



PLANNING REPORT
TO
MACQUARIE UNIVERSITY
ON
GEOTECHNICAL INVESTIGATION
FOR
PROPOSED DEVELOPMENT
AT
8 TO 12 UNIVERSITY AVENUE,
MACQUARIE PARK, NSW

23 January 2018
Ref: 29775ZN2rpt rev3



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EXECUTIVE SUMMARY

JK Geotechnics have completed a geotechnical investigation for the proposed development at 8 to 12 University Avenue, Macquarie Park, NSW. The factual results of the investigation, along with our comments and recommendations for planning purposes are presented in this report. We note that additional comments and recommendations on geotechnical design issues and geotechnical design parameters are presented in a separate report.

In general, the proposed development will comprise a multi-storey commercial and research building over two basement carparking levels.

The geotechnical investigation comprised the drilling of 6 spiral auger and rotary diamond core drilled boreholes to below design bulk excavation level. Standpipe piezometers were installed in 3 of the boreholes to allow for ongoing groundwater level monitoring.

The investigation disclosed a generalised subsurface profile comprising shallow fill over residual soils then sandstone, shale and laminite bedrock, with groundwater within the bedrock profile. Based on the encountered subsurface conditions, we anticipate conventional basement shoring, excavation and construction techniques, as adopted across Sydney, can be utilised on this project.



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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed development at 8 to 12 University Avenue, Macquarie Park, NSW. A Site Location Plan is presented as Figure 1. The investigation was commissioned by Macquarie University Contract No. 16165-30-5229.

We have been supplied with the following documents:

- Kannfinch | Sissions Pre DA architectural drawings dated 23 February 2017.
- Undated LTS Lockley survey plan (Project No. 30431, Reference No 40365DT.
- Acoustic Logic DA Stage Acoustic Assessment report (Ref: 20161608.2/0217A/RO/TT, Revision 0 dated 17 February 2017).

From the above documents, we understand that the basement for the proposed building will extend to the northern, western and southern site boundaries, and the lowest basement level will step down the existing hillside, from west to east, with basement finished floor levels between RL 59.0m (eastern end) and RL62.0m (western end). Bulk excavation to depths between about 4m and 8m are expected to be required for the proposed basements. Typical structural loads for this type of development have been assumed. We note that the proposed building will cover the western half of the site only, with no subsurface works proposed over the eastern half of the site.

From the above documents, we also understand that the proposed works will be split in to two stages as follows:

1. Early Works, generally comprising:
 - a. Site establishment and protection of adjoining property where required;
 - b. Protection, diversion and/or temporary establishment of services and infrastructure as required;
 - c. Erection of perimeter fencing, hoarding, gantry, scaffolding and site accommodation;
 - d. Establishment of temporary access and pedestrian arrangements;
 - e. Tree removal
 - f. Demolition of C2, C3, E1, Security Building C1a, decommissioned sub-station and capping/augmentation of redundant services
 - g. Demolition of the service tunnel within the footprint of the 8 – 12 building
2. Excavation and construction, generally comprising:
 - a. Construction of basement shoring walls.
 - b. Bulk and detailed excavation.
 - c. Construction of the new basement structure and buildings.



The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for comments and recommendations on excavation conditions, hydrogeological conditions, retention options, lateral earth pressures, footings and on-grade floor slabs.

A separate report addressing soil and groundwater contamination, and salinity has been prepared by our specialist environmental consulting division, Environmental Investigation Services (EIS), which should be read in conjunction with this geotechnical report.

2 INVESTIGATION PROCEDURE

Prior to any drilling commencing, the borehole locations were electromagnetically scanned for buried services by a specialist subcontractor. The boreholes were positioned as close as practicable to locations agreed with Macquarie University representatives.

Six boreholes, BH1 to BH6, were drilled to depths between 2.62m (BH1) and 5.82m (BH3) using spiral augering techniques with our track mounted JK300 drill rig. All six boreholes were subsequently extended to depths between 8.56m (BH5) and 12.55m (BH3) using rotary diamond coring techniques with water flush. The apparent compaction of the fill, strength of the natural clays and density of the natural sands were assessed from the results of Standard Penetration Tests (SPTs) completed in the boreholes, along with the results of hand penetrometer tests on recovered cohesive soil samples from the SPT split spoon sampler. The strength of the augered bedrock was assessed from observation of the drilling resistance of a twin pronged tungsten carbide (TC) drill bit attached to the augers, tactile examination of recovered rock chips and correlation with the results of subsequent laboratory moisture content tests. The strength of the cored bedrock was assessed from tactile examination of the recovered rock core and the results of subsequent laboratory Point Load Strength Index ($I_{S(50)}$) tests.

Machine slotted PVC standpipe piezometers were installed in three of the boreholes, BH2, BH3 and BH6, to allow for the monitoring of groundwater levels. Each standpipe was provided with a 2mm sand filter pack, bentonite seal and cast iron gatic cover at ground surface level. Groundwater levels were measured in the standpipes approximately 1 week after installation. No longer term groundwater monitoring was completed.

The borehole locations, as shown on the attached Borehole Location Plan (Figure 2), were set out by taped measurements from existing surface features. The approximate surface level at the



borehole locations was estimated by interpolation between spot heights on the supplied undated LTS Lockley survey plan (Project No. 30431, Reference No 40365DT), which forms the basis for Figure 2. The survey datum is Australian Height Datum (AHD).

Our geotechnical engineer, Michael Egan, was on site full time during the fieldwork and set out the borehole locations, directed the electromagnetic scanning, nominated the sampling and testing and prepared the borehole logs. The borehole logs are attached to this report along with colour core photographs and our Report Explanation Notes which define the logging terms and symbols used and describe the investigation techniques adopted.

Selected samples were returned to Soil Test Services Pty Ltd (STS) a NATA registered laboratory for moisture content and $I_{s(50)}$ testing, the results of which are presented on the attached STS Tables A and B. Selected samples were also returned to Envirolab Services Pty Ltd for pH, chloride content, sulfate content and resistivity testing, the results of which are presented in the attached Envirolab Certificate of Analysis No. 155282 (Appendix A).

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located in hilly terrain characterised by slopes with a maximum gradient of about 10°. The site is rectangular in plan and approximately 300m long east-west by 100m wide north-south.

Macquarie Drive formed the northern boundary and University Avenue the southern boundary.

At the time of our investigation, a multistorey concrete framed carpark (Carparks C1, C2 and C3) was located over the central portion of the site. To the east of the multi-storey carpark was an asphaltic concrete (AC) surfaced at-grade carpark, AC surfaced road and grassed area. To the west of the multi-storey carpark was a single storey concrete framed building, an AC surfaced at-grade carpark and grassed area. The concrete framed building had a single level basement which we understand is connected to the main University service tunnel which runs below Macquarie Drive. The existing structures on site appeared to be in good external condition based on a cursory inspection. Small to medium trees were located across the site, including between the separate portions of the multi-storey carpark.

To the east of the site, was an AC surfaced path and landscaped areas.



To the west of the site was an approximately 10m wide paved area, beyond which was a multi-storey building 'The Hearing Hub'.

3.2 Subsurface Conditions

The 1:100,000 Geological Map of Sydney indicates the site is located at the interface between Ashfield Shale of the Wianamatta Group and the underlying Hawkesbury Sandstone. Bedrock of the Mittagong formation, comprising interbedded shale, laminite and sandstone, is commonly present at the interface between the Ashfield Shale and Hawkesbury Sandstone.

The boreholes disclosed a generalised subsurface profile comprising shallow fill over residual soils then sandstone, shale and laminite bedrock. Groundwater was present within the bedrock profile. For details of the encountered subsurface profile, reference should be made to the attached borehole logs. A summary of the encountered conditions is presented below.

Fill: Fill comprising silty sand, gravel and clayey sand was encountered from surface in all of the boreholes to depths between 0.2m (BH4) and 1.5m (BH5). Where tested, the fill was assessed as being poorly or moderately compacted.

Residual Soils: Residual silty clay was encountered from beneath the fill in BH2, BH3 and BH4, and residual clayey sand and sandy clay from beneath the fill in BH6. The clays were assessed as being of hard strength and the clayey sand in BH6 was assessed as being medium dense.

Bedrock: Bedrock, comprising shale, sandstone and laminite, was encountered from immediately beneath the fill in BH1 and BH5, and from beneath the residual soils in BH2, BH3, BH4 and BH6 at depths between 0.9m (BH1) and 2.2m (BH6). The bedrock was predominantly extremely weathered and of extremely low strength on first contact, generally increasing to medium to high or high strength with depth. Over the cored portions of the boreholes, numerous defects were encountered, including inclined joints, extremely weathered seams and clay seams, with defects becoming more widely spaced with depth. The core loss zones over the cored portion of the boreholes likely represent extremely weathered seams which washed away during coring.

Groundwater: All of the boreholes were 'dry' during and on completion of augering. On 19 October 2016, standing water was measured at depths of 7.65m (RL61.65mAHD), 7.3m (RL62.2mAHD) and 3.4m (RL58.6mAHD) in BH2, BH3 and BH6 respectively.



3.3 Laboratory Test Results

The results of the laboratory moisture content tests correlated well with our field assessment of the in-situ bedrock strength.

The results of the $I_{S(50)}$ tests also correlated well with our field assessment of the in-situ bedrock strength. The Unconfined Compressive Strength (UCS) of the bedrock, as estimated from the $I_{S(50)}$ results ranged from 1MPa to 126MPa, with an average UCS of about 27MPa.

The results of the Envirolab testing are presented in the table below:

	BH2 0.5m to 0.95m depth	BH3 0.5m to 0.95m depth	BH6 0.75m to 0.95m depth	BH6 1.5m to 1.95m depth
pH	4.3	4.8	5.2	4.6
Chloride Content (mg/kg)	20	<10	<10	20
Sulfate Content (mg/kg)	130	26	50	87
Resistivity (ohm.cm)	8,300	31,000	20,000	12,000



3.4 **Bedrock Classification**

Based on the Pells et al (1998) system, the bedrock classifications in the table below apply to the bedrock encountered.

Borehole and surface RL (mAHD)	Depth (m) and RL (mAHD) of Rock Class			
	Class V	Class IV	Class III	Class II
1 70.6m	0.9 to 3.25 (69.7 to 67.35)	3.25 to 9.35 (67.35 to 61.25)	-	9.35 to 11.67 (61.25 to 58.93)
2 69.3m	-	1.2 to 6.0 (68.1 to 63.3)	-	6.0 to 11.67 (63.3 to 57.63)
3 69.5m	1.2 to 2.5 (68.3 to 67.0)	2.5 to 9.3 (67.0 to 60.2)	-	9.3 to 12.55 (60.2 to 56.95)
4 66.6m	1.6 to 2.2 (65.0 to 64.4)	2.2 to 6.5 (64.4 to 60.1)	-	6.5 to 9.8 (60.1 to 56.8)
5 63.2	1.5 to 1.9 (61.7 to 61.3)	1.9 to 3.4 (61.3 to 59.8)	-	3.4 to 8.56 (59.8 to 54.64)
6 62.0	2.2 to 3.0 (59.8 to 59.0)	3.0 to 5.4 (59.0 to 56.6)	-	5.4 to 9.44 (56.6 to 52.56)

We note that whilst sandstone, shale and laminite bedrock were encountered, due to the variability of the bedrock strata, and that laminite bedrock will behave similarly to shale, the classification criteria for shale bedrock was adopted for this site.



4 COMMENTS AND RECOMMENDATIONS

The comments and recommendations in the following Sections of the report apply to both the early works and construction stages as appropriate.

4.1 Dilapidation Surveys

Prior to any demolition and excavation commencing, we recommend that detailed dilapidation reports be prepared for any structures within 10m of the site boundaries, including the service tunnel to the north of the site. Such reports can be used as a baseline against which to assess possible future claims for damage arising from the works.

4.2 Excavation

4.2.1 Excavation Methods

Based on the investigation results, the proposed bulk excavation to a maximum estimated depth of about 8m will encounter the soil and bedrock profiles. The soil and Class V bedrock should be readily excavatable using conventional earthworks equipment. Hard rock excavation conditions must be anticipated within the Class IV and better bedrock.

Particular care will be required during bulk excavation to avoid over-breaks which could result in encroachment beyond the site boundaries and also undermining of the shoring system if this has been terminated above bulk excavation level.

4.2.2 Vibration

We recommend that considerable caution be taken during demolition and rock excavation on the site as there will likely be direct transmission of ground vibrations to adjoining buildings and structures. The proposed demolition and excavation works will be within about 15m of nearby buildings within the university.

Reference should be made to the Acoustic Logic report for recommendations on vibration monitoring and vibration limits for nearby buildings.

If transmitted vibrations on nearby structures are excessive, then geotechnical advice should be sought with respect to alternative excavation options.



During demolition, care must be taken to avoid 'dropping' any structural elements, e.g. suspended concrete slabs, beams, walls etc. as the impacts from these with the ground surface can result in large transmitted vibrations.

Using a rock saw to extend a slot below current excavation depth prior to hammering can be effective in reducing transmitted vibrations during excavation.

The following procedures are recommended to reduce vibrations where rock hammers are used:

- Maintain rock hammer orientated towards the face and enlarge excavation by breaking small wedges off the face.
- Operate one hammer at a time and in short bursts only to reduce amplification of vibrations.
- Use excavation contractors with experience in confined work with a competent supervisor who is aware of vibration damage risks, possible rock face instability issues, etc. The contractor should be provided with a copy of this report and have all appropriate statutory and public liability insurances.

4.2.3 Drainage

All of the boreholes were 'dry' during and on completion of auger drilling. Further, the groundwater levels measured about 2 weeks after installation of the standpipe piezometers were within the bedrock profile, close to the proposed bulk excavation levels.

Given the groundwater levels at close to proposed bulk excavation levels, and the anticipated relatively low permeability of the bedrock profile, expected to be on the order of 10^{-7} m/sec, we consider that construction of a drained basement design would be feasible and appropriate. Groundwater seepage into the basement excavation would be expected to reduce as the excavation progresses, and the surrounding profile is drained. Locally higher inflows could be expected to occur through open joints or bedding planes during and following heavy rainfall events. Such a process would not be expected to cause any adverse effects on any surrounding structures or improvements.

Long term groundwater flows would be expected to be of limited volume and would be able to be controlled by draining to a sump, or sumps for periodic pumped disposal to the stormwater system.



Groundwater seepage into the excavation should be monitored by the site foreman and geotechnical engineer as excavation progresses to confirm that seepage volumes are within the range anticipated.

4.3 Retention

Where space permits, temporary batter slopes within the fill, natural soils and Class V bedrock of 1 Vertical (V) to 1 Horizontal (H) are recommended in the short term, provided that no surcharge loads, including construction loads and existing footing loads, are placed at the top of the batters. However, as the proposed basement will extend to the site boundaries around the majority of the basement perimeter, such batter slopes will not be feasible in some areas. Therefore, we consider that the excavation will need to be supported by an engineer designed shoring system installed prior to excavation commencing. Such shoring will also be required to support areas where the portion of the service tunnel on the existing site is removed.

The shoring system(s) may be incorporated into the permanent basement retention system. The effect of ground movements on any structures and services that lie within the influence zone of the excavation must also be taken into account. The influence zone of the excavation may be defined as a horizontal distance of $2H$ (where 'H' is the depth of the excavation in metres) behind the wall.

To reduce excavation induced movements along site boundaries, the shoring system(s) would most likely need to be anchored or braced as the excavation progresses.

The piles should be installed to sufficient depth below bulk excavation level, including below footing and service excavations, to satisfy stability and founding considerations.

4.4 Footings

On completion of bulk excavation, bedrock, predominantly sandstone, is expected to be exposed over the entire basement excavation. We therefore recommend that the proposed building be uniformly supported on footings founded in the bedrock profile.

4.5 On-Grade Floor Slabs

The basement on-grade floor slabs will directly overlie bedrock and no particular subgrade preparation will be required.



Slab-on-grade construction is therefore considered appropriate. Underfloor drainage must however be provided. The underfloor drainage should connect with the wall drains, where appropriate, and direct groundwater seepage to a sump(s) for pumped disposal to a stormwater system. Joints in the on-grade floor slabs should incorporate dowels or keys.

4.6 Soil Aggression

Based on the soil chemistry test results, a 'Moderate' exposure classification for concrete piles is applicable in accordance with Table 6.4.2 (C) in AS2159-2009.

4.7 Earthquake Design

In accordance with Table 4.1 of AS1170.4-2007, the site subsoil class is 'Class B_e – Rock'.

5 GENERAL COMMENTS

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

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

This report 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 JK Geotechnics. 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.

TABLE A
MOISTURE CONTENT TEST REPORT

Client:	JK Geotechnics	Ref No:	29775ZN
Project:	Proposed Development	Report:	A
Location:	8 & 10 University Avenue, Macquarie Park, NSW	Report Date:	17/10/2016

Page 1 of 1

AS 1289	TEST METHOD	2.1.1
BOREHOLE NUMBER	DEPTH m	MOISTURE CONTENT %
1	1.50-1.61	9.4
1	2.00-2.50	8.1
2	2.00-2.50	4.1
2	3.50-4.00	4.3
3	2.50-2.80	6.0
3	4.00-4.50	9.6
4	1.50-1.63	13.2
5	1.50-1.58	12.1
5	2.00-2.50	4.5
6	3.00-3.50	5.7



SOIL TEST SERVICES

ABN 43 002 145 173

TABLE B
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Development
Location: 8 & 10 University Avenue,
 Macquarie Park, NSW

Ref No: 29775ZN
Report: B
Report Date: 17/10/2016
Page 1 of 3

BOREHOLE NUMBER	DEPTH m	I_s (50) MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH
			(MPa)
1	4.22-4.25	0.4	8
	4.91-4.95	0.3	6
	5.27-5.31	0.5	10
	5.84-5.88	0.3	6
	6.16-6.21	2.2	44
	7.00-7.03	1.2	24
	7.13-7.17	0.2	4
	7.84-7.88	0.7	14
	8.29-8.33	0.6	12
	8.96-9.00	1.6	32
	9.23-9.26	2.5	50
	10.45-10.49	1.3	26
	10.97-11.00	2.3	46
	11.57-11.61	2.1	42
2	4.76-4.80	1.9	38
	5.48-5.53	0.8	16
	6.08-6.12	1.3	26
	6.87-6.91	2.2	44
	7.58-7.62	1.5	30
	8.16-8.20	2.6	52
	8.95-8.99	1.1	22
	9.44-9.47	2.1	42
	10.13-10.18	0.7	14
	10.93-10.97	0.8	16
	11.35-11.39	0.8	16
	11.52-11.56	2.0	40

NOTES: See Page 3 of 3



SOIL TEST SERVICES

ABN 43 002 145 173

TABLE B
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Development
Location: 8 & 10 University Avenue,
Macquarie Park, NSW

Ref No: 29775ZN
Report: B
Report Date: 17/10/2016
Page 2 of 3

BOREHOLE NUMBER	DEPTH m	$I_{s(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH
			(MPa)
3	6.71-6.75	0.7	14
	7.25-7.29	0.5	10
	7.98-8.00	1.6	32
	8.64-8.67	0.5	10
	8.83-8.87	1.2	24
	9.62-9.66	1.6	32
	10.00-10.04	0.8	16
	10.96-11.00	1.7	34
	11.53-11.57	2.3	46
	12.35-12.40	1.4	28
4	3.50-3.53	0.4	8
	4.06-4.09	0.2	4
	4.78-4.82	0.1	2
	5.84-5.88	0.1	2
	6.39-6.42	0.07	1
	6.93-6.96	0.3	6
	7.32-7.36	0.8	16
	7.97-8.00	0.9	18
	8.29-8.32	0.8	16
	8.78-8.83	2.2	44
5	9.70-9.73	1.0	20
	3.05-3.08	0.8	16
	3.81-3.83	1.7	34
	4.32-4.35	1.2	24
	4.95-5.00	6.3	126
	5.53-5.57	3.9	78

NOTES: See Page 3 of 3



SOIL TEST SERVICES

ABN 43 002 145 173

TABLE B
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	Ref No:	29775ZN
Project:	Proposed Development	Report:	B
Location:	8 & 10 University Avenue, Macquarie Park, NSW	Report Date:	17/10/2016

Page 3 of 3

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH
			(MPa)
5	6.18-6.22	1.8	36
	6.96-7.00	1.6	32
	7.82-7.86	2.1	42
	8.49-8.54	1.6	32
6	4.62-4.66	1.5	30
	5.40-5.43	0.5	10
	6.00-6.04	1.1	22
	6.80-6.84	0.7	14
	7.32-7.37	1.4	28
	8.15-8.20	1.7	34
	8.98-9.00	2.9	58
	9.36-9.40	2.4	48

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1MPa, or to one significant figure if less than 0.1MPa
5. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :

$$U.C.S. = 20 I_{S(50)}$$

BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~70.6 m
Date: 6/10/16 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** M.E./N.E.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	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 OF AUGERING										FILL: Silty sand, fine to medium grained, dark brown, with roots and root fibres, trace of fine to medium grained igneous and shale gravel.	D			GRASS COVER
					N > 10 10, 10/ 30mm REFUSAL	70				as above, but trace of clay fines.				APPEARS POORLY COMPACTED
							1		-	FILL: Silty sand, fine to coarse grained, brown and grey, with fine to medium grained igneous and shale gravel and clay fines.	XW	EL		
					N > 4 20, 4/ 10mm REFUSAL	69				SHALE: grey and red brown, with iron indurated bands and clay bands.				
							2			SHALE: dark grey and red brown, trace of iron indurated bands.	DW	VL - L		VERY LOW TO LOW 'TC' BIT RESISTANCE
						68				REFER TO CORED BOREHOLE LOG				
							3							
							67							
							4							
							66							
							5							
							65							
							6							
							64							

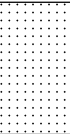
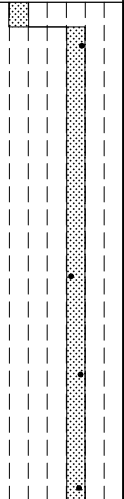
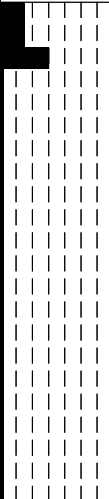
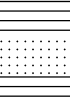
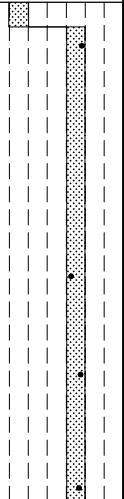
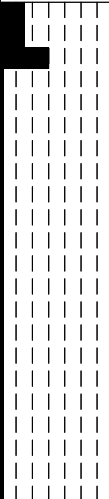
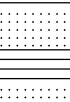
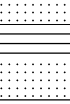
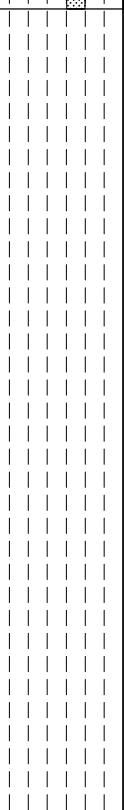
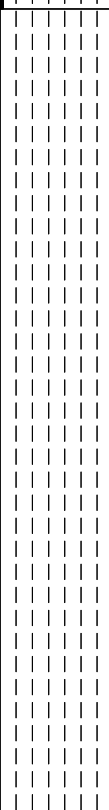
CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~70.6 m
Date: 6/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
								EL-0.03 VL-0.1 L-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
			68		START CORING AT 2.62m					
			3		CORE LOSS 0.64m					
			67		SHALE: dark grey, with red brown iron indurated bands and clay bands, highly fractured.	DW	L			
			4		SILTSTONE: grey, with occasional light grey sandstone laminae bedded at 0-5°.	SW	L - M			
			66		SANDSTONE: fine grained, grey and light brown, with iron indurated seams, bedded at 0-10°.					
			5							
			65							
			6				H			
			64							
			7				L			
			63				M			
			8							
			62		as above, but without iron indurated seams.	FR	H			

Job No.: 29775ZN	Core Size: NMLC	R.L. Surface: ~70.6 m
Date: 6/10/16	Inclination: VERTICAL	Datum: AHD
Plant Type: JK300	Bearing: N/A	Logged/Checked By: M.E./N.E.S.

CORE DESCRIPTION										DEFECT DETAILS					
Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT SPACING (mm)	DESCRIPTION					
										Type, inclination, thickness, planarity, roughness, coating.					
Specific											General				
100% RETURN			61		SANDSTONE: fine grained, grey and light brown, bedded at 0-10°.	DW	VL			(9.24m) XWS, 5°, 10 mm.t (9.35m) XWS, 5°, 10 mm.t					
		10		LAMINITE: thinly laminated fine grained sandstone and siltstone, grey and light grey, bedded at 0-5°							FR	H			(11.38m) J, 40°, P, R
		60													
		11													
		59		END OF BOREHOLE AT 11.67 m											
			12		END OF BOREHOLE AT 11.67 m										
	58														
	13														
	57														
	14														
	56		15												
		55													

29775ZN BHI START CORING AT 2.62m

2

CORE LOSS 0.64m

3

4

5

6

7

8

9

10

11

END OF HOLE 11.67m



Borehole No.
2
1 / 3

BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~69.3 m
Date: 6/10/16 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** M.E./N.E.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	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 OF AUGERING						69				FILL: Silty sand, fine to medium grained, dark brown, with fine to medium grained igneous and shale gravel, roots and root fibres, trace of clay fines.	D			GRASS COVER
					N = 22 5,9,13		1		CL-CH	SILTY CLAY: medium to high plasticity, with ironstone gravel bands.	MC<PL	H	590 >600 >600	RESIDUAL
						68			-	SHALE: grey and red brown, with iron indurated bands.	DW	VL		VERY LOW 'TC' BIT RESISTANCE
							2					M		MODERATE RESISTANCE WITH HIGH BANDS
						67								
							3							
						66								
							4							
						65				REFER TO CORED BOREHOLE LOG				
							5							
						64								
							6							
						63								

CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~69.3 m
Date: 6/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
								EL-0.03 VL-0.1 L-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
					START CORING AT 4.28m					
			65		CORE LOSS 0.11m					
					LAMINITE: thinly laminated fine grained sandstone and siltstone, grey and light grey, bedded at 0-10°.	SW	M - H			(4.42m) Cr, 0°, 10 mm.t (4.49m) XWS, 0°, 5 mm.t (4.68m) XWS, 0°, 70 mm.t (4.92m) XWS, 10°, 30 mm.t (5.02m) XWS, 0°, 50 mm.t
			5							
			64				H			(5.55m) XWS, 10°, 10 mm.t
			6							(5.99m) Cr, 0°, 20 mm.t, IS
			63							(6.86m) XWS, 5°, 20 mm.t
			7							
			62		CORE LOSS 0.06m	FR	H			
					LAMINITE: thinly laminated fine grained sandstone and siltstone, grey and light grey, bedded at 0-10°.					
			8							
			61							
					as above, but brown and grey.					
			9		LAMINITE: thinly laminated fine grained sandstone and siltstone, grey and light grey, bedded at 0-10°.					(8.91m) J, 65°, P, R, IS
			60							
			10		SANDSTONE: fine grained, light grey, with siltstone laminae, bedded at 0-10°.	SW	L			(9.85m) J, 70°, P, R (9.88m) Cr, 5°, 20 mm.t (9.94m) J, 50 - 60°, Un, R, IS (10.03m) HEALED J, 70°, Un (10.08m) J, 45°, P, S, CLAY INFILL 30mm.t
			59			FR	M			

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Borehole No.
2
3 / 3

CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~69.3 m
Date: 6/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
50% RETURN		58			SANDSTONE: fine grained, light grey, with siltstone laminae, bedded at 0-10°. <i>(continued)</i>	FR	M	EL-0.03 VL-0.1 J-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
					END OF BOREHOLE AT 11.67 m		H			(11.23m) XWS, 5°, 5 mm.t
			12							CLASS 18 PVC STANDPIPE INSTALLED TO 11.67m DEPTH. CASING FROM 2.67m TO SURFACE, BACKFILLED WITH 2mm SAND FILTER SAND FROM 11.67m TO 2.1m DEPTH. BENTONITE PLUG FROM 2.1m TO 0.3m DEPTH, COMPLETED WITH CAST IRON GATIC COVER AND CONCRETE.
		57								
			13							
		56								
			14							
		55								
			15							
		54								
			16							
		53								
			17							
		52								

JK_LIB_CURRENT - V8.00.GLB Log J & K CORED BOREHOLE - MASTER 29775ZN MACQUARIE UNI.GPJ <<DrawingFile>> 08/11/2016 10:58 Produced by gINT Professional. Developed by Datigel

JK Geotechnics



JOB No. 29775ZN BH2 START CORING AT 4.28m

4

CORE LOSS
0.11m

5

6

7

C/Loss
0.06m

8

9

10

11

END OF HOLE AT 11.67m



Borehole No.
3
1 / 3

BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~69.5 m
Date: 10/10/16 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** M.E./N.E.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	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 OF AUGERING										FILL: Silty sand, fine to coarse grained, dark brown, with root fibres, trace of clay fines.	D			MULCH COVER
					N = 21 9,10,11	69	1		CH	SILTY CLAY: high plasticity, grey, red brown and brown, with ironstone and shale bands.	MC<PL	H	>600 >600 >600	RESIDUAL
									-	SHALE: grey, red brown and brown, trace of iron indurated bands and clay bands.	XW	EL		
					N = 22 1,7,15	68	2						>600 >600 >600	VERY LOW 'TC' BIT RESISTANCE
						67	3			as above, but without clay bands.	DW	VL - L		
						66	4							
						65	5							
						64								LOW RESISTANCE WITH MODERATE BANDS
							6			REFER TO CORED BOREHOLE LOG				
							63							

CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~69.5 m
Date: 10/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
								EL-0.03 VL-0.1 L-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
		64			START CORING AT 5.82m					
			6		CORE LOSS 0.19m					
			63		SANDSTONE: fine grained, brown and grey, with red brown iron indurated bands.	XW DW	EL M			
			7		LAMINITE: thinly laminated fine grained sandstone and siltstone, grey brown and light grey, bedded at 0-5°.					(6.54m) XWS, 0°, 40 mm.t (6.74m) Be, 10°, Un, R, IS (6.79m) J, 30°, P, R, IS (6.83m) J, 15°, P, R, IS (6.87m) J, 15°, P, R (6.89m) J, 15°, Un, R, IS (7.10m) J, 65°, Un, R, IS (7.17m - 7.33m) 4x HEALED JOINTS, 25-70° (7.29m) J, 20°, Un, R, IS (7.34m) J, 40°, Un, R, IS
			62							(7.58m) J, 65°, P, R, IS (7.80m) J, 70 - 90°, Un, R, IS
			8			SW	M - H			(8.36m) J, 80°, Un, R, IS (8.59m) J, 35°, Un, R, IS (8.69m) Cr, 0°, 40 mm.t (8.81m) J, 50°, P, S
			61							(9.07m) J, 80°, P, R
			9							
			60		SANDSTONE: fine to medium grained, light grey and brown, bedded at 0-5°.					
			10				H			(10.33m) J, 75 - 90°, Un, R
			59			FR				
			11							
			58							

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Borehole No.
3
3 / 3

CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~69.5 m
Date: 10/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
100% RETURN		57			SANDSTONE: fine to medium grained, light grey and brown, bedded at 0-5°. <i>(continued)</i>	FR	H	EL-0.03 VL-0.1 J-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
					END OF BOREHOLE AT 12.55 m					CLASS 18 PVC STANDPIPE INSTALLED TO 12.55m DEPTH. SLOTTED 12.55m TO 3.0m DEPTH, CASING FROM 3.0m TO SURFACE, BACKFILLED WITH 2mm SAND FILTER SAND FROM 12.55m TO 2.5m DEPTH, BENTONITE PLUG FROM 2.5m TO 0.3m DEPTH, COMPLETED WITH CAST IRON GATIC COVER AND CONCRETE.

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JOB No. 29775ZN BH3 STARTED CORING AT 5.82m | CORE LOSS 0.19m

6

7

8

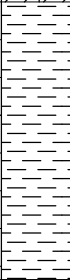
9

10

11

12

END OF HOLE AT 12.55m

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	US	DB	DS										
DRY ON COMPLETION OF AUGERING 100% FILLING OF GWT PENETROMETER						66	1	 	CL-CH	FILL: Silty sand, fine to medium grained, grey brown, trace of fine grained ironstone and shale gravel, clay fines and root fibres. SILTY CLAY: medium to high plasticity, red brown and grey, trace of ironstone bands and root fibres.	D MC<PL	H	>600 >600 >600	RESIDUAL
						65	2		-	SHALE: grey and red brown, with iron indurated bands.	XW DW	EL L		LOW 'TC' BIT RESISTANCE MODERATE RESISTANCE
						64								
						63	3			REFER TO CORED BOREHOLE LOG				
						62	4							
						61	5							
						60	6							

CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~66.6 m
Date: 10/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
								EL-0.03 VL-0.1 L-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
		64			START CORING AT 2.87m					
			3		CORE LOSS 0.05m SANDSTONE: fine grained, grey brown, with red brown iron indurated bands, bedded at 0-5°.	DW	L - M			(3.12m) J, 40°, P, R (3.20m) 4x JOINTS, 0-20° (3.25m) Be, 10°, P, R, IS (3.43m) Be, 5°, Un, R (3.65m) Cr, 0°, 15 mm.t (3.69m) XWS, 5°, 5 mm.t (3.79m) XWS, 5°, 10 mm.t (3.95m) XWS, 0°, 50 mm.t (4.24m) XWS, 15°, 30 mm.t (4.34m) J, 70°, Un, S (4.38m) XWS, 5°, 60 mm.t (4.41m) J, 60°, P, S
			4				VL - L			
			5			XW	EL			
			6							
			61			DW	VL - L			
			6							
			60				L - M			
			7							
			59			SW	M			
			8							
			58		LAMINITE: thinly laminated fine grained sandstone and siltstone, grey and light grey, bedded at 0-5°.	FR	M - H			(8.63m) CS, 5°, 50 mm.t



Borehole No.
4
3 / 3

CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~66.6 m
Date: 10/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
100% RETURN		57			LAMINITE: thinly laminated fine grained sandstone and siltstone, grey and light grey, bedded at 0-5°. (continued)	FR	M - H	EL-0.03 VL-0.1 J-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
			10		END OF BOREHOLE AT 9.80 m					
			56							
			11							
			55							
			12							
			54							
			13							
			53							
			14							
			52							
			15							
			51							

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JOB No. 29775ZN BH4 START CORING AT 2.87m

C/L
0.05m

2

3

4

5

6

7

8

9

E.O.H 9.80m



Borehole No.
5
1 / 2

BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~63.2 m
Date: 7/10/16 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** M.E./N.E.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	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 OF AUGERING						63				FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained sandstone gravel.	D			MULCH COVER APPEARS MODERATELY COMPACTED
					N = 10 4,4,6		1			FILL: Gravel, fine to coarse grained shale and sandstone, with fine to medium grained sand, silt and clay fines and shale and sandstone cobbles.				
						62				FILL: Silty sand, fine to coarse grained, dark brown, trace of medium grained sandstone gravel, clay fines and root fibres.	M			
					N=SPT 7/ 80mm REFUSAL		2		-	SANDSTONE: fine grained, grey and yellow brown, with iron indurated bands and clay bands. SANDSTONE: fine to medium grained, light grey, yellow and red brown.	XW DW	EL L		VERY LOW 'TC' BIT RESISTANCE
							3			REFER TO CORED BOREHOLE LOG				
						60								
							4							
						59								
							5							
						58								
							6							
						57								

CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~63.2 m
Date: 7/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
		61			START CORING AT 2.75m					
					CORE LOSS 0.16m					
		60	3		SANDSTONE: fine to medium grained, grey and yellow brown, with red brown iron indurated bands, bedded at 0-5°.	SW	M			— (3.24m) Be, 10°, Un, R, IS — (3.34m) HEALED J, 45°, P
			4		as above, but trace of grey siltstone laminae.		H			
		59								— (4.42m) XWS, 10°, 10 mm.t
			5		SANDSTONE: fine grained, light grey, bedded at 0-5°.	FR	VH			
		58								
			6				H			
		57								
			7							— (7.57m) J, 25°, Un, R
		56								
			8							— (8.43m) J, 30°, Un, R
		55								
					as above, but with dark grey shale lenses.					
					END OF BOREHOLE AT 8.56 m					

JK_LIB_CURRENT - V8.00.GLB Log J & K CORED BOREHOLE - MASTER 29775ZN MACQUARIE UNI.GPJ <<DrawingFile>> 08/11/2016 10:58 Produced by gINT Professional. Developed by Datagel

JK Geotechnics

JOB No 29775ZN START CORING AT 2.75m BH5

2

CORE LOSS
0.16m

3

4

5

6

7

8

END OF HOLE AT 8.56m.

1 / 2

Client: MACQUARIE UNIVERSITY														
Project: PROPOSED DEVELOPMENT														
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW														
Job No.: 29775ZN				Method: SPIRAL AUGER				R.L. Surface: ~62 m						
Date: 7/10/16				Datum: AHD										
Plant Type: JK300				Logged/Checked By: M.E./N.E.S.										
Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	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 OF AUGERING					N = 17 5,8,9		1		SC	FILL: Silty sand, fine to coarse grained, dark brown, with fine to coarse grained shale and igneous gravel, roots and root fibres. FILL: Clayey sand, fine to coarse grained, brown, grey and red brown, with fine to coarse grained ironstone and sandstone gravel and root fibres. CLAYEY SAND: fine to medium grained, brown, grey and red brown, with ironstone gravel bands.	D			GRASS COVER APPEARS MODERATELY COMPACTED
					N = 22 6,9,13		2		CL	SANDY CLAY: medium plasticity, grey and red brown, fine grained sand, with ironstone gravel bands and silt fines.	MC<PL	H	450 520 510	
							3		-	SANDSTONE: fine grained, yellow brown.	XW	EL		VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
							4				DW	L - M		LOW RESISTANCE
							5							LOW TO MODERATE RESISTANCE
							6							
										REFER TO CORED BOREHOLE LOG				

CORED BOREHOLE LOG

Client: MACQUARIE UNIVERSITY
Project: PROPOSED DEVELOPMENT
Location: 8 & 10 UNIVERSITY AVENUE, MACQUARIE PARK, NSW

Job No.: 29775ZN **Core Size:** NMLC **R.L. Surface:** ~62 m
Date: 7/10/16 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** M.E./N.E.S.

Water Loss/Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_p(50)$	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
								EL-0.03 VL-0.1 L-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
					START CORING AT 4.32m					
					CORE LOSS 0.23m					
			57	5	SANDSTONE: fine grained, grey and yellow brown, bedded at 0-20°.	SW	M - H			(4.58m) CS, 15°, 15 mm.t (4.92m) XWS, 0°, 70 mm.t (5.29m) HEALED J, 45°, P (5.35m) J, 75°, P, R, IS
			56	6						
			55	7	as above, but light grey, with siltstone laminae.		H			(6.78m) HEALED J, 20°, P (6.93m) Cr, 20°, 20 mm.t (6.98m) HEALED J, 25°, Un (7.10m) XWS, 10°, 20 mm.t
			54	8	LAMINITE: thinly laminated fine grained sandstone and siltstone, light grey and grey, bedded at 0-5°.	FR				(7.84m) XWS, 0°, 5 mm.t
			53	9	SANDSTONE: fine grained, light grey, with siltstone laminae, bedded at 0-5°.					
			52	10	END OF BOREHOLE AT 9.44 m					CLASS 18 PVC STANDPIPE INSTALLED TO 9.44m DEPTH, SLOTTED 9.44m TO 2.94m DEPTH, CASING FROM 2.94m TO SURFACE, BACKFILLED WITH 2mm SAND FILTER SAND FROM 9.44m TO 2.5m DEPTH, BENTONITE PLUG FROM 2.5m TO 0.3m DEPTH, COMPLETED WITH CAST IRON GATIC COVER AND CONCRETE.

JK_LIB_CURRENT - V8.00.GLB Log J & K CORED BOREHOLE - MASTER 29775ZN MACQUARIE UNI.GPJ <DrawingFile> 08/11/2016 10:58 Produced by gINT Professional. Developed by Datigel

JK Geotechnics

29775ZN BH6 START CORING AT 4.32m

4

CORE LOSS
0.23m

5

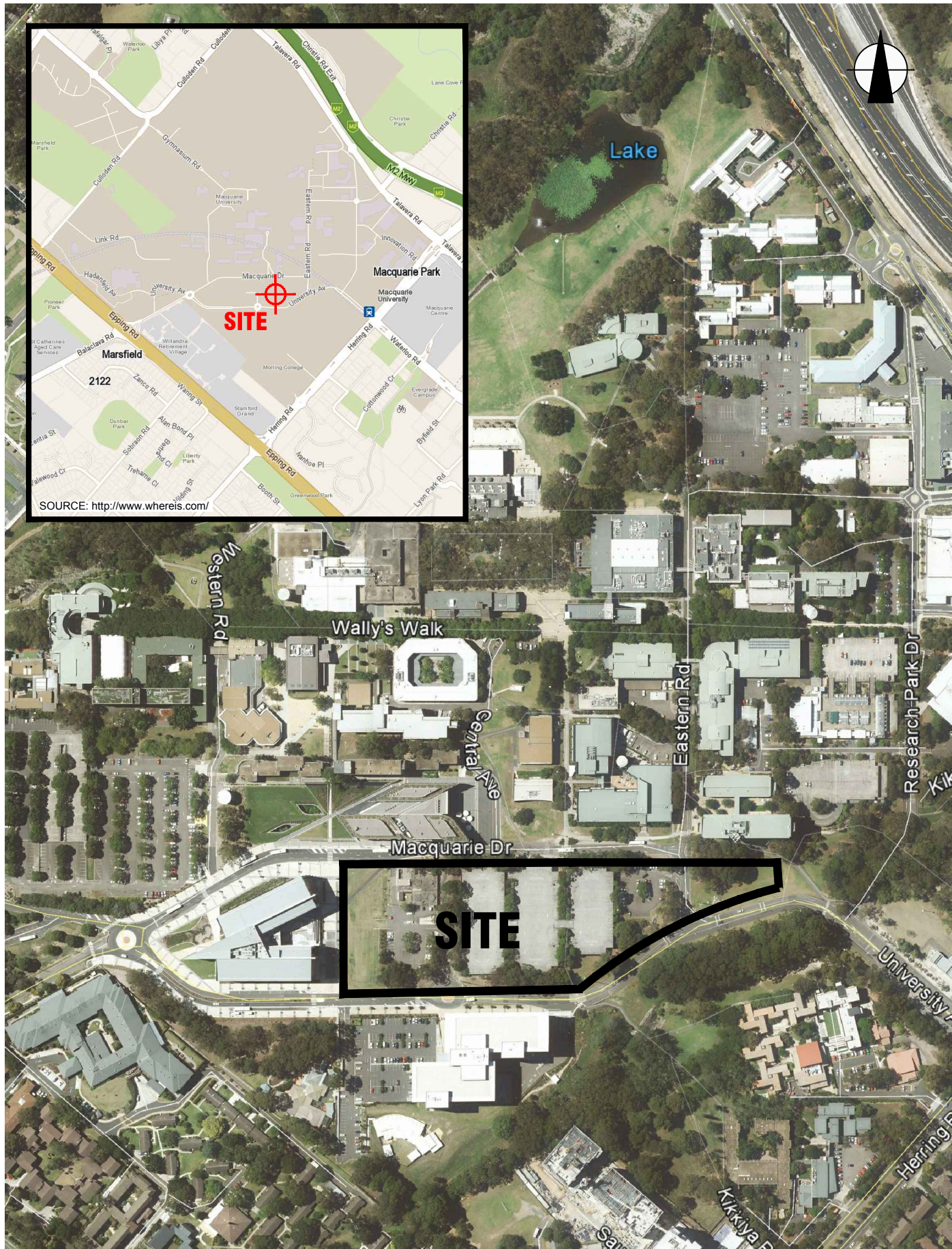
6

7

8

9

END OF HOLE AT 9.44m



AERIAL IMAGE SOURCE: GOOGLE EARTH PRO 7.1.5.1557
AERIAL IMAGE ©: 2015 GOOGLE INC.

Title:

SITE LOCATION PLAN

Location:

8 & 10 UNIVERSITY AVENUE
MACQUARIE PARK, NSW

Report No:

29775ZN

Figure No:

1

JK Geotechnics



This plan should be read in conjunction with the JK Geotechnics report.



VIBRATION EMISSION DESIGN GOALS

German Standard DIN 4150 – Part 3: 1999 provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 1 below.

It should be noted that peak vibration velocities higher than the minimum figures in Table 1 for low frequencies may be quite 'safe', depending on the frequency content of the vibration and the actual condition of the structure.

It should also be noted that these levels are 'safe limits', up to which no damage due to vibration effects has been observed for the particular class of building. 'Damage' is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. Should damage be observed at vibration levels lower than the 'safe limits', then it may be attributed to other causes. DIN 4150 also states that when vibration levels higher than the 'safe limits' are present, it does not necessarily follow that damage will occur. Values given are only a broad guide.

Table 1: DIN 4150 – Structural Damage – Safe Limits for Building Vibration

Group	Type of Structure	Peak Vibration Velocity in mm/s			
		At Foundation Level at a Frequency of:			Plane of Floor of Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use.	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 and 2 and have intrinsic value (eg. buildings that are under a preservation order).	3	3 to 8	8 to 10	8

Note: For frequencies above 100Hz, the higher values in the 50Hz to 100Hz column should be used.



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 (e.g. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 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 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.



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

FILL

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

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

LABORATORY TESTING

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

ENGINEERING REPORTS

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

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

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

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

SITE ANOMALIES

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

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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

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

REVIEW OF DESIGN

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

SITE INSPECTION

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

Requirements could range from:

- i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
- ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
- iii) full time engineering presence on site.



GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL		ROCK		DEFECTS AND INCLUSIONS	
	FILL		CONGLOMERATE		CLAY SEAM
	TOPSOIL		SANDSTONE		SHEARED OR CRUSHED SEAM
	CLAY (CL, CH)		SHALE		BRECCIATED OR SHATTERED SEAM/ZONE
	SILT (ML, MH)		SILTSTONE, MUDSTONE, CLAYSTONE		IRONSTONE GRAVEL
	SAND (SP, SW)		LIMESTONE		ORGANIC MATERIAL
	GRAVEL (GP, GW)		PHYLLITE, SCHIST		
	SANDY CLAY (CL, CH)		TUFF		CONCRETE
	SILTY CLAY (CL, CH)		GRANITE, GABBRO		BITUMINOUS CONCRETE, COAL
	CLAYEY SAND (SC)		DOLERITE, DIORITE		COLLUVIUM
	SILTY SAND (SM)		BASALT, ANDESITE		
	GRAVELLY CLAY (CL, CH)		QUARTZITE		
	CLAYEY GRAVEL (GC)				
	SANDY SILT (ML)				
	PEAT AND ORGANIC SOILS				



UNIFIED SOIL CLASSIFICATION TABLE

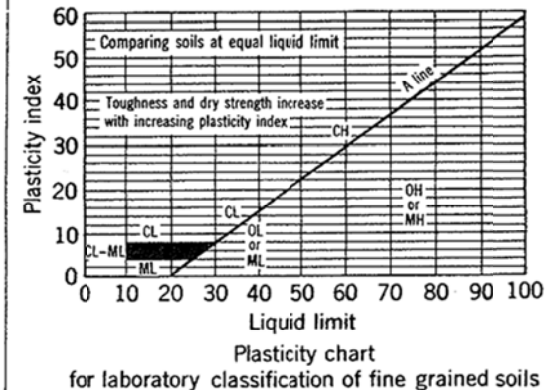
Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)					Group Symbols	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria													
Coarse-grained soils More than half of material is larger than 75 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: <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													
			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 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																	
	Identification Procedures on Fraction Smaller than 380 μm Sieve Size																				
Fine-grained soils More than half of material is smaller than 75 μm sieve size (The 75 μm sieve size is about the smallest particle visible to naked eye)	Sils and clays liquid limit less than 50	Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)		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: <i>Clayey silt, brown</i> ; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML)	$C_U = \frac{D_{60}}{D_{10}}$ 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 Atterberg limits below "A" line with PI greater than 7												
										None to slight	Quick to slow	None									
										Medium to high	None to very slow	Medium									
										Slight to medium	Slow	Slight									
	Sils 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	Pt	Peat and other highly organic soils

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 5% GM, GC, SM, SC Borderline cases requiring use of dual symbols	
Plasticity index	

Comparing soils at equal liquid limit	
Toughness and dry strength increase with increasing plasticity index	
A line	
OH or MH	
CL or ML	
CL-MH	
ML	
Liquid limit	
Plasticity chart for laboratory classification of fine grained soils	

Determine percentages of gravel and sand from grain size curve
Depending on percentage of fines (fraction smaller than 75 μ m sieve size) coarse grained soils are classified as follows:
Less than 5% GW, GP, SW, SP
More than 12% GM, GC, SM, SC
Borderline cases requiring use of dual symbols

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



- Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. 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 _c =	5	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.
		7	
		3R	
	VNS = 25 PID = 100		Vane shear reading in kPa of Undrained Shear Strength. 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_D) Range (%) Very Loose <15	SPT 'N' Value Range (Blows/300mm) 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.	
		Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.	



LOG SYMBOLS continued

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	

APPENDIX A



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Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS

155282

Client:

JK Geotechnics
PO Box 976
North Ryde BC
NSW 1670

Attention: M Egan

Sample log in details:

Your Reference:	29775ZN, Macquarie Park
No. of samples:	4 Soils
Date samples received / completed instructions received	13/10/16 / 13/10/16

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	20/10/16 / 20/10/16
Date of Preliminary Report:	Not Issued

NATA accreditation number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025 - Testing

Tests not covered by NATA are denoted with *.

Results Approved By:

David Springer
General Manager



Envirolab Reference: 155282
Revision No: R 00

Misc Inorg - Soil					
Our Reference:	UNITS	155282-1	155282-2	155282-3	155282-4
Your Reference	-----	BH2	BH3	BH6	BH6
	-				
Depth	-----	0.5-0.95	0.5-0.95	0.75-0.95	1.5-1.95
Date Sampled		6/10/2016	10/10/2016	7/10/2016	7/10/2016
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	18/10/2016	18/10/2016	18/10/2016	18/10/2016
Date analysed	-	18/10/2016	18/10/2016	18/10/2016	18/10/2016
pH 1:5 soil:water	pH Units	4.3	4.8	5.2	4.6
Chloride, Cl 1:5 soil:water	mg/kg	20	<10	<10	20
Sulphate, SO4 1:5 soil:water	mg/kg	130	26	50	87
Resistivity in soil*	ohmm	83	310	200	120

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.

Client Reference: 29775ZN, Macquarie Park

QUALITY CONTROL	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results	Spike Sm#	Spike % Recovery
Misc Inorg - Soil						Base II Duplicate II %RPD		
Date prepared	-			18/10/2016	[NT]	[NT]	LCS-1	18/10/2016
Date analysed	-			18/10/2016	[NT]	[NT]	LCS-1	18/10/2016
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-1	99%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-1	102%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-1	104%
Resistivity in soil*	ohmm	1	Inorg-002	<1.0	[NT]	[NT]	[NR]	[NR]

Report Comments:

Asbestos ID was analysed by Approved Identifier: Not applicable for this job
Asbestos ID was authorised by Approved Signatory: Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NR: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike: A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample): This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.