Appendix F

# Acid Sulfate Soils Assessment

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Malbec Properties Pty Ltd

# Acid Sulfate Soils Assessment

# Proposed Residential Subdivision South West Rocks, NSW

P0802023JR03_v2
June 2010

martens consulting engineers

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 Scope of Work

This report provides the findings of an Acid Sulfate Soils (ASS) assessment completed as part of preparations for a proposed residential subdivision south of Saltwater Creek, South West Rocks, NSW.

The assessment includes a desktop study review of site geomorphic setting and ASS risk maps, detailed site soil landscape investigations and laboratory analysis of collected soil samples.

The objective of the assessment is to determine the extent of any potential and actual acid sulfate soils on-site, the risk of acid sulfate soils exposure during development works, and to prepare an ASS management plan if required based on soil chemistry test results.

The work is prepared in accordance with the following guidelines:

- NSW Acid Sulfate Soil Management Advisory Committee (ASSMAC, 1998); and
- Kempsey Shire Council (1999) *Development Control Plan No. 30: Acid Sulfate Soils*.

## 1.2 Previous Studies

An *Acid Sulfate Soils Assessment* has previously been completed for the site by Hackett Laboratory Services (January 2003). Testing was undertaken across a larger area which included land to the north as well as the subject site. Two test pits were completed within the subject site (Lot 52 DP 831284). Test pits were sampled to a depth of 2 m as this was considered to be the extent of site disturbance that would occur for residential development. No actual or potential acid sulfate soils were identified and an ASS management plan was not considered to be necessary.

## 1.3 Development Proposal

The proposed development involves a residential subdivision including:

- Approximately 310 allotments of varying size ranging between approximately 500 $m^2$ and 1,000 $m^2$;
- Associated services (water, electricity, sewer) and stormwater drainage infrastructure;
- Internal roads and through roads for future development of land north of the site;
- Some vegetation clearing and cut/fill earthworks to accommodate the development; and

- Site access from Belle O'Conner Drive to the south and a new connecting road to the north.

A site plan showing the proposed site layout is included in Attachment A.

Site works that are expected to potentially affect acid sulfate soils at the site include the construction of building foundations and the construction of services, such as sewer, water supply and stormwater drainage systems.

Final depth of cut/fill earthworks, foundations and service trenches are not confirmed, however the current assessment has addressed soil layers as deep as 2.5 m below existing ground level, which is sufficient assessment for excavation to 1.5 m depth.

# 2 Site Description

## 2.1 Location and Setting

South West Rocks is a coastal village located on the North Coast of NSW, approximately 35 km north-west of Kempsey and in the Kempsey Shire Council local government area (LGA).

The subject site has a total area of 39.5 ha and comprises the following allotments:

- Lot 52 DP 831284; and
- Lot 84 DP 792945.

The site is bounded by rural-residential properties to the east, Belle O'Connor Drive to the south, South West Rocks golf course to the west, and Saltwater Creek to the north. Saltwater Creek flows eastwards along the northern site boundary to Saltwater Lagoon north-east of the site. Saltwater Lagoon is connected to the ocean by Saltwater Creek which enters at the western end of Trial Bay Beach. The system is intermittently closed 70% of the time by a sand berm at the entrance (WBM, 2006). Figure 1 shows the locality of the site in a regional context and indicates these features.

The proposed development is part of a larger land release area encompassing land to the north.


Figure 1: Approximate site locality and regional context (Google Maps, 2008).

## 2.2 Field Investigations

Early site investigations were undertaken by Martens & Associates in March, 2008 and included a walkover inspection of the site to assess the existing site's environment setting and determine any environmental conditions that may have potential to impact on the proposed development and/or neighbouring properties.

Further site investigations were undertaken by Martens & Associates during 20 – 22 February 2010 for a range of environmental studies. The acid sulfate soils component included the following:

- Walkover inspection of the site to assess existing site conditions;
- Excavation of ten boreholes to 2.5 – 8.5 m depth below ground level using a hydraulic auger to allow for characterisation of underlying soils on site; and
- Collection of fifty-five soil samples.

Locations of all borehole investigations are shown on the site plan (Attachment A).

## 2.3 Site Description

The site is covered by thick coastal heath 2 – 3 m high in the eastern half of the site (Figure 2) which has been cleared and become grassland in the centre and western portions. Some remnant Eucalyptus and Melaleuca trees are scattered across the site also. There is a residential dwelling on each of the two lots and several dirt tracks cut through the site for vehicle access.

*Figure 2:* View to the south-west across the eastern portion of the site (20 February 2010).

## 2.4 Rainfall and Evaporation

Based on data from a Port Macquarie weather station (approximately 65 km south of the subject site), the South West Rocks area is characterised by moderate – high annual rainfall of 1,532 mm/year. Rainfall varies throughout the year (Table 1) with the summer and autumn seasons being the wettest. Evaporation data recorded at Coffs Harbour (approximately 70 km north of the site) also varies monthly, with the lowest months being May – August. The data indicates that generally rainfall exceeds evaporation during the first half of the year while the opposite is true during the latter half of the year.

*Table 1:* Monthly climatic information for South West Rocks (based on rainfall data from Port Macquarie and evaporation data from Coffs Harbour).

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rain (mm) | 152 | 176 | 175 | 166 | 146 | 132 | 98 | 82 | 82 | 94 | 103 | 127 | 1,532 |
| Evap. (mm) | 201 | 164 | 158 | 122 | 90 | 76 | 83 | 111 | 144 | 172 | 185 | 202 | 1,708 |

## 2.5 Local Topography

The site has very low slopes (generally < 1%) towards Saltwater Creek in the north. Site elevation varies between approximately 5.0 – 5.5 mAHD about a minor ridge near the middle of the southern site boundary to approximately 1.0 – 1.5 mAHD adjacent to Saltwater Creek.

The site conveys flows from two discrete catchments to the south which drain across the site and into Saltwater Creek. The first catchment, flowing into the western portion of the site, is approximately 39.5 ha and largely consists of rural/agricultural properties. However, a recently approved and partly constructed residential subdivision also lies within this catchment. The second catchment, feeding into the eastern portion of the site is approximately 34.7 ha and primarily consists of cleared grazing land.

## 2.6 Geology

The Dorrigo Kempsey 1:250,000 Geological Series Sheet SH 56 – 10 & 11 (Geological Survey of NSW, 1969) indicates that the site is underlain by Quaternary aged alluvial and estuarine sediments typically comprising sands, silts and gravels. The former sediments are underlain by Smokey Cape Adamellite and Kempsey Beds (greywacke, siltstone and conglomerate).

On-site borehole investigations to 2.5 – 8.5 m depth below ground level did not encounter any fresh, hard bedrock. However, extremely weathered claystone/siltstone was encountered 1.5 – 2.5 m below ground level at BH6 and BH7, along the minor ridge in the centre of the property.

## 2.7 Soil Profile

Reference to the 1:100,000 Macksville Nambucca Soil Landscape Series Sheet 9436 (NSW DLWC, 1999) indicates that two soil landscape groups make up the site (Figure 3). Soils in the area of proposed development are primarily characterised as Clybucca (cy), which are comprised of back barrier swamps overlying Pleistocene sands, typically at elevations less than 5 mAHD. The southern portion of the site also partially contains the Korogoro (kr) landscape, consisting of low transgressive Pleistocene dunes.

Limitations associated with these soil landscapes include poor drainage, localised acid sulphate soil potential, high run on (being on lower slopes), flood hazard, permanently high water table, groundwater pollution hazard and foundation hazard.

On-site borehole investigations by Martens & Associates and Douglas Partners (Hydrogeological Assessment, October 2007) found the site to be underlain by stiff clay subsoils occasionally interbedded with sands. Residual clay soil forms a ridge through the centre of the site and depositional layers of sand tend to be thicker either side of this ridge, as shown by a catenary sequence of the soil profile (Attachment E). Residual clay subsoil is underlain by extremely weathered claystone/siltstone parent rock, as observed at borehole's 6 and 7.

Borehole locations are shown on the site plan (Attachment A) and detailed excavation logs are provided as Attachment B.

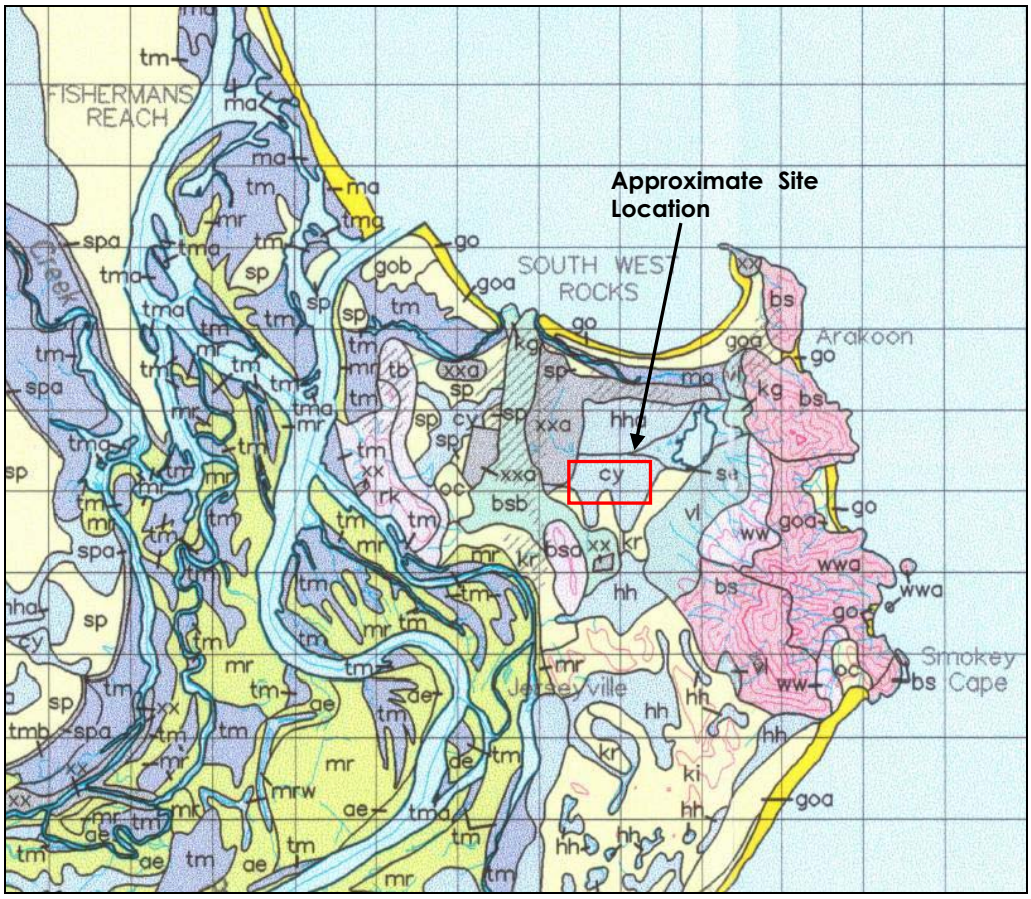



Figure 3 Extract from the *1:100,000 Macksville Nambucca Soil Landscape Series Sheet 9436* (NSW DLWC, 1999) showing the subject site.

## 2.8 Groundwater

The site soil profile (very low permeability, stiff clay subsoils overlain by highly permeable sands) tends to cause perching of groundwater and surface ponding in low lying areas following rainfall since the clay subsoils act as a confining layer and impedes infiltration. In this way the local groundwater table and surface water regime are intrinsically linked.

On-site borehole investigations by Martens & Associates and Douglas Partners (2007) confirmed that the local watertable was shallow in parts of the site, with some low lying areas showing evidence of surface ponding after rainfall (Table 2). Shallow groundwater will have implications for the design of the proposed development including engineering implications for building footings, pavements, drainage and installation of services. The risk of acid sulfate soils generation also increases as wet soils are dried out during construction. It is likely that certain drainage measures will be required to control increases in groundwater levels due to site development and natural seasonal rainfall variations.

*Table 2:* Groundwater levels observed during Martens & Associates site inspection 20 February 2010.

| Borehole | 202 | 203 | 204 | 205 | 208 | 210 | 212 | 213 | 215 |
|---|---|---|---|---|---|---|---|---|---|
| Borehole Surface Level (mAHD) | 3.5 | 4.0 | 4.0 | 3.5 | 4.0 | 4.0 | 4.5 | 4.0 | 4.0 |
| Depth to Water (m) | 1.5 | 1.1 | 0.7 | 1.0 | 0.9 | 0.75 | 1.1 | 0.9 | 0.9 |
| Water Level (mAHD) | 2.0 | 2.9 | 3.3 | 2.5 | 3.1 | 3.25 | 3.4 | 3.1 | 3.1 |

Note: Testing was conducted on 20 February 2010 after 140 mm of rain during the previous 20 days (based on climate records for Kempsey).

Based on detailed investigations completed by Martens & Associates a hydrogeological model of the site has been developed. This model was used to assess the impact of the proposed development on the site's hydrogeological conditions. The investigation concluded that, beneath the developed lands, there would be drawdown of groundwater tables by 60 – 350 mm across the site. Acid Sulfate Soils Assessment

## 2.9 Desktop Review

### *2.9.1 Acid Sulfate Soils Risk Map Classification*

According to the (former) NSW Department of Natural Resources Acid Sulfate Soil Risk Maps, the subject site is categorised as being at risk of having acid sulfate soils (Figure 4). Class 2, Class 4 and Class 5 land exists at the site. According to the ASSMAC (1998) guidelines:

- Works below natural ground level and works by which the watertable is likely to be lowered are likely to present an environmental risk if undertaken in Class 2 land;
- Works beyond 2 metres below natural ground level and works by which the watertable is likely to be lowered beyond 2 metres below natural ground level are likely to present an environmental risk if undertaken in Class 4 land; and
- Works which are likely to lower the watertable below 1 mAHD on adjacent Class 2 or 4 lands are likely to present an environmental risk if undertaken in Class 5 land.

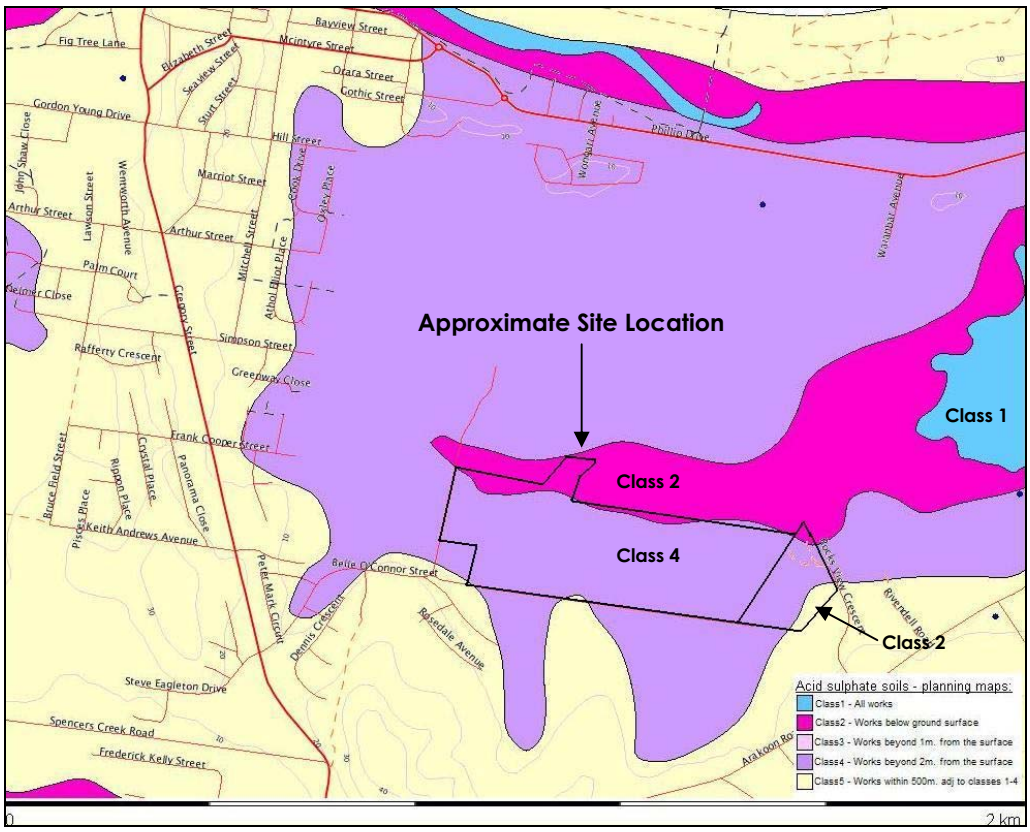



*Figure 4:* NSW DNR Acid Sulfate Soils Risk Map extract.

### 2.9.2 *Geomorphic Setting*

The likelihood of acid sulfate soils occurrence at a site is a function of various geomorphic parameters, in particular those listed in Table 3 (ASSMAC, 1998). Each is an indicator that acid sulfate soils are likely to be present on-site.

*Table 3*: Geomorphic features indicative of acid sulfate soils – Lot 52 DP 831284 and Lot 84 DP 792945, South West Rocks NSW.

| Geomorphic Feature | Present on site? |
|---|---|
| Holocene sediments | Yes (low lying areas) |
| Soil horizons less than 5 m AHD | Yes |
| Marine / estuarine sediments or tidal lakes | No |
| Coastal wetland; backwater swamps; waterlogged or scaled areas; interdune swales or coastal sand dunes. | Yes |
| Dominant vegetation is mangroves, reeds, rushes and other swamp or marine tolerant species. | Partly |
| Geologies containing sulphide bearing material / coal deposits or former marine shales/sediments | Possibly |
| Deep older (Pleistocene) estuarine sediments | Likely |

Several of the geomorphic features listed are present on-site. Therefore, the geomorphic setting of the site indicates that actual or potential ASS could be present and further site testing is recommended.

## 2.10 Soil Sampling and Laboratory Analysis

### 2.10.1 *Sampling Regime*

A soil sample was collected from every soil layer or every half meter generally to maximum depth 2.5 m at each of the ten boreholes distributed across the site, as shown in Table 4. Borehole locations are shown on the site plan (Attachment A).

*Table 4:* Soil samples collected from South West Rocks.

| Depth | Borehole | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **201** | **202** | **203** | **204** | **205** | **206** | **207** | **208** | **209** | **210** |
| 0.2 | | | | X | | X | | | X | |
| 0.5 | X | X | X | X | X | X | X | X | X | X |
| 0.75 | | | X | X | X | | | | | |
| 1.0 | X | X | X | | X | X | X | X | X | X |
| 1.5 | X | X | X | X | | X | X | X | X | X |
| | 1.8 | | | | | | | | | |
| 2.0 | X | X | X | X | X | | | X | X | X |
| | | | | | 2.2 | | | | | |
| 2.5 | | X | X | X | X | X | X | X | X | X |
| | 4.0 | | | | | | | | | |
| | 5.2 | | | | | | | | | |

Total site area is approximately 39.5 ha and the proposed development envelope is approximately 25 ha. ASSMAC (1998) guidelines recommend that two boreholes per hectare is an appropriate number of sampling locations for sites larger than 4 ha. However, the completed soil sampling regime has been designed to assess each soil layer beneath the site (to 2.5 m depth below ground level) based on a catenary sequence identified from borehole logs (Attachment E). Testing locations are also additional to a previous ASS investigation (Hackett Laboratory Services, 2003) which included two boreholes at the site and found no evidence of actual or potential acid sulfate soils. Therefore, the completed sampling density is considered adequate for the site. The scope of works was accepted by NSW Department of Planning (February 2010).

### *2.10.2 pH Screening Test*

Field pH testing was completed for all alluvial soil samples to assess actual or potential acid sulfate soils and as a screening measure for laboratory testing. As stated by the ASSMAC (1998) guidelines, actual acid sulfate soils may be indicated by field pH <4 in soils, and potential acid sulfate soils may be indicated one or more of the following:

- Change in colour of the soil from grey tones to brown tones;
- Effervescence;

- The release of sulphur smelling gases such as sulphur dioxide or hydrogen sulphide;
- A lowering of the soil field pH by at least one unit;
- A final field pH <3.5.

None of the tested samples showed signs of being actual acid sulfate soils (field pH <4), however twelve samples showed signs of being potential acid sulfate soils (Table 5). Nine of these twelve were submitted for laboratory testing.

*Table 5*: Soil samples that showed sign of being potential acid sulfate soils, based on field pH testing and oxidation in 30% hydrogen peroxide: South West Rocks.

| Sample[1] | Depth | RL (mAHD) | Soil Texture | $pH_f$ | $pH_{fox}$ | Effervescence | Odour | Colour Change | Comment | Submitted for Lab Testing |
|---|---|---|---|---|---|---|---|---|---|---|
| 202/0.5 | 0.5 | 3.00 | Sand | 5.25 | 4.35 | Y | Y | | Foam on surface | X |
| 202/2.0 | 2.0 | 1.50 | Sand | 5.47 | 3.72 | | | | | |
| 202/2.5 | 2.5 | 1.00 | Clay | 5.50 | 3.99 | Y | Y | | Reaction – violent (heat) | X |
| 203/0.5 | 0.5 | 3.50 | Silty sand | 6.90 | 4.28 | Y | | | | |
| 204/0.5 | 0.5 | 3.50 | Silty clay | 5.64 | 5.03 | Y (Slight) | | | Foam on surface | X |
| 205/2.2 | 2.2 | 1.30 | Sand | 5.15 | 4.78 | Y (Slight) | | | | X |
| 205/2.5 | 2.5 | 1.00 | Clay | 5.01 | 3.96 | Y | | | | X |
| 208/2.0 | 2.0 | 2.00 | Sand | 5.43 | 4.76 | Y (Slight) | | | | X |
| 208/2.5 | 2.5 | 1.50 | Clay | 5.51 | 4.25 | Y | Y | | Heat, violent reaction | X |
| 209/2.0 | 2.0 | 2.00 | Sand | 5.26 | 2.62 | Y (Slight) | | | Reaction (slight) | X |
| 210/2.0 | 2.0 | 2.00 | Sand | 4.92 | 1.95 | Y (Slight) | | | Reaction (foam), slight heat | X |
| 210/2.5 | 2.5 | 1.50 | Sand | 4.72 | 1.65 | Y | Y | Y | Reaction (violent), heat | |

Notes: [1] Format = Borehole/Depth.

### 2.10.3 *Laboratory Testing Details*

Twenty of the fifty-five collected soil samples were submitted to Envirolab Services laboratories for acid sulfate soils testing using the Suspended Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) method to determine the presence of actual or potential ASS material. Selected soil samples include all soil layers at the site based on a catenary sequence identified from borehole logs (Attachment E), and also take into account pH screening test results (Attachment C). This testing allows for a preliminary assessment of the extent of ASS at the site.

### 2.10.4 *Results*

Laboratory testing results are summarised in Table 5 and the complete laboratory report is provided as Attachment D.

*Table 5*: ASS (SPOCAS) testing results – Lot 52 DP 831284 and Lot 84 DP 792945, South West Rocks NSW. Samples exceeding the ASSMAC action criteria are highlighted.

| Sample ID[1] | Elevation – mAHD | Soil Type | $pH_{KCL}$[2] | $pH_{OX}$[3] | TPA[4] | TSA[5] | $S_{POS}$[6] |
|---|---|---|---|---|---|---|---|
| 2023/202/0.5 | 3.0 | Sand | 4.3 | 3.4 | 290 | 188 | 0.024 |
| 2023/202/1.0 | 2.5 | Sand | 4.8 | 3.7 | 42 | 22 | 0.005 |
| 2023/202/2.5 | 1.0 | Clay | 3.8 | 4.1 | 52 | <5.0 | <0.005 |
| 2023/204/0.2 | 3.8 | Silty Clay | 4.4 | 2.9 | 353 | 253 | 0.049 |
| 2023/204/0.5 | 3.5 | Silty Clay | 5.0 | 3.6 | 203 | 143 | 0.055 |
| 2023/204/1.5 | 2.5 | Sand | 5.2 | 3.5 | <5.0 | <5.0 | 0.012 |
| 2023/205/0.5 | 3.0 | Silty Sand | 4.7 | 3.1 | 80 | 55 | 0.009 |
| 2023/205/1.0 | 2.5 | Sand | 5.1 | 3.7 | 7.5 | <5.0 | <0.005 |
| 2023/205/2.2 | 1.3 | Sand | 4.5 | 3.4 | 25 | 12 | <0.005 |
| 2023/205/2.5 | 1.0 | Clay | 3.9 | 4.0 | 57 | 7.5 | 0.005 |
| 2023/206/0.2 | 4.3 | Silty Clay | 4.3 | 3.8 | 40 | <5.0 | 0.014 |
| 2023/206/0.5 | 4.0 | Clay | 4.2 | 3.5 | 92 | 37 | 0.031 |
| 2023/208/0.5 | 3.5 | Silty Clay | 4.1 | 3.2 | 108 | 32 | 0.018 |
| 2023/208/1.0 | 3.0 | Sand | 4.7 | 3.4 | 20 | 5.0 | 0.010 |
| 2023/208/2.0 | 2.0 | Sand | 4.6 | 3.6 | 12 | <5.0 | <0.005 |
| 2023/208/2.5 | 1.5 | Clay | 4.3 | 4.3 | 15 | <5.0 | 0.005 |
| 2023/209/2.0 | 2.0 | Sand | 5.1 | 3.0 | 10 | 8.7 | 0.021 |
| 2023/210/0.5 | 3.5 | Sand | 5.0 | 2.5 | 20 | 12 | 0.012 |
| 2023/210/1.5 | 2.5 | Sand | 5.2 | 3.8 | <5.0 | <5.0 | <0.005 |
| 2023/210/2.0 | 2.0 | Sand | 4.4 | 2.6 | 85 | 70 | 0.22 |
| **Guideline Limit (Action Criteria)[7]** | | **Coarse Texture (Sands)** | | | **18** | **18** | **0.03** |
| | | **Fine Texture (Silty Clays and Clays)** | | | **62** | **62** | **0.1** |

Notes: [1] Format = Project/Borehole/Depth. [2] pH (actual acidity) (pH units). [3] pH after oxidation with peroxide (potential acidity) (pH units). [4] Titratable Peroxide Acidity (Moles $H^+$/tonne). [5] Titratable Sulfidic Acidity (Moles $H^+$/tonne). [6] Oxidisable sulphur (%). [7] ASSMAC (1998) p.27, for 1-1,000 tonnes disturbed soil.

The ASSMAC (1998) guidelines specify that the proposed site works present a risk of acid generation and, therefore, a management plan is required, if the soil exhibits one of the following criteria:

- Oxidisable sulphur ($S_{POS}$) is >0.03% or TPA or TSA is >18 mol $H^+$/tonne if coarse texture soils (sands); or
- Oxidisable sulphur ($S_{POS}$) is >0.1% or TPA or TSA is >62 mol $H^+$/tonne if fine texture soils (silty clays and clays).

The laboratory results indicate that eleven of the soil samples exceed the criteria based on either TPA or TSA, including samples from all of the tested boreholes except for borehole 209, for which only one sample was tested. Based on these results, an acid sulfate soils management plan is required to address the environmental risk associated with disturbance of site soils.

## 2.11 Conclusion

The site assessment indicates that there are actual and potential acid sulfate soils on-site. Soils also exhibit levels of acidity (TPA) that warrant preparation of a site-specific acid sulfate soils management plan.

A management plan has been prepared to address the risk of acid sulfate soils exposure during site development works. Provided the management plan is implemented, acidic soil conditions should not restrict the proposed development. However, if excavations of more than 1.5 m depth are proposed, then we would recommend further testing of deeper soil deposits.

# 3 Acid Sulfate Soils Management Plan

## 3.1 Objectives and Scope of Application

Management of site soil disturbance during construction activities shall ensure that environmental degradation due to excavation of acid sulfate soils does not occur.

Final depth of cut/fill earthworks, foundations and service trenches are not confirmed, however the current assessment and management plan has addressed soil layers as deep as 2.5 m below existing ground level, which is sufficient for excavation to 1.5 m depth.

## 3.2 Treatment Plan

### *3.2.1 General*

Treatment of all disturbed soil with fine agricultural lime at the rates noted in Section 3.3 is proposed.

Any excavated soil is to be treated with lime immediately (i.e. within 2 hours) and then stockpiled for backfilling or used on-site as fill. Additional, specific treatment procedures are as follows:

- Excavations should be backfilled as soon as possible to reduce the risk of soil oxidation and acid generation.
- Where lime cannot be applied to excavated material immediately after excavation, the material is to be stockpiled on an impermeable liner, surrounded by an earth bund and covered to prevent leachate generation.
- The impermeable liner is to extend over the bund to ensure that any leachate generated by exposure to rainfall is contained.
- Should leachate be collected, it is also to be neutralised with lime, tested to ensure suitability for site disposal, and then discharged to the land surface.
- Any excavated material, treated or untreated with lime, is not to be disposed of into Saltwater Creek.

Once spoil has been adequately limed it is suitable for backfilling or re-use as fill material on-site. However, potential uses of treated spoil shall be a function of the characteristic of the soil and the intended use of the area to be filled. In particular, geotechnical considerations will affect how and where the treated material can be used.

### 3.2.2 *Saturated Soil*

Very moist or saturated soils (particularly fine-grained soils) are generally not able to be adequately treated because it is difficult to effectively mix lime into saturated soils. Therefore the soil needs to be dried out by stockpiling the soil, uncovered during fine weather conditions, on an impermeable liner with a surrounding bund. Once suitably dry, material is to be treated as per general dry material (Section 3.2.1).

If material cannot be dried out, it is to be taken off-site for treatment and/or disposal in accordance with the recommendations of Section 3.5.

The management of leachate from wet soil stockpiles is particularly important. Leachate should be managed as described in Section 3.2.1.

## 3.3 Required Liming Rates

Lime is to be applied to the soil at 11 kg per tonne of soil (based on the highest $S_{POS}$ result of 0.22%), as determined from the laboratory report. This includes a 1.5 safety factor.

As a guide, soil bulk density should be assumed to be approximately 1.6 tonnes/$m^3$.

## 3.4 Dewatering

A degree of site groundwater dewatering shall result from the proposed road side drainage system and the reduction in site groundwater recharge resulting from increased impervious surfaces. This lowering of groundwater tables shall result in the more frequent exposure of potential acid sulfate soils and thus an increased risk of acid drainage.

To address the risk of increased acid drainage form the site it is proposed that, in areas where PASS are encountered during swales construction, swales will be lined with limestone gravels buried beneath the swale centreline. It is proposed that limestone material of 30 – 70 mm sixe shall be used and be placed in a 1.0 m wide by 200 mm deep bed. This material will be geotextile wrapped to ensure it remains free of fines to permit preferential water flow through it. This strategy shall provide a passive pre-treatment system to ensure any generated acid drainage is neutralised prior to discharge from developed areas of the site.

### 3.5 Off-Site Disposal

Any excess excavated soil which is not required for backfilling or as on-site fill is to be disposed of at an appropriately licensed waste transfer station or landfill. The excess spoil is to be treated with lime at the equivalent rates recommended in Section 3.3 before disposal. Final waste classification of this material for off-site disposal is to be completed in accordance with NSW DECC (2009) guidelines for waste classification and in consultation with the receiving waste site.

### 3.6 Record Keeping

- Complete records of all treatment and any further testing shall be maintained by the construction contractor.
- Records should be made available to regulators if requested.
- If off-site disposal is undertaken, a waste classification assessment is required and details of the waste contractor used and records of the quantity of material taken off-site should be kept.

### 3.7 Investigation Limitations

If there is any significant change to the development proposal for the site as described in this report, then the management plan should be reviewed by Martens & Associates.

# 4 References

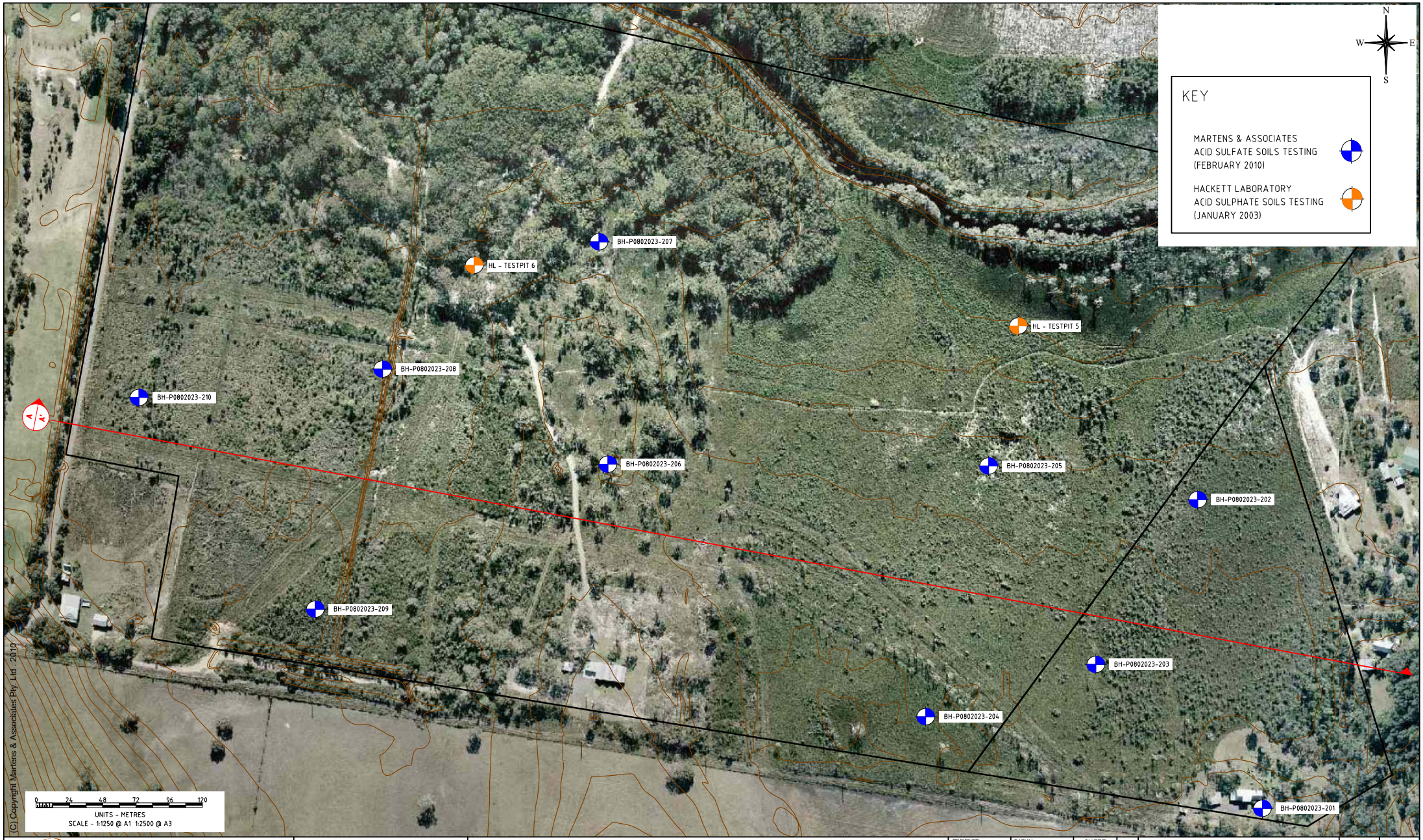
Australian Government Bureau of Meteorology (BOM), 2010, Climate Averages for Australian Sites, available online at http://www.bom.gov.au/climate/averages.

NSW Acid Sulfate Soil Management Advisory Committee (ASSMAC), August 1998, Acid Sulfate Soil Manual.

Kempsey Shire Council (1999) *Development Control Plan No. 30: Acid Sulfate Soils*.

NSW Government Department of Environment and Climate Change (July 2009) *Waste Classification Guidelines*.

# 5 Attachment A – Site Plans



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Internet: http://www.martens.com.au

MARTENS & ASSOCIATES PTY LTD
Sustainable Solutions
Environmental - Geotechnical - Civil
Hydraulic - Wastewater Engineers

CLIENT/ PROJECT
MALBEC PROPERTIES PTY LTD

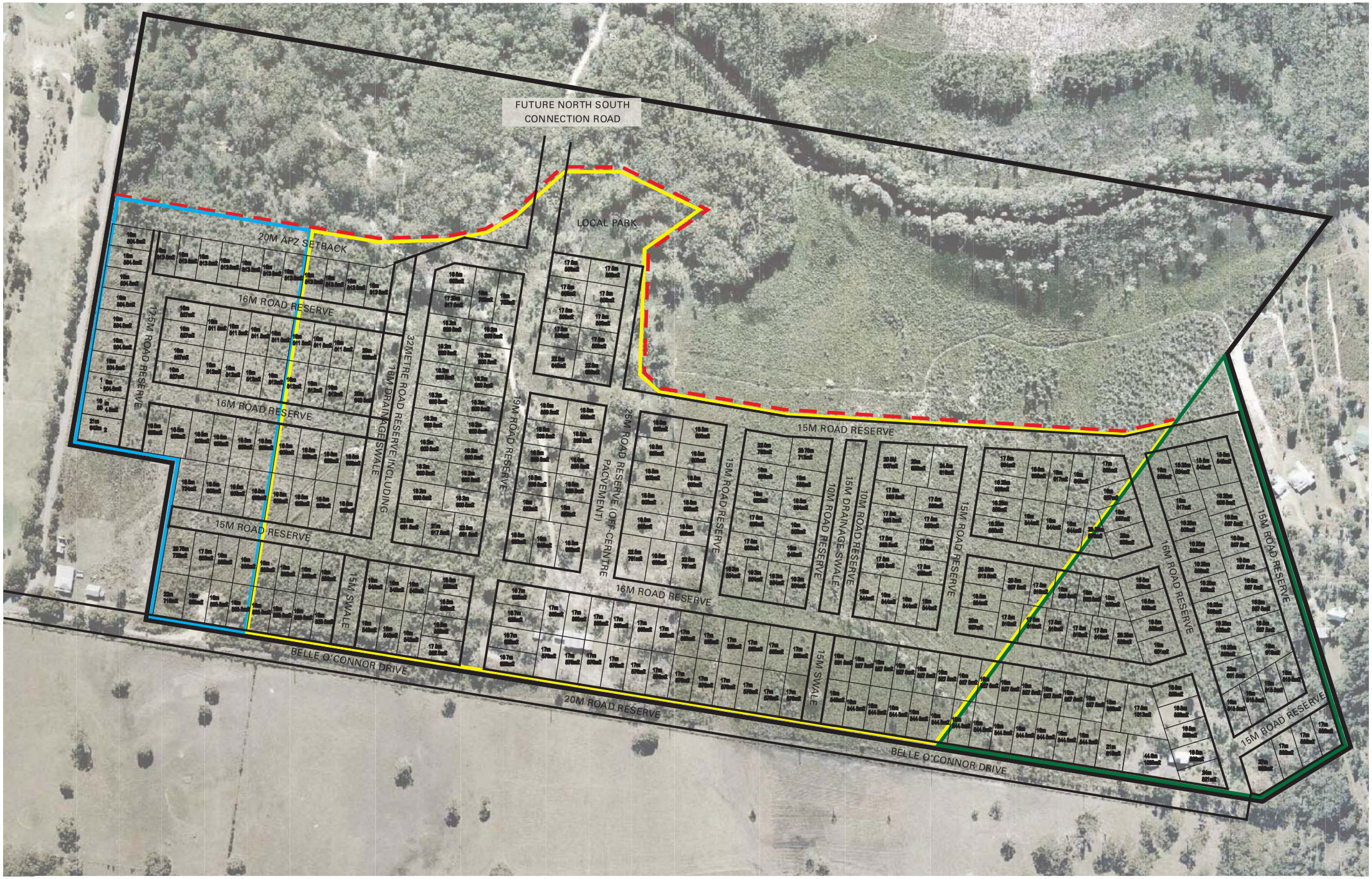
THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in m unless otherwise specified.

TITLE
EXISTING SITE PLAN AND ACID SULFATE SOILS TESTING LOCATIONS:
PROPOSED SUBDIVISION; SOUTH WEST ROCKS, NSW.

PROJECT MANAGER: MR ANDREW NORRIS
DRAWING NUMBER: P0802023JD12V01_SHEET 1

| | |
|---|---|
| DESIGNED: | MLB |
| DRAWN: | MT |
| REVIEWED: | AN |
| DATUM: | mAHD |
| HORIZONTAL RATIO: | 1:1250 @ A1<br>1:2500 @ A3 |
| VERTICAL RATIO: | 1:1250 @ A1<br>1:2500 @ A3 |
| SHEET | 1 OF 1 SHEETS |
| PAPER SIZE: | A1 / A3 |

| REV. | DESCRIPTION | DATE | ISSUED |
|---|---|---|---|
| 1 | MARTENS APRIL 2010 ASS REPORT ATTACHMENT A | 28.04.2010 | MT |




0 50 100 150 200 250m

1:2500 @ A3

**DRAFT ONLY**

SOUTH WEST ROCKS » **DRAFT FINAL LOT LAYOUT**

EDAW | AECOM

01

2784.01 ISSUE E

10 JUNE 2008

# 6 Attachment B – Soil Borehole Excavation Logs

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 20/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH201** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Quaternary/Claystone | **VEGETATION** | Grass | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 6m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 8.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1° |

| EXCAVATION DATA | | | | | | MATERIAL DATA | | | | SAMPLING & TESTING | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | SUPPORT | WATER | MOISTURE | DEPTH (M) | PENETRATION RESISTANCE (L M H R) | GRAPHIC LOG | CLASSIFICATION | DESCRIPTION OF STRATA<br>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) | GROUNDWATER BORE CONSTRUCTION DETAILS |
| A | Nil | N | M | 0.25 | | | CL | SILTY CLAY FILL - Light grey with orange mottles, moist. | | | | | 0.59m above gl<br>0.48m above gl<br>Well Cover<br>Concrete |
| A | Nil | N | M | 0.65 | | | CL | SILTY/SANDY CLAY - Brown, moist, soft to firm. | | | A | 0.5 | 2023/201/ 0.5<br>0.6m bgl<br>Bentonite Seal |
| A | Nil | N | M | 1.0<br>1.2 | | | CL | SILTY CLAY WITH MINOR SAND - Orange/brown mottles, moist, firm to stiff. | | | A | 1.0 | 2023/201/ 1.0<br>Soil and Backfill.<br>1.0 |
| A | Nil | N | M | 1.7 | | | CL | SILTY CLAY - Grey and red mottled, moist, firm to stiff, minor sand. | | | A | 1.5 | 2023/201/ 1.5<br>UPVC Pipe. |
| A | Nil | N | M | 1.9 | | | CL | SANDY CLAY - Brown, moist, with gravels (1-5mm, 10%). | | | A | 1.8 | 2023/201/ 1.8 |
| A | Nil | 2.4 Y | W | 2.0<br>3.0<br>3.5 | | | CL | SILTY CLAY - Grey with minor orange mottles, moist, firm to stiff.<br>Orange mottles disappear at depth. | | | A | 2.0 | 2023/201/ 2.0<br>2.0<br>3.0 |
| A | Nil | Y | W | 4.0<br>5.0 | | | CH | CLAY - Grey to dark grey, very stiff, moist. | | | A | 4.0 | 2023/201/ 4.0<br>4.0<br>5.0 |
| A | Nil | Y | W | 6.0<br>7.0 | | | CH | CLAY - Grey and purple mottles, grading to purple/red in colour, moist, stiff. | | | A | 5.2 | 2023/201/ 5.2<br>5.4m bgl<br>UPVC Screen.<br>6.0<br>Sand Pack.<br>7.0 |
| A | Nil | Y | W | 8.0<br>8.5 | | | CH | CLAY - Light red/purple, moist, very stiff. | | | | | 8.4m bgl<br>8.0 |
| | | | | 9.0 | | | | Borehole terminated at 8.5m on clay. | | | | | 9.0 |

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4



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

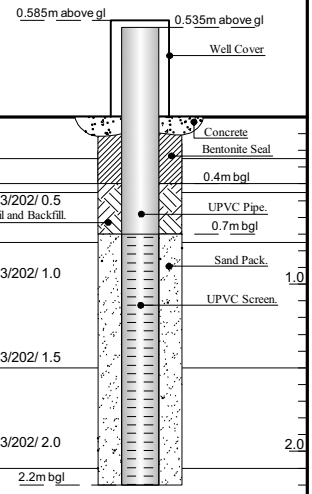
**Engineering Log - Borehole**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 20/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH202** |
| **PROJECT** | **Engineering Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Quaternary | **VEGETATION** | Grass | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 3.5m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 2.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1% |

## 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) | SAMPLING & TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Nil | N | M | 0.25 | | | SP | SAND - Dark grey/brown, moist, medium grained. | | | | | |
| A | Nil | N | M | 0.4 | | | SP | SAND - Light grey, moist, medium grained. | | | | | |
| A | Nil | N | M | 0.45 | | | SM | SILTY SAND - Light grey/black, moist, medium grained. | | | | | |
| A | Nil | N | M | 0.75 | | | SP | SAND - Yellow/dark brown, moist, cemented concreations (5-10%), medium grained. | | | A | 0.5 | 2023/202/ 0.5 Soil and Backfill. |
| A | Nil | N | M | 1.0 | | | SP | SAND - Light red/brown, moist, cemented concreations (5-10%), medium grained. | | | A | 1.0 | 2023/202/ 1.0 |
| | | 1.5 ▽ | | 1.5 | | | | | | | A | 1.5 | 2023/202/ 1.5 |
| A | Nil | Y | W | 2.0 | | | SP | SAND - Grey, wet, medium grained, minor clay content at depth. | | | A | 2.0 | 2023/202/ 2.0 |
| A | Nil | Y | W | 2.1 | | | CL | CLAY - Dark grey, stiff, moist. | | | | | 2.2m bgl |
| | | | | 2.5 | | | | Borehole terminated at 2.5m on clay. | | | A | 2.5 | 2023/202/ 2.5 |

**GROUNDWATER BORE CONSTRUCTION DETAILS**




EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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



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

***Engineering Log - Borehole***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 21/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH203** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Quaternary | **VEGETATION** | Heath | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 4.0m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 2.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1% |

| EXCAVATION DATA | | | | | | MATERIAL DATA | | | | | SAMPLING & TESTING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | SUPPORT | WATER | MOISTURE | DEPTH (M) | PENETRATION RESISTANCE (L M H R) | GRAPHIC LOG | CLASSIFICATION | DESCRIPTION OF STRATA<br>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 |
| A | Nil | N | M | 0.5 | | | SM | SILTY SAND - Grey brown, moist, medium grained. | | | A | 0.5 | 2023/203/ 0.5 |
| A | Nil | N | M | 0.6 | | | SP | SAND - Dark red brown, moist. | | | A | 0.75 | 2023/203/ 0.75 |
| | | 1.1 ▽ | | 1.0 | | | | | | | A | 1.0 | 2023/203/ 1.0 |
| A | Nil | Y | W | 1.5 | | | SP | SAND - Light brown, moist, grades to orange brown at 1.0m, wet below 1.1m, grades to light yellow at 1.6m. | | | A | 1.5 | 2023/203/ 1.5 |
| | | | | 2.0 | | | | | | | A | 2.0 | 2023/203/ 2.0 |
| | | | | 2.1 | | | | | | | | | |
| A | Nil | Y | W | 2.5 | | | CL | CLAY - Dark grey, stiff, moist. | | | A | 2.5 | 2023/203/ 2.5 |
| | | | | | | | | Borehole terminated at 2.5m on stiff clay. | | | | | |
| | | | | 3.0 | | | | | | | | | |
| | | | | 4.0 | | | | | | | | | |
| | | | | 5.0 | | | | | | | | | |
| | | | | 6.0 | | | | | | | | | |
| | | | | 7.0 | | | | | | | | | |
| | | | | 8.0 | | | | | | | | | |
| | | | | 8.5 | | | | | | | | | |
| | | | | 9.0 | | | | | | | | | |

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

martens
MARTENS & ASSOCIATES PTY LTD
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Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au


**Engineering Log - Borehole**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 22/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH204** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Quaternary | **VEGETATION** | Heath | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 4.5m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 2.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1% |

| EXCAVATION DATA | | | | | | MATERIAL DATA | | | | | SAMPLING & TESTING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | SUPPORT | WATER | MOISTURE | DEPTH (M) | PENETRATION RESISTANCE (L M H R) | GRAPHIC LOG | CLASSIFICATION | DESCRIPTION OF STRATA<br>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 |
| A | Nil | N | M | 0.4 | | | OL | ORGANIC SILTY CLAY - Dark brown, moist/wet, soft. | | | A | 0.2 | 2023/203/ 0.2 |
| A | Nil | 0.7 ▽ | M | 0.7 | | | CL | SILTY CLAY - Brown, moist, soft. | | | A | 0.5 | 2023/203/ 0.5 |
| A | Nil | Y | W | 1.0<br>2.0<br>2.5 | | | SP | SAND - Light grey/brown, wet, medium dense, dark brown from 2.0m. | | | A<br>A<br>A<br>A | 0.75<br>1.5<br>2.0<br>2.5 | 2023/203/ 0.75<br>2023/203/ 1.5<br>2023/203/ 2.0<br>2023/203/ 2.5 |
| | | | | 3.0<br>4.0<br>5.0<br>6.0<br>7.0<br>8.0<br>8.5<br>9.0 | | | | Borehole terminated at 2.5m on wet sand. | | | | | |

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

martens
MARTENS & ASSOCIATES PTY LTD
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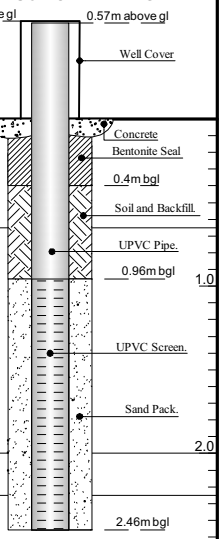
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au


**Engineering Log - Borehole**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 22/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH205** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Quaternary | **VEGETATION** | Grass | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 3.5m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 8.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1% |

| EXCAVATION DATA | | | | | | MATERIAL DATA | | | | SAMPLING & TESTING | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | SUPPORT | WATER | MOISTURE | DEPTH (M) | PENETRATION RESISTANCE (L M H R) | GRAPHIC LOG | CLASSIFICATION | DESCRIPTION OF STRATA<br>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) | GROUNDWATER BORE CONSTRUCTION DETAILS |
| A | Nil | N | M | 0.65 | | | SM | SILTY SAND - Grey, moist, minor clay, medium grained. | | | A | 0.5 | 2023/205/ 0.5 |
| A | Nil | 1.0 ▽ Y | W | 1.0 | | | SP | SAND - Cream, medium grained, moist, minor clay, wet below 1.0m. | | | A<br>A | 0.75<br>1.0 | 2023/205/ 0.75<br>2023/205/ 1.0 |
| | | | | 2.0 | | | | | | | A | 2.0 | 2023/205/ 2.0 |
| A | Nil | Y | W | 2.25 | | | SP | SAND - Grey, wet, medium grained. | | | A | 2.2 | 2023/205/ 2.2 |
| A | Nil | Y | W | 3.0<br>4.0<br>5.0 | | | CL | CLAY - Grey, very stiff. | | | A | 2.5 | 2023/205/ 2.5 |
| A | Nil | Y | W | 6.0<br>6.5 | | | SP | SAND - Grey, with minor clay, wet, medium grained. | | | | | |
| A | Nil | Y | M | 7.0<br>8.0<br>8.5 | | | CL | CLAY - Grey, grading to grey and red/orange mottled, stiff to very stiff. | | | A | 8.0 | 2023/205/ 8.0 |
| | | | | 9.0 | | | | Borehole terminated at 8.5m on stiff clay. | | | | | |




EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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



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

**Engineering Log - Borehole**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 22/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH206** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Claystone/Siltstone | **VEGETATION** | Grass | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 5.0m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 2.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1% |

| EXCAVATION DATA | | | | | | MATERIAL DATA | | | | | SAMPLING & TESTING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | SUPPORT | WATER | MOISTURE | DEPTH (M) | PENETRATION RESISTANCE (L M H R) | GRAPHIC LOG | CLASSIFICATION | DESCRIPTION OF STRATA<br>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 |
| A | Nil | N | M | 0.4 | | | CL | SILTY/SANDY CLAY - Dark grey, moist, soft. | | | A | 0.2 | 2023/206/ 0.2 |
| A | Nil | N | M | 0.7 | | | CL | CLAY - Yellow orange with grey mottles. | | | A | 0.5 | 2023/206/ 0.5 |
| A | Nil | N | W | 1.0 | | | CL | CLAY - Grey with red mottles, gravels (5-20mm, 10-15%), grades to extremely weathered claystone from 1.4m. | | | A | 1.0 | 2023/206/ 1.0 |
| | | | | 2.0 | | | | | | | A | 1.5 | 2023/206/ 1.5 |
| | | | | 2.5 | | | | | | | A | 2.5 | 2023/206/ 2.5 |
| | | | | 3.0 | | | | Borehole terminated at 2.5m on extremely weathered claystone/siltstone. | | | | | |
| | | | | 4.0 | | | | | | | | | |
| | | | | 5.0 | | | | | | | | | |
| | | | | 6.0 | | | | | | | | | |
| | | | | 7.0 | | | | | | | | | |
| | | | | 8.0 | | | | | | | | | |
| | | | | 8.5 | | | | | | | | | |
| | | | | 9.0 | | | | | | | | | |

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

martens



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

**Engineering Log - Borehole**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 22/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH207** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Claystone/Siltstone | **VEGETATION** | Grass | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 4.0m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 2.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1% |

| EXCAVATION DATA | | | | | | MATERIAL DATA | | | | | SAMPLING & TESTING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | SUPPORT | WATER | MOISTURE | DEPTH (M) | PENETRATION RESISTANCE (L M H R) | GRAPHIC LOG | CLASSIFICATION | DESCRIPTION OF STRATA<br>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 |
| A | Nil | N | M | 0.35 | | | SM | SILTY SAND - Light grey, wet, medium grained. | | | | | |
| A | Nil | N | M | 1.0 | | | CL | CLAY - Grey, moist, stiff, angular gravels (5-10mm, 5-10%), orange mottles from 0.8m, gravels increasing with depth. | | | A | 0.5 | 2023/207/ 0.5 |
| | | | | 1.4 | | | | | | | A | 1.0 | 2023/207/ 1.0 |
| A | Nil | N | W | 2.0 | | | EW | EXTREMELY WEATHERED CLAYSTONE/SILTSTONE - Gravelly clay, orange with grey mottles, gravels (5-20mm, 20%). | | | A | 1.5 | 2023/207/ 1.5<br>Possibly tuffaceous? |
| | | | | 2.5 | | | | | | | A | 2.5 | 2023/207/ 2.5 |
| | | | | | | | | Borehole terminated at 2.5m on extremely weathered claystone/siltstone. | | | | | No ground water observed after two hours. |
| | | | | 3.0 | | | | | | | | | |
| | | | | 4.0 | | | | | | | | | |
| | | | | 5.0 | | | | | | | | | |
| | | | | 6.0 | | | | | | | | | |
| | | | | 7.0 | | | | | | | | | |
| | | | | 8.0 | | | | | | | | | |
| | | | | 8.5 | | | | | | | | | |
| | | | | 9.0 | | | | | | | | | |

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

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

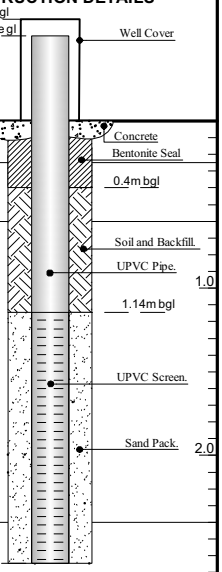

**Engineering Log - Borehole**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 22/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH208** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Quaternary | **VEGETATION** | Grass | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 4.0m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 5.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1% |

## EXCAVATION DATA / MATERIAL DATA / SAMPLING & TESTING

| METHOD | SUPPORT | WATER | MOISTURE | DEPTH (M) | PENETRATION RESISTANCE (L M H R) | GRAPHIC LOG | CLASSIFICATION | DESCRIPTION OF STRATA<br>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) | SAMPLING & TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Nil | N | M | 0.25 | | | SM | ORGANIC SILTY SAND - Dark brown/black. | | | A | 0.2 | 2023/208/ 0.2 |
| A | Nil | N | M | 0.6 | | | CL | SILTY CLAY - Orange brown and grey mottled, moist. | | | A | 0.5 | 2023/208/ 0.5 |
| A | Nil | Y | W | 1.0<br>2.0<br>2.4 | | | SP | SAND - Orange, moist, medium dense, wet and light yellow/grey from 0.9m, yellow from 1.2m, grey from 1.5m. | | | A<br>A<br>A | 1.0<br>1.5<br>2.0 | 2023/208/ 1.0<br>2023/208/ 1.5<br>2023/208/ 2.0 |
| A | Nil | Y | W | 3.0<br>4.0<br>5.0<br>5.5 | | | CL | CLAY - Grey/dark grey, moist, stiff, grades to light grey (some anguler gravels - 5-10mm, <5%) at 4.5-5.0m, light grey green from 5.2-5.5m. | | | A<br>A | 2.5<br>5.0 | 2023/208/ 2.5<br>2023/208/ 5.0 |
| | | | | 6.0<br>7.0<br>8.0<br>8.5<br>9.0 | | | | Borehole terminated at 5.5m on clay. | | | | | |

**GROUNDWATER BORE CONSTRUCTION DETAILS**




EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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



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

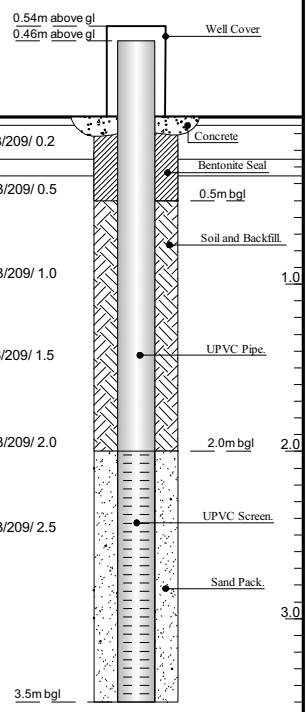
**Engineering Log - Borehole**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 22/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH209** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Quaternary | **VEGETATION** | Grass | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 4.0m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 5.5m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | 1% |

## 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) | SAMPLING & TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Nil | N | M | 0.05 | | | OL | ORGANIC SILTY SAND - Dark brown/black. | | | | | |
| A | Nil | N | M | 0.25 | | | CL | CLAY - Brown, moist. | | | A | 0.2 | 2023/209/ 0.2 |
| A | Nil | N | M | 0.35 | | | CL | SILTY CLAY - Grey, moist. | | | | | |
| | | | | 0.6 | | | | | | | A | 0.5 | 2023/209/ 0.5 |
| | | 1.1 ▽ | | 1.0 | | | | | | | A | 1.0 | 2023/209/ 1.0 |
| | | | | | | | | | | | A | 1.5 | 2023/209/ 1.5 |
| | | | | 2.0 | | | | | | | A | 2.0 | 2023/209/ 2.0 |
| A | Nil | Y | W | 3.9 | | | SP | SAND - Light grey, moist, (wet below 1.1m), medium grained. | | | A | 2.5 | 2023/209/ 2.5 |
| | | | | 4.0 | | | | | | | | | |
| A | Nil | Y | W | 5.0 | | | CL | CLAY - Grey to dark grey, moist, stiff. | | | | | |
| | | | | 5.5 | | | | Borehole terminated at 5.5m on clay. | | | | | |
| | | | | 6.0 | | | | | | | | | |
| | | | | 7.0 | | | | | | | | | |
| | | | | 8.0 | | | | | | | | | |
| | | | | 8.5 | | | | | | | | | |
| | | | | 9.0 | | | | | | | | | |

**GROUNDWATER BORE CONSTRUCTION DETAILS**




EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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



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**Engineering Log - Borehole**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CLIENT** | **Malbec Properties Pty Ltd** | **COMMENCED** | 22/2/10 | **COMPLETED** | 22/2/10 | **REF** | **BH210** |
| **PROJECT** | **Geotechnical Investigations** | **LOGGED** | JSF | **CHECKED** | ASN | **Sheet** | **1 of 1** |
| **SITE** | **South West Rocks** | **GEOLOGY** | Quaternary | **VEGETATION** | Grass | **PROJECT NO.** | P0802023 |
| **EQUIPMENT** | 4WD MOUNTED AUGER | **EASTING** | NA | **RL SURFACE** | 3.5m AHD | | |
| **EXCAVATION DIMENSIONS** | Ø 95mm X 4.2m depth | **NORTHING** | NA | **ASPECT** | North | **SLOPE** | <1% |

| EXCAVATION DATA | | | | | | MATERIAL DATA | | | | SAMPLING & TESTING | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | SUPPORT | WATER | MOISTURE | DEPTH (M) | PENETRATION RESISTANCE (L M H R) | GRAPHIC LOG | CLASSIFICATION | DESCRIPTION OF STRATA<br>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) | GROUNDWATER BORE CONSTRUCTION DETAILS |
| A | Nil | N | M | 0.01 | | | OL | ORGANIC SILTY CLAY - Dark brown/black, moist/wet, soft. | | | | | 0.51m above gl; Well Cover; Concrete |
| A | Nil | N | M | 0.35 | | | CL | SILTY CLAY - Brown orange and grey mottled, moist. | | | | | UPVC Pipe.; Bentonite Seal |
| | | 0.75 ▽ | | | | | | | | | A | 0.5 | 2023/210/0.5; 0.5m bgl; Soil and Backfill. |
| | | | | 1.0 | | | | | | | A | 1.0 | 2023/210/1.0; 0.72m bgl; 1.0 |
| | | | | | | | | | | | A | 1.5 | 2023/210/1.5 |
| A | Nil | Y | W | 2.0 | | | SP | SAND - Brown/orange, moist, medium grained, wet below 0.75m, yellow from 1.0-1.4, grey from 1.4-1.7, brown from 1.7-2.2, minor clay content from 2.5 - increasing with depth. | | | A | 2.0 | 2023/210/2.0; 2.0 |
| | | | | | | | | | | | A | 2.5 | 2023/210/2.5; UPVC Screen.; Sand Pack. |
| | | | | 3.0 | | | | | | | | | 3.0 |
| | | | | 3.5 | | | | | | | | | |
| A | Nil | Y | M | 3.8 | | | CL | CLAY - Grey, wet, very soft. | | | | | 3.72m bgl |
| A | Nil | Y | W | 4.0 | | | SP | SAND - Grey, medium grained, wet. | | | | | 4.0 |
| | | | | 4.2 | | | | Borehole terminated at 4.2m on clay. | | | | | |
| | | | | 5.0 | | | | | | | | | 5.0 |
| | | | | 6.0 | | | | | | | | | 6.0 |
| | | | | 7.0 | | | | | | | | | 7.0 |
| | | | | 8.0 | | | | | | | | | 8.0 |
| | | | | 8.5 | | | | | | | | | |
| | | | | 9.0 | | | | | | | | | 9.0 |

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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



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**Engineering Log - Borehole**

# 7 Attachment C – Field pH Test Report

# ACID SULFATE SOILS FIELD SCREENING REPORT

martens
consulting engineers since 1989

| | | | | |
|---|---|---|---|---|
| **Client** | Malbec Properties Pty Ltd | **Project Title** | Proposed Residential Subdivision South West Rocks | 1 of 3 |
| **Project #** | P0802023JS11V01 | **Address** | Lot 52 DP 831284 and Lot 84 DP 792945 | |

| Sample Ref | Depth (mbgl) | RL (mAHD) | Soil Texture | $pH_f$ | $pH_{fox}$ | Effervescence | Odour | Colour Change | pH Change | Positive Peroxide Test | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 201/0.5 | 0.50 | 4.50 | Silty clay | 4.66 | | | | | | N | |
| 201/1.0 | 1.00 | 4.00 | Silty clay | 5.41 | | | | | | N | |
| 202/0.5 | 0.50 | 3.00 | Sand | 5.25 | 4.35 | Y | Y | | -0.90 | Y | Foam on Surface |
| 202/1.0 | 1.00 | 2.50 | Sand | 5.05 | 5.92 | | | | 0.87 | N | |
| 202/1.5 | 1.50 | 2.00 | Sand | 5.20 | 4.62 | | | | -0.58 | N | |
| 202/2.0 | 2.00 | 1.50 | Sand | 5.47 | 3.72 | | | | -1.75 | Y | |
| 202/2.5 | 2.50 | 1.00 | Clay | 5.50 | 3.99 | Y | Y | | -1.51 | Y | Reaction - Violent (Heat) |
| 203/0.5 | 0.50 | 3.50 | Silty sand | 6.90 | 4.28 | Y | | | -2.62 | Y | |
| 203/1.0 | 1.00 | 3.00 | Sand | 6.43 | 5.78 | | | | -0.65 | N | |
| 203/1.5 | 1.50 | 2.50 | Sand | 6.20 | 5.67 | | | | -0.53 | N | |
| 203/2.0 | 2.00 | 2.00 | Sand | 6.38 | 5.84 | | | | -0.54 | N | |
| 204/0.5 | 0.50 | 3.50 | Silty clay | 5.64 | 5.03 | Y (Slight) | | | -0.61 | Y | Foam on Surface |
| 204/0.75 | 0.75 | 3.25 | Sand | 5.40 | 5.86 | | | | 0.46 | N | |
| 204/1.5 | 1.50 | 2.50 | Sand | 5.51 | 5.91 | | | | 0.40 | N | |
| 204/2.0 | 2.00 | 2.00 | Sand | 5.34 | 5.81 | | | | 0.47 | N | |

| | | | |
|---|---|---|---|
| **Test Device** | Eutech PCTEST35 pH meter | **Sample Recovered** | 20.02.2010 |
| **Sample History** | | **Sample Tested** | 24.02.2010 |
| **Sampled By** | J Fulton and G Taylor | **Test Method** | 30% Hydrogen Peroxide with pH 5.0 - 5.5 |
| **Job Number** | P0802023 | **Procedure** | ST-42 |
| **Laboratory Officer** | J Fulton | **Officer Signature** | |

**NOTES**

# ACID SULFATE SOILS FIELD SCREENING REPORT

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consulting engineers since 1989

| | | | | |
|---|---|---|---|---|
| **Client** | Malbec Properties Pty Ltd | **Project Title** | Proposed Residential Subdivision South West Rocks | 2 of 3 |
| **Project #** | P0802023JS11V01 | **Address** | Lot 52 DP 831284 and Lot 84 DP 792945 | |

| Sample Ref | Depth (mbgl) | RL (mAHD) | Soil Texture | $pH_f$ | $pH_{fox}$ | Effervescence | Odour | Colour Change | pH Change | Positive Peroxide Test | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 204/2.5 | 2.50 | 1.50 | Sand | 5.34 | 5.92 | | | | 0.58 | N | |
| 205/.5 | 0.50 | 3.00 | Silty sand | 5.13 | 5.62 | Y (Slight) | | | 0.49 | N | Foam on Surface |
| 205/1.0 | 1.00 | 2.50 | Sand | 5.39 | 5.81 | | | | 0.42 | N | |
| 205/2.0 | 2.00 | 1.50 | Sand | 5.39 | 5.04 | | | | -0.35 | N | |
| 205/2.2 | 2.20 | 1.30 | Sand | 5.15 | 4.78 | Y (Slight) | | | -0.37 | Y | |
| 205/2.5 | 2.50 | 1.00 | Clay | 5.01 | 3.96 | Y | | | -1.05 | Y | |
| 206/0.2 | 0.20 | 4.30 | Silty clay | 5.51 | | | | | | N | |
| 206/0.5 | 0.50 | 4.00 | Clay | 5.53 | | | | | | N | |
| 207/0.5 | 0.50 | 3.50 | Clay | 5.52 | | | | | | N | |
| 207/1.0 | 1.00 | 3.00 | Clay | 5.29 | | | | | | N | |
| 208/0.5 | 0.50 | 3.50 | Silty clay | 5.27 | 4.42 | | | | -0.85 | N | |
| 208/1.0 | 1.00 | 3.00 | Sand | 5.46 | 5.11 | | | | -0.35 | N | |
| 208/2.0 | 2.00 | 2.00 | Sand | 5.43 | 4.76 | Y (Slight) | | | -0.67 | Y | |
| 208/2.5 | 2.50 | 1.50 | Clay | 5.51 | 4.25 | Y | Y | | -1.26 | Y | Heat, Violent Reaction |
| 209/0.5 | 0.50 | 3.50 | Sandy clay | 5.04 | 6.16 | Y | | | 1.12 | N | Foam on Surface |

| | | | |
|---|---|---|---|
| **Test Device** | Eutech PCTEST35 pH meter | **Sample Recovered** | 20.02.2010 |
| **Sample History** | | **Sample Tested** | 24.02.2010 |
| **Sampled By** | J Fulton and G Taylor | **Test Method** | 30% Hydrogen Peroxide with pH 5.0 - 5.5 |
| **Job Number** | P0802023 | **Procedure** | ST-42 |
| **Laboratory Officer** | J Fulton | **Officer Signature** | |

**NOTES**

# ACID SULFATE SOILS FIELD SCREENING REPORT

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| | | | | |
|---|---|---|---|---|
| **Client** | Malbec Properties Pty Ltd | **Project Title** | Proposed Residential Subdivision South West Rocks | 3 of 3 |
| **Project #** | P0802023JS11V01 | **Address** | Lot 52 DP 831284 and Lot 84 DP 792945 | |

| Sample Ref | Depth (mbgl) | RL (mAHD) | Soil Texture | $pH_f$ | $pH_{fox}$ | Effervescence | Odour | Colour Change | pH Change | Positive Peroxide Test | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 209/1.0 | 1.00 | 3.00 | Sand | 5.21 | 6.07 | Y (Slight) | | | 0.86 | N | |
| 209/1.5 | 1.50 | 2.50 | Sand | 4.94 | 6.15 | | | | 1.21 | N | |
| 209/2.0 | 2.00 | 2.00 | Sand | 5.26 | 2.62 | Y (Slight) | | | -2.64 | Y | Reaction (slight) |
| 209/2.5 | 2.50 | 1.50 | Sand | 5.25 | 5.44 | | | | 0.19 | N | |
| 210/0.5 | 0.50 | 3.50 | Sand | 4.94 | 5.38 | | | | 0.44 | N | |
| 210/1.0 | 1.00 | 3.00 | Sand | 4.75 | 5.83 | | | | 1.08 | N | |
| 210/1.5 | 1.50 | 2.50 | Sand | 4.99 | 6.12 | | | | 1.13 | N | Foam on Surface |
| 210/2.0 | 2.00 | 2.00 | Sand | 4.92 | 1.95 | Y (Slight) | | | -2.97 | Y | Reaction (foam), slight heat |
| 210/2.5 | 2.50 | 1.50 | Sand | 4.72 | 1.65 | Y | Y | Y | -3.07 | Y | Reaction (violent), heat |

| | | | |
|---|---|---|---|
| **Test Device** | Eutech PCTEST35 pH meter | **Sample Recovered** | 20.02.2010 |
| **Sample History** | | **Sample Tested** | 24.02.2010 |
| **Sampled By** | J Fulton and G Taylor | **Test Method** | 30% Hydrogen Peroxide with pH 5.0 - 5.5 |
| **Job Number** | P0802023 | **Procedure** | ST-42 |
| **Laboratory Officer** | J Fulton | **Officer Signature** | |

**NOTES**

# 8 Attachment D – Laboratory Test Report

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

# CERTIFICATE OF ANALYSIS 38271

**Client:**
**Martens & Associates**
6/37 Leighton Place
Hornsby
NSW 2077

**Attention:** Mark Terei

**Sample log in details:**

| | |
|---|---|
| Your Reference: | **P0802023, SouthWest Rocks** |
| No. of samples: | 20 Soils |
| Date samples received: | 26/02/10 |
| Date completed instructions received: | 26/02/10 |

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

**Report Details:**

| | |
|---|---|
| Date results requested by: | 8/03/10 |
| Date of Preliminary Report: | Not Issued |
| Issue Date: | 8/03/10 |

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

**Results Approved By:**

Matt Mansfield
Chemist

| sPOCAS<br>Our Reference:<br>Your Reference<br>Depth<br>Date Sampled<br>Type of sample | UNITS<br>----------<br>---------- | 38271-1<br>2023/202<br>0.5<br>20/02/2010<br>Soil | 38271-2<br>2023/202<br>1.0<br>20/02/2010<br>Soil | 38271-3<br>2023/202<br>2.5<br>20/02/2010<br>Soil | 38271-4<br>2023/204<br>0.2<br>20/02/2010<br>Soil | 38271-5<br>2023/204<br>0.5<br>20/02/2010<br>Soil |
|---|---|---|---|---|---|---|
| Date prepared | - | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 |
| Date analysed | - | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 |
| pH kcl | pH units | 4.3 | 4.8 | 3.8 | 4.4 | 5.0 |
| TAA pH 6.5 | moles $H^+$/t | 103 | 20 | 62 | 100 | 60 |
| s-TAA pH 6.5 | %w/w S | 0.16 | 0.032 | 0.10 | 0.16 | 0.096 |
| pH Ox | pH units | 3.4 | 3.7 | 4.1 | 2.9 | 3.6 |
| TPA pH 6.5 | moles $H^+$/t | 290 | 42 | 52 | 353 | 203 |
| s-TPA pH 6.5 | %w/w S | 0.46 | 0.068 | 0.084 | 0.56 | 0.32 |
| TSA pH 6.5 | moles $H^+$/t | 188 | 22 | <5.0 | 253 | 143 |
| s-TSA pH 6.5 | %w/w S | 0.30 | 0.036 | <0.01 | 0.40 | 0.23 |
| ANCE | % $CaCO_3$ | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| a-ANCE | moles $H^+$/t | <5 | <5 | <5 | <5 | <5 |
| s-ANCE | %w/w S | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| SKCl | %w/w S | <0.005 | <0.005 | 0.007 | 0.009 | 0.023 |
| SP | %w/w | 0.028 | 0.007 | 0.012 | 0.058 | 0.077 |
| SPOS | %w/w | 0.024 | 0.005 | <0.005 | 0.049 | 0.055 |
| a-SPOS | moles $H^+$/t | 15 | <5.0 | <5.0 | 31 | 34 |
| CaKCl | %w/w | <0.005 | <0.005 | 0.015 | <0.005 | <0.005 |
| CaP | %w/w | <0.005 | <0.005 | 0.014 | <0.005 | <0.005 |
| CaA | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| MgKCl | %w/w | <0.005 | <0.005 | 0.10 | <0.005 | <0.005 |
| MgP | %w/w | <0.005 | <0.005 | 0.097 | <0.005 | 0.005 |
| MgA | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| SRAS | %w/w | 0.012 | <0.005 | <0.005 | <0.005 | <0.005 |
| SHCl | %w/w S | 0.025 | <0.005 | 0.008 | 0.019 | 0.068 |
| SNAS | %w/w S | 0.021 | <0.005 | <0.005 | 0.011 | 0.045 |
| a-SNAS | moles $H^+$/t | 9.9 | <5 | <5 | 5.0 | 21 |
| s-SNAS | %w/w S | 0.016 | <0.01 | <0.01 | <0.01 | 0.034 |
| a-Net Acidity | moles $H^+$/t | 128 | 23 | 65 | 136 | 94 |
| Liming rate | kg $CaCO_3$/t | 9.6 | 1.8 | 4.9 | 10 | 7.1 |
| a-Net Acidity without ANCE | moles $H^+$/t | NA | NA | NA | NA | NA |
| Liming rate without ANCE | kg $CaCO_3$/t | NA | NA | NA | NA | NA |

| sPOCAS<br>Our Reference:<br>Your Reference<br>Depth<br>Date Sampled<br>Type of sample | UNITS<br>----------<br>---------- | 38271-6<br>2023/204<br>1.5<br>20/02/2010<br>Soil | 38271-7<br>2023/205<br>0.5<br>20/02/2010<br>Soil | 38271-8<br>2023/205<br>1.0<br>20/02/2010<br>Soil | 38271-9<br>2023/205<br>2.2<br>20/02/2010<br>Soil | 38271-10<br>2023/205<br>2.5<br>20/02/2010<br>Soil |
|---|---|---|---|---|---|---|
| Date prepared | - | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 |
| Date analysed | - | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 |
| pH kcl | pH units | 5.2 | 4.7 | 5.1 | 4.5 | 3.9 |
| TAA pH 6.5 | moles $H^+$/t | 5 | 25 | 10 | 12 | 50 |
| s-TAA pH 6.5 | %w/w S | <0.01 | 0.040 | 0.016 | 0.020 | 0.080 |
| pH Ox | pH units | 3.5 | 3.1 | 3.7 | 3.4 | 4.0 |
| TPA pH 6.5 | moles $H^+$/t | <5.0 | 80 | 7.5 | 25 | 57 |
| s-TPA pH 6.5 | %w/w S | <0.01 | 0.13 | 0.012 | 0.040 | 0.092 |
| TSA pH 6.5 | moles $H^+$/t | <5.0 | 55 | <5.0 | 12 | 7.5 |
| s-TSA pH 6.5 | %w/w S | <0.01 | 0.088 | <0.01 | 0.020 | 0.012 |
| ANCE | % $CaCO_3$ | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| a-ANCE | moles $H^+$/t | <5 | <5 | <5 | <5 | <5 |
| s-ANCE | %w/w S | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| SKCl | %w/w S | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| SP | %w/w | 0.014 | 0.013 | 0.007 | 0.005 | 0.010 |
| SPOS | %w/w | 0.012 | 0.009 | <0.005 | <0.005 | 0.005 |
| a-SPOS | moles $H^+$/t | 7.7 | 5.7 | <5.0 | <5.0 | <5.0 |
| CaKCl | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | 0.008 |
| CaP | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | 0.008 |
| CaA | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| MgKCl | %w/w | <0.005 | <0.005 | <0.005 | 0.008 | 0.071 |
| MgP | %w/w | <0.005 | <0.005 | <0.005 | 0.007 | 0.068 |
| MgA | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| SRAS | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| SHCl | %w/w S | <0.005 | 0.005 | <0.005 | <0.005 | 0.006 |
| SNAS | %w/w S | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| a-SNAS | moles $H^+$/t | <5 | <5 | <5 | <5 | <5 |
| s-SNAS | %w/w S | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| a-Net Acidity | moles $H^+$/t | 13 | 31 | 13 | 15 | 54 |
| Liming rate | kg $CaCO_3$/t | 0.96 | 2.3 | 0.96 | 1.1 | 4.1 |
| a-Net Acidity without ANCE | moles $H^+$/t | NA | NA | NA | NA | NA |
| Liming rate without ANCE | kg $CaCO_3$/t | NA | NA | NA | NA | NA |

| sPOCAS<br>Our Reference:<br>Your Reference<br>Depth<br>Date Sampled<br>Type of sample | UNITS<br>----------<br>---------- | 38271-11<br>2023/206<br>0.2<br>20/02/2010<br>Soil | 38271-12<br>2023/206<br>0.5<br>20/02/2010<br>Soil | 38271-13<br>2023/208<br>0.5<br>20/02/2010<br>Soil | 38271-14<br>2023/208<br>1.0<br>20/02/2010<br>Soil | 38271-15<br>2023/208<br>2.0<br>20/02/2010<br>Soil |
|---|---|---|---|---|---|---|
| Date prepared | - | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 |
| Date analysed | - | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 |
| pH kcl | pH units | 4.3 | 4.2 | 4.1 | 4.7 | 4.6 |
| TAA pH 6.5 | moles $H^+$/t | 52 | 55 | 75 | 15 | 10 |
| s-TAA pH 6.5 | %w/w S | 0.084 | 0.088 | 0.12 | 0.024 | 0.016 |
| pH Ox | pH units | 3.8 | 3.5 | 3.2 | 3.4 | 3.6 |
| TPA pH 6.5 | moles $H^+$/t | 40 | 92 | 108 | 20 | 12 |
| s-TPA pH 6.5 | %w/w S | 0.064 | 0.15 | 0.17 | 0.032 | 0.020 |
| TSA pH 6.5 | moles $H^+$/t | <5.0 | 37 | 32 | 5.0 | <5.0 |
| s-TSA pH 6.5 | %w/w S | <0.01 | 0.060 | 0.052 | <0.01 | <0.01 |
| ANCE | % $CaCO_3$ | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| a-ANCE | moles $H^+$/t | <5 | <5 | <5 | <5 | <5 |
| s-ANCE | %w/w S | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| SKCl | %w/w S | <0.005 | 0.068 | <0.005 | <0.005 | <0.005 |
| SP | %w/w | 0.019 | 0.099 | 0.023 | 0.012 | <0.005 |
| SPOS | %w/w | 0.014 | 0.031 | 0.018 | 0.010 | <0.005 |
| a-SPOS | moles $H^+$/t | 8.8 | 19 | 11 | 6.5 | <5.0 |
| CaKCl | %w/w | 0.006 | <0.005 | <0.005 | <0.005 | <0.005 |
| CaP | %w/w | 0.006 | <0.005 | <0.005 | <0.005 | <0.005 |
| CaA | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| MgKCl | %w/w | 0.011 | 0.031 | 0.037 | 0.005 | 0.010 |
| MgP | %w/w | 0.010 | 0.032 | 0.035 | 0.005 | 0.009 |
| MgA | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| SRAS | %w/w | <0.005 | 0.017 | <0.005 | <0.005 | <0.005 |
| SHCl | %w/w S | 0.007 | 0.078 | 0.009 | <0.005 | <0.005 |
| SNAS | %w/w S | <0.005 | 0.010 | 0.005 | <0.005 | <0.005 |
| a-SNAS | moles $H^+$/t | <5 | <5 | <5 | <5 | <5 |
| s-SNAS | %w/w S | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| a-Net Acidity | moles $H^+$/t | 63 | 79 | 88 | 21 | 11 |
| Liming rate | kg $CaCO_3$/t | 4.7 | 5.9 | 6.7 | 1.6 | 0.80 |
| a-Net Acidity without ANCE | moles $H^+$/t | NA | NA | NA | NA | NA |
| Liming rate without ANCE | kg $CaCO_3$/t | NA | NA | NA | NA | NA |

| sPOCAS<br>Our Reference:<br>Your Reference<br>Depth<br>Date Sampled<br>Type of sample | UNITS<br>----------<br>---------- | 38271-16<br>2023/208<br>2.5<br>20/02/2010<br>Soil | 38271-17<br>2023/209<br>2.0<br>20/02/2010<br>Soil | 38271-18<br>2023/210<br>0.5<br>20/02/2010<br>Soil | 38271-19<br>2023/210<br>1.5<br>20/02/2010<br>Soil | 38271-20<br>2023/210<br>2.0<br>20/02/2010<br>Soil |
|---|---|---|---|---|---|---|
| Date prepared | - | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 |
| Date analysed | - | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 | 1/03/2010 |
| pH kcl | pH units | 4.3 | 5.1 | 5.0 | 5.2 | 4.4 |
| TAA pH 6.5 | moles $H^+$/t | 30 | <5 | 7.5 | <5 | 15 |
| s-TAA pH 6.5 | %w/w S | 0.048 | <0.01 | 0.012 | <0.01 | 0.024 |
| pH Ox | pH units | 4.3 | 3.0 | 3.5 | 3.8 | 2.6 |
| TPA pH 6.5 | moles $H^+$/t | 15 | 10 | 20 | <5.0 | 85 |
| s-TPA pH 6.5 | %w/w S | 0.024 | 0.016 | 0.032 | <0.01 | 0.14 |
| TSA pH 6.5 | moles $H^+$/t | <5.0 | 8.7 | 12 | <5.0 | 70 |
| s-TSA pH 6.5 | %w/w S | <0.01 | 0.014 | 0.020 | <0.01 | 0.11 |
| ANCE | % $CaCO_3$ | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| a-ANCE | moles $H^+$/t | <5 | <5 | <5 | <5 | <5 |
| s-ANCE | %w/w S | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| SKCl | %w/w S | <0.005 | <0.005 | 0.017 | <0.005 | 0.021 |
| SP | %w/w | 0.006 | 0.023 | 0.029 | <0.005 | 0.24 |
| SPOS | %w/w | 0.005 | 0.021 | 0.012 | <0.005 | 0.22 |
| a-SPOS | moles $H^+$/t | <5.0 | 13 | 7.7 | <5.0 | 135 |
| CaKCl | %w/w | 0.090 | <0.005 | <0.005 | <0.005 | <0.005 |
| CaP | %w/w | 0.086 | <0.005 | <0.005 | <0.005 | <0.005 |
| CaA | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| MgKCl | %w/w | 0.12 | 0.005 | <0.005 | <0.005 | <0.005 |
| MgP | %w/w | 0.11 | 0.006 | <0.005 | <0.005 | <0.005 |
| MgA | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| SRAS | %w/w | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| SHCl | %w/w S | <0.005 | <0.005 | 0.016 | <0.005 | 0.012 |
| SNAS | %w/w S | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| a-SNAS | moles $H^+$/t | <5 | <5 | <5 | <5 | <5 |
| s-SNAS | %w/w S | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| a-Net Acidity | moles $H^+$/t | 33 | 14 | 15 | <10 | 150 |
| Liming rate | kg $CaCO_3$/t | 2.5 | 1.1 | 1.1 | <0.75 | 11 |
| a-Net Acidity without ANCE | moles $H^+$/t | NA | NA | NA | NA | NA |
| Liming rate without ANCE | kg $CaCO_3$/t | NA | NA | NA | NA | NA |

| Method ID | Methodology Summary |
|---|---|
| **LAB.64** | sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. |

| QUALITY CONTROL<br>sPOCAS | UNITS | PQL | METHOD | Blank | Duplicate Sm# | Duplicate results<br>Base II Duplicate II %RPD | Spike Sm# | Spike % Recovery |
|---|---|---|---|---|---|---|---|---|
| Date prepared | - | | | 1/3/10 | 38271-1 | 1/03/2010 \|\| 1/03/2010 | LCS | 1/3/10 |
| Date analysed | - | | | 1/3/10 | 38271-1 | 1/03/2010 \|\| 1/03/2010 | LCS | 1/3/10 |
| pH kcl | pH units | | LAB.64 | 5.5 | 38271-1 | 4.3 \|\| 4.3 \|\| RPD: 0 | LCS | 99% |
| TAA pH 6.5 | moles $H^+$/t | 5 | LAB.64 | <5 | 38271-1 | 103 \|\| 113 \|\| RPD: 9 | LCS | 133% |
| s-TAA pH 6.5 | %w/w S | 0.01 | LAB.64 | <0.01 | 38271-1 | 0.16 \|\| 0.18 \|\| RPD: 12 | LCS | 136% |
| pH Ox | pH units | | LAB.64 | 3.8 | 38271-1 | 3.4 \|\| 3.5 \|\| RPD: 3 | LCS | 94% |
| TPA pH 6.5 | moles $H^+$/t | 5 | LAB.64 | <5.0 | 38271-1 | 290 \|\| 300 \|\| RPD: 3 | LCS | 110% |
| s-TPA pH 6.5 | %w/w S | 0.01 | LAB.64 | <0.01 | 38271-1 | 0.46 \|\| 0.48 \|\| RPD: 4 | LCS | 110% |
| TSA pH 6.5 | moles $H^+$/t | 5 | LAB.64 | <5.0 | 38271-1 | 188 \|\| 188 \|\| RPD: 0 | LCS | 109% |
| s-TSA pH 6.5 | %w/w S | 0.01 | LAB.64 | <0.01 | 38271-1 | 0.30 \|\| 0.30 \|\| RPD: 0 | LCS | 110% |
| ANCE | % $CaCO_3$ | 0.05 | LAB.64 | <0.05 | 38271-1 | <0.05 \|\| <0.05 | [NR] | [NR] |
| a-ANCE | moles $H^+$/t | 5 | LAB.64 | <5 | 38271-1 | <5 \|\| <5 | [NR] | [NR] |
| s-ANCE | %w/w S | 0.05 | LAB.64 | <0.05 | 38271-1 | <0.05 \|\| <0.05 | [NR] | [NR] |
| SKCl | %w/w S | 0.005 | LAB.64 | <0.005 | 38271-1 | <0.005 \|\| <0.005 | LCS | 121% |
| SP | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | 0.028 \|\| 0.025 \|\| RPD: 11 | LCS | 111% |
| SPOS | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | 0.024 \|\| 0.021 \|\| RPD: 13 | LCS | 110% |
| a-SPOS | moles $H^+$/t | 5 | LAB.64 | <5.0 | 38271-1 | 15 \|\| 13 \|\| RPD: 14 | LCS | 109% |
| CaKCl | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | <0.005 \|\| <0.005 | LCS | 112% |
| CaP | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | <0.005 \|\| <0.005 | LCS | 103% |
| CaA | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | <0.005 \|\| <0.005 | [NR] | [NR] |
| MgKCl | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | <0.005 \|\| <0.005 | LCS | 109% |
| MgP | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | <0.005 \|\| <0.005 | LCS | 97% |
| MgA | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | <0.005 \|\| <0.005 | [NR] | [NR] |
| SRAS | %w/w | 0.005 | LAB.64 | <0.005 | 38271-1 | 0.012 \|\| 0.014 \|\| RPD: 15 | [NR] | [NR] |
| SHCl | %w/w S | 0.005 | LAB.64 | <0.005 | 38271-1 | 0.025 \|\| 0.025 \|\| RPD: 0 | LCS | 88% |
| SNAS | %w/w S | 0.005 | LAB.64 | <0.005 | 38271-1 | 0.021 \|\| 0.021 \|\| RPD: 0 | [NR] | [NR] |
| a-SNAS | moles $H^+$/t | 5 | LAB.64 | <5 | 38271-1 | 9.9 \|\| 9.8 \|\| RPD: 1 | [NR] | [NR] |
| s-SNAS | %w/w S | 0.01 | LAB.64 | <0.01 | 38271-1 | 0.016 \|\| 0.016 \|\| RPD: 0 | [NR] | [NR] |
| a-Net Acidity | moles $H^+$/t | 10 | LAB.64 | <10 | 38271-1 | 128 \|\| 135 \|\| RPD: 5 | LCS | 110% |
| Liming rate | kg $CaCO_3$/t | 0.75 | LAB.64 | <0.75 | 38271-1 | 9.6 \|\| 10 \|\| RPD: 4 | LCS | 110% |

| QUALITY CONTROL<br>sPOCAS | UNITS | PQL | METHOD | Blank | Duplicate Sm# | Duplicate results<br>Base II Duplicate II %RPD | Spike Sm# | Spike % Recovery |
|---|---|---|---|---|---|---|---|---|
| a-Net Acidity without ANCE | moles $H^+$/t | 10 | LAB.64 | <10 | 38271-1 | NA \|\| NA | [NR] | [NR] |
| Liming rate without ANCE | kg $CaCO_3$ /t | 0.75 | LAB.64 | <0.75 | 38271-1 | NA \|\| NA | [NR] | [NR] |

| QUALITY CONTROL<br>sPOCAS | UNITS | Dup. Sm# | Duplicate<br>Base + Duplicate + %RPD |
|---|---|---|---|
| Date prepared | - | 38271-11 | 1/03/2010 \|\| 1/03/2010 |
| Date analysed | - | 38271-11 | 1/03/2010 \|\| 1/03/2010 |
| pH kcl | pH units | 38271-11 | 4.3 \|\| 4.3 \|\| RPD: 0 |
| TAA pH 6.5 | moles $H^+$/t | 38271-11 | 52 \|\| 52 \|\| RPD: 0 |
| s-TAA pH 6.5 | %w/w S | 38271-11 | 0.084 \|\| 0.084 \|\| RPD: 0 |
| pH Ox | pH units | 38271-11 | 3.8 \|\| 3.5 \|\| RPD: 8 |
| TPA pH 6.5 | moles $H^+$/t | 38271-11 | 40 \|\| 60 \|\| RPD: 40 |
| s-TPA pH 6.5 | %w/w S | 38271-11 | 0.064 \|\| 0.096 \|\| RPD: 40 |
| TSA pH 6.5 | moles $H^+$/t | 38271-11 | <5.0 \|\| 7.5 |
| s-TSA pH 6.5 | %w/w S | 38271-11 | <0.01 \|\| 0.012 |
| ANCE | % $CaCO_3$ | 38271-11 | <0.05 \|\| <0.05 |
| a-ANCE | moles $H^+$/t | 38271-11 | <5 \|\| <5 |
| s-ANCE | %w/w S | 38271-11 | <0.05 \|\| <0.05 |
| SKCl | %w/w S | 38271-11 | <0.005 \|\| <0.005 |
| SP | %w/w | 38271-11 | 0.019 \|\| 0.020 \|\| RPD: 5 |
| SPOS | %w/w | 38271-11 | 0.014 \|\| 0.016 \|\| RPD: 13 |
| a-SPOS | moles $H^+$/t | 38271-11 | 8.8 \|\| 9.8 \|\| RPD: 11 |
| CaKCl | %w/w | 38271-11 | 0.006 \|\| 0.006 \|\| RPD: 0 |
| CaP | %w/w | 38271-11 | 0.006 \|\| 0.006 \|\| RPD: 0 |
| CaA | %w/w | 38271-11 | <0.005 \|\| <0.005 |
| MgKCl | %w/w | 38271-11 | 0.011 \|\| 0.011 \|\| RPD: 0 |
| MgP | %w/w | 38271-11 | 0.010 \|\| 0.010 \|\| RPD: 0 |
| MgA | %w/w | 38271-11 | <0.005 \|\| <0.005 |
| SRAS | %w/w | 38271-11 | <0.005 \|\| <0.005 |
| SHCl | %w/w S | 38271-11 | 0.007 \|\| 0.008 \|\| RPD: 13 |
| SNAS | %w/w S | 38271-11 | <0.005 \|\| <0.005 |
| a-SNAS | moles $H^+$/t | 38271-11 | <5 \|\| <5 |
| s-SNAS | %w/w S | 38271-11 | <0.01 \|\| <0.01 |

| QUALITY CONTROL sPOCAS | UNITS | Dup. Sm# | Duplicate Base + Duplicate + %RPD |
|---|---|---|---|
| a-Net Acidity | moles $H^+$/t | 38271-11 | 63 \|\| 64 \|\| RPD: 2 |
| Liming rate | kg $CaCO_3$ /t | 38271-11 | 4.7 \|\| 4.8 \|\| RPD: 2 |
| a-Net Acidity without ANCE | moles $H^+$/t | 38271-11 | NA \|\| NA |
| Liming rate without ANCE | kg $CaCO_3$ /t | 38271-11 | NA \|\| NA |

**Report Comments:**

Asbestos was analysed by Approved Identifier: Not applicable for this job
INS: Insufficient sample for this test NT: Not tested PQL: Practical Quantitation Limit <: Less than >: Greater than
RPD: Relative Percent Difference NA: Test not required LCS: Laboratory Control Sample NR: Not requested

**Quality Control Definitions**

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

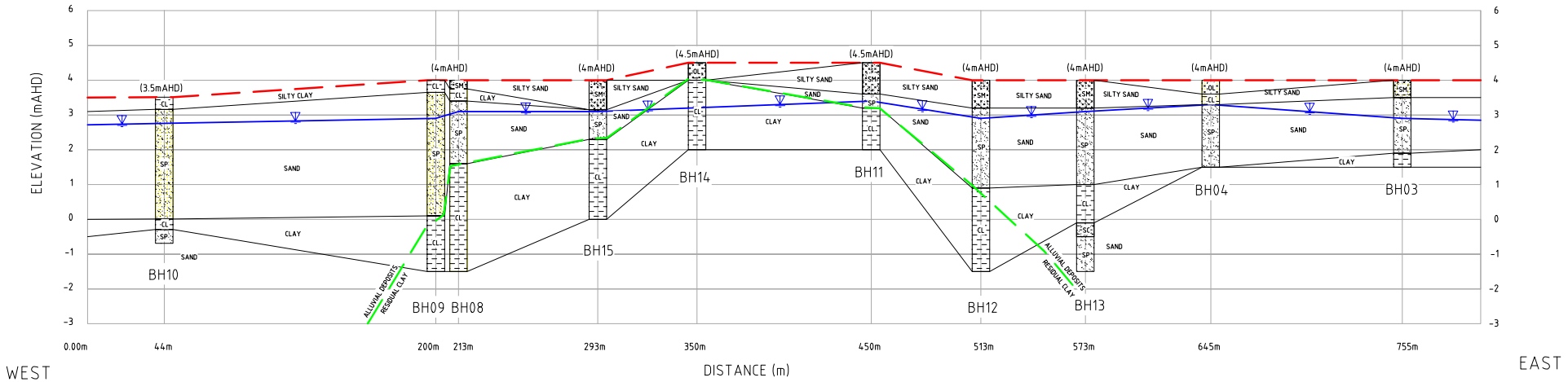
**Laboratory Acceptance Criteria:**

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

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes and LCS: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable. Surrogates: 60-140% is acceptable for general organics and 10-140% for SVOC and speciated phenols.

# 9 Attachment E – Catenary Sequence

SECTION A – A'




KEY

- SILTY SAND (SM)
- ORGANIC CLAYEY SILT (OL)
- SAND (SP)
- CLAY (CL)
- SOIL SAMPLES WHICH RETURN POSITIVE PEROXIDE TEST RESULT OR TRIGGER ASSMAC (1998) ACTION CRITERIA
- ESTIMATED GROUND WATER LEVEL
- APPROXIMATE NATURAL SURFACE LEVEL
- APPROXIMATE BOUNDARY BETWEEN ALLUVIAL DEPOSITS AND RESIDUAL CLAY SOIL

0 24 48 72 96 120
UNITS – METRES
SCALE – 1:1250 @ A1 1:2500 @ A3



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MARTENS & ASSOCIATES PTY LTD
Sustainable Solutions
Environmental - Geotechnical - Civil
Hydraulic - Wastewater Engineers

CLIENT/ PROJECT: MALBEC PROPERTIES PTY LTD

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY. All measurements in m unless otherwise specified.

TITLE: CATENARY SEQUENCE: PROPOSED SUBDIVISION; SOUTH WEST ROCKS, NSW.

PROJECT MANAGER: MR ANDREW NORRIS

DRAWING NUMBER: P0802023JD13V01_SHEET 5

| | |
|---|---|
| DESIGNED: | MT |
| DRAWN: | KT |
| REVIEWED: | AN |
| DATUM: | mAHD |
| HORIZONTAL RATIO: | 1:1250 @ A1<br>1:2500 @ A3 |
| VERTICAL RATIO: | 1:62.5 @ A1<br>1:125 @ A3 |
| SHEET | 1 |
| OF | 1 SHEETS |
| PAPER SIZE: | A1 / A3 |

| REV. | DESCRIPTION | DATE | ISSUED |
|---|---|---|---|
| 1 | MARTENS APRIL 2010 ASS REPORT ATTACHMENT | 28.04.2010 | MT |

# 10 Attachment F – Notes About This Report

# Information

## Important Information About Your Report

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

### Engineering Reports - Limitations

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

### Engineering Reports – Project Specific Criteria

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

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

### Engineering Reports – Recommendations

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

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

### Engineering Reports – Use For Tendering Purposes

Where information obtained from this investigation is provided for tendering purposes, Martens recommend that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. Attention is drawn to the document 'Guidelines for the Provision of Geotechnical Information in Tender Documents', published by the Institution of Engineers, Australia.

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

### Engineering Reports – Data

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

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

### Engineering Reports – Other Projects

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

### Subsurface Conditions - General

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

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

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and

policy by statutory authorities.

- The actions of contractors responding to commercial pressures.

- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

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

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

**Subsurface Conditions - Changes**

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

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

**Subsurface Conditions - Site Anomalies**

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

**Report Use By Other Design Professionals**

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

**Subsurface Conditions - Geoenvironmental Issues**

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

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

**Responsibility**

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

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

**Site Inspections**

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

# Soil Data

## Explanation of Terms (1 of 3)

### Definitions

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

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726 and the S.A.A Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

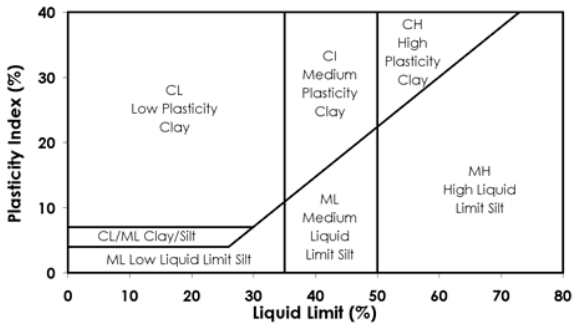
### Particle Size

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

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

### Plasticity Properties

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




### Moisture Condition

Dry — Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist — Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet — As for moist but with free water forming on hands when handled.

### Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

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

### Density of Granular Soils

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

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

### Minor Components

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

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

# Soil Data

## Explanation of Terms (2 of 3)

martens consulting engineers

### Soil Agricultural Classification Scheme

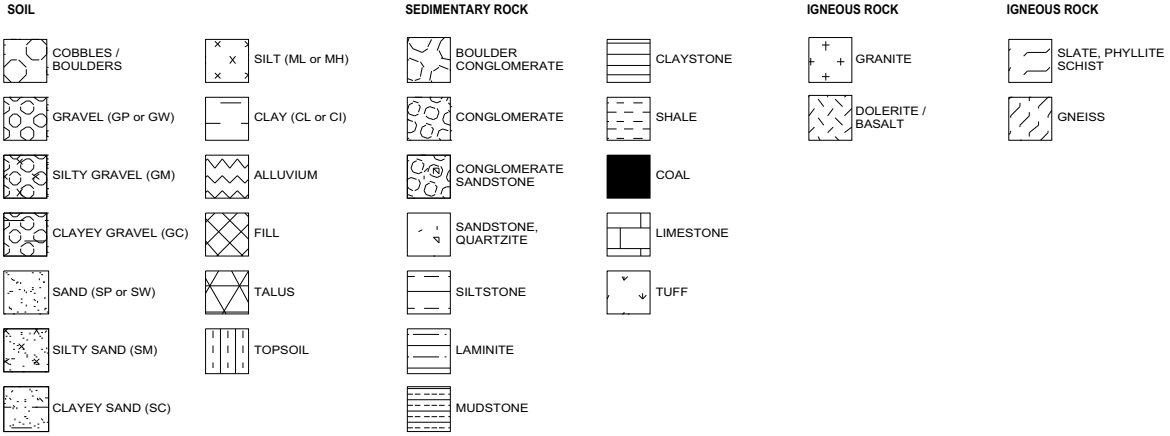
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions 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 |
| FINE GRAINED SOILS More than 50 % of material less than 63 mm is smaller than 0.075 mm | | IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM | | | | |
| | | DRY STRENGTH (Crushing Characteristics) | DILATANCY | TOUGHNESS | DESCRIPTION | USCS | Primary Name |
| | | None to Low | Quick to Slow | 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 weak | < 0.03 | Easily remoulded by hand to a material with soil properties. | EW |
| Very weak | 0.03 - 0.1 | May be crumbled in the hand. Sandstone is 'sugary' and friable. | VW |
| Weak | 0.1 - 0.3 | A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling. | W |
| Medium strong | 0.3 - 1 | A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife. | MS |
| Strong | 1 - 3 | A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife. | S |
| Very Strong | 3 - 10 | A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife. | VS |
| Extremely strong | > 10 | A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer. | ES |

# Rock Data

## Explanation of Terms (2 of 2)

martens consulting engineers

### Degree of Fracturing

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

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

# Test Methods

## Explanation of Terms (1 of 2)

martens consulting engineers

### 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

# Test Methods

## Explanation of Terms (2 of 2)

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.