SGD1
C/- Tattersall Lander Pty Ltd

Acid Sulfate Soils Management Plan: Riverside Estate, Tea Gardens, NSW.

P1404136JR02V01
October 2015

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

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

Contents

1 Introduction

1.1 Overview

The proposed Riverside Estate development at Tea Gardens, NSW (from here on referred to as the 'site') forms part of an approximately northeast – southwest aligned Pleistocene and Holocene coastal barrier mass. It lies immediately to the north of the existing township of Tea Gardens and is bound to the east by the Myall River, to the west by Myall Street (the main road linking Tea Gardens / Hawks Nest with the Pacific Highway) and to the north by the Shearwater Estate. The site location is shown in Figure 1, Attachment F1.

Previous assessments of Acid Sulfate Soils (ASS) risk at the site indicate that:

- Some soils tested are classified as potential acid sulfate soils (PASS).
- Some water samples tested fall below a pH < 5.5, indicative of the presence of actual acid sulfate soils (AASS).
- Soils within some areas of the site exceed Acid Sulfate Soil Assessment Guideline limits for TPA, TSA or S_{POS} (ASSMAC, 1998), warranting preparation of an acid sulfate soils management plan (ASSMP) to appropriately treat and manage ASS in accordance with regulatory requirements.

This ASSMP has been prepared in general accordance with the ASSMAC (1998) guidelines. It considers existing and future environmental impacts from site development relating to PASS and AASS in and around the site. Recommendations are presented on possible mitigation measures for PASS / AASS management during proposed earthworks, likely to disturb PASS / AASS (e.g. cut and fill activities and trenching works). This ASSMP may need to be amended subject to results of additional assessments.

1.2 Objectives

The purpose of this ASSMP is to enable construction activities to be undertaken in a way that minimises / negates impacts of AASS and PASS on the environment and proposed development for each development stage. The ASSMP has been structured in such a way that it can be used as a reference by contractors required to work at the site, by lot purchasers and by lot owners seeking DA approval for future lot development.

1.3 Development Proposal Description

This ASSMP has considered the following site development proposal:

- Site subdivision into small to medium residential lots, carried out in 16 stages (Figure 2, Attachment F1).
- Site cutting and filling to achieve final subgrade levels of between 3.31m and 4m above Australian Height Datum (AHD).
- Construction of internal road and buried services networks.
- Creation of areas dedicated to open space, public recreation and stormwater management corridors.
- Individual lot development.
- Creation of a future commercial area.

Proposed subdivision earthworks are likely to include:

- Bulk site filling of up to approximately 2.5m for Stages 1 to 14 to reach final floor levels of between 3.31m and 4.0m AHD.
- Some cutting of up to approximately 1m for Stages 9 and 10 to reach final floor levels of between 3.5m and 4.0m AHD.
- Predominantly cutting of up to approximately 3m for Stages 15 and 16 to reach a final floor level of 3.5m AHD.
- Cutting of up to approximately 2.5m for proposed roads, services and stormwater management systems in Stages 1 to 16.

Additional works associated with installation of infrastructure and lot development, which may impact the risk of AASS or PASS, are likely to include:

- Earthworks associated with residential development, assumed to extend no greater than 1m below ground level.
- Swimming pool excavations, typically up to 2m deep.
- Bored piers exceeding 1m depth, e.g. where foundations are to extend below the zone of influence of existing structures such as buried sewer mains.

- o Other excavations exceeding 1m depth or requiring dewatering to lower the groundwater level by more than 1m.

Bulk earthworks at the site are unlikely to significantly alter groundwater levels at, and surrounding, the site (MA, 2013). Groundwater level reduction due to groundwater drawdown may occur during installation of deep buried sewer mains. However, drawdown will likely be temporary and localised.

1.4 Site Subsurface Conditions

1.4.1 Subsurface Materials

Subsurface investigations (Figure 3, Attachment F1) indicate that the site is generally covered by a thin layer of topsoil consisting of clayey/sandy silt, silty sand or sandy clay/clay to depths of up to approximately 0.6m bgl. Underlying deposits generally comprised medium to very dense sand/ silty sand, overlain in places by generally stiff to very stiff clay of high plasticity and sandy clay/clayey sand layers.

Elevated areas in the north-eastern corner of the site are likely underlain by residual silty / sandy clay / clay, the result of weathering of underlying siltstone, sandstone and claystone.

A summary of inferred subsoil profiles at investigation locations is presented in Table 1, Attachment F2.

1.4.2 Groundwater

Historical groundwater level measurements at established GMBs are collated in Table 2, Attachment F2. The data includes a long history of instantaneous dipped levels and also some periods of continuous monitoring with data loggers.

The following comments are made based on review of site groundwater level data:

1. Groundwater levels are generally shallow.

2. Groundwater resurfaced at times at GMBs 7 and 23 during the Martens and Associates (July, 2009) continuous data logging period.

3. Short-term groundwater level fluctuations are typically <1m and can occur within hours of heavy rainfall.

4. Lake levels are consistently lower than groundwater levels suggesting that groundwater discharges to the lake in the vicinity of

the existing GMBs. Discharge of groundwater to the lake is expected to occur around the majority of the lake based on likely groundwater gradients.

5. Groundwater response to rainfall is likely to be rapid, i.e. occurring within 1-2 days of incident rainfall. Groundwater responses appear more substantial at higher ground elevations.

6. Earthworks at the site are unlikely to significantly alter groundwater levels at, and surrounding, the site.

2 Acid Sulfate Soils Management

2.1 Significance of ASS

The presence, and generation, of sulfuric acid can lower soil and water pH and produce acid salt resulting in high soil salinity. The lowering of soil / groundwater pH (generally to <4) and a high soil salinity can create soil conditions that adversely impact vegetation growth and/ or are aggressive to buried concrete and steel components of structures (e.g. could lead to corrosion of foundations, pipelines, etc. or blockage of drains and groundwater wells).

In addition, sulfuric acid can mobilise iron, aluminium, arsenic and other heavy metals from the soil profile, the release of which can be detrimental to biota, human health and infrastructure.

2.2 Pathways

If oxidisation of in-situ PASS generates sulfidic acid, then groundwater is the initial pathway for impact migration. Acidity could migrate downwards by leachate, upwards with groundwater rebound or laterally through groundwater flows and dispersion. Heavy metals mobilised by acidic groundwater may migrate along similar pathways.

2.3 Receptors

Possible ecological, human and built environment receptors include:

- Site workers
- Flora and fauna
- Proposed infrastructure

Possible off-site receptors include:

- Wetlands, designated under State Environmental Planning Policy (SEPP) 14, immediately to the east
- The Myall River and Bennetts Beach, separated by foreshore dunes, between approximately 0.3km and 3.0km to the east
- Port Stephens, approximately 3.5km to the south
- Residential and commercial areas, areas using non-potable water or irrigated areas to the south and west.

2.4 Objectives and Scope of Application

Management of site soil disturbance during construction activities should ensure that environmental degradation due to excavation of AASS and PASS does not occur. This ASSMP has considered soil layers as deep as 8.0m bgl.

This ASSMP recognises:

- Subdivision works will be undertaken in stages and comprise a series of or discrete construction phases.
- Earthworks for the proposed subdivision and future lot development may encounter soils that are neither actual nor potential ASS as well as soils that are potential or actual ASS, resulting in disturbance of AASS and PASS.
- It is likely that, based on testing undertaken to date, there will be considerable volumes of excavated materials that are either classifiable as AASS or PASS.

The ASSMP has been developed to reflect staging of construction and the variable ASS qualities and presence within the soil profiles at the site. The objective of this plan is to enable earthworks to be undertaken in a way that minimises / negates ASS risks to existing and future environmental conditions while keeping construction cost to a practical minimum.

2.5 Approach

The approach taken with this plan is one of recognising that, whilst there are some areas of the development area, which may contain AASS or PASS soils, these areas are identified prior to excavation and once excavated, isolated and separately managed from unaffected soils. This approach would lead to:

- Minimisation of disturbance of ASS.
- Allow validation and monitoring to confirm success of ASS management and treatment processes.
- Continuous preservation of water quality.
- Once excavation begins, the following procedure should be adopted:

a) For areas not classified as containing AASS or PASS, the material can be excavated and disposed of without treatment.

b) For excavations in areas classified as AASS or PASS, the treatment plan presented in Section 2.6 should be followed.

2.6 Treatment Plan

I. Construct a guard layer, further discussed in Section 2.6.1, in designated PASS treatment areas.

II. Stockpile disturbed soil in areas covered by the guard layer. Dividing the stockpile area into cells may allow staging of the treatment process in line with the excavation works program.

III. Surround stockpiles with an earthen bund to contain leachate and limit surface run-off water entering or leaving the treatment area.

IV. Cover the stockpile, where possible, to prevent increasing leachate production. The cover should extend over the bund so that rainfall is not directed towards the stockpile. Where covering stockpiles is not possible, suitable allowance is to be made to increase bund and leachate collection systems.

V. Treat all disturbed AASS and PASS, such as by neutralisation with specific rates determined for the area, as discussed in Section 2.6.2.

VI. Capture all leachate collected from the bunded stockpile and neutralised with lime, tested to ensure suitability for site disposal, as discussed in Section 2.6.3.

VII. In the case of saturated soils, these should be stockpiled to enable adequate drainage of retained water prior to treatment (refer points I to VI above).

2.6.1 Guard Layer

A guard layer should be used to prevent leachate, generated in the stockpiled PASS being treated and not neutralised during the treatment process, infiltrating underlying soils and groundwater and impacting non-PASS or non AASS.

A guard layer may comprise:

- o A layer of compacted non-ASS clayey material (typically 300 to 500mm thick) placed over the surface of the treatment area (may be placed in conjunction with neutralising agent below the guard layer).
- o A physical barrier to create a fully contained condition, e.g. a bunded concrete slab, paved area or layer of bitumen. The bund should comprise non-ASS.

2.6.2 Soil Acidity Neutralisation

Acid neutralisation techniques are commonly used in ASS management. Alkaline material, such as crushed limestone or Aglime (calcium carbonate - not hydrated lime or calcium hydroxide), are introduced into the acid materials. Sufficient Aglime is required to ensure neutralisation of existing acidity and potential acidity that may be generated over time through complete oxidisation of sulphides.

Liming rates will depend on neutralising agent adopted and results of testing of representative soil samples prior to excavation (refer preliminary liming rates in Table 3, Attachment F2, or in accordance with test results from further assessments) or during excavation (refer Section 2.8) at a frequency of minimum 1 test per 50m^3 of disturbed soil. The following formula is typically adopted to calculate liming rates using fine grained Aglime with an effective neutralising value (ENV) of at least 98%:

kg $CaCO_3$/ tonne of soil = TPA x 1.02 x 1.5

Where:

TPA – Total Potential Acidity (kg of H_2SO_4/tonne)

1.02 - conversion from kg of H_2SO_4/tonne to kg of $CaCO_3$/tonne

1.5 - a safety factor (may be reduced, subject to further assessment results and subject to the satisfaction of local governing authorities)

For conversion to m^3, multiply kg $CaCO_3$ by the bulk density of the soil.

The liming rate shall not be less than 3.0kg/tonne.

Suitable site machinery should be used to thoroughly mix the lime through the soil, preferably as close as possible to the source. The effectiveness of the adopted dosing rate should be confirmed by regular sample screening of the treated material using pH and peroxide pH field tests. In addition, Aglime quantities above calculated dosing rates may be required to allow for difficulties in mixing and to act as a backup buffer under such circumstances.

A suitable amount of neutralising agent is to be made available at the site for emergency treatment.

Exposed soils in walls and floor of excavations should be treated by spreading of lime on surfaces.

As a precautionary measure, treatment works involving Aglime should not be conducted during windy conditions, unless the material can be appropriately conditioned to prevent dust generation.

Safe procedures are to be adopted for storage and handling of neutralising agents. This should include sufficient training of staff in health and safety relating to the use of neutralising agents.

2.6.3 Leachate Control

Acid is transported by water, therefore excavation works should be carried out, as far as practicable, during dry periods. This would limit the risk of discharge of uncontrolled runoff water into the environment during heavy or prolonged rainfall events. In addition, this would facilitate improved control of collection and management of groundwater and surface runoff water accumulated within excavations, truck wash-down water and leachate water generated during ASS treatment procedures.

Collected water must be directed to collection ponds and treated to a prescribed discharge water quality. Leachate collection ponds should be able to accommodate storm runoff water generated by a 1 year ARI, 72-hour duration storm event.

Disposal of water should be carried out following treatment and testing. Treatment measures may include, but not limited to, the addition of a calcium hydroxide solution e.g. hydrated/ slaked lime to adjust the pH until the treated water has a pH > 6.5.

In addition to the above, we recommend that all surface run-off water external to the site is directed away from excavations and stockpiles to limit the volume of water requiring treatment.

2.7 Alternative Treatment Option

Alternative treatment options may be considered, such as over-excavation of non- or low-risk PASS and burial of high-risk PASS, below the groundwater table. However, a more rigorous assessment of ASS conditions across the site and at depths below groundwater level will need to be carried, including additional laboratory testing to pre-determined liming rates.

2.8 Verification and Monitoring

The suitability of the treatment plan should be verified by monitoring the pH after oxidisation and laboratory TPA or oxidisable sulphur of excavated soil. The following monitoring (Table 3) should be carried out to confirm acceptable neutralisation of excavated PASS and leachate.

Table 3: Recommended monitoring of excavated PASS and collected water.

Type	Frequency	Action level
Soil pH	Daily in distilled water and hydrogen peroxide[1]	<4 (in distilled water) <3 (in hydrogen peroxide)
sPOCAS/ CRS methods	1 / 50m^3 (or part thereof) of neutralised soil	for > 1000 tonne disturbance or coarse texture soils: 0.03% oxidisable sulphur 18 molH+/t TPA/TSA for < 1000 tonne disturbance and medium texture soils: 0.06% oxidisable sulphur 36 molH+/t TPA/TSA Fine texture soils: 0.1% oxidisable sulphur 62 molH+/t TPA/TSA
Treated Leachate Water pH	Daily	<5.5

Notes:

1. Continued until required levels are achieved.

2.9 Soil Sampling

Soil samples of 250-500grams are to be collected by suitably experienced engineer / scientist from designated sample intervals. Sampling, handling and transportation should be undertaken as detailed below:

- Samples are to be placed in labelled plastic bags that are then sealed and refrigerated for transport to a registered laboratory for analysis.
- Samples are to be despatched to the laboratory within 24 hours of sample collection under chain-of-custody protocols.

- Samples are to be stored under cool (4°C) conditions in the laboratory prior to analysis.

2.10 Analysis

All soil samples collected for acid sulphate soil assessment are to be analysed by a NATA registered laboratory for analysis by sPOCAS or Chromium Suite methods as outlined in the Acid Sulfate Soils Laboratory Methods Guidelines (Ahern et al, 2004). Similarly, these methods can be used for verification testing to validate that an appropriate quantity of neutralizing agent has been added to the ASS.

Soil samples are to be screened for pH_{KCl} and either a combination of:

- Total Actual Acidity (TAA);
- Chromium Reducible Sulfur (S_{CR})
- Acid Neutralisation Capacity (optional)
- Net acid soluble sulphur, or retained acidity (S_{NAS}), where appropriate

2.11 Waste Generation

Construction will generate material (spoil), which is likely to contain PASS of AASS. Disposal and/or re-use of spoil will need to be in accordance with the following:

- Excavated material containing <u>no</u> PASS, AASS and free from contaminants will require verification by a qualified environmental engineer and may be re-used on or off-site, subject to geotechnical suitability and requirements of AS3798 (2007).
- Excavated material containing PASS or AASS material, which is treated with lime, will require verification by a qualified environmental engineer after additional validation testing and may be re-used on site, subject to geotechnical suitability and requirements of AS3798 (2007).
- Excess material not required for re-use on site, will need to be chemically assessed in accordance with Parts 1 and 4 of NSW DECC (2009), *Waste Classification Guidelines, Part 1: Waste classification Guidelines.* Final classification of this material for off-site disposal is to be completed in accordance with these guidelines. Following waste classification, material can be used off-site as fill, subject to geotechnical suitability and

requirements of AS3798 (2007), or alternatively disposed of to a licensed land fill.

2.12 Transportation of ASS

PASS to be disposed off-site should be loaded into sealed trucks, to prevent loss of PASS material or leakage of leachate during transportation, and transferred directly to a regulated landfill. Truck wheels and external surfaces are to be cleaned of PASS material prior to leaving site.

2.13 Certification

At the completion of the extraction and treatment process, a report should be prepared by a suitably qualified person demonstrating that the requirements of this management plan have been met.

2.14 Record Keeping

Complete records of all treatment and any further testing undertaken shall be maintained by the construction contractor. Records should include as a minimum:

- Stockpile number and volume.
- Number of soil and groundwater tests, test results and test certificates.
- Calculated and applied liming rates.
- Waste classification and disposal location (if applicable).

Records should be made available to regulators if requested. If off-site disposal is undertaken, a waste classification assessment is required and records of the quantity of material taken off-site should be kept.

2.15 ASS Management Plan Review / Amendment

We recommend that the ASSMP is reviewed in light of results of further assessments, as applicable, and following any additional development consent conditions, to confirm suitability. Following review, the ASSMP should be updated, where required, to accompany construction plan sets for the proposed works to ensure management and treatment of AASS and PASS is undertaken during site works.

Site management procedures should be constantly reviewed to limit opportunities for exposure and oxidisation of ASS.

3 Limitations

Occasionally subsurface soil conditions between completed boreholes / test pits may be found to be different from those expected. This can also occur with groundwater conditions, especially after climatic changes. Depositional environments are particularly variable due to their depositional history. As such rapid changes in material type and acid producing potential can occur over short lateral distances. The management procedures outlined in this report must be observed to assist in mitigating against this variability. Should, during site works, soil or water conditions be found to be significantly different to those detailed in this report, works shall cease immediately and the new conditions should be addressed by Martens & Associates to determine any implications before recommencement.

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for any consequences where recommendations in this report are not implemented in full and properly tested, inspected and documented.

In the event that there are any significant changes to the development proposal described in this report, then all recommendations should be reviewed by Martens & Associates.

4 References

Ahern C R, Stone, Y, and Blunden B (1998), *Acid Sulfate Soils Assessment Guidelines*, published by the Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

Ahern CR, McElnea AE, Sullivan LA (2004), *Acid Sulfate Soils Laboratory Methods Guidelines,* Queensland Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland,

5 Attachment F1 – Figures

KEY

INDICATIVE SITE BOUNDARY

NOTE
PROPOSED DEVELOPMENT LAYOUT SOURCE: TATTERSALL LANDER P/L (AUGUST 2015)
MAP SOURCE: Central Mapping Authority of NSW (1976)
Port Stephens Topographic Map
9332-IV-S First Edition 1:25000 Series

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Martens & Associates Pty Ltd	ABN 85 070 240 890	Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	KT	SITE LOCATION PLAN: RIVERSIDE ESTATE, TEA GARDENS, NSW	Drawing No./ID: Figure 1
Approved:	RE		
Date:	07.09.2015		
Scale @ A3:	1:30000	Suite 201, 20 George St, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 Email: mail@martens.com.au Internet: http://www.martens.com.au	Project: P1404136 File: JD03V01 Revision: A

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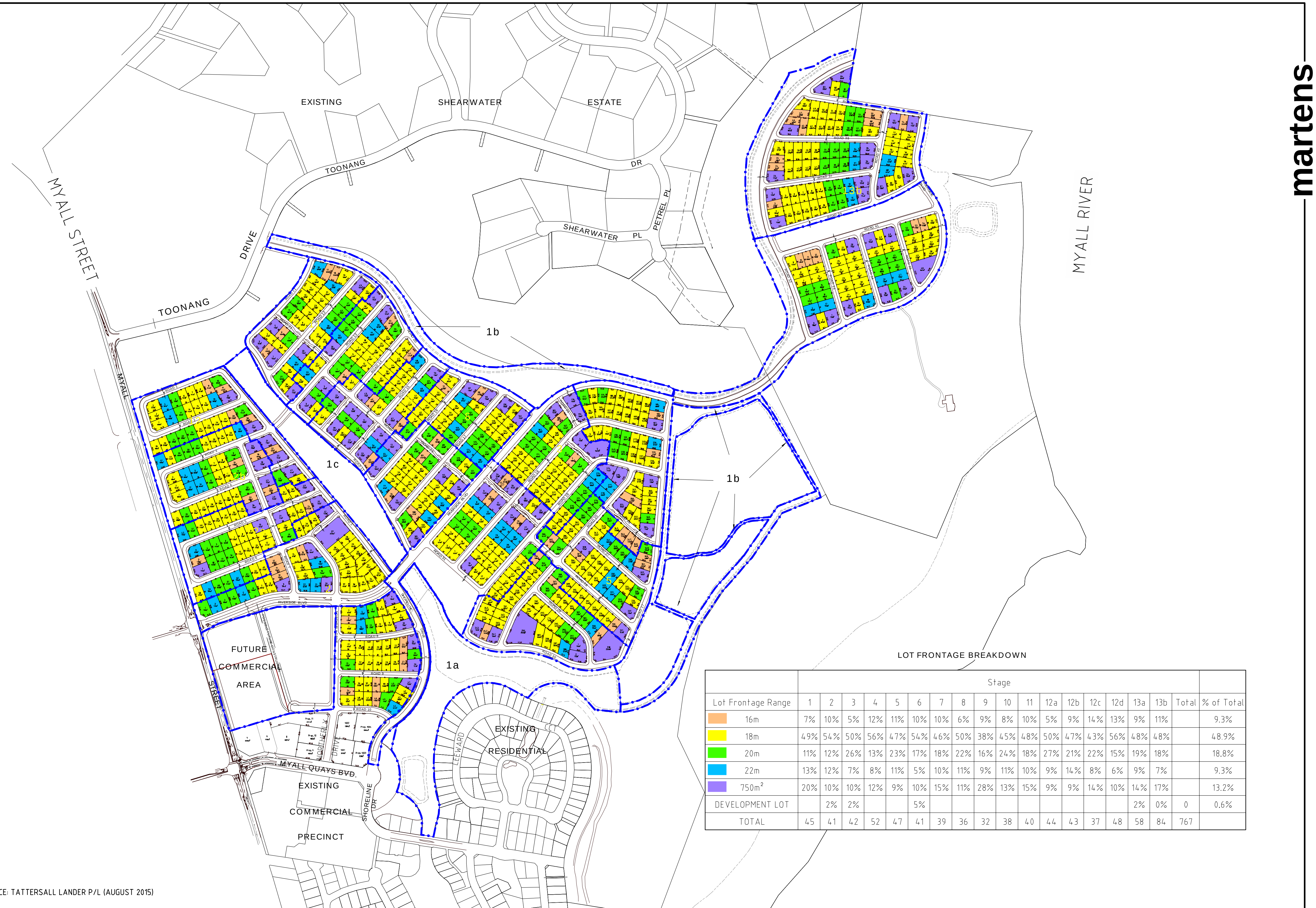

LOT FRONTAGE BREAKDOWN

	Stage																		
Lot Frontage Range	1	2	3	4	5	6	7	8	9	10	11	12a	12b	12c	12d	13a	13b	Total	% of Total
16m	7%	10%	5%	12%	11%	10%	10%	6%	9%	8%	10%	5%	9%	14%	13%	9%	11%		9.3%
18m	49%	54%	50%	56%	47%	54%	46%	50%	38%	45%	48%	50%	47%	43%	56%	48%	48%		48.9%
20m	11%	12%	26%	13%	23%	17%	18%	22%	16%	24%	18%	27%	21%	22%	15%	19%	18%		18.8%
22m	13%	12%	7%	8%	11%	5%	10%	11%	9%	11%	10%	9%	14%	8%	6%	9%	7%		9.3%
750m^2	20%	10%	10%	12%	9%	10%	15%	11%	28%	13%	15%	9%	9%	14%	10%	14%	17%		13.2%
DEVELOPMENT LOT		2%	2%			5%										2%	0%	0	0.6%
TOTAL	45	41	42	52	47	41	39	36	32	38	40	44	43	37	48	58	84	767	

NOTE
PROPOSED DEVELOPMENT LAYOUT SOURCE: TATTERSALL LANDER P/L (AUGUST 2015)

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Date:	07.09.2015
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STAGING PLAN
RIVERSIDE ESTATE, TEA GARDENS, NSW

Drawing No./ID:
Figure 2

Suite 201, 20 George St, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
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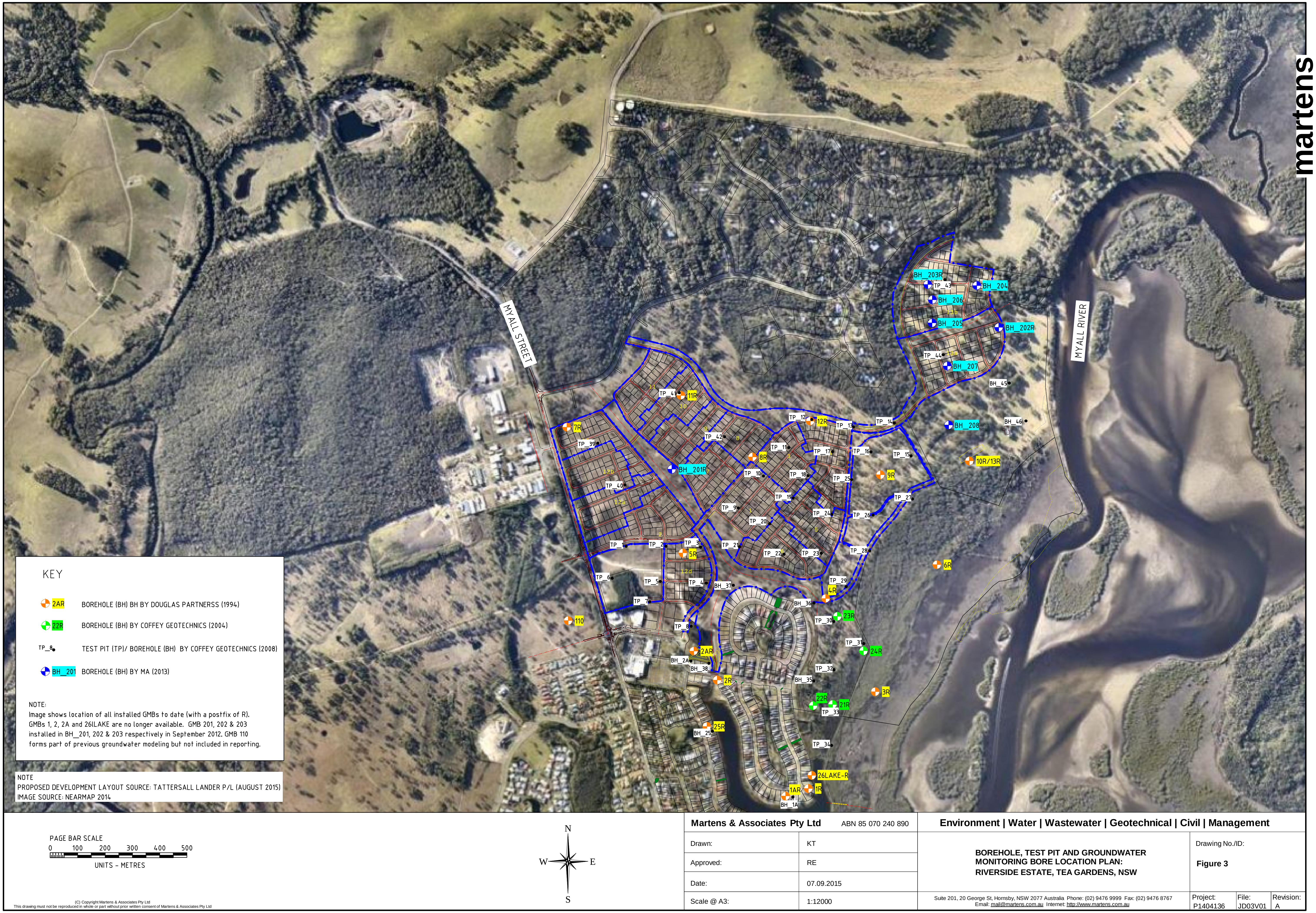
P1404136	JD03V01	A



Martens & Associates Pty Ltd	ABN 85 070 240 890	Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	KT	BOREHOLE, TEST PIT AND GROUNDWATER MONITORING BORE LOCATION PLAN: RIVERSIDE ESTATE, TEA GARDENS, NSW	Drawing No./ID: Figure 3
Approved:	RE		
Date:	07.09.2015		
Scale @ A3:	1:12000	Suite 201, 20 George St, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 Email: mail@martens.com.au Internet: http://www.martens.com.au	Project: P1404136 File: JD03V01 Revision: A

6 Attachment F2 – Tables

Table 1: Soil profile summary.

Test ID	Soil Profile[1,2]			
	Topsoil Silty/clayey sand / Sandy/silty clay	Marine deposits Clay / sandy/silty clay / silty/clayey sand	Marine deposits Sand / silty sand	Residual soil Clay
Bore 13	0-0.5	NE	0.5-10.2	10.2-10.5
BH 21	0-0.1	NE	0.1-3.0	NE
BH 22	NE	NE	0-3.0	NE
BH 23	0-0.2	NE	0.2-3.1	NE
BH 24	0-0.3	NE	0.3-3.0	NE
TP1	0-0.3	0.3-0.6	0.6-1.9	NE
TP2	0-0.4	0.4-1.5	1.5-1.9	NE
TP3	0-0.5	0.5-0.8	0.8-1.8	NE
TP4	0-0.4	0.4-2.0	2.0-2.1	NE
TP5	0-0.4	0.4-0.75	0.75-1.9	NE
TP6	0-0.6	NE	0.6-2.1	NE
TP7	NE	0-1.0	NE	NE
TP8	0-0.6	0-0.6	NE	NE
TP9	0-0.6	0.6-1.1	1.1-2.0	NE
TP10	0-0.45	0.45-0.8	0.8-1.9	NE
TP11	0-0.2	0.2-1.0	1.0-1.9	NE
TP12	0-0.4	0.4-1.0	1.0-2.0	NE
TP13	0-0.6	NE	0.6-2.0	NE
TP14	0-0.4	NE	NE	0.4-1.8
TP15	0-0.5	NE	0.5-1.7	NE
TP16	0-0.25	NE	0.25-1.8	NE
TP17	0-0.5	0.5-1.1	1.1-2.0	NE
TP18	0-0.4	0.4-0.8	0.8-1.9	NE
TP19	0-0.35	0.35-1.2	1.2-1.8	NE

Test ID	Soil Profile[1,2]			
	Topsoil Silty/clayey sand / Sandy/silty clay	Marine deposits Clay / sandy/silty clay / silty/clayey sand	Marine deposits Sand / silty sand	Residual soil Clay
TP20	0-0.2	0.2-1.7	NE	NE
TP21	0-0.45	0.45-0.6	0.6-2.0	NE
TP22	0-0.5	0.5-0.8	0.8-1.9	NE
TP23	0-0.3	0.3-0.8	0.8-2.0	NE
TP24	0-0.4	0.4-0.7	0.7-2.0	NE
TP25	0-0.5	0.5-1.1	1.1-2.0	NE
TP26	0-0.3	NE	0.3-1.5	NE
TP27	0-0.6	0.6-0.8	0.8-1.8	NE
TP28	0-0.6	0.6-1.2	1.2-1.8	NE
TP29	0-0.5	0.5-1.4	1.4-1.7	NE
TP30	0-0.3	NE	0.3-1.7	NE
TP31	0-0.1	0.1-1.1	1.1-1.8	NE
TP32	0-0.3	0.3-1.7	NE	NE
TP33	0-0.25	0.25-1.9	1.9-2.0	NE
TP34	0-0.25	0.25-1.9	1.9-2.0	NE
BH35	NE	NE	0-4.0	NE
BH36	0-0.5	NE	0.5-7.0	NE
BH37	0-0.25	NE	0.25-7.0	NE
BH38	0-0.1	0.1-2.2	2.2-7.0	NE
TP39	0-0.15	0.15-1.4	1.4-1.7	NE
TP40	0-0.2	0.2-1.1	1.1-1.7	NE
TP41	0-0.3	0.3-1.5	1.5-2.5	NE
TP42	0-03	0.3-1-1	1.1-1.7	NE
TP43	NE	NE	0-1.85	NE
TP44	NE	NE	0-1.8	NE
BH45	NE	NE	0-10.45	NE
BH46	0-0.5	NE	0.5-7.45	NE

Test ID	Soil Profile[1,2]			
	Topsoil Silty/clayey sand / Sandy/silty clay	Marine deposits Clay / sandy/silty clay / silty/clayey sand	Marine deposits Sand / silty sand	Residual soil Clay
GMB1A	NE	NE	0-5.5	NE
GMB2A	NE	NE	0-7.0	NE
GMB25	NE	NE	0-5.5	NE
BH201	0-0.25	0.25-1.9	1.9-5.5	NE
BH202	0-0.1	NE	0.1-7.0	NE
BH203	0-0.2	0.2-1.2	1.2-7.0	NE
BH204	0-0.3	0.3-1.0	NE	NE
BH205	0-0.2	NE	0.2-1.0	NE
BH206	0-0.25	0.25-1.0	NE	NE
BH207	0-0.2	NE	0.2-0.7	NE
BH208	0-0.2	NE	0.2-1.0	NE

Notes:

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

2 Indicative depth range below ground level.

Table 2: Groundwater level summary.

GMB	Ground Level (m AHD)	Groundwater Level (m AHD)			Min Depth to Groundwater (m)
		Minimum	Median	Maximum	
GMB1	1.02	0.24	0.63	0.93	0.09
GMB2	2.37	0.69	1.02	2.02	0.36
GMB3	0.85	0.06	0.74	0.79	0.06
GMB4	2.05	0.82 [4]	1.07 [4]	1.30 [4]	0.74 [4]
GMB5	2.61	1.14	1.66	2.56	0.05
GMB6	0.86	0.28 [3]	0.67 [3]	0.77 [3]	0.09 [3]
GMB7	2.96	1.55 [2]	2.42 [2]	2.82 [2]	0.15 [2]
GMB8	2.60	0.73	1.78	2.46	0.14
GMB9	2.86	1.16 [2]	1.71 [2]	2.11 [2]	0.75 [2]
GMB10	1.49	0.39	0.89	1.23	0.26
GMB11	3.40	1.35	2.01	3.01	0.39
GMB12	3.26	1.37	2.12	3.05	0.21
GMB13 [7]	-	-	-	-	-
GMB21	1.03	0.78	0.80	0.81	0.21
GMB22	1.10	0.83	0.85	0.88	0.22
GMB23	1.11	0.76 [2]	0.93 [2]	0.93 [2]	0.18 [2]
GMB24	0.83	0.63	0.65	0.68	0.15
GMB1A [5]	1.71	0.72 [1]	0.82 [1]	1.06 [1]	0.65 [1]
GMB2A [5]	2.48	1.13 [1]	1.20 [1]	1.32 [1]	1.16 [1]
GMB25	1.80	0.78 [1]	0.86 [1]	1.00 [1]	0.80 [1]
GMB26 (lake) [6]	0.49	0.63 [1]	0.70 [1]	0.90 [1]	NA [1]
GMB201	2.74	1.9	1.99	2.08	0.66
GMB202	3.69	0.9	0.95	1.0	2.69
GMB202	5.14	3.82	3.97	4.11	1.03

Notes:

1. Derived based on continuous data logging data (04/06/2009 to 06/07/2009).
2. Derived based on dipped data and continuous data logging data (04/06/2009 to 06/07/2009).
3. Derived based on dipped data and continuous data logging data (late July to mid-November, 1994).
4. Derived based on dipped data and continuous data logging data (late July to late September, 1994).
5. Replacements for GMB1 and GMB2.
6. Lake bed level at standpipe location.
7. No details available.

Table 3: Field screening testing and sPOCAS laboratory analysis summary (Coffey 2008).

Sample ID	Sample Depth (m bgl)	Material Type [1]	Field/ Laboratory Screening Test Results		Laboratory sPOCAS Test Results			Assessment [9]	Liming Rate (kg $CaCO_3$/t) [10]	Management required?
			pH_{KCL} [2] (pH_F) [3]	pH_{OX} [4] (pH_{FOX}) [5]	TPA (mol H+/t)[6]	TSA (mol H+/t)[7]	S_{POS} (%S oxidisable)[8]			
Assessment Criteria:		(F) Fine texture ≥ 40% clay (M) Medium texture 5 – 40% clay (C) Coarse texture ≤ 5% clay	≤ 4: AASS	< 3.5 or pH_{KCL} –pH_{OX}>1: PASS	62 36 18 [11]	62 36 18 [11]	0.100 0.060 0.030 [11]	AASS or PASS (Coarse texture criteria used if >1000t)	-	-
TP1	**0.5-0.6**	C	(7.3)	**(5.3)**				PASS		Yes
TP1	1.0-1.1	C	(5.6)	(4.8)				NA		No
TP2	**1.0-1.1**	C	(5.5)	**(3.4)**				PASS		Yes
TP3	**1.0-1.1**	M	(5.6)	**(3.9)**				PASS		Yes
TP3	1.7-1.8	C	(5.7)	(5.4)				NA		No
TP4	**0.5-0.6**	F	(5.6)	**(4.1)**				PASS		Yes
TP4	**2.0-2.1**	C	(5.8)	**(1.7)**				PASS		Yes
TP5	0.9-1.0	C	(5.8)	(5.0)				NA		No
TP5	1.5-1.6	C	(5.3)	(4.5)				NA		No
TP6	0.6-0.7	M	(4.8)	(4.2)				NA		No
TP6	1.0-1.1	C	(4.8)	(4.2)				NA		No
TP6	**1.5-1.6**	C	(4.7)	**(2.6)**				PASS		Yes
TP6	**2.0-2.1**	C	4.9	**3.9**	15	<2	<0.020	PASS	1.0	Yes
TP9	**1.0-1.1**	C	(4.9)	**(3.6)**				PASS		Yes
TP9	**1.9-2.0**	C	(5.3)	**(4.2)**				PASS		Yes
TP10	0.5-0.6	C	(5.3)	(4.6)				NA		No
TP10	1.1-1.2	C	(5.3)	(4.8)				NA		No
TP10	1.8-1.9	C	(5.5)	(4.6)				NA		No
TP11	**1.0-1.1**	C	(5.7)	**(4.4)**				PASS		Yes
TP12	0.6-0.7	C	(6.0)	**(4.0)**				PASS		Yes
TP12	**1.1-1.2**	C	(5.7)	**(4.1)**				PASS		Yes
TP12	**1.9-2.0**	C	(6.4)	**(4.7)**				PASS		Yes
TP13	**1.1-1.2**	C	(5.3)	**(4.3)**				PASS		Yes
TP14	**0.6-0.7**	F	(5.2)	**(3.3)**	**22**	<2	<0.020	PASS	6.0	Yes
TP14	**1.7-1.8**	F	(4.9)	**(3.4)**				PASS		Yes
TP15	1.1-1.2	C	(4.8)	(3.9)				NA		No

Sample ID	Sample Depth (m bgl)	Material Type [1]	Field/ Laboratory Screening Test Results		Laboratory sPOCAS Test Results			Assessment [9]	Liming Rate (kg $CaCO_3$/t) [10]	Management required?
			pH_{KCL} [2] (pH_F) [3]	pH_{OX} [4] (pH_{FOX}) [5]	TPA (mol H+/t)[6]	TSA (mol H+/t)[7]	S_{POS} (%S oxidisable)[8]			
Assessment Criteria:		(F) Fine texture ≥ 40% clay (M) Medium texture 5 – 40% clay (C) Coarse texture ≤ 5% clay	≤ 4: AASS	< 3.5 or pH_{KCL} –pH_{OX}>1: PASS	62 36 18 [11]	62 36 18 [11]	0.100 0.060 0.030 [11]	AASS or PASS (Coarse texture criteria used if >1000t)	-	-
TP16	0.5-0.6	C	(5.0)	(4.7)				NA		No
TP16	**1.7-1.8**	C	(4.9)	**(3.8)**				PASS		Yes
TP17	1.1-1.2	C	(5.5)	(5.2)				NA		No
TP18	0.6-0.7	C	(4.8)	(4.2)				NA		No
TP18	1.8-1.9	C	(5.3)	(4.5)				NA		No
TP19	**0.5-0.6**	C	4.5	3.6	**95**	**59**	0.020	PASS	4.0	Yes
TP19	**1.1-1.2**	F	(5.2)	**(3.5)**				PASS		Yes
TP20	0.6-0.7	C	(5.0)	(4.2)				NA		No
TP20	1.6-1.7	C	(5.1)	(5.0)				NA		No
TP21	1.1-1.2	C	(5.3)	(5.2)				NA		No
TP22	0.5-0.6	M	(5.8)	(5.4)				NA		No
TP22	**1.8-1.9**	C	(5.6)	**(4.7)**				PASS		Yes
TP24	**0.5-0.6**	M	(5.0)	**(3.6)**				PASS		Yes
TP24	**1.0-1.1**	C	(5.1)	**(3.9)**				PASS		Yes
TP24	1.9-2.0	C	(5.6)	(5.2)				NA		No
TP25	**0.6-0.7**	C	(4.6)	**(3.3)**				PASS		Yes
TP25	**1.9-2.0**	F	4.3	**2.2**	**53**	8	**0.050**	PASS	6.0	Yes
TP26	0.5-0.6	C	(4.9)	(4.7)				NA		No
TP26	1.0-1.1	C	(4.8)	(4.3)				NA		No
TP26	**1.5-1.6**	M	5.4	3.3	**197**	**189**	<0.020	PASS	<1.0	Yes
TP27	**1.1-1.2**	C	5.0	**2.8**	**33**	12	<0.020	PASS	2.0	Yes
TP28	**0.6-0.7**	M	4.4	**3.1**	**94**	**40**	<0.020	PASS	4.0	Yes
TP28	1.7-1.8	C	(5.1)	(4.6)				NA		No
TP29	**1.1-1.2**	C	(5.2)	**(4.0)**				PASS		Yes
TP30	**0.6-0.7**	C	(6.0)	**(4.9)**				PASS		Yes
TP30	**1.5-1.6**	C	5.0	**3.5**	**56**	**45**	**0.080**	PASS	4.0	Yes
TP31	**0.6-0.7**	C	(6.6)	**(4.8)**				PASS		Yes

Sample ID	Sample Depth (m bgl)	Material Type [1]	Field/ Laboratory Screening Test Results		Laboratory sPOCAS Test Results			Assessment [9]	Liming Rate (kg $CaCO_3$/t) [10]	Management required?
			pH_{KCL} [2] (pH_F) [3]	pH_{OX} [4] (pH_{FOX}) [5]	TPA (mol H+/t)[6]	TSA (mol H+/t)[7]	S_{POS} (%S oxidisable)[8]			
Assessment Criteria:		(F) Fine texture ≥ 40% clay (M) Medium texture 5 – 40% clay (C) Coarse texture ≤ 5% clay	≤ 4: AASS	< 3.5 or pH_{KCL} –pH_{OX}>1: PASS	62 36 18 [11]	62 36 18 [11]	0.100 0.060 0.030 [11]	AASS or PASS (Coarse texture criteria used if >1000t)	-	-
TP31	**1.0-1.1**	C	(6.0)	**(3.6)**				PASS		Yes
TP32	**0.7-0.8**	C	(5.2)	**(3.9)**				PASS		Yes
TP32	**1.6-1.7**	C	5.0	**2.8**	**55**	**47**	**0.120**	PASS	6.0	Yes
TP33	**1.1-1.2**	C	5.7	**3.0**	**42**	**40**	**0.120**	PASS	6.0	Yes
TP34	**0.55-0.65**	C	(6.8)	**(4.5)**				PASS		Yes
TP34	**1.0-1.1**	C	4.9	**2.8**	**99**	**84**	**0.160**	PASS	9.0	Yes
TP34	1.9-2.0	C	(6.3)	(5.5)				NA		No
BH35	0.5-1.0	C	(5.8)	(5.0)				NA		No
BH35	**2.0-2.5**	C	(6.2)	**(4.3)**				PASS		Yes
BH35	**3.5-4.0**	C	(6.5)	**(5.2)**				PASS		Yes
BH36	**0.5-1.0**	C	4.6	4.2	**28**	<2	<0.02	PASS	2.0	Yes
BH36	**2.0-2.5**	C	(5.3)	**(3.8)**				PASS		Yes
BH36	**3.5-4.0**	C	5.2	**3.8**	**19**	8	<0.02	PASS	<1.0	Yes
BH36	**5.0-5.5**	C	(6.2)	**(4.2)**				PASS		Yes
BH37	**0.5-1.0**	C	5.1	**4.1**	**102**	**88**	<0.020	PASS	1.0	Yes
BH37	**2.0-2.5**	C	5.0	**3.2**	**102**	**78**	**0.030**	PASS	3.0	Yes
BH37	**3.5-4.0**	C	(5.8)	**(4.3)**				PASS		Yes
BH37	**5.0-5.5**	C	4.5	**2.7**	**120**	**83**	**0.090**	PASS	7.0	Yes
BH37	**6.5-7.0**	C	4.6	**2.7**	**118**	**77**	**0.100**	PASS	8.0	Yes
BH38	**0.5-1.0**	M	4.2	4.1	**137**	**29**	**0.040**	PASS	11.0	Yes
BH38	**2.0-2.5**	M	(5.5)	**(4.2)**				PASS		Yes
BH38	**3.5-4.0**	C	(5.5)	**(4.4)**				PASS		Yes
BH38	**5.0-5.5**	C	(5.9)	**(4.6)**				PASS		Yes
BH38	**6.5-7.0**	C	5.2	**4.2**	17	6	<0.02	PASS	<1.0	Yes
TP39	**0.5-0.6**	F	(7.5)	**(4.4)**				PASS		Yes
TP39	**1.0-1.1**	F	(6.8)	**(3.9)**	**56**	4	0.006	PASS	5.0	Yes
TP39	**1.5-1.6**	C	(7.3)	**(5.5)**				PASS		Yes

Sample ID	Sample Depth (m bgl)	Material Type [1]	Field/ Laboratory Screening Test Results		Laboratory sPOCAS Test Results			Assessment [9]	Liming Rate (kg $CaCO_3$/t) [10]	Management required?
			pH_{KCL} [2] (pH_F) [3]	pH_{OX} [4] (pH_{FOX}) [5]	TPA (mol H+/t)[6]	TSA (mol H+/t)[7]	S_{POS} (%S oxidisable)[8]			
Assessment Criteria:		(F) Fine texture ≥ 40% clay (M) Medium texture 5 – 40% clay (C) Coarse texture ≤ 5% clay	≤ 4: AASS	< 3.5 or pH_{KCL} –pH_{OX}>1: PASS	62 36 18 [11]	62 36 18 [11]	0.100 0.060 0.030 [11]	AASS or PASS (Coarse texture criteria used if >1000t)	-	-
TP40	**0.5-0.6**	F	(6.2)	**(4.6)**				PASS		Yes
TP40	**1.0-1.1**	F	(5.7)	**(4.5)**				PASS		Yes
TP40	1.5-1.6	C	4.8	(4.7)	9	0	<0.005	NA	<1.0	No
TP41	**0.5-0.6**	F	(5.2)	**(3.9)**	**39**	0	<0.005	PASS	5.0	Yes
TP41	**1.0-1.1**	M	(5.2)	**(4.0)**				PASS		Yes
TP41	1.5-1.6	M	(5.0)	(4.4)				NA		No
TP41	**2.4-2.5**	C	(6.0)	**(4.7)**				PASS		Yes
TP42	**0.5-0.6**	F	(5.7)	**(4.3)**				PASS		Yes
TP42	**1.0-1.1**	F	4.6	(4.2)	**37**	0	0.007	PASS	3.0	Yes
TP42	**1.5-1.6**	C	(5.4)	**(4.2)**				PASS		Yes
TP43	0.5-0.6	C	(4.1)	(4.9)				NA		No
TP43	1.0-1.1	C	(5.3)	(4.9)				NA		No
TP43	1.7-1.8	C	5.1	(5.2)	7	0	<0.005	NA	<1.0	No
TP44	0.5-0.6	C	(4.7)	(4.6)				NA		No
TP44	1.0-1.1	C	(5.0)	(4.8)				NA		No
TP44	1.5-1.6	C	(5.0)	(5.1)				NA		No
BH45	**1.0-1.5**	C	(6.4)	**(5.2)**				PASS		Yes
BH45	**2.5-3.0**	C	(6.8)	**(5.4)**				PASS		Yes
BH45	**4.0-4.5**	C	(6.2)	**(4.8)**				PASS		Yes
BH45	**4.0-4.5**	C	(7.1)	**(5.5)**				PASS		Yes
BH45	5.5-5.9	C	5.0	(4.8)	**22**	7	0.011	NA	<1.0	No
BH45	**7.0-7.4**	C	(5.6)	**(5.4)**				PASS		Yes
BH45	**8.5-9.0**	C	(6.7)	**(5.2)**				PASS		Yes
BH45	**10.0-10.5**	C	(7.0)	**(5.1)**				PASS		Yes
BH46	**1.0-1.1**	C	5.4	**(2.3)**	**20**	17	0.028	PASS	3.0	Yes
BH46	2.5-3.0	C	5.2	(4.4)	**18**	10	0.016	NA	<1.0	No
BH46	**4.0-4.5**	C	(7.7)	**(4.7)**				PASS		Yes

Sample ID	Sample Depth (m bgl)	Material Type [1]	Field/ Laboratory Screening Test Results		Laboratory sPOCAS Test Results			Assessment [9]	Liming Rate (kg $CaCO_3$/t) [10]	Management required?
			pH_{KCL} [2] (pH_F) [3]	pH_{OX} [4] (pH_{FOX}) [5]	TPA (mol H+/t)[6]	TSA (mol H+/t)[7]	S_{POS} (%S oxidisable)[8]			
Assessment Criteria:		(F) Fine texture ≥ 40% clay (M) Medium texture 5 – 40% clay (C) Coarse texture ≤ 5% clay	≤ 4: AASS	< 3.5 or pH_{KCL} –pH_{OX}>1: PASS	62 36 18 [11]	62 36 18 [11]	0.100 0.060 0.030 [11]	AASS or PASS (Coarse texture criteria used if >1000t)	-	-
BH46	5.5-6.0	C	5.9	(5.3)	10	8	0.013	NA	<1.0	No
BH46	7.0-7.5	C	(7.3)	**(5.8)**				PASS		Yes
GMB21	1.1-1.2	C	5.9	**3.4**	**18**	**18**	0.04	PASS		Yes
GMB23	1.0-1.1	C	5.1	**3.2**	**20**	**20**	<0.02	PASS		Yes

Notes:

1. Material type based on referenced external consultants' reports
2. Field pH (in 1:5 distilled water) by laboratory analysis (by ALS Environmental)
3. Field pH (in 1:5 distilled water) analysis (by Coffey)
4. Post peroxide oxidation pH by laboratory analysis (by ALS Environmental)
5. Post peroxide oxidation pH (by Coffey)
6. Total Potential Acidity
7. Total Sulfidic Acidity
8. Percentage oxidisable sulfur
9. NA = not AASS or PASS, AASS = Actual Acid Sulfate Soil, PASS = Potential Acid Sulfate Soil
10. Suggested by ALS (refer laboratory test reports in Attachment E)
11. Action criteria for all soil types if > 1,000t will be disturbed (Table 4.4 ASSMAC, 1998)

Shaded cells indicate values exceeding assessment criteria for < 1000t soil disturbance

Bold values indicate values exceeding assessment criteria for > 1000t soil disturbance

7 Attachment F3 – Notes Relating to 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.

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.

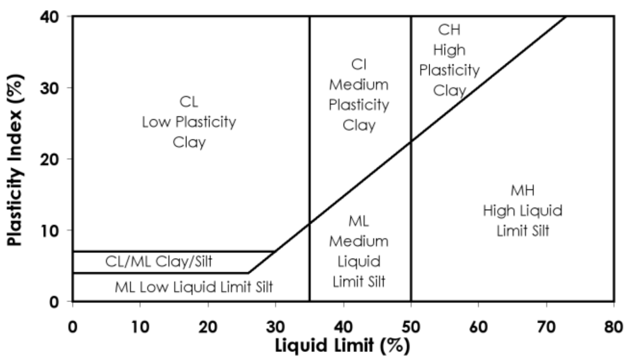
Particle Size

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 Data

Explanation of Terms (2 of 3)

Soil Agricultural Classification Scheme

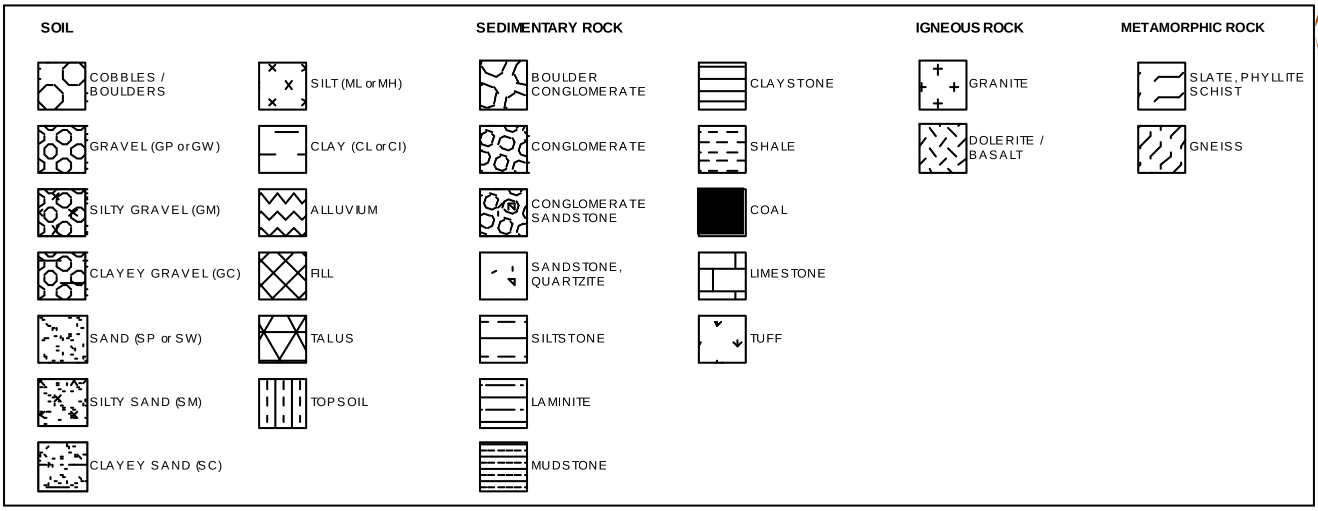
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions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

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

Soil Data

Explanation of Terms (3 of 3)

Symbols for Soil and Rock



Unified Soil Classification Scheme (USCS)

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

Rock Data

martens consulting engineers

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)		**Coating or Filling**		**Roughness**	
BP	Bedding plane parting	Cn	Clean	Po	Polished
X	Foliation	Sn	Stain	Ro	Rough
L	Cleavage	Ct	Coating	Sl	Slickensided
JT	Joint	Fe	Iron Oxide	Sm	Smooth
F	Fracture			Vr	Very rough
SZ	Sheared zone (Fault)	**Planarity**		**Inclination**	
CS	Crushed seam	Cu	Curved	The inclination of defects are measured from perpendicular to the core axis.	
DS	Decomposed seam	Ir	Irregular		
IS	Infilled seam	Pl	Planar		
V	Vein	St	Stepped		
		Un	Undulating		

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:

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

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

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

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.