sheet:1, Rev: 1, Dated 21/11/23).
- Geotechnical Investigation Report prepared by Riley Consultants (Project: Proposed Residential Subdivision 164 Turitea Road, Palmerston North, Job number: 200043-C, dated 2/12/20).
- Addendum to Geotechnical Investigation Report prepared by Riley Consultants (Project: Stage 2 Proposed Residential Subdivision 164 Turitea Road, Palmerston North, Job number: 200043-F, dated 2/12/21).

1.2 PROJECT SCOPE

Work was undertaken in general accordance with RDCL proposal 230880, dated 31st October 2023.

1.3 RELEVANT GUIDELINES

Geotechnical investigations and assessment have been undertaken in accordance with:

- NZ Building Code Clause B1 Structure, 1st edition, Amendment 19.
- NZS4431:2022 Engineered Fill Construction for Lightweight Structures.
- NZS3604:2011 Timber Framed Buildings.
- Ministry of Business, Innovation and Employment (MBIE) guidelines, revised issue of Repairing and Rebuilding Houses Affected by the Canterbury Earthquakes. Parts A & C: Technical Guidance (2012, 2015).
- MBIE (2021) Module 1: Overview of Earthquake Geotechnical engineering Practice Guidelines.
- MBIE (2021) Module 2: Geotechnical Investigations for Earthquake Engineering.
- NZGS (2005) Guidelines for Field Description of Soil and Rock.
- NZS1170.5:2004, part 5: Earthquake Actions – New Zealand.

2 SITE DESCRIPTION

The two properties are approximately 4.5ha and located ~6km to the south of Palmerston North City. The new development is bounded to the east by existing residential dwellings and river terrace to the west.

- Lots 3, 14, 16, 17 and 18 are located on a relatively flat ground at the toe of ~ 30m high northeast facing slope (~ 35°); and
- Lot 19 situated above the slope.
    - Access to Lots 3, 14, 16, 17 and 18 is proposed via Turitea Road on a relatively flat ground;
    - Access to Lot 19 is proposed via preformed track, traversing up the northeast facing slope.

3 DESKTOP STUDY

3.1 SITE GEOLOGY

The New Zealand Geology web map (GNS, 2023) indicates the site is underlain by either;

- Holocene River deposits; comprising
    - Alluvial gravel, sand, silt, mud and clay with local peat; includes modern riverbeds.
- Late Pleistocene River deposits; comprising
    - Poorly to moderately sorted gravel with minor sand or silt underlying terraces.
- Late Pleistocene Ocean beach deposits; comprising
    - Beach deposits consisting of marine gravel with sand; commonly underlying loess and fan deposits.

3.2 SUMMARY OF POTENTIAL GEOHAZARDS

A summary of potential geohazards present on site is in Table 1. The risk assessment is based on review of:

- New Zealand Active Faults Database (GNS Science, 2022);
- Palmerston North City Council open data portal;
- Horizons Regional Council Natural Hazard open data portal; and
- Our geotechnical investigation.

TABLE 1: SUMMARY OF POTENTIAL NATURAL HAZARDS

Geohazard	Risk	Risk Summary
Active Faults	Low	No "Known" active faults directly impact the proposed development
Liquefaction Susceptibility	Moderate	The site is mapped as moderate risk of liquefaction induced ground damage. A liquefaction assessment was conducted to assess potential earthquake induced liquefaction and is discussed in section 5.4.
Flood Risk	Low	The proposed development is inside the predicted flood prone areas. Due to site elevation of R.L. ~56 to 87m flood risk is considered low.
Land Stability	Moderate	The eastern area is predominantly flat, with a ~32m high river terrace along the west. Historical images and site walkover indicate evidence of shallow soil creep on steep slopes and no indication of historic deep-seated instability. Given the slope angles at this site we consider the risk of slope stability to be "Moderate" risk. A slope stability assessment was conducted and is discussed in section 5.5.
Shrink Swell Soils	Low	This site is not subject to shrink swell due to underlaying soil and geology comprising predominantly of granular material. No evidence of shrink swell during site walkover.

4 SITE INVESTIGATION

Site investigation comprised:

- Four (4) Cone Penetrometer Tests (CPT):
  - Terminated between 1.4 and 6.07m below ground level (bgl), due to dense strata encountered;
- Twelve (12) Test Pits (TP):
  - Terminated between 2.7m and 3.4m bgl, due to target depth or dense strata.
- Three (3) hand auger (HA): with
  - Terminated between 0.35m and 1.7m bgl, due to dense strata.
- One (1) Face log (FL): and
- Nineteen (19) Dynamic Cone Penetrometer tests (DCP);
  - Terminated between 0.15m and 2.2m bgl, due to dense strata.

Soils recovered from HA investigations were logged in accordance with New Zealand Geotechnical Society (NZGS) guidelines (Burns et al., 2005).

The site plan illustrating test locations is presented in Figure 1. Site investigation logs are attached as Appendix A.

4.1 COMPLIANCE WITH PNCC LIQUEFACTION GUIDELINES

The site is classified within a "Moderate" liquefaction vulnerability (Palmerston North City Council District Plan, 2018) requiring:

- "Deep" investigations comprising either machine drilled boreholes/CPT testing to a depth of at least 10-15 m bgl; or
- A depth that is demonstrated to be suitable by a suitably qualified and experienced Geotechnical Professional; with
- Assessment of liquefaction potential to be made by suitably qualified and experienced Geotechnical Professional (Refer section 7.3.2 of Geotechnical Site Investigation Guidelines – June 2019).

In this instance CPT testing could not penetrate to full depth and terminated at maximum depth of 6.2m bgl. CPT termination was due to high tip resistance and anchor failure indicating dense material inferred to be dense sand and gravel mixtures.

DPSH was conducted at CPT01, CPT03 & CPT04 to confirm dense material at depth. The DPSH tests indicated very dense material below ~3.3m bgl and refused at the surface at CPT04 test.

In conjunction with the DPSH data, Borehole data information collected from Riley Addendum to the Geotechnical Investigation Stage 2 Proposed Subdivision: 164 Turitea Road, Palmerston North, is consistent with the subsurface geology at test locations.

Example Boreholes include two (2) borehole tests located in adjacent properties.

The relevant Boreholes are:

- MH1
- MH2

The above borehole logs indicate consistent material comprising;

- Surface to ~1.0m bgl: A mixture of Silt (Alluvium);
- Dense Gravel to ~3.0 m bgl (MH1); underlain by
- Dense Sand mixtures layer to at least ~15 m bgl.

The shallow silts and sands have been assessed for liquefaction with results presented in section 5.5 of this report. The deeper gravels and sand mixtures are unlikely to liquefy due to density of materials.

We believe the ground model as indicated above provides sufficient evidence to allow recommendation of foundations to meet the requirements of the Building Code Clause B1 Structural.

The relevant borehole & DPSH logs are attached in Appendix B.

4.2 SUBSOIL CONDITIONS & GROUND MODEL

Based on our investigation and test results we have developed the following generalised soil profile and ground model in Table 2.

TABLE 2: GENERALIZED SUBSOIL CONDITIONS

Depth (m bgl)		Description	Consistency/ Strength
From	To		
0	0.4	Topsoil/Non engineered FILL	Medium Dense
0.4	1.5	SILT mixtures	Stiff to Very Stiff
1.5	~3.0	Sandy GRAVEL	Dense
~3.0	15.2	*SAND and GRAVEL Mixtures	Dense – Very Dense

* Inferred from Riley's Borehole data

4.2.1 NON-ENGINEERED FILL

Existing access to Lot 19 has been modified and covered with non-engineered fill to ~0.4m bgl..

4.2.2 GROUNDWATER

Groundwater was not encountered at the time of investigation.

We have adopted a design static water level (SWL) of 3.0 m bgl at the bottom of the terrace for this assessment.

5 GEOTECHNICAL ASSESSMENT

5.1 SEISMIC SITE CLASS

The site is classified as site subsoil "Class D – Deep or Soft Soil Site" in accordance with NZS1170.5:2004, part 5: Earthquake Actions – New Zealand. This is based on site investigations, our knowledge of the geology from published record and experience in the region.

5.2 GEOTECHNICAL PARAMETERS

Geotechnical soil parameters have been estimated based on correlation from shallow handheld investigation and CPT investigations.

The effective strength parameters used for modelling are summarised in Table 3 and shall be adopted for specific engineering designed foundations.

TABLE 3: EFFECTIVE SOIL PARAMETERS

Depth (m bgl)		Soil Type	Density (kN/m^3)	Effective Cohesion, c' (kPa)	Effective Friction Angle, φ' (^{o})
From	To				
0	0.4	Non engineered Fill	NA	1	28
0.4	1.5	SILT	18	5	32
1.5	~3.0	Sandy GRAVEL	19	1	44

5.3 LIQUEFACTION ASSESSMENT

5.3.1 BASIS OF LIQUEFACTION ASSESSMENT

The liquefaction assessment for the site was based on CPT investigations and assessed using program CLiq v3.0.3.2, accepted industry software package (Geologismiki, 2022) using input parameters in accordance with MBIE Earthquake Geotechnical Engineering Practice Module 1: Overview of the guidelines (2021):

- Magnitude (M) = 6.4 (SLS) & 7.5 (ULS);
- Peak Ground Acceleration (PGA) = 0.13g (SLS) & 0.55g (ULS);
- Water level modelled at 3.0m bgl;
- A 50-year design life; and
- An Importance Level 2 (IL2) was assumed.

5.3.2 OVERALL LIQUEFACTION RISK

The assessment indicates:

- Under Serviceability limit state (SLS) and Ultimate limit state (ULS):
  - Little to no expression of liquefaction is expected; with

- < 25mm vertical settlement; and
- No lateral spread is expected.

The liquefaction assessment is presented full details are in Appendix C.

5.4 MBIE (2012) TECHNICAL CATEGORY

Based on liquefaction assessment, all lots met the criteria for Technical Category 1 (TC1) and is summarised in Table 5. In accordance with MBIE (2012) Technical Guidance Part A and Technical Guidance Part A (2012).

5.5 SLOPE STABILITY ASSESSMENT

A slope stability assessment has been completed under static and seismic conditions for the proposed development.

One (1) critical slope profile (Cross Section A) was chosen based on:

- Topographical contours, proposed development locations; and
- Site observations.

The site plan illustrating the cross-section location is in Figure 1.

Slope stability modelling analysis is attached in Appendix C.

5.5.1 SLOPE STABILITY SCENARIO AND TARGETS

The stability analysis is based on the following scenarios and Targets:

- Static conditions with normal water level (FoS 1.5);
- Static conditions with elevated water table (FoS 1.2);
- Serviceability Limit State (SLS) earthquake event (FoS 1.2); and
- Ultimate Limit State (ULS) earthquake event (FoS 1.2).

5.5.2 BASIS OF ASSESSMENT

The following design assumptions have been used in the slope stability analysis:

- Ground model material parameters derived from site investigation information;

- Limit Equilibrium stability analysis undertaken using Slide2 industry design software from Rocscience.
- The following input parameters were calculated in accordance with the MBIE Module 1 (MBIE, 2021) and Module 6 of the MBIE (MBIE, 2021);
- PGA 0.13g (SLS);
- PGA 0.275g (ULS), assuming 0.55g x 0.5 reduction factor:
- A factored seismic coefficient of 0.5 was used in ULS case which allows for ductility in soils.

We have chosen:

- PGA ULS = amax x 0.5

On the basis of the following:

- NZ Geomechanics News (Dec 2018): Seismic Design of Geotechnical Structures for NCTIR. "In recognition of the fact that actual slopes and many retaining structures are not a rigid body and that the peak acceleration exists for only a short time, the pseudo-static coefficients used in practice generally correspond to acceleration values well below αmax.
- MBIE (Nov 2021) Module 6, Earthquake Resistant Retaining Wall Design uses reduced Wd factors for walls.
- ISSMGE (Feb 2015) New Zealand Simplified Seismic slope stability analysis and risk-based slope Design for earthquake resistance.
- A Designed ground water table of 3.0m bgl. at the base of the slope has been adopted and deeply underlying the top of the slope at ~19m bgl.
- Importance level IL2;
- R = 0.25 (1/25 yr event) – SLS;
- R = 1.0 (1/500 yr event) – ULS; and
- Assigned a 50 yr design life.

5.5.3 SLOPE STABILITY RESULTS

Numerical stability analysis has been undertaken using Slide 2018, industry standard software by Rocscience.

Based on our numerical slope stability analysis, apart from shallow failures at the surface.

- The slope is stable under all conditions.

Proposed profile factor of safety summary is showing in Table 4.

TABLE 4: FACTOR OF SAFETY SUMMARY

Cross Section	Design Case	Factor of Safety	Target	Achieved
CSA	Static	2.1	1.5	Yes
	Static, elevated water table	1.9	1.2	Yes
	Seismic – SLS	1.6	1.2	Yes
	Seismic – ULS	1.2	1.2	Yes

5.6 BEARING CAPACITY

Soil bearing capacity was estimated based on the results of DCP investigations and is summarised in Table 5.

Bearing capacity estimates are based on guidance in the Stockwell paper Determination of Bearing Pressures under Small Structures (M.J. Stockwell 1977).

TABLE 5: SUMMARY OF SHALLOW ULTIMATE BEARING CAPACITY

Lot ID	Depth to 200 kPa UBC (m bgl)	Depth to 300kPa UBC (m bgl)
Lot 3	At a level cleared of Topsoil and Non-engineered Fill ~0.2 bgl.	0.4
Lot 14	At a level cleared of Topsoil and Non-engineered Fill ~0.35 bgl.	0.3
Lot 16	At a level cleared of Topsoil and Non-engineered Fill ~0.2 bgl.	0.3
Lot 17	At a level cleared of Topsoil and Non-engineered Fill ~0.2 bgl.	0.3
Lot 18	At a level cleared of Topsoil and Non-engineered Fill ~0.3 bgl.	0.3
Lot 19	At a level cleared of Topsoil and Non-engineered Fill ~0.2 bgl.	0.6
Accessway to Lot 19	At a level cleared of Topsoil and Non-engineered Fill	0.4

6 ENGINEERING CONSIDERATIONS

Recommendations and opinions contained in this report are based on data from site investigations outlined in Sections 4 & 5. Inferences about the nature and continuity of subsurface geology and ground conditions are made but cannot be guaranteed.

6.1 SUITABILITY FOR DEVELOPMENT

We consider that from a geotechnical perspective, the site is suitable for development subject to the geotechnical recommendations presented in this report.

- All Lots are underlain by insitu silt, silty clay and gravel.
- All Lots are at low risk of liquefaction induced deformation;
- All slopes meet Factor of Sfatey criteria, suitable for development;
- Ultimate bearing capacity of 300 kPa is available on all sites at depth as presented in Table 5;
- Access to Lot 19 and encountered non-engineered fill as per recommendations in Section 6.5; with
- A building setback as per Table 7 is applicable; and
- A site-specific geotechnical investigation is required for building consent.

6.2 PRELIMINARY FOUNDATIONS RECOMMENDATIONS

As guidance shallow foundation solutions in accordance with NZS3604:2011 are appropriate considering:

- Bearing capacity as per Table6; and that
- All foundations need to be stripped of topsoil and any soft/loose unsuitable material prior to construction;
- A site-specific geotechnical investigation to be carried out at building consent stage.

6.3 CUTS AND FILLS

The preferred cut and fill plans were not available at the time of this investigation. It is likely that some cut and fill will be required to form building platforms and access road. For cut and fill options we recommend:

6.3.1 CUTS

To reduce the risk of instability in cut slopes we recommend:

- All cuts greater than 0.9 m in height should be retained, or excavated to angles set out in Table 6;

TABLE 6– RECOMMENDED CUT SLOPE ANGLES FOR CUTS EXCEEDING 0.9 M HEIGHT

Material Type	Recommended Cut Slope Angle up to 3m height
Topsoil, Soft soils (insitu), Non-engineered Fill	3H:1V
Firm / medium dense Soil (insitu) & Engineered Fill (certified)	2H:1V
Dense soils(insitu)	1.5H:1V

For supported cuts up to 3m height, appropriate engineering parameters for the design of retaining walls:

- Loose to firm material: c’ = 3 kPa, ϕ’ = 28°; and
- Stiff / Medium dense to hard material: c’ = 7 kPa, ϕ’ = 32°.
- Dense material: ϕ’ = 42°.

All retaining walls should be backfilled with free draining materials with “Novaflow” style piping to capture and direct water away for adequate disposal.

6.3.2 FILLS

Engineered fills should be placed, and fill surface prepared in accordance with standards set out in (NZS 4431:2023 "Code of Practice for Earthfill for Residential Development"). We recommend:

- Prior to fill placement, natural ground should be benched to insitu materials, free of any organic or non-engineered fill materials;
- Any seepage observed or discovered during construction on site should be drained to an appropriate collection point; and
- Consideration should be given to avoid placing the house on any significant cut-fill boundary without specific site testing following earthworks completion.

6.4 SETBACK

Minor soil creeps and shallow soil slumps are likely to occur on the northeast facing slope. Set back distances for each Lot is presented in Table 7.

TABLE 7– SETBACK DISTANCES

Lot Number	Setback distance
Lots 3, 14 & 16	5m from toe of the slope
Lot 17	5m from toe and crest of the slope
Lot 18	5m from toe of the slope
	3m from crest of the slope
Lot 19	7m from slope crest

Further, we recommend:

- Avoid founding any structures across any significant cut and fill boundaries without specific geotechnical assessment; and
- Planting of steep northeast facing slopes as soon as practical will benefit stability.
- Any structures intended to be built within Setback Zones would require specific geotechnical investigation and foundation design.

6.5 ACCESS DEVELOPMENT

Access to Lot 19 will be formed along the existing alignment traversing the northeast facing slopes. (Figure 1). No evidence for slope instability impacting the proposed road alignment was observed during site walkover with:

- Slopes are moderately steep and display some evidence of shallow soil creep; and

As it relates to development of the access road:

- Appropriate surfacing of access needs to consider subgrade conditions, drainage, likely traffic loads and importantly maintenance over the long term;
  - Subgrade should be stripped of all organic loose and deleterious materials.
  - The carriageway should be shaped to manage surface water flows in a controlled manner. This should at least include:
  - A well-defined “table drain” on the inside of the accessway, well defined discharge points to shed water.

6.6 STORM WATER MANAGEMENT

Stormwater disposal should be specifically designed by professionals with competence in the field. Any comments in this report as it relates to stormwater are for guidance only.

As a minimum we recommend:

- All developments should be undertaken in a manner so as to redirect storm water from proposed building platforms and other impervious surfaces;
- Stormwater should discharge to a suitable point away from existing slopes and in a manner that reduces the risk of erosion.

6.7 EFFLUENT DISPOSAL

Effluent disposal fields:

- Need to consider site specific conditions including soil type and the northeast facing slope;
- Require specific design by a professional experienced in of effluent systems;

6.8 FURTHER GEOTECHNICAL INPUT

We recommend a suitably qualified geotechnical professional be engaged:

- Should ground conditions be found to differ from those contained in this report;
- To confirm appropriate site preparation prior to building placement; including:
  - Documented strip of organic and soft or loose soils; and
  - To confirm the geotechnical suitability of finished building platforms.

7 REFERENCES

1. GNS Science (2023). *New Zealand Geology Web Map 1:250K Geology*. [online] Available at: https://data.gns.cri.nz/geology/
2. NZS4431 (2022). NZS4431:2022 – Engineered Fill Construction for Lightweight Structures. Standards New Zealand.
3. GNS Science (2023). *New Zealand Active Faults Database: Active Faults 250K.* [online] Available at https://data.gns.cri.nz/af/
4. Ministry of Business, Innovation and Employment (2021). Earthquake Geotechnical Engineering Practice – Module 1: Overview of the Guidelines.
5. Ministry of Business, Innovation and Employment (2016). Earthquake Geotechnical Engineering Practice – Module 2: Geotechnical Investigations for Earthquake Engineering.
6. NZS3604 (2011). *NZS3604:2011 - Timber-framed buildings*. Standards New Zealand.
7. Ministry of Business, Innovation and Employment (MBIE) guidelines, revised issue of Repairing and Rebuilding Houses Affected by the Canterbury Earthquakes. Part C: Technical Guidance TC3 (December 2015).
8. AS/NZS1547 (2012). AS/NZS1547:2012 On-Site Domestic Wastewater Management Plan. Australian/New Zealand Standard
9. Standards New Zealand (2004). *Structural Design Actions Part 5: Earthquake Actions*. NZS 1170.5:2004. Wellington: Standards New Zealand.
10. Stockwell. M, J (1977). Determination of allowable bearing pressure under small structures.

8 LIMITATIONS

- This report has been prepared for the particular purpose outlined in the project brief and no responsibility is accepted for the use of any part in other contexts or for any other purpose.
- Ground conditions assessed in this report are inferred from published sources, site inspection and the investigations described. Variations from the interpreted conditions may occur, and special conditions relating to the site may not have been revealed by this investigation, and which are therefore not taken into account. No warranty is included either expressed or implied that the actual conditions will conform to the interpretation contained in this report.
- No responsibility is accepted by Resource Development Consultants Ltd for inaccuracies in data supplied by others. Where data has been supplied by others, it has been assumed that this information is correct.
- Groundwater conditions can vary with season or due to other events. Any comments on groundwater conditions are based on observations at the time.
- This report is provided for sole use by the client and is confidential to the client and their professional advisors. No responsibility whatsoever for the contents of this report shall be accepted for any person other than the client.

9 CLOSURE

We trust this meets your current needs and look forward to working with you. Please call the undersigned on 04 282 1564 should you wish to discuss further.

Sincerely,

Prepared by:

T Goettler

BSc Geol

Engineering Geologist

Reviewed by:

C Wylie

MSc, BSc, CMEngNZ, CPEng,

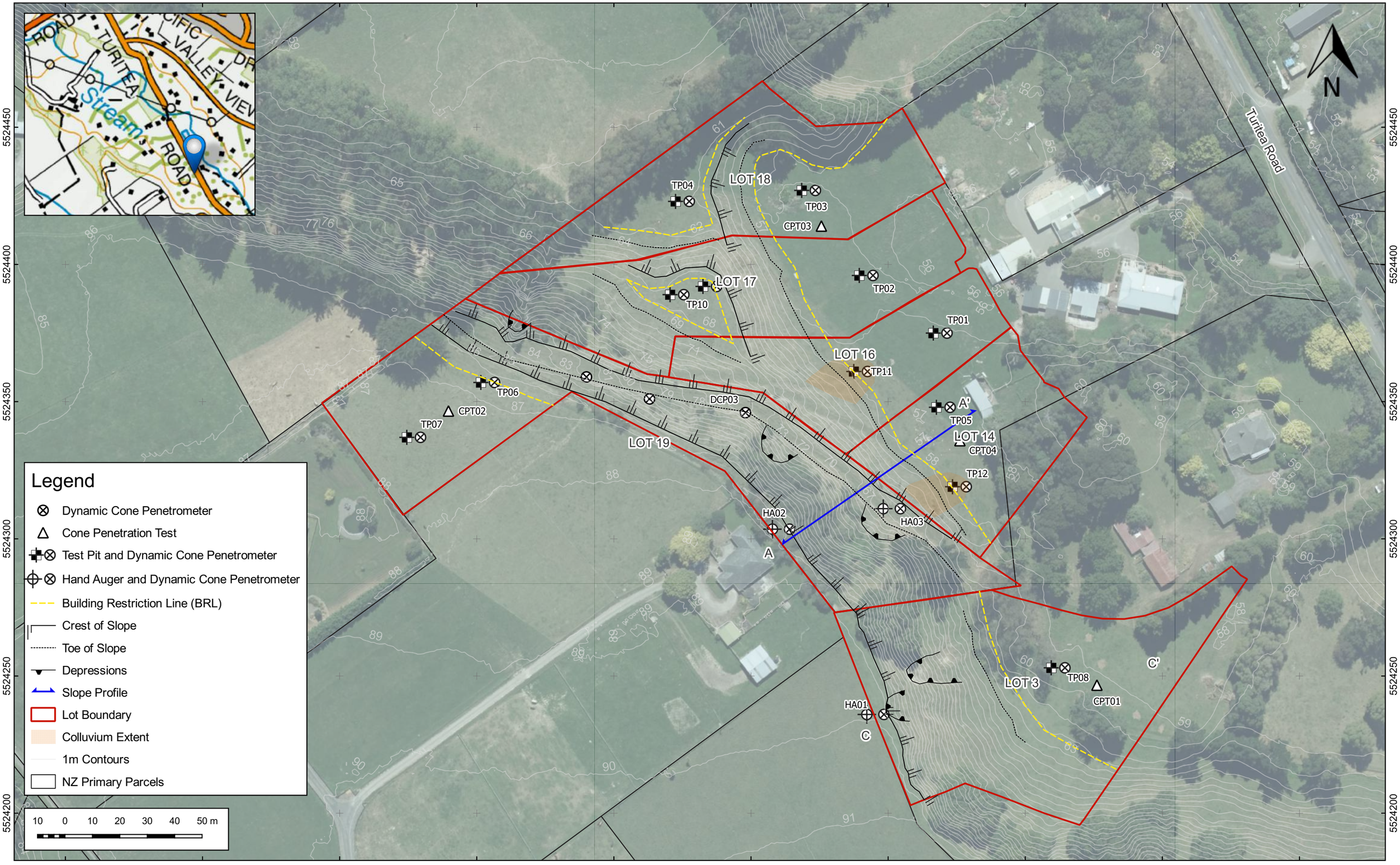
Principal

Attached:

Figures 1	Site Investigation Layout
Appendix	A - D

Important information about your Geotechnical Report

Figure 1: SITE INVESTIGATION LAYOUT



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	Project	230999_158 Turitea Road, Palmerston North	Checked By BB	Date 23.02.24	
	Client	Te Pirangi Developments Ltd	Approved By CW	Date 27.02.24	Figure 1

Appendix A: CPT, DCP AND TP LOGS

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DCP LOG

DCP01

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT:	230999	EASTING: 1824263.00	STARTED: 17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING: 5524351.00	FINISHED: 17/01/2024
		DATUM: NZVD2016	LOGGED BY: SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION: -	CHECKED BY: RS DATE: 14/02/2024
ENGINEER:	RS	AZIMUTH: PLUNGE: 90°	STATUS: Final data

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	DATA	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
		er Not E		5	4 8 12 16		
				30	>>		
					Termination: Double Bounce-30 blows over 90mm		
0.5	-0.5						
1.0	-1.0						
1.5	-1.5						
2.0	-2.0						
2.5	-2.5						
3.0	-3.0						
3.5	-3.5						
4.0	-4.0						
4.5	-4.5						

REMARKS

Soils tested in accordance with NZGS

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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DCP LOG

DCP02

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824240.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524359.00	FINISHED:	17/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	AZIMUTH:	PLUNGE: 90°	STATUS:	Final data

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	DATA	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
		r Not		10 / 20	4 8 12 16		

Termination: Double Bounce-20 blows over 50mm

0.5 -0.5 1.0 -1.0 1.5 -1.5 2.0 -2.0 2.5 -2.5 3.0 -3.0 3.5 -3.5 4.0 -4.0 4.5 -4.5

REMARKS

Soils tested in accordance with NZGS

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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DCP LOG

DCP03

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT:	230999	EASTING: 1824298.00	STARTED: 17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING: 5524346.00	FINISHED: 10/01/2024
		DATUM: NZVD2016	LOGGED BY: SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION: -	CHECKED BY: RS DATE: 14/02/2024
ENGINEER:	RS	AZIMUTH: PLUNGE: 90°	STATUS: Final data

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	DATA	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
		er Not E		5	4 8 12 16		
				26	>>		
					Termination: Double Bounce		
0.5	-0.5						
1.0	-1.0						
1.5	-1.5						
2.0	-2.0						
2.5	-2.5						
3.0	-3.0						
3.5	-3.5						
4.0	-4.0						
4.5	-4.5						

REMARKS

Soils tested in accordance with NZGS

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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FACE LOG

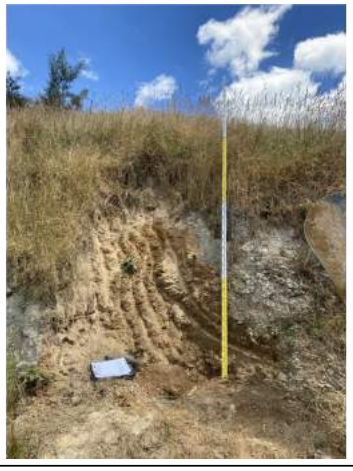
EX01

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	STARTED:	17/01/2024
PROJECT:	230999	EASTING:	1824298.00	FINISHED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524341.00	ENGINEER:	RS
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
		ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
OFFICE:	RDCL - WGTN	DIMENSIONS:	m x m	STATUS:	Draft data

CONTRACTOR: RDCL

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	DCP BLOWS	SAMPLES & TESTS	ADDITIONAL REMARKS
0.0	0.0	Groundwater Not Encountered		SILT, with minor sand, with trace rootlets and gravel; light brown. Soft; dry; low plasticity; gravel, fine to coarse, subangular to subround.	D	S				
0.5	-0.5			Clayey SILT, with trace sand and gravel; orange brown with orange mottling. Stiff to very stiff; moist; moderate plasticity; sand, fine to medium, gravel, fine to coarse, subangular to subround.		SF to VSF				
1.0	-1.0								FSV: 1.00m UTP	
1.5	-1.5			Silty GRAVEL, with some cobbles, with trace rootlets; brown. Medium dense to dense; moist; moderate plasticity; gravel, fine to coarse, subangular to round; iron stained on gravel clasts.	M					
2.0	-2.0					MD - D				
2.5	-2.5									
3.0	-3.0			EOH: 3.00m Termination: Bottom of Face Log						
3.5	-3.5									
4.0	-4.0									
4.5	-4.5									



REMARKS

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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HAND AUGER & DCP LOG

HA01

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824346.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524236.00	FINISHED:	18/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 18/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIAMETER:	50mm	STATUS:	Final data

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	SILT, with minor sand, with trace rootlets; light brown. Firm; dry; low plasticity; sand, fine; [TOPSOIL].		FM			4
0.5	-0.5			SILT, with some clay; grey with orange mottling. Very stiff; dry; low plasticity.	D	VSF		FSV: 0.50m >208 kPa	8, 12, 9, 8, 8, 6, 5, 4
1.0	-1.0			Clayey SILT; orange brown. Stiff to very stiff; moist; low plasticity.	M	SF - VSF		FSV: 1.00m 198/67kPa	5, 5, 10, 14, 13
1.5	-1.5			Clayey SILT, with trace sand and gravel; orange brown. Very stiff; moist; moderate plasticity; sand, fine to medium, gravel, fine to medium, subangular to subround.		VSF		FSV: 1.50m UTP	15, 15, 17
2.0	-2.0			EOH: 1.70m Termination: Hand Auger Spinning and Grinding					
2.5	-2.5								
3.0	-3.0								
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Blow Count

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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HAND AUGER & DCP LOG

HA02

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824311.58	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524303.53	FINISHED:	18/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 18/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIAMETER:	50mm	STATUS:	Final data

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered		SILT, with trace sand; light brown. Dry; low plasticity; sand, fine.	D	S to FM		FSV: 1.00m >208 kPa	10, 8, 10, 11, 11, 10, 11, 10, 9, 10, 15, 20
0.5	-0.5			SILT, with some clay; orange brown. Soft to firm; dry; low plasticity.					
1.0	-1.0			Clayey SILT, with trace sand; grey brown with orange mottling. Very stiff; dry; moderate plasticity; sand, fine.		VSF			
1.5	-1.5			SILT, with some clay, with trace gravel; orange brown. Very stiff; dry; low plasticity; gravel, fine to medium, subangular to subround. EOH: 1.20m Termination: Hand Auger Spinning and Grinding					
2.0	-2.0								
2.5	-2.5								
3.0	-3.0								
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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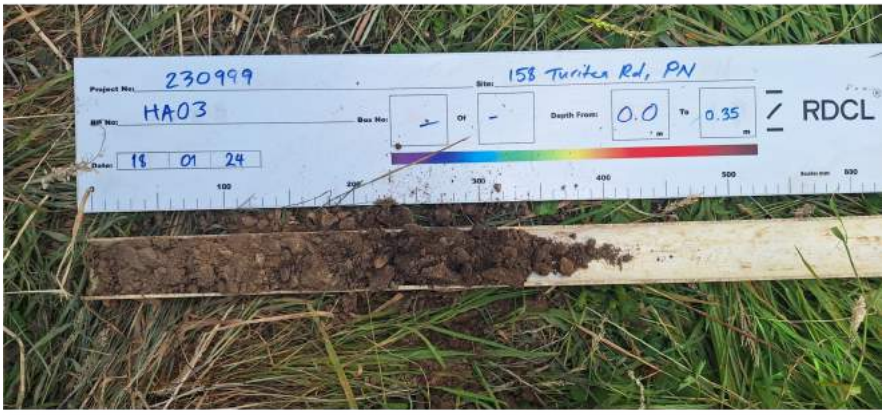
HAND AUGER & DCP LOG

HA03

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824352.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524311.00	FINISHED:	18/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 18/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIAMETER:	50mm	STATUS:	Final data

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
		ter Not En		Silty SAND, with minor gravel, with trace rootlets; light brown. Medium dense; dry; sand, fine to medium; gravel, fine, angular to subround; [TOPSOIL].	D	MD MD to D			5 7 4 4
0.5	-0.5			Silty SAND, with some gravel; dark brown. Medium dense to dense; dry; sand, fine to medium; gravel, fine, angular; charcoall, black; minor orange mottling around gravels; [FILL].					6 6 5 3 3 3 4 8 6 6 7 9 9 11 13 9 15 24 >>
1.0	-1.0			EOH: 0.35m Termination: Hand Auger Spinning and Grinding					
1.5	-1.5								
2.0	-2.0								
2.5	-2.5								
3.0	-3.0								
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								



REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP01

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824369.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524375.00	FINISHED:	17/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	Gravelly SILT, with some cobbles, with minor sand, with trace rootlets and organics; dark brown. Stiff; dry; low plasticity; gravel, fine to coarse, subround; cobbles, up to 200mm; sand, fine; [TOPSOIL].	D	SF		FSV: 0.30m 121/33kPa	3
0.5	-0.5			Silty gravelly SAND, with some cobbles and boulders, with trace rootlets and organics; light yellowish brown. Medium dense; dry; sand, fine to medium; gravel, fine to coarse, subangular to subround; boulders, up to 300mm.		MD			5 4 5 6 7 7 6 6 6
1.0	-1.0			Silty sandy GRAVEL, with some cobbles and boulders; light brown. Dense to medium dense; moist; gravel, fine to coarse, subangular to subround; sand, fine; boulders, up to 300mm.	M	D - MD			18 15 6 7 12
1.5	-1.5			Sandy GRAVEL, with minor silt and boulders; light bluish grey. Dense to very dense; moist to wet; gravel, fine to coarse, round to subangular; sand, medium to coarse.					
2.0	-2.0			2.2m: Orange brown. Cobbles and boulders absent.	M to W	D - VD			20
2.5	-2.5								
3.0	-3.0			EOH: 3.20m Termination: Target Depth					
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Blow Count - 20 blows over 80mm

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP02

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824342.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524396.00	FINISHED:	17/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS TS	SILT, with minor sand, with trace rootlets and gravel; dark brown. Soft; dry; low plasticity; sand, fine; gravel, fine to medium, subangular to subround; [TOPSOIL].	D	S			7
0.5	-0.5			Silty SAND, with trace gravel and cobbles; light brown. Loose to medium dense; dry to moist; sand, fine to medium; gravel, fine to coarse.	D to M	L to MD			8, 9, 3, 7, 3, 2, 3, 6
1.0	-1.0			Sandy GRAVEL, with minor silt and boulders; grey. Dense to very dense; moist to wet; gravel, fine to coarse, round to subangular; sand, medium to coarse; boulders, up to 600mm.	M to W	D - VD			11, 11, 13, 16, 15, 12, 33 >>
1.5	-1.5								
2.0	-2.0			2.2m: With some boulders. Wet.					
2.5	-2.5								
3.0	-3.0			EOH: 3.00m Termination: Target Depth					
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP03

SHEET 1 OF 1

CLIENT: Te Pirangi Developments Ltd	PROJECTION: NZTM2000	SUB-LOCATION:	
PROJECT: 230999	EASTING: 1824321.00	STARTED: 17/01/2024	
LOCATION: 158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING: 5524427.00	FINISHED: 17/01/2024	
	DATUM: NZVD2016	LOGGED BY: SJ/TGo	DATE: 17/01/2024
OFFICE: RDCL - WGTN	ELEVATION: -	CHECKED BY: RS	DATE: 14/02/2024
ENGINEER: RS	DIMENSIONS: m x m	STATUS: Final data	

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	SILT, with minor sand, with trace rootlets and gravel; dark brown. Soft; dry; low plasticity; sand, fine; gravel, fine to coarse, subangular to subround; [TOPSOIL].	D	S			4
0.5	-0.5			Silty SAND, with trace gravel; light brown. Medium dense; moist; sand, fine to medium; gravel, fine to coarse.	M	MD			3
1.0	-1.0			Sandy GRAVEL, with minor silt; brown. Medium dense to dense; moist; gravel, fine to coarse, subangular to subround; sand, fine to coarse.		MD - D			5
1.5	-1.5			SAND, with minor silt, with trace gravel; brown. Dense; moist; sand, fine to coarse; gravel, fine to medium, subangular to subround.					4
2.0	-2.0			Sandy GRAVEL, with minor silt and cobbles, with trace boulders; grey. Dense; moist to wet; gravel, fine to coarse; sand, fine to coarse.	M to W	D			4
2.5	-2.5			2.8m: With some boulders. Wet. 2.9m: Bluish grey.					3
3.0	-3.0			EOH: 3.40m Termination: Target Depth					3
3.5	-3.5								5
4.0	-4.0								7
4.5	-4.5								5
									6
									7
									8
									6
									8
									13
									12
									21 >>

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP04

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824275.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524423.00	FINISHED:	17/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	SILT, with minor sand, with trace rootlets and organics; dark brown. Soft; dry; low plasticity; [TOPSOIL}.	D	S			2
0.5	-0.5			Clayey SILT, with trace sand and gravel; greyish brown with orange mottling. Stiff; moist; moderate plasticity; sand, fine to medium, gravel, fine to coarse, subangular to subround.	M	SF		FSV: 0.50m 146/30kPa	3 3 2 3 3 3 4 4 6 9 10 15
1.0	-1.0								
1.5	-1.5			Silty GRAVEL, with some cobbles, with minor sand, with trace boulders; light grey. Dense; moist to wet; gravel, fine to coarse, subangular to subround; sand, fine; iron staining.					
2.0	-2.0			2.2m: With some boulders; bluish grey.	M to W	D			
2.5	-2.5			2.6m: Saturated.					
3.0	-3.0			EOH: 3.30m Termination: Target Depth					
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce - 22 blows over 40mm

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP05

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824370.12	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524347.95	FINISHED:	17/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	Sandy SILT, with some rootlets, with minor gravel and boulders; brown. Very soft to soft; dry; low plasticity; sand, fine to medium; gravel, fine to coarse, subangular to round; [TOPSOIL].	D	VS to S			5
0.5	-0.5								14
1.0	-1.0			Sandy GRAVEL, with some boulders, with minor silt; brown. Medium dense to very dense; moist to dry; gravel, fine to coarse; sand, fine to coarse; boulders, subangular to round, up to 300mm.	M to D	MD to VD			6
1.5	-1.5								3
2.0	-2.0								3
2.5	-2.5			2.5m: Iron staining.					4
3.0	-3.0			EOH: 3.00m Termination: Target Depth					4
3.5	-3.5								6
4.0	-4.0								10
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce - 20 blows over 10mm

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP06

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824204.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524357.00	FINISHED:	17/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS TS	SILT, with minor sand, with trace rootlets; dark brown. Soft; dry; low plasticity; [TOPSOIL].	D	S			1
0.5	-0.5			Clayey SILT, with trace sand and gravel; grey brown with orange mottling. Stiff to very stiff; moist; moderate plasticity; sand, fine to medium, gravel, fine to coarse, subangular to subround.		SF to VSF		FSV: 0.50m UTP	3 3 5 5 5
1.0	-1.0			Silty GRAVEL, with some cobbles, with minor sand, with trace boulders; light brown. Dense; moist; moderate plasticity; gravel, fine to coarse, subround to round; sand, fine; iron staining on gravel clasts.	M	D			30 >>
1.5	-1.5								
2.0	-2.0			2.0m: Wet.					
2.5	-2.5								
3.0	-3.0			EOH: 3.10m Termination: Target Depth					
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce - 30 blows over 50mm

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP07

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824177.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524337.00	FINISHED:	17/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	SILT, with minor sand, with trace rootlets; dark brown. Soft; dry; low plasticity; [TOPSOIL].	D	S			1
				Clayey SILT, with trace sand; grey brown with orange mottling. Stiff; moist; moderate plasticity; sand, fine.				FSV: 0.50m 131/45kPa	3 4 4 3 3 2 2
1.0	-1.0			1.0m: Firm.		SF		FSV: 1.00m 80/22kPa	1 1 3 5 6 9
1.5	-1.5			1.5m: Very stiff.	M			FSV: 1.50m UTP	19 11 10 11 14 14
2.0	-2.0			Clayey silty GRAVEL, with trace cobbles and boulders; reddish brown. Very dense; moist; gravel, fine to coarse, subangular to subround.		VD			25 >>
2.5	-2.5			2.5m: Weathered boulders.					
3.0	-3.0			EOH: 3.10m Termination: Target Depth					
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce - 25 blows over 90mm

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP08

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824412.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524253.00	FINISHED:	17/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 17/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	SILT, with minor sand, with trace rootlets; dark brown. Soft; dry to moist; low plasticity; [TOPSOIL].	D to M	S			1
0.5	-0.5			Clayey SILT, with minor sand, with trace tree roots; greyish brown with orange mottling. Stiff to very stiff; moist; moderate plasticity; sand, fine.		SF to VSF		FSV: 0.50m UTP	3, 4, 2, 2, 4, 5, 7, 6
1.0	-1.0			0.9m: With some sand. Sand, fine to medium.				FSV: 1.00m 193/45kPa	8, 8, 7, 8, 8, 9, 8, 10, 12, 13, 15, 18
1.5	-1.5			Sandy GRAVEL, with minor silt; dark blackish grey. Dense to very dense; moist; gravel, fine to coarse, subround to round; sand, fine to medium.	M				
2.0	-2.0								
2.5	-2.5			2.2m: With some cobbles, with trace boulders. Wet to saturated.		D - VD			
3.0	-3.0			EOH: 3.25m Termination: Target Depth					23 >>
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce - 23 blows over 70mm

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP09

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824285.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524392.00	FINISHED:	18/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 18/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	Sandy SILT, with trace rootlets; brown. Soft; dry; low plasticity; sand, fine to coarse; [TOPSOIL].	D	S			3
0.5	-0.5			Clayey SILT, with some sand, with minor gravel; light greyish brown strong orange mottling. Stiff; moist; low plasticity; sand, fine to medium; gravel, fine to coarse, subangular to subround; some iron precipitation.		SF		FSV: 0.50m 137/52kPa	3 3 4 3 3 3 3 4
1.0	-1.0			Sandy GRAVEL, with some boulders, with minor silt; brown. Very dense; moist; gravel, fine to coarse, round to subangular; sand, fine to coarse.	M	VD			21 >>
1.5	-1.5								
2.0	-2.0								
2.5	-2.5			Gravelly SAND, with minor boulders, with trace silt; light yellowish brown. Dense to very dense; moist; sand, fine to coarse; gravel, fine to coarse, subangular to subround.		D to VD			
3.0	-3.0			EOH: 3.00m Termination: Target Depth					
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce

SYMBOLS

Standing Water Level

Out flow

In flow

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TEST PIT LOG

TP10

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824273.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524389.00	FINISHED:	18/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 18/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS	Sandy SILT, with trace rootlets and gravel; light brown with orange mottling. Soft to stiff; dry; low plasticity; sand, fine to coarse; gravel, fine, angular; [TOPSOIL].	D	S to SF			2
0.5	-0.5			Clayey SILT, with some gravel, with minor sand; light grey with strong orange mottling. Very stiff; dry to moist; low plasticity; gravel, fine to medium, subround to angular; sand, fine to medium.		VSF		FSV: 0.50m UTP	8 9 10 15 17 20
1.0	-1.0			Sandy GRAVEL, with some silt and boulders; brown. Very dense; dry to moist; gravel, fine to coarse, subangular to round; sand, fine to coarse; boulders, subangular to round.	D to M	VD			
1.5	-1.5								
2.0	-2.0			2.3m: SAND & GRAVEL, with some silt; light brown. Sand, fine to medium, gravel, fine to medium, round to subangular.					
2.5	-2.5			Gravelly SAND, with minor boulders, with trace silt; light yellowish brown. Dense to very dense; moist; sand, fine to coarse; gravel, fine to coarse, subangular to subround.	M	D to VD			
3.0	-3.0			EOH: 3.00m Termination: Target Depth					
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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TEST PIT LOG

TP11

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION: NZTM2000	SUB-LOCATION:
PROJECT:	230999	EASTING: 1824340.00	STARTED: 17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING: 5524361.00	FINISHED: 18/01/2024
		DATUM: NZVD2016	LOGGED BY: SJ/TGo DATE: 18/01/2024
OFFICE:	RDCL - WGTN	ELEVATION: -	CHECKED BY: RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS: m x m	STATUS: Final data

CONTRACTOR: Sutherland MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	T5	Silty SAND, with some gravel and boulders, with trace rootlets; dark brown. Medium dense; moist; sand, fine to medium; gravel, fine to coarse, subangular to round; some junk rubbish, charcoal; [TOPSOIL].	M	MD			4
0.5	-0.5								4
									3
									3
									4
									3
									3
									3
									4
1.0	-1.0			SILT & SAND, with some gravel, with minor boulders; light brown. Medium dense and firm; moist; non-plastic; sand, fine to coarse; gravel, fine to coarse, angular to subround; boulders, round.		MD & FM			4
									7
									8
									8
									7
1.5	-1.5								13
									7
									8
									7
2.0	-2.0			Sandy GRAVEL, with some silt and boulders; brown. Very dense; moist; gravel, fine to coarse; sand, fine to coarse; boulders, subangular to round, up to 300mm.		VD			30 >>
2.5	-2.5			EOH: 2.90m Termination: Target Depth					
3.0	-3.0								
3.5	-3.5								
4.0	-4.0								
4.5	-4.5								

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce - 30 blows over 90mm

SYMBOLS

Standing Water Level

Out flow

In flow

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TEST PIT LOG

TP12

SHEET 1 OF 1

CLIENT:	Te Pirangi Developments Ltd	PROJECTION:	NZTM2000	SUB-LOCATION:	
PROJECT:	230999	EASTING:	1824376.00	STARTED:	17/01/2024
LOCATION:	158 Turitea Road, Fitzherbert, Palmerston North 4472	NORTHING:	5524319.00	FINISHED:	18/01/2024
		DATUM:	NZVD2016	LOGGED BY:	SJ/TGo DATE: 18/01/2024
OFFICE:	RDCL - WGTN	ELEVATION:	-	CHECKED BY:	RS DATE: 14/02/2024
ENGINEER:	RS	DIMENSIONS:	m x m	STATUS:	Final data

CONTRACTOR: Sutherland

MACHINE TYPE & MODEL: 7.5 Tonne

DEPTH (m)	RL (m)	WATER	GRAPHIC LOG	ROCK / SOIL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / DENSITY	CLASSIFICATION	SAMPLES & TESTS	DCP Blows
0.0	0.0	Groundwater Not Encountered	TS TS TS	SAND, with minor gravel and boulders, with trace rootlets and silt; brown. Loose to medium dense; dry to moist; sand, fine to medium; gravel, fine to coarse, subround to angular; [TOPSOIL].	D to M	L - MD			3
0.5	-0.5								3
									7
1.0	-1.0			Sandy GRAVEL, with some silt, with minor boulders; light brown with minor orange mottling. Dense to medium dense; moist; gravel, fine to coarse, angular to subround; sand, fine to coarse; yellowish silt lenses.	M	D to MD			6
									9
1.5	-1.5								7
									9
2.0	-2.0			Sandy GRAVEL, with some boulders, with minor silt; brown. Very dense; moist to wet; gravel, fine to coarse, river gravel; sand, fine to coarse; boulders, subangular to round, up to 300mm; some boulder wet on surface.	M to W	VD			9
									10
2.5	-2.5			EOH: 2.70m Termination: Digger Struggling					6
									8
3.0	-3.0								8
									8
3.5	-3.5								7
									11
4.0	-4.0								9
									6
4.5	-4.5								27 >>

REMARKS

Soils logged in accordance with NZGS (2005) Field Description of Soil and Rock

DCP Termination: Double Bounce

SYMBOLS

- Standing Water Level
- Out flow
- In flow

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Appendix B: RILEY CONSULTANTS REPORT LOGS

RILEY CONSULTANTS

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MACHINE HOLE LOG

Project No.:	Project Name:	Project Location:	No.:
200043	164 Turitea Road	164 Turitea Road, Palmerston North	MH1

Client:	Start Date: 15 Sep 2021	Hole Location:
Whakarongo Holding Co.Ltd	End Date: 15 Sep 2021	Refer to site plan

Co-ordinates :	Ground Level (m): Ground	Hole Depth:	Inclination:	Azimuth:	Sheet:
E 782273, N 413289		15.20	-90°	N/A	1 of 4

Elevation (m)	Depth (m)	Method	Run Box No.	TCR (SCR) RQD (%)	Core Loss (%)	Geological Unit	Legend	Geological Description (In accordance with NZGS Guidelines (2005) Refer to "Geological Info Sheet" for explanation of text abbreviations)	Weathering	Field Strength (Soil | Rock)	Samples	Defect Spacing (mm)	Defect Symbolic Log	Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc)	In-Situ Testing Data / Results	Backfill / Installation
	0.10	Sonic core drilling	0.00	100 - -	0	TOPSOIL		[TOPSOIL].								
	0.5							SILT, with some clay, with trace sand; light brown. Stiff to very stiff; non-plastic; sand, fine; [ALLUVIUM].								
	1.00							0.80m: Grades to trace fine gravel								
	1.5					ALLUVIUM		Silty GRAVEL, with trace sand; brown. Medium dense; non-plastic; gravel, fine to coarse; sand, fine to coarse.							7, 9 / 10, 11, 11, 14 Nc=46	
	1.95							Gravelly CLAY, with some silt, with trace sand; orange brown. Dense; low plasticity; gravel, fine to medium; sand, fine.								
	2.0															
	2.5															
	3.0														4, 12 / 11, 17, 22 for 65mm Nc=50 for 215mm	
	3.5															
	4.00							SAND, with some silt; orange brown. Medium dense; non-plastic; sand, fine to medium.								
	4.0															

Explanations: *Refer to attached "Geo Info" sheet for further details*

- Standing Water Level
- Out flow
- In flow
- Moisture: M = moist; W = Wet; S = Saturated
- Standard Penetration Test (SPT): Filled = Solid cone (C); No Fill = Split spoon (S)
- Vane Shear Strength (kPa): V=Peak, R=Residual; UTP=Unable to penetrate

Backfill: TOPSOIL, PEAT, FILL, CLAY, SILT, SAND, GRAVEL, Bentonite, Grout/concrete, Drill arisings, Filter sand

Remarks:

All dimensions in metres NOT TO SCALE	Drilling Contractor:	Drilling Rig ID:	Driller:	Logged By:	Checked By:
	Pro-Drill	FRASTE CRSXL	Pro-Drill	GJ	SRO

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MACHINE HOLE LOG

Project No.:	Project Name:	Project Location:	No.:
200043	164 Turitea Road	164 Turitea Road, Palmerston North	MH1

Client:	Start Date: 15 Sep 2021	Hole Location:
Whakarongo Holding Co.Ltd	End Date: 15 Sep 2021	Refer to site plan

Co-ordinates :	Ground Level (m): Ground	Hole Depth:	Inclination:	Azimuth:	Sheet:
E 782273, N 413289		15.20	-90°	N/A	2 of 4

Elevation (m)	Depth (m)	Method	Run (Box No.)	TCR (SCR) RQD (%)	Core Loss (%)	Geological Unit	Legend	Geological Description (In accordance with NZGS Guidelines (2005) Refer to "Geological Info Sheet" for explanation of text abbreviations)	Weathering	Field Strength (Soil | Rock)	Samples	Defect Spacing (mm)	Defect Symbolic Log	Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc)	In-Situ Testing Data / Results	Backfill / Installation
	4.95							4.40m: Grades to some clay, slightly plastic							7, 7 / 5, 5, 5, 6 Nc=21	
	5.0	Sonic core drilling		100 - -	0	ALLUVIUM		SAND, with some silt, with trace clay; medium grey. Dense; non-plastic; sand, fine to medium.								
	6.0							6.20m: Grades to greenish grey							2, 2 / 6, 7, 6, 5 Nc=24	
	7.0							7.10m - 7.70m: Grades to some fine gravels								
	8.0														8, 12 / 16, 16, 16, 2 for 5mm Nc=50 for 230mm	

Explanations: *Refer to attached "Geo Info" sheet for further details*

- Standing Water Level
- Out flow
- In flow
- Standard Penetration Test (SPT) Filled = Solid cone (C) No Fill = Split spoon (S)
- Vane Shear Strength (kPa) V=Peak, R=Residual UTP=Unable to penetrate

Moisture: M = moist; W = Wet; S = Saturated

TOPSOIL, PEAT, FILL, CLAY, SILT, SAND, GRAVEL

Backfill: Bentonite, Grout/concrete, Drill arisings, Filter sand

Remarks:

All dimensions in metres NOT TO SCALE	Drilling Contractor:	Drilling Rig ID:	Driller:	Logged By:	Checked By:
	Pro-Drill	FRASTE CRSXL	Pro-Drill	GJ	SRO

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MACHINE HOLE LOG

Project No.:	Project Name:	Project Location:	No.:
200043	164 Turitea Road	164 Turitea Road, Palmerston North	MH1

Client:	Start Date: 15 Sep 2021	Hole Location:
Whakarongo Holding Co.Ltd	End Date: 15 Sep 2021	Refer to site plan

Co-ordinates :	Ground Level (m): Ground	Hole Depth:	Inclination:	Azimuth:	Sheet:
E 782273, N 413289		15.20	-90°	N/A	3 of 4

Elevation (m)	Depth (m)	Method	Run (Box No.)	TCR (SCR) RQD (%)	Core Loss (%)	Geological Unit	Legend	Geological Description (In accordance with NZGS Guidelines (2005) Refer to "Geological Info Sheet" for explanation of text abbreviations)	Weathering	Field Strength (Soil | Rock)	Samples	Defect Spacing (mm)	Defect Symbolic Log	Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc)	In-Situ Testing Data / Results	Backfill / Installation
	9.5	Sonic core drilling		100 - -	0	ALLUVIUM		[CONT] 7.10m - 7.70m: Grades to some fine gravels 9.10m: Grades to light brown							4, 3 / 19, 18, 13 for 50mm Nc=50 for 200mm	
	10.0							10.00m: Grades to medium green grey								
	10.5														7, 10 / 7, 5, 13, 18 Nc=43	
	11.0							11.00m: Grades to medium grey								
	11.5															
	12.0														6, 13 / 20, 21, 9 for 40mm Nc=50 for 190mm	
	12.5															
	12.70							Organic SILT with minor clay; black brown. Hard; low plasticity; organic, amorphous								
	13.0															
	13.50															

Explanations: *Refer to attached "Geo Info" sheet for further details*

- Standing Water Level
- Out flow
- In flow
- Moisture: M = moist; W = Wet; S = Saturated
- Standard Penetration Test (SPT) Filled = Solid cone (C) No Fill = Split spoon (S)
- Vane Shear Strength (kPa) V=Peak, R=Residual UTP=Unable to penetrate
- TOPSOIL, PEAT, FILL, CLAY, SILT, SAND, GRAVEL
- Backfill: Bentonite, Grout/concrete, Drill arisings, Filter sand

Remarks:

All dimensions in metres NOT TO SCALE	Drilling Contractor:	Drilling Rig ID:	Driller:	Logged By:	Checked By:
	Pro-Drill	FRASTE CRSXL	Pro-Drill	GJ	SRO

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Email: www.riley.co.nz

MACHINE HOLE LOG

Project No.:	Project Name:	Project Location:	No.:
200043	164 Turitea Road	164 Turitea Road, Palmerston North	MH1

Client:	Start Date: 15 Sep 2021	Hole Location:
Whakarongo Holding Co.Ltd	End Date: 15 Sep 2021	Refer to site plan

Co-ordinates :	Ground Level (m): Ground	Hole Depth:	Inclination:	Azimuth:	Sheet:
E 782273, N 413289		15.20	-90°	N/A	4 of 4

Elevation (m)	Depth (m)	Method	Run Box No.	TCR (SCR) RQD (%)	Core Loss (%)	Geological Unit	Legend	Geological Description (In accordance with NZGS Guidelines (2005) Refer to "Geological Info Sheet" for explanation of text abbreviations)	Weathering	Field Strength (Soil | Rock)	Samples	Defect Spacing (mm)	Defect Symbolic Log	Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc)	In-Situ Testing Data / Results	Backfill / Installation
	14.0	Sonic core drilling		100 - -	0	ALLUVIUM		SAND, with trace silt; greenish grey. Dense; non-plastic; sand, fine to medium.							5, 3 / 4, 5, 10, 10 Nc=29	
	14.5															
	15.0															
	15.20							END OF HOLE: 15.20m							5, 7 / 12, 10, 12, 11 Nc=45	
	15.5															
	16.0															
	16.5															
	17.0															
	17.5															

Explanations: *Refer to attached "Geo Info" sheet for further details*

- Standing Water Level
- Out flow
- In flow
- Moisture: M = moist; W = Wet; S = Saturated
- Standard Penetration Test (SPT) Filled = Solid cone (C) No Fill = Split spoon (S)
- Vane Shear Strength (kPa) V=Peak, R=Residual UTP=Unable to penetrate
- TOPSOIL, PEAT, FILL, CLAY, SILT, SAND, GRAVEL
- Backfill: Bentonite, Grout/concrete, Drill arisings, Filter sand

Remarks:

All dimensions in metres NOT TO SCALE	Drilling Contractor:	Drilling Rig ID:	Driller:	Logged By:	Checked By:
	Pro-Drill	FRASTE CRSXL	Pro-Drill	GJ	SRO

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MACHINE HOLE LOG

Project No.:	Project Name:	Project Location:	No.:
200043	164 Turitea Road	164 Turitea Road, Palmerston North	MH2

Client:	Start Date: 15 Sep 2021	Hole Location:
Whakarongo Holding Co.Ltd	End Date: 15 Sep 2021	Refer to site plan

Co-ordinates :	Ground Level (m): Ground	Hole Depth:	Inclination:	Azimuth:	Sheet:
E 782191, N 413350		15.20	-90°	N/A	1 of 4

Elevation (m)	Depth (m)	Method	Run Box No.	TCR (SCR) RQD (%)	Core Loss (%)	Geological Unit	Legend	Geological Description (In accordance with NZGS Guidelines (2005) Refer to "Geological Info Sheet" for explanation of text abbreviations)	Weathering	Field Strength (Soil | Rock)	Samples	Defect Spacing (mm)	Defect Symbolic Log	Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc)	In-Situ Testing Data / Results	Backfill / Installation
	0.00	Sonic core drilling	0.00	100 - -	0	TOPSOIL	TS	TOPSOIL								
	0.30							SILT, with some clay and sand; brownish orange. Very stiff to hard; low plasticity; sand, fine; [ALLUVIUM].								
	0.5															
	1.0							1.10m: Grades to minor fine gravel; non plastic								
	1.40							1.30m: Grades to some fine gravel; non plastic								
	1.5					ALLUVIUM		Silty GRAVEL, with trace clay; brownish orange. Medium dense; non-plastic; gravel, fine to medium.							3, 3 / 4, 6, 8, 10 Nc=28	
	2.0															
	2.5															
	2.60							SAND, with some silt, with trace clay; brownish orange. Medium dense to dense; non-plastic; sand, fine to medium.								
	3.0							3.00m: Grades to some clay; medium grey orange mottles; low plasticity							2, 3 / 2, 4, 3, 6 Nc=15	
	3.5															
	4.0							4.10m: Grades to reddish orange with orange and grey mottles								

Explanations: *Refer to attached "Geo Info" sheet for further details*

- Standing Water Level
- Out flow
- In flow
- Standard Penetration Test (SPT) Filled = Solid cone (C) No Fill = Split spoon (S)
- Vane Shear Strength (kPa) V=Peak, R=Residual UTP=Unable to penetrate
- Moisture: M = moist; W = Wet; S = Saturated
- TOPSOIL, PEAT, FILL, CLAY, SILT, SAND, GRAVEL
- Backfill: Bentonite, Grout/concrete, Drill arisings, Filter sand

Remarks:

All dimensions in metres NOT TO SCALE	Drilling Contractor:	Drilling Rig ID:	Driller:	Logged By:	Checked By:
	Pro-Drill	FRASTE CRSXL	pro-Drill	GJ	SRO

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E: www.rileychch.co.nz

4 Fred Thomas Drive
Takapuna
AUCKLAND 0622
Ph: 09.489.7872
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MACHINE HOLE LOG

Project No.:	Project Name:	Project Location:	No.:
200043	164 Turitea Road	164 Turitea Road, Palmerston North	MH2

Client:	Start Date: 15 Sep 2021	Hole Location:
Whakarongo Holding Co.Ltd	End Date: 15 Sep 2021	Refer to site plan

Co-ordinates :	Ground Level (m): Ground	Hole Depth:	Inclination:	Azimuth:	Sheet:
E 782191, N 413350		15.20	-90°	N/A	2 of 4

Elevation (m)	Depth (m)	Method	Run (Box No.)	TCR (SCR) RQD (%)	Core Loss (%)	Geological Unit	Legend	Geological Description (In accordance with NZGS Guidelines (2005) Refer to "Geological Info Sheet" for explanation of text abbreviations)	Weathering	Field Strength (Soil | Rock)	Samples	Defect Spacing (mm)	Defect Symbolic Log	Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc)	In-Situ Testing Data / Results	Backfill / Installation
	4.60	Sonic core drilling		100 - -	0	ALLUVIUM		[CONT] 4.10m: Grades to reddish orange with orange and grey mottles SAND, with some silt; medium grey with orange mottles. Dense; non-plastic; sand, fine to coarse. 4.70m: Grades to 100mm of fine gravel horizon							5, 12 / 10, 15, 20, 5 for 15mm Nc=50 for 240mm 7, 11 / 13, 15, 18, 4 for 20mm Nc=50 for 245mm 12, 7 / 13, 14, 13, 10 for 30mm Nc=50 for 255mm	
	5.0															
	5.5															
	6.0															
	6.5															
	7.0							7.60m: Grades to medium grey								
	7.5															
	8.0															
	8.5															

Explanations: *Refer to attached "Geo Info" sheet for further details*

- Standing Water Level
- Out flow
- In flow
- Moisture: M = moist; W = Wet; S = Saturated
- Standard Penetration Test (SPT) Filled = Solid cone (C) No Fill = Split spoon (S)
- Vane Shear Strength (kPa) V=Peak, R=Residual UTP=Unable to penetrate
- TOPSOIL, PEAT, FILL, CLAY, SILT, SAND, GRAVEL
- Backfill: Bentonite, Grout/concrete, Drill arisings, Filter sand

Remarks:

All dimensions in metres NOT TO SCALE	Drilling Contractor:	Drilling Rig ID:	Driller:	Logged By:	Checked By:
	Pro-Drill	FRASTE CRSXL	pro-Drill	GJ	SRO

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MACHINE HOLE LOG

Project No.:	Project Name:	Project Location:	No.:
200043	164 Turitea Road	164 Turitea Road, Palmerston North	MH2

Client:	Start Date: 15 Sep 2021	Hole Location:
Whakarongo Holding Co.Ltd	End Date: 15 Sep 2021	Refer to site plan

Co-ordinates :	Ground Level (m): Ground	Hole Depth:	Inclination:	Azimuth:	Sheet:
E 782191, N 413350		15.20	-90°	N/A	3 of 4

Elevation (m)	Depth (m)	Method	Run (Box No.)	TCR (SCR) RQD (%)	Core Loss (%)	Geological Unit	Legend	Geological Description (In accordance with NZGS Guidelines (2005) Refer to "Geological Info Sheet" for explanation of text abbreviations)	Weathering	Field Strength (Soil | Rock)	Samples	Defect Spacing (mm)	Defect Symbolic Log	Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc)	In-Situ Testing Data / Results	Backfill / Installation
	9.5	Sonic core drilling		100 - -	0	ALLUVIUM		[CONT] 7.60m: Grades to medium grey 9.50m: Grades to bluish grey							7, 5 / 6, 11, 12, 14 Nc=43 2, 4 / 6, 10, 10, 8 Nc=34 2, 5 / 7, 9, 9, 13 Nc=38	

Explanations: *Refer to attached "Geo Info" sheet for further details*

- Standing Water Level
- Out flow
- In flow
- Standard Penetration Test (SPT) Filled = Solid cone (C) No Fill = Split spoon (S)
- Vane Shear Strength (kPa) V=Peak, R=Residual UTP=Unable to penetrate
- Moisture: M = moist; W = Wet; S = Saturated
- TOPSOIL, PEAT, FILL, CLAY, SILT, SAND, GRAVEL
- Backfill: Bentonite, Grout/concrete, Drill arisings, Filter sand

Remarks:

All dimensions in metres NOT TO SCALE	Drilling Contractor:	Drilling Rig ID:	Driller:	Logged By:	Checked By:
	Pro-Drill	FRASTE CRSXL	pro-Drill	GJ	SRO

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MACHINE HOLE LOG

Project No.:	Project Name:	Project Location:	No.:
200043	164 Turitea Road	164 Turitea Road, Palmerston North	MH2

Client:	Start Date: 15 Sep 2021	Hole Location:
Whakarongo Holding Co.Ltd	End Date: 15 Sep 2021	Refer to site plan

Co-ordinates :	Ground Level (m): Ground	Hole Depth:	Inclination:	Azimuth:	Sheet:
E 782191, N 413350		15.20	-90°	N/A	4 of 4

Elevation (m)	Depth (m)	Method	Run (Box No.)	TCR (SCR) RQD (%)	Core Loss (%)	Geological Unit	Legend	Geological Description (In accordance with NZGS Guidelines (2005) Refer to "Geological Info Sheet" for explanation of text abbreviations)	Weathering	Field Strength (Soil | Rock)	Samples	Defect Spacing (mm)	Defect Symbolic Log	Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc)	In-Situ Testing Data / Results	Backfill / Installation
	14.0	Sonic core drilling		100 - -	0	ALLUVIUM		[CONT] 9.50m: Grades to bluish grey 13.70m: Grades to bluish black							4, 5 / 7, 9, 13, 10 Nc=39	
	14.5															
	15.0							14.80m: Grades to dark grey								
	15.20							END OF HOLE: 15.20m								
	15.5														5, 8 / 10, 10, 13, 17 Nc=50	
	16.0															
	16.5															
	17.0															
	17.5															

Explanations: *Refer to attached "Geo Info" sheet for further details*

- Standing Water Level
- Out flow
- In flow
- Moisture: M = moist; W = Wet; S = Saturated
- Standard Penetration Test (SPT) Filled = Solid cone (C) No Fill = Split spoon (S)
- Vane Shear Strength (kPa) V=Peak, R=Residual UTP=Unable to penetrate
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- Backfill: Bentonite, Grout/concrete, Drill arisings, Filter sand

Remarks:

All dimensions in metres NOT TO SCALE	Drilling Contractor:	Drilling Rig ID:	Driller:	Logged By:	Checked By:
	Pro-Drill	FRASTE CRSXL	pro-Drill	GJ	SRO

Appendix C: LIQUEFACTION ANALYSIS RESULTS

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www.rdcl.co.nz

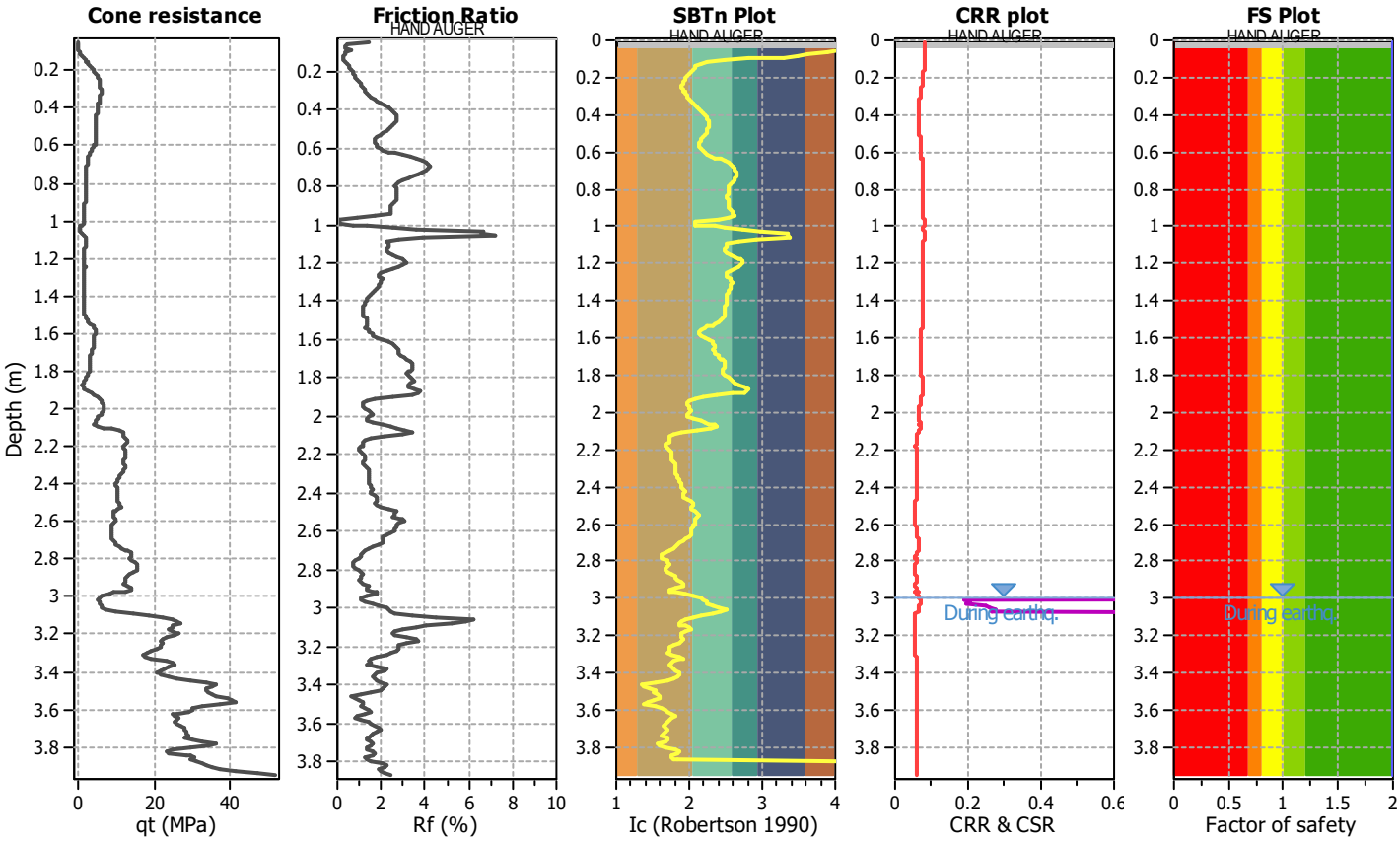
LIQUEFACTION ANALYSIS REPORT

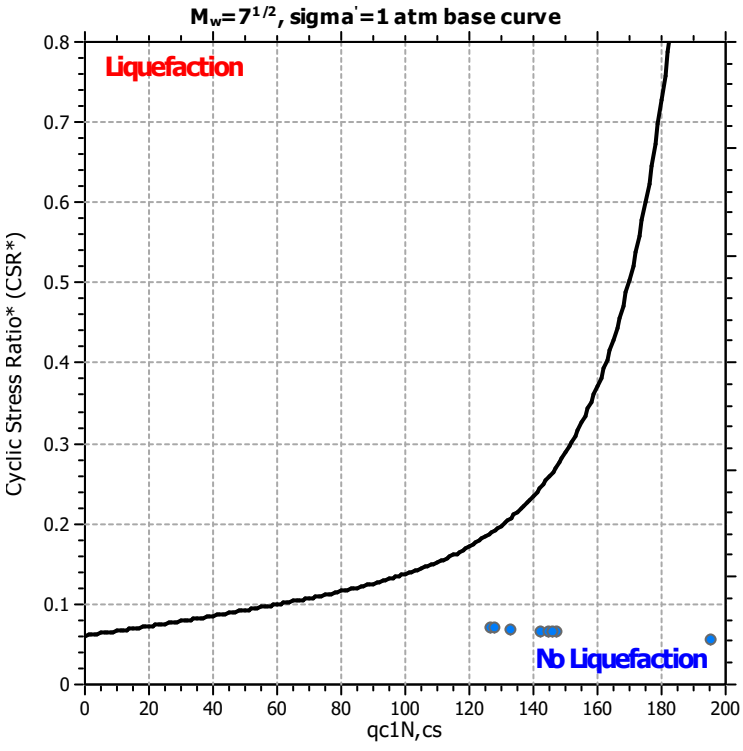
Project title : 230999_Te Pirangi Developments Ltd **Location : 158 Turitea Road, Palmerston North**

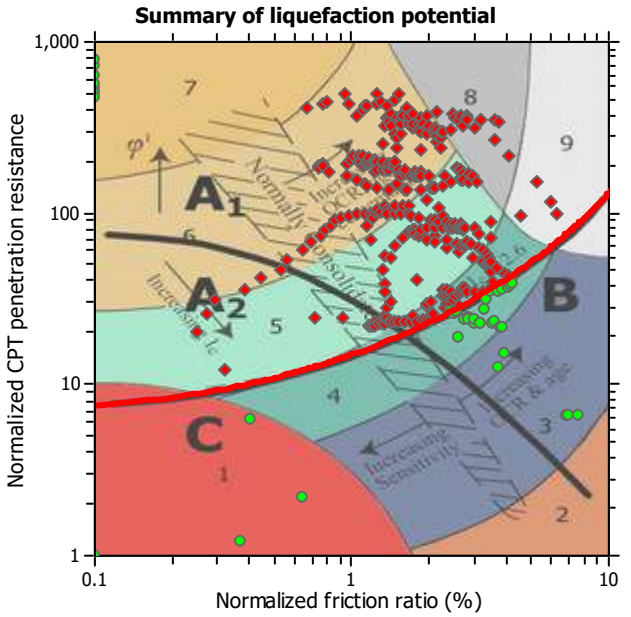
CPT file : CPT01_SLS

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	15.00 m
Earthquake magnitude M_w:	6.40	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	K_σ applied:	No		

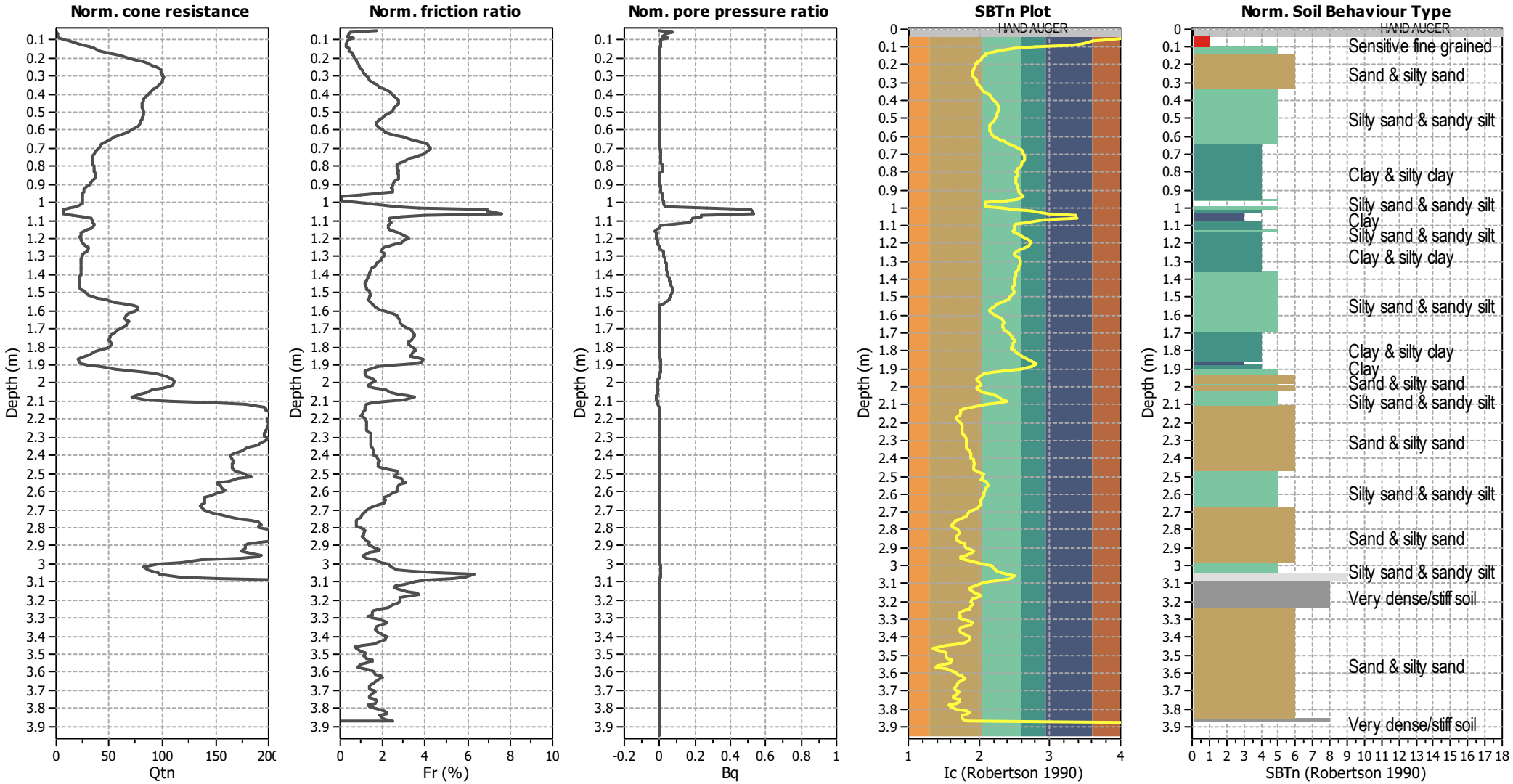






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots (normalized)



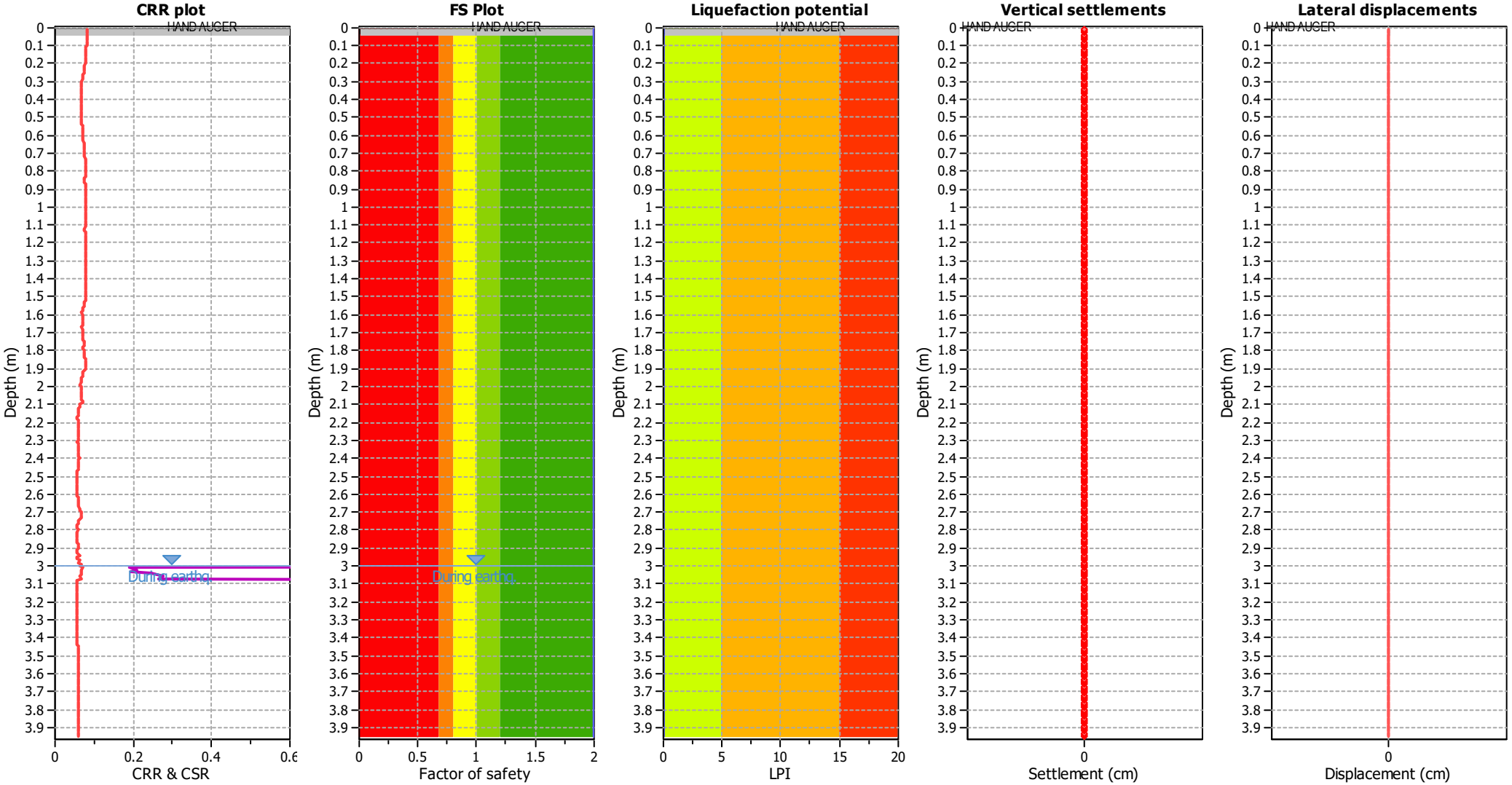
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

SBTn legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

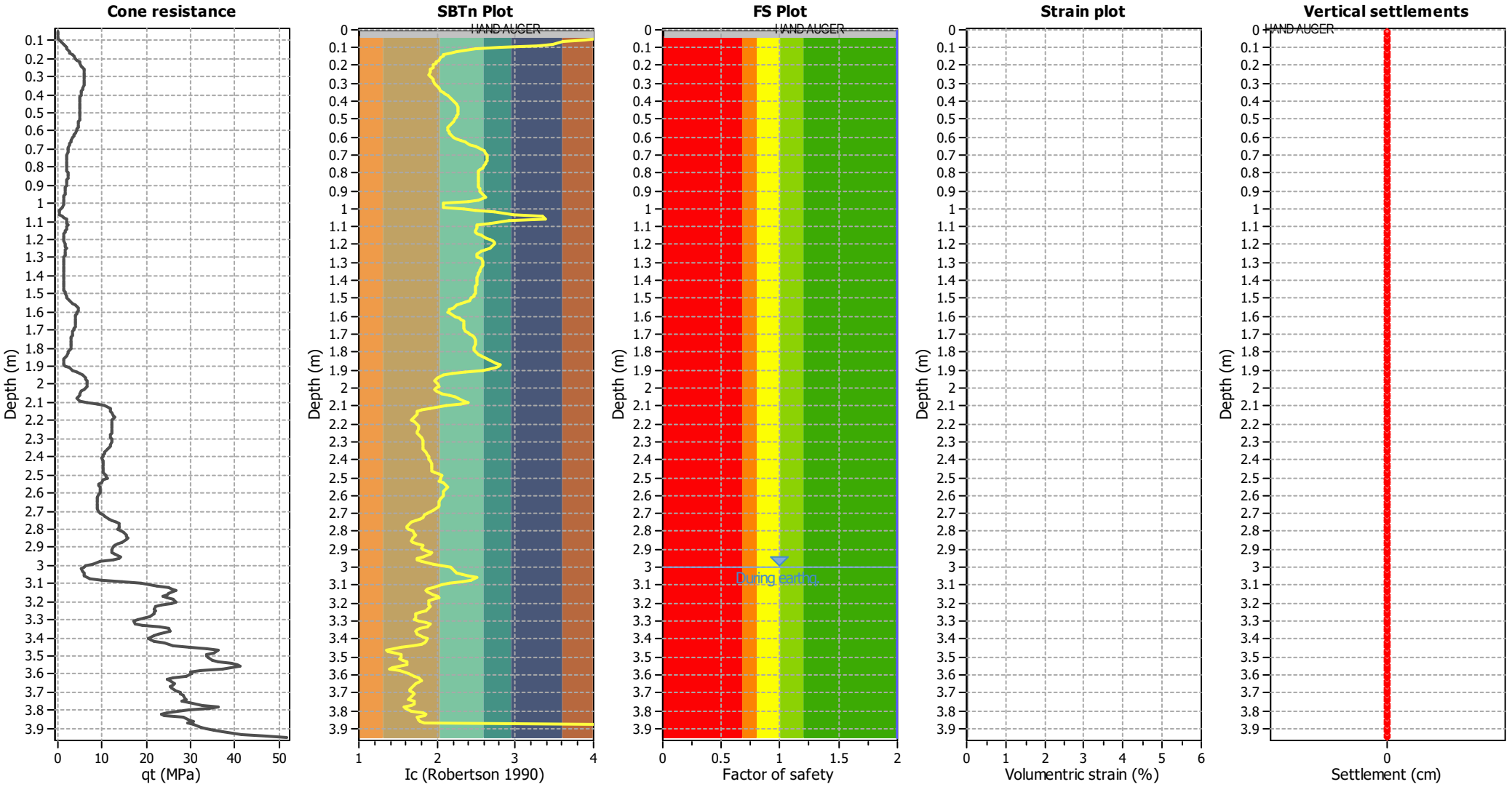
F.S. color scheme

- 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

Estimation of post-earthquake settlements



Abbreviations

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

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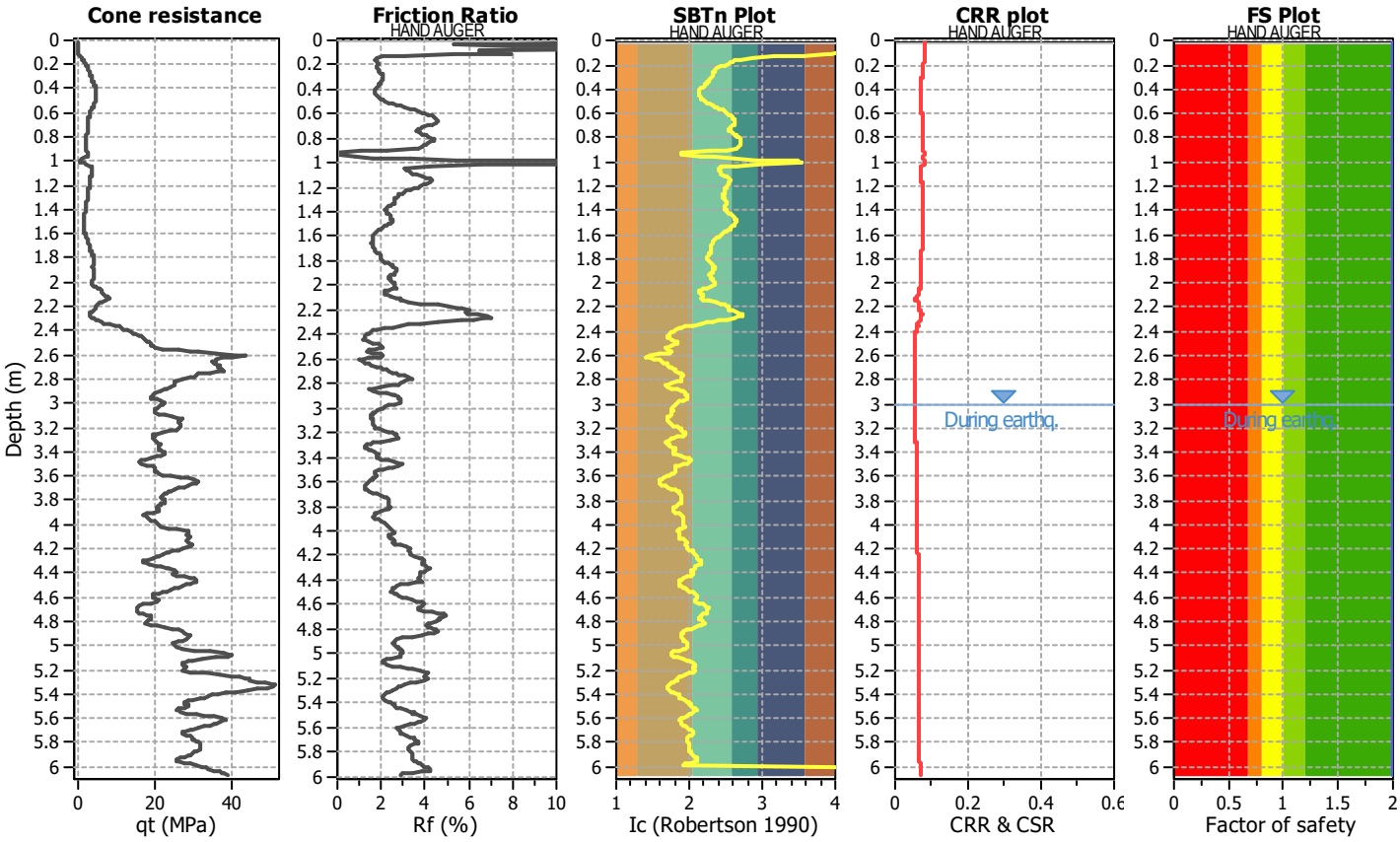
LIQUEFACTION ANALYSIS REPORT

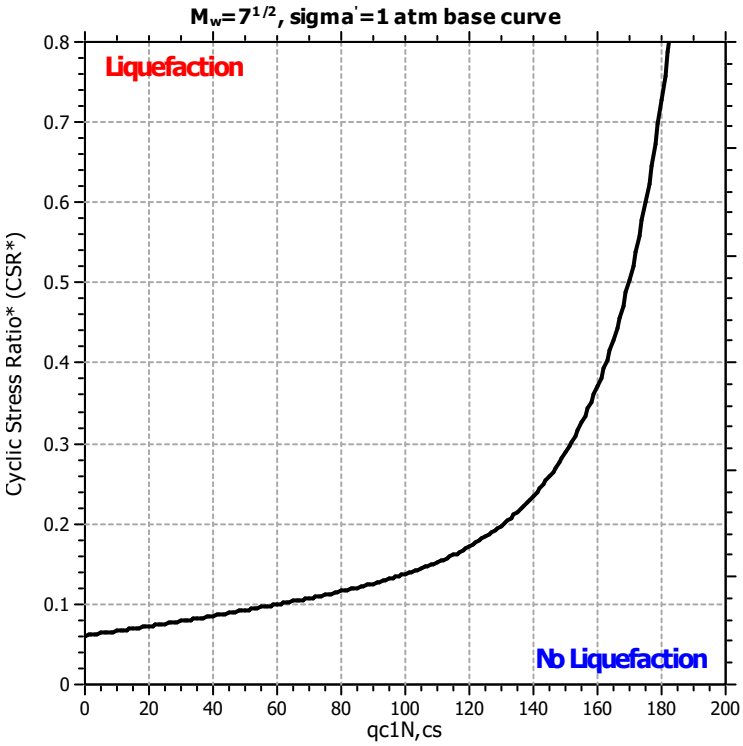
Project title : 230999_Te Pirangi Developments Ltd **Location : 158 Turitea Road, Palmerston North**

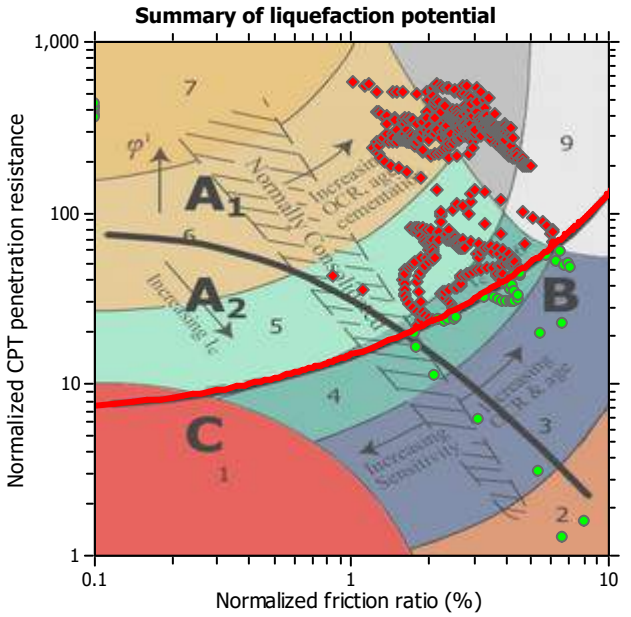
CPT file : CPT02_SLS

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	15.00 m
Earthquake magnitude M_w:	6.40	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	K_σ applied:	No		

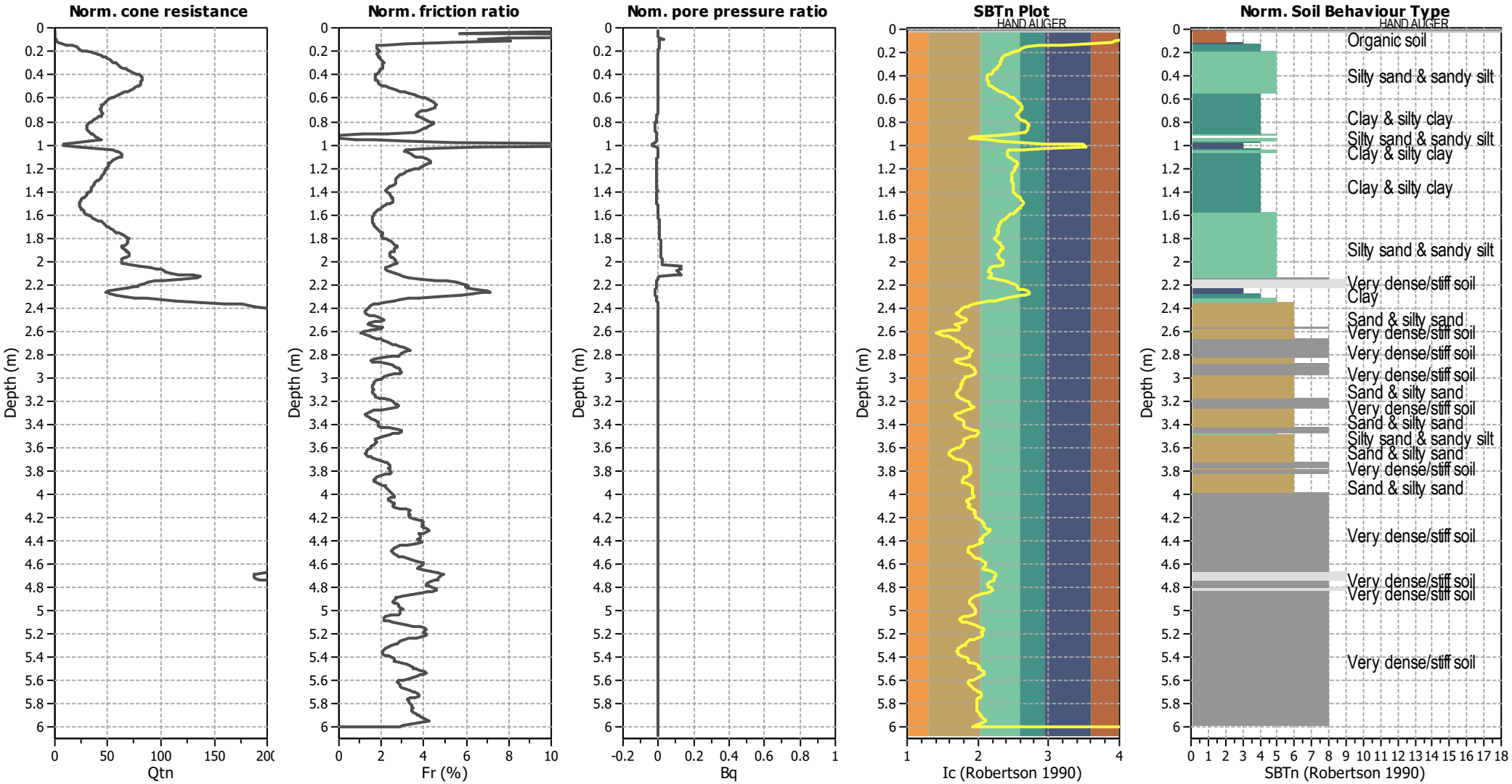






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots (normalized)



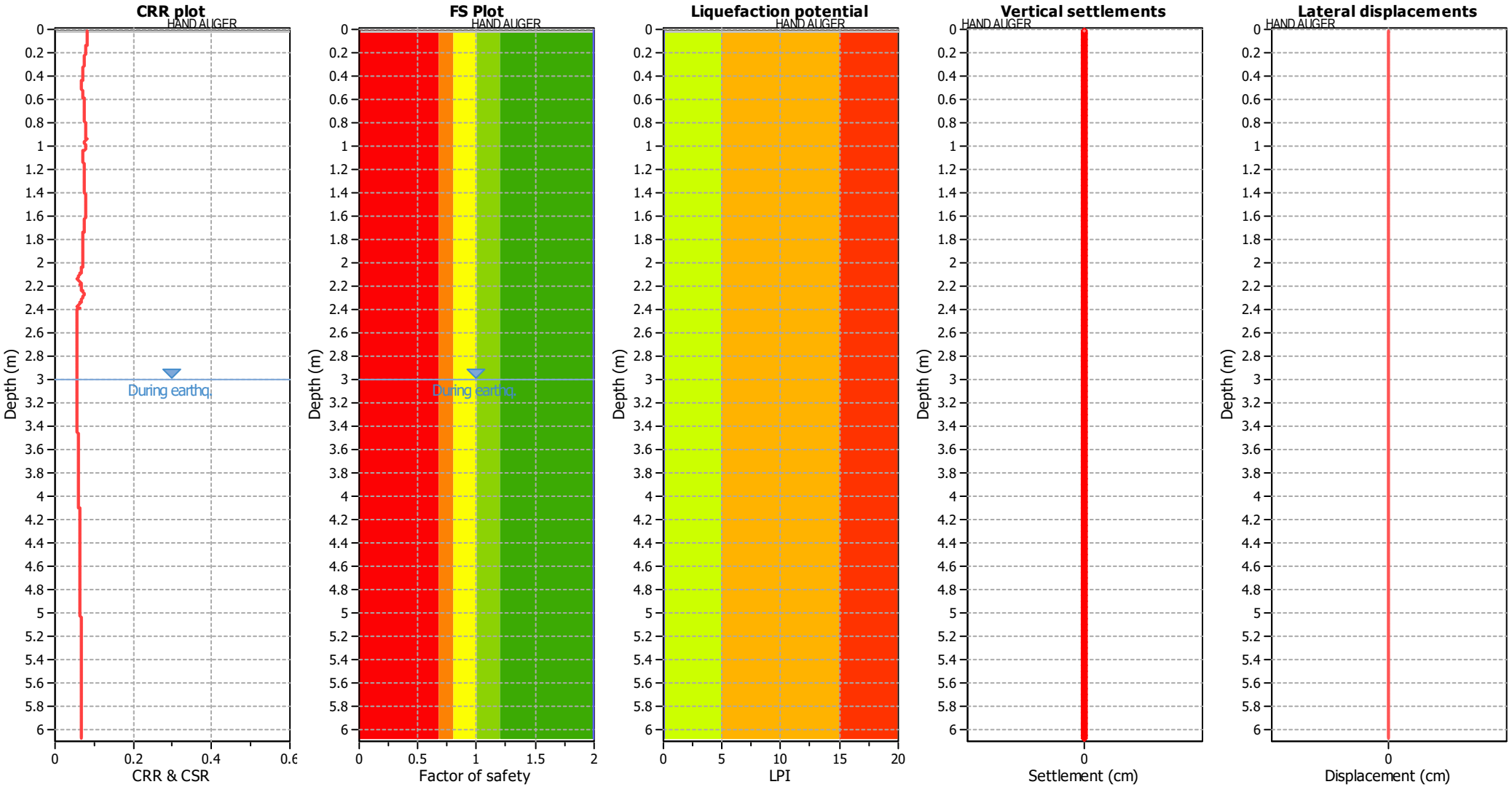
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

SBTn legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

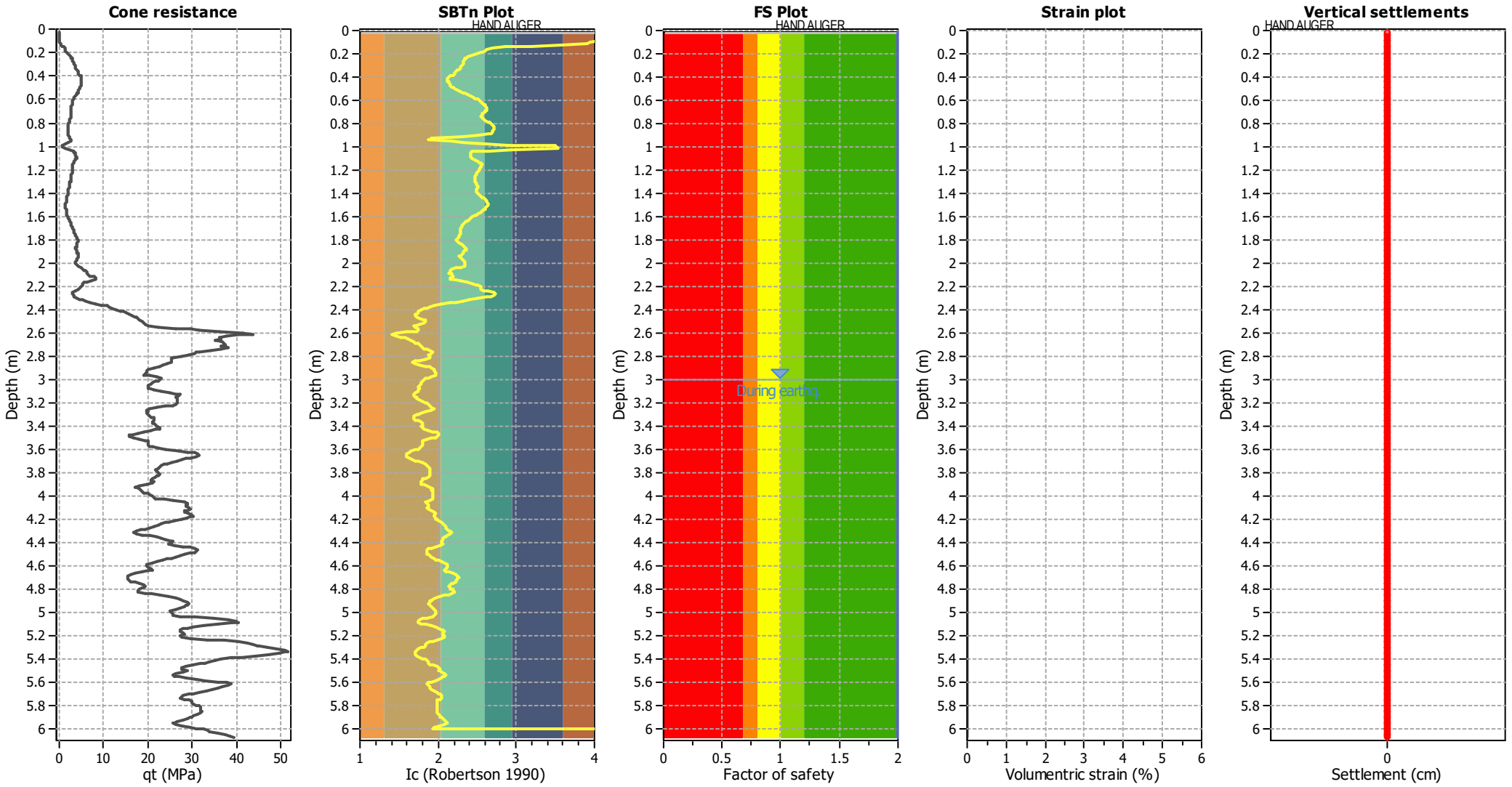
F.S. color scheme

- 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

Estimation of post-earthquake settlements



Abbreviations

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

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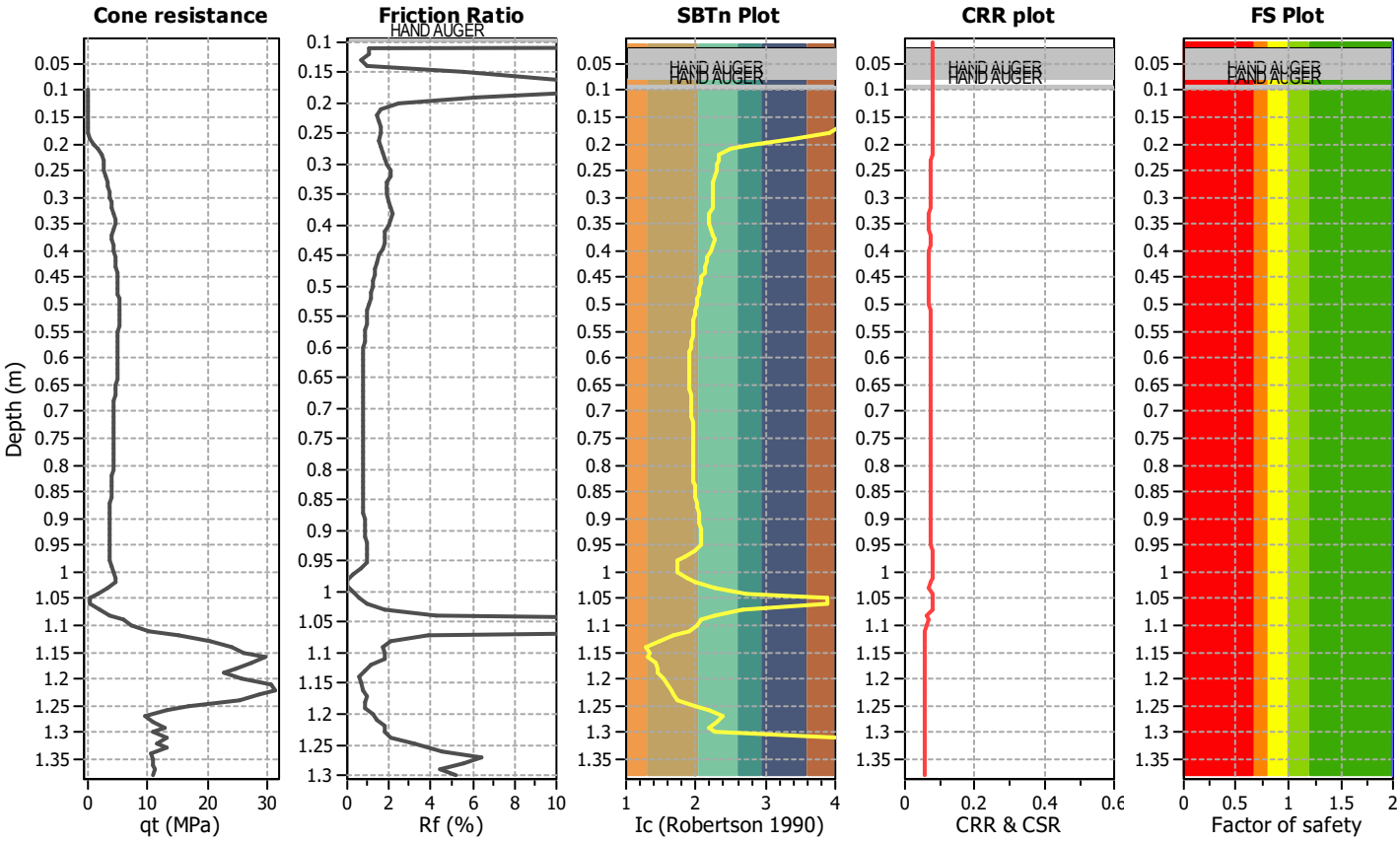
LIQUEFACTION ANALYSIS REPORT

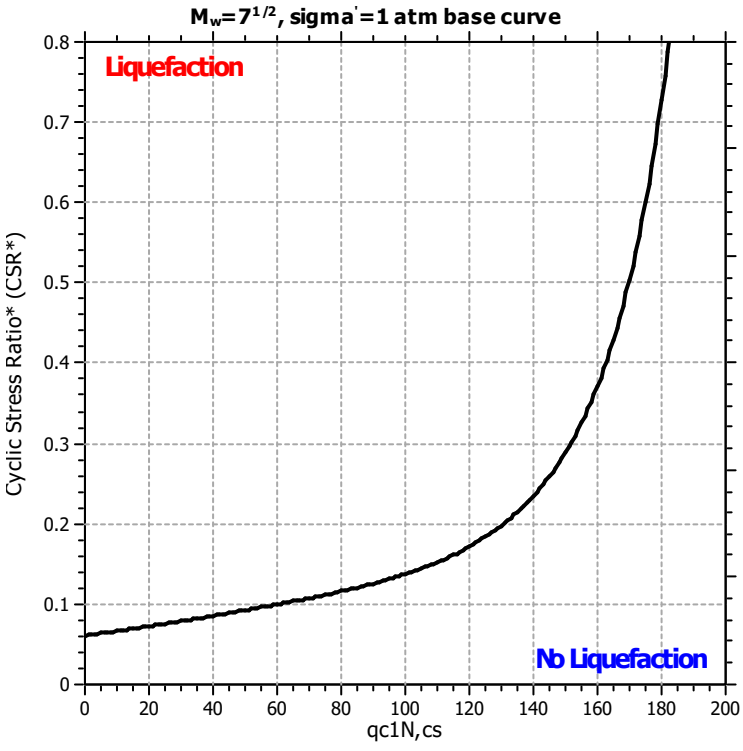
Project title : 230999_Te Pirangi Developments Ltd **Location : 158 Turitea Road, Palmerston North**

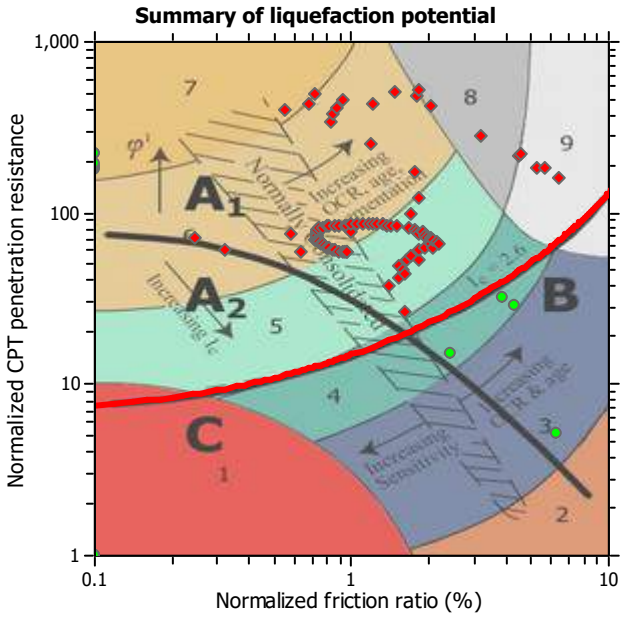
CPT file : CPT03_SLS

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	15.00 m
Earthquake magnitude M_w:	6.40	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	K_σ applied:	No		

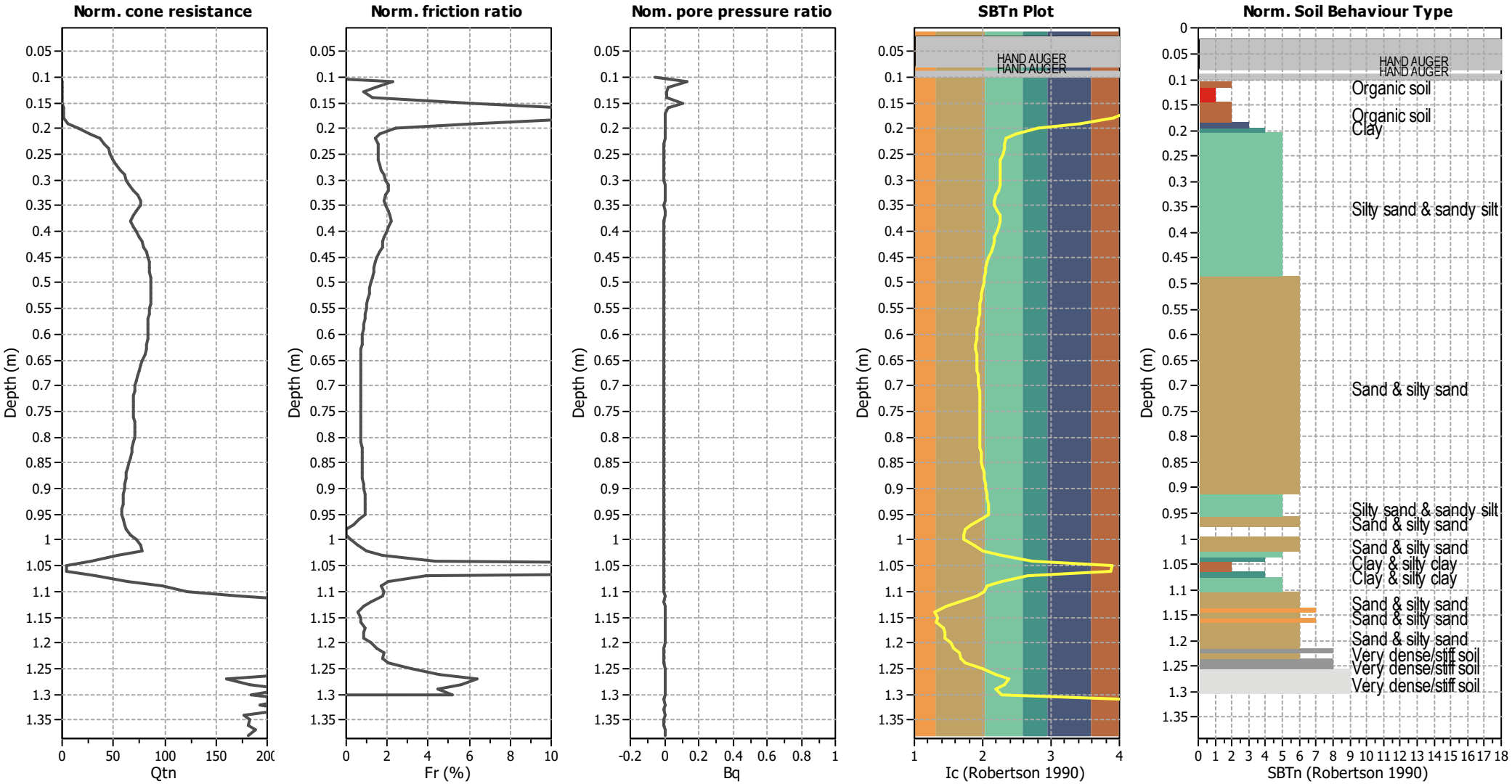






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots (normalized)



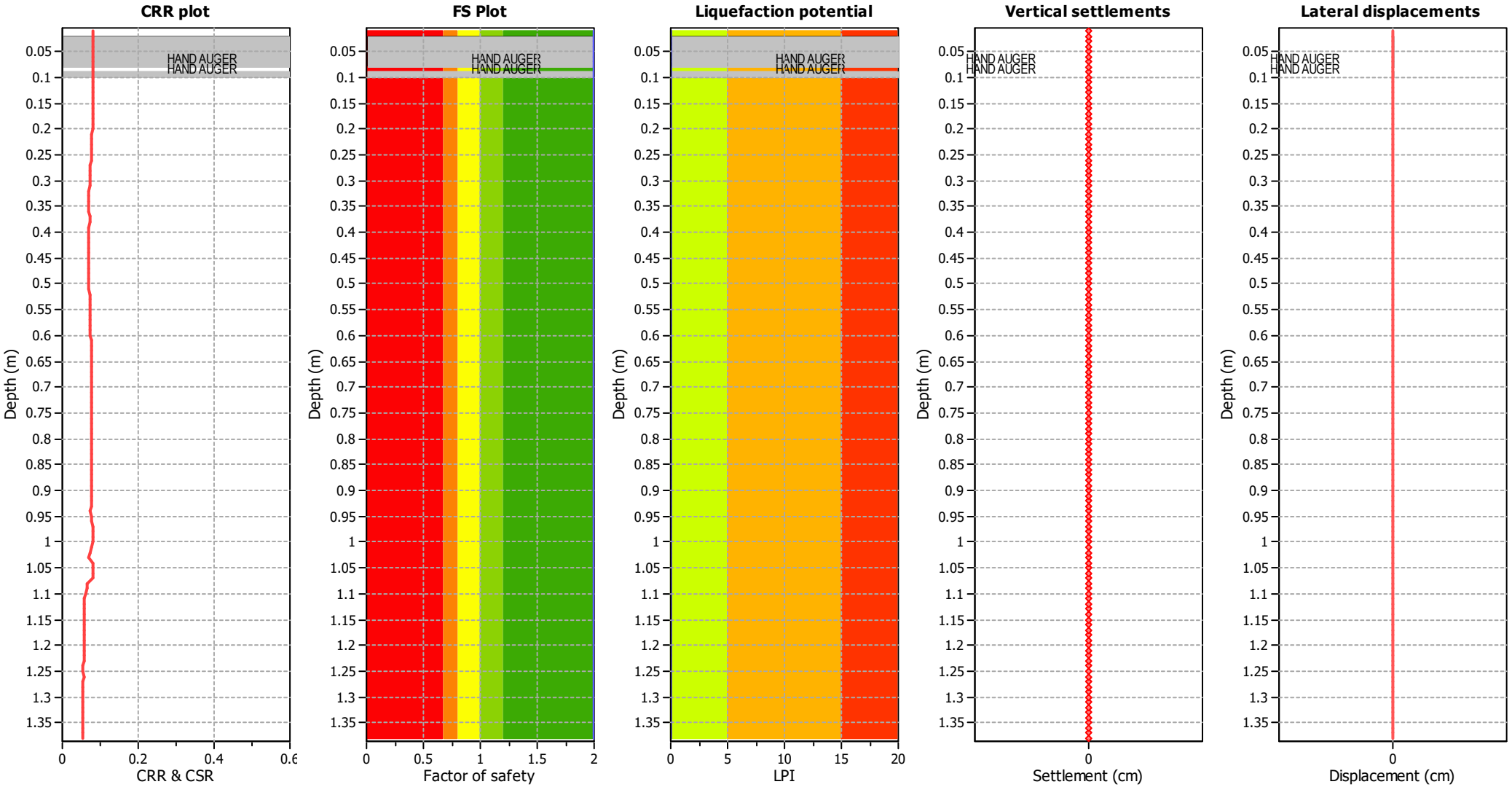
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

SBTn legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 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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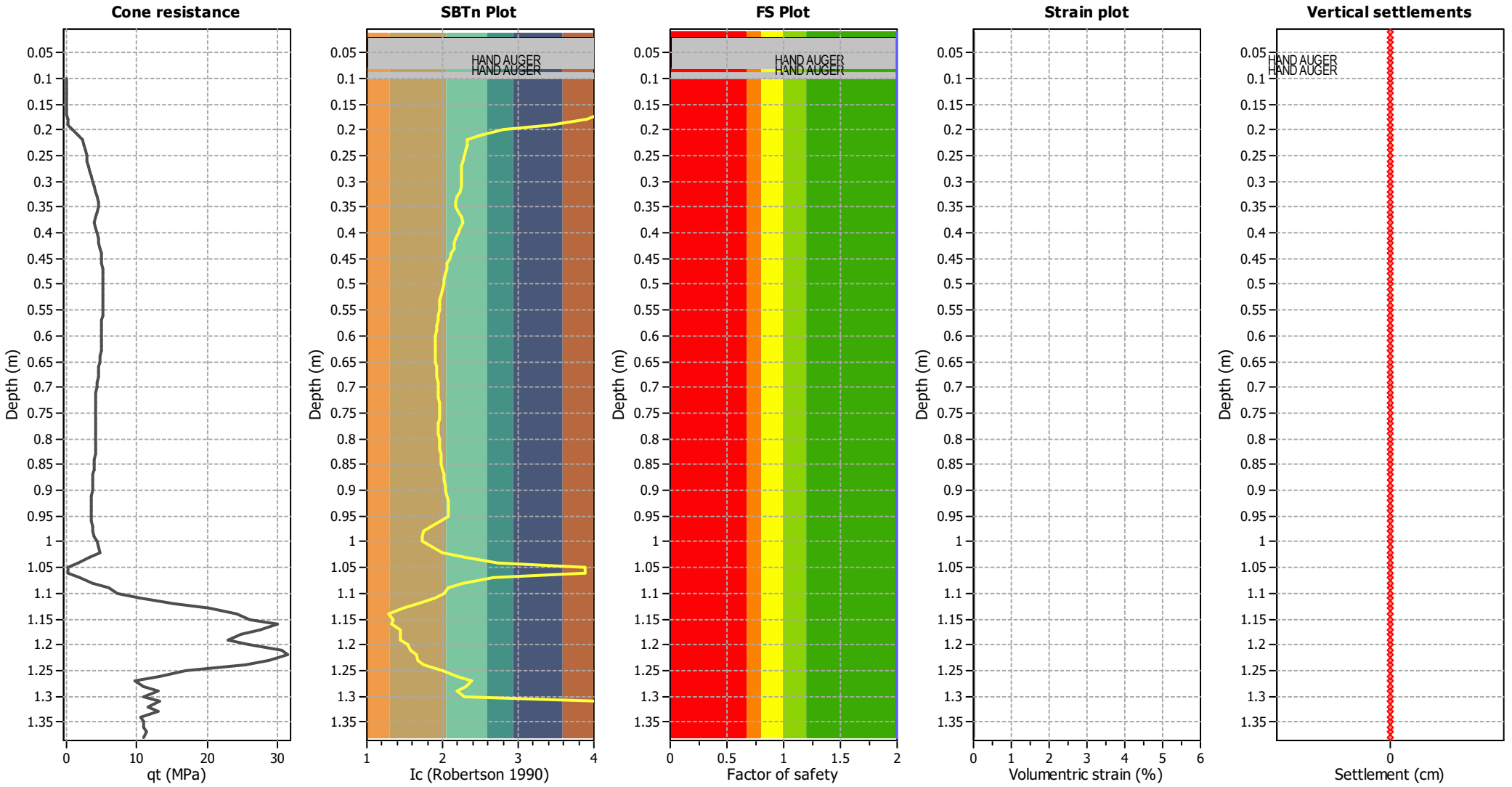
LPI color scheme

- Very high risk
- High risk
- Low risk

Estimation of post-earthquake settlements



Abbreviations

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

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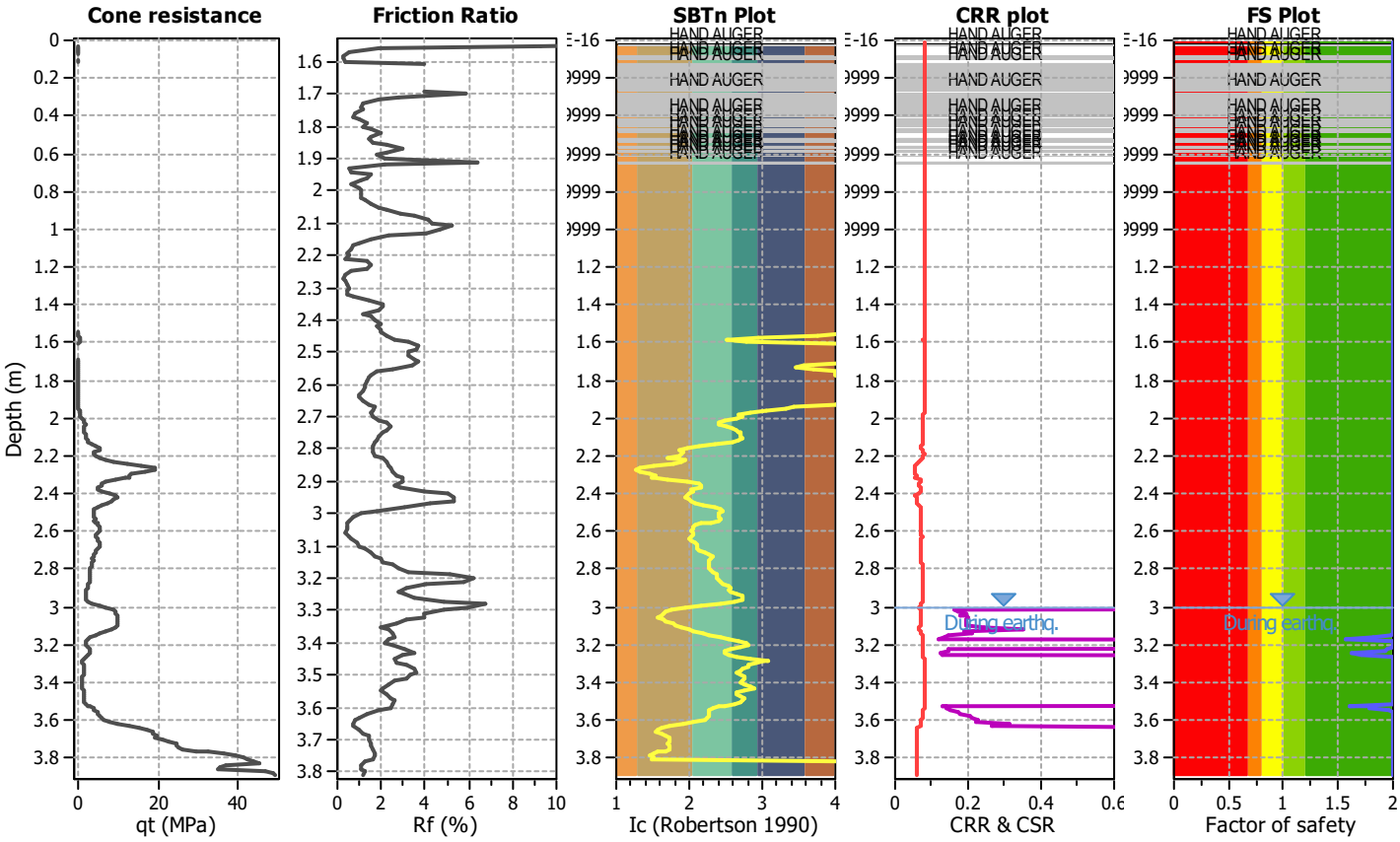
LIQUEFACTION ANALYSIS REPORT

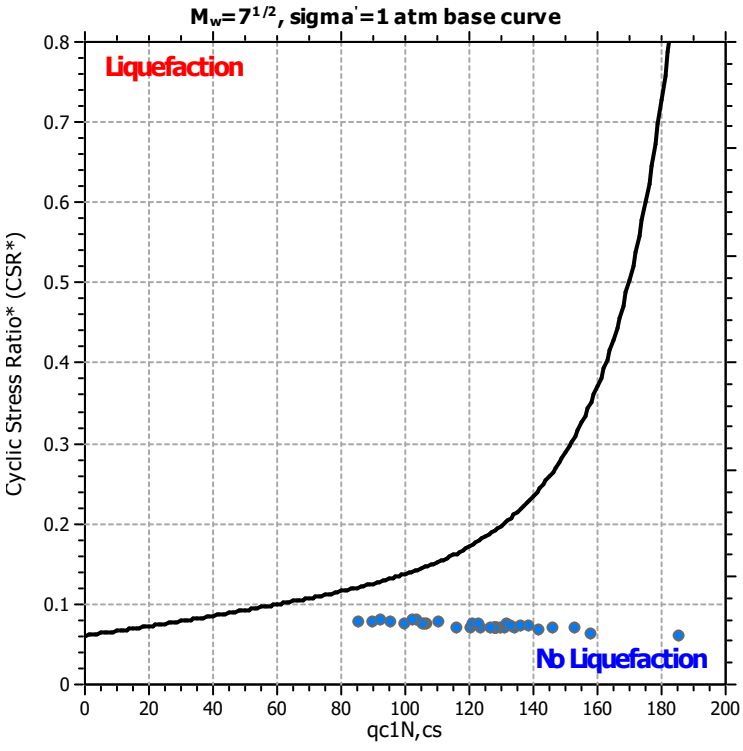
Project title : 230999_Te Pirangi Developments Ltd **Location : 158 Turitea Road, Palmerston North**

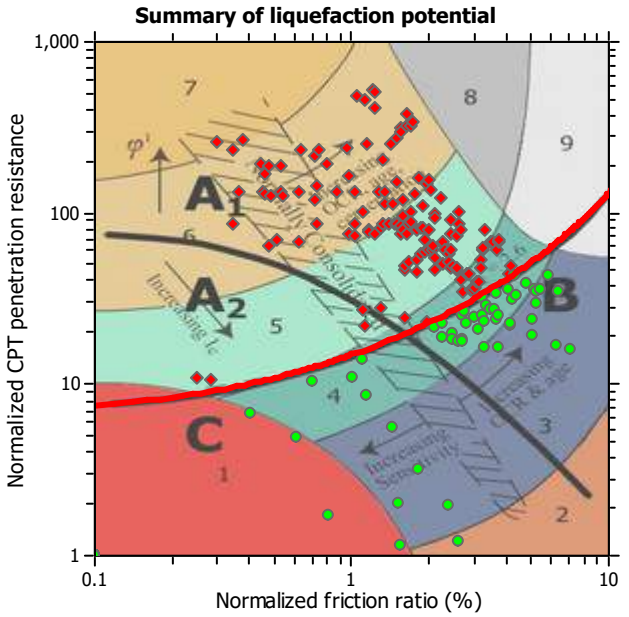
CPT file : CPT03-2

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	15.00 m
Earthquake magnitude M_w:	6.40	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.13	Unit weight calculation:	Based on SBT	K_σ applied:	No		

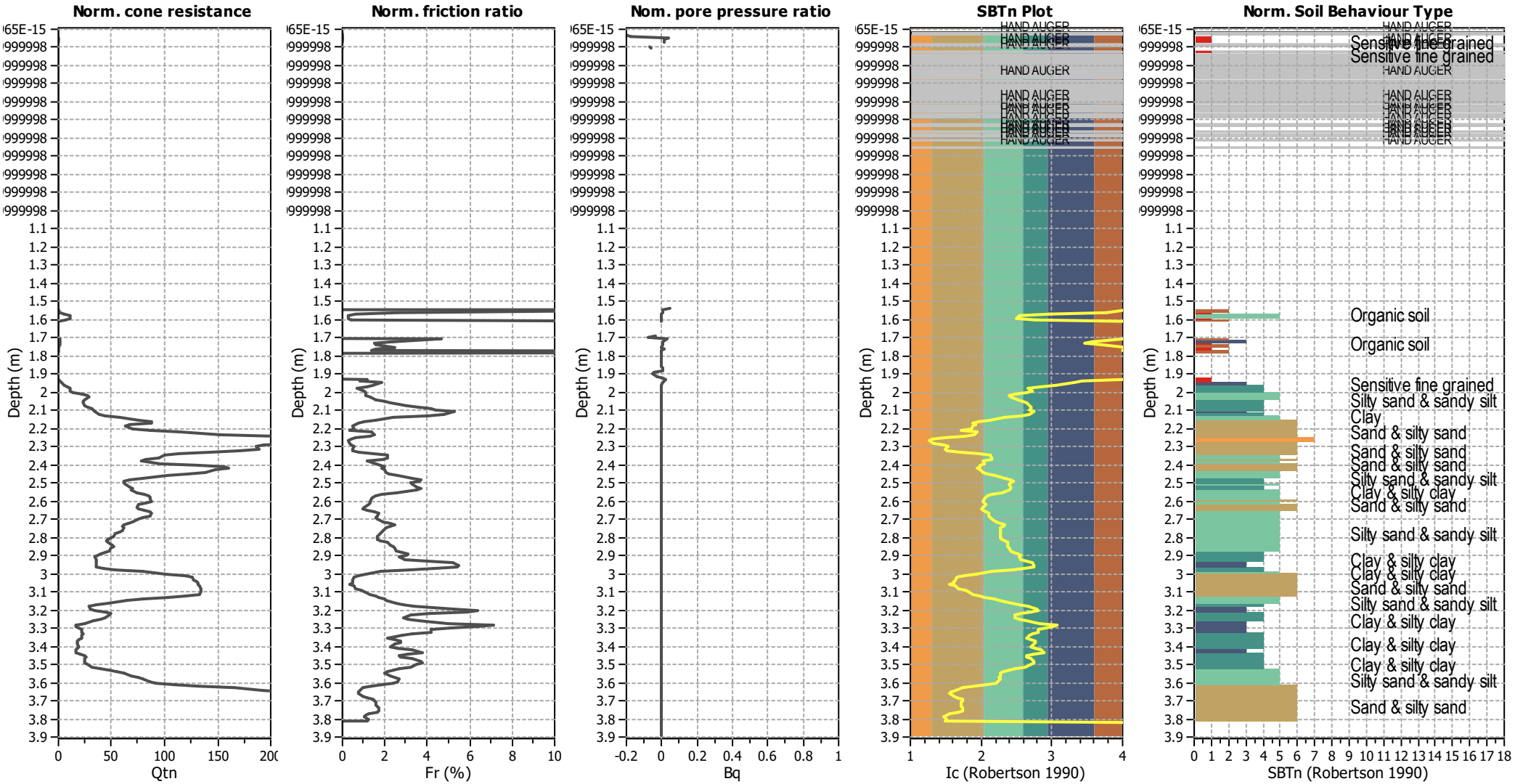






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots (normalized)



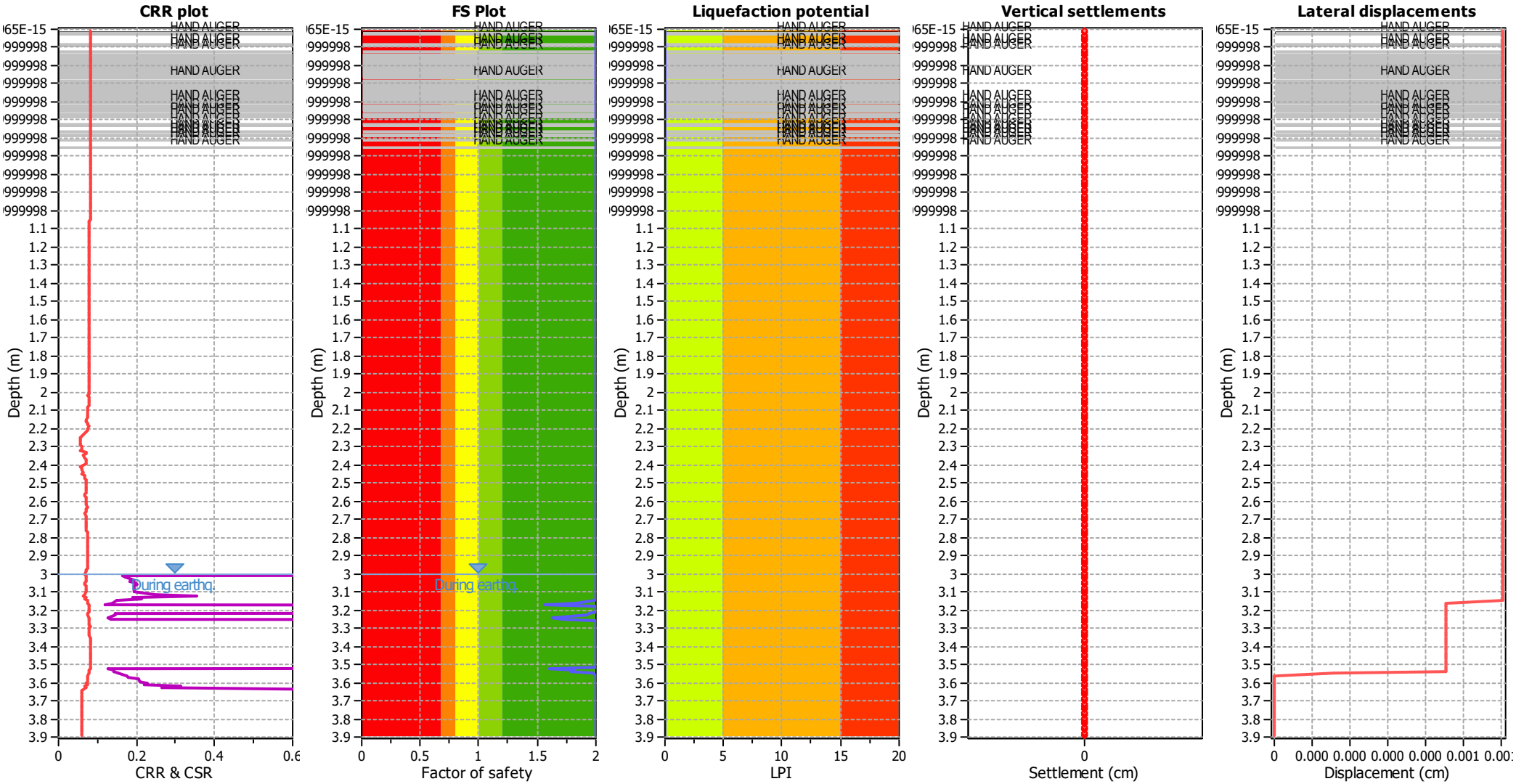
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

SBTn legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	6.40	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.13	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

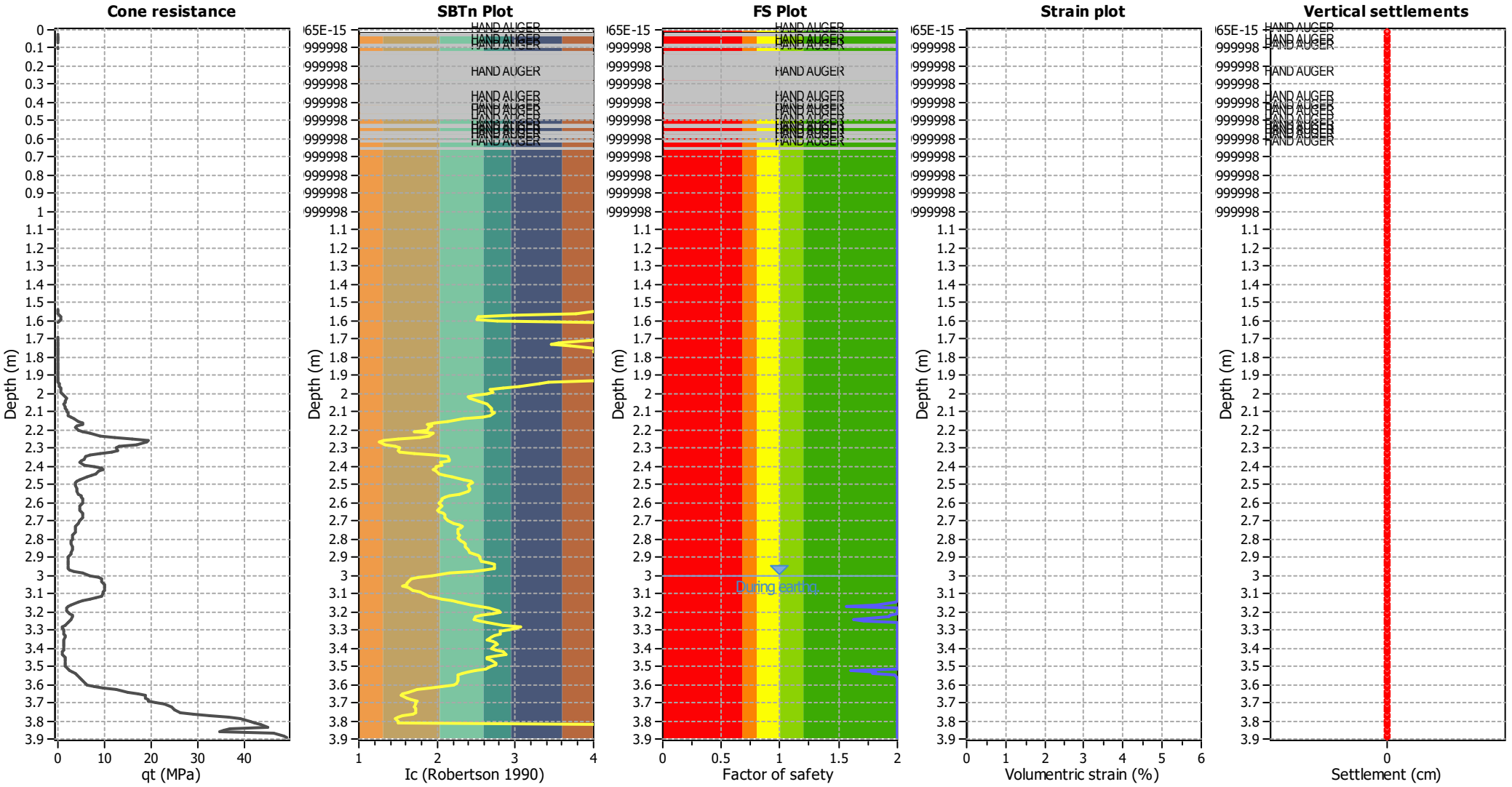
F.S. color scheme

- 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

Estimation of post-earthquake settlements



Abbreviations

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

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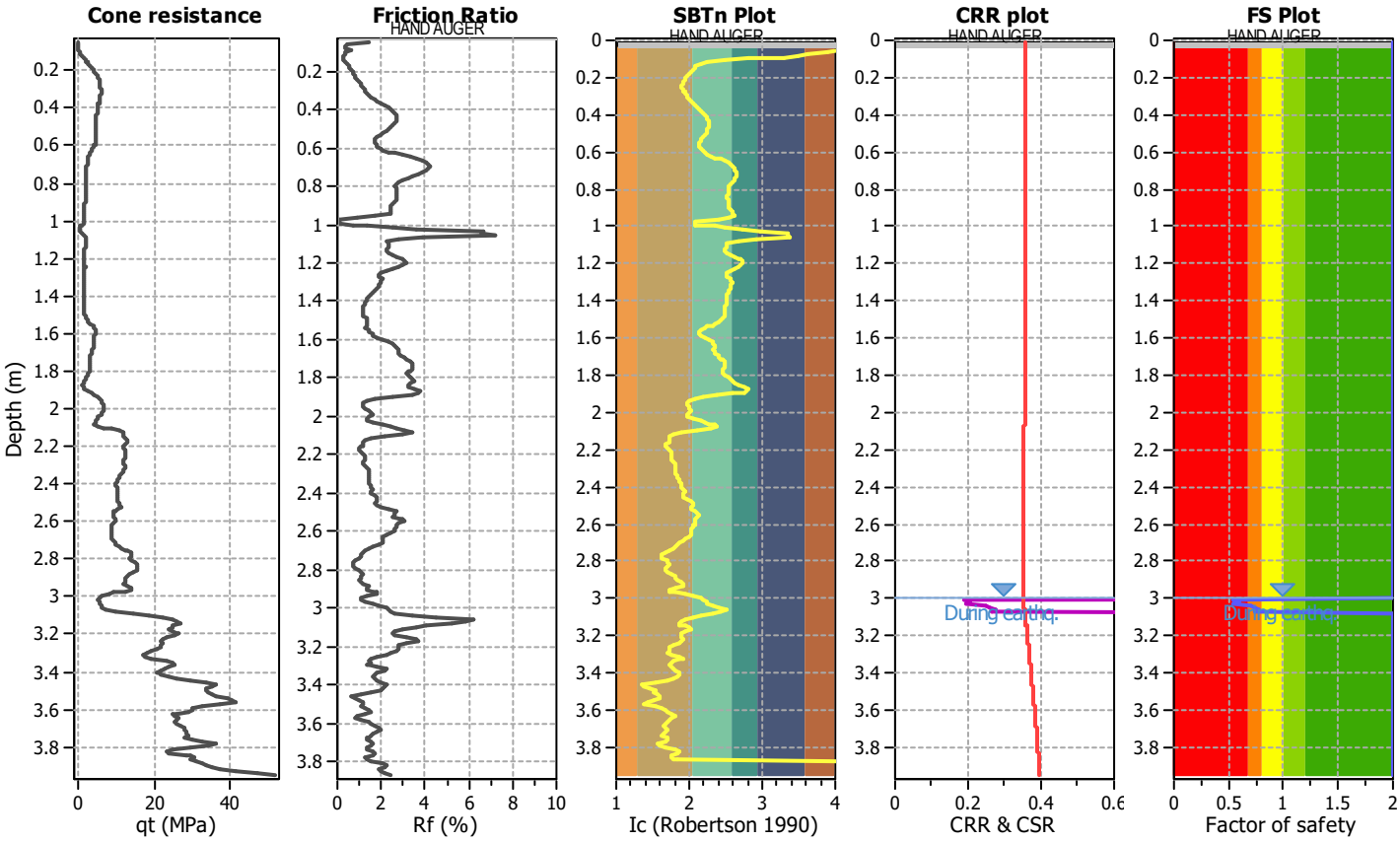
LIQUEFACTION ANALYSIS REPORT

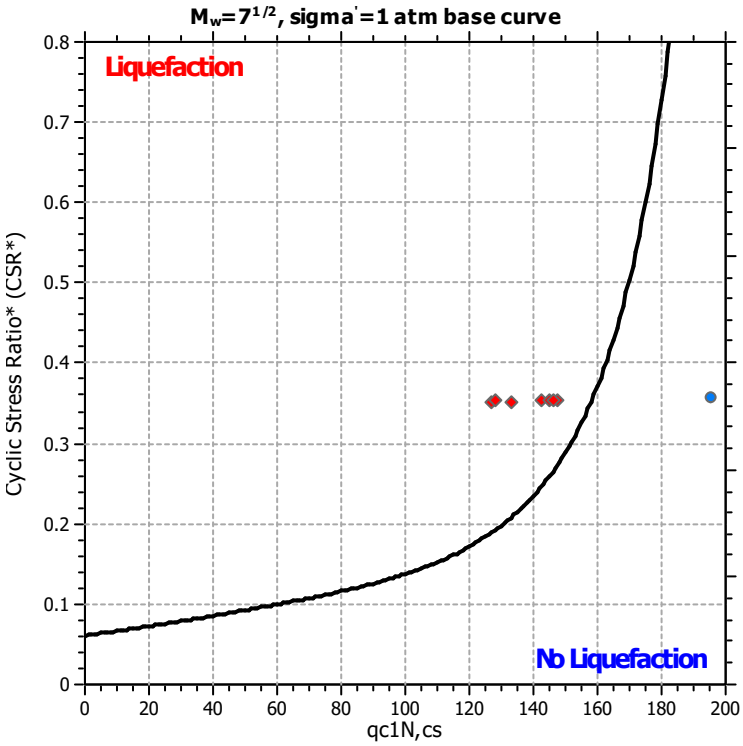
Project title : 230999_Te Pirangi Developments Ltd **Location : 158 Turitea Road, Palmerston North**

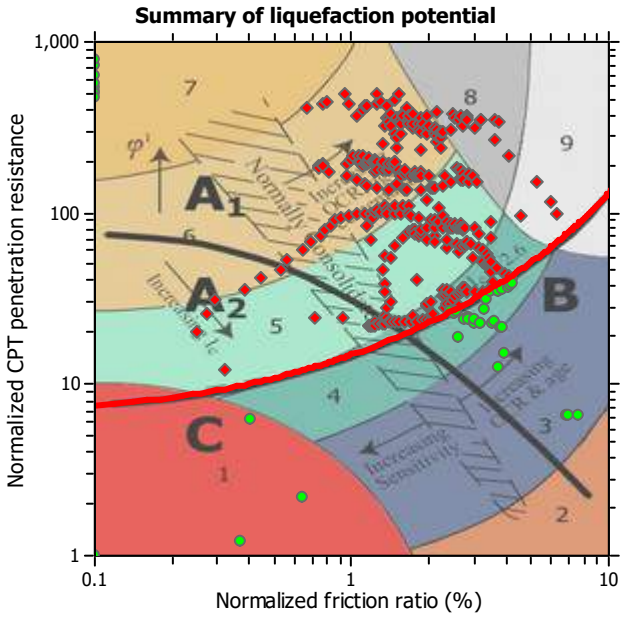
CPT file : CPT01_ULS

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	15.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.55	Unit weight calculation:	Based on SBT	K_σ applied:	No		

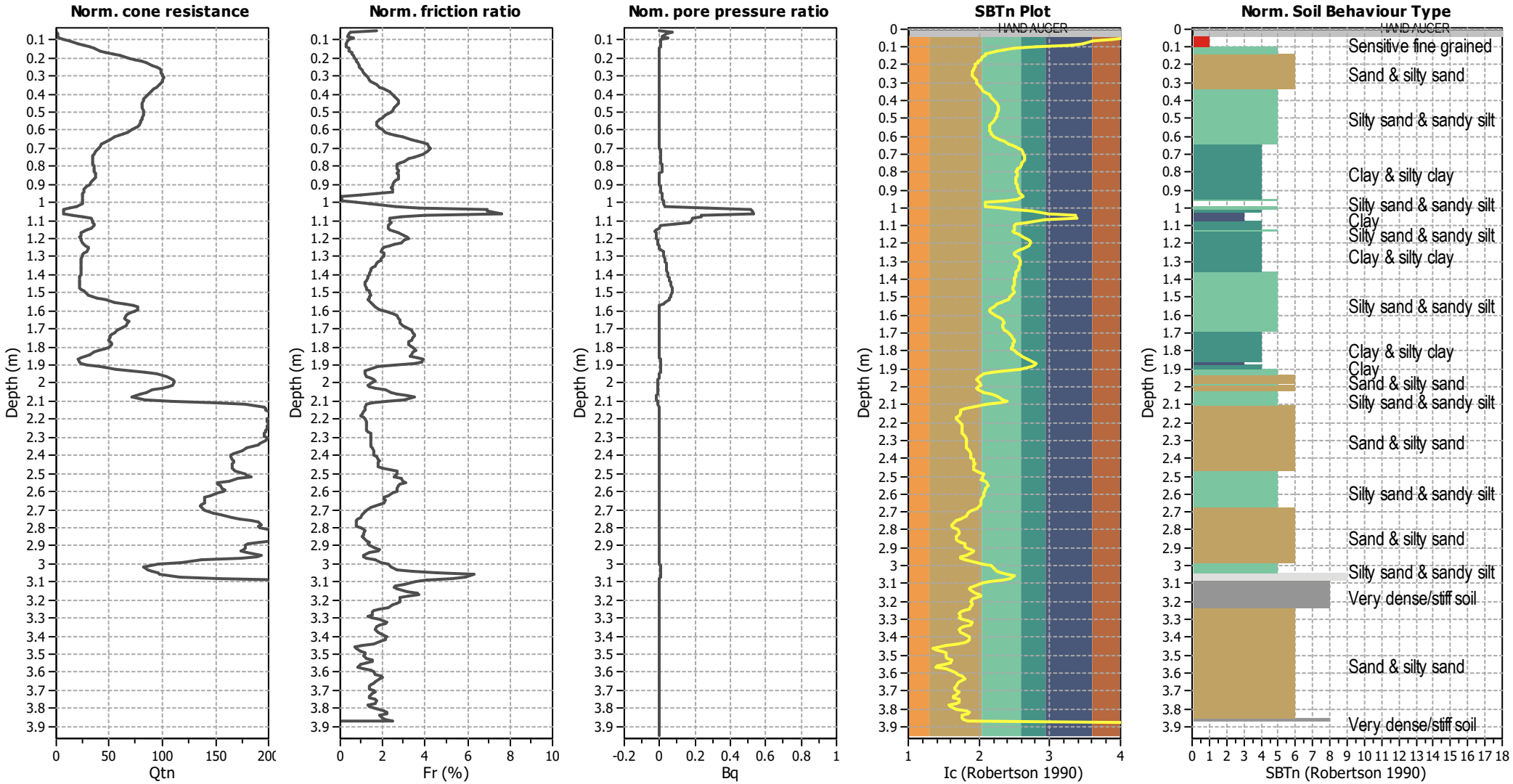






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots (normalized)



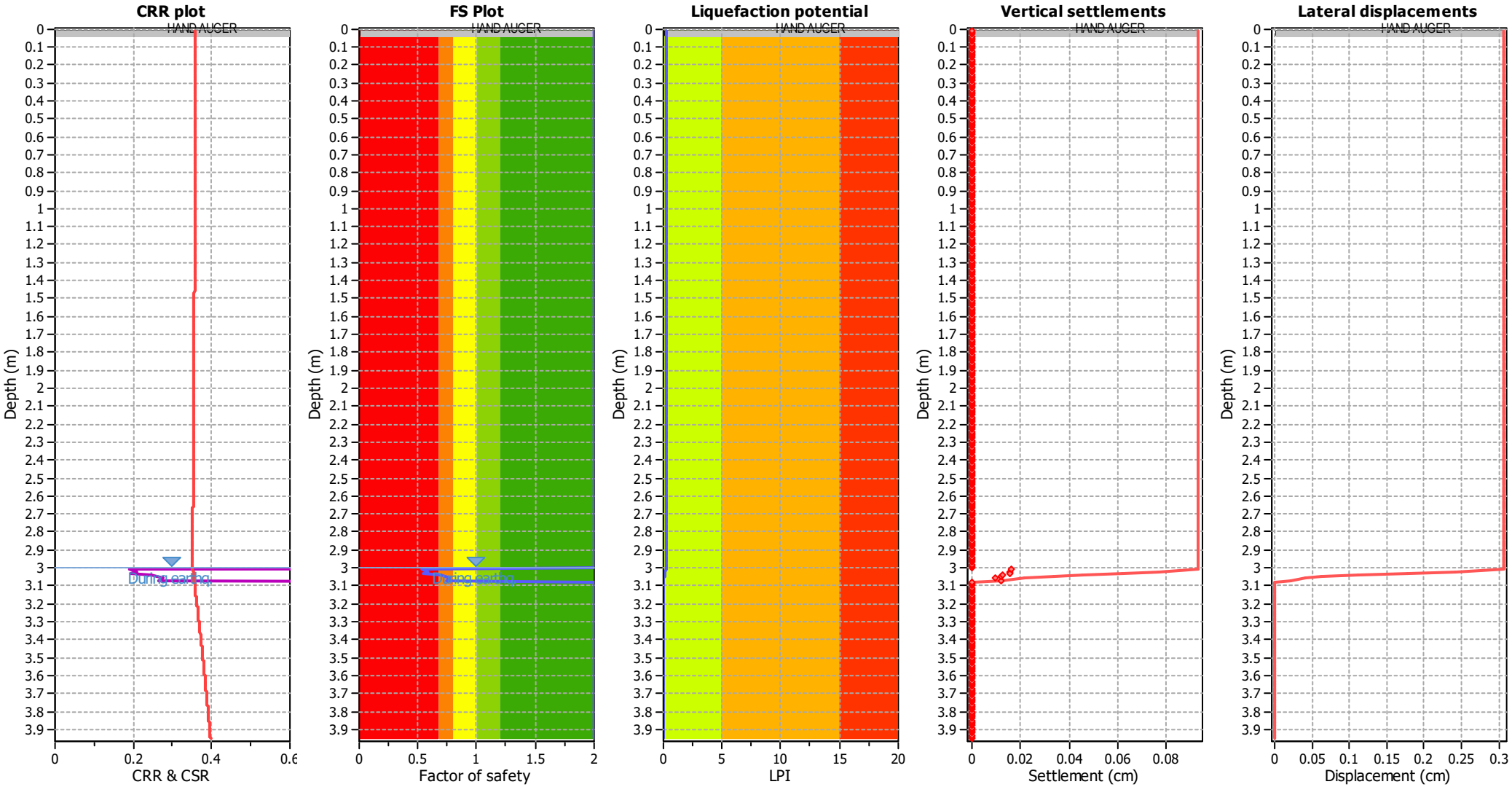
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.55	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

SBTn legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.55	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

F.S. color scheme

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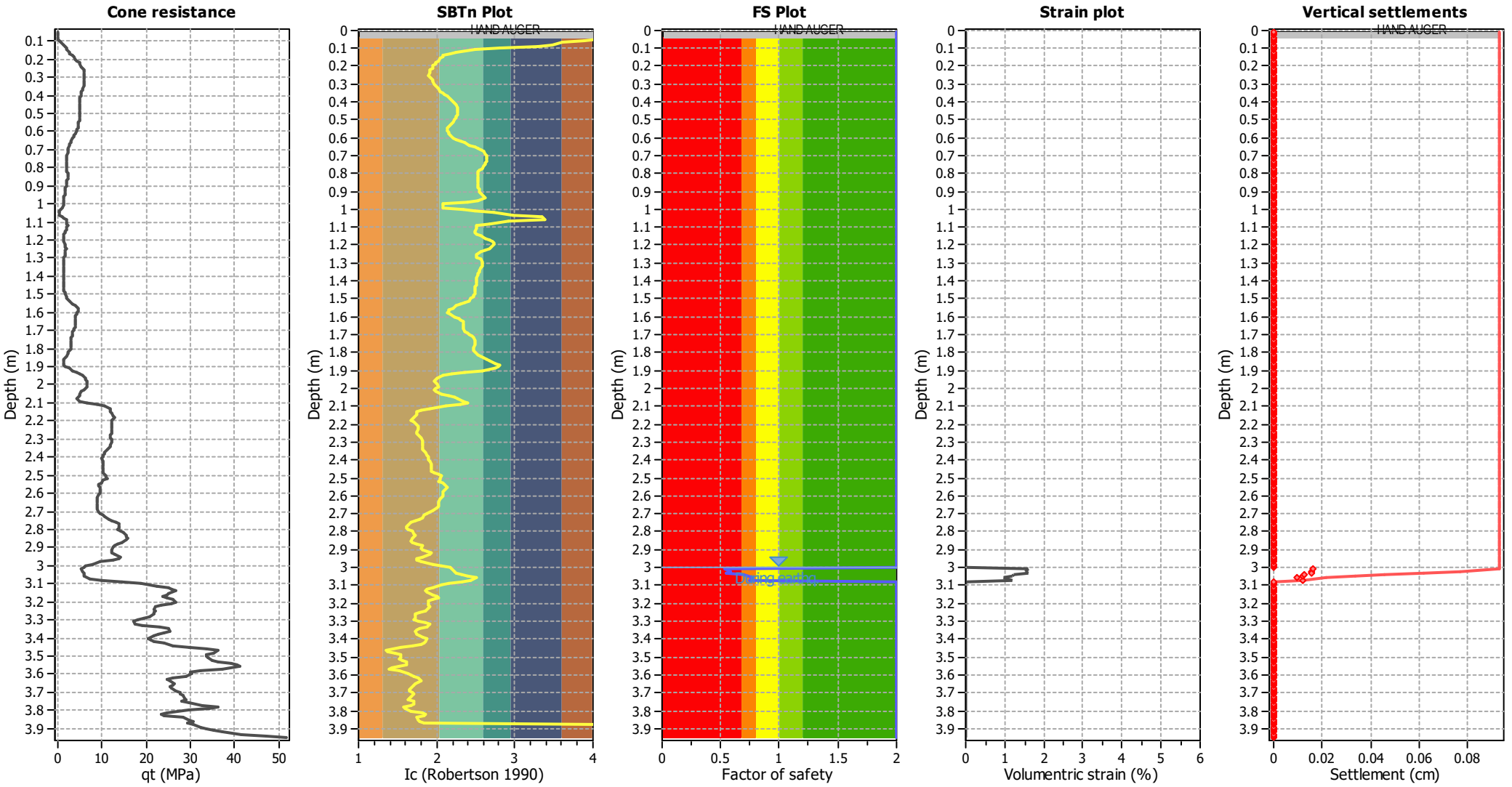
LPI color scheme

- Very high risk
- High risk
- Low risk

Estimation of post-earthquake settlements



Abbreviations

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

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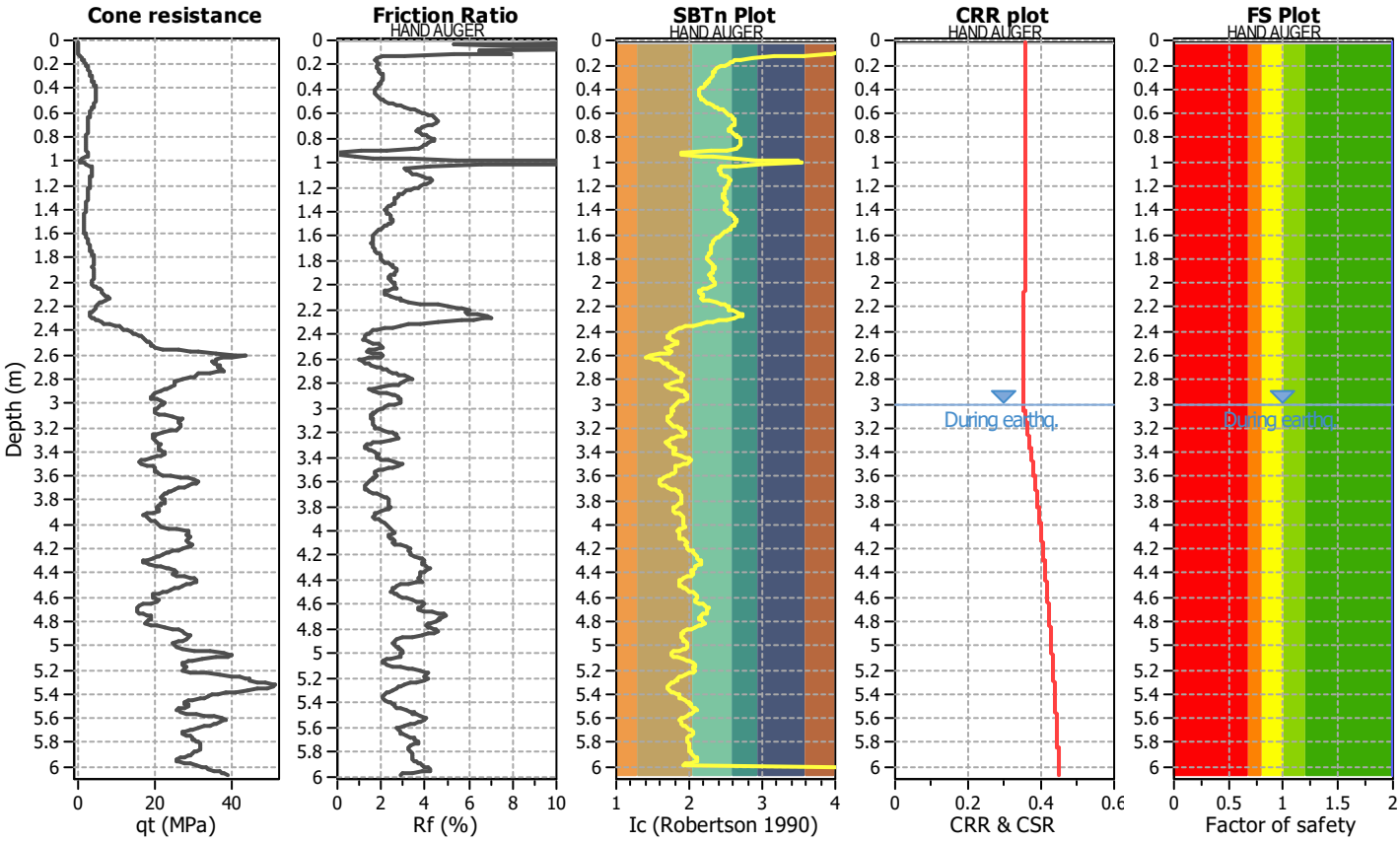
LIQUEFACTION ANALYSIS REPORT

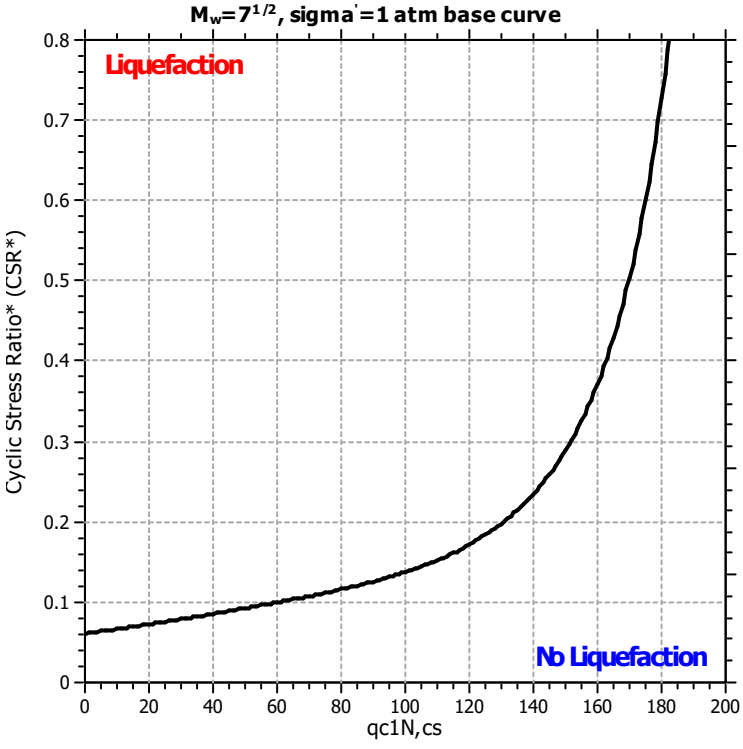
Project title : 230999_Te Pirangi Developments Ltd **Location : 158 Turitea Road, Palmerston North**

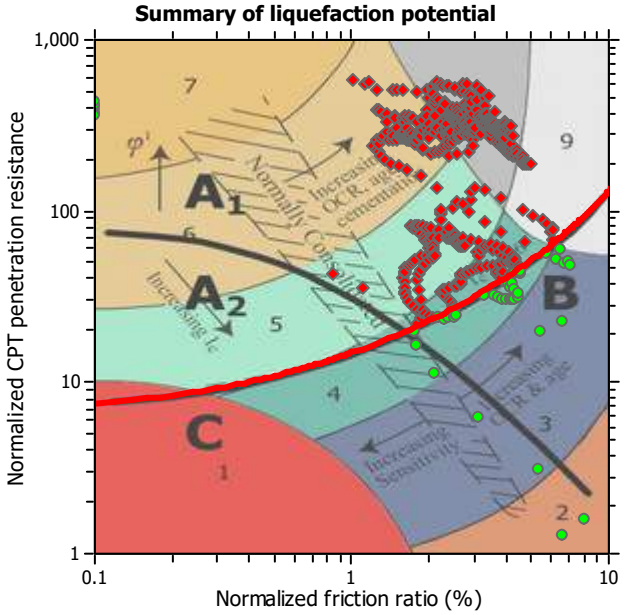
CPT file : CPT02_ULS

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	15.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.55	Unit weight calculation:	Based on SBT	K_σ applied:	No		

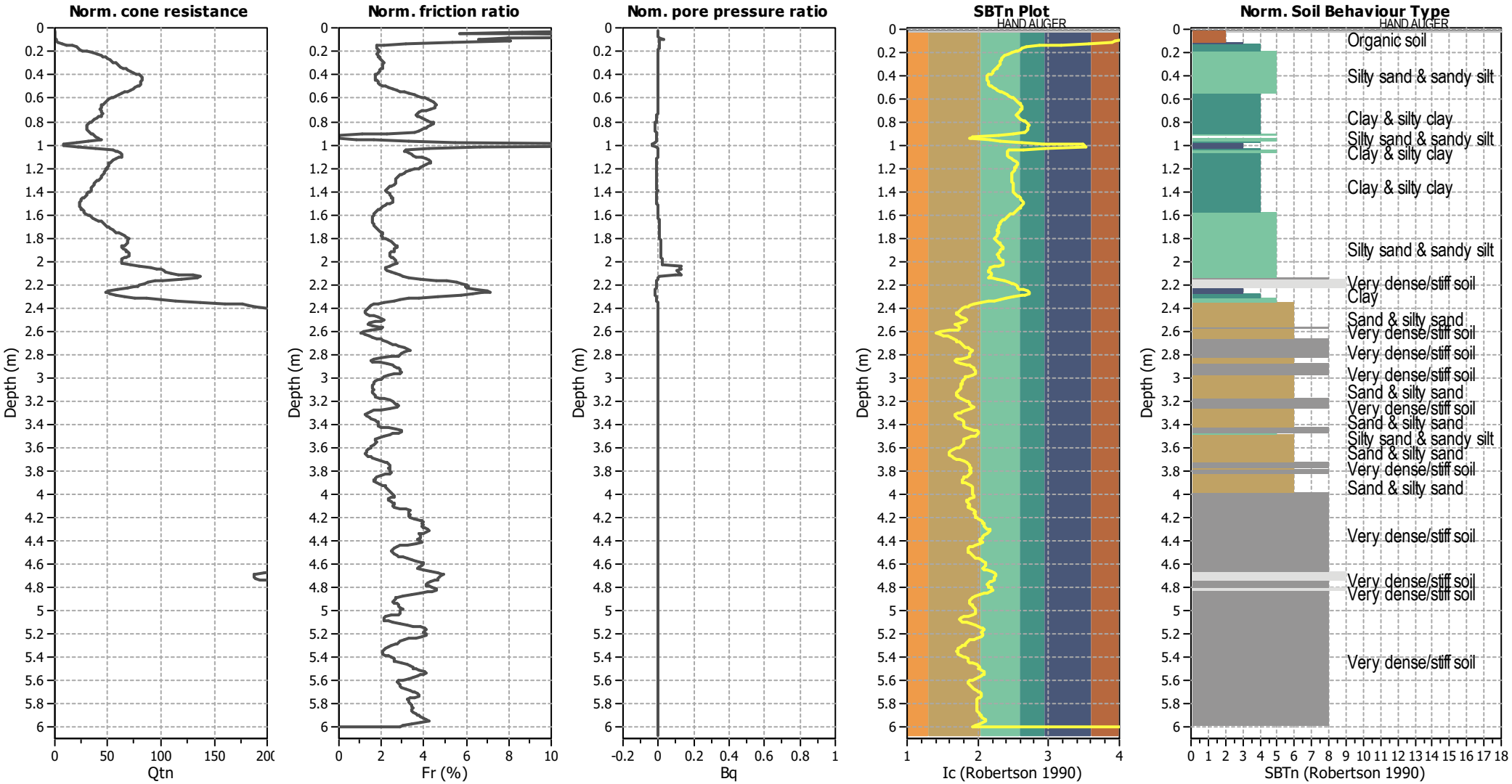






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots (normalized)



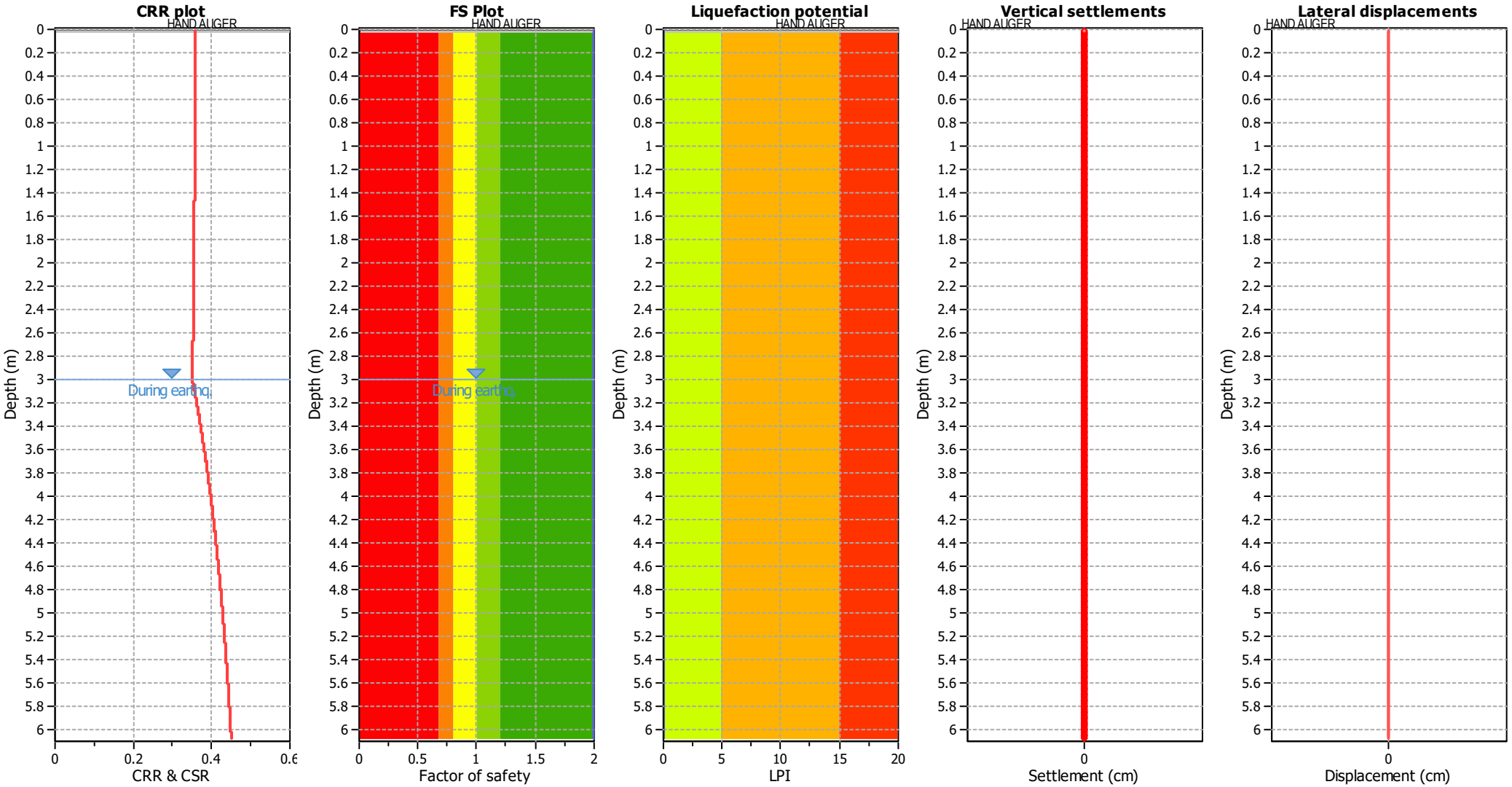
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.55	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

SBTn legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.55	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

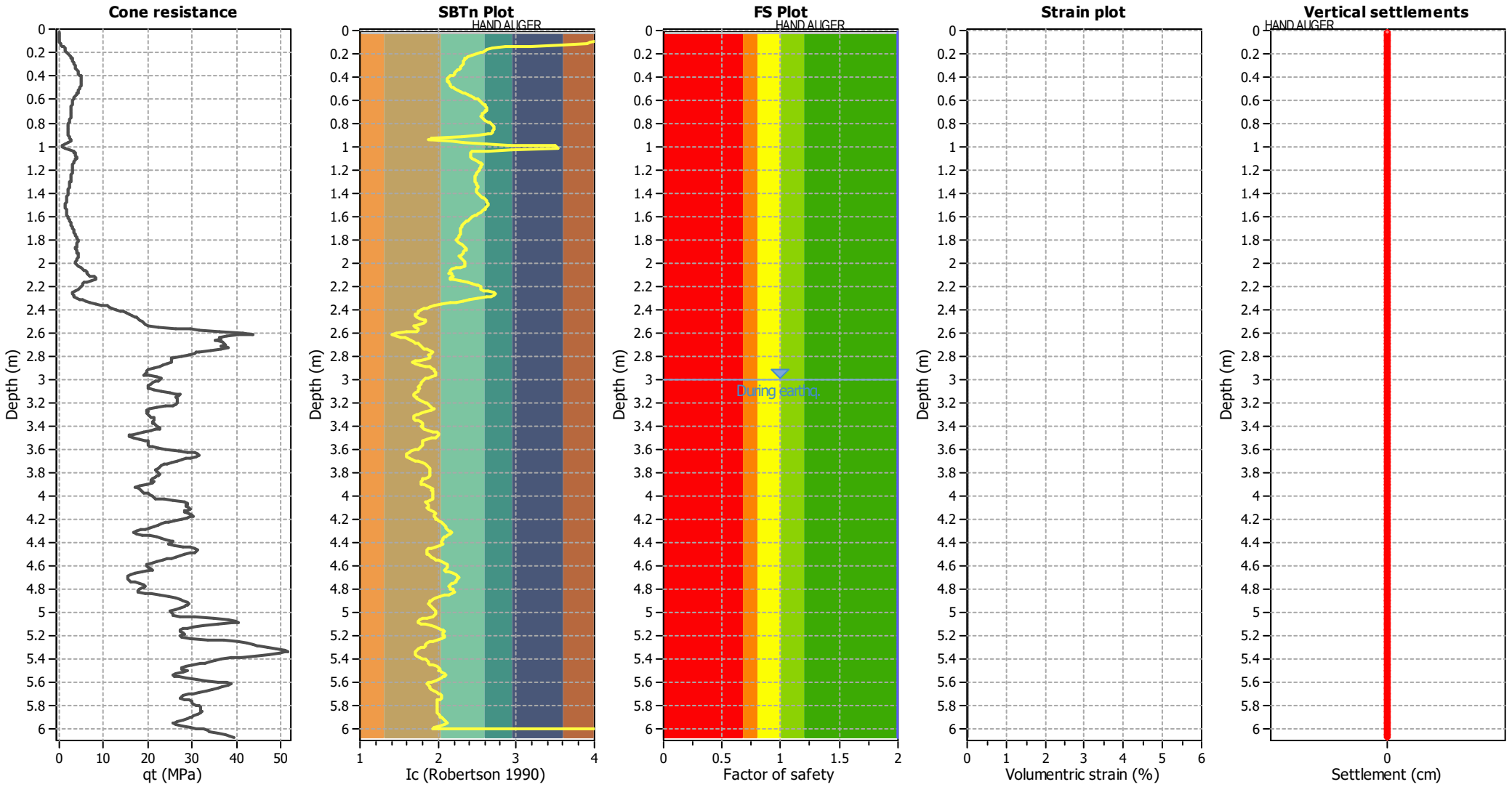
F.S. color scheme

- 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

Estimation of post-earthquake settlements



Abbreviations

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

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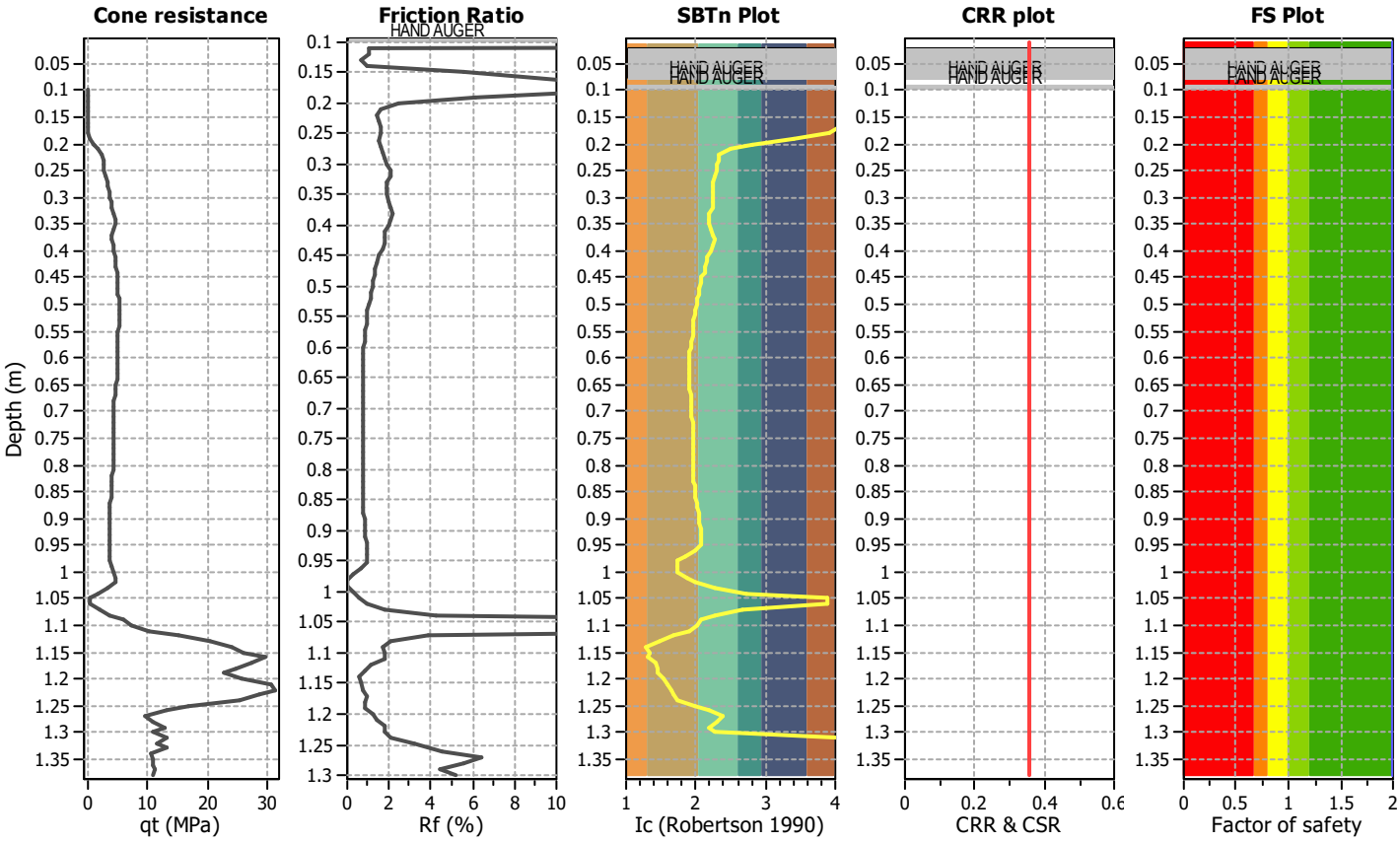
LIQUEFACTION ANALYSIS REPORT

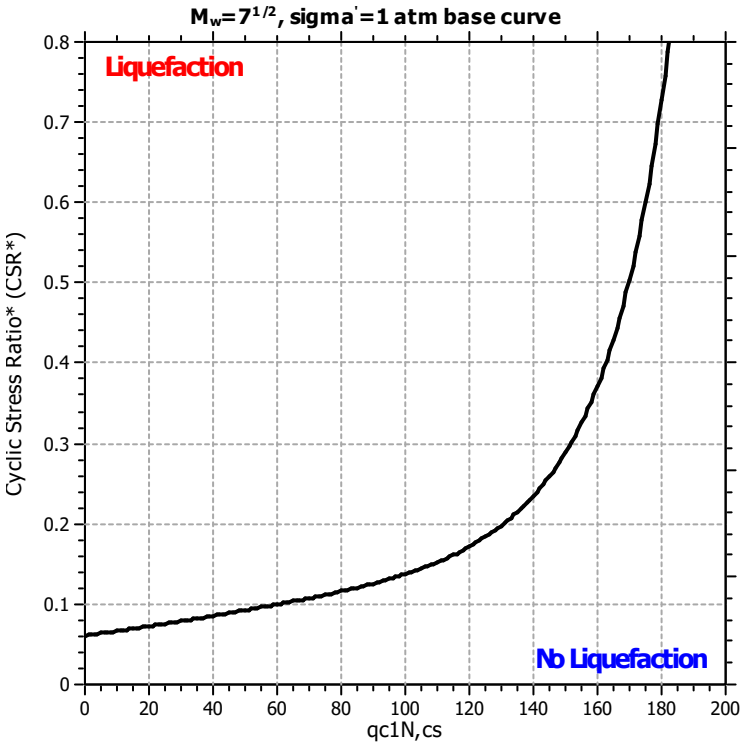
Project title : 230999_Te Pirangi Developments Ltd **Location : 158 Turitea Road, Palmerston North**

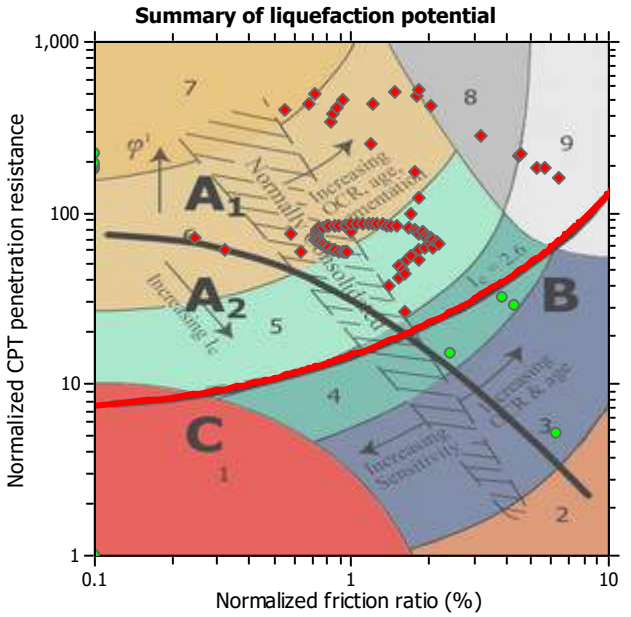
CPT file : CPT03_ULS

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	15.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.55	Unit weight calculation:	Based on SBT	K_σ applied:	No		

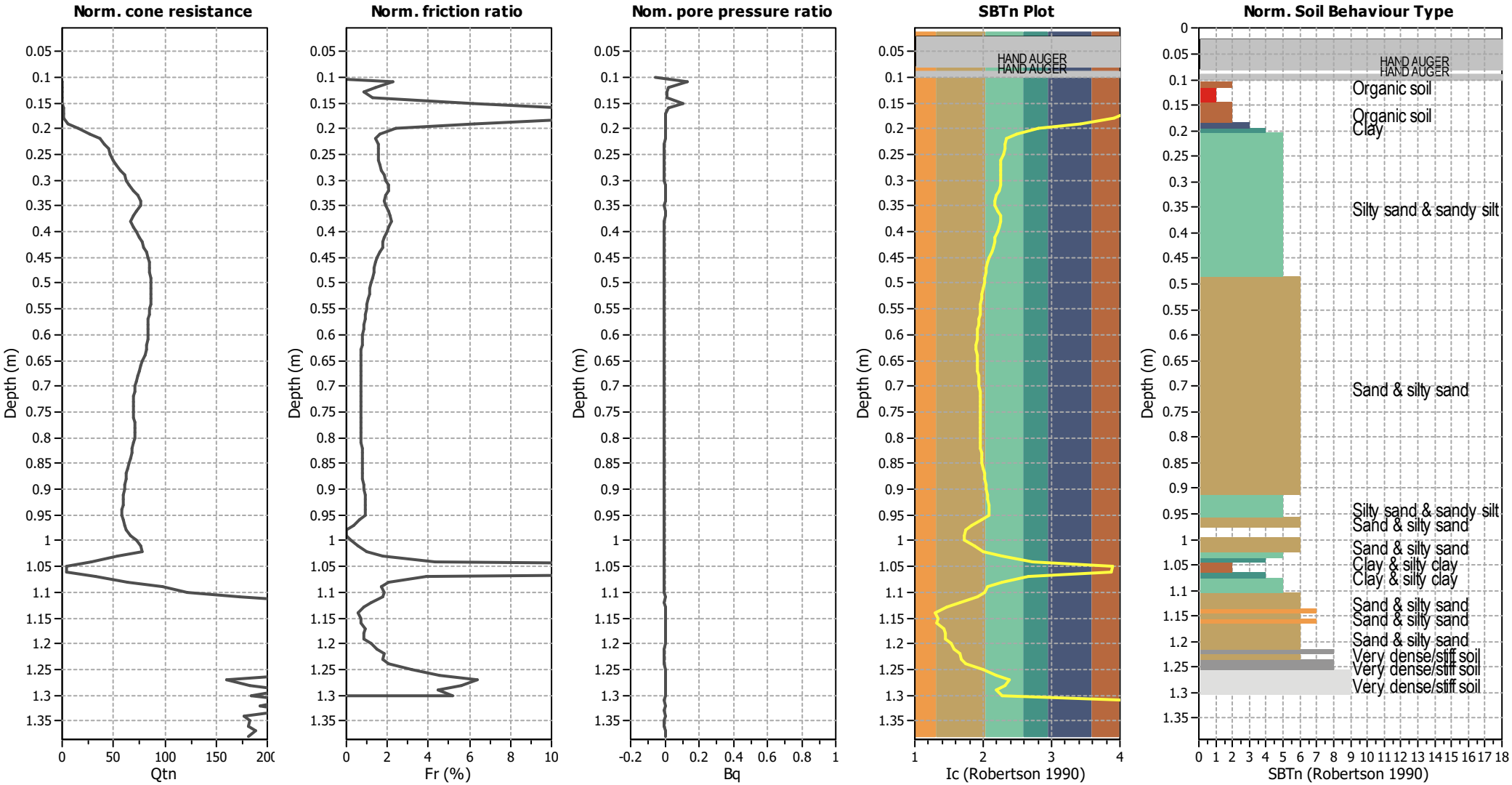






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.55	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
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8. Very stiff sand to
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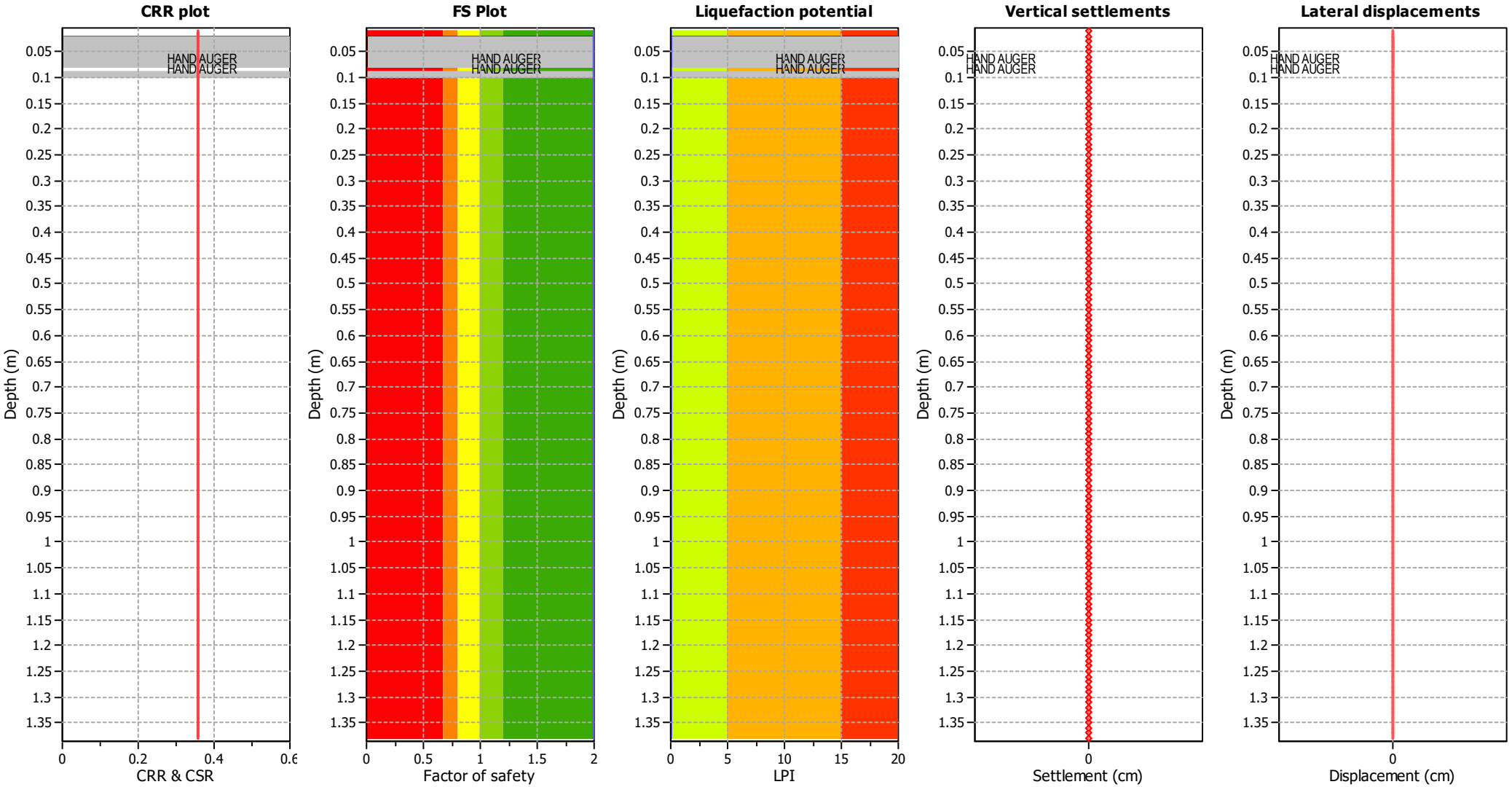
Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.55	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

F.S. color scheme

- Almost certain it will liquefy
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LPI color scheme

- Very high risk
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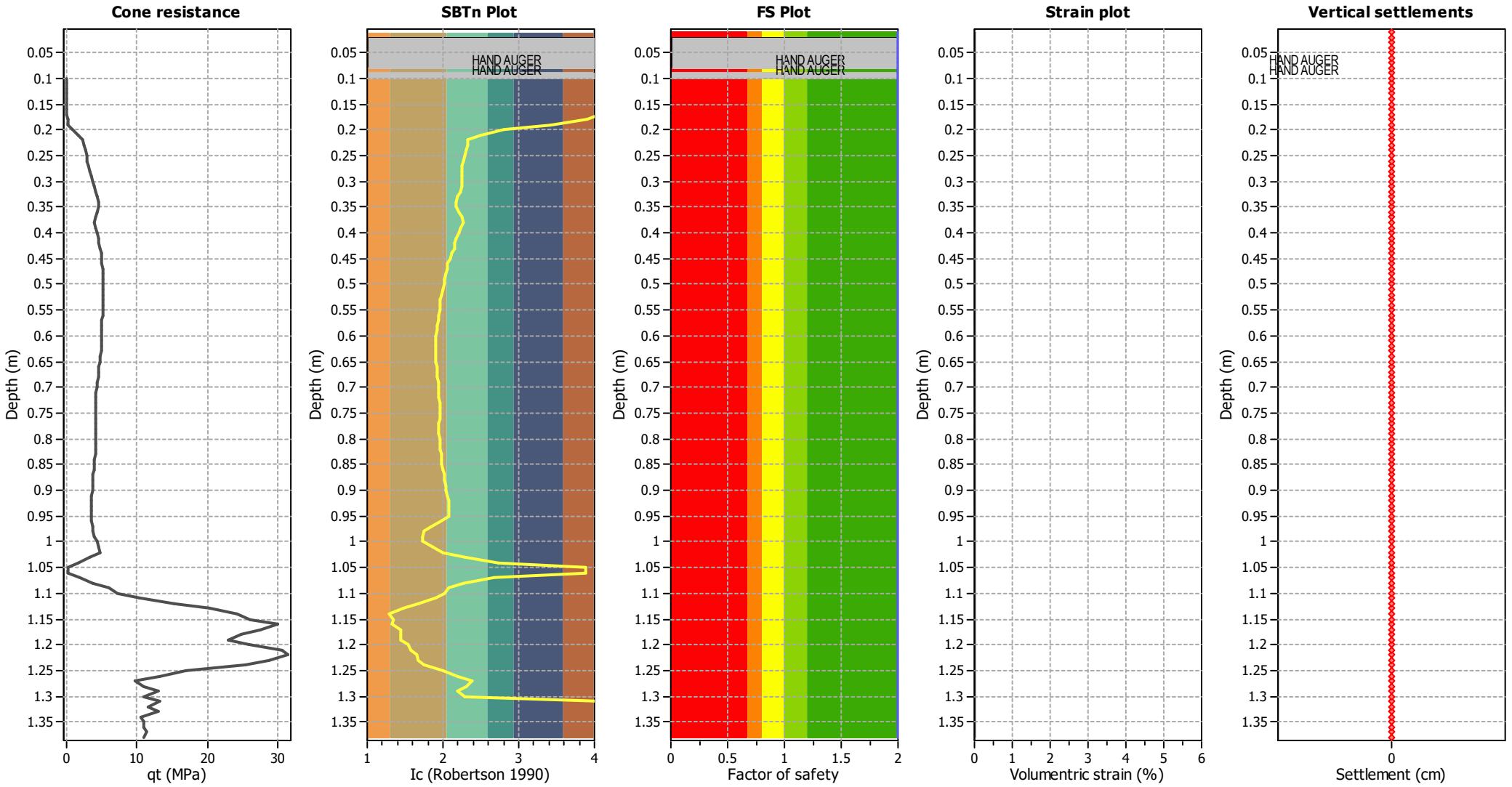
Estimation of post-earthquake settlements



Abbreviations

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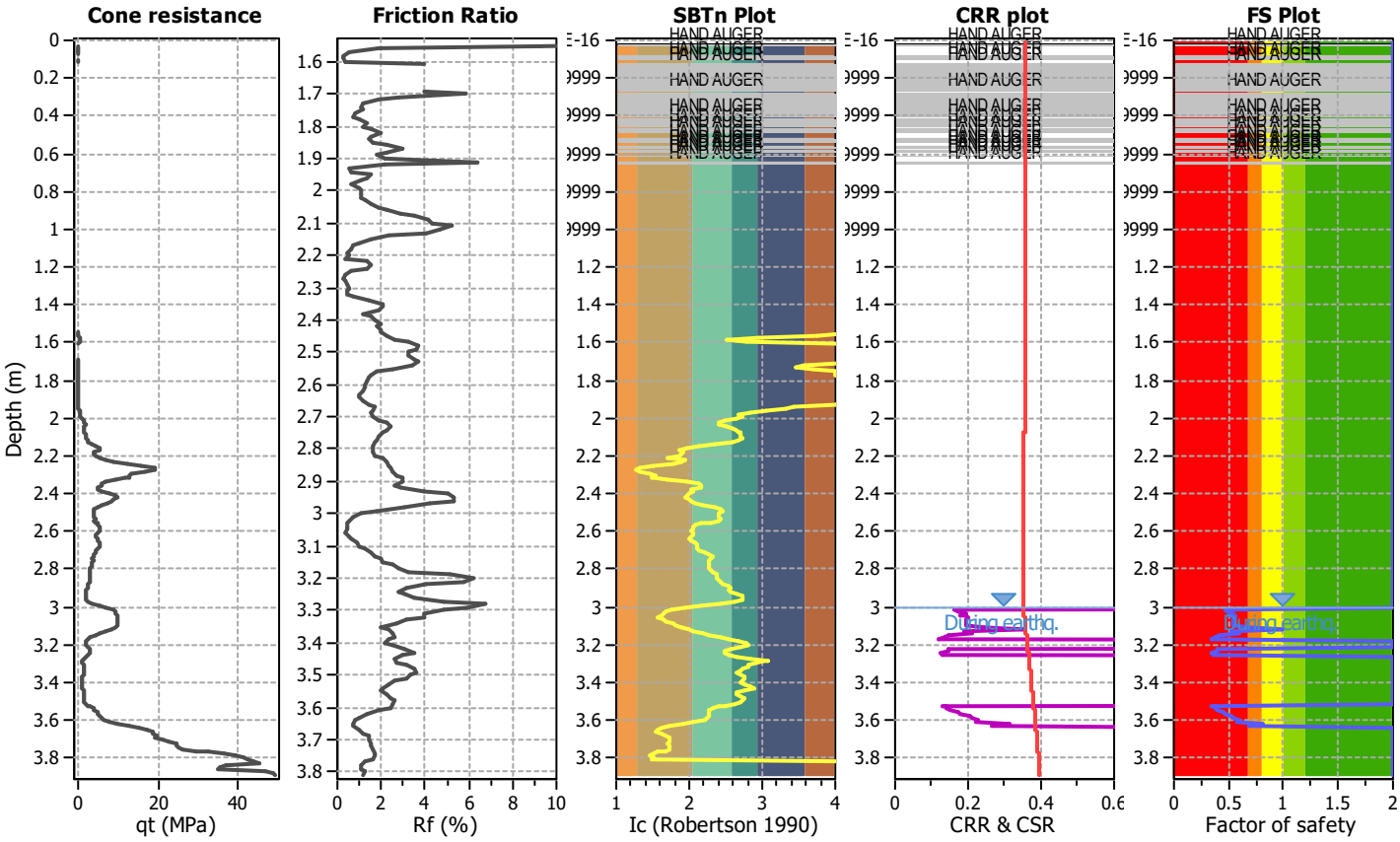
LIQUEFACTION ANALYSIS REPORT

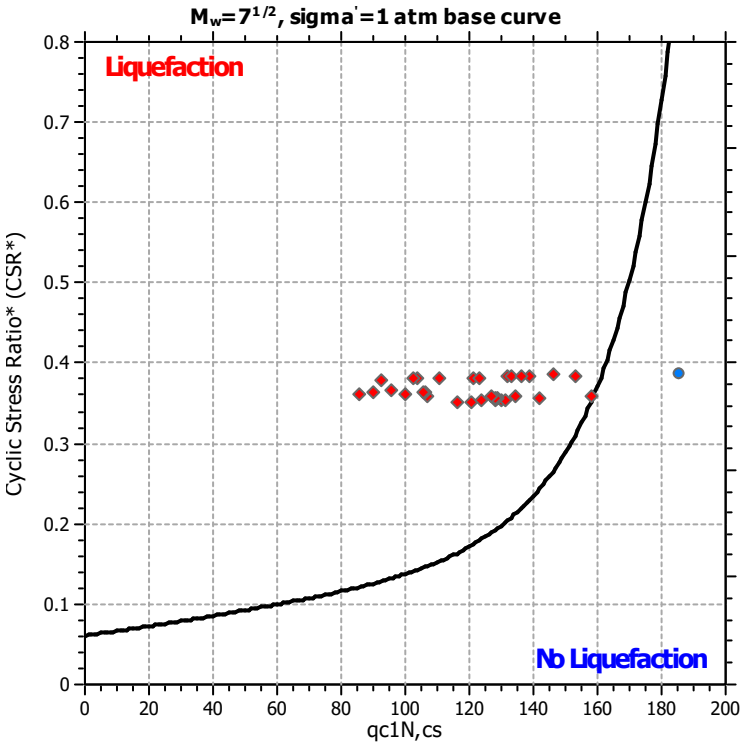
Project title : 230999_Te Pirangi Developments Ltd **Location : 158 Turitea Road, Palmerston North**

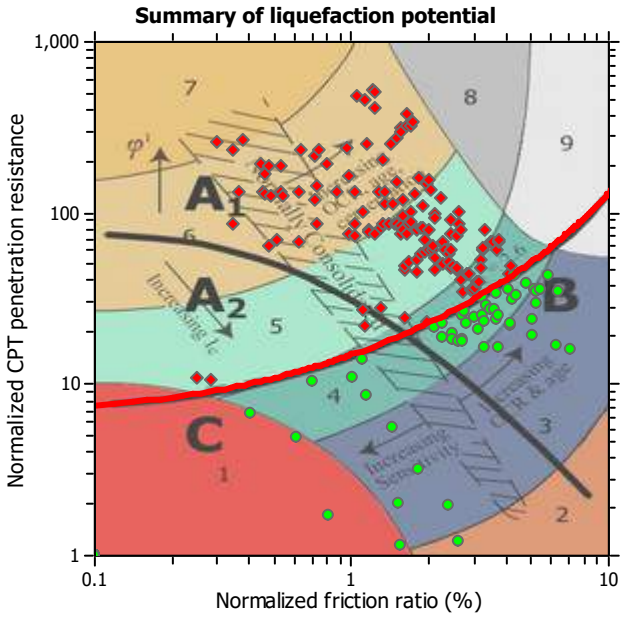
CPT file : CPT03-2

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	3.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	15.00 m
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.55	Unit weight calculation:	Based on SBT	K_σ applied:	No		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
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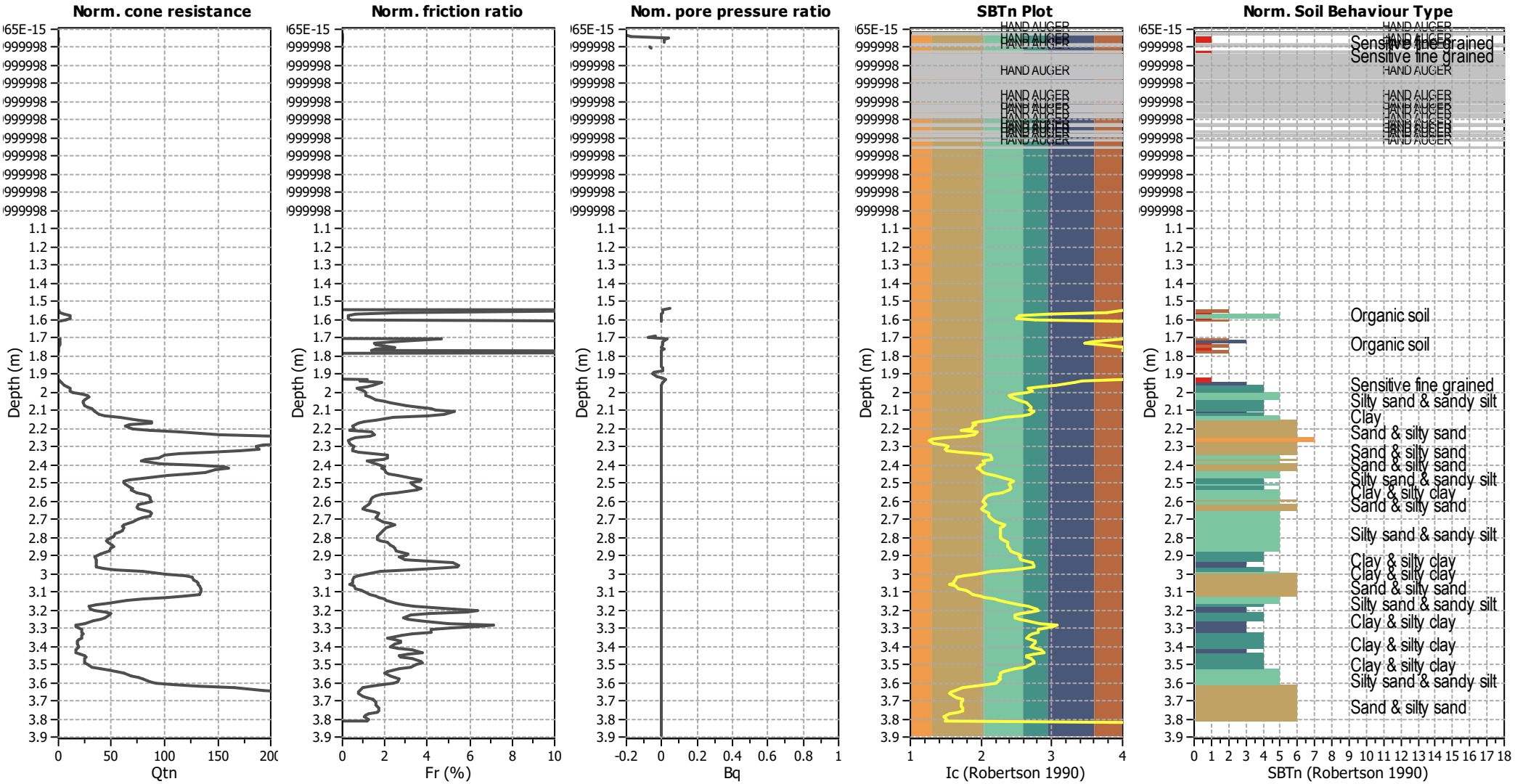
CPT basic interpretation plots (normalized)



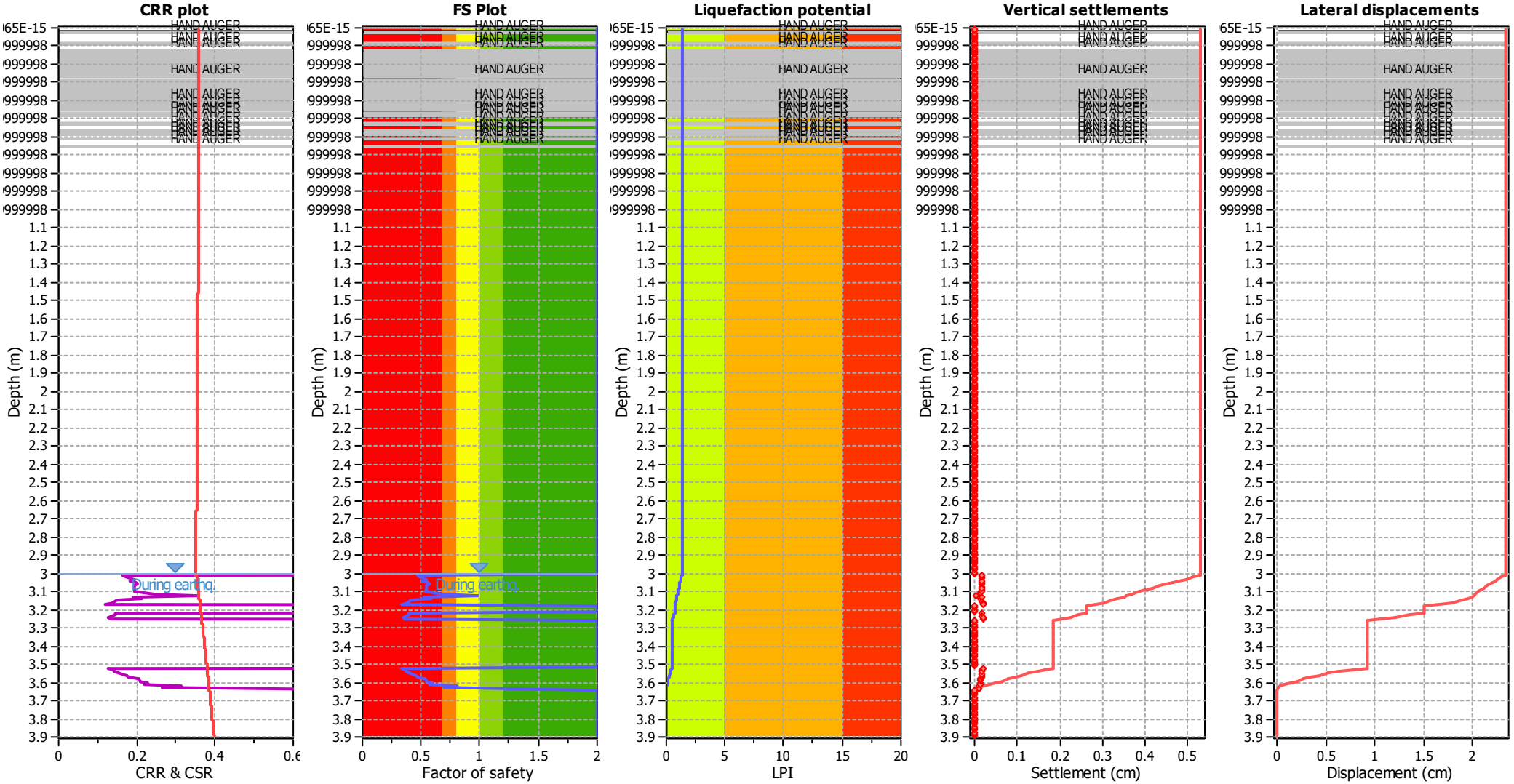
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.55	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

SBTn legend

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

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	3.00 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:	No
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.55	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	3.00 m	Fill height:	N/A	Limit depth:	15.00 m

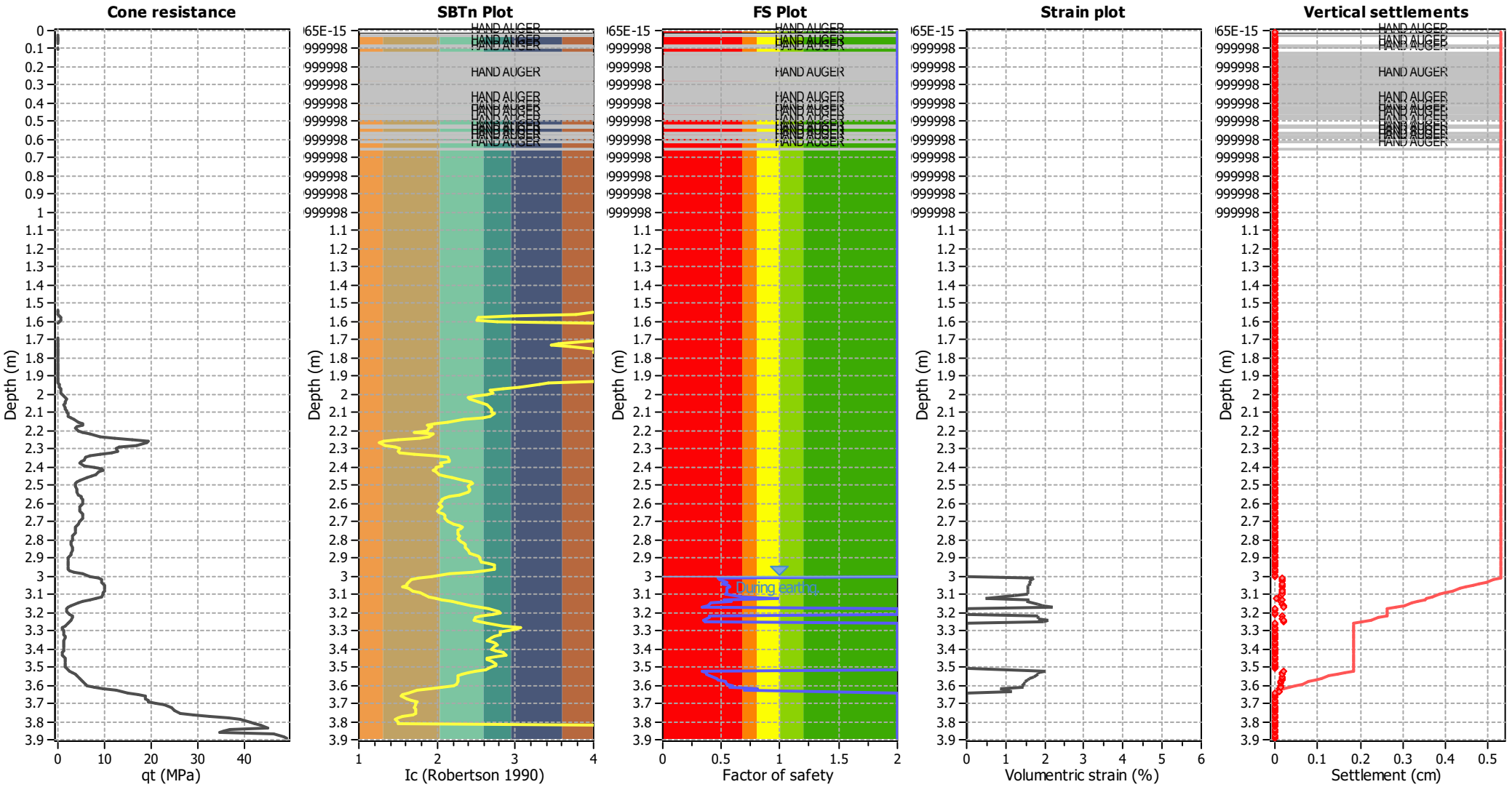
F.S. color scheme

- 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

Estimation of post-earthquake settlements



Abbreviations

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

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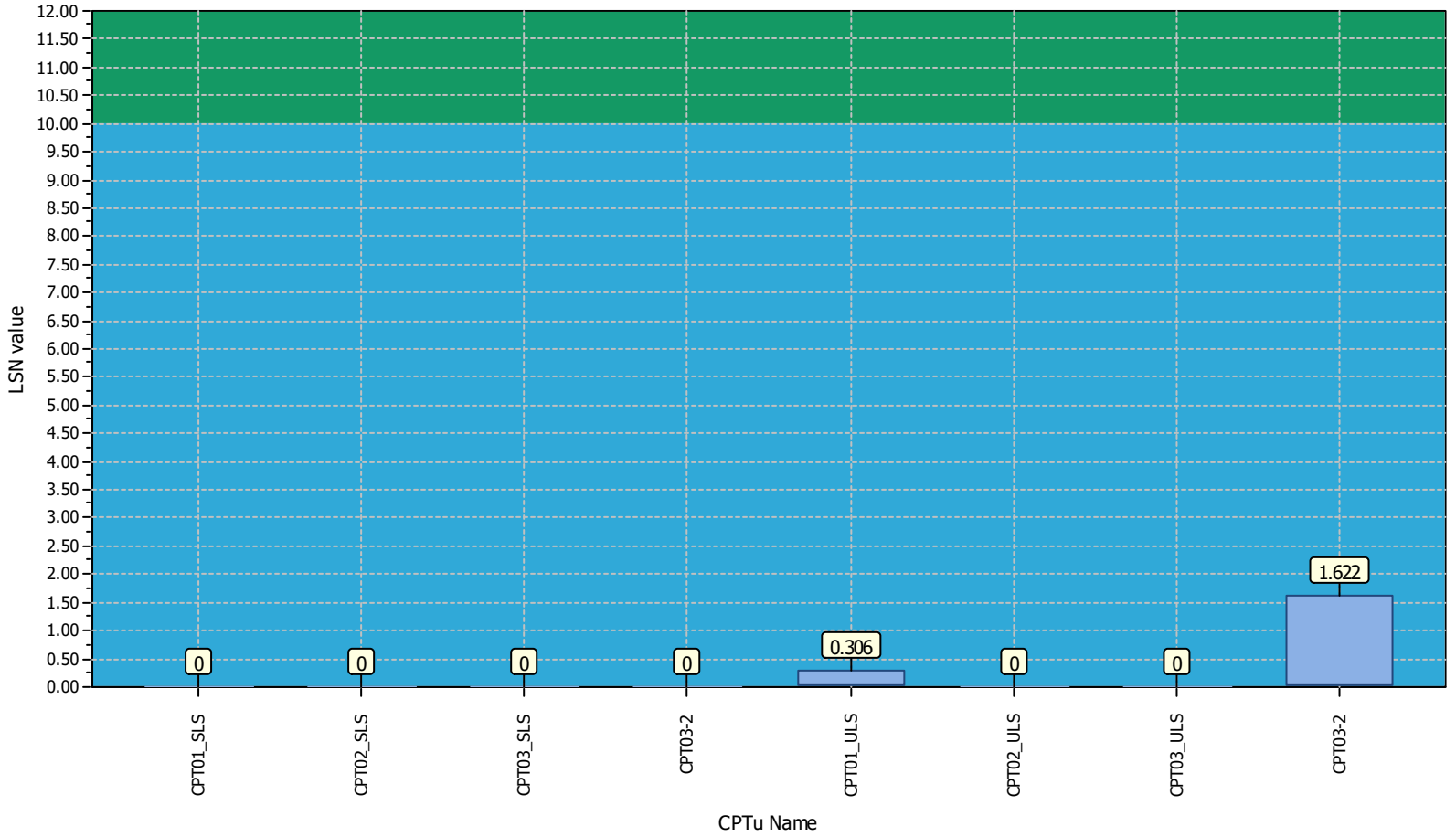
Project title : 230999_Te Pirangi Developments Ltd

Location : 158 Turitea Road, Palmerston North

Overall Liquefaction Severity Number report



LSNcolor 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: 8

100% little liquefaction

0% minor liquefaction

0% moderate liquefaction

0% moderate to major liquefaction

0% major liquefaction

0% severe liquefaction

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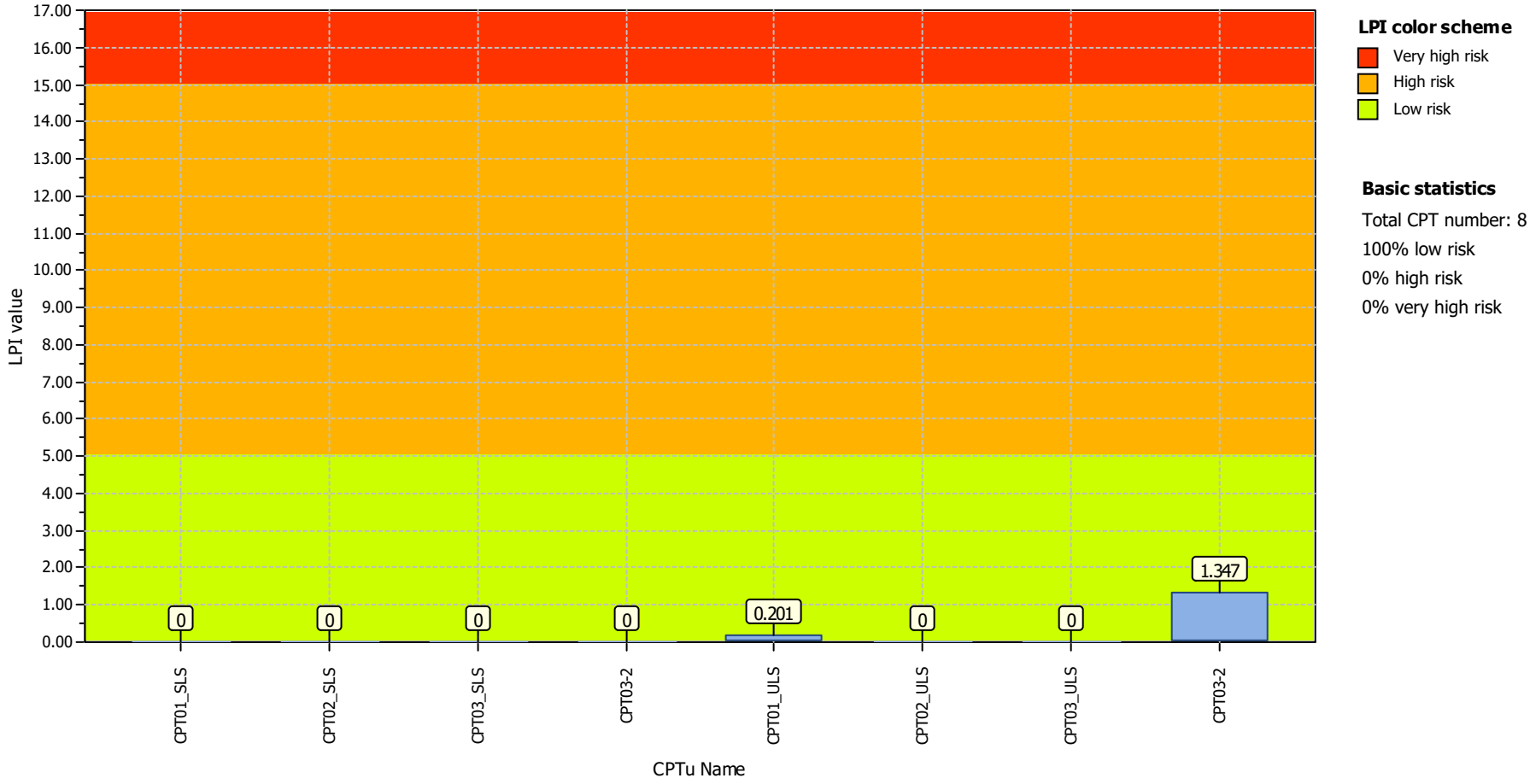
Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

Basic statistics

Total CPT number: 8

100% low risk

0% high risk

0% very high risk

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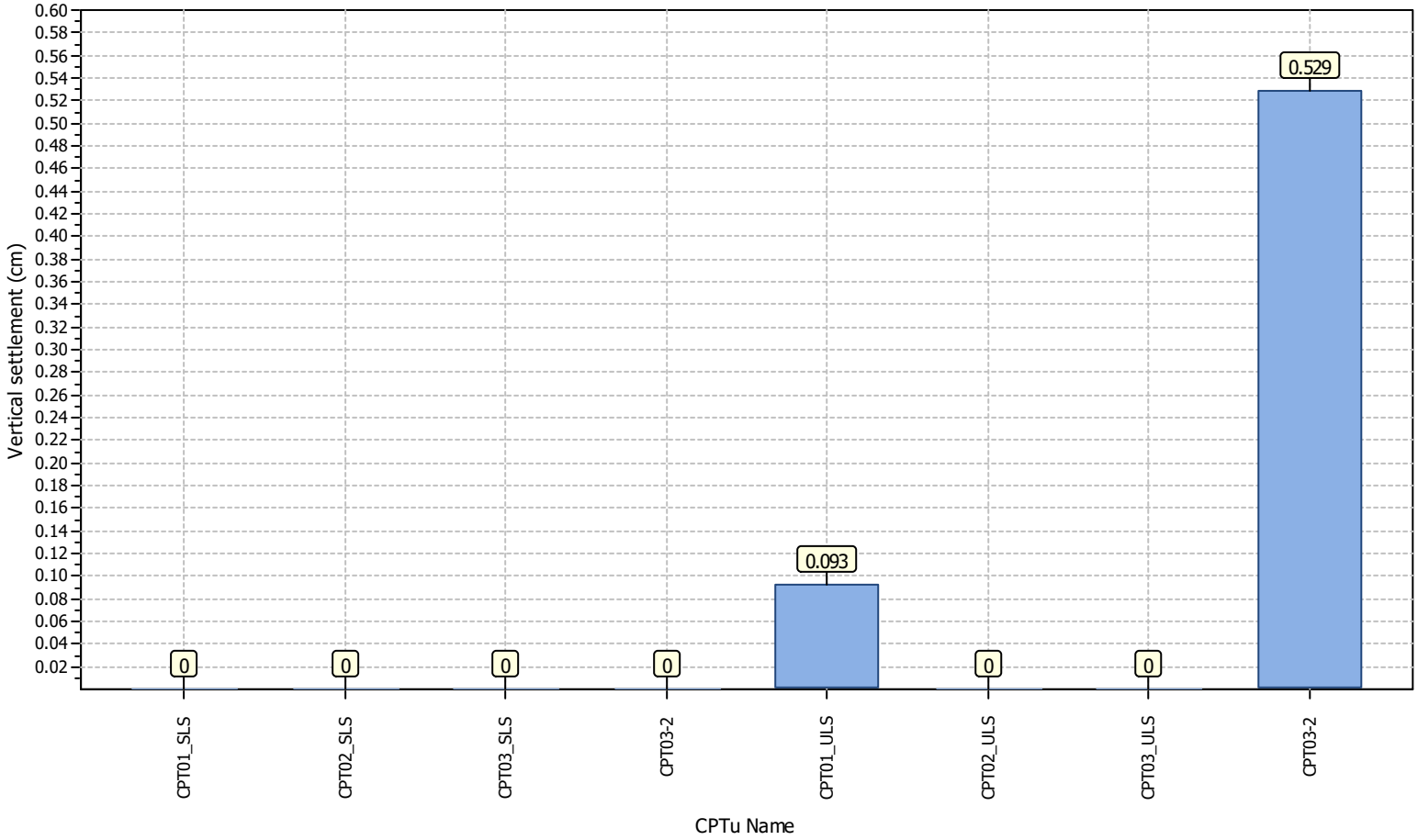
Overall vertical settlements report



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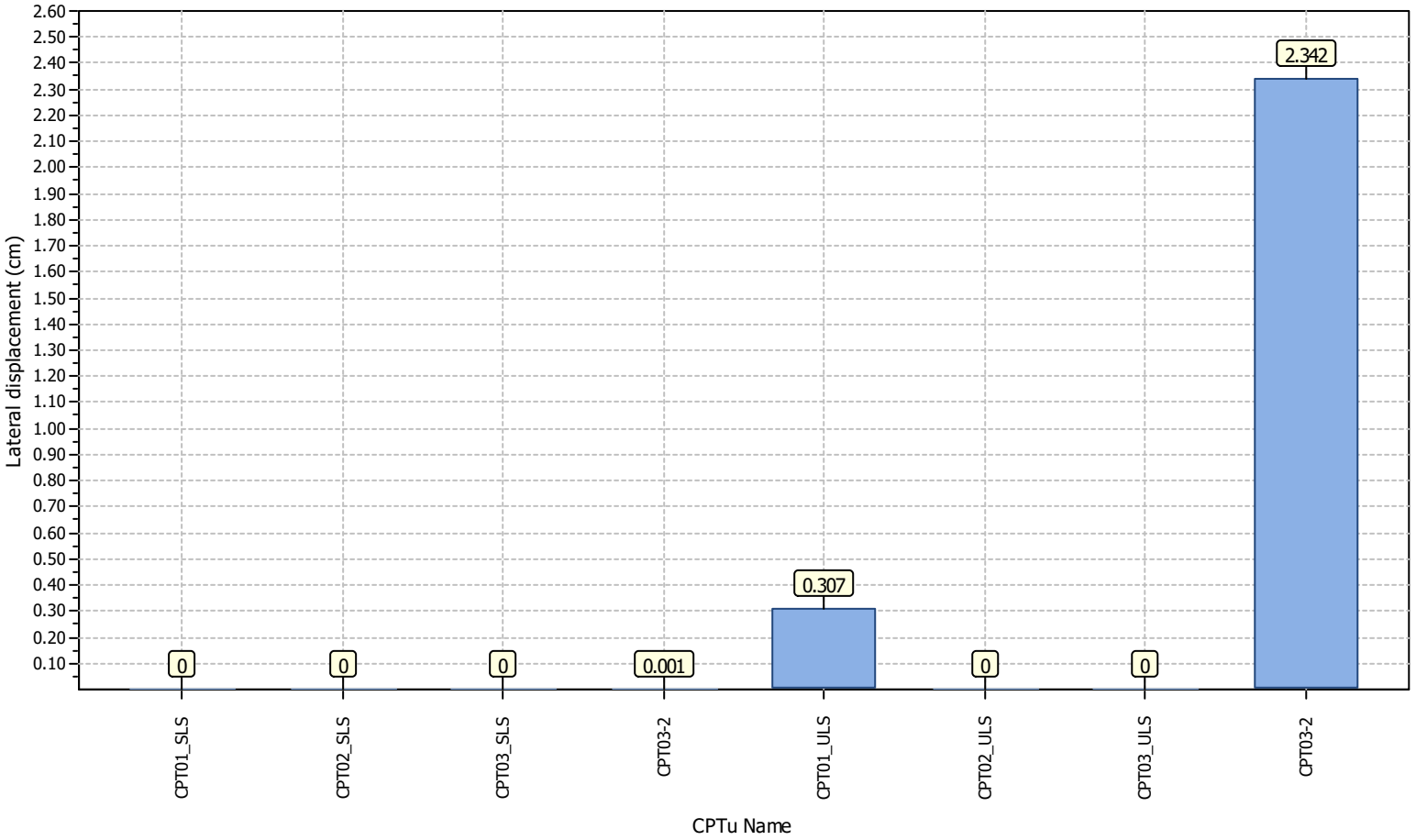
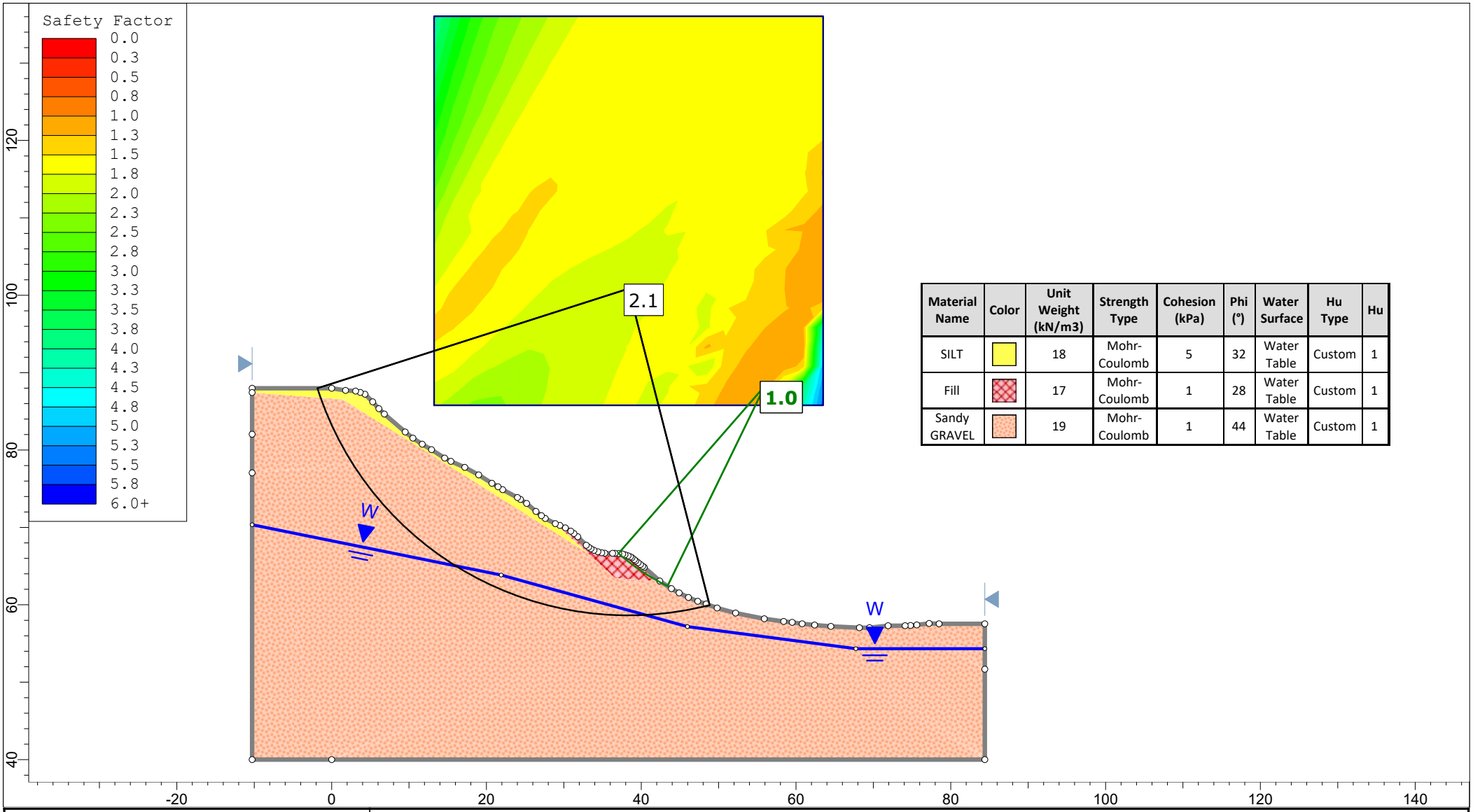
Location : 158 Turitea Road, Palmerston North

Overall lateral displacements report



Appendix D: SLOPE STABILITY ANALYSIS RESULTS



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Water Surface	Hu Type	Hu
SILT		18	Mohr-Coulomb	5	32	Water Table	Custom	1
Fill		17	Mohr-Coulomb	1	28	Water Table	Custom	1
Sandy GRAVEL		19	Mohr-Coulomb	1	44	Water Table	Custom	1

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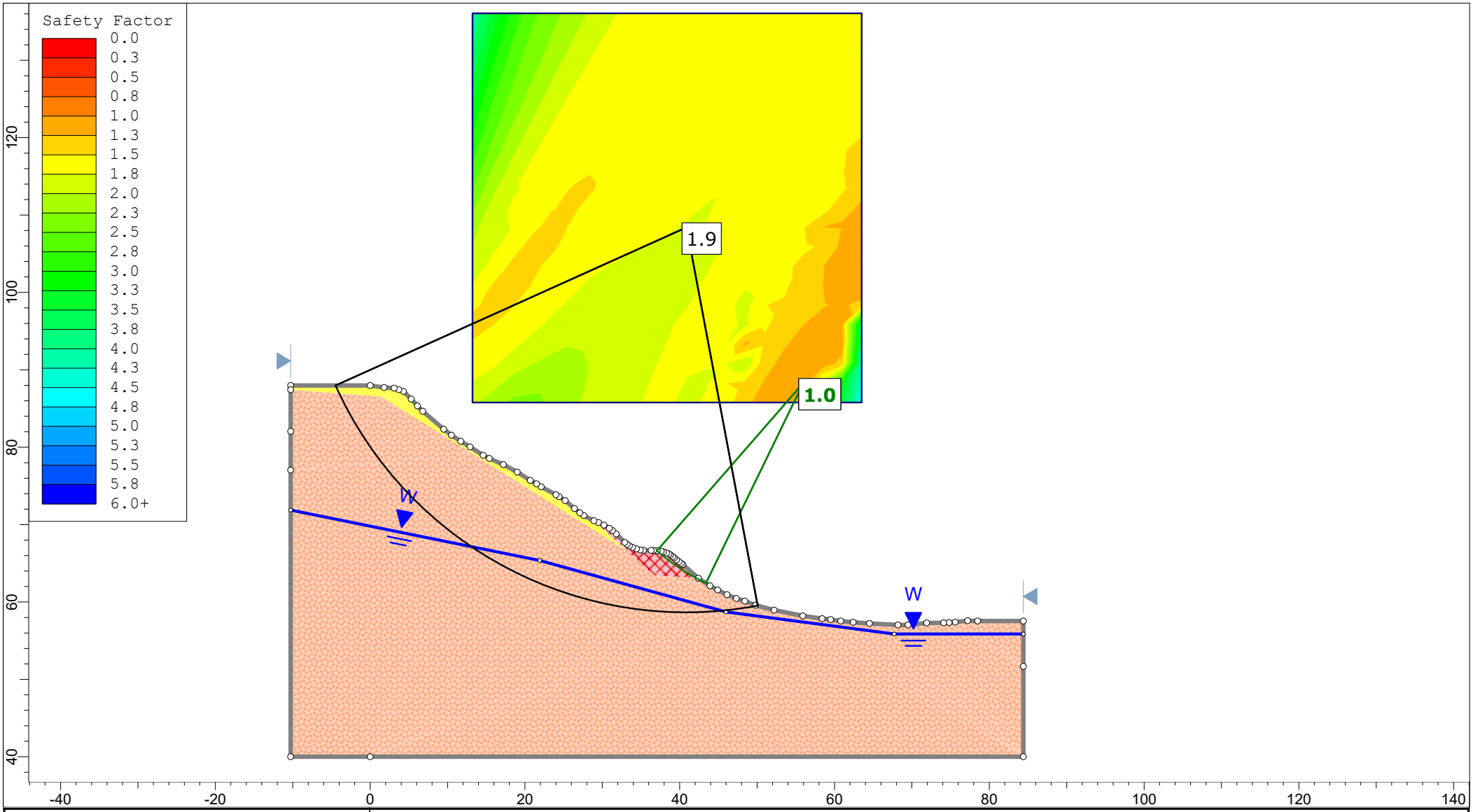
SLIDEINTERPRET 9.028

Project	158 Turitea Road, Palmerston North		
Group	CSA	Scenario	Static
Drawn By	TGo	Company	RDCL
Date	25/01/2024, 1:39:16 pm	File Name	230999_158 Turitea Road, Palmerston North_Te Pirangi Developments Ltd_02.slmd - Group 1, Static



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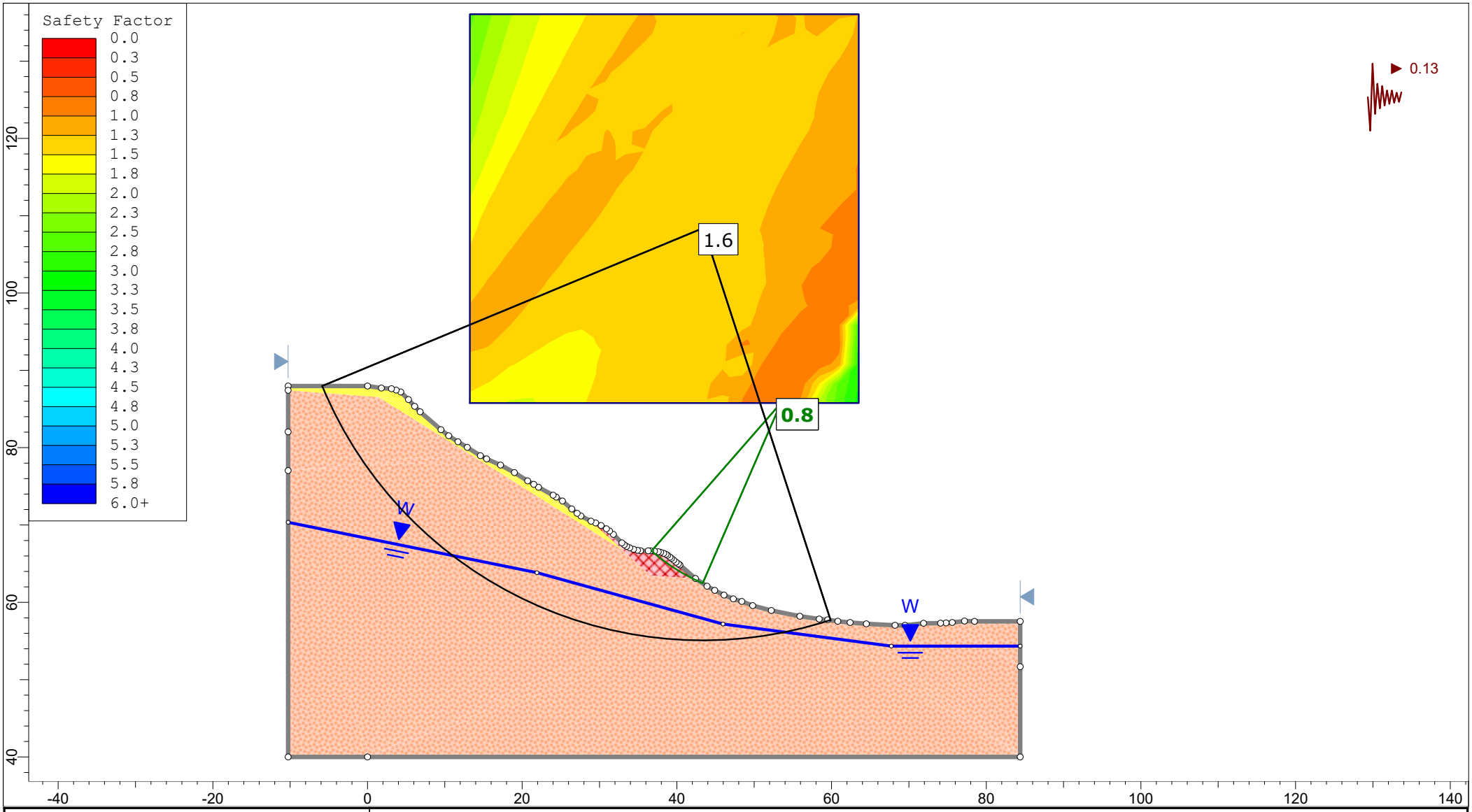
SLIDEINTERPRET 9.028

Project	158 Turitea Road, Palmerston North		
Group	CSA	*Scenario*	EWT
Drawn By	TGo	*Company*	RDCL
Date	25/01/2024, 1:39:16 pm	*File Name*	230999_158 Turitea Road, Palmerston North_Te Pirangi Developments Ltd_02.slmd - Group 1, EWT



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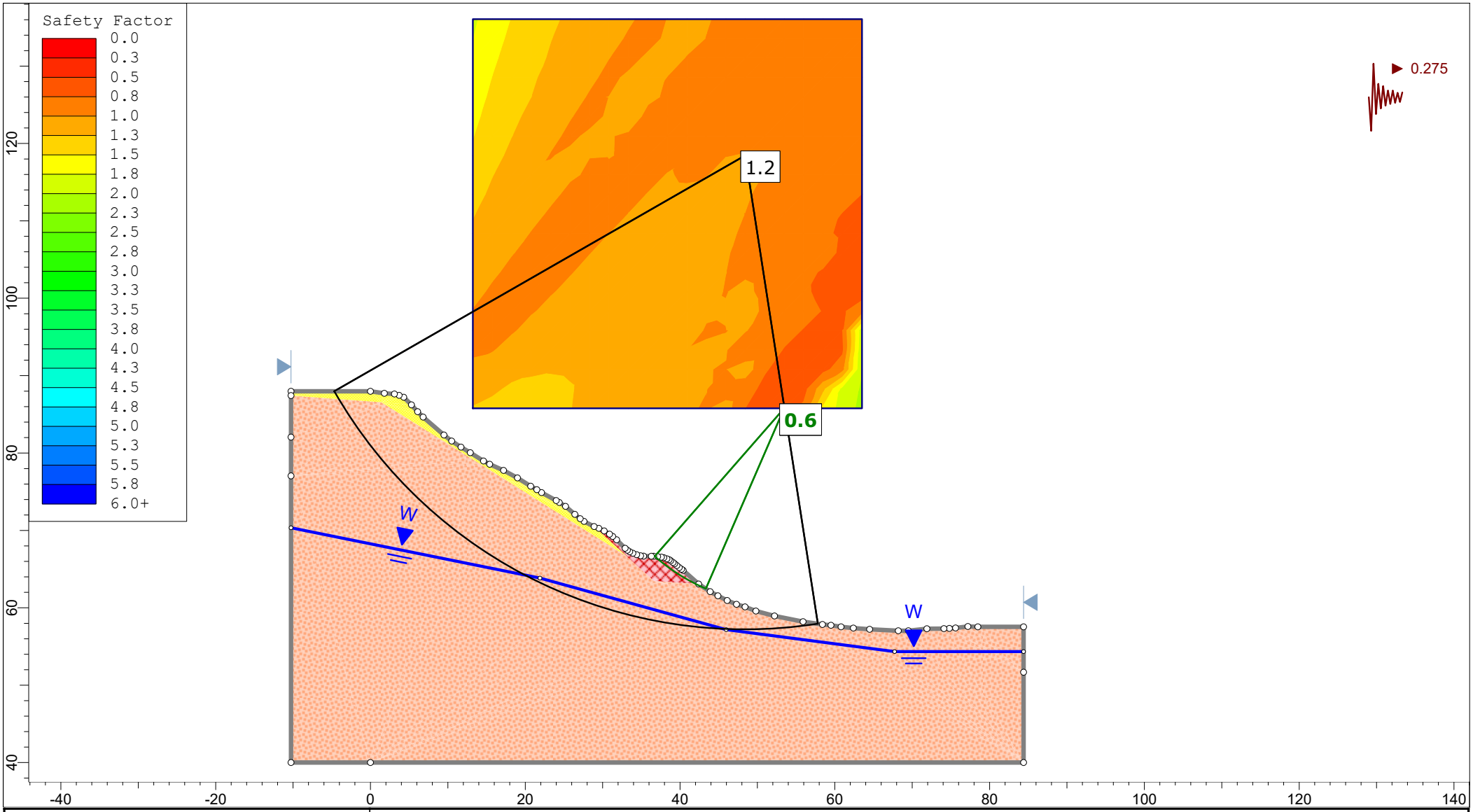
SLIDEINTERPRET 9.028

Project	158 Turitea Road, Palmerston North		
Group	CSA	*Scenario*	SLS
Drawn By	TGo	*Company*	RDCL
Date	25/01/2024, 1:39:16 pm	*File Name*	230999_158 Turitea Road, Palmerston North_Te Pirangi Developments Ltd_02.slmd - Group 1, SLS



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SLIDEINTERPRET 9.028

Project	158 Turitea Road, Palmerston North		
Group	CSA	*Scenario*	ULS
Drawn By	TGo	*Company*	RDCL
Date	25/01/2024, 1:39:16 pm	*File Name*	230999_158 Turitea Road, Palmerston North_Te Pirangi Developments Ltd_02.slmd - Group 1, ULS

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled*. No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed*. The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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e-mail: info@geoprofessional.org www.geoprofessional.org