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geotechnical engineering consultants

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7 January 2014

Wesley Mission
c/o Maitland & Butler Pty Ltd
10 Calderwood Rd
Galston NSW 2159

Attention Mr Rob Burakowski

Dear Sir,

PROPOSED FIRE SUPRESSION WATER TANKS AND PUMP ROOM, 156 OCEAN ST, NARRABEEN
GEOTECHNICAL INVESTIGATION

1 INTRODUCTION

1 1 General

This report presents the results of a geotechnical investigation for the above project The investigation was commissioned on 15 November 2013 by Paul Lacy of Wesley Mission The work was carried out in accordance with a proposal by Asset Geotechnical Engineering Pty Ltd dated 15 November 2013, reference P2808

It is understood that the project involves installation of 2 underground 107,000L water tanks and a pump room Excavation depths of approximately 2 5m below ground level will be required for a finished floor level of RL6 7m The edge of the underground tank is located about 3m from a single storey building according to the supplied plans (Maitland and Butler Pty Ltd, Drawing No WES93-D01-D07, dated 20 November 2013)

1 2 Scope of Work

The main objectives of the investigation were to provide information and assessment of the surface and subsurface conditions, to provide comments and recommendations relating to

- Excavation requirements and batter slopes
- Subgrade preparation and earthworks
- Excavation support design parameters
- Suitable footing systems and geotechnical design parameters for the footing systems
- Requirements for underpinning for the adjoining building
- Groundwater and dewatering
- Acid Sulfate Soils (ASS)

In order to achieve the project objectives, the following scope of work was carried out

- A review of existing regional maps and reports relevant to the site, held within our files
- Visual observations of surface features
- Logging of 2 boreholes drilled using a hand auger to a depth of 3 1m
- Dynamic Cone Penetrometer (DCP) tests were carried out at 3 locations to practical refusal depths of up to 4 8m, to aid with assessment of insitu conditions
- Carrying out preliminary laboratory screening for acid sulphate soils comprising pH and pH in H_2O_2
- Engineering assessment and reporting

This report should be read in conjunction with the attached Information Sheets Particular attention is drawn to the limitations inherent in site investigations and the importance of verifying the subsurface conditions inferred herein

2 FIELDWORK AND LABORATORY TESTING

2 1 Borehole Investigation

The fieldwork was undertaken on 22 November 2013 using hand equipment The test locations are shown on the attached Figure 2

Boreholes BH1 and BH2 were each drilled to a target depth of 3 1m On completion of logging and sampling, each borehole was backfilled once groundwater monitoring was completed

The test locations were set out by our engineer relative to existing site features The subsurface conditions encountered were recorded during the progress of the drilling Surface levels at the test locations were estimated from spot levels shown on the supplied design plans

Engineering logs and explanatory notes are attached to this report

2 2 Laboratory Testing

Soil samples recovered during the fieldwork were delivered to a NATA registered laboratory for Potential and Actual Acid Sulphate Soil (PASS and AASS) indicator testing by measurement of pH and pH in H_2O_2)

Testing was carried out generally in accordance with AS1289 "Methods of Testing Soil for Engineering Purposes" or as described in the attached laboratory test results

3 SITE DESCRIPTION

The site is located on the corner of Ocean Street and Octavia Street in Narrabeen, as shown in Figure 1 The site of the proposed water tanks and pump room is in the north-east corner of the Taylor Village aged care facility, as shown on Figure 2

Topographically, the site is located centrally on a low-lying back beach fringe which extends in a north / north-east direction The inlet channel to Narrabeen Lakes is located approximately 180m to the west of the site, with Narrabeen Beach approximately 200m to the east The overall ground surface slopes in the area are generally flat, however rise to the north approaching the foothills of North Narrabeen, and rise towards Collaroy to the south

The existing site development comprises a two storey rendered retirement building split into units with a basement Surrounding outdoor areas are covered with grass with some paved and concreted areas for driveway and walkway access The existing residence appears to be more than about 30 years old and in overall good condition for its age

A 2 storey residential development is located approximately 10m from the southern boundary separated by a driveway Two storey brick residences and a commercial development are located approximately 10m from the northern boundary beyond Octavia Street A combination of of 2 and 3 storey detached properties are also located beyond Ocean Street to the east The surrounding developments generally appeared to be in reasonable condition, with no obvious cracking observed upon casual inspection

Site vegetation comprises mainly grass, some scattered planter beds and a collection of mature trees along the northern and eastern boundaries

The site is almost flat with a slight fall towards the west of about 1° Site drainage would occur mainly via infiltration into the sandy site soils No surface scouring, ponding or erosional features were observed at the time of inspection

4 SUBSURFACE CONDITIONS

4 1 Soils and Geology

The Sydney 1 100,000 Geological map indicates that the site is underlain by Quaternary sediments comprising fine to medium grained marine and Aeolian (dune) sand with podsols and humus podzol intergrades

The 1 100,000 Sydney Soils Landscape Map shows that the site is within the Tuggerah soil group, however is adjacent to the boundary of the Warriewood soil group These soils experience localised flooding and run-on, extreme wind erosion hazard, high water table, highly permeable layers, and are non-cohesive soils with very low fertility

The Hornsby and Mona Vale 1 25,000 Acid Sulfate Soil Risk Map (Edition II) indicates that the site is within an area of low probability of ASS occurring, and bounds an area with a high-risk potential of acid sulphate soils occurring at between 1m and 3m below the ground surface

4 2 Stratigraphy

The following summary description is provided for the conditions observed at the test locations for this investigation The detailed conditions at each test location are recorded on the attached logs For specific design input, reference should be made to the logs and/or the specific test results, in lieu of the following summary

Table 1 – Generalised Subsurface Profile

Layer	Description	Depth (m) BH1 DCP1	DCP2	BH2* DCP3
FILL	Silty SAND Fine to medium grained grey, dark grey and brown loose	0 – 0 3m	?	0 – 0 3m
NATURAL	SAND and Silty SAND very loose to loose	–	0 0 – 0 7m 4 7 – 4 8m	0 3 – 2 8m
NATURAL	As above, but medium dense to very dense	0 1 – 4 8m+	0 7 – 5m+	2 8 – 3 4m+

Special Note for DCP testing

Particular caution must be used when inferring subsurface conditions from DCP results Refusal can be encountered on obstructions such as gravel, rock floaters, or other inclusions within a soil mass Also, the DCP results in clay soils are significantly affected by the insitu moisture content It is therefore strongly recommended that an experienced geotechnical engineer be engaged to confirm the inferred subsurface conditions during construction, and to provide advice where subsurface conditions are significantly different

4 3 Groundwater

No free groundwater was encountered in the boreholes to a depth of 3 1m, and the DCP rods were observed to be dry on withdrawal It is noted that the groundwater observations may have been taken before water levels had stabilised

4 4 Laboratory Test Results

Results from the laboratory testing undertaken on selected soil samples are attached and summarised in Table 2

Table 2 – Soil Test Results

Test Location & Depth	Test Results		
	pH	pH in H_2O_2	drop in pH
BH1, 0 5-0 6m	7 21	6 69	0 52
BH1, 1 0-1 1m	7 03	6 43	0 6
BH1, 1 5-1 6m	6 83	6 64	0 19
BH1, 2 0-2 1m	9 1	8 5	0 6
BH1, 2 5-2 6m	9 35	7 83	1 52
BH1, 3 0-3 1m	9 19	7 87	1 32
BH2, 0 5-0 6m	8 37	6 75	1 62
BH2, 1 0-1 1m	7 35	6 63	0 72
BH2, 1 5-1 6m	8 42	7 05	1 37
BH2, 2 0-2 1m	7 62	6 94	0 68
BH2, 2 5-2 6m	9 15	7 77	1 38
BH2, 3 0-3 1m	9 16	7 78	1 38

5 DISCUSSIONS & RECOMMENDATIONS

5 1 1 Excavation

Site excavations within the sands should be readily achievable using conventional earthmoving equipment (e g hydraulic excavator bucket) It should be noted that vibrations that are below threshold levels for building damage may be experienced at adjoining developments

At all times, the excavation equipment must be operated by experienced personnel, according to the manufacturer's instructions, and in a manner consistent with minimising vibration effects

5 1 2 Subgrade Preparation

The following general recommendations are provided for subgrade preparation for high level footings, earthworks, pavements, slab-on-ground construction, and minor structures

- Strip any existing fill or topsoil Remove unsuitable materials from site (e g material containing deleterious matter) Stockpile remainder for re-use as landscaping material or remove from site
- Excavate sandy soils to subgrade level, stockpiling for re-use as engineered fill or remove to spoil

- Compact the upper 150mm subgrade depth to a density index (AS1289 5 6 1–2007) not less than 80% Areas which show visible heave under compaction equipment should be over-excavated a further 0 3m and replaced with approved fill compacted to a density index not less than 80%

5 1 3 Filling

Where filing is required, place in horizontal layers not more than 0 3m loose thickness over the prepared subgrade and compact to a density index not less than 70% beneath pavements and 80% beneath structures Soils should be kept moist but not wet during compaction Compact the upper 150mm of subgrade to a density index not less than 80%

Filling within 1 5m of retaining walls or adjacent structures should be compacted using lightweight equipment (e g hand-operated plate compactor or ride-on compactor not more than 3 tonnes static weight) in order to limit compaction-induced lateral pressures The layer thickness should be reduced to 0 2m maximum loose thickness

Any soils to be imported onto the site for the purpose of back-filling and re-instatement of excavated areas should be free of contamination and deleterious material, and should include appropriate validation documentation in accordance with current regulatory authority requirements which confirms its suitability for the proposed land use Further advice should be sought from a specialist environmental consultant if required

5 1 4 Batter Slopes

Temporary batters (i e during excavation) should be graded no steeper than 1H 1V or else supported by a properly engineered shoring system Permanent batters should be graded no steeper than 2H 1V

5 2 Footings

The results of the investigation indicate that the site is underlain by shallow fill over natural sands of variable density Very loose to loose sands were encountered to depths of up to 2 8m (approximately RL6 3m)

Proposed footings for the pump room and water tanks will be at approximately RL6 5m This will be within the medium dense or better sands, or near the base of the loose sands in the vicinity of BH2 High level footings at RL6 5m could be designed for an allowable bearing capacity of 150kPa, provided that subgrade preparation is carried out as per Section 5 1 2

Pile footings could also be considered, however additional geotechnical investigation and ASS assessment would be required For preliminary design, piles founded within medium dense or better sands at a depth of 5m below surface level (at or below about RL4 5m) may be designed for an allowable bearing capacity of 1,500kPa

An experienced geotechnical engineer should review footing designs to check that the recommendations of the geotechnical report have been included, and should assess footing excavations to confirm the design assumptions

5 3 Underpinning

An existing two storey building is located approximately 3m away from the proposed excavation No details of the foundation system / depth are known at this stage

Where adjacent footings are located above the "line of influence" of the proposed excavation, temporary shoring and permanent retaining walls should be designed to withstand surcharge loads from the building and prevent damage as per Section 5 4 The "line of influence" is defined as a line extending upwards and outwards from the

base of the excavation, typically 45° above horizontal for stiff clays or medium dense sands (or better), and 30° above horizontal for soft clays or loose sands For this site, we recommend a value of 30° above horizontal for the "line of influence"

Alternatively, underpinning of existing footings to medium dense or better sands could be designed as per Section 5 2 However additional geotechnical investigation is recommended if underpinning is proposed at the site

5 4 Temporary Shoring

It is understood that permanent batter slopes are not proposed for the development Where there is a lack of clearance due to boundaries / buildings for temporary batters as per Section 5 1 4, temporary shoring will be required Depending on the design of the shoring, it could also be incorporated into the permanent foundation and retaining works

For calculation of lateral pressures on retaining walls and shoring, the parameters in Table 3 may be adopted

Table 5 – Material Design Parameters

Soil Type	Moist Unit Weight (γ_m) kN/m³	Characteristic Internal Friction Angle (ϕ') degrees	Partial Design Uncertainty Factor for Strength	Design Internal Friction Angle (ϕ^*) degrees
Sand	16 0	30	0 85	25 5

Unrestrained retaining walls may be designed using active earth pressure (K_a) values calculated using the Coulomb equation For a vertical, rough wall and horizontal backfill, the K_a value for is calculated to be 0 35 This value should be increased to 0 5 where retaining walls are constructed adjacent to movement sensitive structures

Restrained walls may be designed using a K_o value of 1 0

For assessment of passive restraint embedded below excavation level we recommend a triangular pressure distribution with a coefficient of passive pressure (K_p) of 3 0 for the medium dense or better sand This includes a reduction factor to the ultimate value of K_p to take into account strain incompatibility between active and passive pressure conditions

Where adequate subsoil drainage is provided behind walls, no allowance for groundwater is considered necessary Appropriate surcharge loading at the finished surface level should also be adopted for design of the walls

Detailed construction supervision, monitoring and inspections will be required during the wall construction and bulk excavation to ensure an adequate standard of workmanship and to minimise potential problems

5 5 Groundwater and Dewatering

Based on required bulk excavation depths to approximately RL 6 5m, and from the results of this investigation, it is assessed that the excavations will be above the groundwater level at the site As such, we assess that the construction will have no effect on the local ground water regime

However, localised inflows may occur into the excavation particularly after rainfall Such inflows should be controllable using conventional sump and pump methods Further geotechnical advice should be sought if higher inflows are encountered at the site or excavation below the water table is proposed

5 6 Acid Sulphate Soils

In accordance with ASSMAC[2], pH values of less than or equal to 4 indicate that actual acid sulfate soils (AASS) are present Potential acid sulphate soils (PASS) are indicated where pH in H_2O_2 values are less than 3 5 (preferably 3), and where the pH drop is more than 1 unit

The results of the testing found that no sample had a pH of less than 4 or a pH in H_2O_2 of less than 3 5 From this, AASS or PASS is unlikely to be present in the site soils within the upper 3 1m depth Although 6 samples exhibited a pH drop of more than 1 unit with the addition of H_2O_2, the final pH was higher than the indicator cut-off values for both AASS and PASS

Considering that the material to be excavated at the site is not classified as AASS or PASS, we assess that an Acid Sulphate Soil Management Plan (ASSMP) is not required for this project

6 LIMITATIONS

In addition to the limitations inherent in site investigations (refer to the attached Information Sheets), it must be pointed out that the recommendations in this report are based on assessed subsurface conditions from limited investigations In order to confirm the assessed soil ground water properties in this report, further investigation and laboratory testing should be carried out if the scale of the development warrants, or if any of the properties are critical to the design, construction or performance of the development

It is recommended that a qualified and experienced geotechnical engineer be engaged to provide further input and review during the design development, including site visits during construction to verify the site conditions and provide advice where conditions vary from those assumed in this report Development of an appropriate inspection and testing plan should be carried out in consultation with the geotechnical engineer

This report and details for the proposed development must be submitted to relevant regulatory authorities that have an interest in the property (e g Council) or are responsible for services that may be within or adjacent to the site (e g Sydney Water), for their review prior to commencement of construction

❖ ❖ ❖ ❖ ❖

Please do not hesitate to contact the undersigned if you have any questions regarding this report or if you require further assistance

For and on behalf of
Asset Geotechnical Engineering Pty Ltd

Mark Bartel

Mark Bartel
BE MEngSc GMQ MIEAust RPEQ CPEng NPER (Civil)
Managing Director / Principal Geotechnical Engineer

Encl Information Sheets (3 sheets)
CSIRO BTF 18 (4 sheets)
Field Investigation Results (4 sheets)
Laboratory Test Results (12 sheets)
Figure 1 Site Locality
Figure 2 Test Locations

[2] Stone Y Ahern CR, and Blunden B (1998) Acid Sulfate Soils Manual 1998 Acid Sulfate Soil Management Advisory Committee Wollongbar NSW, Australia

Important Information

SCOPE OF SERVICES

The geotechnical report ('the report") has been prepared in accordance with the scope of services as set out in the contract or as otherwise agreed, between the Client and Asset Geotechnical Engineering Pty Ltd ("Asset') The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints

RELIANCE ON DATA

Asset has relied on data provided by the Client and other individuals and organizations, to prepare the report Such data may include surveys analyses, designs maps and plans Asset has not verified the accuracy or completeness of the data except as stated in the report To the extent that the statements opinions facts information conclusions and/or recommendations ("conclusions") are based in whole or part on the data, Asset will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed withheld, misrepresented or otherwise not fully disclosed to Asset

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion It is far less exact than other engineering disciplines Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e g a report prepared for a consulting civil engineer may not be adequate for a construction contractor) The report should not be used for other than its intended purpose without seeking additional geotechnical advice Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed

LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development Despite investigation the actual conditions at the site might differ from those inferred to exist since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies

The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel The actual interface between materials may be more gradual or abrupt than a report indicates

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences The report is based on conditions that existed at the time of subsurface exploration Construction operations adjacent to the site, and natural events such as floods or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report Asset should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report it is a condition of acceptance of the report that Asset be notified of any variations and be provided with an opportunity to review the recommendations of this report Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly

REPRODUCTION OF REPORTS

This report is the subject of copyright and shall not be reproduced either totally or in part without the express permission of this Company Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimize the likelihood of misinterpretation from logs

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party Asset 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 the report (including without limitation matters arising from any negligent act or omission of Asset or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report) Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters

OTHER LIMITATIONS

Asset will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report

ASSET GEOTECHNICAL
geotechnical engineering consultants

Abbreviations, Notes & Symbols

METHOD

borehole logs		*excavation logs*	
AS	auger screw *	NE	natural excavation
AD	auger drill *	HE	hand excavation
RR	roller / tricone	BH	backhoe bucket
W	washbore	EX	excavator bucket
CT	cable tool	DZ	dozer blade
HA	hand auger	R	ripper tooth
D	diatube		
B	blade / blank bit		
V	V-bit		
T	TC-bit		

* bit shown by suffix e g ADV

coring
NMLC NQ PQ HQ

SUPPORT

borehole logs		*excavation logs*	
N	nil	N	nil
M	mud	S	shoring
C	casing	B	benched
NQ	NQ rods		

CORE—LIFT

casing installed

barrel withdrawn

NOTES, SAMPLES, TESTS

D	disturbed
B	bulk disturbed
U50	thin walled sample 50mm diameter
HP	hand penetrometer (kPa)
SV	shear vane test (kPa)
DCP	dynamic cone penetrometer (blows per 100mm penetration)
SPT	standard penetration test
N*	SPT value (blows per 300mm)
	* denotes sample recovered
Nc	SPT with solid cone
R	refusal of DCP or SPT

USCS SYMBOLS

GW	Well graded gravels and gravel-sand mixtures little or no fines
GP	Poorly graded gravels and gravel-sand mixtures little or no fines
GM	Silty gravels gravel-sand-silt mixtures
GC	Clayey gravels gravel-sand-clay mixtures
SW	Well graded sands and gravelly sands little or no fines
SP	Poorly graded sands and gravelly sands little or no fines
SM	Silty sand sand-silt mixtures
SC	Clayey sand sand-clay mixtures
ML	Inorganic silts of low plasticity very fine sands rock flour silty or clayey fine sands
CL	Inorganic clays of low to medium plasticity gravelly clays sandy clays silty clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts of high plasticity
CH	Inorganic clays of high plasticity
OH	Organic clays of medium to high plasticity
PT	Peat muck and other highly organic soils

MOISTURE CONDITION

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

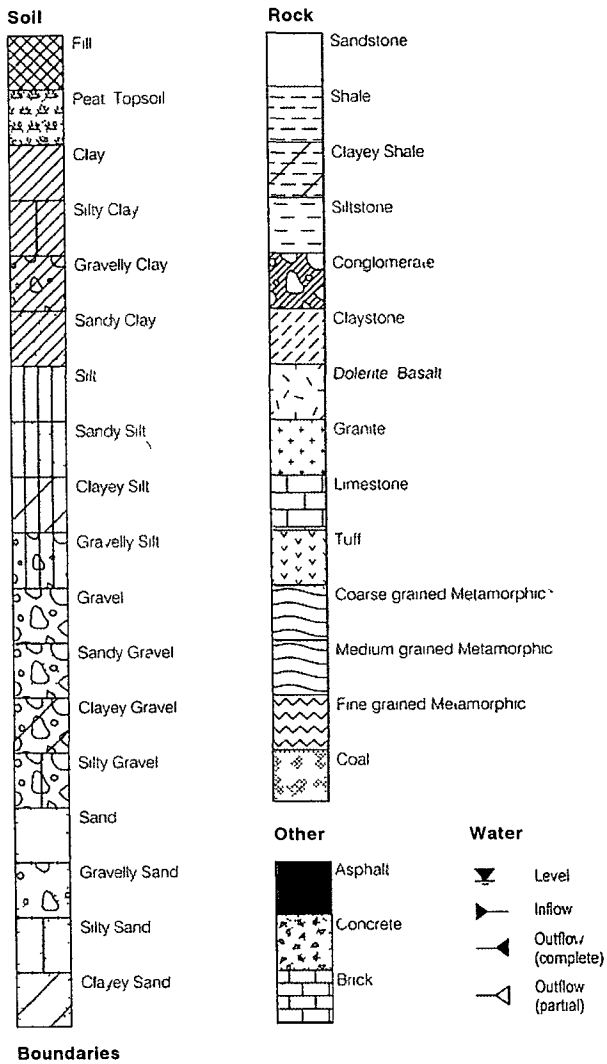
CONSISTENCY

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable

DENSITY INDEX

VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

GRAPHIC LOG



Boundaries

known ------ probable ..... possible

WEATHERING

XW	extremely weathered
HW	highly weathered
MW	moderately weathered
SW	slightly weathered
FR	fresh

STRENGTH

EL	extremely low
VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

RQD (%)

= sum of intact core pieces > 2 x diameter / total length of section being evaluated x 100

DEFECTS

type		*coating*	
JT	joint	cl	clean
PT	parting	st	stained
SZ	shear zone	ve	veneer
SM	seam	co	coating

shape		**roughness**	
pl	planar	po	polished
cu	curved	sl	slickensided
un	undulating	sm	smooth
st	stepped	ro	rough
ir	irregular	vr	very rough

inclination
measured above axis and perpendicular to core

Soil & Rock Terms

AS1726-1993

Soils and rock are described in the following terms which are broadly in accordance with AS1726-1993

SOIL

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry Cohesive and cemented soils are hard friable or powdery Uncemented granular soils run freely through the hand
Moist	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

Moisture content of cohesive soils may also be described in relation to plastic limit (W_P) or liquid limit (W_L) [>> much greater than > greater than < less than << much less than]

CONSISTENCY OF COHESIVE SOILS

Term	Su (kPa)	Term	Su (kPa)
Very soft	< 12	Very Stiff	100 – 200
Soft	12 – 25	Hard	> 200
Firm	25 – 50	Friable	–
Stiff	50 – 100		

DENSITY OF GRANULAR SOILS

Term	Density Index(%)	Term	Density Index (%)
Very Loose	< 15	Dense	65 – 85
Loose	15 – 35	Very Dense	>85
Medium Dense	35 – 65		

PARTICLE SIZE

Name	Subdivision	Size (mm)
Boulders		> 200
Cobbles		63 – 200
Gravel	coarse	20 – 63
	medium	6 – 20
	fine	2 36 – 6
Sand	coarse	0 6 – 2 36
	medium	0 2 – 0 6
	fine	0 075 – 0 2
Silt & Clay		< 0 075

MINOR COMPONENTS

Term	Proportion by Mass	
	coarse grained	fine grained
Trace	≤ 5%	≤ 15%
Some	5 – 2%	15 – 30%

SOIL ZONING

Layers	Continuous exposures
Lenses	Discontinuous layers of lenticular shape
Pockets	Irregular inclusions of different material

SOIL CEMENTING

Weakly	Easily broken up by hand
Moderately	Effort is required to break up the soil by hand

USCS SYMBOLS

Symbol	Description
GW	Well graded gravels and gravel sand mixtures little or no fines
GP	Poorly graded gravels and gravel-sand mixtures little or no fines
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CH	Inorganic clays of high plasticity
OH	Organic clays of medium to high plasticity
PT	Peat muck and other highly organic soils

ROCK

SEDIMENTARY ROCK TYPE DEFINITIONS

Rock Type	Definition (more than 50% of rock consists of)
Conglomerate	gravel sized (>2mm) fragments
Sandstone	sand sized (0 06 to 2mm) grains
Siltstone	silt sized (<0 06mm) particles rock is not laminated
Claystone	clay rock is not laminated
Shale	silt or clay sized particles rock is laminated

LAYERING

Term	Description
Massive	No layering apparent
Poorly Developed	Layering just visible Little effect on properties
Well Developed	Layering distinct Rock breaks more easily parallel to layering

STRUCTURE

Term	Spacing (mm)	Term	Spacing
Thinly laminated	<6	Medium bedded	200 – 600
Laminated	6 – 20	Thickly bedded	600 – 2 000
Very thinly bedded	20 – 60	Very thickly bedded	> 2 000
Thinly bedded	60 – 200		

STRENGTH

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	<0 03	High	1 0 – 3 0
Very low	0 03 – 0 1	Very High	3 0 – 10 0
Low	0 1 – 0 3	Extremely High	>10 0
Medium	0 3 – 1 0		

NOTE Is50 = Point Load Strength Index

WEATHERING

Term	Description
Residual Soil	Soil derived from weathering of rock the mass structure and substance fabric are no longer evident
Extremely	Rock is weathered to the extent that it has soil properties (either disintegrates or can be remoulded) Fabric of original rock is still visible
Highly	Rock strength usually highly changed by weathering rock may be highly discoloured
Moderately	Rock strength usually moderately changed by weathering rock may be moderately discoloured
Slightly	Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh	Rock shows no signs of decomposition or staining

DEFECT DESCRIPTION

Type	
Joint	A surface or crack across which the rock has little or no tensile strength May be open or closed
Parting	A surface or crack across which the rock has little or no tensile strength Parallel or sub-parallel to layering/ bedding May be open or closed
Sheared Zone	Zone of rock substance with roughly parallel near planar curved or undulating boundaries cut by closely spaced joints sheared surfaces or other defects
Seam	Seam with deposited soil (infill) extremely weathered insitu rock (XW) or disoriented usually angular fragments of the host rock (crushed)

Shape	
Planar	Consistent orientation
Curved	Gradual change in orientation
Undulating	Wavy surface
Stepped	One or more well defined steps
Irregular	Many sharp changes in orientation

Roughness	
Polished	Shiny smooth surface
Slickensided	Grooved or striated surface usually polished
Smooth	Smooth to touch Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally <1mm) Feels like fine to coarse sandpaper
Very Rough	Many large surface irregularities amplitude generally >1mm Feels like very coarse sandpaper

Coating	
Clean	No visible coating or discolouring
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral too thin to measure may be patchy
Coating	Visible coating ≤1mm thick Thicker soil material described as seam

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

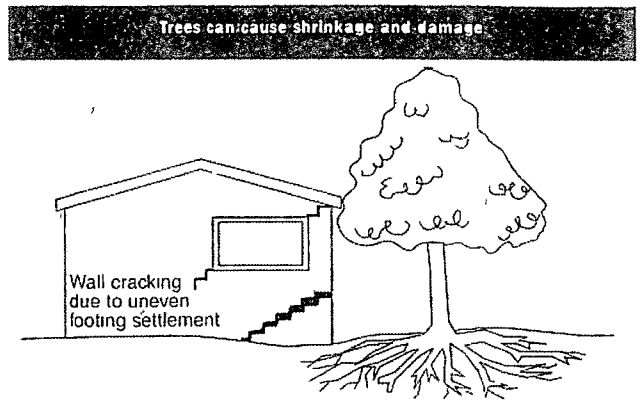
- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends)

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



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

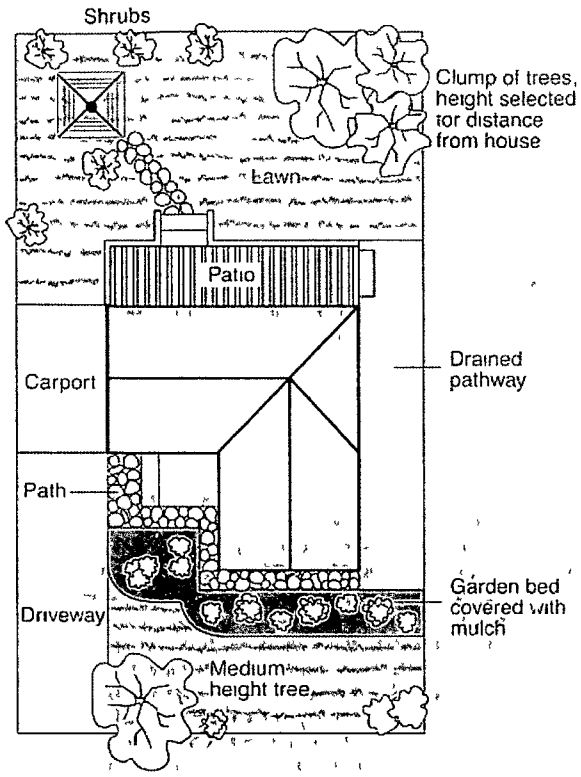
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant

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

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BH no	**BH1**
sheet	1 of 1
job no	2286

Borehole Log

client	MAITLAND AND BUTLER PTY LTD	started	22 11 2013
principal		finished	22 11 2013
project	PROPOSED WATER TANKS AND PUMP ROOM	logged	MT
location	156 OCEAN STREET, NARRABEEN	checked	MAB
equipment	HA	RL surface	9 6 m approx
diameter	100mm inclination -90° bearing --- E N	datum	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/ density index	hand penetro meter kPa 100 200 300 400	structure and additional observations
HA		Dry on completion of augering		9 5				FILL Silty SAND dark brown fine to medium grained trace rootlets and organic material		L		Fill
										MD		
					0 3		SP	SAND Light brown, fine to medium grained trace rootlets form 0 3m 0 6m				Beach/Sand Bar
			D	9 0	0 5			0 7m becoming orangey brown				
			D	8 5	1 0							
			D	8 0	1 5							
			D	7 5	2 0							
			D	7 0	2 5					D		
			D	6 5	3 0							
					3 1			Borehole No BH1 terminated at 3 1m				
				6 0	3 5							
					4 0							

2286_BH GPJ 3/12/13

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BH no	**BH2**
sheet	1 of 1
job no	2286

Borehole Log

client	MAITLAND AND BUTLER PTY LTD	started	22 11 2013
principal		finished	22 11 2013
project	PROPOSED WATER TANKS AND PUMP ROOM	logged	MT
location	156 OCEAN STREET, NARRABEEN	checked	MAB
equipment	HA	RL surface	9 2 m approx
diameter	100mm inclination -90° bearing --- E N	datum	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type plasticity or particle characteristics, colour secondary and minor components)	moisture condition	consistency/ density index	hand penetro meter kPa 100 200 300 400	structure and additional observations
HA		Dry on completion of augering		9 0				FILL Silty SAND dark brown fine to medium grained, trace rootlets, organic material and ironstone cobbles		L		Fill
					0 3		SP	Silty SAND Light brown fine to medium grained trace rootlets form 0 3m 0 5m				Beach/Sand Bar
			D		0 5							
				8 5				0 8m becoming orangey brown				
			D		1 0					VL		
				8 0								
			D		1 5							
				7 5								
			D		2 0							
				7 0								
			D		2 5							
				6 5						L		
										D		
										MD		
			D		3 0							
					3 1			Borehole No BH2 terminated at 3 1m				
				6 0								
					3 5							
				5 5								
					4 0							

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Dynamic Cone Penetrometer

client	MAITLAND & BULTER PTY LTD	started	25/11/2013
principal		finished	25/11/2013
project	PROPOSED WATER TANKS AND PUMP ROOM	logged	MT
location	156 OCEAN STREET, NARRABEEN	checked	AJF/MAB
equipment	9kg hammer, 510mm drop, cone tip	standard	AS1289 6 3 2-1997

test results

Location	DCP1	DCP2	DCP3						
RL (m) AHD									
Depth (m)	Blows per 100mm penetration								
0 00 – 0 10	1	1	1						
0 10 – 0 20	1	1	1						
0 20 – 0 30	2	2	1						
0 30 – 0 40	2	1	1						
0 40 – 0 50	2	1	1						
0 50 – 0 60	2	2	2						
0 60 – 0 70	3	1	1						
0 70 – 0 80	2	2	1						
0 80 – 0 90	2	2	1						
0 90 – 1 00	3	2	0						
1 00 – 1 10	3	2	0						
1 10 – 1 20	3	2	0						
1 20 – 1 30	3	2	0						
1 30 – 1 40	2	2	0						
1 40 – 1 50	2	2	0						
1 50 – 1 60	3	2	0						
1 60 – 1 70	2	2	1						
1 70 – 1 80	2	2	0						
1 80 – 1 90	2	3	0						
1 90 – 2 00	2	3	0						
2 00 – 2 10	3	3	0						
2 10 – 2 20	5	4	0						
2 20 – 2 30	4	5	0						
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2 40 – 2 50	4	5	0						
2 50 – 2 60	4	4	0						
2 60 – 2 70	6	5	0						
2 70 – 2 80	6	5	1						
2 80 – 2 90	5	5	5						
2 90 – 3 00	6	5	4						
3 00 – 3 10	7	7	5						
3 10 – 3 20	7	6	6						
3 20 – 3 30	6	6	9						
3 30 – 3 40	7	5	11						
3 40 – 3 50	8	5							
3 50 – 3 60	7	5							
3 60 – 3 70	7	6							
3 70 – 3 80	8	7							
3 80 – 3 90	8	8							
3 90 – 4 00	6	11							
4 00 – 4 10	6	13							
4 10 – 4 20	8	11							
4 20 – 4 30	10	8							
4 30 – 4 40	10	9							
4 40 – 4 50	14	11							
4 50 – 4 60	18	3							
4 60 – 4 70	10	2							
4 70 – 4 80	7	3							
4 80 – 4 90		3							
4 90 – 5 00		3							
5 00 – 5 10									
5 10 – 5 20									
5 20 – 5 30									
5 30 – 5 40									
5 40 – 5 50									

Notes

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sheet	2 of 2
Job no	2286

Dynamic Cone Penetrometer

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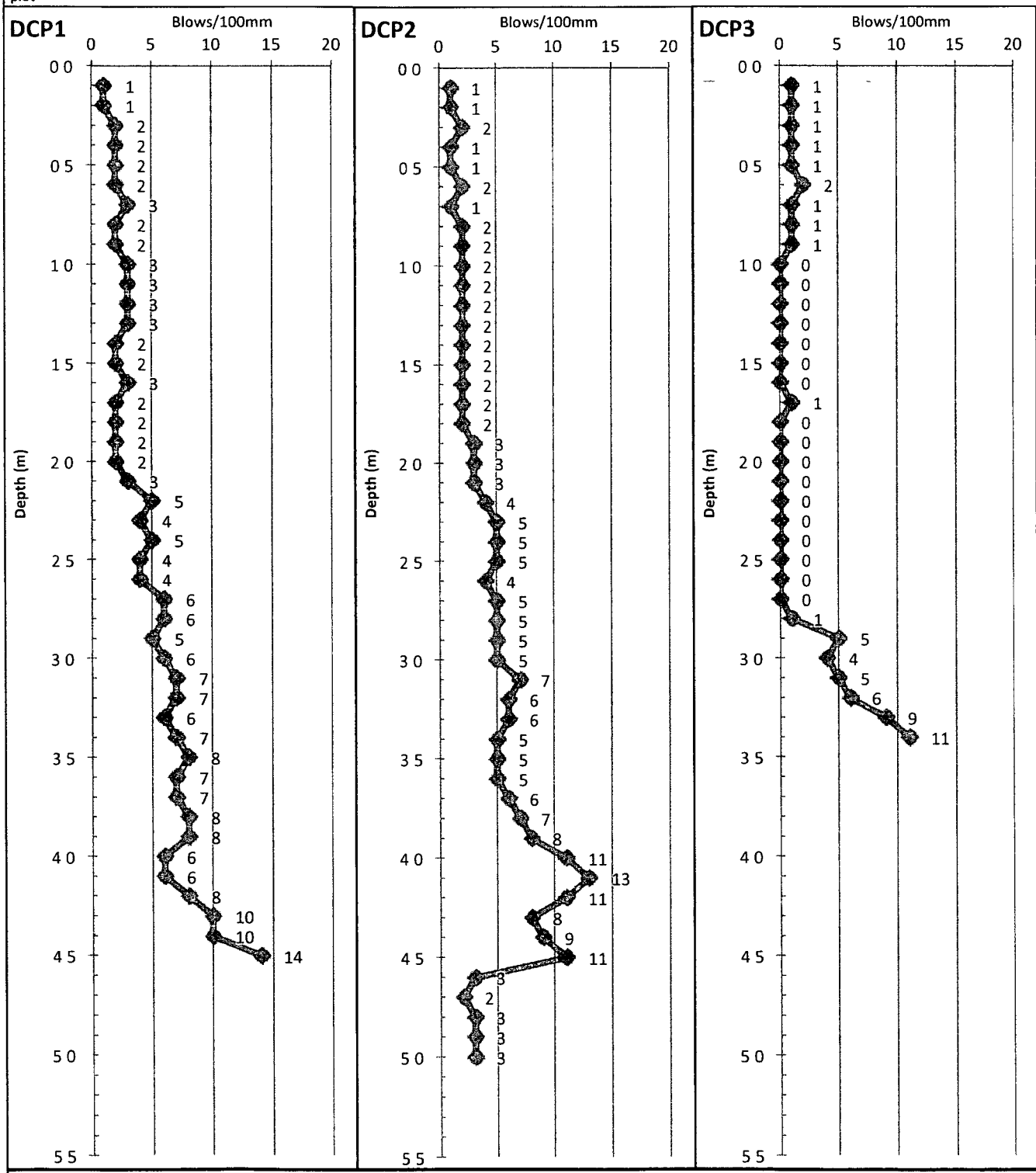
principal		finished	25/11/2013
project	PROPOSED WATER TANKS AND PUMP ROOM	logged	MT
location	156 OCEAN STREET, NARRABEEN	checked	AJF/MAB
equipment	9kg hammer, 510mm drop, cone tip	standard	AS1289 6 3 2-1997
plot			



Notes

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Multiple Analysis Profile

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Batch N° 28472	**Sample N°** 1	**Date Received** 25/11/13	**Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH1 0 5-0 6**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	7 21	Neutral
pH H2O2	6 69	Very Slight Acidity
Colour	7 5YR 5/4 Brown	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows neutral pH with a minor drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

Total No Pages

Consultant
Kelly Lee

Authorised Signatory
Ryan Jacka

Date of Report
27/11/2013

END OF REPORT

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Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH1 1 0-1 1**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	7 03	Neutral
pH H2O2	6 43	Slight Acidity
Colour	7 5YR 5/6 Strong Brown	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows neutral pH with a minor drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

Total No Pages

Consultant
Kelly Lee

Authorised Signatory
Ryan Jacka

Date of Report
27/11/2013

END OF REPORT

SESL AUSTRALIA
Environmental & Soil Sciences

Multiple Analysis Profile

Sample Drop Off 16 Chilvers Road
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Tel 1300 30 40 80
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Batch N° 28472 **Sample N° 3** **Date Received 25/11/13** **Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	***Maitland + Butler - Proposed Water Tanks & Pump Room***
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH1 1 5-1 6**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	6 83	Very Slight Acidity
pH H2O2	6 64	Very Slight Acidity
Colour	7 5YR 5/6 Strong Brown	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows very slight acidity with a minor drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

Total No Pages

Consultant
Kelly Lee

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27/11/2013

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Batch N° 28472 **Sample N° 4** **Date Received 25/11/13** **Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH1 2 0-2 1**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	9 10	Strong Alkalinity
pH H2O2	8 50	Moderate Alkalinity
Colour	7 5YR 6/6 Reddish Yellow	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows strong alkalinity with a minor drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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Batch N° 28472 **Sample N° 5** **Date Received 25/11/13** **Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH1 2 5-2 6**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	9 35	Strong Alkalinity
pH H2O2	7 83	Slight Alkalinity
Colour	10YR 6/6 Brownish Yellow	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows strong alkalinity with a significant drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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Batch N° 28472	**Sample N° 6**	**Date Received 25/11/13**	**Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH1 3 0-3 1**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	9 19	Strong Alkalinity
pH H2O2	7 87	Slight Alkalinity
Colour	10YR 7/6 Yellow	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows strong alkalinity with a significant drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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Batch N° 28472	**Sample N° 7**	**Date Received 25/11/13**	**Report Status ○ Draft ◉ Final**

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH2 0 5-0 6**
Address	**Suite2 05/56 Delhi Rd**	Description	**Soil**
	North Ryde NSW 2113	Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	8 37	Moderate Alkalinity
pH H2O2	6 75	Very Slight Acidity
Colour	7 5YR 5/4 Brown	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows moderate alkalinity with a potentially hazardous drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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Batch N° 28472	**Sample N° 8**	**Date Received 25/11/13**		**Report Status**	○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH2 1 0-1 1**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	7 35	Slight Alkalinity
pH H2O2	6 63	Very Slight Acidity
Colour	7 5YR 5/6 Strong Brown	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows slight alkalinity with a minor drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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Batch N° 28472 **Sample N° 9** **Date Received 25/11/13** **Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH2 1 5-1 6**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	8 42	Moderate Alkalinity
pH H2O2	7 05	Neutral
Colour	7 5YR 6/6 Reddish Yellow	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows moderate alkalinity with a significant drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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Batch N° 28472	**Sample N° 10**	**Date Received 25/11/13**	**Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH2 2 0-2 1**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	7 62	Slight Alkalinity
pH H2O2	6 94	Neutral
Colour	7 5YR 6/6 Reddish Yellow	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows slight alkalinity pH with a minor drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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Batch N° 28472 **Sample N° 11** **Date Received 25/11/13** **Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH2 2 5-2 6**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	9 15	Strong Alkalinity
pH H2O2	7 77	Slight Alkalinity
Colour	7 5YR 6/6 Reddish Yellow	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows strong alkalinity with a significant drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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Batch N° 28472	**Sample N° 12**	**Date Received 25/11/13**	**Report Status** ○ Draft ◉ Final

Client Name	**Asset Geotechnical**	Project Name	**Maitland + Butler - Proposed Water Tanks & Pump Room**
Client Contact	**Michael Tweedie**	Location	**156 Ocean St, Narabeen**
Client Job N°	**2286**	SESL Quote N°	
Client Order N°	**1011**	Sample Name	**BH2 3 0-3 1**
Address	**Suite2 05/56 Delhi Rd North Ryde NSW 2113**	Description	**Soil**
		Test Type	**ASS1**

Analysis	Result	Comments
pH H2O	9 16	Strong Alkalinity
pH H2O2	7 78	Slight Alkalinity
Colour	7 5YR 7/6 Reddish Brown	

Analysed by SESL Australia, NATA #15633

For the purpose of screening for Acid Sulfate Soil (ASS), this soil sample provided by the Client to SESL was analysed to determine if the material is potential acid sulfate soil The sample shows strong alkalinity with a significant drop in pH after oxidation

SESL concludes that this material does not pose a potential acid sulphate soil risk Further screening work is therefore not required

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27/11/2013

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issue	date	description
A	25 11 13	INITIAL ISSUE

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geotechnical engineering consultants
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SYDNEY
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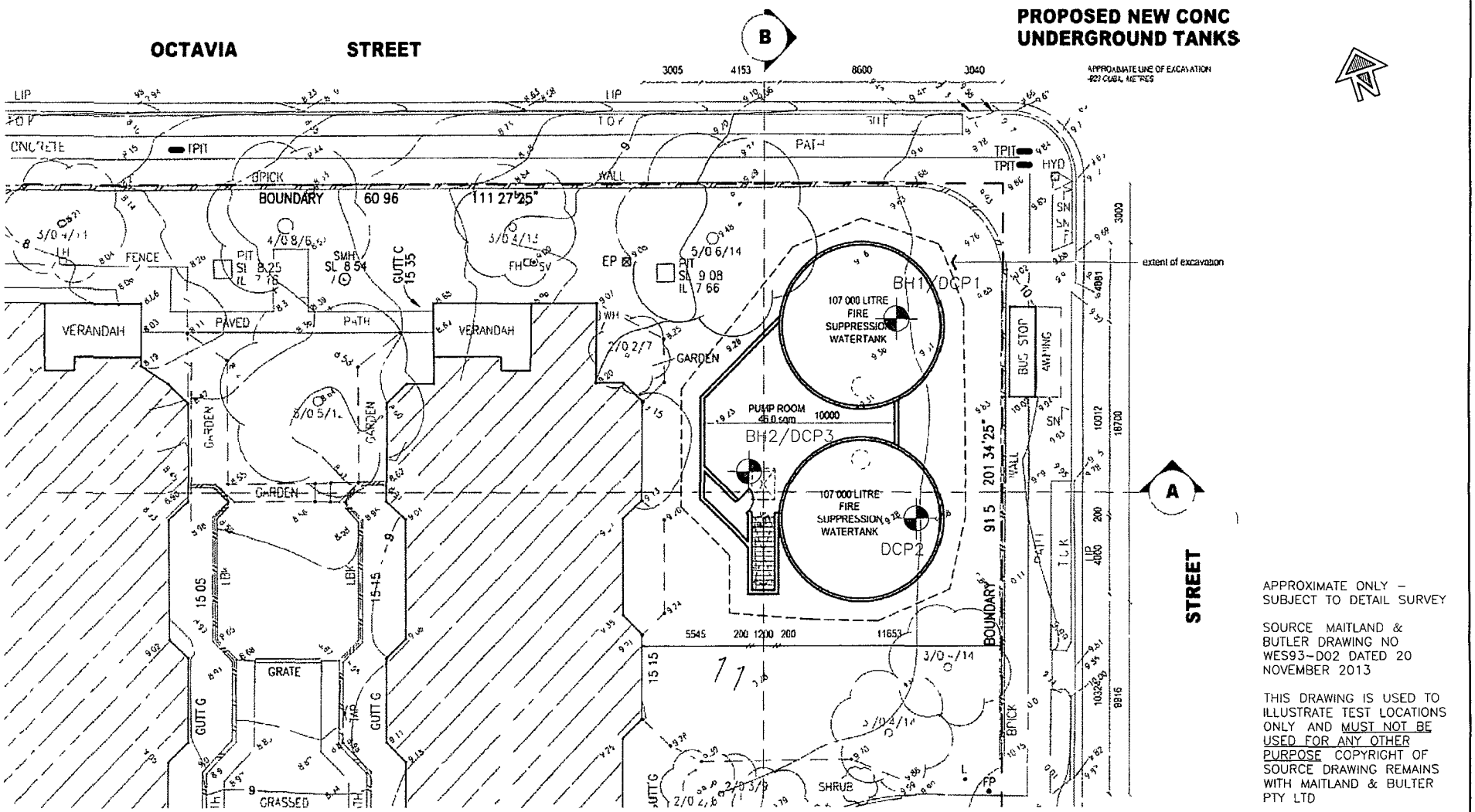
North Ryde NSW 2113
Ph 02 9878 6005
Fax 02 8282 5011

PROPOSED WATER TANKS AND PUMP ROOM
156 OCEAN ST, NARRABEEN
for
MAITLAND & BUTLER PTY LTD

SITE LOCALITY

drawn XL	job no 2286
date 25 11 13	
checked MAB	fig 1
scale 1 5 000 A4	issue A



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PROPOSED WATER TANKS AND PUMP ROOM
156 OCEAN ST, NARRABEEN
for
MAILAND & BUTLER PTY LTD

TEST LOCATIONS

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date 25 11 13		
checked MAB	fig 2	issue A
scale 1 1 000 A4		