Geotechnical Investigation Report

RECREATIONAL AND TOURISM PRECINCT

78-88 TENCH AVENUE, JAMISONTOWN NSW

Prepared for:

MORSON GROUP PTY LTD

Reference: P1136_ 01

18 August 2016

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1 INTRODUCTION

Morrow Geotechnics Pty Ltd has undertaken a Geotechnical Investigation to provide geotechnical advice and recommendations for the proposed development at 78-88 Tench Avenue, Jamisontown NSW (the site).

1.1 Proposed Development

Architectural drawings for the proposed development have been prepared by Morson Group Pty Ltd dated 1 December 2015. From the drawings provided, Morrow Geotechnics understands that the proposed development involves the construction of a new restaurant precinct at or near existing grade along with associated parking areas.

1.2 Purpose of the Investigation

The purpose of the investigation is to provide geotechnical advice and recommendations for:

- Building foundation options, including design parameters.
- Lateral earth pressures and pile design parameters.
- Lot classification in accordance with AS2870.
- Earthquake site classification in accordance with AS1170.4.
- Advice on groundwater level if encountered within the depth of investigation.
- Advice on geotechnical construction constraints.
- Salinity assessment and salinity management plan.
- Pavement design parameters (subgrade CBR, MDD, OMC and modulus of subgrade reaction).

1.3 Investigation Methods

Fieldwork was undertaken by Morrow Geotechnics on 3 August 2016. Work carried out as part of this investigation includes:

- Review of publically available information from previous reports in the project area, published geological and soil mapping and government agency websites;
- Site walkover inspection by a Geotechnical Engineer to assess topographical features, condition of surrounding structures and site conditions;
- Dial Before You Dig (DBYD) services search and services scan of proposed borehole locations;
- Drilling of four boreholes (BH1 to BH4) by a ute mounted drill rig using solid flight augers. Borehole locations are shown on **Figure 1** and borehole logs are presented in **Appendix A**;
- Dynamic Cone Penetrometer (DCP) tests were undertaken adjacent to the borehole locations (DCP1 to DCP4). DCP test results were used to assess soil consistency/density and to infer top of rock and are presented on the corresponding borehole log; and
- Groundwater observations within boreholes during drilling and within open holes following completion of drilling.

Soil samples were collected from the boreholes for testing at NATA accredited laboratories.

2 DESKTOP REVIEW OF SITE CONDITIONS

The site comprises a large level lot on the eastern side of the Nepean River. The level topography is indicative of floodplains and sediment deposits associated with a long site history of flooding. The site is currently occupied by a single storey brick café structure along with paved car parking areas and compacted road base overflow parking. The majority of the site comprises undeveloped, grassed open space which was previously used for market garden purposes.

2.1 Published Geological Mapping

The Department of Mineral Resources Geological Map Penrith 1:100,000 Geological Series Sheet 9129 (DMR 1991) indicates the site to be underlain by Quaternary Pleistocene Alluvial Deposits of the Cranebrook Formation, which typically comprise gravel, sand, silt and clay.

The Soil Conservation Service of NSW Penrith 1:100,000 Soil Landscapes Series Sheet 9129 (2nd Edition) indicates that the residual landscape at the site likely comprises the Freemans Reach Alluvial Landscape. This landscape type typically comprises the present active floodplain of the Nepean River with minor relief, levees and back swamps. Typically deep brown sands and loams. These soils are noted to be present a high streambank erosion hazard, flood hazard, permanently high watertables and localised non-cohesive soil.

3 OBSERVATIONS

3.1 Subsurface Conditions

The stratigraphy at the site is characterised by topsoil over deep alluvial sediments. For the development of a site-specific geotechnical model, the observed stratigraphy has been divided into two geotechnical units with Unit 2 further subdivided into three sub-units. A summary of the subsurface conditions at the investigation locations is presented in **Table 1**. More detailed descriptions of subsurface conditions at the test locations are available in the borehole logs presented in **Appendix A**.

TABLE 1 SUMMARY OF INFERRED SUBSURFACE CONDITIONS

Unit		Material	Approx. Depth Range of Unit [1]				Comments
			BH1	BH2	BH3	BH4	
1		Topsoil	0.0 - 0.6	0.0 - 0.45	0.0 - 0.25	0.0 - 0.5	Topsoil comprising low plasticity silt with some fine grained sand. Unit 1 soils were generally firm consistency.
2	A	Loose Alluvium	0.6 - 1.3	0.45 - 1.5	0.25 - 1.4	0.5 - 1.3	Interbedded alluvial sediment deposits comprising mixtures of sand silt and clay. Unit 2 was observed to grade from loose to very dense consistency/density with depth.
	B	Medium Dense to Dense Alluvium	1.3 - 3.8	1.5 - 2.8	1.4 - 3.3	1.3 - 2.6	
	C	Very Dense Alluvium	3.8 +	2.8+	3.3 +	2.6 +	

Notes:

1 Depths shown are based on material observed within test locations and will vary across the site.

3.2 Groundwater Observations

Groundwater inflow was not observed during the drilling of boreholes as part of the investigation to a depth of 5 mBGL at each borehole location. Unit 2B material within BH2 was encountered as wet between 1.2 and 2.6 mBGL. Given the absence of a standing water level in the underlying sands it is inferred that the water encountered at this level is the result of saturation of cohesive material following heavy rainfall over the preceding fortnight rather than a permanent water table.

3.3 Laboratory Test Results

Ten soil samples were selected for salinity, aggressivity and earthworks testing. A summary of test results is provided in **Table 2**. Laboratory test certificates are presented in **Appendix B.**

TABLE 2 SUMMARY OF LABORATORY TEST RESULTS

Sample ID		BH1 DS1 0.6-0.8m	BH1 DS2 1.2-1.4m	BH1 DS3 2.6-2.8m	BH1 DS4 3.4-3.6m	BH2 BDS1 0.5-1.0m	BH3 DS2 2.5-2.7m	BH4 BDS1 0.5-1.0m	BH4 DS1 0.5-0.7m	BH4 DS2 2.3-2.5m	BH4 DS3 3.5-3.7m
Unit		2A	2B	2B	2B	2A	2B	2A	2A	2B	2C
Aggressivity	pH	-	6.3	7.3	7.2	-	7.1	-	6.9	-	7.0
	Conductivity (µS/cm)	-	38	19	20	-	90	-	16	-	16
	Sulfate SO_4 (mg/kg)	-	13	-	-	-	17	-	-	-	-
	Chloride Cl (mg/kg)	-	8.8	-	-	-	4.3	-	-	-	-
Exchangeable Sodium Percentage (%)		1.9	-	-	-	-	-	-	-	2.6	-
Cation Exchange Capacity (meq/100g)		3.2	-	-	-	-	-	-	-	4.4	-
Maximum Dry Density (t/m^3)		-	-	-	-	1.94	-	1.93	-	-	-
Optimum Moisture Content (%)		-	-	-	-	11.4	-	12.1	-	-	-
Swell (%)		-	-	-	-	0.1	-	0.1	-	-	-
California Bearing Ratio (%)		-	-	-	-	19.0	-	10.0	-	-	-
Emerson Class						5		5			
Moisture (%)		15	14	8.3	16	-	14	-	14	13	11

4 GEOTECHNICAL RECOMMENDATIONS FOR DESIGN

4.1 Foundation Design

Because of the loose, unconsolidated nature of Unit 1 material it is recommended that no footings are founded within Unit 1.

Given the ground conditions encountered during the investigation there may be economic and timing advantages to the use of deep piled foundation at the site. If deep foundations are used for the support of building loads it should be noted that traditional bored piles are likely to collapse during excavation. The use of steel liners or grout-injection methods should be considered to allow construction to a suitable founding depth. Alternatively, screw piles would provide a fast and easily installable option for transferring structural loads to the Unit 2C strata. Screw pile contractors should make their own assessment of the allowable bearing pressures of the soil strata presented in this report based on their knowledge of the performance of their proprietary systems.

The parameters given in **Table 3** may be used for the design of pad footings and bored piles. Morrow Geotechnics recommends that a Preliminary Geotechnical Strength Reduction Factor (GSRF) of 0.4 is used for the design of piles in accordance with AS 2159:2009 if no allowance is made for pile testing during construction. Should pile testing be nominated, the GSRF may be reviewed and a value of 0.55 to 0.6 may be expected.

Ultimate geotechnical strengths are provided for use in limit state design. Allowable bearing pressures are provide for serviceability checks. These values have been determined to limit settlements to an acceptable level for conventional building structures, typically less than 1% of the minimum footing dimension.

TABLE 3 PAD FOOTING AND PILE DESIGN PARAMETERS

Material		Unit 1 Topsoil	Unit 2A Loose Alluvium	Unit 2B Medium Dense to Dense Alluvium	Unit 2C Very Dense Alluvium
Allowable Bearing Pressure (kPa)		0	50	160	500
Ultimate Vertical End Bearing Pressure (kPa)		0	150	480	1500
Elastic Modulus (MPa)		4	10	30	50
Ultimate Shaft Adhesion (kPa)	In Compression	0	10	12	15
	In Tension	0	5	6	8
Susceptibility to Liquefaction during an Earthquake		Medium	Medium	Medium	Low

Notes:

1 Side adhesion values given assume there is intimate contact between the pile and foundation material. Design engineer to check both 'piston' pull-out and 'cone' pull-out mechanics in accordance with AS4678-2002 Earth Retaining Structures.

2 Susceptibility to liquefaction during an earthquake is based on the following definition:

Low	-	Medium to very dense sands, stiff to hard clays, and rock
Medium	-	Loose to medium dense sands, soft to firm clays, or uncontrolled fill below the water table
High	-	Very loose sands or very soft clays below the water table

To adopt these parameters we have assumed that the bases of all pile excavations are cleaned of loose debris and water and inspected by a suitably qualified Geotechnical Engineer prior to pile construction to verify that ground conditions meet design assumptions. Where groundwater ingress is encountered during pile excavation, concrete is to be placed as soon as possible upon completion of pile excavation. Pile excavations should be pumped dry of water prior to pouring concrete, or alternatively a tremmie system could be used.

Selection of footing types and founding depth will need to consider the risk of adverse differential ground movements within the foundation footprint and between high level and deeper footings. Unless an allowance for such movement is included in the design of the proposed development we recommend that all new structures found on natural materials with comparable end bearing capacities and elastic moduli.

4.2 AS2870 Residential Slabs and Footings Site Classification

Shallow footings and slabs on Unit 2A, 2B or 2C material should be designed in accordance with AS2870:2011 based on a Site Classification of 'M.' The site classification has been provided on the basis that the performance expectations set out in Appendix B of AS2870–2011 are acceptable and that future site maintenance will be undertaken in accordance with CSIRO BTF 18.

4.3 Soil Aggressivity

Analysis of the pH, chloride & sulfate content and electrical conductivity of the soil against the guidelines provided in AS2159-2009 indicates:

- 'non-aggressive' to buried concrete structural elements; and
- 'non-aggressive' to buried steel structural elements.

4.4 Excavations

If minor excavations up to 1.5 m depth are required for the development temporary batter slopes of 1.5H:1V will be possible for Unit 1 and Unit 2 material provided that surface water is diverted away from the batter faces. Permanent batters of 2.5H:1V may be employed for all material encountered during the investigation. Permanent batters will require surface protection or revegetation to prevent erosion and slaking

Where excavations extend beneath the zone of influence of nearby structures, services or pavements, or where site constraints such as site boundaries do not allow the construction of temporary batters, excavation retention will be required. For design of cantilevered shoring systems a triangular pressure distribution may be employed using the parameters presented in **Table 4**. For design of rigid anchored or braced walls such as top-down construction, a trapezoidal earth pressure distribution should be used with a maximum pressure of 0.65.Ka.γ.H (kPa), where 'H' is the effective vertical height of the wall in metres.

TABLE 4 EARTH PRESSURE PARAMETERS

Material		Unit 1 Topsoil	Unit 2A Loose Alluvium	Unit 2B Medium Dense to Dense Alluvium	Unit 2C Very Dense Alluvium
Bulk Unit Weight (kN/m^3)		16	17	18	19
Earth Pressure Coefficients	At rest, K_o	0.58	0.52	0.46	0.41
	Passive, K_p	2.46	2.88	3.39	3.85
	Active, K_a	0.41	0.35	0.29	0.26

Notes:

1 Unit Weight is based on visual assessment only, order of accuracy is approximately ±10%.

2 Earth pressures are provided on the assumption that the ground behind the retaining wall is flat and drained.

4.5 AS1170 Earthquake Site Risk Classification

Assessment of the material encountered during the investigation in accordance with the guidelines provided in AS1170.4-2007 indicates an earthquake subsoil class of Class C_e – Shallow Soil for the site.

4.6 Pavement Subgrade and On-Ground Slabs

The results of soaked CBR testing conducted on two subgrade samples indicated CBR values of between 10% and 19%. Based on the moderately variable condition of the encountered material at subgrade level across the borehole locations at the site, Morrow Geotechnics recommends a design subgrade CBR of 8 % and a design modulus of subgrade reaction of 12 kPa/mm is adopted.

For controlled filling depths of less than or equal to 1m, the Japan Road Association method of assessing a weighted subgrade strength can be used, as follows:

$$CBR_W = (D_F \times CBR_F^{0.33} + (1-D_F) \times CBR_S^{0.33})^3$$

where: CBR_W = weighted subgrade CBR (%)

D_F = depth of filling (m)

CBR_F = CBR of filling material (%)

CBR_S = CBR of subgrade (%)

For example, if a 0.3m deep layer of controlled filling using CBR50% material is placed over a subgrade with a CBR value of 8%, then a weighted subgrade CBR of 15% can be adopted for design.

4.7 Soil Salinity

A soil salinity assessment in accordance with the recommendations of Department of Land and Water Conservation, *Site Investigations for Urban Salinity*, 2002 has been carried out at the site. The laboratory Electrical Conductivity (EC) has multiplied by a factor varying from 14, based on the texture of the soil samples obtained, to obtain Corrected Electrical Conductivity designated as ECe as presented in **Table 5** below. In addition to this Exchangeable Sodium Percentage and Cation Exchange Capacity results have been compared with criteria within the guidelines.

TABLE 5 SOIL SALINITY / SODICITY INTERPRETATION

Sample ID	BH1 DS1 0.6-0.8m	BH1 DS2 1.2-1.4m	BH1 DS3 2.6-2.8m	BH1 DS4 3.4-3.6m	BH3 DS2 2.5-2.7m	BH4 DS1 0.5-0.7m	BH4 DS2 2.3-2.5m	BH4 DS3 3.5-3.7m
Unit	2A	2B	2B	2B	2B	2A	2B	2C
Conductivity (µS/cm)	-	38	19	20	90	16	-	16
Corrected Electrical Conductivity (dS/m)	-	0.53	0.27	0.8	1.26	0.22	-	0.22
Exchangeable Sodium Percentage (%)	1.9	-	-	-	-	-	2.6	-
Cation Exchange Capacity (meq/100g)	3.2	-	-	-	-	-	4.4	-
Moisture (%)	15	14	8.3	16	14	14	13	11
Assessed Sodicity / Salinity	**Non-Sodic**	**Non-Saline**	**Non-Saline**	**Non-Saline**	**Non-Saline**	**Non-Saline**	**Non-Sodic**	**Non-Saline**

On the basis of laboratory testing undertaken as part of this investigation the site is assessed to be non-sodic and non-saline.

5 RECOMMENDATIONS FOR FURTHER GEOTECHNICAL SERVICES

Further geotechnical inspections should be carried out during construction to confirm the geotechnical and hydrogeological model. These should include:

- All excavated material transported off site should be classified in accordance with NSW EPA 2014 - Waste Classification Guideline Part 1; Classifying Waste.
- A suitably qualified geotechnical engineer is to assess the condition of exposed material at foundation or subgrade level to assess the ability of the prepared surface to act as a foundation or as a subgrade.
- Regular inspections of battered and unsupported excavations, where proposed, to confirm geotechnical conditions and to assess the suitability of design assumptions and to provide further advice with regards to excavation retention/ support and proposed construction methodologies, if required.

6 STATEMENT OF LIMITATIONS

The adopted investigation scope was limited by the investigation intent. Further geotechnical inspections should be carried out during construction to confirm both the geotechnical model and the design parameters provided in this report.

Your attention is drawn to the document "Important Information", which is included in **Appendix C** of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Morrow Geotechnics, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

7 REFERENCES

AS1726:1993, *Geotechnical Site Investigations*, Standards Australia.

AS2159:2009, *Piling – Design and Installation*, Standards Australia.

AS2870:2011, *Residential Slabs and Footings*, Standards Australia.

AS3798:2007, *Guidelines on Earthworks for Commercial and Residential Developments*, Standards Australia.

Chapman, G.A. and Murphy, C.L. (1989), Soil Landscapes of the Penrith 1:100000 sheet. Soil Conservation Services of NSW, Sydney.

NSW Department of Finance and Service, Spatial Information Viewer, maps.six.nsw.gov.au.

NSW Department of Mineral Resources (1985) Penrith 1:100,000 Geological Series Sheet 9129 (Edition 1). Geological Survey of New South Wales, Department of Mineral Resources.

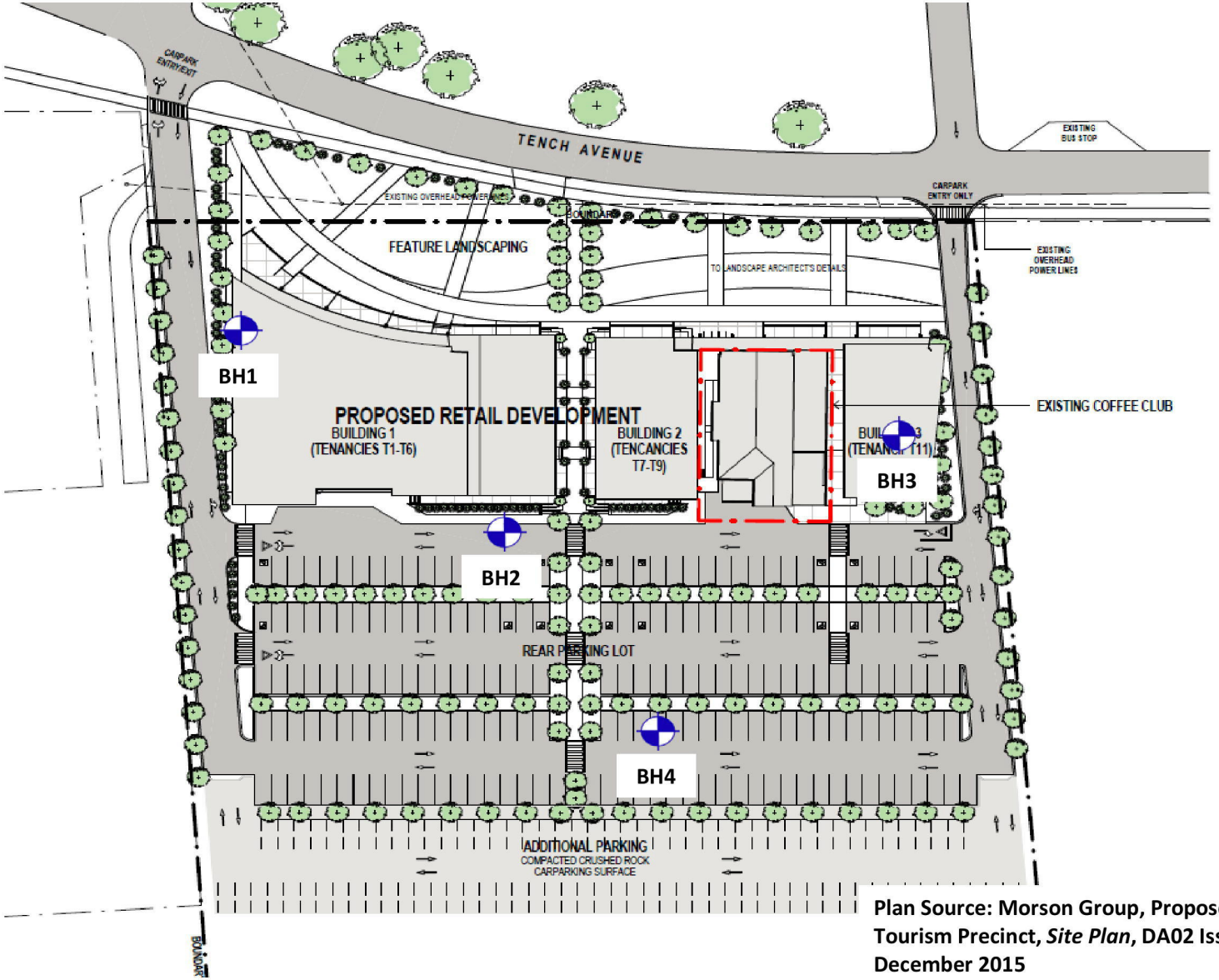
Pells (2004) Substance and Mass Properties for the Design of Engineering Structures in the Hawkesbury Sandstone, Australian Geomechanics Journal, Vol 39 No 3

8 CLOSURE

Please do not hesitate to contact Morrow Geotechnics if you have any questions about the contents of this report.

For and on behalf of Morrow Geotechnics Pty Ltd,

Alan Morrow
Senior Geotechnical Engineer



Plan Source: Morson Group, Proposed Recreation and Tourism Precinct, *Site Plan*, DA02 Issue A, Dated 1 December 2015

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Drawn	AM
Approved	AM
Date	18-08-16
Scale	NTS

Morson Group Pty Ltd
78-88 Tench Avenue, Jamisontown NSW
Geotechnical Investigation
Borehole Location Plan

Figure: **1**

Project: P1136

Appendix A

BOREHOLE LOGS AND EXPLANATORY NOTES

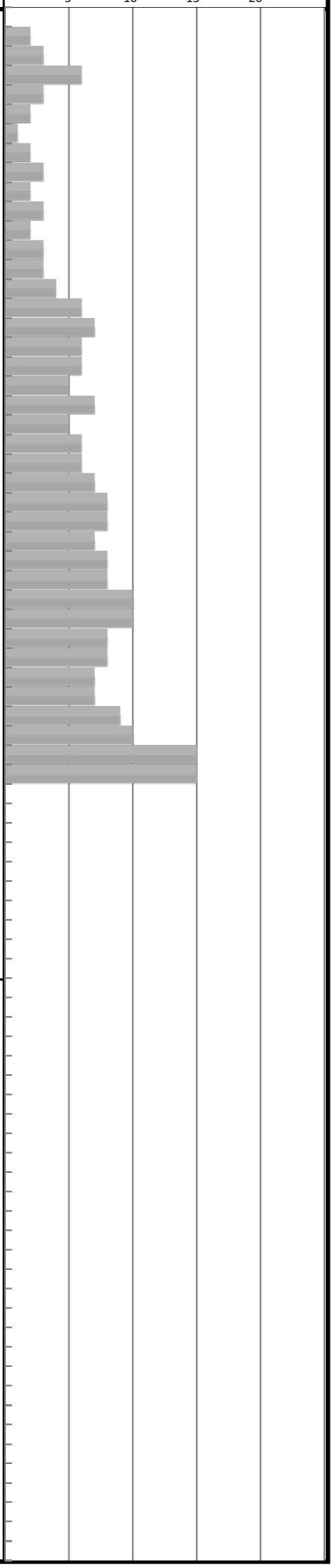
Project No:	P1136	Contractor:	Lithos Pty Ltd	morrow	
Client:	Morson Group Pty Ltd	Drill Rig:	Ute Mounted		
Project:	Recreational and Tourism Precinct				
	78-88 Tench Avenue	Sheet	1 of 1		
	Jamisontown NSW	Logged:	AM		
		Date:	03-08-16		

BH1

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE	DS1-1 0.6-0.8 m		0.5	SILT, low plasticity, dark brown, with some fine grained sand, (TOPSOIL)		
					1.0	Sandy SILT/Silty SAND, fine grained, low plasticity, red brown (ALLUVIUM)	F / L	
			DS1-2 1.2 - 1.4m		1.5	Silty Clayey SAND, fine grained, red brown, poorly graded medium plasticity fines (ALLUVIUM)		
					2.0	AS ABOVE, with some clay	MD	
			DS1-3 2.6 - 2.8m		2.5	SAND, fine grained, orange brown, poorly graded, with some silt (ALLUVIUM)		M
					3.0		D	
			DS1-4 3.4 - 3.6m		3.5	Clayey SAND/Sandy CLAY, fine grained, low to medium plasticity, brown (ALLUVIUM)		
					4.0			
					4.5		VD	
					5.0			
					5.5	End BH1 at 5.0 m Reached Target Depth		
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			

DCP (blows per 100 mm)

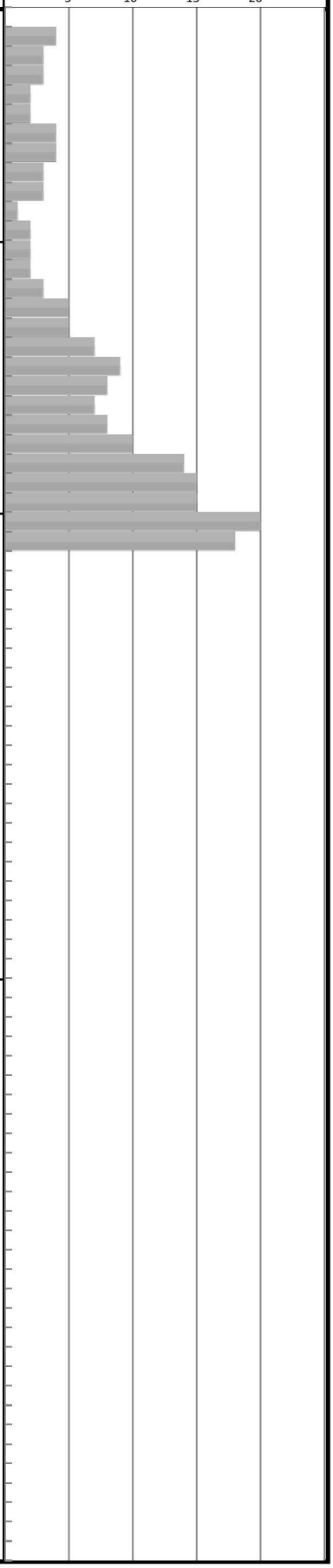
5 10 15 20



Project No:	P1136	Contractor:	Lithos Pty Ltd	morrow	
Client:	Morson Group Pty Ltd	Drill Rig:	Ute Mounted		
Project:	Recreational and Tourism Precinct				
	78-88 Tench Avenue	Sheet	1 of 1		
	Jamisontown NSW	Logged:	AM		
		Date:	03-08-16		

BH2

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE	BDS 2-1 0.5 - 1.0m	ML	0.5	SILT, low plasticity, dark brown, with some fine grained sand, (TOPSOIL)	F / L	M
				ML/ SM	1.0	Sandy SILT/Silty SAND, fine grained, low plasticity, red brown (ALLUVIUM)		
				SC	1.5	Silty Clayey SAND, fine grained, red brown, poorly graded medium plasticity fines (ALLUVIUM)	MD	W
					2.0		D	
					2.5			
				SP	3.0	SAND, fine grained, orange brown, poorly graded, with some silt (ALLUVIUM)	VD	M
					3.5			
					4.0			
					4.5			
					5.0	End BH2 at 5.0 m Reached Target Depth		
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			

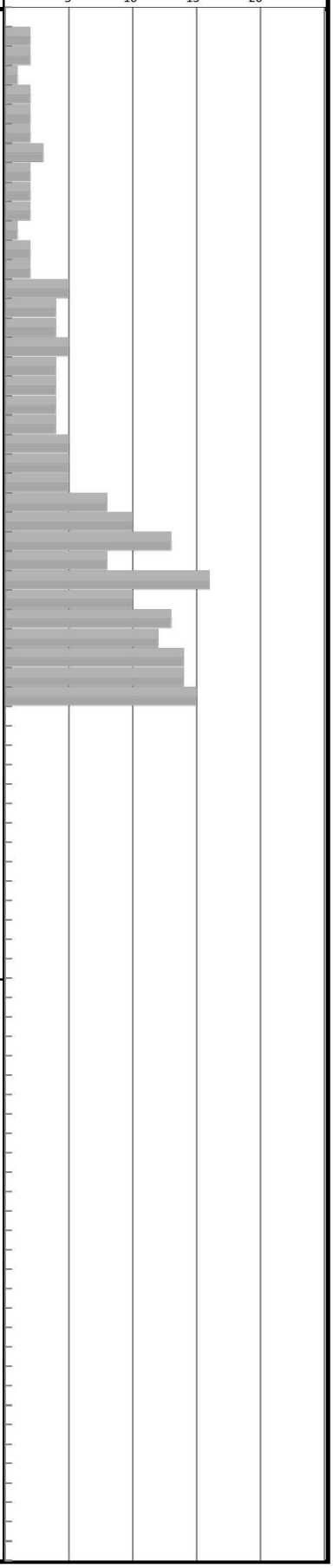


Project No:	P1136	Contractor:	Lithos Pty Ltd
Client:	Morson Group Pty Ltd	Drill Rig:	Ute Mounted
Project:	Recreational and Tourism Precinct 78-88 Tench Avenue Jamisontown NSW	Sheet	1 of 1
		Logged:	AM
		Date:	03-08-16

morrow

BH3

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE	DS3-1 0.4 - 0.6m	ML	0.0	SILT, low plasticity, dark brown, with some fine grained sand, (TOPSOIL)	L / F	M
				ML / SM	0.5	Sandy SILT/Silty SAND, fine grained, low plasticity, red brown, with some clay (ALLUVIUM)		
				SP	1.0	SAND, fine grained, orange brown, poorly graded, with some silt (ALLUVIUM)		
				SC / CI-CL	1.5	Clayey SAND/Sandy CLAY, fine grained, low to medium plasticity, brown (ALLUVIUM)	MD	
			DS3-2 2.5 - 2.7m		2.0			
					2.5		D	
					3.0			
					3.5			
				SC	4.0	Clayey SAND, fine grained, poorly graded, brown (ALLUVIUM)	VD	
					4.5			
					5.0	End BH3 at 5.0 m Reached Target Depth		
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			

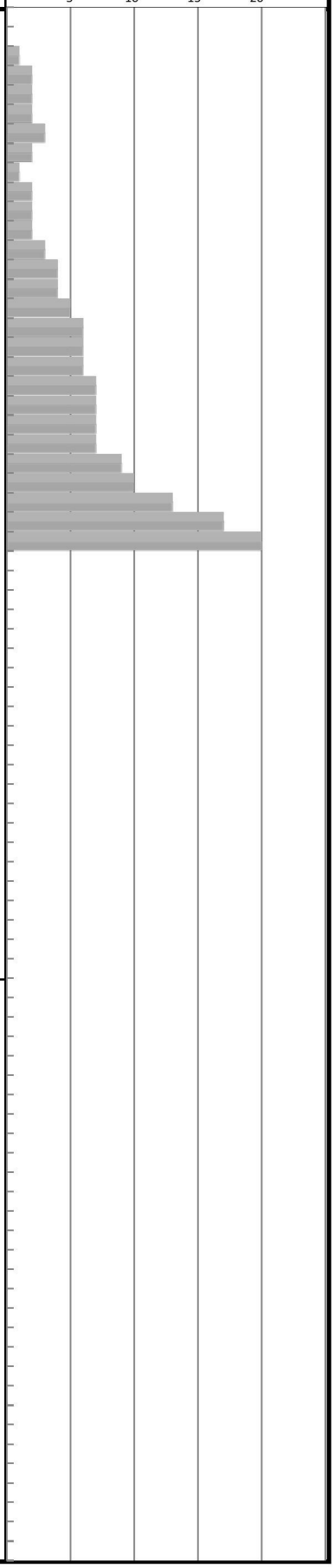


Project No:	P1136	Contractor:	Lithos Pty Ltd	morrow	
Client:	Morson Group Pty Ltd	Drill Rig:	Ute Mounted		
Project:	Recreational and Tourism Precinct 78-88 Tench Avenue Jamisontown NSW	Sheet	1 of 1		
		Logged:	AM		
		Date:	03-08-16		

BH4

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
ADT	L	GWNE		ML	0.5	SILT, low plasticity, dark brown, with some fine grained sand, (TOPSOIL)		
			BDS 4-1 0.5 - 1.0m DS 4-1 0.5 - 0.7m	ML / SM	1.0	Sandy SILT/Silty SAND, fine grained, low plasticity, red brown (ALLUVIUM)	F / L	
				SP	1.5	SAND, fine grained, poorly graded, orange brown, with trace fines (ALLUVIUM)	MD	
					2.0		D	
			DS 4-2 2.3 - 2.5m	CL - CI	2.5	Sandy CLAY, low to medium plasticity, orange brown mottled grey, fine grained sand (ALLUVIUM)		M
					3.0			
			DS 4-3 3.5 -3.7m	SP	3.5	SAND, fine grained, orange brown, poorly graded, with some silt (ALLUVIUM)	VD	
					4.0			
					4.5			
					5.0	End BH4 at 5.0 m Reached Target Depth		
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			

DCP (blows per 100 mm)



EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS

DRILLING/EXCAVATION METHOD

HA	Hand Auger	RD	Rotary blade or drag bit	NQ	Diamond Core - 47 mm
DTC	Diatube Coring	RT	Rotary Tricone bit	NMLC	Diamond Core - 52 mm
NDD	Non-destructive digging	RAB	Rotary Air Blast	HQ	Diamond Core - 63 mm
AS*	Auger Screwing	RC	Reverse Circulation	HMLC	Diamond Core - 63mm
AD*	Auger Drilling	PT	Push Tube	BH	Tractor Mounted Backhoe
*V	V-Bit	CT	Cable Tool Rig	EX	Tracked Hydraulic Excavator
*T	TC-Bit, e.g. ADT	JET	Jetting	EE	Existing Excavation
ADH	Hollow Auger	WB	Washbore or Bailer	HAND	Excavated by Hand Methods

PENETRATION/EXCAVATION RESISTANCE

L **Low resistance.** Rapid penetration/ excavation possible with little effort from equipment used.

M **Medium resistance.** Penetration/ excavation possible at an acceptable rate with moderate effort from equipment used.

H **High resistance.** Penetration/ excavation is possible but at a slow rate and requires significant effort from equipment used.

R **Refusal/ Practical Refusal.** No further progress possible without risk of damage or unacceptable wear to equipment used.

These assessments are subjective and are dependent on many factors, including equipment power and weight, condition of excavation or drilling tools and experience of the operator.

WATER

Water level at date shown

Water inflow

Partial water loss

Complete water loss

GROUNDWATER NOT OBSERVED	Observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave-in of the borehole/ test pit.
GROUNDWATER NOT ENCOUNTERED	Borehole/ test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/ test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following 150mm
seating 30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
Sampling	
DS	Disturbed Sample
BDS	Bulk disturbed Sample
GS	Gas Sample
WS	Water Sample
U63	Thin walled tube sample - number indicates nominal sample diameter in millimetres
Testing	
FP	Field Permeability test over section noted
FVS	Field Vane Shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket Penetrometer test expressed as instrument reading in kPa
WPT	Water Pressure tests
DCP	Dynamic Cone Penetrometer test
CPT	Static Cone Penetration test
CPTu	Static Cone Penetration test with pore pressure (u) measurement

RANKING OF VISUALLY OBSERVABLE CONTAMINATION AND ODOUR (for specific soil contamination assessment

R = 0	No visible evidence of contamination	R = A	No non-natural odours identified
R = 1	Slight evidence of visible contamination	R = B	Slight non-natural odours identified
R = 2	Visible contamination	R = C	Moderate non-natural odours identified
R = 3	Significant visible contamination	R = D	Strong non-natural odours identified

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{\text{Length of core recevered}}{\text{Lengh of core run}} \text{ x } 100$$

SCR = Solid Core Recovery (%)

$$= \frac{\Sigma \text{ Length ofcylindrical core recevered}}{\text{Lengh of core run}} \text{ x } 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\Sigma \text{Axial Lenghts of core} > 100\text{mm}}{\text{Lengh of core run}} \text{ x } 100$$

MATERIAL BOUNDARIES

———— = inferred boundary

- - - - - - - - = probable boundary

— ?— ?— ?— ?— ? = possible boundary

METHOD OF SOIL DESCRIPTION USED ON BOREHOLE AND TEST PIT LOGS

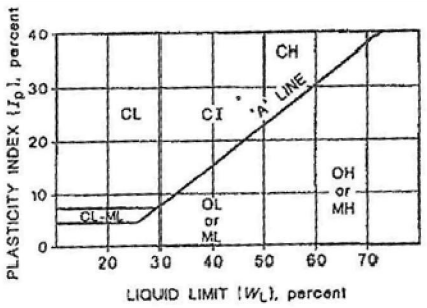
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS1726 – 1993, (Amdt1 – 1994 and Amdt2 – 1994), Appendix A. Material properties are assessed in the field by visual/tactile methods.

PARTICLE SIZE CHARACTERISTICS

Major Division	Sub Division	Particle Size
BOULDERS		>200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	20 to 63 mm
	Medium	6 to 20 mm
	Fine	2 to 6 mm
SAND	Coarse	0.6 to 2 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2mm
SILT		0.002 to 0.075 mm
CLAY		<0.002 mm

PLASTICITY PROPERTIES



USCS SYMBOLS

Major Divisions		Symbol	Description
COARSE GRAINED SOILS More than 50% by dry mass less than 63mm is greater than 0.075mm	More than 50% of coarse grains are >2.mm	GW	Well graded gravel and gravel-sand mixtures, little or no fines.
		GP	Poorly graded gravel and gravel-sand mixtures, little or no fines.
		GM	Silty gravel, gravel-sand-silt mixtures.
		GC	Clayey gravel, gravel-sand-clay mixtures.
	More than 50% of coarse grains are <2 mm	SW	Well graded sand and gravelly sand, little or no fines.
		SP	Poorly graded sand and gravelly sand, little or no fines.
		SM	Silty sand, sand-silt mixtures.
		SC	Clayey sand, sandy-clay mixtures.
FINE GRAINED SOILS More than 50% by dry mass less than 63mm is less than 0.075mm	Liquid Limit less < 50%	ML	Inorganic silts of low plasticity, very fine sands, rock flour, silty or clayey fine sands.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
		OL	Organic silts and organic silty clays of low plasticity.
	Liquid Limit > than 50%	MH	Inorganic silts of high plasticity.
		CH	Inorganic clays of high plasticity.
		OH	Organic clays of medium to high plasticity.
		PT	Peat muck and other highly organic soils.

MOISTURE CONDITION

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays & Silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition & may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

Moisture content of cohesive soils may also be described in relation to plastic limit (WP) or liquid limit (WL) [» much greater than, > greater than, < less than, « much less than].

CONSISTENCY

Symbol	Term	Undrained Shear Strength
VS	Very Soft	0. to 12 kPa
S	Soft	12 to 25 kPa
F	Firm	25 to 50 kPa
St	Stiff	50 to 100 kPa
VSt	Very Stiff	100 to 200 kPa
H	Hard	Above 200 kPa

DENSITY

Symbol	Term	Density Index %	SPT "N" #
VL	Very Loose	< 15	0 to 4
L	Loose	15 to 35	4 to 10
MD	Medium Density	35 to 65	10 to 30
D	Dense	65 to 85	30 to 50
VD	Very Dense	Above 85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.
SPT correlations are not stated in AS1726 – 1993, and may be subject to corrections for overburden pressure and equipment type.

MINOR COMPONENTS

Term	Assessment Guide	Proportion by Mass
Trace	Presence just detectable by feel or eye but soil properties little or no different to general properties of primary component	Coarse grained soils: ≤ 5% Fine grained soil: ≤15%
Some	Presence easily detectable by feel or eye but soil properties little or no different to general properties of primary component	Coarse grained soils: 5 - 12% Fine grained soil: 15 - 30%

TERMS FOR ROCK MATERIAL STRENGTH AND WEATHERING

CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS1726 – 1993, (Amdt1 – 1994 and Amdt2 – 1994), Appendix A. Material properties are assessed in the field by visual/ tactile methods.

STRENGTH

Symbol	Term	Point Load Index, $Is_{(50)}$ (MPa) #	Field Guide
EL	Extremely Low	< 0.03	Easily remoulded by hand to a material with soil properties.
VL	Very Low	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm can be broken by finger pressure.
L	Low	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
VH	Very High	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

 # Rock Strength Test Results

▼ Point Load Strength Index, $Is_{(50)}$, Axial test (MPa)

◀ Point Load Strength Index, $Is_{(50)}$, Diametral test (MPa)

Relationship between rock strength test result ($Is_{(50)}$) and unconfined compressive strength (UCS) will vary with rock type and strength, and should be determined on a site-specific basis. UCS is typically 10 to 30 x $Is_{(50)}$, but can be as low as 5 MPa.

ROCK MATERIAL WEATHERING

Symbol		Term	Field Guide
RS		Residual Soil	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.
EW		Extremely Weathered	Rock is weathered to such an extent that it has soil properties - i.e. it either disintegrates or can be remoulded, in water.
DW	HW	Distinctly Weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. In some environments it is convenient to subdivide into Highly Weathered and Moderately Weathered, with the degree of alteration typically less for MW.
	MW		
SW		Slightly Weathered	Rock slightly discoloured but shows little or no change of strength relative to fresh rock.
FR		Fresh	Rock shows no sign of decomposition or staining.

Appendix B

LABORATORY CERTIFICATES

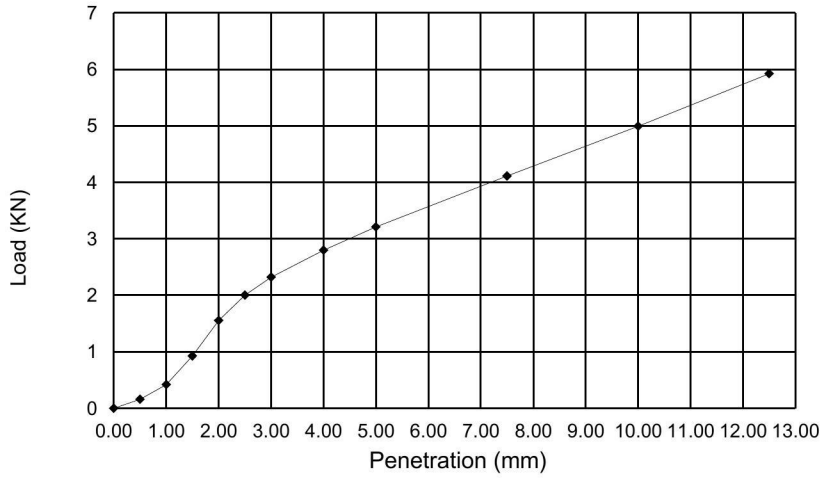
CALIFORNIA BEARING RATIO REPORT

Client:	Morrow Geotechnics	**Source:**	BH2 BDS1
Address:	PO Box 4069, Carlton, NSW, 2218	**Sample Description:**	Refer to Log
Project:	P1136 Jamisontown	**Report No.:**	S15491-CBR
Job No.:	S16328	**Lab No.:**	S15491

Test Procedure:

- ☑ AS1289 6.1.1 Soil strength and consolidation tests - Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen
- ☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort
- ☑ AS1289 2.1.1 Soil moisture content tests - Determination of the moisture content of a soil - Oven drying method (standard method

Sampling:	Sampled by Client	**Date Sampled:**	Unknown
Preparation:	Prepared in accordance with the test method		



Compaction and Placement Data

Compaction Used	Standard	Dry Density				
Maximum Dry Density t/m^3	1.94	At Compaction	1.92	t/m^3	99.0	% Comp.
Optimum Moisture Content %	11.4	After Soaking	1.91	t/m^3	98.0	% Comp.

No. of Layers	3	Moisture Content			Moisture Ratio (%)
Blows per Layer	53	At Compaction	%	11.1	98
Drop of Rammer mm	300	After Soaking	%	12.9	113
Mass of Rammer kg	2.7	After Penetration (Top 30mm)	%	13.7	120
Surcharge Used kg	4.5	After Penetration (Entire Depth)	%	12.1	106
% Ret. 19mm Sieve	7560	Swell After 4 Days Soaking	%	0.1	

Note: material coarser than +19mm Sieve was discarded (as per test method)

California Bearing Ratio

CBR (4-day Soaked) = 19.0 % at 2.5 mm Penetration

Notes:

NATA

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

16/08/2016

Date:

MACQUARIE GEOTECH

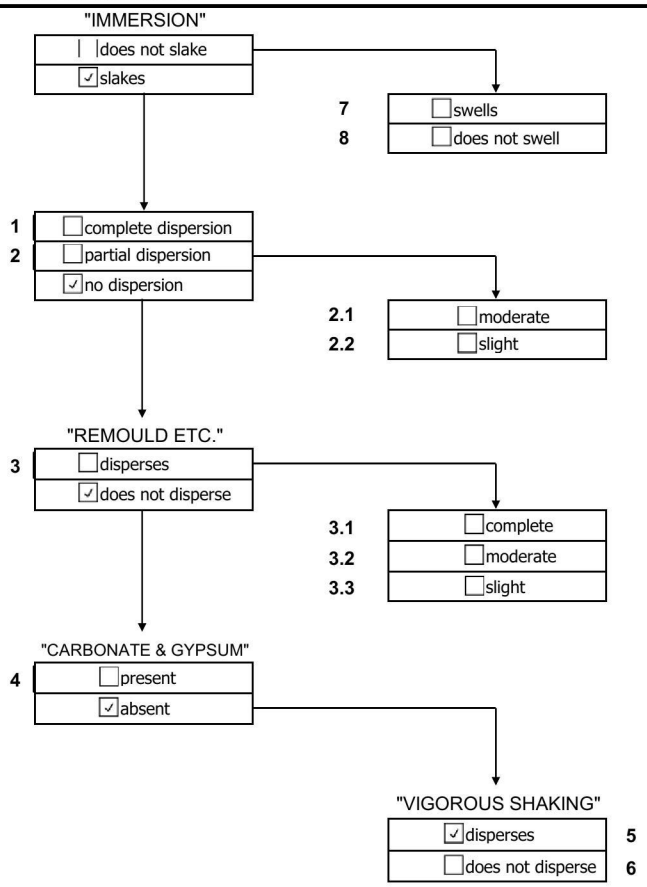
Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

EMERSON CLASS REPORT

Client:	Morrow Geotechnics	**Source:**	BH2 BDS1
Address:	PO Box 4069, Carlton, NSW, 2218	**Sample Description:**	Refer to Log
Project:	P1136 Jamisontown	**Report No:**	S15491-ECT
Job No:	S16328	**Lab No:**	S15491

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling:	Sampled by Client	**Date Sampled:**	Unknown
Preparation:	Prepared in accordance with the test method		



Water Type	**Distilled**
Water Source	**Lab**
Water Temperature (°c)	**20**

RESULT:

Emerson Class No.	**5**

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Date:

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Alexandria NSW 2015

DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

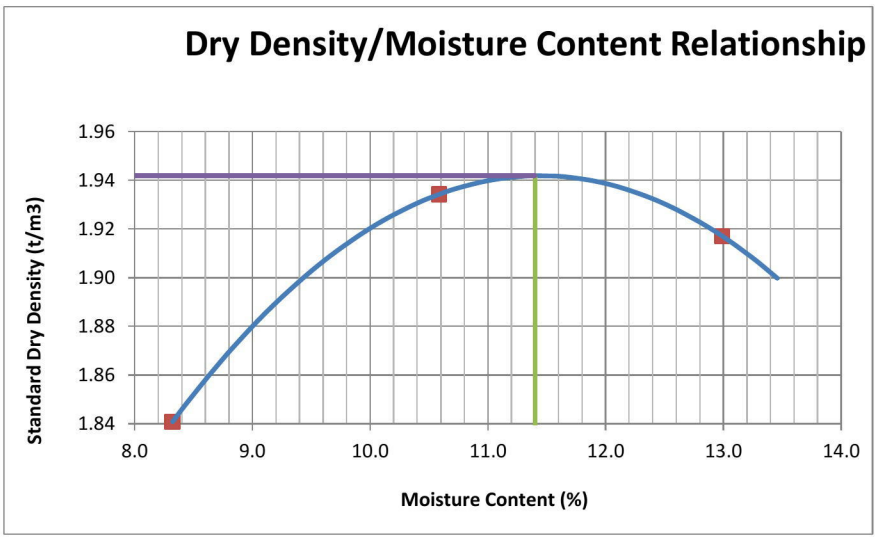
Client:	Morrow Geotechnics	**Source:**	BH2 BDS1
Address:	PO Box 4069, Carlton, NSW, 2218	**Sample Description:**	Refer to Log
Project:	P1136 Jamisontown	**Report No:**	S15491-MDD
Job No:	S16328	**Lab No:**	S15491

Test Procedure:

☑ AS1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

☑ AS1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (Standard method)

Sampling:	Sampled by Client	**Date Sampled:**	Unknown
Preparation:	Prepared in accordance with the test method		



Maximum Dry Density (t/m^3)	1.942
Optimum Moisture Content (%)	11.4
Percentage Oversize on 19mm sieve (%)	0
Percentage Oversize on 37.5mm sieve (%)	0

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Date:

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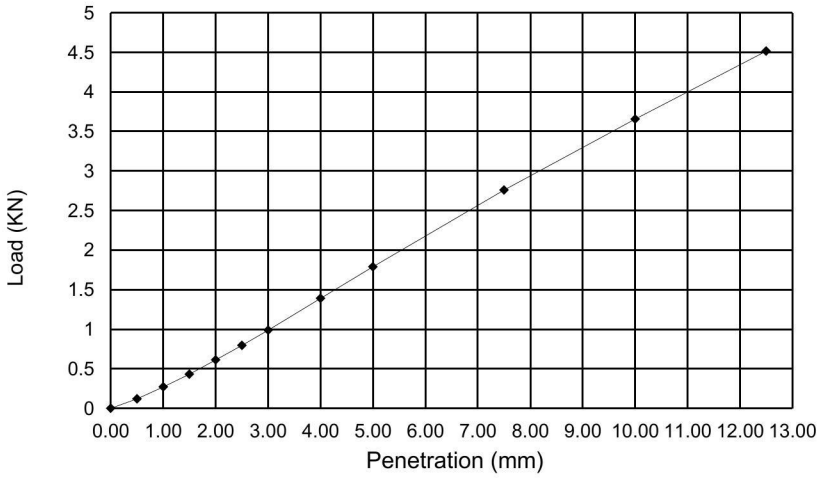
CALIFORNIA BEARING RATIO REPORT

Client:	Morrow Geotechnics	**Source:**	BH4 BDS1
Address:	PO Box 4069, Carlton, NSW, 2218	**Sample Description:**	Refer to Log
Project:	P1136 Jamisontown	**Report No.:**	S15492-CBR
Job No.:	S16328	**Lab No.:**	S15492

Test Procedure:

- ☑ AS1289 6.1.1 Soil strength and consolidation tests - Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen
- ☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort
- ☑ AS1289 2.1.1 Soil moisture content tests - Determination of the moisture content of a soil - Oven drying method (standard method

Sampling:	Sampled by Client	**Date Sampled:**	Unknown
Preparation:	Prepared in accordance with the test method		



Compaction and Placement Data

Compaction Used	Standard	Dry Density				
Maximum Dry Density t/m^3	1.93	At Compaction	1.92	t/m^3	99.0	% Comp.
Optimum Moisture Content %	12.1	After Soaking	1.92	t/m^3	99.0	% Comp.

No. of Layers	3	Moisture Content			Moisture Ratio (%)
Blows per Layer	53	At Compaction	%	12.0	99
Drop of Rammer mm	300	After Soaking	%	13.4	110
Mass of Rammer kg	2.7	After Penetration (Top 30mm)	%	14.3	118
Surcharge Used kg	4.5	After Penetration (Entire Depth)	%	12.2	101
% Ret. 19mm Sieve	0	Swell After 4 Days Soaking	%	0.1	

Note: material coarser than +19mm Sieve was discarded (as per test method)

California Bearing Ratio

CBR (4-day Soaked) = 10.0 % at 5.0 mm Penetration

Notes:

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16/08/2016

Date:

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Bradford Street
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EMERSON CLASS REPORT

Client:	Morrow Geotechnics	**Source:**	BH4 BDS1
Address:	PO Box 4069, Carlton, NSW, 2218	**Sample Description:**	Refer to Log
Project:	P1136 Jamisontown	**Report No:**	S15492-ECT
Job No:	S16328	**Lab No:**	S15492

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client **Date Sampled:** Unknown

Preparation: Prepared in accordance with the test method

"IMMERSION"

- ☐ does not slake
- ☑ slakes
  - 7 ☐ swells
  - 8 ☐ does not swell

1 ☐ complete dispersion
2 ☐ partial dispersion
☑ no dispersion
- 2.1 ☐ moderate
- 2.2 ☐ slight

"REMOULD ETC."

3 ☐ disperses
☑ does not disperse
- 3.1 ☐ complete
- 3.2 ☐ moderate
- 3.3 ☐ slight

"CARBONATE & GYPSUM"

4 ☐ present
☑ absent

"VIGOROUS SHAKING"

- ☑ disperses 5
- ☐ does not disperse 6

Water Type	**Distilled**
Water Source	**Lab**
Water Temperature (°c)	**18**

RESULT:

Emerson Class No. **5**

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

16/08/2016

Date:

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Unit 8/10
Bradford Street
Alexandria NSW 2015

DRY DENSITY / OPTIMUM MOISTURE CONTENT REPORT

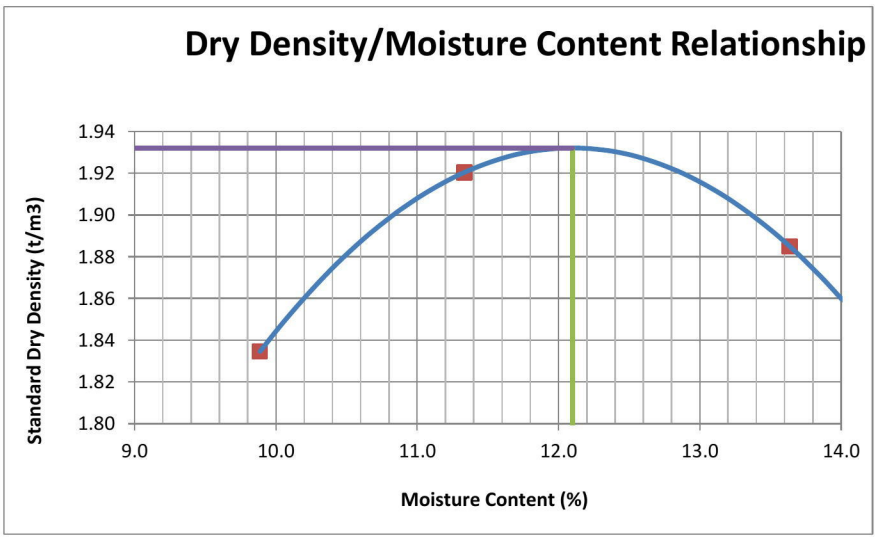
Client:	Morrow Geotechnics	**Source:**	BH4 BDS1
Address:	PO Box 4069, Carlton, NSW, 2218	**Sample Description:**	Refer to Log
Project:	P1136 Jamisontown	**Report No:**	S15492-MDD
Job No:	S16328	**Lab No:**	S15492

Test Procedure:

☑ AS1289.5.1.1 Determination of the dry density/moisture content relation of a soil using standard compactive effort

☑ AS1289.2.1.1 Determination of the moisture content of a soil - Oven drying method (Standard method)

Sampling:	Sampled by Client	**Date Sampled:**	Unknown
Preparation:	Prepared in accordance with the test method		



Maximum Dry Density (t/m^3)	1.932
Optimum Moisture Content (%)	12.1
Percentage Oversize on 19mm sieve (%)	0
Percentage Oversize on 37.5mm sieve (%)	0

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16/08/2016

Date:

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Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Alan Morrow	Manager	Huong Crawford
Client	MORROW GEOTECHNICS PTY LTD	Laboratory	SGS Alexandria Environmental
Address	UNIT 5 12 WINCHESTER STREET CARLTON NSW 2218	Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	(Not specified)	Telephone	+61 2 8594 0400
Facsimile	(Not specified)	Facsimile	+61 2 8594 0499
Email	alan@morrowgeo.com.au	Email	au.environmental.sydney@sgs.com
Project	**P1136**	SGS Reference	**SE155504 R0**
Order Number	(Not specified)	Date Received	04 Aug 2016
Samples	8	Date Reported	11 Aug 2016

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(4354).

SIGNATORIES

Andy Sutton
Senior Organic Chemist

Dong Liang
Metals/Inorganics Team Leader

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name SE155504.001 Soil 03 Aug 2016 BH4-DS1	SE155504.002 Soil 03 Aug 2016 BH4-DS2	SE155504.003 Soil 03 Aug 2016 BH4-DS3	SE155504.004 Soil 03 Aug 2016 BH1-DS1
pH in soil (1:5) Method: AN101 Tested: 11/8/2016						
pH	pH Units	-	**6.9**	-	**7.0**	-
Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 11/8/2016						
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	**16**	-	**16**	-
Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 11/8/2016						
Exchangeable Sodium, Na	mg/kg	2	-	**26**	-	**14**
Exchangeable Sodium, Na	meq/100g	0.01	-	**0.12**	-	**0.06**
Exchangeable Sodium Percentage*	%	0.1	-	**2.6**	-	**1.9**
Exchangeable Potassium, K	mg/kg	2	-	**60**	-	**40**
Exchangeable Potassium, K	meq/100g	0.01	-	**0.15**	-	**0.10**
Exchangeable Potassium Percentage*	%	0.1	-	**3.5**	-	**3.1**
Exchangeable Calcium, Ca	mg/kg	2	-	**530**	-	**520**
Exchangeable Calcium, Ca	meq/100g	0.01	-	**2.6**	-	**2.6**
Exchangeable Calcium Percentage*	%	0.1	-	**60.2**	-	**79.8**
Exchangeable Magnesium, Mg	mg/kg	2	-	**180**	-	**60**
Exchangeable Magnesium, Mg	meq/100g	0.02	-	**1.5**	-	**0.49**
Exchangeable Magnesium Percentage*	%	0.1	-	**33.7**	-	**15.2**
Cation Exchange Capacity	meq/100g	0.02	-	**4.4**	-	**3.2**
pH in soil (1:2) Method: AN101 Tested: 11/8/2016						
pH (1:2)	pH Units	-	-	-	-	-
Conductivity (1:2) in soil Method: AN106 Tested: 11/8/2016						
Conductivity (1:2) @25 C*	µS/cm	1	-	-	-	-
Resistivity (1:2)*	ohm cm	-	-	-	-	-
Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography Method: AN245 Tested: 11/8/2016						
Chloride	mg/kg	0.25	-	-	-	-
Sulphate	mg/kg	0.5	-	-	-	-

Parameter	Units	LOR	Sample Number: SE155504.001 Sample Matrix: Soil Sample Date: 03 Aug 2016 Sample Name: BH4-DS1	SE155504.002 Soil 03 Aug 2016 BH4-DS2	SE155504.003 Soil 03 Aug 2016 BH4-DS3	SE155504.004 Soil 03 Aug 2016 BH1-DS1
Moisture Content Method: AN002 Tested: 8/8/2016						
% Moisture	%w/w	0.5	**14**	**13**	**11**	**15**

Parameter	Units	LOR	Sample Number: SE155504.005 Sample Matrix: Soil Sample Date: 03 Aug 2016 Sample Name: BH1-DS2	SE155504.006 Soil 03 Aug 2016 BH1-DS3	SE155504.007 Soil 03 Aug 2016 BH1-DS4	SE155504.008 Soil 03 Aug 2016 BH3-DS2
pH in soil (1:5) Method: AN101 Tested: 11/8/2016						
pH	pH Units	-	-	**7.3**	**7.2**	-
Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 11/8/2016						
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	-	**19**	**20**	-
Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 11/8/2016						
Exchangeable Sodium, Na	mg/kg	2	-	-	-	-
Exchangeable Sodium, Na	meq/100g	0.01	-	-	-	-
Exchangeable Sodium Percentage*	%	0.1	-	-	-	-
Exchangeable Potassium, K	mg/kg	2	-	-	-	-
Exchangeable Potassium, K	meq/100g	0.01	-	-	-	-
Exchangeable Potassium Percentage*	%	0.1	-	-	-	-
Exchangeable Calcium, Ca	mg/kg	2	-	-	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	-	-	-	-
Exchangeable Calcium Percentage*	%	0.1	-	-	-	-
Exchangeable Magnesium, Mg	mg/kg	2	-	-	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-	-	-	-
Exchangeable Magnesium Percentage*	%	0.1	-	-	-	-
Cation Exchange Capacity	meq/100g	0.02	-	-	-	-
pH in soil (1:2) Method: AN101 Tested: 11/8/2016						
pH (1:2)	pH Units	-	**6.3**	-	-	**7.1**
Conductivity (1:2) in soil Method: AN106 Tested: 11/8/2016						
Conductivity (1:2) @25 C*	µS/cm	1	**38**	-	-	**90**
Resistivity (1:2)*	ohm cm	-	**26000**	-	-	**11000**
Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography Method: AN245 Tested: 11/8/2016						
Chloride	mg/kg	0.25	**8.8**	-	-	**4.3**
Sulphate	mg/kg	0.5	**13**	-	-	**17**

Parameter	Units	LOR	Sample Number: SE155504.005 Sample Matrix: Soil Sample Date: 03 Aug 2016 Sample Name: BH1-DS2	SE155504.006 Soil 03 Aug 2016 BH1-DS3	SE155504.007 Soil 03 Aug 2016 BH1-DS4	SE155504.008 Soil 03 Aug 2016 BH3-DS2
Moisture Content Method: AN002 Tested: 8/8/2016						
% Moisture	%w/w	0.5	**14**	**8.3**	**16**	**14**

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Conductivity (1:2) in soil Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity (1:2) @25 C*	LB107309	µS/cm	1	<1	1%	101%
Resistivity (1:2)*	LB107309	ohm cm	-		1%	NA

Conductivity and TDS by Calculation - Soil Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery
Conductivity of Extract (1:5 dry sample basis)	LB107363	µS/cm	1	6%	95%

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: ME-(AU)-[ENV]AN122

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Exchangeable Sodium, Na	LB107420	mg/kg	2		91%
Exchangeable Sodium, Na	LB107420	meq/100g	0.01	<0.01	NA
Exchangeable Sodium Percentage*	LB107420	%	0.1		NA
Exchangeable Potassium, K	LB107420	mg/kg	2		87%
Exchangeable Potassium, K	LB107420	meq/100g	0.01	<0.01	NA
Exchangeable Potassium Percentage*	LB107420	%	0.1		NA
Exchangeable Calcium, Ca	LB107420	mg/kg	2		87%
Exchangeable Calcium, Ca	LB107420	meq/100g	0.01	<0.01	NA
Exchangeable Calcium Percentage*	LB107420	%	0.1		NA
Exchangeable Magnesium, Mg	LB107420	mg/kg	2		89%
Exchangeable Magnesium, Mg	LB107420	meq/100g	0.02	<0.02	NA
Exchangeable Magnesium Percentage*	LB107420	%	0.1		NA
Cation Exchange Capacity	LB107420	meq/100g	0.02	<0.02	NA

Moisture Content Method: ME-(AU)-[ENV]AN002

Parameter	QC Reference	Units	LOR	DUP %RPD
% Moisture	LB107086	%w/w	0.5	0 - 3%

pH in soil (1:2) Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery
pH (1:2)	LB107309	pH Units	-	1%	99%

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

pH in soil (1:5) **Method: ME-(AU)-[ENV]AN101**

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery
pH	LB107363	pH Units	-	1%	100%

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography **Method: ME-(AU)-[ENV]AN245**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chloride	LB107204	mg/kg	0.25	<0.25	1%	93%
Sulphate	LB107204	mg/kg	0.5	<0.5	1%	97%

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, sediments and sludges, an extract with water (or 0.01M CaCl2) is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2510 B.
AN106	Resistivity of the extract is reported on the extract basis and is the reciprocal of conductivity. Salinity and TDS can be calculated from the extract conductivity and is reported back to the soil basis.
AN122	Exchangeable Cations, CEC and ESP: Soil sample is extracted in 1 M Ammonium Acetate at pH=7 (or 1M Ammonium Chloride at pH=7) with cations (Na, K, Ca & Mg) then determined by ICP OES/ICP MS and reported as Exchangeable Cations. For saline soils, these results can be corrected for water soluble cations and reported as Exchangeable cations in meq/100g or soil can be pre-treated (aqueous ethanol/aqueous glycerol) prior to extraction. Cation Exchange Capacity (CEC) is the sum of the exchangeable cations in meq/100g.
AN122	The Exchangeable Sodium Percentage (ESP) is calculated as the exchangeable sodium divided by the CEC (all in meq/100g) times 100. ESP can be used to categorise the sodicity of the soil as below: ESP < 6% non-sodic ESP 6-15% sodic ESP >15% strongly sodic Method is refernced to Rayment and Higginson, 1992, sections 15D3 and 15N1.-
AN245	Anions by Ion Chromatography: A water sample or extract is injected into an eluent stream that passes through the ion chromatographic system where the anions of interest ie Br, Cl, NO2, NO3 and SO4 are separated on their relative affinities for the active sites on the column packing material. Changes to the conductivity and the UV-visible absorbance of the eluent enable identification and quantitation of the anions based on their retention time and peak height or area. APHA 4110 B

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical Documents/MP-AU-ENV-QU-022 QA QC Plan.pdf

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Appendix C

IMPORTANT INFORMATION

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