Precise Planning

Salinity Assessment:
Lot 22 DP619150 and Lot 95 DP13116, 45 Noongah Street and 25 Gwynn Hughes Road, Bargo, NSW

P1504816JR02V01
January 2017

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

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Contents

1 Introduction

1.1 Overview

This report documents the findings of a salinity assessment completed to determine the suitability of the site for rezoning for residential purposes. The 'site' refers to 45 Noongah Street and 25 Gwynn Hughes Road, Bargo, NSW, with site location shown in Figure 1, Attachment A.

1.2 Proposed Development

We have assumed for the purpose of this assessment that likely future development scenarios will consist of site subdivision for low density residential development which will include:

- Earthworks for preparation of development platforms.
- Construction of above-ground buildings requiring limited bulk excavation, assumed <1m below ground level (bgl).
- Installation of stormwater infrastructure.
- Construction of new local access roads.
- Landscaping.

1.3 Assessment Objectives

The objective of the salinity assessment is to assess the risk of soil salinity so that consideration can be given to local prevailing salinity conditions and the impacts of, and on, the proposed development. This assessment has been carried out in general accordance with the following guidelines:

- Department of Infrastructure, Planning and Natural Resources (DIPNR, 2002), *Salinity Potential in Western Sydney Map*.
- Department of Land and Water Conservation (DLWC, 2002), *Site Investigations for Urban Salinity*.
- Australian Standard (AS) 3600 (2009), *Concrete structures*.

1.4 Investigation Scope of Works

Site investigation undertaken on May 29, 2015, included:

- A site walkover survey to confirm expected topography, geology and geomorphology based on desktop study results, to assess existing site conditions such as soil/ rock exposures, surface drainage and vegetation and to identify evidence of possible saline soil or groundwater conditions.
- Seven boreholes, BH201 to BH207, to characterise sub-surface materials, drilled up to 2.5 m bgl using a 4WD truck-mounted hydraulic drill rig with spiral augers fitted with a V-shaped bit (V-bit) or tungsten carbide bit (TC-bit).
- Collection of soil samples for laboratory testing and future reference.

Investigation locations are shown in Figure 1, Attachment A.

2 Site Conditions

2.1 Site Details

Table 1presents a summary of general site details. Existing site features are shown in Figure 1, Attachment A.

Table 1: Site background information.

Item	Description/Detail
Site address (Lot/DP)	Lot 22 DP619150 and Lot 95 DP13116, 45 Noongah Street and 25 Gwynn Hughes Road, Bargo, NSW
Local Government Area (LGA)	Wollondilly Shire Council
Site area	Approximately 20.695 ha (based on survey by Sydney Registered Surveyors, plan reference: 1056 Noongah)
Existing site development	Single storey dwelling and associated sheds in eastern portion of site have recently been removed The site is surrounded by rural residential allotments to the north and east, bushland to the west and south
Proposed development	Residential (low density)
Typical slopes/aspect/elevation	The site has grades of 0 – 10% towards Hornes Creek, which bisects the site. Site elevation is between approximately 335m AHD in the west, 330m AHD in the east and 325m AHD adjacent to Hornes Creek
Existing vegetation	Trees and grasses
Easements	None identified
Drainage	Hornes Creek, which forms a major tributary of the Bargo River, bisects the site and flows in a northerly direction An east west orientated drainage depression, located in the eastern portion of the site, flowing into Hornes Creek

2.2 Sub-Surface Conditions

2.2.1 Expected Geology

The *Wollongong Port Hacking 1:100,000 Geological Series Sheet 9029-9129* (DME, 1985) indicates the site to be at the boundary of Wianamatta Group (Ashfield Shale) and Hawkesbury Sandstone. Ashfield Shale, mapped as underlying the eastern part of the site, consists of laminate and dark-grey siltstone. Hawkesbury Sandstone, mapped as underlying the western part of the site, typically consists of medium to coarse-grained quartz sandstone, very minor shale and laminate lenses. Sandstone and shale was encountered during borehole investigations.

The NSW Environment and Heritage eSPADE website identifies the western 2/3 of the site as having soils of the Lucas Heights soil landscape consisting of moderately deep hardsetting yellow podzolic soils and yellow soloths on ridges and plateau surfaces and earthy sands in valley flats. The eastern 1/3 of the site is identified as having soils of the Blacktown soil landscape consisting of shallow to moderately deep hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzic soils on lower slopes and in drainage lines.

2.2.2 Sub-Surface Materials

Investigation results confirm the western 2/3 of the site (BH201 – BH204) to be underlain by Hawkesbury Sandstone and the eastern 1/3 (BH205 – BH207) by Ashfield Shale.

Table 2 summarises sub-surface materials and conditions, inferred from borehole test results, to investigation termination depth. Encountered conditions are described in more detail on borehole logs, Attachment B, and associated explanatory notes, Attachment D.

Table 2: Generalised inferred sub-surface profile to termination depth.

Layer[1]	Depth (m bgl)[2]						
	BH201	BH202	BH203	BH204	BH205	BH206	BH207
TOPSOIL: SANDY/SILTY CLAY	0.0 – 0.1	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.1	0.0 – 0.2	0.0 – 0.2
RESIDUAL SOIL: SANDY CLAY Medium to High Plasticity	-	-	0.2 – 1.2	0.2 – 1.2	-	-	-
RESIDUAL SOIL: CLAY Medium to High Plasticity	0.1 – 1.1[3]	0.2 – 1.1	1.2 – 2.5[4]	1.2 – 2.5[4]	0.1 – 1.4	0.2 – 1.5	0.2 – 1.55
RESIDUAL SOIL: CLAY High Plasticity		1.1 – 2.0[3]			1.4 – 2.5[4]	1.5 – 2.1[3]	1.55 – 2.0[3]

Notes:

1 Refer to borehole logs for more detailed material descriptions at test locations.

2 Indicative depth range in metres below ground level, which may vary across site depending on local geological conditions.

3 Borehole terminated on inferred weathered rock.

4 Investigation target depth reached.

2.3 Groundwater

Groundwater inflow was not observed in the boreholes up to a depth of 2.5m bgl. Review of NSW Office of Water's Real Time groundwater database indicates that 1 groundwater bore (GW112473) is located within 650m of the site (Figure 2, Attachment A). Details are provided in Table 3.

Table 3: Available hydrogeological information.

Groundwater Bore Identification	Direction and Distance	Depth To Groundwater (mBGL)	Intended Use	Water Bearing Zone Substrate
GW112473	South (650m)	42.0	Irrigation	Sandstone

From review of the information in Table 3, the groundwater well in the site vicinity is used for irrigation purposes with groundwater levels approximately 42.0 m below ground level. Groundwater levels are likely to be similar at the site as site elevation and topography are similar. However, shallow perched groundwater may be encountered at the site following heavy and prolonged rainfall.

3 Salinity Assessment

3.1 Documented Salinity Risk Potential

The 1:100,000 Salinity Potential in Western Sydney map (DIPNR, 2002) indicates that the site is located off the map (Figure 3, Attachment A). However, the salinity map is based on the geology, with shale and sandstone landscapes (encountered at the 'site'), typically being mapped as moderate and very low salinity potential respectively.

3.2 Broad Scale Salinity Processes

In producing the Salinity Potential Map, DIPNR developed a number of alternative models of processes by which salinity may occur in Western Sydney (WSROC, 2004, pg. 16).

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 signs of saline conditions were observed at 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 Possible Site Conditions Impacting Site Salinity

Site conditions that may impact salinity potential at the site include:

- Creeks bisecting the site.
- Mid-slope site location.

3.5 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 sub-surface water flow associated with urban development.	Low – No evidence of excessive water use or areas of poor drainage at the time of inspection. Perched water was observed in the vicinity of BH202, as a result of recent rainfall events. No evidence of localised salt concentration observed.
Shale Soil Landscapes	In poorly drained duplex (texture contrast) soils, shallow sub-surface water flows laterally across a clayey upper B-Horizon with salt usually accumulating in the clayey sub-soil. Salt concentrations may increase where sub-surface water accumulates and evaporates, e.g. on lower slopes or natural and constructed flats in mid-slope. Exacerbated by sub-soils exposure through deep cutting, by installing buildings into the B-horizon and by impeding sub-surface water flows. Highly dispersive, erodible and poorly draining sodic soils due to salinity.	Moderate – The site is underlain by low permeable clays overlying shale in the eastern portion of the site. Proposed excavations may be required into the clayey 'B-Horizon'. No evidence of impeded surface vegetation growth and surface soil erosion observed.
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 to moderate – Groundwater infiltration in creeks. Groundwater was not encountered in boreholes to 2.5m bgl. 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 - moderate – soils in site drainage depressions are likely deeply weathered, however, site soils appear to be residual, not depositional.

3.6 Salinity Laboratory Results

3.6.1 Overview

Fourteen soil samples from 5 boreholes were submitted to Envirolab Services, a National Association of Testing Authorities (NATA) accredited laboratory, for chemical testing (Electrical Conductivity (EC), pH and soluble SO_4). The testing was carried out for salinity classification and to assess an exposure classification for design of buried concrete structures. Sampling was targeted to achieve a representative coverage of site conditions in line with assessed subsurface profiles, proposed earthworks and investigation scope.

3.6.2 Results – Salinity Classification

Testing results 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]
4816/201/0.2	Clay	0.019	0.133	Non-Saline
4816/201/0.8	Clay	0.017	0.119	Non-Saline
4816/202/0.1	Sandy Clay	0.048	0.408	Non-Saline
4816/202/0.3	Clay	0.082	0.574	Non-Saline
4816/202/1.6	Clay	0.140	0.980	Non-Saline
4816/203/0.1	Sandy Clay	0.024	0.204	Non-Saline
4816/203/0.7	Sandy Clay	0.010	0.085	Non-Saline
4816/203/1.5	Clay	0.046	0.322	Non-Saline
4816/205/0.2	Clay	0.064	0.448	Non-Saline
4816/205/0.8	Clay	0.031	0.217	Non-Saline
4816/205/1.5	Clay	0.040	0.280	Non-Saline
4816/207/0.1	Silty Clay	0.021	0.179	Non-Saline
4816/207/0.4	Clay	0.029	0.203	Non-Saline
4816/207/1.7	Clay	0.340	2.040	Slightly Saline

Note:

1 Project#/Borehole#/Depth (m bgl).

2 Based on EC to EC_e multiplication factors from Table 6.1 in DLWC (2002).

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.

Results indicate near surface sub-surface materials are non-saline (< 1.6m bgl). One deeper sample at 1.7m bgl in BH207 returned a slightly saline value (i.e. > 2 dS/m).

3.6.3 *Results – Exposure Classification*

Sulfate and pH test results are summarised in Table 6. Laboratory test certificates are presented in Attachment D.

Table 6: Exposure classification test results.

Sample ID[1]	EC_e (dS/m) [2]	pH	Sulfate (SO_4) (mg/kg)	Exposure Classification[2]
4816/201/0.2	0.133	6.3	<10	A1
4816/201/0.8	0.119	6.0	<10	A1
4816/202/0.1	0.408	5.3	<10	A1
4816/202/0.3	0.574	6.3	<10	A1
4816/202/1.6	0.98	6.4	<10	A1
4816/203/0.1	0.204	5.3	10	A1
4816/203/0.7	0.085	6.1	<10	A1
4816/203/1.5	0.322	5.0	<10	A1
4816/205/0.2	0.448	6.5	67	A1
4816/205/0.8	0.217	6.1	20	A1
4816/205/1.5	0.28	5.6	30	A1
4816/207/0.1	0.179	5.5	<10	A1
4816/207/0.4	0.203	6.3	20	A1
4816/207/1.7	2.04	5.3	24	A1

Note:

1 Project#/Borehole#/Depth (m bgl).

2 Exposure classification for buried reinforced concrete based on Tables 4.8.1and 4.8.2 of AS 3600 (2009).

In accordance with AS3600 (2009), an exposure classification for concrete of 'A1' may be adopted for preliminary design of buried concrete structures.

3.7 Recommendations

The majority of the site returned non-saline soil values, with one sample suggesting slight salinity. This sample was at 1.5m depth in the shale geology outcrop zone (BH207). Consideration may be given for supplementary testing in this area at DA stage, following review of proposed earthworks and development extents. Slight salinity results at depth are not expected to impact low density residential development provided no excessive irrigation and any permanent water storage areas are lined.

Otherwise, and in general, future buried concrete structures should be designed in accordance with the concrete cover specifications in AS 3600 (2009) for an exposure classification of 'A1'.

4 Limitations

The recommendations presented in this report are based on limited preliminary investigations and include specific issues to be addressed during the design and construction phases of the project. In the event that any of the recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the works undertaken where recommendations are not implemented in full and properly tested, inspected and documented.

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.

5 References

Australian Standard 1726 (1993) *Geotechnical Site Investigations.*

Australian Standard 2870 (2011) *Residential Slabs and Footings.*

Australian Standard 3600 (2009) *Concrete structures.*

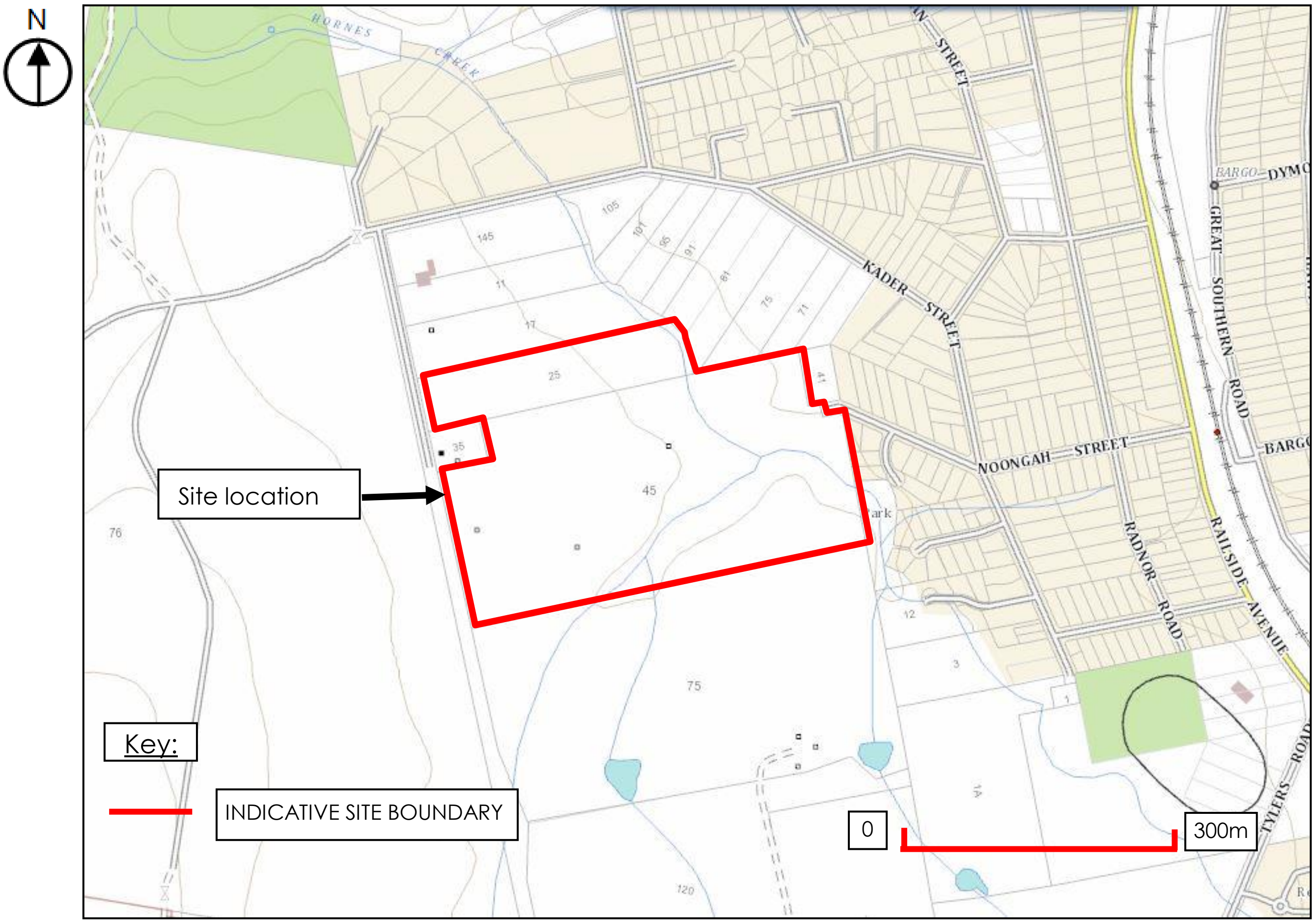
Department of Land and Water Conservation (2002), *Site Investigations for Urban Salinity.*

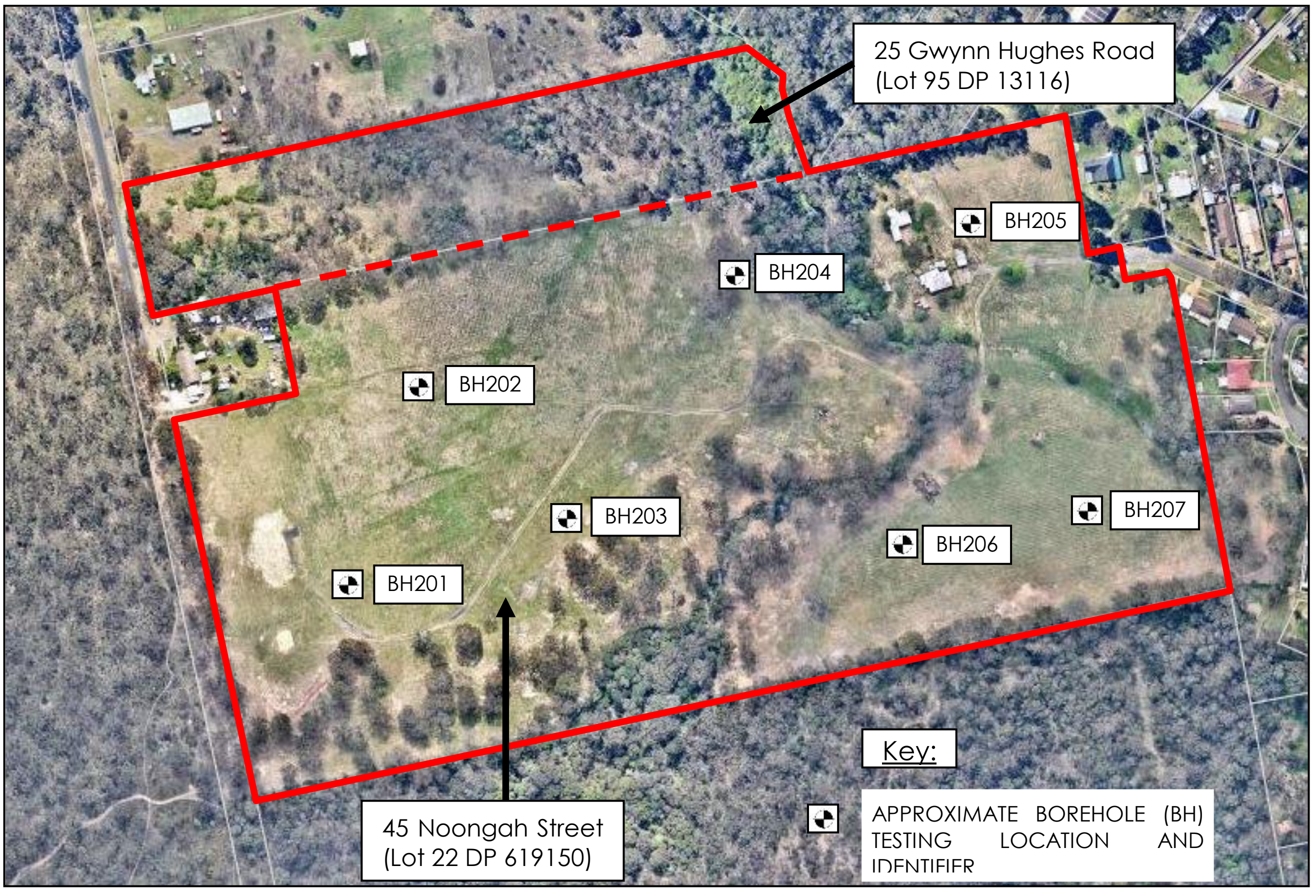
Department of Infrastructure Planning and Natural Resources (DIPNR, 2002) *Salinity Potential in Western Sydney Map.*

Geological Survey of NSW Department of Minerals and Energy (1985), Wollongong Port Hacking 1:100,000 Geological Series Sheet 9029-9129.

Western Sydney Regional Organisation of Councils (2004), *Western Sydney Salinity Code of Practice.*

6 Attachment A - Figures





martens

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Environment | Water | Wastewater | Geotechnical | Civil | Management

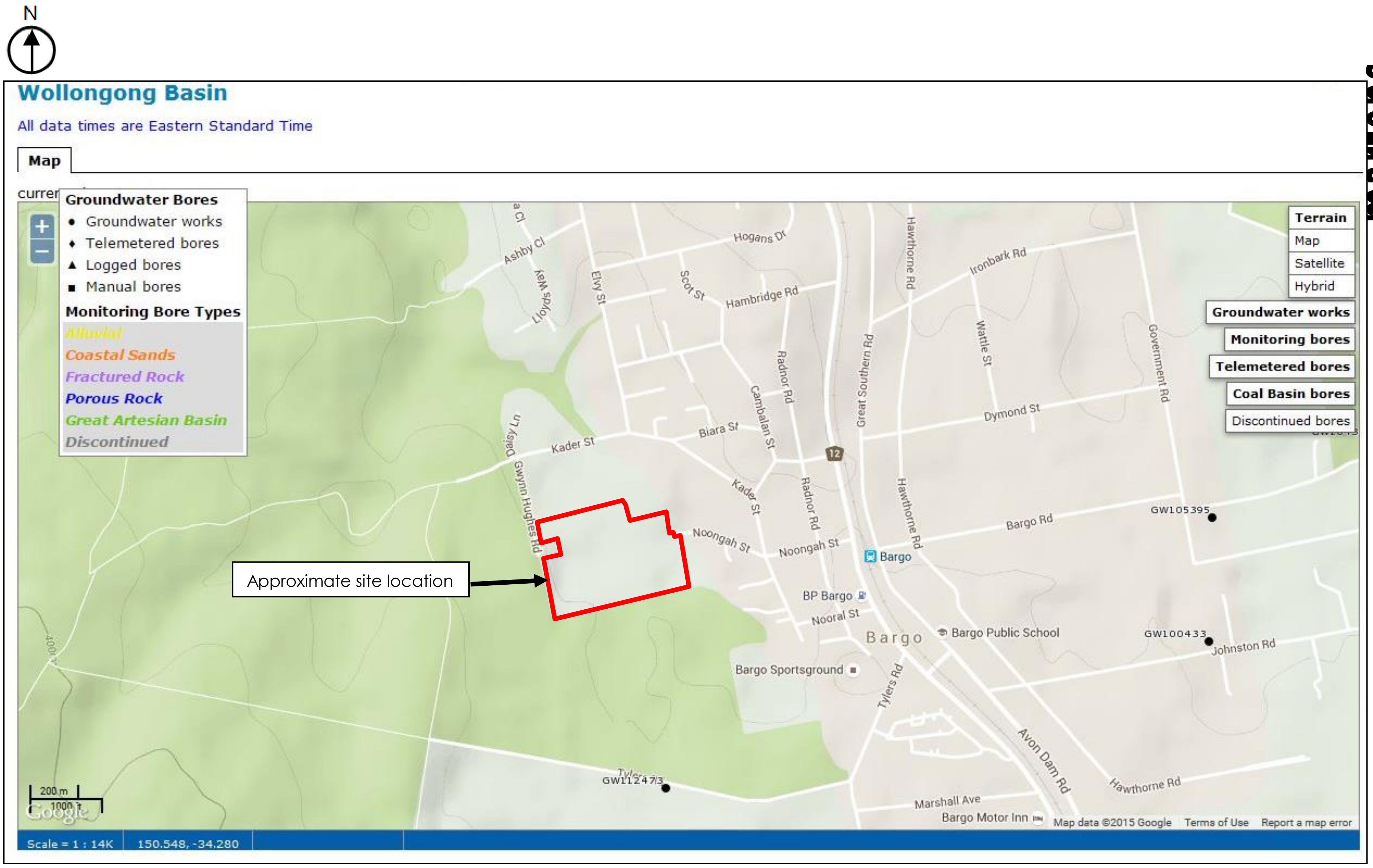
Drawn:	GMT
Approved:	RE
Date:	16.06.2015
Scale:	Not to Scale

Site Location, borehole locations and boundaries
45 Noongah Street and 25 Gwynn Hughes Road,
Bargo, NSW
Source: LPI SIX Viewer (top) and Nearmap, 2014 (bottom)

Drawing No:

FIGURE 1

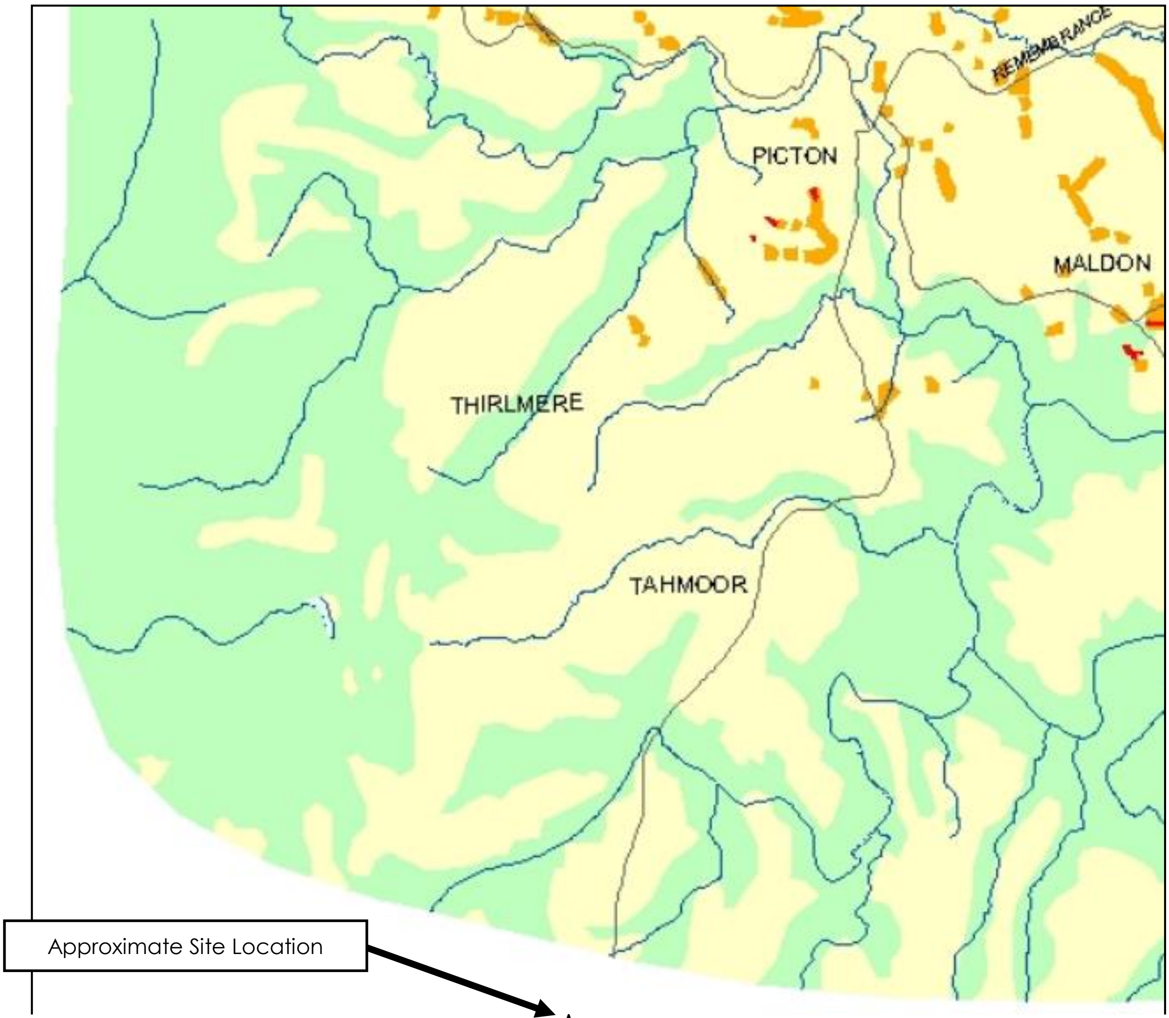
Job No: P1504816JD01V01



Wollongong Basin

All data times are Eastern Standard Time

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GMT	**Groundwater Bore Locations** **45 Noongah Street and 25 Gwynn Hughes Road, Bargo, NSW** **Source: NSW Office of Water Real Time Groundwater Database, 2015**	Drawing No: Figure 2
Approved:	RE		
Date:	16/06/2015		
Scale:	Not to Scale		Job No: P1504816JD02V01



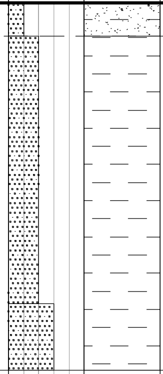
	MAPPING CATEGORY	ASSOCIATED SOIL LANDSCAPES	LANDFORM - GEOLOGY
🟥	**KNOWN SALINITY** Areas where there is a known occurrence of saline soil, or where air photo interpretation and field observations have confirmed more than one of these: a - scalding b - salt efflorescence c - vegetation dieback d - salt 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 Rwm). * 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, Rwm, 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 salinty. * Soils are moderate to well-drained due to their elevated position in the landscape.	* Hill-slopes and hill-crests on Wianamatta Shales (Rwb, Rwm, 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).

SOURCE: 1:100,000 SALINITY POTENTIAL IN WESTERN SYDNEY MAP (DNR, 2002)

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GMT	**1:100,000 SALINITY POTENTIAL IN WESTERN SYDNEY MAP (DNR, 2002)** **45 Noongah Street and 25 Gwynn Hughes Road, Bargo**	Drawing No: FIGURE 3
Approved:	RE		
Date:	16.06.2015		
Scale:	Not to Scale		Job No: P1504816JR02V01

7 Attachment B - Borehole Logs

CLIENT	**Precise Planning**	**COMMENCED**	29/5/15	**COMPLETED**	29/5/15	**REF**	**BH201**
PROJECT	**Salinity Assessment**	**LOGGED**	GMT	**CHECKED**	JF	**Sheet**	**1** of **1**
SITE	**45 Noongah St & 25 Gwynn Hughes Rd, Bargo**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1504816
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 1.1m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	<2%



EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	M	0.1			CL	TOPSOIL: Sandy CLAY - Brown, with rootlets.	F				- TOPSOIL
											A	0.2	4816/101/ 0.2 - RESIDUAL
V	Nil	N	M				CI	CLAY - Medium plasticity, orange/red.	St- VSt				
											A	0.8	4816/101/ 0.8
				1.0									1.0
				1.1							A	1.1	4816/101/ 1.1 - V-bit refusal at 1.1m.
								Borehole terminated at 1.1m on inferred very low strength sandstone.					
				2.0									2.0
				3.0									3.0
				4.0									4.0
				4.5									4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
⊽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	Precise Planning	**COMMENCED**	29/5/15	**COMPLETED**	29/5/15	**REF**	**BH202**
PROJECT	Salinity Assessment	**LOGGED**	GMT	**CHECKED**	JF	Sheet 1 of 1	
SITE	45 Noongah St & 25 Gwynn Hughes Rd, Bargo	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1504816
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 2.0m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	<2%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.2			CL	TOPSOIL: Sandy CLAY - Brown, with rootlets.	F		A	0.2	- TOPSOIL 4816/102/ 0.2
V	Nil	N	M	0.5			CI	CLAY - Medium plasticity, light brown.	St		A	0.3	- RESIDUAL 4816/102/ 0.3
V	Nil	N	M	1.0 1.1			CI-CH	CLAY - Medium to high plasticity, orange/brown.	St-VSt		A	0.7	- RESIDUAL 4816/102/ 0.7 1.0
V	Nil	N	M	2.0			CH	CLAY - High plasticity, orange/red.	VSt-H		A A	1.6 1.9	- RESIDUAL 4816/102/ 1.6 4816/102/ 1.9 - V-bit refusal at 2.0m. 2.0
				3.0 4.0 4.5				Borehole terminated at 2.0m on inferred very low strength sandstone.					3.0 4.0 4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
$\underline{\nabla}$ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
WI Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Precise Planning**	**COMMENCED**	29/5/15	**COMPLETED**	29/5/15
PROJECT	**Salinity Assessment**	**LOGGED**	GMT	**CHECKED**	JF
SITE	**45 Noongah St & 25 Gwynn Hughes Rd, Bargo**	**GEOLOGY**	Shale	**VEGETATION**	Grass
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	NA
EXCAVATION DIMENSIONS	Ø90mm X 2.5m depth	**NORTHING**	NA	**ASPECT**	East

REF BH203
Sheet 1 of 1
PROJECT NO. P1504816
SLOPE <5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.2			CL	TOPSOIL: Sandy CLAY - With rootlets.	F- St		A	0.1	- TOPSOIL 4816/103/ 0.1
V	Nil	N	M	0.5 1.0 1.2			CI	Sandy CLAY - Medium plasticity, light brown orange.	St- VSt		A A	0.7 0.9	- RESIDUAL 4816/103/ 0.7 4816/103/ 0.9
V	Nil	N	M	2.0 2.5			CI- CH	CLAY - Medium to high plasticity, orange/brown/white, with trace sand.	VSt- H		A A	1.5 2.3	- RESIDUAL 4816/103/ 1.5 4816/103/ 2.3
				3.0 4.0 4.5				Borehole terminated at 2.5m on clay.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Precise Planning**	**COMMENCED**	29/5/15	**COMPLETED**	29/5/15	**REF**	**BH204**
PROJECT	**Salinity Assessment**	**LOGGED**	GMT	**CHECKED**	JF	**Sheet 1 of 1**	
SITE	**45 Noongah St & 25 Gwynn Hughes Rd, Bargo**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504816
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 2.5m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	<5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.2			CL	TOPSOIL: Sandy CLAY - With rootlets.	F		A	0.1	- TOPSOIL 4816/204/ 0.1
V	Nil	N	M	0.5 1.0 1.2			CI	Sandy CLAY - Medium plasticity, light brown orange.	F-St		A A	0.3 1.0	- RESIDUAL 4816/204/ 0.3 4816/204/ 1.0
V	Nil	N	M	2.0 2.5			CI-CH	CLAY - Medium to high plasticity, orange/brown.	VSt-H		A A	1.4 2.4	- RESIDUAL 4816/204/ 1.4 4816/204/ 2.4
				3.0 4.0 4.5				Borehole terminated at 2.5m on clay.					

1.0
2.0
3.0
4.0
4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
⊻ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

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Engineering Log - Borehole

CLIENT	**Precise Planning**	**COMMENCED**	29/5/15	**COMPLETED**	29/5/15	**REF BH205**
PROJECT	**Salinity Assessment**	**LOGGED**	GMT	**CHECKED**	JF	**Sheet 1 of 1**
SITE	**45 Noongah St & 25 Gwynn Hughes Rd, Bargo**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.** P1504816
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	NA	
EXCAVATION DIMENSIONS	Ø90mm X 2.5m depth	**NORTHING**	NA	**ASPECT**	West	**SLOPE** <2%

EXCAVATION DATA | MATERIAL DATA | SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.1			CI	Silty CLAY - Medium plasticity, brown, with rootlets and gravels (5-10mm, angular).	F				- TOPSOIL
V	Nil	N	M	0.5 1.0 1.4			CI-CH	CLAY - Medium to high plasticity, brown/red/orange.	F-St		A A	0.2 0.8	- RESIDUAL 4816/205/ 0.2 4816/205/ 0.8
V	Nil	N	M	2.0 2.5			CH	CLAY - High plasticity, orange/red.	VSt-H		A A	1.5 2.4	- RESIDUAL 4816/205/ 1.5 4816/205/ 2.4
				3.0 4.0 4.5				Borehole terminated at 2.5m on clay.					

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-Bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ⊻ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- WI Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- S Standard penetration test
- CBR California Bearing Ratio
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- M Moisture content
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

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

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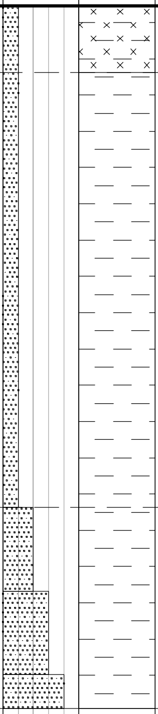
Engineering Log - Borehole

CLIENT	**Precise Planning**	**COMMENCED**	29/5/15	**COMPLETED**	29/5/15	**REF**	**BH206**
PROJECT	**Salinity Assessment**	**LOGGED**	GMT	**CHECKED**	JF	**Sheet**	**1 of 1**
SITE	**45 Noongah St & 25 Gwynn Hughes Rd, Bargo**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504816
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 2.1m depth	**NORTHING**	NA	**ASPECT**	West	**SLOPE**	<5%

EXCAVATION DATA / MATERIAL DATA / SAMPLING & TESTING



METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.2	CI	Silty CLAY - Medium plasticity, brown, with rootlets and gravels (5-10mm, angular).	F		A	0.1	4816/206/ 0.1 - TOPSOIL
V	Nil	N	M	0.5 1.0 1.5	CI-CH	CLAY - Medium to high plasticity, brown/red/orange.	F-St		A	0.6	- RESIDUAL 4816/206/ 0.6
V	Nil	N	M	2.0 2.1	CH	CLAY - High plasticity, orange/red.	VSt-H		A A	1.6 2.0	- RESIDUAL 4816/206/ 1.6 4816/206/ 2.0 - V-bit refusal at 2.1m.
				3.0 4.0 4.5		Borehole terminated at 2.1m on inferred very low strength shale.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
⊻ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
WI Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Precise Planning**	**COMMENCED**	29/5/15	**COMPLETED**	29/5/15	**REF**	**BH207**
PROJECT	**Salinity Assessment**	**LOGGED**	GMT	**CHECKED**	JF	**Sheet** 1 **of** 1	
SITE	**45 Noongah St & 25 Gwynn Hughes Rd, Bargo**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504816
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 2.0m depth	**NORTHING**	NA	**ASPECT**	West	**SLOPE**	<5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	M	0.2			CI	Silty CLAY - Medium plasticity, brown, with rootlets and gravels (5-10mm, angular).	F		A	0.1	- TOPSOIL 4816/207/ 0.1
V	Nil	N	M	0.5 1.0 1.55			CI-CH	CLAY - Medium to high plasticity, brown/red/orange.	St-VSt		A A	0.4 0.9	- RESIDUAL 4816/207/ 0.4 4816/207/ 0.9 1.0
V	Nil	N	M	2.0			CH	CLAY - High plasticity, orange/white.	VSt-H		A A	1.7 1.9	- RESIDUAL 4816/207/ 1.7 4816/207/ 1.9 - V-bit refusal at 2.0m. 2.0
				3.0 4.0 4.5				Borehole terminated at 2.0m on inferred very low strength shale.					3.0 4.0 4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
∇ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
WI Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

8 Attachment C - Salinity Laboratory Report

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS 128916

Client:

Martens & Associates Pty Ltd
Suite 201, 20 George St
Hornsby
NSW 2077

Attention: Grant Taylor

Sample log in details:

Your Reference:	**P1504816 - 45 Noongah 25 Gwynn Hughes Bargo**
No. of samples:	14 soils
Date samples received / completed instructions received	02/06/15 / 02/06/15

This report replaces the R00 due to changes in project's ID.

Analysis Details:

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

Report Details:

Date results requested by: / Issue Date:	10/06/15 / 10/06/15
Date of Preliminary Report:	Not Issued

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

Misc Inorg - Soil						
Our Reference:	UNITS	128916-1	128916-2	128916-3	128916-4	128916-5
Your Reference	-------------	4816/201	4816/201	4816/202	4816/202	4816/202
Depth	------------	0.2	0.8	0.1	0.3	1.6
Date Sampled		29/05/2015	29/05/2015	29/05/2015	29/05/2015	29/05/2015
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	03/06/2015	03/06/2015	03/06/2015	03/06/2015	03/06/2015
Date analysed	-	04/06/2015	04/06/2015	04/06/2015	04/06/2015	04/06/2015
pH 1:5 soil:water	pH Units	6.3	6.0	5.3	6.3	6.4
Electrical Conductivity 1:5 soil:water	µS/cm	19	17	48	82	140
Sulphate, SO4 1:5 soil:water	mg/kg	<10	<10	<10	<10	<10

Misc Inorg - Soil						
Our Reference:	UNITS	128916-6	128916-7	128916-8	128916-9	128916-10
Your Reference	-------------	4816/203	4816/203	4816/203	4816/205	4816/205
Depth	------------	0.1	0.7	1.5	0.2	0.8
Date Sampled		29/05/2015	29/05/2015	29/05/2015	29/05/2015	29/05/2015
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	03/06/2015	03/06/2015	03/06/2015	03/06/2015	03/06/2015
Date analysed	-	04/06/2015	04/06/2015	04/06/2015	04/06/2015	04/06/2015
pH 1:5 soil:water	pH Units	5.3	6.1	5.0	6.5	6.1
Electrical Conductivity 1:5 soil:water	µS/cm	24	10	46	64	31
Sulphate, SO4 1:5 soil:water	mg/kg	10	<10	<10	67	20

Misc Inorg - Soil					
Our Reference:	UNITS	128916-11	128916-12	128916-13	128916-14
Your Reference	-------------	4816/205	4816/207	4816/207	4816/207
Depth	------------	1.5	0.1	0.4	1.7
Date Sampled		29/05/2015	29/05/2015	29/05/2015	29/05/2015
Type of sample		soil	soil	soil	soil
Date prepared	-	03/06/2015	03/06/2015	03/06/2015	03/06/2015
Date analysed	-	04/06/2015	04/06/2015	04/06/2015	04/06/2015
pH 1:5 soil:water	pH Units	5.6	5.5	6.3	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	40	21	29	340
Sulphate, SO4 1:5 soil:water	mg/kg	30	<10	20	24

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 25oC 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.

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			03/06/2015	128916-4	03/06/2015 || 03/06/2015	LCS-1	03/06/2015
Date analysed	-			04/06/2015	128916-4	04/06/2015 || 04/06/2015	LCS-1	03/06/2015
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	128916-4	6.3 || 6.3 || RPD: 0	LCS-1	101%
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	128916-4	82 || 84 || RPD: 2	LCS-1	98%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	128916-4	<10 || 10	LCS-1	107%

QUALITY CONTROL Misc Inorg - Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	128916-12	03/06/2015 || 03/06/2015	128916-3	03/06/2015
Date analysed	-	128916-12	04/06/2015 || 04/06/2015	128916-3	04/06/2015
pH 1:5 soil:water	pH Units	128916-12	5.5 || 5.5 || RPD: 0	[NR]	[NR]
Electrical Conductivity 1:5 soil:water	µS/cm	128916-12	21 || 19 || RPD: 10	[NR]	[NR]
Sulphate, SO4 1:5 soil:water	mg/kg	128916-12	<10 || <10	128916-3	110%

Report Comments:

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

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

Quality Control Definitions

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

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

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

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

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

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

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

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

9 Attachment D - Notes About This Report

Information

Important Information About Your Report

Subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all of course, are necessarily relevant to all reports, but are included as general reference.

Engineering Reports - Limitations

Geotechnical reports are based on information gained from limited sub-surface site testing and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel and are based on the 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 (eg. a three storey building), the information and interpretation may not be relative if the design proposal is changed (eg. 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 that 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 they are not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced and 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 this investigation 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. Attention is drawn to the document 'Guidelines for the Provision of Geotechnical Information in Tender Documents', published by the Institution of Engineers, Australia.

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

Engineering Reports – Data

The report as a whole presents the findings of the site assessment and the report 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) 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 the 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 as it relates 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 for will depend partly on test point (eg. excavation or borehole) spacing and sampling frequency which are often limited by project imposed budgetary constraints.

- 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 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, the Company will be pleased to assist with investigation or 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.

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, the Company 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 report, retain Martens to work with other project professionals who are 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 - Geoenvironmental 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 the Company's proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geoenvironmental 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

Geotechnical 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 recognize 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 is related. 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 based on Australian Standard 1726 and the S.A.A Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

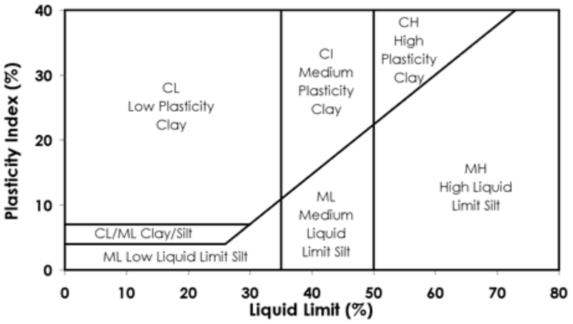
Particle Size

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

Division	Subdivision	Size
BOULDERS		>200 mm
COBBLES		60 to 200 mm
GRAVEL	Coarse	20 to 60 mm
	Medium	6 to 20 mm
	Fine	2 to 6 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties

Plasticity properties can be assessed either in the field by tactile properties, or by laboratory procedures.



Moisture Condition

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C_u (kPa)	Approx SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	2 to 4	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail.
Friable	-		Crumbles or powders when scraped by thumbnail

Density of Granular Soils

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

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

Minor Components

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

Term	Assessment	Proportion of Minor component In:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily detectable by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

Soil Data

Explanation of Terms (2 of 3)

Soil Agricultural Classification Scheme

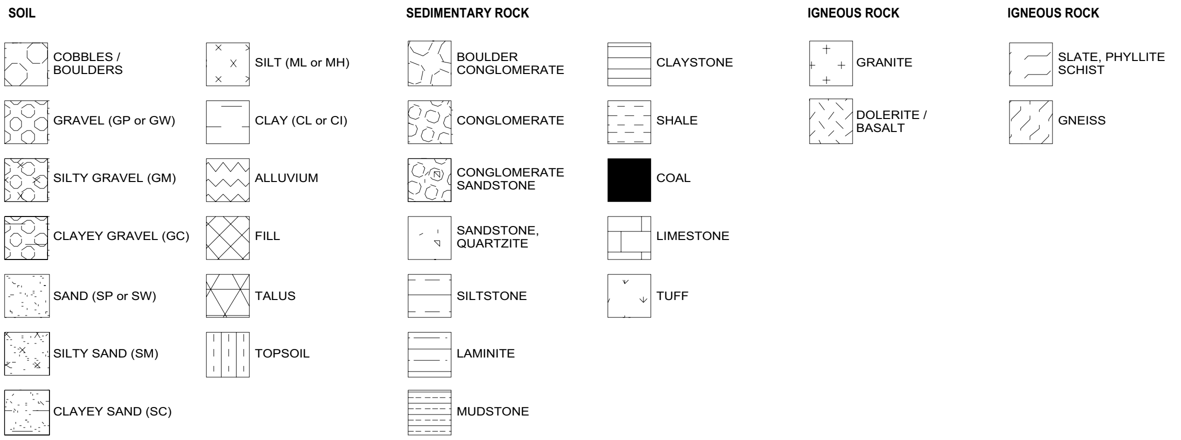
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions 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

Soil Data

Explanation of Terms (3 of 3)

Symbols for Soil and Rock



Unified Soil Classification Scheme (USCS)

<table>
<tr><th colspan="8">FIELD IDENTIFICATION PROCEDURES
(Excluding particles larger than 63 mm and basing fractions on estimated mass)</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS
More than 50 % of material less than 63 mm is larger than 0.075 mm</td><td rowspan="16">(A 0.075 mm particle is about the smallest particle visible to the naked eye)</td><td rowspan="4">GRAVELS
More than half of coarse fraction is larger than 2.0 mm.</td><td colspan="2" rowspan="2">CLEAN GRAVELS (Little or no fines)</td><td colspan="3">Wide range in grain size and substantial amounts of all intermediate particle sizes.</td><td>GW</td><td>Gravel</td></tr>
<tr><td colspan="3">Predominantly one size or a range of sizes with more intermediate sizes missing</td><td>GP</td><td>Gravel</td></tr>
<tr><td colspan="2" rowspan="2">GRAVELS WITH FINES (Appreciable amount of fines)</td><td colspan="3">Non-plastic fines (for identification procedures see ML below)</td><td>GM</td><td>Silty Gravel</td></tr>
<tr><td colspan="3">Plastic fines (for identification procedures see CL below)</td><td>GC</td><td>Clayey Gravel</td></tr>
<tr><td rowspan="4">SANDS
More than half of coarse fraction is smaller than 2.0 mm</td><td colspan="2" rowspan="2">CLEAN SANDS (Little or no fines)</td><td colspan="3">Wide range in grain sizes and substantial amounts of intermediate sizes missing.</td><td>SW</td><td>Sand</td></tr>
<tr><td colspan="3">Predominantly one size or a range of sizes with some intermediate sizes missing</td><td>SP</td><td>Sand</td></tr>
<tr><td colspan="2" rowspan="2">SANDS WITH FINES (Appreciable amount of fines)</td><td colspan="3">Non-plastic fines (for identification procedures see ML below)</td><td>SM</td><td>Silty Sand</td></tr>
<tr><td colspan="3">Plastic fines (for identification procedures see CL below)</td><td>SC</td><td>Clayey Sand</td></tr>
<tr><td rowspan="8">FINE GRAINED SOILS
More than 50 % of material less than 63 mm is smaller than 0.075 mm</td><th colspan="8">IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM</th></tr>
<tr><th colspan="2">DRY STRENGTH (Crushing Characteristics)</th><th colspan="2">DILATANCY</th><th>TOUGHNESS</th><th>DESCRIPTION</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td colspan="2">None to Low</td><td colspan="2">Quick to Slow</td><td>None</td><td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity</td><td>ML</td><td>Silt</td></tr>
<tr><td colspan="2">Medium to High</td><td colspan="2">None</td><td>Medium</td><td>Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays</td><td>CL</td><td>Clay</td></tr>
<tr><td colspan="2">Low to Medium</td><td colspan="2">Slow to Very Slow</td><td>Low</td><td>Organic slits and organic silty clays of low plasticity</td><td>OL</td><td>Organic Silt</td></tr>
<tr><td colspan="2">Low to Medium</td><td colspan="2">Slow to Very Slow</td><td>Low to Medium</td><td>Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts</td><td>MH</td><td>Silt</td></tr>
<tr><td colspan="2">High</td><td colspan="2">None</td><td>High</td><td>Inorganic clays of high plasticity, fat clays</td><td>CH</td><td>Clay</td></tr>
<tr><td colspan="2">Medium to High</td><td colspan="2">None</td><td>Low to Medium</td><td>Organic clays of medium to high plasticity</td><td>OH</td><td>Organic Silt</td></tr>
<tr><td colspan="2">HIGHLY ORGANIC SOILS</td><td colspan="6">Readily identified by colour, odour, spongy feel and frequently by fibrous texture</td><td>Pt</td><td>Peat</td></tr>
<tr><td colspan="10">Low Plasticity – Liquid Limit W_L < 35 % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit W_L > 60 %</td></tr>
</table>

Rock Data

Explanation of Terms (1 of 2)

Definitions

Descriptive terms used for Rock by Martens are given below and include rock substance, rock defects and rock mass.

Rock Substance	In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot, unless extremely weathered, be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.
Rock Defect	Discontinuity or break in the continuity of a substance or substances.
Rock Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Degree of Weathering

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

Term	Symbol	Definition
Residual Soil	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - ie. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	Fr	Rock substance unaffected by weathering

Rock Strength

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

Term	Is (50) MPa	Field Guide	Symbol
Extremely weak	< 0.03	Easily remoulded by hand to a material with soil properties.	EW
Very weak	0.03 - 0.1	May be crumbled in the hand. Sandstone is ‘sugary’ and friable.	VW
Weak	0.1 - 0.3	A piece of 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.	W
Medium strong	0.3 - 1	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	MS
Strong	1 - 3	A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife.	S
Very Strong	3 - 10	A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VS
Extremely strong	> 10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	ES

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 excludes fractures such as drilling breaks.

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

Test Methods

Explanation of Terms (1 of 2)

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 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 sample tube into the 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 Methods

The following is a brief summary of drilling 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 75-100mm in diameter into the ground. The depth of penetration 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 if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) 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 - the hole is advanced by pushing a 100mm 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, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

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 Methods of Testing Soils for Engineering Purposes - Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

as 4, 6, 7
N = 13
(ii) In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

as 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 50mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

CONE PENETROMETER TESTING AND INTERPRETATION

Cone penetrometer testing (sometimes referred to as Dutch Cone - abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in AS 1289 - Test F4.1.

In the test, a 35mm 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 separate 130mm long sleeve, immediately behind the cone. Tranducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output 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:
Cone resistance - the actual end bearing force divided by the cross sectional area of the cone - expressed in MPA.
Sleeve friction - the frictional force of the sleeve divided by the surface area - expressed in kPa.
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 (Mpa) = (0.4 to 0.6) N (blows/300mm)

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

q_c = (12 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.

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 - a 16 mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS 1289 - Test F 3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
Cone penetrometer (sometimes known as the Scala Penetrometer) - a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289 - Test F 3.2). The test was developed initially for pavement sub-grade investigations, with correlations of the test results with California bearing ratio published by various Road Authorities.

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.

TEST PIT / BORE LOGS

The test pit / bore log(s) presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method 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 boreholes 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 boreholes, the frequency of sampling and the possibility of other than 'straight line' variation between the boreholes.

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.