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martens consulting engineers

Geotechnical Assessment: Proposed Seniors Living - 83 Booralie Road, Terrey Hills, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT
MANAGEMENT

P1404413JR02V01
May 2015

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<table>
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<tr><th colspan="2">Author(s)</th><th colspan="2">Reviewer(s)</th><th colspan="2">Project Manager</th><th colspan="2">Signature</th></tr>
<tr><td colspan="2">Gray Taylor</td><td colspan="2">Dr Daniel Martens</td><td colspan="2">Gray Taylor</td><td colspan="2">Gray Taylor.</td></tr>
<tr><th rowspan="2">Revision No.</th><th rowspan="2">Description</th><th rowspan="2">Status</th><th rowspan="2">Release Date</th><th colspan="4">Document Location</th></tr>
<tr><th>File Copy</th><th>MA Library</th><th>Playoust Churcher Architects</th><th>-</th></tr>
<tr><td>1</td><td>Draft for review</td><td>Draft</td><td>18/11/2014</td><td>1E,1P,1H</td><td>1H</td><td>1P</td><td></td></tr>
<tr><td>1</td><td>DA Submission</td><td>Final</td><td>05.08.15</td><td>1E,1P,1H</td><td>1H</td><td>1P</td><td></td></tr>
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All enquiries regarding this project are to be directed to the Project Manager.

Contents

1 Introduction

1.1 Assessment Overview

Martens & Associates Pty Ltd (MA) has been commissioned to carry out a geotechnical assessment to support a proposed seniors living development at 83 Booralie Road, Terry Hills (the site).

The assessment has been conducted to support a development application for a senior living development.

1.2 Development Proposal

At the time of reporting development details were in the preliminary design stage and are summarised as:

- Construction of 26 self-care units and community centre.
- Excavations of up to 2-3 meters below ground level (mbgl) for OSD and rainwater tanks.
- Access road and pathways.
- Services (water, sewer, stormwater) and landscaping.

Preliminary site development plans are provided in Attachment A.

2 Site Description

2.1 Location and Existing Landuse

The site is located at 83 Booralie Road within the Waringah Council Local Government Area (LGA). The approximate 1.95 ha site is surrounded by residential and rural residential developments (Figure 1).

Figure 1: Site location (outlined in black)

Existing infrastructure consists of two residential dwellings and associated storage sheds.

Site contains cleared grassed lands with two areas of eucalypt vegetation / bushland in the north east and to the south.

2.2 Topography and Drainage

Majority of the site (to the north of Keirans Creek) has a southerly aspect with slopes approximately <5°. The site drains towards Keirans Creek which dissects the southern portion of the site. Area to the south of Keirans Creek has a northern aspect with slopes of <5°.

Keirans Creek eventually drains to Cowan Creek / Hawkesbury River

2.3 Groundwater

Table 1 provides a summary of site groundwater levels measured at completion of borehole drilling.

Table 1: Groundwater levels at completion of borehole drilling

Testing Location	Depth of Groundwater Following Drilling (mbgl)
BH1	2.15
BH2	2.25
BH3	2.64
BH4	2.30
BH5	2.50

Groundwater monitoring wells were installed at BH103, BH104 and BH105 with BH103 and BH105 fitted with long term groundwater level monitoring loggers. Groundwater level data from these loggers is summarised in Table 2. The water table was within sandstone at BH103 throughout the entire monitoring period. At BH105 the water table was generally in the clay layer above the sandstone with the water table lowering to a level slightly below the top of the sandstone at the end of the monitoring period. Throughout the entire monitoring period both BH103 and 105 showed a clear trend of decreasing groundwater levels. Further groundwater monitoring is required to confirm typical groundwater levels and fluctuations.

Table 2: Groundwater level logger data summary (period 18.10.2012 to 09.01.2013)

	BH103	**BH105**
Ground level (mAHD)	195	193
Minimum (mAHD)	190.77	190.94
Mean (mAHD)	191.21	191.24
Maximum (mAHD)	191.73	191.55
Range (m)	0.96	0.62
Minimum Depth to GW (m)	3.27	1.45
Mean Depth to GW (m)	3.79	1.76
Maximum Depth to GW (m)	4.23	2.06

2.4 Geology and Soil Landscapes

Geological survey of NSW geology sheet (Sydney 9130) maps the site being underlain by Hawkesbury sandstone consisting of medium to coarse grained quartz sandstone with minor shale and laminate lenses.

3 Geotechnical Assessment

3.1 Field Investigations

Site inspection undertaken on 19 October 2012 included the following:

- General walkover inspection of site and nearby areas to review local geology, topography and vegetation.
- Excavation of eight boreholes using a truck mounted hydraulic drilling rig and hand auger to determine the nature of subsurface materials.
- Dynamic cone penetration (DCP) testing to determine soil engineering properties and depth of subsurface materials at representative locations.
- Installation of ground water monitoring wells in three locations (BH103, BH104 and BH105) for assessment of groundwater depth.
- Collection of soil samples for Atterberg Limits, Shrinkage Index, and CBR analysis.

Location of sub-surface investigations are documented on the site plan provided in Attachment A

3.2 Subsurface Conditions

Site subsurface conditions are variable across the site. Soils consist of silty sand tops soils or clayey sand and clay fill overlaying natural sands and clays which grade to predominantly weak sandstone bedrock below depths between 0.6 – 2.0 mbgl. Medium strong sandstone was only encountered in BH102 at 3.0 (as evidenced by auger refusal). For the majority of boreholes, extremely weak to weak sandstone was encountered down to borehole termination depth of 4.0 – 5.5m below grade. Detailed borehole logs are available in Attachment B.

3.3 Soil and Rock Strength Properties

Soil and rock strength properties have been estimated based on borehole derived soil profile data, *in-situ* DCP testing results and auger refusal characteristics (Table 3). Methods are approximate and preliminary. Should higher bearing pressures be required then additional deeper investigations including rock coring, RQD assessment and point load testing will be required.

Table 3: Preliminary soil and rock strength property estimates

Layer	Depth[1]	Ys[2] (kN/m^3)	ϕ'[3] (◦)	C$_u$[4] (kPa)	ASF[5] (kPa)	ABC[6] (kPa)	Earth Pressures	
							Ka[10]	Kp[11]
TOP SOILS and FILL MATERIAL-	0.0 - 0.9 (variable)	15	-	-	-	-	-	-
Granular subsoils (gravely sands and sands)	0.1 – 0.8 (variable)	18	29	-	15	50	0.35	2.88
Cohesive subsoils (Clays)	1.3 – 2.0 (BH105)	16	-	25	10	50	0.30	2.20
Extremely weak sandstone	0.6 – 5.5 (variable)	18	30	-	15	250	0.33	3
Weak sandstone	1.4 – 5.5 (variable)	19	32	-	40	500[12]	0.30	3.25
Medium Strong Sandstone	2.2 – 4.0 (BH106)	20	34	-	55	800[12]	0.28	3.5

Notes:

[1] Depth range variable, see attached borehole logs for accurate depth intervals.
[2] *In-situ* Unit Weight.
[3] Effective friction angle.
[4] Undrained shear strength.
[5] Allowable Skin Friction.
[6] Allowable End Bearing Capacity.
[7] Maximum unsupported batter slopes (vertical: horizontal).
[8] Permanent: long term unsupported.
[9] Temporary: Unsupported for less than 1 month.
[10] Coefficient of Active Earth Pressure.
[11] Coefficient of Passive Earth Pressure
[12] Bearing pressure in rock may be significantly higher. Further testing and analysis is required to confirm if bearing pressures are greater than this value.

Preliminary earth pressures assume a level surface behind the top of the excavation, no hydrostatic pressure due to adequate drainage behind retaining walls, and no construction or other surcharge loads within 5m behind shoring or retaining wall. The above parameters are for preliminary design purposes.

3.4 Slope Stability

Based on site grades and underlying geology, slope stability is not considered to be a geotechnical constraint for the site. No sign of recent or relic mass movement on site were noted during the onsite investigation. Stability modelling was not part of the scope for this assessment.

3.5 Laboratory Analytical Results

3.5.1 *Atterberg Limits and Linear Shrinkage*

Soil samples from two boreholes containing site natural clays were tested for Atterberg Limits and linear shrinkage to determine shrink swell potential and potential shrinkage with varied moisture levels (Table 4).

Table 4: Atterberg Limit laboratory data

Sample ID [1]	Liquid Limit (%)	Rating [2]	Plasticity Index (%)	Rating [3]	Linear Shrinkage (%)	Potential Volume Change [4]	Expansive Rating [5]
3558/5/0.5-0.6	34	Low	20	Low	8.0	Medium	Non-critical
3558/6/1.5-1.6	39	Low	22	Low	12.0	Medium	Non-critical

Notes:

[1] Project#/Borehole#/Depth(m).

[2] Based on Table 3.5 of Interpreting Soil Test Results (2007) – Ratings for compressibility and shrink-swell potential based on liquid limit.

[3] Based on Table 3.4 of Interpreting Soil Test Results (2007) – Ratings for compressibility and shrink-swell potential based on plasticity index.

[4] Based on Table 3.14 of Interpreting Soil Test Results (2007) – Potential volume change.

[5] Based on Table 3.13 of Interpreting Soil Test Results (2007) – Categories of linear shrinkage

Atterberg testing indicates a low compressibility and shrink swell potential in tested clays.

Linear shrinkage testing indicates a medium range of potential volume change but a non-critical expansive rating for tested clays.

3.5.2 *CBR Testing*

Two soil samples were collected for CBR testing to assess their performance as pavement subgrade materials (Table 5).

Table 5: CBR test results

Borehole	Sample Depth (m)	Soil Description	CBR value
BH102	0.2 - 0.4	Gravely sand	16
BH106	0.2 - 0.4	Gravely sand	14

A preliminary design CBR value of 14 is recommended for site gravely sand material. It is expected that CBR values will vary across the site and there is a likelihood that areas of relatively unsuitable subgrade materials exist on site (particularly deeper clays/ sandy clays). Appropriate site testing during the construction of future roads will need to be undertaken to confirm suitability of material.

3.6 Preliminary Foundation Classification

Uncontrolled fill was observed in four boreholes and approximate fill extent is indicated on site plan (SK001, Attachment A). The origin and placement methods of fill material are unknown. A preliminary site classification of "P" in accordance with AS 2870 (2011) is applied to this area. All other areas of the site considered class 'M' based on clay depth and laboratory testing data (Section 3.5). This is a broad classification for shallow footing design for residential purposes only. Future site development foundations will likely be taken to sandstone bedrock and should be designed from provided geotechnical parameters.

4 Recommendations

4.1 Geotechnical Recommendations

Geotechnical recommendations are provided in Table 6.

Table 6: Geotechnical recommendations.

Geotechnical Issue	Recommendations
Excavations and Vibrations	Excavations for the proposed buildings and OSD and rainwater tanks (up to 3mbgl) will encounter predominantly clay and extremely weak to weak sandstone. There is a possibility that medium strong sandstone will be encountered at excavations depths below 3.0m. In light of this we recommend the following excavation techniques: o Fill material and natural soils should be readily excavated using conventional earthmoving equipment. o Extremely weak to weak sandstone with very low to low strength should generally be readily excavated with a 'toothed' bucket or a ripping tyne (or similar) although progress may be slow in weak sandstone. o Excavations with rock breaker attachments required for excavations of medium strong sandstone or greater. All excavation work should be completed with reference to the Code of Practice 'Excavation Work', Cat. No. 312 dated 31 March 2000 by Workcover. Excavation method statements will need to be prepared by the excavation contractor prior to the issue of CC. It is expected that a temporary batter will be formed around the excavation to the top of the medium strength sandstone which will be vertical cut to bulk excavation level on condition of stability being agreed with by a geotechnical engineer. If stability is not confirmed the batter will need to be continued to the final bulk excavation level with the batter remaining until the basement level structure is complete. Consideration should be given to the use of rock sawing techniques (if medium strong sandstone is encountered) prior to the use of hydraulic hammer equipment to reduce noise and vibrations. Care will be required when excavating close to boundaries and existing buildings as structural distress may occur from vibration produced by construction equipment. The level of acceptable vibrations is dependent on various factors including the type of building structure, its structural condition, the frequency range of vibrations, the natural frequency of the building and the vibration transmitting medium. Recommended maximum levels of ground vibration (as per AS 2187.2, 1993) are 5 mm/s PPV (peak particle velocity) at the site boundary or at closer retained site structures.
Batter Slopes/ Shoring Methods	Soils Any temporary or permanent excavations into soil exceeding 0.75 m depth should be supported by suitably designed and installed retaining or shoring structures or, alternatively, using batter slopes of 1V:2H for temporary slopes (unsupported for less than 1 month) and 1V:3H for permanent long term unsupported slopes. It is recommended that unsupported soil excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk. Rock Temporary excavations into extremely weak to weak sandstone can be made at 1V:1H and 8V:1H for medium strong sandstone. Permanent excavations can be made at 1V:1.5H for weak sandstone and 4V:1H for medium strong sandstone, provided there are no adversely oriented joints or defects in the rock. It is recommended that excavated rock faces be inspected by a geotechnical engineer to determine whether any additional support, such as rock bolts or shotcrete, is required. Where there is insufficient room for temporary batters, excavations will need to be supported by temporary shoring or permanent retaining walls such as a soldier pile/infill panel wall system.

	Heavy Machinery Heavy machinery should be avoided where possible within 2 m of any open soil excavation to prevent excessive vibrations and undue settlement.
Sub-grade Preparation	We recommend that any stripping of soil or sub-grades, be undertaken at the on-set of excavation and suitably stockpiled for on-site re-use (where possible) or off-site disposal to a suitable location. For soil sub-grade areas where fill is to be placed to raise site levels and where on-grade slabs are to be constructed, preparation of sub-grade should consist of: o Proof roll the sub-grade with a minimum 12 tonne deadweight smooth drum vibratory roller to achieve a minimum density index (ID) of 65 % or a minimum density of 98 % Standard Maximum Dry Density (SMDD) for cohesionless soil. o Proof rolling should be closely monitored by the project geotechnical engineer to detect soft or unstable areas which should be removed and replaced with engineered fill or alternatively stabilised or bridged. Density tests should be carried out at a frequency of one test per layer per 500 m^2 or three (3) tests per visit, whichever requires the higher number of tests, to confirm the specifications provided in this report have been achieved. At least Level 2 testing of earthworks should be carried out in accordance with AS3798 (2007). Any areas of insufficient compaction will require reworking. Engineered fill is to be free from organic materials, other contaminants and deleterious substances and have a maximum particle size not exceeding 40 mm. We consider that the excavated clayey soil and weathered shale will be suitable as engineered fill. It should be placed in layers of a maximum of 100 mm loose thickness and compacted at least 98 % SMDD, which can be reduced to 95 % SMDD in landscaped areas. Further testing will be required to confirm this. All site earthworks should be undertaken in accordance with AS3798 (2007) and Aus-Spec 213 (2004). We recommend that any stripping of organic top soil or unsuitable sub-grades such as uncontrolled fill, be undertaken at the on-set of excavation and suitably stockpiled for on-site re-use (where possible) or off-site disposal to a suitable location in accordance with DEECW (2009) waste classification guidelines. All site earthworks should be undertaken in accordance with AS3798 (2007) and Aus-Spec 213 (2004).
Footings and Foundations	Foundations of proposed buildings are to be designed by a suitably qualified and experienced structural or geotechnical engineer. Preliminary sub-surface soil and rock strength parameters are provided in Table 3 for footing design. All footings should be excavated and poured with minimal delay. All footings should be free from all loose or softened materials prior to pouring. If water ponds in the base of the footings, they should be pumped dry and then re-excavated to remove all loose and softened materials. If a delay in pouring is anticipated, a blinding layer of at least 50 mm concrete is to be placed to protect the base of the footing excavation. All footing excavations should be inspected by a geotechnical engineer to confirm the required founding strata has been reached. Due to the relatively shallow depth to rock across the site, it is recommended that proposed buildings be founded within the sandstone bedrock to minimise any potential foundations settlement. Depth to sandstone is predominantly >1m across the site and as such, a piled footing system could be adopted. Due to shallow groundwater and loose granular soils, bored piles are not recommended due to potential for hole collapse during drilling. Alternative piling methods such as grout injected piling or screw piling should be considered. Further geotechnical design advice will need to be provided once the design is progressed.
OSD and Rainwater Tank Retaining Walls	OSD and rainwater tank retaining walls design should take appropriate surcharge and hydrostatic load into account and be designed in light of the preliminary geotechnical parameters provided in Table 3 and any further geotechnical information. Backfill materials between the basement retaining wall and the rock face should comprise a high strength, durable, single sized washed aggregate, such as 'blue metal' gravel. Fill should be placed in a maximum of 200 mm horizontal layers and compacted using a hand held compactor. Care should be taken to ensure excessive compaction stresses are not transferred to retaining walls. Backfill areas to be geotextile wrapped with base drainage system. We recommend a drainage system should be installed behind all backfilled retaining walls to dissipate pore pressures and water that may collect behind the retaining walls to the stormwater system. Further consideration may need to be given to drainage below any basement slabs. Final drainage design is to be required at construction phase of the project, following detailed structural design and additional pump testing to confirm likely groundwater inflow rates.

Groundwater	It is considered that the same proposed excavation may intercept the groundwater table and dewatering is likely. Therefore Department of Primary Industries' Office of Water should be contacted to determine whether a dewatering licence is required. Where dewatering is required, we recommend a groundwater impact report be completed by a geotechnical engineer or hydrogeologist to ensure dewatering works will not adversely impact adjacent and/or nearby structures. Sump and pump methods are considered to be appropriate for dewatering during construction. We recommend monitoring of flow during the early phases of excavation below the water table to assess potential long term pumping requirements. All site discharges should be passed through a filter material prior to release. Groundwater ingress should be monitored during excavation by a geotechnical engineer. OSD and rainwater tank design should consider the requirement for tanking (waterproofing) or groundwater ingress management.
Trafficability and Construction Assess	Trafficability across exposed soil/sub-grade materials and weathered rock is expected to be adequate in dry weather for most construction plants such as conventional rubber tyre plant, four-wheel drive plant and track mounted plant. For any excavations and constructions beneath the permanent groundwater table, movement of plants across dewatered soil/sub-grade or rock surface should be possible. During wet weather, trafficability of all heavy machinery on exposed soil/sub-grade materials may be reduced. Provision for site grading, temporary open drains or toe/crest drains is suggested to collect any overland flow, prevent water ponding and hence minimise potential for any further soil/sub-grade softening or erosion, and to help improve trafficability. The use of dumped aggregate for temporary construction roads may be necessary to allow works during and immediately following wet weather.
Overland Flows	Surface water runoff should be diverted away from excavations during construction and from permanent structures. Diverted flows should be directed to Council, or other approved, stormwater systems to prevent water accumulating in areas surrounding retaining structures or footings. Rainfall and local surface water runoff collecting within excavations during construction should be manageable by using conventional sump and pump methods, suitable sediment control for all discharges should be included.
Off-site removal of excavation spoil	Off-site disposal of soil may require classification in accordance with the NSW EPA/DECC guidelines. We can complete the necessary classification and testing if required. Time allowance should be made for such testing in the construction program unless testing is completed prior to construction.
Soil Erosion Control	Removal of soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in the Council stormwater system and on neighbouring lands. All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required. A Proof roll by a geotechnical engineer will be required prior to pavement construction.

4.2 Further Investigations and Design Development Works

We recommend the following further investigations and design development works are undertaken (Table 7).

Table 7: Recommended supplementary investigations and design development works.

Scope of works	Timing	Who to Complete
Additional borehole investigations across the site, in particular at locations of proposed OSD and rainwater tanks, for full characterisation of underlying geology, determination of rock depths/condition and depth of groundwater table.	During development of CC plans	MA[1]
Consultation with NSW Department of Primary Industries' Office of Water to determine if a dewatering licence is required (if groundwater is encountered).	During development of CC plans	MA[1]
Preparation of a dewatering management plan, where required.	During development of CC plans	MA[1]

NOTE: [1] MA = Martens and Associates Engineer

4.3 Monitoring and Inspection Program

We recommend the following is inspected and monitored (Table 8) during site works.

Table 8: Recommended inspections/monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Inspect excavation retention (shoring, retaining wall, rock support) installations and monitor associated performance.	Daily/As required	Builder/ MA
Inspect unsupported and/or vertical cut rock excavations to assess adequacy of design, if adopted, and additional support requirements.	1.5 m depth increments during excavation	MA
Monitor groundwater seepage from excavation faces to assess adequacy of drainage provision.	When encountered	Builder/MA
Monitor excavation-induced vibrations.	Daily at on-set of rock excavation and as agreed thereafter	MA
Monitor sedimentation downslope of excavated areas.	During and after rainfall events	Builder
Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil.	After rainfall events	Builder
Inspect exposed material at foundation level to verify suitability as foundation/ lateral support/ subgrade.	Prior to reinforcement set-up and concrete placement	MA

4.4 Design and Construction Verification

MA or the PCA is to inspect foundation and excavation conditions during construction to verify ground conditions satisfy design assumptions in this report in support of the application for an Occupation Certificate (OC).

4.5 Contingency Plan

MA is to be notified and may need to provide additional advice if conditions are different to those reported.

In the event that the proposed development works cause an adverse impact on overall site stability or on neighbouring properties, works shall cease immediately. The nature of the impact shall be documented and the reason(s) for the adverse impact investigated. This might require a site inspection or further advice by an experienced geotechnical or structural engineer and a review of geotechnical requirements for site retention and foundations.

5 Investigation 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 / test pits / 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.

6 References

Australian Standard (2009) 3600 *Concrete structures*

Australian Standard (1997) 1289.6.3.2 *Determination of the Penetration Resistance of a Soil using the 9 kg Dynamic Cone Penetrometer.*

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

Australian Standard 2159 (2009) Piling – Design and installation.

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

Australian Standard 3798 (2007) *Guidelines on earthworks for commercial and residential developments.*

Australian Standard 4678 (2002) Earth Retaining Structures .

Das, B.M. (1994) *Principles of Foundation Engineering.*

Geological Survey of NSW, Department of Minerals and Energy (1991), Geological Series: 1:100,000, Wollongong Sheet.

Hazelton, P and Murphy, B. (2007) *Interpreting Soil Test Results : What do all the numbers mean?*

Landcom (2004) Managing Urban Stormwater: Soils and Construction, Vol 1, 4th edition.

7 Attachment A – Proposed Development Plan and Site Testing Plan

Site Calculations (site area 19517 M2)

FSR Required --50% MAX = 9758.5 M2
FSR Proposed --19.6% = 3434.8 M2

Landscape Required --30% MIN = 5855.1 M2
Landscape Proposed --60% = 12096 M2

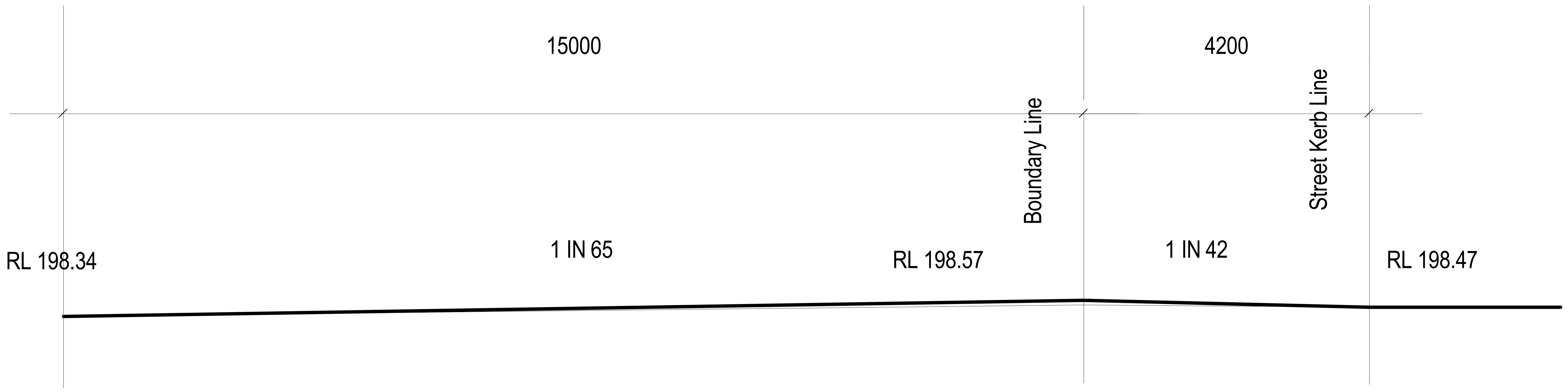
Soft Landscape Required --15% MIN = 2927.55 M2
Soft Landscape Proposed --58% = 11336 M2

NOTE

1- individual lockable letter box for each house accessible from the conc. entry
2- Continuous accessible path of travel to common areas and adjoining public road is less than 1:20 with smooth transition, construction tolerances 3 mm max or 5 mm beveled or rounded edge as per AS 1428.1 section 7.2.
3-Garbage will be collected by private contractor from the front of each house.
4- Pathway lighting is to be designed and located to avoid glare for pedestrians and adjacent houses (20 lux MAX at ground level)

LB ■ Letter Box
Caleyi Grevillea to remain
Existing trees to remain
Existing trees to be removed
RW Rain water tank

01 Site Plan
- Scale: 1:500



02 Driveway section
- Scale: 1:50

rev	date	revision notes	by
A	28/1/15	For Development Application	JM

Figured dimensions to be taken in preference to scaling. Contractor to verify all dimensions on job before commencing any work or making shop drawings

project
PROPOSED DEVELOPMENT
83 BOORALIE ROAD TERREY HILLS

project # 14-668

client
Tolucy Pty/Ltd

dwg
Site Plan and Driveway Section

printed	drawn	ckd	scale@A1
28/01/2015	PCA	LP	1:200@A1

Development Application

stage	drawing #	revision
DA	A103	A

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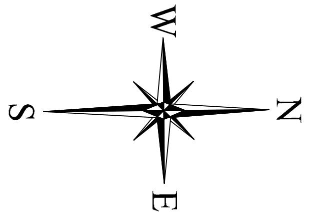
ACN 003 751 611 trading as Playoust Churcher Architects

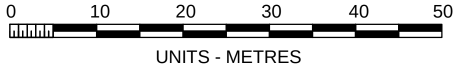
martens

KEY

◑ BH108 - BOREHOLE

⊕ GMB101 - GROUND WATER MONITORING BORE





Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BM	**SITE TESTING PLAN**	Drawing No./ID: **SK001**
Approved:	GT		
Date:	01.11.2014		
Scale @A3:	NA	Suite 201, Level 2, George Street, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 Email: mail@martens.com.au Internet: http://www.martens.com.au	Project: P1404413 File: JD03V01 Revision: A

8 Attachment B – Test Pit / Borehole logs

CLIENT	**Bayview Links Pty Ltd**	**COMMENCED**	18.10.2012	**COMPLETED**	18.10.2012	**REF**	**BH101**
PROJECT	**Geotechnical and Contamination Assessment**	**LOGGED**	BM/GL	**CHECKED**	GT	**Sheet** 1 **of** 1	
SITE	**83 Booralie Road, Terrey Hills, NSW**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203558
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	197mAHD		
EXCAVATION DIMENSIONS	100mmØ X 4.0m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	<5%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**PENETRATION RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**DESCRIPTION OF STRATA** Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	D	0.1			SM	TOP SOIL - SILTY SAND - Light brown, organics present.		L	E	0.1	3558/1/ 0.1
V	Nil	N	D	0.6			SP	GRAVELLY SAND - Red/brown, ferruginised iron stone inclusions, gravels (5-20mm, 20%). Grading to		L-MD	E	0.5	3558/1/ 0.5
V	Nil	N	D	1.0 1.2			EW	SANDY CLAY/ CLAY - Light brown	F-St		E	1.0	3558/1/ 1.0
V	Nil	N 2.15 ⊽	M	2.0			EW	EXTREMELY WEAK SANDSTONE - Light brown, moist.			E	1.5	3558/1/ 1.5
V	Nil	Y	W	3.0 4.0			W	WEAK SANDSTONE - Light brown, saturated.			E	2.5	3558/1/ 2.5
				5.0 6.0 7.0 8.0 9.0				Borehole terminated at 4.0m on weak sandstone.					

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

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

PENETRATION
- 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
- M Moisture content
- Ux Tube sample (x mm)
- E Environmental sample
- pp Pocket penetrometer
- S Standard penetration test
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- WS Water sample
- PID Photo Ionization Detector

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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Hornsby, NSW 2077 Australia
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mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**Bayview Links Pty Ltd**	**COMMENCED**	18.10.2012	**COMPLETED**	18.10.2012	**REF**	**BH102**
PROJECT	**Geotechnical and Contamination Assessment**	**LOGGED**	BM	**CHECKED**	GT	**Sheet** 1 **of** 1	
SITE	**83 Booralie Road, Terry Hills, NSW**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203558
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	196mAHD		
EXCAVATION DIMENSIONS	100mmØ X 3.0m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	<5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**PENETRATION RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**DESCRIPTION OF STRATA** Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	D	0.1			SM	TOP SOIL - SILTY SAND - Light brown, organics present.		L	E D	0.1 0.2-0.4	3558/2/0.1 CBR2
V	Nil	N	D	0.8			SP	GRAVELLY SAND - Red/brown, ferruginised iron stone inclusions, gravels (5-40mm, 40%).		MD	E	0.5	3558/2/0.5
V	Nil	N	D	1.0 1.9			SP	SAND - Light brown, medium to large grained. Grading to		MD-D	E E	1.0 1.5	3558/2/1.0 3558/2/1.5
V	Nil	2.25 ∇ N	D	2.0 3.0			W	WEAK SANDSTONE - Light brown/white, fine grained sand.			E	2.5	3558/2/2.5
				4.0 5.0 6.0 7.0 8.0 9.0				V Bit refusal at 3.0m on medium strong sandstone.					

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

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

PENETRATION
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
M Moisture content
Ux Tube sample (x mm)
E Environmental sample
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample
PID Photo Ionization Detector

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

martens

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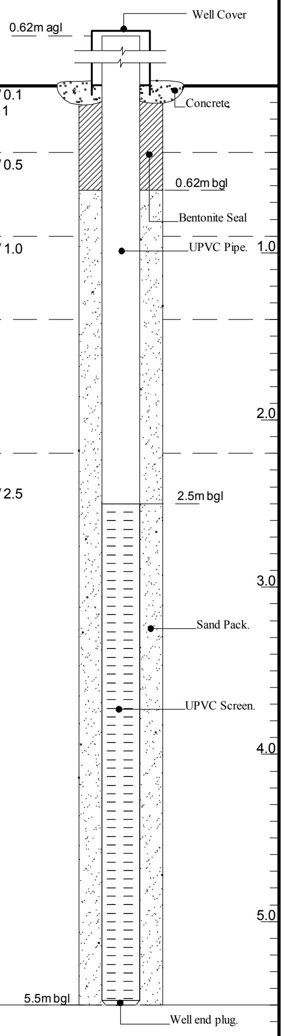
Engineering Log - Borehole

CLIENT	**Bayview Links Pty Ltd**	**COMMENCED**	18.10.2012	**COMPLETED**	18.10.2012	**REF BH103**
PROJECT	**Geotechnical and Contamination Assessment**	**LOGGED**	BM/GL	**CHECKED**	GT	**Sheet 1 of 1**
SITE	**83 Booralie Road, Terry Hills, NSW**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.** P1203558
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	195mAHD	
EXCAVATION DIMENSIONS	100mmØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE** <5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	**DESCRIPTION OF STRATA** Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	WATER WELL DETAILS
V	Nil	N	D	0.4			XX SC	FILL - SILTY CLAYEY SAND - Gravels (5-10mm, 10%), extremely weathered sandstone gravels.		L- MD	E	0.1	3558/3/ 0.1 + DUP 1
V	Nil	N	D	0.9			SM	SILTY SAND - With minor gravels (5-10mm, 5-10%).		MD	E	0.5	3558/3/ 0.5
V	Nil	N	D	1.0 1.4			SP	SAND - Fine to medium grained, ferruginised iron stone inclusion, minor fines, minor gravels (5-10mm, 5-10%).		MD	E	1.0	3558/3/ 1.0
V	Nil	N	M	2.0 2.2			W	SANDY CLAY: Light brown, medium to coarse grained sand. Grades to					
V	Nil	N	M	3.0 4.0 5.0 5.5			W	WEAK SANDSTONE - Light brown grey, becoming saturated with depth.			E	2.5	3558/3/ 2.5
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m in weak sandstone.					



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

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

PENETRATION
- 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
- M Moisture content
- Ux Tube sample (x mm)
- E Environmental sample
- pp Pocket penetrometer
- S Standard penetration test
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- WS Water sample
- PID Photo Ionization Detector

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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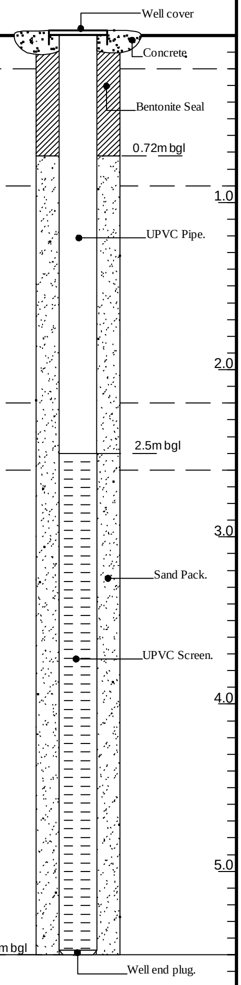
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**Bayview Links Pty Ltd**	**COMMENCED**	18.10.2012	**COMPLETED**	18.10.2012	**REF**	**BH104**
PROJECT	**Geotechnical and Contamination Assessment**	**LOGGED**	BM/GL	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**83 Booralie Road, Terry Hills, NSW**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203558
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	194mAHD		
EXCAVATION DIMENSIONS	100mmØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	<5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	**DESCRIPTION OF STRATA** Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	WATER WELL DETAILS
V	Nil	N	D	0.2			XX SC	FILL - SILTY CLAYEY SAND - Gravels (5-10mm, 10%), extremely weathered sandstone gravels.		L- MD	E	0.1	3558/4/0.1
V	Nil	N	D	0.9			SM	SILTY SAND - With minor gravels (5-10mm, 5-10%).		MD	E	0.5	3558/4/0.5
V	Nil	N	D	1.0 2.0 2.2			SP	SANDY CLAYE- Light grey, with orange mottles			E E	1.0 1.5	3558/4/1.0 3558/4/1.5
V	Nil	2.3 Y	W	2.6			W	EXTREMELY WEAK SANDSTONE - Grey/orange. Grading to			E	2.5	3558/4/2.5
V	Nil	Y	W	3.0 4.0 5.0 5.5			W	WEAK SANDSTONE - Grey, saturated.					
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on sandstone.					



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

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

PENETRATION
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
M Moisture content
Ux Tube sample (x mm)
E Environmental sample
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample
PID Photo Ionization Detector

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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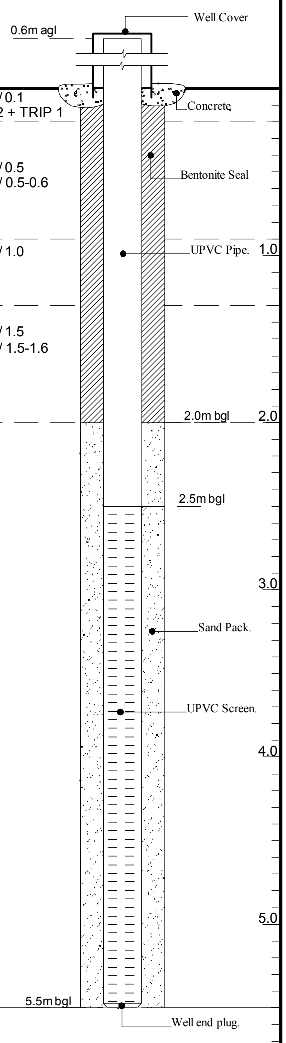
Engineering Log - Borehole

CLIENT	**Bayview Links Pty Ltd**	**COMMENCED**	18.10.2012	**COMPLETED**	18.10.2012	**REF**	**BH105**
PROJECT	**Geotechnical and Contamination Assessment**	**LOGGED**	BM/GL	**CHECKED**	GT	**Sheet** 1 **of** 1	
SITE	**83 Booralie Road, Terry Hills, NSW**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203558
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	193mAHD		
EXCAVATION DIMENSIONS	100mmØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	<5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	WATER WELL DETAILS
V	Nil	N	D	0.2			XX CL	FILL - SILTY CLAY , brown - Gravels (5-20mm, 10%).			E	0.1	3558/5/ 0.1 + DUP 2 + TRIP 1
V	Nil	N	D	0.9			CL	FILL CLAY - extremely weathered sandstone, gravels.			E B	0.5 0.5-0.6	3558/5/ 0.5 3558/5/ 0.5-0.6
V	Nil	N	D	1.0 1.3			SM	SILTY SAND - Dark brown/black, minor gravels.			E	1.0	3558/5/ 1.0
V	Nil	N	D	2.0			CL	CLAY - Light brown, with minor sand and gravel. Grading to			E B	1.5 1.5-1.6	3558/5/ 1.5 3558/5/ 1.5-1.6
V	Nil	2.5 ▽ Y	M	3.0 4.0 5.0 5.5			EW	EXTREMELY WEAK SANDSTONE - Light grey/orange, sandy clay like properties, Note: Seepage observed at approximatley 3.4m during drilling.					
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on sandstone.					



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

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

PENETRATION
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
M Moisture content
Ux Tube sample (x mm)
E Environmental sample
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample
PID Photo Ionization Detector

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	**Bayview Links Pty Ltd**	**COMMENCED**	18.10.2012	**COMPLETED**	18.10.2012	**REF**	**BH106**
PROJECT	**Geotechnical and Contamination Assessment**	**LOGGED**	BM/GL	**CHECKED**	GT	**Sheet** 1 **of** 1	
SITE	**83 Booralie Road, Terry Hills, NSW**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203558
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	191mAHD		
EXCAVATION DIMENSIONS	100mmØ X 4.0m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	<5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.2			XX CL	FILL - SILTY CLAY - Gravels (5-20mm, 10%).			E	0.2	3558/6/0.2 + DUP 4
											D	0.2- 0.4	CBR6
V	Nil	N	D				SP	FILL - SILTY GRAVELY SAND - Light brown, plastics inclusions (wiring).			E	0.5	3558/6/0.5
				0.9									
				1.0							E	1.0	3558/6/1.0
V	Nil	N	D				EW						
				1.4				SANDY CLAY - Light brown with grey and orange mottles			E B	1.5 1.5	3558/6/1.5 3558/6/1.5
V	Nil	N	D				EW						
				2.0									
				2.2									
				3.0							B	3.0- 3.1	3558/6/3.0-3.1
V	Nil	N	D				S	WEAK SANDSTONE - Grey.					
											B	3.8- 4.0	3558/6/3.8-4.0
				4.0									
								Borehole terminated at 4.0m on medium strong sandstone.					
				5.0									
				6.0									
				7.0									
				8.0									
				9.0									

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

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

PENETRATION
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
M Moisture content
Ux Tube sample (x mm)
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S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample
PID Photo Ionization Detector

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
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EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

martens

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Engineering Log - Borehole

CLIENT	Bayview Links Pty Ltd	**COMMENCED**	18.10.2012	**COMPLETED**	18.10.2012	**REF**	**BH107**
PROJECT	Geotechnical and Contamination Assessment	**LOGGED**	BM/GL	**CHECKED**	GT	Sheet 1 of 1	
SITE	83 Booralie Road, Terry Hills, NSW	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203558
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	191mAHD		
EXCAVATION DIMENSIONS	70mmØ X 1.2m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	<5%

EXCAVATION DATA | MATERIAL DATA | SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
HA	Nil	N	D	0.2			SM	TOP SOIL - SILTY SAND - Light brown.		L	E	0.1	3558/7/0.1 + DUP 3
HA	Nil	N	D	1.0 1.2			SP	SAND - Light brown, fine grained, with minor clay.		L	E E	0.5 1.0	3558/7/0.5 3558/7/1.0
HA	Nil	N	D				SC	SANDY CLAY - Light grey, with orange mottles.	F-St		E B	1.5 1.5-1.6	3558/7/1.5 3558/7/1.5-1.6
				2.0 3.0 4.0				EXTREMELY WEAK to WEAK SANDSTONE - Light grey.					
				5.0 6.0 7.0 8.0 9.0				Borehole terminated at 4.0m on extremely weak sandstone.					

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

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

PENETRATION
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
M Moisture content
Ux Tube sample (x mm)
E Environmental sample
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample
PID Photo Ionization Detector

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

martens

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Engineering Log - Borehole

CLIENT	**Bayview Links Pty Ltd**	**COMMENCED**	18.10.2012	**COMPLETED**	18.10.2012	**REF**	**BH108**
PROJECT	**Geotechnical and Contamination Assessment**	**LOGGED**	BM/GL	**CHECKED**	GT	**Sheet** 1 **of** 1	
SITE	**83 Booralie Road, Terry Hills, NSW**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203558
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	191mAHD		
EXCAVATION DIMENSIONS	70mmØ X 1.4m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	<5%

EXCAVATION DATA | **MATERIAL DATA** | **SAMPLING & TESTING**

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
HA	Nil	N	D	0.3			SM	SILTY SAND - Light brown, fine grained.			E	0.1	3558/8/ 0.1
HA	Nil	N	D	1.0 1.4			SP	SAND - Light brown/brown, minor fines, fine to medium grained.			E E	0.5 1.0	3558/8/ 0.5 3558/8/ 1.0
				2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 1.4m on extremely weak sandstone(possibly a floater).					

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

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

PENETRATION
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
M Moisture content
Ux Tube sample (x mm)
E Environmental sample
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample
PID Photo Ionization Detector

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

martens

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Engineering Log - Borehole

9 Attachment C - Laboratory Analytical Certificates

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laboratory@netgeo.com.au

TEST REPORT

Client: Martens & Associates
Project: P#1203558
Location:
GTR Number : P1203558

Job Number: G09/868
Report Number: 2
Report Date: 31/10/2012
Tested By: Jaxson Bryden

Lot Number :
Lot Description :
Location 3558/5/0.5 - 0.6
Client No
Material

Lab Number: G18979
Date Sampled: 23/10/2012
Sampling Procedure: Sampled By Client
Sample Description: CLAY, Light Grey

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1	%	34
Plastic Limit (W_P) AS1289.3.2.1	%	14
Plasticity Index (I_P) AS1289.3.3.1	%	20
Linear Shrinkage AS1289.3.4.1		8.0
LS Comments		-
Sample History:		Natural State
Preparation Method:		Dry
Shrinkage Mould Length(mm)		249.5

REMARKS:

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

Mt Kuring-Gai Laboratory 1318

APPROVED SIGNATORY
Mark Matthews

DATE
31/10/2012

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laboratory@netgeo.com.au

TEST REPORT

Client: Martens & Associates
Project: P#1203558
Location:
GTR Number : P1203558

Job Number: G09/868
Report Number: 2
Report Date: 31/10/2012
Tested By: Jaxson Bryden

Lot Number :

Lot Description :

Location 3558/6/1.5 - 1.6

Client No

Material

Lab Number: G18980

Date Sampled: 23/10/2012

Sampling Procedure: Sampled By Client

Sample Description: CLAY, Light Grey

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1	%	39
Plastic Limit (W_P) AS1289.3.2.1	%	17
Plasticity Index (I_P) AS1289.3.3.1	%	22
Linear Shrinkage AS1289.3.4.1		12.0
LS Comments		-
Sample History:		Natural State
Preparation Method:		Dry
Shrinkage Mould Length(mm)		254

REMARKS:

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

Mt Kuring-Gai Laboratory 1318

APPROVED SIGNATORY
Mark Matthews

DATE
31/10/2012

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CALIFORNIA BEARING RATIO (CBR) TEST REPORT

Page 1 of 1

Client :	Martens & Associates	**Job Number:**	G09/868
Project:	P#1203558	**Report Number:**	1
location:		**Report Date:**	31/10/2012
GTR Number :		**Tested By:**	Mark Matthews

TEST IDENTIFICATION

Sampling Method :Sampled By Client

Lab Number		G18977	G18978	
Sample Date		23/10/12	23/10/12	
Lot Number		-	-	
Lot Description				
Test Pit or Borehole		3558/ CBR 2	3558/CBR 6	
Depth	(m)			
Offset	(m)			
Layer				
Sample Description				

LABORATORY DATA

		AS1289.5.1.1	*AS1289.2.1.1*	
Field Moisture Content	(%)	-	-	
Maximum Dry Density	(t/m^3)	1.98	1.63	
Optimum Moisture Content	(%)	10.9	17.8	

TEST RESULTS

		AS1289.6.1.1	*AS1289.2.1.1*	
Date Tested		2/11/2012	2/11/2012	
Days Soaked		4	4	
Surcharge Weight		4.5 kg	4.5 kg	
Before Soaking				
Dry Density	(t/m^3)	1.95	1.61	
Density Ratio	(%)	98 Standard	99 Standard	
Moisture Content	(%)	10.9	17.2	
Moisture Ratio	(%)	100	97	
After Soaking				
Dry Density	(t/m^3)	1.94	1.61	
Density Ratio	(%)	98 Standard	99 Standard	
Swell	(%)	0.4	0.4	
Moisture Content				
After Soaking	(%)	11.7	20.6	
Top 30mm	(%)	11.4	19.9	
Full Depth After Test	(%)	11.4	19.2	
CBR Value	(%)	**16 @ 5.0mm**	**14 @ 5.0mm**	
Percentage retained on 19.0 mm	(%)	- -	- -	

Remarks : -

Accredited for compliance with ISO/IEC 17025.

Mt Kuring-Gai Laboratory 1318

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory:

Mark Matthews

10 Attachment D - DCP n counts

Dynamic Cone Penetrometer Test Log Summary

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Site	Geotechnical Investigation	**DCP Group Reference**		**4413**
Client	Playoust Churcher Architects	**Log Date**		19.10.2012
Logged by	BM / GL			
Checked by	GT			
Comments				

TEST DATA

Depth Interval (m)	DCP 1	DCP 2	DCP 3	DCP 4	DCP 5	DCP 6	DCP 7	DCP 8	Design
0.15	7	9	3	5	8	3	3	1	**1**
0.30	10	11	4	3	14	4	2	3	**2**
0.45	17	13	6	4	11	5	6	4	**4**
0.60	20	9	6	4	3	3	8	9	**3**
0.75	13	10	6	3	3	3	3	8	**3**
0.90	20	8	8	4	4	3	4	11	**3**
1.05	9	5	7	2	7	2	5	14	**2**
1.20	9	7	3	3	3	2	2	12	**2**
1.35	18	24	4	3	4	1	6	13	**1**
1.50			4	5	3	2	7	10	**2**
1.65			6	5	2	2	7	12	**2**
1.80			6	10	2	3	13	15	**2**
1.95			7	9	5	3	16	10	**3**
2.10			17	9	6		18	12	**6**
2.25			18	30	6		26	10	**6**
2.40					7		27	11	**7**
2.55					7		36	10	**7**
2.70							40	9	**9**
2.85								10	**10**
3.00								11	**11**
3.15								13	**13**
3.30								16	**16**
3.45								19	**19**
3.60								22	**22**
3.75								27	**27**
3.90								30	**30**
	Refusal @ 1.35	Refusal @ 1.40	Refusal @ 2.25	Refusal @ 2.40	Refusal @ 2.6	Refusal @ 2.10	Refusal @ 2.7	Refusal @4.1	

11 Attachment E - 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.

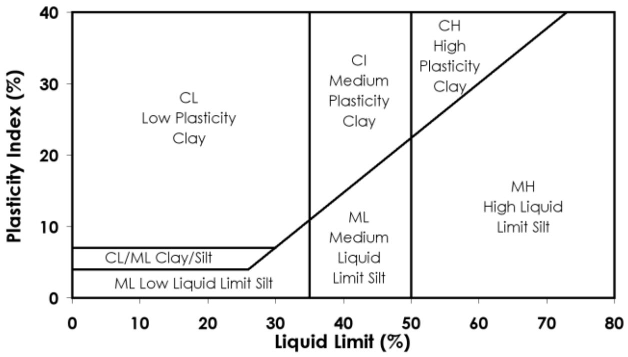
Particle Size

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)	Apprx SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort. Sample extrudes between fingers when squeezed in fist.
Soft	12 - 25	2 to 4	A finger can be pushed into the soil to about 25mm depth. Easily moulded in fingers.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong pressure in the figures.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff	100 - 200	15 – 30	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	> 200	> 30	The surface of the soil can be marked only with the thumbnail. Brittle. Tends to break into fragments.
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 Agricultural Classification Scheme

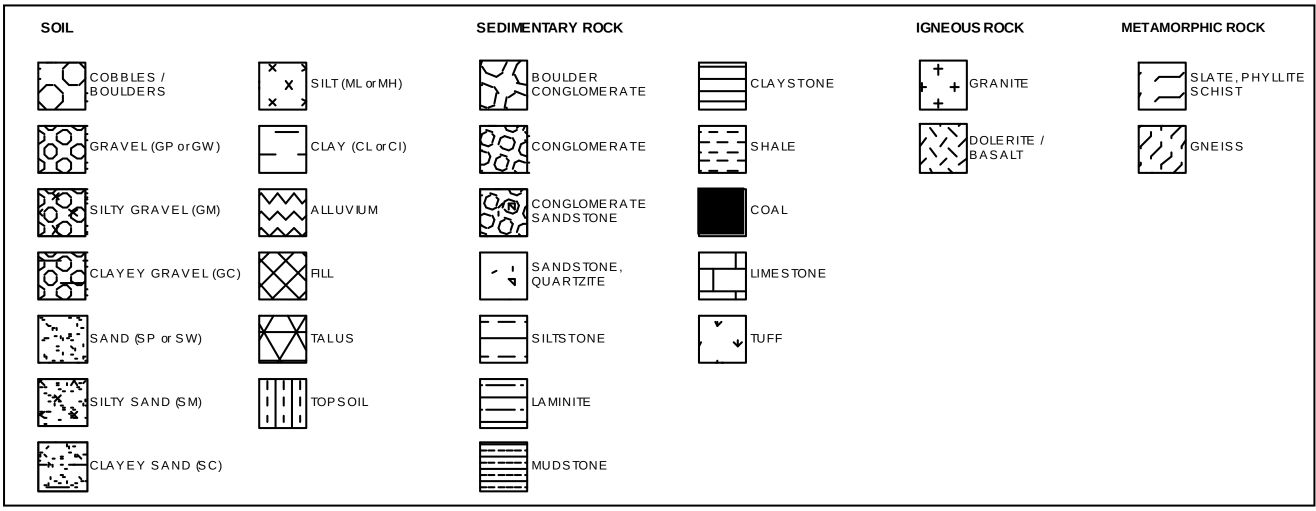
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions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

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					**USCS**	**Primary Name**
COARSE GRAINED SOILS More than 50 % 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 2.0 mm.	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Gravel
				Predominantly one size or a range of sizes with more intermediate sizes missing	GP	Gravel
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty Gravel
				Plastic fines (for identification procedures see CL below)	GC	Clayey Gravel
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of intermediate sizes missing.	SW	Sand
				Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Sand
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty Sand
				Plastic fines (for identification procedures see CL below)	SC	Clayey Sand

		IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
		DRY STRENGTH (Crushing Characteristics)	**DILATANCY**	**TOUGHNESS**	**DESCRIPTION**	**USCS**	**Primary Name**
FINE GRAINED SOILS More than 50 % of material less than 63 mm is smaller than 0.075 mm		None to Low	Quick to Slow	None	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	Silt
		Medium to High	None	Medium	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays	CL	Clay
		Low to Medium	Slow to Very Slow	Low	Organic slits and organic silty clays of low plasticity	OL	Organic Silt
		Low to Medium	Slow to Very Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	Silt
		High	None	High	Inorganic clays of high plasticity, fat clays	CH	Clay
		Medium to High	None	Low to Medium	Organic clays of medium to high plasticity	OH	Organic Silt
HIGHLY ORGANIC SOILS		Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat

Low Plasticity – Liquid Limit W_L < 35 %   Medium Plasticity – Liquid limit W_L 35 to 60 %   High Plasticity - Liquid limit W_L > 60 %

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 low	≤0.03	Easily remoulded by hand to a material with soil properties.	EL
Very low	>0.03 ≤0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>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.	L
Medium	>0.3 ≤1.0	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>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.	H
Very high	>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.	VH
Extremely high	>10	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 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.

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) - diametrall test (MPa)
●	Unconfined compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)	
BP	Bedding plane parting
X	Foliation
L	Cleavage
JT	Joint
F	Fracture
SZ	Sheared zone (Fault)
CS	Crushed seam
DS	Decomposed seam
IS	Infilled seam
V	Vein

Coating or Filling	
Cn	Clean
Sn	Stain
Ct	Coating
Fe	Iron Oxide

Roughness	
Po	Polished
Ro	Rough
Sl	Slickensided
Sm	Smooth
Vr	Very rough

Planarity	
Cu	Curved
Ir	Irregular
Pl	Planar
St	Stepped
Un	Undulating

Inclination

The inclination of defects are measured from perpendicular to the core axis.

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.