Report for: UrbanGrowth

North Tuncurry Development Project

Detailed Acid Sulfate Soil Investigation

July 2014

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Limitations

This report has been prepared for Urban Growth NSW. The purpose of the report is to provide ASS investigation findings for fieldwork conducted at the site up until June 2014. This report does not provide a complete assessment of the environmental status of the site or the surrounding area, and is limited to the scope defined in Section 1.3.

The findings of this report are based on the data collected during the stated investigation period. SMEC performed the fieldwork in a manner consistent with the normal level of care and expertise exercised by members of the environmental assessment and consulting profession.

The findings of the report are based on the concentrations observed in the sampled soil at the time of the assessment. These conditions may change with time and space. No warranty, expressed or implied, is made as to the information and professional advice included in this report. The report shall only be used for the purposes stated in the signed contract and shall not be relied upon by any party other than the client for this Project. Anyone using this document does so at their own risk and should satisfy themselves concerning the applicability of its application and where necessary should seek expert advice in relation to the particular situation.

EXECUTIVE SUMMARY

Snowy Mountains Engineering Corporation (SMEC) was engaged by Urban Growth NSW to undertake additional site investigations associated with the North Tuncurry Development Project (NTDP) site. The investigation scope is for the assessment of Acid Sulfate Soil (ASS) conditions at the subject site in relation to the proposed bulk earthworks to be undertaken as part of the NTDP.

Preliminary soil sampling and analysis carried out at the subject site in 2012 indicated that a number of the soil samples showed the presence of acid soil conditions. The acid soils contained an acid generating capability at levels triggering requirement for detailed assessment of the ASS risk associated with the proposed works.

In response to the preliminary findings, SMEC's Environmental Scientists designed a more detailed series of sampling and testing in locations where proposed excavation is at its greatest in order to establish the extent, depth and strength of any ASS in accordance with the Acid Sulfate Soil Manual (ASSMAC, 1998). This detailed assessment phase focussed on the high risk areas associated with the deeper parts of the proposed bulk excavation, such as at the location of the proposed water management basins (basins) and underground service easements.

This ASS Detailed Investigation Report presents the findings of fieldwork conducted between 19th and 22nd May 2014. The fieldwork involved soil sampling (and field screening) involving drilling through the soil profile at 22 designated sites within the proposed 261ha development area.

The scope of works for the investigation included:

- Undertake site investigations and laboratory analysis to provide information on the potential ASS in the area;
- A maximum of three (3) days drilling, using a Geoprobe 7822DT drill rig at the designated drilling locations;
- Drill locations concentrated around the proposed water management basin locations;
- Logging geologic materials, depths and generating a log of the drilled soil profiles;
- Conducting qualitative pH_F and pH_{FOX} ASS field screening on likely ASS samples;
- Conducting quantitative laboratory analysis (S_{CR} Suite) on samples that indicate likely ASS presence within depths relevant to the proposed works in each area;
- Providing interpretation of ASS data and any requirements for an ASS Management Plan for the proposed earthworks (if required); and
- The preparation of an ASS Detailed Investigation Report documenting the geological and chemical nature and extent of ASS at the site.

A review of the National ASS Risk Mapping (ASRIS) website indicates that the subject site is located within landform areas with a "Low Probability" of encountering ASS. Furthermore, review of the acid sulfate soil maps in the *Great Lakes Local Environmental Plan 2014* (GLC DCP No. 34) indicates that the subject site is located in an area categorised as having a 'land class' of 4 (Refer **Appendix F**), meaning that development consent will be required by Council, and will need to be considered in future stages of the project, based on the following works:

- Works beyond 2m below natural ground surface; and
- Works likely to lower the water table to a depth of more than 2m below the natural ground surface.

During the acid sulfate soil investigation undertaken in 2014, SMEC can confirm that the soils present at the 22 locations are typically back Holocene Beach Ridges with well-developed Podzolic soil horizons. The B horizon of these Podosols is dominated by compounds of organic matter and is generally highly sandy and acidic at surface.

Field screening results indicated low potential acidic conditions to be present. Additional quantitative laboratory analysis (S_{CR}) was conducted on samples presenting potential ASS based on these field screening data and vegetation indicators. The additional S_{CR} results indicate that the soils sampled are non sulfidic acid soils in the study area.

Groundwater modelling for the proposed cut and fill earthworks indicate that the ground water level will rise from the existing groundwater levels under all climatic conditions (except for extreme wet weather in which a large pipe will remove surface water from the site). Therefore the risk of ASS developing as a result of the proposed works will reduce and the risk of developing ASS conditions is unlikely.

It is recommended that a high level acid sulfate soil management plan (ASSMP) be developed for the site to manage contingent ASS conditions not identified in this survey and to protect the environmentally sensitive receiving water bodies adjacent to the study area. The ASSMP for the proposed works is to manage the non sulfidic acid soils and the non sulfidic induced acidic water quality of the existing and naturally occurring water bodies in the study area.

This ASSMP is to become part of the construction environmental management plan for the civil works proposed in this study area and will outlay an incidental finds process for unexpected ASS and impacted groundwater. The ASSMP is to provide a soil movement record for soils moved internally and soil materials imported to site. This ASSMP is to provide the basis for identifying ASS conditions in the soil and in the water bodies.

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ACCRONYMS AND ABBREVIATIONS

AASS	Actual Acid Sulfate Soil
AHD	Australian Height Datum
ASM	Acid Sulfate Materials
ASR	Acid Sulfate Rock
ASS	Acid Sulfate Soil(s)
ASSMAC	Acid Sulfate Soils Management Advisory Committee (NSW), 1998
ASSMP	Acid Sulfate Soil Management Plan
BH	Borehole (drilled borehole)
CoC	Chain of Custody
NA	Net Acidity
NATA	National Association of Testing Authorities
PASS	Potential Acid Sulfate Soil(s)
pH	Potential Hydrogen
pH_F	pH (Field pH)
pH_{FOX}	pH (Field Oxidised pH with 30% hydrogen peroxide reagent)
pH_{KCL}	pH of a 1:5 solution of soil and 1Mol Potassium Chloride
QA/QC	Quality Assurance, Quality Control
RPD	Relative Percentage Difference
SAQP	Sampling and Analysis Quality Plan
S_{CR}	Chromium Reducible Sulfur
S_{HCl}	Sulfur extracted under the Hydrochloric Acid technique
S_{KCl}	Sulfur extracted under the Potassium Chloride technique
S_{NAS}	Net Acid Soluble Sulfur
SMEC	Snowy Mountains Engineering Corporation
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate
S_{POS}	Peroxide Oxidisable Sulfur
S_{RAS}	Residual Acid Soluble Sulfur
TAA	Total Actual Acidity
TP	Test Pit (Excavation)
TPA	Total Potential Acidity
TSA	Total Sulfidic Acidity
TTA	Total Titratable Acidity

1 INTRODUCTION

1.1 Background

Snowy Mountains Engineering Corporation (SMEC) was engaged by Urban Growth NSW to undertake additional site investigations associated with the proposed earthworks at the North Tuncurry Development Project (NTDP) site. The NTDP is a proposed residential development sponsored by Urban Growth NSW under a Project Delivery Agreement with the Crown Lands Branch of NSW Trade and Investment, who control the land. The NTDP area (project area) comprises 615ha of land located to the north of the township of Tuncurry. The proposed development area comprises 261ha of land that is located at the southern portion of the project area – refer **Plate-1**.

Plate-1 – Project and development area

The investigation scope is for the assessment of Acid Sulfate Soil (ASS) conditions at the subject site (*i.e. within the dashed line shown in **Plate-1***). Initial soil sampling and analysis carried out at the subject site in 2012 indicated that a number of the soil samples showed the presence of acid soils triggering the ASS management requirement. As a result of this, SMEC's Environmental Scientists have recommended a more comprehensive series of sampling and testing across the site in order to establish the extent and depth of any ASS in accordance with the Acid Sulfate Soil Manual (ASSMAC, 1998). This is particularly important for areas where proposed ground engaging activities are at their deepest, such as at the location of the proposed water management basins (basins).

This ASS Detailed Investigation Report presents the findings of fieldwork conducted between 19th and 22nd May 2014. The fieldwork involved soil sampling (and field screening) involving drilling through the soil profile at 22 designated sites within the proposed development area.

1.2 Project Objectives

The objectives for this investigation, as described in the Project brief, include:

- Carrying out systematic investigative drilling at designated locations around the subject site and subsequent collection/analysis of soil at designated depth increments through the soil profile;
- Determine if ASS occurs within the subject site through site screening and laboratory analysis of selected samples; and
- Assist Urban Growth NSW in identifying risks associated with the proposed development regarding potential for ASS disturbance.

1.3 Scope of Works

The scope of works for this investigation included the following:

- Review of background information, including existing soil test results, the proposed bulk earthworks plan, and other relevant documentation;
- Assessing geological conditions at the sampling locations and likelihood of ASS occurrence;
- Approximately three (3) days drilling, using a Geoprobe 7822DT drill rig at designated locations around the subject site;
- Collecting soil samples during the drilling at representative soil horizons to a minimum depth of 1.5m below the proposed excavation level in the areas where proposed excavation is at its greatest depths (i.e. water management basins, underground service easements, related cut and fill) – refer **Figure 1**, **Appendix A**;
- Undertake site investigations and laboratory analysis to provide information on the potential for ASS at the subject site;
- Conducting qualitative pH_F and pH_{FOX} ASS field screening on likely ASS samples;
- Conducting quantitative laboratory analysis (S_{CR} suite) on samples that indicate likely ASS presence within depths relevant to the proposed works in each area;
- Providing interpretation of ASS data and any requirements for an ASSMP for the proposed bulk earthworks; and
- The preparation of an ASS Detailed Investigation Report (this report) documenting the geological and chemical nature and extent of ASS (if any).

1.4 What is ASS?

ASS is the generic name given to soils and sediments which are rich in iron sulfides (pyrite). They have formed naturally, commonly in estuarine areas along the east coast of Australia as well as other parts of the continent and throughout the world. If permanently deprived of oxygen, the sulfide minerals in ASS cause no environmental harm and the materials are referred to as Potential Acid Sulfate Soils (PASS).

Coastal PASS occurs predominantly below 5m Australian Height Datum (AHD) and up to 10m AHD in some instances. If exposed to atmospheric oxygen however, the sulfide minerals in the soil oxidise and can produce excess sulfuric acid. Such soils are referred to as Actual Acid Sulfate Soils (AASS). Usually, where Holocene-age (<10,000 years old) alluvial sediments are encountered, AASS overlie PASS.

1.5 ASS Guidelines and Framework

Published guidelines and references for assessment, management and technical information that have been reviewed throughout this investigation are detailed in **Table 1**.

Table 1 – ASS Guidelines and Framework

Guideline	State Produced
Stone Y., Ahern C. R. and Blunden B. 1998. *Acid Sulfate Soils Manual*, Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.	NSW
National Working Party on Acid Sulfate Soils. 2000. *National Strategy for the Management of Coastal Acid Sulfate Soils,* NSW Agriculture, Wollongbar.	NSW
Great Lakes Council. *Acid Sulfate Soils Development Control Plan No. 34 DRAFT*	NSW
Dear et al., 2002. *Queensland Acid Sulfate Soil Technical Manual*, Soil Management Guidelines Version 3.8.	QLD
Ahern CR, McElnea AE, Sullivan LA 2004. *Acid Sulfate Soils Laboratory Methods Guidelines*. In Queensland Acid Sulfate Soils Manual 2004. Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland, Australia.	QLD
Dear et al.. 2004. *Queensland Acid Sulfate Soil Technical Manual Legislation and Policy Guide,* Version 2.2.	QLD
Ahern C. R., Ahern M. R. and Powell B. 1998. *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland*, Queensland Acid Sulfate Soils Investigation Team (QASSIT), Queensland Department of Natural Resources, Brisbane.	QLD

2 SITE DESCRIPTION

As discussed above, the proposed development area comprises approximately 261ha of land that is located in the southern portion of the project area. At present, with the exception of the golf course, old aeroplane runway and access roads, the site is undeveloped. It is understood that sand mining has previously been carried out to the north of the study area, however there is no evidence of mining within the study area (Douglas Partners, 1988). Furthermore, some areas of the site have previously been cleared of vegetation, including the old aeroplane runway site and the golf course.

2.1 Site Location

The subject site is located to the east of The Lakes Way and is bounded to the south by the North Coast TAFE Great Lakes Campus and to the east by the Pacific Ocean (refer to **Plate-1**).

2.2 Nature of the Proposed Works

The NTDP will be located within the 261ha development area and will comprise the following key components:

- Approximately 2,123 residential dwellings;
- 13.2ha of employment lands;
- 9.6ha of parks and open space;
- A village centre;
- Reconfiguration of the existing North Tuncurry Golf Course (total area 59ha); and
- Water management infrastructure, including 18.1ha of water management basins.

SMEC prepared a bulk earthworks plan in April 2014 (refer **Figure 1, Appendix A**) for the proposed development. In summary, the bulk earthworks plan comprises the following:

- Total cut area of approximately 91ha;
- Total cut volume of approximately 1.07 million m^3 (including topsoil stripping); and
- Maximum cut depth of 7.5m.

It is expected that the NTDP will be constructed in a number of stages over a 30 year timeframe.

2.3 Regional Geology and Soils

Geotechnical Investigations have previously been undertaken by Douglas Partners in 1998, WorleyParsons in 2010 and by SMEC in 2012. Data collected from the geological investigations indicate that the development area comprises relatively homogenous geological characteristics, with fine to medium Aeolian sands encountered in all test pits and bore holes from the previous investigations. The deeper bore holes drilled by SMEC in 2012 encountered fine to medium marine sands at 12m below ground level and marine clays from 24m below ground level. Importantly, no low permeability material such as clay or indurated sands has been encountered in any borehole or test pit to date. This indicates that no significant geological barriers to groundwater flow exist within the development area.

Table 2 presents a geological profile that has been interpreted from available data.

Table 2 – Interpreted Geological Profile

Geology Layer	Depth	Description
Holocene Aeolian Sands (Top Soil)	0 to 0.5mbgl	**Sand:** Fine to medium with organic matter and roots.
Holocene Aeolian Sands (below 0.5 metres)	From 0.5 to 12mbgl	**Sand**: Fine to medium, moderately sorted with shells. Some roots encountered.
Holocene Marine Sands	From 12 to 24mbgl	**Sand**: Fine to medium, moderately sorted with shells and some occasional clay bands.
Marine Clay	From 24mbgl	**Sandy Clay**: Dark grey, high plasticity with fine to medium sand

Note: No geotechnical data is available for the northern employment lands that are detached from the primary component of the development area.
Note: mbgl - metres below ground level

During the ASS investigation undertaken in 2014, SMEC can confirm that the soils present at the 22 locations are typically back Holocene Beach Ridges with well-developed Podzol. The B horizon of these Podosols is dominated by compounds of organic matter and is generally highly sandy and acidic at the surface.

2.4 Hydrogeology

As described above, the project area is located above an unconfined coastal aquifer. The site topography is characterised by undulating aeolian dune systems, which have no distinct surface drainage paths as they are shaped by the wind rather than water. Accordingly, all rainfall that falls over the project area is either lost to evapotranspiration processes or drains vertically through the upper soil layer into the aquifer through a process referred to as recharge. Water leaves the aquifer through both evapotranspiration processes and lateral groundwater flow to the east (to the Pacific Ocean) and to the west (to the Wallamba River). The dynamics of these processes vary depending on the groundwater flow characteristics, prevailing rainfall and evapotranspiration rates. **Plate-2** below illustrates the typical groundwater flow divide at the subject site following a groundwater recharge event in July 2011 based on modelling undertaken by SMEC in 2014 as part of the *NTDP Groundwater Modelling Technical Report*.

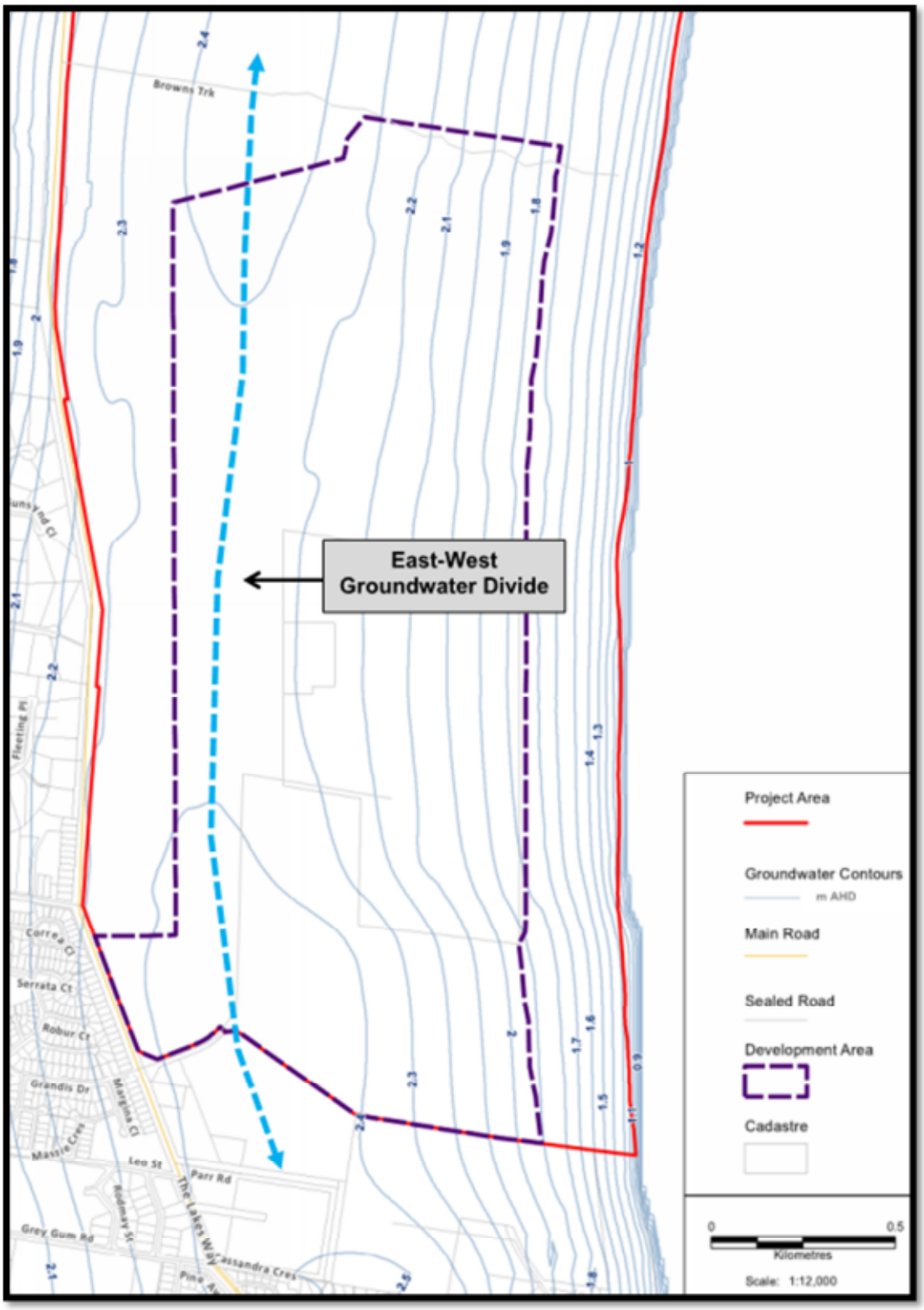

Plate-2 – Indicative groundwater profile on 24 July 2011 following a groundwater recharge event (SMEC, 2014)

In addition to the above, **Plate-3** below illustrates the indicative groundwater contours during typical wet weather conditions under developed conditions, as well as the estimated location of the groundwater divide.

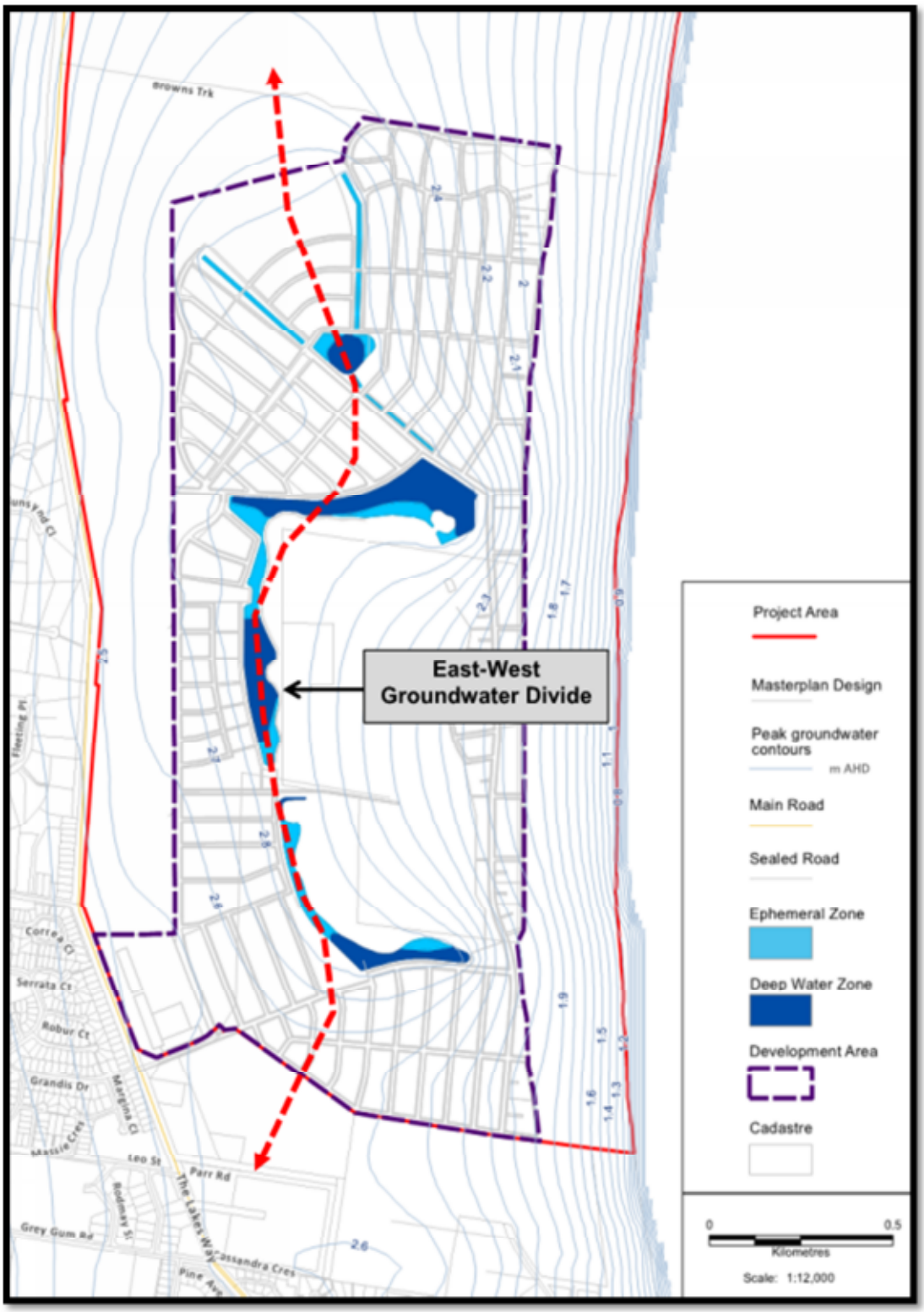

Plate-3 – Developed conditions detailed groundwater model results: Typical 90th Percentile (wet weather) groundwater conditions (SMEC, 2014)

2.4.1 Potential Groundwater Issues

With reference to **Plate-2** and **Plate-3** above, the east-west groundwater divide is located in the western portion of the project area. Groundwater to the east of the divide flows into the Pacific Ocean to the east and groundwater to the west of the divide flows into the Wallamba River Estuary to the west. It is noted that the alignment of the groundwater

divide is likely to be somewhat dynamic with groundwater modelling results (SMEC, 2014) indicating the divide moves further west under higher groundwater conditions.

The area to the west of The Lakes Way is classed as having 'high probability' of ASS (refer **Plate-4**). However, given the groundwater from the areas classed as 'high probability' of ASS flows to the west, away from the subject site and into the Wallamba River, it is not expected to affect the subject site.

Reference to the *NTDP Integrated Water Cycle Management Strategy* (SMEC, 2014) suggests the following in relation to potential changes to groundwater levels as a result of the proposed development:

- Typical developed conditions groundwater levels will be approximately 0.3 to 0.4m higher than existing conditions levels at all times except for extreme wet weather conditions. The higher levels are primarily due to the expected increase in recharge volumes, which are predicted to increase from 36% to 50% of rainfall on an annual average basis as a result of the development (increased impervious areas and reduced evapotranspiration losses). The Groundwater Modelling Technical Report (SMEC, 2014) provides detailed information on the expected changes to recharge characteristics due to the development and discusses the impacts of higher groundwater levels.
- During extreme wet weather conditions, the proposed developed formation groundwater levels will be lower than existing conditions levels due to the proposed groundwater management controls (water management basins and gravity drainage to offsite destination). Under developed conditions and extreme wet weather the groundwater will be higher than the water level in the water management basins, and as a result groundwater will flow into the basins. These conditions are estimated to occur 2% of the time.

Given that the groundwater table is expected to typically be 0.3 to 0.4m higher as a result of the proposed development, it is not likely to adversely impact ASS conditions in either normal flow or high flow events.

2.5 Topography

The topography within the project area is characterised by undulating aeolian dune systems, which have no distinct surface drainage paths as they are shaped by the wind rather than water. The dunes are stabilised by vegetation and are typically orientated along a north-south alignment, parallel to the coast. Spacing between dune crests ranges between 20 and 100m, while the variation in height between a peak and a corresponding trough typically ranges between 0.5 to 2.5m.

Analysis of LiDAR indicates that surface levels within the project area range between 2 to 10m AHD. The highest levels (8 to 10m AHD) are associated with the fore dune system which is offset from the beach by approximately 100 to 150m. The hind dune area (located to the west of the fore dune system), is characterised by lower topography, with levels typically ranging between 3 to 7m AHD. The topography is generally higher in the western portion of the hind dune area than the eastern portion. The proposed 261ha development area is located in the hind dune area. The average surface level within the development area is estimated (from the LiDAR) to be 5.1m AHD.

2.6 ASS Risk Mapping

Review of the NSW Acid Sulfate Soil Risk Mapping and the National Acid Sulfate Soil Risk Mapping (ASRIS) website suggests that the subject site is located within landform areas with a "low probability" indicating that the subject site is classified as having a *low*

probability of occurrence of ASS. Refer **Plate-4** below which illustrates the indicative subject site area in relation to the Acid Sulfate Soil Risk Management Map.

Plate-4 – Acid Sulfate Soil Risk Management Map (ASRIS, 2014)

Furthermore, review of the acid sulfate soil maps in the *Great Lakes Local Environmental Plan 2014* indicates that the subject site is located in an area categorised as having a 'land class' of 4 (Refer **Appendix F**), meaning that development consent will be required by Council for the following works (GLC DCP No. 34):

- Works beyond 2m below natural ground surface; and
- Works likely to lower the water table to a depth of more than 2m below the natural ground surface.

Given that the proposed works will be beyond 2m below the natural ground surface at some locations, development consent will be required from Council.

3 ASS CRITERIA

Table 3 details the texture based action criteria for management of ASS disturbance, as sourced from ASSMAC (1998). The S_{CR} suite of analysis was used to assess ASS presence/absence. The "net acidity" result of each sample was used to compare to the sulfur and acid trail assessment criteria including a comparative estimation of acid neutralising capacity (ANC) under laboratory conditions.

The "net acidity" result for each sample was compared against the criteria within **Table 3**. The components that make up the "net acidity" using acid based accounting techniques (i.e. Actual, Potential or residual acidity) were assessed against the criteria. Where only titratable actual acidity forms all or the majority of the net acidity equation and no other ASS indicators (physical and chemical) are observed, discussion will be provided on whether the materials are likely to be sulfide related or non sulfidic acidity related.

Where soils containing concentrations at or above the action criteria are disturbed, management of spoil may be required (i.e. through development of an ASSMP). As this Project will disturb spoil greater than 1,000 tonnes of soil, the two right hand columns shall be used.

Table 3 – ASS Criteria (ASSMAC, 1998)

Type of Material		Action Criteria 1- 1,000 tonnes Disturbed		Action Criteria if more than 1,000 tonnes Disturbed	
Texture range (McDonald et al. (1990)	**Approx clay content (%<0.002 mm)**	**Sulfur trail % S oxidisable e.g. STOS or SPOS "Net Acidity"**	**Acid trail mol H+/tonne e.g. TPA or TSA "Net Acidity"**	**Sulfur trail % S oxidisable e.g. STOS or SPOS "Net Acidity"**	**Acid trail mol H+/tonne e.g. TPA or TSA "Net Acidity"**
Coarse Texture Sands to loamy sands	≤5	0.03	18	0.03	18
Medium Texture Sandy loams to light clays	5 – 40	0.06	36	0.03	18
Fine Texture Medium to heavy clays and silty clays	≤40	0.1	62	0.03	18

Table Notes: 1. S_{POS} – Sulfur Peroxide Oxidisable Sulfur, S_{TOS} – Sulfur Total Oxidisable Sulfur, TSA – Total Sulfidic Acidity, TPA – Total Potential Acidity, S oxidisable – Sulfur produced from the respective extraction technique, mol H+ - Measure of acid strength

4 FIELDWORK

4.1 Preliminary Investigation (2012)

Initial soil sampling and NATA accredited laboratory analysis in the form of Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) tests was carried out at three (3) locations at the subject site in February 2012. Laboratory results indicated that two (2) sites showed the presence of acid soils, triggering the acid sulfate soil material management requirement to undertake a more detailed investigation. As a result of this, SMEC's Environmental Scientists recommended a more comprehensive series of sampling and testing across the site in order to establish the extent and depth of any ASS in accordance with the ASSMAC guidelines (1998). This is particularly important for areas where proposed ground engaging activities are at their deepest, such as at the location of the proposed water management basins. *Note: This more detailed investigation commenced in May 2014 and is discussed below.*

4.2 Detailed Investigation (2014)

Subsequent additional soil sample collection was undertaken by SMEC personnel in May 2014, with acid sulfate field screening being undertaken of samples from 22 designated sampling locations around the subject site, with a higher concentration of sites in areas of greatest cut, such as locations of the proposed water management basins. Sampling depths ranged from 1m to 7.5m below the ground surface. The drill locations are shown in **Figure 1** and **Figure 2** of **Appendix A**.

4.2.1 Drilling

As previously discussed, the fieldwork associated with this investigation was carried out from the 19th to 22nd May 2014. All fieldwork conducted was carried out by an experienced Environmental Scientist who collected soil samples during both the 2012 and 2014 investigation programs.

Epoca Environmental were engaged to undertake the drilling at the 22 designated locations around the subject site. The drilling was conducted using a Geoprobe 7822DT drilling rig.

Drilling locations were initially located on the ground according to the bulk earthworks plan carried out by SMEC in April 2014. Underground services were scanned and located by a certified Service Locator.

Soil log photos and location photos of each drill location are presented in **Appendix C** and **Appendix D**, respectively.

The methodology and sampling activities carried out at each location were chosen to gain representative data sets on the materials regarding ASS. Further information regarding sampling and analysis for each of the assessment sites is provided in the following sections.

4.2.2 Sampling Rationale and Regime

The sampling regime was undertaken in accordance with the guidelines detailed in **Table 1**. The investigation was concentrated within areas where deeper excavation is proposed (e.g. proposed basins), at the same time sampling from locations around the subject site to gain a widespread representation of the subject site.

The sampling regime for the Project included:

- Preparing a sampling and analysis quality plan (the SAQP) in general accordance with relevant guideline documents (refer to Table 1) at potential areas of disturbance;
- Collecting representative soil samples during drilling;
- Conducting qualitative pH_F and pH_{FOX} ASS field screening on likely ASS samples; and
- Conducting quantitative laboratory analysis (S_{CR} suite) on samples that indicate likely ASS presence.

4.2.3 Sampling Methods

Sampling methods to collect discrete and representative data included:

- obtaining representative soil samples at specified depths within the soil profile (typically 0.5m intervals) to a depth to at least one (1) metre beyond the depth of any proposed excavation for each respective sampling site;
- placing all soil samples, immediately, into clean labelled zip-lock plastic bags then extruding all air;
- removing all visual traces of organic debris and whole shell fragments (where practicable);
- placing samples into an esky with ice (or cooling media) and kept at a temperature below approximately 4.0 degrees Celsius between sampling event and laboratory receipt;
- logging soil and recording all relevant data including photo log;
- documenting GPS coordinates for each respective sampling site;
- appropriate storage and transportation of samples in accordance with strict Chain of Custody (COC) procedures and laboratory technical holding time (THT) requirements; and
- managing field and analytical work in accordance with the SMEC Quality Assurance, Quality Control and Environmental Management systems.

It is noted that the ASSMAC guidelines recommend 2 sampling sites per hectare for sites greater than 4 hectares. However given the estimated area of proposed cut for the NTDP is 91ha, this equates to 182 sampling locations. To provide an effective sampling and analysis program at reasonable cost, a carefully selected group of sampling sites was developed. If initial testing of the selected locations indicated the presence of ASS, the project scope had capacity to increase the number of sampling sites and concentrate the sites around areas where ASS were present. Alternatively, field investigations could be terminated early if sufficient sampling indicated that ASS and PASS do not exist.

A summary of the 22 sampling locations is provided below in **Table 4**.

Table 4 – Sampling Location Summary Table

Sample Location ID	GPS Coordinates		Current Surface Level (m AHD)	Drill Depth Below Surface (m)
	Easting	Northing		
1	452654	6444033	4.90	1.5
2	452960	6444113	4.54	1.5
4	452219	6443712	6.35	2.0
5	452433	6443684	6.44	4.5
6	452706	6443632	4.52	3.0
10	452277	6443366	6.12	1.5
13	452795	6443032	4.35	7.5
15	452515	6443131	5.21	7.5
17	452483	6442743	5.37	7.5
18	452411	6442656	5.90	7.5
20	453009	6442525	4.96	1.5
21	452489	6442483	4.83	7.5
22	452698	6443558	4.54	7.0
23	452387	6442383	6.38	2.5
25	452228	6442220	6.53	1.5
27	452384	6442110	6.39	2.5
28	452213	6442001	6.25	1.5
29	452645	6441943	4.42	6.0
31	452887	6441916	4.11	6.0
33	452381	6441920	6.54	1.5
34	452222	6441734	6.88	1.0
35	452361	6441782	6.24	1.5

5 RESULTS OF INVESTIGATION

5.1 Geological Conditions

Geology encountered within the proposed development generally consisted of the following sequence:

- 0.0 – 0.5m below ground level: Topsoil overlaying Black sand material containing organic matter;
- 0.5 – 3.0m below ground level: Grey to Brown sand material;
- 3.0 – 5.5m below ground level: Pale/Yellow sand material; and
- 5.5 – 7.5m below ground level: Pale/Yellow sand material containing 1-10mm shells.

Refer to **Appendix C** for photos of the soil profile for each of the respective sampling locations.

5.2 Groundwater Characteristics

5.2.1 Groundwater Levels

Groundwater was observed at most of the deeper drill locations around the subject area. The typical depth to groundwater ranged from 3 to 4.5m below the ground surface level. It is likely that groundwater conditions will change seasonally, and after extended periods of wet or dry weather. Further discussion on fluctuations in the groundwater levels can be found in the *North Tuncurry Development Project - Groundwater Modelling Technical Report* SMEC (2014).

5.2.2 Groundwater Quality

A comprehensive groundwater quality monitoring program has been undertaken by SMEC on behalf of Urban Growth NSW. The program included seven (7) sampling rounds over a 38 month period (March 2010 to May 2013) from eleven (11) designated sampling locations. The groundwater quality monitoring program included sampling and analysis of a full suite of water quality analytes, including pH (field) and pH (lab). Table 2 of the Great Lakes Council *Acid Sulfate Soils Development Control plan No. 34* suggests that groundwater with pH<4 is an indicator of ASS. However, all pH results from the abovementioned groundwater monitoring program were greater than pH 4 (minimum pH value recorded was pH 4.2). Furthermore, in-situ pH measurements were typically between 5 and 7 indicating the groundwater is mildly acidic.

Refer to **Table 5** for a summary of the pH results for the groundwater monitoring sites.

Table 5 – Summary of pH results for Groundwater Monitoring (Mar 2010-May 2013)

Analyte & Units		Monitoring Bore										
		MB01	MB02	MB04	MB05	BH05	LC12-03	MB06	MB07	P2	TU11	GC Pond
pH (field)	Samples	5	5	5	5	3	4	5	5	3	4	4
	Min	4.5	5.0	4.5	5.3	5.5	5.5	5.1	5.8	4.2	6.4	6.5
	Avg	5.1	5.7	5.2	5.8	5.7	6.5	5.8	6.3	4.9	6.6	7.0
	Max	5.6	7.1	6.0	7.1	5.9	7.6	7.5	7.0	5.6	6.8	7.5
pH (Lab)	Samples	6	6	5	7	7	3	7	5	0	0	0
	Min	5.6	5.8	5.4	5.7	6.7	7.1	5.9	6.5	-	-	-
	Avg	6.1	6.5	5.7	6.6	6.8	7.3	6.5	6.9	-	-	-
	Max	8.0	8.1	6.1	7.9	6.8	7.5	7.9	7.4	-	-	-

Plate-5 below shows the location of groundwater monitoring bores.

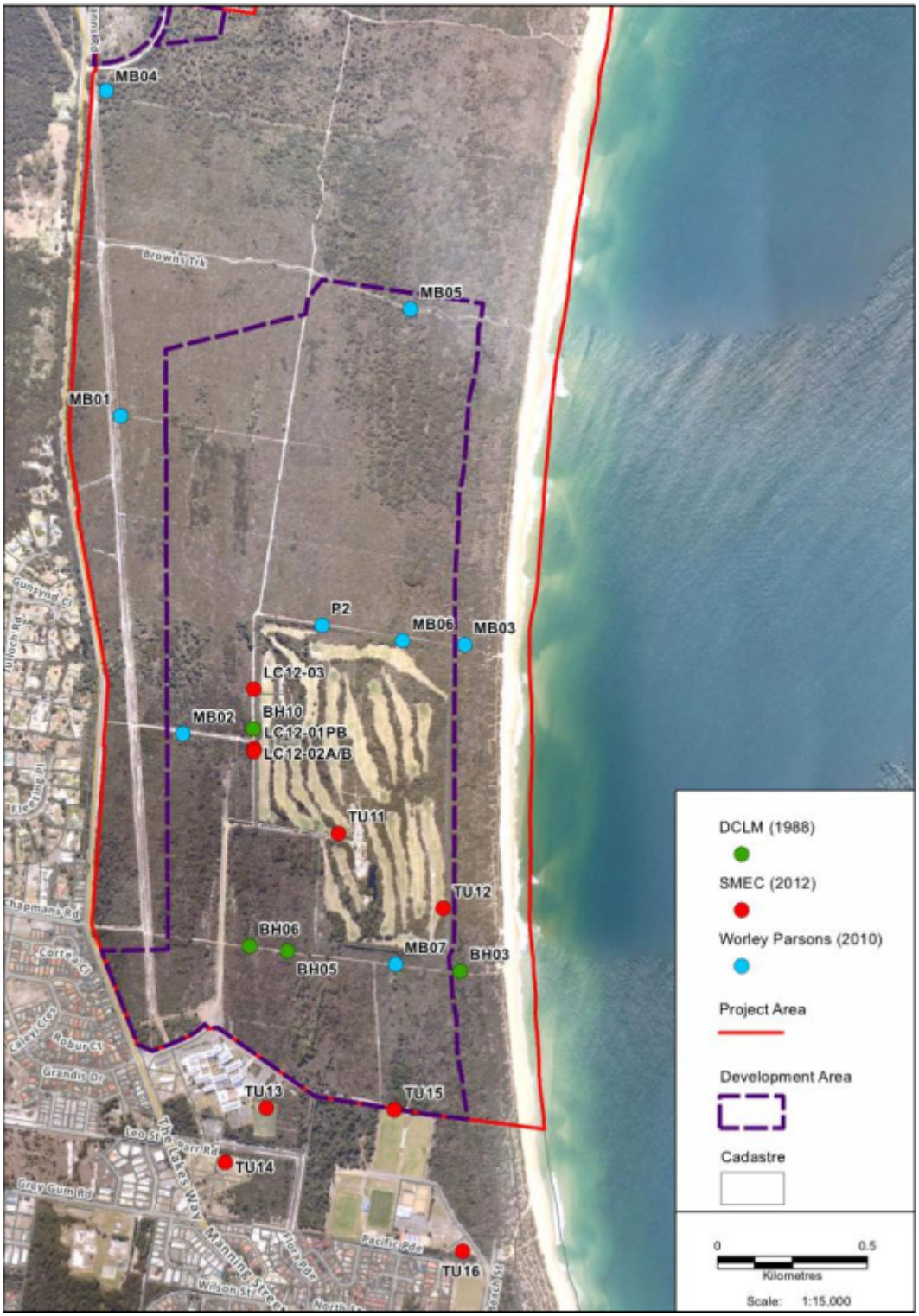

Plate-5 – Location of Groundwater Monitoring Bores

NOTE: DCLM is Department of Conservation and Land Management

5.3 SPOCAS Results (2012)

Table 6 below outlines the results for the SPOCAS analysis undertaken for six (6) individual soil samples collected in 2012. A number of values (red italics text) in the table show indicators of potential acid sulfate materials being present in the study area. The soils may be mature ASS meaning that they have changed as much as is likely to occur.

Table 6 – Results from the SPOCAS analysis (2012)

Analyte grouping/Analyte	Units	Action Criteria		Sample Locations					
		<1000T	>1000T	LC12-01PB 0-1m	LC12-01PB 1-2m	TP01 0.5m	TP01 1.0m	TP02 0.5m	TP02 1.0m
pH KCl (23A)	pH Unit	--	--	*3.7*	6.4	4.5	6.1	6.1	5.9
pH OX (23B)	pH Unit	--	--	*2.3*	4.9	*2.5*	4	3.9	3.6
Net Acidity (sulfur units)	% S	*0.03^*	*0.03^*	*0.08*	<0.02	*0.04*	<0.02	<0.02	<0.02
Net Acidity (acidity units)	mol H+ / t	*18^*	*18^*	*48*	<10	*22*	<10	<10	<10
Liming Rate	kg CaCO3/t	--	--	4	<1	2	<1	<1	<1

Note: Data in red italics are indicative of materials that may require management

^ Action criteria for sands to loamy sands (refer to Table 3)

<1000T: disturbance of less than 1000 tonnes of soil

>1000T: disturbance of more than 1000 tonnes of soil

Based on the above results, additional survey and sampling was planned, particularly in areas where proposed ground engaging activities are at their deepest based on the SMEC bulk earthworks plan. Furthermore, in sandy soils that may have some trace organic material present, SMEC nominated further testing using the chromium reducible assessment technique.

5.4 Detailed Investigation Results (2014)

5.4.1 Field Screening Results

As previously discussed, a more comprehensive soil sampling and analysis investigation was undertaken by SMEC personnel in May 2014. Key field screening results are presented in **Table 7**. Based on the field screening results, quantitative laboratory testing was carried out on selected samples exhibiting PASS or with indeterminate indicators.

Preliminary field screening results indicate that there is generally no presence of ASS on site, with only two (2) sites of the >100 field pH_F tests indicating presence of actual ASS (i.e. field pH_F of soil ≤ 4), however these two samples were taken in the top 0.5m of the soil profile and it is considered the low pH is due to the presence of organic material induced acidity. In addition to the two abovementioned samples, seven samples that exhibited inconclusive screening results were also submitted to the laboratory for more specific laboratory analysis (Chromium Reducible Analysis). Typically, samples that recorded a pH_F or pH_{FOX} value less than pH 4.5 were selected for the laboratory analysis. The soil testing at the laboratory was established to confirm the source of the acidity and identify presence or absence of sulfide materials.

Table 7 – ASS Field Screening Results for samples sent for additional analysis at Envirolab Services Pty Ltd

Sample Location ID	Depth (m)	pH_F	pH_{FOX}	pH Change	Reaction Rate	Qualitative Classification
1	0.5	3.7*	3.4	-0.3	Minor	Unlikely ASS
	1.5	4.1	5.2	+1.1	Minor	Unlikely ASS
13	0.5	4.0*	3.6	-0.4	-	PASS – Additional assessment
17	0.5	4.3	3.9	-0.4	-	PASS – Additional assessment
21	0.5	4.5	DNT	-	-	Unlikely ASS
25	0.5	4.4	DNT	-	-	Unlikely ASS
27	1.5	4.3	3.8	-0.5	Minor	PASS – Additional assessment
	2.5	4.4	4.4	0.0	Minor	Unlikely ASS
28	0.5	4.2	3.9	-0.3	-	Unlikely ASS

*$pH_F \leq 4$, results thought to be due to organic material induced acidity within the top 0.5m of the soil profile

DNT: Did not test

A full suite of field screening results is contained within **Appendix B**.

5.4.2 Laboratory Results

Selected samples were analysed using the Chromium Reducible Analysis. Summary results are presented below in **Table 8**. Full laboratory results are contained in **Appendix E**.

Table 8 – ASS Chromium Reducible Analysis Envirolab Services Pty Ltd

Location ID / Sample Depth (m)	pH_{KCl} (pH units)	S_{CR} (%w/w)	s-TAA pH 6.5 (mol H^+/t)	S_{HCl} (%w/w S)	S_{KCl} (%w/w S)	S_{NAS} (%w/w S)	S-ANC_{BT} (%$CaCO_3$)	Liming Rate (kg $CaCO_3$/t)
1 (0.5m)	3.4	<0.005	150	<0.005	<0.005	<0.005	<0.05	11
1 (1.5m)	4.6	<0.005	5	NT	<0.005	NT	<0.05	<0.75
13 (0.5m)	3.4	<0.005	170	<0.005	<0.005	<0.005	<0.05	13
17 (0.5m)	6.2	<0.005	<5	NT	<0.005	NT	<0.05	<0.75
21 (0.5m)	3.6	<0.005	120	<0.005	<0.005	<0.005	<0.05	9.4
25 (0.5m)	3.6	<0.005	62	<0.005	<0.005	<0.005	<0.05	4.8
27 (1.5m)	4.8	<0.005	<5	NT	<0.005	NT	<0.05	<0.75
27 (2.5m)	4.9	<0.005	<5	NT	<0.005	NT	<0.05	<0.75
28 (0.5m)	3.7	<0.005	100	<0.005	<0.005	<0.005	<0.05	7.6

NT = Not tested

5.4.3 Existing Acidity

Actual acidity, indicated by the TAA test results was recorded in all but 3 samples and ranged from 5 to 170 mol of acid /tonne, with an average 101 moles of acid/tonne in the upper 1.5m of the soil profile (the zone most influenced by the designed cut and fill and water table fluctuation), and <5 moles/tonne below 1.5m depth.

In most cases, in the upper 1.5m of the soil profile actual acidity represents 95-100% of potential acidity and is responsible for a significant portion of the calculated 'net acidity'. This indicates that a significant level of the acidification of the soil has already occurred throughout the soil profile. Retained acidity (acidity bound up in generally stable oxidisation minerals such as jarosite) was not detected in any of the samples analysed.

No soil profiles below 1.5m were identified in the field screening assessment as presenting PASS or ASS conditions.

5.4.4 Potential Acidity

Results of S_{CR} testing indicate that all samples analysed contain less than detectable results of unoxidised sulfur.

It is likely that some of the actual acidity reported may be due to weak organic acids being generated by local vegetation communities.

5.4.5 Actionable Net Acidity

Net acidity levels are generally low across the site. Net acidity values reflect the actual and potential acidity in the soil and with an average 101 moles of acid/tonne in the upper 1.5m of the soil. This level of acidity is above the action criteria although not as a result of the presence of sulfur and should be identified as acid soil and not ASS.

5.5 Quality Assurance / Quality Control

Fieldwork was performed by experienced staff and suitably qualified subcontractors in accordance with SMEC standard procedures.

Samples were submitted to a NATA accredited laboratory (Envirolab Services Pty Ltd). Analytical methods complied with Australian Standards and ASS Testing Methods (*ASS Laboratory Guidelines*, QASSIT, 2004) requirements, with lower Limits of Reporting (LOR) used in the laboratory tests compared with the ASS criteria (conservative).

No duplicate samples were collected for this investigation as the sample batch was small and the internal quality procedures are considered suitable for the purposes of this report.

Sampling and analytical procedures and reported results indicate that the completeness, accuracy and precision of the sampling and analysis program was satisfactory to constitute an appropriate reflection of in-situ concentrations for soil, and are thus suitable to form an adequate basis for the assessment of site conditions related to ASS.

QA/QC documentation is provided in the laboratory reports and certificates within **Appendix E.**

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Objectives

The objectives for this investigation, as described in the Project brief, include:

- Carrying out systematic investigative drilling at designated locations around the subject site and subsequent collection/analysis of soil at designated depth increments through the soil profile;
- Determine if ASS occurs within the subject site through site screening and laboratory analysis of selected samples; and
- Assist Urban Growth NSW in identifying risks associated with the proposed development regarding potential for ASS disturbance.

6.2 Summary of Findings

A review of the National ASS Risk Mapping (ASRIS) website indicates that the subject site is located within landform areas with a "Low Probability" of encountering ASS. A number of drilling sites were established at designated locations around the subject site where excavation is proposed. Furthermore, review of the acid sulfate soil maps in the *Great Lakes Local Environmental Plan 2014* (GLC DCP No. 34) indicates that the subject site is located in an area categorised as having a 'land class' of 4, meaning that development consent will be required by Council for the following:

- Works beyond 2m below natural ground surface; and
- Works likely to lower the water table to a depth of more than 2m below the natural ground surface.

Findings from the investigations for this report have assessed site geology and determined the following typical soil profile:

- 0.0 – 0.5m below ground level: Topsoil overlaying Black sand material containing organic matter;
- 0.5 – 3.0m below ground level: Grey to Brown sand material;
- 3.0 – 5.5m below ground level: Pale/Yellow sand material; and
- 5.5 – 7.5m below ground level: Pale/Yellow sand material containing 1-10mm shells.

Field screening results from the investigation indicate that there is generally no presence of ASS on site, with only two (2) sites of the >100 field pH_F tests indicating the presence of actual ASS (i.e. field pH_F of soil ≤ 4), however these two samples were taken in the top 0.5m of the soil profile and it is considered the low pH is due to the presence of organic material induced acidity. In addition to the two abovementioned samples, seven samples that exhibited inconclusive screening results were also submitted to the laboratory for more specific laboratory analysis (Chromium Reducible Analysis). The soil testing at the laboratory was established to confirm the source of the acidity and identify presence or absence of sulfide materials.

Results of S_{CR} testing indicate that all samples analysed contain less than detectable results of unoxidised sulfur.

It is likely that some of the actual acidity reported may be due to weak organic acids being generated by local vegetation communities.

6.3 Risk Assessment

The site is low lying and will generally be raised under a design that balances cut and fill. Fill material will largely be sourced from excavations to form water management basins. It is expected that the placement of fill will not impact on groundwater quality. Development of the site will cause a slight mounding of the local water table and increase groundwater movement towards the sea and estuary. This should not impact the receiving water bodies with respect to ASS impacts.

Low levels of acid soil have been detected across the site. In the upper 1.5m of the soil profile the actual acidity represents 95-100% of potential acidity and is responsible for a significant portion of the calculated 'net acidity'. No soil profiles below 1.5m were identified in the field screening assessment as presenting PASS or ASS conditions.

Significant disturbance of ASS or PASS is not anticipated, and given the extent of the proposed fill operation, development of the site poses a low risk to the receiving environment with proper management. Careful management will further reduce the environmental risk significantly.

6.4 Conclusions & Recommendations

The NTDP is a proposed residential development sponsored by Urban Growth NSW under a Project Delivery Agreement with the Crown Lands Branch of NSW Trade and Investment, who control the land. The NTDP area (project area) comprises 615ha of land located to the north of the township of Tuncurry. The proposed development area comprises 261ha of land. As part of the bulk earthworks for the project, approximately 1.07 million m^3 of cut is proposed within the development area.

This investigation has identified that low levels of acid soil have been detected across the site in the top 1.5m. No indication of PASS or ASS were identified at depths of 1.5 to 7.5m.

Significant disturbance of ASS or PASS is not anticipated, and given the extent of the proposed fill operation, development of the site poses a low risk to the receiving environment with proper management.

It is recommended that a high level ASSMP be developed for the site to manage contingent ASS conditions that could possibly occur in the future and to protect the environmentally sensitive receiving water bodies adjacent to the study area. The ASSMP for the proposed works should manage the non sulfidic acid soils and the non sulfidic induced acidic water quality for existing and naturally occurring water bodies in the study area.

This ASSMP is to become part of the construction environmental management plan for the civil works proposed in the study area and will outlay an incidental finds process for unexpected ASS and impacted groundwater. The ASSMP is to provide a soil movement record for soils moved internally and soil materials imported to site. This ASSMP is to provide the basis for identifying ASS conditions in the soil and in the water bodies.

7 REFERENCES

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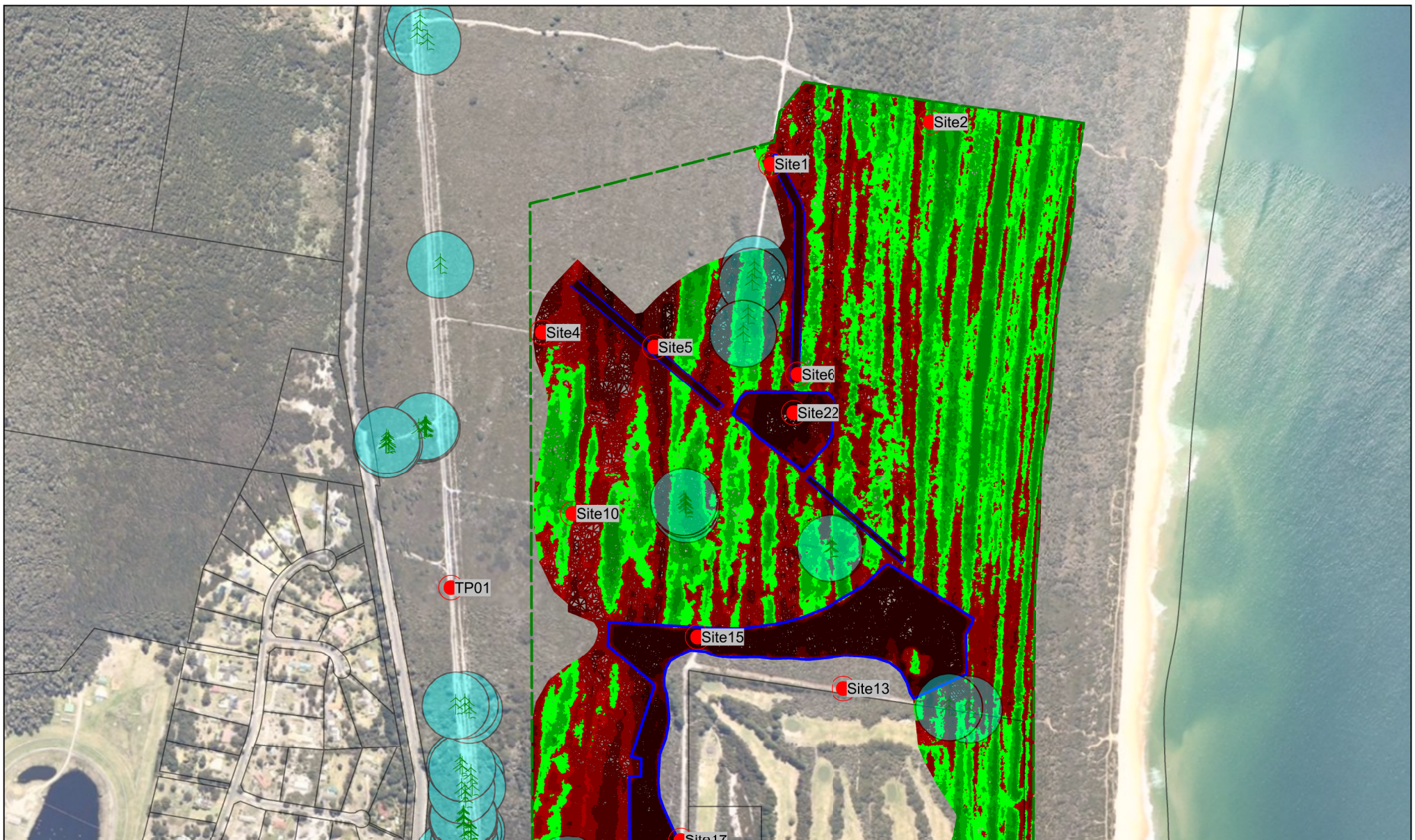
APPENDIX A SITE FIGURES

Figure 1: Bulk Earthworks Plan with Acid Sulfate Soil Testing Locations

Figure 2: Acid Sulfate Soil Testing Locations with Proposed Water Management Basins



LEGEND

- CADASTRAL BOUNDARIES
- DEVELOPMENT AREA
- 50m RADIUS FROM ORCHIDS
- KNOWN EXISTANCE OF ORCHIDS
- PROPOSED OPEN DRAIN
- PROPOSED WATER MANAGEMENT BASIN
- INDICATIVE DRILLING LOCATIONS (2014)

NOTES:

- DRILLING LOCATIONS ARE CONCENTRATED IN AREAS WHERE THE GREATEST EXCAVATION WILL OCCUR DURING CONSTRUCTION
- DRILLING LOCATIONS ARE AT LEAST 50 m FROM KNOWN EXISTANCE OF ORCHIDS
- DRILLING LOCATIONS LOCATED ON EXISTING ROADS (WHERE POSSIBLE) TO MINIMISE VEGETATION CLEARING AND DISTURBANCE
- PRECISE LOCATION OF TP02 UNKNOWN

NORTH

PAGE SIZE A3

SCALE 1:10,000

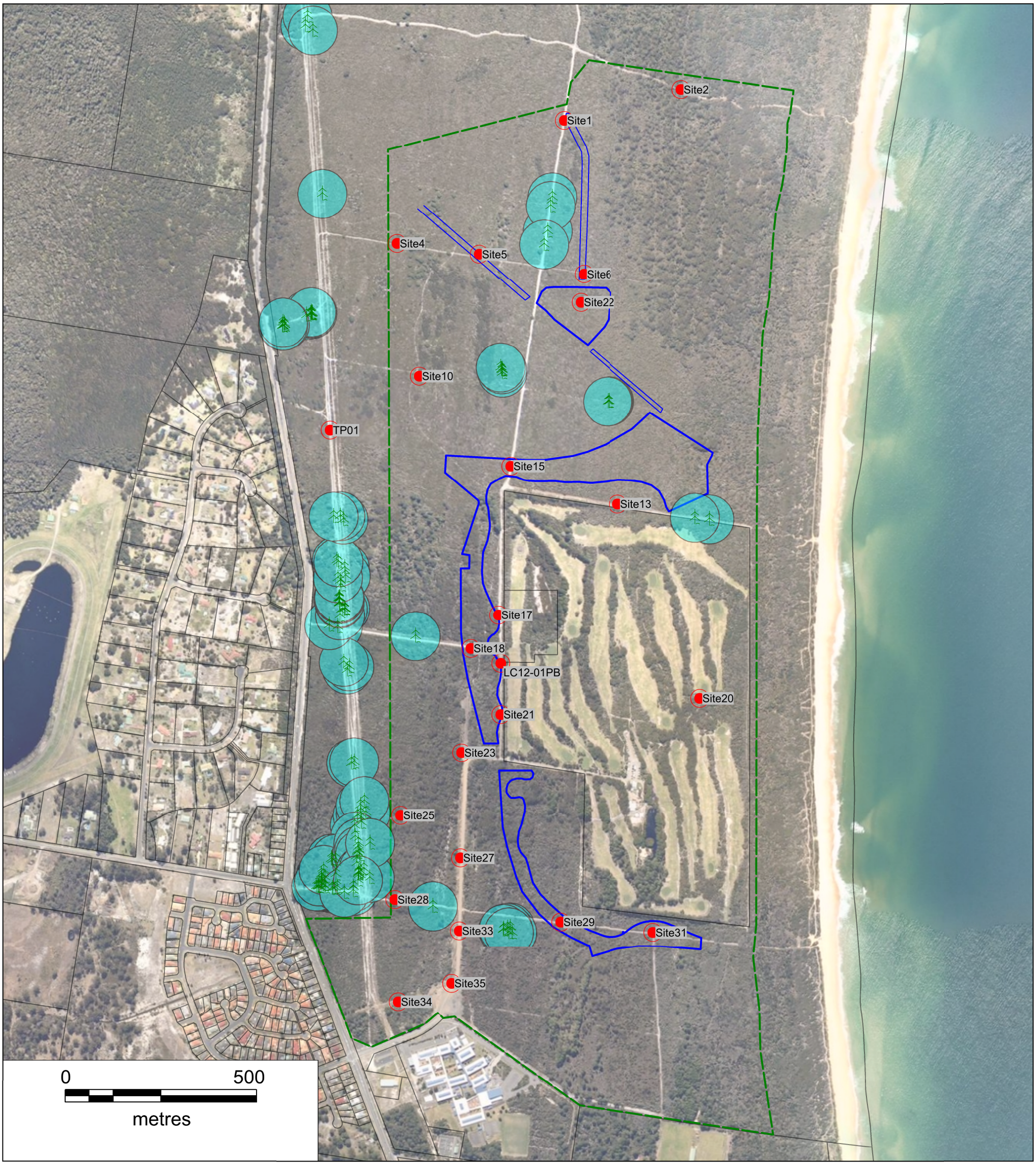
COORDINATE SYSTEM Datum: GDA94 Projection: MGA Zone 56

FIGURE NO. FIGURE 1 REVISION A

CREATED BY DATE 30/06/2014 PROJECT NO. 30011196

PROJECT TITLE NORTH TUNCURRY RESIDENTIAL DEVELOPMENT PROJECT

TITLE **BULK EARTHWORKS PLAN WITH ACID SULFATE SOIL TESTING LOCATIONS**



LEGEND

- CADASTRAL BOUNDARIES
- DEVELOPMENT AREA
- 50m RADIUS FROM ORCHIDS
- KNOWN EXISTANCE OF ORCHIDS
- PROPOSED OPEN DRAIN
- PROPOSED WATER MANAGEMENT BASIN
- INDICATIVE DRILLING LOCATIONS (2014)

NOTES:

- DRILLING LOCATIONS ARE CONCENTRATED IN AREAS WHERE THE GREATEST EXCAVATION WILL OCCUR DURING CONSTRUCTION
- DRILLING LOCATIONS ARE AT LEAST 50 m FROM KNOWN EXISTANCE OF ORCHIDS
- DRILLING LOCATIONS LOCATED ON EXISTING ROADS (WHERE POSSIBLE) TO MINIMISE VEGETATION CLEARING AND DISTURBANCE
- PRECISE LOCATION OF TP02 UNKNOWN

NORTH

PAGE SIZE A3

SCALE 1:10,000

COORDINATE SYSTEM Datum: GDA94 Projection: MGA Zone 56

FIGURE NO. FIGURE 2 REVISION A

CREATED BY DATE 30/06/2014 PROJECT NO. 30011196

PROJECT TITLE NORTH TUNCURRY RESIDENTIAL DEVELOPMENT PROJECT

TITLE **ACID SULFATE SOIL TESTING LOCATIONS WITH PROPOSED WATER MANAGEMENT BASINS**

APPENDIX B ASS FIELD SCREENING AND DATA TABLES

Sample ID/Core ID	Sample Depth or range	Colour	Texture	Mottle	Shells	pH F	pH FOX	pH Change	Reaction Rate*
~~1~~	~~0.5~~	~~BL~~	~~S~~	-	~~A~~	~~3.7~~	~~3.4~~	~~0.3~~	~~Minor~~
1	1	YEL	S		A	4.3	4.9	-0.6	Minor
~~1~~	~~1.5~~	~~YEL~~	~~S~~	-	~~A~~	~~4.1~~	~~5.2~~	~~-1.1~~	~~Minor~~
2	0.5	BL	S		A	4.9			
2	1	YEL	S		A	5.7			
2	1.5	YEL	S		A	5.7			
4	0.5	GR	S		A	5.7			
4	1	GR L	S		A	5.4			
4	1.5	BR	S		A	5.2	4.4	0.8	Minor
4	2	BR L	S		A	5.3			
5	0.5	BL	S		A	5.3			
5	1	GR L	S		A				
5	1.5	BR L	S		A	5.2			
5	2.5	BR D	S		A	5.3			
5	3.5	BR L	S		A	5.7			
5	4.5	BR L	S		A	5.9			
6	0.5	BL	S		A	4.9	4.3	0.6	Minor
6	1	GR L	S		A	5.6	4.7	0.9	Minor
6	1.5	BR	S		A	5.9	4.7	1.2	Minor
6	2	BR D	S		A	5.9	5.1	0.8	Minor
6	2.5	BR L	S		A	6.2	5.1	1.1	Minor
6	3	BR L	S		A	5.7	5.1	0.6	Minor
10	0.5	BL L	S		A	4.8			
10	1	GR	S		A	5.4			
10	1.5	GR	S		A	5.8			
~~13~~	~~0.5~~	~~BL~~	~~S~~	-	~~A~~	~~4~~	~~3.6~~	~~0.4~~	-
13	1.5	BR L	S		A	4.8			
13	2.5	YEL	S		A	5.5			
13	3.5	YEL	S		A	5.4			
13	4.5	YEL	S		A	5.6			
13	5.5	YEL	S		P	6.3			
13	6.5	GR L	S		P				
13	7.5	GR L	S		P				
15	0.5	BL	S		A	4.5			
15	1	GR	S		A	4.8			
15	1.5	GR D	S		A	4.8			
15	2	BR	S		A	4.8			
15	2.5	BR	S		A	4.6			
15	3	YEL	S		A	5.6			
15	3.5	YEL	S		A				
15	4	YEL	S		A	6.2			
15	4.5	YEL	S		A				
15	5	YEL	S		A	6.5			
15	5.5	YEL	S		A				
15	6	YEL	S		A	6.4			
15	6.5	YEL	S		A				
15	7	YEL	S		A				
15	7.5	YEL	S		A				
~~17~~	~~0.5~~	~~BL~~	~~S~~	-	~~A~~	~~4.3~~	~~3.9~~	~~0.4~~	-
17	1.5	GR L	S		A	5.1			
17	2.5	BR	S		A	5.8			
17	3.5	YEL L	S		A	5.8			
17	4.5	YEL	S		A	5.7			
17	5.5	YEL	S		A	5.7			
17	6.5	YEL	S		A	5.9			
17	7.5	YEL	S		P	6.5			
18	0.5	BL L	S		A	4.6			
18	1.5	GR L	S		A	5.7			
18	2.5	BR	S		A	5.3			
18	3.5	BR L	S		A				
18	4.5	BR L	S		A				
18	5.5	YEL	S		A	6			
18	6.5	YEL	S		P	7.8			
18	7.5	YEL	S		P	9.1			
20	0.5	BL	S		A	5.3			
20	1	BR L	S		A	6.5			
20	1.5	BR	S		A	6.7			
~~21~~	~~0.5~~	~~BL~~	~~S~~		~~A~~	~~4.5~~			
21	1.5	BR L	S		A	5			
21	2.5	BR	S		A	5.7			
21	3.5	YEL	S		A	5.8			

21	4.5	YEL	S		A	5.8			
21	5.5	YEL	S		P	5.8			
21	6.5	YEL	S		P	6.8			
21	7.5	YEL	S		P	7.7			
22	0.5	BL	S		A				
22	1	GR L	S		A	5			
22	1.5	GR L	S		A				
22	2	BR D	S		A	5			
22	2.5	BR L	S		A				
22	3	BR L	S		A	6			
22	3.5	BR L	S		A				
22	4	BR L	S		A	6			
22	4.5	BR L	S		A				
22	5	BR L	S		A	6.2			
22	5.5	BR L	S		A				
22	6	BR L	S		P	6			
22	6.5	BR L	S		P				
22	7	BR L	S		P	7.3			
23	0.5	BR D	S		A	5.1			
23	1	GR	S		A	5.3			
23	2.5	BR	S		A	5.3	4.3	1	
~~25~~	~~0.5~~	~~BL~~	~~S~~		~~A~~	~~4.4~~			
25	1	GR	S		A	5.2			
25	1.5	GR	S		A	5.2			
27	0.5	LG	S	P	A	4.9			
27	1	LG	S	P	A				
~~27~~	~~1.5~~	~~LGB~~	~~S~~	~~P~~	~~A~~	~~4.3~~	~~3.8~~	~~0.5~~	~~Minor~~
27	2	LB	S	P	A				
~~27~~	~~2.5~~	~~LB~~	~~S~~	~~P~~	~~A~~	~~4.4~~	~~4.4~~	~~0~~	~~Minor~~
~~28~~	~~0.5~~	~~BL~~	~~S~~	-	~~A~~	~~4.2~~	~~3.9~~	~~0.3~~	-
28	1	GR	S		A	4.7			
28	1.5	GR	S		A	5.1			
29	0.5	BL	S	P	A	5.1			
29	1	GR L	S	P	A	5.3			
29	1.5	B	S	P	A	DNT			
29	2	BR	S	P	A	5.8			
29	2.5	BR	S		A	DNT			
29	3	BR	S	P	A	6.1			
29	3.5	BR	S	P	P	6.2			
29	4	BR	S	P	P				
29	4.5	BR	S	P	P				
29	5	BR	S	P	P	6.8			
29	5.5	BR	S		P				
29	6	BR L	S		P	7.2			
31	0.5	BL	SL		A	4.4			
31	1	G L	S		A	5.1			
31	2	BR	S		A	5.1			
31	3	YEL	S		A	5.4			
31	4		S		A	5.9			
31	5		S		P	7			
31	6		S		P	7.6			
33	0.5	LG	S	P	A	5.5			
33	1	G	S	P	A	5.4			
33	1.5	LB	S	P	A	4.7	4.6	0.1	Minor
34	0.5	BL	S		A	5.2			
34	1	GR	S		A	6.3			
35	0.5	DB	S	P	A	4.3	4	0.3	Minor
35	1	LG	S	P	A	4.5			
35	1.5	LG	S	P	A	4.6			

NOTE: items highlighted green/with strikethrough have been submitted for laboratory testing

Colour Coding

BL = Black

YEL = Yellow

GR = Grey

GR L = Light Grey

BR = Brown

BR L = Light Brown

BR D = Dark Brown

GR D = Dark Grey

YEL L = Light Yellow

BL L = Light Black

LG = Light Grey

LB = Light Black

LGB = Light Grey/Black

DB = Dark Brown

Symbol Coding

S = Sand

P = Present

A = Absent

APPENDIX C DRILLING LOGS

Site 1

Site 2

Site 4

Site 5

Site 6

Site 10

Site 13

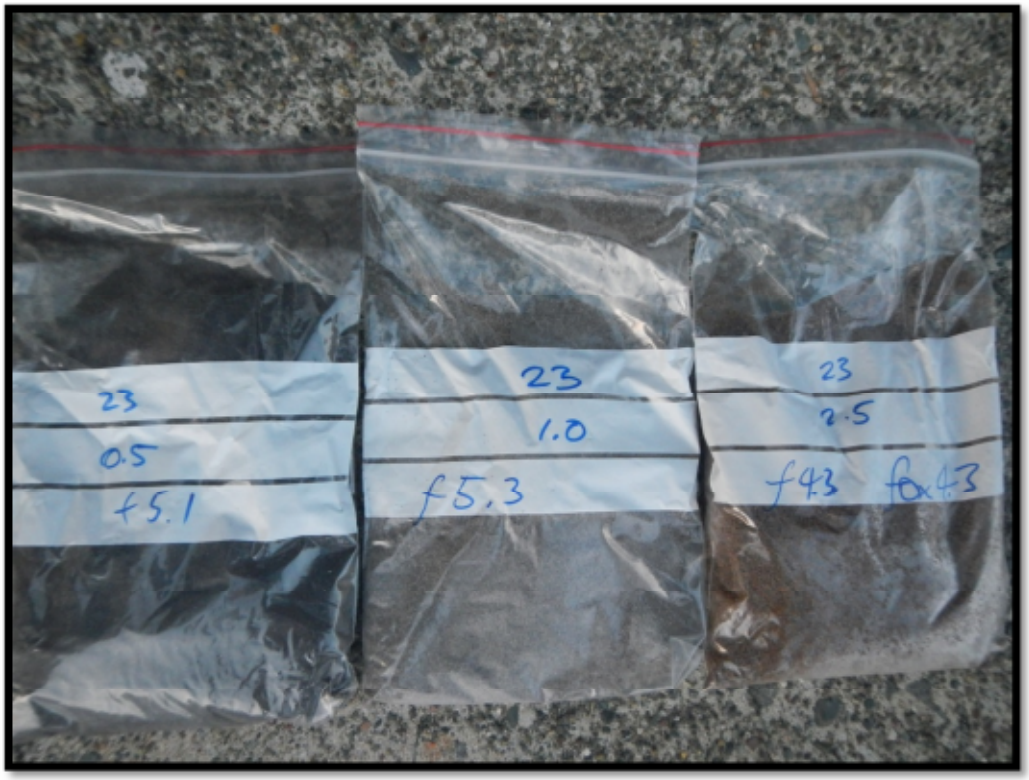
Site 15

Site 17

Site 20

Site 21

Site 22



Site 23

Site 25

Site 27

Site 28

Site 29

Site 31

Site 33

Site 34

Site 35

APPENDIX D DRILL LOCATION PHOTOS

Site 1

Site 2

Site 4

Site 5

Site 6

Site 10

Site 13

Site 15

Site 17

Site 18

Site 20

Site 21

Site 22

Site 23

Site 25

Site 27

Site 28

Site 29

Site 33

Site 34

Site 35

APPENDIX E LABORATORY REPORTS AND CHAIN OF CUSTODY INFORMATION

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 110375

Client:
SMEC Australia
Level 5, 20 Berry St
North Sydney
NSW 2060

Attention: Daniel Saunders

Sample log in details:

Your Reference:	**30011196, North Tuncurry**
No. of samples:	9 Soils
Date samples received / completed instructions received	23/05/2014 / 23/05/2014

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

Report Details:

Date results requested by: / Issue Date:	30/05/14 / 29/05/14
Date of Preliminary Report:	Not Issued

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

Chromium Suite						
Our Reference:	UNITS	110375-1	110375-2	110375-3	110375-4	110375-5
Your Reference	----------	1	1	13	17	25
Depth	----------	0.5	1.5	0.5	0.5	0.5
Date Sampled		21/05/2014	21/05/2014	21/05/2014	21/05/2014	21/05/2014
Type of sample		Soil	Soil	Soil	Soil	Soil
pH kcl	pH units	3.4	4.6	3.4	6.2	3.6
s-TAA pH 6.5	%w/w S	0.24	<0.01	0.28	<0.01	0.10
TAA pH 6.5	moles H^+/t	150	5	170	<5	62
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
a-Chromium Reducible Sulfur	moles H^+/t	<3	<3	<3	<3	<3
S_{HCl}	%w/w S	<0.005	[NT]	<0.005	[NT]	<0.005
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
S_{NAS}	%w/w S	<0.005	[NT]	<0.005	[NT]	<0.005
ANC_{BT}	%$CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
s-ANC_{BT}	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
s-Net Acidity	%w/w S	0.24	<0.01	0.28	<0.01	0.10
a-Net Acidity	moles H^+/t	150	<10	180	<10	64
Liming rate	kg $CaCO_3$/t	11	<0.75	13	<0.75	4.8
a-Net Acidity without ANCE	moles H^+/t	150	<10	180	<10	64
Liming rate without ANCE	kg $CaCO_3$/t	11	<0.75	13	<0.75	4.8

Chromium Suite					
Our Reference:	UNITS	110375-6	110375-7	110375-8	110375-9
Your Reference	----------	27	27	28	21
Depth	----------	1.5	2.5	0.5	0.5
Date Sampled		21/05/2014	21/05/2014	21/05/2014	21/05/2014
Type of sample		Soil	Soil	Soil	Soil
pH kcl	pH units	4.8	4.9	3.7	3.6
s-TAA pH 6.5	%w/w S	<0.01	<0.01	0.16	0.20
TAA pH 6.5	moles H^+/t	<5	<5	100	120
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005
a-Chromium Reducible Sulfur	moles H^+/t	<3	<3	<3	<3
S_{HCl}	%w/w S	[NT]	[NT]	<0.005	<0.005
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005
S_{NAS}	%w/w S	[NT]	[NT]	<0.005	<0.005
ANC_{BT}	%$CaCO_3$	<0.05	<0.05	<0.05	<0.05
s-ANC_{BT}	%w/w S	<0.05	<0.05	<0.05	<0.05
s-Net Acidity	%w/w S	<0.01	<0.01	0.16	0.20
a-Net Acidity	moles H^+/t	<10	<10	100	130
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	7.6	9.4
a-Net Acidity without ANCE	moles H^+/t	<10	<10	100	130
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	<0.75	7.6	9.4

Method ID	Methodology Summary
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL Chromium Suite	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
pH kcl	pH units		Inorg-068	[NT]	110375-1	3.4 || 3.5 || RPD: 3	LCS-1	92%
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	110375-1	0.24 || 0.22 || RPD: 9	[NR]	[NR]
TAA pH 6.5	moles H^+/t	5	Inorg-068	<5	110375-1	150 || 140 || RPD: 7	LCS-1	104%
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	110375-1	<0.005 || <0.005	LCS-1	80%
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3	110375-1	<3 || <3	[NR]	[NR]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	110375-1	<0.005 || <0.005	[NR]	[NR]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	110375-1	<0.005 || <0.005	LCS-1	101%
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	110375-1	<0.005 || <0.005	[NR]	[NR]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	110375-1	<0.05 || <0.05	[NR]	[NR]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	110375-1	<0.05 || <0.05	[NR]	[NR]
s-Net Acidity	%w/w S	0.01	Inorg-068	<0.01	110375-1	0.24 || 0.22 || RPD: 9	[NR]	[NR]
a-Net Acidity	moles H^+/t	10	Inorg-068	<10	110375-1	150 || 140 || RPD: 7	[NR]	[NR]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	110375-1	11 || 10 || RPD: 10	[NR]	[NR]
a-Net Acidity without ANCE	moles H^+/t	10	Inorg-068	<10	110375-1	150 || 140 || RPD: 7	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	110375-1	11 || 10 || RPD: 10	[NR]	[NR]

Report Comments:

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

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

Quality Control Definitions

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

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

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

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

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

Laboratory Acceptance Criteria

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

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

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

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

CHAIN OF CUSTODY

TESTING SAMPLES

CLIENT: SMEC Australia Pty Ltd	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	☐ Standard TAT (List due date):	FOR LABORATORY USE ONLY (Circle)
OFFICE: Newcastle		☐ Non Standard or urgent TAT (List due date):	Custody Seal Intact? Yes No N/A
PROJECT: North Tuncurry Acid Sulfate Soil Investigation	QUOTE NO.: David :	COC SEQUENCE NUMBER (Circle)	Free ice / frozen ice bricks present upon receipt? Yes No N/A
ORDER NUMBER: 30011196 - Acid Sulfate Soil Investigation		COC: (1) 2 3 4 5 6 7	Random Sample Temperature on Receipt: °C
PROJECT MANAGER: Daniel Saunders	CONTACT PH: (02) 99255650	OF: (1) 2 3 4 5 6 7	Other comment:
SAMPLER: Daniel Saunders	SAMPLER MOBILE: 0423 066 956		
COC emailed to Lab? (YES / NO)	EDD FORMAT (or default):		
Email Reports to (will default to PM if no other addresses are listed): Daniel.Saunders@smec.com			
Email Invoice to (will default to PM if no other addresses are listed): josh.ford@smec.com			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
D SAUNDERS			
DATE/TIME: 22/05/2014	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	SCR Suite								Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	1 - 0.5m	21/5	S	Zip Lock Bag / ICE	1									
2	1 - 1.5m													
3	13 - 0.5m													
4	17 - 0.5m													
5	25 - 0.5m													
6	27 - 1.5m													
7	27 - 2.5m													
8	28 - 0.5m													
9	~~30~~ 21 - 0.5m													
				TOTAL										

Job No: 110375

Date Received: 23.05.14

Time Received: 15.~~35~~15

Received by: Lira

Temp: (0) Ambient

Cooling: (Ice) Icepack

Security: Intact/Broken/None

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

APPENDIX F GREAT LAKES COUNCIL ACID SULFATE SOILS MAP

Great Lakes Local Environmental Plan 2014

Great Lakes Council

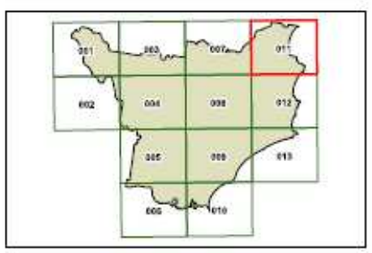
Acid Sulfate Soils Map - Sheet ASS_011

Acid Sulfate Soils

- 1 Class 1
- 2 Class 2
- 3 Class 3
- 4 Class 4
- 5 Class 5

Cadastre

Cadastre 04/07/2013
© NSW Land and Property Information



N

0 1 2 3 4
Kilometres

Projection: GDA 1994 MGA Zone 56

Scale: 1:80,000 @ A3

File Number: 3300_COM_ASS_011_080_20140117