Acid Sulphate Management Plan

Prepared For:

Webber Architects

Site Address:

Warringah Recreation Centre – Cnr Pittwater & Kentwell Road, North Manly

Ref No:

71113A-IDF

Date:

October 2024

Accredited for compliance
With ISO/IEC 17025
NATA Accreditation No.
19226

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Contents

1.0 INTRODUCTION

Ideal Geotech was commissioned to undertake an acid sulphate soils management plan for the proposed commercial development Warringah Recreation Centre; corner of Pittwater and Kentwell Road, North Manly.

An acid sulphate soil investigation was undertaken previously by Ideal Geotech (refer to report number 71113A). The report indicated that a management plan would be required for excavation and disposal of soil from the site.

Following field tests, two soil samples were submitted to ALS Environmental for SPOCAS testing. The soil was assessed against the guidelines set out in the Acid Sulphate Soils Management Advisory Committee (ASSMAC) (1998).

The results of the laboratory analysis show signs of actual acid sulphate soils within the samples collected across the site.

Excavation of soils will require treatment prior to disposal.

2.0 OBJECTIVES OF THE ACID SULPHATE MANAGEMENT PLAN

The objectives of this ASSMP are to consider both the existing and potential future environmental impacts relating to PASS material in and around the project site and to detail mitigation measures to minimise the potential impacts within the surrounding areas.

The control measures in this ASSMP to mitigate the environmental impacts of the proposed excavations to acceptable levels have been developed to achieve the following objectives:

- Control and, where possible, minimisation of acid sulphate soils;
- Confirming the success of impact control measures by the means of validation monitoring;
- Compliance with statutory requirements
- Preserving the water quality on an ongoing basis

Each environmental protection measure is based on proven and industry best practice methodology.

The ASSMP is designed for the excavation phase of the project. It is based on tabulated checklists for management measures, maintenance, reporting, failure identification and corrective action for each identified use.

The control measures proposed in this ASSMP are for:

- Assessment procedures for AASS/PASS utilising a sampling protocol, set criteria to measure and agreed standards for those criteria to evaluate acid potential;
- Ongoing monitoring program (if required);

- Treatment of potential acid sulphate soils if encountered and control structures to prevent leachate discharge offsite without meeting specific soil quality criteria

3.0 SITE DETAILS

Site Address	Warringah Recreation Centre – Cnr Pittwater and Kentwell Road, North Manly
Client	Webber Architects
Council Area	Northern Beaches Council

3.1 Geology

Reference to the Sydney 1:100,000 geological map (Geological Series Sheet 9130) indicates that the site is underlain by Quaternary deposits consisting of silty to peaty quartz sand, silt and clay. Ferruginous and humic cementation in places and common shell layers.

3.2 Site Description

The subject site is roughly rectangular in shape and approximately 10,000m^2 in area and is bound by Pittwater Road to the north east, Kentwell Road to the south, Brookvale Creek to the west and by Warringah Golf Course on all remaining sides.

The site is currently occupied by tennis courts and sports facilities. The site is relatively flat with no notable slopes that will impact construction with a line of large mature trees along the western, northern and eastern boundaries.

4.0 Subsurface Conditions

Fieldwork was undertaken on 3rd July 2024 and included drilling six boreholes (BH1-BH6) using a 4wd mounted drill rig using solid flight spiral augers to a maximum depth of 3.0m at the locations shown on Figure 1, attached in Appendix A.

Borehole logs and field observations are presented in Appendix B.

4.1 Acid Sulphate Soils

Acid Sulphate Soils (ASS) are naturally occurring and usually form in low lying coastal areas, creeks, rivers and flood plains. The sulphates present in the soil are stable when in the saturated/waterlogged state, but react to form sulphuric acid when disturbed and exposed to oxygen.

Maps showing the areas identified as being affected by ASS have been prepared by the Department of Land and Water Conservation. These maps identify the probability of acid sulphate soils occurring in these areas and as such any areas should be specifically investigated before a particular site is classified.

Disturbance of these soil materials will result in an environmental risk that will vary with elevation and depth of disturbance. Any works below natural ground surface or affecting the water table has a risk of being contaminated with acid sulphate soils.

Reference to the Acid Sulphate Soils Map of Prospect-Parramatta indicates that the site is located on the border between disturbed terrain and no known occurrence of acid sulphate soil materials.

5.0 SAMPLING & ANALYSIS PLAN

Sampling and analysis were undertaken in order to assess the presence or absence, location and likely distribution of any AASS or PASS present at the subject site in the area of the proposed development.

5.1 Sampling

Soil sampling was undertaken in general accordance with the Acid Sulphate Soil Guidelines (Refer to Figure 1 for the borehole locations). Test results were compared to the relevant New South Wales Environment Protection Authority (NSW EPA) criteria.

BH1-BH6 were all terminated at a depth of approx. 3.0m below ground surface with samples collected at the depths as listed; BH1- 0.5m & 1.5m, BH2- 1.0m & 2.0m, BH3- 1.0m & 3.0m, BH4- 0.5m & 1.5m, BH5- 1.0m & 2.0m, BH6- 1.5m & 3.0m. The samples were placed directly into labelled clean zip lock bags and placed on ice until delivery to the laboratory for testing. All analyses were performed by a NATA registered laboratory using NATA accredited methods.

6.0 ACID SULPHATE SOILS ASSESSMENT

6.1 Field Screening

The field screening involved the testing of the samples for field pH and peroxide pH, using 30% hydrogen peroxide to oxidise the soil, and comparing both results.

A positive peroxide test, indicating the potential presence of acid sulphate soil, may include one or more of the following.

1. Change in colour from grey tones to brown tones.
2. Effervescence.
3. Release of sulphurous odours.
4. pH following oxidation with H_2O_2 ($_{pHfox}$) <3.
5. Lowering of the pH (pH_f - pH_{fox}) by 1 or greater.
6. Field pH (pH_f) <4.

The results of the field and peroxide tests are provided in Table 1 below

Table 1: Results of Field Screening Tests

Location/Depth	Field pH	Peroxide pH	Reaction to 30% h_2O_2
BH1/0.5m	6.9	3.5	Slight
BH1/1.5m	5.6	2.7	Strong
BH2/1.0m	8.0	5.3	Moderate
BH2/2.0m	6.0	2.6	Slight
BH3/1.0m	5.1	2.6	Slight
BH3/3.0m	6.0	2.7	Slight
BH4/0.5m	5.0	2.7	Slight
BH4/1.5m	6.2	3.2	Strong
BH5/1.0m	6.3	2.9	Slight
BH5/2.0m	5.9	2.1	Strong
BH6/1.5m	5.6	2.5	Strong
BH6/3.0m	5.7	2.0	Strong

Based on findings of the field screenings, indications of PASS were observed. The samples were tested by quantitative laboratory analysis to confirm the presence or absence of acid sulphate soil.

6.2 Laboratory Test Results

The samples were analysed for SPOCAS to confirm the presence or absence of ASS or PASS in the soil. The samples were dispatched to ALS Environmental services for the quantitative analysis for Suspension Peroxide Oxidation Combined Acidity & Sulphate (SPOCAS).

6.3 Assessment Criteria for Acid Sulphate Soils (Laboratory)

The results of analysis for the soils are compared to the below ASSMAC assessment criteria. It is assumed that <1000 tonnes of material would be disturbed hence the action criteria for less than 1000 tonnes have been applied.

6.4 NSW ASSMAC Action Criteria

The NSW ASSMAC action criteria is detailed in Table 2 below for less than 1000 tonnes of disturbance.

Table 2: NSW ASSMAC Action Criteria

Type of Material Texture	Approx Clay Content (% <0.002mm)	Action Criteria <1000 tonnes Sulfur Trail Spos or Stos%	Action Criteria <1000 tonnes Acid Trail TPA or TSA mole H+/t
Coarse e.g. sands	< 5	0.03	18
Loams/light clays	**5 – 40**	**0.06**	**36**
Fine clays/silts	≥ 40	0.1	62

Note: The assessment values chosen are based on loams/light clays which are in bold

6.5 SPOCAS Test Results

The SPOCAS testing identified no exceedances of the threshold criteria in nine of the samples which suggests there is a presence of acid sulphate soils. Refer to Table 3 below.

Table 3: Results of SPOCAS Testing

Sample	pH_{ox}	TAA pH 6.5 moles H+/tonne	TPA pH 6.5 moles H+/tonne	TSA pH 6.5 moles H+/tonne	Spos %w/w
BH1/0.5m	5.9	<2	<2	<2	<0.020
BH1/1.5m	3.0	**177**	**392**	**216**	**0.255**
BH2/1.0m	6.9	<2	<2	<2	<0.020
BH2/2.0m	3.0	11	**96**	**85**	0.124
BH3/1.0m	3.4	25	**74**	**49**	0.028
BH3/3.0m	3.4	13	**65**	**52**	0.043
BH4/0.5m	3.9	5	**44**	**38**	<0.020
BH4/1.5m	4.1	**61**	**313**	**252**	**0.098**
BH5/1.0m	4.2	5	6	<2	<0.020
BH5/2.0m	2.2	**118**	**1810**	**1700**	**0.188**
BH6/1.5m	2.4	**170**	**1160**	**987**	**0.364**
BH6/3.0m	2.1	**97**	**888**	**791**	**0.288**

6.6 Aggressiveness to Steel and Concrete

The aggressiveness or erosion potential of an environment in building materials, particularly concrete and steel is dependent on the levels of pH and types of salts present. In order to determine the degree of aggressiveness, the test values obtained are compared to tables 6.4.2 (C) and 6.5.2 (C) in AS2159 Piling - Design and Installation and tables 5.1 to 5.4 in AS2870-2011 “Residential Slabs and Footings”. The following testing suite was undertaken with results summarised within table 4 below;

- pH
- Electrical Conductivity (EC µS/cm)
- Chloride (Cl)
- Resistivity (ohm.cm)
- Sulphate

Table 4: Results of Aggressivity Testing

Location/Depth	pH	EC_e dS/m	Resistivity Ohm.cm	Cl mg/kg	Sulphate mg/kg
BH1/0.5m	7.1	0.210	31200	<10	<10
BH2/1.0m	8.2	1.260	6370	<10	20

BH3/3.0m	6.2	0.196	18200	<10	<10
BH4/1.5m	6.4	0.238	12300	<10	70
BH5/2.0m	6.1	0.42	8930	60	20

Based on test results detailed in Table 4 the soil conditions are considered to be mildly aggressive to concrete and non-aggressive to steel in soils in groundwater. An exposure classification of A2 for concrete has been determined.

7.0 MANAGEMENT METHOD

Neutralising with agricultural lime is a widely accepted method to minimise the generation of acid and acid products associated with the disturbance of ASS. Agricultural lime is readily available, relatively easy to handle and less hazardous than some other agents.

To be conservative and adopt the precautionary principle it would seem appropriate to adopt a lime application rate to treat the soil that is adequate to neutralise the existing acidity and the potential acid generation due to future oxidisation of sulfidic sediments. It is recognised that the calculated lime application rate includes a 50% safety factor to cater for the inefficient mixing and isolated "hotspots".

Using the worst-case scenario (TPA moles H+/tonne 1810) for samples collected within the potential excavation zone, calculations for proposed agricultural lime application rates are shown in Table 5 below.

Table 5: Lime Application Rates

Site	%S	TPA mol H+/T	Min. Kg lime/m^3 soil (assume BD = 1.6g/cm^3)	Min. Kg lime/m^2/300mm layer
Excavation up to 1.0m	0.028	74	5	1.5
Excavation below 1.0m	0.364	1810	53	16

A bunded treatment pad would be required for the site. Excavated material would be placed into a maximum 300mm deep layer and the appropriate agricultural lime applied and mechanically incorporated into the soil. The layer ensures proper aeration of excavated material when mixing with the lime agent.

7.1 ASS Treatment Area and Procedure

- Provide a non-ASS bunded soil treatment area. The rate of excavated material should be in accordance with appropriate mixing rates on the bunded treatment as stated in Table 5 above.
- Apply a guard layer (5kg/m^2) of agricultural lime to the base of the treatment area.
- Apply lime at adopted application rate and mechanically incorporate into the excavated material.

- Repeat the process until manageable volume of treated material is available for validation testing.
- Undertake soil validation testing at a rate of 1/50m^3 of excavated soil or once per day (whichever is greater). The soil pH should be measured in distilled water as well as in peroxide. This will verify if neutralisation treatment is succeeding as well as confirm that oxidation of acid sulphate soils is not occurring.
- If validation testing indicates excavation material below action criteria remove soil from site as required for final disposal otherwise incorporate required lime and repeat validation testing.

7.2 Dewatering

From investigation of the site, groundwater was encountered at 0.6m at its shallowest. If groundwater is encountered during excavation, a management plan is included below;

- Should the water table be encountered during excavation attempt to minimise dewatering depth required for the installation.
- Time and volume of exposure to acid sulphate soils should be minimised during excavation and dewatering
- Should any discharged water pH levels be below natural groundwater levels then neutralisation via Magnesium calcite (Magnesium hydroxide) should be employed.
- Following any neutralisation, the groundwater can be discharged to a bunded area away from the excavation or to stormwater/sewer, subject to regulation.

7.3 Contingency Plan

Remedial action will be required if the agreed standards or acceptance criteria are not being achieved. Remedial action shall comprise mixing of additional lime through the excavated material and neutralisation of leachate. The required mixing rate to remediate the soil or leachate should be confirmed by monitoring tests.

If overland discharge of groundwater is proposed, a contingency plan should be in place to allow neutralisation and confirmation monitoring prior to injection if pH levels are low or fall below natural background levels.

During periods of heavy or prolonged rainfall, stockpiling of acid sulphate soils should be appropriately contained/bunded to collect leachate for testing and neutralisation (if required) prior to disposal. Alternatively backfilling of acid sulphate soils could be undertaken to prevent the migration of leachate.

Sufficient lime should be stored on site during construction for the neutralisation of acid sulphate soils and contingency measures along with access to appropriate application equipment.

8.0 RECOMMENDATIONS

1. All excavated material on site is to be managed to minimise and ameliorate the existing and potential acidity. Grade 1 agricultural lime (80% ENV) shall be thoroughly incorporated into the material at the application rate shown in Table 5 of this report.

2. Any encounter with the water table and or water below that of natural groundwater pH levels should follow the management plan as in 7.2 above.

3. The management strategy and monitoring schedule is provided as an attachment in appendix A.

9.0 CONCLUSION

Acid sulphate soils have been identified as being a constraint to development at the Warringah Recreation Centre, Corner of Pittwater and Kentwell Road, North Manly. An acid sulfate management plan has been prepared to address treatment of the actual acidity and minimizing the potential generation of acidity during the proposed earthworks.

Should you have any queries, please do not hesitate to contact the undersigned.

For and on behalf of Ideal Geotech

D. Dwyer

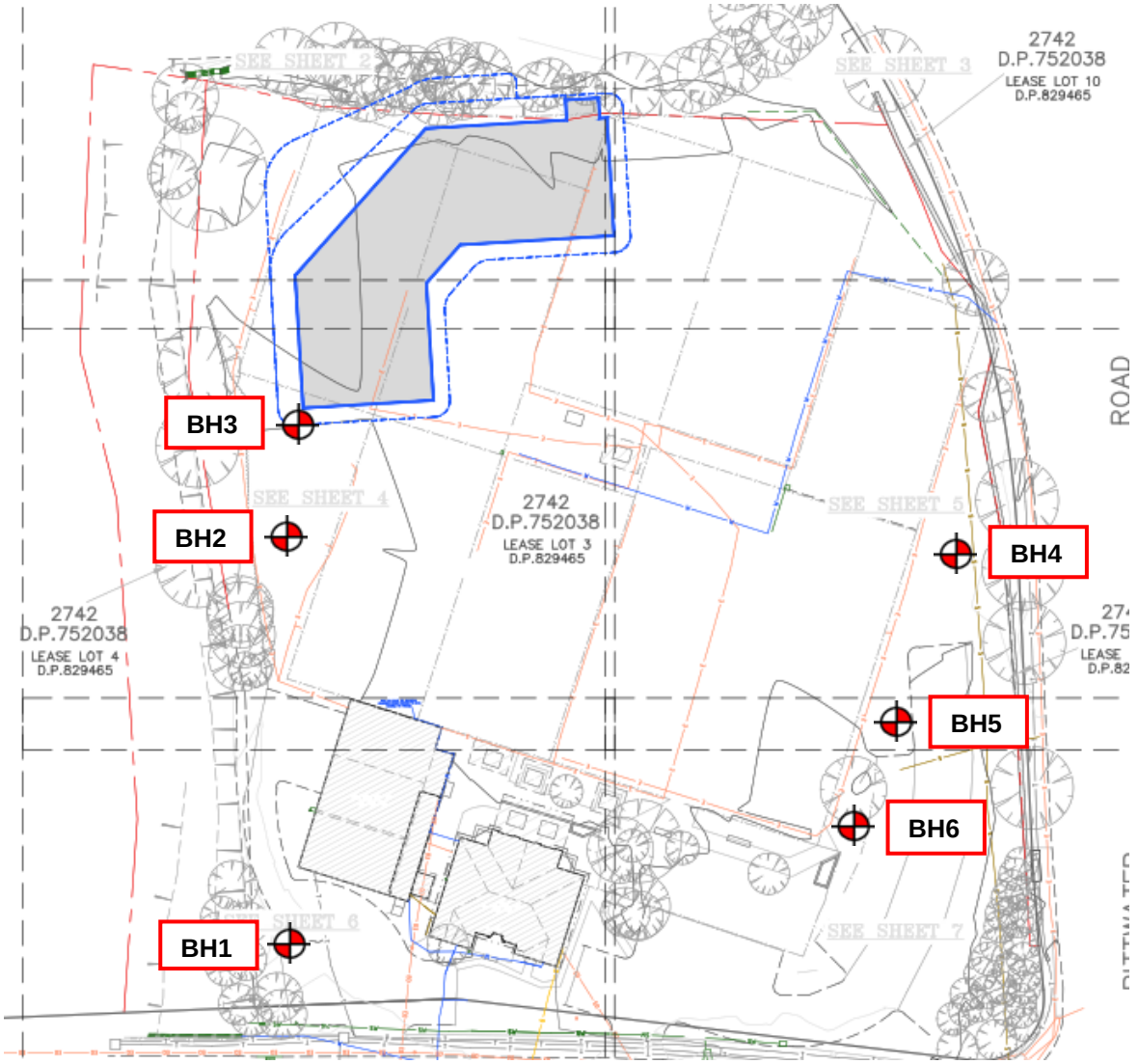
Dane Dwyer
Geotechnical Engineer

10.0 REFERENCES

- *Acid Sulphate Soil Risk Map – Edition 2, St Albans*
- *Stone, Y, and Hopkins G (1998). Acid Sulphate Soils Planning Guidelines.* Published by the Acid Sulphate Soil Management Advisory Committee, Wollongbar, NSW, Australia.
- Ahern C R, Stone, Y, and Blunden B (1998). *Acid Sulphate Soils Assessment Guidelines* Published by the Acid Sulphate Soil Management Advisory Committee, Wollongbar, NSW, Australia

11.0 APPENDICES

11.1 Appendix A – Borehole Location Plan



Title	Borehole Location Plan	**Council**	Northern Beaches Council	**Drawn By**	Ben
Project	Acid Sulphate Soil Assessment	**Job Number**	71113-IDF	**Checked By**	Dane
Site Address	Warringah Recreation Centre – North Manly	**Figure Number**	Figure 1	**Date**	Jul-24

NORTH POINT

11.2 Appendix B – Borehole Logs

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5.1 FIELD LOG

Date: {maxWorklogDate}
Customer Job: -
Ideal Job: 3041-71113
Site Address: Warringah Golf Club Corner of Pittwater and Kingsway Road, NORTH MANLY, NSW, 2100

Borehole: BH1
Surface RL:
Easting:
Northing:

Water		Samples	Depth	Material Origin	FILL Depth	Classification Code	Material Description	Moisture	Density / Consistency
				TOPSOIL		SM	Silty SAND Black Grey	Slightly Moist	Loose
			0.5	NATURAL		SM	Silty Clayey SAND Black Grey	Slightly Wet	Loose
			1.0						
			1.5						
			2.0						
▼			2.5				End Bore 3m		

▼ Water Table **UTP** - Unable to penetrate **DCP** - 9kg Dynamic Cone Penetrometer **PP** - Pocket Penetrometer

SAND – Density Index vs Approx. Penetrometer results

DENSITY		Density Index	DCP Blow Count (blows/100mm)
VL	Very Loose	< 15 %	< 1
L	Loose	15 – 35 %	1 – 3
MD	Medium Dense	35 – 65 %	3 – 9
D	Dense	65 – 85 %	9 – 15
VD	Very Dense	> 85 %	> 15

SILTS & CLAY – Cu vs Approx. Penetrometer results

CONSISTENCY		Undrained Shear Strength (kPa)	DCP Blow Count (blows/100mm)
VS	Very Soft	0 – 12	< 1
S	Soft	12 – 25	1 – 2
F	Firm	25 – 50	2 – 3
St	Stiff	50 – 100	3 – 5
VSt	Very Stiff	100 – 200	5 – 8
H	Hard	> 200	> 8

MOISTURE

D	Dry
M	Moist
W	Wet
W_P	Plastic Limit
W_L	Liquid Limit
m	Moisture

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5.2 FIELD LOG

Date: {maxWorklogDate}
Customer Job: -
Ideal Job: 3041-71113
Site Address: Warringah Golf Club Corner of Pittwater and Kingwell Road, NORTH MANLY, NSW, 2100

Borehole: BH2
Surface RL:
Easting:
Northing:

Water		Samples	Depth	Material Origin	FILL Depth	Classification Code	Material Description	Moisture	Density / Consistency
			0.5	TOPSOIL		SM	Silty SAND Black Grey	Slightly Moist	Loose
			1.0	NATURAL		SM	Silty Clayey SAND Black Grey	Slightly Wet	Loose
			1.5						
			2.0						
▼			2.5				End Bore 3m		

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F	Firm	25 – 50	2 – 3
St	Stiff	50 – 100	3 – 5
VSt	Very Stiff	100 – 200	5 – 8
H	Hard	> 200	> 8

MOISTURE

D	Dry
M	Moist
W	Wet
W_P	Plastic Limit
W_L	Liquid Limit
m	Moisture

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5.3 FIELD LOG

Date: {maxWorklogDate}
Customer Job: -
Ideal Job: 3041-71113
Site Address: Warringah Golf Club Corner of Pittwater and Kingwell Road, NORTH MANLY, NSW, 2100

Borehole: BH3
Surface RL:
Easting:
Northing:

Water		Samples	Depth	Material Origin	FILL Depth	Classification Code	Material Description	Moisture	Density / Consistency
			0.5	TOPSOIL		SM	Silty SAND Black Grey	Slightly Moist	Loose
			1.0						
			1.5	NATURAL		SM	Silty Clayey SAND Black Grey	Slightly Wet	Loose
			2.0						
			2.5				End Bore 3m		

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MOISTURE

D	Dry
M	Moist
W	Wet
W_P	Plastic Limit
W_L	Liquid Limit
m	Moisture

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5.4 FIELD LOG

Date: {maxWorklogDate}
Customer Job: -
Ideal Job: 3041-71113
Site Address: Warringah Golf Club Corner of Pittwater and Kingsway Road, NORTH MANLY, NSW, 2100

Borehole: BH4
Surface RL:
Easting:
Northing:

Water		Samples	Depth	Material Origin	FILL Depth	Classification Code	Material Description	Moisture	Density / Consistency
			0.5	TOPSOIL		SM	Silty SAND Black Grey	Slightly Moist	Loose
▼			1.0	NATURAL		SM	Silty Clayey SAND Black Grey	Slightly Wet	Loose
			1.5						
			2.0						
▼			2.5				End Bore 3m		

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MOISTURE

D	Dry
M	Moist
W	Wet
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5.5 FIELD LOG

Date: {maxWorklogDate}
Customer Job: -
Ideal Job: 3041-71113
Site Address: Warringah Golf Club Corner of Pittwater and Kingsway Road, NORTH MANLY, NSW, 2100

Borehole: BH5
Surface RL:
Easting:
Northing:

Water		Samples	Depth	Material Origin	FILL Depth	Classification Code	Material Description	Moisture	Density / Consistency
				TOPSOIL		SM	Silty SAND Black Grey	Slightly Moist	Loose
▼			0.5	NATURAL		SM	Silty Clayey SAND Black Grey	Slightly Wet	Loose
			1.0						
			1.5						
			2.0						
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MOISTURE

D	Dry
M	Moist
W	Wet
W_P	Plastic Limit
W_L	Liquid Limit
m	Moisture

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5.6 FIELD LOG

Date: {maxWorklogDate}
Customer Job: -
Ideal Job: 3041-71113
Site Address: Warringah Golf Club Corner of Pittwater and Kingwell Road, NORTH MANLY, NSW, 2100

Borehole: BH6
Surface RL:
Easting:
Northing:

Water		Samples	Depth	Material Origin	FILL Depth	Classification Code	Material Description	Moisture	Density / Consistency
			0.5	TOPSOIL		SM	Silty SAND Black Grey	Slightly Moist	Loose
▼			1.0	NATURAL		SM	Silty Clayey SAND Black Grey	Slightly Wet	Loose
			1.5						
			2.0						
▼			2.5				End Bore 3m		

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H	Hard	> 200	> 8

MOISTURE

D	Dry
M	Moist
W	Wet
W_P	Plastic Limit
W_L	Liquid Limit
m	Moisture

11.3 Appendix C – Laboratory Test Results

CERTIFICATE OF ANALYSIS

Work Order	: **ES2422257**	Page	: 1 of 9
Client	: **IdealCorp Pty Ltd**	Laboratory	: Environmental Division Sydney
Contact	: DANE DWYER	Contact	: Customer Services ES
Address	: 16-18 Sammut Street SMITHFIELD NSW, AUSTRALIA 2164	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 71113	Date Samples Received	: 04-Jul-2024 11:00
Order number	: ----	Date Analysis Commenced	: 10-Jul-2024
C-O-C number	: ----	Issue Date	: 15-Jul-2024 14:52
Sampler	: BA		
Site	: ----		
Quote number	: SY/386/19 V8		
No. of samples received	: 12		
No. of samples analysed	: 12		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Edwandy Fadjar	Organic Coordinator	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- ASS: EA029 (SPOCAS): Analysis is performed as per the Acid Sulfate Soils Laboratory Methods Guidelines (2004) and the updated National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT (2018)
- ASS: EA029 (SPOCAS): Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA029 (SPOCAS): Laboratory determinations of ANC needs to be corroborated by effectiveness of the measured ANC in relation to incubation ANC. Unless corroborated, the results of ANC testing should be discounted when determining Net Acidity for comparison with action criteria, or for the determination of the acidity hazard and required liming amounts.
- ASS: EA029 (SPOCAS): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from kg/t dry weight to kg/m3 in-situ soil, multiply reported results x wet bulk density of soil in t/m3.
- ASS: EA003 (NATA Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Strong; 4 - Extreme
- ALS is not NATA accredited for the calculation of saturated resistivity in a soil.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH1 - 0.5m	BH1 - 1.5m	BH2 - 1.0m	BH2 - 2.0m	BH3 - 1.0m
			Sampling date / time	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00
Compound	CAS Number	LOR	Unit	ES2422257-001	ES2422257-002	ES2422257-003	ES2422257-004	ES2422257-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.1	----	8.2	----	----
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	6.9	5.6	8.0	6.0	5.1
pH (Fox)	----	0.1	pH Unit	3.5	2.7	5.3	2.6	2.6
Reaction Rate	----	1	Reaction Unit	1	3	2	1	1
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	15	----	90	----	----
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	6.3	4.6	8.6	6.0	5.2
pH OX (23B)	----	0.1	pH Unit	5.9	3.0	6.9	3.0	3.4
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	177	<2	11	25
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	392	<2	96	74
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	216	<2	85	49
sulfidic - Titratable Actual Acidity (s-23F)	----	0.020	% pyrite S	<0.020	0.283	<0.020	<0.020	0.040
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.020	% pyrite S	<0.020	0.629	<0.020	0.154	0.119
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.020	% pyrite S	<0.020	0.346	<0.020	0.136	0.079
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.020	% S	<0.020	<0.020	<0.020	<0.020	<0.020
Peroxide Sulfur (23De)	----	0.020	% S	<0.020	0.255	<0.020	0.124	0.028
Peroxide Oxidisable Sulfur (23E)	----	0.020	% S	<0.020	0.255	<0.020	0.124	0.028
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	159	<10	78	18
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.020	% Ca	0.058	0.122	0.241	<0.020	<0.020
Peroxide Calcium (23Wh)	----	0.020	% Ca	0.070	0.129	0.416	<0.020	<0.020
Acid Reacted Calcium (23X)	----	0.020	% Ca	<0.020	<0.020	0.176	<0.020	<0.020

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	BH1 - 0.5m	BH1 - 1.5m	BH2 - 1.0m	BH2 - 2.0m	BH3 - 1.0m
				Sampling date / time	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00
Compound	CAS Number	LOR	Unit		ES2422257-001	ES2422257-002	ES2422257-003	ES2422257-004	ES2422257-005
					Result	Result	Result	Result	Result
EA029-D: Calcium Values - Continued									
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t		<10	<10	**88**	<10	<10
sulfidic - Acid Reacted Calcium (s-23X)	----	0.020	% S		<0.020	<0.020	**0.140**	<0.020	<0.020
EA029-E: Magnesium Values									
KCl Extractable Magnesium (23Sm)	----	0.020	% Mg		<0.020	<0.020	<0.020	<0.020	<0.020
Peroxide Magnesium (23Tm)	----	0.020	% Mg		<0.020	<0.020	<0.020	<0.020	<0.020
Acid Reacted Magnesium (23U)	----	0.020	% Mg		<0.020	<0.020	<0.020	<0.020	<0.020
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t		<10	<10	<10	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.020	% S		<0.020	<0.020	<0.020	<0.020	<0.020
EA029-F: Excess Acid Neutralising Capacity									
Excess Acid Neutralising Capacity (23Q)	----	0.020	% CaCO3		----	----	**0.911**	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t		----	----	**182**	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.020	% S		----	----	**0.292**	----	----
EA029-H: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S		<0.02	**0.54**	<0.02	**0.14**	**0.07**
Net Acidity (acidity units)	----	10	mole H+ / t		<10	**336**	<10	**88**	**43**
Liming Rate	----	1	kg CaCO3/t		<1	**25**	<1	**7**	**3**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		<0.02	**0.54**	<0.02	**0.14**	**0.07**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		<10	**336**	<10	**88**	**43**
Liming Rate excluding ANC	----	1	kg CaCO3/t		<1	**25**	<1	**7**	**3**
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		**12.4**	----	**13.9**	----	----
EA084: Saturated Resistivity									
Resistivity at 25°C	----	10	ohm cm		**31200**	----	**6370**	----	----
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		<10	----	**20**	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	BH1 - 0.5m	BH1 - 1.5m	BH2 - 1.0m	BH2 - 2.0m	BH3 - 1.0m
				Sampling date / time	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00
Compound	CAS Number	LOR	Unit		ES2422257-001	ES2422257-002	ES2422257-003	ES2422257-004	ES2422257-005
					Result	Result	Result	Result	Result
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		<10	---	<10	---	---

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH3 - 3.0m	BH4 - 0.5m	BH4 - 1.5m	BH5 - 1.0m	BH5 - 2.0m
			Sampling date / time	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00
Compound	CAS Number	LOR	Unit	ES2422257-006	ES2422257-007	ES2422257-008	ES2422257-009	ES2422257-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.2	----	6.4	----	6.1
EA003 :pH (field/fox)								
pH (F)	----	0.1	pH Unit	6.0	5.0	6.2	6.3	5.9
pH (Fox)	----	0.1	pH Unit	2.7	2.7	3.2	2.9	2.1
Reaction Rate	----	1	Reaction Unit	1	1	3	1	3
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	14	----	17	----	30
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	5.7	6.1	5.1	5.9	4.6
pH OX (23B)	----	0.1	pH Unit	3.4	3.9	4.1	4.2	2.2
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	13	5	61	5	118
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	65	44	313	6	1810
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	52	38	252	<2	1700
sulfidic - Titratable Actual Acidity (s-23F)	----	0.020	% pyrite S	0.020	<0.020	0.098	<0.020	0.188
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.020	% pyrite S	0.105	0.070	0.501	<0.020	2.91
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.020	% pyrite S	0.084	0.062	0.403	<0.020	2.72
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.020	% S	<0.020	<0.020	<0.020	<0.020	<0.020
Peroxide Sulfur (23De)	----	0.020	% S	0.043	<0.020	0.107	<0.020	0.514
Peroxide Oxidisable Sulfur (23E)	----	0.020	% S	0.043	<0.020	0.107	<0.020	0.514
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	27	<10	67	<10	320
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.020	% Ca	0.034	0.076	0.213	0.039	0.132
Peroxide Calcium (23Wh)	----	0.020	% Ca	0.058	0.080	0.242	0.042	0.180
Acid Reacted Calcium (23X)	----	0.020	% Ca	0.023	<0.020	0.029	<0.020	0.048

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	BH3 - 3.0m	BH4 - 0.5m	BH4 - 1.5m	BH5 - 1.0m	BH5 - 2.0m
				Sampling date / time	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00	03-Jul-2024 09:00
Compound	CAS Number	LOR	Unit		ES2422257-006	ES2422257-007	ES2422257-008	ES2422257-009	ES2422257-010
					Result	Result	Result	Result	Result
EA029-D: Calcium Values - Continued									
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t		12	<10	14	<10	24
sulfidic - Acid Reacted Calcium (s-23X)	----	0.020	% S		<0.020	<0.020	0.023	<0.020	0.038
EA029-E: Magnesium Values									
KCl Extractable Magnesium (23Sm)	----	0.020	% Mg		<0.020	<0.020	<0.020	<0.020	0.035
Peroxide Magnesium (23Tm)	----	0.020	% Mg		<0.020	<0.020	<0.020	<0.020	0.046
Acid Reacted Magnesium (23U)	----	0.020	% Mg		<0.020	<0.020	<0.020	<0.020	<0.020
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t		<10	<10	<10	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.020	% S		<0.020	<0.020	<0.020	<0.020	<0.020
EA029-H: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S		0.06	<0.02	0.20	<0.02	0.70
Net Acidity (acidity units)	----	10	mole H+ / t		40	<10	128	<10	438
Liming Rate	----	1	kg CaCO3/t		3	<1	10	<1	33
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		0.06	<0.02	0.20	<0.02	0.70
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		40	<10	128	<10	438
Liming Rate excluding ANC	----	1	kg CaCO3/t		3	<1	10	<1	33
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		23.3	----	50.0	----	63.3
EA084: Saturated Resistivity									
Resistivity at 25°C	----	10	ohm cm		18200	----	12300	----	8930
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		<10	----	70	----	20
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		<10	----	<10	----	60

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH6 - 1.5m	BH6 - 3.0m	---	---	---
			Sampling date / time	03-Jul-2024 09:00	03-Jul-2024 09:00	---	---	---
Compound	CAS Number	LOR	Unit	ES2422257-011	ES2422257-012	-------	-------	------
				Result	Result	---	---	---
EA003 :pH (field/fox)								
pH (F)	---	0.1	pH Unit	5.6	5.7	---	---	---
pH (Fox)	---	0.1	pH Unit	2.5	2.0	---	---	---
Reaction Rate	---	1	Reaction Unit	3	3	---	---	---
EA029-A: pH Measurements								
pH KCl (23A)	---	0.1	pH Unit	4.7	4.8	---	---	---
pH OX (23B)	---	0.1	pH Unit	2.4	2.1	---	---	---
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	---	2	mole H+ / t	170	97	---	---	---
Titratable Peroxide Acidity (23G)	---	2	mole H+ / t	1160	888	---	---	---
Titratable Sulfidic Acidity (23H)	---	2	mole H+ / t	987	791	---	---	---
sulfidic - Titratable Actual Acidity (s-23F)	---	0.020	% pyrite S	0.273	0.155	---	---	---
sulfidic - Titratable Peroxide Acidity (s-23G)	---	0.020	% pyrite S	1.86	1.42	---	---	---
sulfidic - Titratable Sulfidic Acidity (s-23H)	---	0.020	% pyrite S	1.58	1.27	---	---	---
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	---	0.020	% S	<0.020	<0.020	---	---	---
Peroxide Sulfur (23De)	---	0.020	% S	0.364	0.288	---	---	---
Peroxide Oxidisable Sulfur (23E)	---	0.020	% S	0.364	0.288	---	---	---
acidity - Peroxide Oxidisable Sulfur (a-23E)	---	10	mole H+ / t	227	180	---	---	---
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	---	0.020	% Ca	0.141	<0.020	---	---	---
Peroxide Calcium (23Wh)	---	0.020	% Ca	0.159	0.020	---	---	---
Acid Reacted Calcium (23X)	---	0.020	% Ca	<0.020	0.020	---	---	---
acidity - Acid Reacted Calcium (a-23X)	---	10	mole H+ / t	<10	10	---	---	---
sulfidic - Acid Reacted Calcium (s-23X)	---	0.020	% S	<0.020	<0.020	---	---	---
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	---	0.020	% Mg	0.035	<0.020	---	---	---

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	BH6 - 1.5m	BH6 - 3.0m	---	---	---
				Sampling date / time	03-Jul-2024 09:00	03-Jul-2024 09:00	---	---	---
Compound	CAS Number	LOR	Unit		ES2422257-011	ES2422257-012	-------	-------	------
					Result	Result	---	---	---
EA029-E: Magnesium Values - Continued									
Peroxide Magnesium (23Tm)	---	0.020	% Mg		**0.040**	<0.020	---	---	---
Acid Reacted Magnesium (23U)	---	0.020	% Mg		<0.020	<0.020	---	---	---
Acidity - Acid Reacted Magnesium (a-23U)	---	10	mole H+ / t		<10	<10	---	---	---
sulfidic - Acid Reacted Magnesium (s-23U)	---	0.020	% S		<0.020	<0.020	---	---	---
EA029-H: Acid Base Accounting									
ANC Fineness Factor	---	0.5	-		**1.5**	**1.5**	---	---	---
Net Acidity (sulfur units)	---	0.02	% S		**0.64**	**0.44**	---	---	---
Net Acidity (acidity units)	---	10	mole H+ / t		**397**	**276**	---	---	---
Liming Rate	---	1	kg CaCO3/t		**30**	**21**	---	---	---
Net Acidity excluding ANC (sulfur units)	---	0.02	% S		**0.64**	**0.44**	---	---	---
Net Acidity excluding ANC (acidity units)	---	10	mole H+ / t		**397**	**276**	---	---	---
Liming Rate excluding ANC	---	1	kg CaCO3/t		**30**	**21**	---	---	---

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry / Biology).

(SOIL) EA029-D: Calcium Values
(SOIL) EA029-G: Retained Acidity
(SOIL) EA029-B: Acidity Trail
(SOIL) EA029-C: Sulfur Trail
(SOIL) EA029-E: Magnesium Values
(SOIL) EA029-H: Acid Base Accounting
(SOIL) EA003 :pH (field/fox)
(SOIL) EA029-F: Excess Acid Neutralising Capacity
(SOIL) EA029-A: pH Measurements

11.4 Appendix D – Management Plan

Appendix D ***Management Strategy***

ELEMENT ASS1 **Acid Sulfate Soil Treatment**

Why:

- To minimise acid generation and acid products due to oxidation of ASS
- To treat the acid generated by excavation of material.

Performance Objective:

- Compliance with the *Protection of the Environment and Operations Act 1997, NSW Acid Sulfate Soil Manual 1998* and other relevant statutes, policy and guidelines
- Implement best practice environmental management of ASS

Responsible Person:

- Site Manager/representative.

Control Actions:

- Minimise disturbance of acid sulfate soils
- Identify treatment area on site or off-site. Note minimal area available on site unless excavation staged. If off-site approval to be sought from statutory authorities prior to commencement of earthworks.
- Prior to disturbance of ASS install non – ASS bunds to stockpile/treatment areas
- Any stockpiling/treatment pad will require the placement of an agricultural lime guard layer under the stockpile/treatment pad. The guard layer shall be 0.3 times the average liming rate/m^2 for each vertical metre of the stockpile/treatment pad. Maximum stockpiling period = 14 days
- Place all excavated material in bunded area. Wet material will require spreading to allow dewatering to occur prior to further treatment
- Place excavated material in maximum 0.3m deep layers and incorporate agricultural lime at the following rates

Site	%S	TPA mol H+/T	Min. Kg lime/m3 soil (assume BD = 1.6g/cm^3)	Min. Kg lime/m^2/300mm layer
Excavation up to 1.0m	0.028	74	5	1.5
Excavation below 1.0m	0.364	1810	53	16

Monitoring

- Mechanical mixing methods eg rotary hoeing/disc ploughing shall be used.
- Site Manager or representative shall monitor the works daily for evidence of
    1. Yellow efflorescence on soil surface
    2. Iron staining
    3. Sulphurous odour.
- Regular monitoring of any leachate (see ELEMENT ASS2)
- Lime delivery dockets to be collected and checked against calculated lime application rate

Reporting:	• Records to be kept by the Site Manager on the monitoring activities, complaints received, and control actions subsequently taken. Records to be made available to Council, OEH, and OW if requested.

ELEMENT ASS2 ASS Leachate Treatment

Why:	• To avoid negative off-site impacts on water quality from acid generation or acid products
Performance Objective:	• Compliance with the *Protection of the Environment and Operations Act 1997, NSW Acid Sulfate Soil Manual 1998* and other relevant statutes, policy and guidelines • Implement best practice environmental management of ASS
Responsibe Person:	• Site Manager
Control Actions:	• Provide surface water controls to divert surface water run-on • Isolate soil treatment areas in non-ASS bunded areas. • All water discharged from the site to be contained, collected and treated to meet adopted water quality criteria. • Treatment of water within bunded areas may include dosing with hydrated lime at appropriate rates to ensure discharge pH 6.5 – 8.5. (Note extreme care required with hydrated lime to avoid “overshooting” target pH.)
Monitoring: (if leachate evident)	• Daily monitor leachate pH and Electrical Conductivity in treatment and stockpile areas
Action Criteria	• pH < 6.5 or >8.5
Reporting:	• Records to be kept by the Site Manager on the monitoring activities, complaints received, and control actions subsequently taken. Records to be made available to Council, OEH, and OW as requested. • Event = >25mm rainfall in 24hr