PLANNING & NATURAL SYSTEMS

ATTACHMENT F

DA-577/2017 - RESIDENTIAL FLAT BUILDING
PEEL STREET, TUNCURRY

DEVELOPMENT CONTROL UNIT MEETING

30 NOVEMBER 2017

Wakefield Ashurst Developments Pty Ltd

Proposed Residential Apartment Building
15 Peel Street, Tuncurry

Geotechnical and Acid Sulfate Assessment

Report No. RGS01515.1-AB

13 June 2017

REGIONAL
GEOTECHNICAL SOLUTIONS

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Manning-Great Lakes

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Coffs Harbour

RGS01515.1-AB

13 June 2017

Wakefield Ashurst Developments Pty Ltd
C/o Coastplan Group Pty Ltd
4/11-13 Manning Street
TUNCURRY NSW 2428

Attention: Peter Morley

Dear Peter,

RE: Proposed Residential Apartment Building
15 Peel Street, Tuncurry

Geotechnical and Acid Sulfate Assessment

As requested, Regional Geotechnical Solutions Pty Ltd (RGS) has undertaken a geotechnical assessment for the proposed residential unit development at 15 Peel Street, Tuncurry.

Surface and subsurface conditions at the site are presented in the attached report, as well as comments and recommendations on foundation conditions, earthworks and design parameters for foundations.

If you have any questions regarding this project, or require any additional consultations, please contact the undersigned.

For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Steve Morton

Principal Engineer

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Figures

Appendices

1 INTRODUCTION

As requested, Regional Geotechnical Solutions Pty Ltd (RGS) has undertaken a geotechnical assessment of the proposed residential development at 15 Peel Street, Tuncurry.

From the concept drawings provided it is understood that the proposed development comprises one basement and seven stories for residential units. Excavation to approximately 3.3m below existing ground level is anticipated for the basement.

The is occupied by an existing single storey church building that is to be demolished.

The purpose of the work presented herein was to address:

- Foundation design parameters for shallow and piled foundations as appropriate;
- Earth retention parameters for the design of basement earth retention systems;
- Assessment of geotechnical conditions affecting pile construction or installation;
- Presence of acid sulfate soils at the site and the need for an acid sulfate soil management plan;
- Assessment of site conditions on pile and concrete durability (sulphates, chlorides, pH in soil and water);
- Groundwater level and dewatering requirements;
- Short and long term design parameters for the basement shoring design;
- Earthquake site factor (to AS1170.4) and liquefaction potential;
- Site infiltration rates for stormwater disposal design;
- other comments relevant to design and construction as may be revealed by the investigation and testing.

2 FIELD WORK

Field work for the assessment was undertaken on 21 April and 4 May 2017and was based on the supplied drawings. Fieldwork included:

- Observation of the site and surrounding features relevant to the geotechnical conditions of the site;
- Logging and sampling of three (3) boreholes drilled using a Toyota 4WD mounted drilling rig;
- Five (5) Cone Penetration Tests (CPT) within the development footprint; and
- One in-situ falling head permeability infiltration test.

Engineering logs of the boreholes, CPT results, and infiltration test results are presented in Appendix A. The locations of the boreholes, infiltration and CPT tests are shown on Figure 1. They were obtained on site by measurement relative to existing site features.

3 LABORATORY TESTING

Samples retrieved during field work were returned to a NATA registered laboratory for testing which included the following;

- Soil Aggressivity testing on two samples; and
- ASS Screening tests on eight samples; and
- One Chromium Reducible Sulfur test for oxidisable sulphur and acid generating potential.

4 SITE CONDITIONS

4.1 Surface Conditions

The site is situated in flat to gently undulating topography associated with a broad, wind-blown sand plain on the northern side of Wallis Lake. It is located on the southeastern corner of the intersection of Peel Street and Kent Street. The existing church building is situated on slightly elevated ground near the centre of the site and the ground slopes away gently in all directions from this building area towards both Peel Street and Kent Street.

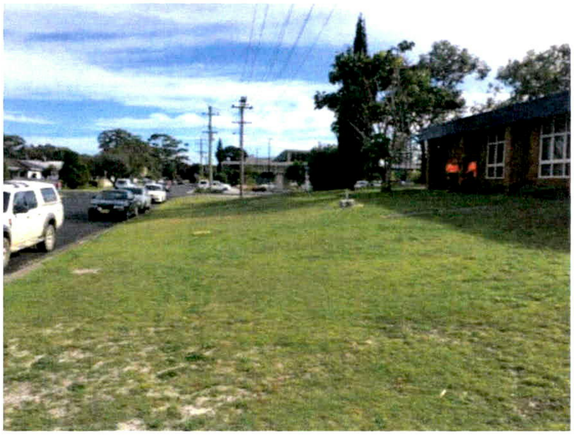
An image of the site taken from the NSW Department of Property Information website is reproduced below.

Approximate extent of site in red.

Some scattered trees were present across the site. The site is bound by a Peel Street to the south west, Kent Street to the north west, Manning Lane to the north east and single and 2 storey dwelling to the south east.

Drainage of the site occurs via a combination of overland flow and surface infiltration into the sandy soil profile that was visible at the ground surface. The site appeared well drained at the time of the site work.

A selection of images of the site is presented below.



Looking north west from southern corner of the site showing existing building and slope towards Peel Street to left

Looking north east from southern corner of the site .Sandy soils exposed. Site appears well drained.

Looking east from western corner of the site. Existing building on slightly elevated mound. Some scattered large trees.

Looking south west from northern corner of the site. Site slopes from edge of mound towards adjacent street.

	
Looking south east from northern corner of site showing well established trees and existing stormwater.	*Looking north west from eastern corner of the site*

4.2 Subsurface Conditions

The Forster 1:100,000 Quaternary Geology map indicates that the site is situated in an area underlain by deep relict sand dune deposits and the subsurface profile in the area comprise marine sand with some irregular beds of peat and fine sediment.

The investigations encountered a deep sand profile. The profile encountered within the boreholes and CPTs undertaken for this investigation is summarised in

Table **1** and Figure 2.

Table 1: Summary of Subsurface Materials

Material Unit	Material Name	Material Description	Depth to Base of Material Layer (m)				
			CPT1	CPT2 BH2	CPT3 BH3	CPT4	CPT5
1	FILL	SAND, fine to medium, grey	0.3	0.2	1.0	0.3	--
2a	Aeolian Sand (Medium Dense - Dense)	SAND, fine to medium, grey, white, pale brown, becoming orange/dark brown below 2.9m	3.5	4.1	4.1	3.5	3.7
2b	Aeolian Sand – with Indurated layers (Very Dense)	SAND, very dense	≥ 8.3	≥ 8.15	≥ 7.60	≥ 17.45	≥ 14.5

Table Notes: -- *Material not encountered*
≥ *Base of material layer not encountered*

Groundwater was encountered in all test locations at depths summarised in Table 2. Groundwater levels do fluctuate as a result of climatic variations such as prolonged rainfall or extended periods of low rainfall etc.

Table 2: Summary of Groundwater Depths (m) Below Existing Surface

CPT1	CPT2 BH2	CPT3 BH3	CPT4	CPT5
3.4	3.1	3.1	3.4	3.4

It should be noted that fluctuations in groundwater levels can occur as a result of seasonal variations, temperature, rainfall and other similar factors, the influence of which may not have been apparent at the time of the assessment.

5 PROPOSED DEVELOPMENT AND GEOTECHNICAL CONSTRAINTS

The proposed development will involve an underground basement and seven stories for residential usage. The drawings provided indicate a basement floor level of RL 0.2m, which will likely require bulk excavation to approximately 0.5m below this level. Groundwater was encountered approximately at RL 0.6m, and therefore bulk excavations are likely to extend approximately 1m into the groundwater table and de-watering will be required. Deeper excavations may locally be required for lift wells or service trenches.

Pending review of the design loads, structures could be supported by raft foundations on Unit 2a or 2b sands, or piles founded within the Unit 2b very dense sand.

6 EXCAVATION CONDITIONS AND DEWATERING

For the proposed basement development, excavations of approximately 3.3 to 4.0m are proposed. Deeper excavations may locally be required for lift wells or service trenches.

Excavation of the Unit 1, 2a and 2b will be achievable with conventional hydraulic excavators or backhoes, pending appropriate dewatering of the excavation area.

It is likely that groundwater inflows into the excavation will occur for excavations of more than 3.0m and therefore dewatering is recommended in any areas of the site where excavations of more than 3.0m depth are proposed. Management of construction dewatering will be required, to reduce the risk of damage to adjacent properties due to dewatering induced settlement. Based on the proximity of adjacent buildings and services it is recommended that recharge and partial cutoff measures be employed during dewatering to reduce off-site drawdown impacts.

Partial cut-off measures could involve the use of sheet piles or similar, founded within the Unit 2b sand materials, together with a line of groundwater injection bores outside the partial cutoff wall to maintain groundwater levels beneath surrounding structures.

Construction of a partial cut-off wall around the basement excavation area would result in reduced groundwater inflows during construction, which would limit groundwater drawdown outside the excavation and thereby reduce the risks of settlement due to lowering of the groundwater table.

Driving of sheet piles may result in settlement of the sands surrounding the site and could result in vibration and/or settlement impacts on the adjacent buildings. Therefore, it is recommended that if sheet piles are used they should be jetted into position. Alternatively, cut-off walls could be constructed using secant pilling. Secant piling would have the advantage that it could potentially be incorporated permanently into the basement walls and the foundation system for the structure, subject to suitability from a structural and architectural perspective.

Prior to dewatering, detailed design of the dewatering system would need to be carried out by a dewatering specialist.

7 EARTH RETENTION & BATTERED SLOPES

Where space permits, temporary batter slopes can be cut in sand materials above the groundwater level at 2H:1V. Excavations below the water table will require dewatering and/or shoring due to the potential for collapse of waterlogged sands into the excavation.

Temporary or permanent retaining walls for the support of basement excavations are likely to require the use of cantilevered walls. The following parameters are provided for cantilevered wall design:

- Bulk unit weight, γ = 20 kN/m^3
- Effective Friction Angle, Ø' = 32°
- Effective Cohesion, c' = 0 kPa
- Active Earth Pressure Coefficient, Ka = 0.31
- Passive Earth Pressure Coefficient, Kp = 3.25
- At Rest Earth Pressure Coefficient, Ko = 0.47

Design of the walls must take into account any surcharge from loadings behind the wall. Drainage measures as described above, if properly maintained, should reduce pore pressures at the back of the wall to zero, however, pore pressures may still be generated at other points behind the wall. The design should incorporate an allowance for such pressures and a fluctuating groundwater table.

8 INFILTRATION RATE

One falling head infiltration test was undertaken below 0.85m from existing ground level. The result indicated an infiltration rate of 3.28 x 10^{-4} m/s.

9 SOIL AGGRESSIVITY

Two samples were submitted to a NATA accredited laboratory for chemical analysis. The results are presented in Appendix B.

In accordance with the aggressivity and exposure classifications provided in AS2159-2009 the soil would be considered non-aggressive to steel and mild or non-aggressive for concrete.

10 ACID SULFATE SOILS

Reference to Coolongolook 1:25,000 Acid Sulfate Soil Risk Map indicates the site is situated within an area that has a high probability of containing ASS below 2m depth.

Sampling and analysis for the presence of Acid Sulfate Soils (ASS) has been undertaken in areas where potential excavations are likely to be undertaken.

Eight samples of Aeolian soils obtained were screened for the presence of actual or potential ASS using methods 21Af and 21Bf of the ASSMAC Acid Sulfate Soils Manual. The test results are attached in Appendix B and summarised in Table3.

Table 3: Summary of ASS Screening Test results

Borehole #	Soil Type	Depth (m)		$pH_{(F)}$	pH $_{(Fox)}$
		From	To		
BH1	SAND	0.4	0.5	5.44	3.57
BH1	SAND	1.9	2.0	5.57	3.62
BH1	SAND	2.9	3.0	5.88	4.84
BH1	SAND	3.9	4.0	8.11	6.09
BH2	SAND	1.8	2.0	7.74	5.27
BH2	SAND	2.6	2.8	7.49	5.12
BH3	SAND	0.8	1.0	7.42	5.27
BH3	SAND	3.8	4.0	7.77	5.79

In the ASS Screening test, pH <4 is an indicator of Actual ASS and pH_{FOX} values of less than 3 and a pH change of greater than 2 can be an indicator of Potential ASS. Based on the results, the soils encountered are not actual or potential acid sulfate soil.

To provide a more comprehensive assessment, one sample was submitted for Chromium Reducible Sulphur (CRS) analysis. A summary of the test results is presented in Table4.

Table 4: Summary of CRS Analysis

Borehole	Depth (m)	Texture	Acid Trail (mol H+/tonne)	Sulfur Trail (% S)

			TAA	Action Criteria*	S_{KCl}	S_{Cr}	Action Criteria*
BH1	0.4 – 0.5	Coarse	22	18	0.002	0.011	0.03

*Note * Action criteria as per the 1998 ASSMAC Acid Sulfate Soil Manual for >1,000 tonnes of disturbed soil*

The test results indicate Titratable Actual Acidity (TAA) above the ASSMAC action criteria of 18 mole H+/tonne but the extractable sulfate sulfur (an indicator of Actual ASS) and the chromium reducible sulfur (indicative of Potential ASS) are well below the ASSMAC action criteria of 0.03% which indicates that the acidity is not sulphuric in nature. As such the materials are not considered to be potential or actual ASS, and an ASS Management Plan is not required for the site.

11 FOUNDATIONS

11.1 Foundation Options

Based on the subsurface conditions encountered at the site, there are several options for support of proposed structures. These options include:

- Stiffened raft footings designed to accommodate total and differential settlements; or
- Piles within the very dense sands below 4m depth.

11.2 Stiffened Raft Footings

The building could be founded on high level pad footings or a stiffened raft specifically designed to accommodate the expected settlements. For footings founded on the existing sands in the lower profile of Unit 2a, an allowable base bearing pressure of 300kPa could be adopted. For the assessment of settlements over the effective depth of influence for the slab, the elastic values for vertical response provided in Table5 can be adopted.

11.3 Piled Foundations

Taking into account the close proximity of buildings to the site and the presence of deep sands with a shallow water table, driven piles should not be adopted due to the likelihood of vibration induced damage to surrounding buildings and services. Grout injected piles (CFA or similar), steel screw piles, or bored piles are appropriate alternatives. Geotechnical design parameters for piled foundations are provided in Table5.

The distribution of the nominated soil types within the profile is summarised in Figure 2. End bearing piles founded in sands should be designed such that the base of the pile is not within four pile diameters of any underlying lower strength layer.

Table 5: Ultimate Design Parameters for Non-Displacement Piles

Material Unit	Material Name	Ultimate End Bearing Capacity, fb	Ultimate Shaft Adhesion-Compression, fms*	Effective Vertical Young's Modulus, E'v	Effective Horizontal Young's Modulus, E'h

2a (above 4m depth)	Aeolian Sand (MD-D)	3000 kPa	30 kPa	20 MPa	15 MPa
2b (between 4m and 16m depth)	Aeolian Sand (VD)	10000 kPa	100 kPa	30 MPa	20 Mpa

Notes: * For piles designed to resist uplift forces, it is recommended that the ultimate skin friction values given above be reduced by 50%

For pile design in accordance with AS2159-2009, 'Piling-Design and installation', the ultimate geotechnical strength (Rd,ug) can be calculated using the shaft capacity and ultimate end bearing capacity values provided in Table. Calculation of the design geotechnical strength (Rd,g) requires an assessment of the geotechnical strength reduction factor (Φg), which is based on a series of project specific variables. In assessing a suitable geotechnical strength reduction factor for this project, the following assumptions have been made:

- Design of piles and pile groups will be undertaken in accordance with the recommendations presented in this report;
- Limited geotechnical involvement will occur during pile installation;
- Some performance monitoring of the supported structure during or after construction;
- The foundations will be designed by a designer of at least moderate experience in similar geotechnical profiles and pile design; and
- Well established pile design methods will be adopted.

Based on the above, and in accordance with AS2159-2009, an overall average risk rating of 1.93 is estimated. Therefore, assuming the pile configuration will have low redundancy, a Geotechnical Strength Reduction Factor of Φg=0.61 would be appropriate for the site if no static load testing is undertaken. This could be increased to Φg=0.70 if a proportion of the piles are dynamically tested or Φg=0.75 if a proportion of the piles are statically tested. In the event that any of the assumptions outlined above are not correct, the Geotechnical Strength Reduction Factor may change and further advice should be sought. Calculation sheets for assessment of the Geotechnical Reduction Factor are presented in Appendix C.

12 EARTHQUAKE SITE FACTOR

Based on the Australian Standard AS1170.4 – 2007 '*Structural Design Actions Part 4: Earthquake Actions in Australia*' the standard nominates earthquake factors based on Subsoil Class and specific locations within Australia. Based on the ground conditions encountered and the location of the site in Tuncurry, design for earthquake effects can be undertaken for a Subsoil Class (De) Deep Soil Site and a site Hazard Factor (Z) of 0.08.

13 LIMITATIONS

The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical practises and standards. To our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. If site conditions encountered during construction vary significantly from those discussed in this report, Regional Geotechnical Solutions Pty Ltd should be contacted for further advice.

This report alone should not be used by contractors as the basis for preparation of tender documents or project estimates. Contractors using this report as a basis for preparation of tender documents should avail themselves of all relevant background information regarding the site before deciding on selection of construction materials and equipment.

If you have any questions regarding this project, or require any additional consultations, please contact the undersigned.

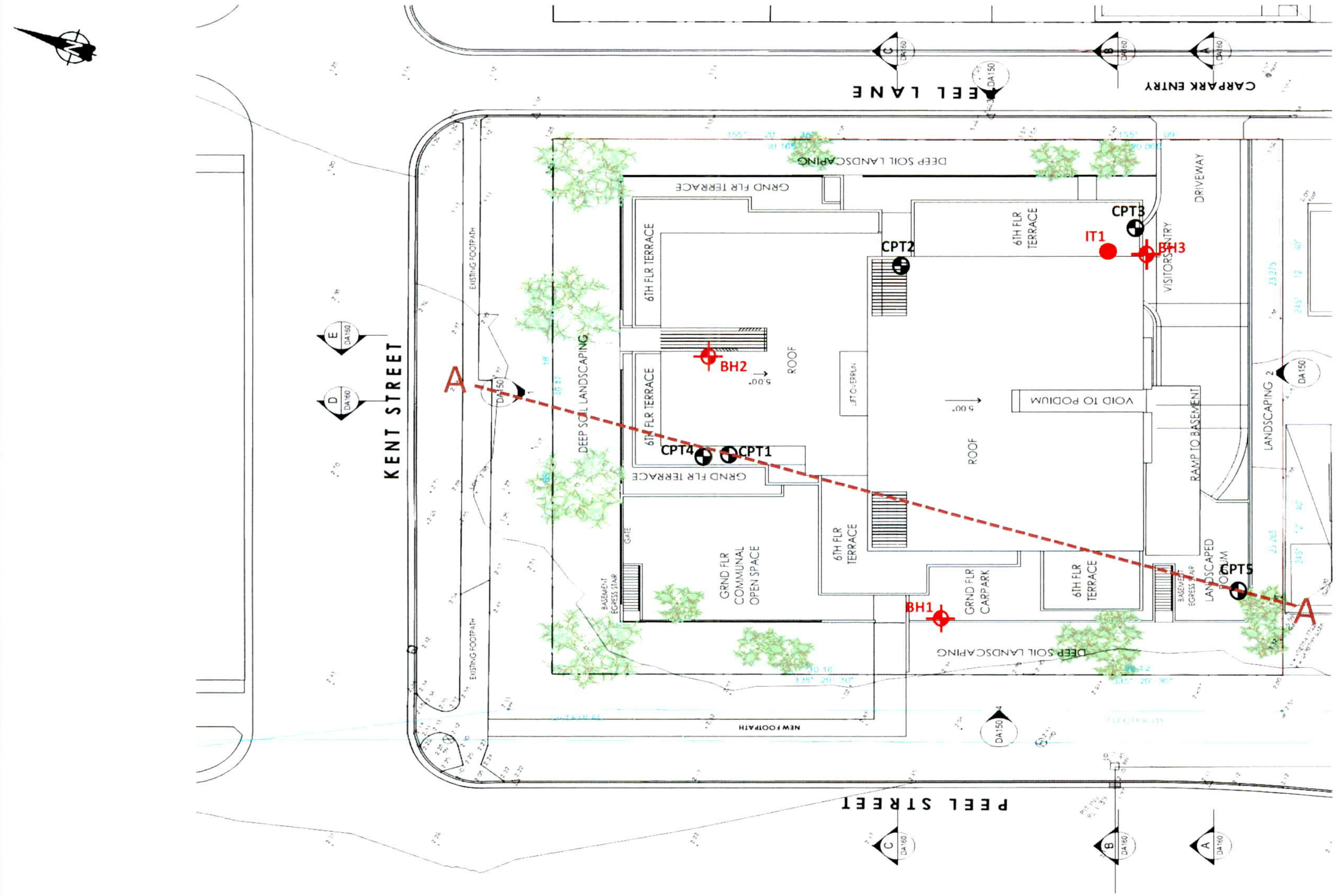
For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Steve Morton

Principal Engineer

Figures

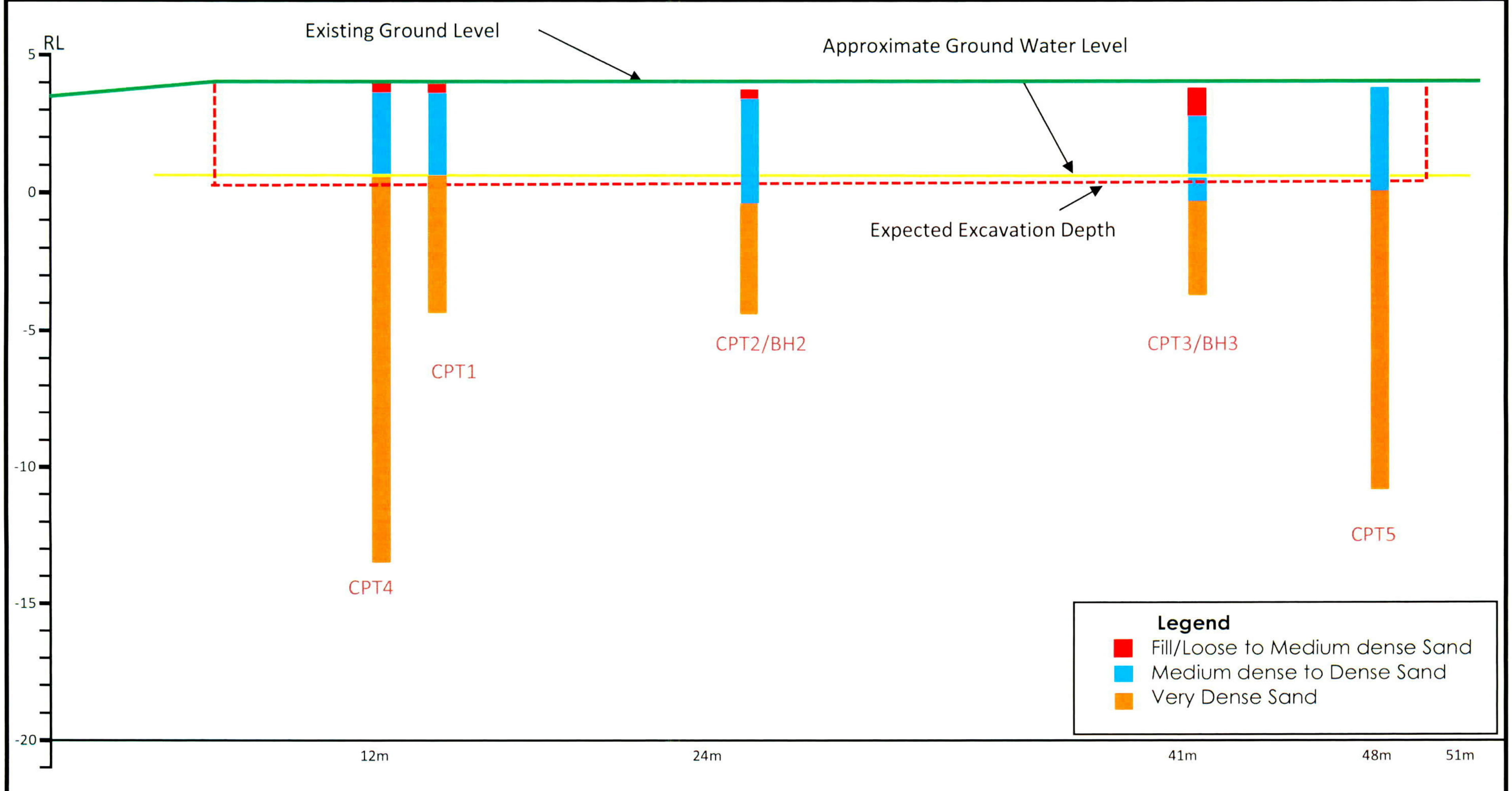


*Note: As per provided drawing titled " Site Plan, drawing no. DA020 P3"

Legend

- Borehole Location
- CPT Location
- Infiltration Test Location

REGIONAL GEOTECHNICAL SOLUTIONS				
	Client	Wakefield Ashurst Development Pty Ltd	Job No.	RGS01515.1
	Project:	Proposed Residential Apartment Building 15 Peel Street, Tuncurry	Drawn By:	CN
			Date:	24-Apr-17
	Title:	Investigation Location Plan	Drawing No.	**Figure 1**



REGIONAL GEOTECHNICAL SOLUTIONS

Client	Wakefield Ashurst Development Pty Ltd	Job No.	RGS01515.1
Project	Proposed Residential Apartment Building 15 Peel Street, Tuncurry	Drawn By	CN
		Date	24/04/2017
Title	Cross Section AA	Drawing No.	Figure 2

Appendix A

Results of Field Investigations

REGIONAL GEOTECHNICAL SOLUTIONS

ENGINEERING LOG - BOREHOLE

BOREHOLE NO: BH1

CLIENT: Wakefield Ashurst Development Pty Limited
PAGE: 1 of 1
PROJECT NAME: Residential Apartment Building
JOB NO: RGS01515.1
SITE LOCATION: 15 Peel Street, Tuncurry
LOGGED BY: CN
TEST LOCATION: See Figure 1
DATE: 4/5/17

DRILL TYPE: Toyota 4WD Mounted Drill Rig
EASTING: 452780 m
SURFACE RL:
BOREHOLE DIAMETER: 100 mm
INCLINATION: 90°
NORTHING: 6439825 m
DATUM: AHD

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics, colour, minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/V		0.40m ASS 0.50m		0.0–0.60m	SP	**SAND:** Fine to medium grained, grey	M				AEOLIAN
		0.90m ASS 1.00m		0.60–1.50m	SP	**SAND:** Fine to medium grained, white					
		1.90m ASS 2.00m		1.50–2.90m	SP	**SAND:** Fine to medium grained, pale brown/brown/white At 1.8m, orange/pale brown/grey					
	Water level (3.0m)	2.90m ASS 3.00m; 3.90m ASS 4.00m		2.90–4.00m	SP	**SAND:** Fine to coarse grained, orange/dark brown At 3.4m, trace shell	W				
				4.00m		Hole Terminated at 4.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata
- Definitive or distict strata change

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency

		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition

D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density

V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

ENGINEERING LOG - BOREHOLE

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Wakefield Ashurst Development Pty Limited	BOREHOLE NO:	BH2
PROJECT NAME:	Residential Apartment Building	PAGE:	1 of 1
SITE LOCATION:	15 Peel Street, Tuncurry	JOB NO:	RGS01515.1
TEST LOCATION:	See Figure 1	LOGGED BY:	CN
		DATE:	4/5/17

DRILL TYPE: Toyota 4WD Mounted Drill Rig | EASTING: 452796 m | SURFACE RL:

BOREHOLE DIAMETER: 100 mm | INCLINATION: 90° | NORTHING: 6439850 m | DATUM: AHD

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics, colour, minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/V		0.90m ASS 1.00m		0.0–1.00m	SP	**FILL:** SAND, fine to medium grained, grey At 0.7, becoming pale brown / pale orange	M				FILL
				1.00–1.60m	SP	**SAND:** Fine to medium grained, dark brown/grey, tree roots/organic					AEOLIAN
		1.80m ASS 2.00m; 2.60m ASS 2.80m		1.60–3.00m	SP	**SAND:** Fine to medium grained, white / pale orange					AEOLIAN
	▽ (approx. 3.3m)	3.80m ASS 4.00m		3.00–4.00m	SP	**SAND:** Fine to coarse grained, orange/dark brown/pale orange	W (from approx. 3.3m)				
				4.00m		Hole Terminated at 4.00 m					

LEGEND:

Water
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

Strata Changes
- Gradational or transitional strata (dashed line)
- Definitive or distict strata change (solid line)

Notes, Samples and Tests

U_{50}	50mm Diameter tube sample
CBR	Bulk sample for CBR testing
E	Environmental sample
ASS	Acid Sulfate Soil Sample
B	Bulk Sample

Field Tests

PID	Photoionisation detector reading (ppm)
DCP(x-y)	Dynamic penetrometer test (test depth interval shown)
HP	Hand Penetrometer test (UCS kPa)

Consistency		UCS (kPa)
VS	Very Soft	<25
S	Soft	25 - 50
F	Firm	50 - 100
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Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

ENGINEERING LOG - BOREHOLE

REGIONAL GEOTECHNICAL SOLUTIONS

CLIENT:	Wakefield Ashurst Development Pty Limited	BOREHOLE NO:	BH3
PROJECT NAME:	Residential Apartment Building	PAGE:	1 of 1
SITE LOCATION:	15 Peel Street, Tuncurry	JOB NO:	RGS01515.1
TEST LOCATION:	See Figure 1	LOGGED BY:	CN
		DATE:	4/5/17

DRILL TYPE: Toyota 4WD Mounted Drill Rig **EASTING:** 452810 m **SURFACE RL:**

BOREHOLE DIAMETER: 100 mm **INCLINATION:** 90° **NORTHING:** 6439823 m **DATUM:** AHD

METHOD	WATER	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components	MOISTURE CONDITION	CONSISTENCY DENSITY	Test Type	Result	Structure and additional observations
AD/V						SP	**SAND:** Fine to medium grained, dark brown, grey	W				AEOLIAN
				0.5								
		0.80m ASS 1.00m		1.0			At 0.7m, becoming white					
				1.5			At 1.5m, orange/dark brown/pale orange					
		1.80m ASS 2.00m		2.0								
				2.5								
		2.70m ASS 2.90m		3.0			At 2.7m, pale brown/white					
				3.30m		SP	**SAND:** Fine to medium grained, orange/dark brown, trace shell					
	▽			3.5				W				
		3.80m ASS 4.00m		4.0			4.00m					
							Hole Terminated at 4.00 m					

LEGEND:

Water

- Water Level (Date and time shown)
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- Gradational or transitional strata
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PID	Photoionisation detector reading (ppm)
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Consistency		UCS (kPa)
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S	Soft	25 - 50
F	Firm	50 - 100
St	Stiff	100 - 200
VSt	Very Stiff	200 - 400
H	Hard	>400
Fb	Friable	

Moisture Condition	
D	Dry
M	Moist
W	Wet
W_p	Plastic Limit
W_L	Liquid Limit

Density		
V	Very Loose	Density Index <15%
L	Loose	Density Index 15 - 35%
MD	Medium Dense	Density Index 35 - 65%
D	Dense	Density Index 65 - 85%
VD	Very Dense	Density Index 85 - 100%

FALLING HEAD INFILTRATION TEST - CASED HOLE

CLIENT: Wakefield Ashurst Development Pty Ltd
PROJECT: Residential Apartment Building
LOCATION: Refer to Figure

Job No.: RGS01515.1
Date: 4-May-17
By: CN

REGIONAL GEOTECHNICAL SOLUTIONS

Test number:	IT1	Test Location:	Refer to Figure 1
Hole radius (m):	0.042	Surface RL:	Not measured
Hole depth(m):	0.85	Casing stickup(m):	0.95
Depth to water table (m):	3.6	Water table RL(m)	Unknown

Reading	Time elapsed (min)	Depth to water (m)	Height of water (m)
1	0	0.000	1.80
2	0.25	0.003	1.80
3	0.5	0.012	1.79
4	0.75	0.019	1.78
5	1	0.025	1.78
6	1.5	0.035	1.77
7	2	0.045	1.76
8	2.5	0.055	1.75
9	3	0.065	1.74
10	3.5	0.075	1.73
11	4	0.085	1.72
12	4.5	0.095	1.71
13	5	0.105	1.70
14	5.5	0.115	1.69
15	6	0.122	1.68
16	6.5	0.132	1.67
17	7	0.141	1.66
18	7.5	0.150	1.65
19	8	0.159	1.64
20	8.5	0.168	1.63
21	9	0.172	1.63
22	9.5	0.185	1.62
23	10	0.192	1.61

Calculations

Constant loss time period:

Reading 1:	4	Time 1:	0.75	Height 1:	1.781
Reading 2:	16	Time 2:	6.5	Height 2:	1.668

Total time (min): 5.75

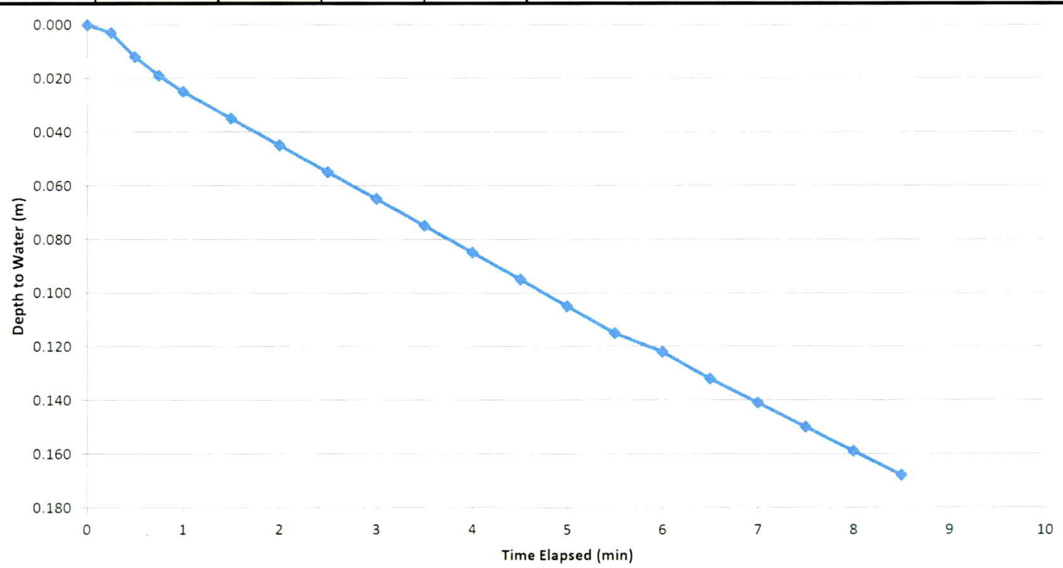
Total head loss (m): -0.113

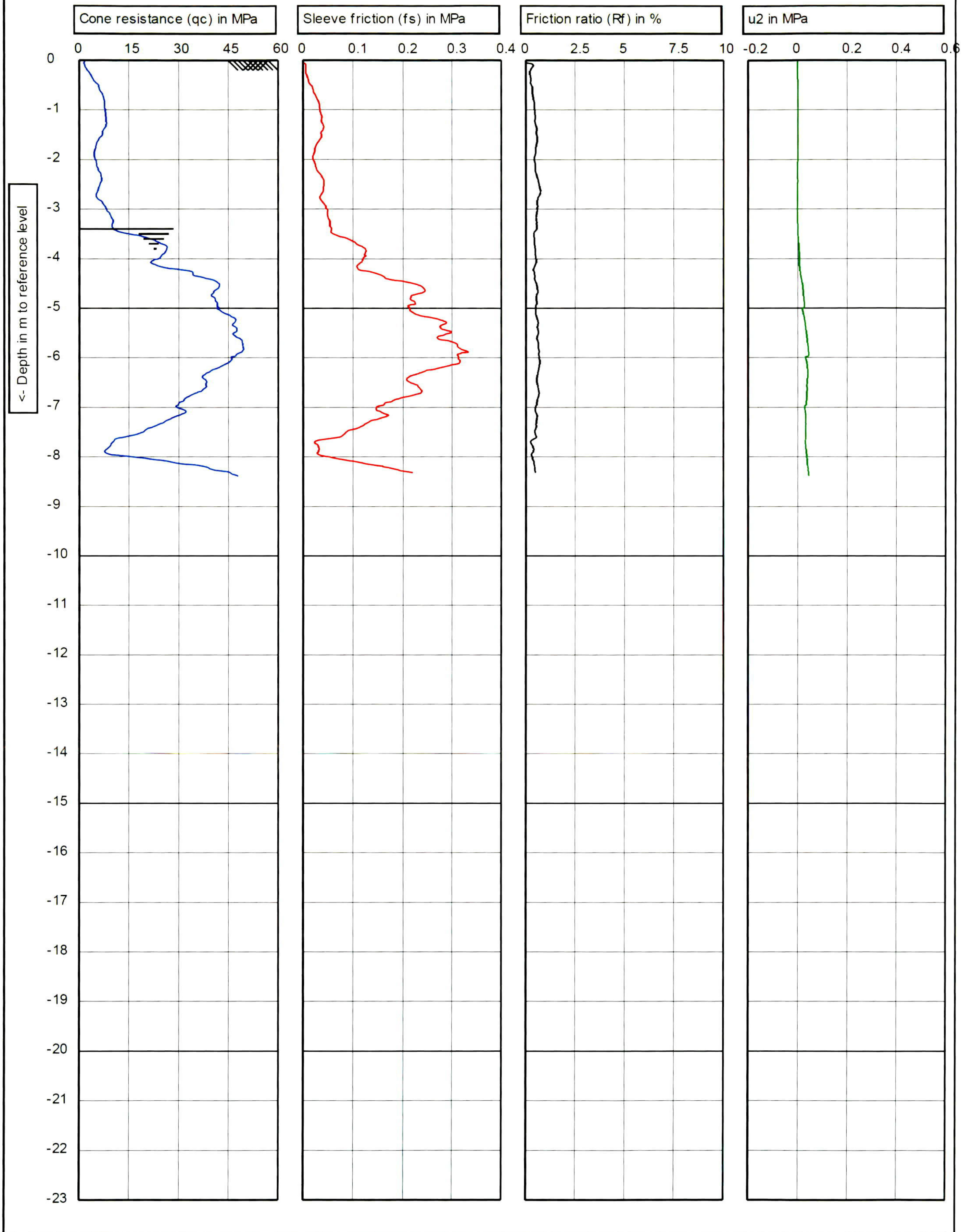
In situ Permeability:

$$K = \frac{(Height\ 2 - Height\ 1)}{(Time\ 2 - Time 1)}$$

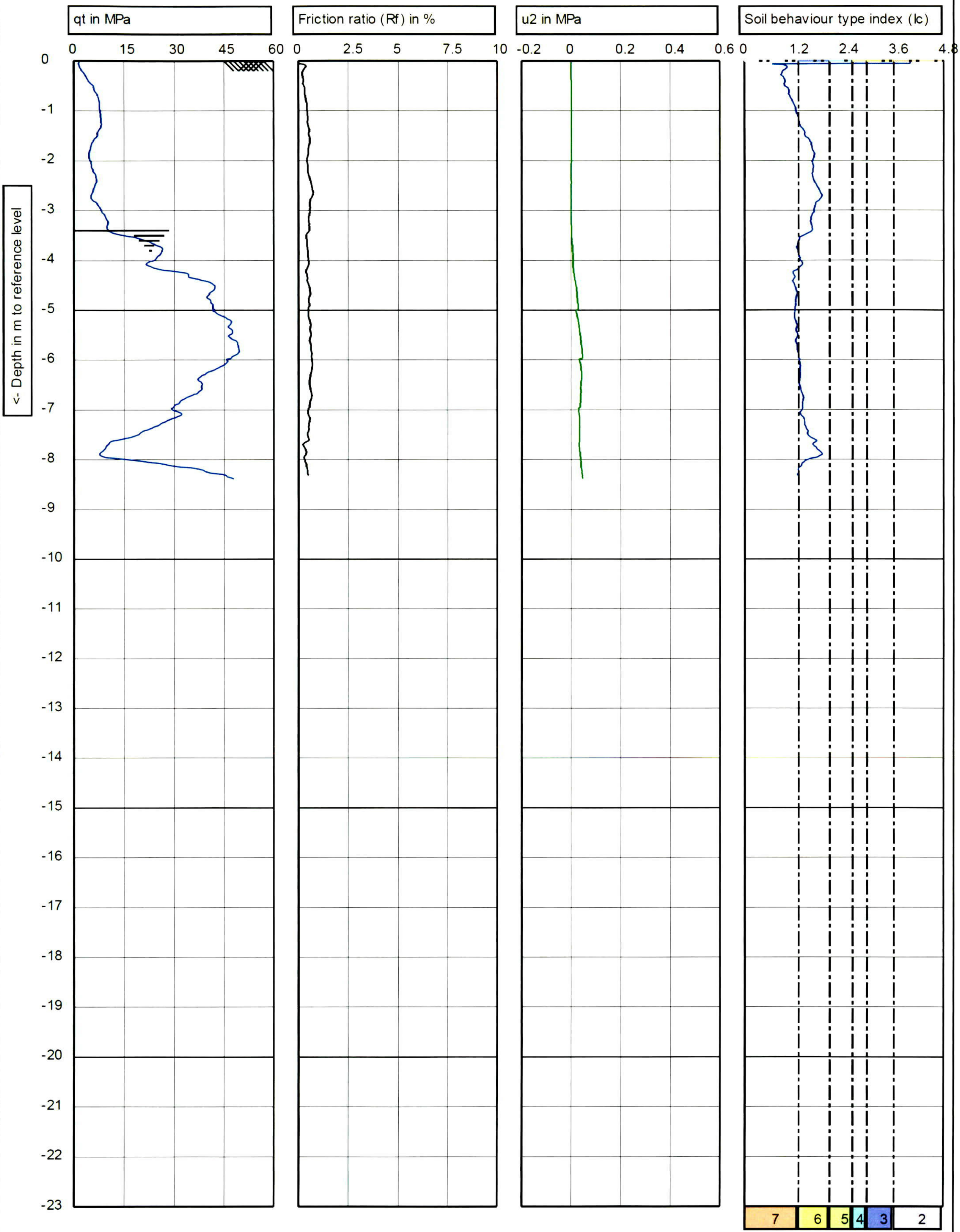
K= 3.28E-04 m/sec

(x 10m/sec)





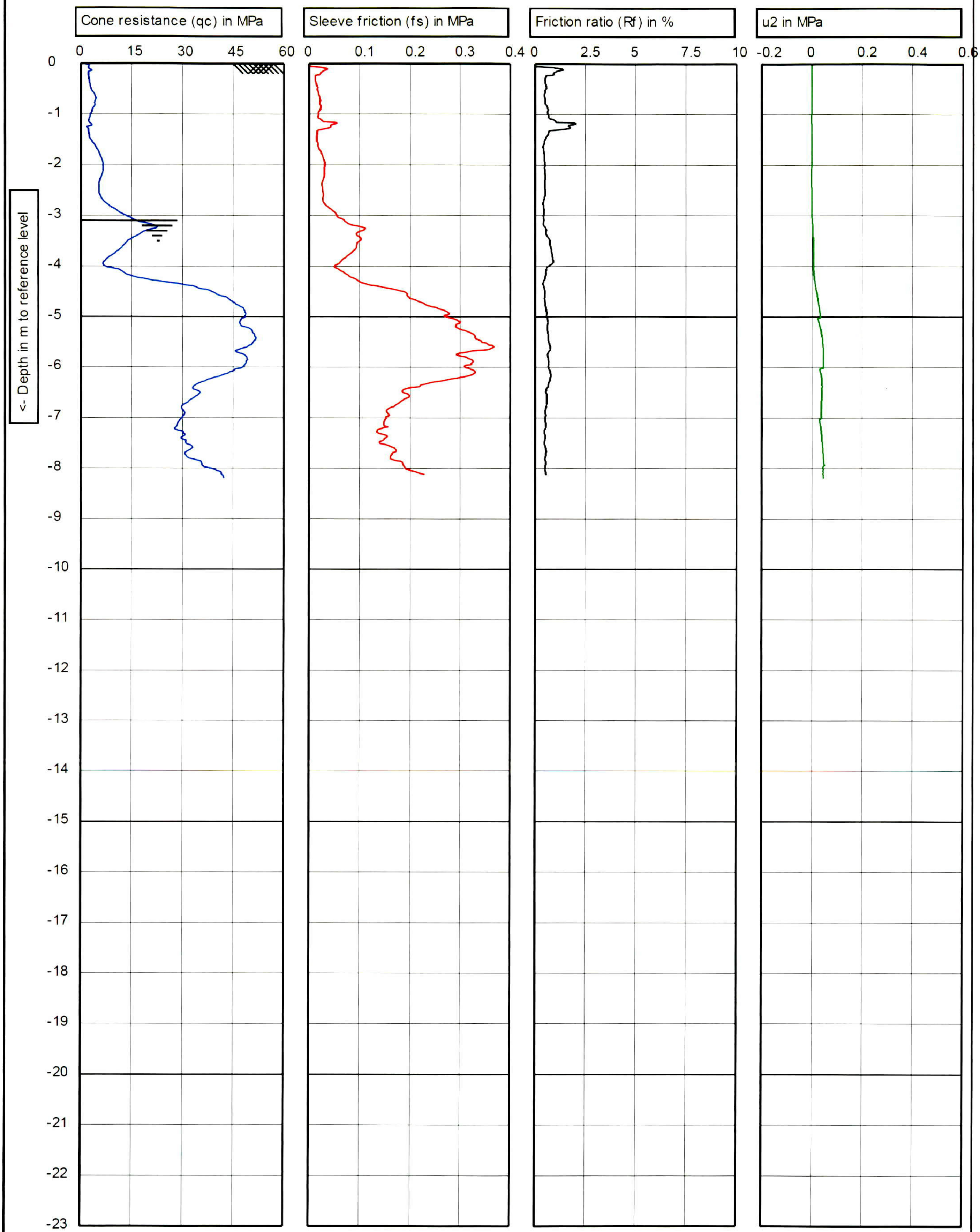
Test according NEN 5140 class 1		Predrill:	0.00 m Predrilled
G.L.: 0.00 m NAP	W.L.: -3.40 m	Date:	21/04/2017
Project:	**Geotechnical Investigation**	Cone no.:	**C10CFIIP.C16116**
Location:	**15 Peel St Tuncurry**	Project no.:	**RGS01515/1**
Position:	**0, 0 RD**	CPT no.:	**CPT-1** 1/3



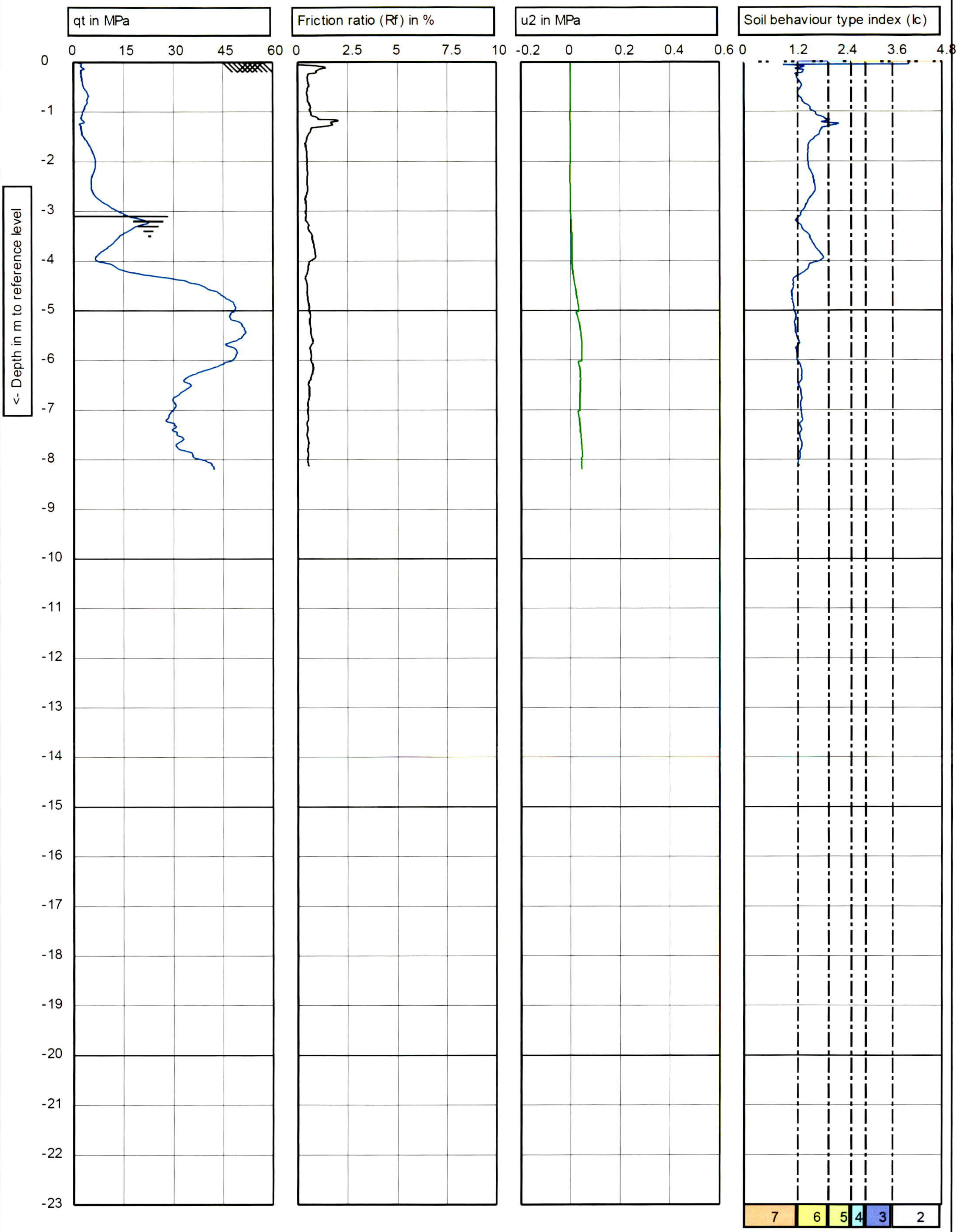
u2; 150 cm²; 10 cm²	Test according NEN 5140 class 1		Predrill:	0.00 m Predrilled
	G.L.: 0.00 m NAP	W.L.: -3.40 m	Date:	21/04/2017
Project:	Geotechnical Investigation		Cone no.:	C10CFIIP.C16116
Location:	15 Peel St Tuncurry		Project no.:	RGS01515/1
Position:	0, 0 RD		CPT no.:	CPT-1 2/3

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

u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Predrill:	0.00 m Predrilled
	G.L.: 0.00 m NAP	W.L.: -3.40 m	Date:	21/04/2017
Project:	Geotechnical Investigation		Cone no.:	C10CFIIP.C16116
Location:	15 Peel St Tuncurry		Project no.:	RGS01515/1
Position:	0, 0 RD		CPT no.:	CPT-1 3/3



u2, 150 cm², 10 cm²	Test according NEN 5140 class 1	Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m NAP** W.L.: **-3.10 m**	Date:	**21/04/2017**
	Project: **Geotechnical Investigation**	Cone no.:	**C10CFIIP.C16116**
	Location: **15 Peel St Tuncurry**	Project no.:	**RGS01515/1**
	Position: **0, 0 RD**	CPT no.:	**CPT-2** **1/3**

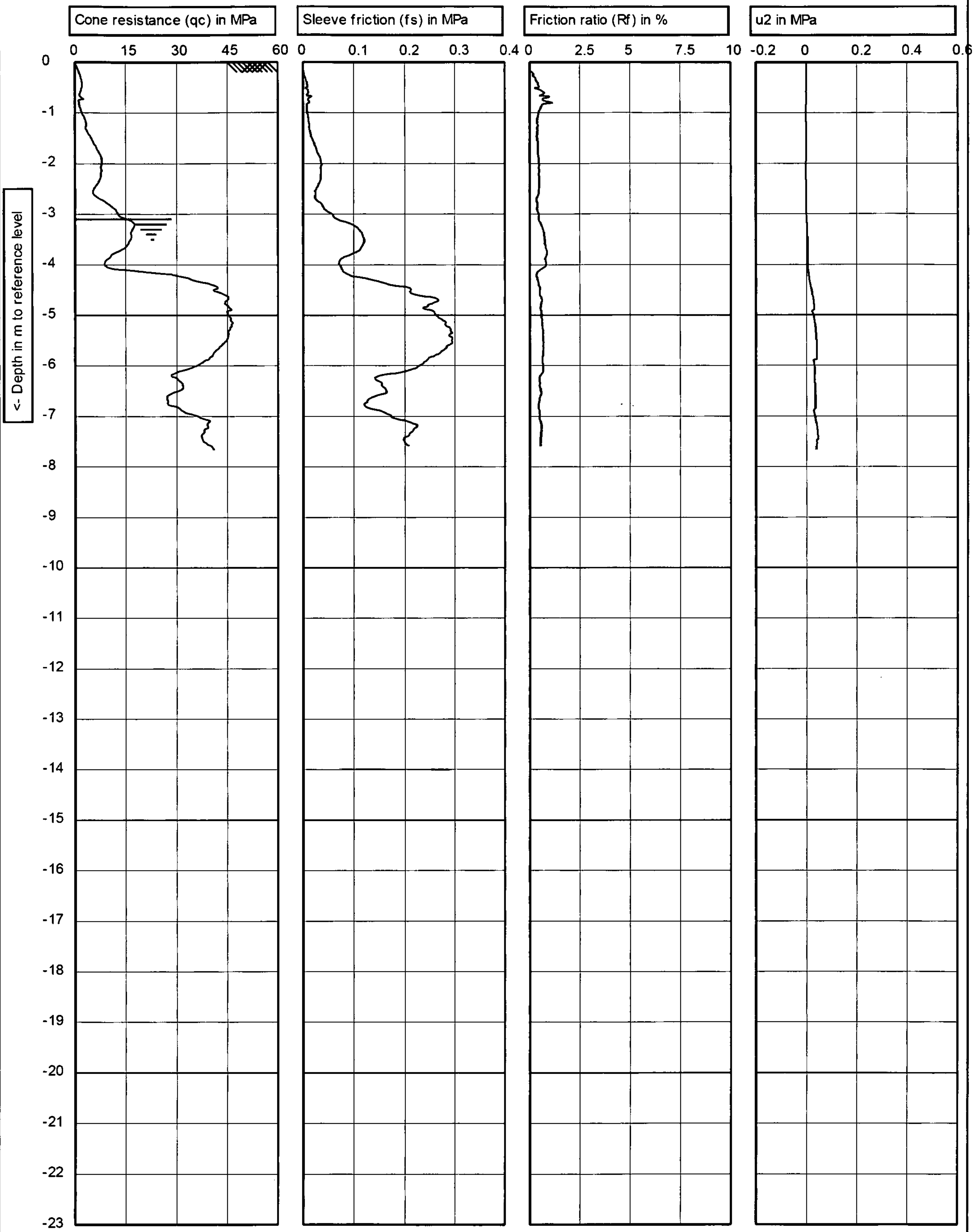


u2 150 cm² 10 cm²	Test according NEN 5140 class 1	Predrill:	**0.00 m Predrilled**
G.L.: **0.00 m NAP**	W.L.: **-3.10 m**	Date:	**21/04/2017**
Project:	**Geotechnical Investigation**	Cone no.:	**C10CFIIP.C16116**
Location:	**15 Peel St Tuncurry**	Project no.:	**RGS01515/1**
Position:	**0, 0 RD**	CPT no.:	**CPT-2** 2/3

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

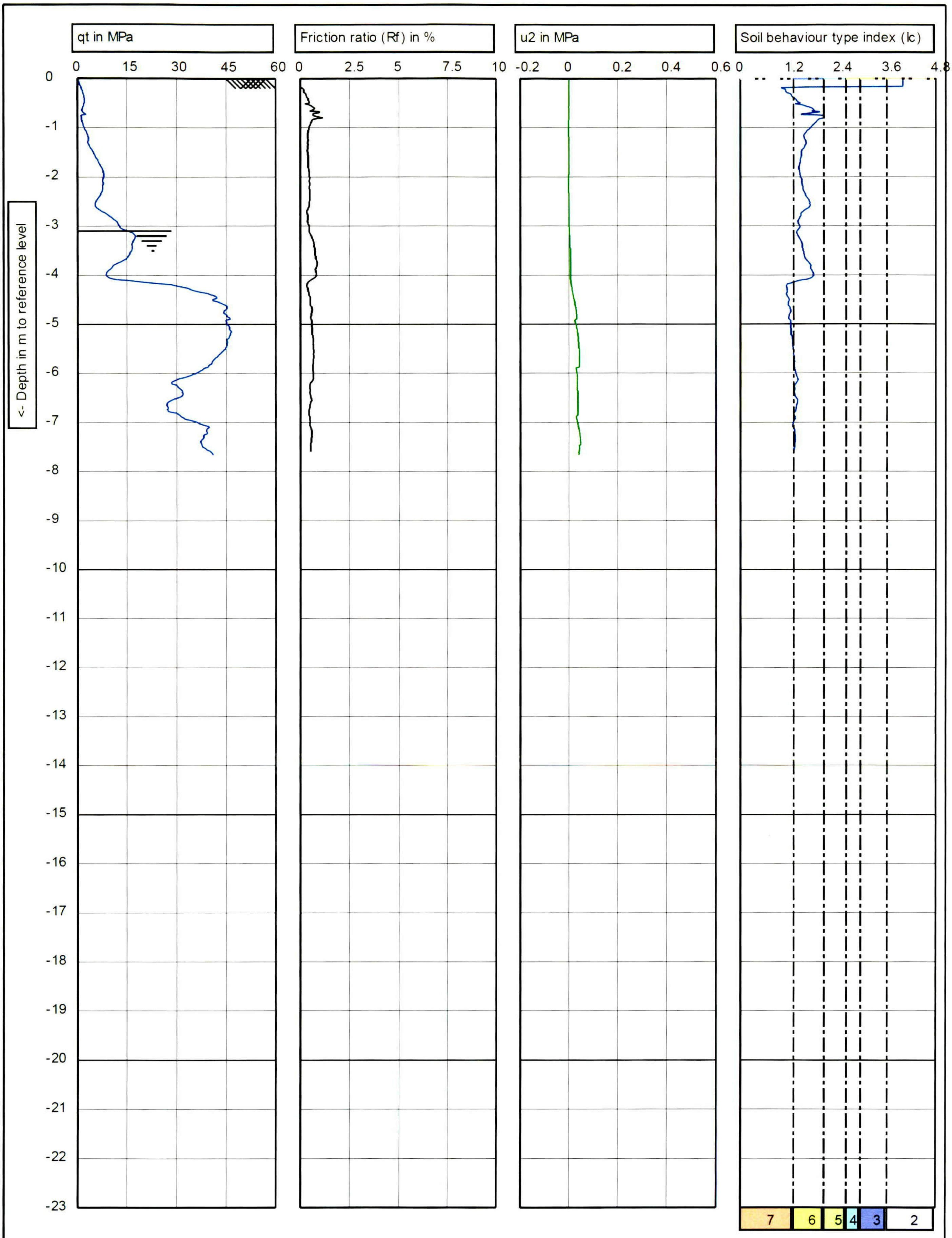
u2 / 150 cm² / 10 cm²	Test according NEN 5140 class 1		Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m NAP**	W.L.: **-3.10 m**	Date:	**21/04/2017**
	Project: **Geotechnical Investigation**		Cone no.:	**C10CFIIP.C16116**
	Location: **15 Peel St Tuncurry**		Project no.:	**RGS01515/1**
	Position: **0, 0 RD**		CPT no.:	**CPT-2** 3/3

1.47



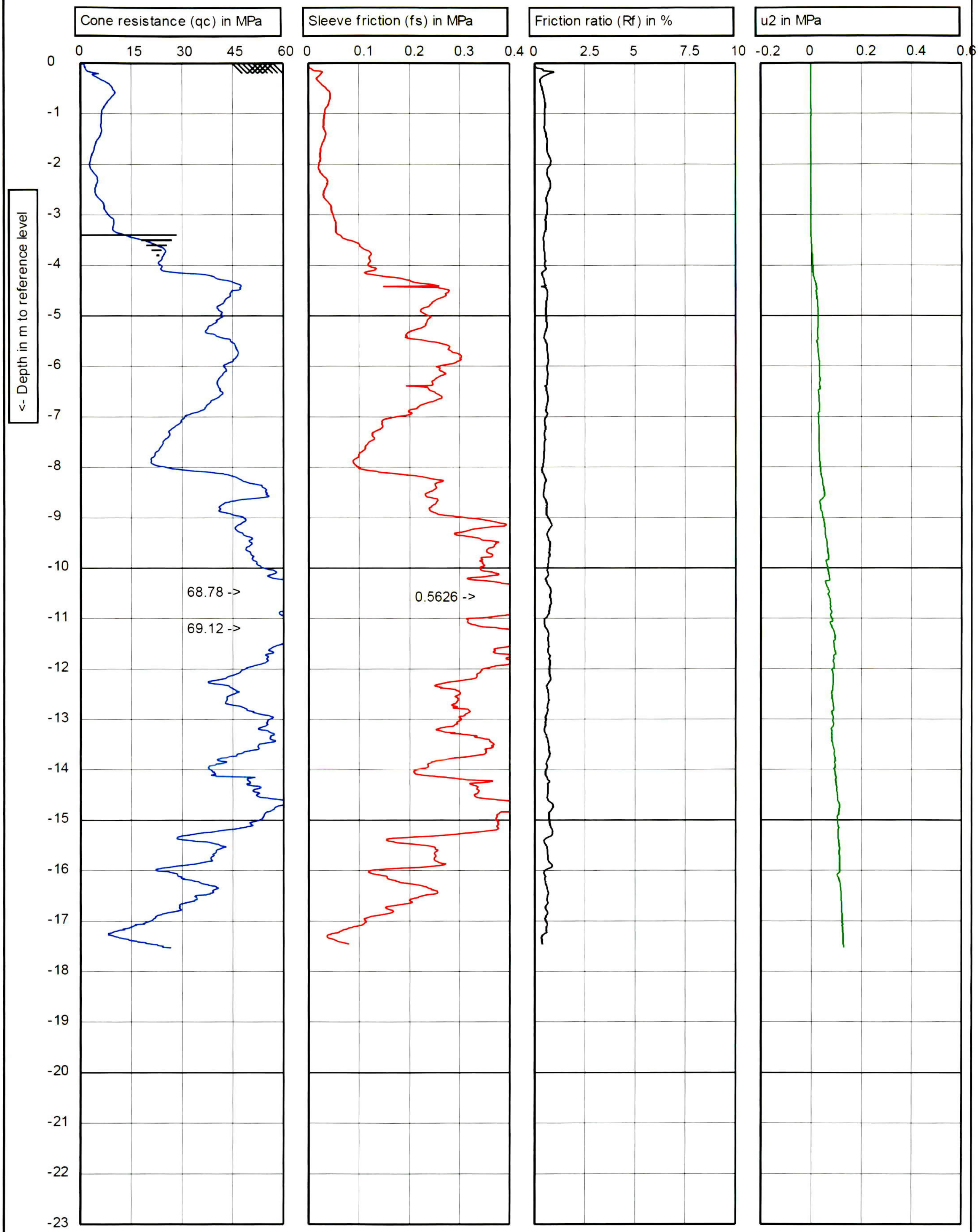
u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Predrill:	0.00 m Predrilled
	G.L.: **0.00 m NAP**	W.L.: **-3.10 m**	Date:	**21/04/2017**
Project:	**Geotechnical Investigation**		Cone no.:	**C10CFIIP.C16116**
Location:	**15 Peel St Tuncurry**		Project no.:	**RGS01515/1**
Position:	**0, 0 RD**		CPT no.:	**CPT-3** 1/3

1.47

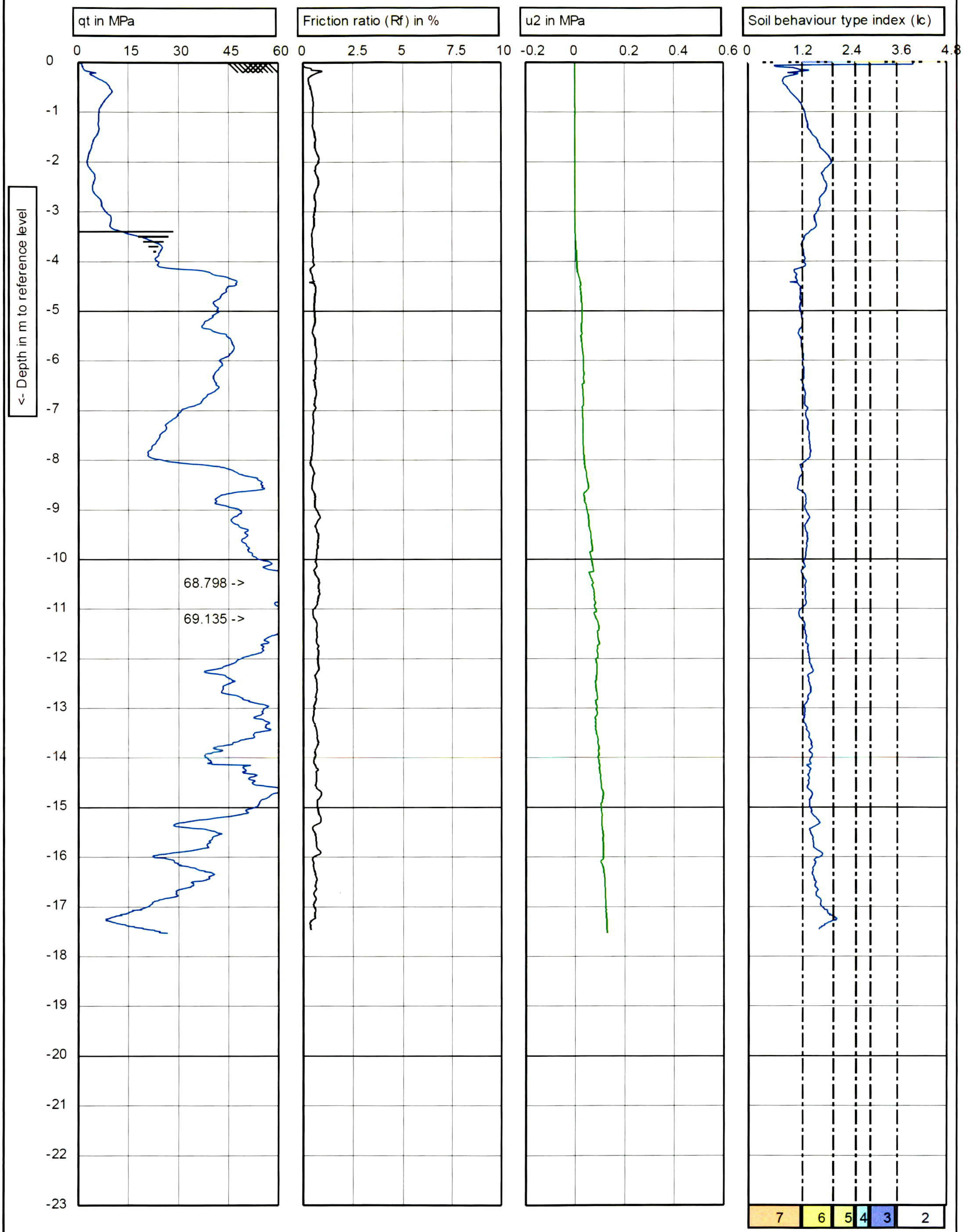


u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m NAP**	W.L.: **-3.10 m**	Date:	**21/04/2017**
Project:	**Geotechnical Investigation**		Cone no.:	**C10CFIIP.C16116**
Location:	**15 Peel St Tuncurry**		Project no.:	**RGS01515/1**
Position:	**0, 0 RD**		CPT no.:	**CPT-3** 2/3

u2 / 150 cm² / 10 cm²	Test according NEN 5140 class 1		Predrill:	0.00 m Predrilled
	G.L.: 0.00 m NAP	W.L.: -3.10 m	Date:	21/04/2017
Project:	Geotechnical Investigation		Cone no.:	C10CFIIP.C16116
Location:	15 Peel St Tuncurry		Project no.:	RGS01515/1
Position:	0, 0 RD		CPT no.:	CPT-3 3/3



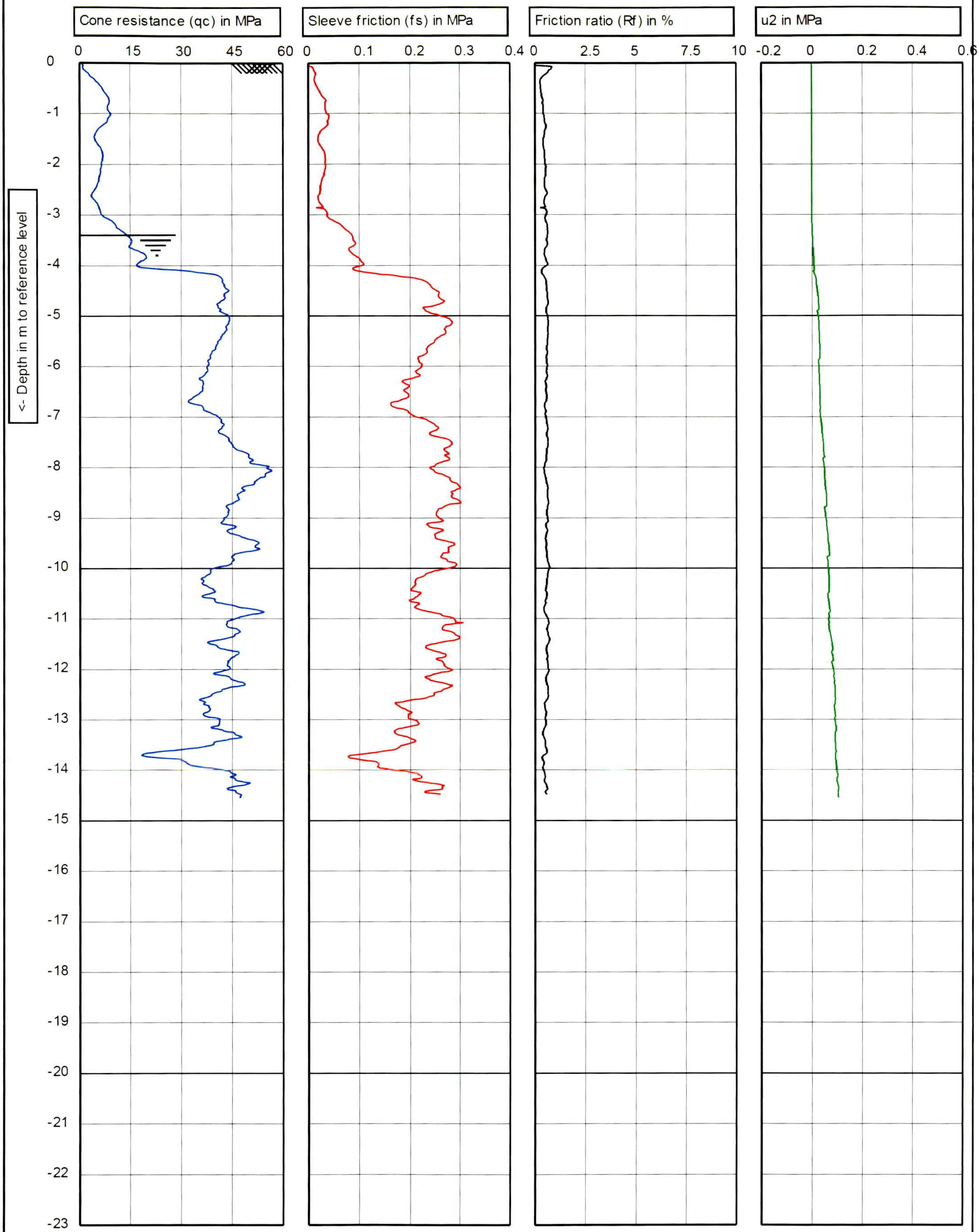
u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m NAP**	W.L.: **-3.40 m**	Date:	**21/04/2017**
Project:	**Geotechnical Investigation**		Cone no.:	**C10CFIIP.C16116**
Location:	**15 Peel St Tuncurry**		Project no.:	**RGS01515/1**
Position:	**0, 0 RD**		CPT no.:	**CPT-4** 1/3



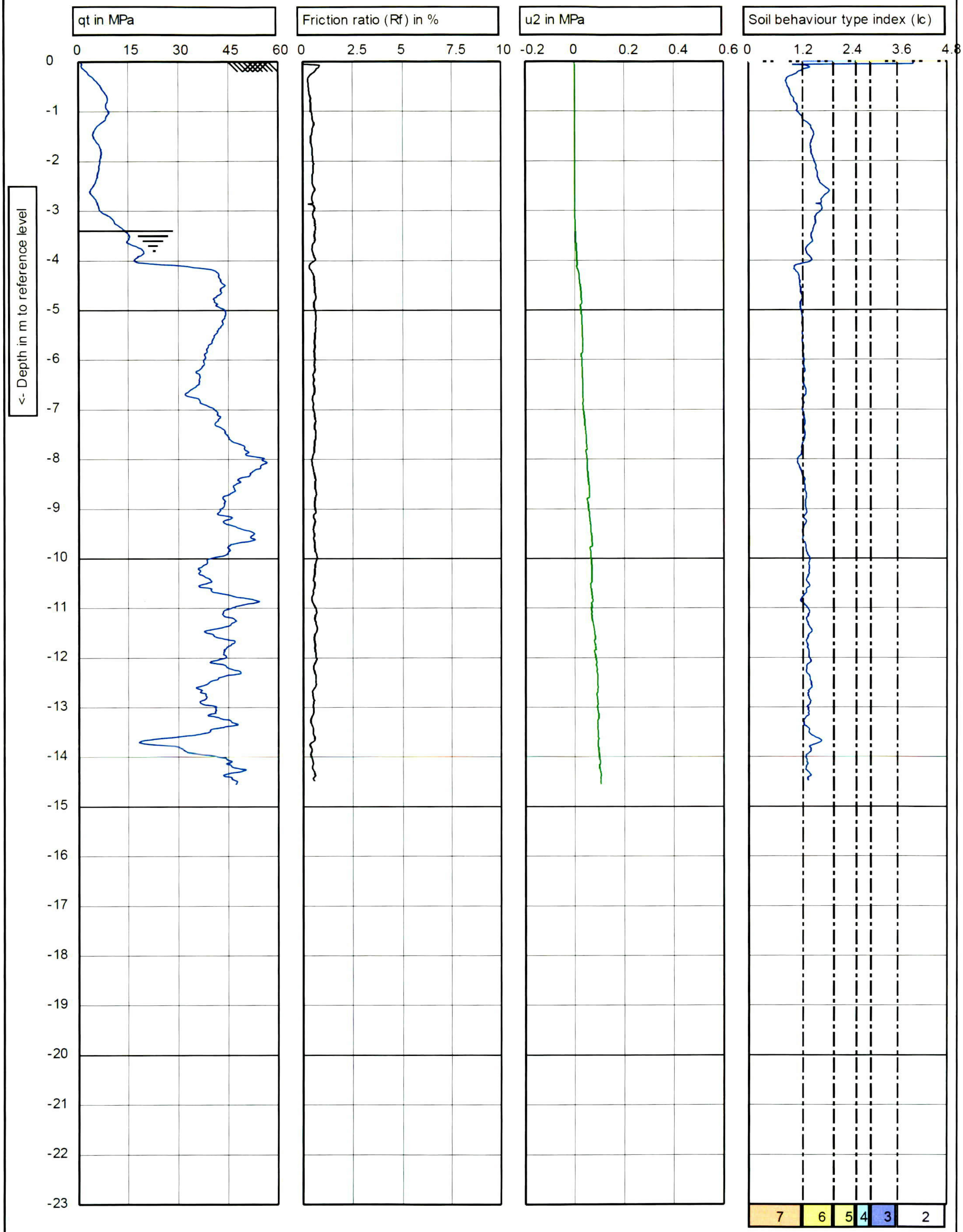
u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m NAP**	W.L.: **-3.40 m**	Date:	**21/04/2017**
Project:	**Geotechnical Investigation**		Cone no.:	**C10CFIIP.C16116**
Location:	**15 Peel St Tuncurry**		Project no.:	**RGS01515/1**
Position:	**0, 0 RD**		CPT no.:	**CPT-4** **2/3**

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

r u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Predrill:	0.00 m Predrilled
	G.L.: **0.00 m NAP**	W.L.: **-3.40 m**	Date:	**21/04/2017**
	Project: **Geotechnical Investigation**		Cone no.:	**C10CFIIP.C16116**
	Location: **15 Peel St Tuncurry**		Project no.:	**RGS01515/1**
	Position: **0, 0 RD**		CPT no.:	**CPT-4** 3/3



u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Predrill:	**0.00 m Predrilled**
	G.L.: **0.00 m NAP**	W.L.: **-3.40 m**	Date:	**21/04/2017**
Project:	**Geotechnical Investigation**		Cone no.:	**C10CFIIP.C16116**
Location:	**15 Peel St Tuncurry**		Project no.:	**RGS01515/1**
Position:	**0, 0 RD**		CPT no.:	**CPT-5** **1/3**



u2
150 cm²
10 cm²

Test according NEN 5140 class 1

G.L.: **0.00 m NAP** W.L.: **-3.40 m**

Predrill: **0.00 m Predrilled**

Date: **21/04/2017**

Cone no.: **C10CFIIP.C16116**

Project no.: **RGS01515/1**

CPT no.: **CPT-5** 2/3

Project: **Geotechnical Investigation**

Location: **15 Peel St Tuncurry**

Position: **0, 0 RD**

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

u2 150 cm² 10 cm²	Test according NEN 5140 class 1		Predrill:	0.00 m Predrilled
	G.L.: 0.00 m NAP	W.L.: -3.40 m	Date:	21/04/2017
Project:	Geotechnical Investigation		Cone no.:	C10CFIIP.C16116
Location:	15 Peel St Tuncurry		Project no.:	RGS01515/1
Position:	0, 0 RD		CPT no.:	CPT-5 3/3

1.47

Appendix B

Laboratory Test Results

RESULTS OF ACID SULFATE SOIL ANALYSIS

8 samples supplied by Regional Geotechnical Solutions Pty Ltd on 9th May 2017 - Lab. ob No. F9251
nalysis requested by Champa Nag. **Your Project: RGS01515.1**

(44 ent Street WING M NSW 2429)

Sample Site	E L lab code	TEXTURE (note 7)	MOISTURE CONTENT (% moisture of total wet weight)	(g moisture / g of oven dry soil)	FIELD/ LAB PEROXIDE SCREENING TECHNIQUE Initial pH_F water	pH_{FOX} peroxide	pH change	Reaction
Method Info.		**	**					
BH1 0.4-0.5	*F9251/1*	Coarse	5.8	0.06	5.44	3.57	-1.87	None
BH1 1.9-2	*F9251/2*	Coarse	5.0	0.05	5.57	3.62	-1.95	None
BH1 2.9-3	*F9251/3*	Coarse	10.4	0.12	5.88	4.84	-1.04	None
BH1 3.9-4	*F9251/4*	Coarse	15.7	0.19	8.11	6.09	-2.02	None
BH2 1.8-2	*F9251/5*	Coarse	2.5	0.03	7.74	5.27	-2.47	None
BH2 2.6-2.8	*F9251/6*	Coarse	3.0	0.03	7.49	5.12	-2.37	None
BH3 0.8-1	*F9251/7*	Coarse	2.6	0.03	7.42	5.27	-2.15	None
BH3 3.8-4	*F9251/8*	Coarse	21.1	0.27	7.77	5.79	-1.98	None

NOTE:

1 - ll analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 - Samples analysed by SPOC S method 23 (ie Suspension Peroxide Oxidation Combined cidity sulfate) and Chromium Reducible Sulfur technique (Scr - Method 22)
3 - Methods from hern CR McElnea E Sullivan L (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines***. LD DNRME.
4 - ul Density is required for liming rate calculations per soil volume. Lab. ul Density is no longer applicable - field bul density rings can be used and dried eighed in the laboratory.
5 - **ABA Equation**: **Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)**
6 - The neutralising requirement lime calculation includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)
7 - For Texture: coarse sands to loamy sands medium sandy loams to light clays fine medium to heavy clays and silty clays
8 - .. denotes not requested or required. 0 is used for NC and Snag calcs if T p <6.5 or 4.5
9 - SCREENING CRS T and NC are N T accredited but other SPOC S segments are currently not N T accredited
10- Results at or belo detection limits are replaced ith 0 for calculation purposes.
11 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).
12 - Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.
13 denotes these test procedure or calculation are as yet not N T accredited but quality control data is available

NATA
ACCREDITATION
Accreditation No. 14960
Accredited for compliance with ISO/IEC 17025

(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H^+/t; medium Scr≥0.06%S or 37mole H^+/t; fine Scr≥0.1%S or 62mole H^+/t) - as per QUA[illegible] es

chec ed: ....
Graham Lancaster
Laboratory Manager

RESULTS OF ACID SULFATE SOIL ANALYSIS

8 samples supplied by Regional Geotechnical Solutions Pty Ltd on 9th May, 2017 - Lab. Job No. F9251
Analysis requested by Champak Nag. Your Project: RGS01515.1

(44 Bent Street WINGHAM NSW 2429)

Required if pH_{KCl} <4.5

Sample Site	EAL lab code	TEXTURE (note 7)	MOISTURE CONTENT (% moisture of total wet weight)	MOISTURE CONTENT (g moisture / g of oven dry soil)	FIELD/ LAB PEROXIDE SCREENING TECHNIQUE: Initial pH_F water	pH_{FOX} peroxide	pH change	Reaction	TITRATABLE ACTUAL ACIDITY (TAA) (To pH 6.5): pH_{KCl}	TAA (mole H^+/tonne)	Extractable sulfate sulfur $\%S_{KCl}$	REDUCED INORGANIC SULFUR (% chromium reducible S): (%Scr)	(mole H^+/tonne)	RETAINED ACIDITY (HCL extract) (as $\%S_{HCL}$ - $\%S_{KCl}$): ($\%S_{NAS}$)	S_{NAS} (mole H^+/tonne)	NET ACIDITY Chromium Suite mole H^+/tonne (based on %Scrs)	LIME CALCULATION Chromium Suite kg $CaCO_3$/tonne DW (includes 1.5 safety Factor when liming rate is +ve)
Method Info.		**	**						*(ACTUAL ACIDITY-Method 23)*			*(POTENTIAL ACIDITY-Method 22B)*		*(RETAINED ACIDITY)*		*** & note 5*	*** & note 4 and 6*
BH1 0.4-0.5	*F9251/1*	Coarse	5.8	0.06	5.44	3.57	-1.87	None	4.37	22	0.002	0.011	7	0.000	0	29	2
BH1 1.9-2	*F9251/2*	Coarse	5.0	0.05	5.57	3.62	-1.95	None	..	..	..	..	..	..	..	..	..
BH1 2.9-3	*F9251/3*	Coarse	10.4	0.12	5.88	4.84	-1.04	None	..	..	..	..	..	..	..	..	..
BH1 3.9-4	*F9251/4*	Coarse	15.7	0.19	8.11	6.09	-2.02	None	..	..	..	..	..	..	..	..	..
BH2 1.8-2	*F9251/5*	Coarse	2.5	0.03	7.74	5.27	-2.47	None	..	..	..	..	..	..	..	..	..
BH2 2.6-2.8	*F9251/6*	Coarse	3.0	0.03	7.49	5.12	-2.37	None	..	..	..	..	..	..	..	..	..
BH3 0.8-1	*F9251/7*	Coarse	2.6	0.03	7.42	5.27	-2.15	None	..	..	..	..	..	..	..	..	..
BH3 3.8-4	*F9251/8*	Coarse	21.1	0.27	7.77	5.79	-1.98	None	..	..	..	..	..	..	..	..	..

NOTE:
1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)
3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). *Acid Sulfate Soils Laboratory Methods Guidelines*. QLD DNRME.
4 - Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density rings can be used and dried/ weighed in the laboratory.
5 - ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)
6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)
7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
8 - .. denotes not requested or required. '0' is used for ANC and Snag calcs if TAA pH <6.5 or >4.5
9 - SCREENING, CRS, TAA and ANC are NATA accredited but other SPOCAS segments are currently not NATA accredited
10- Results at or below detection limits are replaced with '0' for calculation purposes.
11 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).
12 - Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.
13 ** denotes these test procedure or calculation are as yet not NATA accredited but quality control data is available

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(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H^+/t; medium Scr≥0.06%S or 37mole H^+/t; fine Scr≥0.1%S or 62mole H^+/t) - as per QUASSIT Guidelines

checked: ....
Graham Lancaster
Laboratory Manager

RESULTS OF SOIL ANALYSIS (Page 1 of 1)

8 samples supplied by Regional Geotechnical Solutions Pty Ltd on 9th May, 2017 - Lab. Job No. F9251
Analysis requested by Champak Nag. **Your Project: RGS01515.1**
(44 Bent Street WINGHAM NSW 2429)

	Method	Sample 4 BH1 3.9-4	Sample 6 BH2 2.6-2.8
	EAL job No.	*F9251/4*	*F9251/6*
Moisture (%)	*inhouse*	16	3
Texture	*See note 2 below.*	Coarse	Coarse
Soil pH (1:5 water)	Rayment and Lyons 4A1	5.94	5.94
Soil Conductivity (1:5 water dS/m)	Rayment and Lyons 4B1	0.124	0.106
Soil Resistivity (ohm.mm)	** Calculation	80,645	94,340
Chloride (mg/kg)	** Water Extract- Rayment and Lyons 5A2b	24	4
Chloride **(as %)**	** Calculation	0.002	0.000
Sulfate (mg/kg)	** Water Extract-Apha 3120 ICPOES	19	3
Sulfate **(as % SO_3)**	** Calculation	0.002	0.000
Chloride / Sulfate Ratio	** calculation	1.2	1.4

Notes:
1. ppm = mg/Kg dried soil
2. For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
3. All results as dry weight DW - soils were dried at 60oC for 48hrs prior to crushing and analysis.
4. For conductivity 1 dS/m = 1 mS/cm = 1000 μS/cm
5. Methods from Rayment and Lyons. Soil Chemical Methods - Australasia
6. Based on Australian Standard AS: 159-1995
7 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). *Acid Sulfate Soils Laboratory Methods Guidelines*. QLD DNRME.
8. ** denotes these test procedure or calculation are as yet not NATA accredited but quality control data is available

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Accreditation No. 14960.
Accredited for compliance with ISO/IEC 17025.

Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal

checked: ....
Graham Lancaster
Laboratory Manager

Appendix C

Determination of the Geotechnical Strength Reduction Factor

Determination of the Geotechnical Strength Reduction Factor, Φ_g

AS2159-2009, Section 4.3.1

Job Number: RGS01515.1
Client: Wakefield Ashurst Development Pty Ltd
Project: Proposed Development
Site Location: 15 Peel Street, Tuncurry

Pile Testing?	Yes
Φ_{tf}	0.9
Static/Rapid or Dynamic Load Testing?	Static
K	0.5
P	2

Weighting Factors & Individual Risk Ratings for Risk Factors (Table 4.3.2(A))

Risk Factor	Individual Risk Rating (IRR)		
	Weighting Factor, w_i	**Risk weighting (VL=1, M=3 or VH=5)**	**Risk Rating**
Site			
Geological Complexity	2	1	2
Extent of Investigation	2	2	4
Amount/Quality of data	2	2	4
Design			
Experience in similar	1	2	2
Method assessment geotech parameters	2	2	4
Design Method	1	2	2
Method of utilizing results	2	2	4
Installation			
Level of Construction Control	2	2	4
Level of Performance monitoring	0.5	4	2

ARR 1.93
Redundancy in System Low

	Low	High
Basic Geotechnical Reduction Factor, Φ_{gb}	0.61	0.7

Adopted Φ_{gb}	**0.61**
Geotechnical Strength Reduction Factor, Φ_g	**0.755**

Determination of the Geotechnical Strength Reduction Factor, Φ_g

AS2159-2009, Section 4.3.1

Job Number:	RGS01515.1
Client:	Wakefield Ashurst Development Pty Ltd
Project:	Proposed Development
Site Location:	15 Peel Street, Tuncurry

Pile Testing?	No
Φ_{tf}	
Static/Rapid or Dynamic Load Testing?	
K	
P	

Weighting Factors & Individual Risk Ratings for Risk Factors (Table 4.3.2(A))

Risk Factor	Individual Risk Rating (IRR)		
	Weighting Factor, w_i	Risk weighting (VL=1, M=3 or VH=5)	Risk Rating
Site			
Geological Complexity	2	1	2
Extent of Investigation	2	2	4
Amount/Quality of data	2	2	4
Design			
Experience in similar	1	2	2
Method assessment geotech parameters	2	2	4
Design Method	1	2	2
Method of utilizing results	2	2	4
Installation			
Level of Construction Control	2	2	4
Level of Performance monitoring	0.5	4	2

ARR	1.93
Redundancy in System	Low

	Low	High
Basic Geotechnical Reduction Factor, Φ_{gb}	0.61	0.7

Adopted Φ_{gb}	**0.61**
Geotechnical Strength Reduction Factor, Φ_g	**0.61**