TERRA INSIGHT

No. 60 Macleay Street, Narrawallee NSW

Report on Acid Sulfate Soil Investigation

Prepared for:

Planning Law Solutions

Our Ref: TERRA21-502.Rep1.Rev0

Prepared for:
Planning Lawyer Solutions
Level 8, 65 York St SYDNEY NSW 2000

19 November 2021

Attention: Mr M Hawell

RE: No. 60 Macleay Street, Narrawallee NSW
Report on Acid Sulfate Soil Investigation

Dear Sir,

Please find enclosed our report in relation to the acid sulphate soil assessment that was conducted for the above Site. This report should be read in conjunction with the attached document 'About Your Report' in Appendix A. The results of this assessment are documented herein. Should you have any questions please contact the undersigned.

For and on behalf of Terra Insight

Karen Gates
Principal Engineer/ Director
CPEng MIEaust BEng MEngSc(Geot) MEnvMgt MBA

Contents

Tables

Figures

Appendices

1 Introduction

At the request of Planning Law Solutions (the client) on behalf of the site owners, Terra Insight Pty Ltd (Terra) has carried out an acid sulphate soil (ASS) assessment and site classification for No. 60 Macleay Street, Narrawallee NSW, hereafter referred to as the Property.

The proposed area for development is within the southern portion of the property near the site access, in an area hereafter referred to as the site. It is understood that a new dwelling with a swimming pool and detached carport is proposed for the site as shown in plans attached in Appendix B. The depth of excavation for footing is not expected to exceed 1.5m depth unless pier footings are required which may locally go deeper depending on site subsurface conditions.

The objective of the geotechnical investigation was to determine whether acid sulphate soil are present on the site within the area of proposed excavation and if present, their net acidity and liming rate and the requirement for an Acid Management Plan if applicable.

2 Scope of work

The scope of work for this assessment included the following:

- A review of geological maps and aerial photography covering the site;
- A review of acid sulphate mapping covering the site;
- A visit to site to make observations of site surface conditions by a Geotechnical Engineer;
- A subsurface investigation for ASS in accordance with NSW EPA requirements, comprising:
  - Four boreholes (named BH01 to BH04) to 2.0m or refusal on weathered material.
  - Sampling of the subsurface soils at 0.5m intervals;
  - DCP testing at two locations and;
  - Logging of the materials encountered by a geotechnical engineer;
- Laboratory testing including ASS field screen testing of all samples collected from the site and where the ASS field screen result indicates the potential for ASS to be present on the site, an ASS Chromium suite test on a representative sample of the ASS material; and
- Provision of report providing the findings of the assessment and recommendations in accordance with the objectives outlined above.

The scope of work was undertaken using a mechanical auger of diameter (150mm) fitted to a 1.8t Kubota excavator.

3 Investigation Findings

3.1 Site details

No. 60 Macleay Street, Narrawallee NSW, is located approximately 600m to the west of Narrawallee Beach and to the south of Narrawallee Creek . The property is formally known as Lot 145 of DP 718994. The property is a large property of about 3.2Ha extent and is bounded by Narrawallee creek to the north, undeveloped woodland to the east and west and residential properties along the southern boundaries. The area proposed for development is an area on the southern portion of the site adjacent to the site access and includes an area of about 650m^2.

3.2 Geology

On-line geological mapping accessed using Minview, indicates the site is predominately underlain by Quaternary aged Coastal backbarrier flat deposits. This material is comprised of fine- to medium-grained quartz-lithic sand with carbonate and humic components (marine-deposited), indurated sand, silt, clay, gravel, organic mud and peat as shown in Figure 1. This subsurface geology extends south and north of the proposed area for development by at least 100m.

To the south of the site, the surface is underlain by the Snapper Point Formation of the Shoalhaven Group. This unit is comprised of fine- to medium-grained sandstone, pebbly sandstone and polymictic pebble conglomerate (down

sequence), medium- to coarse-grained sandstone with lithic pebbles and fragments, minor siltstone (up sequence); brachiopod, bivalve and bryozoan fossils. This unit is expected to underly the coastal deposits at depth.

To the east are beach sands (dunal deposits) associated with wind blown materials. To the north are organic rich estuarine swamp deposits.

3.3 Historical Aerial Imagery

Historical aerial photography of the site (refer Figure 2) indicates that the site and the surrounding area was undeveloped in 1956. The site is located on an elevated area south of a creek and west of an infilled oxbow on the creek. At this time the site and surrounding land is mostly comprised of woodland which extends to a low lying near level coastal plain adjacent to the creek. To the north of the site, an old meander of the Narrawallee Creek is visible potentially traversing through the lower northern portion of the property.

By 1991, subdivision of the area to the south of and including the site has occurred . These works appear to include some localised filling of the old ox bow to the east of the site which is now a drainage feature. Some fill may have been locally placed on the site and on properties around the northern edge of Macleay Street.

From 2004 to the present day, development of residential properties has occurred to the south of the site. The site has remained relatively unchanged except for increase in density of vegetation (mainly trees).

3.4 Acid Sulfate Soils (ASS) Mapping

Acid Sulfate Soils (ASS), if present, are likely to be associated with low lying areas adjacent to Lake Illawarra and nearby creeks. These soils are typically encountered at surface elevations below 5m AHD, but can be found as high as 12m AHD in rare cases. The site has an elevation of approximately 2m to 3m AHD and is therefore at an elevation where it could be potentially impacted by deposition of ASS associated with deposition of these soils during the Holocene era (within the last 10,000 years) around Lake Illawarra.

Acid sulfate soil risk mapping of Milton (Figure 3), indicates the site is within an area that has a low probability of ASS occurrence, with depths of potential ASS occurrence between 1m and 3m below the ground surface. Mapping indicates the area is denoted by Wa2 which is defined as follows:

- Wa2 – area with a low probability of ASS occurrence with soils deposited by ‘Aeolain’ (transported by wind) processes within a ‘sandplain’ with current surface elevation of 2 to 4m AHD.

This means that if ASS is present on the site, it is likely to occur at elevations of 2 m AHD (at or near the ground surface) to -1m AHD.

3.5 Site Observations

Observations of the site were made at the time of the site inspection. Photographs taken of the general site conditions are provided in Appendix C. These indicate:

- The site within the property appears to be raised above the areas to the north of the site and is at similar elevations to the neighbouring residential properties as shown on photographs 1 to 4.
- The site is relatively flat, with the embankment slopes falling moderately to the north from a height of about 3m down to level land south of the creek with an elevation of 2m and lower.
- The site is vacant of structures and is predominately grassed with some mature trees nearby.
- Land to the north of the site is level and is grassed with mature trees and shrubs throughout as shown on photograph 5.
- Some land to the north of the site had some visible waterlogged in a slight depression just north of the site as shown on photograph 3.

3.6 Subsurface conditions

The subsurface investigation was undertaken on the 26th October 2021. The investigation consisted of the auguring and sampling of four test locations, using a mechanical auger attachment with 1.8t excavator, to depths of 2.0m.

The test locations are named BH01 to BH04. The location of each test site is shown on Figure 4. The subsurface conditions encountered in the boreholes are summarised on Table 3.1. Engineering logs are provided in Appendix D. Images of the materials recovered are shown in Appendix C photographs 6 to 8.

Table 3.1: Summary of subsurface investigation

Subsurface conditions *(Soil name, plasticity or particle characteristics, colour, secondary components and minor components)*	Structure and other comments	Depth encountered in test site/exposure (m)			
		BH01	BH02	BH03	BH04
Silty SAND/Clayey SAND: fine to medium sand, grey, grey/brown, low plasticity	Topsoil	0.0-0.2	0.0-0.1	0.0-0.1	0.0-0.3
Silty Sandy CLAY/Sandy CLAY: medium plasticity, brown, orange/brown, yellow brown, red brown, fine to medium sand	Fill	0.2-0.8	NE	0.1-0.4	0.3-0.6
Silty Sandy CLAY: medium plasticity, white, orange mottled, fine to medium plasticity	Alluvium	0.8-1.0	0.1-0.7	0.4-0.7	0.6-1.1
Sandy CLAY: medium plasticity, red brown, fine to coarse sand, with fine to medium sub angular gravels		1.0-2.0*	0.7-2.0*	0.7-2.0*	1.1-2.0*

Notes * - End of hole at target depth; ᶠ - Early refusal, NE – not encountered

Dynamic cone penetrometer (DCP) testing was undertaken at BH01 & BH03 to assess the in-situ consistency of the clayey soil underlying the site. The DCP test was undertaken to depths of 3.0m and 4.0m respectively. The DCP test indicates the subsurface soils in both test locations have variable consistency from firm to very stiff, but generally stiff below 0.5m depth.

Extraction of the DCP from BH03 recovered wet sandy material on the DCP tip (refer photograph 8) which may be indicative of a sandy layer at about 2.5m to 3.5m depth with these sands being of medium density. Based on this DCP, a water level of about RL of 1.0m to 0.0m AHD may be present and this may be tidal. The subsurface soils were observed to be moist to target depth of 2.0m.

3.7 Laboratory Analysis

Acid sulfate soils (ASS) are grouped into two types:

- **Actual (Active) Acid Sulfate Soils (AASS)** where the soils are oxidising, and acid is already being produced. These soils are typically identified because the pH of the soil when mixed with water is low (e.g. pHf < 4);
- **Potential (Passive) Acid Sulfate Soils (PASS)** where there is the potential for acid to be generated but the soil is not yet exposed to oxidizing conditions. In this case, a low pH is produced when the soil is mixed with an oxidizing solution resulting in a low pH (e.g. pH_{fox} < 3). Other indicators of PASS soils are a notable reaction when the oxidizing solution is applied and a pH_{fox} is at least one unit lower than pH_f.

A summary of the results of acid sulfate soils field screening tests undertaken on samples of soil retrieved from each of the test sites as summarised in Table 3-2 on the following page and provided in Appendix E.

The ASS field screening did not identify any Actual ASS on the site. However, the ASS field screening identified some strong reactions during the testing with most of the samples showing a drop in pH greater than or equal to one (1). Some samples noted a drop in pH_{fox} to below 4, indicating a moderate potential for ASS to be present.

To determine the potential causes of acid generation, Chromium Suite testing was undertaken on a sample of soil (reference BH02 S3 1.0m depth). The results for this test are provided in Table 3.3 and in appendix D. This testing indicates some acidity (about 25% of the total acidity) is due to sulfur based compounds (which could be acid sulfate soil or other forms of sulfur), however these levels are very low. Other forms of acidity (such as humic material) are generating most of the acidity within the soil.

Table 3-2: Summary of ASS field screening laboratory results

Test Hole Number	Sample Depth (m)	$pH_{(f)}$	$pH_{(fox)}$	Reaction (X slight, XX Moderate, XXX strong, to XXXX extreme)	ΔpH $pH_{(f)}$ - $pH_{(Fox)}$	AASS indicator ($pH_f < 4$)[A]	PASS indicators			Potential for ASS[D]
							pHfox[C] <3	ΔpH[B] (>1)	Strong or very strong reaction	
BH01	0.5	5.4	3.5	XX	1.9	✗	✗	✓	✗	LOW
	1.0	4.9	3.4	X	1.5	✗	✗	✓	✗	LOW
	1.5	4.8	3.6	XXXX	1.2	✗	✗	✓	✓	MODERATE
	2.0	4.9	3.6	XXXX	1.3	✗	✗	✓	✓	MODERATE
BH02	0.5	4.9	4.0	X	0.9	✗	✗	✗	✗	LOW
	1.0	5.2	3.4	XXXX	1.8	✗	✗	✓	✓	MODERATE
	1.5	5.4	3.7	XXXX	1.7	✗	✗	✓	✓	MODERATE
	2.0	5.4	3.5	XXXX	1.9	✗	✗	✓	✓	MODERATE
BH03	0.5	5.1	3.7	XXXX	1.4	✗	✗	✓	✓	MODERATE
	1.0	5.0	3.5	XXX	1.5	✗	✗	✓	✓	MODERATE
	1.5	5.0	3.8	XXXX	1.2	✗	✗	✓	✓	MODERATE
	2.0	5.2	3.7	XXXX	1.5	✗	✗	✓	✓	MODERATE
BH04	0.5	4.9	3.7	XXX	1.2	✗	✗	✓	✓	MODERATE
	1.0	4.8	3.7	XXX	1.1	✗	✗	✓	✓	MODERATE
	1.5	5.3	4.2	XXXX	1.1	✗	✗	✓	✓	LOW
	2.0	5.4	4.4	XXXX	1.0	✗	✗	✗	✓	LOW

Notes to table: *A) This indicator is not used on its own as soils with high organic content can contain humic acid or manganese oxides which also produce a reaction;*

B) As the ΔpH increases, there is an increased probability that PASS is present.

C) The lower the pHfox the greater the potential for PASS to be present. Where pHfox < 3 and there is a strong reaction and high ΔpH, there is a high probability that PASS is present. Where the pHfox < 4 the result is less positive and further laboratory testing is required to determine the source of acid generation. Where pHfox < 5 the test is inconclusive, sulfides may be present either in small quantities or may be poorly reactive under quick field test conditions or the sample may contain carbonate which neutralises some or all acid production by oxidation. Equally the low value may be due to weak organic acids and there may be no sulfides present. Further testing to identify the cause of acid generation is recommended.

D) Samples which meet all the QASSIT indicators for PASS are assigned a high potential. Samples which meet some of the indicators for PASS are assigned a moderate potential. Samples which show an inconclusive result are assigned a low potential. It is noted that it is possible for some 'non-ASS soils' to generate acid and have all or some of the indicators of ASS. Further testing is required to assess the nature of acid generation.

Table 3-3: Summary of Chromium Suite laboratory test results

Test Location	Soil Type	Depth (m)	pH KCL	Actual Acidity [A] % S-TAA	Potential (Cr reducible) Acidity (% Sr)	Retained Acidity [C] (% S-S_{nas})	- Acid Neutralising Capacity ANCB (% S)[B]	Net Acidity (%S)	Fineness Factor	Liming Rate excluding ANC (kg/t)
LOR			*0.1*	*2*	*0.005*	*0.02*	*0.01*	*0.06*	*0.5*	*1*
BH02 S2 1.0m	**Sandy CLAY:**	1.0	5.3	0.03	0.009	NA	NA	0.04	1.5	1.7

Notes to table: LOR – level of reporting. NA – not applicable. A) only required where pH_{kci} is < 5.5, B) only required where pH_{kci} is >6.5 C) only required where pH_{kcl}<4

4 Engineering Assessment

4.1 Acid Sulfate Soils

The NSW ASS guidelines require a formal treatment plan for ASS where the level of Net Acidity (% S) is greater than the following:

- Sands and loamy (clayey) sands: 0.03%.
- Sandy Loams (Sandy Clays) and light clays 0.06%
- Medium to heavy Clays 0.1%

The Chromium Suite ASS testing indicates Net Acidity (%S) on the site is typically 0.04% with that generated by sulfur report at 0.009%. These levels are below than the NSW EPA trigger level of 0.06% for the sandy clayey soils. Consequently, a formal management plan is not required for the site.

However, as the soils do show some acidity, it is recommended that the soils are treated with lime and classified as GSW in terms of disposal. Soils should be limed if they are to be disturbed and then reused as fill on the site at a rate of 1.7kg/tonne.

4.2 Waste minimisation

Waste materials will be generated because of site earthworks. To minimise the costs associated with construction (including off-site disposal of excavated materials), it is preferable to minimise the disturbance of the in-situ soils and/or re-use these materials where possible. Footings which minimise the need for deep excavations, such as driven or screw piers, are best suited to the site.

4.3 Site classification

The classification of the site has been assessed in accordance with Australian Standard AS2870 - Residential slabs and footings (2011) and the following site conditions:

- The site is located within Climatic Zone 1.
- The site is level throughout.
- The site is predominantly grassed with some mature trees nearby.
- Poor drainage is observed on the site forming water ponding on the surface which has caused abnormal moisture conditions on the site.
- The subsurface is comprised of topsoil, underlain by firm to stiff clayey fill to depths of about 0.5m and then natural alluvium to depths below 2.0m. The filling on the site should be assumed as 'uncontrolled' and may be subject to increased total and differential settlement.
- Based on local knowledge, the fill appears to be derived from the alluvial soils nearby the site. Shrink swell index testing of the sandy clayey soils from nearby sites in the same geological setting (within Narrawallee) indicate a shrink swell index of 1.0% to 3%. For conservatism, based on visual assessment of the soils, a Shrink Swell Index of 2.0% has been adopted for this assessment.
- The characteristic surface movements for the Site in its current condition has been calculated at 25mm to 30mm. This is within the range of **Class M** movements. However, this will be impacted by further changes to the site such as vegetation which could increase movements to 45mm.

In accordance with AS2870 and considering the above, the site has been classified as Class M. The above site classifications and footing recommendations are for the site conditions advised at the time of fieldwork. Consequently, the site classification may need to be reviewed if the proposed earthworks are changed (eg the site is filled or cut by more than 300mm).

4.4 Footing design parameters

The following is recommended:

- All topsoil should be stripped from the proposed structure footprint.
- The footprint shall be proof rolled to identify any soft spots that may require further treatment.
- All footings should be designed by a competent structural engineer with reference to the guidelines in AS 2870-2011, Residential Slabs and Footings, for Class M site.
- All footings for the same structure should be founded on strata of similar density/stiffness and reactivity to minimise the risk of differential movements, with articulation provided where appropriate. It is recommended that footings are supported on stiff or better material or the medium dense dans at depths below 1.0m.
- No fill is to be imported onto the site without further consultation with a geotechnical engineer. Importation of fill may change the site classification.

High level deep strip or pad footings or bucket piers in the natural soils on the site can be designed based on an allowable bearing capacity of 100kPa.

Piers can also be adopted. Piers can comprise bored, driven or screw piers. However, as the ground water table is likely to be at 0.0m to 1.0m AHD (approximately 2.0m to 3.0m depth), bored piers are unlikely to be the most cost-effective option. Consequently, Terra would recommend the adoption of screw or driven piers which will also provide better end bearing capacity.

Driven or screw piers designed to bear on the stiff sandy clays or medium dense sands at depths below 1.5 - 2.0m can be design on an ultimate end bearing capacity of 1.0MPa. A geotechnical strength reduction factor of 0.40 shall be applied to the ultimate end bearing for piers unless otherwise recommended by a structural engineer based on structural design and level of testing during installation.

If foundations for proposed structures are located within the zone of influence of any service trenching, the service trench shall be bridged with the structure supported by pier footings. The depth of the pier footing should be extended below the zone of influence ignoring shaft adhesion. A structural engineer should be consulted for detailing.

4.5 Footing maintenance

Designs and design methods presented in AS 2870-2011 are based on the performance requirement that significant damage can be avoided if site conditions are properly maintained. Performance requirements and foundation maintenance are outlined in Appendix B of AS 2870. This typically apply to reactive clay sites, but it is important to note that granular non-reactive sites can also be affected by vegetation effects such as root jacking and poor surface water management practices.

Appendix B of AS 2870-2011 indicates that to reduce but not eliminate the possibility of damage, trees should be restricted to a distance from the building at least their mature height. Where rows or groups of trees are proposed, the distance from the building should be increased.

The site classification above assumes that the performance requirements as set out in Appendix B of AS 2870 are acceptable and that site foundation maintenance is undertaken to avoid extremes of wetting and drying. Details on appropriate site and foundation maintenance practices are presented in Appendix B of AS 2870-2011 and in CSIRO Information Sheet BTF 18, Foundation Maintenance and Footing Performance: A Homeowner's Guide, which is attached as Appendix F.

Figures

Site Geology

Symbol	Group	Unit	Lithology
QH_es	-	Estuarine swamp	Organic-rich mud, peat, clay, silt, very fine- to fine-grained sand (marine-deposited), fine- to medium-grained sand (fluvially deposited)
QP_bf	-	Coastal deposits - backbarrier flat facies	Fine- to medium-grained quartz-lithic sand with carbonate and humic components (marine-deposited), indurated sand, silt, clay, gravel, organic mud, peat
Pshs	Shoalhaven Group	Snapper Point Formation	Fine- to medium-grained sandstone, pebbly sandstone and polymictic pebble conglomerate (down sequence), medium- to coarse-grained sandstone with lithic pebbles and fragments, minor siltstone (up sequence); brachiopod, bivalve and bryozoan fossils

Site Location

revision	description	drawn	approved	date
	Site location	XJ	KEG	19/11/2021

N

TERRA INSIGHT

client:	**Planning Lawyer Solutions**
project:	**Acid Sulfate Soil Investigation No. 60 Macleay Street Narrawallee**
scale	NTS
title:	**Site Location**
original size	**A3**
project no:	**TERRA21-502**
figure no:	**FIGURE 1**

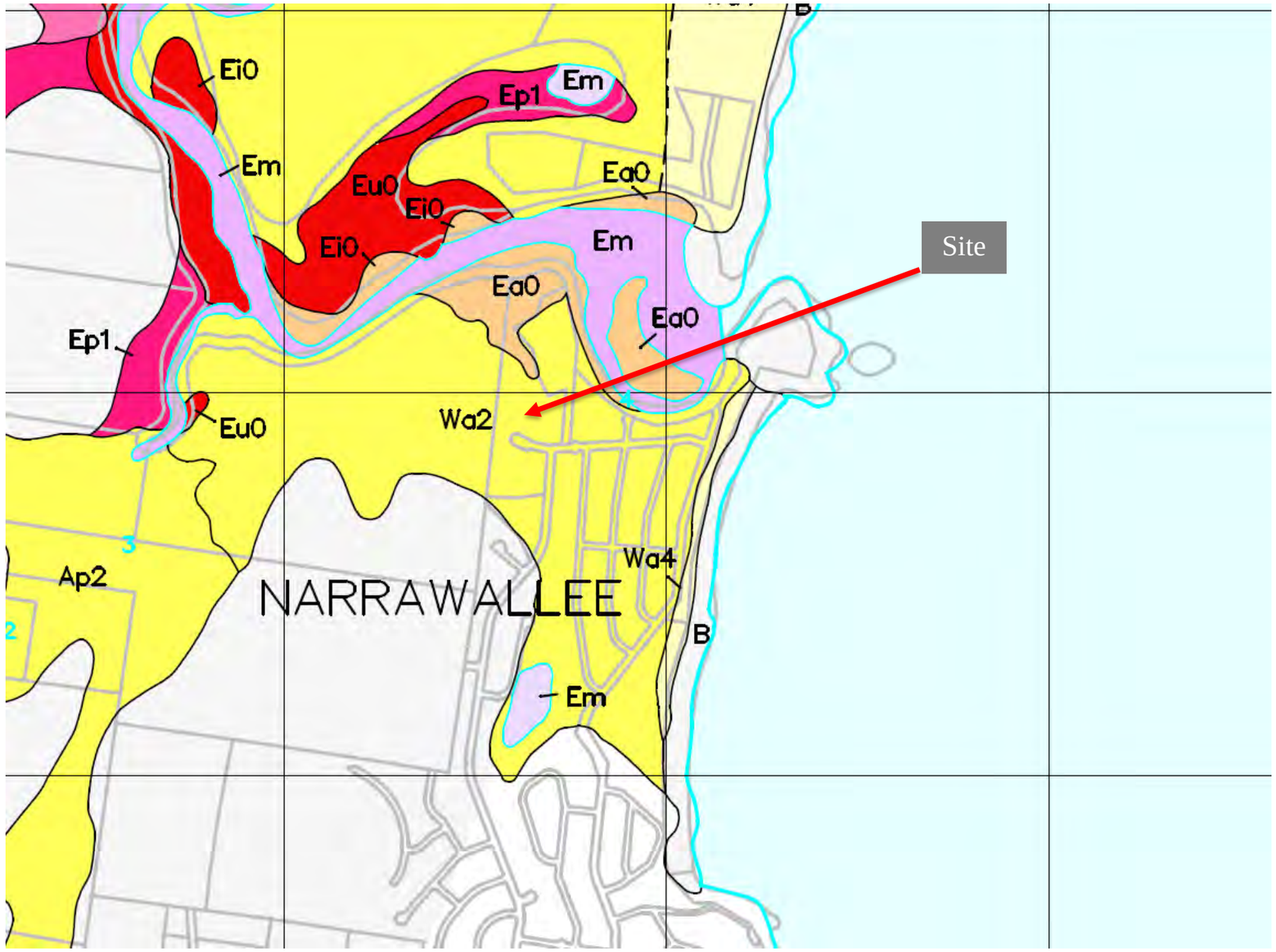
Historical Imagery

revision	description	drawn	approved	date
	Historical Aerial Imagery	XJ	KEG	19/11/2021

N

TERRA INSIGHT

client:	**Planning Lawyer Solutions**		
project:	**Acid Sulfate Soil Investigation** **No. 60 Macleay Street Narrawallee**		
scale	NTS	title:	**Historical Imagery**
original size	**A3**	project no: **TERRA21-502**	figure no: **FIGURE 2**



Milton Acid Sulfate Soil Mapping Excerpt

revision	description	drawn	approved	date
	Acid Sulfate Soil Mapping	XJ	KEG	5/11/2021

N

TERRA INSIGHT

scale	NTS
original size	**A3**

client: **Planning Lawyer Solutions**

project: **Acid Sulfate Soil Investigation No. 60 Macleay Street Narrawallee**

title: **Acid Sulfate Soil Mapping**

project no: **TERRA21-502**

figure no: **FIGURE 4**

KEY

Map Class Description	Depth to Acid Sulfate Soil Materials		Environmental Risk	Typical Landform Types
HIGH PROBABILITY High probability of occurrence of acid sulfate soil material within the soil profile. The environment of deposition has been suitable for the formation of acid sulfate soil materials. Acid sulfate soil materials are widespread or sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.	Severe environmental risk if bottom sediments are disturbed by activities such as dredging.	Bottom sediments of lakes, lagoons, tidal creeks, rivers and estuaries.
		At or near the ground surface.	Severe environmental risk if acid sulfate soil materials are disturbed by activities such as shallow drainage, excavation or clearing.	Estuarine swamps, intertidal flats and supratidal flats.
		Within 1 metre of the ground surface.	Severe environmental risk if acid sulfate soil materials are disturbed by activities such as shallow drainage, excavation or clearing.	Low alluvial plains, estuarine sandplains, estuarine swamps, backswamps, and supratidal flats.
		Between 1 and 3 metres below the ground surface.	Environmental risk if acid sulfate soil materials are disturbed by activities such as deep excavation for pipelines, dams or deep drains.	Alluvial plains, alluvial swamps, alluvial levees and sandplains.
		Greater than 3 metres below the ground surface.*	Environmental risk if acid sulfate soil materials are disturbed by activities such as deep excavations, eg, large structure foundations or deep dams.	Elevated levees and sandplains, alluvial plains and alluvial swamps in estuarine reaches of catchments.
LOW PROBABILITY Low probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has generally not been suitable for the formation of acid sulfate soil materials. Soil materials are often Pleistocene in age. Acid sulfate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.	The majority of these landforms are not expected to contain acid sulfate soil materials. Therefore, land management is generally not affected by acid sulfate soils. However, highly localised occurrences may be found, especially near boundaries with environments with a high probability of occurrence. Disturbance of these soil materials will result in an environmental risk that will vary with elevation and depth of disturbance.	Elevated alluvial plains and levees dominated by fluvial sediments. Plains and dunes dominated by aeolian soils. Pleistocene plains. Lacustrine and alluvial bottom sediments.
		At or near the ground surface.		
		Within 1 metre of the ground surface.		
		Between 1 and 3 metres below the ground surface.		
		Greater than 3 metres below the ground surface.*		
NO KNOWN OCCURRENCE Acid sulfate soils are not known or expected to occur in these environments.		No known occurrences of acid sulfate soil materials.	Land management activities not likely to be affected by acid sulfate soils.	Bedrock slopes, elevated Pleistocene and Holocene dunes and elevated alluvial plains.
DISTURBED TERRAIN		Disturbed terrain may include filled areas, which often occur during reclamation of low lying swamps for urban development. Other disturbed terrain includes areas which have been mined or dredged, or have undergone heavy ground disturbance through general urban development or construction of dams or levees. Soil investigations are required to assess these areas for acid sulfate potential.		

*Deep occurrences of acid sulfate soil materials not able to be confirmed by field inspection and sampling

Landform Process Class		Landform Element				Elevation#	
W	Aeolian	b	Backplain	t	Levee toe	0	0-1 m
A	Alluvium	k	Backswamp	o	Ox-bow	1	1-2 m
B	Beach	m	Bottom sediments	p	Plain	2	2-4 m
E	Estuarine	n	Channel	a	Sandplain	4	>4 m
L	Lacustrine	d	Dune	s	Swamp	Additional Descriptive Codes	
S	Swamp	r	Interbarrier swamp	y	Splay	(p)	Pleistocene
		i	Intertidal flat	u	Supratidal flat	(s)	Acidic scald
		g	Lagoon	w	Swale		
X	Disturbed Terrain*	l	Levee	c	Tidal creek		

*Elevation levels given on the map refer to the elevation of the ground surface at the time of mapping. Depending on the nature of the disturbance, these elevation levels may or may not represent the original ground surface elevation.

#Approximate AHD

Acid Sulfate Soil Mapping Key

revision

description	drawn	approved	date
ASS Key	XJ	KEG	5/11/2021

TERRA INSIGHT

client:	**Planning Lawyer Solutions**
project:	**Acid Sulfate Soil Investigation** **No. 60 Macleay Street Narrawallee**
scale	NTS
title:	**Acid Sulfate Soil Mapping**
original size	**A3**
project no:	**TERRA21-502**
figure no:	**FIGURE 3**

Test Site Locations

Legend

Terra Test site

revision	description	drawn	approved	date
	Test Site Location	XJ	KEG	5/11/2021

N

TERRA INSIGHT

scale	NTS
original size	**A3**

client: **Planning Lawyer Solutions**

project: **Acid Sulfate Soil Investigation**
No. 60 Macleay Street Narrawallee

title: **Test Site Locations**

project no: **TERRA21-502**

figure no: **FIGURE 4**

Appendix A: Your Report

TERRA INSIGHT

Your Report

These notes have been prepared to help you understand the advice provided in Your Report and its limitations.

Your Report is based on what you tell us

Your Report has been developed based on the information you have provided such as the scope and size of your project. It applies only to the site investigated. If there are changes to the proposed works, then the advice provided within Your Report may need to be reviewed

Your Report is written with your needs in mind

The advice provided within Your Report is also not relevant to another purpose other than that originally specified at the time the report was issued. Please seek advice from Terra Insight before you share Your Report with another third party – except for the purpose for which the report was written.

Terra Insight assumes no responsibility and will not be liable to any other person or organisation for, or in relation to, any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in Your Report.

Your Report is based on what we observed

The advice provided within Your Report assumes that the site conditions, revealed through selective point sampling (undertaken in accordance with normal practices and standards) at a particular point in time, are indicative of the actual conditions on your site. However, the nature of the materials underlying your site is affected by natural processes and the activity of man. Under no circumstances can it be considered that these findings represent the actual state at all points. The subsurface conditions may vary significantly on the other parts of the site, particularly where no nearby sampling and testing work has been carried out.

As a result conditions on your site can change with time; they can also vary spatially. As a result, the actual conditions encountered may differ from those detailed within Your Report. Although nothing can be done to change the actual site conditions which exist, steps can be taken to gain a better understanding of the subsurface conditions underlying your site and reduce the potential for unexpected conditions to be encountered

The advice within Your Report also relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it. Only Terra Insight is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If the details of your project have changed, the site conditions have changed or a significant amount of time as elapsed since our report was written, the advice provided within Your Report may need to be reviewed.

Your Report has been written by a Professional

The report has been prepared using accepted procedures and practices of the consulting profession at the time it was prepared, and the opinions, recommendations and conclusions set out in the report are made in accordance with generally accepted principles and practices of that profession.

Your Report is better when it is kept together

Your Report presents all the findings of the site assessment and should not be copied in part or altered in any way. Keeping Your Report intact reduces the potential for yourself or other design professionals to misinterpret the report.

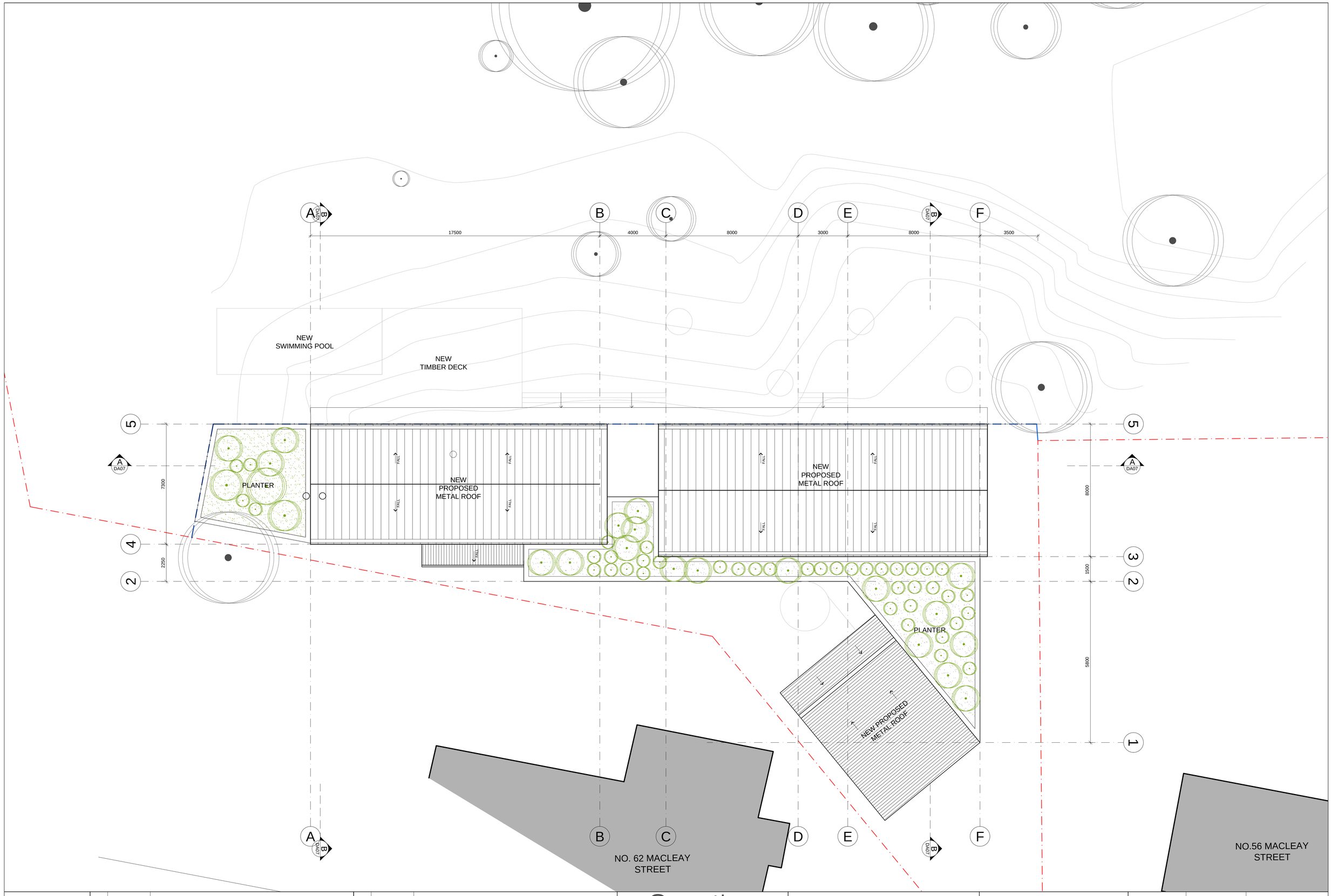
Your Geo-Environmental Report

If Your Report is for geotechnical purposes only, it will not relate any findings, conclusions, or recommendations about the potential for hazardous materials to exist at the site unless you have specifically asked us to do so. If your report is written for Geo-Environmental purposes the following should be noted in addition to the above:

- Advancements in professional practice regarding contaminated land and changes in applicable statues and/or guidelines may affect the validity of this report. Consequently, the currency of conclusions and recommendations in Your Report should be verified if you propose to use this report more than 6 months after its date of issue;
- Your Report is based on information gained from environmental conditions (including assessment of some or all of soil, groundwater, vapour and surface water) and supplemented by reported data of the local area and professional experience. The assessment has been scoped with consideration to industry standards, regulations, guidelines and your specific requirements, which includes budget and timing;
- The characterisation of site conditions is an interpretation of information collected during assessment, in accordance with industry practice. Any interpretation in Your Report is not a complete description of all material on or in the vicinity of the site, due to the inherent variation in spatial and temporal patterns of contaminant presence and impact in the natural environment.
- We may have relied on data and other information provided by you and other qualified individuals in preparing Your Report. We have not verified the accuracy or completeness of such data or information except as otherwise stated in Your Report. For these reasons Your Report must be regarded as interpretative, in accordance with industry standards and practice, rather than being a definitive record.
- For each purpose, a tailored approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible quantify, risks that both recognised and potential contamination posed in the context of the agreed purpose. If the proposed use of the site changes, the assessment may no longer be valid and will need to be reviewed.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Appendix B: Proposed Plans



NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION. USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.

rev	date	details
A	14.07.2020	DEVELOPMENT APPLICATION

rev	date	details

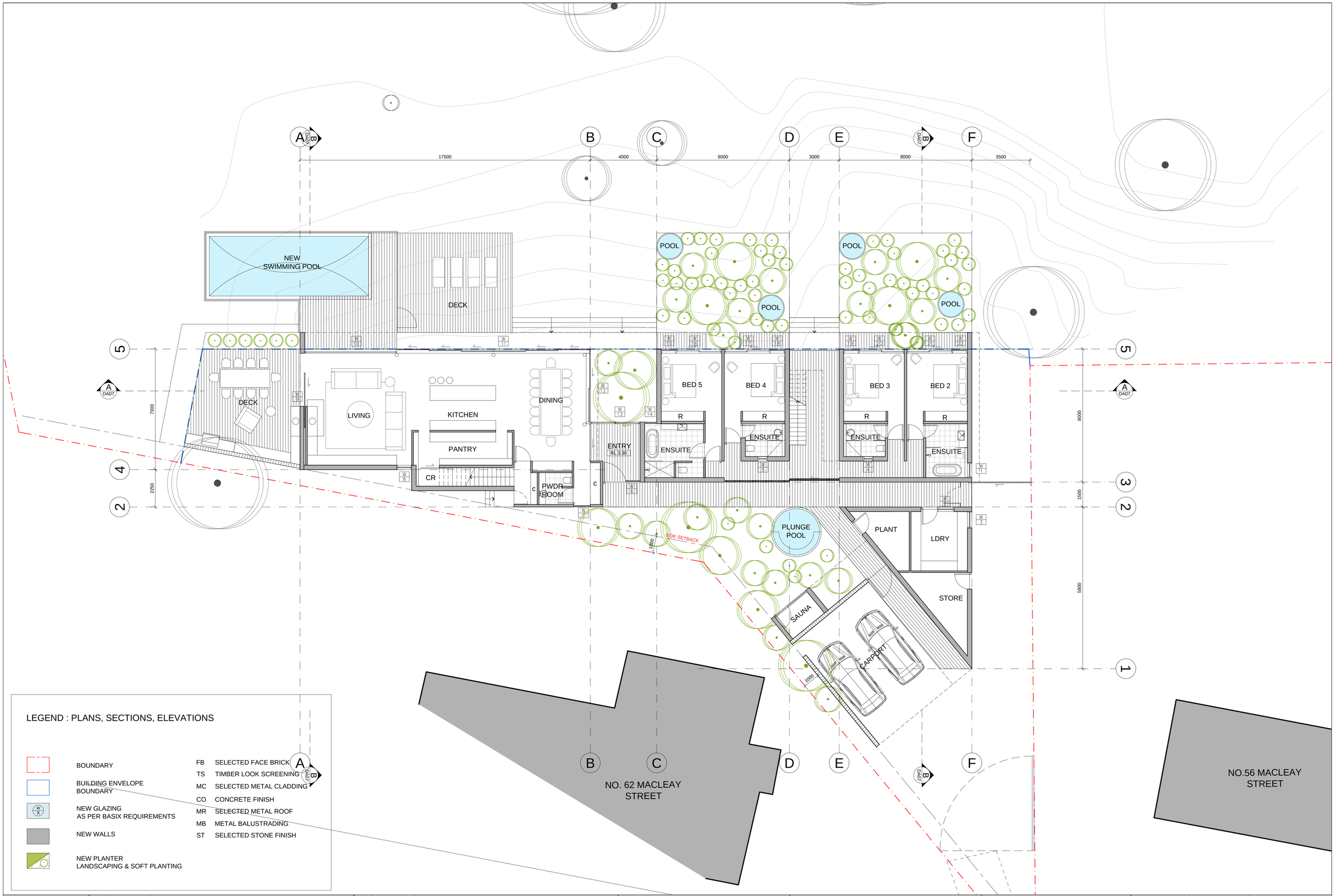
Smyth & Smyth ARCHITECTURE | INTERIORS
306/77 dunning avenue
rosebery nsw 2018
t 9662 2720
www.smythandsmyth.com.au
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING
AT
60 MACLEAY STREET, NARRAWALLEE
FOR MRS. D & MR. T HARTWIG
project description:

PROPOSED ROOF PLAN
this sheet:

north

date: 02.07.20		scale: 1:100 A1	
drawn: JM		checked: DS	
933		DA 02	A
project no.		sheet no.	revision



LEGEND : PLANS, SECTIONS, ELEVATIONS

- BOUNDARY
- BUILDING ENVELOPE BOUNDARY
- NEW GLAZING AS PER BASIX REQUIREMENTS
- NEW WALLS
- NEW PLANTER LANDSCAPING & SOFT PLANTING

FB	SELECTED FACE BRICK
TS	TIMBER LOOK SCREENING
MC	SELECTED METAL CLADDING
CO	CONCRETE FINISH
MR	SELECTED METAL ROOF
MB	METAL BALUSTRADING
ST	SELECTED STONE FINISH

NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION. USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.

rev	date	details
A	14.07.2020	DEVELOPMENT APPLICATION

rev	date	details

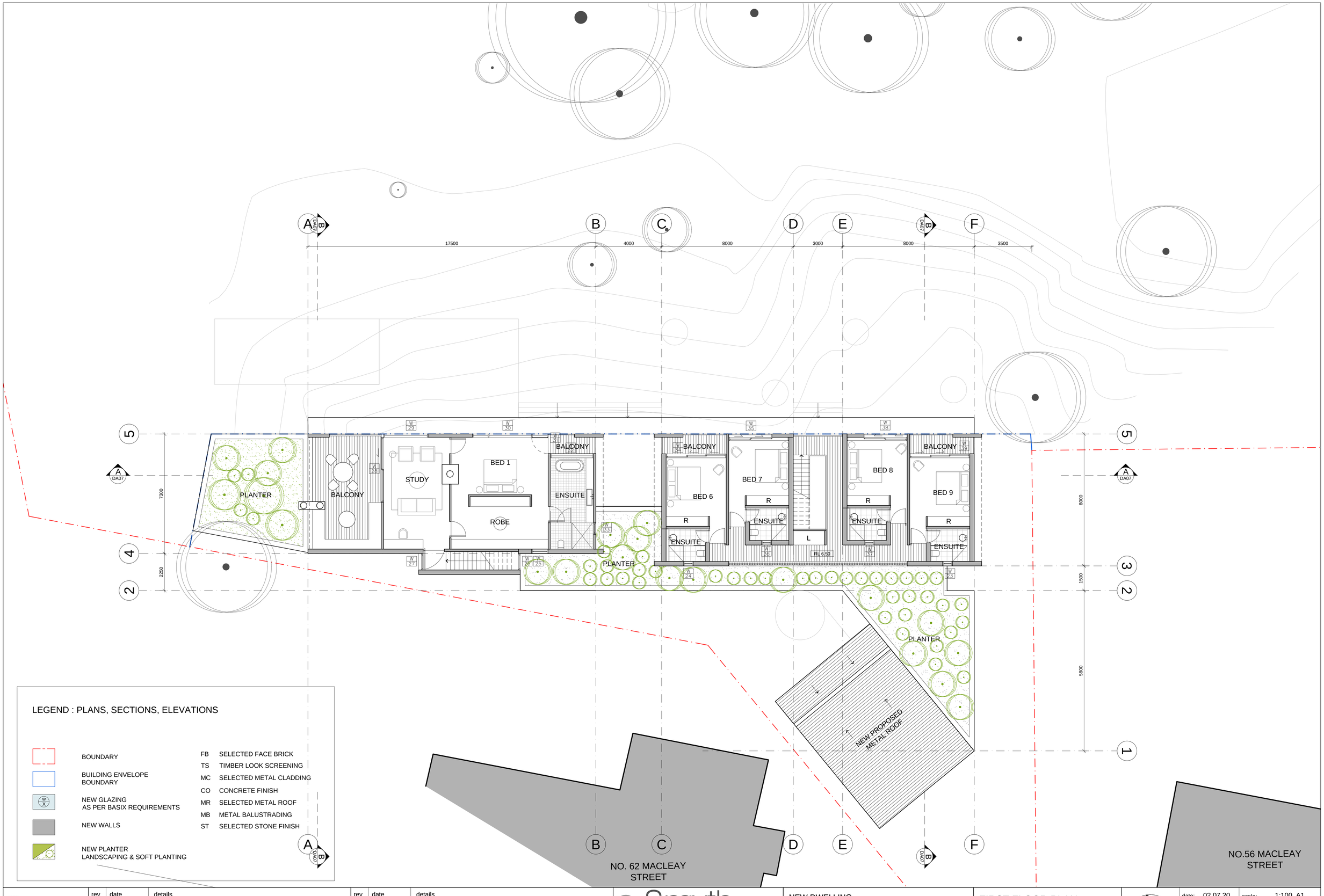
Smyth & Smyth ARCHITECTURE | INTERIORS
306/77 dunning avenue
rosebery nsw 2018
t 9662 2720
www.smythandsmyth.com.au
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING
AT
60 MACLEAY STREET, NARRAWALLEE
FOR MRS. D & MR. T HARTWIG
project description:

GROUND FLOOR PLAN
this sheet:

north

date: 02.07.20	scale: 1:100 A1		
drawn: JM	checked: DS		
933	DA 03	A
project no.	sheet no.	revision



LEGEND : PLANS, SECTIONS, ELEVATIONS

- BOUNDARY
- BUILDING ENVELOPE BOUNDARY
- W / X — NEW GLAZING AS PER BASIX REQUIREMENTS
- NEW WALLS
- NEW PLANTER LANDSCAPING & SOFT PLANTING

FB	SELECTED FACE BRICK
TS	TIMBER LOOK SCREENING
MC	SELECTED METAL CLADDING
CO	CONCRETE FINISH
MR	SELECTED METAL ROOF
MB	METAL BALUSTRADING
ST	SELECTED STONE FINISH

NOTE:
CHECK ALL DIMENSIONS ON SITE BEFORE COMMENCING FABRICATION. USE FIGURED DIMENSIONS AND DO NOT SCALE OFF THE DRAWINGS.

rev	date	details
A	14.07.2020	DEVELOPMENT APPLICATION

rev	date	details

Smyth & Smyth ARCHITECTURE | INTERIORS
306/77 dunning avenue
rosebery nsw 2018
t 9662 2720
www.smythandsmyth.com.au
NOMINATED ARCHITECT - DAVID SMYTH - REGISTRATION NO. 10044 NSW

NEW DWELLING
AT
60 MACLEAY STREET, NARRAWALLEE
FOR MRS. D & MR. T HARTWIG
project description:

FIRST FLOOR PLAN
this sheet:

north

date: 02.07.20 | scale: 1:100 A1
drawn: JM | checked: DS
933 project no. | DA 04 sheet no. | A revision

Appendix C: Site Images

Photograph 1: View of the site looking west along the elevated back barrier berm.

Photograph 2: View looking north-east along the site.

Photograph 3: View looking south-west from lower portion of property towards the site with water ponding.

Photograph 4: View looking south-east looking towards the site.

revision	description	drawn	approved	date
	Plate1	XJ	KEG	19/11/2021

TERRA INSIGHT

client:	**Planning Lawyer Solutions**		
project:	**Acid Sulfate Soil Investigation No. 60 Macleay Street Narrawallee**		
scale	NTS	Title	**Images of the site**
original size	**A3**	project no: **TERRA21-502**	Plate no:**1**

Photograph 5: View looking north at level area.

Photograph 6: Material encountered in BH01.

Photographs 7: Material encountered in BH02.

Photograph 8: Natural material encountered on DCP tip.

revision	description	drawn	approved	date
	Plate2	XJ	KEG	19/11/2021

TERRA INSIGHT

client:	**Planning Lawyer Solutions**
project:	**Acid Sulfate Soil Investigation** **No. 60 Macleay Street Narrawallee**
Title	**Images of the site**
scale	NTS
original size	**A3**
project no:	**TERRA21-502**
Plate no:	**2**

Appendix D: Engineering logs

TERRA INSIGHT

How to interpret the engineering logs in Your Report

FIELD DECRIPTIONS OF SOILS

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)				USC	PRIMARY NAME
COARSE GRAINED SOILS More than 65% of materials less than 63 mm is larger than 0.075 mm	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	GRAVEL
			Predominantly one size or a range of sizes with more intermediate sizes missing.	GP	GRAVEL
		GRAVELS WITH FINES Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	SILTY GRAVEL
			Plastic fines (for identification procedures see CL below)	GC	CLAYEY GRAVEL
	SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes	SW	SAND
			Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).	SM	SILTY SAND
			Plastic fines (for identification procedures see CL below).	SC	CLAYEY SAND

FINE GRAINED SOILS More than 35% of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm (Note a 75Um particle is about the smallest particle that is visible to the naked eye.)				
		DRY STRENGTH	DILATANCY	TOUGHNESS	USC	PRIMARY NAME
	SILTS & CLAYS Liquid limit less than 50	None to Low	Quick to slow	None	ML	SILT
		Medium to High	None	Medium	CL	CLAY
		Low to medium	Slow to very slow	Low	CL	ORGANIC SILT
	SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium	MH	SILT
		High	None	High	CH	CLAY
		Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC	Readily identified by colour, odour, spongy feel and frequently by fibrous texture by fibrous texture.				PT	PEAT

● Low plasticity – Liquid Limit w_L less than 35%. ● Medium plasticity – w_L between 35% and 50%. ● High plasticity – w_L greater than 50%.

Particle size descriptive terms

NAME	SUBDIVISION	SIZE
Boulders Cobbles		>200 mm 63 mm to 200 mm
Gravel	coarse medium fine	20 mm to 63 mm 6 mm to 20 mm 2.36 mm to 6 mm
Sand	coarse medium fine	600 µm to 2.36 mm 200 µm to 600 µm 75 µm to 200 µm

Minor components

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

TERRA INSIGHT

How to interpret the engineering logs in Your Report

Moisture condition

TERM	DEFINITION
Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Soil structure

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

Consistency of cohesive soils

TERM	UNDRAINED STRENGTH s_u (kPa)	VISUAL OBSERVATION IN FIELD
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 – 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 – 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 – 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 – 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

Density of granular soils

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 – 35
Medium Dense	35 – 65
Dense	65 – 85
Very Dense	Greater than 85

Geological origin

TRANSPORTED SOILS

Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TERRA INSIGHT

How to interpret the engineering logs in Your Report

FIELD DESCRIPTIONS OF ROCK

The descriptive terms used by Terra Insight are given below. They are broadly consistent with Australian Standard AS1726-1993.

Rock Substance	In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Classification of weathering products

Term	Abbreviation	Definition
Residual Soil	RS	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	XW	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	HW	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	MW	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	SW	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	FR	Rock substance unaffected by weathering.

Notes on Weathering:

AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.

Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

Rock substance strength terms

Term	Abbreviation	UCS (MPa)	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	VL	<2	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	6 to 20	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	60 to 200	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	EH	>200	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index Is(50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

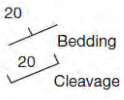
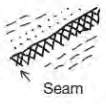
SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

TERRA INSIGHT

How to interpret the engineering logs in Your Report

Common defects observed in rock

Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.

Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Veneer	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

TERRA INSIGHT

Borehole No.
BH01
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA21-502

Client:	Planning Lawyer	Commenced:	26/10/2021
Project Name:	Geotechincal Investigation	Completed:	26/10/2021
Hole Location:	No. 60 Macleay Street, Narrawallee NSW	Logged By:	XJ
Hole Position:	269702.0 m E 6090151.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	0.85 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	Gary Fox

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm Termination	Structure and Additional Observations
			Not Encountered	S1 0.00-0.50 m					SM	Silty SAND: fine to medium sand, grey, low plasticity	M	MD	3 8 4	TOPSOIL
									CI-CH	Silty Sandy CLAY: medium to high plasticity, yellow brown, fine to medium sand	M	F	2	FILL
				S2 0.50-1.00 m		0.4	0.5		CI	Sandy CLAY: medium plasticity, brown, fine to medium sand	M	St	10 6 9 4	
									CI	Silty Sandy CLAY: medium plasticity, white, fine to medium plasticity	M	St	7 6	ALLUVIAL SOIL
				S3 1.00-1.50 m		-0.2	1.0		CI	Sandy CLAY: medium plasticity, red brown, fine to coarse sand, with fine to medium sub angular gravels			6 11 9 8	
				S4 1.50-2.00 m		-0.7	1.5				M	St	9 5 4 5 6 5	
						-1.2	2.0			Hole Terminated at 2.00 m Target			5	
						-1.7	2.5						5 5 4 6 8 9 9 8	
						-2.2	3.0							
						-2.7	3.5							

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
BH02
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA21-502

Client:	Planning Lawyer	Commenced:	26/10/2021
Project Name:	Geotechincal Investigation	Completed:	26/10/2021
Hole Location:	No. 60 Macleay Street, Narrawallee NSW	Logged By:	XJ
Hole Position:	296695.0 m E 6090161.0 m N MGA94 Zone 56	Checked By:	KG
Drill Model and Mounting:	1.8t excavator	Inclination: -90°	RL Surface: 0.70 m
Hole Diameter:		Bearing:	Datum: AHD Operator: Gary Fox

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm	Structure and Additional Observations
				S1 0.00-0.50 m		0.2	0.5		CL-CI	Clayey SAND: fine to medium sand, grey brown, low plasticity fines	W	F		TOPSOIL
									CI-CH	Silty Sandy CLAY: medium plasticity, white, fine to medium sand	D - M	St		ALLUVIAL SOIL
				S2 0.50-1.00 m		-0.3	1.0		SW	Sandy CLAY: medium plasticity, red brown, fine to coarse sand, with fine to medium sub angular gravels	M	St		
				S3 1.00-1.50 m		-0.8	1.5							
				S4 1.50-2.00 m		-1.3	2.0			Hole Terminated at 2.00 m Target				
						-1.8	2.5							
						-2.3	3.0							
						-2.8	3.5							

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
BH03
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA21-502

Client:	Planning Lawyer	Commenced:	26/10/2021
Project Name:	Geotechincal Investigation	Completed:	26/10/2021
Hole Location:	No. 60 Macleay Street, Narrawallee NSW	Logged By:	XJ
Hole Position:	269685.0 m E 6090168.0 m N MGA94 Zone 56	Checked By:	KG
Drill Model and Mounting:	1.8t excavator	Inclination: -90°	RL Surface: 0.05 m
Hole Diameter:		Bearing:	Datum: AHD Operator: Gary Fox

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm Termination	Structure and Additional Observations
			Not Encountered	S1 0.00-0.50 m			0.0		SW	Clayey SAND: fine to medium sand, grey brown, low plasticity fines	M - W	F	3	TOPSOIL
									Cl	Sandy CLAY: medium plasticity, orange brown and yellow brown and grey mottled, fine to medium sand	M	St	4 4 7	FILL
				S2 0.50-1.00 m		-0.5	0.5		Cl	Silty Sandy CLAY: medium plasticity, white, fine to medium sand	D - M	St	8 7 8	ALLUVIAL SOIL
				S3 1.00-1.50 m		-1.0	1.0		Cl	Sandy CLAY: medium plasticity, red brown, fine to coarse sand, with fine to medium sub angular gravels	M	St	7 14 11 14 8 9 5 8	
				S4 1.50-2.00 m		-1.5	1.5						6 6 3 3 4	
						-2.0	2.0			Hole Terminated at 2.00 m Target			4 9 11 7 6	
						-2.5	2.5						5 4 6 5 4	
						-3.0	3.0						5 4 4 4 5	
						-3.5	3.5						6 5	

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

TERRA INSIGHT

Borehole No.
BH04
Page 1 of 1

Engineering Log - Borehole

Project No.: TERRA21-502

Client:	Planning Lawyer	Commenced:	26/10/2021
Project Name:	Geotechincal Investigation	Completed:	26/10/2021
Hole Location:	No. 60 Macleay Street, Narrawallee NSW	Logged By:	XJ
Hole Position:	269678.0 m E 6090181.0 m N MGA94 Zone 56	Checked By:	KG

Drill Model and Mounting:	1.8t excavator	Inclination:	-90°	RL Surface:	0.30 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	Gary Fox

Drilling Information								Soil Description					Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Group Symbol	Material Description Soil name, plasticity/grainsize characteristics, colour, description of secondary component. Minor components, i.e., some/trace . . . other soil substance observations	Moisture Condition	Consistency Relative Density	DCP NO OF BLOWS PER 100 mm	Structure and Additional Observations
				S1 0.00-0.50 m					SM	Silty SAND: fine to medium sand, grey, low plasticity	M - W	MD		TOPSOIL
				S2 0.50-1.00 m		-0.2	0.5		CI-CH	Silty Sandy CLAY: medium to high plasticity, yellow brown, fine to medium sand	M	St		FILL
				S3 1.00-1.50 m		-0.7	1.0		CI	Sandy CLAY: medium plasticity, brown, fine to medium sand	M	St		ALLUVIAL SOIL
				S4 1.50-2.00 m		-1.2	1.5		CI	Silty Sandy CLAY: medium plasticity, white, fine to medium plasticity	M	St		
						-1.7	2.0			Hole Terminated at 2.00 m Target				
						-2.2	2.5							
						-2.7	3.0							
						-3.2	3.5							

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test

Moisture Condition
D - Dry
M - Moist
W - Wet

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
Fr - Friable
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Plastic Limit
< PL
= PL
< PL

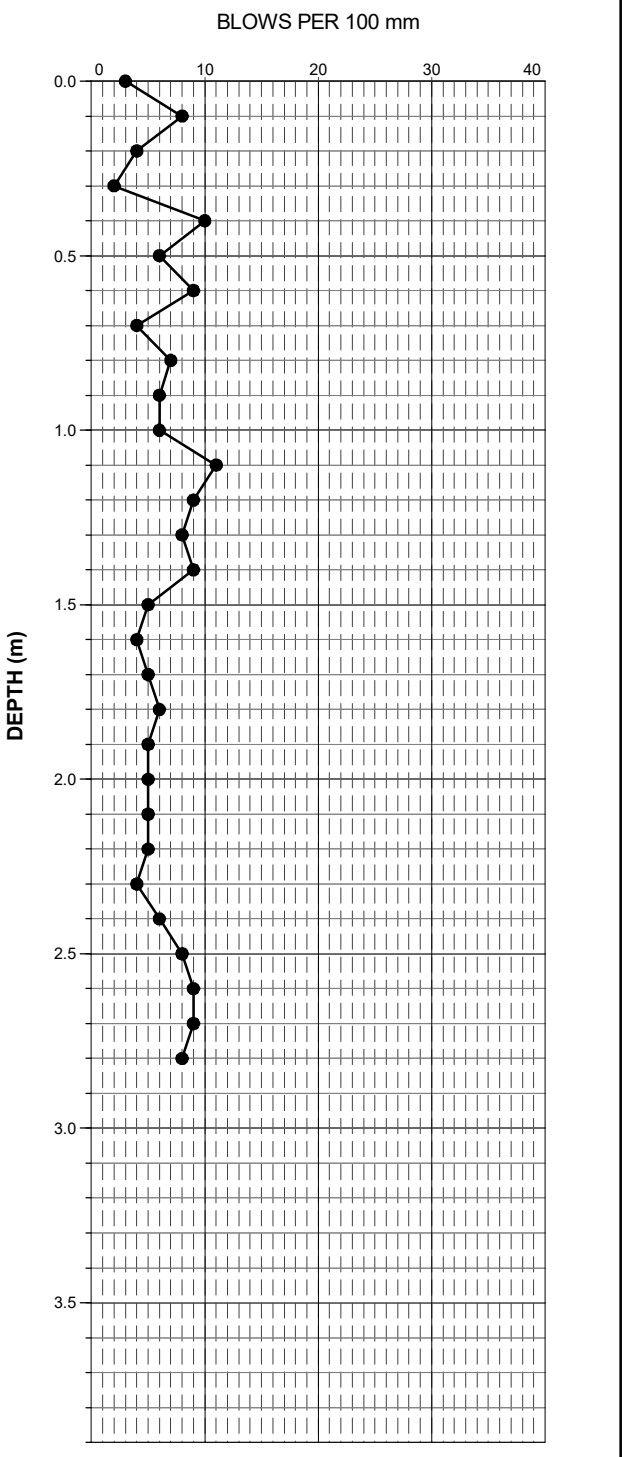
TERRA INSIGHT

9 KG DYNAMIC CONE PENETROMETER

Hole ID: **BH01**

CLIENT	: Planning Lawyer	POSITION	:	SHEET	: 1 OF 1
CONTRACTOR	:	EASTING	: 269702.0 m	STATUS	:
PROJECT	: Geotechincal Investigation	NORTHING	: 6090151.0 m	LOGGED BY	: XJ
LOCATION	: No. 60 Macleay Street, Narrawallee NSW	COORD. SYS.	: MGA94 Zone 56	DRILL DATE	: 26/10/2021
PROJECT No.	: TERRA21-502	GROUND RL	: 0.85 m AHD		

DEPTH (m)	NO OF BLOWS PER 100 mm
0.00	3
0.10	8
0.20	4
0.30	2
0.40	10
0.50	6
0.60	9
0.70	4
0.80	7
0.90	6
1.00	6
1.10	11
1.20	9
1.30	8
1.40	9
1.50	5
1.60	4
1.70	5
1.80	6
1.90	5
2.00	5
2.10	5
2.20	5
2.30	4
2.40	6
2.50	8
2.60	9
2.70	9
2.80	8



Final Depth (m)	2.80

RIG	:	CHECKED BY	: KG	REMARK
INCLINATION	:	CHECKED DATE	: 26/10/2021	Termination
AZIMUTH	:	APPROVED BY	: KG	
HOLE DIA.	:	APPROVED DATE	: 26/10/2021	

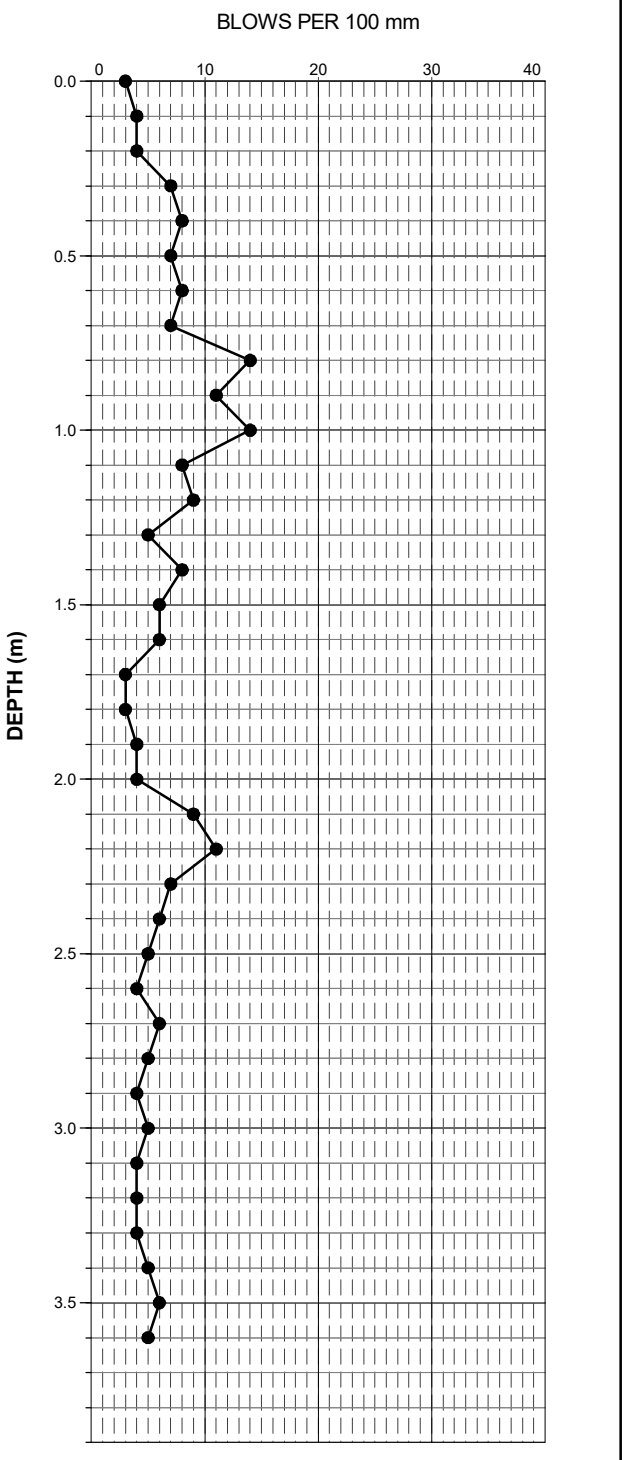
9 KG DYNAMIC CONE PENETROMETER

TERRA INSIGHT

Hole ID **BH03**

CLIENT	: Planning Lawyer	POSITION	:	SHEET	: 1 OF 1
CONTRACTOR	:	EASTING	: 269685.0 m	STATUS	:
PROJECT	: Geotechincal Investigation	NORTHING	: 6090168.0 m	LOGGED BY	: XJ
LOCATION	: No. 60 Macleay Street, Narrawallee NSW	COORD. SYS.	: MGA94 Zone 56	DRILL DATE	: 26/10/2021
PROJECT No.	: TERRA21-502	GROUND RL	: 0.05 m AHD		

DEPTH (m)	NO OF BLOWS PER 100 mm
0.00	3
0.10	4
0.20	4
0.30	7
0.40	8
0.50	7
0.60	8
0.70	7
0.80	14
0.90	11
1.00	14
1.10	8
1.20	9
1.30	5
1.40	8
1.50	6
1.60	6
1.70	3
1.80	3
1.90	4
2.00	4
2.10	9
2.20	11
2.30	7
2.40	6
2.50	5
2.60	4
2.70	6
2.80	5
2.90	4
3.00	5
3.10	4
3.20	4
3.30	4
3.40	5
3.50	6
3.60	5



Final Depth (m)	3.60

RIG	:	CHECKED BY	: KG	REMARK
INCLINATION	:	CHECKED DATE	: 26/10/2021	Termination
AZIMUTH	:	APPROVED BY	: KG	
HOLE DIA.	:	APPROVED DATE	: 26/10/2021	

Appendix E: Laboratory Results

TerraInsight Pty Ltd
U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Attention: **Karen Gates**

Report **839296-S**
Project name 60 MACLEY ST NARRAWALLEE
Project ID TERRA21-502
Received Date Nov 08, 2021

Client Sample ID			**BH02_S2_1.0**
Sample Matrix			**Soil**
Eurofins Sample No.			**B21-No20230**
Date Sampled			**Oct 26, 2021**
Test/Reference	LOR	Unit	
Extraneous Material			
<2mm Fraction	0.005	g	24
>2mm Fraction	0.005	g	< 0.005
Analysed Material	0.1	%	100
Extraneous Material	0.1	%	< 0.1
Chromium Suite - NASSG (Excluding ANC)			
CRS suite - NASSG (Excluding ANC) - Liming Rate	1	kg CaCO3/t	1.7
CRS suite - NASSG (Excluding ANC) - Net Acidity (Acidity Units)	10	mol H+/t	22
CRS Suite - NASSG (Excluding ANC) - Net Acidity (Sulfur Units)	0.02	% S	0.04
pH-KCL	0.1	pH Units	5.3
Acid trail - Titratable Actual Acidity	2	mol H+/t	17
sulfidic - TAA equiv. S% pyrite	0.003	% pyrite S	0.030
Chromium Reducible Sulfur[S04]	0.005	% S	0.009
Chromium Reducible Sulfur -acidity units	3	mol H+/t	5.6
Sulfur - KCl Extractable	0.02	% S	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0
HCl Extractable Sulfur	0.02	% S	N/A
Net Acid soluble sulfur	0.02	% S	N/A
Net Acid soluble sulfur - acidity units	10	mol H+/t	N/A
Net Acid soluble sulfur - equivalent S% pyrite[S02]	0.02	% S	N/A
Acid Neutralising Capacity (ANCbt)	0.01	% CaCO3	N/A
Acid Neutralising Capacity - acidity (a-ANCbt)	2	mol H+/t	N/A
Acid Neutralising Capacity - equivalent S% pyrite (s-ANCbt)[S03]	0.02	% S	N/A
ANC Fineness Factor		factor	1.5
CRS Suite - Net Acidity (Sulfur Units)	0.02	% S	0.04
CRS Suite - Net Acidity (Acidity Units)	10	mol H+/t	22
CRS Suite - Liming Rate[S01]	1	kg CaCO3/t	1.7
% Moisture	1	%	12

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Extraneous Material	Brisbane	Nov 09, 2021	6 Week
- Method: LTM-GEN-7050/7070			
Chromium Suite - NASSG (Excluding ANC)	Brisbane	Nov 09, 2021	6 Week
- Method: LTM-GEN-7070 Chromium Reducible Sulfur Suite			
% Moisture	Brisbane	Nov 09, 2021	14 Days
- Method: LTM-GEN-7080 Moisture			

eurofins | Environment Testing

web: www.eurofins.com.au
email: EnviroSales@eurofins.com

Eurofins Environment Testing Australia Pty Ltd
ABN: 50 005 085 521

Melbourne
6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
NATA # 1261 Site # 1254

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Newcastle
4/52 Industrial Drive
Mayfield East NSW 2304
PO Box 60 Wickham 2293
Phone : +61 2 4968 8448
NATA # 1261 Site # 25079

Eurofins ARL Pty Ltd
ABN: 91 05 0159 898

Perth
46-48 Banksia Road
Welshpool WA 6106
Phone : +61 8 6253 4444
NATA # 2377 Site # 2370

Eurofins Environment Testing NZ Limited
NZBN: 9429046024954

Auckland
35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: TerraInsight Pty Ltd
Address: U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Project Name: 60 MACLEY ST NARRAWALLEE
Project ID: TERRA21-502

Order No.:
Report #: 839296
Phone: 0458 008 030
Fax:

Received: Nov 8, 2021 12:59 PM
Due: Nov 15, 2021
Priority: 5 Day
Contact Name: Karen Gates

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Moisture Set	Chromium Suite - NASSG (Excluding ANC)
Melbourne Laboratory - NATA # 1261 Site # 1254							
Sydney Laboratory - NATA # 1261 Site # 18217							
Brisbane Laboratory - NATA # 1261 Site # 20794						X	X
Mayfield Laboratory - NATA # 1261 Site # 25079							
Perth Laboratory - NATA # 2377 Site # 2370							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH02_S2_1.0	Oct 26, 2021		Soil	B21-No20230	X	X
Test Counts						1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

Units

mg/kg: milligrams per kilogram
mg/L: milligrams per litre
ug/L: micrograms per litre
ppm: Parts per million
ppb: Parts per billion
%: Percentage
org/100mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should be used as a guide only and may be different when site specific Sampling Analysis and Quality Plan (SAQP) have been implemented

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs..

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM where no positive PFAS results have been reported have been reviewed and no data was affected.

.

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
LCS - % Recovery							
Chromium Suite - NASSG (Excluding ANC)							
pH-KCL	%	100			80-120	Pass	
Acid trail - Titratable Actual Acidity	%	91			80-120	Pass	
Chromium Reducible Sulfur	%	97			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Chromium Suite - NASSG (Excluding ANC)				Result 1	Result 2	RPD			
CRS suite - NASSG (Excluding ANC) - Liming Rate	B21-No24550	NCP	kg CaCO3/t	1.6	1.6	1.0	30%	Pass	
CRS suite - NASSG (Excluding ANC) - Net Acidity (Acidity Units)	B21-No24550	NCP	mol H+/t	21	22	1.0	30%	Pass	
CRS Suite - NASSG (Excluding ANC) - Net Acidity (Sulfur Units)	B21-No24550	NCP	% S	0.03	0.03	1.0	30%	Pass	
pH-KCL	B21-No24550	NCP	pH Units	9.4	9.4	<1	30%	Pass	
Acid trail - Titratable Actual Acidity	B21-No24550	NCP	mol H+/t	< 2	< 2	<1	30%	Pass	
sulfidic - TAA equiv. S% pyrite	B21-No24550	NCP	% pyrite S	< 0.003	< 0.003	<1	30%	Pass	
Chromium Reducible Sulfur	B21-No24550	NCP	% S	0.034	0.035	1.0	30%	Pass	
Chromium Reducible Sulfur -acidity units	B21-No24550	NCP	mol H+/t	21	22	1.0	30%	Pass	
Sulfur - KCl Extractable	B21-No24550	NCP	% S	N/A	N/A	N/A	30%	Pass	
HCl Extractable Sulfur	B21-No24550	NCP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur	B21-No24550	NCP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur - acidity units	B21-No24550	NCP	mol H+/t	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur - equivalent S% pyrite	B21-No24550	NCP	% S	N/A	N/A	N/A	30%	Pass	
Acid Neutralising Capacity (ANCbt)	B21-No24550	NCP	% CaCO3	2.8	3.0	4.0	30%	Pass	
Acid Neutralising Capacity - equivalent S% pyrite (s-ANCbt)	B21-No24550	NCP	% S	0.91	0.95	4.0	30%	Pass	
ANC Fineness Factor	B21-No24550	NCP	factor	1.5	1.5	<1	30%	Pass	
CRS Suite - Net Acidity (Sulfur Units)	B21-No24550	NCP	% S	< 0.02	< 0.02	<1	30%	Pass	
CRS Suite - Net Acidity (Acidity Units)	B21-No24550	NCP	mol H+/t	< 10	< 10	<1	30%	Pass	
CRS Suite - Liming Rate	B21-No24550	NCP	kg CaCO3/t	< 1	< 1	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S01	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'
S02	Retained Acidity is Reported when the pHKCl is less than pH 4.5
S03	Acid Neutralising Capacity is only required if the pHKCl if greater than or equal to pH 6.5
S04	Acid Sulfate Soil Samples have a 24 hour holding time unless frozen or dried within that period

Authorised by:

Ursula Long	Analytical Services Manager
Myles Clark	Senior Analyst-SPOCAS (QLD)

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

TerraInsight Pty Ltd
U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Attention: **Karen Gates**

Report **835474-S**
Project name 60 MACLEY ST NARRAWALLEE
Project ID TERRA21-502
Received Date Oct 26, 2021

Client Sample ID			BH01_S1_0.5	BH01_S2_1.0	BH01_S3_1.5	BH01_S4_2.0
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**W21-Oc56618**	**W21-Oc56619**	**W21-Oc56620**	**W21-Oc56621**
Date Sampled			**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	5.4	4.9	4.8	4.9
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	3.5	3.4	3.6	3.6
Reaction Ratings*[S05]	0	-	2.0	1.0	4.0	4.0

Client Sample ID			BH02_S1_0.5	BH02_S2_1.0	BH02_S3_1.5	BH02_S4_2.0
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**W21-Oc56622**	**W21-Oc56623**	**W21-Oc56624**	**W21-Oc56625**
Date Sampled			**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	4.9	5.2	5.4	5.4
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	4.0	3.4	3.7	3.5
Reaction Ratings*[S05]	0	-	1.0	4.0	4.0	4.0

Client Sample ID			BH03_S1_0.5	BH03_S2_1.0	BH03_S3_1.5	BH03_S4_2.0
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**W21-Oc56626**	**W21-Oc56627**	**W21-Oc56628**	**W21-Oc56629**
Date Sampled			**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	5.1	5.0	5.0	5.2
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	3.7	3.5	3.8	3.7
Reaction Ratings*[S05]	0	-	4.0	3.0	4.0	4.0

Client Sample ID			BH04_S1_0.5	BH04_S2_1.0	BH04_S3_1.5	BH04_S4_2.0
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**W21-Oc56630**	**W21-Oc56631**	**W21-Oc56632**	**W21-Oc56633**
Date Sampled			**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**	**Oct 26, 2021**
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	4.9	4.8	5.3	5.4
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	3.7	3.7	4.2	4.4
Reaction Ratings*[S05]	0	-	3.0	3.0	4.0	4.0

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Acid Sulfate Soils Field pH Test	Brisbane	Nov 04, 2021	7 Days

- Method: LTM-GEN-7060 Determination of field pH (pHF) and field pH peroxide (pHFOX) tests

eurofins | Environment Testing

web: www.eurofins.com.au
email: EnviroSales@eurofins.com

Eurofins Environment Testing Australia Pty Ltd
ABN: 50 005 085 521

Melbourne
6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
NATA # 1261 Site # 1254

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Newcastle
4/52 Industrial Drive
Mayfield East NSW 2304
PO Box 60 Wickham 2293
Phone : +61 2 4968 8448
NATA # 1261 Site # 25079

Eurofins ARL Pty Ltd
ABN: 91 05 0159 898

Perth
46-48 Banksia Road
Welshpool WA 6106
Phone : +61 8 6253 4444
NATA # 2377 Site # 2370

Eurofins Environment Testing NZ Limited
NZBN: 9429046024954

Auckland
35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: TerraInsight Pty Ltd
Address: U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Project Name: 60 MACLEY ST NARRAWALLEE
Project ID: TERRA21-502

Order No.:
Report #: 835474
Phone: 0458 008 030
Fax:

Received: Oct 26, 2021 4:53 PM
Due: Nov 2, 2021
Priority: 5 Day
Contact Name: Karen Gates

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA # 1261 Site # 1254						
Sydney Laboratory - NATA # 1261 Site # 18217						
Brisbane Laboratory - NATA # 1261 Site # 20794						X
Mayfield Laboratory - NATA # 1261 Site # 25079						
Perth Laboratory - NATA # 2377 Site # 2370						
External Laboratory						
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**	
1	BH01_S1_0.5	Oct 26, 2021		Soil	W21-Oc56618	X
2	BH01_S2_1.0	Oct 26, 2021		Soil	W21-Oc56619	X
3	BH01_S3_1.5	Oct 26, 2021		Soil	W21-Oc56620	X
4	BH01_S4_2.0	Oct 26, 2021		Soil	W21-Oc56621	X
5	BH02_S1_0.5	Oct 26, 2021		Soil	W21-Oc56622	X
6	BH02_S2_1.0	Oct 26, 2021		Soil	W21-Oc56623	X
7	BH02_S3_1.5	Oct 26, 2021		Soil	W21-Oc56624	X
8	BH02_S4_2.0	Oct 26, 2021		Soil	W21-Oc56625	X
9	BH03_S1_0.5	Oct 26, 2021		Soil	W21-Oc56626	X

Date Reported:Nov 05, 2021

Date Reported:Nov 05, 2021

eurofins | Environment Testing

web: www.eurofins.com.au
email: EnviroSales@eurofins.com

Eurofins Environment Testing Australia Pty Ltd
ABN: 50 005 085 521

Melbourne
6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
NATA # 1261 Site # 1254

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Newcastle
4/52 Industrial Drive
Mayfield East NSW 2304
PO Box 60 Wickham 2293
Phone : +61 2 4968 8448
NATA # 1261 Site # 25079

Eurofins ARL Pty Ltd
ABN: 91 05 0159 898

Perth
46-48 Banksia Road
Welshpool WA 6106
Phone : +61 8 6253 4444
NATA # 2377 Site # 2370

Eurofins Environment Testing NZ Limited
NZBN: 9429046024954

Auckland
35 O'Rorke Road
Penrose, Auckland 1061
Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: TerraInsight Pty Ltd
Address: U34 no 10-12 Sylvester Ave
Unanderra
NSW 2626

Project Name: 60 MACLEY ST NARRAWALLEE
Project ID: TERRA21-502

Order No.:
Report #: 835474
Phone: 0458 008 030
Fax:

Received: Oct 26, 2021 4:53 PM
Due: Nov 2, 2021
Priority: 5 Day
Contact Name: Karen Gates

Eurofins Analytical Services Manager : Ursula Long

Sample Detail						Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA # 1261 Site # 1254						
Sydney Laboratory - NATA # 1261 Site # 18217						
Brisbane Laboratory - NATA # 1261 Site # 20794						X
Mayfield Laboratory - NATA # 1261 Site # 25079						
Perth Laboratory - NATA # 2377 Site # 2370						
External Laboratory						
10	BH03_S2_1.0	Oct 26, 2021		Soil	W21-Oc56627	X
11	BH03_S3_1.5	Oct 26, 2021		Soil	W21-Oc56628	X
12	BH03_S4_2.0	Oct 26, 2021		Soil	W21-Oc56629	X
13	BH04_S1_0.5	Oct 26, 2021		Soil	W21-Oc56630	X
14	BH04_S2_1.0	Oct 26, 2021		Soil	W21-Oc56631	X
15	BH04_S3_1.5	Oct 26, 2021		Soil	W21-Oc56632	X
16	BH04_S4_2.0	Oct 26, 2021		Soil	W21-Oc56633	X
Test Counts						16

Date Reported:Nov 05, 2021

Date Reported:Nov 05, 2021

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

Units

mg/kg: milligrams per kilogram
mg/L: milligrams per litre
ug/L: micrograms per litre
ppm: Parts per million
ppb: Parts per billion
%: Percentage
org/100mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should be used as a guide only and may be different when site specific Sampling Analysis and Quality Plan (SAQP) have been implemented

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs..

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM where no positive PFAS results have been reported have been reviewed and no data was affected.

.

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Acid Sulfate Soils Field pH Test				Result 1	Result 2	RPD			
pH-F (Field pH test)*	W21-Oc56624	CP	pH Units	5.4	5.4	pass	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S05	Field Screen uses the following fizz rating to classify the rate the samples reacted to the peroxide: 1.0; No reaction to slight. 2.0; Moderate reaction. 3.0; Strong reaction with persistent froth. 4.0; Extreme reaction.

Authorised by:

Ursula Long	Analytical Services Manager
Myles Clark	Senior Analyst-SPOCAS (QLD)

Glenn Jackson
General Manager

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Appendix F: CSIRO Guidelines

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

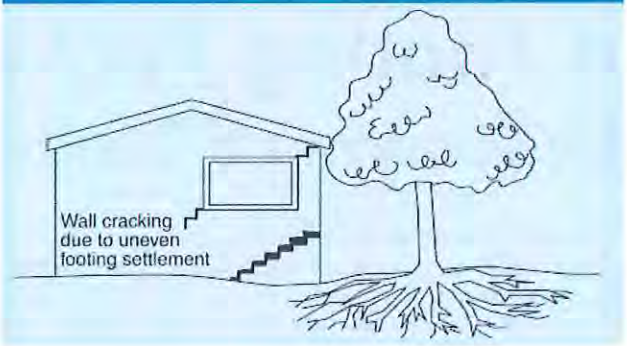
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

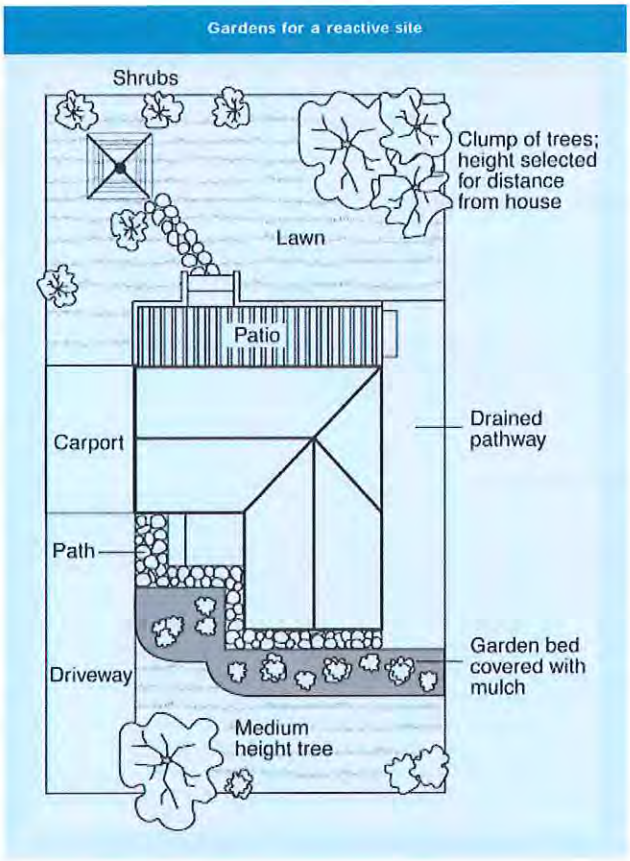
Protection of the building perimeter

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

Freecall 1800 645 051 Tel (03) 9662 7666 Fax (03) 9662 7555 www.publish.csiro.au

Email: publishing.sales@csiro.au