# Acid Sulfate Soils Investigation

**Lot 40, No 136 Narrabeen Park Parade**

**Mona Vale NSW 2103**


**Submitted To**
**Metricon Homes**
Building E, Level 4, 32 Lexington Drive
Baulkham Hills NSW 2153

**Site Number**
130018

**Date**
1/11/2019

**Author**
Raj Singh

**Published**
1/11/2019

Document Revision: 0
Template Version: ii
Template Name: Master with Cover

**Intrax Consulting Engineers Pty Ltd**
ABN: 31 106 481 252

**Head Office**
Level 4, 469 Latrobe Street,
Melbourne, Vic 3000
p: 1300 INTRAX
w: www.intrax.com.au

# Table of Contents



Confidentiality

All documents are subject to the 'Intrax Terms and Conditions' and 'Intrax Terms and Conditions -NAC' documents. These documents are available on our website for your perusal.

Conditions of Use

This report is not intended for use by any other person or third party other than the named client.

Direct Contact

Any questions or queries regarding this report should be directed to the Geotechnical Department, Engineering Team on 1300 or scott.emmett@intrax.com.au.



### Document Revision History

| Date | Rev | Author | Approved by | Comments |
|---|---|---|---|---|
| 01-Nov-19 | 0 | Raj Singh | Scott Emmett | First Edition |

| | | | | |
|---|---|---|---|---|
| | | | | |

# List of Appendices

**APPENDIX A:** Site Plan and Borehole Logs

**APPENDIX B:** Site Photography

**APPENDIX C:** Laboratory Data

**REFERENCED STANDARDS:**

AS 1726-2017, Geotechnical site investigations, Standards Australia, Sydney, Retrieved from SAI Global

AS 2159-2009, Piling-Design and Installation, Standards Australia, Sydney, Retrieved from SAI Global

AS 2870-2011, Residential slabs and footings, Standards Australia, Sydney, Retrieved from SAI Global

AS 3798-2007, Guidelines on earthworks for commercial and residential developments, Standards Australia, Sydney, Retrieved from SAI Global

ASSMAC, 1998: Acid Sulfate Soils Management Advisory Committee, 1998: Acid Sulfate Soil Manual

**REPORT AUTHOR/S:**

Mr Raj Singh
Senior Geotechnical Engineer
BTech (Civil), ME (Geotechnical)

Mr Scott Emmett
Geologist
BSc (EarthScience) Hons, MAIG 10246

**REPORT CONTACT:**

**Raj Singh**

02 8355 1200
raj.singh@intrax.com.au

Intrax Consulting Engineers Pty Ltd
Geotechnical Consultants
C2.07/22-36 Mountain Street
ULTIMO NSW 2007

# 1 Introduction

Intrax Consulting Engineers has completed a Acid Sulphate Soils Assessment (ASSA) for the proposed double storey residential dwelling at Lot. 40, No. 136, Narrabeen Park Parade, Mona Vale, NSW, 2103.

The investigation was carried out in accordance with the email fee proposal commissioned by Metricon Homes.

This report outlines the geotechnical site investigation carried out on 25/10/2019 and subsequent laboratory testing. The report includes the comment on the presence/absence of Acid Sulphate Soils (ASSA).

# 2 Project and Site Description

## 2.1 Project Description

Based on the information supplied by the client, it is understood that project would involve construction of a new single storey residential dwelling.

## 2.2 Site Description

The site is located to the west of Narrabeen Park Parade and occupies an area of about 594.4m$^2$. The site area slopes down to the south east at 9$^0$ to 10$^0$. Site is occupied with a residential dwelling. Some medium size trees were observed at the rear of existing house. Site is bounded by

- Narrabeen Park Parade to the north.
- Residential dwellings to the south, east and west.

The surface soils generally comprised surficial fill overlying natural clay.

Site conditions on the date of inspection are visible in the attached photography in Appendix B with the site features indicated in the site plan, refer Appendix A.

# 3 Method of Investigation

## 3.1 Desktop Assessment

Geological maps from the Geological Survey of NSW, aerial photography and our local experienced were used to assess the anticipated site conditions and the area geology.

## 3.2 Fieldwork

The fieldwork consisted of drilling a total of four (4) boreholes (BH1 to BH4) to a maximum depth of 1.2 metres with solid flight auger powered by a Christie Engineering Hydraulic drill rig. The approximate locations of the boreholes are shown on the attached site plan in Appendix A. The subsurface materials were visually classified in accordance with AS1726-2017: Geotechnical Site Investigation.

Soil samples for acid sulfate assessment were collected using a stainless-steel trowel from the auger. Sampling tools were decontaminated between each sample collection using water, DECON 90 and a scrubbing brush. All samples were placed in glass jars with plastic caps and Teflon seals with minimum headspace. Each sample was labelled with job number, the sample location and date. All samples were recorded on the Chain of Custody (COC) record stored in our office files.

On completion of fieldwork, the samples were delivered under cold storage conditions to SGS Alexandria, a NATA registered laboratory, for analysis under Standard COC procedures.

## 3.3 Laboratory Testing

Laboratory testing included the following:

- Six samples for pH screening to aid in assessment of acid sulfate soils.

Results of laboratory test are outlined in section 5 and detailed in Appendix C.

# 4 Results of Investigation

## 4.1 Desktop Assessment

Investigation of geological maps from the Geological survey of NSW has identified the expected site geology is Newcastle Coal Measures (Pn) which comprise conglomerate, sandstone, tuff, shale, coal. This geology was consistent with the visual identification of material on site. An extract of the local geological map is provided below.

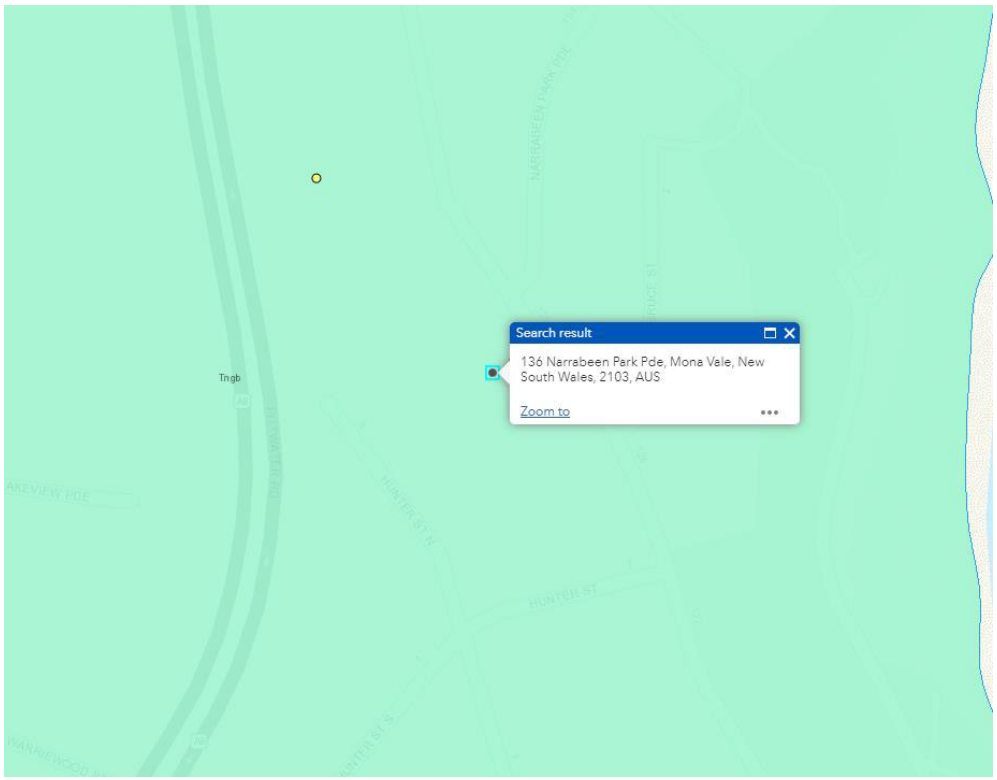



*Figure 1: Extract of local geology, Intrax GIS database*

## 4.2 Subsurface Conditions

The boreholes revealed the substrata typically consisted of the following soil profile. Variation from this profile existed across the site, refer to borehole logs in Appendix A for details.

| | |
|---|---|
| FILL | Silty CLAY, medium plasticity, dark grey, trace sand gravel |
| NATURAL | CLAY, high plasticity, pale grey brown mottled orange, root material |

### 4.2.1 Ground Water

Groundwater was not intersected at a depth of 1.2 meters during borehole drilling.

Substrata conditions encountered are such that infiltration and occurrence of perched water at the interface between different material layers should not be disregarded.  site excavation should take note of this.

# 5 Acid Sulphate Soils Assessment (ASSA)

## 5.1 Definition and Theoretical Background

ASS are naturally occurring sediments and soils containing iron sulphides (principally iron sulphide, iron disulphide or their precursors). Oxidation of these soils through exposure to the atmosphere or through lowering of groundwater levels results in the generation of sulfuric acid.

Most ASS are of Holocene age (<10000 years) and their formation requires the presence of iron-rich sediments, sulphate (usually from sea water), removal of reaction products such as bicarbonate, the presence of sulphate-reducing bacteria and an abundant supply of organic matter. These conditions generally exist in mangroves, salt marshes, inter-tidal areas and on the beds of coastal rivers and lakes.

ASS is further sub-divided into Actual Acid Sulfate Soils (AASS) and Potential Acid Sulphate Soil (PASS). AASS and PASS are generally found in the same soil profile with AASS overlying PASS.

AASS are soils that contain highly acidic soil horizons or layers resulting from the oxidation of iron sulphides. The oxidation produces hydrogen ions in excess of the buffering or neutralising capacity of the soil.

PASS are soils containing iron sulphides or sulfidic material (usually ferrous iron disulphide or pyrite) which are waterlogged soils, rich in pyrite, that have not been exposed to air and oxidised. Any disturbance that admits oxygen (such as excavation works) will lead to the development of actual acid sulphate soil layers, which may pose an environmental risk.

## 5.2 Indicators of AASS and PASS

The Indicators of PASS materials are as follows:

**Screening tests:** PASS indicators include significant negative pH shifts during screening tests and pH following oxidation (pHFox) below pH 3. Samples with pHF < pH 4.0 indicate that in-situ conditions are already acidic. For pHF approximately equal to 7 the soil is considered neutral.

**Chromium Suite tests:** Indicators of PASS materials include significant actual acidity (TAA greater than 18 Mole H+/t) and Chromium Reducible Sulphur percentages SCR greater than 0.03%. Samples with pHKCL < 6.5 indicate that in-situ conditions are already somewhat acidic, but TAA greater than 18 mole H+/t is required for this to be significant (depending on scale of the job and nature of the soil).

## 5.3 Assessment Criteria

The ASSMAC (1998) action criteria for treatment of ASS based on the percentage of oxidisable sulphur or equivalent Titratable Actual Acidity (TAA) or Titratable Peroxide Acidity (TPA) for broad soil texture categories are presented in Table 3. When analysis results exceed the action criteria, a treatment regime and management plan for the materials is triggered. For disturbances of less than 1000 tonnes, the action criteria vary according to the texture of the material, however if more than 1000 tonnes is to be disturbed, all action criteria are the same: S% 0.03% and Acid 18 mole H+/tonne. For the purposes of this assessment the criteria applicable for disturbing less than 1000 tonnes of soil disturbed has been adopted with a course texture.

The action criteria for ASS soil analysis are presented below.

**Table 4.4. Action criteria based on ASS soil analysis for three broad texture categories**

| *Type of Material* | | *Action Criteria 1-1000 tonnes disturbed* | | *Action Criteria if more than 1000 tonnes disturbed* | |
|---|---|---|---|---|---|
| *Texture range.McDonald et al. (1990)* | *Approx. clay content (%<0.002 mm)* | *Sulfur trail % S oxidisable (oven-dry basis) eg $S_{TOS}$ or $S_{POS}$* | *Acid trail mol $H^+$/tonne (oven-dry basis) eg, TPA or TSA* | *Sulfur trail % S oxidisable (oven-dry basis) eg $S_{TOS}$ or $S_{POS}$* | *Acid trail mol $H^+$/tonne (oven-dry basis) eg, TPA or TSA* |
| **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 |

Figure 2: Extract from Stone, Y, Ahern CR, and Blunden B (1998)

## 5.4 Laboratory Test Results

### 5.4.1 pH Screening Testing

Six (6) samples were collected from BH1 to BH4 to test for pH screening tests to assess the actual and potential acidity of insitu samples.

A summary of pH screening test results is presented in Table 1 below:

*Table 1: Field pH and Peroxide pH Test Results*

| Sample Location/Depth (m) | pH | Peroxide pH | pH Reduction | Reaction Rate |
|---|---|---|---|---|
| BH1-0.5 | 6.3 | 5.4 | 1.0 | X |
| BH1-1.0 | 6.2 | 5.5 | 0.7 | X |
| BH1-1.3 | 5.1 | 5.6 | -0.5 | X |
| BH2-0.5 | 6.1 | 5.6 | 0.5 | X |
| BH2-1.0 | 6.2 | 5.1 | 1.0 | XX |
| BH2-1.5 | 5.3 | 4.5 | 0.8 | XX |

*Note: Reaction Rate means x – Slight; xx – Moderate; xxx – Strong; xxxx – Extreme/Vigorous*

# 6 Conclusion

Based on the above SGS screening test results, it is assessed that insitu soils does not contain any Actual or potential acid sulfate soils. Therefore, no Acid Sulfate Soil Management is required for this site. Inspections (Hold Points)

# 7 Limitations of Report

1. The recommendations in this report are based on the following:
    a. Information about the site & its history, proposed site treatment and building type conveyed to us by the client and or their agent
    b. Professional judgements and opinions using the most recent information in soil testing practice that is available to us.
    c. The location of our test sites and the information gained from this and other investigations.

    Should the client or their agent neglect to supply us with correct or relevant information, including information about previous buildings, trees or past activities on the site, or should changes be made to the building type, size and or/position, this report may be made obsolete, irrelevant or unsuitable. In such cases, Intrax will not accept any liability for the consequences and Intrax reserves the right to make an additional charge if more testing or a change to the report is necessary.
2. The recommendations made in this report may need to be reviewed should any site works disturb any soil 200mm below the proposed founding depth.
3. The descriptions of the soils encountered in the boreholes follow those outlined in AS1726-2017; Geotechnical Site Investigations. Colour descriptions can vary with soil moisture content and individual interpretation.
4. If the site conditions at the time of construction differ from those described in this report then Intrax must be contacted so a site inspection can be carried out prior to any footing being poured. The owner/builder will be responsible for any fees associated with this additional work.
5. This report assumes that the soil profile observed in the boreholes are representative of the entire site. If the soil profile and site conditions appear to differ substantially from those reported herein, then Intrax should be contacted immediately and this report may need to be reviewed and amended where appropriate. The owner/builder will be responsible for any fees associated with this additional work.
6. The user of this report must take into account the following limitations. Soil and drilling depths are given to a tolerance of +/- 200mm.

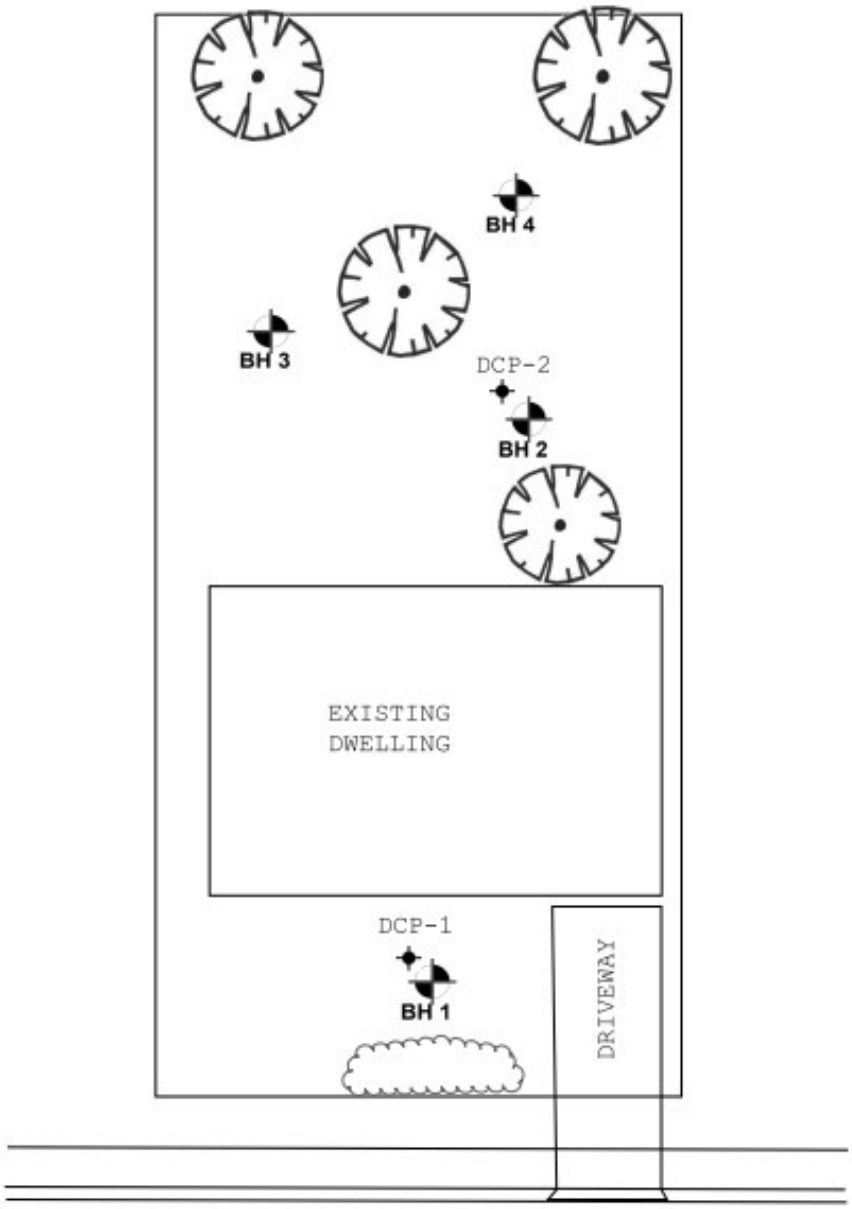
    It must be understood and a condition of acceptance of this report is that whilst every effort is made to identify fill material across the site, difficulties exist in determining fill material, in particular, for example, well compacted site or area derived fill, when utilising a small diameter auger. Consequently Intrax emphasises that we will not be responsible for any financial losses, consequential or otherwise, that may occur as a result of not accurately determining the fill profile across the site.
7. Finally, no responsibility will be taken for this report if it is altered in any way or is not reproduced in full.

# Appendix A

## Site Plan and Borehole Logs

# Site Plan

Site Address: Lot. 40, No. 136, Narrabeen Park Parade, Mona Vale, Nsw, 2103




| | |
|---|---|
| Client: Metricon Homes Pty Ltd | Scale (A4): Not to scale |
| Project: Lot. 40, No. 136, Narrabeen Park Parade, Mona Vale, NSW, 2103 | Date: 01.11.2019 |
| | Sheets: 1 |
| Drawing: Site Plan | Project No. 130018 Ver. 1 |

Intrax
Engineering
Confidence

Civil
Forensic
Hydraulic
Structural
Surveying
Residential
Geotechnical
Building Services

**35 Bank Street South Melbourne**
**VIC 3205 03 8371 0100**

Geelong 03 5221 8282
New South Wales 02 4869 5666
Queensland 07 3813 5617
South Australia 08 8165 0122

A.B.N. 31 106 481 252
www.intrax.com.au

**Borehole Log:** BH1 **Sheet:** 1 of 1

Client: Metricon Homes Pty Ltd Drill Rig: Christie Mechanical Rig

Project: Proposed Residential Dwelling Logged: RS

Location: No. 136, Narrabeen Park Parade, Mona Vale, NSW Date: 25/10/2019

| Method | Depth (metres) | DCP blows count | Material Description | Soil Classification | Moisture | Consistency / Density | Structure, Origin, Water and Additional Observations | Disturbed Samples (D) |
|---|---|---|---|---|---|---|---|---|
| MA | 0.50 | | Silty CLAY, medium plasticity, dark brown mottled black orange, root material, trace sand gravel | CI | >PL | | FILL | D at 0.5m |
| | 1.00 | | CLAY, high plasticity, pale grey brown mottled orange, root material, trace gravel | CH | >PL | | NATURAL | D at 1.0m<br>D at 1.3m |
| | 1.50 | | Groundwater was not encountered<br>BH1 terminated at 1.3m depth | | | | | |
| | 2.00 | | | | | | | |
| | 2.50 | | | | | | | |
| | 3.00 | | | | | | | |
| | 3.50 | | | | | | | |
| | 4.00 | | | | | | | |
| | 4.50 | | | | | | | |
| | 5.00 | | | | | | | |

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

**Borehole Log:** BH2 **Sheet:** 1 of 1

Client: Metricon Homes Pty Ltd Drill Rig: Christie Mechanical Rig

Project: Proposed Residential Dwelling Logged: RS

Location: Lot. 40, No. 136, Narrabeen Park Parade, Mona V. Date: 25/10/2019

| Method | Depth (metres) | DCP blows count | Material Description | Soil Classification | Moisture | Consistency / Density | Structure, Origin, Water and Additional Observations | Disturbed Samples (D) |
|---|---|---|---|---|---|---|---|---|
| MA | 0.50 | | Silty CLAY, medium plasticity, dark brown mottled black orange, root material, trace sand gravel | CI | >PL | | FILL | D at 0.5m |
| | 1.00 | | CLAY, high plasticity, pale grey brown mottled orange, root material, trace gravel | CH | >PL | | NATURAL | D at 1.0m |
| | 1.50 | | Groundwater was not encountered<br>BH2 terminated at 1.2m depth | | | | | |
| | 2.00 | | | | | | | |
| | 2.50 | | | | | | | |
| | 3.00 | | | | | | | |
| | 3.50 | | | | | | | |
| | 4.00 | | | | | | | |
| | 4.50 | | | | | | | |
| | 5.00 | | | | | | | |

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

**Borehole Log:** BH3 **Sheet:** 1 of 1

Client: Metricon Homes Pty Ltd Drill Rig: Christie Mechanical Rig

Project: Proposed Residential Dwelling Logged: RS

Location: Lot. 40, No. 136, Narrabeen Park Parade, Mona V Date: 25/10/2019

| Method | Depth (metres) | DCP blows count | Material Description | Soil Classification | Moisture | Consistency / Density | Structure, Origin, Water and Additional Observations | Disturbed Samples (D) |
|---|---|---|---|---|---|---|---|---|
| MA | 0.50 | | Silty CLAY, medium plasticity, dark brown mottled black orange, root material, trace sand gravel | CI | >PL | | FILL | |
| | 1.00 | | CLAY, high plasticity, pale grey brown mottled orange, root material, trace gravel | CH | >PL | | NATURAL | |
| | 1.50 | | Groundwater was not encountered<br>BH3 terminated at 1.2m depth | | | | | |
| | 2.00 | | | | | | | |
| | 2.50 | | | | | | | |
| | 3.00 | | | | | | | |
| | 3.50 | | | | | | | |
| | 4.00 | | | | | | | |
| | 4.50 | | | | | | | |
| | 5.00 | | | | | | | |

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

**Borehole Log:** BH4 **Sheet:** 1 of 1

Client: Metricon Homes Pty Ltd Drill Rig: Christie Mechanical Rig

Project: Proposed Residential Dwelling Logged: RS

Location: Lot. 40, No. 136, Narrabeen Park Parade, Mona V. Date: 25/10/2019

| Method | Depth (metres) | DCP blows count | Material Description | Soil Classification | Moisture | Consistency / Density | Structure, Origin, Water and Additional Observations | Disturbed Samples (D) |
|---|---|---|---|---|---|---|---|---|
| MA | 0.50 | | Silty CLAY, medium plasticity, dark brown mottled black orange, root material, trace sand gravel | CI | >PL | | FILL | |
| | 1.00 | | CLAY, high plasticity, pale grey brown mottled orange, root material, trace gravel | CH | >PL | | NATURAL | |
| | 1.50 | | Groundwater was not encountered<br>BH4 terminated at 1.2m depth | | | | | |
| | 2.00 | | | | | | | |
| | 2.50 | | | | | | | |
| | 3.00 | | | | | | | |
| | 3.50 | | | | | | | |
| | 4.00 | | | | | | | |
| | 4.50 | | | | | | | |
| | 5.00 | | | | | | | |

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

# EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS

## DRILLING/EXCAVATION METHOD

| | | | | | |
|---|---|---|---|---|---|
| HA | Hand Auger | W | Washbore | PT | Push Tube |
| MA- | Mechanical Auger Drilling | HQ | Diamond Core - 63 mm | EX | Excavator |
| -V | V-Bit | NMLC | Diamond Core - 52 mm | HAD | Hollow Auger Drilling |
| -TC | TC-Bit, e.g. ADT | NQ | Diamond Core - 47 mm | | |

## PENETRATION/EXCAVATION RESISTANCE

| | |
|---|---|
| L | Low resistance. Rapid penetration possible with little effort from the equipment used. |
| M | Medium resistance. Excavation/possible at an acceptable rate with moderate effort from the equipment used |
| H | High resistance. Further penetration is possible at a slow rate and requires significant effort from the equipment |
| R | Refusal or Practical Refusal. No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine. |

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition or excavation or drilling tools, and experience of the operator.

## WATER

| | | | |
|---|---|---|---|
| $\nabla$ | Water level at date shown | $\Leftarrow$ | Partial water loss |
| $\Rightarrow$ | Water inflow | $\|\Leftarrow\|$ | Complete water loss |

| | |
|---|---|
| NO | Ground Water Not Observed: Ground water obersvation not possible. Ground water may or may not be present |
| NE | Ground Water Not Encountered: Ground water was not evident during excavation or a short time after completion. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period. |

## SAMPLING AND TESTING

| | |
|---|---|
| SPT | Standard Penetration Test to AS1289.6.3.1 - 2004 |
| 3,6,9 N=15 | 3,6,9 = blows per 150mm. N = blows per final 300mm penetration |
| 30/80mm | Practical refusal, with blows and depth of penetration before refusal occurred |
| RW | Penetration caused under rod weight only |
| HW | Penetration caused under hammer and rod weight only |
| HB | Hammer bounce without penetration |
| R | Refusal to test |
| DCP | Dynamic Cone Penetrometer Test to AS1289.6.3.2 - 1997 |
| DCP (p) | Dynamic Cone Penetrometer Test to AS1289.6.3.3 - 1997 Perth Sand Penetrometer |
| 6 | 6 = blows per 100mm of penetration |

| | |
|---|---|
| DS | Disturbed sample |
| BDS | Bulk disturbed sample |
| U63 | Undisturbed thin wall push tube sample, nominal sample diameter denoted in millimetres |
| W | Water sample |
| G | Gas sample |
| V | pilcon shear vane (kPa) |
| PP | Pocket penetrometer (kPa) |
| FP | Field permeability test over section noted |
| ES | Environmental sample |
| PI | Plastic Index (%) |
| PL | Plastic Limit (%) |
| LL | Liquid Limit (%) |
| MC | Moisture Content (%) |
| CBR | Californian Bearing Ration (%) |

## ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{Length\ of\ core\ recovered}{Length\ of\ core\ run} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum Axial\ lengths\ of\ core > 100\ mm}{Length\ of\ core\ run} \times 100$$

# EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - SOIL DESCRIPTION (AS1726 - 2017)

## SOIL CLASSIFICATION SYSTEM

### Coarse Grained Soil

- **GW** Well graded gravels, gravel-sand mixtures, little or no fines
- **GP** Poorly-graded gravels, gravel-sand mixtures, little or no fines, uniform gravels
- **GM** Silty gravels, gravel-sand-silt mixtures
- **GC** Clayey gravels, gravel-sand-clay mixtures
- **SW** Well-graded sands, gravelly sands, little or no fines
- **SP** Poorly-graded sands, gravelly sand, little or no fines
- **SM** Silty sands, sand-silt mixtures
- **SC** Clayey sands, sand-clay mixtures

### Fine Grained Soils

- **ML** Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silts with low plasticity
- **CL, CI** Inorganic clays of low to medium plasticity, gravelly clays, sandy clays
- **OL** Organic silts and organic silty clays of low plasticity
- **MH** Inorganic silts, micaceous or diatomaceous fine sand for silty soils
- **CH** Inorganic clays of high plasticity
- **OH** Organic clays of medium to high plasticity, organic silts
- **PT** Peat, humus, swamp soils with high organic contents

First Letter: G = Gravel, S = Sand, M = Silt, C = Clay; Second Letter: W = Well-graded, P = Poorly-graded, M = Mixture, O = Organic, L = Low plasticity, H = High plasticity

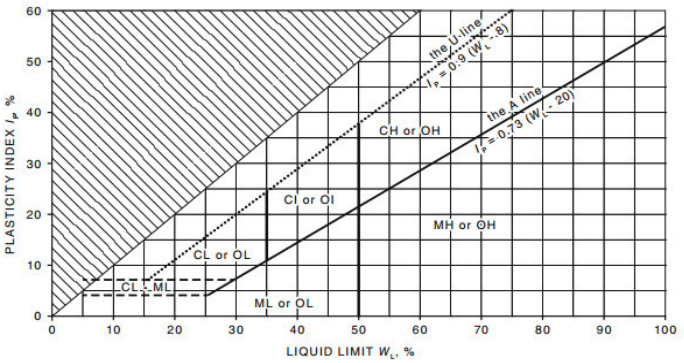
Soils may be a combination of multiple soil classifications where borderline

## PARTICLE SIZE

| Soil | Major Division | Sub-Division | Particle Size (mm) |
|---|---|---|---|
| Coarse | Boulders | | >200 |
| | Cobbles | | 63 - 200 |
| | Gravel | Coarse | 20 - 63 |
| | | Medium | 6 - 20 |
| | | Fine | 2.36 - 6 |
| | Sand | Coarse | 0.6 - 2.36 |
| | | Medium | 0.2 - 0.6 |
| | | Fine | 0.075 - 0.2 |
| Fine | Silt | | 0.002 - 0.075 |
| | Clay | | < 0.002 |

0.075mm is the approximate minimum particle size discernible by eye

## PLASTICITY CHART




## MOISTURE CONDITION

| | | | |
|---|---|---|---|
| Coarse | D | Dry | Sands and gravels are free flowing. |
| | M | Moist | Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere. |
| | W | Wet | Soils exude free water. Sands and gravels tend to cohere. |
| Fine | PL | Plastic Limit | Moisture content of fine grain soils are described; as below plastic limit (<PL), near to plastic limit (=PL), above plastic limit (>PL), near to the liquid limit (=LL), or above the liquid limit (>LL) |
| | LL | Liquid Limit | |

## CONSISTENCY AND DENSITY

### Fine Grained Soils

| | | | Pocket Pentrometer Reading (kPa) |
|---|---|---|---|
| VS | Very Soft | Exudes between fingers when squeezed | <25 |
| S | Soft | Can be moulded by light finger pressure | 20 - 50 |
| F | Firm | Can be moulded by strong finger pressure | 50 - 100 |
| St | Stiff | Cannot be moulded by fingers. Can be indented by thumb | 100 - 200 |
| VSt | Very Stiff | Can be indented by thumb nail | 200 - 400 |
| H | Hard | Can be indented by thumb nail with difficulty | >400 |

### Coarse Grained Soil

| | | Density Index % | 'N' Value |
|---|---|---|---|
| VL | Very Loose | ≤15 | 0 - 4 |
| L | Loose | 15 - 35 | 4 - 10 |
| MD | Medium Dense | 35 - 65 | 10 - 30 |
| D | Dense | 65 - 85 | 30 - 50 |
| VD | Very Dense | >85 | >50 |

## SECONDARY OR MINOR SOIL COMPONENTS

| Designation of components | In coarse grained soils | | | | In fine grained soils | |
|---|---|---|---|---|---|---|
| | %Fines | Terminology | %Accessory Coarse Fraction | Terminology | %Sand/gravel | Terminology |
| Minor | ≤5 | 'trace' clay/silt | ≤15 | 'trace' sand/gravel | ≤15 | 'trace' sand/gravel |
| | 5 - 12 | 'with' clay/silt | 15 - 30 | 'with' sand/gravel | 15 - 30 | 'with' sand/gravel |
| Secondary | > 15 | Prefix silty or clayey | >30 | Prefix sandy or gravelly | >30 | Prefix sandy or gravelly |

# EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - ROCK DESCRIPTION (AS1726 - 2017)

## STRENGTH OF INTACT ROCK

| Symbol | Term | Point Load Index, ($I_{s50}$) MPa | Field Guide to Strength |
|---|---|---|---|
| **VL** | Very Low | $0.03 \le I_{s50} < 0.1$ | Material crumbles under firm blows with sharp end of pick; can be peeled with knife; pieces up to 30mm thick can be broken by finger pressure |
| **L** | Low | $0.1 \le I_{s50} < 0.3$ | Easily scored with knife; indentations 1mm to 3mm after firm blow with pick point; core 150mm long and 50mm diameter can be broken by hand; sharp edges of core friable |
| **M** | Medium | $0.3 \le I_{s50} < 1.0$ | Readily scored with knife; core 150mm long and 50mm diameter can be broken by hand with difficulty |
| **H** | High | $1.0 \le I_{s50} < 3$ | Core 150mm long and 50mm diameter cannot be broken by hand but can be broken by single firm blow of pick; rock rings under hammer |
| **VH** | Very High | $3 \le I_{s50} < 10$ | Hand held specimen breaks with pick after more than one blow; rock rings under hammer |
| **EH** | Extremely High | $10 \le I_{s50}$ | Specimen requires many pick blows to break intact rock, rock rings under hammer |

Material with rock strength less than 'Very Low' are described using soil properties

## DEGREE OF ROCK WEATHERING

| Term | | Symbol | | Definition |
|---|---|---|---|---|
| Residual Soil | | RS | | Soil derived from the weathering of rock; the mass structure and material fabric are no longer evident the soil has not been significantly transported. |
| Extremely Weathered | | XW | | Material is weathered to such an extent that it has soil properties, i.e. it either disintegrates or can be remoulded, in water. Fabric of original rock still visible. |
| Highly Weathered | Distinctly Weathered | HW | DW | Rock strength is changed by weathering. The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Some minerals are decomposed to clay minerals. Porosity may be increased by leach, or may be decreased due to deposition of weathering products in pores. |
| Moderately Weathered | | MW | | The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock. |
| Slightly Weathered | | SW | | Rock is slightly discoloured but shows little or no change of strength from fresh rock |
| Fresh | | FR | | Rock shows no sign of decomposition or staining |

Distinctly Weathered is to be used when it is not possible to differentiate between highly and moderately weathered.

Extremely Weathered material is to be described using soil properties

## ROCK MASS PROPERTIES

| Term | Separation of Stratification Planes |
|---|---|
| Thinly laminated | < 6mm |
| Laminated | 6mm to 20 mm |
| Very thinly bedded | 20mm to 60mm |
| Thinly bedded | 60mm to 200mm |
| Medium bedded | 0.2m to 0.6m |
| Thickly bedded | 0.6m to 2.0m |
| Massive | < 2m |

| Term | Description |
|---|---|
| Fragmented | Primarily fragments < 20mm length and mostly of width < core diameter |
| Highly fractured | Core lengths generally less than 20mm to 40mm with occasional fragments |
| Fractured | Core lengths mainly 30mm to 100mm with occasional shorter and longer pieces |
| Slightly fractured | Core lengths generally 0.3m to 1.0m with occasional longer and shorter sections |
| Unbroken | Core has no fractures |

## DEFECT TYPES AND DESCRIPTIONS

| Defect Type | | Defect Shape | | Surface Roughness | | Defect Coatings | |
|---|---|---|---|---|---|---|---|
| BR | Bedding parting | PL | Planar | VR | Very rough | CL | Clean |
| JT | Joint | ST | Stepped | RO | Rough | ST | Stained |
| SR | Sheared surface | CR | Curved | SM | Smooth | VN | Veneer |
| SZ | Sheared zone | IR | Irregular | PO | Polished | CT | Coating |
| SS | Sheared seam | UN | Undulating | SL | Slickenside | | |
| CS | Crushed seam | | | | | | |
| IS | Infill seam | | | | | | |
| XS | Extremely Weathered Seam | | | | | | |

**Vertical Boreholes** - The dip of the defect is given from the horizontal

**Inclined Boreholes** - The angle of the defect is given from the core axis

# Appendix B

## Site Photography

# Appendix C

## Laboratory Data

# ANALYTICAL REPORT

Accreditation No. 2562

| CLIENT DETAILS | | LABORATORY DETAILS | |
|---|---|---|---|
| Contact | Raj Singh | Manager | Huong Crawford |
| Client | INTRAX CONSULTING ENGINEERS PTY LTD | Laboratory | SGS Alexandria Environmental |
| Address | C 207<br>22-36 MOUNTAIN STREET<br>ULTIMO NSW 2007 | Address | Unit 16, 33 Maddox St<br>Alexandria NSW 2015 |
| Telephone | 61 2 48695666 | Telephone | +61 2 8594 0400 |
| Facsimile | (Not specified) | Facsimile | +61 2 8594 0499 |
| Email | raj.singh@intrax.com.au | Email | au.environmental.sydney@sgs.com |
| Project | **130018** | SGS Reference | **SE199249 R0** |
| Order Number | (Not specified) | Date Received | 25 Oct 2019 |
| Samples | 6 | Date Reported | 31 Oct 2019 |

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(4354).

SIGNATORIES

Dong LIANG
Metals/Inorganics Team Leader

| Parameter | Units | LOR | Sample Number<br>Sample Matrix<br>Sample Date<br>Sample Name | SE199249.001<br>Soil<br>25 Oct 2019<br>130018 BH1: 500 | SE199249.002<br>Soil<br>25 Oct 2019<br>130018 BH1: 1000 | SE199249.003<br>Soil<br>25 Oct 2019<br>130018 BH1: 1300 | SE199249.004<br>Soil<br>25 Oct 2019<br>130018 BH2: 500 |
|---|---|---|---|---|---|---|---|
| **Field pH for Acid Sulphate Soil Method: AN104 Tested: 31/10/2019** | | | | | | | |
| pHf | pH Units | - | | **6.3** | **6.2** | **5.1** | **6.1** |
| pHfox | pH Units | - | | **5.4** | **5.5** | **5.6** | **5.6** |
| Reaction* | No unit | - | | X | X | X | X |
| pH Difference* | pH Units | -10 | | **1.0** | **0.7** | **-0.5** | **0.5** |

| Parameter | Units | LOR | Sample Number: SE199249.005<br>Sample Matrix: Soil<br>Sample Date: 25 Oct 2019<br>Sample Name: 130018 BH2: 1000 | Sample Number: SE199249.006<br>Sample Matrix: Soil<br>Sample Date: 25 Oct 2019<br>Sample Name: 130018 BH2: 1500 |
|---|---|---|---|---|
| **Field pH for Acid Sulphate Soil Method: AN104 Tested: 31/10/2019** | | | | |
| pHf | pH Units | - | **6.2** | **5.3** |
| pHfox | pH Units | - | **5.1** | **4.5** |
| Reaction* | No unit | - | XX | XX |
| pH Difference* | pH Units | -10 | **1.0** | **0.8** |

# QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

**Field pH for Acid Sulphate Soil** **Method: ME-(AU)-[ENV]AN104**

| Parameter | QC Reference | Units | LOR | DUP %RPD | LCS %Recovery |
|---|---|---|---|---|---|
| pHf | LB186633 | pH Units | - | 0% | NA |
| pHfox | LB186633 | pH Units | - | 2% | NA |

# METHOD SUMMARY

| METHOD | METHODOLOGY SUMMARY |
|---|---|
| AN104 | pHF is determined on an extract of approximately 2g of as received sample in approximately 10 mL of deionised water with pH determined after standing 30 minutes. |
| AN104 | pHFox is determined on an extract of approximately 2g of as received sample with a few mLs of 30% hydrogen peroxide (adjusted to pH 4.5 to 5.5) with the extract reaction being rated from slight to extreme, with pH determined after reaction is complete and extract has cooled. Referenced to ASS Laboratory Methods Guidelines, method 23Af-Bf, 2004.<br><br>X Slight Reaction<br>XX Moderate Reaction<br>XXX Strong/High Reaction<br>XXXX Extreme/Vigorous Reaction (gas evolution and heat generation) |

## FOOTNOTES

| | | | |
|---|---|---|---|
| IS | Insufficient sample for analysis. | LOR | Limit of Reporting |
| LNR | Sample listed, but not received. | ↑↓ | Raised or Lowered Limit of Reporting |
| * | NATA accreditation does not cover the performance of this service. | QFH | QC result is above the upper tolerance |
| | | QFL | QC result is below the lower tolerance |
| ** | Indicative data, theoretical holding time exceeded. | - | The sample was not analysed for this analyte |
| | | NVL | Not Validated |

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.