LCI Consultants

Preliminary Salinity Assessment: 57 Station Road, Seven Hills, NSW

martens consulting engineers

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P2007944JR03V01
May 2021

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All enquiries regarding this project are to be directed to the Project Manager.

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1 Proposed Development and Investigation Scope

The proposed development details and investigation scope are summarised in Table 1.

Table 1: Summary of proposed development and investigation scope.

Item	Details
Property Address	57 Station Road, Seven Hills, NSW ('the site')
Lot / DP	Lot B in DP404669
Site Area	2.6 ha (based on SIX Maps)
LGA	Blacktown City Council ('Council')
Assessment Purpose	The purpose of this salinity assessment is to support a Development Application (DA) to Council.
Previous Assessment	A preliminary geotechnical assessment was previously conducted by Martens and Associates (MA) to assess the feasibility of the site for a proposed development and provide preliminary recommendation for design and construction of the proposed development. The assessment involved drilling of five boreholes (BH101 to BH105) and installing two groundwater monitoring wells (MW01 in BH101 and MW02 in BH103) as shown in Figure 2, Attachment A. The findings and recommendations of the preliminary geotechnical assessment was presented in MA's report referenced P2007944JR02V02, dated December 2020 (MA, 2020). Results have not been reproduced in this report unless integral to our assessment.
Proposed Development	We understand from the master plan of the development (LCI, 2020) and LCI Consultants that the proposed development will include (refer Figure 1, Attachment A): o An at-grade multistorey hyper scale data centre, comprising: i) A one storey building (SYD 09) in the western portion of the site, which will likely require minor cut and fill up to approximately 2.0 m. Structural loads are expected to be supported by slab on ground or footings. ii) A two storey building (SYD 08) in the eastern portion of the site. No or little cut / fill is expected to be required as part of this construction. Structural loads are expected to be supported by a suspended slab supported by pile foundation. o Construction of car parking areas.
Investigation scope of work	Field investigations conducted on 28 April 2021 included: o Review of DBYD survey plans and buried services search. o A site walkover inspection to gain an appreciation of the site. o Drilling of five boreholes (BH301 to BH305) up to 5.0 metres below ground level (mbgl) (refer Attachment B for borehole logs, and associated explanatory notes in Attachment D). o Collection of soil samples from boreholes for laboratory testing and for future reference. Investigation locations are shown in Figure 2, Attachment A.
Laboratory Testing	Testing carried out by Envirolab services, a National Association of Testing Authorities (NATA) accredited laboratory, included salinity and aggressivity testing (Electrical Conductivity (EC), pH and soluble SO4) on sixteen soil samples. A laboratory test certificate is provided in Attachment C.

2 General Site Details and Investigation Findings

2.1 General Site Details

General site details and investigation findings of subsurface conditions are summarised in Table 2.

Table 2: Summary of general site details based on desktop review, site walkover and site investigations.

Item	Comment
Topography	Within undulating terrain, on a northeast facing slope, approximately 35 m south of Blacktown Creek. The site is characterised by two near level terraces (western upper and eastern lower terraces) separated by a northwest-southeast aligned approximately 4 m high steep cut batter near the central portion of the site. A gravel driveway extends from the Station Road along the northern boundary of the site to access the eastern lower terrace. A northwest-southeast aligned drainage depression extends along the eastern boundary of the site. A layout of the site is presented in Figure 2, Attachment A. Historical aerial photographs (Nearmap) show that a former east-west aligned drainage channel extends diagonally near the eastern portion of the site. The drainage channel was filled as part of the previous development purposes.
Expected geology	The majority of the site is mapped in the Ashfield Shale outcrop zone with a small portion of the site along the eastern site boundary mapped in the Quaternary deposits. Ashfield Shale typically comprises dark-grey to black claystone-siltstone and fine sandstone-siltstone laminite. Quaternary deposits generally comprises fine-grained sand, silt and clay (*Penrith 1:100,000 Geological Series Sheet 9030*, 1991).
Expected soil landscape	The NSW Office of Environment and Heritage's (OEH) information system (eSPADE) indicates the site to be located in the Blacktown (bt) soil landscape, consisting of gently undulating rises on Wianamatta Group shales. This soil landscape is characterised by > 200 cm of soil on lower side slopes. This soil landscape is often associated with localised seasonal waterlogging, localised water erosion hazard, moderately reactive highly plastic subsoil and localised surface movement potential.
Typical slopes, aspect, elevation	The near level terraces have grades of less than approximately 10% towards the northeast. The central steep cut batter has grades of approximately 50 %. Site elevation ranges between approximately 30 mAHD in the north eastern corner and 38 mAHD in the south western corner of the site (Based on Google Earth).
Existing Development	The site is currently occupied by a timber warehouse in the eastern portion, a car scrap yard in the south western portion and a skip bin yard in the north western portion of the site.
Vegetation	Grass, with shrubs and trees along the eastern and southern site boundaries. The central cut batter is densely vegetated.
Drainage	Via overland flow towards the northeast into the drainage depression discharging into Blacktown Creek to the east.

2.2 Subsurface Conditions

Unit A: Fill comprising sandy gravel / silty sand / silty clay encountered up to between approximately 0.2 (western portion) mbgl and 2.2 mbgl (eastern portion).

Unit B: Alluvial firm to stiff silty clay with organics encountered in the eastern portion of the site up to between approximately 1.4 mbgl (BH305) and 1.9 mbgl (BH304). This unit was not encountered in the western portion (upper terrace) of the site.

Unit C: Residual soil comprising:

C1: Generally stiff silty clay encountered in the eastern portion of the site below Unit B, up to between approximately 4.3 mbgl (BH105) and 5.5 mbgl (BH103). This unit was not encountered in the western portion (upper terrace) of the site.

C2: Residual very stiff grading to hard silty clay encountered in the western portion of the site up to between approximately 2.1 mbgl (BH101) and 2.3 mbgl (BH102).

Unit D: Weathered shale, encountered from between 2.1 mbgl (western portion) and 4.3 mbgl (eastern portion).

2.3 Groundwater

Groundwater inflow was not encountered during drilling of BH101, BH102, BH301 to BH303 and BH305 up to between approximately 1.3 mbgl (BH301) mbgl and 5.7 mbgl (BH102). Groundwater inflow could not be observed below 4.64 mbgl in BH101 due to the introduction of drilling fluids during rock coring.

Groundwater inflow was encountered during drilling of BH304, BH103, BH104 and BH105 at 4.3 mbgl, 5.35 mbgl, 4.2 mbgl and 1.3 mbgl, respectively.

A summary of standing groundwater level readings in MW01 and MW02, recorded on 16 and 20 October 2020 is provided in Table 3.

Table 3: Summary of standing groundwater levels measured in monitoring wells.

Location	Approximate Surface Level (mAHD) [1]	Standing Water Levels (mAHD / mbgl)	
		16/10/2020	20/10/2020
MW01	37.0	36.45 / 0.55	33.5 / 3.50
MW02	31.0	28.2 / 2.80	27.91 / 3.09

Notes:

1. Surface level estimated from Google Earth.

3 Salinity Assessment

3.1 Documented Salinity Risk Potential

The 1:100,000 *Salinity Potential in Western Sydney Map* (DIPNR, 2002) indicates the site to be located in an area of moderate salinity potential (Figure 3, Attachment A).

3.2 Broad Scale Salinity Processes

In producing the Salinity Potential Map, the Western Sydney Regional Organisation of Councils (WSROC) developed a number of alternative models of processes by which salinity may occur in Western Sydney (WSROC, 2003, pgs. 16 to 20).

A list of key broad scale salinity processes likely to impact the site, including summarised descriptions of each process, is presented in Table 4.

3.3 Signs of Potential Saline Soils at the site

No obvious sign of saline conditions were observed across the site:

- Vegetation growth appeared healthy and uninhibited.
- No water marks or salt crystals were observed on the ground surface.
- Site surface drainage appeared generally good.
- No evidence of concentrated surface erosion was observed.

3.4 Assessed Salinity Risk Potential

In Table 4, the broad scale salinity processes have been assessed in terms of likelihood of occurring at the site, considering the proposed development, site observations and investigation findings.

Table 4: Potential for broad scale salinity processes at the site.

Key salinity process	Description	Potential at subject site
Localised concentration of salinity	Localised concentration of salts due to relatively high evaporation rates. Usually associated with waterlogged soil and poor drainage. Exacerbated by increased water use and / or blocking of surface and subsurface water flow associated with urban development.	Low – No evidence of localised salt concentration, waterlogged soil or poor drainage observed.
Shale soil landscapes	In poorly drained duplex (texture contrast) soils, shallow subsurface water flows laterally across a clayey upper B-Horizon with salt usually accumulating in the clayey subsoil. Salt concentrations may increase where subsurface water accumulates and evaporates, e.g. on lower slopes or natural and constructed flats in mid-slope. Exacerbated by subsoils exposure through deep cutting, by installing buildings into the B-horizon and by impeding subsurface water flows. Highly dispersive, erodible and poorly draining sodic soils due to salinity.	Moderate to High – The site is underlain by low permeable clays, overlying shale. No evidence of impeded surface soil erosion observed. No bulk excavation is associated with the proposed development.
Deep groundwater salinity	Brackish or saline groundwater rises to a level where, through capillary action in the soil, the water with dissolved salts reaches the ground surface and evaporates, resulting in localised salt concentration. Groundwater rises are typically caused by increased water infiltration, e.g. above average rainfall, vegetation loss, irrigation, increased water use in urban areas, construction of surface pits. Exacerbated by buildings or infrastructure intercepting the zone of groundwater level fluctuation.	Low – Proposed development does not involve any bulk excavation. The proposed development is not expected to intercept or raise groundwater levels. Proposed structures are to be constructed with appropriate drainage measures installed.
Deeply weathered soil landscape	High salt loads with high sulphate levels related to un-mapped deeply weathered soil landscapes beneath fluvial gravel, sand and clay. Usually in mid-slope or on hilltops affected by perched saline groundwater.	Low – No evidence of deeply weathered soils observed. Encountered soils at the site are residual.

3.5 Laboratory Test Results

3.5.1 Salinity Classification

Laboratory test results for salinity classification are summarised in Table 5.

Table 5: Salinity test results.

Sample ID [1]	Material	$EC_{(1:5)}$ (dS/m)	EC_e (dS/m) [2]	Salinity Classification [3]
BH301/0.15	Sandy GRAVEL	0.75	12.75	Very saline
BH301/0.7	Silty CLAY	0.46	3.22	Slightly saline
BH302/0.3	Silty CLAY	0.13	0.91	Non-saline
BH302/1.8	Silty CLAY	0.072	0.50	Non-saline
BH302/2.3	Silty CLAY	0.051	0.36	Non-saline
BH303/0.3	Sandy GRAVEL	0.61	8.54	Very saline
BH303/0.7	Silty CLAY	0.68	4.76	Moderately saline
BH303/3.2	Silty CLAY	0.61	4.27	Moderately saline
BH303/4.6	Silty CLAY	0.32	2.24	Slightly saline
BH304/0.15	Sandy GRAVEL	0.19	2.66	Slightly saline
BH304/0.8	Silty CLAY	0.26	1.82	Non-saline
BH304/2.1	Silty CLAY	0.37	2.59	Slightly saline
BH304/4.4	Silty CLAY	0.34	2.38	Slightly saline
BH305/0.7	Silty CLAY	0.082	0.57	Non-saline
BH305/1.6	Silty CLAY	0.09	0.63	Non-saline
BH305/2.2	Silty CLAY	0.20	1.40	Non-saline
BH103/2.3-2.5 [4]	Silty CLAY	0.77	5.39	Moderately saline
BH104/0.7-0.8 [4]	Silty CLAY	0.088	0.62	Non-saline
BH105/2.5-2.95 [4]	Silty CLAY	0.084	0.59	Non-saline

Notes:

1. Borehole#/Depth (mbgl).
2. Based on EC to EC_e multiplication factors from Table 6.1 in *Site Investigations for Urban Salinity* (2002) guidelines. A multiplication factor of 17.0 was adopted for sandy gravel.
3. Based on Table 6.2 of DLWC (2002) where EC_e <2 dS/m = non-saline, EC_e of 2-4 dS/m = slightly saline, EC_e of 4-8 dS/m = moderately saline, EC_e of 8-16 dS/m = very saline and EC_e of >16 dS/m = highly saline.
4. Reproduced from MA, 2020.

3.5.2 Conclusions and Recommendations

We conclude and recommend the following:

- Near surface fill material can generally be categorised as very-saline. Alluvial and residual silty clay, particularly in the vicinity of drainage channel can be categorised as slightly-saline to moderately saline.

- We recommend that saline soil management strategies are prepared at construction certificate stage following review of proposed development levels. Further testing may need to be undertaken, particularly in the vicinity of former drainage channels depending on the proposed cut / fill and final development levels, to delineate extent of saline soils and salinity risk. Preliminary management strategies may include a combination of, but not be limited to, the following:

    - Maintaining natural water balance.

    - Limiting irrigation.

    - Limiting soil disturbance, such as cut and fill, so saline or sodic subsoils are not exposed or groundwater is not intercepted.

    - Planting of suitable salt-tolerant plant species.

    - Retention of existing deep-rooted vegetation.

    - Offset landscaping and gardens from building and retaining walls.

    - Treating soils with gypsum before landscaping to suit selective species.

    - Where consistent with future land use and landscaping plan, planting of deep-rooted, preferably native, trees to increase water absorption.

    - Sealing, e.g. by lining, of stormwater detention ponds and water features to reduce infiltration.

    - Preparing sediment and erosion control plans that take into account saline soils.

    - Replacing excavated soils in their original order.

- Any long term irrigation or watering on-site is to be at a level that does not cause groundwater to become perched.

Typical management strategies for new buildings and services include:

- Limiting soil disturbance, such as compaction of soils, cutting and filling.
- Designing and building structures to limit interference with natural water flow on site.
- Using appropriate construction materials and techniques to salt proof buildings and infrastructure.
- Utilising damp proof courses and water proofing of slabs.
- Using exposure grade bricks / masonry below damp course or in retaining walls.
- Providing concrete strength and cover to steel reinforcing in accordance with AS 3600 (2018) and the exposure classifications outlined in Table 6.
- Limiting excess surface water infiltration into the soil by designing, installing and maintaining appropriate stormwater drainage (gutters, downpipes, pits and pipes).
- Further assessment including laboratory testing, to improve characterisation of site salinity conditions, particularly in proposed development areas, and assess potential ensuing implications on the proposed development and mitigation requirements.

4 References

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Western Sydney Regional Organisation of Councils (WSROC, 2003) *Western Sydney Salinity Code of Practice*.

5 Attachment A – Figures

Key:

- Indicative borehole and monitoring well locations
- Indicative site boundary
- Area not investigated

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	WB	**SITE LAYOUT AND GEOTECHNICAL TESTING PLAN** **57 Station Road, Seven Hills, NSW**	Drawing: **FIGURE 2**
Approved:	SK		
Date:	04.05.2021		
Scale:	NA		Job No.: P2007944JR03V01

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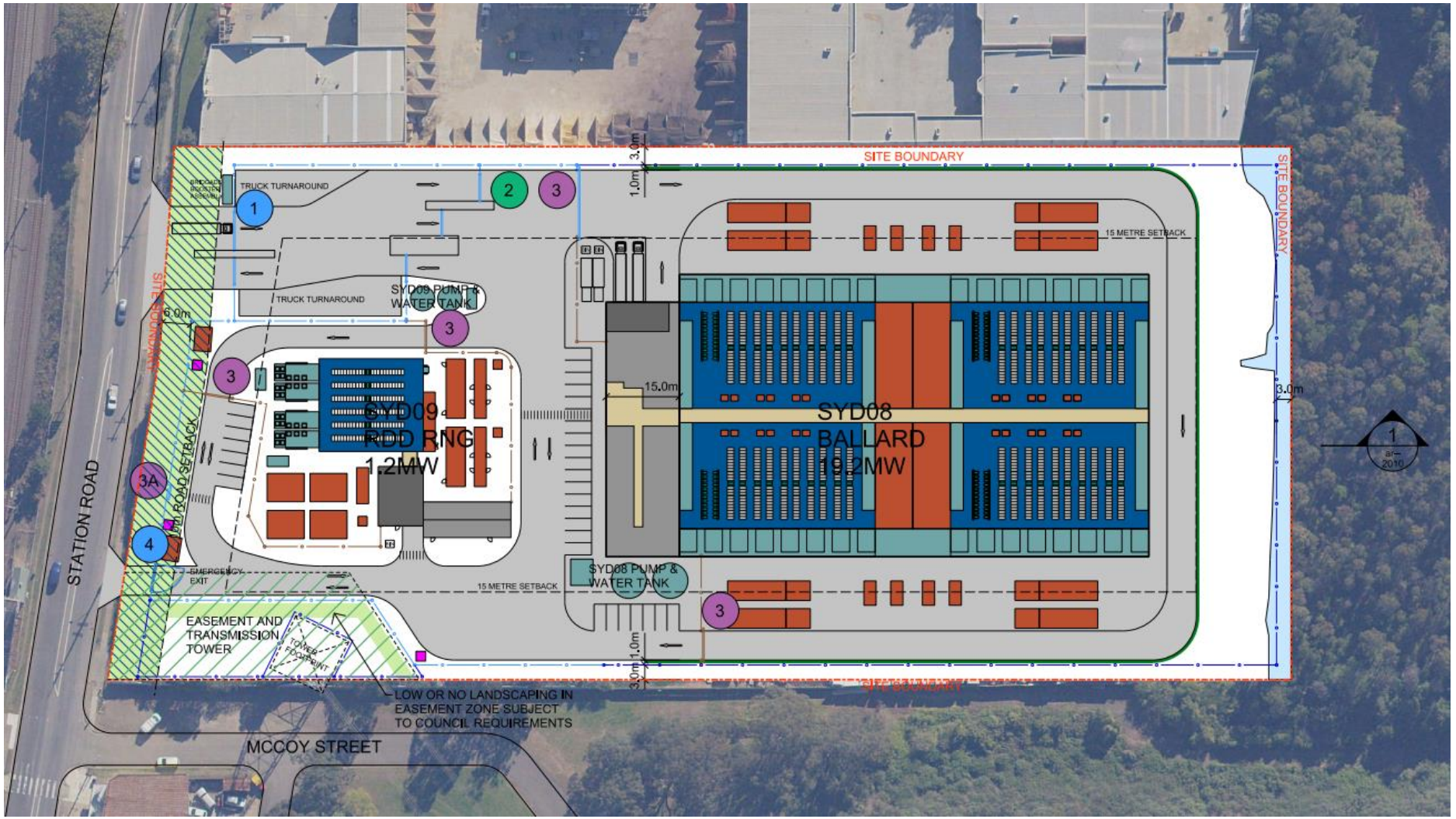
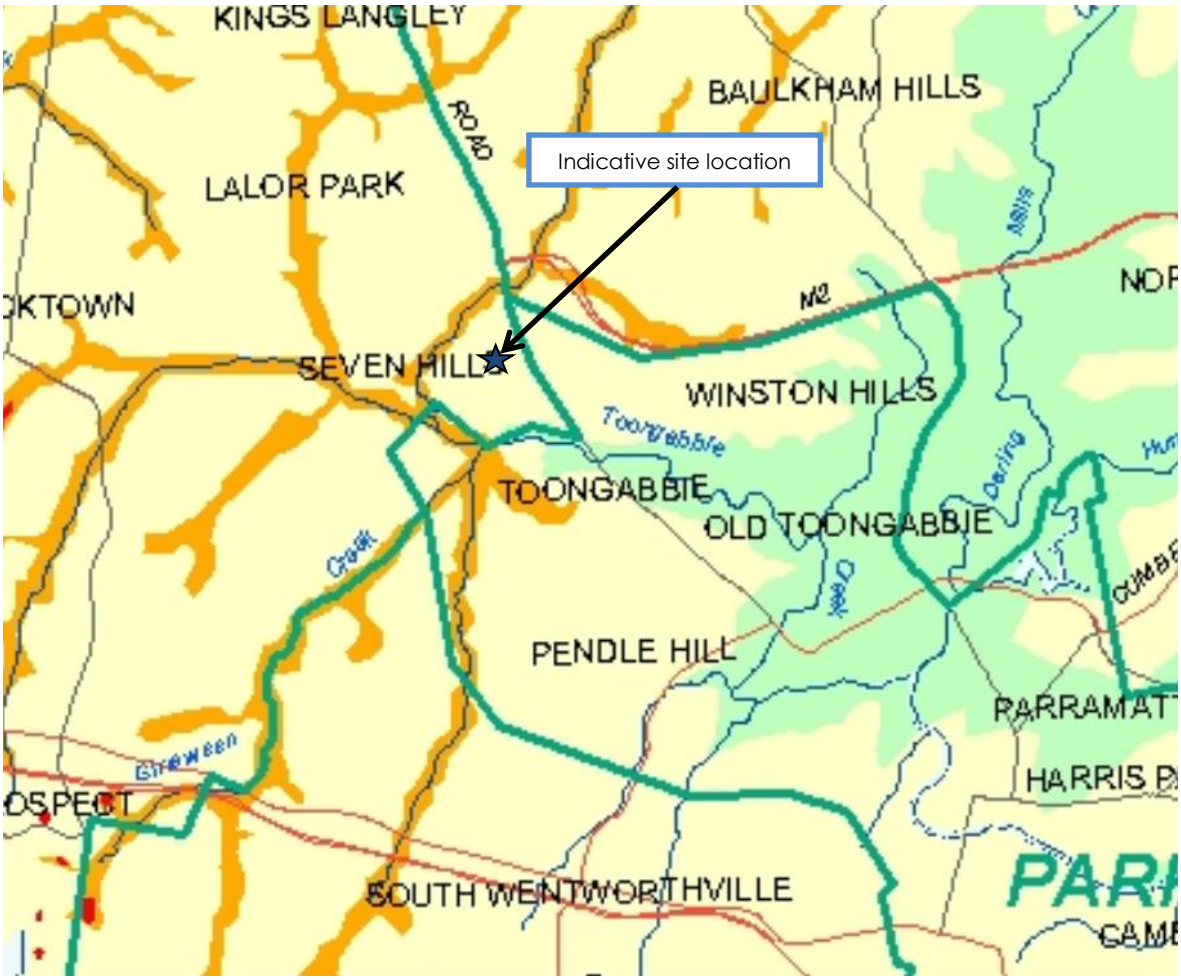


Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	WB	**MASTER PLAN OF THE PROPOSED DEVELOPMENT** **57 Station Road, Seven Hills, NSW** Source: LCI, 2020	Drawing: **FIGURE 1**
Approved:	SK		
Date:	04.05. 2021		
Scale:	NA		Job No.: P2007944JR03V01



MAPPING CATEGORY	ASSOCIATED SOIL LANDSCAPES	LANDFORM - GEOLOGY
KNOWN SALINITY Areas where there is a known occurrence of saline soil, or where air photo interpretation and field observations have confirmed more than one of these: a - scalding b - salt efflorescence c - vegetation dieback d - salt tolerant plant species e - waterlogging A high relative wetness index occurs in these areas.	* Salinity outbreaks occur in Blacktown (bt), Luddenham (lu) and Richmond (ri) Soil Landscapes - common at breaks of slope, lower slopes and drainage lines. * Berkshire Park (bp) and Upper Castlereagh (up) Soil Landscapes have localised salinity due to the impermeable nature of the clay parent material. * South Creek (sc), Monkey Creek (mk), Freemans Reach (fr) and Theresa Park (tp) Soil Landscapes have common saline outbreaks due to high run-on and low local relief. * Soils in the above landscapes have high clay content in subsoils and are imperfectly to poorly drained.	* Break of slope, lower slope and drainage lines of Wianamatta Shales (Rwb,Rwa and Rwn). * Localised salinity also occurs at the geological boundary between Tertiary Gravels (Tl, Tr) and underlaying Wianamatta Shales (Rwb,Rwa/ Quaternary Alluvials (Qpd, Qpa, Qpl, Qal). * Localised salinity occurs in Quaternary Alluvium (Qal, Qpn. Qpd) which underlies many of the drainage systems and wetland margins.
HIGH SALINITY POTENTIAL Areas where soil, geology, topography and groundwater conditions predispose a site to salinity. These conditions are similar to areas of known salinity (see above). These areas are most common in lower slopes and drainage systems where water accumulation is high (ie. high relative wetness index).	* Soil Landscapes include Birrong (bi), Blacktown (bt) Berkshire Park (bp), Freemans Reach (fr), South Creek(sc0, Theresa Park (tp), Richmond (ri) and Luddenham (lu). Drainage systems and convergent slopes are areas of highest risk. * Soils in these landscapes have high clay content in the subsoils, low permeability and high run-on. * Soil profiles may display signs of high salt concentrations at depth (i.e. >0.5m).	* Salinity is most likely to occur in lower slopes, foot-slopes, floodplains and creek lines on Quaternary Sediments (Qal, Qpn, Qpd, Qpc, Qpp, Qha)/Wianamatta Shales (Rwb, Rwn, Rwa) where run-on is high, resulting in seasonally high water tables and soil saturation.
MODERATE SALINITY POTENTIAL Areas on Wianamatta Group Shales and Tertiary Alluvial Terraces. Scattered areas of scalding and indicator vegetation have been noted but no concentrations have been mapped. Saline areas may occur in this zone, which have not yet been identified or may occur if risk factors change adversely.	* Areas of Agnes Banks (ab), Berkshire Park (bp), Blacktown (bt), Luddenham (lu) and Lucas Heights (lh). * Steeper areas with moderate to high local relief and well drained subsoils such as Picton (pn), West Pennant Hills (wp) and Glenorie (gn) are at a lower risk of developing salinity. * Soils are moderate to well-drained due to their elevated position in the landscape.	* Hill-slopes and hill-crests on Wianamatta Shales (Rwb, Rwn, Rwa). * Raised abandoned alluvial terraces and drainage lines on Quaternary Alluvium (Qal, Qpn, Qpd, Qpc, Qpp) from Richmond to Camden and east to Rookwood. Localised areas of elevated, well-drained Tertiary Gravels (Ta, Tl, Tr).
VERY LOW SALINITY POTENTIAL Areas where salinity processes do not operate or are of minor significance. Soils are rapidly drained and underlaying strata (Hawkesbury/Narrabeen Sandstone) are highly permeable, resulting in continual flushing and removal of salts in the landscape. No salinity has been observed in these areas and is not expected to occur.	* Rapidly drained soil landscapes with shallow soils include Warragamba (wb) and Hawkesbury (ha). * Gymea (gy) and Faulconbridge (fb) Soil Landscapes consist of highly permeable sands with well-drained subsoils. * Soils are well to rapidly drained. * Soils have high sand content.	* Occurring on Hawkesbury and Narrabeen Sandstone (Rh, Rno). * Groundwater is relatively fresh in these areas due to the sandstone's elevated position in the landscape and highly permeable nature, resulting in continuous flushing of the system (removal of any accumulated salts).

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	WB	**1:100,000 MAP OF SALINITY POTENTIAL IN WESTERN SYDNEY** **57 Station Road, Seven Hills, NSW** (Source: DIPNR, 2002)	Drawing No: **FIGURE 3**
Approved:	SK		
Date:	04.05.2021		
Scale:	Not to Scale		File No: P2007944JR03V01

6 Attachment B – Test Borehole and Monitoring Well Logs

CLIENT	LCI Consultants		COMMENCED	28/04/2021	COMPLETED	28/04/2021	**REF BH301**
PROJECT	Preliminary Salinity Assessment		LOGGED	AG	CHECKED	WB/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD ute-mounted hydraulic dril rig	EASTING	150.94785	RL SURFACE	35 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 1.30 m depth	NORTHING	-33.77903	ASPECT	North	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	H	Not Encountered	0	35.00								
				0.20	0.15/S/1 D 0.15 m			GP	FILL: Sandy GRAVEL; fine to coarse grained; grey, dark grey, trace plastic.			FILL
				34.80				CI-CH	Silty CLAY; medium to high plasticity; red, grey, reddish-orange; trace gravel.			RESIDUAL SOIL
			1		0.7/S/1 D 0.70 m							
				1.30					Hole Terminated at 1.30 m (Target depth reached)			
			2									
			3									
			4									
			5									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	28/04/2021	COMPLETED	28/04/2021	**REF BH302**
PROJECT	Preliminary Salinity Assessment		LOGGED	AG	CHECKED	WB/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD ute-mounted hydraulic dril rig	EASTING	150.9486	RL SURFACE	31 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 2.50 m depth	NORTHING	-33.77803	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	L	Not Encountered	1	31.00	0.3/S/1 D 0.30 m			CI	FILL:Silty CLAY; medium plasticity; red, brown, grey, dark grey; trace gravel and timber pieces.	M (<<PL)		FILL
				1.50						M (<PL)		
				29.50	1.6/S/1 D 1.60 m				Becoming predominantly grey, pale grey, pale olive.			
				1.70								
				29.30	1.8/S/1 D 1.80 m			CI-CH	Silty CLAY; medium to high plasticity; black, dark grey.	M (>PL)		ALLUVIUM
			2	2.10								
	L-M			28.90	2.3/S/1 D 2.30 m			CI-CH	Silty CLAY; medium to high plasticity; pale olive, orange, yellow, reddish-orange.	M (<<PL)		RESIDUAL SOIL
				2.50								
									Hole Terminated at 2.50 m (Target depth reached)			
			3									
			4									
			5									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	28/04/2021	COMPLETED	28/04/2021	**REF BH303**
PROJECT	Preliminary Salinity Assessment		LOGGED	AG	CHECKED	WB/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD ute-mounted hydraulic dril rig	EASTING	150.94853	RL SURFACE	31 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 4.80 m depth	NORTHING	-33.77838	ASPECT	North	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	H	Not Encountered		31.00				GP	FILL: Sandy GRAVEL; fine to coarse grained; grey, dark grey; with concrete fragments.	D		FILL
	M				0.3/S/1 D 0.30 m							
				0.50								
				30.50				CI-CH	FILL: Silty CLAY; medium to high plasticity; grey, pale grey, reddish-orange; trace ironstone gravels.			
					0.7/S/1 D 0.70 m							
			1							M (<PL)		
				1.70								
				29.30				CI-CH	Silty CLAY; medium to high plasticity; black.			ALLUVIUM
			2		2.0/S/1 D 2.00 m							
	L			*3.00*								
			3	28.00				CI-CH	Silty CLAY; medium to high plasticity; brown, pale olive, dark olive and grey.	M (=PL)		RESIDUAL SOIL
					3.2/S/1 D 3.20 m							
			4									
				4.40								
				26.60				CI-CH	Silty CLAY; medium to high plasticity; grey, brown, yellow, orange.			
					4.6/S/1 D 4.60 m							
				4.80								
			5						Hole Terminated at 4.80 m (Target depth reached)			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	28/04/2021	COMPLETED	28/04/2021	**REF BH304**
PROJECT	Preliminary Salinity Assessment		LOGGED	AG	CHECKED	WB/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD ute-mounted hydraulic dril rig	EASTING	150.94916	RL SURFACE	31 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 5.00 m depth	NORTHING	-33.77882	ASPECT	North	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	H			31.00				GP	FILL: Sandy GRAVEL; fine to coarse grained; with cobbles.	D		FILL
				0.20	0.15/S/1 D 0.15 m							
				30.80				CI	FILL: Silty CLAY; medium plasticity; grey, brown, reddish-orange, yellow; trace gravels; trace sand.			
					0.8/S/1 D 0.80 m							
			1							M (<PL)		
				1.90								
				29.10				CI-CH	Silty CLAY; medium to high plasticity; grey, pale grey; trace ironstone gravels.			ALLUVIUM
			2		2.1/S/1 D 2.10 m							
	L-M											
			3							M (=PL)		
				3.80								
				27.20					Becoming predominantly dark grey and black.			
		▽	4		4.4/S/1 D 4.40 m							
				5.00								
			5						Hole Terminated at 5.00 m (Target depth reached)			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	28/04/2021	COMPLETED	28/04/2021	**REF BH305**
PROJECT	Preliminary Salinity Assessment		LOGGED	AG	CHECKED	WB/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD ute-mounted hydraulic dril rig	EASTING	150.9488	RL SURFACE	30 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 2.40 m depth	NORTHING	-33.77881	ASPECT	North	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	H	Not Encountered	0	30.00	0.2/S/1 D 0.20 m			CI	FILL: Silty CLAY; medium plasticity; brown, grey, trace sand; trace gravels; trace timber pieces.	M (<PL)		FILL
					0.7/S/1 D 0.70 m					M (<<PL)		
	L-M		1	*1.40*								
				28.60				CI	Silty CLAY; medium plasticity; dark grey, black; trace decayed roots; trace gravels.			ALLUVIUM
					1.6/S/1 D 1.60 m					M (=PL)		
				1.90								
			2	28.10				CI-CH	Silty CLAY; medium to high plasticity; pale olive, yellow, orange, grey, trace gravels.			RESIDUAL SOIL
					2.2/S/1 D 2.20 m					M (<<PL)		
				2.40								
									Hole Terminated at 2.40 m (Target depth reached)			
			3									
			4									
			5									

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	16/10/2020	COMPLETED	16/10/2020	**REF BH101**
PROJECT	Preliminary Geotechnical Assessment		LOGGED	WB	CHECKED	SVK/SK	Sheet 1 OF 2
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	150.947614	RL SURFACE	37 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 7.20 m depth	NORTHING	-33.779433	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V				37.00	PID 0.00 m 0.3 ppm			CI-CH	FILL: Silty CLAY; medium to high plasticity; dark brown, brown, grey, pale grey; trace sand; trace mixed gravels; inferred moderately compacted.			FILL
				0.30	0.00-0.1/Dup02 D0.1							
				36.70	0.00-0.10 m			CH				RESIDUAL SOIL
					0.00-0.1/S/1 D				Silty CLAY; high plasticity; red, red-brown, pale grey; strong hydro carbon odour.			
					0.00-0.10 m							
	M				0.00-0.3/S/1 D							
					0.00-0.30 m					M	VSt	
				1.00	0.4-1.0/CBR/1 CBR							
				36.00	0.40-1.00 m			CI	Silty CLAY; medium plasticity; brown, red-brown, pale grey; strong hydro carbon odour.	(<PL)		
					PID 0.50 m 0.2 ppm							
					0.6-0.8/S/1 D							
				1.60	0.60-0.80 m							
				35.40	SPT 1.00-1.45 m				Trace ironstone gravels; inferred hard.			
	H				5,8,9						H	
			2		N=17							
				2.10	PID 1.00 m 0.8 ppm							
				34.90	1				SHALE; grey, red-brown, brown; highly weathered; inferred low strength.			WEATHERED ROCK
					1.0-1.5/S/1 D							2.10: V-bit refusal.
					1.00-1.50 m							
	M				PID 1.10 m 43 ppm							
					PID 2.00 m 108.7 ppm							
					2.7-2.8/R/1 D							
				3.10	2.70-2.80 m							
AD/T		Not Observed		33.90	PID 2.80 m 25.6 ppm				Grey; inferred low to medium strength.			
					3.1-3.3/R/1 D							
					3.10-3.30 m							
					PID 3.30 m 5.2 ppm							
	H		4									
				4.64								
									Continued as Cored Borehole			
			6									
			8									
			10									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants	COMMENCED	16/10/2020	COMPLETED	16/10/2020	**REF BH101**	
PROJECT	Preliminary Geotechnical Assessment	LOGGED	WB	CHECKED	SVK/SK	Sheet 2 OF 2	
SITE	57 Station Road, Seven Hills, NSW	GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	150.947614	RL SURFACE	37 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 7.20 m depth	NORTHING	-33.779433	ASPECT	East	SLOPE	<5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
				2							
				4							
					4.64		Continuation from non-cored borehole				
NMLC	Not Observed	100	0 (95)	6	32.36		SHALE; dark grey and brown; thinly laminated.	SW - MW		4.64-4.66: BPSet 3, 5°, CT, Pl, Sm 4.67: JT, 20°, CT, Pl, Sm 4.70-4.73: BPSet 2, 5°, CT, UN, Ro 4.75-4.78: BPSet 2, CN, Pl, Ro 4.82-4.89: BPSet 4, 0 - 5°, Closely bedded 4.92-4.95: BP, 0°, CN, UN, Ro 5.00: HB 5.03: HB 5.07-5.08: DS, Clay 5.12-5.14: BPSet 2, 0 - 5°, CT, UN, Ro 5.17: JT, 10°, CN, UN, Ro 5.20: BP, 0°, VNR, Pl, Sm 5.30: BP, 0°, Closed 5.35: JT, 30 - 45°, VNR, UN, Ro 5.39: BP, 0 - 5°, VNR, Pl, Sm 5.43: BP, 0°, Closed 5.44: JT, 45°, VNR, UN, Ro 5.55-5.56: BP, 0°, CN, UN, Ro 5.62-5.63: DS, Clay 5.65: BP, 0°, CN, UN, Ro 5.67-5.68: DS, Clay 5.74-5.78: BPSet 5, 0 - 10°, Closely bedded 5.81: JT, 10°, CN, UN, Ro 5.86-5.87: CS 5.87: JT, 30°, CN, UN, Ro 5.90-5.94: BPSet 2, 5°, CN, UN, Ro 5.96: JT, 15°, CN, UN, Ro 5.98: BP, 0°, CN, Pl, Ro 6.00: BP, 0°, CN, Pl, Ro 6.05-6.06: BPSet 2, 0 - 5°, CN, Pl, Ro 6.07-6.09: CS 6.11-6.16: BPSet 3, 0°, CN, Pl, Ro, 10-30mm spacing 6.20: BP, 0°, CT, Pl, Sm 6.25: BP, 0°, CN, Pl, Ro 6.30-6.31: CS 6.33-6.40: BP, 0°, CN, Pl, Ro, 20-50mm spacing. 6.43-6.46: JTSet 3, 30°, CN, UN, Ro, 10-20mm spacing 6.50: BP, 0°, CN, UN, Ro 6.53: BP, 0°, Closed 6.55-6.58: BP, 0 - 5°, CN, Pl, Ro 6.60-6.70: JT, 60°, VNR, UN, Ro 6.73: BP, 0°, CN, Pl, Ro 6.74-6.78: JT, 45°, CN, UN, Ro 6.78-6.86: BPSet 2, 0 - 5°, VNR, Pl, Ro 6.79: BP, 0°, CN, Pl, Ro 6.87-6.88: BP, 0°, CT, Pl, Sm 6.93-6.94: CS 7.00: HB 7.00-7.05: JTSet 2, 80 - 90°, CN, UN, Ro 7.03-7.12: BPSet 3, 0°, CN, UN, Ro, 20-70mm spacing 7.12: BP 7.12-7.20: CS	
					5.80 31.20		Black with dark grey.	FR - SW			
				8	*7.20* 29.80		Hole Terminated at 7.20 m				
				10							

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	16/10/2020	COMPLETED	16/10/2020	**REF BH101/MW01**
PROJECT	Preliminary Geotechnical Assessment		LOGGED	WB	CHECKED	SVK/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	150.947614	RL SURFACE	37 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 7.20 m depth	NORTHING	-33.779433	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG / USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
				37.00	0.00-0.1/Dup02 D0.1		CI-CH	FILL: Silty CLAY; medium to high plasticity; dark brown, brown, grey, pale grey; trace sand; trace mixed gravels; inferred moderately compacted.			ID MW01 Static Water Level
				0.30	0.00-0.10 m						Concrete
				36.70	0.00-0.1/S/1 D						Cuttings
					0.00-0.10 m		CH	Silty CLAY; high plasticity; red, red-brown, pale grey; strong hydro carbon odour.			
					0.00-0.3/S/1 D						
					0.00-0.30 m						
					0.4-1.0/CBR/1 CBR						
AD/V	M	16/11/20		*1.00*	0.40-1.00 m				M (<PL)	VSt	Bentonite
				36.00	0.6-0.8/S/1 D		CI	Silty CLAY; medium plasticity; brown, red-brown, pale grey; strong hydro carbon odour.			
					0.60-0.80 m						Casing
					1						
				1.60	1.0-1.5/S/1 D						
	H			35.40	1.00-1.50 m			Trace ironstone gravels; inferred hard.		H	
			2	*2.10*							
				34.90				SHALE; grey, red-brown, brown; highly weathered; inferred low strength.			
	M				2.7-2.8/R/1 D						
					2.70-2.80 m						Screen
				3.10							
AD/T		20/10/20		33.90	3.1-3.3/R/1 D			Grey; inferred low to medium strength.			
					3.10-3.30 m						
			4								Sand
				4.64							
				32.36	1 C 4.64-7.20 m			SHALE; dark grey and brown; thinly laminated.			
NMLC	H				C 5.20-5.28 m						
				5.80							
				31.20				Black with dark grey.			
			6								
					C 6.78-6.86 m						
				7.20							
								Hole Terminated at 7.20 m			
			8								
			10								

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - TEST

CLIENT	LCI Consultants		COMMENCED	16/10/2020	COMPLETED	16/10/2020	**REF BH102**
PROJECT	Preliminary Geotechnical Assessment		LOGGED	WB	CHECKED	SVK/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	150.947696	RL SURFACE	35 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 5.70 m depth	NORTHING	-33.779003	ASPECT	Northeast	SLOPE <5%

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG / USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		Not Encountered		*0.20* 34.80	0.00-0.2/S/1 D 0.00-0.20 m PID 0.10 m 1.8 ppm 0.3-1.0/CBR/1 CBR 0.30-1.00 m		SM	FILL: Silty SAND; pale grey, pale brown; trace mixed gravels; inferred moderately compacted; poorly graded.	D		FILL
							CH	Silty CLAY; high plasticity; red, red-brown, orange; pale grey.			RESIDUAL SOIL
	M			*0.80* 34.20	0.4-0.5/S/1 D 0.40-0.50 m 0.8-0.9/S/1 D 0.80-0.90 m			Brown, pale grey, red-brown.		VSt	
				1.40 33.60	SPT 1.00-1.45 m 4,6,10 N=16			Pale grey, red-brown; inferred hard.	M (<<PL)		
	H		2		PID 1.00 m 0.2 ppm 1 1.0-1.45/S/1 D 1.00-1.45 m					H	
				2.30 32.70	PID 1.50 m 1.9 ppm 1.80-2.00/S/1 D 1.80-2.00 m PID 2.30 m 0.2 ppm			SHALE; grey, pale grey, red-brown; highly weathered; inferred low strength.			WEATHERED ROCK 2.30: V-bit refusal.
				2.80 32.20				Black with dark grey.			
AD/T	M										
			4	*4.00* 31.00				Inferred low to medium strength.			
	H			*5.70*							
			6					Hole Terminated at 5.70 m			5.70: TC-bit refusal on inferred medium strength shale.
			8								
			10								

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	15/10/2020	COMPLETED	15/10/2020	**REF BH103**
PROJECT	Preliminary Geotechnical Assessment		LOGGED	WB	CHECKED	SVK/SK	Sheet 1 OF 2
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	150.948642	RL SURFACE	31 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 8.82 m depth	NORTHING	-33.778558	ASPECT	Northeast	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M		2	31.00	PID 0.00 m 7.1 ppm 0.00-0.2/S/1 D 0.00-0.20 m PID 0.10 m 8 ppm			CL-CI	FILL: Silty CLAY; low to medium plasticity; pale grey, grey, brown, red-brown; trace fine siltstone and shale gravel; inferred poorly to moderately compacted.			FILL
					SPT 1.00-1.45 m 3,5,6 N=11 1 1.0-1.45/S/1 D 1.00-1.45 m PID 1.50 m 8 ppm 1.8-2.0/S/1 D 1.80-2.00 m					M (<<PL)		
				2.20								
				28.80	2.3-2.5/S/1 D 2.30-2.50 m SPT 2.50-2.95 m 2,3,3 N=6			CI-CH	Silty CLAY; medium to high plasticity; dark grey; trace fine subrounded to rounded gravels; organic smell.		F	ALLUVIUM
				3.00								
				28.00	PID 2.50 m 7 ppm 2 2.5-2.95/S/1 D 2.50-2.95 m 2.9-3.0/S/1 D 2.90-3.00 m			CH	Silty CLAY; high plasticity; brown, red-brown, grey; trace fine ironstone gravels; inferred stiff.			RESIDUAL SOIL
			4		PID 3.00 m 7.3 ppm					M (<PL)		
				4.00	3.7-4.0/S/1 D							
				27.00	3.70-4.00 m PID 4.00 m 7 ppm				Brown, red-brown, orange, grey and pale grey.		St	
					4.5-4.8/S/1 D 4.50-4.80 m							
		▽		*5.50*								
AD/T				*5.65*	PID 5.50 m 7.4 ppm				SHALE; dark grey; highly weathered; inferred low strength.			WEATHERED ROCK
			6						Continued as Cored Borehole			5.50: V-bit refusal.
			8									
			10									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	15/10/2020	COMPLETED	15/10/2020	**REF BH103**
PROJECT	Preliminary Geotechnical Assessment		LOGGED	WB	CHECKED	SVK/SK	Sheet 2 OF 2
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	150.948642	RL SURFACE	31 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 8.82 m depth	NORTHING	-33.778558	ASPECT	Northeast	SLOPE <5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
				2							
				4							
					5.65		Continuation from non-cored borehole				
NMLC		100	72 (100)	6	25.35		SHALE; black with dark grey; thinly laminated.	SW FR		5.65-5.79: BPSet 6, 0°, CN, Pl, Sm, 10-30mm spacing. 6.00: HB 6.07-6.22: BPSet 3, 0°, CN, Pl, Sm, 60-90mm spacing. 6.46-6.55: BPSet 2, 0°, CN, Pl, Sm 6.72: BP, 0°, CN, UN, Ro	
					6.70 24.30		Water loss.			7.00: HB 7.07-7.10: BPSet 2, 0 - 5°, CN, Pl, Sm 7.12: HB 7.13: HB 7.16: JT, 5°, CT, Pl, Ro 7.30: DB 7.40: BP, 0°, CN, UN, Ro 7.59: BP, 0°, CN, UN, Ro 7.75-7.76: BPSet 2, 0°, CN, UN, Ro 7.86: BP, 0°, CN, Pl, Sm 7.90-7.91: JTSet 2, 0 - 5°, CN, UN, Ro 8.00: HB 8.12: HB 8.46: BP, 0°, CN, Pl, Sm 8.53-8.54: BPSet 2, 0°, CN, Pl, Ro 8.65: JT, 0°, CN, UN, Ro 8.73: BP, 0°, CN, Pl, Ro 8.75: JT, 5°, CN, UN, Ro	
			78 (100)	8	*8.82*						
					22.18		Hole Terminated at 8.82 m				
				10							

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	15/10/2020	COMPLETED	15/10/2020	**REF BH103/MW02**
PROJECT	Preliminary Geotechnical Assessment		LOGGED	WB	CHECKED	SVK/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	150.948642	RL SURFACE	31 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 8.82 m depth	NORTHING	-33.778558	ASPECT	Northeast	SLOPE <5%

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID / Static Water Level
AD/V		16/10/20		31.00	0.00-0.2/S/1 D 0.00-0.20 m			CL-CI	FILL: Silty CLAY; low to medium plasticity; pale grey, grey, brown, red-brown; trace fine siltstone and shale gravel; inferred poorly to moderately compacted.			MW02
					1 1.0-1.45/S/1 D 1.00-1.45 m					M (<<PL)		
			2		1.8-2.0/S/1 D 1.80-2.00 m							
				2.20								
				28.80	2.3-2.5/S/1 D 2.30-2.50 m			CI-CH	Silty CLAY; medium to high plasticity; dark grey; trace fine subrounded to rounded gravels; organic smell.		F	
					2 2.5-2.95/S/1 D 2.50-2.95 m							
		20/10/20		*3.00*								
				28.00	2.9-3.0/S/1 D 2.90-3.00 m			CH	Silty CLAY: high plasticity; brown, red-brown, grey; trace fine ironstone gravels; inferred stiff.			
					3.7-4.0/S/1 D 3.70-4.00 m					M (<PL)		
			4	*4.00*								
				27.00					Brown, red-brown, orange, grey and pale grey.		St	
	M				4.5-4.8/S/1 D 4.50-4.80 m							
				5.50								
AD/T				*5.65*					SHALE; dark grey; highly weathered; inferred low strength.			
				25.35	1 C 5.65-8.82 m				SHALE; black with dark grey; thinly laminated.			
			6									
				6.70								
				24.30					Water loss.			
NMLC										M (<PL)		
			8									
				8.82								
									Hole Terminated at 8.82 m			
			10									

PIEZOMETER DETAILS: Concrete; Cuttings; Casing; Bentonite; Screen; Sand

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - TEST

CLIENT	LCI Consultants	COMMENCED	15/10/2020	COMPLETED	16/10/2020	**REF BH104**
PROJECT	Preliminary Geotechnical Assessment	LOGGED	WB	CHECKED	SVK/SK	Sheet 1 OF 2
SITE	57 Station Road, Seven Hills, NSW	GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	150.948763	RL SURFACE	30 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 8.50 m depth	NORTHING	-33.778073	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	H			30.00	PID 0.00 m 1.3 ppm 0.1-0.3/S/1 D 0.10-0.30 m			CI-CH	FILL: Silty CLAY; medium to high plasticity; grey, brown; trace sand; trace mixed gravels; inferred moderately compacted.	M (<<PL)		FILL
				0.50								
AD/T	L			29.50	PID 0.60 m 0.3 ppm 0.7-0.8/S/1 D 0.70-0.80 m			CI	FILL: Silty CLAY; medium to high plasticity; grey, dark grey, brown, red-brown; trace mixed gravels; trace wood; trace fabric; inferred poorly compacted.			
	L				SPT 1.00-1.45 m 2,4,5 N=9							
				1.50	1							
				28.50	PID 1.50 m 9.1 ppm 1.6-1.8/S/1 D 1.60-1.80 m			CI	Silty CLAY; medium plasticity; grey; organic smell; inferred firm to stiff.		F - St	ALLUVIUM
			2	*2.20*						M (<PL)		
				27.80	2.3-2.4/S/1 D 2.30-2.40 m			CH	Silty CLAY; high plasticity; brown, grey; with shale bands.			RESIDUAL SOIL
AD/V	M				SPT 2.50-2.95 m 2,5,6 N=11							
					PID 2.50 m 7 ppm 2						St	
				3.50								
				26.50				CI	Silty CLAY; medium plasticity; brown; trace sand; trace fine shale gravels.			
					3.8-4.0/S/1 D							
			4	*4.00*	3.80-4.00 m							
		▽		26.00	SPT 4.00-4.45 m 2,3,5 N=8				Brown, red-brown, grey, orange; trace fine ironstone gravels.	M (>PL)		
	H			*4.40*							VSt - H	
AD/T				*4.60*	PID 4.00 m 7.6 ppm				Inferred very stiff to hard.			
	M			*4.72*	3				SHALE; dark grey; highly weathered; inferred low strength.			WEATHERED ROCK
					4.0-4.45/S/1 D 4.00-4.45 m				Continued as Cored Borehole			4.60: V-bit refusal.
			6									
			8									
			10									

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	15/10/2020	COMPLETED	16/10/2020	**REF BH104**
PROJECT	Preliminary Geotechnical Assessment		LOGGED	WB	CHECKED	SVK/SK	Sheet 2 OF 2
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	150.948763	RL SURFACE	30 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 8.50 m depth	NORTHING	-33.778073	ASPECT	East	SLOPE <5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
				2							
				4							
					4.72		Continuation from non-cored borehole				
					25.28		SHALE; dark grey and brown; thinly laminated.	MW		4.79: BP, 0°, CT, Pl, Sm 4.83-4.84: DS, Silty clay 4.88-4.89: DS, Silty clay 4.92: BP, 0°, CN, Pl, Sm 4.97-5.00: BPSet 2, 0°, VNR, Pl, Sm 5.03-5.33: BPSet 10, 0 - 5°, CN, Pl, Ro, 10-50mm spacing 5.34: JT, 5°, CN, UN, Ro 5.37-5.44: BPSet 3, 5°, CN, Pl, Ro, 10-50mm spacing 5.48-5.60: JTSet 3, 0 - 5°, CN, UN, Ro, 10-100mm spacing 5.66-5.68: BPSet 2, 5 - 10°, CN, Pl, Ro 5.77: BP, 5°, VNR, UN, Ro 5.95: BP, 0°, CN, UN, Ro 6.00: HB 6.30: JT, 5°, CN, UN, Ro 6.68-6.70: BPSet 3, CN, Pl, Sm, 10mm spacing 7.00: HB 7.14: BP, 0°, CN, Pl, Ro 7.19: HB 7.20: DB 7.54: BP, 5°, CN, UN, Ro 7.96: BP, 5°, CN, UN, Ro 8.00: HB 8.04: CS 8.20: JT, 10 - 15°, CN, UN, Ro 8.26: BP, 0 - 5°, CN, UN, Ro	
		100	49 (100)	6	*5.08*		Black with dark grey.	SW			
					24.92			FR			
			89 (100)	8	*8.50*						
					21.50		Hole Terminated at 8.50 m				
				10							

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Engineering Log - BOREHOLE

CLIENT	LCI Consultants		COMMENCED	16/10/2020	COMPLETED	16/10/2020	**REF BH105**
PROJECT	Preliminary Geotechnical Assessment		LOGGED	WB	CHECKED	SVK/SK	Sheet 1 OF 1
SITE	57 Station Road, Seven Hills, NSW		GEOLOGY	Ashfield Shale	VEGETATION	None	PROJECT NO. P2007944
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING	150.949336	RL SURFACE	30 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 5.20 m depth	NORTHING	-33.778533	ASPECT	East	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	H			30.00	PID 0.10 m 2.1 ppm 0.2-0.3/S/1 D 0.20-0.30 m PID 0.50 m 3.9 ppm			SM	FILL: Silty SAND; fine to medium grained; grey, brown, pale grey; trace concrete fragments; trace mixed gravels; inferred moderately compacted; poorly graded.	M		FILL
				1.00	0.9-1.0/S/1 D							
	L	▽		29.00	0.90-1.00 m SPT 1.00-1.45 m 3,4,5 N=9				Trace clay; inferred poorly to moderately compacted.	W		
				1.50								
AD/V	M		2	28.50 *1.80* 28.20	PID 1.00 m 0.5 ppm 1 1.0-1.45/S/1 D 1.00-1.45 m 1.6-1.7/S/1 D 1.60-1.70 m 1.9-2.0/S/1 D 1.90-2.00 m PID 2.25 m 0.1 ppm SPT 2.50-2.95 m 3,6,7 N=13 2 2.5-2.95/S/1 D 2.50-2.95 m			CL-CI CI	Silty CLAY; low to medium plasticity; grey, hydrocarbon smell; inferred stiff. Silty CLAY; medium plasticity; brown, grey.	M (>PL)	St	ALLUVIUM RESIDUAL SOIL
			4	*4.30*								
AD/T				25.70					SHALE; dark grey; highly weathered; inferred low strength.			WEATHERED ROCK 4.30: V-bit refusal.
				5.20					Hole Terminated at 5.20 m			5.20: TC-bit refusal on inferred medium strength shale.
			6									
			8									
			10									

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Engineering Log - BOREHOLE

7 Attachment C – Laboratory Test Certificate

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CERTIFICATE OF ANALYSIS 267926

Client Details

Client	Martens & Associates Pty Ltd
Attention	Akshaya Ghimire
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P2007944COC06V02, 57 Station Rd Seven Hills NSW**
Number of Samples	17 Soil
Date samples received	28/04/2021
Date completed instructions received	30/04/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	04/05/2021
Date of Issue	04/05/2021
Reissue Details	This report replaces R00 created on 04/05/2021 due to: revised report with additional results.

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		267926-1	267926-2	267926-3	267926-4	267926-5
Your Reference	UNITS	7944/BH301/0.15	7944/BH301/0.7	7944/BH302/0.3	7944/BH302/1.8	7944/BH302/2.3
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	03/05/2021	03/05/2021	03/05/2021	03/05/2021	03/05/2021
Date analysed	-	03/05/2021	03/05/2021	03/05/2021	03/05/2021	03/05/2021
pH 1:5 soil:water	pH Units	7.7	5.4	8.0	6.6	7.4
Electrical Conductivity 1:5 soil:water	µS/cm	750	460	130	72	51
Chloride, Cl 1:5 soil:water	mg/kg	320	350	20	35	34
Sulphate, SO4 1:5 soil:water	mg/kg	440	290	83	25	24

Misc Inorg - Soil						
Our Reference		267926-6	267926-7	267926-8	267926-9	267926-10
Your Reference	UNITS	7944/BH303/0.3	7944/BH303/0.7	7944/BH303/3.2	7944/BH303/4.6	7944/BH304/0.15
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	03/05/2021	03/05/2021	03/05/2021	03/05/2021	03/05/2021
Date analysed	-	03/05/2021	03/05/2021	03/05/2021	03/05/2021	03/05/2021
pH 1:5 soil:water	pH Units	7.1	4.8	8.0	8.2	9.4
Electrical Conductivity 1:5 soil:water	µS/cm	610	680	610	320	190
Chloride, Cl 1:5 soil:water	mg/kg	470	790	590	290	65
Sulphate, SO4 1:5 soil:water	mg/kg	150	120	150	92	93

Misc Inorg - Soil						
Our Reference		267926-11	267926-12	267926-13	267926-14	267926-15
Your Reference	UNITS	7944/BH304/0.8	7944/BH304/2.1	7944/BH304/4.4	7944/BH305/0.7	7944/BH305/1.6
Date Sampled		28/04/2021	28/04/2021	28/04/2021	28/04/2021	28/04/2021
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	03/05/2021	03/05/2021	03/05/2021	03/05/2021	03/05/2021
Date analysed	-	03/05/2021	03/05/2021	03/05/2021	03/05/2021	03/05/2021
pH 1:5 soil:water	pH Units	6.1	5.0	5.4	6.2	7.4
Electrical Conductivity 1:5 soil:water	µS/cm	260	370	340	82	90
Chloride, Cl 1:5 soil:water	mg/kg	190	430	380	36	50
Sulphate, SO4 1:5 soil:water	mg/kg	160	34	20	75	20

Misc Inorg - Soil		
Our Reference		267926-16
Your Reference	UNITS	7944/BH305/2.2
Date Sampled		28/04/2021
Type of sample		Soil
Date prepared	-	03/05/2021
Date analysed	-	03/05/2021
pH 1:5 soil:water	pH Units	8.6
Electrical Conductivity 1:5 soil:water	µS/cm	200
Chloride, Cl 1:5 soil:water	mg/kg	94
Sulphate, SO4 1:5 soil:water	mg/kg	51

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

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	267926-5
Date prepared	-			03/05/2021	2	03/05/2021	03/05/2021		03/05/2021	03/05/2021
Date analysed	-			03/05/2021	2	03/05/2021	03/05/2021		03/05/2021	03/05/2021
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	2	5.4	5.4	0	100	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	2	460	450	2	102	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	350	340	3	92	72
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	290	300	3	100	92

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	10	03/05/2021	03/05/2021		[NT]	[NT]
Date analysed	-			[NT]	10	03/05/2021	03/05/2021		[NT]	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	10	9.4	[NT]		[NT]	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	[NT]	10	190	[NT]		[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	10	65	62	5	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	10	93	88	6	[NT]	[NT]

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	16	03/05/2021	03/05/2021		[NT]	[NT]
Date analysed	-			[NT]	16	03/05/2021	03/05/2021		[NT]	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	16	8.6	8.6	0	[NT]	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	[NT]	16	200	170	16	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	16	94	[NT]		[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	16	51	[NT]		[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

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

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

Spikes for Physical and Aggregate Tests are not applicable.

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

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

8 Attachment D – Notes About This Report

Information

Important Information About Your Report (1 of 2)

These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all are necessarily relevant to all reports but are included as general reference.

Engineering Reports - Limitations

The recommendations presented in this report are based on limited investigations and include specific issues to be addressed during various phases of the project. If the recommendations presented in this report are not implemented in full, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the works undertaken.

Occasionally, sub-surface conditions between and below the completed boreholes or other tests may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact Martens & Associates.

Relative ground surface levels at borehole locations may not be accurate and should be verified by on-site survey.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel. They are based on information obtained, on current engineering standards of interpretation and analysis, and on the basis of your unique project specific requirements as understood by Martens. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the Client.

Where the report has been prepared for a specific design proposal (e.g. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (e.g. to a twenty storey building). Your report should not be relied upon, if there are changes to the project, without first asking Martens to assess how factors, which changed subsequent to the date of the report, affect the report's recommendations. Martens will not accept responsibility for problems that may occur due to design changes, if not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that site conditions, as may be revealed through selective point sampling, are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced. Therefore your site investigation report recommendations should only be regarded as preliminary.

Only Martens, who prepared the report, are fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report, there is a risk that the report will be misinterpreted and Martens cannot be held responsible for such misinterpretation.

Engineering Reports – Use for Tendering Purposes

Where information obtained from investigations is provided for tendering purposes, Martens recommend that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document.

Martens would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Engineering Reports – Data

The report as a whole presents the findings of a site assessment and should not be copied in part or altered in any way.

Logs, figures, drawings *etc* are customarily included in a Martens report and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), desktop studies and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Engineering Reports – Other Projects

To avoid misuse of the information contained in your report it is recommended that you confer with Martens before passing your report on to another party who may not be familiar with the background and purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Subsurface Conditions - General

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

- Unexpected variations in ground conditions - the potential will depend partly on test point (eg. excavation or borehole) spacing and sampling frequency, which are often limited by project imposed budgetary constraints.

Important Information About Your Report (2 of 2)

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and policy by statutory authorities.
- The actions of contractors responding to commercial pressures.
- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between logged materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

If these conditions occur, Martens will be pleased to assist with investigation or providing advice to resolve the matter.

Subsurface Conditions - Changes

Natural processes and the activity of man create subsurface conditions. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Reports are based on conditions which existed at the time of the subsurface exploration / assessment.

Decisions should not be based on a report whose adequacy may have been affected by time. If an extended period of time has elapsed since the report was prepared, consult Martens to be advised how time may have impacted on the project.

Subsurface Conditions - Site Anomalies

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

Report Use by Other Design Professionals

To avoid potentially costly misinterpretations when other design professionals develop their plans based on a Martens report, retain Martens to work with other project professionals affected by the report. This may involve Martens explaining the report design implications and then reviewing plans and specifications produced to see how they have incorporated the report findings.

Subsurface Conditions – Geo-environmental Issues

Your report generally does not relate to any findings, conclusions, or recommendations about the potential for hazardous or contaminated materials existing at the site unless specifically required to do so as part of Martens' proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geo-environmental or site contamination assessments. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Martens for information relating to such matters.

Responsibility

Geo-environmental reporting relies on interpretation of factual information based on professional judgment and opinion and has an inherent level of uncertainty attached to it and is typically far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded.

To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Martens to other parties but are included to identify where Martens' responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Martens closely and do not hesitate to ask any questions you may have.

Site Inspections

Martens will always be pleased to provide engineering inspection services for aspects of work to which this report relates. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

Soil Data

Explanation of Terms (1 of 3)

Definitions

In engineering terms, soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material does not exhibit any visible rock properties and can be remoulded or disintegrated by hand in its field condition or in water, it is described as a soil. Other materials are described using rock description terms.

The methods of description and classification of soils and rocks used in this report are typically based on Australian Standard 1726 and the Unified Soil Classification System (USCS) – refer Soil Data Explanation of Terms (2 of 3). In general, descriptions cover the following properties: strength or density, colour, moisture, structure, soil or rock type and inclusions.

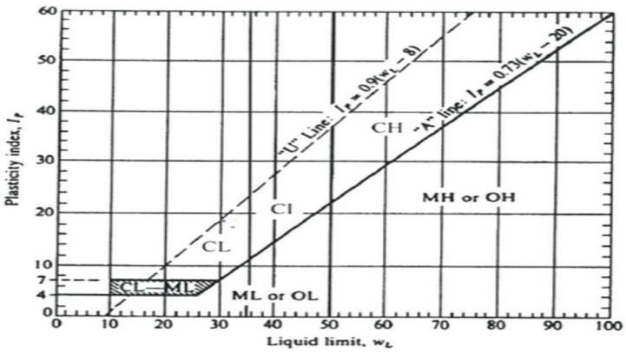
Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy CLAY). Unless otherwise stated, particle size is described in accordance with the following table.

Division	Subdivision		Particle Size (mm)
Oversized	BOULDERS		>200
	COBBLES		63 to 200
Coarse Grained Soil	GRAVEL	Coarse	19 to 63
		Medium	6.7 to 19
		Fine	2.36 to 6.7
	SAND	Coarse	0.6 to 2.36
		Medium	0.21 to 0.6
		Fine	0.075 to 0.21
Fine Grained Soil	SILT		0.002 to 0.075
	CLAY		< 0.002

Plasticity Properties

Plasticity properties of cohesive soils can be assessed in the field by tactile properties or by laboratory procedures.



Soil Moisture Condition

Coarse Grained (Granular) Soil:

Dry (D):	Looks and feels dry. Cemented soils are hard, friable or powdery. Uncemented soils run freely through fingers.
Moist (M):	Feels cool and damp and is darkened in colour. Particles tend to cohere.
Wet (W):	As for moist but with free water forming on hands when handled.

Fine Grained (Cohesive) Soil:

Moist, dry of plastic limit[1] (w < PL):	Looks and feels dry. Hard, friable or powdery.
Moist, near plastic limit (w ≈ PL):	Can be moulded, feels cool and damp, is darkened in colour, at a moisture content approximately equal to the PL.
Moist, wet of plastic limit (w > PL):	Usually weakened and free water forms on hands when handled.
Wet, near liquid limit[2] (w ≈ LL)	
Wet, wet of liquid limit (w > LL)	

[1] Plastic Limit (PL): Moisture content at which soil becomes too dry to be in a plastic condition.

[2] Liquid Limit (LL): Moisture content at which soil passes from plastic to liquid state.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.
(Note: consistency is affected by soil moisture condition at time of measurement)

Term	C_u (kPa)	Field Guide
Very Soft (VS)	≤12	A finger can be pushed well into the soil with little effort. Sample exudes between fingers when squeezed in fist.
Soft (S)	>12 and ≤25	A finger can be pushed into the soil to about 25mm depth. Easily moulded by light finger pressures.
Firm (F)	>25 and ≤50	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong figure pressure.
Stiff (St)	>50 and ≤100	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff (VSt)	>100 and ≤200	The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent.
Hard (H)	> 200	The surface of the soil can only be marked with the thumbnail. Brittle. Tends to break into fragments.
Friable (Fr)	-	Crumbles or powders when scraped by thumbnail. Can easily be crumbled or broken into small pieces by hand.

Density of Granular Soils

Non-cohesive soils are classified on the basis of relative density, generally from standard penetration test (SPT) or Dutch cone penetrometer test (CPT) results as below:

Relative Density	%	SPT 'N' Value* (blows/300mm)	CPT Cone Value (q_c MPa)
Very loose	≤15	< 5	< 2
Loose	>15 and ≤35	5 - 10	2 - 5
Medium dense	>35 and ≤65	10 - 30	5 - 15
Dense	>65 and ≤85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

* Values may be subject to corrections for overburden pressures and equipment type and influenced by soil moisture condition at time of measurement.

Minor Components

Minor components in soils may be present and readily detectable, but have little bearing on general geotechnical classification. Terms include:

Description of components	Proportion of component in:					
	coarse grained soil				fine grained soil	
	% Fines	Terminology	% Accessory coarse fraction	Terminology	% Sand/ gravel	Terminology
Minor	≤5	Trace clay / silt, as applicable	≤15	Trace sand / gravel, as applicable	≤15	Trace sand / gravel, as applicable
	>5,≤12	With clay / silt, as applicable	>15,≤30	With sand / gravel, as applicable	>5,≤30	With sand / gravel, as applicable
Secondary	>12	Prefix soil name as 'silty' or 'clayey', as applicable	>30	Prefix soil name as 'sandy' or 'gravelly', as applicable	>30	Prefix soil name as 'sandy' or 'gravelly', as applicable

Soil Data

Explanation of Terms (2 of 3)

martens consulting engineers

Symbols for Soils and Other

SOILS


COBBLES/BOULDERS


GRAVEL (GP or GW)


Silty GRAVEL (GM)


Clayey GRAVEL (GC)


SAND (SP or SW)


Silty SAND (SM)


Clayey SAND (SC)


SILT (ML or MH)


ORGANIC SILT or CLAY (OH or OL)


CLAY (CL, CI or CH)


Silty CLAY


Sandy CLAY


PEAT (Pt)


Gravelly CLAY

OTHER


FILL


TALUS


ASPHALT


CONCRETE


TOPSOIL

Unified Soil Classification Scheme (USCS)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					USCS	Primary Name
COARSE GRAINED SOILS More than 65 % of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm.	GRAVEL and GRAVEL-SAND Mixtures (≤ 5% fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes; not enough fines to bind coarse grains; no dry strength	GW	GRAVEL
				Predominantly one size or a range of sizes with some intermediate sizes missing; not enough fines to bind coarse grains; no dry strength	GP	GRAVEL
			GRAVEL-SILT and GRAVEL-SAND-SILT mixtures (≥ 12% fines) [1]	With excess non-plastic fines (for identification procedures see ML below); zero to medium dry strength; may also contain sand	GM	Silty GRAVEL
				With excess plastic fines (for identification procedures see CL below); medium to high dry strength; may also contain sand	GC	Clayey GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	SAND and GRAVEL-SAND mixtures (≤5% fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes; not enough fines to bind coarse grains; no dry strength.	SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing; not enough fines to bind coarse grains; no dry strength	SP	SAND
			SAND-SILT and SAND-CLAY mixtures (≥ 12% fines) [1]	With excess non-plastic fines (for identification procedures see ML below); zero to medium dry strength;	SM	Silty SAND
				With excess plastic fines (for identification procedures see CL below); medium to high dry strength	SC	Clayey SAND

FINE GRAINED SOILS More than 35 % of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
	DRY STRENGTH (Crushing Characteristics)	DILATANCY	TOUGHNESS	DESCRIPTION	USCS	Primary Name
	None to Low	Quick to Slow	Low	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silt with low plasticity [2]	ML	SILT [3]
	Medium to High	None to Slow	Medium	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays	CL (or CI[4])	CLAY
	Low to Medium	Slow	Low	Organic slits and organic silty clays of low plasticity	OL	Organic SILT or CLAY
	Low to Medium	None to Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	SILT [3]
	High to Very High	None	High	Inorganic clays of high plasticity, fat clays	CH	CLAY
	Medium to High	None to Very Slow	Low to Medium	Organic clays of medium to high plasticity, organic silt of high plasticity	OH	Organic SILT or CLAY
HIGHLY ORGANIC SOILS	Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	PEAT

Notes:

1. Between 5% and 12% - dual classification, e.g. GP-GM.
2. Low Plasticity Clay – Liquid Limit W_L ≤35%; Medium Plasticity Clay – Liquid limit W_L >35%, ≤50%; High Plasticity Clay - Liquid limit W_L > 50%.
3. Low Plasticity Silt – Liquid Limit W_L ≤50%; High Plasticity Silt - Liquid limit W_L > 50%.
4. CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.

Soil Data

Explanation of Terms (3 of 3)

Soil Agricultural Classification Scheme

In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions by Northcote, K.H. (1979) *The factual key for the recognition of Australian Soils*, Rellim Technical Publications, NSW, p 26 - 28.

Symbol	Field Texture Grade	Behaviour of moist bolus	Ribbon length	Clay content (%)
S	Sand	Coherence nil to very slight; cannot be moulded; single grains adhere to fingers	0 mm	< 5
LS	Loamy sand	Slight coherence; discolours fingers with dark organic stain	6.35 mm	5
CLS	Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain	6.35mm - 1.3cm	5 - 10
SL	Sandy loam	Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are readily visible	1.3 - 2.5	10 - 15
FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard	1.3 - 2.5	10 - 20
SCL-	Light sandy clay loam	Bolus strongly coherent but sandy to touch, sand grains dominantly medium size and easily visible	2.0	15 - 20
L	Loam	Bolus coherent and rather spongy; smooth feel when manipulated but no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present	2.5	25
Lfsy	Loam, fine sandy	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated	2.5	25
SiL	Silt loam	Coherent bolus, very smooth to silky when manipulated	2.5	25 + > 25 silt
SCL	Sandy clay loam	Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix	2.5 - 3.8	20 - 30
CL	Clay loam	Coherent plastic bolus; smooth to manipulate	3.8 - 5.0	30 - 35
SiCL	Silty clay loam	Coherent smooth bolus; plastic and silky to touch	3.8 - 5.0	30- 35 + > 25 silt
FSCL	Fine sandy clay loam	Coherent bolus; fine sand can be felt and heard	3.8 - 5.0	30 - 35
SC	Sandy clay	Plastic bolus; fine to medium sized sands can be seen, felt or heard in a clayey matrix	5.0 - 7.5	35 - 40
SiC	Silty clay	Plastic bolus; smooth and silky	5.0 - 7.5	35 - 40 + > 25 silt
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing	5.0 - 7.5	35 - 40
LMC	Light medium clay	Plastic bolus; smooth to touch, slightly greater resistance to shearing than LC	7.5	40 - 45
MC	Medium clay	Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture, some resistance to shearing	> 7.5	45 - 55
HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing	> 7.5	> 50

Rock Data

Explanation of Terms (1 of 2)

Symbols for Rock

SEDIMENTARY ROCK


BRECCIA


CONGLOMERATE


CONGLOMERATIC SANDSTONE


SANDSTONE/QUARTZITE


SILTSTONE


MUDSTONE/CLAYSTONE


SHALE


COAL


LIMESTONE


LITHIC TUFF

IGNEOUS ROCK


GRANITE


DOLERITE/BASALT

METAMORPHIC ROCK


SLATE, PHYLLITE, SCHIST


GNEISS


METASANDSTONE


METASILTSTONE


METAMUDSTONE

Definitions

Descriptive terms used for Rock by Martens are based on AS1726 and encompass rock substance, defects and mass.

Rock Material	The intact rock that is bounded by defects.
Rock Defect	Discontinuity, fracture, break or void in the material or minerals across which there is little or no tensile strength.
Rock Structure	The nature and configuration of the different defects within the rock mass and their relationship to each other.
Rock Mass	The entirety of the system formed by all of the rock material and all of the defects that are present.

Degree of Weathering

Rock weathering is defined as the degree of decline in rock structure and grain property and can be determined in the field.

Term	Symbol	Definition
Residual soil[1]	RS	Material is weathered to such an extent that it has soil properties. Mass structure, material texture, and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely weathered[1]	XW	Material is weathered to such an extent that it has soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System. Mass structure and material texture and fabric of original rock are still visible.
Highly weathered[2]	HW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the original colour of the rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately weathered[2]	MW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the rock is not recognisable. Rock strength shows little or no change from fresh rock.
Slightly weathered	SW	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	FR	Rock substance unaffected by weathering. No sign of decomposition of individual materials or colour changes.

Notes:
1 RS and EW material is described using soil descriptive terms.
2. The term "Distinctly Weathered" (DW) may be used to cover the range of substance weathering between EW and SW

Rock Strength

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the loading. The test procedure is described by the International Society of Rock Mechanics.

Term (Strength)	I_s (50) MPa	Uniaxial Compressive Strength MPa	Field Guide	Symbol
Very low	>0.03 ≤0.1	0.6 – 2	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>0.1 ≤0.3	2 – 6	Core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium	>0.3 ≤1.0	6 – 20	Core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>1 ≤3	20 – 60	Core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife. Breaks with single blow from pick.	H
Very high	>3 ≤10	60 – 200	Core 150mm long x 50mm diameter, broken readily with hand held hammer. Cannot be scratched with knife. Breaks after more than one pick strike.	VH
Extremely high	>10	>200	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	EH

Rock Data

Explanation of Terms (2 of 2)

Degree of Fracturing

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude fractures such as drilling breaks (DB) or handling breaks (HB).

Term	Description
Fragmented	The core is comprised primarily of fragments of length less than 20 mm, and mostly of width less than core diameter.
Highly fractured	Core lengths are generally less than 20 mm to 40 mm with occasional fragments.
Fractured	Core lengths are mainly 30 mm to 100 mm with occasional shorter and longer sections.
Slightly fractured	Core lengths are generally 300 mm to 1000 mm, with occasional longer sections and sections of 100 mm to 300 mm.
Unbroken	The core does not contain any fractures.

Rock Core Recovery

TCR = Total Core Recovery

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100\,\%$$

SCR = Solid Core Recovery

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100\,\%$$

RQD = Rock Quality Designation

$$= \frac{\sum \text{Axial lengths of core} > 100 \text{ mm long}}{\text{Length of core run}} \times 100\,\%$$

Rock Strength Tests

- ▼ Point load strength Index (Is50) - axial test (MPa)
- ▶ Point load strength Index (Is50) - diametral test (MPa)
- ● Uniaxial compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)

BP	Bedding plane parting
FL	Foliation
CL	Cleavage
JT	Joint
FC	Fracture
SZ/SS	Sheared zone/ seam (Fault)
CZ/CS	Crushed zone/ seam
DZ/DS	Decomposed zone/ seam
FZ	Fractured Zone
IS	Infilled seam
VN	Vein
CO	Contact
HB	Handling break
DB	Drilling break

Planarity

Pl	Planar
Cu	Curved
Un	Undulating
St	Stepped
Ir	Irregular
Dis	Discontinuous

Roughness

Pol	Polished
Sl	Slickensided
Sm	Smooth
Ro	Rough
VR	Very rough

Thickness

Zone	> 100 mm
Seam	> 2 mm < 100 mm
Plane	< 2 mm

Coating or Filling

Cn	Clean
Sn	Stain
Ct	Coating
Vnr	Veneer
Fe	Iron Oxide
X	Carbonaceous
Qz	Quartzite
MU	Unidentified mineral

Inclination

Inclination of defect is measured from perpendicular to and down the core axis.
Direction of defect is measured clockwise (looking down core) from magnetic north.

Test, Drill and Excavation Methods

Explanation of Terms (1 of 3)

Sampling

Sampling is carried out during drilling or excavation to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling or excavation provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples may be taken by pushing a thin-walled sampling tube, e.g. U_{50} (50 mm internal diameter thin walled tube), into soils and withdrawing a soil sample in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

Drilling / Excavation Methods

The following is a brief summary of drilling and excavation methods currently adopted by the Company and some comments on their use and application.

Hand Excavation - in some situations, excavation using hand tools, such as mattock and spade, may be required due to limited site access or shallow soil profiles.

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger, generally 75-100 mm in diameter, into the ground. The penetration depth is usually limited to the length of the auger pole; however extender pieces can be added to lengthen this.

Test Pits - these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils and, if it is safe to descend into the pit, collection of bulk disturbed samples. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (e.g. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling (Push Tube) - the hole is advanced by pushing a 50 - 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength *etc.* is only marginally affected.

Continuous Spiral Flight Augers - the hole is advanced using 90 - 115 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface or, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling - similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling - a continuous core sample is obtained using a diamond tipped core barrel of usually 50 mm internal diameter. Provided full core recovery is achieved (not always possible in very weak or fractured rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

In-situ Testing and Interpretation

Cone Penetrometer Testing (CPT)

Cone penetrometer testing (sometimes referred to as Dutch Cone) described in this report has been carried out using an electrical friction cone penetrometer.

The test is described in AS 1289.6.5.1-1999 (R2013). In the test, a 35 mm diameter rod with a cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system.

Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the push rod centre to an amplifier and recorder unit mounted on the control truck. As penetration occurs (at a rate of approximately 20 mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

(i) Cone resistance (q_c) - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa.

(ii) Sleeve friction (q_f) - the frictional force of the sleeve divided by the surface area, expressed in kPa.

(iii) Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower (A) scale (0 - 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main (B) scale (0 - 50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1 % - 2 % are commonly encountered in sands and very soft clays rising to 4 % - 10 % in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6)\ N \text{ (blows/300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:

$$q_c = (12 \text{ to } 18)\ C_u$$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes *etc.* This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Standard Penetration Testing (SPT)

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample.

The test procedure is described in AS 1289.6.3.1-2004. The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm penetration depth increments and the 'N' value is taken as the number of blows for the last two 150 mm depth increments (300 mm total penetration). In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued. The test results are reported in the following form:

(i) Where full 450 mm penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows:

as 4, 6, 7
N = 13

(ii) Where the test is discontinued, short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

Dynamic Cone (Hand) Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods. Two relatively similar tests are used.

Perth sand penetrometer (PSP) - a 16 mm diameter flat ended rod is driven with a 9 kg hammer, dropping 600 mm. The test, described in AS 1289.6.3.3-1997 (R2013), was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

Cone penetrometer (DCP) - sometimes known as the Scala Penetrometer, a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm. The test, described in AS 1289.6.3.2-1997 (R2013), was developed initially for pavement sub-grade investigations, with correlations of the test results with California Bearing Ratio published by various Road Authorities.

Pocket Penetrometers

The pocket (hand) penetrometer (PP) is typically a light weight spring hand operated device with a stainless steel loading piston, used to estimate unconfined compressive strength, q_u, (UCS in kPa) of a fine grained soil in field conditions. In use, the free end of the piston is pressed into the soil at a uniform penetration rate until a line, engraved near the piston tip, reaches the soil surface level. The reading is taken from a gradation scale, which is attached to the piston via a built-in spring mechanism and calibrated to kilograms per square centimetre (kPa) UCS. The UCS measurements are used to evaluate consistency of the soil in the field moisture condition. The results may be used to assess the undrained shear strength, C_u, of fine grained soil using the approximate relationship:

$$q_u = 2 \times C_u.$$

It should be noted that accuracy of the results may be influenced by condition variations at selected test surfaces. Also, the readings obtained from the PP test are based on a small area of penetration and could give misleading results. They should not replace laboratory test results. The use of the results from this test is typically limited to an assessment of consistency of the soil in the field and not used directly for design of foundations.

Test Pit / Borehole Logs

Test pit / borehole log(s) presented herein are an engineering and / or geological interpretation of the subsurface conditions. Their reliability will depend to some extent on frequency of sampling and methods of excavation / drilling. Ideally, continuous undisturbed sampling or excavation / core drilling will provide the most reliable assessment but this is not always practicable, or possible to justify on economic grounds. In any case, the test pit / borehole logs represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of test pits / boreholes, the frequency of sampling and the possibility of other than 'straight line' variation between the test pits / boreholes.

Laboratory Testing

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

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly, or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent prior weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

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

Test, Drill and Excavation Methods

Explanation of Terms (3 of 3)

DRILLING / EXCAVATION METHOD

HA	Hand Auger	RD	Rotary Blade or Drag Bit	NQ	Diamond Core - 47 mm
AD/V	Auger Drilling with V-bit	RT	Rotary Tricone bit	NMLC	Diamond Core – 51.9 mm
AD/T	Auger Drilling with TC-Bit	RAB	Rotary Air Blast	HQ	Diamond Core – 63.5 mm
AS	Auger Screwing	RC	Reverse Circulation	HMLC	Diamond Core – 63.5 mm
HSA	Hollow Stem Auger	CT	Cable Tool Rig	DT	Diatube Coring
S	Excavated by Hand Spade	PT	Push Tube	NDD	Non-destructive digging
BH	Tractor Mounted Backhoe	PC	Percussion	PQ	Diamond Core - 83 mm
JET	Jetting	E	Tracked Hydraulic Excavator	X	Existing Excavation

SUPPORT

Nil	No support	S	Shotcrete	RB	Rock Bolt
C	Casing	Sh	Shoring	SN	Soil Nail
WB	Wash bore with Blade or Bailer	WR	Wash bore with Roller	T	Timbering

WATER

▽ Water level at date shown

▷ Water inflow

◁ Partial water loss

◀ Complete water loss

GROUNDWATER NOT OBSERVED (NO)	The 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 (NX)	The 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.

PENETRATION / EXCAVATION RESISTANCE

L	Low resistance: Rapid penetration possible with little effort from the equipment used.
M	Medium resistance: Excavation possible at an acceptable rate with moderate effort from the equipment used.
H	High resistance: Further penetration possible at slow rate & requires significant effort equipment.
R	Refusal/ Practical Refusal. No further progress possible without risk of damage/ unacceptable wear to digging implement / machine.

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

SAMPLING

D	Small disturbed sample	W	Water Sample	C	Core sample
B	Bulk disturbed sample	G	Gas Sample	CONC	Concrete Core

U63 Thin walled tube sample - number indicates nominal undisturbed sample diameter in millimetres

TESTING

SPT 4,7,11 N=18	Standard Penetration Test to AS1289.6.3.1-2004 4,7,11 = Blows per 150mm. 'N' = Recorded blows per 300mm penetration following 150mm seating
DCP	Dynamic Cone Penetration test to AS1289.6.3.2-1997. 'n' = Recorded blows per 150mm penetration

Notes:

RW	Penetration occurred under rod weight only
HW	Penetration occurred under hammer and rod weight only
20/100mm	Where practical refusal or hammer double bouncing occurred, blows and penetration for that interval are reported (e.g. 20 blows for 100 mm penetration)

CPT	Static cone penetration test
CPTu	CPT with pore pressure (u) measurement
PP	Pocket penetrometer test expressed as instrument reading (kPa)
FP	Field permeability test over section noted
VS	Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
PM	Pressuremeter test over section noted
PID	Photoionisation Detector reading in ppm
WPT	Water pressure tests

SOIL DESCRIPTION

Density		Consistency		Moisture	
VL	Very loose	VS	Very soft	D	Dry
L	Loose	S	Soft	M	Moist
MD	Medium dense	F	Firm	W	Wet
D	Dense	St	Stiff	Wp	Plastic limit
VD	Very dense	VSt	Very stiff	Wl	Liquid limit
		H	Hard		

ROCK DESCRIPTION

Strength		Weathering	
VL	Very low	EW	Extremely weathered
L	Low	HW	Highly weathered
M	Medium	MW	Moderately weathered
H	High	SW	Slightly weathered
VH	Very high	FR	Fresh
EH	Extremely high		