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REPORT

TO

KARIMBLA CONSTRUCTION SERVICES PTY LTD

ON

HYDROGEOLOGICAL ASSESSMENT

FOR

PROPOSED RESIDENTIAL DEVELOPMENT

AT

132-138 KILLEATON STREET, ST IVES, NSW

5 August 2011

Ref: 23765Z2rpt

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

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1 INTRODUCTION

This report presents the results of our hydrogeological assessment of the site for the proposed residential development at 132-138 Killeaton Street, St Ives, NSW. The assessment was commissioned by Karimbla Construction Services Pty Ltd (Order No 30664, dated 14 June 2011). The commission was in accordance with Item 2 of our proposal (ref P23765Zemail) dated 14 June 2011.

Based on the provided excavation drawings (Drawing Nos E-520-EXC, E-521-EXC and E-522-EXC, all Rev 2) prepared by Meriton Apartments Pty Ltd, we understand that the proposed development will comprise five multi-storey unit buildings, over a common stepped basement level. Bulk excavations to depths between about 3m and 6m will be required to achieve the finished basement floor reduced levels (RLs) between 153.1m and 156.30m.

The purpose of the assessment was to address the hydrogeological issues associated with the proposed development, in particular, existing groundwater levels and flow directions, permeability values for the underlying clay and shale horizons and flow rates into the proposed basement.

Jeffery and Katauskas Pty Ltd (J&K) previously completed geotechnical investigations of the site and the results were presented in our reports (ref 23765VIrpt) dated 13 August 2010 and (ref 23765Z Let) dated 21 July 2011. The borehole logs from the previous investigations are included in attached Appendix A. We further note that Environmental Investigation Services (EIS), the environmental division of J&K, have addressed the groundwater quality issues. This report must therefore be read in conjunction with the EIS report (ref E23765KBrpt).

2 STANDPIPE INSTALLATION AND TESTING

Standpipes were installed at two locations (BH301 and BH303) across the site in order to augment the previous hydrogeological information and for groundwater monitoring and testing purposes. The installation comprised two clusters of two boreholes each which were auger drilled using our track mounted JK300 rig. At BH301, a 'deep' and a 'shallow' borehole were drilled to depths of 8.54m and 1.5m, respectively. At BH303, a 'deep' and 'shallow' borehole was drilled to depths of 6.1m and 3.38m, respectively. The 'shallow' boreholes at each location were terminated in the clay profile whilst the 'deep' boreholes were extended into the underlying bedrock. A standpipe was installed into each 'deep' borehole which isolated the groundwater within the rock mass from the groundwater within the overlying clay profile. A standpipe was installed in the 'shallow' borehole at BH303. The groundwater level was below the base of the clay profile in BH301 and therefore a standpipe was not installed into the 'shallow' borehole at BH301. The details for the 'deep' and 'shallow' standpipes are presented in attached Figure 2.

The borehole/standpipe locations, as indicated in Figure 1, were set out using taped measurements from existing surface features. The surface RLs at the borehole/standpipe locations were estimated by interpolation between spot heights shown on the provided unreferenced survey plan.

The subsurface soil and rock profile was assessed by logging the materials recovered during borehole drilling. Groundwater measurements were made during and shortly following completion of drilling individual boreholes. Seven days following installation of the standpipes, additional groundwater level measurements were completed and pump-out tests were conducted.

In order to assess the permeability of the subsurface soil and rock mass, the groundwater within each of the standpipes was pumped and the rate of groundwater recovery was measured. Using established seepage formulae, an approximate insitu permeability coefficient for the relevant horizon tested, was calculated.

Our geotechnical engineer was present full time on site during the fieldwork and set out the borehole locations, logged the subsurface profile, directed standpipe installation, and carried out the pump-out tests.

3 SITE DESCRIPTION

The site is located within undulating topography that generally has slopes from west to east down towards Middle Harbour Creek and Garigal National Park. The site itself had a slightly sloping ground surface with levels declining between RL158m at south and RL160m at north. The site has a frontage of about 175m along Killeaton Street, which formed the northern boundary. The site extended to the south by about 250m at the furthest point.

Only the former monastery building remained on site as shown on Figure 1, leaving behind mostly grassed and landscaped areas with trees. To the west, the site adjoins a college campus that consists of two storey brick and metal clad buildings and a single storey brick classroom building, concrete paved carparking, a playground and a landscape area. To the south, the site adjoins a grass covered football field and tennis courts. The adjoining sites to the east comprise seven single storey brick cottages, a tennis court and an inground pool. The cottages to the east were set back by 4m to 8m from the common boundary. All of the above mentioned neighbouring buildings appeared to be in good condition when briefly viewed from within the subject site.

4 SUBSURFACE CONDITIONS

Based on the previous geotechnical investigation, the site is underlain by a surficial topsoil/fill, over residual silty clays then shale bedrock at relatively shallow to moderate depth. A relatively shallow groundwater level was also encountered.

Copies of the borehole logs from the previous geotechnical investigations are included in Appendix A. The borehole locations are indicated on attached Figure 1, which also indicates contours of the underlying rock surface levels. Groundwater levels measured in standpipes in several boreholes across the site were as follows:

Location (BH)	101	201	202	301	303
Groundwater Surface RL (m)	157.6	156.8	157.3	156.2	158.3

In essence, therefore, the groundwater surface was assessed to have an overall slope down towards the south-east of about 1.5° to 2°.

5 HYDROGEOLOGICAL EVALUATION

Reference to the Pymble orthophoto (U0960-3), 1:4000 series, indicates that the site is located over the high point in the local topography with ground slopes down to the east and south at about 6° and 2°, respectively, towards tributaries of Middle Harbour Creek. The ground also slopes down to the west at about 2° towards the Ku-ring-gai Creek.

It is evident from the table in Section 4 above that the groundwater flows from the north-west down across the site to the south-east and feeds Middle Harbour Creek beyond.

Based on the investigation results, the proposed basement level will generally extend into bedrock and will also intersect the groundwater.

We have reviewed the data obtained from the borehole pump-out tests. Average permeability values of about $5x10^{-8}$m/sec and 10^{-7}m/sec were indicated for the clays and underlying upper rock mass, respectively.

Using the above estimated permeabilities, seepage analyses were carried out using the 2D finite element computer program SEEP/W. A sensitivity analysis was also undertaken by varying the relative mass permeabilities, assuming anisotropic conditions, sealing the upper basement walls and also inserting perimeter cut off walls up to 3m deep.

Based on the above, a groundwater inflow rate into the proposed basement excavation of between about 2500l/day to 4000l/day has been estimated. We note that the effects of waterproofing the perimeter upper basement walls reduces the total inflow only very marginally, as do the cut off walls.

We further note that the site is located at the crest of a hill and as such, there is a very limited catchment over which surface water can feed the groundwater. Given the above and based on the knowledge that shales are tight aquifers which generally comprise a complex of perched water tables, it is possible that the rate of inflow will decrease once the excavation has initially drained the local area.

6 RECOMMENDATIONS

As the proposed basement excavation will intersect the groundwater, temporary dewatering will be required during construction. Also, given the limited groundwater inflow which has been predicted, the completed basement should be designed as drained with pump-out facilities.

During construction and over the long term, the limited groundwater volumes must be collected in sumps and pumped to the stormwater system. The groundwater would need to be tested and, depending on groundwater quality, treatment may be required prior to offsite disposal. In this regard, reference to the EIS report detailed in Section 1 above, must be made.

As indicated in Section 5 above, the provision of water tight perimeter walls and/or the installation of cut off walls only results in a marginal reduction in the basement inflow rates. We thus consider that such measures are not warranted.

7 GENERAL COMMENTS

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 require any further information regarding the above please do not hesitate to contact the undersigned.

For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD

AGI ZENON
Senior Associate

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 301
1/2

Client: MERITON APARTMENTS PTY LTD
Project: PROPOSED RESIDENTIAL APARTMENT BUILDINGS
Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765Z
Date: 22-6-11
Method: SPIRAL AUGER JK300
R.L. Surface: ≈ 158.4m
Datum: AHD
Logged/Checked by: D.W./

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			FILL: Silty clay topsoil, medium plasticity, grey and orange brown, trace of root fibres.	MC>PL			GRASS COVER
								CH	SILTY CLAY: high plasticity, light grey mottled orange brown.	MC>PL	VSt-H	-	RESIDUAL
					N = 10 4,4,6	1						350 480 440	
								CL	as above, but medium plasticity.	MC≈PL	H		
					N > 40 17,20, 20/90mm							>600	
▼ ON COMPLETION OF CORING								-	SHALE: grey.	DW	VL	>600	
						2			SHALE: dark grey.		L-M		MODERATE 'TC' BIT RESISTANCE
						3							MODERATE RESISTANCE WITH LOW BANDS
											M		
▶						4							MODERATE RESISTANCE
▼ ON COMPLETION OF AUGERING						5				SW	M-H		HIGH RESISTANCE
						6			REFER TO CORED BOREHOLE LOG				'DEEP' STANDPIPE INSTALLED TO 5m (REFER TO FIGURE 2 FOR DETAILS)
						7							

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Borehole No. **301** 2/2

CORED BOREHOLE LOG

Client: MERITON APARTMENTS PTY LTD
Project: PROPOSED RESIDENTIAL APARTMENT BUILDINGS
Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765Z | **Core Size:** NMLC | **R.L. Surface:** ≈ 158.4m
Date: 22-6-11 | **Inclination:** VERTICAL | **Datum:** AHD
Drill Type: JK300 | **Bearing:** - | **Logged/Checked by:** D.W./

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 SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS: DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		5		START CORING AT 5.89m					
50% RET-URN		6		SHALE: dark grey.	SW	H			- XWS, 1mm.t - J, 20°, P, S
		7							- J, 20°, P, S - J, 20°, P, S - J, 45°, P, S - Cr, 5mm.t
		8				M-H			- J, 75°, P, S - Cr, 5mm.t - J, 85°, P, S
				END OF BOREHOLE AT 8.54m					
		9							
		10							
		11							

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BOREHOLE LOG

Borehole No. 302
1/2

Client: MERITON APARTMENTS PTY LTD

Project: PROPOSED RESIDENTIAL APARTMENT BUILDINGS

Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765Z
Date: 22-6-11

Method: SPIRAL AUGER
JK300

Logged/Checked by: D.W./

R.L. Surface: ≈ 159.1m
Datum: AHD

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			FILL: Silty clay topsoil, medium plasticity, dark grey, trace of root fibres.	MC>PL			GRASS COVER
								CH	SILTY CLAY: high plasticity, grey and light grey mottled orange brown.	MC>PL	H	-	RESIDUAL
					N = 7 3,3,4							400 420 400	
▼ ON COMPLETION OF CORING						1			as above, but medium plasticity, light grey mottled orange brown and red brown.	MC<PL	VSt-H	330 >600	
					N = 23 10,10,13				as above, but with XW shale bands and ironstone gravel.	XW	EL		
						2		-	SHALE: light grey mottled orange brown and red brown, with iron indurated bands.	DW	VL-L		MODERATE 'TC' BIT RESISTANCE WITH LOW BANDS
									SHALE: dark grey, with orange brown laminae, with M strength iron indurated bands.		L		MODERATE RESISTANCE
						3							
						4					L-M		
▼ ON COMPLETION OF AUGERING						5					M		MODERATE RESISTANCE WITH HIGH BANDS
						6			REFER TO CORED BOREHOLE LOG				
						7							

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Borehole No. **302** 2/2

CORED BOREHOLE LOG

Client: MERITON APARTMENTS PTY LTD

Project: PROPOSED RESIDENTIAL APARTMENT BUILDINGS

Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765Z **Core Size:** NMLC **R.L. Surface:** ≈ 159.1m

Date: 22-6-11 **Inclination:** VERTICAL **Datum:** AHD

Drill Type: JK300 **Bearing:** - **Logged/Checked by:** D.W./

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 SPACING (mm) (600 300 100 50 30 10)	DEFECT DETAILS: DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) Specific / General
		5		START CORING AT 5.88m					
50% RET-URN		6		SHALE: dark grey, with crushed zones and weathered seams, frequent ironstained joints.	DW	VL-L			
		7		SHALE: dark grey.	SW	L-M M M-H H M-H			- J, 45°, P, S, IS - J, 90° P, S - J, 80°, P, S, IS - J, 45°, P, S - Cr, 20mm.t - J, 70° P, S, IS - J, 45° P, S, IS - J, 45° P, S - Cr, 10mm.t - J, 60° P, S, IS - J, 75° P, S, IS - Be, 0°, P, S, IS - J, 45° P, S - J, 50° P, S - J, 50° P, S - J, 20° P, S - Cr, 10mm.t - J, 20° P, S - J, 45° P, S - J, 45° P, S - J, 70° P, S
		8							
		9							
		10		END OF BOREHOLE AT 9.90m					
		11							

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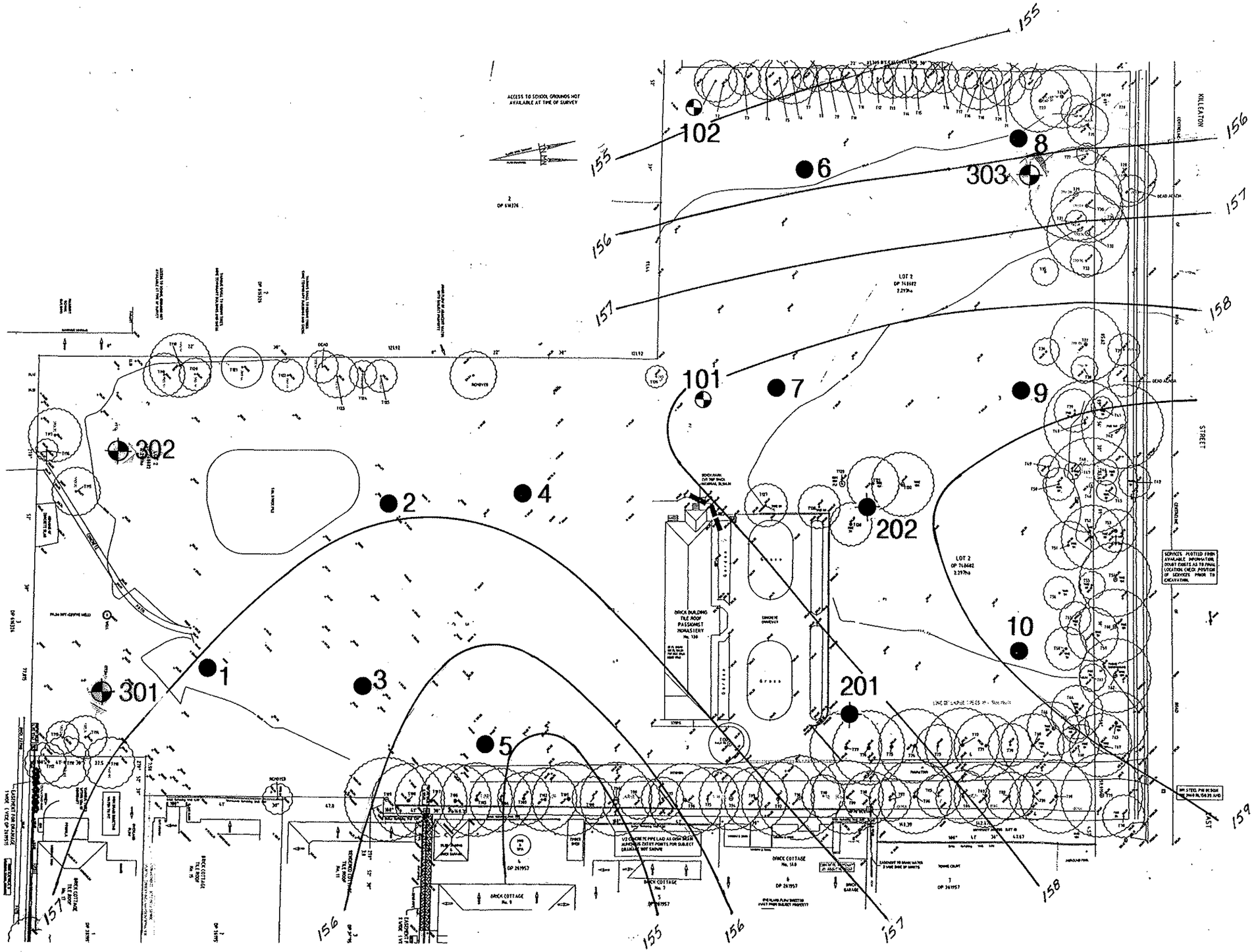
BOREHOLE LOG

Borehole No. 303
1/1

Client: MERITON APARTMENTS PTY LTD
Project: PROPOSED RESIDENTIAL APARTMENT BUILDINGS
Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765Z
Date: 23-6-11
Method: SPIRAL AUGER JK300
Logged/Checked by: D.W./
R.L. Surface: ≈ 159.4m
Datum: AHD

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			FILL: Silty clay topsoil, low to medium plasticity, dark grey, trace of root fibres.	MC>PL			GRASS COVER
								CL-CH	SILTY CLAY: medium to high plasticity, light grey mottled orange brown.	MC>PL	-	-	RESIDUAL
▼ AFTER 1 HR						1		CL	SILTY CLAY: low to medium plasticity, light grey mottled orange brown and red brown, with fine to coarse grained ironstone gravel.				
▼ AFTER 30 MINS						2							
						3			as above, but with EL strength XW shale bands.	MC≈PL			
						4		-	SHALE: grey and dark grey.	DW	L	-	
						5					L-M		'SHALLOW' & 'DEEP' STANDPIPE INSTALLED TO 3.38m & 6.02m RESPECTIVELY (REFER TO FIG 2 FOR DETAILS)
▼ ON COMPLETION						6			END OF BOREHOLE AT 6.1m				
						7							



LEGEND

- BOREHOLE JUNE 2011
- BOREHOLE FEB 2010
- BOREHOLE OCT 2006
- BOREHOLE AUG 2002

SCALE (m)

0 40

BOREHOLE LOCATION PLAN

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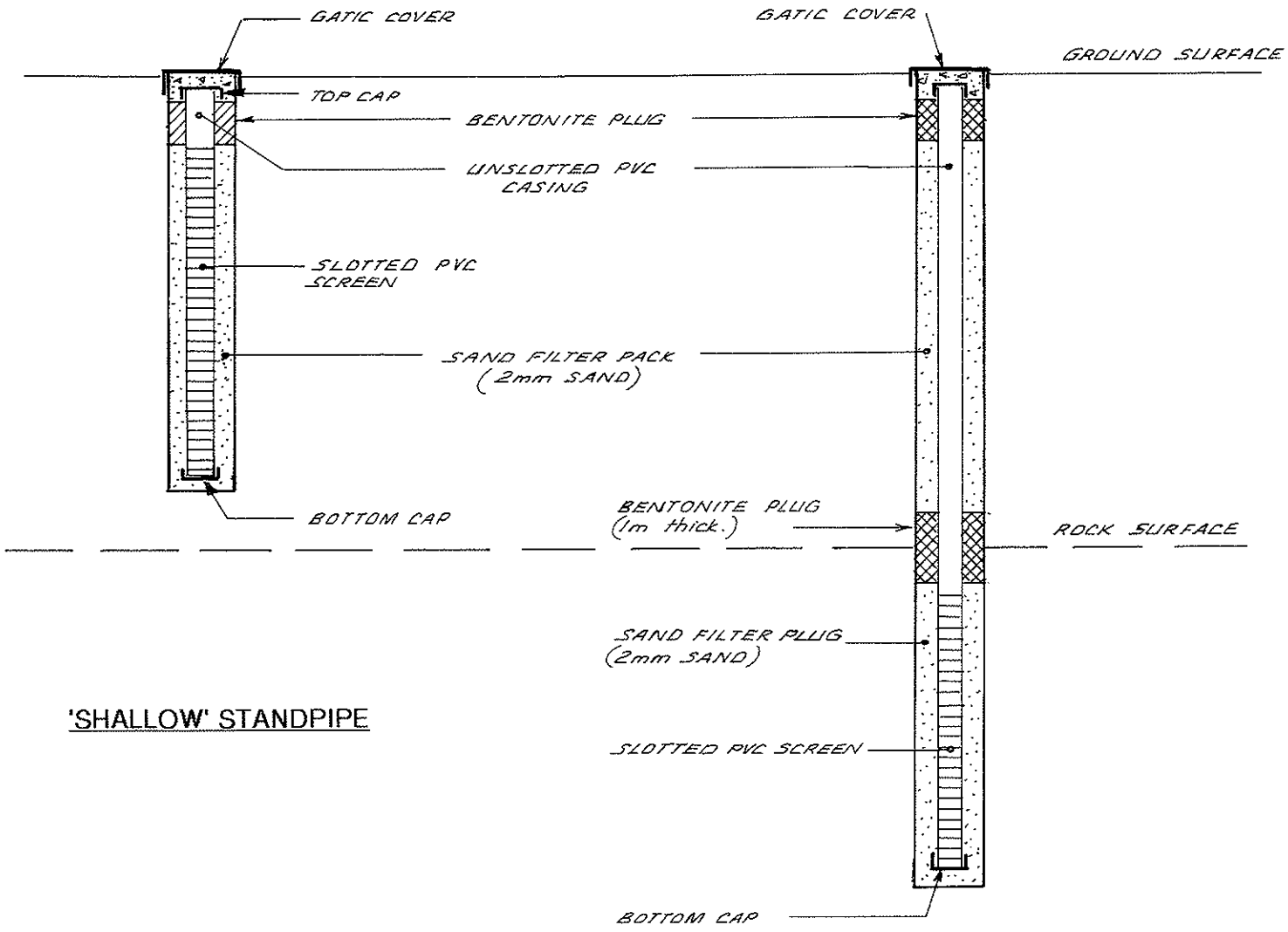
Report No. 23765Z **Figure No. 1**



STANDPIPE DETAILS

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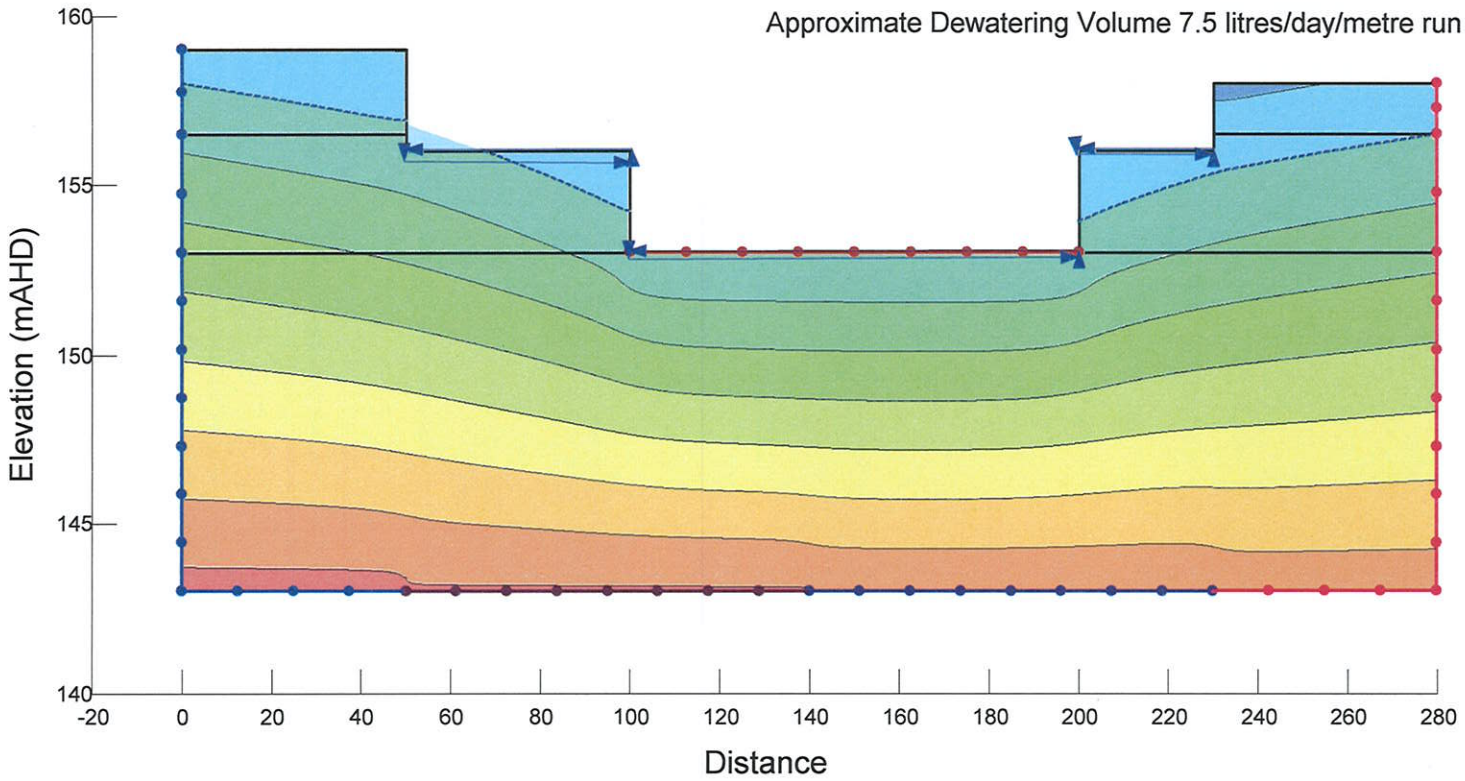
Report No. 23765Z Figure No. 2

Groundwater Seepage Analysis

132 - 138 Killeaton Street, St Ives, NSW

Seepage Flows into Basement Excavation

Approximate Dewatering Volume 7.5 litres/day/metre run



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Report No. 23765Z2 Figure No. 3

APPENDIX A

Relevant Borehole Logs From Previous Geotechnical Investigation

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Borehole No. 1 1/2

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK250 **R.L. Surface:** ≅ 159.1m

Date: 29-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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			TOPSOIL/FILL: Silty clay, low plasticity, dark grey mottled yellow brown, with fine gravel.	MC > PL			GRASS COVER
					N = 21 5,9,12			CH	SILTY CLAY: high plasticity, mottled light grey, yellow and red brown, with ironstone gravel	MC≅PL	H	>600 >600 >600	
						1							
					N > 20 11,20/ 100mm				as above, but with low strength shale bands.			>600 >600	
						2		-	SHALE: dark grey and brown, with ironstone bands.	DW	L	>600	LOW TO MODERATE 'TC' BIT RESISTANCE
									as above, but dark grey.	DW	M		MODERATE RESISTANCE
						3							
						4				DW-SW	M-H		MODERATE TO HIGH RESISTANCE
						5							
▶										SW	H		HIGH RESISTANCE
						6			REFER TO CORED BOREHOLE LOG				
						7							

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Borehole No. 1 2/2

CORED BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V | **Core Size:** NMLC | **R.L. Surface:** ≅ 159.1m
Date: 29-8-02 | **Inclination:** VERTICAL | **Datum:** ASSUMED
Drill Type: JK250 | **Bearing:** - | **Logged/Checked by:** Y.N./DB

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
		5		START CORING AT 6.0m						
80% RET-URN		6		SHALE: dark grey bedded grey.	SW	H			· J, 90°, IR	
		7							· J, 30°, S, P	
						M			· J, 80°, S, P	
		8							· Cr, 50mm.t · J 65°, S, P · J, 35°, S, P	
						H			· CS, 3mm.t · J, 70°, S, P · Cr, 30mm.t	
						M			· J, 60°, S, P · J, 60°, S, P · J, 45°, S, P	
		9		END OF BOREHOLE AT 9.0m					· J, 50°, S, P	
		10								
		11								

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 2 1/2

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK450 **R.L. Surface:** ≅ 159.5m

Date: 30-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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
DRY ON COMPLETION						0			TOPSOIL/FILL: Silty clay, medium plasticity, dark grey mottled brown and grey.	MC > PL			GRASS COVER
					N = 10 3,4,6			CH	SILTY CLAY: high plasticity, light grey mottled yellow.	MC≅PL	VSt -H	500 400 400	
						1							
					N = 36 6,15,21			CL	as above, but medium plasticity, with low strength shale bands.	MC < PL	H	>600 550 570	
						2							
								-	SHALE: dark grey, bedded grey.	XW	VL		VERY LOW 'TC' BIT RESISTANCE
						3				XW-DW	L		VERY LOW TO LOW RESISTANCE
						4			as above, but dark grey.	DW	M		MODERATE RESISTANCE
AFTER 1 HOUR						5			as above, but dark grey.				
						6				DW	L-M		LOW RESISTANCE
						7							

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Borehole No. 2 2/2

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK450 **R.L. Surface:** ≅ 159.5m

Date: 30-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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
				■					SHALE: dark grey.	DW	M		MODERATE RESISTANCE
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							
						14							

Jeffery and Katauskas Pty Ltd
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Borehole No. 3 1/1

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK250 **R.L. Surface:** ≅ 159.2m

Date: 29-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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			TOPSOIL/FILL: Silty clay, medium plasticity, yellow brown mottled grey with roots.	MC≅PL			GRASS COVER
								CH		MC≅PL	H		
					N = 12 4,6,6	1			SILTY CLAY: high plasticity, mottled light grey, yellow and red brown.			460 450 450	
					N = 36 10,17,19	2		CL	as above, but medium plasticity, with iron indurated and very low strength shale bands.	MC<PL		480 550 480	
▼ AFTER 20 HRS						3		-	SHALE: dark grey, bedded grey and brown, with ironstone bands.	XW-DW	L		LOW 'TC' BIT RESISTANCE
						4				DW	L-M		LOW TO MODERATE RESISTANCE
▶						5			as above, but dark grey.		M		MODERATE RESISTANCE
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 4 1/1

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK450 **R.L. Surface:** ≅ 159.2m

Date: 30-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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
DRY ON COMPLETION						0			TOPSOIL/FILL: Silty clay, low plasticity, dark grey mottled grey.	MC > PL			GRASS COVER
					N = 11 3,4,7			CH	SILTY CLAY: high plasticity, light grey mottled yellow brown.	MC≅PL	H	- 550 550 550	
					N > 39 8,16, 23/100mm	1			as above, but with low strength shale bands.	MC < PL		550 450 500	
						2		-	SHALE: dark grey bedded grey and dark brown.	XW-DW	VL-L		VERY LOW TO LOW 'TC' BIT RESISTANCE
						3			as above, but dark grey.	DW	L		
▼ AFTER 4 HRS						4 5 6					L-M		LOW TO MODERATE RESISTANCE
						7			END OF BOREHOLE AT 7.0m				

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 5 1/2

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK250 **R.L. Surface:** ≅ 159.2m

Date: 29-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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			TOPSOIL/FILL: Silty clay, low plasticity, dark grey, with roots.	MC≅PL			GRASS COVER
					N = 12 3,5,7	1		CH	SILTY CLAY: high plasticity, mottled light grey, red brown and yellow.	MC > PL	VSt	400 350 400	
					N = 30 7,10,20	2			as above, but with ironstone and very low strength shale bands.	MC < PL	H	>600 >600 >600	
						3							
						4		-	SHALE: dark grey with red brown ironstained bands.	DW	L	-	LOW 'TC' BIT RESISTANCE
						5				DW	L-M		MODERATE 'TC' BIT RESISTANCE WITH LOW RESISTANCE
						6							
						7			REFER TO CORED BOREHOLE LOG				

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 5 2/2

CORED BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Core Size:** NMLC **R.L. Surface:** ≅ 159.2m

Date: 29-8-02 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK250 **Bearing:** - **Logged/Checked by:** Y.N./

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
		6							
				START CORING AT 7.0m					
		7		SHALE: dark grey bedded grey, highly fractured.	DW	M-H			· J, 60°, IS, S, P · J, 45°, IS, S, P · Cr, 50mm.t
						VL			· Cr, 80mm.t
						M			
		8			XW	EL-VL			· Cr, 100mm.t · Cr, 150mm.t
70% RET-URN				as above, but grey with clay seams.	DW	M			· Cr, 120mm.t · Cr, 70mm.t
		9		INTERBEDDED SHALE AND SANDSTONE: fine grained, light grey and grey.					· J, 45°, SP, 2mm.t, CS · CS, 10mm.t
				SANDSTONE: fine grained, light grey.	DW	M			
					SW	H			
		10		END OF BOREHOLE AT 10.0m					
		11							
		12							

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Borehole No. 6 1/2

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK450 **R.L. Surface:** ≅ 158.7m

Date: 30-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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
DRY ON COMPLETION						0			TOPSOIL/FILL: Silty clay, low plasticity, dark brown and grey.	MC<PL			GRASS COVER
					N = 14 4,6,8	1		CL	SILTY CLAY: medium plasticity, mottled red brown, yellow and light grey.	MC<PL	H	- 550 570 520	
					N = 38 11,14,24	2			as above, but ironstone iron indurated.			>600 >600 >600	
						3		-	SHALE: grey, with ironstone bands.	XW	L	-	VERY LOW 'TC' BIT RESISTANCE
						4			SHALE: dark grey, with light grey clay bands.				
▼ AFTER 2 HRS						5			as above, but with ironstone bands.	DW	L-M		LOW RESISTANCE
						6		-	SANDSTONE: fine grained, light grey.	DW	M		MODERATE RESISTANCE
						7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 6 2/2

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V
Date: 30-8-02
Method: SPIRAL AUGER JK450
Logged/Checked by: Y.N./
R.L. Surface: ≅ 158.7m
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
				■					SANDSTONE: fine grained, light grey.	DW	M		
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							
						14							

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Borehole No. 7 1/1

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK450 **R.L. Surface:** ≅ 159.8m

Date: 30-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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			TOPSOIL/FILL: Silty clay, medium plasticity, grey and dark grey, with roots.	MC > PL			GRASS COVER
				■	N = 11 3,4,7	1		CH	SILTY CLAY: high plasticity, light grey mottled yellow and brown.	MC > PL	VSt	250 320 300	
				■	N = 31 7,12,19	2			as above, but with shale bands.	MC < PL	H	>600 >600 >600	
▼ AFTER 3 HRS						3		-	SHALE: dark grey.	XW-DW	VL	-	VERY LOW 'TC' BIT RESISTANCE
						4							
						5				DW	L-M		LOW RESISTANCE
				■		6					M		MODERATE RESISTANCE
						7			END OF BOREHOLE AT 6.0m				

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Borehole No. 8 1/1

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK450 **R.L. Surface:** ≅ 158.8m

Date: 30-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./ [illegible]

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			TOPSOIL/FILL: Silty clay, low plasticity, dark grey mottled brown.	MC > PL			GRASS COVER
					N = 15 4,6,9	1		CH	SILTY CLAY: medium plasticity, red brown mottled yellow and light grey, with ironstone gravel.	MC < PL	H	- 550 550 500	
					N = 31 8,13,18	2						>600 >600 >600	
▼ AFTER 2 HRS						3		-	SHALE: grey, with ironstone bands.	XW-DW	VL-L	-	VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
						4			SHALE: bedded dark grey, yellow brown and grey, with ironstone bands.	DW	L-M		LOW RESISTANCE
						5					M		MODERATE RESISTANCE
▶						6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No. 9 1/1

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK450 **R.L. Surface:** ≅ 160.4m

Date: 30-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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			TOPSOIL/FILL: Silty clay, medium plasticity, brown and grey.	MC > PL			GRASS COVER
								CH	SILTY CLAY: medium to high plasticity, red brown mottled yellow and light grey, with ironstone bands.	MC < PL	H		
					N = 21 6,9,12							>600 >600 >600	
						1							
									as above but with light grey mottled red brown, with shale bands.			>600 >600	
					N > 26 15,26/ 150mm			-	SHALE: dark grey bedded brown, with ironstone bands.	DW	L-M	-	LOW 'TC' BIT RESISTANCE WITH LOW BANDS
						2							
						3							
▼ AFTER 1&1/4 HRS									as above, but dark grey.	DW	M		LOW RESISTANCE WITH VERY LOW BANDS
						4							
						5					M-H		LOW TO MODERATE RESISTANCE
▶						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. 10 1/1

BOREHOLE LOG

Client: SIMHILT CONSTRUCTIONS PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW

Job No. 17065V **Method:** SPIRAL AUGER JK450 **R.L. Surface:** ≅ 160.4m

Date: 30-8-02 **Datum:** ASSUMED

Logged/Checked by: Y.N./

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			TOPSOIL/FILL: Silty clay, medium plasticity, brown and grey, with roots.	MC > PL			GRASS COVER
								CH		MC < PL	H		
					N = 18 4,8,11	1			SILTY CLAY: medium to high plasticity, red brown mottled yellow and light grey, with ironstone gravel.			450 500 450	
						2			SHALE: dark grey bedded yellow brown, with ironstone bands.	DW	L-M	-	LOW 'TC' BIT RESISTANCE WITH VERY LOW BANDS
▼ AFTER 1 HOUR						3			as above, but dark grey.				
						4					M		LOW RESISTANCE WITH MODERATE RESISTANCE
▶						5							
						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. **201** 1/3

BOREHOLE LOG

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765V **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 159.4m

Date: 17-2-10 **Datum:** AHD

Logged/Checked by: L.Y./

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			FILL: Sandy silty clay, low plasticity, dark grey, with a trace of roots.	MC > PL			GRASS COVER APPEARS MODERATELY COMPACTED
				■	N = 10 3,4,6			CH	SILTY CLAY: high plasticity, light grey mottled brown, with a trace of ironstone gravel.	MC > PL	H	500 550 570	RESIDUAL
				■	N = 34 9,13,21	2						>600 >600 >600	
▼ AFTER 25 DAYS				■	N > 13 17,13/ 150mm REFUSAL	3		-	SHALE: grey.	XW-DW	VL	-	VERY LOW TO LOW 'TC' BIT RESISTANCE WITH LOW BANDS
						4			REFER TO CORED BOREHOLE LOG				
						5							
						6							
						7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **201** 2/3

CORED BOREHOLE LOG

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765V **Core Size:** NMLC **R.L. Surface:** ≈ 159.4m

Date: 17-2-10 **Inclination:** VERTICAL **Datum:** AHD

Drill Type: JK300 **Bearing:** - **Logged/Checked by:** L.Y./

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
		4		START CORING AT 4.29m					
				CORE LOSS 0.1m					
				SHALE: dark grey, with iron indurated bands.	DW	L			- Cr, 340mm.t
		5							- Cr, 70mm.t
		6							- XWS, 40mm.t - XWS, 60mm.t - XWS, 50mm.t
				CORE LOSS 0.09m					
				SHALE: dark grey.	DW	L			- Cr, 90mm.t - Cr, 50mm.t
		7		SANDSTONE: fine grained, light grey, with occasional bedding at 0-30°.	DW-SW	M-H			
FULL RETURN		8							- Be, 60°, P, R
		9							
		10							- Be, 40°, P, R

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. **201** 3/3

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765V **Core Size:** NMLC **R.L. Surface:** ≈ 159.4m

Date: 17-2-10 **Inclination:** VERTICAL **Datum:** AHD

Drill Type: JK300 **Bearing:** - **Logged/Checked by:** L.Y./

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
				SANDSTONE: fine grained, light grey, with occasional bedding at 0-30°.	DW-SW	M-H	×		
		12		END OF BOREHOLE AT 11.70m					50mm DIAMETER PVC STANDPIPE INSTALLED TO 11.7m, SLOTTEL BETWEEN 11.7 AND 8.7m
		13							
		14							
		15							
		16							
		17							

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Borehole No. **202** 1/2

BOREHOLE LOG

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765V **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 160.3m

Date: 17-2-10 **Datum:** AHD

Logged/Checked by: L.Y./

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			FILL: Sandy silty clay, low plasticity, dark grey, with a trace of roots.	MC > PL			APPEARS MODERATELY COMPACTED
					N = 9 3,4,5	1		CH	SILTY CLAY: high plasticity, light grey mottled brown.	MC > PL	VSt -H	330 370 410	RESIDUAL
					N = 28 9,14,14						H	> 600 > 600 > 600	
▼ AFTER 25 DAYS					N > 27 27/150mm REFUSAL	2		-	SHALE: grey, with ironstone bands.	XW	EL-VL	-	VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
						3							
						4							
						5				DW	L-M		LOW RESISTANCE WITH MODERATE BANDS.
						6			REFER TO CORED BOREHOLE LOG				
						7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **202** 2/2

CORED BOREHOLE LOG

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 132-138 KILLEATON STREET, ST IVES, NSW

Job No. 23765V **Core Size:** NMLC **R.L. Surface:** ≈ 160.3m

Date: 17-2-10 **Inclination:** VERTICAL **Datum:** AHD

Drill Type: JK300 **Bearing:** - **Logged/Checked by:** L.Y./ 7

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
		5		START CORING AT 5.65m					
FULL RET-URN		6		SHALE: dark grey.	DW	M			- Cr, 75mm.t - CR, 100mm.t
		7							
		8		SANDSTONE: fine grained, light grey, with cross bedding at 5-15°.	DW-SW	M-H			
		9							
		10				H			
		11							
				END OF BOREHOLE AT 11.24m					50mm DIAMETER PVC STANDPIPE INSTALLED TO 11.24m, SLOTTED BETWEEN 11.24m AND 8.24m

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Borehole No. **101** 1/3

BOREHOLE LOG

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW.

Job No. 20607V **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 159.70m

Date: 5-10-06 **Datum:** ASSUMED

Logged/Checked by: H.D./

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
DRY ON COMPLE -TION OF AUGER -ING				■	N = 8 2,4,4	0			FILL: Sandy clay, medium plasticity, dark brown.	MC > PL			GRASS COVER APPEARS POORLY COMPACTED
				■				CH	SILTY CLAY: high plasticity, light grey.	MC > PL	VSt	300 250 250	RESIDUAL
						1			As above, but with XW shale bands.	MC < PL	H		
ON COMPLE -TION OF CORING ▼				■	N > 15 7, 15/ 150mm REFUSAL				SHALE: dark grey.	XW	EL	>600 >600	VERY LOW 'TC' BIT RESISTANCE
				■		2				DW	L		LOW RESISTANCE
									REFER TO CORED BOREHOLE LOG				50mm PVC STANDPIPE INSTALLED TO 11.6, SLOTTED FROM 6.0m, BAILED TO 6.2m DEPTH ON COMPLETION.
						3							
						4							
						5							
						6							
						7							

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CORED BOREHOLE LOG

Borehole No. 101 2/3

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW.

Job No. 20607V | **Core Size:** NMLC | **R.L. Surface:** ≈ 159.70m

Date: 5-10-06 | **Inclination:** VERTICAL | **Datum:** ASSUMED

Drill Type: JK550 | **Bearing:** - | **Logged/Checked by:** H.D./

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) (600 300 100 60 30 10)	DEFECT DETAILS: DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) Specific / General
		2		START CORING AT 2.65m					
90% RET-URN				CORE LOSS: 0.35m.					
		3		SHALE: dark grey.	XW	EL			
					XW-DW	EL-VL			
▼ 19HRS AFTER BAILING CORE WATER		4			DW	VL	×		· CS, 0°, 60mmt. · CS, 0°, 40mmt.
							×		· CS, 5°, 110mmt.
		5			XW	EL			
				CORE LOSS: 0.10m.					
				SHALE: dark grey.	DW	VL-L			
		6		CORE LOSS: 0.20m.					
				SHALE: dark grey with medium strength iron indurated seams.	XW	EL			· CS, 0°, 100mmt.
		7		SILTY CLAY: medium to high plasticity, light grey.	RS	H			· HP = 460, 490, 540 kPa.
		8		SANDSTONE: fine to medium grained, light grey and dark grey.	DW	VL			· XWS, 0°, 100mmt. · J, 60°, P, S, RUNS 100mm · XWS, 5°, 120mmt. · J, 50°, P, S, RUNS 110 mm.
				SANDSTONE: coarse to medium grained, light grey with dark grey laminae, bedded at 5-20°.	DW	L	×		
		9			Fr	M-H			· J, 80-90°, Un, R, RUNS 600mm, PARTLY HEALED.

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CORED BOREHOLE LOG

Borehole No. 101 3/3

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW.

Job No. 20607V | **Core Size:** NMLC | **R.L. Surface:** ≈ 159.70m

Date: 5-10-06 | **Inclination:** VERTICAL | **Datum:** ASSUMED

Drill Type: JK550 | **Bearing:** - | **Logged/Checked by:** H.D./

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
		10		SANDSTONE: fine to medium grained, light grey with dark grey laminae, bedded at 5-20°.	Fr	H	×		· J, 70-80°, Un, R, RUNS 500mm · Be, 0°, P, S · CS, 0°, 10mm · Be, 5-10°, Un, R, CLAY INFILL
		11					×		· J, 70°, P, S, RUNS 30mm.
				END OF BOREHOLE AT 11.60m			×		
		12							
		13							
		14							
		15							

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BOREHOLE LOG

Borehole No. 102
1/2

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW.

Job No. 20607V **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 158.50m

Date: 6-10-06 **Datum:** ASSUMED

Logged/Checked by: H.D./

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
DRY ON COMPLE-TION OF AUGER-ING					N = 10 3,4,6	0		CH	TOPSOIL: Sandy clay, medium plasticity, dark brown.	MC < PL	H	-	GRASS COVER
									SILTY CLAY: high plasticity, yellow brown mottled red brown.	MC < PL		480 450 510	RESIDUAL
						1			SILTY CLAY: high plasticity, light grey mottled red brown, with fine grained ironstone gravel.				
					N = 30 9,12,18							>600 >600	
▼ ON COMPLE-TION OF CORING						2							
								CL	SILTY CLAY: medium plasticity, light grey mottled yellow brown, with XW shale bands.				
					N = 38 10,15,23	3						>600 >600	
						4		-	SHALE: grey with medium strength iron indurated bands.	XW	EL	-	VERY LOW 'TC' BIT RESISTANCE
									REFER TO CORED BOREHOLE LOG				
						5							
						6							
						7							

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Borehole No. 102 2/2

CORED BOREHOLE LOG

Client: DASMIN PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 138 KILLEATON STREET, ST IVES, NSW.

Job No. 20607V **Core Size:** NMLC **R.L. Surface:** ≈ 158.50m

Date: 6-10-06 **Inclination:** VERTICAL **Datum:**

Drill Type: JK550 **Bearing:** - **Logged/Checked by:** H.D./

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
		4		START CORING AT 4.56m					
				CORE LOSS: 0.15m.					
90% RET-URN		5		SHALE: dark grey speckled orange brown.	XW	EL	×		· M strength seam, 60mmt.
				CORE LOSS: 0.06m	RS	(H)			· HP = 500, 430, 480kPa.
				SANDY CLAY: medium plasticity, dark grey.	XW	EL	×		
		6		SANDSTONE: fine to medium grained, dark grey and light grey.					
				SANDSTONE: fine to medium grained, light grey speckled yellow brown.			×		
		7		CORE LOSS: 0.05m.	DW	M			· FRACTURED ZONE, 300mmt.
FULL RET-URN				SANDSTONE: fine to medium grained, brown and red brown, bedded at 5-15°.			×		
				SANDSTONE: fine to medium grained, light grey, with brown laminae, bedded at 5°.	SW		×		
		8		CORE LOSS: 0.05m	SW	M	×		· CS, 10°, 30mmt.
				SANDSTONE: fine to medium grained, light grey with brown laminae, bedded at 10-20°.	Fr				· XWS, 5°, 30mmt.
		9		SANDSTONE: fine to medium grained, light grey with dark grey laminae, bedded at 5-20°.			×		· J, 60°, Un, R, RUNS 100mmt.
							×		· Be, 10°, P, S, CLAY INFILL.
		10		END OF BOREHOLE AT 10.0m					

APPENDIX B

Report Explanation Notes

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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.

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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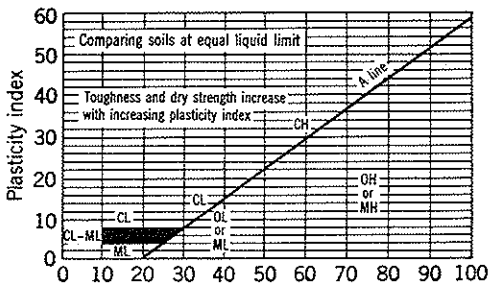
UNIFIED SOIL CLASSIFICATION TABLE

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 Not meeting all gradation requirements for *GW* 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 Atterberg limits above "A" line, with *PI* greater than 7
			Predominantly one size or a range of sizes with some intermediate sizes missing			*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)			*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)			*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		
	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 Not meeting all gradation requirements for *SW* 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 Atterberg limits below "A" line with *PI* greater than 7
			Predominantly one size or a range of sizes with some intermediate sizes missing			*SP*	Poorly graded sands, gravelly sands, little or no fines		
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)			*SM*	Silty sands, poorly graded sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)			*SC*	Clayey sands, poorly graded sand-clay mixtures		
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								
	Silts and clays: liquid limit less than 50		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)				
			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 (I_D) 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	