# Report on Geotechnical Assessment

## 8 Forest Road, Warriewood

81022041

Prepared for
EQ Constructions

17 February 2022

Cardno

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| 1 | 12/11/2021 | First Issue | RH | GA |
| 2 | 22/12/2021 | Revised pile parameters following CPT testing | RH | GA |
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# 1 Introduction

## 1.1 Overview

This report presents the results of geotechnical investigation undertaken by Cardno (NSW/ACT) Pty Ltd (Cardno) on a proposed rural/residential development, 8 Forest Road, Warriewood. The work was commissioned by Mr David Zhao, via acceptance of Cardno fee proposal reference 48980522-0059 dated 22/10/2021. The following documents were provided to Cardno to assist in the geotechnical investigation and preparation of this geotechnical report:

- Geotechnical Risk Assessment report undertaken by JK Geotechnics Pty Ltd (Ref: 33371BMrpt1, Dated: 07/10/2020);
- Water Cycle Management Report undertaken by Martens Consulting Engineers (Ref: P1504988JR03V04, Revision No: 4, Dated: 24 February 2017)
- Preliminary Groundwater Level Assessment undertaken by Martens Consulting Engineers (Ref: P 1504988JC07V04, Revision No: 4, Dated: 25 November 2020)
- Pittwater Council's Geotechnical Risk Management Policy (Council Policy – No 178, Adopted 20/07/2009, Amended 04/11/2013);
- Development plans (DP) prepared by Architecture Design Studio Pty Ltd (ADS) titled "Residential Development – 8 Forest Road Warriewood" (Project No: Pn_0800, Rev 03, Dated: 11/02/2022); and
- Basement layout plans titled "A0999.1 – 03 – Basement 1 – East GA Plan.pdf" (Drawing Title: GA Plans Basement 1 – East, Project No: Pn_0800, Drawing No: A0999.1, Revision: 03, Dated: 13/10/2021).

## 1.2 Proposed Development

Based on the development plans (DP) prepared by ADS (Ref No. Pn_0800, dated February, 2022) and provided by the client, it is understood that the proposed development comprises the following:

- Construction of 66 residential apartments within four separate three storey structures with a joint underground basement.
- Construction of 14 town houses within the eastern portion of the site.
- Creation of two on-site detention basins along the northern perimeter of the site.
- Construction of internal roads and associated infrastructure.

## 1.3 Objectives

The purpose of this investigation was to obtain geotechnical information on subsurface conditions as a basis for the following comments and recommendations:

- Pavement design for the proposed internal roads.
- Comment on founding conditions, footing design recommendations, water table, pile and retaining design parameters.
- Earthquake classification.
- Recommendations for earthworks procedures and guidelines.
- A general description of the surface and subsurface conditions
- Retaining wall design parameters.

# 2 Previous Investigations

Previous geotechnical investigations at 8 Forest Road, Warriewood have been undertaken by Cardno for the purpose of providing comments and recommendations for preliminary contamination assessment (phase 1) and geotechnical assessment for the proposed residential development. Details from the previous geotechnical investigation are reported under “Proposed Residential Development” (File ref: CGS2698-005.0, Dated: 12/10/2015, version 0) [1].

The previous investigation undertaken by Cardno within the proposed development included the exploration of sub-surface conditions by test pitting (TP), test bores (TB) and dynamic cone penetrometer (DCP) testing, and gathering samples for laboratory assessment for the preliminary contamination assessment.

Results and recommendations of the previous geotechnical investigations have been utilised (where appropriate) to provide comment and recommendations throughout this report.

## 2.1 Published Data

### 2.1.1 Geological maps

Reference to 1:100,000 Sydney Geology map [2] indicates that the site is situated on Wianamatta Group Hawkesbury Sandstone (rh) known to typically comprise of medium to coarse grained quartz sandstone, very minor shale and laminate lenses.

### 2.1.2 Acid Sulphate Soils

A review of the Department of Land and Water Conservation, Acid Sulfate Soils Rick Map (Hornsby/Mona Vale) indicates that there are no known occurrences of Acid Sulfate Soils within the proposed development.

## 2.2 Subsurface Conditions

The previous investigation [1] comprised a site walkover by an experienced geotechnical engineer from Cardno as well as intrusive testing and sampling. Intrusive testing comprised excavation of twelve test pits across the site, four test bores along Narrabeen Creek and three deeper boreholes at the location of the proposed residential apartments. The location of test pits and boreholes are shown on Figure GE-2, attached in Appendix A

The subsurface conditions encountered are summarised as follows:

- FILL: Generally comprising SAND, Silty/Gravelly SAND with foreign matter, was encountered in a number of test pits in proximity to existing fill stockpiles. Fill materials were generally encountered within the top 0.5m of the subsurface profile.
- TOPSOIL: Generally comprising brown fine to medium grained Silty SANDwith organics was encountered to depths of generally 0.3m; overlying
- COLLUVIAL: Generally comprising SANDs & Clayey SANDs varying in consistency from loose to dense, encountered below all topsoil & filling; overlying
- RESIDUAL: Residual soils generally comprising medium dense to dense Clayey SANDs & firm to very stiff Sandy CLAYs were encountered below all topsoil, filling & colluvial materials, generally to the depth of the investigation.
- BEDROCK: Weathered SANDSTONE bedrock was only encountered in test pits excavated at the southern boundary of the site. Bedrock was not encountered within BH001-BH003, advanced to depths ranging from 12.0m to 16.0m below ground level (BGL). The boreholes were drilled at the approximate location of the proposed residential apartments.

Test pit and borehole logs attached in Appendix B should be referenced for full details of the subsurface profile encountered.

## 2.3 Laboratory Testing

Geotechnical laboratory testing on selected samples recovered during the fieldwork comprised four shrink/swell tests and three four-day soaked California Bearing Ratio (CBR) tests. The results of the testing undertaken are outlined in Table 2-1 and Table 2-2 below.

Table 2-1 Shrink/swell testing results

| Hole ID | Depth (m) | Sample Type | Soil Type | Swelling strain ($E_{sw}$) (%) | Shrinkage strain ($E_{sh}$) (%) | Shrink/Swell index ($I_{ss}$) (%) |
|---|---|---|---|---|---|---|
| TP008 | 1.5 – 1.6 | U50 | Clayey SAND | 0.0 | 0.1 | 0.1 |
| TP010 | 0.9 – 1.15 | U50 | Clayey SAND | 1.0 | 0.0 | 0.6 |
| TP010 | 0.8 – 1.2 | B | Clayey SAND | 0.0 | 0.5 | 0.3 |
| TP012 | 1.1 – 1.3 | U50 | Clayey SAND | 0.0 | 0.7 | 0.4 |

Notes:
U50: Testing undertaken on thin wall tube samples
B: Testing undertaken on remoulded disturbed samples

Table 2-2 Laboratory CBR test results

| Hole ID | Depth (m) | Soil Type | W (%) | SOMC (%) | SMDD (t/m$^3$) | Swell (%) | CBR (%) |
|---|---|---|---|---|---|---|---|
| TP004 | 0.6 – 0.9 | SAND | 9.6 | 12.5 | 1.82 | 0.5 | 45 |
| TP010 | 0.8 - 1.2 | Clayey SAND | 11.7 | 12.0 | 1.98 | -0.5 | 70 |
| TP012 | 0.3 – 0.4 | Sandy CLAY | 10.1 | 12.0 | 1.86 | -0.5 | 45 |

Notes to table:
W: Field moisture content
SMDD: Standard Maximum Dry Density

## 2.4 Groundwater Conditions

Previous investigations reported under covers “Preliminary Groundwater Level Assessment” (Ref: P 1504988JC07V04, Revision No: 4, Dated: 25 November 2020) [3] and “Water Cycle Management Report” (Ref: P1504988JR03V04, Revision No: 4, Dated: 24 February 2017) [4] were undertaken by Marten’s Consulting Engineers for the analysis of groundwater conditions, stormwater quality assessments, and ecological monitoring and assessment.

The investigation comprised installation of groundwater wells MW102 and MW103 to depths of 8.5 m on 7 February 2016, with further analysis undertaken on 10 February 2016 to assess groundwater levels. As stated within the Preliminary Groundwater Level Assessment report [3], observations from drilling, groundwater level dip results and general engineering judgements concluded that groundwater levels in the northern portion of the site ranged between 17.25 mAHD and 18.00 mAHD in monitoring wells MW102 and MW103 respectively.

It should be noted that groundwater levels were measured following an extended period of dry weather and are likely to fluctuate with variations in climatic and site conditions.

# 3 Additional Investigation

## 3.1 Site Investigation

Due to the minimal subsurface strength data from the previous investigations below 5m BGL, Cardno undertook an additional investigation to fill in these data gaps. Cardno's site investigation was undertaken on 3 December 2021 and comprised the following:

- A site walkover and visual inspection by a geotechnical engineer from Cardno including site mapping and logging of significant site features.
- Cone Penetrometer Testing (CPT) at six locations within the development envelope to depths of 11.14-15.38 m BGL

A geotechnical engineer from Cardno supervised all fieldwork activities. Approximate CPT locations are shown in drawing Figure 1, attached in Appendix A. The results of the CPT testing are detailed in the report sheets attached in Appendix D.

## 3.2 Investigation Findings

Following the site investigation, the data collected from the CPTs was analysed by an experienced geotechnical engineer with the subsequent findings noted.

- The residual sandy clay appeared to be generally very stiff in all CPT locations (not firm to very stiff as previously reported).
- The groundwater level was approximately encountered at 5m BGL in all CPT locations. However it should still be noted that these levels have the potential to fluctuate with variations in climatic and site conditions.

# 4 Earthworks

Based on the supplied DP, it is expected that excavations in the order of 2-3 m BGL will be required to facilitate basement level construction.

Boreholes drilled within the footprint of the proposed residential apartment structures is expected to comprise topsoil, overlying loose to medium dense sand / clayey sand (0.3 to 4.8m BGL), overlying very stiff residual sandy clays (from 4.8m) to the depth of investigation (12.0m to 16.0m BGL). As such, excavations should be readily undertaken using conventional earthmoving equipment such as a backhoe or medium sized (10-20 tonne) excavator.

## 4.1 Excavations and Stability

Design and construction of a shoring system would be required to support the basement excavations where grading and battering is not possible due to the vicinity to the site boundaries. Design recommendations for the shoring system are provided in Section 7.2. The below recommendations should be adopted for all the remaining excavations when not subject to structural/construction loading.

All temporary excavation faces above groundwater levels within the silty/sandy clayey soils must be battered back at 2H:1V or flatter. Long term batters within the clayey soils must be battered back at 3H:1V or flatter and protected by vegetation. Batters steeper than 2H:1V should be inspected by a geotechnical engineer and preferably should be supported by engineer designed retaining structure. Design parameters for the purpose of retaining structures are presented in Section 7 of this report.

Battering of the excavated faces should consider the vicinity of neighbouring structures and potential surface deflections that could result in damage. It should be noted that the above recommendations are generally applicable to short term stability and do not account for slopes proximal to neighbouring structures and their surcharge. As such, long term stability of unretained excavated faces during the constructions should be geotechnically assessed and designed. It is recommended to prepare a safety in design register for all the excavation works retained or not-retained with the document updated throughout the constructions works by the contractor.

It is recommended to prepare an earthworks management plan to consider the stability of the batter and excavated faces during the piling and temporary works to minimise the risk of slope/excavation failures resulting from construction equipment loads or other adverse conditions.

## 4.2 Suitability of Cut Materials for Reuse or Disposal

### 4.2.1 Requirements for Waste Classification

Classification of the site in-situ material in accordance with the EPA guidelines "*Waste Classification Guidelines, Part 1: Classifying Waste* [5]"will be required prior to the removal off-site.

### 4.2.2 Requirements for Reuse in Reconstruction

Excavated residual clay material is expected to be suitable for use as general fill, however should not be used as structural fill under footings or adjacent retaining walls. Natural materials with high silt, organic content and/or building rubble are not recommended for use as general fill.

## 4.3 Filling

Fill to be subject to structural loading must be placed and compacted in accordance with AS 3798-2007 *Guidelines on Excavation for Commercial and Residential Structures* [6]. The following procedure should be adopted for construction of filling:

- Filling should be placed on stripped surfaces which are free of uncontrolled fill, topsoil or other deleterious material, and have been inspected by a suitably qualified geotechnical consultant.
- The fill material must be free of vegetation such as tree stumps, roots, root fibres or other organic matter.
- Fill should not comprise material with particle sizes of greater than 100 mm or 2/3 of the compacted layer thickness.

- Where fill is to be placed on slopes steeper than 8H:1V, benching will be required. This should comprise horizontal benches with adequate width (minimum 1.0m) to accommodate the nominated compaction equipment.
- Placement of fill in uniform horizontal layers with compaction of each layer to a minimum dry density ratio of 95% Standard Compaction (Australian Standard AS 1289 Clause 5.1.1) at moisture contents of in the order of 85 - 115% of SOMC or ±2% but generally as close to SOMC as practical.
- Where vibratory equipment is proposed, the potential for vibration transfer to neighbouring structures and potential damage should be considered by the contractor.

## 4.4 Dewatering

As stated within the Preliminary Groundwater Level Assessment report [3], observations from drilling, groundwater level dip results, and general engineering judgements concluded that groundwater levels north of the site ranged between 17.25 m AHD and 18.00 m AHD in monitoring wells MW102 and MW103 respectively. Thus, groundwater levels are not likely to be encountered at the proposed basement levels of 21.1 m AHD and 22.1 m AHD. However, groundwater levels encountered during the site investigations were measured following a long dry period and as such are expected to rise following heavy rainfall periods.

# 5 Pavement Thickness Design

Pavement thickness design has been undertaken based on the findings of the previous geotechnical investigation and Pittwater Council requirements. The following guidelines have been adopted for the design of the internal roads:

- Pavement thicknesses for flexible pavements in accordance with mechanistic procedure presented in Austroads Guide to Pavement Technology, Part 2: Pavement Structural Design [7]; and
- Pittwater Council Warriewood Valley Roads Master Plan (PCRMP) [8].

## 5.1 Design Subgrade

Based on subsurface conditions encountered during the previous investigation, subgrade conditions across the site and current conditions (prior to earthworks) are likely to comprise sand, sandy clay and clayey sand.

The results of the laboratory CBR testing indicate soaked CBR values in the order of 45.0% to 70.0% for the residual sands, clayey sands and sandy clays present at subgrade level (prior to any regrading activities) when compacted to 100% relative density using standard compactive effort.

With reference to above, the following design CBR's have been adopted for design:

- CBR = 3%: Natural sandy clays; and
- CBR = 10%: Natural sands and clayey sands.

Due to the limited amount of testing undertaken, it is recommended that additional CBR testing is undertaken during construction to confirm subgrade conditions.

## 5.2 Design Traffic

Design traffic has been assumed in accordance with Pittwater Council Warriewood Valley Roads Master Plan (PCRMP) [8] based on road designations of Local Road with Design Traffic of 6 x $10^5$ ESA (Design Equivalent Standard Axles).

Where traffic data varies from the information provided in this report, review of pavement design may be required.

## 5.3 Pavement Composition

Pavement designs have been conducted in accordance with Austroads AGPT02-12 *Guide to Pavement Technology Part 2: Pavement Structural Design* [9].

It should be noted that the layer thicknesses detailed are minimum thicknesses regardless of construction tolerances.

Pavement compositions for the internal roads are detailed below in Table 5-1.

Table 5-1 Pavement thickness design for internal roads

| Road Category | Thickness | | Recommended Material Type (1) |
|---|---|---|---|
| Wearing Surface (mm) | 40mm | 40mm | AC10 (C320 binder or similar) |
| Basecourse (mm) | 150mm(2) | 150mm(2) | DGB20 |
| Subbase (mm) (1) | 290mm | 150mm | DGB20/DGS40 |
| **Total Thickness (mm)** | 480mm | 340mm | |
| Subgrade Material | CLAY | SAND | |
| Subgrade CBR | 3% | 10% | |
| Design Traffic (ESA) | | $6 \times 10^5$ | |
| Design Life | | 30 years | |

Notes to table:
(1) Refer to Section 5.4.2 for material specifications.
(2) 150mm basecourse has been selected for tie in with 190mm kerb and gutter. Minimum 140mm base material as per Figure 8.4 of Austroads [7] has been neglected for constructability purposes.

Inspection of the finished subgrade by a geotechnical engineer is required to assess subgrade conditions. Where unsuitable subgrade conditions are encountered, over-excavation and replacement may be required. Over-excavation depth and select subgrade quality would be subject to inspection by a suitably qualified geotechnical consultant.

## 5.4 Construction Notes

### 5.4.1 Subgrade Preparation

Where construction of a new pavement is proposed, subgrade preparation should be in general accordance with the relevant council construction specifications and the following procedures.

- Excavation to design subgrade level, with stockpiling of the excavated material for potential reuse as select material (if acceptable) following reconditioning and removal of oversized material. Material is to be removed offsite for disposal or recycling where not required or not acceptable as select layer.
- Excavation of unsuitable filling and elimination of abrupt changes between subgrade conditions, such from rock to soil, and from granular fill to fine grained natural soils.
- All subgrade surfaces in cut shall be ripped, loosened and compacted to a minimum depth of 150mm below the design subgrade, including up to 150mm behind the back of the kerb.
- Subgrades in rock are to be thoroughly ripped to a minimum of 300mm below the design subgrade level and to extend to the sides of the formation to provide drainage away from the pavement. Ripped material is to conform to the particle size characteristics described for fill material and is to be compacted to form the subgrade construction layer unless the ripped material is deemed unsuitable for subgrade purposes.
- Fill material to be used as subgrade shall conform to the appropriate specifications as detailed in this report and Pittwater Council Specifications.
- Static proof-rolling of the exposed subgrade using a heavy (minimum 10 tonne) roller under the direction of an experienced geotechnical consultant.
- Loose or yielding areas should be excavated and replaced with compacted select fill or suitable subgrade replacement comprising of material of similar consistency to the subgrade. This would be subject to inspection by a suitably qualified geotechnical consultant.
- Where filling or subgrade replacement is required, the materials employed should be free of organics or other deleterious material. The material should also have a maximum particle size of 100mm or one third of the layer thickness, with a soaked CBR > 10%.
- Compaction of the subgrade, filling or select should be to a minimum 100% of SMDD (or 70% Density Index for non-cohesive materials) in layers of not greater than 250mm loose thickness. Moisture contents should be within 70% to 90% of SOMC.

Following satisfactory preparation of the subgrade, the pavement should be placed in accordance with the requirements of the appropriate section of this report, depending on the proposed pavement type.

### 5.4.2 Specification and Compaction Requirements

Pavement materials and compaction requirements for the new pavement construction should conform to Pittwater Council specifications and the following requirements.

Table 5-2 Material Specification and Compaction Requirements

| Pavement Course | Material Specification | Compaction Requirements |
|---|---|---|
| **Base Course**<br>High quality crushed rock | Material complying with RMS QA Specifications 3051 Category C & D [10] with LL ≤ 23%, PL ≤ 20% | Min 98% Modified (AS 1289 5.2.1) |
| **Subbase**<br>Subbase quality crushed rock | Material complying with RMS QA Specifications 3051 Category C & D [10] with LL ≤ 23%, PL ≤ 20% | Min 95% Modified (AS 1289 5.2.1) |
| **Select**<br>Crushed rock or gravel | CBR ≥ 15% | Min 100% Standard (AS 1289 5.1.1) |
| **Subgrade**<br>or replacement | Minimum CBR 3% or 10% as specified in pavement design. | Min 100% Standard (AS 1289 5.1.1) |

Minimum testing on all potential imported pavement materials should be to RMS QA Specification 3051 [10] including a four-day soaked CBR, Atterberg Limits, Particle Size Distribution analysis and Wet/Dry strength determination. Pre-treatment of material prior to testing would be advisable for materials subject to breakdown.

### 5.4.3 Wearing Course

Wearing courses should be in accordance with Pittwater Council specifications with consideration to RMS QA Specifications R116 [11] and Austroads AGPT04B-07 Guide to Pavement Technology, Part 4B: Asphalt [12].

The design and construction of wearing courses should be in in consultation with the preferred supplier taking into account traffic volume and type. All pavement surfaces should be primed or primer sealed prior to the application of bituminous spayed seal.

### 5.4.4 Drainage

The moisture regime associated with a pavement has a major influence on the performance considering the stiffness/strength of the pavement materials is dependent on the moisture content of the material used. Accordingly, to protect the pavement materials from wetting up and softening, particular care would be required to provide a waterproof seal for the pavement materials, together with adequate surface and sub-surface drainage of the pavement and adjacent areas.

Owing to the potential for cracking along the interface where new pavements are joined to existing pavements, it is suggested that an intra-pavement drain should be provided at the interface between any section of new and existing pavements.

Following investigation and observation of the present geotechnical conditions, it is recommended that subsoil drainage be installed at subgrade level on both sides of the road. Detailing of subsoil drainage should be in accordance with Austroads 2017 [7] taking into consideration the presence of moderately to highly expansive soils. The subgrade should be constructed with sufficient cross fall (in general 3%) to assist in reducing retention time for moisture entering the pavement. The subsoil drains should be located below or behind the kerb to intercept any moisture ingress from outside and within the roadway. The drains will require flush-out points and regular maintenance to ensure their correct operation, and detailing should take into account the presence of moderately expansive soils where encountered. Provision of adequate cross fall to direct runoff from the pavement to drainage lines should be achieved as a result of reconstruction and possibly rehabilitation.

The pavement thickness designs presented above assume drained pavement conditions. The selection, construction and maintenance of appropriate drainage mechanisms would be required for adequate performance. The selection of appropriate construction materials that are relatively insensitive to moisture change is also essential in area subject to periodic inundation, even if for a relatively short period of time.

### 5.4.5 Pavement Compaction

Difficulty obtaining specified compaction requirements can be expected in areas of low strength subgrade which are evident in areas where the road is to be constructed in fill and firm clays near surface are expected and subgrade replacement is not undertaken. Vibratory compaction can lead to potential problems with the development of excess pore pressures and permanent deformation of the subgrade. Large capacity oscillating rollers are better suited to deep lift compaction. Static or low amplitude rolling may be appropriate in conjunction with thinner layers in poor subgrade areas.

It is essential to ensure that compaction is achieved though the full thickness of any pavement layers. A rough interface and bond is required between all pavement layers, generally achieved through scarification of the first layer prior to placement and compaction of the second and subsequent pavement layers.

### 5.4.6 Pavement Interface and Tie-in

Where new pavement construction abuts an existing pavement, care should be exercised to bench into the base course layer for a minimum of 0.5m for the entire pavement width.

Adequate compaction of the subgrade and pavements in this area is essential to maximise performance of the pavement. It is noted that where variable pavements are abutted, the potential for localised failure is generally greater. Consideration should be given to sealing any cracks that may develop between existing and new pavements. The use of a strain alleviating membranes at the interface may also be appropriate. It may also be prudent to install intra-pavement drainage at subgrade level at interfaces of variable existing and new pavements.

### 5.4.7 Inspections

The subgrade will require inspection by an experienced geotechnical consultant after boxing out or filling to design subgrade level. The purpose of inspections is to confirm design parameters, assess the suitability of the subgrade to support the pavement, and delineate areas which may require subgrade replacement or remedial treatment prior to construction.

### 5.4.8 References

All works and materials used in construction should be designed and constructed in accordance with Pittwater Council Specifications or as specified in this report. Where discrepancies may occur, clarification should be sought from Council.

Earthworks and testing should generally be undertaken in accordance with AS 3798-2007 *Guidelines on Earthworks for Commercial and Residential Developments* [6] where not otherwise specified.

# 6 Foundation Conditions and Footing Design Recommendations

General design parameters and recommendations are presented in the following sections and should be used as guidance for design. The detailed design of the foundations should consider the structural loads against serviceability and ultimate limit state criteria. It is recommended that analysis be undertaken during structural design to determine suitable foundation selection and expected settlements.

## 6.1 Foundation Design

### 6.1.1 Pile Design Criteria

Design of the proposed structure foundations should be undertaken in accordance with the requirements of the following:

- AS 2159 (2009) Piling – Design & Instillation [13];
- Other relevant Australian and international standards; and
- Engineering principals.

For pile foundations, AS 2159-2009 [13] requires that the ultimate design geotechnical strength ($R_{d,g}$) is not less than the design action effect ($E_d$). The design geotechnical strength is calculated as the ultimate geotechnical strength ($R_{d,ug}$) multiplied by a geotechnical strength reduction factor ($\phi_g$).

The value of the geotechnical strength reduction factor is influenced by the following factors:

- ϕgb – Basic geotechnical strength reduction factor, which is influenced by an assessment of the various risk factors relating to the site, design methodology and the method of pile instillation.
- ϕtf – Intrinsic testing factor based on the type of pile testing to be undertaken; and
- K – Testing benefit factor dependant on the percentage of piles to be tested.

The assessment of individual risk ratings for risk factors as set out in Table 4.3.2 (A) of AS 2159-2009 [13] will need to be undertaken by the designer of the foundations. However, to assist in the design of foundations, an assessment of the average risk rating has been undertaken based on the following factors and assumptions:

- Level and quality of the geotechnical investigation that has been undertaken to date which includes in-situ and laboratory testing on the subsurface profile;
- A low-redundancy foundation system (i.e. isolated piles set out at large spacing's);
- No pile strength testing will be undertaken;
- Similar experience with the design of foundations into residual and colluvial soils; and
- A competent and experienced piling contractor to install the piles.

Based on the assessment of the above factors and assumptions, an Average Risk Rating (ARR) for the design of the foundations into the residual soil of 3.83 could be adopted.

Based on Table 4.3.2 (C) of AS 2159-2009 [13], an ARR of 3.83 is defined as moderate to high risk. The basic geotechnical strength reduction factor ($\phi_g$) for single isolated piles founded into the residual soil profile within the site is assessed to be 0.45.

An increase in the geotechnical strength reduction factor could be adopted by adopting the following procedures:

- Inspection of the foundation conditions by a geotechnical engineer
- Pile testing regime depending on the type and extent of the testing. Dynamic testing of bored piles are not typically undertaken due the magnitude of column loads. Therefore, an increase on the basic geotechnical strength reduction factor by dynamic testing is not recommended. Osterberg, static or statnamic tests could be utilised to increase the geotechnical reduction factor.
- Adoption of a high redundancy system such as pile rafts or large pile groups under a common pile cap of 4 or more piles.

Consideration should be given towards Section 4.4.3 of AS2159-2009 [13] when considering the design of pile groups and that the ultimate design geotechnical strength ($R_{d,ug}$) of a group of piles in compression or uplift should take into account the effects of pile group action. It is recommended that the ultimate geotechnical strength shall be taken as the lesser of:

(a) The sum of the ultimate geotechnical strength capacities of the individual piles in the group; and

(b) The design ultimate geotechnical strength of an equivalent rigid block containing the piles and the soil between them.

Spacing of piles within a pile group should generally be not be less than 2.5 times the pile diameters unless a comprehensive assessment of group interaction is undertaken and indicated that this does not adversely affect the overall pile group.

Group interaction of settlement of pile groups should also be considered during the detail design phase and consideration of settlement should take into account the use of a flexible or rigid pile cap.

For all piles where the basic geotechnical strength reduction factor is greater than 0.4, AS2159-2009 [13] requires the integrity of the pile shaft to be assessed by testing and inspection.

Ultimate and serviceability limit state of the piles or pile groups should be undertaken during the detailed design phase of the proposed development.

### 6.1.2 Foundation Parameters

An interpretation of the subsurface conditions has been undertaken and presented in Section 2.2.

Considering the site subsurface conditions, uncased bored piles are not considered suitable due to the presence of shallow groundwater across the site and colluvial sands. The following pile types could be considered for the foundations:

- Bored and cased piles and tremie concrete placement.
- Continuous Flight Auger (CFA) or concrete injected.
- Displacement (driven) piles. Consideration must be given to vibration and noise transfer to the neighbouring properties.

Screw piles could also be considered for the design, however, these pile types should be designed and certified by a specialise contractor. Serviceability life of these piles would also need to be considered and provided by the pile manufacturer for the life of the structure.

Design values presented in Table 6-1 assumes that:

- Pile foundations comprise centrally loaded driven or CFA piles suitably embedded at depths beyond the colluvial materials and into residual material of similar consistency and compositions.
- Piles are constructed using appropriate construction practice.
- General design parameters are presented in the following sections and should be used as guidance for the design.
- Serviceability limit state design is undertaken for the foundation to consider the settlement of the various foundation types and structural tolerances.
- Design is undertaken using appropriate design methodology and utilising the principal parameters in Table 6-1.
- The ultimate geotechnical strength values $R_{ug}$ are for guidance only.

Isolated driven piles required to support the structure could be designed using the parameters presented in Table 6-1 below. Reference to AS 2159-2009 *Piling Design and Installation* [13] a geotechnical reduction factor ($\phi_g$) of 0.45 is recommended to calculate the ultimate geotechnical design strength $R_g^*$ based on the above equations and parameters presented. The reduction factor has been estimated utilising the procedure outlined in AS 2159-2009 Table 4.3.2 (A) with Individual Risk Rating (IRR) nominated based on the site conditions, design procedure and assumed construction control monitoring procedures outlined in Section 6.1.1.

Design values presented in Table 6-1 assumes that piles are installed using appropriate construction practice.

Table 6-1 Geotechnical Design Parameters for Proposed Residential Apartments Pile Footing

| Parameter | COLLUVIAL: Loose to medium dense SAND/ Clayey SAND | RESIDUAL: Firm to very stiff Sandy CLAY |
|---|---|---|
| Ultimate End Bearing (kPa) | piles to not be embedded in this material | 1200 |
| Ultimate Shaft Adhesion (Compression) within the layer (kPa) | 20 | 60 |

Settlement estimation should be undertaken and compared against serviceability requirements as part of the detailed geotechnical design of the piles.

Installation of piles shall be undertaken in the presence of an experienced geotechnical engineer to confirm that correct construction practice is implemented.

Where driven piles are utilised, consideration must be given to vibration transfer to the nearby structures and potential vibration induced damage.

The above preliminary design parameters are subject to inspection of the foundation conditions by experienced geotechnical engineer to confirm the founding conditions. All foundation excavations should be kept free of fall-ins and water ponding.

# 7 Retaining Structures

## 7.1 Design Criteria

This section outlines design criteria and parameters for the purpose of retaining structures design.

The following design criteria should be adopted for the design of the retaining structures:

- AS 4678 (2002) – Earth Retaining Structures [13];
- AS 3798 (2007) – Guideline on Earthworks for Commercial and Residential Developments [6]; and
- An accepted industry practice for global stability factors of safety (FOS) for slopes of 1.5 for long-term conditions and 1.2 for short term construction conditions.

For a simplified or preliminary design, retaining structures such as cantilever or gravity walls may adopt a triangular earth-pressure distribution. During detailed design, the designer should select earth pressure coefficients based on the specific geotechnical and geometrical situation under consideration. The retaining walls design should comprise assessment of foundation bearing capacity, sliding, overturning and global stability checks.

A geotechnical reduction factor is recommended to be applied to the estimated ultimate geotechnical strength (not parameters) for ultimate limit state design calculations.

## 7.2 Retaining Wall Design Parameters

The subsurface profile to be retained by the shoring structure is generally expected to comprise:

- Colluvial sands at depths from surface up to 2.5 m BGL overlying
- Firm to very stiff residual clays at depths from approximately 2.5 m to the proposed depth of the excavation (and to the depth of this investigation).

It should be noted that the above conditions are inferred from the discrete borehole locations and variation of the subsurface conditions should be considered in the design.

It's recommended to calculate the lateral earth coefficient values based on the wall geometry, type and backfill slopes using the values provided in the following table. The earth coefficients presented in the following table have been calculated for level backfill/ground surface and vertical wall arrangements. The designer should reference to the requirements of AS 4678 (2002) – Earth Retaining Structures [13] for the selection of appropriate groundwater levels for the design purpose, however, groundwater was encountered at 18.0 m AHD (on average) at the time of investigation and during the short monitoring period (as indicated in this report).

Recommended design parameters for retaining walls are presented below in Table 7-1.

Table 7-1 Retaining Wall Design Parameters

| Description | Bulk Density (kN/m$^3$) | Effective Friction Angle ϕ' (deg) | Cohesion C' (kPa) | Undrained Cohesion Cu (kPa) | Effective Elastic Modulus E' (MPa) | Active Earth Pressure Coefficient $K_A$ | Passive Earth Pressure Coefficient $K_P$ |
|---|---|---|---|---|---|---|---|
| Medium dense colluvial sands up to 2.2m BGL | 18 | 32 | 0 | 0 | 30 | 0.31 | 3.25 |
| Firm to very stiff residual clays to 4.5m BGL | 19 | 26 | 5 | 50 | 15 | 0.39 | 2.56 |

Notes to table:
(1) Coefficients stated above are for use with effective stress calculation.

### 7.3 Construction Recommendations

- Retaining wall backfill should comprise granular, free-draining material with appropriate separation geofabric placed between the wall and granular backfill;
- All foundations should be founded on similar strata to limit the effects of differential settlement;
- Subsurface drainage lines should be placed behind the permanent and temporary (depending on the type) retaining wall, to direct seepage to appropriate points of discharge. Subsurface lines should be installed with consideration of maintenance and flush-out points; and
- Retaining wall foundations as well as anchor bond material should be inspected by experienced geotechnical engineer.
- Vibration induced damage to the neighbouring structures should be considered where driven sheet piles are considered.

# 8 Site Sub-Soil Classification for Earthquakes

For the purposes of earthquake design, the site has been given a site sub-soil classification of **Class $C_e$ – Shallow Soil Site** in accordance with AS1170.4 – 2007 [14]. The hazard factor (Z) for Sydney, NSW is 0.08 as seen also in AS1170.4 – 2007 [14].

# 9 Limitations

Cardno (NSW/ACT) Pty Ltd have performed investigation and consulting services for this project in general accordance with current professional and industry standards. The extent of testing was limited to discrete test locations and variations in ground conditions can occur between test locations that cannot be inferred or predicted.

A geotechnical consultant or qualified engineer shall provide inspections during construction to confirm assumed conditions in this assessment. If subsurface conditions encountered during construction differ from those given in this report, further advice shall be sought without delay.

Cardno (NSW/ACT) Pty Ltd, or any other reputable consultant, cannot provide unqualified warranties nor does it assume any liability for the site conditions not observed or accessible during the investigations. Site conditions may also change subsequent to the investigations and assessment due to ongoing use.

This report and associated documentation was undertaken for the specific purpose described in the report and shall not be relied on for other purposes. This report was prepared solely for the use by EQ Constructions and any reliance assumed by other parties on this report shall be at such parties own risk.

# 10 References

[1] Cardno (NSW/ACT) Pty Ltd, “Preliminary Contamination and Geotechnical Assessment,” October 2015.

[2] Geological Survey of NSW, “Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1),” Department of Mineral Resources, 1983.

[3] Martens Consulting Engineers, “Preliminary Groundwater Level Assessment,” November 2020.

[4] Martens Consulting Engineers, “Water Cycle Management Report,” February 2017.

[5] NSW Department of Environment and Climate Change (DECC), “Waste Classification Guidelines, Part 1 - Classifying Waste,” Department of Environment and Climate Change NSW, December 2009.

[6] Australian Standard AS3798-2007, “Guidelines on Earthworks for Commercial and Residential Structures,” Standards Australia, 2007.

[7] Austroads AGPT02-17, “Guide to Pavement Technology Part 2: Pavement Structural Design,” Austroads Ltd, 2017.

[8] Pittwater Council, “Warriewood Valley Roads Master Plan,” Pittwater Council, 2013.

[9] Austroads AGPT02-12, “Guide to Pavement Technology Part 2: Pavement Structural Design,” Austroads Ltd, 2012.

[10] RMS QA Specification 3051 (Ed 6 Rev 2), “Granular Base and Subbase Materials for Surfaced Road Pavements,” Roads and Maritime Services, April 2011.

[11] RMS QA Specification R116 (Ed 8 Rev 2), “Heavy Duty Dense Graded Asphalt,” Roads and Maritime Services, January 2012.

[12] Austroads AGPT04B-07, Guide to Pavement Technology Part 4B: Asphalt, Austroads Ltd, May 2007.

[13] Australian Standard AS2159-2009, “Piling - Design & Installation,” Standards Australia, 2009.

[14] Australian Standard AS1170.4, “Earthquake Actions in Australia,” Standards Australia, 2007.

# APPENDIX A

## FIGURES

NOTES:
Image underlay adapted from client supplied plans.

LEGEND:

= CPTX Approximate CPT locations and numbers.

NORTH

RY LINE

FFL 28.40 FFL 29.10 FFL 29.90 FFL 30.90

FFL 31.40 FFL 32.10 FFL 32.90 FFL 33.90

CPT6

BUILDING A
MID GREY PEBBLE
FINISH ON RC SLAB
FFL 32.50

CPT1

SKYLIGHT

CPT5

CPT3

CPT4

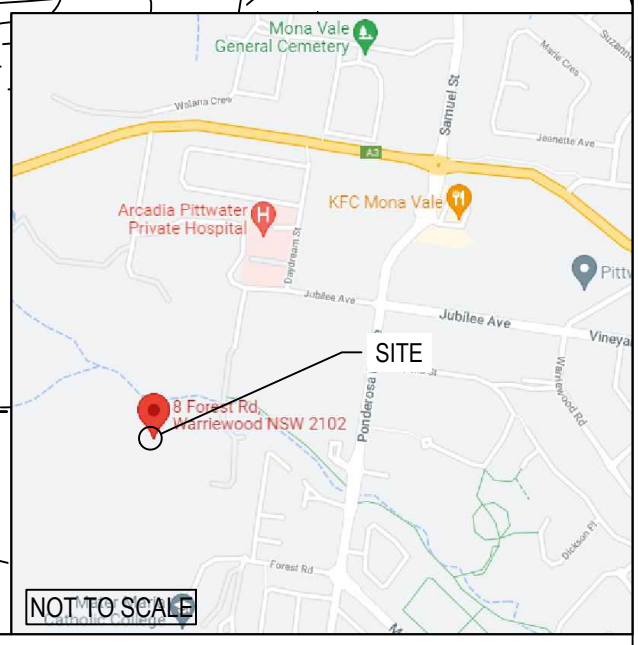
CPT2

SKYLIGHT

SKYLIGHT

SKYLIGHT

SKYLIGHT






Cardno
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Web: www.cardno.com.au

| | | |
|---|---|---|
| Drawn HS | Date 16.12.21 | |
| Checked | Date | |
| Designed | Date | |
| Verified | Date | |
| Approved | | |

Client: EQ Constructions

Project: Residential Development
8 Forest Road
Warriewood

Title: Test Location Plan

Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

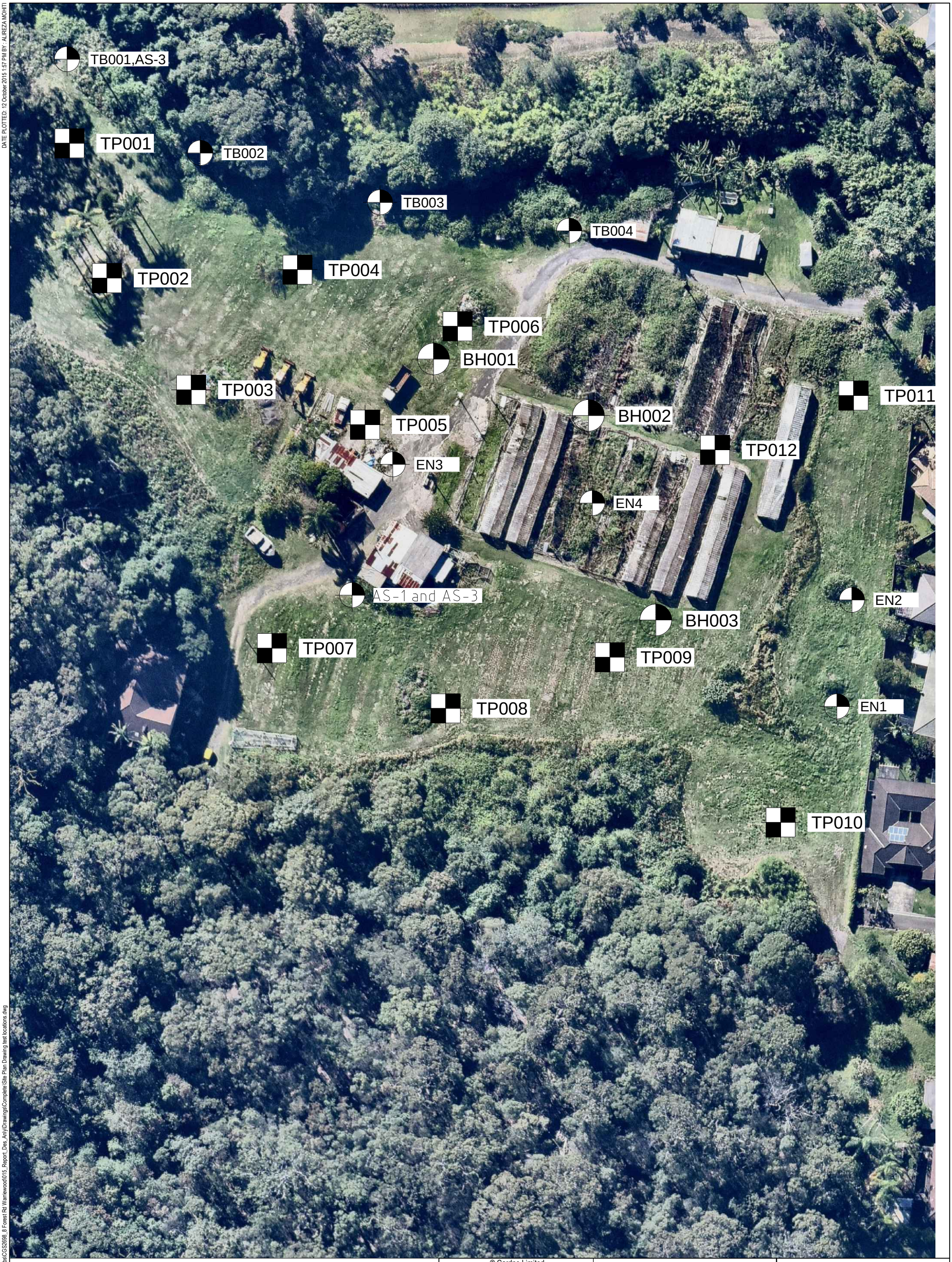
| Project Number | Scale | Size |
|---|---|---|
| 81022041 | | A3 |

Figure Number: Figure 1

Revision: A

DATE PLOTTED: 16 December 2021 9:56 AM BY: J HENRY SOUNDY

XREFs:
CAD File: N:\Projects\810\FY22\041_Warriewood Project_Data-In\Fieldwork\Site Plan\Geo Site Plan Template.dwg




DRAWING ADAPTED FROM NEARMAP

TEST PIT, TEST BORE,
BOREHOLE AND
ENVIROMENTAL
SAMPLING LOCATION

NORTH



Cardno
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Web: www.cardno.com.au

WARRIEWOOD VALE PTY LTD
PRELIMINARY CONTAMINATION
AND GEOTECHNICAL ASSESSMENT
TESTING LOCATION PLAN
8 FOREST RD, WARRIEWOOD

| Datum | Date | Scale | Size |
|---|---|---|---|
| | 01/10/2015 | NTS | A3 |

| Drawing Number | Revision |
|---|---|
| CGS698-GE-2 | 0 |

martens

N


**KEY:**

Indicative borehole and monitoring well location

| | | | |
|---|---|---|---|
| **Martens & Associates Pty Ltd** ABN 85 070 240 890 | | **Environment \| Water \| Wastewater \| Geotechnical \| Civil \| Management** | |
| Drawn: | MH | **GEOTECHNICAL TESTING PLAN** | DRAWING **FIGURE 7** |
| Approved: | SL | | |
| Date: | 10.02.2017 | | |
| Scale: | NA | | Job No: P1504988 |

APPENDIX

# B

ENGINEERING LOGS

# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP001**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m<br>TP001-1 | 0.0 | | | TOPSOIL; Silty SAND, fine to medium, dark grey, trace organics and root fibre | M | | 4<br>3 | | PID=0.1 |
| | | 0.30m | | | SAND, fine to medium, pale grey, with silt | M | MD - D | 4<br>4<br>3<br>4<br>4<br>7<br>15 | | Colluvium |
| | | 1.40m | | | Clayey SAND, fine to coarse, dark brown | M | MD - D | | | |
| | | 2.50m | | | Testpit TP001 terminated at 2.50 m<br>Target depth | | | | | |

0.5 1.0 1.5 2.0 2.5 3.0

HAND PENETROMETER (kPa): 100 200 300 400

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

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# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP002**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m TP002-1 | 0.0 | | | SAND, fine to coarse, pale grey, with silt | | | | | Topsoil removed<br>PID=0.0<br>Colluvium |
| | | 0.5 | | | | M - W | MD | | | |
| | | | | | 0.85m<br>Clayey SAND, fine to coarse, dark brown, trace gravel | | | | | |
| | | 1.0 | | | | M - W | MD - VD | | | |
| ▶ | | 1.5 | | | | | | | | Seepage at 1.5m |
| | | | | | 1.60m<br>Sandy CLAY, low to medium plasticity, orange-brown | | | | | |
| | | 2.0 | | | | MC > PL | St - VSt | | | |
| | | 2.5 | | | 2.50m<br>Testpit TP002 terminated at 2.50 m<br>Target depth | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

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# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP003**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m<br>TP003-1 | 0.0 | | | FILL; SAND, with foreign matter including plastic, metal sheet, timber, empty plastic container, glass fragments | M | | 5<br>6 | | PID=0.0 |
| | | 0.30m | | | SAND, fine to coarse, pale grey, with silt | M | MD - D | 7<br>15<br>R | | Slopewash/Colluvium |
| | | 1.00m | | | Clayey SAND (Quartzite Sand), fine to coarse, brown-orange, trace cobbles (rounded to sub-rounded sandstone) | MC < PL | D - VD | | | |
| | | 1.63m | | | Sandy CLAY, medium plasticity, orange-brown | MC < PL | St - VSt | | | Residual |
| | | 2.50m | | | Testpit TP003 terminated at 2.50 m<br>Target depth | | | | | |

HAND PENETROMETER (kPa): 100, 200, 300, 400
DEPTH (m): 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

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# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP004**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m TP004-1 | 0.0 | | | FILL (TOPSOIL); Silty SAND, fine to coarse, dark brown, trace root fibres and gravel | M | | | | Topsoil Stockpile<br>PID=0.0 |
| | 0.60m B | 0.5 | | | 0.60m<br>SAND, fine to coarse, pale grey, with silt | M | MD - D | | | colluvium |
| | 0.90m | 1.0 | | | 1.40m<br>Clayey SAND (Coffee Rock), fine to coarse, dark brown, with gravel | M | D - VD | | | Hrad excavating at 2.2m |
| | | 1.5 | | | | | | | | |
| | | 2.0 | | | | | | | | |
| | | 2.5 | | | 2.50m<br>Testpit TP004 terminated at 2.50 m<br>Target depth | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

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B - Bulk Disturbed Sample
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HP - Hand/Pocket Penetrometer

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VSt - Very Stiff
H - Hard

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VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
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VH - Very high
EH - Extremely high

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RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
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FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

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# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP005**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m<br>TP005-1 | 0.0 | | | FILL; Silty SAND, fine to coarse, dark brown, trace metal fragments | M | | 10<br>7 | | Surfacial Filling/disturbance<br>PID=0.0 |
| | | 0.30m | | | TOPSOIL; Silty SAND, fine to coarse, dark brown, trace root fibre | M | | 7<br>5<br>5 | | |
| | | 0.80m | | | Silty SAND, fine to medium, pale grey | M | MD | 8 | | Colluvium |
| | | 1.00m | | | Clayey SAND (Coffee Rock), dark brown mottled brown, trace gravel | M | D - VD | | | |
| | | 2.50m | | | Testpit TP005 terminated at 2.50 m<br>Target depth | | | | | |

HAND PENETROMETER (kPa): 100, 200, 300, 400

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
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B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

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L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
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XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

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# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP006**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUNDWATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m TP006-1 | 0.0 | | | FILL; Silty SAND, fine to coarse, dark brown, containing metal sheet, plastic pipe, glass, timber (greenhouse demolition reject), bricks, glass bottle, household reject, plastic container, disused battery | M | | | | Stockpile<br>PID=0.8 |
| | | 0.30m | | | TOPSOIL; Silty SAND, fine to coarse, dark brown, trace root fibre | M | | | | |
| | | 0.5 | | | SAND, fine to medium, pale grey | M | MD - D | | | Colluvium |
| | | 1.0 | | | | | | | | |
| | | 1.30m | | | Clayey SAND (Coffee Rock), dark brown mottled brown, trace gravel | M | D - VD | | | easy to excavate |
| | | 1.5 | | | | | | | | |
| | | 2.0 | | | | | | | | |
| | | 2.50m | | | Testpit TP006 terminated at 2.50 m<br>Target depth | | | | | |
| | | 2.5 | | | | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP007**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUNDWATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m<br>TP007-1 | 0.0 | | | TOPSOIL; Silty SAND, fine to coarse, dark brown, trace root fibre | M | | 5 | | PID=0.4 |
| | | 0.20m | | | Silty SAND, fine to coarse, pale grey-grey | | | 5 | | Colluvium |
| | | 0.5 | | | | | | 4 | | |
| | | | | | | | | 3 | | |
| | | | | | | M | MD | 6 | | |
| | | | | | | | | 10 | | |
| | | 1.0 | | | | | | 13 | | |
| | | | | | | | | R | | |
| | 1.30m | | | | 1.30m | | | | | |
| | U50 | | | | Clayey SAND, fine to coarse, brown mottled orange, trace gravel (Coffee Rock) | | | | | |
| | 1.50m | 1.5 | | | | M | D - VD | | | |
| | | | | | 1.90m | | | | | |
| | | | | | QUARTZITE SANDSTONE, fine to coarse, brown mottled orange | XW | EL | | | Bedrock |
| | | 2.0 | | | 2.00m | | | | | |
| | | | | | Testpit TP007 terminated at 2.00 m<br>Refusal<br>on sandstone | | | | | |
| | | 2.5 | | | | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP008**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0 | | | FILL (Surfacial); Silty SAND, fine to coarse, dark grey-brown, comprises metal sheet, cobbles, containing timber, metal scrap | M | | | | Topsoil Stockpile |
| | 0.10m TP008-1 QD1 and QD2 | | | | 0.15m<br>Clayey SAND, fine to coarse, pale brown, trace sandstone cobbles | D | VD - D | | | PID=0.6<br>Slopewash/Colluvium |
| | 1.50m U50 1.60m | 1.5 | | | 1.80m<br>Sandy CLAY, low to medium plasticity, orange-brown, trace gravel | MC < PL | VSt - H | | | Residual |
| | | 2.0 | | | 2.30m<br>Testpit TP008 terminated at 2.30 m<br>Refusal<br>on sandstone | | | | | |
| | | 2.5 | | | | | | | | |
| | | 3.0 | | | | | | | | |

HAND PENETROMETER (kPa): 100, 200, 300, 400

**MOISTURE & GROUNDWATER**
- D - Dry
- M - Moist
- W - Wet
- OMC - Optimum MC
- PL - Plastic Limit
- ▶— - Water seepage/inflow
- ▼ - Water level

**SAMPLES & FIELD TESTS**
- U - Undisturbed Sample
- D - Disturbed Sample
- ES - Environmental sample
- B - Bulk Disturbed Sample
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer

**CONSISTENCY**
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

**RELATIVE DENSITY**
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

**ROCK STRENGTH**
- EL - Extremely low
- VL - Very low
- L - Low
- M - Medium
- H - High
- VH - Very high
- EH - Extremely high

**ROCK WEATHERING**
- RS - Residual soil
- XW - Extremely weathered
- DW - Distinctly weathered
- SW - Slightly weathered
- FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP009**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m<br>TP009-1 | 0.0 | | | TOPSOIL; Silty SAND, fine to coarse, dark grey-grey | M | | 8<br>3 | | PID=0.5 |
| | | 0.30m | | | SAND, fine to coarse, grey-pale grey, with silt | M - D | L - MD | 3<br>2<br>3<br>3<br>12 | | Slopewash/Colluvium |
| | | 1.00m | | | Clayey SAND, fine to coarse grained, grey, low plasticity, trace gravel<br>(Coffee Rock) | MC < PL | D - VD | 8<br>12 | | |
| | | 1.90m | | | SAND, fine to coarse, pale brown, trace gravel | M - D | D - VD | | | Residual |
| | | 2.50m | | | Testpit TP009 terminated at 2.50 m<br>Target depth | | | | | |

HAND PENETROMETER (kPa): 100, 200, 300, 400

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP010**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUNDWATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m TP010-1 | 0.0 | | | TOPSOIL; Silty SAND, fine to coarse, dark brown, trace root fibre | M | | | | PID=0.8 |
| | | | | | 0.20m<br>SAND, fine to coarse, pale grey-grey | M | MD - D | | | Slopewash/Colluvium |
| | | 0.5 | | | 0.75m | | | | | |
| | 0.80m<br>B<br>0.90m<br>U50 | | | | Clayey SAND, fine to coarse grained, orange mottled dark brown, trace gravel | M | VSt - H | | | Residual |
| | 1.15m<br>1.20m | 1.0 | | | | | | | | |
| | | 1.5 | | | 1.90m<br>QUARTZITE SANDSTONE, fine to coarse, orange mottled brown-red, trace gravel | XW | EL | | | |
| | | 2.0 | | | 2.15m<br>Testpit TP010 terminated at 2.15 m<br>Refusal<br>on sandstone | | | | | |
| | | 2.5 | | | | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP011**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUNDWATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m TP011-1 | 0.0 | | | FILL; Gravelly SAND, fine to coarse, dark brown-black, contains plastic fragments, metal scrap, glass fragments, timber posts | M | | | | PID=0.1 |
| | | 0.20m | | | SAND, fine to coarse, dark grey-brown, with silt | | | | | Colluvium |
| | | 0.5 | | | | M | MD - D | | | |
| | | 1.00m | | | Sandy CLAY, low plasticity, orange-brown mottled red | | | | | Residual |
| | | 1.5 | | | | MC = PL | VSt - H | | | |
| | | 2.0 | | | | | | | | |
| | | 2.50m | | | Testpit TP011 terminated at 2.50 m<br>Target depth | | | | | |
| | | 2.5 | | | | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTPIT LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TP012**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m<br>TP012-1 | 0.0 | | | TOPSOIL; Silty SAND, fine to coarse, dark grey | M | | 3 | | PID=7.7 |
| | 0.30m<br>B<br>0.40m | 0.20m | | | Silty SAND, fine to coarse, dark grey-orange, with silt | M | L - MD | 4<br>5<br>3 | | Colluvium |
| | | 0.5<br>0.60m | | | Clayey SAND, fine to medium grained, orange-brown mottled red | MC < PL | F - St | 3<br>2<br>3<br>2<br>6<br>3<br>2<br>3<br>8<br>11 | | Residual |
| | 1.10m<br>U50<br>1.30m | 1.0<br>1.5<br>2.0 | | | | | | | | |
| | | 2.5<br>2.50m | | | Testpit TP012 terminated at 2.50 m<br>Target depth | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTBORE LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TB001**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m<br>TB001-1 | 0.0 | | | FILL (Surfacial); Sandy SILT, grey | M | | | | PID=1.4<br>sample AS-3 from surface with ACM fragments at vicinity |
| | | | | | 0.20m<br>SAND, fine to coarse, grey-pale brown | | | | | Colluvium |
| | | 0.5 | | | | M | MD - D | | | |
| | | | | | 1.00m<br>Clayey SAND (Coffee Rock), fine to coarse grained, dark brown | | | | | |
| | | 1.0 | | | | | | | | |
| | | 1.5 | | | | | | | | |
| | | | | | | M | VD - D | | | |
| | | 2.0 | | | | | | | | |
| | | 2.5 | | | 2.60m<br>Testbore TB001 terminated at 2.60 m<br>Target depth | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

File: CGS2698 TB001 Page 1 OF 1

GEOTECH.GLB Log CARDNO_TESTHOLE_LOG CGS_2698_FOREST RD_WARRIEWOOD.GPJ 01/10/2015 15:34 8.30.003

# TESTBORE LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TB002**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m TB002-1 | 0.0 | | | FILL; Silty SAND, fine to coarse grained, grey, contains foreign materials including plastic rope | | | | | PID=0.7 |
| | | | | | 0.30m<br>TOPSOIL; Silty SAND, fine to coarse grained, dark grey | M | | | | |
| | | 0.5 | | | 0.50m<br>SAND, fine to coarse, grey-pale brown | | | | | Colluvium |
| | | 1.0 | | | | M | D - MD | | | |
| | | 1.5 | | | | | | | | |
| | | 2.0 | | | 2.00m<br>Clayey SAND (Coffee Rock), fine to coarse grained, dark brown | M | D - VD | | | |
| | | 2.5 | | | 2.60m<br>Testbore TB002 terminated at 2.60 m<br>Target depth | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTBORE LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TB003**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m<br>TB003-1 | 0.0 | | | FILL; Sandy SILT, dark grey, contains cable and cobbles | | | | | Surfacial Filling<br><br>PID=0.7 |
| | | | | | 0.20m<br>SAND, fine to coarse, grey-pale brown | | | | | |
| | | 0.5 | | | | M | D - MD | | | Colluvium |
| | | 1.0 | | | 1.10m<br>Sandy CLAY, low plasticity, pale brown-orange, fine to coarse grained sand | | | | | |
| | | 1.5 | | | | | | | | |
| | | 2.0 | | | | MC = PL | St - VSt | | | |
| | | 2.5 | | | 2.50m<br>Testbore TB003 terminated at 2.50 m<br>Target depth | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# TESTBORE LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : TB004**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

EQUIPMENT TYPE : 5t Excavator | METHOD : Toothed Bucket
DATE EXCAVATED : 14/9/15 | LOGGED BY : AM | CHECKED BY : IGP
LOCATION : See Drawing for location

| GROUND WATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | DYNAMIC PENETROMETER | HAND PENETRO-METER (kPa) 100 200 300 400 | STRUCTURE & Other Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10m TB004-1 | 0.0 | | | FILL; Sandy SILT, dark grey, contains cable and cobbles | M | | | | PID=0.2 |
| | | 0.5 | | | 0.50m<br>SAND, fine to coarse, grey-pale brown | | | | | Colluvium |
| | | 1.0 | | | | | | | | |
| | | 1.5 | | | | | | | | |
| | | 2.0 | | | | | | | | |
| | | 2.5 | | | 2.50m<br>Testbore TB004 terminated at 2.50 m<br>Target depth | | | | | |
| | | 3.0 | | | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# BOREHOLE LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : BH001**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

RIG TYPE : 4WD mounted drill rig | METHOD : Auger | CONTRACTOR : Fico Group | DRILLER :

DATE STARTED : 15/9/15 | DATE COMPLETED : 15/9/15 | DATE LOGGED : 15/9/15 | LOGGED BY : AM | CHECKED BY : IGP

LOCATION : See Drawing for location

| DRILLING | | | | | MATERIAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | GROUND WATER LEVELS | SAMPLES & FIELD TESTS | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | STRUCTURE & Other Observations |
| | | | | 0.0 | | | TOPSOIL; Silty SAND, fine to coarse, dark grey | M | | |
| | | | | | | | 0.40m<br>SAND, fine to coarse, pale grey-grey, with silt | M | L - MD | |
| | | 1.00m<br>SPT<br>0, 1, 1 N=2<br>1.45m | | 1.0 | | | 1.00m<br>QUARTZITE SAND, brown-dark brown, with silt and clay (Clayey Sand/Coffee Rock) | | | Colluvium |
| | | | | 2.0 | | | | | VL - MD | |
| | | 2.50m<br>SPT<br>3, 3, 3 N=6<br>2.95m | | | | | @ 2.2m same as above, but higher clay content, brown with slight red mottling | M | | |
| | | 4.00m<br>SPT<br>2, 4, 8 N=12<br>4.45m | | 4.0 | | | | | L - MD | |
| | ▶— | | | 5.0 | | | 5.30m | | | |
| | | 5.50m<br>SPT<br>2, 3, 3 N=6<br>5.95m | | 6.0 | | | Sandy CLAY, low to medium plasticity, pale grey-grey, fine to coarse quartzite sand, | | | Residual |
| | | | | 7.0 | | | | | | |
| | | | | 8.0 | | | | | | |
| | | | | 9.0 | | | | | | |
| | | | | 10.0 | | | | MC > PL | St - VSt | |
| | | | | 11.0 | | | | | | |
| | | | | 12.0 | | | | | | |
| | | | | 13.0 | | | | | | |
| | | | | 14.0 | | | | | | |
| | | | | 15.0 | | | | | | |
| | | | | 16.0 | | | 16.00m<br>Borehole BH001 terminated at 16.00 m<br>Target depth | | | |

**MOISTURE & GROUNDWATER**
- D - Dry
- M - Moist
- W - Wet
- OMC - Optimum MC
- PL - Plastic Limit
- ▶— - Water seepage/inflow
- ▼ - Water level

**SAMPLES & FIELD TESTS**
- U - Undisturbed Sample
- D - Disturbed Sample
- ES - Environmental sample
- B - Bulk Disturbed Sample
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer

**CONSISTENCY**
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

**RELATIVE DENSITY**
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

**ROCK STRENGTH**
- EL - Extremely low
- VL - Very low
- L - Low
- M - Medium
- H - High
- VH - Very high
- EH - Extremely high

**ROCK WEATHERING**
- RS - Residual soil
- XW - Extremely weathered
- DW - Distinctly weathered
- SW - Slightly weathered
- FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# BOREHOLE LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : BH002**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

RIG TYPE : 4WD mounted drill rig | METHOD : Auger | CONTRACTOR : Fico Group | DRILLER :

DATE STARTED : 15/9/15 | DATE COMPLETED : 15/9/15 | DATE LOGGED : 15/9/15 | LOGGED BY : AM | CHECKED BY : IGP

LOCATION : See Drawing for location

| DRILLING | | | | | MATERIAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | GROUND WATER LEVELS | SAMPLES & FIELD TESTS | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | STRUCTURE & Other Observations |
| | | | | 0.0 | | | 0.30m TOPSOIL; Silty SAND, fine to coarse, dark grey-brown, trace organics and root fibres | M | | |
| | | 1.00m SPT 1, 2, 2 N=4 1.45m | | 1.0 | | | QUARTZITE SAND, fine to coarse, grey-dark grey, with silt | M | L - MD | Colluvium |
| | | 2.50m SPT 5, 7, 7 N=14 2.95m | | 2.0 | | | @2.0m colour change to pale brown-orange | | MD - D | |
| | | | | 3.0 | | | 3.00m Clayey SAND, fine to coarse, orange-red mottled pale grey | MC < PL | MD - D | Residual |
| | | 4.00m SPT 10, 8, 6 N=14 4.45m | | 4.0 | | | 4.80m | | | |
| | ▶ | | | 5.0 | | | Sandy CLAY, low to medium plasticity, pale grey mottled orange-red, fine to coarse grained sand | | | |
| | | 5.50m SPT 3, 6, 6 N=12 5.95m | | 6.0 | | | | MC = PL | St - VSt | |
| | | | | 7.0 | | | | | | |
| | | | | 8.0 | | | | MC = PL | H | |
| | | | | 9.0 | | | | | | |
| | | | | 10.0 | | | | | | |
| | | | | 11.0 | | | | MC > PL | St - VSt | |
| | | | | 12.0 | | | | | | |
| | | | | 13.0 | | | | | | |
| | | | | 14.0 | | | 14.50m | | | |
| | | | | 15.0 | | | Borehole BH002 terminated at 14.50 m<br>Target depth | | | No rock encountered. Highly weathered profile after encounter water |
| | | | | 16.0 | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# BOREHOLE LOG

CLIENT : Plateau Nominees Pty Ltd
PROJECT : Preliminary Contamination and Geotechnical Assessment
LOCATION : 8 Forest Road, Warriewood

**HOLE NO : BH003**
**PROJECT REF : CGS2698**
SHEET : 1 OF 1

RIG TYPE : 4WD mounted drill rig | METHOD : Auger | CONTRACTOR : Fico Group | DRILLER :

DATE STARTED : 15/9/15 | DATE COMPLETED : 15/9/15 | DATE LOGGED : 15/9/15 | LOGGED BY : AM | CHECKED BY : IGP

LOCATION : See Drawing for location

| DRILLING | | | | | MATERIAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | GROUND WATER LEVELS | SAMPLES & FIELD TESTS | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION<br>Soil Type, plasticity or particle characteristic, colour<br>Rock Type, grain size, colour<br>Secondary and minor components | MOISTURE / WEATHERING | CONSISTENCY / REL DENSITY / ROCK STRENGTH | STRUCTURE & Other Observations |
| | | | | 0.0 | | | 0.30m TOPSOIL; Silty SAND, fine to coarse, dark brown, with organics, trace root fibres | M | | |
| | | 1.00m<br>SPT<br>2, 3, 2 N=5<br>1.45m | | 1.0 | | | Clayey SAND, fine to coarse, dark brown-grey | | | |
| | | 2.50m<br>SPT<br>4, 4, 5 N=9<br>2.95m | | 2.0 | | | @1.8m same as above, but colour change to brown mottled red | M | L - MD | Residual |
| | | 4.00m<br>SPT<br>2, 3, 4 N=7<br>4.45m | | 3.0<br>4.0 | | | 4.10m<br>Sandy CLAY, low to medium plasticity, pale grey mottled orange, trace gravel | | | |
| | | 5.50m<br>SPT<br>2, 3, 3 N=6<br>5.95m | | 5.0<br>6.0 | | | | MC = PL | F - St | |
| | | | | 7.0<br>8.0<br>9.0<br>10.0 | | | | MC > PL | St - F | |
| | | | | 11.0<br>12.0 | | | 12.00m<br>Borehole BH003 terminated at 12.00 m<br>Target depth | | | No Rock Encountered |
| | | | | 13.0<br>14.0<br>15.0<br>16.0 | | | | | | |

**MOISTURE & GROUNDWATER**
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

**SAMPLES & FIELD TESTS**
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

**CONSISTENCY**
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

**RELATIVE DENSITY**
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

**ROCK STRENGTH**
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

**ROCK WEATHERING**
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO LTD

# APPENDIX C

## LABORATORY TEST REPORTS

Cardno Geotech Solutions
ABN: 95 001 145 035
Address: Unit 4, 5 Arunga Drive
Beresfield NSW 2322

Laboratory: Geotech Solutions Newcastle
Phone: 02 4949 4300 Fax: 02 4966 0485
Email: james.young@cardno.com.au

# CALIFORNIA BEARING RATIO REPORT

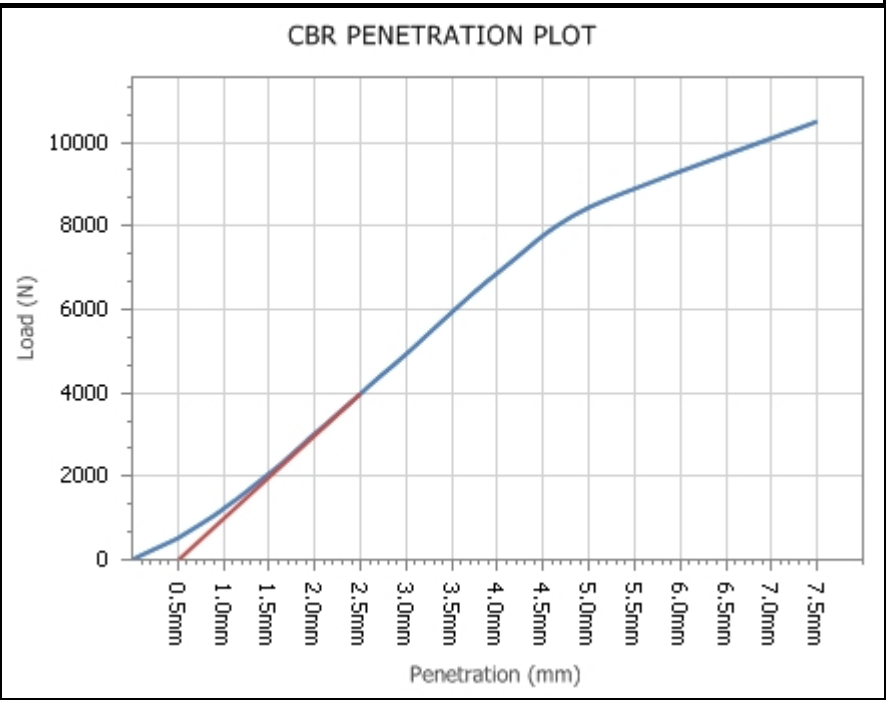
| | | | |
|---|---|---|---|
| Client: | Warriewood Vale Pty Ltd | Report Number: | 15689/R/2015-2 |
| Client Address: | 3A MACQUARIE ROAD, MORISSET PARK | Project Number: | 15689/P/2698 |
| Project: | 8 Forest Road - Geotechnical Assessment | Lot Number: | |
| Location: | 8 Forest Road, Warriewood | Internal Test Request: | 15689/T/1427 |
| Component: | | Client Reference/s: | |
| Area Description: | | Report Date / Page: | 08/10/2015 Page 1 of 3 |

| | |
|---|---|
| Test Procedures | AS1289.6.1.1, AS1289.5.1.1, AS1289.2.1.1 |

| | | | | |
|---|---|---|---|---|
| Sample Number | 15689/S/6620 | Sample Location | | |
| Sampling Method | AS1289.1.2.1 Cl 6.5.4 (Insitu, Machine Pit) | Pit No. | | TP004 |
| Date Sampled | 14/09/2015 | Sample Type | | Bulk |
| Sampled By | Alireza Mohiti | Sample Depth | m | 0.60-0.90 |
| Date Tested | 06/10/2015 | | | |
| Material Source | In situ | Material Limit Start | | - |
| Material Type | - | Material Limit End | | - |
| Client Reference | - | Compactive Effort | | Standard |

| | |
|---|---|
| Material Description | Silty SAND, pale grey brown |

| | |
|---|---|
| Maximum Dry Density (t/m³): | 1.82 |
| Optimum Moisture Content (%): | 12.5 |
| Field Moisture Content (%): | 9.6 |
| Sample Percent Oversize (%) | 0.0 |
| Oversize Included / Excluded | Excluded |
| Target Density Ratio (%): | 100 |
| Target Moisture Ratio (%): | 100 |
| Placement Dry Density (t/m³): | 1.81 |
| Placement Dry Density Ratio (%): | 99.5 |
| Placement Moisture Content (%): | 12.7 |
| Placement Moisture Ratio (%): | 100.0 |
| Test Condition / Soaking Period: | Soaked / 4 Days |
| CBR Surcharge (kg) | 4.5 |
| Dry Density After Soak (t/m³): | 1.81 |
| Moisture (top 30mm) After Soak (%) | 13.7 |
| Moisture (remainder) After Soak (%) | 13.2 |
| CBR Swell (%): | 0.5 |
| Minimum CBR Specification (%): | - |
| **CBR Value @ 5.0mm (%):** | **45** |




| | |
|---|---|
| Remarks | Re-Issued Report Replaces Report No 15689/R/2015-1. |

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

Accreditation Number: 15689

Approved Signatory: Ian Piper
Form ID: W7Rep Rev 1

Cardno Geotech Solutions
ABN: 95 001 145 035
Address: Unit 4, 5 Arunga Drive
Beresfield NSW 2322

Laboratory: Geotech Solutions Newcastle
Phone: 02 4949 4300 Fax: 02 4966 0485
Email: james.young@cardno.com.au

# CALIFORNIA BEARING RATIO REPORT

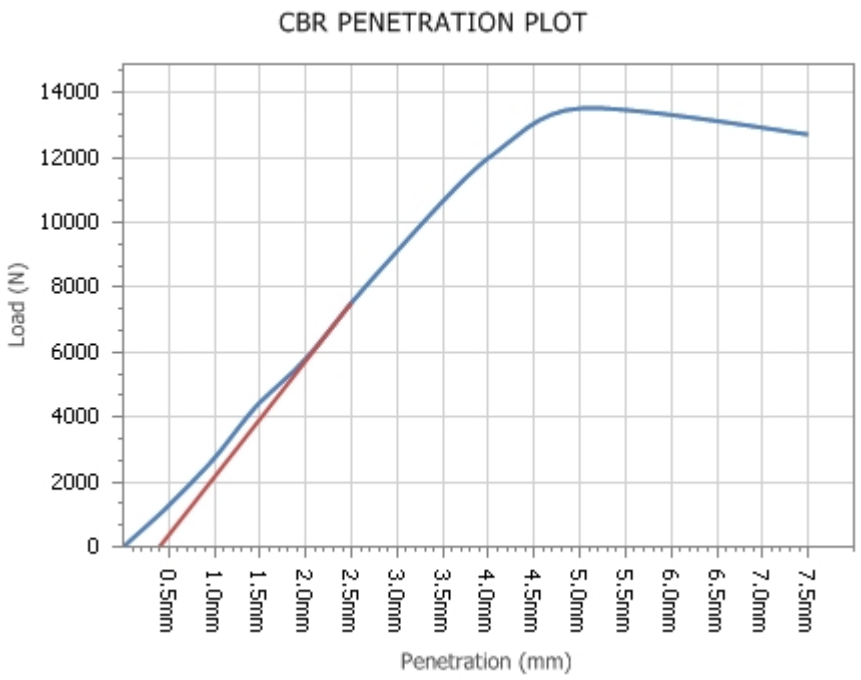
| | | | |
|---|---|---|---|
| Client: | Warriewood Vale Pty Ltd | Report Number: | 15689/R/2015-2 |
| Client Address: | 3A MACQUARIE ROAD, MORISSET PARK | Project Number: | 15689/P/2698 |
| Project: | 8 Forest Road - Geotechnical Assessment | Lot Number: | |
| Location: | 8 Forest Road, Warriewood | Internal Test Request: | 15689/T/1427 |
| Component: | | Client Reference/s: | |
| Area Description: | | Report Date / Page: | 08/10/2015 Page 2 of 3 |

| | |
|---|---|
| Test Procedures | AS1289.6.1.1, AS1289.5.1.1, AS1289.2.1.1 |

| | | | | |
|---|---|---|---|---|
| Sample Number | 15689/S/6623 | Sample Location | | |
| Sampling Method | AS1289.1.2.1 Cl 6.5.4 (Insitu, Machine Pit) | Pit No. | | TP010 |
| Date Sampled | 14/09/2015 | Sample Type | | Bulk |
| Sampled By | Alireza Mohiti | Sample Depth | m | 0.80-1.20 |
| Date Tested | 06/10/2015 | | | |
| Material Source | In situ | Material Limit Start | | - |
| Material Type | - | Material Limit End | | - |
| Client Reference | - | Compactive Effort | | Standard |

| | |
|---|---|
| Material Description | Clayey SAND with Gravel, orange mottled red/brown |

| | |
|---|---|
| Maximum Dry Density (t/m³): | 1.98 |
| Optimum Moisture Content (%): | 10.0 |
| Field Moisture Content (%): | 11.7 |
| Sample Percent Oversize (%) | 3.0 |
| Oversize Included / Excluded | Excluded |
| Target Density Ratio (%): | 100 |
| Target Moisture Ratio (%): | 100 |
| Placement Dry Density (t/m³): | 1.99 |
| Placement Dry Density Ratio (%): | 100.0 |
| Placement Moisture Content (%): | 9.8 |
| Placement Moisture Ratio (%): | 99.0 |
| Test Condition / Soaking Period: | Soaked / 4 Days |
| CBR Surcharge (kg) | 4.5 |
| Dry Density After Soak (t/m³): | 1.99 |
| Moisture (top 30mm) After Soak (%) | 11.6 |
| Moisture (remainder) After Soak (%) | 10.6 |
| CBR Swell (%): | -0.5 |
| Minimum CBR Specification (%): | - |
| **CBR Value @ 5.0mm (%):** | **70** |




| | |
|---|---|
| Remarks | Re-Issued Report Replaces Report No 15689/R/2015-1. |

NATA

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

Accreditation Number: 15689

Approved Signatory: Ian Piper
Form ID: W7Rep Rev 1

Cardno Geotech Solutions
ABN: 95 001 145 035
Address:
Unit 4, 5 Arunga Drive
Beresfield NSW 2322

Laboratory: Geotech Solutions Newcastle
Phone: 02 4949 4300 Fax: 02 4966 0485
Email: james.young@cardno.com.au

# CALIFORNIA BEARING RATIO REPORT

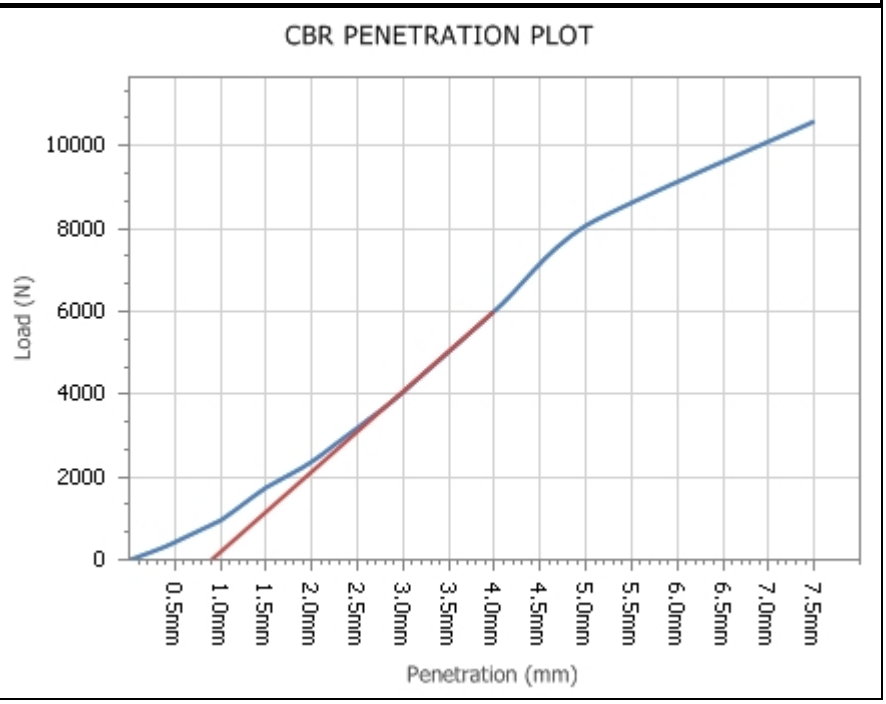
| | | | |
|---|---|---|---|
| Client: | Warriewood Vale Pty Ltd | Report Number: | 15689/R/2015-2 |
| Client Address: | 3A MACQUARIE ROAD, MORISSET PARK | Project Number: | 15689/P/2698 |
| Project: | 8 Forest Road - Geotechnical Assessment | Lot Number: | |
| Location: | 8 Forest Road, Warriewood | Internal Test Request: | 15689/T/1427 |
| Component: | | Client Reference/s: | |
| Area Description: | | Report Date / Page: | 08/10/2015 Page 3 of 3 |

| | |
|---|---|
| Test Procedures | AS1289.6.1.1, AS1289.5.1.1, AS1289.2.1.1 |

| | | | | |
|---|---|---|---|---|
| Sample Number | 15689/S/6625 | Sample Location | | |
| Sampling Method | AS1289.1.2.1 Cl 6.5.4 (Insitu, Machine Pit) | Pit No. | | TP012 |
| Date Sampled | 14/09/2015 | Sample Type | | Bulk |
| Sampled By | Alireza Mohiti | Sample Depth | m | 0.30-0.40 |
| Date Tested | 06/10/2015 | | | |
| Material Source | In situ | Material Limit Start | | - |
| Material Type | - | Material Limit End | | - |
| Client Reference | - | Compactive Effort | | Standard |

| | |
|---|---|
| Material Description | Silty SAND, dark grey/brown |

| | |
|---|---|
| Maximum Dry Density (t/m³): | 1.86 |
| Optimum Moisture Content (%): | 12.0 |
| Field Moisture Content (%): | 10.1 |
| Sample Percent Oversize (%) | 0.0 |
| Oversize Included / Excluded | Excluded |
| Target Density Ratio (%): | 100 |
| Target Moisture Ratio (%): | 100 |
| Placement Dry Density (t/m³): | 1.86 |
| Placement Dry Density Ratio (%): | 100.0 |
| Placement Moisture Content (%): | 12.1 |
| Placement Moisture Ratio (%): | 100.0 |
| Test Condition / Soaking Period: | Soaked / 4 Days |
| CBR Surcharge (kg) | 4.5 |
| Dry Density After Soak (t/m³): | 1.86 |
| Moisture (top 30mm) After Soak (%) | 12.5 |
| Moisture (remainder) After Soak (%) | 12.6 |
| CBR Swell (%): | -0.5 |
| Minimum CBR Specification (%): | - |
| **CBR Value @ 5.0mm (%):** | **45** |




| | |
|---|---|
| Remarks | Re-Issued Report Replaces Report No 15689/R/2015-1. |

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Accredited for compliance with ISO/IEC 17025

Accreditation Number: 15689

Approved Signatory: Ian Piper
Form ID: W7Rep Rev 1

Cardno Geotech Solutions
Shaping the Future

**Cardno Geotech Solutions**
ABN: 95 001 145 035

**Address:**
Unit 4, 5 Arunga Drive
Beresfield NSW 2322

**Laboratory:** **Geotech Solutions Newcastle**
**Phone:** 02 4949 4300 **Fax:** 02 4966 0485

**Email:** james.young@cardno.com.au

# SHRINK SWELL INDEX

| | | | |
|---|---|---|---|
| Client: | Warriewood Vale Pty Ltd | Report Number: | 15689/R/2017-3 |
| Client Address: | 3A MACQUARIE ROAD, MORISSET PARK | Project Number: | 15689/P/2698 |
| Project: | 8 Forest Road - Geotechnical Assessment | Lot Number: | |
| Location: | 8 Forest Road, Warriewood | Internal Test Request: | 15689/T/1427 |
| Component: | | Client Reference/s: | |
| Area Description: | | Report Date / Page: | 08/10/2015 Page 1 of 4 |

| | | | | |
|---|---|---|---|---|
| Test Procedures: | AS1289.7.1.1, AS1289.2.1.1 | Pit No. | | TP008 |
| Sample Number | 15689/S/6622 | Sample Type | | U50 |
| Sampling Method | AS1289.1.2.1 Cl 6.5.4 (Insitu, Machine Pit) | Sample Depth | m | 1.50-1.60 |
| Date Sampled | 14/09/2015 | | | |
| Sampled By | Alireza Mohiti | Material Source | | In situ |
| Date Tested | 18/09/2015 | Material Type | | - |

| | | | |
|---|---|---|---|
| Soil Description: | Clayey SAND, pale brown | | |
| Cracking / Crumbling: | Minor/Minor | | |
| Estimated Inert Inclusions (%): | 0.00 | Swell Pre-Soak Moisture Content (%) | 10.6 |
| Shrinkage Moisture Content (%): | 12.2 | Swell Post-Soak Moisture Content (%) | 12.6 |

| | | | |
|---|---|---|---|
| Shrinkage Strain (%) | 0.1 | Shrink / Swell Index | 0.1 |
| Swell Strain (%) | 0.0 | | |

| | |
|---|---|
| Remarks | Re-Issued Report Replaces Report No 15689/R/2017-2. |

NATA

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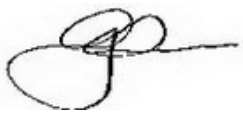
Accreditation Number: 15689



Approved Signatory: Ian Piper
Form ID: W21Rep Rev 1

Cardno Geotech Solutions
ABN: 95 001 145 035
Address:
Unit 4, 5 Arunga Drive
Beresfield NSW 2322

Laboratory: Geotech Solutions Newcastle
Phone: 02 4949 4300 Fax: 02 4966 0485
Email: james.young@cardno.com.au

# SHRINK SWELL INDEX

| | | | |
|---|---|---|---|
| Client: | Warriewood Vale Pty Ltd | Report Number: | 15689/R/2017-3 |
| Client Address: | 3A MACQUARIE ROAD, MORISSET PARK | Project Number: | 15689/P/2698 |
| Project: | 8 Forest Road - Geotechnical Assessment | Lot Number: | |
| Location: | 8 Forest Road, Warriewood | Internal Test Request: | 15689/T/1427 |
| Component: | | Client Reference/s: | |
| Area Description: | | Report Date / Page: | 08/10/2015 Page 2 of 4 |

| | | | | |
|---|---|---|---|---|
| Test Procedures: | AS1289.7.1.1, AS1289.2.1.1 | Pit No. | | TP010 |
| Sample Number | 15689/S/6623 | Sample Type | | Bulk |
| Sampling Method | AS1289.1.2.1 Cl 6.5.4 (Insitu, Machine Pit) | Sample Depth | m | 0.80-1.20 |
| Date Sampled | 14/09/2015 | | | |
| Sampled By | Alireza Mohiti | Material Source | | In situ |
| Date Tested | 28/09/2015 | Material Type | | - |

| | | | |
|---|---|---|---|
| Soil Description: | Clayey SAND with Gravel, orange mottled red/brown | | |
| Cracking / Crumbling: | Minor/Minor | | |
| Estimated Inert Inclusions (%): | 0.00 | Swell Pre-Soak Moisture Content (%) | 10.8 |
| Shrinkage Moisture Content (%): | 11.4 | Swell Post-Soak Moisture Content (%) | 12.0 |

| | | | |
|---|---|---|---|
| Shrinkage Strain (%) | 0.5 | Shrink / Swell Index | 0.3 |
| Swell Strain (%) | 0.0 | | |

| | |
|---|---|
| Remarks | Re-Issued Report Replaces Report No 15689/R/2017-2. |

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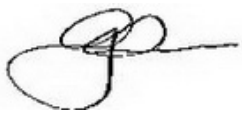
Accreditation Number: 15689



Approved Signatory: Ian Piper
Form ID: W21Rep Rev 1

Cardno Geotech Solutions
Shaping the Future

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**Email:** james.young@cardno.com.au

# SHRINK SWELL INDEX

| | | | |
|---|---|---|---|
| Client: | Warriewood Vale Pty Ltd | Report Number: | 15689/R/2017-3 |
| Client Address: | 3A MACQUARIE ROAD, MORISSET PARK | Project Number: | 15689/P/2698 |
| Project: | 8 Forest Road - Geotechnical Assessment | Lot Number: | |
| Location: | 8 Forest Road, Warriewood | Internal Test Request: | 15689/T/1427 |
| Component: | | Client Reference/s: | |
| Area Description: | | Report Date / Page: | 08/10/2015 Page 3 of 4 |

| | | | | |
|---|---|---|---|---|
| Test Procedures: | AS1289.7.1.1, AS1289.2.1.1 | Pit No. | | TP010 |
| Sample Number | 15689/S/6624 | Sample Type | | U50 |
| Sampling Method | AS1289.1.2.1 Cl 6.5.4 (Insitu, Machine Pit) | Sample Depth | m | 0.90-1.15 |
| Date Sampled | 14/09/2015 | | | |
| Sampled By | Alireza Mohiti | Material Source | | In situ |
| Date Tested | 28/09/2015 | Material Type | | - |

| | | | |
|---|---|---|---|
| Soil Description: | Clayey SAND, orange mottled red/brown | | |
| Cracking / Crumbling: | None/Minor | | |
| Estimated Inert Inclusions (%): | 0.00 | Swell Pre-Soak Moisture Content (%) | 11.1 |
| Shrinkage Moisture Content (%): | 13.4 | Swell Post-Soak Moisture Content (%) | 14.8 |

| | | | |
|---|---|---|---|
| Shrinkage Strain (%) | 1.0 | Shrink / Swell Index | 0.6 |
| Swell Strain (%) | 0.0 | | |

| | |
|---|---|
| Remarks | Re-Issued Report Replaces Report No 15689/R/2017-2. |

NATA

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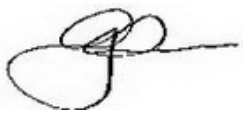
Accredited for compliance with ISO/IEC 17025

Accreditation Number: 15689



Approved Signatory: Ian Piper
Form ID: W21Rep Rev 1

Cardno Geotech Solutions
Shaping the Future

**Cardno Geotech Solutions**
ABN: 95 001 145 035

**Address:**
Unit 4, 5 Arunga Drive
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**Laboratory:** **Geotech Solutions Newcastle**
**Phone:** 02 4949 4300 **Fax:** 02 4966 0485

**Email:** james.young@cardno.com.au

# SHRINK SWELL INDEX

| | | | |
|---|---|---|---|
| Client: | Warriewood Vale Pty Ltd | Report Number: | 15689/R/2017-3 |
| Client Address: | 3A MACQUARIE ROAD, MORISSET PARK | Project Number: | 15689/P/2698 |
| Project: | 8 Forest Road - Geotechnical Assessment | Lot Number: | |
| Location: | 8 Forest Road, Warriewood | Internal Test Request: | 15689/T/1427 |
| Component: | | Client Reference/s: | |
| Area Description: | | Report Date / Page: | 08/10/2015 Page 4 of 4 |

| | | | | |
|---|---|---|---|---|
| Test Procedures: | AS1289.7.1.1, AS1289.2.1.1 | Pit No. | | TP012 |
| Sample Number | 15689/S/6626 | Sample Type | | U50 |
| Sampling Method | AS1289.1.2.1 Cl 6.5.4 (Insitu, Machine Pit) | Sample Depth | m | 1.10-1.30 |
| Date Sampled | 14/09/2015 | | | |
| Sampled By | Alireza Mohiti | Material Source | | In situ |
| Date Tested | 28/09/2015 | Material Type | | - |

| | | | |
|---|---|---|---|
| Soil Description: | Clayey SAND, orange/brown mottled red | | |
| Cracking / Crumbling: | None/Minor | | |
| Estimated Inert Inclusions (%): | 0.00 | Swell Pre-Soak Moisture Content (%) | 12.5 |
| Shrinkage Moisture Content (%): | 13.1 | Swell Post-Soak Moisture Content (%) | 14.2 |

| | | | |
|---|---|---|---|
| Shrinkage Strain (%) | 0.7 | Shrink / Swell Index | 0.4 |
| Swell Strain (%) | 0.0 | | |

| | |
|---|---|
| Remarks | Re-Issued Report Replaces Report No 15689/R/2017-2. |

NATA

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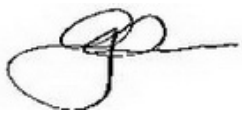
Accredited for compliance with ISO/IEC 17025

Accreditation Number: 15689



Approved Signatory: Ian Piper
Form ID: W21Rep Rev 1

# APPENDIX

# D

## CPT RESULTS

Cardno

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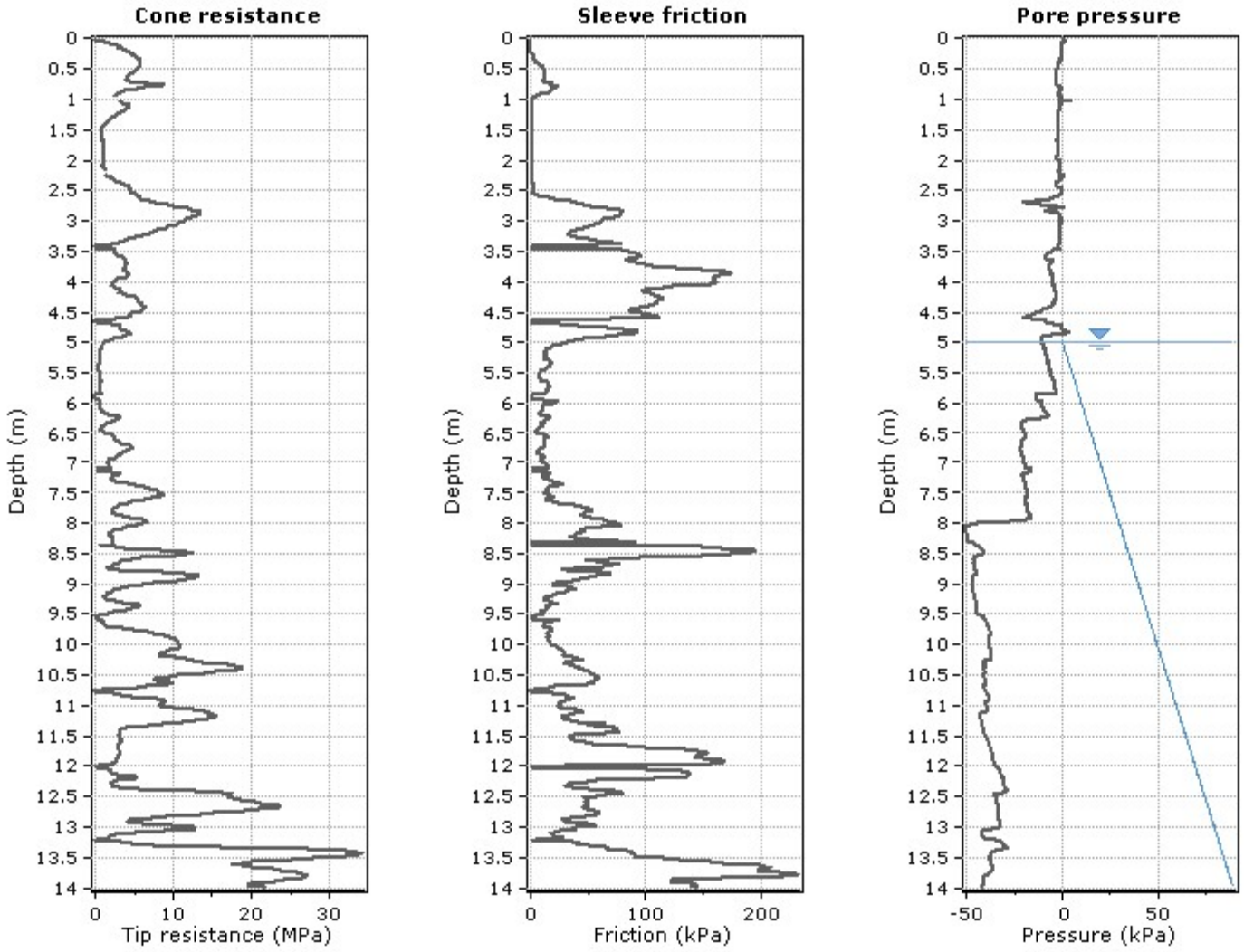
Stantec

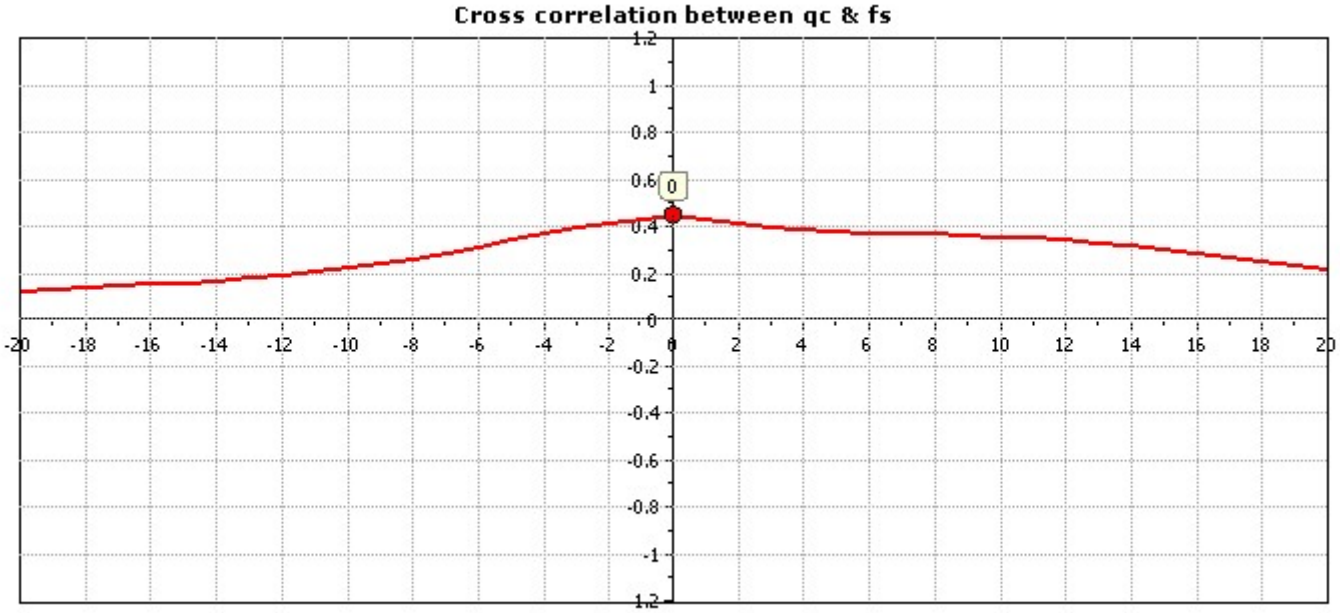
**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT1**
Total depth: 13.98 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



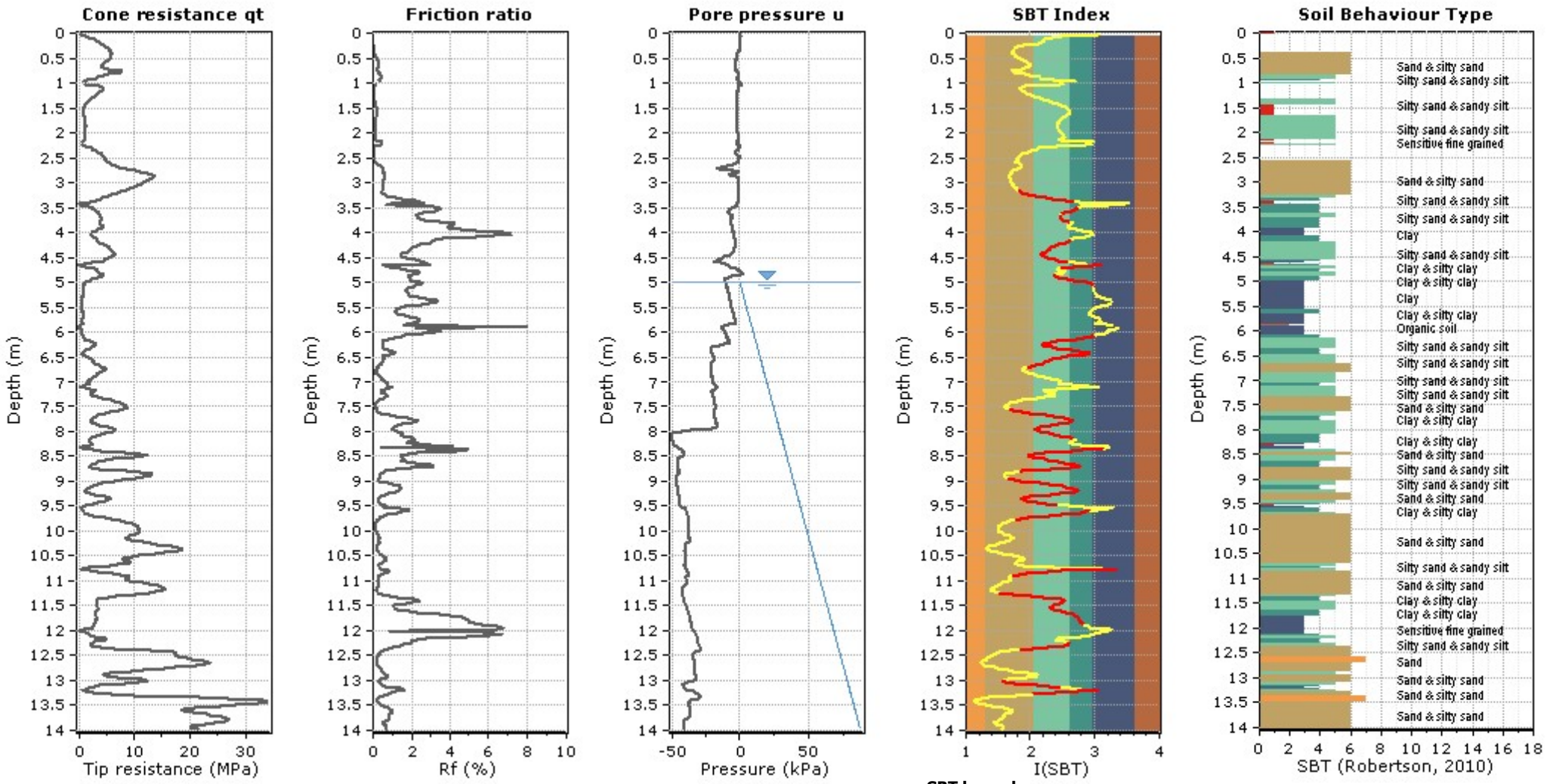

The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

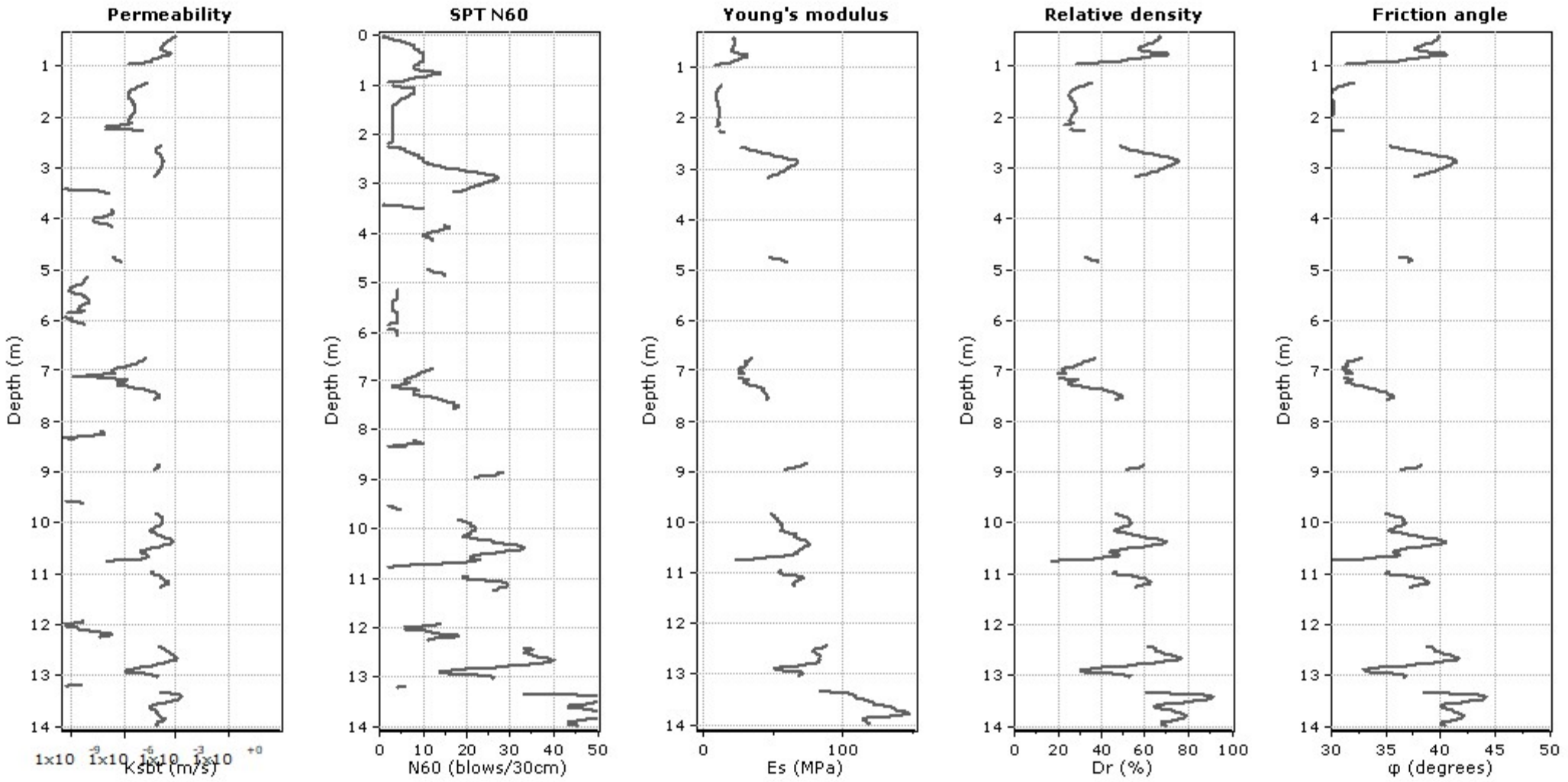
**CPT: CPT1**
Total depth: 13.98 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT1**
Total depth: 13.98 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



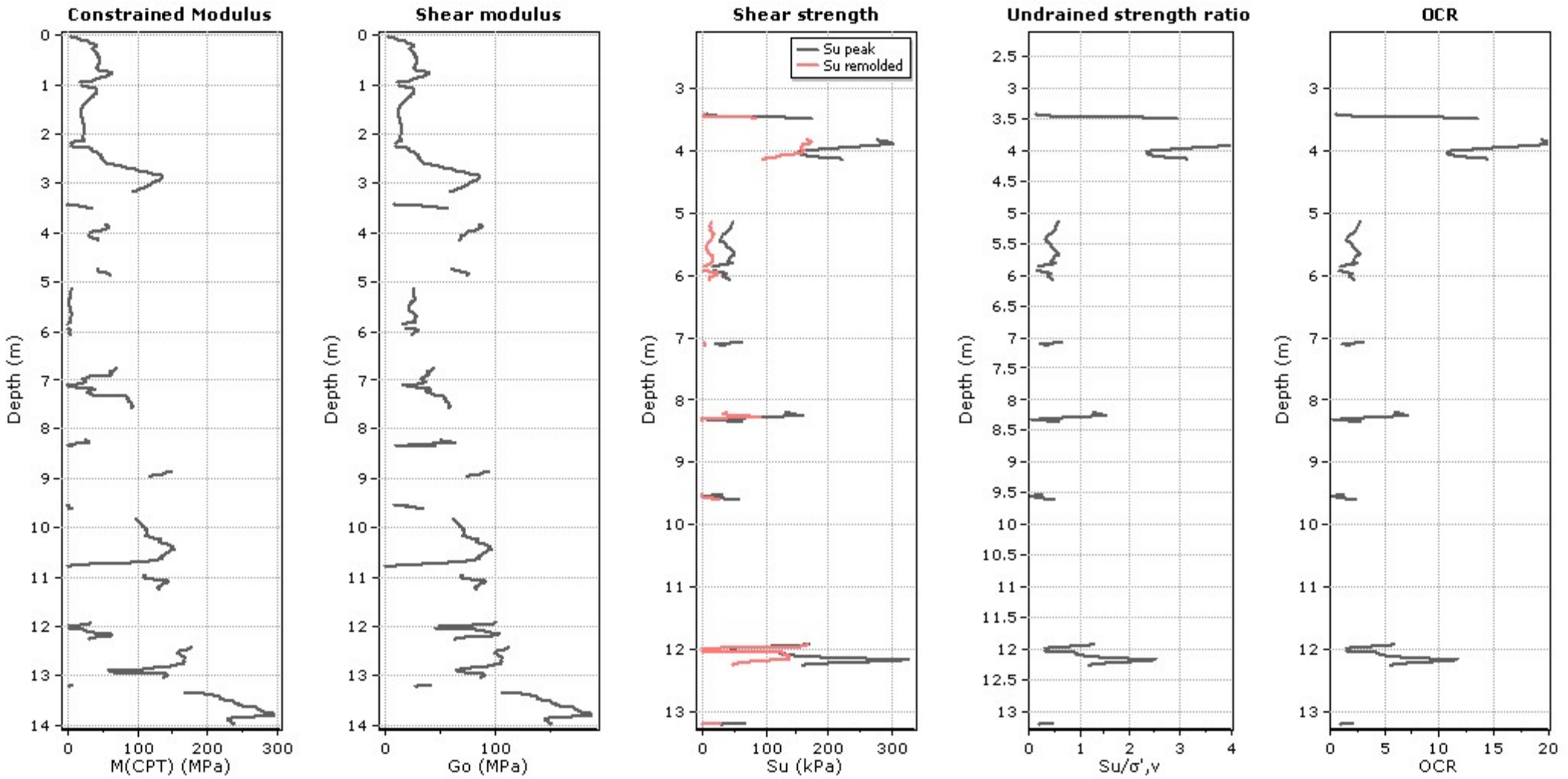

**Calculation parameters**

Permeability: Based on $SBT_n$
SPT $N_{60}$: Based on $I_c$ and $q_t$
Young's modulus: Based on variable alpha using $I_c$ (Robertson, 2009)
Relative density constant, $C_{Dr}$: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT1**
Total depth: 13.98 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



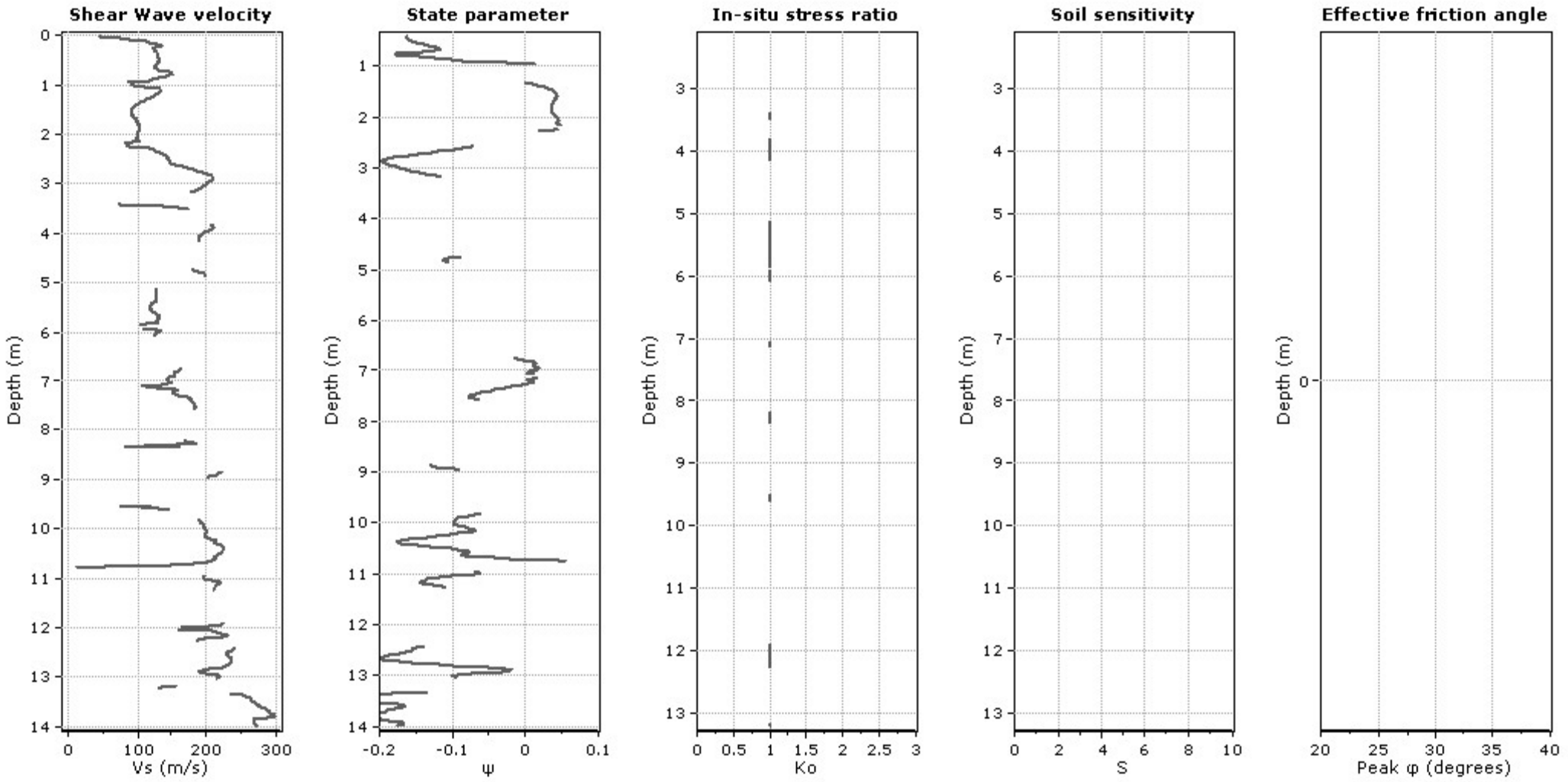

**Calculation parameters**

Constrained modulus: Based on variable alpha using $I_c$ and $Q_{tn}$ (Robertson, 2009)
Go: Based on variable alpha using $I_c$ (Robertson, 2009)
Undrained shear strength cone factor for clays, $N_{kt}$: 14
OCR factor for clays, $N_{kt}$: 0.33
User defined estimation data
Flat Dilatometer Test data

**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT1**
Total depth: 13.98 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




**Calculation parameters**

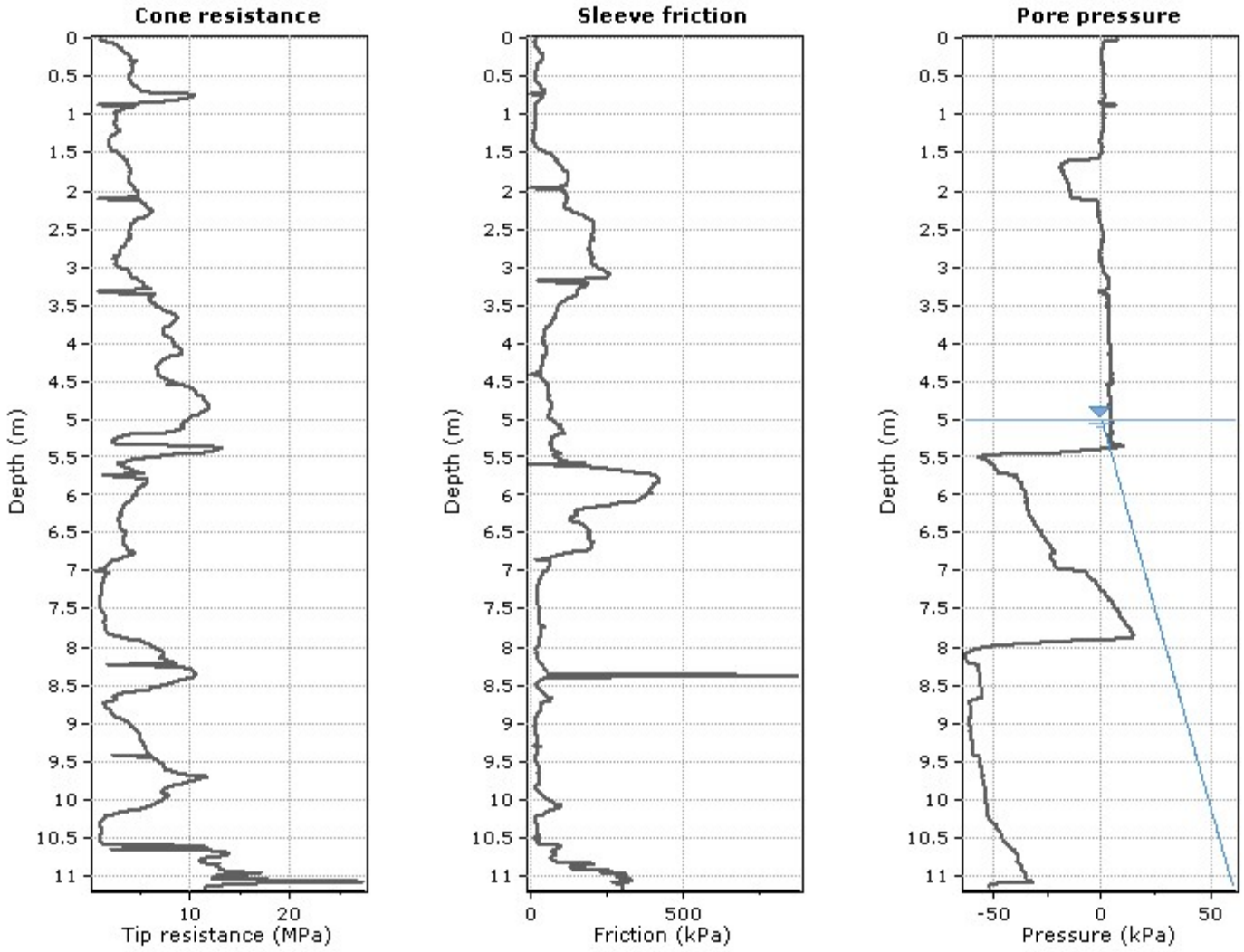
Soil Sensitivity factor, $N_S$: 350.00

User defined estimation data

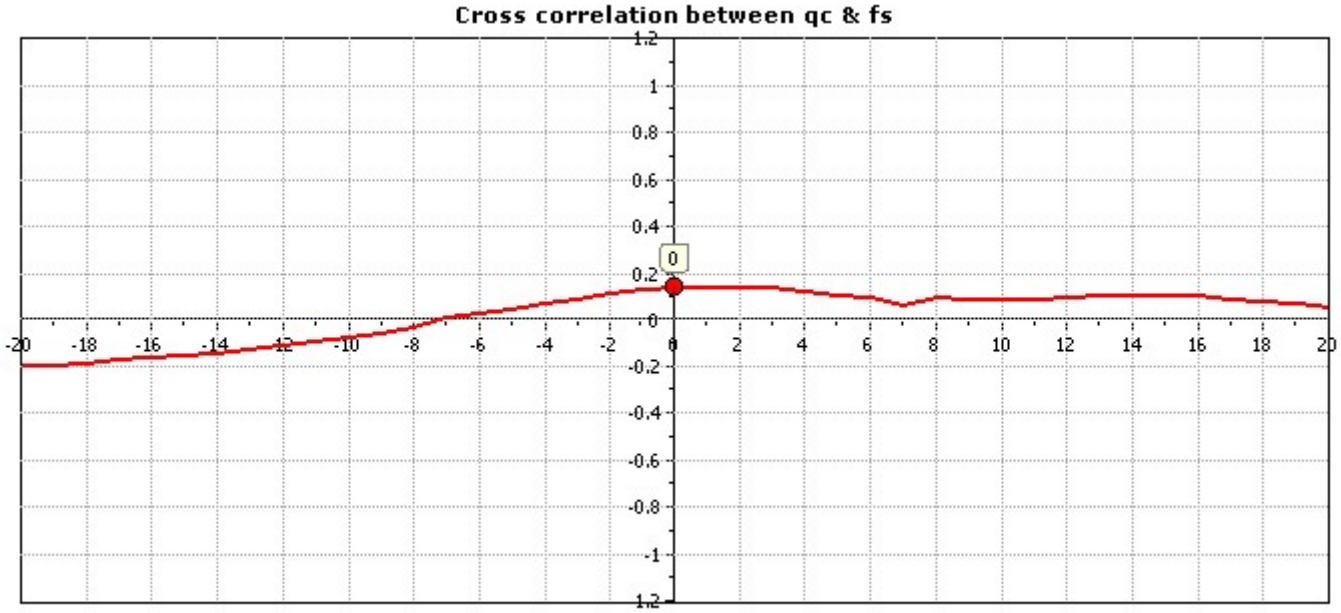
**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT2**
Total depth: 11.14 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



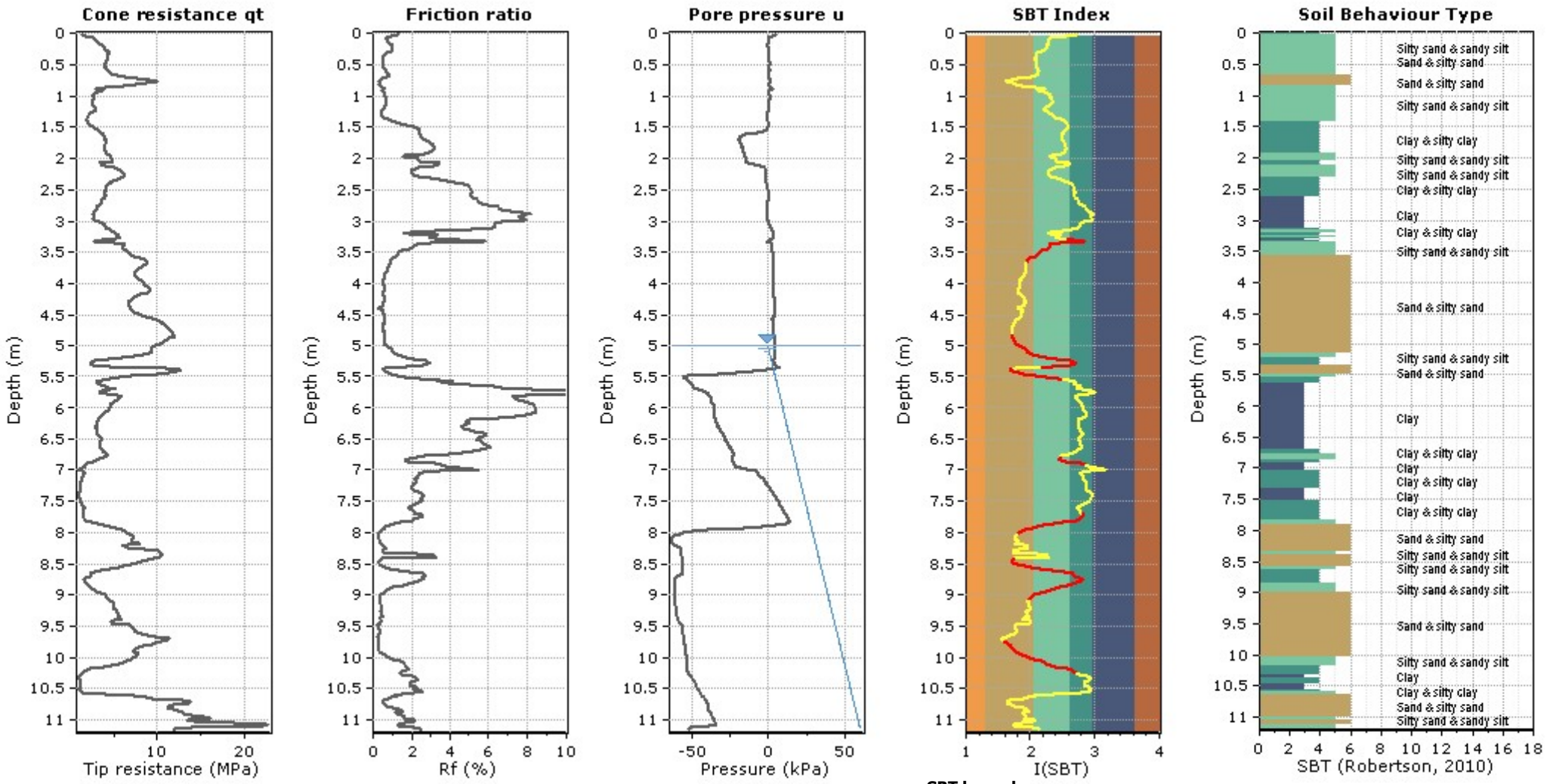

The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

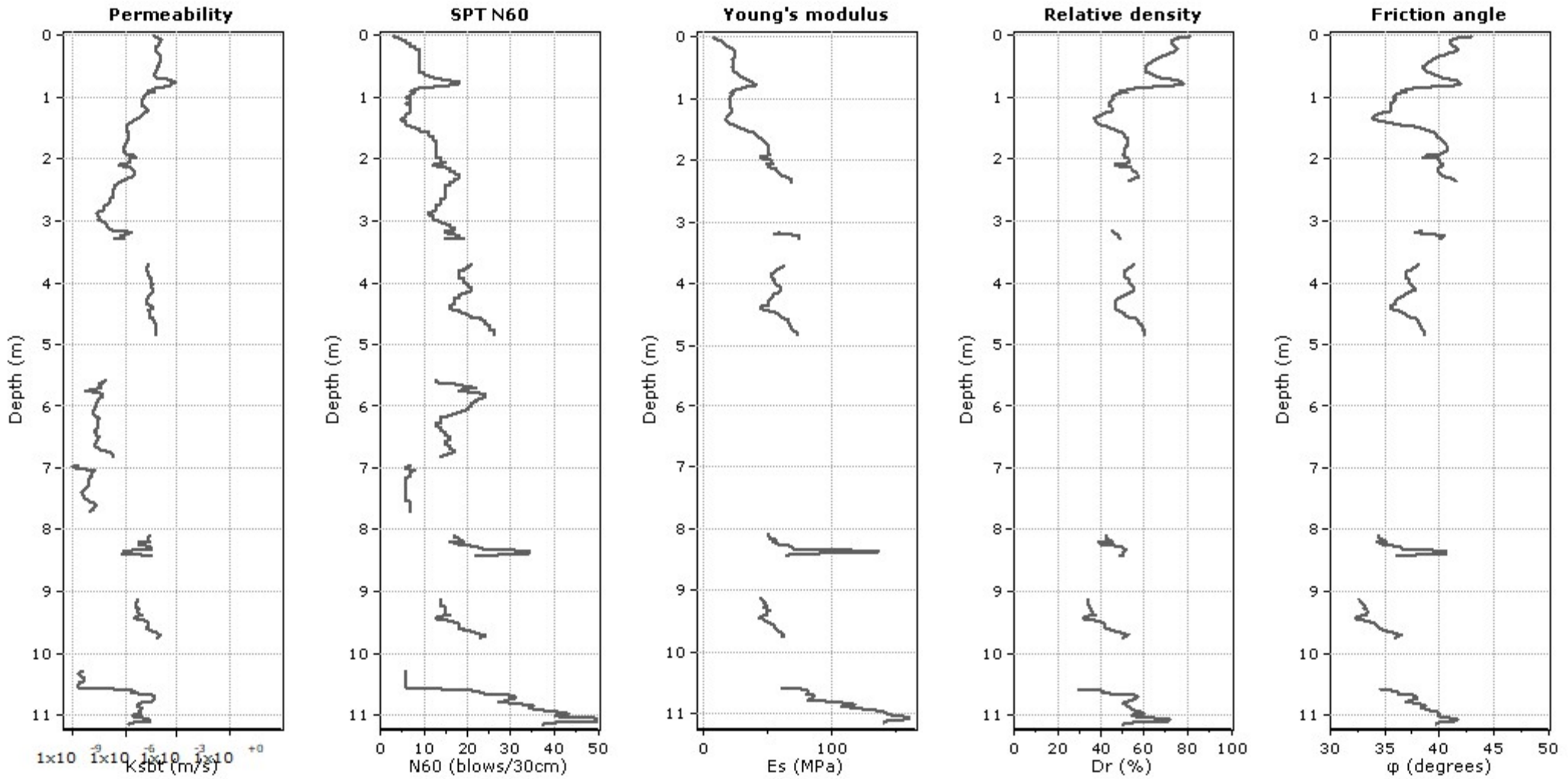
**CPT: CPT2**
Total depth: 11.14 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT2**
Total depth: 11.14 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



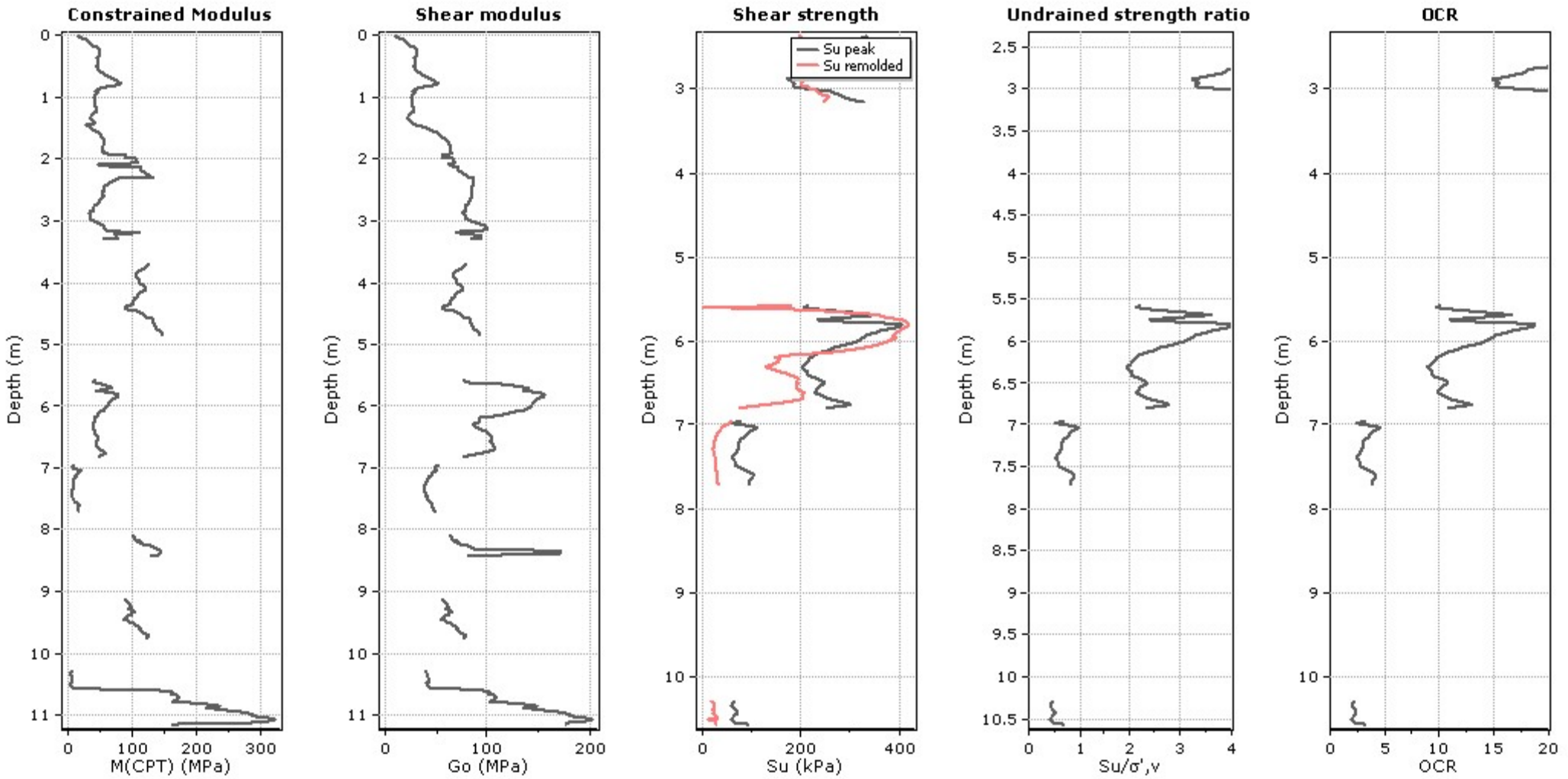

**Calculation parameters**

Permeability: Based on $SBT_n$
SPT $N_{60}$: Based on $I_c$ and $q_t$
Young's modulus: Based on variable alpha using $I_c$ (Robertson, 2009)
Relative density constant, $C_{Dr}$: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT2**
Total depth: 11.14 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



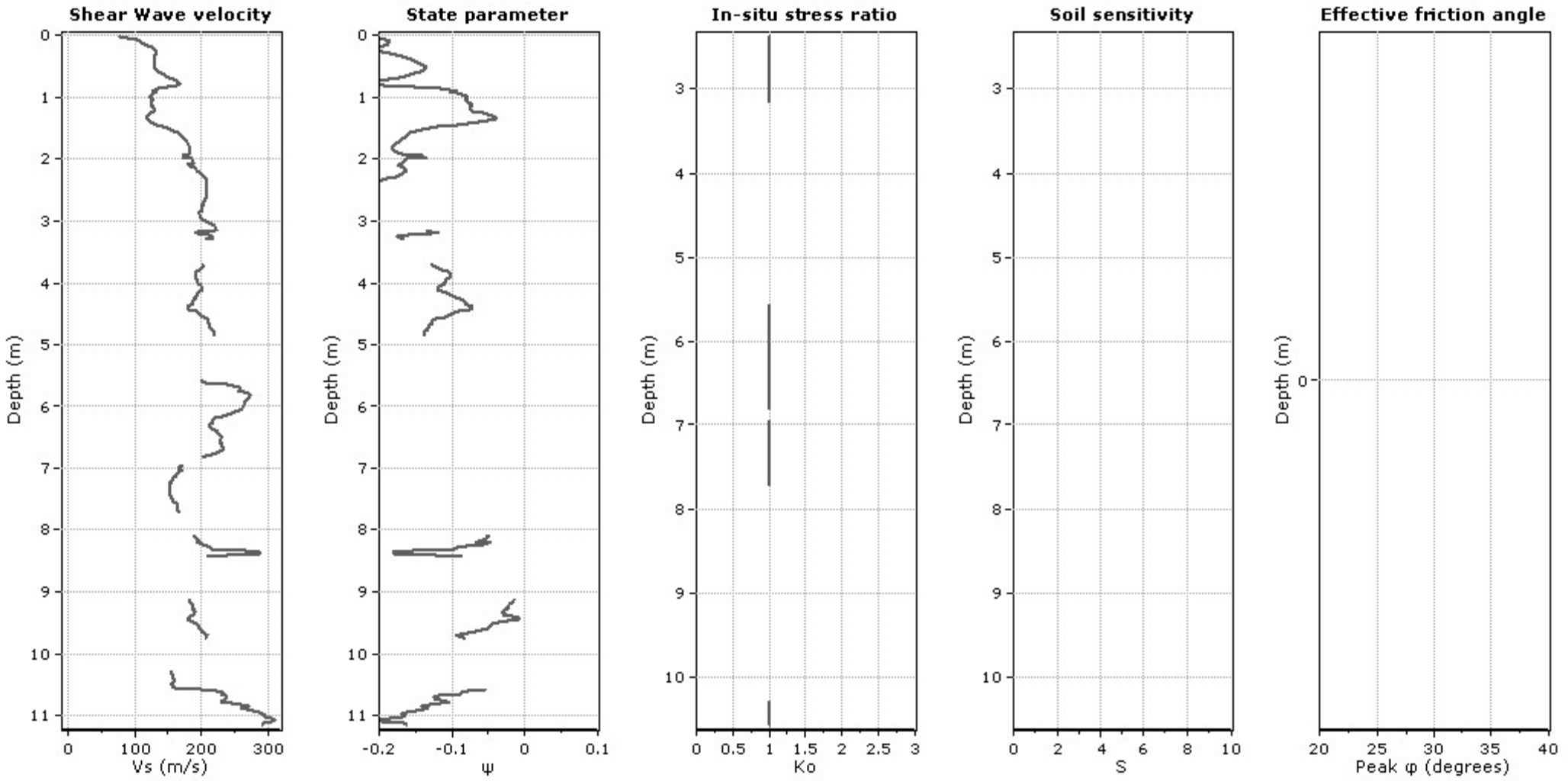

**Calculation parameters**

Constrained modulus: Based on variable alpha using $I_c$ and $Q_{tn}$ (Robertson, 2009)
Go: Based on variable alpha using $I_c$ (Robertson, 2009)
Undrained shear strength cone factor for clays, $N_{kt}$: 14
OCR factor for clays, $N_{kt}$: 0.33
User defined estimation data
Flat Dilatometer Test data

**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT2**
Total depth: 11.14 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




**Calculation parameters**

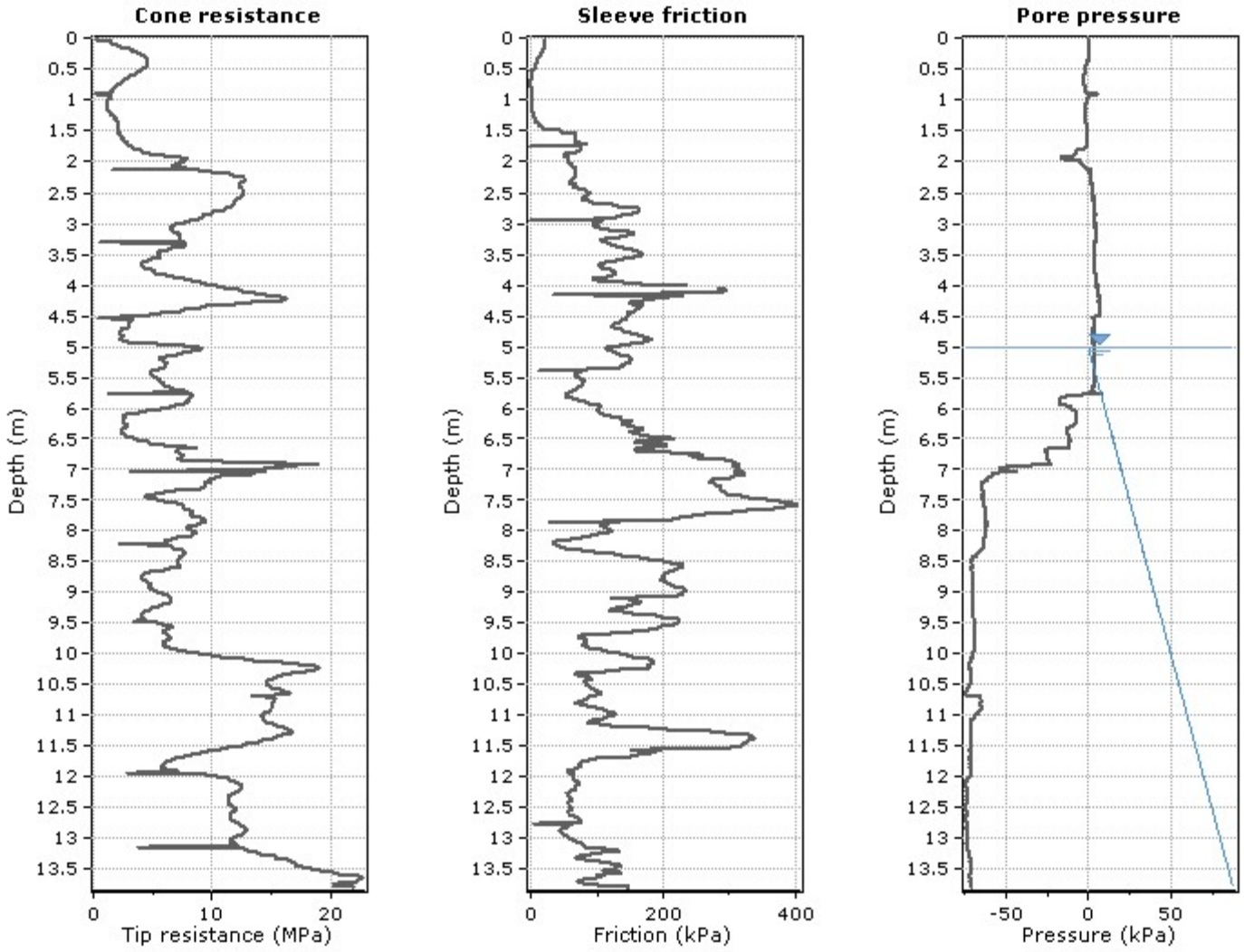
Soil Sensitivity factor, $N_S$: 350.00

User defined estimation data

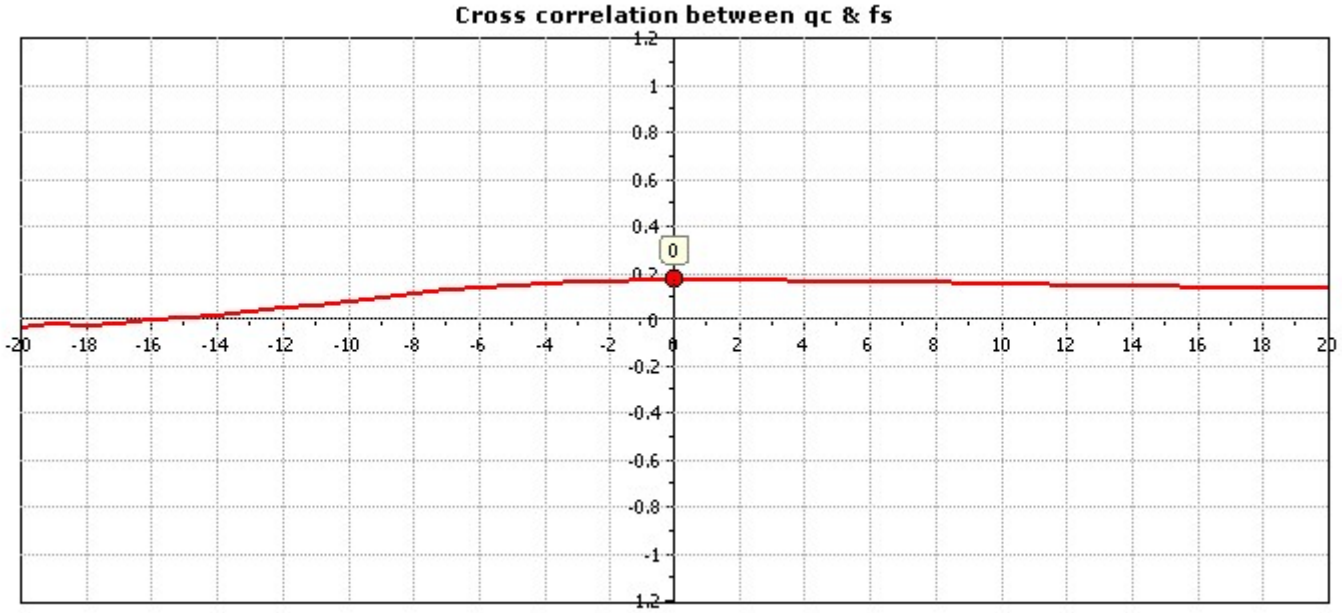
**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT3**
Total depth: 13.78 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



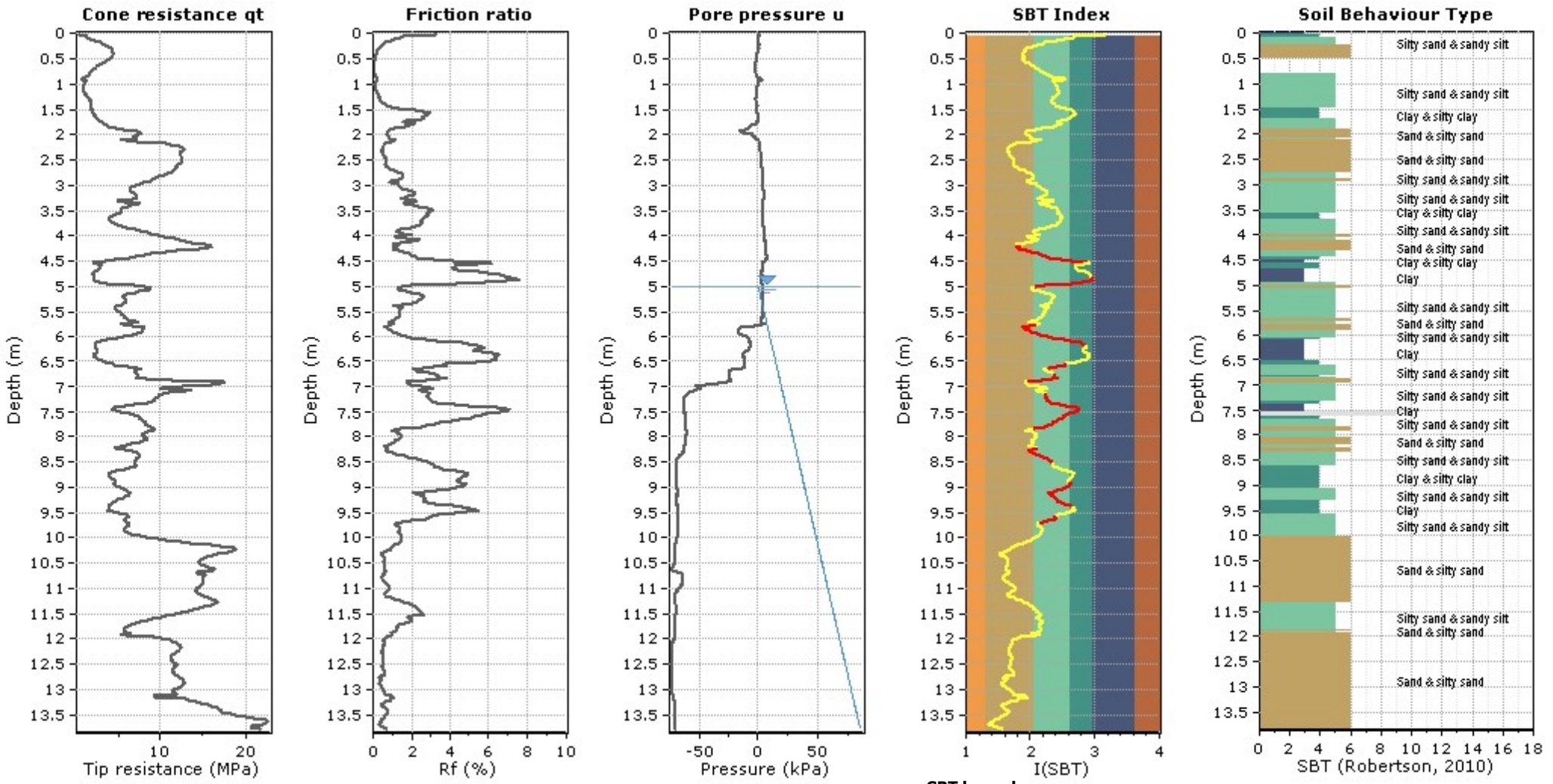

The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

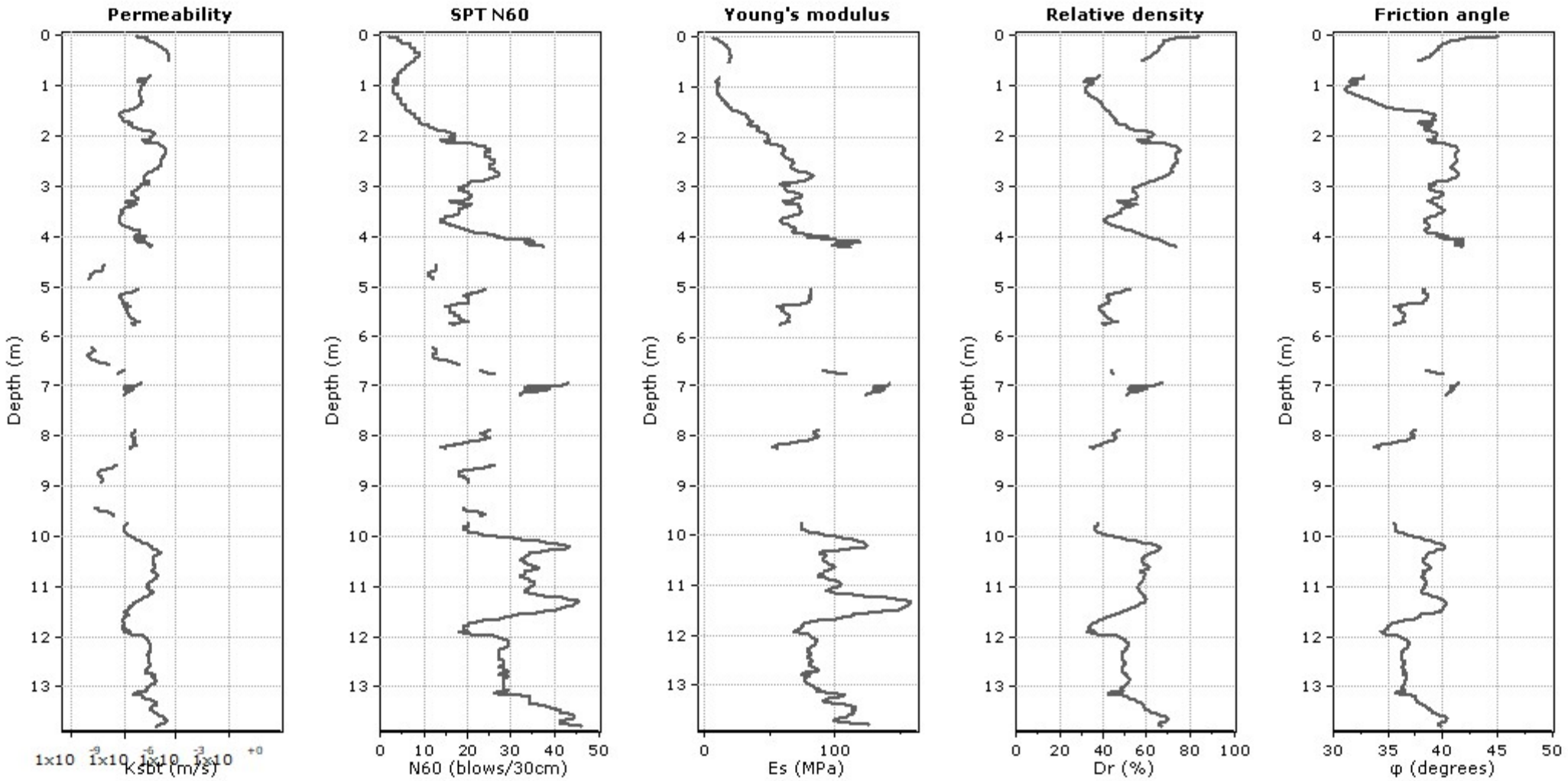
**CPT: CPT3**
Total depth: 13.78 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT3**
Total depth: 13.78 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



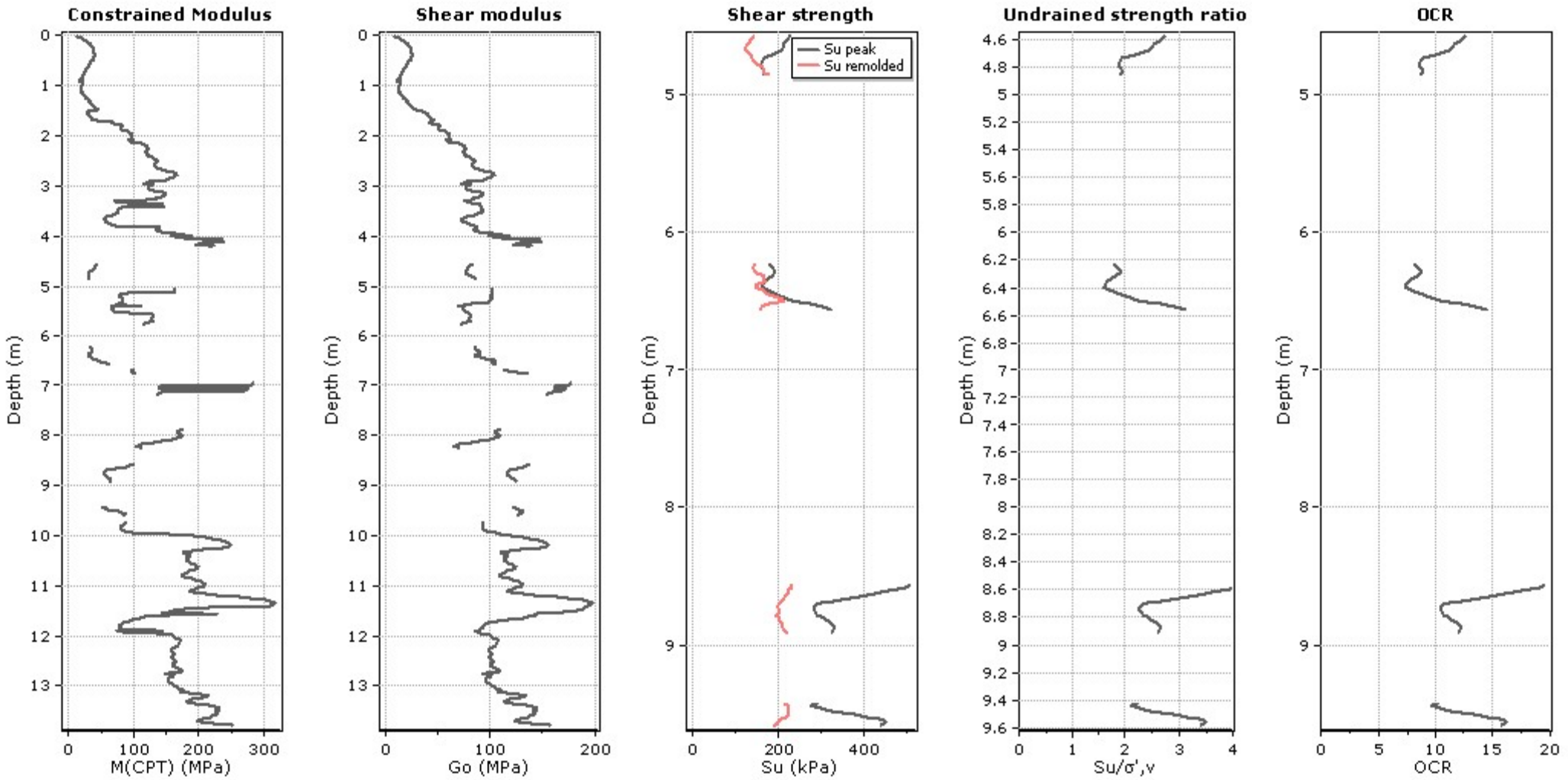

**Calculation parameters**

Permeability: Based on $SBT_n$
SPT $N_{60}$: Based on $I_c$ and $q_t$
Young's modulus: Based on variable alpha using $I_c$ (Robertson, 2009)
Relative density constant, $C_{Dr}$: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

**Cardno (NSW/ACT) Pty Ltd**
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT3**
Total depth: 13.78 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




**Calculation parameters**

Constrained modulus: Based on variable alpha using $I_c$ and $Q_{tn}$ (Robertson, 2009)
Go: Based on variable alpha using $I_c$ (Robertson, 2009)
Undrained shear strength cone factor for clays, $N_{kt}$: 14
OCR factor for clays, $N_{kt}$: 0.33
User defined estimation data
Flat Dilatometer Test data

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**CPT: CPT3**
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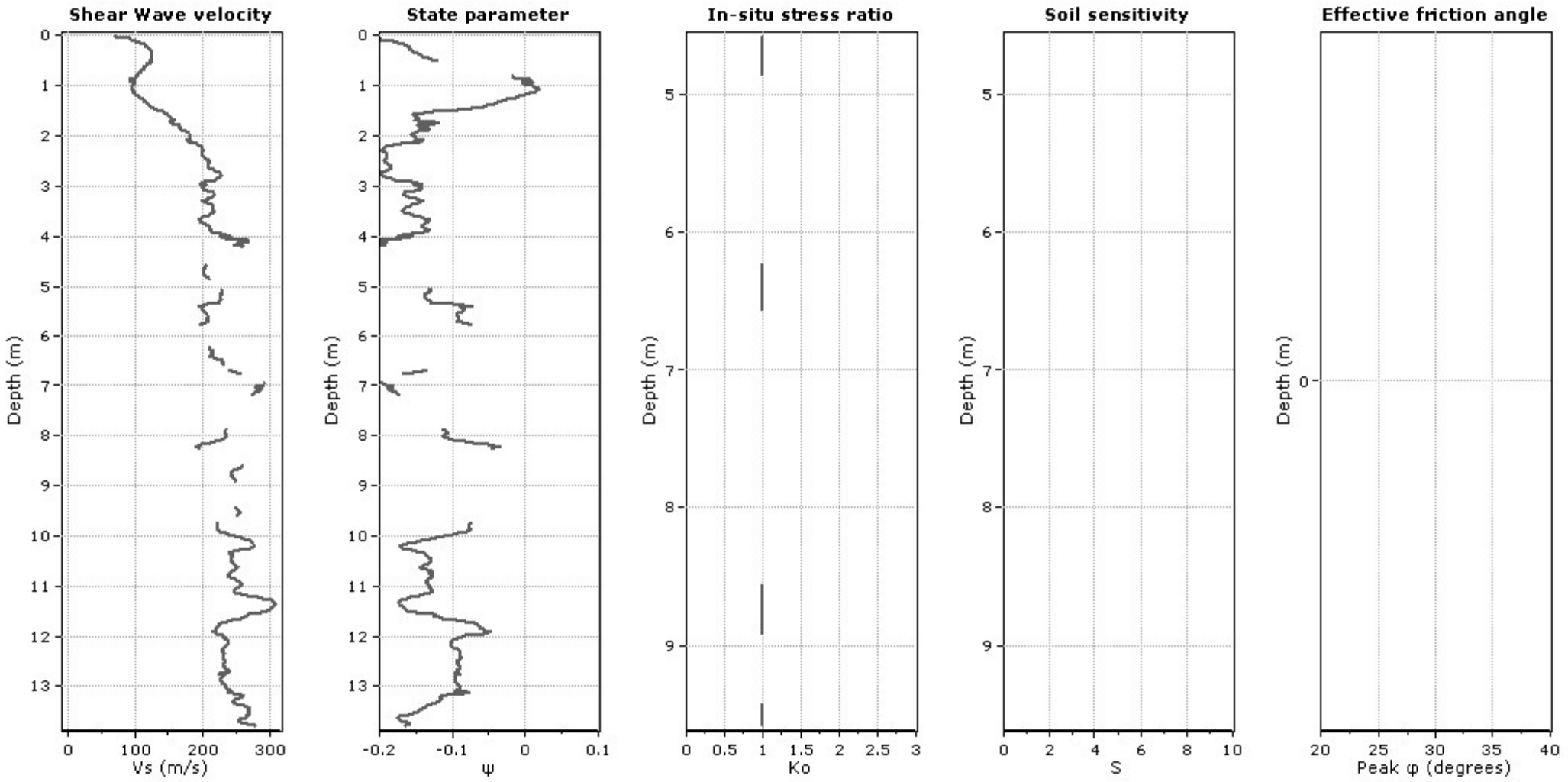
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




**Calculation parameters**

Soil Sensitivity factor, $N_S$: 350.00

User defined estimation data

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L9 The Forum, 203 Pacific Hwy
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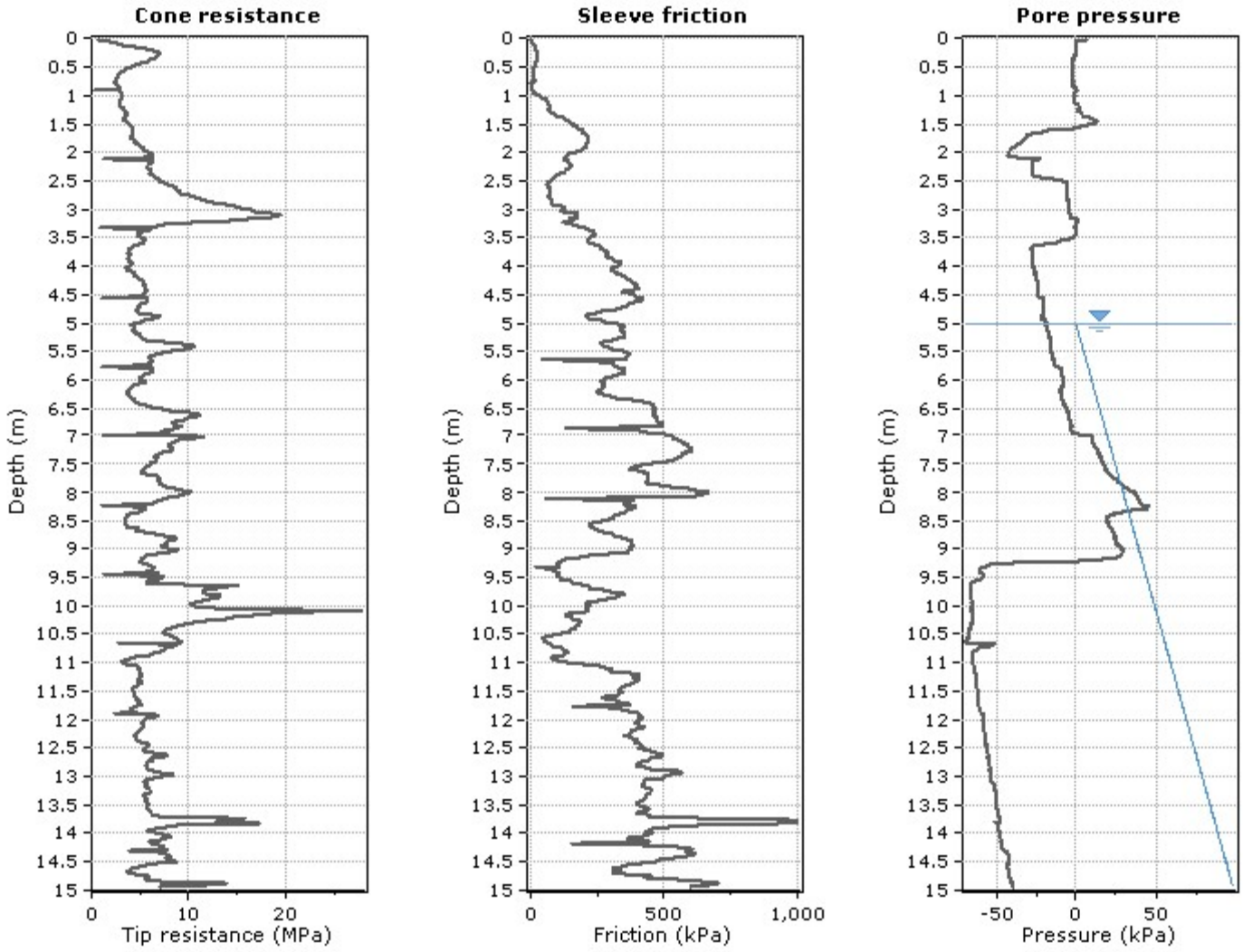
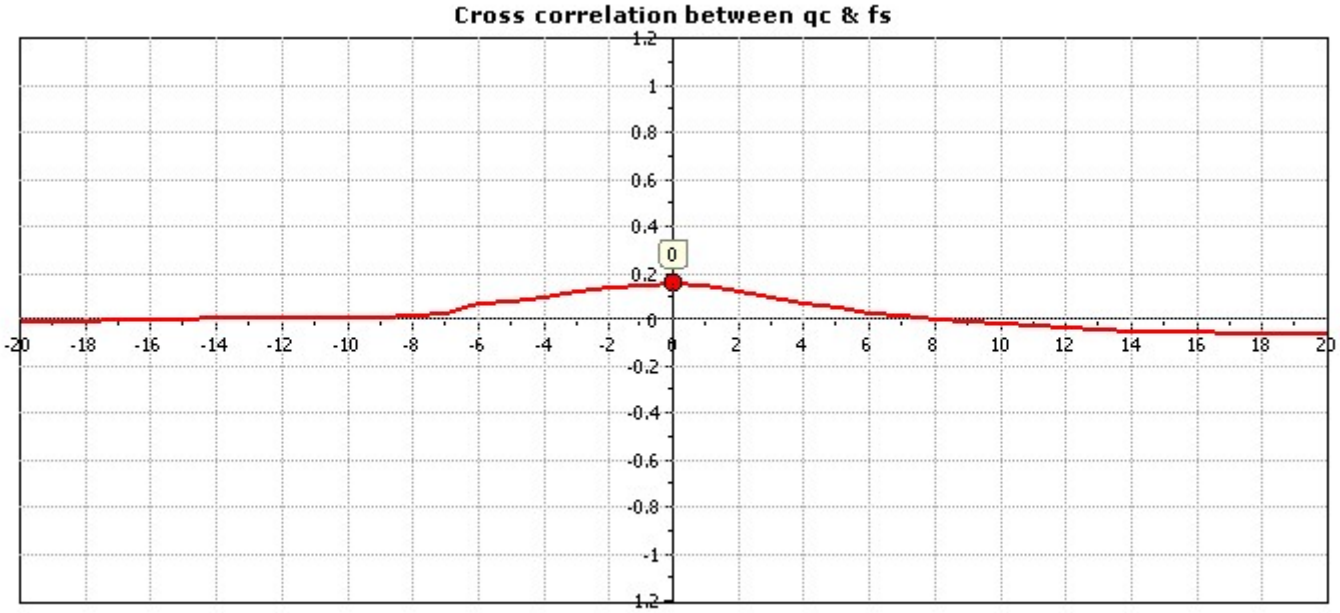
**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT4**
Total depth: 14.94 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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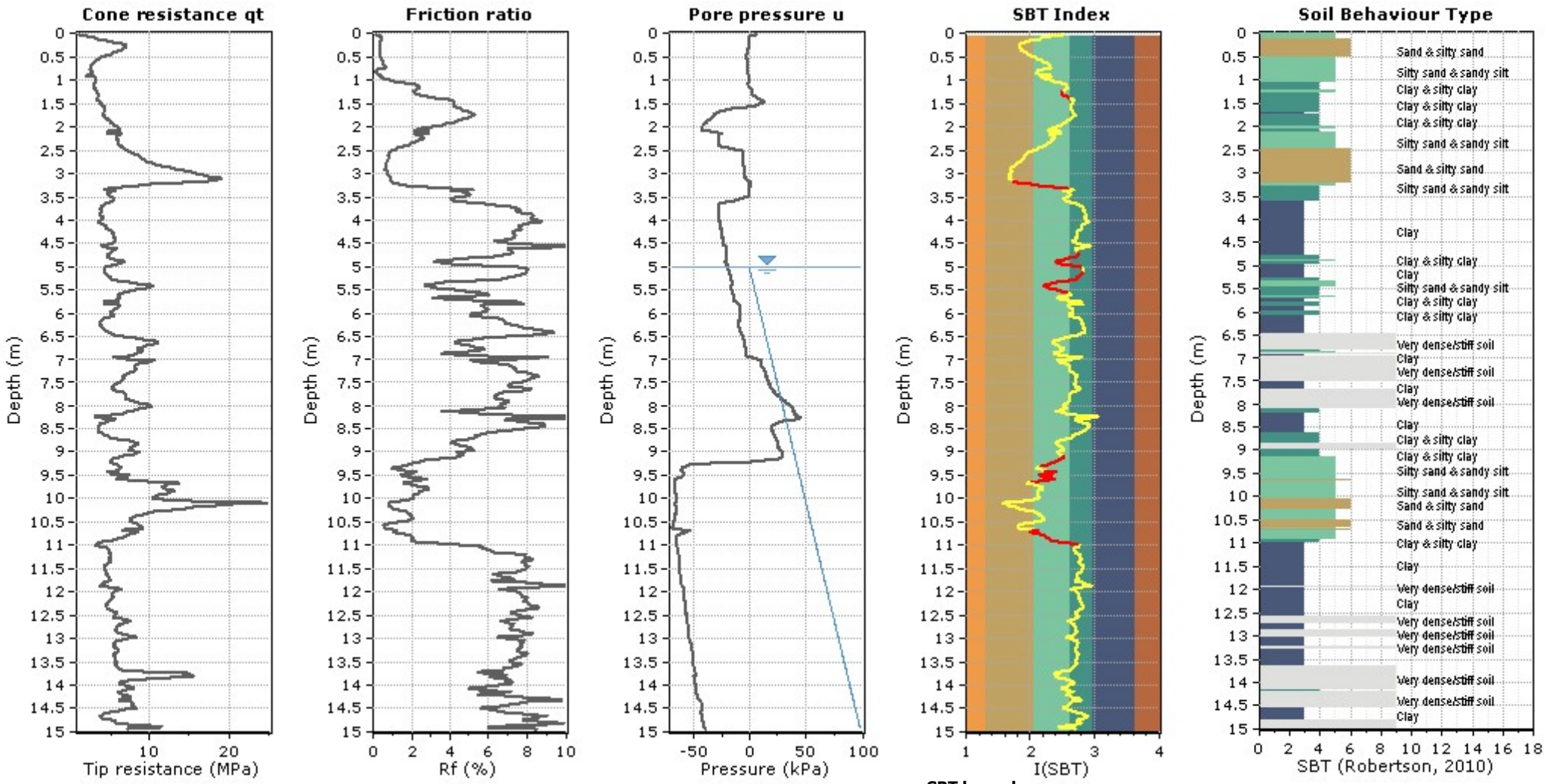
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



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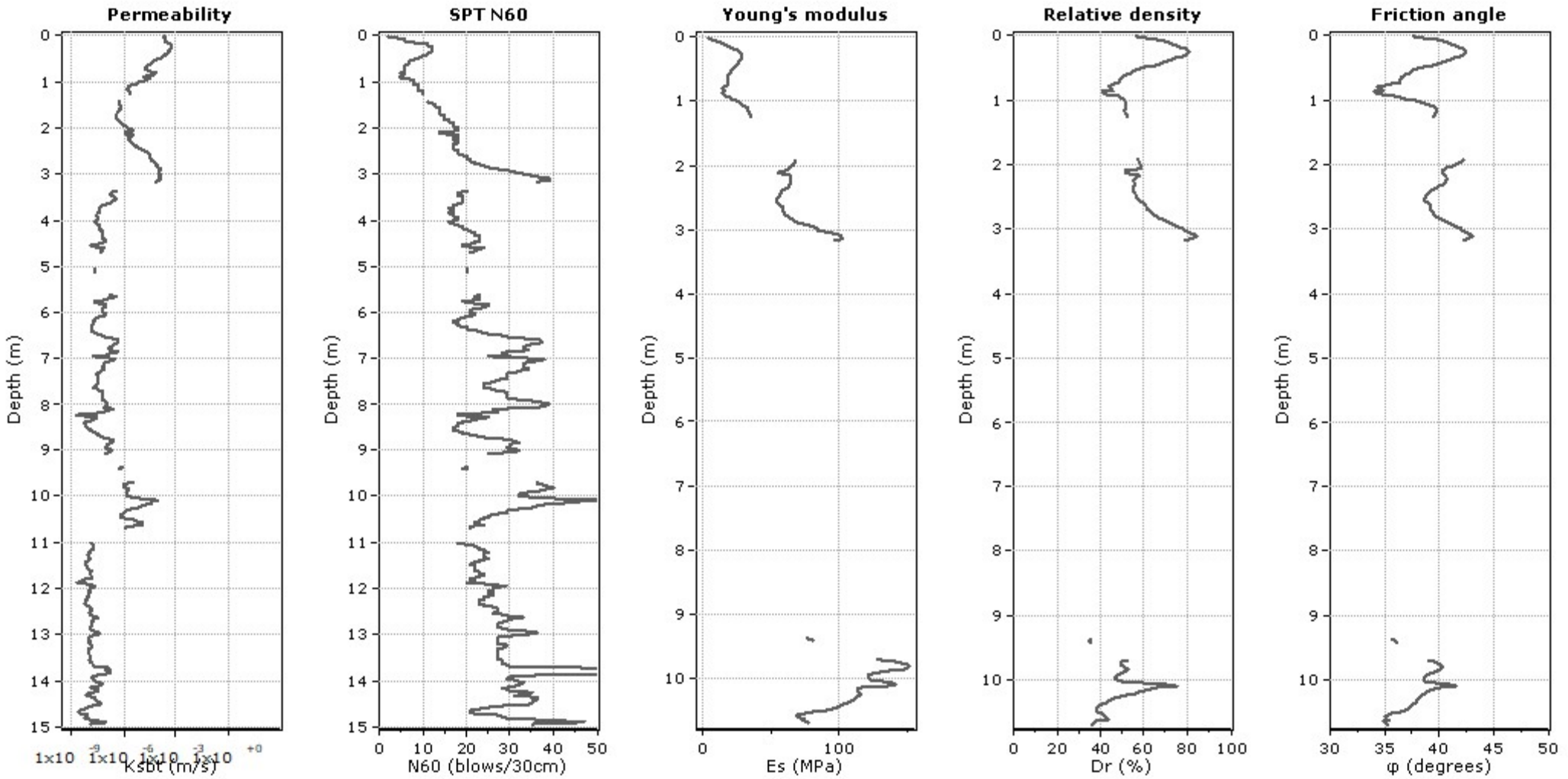
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




**Calculation parameters**

Permeability: Based on $SBT_n$
SPT $N_{60}$: Based on $I_c$ and $q_t$
Young's modulus: Based on variable alpha using $I_c$ (Robertson, 2009)
Relative density constant, $C_{Dr}$: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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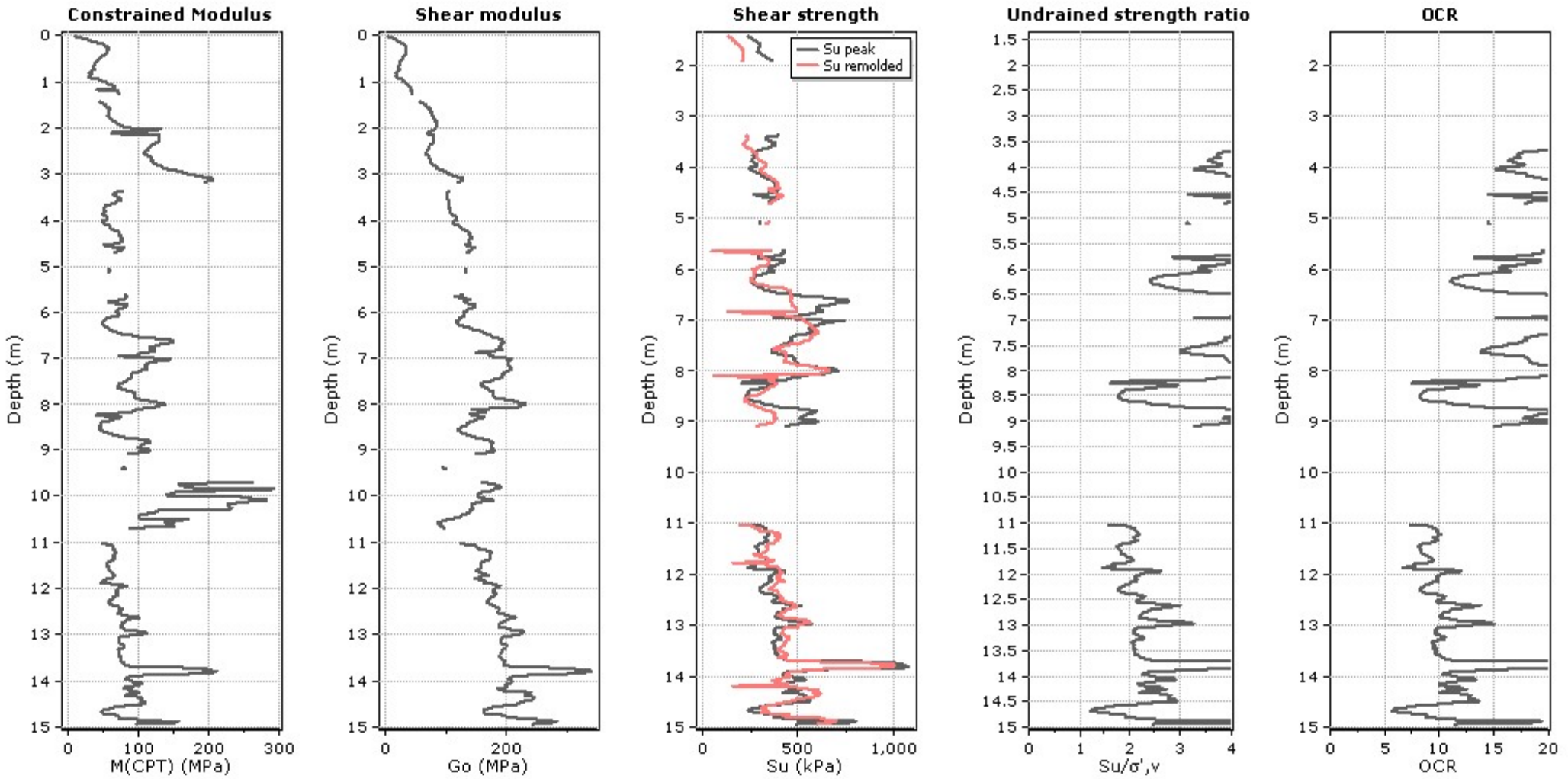


**Calculation parameters**

Constrained modulus: Based on variable alpha using $I_c$ and $Q_{tn}$ (Robertson, 2009)
Go: Based on variable alpha using $I_c$ (Robertson, 2009)
Undrained shear strength cone factor for clays, $N_{kt}$: 14
OCR factor for clays, $N_{kt}$: 0.33
User defined estimation data
Flat Dilatometer Test data

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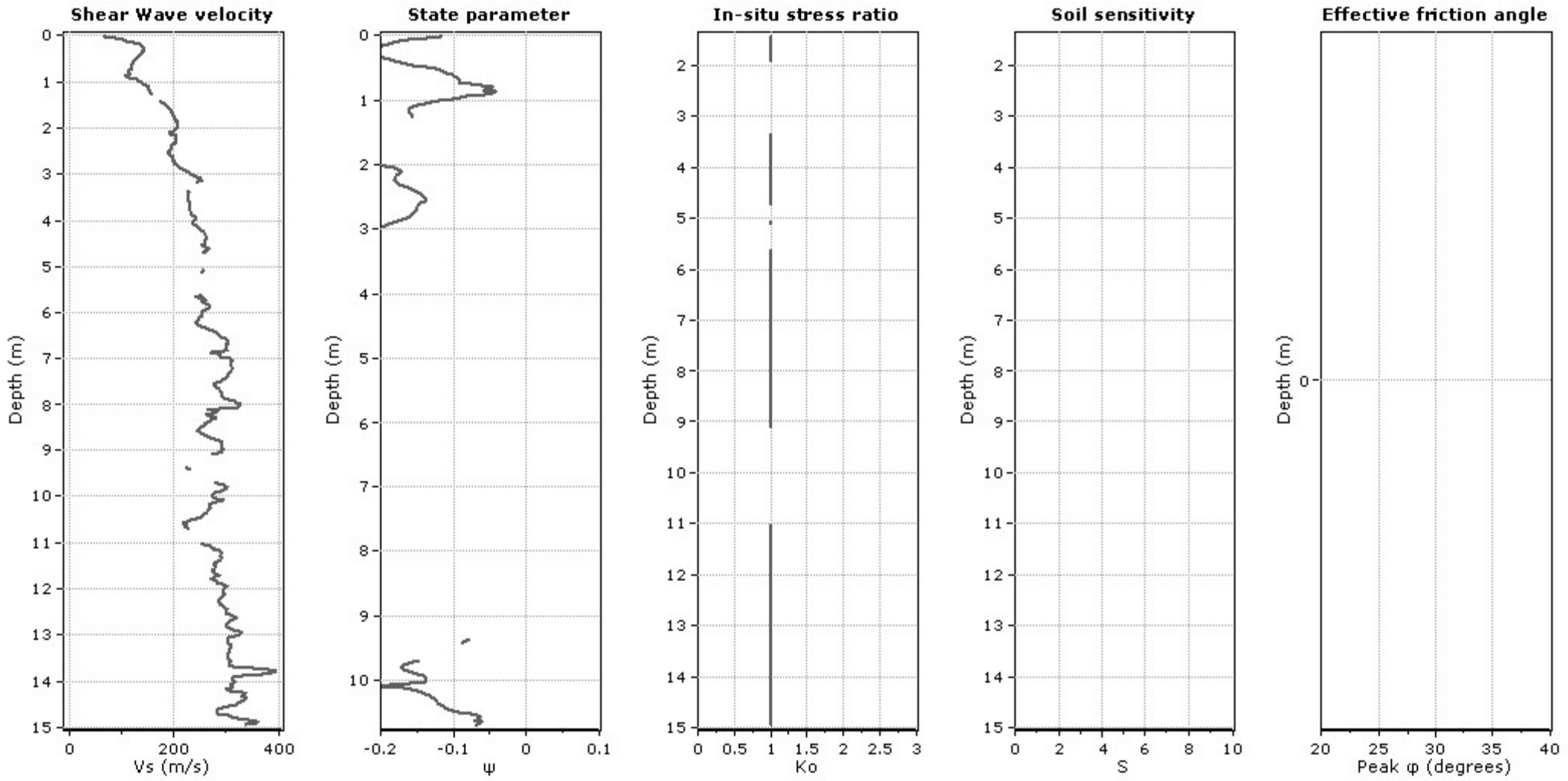
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




**Calculation parameters**

Soil Sensitivity factor, $N_S$: 350.00

User defined estimation data

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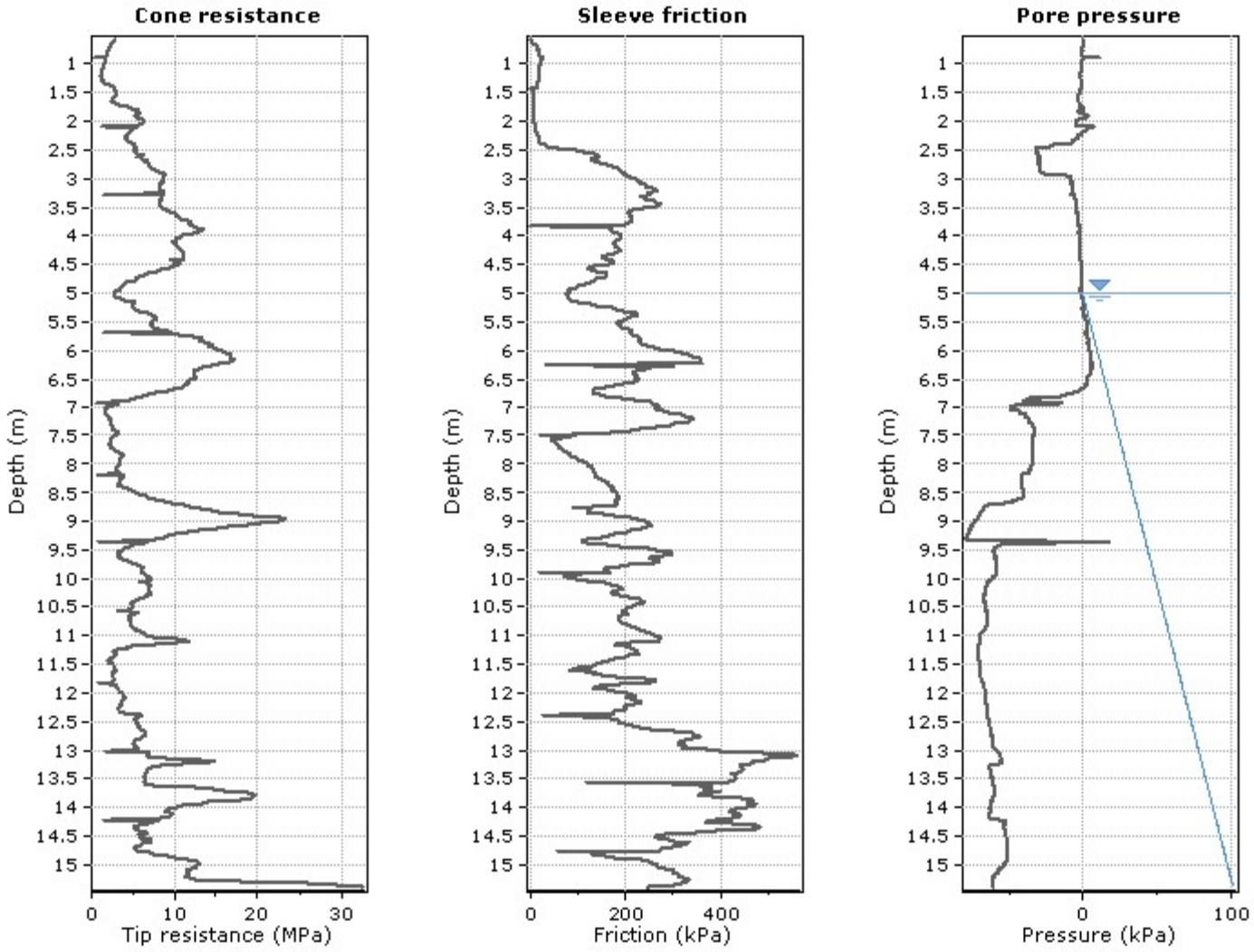
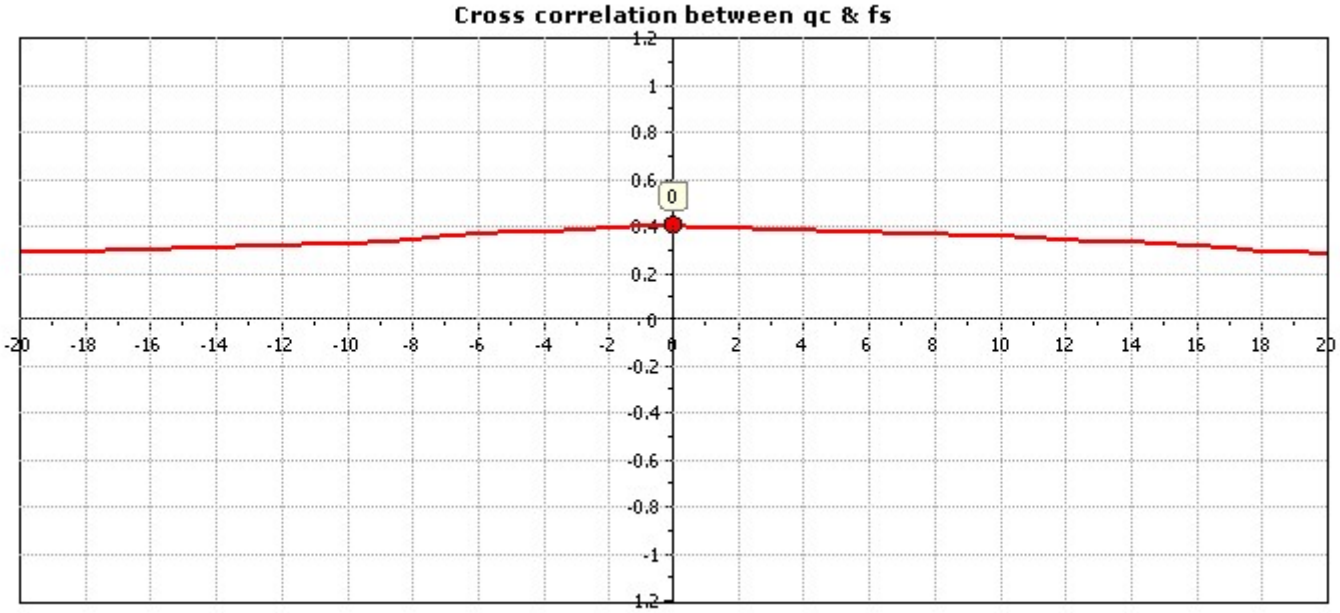
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT5**
Total depth: 15.38 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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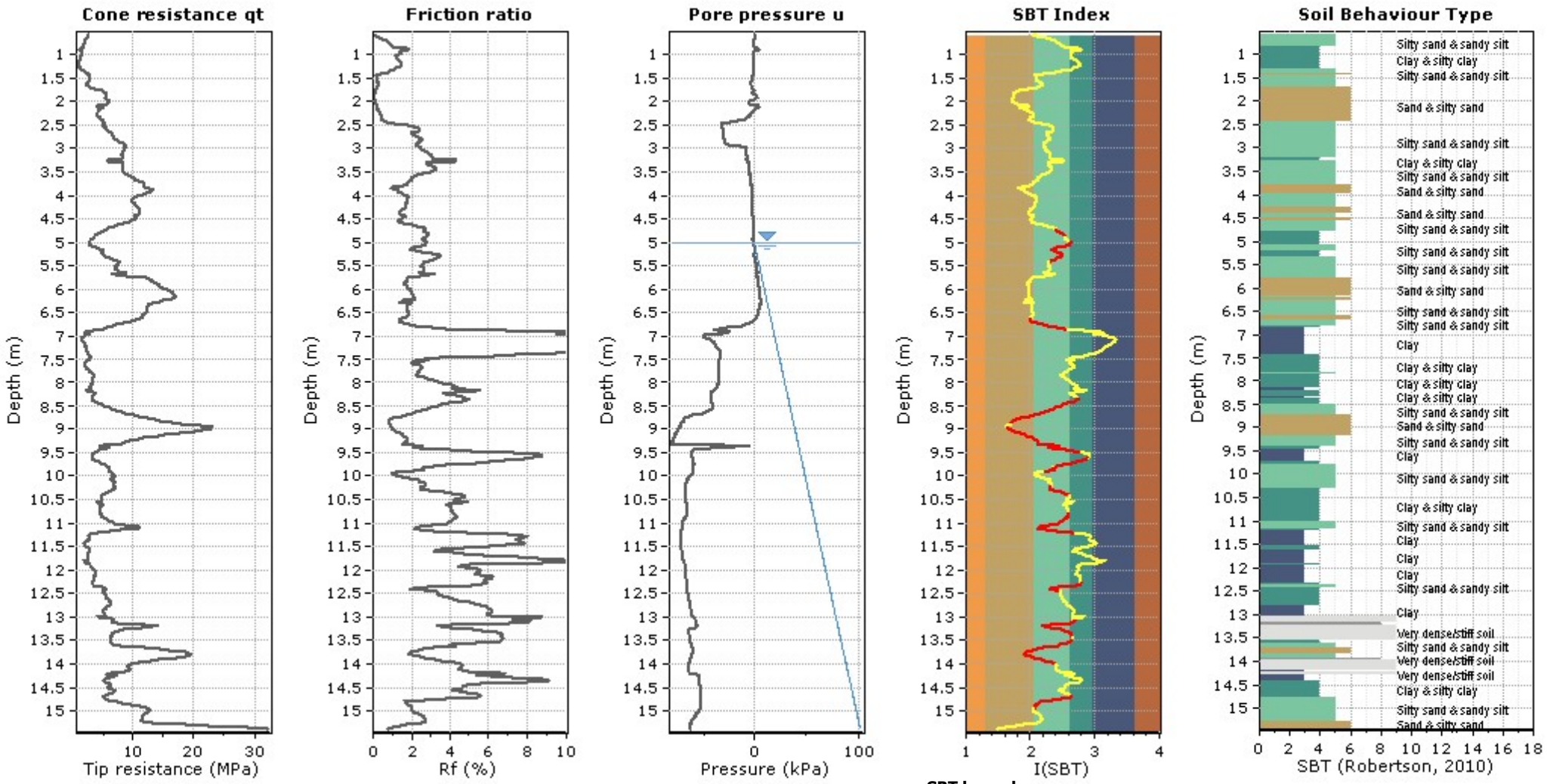
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT5**
Total depth: 15.38 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR



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Cone Type: Geotech NOVA 10cm2
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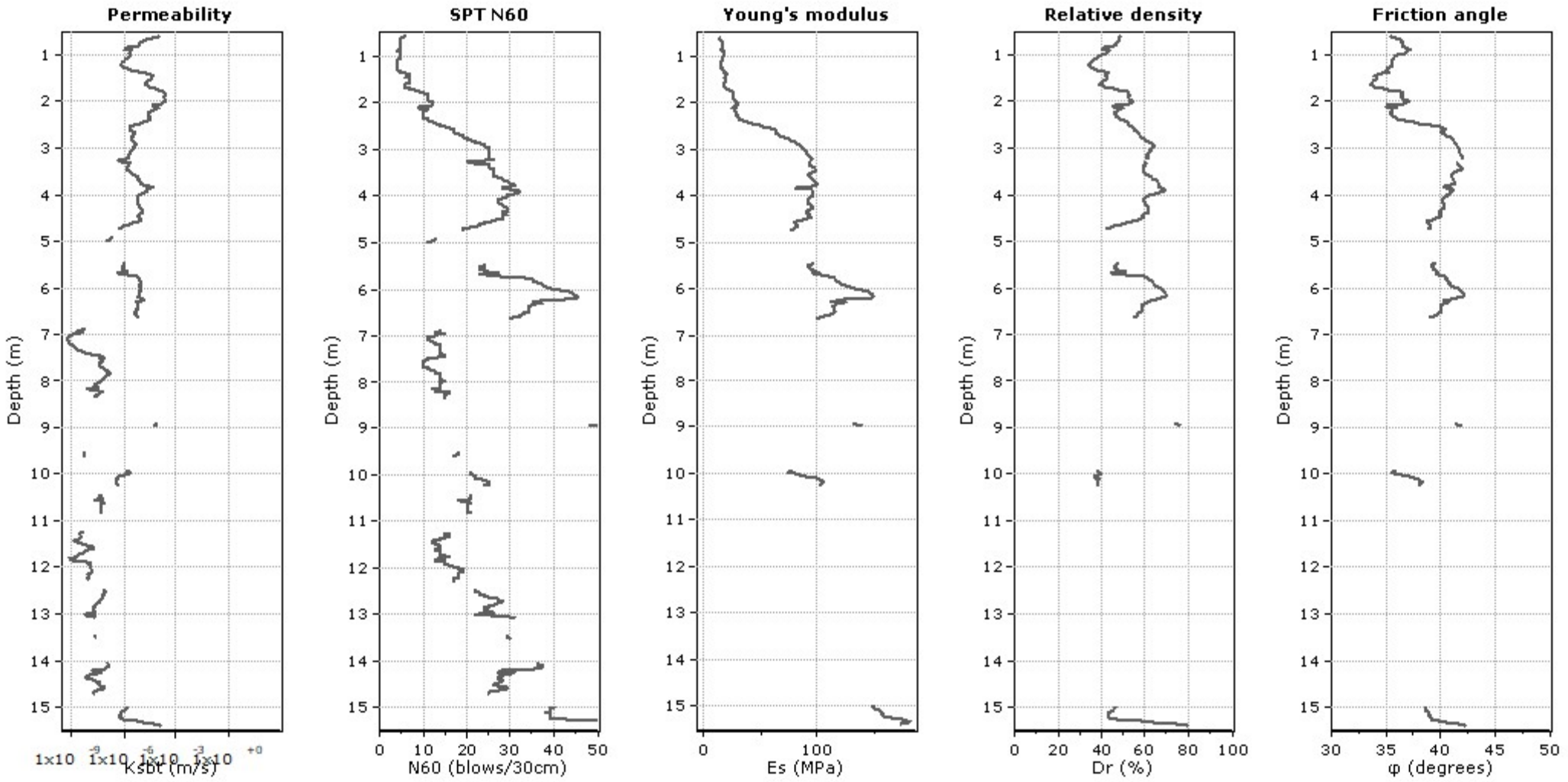


**Calculation parameters**

Permeability: Based on $SBT_n$
SPT $N_{60}$: Based on $I_c$ and $q_t$
Young's modulus: Based on variable alpha using $I_c$ (Robertson, 2009)
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Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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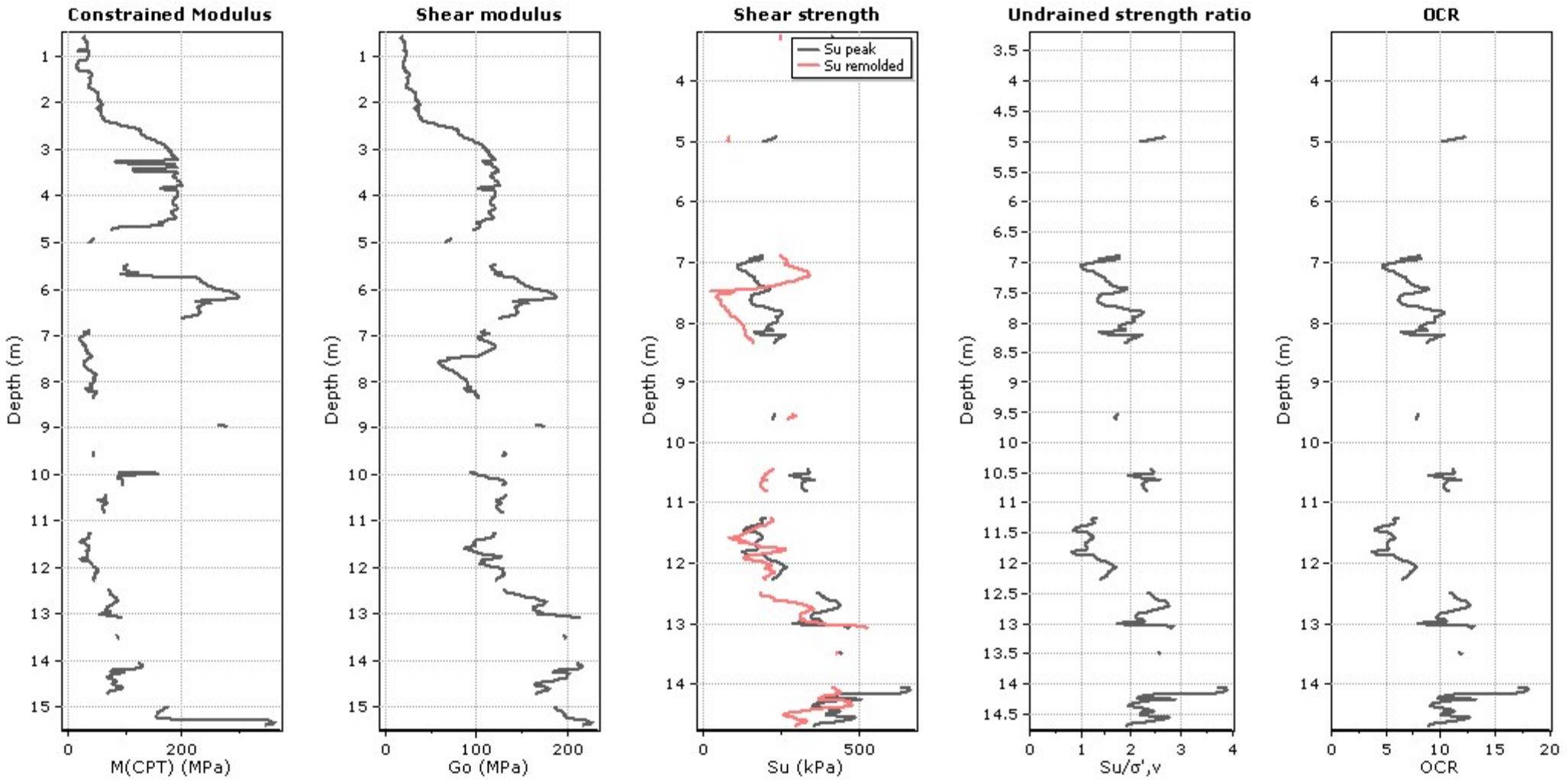


**Calculation parameters**

Constrained modulus: Based on variable alpha using $I_c$ and $Q_{tn}$ (Robertson, 2009)
Go: Based on variable alpha using $I_c$ (Robertson, 2009)
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Flat Dilatometer Test data

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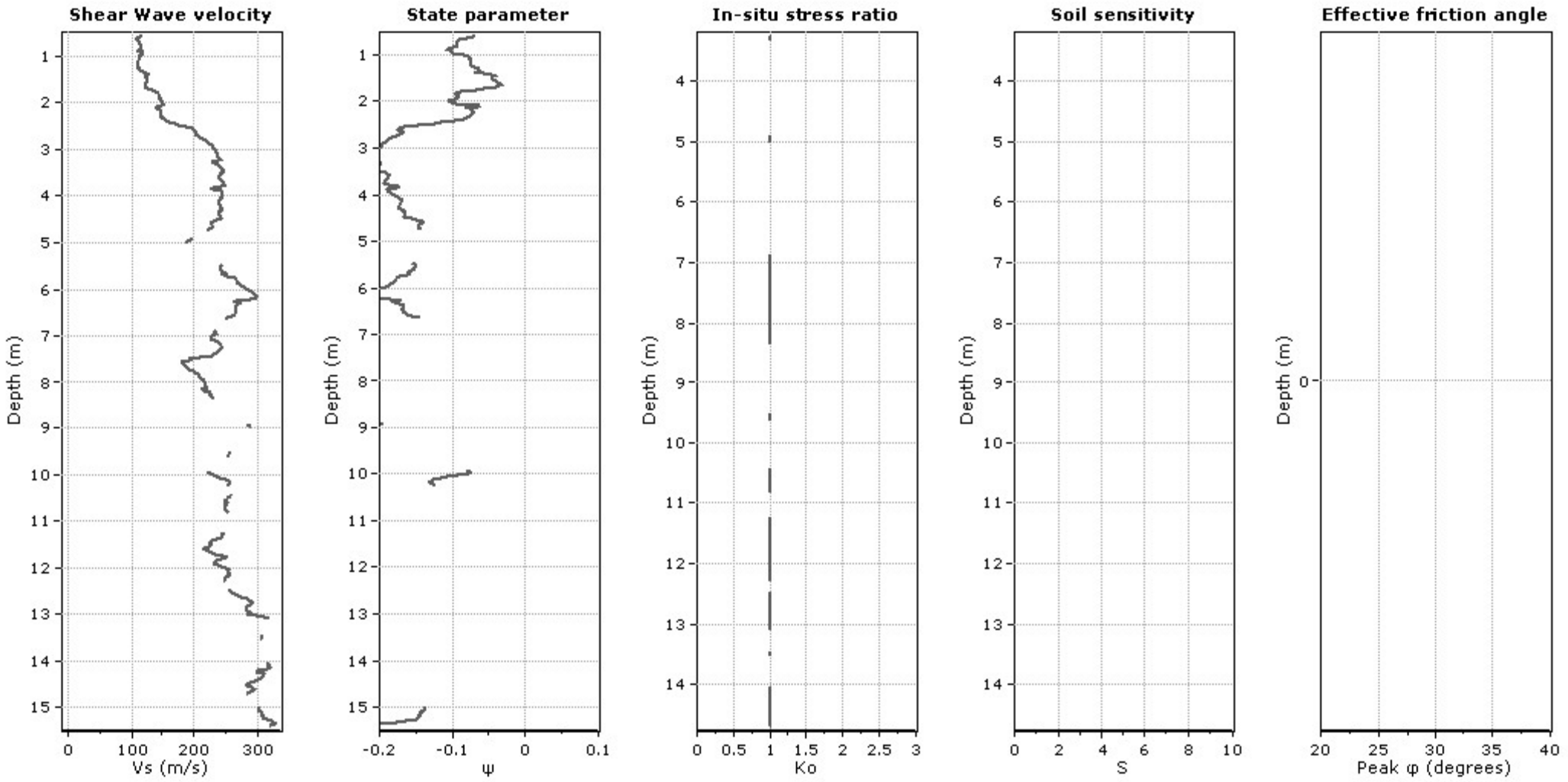


**Calculation parameters**

Soil Sensitivity factor, $N_S$: 350.00

User defined estimation data

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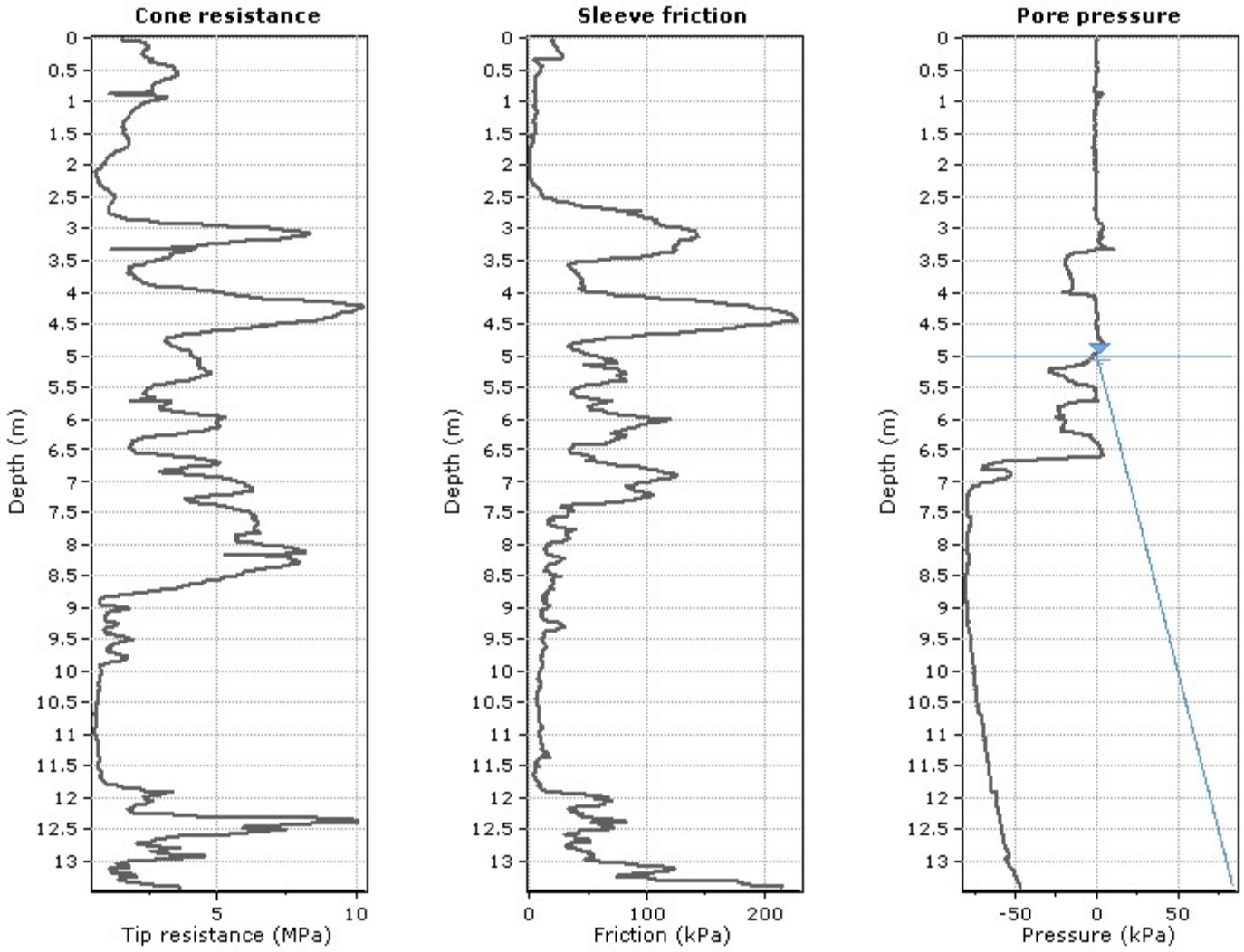
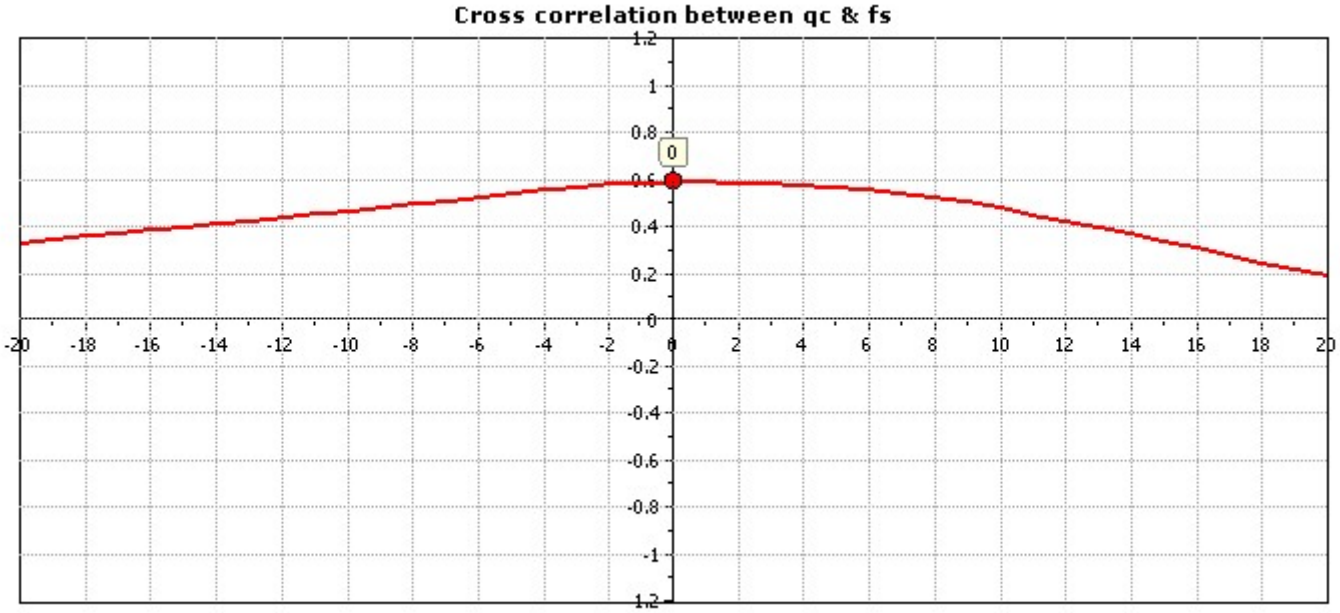
L9 The Forum, 203 Pacific Hwy
St Leonards NSW 2065
https://www.cardno.com/

**Project:** **81022041**
**Location:** **Warriewood NSW**

**CPT: CPT6**
Total depth: 13.40 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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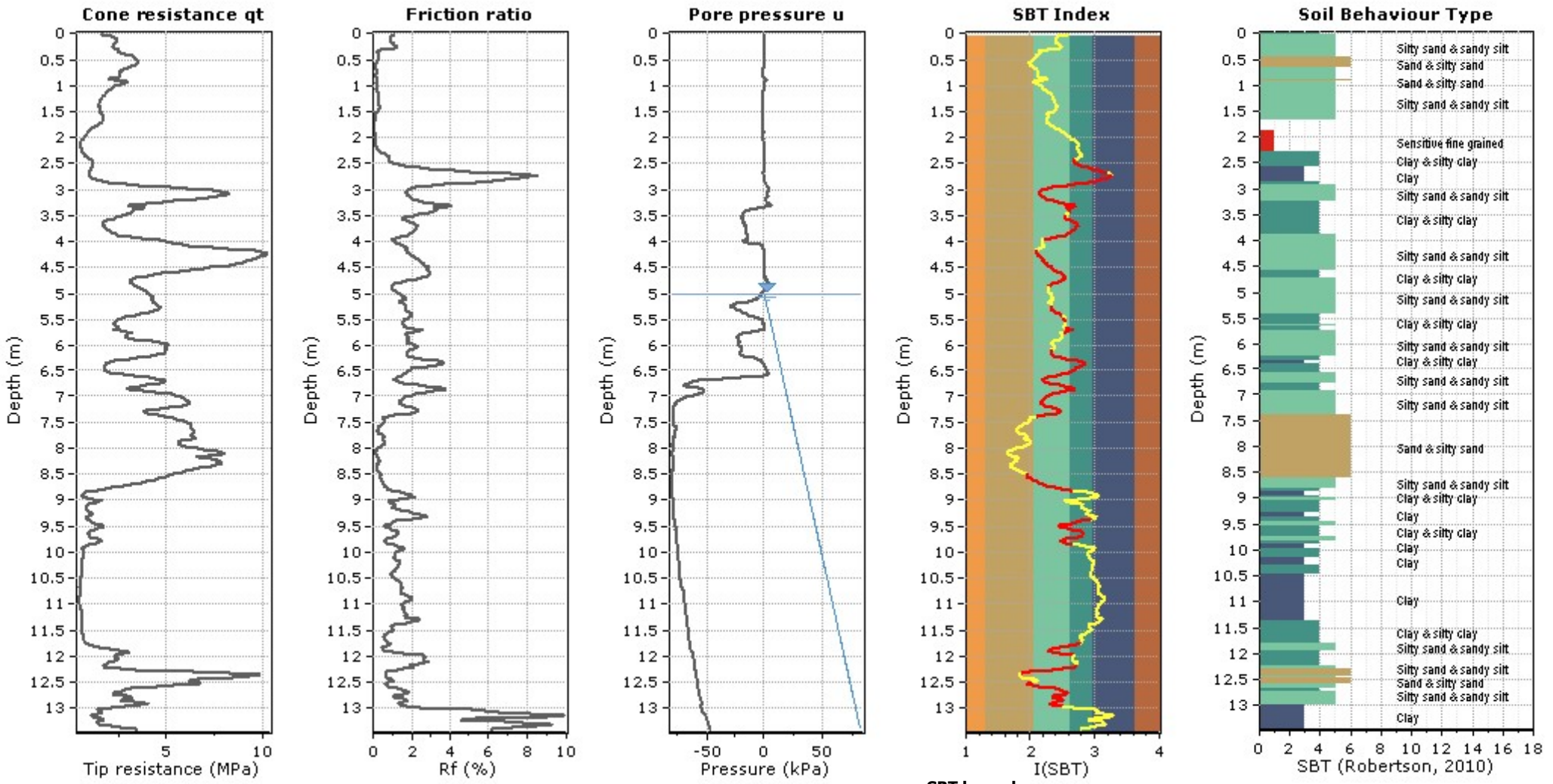
**CPT: CPT6**
Total depth: 13.40 m, Date: 3/12/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Geotech NOVA 10cm2
Cone Operator: JGR




**SBT legend**

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

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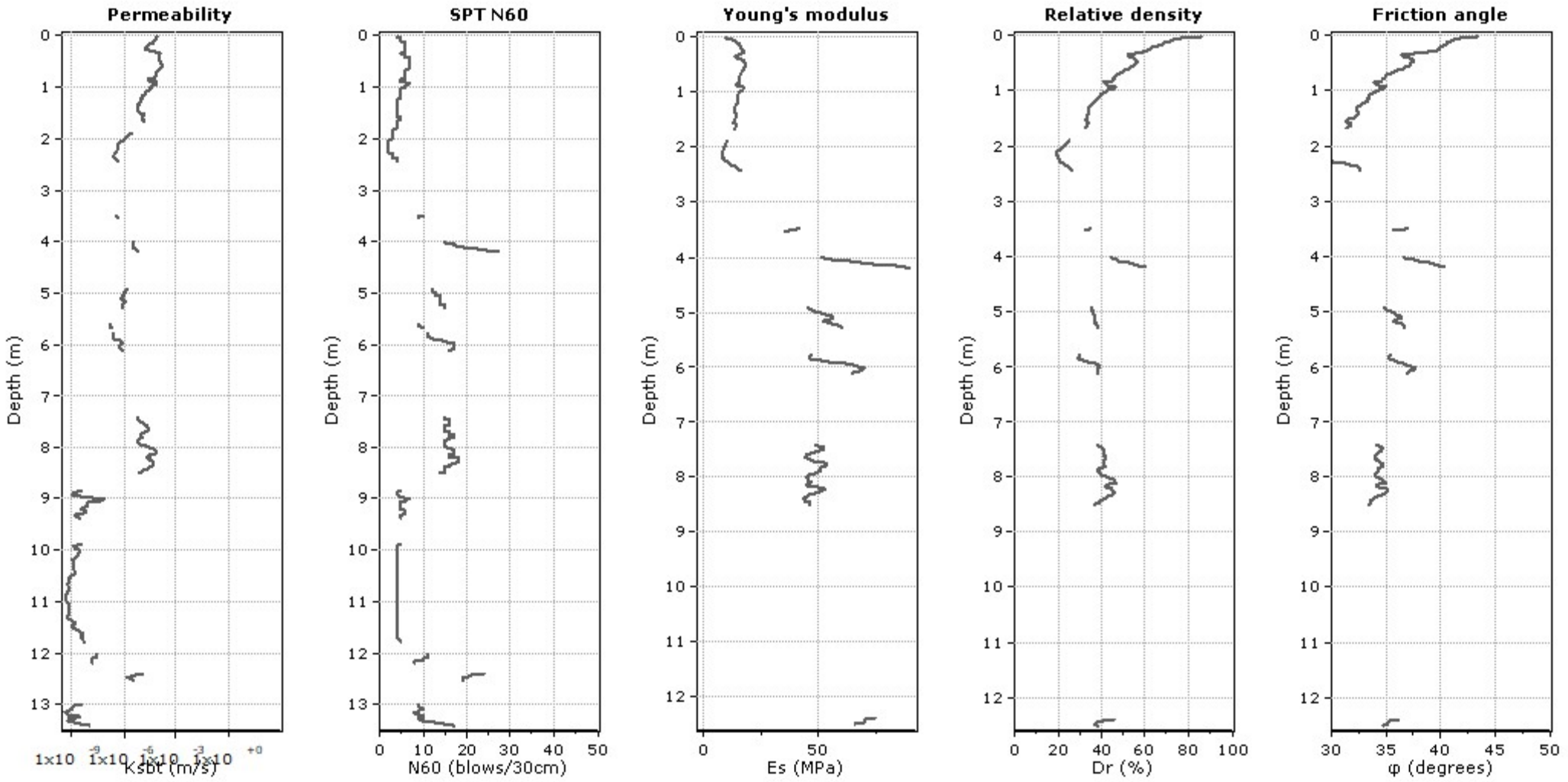


**Calculation parameters**

Permeability: Based on $SBT_n$
SPT $N_{60}$: Based on $I_c$ and $q_t$
Young's modulus: Based on variable alpha using $I_c$ (Robertson, 2009)
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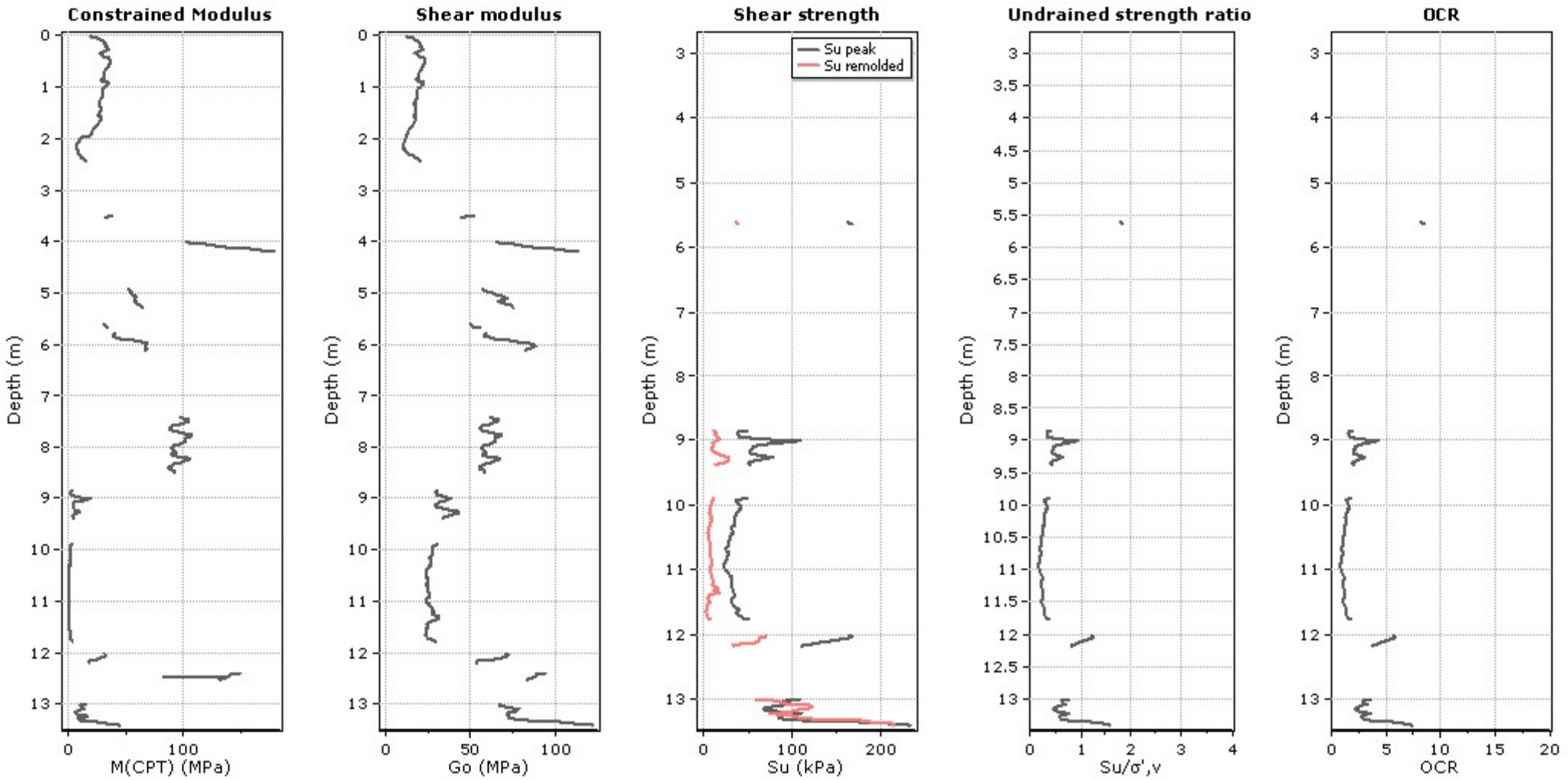


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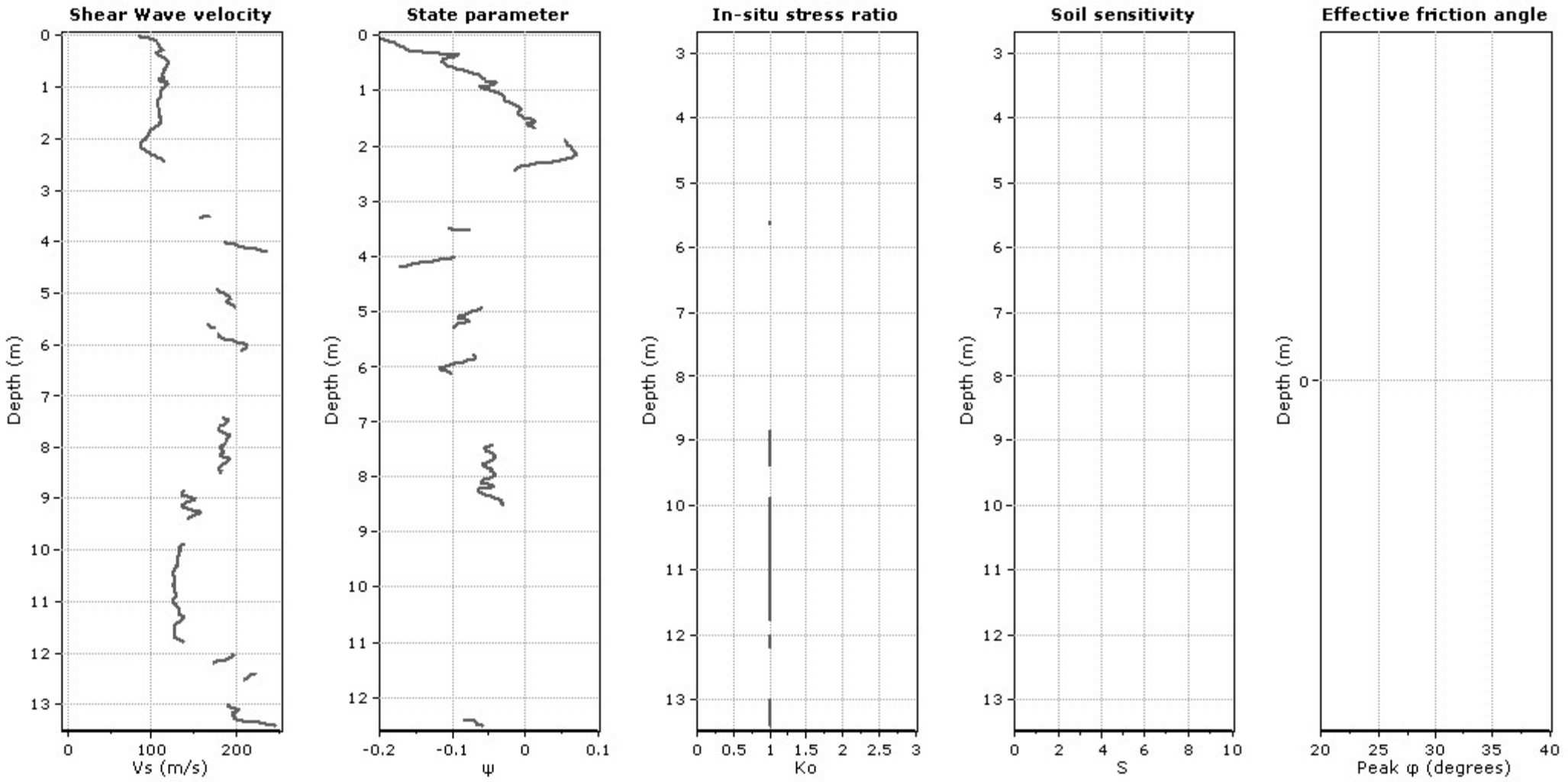


**Calculation parameters**

Soil Sensitivity factor, $N_S$: 350.00

User defined estimation data