

# Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS  
ABN 17 003 550 801



AS/NZS ISO 9001  
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12 January, 2012

Ref: 25264Z Let2

Health Infrastructure NSW  
C/- Sweett (Australia) Pty Ltd  
Level 9  
8-10 Loftus Street  
SYDNEY NSW 2000

ATTENTION: Mr Jonathan Darwen

Dear Sir

**SUPPLEMENTARY GEOTECHNICAL INVESTIGATION**  
**ST GEORGE HOSPITAL**  
**GRAY STREET, KOGARAH**

This letter reports the results of the supplementary geotechnical investigation carried out at the above site. The investigation was commissioned by Mr Jonathan Darwen of Sweett (Australia) Pty Ltd and was carried out in accordance with our proposal (ref P25264Zemail) dated 7 December 2011. This report forms an addendum to our previous report for the site (ref 25264Zrpt) dated 2 November 2011.

The supplementary investigation comprised the following scope of work:

- One borehole (BH101) was auger drilled to a depth of 4m using our track mounted JK300 rig in the footprint of the proposed new Emergency Department.
- One borehole (BH104) was hand auger drilled to a refusal depth of 0.9m within the footprint of the proposed Sub-Acute Building. A Dynamic Cone Penetration (DCP) test (DCP104) was also carried out at this location.



Principals: L J Speechley BE(Hons) MEngSc; P Stubbs BSc(Eng) MICE FGS; D Treweek DipTech; B F Walker BE DIC MSc.  
Senior Associates: D J Bliss BE(Hons) MEngSc; A L Jackaman BE MEngSc; A J Kingswell BSc(Hons) MSc;  
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Associates: A J Hulskamp BE(Hons) MEngSc; N E Smith BE MEngSc; W Theunissen BE MEngSc; A B Walker BE(Hons) MEngSc.  
Principal Consultant: R P Jeffery BE DIC MSc.





- One borehole (BH103) was auger drilled to a refusal depth of 1.6m using our JK300 rig adjacent to the proposed Engineering Building.
- One borehole (BH102) was auger drilled to a refusal depth of 0.7m using our track mounted JK300 rig adjacent to the proposed Oxygen Hardstand Area.
- Two boreholes (BH105 and BH106) were hand augered to refusal depths of 0.75m to the west of the proposed Oxygen Hardstand Area. These boreholes were complemented by DCP105 and DCP106 which were carried out to refusal depths of 0.9m and 2.1m, respectively.

The investigation locations, as indicated in attached Figure 1, were nominated by Cardno, and were set out using taped measurements from existing surface features.

Representative soil and rock chip samples were recovered from site and submitted to a NATA registered laboratory for moisture content, Atterberg Limits, linear shrinkage, Standard compaction, and four-day soaked CBR testing.

The borehole logs, DCP test results, laboratory test results, and updated graphical borehole summaries are attached, together with the Report Explanation Notes.

The same investigation procedure was adopted for the initial and supplementary investigations. The site description and subsurface conditions presented in our previous report are applicable, and the comments and recommendations presented in our previous report remain valid.



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

Yours faithfully

For and on behalf of

JEFFERY AND KATAUSKAS PTY LTD

A ZENON

Senior Associate.

Encl: Table A: Atterberg Report  
Table B: California Bearing Ratio Report  
Borehole Logs 101 to 106  
DCP Test Results (104 to 106)  
Figure 1: Borehole Location Plan  
Figure 2: Graphical Borehole Summary  
Figure 3: Graphical Borehole Summary  
Report Explanation Notes.

## ATTERBERG REPORT

**Client:** Health Infrastructure (NSW)  
**Project:** Proposed Alterations & Additions  
**Location:** St George Hospital, Gray Street, Kogarah

**Ref No:** 25264Z2  
**Report No:** 2  
**Report Date:** 13/01/12  
Page 1 of 1

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %
101	2.80-3.50	9.6				
101	3.80-4.00	4.7				
103	1.00-1.60	10.1				
105	0.60-0.75	26.8	60	23	37	15.0
106	0.50-0.70	18.9	43	18	25	10.0

**Notes:**

- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions
- Date of receipt of sample 19/12/2011

## CALIFORNIA BEARING RATIO TEST REPORT

**Client:** Health Infrastructure (NSW)  
**Project:** Proposed Alterations & Additions  
**Location:** St George Hospital, Gray Street, Kogarah

**Ref No:** 25264Z2  
**Report No:** 1  
**Report Date:** 13/01/12  
Page 1 of 1

BOREHOLE NUMBER	BH 102
DEPTH (m)	0.10 - 0.70
Days of Soak	4
Surcharge (kg)	9.0
Maximum Dry Density (t/m <sup>3</sup> )	1.92 STD
Optimum Moisture Content (%)	12.1
Moulded Dry Density (t/m <sup>3</sup> )	1.93
Sample Density Ratio (%)	101
Sample Moisture Ratio (%)	109
Moisture Contents	
Insitu (%)	13.7
Moulded (%)	13.2
After soaking and	
After Test, Top 30mm(%)	13.5
Remaining Depth (%)	13.0
Material Retained on 19mm Sieve (%)	1*
Swell (%)	0.0
<b>C.B.R. value:</b>	@5.0mm penetration 3.0

### NOTES:

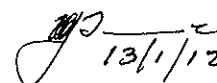
- Refer to appropriate Borehole logs for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1
- \* Not used in test sample
- Date of receipt of sample 19/12/2011



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Authorised Signature / Date  
(D. Trewick)

  
13/1/12



Borehole No.

**101**

1/1

# BOREHOLE LOG

**Client:** HEALTH INFRASTRUCTURE (NSW)  
**Project:** PROPOSED ALTERATIONS AND ADDITIONS  
**Location:** ST GEORGE HOSPITAL, GRAY STREET, KOGARAH, NSW

**Job No.** 25264Z2

**Method:** SPIRAL AUGER  
JK300

**R.L. Surface:** ≈ 28.4m

**Date:** 15-12-11

**Datum:** AHD

**Logged/Checked by:** H.W./*RE*

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB	DS									
DRY ON COMPLETION						0			FILL: Gravelly sand, fine to medium grained, dark brown, fine to coarse grained slag gravel.	D			
					N = 12 8,8,4			CL	SANDY CLAY: low plasticity, orange brown and grey, with fine to medium grained ironstone gravel, trace of ash and root fibres.	MC < PL	VSt	350 300 320	RESIDUAL
					N = 34 20,20,14				SANDSTONE: fine to medium grained, light grey and yellow brown, with iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
									SANDSTONE: fine to medium grained, light grey.	DW	VL-L		LOW RESISTANCE
						4			END OF BOREHOLE AT 4.0m	SW	H		'TC' BIT REFUSAL
						5							
						6							
						7							



Borehole No.  
**102**  
1/1

BOREHOLE LOG

Client:

HEALTH INFRASTRUCTURE (NSW)

Project:

PROPOSED ALTERATIONS AND ADDITIONS

Location:

ST GEORGE HOSPITAL, GRAY STREET, KOGARAH, NSW

Job No. 25264Z2

Method: SPIRAL AUGER

R.L. Surface: ≈ 26.9m

Date: 15-12-11

JK300

Datum: AHD

Logged/Checked by:

H.W./*fl*

Groundwater Record	SAMPLES			Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	USO	DB DS									
DRY ON COMPLETION					0		- CL	ASPHALTIC CONCRETE: 30mm.t FILL: Gravelly sand, fine to medium grained, grey, fine to medium grained igneous. SANDY CLAY: low plasticity, light grey mottled orange brown, with fine to medium grained ironstone gravel. END OF BOREHOLE AT 0.7m	MC≈PL	St	150 200 200	RESIDUAL
					1							'TC' BIT REFUSAL ON INFERRED BEDROCK
					2							
					3							
					4							
					5							
					6							
					7							

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Borehole No.

**103**

1/1

# BOREHOLE LOG

**Client:** HEALTH INFRASTRUCTURE (NSW)  
**Project:** PROPOSED ALTERATIONS AND ADDITIONS  
**Location:** ST GEORGE HOSPITAL, GRAY STREET, KOGARAH, NSW

**Job No.** 25264Z2

**Method:** SPIRAL AUGER  
JK300

**R.L. Surface:** ≈ 22.8m

**Date:** 15-12-11

**Datum:** AHD

**Logged/Checked by:** H.W./ *[Signature]*

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	USO	DB	DS									
<div> <div>ON</div> <div>COMPLETION</div> </div>						0			CONCRETE: 120mm.t CONCRETE: 570mm.t				8mm DIA. REINFORCEMENT, 75mm TOP COVER
						1		SC	CLAYEY SAND: fine to medium grained, light grey and orange brown. SANDSTONE: fine to medium grained, light grey.	M	-	-	
								-		DW-SW	H	-	HIGH 'TC' BIT RESISTANCE
									END OF BOREHOLE AT 1.6m				'TC' BIT REFUSAL
						2							
						3							
						4							
						5							
						6							
						7							





Borehole No.

**104**

1/1

# BOREHOLE LOG

**Client:** HEALTH INFRASTRUCTURE (NSW)  
**Project:** PROPOSED ALTERATIONS AND ADDITIONS  
**Location:** ST GEORGE HOSPITAL, GRAY STREET, KOGARAH, NSW

**Job No.** 25264Z2

**Method:** HAND AUGER

**R.L. Surface:** ≈ 25.9m

**Date:** 15-12-11

**Datum:** AHD

**Logged/Checked by:** H.W. / *[Signature]*

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	USO	DB	DS									
DRY ON COMPLETION					REFER TO DCP TEST RESULTS	0			FILL: Clayey sand, fine to medium grained, dark brown, with fine to medium gravel sandstone gravel and root fibres.	D			GRASS COVER
								SM SC	SILTY SAND: fine to medium grained, brown, with clay fines.	D	L	-	RESIDUAL
						1			CLAYEY SAND: fine to coarse grained, brown and orange brown, with fine to coarse grained sandstone gravel. END OF BOREHOLE AT 0.9m				HAND AUGER REFUSAL ON INFERRED BEDROCK
						2							
						3							
						4							
						5							
						6							
						7							



Borehole No.

**105**

1/1

# BOREHOLE LOG

**Client:** HEALTH INFRASTRUCTURE (NSW)  
**Project:** PROPOSED ALTERATIONS AND ADDITIONS  
**Location:** ST GEORGE HOSPITAL, GRAY STREET, KOGARAH, NSW

**Job No.** 25264Z2 **Method:** HAND AUGER **R.L. Surface:** ≈ 29.9m  
**Date:** 15-12-11 **Datum:** AHD

**Logged/Checked by:** H.W./ *H.W.*

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB	DS									
DRY ON COMPLETION					REFER TO DCP TEST RESULTS	0			FILL: Gravelly clayey sand, fine to medium grained, grey, fine to coarse grained ironstone gravel.	M			APPEARS POORLY COMPACTED
								CH	SILTY CLAY: high plasticity, orange brown, with fine to coarse grained ironstone gravel. END OF BOREHOLE AT 0.75m	MC > PL	St VSt	250 150 120 350 310 380	HAND AUGER REFUSAL
						1							
						2							
						3							
						4							
						5							
						6							
						7							



Borehole No.

**106**

1/1

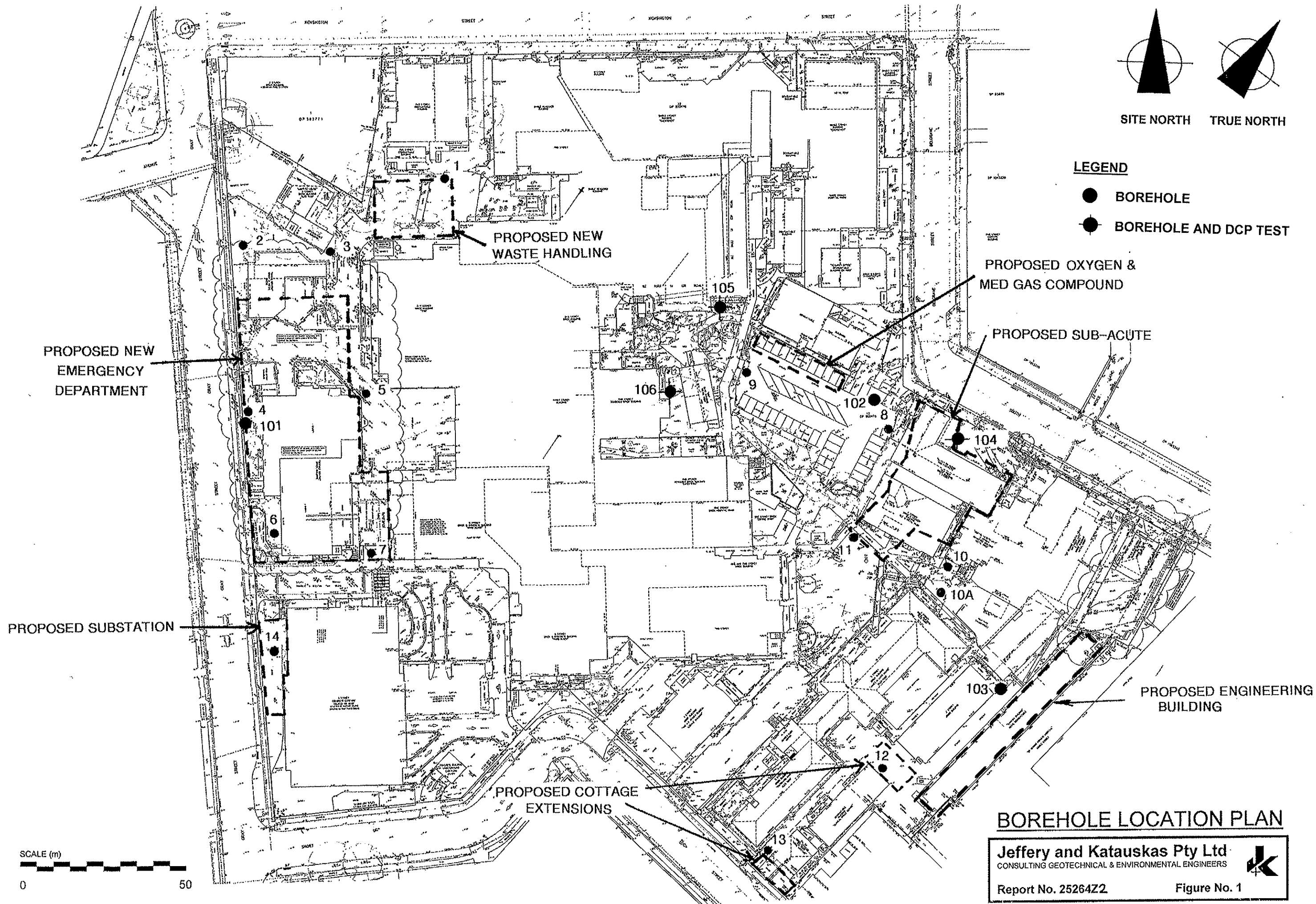
# BOREHOLE LOG

<b>Client:</b> HEALTH INFRASTRUCTURE (NSW) <b>Project:</b> PROPOSED ALTERATIONS AND ADDITIONS <b>Location:</b> ST GEORGE HOSPITAL, GRAY STREET, KOGARAH, NSW													
<b>Job No.</b> 25264Z2 <b>Date:</b> 15-12-11		<b>Method:</b> HAND AUGER			<b>R.L. Surface:</b> ≈ 29.9m <b>Datum:</b> AHD								
<b>Logged/Checked by:</b> H.W./ <i>[Signature]</i>													
Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB	DS									
DRY ON COMPLETION					REFER TO DCP TEST RESULTS	0			FILL: Clayey silty sand, fine to medium grained, dark brown, with root fibres.	M			APPEARS POORLY COMPACTED
								CH	SILTY CLAY: high plasticity, grey and red brown, with fine to coarse grained ironstone gravel. END OF BOREHOLE AT 0.75m	MC≈PL	H	> 600 > 600	HAND AUGER REFUSAL
						1							
						2							
						3							
						4							
						5							
						6							
						7							



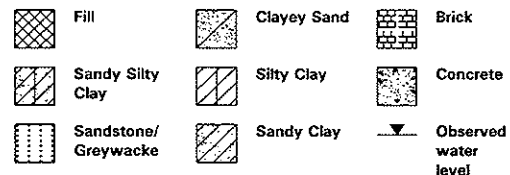
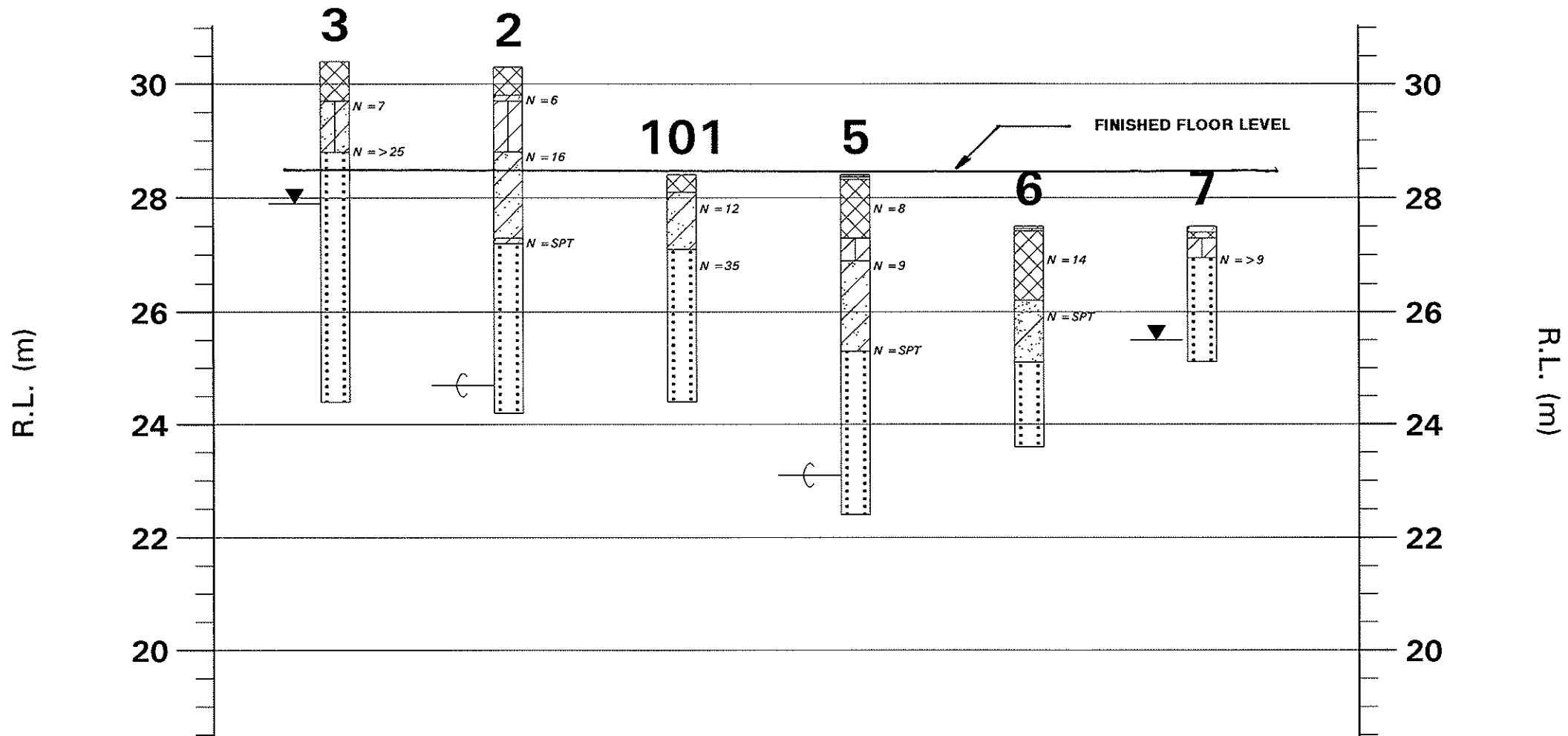
## DYNAMIC CONE PENETRATION TEST RESULTS

Client:	HEALTH INFRASTRUCTURE (NSW)						
Project:	PROPOSED ALTERATIONS AND ADDITIONS						
Location:	ST GEORGE HOSPITAL, GRAY STREET, KOGARAH, NSW						
Job No.	25264Z2			Hammer Weight & Drop: 9kg/510mm			
Date:	15-12-11			Rod Diameter: 16mm			
Tested By:	H.W.			Point Diameter: 20mm			
Number of Blows per 100mm Penetration							
Test Location	RL ~25.9m	RL ~29.9m	RL ~29.9m				
Depth (mm)	104	105	106				
0 - 100	2	2	↓				
100 - 200	5	2	1				
200 - 300	4	2	1				
300 - 400	4	4	↓				
400 - 500	7	2	5				
500 - 600	3	3	7				
600 - 700	3	6	6				
700 - 800	1	8	5				
800 - 900	18	6	3				
900 - 1000	REFUSAL	11	4				
1000 - 1100		REFUSAL	12				
1100 - 1200			23				
1200 - 1300			13				
1300 - 1400			8				
1400 - 1500			6				
1500 - 1600			6				
1600 - 1700			7				
1700 - 1800			11				
1800 - 1900			6				
1900 - 2000			7				
2000 - 2100			7				
2100 - 2200			10/50mm				
2200 - 2300			REFUSAL				
2300 - 2400							
2400 - 2500							
2500 - 2600							
2600 - 2700							
2700 - 2800							
2800 - 2900							
2900 - 3000							
Remarks:	1. The procedure used for this test is similar to that described in AS1289.6.3.2-1997, Method 6.3.2. 2. Usually 8 blows per 20mm is taken as refusal 3. Survey datum is AHD.						



# GRAPHICAL BOREHOLE SUMMARY

NEW EMERGENCY DEPARTMENT BUILDING



Borehole Collapse Depth  
 SPT "N" VALUE

Nc SOLID CONE  
 BLOW  
 COUNTS PER  
 150mm

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 100 (vert) ; NTS (horiz)

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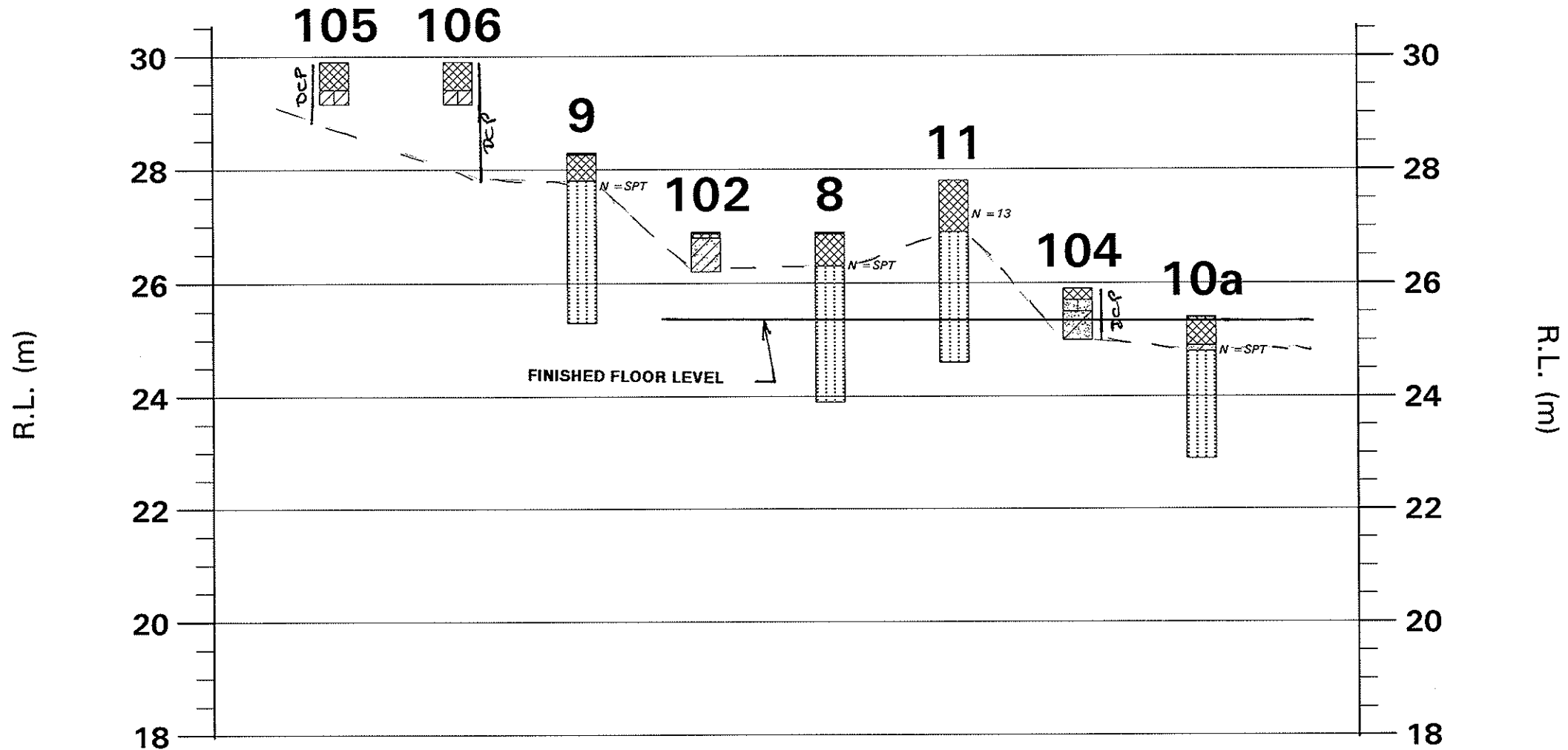
Job No.: 25264Z2

Figure No.: 2



# GRAPHICAL BOREHOLE SUMMARY

OXYGEN TANK HARDSTAND & NEW SUB-ACUTE BUILDING



	Fill		Asphaltic/Bituminous Paving or Coal		Sandy Clay		Concrete
	Silty Clay		Sandstone/Greywacke		Silty Sand	<b>N</b>	SPT "N" VALUE
			Clayey Sand	<b>Nc</b>	SOLID CONE BLOW COUNTS PER 150mm		

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 100 (vert) ; NTS (horiz)

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Job No.: 25264Z2

Figure No.: 3





## 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  

$$N > 30$$

$$15, 30/40\text{mm}$$

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<sub>c</sub>" 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 sub-surface 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.



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

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.

## **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.

# 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

# UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75 $\mu\text{m}$ and basing fractions on estimated weights)				Group Symbols	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of material is larger than 75 $\mu\text{m}$ sieve size <sup>b</sup> (The 75 $\mu\text{m}$ 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: <i>Silty sand, gravelly</i> ; 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)	$C_u = \frac{D_{60}}{D_{10}}$ 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 Atterberg limits above "A" line, with $PI$ greater than 7 $C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for SP Atterberg limits below "A" line or $PI$ less than 5 Atterberg limits below "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	Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than 75 $\mu\text{m}$ sieve size) coarse grained soils are classified as follows: Less than 5% More than 12% 5% to 12% Borderline cases requiring use of dual symbols	
			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		
Identification Procedures on Fraction Smaller than 380 $\mu\text{m}$ Sieve Size							
Fine-grained soils More than half of material is smaller than 75 $\mu\text{m}$ sieve size (The 75 $\mu\text{m}$ sieve size is about the smallest particle visible to naked eye)	Silt and clays liquid limit less than 50	Dry Strength (crushing characteristics)	None to slight	Quick to slow	None	ML	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: <i>Clayey silt, brown</i> ; 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	
		Dilatancy (reaction to shaking)	Slight to medium	Slow	Slight	OL	
			Slight to medium	Slow to none	Slight to medium	MH	
	Silt and clays liquid limit greater than 50	Toughness (consistency near plastic limit)	High to very high	None	High	CH	
			Medium to high	None to very slow	Slight to medium	OH	
		None	Medium to high	None to very slow	Slight to medium	OH	
			Medium to high	None to very slow	Slight to medium	OH	
Highly Organic Soils						PI	Peat and other highly organic soils

Use grain size curve in identifying the fractions as given under field identification

Comparing soils at equal liquid limit

Plasticity index

Liquid limit

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.



## 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 <sub>c</sub> = 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)  (Cohesionless 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.
	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)	VL	Density Index (I <sub>D</sub> ) Range (%)      SPT 'N' Value Range (Blows/300mm) 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	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
	250	
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T <sub>60</sub>	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.



## 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 ( $I_s$  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	$I_s$ (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	