REPORT

TO

KARIMBLA CONSTRUCTION SERVICES PTY LTD

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED RESIDENTIAL DEVELOPMENT

AT

CNR LOFTUS & HIRST STREETS, ARNCLIFFE, NSW

22 April 2009

Ref: 22817Zrpt

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed residential development on the corner of Loftus and Hirst Streets, Arncliffe, NSW. The investigation was commissioned by Karimbla Construction Services Pty Ltd, by Purchase Order No 23975 dated 26 March 2009. The commission was on the basis of our Proposal (Ref: P30406Zemail) dated 22 December 2008.

We understand from discussions with Meriton Apartments and from the provided excavation plan (Drawing No E-510-EXC) prepared by Meriton Apartments Pty Ltd, that a multi-storey residential development is proposed over two basement levels. The basements will extend almost to the site boundaries in doughnut fashion around a central garden area. Excavations varying between about 4m and 6m below existing grade will be required in order to achieve the lower basement level. We have assumed that typical structural loads for this type of development apply.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for comments and recommendations on geotechnical issues associated with the proposed development including excavation conditions, dewatering, excavation support, retaining walls, footings and on-grade floor slabs.

2 INVESTIGATION PROCEDURE

The fieldwork for the investigation included five electric friction cone penetrometer (EFCP) probes (EFCP1 to EFCP5) to depths between 11.04m and 20.37m. In addition, four boreholes (BH1 to BH3, and BH5) were auger drilled and wash-bore advanced adjacent to the relevant EFCP locations to depths between 11.23m and 18.03m. The boreholes were then extended into the underlying bedrock using rotary coring techniques with water flush to final depths between 14.09m and 21.12m. The investigation locations, as indicated on attached Figure 1, were set out using taped measurements from existing surface features and apparent site boundaries. The investigation locations, which were dictated by access considerations given the constraints of the existing development on site, were electromagnetically scanned for buried services prior to probing/ drilling commencing. The surface reduced levels (RLs) at the investigation locations were estimated by interpolation between spot heights shown on the provided excavation plan.

The nature and composition of the subsurface soils and rocks were assessed by logging the materials recovered during drilling and by interpretation of the EFCP test results. We note that continuous spiral auger drilling and wash-boring techniques were used to advance the boreholes within the soil profile and therefore the borehole logs are indicative only. The interpreted subsoil profile from the EFCP test results is considered to be a more reliable representation of the subsoils. The relative density of the subsoils was assessed by interpretation of the EFCP test results. The strength of the bedrock was assessed by inspection of the recovered rock core and subsequent correlation with laboratory point load strength index test results. Groundwater observations were made during auger drilling and on completion of EFCP testing. The pore pressure determinations made during EFCP testing were affected by the clay profile and are not reliable. Long-term groundwater monitoring was not carried out. For further details of the investigation procedure adopted, reference should be made to the attached Report Explanation Notes.

Our geotechnical engineers were onsite full time during the investigation and set out the test locations, directed electromagnetic scanning, nominated sampling and testing and logged the encountered subsurface profile. The interpretive profile from the EFCP tests was completed by our geotechnical engineers in the office. The borehole logs and the EFCP test results are presented with this report, together with a glossary of logging terms and symbols used.

The recovered rock core was submitted to the Soil Test Services (STS) NATA registered laboratory, where it was photographed and selected sections of rock core subjected to point load strength index testing. The laboratory test results are summarised in attached Table A and have been plotted on the borehole logs. The core photographs are presented opposite the relevant borehole logs. Contamination screen testing of the site soils was not within the agreed scope of this investigations.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site has a rhombic plan shape and is bounded by Hirst, Loftus and Boner Streets to the south, east and west respectively, in relatively flat topography associated with the Wolli Creek flood plain.

At the time of the investigation, the south-western portion of the site was occupied by a concrete clad warehouse building with associated concrete paved parking/ hardstand over the south-east. This concrete paved area sloped down at between 1° and 3° towards Boner Street. The southern end of the warehouse and concrete paved area had been cut into the hillslope and a concrete block wall retained the Hirst Street frontage between 0.8m and 3m above the site.

A single storey brick and sheeted warehouse building with concrete paved surround was located over the north-western portion of the site.

A three storey rendered building was located over the centre of the eastern end of the site. The ground floor level was partly inground over the west and the building had concrete surrounds.

Over the north-eastern corner was a single storey rendered building and a single storey brick and sheeted building.

All of the above buildings were generally in good condition, based on a cursory inspection, but with 5mm to 10mm wide horizontal cracks evident in the three storey building over the east and 10mm to 20mm stepped diagonal cracks evident over the north-east corner in the building over the north-west.

Beyond the western end of the northern site boundary were the grassed fields of a school. Beyond the eastern end of the northern site boundary were the rear yards of two residential lots. The neighbouring houses were set back about 8m beyond the site boundary.

3.2 Subsurface Conditions

The 1:100,000 geological map of Sydney indicates that the site is underlain by estuary or alluvial deposits over Hawkesbury Sandstone. The investigation has revealed a subsurface profile below the pavements comprising deep alluvial soils over sandstone bedrock. A relatively shallow groundwater level was also encountered. A graphical borehole summary is presented in attached Figure 2, and a summary of the subsurface conditions, as encountered, is presented below:

- A pavement comprising 30mm asphaltic concrete (AC) over a silty sand with gravel base was encountered to a depth of 0.15m in BH1.
- Concrete paving between 80mm and 200mm thick over a silty sand with gravel base was encountered to depths between 0.25m and 0.6m in the remaining boreholes.
- Alluvial soils comprising sands, silty and clayey sands, sandy clays and silty clays were encountered beneath the fill. The clays were assessed as being of variable plasticity and generally between stiff and hard strength. The sands were generally assessed as being medium dense with very loose and dense sands also present.
- Sandstone bedrock was encountered at depths between 11.23m (BH2) and 18.03m (BH3) with no trend of surface slope direction apparent. The upper 0.5m of sandstone in BH1 was of extremely and very low strength. Below 0.5m in BH1 and on first contact in the remaining boreholes, the sandstone classifies as Class 3 or Class 4 based on the methods of Pells *et al* (1998).
- Groundwater seepage or a groundwater level was encountered at a depth of approximately 2m below ground level.

3.3 Laboratory Test Results

The point load strength index testing on the recovered sandstone core correlated reasonably well with our field assessment of rock strength. The unified compressive strength of the sandstone bedrock, as estimated from the point load strength index test results, generally varied between 6MPa and 18MPa with outliers of 3MPa and 36MPa.

4 COMMENTS AND RECOMMENDATIONS

4.1 Geotechnical Issues

The proposed multi-storey building, which will include excavations to a maximum depth of 6m, overlies a subsurface profile comprising deep alluvial deposits (interbedded sands and clays) which vary erratically both in depth and extent. The groundwater level was encountered at about 2m depth and sandstone bedrock occurred at depths between about 11m and 18m.

The principal geotechnical issues are therefore related to the following:

- The proposed bulk excavation will extend below the groundwater level and will thus require dewatering.
- The relatively heavily loaded structure will require to be supported onto bedrock, using piled footings which will need to be installed through sandy soils below the groundwater level.
- Temporary support of the bulk excavation which will extend almost to the site boundaries.

The above issues are discussed in detail in the sections that follow.

4.2 Excavation Conditions

The proposed bulk excavation to a maximum depth of about 6m will encounter the soil profile and the groundwater level. Following dewatering, as detailed in 4.3 below, the soil profile may be excavated using conventional earthworks equipment such as hydraulic excavators.

4.3 Dewatering

Groundwater was measured at a depth of about 2m below existing ground surface level and may well be higher following heavy or prolonged rainfall.

Dewatering will therefore be required during excavation and basement construction and should be integrated with the proposed shoring. A dewater-recharge system will be required so as to maintain the groundwater level outside the excavation and to reduce any settlements of adjoining structures which could occur with groundwater drawdown. A detailed groundwater modelling analysis must be carried out to estimate pump-out and recharge rates, as well as the required depth of perimeter wall penetration to satisfy piping considerations.

We suggest that the perimeter retaining walls be installed into the underlying relatively impermeable clays, in an attempt to 'cut off' the groundwater and seal the excavation. It is unlikely that full cut-off or sealing will be achieved, particularly due to the interbedded sandy and clayey nature of the subsoils. However, the volume of water into the excavation and therefore the required pump-out capacity is likely to be significantly reduced. A series of boreholes should be drilled along the perimeter of the excavation to provide a longitudinal section of the clay surface depth.

We recommend that during construction, groundwater levels, both within and outside the excavation, be carefully controlled by regular monitoring using standpipes. Over the longer term, the completed basement would need to be tanked and designed to take the hydrostatic lateral and uplift pressures into account.

4.4 Excavation Support

As the proposed bulk excavation will extend close to the site boundaries, temporary support of the underlying soils along the external face will be required, using an engineered retention system which is installed prior to excavation commencing. Along the internal face, a 1 Vertical (V) in 2 Horizontal (H) batter may be formed. A conventional retaining wall should then be constructed at the toe of the batter then tanked and subsequently backfilled.

Suitable retention systems include a sheet pile wall, a secant pile wall or a diaphragm wall. Whilst the sheet pile wall is feasible, installation should be by means of oscillators rather than hammers so as to reduce vibrations. Further, this system may not easily penetrate dense sands or hard clays and provision for pre-drilling should be made.

The shoring walls must be founded below the proposed bulk excavation level (including nearby footing or other localised excavations) to satisfy stability, founding and piping requirements. Lateral restraint in the form of anchors or internal props would also be required and must be installed progressively as excavation proceeds.

Anchors are likely to be difficult to install and to seal beneath the groundwater level. Top-down construction, or internal propping, may also be considered. We note that permission from the surrounding property owners would be required prior to anchor installation. Such property owners would include the school, the house owners and the Council.

4.5 Retaining Walls

The major consideration in the selection of earth pressures for the design of retaining walls is the need to limit deformations occurring outside the excavation. The following characteristic earth pressure coefficients and subsoil parameters may be adopted for the design of temporary or permanent systems to retain the soil profile:

- For progressively anchored or propped walls supporting areas where minor movements can be tolerated (ie. the entire external perimeter provided there are no movement-sensitive buried services along the street frontages), we recommend the use of a uniform rectangular lateral earth pressure distribution of 6H kPa, where 'H' is the retained height in metres, assuming a horizontal retained surface.
- For progressively anchored or propped walls which support areas which are highly sensitive to lateral movements (such as adjacent to movement-sensitive buried services), a uniform rectangular lateral earth pressure distribution of 8H kPa should be adopted.
- Along the internal face, conventional retaining walls may be designed using a triangular lateral earth pressure distribution with an 'at rest' earth pressure coefficient, K_o, of 0.55 for the retained height, assuming a horizontal retained surface.
- A bulk unit weight of 18kN/m^3 may be adopted for the soil profile above the groundwater level.
- Alternatively, detailed numerical analyses should be carried out using WALLAP or similar computer-based programs to model the progressively anchored or propped shoring walls as excavation proceeds. An effective angle of internal friction, ϕ', of 28°, an effective cohesion of zero and a bulk unit weight of 18kN/m^3 (above groundwater level) may be adopted for the analyses to confirm the minimum depth of toe embedment and the likely order of magnitude of wall

deflection during the various phases of excavation/ shoring. Where excessive lateral deflection results, the wall will require stiffening to the extent that deflections are maintained within acceptable limits.

- Any surcharge affecting the walls (including traffic, construction loads, sloping backfill, etc) should be allowed in the design using the 'at rest' earth pressure coefficient from above.
- Shoring walls should be designed to withstand applicable hydrostatic pressure, both on the 'active' and 'passive' sides of the wall. For the completed basement walls, we recommend that the groundwater level adopted for design be no less than the highest level recorded during the investigation (ie. RL8.75m), with an allowance for rises of say, 0.5m, for storm surcharge. Under extreme conditions, groundwater should be taken at least to the ground surface.
- Lateral toe restraint may be achieved by adequate embedment of the retaining wall below bulk excavation level. A triangular lateral earth pressure distribution with a 'passive' earth pressure coefficient, K_p, of 2.9, may be adopted for embedment design, assuming horizontal ground in front of the wall. The upper 0.5m below bulk excavation level should be ignored in the analysis to take excavation tolerances into account. Any localised excavations in front of the wall such as for drainage, footings, etc, should also be allowed in the design. We note that significant movement is required in order to mobilise the full 'passive' pressure of the soil. We therefore recommend that a factor of safety of 2 be adopted so as to reduce such deflections.
- Soil anchors bonded into the soil profile should be designed using an allowable bond stress of 50kPa. Wall anchors should be proof tested to 1.3 times the working load under the direction of an experienced engineer or construction superintendent independent of the anchor contractors. Anchors must be bonded behind a 45° line, drawn upwards from the base of the excavation.

Anchor group interaction must also be taken into account. Permanent anchors should have appropriate corrosion provisions.

We recommend that only experienced contractors be considered for wall construction and anchoring installation. Where anchors extend beyond the site boundary, permission of adjoining property owners will be required.

It is inevitable that the excavation will induce movements of the adjacent ground that falls within the zone of influence of the excavation. The actual wall movements are highly dependent on the construction sequence, detailing and quality of installation and should be closely monitored in critical areas. The extent of significant influence can be defined as extending a horizontal distance out from the excavation perimeter equal to 1.5 times the excavation depth. Hence, any existing adjoining structures or buried services which fall within this zone of influence would be susceptible to some damage due to excavation induced movements.

4.6 Footings

Given the expected magnitude of column loads, we recommend that the proposed building structure be founded within the underlying bedrock using piled footings. Suitable sandstone was encountered at depths between 11.3m and 18.3m (ie. between RL–1.0m and RL–10.8m). Piled footings, founded at least 0.5m into sandstone bedrock of low or higher strength, may be designed for an allowable end bearing pressure of 3MPa. In addition, an allowable shaft adhesion value of 300kPa may be applied to that length of rock socket in excess of 0.5m. We note that the above are based on serviceability criteria of settlement at the toe less than 1% of the pile diameter.

If the designer wishes to adopt the limit state design methods of the Piling Code (AS2159), then an ultimate end bearing value of 10MPa, together with an ultimate shaft adhesion value of 600kPa should be adopted, together with a geotechnical strength reduction factor ϕ_g of 0.75. A Young's Modulus value of 600MPa should be assumed for pile settlement analysis.

Grout injected auger piles (also known as CFA piles) would be a suitable pile type given the subsurface conditions. Conventional bored piles would be unsuitable in view of the sandy subsoils combined with the high groundwater level. Temporary liners, together with mud stabilisation, would be required for bored pile construction. Driven displacement piles may be feasible for the prevailing ground conditions, however the effects of vibrations and noise on surrounding buildings and structures would probably preclude their use.

A geotechnical engineer should witness the initial pile installation, which should be located close to a previously drilled borehole, so that the drilling records and borehole log can be compared and the founding depth confirmed.

4.7 Basement On-grade Floor Slab

The earthworks recommendations provided here should be complemented by reference to AS3798.

The subgrade at design level is likely to be a sandy or clayey soil and should be proof rolled with a 5 tonne minimum vibratory smooth drum roller under the direction of an experienced geotechnician or geotechnical engineer. The objectives of proof rolling are to compact the near surface soils and to detect any unstable areas. Unstable subgrade detected during proof-rolling should be locally excavated down to a competent base and replaced with engineered fill, or further advice should be sought. Clayey soils which are saturated are likely to fail under proof-rolling. Should

this occur, the geotechnical engineer must recommend an appropriate bridging layer. The dewatering will need to achieve a water level at least 1m below bulk excavation level to allow effective proof rolling.

Engineered fill should preferably comprise well graded, granular materials such as crushed sandstone, which is free of deleterious substances and has a maximum particle size of 60mm. All fill used to backfill excavations can be compacted in layers of not greater than 150mm loose thickness, to a density at least 98% of Standard Maximum Dry Density (SMDD).

The on-grade basement slab will need to be tanked and designed for hydrostatic uplift pressures. Care is required with tanking details, particularly at joints between wall and slab and at joints between pile cap/column and slab.

4.8 Further Geotechnical Input

The following summarises the further geotechnical input which is required and which has been detailed in the preceding sections of this report:

- Further investigation to establish depth of clay along the excavation perimeter.
- Inspection of shoring pile walls during construction.
- Proof-loading of anchors, if appropriate.
- Monitoring of groundwater levels during dewatering.
- Witnessing of pile footing installation.
- Proof-rolling of the subgrade.
- Density testing of engineered fill.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Jeffery and Katauskas Pty Ltd accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

Occasionally, the subsurface conditions between the completed EFCP tests/ boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

The offsite disposal of soil will most likely require classification in accordance with the Department of Environment & Climate Change (NSW) guidelines as Virgin Un-Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous waste. We can complete the necessary classification and testing if you wish to commission us. As testing requires about seven days to complete, allowance should be made for such testing in the construction program unless testing is completed

prior to construction. If contamination is found to be present then substantial further testing and delays should be expected. We strongly recommend this issue be addressed prior to commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of Jeffery and Katauskas Pty Ltd. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

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For and on behalf of
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SOIL TEST SERVICES

ABN 43 002 145 173

Ref No: 22817Z

TABLE A
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
1	17.93-17.97	0.4	8
	18.32-18.35	0.7	14
	19.49-19.51	0.8	16
	20.15-20.18	0.9	18
2	11.35-11.39	0.1	2
	12.34-12.37	0.6	12
	13.57-13.61	0.4	8
3	18.88-18.92	0.5	10
	19.85-19.90	0.8	16
	20.81-20.84	1.8	36
5	17.33-17.35	0.3	6
	18.43-18.46	0.3	6
	19.43-19.47	0.4	8

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RTA T223.
4. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :
   U.C.S. = 20 $I_{S(50)}$

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 1
1/4

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 8-4-09

Method: CONTINUOUS SPIRAL AUGER & WASHBORE JK350

Logged/Checked by: G.F./

R.L. Surface: ≈ 10.6m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0		-	ASPHALTIC CONCRETE: 30mm.t	M	-	-	
								SM	FILL: Silty sand, fine to medium grained, dark brown, with a trace of fine to medium grained gravel.	M	-	-	
						1			SILTY SAND: fine to medium grained, grey.				
									as above, but light brown.				
▶						2		SC	CLAYEY SAND: fine to medium grained, light grey.	W			
						3		SP	SAND: fine to medium grained, light grey, with a trace of clay.				
						4							
						5							
						6							
									SAND: fine to medium grained, light brown and orange brown, with a trace of silt and clay.				
						7							

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Borehole No. 1 2/4

BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 8-4-09
Method: CONTINUOUS SPIRAL AUGER & WASHBORE JK350
R.L. Surface: ≈ 10.6m
Datum: ASSUMED
Logged/Checked by: G.F./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						8		SP	SAND: fine to medium grained, light brown and orange brown, with a trace of silt and clay.	W			
						9							
						10							
						11							
						12							
						13							COMMENCE WASHBORING
						14							

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Borehole No. 1 3/4

BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z **Method:** CONTINUOUS SPIRAL AUGER & WASHBORE JK350 **R.L. Surface:** ≈ 10.6m

Date: 8-4-09 **Datum:** ASSUMED

Logged/Checked by: G.F./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						15			SAND: fine to medium grained, light brown and orange brown, with a trace of silt and clay.	W			
						16							
						17							
									REFER TO CORED BOREHOLE LOG				END WASHBORE NOTE: DUE TO DRILLING TECHNIQUES ADOPTED, SOIL PROFILE IS INDICATIVE ONLY. REFER TO EFCP 1
						18							
						19							
						20							


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JOB NO: 22817Z, BH1, START CORING AT 17.38m
17
18
19
20
END AT 20.28m

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Borehole No. 1 4/4

CORED BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z **Core Size:** NMLC **R.L. Surface:** ≈ 10.6m
Date: 8-4-09 **Inclination:** VERTICAL **Datum:** ASSUMED
Drill Type: JK350 **Bearing:** - **Logged/Checked by:** G.F./

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION (Rock Type, grain characteristics, colour, structure, minor components.)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT DETAILS: DEFECT SPACING (mm) 600 200 100 60 30 10	DEFECT DETAILS: DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) Specific / General
		16							
		17		START CORING AT 17.38m					
FULL RET-URN		18		SANDSTONE: fine to medium grained, light grey and orange brown, with iron indurated bands.	DW	VL-L	×		- XWS, 30mm.t
				SANDSTONE: fine to medium grained, orange brown and light grey.	XW	EL			
				SANDSTONE: fine to medium grained, orange brown, red brown and light grey, with iron indurated bands.	DW	L	×		- J, 30°, P, R, IS
		19		SANDSTONE: fine to medium grained, light grey, red brown and orange brown.		M	×		- XWS/CS, 5mm.t - Be, 5°, P, S, IS - XWS, 2mm.t
				SANDSTONE: fine to medium grained, light grey, with occasional orange brown and red brown staining.			×		- XWS/CS, 50mm.t
		20		SANDSTONE: fine to medium grained, light grey, with dark grey laminae, bedded at 0-10°.			×		- XWS, 10mm.t - Be, 0°, P, S
				END OF BOREHOLE AT 20.28m					
		21							
		22							

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Borehole No. 2 1/3

BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 8-4-09
Method: CONTINUOUS SPIRAL AUGER & WASHBORE JK350
Logged/Checked by: G.F./
R.L. Surface: ≈ 10.3m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			CONCRETE: 150mm.t				7mm DIAMETER REINFORCEMENT, 100mm TOP COVER
								-	FILL: Silty clay, medium plasticity, brown, with a trace of fine to medium grained gravel.	MC>PL	-	-	
								SM	SILTY SAND: fine to medium grained, grey.	M	-	-	
						1							
								CL	SANDY CLAY: medium plasticity, light brown and grey.				HYDROCARBON ODOUR
▶						2							
										W			
						3			SANDY CLAY: medium plasticity, light grey.	MC>PL			
						4							
						5							
						6							
▶						7							

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BOREHOLE LOG

Borehole No. 2 2/3

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z **Method:** CONTINUOUS SPIRAL AUGER & WASHBORE JK350 **R.L. Surface:** ≈ 10.3m

Date: 8-4-09 **Datum:** ASSUMED

Logged/Checked by: G.F./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						8		CL	SANDY CLAY: medium plasticity, light grey.	MC > PL				
						9							
						10							
						11							COMMENCE WASHBORING
						12			REFER TO CORED BOREHOLE LOG				END WASHBORING NOTE: DUE TO DRILLING TECHNIQUES ADOPTED, SOIL PROFILE IS INDICATIVE ONLY. REFER TO EFCP 2
						13							
						14							


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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
JOB NO: 22817Z, BH2, START CORING AT 11.23m
11
12
13
14
END AT 14.09m

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **2** 3/3

CORED BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z **Core Size:** NMLC **R.L. Surface:** ≈ 10.3m
Date: 8-4-09 **Inclination:** VERTICAL **Datum:** ASSUMED
Drill Type: JK350 **Bearing:** - **Logged/Checked by:** G.F./

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION (Rock Type, grain characteristics, colour, structure, minor components.)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ (EL VL L M H VH EH)	DEFECT DETAILS: DEFECT SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS: DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) Specific	General
		10								
		11		START CORING AT 11.23m						
FULL RET-URN		12		SANDSTONE: fine to medium grained, orange brown and light grey.	DW	L	×		- Bc, 15°, P, S, IS, CLAY INFILL - Bc, 0°, P, S, IS - J, 70-75°, P, R	
				SANDSTONE: fine to medium grained, light grey, with orange brown laminae, and occasional red brown staining and iron indurated bands.		M	×		- XWS, 2mm.t	
		13		SANDSTONE: fine to medium grained, light grey and red brown, with occasional dark grey laminae, bedded at 0-5°.		VL/M	×			
		14		SANDSTONE: fine to medium grained, light grey.						
				END OF BOREHOLE AT 14.09m						
		15								
		16								

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BOREHOLE LOG

Borehole No. 3
1/4

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 9-4-09
Method: HAND AUGER/CONTINUOUS SPIRAL AUGER & WASHBORE JK350
Logged/Checked by: G.F./
R.L. Surface: ≈ 10.8m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0		-	CONCRETE: 80mm.t	M	-	-	NO OBSERVED REINFORCEMENT
								SM	FILL: Silty sand, fine to medium grained, dark grey, with a trace of fine to medium grained gravel.	M	-	-	HAND AUGER TO 1.2m
									SILTY SAND: fine to medium grained, grey.				
						1		SC	as above, but light grey.				
								SM	CLAYEY SAND: fine to medium grained, grey and light brown.				
									SILTY SAND: fine to medium grained, dark grey, with cemented sand nodules.				
▶						2		SC	CLAYEY SAND: fine to medium grained, grey and light grey.	W			
						3							
								CL	SANDY CLAY: low to medium plasticity, light grey.	MC≥PL			POSSIBLY CLAYEY SAND
						4							
						5							
								SC	CLAYEY SAND: fine to medium grained, light orange brown.	W			
						6							
								SP	SAND: fine to medium grained, light grey, with a trace of silt and clay.				
						7							

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Borehole No. **3** 2/4

BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 9-4-09
Method: HAND AUGER/CONTINUOUS SPIRAL AUGER & WASHBORE JK350
Logged/Checked by: G.F./
R.L. Surface: ≈ 10.8m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
								SP	SAND: fine to medium grained, light grey, with a trace of silt and clay.	W			
						8		SM	SILTY SAND: fine to medium grained, light orange brown, with a trace of clay.				
						9							
						10							
						11							
						12							
						13							
						14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 3 3/4

BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 9-4-09
Method: HAND AUGER/CONTINUOUS SPIRAL AUGER & WASHBORE JK350
Logged/Checked by: G.F./
R.L. Surface: ≈ 10.8m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						15		SM	SILTY SAND: fine to medium grained, light orange brown, with a trace of clay.	W			
						16			as above, but orange brown, with a trace of silt.				
						17							
						18							
									REFER TO CORED BOREHOLE LOG				END WASHBORE NOTE: DUE TO DRILLING TECHNIQUES ADOPTED, SOIL PROFILE IS INDICATIVE ONLY. REFER TO EFCP 3
						19							
						20							


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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
JOB NO: 22817Z, BH3, START CORING AT 18.03m
18
19
20
21
END AT 21.12m

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **3** 4/4

CORED BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z **Core Size:** NMLC **R.L. Surface:** ≈ 10.8m

Date: 8-4-09 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK350 **Bearing:** - **Logged/Checked by:** G.F./ AR

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT DETAILS DEFECT SPACING (mm) 500 300 100 50 30 10	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		17							
		18		START CORING AT 18.03m					
90% RET-URN		18		SANDSTONE: fine to medium grained, red brown and orange brown, with iron indurated bands.	DW	M	×		- XWS/CS, 100mm.t - XWS, 20mm.t - XWS/CS, 130mm.t - CS, 40mm.t
		19		SANDSTONE: fine to medium grained, red brown, light grey and orange brown.					
		20		SANDSTONE: fine to medium grained, orange brown and light grey		L	×		- XWS, 5mm.t - XWS, 2mm.t - XWS, 40mm.t
		21		SANDSTONE: fine to medium grained, light grey, orange brown and red brown staining.		H	×		- Be, 0-5°, P, S, IS
		22		END OF BOREHOLE AT 21.12m					
		23							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **5** 1/4

BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 7-4-09

Method: CONTINUOUS SPIRAL AUGER & WASHBORE JK350

Logged/Checked by: G.F./

R.L. Surface: ≈ 9.2m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			CONCRETE: 200mm.t				8mm DIAMETER REINFORCEMENT, 70mm TOP CVOVER
								-	FILL: Silty sand, fine to medium grained, grey brown, with a trace of fine to medium grained gravel.	M	-	-	
								SM	SILTY SAND: fine to medium grained, grey brown.	M	-	-	
						1		SC	CLAYEY SAND: fine to medium grained, grey.				
▶						2		SP	SAND: fine to medium grained, light grey, with occasional clay bands.	W			
						3							
						4							
						5							
						6							
						7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 5 2/4

BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 7-4-09
Method: CONTINUOUS SPIRAL AUGER & WASHBORE JK350
R.L. Surface: ≈ 9.2m
Datum: ASSUMED
Logged/Checked by: G.F./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
								SP	SAND: fine to medium grained, light grey, with occasional clay bands.	W			
						8		SC	CLAYEY SAND: fine to medium grained, light grey.				
						9							COMMENCE WASHBORING
						10							
						11							
						12							
						13							
						14							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 5 3/4

BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z
Date: 7-4-09
Method: CONTINUOUS SPIRAL AUGER & WASHBORE JK350
R.L. Surface: ≈ 9.2m
Datum: ASSUMED
Logged/Checked by: G.F./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						15		SC	CLAYEY SAND: fine to medium grained, light grey.	W			
						16							
						17			REFER TO CORED BOREHOLE LOG				END WASHBORE NOTE: DUE TO DRILLING TECHNIQUES ADOPTED, SOIL PROFILE IS INDICATIVE ONLY. REFER TO EFCP 5
						18							
						19							
						20							


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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
JOB NO: 22817Z, BH5, START CORING AT 16.95m
17
18
CORE LOSS 0.20m
19
20
END AT 19.98m

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **5** 4/4

CORED BOREHOLE LOG

Client: KARIMBLA CONSTRUCTION SERVICES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LOFTUS, HIRST AND BONAR STREETS, ARNCLIFFE, NSW

Job No. 22817Z **Core Size:** NMLC **R.L. Surface:** ≈ 9.2m

Date: 7-4-09 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK350 **Bearing:** - **Logged/Checked by:** G.F./

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT DETAILS DEFECT SPACING (mm) 500 300 100 50 30 10	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		16		START CORING AT 16.95m					
		17		SANDSTONE: fine to medium grained, orange brown, light grey and red brown, with iron indurated bands.	DW	L-M	×		
		18					×		- XWS, 2mm.t - Be, 5°, P, S, IS - Be, 5°, P, S, IS - XWS, 10mm.t - CS, 40mm.t
				CORE LOSS 0.20m					
		19		SANDSTONE: fine to medium grained, orange brown, light grey and red brown, with iron indurated bands.	DW	M			- Be, 5°, P, S, IS - Be, 5°, P, S, IS - XWS, 15mm.t - Be, 5°, P, S, IS
						VL			
				SANDSTONE: fine to medium grained, light grey.		L-M	×		
		20		END OF BOREHOLE AT 19.98m					
		21							
		22							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

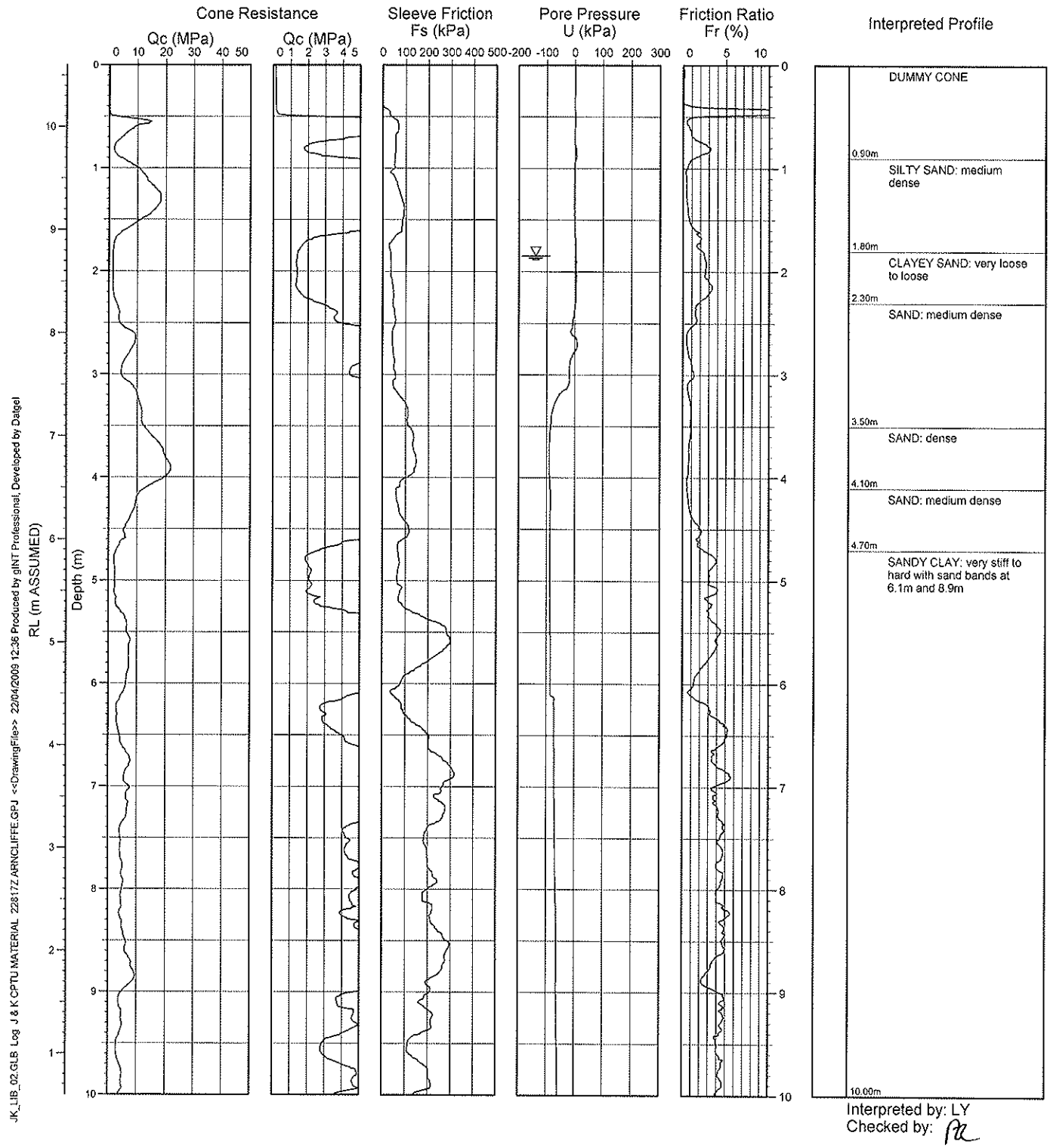
EFCP No. 1

1 / 2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES
Project:	PROPOSED RESIDENTIAL DEVELOPMENT
Location:	LOFTUS STREET, ARNCLIFFE, NSW

Job No.: 22817Z	**R.L. Surface:** ~10.6 m	**Data File:**
Date: 06/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

Checked by:

JK_UB_02.GLB Log J & K CPTU MATERIAL 22817Z ARNCLIFFE.GPJ <<DrawingFile>> 22/04/2009 12:36 Produced by gINT Professional, Developed by Datgel

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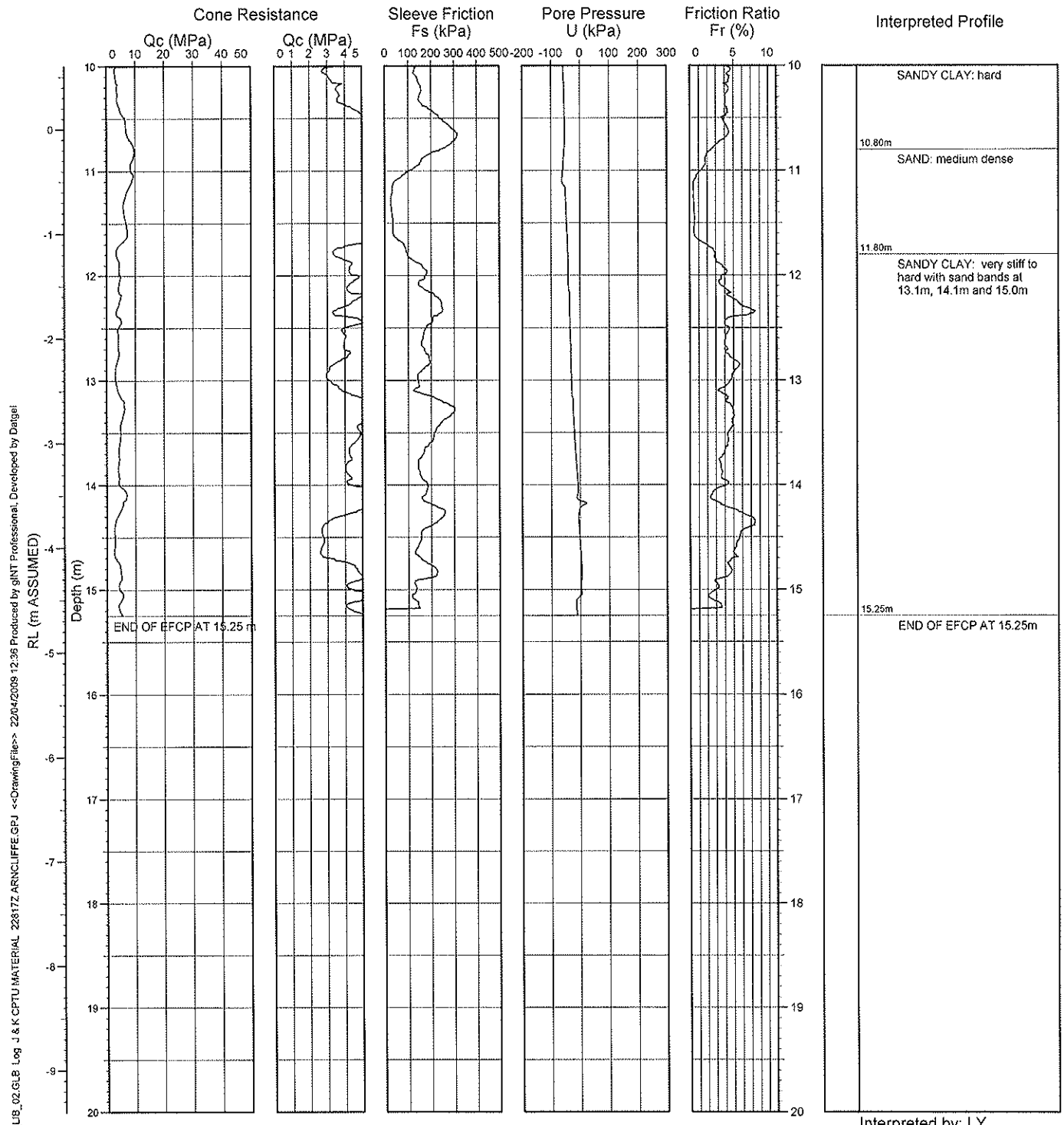
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No. 1 2 / 2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES	
Project:	PROPOSED RESIDENTIAL DEVELOPMENT	
Location:	LOFTUS STREET, ARNCLIFFE, NSW	
Job No.: 22817Z	**R.L. Surface:** ~10.6 m	**Data File:**
Date: 06/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

Checked by:

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

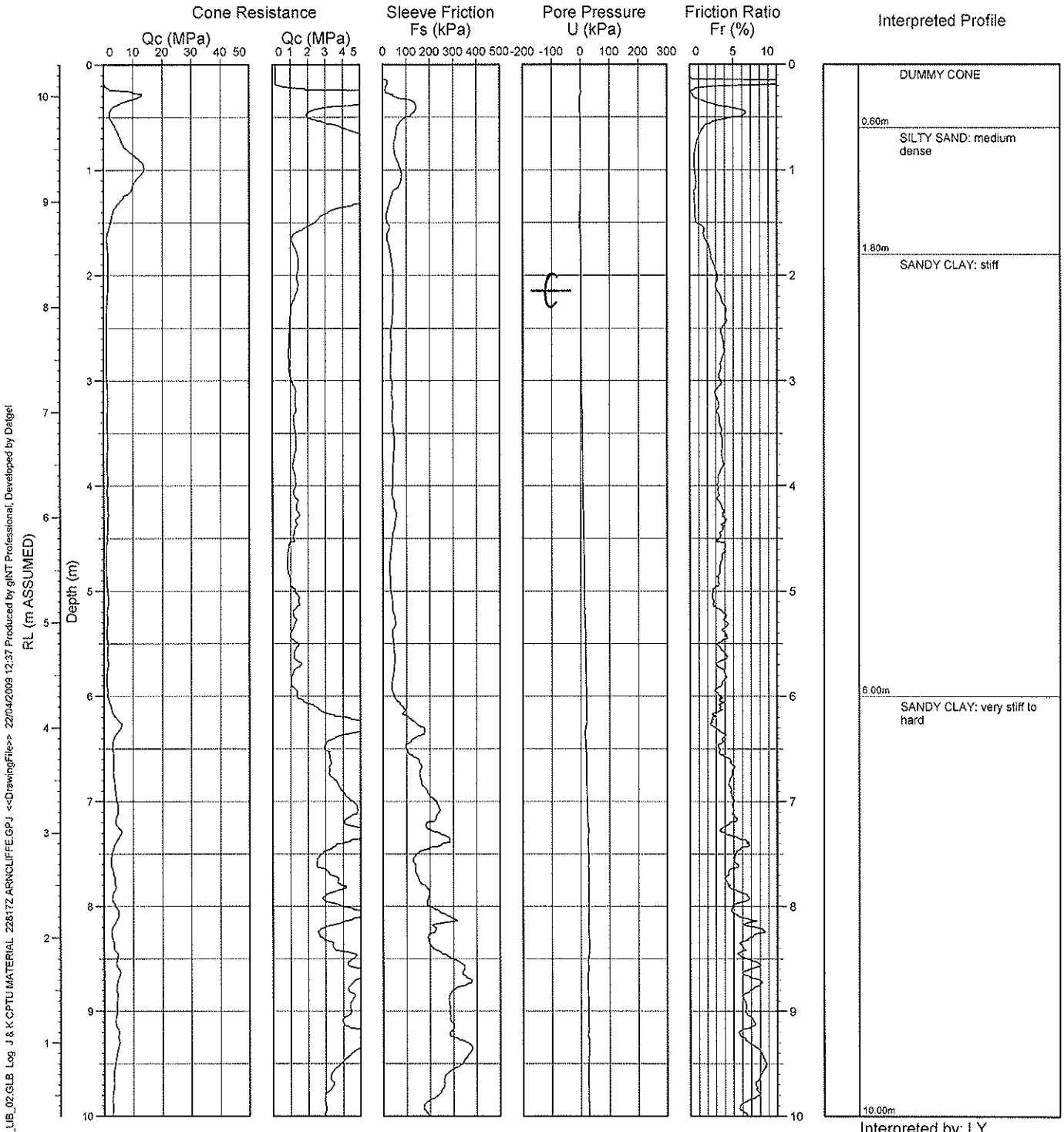
EFCP No. 2

1 / 2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES
Project:	PROPOSED RESIDENTIAL DEVELOPMENT
Location:	LOFTUS STREET, ARNCLIFFE, NSW

Job No.: 22817Z	**R.L. Surface:** ~10.3 m	**Data File:**
Date: 07/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

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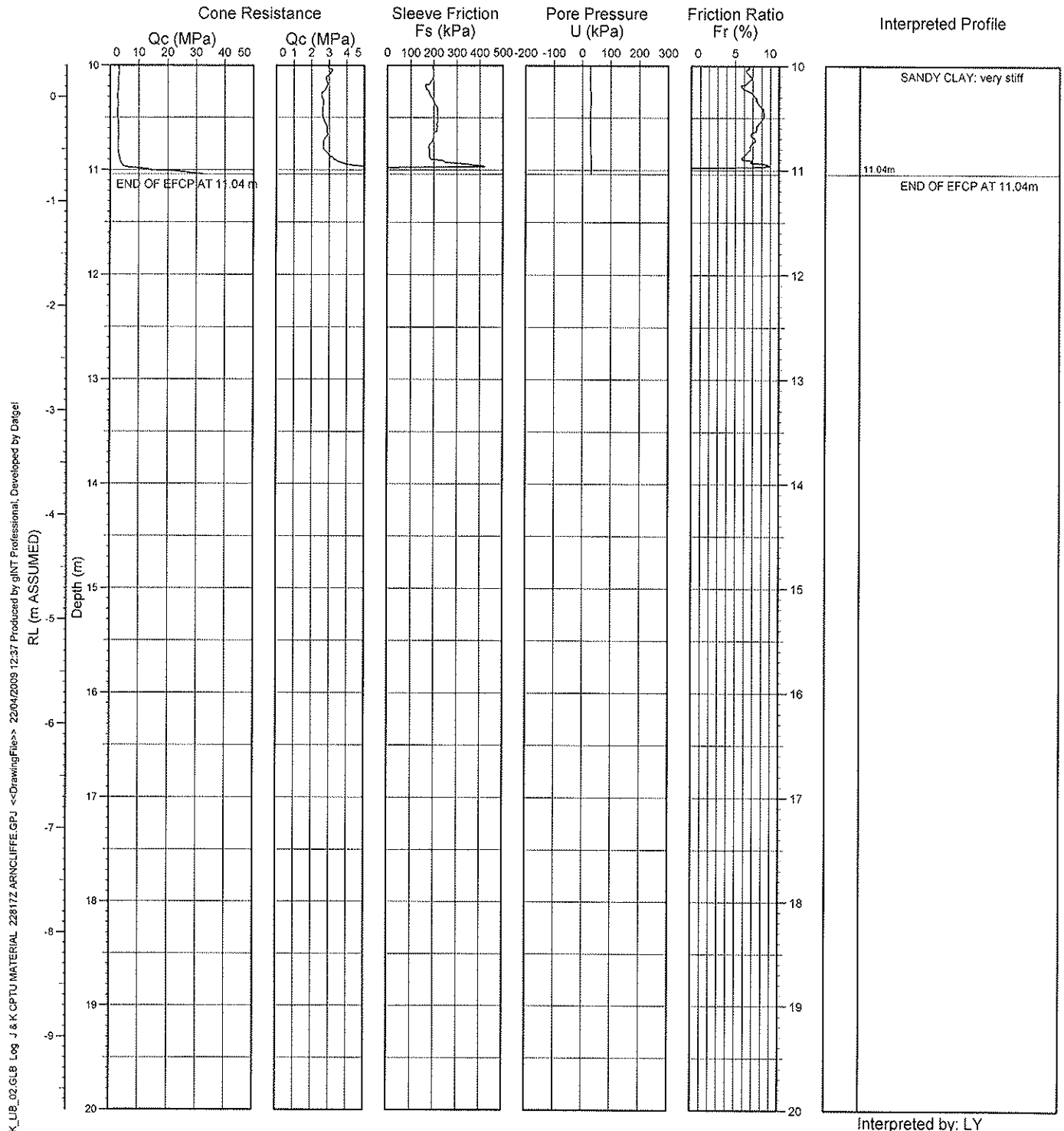
EFCP No. 2 2 / 2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES		
Project:	PROPOSED RESIDENTIAL DEVELOPMENT		
Location:	LOFTUS STREET, ARNCLIFFE, NSW		
Job No.: 22817Z	**R.L. Surface:** ~10.3 m	**Data File:**	
Date: 07/04/09	**Datum:** ASSUMED	**Operator:** L.Y.	



Interpreted by: LY

Checked by:

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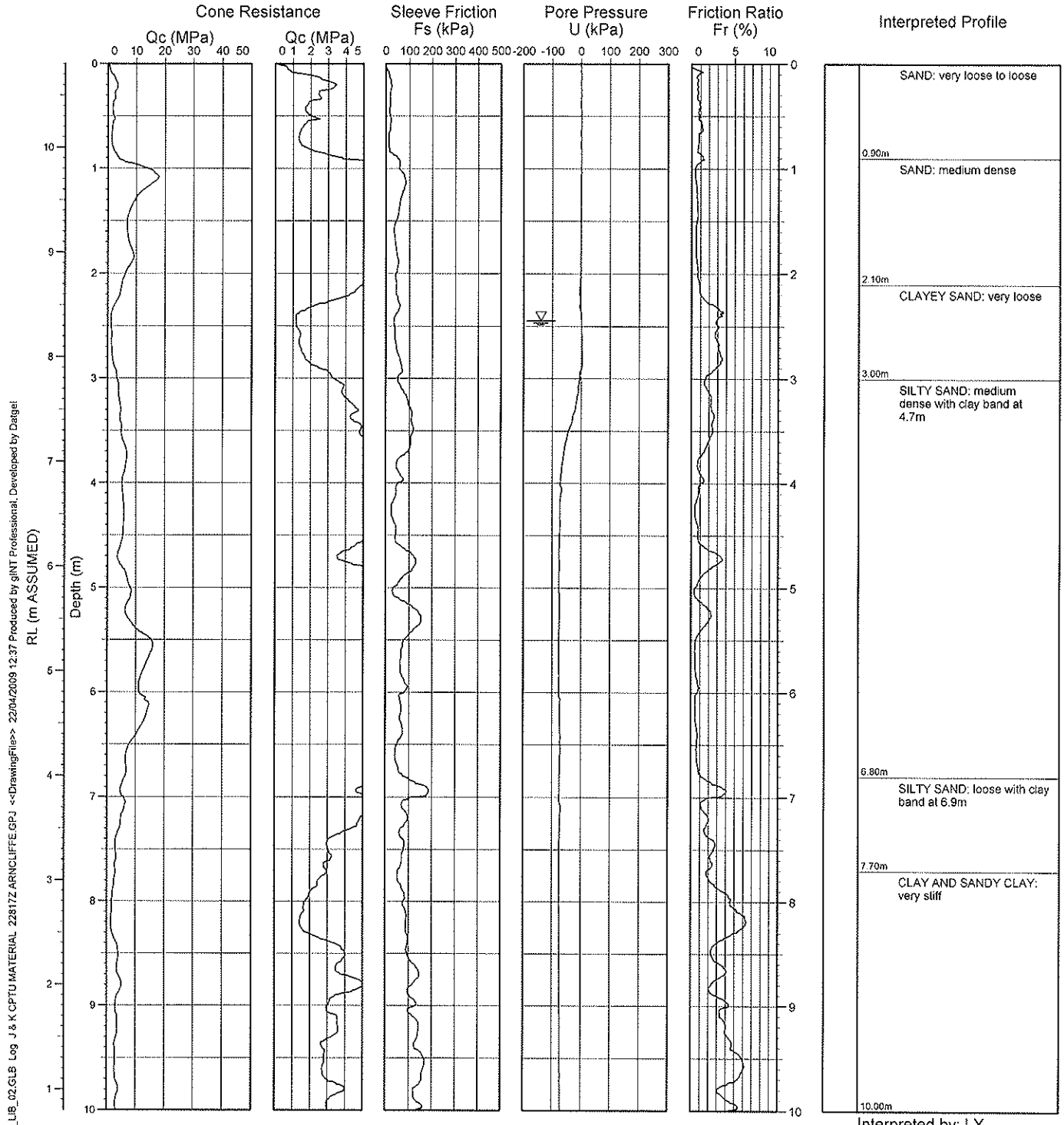
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No. 3 1 / 2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES	
Project:	PROPOSED RESIDENTIAL DEVELOPMENT	
Location:	LOFTUS STREET, ARNCLIFFE, NSW	
Job No.: 22817Z	**R.L. Surface:** ~10.8 m	**Data File:**
Date: 06/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

Checked by:

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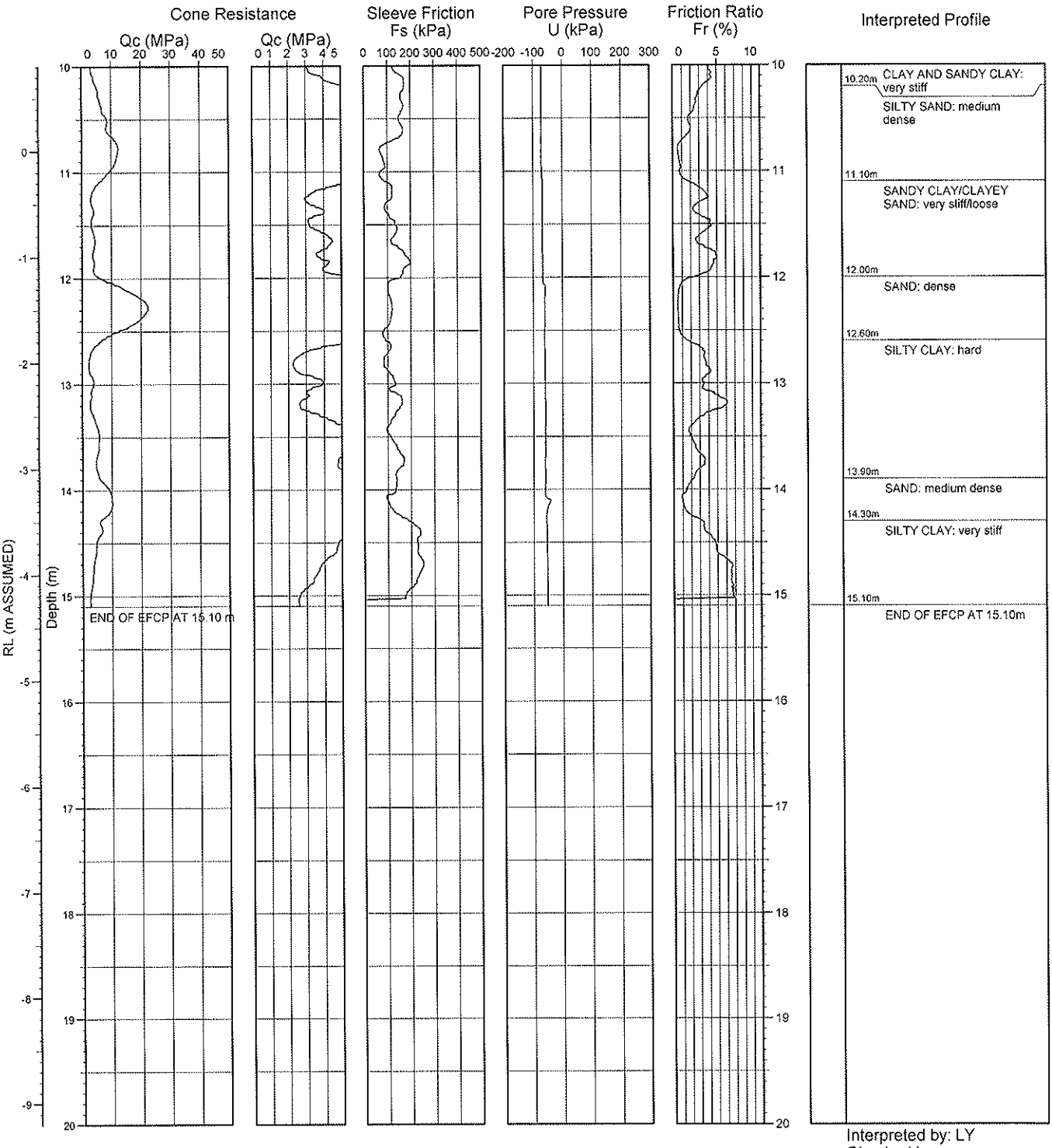
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No. 3 2 / 2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES		
Project:	PROPOSED RESIDENTIAL DEVELOPMENT		
Location:	LOFTUS STREET, ARNCLIFFE, NSW		
Job No.: 22817Z	**R.L. Surface:** ~10.8 m	**Data File:**	
Date: 06/04/09	**Datum:** ASSUMED	**Operator:** L.Y.	



Interpreted by: LY

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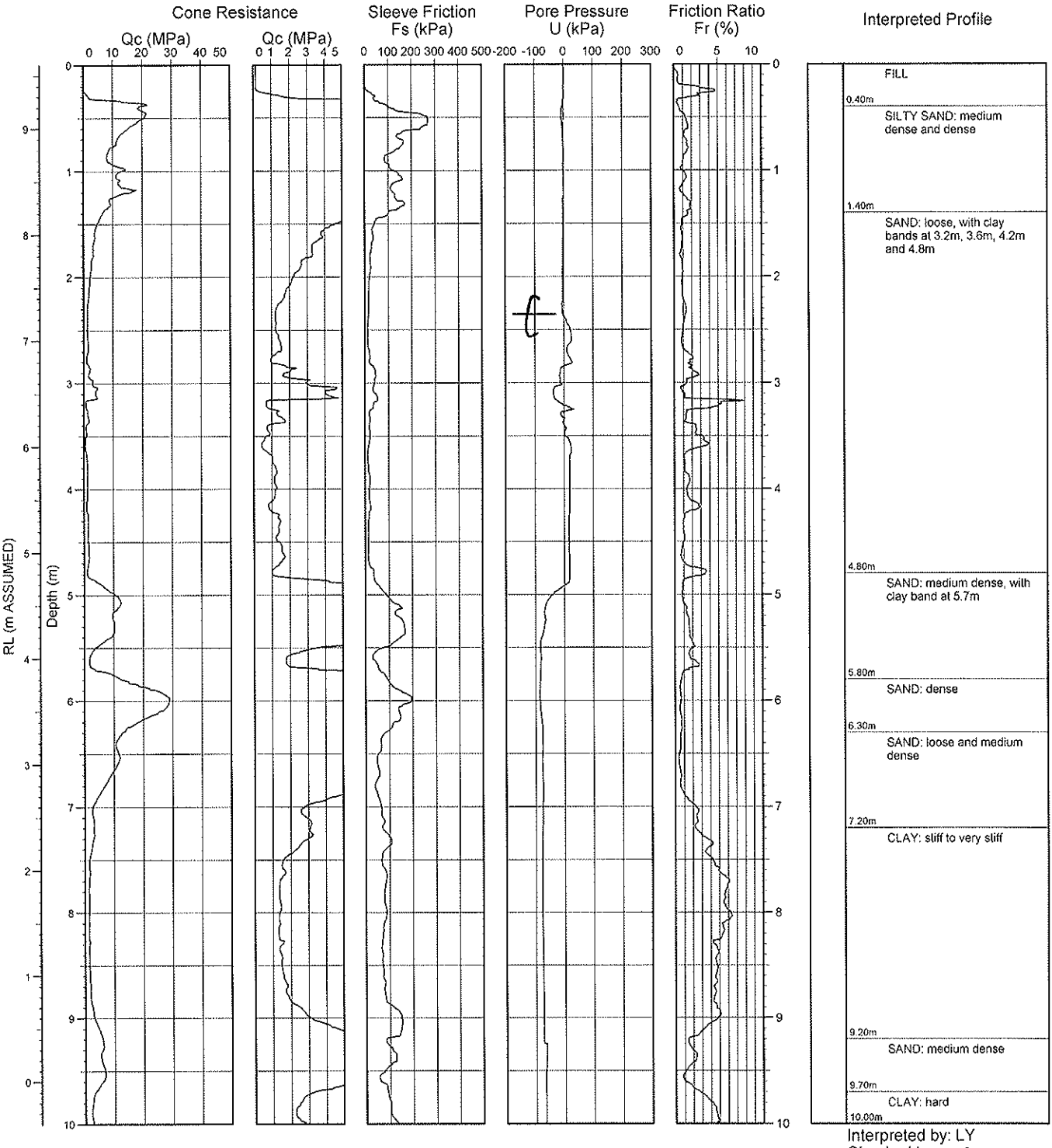
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No. 4 1 / 3

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES	
Project:	PROPOSED RESIDENTIAL DEVELOPMENT	
Location:	LOFTUS STREET, ARNCLIFFE, NSW	
Job No.: 22817Z	**R.L. Surface:** ~9.6 m	**Data File:**
Date: 07/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

Checked by:

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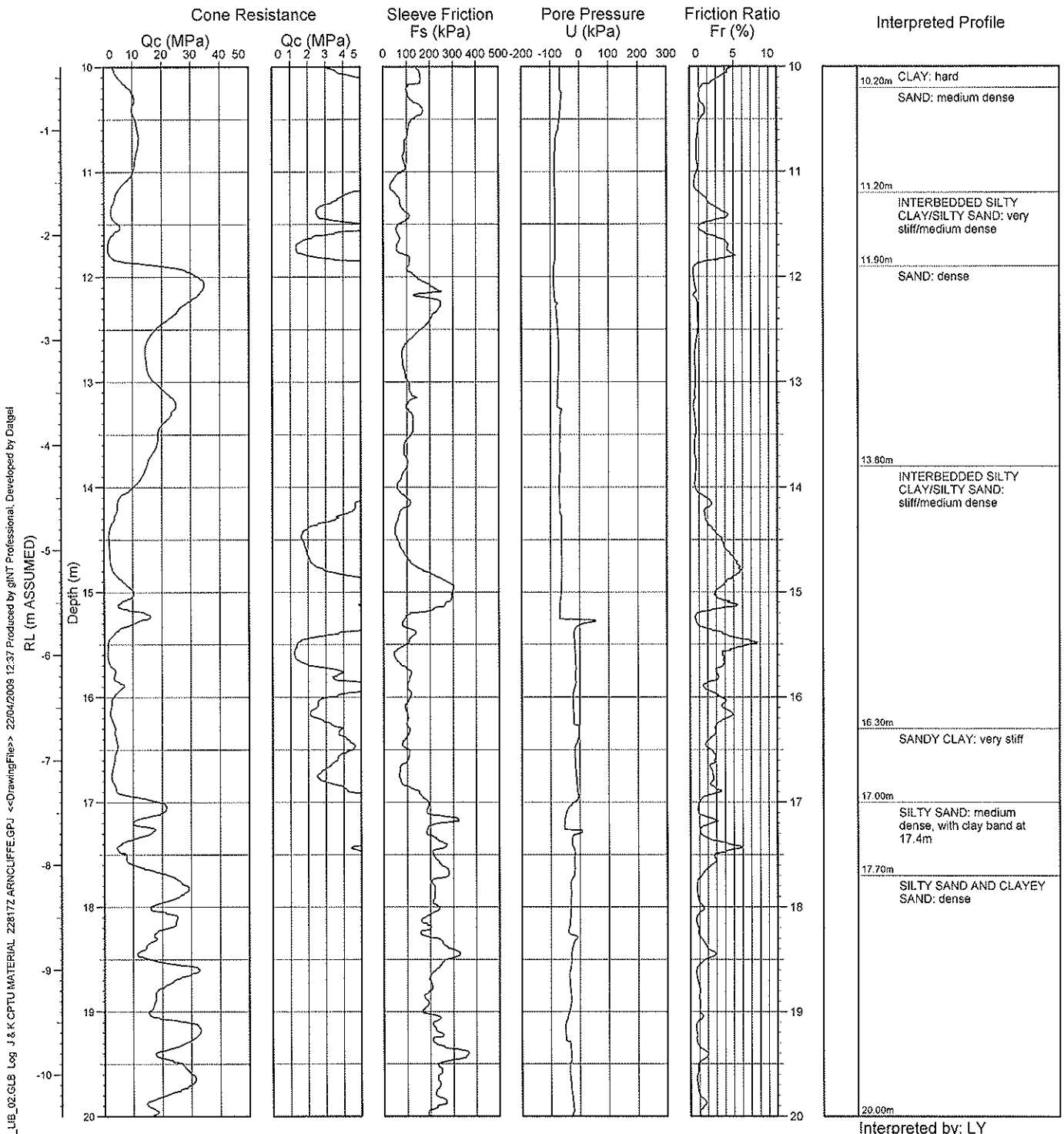
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No. 4 2 / 3

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES
Project:	PROPOSED RESIDENTIAL DEVELOPMENT
Location:	LOFTUS STREET, ARNCLIFFE, NSW

Job No.: 22817Z	**R.L. Surface:** ~9.6 m	**Data File:**
Date: 07/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

Checked by:

JK_LIB_02.GLB Log J & K CPTU MATERIAL 22817Z ARNCLIFFE.GPJ <<DrawingFile>> 22/04/2009 12:37 Produced by gINT Professional, Developed by Datgel

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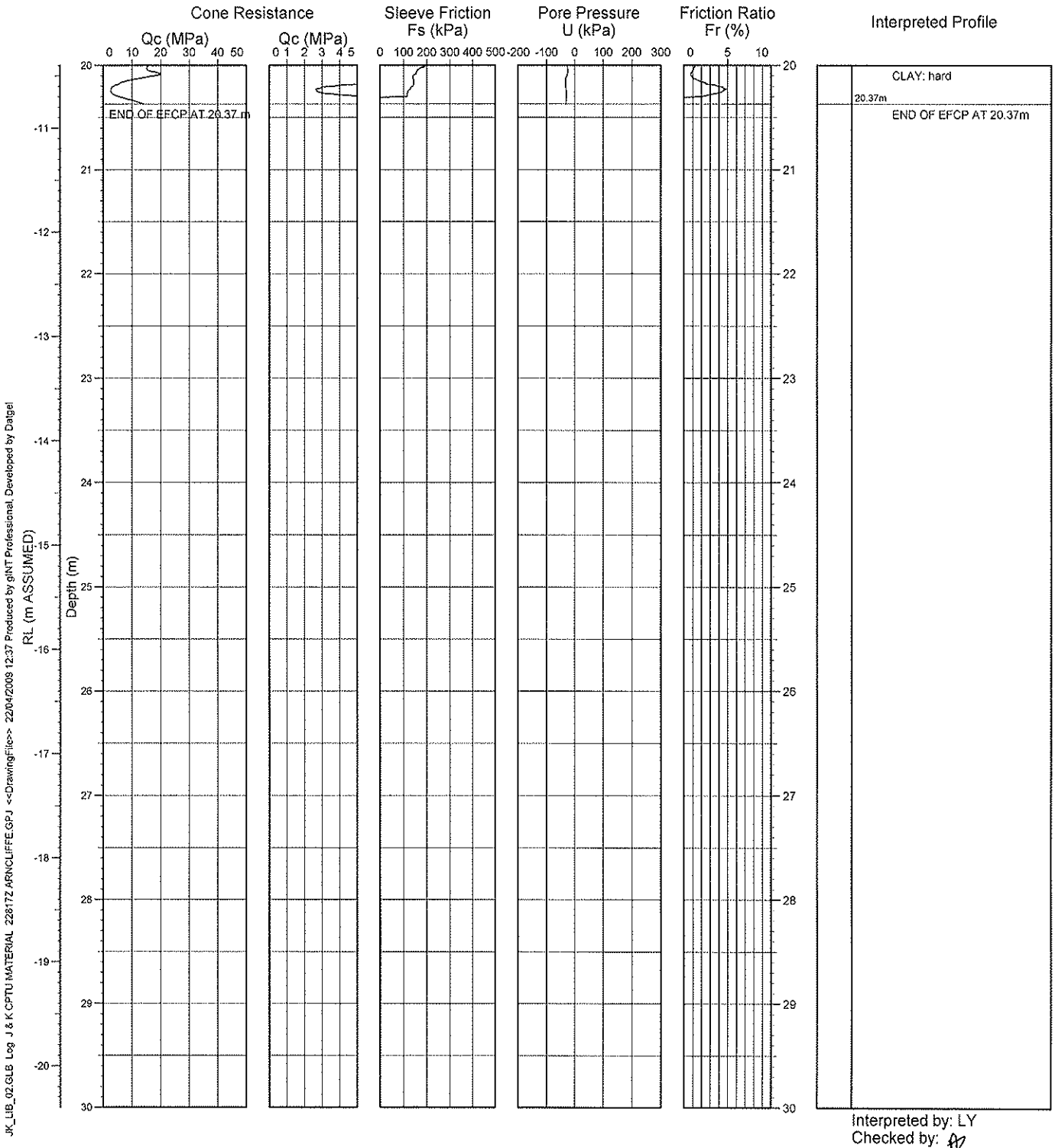
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No. 4 3 / 3

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES
Project:	PROPOSED RESIDENTIAL DEVELOPMENT
Location:	LOFTUS STREET, ARNCLIFFE, NSW

Job No.: 22817Z	**R.L. Surface:** ~9.6 m	**Data File:**
Date: 07/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

Checked by:

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

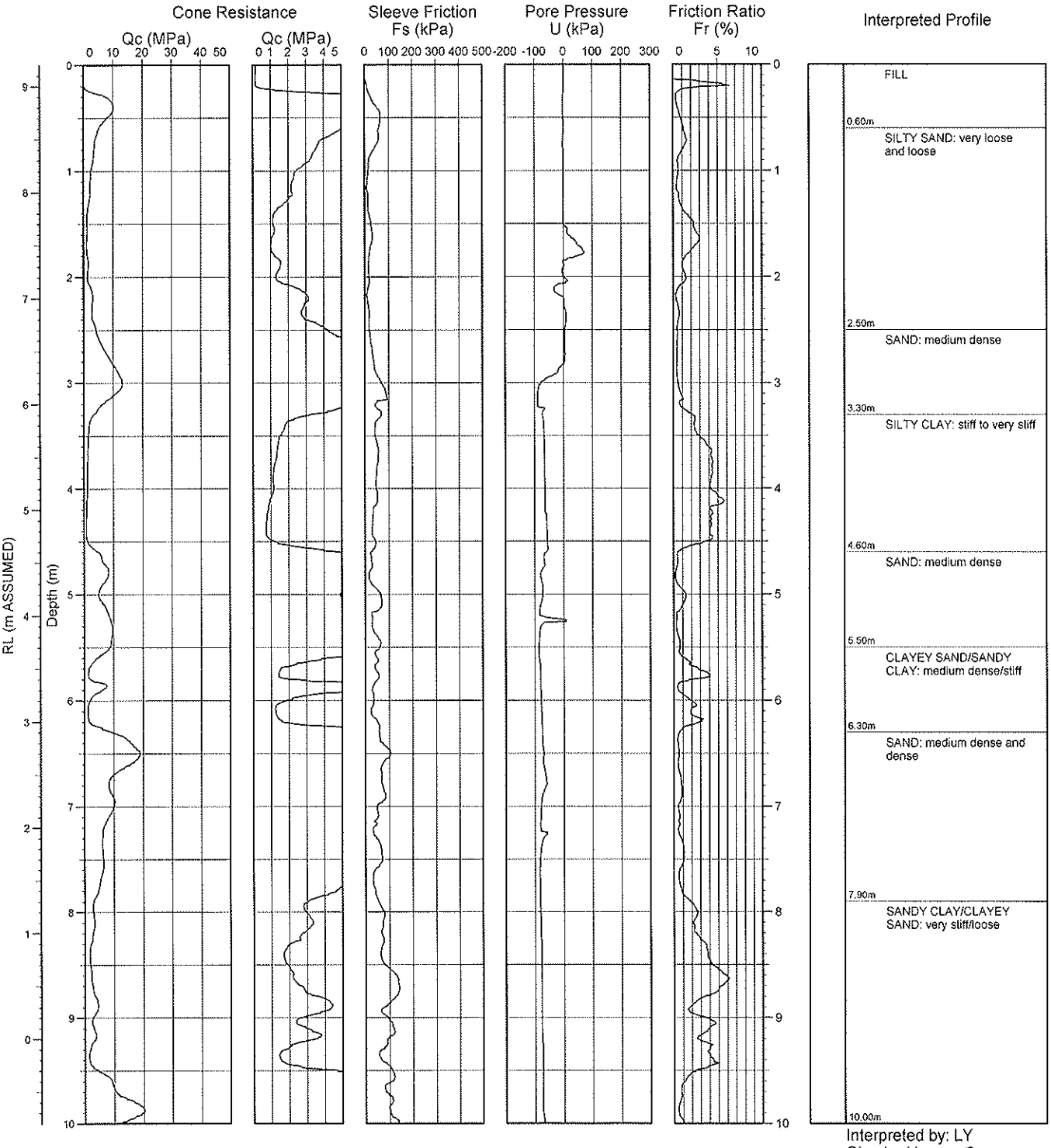
EFCP No. 5

1 / 2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES
Project:	PROPOSED RESIDENTIAL DEVELOPMENT
Location:	LOFTUS STREET, ARNCLIFFE, NSW

Job No.: 22817Z	**R.L. Surface:** ~9.2 m	**Data File:**
Date: 06/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

Checked by:

JK_LIB_02.GLB Log J & K CPTU MATERIAL 22817Z ARNCLIFFE.GPJ <<DrawingFile>> 21/04/2009 12:34 Produced by gINT Professional, Developed by Datgel

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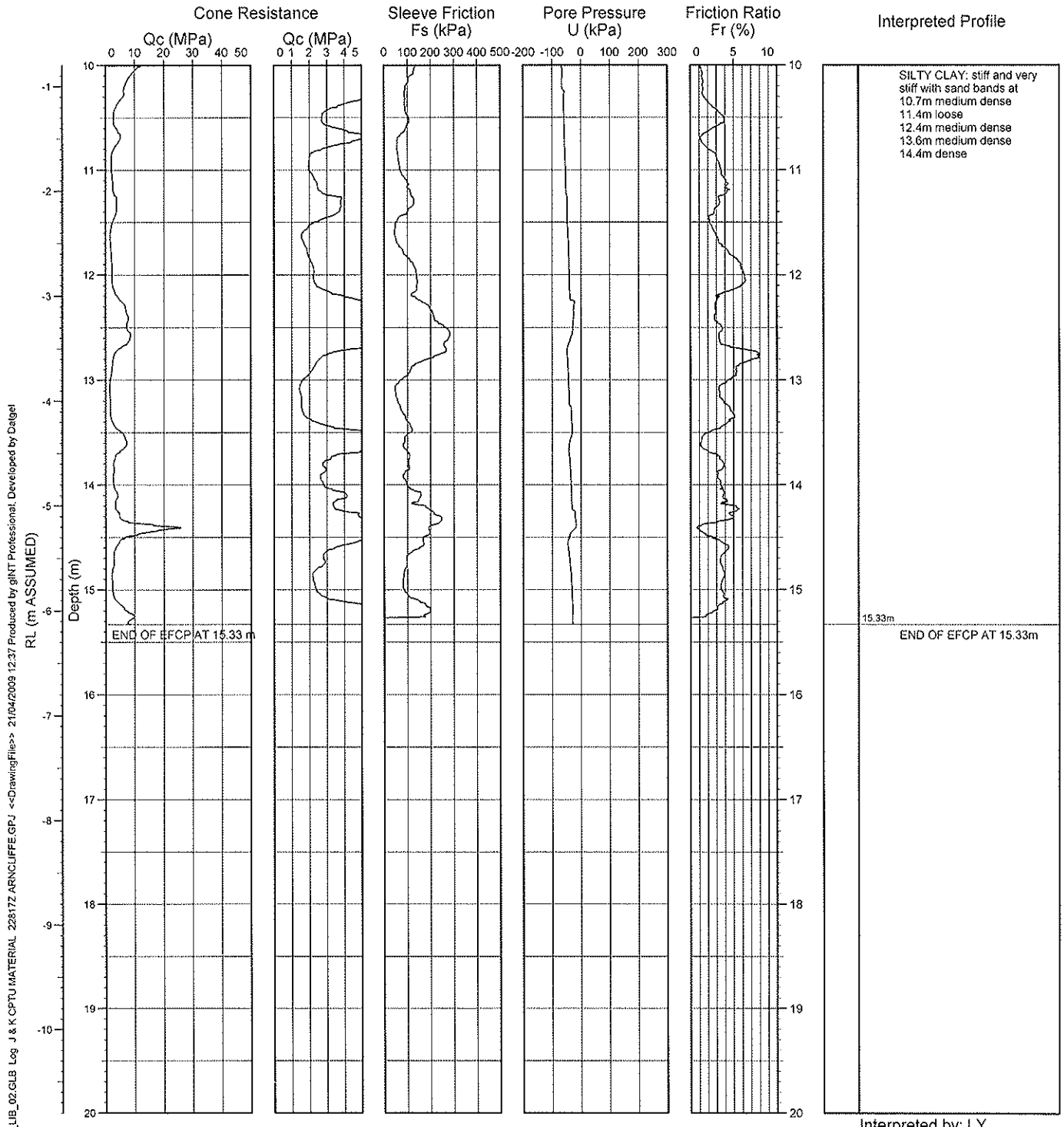
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No. 5 2 / 2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	KARIMBLA CONSTRUCTION SERVICES
Project:	PROPOSED RESIDENTIAL DEVELOPMENT
Location:	LOFTUS STREET, ARNCLIFFE, NSW

Job No.: 22817Z	**R.L. Surface:** ~9.2 m	**Data File:**
Date: 06/04/09	**Datum:** ASSUMED	**Operator:** L.Y.



Interpreted by: LY

Checked by:

LOFTUS STREET

STREET

HIRST

BONAR STREET

BRICK AND CONCRETE OFFICE BUILDING "BUTLERS HIRE"

CONCRETE WAREHOUSE

METAL AWNING

2 STOREY CONCRETE METAL AND GLASS OFFICE BUILDING CAR PARKING UNDER

SINGLE STOREY RENDERED BUILDING METAL ROOF

BRICK, METAL AND CORRUGATED FIBRO CEMENT WORKSHOP CORRUGATED FIBRO CEMENT ROOF

1

2

3

4

5

LEGEND

BOREHOLE AND ELECTRICAL FRICTION CONE PENETRATION TEST

ELECTRICAL FRICTION CONE PENETRATION TEST

SCALE (m)

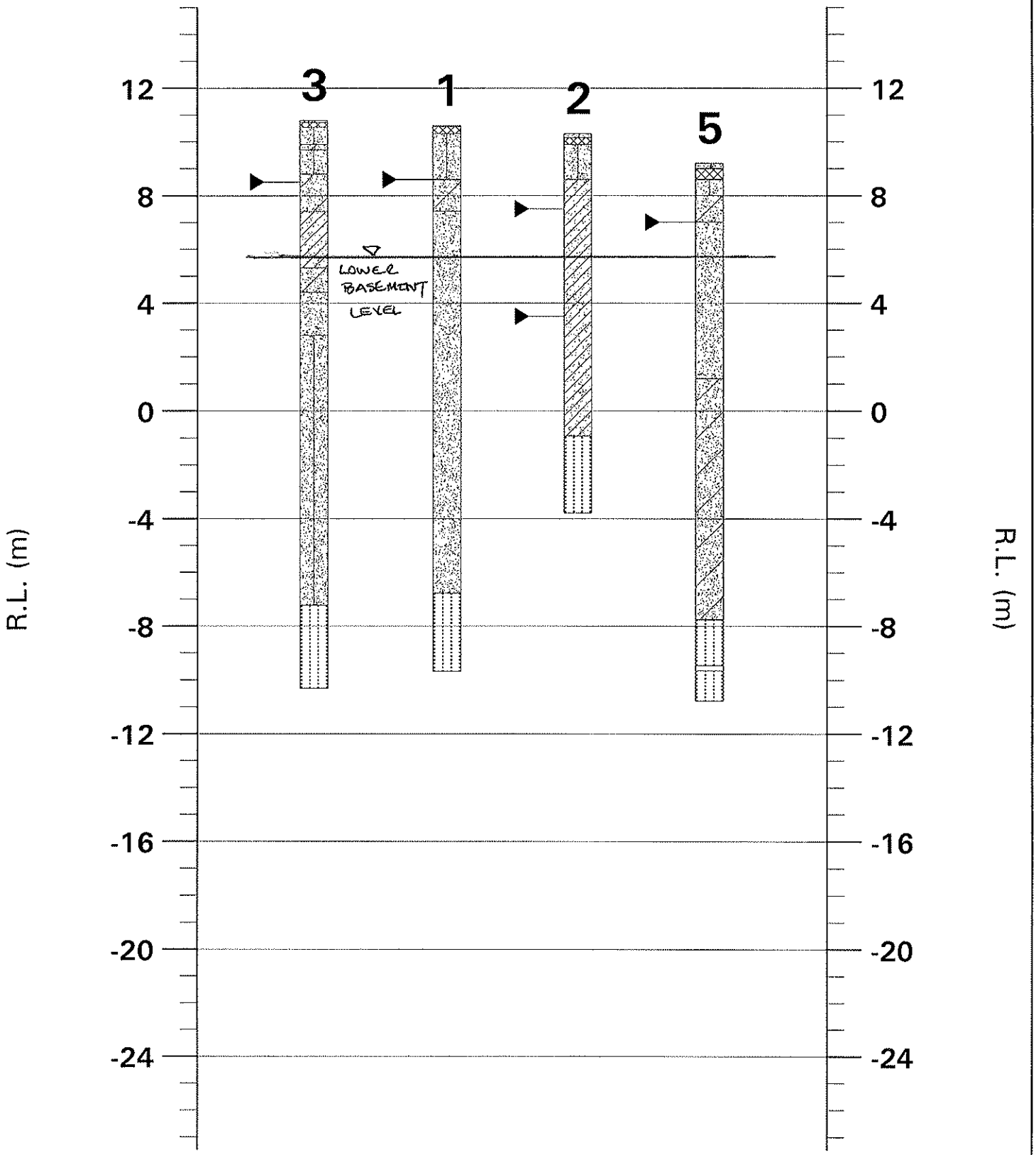
0 25

INVESTIGATION LOCATION PLAN

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

Report No. 22817Z **Figure No. 1**

GRAPHICAL BOREHOLE SUMMARY



Concrete
Fill
Silty Sand
Clayey Sand
Sandy Clay
Sand
Sandstone/ Greywacke
Asphaltic/ Bituminous Paving or Coal
Core Loss/ Empty
Groundwater seepage level
N SPT "N" VALUE
Nc SOLID CONE BLOW COUNTS PER 150mm

Scale:1 : 200 (vert) ; NTS (horiz)

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Job No.: 22817Z Figure No.: 2

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ABN 17 003 550 801

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (eg sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'Shale' is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

  N = 13
  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N>30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or 'reverted' chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg bricks, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soil for Engineering Purposes'*. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document *'Guidelines for the Provision of Geotechnical Information in Tender Documents'*, published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or

iii) full time engineering presence on site.

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GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL


FILL


TOPSOIL


CLAY (CL, CH)


SILT (ML, MH)


SAND (SP, SW)


GRAVEL (GP, GW)


SANDY CLAY (CL, CH)


SILTY CLAY (CL, CH)


CLAYEY SAND (SC)


SILTY SAND (SM)


GRAVELLY CLAY (CL, CH)


CLAYEY GRAVEL (GC)


SANDY SILT (ML)


PEAT AND ORGANIC SOILS

ROCK


CONGLOMERATE


SANDSTONE


SHALE


SILTSTONE, MUDSTONE, CLAYSTONE


LIMESTONE


PHYLLITE, SCHIST


TUFF


GRANITE, GABBRO


DOLERITE, DIORITE


BASALT, ANDESITE


QUARTZITE

DEFECTS AND INCLUSIONS


CLAY SEAM


SHEARED OR CRUSHED SEAM


BRECCIATED OR SHATTERED SEAM/ZONE


IRONSTONE GRAVEL


ORGANIC MATERIAL

OTHER MATERIALS


CONCRETE


BITUMINOUS CONCRETE, COAL


COLLUVIUM

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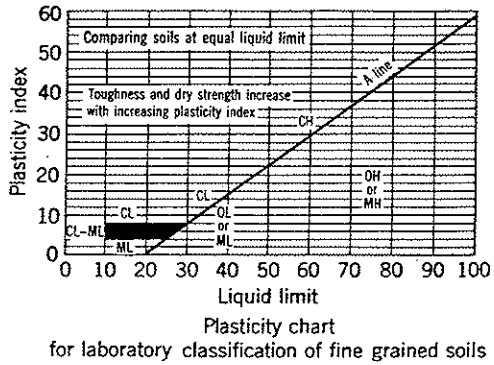
UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)						Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils: More than half of material is *larger* than 75 μm sieve size[b] (The 75 μm sieve size is about the smallest particle visible to naked eye)	Gravels: More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes			*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% — *GW, GP, SW, SP* More than 12% — *GM, GC, SM, SC* 5% to 12% — *Borderline* cases requiring use of dual symbols $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing			*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)			*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)			*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with *PI* greater than 7
	Sands: More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes			*SW*	Well graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing			*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)			*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)			*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7
Fine-grained soils: More than half of material is *smaller* than 75 μm sieve size	Identification Procedures on Fraction Smaller than 380 μm Sieve Size		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)				
	Silts and clays: liquid limit less than 50		None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)	
			Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity		
	Silts and clays: liquid limit greater than 50		Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays		
			Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity		
Highly Organic Soils			Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils		



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. GW-GC, well graded gravel-sand mixture with clay fines).

2) Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

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LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (Id) Range (%)** / **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose <15 0-4
	L	Loose 15-35 4-10
	MD	Medium Dense 35-65 10-30
	D	Dense 65-85 30-50
	VD	Very Dense >85 >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

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LOG SYMBOLS

ROCK MATERIAL WEATHERING CLASSIFICATION

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 ironstaining. 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 defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL	0.03	Easily remoulded by hand to a material with soil properties.
Very Low:	VL	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.
Low:	L	0.3	A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium Strength:	M	1	A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
High:	H	3	A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
Very High:	VH	10	A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	