Technical Paper

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Acid Sulfate Soil Assessment

PRELIMINARY ACID SULFATE SOIL ASSESSMENT REPORT

FOR THE NORTH BYRON PARKLANDS PROJECT & CONCEPT PLAN APPLICATION

AT

NORTH BYRON PARKLANDS SITE, WOOYUNG, NSW

An assessment of potential and actual acid sulfate soils

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For: **North Byron Parklands (C/- SJ Connelly CPP Pty Ltd)**
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1 INTRODUCTION

EAL Consulting Services of the Environmental Analysis Laboratory (EAL) has been commissioned by North Byron Parklands (on behalf of Billinudgel Property Pty Ltd) to undertake a preliminary acid sulfate soil assessment for a proposed temporary place of assembly with camping and associated infrastructure at Jones Road, Wooyung, NSW (Fig. 1; Appendix 1).

This report is prepared in respect of a current Concept Plan and Project Application Environmental Assessment report (EA) for the North Byron Parklands (Parklands) project. This EA has been prepared on behalf of Billinyudgel Property trust (Billinudgel Property Pty Ltd). The total allotment area (i.e. North Byron Parklands) is approximately 263.4ha. The area assessed for this investigation (Proposed Cultural Event Site) is considered to be approximately 93 ha (Fig. 2; Appendix 1).

In accordance with the guidance provided in Stone et al. (1998), a preliminary assessment is required prior to the development of an effective Acid Sulfate Soil Management Plan (ASSMP). The requirements for the management and mitigation of ASS will be based upon the findings of this (and/or any other relevant) investigation(s) and a detailed description of the extraction/excavation activities associated with the proposed development of the site.

1.1 SCOPE OF WORKS

The objectives of this assessment are in accordance with Section 2 of the Acid Sulfate Soil Management Advisory Committee (ASSMAC) Assessment Guidelines (Stone et al. 1998):

"…. *To determine whether Acid Sulfate Soils are present and if works are likely to disturb these soils."*

The following applies to this assessment;

1. *To establish whether Acid Sulfate Soils are present on the site and if they are in such concentrations so as to warrant further investigations; and*
2. *To provide information to assist in decision-making.*

Therefore, this preliminary assessment is used to identify the following:

- The presence and distribution of potential and/or actual acid sulfate soil(s) within the subject site;
- The potential for intersection and disturbance of potential and/or actual acid sulfate soil(s) as part of the development of the site.

The preliminary assessment will also:

- Discuss the current site conditions with respect to acid sulfate soils;
- Undertake a site-specific soil sampling and analysis program to identify the presence (or absence) of ASS and peat soils (utilising previously collected information (i.e. Coffey 2007 and APP 2007));
- Assess the need for further investigations;
- Provide an assessment of requirements and recommendations for acid sulfate soil management.

The relevant guidelines used for the investigation are as follows:

- Stone, Y., Ahern, C. and Blunden, B. (1998). *Acid Sulfate Soils Manual*, Acid Sulfate Soil Management Advisory Committee (ASSMAC) Wollongbar, NSW.
- Ahern, CR, McElnea AE, Sullivan LA (2004). *Acid Sulfate Soils Laboratory Methods Guidelines*. QLD DNRME.

1.2 SITE IDENTIFICATION

The property description(s) for the North Byron Parklands site, their areas and current zonings are provided below (as provided by SJ Connelly CPP 2009).

Lot/DP Description	**Area (ha.)**
Lot 403 and Part Lots 402,404 DP 755687	104.71
Lot 1 DP 1145020*	2.47
Part Lot 46 DP 755687	8.43
Part Lot 10 DP 875112	4.29
Part Lot 2 DP848618	8.9
Part Lot 30 DP880376	9.89
Part Lot 102 DP1001878	15.17
Part Lot 12 DP848618	2.05
TOTAL of APPLICATION AREA	**155.91**

The site is an irregular shaping of individual allotments located approximately 7.0 km north-west of the CBD of Brunswick Heads. The site is located in a coastal area and primary access is to be via a proposed access off the Tweed Valley Way within the sites southern extent.

1.3 PROPOSED DEVELOPMENT DESCRIPTION

The purpose of the North Byron Shire Parklands site is to provide a location to host cultural, arts and music events. The site is to contain areas for car parking and camping along with conference facilities a cultural centre and a mix of ecological restoration and agricultural uses. Fig. 2 (Appendix 1) illustrates the layout of the proposed development. Key development activities regarding ASS include:

- Construction of access roads, amenities block(s) and recreational facilities (as well as associated infrastructure; services and utilities) as depicted in Fig. 3.

1.4 ASS DEFINITIONS

The term 'acid sulfate soils' includes both 'potential' and 'actual' acid sulfate soils. Actual and potential acid sulfate soils are often found in the same soil profile, with actual acid sulfate soils generally overlying potential acid sulfate soil horizons.

"Actual acid sulfate soils" (or *sulfuric soils*) are soils containing highly acidic soil horizons or layers resulting from the oxidation of soil materials that are rich in sulfides, primarily pyrite. This oxidation produces acidity in excess of the sediment's capacity to neutralise the acidity resulting in soils of pH4.0 or less.

Isbell (2002) describes sulfuric soils as "*soil material that has a pH less than 4 (1:1 by weight in water, or in a minimum of water to permit measurement) when measured in dry season conditions as a result of the oxidation of sulfidic materials (defined above). Evidence that low pH is caused by oxidation of sulfides is one of the following:*

- *yellow mottles and coatings of jarosite (hue of 2.5Y or yellower and chroma of about 6 or more).*
- *underlying sulfidic material*."

"Potential acid sulfate soils" (or *sulfidic soils*) are soils that contain iron sulfides or sulfidic material that has not been exposed to air and oxidised. The field pH of these soils in their unoxidised state is>4.0. They may be neutral or slightly alkaline.

Isbell (2002) describes sulfidic soils as "*a subsoil, waterlogged, mineral or organic material that contains oxidisable sulfur compounds, usually iron disulfide (e.g. pyrite, FeS_2), that has a field pH of 4 or more but which will become extremely acid when drained. Sulfidic material is identified by a drop in pH by at least 0.5 unit to 4 or less (1:1 by weight in water, or in a minimum of water to permit measurement) when a 10mm thick layer is incubated at field capacity for 8 weeks. For a quick screening test that is not definitive, a 10 g sample treated with 50 ml of 30 % H_20_2 will show a fall in pH to 2.5 or less*."

1.5 ASS RISK MAPPING

The subject site is depicted in the Department of Land and Water Conservation's (DLWC) *Burringbar/Pottsville 1:25,000 Acid Sulfate Soil Risk Map Edition Two* (DLWC 1997). Three (3) separate Risk classes have been identified across the subject, shown below in Table 1.

Table 1. Identified ASS Risk classes for the subject site

Risk Class	Probability of Occurrence	Landform Process	Landform Element	Elevation (m)
Lap2	Low	Alluvial	Plain	2 - 4
Lap2(p)	Low	Alluvial	Plain	2 - 4
Las1(p)	Low	Alluvial	Swamp	1 - 2

ASS occurrence within these landforms is typically highly localised, with disturbance and subsequent risk of exposure and oxidation primarily varying with elevation and depth of disturbance.

Byron Shire Council's LEP (1988) Clause 63 regulates and identifies works that have the potential to disturb ASS. The subject site is identified in Council's ASS Planning map with the indicated classes shown in Table 2.

Table 2. BSC ASS Planning Classes (1988) identified for the subject site

ASS Risk Class	Specified Works
Class 2	• Works below the ground surface • Works by which the water table is likely to be lowered
Class 3	• Works beyond 1 m below the natural ground surface • Works by which the water table is likely to be lowered beyond 1 m below the natural ground surface

The risk maps for determining the depth to the ASS layer utilised the relationship between ground surface elevated and the critical elevation for the upper level of ASS occurrence, being 1m AHD.

Fig. 3 (Appendix 1) illustrates the DLWC (1997) ASS Risk mapping for the site, on which BSC ASS planning maps are based.

2 ENVIRONMENTAL SETTING

2.1 TOPOGRAPHY AND HYDROLOGY

The subject site is intersected by three ridgelines. The majority of the site is at elevations of 10m or less. The foothill of a ridgeline intersects the southern-most corner of the site to an elevation of approximately 20m. The middle of the site is intersected by Jones Road (in a predominantly east west orientation) which also follows a ridgeline (Marshall's Ridges) to an elevation of approximately 30m. The north-western corner of the site rises to approximately 90m in elevation. Thus the subject site (and majority of study area) has a slope of 0 – 2%. Other areas of the site have slopes up to 20%.

The site has been extensively drained for agricultural purposes. A number of first order ephemeral streams and natural drainage paths descend the slopes of the three ridgelines intersecting the site to be intercepted by the constructed drainage paths in the sites north.

The southern section of the site is intersected by Yelgun Creek which is predominantly fed by draining the ridges and slopes to the west of the site.

2.2 LOCAL GEOLOGY AND SOILS

The geology of the site comprises three distinct geological units:

1. Rolling hills on metamorphics of the Neranleigh-Fernvale Group, associated with the *Billinudgel* (**bi**) erosional landscape, described by Morand (1996) as:
   - Deep (>100 cm), moderately well-drained Red Podzolic Soils (Dr2.21, DR4.21) on crests; moderately deep (70-100cm), moderately well-drained Yellow Earths (Gn3.74, Uf6.33) and Yellow Podzolic Soils (Dy3.11, Dy2.11) on slopes and better-drained areas;
   - These soils are depicted by Morand (1996) to occur within the central, north-western and southernmost portions of the site above elevations of 10m AHD. BH4, BH9, BH10, BH11 and BH12 were excavated within the boundary zone between the raised ridgeline (i.e. **bi** soils) and the inner barrier dune system (i.e. **kib** soils).

2. Low-lying, gently undulating Pleistocene sand sheets overlying peat and alluvium, associated with the *Kingscliff Variant b* (**kib**) aeolian and *Pottsville* (**po**) aeolian/swamp landscapes, described by Morand (1996) as:

Kingscliff Variant b:

- Deep (>200 cm), generally well-drained Podzols (Uc2.22, Uc2.21;
- These soils are depicted by Morand (1996) to occur within the northern and north-eastern sections of the site below 10m AHD. BH1 -3 and BH5 – 8 were excavated within the inner barrier dune system.

Pottsville:

- Deep (>300 cm), poorly drained Podzols and Humus Podzols (Uc2.33); deep (>300 cm), poorly drained Humic Gleys (Uf6.51) and Acid Peats (O) in very low depressions;
- These soils are depicted by Morand (1996) to occur within the south-eastern section of the site, also below 10m AHD. BH14 – BH17 were excavated within the **po** landscape.

3. Deep Quaternary alluvium (alluvial fans and valley infills) derived from surrounding metamorphics, associated with Op*hir Glen (og)* transferral landscape *and Crabbes Creek (cr)* alluvial landscape, described by Morand (1996) as:

Crabbes Creek:

- Deep (>200 cm), well-drained Brown Alluvial Clays and Clay Loams (Uf6.12, Um1.43) on lower terraces; deep (>200 cm), well-drained Brown Alluvial Clays (Uf6.12, Uf6.33, Uf6.53) on upper terraces;
- These soils were located in the south-western section of the site, west of the soils described as the po landscape (Morand 1996). Bh13 was excavated within the **cr** landscape..
- These soils are mapped in the central section of the site and in the southern most section of the site. Sampling did not occur in this area.

Ophir Glen:

- Deep (>100 cm), poorly drained Yellow Podzolic Soils (DY3.11); deep (>100 cm), moderately well-drained minimal Prairie Soils (Gn3.41). Deep (>100cm), poorly drained minimal Brown Podzolic Soils (Db3.11) on lower portions of some coastal fans;
- These soils are mapped in the central western section of the site. Sampling did not extend to this area.

Observations made of the soils encountered during this investigation are consistent with the Morand (1996) descriptions of the above soils with some localised variations between soil types typically associated with boundary overlapping.

2.3 LOCAL HYDROGEOLOGY

The soils of the low-lying coastal barrier within lands below 10m AHD are considered to represent a Coastal Sand Bed Groundwater System, supporting wetlands, terrestrial vegetation and hypogean ecosystems. Wetlands associated with this system are often referred to as groundwater windows as they typically indicate the groundwater levels in the surrounding sand beds and ridges (DLWC 2002). Maintenance of the existing salt water /fresh water interface is essential in order to prevent salt water intrusion following dewatering or excessive extraction of groundwater.

A search of existing licensed groundwater bores within 250m of the subject site was conducted using the NSW Natural Resource Atlas (NRATLAS 2010) website. One (1) licensed groundwater bore is located within the bounds of the site. This bore (GW305158) is located in the western section of Lot 102 DP1001878. GW305158 is licensed for both domestic and stock purposes. It has a final depth of 42m with a Standing Water level of 2.80m below ground level (bgl). The Water bearing zone is located between 22 to 38m bgl. Four (4) other licensed groundwater bores were identified within 250m of the site. Three (3) are licensed for monitoring purposes with the fourth being licensed for Domestic uses.

Groundwater table heights within low-lying alluvial and aeolian plains were found to be typically within a metre of the natural land surface (refer Borelogs; Appendix 2).

3 INVESTIGATION METHODOLOGY

3.1 GENERAL METHODOLOGY

The methodology used to conduct this preliminary ASS assessment included:

- A review of any available documentation that may be of assistance in establishing the presence of ASS within the subject area (e.g. mapping, assessments and investigations conducted for nearby developments as well as soil and water analyses);
- A site inspection/sampling effort to identify the subsurface conditions within the proposed areas of disturbance in order to ascertain if potential and/or actual acid generating layers are present;
- Identification of the potential for groundwater intercept, including existing groundwater bore searches and field excavations ; and
- Identification of the need for further ASS and groundwater investigation works.

3.2 SOIL SAMPLING AND ANALYSIS METHODOLOGY

Site assessments included subsurface investigations by way of borehole excavations. The methodology for subsoil investigations included:

- Field visual assessment of site indicators for presence of actual or potential acid sulfate soils;
- Boreholes were manually excavated in seventeen (17) locations across the site (Fig. 4; Appendix 1) in order identify local subsurface conditions and local water table heights;
- Samples were collected every 500 mm vertically down the excavated soil profile or from each soil horizon encountered during excavations;
- All sampling was undertaken by Troy Shepherd and Matt Pocock of EAL;
- All samples were collected using a stainless steel extendable (gouge) auger, decontaminated (DECON – 90) between each sample collection point;
- Soil samples were sealed in double plastic bags to exclude all air and reduce oxidation. Samples were kept cold in an esky and immediately delivery to the EAL;

- All soil preparation and analysis was conducted by EAL using NATA (National Association of Testing Authorities) certified analysis. All soil samples collected were dried at 80°C. Samples were ground in a ring mill grinder to a fine powder (<10 micron) which was stored in sealed polypropylene vials. Samples are stored for greater than 12 months to allow retesting if required; and
- All samples (69) were subjected to Chromium Reducible Sulfur analysis (in accordance with Methods 21, 23 and 22B – Stone et al. 1998) suite (including Titratable Actual Acidity (TAA) and CRS oxidisable sulphur) and thirty-nine (39) samples were subjected to Extractable sulfate sulfur analysis (in accordance with Method 23C – Stone et al. 1998). All methods are NATA registered.

3.3 ASS ACTION CRITERIA

Stone et al. (1998) outlines the action criteria based on threshold values for oxidisable sulfur or acidity. These criteria are based on three (3) broad texture categories, as shown in Table 3 (below) and are intended to trigger the need for detailed acid sulfate soil management where development is planned.

Table 3: Acid Sulfate Soil Action Criteria (Stone et al*.* 1998)

Texture Category	**Texture Range**	**Approx. Clay Content (< 0.002mm) %**	**Action Criteria**	
			Sulfur Trail (%S oxidisable	Acid Trail mol H^{+}/tonne
Coarse	Sands to Loamy Sands	5	0.03	19
Medium	Sandy Loams to Light Clays	5 – 40	0.06	37
Fine	Medium to Heavy Clays and Silty Clays	40	0.10	62

For projects that will disturb more than 1000 tonnes of ASS, the 0.03% % S trigger is typically adopted for all soil texture types. For the purpose of this assessment, the 0.03%S trigger and 19molH+/tonne trigger values have been adopted to signify. For the purpose of identifying AASS, extractable sulfate sulfur levels (%SKCl) of 0.03% have been adopted as the trigger for this assessment, in conjunction with the presence of underlying PASS indications.

4 PREVIOUSLY COLLATED INFORMATION

4.1 COFFEY GEOTECHNICS GEOTECHNICAL INVESTIGATION (MARCH 07)

Coffey Geotechnics have conducted an ASS assessment (March 2007) of the northern section of the site (as shown in Fig. 5; Appendix). Coffey's report indicates that the 2007 assessment of ASS consisted of the analysis of twelve (12) individual soil samples collected from the four (4) boreholes (HA1, HA2, HA3 and HA4). A review of the laboratory certificates (E7052; Coffey 2007) indicates that the soils collected were highly acidic with levels of oxidisable sulfur recorded as above limits of detection. Titratable Actual Acidity (TAA) results for E7052 shows that significant existing acidity is present within soils down the profile, and with the presence of detectable levels of elevated oxidisable sulfur levels, the soils from HA1 – HA4 were considered to be (actual) ASS.

4.2 APP ASS MANAGEMENT PLAN (JUNE 07)

Following the findings of the ASS assessment conducted by Coffey (March 2007), Ardill Payne and Partners (APP) prepared an Acid Sulfate Soil Management Plan (ASSMP) for the site. APP stated that in the event that excavations exceed the depth of the topsoil layer in class 3 areas, or if potential ASS soils are encountered, management and treatment actions will be required.

5 RESULTS

5.1 SOIL STRATIGRAPHY AND IDENTIFIED SOIL UNITS

Coffey (2007) summarised the stratigraphy of the site as follow:

- TOPSOIL: Silty Clays and Peats between 0.2m and 0.7m, overlying;
- ALLUVIAL SOIL: Firm to stiff Clays to 1.5m, OR;
- RESIDUAL SOIL: Stiff Silty Clay in the vicinity of elevated landscapes near Jones Road, overlying:
- EXTREMELY WEATHERED SILTSTONE: high strength bedrock with closely spaced defects beyond the maximum investigation depth.

EAL's subsurface investigation efforts indicate that the conditions as described above are consistent across the site within the specific geological units. In addition to the soil units identified by Cofffey (2007), EAL's investigation identified sands, sandy clays and indurated sands (coffee rock) within the alluvial landscapes below 10m AHD.

Highly organic peat soils and associated alluvial sands and clays were identified across the majority of the northern section of the site (Fig. 10; Appendix 1).

5.2 ANALYTICAL RESULTS

Sixty-nine (69) individual samples representative of the soil layers encountered during the excavation of the seventeen (17) boreholes were collected and forwarded for chemical analyses.

CRS and TAA analyses were conducted upon all of samples the collected. Thirty-nine (39) samples were screened for Extractable sulphate Sulphur, Extractable Calcium and Extractable Magnesium. Samples tested for these characteristics were based on the CRS and TAA analyses results. Analyses included SPOCAS Method 23 (Suspension Peroxide Oxidation Combined Acidity & Sulfate) and Scr - Method 22B ('Chromium Reducible Sulfur (CRS) technique) as specified in Ahern et al*.* (2004). Table 4 below provides a summary of the laboratory analysis results with complete laboratory certificates provided in Appendix 3.

In addition to the ASS analysis of soils, five (5) samples of organic peat soil were collected and analysed to determine the organic matter content (%OM) for the purpose of identifying the potential bushfire hazard associated with peat soils. Table 5 (below) presents the results of these analyses.

Table 4: Soil Analysis Results

Sample No.	Depth (m bgl)	Texture	Titratable Actual Acidity (TAA) mole H^+/tonne (to pH 6.5)			Reduced Inorganic Sulfur (%Chromium Reducible S)			Reduced Inorganic Sulfur mole H^+/tonne	NET ACIDITY Chromium Suite mole H^+/tonne		
			Coarse	Medium	Fine	Coarse	Medium	Fine		Coarse	Medium	Fine
Action Criteria			**19**	**37**	**62**	**0.03**	**0.06**	**0.1**		**19**	**37**	**62**
BH 1												
C 1/1	0.0 – 0.3	Fine		277			0.05		31		318	
C 1/2	0.4 – 0.6	Medium		55			0.02		12		67	
C 1/3	0.9 – 1.1	Medium		24			0.02		12		36	
C 1/4	1.3 – 1.5	Medium		237			0.02		12		250	
BH 2												
C 2/1	0.0 – 0.3	Fine		233			0.04		25		258	
C 2/2	0.4 – 0.6	Coarse		22			0.02		12		34	
C 2/3	0.9 – 1.1	Medium		66			0.02		12		78	
BH 3												
C 3/1	0.0 – 0.3	Medium		416			0.06		37		465	
C 3/2	0.5 – 0.7	Coarse		9			< 0.01		0		9	
C 3/3	0.9 – 1.1	Coarse		10			0.02		12		22	
C 3/4	1.3 – 1.5	Medium		64			0.05		31		95	
BH 4												
C 4/1	0.0 – 0.3	Medium		115			0.03		19		134	
C 4/2	0.3 - 0.5	Fine		118			0.01		6		124	
C 4/3	0.6 – 0.8	Fine		77			0.01		6		85	
C 4/4	1.3 – 1.5	Fine		97			0.01		6		104	
BH 5												
C 5/1	0.0 – 0.3	Coarse		428			0.06		37		465	
C 5/2	0.4 – 0.6	Coarse		28			0.01		6		35	
C 5/3	0.7 – 0.9	Medium		75			0.02		12		87	
C 5/4	1.3 – 1.5	Medium		42			0.01		6		49	

<table>
<tr><th rowspan="2">Sample No.</th><th rowspan="2">Depth (m bgl)</th><th rowspan="2">Texture</th><th colspan="3">Titratable Actual Acidity (TAA) mole H+/tonne (to pH 6.5)</th><th colspan="3">Reduced Inorganic Sulfur (%Chromium Reducible S)</th><th rowspan="3">Reduced Inorganic Sulfur mole H+/tonne</th><th colspan="3">NET ACIDITY Chromium Suite mole H+/tonne</th></tr>
<tr><th>Coarse</th><th>Medium</th><th>Fine</th><th>Coarse</th><th>Medium</th><th>Fine</th><th>Coarse</th><th>Medium</th><th>Fine</th></tr>
<tr><th colspan="3">Action Criteria</th><th>19</th><th>37</th><th>62</th><th>0.03</th><th>0.06</th><th>0.1</th><th>19</th><th>37</th><th>62</th></tr>
<tr><td colspan="13">BH 6</td></tr>
<tr><td>C 6/1</td><td>0.0 – 0.3</td><td>Coarse</td><td colspan="3">373</td><td colspan="3">0.08</td><td>50</td><td colspan="3">423</td></tr>
<tr><td>C 6/2</td><td>0.4 – 0.6</td><td>Coarse</td><td colspan="3">8</td><td colspan="3">< 0.01</td><td>0</td><td colspan="3">8</td></tr>
<tr><td>C 6/3</td><td>0.9 – 1.1</td><td>Coarse</td><td colspan="3">7</td><td colspan="3">< 0.01</td><td>0</td><td colspan="3">7</td></tr>
<tr><td>C 6/4</td><td>1.3 – 1.5</td><td>Medium</td><td colspan="3">57</td><td colspan="3">0.05</td><td>31</td><td colspan="3">88</td></tr>
<tr><td colspan="13">BH 7</td></tr>
<tr><td>C 7/1</td><td>0.0 – 0.3</td><td>Fine</td><td colspan="3">98</td><td colspan="3">0.02</td><td>12</td><td colspan="3">111</td></tr>
<tr><td>C 7/2</td><td>0.4 – 0.6</td><td>Fine</td><td colspan="3">71</td><td colspan="3">0.01</td><td>6</td><td colspan="3">77</td></tr>
<tr><td>C 7/3</td><td>0.9 – 1.1</td><td>Fine</td><td colspan="3">57</td><td colspan="3">0.01</td><td>6</td><td colspan="3">67</td></tr>
<tr><td>C 7/4</td><td>1.3 – 1.5</td><td>Fine</td><td colspan="3">156</td><td colspan="3">0.01</td><td>6</td><td colspan="3">168</td></tr>
<tr><td colspan="13">BH 8</td></tr>
<tr><td>C 8/1</td><td>0.0 – 0.3</td><td>Coarse</td><td colspan="3">332</td><td colspan="3">0.05</td><td>31</td><td colspan="3">371</td></tr>
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<tr><td>C 8/3</td><td>0.9 – 1.1</td><td>Coarse</td><td colspan="3">7</td><td colspan="3">< 0.01</td><td>0</td><td colspan="3">7</td></tr>
<tr><td>C 8/4</td><td>1.3 – 1.5</td><td>Medium</td><td colspan="3">60</td><td colspan="3">0.08</td><td>50</td><td colspan="3">110</td></tr>
<tr><td colspan="13">BH 9</td></tr>
<tr><td>C 9/1</td><td>0.0 – 0.3</td><td>Fine</td><td colspan="3">56</td><td colspan="3">0.01</td><td>6</td><td colspan="3">62</td></tr>
<tr><td>C 9/2</td><td>0.4 – 0.6</td><td>Fine</td><td colspan="3">98</td><td colspan="3">0.01</td><td>6</td><td colspan="3">105</td></tr>
<tr><td>C 9/3</td><td>0.9 – 1.1</td><td>Fine</td><td colspan="3">100</td><td colspan="3">0.02</td><td>12</td><td colspan="3">115</td></tr>
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<tr><td colspan="13">BH 10</td></tr>
<tr><td>C 10/1</td><td>0.0 – 0.3</td><td>Fine</td><td colspan="3">53</td><td colspan="3">0.03</td><td>19</td><td colspan="3">71</td></tr>
<tr><td>C 10/2</td><td>0.4 – 0.6</td><td>Fine</td><td colspan="3">91</td><td colspan="3">0.03</td><td>19</td><td colspan="3">109</td></tr>
<tr><td>C 10/3</td><td>0.9 – 1.1</td><td>Fine</td><td colspan="3">96</td><td colspan="3">0.02</td><td>12</td><td colspan="3">109</td></tr>
<tr><td>C 10/4</td><td>1.3 – 1.5</td><td>Fine</td><td colspan="3">98</td><td colspan="3">0.02</td><td>12</td><td colspan="3">113</td></tr>
<tr><td colspan="13">BH 11</td></tr>
<tr><td>C 11/1</td><td>0.0 – 0.3</td><td>Fine</td><td colspan="3">203</td><td colspan="3">0.04</td><td>25</td><td colspan="3">228</td></tr>
</table>

Sample No.	Depth (m bgl)	Texture	Titratable Actual Acidity (TAA) mole H+/tonne (to pH 6.5)			Reduced Inorganic Sulfur (%Chromium Reducible S)			Reduced Inorganic Sulfur mole H+/tonne	NET ACIDITY Chromium Suite mole H+/tonne		
			Coarse	Medium	Fine	Coarse	Medium	Fine		Coarse	Medium	Fine
Action Criteria			19	37	62	0.03	0.06	0.1		19	37	62
C 11/2	0.4 – 0.6	Fine	175			0.02			12	189		
C 11/3	0.9 – 1.1	Fine	149			0.02			12	163		
C 11/4	1.3 – 1.5	Fine	105			0.06			37	145		
BH 12												
C 12/1	0.0 – 0.3	Fine	180			0.03			19	199		
C 12/2	0.4 – 0.6	Fine	190			0.02			12	204		
C 12/3	0.9 – 1.1	Fine	111			0.02			12	127		
C 12/4	1.3 – 1.5	Fine	120			0.07			44	165		
BH 13												
C 13/1	0.0 – 0.3	Fine	72			0.01			6	86		
C 13/2	0.4 – 0.6	Fine	200			0.02			12	214		
C 13/3	0.9 – 1.1	Fine	186			0.01			6	196		
C 13/4	1.3 – 1.5	Fine	155			< 0.01			0	157		
BH 14												
C 14/1	0.0 – 0.3	Fine	62			0.02			12	74		
C 14/2	0.4 – 0.6	Fine	109			0.03			19	133		
C 14/3	0.9 – 1.1	Fine	191			0.02			12	207		
C 14/4	1.4 – 1.6	Coarse	29			< 0.01			0	30		
C 14/5	1.8 – 2.0	Coarse	25			0.01			6	31		
BH 15												
C 15/1	0.0 – 0.3	Fine	181			0.07			44	232		
C 15/2	0.4 – 0.6	Fine	223			0.12			75	315		
C 15/3	0.9 – 1.1	Fine	54			< 0.01			0	55		
C 15/4	1.4 – 1.6	Fine	138			< 0.01			0	141		
C 15/5	1.8 – 2.0	Medium	58			< 0.01			0	61		
BH 16												
C 16/1	0.0 – 0.3	Fine	67			0.04			25	92		

Sample No.	Depth (m bgl)	Texture	Titratable Actual Acidity (TAA) mole H^+/tonne (to pH 6.5)			Reduced Inorganic Sulfur (%Chromium Reducible S)			Reduced Inorganic Sulfur mole H^+/tonne	NET ACIDITY Chromium Suite mole H^+/tonne		
Action Criteria			Coarse	Medium	Fine	Coarse	Medium	Fine		Coarse	Medium	Fine
			19	37	62	0.03	0.06	0.1		19	37	62
C 16/2	0.4 – 0.6	Fine		69			0.10		62		131	
C 16/3	0.9 – 1.1	Medium		28			0.01		6		34	
C 16/4	1.4 – 1.6	Medium		18			< 0.01		0		18	
C 16/5	1.8 – 2.0	Coarse		16			< 0.01		0		16	
BH 17												
C 17/1	0.0 – 0.3	Fine		107			0.09		56		163	
C 17/2	0.4 – 0.6	Medium		16			0.01		6		22	
C 17/3	0.8 – 1.0	Coarse		325			0.02		12		369	

Table 5: Peat Soil Analysis Results

Analyte	Peat 2	Peat 3	Peat 4	Peat 5	Peat 7
Total Carbon (%)	16.52	31.05	32.28	16.13	20.23
Organic Matter (%)	28.9	54.3	56.5	28.2	35.4

6 DISCUSSION

6.1 PRESENCE OF ASM

The presence of potential and actual acid sulfate soils within the study area has been confirmed during this preliminary assessment. As suggested by DLWC (1997) and BSC ASS risk mapping, the Acid Sulfate Materials (ASM) are predominantly located within the low-lying interbarrier flat, sporadically overlain by alluvial and fluvial sediment layers.

The soils of the site are naturally acidic, which is consistent with Morand (1996) descriptions. The analysis effort detected high levels of actual acidity throughout the soil profile, and in association with the low levels of potential sulfidic acidity, the majority of soils analysed recorded a net acidity (as per the Acid Base Accounting method) in excess of the relevant trigger criteria as defined by soil texture.

6.2 PRESENCE AND DISTRIBUTION OF POTENTIAL ASM

Analysis of samples collected from BH3, BH5 – 6, BH8, and BH15 – 16 shows that sporadic occurrences of soils containing oxidisable sulfur levels in excess of the action criteria (as identified in Stone et al (1998)) are present within lands across the site below 3.0m AHD. Oxidisable sulfur recorded in these twenty-two (22) boreholes ranged between < 0.01 ("Limit of Reporting") and 0.12 %Scr.

It is important to note that the CRS technique is more accurate, has lower detection limits and is not prone to interferences by organic matter. In the past, many sites have been falsely classified as 'Acid Sulfate Sites' but are only naturally occurring 'Organic Acid Sites' typical of coastal swamplands in this region.

As shown in Figs. 6 – 9, potential ASS is typically associated with the following layers:

- TOPSOILS– Silty Clays and Peats, typically encountered in layers occurring at 3.0 – 1.5/1.0 m AHD within the northern (BH1 – 3 and BH5 – 8) and southern alluvial sediments (BH14 – 17);
- ALLUVIAL SOILS – Clayey Sands and Sandy Clays, typically encountered in layers occurring below 1.0 m AHD within the northern alluvial sediments (in the vicinity of BH6);
- ALLUVIAL SOILS – Fine to coarse grained Brown Indurated Sands, typically encountered in layers occurring at 1.0m AHD and restricted to the eastern barrier system (BH6 – 8).

6.3 PRESENCE AND DISTRIBUTION OF ACTUAL ASM

With regard to actual acidity, surface soils are most likely to oxidise to form actual acidity and hence, are the most important soils for actual acidity assessment. However, all soils were assessed in this study for actual acidity due to the porous nature (i.e. capacity for diffusion of oxygen into the soil profile) of sandy sediments encountered on site.

A comparison of the acidity concentrations determined using the acid trail (i.e.TPA) and sulfur trail (SCR in equivalent acidity units) can provide useful information on the source of acidity in the sample. Some acid soils have high TPA concentrations but the SCR may be low or even below the action limit, which may reflect organic acidity or acidity from oxidation and/or titration of metal (iron, aluminium or manganese) containing compounds. While this acidity is commonly not rapidly released into the environment in the short term, it should not be immediately dismissed as being of no consequence (Ahern, McElnea and Sullivan 2004). Current ASS action criteria guidelines do not distinguish between sources of acidity, only acidity concentration.

All excavated bores (BH 1 – 17) recorded Titratable Actual Acidity values above the adopted action criteria, indicating a likelihood of Actual ASS. Of the seventeen (17) bores, TAA values recorded in BH 1 – 3, BH 5 – 8 and BH 11 – 12 were considered to result from the artificial accentuation (by the KCl extraction procedure) of slow reacting, naturally occurring organic acids (such as humates, humic acids and fulvic acids) associated with the highly organic surface soils (peats).

The presence of Potential acidity (%Scr< 0.03) as well as Actual acidity (TAA < 19) typically indicates that the most likely source of existing (actual) acidity is the oxidation of sulfidic soil materials (i.e. potential acid sulfate soils). Additional AASS testing of select samples also showed that sulfidic acidity was relatively low in most soil samples indicating that although present, sulfuric acidity within the soil profile was not the dominant.

Nevertheless, as defined in Stone et al (1998), the acid trail values of the preliminary ASS assessment conducted across the NBP Parklands site characterises the soils of the site as Actual ASS and shall require specific treatment measures during construction of necessary infrastructure and services.

6.4 PRESENCE OF PEAT SOILS

As part of the ASS investigation, an assessment of the presence of peat soils across the site has been conducted for bushfire hazard purposes. Fig. 10 (Appendix 1) shows the assumed extent of peat soils across the northern section of the site. No indications of peat soils were encountered within the southern allotments below the ridgeline supporting Jones Road.

6.4.1 Potential Peat Fire Hazard

Peat soils under drought conditions, or having been significantly drained may represent a considerable fire risk. Table 5 (above) indicates that by volume, the peat soils present on site contain considerable percentages of organic matter (< 50%). The high organic matter content of these soils increases the risk of ignition, with such materials capable of concealed and continued burning of the significant fuel loads.

Additional information outside the scope of this investigation pertaining to the fire hazard(s) posed by these materials is expected to be provided in concurrently prepared bushfire investigations for the site.

6.5 POTENTIAL FOR DISTURBANCE OF ASM

Fig. 11 (appendix 1) illustrates the expected extent of ASS risk across the site and corresponding occurrence of ASS. The majority of ASS materials lie below 4m AHD. The provision of utilities (mains water and reticulated sewer, power, telecommunications etc.) is in all likelihood, a certainty, and such activities will require excavation to cater for both subsurface and aboveground infrastructure. In such cases where the likelihood of ASS disturbance is high, implications arise in terms of ASS oxidation as a result of these works. In association with acidic discharges to nearby sensitive environments (during and following construction efforts), the potential for damage to constructed services and structures (due to acidic corrosion) may also occur.

An associated danger of ASS oxidation is the effect of soil (and pore water) acidification upon the chemical composition of the soil and its components. The mobilisation of dissolved metals such as aluminium, iron, manganese and cadmium may have serious toxicological impacts upon aquatic and terrestrial biota exposed to suitably high concentrations of such substances. Elevated levels of mobilised trace heavy metals in soil and water can be toxic to aquatic life if released into the drainage system during high flow events or a rise in the local groundwater table.

Stone et al. (1998) describes the variation of potential ASS impacts dependent upon the soil texture and mineralogy, demonstrating that certain characteristics inherent of a particular soil may reduce the acidification potential (such as the natural buffering capacity of a soil's clay or shell (i.e. $CaCO_3$) content). The sand content and the absence of significant quantities of shell fragments observed within the collected samples indicates that the potential Acid Neutralising Capability (ANC) of the collected samples is most likely insignificant with respect to the overall net acid generating potential of analysed soils.

Any disturbance activities undertaken within the low-lying areas (i.e. lands < 3.om AHD) of the site without the implementation of suitable plan of management and appropriate handling practices would be expected to produce an impact following the acidification of the disturbed ASS bearing soil layers and the subsequent leaching of the acidic waters and any associated dissolved toxicants (Al^{3+} and Fe^{3+}). The requirement for treatment and management of these soils will be dependent upon the nature and extent of soil disturbance associated with the proposed future development of the site.

6.5.1 Potential Acid Sulfate Material

Within the low-lying northern portion of the site, excavations below 3.0m AHD are expected to result in the disturbance of potential ASM associated with highly organic peat soils. Limited occurrences of indurated sands (or coffee rock) also present a significant ASS risk if disturbed. These materials are specifically limited to the northern (and principally north-eastern) sections of the site and occur at elevations below 1.5m AHD.

Potential ASM within the southern-most sections of the site are limited to silty clay/clay topsoils encountered below 3.0m AHD.

The excavations proposed as part of the NBP parklands development would result in the intersection and excavation of large quantities of potential ASM. Such works would require intensive acid sulfate soil management actions in order to prevent the generation of chronically acidic groundwater's and acidification by-products.

6.5.2 Actual Acid Sulfate Material

Actual ASM was found to be predominantly confined to the extremely low-lying areas of the site, associated with well drained recently deposited organic clays and clayey sands. Results of TAA analysis indicated that actual acidity consistently exceeded the action levels down the profile to the maximum depth of excavation.

The excavations proposed as part of the NBP parklands development would result in the intersection and excavation of large quantities of actual ASM. Such works would require intensive acid sulfate soil management actions in order to prevent the generation of chronically acidic groundwater's and acidification by-products.

6.6 RECOMMENDATIONS

The preparation of a site-specific Acid Sulfate Soil Management Plan (ASSMP) is required to suitably mitigate the potential impacts arising from the disturbance from ASM intercepted and disturbed as part of the proposed development activities.

A suitably tailored ASSMP will include the following:

- Identification of activities that are expected to intersect and disturb ASM;
- Identification of the ASS risks and identified ASS layers on site;
- The estimation of volumes of ASS requiring treatment and proposed treatment measures;

- Estimated liming rates and treatment procedures;
- Validation procedures and target criteria of treated soils;
- Monitoring protocols and target criteria for surface and groundwaters within the site; and
- Contingency procedures for ASS impacts associated with the development (including unidentified occurrences of ASS).

The ASSMP is to be prepared by a suitably experienced consultant and should encompass (but not be limited to) the items stipulated above.

7. CONCLUSION

The findings of the Preliminary ASS Assessment can be summarised as follows:

- Three (3) main landform units dominate the site: rolling hills and ridgelines on Naranleigh-Fernvale metamoprhics, low-lying Pleistocene sand sheets overlying peat and alluvium and deep Quaternary alluvium (alluvial fans and valley infills) derived from the surrounding elevated metamorphic hills and ridges;
- Topsoils at the site ranged from fine to medium silty/clayey sands (within low areas immediately adjacent hills and ridgelines), highly organic peat soils (silty high plasticity clay) and silty clays/sandy clays (within interbarrier alluvial plains) and ;silty clays upon midslopes of hills and ridgelines;
- Within the lands below 10m AHD, subsoils consist of high to medium plasticity silty clays/sandy clays and clays with sporadically distributed sand (lenses) and occurrences of indurated sands (coffee rock);
- Sixty-nine (69) individual samples were collected from seventeen (17) soil boreholes and analysed for TAA and $\%S_{CR}$. Six (6) soil bores were found to contain potential ASM in excess of the adopted action criteria values (refer s. 3.3). All excavated boreholes recorded TAA values above the adopted action criteria, indicating a likelihood of Actual ASS;
- Analysis indicates that ASM is predominantly within soils below 3.0m AHD;
- The assumed extent of peat soils extends across the northern section of the site, confined to the north-eastern allotments (Lots 403 & 403 DP755687). No indications of peat soils were encountered within the southern and western allotments below the ridgeline supporting Jones Road;
- Groundwater heights were observed to mimic local topography with typical depths to groundwater recorded as 1.5m AHD within the low-lying alluvial and backbarrier plains.

Excavations proposed as part of the NBP Parklands development would result in the excavation and disturbance of identified ASM, triggering the need to implement comprehensive ASS management works as part of the development application.

REFERENCES

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APPENDIX 1: FIGURES

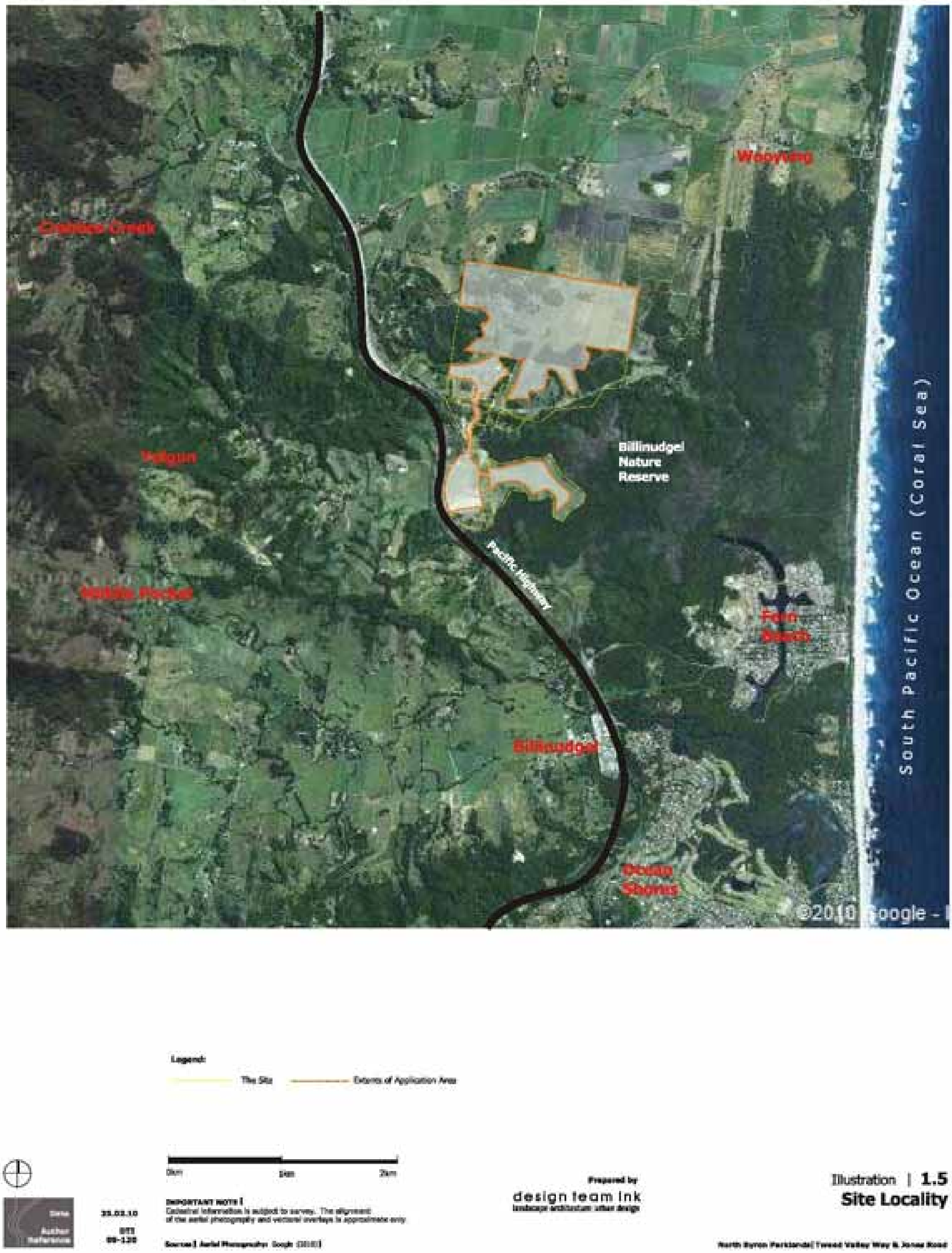

Figure 1: Location of the NBP Site. (Source: Google maps - http://maps.google.com.au/maps)

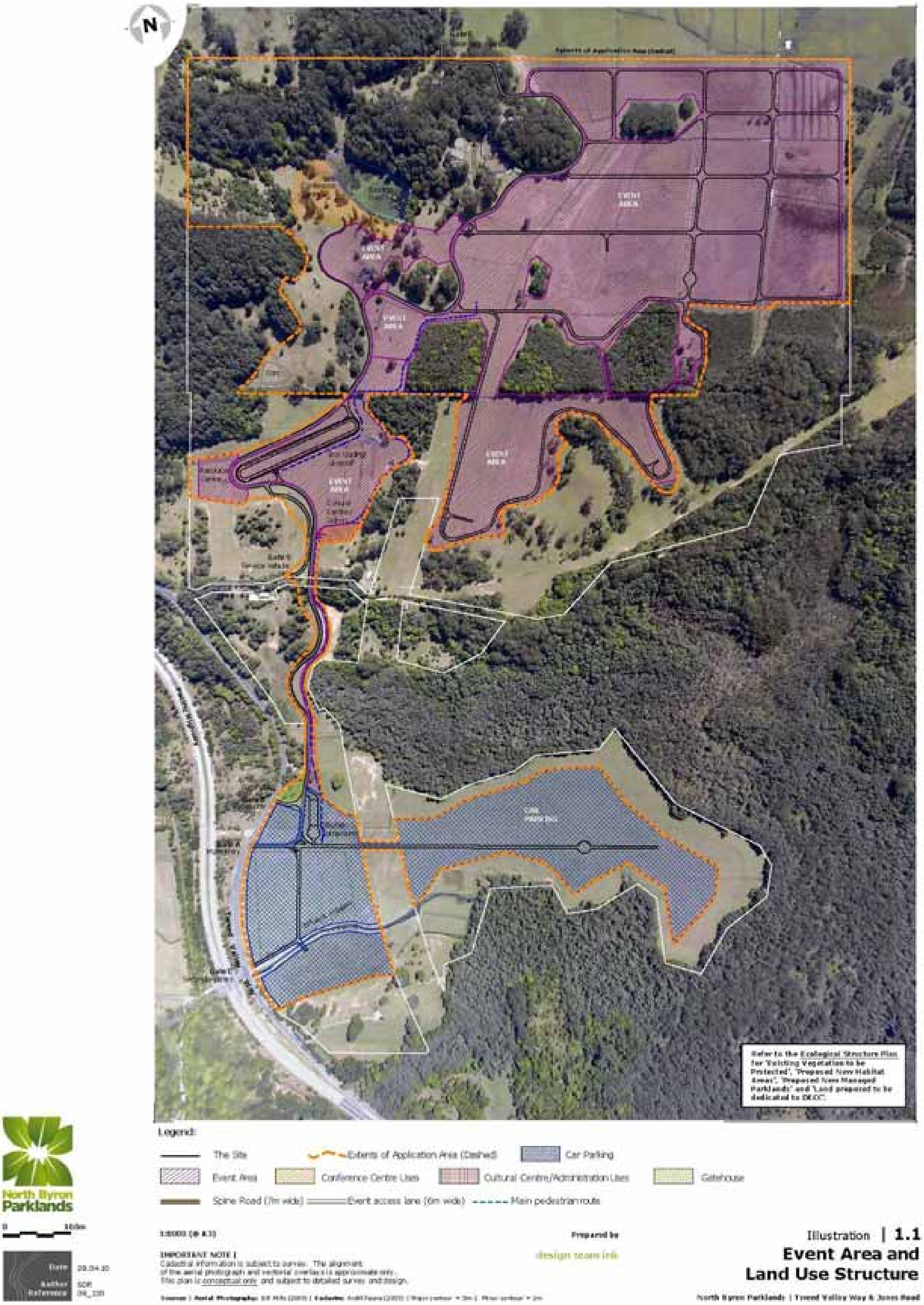

Figure 2: Early Design Plan NBP site

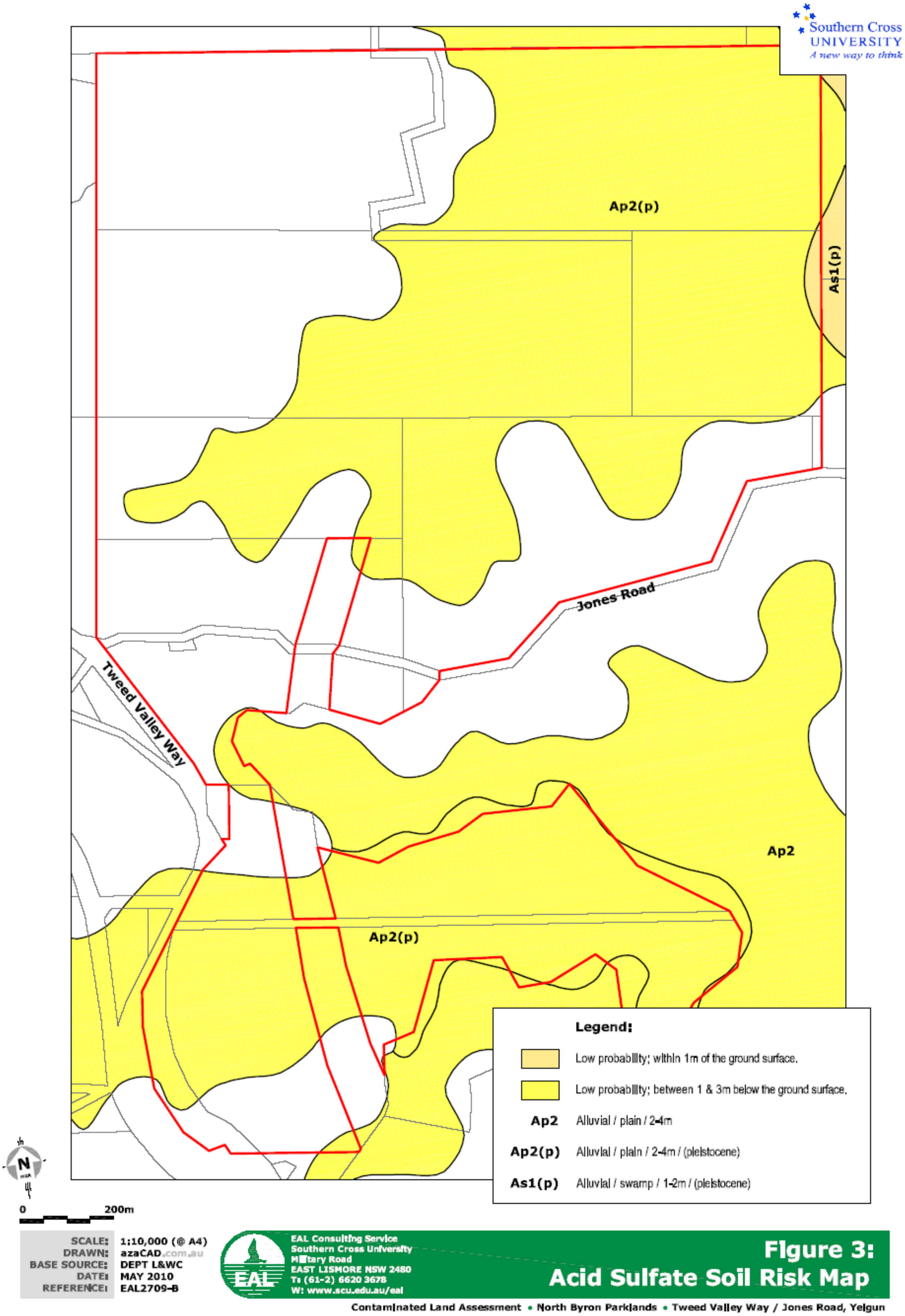

Figure 3: ASS Risk Mapping of the NBP site (DLWC 1997)

Figure 4: Soil sampling locations and section origins

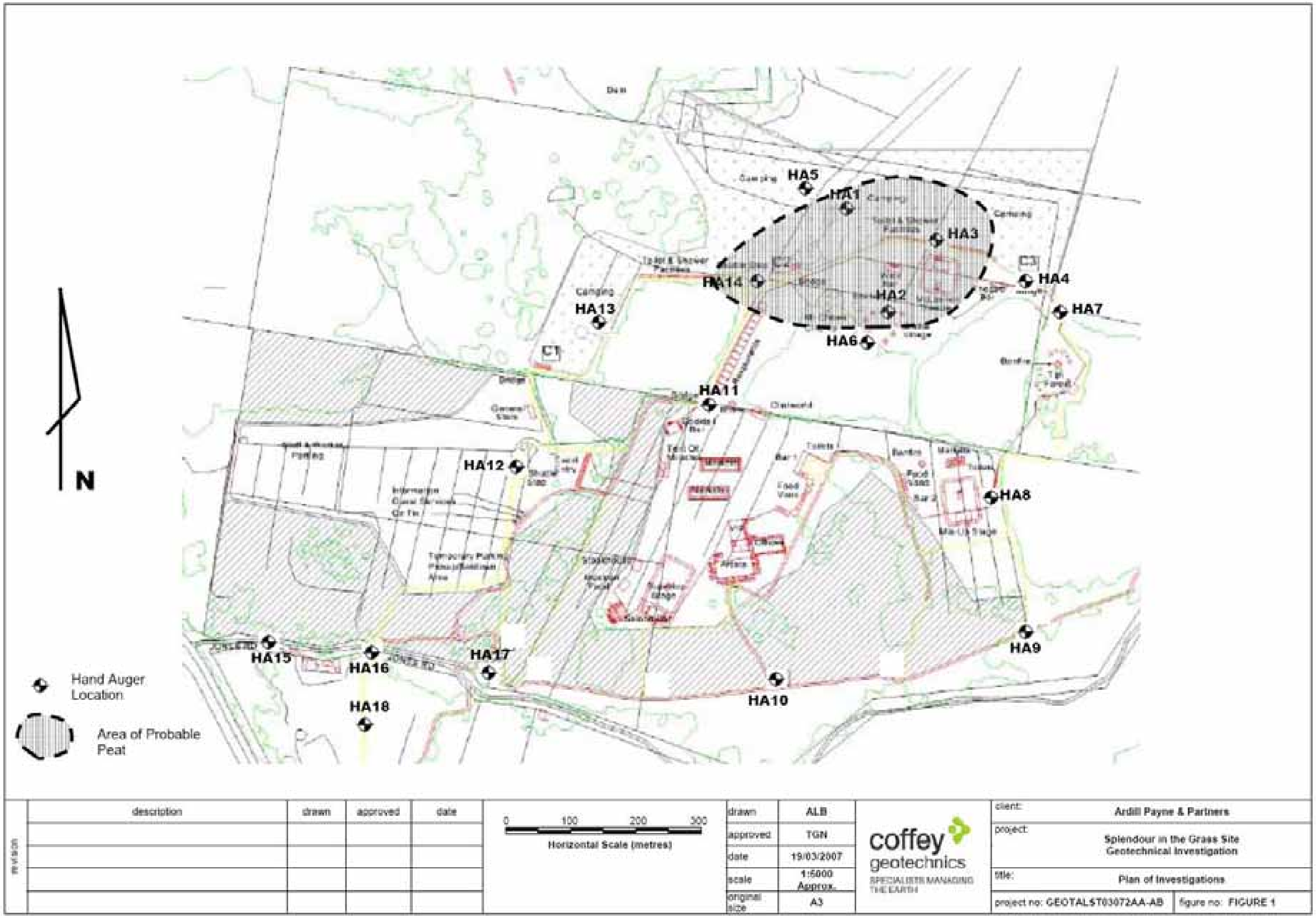

Figure 5: Coffey 2007 Soil sampling locations

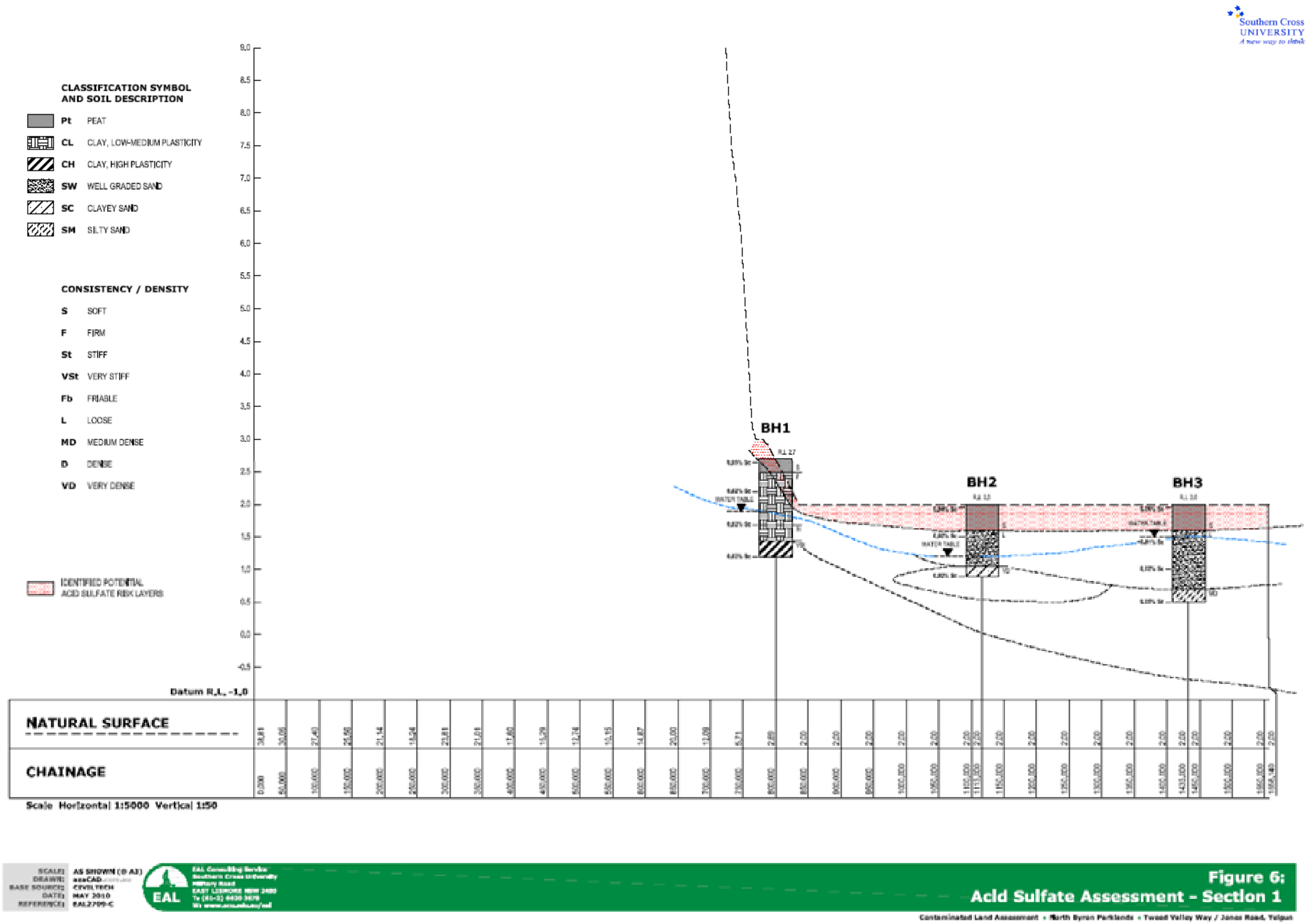

Figure 6: Geotechnical Long Section 1

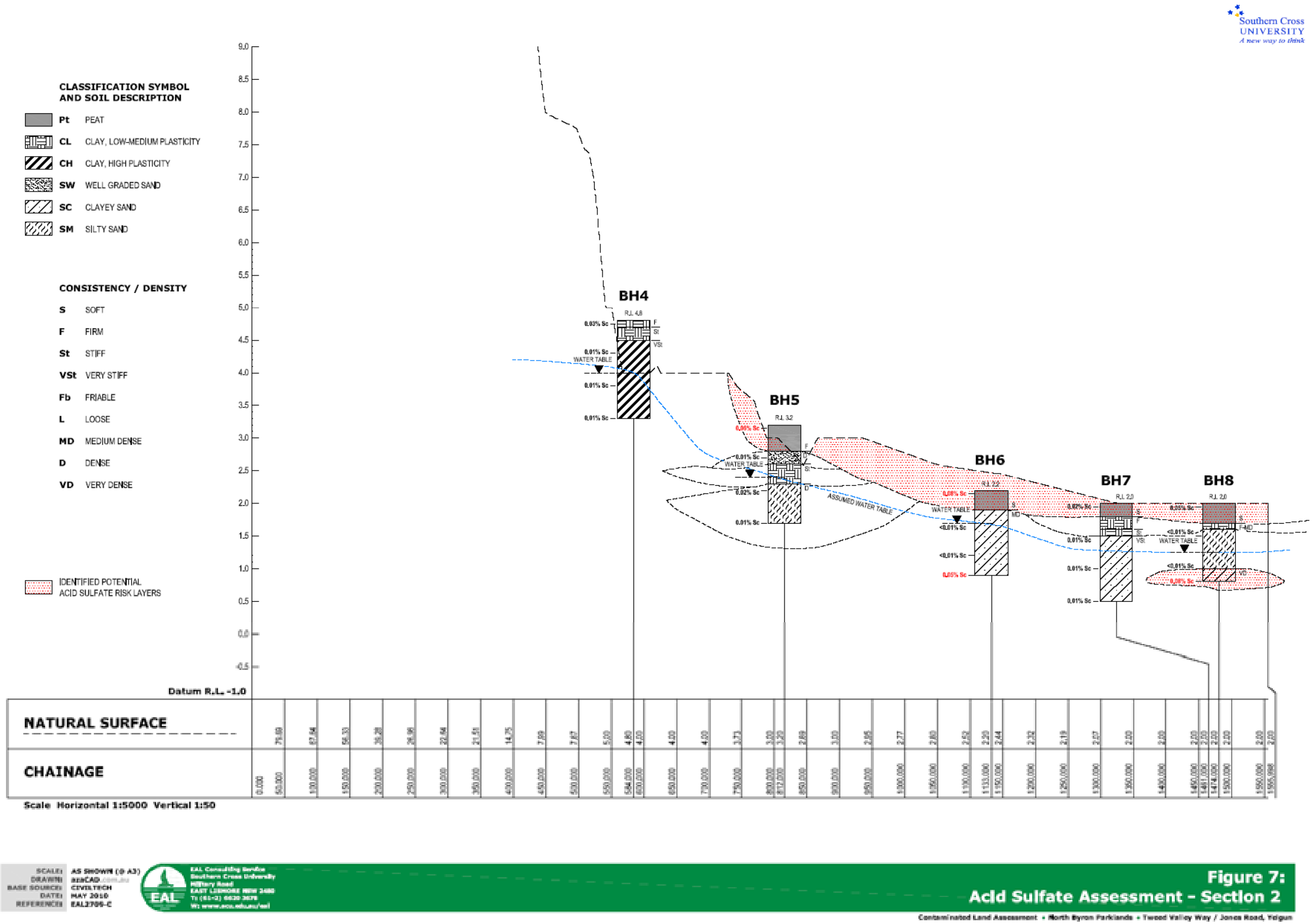

Figure 7: Geotechnical Long Section 2

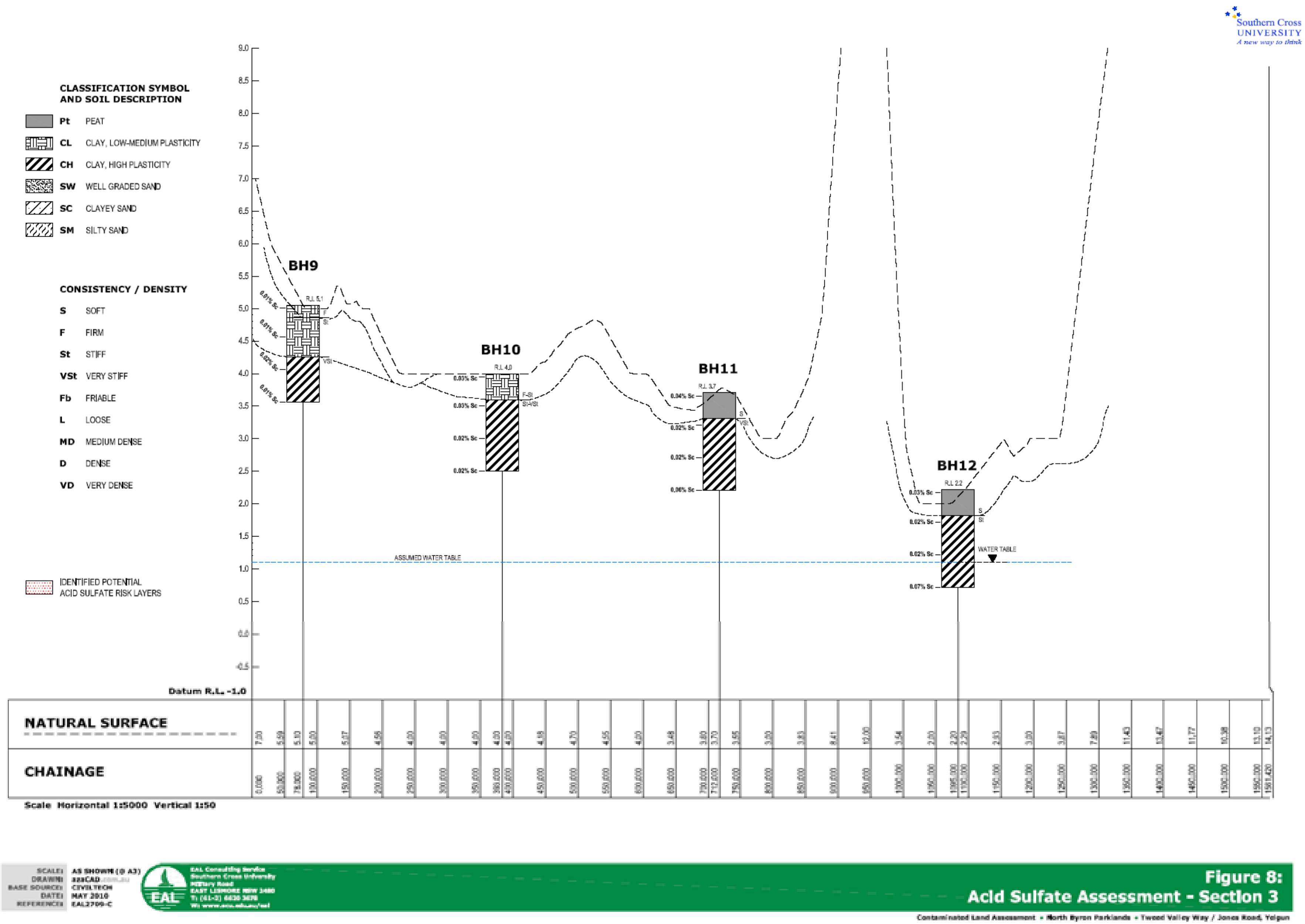

Figure 8: Geotechnical Long Section 3

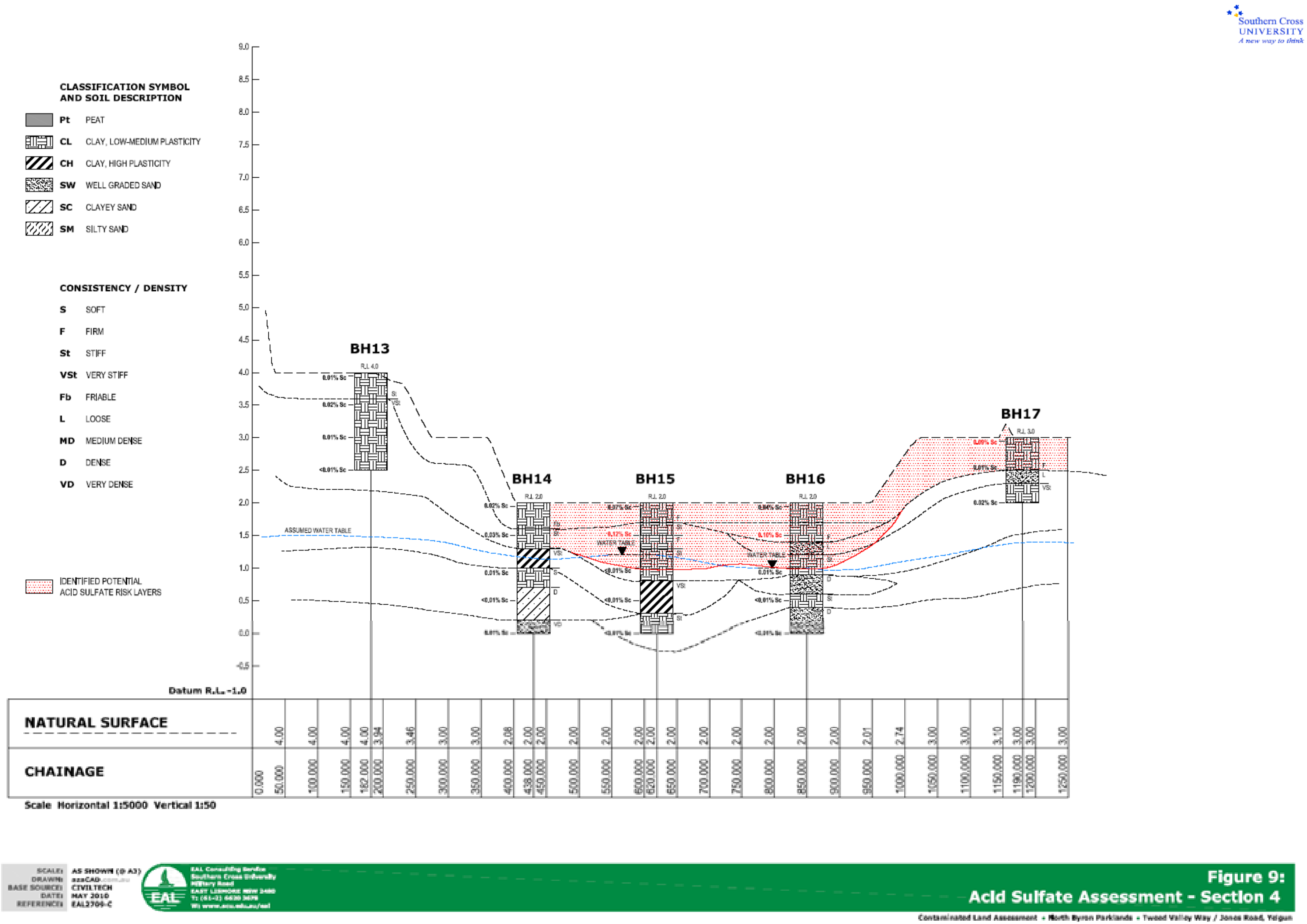

Figure 9: Geotechnical Long Section 4

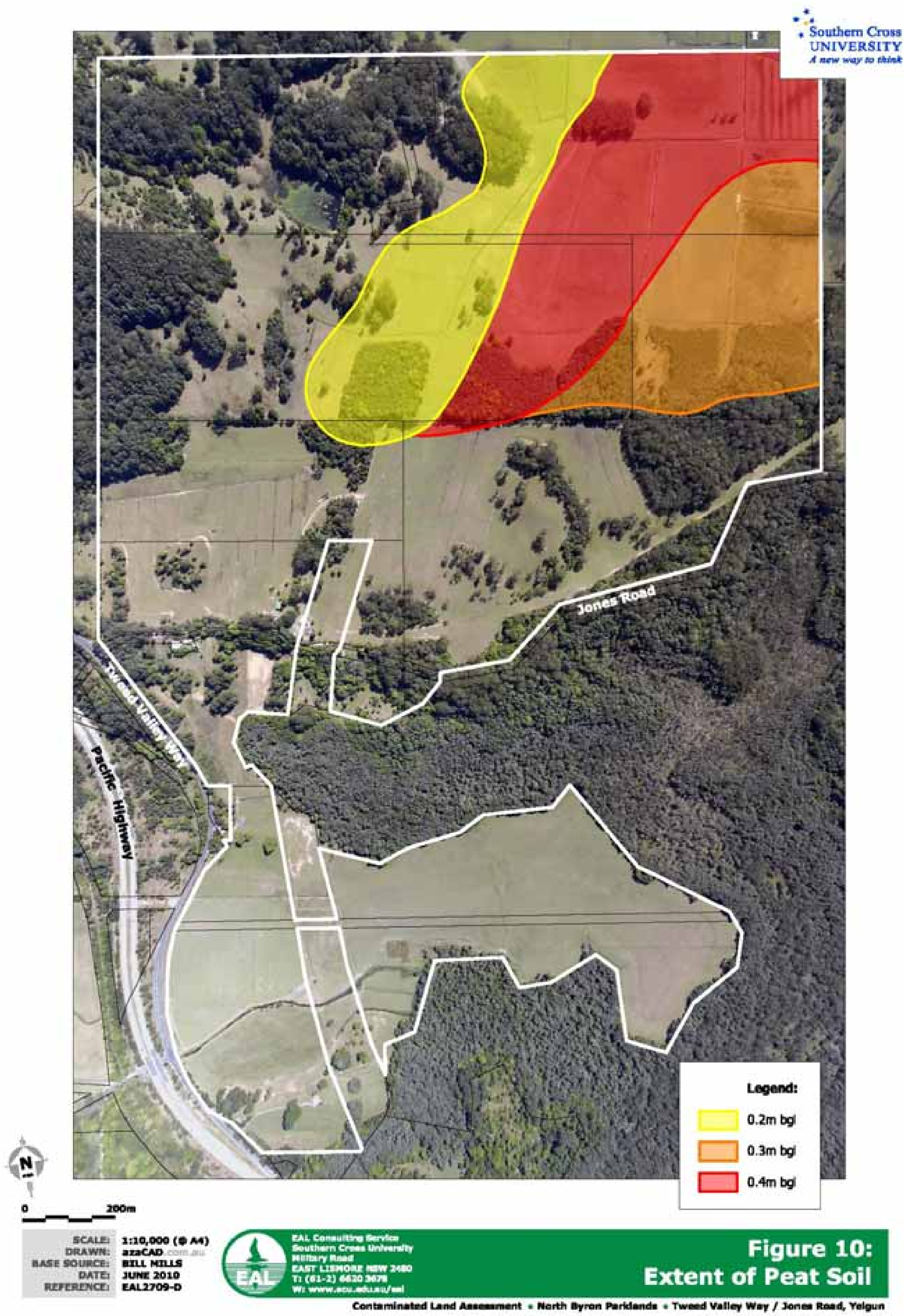

Figure 10: Assumed Extent of Peat soils

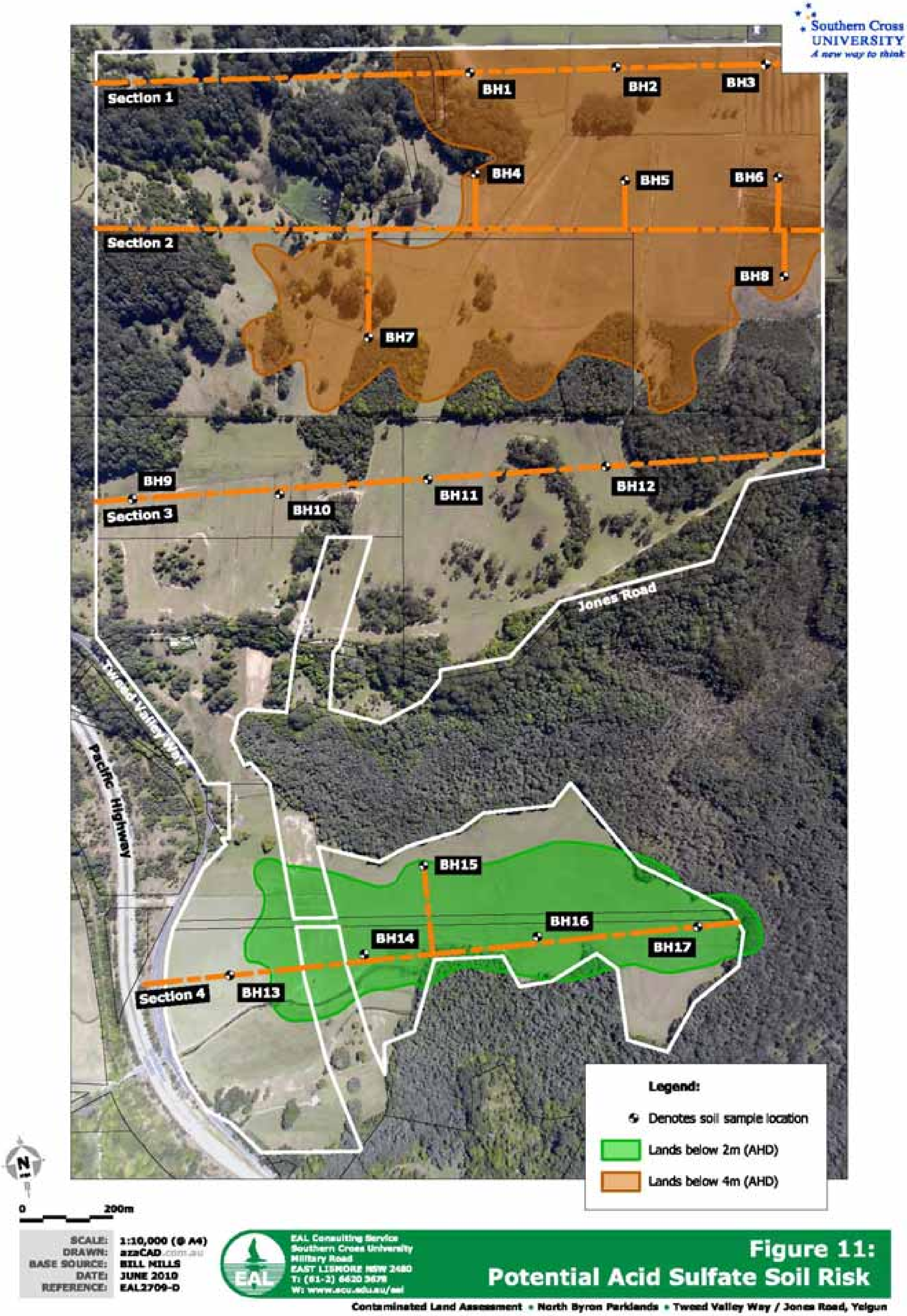

Figure 11: Assumed Extent of ASS Risk and critical depths of occurrence

APPENDIX 2: SOIL BORELOGS

Southern Cross UNIVERSITY
A new way to think

BORELOG

EAL Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Yelgun, NSW	Reference:	EAL2709
LOCATION:	[illegible]	Date:	25 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	[illegible]	BHT

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reaction pH (Peroxide)	Reaction
	0.2		Pt	Black organic Peat, root intrusions to 0.2m.	0 - 0.3m	D	S	-	-	..
			CL	Dark Grey Clay of medium plasticity and moderate dry strength. Organic material (roots and wood) to 0.5m. Trace fine sands increasing with depth. Moist at 0.5m.	0.4 - 0.6m	D-M	F	-	-	..
Groundwater encountered at 0.9m	1.0		CL	Grey Clay of medium plasticity and moderate dry strength. Trace fine sands increasing with depth.	0.9 - 1.1m	W	St	-	-	..
			CH	Grey Clay of high plasticity and moderate dry strength. Trace fine sands increasing with depth.	1.3 - 1.5m	W	VSt	-	-	..
				Borehole terminated at 1.5m bgl						
	2.0									

SOIL CLASSIFICATION SYMBOLS — WEATHERED ROCK CLASSIFICATION SYMBOLS — MOISTURE STATUS — REACTION — CONSISTENCY/DENSITY — Logged: [illegible] — Checked: [illegible] — Equipment: Hand Auger

Revision 1

AN-F-BOT.15

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BORELOG

EAL Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	56J 0551606 6850816	Date:	25 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No:	BH2

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
	0.2		Pt	Black organic Peat, root intrusions to 0.4m.	0-0.3m	D	S	-	-	-
Groundwater encountered at 0.4m	0.8		SW	Grey Sand of low plasticity and low dry strength. Wet at 0.5m.	0.4-0.6m	M-W	L	-	-	-
			SC	Brown Clayey Sand of low plasticity and high dry strength. (Coffee Rock)	0.5-1.1m	W	VD	-	-	-
	2.0			Borehole terminated at 1.1m bgl (Coffee Rock refusal)						

SOIL CLASSIFICATION SYMBOLS

GP Poorly graded Gravel
GW Well graded Gravel
GM Gravel, Silt or Sand fines
GC Gravel, Clay fines
SP Poorly graded Sand
SW Well graded Sand
SM Silty Sand
SC Clayey Sand
ML Silt, low liquid limit
CL Clay, low-medium plasticity
CH Clay, high plasticity
OH Organic Clay, high plasticity
Pt Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS Residual Soil
EW Extremely Weathered
DW Distinctly Weathered
SW Slightly Weathered
F Fresh

MOISTURE STATUS

D Dry
M Moist
W Wet

REACTION

N None
M Minor
V Vigorous

CONSISTENCY/DENSITY

VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
Fr Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Logged: TS
Checked: ND
Equipment: Hand Auger

Revision 1

AN-F-001.15

BORELOG

Southern Cross University – A new way to think | EAL Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Yelgun, NSW	Reference:	EAL2709
LOCATION:	[illegible]	Date:	11 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH3

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Peroxide pH (Peroxide)	Reaction
Groundwater encountered at 0.6m	0.2		Pt	Black organic Peat. Root intrusions to 0.4m.	0 - 0.3m	D	S	-	-	-
	0.6, 1		SW	Grey Sand of low plasticity and low dry strength. Wet at 0.75m.	0.5 - 0.7m; 0.9 - 1.1m	M-W	L	-	-	-
			SM	Black Coffee Rock of low plasticity and low dry strength.	1.3 - 1.5m	W	MD	-	-	-
	1.5			Borehole terminated at 1.5m bgl. (Coffee Rock refusal)						

SOIL CLASSIFICATION SYMBOLS

GP Poorly graded Gravel
GW Well graded Gravel
GM Gravel, silt or Sand fines
GC Gravel, Clay fines
SP Poorly graded Sand
SW Well graded Sand
SM Silty Sand
SC Clayey Sand
ML Silt, low liquid limit
CL Clay, low-medium plasticity
CH Clay, high plasticity
OH Organic Clay, high plasticity
Pt Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS Residual Soil
EW Extremely Weathered
DW Distinctly Weathered
SW Slightly Weathered
F Fresh

MOISTURE STATUS

D Dry
M Moist
W Wet

REACTION

N None
M Minor
V Vigorous

CONSISTENCY/DENSITY

VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Logged: TS

Checked: VG

Equipment: Hand Auger

Revision 1

AN-F-BOT.15

BORELOG

Southern Cross University — A new way to think

EAL — Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Yelgun, NSW	Reference:	EAL2709
LOCATION:	[illegible]	Date:	11 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH4

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
			CL	Brown Clay (Loam topsoil)	0 – 0.3m	D	F	–	–	
	0.2		CI	Light Red and White mottled Black to Brown Clay of medium plasticity and low dry strength. Root intrusions.		D	St	–	–	..
			CH	Dark Grey Clay of high plasticity and high dry strength.	0.3-0.5m	M-W	VSt	–	–	..
	0.6		CH	Grey Clay of high plasticity and high dry strength.	0.6-0.8m	M-W	VSt	–	–	..
Groundwater encountered at 0.6m			CH	Light Orange mottled Grey Clay of high plasticity and high dry strength.	1.3-1.5m	W	VSt	–	–	..
	1.5			Borehole terminated at 1.5m bgl						

SOIL CLASSIFICATION SYMBOLS

GP	Poorly graded Gravel
GW	Well graded Gravel
GM	Gravel, Silt or Sand fines
GC	Gravel, Clay fines
SP	Poorly graded Sand
SW	Well graded Sand
SM	Silty Sand
SC	Clayey Sand
ML	Silt, low liquid limit
CL	Clay, low-medium plasticity
CH	Clay, high plasticity
OH	Organic Clay, high plasticity
Pt	Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS	Residual Soil
EW	Extremely Weathered
DW	Distinctly Weathered
SW	Slightly Weathered
F	Fresh

MOISTURE STATUS

D	Dry
M	Moist
W	Wet

REACTION

N	None
M	Minor
V	Vigorous

CONSISTENCY/DENSITY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard
Fb	Friable
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Logged: TB

Checked: VD

Equipment: Hand Auger

Revision 1

AN-F-BOT.15

BORELOG

Southern Cross University — A new way to think

EAL — Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	56 J 0551802 6850721	Date:	11 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH5

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
	0.2		Pt	Black organic Peat, root intrusions to 0.4m.	0-0.3m	D	F	-	-	-
			SW	Grey Sand of low plasticity and low dry strength.	0.4-0.5m	D	D	-	-	-
Groundwater encountered at 0.6m	0.6		CL	Dark Grey Clay of medium plasticity and moderate dry strength. Trace fine sand particles increasing with depth.	0.7-0.8m	M-W	St	-	-	-
			SM	Brown Silty Sand of low plasticity and low dry strength. Wet at 1m.	1.3-1.5m	W	D	-	-	-
	1.5			Borehole terminated at 1.5m bgl						

SOIL CLASSIFICATION SYMBOLS

GP	Poorly graded Gravel
GW	Well graded Gravel
GM	Gravel, Silt or Sand fines
GC	Gravel, Clay fines
SP	Poorly graded Sand
SW	Well graded Sand
SM	Silty Sand
SC	Clayey Sand
ML	Silt, low liquid limit
CL	Clay, low-medium plasticity
CH	Clay, high plasticity
OH	Organic Clay, high plasticity
Pt	Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS	Residual Soil
XW	Extremely Weathered
DW	Distinctly Weathered
SW	Slightly Weathered
F	Fresh

MOISTURE STATUS

D	Dry
M	Moist
W	Wet

REACTION

N	None
F	Few
V	Vigorous

CONSISTENCY/DENSITY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard
Fb	Friable
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Logged: TS

Checked: VS

Equipment: Hand Auger

Revision 1

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Southern Cross UNIVERSITY *A new way to think*

BORELOG

EAL Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Yelgun, NSW	Reference:	EAL2709
LOCATION:	[illegible]	Date:	11 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH[illegible]

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Peroxide pH (Peroxide)	Reaction
	0.2		Pt	Black organic Peat, root intrusions to 0.3m.	0 - 0.5m	D	S	-	-	..
Groundwater encountered at 0.6m	0.6		SC	Light Grey Sand of low plasticity and low dry strength. Wet at 0.5m	0.4-0.6m; 0.9-1.1m	M-W	MD	-	-	..
			SC	Black to Brown Coffee Rock of low plasticity and low dry strength.	1.1-1.3m	W	MD	-	-	..
	1.6			Borehole terminated at 1.3m bgl (Coffee Rock refusal)						

SOIL CLASSIFICATION SYMBOLS		WEATHERED ROCK CLASSIFICATION SYMBOLS		CONSISTENCY/DENSITY			
GP	Poorly graded Gravel	RS	Residual Soil	VS	Very Soft	Logged:	TB
GW	Well graded Gravel	EW	Extremely Weathered	S	Soft		
GM	Gravel, Silt or Sand fines	DW	Distinctly Weathered	F	Firm	Checked:	VB
GC	Gravel, Clay fines	SW	Slightly Weathered	St	Stiff		
SP	Poorly graded Sand	F	Fresh	VSt	Very Stiff		
SW	Well graded Sand		**MOISTURE STATUS**	H	Hard	Equipment: Hand Auger	
SM	Silty Sand	D	Dry	Fb	Friable		
SC	Clayey Sand	M	Moist	VL	Very Loose		
ML	Silt, low liquid limit	W	Wet	L	Loose		
CL	Clay, low-medium plasticity		**REACTION**	MD	Medium Dense		
CH	Clay, high plasticity	N	None	D	Dense		
OH	Organic Clay, high plasticity	[illegible]	[illegible]	VD	Very Dense		
Pt	Peat	V	Vigorous				

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BORELOG

Southern Cross University – A new way to think

EAL – Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	56J 0555557 6850457	Date:	25 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH7

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
No groundwater encountered	0.2		Pt	Brown organic Peat	0-0.3m	D	S	-	-	..
			CL	Orange and Red mottled Grey Clay of medium plasticity and medium dry strength. Root intrusions.		D	F	-	-	..
			CL	Black Clay of medium plasticity and medium dry strength.	0.4-0.5m	D	St	-	-	..
	0.6		CH	Light Orange mottled Grey Clay of medium-high plasticity and medium dry strength.		D	VSt	-	-	..
			CH	Light Orange mottled Grey Clay of high plasticity and high dry strength. Increasing Orange mottle with depth to approx. 50%.	0.9-1.1m 1.3-1.5m	D	VSt	-	-	..
	1.5			Borehole terminated at 1.5m bgl						

SOIL CLASSIFICATION SYMBOLS

GP	Poorly graded Gravel
GW	Well graded Gravel
GM	Gravel, silt or Sand fines
GC	Gravel, Clay fines
SP	Poorly graded Sand
SW	Well graded Sand
SM	Silty Sand
SC	Clayey Sand
ML	Silt, low liquid limit
CL	Clay, low-medium plasticity
CH	Clay, high plasticity
OH	Organic Clay, high plasticity
Pt	Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS	Residual Soil
XW	Extremely Weathered
DW	Distinctly Weathered
SW	Slightly Weathered
F	Fresh

MOISTURE STATUS

D	Dry
M	Moist
W	Wet

REACTION

N	None
[illegible]	[illegible]
V	Vigorous

CONSISTENCY/DENSITY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard
Fb	Friable
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Logged: TE

Checked: VB

Equipment: Hand Auger

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A new way to think

BORELOG

Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	56 J [illegible]	Date:	11 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH8

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
	0.2		Pt	Black organic Peat root intrusions to 0.4m.	0 - 0.5m	D	S	-	-	..
1	0.6		CL-SM	Top 100mm Black Clay transition zone to Grey Silty Sand of low plasticity and low dry strength.	0.4-0.5m	M-W	F-MD	-	-	..
Groundwater encountered at 0.70m bgl			SC	Black Clayey Sand of low plasticity and low dry strength. (Coffee Rock)	0.9-1.1m 1.1-1.2m	W	VD	-	-	..
				Borehole terminated at: 1.2m bgl (Coffee Rock refusal)						
	1.6									

SOIL CLASSIFICATION SYMBOLS		WEATHERED ROCK CLASSIFICATION SYMBOLS		CONSISTENCY/DENSITY			
GP	Poorly graded Gravel	RS	Residual Soil	VS	Very Soft	Logged:	TB
GW	Well graded Gravel	XW	Extremely Weathered	S	Soft		
GM	Gravel, Silt or Sand fines	DW	Distinctly Weathered	F	Firm		
GC	Gravel, Clay fines	SW	Slightly Weathered	St	Stiff	Checked:	VB
SP	Poorly graded Sand	F	Fresh	VSt	Very Stiff		
SW	Well graded Sand	MOISTURE STATUS		H	Hard		
SM	Silty Sand	D	Dry	Fb	Friable	Equipment:	
SC	Clayey Sand	M	Moist	VL	Very Loose	Hand Auger	
ML	Silt, low liquid limit	W	Wet	L	Loose		
CL	Clay, low-medium plasticity	REACTION		MD	Medium Dense		
CH	Clay, high plasticity	N	None	D	Dense		
OH	Organic Clay, high plasticity	M	Poor	VD	Very Dense		
Pt	Peat	V	Vigorous				

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BORELOG

EAL Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	[illegible] 0550431 6580173	Date:	25 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH9

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
No groundwater encountered	0.2		CL	Brown Clay (Loam), root intrusions to 0.2m.	0-0.3m	D	F	-	-	..
			CL	Red mottled Brown Clay of medium plasticity and moderate dry strength.	0.4-0.5m	D	St	-	-	..
	0.6		CL	Orange mottled Brown Clay of medium plasticity and moderate dry strength.		D	St	-	-	..
			CH	Orange mottled Grey Clay of high plasticity and high dry strength. Becoming lighter Grey with depth.	0.9-1.1m 1.3-1.5m	D	VSt	-	-	..
	1.5			Borehole terminated at 1.5m bgl						

SOIL CLASSIFICATION SYMBOLS		WEATHERED ROCK CLASSIFICATION SYMBOLS		CONSISTENCY/DENSITY			
GP	Poorly graded Gravel	RS	Residual Soil	VS	Very Soft	Logged:	[illegible]
GW	Well graded Gravel	XW	Extremely Weathered	S	Soft		
GM	Gravel, silt or Sand fines	DW	Distinctly Weathered	F	Firm	Checked:	[illegible]
GC	Gravel, Clay fines	SW	Slightly Weathered	St	Stiff		
SP	Poorly graded Sand	F	Fresh	VSt	Very Stiff		
SW	Well graded Sand	**MOISTURE STATUS**		H	Hard		
SM	Silty Sand	D	Dry	Fb	Friable	Equipment:	Hand Auger
SC	Clayey Sand	M	Moist	VL	Very Loose		
ML	Silt, low liquid limit	W	Wet	L	Loose		
CL	Clay, low-medium plasticity	**REACTION**		MD	Medium Dense		
CH	Clay, high plasticity	N	None	D	Dense		
OH	Organic Clay, high plasticity	[illegible]	[illegible]	VD	Very Dense		
Pt	Peat	V	Vigorous				

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BORELOG

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EAL — Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	SEJ 0550744 6850151	Date:	25 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Sample No.:	BHTG

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
No groundwater encountered	0.2		CL	Grey Clay of medium plasticity and moderate dry strength. Root intrusions to 0.3m.	0 - 0.3m	D	F - St	-	-	-
	0.6		CH	Orange mottled (approx. 20-50%) Grey Clay of high plasticity and high dry strength.	0.4-0.6m 0.9-1.1m 1.3-1.5m	D	St - VSt	-	-	-
	1.6			Borehole terminated at 1.5m bgl						

SOIL CLASSIFICATION SYMBOLS

WEATHERED ROCK CLASSIFICATION SYMBOLS: Residual Soil; Extremely Weathered; Distinctly Weathered; Slightly Weathered; Fresh

MOISTURE STATUS: Dry; Moist; Wet

REACTION: None; Weak; Vigorous

CONSISTENCY/DENSITY: Very Soft; Soft; Firm; Stiff; Very Stiff; Hard; Friable; Very Loose; Loose; Medium Dense; Dense; Very Dense

Logged: [illegible]
Checked: [illegible]
Equipment: Hand Auger

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BORELOG

EAL — Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Yelgun, NSW	Reference:	EAL2709
LOCATION:	56J 0551062 6840110	Date:	25 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH1

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reaction pH (Peroxide)	Reaction
No groundwater encountered	0.2		Pt	Brown organic Peat of low plasticity and low dry strength. Root intrusions to 0.3m.	0 - 0.3m	D	S	-	-	-
	0.6		CH	Red mottled Grey Clay of high plasticity and high dry strength becoming lighter Grey with depth.	0.4-0.6m 0.9-1.1m 1.3-1.5m	D	VSt	-	-	-
	1.5			Borehole terminated at 1.5m bgl						

SOIL CLASSIFICATION SYMBOLS

GP Poorly graded Gravel
GW Well graded Gravel
GM Gravel, Silt or Sand fines
GC Gravel, Clay fines
SP Poorly graded Sand
SW Well graded Sand
SM Silty Sand
SC Clayey Sand
ML Silt, low liquid limit
CL Clay, low-medium plasticity
CH Clay, high plasticity
OH Organic Clay, high plasticity
Pt Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS Residual Soil
EW Extremely Weathered
DW Distinctly Weathered
SW Slightly Weathered
F Fresh

MOISTURE STATUS

D Dry
M Moist
W Wet

REACTION

N None
M Minor
V Vigorous

CONSISTENCY/DENSITY

VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Logged: TB

Checked: VD

Equipment: Hand Auger

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BORELOG

EAL Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	56J 0551463 6830074	Date:	25 Mar 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH12

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
No groundwater encountered	0.2		Pt	Brown organic Peat of low plasticity and low dry strength. Root intrusions to 0.3m.	0 – 0.3m	D	S	–	–	–
	0.6		CH	Brown to Grey Clay of medium plasticity and moderate dry strength. Trace Red and Orange mottle throughout.	0.4-0.6m 0.9-1.1m 1.3-1.5m	D	St	–	–	–
	1.0			Borehole terminated at 1.5m bgl						

SOIL CLASSIFICATION SYMBOLS
WEATHERED ROCK CLASSIFICATION SYMBOLS
MOISTURE STATUS
REACTION
CONSISTENCY/DENSITY

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BORELOG

Southern Cross UNIVERSITY — *A new way to think*

EAL Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	56J 0560474 6849108	Date:	15 Apr 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.:	BH73

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide)	Reaction
No groundwater encountered	0.2		Ct	Brown Silty Clay (Loam) of low plasticity and low dry strength. Root intrusion to 0.5m.	0-0.2m	D	St	-	-	-
			CL	Brown to Dark Brown Clay of medium plasticity and moderate dry strength.	0.4-0.5m	D	VSt	-	-	-
	0.6		CL	Light Orange mottled Grey Clay of medium to high plasticity and moderate dry strength. Some fine sand particles within layer restricted to top 100mm.	0.9-1.1m	D	VSt	-	-	-
			CL	Orange mottled Grey Clay (heavy mottle) of medium plasticity and moderate dry strength. Trace fine sand particles increasing in occurrence from 1.25m bgl.	1.4-1.5m	D	VSt	-	-	-
	1.6			Borehole terminated at 1.5m bgl.						

SOIL CLASSIFICATION SYMBOLS

GP	Poorly graded Gravel
GW	Well graded Gravel
GM	Gravel, silt or Sand fines
GC	Gravel, Clay fines
SP	Poorly graded Sand
SW	Well graded Sand
SM	Silty Sand
SC	Clayey Sand
ML	Silt, low liquid limit
CL	Clay, low-medium plasticity
CH	Clay, high plasticity
OH	Organic Clay, high plasticity
Pt	Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS	Residual Soil
EW	Extremely Weathered
DW	Distinctly Weathered
SW	Slightly Weathered
F	Fresh

MOISTURE STATUS

D	Dry
M	Moist
W	Wet

REACTION

N	None
[illegible]	[illegible]
V	Vigorous

CONSISTENCY/DENSITY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard
Fb	Friable
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Logged: [illegible]

Checked: [illegible]

Equipment: Hard Auger

Revision 1

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BORELOG

Southern Cross University — A new way to think

EAL — Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	[illegible]	Date:	15 Apr 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.	BHT4

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Peroxide pH (Peroxide)	Reaction
No groundwater encountered	0.2		CI	Brown Silty Clay (Loam) of low plasticity and low dry strength. Root intrusion to 0.2m.		D	Fb	-	-	--
			CL	Brown Clay of low to medium plasticity and moderate dry strength.		M	St	-	-	--
	0.6		CH	Black Clay (hard) of high plasticity and high dry strength.		D-M	VSt	-	-	--
			CL	Light Orange Clay of medium plasticity and moderate dry strength. Trace fine sands increasing in occurrence from 1.3m bgl.		M	S	-	-	--
	1.6		SC	Grey Clayey Sand of low to medium plasticity and low dry strength. Decreasing in clay content from 1.8m bgl.		M-W	D	-	-	--
	2.0		SW	Grey Sand of low plasticity and low dry strength.		W	VD	-	-	--
				Borehole terminated at 2.0m bgl.						

SOIL CLASSIFICATION SYMBOLS
GP Poorly graded Gravel
GW Well graded Gravel
GM Gravel, silt or Sand fines
GC Gravel, Clay fines
SP Poorly graded Sand
SW Well graded Sand
SM Silty Sand
SC Clayey Sand
ML Silt, low liquid limit
CL Clay, low-medium plasticity
CI Clay, [illegible] plasticity
CH Organic Clay, high plasticity
Pt Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS
RS Residual Soil
XW Extremely Weathered
DW Distinctly Weathered
SW Slightly Weathered
F Fresh

MOISTURE STATUS
D Dry
M Moist
W Wet

REACTION
N None
[illegible]
V Vigorous

CONSISTENCY/DENSITY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Logged: TB
Checked: VG
Equipment: Hand Auger

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Southern Cross University
A new way to think

BORELOG

EAL Environmental Analysis Laboratory

PROJECT:	North Byron Parklands Yelgun, NSW	Reference:	EAL2709
LOCATION:		Date:	15 Apr 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No.	BH7.5

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Peroxide pH (Peroxide	Reaction
	0.2		CL	Brown Clay (Loam) of low plasticity and low dry strength. Root intrusion to 0.25m.		D	F	-	-	..
			CL	Black Clay of medium plasticity and moderate dry strength.		D	St	-	-	..
			CL	Black mottled Orange Clay of low plasticity and low dry strength. Trace fine sand particles throughout.		D	F	-	-	..
▼ Groundwater encountered at 0.6m	0.6		CL	Grey Clay of medium plasticity and moderate dry strength. Fine sands restricted to top 100mm.		M-W	St	-	-	..
	1.5		CH	Orange mottled Grey Clay of high plasticity and high dry strength.		W	VSt	-	-	..
	2.0		CL	Grey Clay of medium plasticity and moderate dry strength. Fine sands throughout.		W	St	-	-	..
				Borehole terminated at 2.0m bgl.						

SOIL CLASSIFICATION SYMBOLS

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS Residual Soil
XW Extremely Weathered
DW Distinctly Weathered
SW Slightly Weathered
F Fresh

MOISTURE STATUS

D Dry
M Moist
W Wet

REACTION

None
Poor
Vigorous

CONSISTENCY/DENSITY

VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Logged:

Checked:

Equipment: Hand Auger

Revision 1

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1703

PROJECT: North Byron Parklands Wooyung, NSW
LOCATION: 56J 0551163 6849138
CLIENT: SJ Connelly CPP (on behalf of NBP)

Reference: EAL2709
Date: 16 Apr 10
Borehole No. BH:16

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide	Reaction
	0.2		CL	Brown Clay (Loam) of low plasticity and low dry strength. Root intrusion to 0.2m.		D	F	–	–	--
			CL	Brown Clay of medium plasticity and moderate dry strength. Trace fine sands throughout.		D	F	–	–	–
	0.8		SW	Orange mottled Grey Sand of low plasticity and low dry strength.		D	L	–	–	--
			CL	Brown Clay of medium plasticity and moderate dry strength Trace fine sands throughout.		M-W	St	–	–	--
Groundwater encountered at 1.0m			SW	Dark Orange mottled Sand of low plasticity and low dry strength.		W	D	–	–	--
	1.5		CL	Dark Orange mottled Clay of medium plasticity and moderate dry strength. Trace fine sands throughout.		W	St	–	–	--
	2.0		SW	Orange mottled Sand of of low plasticity and low dry strength.		W	D	–	–	--
				Borehole terminated at 2.0m bgl.						

SOIL CLASSIFICATION SYMBOLS
GP Poorly graded Gravel
GW Well graded Gravel
GM Gravel, Silt or Sand fines
GC Gravel, Clay fines
SP Poorly graded Sand
SW Well graded Sand
SM Silty Sand
SC Clayey Sand
ML Silt, low-liquid limit
CL Clay, low-medium plasticity
CH Clay, high plasticity
OH Organic Clay, high plasticity
Pt Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS
RS Residual Soil
EW Extremely Weathered
DW Distinctly Weathered
SW Slightly Weathered
F Fresh

MOISTURE STATUS
D Dry
M Moist
W Wet

REACTION
N None
M Minor
V Vigorous

CONSISTENCY/DENSITY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Logged: TS
Checked: VD
Equipment: Hard Auger

Revision 1

AN-F-901.15

[redacted]

PROJECT:	North Byron Parklands Wooyung, NSW	Reference:	EAL2709
LOCATION:	56J 0551348 6849146	Date:	16 Apr 10
CLIENT:	SJ Connelly CPP (on behalf of NBP)	Borehole No:	BH17

Ground Water	Depth (m)	Graphic Log	Soil Symbol	Soil Description (soil type, colour, plasticity, particle characteristics, other)	Sample Collected	Moisture Status	Consistency / Density	Field pH (1:5)	Reacted pH (Peroxide	Reaction
No groundwater encountered	0.2		CL	Brown Clay (Loam) of low plasticity and low dry strength. Root intrusion to 0.25m.		D	F	-	-	-
			CL	Brown Clay of low plasticity and low dry strength. Trace fine sand throughout.		D	F	-	-	-
			SW	Light Orange mottled White Sand of low plasticity and low dry strength.		D	L	-	-	-
	0.8		CL	Top 100mm Grey Clay of medium plasticity and moderate dry strength with trace fine sands. Botton 200mm Red Clay of medium plasticity and moderate dry strength.		D	VSt	-	-	-
				Borehole terminated at 1.4m bgl (refusal).						
	1.6									
	2.0									

SOIL CLASSIFICATION SYMBOLS

GP	Poorly graded Gravel
GW	Well graded Gravel
GM	Gravel, Silt or Sand fines
GC	Gravel, Clay fines
SP	Poorly graded Sand
SW	Well graded Sand
SM	Silty Sand
SC	Clayey Sand
ML	Silt, low liquid limit
CL	Clay, low-medium plasticity
CH	Clay, high plasticity
OH	Organic Clay, high plasticity
Pt	Peat

WEATHERED ROCK CLASSIFICATION SYMBOLS

RS	Residual Soil
EW	Extremely Weathered
DW	Distinctly Weathered
SW	Slightly Weathered
F	Fresh

MOISTURE STATUS

D	Dry
M	Moist
W	Wet

REACTION

N	None
M	Minor
V	Vigorous

CONSISTENCY/DENSITY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard
Fb	Friable
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Logged: TS

Checked: VD

Equipment: Hand Auger

Revision 1

AH-F-301.15

APPENDIX 3: LAB ANALYSIS CERTIFICATES

PAGE 1 OF 1

RESULTS OF ACID SULFATE SOIL ANALYSIS

20 samples supplied by EAL Consulting on 11 March, 2010 – Lab. Job No. A7718
Analysis requested by Yoni Dawson. Your Project: Byron Parklands Project

Sample Site	EAL lab code	TEXTURE (note 6)	MOISTURE CONTENT (% moisture of total wet weight)	MOISTURE CONTENT (g moisture / g of oven dry soil)	FIELD/ LAB PEROXIDE SCREENING TECHNIQUE: Initial pH_F water	pH_{FOX} peroxide	pH change	Reaction	TITRATABLE ACTUAL ACIDITY (TAA): pH_{KCl}	TAA (To pH 6.5) (mole H^+/tonne)	Extractable sulfate sulfur $\%S_{KCl}$	Extractable sulfate sulfur mole H^+/tonne (AASS acidity)	REDUCED INORGANIC SULFUR (% chromium reducible S) (%Scr)	REDUCED INORGANIC SULFUR (mole H^+/tonne)	RETAINED ACIDITY (HCL extract) (as $\%S_{HCL} - \%S_{KCl}$) ($\%S_{NAG}$)	S_{NAG} (mole H^+/tonne)	NET ACIDITY Chromium Suite mole H^+/tonne (based on %Scrs)	LIME CALCULATION Chromium Suite kg $CaCO_3$/tonne DW (includes 1.5 safety Factor when liming rate is +ve)
Method No.																	note 5	note 4 and 6
C3 0-0.3m	A7718/1	Medium	60.1	1.50	4.15	1.80	-2.35	Very High	3.94	416	0.015	9	0.06	37	0.024	11	465	34.9
C3 0.5-0.7m	A7718/2	Coarse	21.2	0.27	5.66	4.00	-1.66	Low	5.78	9	..	-	<0.01	0	..	..	9	0.7
C3 0.9-1.1m	A7718/3	Coarse	16.9	0.20	5.67	1.84	-3.83	Medium	5.76	10	..	-	0.02	12	..	..	22	1.7
C3 1.3-1.5m	A7718/4	Medium	20.5	0.26	5.82	3.40	-2.42	Medium	4.76	64	..	-	0.05	31	..	..	95	7.1
C4 0-0.3m	A7718/5	Medium	41.6	0.71	5.15	3.55	-1.60	Low	4.88	115	..	-	0.03	19	..	..	134	10.0
C4 0.3-0.5m	A7718/6	Fine	27.6	0.38	4.90	2.47	-2.43	Medium	4.55	118	..	-	0.01	6	..	..	124	9.3
C4 0.6-0.8m	A7718/7	Fine	19.0	0.23	4.43	3.32	-1.11	Medium	3.81	77	0.006	4	0.01	6	0.004	2	85	6.4
C4 1.3-1.5m	A7718/8	Fine	18.9	0.23	4.48	3.08	-1.38	Medium	3.47	97	0.015	9	0.01	6	0.002	1	104	7.8
C5 0-0.3m	A7718/9	Coarse	60.8	1.54	4.17	2.53	-1.64	Medium	4.05	428	..	-	0.06	37	..	..	465	34.9
C5 0.4-0.6m	A7718/10	Coarse	17.7	0.21	5.13	3.78	-1.35	Low	4.94	28	..	-	0.01	6	..	..	35	2.6
C5 0.7-0.9m	A7718/11	Medium	29.0	0.41	5.19	4.06	-1.13	Low	4.87	75	..	-	0.02	12	..	..	87	6.5
C5 1.3-1.5m	A7718/12	Medium	27.1	0.37	5.59	4.51	-1.08	Low	5.22	42	..	-	0.01	6	..	..	48	3.6
C6 0-0.3m	A7718/13	Coarse	57.6	1.36	4.12	2.02	-2.10	Very High	4.12	373	..	-	0.08	50	..	..	423	31.7
C6 0.4-0.6m	A7718/14	Coarse	19.7	0.25	5.90	3.60	-2.30	Low	5.93	8	..	-	<0.01	0	..	..	8	0.6
C6 0.9-1.1m	A7718/15	Coarse	20.7	0.26	5.85	2.96	-2.89	Low	5.90	7	..	-	<0.01	0	..	..	7	0.5
C6 1.1-1.3m	A7718/16	Medium	16.4	0.20	5.25	1.91	-3.34	Medium	4.72	57	..	-	0.05	31	..	..	88	6.6
C8 0-0.3m	A7718/17	Coarse	58.1	1.39	4.02	2.12	-1.90	Medium	3.95	332	0.014	8	0.05	31	0.016	7	371	27.8
C8 0.4-0.6m	A7718/18	Coarse	18.7	0.23	5.89	4.35	1.54	No Reaction	5.87	8	..	-	<0.01	0	..	..	8	0.6
C8 0.9-1.1m	A7718/19	Coarse	12.8	0.15	5.89	3.31	-2.58	No Reaction	6.18	7	..	-	<0.01	0	..	..	7	0.5
C8 1.1-1.3m	A7718/20	Medium	15.2	0.18	5.64	2.20	-3.44	Medium	5.22	60	..	-	0.08	50	..	..	110	8.2

NOTES:

1 All analysis is Dry Weight (DW) – samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & Sulfate) and 'Chromium Reducible Sulfur' technique (Scr – Method 22B)
3 Methods from Ahern, CR, McElnea AE, Sullivan LA (2004). Acid Sulfate Soils Laboratory Methods Guidelines. QLD DNRME.
4 – Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density rings can be used and dried/ weighed in the laboratory.
5 - ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scr or Spos) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)
6 The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)
7 For Texture: coarse – sands to loamy sands; medium – sandy loams to light clays; fine – medium to heavy clays and silty clays
8 – .. denotes not requested or required. '0' is used for ANC and Snag calcs if TAA pH <6.5 or >4.5
9 SCREENING, CRS, TAA and ANC are NATA accredited but other SPOCAS segments are currently not NATA accredited
10 – Results at or below detection limits are replaced with '0' for calculation purposes.
11 – Projects that disturb >1000 tonnes of soil, the 0.03% S classification guideline would apply (refer to acid sulfate management guidelines).

(Classification of potential acid sulfate material if: coarse Scr 0.03% S or 19 mole H+/t; medium Scr 0.06% S or 37 mole H+/t; fine Scr 0.1% S or 62 mole H+/t) – as per QUASSIT Guidelines

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PAGE 1 OF 1

RESULTS OF ACID SULFATE SOIL ANALYSIS

27 samples supplied by Environmental Analysis Laboratory on [illegible] March 2010 – Lab Job No. [illegible]
Analysis requested by [illegible] – Your Project: [illegible]

Sample Site	Depth (m)	EAL lab code	TEXTURE (note 6)	MOISTURE CONTENT (% moisture of total wet weight)	MOISTURE CONTENT (g moisture / g of oven dry soil)	TITRATABLE ACTUAL ACIDITY (TAA) pH_{KCl}	TITRATABLE ACTUAL ACIDITY (TAA) (To pH 6.5) (mole H^+/tonne)	Extractable sulfate sulfur mole H^+/tonne (AASS acidity)	REDUCED INORGANIC SULFUR (% chromium reducible S) (%Scr)	REDUCED INORGANIC SULFUR (mole H^+/tonne)	RETAINED ACIDITY (HCL extract) (as $\%S_{HCL} - \%S_{kcl}$) ($\%S_{NAG}$)	RETAINED ACIDITY S_{NAG} (mole H^+/tonne)	NET ACIDITY Chromium Suite mole H^+/tonne (based on %Scrs)	LIME CALCULATION Chromium Suite kg $CaCO_3$/tonne DW (includes 1.5 safety Factor when liming rate is +ve)
Method No.													note 5	note 4 and 6
C1/1	0.0 - 0.3	[illegible]	Fine	53.7	1.16	3.89	277	18	0.05	31	0.052	18	328	24.4
C1/2	0.4 - 0.6	[illegible]	Medium	34.0	0.51	4.33	55	..	0.02	12	-	-	67	5.1
C1/3	0.9-1.1	[illegible]	Medium	21.2	0.27	4.67	24	..	0.02	12	-	-	36	2.7
C1/4	1.3-1.5	[illegible]	Medium	15.0	0.18	4.21	237	-	0.02	12	-	-	250	18.7
C2/1	0.0 - 0.3	[illegible]	Fine	44.8	0.81	4.14	250	..	0.04	25	..	..	258	19.3
C2/2	0.4-0.6	[illegible]	Coarse	16.7	0.20	4.98	22	..	0.02	12	-	-	34	2.6
C2/3	0.9-1.1	[illegible]	Medium	25.1	0.34	4.91	66	..	0.02	12	-	-	78	5.9
C7/1	0.0 - 0.3	[illegible]	Fine	34.2	0.52	4.71	98	..	0.02	12	-	-	111	8.3
C7/2	0.4 - 0.6	[illegible]	Fine	17.4	0.21	4.20	71	..	0.01	6	-	-	77	5.8
C7/3	0.9-1.1	[illegible]	Fine	19.2	0.24	3.82	57	18	0.01	6	0.012	6	63	5.2
C7/4	1.3-1.5	[illegible]	Fine	21.8	0.28	3.38	158	25	0.01	6	0.016	7	169	12.7
C8/1	0.0 - 0.3	[illegible]	Fine	26.3	0.36	4.34	56	..	0.01	6	..	..	62	4.6
C8/2	0.4 - 0.6	[illegible]	Fine	23.1	0.34	4.72	98	..	0.01	6	-	-	103	7.8
C8/3	0.9-1.1	[illegible]	Fine	20.8	0.26	3.78	100	3	0.02	12	0.008	4	118	8.7
C8/4	1.3-1.5	[illegible]	Fine	20.1	0.25	3.61	97	6	0.01	6	0.003	1	104	7.8
C10/1	0.0 - 0.3	[illegible]	Fine	22.7	0.29	4.51	53	..	0.03	19	-	-	71	5.3
C10/2	0.4 - 0.6	[illegible]	Fine	23.8	0.31	4.20	91	..	0.03	19	..	..	109	8.2
C10/3	0.9-1.1	[illegible]	Fine	18.2	0.24	3.68	93	7	0.02	12	0.007	1	108	8.1
C10/4	1.3-1.5	[illegible]	Fine	19.2	0.24	3.78	93	10	0.02	12	0.011	5	115	8.6
C11/1	0.0 - 0.3	[illegible]	Fine	33.4	0.45	4.38	203	..	0.04	25	-	-	228	17.1
C11/2	0.4 - 0.6	[illegible]	Fine	28.4	0.40	3.92	175	3	0.02	12	0.003	1	189	14.2
C11/3	0.9-1.1	[illegible]	Fine	23.6	0.31	3.66	149	7	0.02	12	0.005	2	164	12.3
C11/4	1.3-1.5	[illegible]	Fine	20.7	0.26	3.51	105	15	0.06	37	0.008	4	146	11.0
C12/1	0.0 - 0.3	[illegible]	Fine	48.5	2.28	4.44	180	..	0.03	19	-	-	199	14.9
C12/2	0.4 - 0.6	[illegible]	Fine	28.1	0.36	3.85	180	5	0.02	12	0.006	3	205	15.4
C12/3	0.9-1.1	[illegible]	Fine	21.4	0.27	3.76	111	7	0.02	12	0.015	7	130	9.8
C12/4	1.3-1.5	[illegible]	Fine	21.0	0.27	3.55	120	6	0.07	44	0.004	2	165	12.4

NOTES:
1 - All analysis a Dry Weight (DW) – samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 – Samples analysed by SPOCAS method and 'Chromium Reducible Sulfur' technique [illegible]
3 Methods from Ahern, CR, McElnea AC, Sullivan LA (2004). Acid Sulfate Soils Laboratory Methods Guidelines. QLD DNRME.
4 – [illegible]
5 – [illegible]
6 – [illegible]
7 – [illegible]
8 – [illegible]
9 – [illegible]
10 – [illegible]
11 – [illegible]

[illegible]

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RESULTS OF SAMPLE/SOIL ANALYSIS

5 sample supplied by EAL Consulting on the 25 March, 2010 - Lab Job No. A7916
Analysis requested by Katie Whitney. Project: Splendor Wooyong

	Method	Sample 1 Peat 2	Sample 2 Peat 3	Sample 3 Peat 4	Sample 4 Peat 5	Sample 5 Peat 7
	Job No.	*A7916/1*	*A7916/2*	*A7916/3*	*A7916/4*	*A7916/5*
Total Carbon (%C)	LECO CNS2000 Analyser	16.52	31.05	32.28	16.13	20.23
Organic Matter (%)	By calculation	28.9	54.3	56.5	28.2	35.4

Notes:
1. All results as dry weight DW - samples were dried at 60°C for 48hrs prior to crushing and analysis.
2. Organic Matter = (%C Total Carbon) x 1.75

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PAGE 1 OF 1

RESULTS OF ACID SULFATE SOIL ANALYSIS

22 samples supplied by Environmental Analysis Laboratory on 19th April, 2010 - Lab. Job No. A8257
Analysis requested by Nick Davison. - Your Project: [illegible]

Sample Site	Depth (m)	EAL lab code	TEXTURE (note 6)	MOISTURE CONTENT (% moisture of total wet weight)	MOISTURE CONTENT (g moisture / g of oven dry soil)	TITRATABLE ACTUAL ACIDITY (TAA) pH_{KCl}	TAA (To pH 6.5) (mole H^+/tonne)	Extractable sulfate sulfur $\%S_{KCl}$	Extractable sulfate sulfur mole H^+/tonne (AASS acidity)	REDUCED INORGANIC SULFUR (% chromium reducible S) (%Scr)	REDUCED INORGANIC SULFUR (mole H^+/tonne)	RETAINED ACIDITY (HCL extract) (as $\%S_{HCL} - \%S_{KCl}$) ($\%S_{NAG}$)	RETAINED ACIDITY S_{NAG} (mole H^+/tonne)	NET ACIDITY Chromium Suite mole H^+/tonne (based on %Scrs)	LIME CALCULATION Chromium Suite kg $CaCO_3$/tonne DW (includes 1.5 safety Factor when liming rate is +ve)
Method No.														note 5	note 4 and 6
C13/1	0-0.2	[illegible]	Fine	21.7	0.28	4.28	72	0.000	0	0.01	8	0.017	8	88	6.4
C13/2	0.4-0.6	[illegible]	Fine	22.4	0.29	3.57	200	0.007	4	0.02	12	0.003	1	214	16.1
C13/3	0.9-1.1	[illegible]	Fine	19.8	0.25	3.36	186	0.012	7	0.01	6	0.009	4	196	14.7
C13/4	1.3-1.5	[illegible]	Fine	15.6	0.18	3.44	155	0.020	12	<0.01	0	0.005	2	157	11.8
C14/1	0-0.2	[illegible]	Fine	21.2	0.27	4.51	62	-	-	0.02	12	..	0	74	5.6
C14/2	0.4-0.6	[illegible]	Fine	24.8	0.33	4.14	109	0.006	3	0.03	19	0.011	5	133	10.0
C14/3	0.9-1.1	[illegible]	Fine	32.9	0.49	3.68	191	0.002	1	0.02	12	0.008	4	207	15.5
C14/4	1.4-1.6	[illegible]	Course	14.6	0.17	4.42	29	0.000	0	<0.01	0	0.002	1	30	2.2
C14/5	1.8-2.0	[illegible]	Course	13.9	0.16	4.54	25	-	-	0.01	6	..	0	31	2.3
C15/1	0-0.2	[illegible]	Fine	32.9	0.49	4.15	181	0.008	2	0.07	44	0.016	7	232	17.4
C15/2	0.4-0.6	[illegible]	Fine	41.8	0.72	4.44	225	0.013	8	0.12	75	0.038	18	315	23.7
C15/3	0.9-1.1	[illegible]	Fine	14.8	0.17	4.48	54	0.006	4	<0.01	0	0.002	1	55	4.1
C15/4	1.4-1.6	[illegible]	Fine	20.3	0.28	3.48	158	0.020	12	<0.01	0	0.007	3	141	10.6
C15/5	1.8-2.0	[illegible]	Medium	16.6	0.20	4.07	58	0.001	1	<0.01	0	0.006	3	61	4.6
C16/1	0-0.2	[illegible]	Fine	20.2	0.25	4.83	67	-	-	0.04	25	..	0	92	6.9
C16/2	0.4-0.6	[illegible]	Fine	19.1	0.24	4.81	69	-	-	0.10	62	..	0	131	9.8
C16/3	0.9-1.1	[illegible]	Medium	14.8	0.17	5.39	28	-	-	0.01	6	..	0	34	2.8
C16/4	1.4-1.6	[illegible]	Medium	10.2	0.11	5.24	18	-	-	<0.01	0	..	0	18	1.4
C16/5	1.8-2.0	[illegible]	Course	17.5	0.21	5.54	16	-	-	<0.01	0	..	0	16	1.2
C17/1	0-0.2	[illegible]	Fine	26.1	0.35	4.78	107	-	-	0.09	56	..	0	163	12.2
C17/2	0.4-0.6	[illegible]	Course	10.0	0.11	5.67	16	-	-	0.01	6	..	0	22	1.6
C17/3	0.9-1.0	[illegible]	Fine	36.0	0.61	4.47	325	0.001	1	0.02	12	0.069	32	369	27.7

NOTE:
1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground).
2 Samples analysed by SPOCAS method 23 [illegible] and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)
3 - Reference from Ahern, CR, McElnea AE, Sullivan LA (2004). Acid Sulfate Soils Laboratory Methods Guidelines. QLD DNRME.
4 - [illegible]
5 - [illegible]
6 - [illegible]
7 For Texture: [illegible]
8 - .. denotes not requested or required. [illegible]
9 - [illegible]
10 - Results at or below detection limits are replaced with '0' for calculation purposes.
11 - [illegible]

[illegible]

Lab Accred No. [illegible]

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