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GEOTECHNICAL INVESTIGATION
4 & 6 BIGGE STREET, LIVERPOOL

FOR

RESITECH AUSTRALIA

PROJECT NO. 10530/2308A **JULY 2009**
REPORT NO. 09/2308A

TABLE OF CONTENTS

1. INTRODUCTION

This report presents the results of a geotechnical investigation for a proposed residential development at 4 & 6 Bigge Street, Liverpool. We understand the development is to consist of eight above ground storeys structure with basement car parking. The latter will involve excavating to a maximum depth of about six metres below the existing groundsurface.

The purpose of the investigation was to:

- determine the subsurface conditions at the site,
- provide comments on the foundation conditions,
- recommend foundation design parameters,
- comment on the temporary and permanent support of the proposed excavation, and
- comment on the rock excavation.

The work was undertaken at the request of Mr. Brett Wood of Resitech Australia.

Our scope of work did not include a contamination assessment.

2. SITE CONDITIONS

The site is some 1759 m^2 in area and is located on the eastern side of Bigge Street. At the time of the fieldwork the site was vacant. The surrounding buildings are residential.

There was no site vegetation, the non building areas were covered by pavement.

The existing groundsurface falls towards the north, relief being about 1.5 metres.

3. GEOLOGY

The Penrith geological series sheet, at a scale of 1:100,000 show the site is underlain by Triassic Age Bringelly Shale of the Wianamatta Group. Rocks within this formation typically comprise shale, claystone and laminite.

No rock outcrops were observed on the site.

4. FIELDWORK

Five boreholes numbered BH101 to BH105 inclusive, were drilled to depths of between 8.0 and 9.2 metres at the locations shown on Drawing No. 09/2308A. The boreholes were advanced using Explorer 2000 drilling rig owned and operated by Terratest Pty Limited. The fieldwork was directed by one of our experienced geologists who chose the borehole locations and logged the subsurface conditions encountered. In order to determine soil strengths Standard Penetration Tests (SPTs) were periodically carried out in each of the boreholes. When the rock was of sufficient strength, it was cored with a diamond encrusted cutting shoe. In order to monitor groundwater levels PVC standpipe piezometers were installed in BH101 and BH103.

The subsurface conditions encountered are recorded on the borehole logs given in Appendix A. Photographs of the rock core retrieved are given in Appendix A together with a description of the terms used on the logs. Notes relating to geotechnical reports are also attached.

The strength of the rock was estimated by undertaking Point Load Strength tests. Results of the testing are given in Appendix B.

5. SUBSURFACE CONDITIONS

We have assumed the subsurface conditions encountered in the borehole are representative of the site.

In making an assessment of the subsurface conditions across a site from a limited number of boreholes there is the possibility that variations may occur between test locations. The data derived from the site investigation programme are extrapolated across the site to from a geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. No matter how comprehensive the investigation may be, it is not always possible to detect all subsurface anomalies and variations that may be present.

The subsurface conditions consist of topsoil, minor filling and silty clays overlying weathered shale and sandstone. Details are given below:

TOPSOIL AND FILL:	Topsoil and with fill are present to depths of 0.4 to 0.5 metres.
SILTY CLAYS:	These are present to depths of 2.7 to 3.9 metres. The strength of these materials range between firm to stiff and very stiff.
SHALE:	Weathered shale was observed in all boreholes to the depth of drilling, 8.0 to 9.2 metres. The shale is of extremely low strength when first encountered and becomes low to medium and medium strength with depth.

When water is used in the drilling process it can mask the real water level present. The groundwater depths were measured on various occasions. The depths recorded are given below:

Date	Depth (m)	
	BH1	BH3
06/07/09	6.7	4.7
07/07/09	6.7	4.7
08/07/09	8.0*	6.9*
13/07/09	6.8	5.6

* Water was bailed out after reading on 07/07/2009.

6. EXCAVATION CONDITIONS AND SUPPORT

The construction of the basement will involve excavating near to the property boundaries. It is of course important that the excavation is adequately supported at all times and that it does not endanger the adjacent properties.

Conventional earth moving equipment, such as excavators, should be capable of removing the soils and some of the jointed rock to a depth of 4 to 5 metres. Below these depths, rock excavation will more than likely require some form of assistance. Care should be taken when using this equipment not to damage adjacent buildings. Based on the subsurface conditions observed in the boreholes and general experience in this geological environment, it is expected that excavation on this site will encounter some medium strength shales. It is important that the excavation contractor has equipment capable of removing this rock.

Excavators alone without assistance from a breaker will probably not be able to remove any significant amount of the rock below about 5 metres. Hydraulic breakers mounted on an excavator or jack hammers will be required to break up the majority of the rock before it can be removed using an excavator. Other forms of excavation that may be required include ripping, sawing and grinding.

Particular care will be required to ensure that buildings or other developments on adjacent properties are not damaged when excavating the rock. Some of the structures on the adjacent properties may be founded directly on the shale. Buildings founded directly on rock can often be very susceptible to damage from vibrations transmitted directly through competent rock.

It is extremely difficult to definitively predict the affect of the above type of excavation on adjacent buildings. There are various relations available that have been used to carry out such predictions, but these do not easily take account of the natural variability of rock. There have been many cases in Sydney where predictions based on experience of the above relationships have been proved inaccurate and adjacent structures have been damaged. For these reasons the following comments should only be taken as a guide. Particular care must be exercised when removing the rock and onsite guidance by a vibration specialist will likely be necessary during the early part of the excavation.

When excavating rock adjacent to buildings in adjoining properties a specialist should be employed to monitor onsite vibrations and advise the permissible size of excavation equipment that can be used. If a specialist is not engaged, rock should not be excavated using large hydraulic rock breakers closer than 20 metres to adjoining buildings. Small rock breakers can be used 5 to 6 metres from adjacent buildings.

Saw cutting should be carried out before any rock breaking is commenced. It would be appropriate before commencing excavation to undertake a dilapidation survey of any adjacent structures that may potentially be damaged. This will provide a reasonable basis for assessing any future claims.

Depending on the proximity of the excavation to some of the property boundaries, temporary support will be required for the soils and rock. Reinforced concrete piles with shotcrete infill are probably the most cost-effective option for providing this support. The piles may be drilled and fixed into the material below the base of the excavation. This will provide one fixing point. Where the pile toe is fixed in the rock a passive pressure of 200 kPa may be adopted for the design with a minimum embedment of 1 metre. Additional support may be provided using rows of anchors. These anchors may be installed into the jointed shale and proportioned using an allowable bond of 300 kPa. All bond lengths should be located outside the active wedge and should not be less than 3 metres.

It is vital that an experienced engineering geologist or geotechnical engineer observes that excavation as it progresses. At that time he will be able to recommend any support that is required for either temporary or permanent conditions.

When considering the design of the supports, it will be necessary to allow for the groundsurface slope, loading from adjacent structures and water pressure. Where the structures are within the zone of influence of the excavation, it will be necessary to adopt K_o conditions when designing the temporary support. Anchors or props can be used to provide the required support. If anchors extend into adjoining properties, it will be necessary to obtain the permission of the property owners. When props or anchors are sued for support, a rectangular earth pressure distribution should be adopted on the active side of the support. The permanent basement support should be designed assuming K_o conditions.

The following parameters are suggested for the design of the temporary and permanent retaining wall system:

Soil & Weathered Shale (to a depth of 4 metres)

Active Earth Pressure Coefficient (K_a) = 0.4

At Rest Pressure Coefficient (K_o) = 0.5

Total (Bulk) Density = 20 kN/m^3

Shale (below a depth of 4 metres)

Earth Pressure Coefficient = 0.1 or horizontal pressure of 10 kPa (whichever is smaller)

Total (Bulk) Density = 23 kN/m^3

7. FOUNDATIONS

The allowable bearing pressures given below have been determined using the procedures given by Pells et al, in their paper titled “Design Loadings for Foundations on Shale and Sandstone in the Sydney Region,” published in the Australian Geomechanics Journal, 1998.

At the proposed depth of founding (6 metres) the low to medium strength rock present is assessed to be at least Class III shale. An allowable bearing pressure of 3.5 MPa may be used to proportion the footings at this level. At the western end of the site it may be necessary to locally deepen the footing excavations to achieve the required strength. This deepening is not expected to be more than 1 metre.

In order to ensure the bearing values given can be achieved, care should be taken to ensure the bases of the excavations are free of all loose material prior to concreting. It is recommended that all footing excavations be protected with a layer of blinding concrete as soon as possible, preferably immediately after excavating, cleaning, inspection and approval. The possible presence of groundwater needs to be considered when pouring concrete.

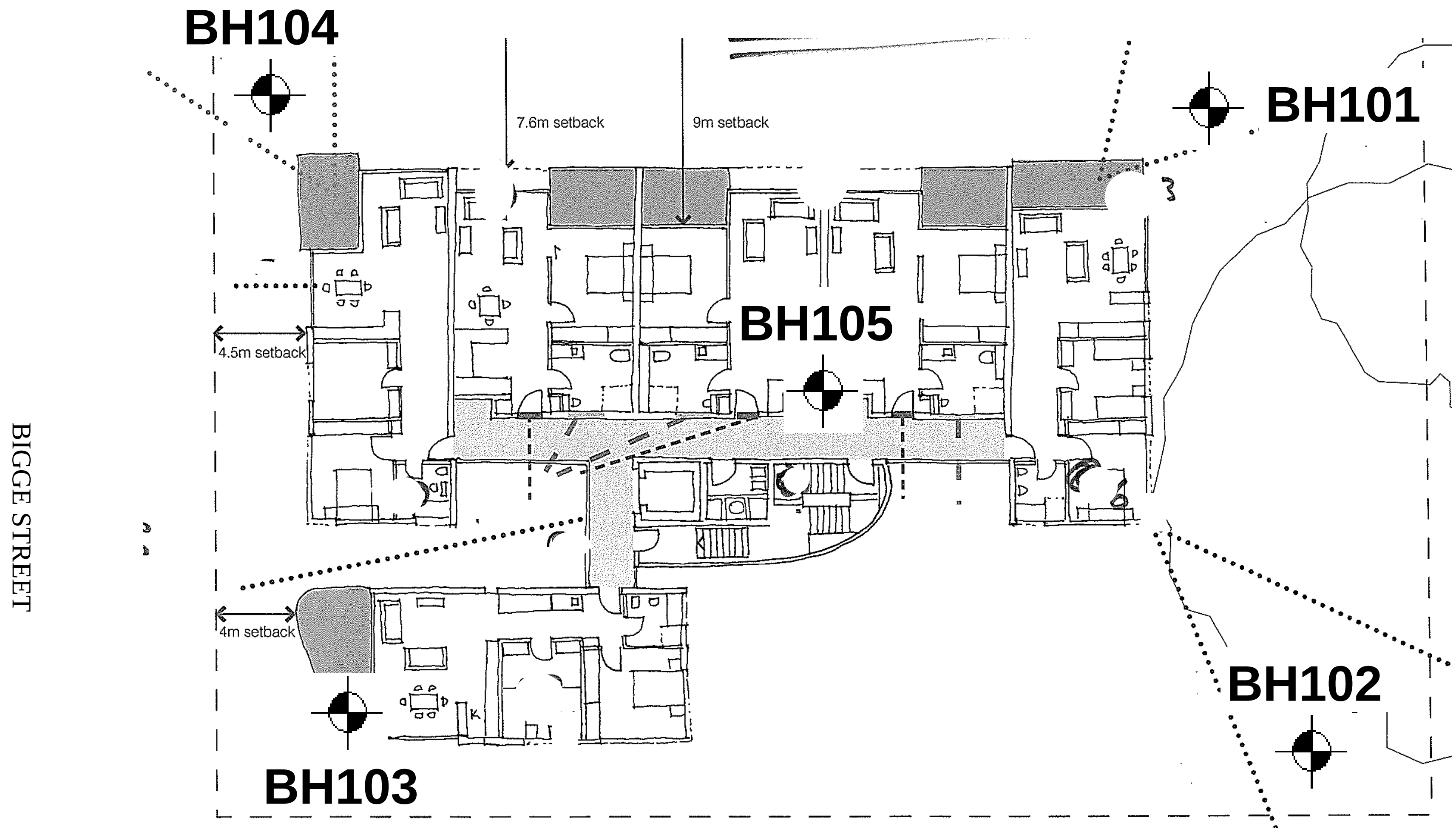
Based on the groundwater levels recorded, some groundwater flow can be expected into the excavation. The amount of water is unknown, however, a sump with a pump should be adequate to remove most of the water.

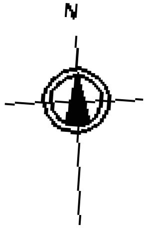
8. FINAL COMMENTS

During construction should the subsurface conditions vary from those inferred above we should be contacted to determine if any changes should be made to our recommendations.

The exposed bearing surfaces should be inspected by a geotechnical engineer to ensure the bearing value given has been achieved.

Laurie Ihnativ, BE, MEngSc, MBA, MIE Aust.
Manager, SMEC Testing Services Pty Limited





SMEC TESTING SERVICES Pty. Ltd.	Scale: Unknown	Date: July 2009
Client: RESITECH AUSTRALIA		
GEOTECHNICAL INVESTIGATION 4-6 BIGGE STREET, LIVERPOOL BOREHOLE LOCATIONS		Project No. 10530/2308A Drawing No: 09/2308A

NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

These notes have been provided to outline the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

When copies of reports are made, they should be reproduced in full.

Geotechnical Reports

Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work and is supplemented by knowledge of the local geology and experience of the range of properties that may be exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (eg. design of a three-storey building), the information and interpretation may not be appropriate if the design is changed (eg. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by SMEC Testing Services Pty Limited in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, SMEC Testing Services Pty Limited would be pleased to resolve the matter through further investigation, analysis or advice.

Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, SMEC Testing Services Pty Limited should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

Subsurface Information

Logs of a borehole, recovered core, test pit, excavated face or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling and/or observation spacings and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume or material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements outside of specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localised perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures mask or prevent groundwater inflow.

The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

Supply of Geotechnical Information or Tendering Purposes

It is recommended tenderers are provided with as much geological and geotechnical information that is available and that where there are uncertainties regarding the ground conditions, prospective tenders should be provided with comments discussing the range of likely conditions in addition to the investigation data.

APPENDIX A

BOREHOLE LOGS & EXPLANATION SHEETS

SMEC Testing Services Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Resitech Australia
Project: 4-6 Bigge Street, Liverpool
Location: Refer to Drawing No. 09/2308A

Project No.: 10530/2308A
Date : July 1, 2009
Logged: JK

BOREHOLE NO.: BH 101

Sheet 1 of 3

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
			SILTY CLAY: dark brown, medium plasticity TOPSOIL	CL	FIRM	M
	SPT 1.0-1.45 m 6, 7, 9 N = 16	1.0	SILTY CLAY: orange brown with light grey, medium plasticity	CL	VERY STIFF	M
		2.0	SILTY CLAY: light grey with orange brown, medium plasticity	CL	STIFF TO VERY STIFF	M
	SPT 2.5-2.95 m 7, 14, 20 N = 34	3.0	SILTY CLAY: light grey with dark grey and occasional red brown, low plasticity, occasional shale gravel (CW shale)	CL	VERY STIFF	M-D
			SHALE: dark grey with red brown, fine grained sand, clay seams		EXTREMELY LOW STRENGTH	D
		4.0 5.0	WASHBORE DRILLING DISCONTINUED AT 3.8 M STANDPIPE PIEZOMETER INSTALLED For core details, refer to core log sheets			

NOTES: D - disturbed sample U - undisturbed tube sample B - bulk sample
WT - level of water table or free water N - Standard Penetration Test (SPT)

See explanation sheets for meaning of all descriptive terms and symbols

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm): 100
Angle from Vertical (°) 0

SMEC Testing Services Pty Ltd **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: Resitech Australia
Project: 4-6 Bigge Street, Liverpool
Location: Refer to Drawing No. 09/2308A
Project / STS No.: 10530/2308A
Date : July 1, 2009
Logged: JK
Checked By: JH
BOREHOLE NO.: BH 101
Sheet 2 of 3

DRILLING				MATERIAL STRENGTH									DISCONTINUITIES						
						Estimated Rock Strength							Joint Spacing (mm)						
Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20	40	100	300	1000	**Visual**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
			1.0																
			2.0																
			3.0																
				For non core details, refer to non core log sheets															
				START CORING AT 3.8 M															
NMLC CORING				SHALE: dark grey, fine grained sand, some light grey/red brown, clay bands	MW		▨								▨				3.8-4.1 m, CZ, Cy
			4.0				▨								▨				
							▨								▨				4.2 m, Jt, 30 deg. Ir, Ro 4.36 m, Jt, 0 deg. Pl, Ro 4.47-4.75 m, numerous Jt opening upon drying
			5.0				▨								▨				5.07 m, Jt, 10 deg. Ir, Ro, 5.15 m, Jt, 0 deg. PL, Ro
				SHALE: dark grey with occasional light grey, fine grained sand	Fr/ St			▨								▨			5.23-5.30 m, Jt, Cy, Fe
								▨								▨			5.68 m, Jt, 0 deg. PL, Ro 5.79 m, Jt, 0 deg. Pl, Ro 5.97 m, Jt, 0 deg. Pl, Ro
			6.0					▨								▨			

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

SMEC Testing Services Pty Ltd **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: Resitech Australia
Project: 4-6 Bigge Street, Liverpool
Location: Refer to Drawing No. 09/2308A
Project / STS No.: 10530/2308A
Date : July 1, 2009
Logged: JK
Checked By: JH
BOREHOLE NO.: BH 101
Sheet 3 of 3

DRILLING				**MATERIAL STRENGTH**										**DISCONTINUITIES**						
						Estimated Rock Strength							**Joint Spacing (mm)**						
Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20	40	100	300	1000	**Visual**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
				SHALE: dark grey with occasional light grey, fine grained sand	Fr/St			▨							▨				6.19 m, Jt, 0 deg. Pl, Sm 6.34 m, Jt, 5 deg. Pl, Sm 6.44 m, Jt, 0 deg. PL, Sm 6.60 m, Jt, 5 deg. Ir. Ro, Cy 6.65-7.0 m, CZ, Cy 7.06 m, Jt, 0 deg. Pl, Ro 7.18 m, Jt, 5 deg. Pl, Ro
			7.0					▨							▨				7.33 m, Jt, 0 deg. PL, Ro 7.38 m, Jt, 0 deg. PL, Ro 7.74 m, Jt, 0 deg. Pl, Sm
			8.0	BOREHOLE DISCONTINUED AT 8.0 M															
			9.0																
			10.0																
			11.0																
			12.0																

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

Project: 4-6 Bigge street, Liverpool
Project No: 10530/2308A
Client: Resitech Australia
Date Cored:1/7/09
Borehole No: 101
Depth (m): 3.8m to 8.0m end
Box 1 of 1

SMEC Testing Services Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Resitech Australia	Project No.: 10530/2308A	**BOREHOLE NO.:**	**BH 102**
Project: 4-6 Bigge Street, Liverpool	Date : July 1, 2009		
Location: Refer to Drawing No. 09/2308A	Logged: JK	Sheet 1 of 3	

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
			SILTY CLAY: dark brown, low plasticity TOPSOIL	CL	FIRM	M
			SILTY CLAY: orange brown with light grey, medium to high plasticity	CL/CH	FIRM TO STIFF	M
	SPT 1.0-1.45 m 3, 4, 5 N = 9 SPT 2.5-2.95 m 4, 7, 12 N = 19	1.0 2.0	SILTY CLAY: light grey with orange brown, medium plasticity occasional to trace of shale gravel	CL	FIRM TO STIFF BECOMING VERY STIFF	M
		3.0	SHALE: dark grey with light grey and orange brown, fine grained sand, clay seams		EXTREMELY LOW STRENGTH	D
		4.0 5.0	WASHBORE DRILLING DISCONTINUED AT 3.9 M For core details, refer to core log sheets			

NOTES: D - disturbed sample	U - undisturbed tube sample	B - bulk sample
WT - level of water table or free water		N - Standard Penetration Test (SPT)

See explanation sheets for meaning of all descriptive terms and symbols

Contractor: Terratest
Equipment: Edson 2000
Hole Diameter (mm): 100
Angle from Vertical (°) 0

SMEC Testing Services Pty Ltd **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: Resitech Australia
Project: 4-6 Bigge Street, Liverpool
Location: Refer to Drawing No. 09/2308A
Project / STS No.: 10530/2308A
Date : July 1, 2009
Logged: JK
Checked By: JH
BOREHOLE NO.: BH 102
Sheet 2 of 3

DRILLING | **MATERIAL STRENGTH** | **DISCONTINUITIES**

Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	Estimated Rock Strength: Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	Joint Spacing (mm)	20	40	100	300	1000	**Visual**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
			1.0 2.0 3.0	For non core details, refer to non core log sheets START CORING AT 3.9 M																
N M L C C O R I N G			4.0	NO CORE - 3.9 - 4.0 M																
				SHALE: dark grey/brown with orange brown, fine grained sand	MW/ HW	▨									▨					Numerous Jt, 0-10 deg. Ir, Ro Cy, opening upon drying
				SHALE: dark grey with orange brown and red brown, fine grained sand		▨	▨								▨					
			5.0	NO CORE - 4.64 - 5.09 M																
				SHALE: dark brown/grey, fine grained sand, clay seams	HW/ MW		▨	▨							▨					Numerous Jt, Ir, Ro, Cy + cy seams
			6.0	SHALE: dark grey with light grey, fine grained sand	Fr/St			▨	▨							▨				5.7 m, Jt, 0 deg. Pl, Sm 5.88 m, Jt, tight 0-90 deg. Fe staining 5.92-6.07 m, Jt, 45 deg. Pl, Sm, Fe veneer

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

SMEC Testing Services Pty Ltd **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: Resitech Australia
Project / STS No.: 10530/2308A
BOREHOLE NO.: BH 102
Project: 4-6 Bigge Street, Liverpool
Date : July 1, 2009
Location: Refer to Drawing No. 09/2308A
Logged: JK
Checked By: JH
Sheet 3 of 3

DRILLING				MATERIAL STRENGTH		Estimated Rock Strength							DISCONTINUITIES Joint Spacing (mm)						
Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20	40	100	300	1000	**Visual**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
				SHALE: dark grey with light grey, fine grained sand	Fr/St			▨	▨						▨				6.04-6.4 M, Jt, 90 deg. Ir, Cy
							▨	▨							▨				6.4 m, Jt, 0 deg. Ir, Ro 6.8 m, Jt, 0 deg. Ir, Ro
			7.0					▨	▨						▨				7.18 m, Jt, 0 deg. Pl, Sm 7.24 m, Pt, 0 deg. 7.33 m, Pt, 0 deg. 7.45 m, Jt, 0 deg. PL, Sm 7.67 m, Jt, 0 deg. Pl, Ro 7.85 m, Jt, 0 deg, Ro, Cy veneer 7.96 m, Jt, 0 deg. Pl, Sm
			8.0	BOREHOLE DISCONTINUED AT 8.0 M															
			9.0																
			10.0																
			11.0																
			12.0																

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

Project: 4-6 Bigge street,
Liverpool
Project No: 10530/2308A
Client: Resitech Australia
Date Cored:1/7/09
Borehole No: 102
Depth (m) 3.9m to 8.0m End
Box 1 of 1

SMEC Testing Services Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Resitech Australia	Project No.: 10530/2308A	**BOREHOLE NO.: BH 103**
Project: 4-6 Bigge Street, Liverpool	Date : July 1, 2009	
Location: Refer to Drawing No. 09/2308A	Logged: JK	Sheet 1 of 3

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
			SILTY CLAY: dark brown with orange brown and light grey, medium plasticity FILL	CL	SOFT	M
	SPT 0.9-1.35 m 3, 5, 8 N = 13	1.0	SILTY CLAY: light grey with orange brown, medium plasticity	CL	FIRM TO STIFF BECOMING STIFF	M
		2.0				
	SPT 2.4-2.85 m 4, 7, 11 N = 18				STIFF TO VERY STIFF	
		3.0				
			SILTY CLAY: light grey with red brown and occasional dark grey, low plasticity, trace of shale and ironstone gravel (CW shale)	CL	HARD	M-D
		4.0	SHALE: ark grey with light grey and occasional orange brown, fine grained sand, clay seams		EXTREMELY LOW STRENGTH	D
		5.0				
			WASHBORE DRILLING DISCONTINUED AT 5.0 M STANDPIPE PIEZOMETER INSTALLED For core details, refer to core log sheets			

NOTES: D - disturbed sample U - undisturbed tube sample B - bulk sample
WT - level of water table or free water N - Standard Penetration Test (SPT)

See explanation sheets for meaning of all descriptive terms and symbols

Contractor: Terratest
Equipment: Edson 2000
Hole Diameter (mm): 100
Angle from Vertical (°) 0

SMEC Testing Services Pty Ltd **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: Resitech Australia	Project / STS No.: 10530/2308A	**BOREHOLE NO.: BH 103**
Project: 4-6 Bigge Street, Liverpool	Date : July 1, 2009	
Location: Refer to Drawing No. 09/2308A	Logged: JK Checked By: JH	Sheet 2 of 3

DRILLING				**MATERIAL STRENGTH**									**DISCONTINUITIES**						
						Estimated Rock Strength							**Joint Spacing (mm)**						
Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20	40	100	300	1000	**Visual**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
			1.0																
			2.0																
			3.0																
			4.0																
				For non core details, refer to non core log sheets															
			5.0	START CORING AT 5.0 M															
N				NO CORE - 5.0 - 5.14 M															
M				SHALE: dark grey, occasional red brown/orange brown,	MW/	▨								▨					5.14-5.31 m, CZ, Cy
L				fine grained sand, clay seams	SW	▨								▨					
C							▨	▨						▨					
C							▨	▨						▨					5.41 m, Pt, 0 deg. Ir, Ro
O							▨	▨						▨					
R								▨	▨						▨				
I								▨	▨						▨				5.72 m, Jt, 0 deg. Ir, Ro
N								▨	▨						▨				
G			6.0					▨	▨						▨				5.93 m, Jt, 0 deg. Ir, Ro

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

SMEC Testing Services Pty Ltd **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: Resitech Australia
Project / STS No.: 10530/2308A
Project: 4-6 Bigge Street, Liverpool
Date : July 1, 2009
Location: Refer to Drawing No. 09/2308A
Logged: JK
Checked By: JH

BOREHOLE NO.: BH 103

Sheet 3 of 3

DRILLING				**MATERIAL STRENGTH**									**DISCONTINUITIES**							
						Estimated Rock Strength							**Joint Spacing (mm)**							
Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20	40	100	300	1000		**Visual**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
				SHALE: dark grey, occasional red brown/orange brown, fine grained sand, clay seams	SW			▨	▨						▨					6.05 m, Pt, 0 deg. Ir, Ro 6.16 m, Jt, 0 deg. Pl, Ro 6.36-6.47 m, Cy, Sm 6.58 m, Jt, 0 deg. Ir, Ro, Cy infill 6.66 m, Jt, 0 deg. Ir, Ro 6.76 m, Jt, 0 deg. Ir, Ro
			7.0					▨	▨							▨				6.90 m, Pt, 0 deg. Pl, Ro 7.05 m, Jt, 0 deg. Pl, Sm 7.07-7.11 m, Jt, 90 deg. Ir, tight 7.63 m, Jt, 0 deg. Ir, Ro, minor Cy
			8.0	BOREHOLE DISCONTINUED AT 8.0 M																
			9.0																	
			10.0																	
			11.0																	
			12.0																	

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

Project: 4-6 Bigge street,
Liverpool
Project No: 10530/2308A
Client: Resitech Australia
Date Cored:1/7/09
Borehole No: 103
Depth (m) 5.0m to 8.0m End
Box 1 of 1

SMEC
Testing
Services

SMEC Testing Services Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Resitech Australia
Project: 4-6 Bigge Street, Liverpool
Location: Refer to Drawing No. 09/2308A

Project No.: 10530/2308A
Date : July 2, 2009
Logged: JK

BOREHOLE NO.: BH 104

Sheet 1 of 3

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
			SILTY CLAY: dark brown with light grey and orange brown, low plasticity, trace of gravel TOPSOIL/FILL	CL	SOFT	M
			SILTY CLAY: orange brown with light grey, medium to high plasticity,	CL/CH	FIRM TO STIFF	M
	SPT 1.0-1.45 m 4, 4, 6 N = 10 SPT 2.4-2.85 m 4, 8, 20 N = 28	1.0 2.0 3.0	SILTY CLAY: light grey with orange brown, medium plasticity, occasional to trace of ironstone and shale gravel (CW shale)	CL	STIFF BECOMING VERY STIFF	M
			SHALE: dark grey/brown, fine grained sand, clay seams		EXTREMELY LOW STRENGTH	D
		4.0 5.0	WASHBORE DRILLING DISCONTINUED AT 3.9 M For core details refer to core log sheets			

NOTES: D - disturbed sample U - undisturbed tube sample B - bulk sample
WT - level of water table or free water N - Standard Penetration Test (SPT)

See explanation sheets for meaning of all descriptive terms and symbols

Contractor: Terratest
Equipment: Edson 2000
Hole Diameter (mm): 100
Angle from Vertical (°) 0

SMEC Testing Services Pty Ltd

GEOTECHNICAL LOG - CORED BOREHOLE

Client: Resitech Australia
Project: 4-6 Bigge Street, Liverpool
Location: Refer to Drawing No. 09/2308A

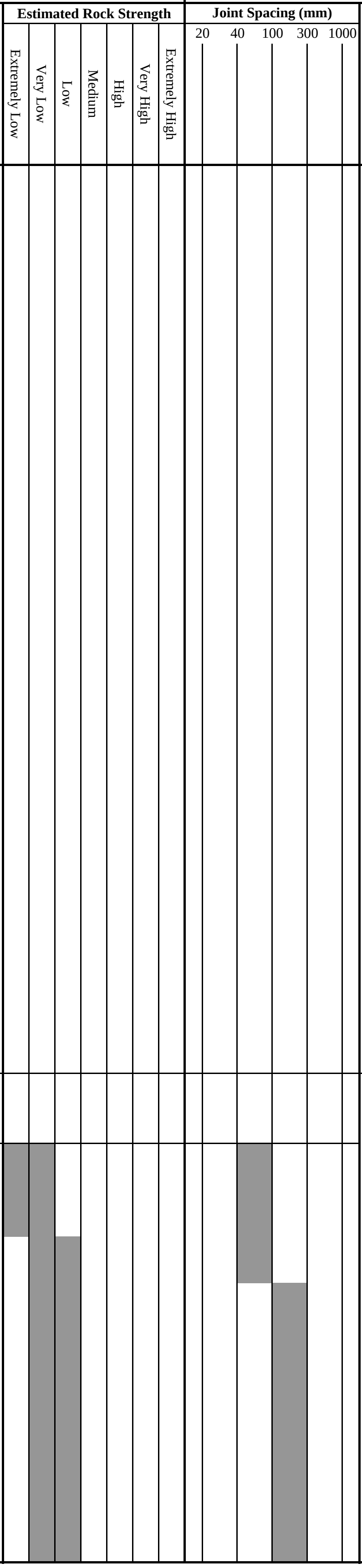
Project / STS No.: 10530/2308A
Date : July 1, 2009
Logged: JK
Checked By: JH

BOREHOLE NO.: BH 104

Sheet 2 of 3

DRILLING				**MATERIAL STRENGTH**		**DISCONTINUITIES**
Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
			1.0 2.0 3.0	For non core details, refer to non core log sheets		
				START CORING AT 3.9 M		
NMLC CORING			4.0	NO CORE - 3.9 - 4.25 M		
				SHALE: dark grey with orange brown and occasional light grey, fine grained sand, clay seams	MW	4.25-4.34 m, Sm, Cy 4.36 m, Jt, 10 deg. Pl, Ro 4.44 m, Jt, 5 deg. Ir, Ro, fractured 4.50-4.56 m, Jt, Ir, Ro, Cy 4.75 m, Jt, 0 deg. Ir, Ro, fractured Cy 4.83 m, Pt, 0 eg. Ir, Ro 4.98-5.0 m, Jt, 0 deg. Ir, Ro, Cy 5.12-5.16 m, JT, 30 deg. Pl, Ro 5.3 m, Jt, 5 deg. Ir, Ro, minor Cy tight Jt, opening upon drying 5.59 m, Jt, 5 deg. Pl, Ro 5.66-5.73 m, Jt, 45 deg. Pl, Ro
			5.0 6.0			

Estimated Rock Strength / **Joint Spacing (mm)** / **Visual**



Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

SMEC Testing Services Pty Ltd **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: Resitech Australia	Project / STS No.: 10530/2308A		**BOREHOLE NO.: BH 104**
Project: 4-6 Bigge Street, Liverpool	Date : July 1, 2009		
Location: Refer to Drawing No. 09/2308A	Logged: JK	Checked By: JH	Sheet 3 of 3

DRILLING				**MATERIAL STRENGTH**		**Estimated Rock Strength**							**DISCONTINUITIES**						
													Joint Spacing (mm)						
Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20	40	100	300	1000	**Visual**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
				SHALE: dark grey with orange brown and occasional light grey, fine grained sand, clay seams	MW		▨	▨						▨					6.0-6.16 m, Jt, 85 deg. Pl, Ro, Fe veneer 6.27 m, Jt, 0 deg. PL, Ro Numerous tight Jt, opening upon drying 6.4-6.44 m, CZ, Cy 6.63-6.71 m, Cz, Cy 6.8-6.9 m, Jt, Cz, Cy, Ir, Ro 6.92 m, Pt, 0 deg. Pl, Sm
			7.0	SHALE: dark grey with occasional orange brown, and light grey, fine grained sand	Fr/St			▨	▨						▨				7.03 m, Jt, 0 deg. PL, Sm 7.08 m, Jt, 0 deg. PL, Sm, minor Cy 7.10-7.15 m, Jt, Ir, Ro, Und 7.52 m, Pl, 3 deg. Ir, Ro 7.87 m, Jt, 0 deg. Pl, Ro
			8.0	BOREHOLE DISCONTINUED AT 8.0 M															
			9.0																
			10.0																
			11.0																
			12.0																

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

Project: 4-6 Bigge Street,
Liverpool
Project No: 10530/2308A
Client: Resitech Australia
Date Cored:2/7/09
Borehole No: 104
Depth (m): 3.90 - 8.00 End
Box 1 of 1

SMEC Testing Services Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Resitech Australia	Project No.: 10530/2308A	**BOREHOLE NO.: BH 105**
Project: 4-6 Bigge Street, Liverpool	Date : July 2, 2009	
Location: Refer to Drawing No. 09/2308A	Logged: JK	Sheet 1 of 3

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
			SILTY CLAY: dark brown, medium plasticity, occasional gravel TOPSOIL/FILL	CL	SOFT	M
			SILTY CLAY: red brown/orange brown with light grey, medium to high plasticity trace of ironstone and shale gravel	CL/CH	FIRM TO STIFF BECOMING VERY STIFF	M
	SPT 0.9-1.35 m 5, 7, 8 N = 15	1.0				
		2.0				
	SPT 2.3-2.75 m 5, 11, 17 N = 28					
		3.0				
			SHALE: dark grey/brown with occasional orange brown, fine grained sand, clays seams		EXTREMELY LOW STRENGTH	D
		4.0	WASHBORE DRILLING DISCONTINUED AT 3.9 M For core details, refer to core log sheets			
		5.0				

NOTES: D - disturbed sample U - undisturbed tube sample B - bulk sample
WT - level of water table or free water N - Standard Penetration Test (SPT)

See explanation sheets for meaning of all descriptive terms and symbols

Contractor: Terratest
Equipment: Edson 2000
Hole Diameter (mm): 100
Angle from Vertical (°) 0

SMEC Testing Services Pty Ltd

GEOTECHNICAL LOG - CORED BOREHOLE

Client: Resitech Australia
Project: 4-6 Bigge Street, Liverpool
Location: Refer to Drawing No. 09/2308A
Project / STS No.: 10530/2308A
Date : July 1, 2009
Logged: JK
Checked By: JH
BOREHOLE NO.: BH 105
Sheet 2 of 3

DRILLING				MATERIAL STRENGTH									DISCONTINUITIES						
						Estimated Rock Strength							Joint Spacing (mm)						
Method	Water	Recovery	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20	40	100	300	1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
			1.0																
			2.0																
			3.0																
				For non core details, refer to non core log sheets															
				START CORING AT 3.9 M															
NMLC CORING			4.0	SHALE: dark brown/dark grey, fine grained sand	HW	▨								▨					3.9-5.0 m, numerous Jt, 0-90 deg. Ir, Pl, Ro minor cy infill
				SHALE: orange brown with dark grey and occasional light grey fine grained sand, occasional ironstone	MW			▨						▨					
			5.0					▨						▨					
				SHALE: dark grey with occasional light grey, fine grained sand	Fr			▨	▨						▨				5.0 m, JT, Pl, Sm 5.3 m, Jt, 0 deg. Pl, Sm 5.6 m, Jt, 0 deg. PL, Ro, cy 5.75-5.9 m, Jt, 90 deg. Ir, Ro, Cy
			6.0					▨	▨						▨				

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

SMEC Testing Services Pty Ltd **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: Resitech Australia
Project: 4-6 Bigge Street, Liverpool
Location: Refer to Drawing No. 09/2308A

Project / STS No.: 10530/2308A
Date : July 1, 2009
Logged: JK
Checked By: JH

BOREHOLE NO.: BH 105
Sheet 3 of 3

DRILLING				MATERIAL STRENGTH										DISCONTINUITIES						
						Estimated Rock Strength							Joint Spacing (mm)							
Method	**Water**	**Recovery**	**Depth (m)**	**Rock Type** (Colour, Grain Size, Structure & Minor Components)	**Weathering**	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20	40	100	300	1000	**Visual**	**Additional Data** (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
				SHALE: dark grey with occasional light grey, fine grained sand	Fr			▨	▨						▨				
								▨	▨						▨				6.2-6.5 m, Jt, 90 deg. Ir, Ro, Cy
								▨	▨						▨				6.84-6.92 m, Jt, 90 deg. Ir, Ro, Cy
			7.0					▨	▨						▨				
									▨						▨				7.04-7.05 m, Cy, Sm
									▨						▨				7.25 m, Pt, 0 deg. Pl, Sm
									▨						▨				7.31 m, Pt, 0 deg. Pl, Sm
									▨						▨				7.43 m, Jt, 0 deg. Pl, Ro
									▨						▨				7.70-7.83 m, pebble inclusions
			8.0						▨						▨				7.96 m, Pt, 0 deg. Pl, Ro
									▨						▨				8.12 m, Jt, 0 deg. PL, Ro
									▨						▨				8.14-8.16 m, Jt, 90 deg. Ir, Ro
									▨						▨				8.21-8.24 m, Jt 90 deg. Ir, Ro
									▨						▨				8.34 m, Jt, 0 deg. Pl, Ro
									▨						▨				8.48 m, Jt, 5 deg. Pl, Sm
									▨						▨				8.67-8.77 m, CZ, Jt, Ir, Ro
									▨						▨				8.88-9.13 m, Jt, 90 deg. Ir, Ro
			9.0						▨						▨				
				BOREHOLE DISCONTINUED AT 9.2 M															
			10.0																
			11.0																
			12.0																

Notes:

Contractor: Terratest
Equipment: Explorer 2000
Hole Diameter (mm):
Angle from Vertical (°):

See explanation sheets for meaning of all descriptive terms and symbols

Project: 4-6 Bigge Street, Liverpool

Project No: 10530/2308A

Client: Resitech Australia

Date Cored:2/7/09

Borehole No: 105

Depth (m): 3.90 - 8.00

Box 1 of 2

Project: 4-6 Bigge Street,
Liverpool
Project No: 10530/2308A
Client: Resitech Australia
Date Cored:2/7/09
Borehole No: 105
Depth (m): 8.00 - 9.20 End
Box 2 of 2

E1. CLASSIFICATION OF SOILS

E1.1 Soil Classification and the Unified System

An assessment of the site conditions usually includes an appraisal of the data available by combining values of engineering properties obtained by the site investigation with descriptions, from visual observation of the materials present on site.

The system used by SMEC in the identification of soil is the Unified Soil Classification system (USC) which was developed by the US Army Corps of Engineers during World War II and has since gained international acceptance and has been adopted in its metricated form by the Standards Association of Australia.

The Australian Site Investigation Code (AS1726-1981, Appendix D) recommends that the description of a soil includes the USC group symbols which are an integral component of the system.

The soil description should contain the following information in order:

Soil composition

- SOIL NAME and USC classification symbol (IN BLOCK LETTERS)
- plasticity or particle characteristics
- colour
- secondary and minor constituents (name estimated proportion, plasticity or particle characteristics, colour

Soil condition

- moisture condition
- consistency or density index

Soil structure

- structure (zoning, defects, cementing)

Soil origin

interpretation based on observation eg FILL, TOPSOIL, RESIDUAL, ALLUVIUM.

E1.2 Soil Composition

(a) Soil Name and Classification Symbol

The USC system is summarized in Figure E1.2.1. The primary division separates soil types on the basis of particle size into:

- Coarse grained soils - more than 50% of the material less than 60 mm is larger than 0.06 mm (60 µm).
- Fine grained soils - more than 50% of the material less than 60 mm is smaller than 0.06 mm (60 µm).

Initial classification is by particle size as shown in Table E1.2.1. Further classification of fine grained soils is based on plasticity.

TABLE E1.2.1 - CLASSIFICATION BY PARTICLE SIZE

NAME	SUB-DIVISION	SIZE
Clay (1)		< 2 µm
Silt (2)		2 µm to 60 µm
Sand	Fine Medium Coarse	60 µm to 200 µm 200 µm to 600 µm 600 µm to 2 mm
Gravel (3)	Fine Medium Coarse	2 mm to 6 mm 6 mm to 20 mm 20 mm to 60 mm
Cobbles (3)		60 mm to 200 mm
Boulders (3)		> 200 mm

Where a soil contains an appropriate amount of secondary material, the name includes each of the secondary components (greater than 12%) in increasing order of significance, eg sandy silty clay.

Minor components of a soil are included in the description by means of the terms “some” and “trace” as defined in Table E1.2.2.

TABLE E1.2.2 - MINOR SOIL COMPONENTS

TERM	DESCRIPTION	APPROXIMATE PROPORTION (%)
Trace	presence just detectable, little or no influence on soil properties	0-5
Some	presence easily detectable, little influence on soil properties	5-12

The USC group symbols should be included with each soil description as shown in Table E1.2.3

TABLE E1.2.3 - SOIL GROUP SYMBOLS

SOIL TYPE	PREFIX
Gravel	G
Sand	S
Silt	M
Clay	C
Organic	O
Peat	Pt

The group symbols are combined with qualifiers which indicate grading, plasticity or secondary components as shown on Table E1.2.4

TABLE E1.2.4 - SOIL GROUP QUALIFIERS

SUBGROUP	SUFFIX
Well graded	W
Poorly Graded	P
Silty	M
Clayey	C
Liquid Limit <50% - low to medium plasticity	L
Liquid Limit >50% - low to medium plasticity	H

(b) Grading

"Well graded"	Good representation of all particle sizes from the largest to the smallest.
"Poorly graded"	One or more intermediate sizes poorly represented
"Gap graded"	One or more intermediate sizes absent
"Uniformly graded"	Essentially single size material.

(c) Particle shape and texture

The shape and surface texture of the coarse grained particles should be described.

Angularity may be expressed as "rounded", "sub-rounded", "sub-angular" or "angular".

Particle **form** can be "equidimensional", "flat" or elongate".

Surface texture can be "glassy", "smooth", "rough", pitted" or striated".

(d) Colour

The colour of the soil should be described in the moist condition using simple terms such as:

Black White Grey Red
Brown Orange Yellow Green
Blue

These may be modified as necessary by "light" or "dark". Borderline colours may be described as a combination of two colours, eg. red-brown.

For soils that contain more than one colour terms such as:

Speckled	Very small (<10 mm dia) patches
Mottled	Irregular
Blotched	Large irregular (>75 mm dia)
Streaked	Randomly oriented streaks

(e) Minor Components

Secondary and minor components should be individually described in a similar manner to the dominant component.

E1.3 Soil Condition

(a) Moisture

Soil moisture condition is described as "dry", "moist" or "wet".

The moisture categories are defined as:
Dry (D) - Little or no moisture evident. Soils are running.
Moist (M) - Darkened in colour with cool feel. Granular soil particles tend to adhere. No free water evident upon remoulding of cohesive soils.

In addition the moisture content of cohesive soils can be estimated in relation to their liquid or plastic limit.

(b) Consistency

Estimates of the consistency of a clay or silt soil may be made from manual examination, hand penetrometer test, SPT results or from laboratory tests to determine undrained shear or unconfined compressive strengths. The classification of consistency is defined in Table E1.3.1.

TABLE E1.3.1 - CONSISTENCY OF FINE-GRAINED SOILS

TERM	UNCONFINED STRENGTH (kPa)	FIELD IDENTIFICATION
Very Soft	<25	Easily penetrated by fist. Sample exudes between fingers when squeezed in the fist.
Soft	25 – 50	Easily moulded in fingers. Easily penetrated 50 mm by thumb.
Firm	50 – 100	Can be moulded by strong pressure in the fingers. Penetrated only with great effort.
Stiff	100 – 200	Cannot be moulded in fingers. Indented by thumb but penetrated only with great effort.
Very Stiff	200 – 400	Very tough. Difficult to cut with knife. Readily indented with thumb nail.
Hard	>400	Brittle, can just be scratched with thumb nail. Tends to break into fragments.

Unconfined compressive strength as derived by a hand penetrometer can be taken as approximately double the undrained shear strength ($q_u = 2\ c_u$).

(c) Density Index

The insitu density index of granular soils can be assessed from the results of SPT or cone penetrometer tests. Density index should not be estimated visually.

TABLE E1.3.2 - DENSITY OF GRANULAR SOILS

TERM	SPT N VALUE	STATIC CONE VALUE q_c (MPa)	DENSITY INDEX (%)
Very Loose	0 – 3	0 - 2	0 - 15
Loose	3 – 8	2 - 5	15 - 35
Medium Dense	8 – 25	5 - 15	35 - 65
Dense	25 – 42	15 - 20	65 - 85
Very Dense	>42	>20	>85

E1.4 Soil Structure

(a) Zoning

A sample may consist of several zones differing in colour, grain size or other properties. Terms to classify these zones are:

Layer - continuous across exposure or sample
Lens - discontinuous with lenticular shape
Pocket - irregular inclusion
Each zone should be described, their distinguishing features, and the nature of the interzone boundaries.

(b) Defects

Defects which are present in the sample can include:

- fissures
- roots (containing organic matter)
- tubes (hollow)
- casts (infilled)

Defects should be described giving details of dimensions and frequency. Fissure orientation, planarity, surface condition and infilling should be noted. If there is a tendency to break into blocks, block dimensions should be recorded

E1.5 Soil Origin

Information which may be interpretative but which may contribute to the usefulness of the material description should be included. The most common interpreted feature is the origin of the soil. The assessment of the probable origin is based on the soil material description, soil structure and its relationship to other soil and rock materials.

Common terms used are:

“Residual Soil” - Material which appears to have been derived by weathering from the underlying rock. There is no evidence of transport.

“Colluvium” - Material which appears to have been transported from its original location. The method of movement is usually the combination of gravity and erosion.

“Landslide Debris” - An extreme form of colluvium where the soil has been transported by mass movement. The material is obviously distributed and contains distinct defects related to the slope failure.

“Alluvium” - Material which has been transported essentially by water. Usually associated with former stream activity.

“Fill” - Material which has been transported and placed by man. This can range from natural soils which have been placed in a controlled manner in engineering construction to dumped waste material. A description of the constituents should include an assessment of the method of placement.

E1.6 Fine Grained Soils

The physical properties of fine grained soils are dominated by silts and clays.

The definition of clay and silt soils is governed by their Atterberg Limits. Clay soils are characterised by the properties of cohesion and plasticity with cohesion defines as the ability to deform without rupture. Silts exhibit cohesion but have low plasticity or are non-plastic.

The field characteristics of clay soils include:

- dry lumps have appreciable dry strength and cannot be powdered
- volume changes occur with moisture content variation
- feels smooth when moist with a greasy appearance when cut.

The field characteristics of silt soils include:

- dry lumps have negligible dry strength and can be powdered easily
- dilatancy - an increase in volume due to shearing - is indicted by the presence of a shiny film of water after a hand sample is shaken. The water disappears upon remoulding. Very fine grained sands may also exhibit dilatancy.
- low plasticity index
- feels gritty to the teeth

E1.7 Organic Soils

Organic soils are distinguished from other soils by their appreciable content of vegetable matter, usually derived from plant remains.

The soil usually has a distinctive smell and low bulk density.

The USC system uses the symbol Pt for partly decomposed organic material. The O symbol is combined with suffixes “O” or “H” depending on plasticity.

Where roots or root fibres are present their frequency and the depth to which they are encountered should be recorded. The presence of roots or root fibres does not necessarily mean the material is an “organic material” by classification.

Coal and lignite should be described as such and not simply as organic matter.

E2 CLASSIFICATION OF ROCKS

E2.1 Uniform Rock Description

The aim of a rock description for engineering purposes is to give an indication of the expected engineering properties of the material.

In a similar manner to soil materials, the assessment of site conditions where rock is encountered has to be based on the use of a descriptive method which is uniform and repeatable. Description has to:

- provide a clear identification of the rock substance and its engineering properties, and
- include details of the features which affect the engineering properties of the rock mass.

There is no internationally accepted system for rock description but SMEC Testing Services Pty Ltd has adopted a method which incorporates terminology defined by common usage in the engineering geological profession. Most feature definitions are as recommended by the International Society of Rock Mechanics and by the Standards Association of Australia.

For uniform presentation the different features are described in order:

Rock Substance

- NAME (in block letters)
- Mineralogy
- Grain Size
- Colour
- Fabric
- Strength
- Weathering/Alteration

Rock Mass

- Defect type
- Defect orientation
- Defect features
- Defect spacing

E2.2 Rock Substance

(a) Rock name

Each rock type has a specific name which is based on:

- mineralogy
- grain size
- fabric
- origin

The only method of determining the precise rock name is by thin section petrography.

Field identification of rocks for engineering purposes should be based on the use of common, easily understood, simple, geological names. In many cases knowledge of the precise name is of little consequence in the assessment of site conditions. If required the "field name" can be qualified by reference to a petrographic report. Reference to local geological reports often provides information on the rock types which may be expected.

(b) Mineralogy

The rock description should include the identification of the prominent minerals. This identification is usually restricted to the more common minerals in medium and coarse grained rocks.

(c) Grain Size

Rock material descriptions should include general grouping of the size of the predominant mineral grains as defined in Table E2.2.1. The maximum size, or size range, of the larger mineral grains or rock fragments should be recorded.

TABLE E2.2.1. - GRAIN SIZE GROUPS

TERM	GRAIN SIZE (mm)
Very Coarse	>60
Coarse	2 - 60
Medium	0.06 - 2
Fine	0.002 - 0.06
Very Fine	<0.002
Glassy	

(d) Colour

The colour of the rock should be described in the moist condition using simple terms such as:

Black	White	Grey	Red
Brown	Orange	Yellow	Green
Blue			

These may be modified as necessary by "light" or "dark". Borderline colours may be described by a combination of two colours, eg: grey-blue.

(e) Fabric

The fabric of a rock includes all the features of texture and structure, though the term refers specifically to the arrangement of the constituent grains or crystals in a rock. The fabric can provide an indication of the mode of formation of the rock:

- in sedimentary rocks bedding indicates depositional conditions,
- in igneous rocks the texture indicates the rate of cooling, and
- in metamorphic rocks the foliation indicates the stress conditions

Descriptions of fabric should include structure orientation, either with reference to North and horizontal, or to a plane normal to the core axis.

Tables E2.2.2, E2.2.3 and E2.2.4 list common textural features of sedimentary, igneous and metamorphic rocks with the subdivision of stratification spacing in Table E2.2.5.

TABLE E2.2.2 - COMMON STRUCTURES IN IGNEOUS ROCKS

STRATIFICATION (Planar)	STRATIFICATION (Irregular)
Bedding	Washout
Cross Bedding	Slump Structure
Graded Bedding	Shale Breccia
Lamination	
Cross Lamination	

TABLE E2.2.3 - COMMON STRUCTURES IN IGNEOUS ROCKS

	FINE GRAINED ROCKS	COARSE GRAINED ROCKS
Uniform Grain Size	Massive	Massive
	Flow Banded	Granitic
	Vesicular	Pegmatitic
Different Grain Size	Porphyritic	Porphyritic

TABLE E.2.2.4 - COMMON STRUCTURES IN METAMORPHIC ROCKS

FINE GRAINED ROCKS	COARSE GRAINED ROCKS
Slatey Cleavage	Granoblastic
Spotted	Porphyroblastic
Hornsfelsic	Lincated
Foliated	Gneissic
Mylonitic	Mylonitic

TABLE E2.2.5 - STRATIFICATION SPACING

TERM	SEPARATION (mm)
Very Thickly Bedded	>2000
Thickly Bedded	600 - 2000
Medium Bedded	200 - 600
Thinly Bedded	60 - 200
Very Thinly Bedded	20 - 60
Laminated	6 - 20
Thinly Laminated	<6

(f) Strength

Substance strength is one of the most important engineering features of a rock and every description should include at least an estimate of the rock strength class of the material. This estimate can be calibrated by test results, either by Point Loan Strength Index or by Unconfined Compressive Strength.

The rock strength class in As 1726-1981 is defined by Point Loan Strength Index I_s,(50). The relationship between Point Loan and Unconfined Strength is commonly assumed to be about 20, but can range from 4 (in some carbonate rocks) to 40 (in some igneous rocks). It is necessary to confirm the relationship for each rock type and project. classification should be based on material at field moisture content, as some rocks give a significantly higher strength when tested dry.

Table E2.2.6 defines the rock strength classes, with indicative field tests listed in Table E2.2.7 which assist in classification when testing equipment is not available.

TABLE E2.2.6 - CLASSIFICATION OF ROCK STRENGTH

SYMBOL	TERM	POINT LOAD STRENGTH (MPa)	APPROX Qu (MPa)
EL	extremely low	<0.03	<1
VL	very low	0.03 - 0.1	1 - 3
L	low	0.1 - 0.3	3 - 10
M	medium	0.3 - 1	10 - 30
H	high	1 - 3	30 - 70
VH	very high	3 - 10	70 - 200
EH	extremely high	>10	>200

TABLE E2.2.7 - FIELD TESTS FOR ROCK STRENGTH CLASSIFICATION

STRENGTH CLASS	FIELD TEST
Extremely Low	Indented by thumb nail with difficulty
Very Low	Scratched by thumb nail
Low	Easily broken by hand or pared with a knife
Medium	Broken by hand or scraped with a knife
High	Broken in hand by firm hammer blows
Very High	Broken against solid object with several hammer blow
Extremely High	Difficult to break against solid object with several hammer blows

(g) Weathering/Alteration

In addition to the description of rock substance as examined, an assessment is required of the extent to which the original rock material has been affected by subsequent events. The usual processes are:

- Weathering - Decomposition due to the effect of surface or near surface activities
- Alteration - Chemical modification by the action of materials originating from within the mantle below.

The classification of weathering/alteration presented in Table E2.2.8 is based on the extent/degree to which the original rock substance has been affected. This classification has little engineering significance, as the properties of the rock as examined may bear no relationship to the properties of the fresh rock.

TABLE E2.2.8 - CLASSIFICATION OR ROCK WEATHERING/ALTERATION

TERMS	DEFINITION
Fresh (Fr)	Rock substance unaffected.
Fresh Stained (FR St)	Rock substance unaffected. Staining of defect surfaces.
Slightly (SW)	Partial staining or discolouration of rock substance.
Moderately (MW)	Staining or discolouration extends throughout the whole rock substance.
Highly (HW)	Rock substance partly decomposed.
Completely (CW)	Rock substance entirely decomposed.

E2.3 Rock Mass

The engineering properties of rock mass reflect the effect which the presence of defects has on the properties of the rock substance. Description of the rock mass properties consists of supplementing the description covered by Section E2.2 with data on the defects which are present.

(a) Defect type

The different defect types are described in Table E2.3.1.

(b) Defect orientation

Descriptions of defects should include orientation, either of individual fractures or of groups of fractures. Orientation should be with reference to North and horizontal, or to a plane normal to the core axis.

TABLE E2.3.1 - ROCK DEFECT TYPES

TYPE	SYMBOL	DESCRIPTION
Parting	Pt	A defect parallel or subparallel to a layered arrangement of mineral grains or micro-fractures which has caused planar anistrophy in the rock substance.
Joint	Jt	A defect across which the rock substance has little tensile strength and is not related to textural or structural features with the rock substance.
Sheared Zone	SZ	A zone with roughly parallel planar boundaries or rock substance containing closely spaced, often slickensided, joints.
Crushed Zone	CZ	A zone with roughly parallel planar boundaries of rock substance composed of disoriented, usually angular, fragments of rock.
Seam	Sm	A zone with roughly parallel boundaries infilled by soil or decomposed rock.

(c) Defect features

The character of a defect is described by its continuity, planarity, surface roughness, width, and infilling.

Continuity	In outcrop the extent of a joint, bedding plane or similar defect both along and across the strike can be measured. In core, continuity measurement is restricted to defects nearly parallel to the core axis.
Planarity	Described as “Planar”, “Irregular”, “Curved” or “Undulose”.
Roughness	Described as “Rough”, “Smooth”, “Polished” or “Slickensided”.
Width	Measured in millimetres normal to the plane of nthe defect
Infilling	Described as “Clean”, “Stained”, “Veneer” (<1 mm) or “Infill” (>1 mm). The coating or infilling material should be identified.

(d) Defect spacing

The spacing of defects, particularly where they occur in parallel groups or sets, provides an indication of the rock block sizes which:

- have to be supported in the face or roof of an excavation
- will be produced by the excavation operation.

It is preferable to provide measured data but discontinuity spacing is grouped as shown in Table E2.3.2.

TABLE E2.3.2 - DISCONTINUITY SPACING

DESCRIPTION	SPACING (mm)
Extremely Widely Spaced	>6000
Very Widely Spaced	2000 - 6000
Widely Spaced	600 - 2000
Medium Spaced	200 - 600
Closely Spaced	60 - 200
Very Closely Spaced	20 - 60
Extremely Closely Spaced	<20

APPENDIX B

POINT LOAD TEST RESULTS

SMEC Testing Services Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 Fax: (02)9756 1137 Email: smectesting@pacific.net.au

Point Load Strength Index Report

Project: 4-6 BIGGE STREET, LIVERPOOL
Client: RESITECH AUSTRALIA
Address: Locked Bag 4001, Ashfield BC
Test Method: AS4133.4.1

Project No.: 10530/2308A
Report No.: 09/0662
Report Date: 9/07/2009
Page: 1 of 3

Sampling Proceedure: Geotechnical Investigation (Not covered under NATA Terms of Registration)	Sampling Proceedure: Geotechnical Investigation (Not covered under NATA Terms of Registration)
Date Samples Drilled / Taken: 1/7/09	Date Samples Drilled / Taken: 1/7/09
Borehole No. BH101	Borehole No. BH102

Depth	Test Type	Is(50) (Mpa)	Rock Type	Rock Structure	Moisture	Depth	Test Type	Is(50) (Mpa)	Rock Type	Rock Structure	Moisture
5.33	D	0.34	SH	LA	M-D	5.75	D	0.29	SH	LA	M-D
	A	0.15	SH	LA	M-D		A	0.1	SH	LA	M-D
6.26	D	0.13	SH	LA	M-D	6.96	D	0.18	SH	LA	M-D
	A	0.24	SH	LA	M-D		A	0.4	SH	LA	M-D
7.96	D	0.2	SH	LA	M-D						
	A	0.34	SH	LA	M-D						

STRUCTURE
MA= MASSIVE
BE= BEDDED
LA= LAMINATED
CR= CRYSTALLINE

TEST TYPE
A= AXIAL
D= DIMETRAL
I= IRREGULAR
C= CUBE

MOISTURE CONDITION
W= WET
M= MOIST
D= DRY

ROCK TYPE
SS= SANDSTONE
ST= SILTSTONE
SH= SHALE
YS= CLAYSTONE
IG= IGNEOUS

Remarks:

Approved Signatory...
Laurie Ihnativ - Manager

Technician: JK

SMEC Testing Services Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 Fax: (02)9756 1137 Email: smectesting@pacific.net.au

NATA Accredited Laboratory Number: 2750
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Point Load Strength Index Report

Project: 4-6 BIGGE STREET, LIVERPOOL — Project No.: 10530/2308A
Client: RESITECH AUSTRALIA — Report No.: 09/0662
Address: Locked Bag 4001, Ashfield BC — Report Date: 9/07/2009
Test Method: AS4133.4.1 — Page: 2 of 3

Sampling Proceedure: Geotechnical Investigation (Not covered under NATA Terms of Registration) Date Samples Drilled / Taken: 1/7/09 Borehole No. BH103						Sampling Proceedure: Geotechnical Investigation (Not covered under NATA Terms of Registration) Date Samples Drilled / Taken: 1/7/09 Borehole No. BH104					
Depth	Test Type	Is(50) (Mpa)	Rock Type	Rock Structure	Moisture	Depth	Test Type	Is(50) (Mpa)	Rock Type	Rock Structure	Moisture
5.67	D	0.29	SH	LA	M-D	5.28	D	0.01	SH	LA	M-D
	A	0.41	SH	LA	M-D		A	0.04	SH	LA	M-D
7.15	D	0.2	SH	LA	M-D	6.23	D	0.08	SH	LA	M-D
	A	0.37	SH	LA	M-D		A	0.05	SH	LA	M-D
						7.4	D	0.33	SH	LA	M-D
							A	0.27	SH	LA	M-D

STRUCTURE	TEST TYPE	MOISTURE CONDITION	ROCK TYPE
MA= MASSIVE	A= AXIAL	W= WET	SS= SANDSTONE
BE= BEDDED	D= DIMETRAL	M= MOIST	ST= SILTSTONE
LA= LAMINATED	I= IRREGULAR	D= DRY	SH= SHALE
CR= CRYSTALLINE	C= CUBE		YS= CLAYSTONE
			IG= IGNEOUS

Remarks:

Approved Signatory...

Technician: JK

Laurie Ihnativ - Manager

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14/1 Cowpasture Place, Wetherill Park NSW 2164
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Point Load Strength Index Report

Project: 4-6 BIGGE STREET, LIVERPOOL
Client: RESITECH AUSTRALIA
Address: Locked Bag 4001, Ashfield BC
Test Method: AS4133.4.1

Project No.: 10530/2308A
Report No.: 09/0662
Report Date: 9/07/2009
Page: 3 of 3

Sampling Proceedure: Geotechnical Investigation (Not covered under NATA Terms of Registration)
Date Samples Drilled / Taken: 1/7/09
Borehole No. BH105

Sampling Proceedure: Geotechnical Investigation (Not covered under NATA Terms of Registration)
Date Samples Drilled / Taken:
Borehole No.

Depth	Test Type	Is(50) (Mpa)	Rock Type	Rock Structure	Moisture	Depth	Test Type	Is(50) (Mpa)	Rock Type	Rock Structure	Moisture
4.39	D	0.02	SH	LA	M-D						
	A	0.15	SH	LA	M-D						
5.25	D	0.29	SH	LA	M-D						
	A	0.14	SH	LA	M-D						
7.34	D	0.39	SH	LA	M-D						
	A	0.26	SH	LA	M-D						
8.38	D	0.15	SH	LA	M-D						
	A	0.48	SH	LA	M-D						

STRUCTURE
MA= MASSIVE
BE= BEDDED
LA= LAMINATED
CR= CRYSTALLINE

TEST TYPE
A= AXIAL
D= DIMETRAL
I= IRREGULAR
C= CUBE

MOISTURE CONDITION
W= WET
M= MOIST
D= DRY

ROCK TYPE
SS= SANDSTONE
ST= SILTSTONE
SH= SHALE
YS= CLAYSTONE
IG= IGNEOUS

Remarks:

Approved Signatory...

Technician: JK

Laurie Ihnativ - Manager