Geotechnical Investigation

Lot 10 and Part Lot 11 DP1195449, CNR OF EGRET STREET & CORMORANT ROAD, KOORAGANG ISLAND

Prepared for Sovechles Development

Prepared by RCA Australia

RCA ref 10556a-201/0

June 2014

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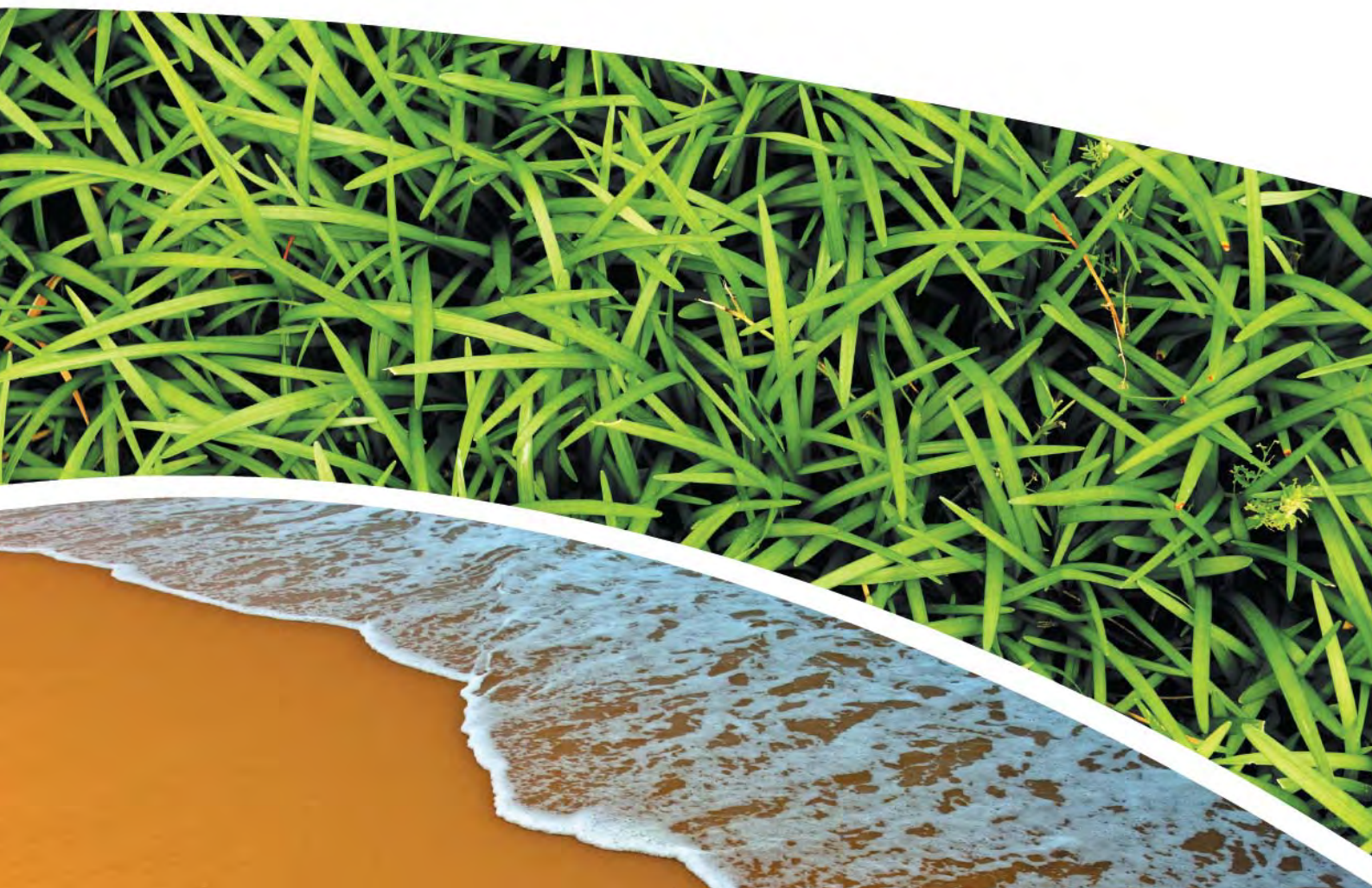

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RCA ref 10556a-201/0

6 June 2014

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GEOTECHNICAL INVESTIGATION
LOT 10, 11 AND 12, DP 1195449, CORMORANT ROAD, KOORAGANG

1 INTRODUCTION

This report presents the findings of geotechnical investigation studies carried out for Sovechles Development on the proposed service centre and commercial development located at Lots 10, 11 and 12, DP 1195449, Cormorant Road, Kooragang.

This work was commissioned by Mr Mitchell Sovechles of Sovechles Development on 25 March 2014.

Based on plans provided by Sovechles Development and discussions with Mitchell Sovechles, it is understood that the proposed development comprises:

- construction a of commercial centre with service station and restaurant;
- associated car parking and pavements.

Data provided in relation to the project comprised a preliminary plan view drawing of the proposed development by RJ Sinclair (Project 13-065, Drawing SK-01).

This report contains descriptions of the surface and subsurface conditions at the site together with recommendations for earthworks, foundation design, pavement design and acid sulphate soil potential. The factual data on which this report is based is presented in the attached appendices.

2 SITE DESCRIPTION

The site is located on a vacant plot of land on the north western corner of Egret Street and Cormorant Road. The approximate location of the site is shown on the site location plan which is attached as **Drawing 1**, in **Appendix A** and a site sketch showing approximate test pit locations is attached as **Drawing 1**, in **Appendix A**.

The site of the proposed development is situated on Kooragang Island with the surrounding area comprising industrial developments including the Boral industrial facility to the north, Sims Metal industrial facility to the east, coal storage area to the west and coal loading dock on the south arm of the Hunter River to the south.

An access road to the site is located to the west, starting at the entrance to the Boral Facility (connecting to Egret Street) to the north of the site and running to the southern boundary of the site.

The site is relatively level with existing ground surface slopes across the site generally sloping to the south towards the river with slopes typically of the order of 0 to 1^{o}. The natural surface slopes across the site have been modified by extensive filling. It is understood that the area was originally Mangrove and that existing levels have been established by filling over an extended period of time.

Drainage across the site is expected to comprise surface drainage with infiltration into the sandy fill.

Vegetation on and adjoining the site at the time of the field investigation comprised several mature trees to the north and several clusters of small shrubs and trees spread over the site. Grass covered the majority of the site.

3 FIELD AND LABORATORY INVESTIGATIONS

3.1 FIELD INVESTIGATION

Fieldwork was conducted on 2 and 3 April and 14 April 2014, and consisted of the following:

- Visual appraisal of the site including mapping of site conditions.
- Excavation of thirty (30) test pits by excavator to depths ranging 2.8m to 3.2m for geotechnical and environmental purposes.
- Perth sand penetrometer tests (blunt tip) beside test pit locations to assess in situ soil density.
- Cone penetrometer testing (CPT) at six (6) locations to depths ranging 13.5m to 20m to provide a continuous profile of soil type and strength.
- Three boreholes drilled from 4.7m to 5.0m metres this included the installation of three (3) groundwater monitoring wells and standard penetration testing (SPT) at 1.5 metre intervals starting at 1.0m.

All fieldwork was carried out by and in the presence of RCA Australia (RCA) personnel. Approximate test locations are shown on the attached site plan (**Drawing 1**).

Test locations have been set out from existing site features by hand held GPS and should only be considered as approximate. Test depths have been recorded relative to the existing ground surface at the time of investigation.

All test pits were backfilled on completion.

Engineering logs of test pits and boreholes are presented in **Appendix B**, together with explanation sheets. CPT logs are presented in **Appendix D**. Groundwater levels have been noted on the test pit and borehole logs at the time of fieldwork. Fluctuations in groundwater conditions may be expected due to variations in rainfall and tidal influences.

3.2 LABORATORY TESTING

Laboratory testing of samples recovered during fieldwork consisted of:

- three (3) four day soaked California bearing ratio (CBR) tests to assess subgrade strength;
- five (5) groundwater chemistry tests – pH, EC, sulphate, chloride (aggressivity to construction materials).
- ten (10) Acid Sulfate screening tests to determine the acid sulphate potential of subsurface samples.
- three (3) SPOCAS (Suspension Peroxide Oxidation Combined Acidity & Sulfur) tests.

Laboratory test result sheets are attached in **Appendix C**.

4 INVESTIGATION FINDINGS

4.1 SUBSURFACE CONDITIONS

4.1.1 REGIONAL GEOLOGY

Based on published geological maps, the site is judged to be situated in an area of Quaternary alluvium.

As previously mentioned in Section 2 the existing surface levels at the site are the result of raising the natural surface levels by filling.

4.1.2 SUBSURFACE CONDITIONS

The subsurface conditions encountered at the site are detailed on the test pit and bore logs as well as the CPT test reports, which are attached in **Appendix B** and **Appendix D**, respectively.

In summary, the subsurface conditions encountered comprise:

- FILL/SAND to depths of approximately 3.2m, the density of the sand was variable but generally medium dense or better; overlying
- CLAY 3.2 to 4.8m, generally in a soft to firm condition; overlying
- SAND (includes SAND, silty SAND and SAND with silt) generally medium dense to dense to 14-18m depth; overlying
- CLAY, generally stiff to very stiff to the limit of testing at 20m.

Clay lenses are present in the sand profile (eg, in CPT1 at 2.5m, 6.5m and 7.5m, CPT2 between 7m and 8m and CPT4 at 9.5m).

The CPT profiles are shown on **Figure 1**.

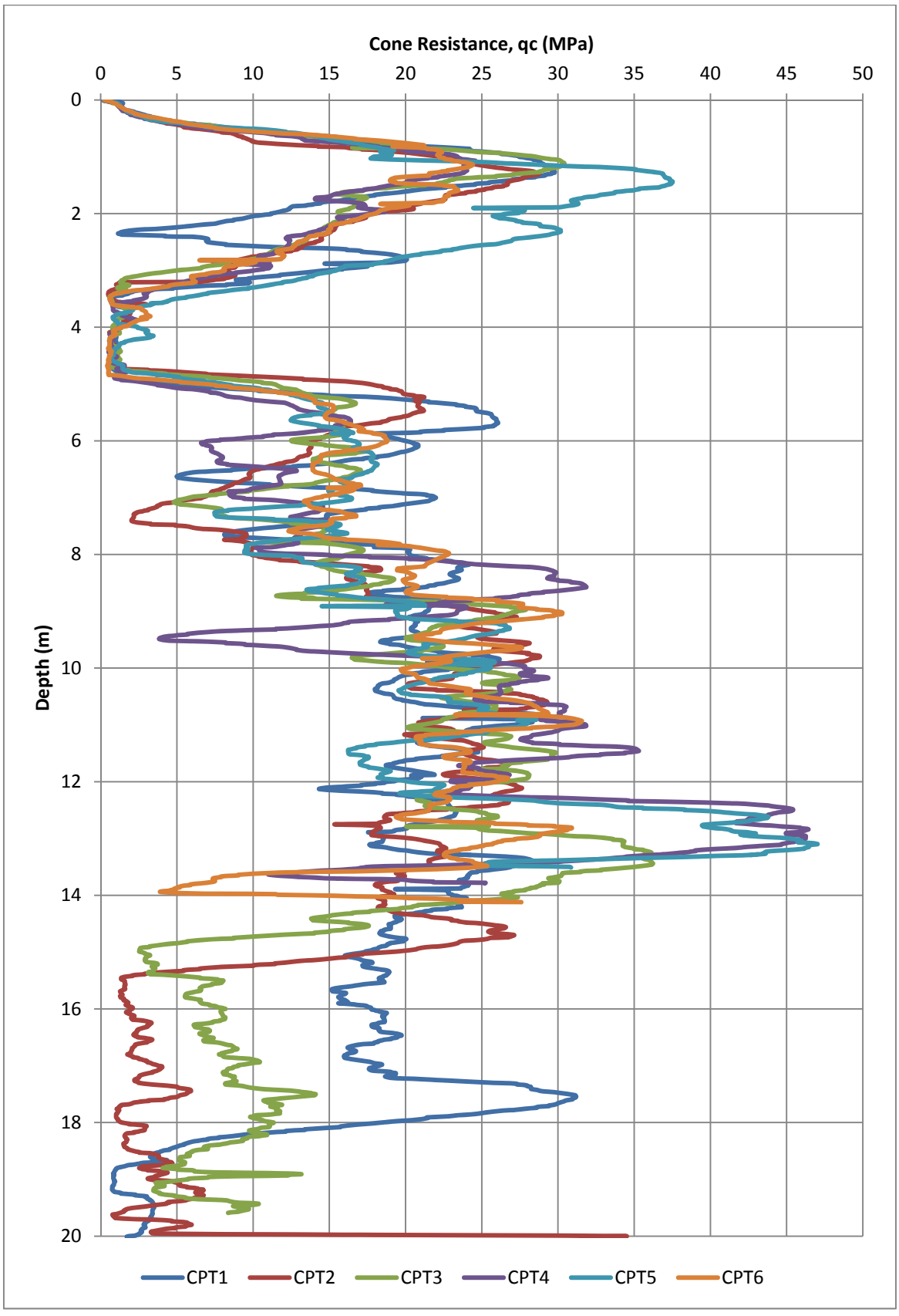


Figure 1 *Overlay of Cone Resistance Profiles*

Perth sand penetrometer testing at the test pit locations generally indicates that the upper two metres of sand fill is medium dense or better. Perth sand penetrometer results are attached in **Appendix B**.

Standard penetration testing was conducted at each monitoring well at 1.0, 2.5 and 4.0 metres. Blow counts were consistent with the CPT data indicating medium dense or better sands in the upper 2.0 metres overlying very loose to loose sands and soft to firm clay.

The standard penetration test (SPT) results are shown on **Figure 2**.

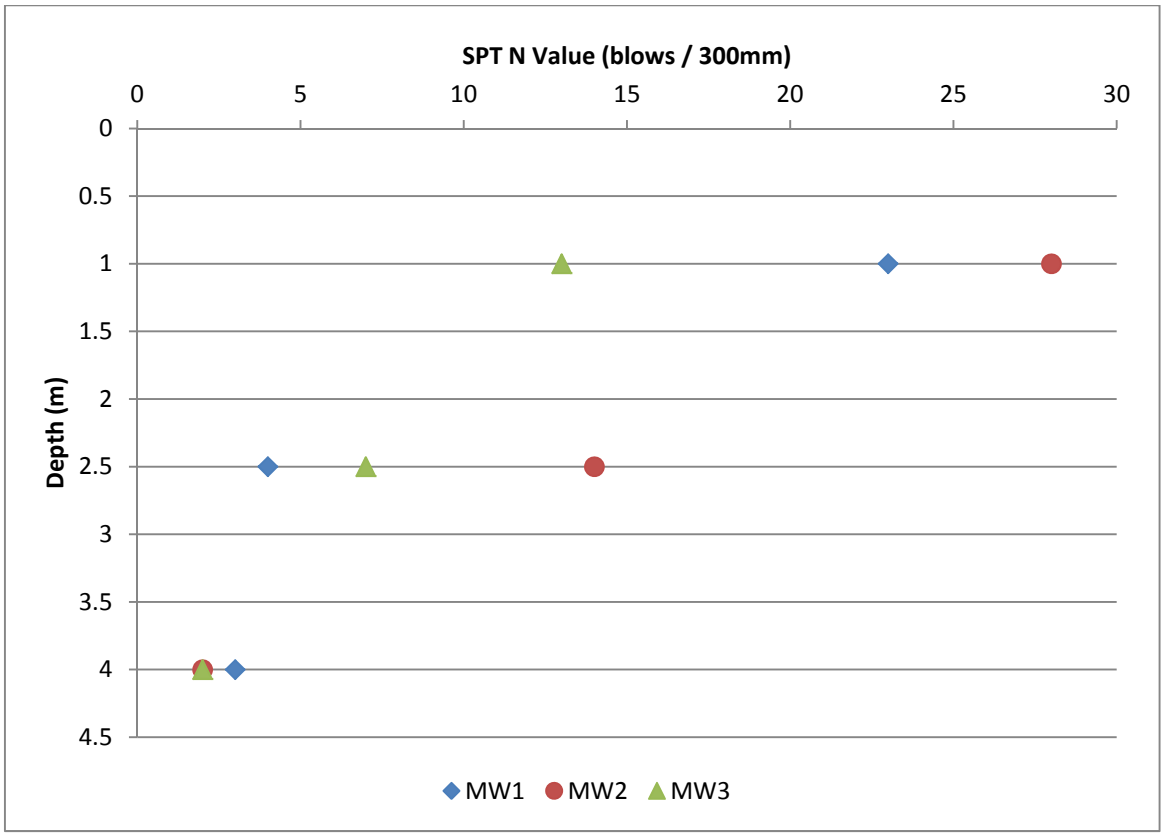


Figure 2 *SPT N Values with depth*

At the time of fieldwork groundwater was encountered at depths of 2.6m to 3.0m in test pits and 2.4m to 3.0m in the CPTs. Seepage in several test pits was encountered at depths from 2.1 to 2.7 metres. The depth to groundwater is likely to fluctuate by variation in rainfall and tidal influences.

4.2 LABORATORY TEST RESULTS

4.2.1 COMPACTION AND CBR

The results of the standard compaction and CBR testing undertaken on samples of the existing subgrade materials encountered over the site are summarised on **Table 1**. Samples were compacted to a target dry density ratio of 100% Standard, surcharged with 4.5kg and soaked for four days.

Table 1 *Summary of Compaction and CBR Test Results*

Test Pit	Depth (m)	Soil Type	FMC (%)	MDD (t/m^3)	CBR (%)
TP7	0.5 – 0.6	Fill/Sand	4.2	1.7	25
TP9	0.8 – 1.0	Fill/Sand	3.8	1.74	45
TP15	0.5 – 0.6	Fill/Sand	3.4	1.7	45

NOTES: FMC – field moisture content.
MDD – maximum dry density (Standard compaction).
CBR – California bearing ratio, penetration 2.5 / 5.0mm.

4.2.2 SOIL AGGRESSIVITY

The results of the groundwater chemistry tests are summarised on **Table 2**.

Table 2 *Groundwater Chemistry Results*

Monitoring Well	Depth (m)	EC (µS/cm)	pH	Chloride (mg/kg)	Sulfate (mg/kg)
MW1	3.0	596	7.77	29	63
MW1	4.0	835	7.82	57	120
MW2	3.0	511	7.95	11	26
MW2	4.0	614	7.79	27	66
MW3	3.0	577	7.78	27	57

4.2.3 ACID SULFATE SOILS

The results of the acid sulphate screening tests are detailed on the laboratory test reports attached in **Appendix C** and are summarised on **Table 3**.

Table 3 *Acid Sulfate Screening Test Results*

Test Pit	Depth (m)	Soil Type	pH (F)	pH (Fox)	pH Change	Reaction Rate
TP7	1.2-1.4	Fill/Sand	7.88	6.10	1.78	0
TP9	0.9-1.0	Fill/Sand	7.99	6.20	1.79	0
TP9	2.0-2.1	Fill/Sand	7.92	6.15	1.77	0
TP10	0.3-0.4	Fill/Sand	7.79	6.00	1.79	0
TP17	2.5-2.6	CLAY	8.05	5.51	2.54	0
TP18	2.0-2.1	Fill/Sand	7.84	6.10	1.74	0
TP18	3.0-3.1	Fill/Sand	7.98	5.95	2.03	0

Test Pit	Depth (m)	Soil Type	pH (F)	pH (Fox)	pH Change	Reaction Rate
TP24	2.1-2.2	Fill/Sand	8.13	5.73	2.40	0
TP24	2.5-2.6	CLAY	8.22	6.00	2.22	0
TP25	1.5-1.6	Fill/Sand	8.31	6.40	1.91	0

The ASSMAC guidelines (1998) indicate that potential acid sulphate soil conditions are present where the pH of soil in peroxide (pH (Fox)) is less than 3.5 and/or the pH change during the test is greater than 1. Based on the ASSMAC guidelines (1998) and the results of the screening tests, there appeared to be a potential for acid forming conditions upon oxidation for all of the samples tested, with all ten (10) samples on which screening testing were undertaken exhibiting a pH change of more than 1. None of the samples exhibited a pH in peroxide (pH (Fox)) of less than 3.5. It is noted that all the samples exhibited alkaline conditions in their field state.

Samples were selected for further analysis by the SPOCAS (Suspension Peroxide Oxidation Combined Acidity and Sulfate) method based on the results of the screening testing and the results of this analysis are detailed on the laboratory test reports attached in **Appendix C** and are summarised on **Table 4**.

Table 4 *Summary of SPOCAS Test Results*

Test Pit	Depth (m)	Soil Type	Titratable Actual Acidity (TAA)	Titratable Sulfidic Acidity (TSA)	Peroxide Oxidisable Sulfur (Spos)	Net Acidity
			mole H^+/ tonne	mole H^+ / tonne	%S	mole H^+/ tonne
TP9	2.0 – 2.1	SAND	<2	<2	<0.02	<10
TP17	2.5 - 2.6	SAND	<2	<2	0.03	<10
TP24	2.5 – 2.6	CLAY	<2	154	0.59	226

Note: Results shown in shaded cells exceed the ASSMAC (1998) action criteria.

Of the three (3) samples on which further analysis by the SPOCAS method was undertaken, the clay sample from test pit TP24 had concentrations of acidity and sulphur that exceed the ASSMAC (1998) action criteria for fine soils such as silts and clays. The sand fill sample from TP17 was marginal when measured against the ASSMAC (1998) action criteria.

5 DISCUSSION AND COMMENTS

5.1 SITE CLASSIFICATION

5.1.1 GENERAL

Australian Standard *AS 2870–2011 Residential Slabs and Footings–Construction* (herein referred to as *AS 2870-2011*) establishes performance requirements and specific designs for common foundation conditions as well as providing guidance on the design of footing systems using engineering principles.

Site classes as defined on Table 2.1 and 2.3 of *AS 2870-2011* are presented on **Table 5**.

Table 5 *General Definition of Site Classes (AS 2870-2011)*

Class	Foundation	Characteristic Surface Movement, ys
A	Most sand and rock sites with little or no ground movement from moisture changes	
S	Slightly reactive sites, which may experience only slight ground movement from moisture changes	0 mm < ys ≤ 20 mm
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes	20 mm < ys ≤ 40 mm
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes	40 mm < ys ≤ 60 mm
H2	Highly reactive clay sites, which can experience very high ground movement from moisture changes	60 mm < ys ≤ 75 mm
E	Extremely reactive clay sites, which may experience extreme ground movement from moisture changes	ys > 75 mm
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	
A	Most sand and rock sites with little or no ground movement from moisture changes	

In regard to the performance of footings systems, *AS 2870-2011* states “footing systems complying with this standard are intended to achieve acceptable probabilities of serviceability and safety of the building during its design life. Buildings supported by footing systems designed and constructed in accordance with this Standard on a normal site which is -

(a) not subject to abnormal moisture conditions; and

(b) maintained such that the original site classification remains valid and abnormal moisture conditions do not develop;

are expected to experience usually no damage, a low incidence of damage Category 1 and an occasional incidence of damage Category 2”. Damage categories are defined in Appendix C of *AS 2870-2011*, which is reproduced in CSIRO Sheet BTF 18, *A Guide to Home Owners on Foundation Maintenance and Footing Performance*, which is attached to this report.

5.1.2 SITE CLASSIFICATION AND DISCUSSION

As discussed in Section 4.1.2, the soil profile encountered in the test pits excavated at the site were characterised by sand fill.

Based on the depth of fill in excess of two metres encountered at the site and in accordance with *AS 2870-2011*, the site in its existing condition would be classified as a Class P site.

The above site classification is for the site conditions present at the time of fieldwork and consequently the site classification may need to be reviewed in consideration of site works that may be undertaken subsequent to this report. Site works may include:

- changes to the existing soil profile by cutting and filling;
- landscaping, including trees removed from the general building area and those planted;
- drainage and watering systems.

Designs and design methods presented in *AS 2870-2011* are based on the performance requirement that significant damage can be avoided provided that site conditions are properly maintained. Performance requirements and foundation maintenance are outlined in Appendix B of *AS 2870-2011*. The above site classification assumes that the performance requirements as set out in Appendix B are acceptable and that site foundation maintenance is undertaken to avoid extremes of wetting and drying.

Details on appropriate site and foundation maintenance practices are presented in Appendix B of *AS 2870-2011* and in CSIRO Sheet BTF 18, *A Guide to Home Owners on Foundation Maintenance and Footing Performance*.

5.2 SITE EARTHWORKS

5.2.1 EXCAVATIONS

It is generally expected that the soil profiles encountered at the site could be excavated by conventional earthmoving equipment such as bobcats, backhoes and excavators.

It is unlikely that the sand soils above groundwater level would be stable at angles greater than about 30°. Consequently, allowance should be made for either battering back or support of the sides of excavations above groundwater level.

Unsupported excavations could be expected to undergo slumping into the excavation where seepage or groundwater is encountered (groundwater was encountered on the site between 2.1m and 3.0m below ground level at the time of the field investigation work and may be shallower than this depending on tidal and climate influences). If/where excavations were proposed below the groundwater level, the sand strata encountered at the site will not be stable and excavations below the groundwater level are expected to require support/shoring together with groundwater control/dewatering.

All long-term excavations should either be supported by properly designed and constructed retaining walls or alternatively battered at 2H:1V or flatter. The soils encountered at the site are judged to be susceptible to erosion and should be protected by vegetation or similar, together with adequate drainage where exposed.

It is understood that underground fuel tanks are to be installed at the site. No information regarding the dimensions and structural loads of these tanks has been provided for the purposes of this investigation. Depending on the depth of embedment of the tanks consideration will need to be given to the potential for the development of uplift forces if founded below the groundwater table. It is noted that given the proximity to the river and the potential for flooding, with a rise of the groundwater table potentially too close to the surface, it may be prudent to consider provision for this worst case in the design of the tanks. Options to accommodate potential uplift forces include:

- provision of piles that are designed to act in tension in the event the groundwater table is above the base of the fuel tanks;
- provision of mass foundations to negate the effects of buoyancy.

5.2.2 FILLING

Any proposed filling on the site should be placed and compacted in accordance with *AS 3798-2007, Guidelines on Earthworks for Commercial and Residential Developments*.

Site preparation for the placement of fill should include the following:

- Removal of any existing topsoil and deleterious soils together with any surface vegetation, eg, grass/weeds, and heavily root affected soils, to expose a clean sand subgrade.
- Proof rolling of the exposed sand subgrade.

It is noted that the exposed subgrade will be fill (generally sand) and in the absence of any documentation it is considered to be uncontrolled fill. For areas to support structural loads and/or pavements additional advice is provided later in the report.

Where site levels need to be raised, clean sand fill should be placed in layers and compacted to achieve the following minimum density index (*AS 1289.5.5.1*):

- 70% as general site fill.
- 80% beneath structures and in areas of proposed pavements.

It is recommended that clean sand fill should be used for any proposed filling at the site. The sand soils at the site are generally expected to be suitable for re-use as fill provided that any deleterious material is removed prior to incorporation of the material into fill earthworks.

Owing to the presence of the sands (including loose sands) together with groundwater, the effects of vibrations associated with proof rolling and compaction should be taken into consideration, with particular care given to the choice of compaction equipment and method. Observation and monitoring of existing adjacent development and structures for any signs of settlement or distress should be undertaken in conjunction with any proposed proof rolling and compaction.

All fill should be supported by properly designed and constructed retaining walls or else battered at 2H:1V or flatter and protected against erosion by vegetation or similar and the provision of adequate drainage. Owing to the presence of a 1.5m to 2m thick layer of soft to firm clays below the sand fill, consideration of the potential for consolidation (time dependent settlement) should also be taken into account. Where levels are to be raised significantly or structural loads applied, this layer raises to potential for development of differential settlements with time. As discussed in Section 5.3, structural loads may

require support on deep foundations to avoid this issue. For general fill areas if more than about 1m of fill is proposed to be added it is recommended that calculations of settlement be undertaken so that allowances for the movement may be made in design of services and other settlement sensitive elements of the facility.

5.3 FOUNDATIONS

5.3.1 GENERAL

As discussed in Section 1 proposed new structures for the site include a single storey commercial building, several carparks, underground petrol and diesel tanks and two canopy structures for cars and trucks.

5.3.2 HIGH LEVEL FOUNDATIONS

High-level footing alternatives for proposed structures could be expected to include slabs on ground with edge beams or pad footings for the support of concentrated loads.

Owing to the presence of sand fill and soft to firm clay in the upper 5m, high level footings are considered to carry a risk of poor performance associated with settlement (both total and differential) and subsequent distress of the proposed structures and services. It is also considered that there could be the potential for settlement under dynamic loading, eg, vibrations from earthquakes, etc. Earthquake or other induced vibrations may have the potential to induce densification of the sands resulting in unexpected settlements and subsequent distress of the proposed structure.

In consideration of the risk associated with settlement, high-level footings are not recommended. For lightweight and/or settlement tolerant structures consideration could be given to an earthworks methodology to improve the density of the sand, however this will not treat the risk from the presence of the soft to firm clay layer beneath. The best way to mitigate that risk would be a six to 12 months preload and it is assumed that this is not feasible.

In summary, options for consideration are as follows:

- Found structural loads on deep foundations as discussed in Section 5.3.3 with the design of any ground slabs as suspended slabs.
- Adopt high-level foundations for lightweight and/or settlement tolerant structures with acceptance of some risk of poor performance through time dependent settlement. It is recommended if this option is adopted that the upper 1m of filling is excavated and recompacted under engineering control. This would comprise the excavation of the upper 1m of fill and recompaction in accordance with AS 3798-2007, Guidelines on Earthworks for Commercial and Residential Developments, in layers compacted to 85% density index or equivalent. Allowance for differential settlement of the order of 20 to 40mm is suggested with treatments such as articulation and provision for flexible services connections.

It is suggested that high-level footings founded on sand fill placed under engineering control may be proportioned based on an allowable bearing pressure of 100kPa. If bearing pressures in excess of 100kPa were required, it is recommended that piered or piled foundations as discussed in Section 5.4.3 be used.

The base of all footing excavations should be cleaned of fall-in prior to formation of the footing and inspection of the base of footing excavations should be undertaken during construction to confirm founding conditions.

The alternative to high-level footings is deep foundations, which are discussed in the following sections.

5.3.3 DEEP FOUNDATIONS

Suitable deep foundations would include the following:

- bored piers;
- cast in situ piles such as grout injected piles;
- driven displacement piles such as treated timber piles or steel or concrete sections;
- screw piles.

A suitable founding stratum for piered or piled foundations is expected to comprise medium dense or better sands below depths of about 5m.

Bored piers and piled foundations are discussed in the following sections.

5.3.3.1 BORED PILES

Bored piers would require casing due to the presence of sands and the relatively shallow groundwater table at the site which is likely to make them uneconomical and difficult to form in the subsurface conditions encountered.

5.3.3.2 GROUT INJECTED/CASED BORED PILES

Allowable design parameters for grout injected piles or bored cased piers are shown on **Table 6**.

Table 6 *Ultimate Downthrust Pile Shaft Adhesion and End Bearing Stress*

Founding Strata	End Bearing Pressure (kPa)		Ultimate Shaft Adhesion (kPa)
	Ultimate[(1)]	Serviceability[(2)]	
Medium dense or better sands below a depth of about 5m	1500	500	50

(1) Ultimate values occur at large settlement (>5% of minimum footing dimensions).

(2) End bearing pressure to cause settlement of <1% of minimum footing dimension.

Parameters for piers assume L>4D (L= pile length, D = pile diameter).

A geotechnical reduction factor of 0.5 is suggested for the above values.

The support of bored pier holes could be expected to be required and accordingly it is recommended that allowance should be made during construction for the support of pier holes. Inspection of the base of piered footing excavations should be undertaken during construction to confirm founding conditions. The base of all footings should be cleaned of fall-in prior to formation of the footing.

Owing to founding levels being below the groundwater level (in order to found on medium dense or better sands) it is unlikely that bored piers would be economical when compared to other available alternatives, eg, driven piles or screw piles, owing to the difficulty in forming bored piers in the subsurface conditions encountered. It is also expected that cast in situ piles such as grout injected piles are likely to be economical when compared to other available pile alternatives.

5.3.3.3 DRIVEN CAST IN SITU PILES

Driven piles such as treated timber piles or driven steel or concrete piles could be considered with piles being driven into the medium dense or better sands below depths of about 5m.

Suitable alternatives for piled foundations include driven treated timber mini-piles. Treated timber mini-piles of nominal 125mm to 150mm diameter can be driven to depths below 5m and where driven into the medium dense to dense sands at the site, may have an allowable bearing capacity in the range of 50 to 70kN. Actual pile load capacities should be based on the pile driving records in conjunction with an appropriate recognised dynamic pile driving formulae.

Where increased load capacities were required consideration could be given to the use of larger diameter hardwood timber piles. The down thrust load capacity of timber piles driven to practical refusal in dense sands with appropriately sized equipment could be expected to approach the structural capacity of the pile.

Steel and concrete pile capacity can be significantly greater than that available from timber piles. The down thrust load capacity of steel or concrete piles driven to practical refusal in dense sands with appropriately sized equipment could be expected to approach the structural capacity of the pile.

It would generally be expected that driven piles with solid cross-sections such as timber or concrete piles would achieve practical refusal in the dense sands. Driven steel piles with a relatively small cross-section, eg, steel H sections, are likely to penetrate the dense sands to some degree.

The capacity of driven piles should be confirmed by use of a suitable dynamic pile analysis package. Settlements of piles founded at practical refusal in the dense sands and with capacity confirmed by use of a suitable dynamic pile analysis package are likely to be within tolerable limits.

The effects of vibrations associated with any proposed pile driving would need to be considered, particularly if/where driving piles in proximity to existing adjacent development and structures and consultations should be held with piling contractors in this regard. Observation and monitoring of any existing adjacent development and structures for any signs of vibration related distress should be undertaken in conjunction with any proposed pile driving.

Screw piles are an alternative to driven piles. Screw piles are end-bearing displacement piles that are screwed to founding depths by excavator or backhoe with the pile capacity determined from installation torque. The advantage of screw piles is the minimal noise and vibration levels during installation and being able to add extension lengths as required. It is expected that screw piles could be seated in the medium dense to dense sands below about 5m depth. However, screw piles are likely to be more expensive than driven piles. A specialist screw pile contractor should be consulted to determine suitable founding depth for screw piles.

5.3.1 EARTHQUAKE DESIGN

In accordance with *AS 1170.4-2007* the site is classified as a sub-soil Class D_e – deep or soft soil site.

5.3.2 FOUNDATION DURABILITY

Exposure classifications for buried steel and concrete elements based on the aggressivity test results summarised on and attached in **Appendix C** were assessed in accordance with *AS 2159-2009, Piling – Design and Installation*. The laboratory test results indicated the following exposure classifications to steel and concrete for the soil samples tested:

- Steel – Moderate.
- Concrete – Mild.

Assessment of exposure classifications using another method/standard (if required) could be based on the laboratory test results summarised on **Table 2** and attached in **Appendix D**.

5.4 PAVEMENT DESIGN

5.4.1 DESIGN TRAFFIC LOADINGS

Traffic loadings for the proposed pavements at the site are not known, however it is understood that the facility will be trafficked by heavy road based vehicles (eg, Class 10 B Double and fuel tankers) while also providing parking for light vehicles.

For the purposes of rigid pavement design a traffic loading of heavy vehicle axle group (HVAG) of 1×10^6 has been assumed.

For areas only subject to light traffic a design traffic loading of 1×10^5 ESAs has been assumed.

If advice indicates different traffic loadings to those for which pavement design has been undertaken, the pavement design may need to be reviewed.

5.4.2 SUBGRADE CONDITIONS

Based on the subsurface conditions encountered in the test pits excavated at the site as shown on the test pit logs attached in **Appendix B** and summarised in Section 4.1.2 subgrade conditions for pavement construction are generally expected to comprise a variable depth of sand fill to up to 3.0m.

The results of the laboratory CBR test (summarised on **Table 1**) undertaken on samples of the sand fill materials encountered at the site returned soaked CBR values of 25-45%.

The available information (AUSTROADS 2012) indicates typical CBR values for a sand subgrade of 10-18%. In consideration of the above, a subgrade CBR of 10% has been adopted for pavement design purposes for proposed pavements at the site.

It is noted that the subgrade consist of uncontrolled sandy fill to up to 3m depth. Specific recommendations relating to subgrade preparation are provided in Section 0.

5.4.3 PAVEMENT COMPOSITION

5.4.3.1 GENERAL

A flexible pavement option is provided for lightly loaded areas while a rigid pavement is recommended and provided for all areas subject to heavy vehicle loading.

5.4.3.2 UNBOUND FLEXIBLE PAVEMENT

It is expected that a suitable pavement composition for an unbound flexible pavement for the service centre could comprise thicknesses shown on **Table 8**.

Table 7 *Flexible Pavement Composition (Light Vehicles Only)*

Pavement Layer	Traffic Loading (ESAs)
	1 x 10^5
Wearing Course (mm)	40AC
Basecourse (mm)	100
Subbase (mm)	100
Total Thickness (mm)	240

It is noted that previous experience has indicated difficulties achieving compaction requirements of thin pavement layers directly over sands. Options include the adoption of a pavement composition comprising a 200mm basecourse, with compaction of the basecourse in a single layer.

A 7mm prime seal should be placed over the basecourse prior to placement of the asphaltic concrete wearing course.

The asphaltic concrete wearing course thickness indicated, is considered to be the minimum required wearing course thickness. In our experience there is a risk with the use of a thin asphaltic concrete wearing course associated with deformations/distress of the asphaltic concrete wearing course, particularly from turning/screwing loads at locations such as corners and turning circles. Accordingly, periodic maintenance/rehabilitation of the asphaltic concrete wearing course may be required and it is suggested that allowance should be made in this regard. Alternatively, consideration could be given to the use of a thicker asphaltic concrete wearing course in order to increase the life and improve the performance of the asphaltic concrete wearing course, with the use of a suitably toughened asphaltic concrete wearing course in areas, eg, corners and turning circles, which may be subject to turning/screwing loads. Another option for the car park is rigid pavement.

Pavement material specifications and compaction requirements are shown on **Table 9**.

5.4.3.3 RIGID PAVEMENT

Pavement compositions for a rigid pavement for the heavily loaded areas of the proposed service centre are shown in **Table 8**.

Table 8 *Pavement Compositions for a Rigid Pavement*

Pavement Composition	Thickness of Pavement Course	
	With concrete shoulders (1)	Without concrete shoulders
Continuously reinforced concrete basecourse	180mm	200mm
Subbase	150mm bound	150mm bound
Total pavement thickness	330mm	350mm
Subgrade CBR used for design	10%	10%

(1) Refer to Section 9.3.5 of AUSTROADS Guide to Pavement Structural Design (2010) and the RTA Austroads Supplement to the Guide to Pavement Structural Design (January 2011) for guidance on what constitutes concrete shoulders.

Material specifications are provided in Section 5.4.4.

Design of reinforcement and jointing details for a rigid pavement should be undertaken by a suitably qualified structural engineer.

5.4.4 PAVEMENT MATERIALS AND COMPACTION REQUIREMENTS

5.4.4.1 UNBOUND PAVEMENT MATERIALS

Pavement material specifications and compaction requirements for unbound pavement materials are shown on **Table 9**.

Table 9 *Pavement Materials and Compaction Requirements*

Pavement Course	Material Specification	Compaction Requirements
Basecourse High quality crushed rock or base quality gravel	Material complying with Reference (6). CBR > 80% PI < 6%	Min 98% Modified (AS 1289 5.2.1)
Subbase Subbase quality gravel	Material complying with Reference (6). CBR > 30% PI < 12%	Min 95% Modified (AS 1289 5.2.1)
Fill Select subgrade or subgrade replacement	CBR > 15%	Min 100% Standard (AS 1289 5.1.1)
Subgrade		Min 100% Standard (AS 1289 5.1.1)

NOTES: CBR – California bearing ratio PI – Plasticity index.

5.4.4.2 RIGID PAVEMENT MATERIALS

In accordance with the Austroads Guide to Pavement Technology Part 2: Pavement Structural Design (2012), it is recommended that concrete with a minimum 28 day flexural strength of 4.5MPa be used for the concrete basecourse.

The bound subbase in the rigid pavement composition should have a characteristic 28 day compressive strength of not less than 5MPa.

5.4.5 PAVEMENT DRAINAGE

Particular care would be required to provide adequate surface and subsurface drainage of the pavement and adjacent area.

5.4.6 SUBGRADE PREPARATION

The subgrade comprises uncontrolled sand fill underlain by soft to firm clay. The following subgrade treatment methodology is suggested to minimise risk of poor performance through settlement:

- Excavate the upper 1m of sand fill to expose a clean sand subgrade.
- Proof roll the exposed subgrade with a heavy (minimum 10 tonne static) roller. Soft or weak areas detected during the proof rolling should be excavated and replaced with compacted fill/subgrade replacement comprising select subgrade filling having a CBR >15%.
- Recompact sand fill under engineering control (in accordance with AS 3798-2007, Guidelines on Earthworks for Commercial and Residential Developments) in layers compacted to 85% density index or equivalent.
- Formation of the pavement in accordance with the above recommendations and specifications.

Particular care should be taken in the choice of compaction equipment and methods where pavement construction is to be undertaken in the vicinity of the existing development. Observation and monitoring of existing adjacent development for any signs of distress should be undertaken in conjunction with proof rolling and compaction of the subgrade and pavement materials.

5.5 ACID SULFATE SOILS

The Newcastle Acid Sulfate Soil Risk map indicates that the area comprises disturbed ground. Neighbouring undisturbed areas are shown to be estuarine in nature and to have a high probability of acid sulfate soil within 1m of the soil surface and it might be expected that the natural clay under the sand fill would be of this character.

5.5.1 ASSESSMENT CRITERIA

Reference to the ASSMAC Acid sulfate Soil Manual indicates the soil action criteria for soils according to their texture and the combined existing and potential acidity of the material. The action criteria also take into account the volume of soil to be disturbed, as shown in **Table 10**.

Table 10 *Texture Based Acid Sulfate Action Criteria*

Type of Material		**Action Criteria if 1 to 1000 Tonnes of material is Disturbed**		**Action Criteria > 1000 Tonnes of material is Disturbed**	
Soil Texture	Approx. Clay Content (%)	Equivalent Sulphur (%S)	Equivalent Acidity (mol H^+/tonne)	Equivalent Sulphur (%S)	Equivalent Acidity (mol H^+/tonne)
Coarse (silty sand to sands)	≤5	0.03	18	0.03	18
Medium (sandy loam-light clay)	5-40	0.06	36	0.03	18
Fine (Medium to heavy clays and silty clays)	≥40	0.1	62	0.03	18

5.5.2 ANALYSIS OF TEST RESULTS

Reference to the ASSMAC assessment guidelines indicate that test results of the estuarine clay sample presented in **Table 4** exceed the ASSMAC action criteria as presented in **Table 10** and hence the soils tested are classified as potential acid sulfate soils. The sand fill at the site was found to be alkaline in nature and showed only marginal propensity to acid formation. The results of the analysis indicate that an acid sulfate soil management plan will be required for all excavations that may disturb the clay soils at the site (typically at depths below 3m).

6 LIMITATIONS

This report has been prepared for Sovechles Development in accordance with the agreement with RCA. The services performed by RCA have been conducted in a manner consistent with that generally exercised by members of its profession and consulting practice.

This report has been prepared for the sole use of Sovechles Development for the specific purpose and the specific development described in the report. The report may not contain sufficient information for purposes or developments other than that described in the report or for parties other than Sovechles Development. This report shall only be presented in full and may not be used to support objectives other than those stated in the report without permission.

The information in this report is considered accurate at the date of issue with regard to the current conditions of the site. The conclusions drawn in the report are based on interpolation between boreholes, test pits or piezocone. Conditions can vary between test locations that cannot be explicitly defined or inferred by investigation.

Yours faithfully
RCA AUSTRALIA

Dr Mark Allman
Geotechnical Services Manager

REFERENCES

[1] CSIRO. Foundation Maintenance and Footing Performance: A Homeowner's Guide. Information Sheet BTF 18, 2003.

[2] Cement and Concrete Association of Australia (1997) "Industrial Pavements – Guidelines for Design, Construction and Specification", August 1997.

[3] Standards Association of Australia. AS 2870-2011: Residential Slabs and Footings. Standards Association of Australia, 2011.

[4] Standards Association of Australia. AS 3798-2007: Guidelines on Earthworks for Commercial and Residential Developments. Standards Association of Australia, 2007.

[5] AUSTROADS, "Guide to Pavement Technology Part 2: Pavement Structural Design", Austroads Publication No. AGPT02-12, Sydney, 2012.

[6] Roads and Traffic Authority NSW, "Unbound and Modified Base and Subbase Materials for Surfaced Road Pavements", QA Specification 3051, Edition 3, 1994.

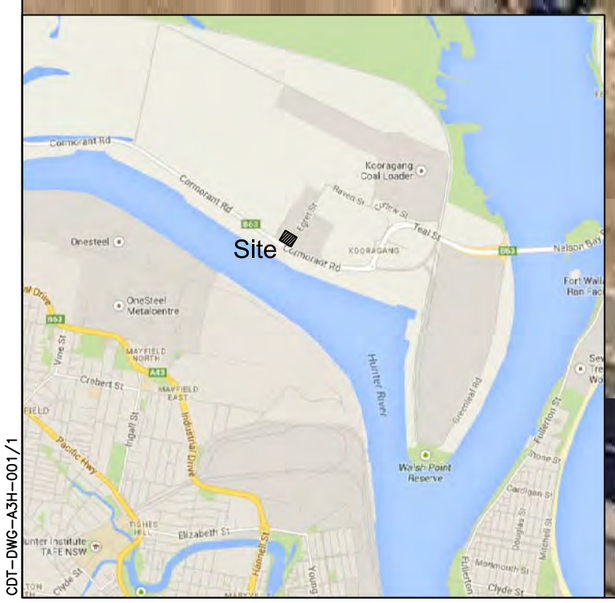
[7] NSW Acid Sulfate Soil Management Advisory Committee, Acid Sulfate Soil Manual, August 1998.

Appendix A

Drawings

TP30
CPT5
TP29
TP31
TP28
CPT6
TP32
TP20
CPT4
TP27
TP21
TP26
CPT1
MW1
Lot 1
DP1195449
TP22
CPT2
TP19
TP17
TP16
TP23
TP25
TP18
CPT3
TP15
TP5
TP6
TP24
MW2
TP14
TP13
TP4
TP7
TP9
Egret Street
TP8
TP12
TP10
TP3
TP11
MW3
Cormorant Road
TP2
TP1

Locality Plan
N.T.S.



LEGEND

- Approximate Lot and site boundary
- Approximate groundwater bore location
- Approximate environmental test pit location
- Approximate environmental and geotechnical test pit location
- Approximate CPT sample location
- Approximate composite sample location

0 25 50 75 100
metres

Aerial image taken from Nearmap
January 30 2014

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SITE AND TEST PIT LOCATION PLAN
LOT 1 DP1195449
CORMORANT ROAD
KOORAGANG ISLAND

CLIENT	Sovechles Devolopment			RCA Ref	10556a-201/0
DRAWN BY	JC	SCALE	1 : 1000 (A3)	DRAWING No 1	REV 0
APPROVED BY	MA	DATE	5/6/2014	OFFICE	NEWCASTLE

CDT-DWG-A3H-001/1

Appendix B

Engineering Logs

Explanatory Notes

Perth Sand Penetrometer Test Results

GEOTECHNICAL TEST PIT LOG

TP1

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	FILL, SAND, medium grained, pale brown, with shell fragments	M		FILL
				0.5						
				1.0						
				1.20		CH	FILL, CLAY, high plasticity, black			
				1.30		SP	FILL, SAND, fine to medium grained, pale brown			
				1.5						
				1.90		CH	FILL, CLAY, high plasticity, dark grey			
				2.0						
				2.10		SP	FILL, SAND, fine to medium grained, brown mottled grey			
				2.5						
▽ 02/04/14				3.0						
				3.10			TEST PIT TP1 TERMINATED AT 3.10 m			

LOGGED: JG/JC

CHECKED: MA

DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP2

RCA AUSTRALIA
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PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	FILL, SAND, medium grained, pale brown	M		FILL
				0.5						
				1.0						
				1.20		SM	FILL, Silty SAND, fine grained, dark brown mottled orange			
				1.30		SP	FILL, SAND, fine to medium grained, brown			
				1.5						
2/4/2014				1.95		CH	FILL, Silty CLAY, high plasticity, dark grey			
				2.00		SP	FILL, SAND, fine to medium grained, dark grey			
				2.5						
				3.00			TEST PIT TP2 TERMINATED AT 3.00 m			

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP3

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	FILL, SAND, fine to medium grained, pale brown grey	M		FILL
				0.5						
				1.0						
				1.5						
				2.0						
				2.20		SP	FILL, SAND, fine to medium grained, dark grey			
				2.40		ML	FILL, SILT, with organic matter			
2/4/2014				2.50		CH	FILL, Sandy CLAY, high plasticity, dark grey Shell fragments from 2.6m to 2.7m			
				2.70		SP	FILL, SAND, fine to medium grained, dark grey, with shell fragments			
				3.0						
				3.10			TEST PIT TP3 TERMINATED AT 3.10 m			

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP4

SHEET 1 OF 1

RCA AUSTRALIA
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PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	FILL, SAND, medium grained, brown	M		FILL
				0.5						
				1.0						
				1.5						
				2.0						
				2.5						
▽ 02/04/14				2.80		SP	FILL, SAND, fine to medium grained, grey, with shell fragments	W		
				3.0						
				3.20			TEST PIT TP4 TERMINATED AT 3.20 m			

LOGGED: JG/JC

CHECKED: MA

DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP5

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered				0.0		SP	FILL, SAND, fine to medium grained, pale brown/yellow, with shell fragments	D		FILL
				0.5			Becoming pale brown at 0.8m			
				1.0						
				1.5						
				2.0						
				2.5						
				2.90		SP	FILL, SAND, fine to medium grained, dark grey, with shell fragments	M		
				3.0						
				3.20			TEST PIT TP5 TERMINATED AT 3.20 m			

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP7

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
				0.05		SM	TOPSOIL/FILL, SAND, fine grained, brown	D		TOPSOIL / FILL
						SP	FILL, SAND, medium grained, pale brown, with shell fragments			FILL
			0.50m B 0.60m	0.5						
				1.0						
			1.20m D 1.40m							
				1.5						
				2.0						
				2.5						
▽				2.70		SP	FILL, SAND, medium grained, grey	M		
				2.80		CH	FILL, Sandy CLAY, high plasticity, dark grey			
				2.90			TEST PIT TP7 TERMINATED AT 2.90 m Due to pit collapsing			
				3.0						

LOGGED: JG/JC

CHECKED: MA

DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP9

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
				0.05		SM	TOPSOIL/FILL, Silty SAND, fine grained, brown	M		TOPSOIL / FILL
						SP	FILL, SAND, medium grained, brown, with shell fragments			FILL
			0.80m B-(D 0.9-1.0m) 1.00m	0.5 1.0						
			2.00m D 2.10m	1.5 2.0						
▽				2.5 2.60		SP	FILL, SAND, medium grained, dark grey, shell fragments and coal up to 30mm diameter	W		
				3.00			TEST PIT TP9 TERMINATED AT 3.00 m			

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GEOTECHNICAL TEST PIT LOG

TP10

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered			0.30m D 0.40m	0.5 1.0 1.5 2.0 2.5		SP	FILL, SAND, medium grained, pale brown	M		FILL
				3.00		SP	FILL, SAND, medium grained, dark grey, with silt, shell fragments and coal fragments			
				3.10			TEST PIT TP10 TERMINATED AT 3.10 m			

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP11

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered						SM	FILL, Silty SAND, medium grained, brown, with coarse grained, angular to sub angular gravel,			FILL
				0.30		SP	FILL, SAND, medium grained, pale brown			
				0.5						
				1.0						
				1.5						
				2.0						
				2.20		SP	FILL, SAND, medium grained, dark grey, with coal fines and shell fragments			
				2.5						
				2.80			TEST PIT TP11 TERMINATED AT 2.80 m			
				3.0						

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP15

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
Not Encountered			0.50m B 0.60m	0.30		SM	FILL, SAND, medium grained, brown, with shell fragments	M		FILL
				0.5		SP	FILL, SAND, medium grained, pale brown, with shell fragments			
				1.0						
				1.5						
				2.0						
				2.5						
				2.80		Pt	FILL, SAND, medium grained, grey, with shell fragments			
				3.00			TEST PIT TP15 TERMINATED AT 3.00 m			

LOGGED: JG/JC

CHECKED: MA

DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP18

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SM	TOPSOIL/FILL, Silty SAND, fine grained, brown	M		TOPSOIL / FILL
				0.10		SP	FILL, SAND, medium grained, pale brown			FILL
				0.5						
				1.0						
				1.5						
			2.00m D 2.10m	2.0						
				2.5						
02/04/14								W		
			3.00m D 3.10m	3.00		SP	FILL, SAND, medium grained, grey, shell fragments			
				3.20			TEST PIT TP18 TERMINATED AT 3.20 m			

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP19

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	FILL, SAND, medium grained, pale brown, with shell fragments	M		FILL
				0.5						
				1.0						
				1.5						
				2.0						
				2.5						
2/4/2014				2.70		SP	FILL, SAND, medium grained, dark grey	W		
				3.00			TEST PIT TP19 TERMINATED AT 3.00 m			

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP20

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556
CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 03/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
				0.10			TOPSOIL/FILL, SAND, medium grained, brown, with silt	M		TOPSOIL / FILL
			0.20m TP20a 0.40m				FILL, SAND, medium grained, brown, with shell fragments			FILL Sample part of composite 2
				0.5						
			0.90m TP20b 1.10m	1.0			Becoming pale brown			
				1.5						
			1.90m TP20c 2.10m	2.0						
				2.5						
▽			2.90m TP20d 3.10m	3.00			FILL, SAND, medium gained, grey, with shell fragments	W		
				3.20			TEST PIT TP20 TERMINATED AT 3.20 m			

LOGGED: JG | CHECKED: MA | DATE: 05/06/2014

GEOTECHNICAL TEST PIT LOG

TP21

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	FILL, SAND, medium grained, pale grey	M		FILL
				0.5						
				1.0						
				1.5						
				2.0						
				2.5						
▽ 02/04/14				3.00		SP	FILL, SAND, fine to medium grained, grey with shell fragments	W		
				3.20			TEST PIT TP21 TERMINATED AT 3.20 m			

LOGGED: JG/JC

CHECKED: MA

DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP22

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556
CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 03/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
							TOPSOIL/FILL, SAND, brown	M		TOPSOIL / FILL
				0.10						
			0.20m				FILL, SAND, medium grained, brown			FILL
			TP22a							
			0.30m							
				0.5						
			0.90m							
			TP22b							
				1.0						
			1.10m							
				1.20			FILL, Silty Sandy CLAY, black/dark brown			
				1.30			FILL, SAND, medium grained, pale brown, with shell fragments			
				1.5						
			1.90m							
			TP22c							
				2.0						
			2.10m							
				2.5						
			2.90m				Becoming saturated at 2.8m			
				2.90			FILL, SAND, medium grained, grey, with shell fragments	W		
▽			TP22d							
				3.0						
			3.10m							
				3.20			TEST PIT TP22 TERMINATED AT 3.20 m			

LOGGED: JG | CHECKED: MA | DATE: 05/06/2014

GEOTECHNICAL TEST PIT LOG

TP23

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556
CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 03/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
							TOPSOIL/FILL, SAND, brown	M		TOPSOIL / FILL
				0.10			FILL, SAND, medium grained, pale brown			FILL
			0.20m							
			TP23a QA9							
			0.40m							
				0.5						
			0.90m							
			TP23b							
			1.10m	1.0						
				1.5						
			1.90m							
			TP23c				Becoming saturated at 2.0m			
			2.10m	2.0						
				2.5						
			2.90m							
▽			TP23d	3.00			FILL, SAND, medium grained, grey	W		
			3.10m							
				3.20			TEST PIT TP23 TERMINATED AT 3.20 m			

LOGGED: JG | CHECKED: MA | DATE: 05/06/2014

GEOTECHNICAL TEST PIT LOG

TP24

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	FILL, SAND, medium grained, pale brown	M		FILL
				0.5						
				1.0						
				1.5						
				2.0						
			2.10m D 2.20m							
			2.50m D 2.60m	2.50		CH	FILL, Silty CLAY, high plasticity, black, with fine grained sand			
02/04/14 ▽				2.60		SP	FILL, SAND, medium grained, grey, with shell fragments	W		
				3.00			TEST PIT TP24 TERMINATED AT 3.00 m			

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP25

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SM	TOPSOIL/FILL, Silty SAND, fine grained, brown	M		TOPSOIL / FILL
				0.20		SP	FILL, SAND, medium grained, light brown			FILL
				0.5						
				1.0						
			1.50m D 1.60m	1.5						
				2.0						
				2.50		CH	FILL, Silty CLAY, high plasticity, black, with fine grained sand			
▽ 02/04/14				2.70		SP	FILL, SAND, medium grained, dark grey	W		
				3.00			TEST PIT TP25 TERMINATED AT 3.00 m			

LOGGED: JG/JC

CHECKED: MA

DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP26

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information					
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
				0.0		SP	FILL, SAND, medium grained, pale brown	M		FILL
				0.5						
				1.0						
				1.5						
				2.0			Shell fragments appearing at 2.1m			
▽ 02/04/14				2.50		SP	FILL, SAND, medium grained, grey to brown, with shell fragments			
				3.00			TEST PIT TP26 TERMINATED AT 3.00 m			

LOGGED: JG/JC

CHECKED: MA

DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP29

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	TOPSOIL/FILL, SAND, medium grained, brown, with silt	M		TOPSOIL / FILL
				0.10		SP	FILL, SAND, medium grained, brown to grey, with shell fragments			FILL
				0.5						
				1.0						
				1.50		SP	FILL, SAND, medium gained, pale brown, with shell fragments			
				1.60		SP	FILL, SAND, medium grained, grey			
				2.0						
02/04/14				2.5				W		
				3.0						
				3.10			TEST PIT TP29 TERMINATED AT 3.10 m			

LOGGED: JG/JC | CHECKED: MA | DATE: 28/05/2014

GEOTECHNICAL TEST PIT LOG

TP31

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Station
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE: 02/04/2014
SURFACE RL:
COORDS:
EXCAVATION METHOD: 5.5t Excavator

Test Pit Information					Field Material Information						
WATER	DYNAMIC PENETROMETER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	STRUCTURE AND ADDITIONAL OBSERVATIONS
						SP	TOPSOIL/FILL, SAND, fine grained, brown, with silt	M		TOPSOIL / FILL
				0.10		SP	FILL, SAND, medium grained, light brown, with shell fragments			FILL
				0.5						
				1.0						
				1.5						
				2.0						
				2.5						
02/04/14				2.80		SP	FILL, SAND, medium grained, grey	W		
				3.00			TEST PIT TP31 TERMINATED AT 3.00 m			

LOGGED: JG/JC

CHECKED: MA

DATE: 28/05/2014

GEOTECHNICAL BOREHOLE LOG

MW1

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE COMMENCED: 08/05/2014
DATE COMPLETED: 08/05/2014
SURFACE RL:
COORDS:
DRILL MODEL: 4WD Mounted Rig
DRILLER NAME:

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
				0.10			TOPSOIL/FILL, SAND, fine to medium grained, brown, with some shell fragments	SM		
							FILL, SAND, fine to medium grained, pale brown, with some shell fragments			Concrete
										Bentonite
		1.00m	1.00m	1						
		SPT 6, 12, 11 N=23 1.45m	D 1.45m							
	▽			2						
		2.50m	2.50m	2.50			FILL, SAND, fine to medium grained, grey, with some shell fragments	S		
		SPT 1, 2, 2 N=4 2.95m	D 2.95m	3						Gravel
		4.00m	4.00m	4.00			FILL, Sandy CLAY, low plasticity, dark grey			
		SPT 0, 1, 1 N=2 4.45m	D 4.45m				Sulfuric odour First SPT finished under the weight of the hammer			
				5.00			BOREHOLE MW1 TERMINATED AT 5.00 m			
				6						

LOGGED: JG | CHECKED: MA | DATE: 06/06/2014

GEOTECHNICAL BOREHOLE LOG

MW2

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE COMMENCED: 08/05/2014
DATE COMPLETED: 08/05/2014
SURFACE RL:
COORDS:
DRILL MODEL: 4WD Mounted Rig
DRILLER NAME:

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
				0.10			TOPSOIL/FILL, SAND, fine to medium grained, brown, with some shell fragments	SM		Concrete
							FILL, SAND, fine to medium grained, pale grey, with some shell fragments			Bentonite
		1.00m	1.00m	1						
		SPT 7, 13, 15 N=28 1.45m	D 1.45m	1.30			FILL, Sandy CLAY, low plasticity, dark brown			
				1.40			FILL, SAND, fine to medium grained, pale grey, with some shell fragments			
	▽			2						
		2.50m	2.50m				Becoming saturated at 2.5m			
		SPT 3, 6, 8 N=14 2.95m	D 2.95m	2.70			FILL, SAND, fine to medium grained, grey, with shell fragments	S		Gravel
				3						
		4.00m	4.00m	4.00			FILL, Sandy CLAY, low plasticity, dark grey, fine to medium grained sand			
		SPT 0, 1, 1 N=2 4.45m	D 4.45m							
				4.70			BOREHOLE MW2 TERMINATED AT 4.70 m			
				5						
				6						

LOGGED: JG | CHECKED: MA | DATE: 06/06/2014

GEOTECHNICAL BOREHOLE LOG

MW3

SHEET 1 OF 1

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL

PROJECT No: 10556a
CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Cnr Egret St & Cormorant Road, Kooragang Island

DATE COMMENCED: 08/05/2014
DATE COMPLETED: 08/05/2014
SURFACE RL:
COORDS:
DRILL MODEL: 4WD Mounted Rig
DRILLER NAME:

Borehole Information					Field Material Information					
METHOD	WATER	FIELD TEST	SAMPLE	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION (SOIL NAME; plasticity/grain size, colour, particle shape, secondary components, minor constituents) (ROCK NAME; grain size, colour, minor constituents)	MOISTURE/ WEATHERING	CONSISTENCY/ RELATIVE DENSITY/ STRENGTH	BORE CONSTRUCTION
				0.10			TOPSOIL/FILL, SAND, fine to medium grained, brown	SM		
							FILL, SAND, fine to medium grained, pale grey, with some shell fragments			Concrete
										Bentonite
		1.00m	1.00m	1						
		SPT 4, 7, 6 N=13	D							
		1.45m	1.45m							
				2						
	▽									
		2.50m	2.50m	2.50						
		SPT 2, 1, 6 N=7	D				FILL, SAND, fine to medium grained, grey, with shell fragments	S		
		2.95m	2.95m	2.80						
				2.90			FILL, Silty CLAY, low plasticity, dark grey/black			
				3			FILL, SAND, fine to medium grained, dark grey, with shell fragments			Gravel
		4.00m	4.00m	4.00						
		SPT 0, 1, 1 N=2	D				FILL, Sandy CLAY, low plasticity, dark grey, fine to medium grained sand, with some vegetive matter			
		4.45m	4.45m							
				5.00			BOREHOLE MW3 TERMINATED AT 5.00 m			
				6						

LOGGED: JG | CHECKED: MA | DATE: 06/06/2014

Explanatory Notes – Soil Description

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer.

METHOD

Method	Description
AS	Auger Screwing
AD/V	Auger Drilling with V Bit
AD/T	Auger Drilling with TC bit
BH	Backhoe
CT	Cable Tool Rig
N	Natural Exposure
X	Existing Excavation
E	Excavator
EH	Excavator with Hammer
HA	Hand Auger
HQ	Diamond Core-63mm
NMLC	Diamond Core-52mm
NQ	Diamond Core-47mm
PT	Push Tube
RR	Rock Roller
DB	Washbore Drag Bit
WS	Washbore
AT	Air Track
DT	Diatube
Percussion	Percussion Drilling

Water


Water level at date shown


Seepage

NOT ENCOUNTERED: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

NOT OBSERVED: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample-50mm
ES	Soil Sample, Environmental
EW	Water Sample, Environmental
G	Gas Sample

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
CI	Clay of medium plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty soil

MOISTURE CONDITION

Dry	Cohesive soils are friable or powdery Cohesionless soil grains are free-running.
Moist	Soil feels cool, darkened in colour Cohesive soils can be moulded Cohesionless soil grains tend to adhere.
Wet	Cohesive soils usually weakened Free water forms on hands when handling.

For cohesive soils the following codes may also be used:

MC>PL	Moisture Content greater than the Plastic Limit.
MC-PL	Moisture Content near the Plastic Limit.
MC<PL	Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows.

Description of Plasticity	LL(%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS – CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding. A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. Undrained shear strength Cu = 0.5×UCS. The UCS values are recorded in kPa as follows:

Strength	Symbol	Unconfined Compressive Strength, q_u (kPa)
Very Soft	VS	< 25
Soft	S	25 to 50
Firm	F	50 to 100
Stiff	St	100 to 200
Very Stiff	VSt	200 to 400
Hard	H	> 400

COHESIONLESS SOILS – RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) N values. Other condition terms, such as friable, powdery or crumbly may also be used.

Term	Symbol	Density Index	N Value (blows/0.3m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	Coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	Fine	2.36 mm to 6 mm
Sand	Coarse	0.6 mm to 2.36 mm
	medium	0.2 mm to 0.6 mm
	fine	0.075 mm to 0.2 mm

Explanatory Notes - Rock Description

METHOD

Refer soil description sheet.

WATER

Refer soil description sheet.

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

TCR (%) = $\frac{\text{length of core recovered}}{\text{length of core run}}$

RQD (%) = $\frac{\text{sum of axial lengths of core > 100mm long}}{\text{length of core run.}}$

ROCK MATERIAL WEATHERING

Rock weathering is described using the abbreviations and definitions used in AS1726.

Term	Symbol	Definition
Residual soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has 'soil' properties, ie, it either disintegrates or can be remoulded in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM – Commission on Standardisation of Laboratory and Field Tests, 'Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index' as follows:

Term	Symbol	Point Load Index Is_{50} (MPa)
Extremely Low	EL	≤0.03
Very Low	VL	>0.03 to ≤0.1
Low	L	>0.1 to ≤0.3
Medium	M	>0.3 to ≤1.0
High	H	>1 to ≤3
Very High	VH	>3 to ≤10
Extremely High	EH	>10

◀ Diametral Point Load Index test.

▼ Axial Point Load Index test.

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 0.2 m	Thick
Very widely spaced	>2 m	Very thick

DEFECT DESCRIPTION

Type	Definition
JT	Joint
BP	Bed Parting
CO	Contact
CS	Clay Seam
CZ	Crush Zone
DK	Dyke
DZ	Decomposed Zone
FC	Fracture
FZ	Fracture Zone
FL	Foliation
FLT	Fault
VN	Vein
SM	Seam
IS	Infilled Seam
SZ	Shear Zone
DB	Drill Break
HB	Handling Break

Planarity	Roughness
PR – Planar	RF – Rough
IR – Irregular	VR – Very Rough
ST – stepped	S – Smooth
U – Undulating	SL – Slickensides
CU - Curved	POL – Polished

Symbol	Coating or infill
X	Carbonaceous
CA	Calcite
Fe	Iron oxide
KT	Chlorite
Clay	Clay
CN	Clean
Qz	Quartz
SN	Stain
VNR	Veneer

The inclinations of defects are measured from perpendicular to the core axis.

RCA AUSTRALIA
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AWS-TEM-022/2

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Fax: (02) 4902 9299

PERTH SAND PENETROMETER TEST REPORT

(Australian Standard 1289.6.3.3)

CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Lot 10,11,12 Cormorant Road Kooragang
DATE OF TESTING: 3-4 April 2014

PROJECT No: 10556
DATE OF REPORT:
TESTED BY: JC
PAGE: 1

Test Number	TP1	TP2	TP3	TP4	TP5	TP7	TP 9	TP 10
Soil Description	SAND	SAND	SAND	SAND	SAND	SAND	SAND	SAND
Moisture Condition	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Groundwater Level	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Depth (m)	Number of Blows/150mm from 600mm drop							
0.00 - 0.15	Seated	Seated	Seated	Seated	Seated	Seated	Seated	Seated
0.15 - 0.30	6	8	4	3	4	2	3	1
0.30 - 0.45	8	10	9	7	10	4	4	5
0.45 - 0.60	13	18	15	12	6	3	4	8
0.60 - 0.75	20	21	12	12	8	3	5	9
0.75 – 0.90	22	21	20	11	12	2	7	8
0.90 – 1.05	20	18	12	16	3	4	9	11
1.05 – 1.20	24	16	12	9	7	8	6	10
1.20 – 1.35	28	12	10	8	8	6	8	10
1.35 – 1.50		11	11	9	7	6	7	16
1.50 – 1.65		10	12	8	10	7	8	30
1.65 – 1.80		10	8	12	11	8	5	
1.80 – 1.95		6	21	7	12	8	5	
1.95 – 2.10		7	24	7	11	9	9	
2.10 – 2.25		9		15	15	7	11	
2.25 – 2.40		10		21	14	7	9	
2.40 – 2.55		12		25	14	4	8	
2.55 – 2.70		14			14	12	9	
2.70 – 2.85		12			15	9	9	
2.85 – 3.00		16			12	15	9	

Note: Testing undertaken using the apparatus (i.e. Perth sand penetrometer) conforming to the requirements of AS 1289.6.3.3, but using the methods of test described in AS 1289.6.3.2.

RCA Australia	**Tested by: JC**	**Date: 4/4/14**
Office:	**Checked by: MA**	**Date: 28/5/14**

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PERTH SAND PENETROMETER TEST REPORT

(Australian Standard 1289.6.3.3)

CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Lot 10,11,12 Cormorant Road Kooragang
DATE OF TESTING: 3-4 April 2014

PROJECT No: 10556
DATE OF REPORT:
TESTED BY: JC
PAGE: 2

Test Number	TP11	TP15	TP18	TP19	TP21	TP24	TP25	
Soil Description	SAND	SAND	SAND	SAND	SAND	SAND	SAND	
Moisture Condition	Dry	Dry	Dry	Dry	Dry	Dry	Dry	
Groundwater Level	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Depth (m)	Number of Blows/150mm from 600mm drop							
0.00 - 0.15	Seated	Seated	Seated	Seated	Seated	Seated	Seated	Seated
0.15 - 0.30	4	11	7	15	3	5	6	
0.30 - 0.45	9	15	4	2	5	8	10	
0.45 - 0.60	30	8	12	6	5	24	25	
0.60 - 0.75		7	9	11	8			
0.75 – 0.90		7	8	10	7			
0.90 – 1.05		4	19	14	7			
1.05 – 1.20		9	20	12	11			
1.20 – 1.35		5	18	12	12			
1.35 – 1.50		13	21	30	10			
1.50 – 1.65		11	20		10			
1.65 – 1.80		12	16		17			
1.80 – 1.95		11	6		18			
1.95 – 2.10		11	9		24			
2.10 – 2.25		11	8					
2.25 – 2.40		15	8					
2.40 – 2.55		19	8					
2.55 – 2.70		18	8					
2.70 – 2.85		30	12					
2.85 – 3.00			13					

Note: Testing undertaken using the apparatus (i.e. Perth sand penetrometer) conforming to the requirements of AS 1289.6.3.3, but using the methods of test described in AS 1289.6.3.2.

RCA Australia	**Tested by: JC**	**Date: 4/4/14**
Office:	**Checked by: MA**	**Date: 28/5/14**

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PERTH SAND PENETROMETER TEST REPORT

(Australian Standard 1289.6.3.3)

CLIENT: Sovechles Development
PROJECT: Kooragang Service Centre
LOCATION: Lot 10,11,12 Cormorant Road Kooragang
DATE OF TESTING: 3-4 April 2014

PROJECT No: 10556
DATE OF REPORT:
TESTED BY: JC
PAGE: 3

Test Number	TP26	TP29	TP31					
Soil Description	SAND	SAND	SAND					
Moisture Condition	Dry	Dry	Dry					
Groundwater Level	3.0	3.0	3.0					
Depth (m)	Number of Blows/150mm from 600mm drop							
0.00 - 0.15	Seated	Seated	Seated	Seated	Seated	Seated	Seated	Seated
0.15 - 0.30	6	8	4					
0.30 - 0.45	8	10	10					
0.45 - 0.60	13	18	10					
0.60 - 0.75	20	21	8					
0.75 – 0.90	22	21	12					
0.90 – 1.05	20	18	14					
1.05 – 1.20	24	16	12					
1.20 – 1.35	28	12	17					
1.35 – 1.50		11	17					
1.50 – 1.65		10	26					
1.65 – 1.80		10						
1.80 – 1.95		6						
1.95 – 2.10		7						
2.10 – 2.25		9						
2.25 – 2.40		10						
2.40 – 2.55		12						
2.55 – 2.70		14						
2.70 – 2.85		12						
2.85 – 3.00		16						

Note: Testing undertaken using the apparatus (i.e. Perth sand penetrometer) conforming to the requirements of AS 1289.6.3.3, but using the methods of test described in AS 1289.6.3.2.

RCA Australia	**Tested by: JC**	**Date: 4/4/14**
Office:	**Checked by: MA**	**Date: 28/5/14**

Appendix C

Laboratory Results

RCA LABORATORIES
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CONSTRUCTION MATERIALS TESTING

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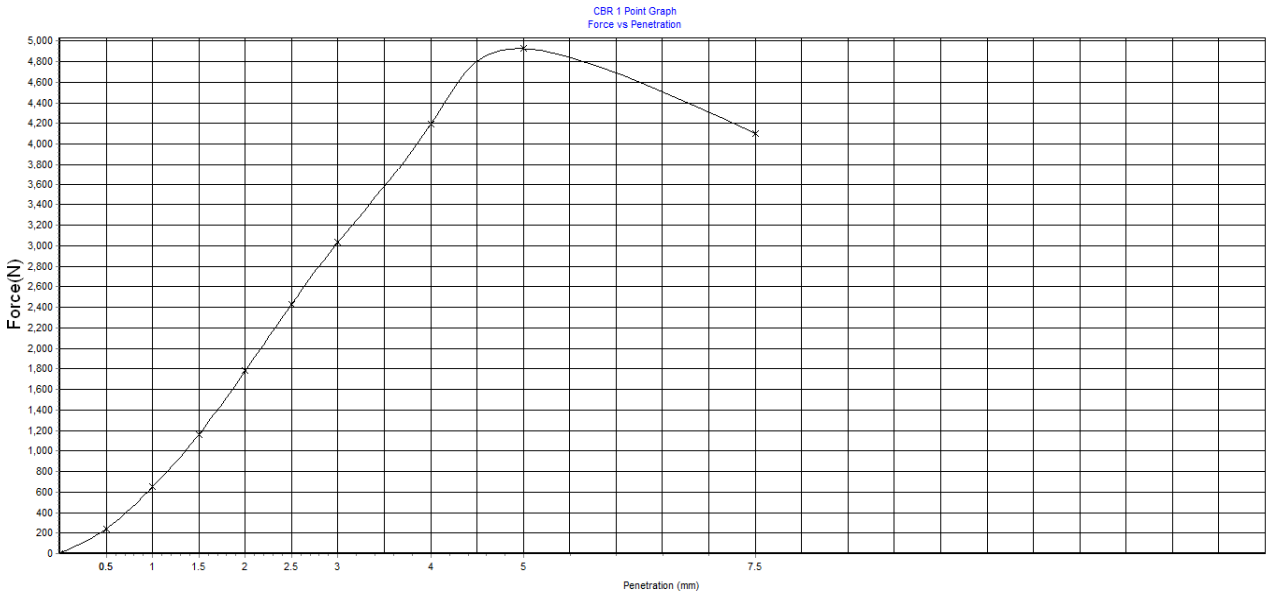
WEB www.rca.com.au
ABN 53 063 515 711
NATA Accredited Laboratory: 9811
Corporate Site No: 9804
Construction Materials Testing

California Bearing Ratio Report (1 Point)

Client:	**Sovechles Developments Pty Ltd**	Report Number:	**10556a - 001**
Client address:	**36 Kemp Street The Junction NSW 2303**		
Job Number:	**10556a**	Report Date:	**16/04/2014**
Project:	**Installation & Sampling of Groundwater Monitoring Wells for UPSS Regulation**	Order Number:	
Location	**Cnr Cormorant Road & Egret Street , Kooragang**		**Page 1 of 1**
Lab No:	**14-416**	Sample Location	
Date Sampled:	**3/04/2014**	TP7	
Date Tested:	**15/04/2014**	0.5m - 0.6m	
Sampled By:	**Julian Cavicchia**		
Sample Method:	**AS 1289.1.2.1-6.5.1**		
Material Source:	**-**	Test Method :	AS 1289.6.1.1
For Use As:	**-**	Lot Number:	**-**
Remarks:	**-**	Item Number :	**-**



Maximum Dry Density - MDD (t/m³) :	**1.700**	Dry Density after Soak (t/m³) :	**1.681**
Maximum Moisture Content (%) :	**24.0**	Moisture Content after Soak (%) :	**25.1**
Compactive Effort :	**Vibrated**	Density Ratio after Soak (%) :	**99**
Nominated % Maximum Dry Density Compaction :	**100**	Field Moisture Content (%) :	**4.2**
Nominated % Optimum Moisture Content Compaction :	**100**	Moisture Content (Top) after Penetration (%) :	**25.2**
Achieved Dry Density before Soak (t/m³) :	**1.681**	Optional Moisture Content (Remainder) after Penetration (%) :	**24.6**
Achieved Percentage of Maximum Dry Density (%) :	**99**	CBR 2.5mm (%) :	**25**
Achieved Moisture Content (%) :	**24.4**	CBR 5.0mm (%) :	**25**
Achieved Percentage of Optimum Moisture Content (%) :	**102**	Minimum Specified CBR Value (%) :	**-**
Test Condition (Soaked/Unsoaked) / Soaking Period (Days) :	**Soaked / 4 days**	**CBR Value (%) :**	**25**
Swell (%) / Surcharge (kg):	**0.0 / 4.5 kg**	+19mm Material (%) 0	Oversize replacement excluded

Soil Description : SAND

Approved Signatory
Matt Flood
NATA Accred No:9811

Form Number
RP50-3

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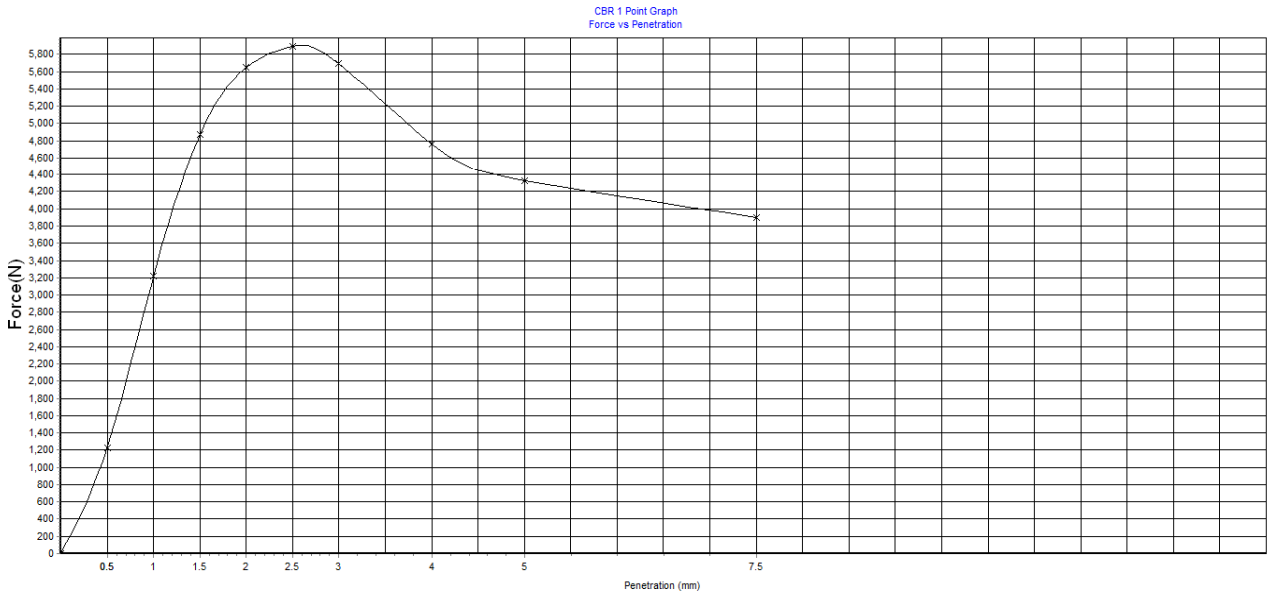
WEB www.rca.com.au
ABN 53 063 515 711
NATA Accredited Laboratory: 9811
Corporate Site No: 9804
Construction Materials Testing

California Bearing Ratio Report (1 Point)

Client:	**Sovechles Developments Pty Ltd**	Report Number:	**10556a - 002**
Client address:			
Job Number:	**10556a**	Report Date:	**16/04/2014**
Project:	**Installation & Sampling of Groundwater Monitoring Wells for UPSS Regulation**	Order Number:	
Location	**Cnr Cormorant Road & Egret Street , Kooragang**		**Page 1 of 1**
Lab No:	**14-417**	Sample Location	
Date Sampled:	**3/04/2014**	TP9	
Date Tested:	**15/04/2014**	0.8m - 1.0m	
Sampled By:	**Julian Cavicchia**		
Sample Method:	**AS 1289.1.2.1-6.5.1**		
Material Source:	**-**	Test Method :	AS 1289.6.1.1
For Use As:	**-**	Lot Number:	**-**
Remarks:	**-**	Item Number :	**-**



Maximum Dry Density - MDD (t/m³) :	**1.740**	Dry Density after Soak (t/m³) :	**1.722**
Maximum Moisture Content (%) :	**21.7**	Moisture Content after Soak (%) :	**21.9**
Compactive Effort :	**Vibrated**	Density Ratio after Soak (%) :	**99**
Nominated % Maximum Dry Density Compaction :	**100**	Field Moisture Content (%) :	**3.8**
Nominated % Optimum Moisture Content Compaction :	**100**	Moisture Content (Top) after Penetration (%) :	**22.7**
Achieved Dry Density before Soak (t/m³) :	**1.722**	Optional Moisture Content (Remainder) after Penetration (%) :	**21.9**
Achieved Percentage of Maximum Dry Density (%) :	**99**	CBR 2.5mm (%) :	**45**
Achieved Moisture Content (%) :	**21.2**	CBR 5.0mm (%) :	**20**
Achieved Percentage of Optimum Moisture Content (%) :	**98**	Minimum Specified CBR Value (%) :	**-**
Test Condition (Soaked/Unsoaked) / Soaking Period (Days) :	**Soaked / 4 days**	**CBR Value (%) :**	**45**
Swell (%) / Surcharge (kg):	**0.0 / 4.5 kg**	+19mm Material (%) 0	Oversize replacement excluded

Soil Description : SAND

NATA

Accredited for compliance with ISO/IEC 17025.

Approved Signatory
Matt Flood
NATA Accred No:9811

Form Number
RP50-3

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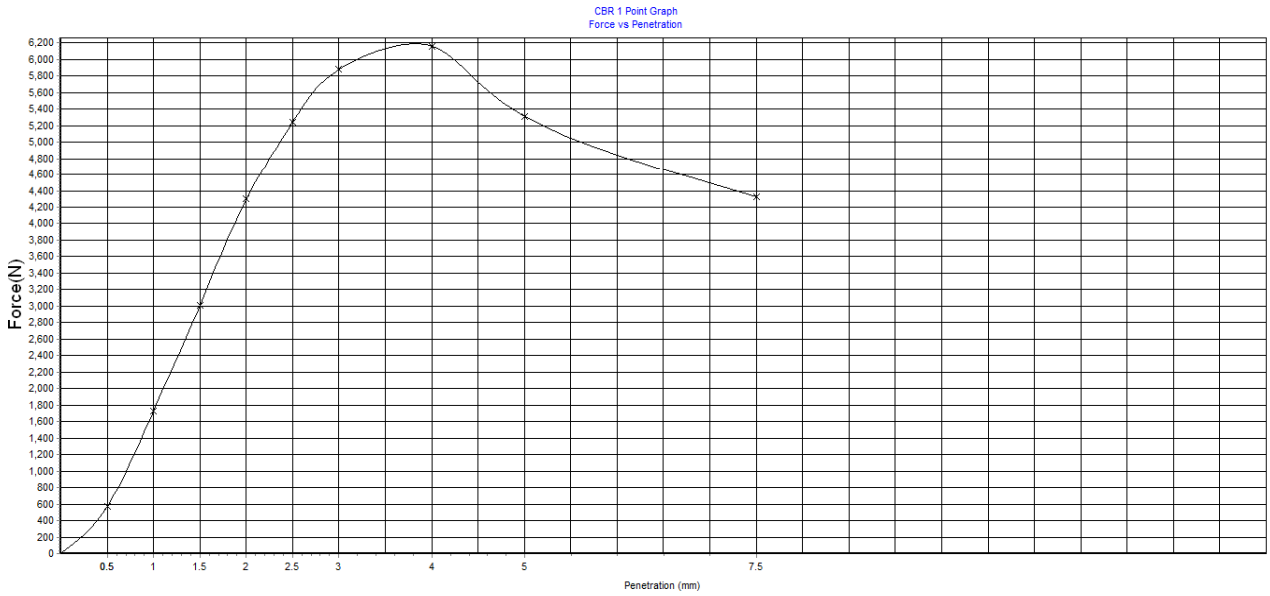
ABN 53 063 515 711
NATA Accredited Laboratory: 9811
Corporate Site No: 9804
Construction Materials Testing

California Bearing Ratio Report (1 Point)

Client:	**Sovechles Developments Pty Ltd**	Report Number:	**10556a - 003**
Client address:	**36 Kemp Street The Junction NSW 2303**		
Job Number:	**10556a**	Report Date:	**16/04/2014**
Project:	**Installation & Sampling of Groundwater Monitoring Wells for UPSS Regulation**	Order Number:	
Location	**Cnr Cormorant Road & Egret Street , Kooragang**		**Page 1 of 1**
Lab No:	**14-418**	Sample Location	
Date Sampled:	**3/04/2014**	TP15	
Date Tested:	**15/04/2014**	0.5m - 0.6m	
Sampled By:	**Julian Cavicchia**		
Sample Method:	**AS 1289.1.2.1-6.5.1**		
Material Source:	**-**	Test Method :	AS 1289.6.1.1
For Use As:	**-**	Lot Number:	**-**
Remarks:	**-**	Item Number :	**-**



Maximum Dry Density - MDD (t/m³) :	**1.700**	Dry Density after Soak (t/m³) :	**1.704**
Maximum Moisture Content (%) :	**22.7**	Moisture Content after Soak (%) :	**22.8**
Compactive Effort :	**Vibrated**	Density Ratio after Soak (%) :	**100**
Nominated % Maximum Dry Density Compaction :	**100**	Field Moisture Content (%) :	**3.4**
Nominated % Optimum Moisture Content Compaction :	**100**	Moisture Content (Top) after Penetration (%) :	**23.4**
Achieved Dry Density before Soak (t/m³) :	**1.704**	Optional Moisture Content (Remainder) after Penetration (%) :	**22.3**
Achieved Percentage of Maximum Dry Density (%) :	**100**	CBR 2.5mm (%) :	**45**
Achieved Moisture Content (%) :	**22.1**	CBR 5.0mm (%) :	**25**
Achieved Percentage of Optimum Moisture Content (%) :	**97**	Minimum Specified CBR Value (%) :	**-**
Test Condition (Soaked/Unsoaked) / Soaking Period (Days) :	**Soaked / 4 days**	**CBR Value (%) :**	**45**
Swell (%) / Surcharge (kg):	**0.0 / 4.5 kg**	+19mm Material (%) 0	Oversize replacement excluded

Soil Description : SAND

NATA

Accredited for compliance with ISO/IEC 17025.

Approved Signatory
Matt Flood
NATA Accred No:9811

Form Number
RP50-3

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1408516**	Page	: 1 of 4
Client	: **ROBERT CARR & ASSOCIATES P/L**	Laboratory	: Environmental Division Brisbane
Contact	: JULIAN CAVICCHIA	Contact	: Customer Services
Address	: P O BOX 175 CARRINGTON NSW, AUSTRALIA 2294	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: julianc@rca.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 02 49029200	Telephone	: +61 7 3243 7222
Facsimile	: +61 02 49029299	Facsimile	: +61 7 3243 7218
Project	: 10556a	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 08-APR-2014
Sampler	: ----	Issue Date	: 15-APR-2014
Site	: ----		
		No. of samples received	: 5
Quote number	: SY/393/13	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **ASS: EA029 (SPOCAS): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from kg/t dry weight to kg/m3 in-situ soil, multiply reported results x wet bulk density of soil in t/m3.**
- **ASS: EA029 (SPOCAS): Retained Acidity not required because pH KCl greater than or equal to 4.5**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Satish Trivedi	2 IC Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils
		Brisbane Inorganics

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Compound	CAS Number	LOR	Unit	Client sample ID	TP9 2.0-2.1	TP10 0.3-0.4	TP17	TP18 3.0-3.1	TP24 2.5-2.6
				Client sampling date / time	03-APR-2014 11:00	03-APR-2014 11:00	03-APR-2014 11:00	03-APR-2014 11:00	03-APR-2014 11:00
					EB1408516-001	EB1408516-002	EB1408516-003	EB1408516-004	EB1408516-005
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		9.2	9.0	8.9	9.0	8.3
EA029-A: pH Measurements									
pH KCl (23A)	----	0.1	pH Unit		9.8	----	9.7	----	8.0
pH OX (23B)	----	0.1	pH Unit		8.0	----	8.0	----	4.0
EA029-B: Acidity Trail									
Titratable Actual Acidity (23F)	----	2	mole H+ / t		<2	----	<2	----	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t		<2	----	<2	----	154
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t		<2	----	<2	----	154
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S		<0.02	----	<0.02	----	<0.02
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S		<0.02	----	<0.02	----	0.25
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S		<0.02	----	<0.02	----	0.25
EA029-C: Sulfur Trail									
KCl Extractable Sulfur (23Ce)	----	0.02	% S		<0.02	----	<0.02	----	0.14
Peroxide Sulfur (23De)	----	0.02	% S		<0.02	----	0.03	----	0.74
Peroxide Oxidisable Sulfur (23E)	----	0.02	% S		<0.02	----	0.03	----	0.59
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t		<10	----	17	----	369
EA029-D: Calcium Values									
KCl Extractable Calcium (23Vh)	----	0.02	% Ca		0.12	----	0.11	----	0.69
Peroxide Calcium (23Wh)	----	0.02	% Ca		2.05	----	1.03	----	0.83
Acid Reacted Calcium (23X)	----	0.02	% Ca		1.93	----	0.92	----	0.14
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t		964	----	459	----	71
sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S		1.54	----	0.74	----	0.11
EA029-E: Magnesium Values									
KCl Extractable Magnesium (23Sm)	----	0.02	% Mg		<0.02	----	<0.02	----	0.04
Peroxide Magnesium (23Tm)	----	0.02	% Mg		<0.02	----	<0.02	----	0.08
Acid Reacted Magnesium (23U)	----	0.02	% Mg		<0.02	----	<0.02	----	0.03
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t		<10	----	<10	----	28
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S		<0.02	----	<0.02	----	0.04
EA029-F: Excess Acid Neutralising Capacity									
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3		5.74	----	2.88	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP9 2.0-2.1	TP10 0.3-0.4	TP17	TP18 3.0-3.1	TP24 2.5-2.6
				Client sampling date / time	03-APR-2014 11:00	03-APR-2014 11:00	03-APR-2014 11:00	03-APR-2014 11:00	03-APR-2014 11:00
Compound	CAS Number	LOR	Unit		EB1408516-001	EB1408516-002	EB1408516-003	EB1408516-004	EB1408516-005
EA029-F: Excess Acid Neutralising Capacity - Continued									
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t		**1150**	----	**575**	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S		**1.84**	----	**0.92**	----	----
EA029-H: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		**1.5**	----	**1.5**	----	**1.5**
Net Acidity (sulfur units)	----	0.02	% S		<0.02	----	<0.02	----	**0.36**
Net Acidity (acidity units)	----	10	mole H+ / t		<10	----	<10	----	**226**
Liming Rate	----	1	kg CaCO3/t		<1	----	<1	----	**17**
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		**8.8**	**2.6**	**14.2**	**17.4**	**41.5**
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		<10	<10	**40**	**60**	**530**
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	10	mg/kg		<10	<10	<10	**10**	**210**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1411886**	Page	: 1 of 3
Client	: **ROBERT CARR & ASSOCIATES P/L**	Laboratory	: Environmental Division Sydney
Contact	: JULIAN CAVICCHIA	Contact	: Client Services
Address	: P O BOX 175 CARRINGTON NSW, AUSTRALIA 2294	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: julianc@rca.com.au	E-mail	: sydney@alsglobal.com
Telephone	: +61 02 49029200	Telephone	: +61-2-8784 8555
Facsimile	: +61 02 49029299	Facsimile	: +61-2-8784 8500
Project	: 10556A SANDY CREEK ROAD MUSSWELLBROOK	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 29-MAY-2014
Sampler	: JC	Issue Date	: 02-JUN-2014
Site	: ----		
		No. of samples received	: 5
Quote number	: SY/393/13	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alison Graham	Supervisor - Inorganic	Newcastle - Inorganics
Ankit Joshi	Inorganic Chemist	Sydney Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

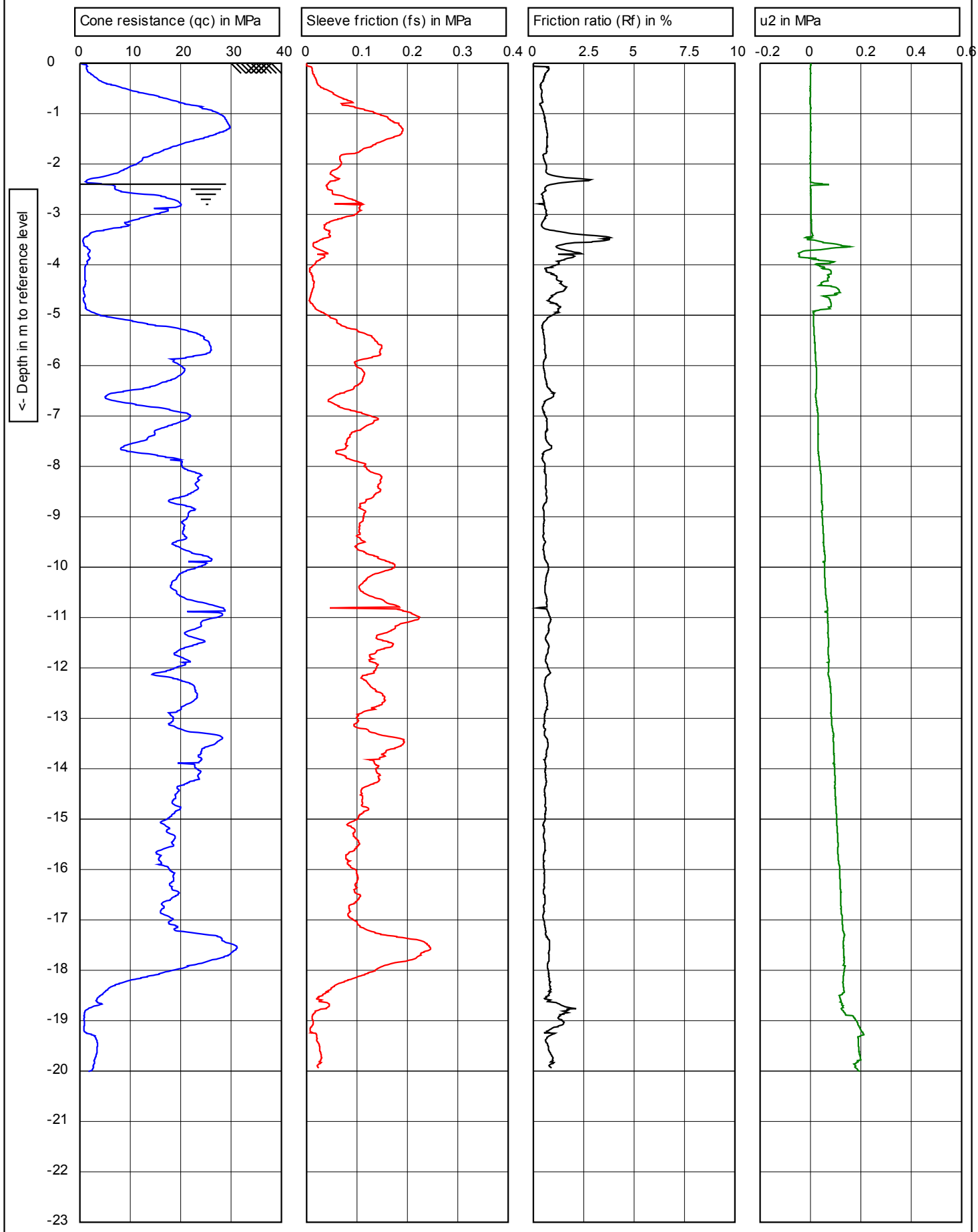
Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	MW1 3.0M	MW1 4.0	MW2 3.0	MW2 4.0	MW3 3.0
				Client sampling date / time	29-MAY-2014 11:00	29-MAY-2014 11:00	29-MAY-2014 11:00	29-MAY-2014 11:00	29-MAY-2014 11:00
					ES1411886-001	ES1411886-002	ES1411886-003	ES1411886-004	ES1411886-005
EA005: pH									
pH Value	----	0.01	pH Unit		**7.77**	**7.82**	**7.95**	**7.79**	**7.78**
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**596**	**835**	**511**	**614**	**577**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**63**	**120**	**26**	**66**	**57**
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**29**	**57**	**11**	**27**	**27**

Appendix D

CPT Report Sheets



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
150 cm²
10 cm²

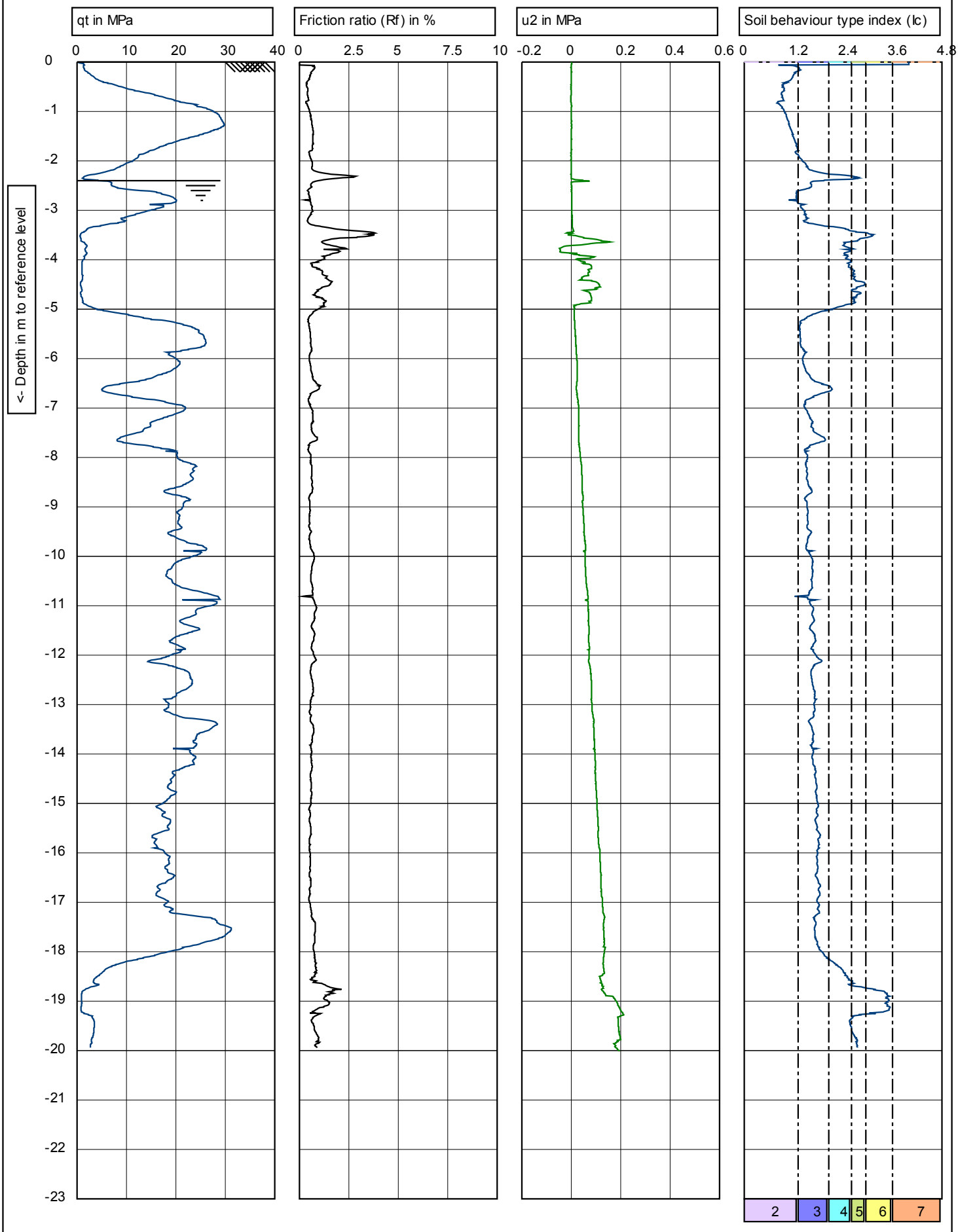
Test according NEN 5140 class 1

G.L. : **0 NAP** W.L. : **-2.4**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-1** 1/3

CPTask V1.14



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
150 cm²
10 cm²

Test according NEN 5140 class 1

G.L. : **0 NAP** | W.L. : **-2.4**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

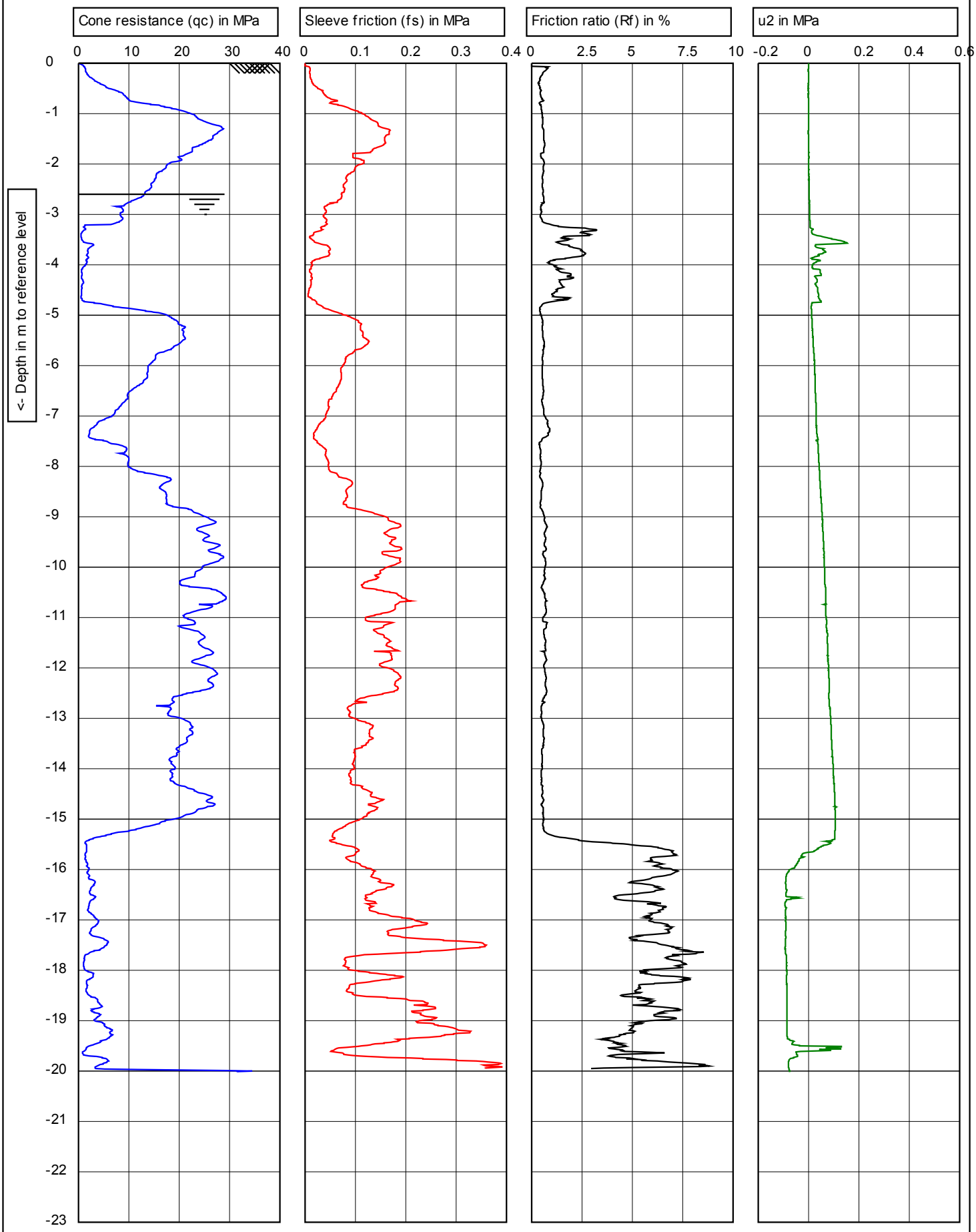
Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-1** 2/3

CPTask V1.14

(2) Gravelly sand
(3) Sand clean to silty
(4) Sand mixtures
(5) Silt mixtures
(6) Clay
(7) Organic soils

NEWSYD GEOTECHNCIAL TESTING Ph:0408292638	r u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Pre drill :	**0**
		G.L. : **0 NAP**	W.L. : **-2.4**	Date :	**4/14/2014**
Project : **Geotechnical Investigation** Location : **Kooragang Island** Position :				Cone no. :	**C10CFIIP.F91**
				Project no. :	**10566A**
				CPT no. :	**CPT-1** **3/3**

CPTask V1.14



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
150 cm²
10 cm²

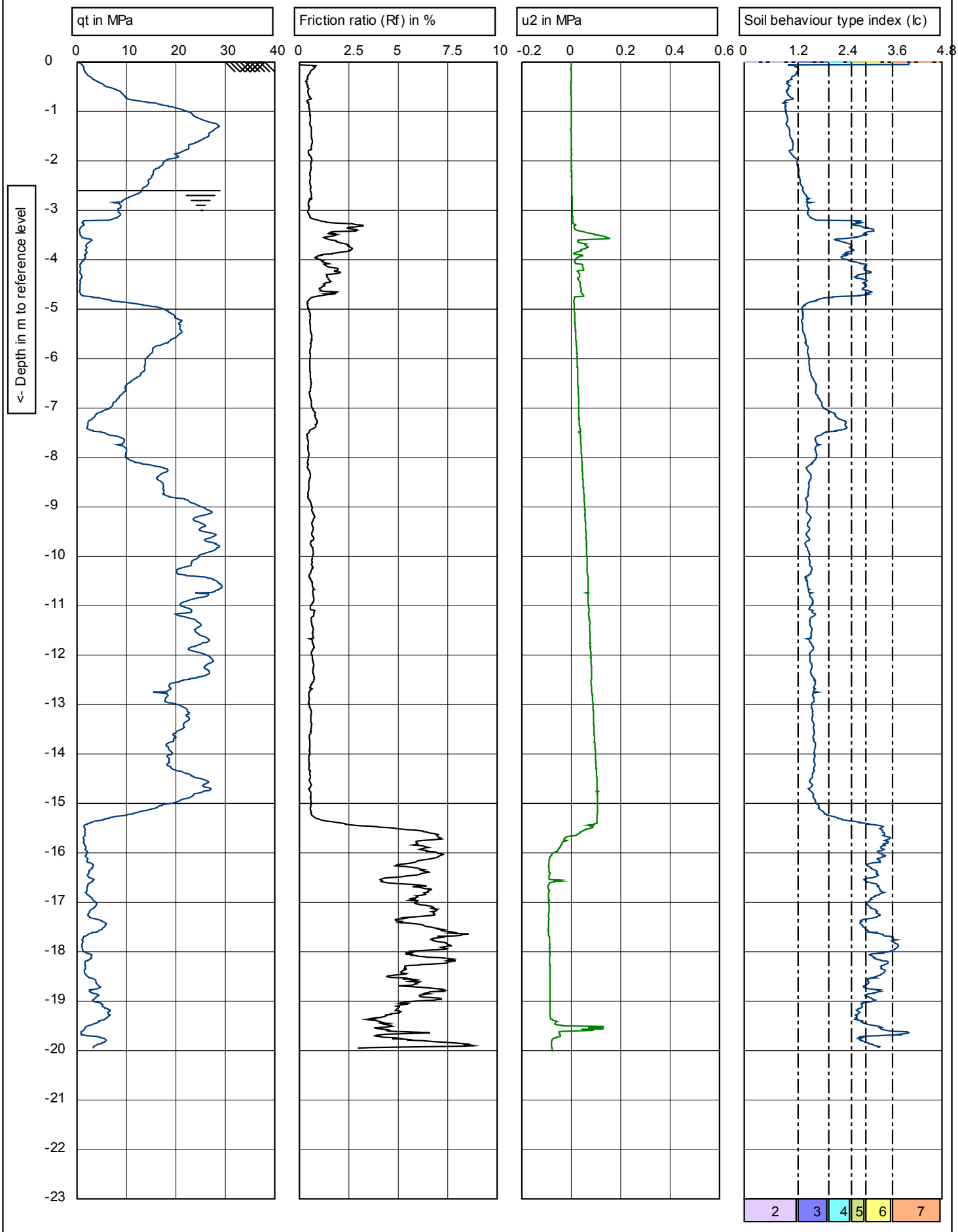
Test according NEN 5140 class 1

G.L. : **0 NAP** W.L. : **-2.6**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-2** 1/3

CPTask V1.14



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
L 150 cm²
10 cm²

Test according NEN 5140 class 1

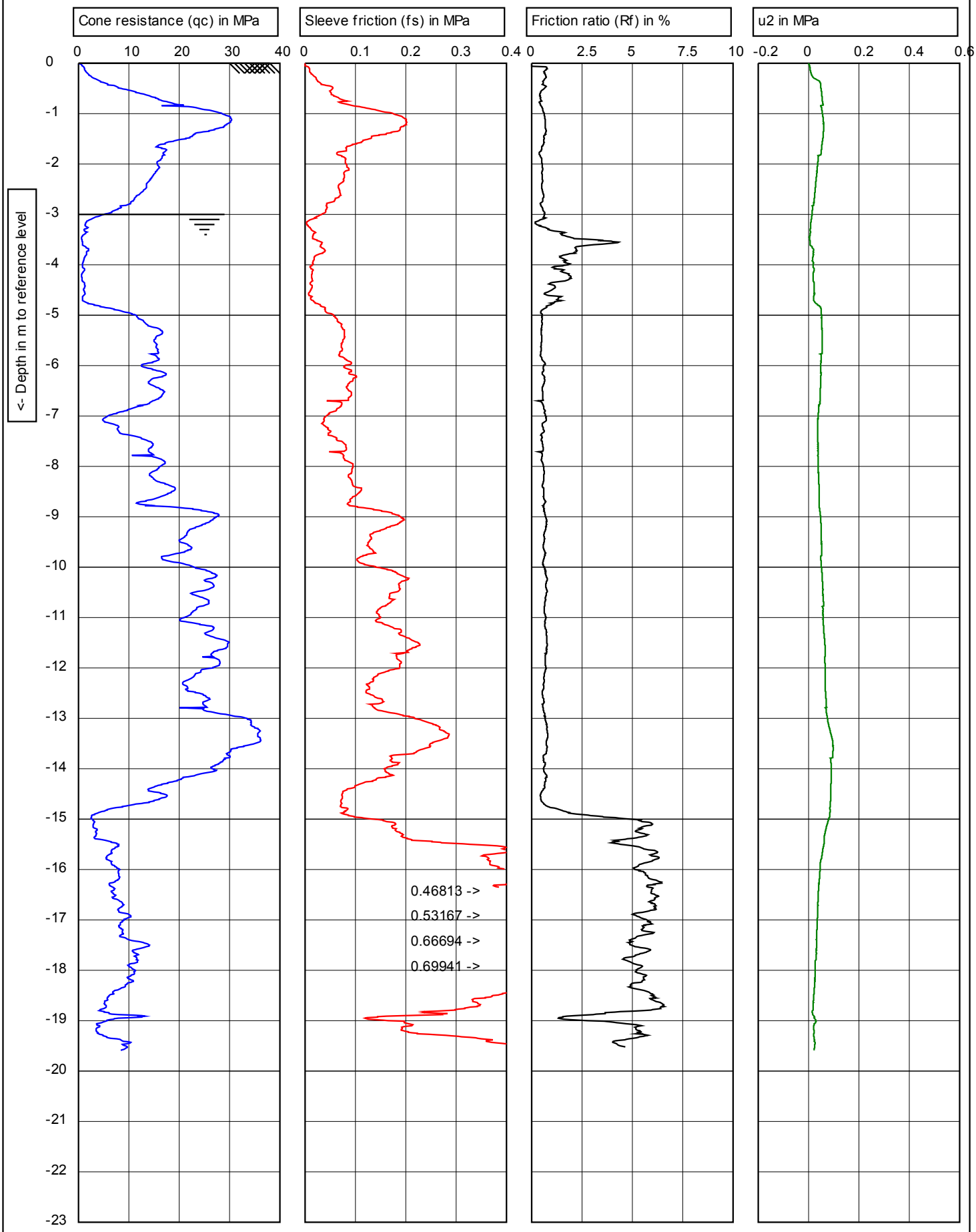
G.L. : **0 NAP** W.L. : **-2.6**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-2** **2/3**

CPTask V1.14

(2) Gravelly sand
(3) Sand clean to silty
(4) Sand mixtures
(5) Silt mixtures
(6) Clay
(7) Organic soils



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

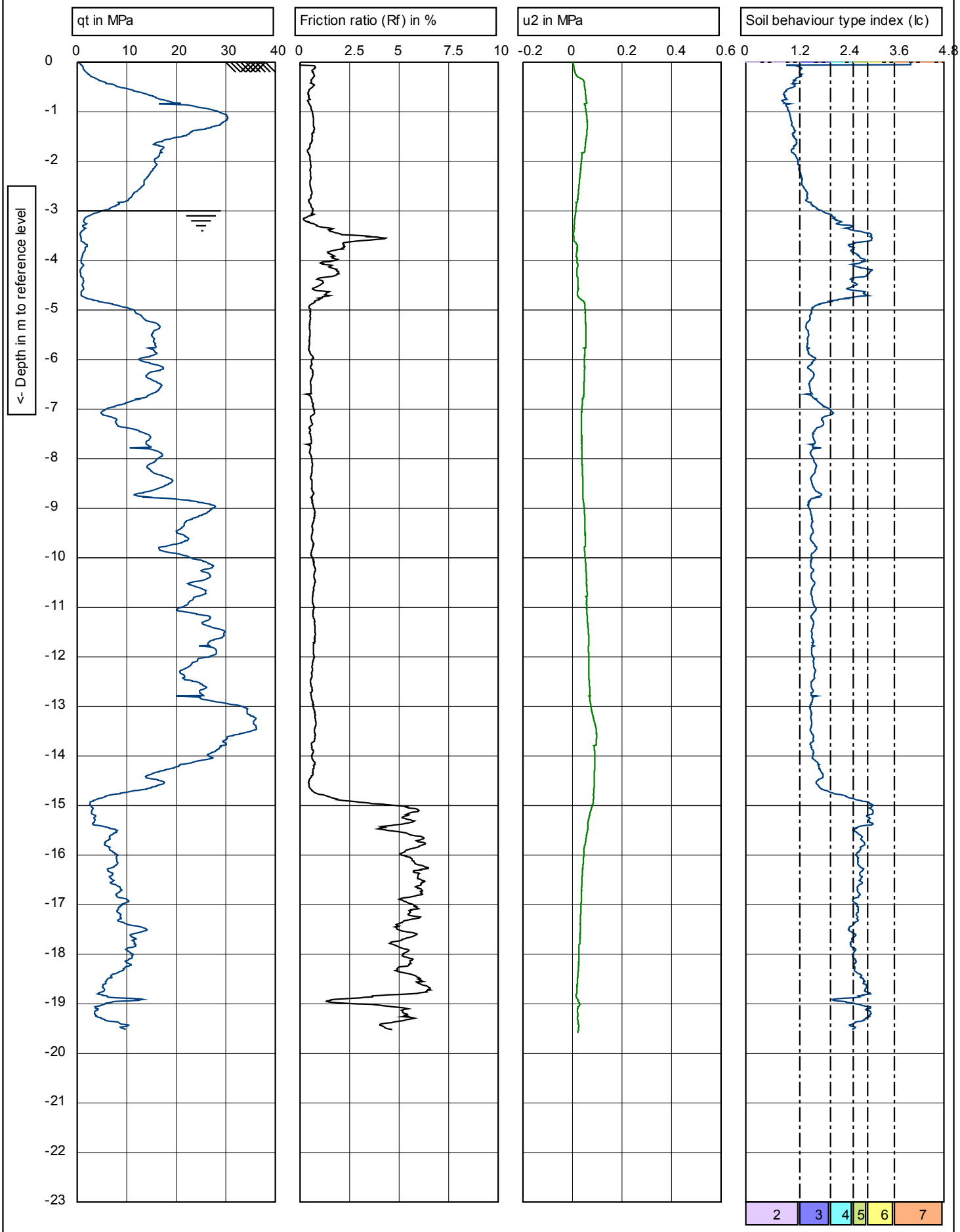
Test according NEN 5140 class 1

G.L. : **0 NAP** W.L. : **-3**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-3** **1/3**

CPTask V1.14



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
L 150 cm²
10 cm²

Test according NEN 5140 class 1

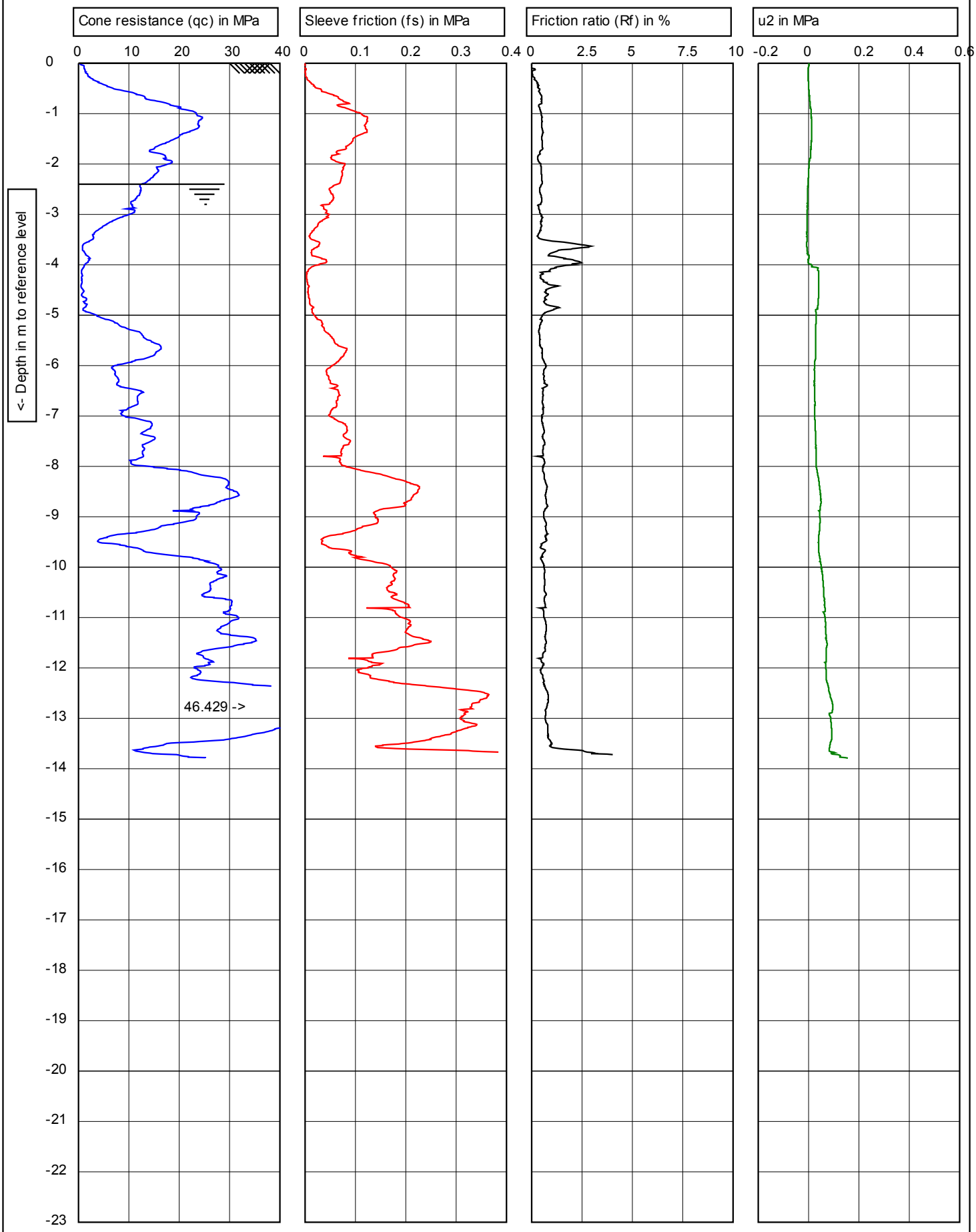
G.L. : **0 NAP** W.L. : **-3**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-3** 2/3

CPTask V1.14

(2) Gravelly sand
(3) Sand clean to silty
(4) Sand mixtures
(5) Silt mixtures
(6) Clay
(7) Organic soils



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
150 cm²
10 cm²

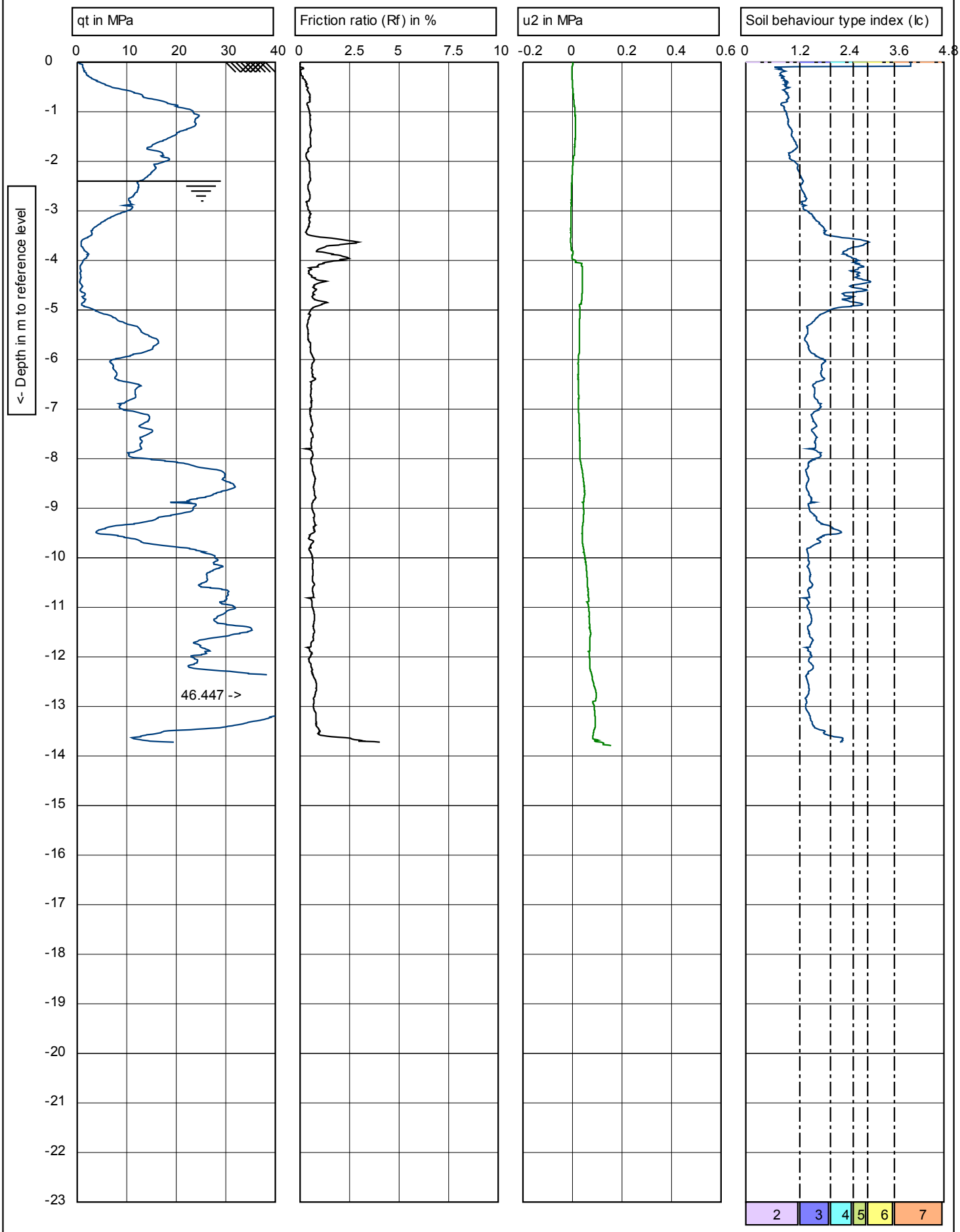
Test according NEN 5140 class 1

G.L. : **0 NAP** W.L. : **-2.4**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-4** 1/3

CPTask V1.14



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
150 cm²
10 cm²

Test according NEN 5140 class 1

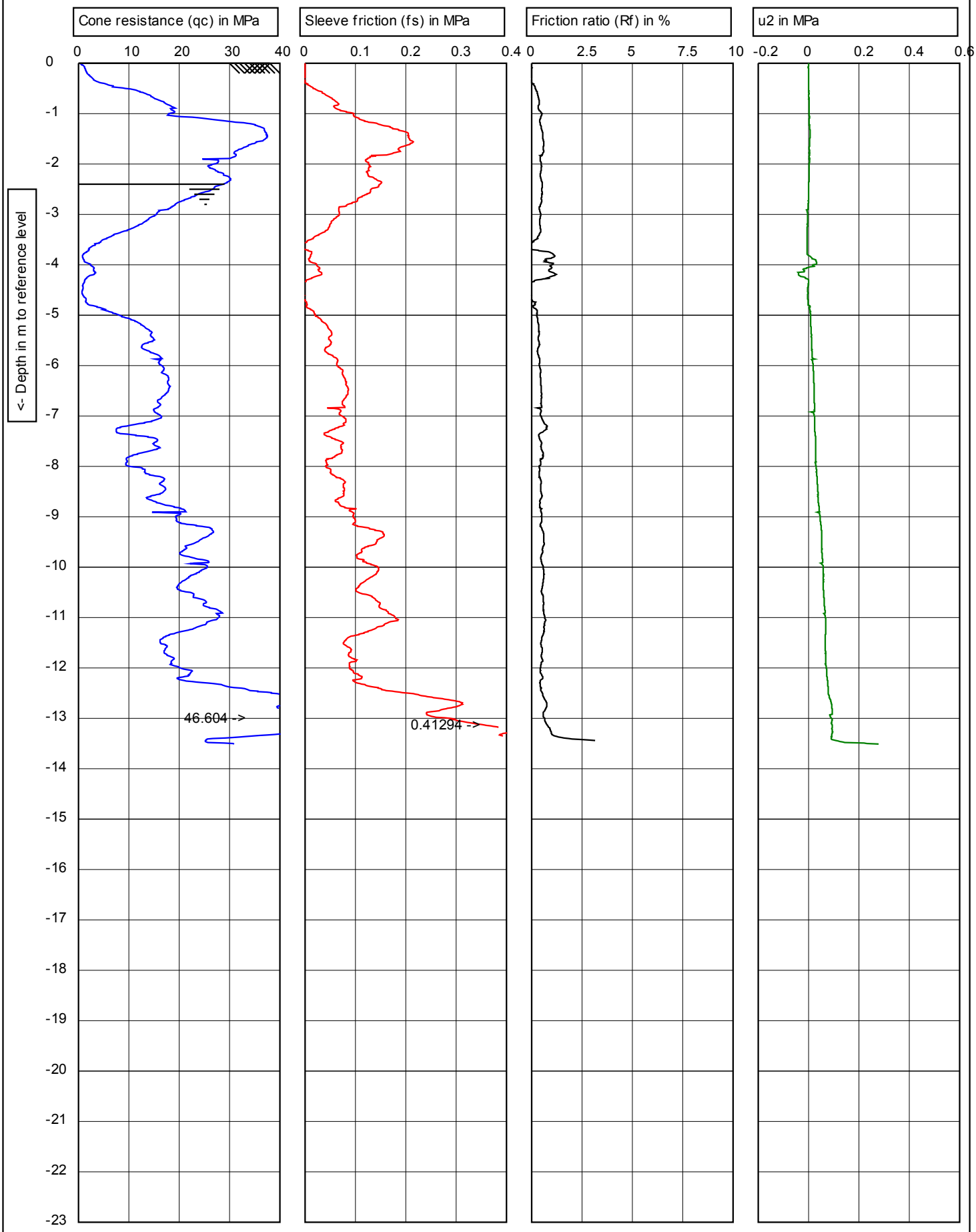
G.L. : **0 NAP** | W.L. : **-2.4**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-4** 2/3

CPTask V1.14

(2) Gravelly sand
(3) Sand clean to silty
(4) Sand mixtures
(5) Silt mixtures
(6) Clay
(7) Organic soils



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
L 150 cm²
10 cm²

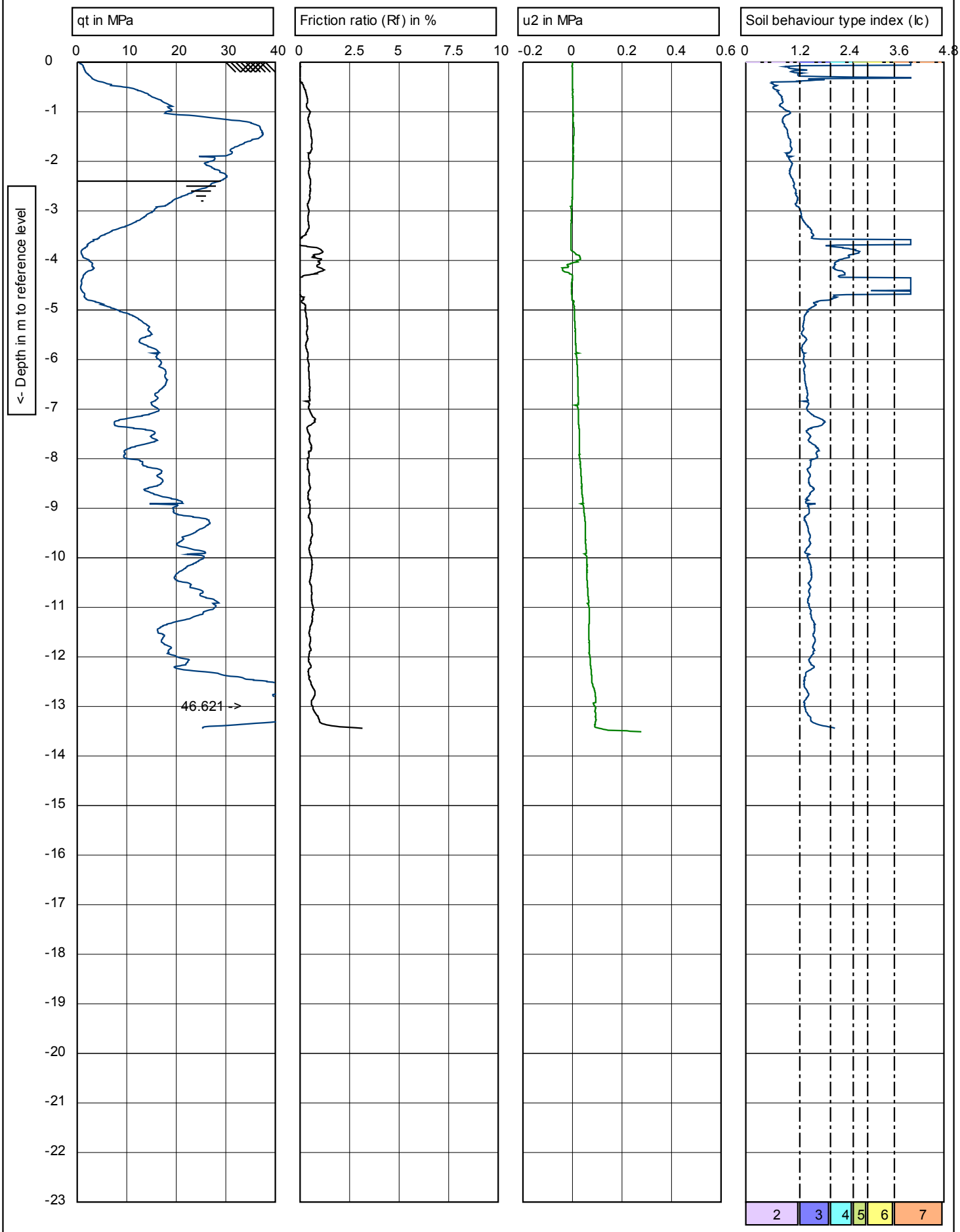
Test according NEN 5140 class 1

G.L. : **0 NAP** | W.L. : **-2.4**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-5** **1/3**

CPTask V1.14



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
L 150 cm²
10 cm²

Test according NEN 5140 class 1

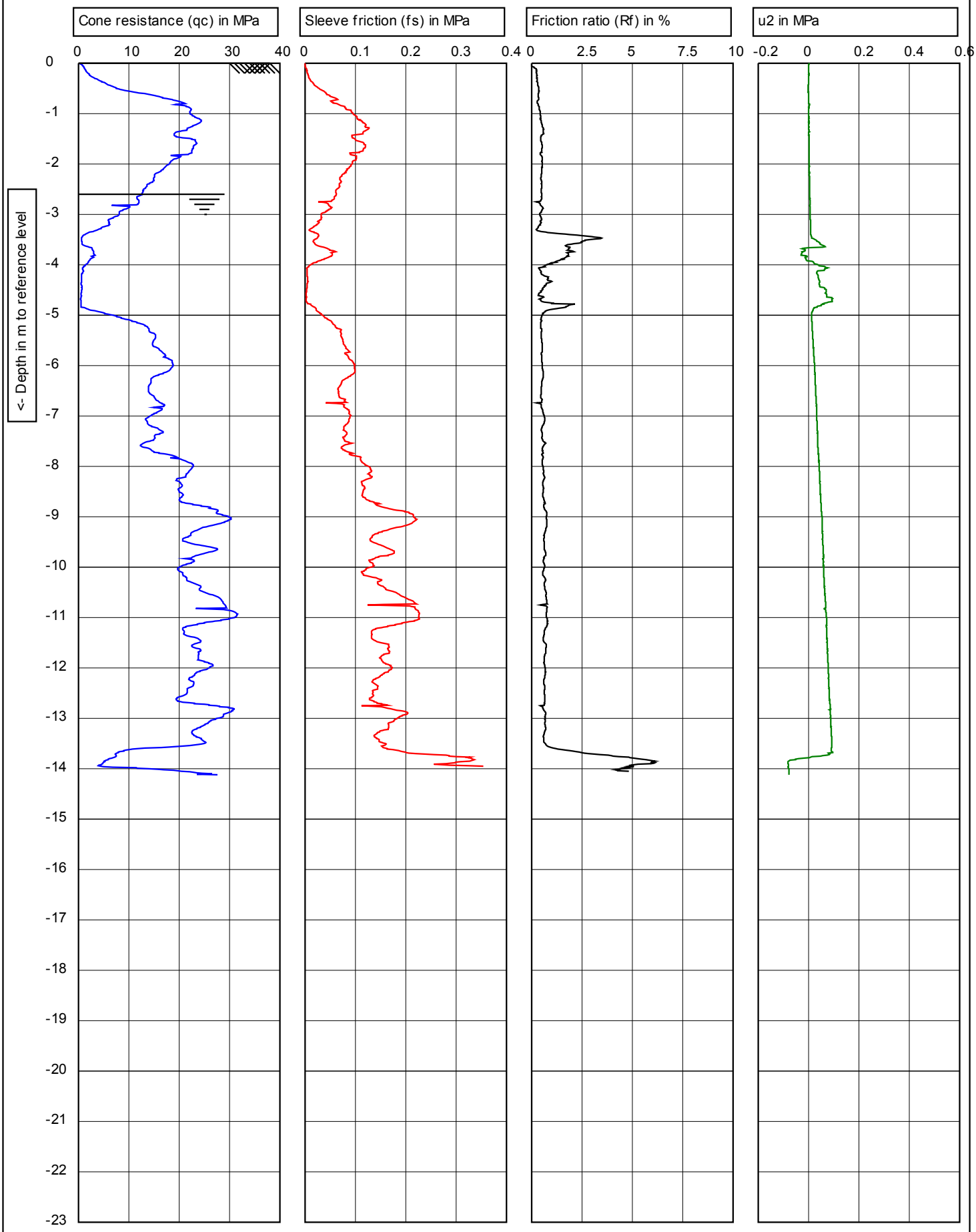
G.L. : **0 NAP** | W.L. : **-2.4**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-5** 2/3

CPTask V1.14

(2) Gravelly sand
(3) Sand clean to silty
(4) Sand mixtures
(5) Silt mixtures
(6) Clay
(7) Organic soils



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
150 cm²
10 cm²

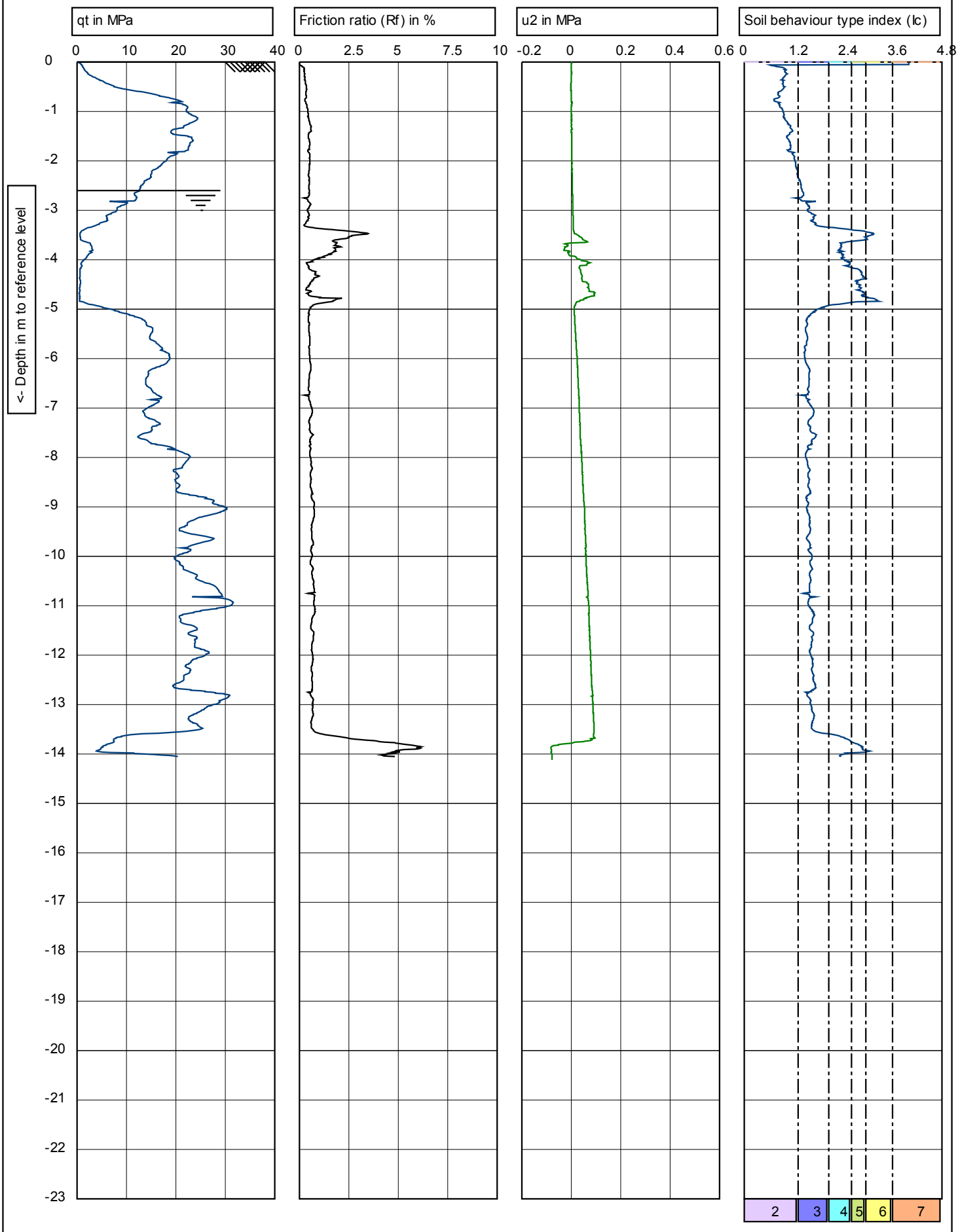
Test according NEN 5140 class 1

G.L. : **0 NAP** W.L. : **-2.6**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-6** 1/3

CPTask V1.14



NEWSYD GEOTECHNCIAL TESTING
Ph:0408292638

r u2
150 cm²
10 cm²

Test according NEN 5140 class 1

G.L. : **0 NAP** W.L. : **-2.6**

Project : **Geotechnical Investigation**
Location : **Kooragang Island**
Position :

Pre drill :	**0**
Date :	**4/14/2014**
Cone no. :	**C10CFIIP.F91**
Project no. :	**10566A**
CPT no. :	**CPT-6** 2/3

CPTask V1.14

(2) Gravelly sand
(3) Sand clean to silty
(4) Sand mixtures
(5) Silt mixtures
(6) Clay
(7) Organic soils